Results of needs inventory 2021–2022

Appendix to the Swedish Research Council's Guide to Infrastructure 2022

Swedish Research Council

2022

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Foreword

Leading edge research often requires access to resources and competences that are built up systematically over a longer period of time. Examples of these are major research facilities, laboratory environments, experimental workshops, complex digital research systems and databases. These types of research resources provide preconditions for long-term research that drives the research frontier forwards, and meet the needs of more than one research team. The accessibility and long-term development of the research resources lead us to describe them as research infrastructures.

The Swedish Research Council strives to provide preconditions for the very best research by contributing to the development of the research infrastructure landscape, prioritising available resources and acting as a catalyst for coordination at national and international level. One of the most important strategic documents for this work is the Guide to Research Infrastructure that the Swedish Research Council produces ever four years. The next version of the Guide will be published in autumn 2022.

Another piece of the puzzle for mapping the new research infrastructure needs of the research community is the regular inventory that the Swedish Research Council carried out for the fourth time in 2021–2022. The areas assessed in this inventory as having the highest priority have been included in this publication. In the work on the final prioritisation of the new needs that are right now assessed as being the most urgent, we have taken into account the view that all scientific fields shall have the best possible support in their development, and that initiatives shall be sustainable in the long term.

The Swedish Research Council's Council for Research Infrastructures (RFI) wishes to thank the persons and groupings who have provided inputs to the work on the needs inventory. In addition to all who have proposed new infrastructure needs in conjunction with the inventory, and RFI's advisory groups, which have assessed the proposals submitted and assisted in the production of texts, the consultations RFI has had with the scientific councils and the Committee for Artistic Research, as well as the Universities' Reference Group for Research Infrastructure, URFI, have been very valuable. A continuous dialogue with the research community is crucial for ensuring we can fulfil new infrastructure needs in the best possible way.

Stockholm, 29 September 2022,

Lisbeth Olsson

Secretary General for Research Infrastructure, Swedish Research Council

Sammanfattning

Vid den inventering av behov av ny eller utvecklad forskningsinfrastruktur som Vetenskapsrådet genomförde hösten 2021 inkom drygt 40 förslag på behov från lärosäten, myndigheter med forskningsuppdrag, finansiärer och forskargrupperingar.

Vetenskapsrådets Råd för forskningens infrastrukturer, RFI:s, rådgivande grupper, RÅG, har bedömt alla inkomna förslag efter kriterierna vetenskaplig relevans, strategisk och nationell relevans samt eventuella andra viktiga aspekter. I bedömningen har även yttranden från Vetenskapsrådets tre ämnesråd och dess kommitté för konstnärlig forskning samt lärosätenas referensgrupp för infrastruktur, URFI, vägts in. Bedömningen, med förslag på betyg från RÅG, bearbetades och fastställdes sedan av RFI (se kapitel 1.1 Bedömning av behovsförslag 2021–2022).

Behov som anses vetenskapligt och strategiskt viktiga och där planerna på en nationell forskningsinfrastruktur är tillräckligt framskridna för att de ska kunna initieras 2024 har klassificerats som A1. Att ett behov klassas som A1 är också som regel en förutsättning, men inte en garanti, för inkludering i kommande utlysning av bidrag till forskningsinfrastruktur av nationellt intresse. Infrastrukturbehov som klassificerats som A2 anses vara vetenskapligt viktiga och redo för implementering på samma nivå som A1, men Vetenskapsrådet har av strategiska, ekonomiska eller andra skäl valt att i nuläget inte överväga att inkludera dem i kommande utlysning. Behov som är av högt vetenskapligt värde men som kräver mer utveckling innan de kan komma i fråga för utlysning har klassificerats som A3. Totalt rör det sig om 8 förslag i kategorin A1, 17 i kategorin A2 och 11 i kategorin A3.

Summary

At the inventory of needs for new or developed research infrastructure that the Swedish Research Council conducted during autumn 2021, just over 40 descriptions of needs for new or developed research infrastructure were received from higher education institutions, public agencies with research mandates, funding bodies and researcher groupings.

The advisory groups (RÅGs) to the Swedish Research Council's Council for Research Infrastructure (RFI) have assessed all the proposals received according to the criteria scientific relevance, strategic and national relevance and any other aspects important to consider. The assessment has also weighed in statements from the Swedish Research Council's three scientific councils, its Committee for Artistic Research, and the Higher Education Institutions' Reference Group for Research Infrastructure (URFI). The assessment, with proposals for grades from RÅG, was further worked on and then adopted by RFI (see chapter 1.1 Assessment of needs proposals 2021–2022).

Needs considered to be scientifically and strategically important, where the plans for national infrastructure are sufficiently clear that they can start being implemented during 2024, were categorised as 'A1'. The fact that a need has been categorised as A1 is also usually a precondition, but not a guarantee, that it will be included in an upcoming call for grants to research infrastructure of national interest. Infrastructure needs categorised as 'A2' are considered to be scientifically important and ready for implementation at the same level as A1, but for strategic, financial or other reasons, the Swedish Research Council has decided to not consider including them in the upcoming call at present. Needs that are of high scientific value but require more time before they can be considered for inclusion in a call have been categorised as 'A3'. In total, 8 needs have been included in the category A1, 17 in the category A2, and 11 in the category A3.

1 Prioritising and funding research infrastructure

The needs for research infrastructure – large research facilities, laboratory environments, experimental workshops, complex digital research systems and comprehensive databases – are increasing in nearly all research fields. Technical developments provide new opportunities and ever more complex scientific questions drive this development forward. This increases the need for access to and collaboration between research infrastructures.

To address this development, the Swedish Research Council works according to a model for prioritising and funding research infrastructure. The model follows a two-year cycle, starting with a needs inventory and ending with a targeted call. Since 2015, the needs inventory is carried out every second year, with the aim of creating a good overview of new needs for research infrastructure of national interest. A research infrastructure of national interest does not have to be located in Sweden, as Swedish engagement in international research infrastructures can also constitute a Swedish national interest and need. We refer to the Guide to Research Infrastructure, to be published in late autumn 2022, for a more detailed description of how RFI works with research infrastructure. The purpose of the Guide is to identify needs, challenges and opportunities relating to research infrastructure, and in the report RFI also proposes recommendations aimed at strengthening Swedish research.

There is no unified definition of what a research infrastructure is; instead this varies according to the context. The Swedish Research Council's definition of what is covered by the concept of "research infrastructure of national interest" aims to demarcate the type of research infrastructures the Swedish Research Council intends to fund:

"A research infrastructure of national interest is intended to provide resources that enable research by several research teams and for different projects within one or more research fields."

RFI funds research infrastructure that is of a long-term nature and that is of strategic importance for the Swedish research community. In addition to the definition, the Swedish Research Council therefore applies a number of criteria intended to clarify and demarcate the type of infrastructure funded by RFI[1]: Research infrastructure of national interest shall

- enable research of the highest scientific quality
- be openly accessible primarily to researchers, but also to the business sector, the public sector, and other relevant actors. When access is limited, prioritisation shall primarily be on the basis of scientific excellence

[1] These are being reviewed by RFI, and may be revised during autumn 2022.

- create clear national added value
- have long-term plans for the scientific operation and its development
- take long-term responsibility for management and control, funding, competence accumulation and development of the operation
- contribute to societal development, for example by enabling research that addresses issues relating to societal challenges.

Given the definition of research infrastructure of national interest, the criteria entail that there are important infrastructures that fall outside this definition. The considerable local infrastructure that is necessary for a very large part of the research carried out is not included. Here, responsibility rests with HEIs and other research funding bodies. This means that the Swedish Research Council regards itself as one of several actors with responsibility for providing Swedish research with the infrastructure necessary to carry out research of the highest quality, and to safeguard Sweden's position as a prominent knowledge nation.

In the needs inventory, researchers, higher education institutions and public agencies with research mandates can describe needs for new infrastructure of national interest to the Swedish Research Council. Via a review process, areas are identified where research is assessed as having a great need for new or expanded infrastructure. Besides functioning as support for the Swedish Research Council's work on prioritising research infrastructure, it is our hope that the inventory will be of benefit for the entire Swedish research system, not least other funding bodies and higher education institutions.

The needs inventory forms an important part of the Swedish Research Council's work. Among other things, it forms the basis for RFI's targeted call for grants to research infrastructure of national interest, and it also forms part of the Swedish Research Council's strategic work with research infrastructure. However, all needs identified in the inventory will not be covered by the call. RFI decides on the areas to be included in the call on the basis of strategic consideration of the scientific benefit to Swedish research, an assessment of how well-developed and realistic the planning of the identified infrastructure need is, and a budgetary assessment. As research infrastructure of national interest requires national mobilisation and coordination, a joint application is normally expected for each need area covered by the call.

In conjunction with funds being made available in the call for the areas identified in the needs inventory and prioritised by RFI, existing infrastructures financed via RFI are usually offered the opportunity to apply for renewed funding for their activities. By using the same review process to evaluate older infrastructures that need continued funding against new infrastructures, preconditions are created for a process that balances long-term stability against necessary renewal.

1.1 Assessment of the needs proposals 2021–2022

RFI och RFI's advisory groups have central roles in the assessment of the needs proposals received by the Swedish Research Council during autumn 2021, but

views from the Swedish Research Council's scientific councils and committees and the Universities' Reference Group for Research Infrastructures (URFI) also carry great weight.

The assessment process is based on the individual proposals submitted. In many cases, such a specific proposal forms the basis for one of the following descriptions of research infrastructure. In a few cases, however, several proposals have been received referencing the same or similar needs. In these cases, we have assessed the proposals together, as a single need. All needs have been divided up into six categories, from A1 to X:

- A1: The need described can be fulfilled by an infrastructure of national interest, and the thematic area is assessed as being ready for a call.
- A2: The need described can be fulfilled by an infrastructure of national interest within the Swedish Research Council's area of responsibility, but is currently not prioritised by the Swedish Research Council (the specific grade is used only by RFI).
- A3: The need described can be fulfilled by an infrastructure of national interest, but the thematic area is not assessed as being ready for a call.
- B: The need described cannot be fulfilled by an infrastructure of national interest.
- C: Not relevant for prioritising by the Swedish Research Council, as the need can be addressed within an existing national or international infrastructure, or should be funded/managed by another organisation or in another way.
- X: The need could not be assessed due to incomplete information or unclear description.

The needs in the categories A1, A2 and A3 are described in Section 2. Needs that are assessed as scientifically and strategically important, and where the plans for a national research infrastructure are sufficiently developed for them to be initiated during 2024 have been classified as A1. The fact that a need has been classified as A1 is also usually a precondition, but not a guarantee, that it will be included in an upcoming call for research infrastructure of national interest. During the final assessment, RFI has striven to fulfil needs in all scientific fields. The areas are not clearly delineated, but follow the division of research infrastructures used in the Guide, namely e-infrastructure, humanities, individuals and society, earth, climate and environment, life science, materials and the constituents of life, space, technology and energy, and the smallest components of the universe. In September 2022, RFI will decide on the 2023 call, and on which of the proposed new areas that will be able to apply. Consideration is taken of RFI's budgetary limits.

The decision on the contents of this publication was made by RFI in May 2022.

2 Needs for research infrastructure per area (A1, A2 and A3)

This section describes, by scientific field and in alphabetical order, a number of research infrastructure needs that are assessed as being of national interest for research in the categories A1–A3.

The texts describe the needs that have been submitted in the needs inventory, and which have then been assessed – singly or in groups – to be of national interest. The idea is that these descriptions should provide inspiration and support to organisations and research teams that wish to develop national research infrastructure, and also to funding bodies that are interested in contributing to such infrastructure. The aim of the Swedish Research Council is to describe needs and expected results, but not to propose any concrete solutions. It is up to the parties that intend to build up and operate the infrastructure to describe how the specific infrastructure need should best be met. For the areas that result in an application for a grant to infrastructure of national interest, it is, however, of crucial importance that there is a national perspective, that the infrastructure is openly accessible according to scientific prioritisation, and that the relationship to infrastructure within or in close proximity to the area is described.

A1 – Relevant for consideration as infrastructure of national interest, ready for a call

The following describes the infrastructure needs classified as A1, divided up per subject area and thereafter in alphabetical order.

e-infrastructure

Large-scale infrastructure for experimental ICT system research

Digital infrastructure and modern communications technology are important building blocks for the digital transformation of society. To enable experiments in design, operation and automation of advanced linked digital systems, there is a need for underlying infrastructure.

Description of the area

In modern digital infrastructures, communication, data processing and storage are integrated with sensors, instruments and other equipment that generate large amounts of data. Data is processed in real time, often with the help of models developed through machine learning and large-scale computation. These distributed heterogenous systems are characterised by a high degree of complexity, which means that there is a need for research, stretching from design and architecture to algorithms, effectiveness and security issues.

Development/need

Currently, Sweden only has small test environments operated by individual research teams, while at European level work is in progress to create a linked environment of experimental resources within the area (Scientific Large Scale Infrastructure for Computing/Communication Experimental Studies, SLICES RI). By creating a Swedish research infrastructure for dynamic test environments, coordinated with the development of SLICES RI, Swedish research will be strengthened.

Humanities

Infrastructure for laboratory archaeology

In laboratory archaeology, a number of analysis methods are used to study archaeological material. There is currently a consortium consisting of existing archaeological laboratories with the potential to develop a national infrastructure, which would provide coordinated and innovative support for interdisciplinary research within rapidly expanding laboratory research fields.

Description of the area

Together, archaeological research laboratories in Sweden have high capacity and competence within a broad spectrum of analysis methods, such as archaeobotanics, paleoentomology, land chemistry, archaeometallurgy, dendrochronology, ceramic studies, lipid analysis, etc. Current and potential users of a national infrastructure for laboratory archaeology are researchers at Swedish higher education institutions, but also researchers and other personnel at governmental and private organisations, such as museums, county administrative boards and archaeological consultancy companies. In addition to national users, another large user group consists of international researchers and personnel at other types of organisations.

Development/need

An infrastructure that gathers together archaeological laboratories into a national resource would strengthen Swedish research in this field. Laboratory archaeology is an interdisciplinary field. Over the last few years, development within the area has been comprehensive, and Swedish research is ground-breaking in several areas. To safeguard continued successful research within the field, access to knowledge, quality-assured analysis methods and support needs to be improved. If existing laboratories were to expand their activities and integrate with each other, they could create a research infrastructure of national relevance. Such an infrastructure would be able to offer powerful and extensive analysis opportunities of great strategic importance for Swedish research. The dividing lines against other existing infrastructures, such as SweDigArch and aDNAanalyser within SciLifeLab, would then have to be clarified.

Individuals and society

Infrastructure for Electoral Democracy in Europe (MEDem)

The purpose of MEDem (Monitor for Electoral Democracy in Europe) is to establish, operate and develop a pan-European distributed research infrastructure for voting behaviour and democracy development using Sweden as one of the central nodes. An over-arching goal is to be included in the next ESFRI Roadmap (2025).

Description of the area

Many democracies in Europe and the rest of the world are facing major challenges, not least in those democratic countries that have been moving towards more authoritarian governance. Knowledge of how citizens, persons in power, parliaments, governments and media interact and relate to each other, for example in the fight for votes, is central for understanding modern democracies. Over time, the national election surveys that are carried out in practically all European countries have been broadened from covering voter behaviour to also include the parties and candidates that voters vote for. How media reports on party politics is also sometimes included in the surveys. At the same time, the collection and analysis of election survey data between countries has intensified. In addition, there are summaries with contextual data about the economic and political circumstances that have surrounded the democratic elections. Swedish election research is world-leading, and research into voting behaviour and democracy development is being done at several Swedish higher education institutions.

Development/need

Even though election research is a well-established research field, the lack of coordination between election surveys in different countries acts as a drag on research. Coordination of databases with long time series that enable comparisons between countries would be of great importance for Swedish and international social sciences research. MEDem shall offer integrated and harmonised data for researchers and other stakeholders by gathering together existing research initiatives and infrastructures under a joint umbrella. There are also plans to develop a visualisation tool for access to data. Here, it should be possible to use already existing software, for example the national infrastructure InfraVis, which is under development.

Swedish participation in Generations and Gender Programme (GGP)

GGP is a distributed social sciences research infrastructure for research into areas such as family dynamics and fertility. GGP has been included in the ESFRI roadmap since 2021.

Description of the area

Falling birth rates, increasing social inequality in the birth rates of persons with low and high educational attainments, differences in the conditions of life between persons born in Sweden and abroad, and behavioural changes in terms

of relationships, family life and family constellations – all these factors and changes are assumed to entail long-term consequences for Swedish society, the welfare state, and social equality. To understand these factors and consequences in depth, an infrastructure is needed that combines data about individuals, via surveys, with register data. This is done in Sweden today via the Swedish section of GGP, which is part of GGP-ESFRI. The latter enables comparisons between Sweden and other countries. Swedish participation in the programme began in 2010, and today fulfils a a central comparative function of GGP.

Development/need

GGP can provide combined data for research into changes in fertility and family dynamics, and how different factors in the surrounding environment contribute to differences between European countries. GGP offers open and free-of-charge access to harmonised data for studying causes and consequences of birth rates and family changes. GGP collaborates with other leading European research infrastructures, such as ESS, SHARE, EVS and CESSDA, for the purpose of creating synergies between them. To enable continued comparisons between countries within the research fields in questions, the Swedish section of GGP needs to maintain the current and future versions of the survey as part of GGP-ESFRI. Against the background of the similarities that exist between infrastructures such as ESS, SHARE and GGP, and the collaboration that occurs at European level, the opportunities for coordination between Swedish GGP and CORS (Comparative Research Center Sweden) should continue to be investigated and discussed.

Earth, climate and environment

National infrastructure for research vessels

Sweden has a number of research vessels or ships equipped for research activities. The vessels are owned and operated by higher education institutions and public agencies. A national infrastructure for research vessels would coordinate the access to research time and contribute to harmonising data.

Description of the area

Research vessels are used for observations, process studies and experiments, primarily within the field of natural sciences, such as oceanography, marine biology, limnology, marine geology, atmospheric research and natural resources management. The Swedish research vessels operate nationally or regionally, and in addition to research activities they also participate to a varying degree in the national environmental monitoring programmes.

Development/need

As a knowledge nation, and with a long coastline and many lakes, Sweden has a rich tradition of research carried out with the help of research vessels. Data collection may be done through instrumentation onboard the vessels, instrumentation located in the waters in which the vessels operate, or by using the vessels to launch UAVs (Underwater Autonomous Vehicles) and other autonomous vessels. Sweden today has five large and around ten smaller research vessels, owned and operated by the various higher education institutions or public agencies. A national coordinating infrastructure would be able to ensure that Swedish researchers have the option of accessing all research vessels included, irrespective of their organisational affiliation, and that the vessel most suited to the task is used. The infrastructure could also contribute to developing harmonised best practices in terms of methods, data collection and data storage.

Space[2]

Infrastructure for astroparticle physics with neutrinos

IceCube South Pole Neutrino Observatory is a neutrino telescope for astroparticle physics, and is built up from light-sensitive detectors embedded in a cubic kilometre volume of ice at the South Pole. IceCube was started by Sweden, Belgium, Germany and USA, and today has twelve member countries.

Description of the area

The primary goal of the observatory is to investigate high-energy neutrinos and their cosmic origin. Neutrinos are a type of elementary particle that are difficult to observe, as they rarely interact. However, water offers the opportunity to observe neutrinos indirectly, and at IceCube this feature is used by locating detectors buried in Antarctic ice. Discoveries helped by IceCube include flows of high-energy neutrinos originating from beyond our solar system, and the identification of the first probable source of such neutrinos. Through its observations, the telescope can not just help to answer questions about high-energy processes in the universe, but also increase our understanding of the smallest building blocks of matter and their interactions.

Swedish participation means, in addition to participating researchers building up their competences and taking part in measurements and publications, that leading Swedish technology, for example in the form of highly specialised cabling and wind turbines specifically developed for polar regions, can be developed and used.

Development/need

IceCube was built in 2004–2010, and has since then mapped neutrinos within a given energy interval, which has led to a number of discoveries. However, to allow more effective study of neutrinos with ultra-high energy, IceCube needs to be increased considerably in size. An upgrade of the observatory will lead to more precise determination of the direction and energy of the individual neutrinos, and by extension their characteristics. This can be done through increasing the number of optical readings and by using radio technology to measure radio signals from neutrino interactions in the ice. There is a trial area in Greenland for evaluating hardware for IceCube before the final step of upgrades at the South Pole is taken.

Infrastructure for solar physics – European Solar Telescope

European researchers in solar physics are planning the next generation solar telescope – the European Solar Telescope (EST). The telescope will be built on the island of La Palma in the Canaries, and is expected to become operational in 2029.

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[2] RFI also decided that membership of LOFAR ERIC should be included in this category, but as the proposal entails a cost-neutral organisational change, it is not described in detail but dealt with using a separate procedure.

Description of the area

Research in solar physics focuses on understanding the structure and dynamics of the solar atmosphere. Increasing the understanding of these processes, as well as the impact the Sun has on Earth, is important for research areas such as astrophysics, geophysics, climate research, space physics and biology. Knowledge about the sun and its changeability is significant also for our everyday lives, where factors such as space weather is a major challenge for a high-technology society. Research within solar physics requires access to either ground-based telescopes or space probes and satellites.

Development/need

EST is planning to study the following overarching questions: What can the Sun teach us about fundamental astrophysical processes? What drives solar variability on different scales? What impact does solar activity have on life on Earth? The aim is to build the world's largest solar telescope, with a primary mirror with a 4.2 metre diameter, which entails an increase of a factor of 4 in spatial resolution and an increase of a factor of 15 in light collection ability, compared to today's largest European solar telescope. EST and the American DKIST, which became operational in 2021, will be the only ones of their kind in 2029. The two telescopes have partly differing technical specifications, and as they are located on different continents, new discoveries may be made from observing the same phenomena from two directions. However, it would be desirable for EST to also define its own niche in conjunction with the design being completed.

As the Swedish solar telescope SST also functions as a testbed for instrumentation for EST, it is important that the Swedish expertise can be transferred to EST. The Swedish Research Council is funding Swedish participation in the planning ahead of EST and parts of SST.

A2 – Relevant for consideration as infrastructure of national interest within the mandate of the Swedish Research Council, but funding currently not prioritised by the Swedish Research Council

The following describes the infrastructure needs classified as A2, divided up per subject area and thereafter in alphabetical order.

Earth, climate and environment

National pool of geophysical field instruments

Geophysical surveys are fundamental for the understanding of processes in and below the Earth's crust. Field measurements contribute to research and technical development, not just in geophysics, but also many closely related areas.

Description of the area

Research in geophysics focuses on understanding the Earth's structure and the geological development, based on measurements of the Earth's physical characteristics. The measurements contribute knowledge for basic research in fields such as structural geology, tectonics, geodynamics, archaeology and glaciology. Applications exist in areas such as prospecting and use of mineral resources, dam and tunnel construction and the development of solutions for carbon dioxide storage in bedrock.

Development/need

The area and the instrumentation used stretches across a number of disciplines, methods and techniques, where the instrumentation in the area has become ever more sophisticated and costly. A national pool of geophysical instruments would address the needs of Swedish researchers, by giving access to a large number of modern instruments that cannot be supplied by an individual research team or individual higher education institution. It would also contribute to increasing the utilisation rate of investments made in instrumentation. Another important task is to ensure that technical and methodological knowledge about instrumentation is included as user support for those who are using the infrastructure.

Life science

Infrastructure for research into environmental exposure, exposomics

Research into environmental exposure, that is, the exposomics of the environment and humans, aims to systematically measure and investigate the effects of the exposure to chemicals that humans and the environment are subjected to. The results of the research contribute to mapping and minimising the risks of chemicals use.

Description of the area

Exposure to pollution in the air, water, food and waste is a major cause of disease and early death. A great need therefore exists for increased knowledge about the spread of chemical substances in the environment and their impact on human health; a concept that is jointly called exposomics. Research in the area aims to increase knowledge, enable risk reduction, support the safe use of chemicals, and to develop systems for early warning of new chemical threats.

Development/need

A national research infrastructure for exposomics could support both basic and applied research, and would be based on an existing network with established research and knowledge from several fields. Integration of analysis methods, samples and data in biobanks and biomonitoring networks together with population-based cohorts and register studies provide comprehensive access to data.

It is very important that the infrastructure maintains a clear focus and is clear about limitations and demarcations of the operation. Synergy effects with existing national research infrastructure, such as ACTRIS, and the option to link up to international networks should also be reviewed. A concrete picture of how the infrastructure is intended to function would clarify how its users could benefit from it in practice.

Infrastructure for cryo-electron microscopy in life sciences

Developments in cryo-electron microscopy (cryo-EM) have provided new opportunities to determine and visualise 3D structures of biomolecules, both as isolated particles and in their natural environment. Increased interest from the research community means that existing national resources are having difficulty meeting users' needs of instrument time and user support.

Description of the area

Using various cryo-EM techniques, it is possible to determine the three-dimensional structures of proteins and other biomolecules with high resolution, which is crucial for understanding how they work in different cellular processes. Recent technology advances mean that a very detailed image of biomolecules and their complexes can be achieved, and that it is also possible to study how the molecules look inside the cells. In addition to basic research into the function of proteins in health and disease, there are opportunities for applications in several areas, such as medicine development, biomaterials and industrial biotechnology.

Development/need

Since 2016, SciLifeLab has had a national research infrastructure for cryo-EM located in Stockholm and Umeå. Increased interest in these techniques means that the existing resources are having difficulty meeting the national need for instrument time and support, and a number of higher education institutions have therefore invested in their own equipment. There is now a need for this equipment to be coordinated, made accessible and linked to the national microscopy infrastructure at SciLifeLab. The strategic and scientific added value of a distributed infrastructure linked to the existing resource must, however, be clarified, as must how responsibility for a national infrastructure for cryo-EM in life science can be shared between higher education institutions and SciLifeLab in the long term.

Infrastructure for coordination of population-based cohort studies

Coordination of Swedish population-based cohort studies in a national infrastructure enables analysis of data sets from several different studies and opens the door to applications in new research fields.

Description of the area

Population-based cohort studies follow one or several groups of individuals over their lifespans. Cohort data are used in particular in the field of public health, but also within related disciplines, such as sociology, criminology and demography. Coordination of Swedish cohort studies would significantly increase the usefulness and quality of the studies, as the basis for the studies would be broadened at the same time as the power of the statistical calculations would be raised. In this way, new opportunities for studies that are currently difficult to carry out would be created, for example concerning rare diseases.

Development/need

Within Cohorts.se, a number of Swedish population-based cohort studies are currently being coordinated, in a collaboration between epidemiologists at several Swedish higher education institutions. In addition to the work of safeguarding the quality and data security of the studies, the users also need assistance in several stages of the research process: identification of suitable cohort studies, preparation of research applications and management of the ethical and legal aspects that arise when using data. A Swedish cohort consortium would be able to drive the development of epidemiological research methods and strengthen Swedish epidemiological competence, fellowship and competitiveness. A coordinating national research infrastructure means that data already collected could be utilised more efficiently, and in several different research projects. It is, however, important to develop the relationship to already existing research infrastructures, and to discuss how greater coordination could be achieved. There are also ethical and legal issues that must be addressed.

Infrastructure for spatial molecular analysis of materials, tissues and cells

Spatial molecular analysis adds an extra dimension to the determination of the molecular content of different types of samples, as you then also find out where in the tissue or the material the various molecules are present. The analyses are important in many areas, but particularly in life sciences.

Description of the area

Techniques for spatial molecular analysis enabled detailed analysis of the levels of RNA, proteins and small molecules in individual cells, in tissue cross-sections or in inorganic materials. The methods have been developed greatly over the last few years, and areas of use exist in a broad spectrum of disciplines. In life sciences, the molecular landscape can provide a detailed picture of differences between individual cells, or between the states of healthy and diseased tissue. Other areas of use are found in fields such as materials science and geoscience.

Development/need

Sweden is very advanced in spatial molecular analysis, and in addition to the national infrastructure for spatial and single-cell biology at SciLifeLab, there are similar and complementary techniques at local facilities. A national research infrastructure would bring together existing and new techniques in the area and simplify access to these for researchers in Sweden. By combining complementary methods, such a research infrastructure would contribute to new, competitive research. As the research field is relatively young, it is important to clarify what the need for the methods is at national level, and how broad-based use within different research fields can best be achieved.

Materials and the constituents of life

Large-scale instrumentation for synchrotron-radiation-based techniques at MAX IV and the upcoming PETRA IV

MAX IV and PETRA IV (the upcoming major upgrade of PETRA III) are both large-scale X-ray infrastructures where Swedish researchers can and will be able to participate in the build-up of new beamlines and use them for their research into everything from basic quantum physics to medicine and archaeology.

Description of the area

Synchrotron radiation is a powerful tool for research in fields such as basic quantum physics, materials science, structural biology, biotechnology, medicine, energy and cultural heritage. The MAX IV laboratory in Lund and the planned PETRA IV at DESY in Hamburg are both fourth-generation synchrotron radiation facilities, whose great brilliance and coherence will offer opportunities to study structure, energy levels and function with very high resolution and at several levels simultaneously, for example in materials and biological cells during realistic operational and environmental conditions.

Development/need

At MAX IV, there is potential to build up world-leading new equipment and new beamlines in wavelength ranges from infrared radiation to hard X-ray radiation. These are relevant for a number of research fields, such as X-ray tomography of biological and medical samples, energy material during realistic operational and environmental conditions, and studies of dynamics of soft materials with the help of coherent distribution. There are also opportunities to use the MAX IV facility to build up free electron laser capacity for studies of ultra-fast phenomena. The higher photon energies at PETRA IV, where construction is intended to begin in 2026, would be able to offer complementary opportunities in areas such as materials science.

Space

METIS – instrumentation for ELT

The Extremely Large Telescope (ELT) is being developed by the European Southern Observatory (ESO), where Sweden is one of the member countries. The telescope is being constructed in Chile and will be the world's largest optical/infrared telescope. Researchers from Sweden have been asked to participate in the development of the METIS instrument, a camera and spectrograph for the infrared area, at ELT.

Description of the area

ELT is being constructed in Chile, and will have a light collection capacity and angle resolution that is several times greater than that of the current largest optical telescope. Using ELT, researchers will be able to study features such as exoplanets, the birth and death of stars, super-massive black holes and our early universe. The METIS instrument at ELT will increase understanding of areas such as the existence and characteristics of Earth-like planets, the development of astronomical objects such as stars and galaxies, and the origin of the large-scale structure of the universe. The Swedish ELT consortium (SELTIC) is operated from Stockholm University with participation from the universities in Uppsala and Lund.

Development/need

The potential of ELT is entirely dependent on the instruments the telescope will be equipped with. The opportunities for researchers from Sweden to conduct early ground-breaking research is largely dependent on their participation in the design of the instruments. The consortium constructing the METIS camera and spectrograph at ELT are in need of software development for data processing, which is an area where Sweden has good expertise. Taking part in the development of METIS would on the one hand mean that Swedish researchers get early access to guaranteed observation time, which would enable entirely new scientific discoveries, and also that researchers and industry in Sweden are closer linked to ELT. Swedish researchers already participate in two other instruments being constructed at ELT, namely ANDES (formerly HIRES) and MOSAIC, via funding from the Swedish Research Council. These will become operational later than METIS.

SpacePlasmaLab

The Swedish Institute of Space Physics has a Spacelab for developing instruments for satellites and space probes. There are now plans to expand the operation with a laboratory for space plasma research, SpacePlasmaLab. Here, scientific instruments for space plasma research will be tested and calibrated by exposing them to radiation and particles, to simulate the environment they will be encountering in space.

Description of the area

Plasma constitutes the primary state of matter in the universe. Space plasma research studies features such as the plasma in stars' atmospheres, star winds and plasma in planets' ionospheres and magnetospheres. Instruments on satellites and probes are important for research into space plasma, as only they can take direct in-situ measurements of different types of space plasma and the processes that govern them.

Development/need

The increased complexity of space research assignments and the sensitivity of the instruments used drive the need for an advanced facility for testing in a simulated space radiation environment. Before new scientific instruments for space plasma research can be sent into space, they need to be tested and calibrated, which is something that could be done at the planned SpacePlasmaLab. The facility will not generate primary scientific data; instead, it will enable the development of scientific instruments that in turn deliver space science data. New scientific discoveries about the solar system and from space plasma science are, however, expected.

The infrastructure will consist of a set of vacuum systems and sources that produce the particles found in space plasma – positive and negative ions, electrons, energetic neutral atoms and photons. A key area will be to investigate how a new generation of space instruments react to the space environment. Experiments and testing of other space equipment and some research in materials science can also be carried out.

Technology and energy

National infrastructure for instrumentation

Several large-scale research infrastructures are carrying out considerable development of instruments and methods, as well as constructing new components. Gathering such development into a single environment could strengthen the work and increase the opportunities to provide leading-edge equipment. One such environment is the FREIA laboratory (Facility for Research Instrumentation and Accelerator Development), which is located at the Ångström laboratory at Uppsala University.

Description of the area

The research carried out at the FREIA laboratory is primarily focused on accelerator physics. To develop accelerators, advanced instruments are needed, and research into instrumentation physics is therefore also carried out at the FREIA laboratory. At the laboratory, physicists and engineers work on developing particle accelerators and other scientific instruments. Accelerator technology is important for research into high energy physics, and also enables research in materials science and bioscience at synchrotron radiation facilities and spallation sources, such as MAX IV and the European Spallation Source (ESS).

Development/need

Large-scale research infrastructure often requires state-of-the-art instrumentation, developed by researchers and engineers with leading-edge competence. The work requires continuity and should be done during long unified time frames, stretching up to decades, to cover the life cycles in question. Establishment of a national instrumentation infrastructure can support Swedish researchers in their work, and help Sweden achieve a greater return on its investments. Furthermore, a national instrumentation infrastructure can support advanced technology environments and increase the opportunities for Swedish companies to take part in the development at infrastructures.

The FREIA laboratory can stimulate and strengthen development and innovation in accelerator and detector construction, and allow larger and more advanced projects than small research teams can manage.

Infrastructure for laser-based measuring technologies – Laserlab Sweden

Laserlab Sweden, where advanced laser measuring techniques are used by many different research fields, is a distributed infrastructure with nodes in Lund, Umeå, Stockholm (KTH Royal Institute of Technology), Uppsala and Gothenburg (University of Gothenburg and Chalmers University of Technology). Laser measuring methods have been developed over many years and in several different university laboratories, so there is now a lot of advanced method knowledge and equipment in Sweden. Through increased coordination, opportunities are created to make these resources accessible for more researchers.

Description of the area

The laser measuring methods have been developed over a long time and continue to develop fast, both within physics and within fields where these methods have not previously been used. The laser measuring methods made accessible in Laserlab Sweden address many scientific fields, such as atom and molecular physics, biomedicine/biophotonics and attosecond physics/chemistry. In addition to being used to answer basic research questions and applied research, commercial actors may also be given access to the resources.

The resources at the laboratories consist of both specialised commercial and inhouse-developed laser systems, and also the specialist testing environments required.

Development/need

Lasers and laser measuring methods are today established methods in research and development, but also drive the research frontier forward in many areas. Laser measuring methods will continue to be developed and support many thematic areas in basic research, applied research and development. Two areas outside atom and molecular physics that can be mentioned are ultra-fast methods (attosecond physics/chemistry) and biophotonics.

In order to meet increased needs for access to laser-based measuring technologies by opening up Laserlab Sweden to a broader user base, services in the form of technical personnel, increased visibility and improved user training must be developed. Additionally, some of the very specialised systems must be adapted to improve their user-friendliness.

The smallest components of the universe

Swedish participation in AGATA

The gamma detector AGATA (Advanced Gamma Tracking Array) will be answering fundamental questions relating to nuclear physics. It is a European collaboration involving around 40 research laboratories and universities from 12 countries. The mobile detector is primarily intended for use at the research infrastructures FAIR in Germany and SPIRAL2 in France.

Description of the area

The aim of AGATA is to construct and maintain the first complete 4pi space angle detector entirely constructed from highly refined and electrically segmented germanium. It will be using both stable and radioactive ion beams to study atomic nuclei.

The detector will open the door to precise energy and 3D positioning of gamma radiation. This in turn provides opportunities for better understanding of atomic nuclei, in particular short-lived nuclei, which normally do not exist in nature except in extreme environments, such as supernovas. The research will help to increase and broaden understanding of nuclear physics and its processes.

The AGATA detector has the capacity to measure gamma rays over a large energy span, with unsurpassed effectiveness, positional resolution and with high capacity. When it reaches its full capacity, AGATA is expected to be a key instrument in the next generation of European radioactive ion beam accelerator facilities, in the first instance FAIR in Germany and SPIRAL2 in France. For example, it is intended to be used within the NUSTAR programme at FAIR.

Development/need

Sweden has been an active part of AGATA since the planning stage at the end of the 1990s. AGATA is now in its second construction phase, and will be able to answer fundamental aspects of nuclear multi-body systems, in particular of short-lived nuclei. Related studies will have a broad impact on nuclear physics. This includes studies of how elements are synthesised in stars and star mergers, but also for understanding the underlying microscopic structure of atomic nuclei of everything from light to super-heavy elements.

A3 – Relevant for consideration as infrastructure of national interest, not ready for call

The following describes the infrastructure needs classified as A3, divided up per subject area and thereafter in alphabetical order.

e-infrastructure

EBRAINS Sweden

EBRAINS is a digital infrastructure being developed for brain research. It is based on the European research project Human Brain Project (HBP).

Description of the area

Brain research is an active and complex research field, using many different approaches and methods, which generates many different types of data. The field would greatly benefit from combining different types of data to construct interlinked models with the help of system biology methods. A central e-infrastructure that provides data and methods for this purpose would be of great benefit to brain research.

Development/need

A Swedish EBRAINS node could be optimised for the needs of Swedish researchers, and enable integration of Swedish brain research methods and related services. By forming a Swedish node, neuroscience would have greater opportunities to benefit from the research at the European research infrastructure EBRAINS. Swedish researchers could contribute to the future development of the infrastructure, based on joint principles and ethically and responsible attitudes. However, the need for a national infrastructure has to be clarified. To have an impact as a national infrastructure, the focus should be on specific questions and technology collaboration, which need to be defined more precisely.

Humanities

Database for gender and work

GaW (Gender and Work Database) is a database at Uppsala University focusing on gender and work patterns during the period 1550–1880, and has the ambition of becoming a research infrastructure of national interest.

Description of the area

There is a lot of information and knowledge about the occupations and income persons had in the past, largely based on different types of register-like data (censuses, church registers, etc.). But to find out at more detailed level how persons have made a living over time, another type of data is needed, based on human activities. GaW contains such data, in the form of 'verb phrases', produced primarily from court minutes. This data links activities, such as work, with the persons that carried them out. Data in GaW shows at detailed level what people did to make a living, and not least shows details of women's early largely unknown work. A large advantage in Sweden is that court minutes between 1550 and 1880 have been saved entirely without any interruption. GaW is a unique historical database, where the freely accessible data and methodology have been and are of importance, not just for historians but also for linguists and archaeologists, for example, both in Sweden and abroad.

Development/need

There is a need to develop GaW in order for it, in the form of a research infrastructure of national interest, to further contribute to scientific development within a number of disciplines, for example through more activities and contextual data, geo-coding of all activities and persons, translation of metadata to English, and improved user support and training. But before this is done, further clarification is needed of in what way the data base shall be expanded into a significantly developed research infrastructure that is needed in order to work with new scientific questions.

Joint Nordic Runic text database

A Runic text database with the ambition of becoming a research infrastructure of national interest with relevance for user groups in more disciplines that at present exists at Uppsala University. A developed infrastructure would enable new research in areas such as language history, linguistics and archaeology.

Description of the area

Runic writing is a central source of knowledge about Scandinavian history and language during pre-Christian times and the Scandinavian Middle Ages. Runology is a small and highly specialised academic field, and researchers in other related areas, such as archaeology, history of art, history of ideas, and linguistics, who are interested in Runic writing, are therefore dependent on access to authoritative and reliable versions of these texts. The Scandinavian Runic text database at Uppsala University is an internet-based resource, which in its current form contains around 7 000 Runic inscriptions.

Development/need

An upgrade is planned in several ways. By coding the runes in XML and annotating them in the database, it is possible to integrate the database with other resources, such as the infrastructure Swe-CLARIN. By digitising and making accessible material relating to runes, such as manuscripts, drawings and photographs, and also modern Runic traditions, new research will be enabled. Technical work with user interfaces and coding therefore needs to be carried out to link the Runic text database to other databases. However, it is currently not sufficiently clear to what extent Swedish research needs the Runic text database to developed into an infrastructure of national interest.

Swedish patent database

The area relates to the role played by technical innovations in economic growth, and for this purpose a unified digital research infrastructure for Swedish patent research is needed. The purpose is to provide access to digitised, organised and de-identified high precision data about technical patents in an uninterrupted time series.

Description of the area

Today's economy is a knowledge economy, in which new technological inventions and advances are assumed to be be what sets the pace of economic development. To understand and measure technical innovation and factors related to patents, access to linked patent data is needed. Patents have been issued on a formal basis in Sweden since 1819, and the patent documentation also includes information about inventions. Swedish patent data can therefore offer an unbroken time series of more than 200 years of inventions. By combining automated and manual coding, unique identifiers can be created for each actor in the registers, which enables investigations of invention processes over time and space. In addition, patents can also be regarded as socio-cultural objects that can help researchers understand the link between objects/inventions, personal networks and money, and how they have been able to shape our current knowledge about technical objects and innovation processes.

Development/need

Currently, only patents issues as from 1975 and onwards are searchable via the Swedish Patent and Registration Office (PRV), and these data also have large failings. For example, they lack information about inventors, and the system is not adapted to the needs of researchers. A research infrastructure in the form of a patent database could provide data about unique persons, where the persons worked and with whom, and the professional status of the person at the time the patent was registered. It could serve as a resource for research into economic development and innovation, and for analysis of various historical and socio-economic explanatory factors. Exactly how great the national interest is in an unbroken series of patent data is unclear, however, and needs to be defined more precisely. Nor is it clear whether such a patent register would fall under the remit of PRV.

Earth, climate and environment

Infrastructure for boreal forestry experiments

How the boreal forest and its biodiversity is reacting to climate and environmental changes is of crucial importance for Sweden's access to ecosystem services. An infrastructure where changes to environmental factors can be adjusted experimentally and create scenarios would provide important knowledge about the future of the boreal forest.

Description of the area

Boreal forests are covering a large part of the Earth's surface, and is the dominant forest type in Sweden. An ecosystem's reaction to climate and environmental changes can be quick and comprehensive if certain thresholds are crossed. An experimental infrastructure, where several different environmental factors can be varied by themselves or in combinations can simulate circumstances that would not previously have occurred naturally. The resulting changes in nutrient flows, biogeochemical cycles and so on, which in turn lead to changes in growth, biological diversity and other ecosystem services, create understanding of how the forest's ecosystem develops under different scenarios. A boreal forest experiment infrastructure can be used to answer questions in ecology, forestry, natural resource management and other areas.

Development/need

The need to develop experimental infrastructures to study ecosystems is generally large in Sweden. Considering the rejuvenation period of forests, an infrastructure for forest experimental activities must be able to adopt a very long-term perspective. There are currently several forest trial parks located in different parts of Sweden, where the oldest have been in place for a hundred years. In addition, there are distributed research infrastructures focusing on greenhouse gas and aerosol measurements, as well as terrestral field research stations. An infrastructure dedicated to boreal forest experiments should be coordinated with these already existing facilities in order to find synergies and create the long-term approach needed.

Life science

Research infrastructure for 3D printing and bioprinting in life sciences

3D printing or additive manufacturing is based on building up three-dimensional models of complex structures layer by layer. There is great potential for the technique in life sciences, with applications from specially adapted components in basic research to patient-specific anatomical models for clinical use.

Description of the area

Using 3D printing, objects can be formed from different inorganic and organic materials, and, for biomaterials, often combined with cells or active compounds in what is known as 'bioprinting'. The technique can, for example, be used to create tailored laboratory equipment in miniature, structures for testing biological effects of medicines, and anatomical models for planning surgery. The methodology is still relatively young and under rapid technological development, and therefore the limits to what is possible to produce are continuously being expanded.

Development/need

A national research infrastructure shall combine expertise that cannot normally be accommodated in a single research team. By gathering together competence in design, 3D printing, biology and medicine and applying a life sciences-oriented way of thinking, a national research infrastructure could help a broad group of researchers to realise their project ideas. As the technology is new in life sciences, however, it is still unclear what the needs for 3D printing are, and how large the user base is. The opportunities for strategic coordination with local and regional actors in Sweden should be further investigated, and experiences of national use of facilities such as U-PRINT within SciLifeLab should be presented to validate the national benefit.

Infrastructure for pre-clinical PET-MRI

Pre-clinical PET-MRI, or positron emission tomography combined with magnetic resonance imaging, is a technique for molecular imaging where biological processes are monitored *in vivo.* The technique is used both within basic research and in more patient-related treatments.

Description of the area

Pre-clinical PET-MRI is a method for molecular imaging used within biomedical research. Biological processes can be mapped by monitoring radioactively marked molecules in a non-invasive manner *in vivo*, in both humans and animals. The technique is important for basic research and translational life sciences research in several fields. The activities include development of inset markers for pre-clinical *in vivo* and *in vitro* validation with modern equipment.

Development/need

A platform for pre-clinical PET-MRI currently exists at Uppsala University with links to SciLifeLab. The aim of facilities in SciLifeLab is that they should be nationally accessible, but this is not the case for the platform pre-clinical PET-MRI today. To fulfil the research community's need for pre-clinical PET-MRI, existing instruments within the platform, such as MR scanners and equipment for analysing metabolites, need to be upgraded. The animal facility also needs a major upgrade. In addition, there are several local facilities and instruments at other higher education institutions, which could potentially be included in a future infrastructure. How great the need is for a national infrastructure for pre-clinical PET-MRI has to be clarified further, as does how such an infrastructure could then be organised.

Ultra-high field MR 7Tesla platform (7T)

The national 7Tesla platform for medical imaging of the brain in particular, but in the longer term also other organs, is located at Lund University.

Description of the area

Medical imaging has revolutionised our ability to diagnose diseases and understand biological processes in the human body. One of the imaging techniques that are driving research forward is Ultra-High Field Magnetic Resonance Imaging (UFH MRI), which is available at the Swedish 7T platform in Lund at the university's Bioimaging Center. UHF MRI provides very high resolution in studies of the brain and its blood flows, and has resulted in new medicines for epilepsy, for example. The current hope is that the technology will also drive development forward in research into organs other than the brain.

Development/need

The existing local 7T MRI facility offers advanced services in medical imaging. To continue being relevant for prominent research, it needs to be upgraded. The upgrade is expected to lead to the technology becoming accessible for other research fields, such as cancer and metabolic diseases. How such an upgraded infrastructure would work together with other infrastructures in imaging, and whether it would attract a sufficient number of users from other organisations to function as a national infrastructure needs to be investigated further.

Materials and the constituents of life

Imaging soft X-ray spectroscopy at European XFEL

European XFEL is an international research infrastructure in Germany that Sweden participates in. Sweden has delivered equipment for imaging soft X-ray spectroscopy through an in-kind contribution.

Description of the area

Imaging soft X-ray spectrometry at the SQS beamline at European XFEL provides opportunities to study ultra-rapid courses of events within a number of non-linear areas, which will now be possible to carry out experimentally in situ, and also with the help of the pump-probe options that exist at the SQS beamline. The experiments are aimed at basic research in atomic, molecular and optical physics.

Development/need

When it is operational, the instrument will be part of the SQS beamline at European XFEL, and will match the characteristics at the facility. The need for further development is justified by the opportunity to optimise the instrument, and to develop specific testing environments for this instrument and in that way support the Swedish user community. The development is also in line with what XFEL is planning.

National centre for physical characteristics in geoscience and materials science

A national centre to cover the need for increased access to and support for the use of equipment that can measure physical characteristics of materials in a number of scientific disciplines.

Description of the area

Physical characteristics of materials are important in many natural and engineering sciences, including physics, chemistry, materials and geoscience. Materials' physical characteristics are usually quantified using laboratory experiment equipment, which plays a key role in driving the research fields forwards. Irrespective of whether it is the magnetism of a geological mineral, or a newly developed synthetic material, the equipment used to characterise the materials is the same. Such equipment requires technical support and entails considerable costs that go over and above the budget that individual research grants can cover. Because of this, Sweden has a general lack of instrumentation, coordination and support of existing experimental equipment.

Development/need

Part of this research can be regarded as routine measurements, while the majority of the experimental research at the proposed facility aims to stretch the limits of geosciences and materials science. The proposed infrastructure will be coordinated with large-scale facilities for characterisation of material, such as MAX IV and ESS. This enables experiments to be carried out at these

infrastructures, where the experimental installation is developed as part of the proposed national centre for physical characteristics. In addition to the need for infrastructure, the proposed infrastructure would also enable synergies for the development of instrumentation, bring together researchers across disciplines, and function as a catalyst for emerging new scientific ideas and research. Although there is a broad national interest in the infrastructure, the specific needs will have to be investigated further. This includes how it relates to existing infrastructures, how it should be organised, and what the added value would be of establishing a research infrastructure of this kind.

The smallest components of the universe

LHCb experiment

The Large Hadron Collider beauty (LHCb) experiment is a particle physics detector experiment at CERN in Switzerland and France. The next generation of the experiment is currently being constructed.

Description of the area

LHCb is an experiment developed to investigate what happened right after the Big Bang, and ensured matter could survive and build up the universe we live in today. More specifically, using the LHCb experiment, it is possible to study a number of different hadron physics phenomena, and thereby better understand and challenge the ‘standard model’, which is the best current description of the nature in the area.

Development/need

LHCb has been operational and captured data since 2010, and is considered world-leading in its area of hadron physics measurements. The high energies in the particle accelerator LHC opens the door to large amounts of measurement data and has no kinematic limitations in terms of what types of hadrons can be produced.

The experiment is currently undergoing an upgrade, which is paid for by the members. Swedish membership of LHCb would give access to both the data that has already been collected and also the data that will be collected with the upgraded detector. Active Swedish participation would probably include operation, maintenance, support and further computing resources.

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