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Confédération suisse
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de la formation et de la recherche DEFR

Secrétariat d'Etat à la formation,
à la recherche et à l'innovation SEFRI
Recherche et innovation

Feuille de route suisse pour les infrastructures de recherche en vue du message FRI 2021–2024

(Feuille de route suisse pour les infrastructures de recherche 2019)

Document de base pour le message FRI 2021–2024 dont le Conseil fédéral a pris connaissance le 17 avril 2019

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Résumé

La Feuille de route pour les infrastructures de recherche 2019 est un instrument de planification stratégique. Elle recense d'une part les infrastructures nationales nouvellement planifiées ainsi que la participation de la Suisse à des infrastructures de recherche internationales. D'autre part, l'état de réalisation des infrastructures proposées lors de la précédente Feuille de route est actualisé dans la présente Feuille de route. Elle s'inscrit dans le processus d'élaboration des messages FRI 2021–2024 et UE pour la période pluriannuelle à venir. En outre, cette Feuille de route fournit des indications sur les besoins de financement aux niveaux national et international à moyen terme. La Feuille de route ne contient ni décision de financement ni décision de répartition entre les crédits de la Confédération.

La recherche et l'innovation sont des conditions préalables aux progrès économiques et sociétaux. Ainsi, les acteurs du domaine de la recherche dépendent, dans toutes les disciplines, d'infrastructures de recherche excellentes sur lesquelles fonder leurs activités. Il s'agit notamment de grandes installations de recherche (p. ex. les accélérateurs de particules), d'e-infrastructures (p. ex. les ordinateurs à haute performance) ou de bases de données. Tous les domaines de la recherche sont concernés, de la physique à la biologie en passant par l'informatique et les sciences humaines et sociales. La plupart des infrastructures couvrent plusieurs domaines simultanément. Avec, d'une part, des projets de recherche toujours plus multidisciplinaires et, d'autre part, les développements technologiques, l'importance de ces infrastructures de recherche coûteuses mais accessibles à tous les domaines de recherche va croissant, de même que le besoin de nouvelles infrastructures. Cette situation requiert, de la part des organes de financement, une planification financière à moyen et à long terme où il faut comparer soigneusement la mise en place de nouvelles infrastructures de recherche nationales aux possibilités de participer à des infrastructures de recherche internationales, et soupeser l'option de construire de nouvelles infrastructures de recherche et celle d'exclure, de maintenir ou de développer les infrastructures de recherche existantes.

La présente Feuille de route suisse pour les infrastructures de recherche 2019 fournit, dans la perspective du message FRI 2021–2024, un aperçu général des nouvelles infrastructures de recherche planifiées et une mise à jour de celles qui ont fait leur entrée dans la Feuille de route 2015 (en perspective du message FRI 2017–2020) et dont le financement devra être assuré à l'avenir également. Un inventaire plus complet, incluant de nombreuses infrastructures en exploitation avant la période 2017–2020, se trouve dans le rapport publié par le Secrétariat d'Etat à la formation, à la recherche et à l'innovation (SEFRI) et intitulé « Feuille de route suisse pour les infrastructures de recherche 2015 ».

Le SEFRI a coordonné le processus de la Feuille de route conformément à la loi fédérale sur l'encouragement de la recherche et de l'innovation (LERI). Les projets d'infrastructures de recherche en Suisse proposés par les chercheurs ont été sélectionnés par les organes responsables (Conseil des EPF et swissuniversities) selon des critères d'inclusion et d'autres critères propres à l'institution (p.ex. stratégies internes). A cette présélection (Phase 1) ont succédé deux phases d'évaluation supplémentaires. Au deuxième niveau d'évaluation (Phase 2), le Fonds national suisse de la recherche scientifique (FNS) a examiné les projets soumis selon des critères scientifiques pour les classer en trois catégories de priorité (A, B, C). Les projets ont ensuite été examinés au troisième niveau d'évaluation (Phase 3) par les organes responsables (Conseil des EPF et swissuniversities) selon des critères liés à la planification, à la gouvernance et au management, et sous l'angle de leur réalisation financière et du soutien par les institutions. Au total, les institutions responsables ont proposé de réaliser en Suisse 15 infrastructures de recherche dont huit totalement nouvelles et sept représentant des mises à niveau substantielles (« upgrade »). Sur les 15 projets évalués par le FNS sept (dont quatre sont des mises à niveau) ont été évalués comme ayant une importance scientifique élevée (priorité « A »). Seuls ces projets, qui ont tous passé avec succès l'examen de la Phase 3, entrent dans la présente Feuille de route.

Dans le cadre de cette Feuille de route, le FNS a également reçu le mandat du SEFRI de prendre position sur la pertinence de 15 infrastructures de recherche internationales. Le mandat consistait à examiner l'importance d'une participation suisse à ces infrastructures et organisations internationales. Le FNS a jugé douze infrastructures de recherche comme prioritaires (« importance élevée »).

1. Introduction

1.1. Contenu du rapport sur la Feuille de route

Le Secrétariat d'Etat à la formation, à la recherche et à l'innovation (SEFRI) est responsable de la rédaction de la présente Feuille de route pour les infrastructures de recherche 2019 (« Feuille de route 2019 ») et du processus réalisé avec les partenaires que sont le Conseil des EPF, la Conférence des recteurs des hautes écoles suisses (swissuniversities) et le Fonds national suisse (FNS).

Le chapitre 2 fournit une rétrospective sur la période FRI en cours et sur les obligations nationales et internationales résultant de la Feuille de route 2015. Une mise à jour de ces projets nationaux (état de leur réalisation) se trouve à l'annexe A2. Le chapitre 3 présente la procédure de la Feuille de route 2019. On trouvera au chapitre 4 les résultats de la procédure de relevé (Phase 1) et l'évaluation du FNS avec un aperçu global des infrastructures de recherche dont le FNS recommande la réalisation (Phase 2).

Le chapitre 5 présente plus en détail quelles infrastructures sont recommandées par le FNS, leur évaluation par les organes responsables ainsi que les résultats finaux (Phase 3). Le chapitre 6 expose les autres mesures d'encouragement en faveur des infrastructures de recherche soutenues par les institutions chargées d'encourager la recherche (FNS, Académies suisses des sciences). Finalement, le chapitre 7 montre les projets prévus dans le cadre de la Feuille de route européenne ESFRI[1] et des organisations de recherche internationales.

L'annexe A1 répertorie les infrastructures de recherche nationales de haute importance scientifique nouvellement annoncées et l'annexe B1 les infrastructures de recherche internationales pour lesquelles une participation de la Suisse doit être examinée. Finalement, l'annexe B2 liste les organisations internationales de recherche auxquelles la Suisse participe ou prévoit de participer.

1.2. Objectif de la Feuille de route

Les infrastructures de recherche constituent, dans de nombreuses disciplines, une condition essentielle permettant d'obtenir de nouveaux résultats scientifiques, de développer des domaines spécialisés ou d'explorer de nouveaux domaines de recherche. Le besoin de telles infrastructures de recherche s'est encore accru ces dernières années et entraîne une augmentation des besoins de financement. De plus, les grandes infrastructures de recherche d'importance nationale ou internationale requièrent une coordination sur le plan national et international à moyen et à long terme. Elles exigent également une planification avisée, afin que les ressources limitées soient allouées de manière aussi efficiente et efficace que possible et qu'un accès réglé et ciblé pour les acteurs du domaine de la recherche et de l'innovation soit assuré.

Lorsqu'il s'agit d'une participation de la Suisse à une organisation de recherche internationale basée sur un contrat de droit international, des aspects juridiques et de politique extérieure viennent encore accroître les besoins de planification et de coordination.

Dans un tel contexte, la présente Feuille de route suisse pour les infrastructures de recherche 2019 (« Feuille de route 2019 ») sert d'instrument de planification et constitue l'un des documents de base pour élaborer les décisions financières correspondantes de la Confédération dans le cadre des messages FRI 2021–2024 et UE. La Feuille de route en soi ne constitue ni un relevé visant des financements spéciaux ni une procédure comportant des décisions de financement.

[1] Forum stratégique européen sur les infrastructures de recherche (European Strategy Forum on Research Infrastructures, ESFRI).

Les décisions de financement en vue de la réalisation des différents projets d'infrastructure de recherche interviendront, dans la mesure où elles relèvent de la compétence de la Confédération[2], dans le cadre du message FRI 2021–2024 comme suit :

- sur la base de la planification stratégique des hautes écoles et des programmes pluriannuels des organes de soutien compétents ;
- sur la base des résultats de la procédure d'évaluation de cette Feuille de route ;
- sur la base de l'examen du besoin réel d'une contribution fédérale spécifique au sens de la loi sur les subventions (RS 616.1) ;
- sur la base du cadre financier des arrêtés financiers pluriannuels (FRI et UE) tel que déterminé par le Conseil fédéral pour la période 2021-2024.

[2] Pour la question de la compétence de la Confédération, voir chapitre 5.1.

2. Rétrospective sur la période FRI 2017–2020

2.1. Introduction

La présente Feuille de route 2019 est la troisième publication d'un tel rapport du SEFRI. Les deux précédents rapports ont été publiés en 2011 et 2015. La première Feuille de route a servi de base au chapitre « Infrastructures de recherche » du message FRI 2013-2016. Elle constituait avant tout une réponse à la Feuille de route européenne ESFRI 2008 qui invitait les pays européens à établir des feuilles de route nationales afin d'améliorer les conditions de planification et de financement des grands projets d'infrastructure de recherche coordonnés à l'échelle internationale.

2.2. Période FRI 2017–2020 : Feuille de route suisse pour les infrastructures de recherche 2015 et sa mise en place

La Feuille de route suisse pour les infrastructures de recherche 2015 (Feuille de route 2015) était d'une part axée sur les infrastructures ayant une mission nationale et d'autre part sur les infrastructures internationales et une possible participation de la Suisse à ces dernières.

Le Conseil fédéral a pris connaissance, le 24 juin 2015, du rapport final sur la Feuille de route 2015. Sur la base de l'examen de la nécessité effective du soutien spécifique de la Confédération et d'un contrôle de la disponibilité des ressources financières pour les divers crédits d'encouragement visés, le Conseil fédéral a proposé dans le cadre du message FRI 2017–2020 au Parlement de continuer de soutenir les infrastructures existantes de recherche suivantes :

a) Infrastructures de recherche nationales

Le Conseil fédéral attend du domaine des EPF qu'il exploite de grandes infrastructures de recherche d'importance nationale et internationale, qu'il poursuive leur développement et qu'il les mette à disposition des chercheurs. Selon la Feuille de route 2015 et conformément à son plan stratégique 2017–2020 le **Conseil des EPF** soutient pour la période 2017–2020 :

- les infrastructures faisant partie du processus de la Feuille de route 2015 :
  - HPCN/HPCN-20 (ETHZ) ;
  - Construction de la nouvelle ligne ATHOS du laser suisse à électrons libres dans le domaine des rayons X SwissFEL du PSI ;
  - Swiss Light Source SLS 2.0 (PSI) ;
  - Initiative for Data Science in Switzerland (Swiss Data Science Center) (ETHZ, EPFL) ;
  - Centre de recherche en physique des plasmas (Swiss Plasma Center) (EPFL) ;
  - Next Evolution in Sustainable Building Technologies (NEST) (Empa, Eawag) ;

- les autres infrastructures de recherche hors du processus de la Feuille de route 2015 :
  - Optimisation du détecteur CMS au CERN (dirigée par l'ETHZ) ;
  - Blue Brain Project de l'EPFL (partie du Flagship européen Human Brain Project).

Dans le domaine des EPF, la poursuite du développement des infrastructures existantes et la réalisation des nouvelles infrastructures citées ci-dessus dans le cadre du message FRI 2017–2020 coûte environ 531 millions de francs (dont environ 452 millions de francs à charge de la Confédération).

Les infrastructures des **hautes écoles cantonales** sont financées en premier lieu par les institutions et de façon subsidiaire par la Confédération au travers des contributions de base selon la loi fédérale sur l'encouragement et la coordination des hautes écoles (LEHE). Les infrastructures de recherche que les hautes écoles cantonales ont planifiées durant la période 2017–2020 et qui se trouvent dans la Feuille de route 2015 sont décrites à l'annexe A2.

Dans le cadre de son soutien au titre de **l'art. 15 LERI** (contribution en faveur d'établissements de recherche d'importance nationale), le **SEFRI**, compétent en la matière, a alloué des contributions pour les projets ci-après prévus dans la Feuille de route :

- Plateforme de services en recherche clinique Swiss Clinical Trial Organisation (SCTO ; inclut le réseau suisse des centres de recherche pédiatrique SwissPedNet et le réseau européen EPCTRI[3]) ;
- Nouveaux centres de compétences technologiques :
    - Balgrist Campus Zurich (plateformes dans le domaine orthopédique) et
    - sitem insel Bern (infrastructure dans le domaine de la médecine translationnelle).

Les coûts à la charge du SEFRI pour les trois infrastructures mentionnées ci-dessus s'élèvent à environ 55 millions de francs pour la période 2017–2020.

Autres mesures de la Confédération pour le financement des infrastructures de recherche (période 2017–2020).
Les institutions chargées d'encourager la recherche ont précisé leurs planifications exposées dans la feuille de route 2015.

Dans le cadre de l'examen de son portefeuille, le **Fonds national suisse (FNS)** a précisé ses principes de financement des infrastructures de recherche pour la période 2017–2020 et décidé d'allouer des contributions à de nouvelles infrastructures de recherche au titre de financement de démarrage, généralement pour une durée maximale de dix ans, à condition que le financement ultérieur soit assuré par une organisation de soutien. Ce principe ne pouvant pas être mis en œuvre entièrement au cours de la période de financement 2017–2020, des examens supplémentaires ont été nécessaires[4].

Pendant la période actuelle, le FNS continue à soutenir diverses infrastructures de recherche intégrées internationalement dans les domaines de l'environnement, de la recherche climatique, de la médecine et des sciences humaines et sociales[5]. Au niveau des programmes, le FNS aide les hautes écoles universitaires à financer les coûts d'investissement par le biais du programme R'Equip (soutien aux équipements de recherche) et du programme Funding Large international Research projects (FLARE[6]).

Avec les moyens mis à disposition dans le cadre du message FRI 2017–2020, le FNS soutient les infrastructures de recherche à hauteur d'environ 232 millions de francs (y compris FLARE).

Les **Académies suisses des sciences** soutiennent au moyen des crédits mis à disposition dans le cadre du message FRI 2017–2020 les « entreprises à long terme » (ASSH)[7] et les secrétariats scientifiques (SCNAT) à hauteur de 43,6 millions de francs. La période FRI en cours a également vu le transfert de la responsabilité du financement de huit éditions du FNS à l'ASSH, sachant que les moyens correspondants à hauteur de 10,6 millions de francs pour la période 2017–2020 sont restés inscrits au FNS.

Au cours de la période FRI actuelle, la Confédération (SEFRI) a également lancé une **initiative nationale d'encouragement « Médecine personnalisée »** et a chargé l'Académie suisse des sciences médicales (ASSM) de mettre en place une infrastructure nationale de données dans le domaine clinique. Cette initiative (SPHN)[8] a été mise en œuvre dans le cadre d'une collaboration entre les hautes écoles et les hôpitaux universitaires et le FNS en tant qu'organe de financement, en coordination avec l'initiative du domaine des EPF sur la médecine personnalisée (PHRT[9] axe stratégique du Conseil des EPF).

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[3] L'EPCTRI (European Paediatric Clinical Trial Research Infrastructure) a été intégré au réseau européen d'essais cliniques ECRIN.

[4] L'une des conséquences de la rationalisation du portefeuille a été le transfert des éditions à long terme du FNS à l'Académie suisse des sciences humaines et sociales (ASSH).

[5] Voir chapitre 7.

[6] Le programme FLARE (Funding Large international Research projects) permet de soutenir la conception et l'utilisation, par la communauté scientifique suisse, d'infrastructures de recherche internationales dans le domaine de la physique des particules, de l'astrophysique et de la physique des astroparticules.

[7] DaSCH est soutenue par l'ASSH à hauteur de 2 millions de francs pour la période 2017-2020.

[8] Swiss Personalized Health Network.

[9] Personalized Health and Related Technologies.

Les moyens mis à disposition pour ces deux initiatives s'élèvent à 70 millions de francs pour le SEFRI et 50 millions pour le domaine des EPF.

b) Organisations et infrastructures internationales de recherche

La participation de la Suisse aux organisations internationales de recherche est conforme aux objectifs fixés par le Conseil fédéral dans son rapport « Stratégie internationale de la Suisse dans le domaine de la formation, de la recherche et de l'innovation » (4 juillet 2018). La ligne directrice à suivre à cet égard est la suivante : « Les infrastructures, programmes et services étrangers sont ouverts aux acteurs suisses et leur permettent de garantir et d'améliorer la qualité de leurs propres prestations ».

En ce qui concerne les investissements dans les organisations internationales de recherche, il faut relever que les engagements pris par la Suisse dans ce contexte présentent un caractère obligatoire au regard du droit international. Ainsi, les nouveaux projets réalisés dans le cadre d'organisations internationales de recherche dont la Suisse est déjà membre sont à financer en priorité. La poursuite de la participation aux organisations internationales de recherche auxquelles la Suisse est associée pour une durée donnée vient en second lieu. Enfin, vient en troisième priorité l'adhésion de la Suisse à d'autres organisations internationales de recherche existantes ou nouvelles.

Dans le contexte du message FRI 2017–2020 et sur la base de la Feuille de route 2015, le Parlement a ouvert des crédits pour le renouvellement de la participation temporaire de la Suisse à l'Institut Laue-Langevin (ILL) et pour la participation de la Suisse à la création de l'organisation Cherenkov Telescope Array (CTA)[10]. Par contre, il a fallu renoncer alors aux investissements dans les nouveaux projets internationaux SKA, ELI et LBNF-DUNE proposés dans la Feuille de route 2015, pour des raisons financières ou en raison de leur faible degré de maturité. Au cours des trois dernières années, les travaux de développement se sont poursuivis et les projets ont mûri, ce qui justifie une réévaluation de leur importance pour la Suisse au cours de la période 2021–2024[11].

Projets ESFRI et forme légale ERIC

Dans le cadre de leur autonomie les hautes écoles (ou les institutions de recherche) peuvent participer à des projets du Forum stratégique européen sur les infrastructures de recherche (ESFRI, European Strategy Forum on Research Infrastructures). Une compétence directe de la Confédération n'intervient que dans les cas où cette participation fait l'objet d'un traité international. Cela est le cas, par exemple, lorsqu'un projet ESFRI adopte la forme légale ERIC (European Research Infrastructure Consortium), une tendance qui tend à se développer.

Les infrastructures de recherche internationales l'ayant adoptée bénéficient grâce à la forme légale ERIC, élément du droit de l'Union européenne (UE), d'un cadre juridique et organisationnel stable et durable pour déployer leurs activités. Elles jouissent parmi les Etats reconnaissant cette forme légale de privilèges équivalents à ceux d'organisations intergouvernementales. Enfin, ces infrastructures de recherche internationales peuvent briguer plus aisément des encouragements financiers de l'UE. Sous l'angle de l'encouragement de la recherche par la Confédération, il est donc hautement prioritaire de garantir le meilleur accès possible à tous les ERIC d'intérêt stratégique pour les institutions de recherche et les groupes de chercheurs suisses. Ce but suppose normalement la participation de la Suisse comme membre d'un ERIC.

Toutefois, pour devenir membre d'un ERIC, un Etat doit avoir pour l'ERIC en question communiqué à la Commission européenne sa reconnaissance de l'ordonnance de l'UE établissant la forme légale ERIC. En Suisse, cette reconnaissance doit être approuvée, avec les bases légales actuelles, au cas par cas par le Parlement.

[10] Voir chapitre 7.2

[11] Voir chapitre 7.2

Les projets ESFRI avec une participation Suisse durant la période 2017–2020 (en principe statut d'observateur non contraignant sur le plan du droit international) et qui ont évolué vers des ERIC (état des lieux 31.12.2018) sont listés ci-dessous :

Recherche biomédicale / recherche clinique :

- **BBMRI ERIC**: Interconnexion de banques de données biologiques; nœud de connexion pour la Suisse: Swiss Biobanking Platform (soutien dans le cadre du budget FNS).
- **ECRIN ERIC :** Interconnexion de centres pour des études cliniques; nœud de connexion pour la Suisse: Swiss Clinical Trial Organisation (SCTO, soutien dans le cadre du budget FNS).
- **ELIXIR :** Infrastructures bioinformatiques dans le cadre d'EMBL[12] ; nœud de connexion pour la Suisse: Swiss Institute for Bioinformatics (SIB, contributions fédérales fixées selon les articles 15 et 28 LERI / crédit d'engagement pour la coopération internationale dans la recherche ; pas de structure ERIC ; une obligation de droit international a été contractée par la Suisse durant la période FRI 2013−2016).

Recherche sur les matériaux et en sciences de la vie :

- **European Spallation Source ERIC (ESS ERIC) :** Source de neutrons pour la recherche en matériaux et en sciences du vivant à Lund (Suède), destinée à devenir l'instrument le plus puissant de ce genre au monde ; une obligation de droit international a été contractée par la Suisse durant la période FRI 2013−2016.

Recherche sur l'environnement/le climat :

- **ICOS ERIC :** Physique atmosphérique et recherche sur les écosystèmes; nœud de connexion pour la Suisse: ETHZ et HFSJG[13] (soutien dans le cadre du budget FNS et apport de fonds propres des institutions du domaine des EPF).
- **EPOS ERIC :** Recherche sismique; nœud de connexion: ETHZ / SED[14] (domaine des EPF et autres).
- **ECCSEL ERIC :** Diverses infrastructures de recherche dédiées à la recherche sur l'élimination, le stockage et l'utilisation du dioxyde de carbone pour la production d'énergie (domaine des EPF et autres)[15].

Recherche en sciences humaines et sociales :

- **ESSurvey ERIC :** Enquêtes sociologiques à long terme; nœud de connexion pour la Suisse: FORS[16] (soutien dans le cadre de l'art. 15, LERI).
- **CESSDA ERIC :** Interconnexion des archives de données sociologiques; nœud de connexion pour la Suisse: FORS (soutien dans le cadre de l'art. 15, LERI).
- **SHARE ERIC :** Enquêtes sociologiques à long terme; nœud de connexion pour la Suisse: IEMS[17] et FORS (soutien dans le cadre de l'art. 15, LERI).
- **DARIAH ERIC :** Réseau européen des infrastructures de recherche numérique en sciences humaines (les universités sont membres en tant que partenaires du consortium, pas de représentation formelle au niveau ministériel)[18].

[12] European Molecular Biology Laboratory.

[13] Stations de recherche de haute montagne du Jungfraujoch et du Gornergrat.

[14] Swiss Seismological Service (SED, Schweizerische Erdbebendienst).

[15] Un renouvellement du statut d'observateur est envisagé en 2020 pour ECCSEL ERIC.

[16] Fondation suisse pour la recherche en sciences sociales (FORS).

[17] Institut d'économie et de management de la santé (IEMS), Université de Lausanne.

[18] Il n'y a pas encore de représentation officielle de la Suisse. Sept universités suisses et l'ASSH participent actuellement à DARIAH en tant que partenaires du consortium.

3. Feuille de route suisse pour les infrastructures de recherche 2019

3.1. But et objet selon la LERI

La présente Feuille de route fournit une vue d'ensemble des infrastructures de recherche nouvellement planifiées (voir annexe A1) et l'état d'avancement des projets d'infrastructures planifiées lors de la Feuille de route 2015 (annexe A2). Elle remplit ainsi son rôle d'instrument de coordination, afin d'assurer la cohérence entre les mesures d'encouragement de la recherche déployées au niveau national et international (art. 41 LERI et art. 55 O-LERI).
La Feuille de route repose sur la définition européenne et plus précisément sur la définition suivante de la notion d'« infrastructure de recherche »:

- l'infrastructure de recherche fournit une contribution importante au développement d'un domaine de recherche (« plus-value » scientifique);
- l'infrastructure de recherche est utilisée intensivement par les chercheurs en Suisse (importance nationale);
- l'accès à l'infrastructure de recherche est réglé pour les communautés de chercheurs nationales et internationales;
- l'infrastructure de recherche peut se situer dans un seul emplacement ou s'organiser au sein d'un réseau comprenant plusieurs sites et une structure de gestion centralisée ;
- une infrastructure de recherche ne poursuit pas en premier lieu une recherche autonome mais est à disposition des chercheurs pour leurs projets.

De plus, l'infrastructure doit remplir les critères suivants[19] (nouveau par rapport à la Feuille de route 2015) :

- il s'agit de nouvelles infrastructures de recherche ou de mises à niveau substantielles d'infrastructures de recherche existantes ;
- le degré de maturité est avancé et se trouve juste avant la mise en œuvre ;
- l'infrastructure de recherche a des coûts d'investissement et d'exploitation d'au moins 5 millions de francs pour la période 2021–2024.

Typiquement, les infrastructures de recherche suisses sont développées et réalisées à moyen ou à long terme (généralement plus de dix ans). Elles dépassent donc l'horizon de planification d'un message FRI.

3.2. Compétences et déroulement de la procédure

3.2.1. Compétences

Selon la LERI, le soutien aux infrastructures de recherche relève avant tout de la compétence (c'est-à-dire responsables du financement) des hautes écoles et des établissements de recherche du Domaine des EPF. Le FNS assume un rôle subsidiaire en soutenant les infrastructures de recherche qui servent au développement de domaines spécialisés en Suisse. La Confédération, quant à elle, est compétente pour l'encouragement apporté à titre subsidiaire aux infrastructures de recherche d'importance nationale et pour la participation de la Suisse à des infrastructures de recherche coordonnées à l'échelle internationale (voir chapitre 5.1).

[19] Guide sur la Feuille de route suisse pour les infrastructures de recherche 2019 (dans la perspective de la planification FRI 2021-2024) Objectifs, processus et critères.

3.2.2. Déroulement de la procédure

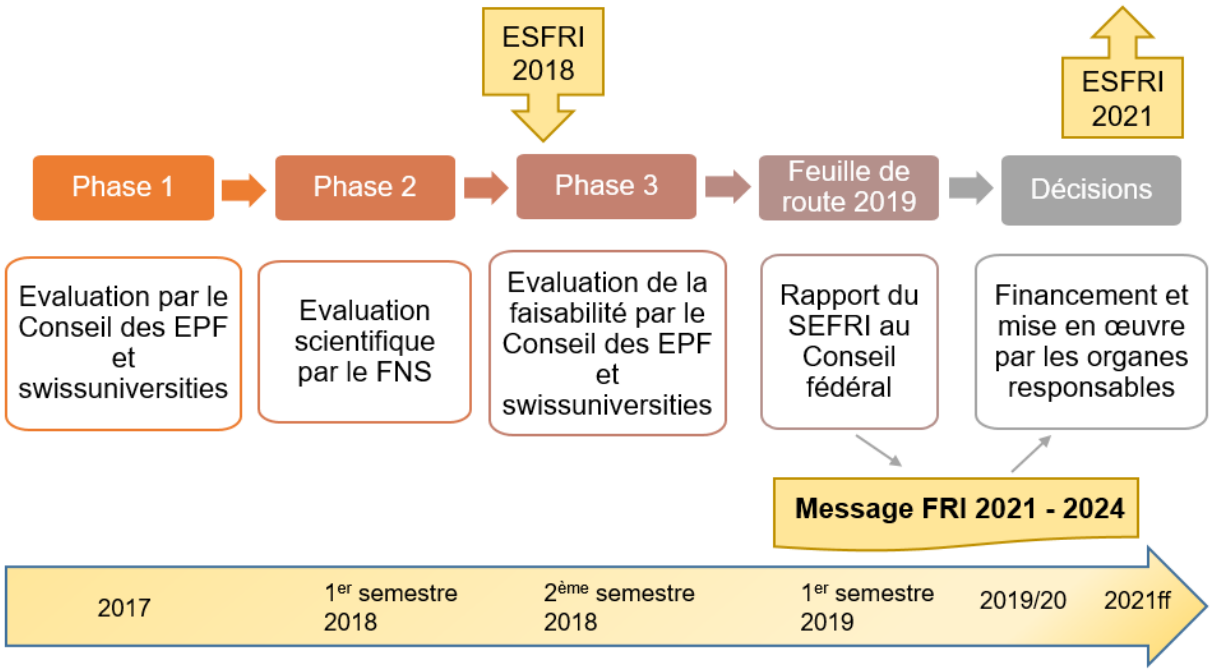

Figure 3.1: Déroulement de la procédure pour les nouveaux projets d'infrastructures nationaux.

a) Infrastructures de recherche nationales nouvellement planifiées

Phase 1 : Les organes responsables (swissuniversities et le Conseil des EPF) ont recensé entre janvier et octobre 2017 les infrastructures de recherche nouvellement planifiées (présélection, voir chapitre 4).

Phase 2 : La Phase 2 a consisté en une évaluation scientifique par le FNS (2ème niveau d'évaluation) des infrastructures sélectionnées lors de la Phase 1. De cette évaluation a résulté une priorisation selon les critères décrits au chapitre 4. Seuls les projets d'infrastructure du niveau d'excellence le plus élevé (« A ») ont été pris en compte pour la suite de la procédure de sélection. L'évaluation rendue par le FNS a donc abouti à une nouvelle sélection.

Phase 3 : Les projets d'infrastructure classés au niveau A ont fait l'objet d'un examen approfondi par les organes responsables qui ont examiné la faisabilité des projets (gouvernance, gestion, finances). La description détaillée de chacune de ces infrastructures se trouve à l'annexe A1.

b) Mise à jour des données des infrastructures nationales de la Feuille de route 2015

Les données pour la mise à jour des informations des 23 infrastructures suisses nouvellement planifiées sur la Feuille de route 2015 ont été récoltées entre juillet et novembre 2018 auprès des organes responsables (swissuniversities et Conseil des EPF). Les informations actualisées se trouvent à l'annexe A2.

c) Mise à jour des données des organisations internationales et projets ESFRI

Les données pour la mise à jour des informations sur les infrastructures et organisations internationales ont été récoltées par le SEFRI et utilisées par le FNS pour les prises de position (voir chapitre 7 et annexe B2).

4. 1er et 2ème niveaux d'évaluation (Phases 1 et 2): procédure de relevé et d'évaluation

4.1. Procédure et critères d'évaluation

Le Conseil des EPF et swissuniversities ont procédé à un relevé auprès de leurs institutions respectives afin de recenser les propositions de nouveaux projets d'infrastructures de recherche, incluant également des mises à niveau substantielles. Dans un premier temps, les « esquisses » de nouvelles infrastructures, remises par les institutions responsables (hautes écoles et établissements de recherche du domaine des EPF), ont été examinées sous l'angle de leur cohérence avec la planification stratégique des hautes écoles concernées et par rapport aux conditions d'éligibilité définies au chapitre 3.1.

Résultat d'évaluation (1er niveau d'évaluation) :17 nouveaux projets ont été sélectionnés. Sur mandat du SEFRI, le FNS en a finalement évalué 15[20] (2ème niveau d'évaluation) en se fondant sur les critères ci-dessous :

- Qualité de l'infrastructure, de la recherche et des chercheurs impliqués ;
- Importance scientifique ;
- Accessibilité et groupes d'utilisateurs ;
- Faisabilité scientifique.

Les résultats de l'évaluation du FNS se répartissent dans trois catégories :

Priorité A	Importance scientifique élevée	7 projets
Priorité B	Importance scientifique moyenne	7 projets
Priorité C	Importance scientifique faible	1 projet

4.2. Aperçu par domaines et institutions

Les 15 infrastructures de recherche évaluées par le FNS se répartissent comme suit entre les quatre grands domaines (Figure 4.1) :

- 3 pour les sciences humaines et sociales
- 8 pour les mathématiques, l'ingénierie et les sciences de la nature (MINT)
- 3 pour les sciences de la vie
- 1 pour les e-infrastructures

Les institutions porteuses suivantes ont annoncé de nouveaux projets :

- 6 projets pour le domaine des EPF
- 8 projets pour les universités cantonales
- 1 projet pour les hautes écoles spécialisées

Le volume financier de ces 15 nouveaux projets a été estimé à quelque 708 millions de francs (coûts totaux d'exploitation et d'investissement pour la période 2021–2024, état : août 2018)[21]. La Figure 4.2 ci-après montre la répartition de ces coûts entre les quatre grands domaines scientifiques et la Figure 4.3 présente la répartition du volume financier entre les catégories de priorité A, B et C.

Les projets évalués se répartissent entre toutes les disciplines, le domaine MINT en comptant toutefois le plus grand nombre (Figure 4.1). Quant à la répartition du volume financier par domaines (Figure 4.2), elle indique clairement que le domaine MINT présente les coûts les plus élevés. A noter que le domaine des e-infrastructures ne comprend qu'un seul projet mais représente 24% des coûts. En ce qui concerne la répartition des coûts selon les catégories de priorité, il apparaît que près de deux tiers des coûts prévus sont imputables à la catégorie des projets de priorité A (Figure 4.3).

[20] Le chiffre de 15 projets évalués sur un total de 17 résulte du fait qu'un projet du Conseil des EPF n'a pas été soumis au FNS et qu'un projet de swissuniversities a été retiré après la soumission au FNS.

[21] Les besoins financiers ont été revus à la hausse, confirmés ou revus à la baisse et précisés à la lumière de clarifications financières dans le cadre de l'évaluation approfondie (3ème niveau d'évaluation).

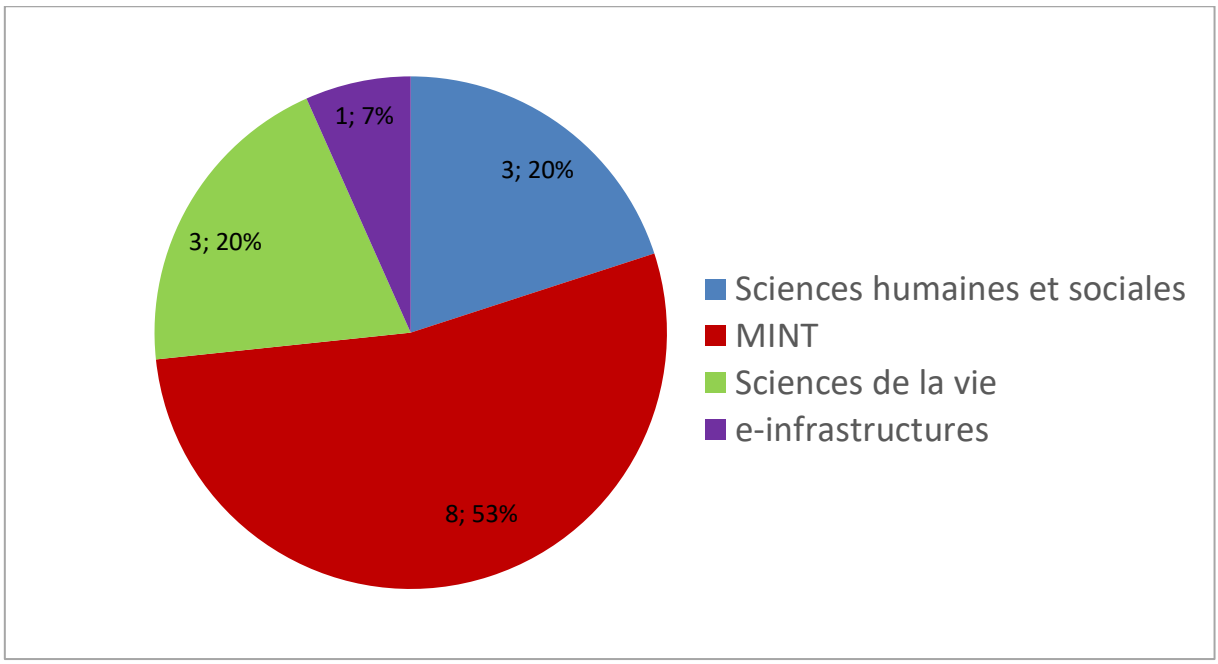

Figure 4.1: Répartition par domaine (n=15 projets).

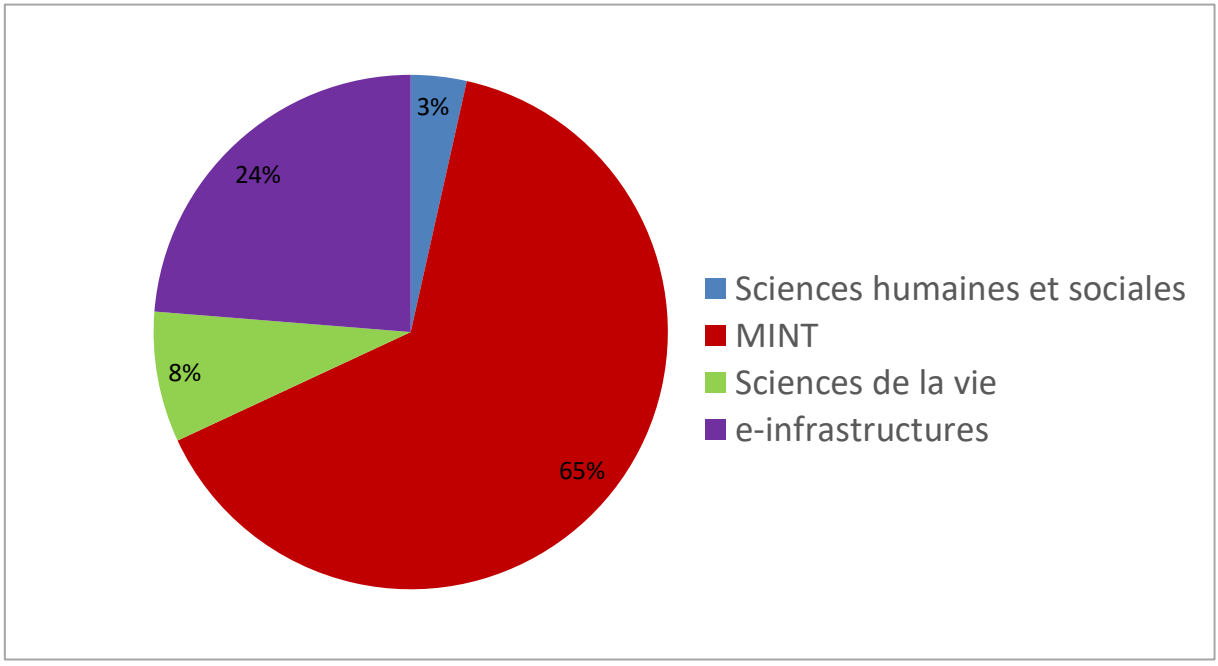

Figure 4.2: Répartition des ressources financières entre les domaines (n=15 projets pour un total de 708 millions de francs).

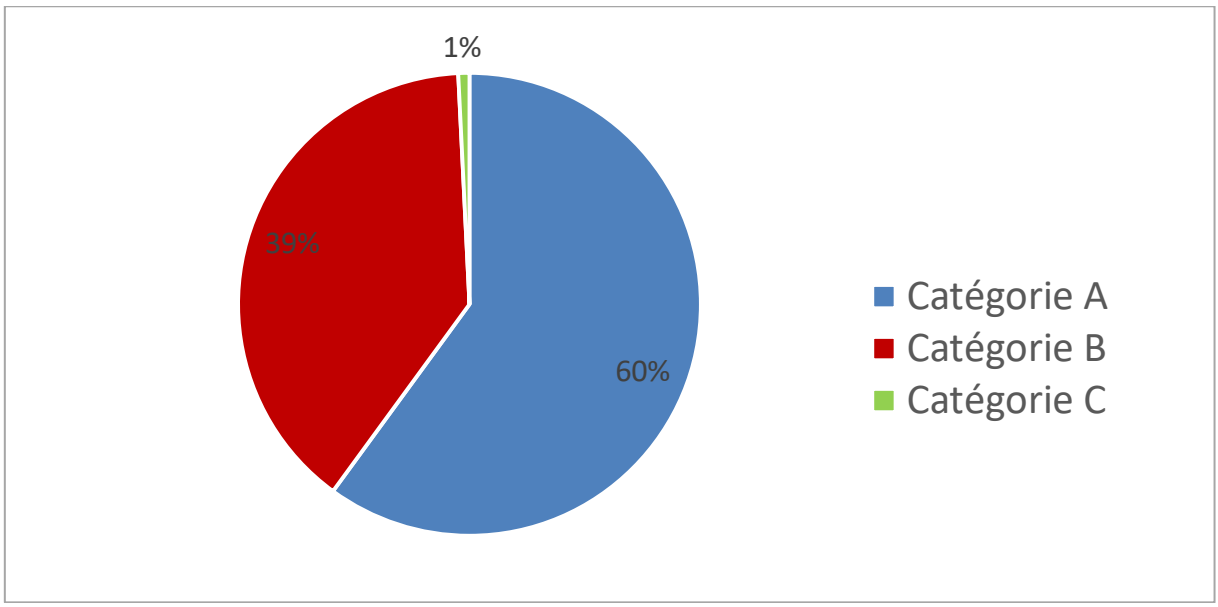

Figure 4.3: Répartition des ressources financières en fonction des priorités (n=15 projets pour un total de 708 millions de francs).

5. 3ème niveau d'évaluation (Phase 3) par les organes responsables

5.1. Répartition des tâches

En vertu de la loi fédérale sur l'encouragement de la recherche et de l'innovation (LERI), les hautes écoles, ou les organes qui en sont responsables, sont prioritairement compétentes pour soutenir et financer les infrastructures de recherche. Les institutions chargées d'encourager la recherche (FNS, Académies) assument un rôle subsidiaire dans le financement des infrastructures de recherche (art. 10, al. 3, let. c et art. 11, al. 6, LERI). La Confédération, quant à elle, est compétente pour encourager subsidiairement les infrastructures de recherche d'importance nationale (art. 15, LERI) et la participation de la Suisse à des infrastructures de recherche coordonnées sur le plan international si cette participation fait l'objet d'un traité international (art. 28 LERI).

Dans le domaine des EPF, le Conseil des EPF, les deux universités ETHZ et EPFL et les quatre établissements de recherche (PSI, WSL, Empa et Eawag) sont responsables de la réalisation de leurs infrastructures de recherche dans le cadre de la loi sur les EPF et des objectifs stratégiques du Conseil fédéral pour le domaine des EPF (également avec des fonds tiers). En ce qui concerne les hautes écoles cantonales, la Confédération participe en vertu de la loi sur l'encouragement et la coordination des hautes écoles (LEHE) de manière subsidiaire au financement d'infrastructures de recherche dans le domaine des compétences des hautes écoles cantonales par le biais des contributions de base. Quant aux contributions liées à des projets (art. 59, al. 2, LEHE), elles permettent en premier lieu de financer pour une durée limitée des projets de coopération qui sont importants pour l'ensemble du système des hautes écoles et qui portent principalement sur l'enseignement et l'offre d'études.

Au vu de ce qui précède, tous les 15 projets évalués par le FNS lors de la Phase 2 relevaient de la compétence du Conseil des EPF (six projets) ou de swissuniversities (neuf projets dont huit projets des universités cantonales et 1 d'une haute école spécialisée).

Chacun des deux organes responsables a effectué – pour les projets classés A par le FNS (sept projets au total) – la Phase 3 de l'évaluation selon sa propre procédure, se référant aux critères communs en examinant la planification, la gouvernance et la gestion ainsi que les finances et le soutien des institutions.

5.2. Evaluation approfondie: faisabilité (financement, planification, gouvernance et gestion) – Résultats

A l'issue de la Phase 3 de l'évaluation les organes responsables ont recommandé les sept projets classés A (importance scientifique élevée) par le FNS pour une étude approfondie en vue de leur réalisation. Le Tableau 5.1 fournit un aperçu de ces infrastructures de recherche considérées comme prioritaires, classées selon le volume financier. Les coûts totaux estimés pour la période 2021–2024 s'élèveraient à environ 412,82 millions de francs, dont 366,9 millions pour la Confédération (état: janvier 2019). La Figure 5.1 montre la répartition des coûts entre les domaines pour les sept projets recommandés. A noter que les trois domaines e-infrastructures, sciences humaines et sociales ainsi que sciences de la vie ne contiennent chacun qu'un seul projet alors que le domaine MINT en contient quatre.

Tableau 5.1: Infrastructures priorisées et coûts pour la période 2021–2024.

Domaine	Institution	Projet	Coûts totaux (CHF mio)[22]	Coûts Confédération (CHF mio)[23]
e-infrastructures	ETH Zurich	High-Performance Computing and Networking Infrastructure (HPCN-24)	174,00	162,00
MINT	PSI	Swiss Light Source SLS 2.0	167,00	167,00
MINT	EPFL & ETHZ	Catalysis Hub (CAT+)	32,70	31,90
Sciences de la vie	Université de Zurich	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	18,00	6,00[24]
MINT	Université de Zurich	Airborne Research Facility for the Earth System (ARES)	9,22	-
Sciences humaines et sociales	Université de Zurich	Linguistic Research Infrastructure (LiRI)	6,80	-
MINT	Université de Zurich	Center of Structural Electron Microscopy (COSEM)	5,10	-
		Total	**412,82**	**366,9**

L'annexe A1 de la présente Feuille de route fournit une description détaillée de ces infrastructures de recherche proposées.

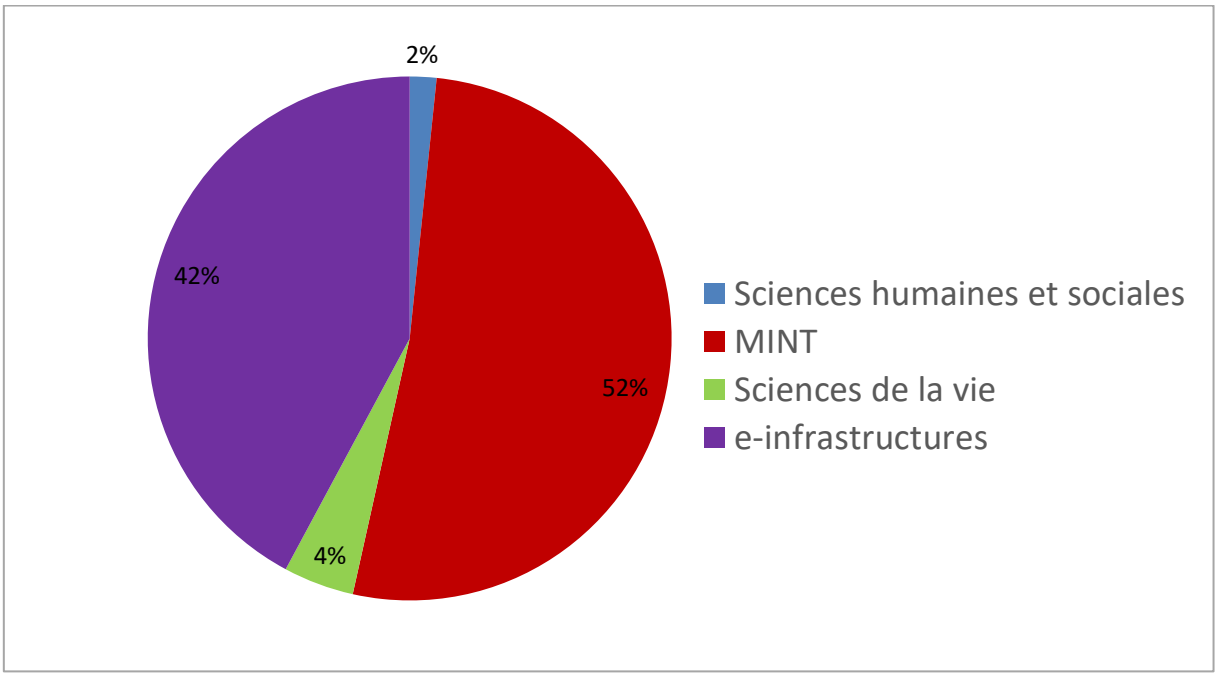

Figure 5.1: Répartition des ressources financières entre les domaines (n=7 projets recommandés pour un total de 412,82 millions de francs).

a) Domaine des EPF (état janvier 2019)

Conformément à la planification du Conseil des EPF[25], les infrastructures de recherche du Tableau 5.2 revêtent une importance stratégique particulière. Suite aux évaluations positives, le Conseil des EPF appuie l'inscription des trois projets du Tableau 5.2 dans la Feuille de route.

[22] Le détail du budget se trouve à l'annexe A1.

[23] Les « coûts Confédération » incluent les institutions du domaine des EPF et le Conseil des EPF. Par contre, les fonds FNS compétitifs (p.ex. R'Equip) ne sont pas inclus.

[24] Contribution de l'ETHZ.

[25] Planification stratégique 2021-2024 du Conseil des EPF pour le domaine des EPF, 2019.

Tableau 5.2: Infrastructures du domaine des EPF priorisées

N°[26]	Désignation du projet	Principal responsable (institution porteuse)	Estimation des besoins financiers 2021-2024 (CHF mio)	A la charge du plafond de dépenses du domaine des EPF (CHF mio)
1	High-Performance Computing and Networking(HPCN-24)	Conseil des EPF (ETHZ)	174,0	162,0
2	Swiss Light Source SLS 2.0	Conseil des EPF (PSI)	167,0	167,0
3	Catalysis HUB (CAT+)	Conseil des EPF (EPFL & ETHZ)	32,7	31,9
		Total	**373,7**	**360,9**

La réalisation complète des trois projets d'infrastructures de recherche (deux mises à niveau, un nouveau) occasionne des besoins financiers estimés à 373,7 millions de francs pour les années 2021 à 2024. Un montant de 360,9 millions de francs (dont 216 millions fournis par le Conseil des EPF) devra être couvert par le plafond de dépenses du domaine des EPF. S'il ne peut pas assurer le financement dans le cadre du plafond de dépenses fixé par le Parlement pour 2021 à 2024, le Conseil des EPF décidera le moment venu de la réalisation et des modalités de financement des projets dans le cadre de ses possibilités financières.

En dehors de l'investissement dans de nouvelles infrastructures de recherche, des moyens substantiels seront mobilisés pendant les années 2021 à 2024 pour l'exploitation et le développement ou l'extension d'infrastructures de recherche existantes. Le Conseil des EPF prévoit ainsi dans sa planification stratégique 2021–2024 une contribution de 88 millions de francs au développement du projet de neuroinformatique Blue Brain de l'EPFL.

Conclusion :

- Les trois projets d'infrastructures de recherche mentionnés plus haut entraîneront pendant la période FRI 2021–2024 des coûts de 360,9 millions de francs pour la Confédération (en tant qu'instance responsable du domaine des EPF).
- Les moyens effectifs feront partie du plafond de dépenses pour les EPF qui sera prévu dans le message FRI 2021–2024.
- La décision quant à la réalisation et à l'ampleur du financement de ces infrastructures de recherche pendant la période 2021–2024 incombe au Conseil des EPF et aux institutions du domaine des EPF.

[26] Des informations détaillées se trouvent dans l'annexe A1 où les projets sont classés avec cette même numérotation.

b) Haute écoles cantonales (état janvier 2019)

Suite à une évaluation positive et dans le cadre des planifications stratégiques des hautes écoles cantonales, swissuniversities a proposé la réalisation des quatre projets suivants:

Tableau 5.3: Infrastructures des universités cantonales priorisées

N°[27]	Désignation du projet	Principal responsable (institution porteuse)	Estimation des besoins financiers 2021-2024 (CHF mio)	A la charge de la Confédération (CHF mio)
4	Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)	Université de Zurich	18,00	6,00[28]
5	Airborne Research Facility for the Earth System (ARES)	Université de Zurich	9,22	-
6	Center of Structural Electron Microscopy (COSEM)	Université de Zurich	5,10	-
7	Linguistic Research Infrastructure (LiRI)	Université de Zurich	6,80	-
		Total	**39,12**	**6,00**

Les besoins financiers totaux pour la réalisation intégrale de ces quatre infrastructures de recherche sont estimés à 39,12 millions de francs. Aucun projet n'a été soumis par swissuniversities au titre des contributions liées à des projets.

Conclusion :

- La réalisation intégrale de ces nouveaux projets d'infrastructures de recherche entraînerait 6 millions de francs à la charge de la Confédération via l'ETHZ (projet 1,2 GHz NMR)
- La décision quant à la réalisation et à l'ampleur du financement de ces infrastructures de recherche pendant la période 2021–2024 incombe aux hautes écoles responsables.

c) Confédération

La Confédération n'est directement responsable d'aucun projet classifié dans la catégorie A. Les requêtes des infrastructures d'importance nationale (art. 15 LERI) feront l'objet d'une procédure indépendante. Les requérants devront soumettre leur projet jusqu'au 30 juin 2019 (art. 12, O-LERI-DEFR, RS 420.111). Ces projets seront évalués par le Conseil suisse de la science et la décision du DEFR tombera en fin d'année 2020.

[27] Des informations détaillées se trouvent dans l'annexe A1 où les projets sont classés avec cette même numérotation.
[28] Contribution de l'ETHZ

6. Infrastructures de recherche financées par les organes de soutien de la Confédération

Outre la compétence prépondérante des hautes écoles et des établissements de recherche du Domaine des EPF ou de leurs collectivités responsables pour le financement des infrastructures de recherche, les organes de soutien de la Confédération (notamment FNS et Académies) remplissent aussi un rôle d'encouragement subsidiaire à cet égard en vertu de la LERI. Ils ont déjà transmis leurs planifications dans le cadre de leurs programmes pluriannuels 2021–2024.

6.1. FNS

Le soutien du FNS aux infrastructures de recherche prend normalement la forme d'allocations financières spécifiques, liées à leur affectation et limitées dans le temps.

Durant la période 2021–2024, le FNS va élargir son portefeuille avec des *infrastructures (et des répertoires) de données* d'importance nationale et qui sont essentielles à la recherche scientifique. Ces infrastructures, trop coûteuses pour des institutions individuelles, fourniront des services de qualité à la communauté scientifique en Suisse et sur le plan international grâce à une politique d'accès transparente et d'interopérabilité des données.

Différents types d'infrastructures (et de répertoires) de données correspondent à cette définition et des critères d'évaluation spécifiques et couvrant de nombreuses infrastructures de données devront être établis. De ce fait le FNS propose de développer ses activités dans ce domaine de manière graduelle durant la période 2021–2024.

Ainsi, à partir de 2021, le FNS est compétent pour le financement et l'évaluation des infrastructures existantes FORS et DaSCH, ainsi que pour les cohortes (parmi celles-ci, les deux cohortes Swiss HIV cohort study (SHCS) et Swiss transplant cohort study (STCS) qui sont de haute priorité pour l'Office fédéral de la santé publique). Les cohortes en général seront soutenues avec les instruments établies pour la promotion de la recherche.

Afin de répondre au besoin grandissant d'infrastructures de données spécialisées (en plus des infrastructures d'importance nationale existantes) le FNS prévoit des financements initiaux (« start-up grants ») et de développement pour les infrastructures de données ayant le potentiel d'atteindre une importance nationale. Le financement d'infrastructures qui ne sont pas considérées comme d'importance nationale sera limité à une phase initiale de dix ans en accord avec la politique de soutien du FNS pour les infrastructures de recherche.

Le FNS va également poursuivre les programmes R'Equip (pour l'acquisition de grands instruments) et FLARE (pour les infrastructures de recherche internationales dans le domaine de la physique des particules, de l'astrophysique et de la physique des astroparticules).

Dans le cadre du programme pluriannuel 2021–2024, le FNS prévoit de soutenir les programmes et les infrastructures ci-dessous :

Infrastructures de recherche	**Budget 2021–2024** millions de francs (selon le programme pluriannuel)
a) Instruments	
Infrastructures de recherche et R'Equip	115,1
b) Encouragement d'infrastructures de données sur mandat de la Confédération (SEFRI)	
FORS (transfert de l'art. 15 LERI)	32,8
DASCH (transfert des Académies)	9,2
Répertoires de données/activités supplémentaires dans les infrastructures de données[29]	10,0
Cohortes SHCS et STCS	20,0
c) Autres financements (plateformes)	
SCTO	4,0
Swiss Biobank Platform	4,0
Etudes longitudinales (cohortes)	32,0
Total	**227,1**

Conclusion :

- En plus des programmes existants (p.ex. R'Equip) le FNS va soutenir des répertoires et des infrastructures de données et des cohortes.
- La réalisation et le soutien d'infrastructures de recherche relevant de la compétence du FNS intervient dans le cadre des moyens financiers octroyés au FNS dans le cadre du message FRI 2021–2024 (plafond de dépenses).

[29] Dans le cadre de l'art. 59 LEHE (contributions liées à des projets), swissuniversities demande 45 millions de francs pour des répertoires de données. Il convient de s'assurer que l'état des lieux relatif aux répertoires de données exigé par le SEFRI soit présenté, que les objectifs de tels répertoires dans les hautes écoles (y c. axes prioritaires des EPF dans le domaine de l'initiative nationale du centre de données, voir annexe A2) soient coordonnés sur cette base avec les activités du FNS et que les moyens réservés à cet effet au FNS et chez swissuniversities soient utilisés de façon complémentaire (de sorte à éviter des structures parallèles).

6.2. Académies

Dans le cadre du programme pluriannuel 2021–2024, l'**ASSH** prévoit de financer les infrastructures de recherche ci-dessous avec un budget de 59,69 millions de francs :

Éditions (transfert du FNS)	13,15 millions CHF
Entreprises à long terme (continuation)	46,54 millions CHF

Dans le cadre du programme pluriannuel 2021–2024, la **SCNAT** prévoit un budget pour les infrastructures de recherche ci-dessous avec un budget total de 22,84 millions de francs :

Secrétariats scientifiques (transfert du FNS)	8,84 millions CHF
Collections en sciences naturelles (nouveau projet)	14,00 millions CHF

Dans le cadre du programme pluriannuel 2021–2024 l'**ASSM** prévoit un budget de 33 millions de francs :

Initiative SPHN (continuation)	33,00 millions CHF
Total pour les Académies	**115,53 millions CHF**

Conclusion :

- Le soutien des infrastructures de recherche relevant de la compétence des Académies est financé sur les enveloppes financières mises à la disposition des Académies dans le cadre du message FRI 2021–2024 (plafond de dépenses).

7. Infrastructures de recherche internationales

7.1. Projets ESFRI dont la pertinence pour la Suisse doit être examinée

Des institutions suisses participent à plusieurs projets ESFRI, sans compétence directe de la Confédération. Il s'agit de projet ESFRI qui ont adopté la forme légale ERIC. Pour ces projets la Suisse a demandé un statut d'observateur qui n'entraîne pas d'engagement au sens du droit international. Cependant, la participation d'institutions suisses à ces projets ESFRI peut avoir des conséquences pour les investissements de la Confédération dans le domaine des EPF, pour les contributions aux investissements en faveur des universités et des hautes écoles spécialisées, pour les contributions visées à l'art. 15 LERI ou encore pour les tâches relevant de la compétence du FNS ou des Académies.

Le SEFRI a mandaté le FNS pour une prise de position sur les infrastructures internationales auxquelles la Suisse participe déjà sous la responsabilité des institutions concernées. Les infrastructures listées ci-dessous figurent sur la Feuille de route ESFRI 2018[30].

En novembre 2018 le FNS a rendu ses prises de position[31] sur l'importance nationale des infrastructures suivantes : eLTER, SILECS, ECCSEL, ACTRIS, ELI, BBMRI, ECRIN, EPOS, ICOS, CESSDA, ESSurvey, SHARE, DARIAH, EST et PRACE. Les questions suivantes ont été posées au FNS par le SEFRI afin de rendre compte de l'importance nationale de chaque infrastructure :

- Dans quelle mesure la participation suisse à l'infrastructure internationale est-elle indispensable à la communauté scientifique pour le futur développement en Suisse ?
- Quelles infrastructures peuvent être classées A, B ou C selon leur importance pour la communauté scientifique en Suisse (A : importance élevée ; B : importance moyenne ; C : importance faible) ?

[30] www.esfri.eu/

[31] Il s'agit ici d'une prise de position du FNS sur l'importance de ces infrastructures internationales pour la Suisse. Les projets ESFRI ont déjà évalués scientifiquement au niveau européen.

a) Infrastructures auxquelles des institutions suisses participent déjà (2021–2024)

Infrastructure	Principale institution suisse impliquée (« national node »)	Priorité pour la Suisse	Coûts approx. Confédération (SEFRI ou FNS) (mio CHF)[32]
European Plate Observing System **(EPOS ERIC)**	ETHZ	A	0,65 (SEFRI)
European Clinical Research Infrastructure Network **(ECRIN ERIC)**	SCTO	A	0,22 (SEFRI)
Integrated Carbon Observation System **(ICOS ERIC)**	ETHZ	A	0,32 (FNS)
Biobanking and molecular resources research infrastructure **(BBMRI ERIC)**	SBP	A	0,26 (FNS)
Consortium of European Social Science Data Archives **(CESSDA ERIC)**	Université de Lausanne	A	0,13 (FNS)
European Social Survey **(ESSurvey ERIC)**	Université de Lausanne	A	0,43 (FNS)
Survey of Health, Ageing and Retirement in Europe **(SHARE ERIC)**	Université de Lausanne	A	0,10 (FNS)
Partnership for Advanced Computing in Europe **(PRACE)**	ETHZ	A	-
European Carbon Dioxide Capture and Storage Laboratory Infrastructure **(ECCSEL ERIC)**	ETHZ	A	0,26 (SEFRI)

b) Infrastructures pour lesquelles des institutions suisses ont marqué un intérêt

Infrastructure	Institutions responsables suisses impliquées (« national node »)	Priorité pour la Suisse	Coûts approx. Confédération (SEFRI) (mio CHF)[33]
Aerosol, Clouds, and Trace Gases Research Infrastructure **(ACTRIS)**	PSI	A	5,09[34]
Digital Research Infrastructure for the Arts and Humanities **(DARIAH ERIC)**	Consortium[35]	A	À définir (FNS)
European Long-Term Ecosystem and socio-ecological Research Infrastructure **(eLTER)**	WSL, ETHZ, Université de Bâle	A	-
Extreme Light Infrastructure **(ELI)**	ETHZ	B	-
European Solar Telescope **(EST)**	USI[36]	B	-
Infrastructure for Large-scale Experimental Computer Science **(SILECS)**[37]	Université de Genève	B-C	-

[32] Coûts de participation.

[33] Période 2021-2024.

[34] Le montant indiqué ici inclut également une requête des institutions (principalement l'ETHZ) pour une participation aux activités d'ACTRIS.

[35] Consortium composé des Universités de Bâle, Berne, Genève, Lausanne, Neuchâtel et Zurich ainsi que de l'EPFL et de l'ASSH.

[36] Université de la Suisse italienne.

[37] SILECS a été soumis (coordination en France) pour figurer sur la Feuille de route ESFRI 2018 mais n'a pas été retenu.

Douze infrastructures ont été considérées comme d'importance élevée pour la communauté scientifique suisse (priorité A). Parmi celles-ci, deux sont en planification (ACTRIS et eLTER) et une ne comprend pas encore de participants suisses (ECCSEL ERIC). Les infrastructures SILECS, EST et ELI ne sont pas prioritaires (priorité B/C). Seules les infrastructures internationales avec priorité A seront examinées de manière approfondie et décrites à l'annexe B1[38].

Conclusion :

- Dans le cadre du message FRI 2021–2024, en tenant compte des prises de position du FNS et des considérations politiques nationales et internationales et financières (crédits disponibles), le SEFRI examinera la possibilité d'une participation de la Suisse à ces infrastructures internationales avec priorité A.
- Les frais de participation à une infrastructure ESFRI sont financés par les prestations propres des universités (en espèces et en nature) ainsi que par le soutien subsidiaire de la Confédération à hauteur de 6,22 millions de francs (SEFRI) et de 1,24 millions de francs du FNS (ces derniers dans le cadre de l'enveloppe globale mise à disposition avec le message FRI 2021–2024).

c) Mise à jour de la Feuille de route ESFRI 2018

Depuis la dernière publication de la Feuille de route suisse en 2015, de nouveaux projets d'infrastructures, pour lesquels des institutions suisses ont marqué un intérêt, ont été intégrées à la Feuille de route européenne ESFRI.

- Infrastructures de recherche existantes (n'ayant pas encore accédé au statut ERIC) :
  - **ACTRIS** : dans la Feuille de route suisse 2015, la communauté suisse de la recherche avait exprimé son intérêt à participer à cette infrastructure de recherche. Les examens du SEFRI, établis en tenant compte de l'avis du FNS, ont conduit à la décision d'évaluer une éventuelle participation de la Suisse à ACTRIS au cours de la prochaine période FRI et de reporter la question d'une adhésion, vraisemblablement en 2024-2025 (date prévue pour la création de l'ERIC). ACTRIS est coordonné par le PSI et cofinancé par le consortium de hautes écoles et d'institutions de recherche.
  - **EST** : les examens effectués par le SEFRI en tenant compte de l'avis du FNS ont abouti à la décision de ne pas poursuivre l'option d'une participation à EST pour le moment.

- De plus, la communauté suisse a exprimé son intérêt pour l'infrastructure de recherche suivante qui a été nouvellement intégrée dans la feuille de route 2018 ESFRI :
  - **eLTER** (sur la feuille de route de l'ESFRI depuis 2018) : dans la Feuille de route suisse 2015, la communauté suisse de la recherche a exprimé son intérêt à y participer. L'examen du SEFRI et l'avis exprimé par le FNS ont abouti à la conclusion qu'une éventuelle participation de la Suisse à eLTER sera évaluée au cours de la prochaine période FRI et que la question de l'adhésion devrait se poser en 2025 (lorsque l'ERIC sera créé). eLTER sera coordonné par le WSL et financé par le WSL, l'ETHZ et l'Université de Bâle.

7.2. Organisations et infrastructures de recherche internationales dans lesquelles la Suisse est membre au niveau gouvernemental

Les contributions aux organisations et infrastructures de recherche internationales dans lesquelles la Suisse est membre au niveau gouvernemental ont un caractère obligatoire sur le plan du droit international et constituent des dépenses liées. Elles sont ainsi soumises au Parlement chaque année dans le cadre du message sur le budget. Cette procédure concerne les infrastructures de recherche internationales suivantes : CERN, ESO, EMBC/EMBL, ESRF et European XFEL.

Toutefois, lorsque des infrastructures de cette classe sont en phase de planification ou de construction, les contributions suisses sont financées à partir de crédits ouverts dans le cadre des messages FRI (European Spallation Source ERIC, CTA) ou du message sur la participation de la Suisse aux

[38] ELI était déjà en cours d'examen durant la période 2017-2020 et la prise de position du FNS ne recommande pas un arrêt de l'examen. Cette infrastructure est aussi décrite à l'annexe B1.

programmes cadres de recherche de l'UE (ITER/Fusion for Energy). Les contributions aux infrastructures dans lesquelles la participation de la Suisse est limitée à une durée fixée (ILL) sont également demandées dans le cadre des messages FRI.

Des développements survenus pour ces infrastructures durant la période 2017–2020 découlent les besoins suivants pour la période 2021–2024 :

- Prolonger la participation de la Suisse à ILL au moins jusqu'à la pleine mise en service de European Spallation Source ERIC (voir tableau à l'annexe B2) ;
- Contribuer aux coûts de construction additionnels de European Spallation Source ERIC (32 millions de francs pour 2021–2024) et de ITER/Fusion for Energy (110 millions de francs pour 2021–2024) ;
- Participer comme membre fondateur à l'établissement de l'infrastructure CTAO ERIC (10 millions de francs pour 2021–2024) ;
- Rejoindre l'infrastructure SKA (9 millions de francs pour 2021–2024).

Les montants correspondants devront, sous réserve des décisions du Conseil fédéral, être demandés dans le message FRI 2021–2024 ou le message sur la participation de la Suisse aux programmes-cadres de recherche de l'UE. Les infrastructures CTA et SKA faisaient partie des quatre infrastructures de cette classe identifiées dans la Feuille de route 2015 qui ont été examinées en particulier lors de la période 2017–2020.

L'examen des deux autres infrastructures identifiées, ELI et LBNF-DUNE n'a pas conclu à un besoin de financement en 2021–2024 émanant du budget FRI. Toutefois, l'examen de ces deux infrastructures sera poursuivi durant la période 2021–2024 en vue du message FRI 2025–2028, en parallèle des infrastructures décrites au chapitre 7.1.

Un tableau avec le détail des coûts se trouve à l'annexe B2.

8. Bilan et Perspective

Les infrastructures de recherche proposées pour la mise en œuvre dans la présente Feuille de route 2019 reflètent l'état de la planification à fin mars 2019.

Le DEFR (SEFRI) est chargé de prendre en compte les programmes pluriannuels des organes de soutien figurant dans la Feuille de route suisse 2019 et de soumettre – dans les limites des moyens FRI disponibles – ses éventuelles propositions de réalisation au Conseil fédéral avec le message FRI 2021–2024.

En tant qu'instrument de planification, la Feuille de route offre une vue d'ensemble des nouvelles infrastructures de recherche et une mise à jour de la réalisation des projets sélectionnés dans la Feuille de Route 2015. En plus, elle sert de base à la coordination nécessaire de la planification nationale des infrastructures de recherche avec la planification correspondante au niveau international et européen au moyen de la Feuille de route ESFRI.

Cependant cette Feuille de route ne contient aucune décision sur le montant ou la répartition des éventuelles ressources fédérales entre les crédits d'encouragement prévus par le message FRI 2021–2024. En ce qui concerne les hautes écoles cantonales, la Confédération soutient à titre subsidiaire et indirecte des infrastructures en vertu de la loi sur l'encouragement et la coordination des hautes écoles (LEHE). Dans le domaine des EPF, le Conseil des EPF, les deux universités ETHZ et EPFL et les quatre instituts de recherche, sont responsables de la réalisation de leurs infrastructures de recherche dans le cadre de la loi sur les EPF et des objectifs stratégiques du Conseil fédéral pour le domaine des EPF. Pour les infrastructures de recherche faisant partie de la planification pluriannuelle des organes de recherche, la réalisation et le financement des projets seront décidé selon la contribution financière de la Confédération pour le FNS et les académies. La Confédération est responsable pour la participation suisse à des infrastructures internationales (européennes) de recherche.

Les ressources seront décidées – selon le plafond de dépenses pour le domaine EPF, le crédit selon la LEHE, le crédit pour les organes de recherche et le crédit pour la collaboration internationale – dans le contexte du message FRI 2021–2024 par le Parlement.

En vue de la prochaine Feuille de route 2023 le SEFRI va examiner le processus avec les partenaires et l'adapter en fonction des résultats de cet examen.

9. Glossaire

Abréviation	Signification
ASSH	Académie suisse des sciences humaines et sociales
ASSM	Académie Suisse des Sciences Médicales
CF	Conseil fédéral
CPro	Contributions liées à des projets
CSHE	Conférence suisse des hautes écoles (selon LEHE)
CSS	Conseil suisse de la science
DEFR	Département fédéral de l'économie, de la formation et de la recherche
Eawag	Eidgenössische Anstalt für Wasserversorgung, Abwasserreinigung und Gewässer-schutz (domaine des EPF)
Empa	Laboratoire fédéral d'essai des matériaux et de recherche (domaine des EPF)
EPF	Ecoles polytechniques fédérales
EPFL	EPF de Lausanne
ETHZ	EPF de Zurich
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
FNS	Fonds national suisse de la recherche scientifique
FRI	Formation, recherche et innovation
LEHE	Loi sur l'encouragement et la coordination des hautes écoles, RS 414.20
LERI	Loi fédérale sur l'encouragement de la recherche et de l'innovation, RS 420.1
PPA	Programme pluriannuel
PSI	Paul Scherrer Institut (domaine des EPF)
SCNAT	Académie suisse des sciences naturelles
SEFRI	Secrétariat d'Etat à la formation, à la recherche et à l'innovation
swissuniversities	Conférence des recteurs des hautes écoles suisses (selon LEHE)
WSL	Institut fédéral de recherches sur la forêt, la neige et le paysage (domaine de EPF)

Feuille de route suisse pour les infrastructures de recherche 2019

Annexe A

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Annexe A1 : Nouveaux projets d'infrastructures nationales de la Feuille de route 2019 (ou mises à niveau substantielles)

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2. Swiss Light Source SLS 2.0....41

3. Catalysis Hub (CAT+)....43

4. Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)....45

5. Airborne Research Facility for the Earth System (ARES)....47

6. Center of Structural Electron Microscopy (COSEM)....49

7. Linguistic Research Infrastructure (LiRI)....51

Remarques importantes:

1) **Les informations financières ci-dessous représentent des planifications fournies par les hautes écoles / responsables des infrastructures.**
2) **Les chiffres financiers mentionnés dans le présent document pour les périodes FRI 2021–2024 et 2025–2028 sont des données prévisionnelles et sont indiqués uniquement à titre d'estimation grossière des coûts probables à venir et de leur répartition.**
3) **Dernière mise à jour des informations : janvier 2019**

1. High-Performance Computing and Networking (HPCN-24)[39]

Category: e-Infrastructure

Host institution(s): ETH Zurich

Main funding sources: ETH Board, ETH Zurich

Description / Development prospects

a. National level

Overview

The Swiss National Supercomputing Centre (CSCS) in Lugano develops and operates an open access research infrastructure for extreme-scale scientific computing, which is also referred to as supercomputing. This research infrastructure is a User Lab, the resources of which are accessed openly and managed through a transparent, peer review process. There are two tiers of allocations. Researchers from all over the world can apply for: Tier 1 projects for requests of up to one million node-hours p.a., which are allocated by a panel of eminent, international scientists; and Tier 0 allocations for very large projects that require more than one million node-hours p.a. The announcement of Tier 0 calls and subsequent proposal screening is managed by the Partnership for Advanced Computing in Europe (PRACE), of which Switzerland is a member represented by ETH Zurich. The structure of the two review processes is comparable. Furthermore, several Swiss academic institutions and research projects benefit directly from the economies of scales reached by CSCS thanks to the User Lab.

In 2019, the CSCS User Lab is among the globally leading research infrastructures of its kind. For this to be still true in five to ten years, the supercomputing systems have to be renewed regularly. Specifically, the current flagship supercomputer Piz Daint will have to be replaced by 2022. This major infrastructure upgrade comes at a time when Moore's Law, the main engine for the performance enhancements in supercomputing since the 1970s, is tapering off and the industry appears to be supply-limited (i.e. prices are increasing). This will lead to a continuing architectural diversification and increase in more complexity in the usage of supercomputers.

Detailed description

Fortunately, CSCS, with its established application-driven co-design approach to the development of supercomputers, along with Swiss-based researchers, who have contributed to application development projects funded by the Platform for Advanced Scientific Computing (PASC), are in a very strong position to tackle these technological challenges in the coming decade. Our plan builds on this experience and will provide Switzerland (and science in general) with a technologically advanced and very capable supercomputing infrastructure. It will not be the largest in terms of peak floating-point performance, but one of the most productive in terms of application performance and productivity.

The design of the supercomputer to replace Piz Daint will be based on very ambitious performance goals for next generation simulations of weather and climate. Choosing a single domain will result in an architecture that will be usable in many other domains but focusing the design on one enables us to set clear goals for ambitious design goals and to define consistent success metrics.

The buildup of the successor to Piz Daint began in 2018 with site preparation. A test and development system will be installed in late 2019 and the actual system will start to be brought onsite in 2020. A rigorous evaluation of node architectures with all processors options is being carried out since 2018 and will continue until 2020. In late 2021, full scale-out of the system will be started and is expected to complete in 2022. Operations will begin in 2023 and run through 2028 at least. An upgrade of the compute nodes is anticipated for 2026.

b. International level

[39] This infrastructure was already listed on the Roadmap for Research Infrastructures 2015 (upgrade for the Roadmap for Research Infrastructures 2019).

All resources of the User Lab are accessible to all scientists, irrespective of the country they are based in, and allocation decisions are taken purely on the basis of a transparent peer-review-based process. From European perspective, about 40% of the resources are allocated via the Tier 0 program of PRACE, in which Switzerland is one of the leading partners.
The software strategy for weather and climate builds on domain specific libraries (DSL), technologies developed by CSCS and ETH Zurich, which will support the major European models such at IFS of the European Centre for Midrange Weather Forecasts or the ICON model developed by the Max Planck Institute for Meteorology and the German Weather Service (DWD), as well as the leading US model FV3 developed by the Geophysical Fluid Dynamics Laboratory (GFDL) at Princeton.

c. Development prospects

Computing technologies have to be continually renewed, even in the post Moore's Law era. Thus, the Swiss High-Performance Computing and Networking (HPCN) initiative, that funds both the User Lab at CSCS as well as PASC, consists of a long-term funding envelope for investments and a long-term commitment by ETH Zurich to fund operations of the user lab. This funding envelope is flat, despite the fact that prices for computing technologies have been increasing substantially in recent years (end of Moore's Law and supply-limited market). Experience at CSCS over the past 10 years has shown that price hikes could be mitigated through active pursuit of new technologies – CSCS was one of the first computing centers worldwide to introduce GPU technologies. During the next phase, the replacement of Piz Daint by 2022, much of the needed performance increase will come from investments in software that are mostly funded with national and international contributions outside of the current HPCN initiative. The subsequent upgrade that is planned for the 2025-2028 time period will certainly build on these continued investments in software. However, it is entirely possible, that fundamentally new processor architectures will be available by that time, which could boost simulation performance substantially – such technologies are being developed at ETH Zurich in collaboration with industry. Of course, it is also possible that such technologies do not develop as expected and that the necessary performance increases can only be achieved through expansion of the footprint of the infrastructure. With such a scenario, costs will go up and one would have to reconsider the business and funding model of the infrastructure. In 2019, it is too early for such decisions, hence we work with a flat funding envelope.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution Universitites PASC: 6 Mio	Higher Education Institution Universities PASC: 6 Mio	Higher Education Institution Universities PASC: 6 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation ETH Board: 92 Mio ETH Zurich: 64 Mio ETH Zurich PASC: 6 Mio	Swiss Confederation ETH Board: 92 Mio ETH Zurich: 64 Mio ETH Zurich PASC: 6 Mio	Swiss Confederation ETH Board: 92 Mio ETH Zürich: 64 Mio ETH Zurich PASC: 6 Mio
Third parties PRACE AISBL & IP: 6 Mio	Third parties PRACE AISBL & IP / EuroHPC: 6 Mio	Third parties PRACE AISBL & IP / EuroHPC: 6 Mio
Total budget **174 Mio**	**Total** **174 Mio**	**Total** **174 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 80 Mio Operating costs 70 Mio Other costs 24 Mio	Investments 80 Mio Operating costs 70 Mio Other costs 24 Mio	Investments 80 Mio Operating costs 70 Mio Other costs 24 Mio
Total costs **174 Mio**	**Total** **174 Mio**	**Total** **174 Mio**

Development Phases	Years
Design	2018-2020
Preparation	2020-2021
Implementation	2021-2022
Operation	2023-2028+

2. Swiss Light Source SLS 2.0[40]

Category: Instrument

Host institution(s): PSI

Main funding sources: ETH Board, PSI

Description / Development prospects

a. National level

Overview

The Swiss Light Source (SLS), operational since 2001, remained one of the leading examples of third-generation storage-ring technology for more than a decade. However, the increasing scope and impact of the uses of synchrotron light sources in almost all areas of the natural and engineering sciences, improvements in source and instrument technology generally, and the advent of diffraction-limited storage-rings (DLSRs) in particular, mean that the SLS must undergo a comprehensive upgrade to remain competitive and attract cutting-edge science.

SLS 2.0 will provide a dramatic increase in brightness (up to a factor of 50) by replacing the current magnet lattice of the storage ring by a new multi-bend achromat (MBA) magnet structure. This, combined with advanced hardware and instrumentation, will enhance the performance of all techniques currently practiced at the SLS by up to three to four orders of magnitude in some cases, while heralding on the one side new and game-changing sources and on the other, new and innovative techniques. SLS 2.0 is perfectly aligned with the ETH Domain initiatives in advanced manufacturing, personalized health and related technologies, and energy and data sciences.

SLS 2.0 will complement the access to Swiss users to the European Synchrotron Radiation Facility (ESRF), an international research organization based in Grenoble from which Switzerland is a member.

Detailed description

The upgrade focuses on the transformation of the storage ring lattice to MBA technology and the upgrade of the beamlines and end stations to take full advantage of the increased brightness of the machine. The upgrades of the accelerator and the beamlines and PSI's leadership in development of complementary technology (e.g. insertion-device design, pixelated x-ray detectors, x-ray optics) will yield unique research opportunities especially in imaging, diffraction, and spectroscopy, areas in which SLS presently is a leading player:

- In x-ray ptychography (a microscopic technique pioneered at SLS) it will be possible to collect images in seconds or minutes instead of hours.
- SLS is among the leaders in x-ray tomography, resulting in benefits to clinical medicine as well as fundamental and applied sciences. SLS 2.0 will generate more brilliant as well as harder x-ray beams with a larger penetrating power, allowing static and time-dependent tomography for a much larger range of systems.
- The smaller beam produced by SLS 2.0 will enable analysis of sub-micrometer scale crystals of proteins, a feature currently not achievable at SLS.
- SLS houses the world's premier beamlines for imaging electron states in devices, both buried and at surfaces, and in novel materials. SLS 2.0 will enable collection of such images for the small devices of contemporary and future technological importance.

SLS 2.0 will perfectly complement the new x-ray free-electron laser SwissFEL: SLS 2.0 will focus on high (spatial) resolution imaging and spectroscopy at slow time scales (ps to ms) whereas SwissFEL will place emphasis on ultrafast (fs) time domain experiments.

[40] This infrastructure was already listed on the Roadmap for Research Infrastructures 2015 (upgrade for the Roadmap for Research Infrastructures 2019).

b. International level

The first DLSR at MAX-IV in Lund, Sweden, came on line in Summer 2016. Sirius in Campinas, Brazil, is expected to follow early in 2019, while the ESRF began its upgrade to DLSR-status in December 2018 and plans to host its first users in 2020. The ALS in Berkeley is commencing an upgrade program that should be finished shortly after projected completion of SLS 2.0. The small footprint of the SLS building has driven entirely novel technical developments, including longitudinally-graded dipoles and reverse bends. With these innovations, SLS 2.0 will offer brilliances comparable to or better than almost all leading worldwide facilities.

c. Development prospects

The upgrade of the SLS will on the one hand significantly enhance the quality and in many cases also the speed of existing experimental methods, and on the other, herald entirely innovative techniques in areas as diverse as advanced manufacturing, drug design, and electronic-device manufacturing and characterization. This will have a game-changing impact on both Swiss and international basic research and on Swiss industry. It is thus of utmost importance that the SLS upgrade program propels PSI back to the forefront of cutting-edge science for the forthcoming two decades. In addition, and as a key element of PSI's basic mission, continuous upgrades of both the machine and endstations will be performed during the operating phase in order to ensure our long-term competitiveness.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation PSI: 2 Mio	Swiss Confederation ETH Board: 99 Mio PSI: 68 Mio	Swiss Confederation PSI: 29 Mio
Third parties 0	Third parties 0	Third parties 0
Total budget **2 Mio**	**Total** **167 Mio**	**Total** **29 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0 Operating costs 0 Other costs 2 Mio	Investments 116 Mio Operating costs 0 Other costs 51 Mio	Investments 9 Mio Operating costs 0 Other costs 20 Mio
Total costs **2 Mio**	**Total** **167 Mio**	**Total** **29 Mio**

Development Phases	Years
Design	2017-2021
Preparation	2019-2023
Implementation	2021-2024
Operation	2024

3. Catalysis Hub (CAT+)

Category: Technical Infrastructure

Host institution(s): ETH Zurich and EPFL

Main funding sources: ETH Board, ETH Zurich, EPFL, SNSF, EU

Description / Development prospects

a. National level

Overview

The Catalysis Hub (*Catalysis Hub – Cat+*) provides a unique integrated research infrastructure for the efficient discovery of catalytic technologies for sustainable conversion processes and energy research. This Open Swiss platform co-headed by EPFL and ETH Zurich will be an open access facility for catalysis research devoted to the discovery, the characterization and the testing of large numbers of homogeneous and heterogeneous catalysts and catalytic processes based on high-throughput experimentation, computations and advanced data analysis.

Detailed description

The Catalysis Hub – *Cat+* is designed as an open access facility for catalysis research. It will be devoted to the discovery, the characterization and the testing of large numbers of homogeneous and heterogeneous catalysts and catalytic processes. This requires an integrated workflow, with the fully automated synthesis, characterization and evaluation of molecular and solid catalysts that will be augmented by advanced integrated computational modelling and data analysis through machine learning – artificial intelligence approaches. This world-leading Catalysis Hub (*Catalysis Hub – Cat+*) will build on the assets of the ETH Domain and will provide the entire Swiss academic and industrial community with access to state-of-the-art and next-generation equipment for catalyst and reaction discovery as well as process optimization. Cat+ will also provide advanced and operando spectroscopy tools and methods to drive rational design and to understand how to overcome limitations with respect to catalyst deactivation. The Cat+ will group leading experts of every required aspect for catalyst discovery and development. The access to the hub will be secured by rapid online submission and evaluation of proposals followed by the execution of the task by an efficient team of experts in close collaboration with the applicant research group.

Physically, *Cat+* will be distributed across two main campuses depending on the specific expertise to allow for an efficient dissemination within Switzerland: the East Campus (ETH Zurich/Empa) and West Campus (EPFL) of the *Catalysis Hub – Cat+* will focus on heterogeneous and molecular catalysts, respectively.

b. International level

Efficient catalytic technologies are a recognized tool to address the needs of sustainable chemical production and energy storage/conversion. In this respect, top-level research and teaching institutions worldwide are significantly investing in dedicated catalysis research centers to advance the catalyst discovery and development process. Cat+ will ensure that the ETH Domain and Switzerland as a whole have access to the necessary infrastructure and provides the platform to raise talents and to stay competitive on a global level. Cat+ is open to Swiss academics and industries. It will also welcome international participations and seeks the exchange with other leading centers for advancing the state-of-the-art in catalysis research.

c. Development prospects

The key aim for the initiation years of Cat+ is to provide the appropriate next generation infrastructure equipment for all aspects of catalyst discovery and development and pair it with the best available experts of the ETH Domain. This unifying approach enables the center to react efficiently to tackle the challenges of future catalysis research and sustainable development. Beyond 2025, we expect that the majority of the Cat+ users will be able to fund their use of the infrastructure by a pay-per-use basis.

Additionally, we expect in the long-term significant industry interest once the full potential of Cat+ is unlocked. Both should allow a transition to a sustainable model ensuring long-term perspective and later upgrades of Cat+.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation ETH Board: 25 Mio ETH Zurich, EPFL: 6.9 Mio	Swiss Confederation ETH Board: 9.2 Mio ETH Zurich, EPFL, others: 3.0 Mio
Third parties 0	Third parties SNSF, EU: 0.5 Mio Private sector: 0.3 Mio	Third parties SNSF, EU: 1.4 Mio Private sector: 0.8 Mio
Total budget **0**	**Total** **32.7 Mio**	**Total** **14.4 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0 Operating costs 0 Other costs 0	Investments 20.2 Mio Operating costs 6.7 Mio Other costs 5.8 Mio	Investments 5.8 Mio Operating costs 6.7 Mio Other costs 1.9 Mio
Total costs **0**	**Total** **32.7 Mio**	**Total** **14.4 Mio**

Development Phases	Years
Design	2019-2020
Preparation	2020-2021
Implementation	2020-2022
Operation	2023-onward

4. Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR)[41]

Category: Instrument

Host institution(s): University of Zurich, ETH Zürich, University of Basel

Main funding sources: Cantonal Funding, ETHZ

Description / Development prospects

a. National level

Overview

A national facility for ultrahigh-field solution NMR spectroscopy will be established to propel the excellent position of Switzerland as a leading country in NMR spectroscopy. This national facility will be located in a new building located at the Irchel Campus of the University of Zurich, operated by the Department of Chemistry of the University of Zurich, and steered by the three partnering institutions. Funding for the new platform will originate from University of Zurich, ETH Zurich and the University of Basel. Access to the facility will be open to all academic research groups in Switzerland and to participating industrial partners. Data from the new spectrometer are expected to greatly benefit biomedical research in Switzerland.

Detailed description

The 1.2 GHz NMR instrument will provide a major increase in experimental sensitivity and resolution for the analysis of biomolecules. The magnet uses a novel break-through technology, high-temperature superconducting coil materials, to achieve a major technological advance. The resulting reduction in required sample concentrations and the larger achievable molecular sizes will significantly extend the applicability of solution NMR spectroscopy to highly challenging and important biomolecular systems. Those are studied by the applicant groups and many other Swiss research groups. Applications will encompass studies of structure, function, dynamics and folding of biomacromolecules including, but not limited to integral membrane proteins, membrane protein complexes, pathogenic bacterial systems, large molecular machines, protein–RNA complexes, and medically relevant drug targets. Further applications are the development of drugs and of new high-resolution NMR methods. The generated data will provide key insights into fundamental biological mechanisms such as protein biogenesis, signaling, allosteric regulation, catalysis, RNA regulation and splicing, as well as epigenetics in normal and disease-causing biomolecular systems.

Many biologically relevant targets are in a size-range that tremendously benefits from the increased sensitivity of ultrahigh-field NMR instruments. Research in the biomedical area is highly competitive in Switzerland, and access to a 1.2 GHz spectrometer will strengthen research in that field. Moreover, it will help to recruit top scientists working in the above-mentioned biomedical areas to Swiss universities or research institutions.

Currently, NMR centers in Switzerland exist at the ETH Zurich (500–900 MHz), University of Basel (500–900 MHz), EPF Lausanne (400–800 MHz), and University of Zurich (500–700 MHz).

b. International level

At the European level, large NMR centers are located e.g. in Berlin, Frankfurt, Göttingen, Munich, Florence, Grenoble, Lyon, Gif-sur-Yvette, Lille, Utrecht, Nijmegen, Oxford, Cambridge, Birmingham, Gothenburg, Kopenhagen, Brno and Ljubljana.

Outside of Europe, large NMR facilities exist in the US, Canada, Japan, China, Australia, Brazil, India, Russia, Saudi-Arabia, and Taiwan. With the currently installed equipment, Switzerland is worldwide at the forefront in solution Bio-NMR.

The situation will, however, potentially change with the availability of 1.2 GHz solution NMR instruments. Several such machines have been ordered already, by research institutions from Germany (Munich,

[41] This infrastructure was already listed on the Roadmap for Research Infrastructures 2015 (upgrade for the Roadmap for Research Infrastructures 2019).

Berlin, Frankfurt, Göttingen, Jülich), the Netherlands (Utrecht), Italy (Florence), France (Lille), the United States (Memphis), and Great Britain and Korea.

The Swiss National Ultrahigh-Field Solution NMR Facility will also seek to develop ties to the INSTRUCT program in Structral Biology within the European Strategy Forum on Research Infrastructures (ESFRI) in order to foster scientific exchange.

c. Development prospects

Solution NMR has played a major role in structural biology solving structures of many < 30 KDa proteins. It has extensively been applied to probe for interactions between drugs and their receptors, and thereby critically contributed to the development of many drugs. NMR in a unique way, is additionally capable of investigating the dynamics of biomolecules, a property that is at the heart of enzymatic function. This subject is an area of extensive present research and will continue to be of utmost importance even when most structures or folds have been discovered. Groundbreaking work for example has been performed on the function of the ribosome, the proteasome megadalton protein assembly involved in protein degradation, the entire catalytic cycle of dihydrofolate reductase, a pharmaceutically highly relevant protein, or on so-called G-protein coupled receptors, membrane proteins that present targets for most drugs. Novel developments in structural biology also include combinations of NMR and cryo-electron microscopy (cryo-EM) or small-angle X ray scattering (SAXS) to resolve structures of very large protein-protein or protein-nucleic acid complexes. NMR is particularly suitable to determine folds of proteins that contain large unfolded parts. A class of pathogenic proteins that are of high medical importance are those involved in neurodegenerative diseases, many of which belong to the intrinsically unfolded proteins (IDPs). For all the above-mentioned systems access to ultrahigh-field NMR spectrometers will be crucial.

Biomedical research is now moving into the systems biology field, in which interactions between complex biomolecular systems become relevant. Again, the systems will be much more amenable to a detailed analysis with data of increased resolution as available from a ultrahigh-field NMR spectrometer.

Finally, the hardware developments are made by a market-leading Switzerland/Germany based company. Investigating into high-end products will thus motivate further developments and research in this cutting-edge technology and help securing Switzerland's role as a major player in high-tech industry.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution UniBas/UZH: 11.0 Mio	Higher Education Institution 5.0 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation ETH: 6.0 Mio	Swiss Confederation 0
Third parties 0	Third parties SNSF: 1.0 Mio	Third parties 0
Total budget 0	**Total 18.0 Mio**	**Total 5.0 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0	Investments 16.0 Mio	Investments 1.0 Mio
Operating costs 0	Operating costs 2.0 Mio	Operating costs 4.0 Mio
Other costs 0	Other costs 0	Other costs 0
Total costs 0	**Total 18.0 Mio**	**Total 5.0 Mio**

Development Phases	Years
Design	2017-2020
Preparation	2020-2021
Implementation	2022-2023
Operation	2023-2028ff.

5. Airborne Research Facility for the Earth System (ARES)[42]

Category: Integrated Research Infrastructure

Host institution(s): University of Zurich

Main funding sources: UZH, ETH, EPFL, Empa, Eawag, UniL, UniFR, private foundations

Description / Development prospects

a. National level

Overview

The Airborne Research Facility for the Earth System (ARES) is an integrated research infrastructure to measure terrestrial processes of the Earth system at regional scale. Data from complementary remote sensing instruments are assimilated in models within a dedicated computing infrastructure. The tight integration of state of the art sensors with sophisticated models through a computing infrastructure will be unique within Switzerland and Europe, delivering world-class data and science output to the Earth System Science community, fostered by a FAIR (findable, accessible, interoperable, and reusable) infrastructure with an open access data policy. ARES will be available primarily for Swiss researchers and collecting data in Switzerland. As an open platform, it will also be made available to researchers on an international level to optimise the system usage through deployments outside of Switzerland.

Detailed description

The integrated research infrastructure Airborne Research Facility for the Earth System (ARES) is composed of three components as follows:

High-precision Earth observing instruments mounted on an airborne platform measure the electromagnetic spectrum reflected and emitted from the Earth surface. The complimentary instruments comprise (a) an imaging spectrometer, (b) a multispectral laser scanner, and (c) photogrammetric camera. These sensor systems are interfaced by high precision navigation and position instrumentation for automated data acquisition and geometric processing.

Data acquired by the various instruments are processed to traceable physical units in dedicated processing chains and then assimilated by Earth System models to provide indicators describing the key chemical, biological, structural, geometrical and physical properties of the rapidly changing environment.

The computing infrastructure will be based on existing data centres, upgraded to support ARES data storage, processing and querying to allow the efficient parameterisation of Earth System models. Data analysis, traceability and reproducibility are enabled through consistent metadata including provenance. These will be key to enhance the scientific impact of ARES through open data access. The availability of spatially co-registered, temporally coherent ARES products will enable scientists to explore yet unknown interactions between Earth System processes using big data approaches.

The ARES team has partially been using the Airborne PRISM Experiment (APEX, http://www.apex-esa.org) instrument so far. APEX is a joint development of the University of Zurich (CH) and VITO (Be) under the framework of ESA PRODEX. APEX has reached end–of–life in 2017. The University of Zurich has successfully negotiated a cooperation agreement with NASA Jet Propulsion Laboratory (JPL, Pasadena, CA, USA) to fly their AVIRIS-NG instrument in a transition period (2018–2023), if needed. A first successful deployment of AVIRIS-NG in Europe took place in 2018. Further, the University of Zurich has signed a Space Act Agreement (SAA) with NASA JPL in December 2018 to jointly develop a new generation imaging spectrometer (Compact Wide Field-of-View Imaging Spectrometer II (CWIS-II)). CWIS-II will be the first instrument used for ARES.

With a planned upgrade in 2021–2024, the airborne imaging spectrometer will be complemented by a single-photon waveform laser (airborne laser scanner) and a high resolution panchromatic camera. It is foreseen to acquire first airborne data using ARES in 2021, and with the full instrument package (imaging spectrometer, LiDAR, panchromatic camera) starting in 2022. It is expected to acquire data for the core

[42] This infrastructure was already listed on the Roadmap for Research Infrastructures 2015 (upgrade for the Roadmap for Research Infrastructures 2019).

investigators (namely: University of Zurich, ETH Zurich, Eawag, Empa, EPFL, University of Lausanne, University of Fribourg, and the International Centre for Earth Simulation (ICES)), and expand to other investigators with interest in such data and products (including commercial use).

b. International level

ARES remains unique in its setting. Several international key infrastructures exist, using advanced imaging spectrometers as well as LiDAR instruments. Key infrastructures are the Carnegie Airborne Observatory (CAO), focusing on tropical forests and coral reefs, the Airborne Package of the National Ecological Observatory Network (NEON), covering the North American continent, and NASA instruments (G–LiHT Imager (NASA Goddard), AVIRIS–NG and ASO (NASA JPL)). All of those facilities have been in existence for several years already. ARES will cover primarily temperate, Mediterranean, taiga and tundra ecosystems, previously not well assessed.

c. Development prospects

Observational approaches using air– and spaceborne instruments feeding Earth System models have gained in importance over time. Airborne platforms increasingly contribute to testing and standardizing retrievals for the Earth System before implemented at larger scale in satellite instruments. In parallel, space agencies are developing space-based infrastructure to measure key contributions to the Earth System. The European Space Agency (ESA) as well as the European Union's Earth Observation Programme Copernicus are developing new satellite concepts (c.f., Copernicus Hyperspectral Imaging Mission for the Environment (CHIME)), NASA JPL is planning to build the Earth Surface Mineral Dust Source Investigation (EMIT) instrument, and is currently flying the Global Ecosystem Dynamics Investigation LiDAR (GEDI) and is planning an hyperspectral imager to study surface biology and geology as a recommendation from the decadal survey of the National Academies of Science, Engineering and Medicine. In addition, regional, national and international efforts are underway to produce 'data cubes'–collections of relevant Earth System data, variables and processes, allowing to monitor our accelerated changing environment. ARES is in the key position to contribute uniquely to the development of those new missions and data cubes, in particular providing access to environments previously not mapped in detail as well as providing an integrated system approach, ranging from measurements to data products and Earth System processes based on open access and FAIR schemes. ARES is an open platform and can be further expanded to include additional sensor payloads, such as imaging thermal spectrometers, synthetic aperture radar instruments, or fluorescence imagers.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution (2017-2024) UZH, UniL, UniFR: 5.96 Mio	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton tbd: 2.00 Mio
Swiss Confederation (2017-2024) ETHZ, Eawag, Empa, EPFL: 3.93 Mio	Swiss Confederation 0	Swiss Confederation tbd: 1.00 Mio
Third parties (2017-2024) Private foundations: 0.44 Mio	Third parties tbd: 9.22 Mio	Third parties tbd: 0.50 Mio
Total budget 10.33 Mio	**Total 9.22 Mio**	**Total 3.50 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 7.37 Mio Operating costs 1.90 Mio Other costs 1.06 Mio	Investments 6.32 Mio Operating costs 1.65 Mio Other costs 1.25 Mio	Investments 0.65 Mio Operating costs 1.90 Mio Other costs 0.95 Mio
Total costs 10.33 Mio	**Total 9.22 Mio**	**Total 3.50 Mio**

Development Phases	Years
Design	2017-2020
Preparation	2017-2021
Implementation	2019-2023
Operation	2021-2028

6. Center of Structural Electron Microscopy (COSEM)

Category: Instrument

Host institution(s): University of Zurich

Main funding sources: University of Zurich, Foundations

Description / Development prospects

a. National level

Overview

The importance of modern cryo-electron microscopy (cryo-EM) for molecular and cellular structural biology is founded on the recent revolution in the field, which was acknowledged by the award of *the 2017 Nobel Prize in Chemistry* to three pioneers of the technique. Cryo-EM has by now replaced X-ray crystallography as premier method for the structure determination of challenging biological specimen, such as membrane proteins and macromolecular complexes, which is reflected in numerous articles that were published in top journals in recent years. The breakthrough in molecular structural biology is now followed by a similar revolution in cell biology, which allows structure determination of macromolecular complexes *in situ*, thereby permitting the detailed structural analysis of tissues in health and disease. As consequence of the described developments, the number of users and thus the demand for access to high-end cryo-electron microscopes has strongly increased and is expected to increase further in the future. We thus propose the establishment of the 'Center of Structural Electron Microscopy' (COSEM) that will provide access to state-of-the-art cryo-EM infrastructure to researchers of the University of Zurich (UZH) and in Switzerland. COSEM builds on the already established high-end Cryo-EM infrastructure at UZH and plans to update and extend it. The described project should thus be considered as major upgrade of an existing infrastructure. The center will be managed by the Center of Microscopy and Image Analysis (ZMB) of UZH, which already runs the existing electron microscopes, and will be supervised by a scientific advisory committee. Whereas part of the funds requested for the project will be used to finance the running costs of the center, a significant share will be contributed by user fees. The establishment of COSEM will meet the increasing demand for cryo-EM at UZH and nationwide and thus keep Switzerland internationally competitive in this rapidly growing field. The center will be part of the decentralized services for cryo-EM and thus will be an attractive factor for current and future faculty. The long-term objective is a decentralized national center for cryo-EM established by several national research institutions in which COSEM will participate.

Detailed description

COSEM will to a large extent rely on existing cryo-electron microscopes but additionally attempts for the acquisition of novel infrastructure. In its final stage the center is planned to run two 300 keV Titan Krios, a 200 keV Talos Arctica and a cryo-Focused Ion Beam (cryo-FIB). One 200 keV cryo-electron microscope (Titan Krios 1) is already in operation and the funding of the second (Titan Krios 2) is secured and will be in function by 2020. The financing of the 200 keV Talos Arctica, the cryo-FIB (including a cryo-stage), the update of the two 300-keV microscopes (update of Krios 1 with a novel detector and update of Krios 2 with a phase plate) and service contracts for the new detectors is currently still open. COSEM will be part of the ZMB, which will provide management and technical support and maintain the interface to the users. The ZMB is an open and advanced facility at UZH, which provides access to various high-end imaging techniques in microscopy. The facility and instruments are open to research groups of UZH as well as to external institutions for a nominal fee covering project-related costs (e.g. training, operator-based imaging and quality assurance). All of this ensures a cost-effective and open access to state-of-the-art imaging technologies and expertise. The ZMB also contributes significantly to training and education of scientists in imaging and microscopy. Thus, internal and external users will be trained by the ZMB staff before being able to sign up for microscopy time. Training will be provided for sample preparation, the operation of microscopes and data analysis. Whereas a similar operation scheme is foreseen for COSEM, the use of delicate high-end cryo-electron microscopes will require a more extended training and a larger financial contribution to the running costs. To meet these aims and provide support for all instrumentations, the ZMB already employs experts in advanced electron microscopy techniques and an IT specialist. It is planned that they will be supported by another scientist

dedicated to the operation of COSEM, who will be recruited during the implementation phase and whose salary will be covered from the requested budget. The scientist will be employed by the ZMB and will be responsible for the maintenance of the microscopes and the training of novel users.

b. International level

COSEM is planed to be a world-leading center for structural biology and therefore would draw world-wide attention. The requested investment would allow us to establish and maintain a leading facility in the fields of structural and cell biology. The instruments will also be available to scientists abroad if the local community will not utilize the center's capacity.

c. Development prospects

Despite the recent breakthroughs, cryo-EM remains a dynamic and rapidly developing field. Direct electron detectors were introduced only 6 years ago and are still under development. Similarly, sample preparation and image analysis are likely to be developed further in the coming 5-10 years. Whereas the structure determination of single particle analysis is now routine and accessible to a large user community, a similar development for cryo-electron tomography has still to occur. Therefore, a major aim of COSEM will be to maintain its high-end standards and to drive new technological developments. For that purpose, the members of the ZMB including the employed staff scientist and the scientific advisory committee will routinely attend technical conferences and interact with the relevant companies. It is foreseen that next generation detectors, phase plates and image processing software will become available over the projected duration of the center. COSEM and the ZMB are committed to follow these developments and to maintain the center as a facility offering state-of-the-art services to researchers in Switzerland.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution UZH: 2.9 Mio	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF: 0.7 Mio Foundations: 1.0 Mio	Third parties User fees: 0.4 Mio tbd: 4.7 Mio	Third parties User fees: 0.4 Mio tbd: 0.8 Mio
Total budget **4.6 Mio**	**Total** **5.1 Mio**	**Total** **1.2 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 4.6 Mio Operating costs 0 Other costs 0	Investments 3.7 Mio Operating costs 1.4 Mio Other costs 0	Investments 0 Operating costs 1.2 Mio Other costs 0
Total costs **4.6 Mio**	**Total** **5.1 Mio**	**Total** **1.2 Mio**

Development Phases	Years
Design	2018-2020
Preparation	2019-2020
Implementation	2021-2024
Operation	2021-2028

7. Linguistic Research Infrastructure (LiRI)

Category: Information and services infrastructure

Host institution(s): University of Zurich

Main funding sources: University of Zurich

Description / Development prospects

a. National level

Overview

To shift linguistic research in Switzerland to a higher internationally competitive level, two inter-departmental institutions at the Faculty of Arts and Social Sciences at UZH, namely the Zurich Competence Center for Linguistics (ZüKL) and the University Research Priority Program "Language and Space" (URPP SpuR), as well as some laboratories distributed over the campus and several institutes, successfully applied for a substantial upgrade of existing local linguistic infrastructure.

The new infrastructure LiRI will, firstly, strengthen laboratory research in linguistics and neighboring areas, which has become central in the era of Digitization and Big Data in the study of language and speech, and will support data storage, data processing and analyses of the data with up-to-date datascience support in an unprecedented way. Secondly, this upgrade will allow pioneering new research combining naturalistic data with rigorous methods that so far could only be applied in the lab. This will bring Switzerland to the forefront of experimental and Big Data-based linguistics research.

Detailed description

In addition to a bundle of new Data acquisition/generation devices (mainly in phonetics, psycholinguistics and neurolinguistics with mobile and stationary eye-tracking devices, EEG systems, sound-proof-cabins, an anechoic chamber etc.), concentrated in one new linguistic laboratory unit, the core and linking base of the LiRI infrastructure will be a LiRI Information System (LIS) whose main functions will be:

a. to channel the large volume of data produced not only by the LiRI Data acquisition components, but also by data coming from academic institutions from outside UZH (working with language data and linguistic databases) into standardized, interoperable and open accessible resources (Data Management); detailed access rules for contributing and non-contributing partners will be set up as part of the LiRI rules of procedure as well as a set of minimal standards for the quality of hosted research data, digital assets and metadata; all tools and data hosted by LiRI will be subjected to the FAIR principles of Open Access.
b. to support empirical research from data acquisition to publication (Data Science).

LiRI is conceived in its full form as a national platform for linguistic data storage/processing/science, uniting if possible as many linguistic data resources of all kinds (text, audio, video, EEG etc.) in one data center. Many linguistic research units from all over the country as well as academic institutions and cooperation partners as the academy (SAGW). LiRI will thus considerably strengthen national cooperations and boost interuniversity dialogue and projects.

b. International level

LiRI will boost the visibility of linguistics at UZH, which integrates the largest linguistic research community of Switzerland (about 20 full professors, manyfold third-party funded projects and huge local research and training initiatives). Existing international collaborations and the international Advisory Board will contribute to the development of LiRI into one of very few large laboratory and Data Management units for linguistics (and related disciplines) in Europe. Additionally, LiRI is embedded in European infrastructure initiatives. UZH already collaborates with DARIAH, a pan-European infrastructure for arts and humanities scholars working with computational methods. UZH has interest in participating in CLARIN (initiative led and directed by *ZüKL*, the Zurich Competence Center for Linguistics; some of our leading experts are already members of CLARIN D). Membership in these two organizations would allow the research community to contribute to and to benefit from the two most important European infrastructure networks. Through systematic metadata requirements they help to

structure all future linguistic data, including those coming from our external cooperation partners and make them accessible long-term through widely used repositories.

c. Development prospects

LiRI will bring UZH and its national and international partners to the forefront of experimental and Big Data-based linguistic research, taking into consideration also the European funding agencies' policy of sustainable research infrastructures in the present and future program ("Horizon Europe": https://ec.europa.eu/research/infrastructures). The new devices, synthetic lab structure and the new staff (data scientists/research methods consultants, technician, system administrator/coordinator) will allow to increase the number and size of third-party funded projects, both nationally and internationally (SNSF: NCCR funding scheme, ERC funding schemes, other European Programs), with scholars in academia and industry (e.g. hearing aids, brain-computer interfaces, neuromodulation, learning and training software). We expect a rapid growth of demand from 2020 onwards (when LiRI will start to be implemented), and aim to launch new research projects of considerable size such as NCCRs or ERC grants as well as by industry partners, who already show interest into the new laboratory devices and grant seed money for pilot studies. The planned participation in CLARIN thanks to the repository facility integrated in LIS will enhance both new research initiatives and demand of support in data storage, data management and data science provided by LiRI.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution UZH: 2.15 Mio	Higher Education Institution UZH: 5.07 Mio	Higher Education Institution UZH: 3.6 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF: 0.55 Mio User fees: 0.05 Mio Tbd: 0.15 Mio	Third parties SNSF: 0.95 Mio User fees: 0.66 Mio Tbd: 0.12 Mio	Third parties User fees: 1.12 Mio Tbd: 0.08 Mio
Total budget **2.90 Mio**	**Total** **6.80 Mio**	**Total** **4.80 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 1.61 Mio Operating costs 1.14 Mio Other costs 0.15 Mio	Investments 2.06 Mio Operating costs 4.62 Mio Other costs 0.12 Mio	Investments 0 Operating costs 4.72 Mio Other costs 0.08 Mio
Total costs **2.90 Mio**	**Total** **6.80 Mio**	**Total** **4.80 Mio**

Development Phases	Years
Design	2017-2018
Preparation	2018-2019
Implementation	2020-2022
Operation	2023-2037

Annexe A2 : Mise à jour des infrastructures nationales de la Feuille de route 2015

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Remarque préliminaire

Les infrastructures de recherche ayant été recommandées pour la réalisation dans la Feuille de route 2015 ont fait l'objet d'une mise à jour de leur état d'avancement entre la fin 2018 et le début 2019. Les données récoltées auprès des responsables des infrastructures sont présentées dans la présente annexe A2. Les projets d'infrastructures apparaissent selon leur discipline :

- Sciences humaines et sociales
  - Swiss Art Research Infrastructure (SARI)
  - Data and Service Center for the Humanities (DaSCH), anciennement Swiss Digital Humanities Center (SDHC)
  - Mixed-Reality Lab for Behavioral Research (MIRAL)

- MINT
  - Swiss National Ion-microbe Platform (SwissNIP)
  - Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials (DynaMatLab)
  - Next Evolution in Sustainable Building Technologies (NEST)
  - The future of dark matter detection with liquid xenon XENONnT and DARWIN
  - ATHOS beamline at the Swiss X-ray Free Electron Laser SwissFEL
  - Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI)
  - Center for biomedical research in space
  - Swiss Plasma Center (SPC)

- Sciences de la vie
  - National Research Centre for Animal Cognition
  - Swiss Research Network of Clinical Pediatric Hubs (SwissPedNet) (including the Center for Pediatric Systems Pharmacology and Technology, SwissPedPha)
  - Swiss Center for Musculoskeletal Biobanking and Imaging and Clinical Movement Analysis (Balgrist campus)
  - Neuchâtel Platform for Analytical Chemistry (NPAC)
  - Information and computational service infrastructure network to support biomedical research in Switzerland (BioMedIT))

- e-Infrastructures
  - The Swiss edu-ID and the Swiss Academic Cloud based on the Academic Network SWITCHlan
  - Swiss Data Science Center (SDSC)

A noter que les données des infrastructures de la Feuille de route 2015 ayant soumis une mise à niveau substantielle (« major upgrade ») pour la Feuille de route 2019 figurent seulement à l'annexe A1. Il s'agit des projets High-Performance Computing and Networking (HPCN-24), Swiss Light Source SLS 2.0, Airborne Research Facility for the Earth System (ARES) et Swiss National Ultrahigh-Field Solution NMR Facility (1.2 GHz NMR).

Toutes les infrastructures décrites ici ne remplissent pas le nouveau critère de la Feuille de route 2019 concernant le budget minimum de 5 millions de francs, puisqu'il s'agit d'une mise à jour des données des infrastructures de la Feuille de route 2015. Les infrastructures de la Feuille de route 2015 devaient cependant remplir les critères suivants :

- *fournir une contribution importante au développement d'un domaine de connaissance ou de recherche (plus-value scientifique);*
- *être utilisées intensivement par les chercheurs en Suisse (importance nationale);*
- *être en principe ouvertes aux communautés de chercheurs nationales et internationales (accès ouvert);*
- *être situées dans un seul emplacement ou être organisées au sein d'un réseau comprenant plusieurs sites et une structure de gestion centralisée.*

Remarques importantes:

1) **Les informations financières ci-dessous représentent des planifications fournies par les hautes écoles / responsables des infrastructures.**
2) **Les chiffres financiers mentionnés dans le présent document pour les périodes FRI 2021–2024 et 2025–2028 sont des données prévisionnelles et sont indiqués uniquement à titre d'estimation grossière des coûts probables à venir et de leur répartition.**
3) **Dernière mise à jour des informations : octobre 2018-février 2019**

Swiss Art Research Infrastructure (SARI)

Category: Information and Service Infrastructures

Host institution(s): University of Zurich

Main funding sources: University of Zurich, ETH Zurich, external Foundations

Description / Development prospects

a. National level

Overview

The Swiss Art Research Infrastructure (SARI) provides access to advanced digital research tools and domain-specific research environments combined with unified and mutual access to research and collection data, digitised visual/textual resources, and related reference data in the field of art history, architecture and urban planning, archaeology, history studies, religious studies, and related disciplines. By providing universal access to both pivotal, new digital research technologies and digital resources through its modular, tailor-made research environment and state-of-the-art technological framework, SARI enhances the accessibility, interoperability re-usability, and long-term sustainability of future research and collection data in art history and related disciplines according to FAIR principles. Thus, SARI combines and leverages the unique scholarly expertise and visibility of specialised research institutions in Switzerland and enables new and advanced approaches in future digital research.

Detailed description

SARI develops and maintains a technological framework for unified access to domain-specific research resources, advanced research tools, and tailor-made research environments entirely based on internationally acknowledged, sustainable, and yet extendable standards for data modelling and data exchange in the semantic web. This includes the Resources Description Framework (RDF) and Linked Open Data technology (LOD) for semantic data and semantic web technology, the International Image Interoperability Framework (IIIF) for access to digital assets, and the Conceptual Reference Model of the International Council of Museums (CIDOC-CRM) for data modelling and harmonisation specific to the field art history (among others). Thus, SARIs comprehensive technology stack operates entirely open source-based, and its underlying standards for data modelling are fully aligned with standards and principles recommended by the W3C, assuring long-term findability, accessibility, interoperability, and re-usability of research data in the semantic web. As an outcome, research and collection data made available through SARIs technological framework are accessible as part of a global knowledge graph (both machine-readable and human-interpretable) and, thus, are available for both further research methods and sustainable long-term achievability according to the FAIR principles, as requested by most national and international funding agencies. This results in an unprecedented framework for sustained, unified, mutual, and mainly open access to research and collection data, first-hand digital visual resources, and scholarly acknowledged reference data from numerous specialised research institutions, academic research projects, museums, archives, and collections. SARIs framework thus overcomes not only the institutional and technical fragmentation in the field of art history, but also national language barriers by giving access to scholarly established, yet extendable multilingual vocabularies, As such, SARI becomes a role model for further, international institutional and academic cooperations.

With the primary operative partners University of Zurich, ETH Zurich, and the SIK-ISEA, Switzerland's leading institutions in the field of digital art history are substantially contributing technology and pivotal data to SARI. Thanks to the collaboration with all major national and international institutions in the field, SARI fosters a cost-effective use of existing resources and the tools and research and teaching across disciplines (see below for international partners).

b. International level

In order to guarantee maximum leverage, SARI is developing its research environment and research tools in close cooperation with international partners, such as the British Museums 'ResearchSpace' project (long-term funded by the Andrew W. Mellon Foundation) and uses the same technology stack as major cultural institutions worldwide (The Getty Research Institute and Museums, Yale Center for British Art, British Museum, etc.) to mutually provide access to research resources, thus resulting in the availability of millions

of digital assets and large numbers of data sets worldwide through the same, unified technology stack implemented by SARI. Pivotal extensions to semantic ontologies related to CIDOC-CRM are currently being developed in cooperation with the CIDOC-CRM special interest group, the FORTH-ICS (Foundation for Research and Technology, Hellas/Heraklion), while upcoming ontological standards such as 'linked.art' are actively developed with the J. Paul Getty Trust, Los Angeles. Where needed, multilingual, domain-specific reference vocabularies are being developed in cooperation with major national and international players (libraries, research institutions, etc.) to ensure maximum acceptance both institutionally and within the international scientific community (GND, ULAN, AAT, others). As a result, SARIs semantic technology, research environment and tools are currently being adopted and further developed by leading institutions in the field. This includes the Harvard Centre for Renaissance Studies 'Villa I Tatti', Florence, the Bibliotheca Hertziana/MPG, Rome, and the Institute for the History of Science, MPG/Berlin (as part of the International Consortium for Open Research Data in the Humanities, CORDH, founded in 2018).

c. Development prospects

Based on the increasing availability of domain-specific datasets and a rapidly growing interest in digital research technology and methods in art history and related disciplines, we identify a dramatically growing demand for advanced digital research technology, research tools and universal access to digital research resources from specialised institutions, as provided by SARI. Requirements from national and international funding agencies to provide findable, accessible, interoperable, and re-usable research data (FAIR) accelerate this demand. As a result, SARI is activily collaborating in numerous research project proposals to SNSF, ERC and alike, to pursue its mission to provide advanced digital research tools in domain-specific research environments. To avoid redundancies on a national level, SARI is closely collaborating with the Data and Service Center for the Humanities (DaSCH). In this, SARI is defining standards for data modelling and data exchange specific to the field of art history, that align with DaSCH's data ontology and infrastructure for long-term accessibility allowing for a smooth transition of research data produced on within SARI into DaSCH's longterm storage (KNORA). Likewise, SARI implements DaSCH's technological framework (IIIF-Sever "Sipi"), making DaSCH the preferred service provider for research data produced in SARI (for international development perspectives, see above).

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton University of Zurich: 3.04 Mio	Canton 0	Canton 0
Swiss Confederation ETH Zurich: 0.66 Mio	Swiss Confederation ETH Zurich: 0.42 Mio (projection)	Swiss Confederation ETH Zurich: 0.42 Mio (projection)
Third parties Ext. Foundation: 0.80 Mio	Third parties SNSF: 0.65 Mio (projection) Zurich Research Center, MPG: 2.00 Mio Foundations: 0.40 Mio (projection)	Third parties SNSF: 0.65 Mio. (projection) Foundations: 0.40 Mio (projection)
Total budget **4.5 Mio**	**Total** **3.47 Mio**	**Total** **1.47 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0.56 Mio Operating costs 2.86 Mio Other costs 1.08 Mio	Investments 0.5 Mio (max projection) Operating costs 0.97 Mio (max projection) Other costs 2 Mio (projection, MPG)	Investments 0.5 Mio (max projection) Operating costs 0.97 Mio (max projection) Other costs 0
Total costs **4.5 Mio**	**Total** **3.47 Mio**	**Total** **1.47 Mio**

Development Phases	Years
Design	(2014-) 2017
Preparation	2017
Implementation	2018-2019
Operation	2019-beyond

Data and Service Center for the Humanities (DaSCH)

Category: Information and service infrastructures

Host institution(s): Digital Humanities Lab, University of Basel on behalf of the Universities of Basel, Bern and Lausanne

Main funding sources: Swiss Academy of Humanities and Social Sciences (SAHSS), Universities

Description / Development prospects

a. National level

Overview

The Data and Service Center for the Humanities (DaSCH) (previously called the Swiss Digital Humanities Center, SDHC) provides data curation, long-term access, persistent identifiers (for data records, based on the "Archival Resource Key", ARK), research and analysis tools for qualitative research data in the humanities. Qualitative data being defined as complex, interwoven data and connected digital objects (e.g. databases with or without linked digital objects such as images, facsimiles, movies). DaSCH guarantees the long-term accessibility of research data in the Humanities and the adherence to open standards while propagating the use of advanced digital methods and technologies in a way that the persistence of data and tools to work with scientific data from the humanities can be achieved. It provides FAIR access to the data and supports all relevant standards for interoperability.

Detailed description

The DaSCH develops and maintains a software platform consisting of a database based on Linked Open Data technologies (LOD) and the "Resource Description Framework" (RDF), a middle ware (Knora) which implements a full timestamp-based versioning (version history) on field level, permission control and an application programmers interface (API) that is compliant to the open REST-standard ("Representational State Transfer"). The flexible data modeling with LOD allows DaSCH to use *one single* infrastructure for data, metadata, models and structures from any project irrelevant of the data concept used. The architecture of Knora goes well beyond the "Open Archival Information System" (OAIS) reference model for digital archives, where OAIS only *emulates* the processes of an analogue archive containing physical artifacts into the digital domain. For *qualitative* research data this model is not sufficient: The data themselves and not only their descriptive metadata need to be searchable at any time, data have to be annotable and linkable on a very fine-grained level. In addition, the data objects need to be changeable, e.g. if new findings emerge, while previous versions are preserved. The field level-based version history of Knora enables these features and therefore the term "*keep-alive*" archive is used. Citations using permanent identifiers based on ARK (provided by the DaSCH) always show a data object as it has been at the moment the ARK identifier has been created. An important aspect of qualitative data in the humanities is that, in most cases, the preservation of such datasets alone does make little sense. The way the *datasets* are accessed and *re-used*, queries and views etc., often form an integral part of the knowledge represented by the datasets. Thus, the infrastructure of DaSCH is providing components to *emulate* queries and user interfaces using modern responsive web technologies.

DaSCH implements, encourages or enforces the use of well adapted and accepted standards. The REST API is based on "JavaScript Object Notation – Linked Data" (JSON-LD) which is a widely accepted standard for linked open data. For images, DaSCH uses exclusively the International Image Interoperability Framework (IIIF), texts can be imported/exported as standard TEI/XML (Text Encoding Inititaive). Therefore, DaSCH consequently guarantees a high degree of interoperability for research data. DaSCH also fully complies with the FAIR data principles as required by most funding agencies. Still, if required (e.g. copyright issues, data protection law etc.), a fine-grained access control is possible.

b. International level

International comparison shows that there is no single repository that can meet everyone's needs. There are various approaches ensuring long-term access to research data. The solution DaSCH provides is very well positioned in an international comparison. DaSCH uses an adequate, very advanced and

innovative technology that is very promising for the future and shows great potential. It is open to international cooperation by using accepted standards (IIIF, LOD, RDF, REST, JSON-LD etc.) and close collaborations and exchanges with similar national and international institutions have been established.

c. Development prospects

Since research in the Humanities shows an ever increasing dependence on digital data, tools and methods, the demand for the services of DaSCH is expected to grow dramatically in the future. In addition almost all Swiss universities are establishing “Digital Humanities” departments which will further increase the need for long-term storage of curated qualitative data in the Humanities. It is planned that DaSCH will be in charge of the institutionalization of the New Infrastructure for Editions (NIE-INE, swissuniversities P5 project) which will further increase the volume of DaSCH. In the interest of avoiding redundancy, the DaSCH closely cooperates with both with the Swiss Art Research Infrastructure (SARI) and the Swiss Center for Expertise in Social Sciences (FORS) both on institutional and technical level. The DaSCH adopts the standards of SARI in the domain of Arts and Architecture while the it is securing long-term accessibility and and provides interoperabitily tools (e.g. IIIF-Server “SIPI”) for SARI. Common standards for software platforms (LOD, RDF, ontologies, angular framework etc.) allow efficient knowledge sharing with SARI and FORS. Common portals and data gateways are planned in order to offer single-stop services for research projects that cross domain boundaries.

Remark to d) Costs: The budget figures for the period 2021–2024 are target figures.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 1’545’000	Canton 4’080’000	Canton tbd
Swiss Confederation 2’000’000	Swiss Confederation 6’870’000	Swiss Confederation tbd
Third parties 200’000	Third parties 400’000	Third parties tbd
Total budget 3’745’000	**Total 11’350’000**	**Total tbd**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 1’356’171 Operating costs 2’264’582 Other costs 124’247	Investments 4’110’156 Operating costs 6’863’286 Other costs 376’557	Investments tbd Operating costs tbd Other costs tbd
Total costs 3’745’000	**Total 11’350’000**	**Total tbd**

Development Phases	Years
Design	2010-2012
Preparation	2013-2015
Implementation	2016
Operation	2017-

Mixed-Reality Lab for Behavioral Research (MIRAL)

Category: (Instruments, Information and service infrastructures, Technical infrastructures) Instruments (Category a)

Host institution(s): University of St. Gallen

Main funding sources: University of St. Gallen

Description / Development prospects

a. National level

Overview

With the Mixed Reality Lab for Behavioral Research (MIRAL), the University of St. Gallen has established a research infrastructure (RI) with the long-term objective of developing an internationally renowned mixed-reality lab for research on behavior of students, consumers, managers, and employees in both physical and computer-enhanced environments.

Detailed description

With its combination of biometrical measurement capabilities, VR facilities, multi-user decision making lab environment and extensive student panel the MIRAL is currently of key interest for behavioral researchers at the University of St. Gallen. MIRAL also welcomes researchers from other Swiss and international research (particularly behavioral consumer and management researchers but also behavioral finance and behavioral economics researchers).

The RI not only allow researchers of the host institution to use a state-of-the-art laboratory to conduct their behavioral research but is also to considerably increasing its action scope. To scientists in Switzerland and beyond, the MIRAL represents a unique research environment which will further improve the reputation of the university and the Swiss national research site. The MIRAL also strengthens the excellent status of Switzerland in the research community by providing a one of its kind lab infrastructure investigating research problems of the next decade in the computer-aided environments between the physical and virtual world.

b. International level

The behavioral researchers at the University of St. Gallen are extensively collaborating with other Swiss, European, and North-American schools, which continuously profits from the RI and strengthen the academic position of Swiss behavioral research across different disciplines both nationally and internationally.

c. Development prospects

The MIRAL will be established in two stages. In the first stage (2014-2017), the University of St. Gallen invested monetary and intellectual resources to establish a state-of-the-art behavioral lab. This lab now includes common laboratory infrastructure to address research questions in the real, physical and the virtual, online world (e.g., infrastructure, PCs, shopping aisle). In the second stage (2018-2021), MIRAL will be improving integration of VR environments and biometrical measurement, extending its biometrical measurement capabilities (EEG, ECG) and developing lab team's capabilities for enhanced support in terms of scientific rigor of experiments.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 1.952 Mio.	Higher Education Institution 1.450 Mio	Higher Education Institution 1.550 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 0.612 Mio.	Third parties 0	Third parties 0
Total budget 2.564Mio	**Total 1.450 Mio**	**Total 1.550 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments N/A Operating costs N/A Other costs N/A	Investments 0.350 Mio Operating costs 0.950 Mio Other costs 0.150 Mio	Investments 0.450 Mio Operating costs 0.950 Mio Other costs 0.150 Mio
Total costs 2.564 Mio	**Total 1.450 Mio**	**Total 1.550 Mio**

Development Phases	Years
Design	2014-2015
Preparation	2015
Implementation	2015-2018
Operation	2018-

Swiss National Ion-microbe Platform (SwissNIP)

Category: Technical Infrastructure

Host institution(s): University of Lausanne

Main funding sources: University of Lausanne / SNF

Description / Development prospects

a. National level

Overview

The SwissNIP platform hosts analytical facilities for high spatial resolution chemical and isotopic surface analyses in Earth sciences, with applications to materials- and life sciences. It includes cutting-edge analytical instruments currently federated under the Center of Advanced Surface analysis (operated by the University of Lausanne and the EPFL) and the SwissSIMS, which is owned by the University of Lausanne, Bern, Geneva and the ETHZ. All these instruments are located at the University of Lausanne, in the building Geopolis.

Detailed description

The SwissNIP facility is being upgraded with two newly developed RF-Hyperion sources for high spatial resolution analysis of positive ions and their isotopes. This will further enhance the capability to perform quantified, high-resolution isotopic and elemental analyses without loss of analytical precision. The new RF-sources will allow us to analyze metals (i.e., electro-positive elements and isotopes) with high precision and a spatial resolution of ca. 50 nm on the NanoSIMS, and about 1 micrometer on the SwissSIMS. This ion microprobe platform is unique in Switzerland (indeed in Europe) and gives Swiss scientists a unique advantage. Furthermore, UNIL has acquired and installed a Field Emission Gun (FEG) electron microprobe that provides high resolution major- and minor element analytics to a scale of ca. 100 nm. It is the perfect electron-beam instrument in combination with the upgraded ion microprobes. The FEG instrument will be made available (for max. 25%) of the time for projects linked to the SwissNIP project. In addition, the (first ever!) CryoNanoSIMS has become fully operational in the fall of 2015 permitting samples to be prepared and analyzed for chemical and isotopic composition at ultra-high spatial resolution without any loss of soluble compounds from the cells under study. This capability is now boosted by a joint acquisition between UNIL and EPFL of a state-of-the-art Gemini 500 CryoSEM instrument, also installed in Geopolis.

Access to the facility is open for all Swiss and international researchers, granted on the basis of project proposals submitted to the SwissSIMS scientific steering committee, which is composed of members of the Swiss and international scientific community. Since the platform does not have any proper federal funding, individual users are required to pay for their analysis time. While the SwissSIMS is run entirely as a national facility, the NanoSIMS, the LA-ICPMS and the FEG_EMPA are made available to the Swiss research community at 25% of the time. The budget was calculated at the percentage.

b. International level

Today, the combination of cutting-edge large-radius ion microprobe SwissSIMS and NanoSIMS under one roof exists only in two other research institutions in the world. With the proposed upgrade to new and much more powerful ion sources and the development of the CryoNanoSIMS, plus the availability of a FEG electron microprobe for ultra-high spatial resolution major element analysis, and a CryoSEM insrument, the SwissNIP platform offers Swiss researchers an absolutely state-of-the-art analytical facility.

c. Development prospects

The facility will be maintained and upgraded to stay at the forefront of analytical capacities. The main limiting factors at this point are financial and personnel limitations. We strife to obtain financing for an additional technical position to guarantee the 24/7 operation of the facility. At this point, new developments are under way especially in the area of NanoSIMS technology, in particular with regard

to ion source technology and new, stable electronics, which will permit extremely high analytical precision stable isotope analysis with ultra high spatial resolution, representing a big step forward in analytical capability. At this point, we project an investment of 4.5 M CHF for that. Hence we will attempt to raise funding for these new developments. Depending on advances made on the quantitative side of the TofSIMS analytics we might consider entering this domain at a future time.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 3'840'000	Higher Education Institution 4'250'000	Higher Education Institution 3'050'000
Canton 0	Canton 0	Canton 0
Swiss Confederation ETH domain: 1'430'000	Swiss Confederation ETH domain: 2'450'000	Swiss Confederation ETH domain: 1'200'00
Third parties SNSF:410'000; EU: 70'000	Third parties SNSF: 1'000'000; tbd: 500'000	Third parties SNSF: 500'000
Total budget 5'750'000	**Total 8'200'000**	**Total 4'750'000**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 2'170'000 Operating costs 3'580'000 Other costs 0	Investments 4'500'000 Operating costs 3'700'000 Other costs 0	Investments 1'000'000 Operating costs 3'750'000 Other costs 0
Total costs 5'750'000	**Total 8'200'000**	**Total 4'750'000**

Development Phases	Years
Design	2011
Preparation	2011-2012
Implementation	2013-2018
Operation	2017-2030

Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials (Dy-naMatLab)

Category: Instruments

Host institution(s): SUPSI

Main funding sources: SUPSI, Competitive Funds

Description / Development prospects

a. National level

Overview

The Swiss Laboratory for the Advanced Studies on the Dynamic Behavior of Materials is a centre specialised in the mechanical characterization of materials in dynamics able to measure accurately the stress-strain curves of materials in tension, compression and shear in a large range of strain-rates (from 10^{-6} a 10^{5} s^{-1}) and temperature.

The Laboratory acts as a point of reference for the industry and research centres (at regional, national and international level) as key-player support in the design, development and optimization of production processes.

The Laboratory develops research on materials and structures subject to dynamic-impulsive loads, favours the technological transfer and diffuses an integrated approach facing to design-testing to improve safety and quality of products.

Detailed description

In the laboratory is possible to perform tests in tension, compression, shear, torsion and bending for different materials at high strain-rates and in a large field of temperature (77÷1'500 °K). For example:

- Thin sheet steel used by the automotive industry.
- Steel used for the structures of nuclear reactors or defence.
- Plain and fibre-reinforced concrete.
- Aluminum and magnesium alloys used in aero-space.
- Fibre-reinforced composite polymers.

The core facilities of the Laboratory are based on the Modified Hopkinson Bars apparatus. Several set-ups are used to study the uni-, bi- and tri-axial behaviour of the materials in a wide range of strain-rate tests ($1 \div 10^{5}$ s^{-1}). These apparatus can be long from some meters to 15m, and have different bar diameters, needed to test for example:

- Metals (diameter 10 and 12 mm).
- Polymers (diameter 20 mm).
- Concretes and rocks (diameter 60 mm).

Additional facilities are present to test materials in intermediate strain rate regime (0.1-100 s^{-1}) and in quasi- static regime. Systems of transient recorder (50 Msample/s) and measurement chains (displacement transducers, fast camera, etc.) permit to register all data.

b. International level

The Swiss Laboratory for Advanced Studies on the dynamic behaviour of materials continues in the same way followed by the existing DynaMat Laboratory. The Research Infrastructure will enhance the role as reference point for industries and research centre as well as international universities. The development of training and mentoring of Swiss and international young researchers will create the opportunity to do cutting-edge studies and collaborate with other world-class facilities and experts. The Laboratory will act as a node of the network of world's leading research institutions involved in the dynamic behaviour of materials, providing a supportive environment for Swiss industry. This infrastructure is inserted in the International network of laboratories of dynamic of materials (DYMAT).

c. Development prospects

Dynamic behaviour of materials represents an ever expanding area of broad interest to the scientific community and industry. Understanding the dynamic response of materials improves design and safety of products and structures by means of calibration and validation of numerical models.
The Swiss Laboratory for Advanced Studies on the dynamic behaviour of materials is strongly specialized in the experimental issues, analysing the material behaviour in mono-axial, bi-axial and tri-axial loading conditions in combination with additional variables as temperature and other severe conditions (i.e. irradiation).
To reach the objective of being a reference laboratory on the mentioned topics, it is necessary to constantly improve the set of devices through the design of new machines and the construction of complementary set-ups. New machines are essential to respond to the needs of research and development in the field of dynamic behaviour of materials have been included. In order to cover a wide area of applications it is necessary to study the torsion behaviour as well as the combination of tension/torsion. Traditional Split Hopkinson Pressure Bar (SHPB) can easily respond to the dynamic indentation purposes (two set-ups have been scheduled). Many industrial applications involve biaxial stress conditions, consequently dynamic biaxial behaviour studies are required. The new RI must cover these issues by means of the developing of biaxial apparatus at medium and high strain rate (biaxial MHB). Moreover the new TriHB has to be completed as well as the Collision test apparatus have to be built. Finally, the system of MHB in bending is required to study the fracture mechanics parameters in a wide range of strain rate.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 2’090’370	Higher Education Institution 2’723’700	Higher Education Institution 2’167’900
Canton 895’873	Canton 1’167’300	Canton 929’100
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 970’000	Third parties 1’000’000	Third parties 1’200’000
Total budget 3’956’243	**Total 4’891’000**	**Total 4’297’000**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 797’000 Operating costs 2’460’000 Other costs 699’243	Investments 594’000 Operating costs 3’460’000 Other costs 837’000	Investments 0 Operating costs 3’460’000 Other costs 837’000
Total costs 3’956’243	**Total 4’891’000**	**Total 4’297’000**

Development Phases	Years
Design	2017-2020
Preparation	2020-2022
Implementation	2022-2026
Operation	2026-2028

Next Evolution in Sustainable Building Technologies (NEST)

Category: Technical Infrastructure

Host institution(s): Empa, Eawag

Main funding sources: ETH Domain, Canton of Zurich, SFOE, SERI, Ernst Göhner Stiftung, Swisslife/ZKB, and numerous industrial partners

Description / Development prospects

a. National level

Overview

After the inauguration of NEST in May 2016 with the first two units operational, NEST has become a lighthouse for innovation in the building sector. A vast number of research groups from the ETH Domain and the Universities of Applied Sciences together with their industrial partners (presently more than 130) are using NEST in order to explore the viability of new materials, systems and concepts. The unique flexibility of NEST combined with the inclusion of real users in all experiments has proven to be a true catalysator for innovation. First products and concepts which have been initially developed within NEST projects are already on the market and many more are in the pipeline. Furthermore, NEST has a broad coverage in national and international media, is repeatedly winning awards and is visited by roughly 1'000 persons per month since the opening.

Detailed description

The development of the NEST concept started in 2009. By the end of 2013 the consortia for the first units were formed and finances for the construction of the backbone were assured. The actual construction started in 2014 and the official inauguration of NEST took place in May 2016 with the two units meet2create (Lucerne University of Applied Sciences and Arts) and Vision Wood (Empa & ETH Zurich) ready and the energy hub (Empa) and water hub (Eawag) became operational later the same year.

Since then three more units have been finished: Solar Fitness&Wellness (Empa), Urban Mining and Recycling (KIT and University of Stuttgart) and SolAce (EPFL). The dfab house (NCCR Digital Fabrication) was opened in February 2019. HiLo (ETH Zurich) will be constructed in 2019 and two to three more units are presently in an early stage. A total of more than 80 peer reviewed papers have been published in combination with the units.

NEST is definitely contributing to the acceleration of innovation in the building sector. The gap between academia and industry can be narrowed thanks to the collaboration between all stakeholders within a NEST project. However, it is important to further develop instruments and tools to facilitate the transfer of know-how and to accelerate the learning rate of all players involved.

b. International level

NEST is also gaining international recognition in the Living Lab scene thanks to the unique features it offers. To the best of our knowledge, there exists no comparable platform with a similar approach which is not user but research dominated. The number of international delegations from the public sector and from industry is increasing. Numerous large international companies have recently joined NEST as partners or are planning to do so in the near future. Collaborations with high ranked institutions such as Harvard University or Imperial College have been established.

The highlight on the international level however was the creation of the living unit Urban Mining and Recycling under the leadership of University of Stuttgart and Karlsruhe Institute of Technology. The unit was opened early 2018 and is a true break-through in terms of circular economy in the construction sector.

c. Development prospects

It can be expected that within 2-3 years the available space for units will be used up and then the replacement of units from the first generation with new units will take place. The topic of the units is not defined yet, it is planned to keep the open innovation approach and to react flexible on the interest of

potential partners. However, efficient use of resources (materials, energy, water) will remain a core topic together with comfort and usability. The potential of digitalization in all these aspects will be further investigated. Besides digital planning and construction, topics such as the role of robots during the use phase will be of special interest. This includes the use of drones for inspection and repair or letting robots be part of the operation of a bistro. Again, user acceptance of such new concepts will be one of the central parts of research. While in the first years the focus was very much on the development of new units, more weight will be given in the coming years to the research going on during operation of the units. This research should help to increase the market readiness of solutions developed within NEST. Other goals for the next years are one more unit with a strong international partnership and the developments of new tools and instrument for the technology transfer to the building sector.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton Canton of Zurich 3.5 Mio.	Canton Canton of Zurich: 1 Mio.	Canton Canton of Zurich: 1 Mio.
Swiss Confederation ETH Board: 4 Mio. Empa: 3 Mio. Eawag: 0.2 Mio. ETH Zurich: 2 Mio. SFOE: 1 Mio.	Swiss Confederation ETH Board: 4 Mio. Empa: 4 Mio. Eawag: 1 Mio. SFOE: 1 Mio.	Swiss Confederation ETH Board: 4 Mio. Empa: 4 Mio Eawag: 1 Mio. SFOE: 1 Mio.
Third parties Industry: 9 Mio	Third parties Private Foundations: 2 Mio. Industry: 7 Mio.	Third parties Private Foundations: 2 Mio. Industry: 7 Mio.
Total budget **22.7 Mio.**	**Total** **20 Mio.**	**Total** **20 Mio.**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 19.5 Mio. Operating costs 3.2 Mio. Other costs 0	Investments 10 Mio. Operating costs 8 Mio. Other costs 2 Mio.	Investments 10 Mio. Operating costs 8 Mio. Other costs 2 Mio.
Total costs **22.7 Mio.**	**Total** **20 Mio.**	**Total** **20 Mio.**

Development Phases	Years
Design	2009-2013
Preparation	2013-2014
Implementation	2014-2016
Operation	2016-2030

The future of dark matter detection with liquid xenon XENONnT and DARWIN

Category: MINT

Host institution(s): university of Zurich

Main funding sources: SNF, ERC and international partners

Description / Development prospects

a. National level

Overview

DARk matter WImp search with Noble liquids (DARWIN) will be a new observatory in astroparticle physics, with the aim to identify the nature of dark matter, to reveal the nature of neutrinos (via the search for the neutrinoless double beta decay of ^{136}Xe), to observe solar neutrinos via elastic neutrino-electron and coherent neutrino-nucleus scatters, as well as solar axions and axion-like particles. It will employ a time projection chamber (TPC) filled with liquid xenon (50 tons in total, 40 tons inside the TPC), viewed by arrays of VUV-sensitive photosensors to detect both light and charge signals after a particle interacts with the xenon target. The TPC and its cryostat will be surrounded by a 15 m water Cherenkov shield, to veto interactions of cosmic muons and their secondary particles. The most likely location of the observatory will be at the Gran Sasso Underground Laboratory (LNGS) in Italy, the location of the current XENON1T and XENONnT experiments. The direct dark matter search via collisions of dark matter particles with atomic nuclei is highly complementary to indirect searches with AMS, CTA and IceCube and with direct dark matter production at the LHC, and many of the science channels complement independent experimental efforts in these areas by providing new information.

Detailed description

DARWIN, which has been founded and is currently lead by Swiss groups, is the successor of the very successful XENON program, with leading contributions from the UZH group. The XENON1T experiment, based on a xenon TPC with 3.2 tons of liquid xenon in total, has set the world's best constraints on the interactions of dark matter particles with nucleons for particle masses above 6 GeV. XENONnT, using 8 tons of liquid xenon, is in construction phase and is expected to take first science data in late 2019. UZH is strongly involved in the design and construction of the inner detector, the TPC, in the characterization in liquid xenon and cryogenic read-out of the photosensors, as well as in material screening with a high-purity germanium facility. DARWIN is in R&D and design phase, supported by two ERC grants (advanced grant at UZH, and consolidator at the University of Freiburg in Germany). As part of the ERC project, the UZH group is focussing on the optimization of the TPC, namely its light and charge readout. It will build a vertical TPC prototype, to demonstrate electron drift over 2.6 m (the final size of the DARWIN TPC), and is investigating new, solid-state photosensors (SiPMs) which are excellent candidates to replace existing photomultiplier tubes (PMTs).The goal is to build a first TPC prototype with 4-pi light readout, which would enable to decrease the energy threshold of the observatory, and thus increase its sensitivity to low-mass dark matter particles.

b. International level

The DARWIN observatory will be built and operated by an international collaboration which currently is composed of 28 groups from Europe, Asia and USA. It is expected that additional groups will join in the next couple of years. This next-generation dark matter and neutrino project is on the new roadmap of the Astroparticle Physics European Consortium (APPEC), which has recently published its strategy for the years 2017-2026, as well as on several national roadmaps (e.g. Germany and Netherlands). With an expected exposure of 200 ton x years, DARWIN will probe cross sections of dark matter particles down to 2 x 10^{-49} cm^2, two orders of magnitude below the sensitivity of XENON1T, and will thus reach the so-called neutrino floor, where nuclear recoil signals from atmospheric neutrinos will constitute an irreducible background. It will probe dark matter particle masses up to several TeV, and will thus be highly complementary to the high-luminosity LHC. The observatory will also be able to measure for the first time the solar pp-neutrino flux with precision at or below the 1% level, thus testing solar models, and will be competitive in the search for the neutrinoless double beta decay process. Its discovery would have far-reaching implications, proving that neutrinos are their own antiparticles.

c. Development prospects

The goal of the present Memorandum of Understanding (MoU) of the DARWIN collaboration, signed by all the groups in late 2017, is to coordinate the R&D work which will serve as the basis for the Conceptual Design Report, to be submitted 2020/21. It will be followed by engineering studies and a Technical Design Report, expected for 2022/23. The construction phase will last from 2023-2024, with the commissioning and the start of science data taking planned for 2025 and 2026, respectively. It is planned that the observatory will take data for at least ten years.

d. Costs (in CHF)

The costs in the Costs overview part refer to the total estimated costs of the project, including Swiss and international contributions. The third parties in the Swiss budget refers to the UZH ERC, as well as to the ERC grant at Freiburg University, and to other funds from our international partners. We note that the total cost depends on the xenon gas price, which can fluctuate.

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties SNSF (FLARE) 2 Mio EU (ERC UZH): 2.2 Mio CHF (euro 1.15) EU (ERC Freiburg): 2.3 Mio. CHF (Euro 1.15) International partners: 25.0 Mio	Third parties SNSF (FLARE) 5 Mio EU (ERC UZH): 1.6 Mio CHF (euro 1.15) EU (ERC Freiburg): 0.6 Mio. CHF (Euro 1.15) International partners: 44.3 Mio	Third parties SNSF (FLARE) 1.2 Mio International partners: 12.3 Mio
Total budget **31.5 Mio**	**Total** **51.5 Mio**	**Total** **13.5 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 30 Mio Operating costs 1.5 Mio Other costs 0	Investments 50 Mio Operating costs 1.5 Mio Other costs 0	Investments 12 Mio Operating costs 1.5 Mio Other costs 9
Total costs **31.5 Mio**	**Total** **51.5 Mio**	**Total** **13.5 Mio**

Development Phases	Years
Design	2017-2022
Preparation	2023-2024
Implementation	2025-2026
Operation	2026-2036

ATHOS beamline at the Swiss X-ray Free Electron Laser SwissFEL

Category: Instruments

Host institution(s): Paul Scherrer Institute (PSI)

Main funding sources: ETH Domain

Description / Development prospects

a. National level

Overview

X-ray free-electron lasers (XFELs) are a new generation of light sources offering novel experimental capabilities in diverse areas of science by providing very intense and tightly focused beams of x-rays with pulses ranging from 50 femtosecond to sub-femtosecond and wavelengths down to 0.1 nanometer. This time resolution is essential to investigate ultrafast dynamic processes in atomic and molecular structures since these processes are defined by the femtosecond vibration of an atom in a chemical bond. SwissFEL is designed to cover a wide range of x-ray energies. Phase I of the project was focused on the construction of the accelerator complex and the hard x-ray beamline ARAMIS. The civil construction was finished in 2014 and first pilot user experiments were performed in 2017. The pilot user operation and consolidation phase will continue until end of 2018 followed by normal user operation starting in 2019. Phase II of the project, the ATHOS beamline, will expand the capabilities to soft x-rays (250 to 1900 eV) and will double the scientific capacity of SwissFEL. ATHOS will provide beams to two state-of-the-art experimental stations that are designed to make optimal use of the technical capabilities of SwissFEL, to attract national and international users and to foster scientific, technological and educational exchange within Switzerland and across borders. The ATHOS layout allows an extension to a third scientific instrument to be built after 2020. First light from ATHOS should be realized by the end of 2019 with first pilot user experiment expected for 2021. As a next-generation cutting-edge research infrastructure ATHOS (together with ARAMIS, the Swiss Light Source (SLS) and its upgrade (SLS 2.0), as well as the Swiss Neutron Source (SINQ) and the Swiss Muon Source (SμS)) will play an important role in the scientific portfolio of Switzerland. Many of the research results produced at the ATHOS beamline will lead to important knowledge relevant to a large variety of fields, encompassing topics as energy conversion, more efficient drug development and the design of smaller computer chips.
SwissFEL with its two beamlines ATHOS and ARAMIS will complement the access to Swiss users to European XFEL, an international research organization based in Hamburg in which Switzerland is a member.

Detailed description

ATHOS will add a second electron beam transport system to SwissFEL that will feed a variable-gap undulator line for producing soft x-ray laser beams. ATHOS will operate simultaneously with ARAMIS (energy range 1.8 keV – 12.4 keV) and will be optimized for producing radiation in the 250 - 1900 eV x-ray regime, with full polarization control. This energy region covers absorption edges for the light elements oxygen, carbon and nitrogen that play an important role in many chemical and biological processes, as well as those of the transition metals manganese, iron, cobalt, nickel, and copper, which are prominent components in classical and quantum devices. Also the absorption edge of silicon can be reached with ATHOS to cover the science related to semiconductor research.
A key feature of the ATHOS facility is the use of small magnetic chicanes between each undulator in order to manipulate the electron bunch during the lasing process and thus offering new capabilities beyond those implemented at operating facilities:
- Full control of soft x-ray polarization (circular, linear, elliptical). Such a capability is extremely useful for the study of magnetic materials.
- Sub-femtosecond pulses with enough energy (above 100 μJ) very important for atomic, molecular and optical physics, as well as for non-linear x-ray optics.
- Parallel operation with ARAMIS at full 100 Hz rate. With a dedicated accelerating module in the ATHOS branch the electron bunch and photon beams in ATHOS can be rapidly tuned for its full photon energy range without disturbing ARAMIS operation.
- Simultaneous production of two-color pulses with adjustable delay by splitting the 16 undulators in two sections separated by a delay chicane. Such pulses will be particularly convenient for performing stimulated resonant inelastic x-ray scattering (RIXS).

- Energy “broadband” mode providing a bandwidth up to 10% and the ultra-narrow bandwidth of the “high brightness” mode are unique operation schemes of ATHOS. Those capabilities will allow either, the simultaneous measurement of orbital and spin moments by observing two absorption L-edges shot by shot, or high resolution RIXS with high transmission. Furthermore, it will allow the collection of single-shot RIXS spectra.
- Terahertz (THz) pump pulses for ATHOS that will be used to pump samples in two different ways: “B-field” to start magnetic dynamics, “E-field” to initiate chemical reactions on surfaces.

Access to ATHOS will be dealt in the same manner as for the existing facilities of PSI (selection of proposals for beamtime based on scientific excellence by an international review committee, access will be handled by the PSI User Office).

b. International level

The impact of XFELs, the new generation of x-ray radiation source, has been demonstrated so far by the first two XFELs in operation: LCLS at Stanford (operating since 2009), SACLA in Japan (operating since 2011) and European XFEL in Hamburg (operating since 2017). In 2017, first successful experiments were performed with SwissFEL, contributing to science development. Analogous to the other analytical research facilities of PSI, SwissFEL is open to the international research community. SwissFEL will provide a total of 5000 hours beamtime per year and per FEL beamline (ATHOS and ARAMIS) at different experimental stations.

c. Development prospects

The implementation of ATHOS is done in a way that the interruptions in the operation of the ARAMIS branch is kept to a minimum level mainly combined with the necessary maintenance shutdowns of SwissFEL (3 times 3 weeks per year). Electron beam transmission through the first 110 m of ATHOS line has been recently demonstrated as well as the transport of two bunches in one radiofrequency pulse. The undulator prototype providing circularly polarized light is currently under assembly and will be tested by end 2018. The design of the light transport layout is close to completion and experimental stations are being designed in order to best fit the particularities of the ATHOS light. The Swiss research community will be able to benefit from this strategic relevant position of PSI at the forefront of these developments, since SwissFEL as national facility is strongly oriented towards the research interests and expertise of Swiss researchers. Due to early and close collaboration between the SwissFEL project and industrial partners, Swiss industry will be able to transfer the acquired technological expertise to the market and allows them to play an internationally competing leading role in the development of high-technology spin-off products.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 4 Mio.	Canton 0	Canton 0
Swiss Confederation ETH Board: 40 Mio., PSI: 0.5 Mio.	Swiss Confederation PSI: 15 Mio.	Swiss Confederation PSI: 11 Mio.
Third parties SNSF: 1 Mio. Innosuisse: 0.65 Mio.	Third parties SNSF: 1 Mio.	Third parties SNSF: 1 Mio
Total budget 46.15 Mio.	**Total 16 Mio.**	**Total 12 Mio.**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 46.15 Mio. Operating costs 0 Other costs 0	Investments 8 Mio. Operating costs 8 Mio. Other costs 0	Investments 4 Mio. Operating costs 8 Mio. Other costs 0
Total costs 46.15 Mio	**Total 16 Mio.**	**Total 12 Mio.**

Development Phases	Years
Design	2016-2018
Preparation	2017-2018
Implementation	2019-2021
Operation	2021-2041

Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI)

Category: Technical infrastructures: (e-infrastructure, MINT)

Host institution(s): University of Geneva

Main funding sources: Swiss universities; State Secretariat of Education, Research and Innovation (SERI)

Description / Development prospects

a. National level

Overview

The Common Data Center Infrastructure (CDCI) was created in 2017 to foster the development of data center activities in the context of both space-based and ground-based facilities dedicated astrophysics at large, i.e. including astroparticle and cosmology. The CDCI is based on 20 years of activities, starting with the establishment of the INTEGRAL Science Data Centre in Geneva, which is in charge of a significant fraction of the ground-segment operations of ESA's INTEGRAL space observatory. The CDCI envisages a major transformation in 2021 to increase its scope to include space weather and Earth observations activities, to cover the operational phases of the relevant missions with Swiss involvement, and to develop a significant computing infrastructure. The CDCI shall provide support to any Swiss scientist interested in leading data center activities, in particular by contributing directly to the early phase of the missions. A major goal of the CDCI is to ensure the long-term preservation of the data and of the specific data analysis expertise after the mission is terminated, in particular through the deployment of web services.

Detailed description

The service infrastructure "Common Data Center Infrastructure (CDCI)" is the result of very significant activities at the University of Geneva (UNIGE) for the establishment, starting in 1995, of a data center for ESA's X-ray and gamma-ray observatory INTEGRAL, the INTEGRAL Science Data Centre. This center processes and archives the data from the INTEGRAL satellite and provides software to the community to allow any scientist to exploit the data. Thanks to this successful development, we developed a widely recognized expertise, which allowed us to start similar activities for a number of different space projects linked to astrophysics, among which the ESA missions Planck, Gaia, CHEOPS and Euclid and the Swiss-Chinese mission POLAR. The participation in this project has been largely funded through specific programs of the Swiss Space Office of the Confederation. However, with the increase in the number of missions, the need for a dedicated infrastructure providing synergies between the different projects became quickly apparent. These synergies range from administrative management of the project, computer system administration, software and web services, to the software tools and approaches used in the development of such activities. The first goal of the CDCI is to ensure that a stable and efficient infrastructure can be offered to all projects of data center developments for astrophysical space missions. The CDCI, being driven by scientific competence, is also an opportunity to extend the data center activities to any other domain related to astrophysics, like astroparticle and cosmology, including ground-based facilities. In order to increase its national relevance, starting in 2021, the CDCI shall also cover the related domains of space weather and Earth observations, and will be co-led with University of Zürich.

The CDCI shall offer its services to all Swiss scientists interested in participating in data center activities. In the early-development phases, before a dedicated team can be put in place, the CDCI will offer support to the scientists in the preparation of the Swiss contribution to the proposed missions, including the negotiations with the different partners and the preparation of the proposals. Different models of interactions between the team and the CDCI can be put in place, depending on the specifics of the project, and the proximity of the team in particular. Currently, INTEGRAL, POLAR, Gaia, CHEOPS, Euclid and CTA are directly benefiting from the services of the CDCI. When possible and when requested by the mission's Swiss P.I., the CDCI shall also directly contribute to the software and algorithm development; it shall provide the computing infrastructure and participate in the operations. The computing infrastructure shall also be used for dedicated scientific computing programs.

Another task of the CDCI is to serve data of current and past missions to the widest possible com-munity with as much added value as possible. Most missions retain their scientific values many decades after the end of the mission. Without dedicated effort, this knowledge can disappear in little more than a few years.

Furthermore, software ages, and becomes more and more difficult to install on new hardware. The CDCI keeps alive the data of the missions it is involved in. This means not only maintaining the data archives and software, but also providing web services allowing to run simplified and yet powerful and fully validated analyses. For this purpose, the CDCI shall use modern software technologies, deploying containers on a cloud. The first development of the CDCI, the INTEGRAL Online Data Analysis, has been released to the public by the end of 2018.

b. International level

Being at the service of missions that are most often the result of large international collaborations, the activities of the CDCI are very relevant on the international scene. Current activities are mostly concerned with space missions under the leadership of ESA. Several missions are done in collaboration with, or are led by, other space agencies, like NASA (U.S.A), JAXA (Japan) or China. Ground-based facilities, space weather and Earth observations further extend international collaborations to new countries, in particular in South America (CTA), Oceania (SKA) and South Africa (SKA). The activities supported by the CDCI will provide Switzerland with a large visibility of in these projects.

c. Development prospects

Data center activities for astrophysics at a significant level in Switzerland started with a unique mission, INTEGRAL. The University of Geneva and its Swiss partners have been very successful in obtaining significant participations in several space missions either in operation (INTEGRAL, Gaia) or in development (CHEOPS, Euclid). The CDCI already supports the candidate ESA Medium-size missions M5 SPICA and THESEUS, as well as the Large-size missions L2 Athena and L3 LISA. Several projects are currently in discussion with China, in particular the flagship mission eXTP. For ground-based facilities, the participation in CTA is already well advanced. Extensions of the CDCI will cover Earth observation's Swiss Data Cube and ARES projects. The current size of the CDCI is much too small in view of the wealth of data that will be generated by the new missions. In addition, the new projects will require significant increase in the computing infrastructure. A large contribution from the University of Zürich and from the Canton de Genève will be obtained.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 2.119 Mio	Higher Education Institution 3.74 Mio	Higher Education Institution 4.74 Mio
Canton 0	Canton 1.0 Mio	Canton 0
Swiss Confederation SERI/SSO: 1.787 Mio	Swiss Confederation [43]SERI (article 15): 4.74 Mio	Swiss Confederation [44]SERI (article 15): 4.74 Mio
Third parties ESA: 69kCHF (euros, 1.15)	Third parties 0	Third parties 0
Total budget 3.975 Mio	**Total 9.48 Mio**	**Total 9.48 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 80kCHF Operating costs 3.895 Mio Other costs 0	Investments 1.2 Mio Operating costs 8.28 Mio Other costs 0	Investments 1.2 Mio Operating costs 8.28 Mio Other costs 0
Total costs 3.975 Mio	**Total 9.48 Mio**	**Total 9.48 Mio**

Development Phases	Years
Design	2014-2015
Preparation	2015-2016
Implementation	2016-2017
Operation	2017-2028

[43] Planned proposal for funding according to article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Numbers can change as the proposal not submitted yet. Funding decision by EAER fall/winter 2020.

[44] Planned proposal under article 15 RIPA for the next period. Numbers can change as the proposal not submitted yet. Funding decision in fall/winter 2024.

Center for biomedical research in space

Category: Instruments and service infrastructure

Host institution(s): Lucerne University of Applied Sciences and Arts, Center of Competence in Biomedical Science & Technology

Main funding sources: Third party funding

Description / Development prospects

a. National level

Overview

The Center of Competence in Biomedical Science & Technology (CC BST) of the Institute of Medical Engineering at the Lucerne University of Applied Sciences and Arts, is maintaining a new research infrastructure called "Center for Biomedical Research in Space" (CBRS). The unique CBRS allows an easy and uncomplicated access to low gravity research platforms for researchers, industry, and individuals in education.

The CC BST already maintains a registered ground based facility of the European Space Agency ESA and in this function, it is offering the instruments to conduct experiments under simulated/short-term microgravity conditions to researchers from all over Europe. The tasks that are conducted at the CBRS are to make use of our status at ESA but on a national level and to carry out biomedical research under reduced gravity. At the same time, the CBRS is promoting microgravity research among scientists, companies and schools in Switzerland.

Detailed description

The core service of the CBRS provides access to several types of ground-based microgravity research platforms like the Random Positioning Machine (RPM), parabolic flights performed by the Swiss Air Force and sounding rockets. Later on, additional microgravity research platforms will be added like magnetic levitation, drop tower or flights with space carriers of companies like "Space Applications Services" or "Virgin Galactic".

Supplementary, the CBRS services include the use of biological laboratories as well as dedicated "e-infrastructures". The laboratories are of particular use for scientists who are investigating time-critical processes that require immediate post-processing after microgravity exposure. Another goal of the "e-infrastructure" is to create a permanent service data infrastructure that responds to the needs of exploitation of intensive data production under simulated and short-term microgravity conditions as well as to establish a flexible, extensible state of the art service infrastructure that is able to provide support during the entire science work cycle.

The CBRS is a non-profit center that is part of the legal entity of Lucerne University of Applied Sciences and Arts, School of Engineering & Architecture. The center is available to everyone who is interested in conducting biomedical research under reduced gravitational loads. There will be an outreach program in place to gain maximal visibility to the related science community as well as to the public.

b. International level

In the year 2000, the former Space Biology Group of ETH Zurich, (today the CC BST) was appointed as one of the few official ground based facilities of the European Space Agency ESA. Since then, we have been hosting international research groups for conducting their studies multiple times per year. The service we are providing is paid by the users. In addition, our work is honored by being mentioned in scientific publications as well as in presentations at symposia or conventions. Being able to maintain the CBRS and thus expanding the services further will attract even more researchers to conduct their experiments in our center.

c. Development prospects

The RPM is a frequently used instrument in laboratories all over the world and it is applied for investigating microgravity effects on biological systems for example. Its intense use is reflected in the

steadily increasing numbers of reports published every year in scientific journals. Thus, the CBRS aims at providing enough RPMs for the scientists.

An additional goal of the CBRS is to implement new features to the RPMs like enabling to take microscopy pictures while operating. This broadens the operative range of the RPMs substantially, which increases the attractiveness of this instrument even more. Therefore, technological development will be fostered to incorporate more and more analytical tools into the RPM. For doing so, cooperations will be established with leading Swiss research groups in technology at HSLU and elsewhere as well as with the industry. There is no doubt that such technological development will end in space or in terrestrial applications.

Not only the RPM but other microgravity research platforms (as mentioned above) will be promoted similarly by the CBRS. In order to keep up with the demands of scientists on “e-infrastructure”, substantial effort will be put into establishing and maintaining a database that offers the latest features to the users.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 160’000 CHF	Higher Education Institution 180’000 CHF	Higher Education Institution tbd 200’000 CHF
Canton 200’000 CHF	Canton tbd 320’000 CHF	Canton tbd 400’000 CHF
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties Space Foundatons 210’000 CHF	Third parties Space Foundations 180’000 CHF	Third parties Space Foundations tbd 190’000 CHF
Total budget 570’000 CHF	**Total 680’000 CHF**	**Total 790’000 CHF**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 200’000 CHF Operating costs 360’000 CHF Other costs 10’000 CHF	Investments 240’000 CHF Operating costs 420’000 CHF Other costs 20’000 CHF	Investments 280’000 CHF Operating costs 480’000 CHF Other costs 30’000 CHF
Total costs 570’000 CHF	**Total 680’000 CHF**	**Total 790’000 CHF**

Development Phases	Years
Design	2015-2016
Preparation	2016-2017
Implementation	2017-2019
Operation	2019-2028

Swiss Plasma Center (SPC)

Category: Instruments

Host institution(s): Ecole polytechnique fédérale de Lausanne

Main funding sources: (as of 2017): ETH Domain, EURATOM, ITER, SERI, SNSF, other including Innosuisse

Description / Development prospects

a. National level

Overview

The SPC is the major Swiss plasma and fusion laboratory. Its main goal is to contribute to the worldwide development of this new energy source through strong education and research programmes.

Detailed description

Research and development projects of the SPC are grouped in 6 Research Lines:
Theory of Plasmas, Basic Plasma Physics (experimental, TORPEX), Hot Plasmas Physics (fusion, tokamak, TCV), International collaborations, Superconductivity for Fusion and Plasma Applications.

Theory of Plasmas

Plasma is an extremely complex medium, characterized by phenomena that occur on a wide range of temporal and spatial scales, which are all nonlinearly coupled. Plasma theory activities aim at the understanding of these physical phenomena mainly through first-principle based simulations.

Basic Plasma Physics (experimental, TORPEX)

The goal of the SPC Basic Plasma Physics group is to progress in the understanding of fundamental phenomena that occur in magnetized plasmas and that can have an impact in fusion energy research. It also provides a natural link between tokamak research and plasma theory, by offering an optimal environment for the validation of theoretical models, based on the toroidal device TORPEX.

Hot Plasmas Physics (fusion, tokamak, TCV)

The mission of the TCV programme is to apply its unique capabilities (plasma shaping, heating and current drive using waves in the electron cyclotron frequency range and neutral beams, advanced plasma control) to the exploration of the physics of magnetically confined plasmas, partly in direct support of the ITER project but also exploring some of the alternative paths that may be required beyond ITER on the way to DEMO, the first prototype fusion reactor.

International collaborations

Under this heading, besides the work in Superconductivity for Fusion, the SPC is also involved in activities in the field of electron cyclotron wave sources and antennas for ITER and DEMO, and the scientific exploitation of JET.

Superconductivity for Fusion

Activities in superconductivity are twofold. On one hand, the group carries tests of superconductors using the SULTAN device, the only installation worldwide capable of qualifying the superconductors used in fusion devices like ITER. On the other hand, it participates to the design of superconducting coils for future installations such as DEMO and develops high temperature superconductors for fusion, medical applications, and advanced particle accelerators.

Plasma Applications

Applications of thermal and non-thermal plasmas in industry and society cover important technologies and markets such as semiconductor manufacturing, packing industry, and solar cell production, and are progressively extended to include agricultural, biological and medical applications.

b. International level

SPC contributes to the experimental campaigns carried out at JET, to the construction and the preparation of the scientific exploitation of ITER, and to the DEMO design. The TCV tokamak is one of the three national facilities (Switzerland, Germany, United Kingdom) that are operated in the context of the EURATOM Eurofusion Consortium.

c. Development prospects

Capitalizing on the success of CRPP, the Swiss Plasma Center has been created, developing state-of-the art infrastructures and combining existing human resources at SPC with nation-wide synergies across interconnected areas of excellence, reinforcing the international aura and impact of Switzerland in plasma and fusion research. The main focus is on fusion, to enable EPFL to fulfill, on behalf of the Swiss Confederation, its role and obligations in the broader context of Europe, EURATOM and ITER. The aim is to improve our understanding and control capabilities of plasmas, covering both fundamental aspects and industrial applications. This investment enables the SPC to focus on two thrust areas:

TCV tokamak systems and related spin-offs

TCV is one of three national tokamak facilities rated as essential for the Fusion Roadmap, which aims at reaching electricity production from fusion energy by 2050. Three infrastructure enhancements are necessary to extend the relevance of TCV research for fusion power plants and the time horizon of the impact on the international fusion endeavor:

o a new divertor chamber, in the process of being inserted at the periphery of the plasma to achieve reactor relevant conditions and pioneer solutions to the crucial problem of plasma exhaust;

o two dual frequency gyrotrons for improving the plasma performance;

o a second 1 MW NBH system with high-energy capabilities, to study burning plasma regimes;

o improvements in diagnostic capabilities, with extended 2D coverage and potential for real time control.

Basic plasma physics and applications

The focus in this area is on plasma societal applications, with the aim of adapting present devices and acquiring new infrastructural elements to open the way to the exploration of environmental applications of plasmas, such as water purification, sterilization, or plasma medicine. A bio-plasma laboratory has been started, which enables several synergies with local industries in the field of food and agriculture, and with UNIL and EPFL biology and life sciences research groups.

In general, the period through 2024, during which we do not anticipate major construction work, will be devoted to exploiting the present set of upgrades. As new experimental results will be collected, in our domestic campaigns and in the context of international collaborations, a strategic definition of the further steps for which the contribution of TCV would be crucial will become possible. These steps may involve additional infrastructural developments, such as the development of state-of-the-art adaptive diagnostics, a changeover in the TCV plasma facing materials, and the deployment of novel high-field magnet technologies for improving the attractiveness of the tokamak concept for reactor applications.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation EPFL: 70 Mio., ETH Board: 10 Mio.; SERI: 4 Mio.; PSI: 3 Mio.	Swiss Confederation EPFL: 70 Mio.; SERI: 4 Mio.; PSI: 3 Mio.	Swiss Confederation tbd
Third parties EURATOM: 20 Mio. (€, 1.15); ITER: 12 Mio.; SNSF: 5 Mio.; OTHER: 4 Mio.	Third parties EURATOM: 20 Mio. (€, 1.15); ITER: 4 Mio; SNSF: 5 Mio.; OTHER: 4 Mio.	Third parties tbd
Total budget 128 Mio.	**Total 110 Mio.**	**Total tbd**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 30 Mio. Operating costs 66 Mio. Other costs 32 Mio.	Investments 15 Mio. Operating costs 65 Mio. Other costs 30 Mio.	Investments tbd Operating costs tdb Other costs tbd
Total costs 128 Mio.	**Total 110 Mio.**	**Total tbd**

Development Phases	Years
Design	2015-2018
Preparation	2017-2019
Implementation	2018-2020
Operation	2019 and beyond

National Research Centre for Animal Cognition

Category: Infrastructure

Host institution(s): University of Neuchatel

Main funding sources: University, City of La Chaux-de-Fonds, Third parties

Description / Development prospects

a. National level

Overview

Our general goal is to establish a research and education centre for studying animal intelligence. With this project, Switzerland will take a world-leading role in research in comparative cognition, support some of our National zoos in their mission to engage with research, enhance the public's understanding of scientific processes and establish new partnerships of excellence, notably by collaborating with research field stations in Africa. The project will be coordinated by the University of Neuchatel with an associated network of research stations in La Chaux-de-Fonds, Basel Zoo, Budongo Conservation Field Station (Uganda) and the Centre Suisse de Recherches Scientifiques (Ivory Coast). Our general vision is to carry out research in public view and link it with education. In Africa, we will be able to set up webcam links and to receive groups of university students and school children to carry out projects.

Detailed description

Our scientific plan is to ask fundamental research questions in ***comparative psychology,*** ultimately to better understand what makes us human. With 'comparative' we refer to an established method in evolutionary studies, that is, to reconstruct evolutionary history by investigating animal species with different degrees of relatedness and social organisation. With 'psychology' we refer to the scientific study of cognition and its physiological, behavioural and neural mechanisms. Our research aims at an evolutionary understanding of cognitive phenomena, such as economical decision-making, language and communication, reasoning, and social awareness. To this end, we propose to carry out non-invasive, behavioural studies with different species of primates and non-primates, chimpanzees, gorillas, orang- utans, sooty mangabeys, capuchin monkeys, dogs and wolves. All animal species will be housed as part of regular zoo exhibits or studied in their natural habitats.

Research facilities at Basel Zoo and at Zoo 'Bois du Petit Chateau' in La Chaux-de-Fonds consist of indoor compartments, specially designed indoor testing units, and spacious outside areas. In Africa, research facilities consist of specially equipped field stations for primate research to host researchers for long- term studies and small groups of visitors for short stays. Our request is to build new or modify existing infrastructure. **Unit 1** - great ape research facility at Basel Zoo (modification of existing infrastructure: completed); **Unit 2** - canine research facility near La Chaux-de-Fonds (new large outside area to house a pack of wolves, new indoor compartments with testing units for wolves and dogs; **Unit 3** - monkey research facility at Zoo du Bois du Petit-Château (hereafter ZBPC) La Chaux-de-Fonds (outside area to house two groups of monkeys, indoor compartments with testing units); **Unit 4** - field station Ivory Coast (www.csrs.ch - housing, lab and office space in Tai National Park): completed; **Unit 5** – field station Uganda (www.budongo.org - housing, lab and office space in Budongo Forest: completed). For Basel Zoo (unit 1), work has been completed with university funding. The primate facility in La Chaux-de-Fonds will require newly built infrastructure, adjacent to the ZBPC, to provide housing for one group of New World and Old World monkeys each, capuchin monkeys and sooty mangabeys (unit 3). For the canines (unit 2), our goal is to set up a similar testing facility suitable for domestic dogs and grey wolves. This will require new infrastructure in the vicinity of La Chaux-de-Fonds, also managed by the ZBPC. Additional office and storage rooms will be required, as well as space of public engagement activities. For the African field stations, work has been completed with university funding.

b. International level

In the US, the Yerkes Primate Center in Atlanta and the regional primate centre in Bastrop regularly carry out cognition research. Both Lincolm Park Zoo and the National Zoo in Washington have facilities where the public can observe behavioural experiments with great apes. Japan has also invested heavily in animal cognition with a Primate Research Institute housing approximately 500 primates. In Europe,

France has several centres in Strasbourg, Aix, and Rennes. In Germany, the Max-Planck Society has established an institute in Leipzig in addition to the German Primate Research Centre in Goettingen. In the UK, Edinburgh Zoo hosts two research units devoted to primate cognition, the Living-Links and Budongo Trail research facilities, and there are plans to develop a similar facility for birds. For canine cognition (dogs & wolves), world-leading facilities are the 'Wolf Science Center' and the 'Clever Dog lab' at the University of Vienna, the 'Family Dog Project' in Budapest, and the dog cognition laboratory at Duke University. All these facilities are based on studying the natural behaviour of intact animals non-invasively. No comparable facilities exist in Switzerland, apart from the University of Fribourg, who keep primates for highly invasive experimentation, which is not suitable for behaviourally based cognitive studies nor for public understanding of science purposes.

c. Development prospects

The proposed facilities offer multiple advantages for future research. First, it will offer standardised testing procedures that will eliminate experimenter bias. Second, due to automated and voluntary access, sample sizes will become very large, allowing for more powerful statistical analyses than currently used in such studies. Third, comparing multiple species in their cognitive performance will enable us to carry out comparative studies to identify evolutionary and co-evolutionary trends. Fourth, we will aim to integrate research across various disciplines, including neurosciences, economics and behavioural ethology, while taking advantage of the latest methodological advances, such as eye-tracking, infrared-based pupil dilation, remote body tracking and electroencephalography (EEG and event-related potentials (ERPs)) technologies. Finally, the direct link with fieldwork will inform our research about the functional significance of the observed behavioural phenomena.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 270'000	Higher Education Institution 0	Higher Education Institution 0
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 0	Third parties 3'446'667	Third parties 1'000'000
Total budget 270'000	**Total 3'446'667**	**Total 1'000'000**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 270,000 Operating costs 0 Other costs0 0	Investments 3,446,667 Operating costs 0 Other costs 0	Investments 1,000,000 Operating costs 0 Other costs 0
Total costs 270'000	**Total 3'446'667**	**Total 1'000'000**

Development Phases	Years
Design	2021-2022
Preparation	2022-2023
Implementation	2023-2024
Operation	2024-2028

Swiss Research Network of Clinical Pediatric Hubs (SwissPedNet)

Category: Service infrastructure (Data / Service Centers: Clinical research specific services)

Host institution(s): Mainly hospitals[45].
Main funding sources: Host institutions

Description / Development prospects

a. National level

Overview
SwissPedNet is a nation-wide research organization consisting of Clinical Pediatric Hubs located at the nine largest (university) pediatric hospitals of Switzerland, a central coordination office at the SCTO, a central infrastructure for registries (SwissPedRegistry), the research infrastructure providing services in pediatric pharmacology (SwissPedPha). SwissPedPha utilizes developmental and pediatric pharmacology expertise and applies advanced pharmacometric modeling & simulation approaches to support and enhance design and analysis of clinical trials conducted by one or several SwissPedNet hubs.

Each Pediatric Hub has age- and development-adequate infrastructures (clinical facilities for children) and is staffed with pediatrics-trained personnel, guaranteeing the quality aspects for research in children.

Detailed description
While being dedicated to children, Pediatric Hubs are locally closely linked to the SCTO Clinical Trial Units (CTUs) network, sharing non-pediatric-specific aspects of clinical research with the corresponding facilities for adults. To allow for resource saving synergies, the central office of the SwissPedNet is located within the SCTO Executive Office.

SwissPedNet will be able to integrate and support most of the existing, disease- or organ-specific research networks and pediatric cohorts in Switzerland and thus to achieve further efficiency and to address the manifold aspects of clinical research. Several interfaces/links with already existing and proposed infrastructures, organizations and projects are already established or ready for cooperation. The overall objective is to further develop, professionalize and fortify the national structures (SwissPedRegistry, SwissPedPha) and the nine existing Clinical Pediatric Hub structures. Key tasks of SwissPedPha are to improve quality of designs of pediatric studies conducted by SwissPedNet and to optimize analyses of data generated within SwissPedNet. Positions for research associates and pediatric study nurses are a prerequisite at each Hub to guarantee good clinical practice (GCP) compliance and assure all quality and safety aspects within clinical pediatric research.

b. International level

SwissPedNet is member of Enpr-EMA, the European Network of Paediatric Research at the European Medicines Agency, since February 27, 2013. Enpr-EMA works by allowing networking and collaboration with members from within and outside the European Union (EU), including academia and the pharmaceutical industry.

SwissPedNet is member of the consortium in two European infrastructure projects funded by Horizon2020: (1) PedCRIN is the pediatric branch of ECRIN and aims to develop capacity for the management of multinational pediatric non-commercial clinical trials (2017-2020). (2) Id-EPTRI (European Paediatric Translational Research Infrastructure) is a new complementary RI in the context of the existing RIs intended to putting together and networking all the available competences and technologies useful to enhance pediatric research in pediatric medicines from drug discovery and early development phases to be translated into clinical phases and medicines uses.

[45] Kantonsspital Aarau, Klinik für Kinder und Jugendliche; Universitäts-Kinderspital beider Basel; Ente Ospedaliero Cantonale, Pediatria, Bellinzona; Inselspital Bern, Kinderkliniken; Hôpitaux Universitaires Genève, Hôpital des Enfants; Centre Hospitalier Universitaire Vaudois, Département femme-mère-enfant; Luzerner Kantonsspital, Kinderspital Luzern; Ostschweizer Kinderspital St. Gallen; Universitäts-Kinderspital Zürich; Institut für Sozial- und Präventivmedizin, Universität Bern, SwissPedRegistry; Pediatric Pharmacology and Pharmacometrics Research Center at Universitäts-Kinderspital beider Basel, SwissPedPha

SwissPedNet is member of the consortium of the IMI2 funded project c4c/conect4children: the collaborative network for European clinical trials for children is a project for the development, implementation and evaluation of robust, sustainable and integrated pan-European network trial delivery. Since its inception SwissPedPha has been recognized internationally and this has resulted in collabo-rations with several European countries such as Belgium, Norway, Germany, and the Netherlands. Until now these collaborations have focused on the unique expertise of SwissPedPha in advanced pharmacometric modeling & simulation as well as developmental pharmacology. The existing collaborations have resulted in multiple joint publications, training of international master and PhD students in Switzerland. The opportunity provided by the funding of SwissPedPha has resulted in a clear visibility and has made Switzerland one of the top three countries in Europe in the discipline of pediatric pharmacology and pharmacometrics. The other two countries are France and the Netherlands.

c. Development prospects

The current funding of CHF 71'000.-/institution/year enables the hubs to employ 0.5–0.6 FTE for national clinical research. Many activities in pediatrics are still being developed. As soon as processes become more established and more multicentre clinical studies come to Switzerland, these resources will be insufficient. It will then be necessary to increase staffing to 0.8–1.0 FTE at each hub, which will require an additional CHF 539'000 in funding per year, or CHF 2.156 million over the whole funding period.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 6'100'000	Higher Education Institution 2'508'163	Higher Education Institution 2'508'163
Canton 3'500'000	Canton 8'727'400	Canton 8'727'400
Swiss Confederation SERI (SCTO[46]): 3'124'000	Swiss Confederation SERI (SCTO[47]): 5'280'000	Swiss Confederation SERI (SCTO[48]): 5'438'400
Third parties 0	Third parties 2'010'000	Third parties 2'010'000
Total budget 12'724'000	**Total 18'525'563**	**Total 18'683'963**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0 Operating costs 12'724'000 Other costs 0	Investments 0 Operating costs 18'525'563 Other costs 0	Investments 0 Operating costs 18'683'963 Other costs 0
Total costs 12'724'000	**Total 18'525'536**	**Total 18'683'963**

Development Phases	Years
Design	2011
Preparation	2012
Implementation	2012-2016
Operation	2017ff

[46] SCTO: Swiss Clinical Trial Organisation supported by SERI (art.15 of the Federal Act on the Promotion of Research and Innovation (RIPA). SCTO received CHF 14 mio for 2017-2020 (art. 15, RIPA) and allocated CHF 3.124 mio to SwissPedNet.

[47] SCTO will apply for CHF 21.4 mio for the 2021-2024 (art. 15, RIPA) and plan to allocate CHF 5.28 mio to SwissPedNet. Numbers can change as the proposal not submitted yet.

[48] SCTO plan to allocate CHF 5.438 mio to SwissPedNet from its yet unknown art. 15 (RIPA) contribution in 2025-2028 unknown).

Swiss Center for Musculoskeletal Biobanking and Imaging and Clinical Movement Analysis (Balgrist campus)

Category: Technology Competence Center

Host institution(s): Balgrist Campus AG

Main funding sources: Donations, SERI (Art. 15 FIFG), rental income and user contributions

Description / Development prospects

a. National level

Overview

Balgrist Campus is an initiative of the ResOrtho Foundation dedicated to the creation of an optimal infrastructure for musculoskeletal research and education and "Schweizerischer Verein Balgrist", a non for profit organization with the mission to improve the care of the musculoskeletal patient. Balgrist Campus has established a Swiss platform for nationwide research, development, and translation in the field of musculoskeletal science and medicine to the benefit of musculoskeletal patients of today and tomorrow, closing the loop between understanding of musculoskeletal disorders and treatment. The core facilities of this musculoskeletal research and development center include:

The **Swiss Center for Musculoskeletal Biobanking (SCMB):** This platform forms the hub of a nationally accessible (multi-center clinical) network for the indexing, archiving, analyzing, and cataloguing of anonymous but well documented human tissue for musculoskeletal research.

The **Swiss Center for Musculoskeletal Imaging (SCMI):** Is a diagnostic imaging research core facility, which ultimately envisions musculoskeletal imaging from the molecule to the moving body leveraging the world-leading musculoskeletal radiology center at the University Hospital Balgrist

The **Swiss Center for Clinical Movement Analysis (SCMA):** Is a center dedicated to functional analysis of musculoskeletal organs and tissues based on movement analysis.

These elements form three pillars of a scientific center serving as an open-access repository for patient specific data and derivative analytics and as an open access research infrastructure for musculoskeletal disorders of large socioeconomic importance to Switzerland.

Detailed description

Balgrist Campus fills a substantial gap in the Swiss research landscape by providing an environment dedicated to connecting academic research and industry. Its association with a leading academic clinical center holds large potential for addressing the burden of musculoskeletal diseases, by serving as a national hub for basic and applied research as well as for the development of strategies of prevention, diagnosis and treatment of musculoskeletal injury and disease.

This project is of national importance: Approximately 18% of all Swiss hospitalizations are directly related to musculoskeletal disorders. The project focuses on a subject of worldwide socio-economic relevance, and has the potential to contribute to relieving the burden of musculoskeletal disease; Switzerland is particularly suited to serve this purpose as modern orthopedic medicine has largely been shaped by Swiss academic leaders, but also by the extraordinarily developed Swiss biotechnological industry. Balgrist Campus consolidates this national strength and builds upon it.

Balgrist Campus hosts a number of research groups from across Switzerland as well as industrial partners. This setting incorporates partners from research hospitals contributing to multi-center studies, including the targeted banking of patient tissues for thorough molecular and cellular characterization. The research network includes engineers, clinical scientists, epidemiologists, and others seeking to understand musculoskeletal problems, and translate gained understanding into viable clinical solutions. Research infrastructure within the Balgrist Campus is available to external Swiss research institutions on a cost contribution basis.

In contrast to other national research institutions, the Balgrist Campus focuses exclusively on musculoskeletal disorders - a fact which makes the research infrastructures within the Balgrist Campus particularly well suited and uniquely powerful. The base of this power comes both from the physical connection of the Campus to a major Swiss Orthopaedic and Paraplegic clinical center, as well as from an already existing critical mass of musculoskeletal research and development in Zurich.

Balgrist Campus opened in December 2015 and has reached full capacity within three years. Three additional research infrastructures were constructed and are fully operational as of November 2018. The ETH Zurich, the Balgrist University Hospital, the University of Zurich and the University Hospital Zurich have relocated personnel into the Campus. Collaborations exist with multiple national research groups at the University of Zurich, the University of Basel, EPFL and several industrial partners.

In 2017 the Balgrist Beteiligungs-AG was established at Balgrist Campus to support innovative development projects and their transition to startup companies. Within the first two years, 5 startups have been supported and several patent applications submitted. The collaboration with established medtech companies already led to a sale of one of the projects and two licensing arrangements.

b. International level

The infrastructure, the unique proximity to the clinical environment and well documented patient data repositories already draw international scientist to the Campus. In 2017, Prof. Sam Ward, University of California San Diego, was visiting Balgrist Campus under the “guest sabbatical” programme. In 2019, Prof. Nassir Navab, TU Munich is invited to continue the international collaboration on the topic of musculoskeletal health. Several international commercial partners, currently from Germany and Canada have decided to relocate some of their employees and equipment to Balgrist Campus. Most recently, Siemens Healthineers have decided to place two employees in the Campus to support translation of research results into clinical application.

c. Development prospects

In early 2019, the Children’s Hospital of Zurich has relocated research groups to the Campus, intensifying and enlarging collaboration between the university medical institutions. The research infrastructures at the Balgrist Campus have already enabled affiliated investigators and their national and international collaborators to apply for research project funding at the Swiss National Science foundation, the EUH2020 program, and the U.S. National Institutes of Health.
The SCMB at Balgrist Campus is participating in a SNSF application which aims to establish a multi-center biobank IT infrastructure. This direct IT connection between biobanks is focusing on the secure handling of sensitive medical data in order to protect the privacy and confidentiality.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 13.1 Mio	Higher Education Institution 13.5 Mio	Higher Education Institution 13.5 Mio
Canton Lottery fund 9.0 Mio	Canton tbd	Canton tbd
Swiss Confederation SERI (Article15): 15.4 Mio	Swiss Confederation [49]SERI (Article 15): 18.4 Mio	Swiss Confederation tbd
Third parties ResOrtho&Balgrist Foundations 68.3 Mio	Third parties User costs & Balgrist Foundations 5 Mio	Third parties User cost contributions 7.4 Mio
Total budget 105.8 Mio	**Total 36.9 Mio**	**Total 20.9 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 87.9 Mio Operating costs 17.4 Mio Other costs 0.5 Mio	Investments 11.8 Mio Operating costs 24.6 Mio Other costs 0.5 Mio	Investments tbd Operating costs 20.9 Mio Other costs 0
Total costs 105.8 Mio	**Total 36.9 Mio**	**Total 20.9 Mio**

Development Phases	Years
Design	2015-2016
Preparation	2017
Implementation	2018
Operation	2019ff

[49] Planned proposal for funding according to article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Funding decision by EAER in fall/winter 2020.

Neuchâtel Platform for Analytical Chemistry (NPAC)

Category: Technical infrastructure

Host institution(s): University of Neuchâtel

Main funding sources: University of Neuchâtel (leading house), users (academic and research institutions, industries)

Description / Development prospects

a. National level

Overview

The Neuchâtel Platform for Analytical Chemistry (NPAC) was created in 2014 as the result of a merger between the UniNE chemical analytical facilities and the chemical analytical service of the *Swiss Plant Science Web*. NPAC now performs chemical analytical services for all Swiss universities, federal research institutions and industries. The aim is to expand the platform in order for it to become Switzerland's top, as well as one of the world's leading centers in chemical analytics and metabolomics. This requires an investment in reinforcing and expanding the platform's analytical capabilities, ensuring that NPAC will perform to its full potential.

Detailed description

The analytical service at the University of Neuchâtel currently performs more than 25'000 analyses per year and greatly facilitates the research of scientists and industries throughout Switzerland and beyond. The platform uses state-of-the-art liquid (LC) and gas (GC) chromatography, mass spectrometry (MS), and nuclear magnetic resonance spectroscopy (NMR) in order to support research on the isolation, characterization, identification and quantification of bioactive molecules of scientific and practical interest. In the last five years, NPAC has collaborated with more than 70 research groups from all Swiss universities, as well as from several federal and foreign research institutions, resulting in more than 95 peer-reviewed publications. We wish to further develop the NPAC facilities and expand the platform to become one of the world's leading centers in chemical analytics applied to biological samples, in particular from plants. As such, NPAC can greatly advance national and international research in a field that is of utmost importance to industry, agriculture, and the protection of the environment. This requires reinforcement with additional personnel and state-of-the-art equipment.

b. International level

Advances in chemical analytical technologies, in particular in the field of metabolomics, have greatly increased the potential to help scientists to discover novel biologically active compounds. This has been particularly successful in the field of plant sciences and the University of Neuchâtel, in the context of the NCCR *Plant Survival*, has greatly contributed to these recent developments at an international level. We can claim that there is no equivalent research infrastructure devoted to plant sciences in Switzerland. Within Europe, several institutions, such as the Max Planck Institute for Chemical Ecology (Jena, Germany), and the University of Leiden (The Netherlands), have comparable infrastructures, but they are less devoted to serve other research groups and in some cases even rely on our help. As an example, more than 25% of all the scientific publications of NPAC in the last five years have been made in collaboration with researchers outside Switzerland. Hence, NPAC is worldwide already recognized as one of the top analytical services.

c. Development prospects

In the below table we indicate the commitment by UniNE and the additional funding that we expect to obtain from other sources (SNSF, industries etc.). With these investments we will be able to optimize the platform's capacity, as it would allow NPAC to obtain the most advanced technologies that are currently available and enable it to handle the expected increase in the number of samples to analyze. Since roadmap 2015, the University of Neuchâtel has fully honoured its commitments and made the following specific investments:

Appointment of a technician (100%) in 2015 (UniNE funding)

Purchase of a gas chromatograph coupled to a mass spectrometer in 2015 (CHF 95'000, UniNE funding)
Purchase of a micro-UHPLC tandem MS in 2015 (CHF 420'000, UniNE funding)

In addition, the following investments are now foreseen for the period 2017-2020:
Appointment of a second technician (40%), will be filled in October 2018 (UniNE funding)
Purchase of a 600 MHz NMR (CHF 1'000'000) in 2019 (UniNE + third party funding)
Purchase of a UHPLC-high resolution MS (CHF 600'000) in 2019 (UniNE + SNF R'Equip)
Purchase of a second gas chromatography-mass spectrometry system (CHF 200'000) in 2019 (ERC grant funding)
Purchase of a proton transfer reaction mass spectrometer (CHF 300'000) in 2019 (ERC grant funding)

With the above purchases NPAC will have all the equipment that is needed to operate at its full potential, and for the period 2021-2024 only one additional replacement is foreseen:
Purchase of a UHPLC-tandem MS (CHF 550'000) in 2023 (third party funding)

For the period 2025-2028, an increase in funding is needed to upgrade or replace obsolete equipment, and to invest in next-generation technological breakthroughs that will become commercially available.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 1'836'000	Higher Education Institution 624'000	Higher Education Institution 857'000
Canton 0	Canton 0	Canton 0
Swiss Confederation 0	Swiss Confederation 0	Swiss Confederation 0
Third parties 1'300'000	Third parties 555'000	Third parties 1'500'000
Total budget 3'136'000	**Total 1'174'000**	**Total 2'357'000**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 3'415'000 Operating costs 521'000 Other costs 0	Investments 550'000 Operating costs 624'000 Other costs 0	Investments 1'700'000 Operating costs 657'000 Other costs 0
Total costs 3'136'000	**Total 1'174'000**	**Total 2'357'000**

Development Phases	Years
Design	2013
Preparation	2013-2015
Implementation	2015-2027
Operation	2015-2028

Information and computational service infrastructure network to support biomedical research in Switzerland (BioMedIT)

Category: Information and service infrastructures

Host institution(s): SIB Swiss Institute of Bioinformatics, in collaboration with universities of Basel, Lausanne, Berne, Genève, Zurich, and associated university hospitals; Swiss TPH; ETH Zurich and Lausanne; university of applied science HES-SO.

Main funding sources: Structural funds by participating universities and associated university hospitals, contributions by large scale research projects; State Secretariat of Education, Research and Innovation (SERI)

Description / Development prospects

a. National level

Overview

Over the last decade, new disruptive technologies (e.g. in genetics, genomics, imaging, proteomics, microfluidics, nanotechnologies, portable/implantable measurement devices, “big data” AI/ML techniques etc.) have changed the paradigms for biomedical research and are about to fundamentally transform healthcare and medicine. In order to enable research and translation of the wealth of data produced by such modern technologies into medical practice and new treatments, strong capabilities in clinical bioinformatics, computational biology and secure computational service infrastructure are required. Besides biomedical research, other areas of research such as social sciences are increasingly processing confidential personal information and are therefore faced with similar challenges of IT security and data protection.

BioMedIT has been established as a nationwide distributed network of core facilities with central coordination, providing secure computational infrastructures, services, and competences for research in Switzerland. The project builds on existing expertise and research infrastructure in the partnering institutions by extending their capacity and capabilities. BioMedIT is managed by the SIB Swiss Institute of Bioinformatics and is tightly integrated with the activities of the Data Coordination Center of the Swiss Personalized Health Network (SPHN) initiative of the Confederation. While the implementation is driven by biomedical applications, the resulting secure RI network has a broad range of applications beyond life sciences.

Detailed description

Most current research IT facilities at Swiss universities are tailored towards handling basic research data with little constraints on IT security and data protection requirements. However, biomedical research using personal data from citizens and patients (e.g. clinical data, genomics, tracking and sensor data) imposes very high requirements to the IT infrastructure and expertise, which differ substantially from all-purpose research infrastructures. BioMedIT extends the capacity and capabilities of research IT facilities at Swiss universities to meet the needs of translational biomedical research, especially in the context of SPHN. By establishing mechanisms enabling nationwide exchange of health-related data (e.g. harmonization of data semantics, exchange formats, etc.) SPHN will also allow using health data in research.

BioMedIT has been established as a nationwide distributed network of core facilities with central coordination, providing secure computational infrastructure, services, and competences for biomedical research in Switzerland. Participating nodes operate their infrastructures based on common standards for IT security, apply common mechanisms for secure data exchange between hospitals and research institutions, and will provide interoperable software and data analysis workflow execution capabilities across the network. Currently, BioMedIT high-performance computing and storage infrastructure is located at three distributed sites (SIS ETH Zürich, sciCORE University of Basel, and Vital-IT SIB Lausanne / Geneva) which provide ICT services to all members of the network. Additional sites may join the network in the future. Specific software projects are performed decentral at various partner sites, according to the local technical and scientific competences.

National collaborations include the SDSC Swiss Data Science Center on the development of workflows for secure reproducible data analysis, and the PHRT platforms on management and processing of omics data for personalized health research.

BioMedIT is managed by the SIB Swiss Institute of Bioinformatics under the responsibility of the BioMedIT Board, closely coordinated with the SPHN Data Coordination Centre. Working groups on “IT Security”, “Workflow Interoperability” and “Bioinformatics and data analytics” provide guidance on future developments.

b. International level

The SIB represents the Swiss node of ELIXIR – an initiative to coordinate Bioinformatics infrastructures in Europe – and BioMedIT thereby closely collaborates with other European partners in this area. Specifically to mention are efforts for harmonizing identity and access management (IAM) mechanisms across European research institutions (ELIXIR AAI), workflow execution interoperability, and the development of a decentralized federated version of the European Genome-phenome Archive (EGA). BioMedIT recently started collaboration with colleagues in Germany and Netherland towards the development of a platform for distributed privacy-preserving data analysis (“Personal Health Train”) making use of FAIR data access points.

c. Development prospects

The main focus of the first phase of the BioMedIT project (2017-2020) is on establishing a nation-wide distributed network of core facilities with central coordination, operating under the same policies, establishing secure and performant computational infrastructure, develop and implement concepts for service interoperability. In the second phase (2021-2024) it is expected that the scope of SPHN will extend beyond the current set of partner hospitals to include health information from other data providers, healthy citizens, sensors and wearables, and large scale *omics projects. This will require corresponding further development of the ICT infrastructure network during this phase.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 11.1 Mio	Higher Education Institution 11.1 Mio	Higher Education Institution 8.4 Mio
Canton 0	Canton 0	Canton 0
Swiss Confederation SERI(Article 15):18.5 Mio	Swiss Confederation [50]SERI (article 15): 18.5 Mio	Swiss Confederation [51]SERI (article 15): 14.1 Mio
Third parties 1.5 Mio	Third parties 1.5 Mio	Third parties 1.5 Mio
Total budget 31.1 Mio	**Total 31.1 Mio**	**Total 24.0 Mio**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 6.0 Mio Operating costs 25.1 Mio Other costs 0	Investments 6 Mio Operating costs 25.1 Mio Other costs 0	Investments 6 Mio Operating costs 18.0 Mio Other costs 0
Total costs 31.1 Mio	**Total 31.1 Mio**	**Total 24.0 Mio**

Development Phases	Years
Design	2017
Preparation	2017
Implementation	2018 - 2024
Operation	2025 - 2028

[50]Planned proposal by SIB for funding according to article 15 of the Federal Act on the Promotion of Research and Innovation (RIPA). Funding decision by EAER fall/winter 2020.

[51] Planned proposal under article 15 RIPA for the next period. Funding decision in fall/winter 2024.

The Swiss edu-ID and the Swiss Academic Cloud based on the Academic Network SWITCHlan

Category: Distributed

Host institution(s): SWITCH Foundation

Main funding sources: SWITCH's funding scheme is built on contributions of the community and of Swiss and European research funding bodies as well as SWITCH own equities. As the community fully pays for running services, new projects and innovations are supported by additional, national and international funds and own means.

Description / Development prospects

a. National level

Overview

SWITCH is a foundation of the Swiss universities, whose mission is to provide outstanding information and communication services (e-Infrastructures) to research and education.The e-infrastructure of SWITCH consists of mainly three parts, which complete each other in an indeal way: SWITCHlan as physical network layer, SWITCHengines as infrastructure layer and SWITCHedu-ID (AAI) as middleware layer. As such, SWITCH has moved towards an integration of networks, cloud infrastructure and ID/access services and continues to improve its functionality in order to present the user an integrated offering.

Detailed description

SWITCHlan: As a physical link, SWITCHlan brings together universities and research institutions from all over Switzerland (http://www.switch.ch/network/). SWITCH has built this Education and Research Network on its own and is constantly developing it further. Stable Internet access, the rapid and secure exchange of data at 100 Gigabit/second and an excellent connection to international networks – SWITCH offers all of this from a single source. Our SWITCHlan education and research network provides the high-quality communication infrastructure that is required for meaningful cooperation and exchange across national borders. To protect the network and the exchange of the scientific information SWITCH runs a computer emergency response team (CERT), which is constantly expanding its security services in the university environment, SWITCH-CERT is in a position to take effective action in the event of security emergencies – also if they exceed national borders.

SWITCHengines: provides compute and storage services in the form of virtual machines to researchers, lecturers and IT-services of Swiss universities and related institutions. This infrastructure can serve the special needs and national regulations for academic computing and information management. SWITCH will contribute its cloud infrastructure for supporting the research community - in balance with e-Science- and IT-teams of universities. Its components are located in Zurich and in Lausanne.

SWITCHaai: is based on the concept of federated identity management. It has been established between 2000 and 2015 in the higher education sector of Switzerland. Today, it gives over 300'000 user access to over 1'000 services. Since 2016 SWITCH has been working together with its partners, the Swiss universities, to migrate the organization-centric SWITCHaai identity management system into the user-centric SWITCH edu-ID. To address the trends of life-long learning, increased mobility and collaboration needs, the SWITCH edu-ID issues persistent identities with scalable quality in an extensible framework. An established identity management system across all academic institution is a mandatory prerequisite for presenting the user uniform access to services.

b. International level

SWITCHlan: On the international level, the SWITCH network team is project partner in the GEANT-Project (www.geant.org). GEANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs). GEANT connects over 50 million users at 10,000 institutions across Europe.

SWITCHengines: We collaborate in continuing development of the open source products (most notably OpenStack, Ceph and newly Kubernetes).

SWITCHaai: supports interfederation, which means that SWITCHaai users can also access services which authorizes international users. This effort is part of the GEANT project, supported by the European Union.

c. Development prospects

SWITCHlan has laid the foundations for the development until 2020 and beyond. Therefore within period 2020-2024, the network will undergo incremental improvements in specific locations and we expect individual institutions to upgrade their connectivity to higher bandwidths. It should also be noted that the benefits of the upgrade consist not only of increased bandwidth and improved resilience, but also in new functionality and flexibility. On the international level, SWITCH will continue its participation in the series of GÉANT projects within the framework Horizon2020, currently planning to contribute to GN4-3. SWITCH-CERT is continuously extending and improving its detection and response capabilities as well as the accuracy of the Swiss threat landscape. In addition, SWITCH-CERT works with the community on development of further managed security services.
SWITCHengines is being run as production quality cloud infrastructure. The supported functionality is being continuously extended according to the users's needs. Most recent new services comprise a dedicated administrative user interface custom-tailored to the needs of universities and the support for virtual private cloud (L2 connectivity between Campus and Engines networks) and container technology. The service infrastructure is being expanded according to the growth of its usage.
SWITCHaai: The development concentrates on two avenues: First and foremost it coordinates and supports the institutions to adopt the edu-ID. Secondly, it enhances the supported functionality of edu-ID in various ways beyond what is possible with SWITCHaai today. This is a strong motivation for the institutions to adopt the edu-ID.
Remark to the costs: The cost for the SWITCHlan and of the SWITCHaai / SWITCH edu-ID infrastructure are not available as the participating institutions do not publish their costs on their side. The following figures contain the central part of SWITCH only. For this infrastructure, which all provide running services, full cost are covered by the institutions in higher education and research (universities, universities of applied sciences, universities of teacher education). Some subsidies come from the EC via Horizon2020 and the next framework program. The investments are written of and therefore included in the operating cost.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 51'500'000	Higher Education Institution 60'800'000	Higher Education Institution 67'000'000
Canton 0	Canton 0	Canton 0
Swiss Confederation [52]PgB-5: 2'000'000	Swiss Confederation PgB: 1'000'000	Swiss Confederation PgB: 2'000'000
Third parties EU: 1'500'000	Third parties EU: 1'000'000	Third parties EU: 1'000'000
Total budget 55'000'000	**Total 62'800'000**	**Total 70'000'000**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments N/A	Investments 11'600'000	Investments tbd
Operating costs N/A	Operating costs 62'800'000	Operating costs tbd
Other costs N/A	Other costs 0	Other costs tbd
Total costs 55'000'000	**Total 62'800'000**	**Total 70'000'000**

Development Phases	Years
Design	Continuous development
Preparation	N/A
Implementation	N/A
Operation	2017 – 2028 ff

[52] PgB-5: Projects financed according to article 59 ("project contributions) of the Federal Act on Funding and Coordination of the Swiss Higher Education Sector.

Swiss Data Science Center (SDSC)

Category: Information and Service Infrastructure
Host institution(s): EPFL and ETH Zurich
Main funding sources: ETH Domain
Description / Development prospects

a. National level

Overview

The ETH Domain launched the Initiative for Data Science in Switzerland (IDSS) in 2015 to strengthen data science through education and research and the provision of infrastructure. Within this initiative, EPFL and ETH Zurich initiated the Swiss Data Science Center (SDSC) and now jointly lead and operate the Center in close collaboration with the research institutes of the ETH Domain. The Center's mission is to accelerate the adoption of data science and machine learning techniques within the academic community at large as well as in industry. The SDSC is composed of a multi-disciplinary team of data and computer scientists plus experts in selected domains, with offices in Lausanne and Zurich. By breaking down disciplinary boundaries, the SDSC acts as a real interface and service layer for data science projects while addressing transverse security and privacy issues, enabling multidisciplinary collaborations.

Detailed description

The SDSC supports data science research projects focussing on in-depth data analysis in specific scientific domains and on the development of technology and methods for data science research. The SDSC aims to facilitate a strong synergy between data providers, data and computer scientists, and subject-matter experts, fostering scientific breakthroughs with significant societal impact. Projects showing an interdisciplinary character by linking research groups from traditionally separated disciplines are privileged. Ongoing projects cover a broad range of scientific fields, such as physics, biology (incl. medicine), environmental sciences, computer science and economics.

The SDSC is developing RENKU, an open-source software platform designed to facilitate the exchange of data and knowledge between all the actors involved in data science collaborations, while enforcing their respective data management plans. During the initial phase, data, methods and publications generated by various academic projects are feeding the analytics platform. The platform will ultimately create an international community to share data, tools, methods and information in a federated environment.

RENKU offers:

- Reproducibility
  RENKU fosters reproducible research by enabling scientists to retrieve history and data provenance, and go back in time to every step of published science.
- Reusability and repetition
  The platform facilitates the sharing and reuse of data and algorithms, and empowers specialists to use other people's work in their own projects and execute them in an infrastructure agnostic environment. Attributions are therefore also consistently guaranteed.
- Collaboration
  RENKU supports a collaborative environment for dynamic and interactive prototyping by enabling content-rich discussions.
- Security
  RENKU makes use of state of the art security and privacy preserving technologies and best practices. It will give fine grained control over who accesses any data, from where and how.
- Federation
  RENKU is designed to connect independently administered platforms and positions itself as a unique one-stop shop for high quality data by allowing a federated access across institutions, giving each the freedom to enforce its own access controls over resources.
- Discovery

Thanks to its automatically maintained and enriched knowledge graph, the platform supports targeted exploration as well as unforeseen discoveries by giving scientists access to the big picture through interconnected metadata.
RENKU is an open-access platform operated on a cost-recovery basis for academic users. The access policy for industry users is currently being developed.

b. International level

At a time when data science has become extremely important, with the majority of top-tier international research and teaching institutions investing significantly in dedicated centers and programmes, the successful launch of the SDSC lays the foundation of a truly national Data Science Center striving to be globally competitive. Discussions are currently taking place with international universities about a potential adoption of RENKU.

c. Development prospects

Thanks to its unique structure, the SDSC, jointly initiated and lead by EPFL and ETH Zurich and closely collaborating with the research institutes of the ETH domain brings together the expertise of leading researchers throughout the country. The SDSC will extend the reach and visibility to national and international academic institutions and accelerate the adoption of data science by (Swiss) industry. There are currently 20 ongoing academic projects fostering the use of RENKU, and the center is expected to go up to 40 projects.

d. Costs (in CHF)

2017-2020	2021-2024	2025-2028
Higher Education Institution 0	Higher Education Institution tbd	Higher Education Institution tbd
Canton 0	Canton tbd	Canton tbd
Swiss Confederation ETH Board: 30 Mio. EPFL, ETH Zurich: 5.7 Mio.	Swiss Confederation ETH Board: 40 Mio. EPFL, ETH Zurich: tbd	Swiss Confederation tbd
Third parties Users/Grants: 7.3 Mio.	Third parties tbd	Third parties tbd
Total budget **43 Mio.**	**Total** **tbd**	**Total** **tbd**
Costs overview (2017-2020)	**2021-2024**	**2025-2028**
Investments 0 Operating costs 30 Mio. Other costs 13 Mio	Investments tbd Operating costs tbd Other costs tbd	Investments tbd Operating costs tbd Other costs tbd
Total costs **43 Mio**	**Total** **tbd**	**Total** **tbd**

Development Phases	Years
Design	2014-2015
Preparation	2015-2016
Implementation	2017-2018
Operation	2018-2024 and beyond

Feuille de route suisse pour les infrastructures de recherche 2019

Annexe B

Annexe B1 : Participations à des infrastructures de recherche internationales à examiner 95

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Annexe B1 : Participations à des infrastructures de recherche internationales à examiner

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Remarque préliminaire

Infrastructures auxquelles des institutions suisses participent déjà :

- European Plate Observing System (EPOS ERIC)
- European Clinical Research Infrastructure Network (ECRIN ERIC)
- Integrated Carbon Observation System (ICOS ERIC)
- Biobanking and molecular resources research infrastructure (BBMRI ERIC)
- Consortium of European Social Science Data Archives (CESSDA ERIC)
- European Social Survey (ESSurvey ERIC)
- Survey of Health, Ageing and Retirement in Europe (SHARE ERIC)
- Partnership for Advanced Computing in Europe (PRACE)
- Laboratory Infrastructure (ECCSEL ERIC)

Infrastructures pour lesquelles des institutions suisses ont marqué un intérêt :

- Aerosol, Clouds, and Trace gases (ACTRIS)
- Digital Research Infrastructure for the Arts and Humanities (DARIAH ERIC)
- European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER)
- Extreme Light Infrastructure (ELI)

Remarques importantes:

1) **Les informations financières ci-dessous représentent des planifications fournies par les hautes écoles / responsables des infrastructures.**
2) **Les chiffres financiers mentionnés dans le présent document pour les périodes FRI 2021–2024 et 2025–2028 sont des données prévisionnelles et sont indiqués uniquement à titre d'estimation grossière des coûts probables à venir et de leur répartition.**
3) **Dernière mise à jour des informations : janvier 2019**

European Plate Observing System ERIC (EPOS)

Legal form: *ERIC*

Main funding sources: *Host state, member states, EU structural funds*

Funding in Switzerland:

Funding projection	Total CH-share[53] (Mio CHF)	Participation fees[54] (Mio CHF)
2017-2020	2.05	0.33
2021-2024	4.10	0.65
2025-2028	4.46	0.78

Description

The European Plate Observing System ERIC (EPOS, www.epos-eu.org) creates a single sustainable, permanent observational infrastructure for Earth sciences, integrating existing geophysical monitoring networks (e.g. seismic and geodetic networks), local observatories (e.g. volcano observatories) and experimental laboratories (e.g., experimental and analytic lab for rock physics and tectonic analogue modeling) in Europe and adjacent regions. It coordinates the currently scattered, but highly advanced, European facilities into one distributed, coherent multidisciplinary research infrastructure and promotes innovative approaches for a better understanding of the physical processes controlling earthquakes, volcanic eruptions and tsunamis, as well as those driving tectonics and Earth surface dynamics.

The EPOS infrastructures provide key parameters for the multi-disciplinary study of the interior structure, composition and dynamics of the Earth, for exploration activities related to the identification and exploitation of natural and energy resources and for the assessment and monitoring of natural hazards. In addition to Earth scientists modeling the structure and processes in the Earth interior, users of EPOS data include engineers and private practitioners, federal and cantonal offices, construction industry, critical infrastructures, and the insurance sector. EPOS has been included as a landmark in the 2018 ESFRI roadmap (http://roadmap2018.esfri.eu/projects-and-landmarks/browse-the-catalogue/epos/) and the EPOS ERIC has been established late 2018 with Switzerland as founding observer.

National relevance

EPOS offers a unified framework, platforms and tools to provide access to data and products from the main Swiss research and monitoring infrastructures to Swiss and European researchers and service agencies, covering earthquake data, geodetic and geological mapping, geomagnetic and remote sensing data, near-fault multiparameter data, data collected in laboratories (rock deformation, geochemistry, volcanology) and deep underground laboratories and geoenergy testbeds for low carbon energy. In addition to its academic impact, EPOS thus secures data access at European scale to deliver monitoring services of national interest and related to federal duties. EPOS data and activities also provide a key contribution to the development of geothermal technologies and safe underground waste storage, for the implementation of Switzerland's energy, climate and climate adaptation strategies.

Within EPOS, Switzerland coordinates the domain of seismology, leads the development of the new European harmonized earthquake hazard model and provides Virtual Access to earthquake hazard information through the European Facilities for Earthquake Hazard and Risk (www.efehr.org) , provides Transnational Access to the Bedretto Underground Laboratory (experimental facility for reservoir stimulation, geoenergy technologies and earthquake physics) and to the experimental rock physics laboratories at ETHZ and EPFL, operates one of the European data distribution nodes for access to seismological waveform data, and provides Virtual Access to the multiparameter data collected by the Near Fault Observatory in the Valais.

[53] The total includes the participation fees and the provision of European level services within EPOS, and is contributed mainly by ETHZ, EPFL and other Swiss Universities.

[54] The participation fees from 2021 onward will be a part of the ERI dispatch 2021-2024. For 2019/2020 the participation fees are covered by ETH Zürich.

European Clinical Research Infrastructure Network ERIC (ECRIN)

Legal form: *ERIC*

Main funding sources: *Member states, Project (trials) specific funding (H2020, IMI, ERA-Nets, EDCTP and other*

Funding in Switzerland:

Funding projection	Total CH-share[55] (Mio CHF)	Participation fees[56] (Mio CHF)
2017-2020	0.57	0.11
2021-2024	0.69	0.22
2025-2028	0.69	0.22

Description

The European Clinical Research Infrastructure Network (ECRIN, https://www.ecrin.org/) is a non-profit, intergovernmental organisation that supports multinational clinical trials in Europe. Multi-country trials provide increased access to patients, resources, and expertise, and, in turn, potentially more robust trial results and greater public health impact.

ECRIN with the legal status of an ERIC is a network of networks that connects research facilities at multiple sites in countries across Europe and provides support and services for top-level multinational clinical research. The organisational model is based on country memberships and has currently 11 members including Switzerland as Observer, represented by the SCTO. Switzerland participated in ECRIN since its initiation / development phases as FP6&FP7 European Framework Programme funded projects, granting Swiss researchers full access to ECRIN services and support.

Each member country hosts a European Correspondent who are at the heart of the national networks and who manage the clinical trial portfolio and coordinate with the national scientific partner (i.e., network of clinical trial units, or CTUs), with support from the Paris-based Core Team.

With a focus on investigator-led, academic studies, ECRIN provides consultancies, services and tools for clinical trial preparation, protocol review, and trial management services, facilitating the pathway through Europe's fragmented health and legal systems that fit in and counteract on the latest scientific and legal environment. ECRIN provides freely accessible tools and standards as well as clinical research centre certifications (data management, pharmacovigilance) and maintains a regulatory database (Campus, http://campus.ecrin.org/).

National relevance

ECRIN membership provides multiple advantages including full access to ECRIN management and consultancy services independent of the pathology concerned. Provided at no additional cost, these services support countries to achieve ECRIN's mission of developing and implementing multi-site, multinational clinical trials.

The structure of the SCTO perfectly fits the ECRIN terms for a national hub. With its CTU network the SCTO provides a unique infrastructure available in this field in Switzerland. The Swiss academic research community benefits from increased research and trial collaboration opportunities and greater patient access, and thus, attractively and competitively positions Swiss clinical research in the international competition with respect to innovation and quality.

Moreover, sharing best practices and resources among national scientific ECRIN partners are major added values for the academic research community, saving potential costs. Participation in ECRIN furthermore ensures early access to information about regulatory changes in clinical research in Europe.

[55] The total includes the participation fees and personal costs (contributed mainly by SERI via article 15).

[56] The participation fees from 2021 onward will be a part of the ERI dispatch 2021-2024.

Integrated Carbon Observation System ERIC (ICOS)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH-share[57] (Mio CHF)	Participation fees[58] (Mio CHF)
2017-2020	6.68	0.30
2021-2024	6.78	0.32
2025-2028	7.01	0.32

Description

The Integrated Carbon Observation System (ICOS, https://www.icos-ri.eu/) provides high-precision, long-term and standardized observations of the carbon cycle, namely of greenhouse gases (GHG) in the atmosphere and of their exchange between atmosphere, ecosystems and oceans. Only such integrated and highly harmonized measurements can serve to quantify GHG emissions and sinks of the European continent and facilitate research relevant to mitigate and adapt to anthropogenic climate change. The ICOS European Research Infrastructure Consortium (ICOS ERIC) has become operational on 23 November 2015. ICOS ERIC currently consists of 12 European member and observer countries (such as Switzerland) with their own national networks (with overall more than 100 measurements stations). ICOS ERIC's Head Office is located in Helsinki. ICOS data and data products are fully open access, following the FAIR principles, available at the ICOS Carbon Portal (the one-stop shop for all ICOS data and data products). Data will thus not only stimulate scientific studies and modeling efforts, but also provide science-based information to stakeholders and user communities, answering to global demands such as of the Paris Agreement and the UN Sustainable Development Goals as well as to national policies.

ICOS Switzerland (ICOS-CH) is the Swiss contribution to the ICOS research infrastructure (ICOS RI). The ICOS-CH consortium consists of ETH Zurich (National Focal Point), Empa, WSL, University of Bern, University of Basel and MeteoSwiss. ICOS-CH contributes to ICOS RI with two Class 1 stations, i.e., of the most advanced category: one atmospheric station (Jungfraujoch, JFJ) and one ecosystem station (Davos, DAV). JFJ has been officially certified as ICOS Class 1 atmosphere station in May 2018, while DAV expects to receive the certificate as labelled ICOS Class 1 ecosystem station in early 2019. Both stations are unique in terms of their geographical location. JFJ is the highest, permanently manned research station within Europe (3453 m a.s.l.), while DAV is currently the only sub-alpine (1639 m a.s.l.) Candidate Class 1 forest station within ICOS. Long-term observational data are one of the main pillars of ICOS RI, to which the two Swiss ICOS stations contribute with an outstanding measurement history (JFJ: since 1974; DAV: since 1997). These precious contributions must be continued by complying with the now established ICOS RI standards, and with a time horizon of 20 years.

National relevance

ICOS-CH (www.icos-switzerland.ch) with the two unique measurements stations and its exceptional geographical location in the central part of the Alps is an out-standing node within the ICOS RI network. Similarly, the scientific excellence of ICOS-CH partners is highly visible within ICOS RI and beyond, and attracts new scientific collaborations. Moreover, ICOS-CH profits from intense scientific exchange with other leading European experts and direct access to central services, including calibration facilities, cutting-edge data processing, and a dedicated out-reach, dissemination and communication strategy. Furthermore, participation in ICOS RI allows Switzerland to actively shape the future scientific agenda in Europe and beyond with respect to carbon cycle and greenhouse gas research. By providing standardized data, ICOS-CH supports policy towards the fulfilment of the resolutions of the Paris Agreement aiming at the mitigation of climate change.

[57] The total includes the participation fees and is contributed mainly by SNSF, with further contributions by all partners, i.e. ETH Zurich, Empa, WSL, MeteoSwiss, Universities of Bern and Basel.

[58] The participation fees are paid currently by SNSF.

Biobanking and Molecular Resources Research Infrastructure ERIC (BBMRI)

Legal form: *ERIC*

Main funding sources: *Host state, member states, EU structural funds, participation in EU programs*

Funding in Switzerland:

Funding projection	Total CH-share[59] (Mio CHF)	Participation fees[60] (Mio CHF)
2017-2020	0.12	0.12
2021-2024	0.26	0.13
2025-2028	0.26	0.13

Description

BBMRI-ERIC (http://www.bbmri-eric.eu/) aims to develop a Pan-European distributed research infrastructure in order to facilitate access to high quality (biological) resources and facilities for biomolecular and biomedical research purposes. Essential for the understanding of the diversity of human diseases, biological material stored in biobanks and the corresponding data are considered as the essential raw material for the advancement of biotechnology and personalised medicine. To coordinate international biobanking activities and increase samples and data quality making biobanks interoperable and accessible, BBMRI-ERIC is establishing services and tools for users and owners of biobanks.

BBMRI-ERIC is engaging with numerous stakeholders: European Community, researchers, institutions, patient organisations, standardisation organisations, other research infrastructures, health and research ministries, biobanking intiatives and societies. 19 countries are participating as members (Austria, Belgium, Czech Republic, Estonia, Finland, France, Germany, Greece, Italy, Latvia, Malta, the Netherlands, Nor-way, Sweden, and the United Kingdom), 4 as observers (Switzerland, Cyprus, Poland and Turkey) and one international organisation (International Agency for Research on Cancer (IARC)/WHO).

The relevant scientific partners in using BBMRI-ERIC in Switzerland are:

- Swiss Biobanking Platform: as the national node of BBMRI-ERIC and the national reference on biobanking activities. Networking through SBP, the research community in biology and health in Switzerland are the users of the BBMRI-ERIC services.
- The SNSF, indirectly through SBP, by introducing minimal biobanking standards as a requirement in research instruments

National relevance

In Switzerland, biobanks operate with heterogeneous processes, are not registered, making the search and comparability for samples difficult and their use critical due to compatibility issues. Moreover, biobanking practice has greatly evolved over the last years, from the individual collection of biological material to professional infrastructures dealing with ethical, legal, accessibility and data sharing, reproducibility, data protection and quality issues leading to a dramatic increase in the costs of biobanking activities. Swiss Biobanking Platform has been created by the SNSF in order to respond to the needs of the Swiss research community in terms of coordination and harmonization of biobanking activities in multiple fields of research by increasing the visibility, quality, transparency, accessibility and interoperability of biobanks. These needs concur with the long-term efforts of the SNSF in biology and medicine to foster excellent research. SBP aims at being the reference platform for biobanking activities in Switzerland, by providing services to the research community linked to BBMRI-ERIC. In this respect, promoting harmonized processes and coordination of biobanking activities in Switzerland must be made following international standards to allow Swiss researchers and institutions to enter the European net-work and benefit from the tools developed by BBMRI-ERIC.

[59] The total includes the participation fees.

[60] The participation fees are planned to be paid by SNSF through the budget allocated to SBP.

Consortium of European Social Science Data Archives ERIC (CESSDA)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH-share[61] (Mio CHF)	Participation fees[62] (Mio CHF)
2017-2020	6.45	0.12
2021-2024	7.90	0.13
2025-2028	8.52	0.13

Description

The provision of social science data and metadata is vital to our understanding of the major challenges facing society today. The Consortium of European Social Science Data Archives (CESSDA, https://www.cessda.eu/) has the mission of building on existing national infrastructure within the member countries and strengthening and expanding pan-European among social science data archives. CESSDA members (Switzerland has the status of observer) seek to enhance the scientific excellence and efficacy of European research in the social sciences, as well as to facilitate access to data and metadata regardless of national borders.

CESSDA was recognized by the European Strategic Forum for Research Infrastructures (ESFRI) and included in the ESFRI Roadmap in 2006. It was pronounced an ESFRI Landmark in 2016. The European Commission set up the infrastructure CESSDA as a European Research Infrastructure Consortium (CESSDA ERIC) under the Council Regulation (EC) No 723/2009 on 9 June 2017. The governance and operation of the consortium CESSDA is based on the CESSDA Statutes and Annexes. According to the Statutes each member of the consortium must appoint a national service provider that performs CESSDA tasks in the country. The Service Providers must meet the specific demands and requirements set out in the CESSDA Statutes and must be appropriately supported (financially and operationally) by the individual Member state's ministry of research or delegated institution. The major part of the development work of CESSDA ERIC is performed by the currently 17 National Service Providers.

National relevance

A principal goal of CESSDA is to provide full-scale sustainable research infrastructure that enables the research community to conduct high-quality research, leading to effective solutions to major challenges facing society. To achieve this, CESSDA supports national and international research and cooperation in the social, economic and political sciences, corresponding to the European long-term strategic document "Europe 2020. A Strategy for Smart, Sustainable and Inclusive Growth".

CESSDA supports social science research across the European Research Area (ERA) by providing, on a not-for-profit basis, a comprehensive and integrated social science data research infrastructure that facilitates and supports research, teaching, and learning throughout the social sciences and beyond. This is achieved through the development and coordination of standards, protocols, and professional best practices pertaining to the preservation and dissemination of data and associated digital objects, and by facilitating researchers' access to relevant resources of the European social science research community. CESSDA provides effective leadership and serves as a catalyst for change across its area of interest by supporting member and partner organizations and enabling them to derive maximum benefit from membership; it openly and constructively engages with its various user communities (researchers as data producers and data users, funding bodies across EU, and its own Service Providers) and works with other stakeholders for their mutual benefit.

The total contribution for CESSDA in the budget includes the costs of the "Data and research information services (DARIS)" located at FORS, which is the Swiss National Service Provider for CESSDA.

[61] The total includes the participation fees and is contributed mainly by SNSF.

[62] The participation fees through the contribution to FORS (article 15, RIPA) and will be a part of the SNSF budget from 2021 (portfolio reorganization).

European Social Survey ERIC (ESSurvey)

Legal form: *ERIC*

Main funding sources: *Host state, member states*

Funding in Switzerland:

Funding projection	Total CH-share[63] (Mio CHF)	Participation fees[64] (Mio CHF)
2017-2020	2.9	0.43
2021-2024	2.9	0.43
2025-2028	3.0	0.43

Description

The European Social Survey (ESS, https://www.europeansocialsurvey.org/) is a pan-European research infrastructure providing freely accessible data for academics, policymakers, civil society and the wider public. This academically driven cross-national survey has been conducted across Europe since its establishment in 2001. In 2013 the ESS was acquired ERIC status (European Research Infrastructure Consortium), and in 2016 was recognised as an ESFRI Landmark. As of end of 2018, the ESS ERIC counts 23 member countries, 1 observer country (Switzerland) and 4 confirmed guest countries, being so the Research Infrastructure Consortium with most members.

The ESS has become a gold standard for comparative surveys in the social sciences, known for its high methodological quality standards, and very widely used. Every two years, face-to-face interviews are conducted with newly selected, cross-sectional samples. The survey measures the attitudes, beliefs and behaviour patterns of diverse populations in more than thirty nations. The ESS data is available free of charge for non-commercial. ESS has over 130,000 registered users, and over 3,000 identified publications. **National relevance**

Switzerland has participated in each round of the European Social Survey to date, thanks to the continuous financial support of the Swiss National Science Foundation. The uninterrupted, high quality and timely prepared Swiss datasets make it possible that Switzerland's data are included in a very large proportion of publications using ESS data that Switzerland's ESS team and other Swiss researchers are very present in the international community related to this survey, and that Switzerland contributes to major methodological and substantial discussions in the social sciences. Over 4'000 out of 130'000 registered users are from Switzerland, and nearly 7'600 ESS datasets have been distributed so far to Swiss users.

In order to guarantee for the continuation and expansion of the impact of the ESS data of and in Switzerland, we have to continue to ensure the production of high quality data with comprehensive documentation and the timely delivery of the data for inclusion in the first international release. Furthermore, it must be noted that the work with ESS data of the Swiss ESS team and their presentations of the survey in academic and public arenas, as well as their expertise contribution to the central ESS contribute to the impact of this out-standing survey, both at home and abroad.

[63] The total includes the participation fees and is contributed mainly by SNSF.

[64] The participation fees through the contribution to FORS (article 15, RIPA) and will be a part of the SNSF budget from 2021 (portfolio reorganization).

Survey of Health, Ageing and Retirement in Europe ERIC (SHARE)

Legal form: *ERIC*

Main funding sources: *Host states, member states, EU structural funds, Grant from National Institute on Aging (NIA), H2020 INFRA program*

Funding in Switzerland:

Funding projection	Total CH-share[65] (Mio CHF)	Participation fees (Mio CHF)
2017-2020	3.8	0.05
2021-2024	3.8	0.1
2025-2028	Project ends in 2024	Project ends in 2024

Description

The Survey of Health, Ageing and Retirement in Europe (SHARE; http://www.share-project.org/organisation/share-eric.html) is a multidisciplinary and cross-national panel database of micro data on health, socio-economic status and social and family networks. In biennial survey waves, people aged 50 or older from 27 European countries and Israel are interviewed. The first wave of SHARE was conducted in 2004 as a representative survey and has since been repeated every two years with increasing number of country participation. Overall, more than 297'000 interviews with more than 120'000 individuals have been accomplished in the survey waves 1 to 7. The data are available to the entire research community free of charge.

With SHARE data researchers can provide better understanding of how individuals and families are affected by ageing. SHARE exploits Europe as a "natural laboratory" to investigate the population ageing process and brings together many scientific disciplines, including demography, economics, biology and statistics. The results of the research can be used by science and politics in finding solutions to the challenges of our social security and health care systems.

National relevance

Population ageing is also a reality in Switzerland and a challenge at all levels as well. As in all European countries, it puts the pension system under strain, increases health costs and puts social cohesion at risk. In view of the reforms and adaptations that are currently implemented, discussed or envisaged, SHARE is an important source of evidence which helps to better cope with the challenges in the health, employment and social sector. SHARE data allow to provide an overview of the actual situation, to monitor its evolution and to examine the impact of specific reforms on the elderly population in general or on different specific groups. As such, SHARE data and the analyses based upon them are an important source of evidence which helps the ageing countries to better design policy measures.

Thanks to the continuous financial support of the Swiss National Science Foundation, Switzerland has participated in each round of SHARE since its beginning in 2004 (Switzerland has an observer status in SHARE ERIC). This has contributed to the consistent provision of data of very high quality to researchers. The uninterrupted, high quality and timely prepared Swiss datasets make it possible that Switzerland's data are included in a very large proportion of publications using SHARE data. The Swiss data are not only used by Swiss researchers, but also by researchers working abroad. Indeed, a large majority of the publications involve comparative analyses and include the Swiss data as well. In addition, supported by the easy access to the data and the popularity of the survey, the SHARE data are also a reference for international contextualization and very often used in publications for this purpose, like the OECD statistics or the WHO, helping Switzerland being present on the international scene. In Switzerland, the SHARE data are also a reference for institutes such Obsan or statistical offices, which provide a statistical support for the Confederation, the cantons and other institutions.

[65] The total includes the participation fees and is contributed mainly by SNSF.

Digital Research Infrastructure for the Arts and Humanities ERIC (DARIAH)

Legal form: *ERIC*

Main funding sources: *Member states, H2020 DESIR (2017-2019, European Research funds); SAGW*

Funding in Switzerland:

Funding projection	Total CH-share[66] (Mio CHF)	Participation fees (Mio CHF)
2017-2020	0.14	-
2021-2024	0.70	0.22
2025-2028	0.72	0.24

Description

DARIAH (https://www.dariah.eu/) is an acronym for Digital Research Infrastructure for the Arts and Humanities. It serves as pan-European co-operation of research infrastructures for humanists working with computer based methods. It promotes digital research as well as the teaching of digital research methods. Since 15th August 2014 DARIAH has been organized as a European Research Infrastructure Consortium (ERIC). For the time being, 17 countries are full members of DARIAH; they constitute the General Assembly. Switzerland is currently not member of the ERIC DARIAH, but nine academic institutions are Cooperating Partners of DARIAH. In order to coordinate the DARIAH-relevant activities in Switzerland in an efficient way, the Universities of Basel, Bern, Geneva, Lausanne, Neuchâtel, Zürich, the EPFL and the academy SAHSS signed on 30 October 2018 the Consortium DARIAH-CH. The purposes of the Consortium are to prepare the national infrastructure of DARIAH-CH from 2021 onwards by establishing and financing a Swiss National Point of Contact.

National relevance

Well-designed research infrastructures form one of the most important strategic goals of the European Research Area. A remarkable sign of this development is, for example, the establishing of a common cloud for research data in Europe until 2020, the European Open Science Cloud. Open Science, and related to that, Open Data and the FAIR Data Principles including suitable data management procedures, are the main challenges that both the humanities and the cultural studies have to tackle in the near future. Moreover, the skillful use of digital methods in the humanities is still not part of the general knowledge of the majority of Swiss students and researchers, although efforts were taken or are being planned by several Swiss universities and EPF by founding Digital Humanities Labs (Basel, EPFL, Geneva, Lausanne, Zurich) or programs or doctoral schools for the digital humanities (DH).

In this situation, the Swiss humanities research landscape needs collaborative international partnership. DARIAH forms the most powerful network of research infrastructures and humanists in Europe one can join to get support for achieving the above-mentioned challenges. In general, for Switzerland as non-EU-member state, the cooperation in European programs can be challenging. DARIAH offers a possibility to get involved on a national level with a European research community without the disadvantage of a special status or restrictions. The list below shows the advantages for members:

- involvement in European research, infrastructure programs and flagship-projects in the DH;
- participation in the strategic bodies of DARIAH without restrictions;
- clustering effect for communities by establishing a national coordination office;
- exchange of know-how in digital methods and infrastructures for the humanities;
- higher visibility for successful national DH-projects on a European level.

[66] The total includes the participation fees, planned to be paid by the SNSF, and the costs for the Swiss coordinating office, paid by the Consortium DARIAH-CH since 2021, and a preparation step paid by the H2020 project DESIR in 2017-2019.

Partnership for Advanced Computing in Europe (PRACE)

Legal form: *Association*

Main funding sources: *Member states*

Funding in Switzerland:

Funding projection	Total CH-share[67] (Mio CHF)	Participation fees[68] (Mio CHF)
2017-2020	2.62	0.24
2021-2024	2.62	0.28
2025-2028	2.62	0.28

Description

The mission of PRACE (Partnership for Advanced Computing in Europe, http://www.prace-ri.eu/) is to enable high-impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society. The objective of PRACE is the provision of a persistent pan-European High-Performance Computing ("HPC") service and infrastructure, which shall be managed as a single non-profit European entity ("PRACE AISBL"). PRACE has a strong interest in improving energy efficiency of computing systems and reducing their environmental impact.

The PRACE AISBL was established in 2010. The PRACE AISBL shall enable the provision of world class computer services to the key scientific and industrial communities in Europe and it is of utmost importance to the PRACE Council that the PRACE AISBL continues successfully. The initial objectives of PRACE which have been expressed in the "Memorandum of Understanding concerning the establishment of a European Tier-0 High Performance Computing Service", signed in 2007, remain the same during PRACE 2.

The computer systems and their operations accessible through PRACE are provided by 5 PRACE members (BSC representing Spain, CINECA representing Italy, ETH Zurich/CSCS representing Switzerland, GCS representing Germany and GENCI representing France). Four hosting members secured funding for the initial period from 2010 to 2015. In 2016 a fifth Hosting Member, ETH Zurich/CSCS (Switzerland) opened its system via the PRACE peer review process to researchers from academia and industry.

The PRACE project partners have received or are receiving EC funding under the PRACE Preparatory and Implementation Phase Projects (PRACE-1IP, 2010-2012, RI-261557 | PRACE-2IP, 2011-2013, RI-283493 | PRACE-3IP, 2012-2017, RI-312763 | PRACE-4IP, 2015-2017, 653838 | PRACE-5IP, 2017-2019, 730913). The total funding of the PRACE Projects amounts to €132M over 10 years (2010 – 2019) of which €97M is provided by the European Commission (EC).

National relevance

Being part of the PRACE RI has a number of advantages for Switzerland:

- Swiss scientists receive access to extreme-scale computing resources of different architectures;
- the visibility and quality of the Swiss Tier-0 program (formerly called CHRONOS) will be enhanced being part of a wider frame;
- The support structure (level 2 and 3) for the Tier-0 allocations is funded by the general partners and will be considered a consolidated contribution to the User Lab;
- The level 3 support for projects that can be candidate Tier 0 will help scientists in Switzerland and elsewhere in Europe to attain more ambitious goals at scale.

[67] The total includes the participation fees and is contributed mainly by ETHZ.

[68] The participation fees are paid by ETHZ.

European Carbon Dioxide Capture and Storage Laboratory Infrastructure ERIC (ECCSEL)

Legal form: *ERIC*

Main funding sources: *Member states*

Funding in Switzerland:

Funding projection	Total CH-share[69] (Mio CHF)	Participation fees[70] (Mio CHF)
2017-2020	1.16	0.08
2021-2024	4.58	0.26
2025-2028	4.56	0.24

Description

ECCSEL (http://www.eccsel.org/about/eccsel-eric/) was established in June 2017 to enable cutting-edge research on Carbon Dioxide Capture, and Storage (CCS) technologies, to enable low to zero CO_2 emissions from power generation and industry to mitigate climate change. ECCSEL is a pan-European distributed research infrastructure, i.e. an ERIC (European Research Infrastructure Consortium). ECCSEL's main objectives are to: 1) establish and operate a world class distributed CCS Research Infrastructure in Europe; 2) integrate, upgrade and build CCS research facilities; 3) enhance European science, technology development, innovation and education in the field of CCS; 4) enhance technology transfer, foster innovation, enable spin-off activities and generate new business.

Within the initial 5 European founding Member countries (France, Italy, the Netherlands, UK and Norway (Operations Centre, in Trondheim)), 13 service providers offer researchers across the globe easy access to 56 world class research facilities across Europe (see http://www.eccsel.org/ for a detailed list). ECCSEL is expected to grow in terms both of Member Countries and of major investments for both upgraded and new facilities. Already now, the ECCSEL ERIC comprises unique infrastructure for the study of CCS from the fundamental, lab scale to the demonstration and piloting phase.

National relevance

All climate change mitigation scenarios acknowledge the key role that CCS systems will have in the next decades not only to mitigate carbon dioxide emissions but also to enable the active removal of carbon dioxide from the atmosphere. Over the last two decades, Swiss researchers and Swiss industry have been playing an important role at the national, European and international level to advance the science and engineering of CCS systems. Swiss research institutions can contribute unique experimental facilities to ECCSEL, such as geo-mechanical characterization infrastructure, set-ups for the study of CO_2 capture processes, underground laboratories to conduct CO_2 injection/storage field tests (the three underground laboratories at the Grimsel Test Site, Mont Terry Rock Laboratory and Bedretto laboratory).

This situation makes the Swiss participation to the ECCSEL-ERIC both extremely effective and useful. Moreover, it makes the yearly investments of the Swiss Federal Offices (first of all SFOE and swisstopo) on national and international programs on CCS and on research infrastructure that serves the CCS scientific community (the underground laboratories mentioned above) even more productive.

Belonging to the ECCSEL consortium and community enables Swiss researchers to be key contributors to the international efforts in developing and demonstrating CCS technologies. This in turn helps the Swiss community to participate with scientific weight to international projects, initiatives and negotiations. At the national level, it allows attracting interest as well as additional research funds from both the public and the private sector. It is clear that as it develops and gains new partners, new experimental facilities and scientific and political weight, being part of ECCSEL will be crucial not only from a scientific point of view but also from the practical perspective of finding feasible solutions to cope with Swiss greenhouse gas emissions and to enable the deployment of negative emissions solutions.

[69] The total includes the participation fees and is contributed mainly by institutions of the ETH Domain, namely ETH Zurich, EPF Lausanne and Paul Scherrer Institute, by the PIs involved, as well as by swisstopo (for underground laboratory infrastructure).

[70] The participation fees are paid by SERI from 2021 (till 2020 paid by ETHZ and other Swiss partner).

Aerosol, Clouds, and Trace Gases (ACTRIS)

Legal form: *ERIC (foreseen)*

Main funding sources: *Host state, member states, EU structural funds, Research performing institutions participating in hosting ACTRIS facilities.*

Funding in Switzerland:

Funding projection	Total CH-share[71] (Mio CHF)	SERI[72] (Mio CHF)
2017-2020	4.86	-
2021-2024	11.14	5.09
2025-2028	10.8	5.00

Description

Atmospheric composition and processes play a vital role in environmental and societal challenges such as air quality, adverse health impacts or climate change. ACTRIS-RI (Aerosols, Clouds and Trace gases Research Infrastructure, https://www.actris.eu/) is a pan-European initiative to consolidate permanent and long-term observations of aerosols, clouds and trace gases at distributed National Facilities. ACTRIS-RI is composed of observing stations, instrument calibration centers, and a data center, as well as exploratory platforms (https://www.eurochamp.org/Eurochamp2020.aspx). By 2025, ACTRIS-RI shall be fully operational as an ERIC (European Research Infrastructure Consortium).

Switzerland contributes to ACTRIS through the following facilities: Jungfraujoch is a world-leading station, equipped with the best instruments for the measurements of aerosols and trace gases, and complemented by lidar ceilometer observations from Kleine Scheidegg. The observations from this renowned remote location will be complemented by measurements on the Swiss Plateau at Payerne and Beromünster providing in-situ and remote-sensing data of aerosols, trace gases and clouds: Furthermore, Switzerland will contribute to ACTRIS with Atmospheric Simulation Chambers (PSI), as a partner of the Calibration center for trace gases (CiGAS, Empa), and by providing traceability of aerosol optical depth (AOD) measurements to the WMO primary AOD reference (PMOD).

The national partners/stakeholders are PSI, Empa, MeteoSwiss, ETHZ, PMOD/WRC, University of Bern, and the high-Altitude Research Station Jungfraujoch.

National relevance

Sustained coordination within Europe is indispensable for the future high-quality analysis of atmospheric aerosols, trace gases and clouds. This calls for establishing standardized measurement and quality control protocols to ensure harmonized data sets of high accuracy. Moreover, the ACTRIS data centers play a key role in maximizing scientific and societal benefit by making these data sets openly accessible – in machine readable form and near real time – and in establishing routine and online transfer of observational data to other services such as the Copernicus Atmosphere Monitoring Service (CAMS). Only a common approach embedded in the international community allows to efficiently address future needs and challenges.

Switzerland is well embedded in the European science community for atmospheric aerosols, trace gases and clouds, and the research groups involved are among the world leaders in the analysis of aerosols, aerosol–cloud interactions and trace gases. All Swiss activities (including NABEL) have established strong links to the European research communities and stakeholders (e.g. EMEP, EUMETNET) and global key players, such as the Global Atmosphere Watch (GAW) Program of the World Meteorological Organization (WMO) with its connection with the meteorological science community and MeteoSwiss. Switzerland has been active in several scientific advisory groups of GAW, to which ACTRIS is a critical European contribution.

[71] The total includes the participation fees as well as contributions by PSI, Empa, MeteoSwiss, ETHZ, PMOD/WRC, University of Bern, and the high-Altitude Research Station Jungfraujoch, plus the requested contribution by SERI.

[72] Additional amount requested by the above Institutions for participation in the activities of ACTRIS.

European Long-Term Ecosystem and socio-ecological Research Infrastructure (eLTER)

Legal form: *eLTER is a pan-European network, based on bylaws accepted by national networks, of LTER international (ILTER) which is based on an international convention*

Main funding sources: *Host states, member states, EU funding from H2020/FP9 INFRA program*

Funding in Switzerland:

Funding projection	Total CH-share[73] (Mio CHF)	Participation fees[74] (Mio CHF)
2017-2020	6.36	0.05
2021-2024	6.36	0.05
2025-2028	6.36	0.05

Description

The overall purpose of the eLTER RI (http://www.lter-europe.net/elter-esfri) is to provide a pan-European integrated Research Infrastructure (RI) of long-term research sites for multiple and cross-disciplinary use in the fields of ecosystem, critical zone and socio-ecological research contributing to Global Research Infrastructures such as ILTER and GEOSS. The eLTER RI features a unique "whole system approach" from plot to land-scape scale, integrated in a nested design and allowing for interdisciplinary natural science research and investigating human-environment-systems at landscape scales.

The aim is to secure scientific excellence through the highest quality of interoperable services in close interaction with related European and global RIs. This excellence implies both, increased research quality through scientific cross-disciplinary synthesis and quantity in terms of the number of appropriately equipped research sites. The eLTER RI will provide indispensable integrated data sets for system model development and validation, hence supporting system understanding, predictions and decision-making.

Pan-European RI components will seamlessly link the network of up to 25 National Research Infrastructures, comprising approx. 200 sites and multiple user communities of eLTER RI services. The design secures full complementarity with related environmental in-situ RIs like ICOS, DANUBIUS and AnaEE. Generic services from e-infrastructures (e.g. LifeWatch, EUDAT) will be complemented by cost-efficient elements such as DEIMS (https://deims.org/) to serve continental and global users.

National relevance

With the anticipated consideration for the ESFRI roadmap 2019, LTER Switzerland will be an attractive partner in the European research landscape, and the Swiss research system will greatly benefit from the eLTER–ESFRI network in terms of the following main aspects: (1) Facilitated transnational access to proof tested categories of approx. 200 in-situ facilities and to harmonized data from long-term observations (including remotely sensed data) of environmental and socio-economic key parameters. (2) The eLTER network provides a high potential at local, national and European scale, for standardization, common protocols, established standards and basic interfaces with related infrastructures data assembly, from which LTER Switzerland could take great advantage. (3) Facilitated access to future ESFRI related calls, applying "ecosystem" or "whole-systems" approaches. (4) The participation in eLTER will allow the Swiss research system to apply a comprehensive and integrated view on interactions within natural and human influenced systems. (5) The participation of LTER Switzerland in eLTER, will further increase the visibility of the Swiss research system and thus foster international networking and globally competitive research frameworks for cutting edge science and extend the opportunities to promote the excellent expertise in Swiss forest and ecosystem research and unrivalled research facilities.

[73] The total includes the participation fees and is contributed mainly by the Swiss Federal Research Institute WSL.

[74] The participation fees are paid by WSL, Uni Basel (SLU), Uni Basel (ALPFOR), ETHZ (Grassland Sciences).

Extreme Light Infrastructure (ELI)

Legal form: *ERIC (planned)*
Main funding sources: *Host states, member states, EU structural funds*
Funding in Switzerland:

The mode of participation of Switzerland in ELI isn't yet settled. In a first phase, the ELI Host States could request a financial support from Switzerland in view of the ELI operation in the context of the Swiss contribution to the enlarged EU.

Description

The Extreme Light Infrastructure (ELI, https://eli-laser.eu/the-eli-project/) is the first international laser user facility. It is implemented in three pillars located in Central-Eastern Europe and to be organized under the umbrella of an ELI ERIC. ELI provides access to unique lasers and secondary sources (particles, x-rays) that push the frontier of extreme light-matter interaction science in terms of highest intensities, shortest time scales and broadest spectral coverage.

This infrastructure will be dedicated to multidisciplinary scientific and technical applications. Its capabilities are based on ten different primary laser sources, plus an accelerator based gamma-beam source, completed with specific user related instruments. Multiple beamlines allow the use of coherent radiation with unprecedented peak power (>10 PW), intensity (>10^{22} W/cm^2) and temporal resolution (attosecond: 10^{-18} s), as well as laser-accelerated particles for fundamental studies in atomic, molecular, plasma and nuclear physics. This infrastructure is intended for multidisciplinary scientific and technical applications, including but not limited to:

- Basic and applied research in physical, chemical, material and life sciences.
- Strong-field quantum electrodynamics and associated vacuum effects.
- Cutting edge laser technologies related to power, intensity and time-resolution.
- A combination of laser and accelerator technologies to investigate nuclear structure and reactions, as well as nuclear astrophysics with unprecedented precision and accuracy.

Users are expected to come from several scientific fields, ranging from materials science, biology, chemistry and medicine to nuclear physics and laboratory astrophysics. The knowledge and know-how produced will have a large impact on highly advanced technological fields, from optical components to electronics, advanced materials, biomedical equipment, etc.

The implementation of the first three pillars of ELI located in Czech Republic, Hungary and Romania, started in 2011 and is to be completed in 2019. It is being funded by a combination of European Regional Development Funds (ERDF) and national contributions from the host countries (totaling ~850 MEUR). ELI's Operation Phase begins in 2018. The three pillars will be operated, governed and funded by a newly established ELI ERIC, composed of interested member countries. ELI will operate as an international laser user facility, open to access by an international user community, with a Steady-State Operations budget (planned 2023) of approximately 75 Mio. Euros.

National relevance

In its size and scope, ELI complements research infrastructures in Switzerland very well. The lasers are larger, more intense and more powerful than those in any laboratory that is presently existing or planned at university level in Switzerland. In terms of parameters, ELI also complements the SwissFEL facility at PSI. Switzerland has a strong Ultrafast Science community that can expand the parameters space for its research through access to ELI and thereby maintain its international competitiveness. Lasers and secondary sources will also attract Swiss researchers beyond Ultrafast Science for diverse applications in physics, chemistry, biology and materials science.

Annexe B2 : Participation à des organisations internationales de recherche

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European Organization for Nuclear Research (CERN) *115*
European Southern Observatory (ESO) *116*
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European Spallation Source ERIC (ESS) *121*
European Molecular Biology Laboratory (EMBL) *122*
European Life Science Infrastructure for Biological Information (ELIXIR) *123*
International Experimental Fusion Reactor (ITER) *124*
Cherenkov Telescope Array (CTA) *126*
Square Kilometer Array (SKA) *128*
Neutrino experimental facilities in USA and in Japan *130*

Remarque préliminaire

La Suisse est membre de plusieurs organisations internationales de recherche en vertu d'accords multilatéraux. Le tableau ci-dessous résume l'impact des besoins financiers estimés pour cette classe d'infrastructures sur le domaine formation et recherche durant les périodes couvrant les messages FRI 2017-2020 et 2021-2024.

Le tableau a été réalisé par le SEFRI en février 2018 en tenant compte pour la période 2017-2020 des paiements effectués en 2017 et des paiements prévus pour la période 2018-2020, qui s'inscrivent tous dans le cadre des crédits ouverts par le Parlement. Pour ce qui concerne la période 2021-2024, l'estimation du SEFRI porte sur les paiements que la Suisse pourrait être amenée à réaliser en fonction des engagements déjà pris et d'autres engagements qu'elle pourrait être amenée à prendre dans un proche futur (les chiffres correspondants sont indiqués *en italique souligné* dans le tableau).

Aucun écart majeur au regard de ces estimations n'est à reporter entre février 2018 et la date de la publication de la feuille de route.

Sources légales du financement	**Organisation internationale de recherche (IFO)**	**2017-2020 (CHF mio *prévus*)**	**2021-2024 (CHF mio *estimés*)**
IFO existantes *messages budget / ESS / FRI 13-16*	CERN	181	189
	ESO	38	45.5
	EMBC/EMBL	24	26.5
	ESRF	17	18
	European XFEL	7.5	15.5 [1]
	European Spallation Source ERIC (ESS)	58.5	50 + *32* [2]
	ILL (2014-2018)	6.5	-
	Mesures d'accompagnement	12	12
somme		**344.5**	**388.5**
IFO nouvelles *messages FRI 17-20 / CTA*	ILL (2019-2023) [3]	6.5	8.5
	CTA [4]	*2.5*	*10*
somme		344.5 + 9 = **353.5**	388.5 + 21 = **409.5**
IFO nouvelles *message FRI 21-24*	ILL (2024-2028) [5]		*2.5*
	SKA	-	*9*
	ELI [7]	-	*0* [6]
	LBNF-DUNE	-	*0* [6]
	Demandes de gestes spéciaux du CERN	-	*0* [6]
somme		**353.5**	409.5 +9 = **418.5**
IFO « CH-UE » *messages UE 14-20 / 21-27*	ITER/Fusion for Energy	78.5	*29* + *110* [8]
Impact sur le domaine formation et recherche		353.5 + 78.5 = **432**	418.5 + 139 = **557.5**

[1] Dès 2023, les contributions de la Suisse à European XFEL seront indexées à l'utilisation – intensive – de l'infrastructure par les chercheurs suisses durant les années antérieures, ce qui laisse augurer d'une augmentation de ces contributions.

[2] *Estimation* des éventuelles contributions de la Suisse aux coûts additionnels durant la période 2021-2024.

[3] La participation de la Suisse aux IFO n'est en général pas limitée dans le temps, sauf pour l'ILL. Dans ce cas la Suisse prend des engagements de 5 ans qui doivent être activement renouvelés à chaque échéance. Ainsi, chaque participation de 5 ans à l'ILL (ILL 2014-2018, ILL 2019-2023, ILL 2024-2028) peut être considérée sous l'angle légal comme une participation spécifique à une IFO. Les conditions de participation de la Suisse à « ILL 2019-2023 » ont été négociées en 2018 par le SEFRI.

[4] En raison du retard pris par le démarrage de la construction de CTA, il est prévu de payer seulement 2.5 millions de francs sur la période 2017-2020 au lieu des 8 millions de francs alloués via les décisions découlant de l'examen du message FRI 2017-2020.

[5] Un retrait progressif d'ILL est prévu. Toutefois, la décision concernant la poursuite et l'ampleur de la participation suisse à « ILL 2024-2028 » devra tenir compte des retards pris par la construction de European Spallation Source ERIC d'une part et les besoins des chercheurs suisses d'accéder à des sources de faisceaux de neutrons de qualité d'autre part.

[6] Les contributions éventuelles de la Suisse n'affectent pas le budget FRI sur la période 2021-2024. Le SEFRI envisage toutefois une contribution fédérale aux activités du CERN en soutien à l'infrastructure LBNF-DUNE, qui sera financée par des fonds dont la Suisse dispose déjà auprès du CERN.

[7] La description d'ELI se trouve à l'annexe B1 avec les organisations ayant fait l'objet d'une prise de position du FNS.

[8] Aucun engagement contraignant n'a encore été pris quant à la poursuite des contributions financières de la Suisse à l'UE dans le contexte d'ITER/Fusion for Energy au-delà de 2020. Les contributions estimées pour la période 2021-2024 se partagent entre un terme d'ores et déjà prévu (29 CHF mio) et un autre terme découlant des coûts additionnels liés au retard pris par la construction d'ITER (110 CHF mio).

La Suisse examine durant la période actuelle une éventuelle participation (pas forcément sous la forme d'une affiliation à l'organisation) aux organisations suivantes :

- CTA: Cherenkov Telescope Array
- SKA: Square Kilometre Array
- LBNF-DUNE: Long-Baseline Neutrino Facility/Deep Underground Neutrino Experiments
- ELI[75]: Extreme Light Infrastructure

Remarques importantes:

1) **Les chiffres financiers mentionnés dans le présent document pour les périodes FRI 2021–2024 et 2025–2028 sont des données prévisionnelles et sont indiqués uniquement à titre d'estimation grossière des coûts probables à venir et de leur répartition.**
2) **Dernière mise à jour des informations : juillet 2018**

[75] La description d'ELI se trouve à l'annexe B1 avec les organisations ayant fait l'objet d'une prise de position du FNS.

European Organization for Nuclear Research (CERN)

Description

The European Organisation for Nuclear Research (CERN, https://home.cern/) in Geneva, which was founded in 1953, provides the platform for cooperation between European states for exclusively peaceful purposes in the field of nuclear and particle physics and promotes leading research in high-energy physics with its purpose-built particle accelerators and detectors.

The Proton Synchrotron PS and Super Proton Synchrotron SPS are world-class particle accelerators used for research. In 2009, the Large Hadron Collider (LHC) has been put into operation. The LHC was built in the same ring tunnel that formerly was used to house the Large Electron-Positron Collider (LEP). By the time it was decommissioned at the end of 2000, the LEP had made a lasting contribution to the scientific knowledge of elementary particles. Since 2006, CERN has broadened its field of activity to include neutrino physics. This has enabled research on CERN-produced neutrinos to be carried out inside large underground detectors at the Gran Sasso Laboratory in Italy.

The 22 member states of CERN are Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Israel, Italy, the Netherlands, Norway, Poland, Portugal, Romania, Sweden, Switzerland, Slovakia, Spain, and the United Kingdom.

CERN is located on the Swiss-French border near Geneva and employs approximately 2,500 people on a permanent basis, who together with about 12,000 visiting researchers per year from all around the world advance scientific knowledge in the field of nuclear and particle physics. In the some 60 years of its existence CERN has been a leading force in all the major discoveries concerning the composition of matter. It conducts research into the question both of the origin and nature of the basic building blocks of matter and the forces that hold them together. The discovery of the Higgs particle at CERN was recognised with the Nobel Prize for physics in 2013.

National relevance

Swiss researchers from 12 institutes representing all universities are active in CERN experiments, primarily in the fields of particle physics (high energetic collisions, neutrinos, astroparticles, matter/antimatter), medicine and technological research (electronics, materials). Great importance is also attached to technology transfers to Swiss industry. Swiss universities are heavily involved in the development and expansion of the CERN infrastructure, including the construction of the large detectors ATLAS, CMS and LHCb for the LHC. This has called for an important financial and scientific commitment, particularly from the universities of Basel, Bern, Geneva, Lausanne and Zurich as well as the Federal Institutes of Technology (ETH) in Zurich and Lausanne. The latter is also involved in the luminosity upgrade of the LHC (HL-LHC) that will be commissioned by 2026. The Paul Scherrer Institute, the university of Geneva and the ETH of Zurich and Lausanne signed in 2018 a collaboration agreement with the CERN for R&D work mainly in the field of high-field superconducting magnet design and circular collider design in view of a Future Circular Collider (FCC). Depending on the European Strategy for Particle Physics, to be updated by 2020, the FCC could be the next big accelerator built at CERN.

CERN employs around 200 Swiss researchers, engineers, technicians and business people, trainees and students at its facilities. CERN is also an attractive economic partner for Switzerland: more than three times the amount of Switzerland's annual contribution to CERN is recouped in the form of contracts for the Swiss industrial and services sectors.

Switzerland finances around 4% of CERN's annual overall budget. Responsibility for Switzerland's contribution to CERN rests with SERI.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~4500 Mio CHF	Swiss Confederation: ~181 Mio CHF	~4600 Mio CHF	Swiss Confederation: ~189 Mio CHF	~4700 Mio CHF	Swiss Confederation: ~200 Mio CHF

* The Swiss part of the global funding constitutes its membership contributions.

European Southern Observatory (ESO)

Description

ESO, the European Southern Observatory (https://www.eso.org), is the foremost intergovernmental astronomy organisation in Europe and the world's most productive astronomical observatory. ESO provides state-of-the-art research facilities to astronomers.

The 16 member states of ESO are Austria, Belgium, the Czech Republic, Denmark, Finland, France, Germany, Italy, Ireland, the Netherlands, Poland, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Several other countries have expressed an interest in membership. Australia has concluded a partnership agreement with ESO, whereas Chile acts as the host state of ESO.

ESO's main mission, laid down in the 1962 Convention, is to provide state-of-the-art research facilities to astronomers and astrophysicists, allowing them to conduct front-line science in the best conditions. ESO employs around 700 staff members. By building and operating a suite of the world's most powerful ground-based astronomical telescopes enabling important scientific discoveries, ESO offers numerous possibilities for technology spin-off and transfer, together with high technology contract opportunities.

The ESO Headquarters (comprising the scientific, technical and administrative centre of the organisation) are located in Garching near Munich, Germany. In Chile, ESO operates the Santiago Centre as well as three unique observing sites: La Silla, Paranal and Chajnantor. At the La Silla Paranal Observatory in Chile, the ESO operates an array of the world's most advanced telescopes, including the Very Large Telescope (VLT). Furthermore, the ESO represents its members within the international Atacama Large Millimetre Array (ALMA) project - a network of 64 radio telescopes, each with a diameter of 7-12 metres, located on the Chajnantor Plateau at an altitude of 5’100 m. ALMA was inaugurated as a partnership with North America and Japan in 2013, although the first scientific observations had already begun in 2011 using part of the facility.

Since 2005 ESO has been working with its community and industry to develop an extremely large optical/infrared telescope. Dubbed ELT for Extremely Large Telescope, this revolutionary new ground-based tele-scope concept will have a 39-metre main mirror and will be the largest optical/near-infrared telescope in the world. The ELT programme was approved in 2012 and green light for construction was given at the end of 2014. First light is targeted for 2025.

National relevance

ESO telescopes provide the data for many results and breakthroughs in astronomy, and lead to a large number of scientific publications each year. Astronomers use these state-of-the-art observatories to study objects from within our Solar System to the farthest reaches of the Universe.

With two scientific papers being published every day, the ESO Observatories are in fact the most productive ground-based astronomical facilities in the world.

Swiss membership to the ESO provides Swiss astronomy researchers with access to the entire ESO infrastructure.

Thanks to the outstanding quality of the Swiss astronomy institutes (Bern, Geneva, Lausanne and Zurich), which are able to make the most of Swiss participation in the ESO (and the ESA in the field of space astronomy), Swiss astrophysics research enjoys a strong international reputation.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~862 Mio EUR	Swiss Confederation: ~38 Mio CHF	~950 Mio EUR	Swiss Confederation: ~45.5 M CHF	~1000 Mio EUR	Swiss Confederation: ~50 Mio CHF

* The Swiss represents its membership contribution and contributions to ELT (Extremely Large Telescope).

European Synchrotron Radiation Facility (ESRF)

Description

The ESRF (https://www.esrf.eu/) is one of the world's largest synchrotron science centres. Every year, 7000 scientists from 22 partner countries and from around the world travel to Grenoble to use ESRF's extremely brilliant X-rays for leading-edge research activities. ESRF operates 44 beamlines exploiting the full range of X-rays related experimental techniques and provides its user a large scope of services. Since 2017, the organization also operates a high-end cryoelectron microscope.

The 13 States that are parties to the ESRF Convention are France, Germany, Italy, United Kingdom, Russia, Belgium, the Netherlands, Denmark, Finland, Norway, Sweden, Spain and Switzerland. In addition, Austria, Israel, Czech Republic, Hungary, Poland, Portugal, India and South Africa have concluded time-limited partnerships with ESRF.

ESRF scientific output includes more than 1800 scientific publications per year, of which more than 300 in high-impact journals, ranging over a broad spectrum of research areas, such as hard and soft condensed matter science, applied material science, chemistry, structural biology, medicine, Earth and environmental sciences, cultural heritage. Moreover, ESRF conducts its own research on synchrotron physics, synchrotron methods and instrumentations, and soft matter structure.

ESRF is in operation since 1992. After 20 years of success and scientific excellence, the ESRF, the world's first third-generation light source, has embarked upon an ambitious and innovative modernisation project – the Upgrade Programme, which aims at maintaining ESRF's world-leading role through a continuous quest for higher performance figures, meeting the needs of returning users, and attracting scientists from new disciplines. After the successful delivery of the first phase of this programme in the period 2009-2015, the ESRF launched, in May 2015, the ESRF – Extremely Brilliant Source (ESRF – EBS) project. The ESRF-EBS project was highlighted as an ESFRI landmark in the 2016 ESFRI roadmap.

ESRF-EBS represents an investment of 150 M€ over the period 2015-2022. The principal aim of this project is to construct and commission the new 844m circumference ESRF-EBS storage ring. About 90% of the existing infrastructure will be re-used, and the new ESRF-EBS design has been conceived with greatly improved energy efficiency, reducing electricity costs by 20%. With performances multiplied by 100 in terms of brilliance and coherence, this new source of synchrotron radiation will offer unprecedented tools for the exploration of matter and for the understanding of life at the macromolecular level.

National relevance

ESRF is one of the leading world-class synchrotron radiation facility providing unique beam characteristics and instruments. Swiss researchers from over 20 institutes and research centres use circa 4% of the ESRF available beamtime for their investigations and experiments. The vigorous Swiss use of the ESRF attests the complementarity for Swiss researchers of the access to the ESRF with the availability of the Swiss Light Source (SLS) at the Paul Scherrer Institute (PSI).

Synergies between ESRF and SLS shall be leveraged as the ESRF will undergo in 2019 and 2020 a 21 months long shut down in the context of the EBS upgrade, as well as during the foreseen shut down of the SLS due to the coming implementation of the upgrade SLS 2.0.

During the construction, the operation and the upgrade of the ESRF, Swiss industry delivered several high-technology components and systems to the site in Grenoble. Over the period jan. 2015 to sept. 2018, the value of contracts going to Swiss industry for operations, maintenance and upgrades at the ESRF corresponds to around 51% of the contribution that Switzerland makes to the ESRF's total budget (three year average). Switzerland is one of the ESRF member with the highest industrial return. This return is expected to significantly increase in 2019 in the context of the procurement of X-rays detectors for EBS-upgrade.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss**
~340 Mio EUR	Swiss Confederation: ~17 Mio CHF	~370 Mio EUR	Swiss Confederation: ~18 Mio CHF	~400 Mio EUR	Swiss Confederation: ~20 Mio CHF

* Membership contributions and contributions to EBS upgrade program.
** Membership contributions

Development phases

Design	Preparation	Implementation	Operation
1977-1987	1987-1989	1988-1992	1992-

Institut Laue-Langevin (ILL)

Description

Since its inception in 1967, the Institut Laue - Langevin (ILL, https://www.ill.eu/) has sought to become the most reliable neutron source for research and studies in the fields of material sciences, solid-state physics, chemistry, crystallography, molecular biology as well as nuclear and fundamental physics.

Owing to its high-flux reactor, which became operational in 1971, ILL operates one of the most intense neutron sources in the world, feeding some 40 experimental stations. Thanks to its outstanding infrastructure, the ILL has positioned itself at the forefront of neutron research. Every year several hundred scientists carry out their experiments and measurements at this unique research facility in Grenoble.

The 3 states that are parties to the ILL protocol are France, Germany and the United Kingdom. Italy, Spain, Switzerland, Poland Austria, the Czech Republic, Hungary, Slovakia, Belgium, Denmark and Sweden have concluded time-limited partnerships with ILL.

With a total staff of almost 500, ILL's operations costs reach approximately EUR 90 million a year. Since ILL is a nuclear facility it is obliged to comply with heightened security requirements since the Fukushima accident, and in an industrial environment that has become generally difficult. Operating the facility has therefore become tougher but the fundamental importance of the services it supplies for research throughout the world amply justify the efforts of its members and associates.

In order to ensure its leading position in world neutron science and further increase the performance of its infrastructure, ILL has been going through an upgrade process since 2001 which is being carried out in two phases. The first, Millennium, which was completed in 2015, involved the installation of 14 new or completely overhauled instruments, including replacement of the neutron sources, enabling the multiplication of the rate of detection by a factor of 24. The second phase, Endurance, is being carried out in stages since 2015. It is expected to enable the installation of seven new instruments and the updating of four existing ones.

National relevance

Switzerland's scientific partnership in ILL is based on a time-limited partnership agreement signed in 1988 which was extended by five years in 1993, 1998, 2004, 2008, and 2014. Switzerland is thus participating for a seventh five-year period (2019-2023) in this institute at the leading edge of world research into neutron diffusion. Its annual contribution in 2019 is CHF 3.2 million, representing 2.4% of ILL's budget, which determines the rate of utilisation of the facility for Swiss researchers. The State Secretariat for Education, Research and Innovation (SERI) is responsible for Switzerland's participation in ILL. The use and maintenance of ILL infrastructure creates substantial orders for Swiss industry. The Swiss Industry Liaison Office is responsible for promoting relations between Swiss companies and ILL.

See also the page on European Spallation Source ERIC (ESS) in Annex B2 for more information on neutron sources.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~390 Mio EUR	Swiss Confederation: ~13 Mio CHF	~400 Mio EUR	Swiss Confederation: ~8.5 Mio CHF	~410 Mio EUR	Swiss Confederation: ~2.5 Mio CHF

* Scientific membership contributions (see also table at the beginning of Annex B2).

European X-Ray Free Electron Laser (European XFEL)

Description

In the 3.4 km long tunnels of European XFEL (https://www.xfel.eu), extremely intense X-ray flashes are generated. With its special characteristics of ultrashort pulses and ultrahigh brilliance, the European XFEL offers com-pletely new opportunities in many areas of research. Therefore, the relevant Swiss partners and stakeholder are diverse. They come from public funded research (e.g. PSI) as well as from industry (e.g. pharma).

The 11 States that are parties to the European XFEL Convention are France, Germany, Italy, United Kingdom, Russia, Denmark, Poland, Sweden, Slovakia, Hungary and Switzerland.

The goal of the RI is to offer new opportunities to top researchers from many areas and to enable excellent and cutting edge research experiments.

The RI was inaugurated in September 2017. Initially, only one beamline alimenting two instruments (SPB/SFX and FXE) was functional. In 2018, an additional beamline alimenting two instruments (SCS and SQS) has opened. In 2019, a third beamline alimenting two additional instruments (HED and MID) will become functional.

National relevance

Besides the purely scientific interest (covering many fields: physics, structural biology, material sciences, etc.), European XFEL is very relevant for Switzerland because of its complementarity with SwissFEL, which is also a free electron laser that was built lately at Paul Scherrer Institute. During the planning and construction phase, SwissFEL has largerly profited from the expertise of European XFEL and vice versa. There is an ongoing exchange between both infrastructures.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss**	Global	Swiss**
~542 Mio EUR	Swiss Confederation: ~7.5 Mio CHF	~600 Mio EUR	Swiss Confederation: ~15.5 Mio CHF	~650 Mio EUR	Swiss Confederation: ~11 Mio CHF

* Construction and operation
** Operation

Development phases

Design	Preparation	Implementation	Operation
Before 2005	2005-2009	2009-2019	2017-

European Spallation Source ERIC (ESS)

Description

The European Spallation Source ERIC (ESS, https://europeanspallationsource.se/) in Lund (Sweden) is a research facility under construction that will produce long pulses of neutron radiation with very high intensity. In contrast to X-rays normally used in materials research, neutrons do not interact with the layer of electrons of the atoms of the materials under investigation. For this reason it enables research into the structure and dynamics of materials at the molecular and atom scale that is not possible with X-rays.

ESS will be the most powerful source of neutrons in the world and as such will offer unique opportunities for cutting-edge research into both applied and basic fields of research. Whether the aim is to probe the molecular composition of the materials of archaeological artefacts or of metal construction parts, analyse biomolecular processes, understand the electronic structure and dynamics of new superconductors, or identify the basic causes of parity violation in elementary particle physics, ESS will make it possible to make new discoveries and technological progress in these and other fields of research.

The 13 States that are members of European Spallation Source ERIC are France, Germany, Italy, United Kingdom, Denmark, Sweden, Norway, Estonia, Hungary, Poland, Czech Republic, Spain and Switzerland. Construction of the facility began at the beginning of 2014. The costs of construction and operations of ESS until 2026 are expected to amount to some EUR 2.74 billion, of which EUR 1.83 billion will be spent on building (at 2013 prices). Operations are planned to start in 2019 and be in full operation as from 2026 with annual costs of approximately EUR 140 million.

In contrast to the traditional sources of neutrons, the neutrons at ESS are not produced through splitting atoms in a reactor, but through firing metal (Wolfram) with protons (‘spallation'). Both in terms of the new technology and performance data, ESS enters new territory and will become by far the most powerful source of neutrons in the world.

Neutron sources are already in operation in the US, including HFIR (reactor) and SNS (spallation), in Japan with JPARC (spallation), Germany, with e.g. FRM II and BER II (reactors), France with ILL (reactor) as well as Switzerland with SINQ (spallation). Owing to its higher performance by several orders of magnitude, ESS will complement these facilities: the newly accessible research fields accessible through ESS cannot be processed at the existing neutron source facilities.

National relevance

Switzerland has been involved in the planning of ESS and the construction work from the outset and will continue to take an active part in its operation. With the federal decree of 20 March 2015 on Switzerland's participation in ESS-ERIC, the Federal Assembly approved a total of CHF 130 million until 2026, corresponding to approximately 3.5% of construction and operation costs. Swiss researchers and institutions, such as the PSI and EPFL, have already been prominent in the ESS planning phase and will continue to be actively involved in the future.

Switzerland's involvement in ESS complements the investments in existing neutron source facilities both at the national level (SINQ) and international level (ILL), as a result of which Swiss researchers are ensured the best possible access to such leading research centres.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~1200 Mio EUR	Swiss Confederation: ~58.5 Mio CHF	~700 Mio EUR	Swiss Confederation: ~82 Mio CHF	~600 Mio EUR	Swiss Confederation: ~30 Mio CHF

* Membership contributions

Development phases

Design	Preparation	Implementation	Operation
Till 2011	2011-2015	2015-2026	2023-

European Molecular Biology Laboratory (EMBL)

Description

EMBL (https://www.embl.de) was set up in 1974 in order to promote molecular biology across Europe, and to create a centre of excellence for Europe's leading young molecular biologists. To accomplish this, EMBL has pursued five major missions:

- Basic research in molecular biology: Through its past and current Scientific Programmes, EMBL has developed an integrative, interdisciplinary structure that is ideally suited to tackle the challenge that lies ahead for the Life Sciences: understanding complex biological systems.

- Technology and instrumentations: Instrument and technology development have a long history at EMBL. Some of the first experiments carried out in the Laboratory involved the adaptation of radiation from a synchrotron source for use with biological material. Other areas of instrument development include DNA sequencing, cell fractionation, light and electron microscopy methods, mass spectrometry of proteins, X-ray imaging plates, synchrotron beam-lines and automated cell micro injectors.

- Facilities and services: EMBL provides various biological databases run by the European Bioinformatics Institute in Hinxton. Millions of users consult these databases each year, seeking information on DNA sequences, protein structures, gene expression profiles, human genetic polymorphism or comparative analyses of entire genomes. At two of its sites, Hamburg and Grenoble, EMBL provides access to world-leading sources of X-ray and neutron radiation. The Advanced Light Microscopy Facility (ALMF) of EMBL in Heidelberg is the centre of a series of national nodes throughout Europe that allow real time imaging of molecular and cellular events. Other, smaller facilities include mass spectrometers, microarray systems, electron microscopes, DNA sequencing and protein production instruments.

- Teaching and training: The multifaceted training programme of EMBL is world-renowned and makes the Laboratory a true meeting place for biologists in Europe. In addition EMBL, often in collaboration with its sister organisation EMBC, organises multiple training courses, workshops and symposia every year for life scientists and wider audience. .

- Technology transfer: EMBL is actively engaged in developing its discoveries to benefit society. EMBL Enterprise Management Technology Transfer GmbH (EMBLEM, established in 1999) is an affiliate and the commercial arm of the European Molecular Biology Laboratory. EMBLEM facilitates and accelerates the transfer of innovative technology from basic research to industry (spanning the pharmaceutical, biotech, ITC and mechanical/electrical engineering markets).

The 25 member states of EMBL are Austria, Belgium, the Czech Republic, Croatia, Denmark, Finland, France, Germany, Greece, Hungary, Island, Israel, Italy, Ireland, Luxembourg, Malta, Montenegro, the Netherlands, Norway, Portugal, Spain, Slovakia, Sweden, Switzerland and the United Kingdom. Australia and Argentina have concluded an association agreement with EMBL.

National partners/stakeholders: all Swiss universities and institutions active in the field of the organisation, young researchers that would want to work at EMBL.

National relevance

EMBL is a unique and powerful hub for R&D in continental Europe from which the latest research and technologies can dissipate with unmatched efficiency to the Swiss life science and medical research communities. Notably, this efficiency depends also on proactive networking behavior of the researchers in Switzerland.

Funding (including the Swiss participation in EMBL's sister organization EMBC)

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~450 Mio EUR	Swiss Confederation: ~24 Mio CHF	~500 Mio EUR	Swiss Confederation: ~26.5 Mio CHF	~550 Mio EUR	Swiss Confederation: ~34 Mio CHF

* Membership contributions

European Life Science Infrastructure for Biological Information (ELIXIR)

Description

The goal of ELIXIR (https://www.elixir-europe.org) is to coordinate resources such as databases, software tools, training materials, cloud storage, and supercomputers so that they form a single infrastructure. This infrastructure, funded in 2014, makes it easier for scientists to find and share data, exchange expertise, and agree on best practices. Ultimately, it will help them gain new insights into how living organisms work.

ELIXIR's Compute Platform is creating a network of supercomputer services that is making it easier for researchers to manage the huge increase in life science data. It enables researchers across Europe to use existing facilities to store, transfer and analyse large datasets. The Data Platform is establishing quality criteria and markers for datasets. ELIXIR can deal with the increasing complexity of data that exists in a wide range of formats and descriptions. ELIXIR's Interoperability Platform is finding ways to standardise data saving and description and the Training Platform is running courses on dealing with large and complex data sets.

ELIXIR is needed to build a more robust bioinformatics infrastructure. Bioinformatics is a discipline that uses computer programmes to gain insights from large data sets, particularly data from gene sequencers. ELIXIR promotes an exchange of knowledge and support around Europe so that smaller bioinformatics resources can grow and join a pan-European infrastructure. This makes new data sets available to researchers across Europe.

Handling and analysing the massive amounts of data now generated in life science often takes more resources than agri-business and biotech firms have. One solution is to collaborate with public services like ELIXIR. ELIXIR runs an industry programme that promotes these collaborations across the globe. It will stimulate innovations in biotechnology and pharmaceutical industries, as well as in agricultural and environmental research.

The 22 members of ELIXIR are Belgium, the Czech Republic, Denmark, EMBL[76], Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Slovenia, Sweden, Switzerland and the United Kingdom.

National partners/stakeholders are organised within the National Node coordinated by SIB.

National relevance

ELIXIR provides the national and international life science community with a state-of-the-art bioinformatics infrastructure, including resources, expertise and services.

ELIXIR federates world-class researchers and delivers training in bioinformatics.

SIB as the national node plays an important role nationally and internationally.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss*	Global	Swiss*
~26 Mio EUR (hub budget)	Swiss Confederation: ~1.1 Mio CHF (contribution to hub)	~30 Mio EUR (hub budget)	Swiss Confederation: ~1.5 Mio CHF (contribution to hub)	~33 Mio EUR (hub budget)	Swiss Confederation: ~1.7 Mio CHF (contribution to hub)

* Contribution towards the ELIXIR Hub in UK

Development phases

Design	Preparation	Implementation	Operation
2007-2010	2011-2013	2014-2018	From 2019

[76] European Molecular Biology Laboratory.

International Experimental Fusion Reactor (ITER)

Description

ITER (https://www.iter.org/) is a cooperation project launched through an international treaty signed in in 2006 to build the ITER fusion reactor in Cadarache (France). ITER is expected to facilitate the final developmental step from experimental nuclear fusion to the delivery of fusion electricity to the grid. Being the largest tokamak ever built and employing superconducting technologies for magnetic confinement, ITER has the following goals:

1) To produce 500 MW of fusion power out of 50 MW of input heating power, reaching a tenfold return on energy (Q=10).

2) To demonstrate the integrated operation of technologies for a fusion power plant, bridging the gap between today's smaller-scale experimental fusion devices and the demonstration fusion power plants of the future.

3) To achieve a deuterium-tritium plasma in which the reaction is primarily sustained through internal heating, i.e. to sustain a “burning plasma”.

4) To test methodologies to produce inside the vacuum vessel the tritium that is required by the fusion reaction and test mockup in-vessel tritium breeding blankets.

5) To demonstrate the safety characteristics of a fusion device.

According to the new baseline, adopted ad referendum by the ITER members in 2016, the most important milestones of ITER are i) the achievement of a first non-nuclear plasma in 2025 and ii) the start of decisive nuclear deuterium-tritium experiments in 2035.

ITER Organization (IO) is the international organization responsible of the construction, operation, de-activation and dismantling of the ITER fusion reactor. Its members are China, India, Japan, South Korea, USA and the EU. Each member bears 9% of the ITER costs, except for the EU, which bears 45% as ITER Host Party. Each member set up a domestic agency dedicated to the delivery of its contribution to ITER.

Based in Barcelona, Fusion for Energy (F4E) is the EU domestic agency responsible for the delivery of the European contribution to ITER. Established in 2007, the European Joint Undertaking for ITER and the Development of Fusion Energy, known as Fusion for Energy (F4E), is the EU domestic agency responsible for the preparation and the delivery of the EU contribution to ITER. It is also responsible for the EU contribution to the Broader Approach, a collaboration with Japan aiming at complementing the ITER project and accelerating the realisation of fusion energy through R&D and advanced technologies for future demonstration fusion power reactors (DEMO).

F4E members are Euratom (represented by the European Commission), the 28 EU Member States and Switzerland. Switzerland participates therefore to the construction of ITER, through F4E. Switzerland is represented by the EU in the governance of IO, as all the EU Member States are.

National relevance

The realization of ITER is currently the worldwide cornerstone of fusion research, combining all efforts to assemble the worldwide flagship tokamak. Several other fusion devices contribute to ITER preparation and shall complement its results to tackle the next steps toward industrial fusion energy. This includes a few tokamaks (JET, JT-60 SA, MAST, AUG, TCV), a stellarator (W7-X), an experimental reactor (JHR), and fusion materials irradiation test facilities (IFMIF-EVEDA and IFMIF-DONES).

European fusion research activities are also focused on ITER, both through F4E activities and the implementation of the European Fusion Electricity Roadmap in the frame of the Euratom fusion research programme. As Swiss academic institutions that are active in fusion research are themselves strongly aligned on international multilateral research collaborations instruments. IO, F4E and Euratom fusion research programme currently play a central role for Swiss fusion research and will continue doing so during several decades.

Conversely, Swiss fusion research institutions provide specific and worldly recognized high-end competence. The Swiss national competence center for fusion research, the Swiss Plasma Center (SPC) based at EPFL, operates one of the three most important medium-sized tokamaks in Europe, the so-called TCV[77]. This device is key to fusion research to study plasma geometry, which is of first relevance to ITER. Amongst many activities, the SPC is involved in the design of ITER heating systems, as well as responsible for testing all ITER superconducting cables using its SULTAN device at the Paul Scherrer Institute. The University of Basel is collaborating with F4E and IO to study plasma wall interaction in fusion devices. The Swiss high-tech industry is also involved in F4E and IO activities. Swiss companies are designing, producing and delivering substantial components of ITER, such as high voltage power supply units, vacuum elements, cryogenic installation as well as various services.

The participation of Swiss private and public institutions in the ITER construction generates an interesting industrial return. Over the period 2007-2017 the estimated industrial return reaches 135 MCHF, i.e. 85% of the 159 MCHF Switzerland invested so far in ITER.

Funding

2017-2020		2021-2024		2025-2028	
Global	Swiss*	Global	Swiss**	Global	Swiss**
2561 Mio EUR	Swiss Confederation: 78.5 Mio CHF	4524 Mio EUR	Swiss Confederation: 139 Mio CHF	3415 Mio EUR	Swiss Confederation: 104.7 Mio CHF

* Membership contributions to F4E Joint Fund and contributions over Euratom.
** Membership contributions to F4E Joint Fund and further contributions to be renegotiated.

Development phases

Design	Preparation	Implementation	Operation
N/A	N/A	2007-2025	2026-2037

[77] For more details see the description of the Swiss Plasma Center (SPC) in the Annex A2.

Cherenkov Telescope Array (CTA)

Description

The CTA Observatory (http://cta-observatory.org) will be the ultimate generation of high-energy gamma-ray observatory. Up to 118 dedicated Cherenkov telescopes of three different sizes will be deployed on two sites: one on the ESO site of Paranal (Chile) and one on the Island of La Palma (Spain). CTA will be run as a European Research Infrastructure Consortium (ERIC) with Headquarter in Bologna (Italy) and a Data Management Science Center (SDMC) in Zeuthen (Germany). The Key Science Cases will be exploited by a Consortium of more than 200 research institutions in 31 countries with about 1420 members. The data, which will be distributed by the SDMC, will be open access and scientists will be able to request observation time through a competitive time allocation process.

Building up the full array should cost about 400 Million EUR, but future member states of CTAO ERIC agreed to start with the construction as soon as a threshold of 250 Million EUR is secured. This step should be reached in 2019. Full operation should not be reached until 2025. Contributions to the construction of CTA shall largely be in-kind, allowing research institutions to get involved in the conception of instrumentation and delivering benefits to industry among member states. It is foreseen to operate CTA for at least 30 years. CTA represents also a computing challenge: the total volume of data to be managed by the Observatory archive will be of the order of 25 PB per year.

Images of gamma-ray sources will be reconstructed from the collection of many shower events on the camera planes of the CTA telescopes. Atmospheric showers are the result of the interactions of gamma-rays from sources in the atmosphere, namely CTA exploits an Imaging Atmospheric Cherenkov Technique (IACT), turning the Earth atmosphere into a detector. With these tools, CTA aims at detecting high-energy gamma-rays between about 20 GeV to 300 TeV from cosmic sources. It will be sensitive to the most powerful accelerators in the universe within a distance exceeding by far the remits of our galaxy. CTA aims notably at understanding how black holes and pulsars function. CTA will be at the center of multi-wavelength and multi-messenger programs with observatories in other electromagnetic bands and using gravitational waves and high-energy neutrinos. For these reasons, CTA has the unique potential to offer a fertile ground of collaboration to the particle physics and the astrophysics communities around the world. It will also offer to the growing astroparticle physics community a proper global intergovernmental research organization of structure and stability comparable to CERN or ESO.

CTA is highlighted as a priority in the European Astroparticle Physics Strategy 2017-2026 of APPEC (http://www.appec.org/roadmap). It is also acknowledged as an ESFRI Landmark in the 2018 update of the European Strategy Forum of Research Infrastructures (ESFRI) Roadmap.

National relevance

For the moment, the activity around CTA in Switzerland is mainly driven by scientists coming from the particle physics. For instance, Prof. Straumann (University of Zurich) was Managing Director of the precursor international company CTA GmbH from 2016 till 2017 and Prof. Montaruli (University of Geneva) has been coordinating the development of one of the CTA proposed telescope, the so called single-mirror SST-1M. Prof. Biland (ETHZ) has also taken part to multiple panels to review CTA and has been operating a demonstrator, called FACT, for the new sensor technology employed by all SST prototypes, the Silicon PhotoMultipliers (SiPMs). Dr. Walter's group (University of Geneva) covers coordinating positions in the software control of telescope and data working packages. CTA, as precursor of the Big Data in Astronomy, may pave the way to bigger challenges such as Square Kilometre Array (SKA), possibly bringing the Swiss National Supercomputing Centre complementing efforts in Geneva (CDCI)[78].

The scientific relevance of CTA for Switzerland and the world is enormous, in the data frame and analysis techniques, including machine learning and modern imaging techniques, and to set contacts with specialized industries which could participate to the construction of telescopes. In the coming future,

[78] For more details see the description of the Common Data Center for Astronomy, Astroparticle and Cosmology (CDCI) in the Annex A2

Swiss Institutions involved in CTA will be heavily involved in the construction and testing of telescope elements trying to cooperate at most with local industry.

A funding line of 8 Million CHF has been reserved in the ERI Dispatch 2017-2020 so as to pave the way towards the accession of Switzerland to the CTAO ERIC. Sharing of contributions isn't settled yet though. SERI participates in ongoing negotiations towards the establishment of CTAO ERIC with the other expected future Member states and organisations (DE, FR, IT, UK, SL, CZ, PL, ES, JP, TH, ESO).

Development phases

Design	Preparation	Implementation	Operation
2012-2016	2017-2020	2021-2024	2025-2028ff

Square Kilometer Array (SKA)

Description

Description

The SKA (https://www.skatelescope.org/) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development when it comes to the observation of the Universe at radio-wavelength (from centimetres to metres). The SKA will eventually use thousands of dishes (in South-Africa and nearby countries) and up to a million low-frequency antennas (in Western Australia). It will be run as an intergovernmental research organization with Headquarter in Jodrell Bank, close to Manchester (UK).

Building up the full SKA should cost a few Billion EUR. However, the SKA will be built in two main phases. The first phase (SKA1) will involve testing the full system in a "proof of concept" manner. For SKA1, Australia will host the low-frequency instrument with more than 500 stations, each containing 256 individual antennas, whilst South Africa will host an array of some 200 dishes, incorporating the 64-dish MeerKAT precursor array (in operation since July 2018). The cost of SKA1 has been capped at 650 Million EUR in 2013 value. Its construction should start in mid-2020 and its full operation should not be reached until 2025. The second phase (SKA2) is still under discussion. It will complete the telescope arrays at both sites so that SKA can operate some 2000 high and mid frequency dishes and aperture arrays and a million low-frequency antennas. Already SKA1 will be a huge "big-data" challenge: the total volume to be managed by the Observatory archive will be of the order of 300 PB per year. Very high-performance central supercomputers capable of more than 100 petaflops of raw processing power will be required, stretching technology to its absolute limits.

SKA will enable astronomers to monitor the sky in unprecedented sensitivity (10x to 100x more sensitive than current facilities) and survey the entire sky much faster (100x to 10'000x) than any observatory currently in existence. Its unique configuration will give the SKA unrivalled scope in observations, largely exceeding the image resolution quality of the Hubble Space Telescope, but at radio-wavelength. SKA will also offer to the growing radio-astronomy community a proper global intergovernmental research organization of structure and stability comparable to CERN or ESO.

SKA is acknowledged as an ESFRI Landmark since the 2016 update of the European Strategy Forum of Research Infrastructures (ESFRI) Roadmap. On 12th March 2019, representatives of UK, ZA, AU, IT, NL and PT signed the treaty that aims at establishing SKA as an intergovernmental organization. Ratification of the treaty by at least five signatories is required for this establishment to take place.

National relevance

Radio-Astronomy in Switzerland existed for a number of decades, through observations conducted at the Bleien Radio Observatory. Since its beginning in 1979, the radio observations mainly focused on the observation of the Solar flares. A growing number of Swiss astrophysicists and cosmologists are now very active in radio-astronomy. They are using the ALMA millimetre radio-interferometer in the context of the Swiss membership in ESO and are also collaborating with other scientists involved in various precursors of SKA. However, the Swiss interest in SKA is going much beyond the fundamental astrophysics questions, as SKA addresses many engineering challenges for which Switzerland developed internationally renowned expertise, for instance in reliable and precise atomic clocks and timing transport technologies which reside at the heart of SKA. With the Swiss National Supercomputer Center in Lugano, Switzerland has leading worldwide expertise in high-performance computing and could efficiently participate in the SKA "big-data" challenge. A joint EPFL-IBM Research Zurich initiative on alternative algorithms useful to SKA started five years ago and is about to publish their findings.

In the framework of the 2015 Roadmap, the SKA has been identified as an important large research infrastructure for which the participation of Switzerland is to be considered. Since 2016, SERI attends as observer the meetings of the SKA Board of Directors. The ETH Board supports the insertion of a funding line dedicated to SKA in an ERI dispatch. Sharing of contributions is not settled yet. Also since 2016, the Swiss SKA community organizes with the support of EPFL annual "Swiss SKA Days"

(ska.epfl.ch) during which a number of Swiss industries and start-ups have shown strong interest in the SKA project.

Development phases

Design	Preparation	Implementation	Operation
2012-2019	2019-2020	2020-2027	2020-2035ff

Neutrino experimental facilities in USA and in Japan

Description

Two accelerators in USA (at the Fermi National Accelerator Laboratory – Fermilab, near Chicago) and in Japan (at the Japan Proton Accelerator Research Complex – J-PARC, Tokai) produce neutrino beams for scientific purposes. Both facilities already operate several experiments involving Swiss groups and are foreseen to host large complementary projects with international participation. Complementarity experiments using different techniques provide important cross-checks that add credibility to the results of the measurements. These facilities are designed to answer most fundamental questions about the nature of elementary particles and fundamental forces and their role in the universe. We mention, for example, the long-standing issue of the observed supremacy of matter over antimatter, one of the fundamental questions in particle physics and cosmology.

LBNF/DUNE

The Long-Baseline Neutrino Facility (LBNF, https://lbnf.fnal.gov/) together with the Deep Underground Neutrino Experiment (DUNE) in the USA, will be a world-class multipurpose observatory for neutrinos from beam and astrophysical origin and for matter instability searches. LBNF/DUNE is among the top priorities in scientific and infrastructure roadmaps in Europe and the Americas with growing interest from Asia.

Two complexes will be built, with a “near” site facility at Fermilab and a “far” site at the Sanford Underground Research Facility (SURF). The world’s most intense beam of neutrinos will be produced at Fermilab and aimed at the SURF site at a distance of 1300 km from Fermilab. The design of the LBNF/DUNE facilities and detectors are driven by the primary scientific goals of carrying out a comprehensive program of neutrino oscillation measurements, besides also significantly improving the search sensitivity for proton decays, detecting and measuring neutrinos from core-collapse supernovae and be ready for unexpected discoveries. One main goal is to reach sensitivity to measure charge-parity symmetry violation (CPV) in neutrino oscillations, which would give insight into the origin of the mentioned matter-antimatter asymmetry.

The detectors at the far and near site will be built by the DUNE collaboration and will be based on volumes of liquefied argon equipped with time-projection chambers, an advanced type of neutrino detector. Two large scale prototypes are being tested in particle beams at CERN, one of the two detector technology solutions for the far site detector has been pioneered by ETHZ, and the University of Bern has designed the near detector. Strong efforts are also ongoing on R&D in the preparation of the analysis of the data and theoretical studies at ETHZ, Uni Bern and Uni Basel. A. Rubbia (ETHZ) has been the first spokesperson of the DUNE collaboration and A. Ereditato (Uni Bern) member of the International Governance steering board.

LBNF/DUNE is a global organization with currently 1100 scientists and engineers from 175 institutes in 31 countries, with 3% of the members from Switzerland.

The main excavation at the far site in South Dakota has started and the beginning of beam operation is planned for 2026 and will last for at least 10 years. The total construction cost of LBNF/DUNE is estimated at around 2500 million USD.

HyperK

Hyper Kamiokande (HyperK, http://www.hyperk.org/) is an extension of the highly successful program that started with the Kamiokande experiment and continues with Super-Kamiokande (SuperK), which has yielded two Nobel prizes. HyperK is a water Cherenkov detector centered on a huge underground tank containing 300,000 tonnes of water, with a sensitive volume about a factor of 10 larger than its predecessor SuperK. Like SuperK, HyperK will be located in Kamioka on the west coast of Japan directly in the path of a neutrino beam generated 295 km away at the J-PARC facility in Tokai, allowing it to make high-statistics measurements of neutrino oscillations. Together with a near-detector located close to J-PARC, SuperK formed the “T2K” long-baseline neutrino programme. An order of magnitude more sensitive than SuperK, HyperK will serve as the next far-detector for Tokai-to-Kamiokande experiments, with a rich physics portfolio. This ranges from the study of the CP violation in the leptonic sector and

measurements of neutrino-mixing parameters, to studies of proton decay, atmospheric neutrinos and neutrinos from astrophysical sources. The staged Japanese neutrino program allows for continuous production of world class physics results from T2K to the future HyperK experiments at the time it ensures the training of the new generation of neutrino physicists. The knowledge acquired both in detector operation and the understanding of physics processes will improve the precision of future experimental results.

The still growing Hyper-K proto-collaboration was formed in 2015 and is currently composed of around 300 members from 82 institutes coming from 17 countries. Prof. A. Blondel (University of Geneva) is member of the Steering Committee of the HyperK proto-collaboration and Prof. F. Sanchez (University of Geneva) is currently the Swiss representative in the International Board of the project.

On 12 September 2018, the Japanese government granted seed funding towards the construction of the HyperK experiment for 2019, which will enable progress in preparatory work for construction and efforts to secure international collaboration. The construction of the HyperK detector is planned to begin in 2020.

National relevance

Neutrino physics is a main priority of experimental and theoretical particle and astroparticle physics in Switzerland. It is one of the three pillars of CHIPP, the Swiss Institute of Particle Physics. There is a long history of major achievements of Swiss groups, in particular on neutrino oscillations with the K2K (JP), OPERA (CERN and Gran Sasso National Laboratory), T2K (JP) and MicroBooNE (USA) experiments. The Swiss researchers involved in the Japanese effort have been recognized by the prestigious Breakthrough Prize in Fundamental Physics in 2016 for the discovery and exploration of neutrino oscillations, and the related Nobel prize in 2015.

The main subjects of neutrino physics in Switzerland are presently neutrino oscillations at long and short baselines, ultra-high energetic neutrinos from the cosmos and the neutrino-less double beta decay. The development of innovative detectors plays a crucial role in all of these activities, as well as the theoretical and phenomenological aspects of neutrino physics and the study of new particle accelerator infrastructures and technologies, i.e. at PSI. CERN as the European laboratory for Particle Physics being located in Switzerland is closely tied to the Swiss neutrino efforts and is an integral part of the global strategy by hosting the Neutrino Platform.

The approved LBNF/DUNE originates from the merging of the LBNO project in Europe (led by ETHZ) and LBNE, an early project initiated in the USA for beams and detectors. Swiss researchers are currently strongly engaged in the far and near detector design and construction: the University of Bern has led the design of the near detector based on past experience and is testing a prototype at Fermilab, while ETHZ is leading the dual-phase approach for the far apparatus. Very relevant, as well, is the theory group at the University of Basel contributing to the study of discovery prospects for new physics. Overall, the scientific impact and visibility of Switzerland is large and very well acknowledged.

Swiss groups (University of Bern, University of Geneva and ETHZ) have made considerable investments in the construction, operation and scientific exploitation of the T2K experiment. ETHZ and University of Geneva are committed to the exploitation of the experiment until the end of the T2K operation. The University of Geneva is leading the R&D efforts towards the construction of two of the subsystems for the near detector upgrade in close collaboration with the CERN Neutrino Platform. The T2K upgrade and the near detector infrastructures, to which Swiss groups made key contributions, are considered as the precursor of the HyperK. In addition, the University of Geneva is exploring the possible contribution to the readout electronics of the future HyperK inner detector sensors based on electronics boards developed at PSI and promoting possible contributions of CERN on the accelerator upgrade of the J-PARC facility.

Based on knowhow, cooperation with previous experiments and industry partners, it is expected that Switzerland can play an important role in the mechanical site infrastructure and cryogenic equipment for LBNF/DUNE. Contributions to HyperK are also expected for the near detector facility infrastructure such as magnet or gas systems and the J-PARC beam upgrade, in cooperation with CERN, PSI and the Swiss industry.

These projects are part of the Swiss strategy for exploring neutrino physics as detailed in the 2015 Whitepaper on neutrino physics in Switzerland. A commensurate contribution from Switzerland to these infrastructures would match and value, on the one hand, the merit of the science initiative, and on the other hand, the visible and substantial engagement of the Swiss groups. In order to support simultaneously LBNF/DUNE, the related work of Swiss groups and CERN as a center for the European participation in large international neutrino experiments, SERI foresees a special contribution from the Confederation to CERN for the activities related to the LBNF/DUNE experiment involving Swiss groups. Such a financial support will make use of already existing Swiss funds by the CERN.