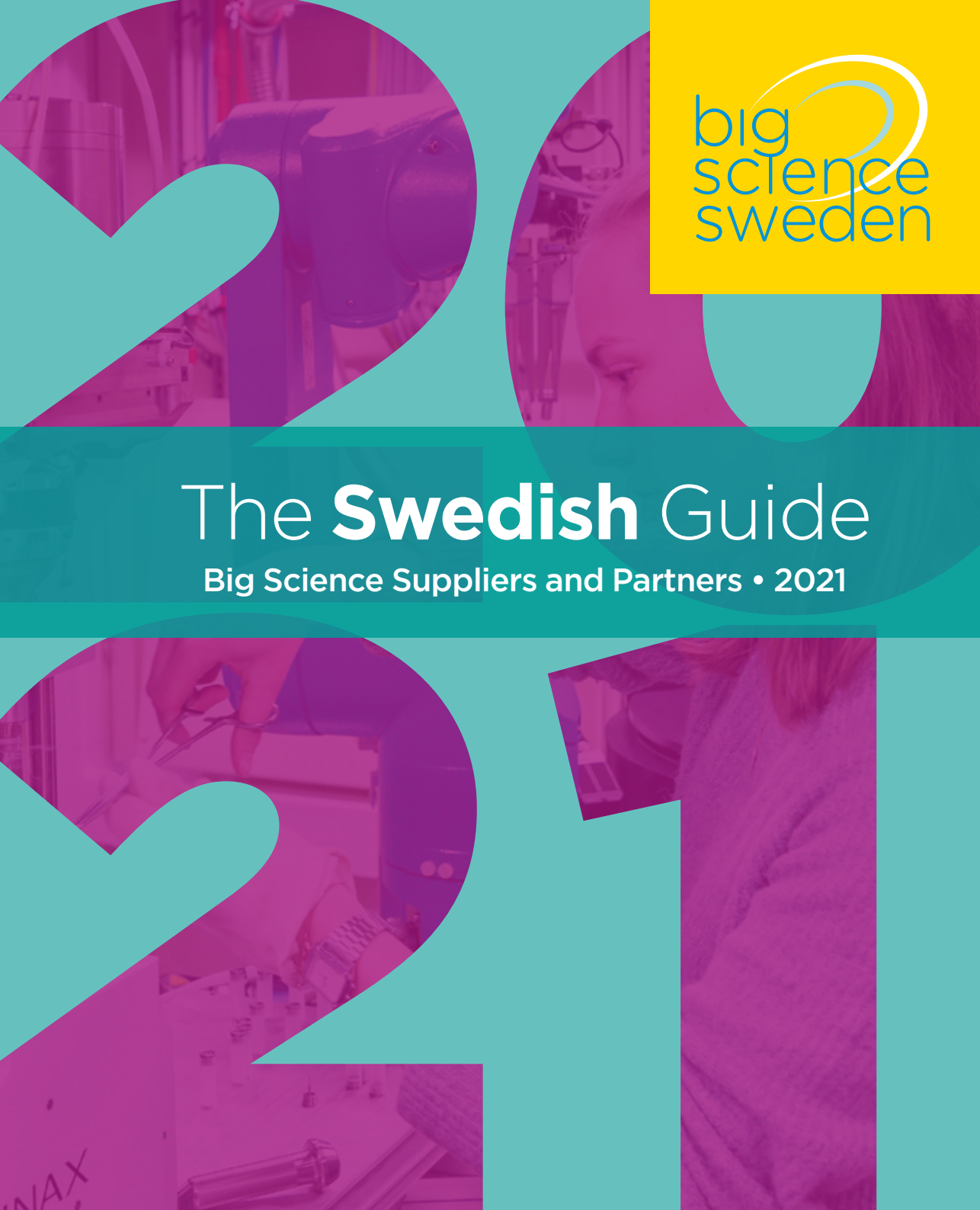
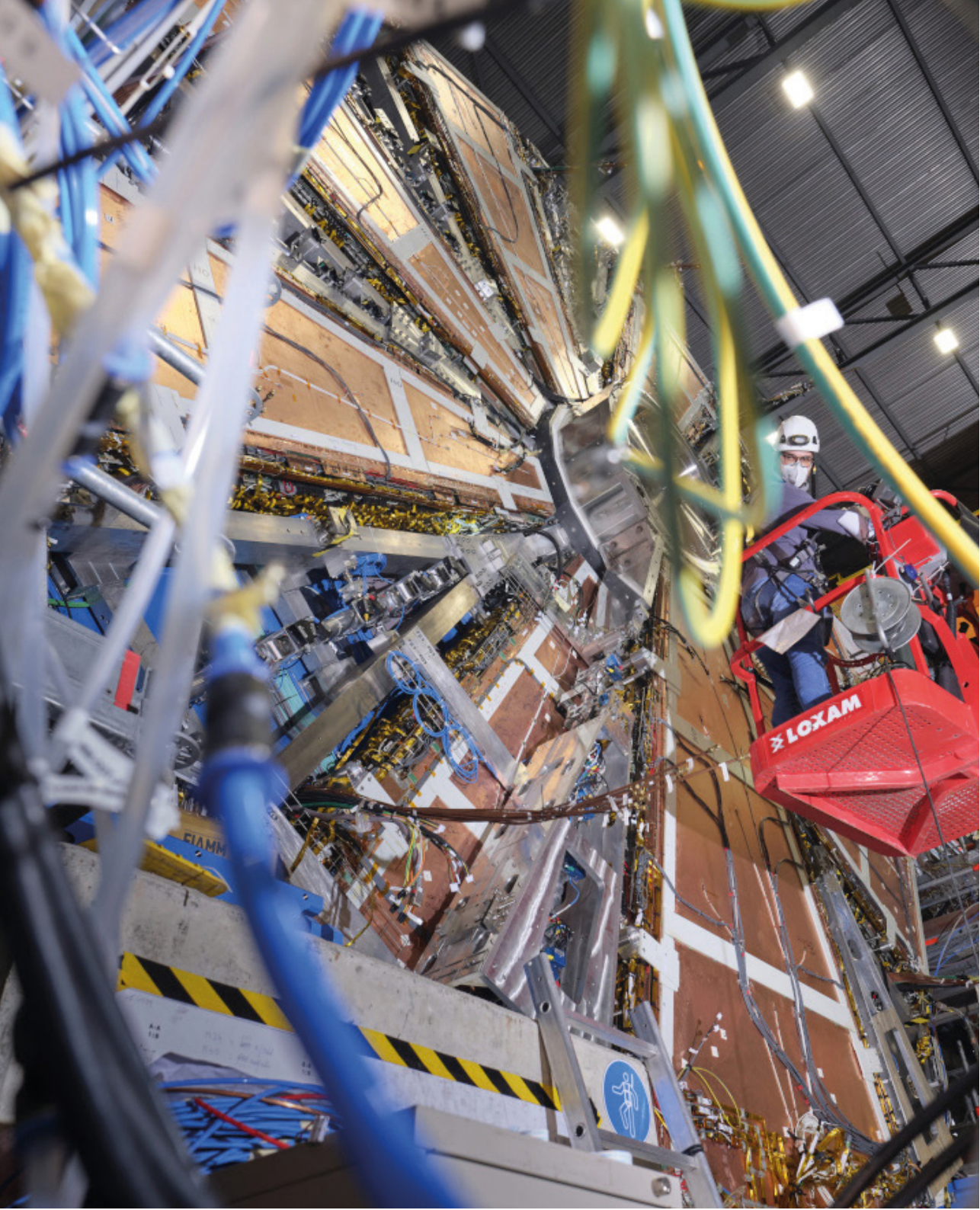
big science sweden

# The **Swedish** Guide

## Big Science Suppliers and Partners • 2021




LOXAM

# JOIN US IN DRIVING BIG SCIENCE TECHNOLOGY

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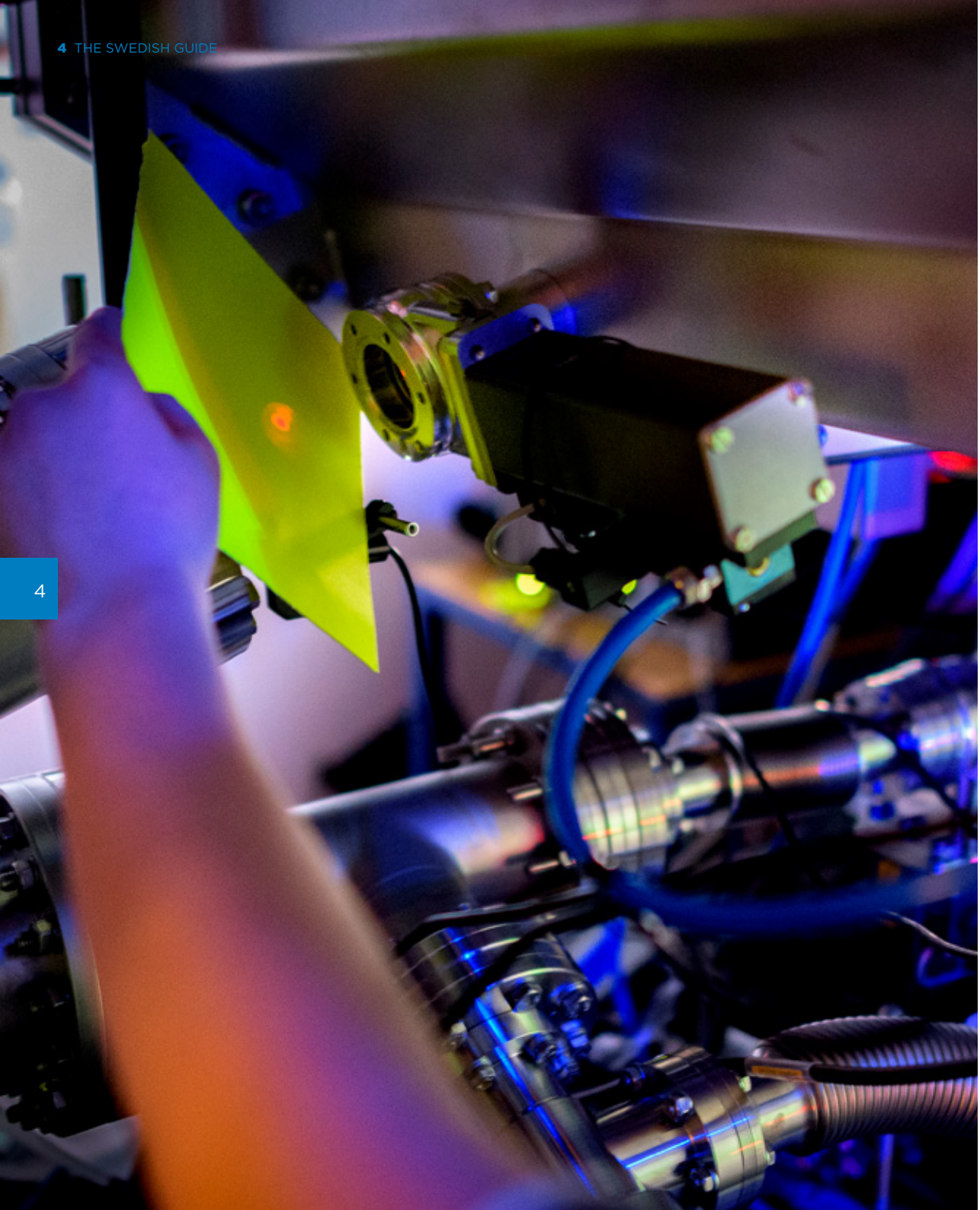

# EDITORIAL

## Big Science Sweden – an arena for business, collaboration, high-tech development, and innovation

At the beginning of 2020, when the last edition of the Swedish Guide was published, who could imagine that it would be such an unusual year? That we would not be able to travel, that all our meetings would be digital, and that much of Europe would be in lockdown. Without doubt, 2020 was a special year.

You're holding in your hand the fourth edition of The Swedish Guide, which we hope you will enjoy and find useful. We're proud to present 229 companies with the capacity and competencies to supply goods, services, and solutions to the leading research facilities, enabling them to carry out state-of-the-art research. ESS and MAX IV are under construction in Sweden, a clear indication that Swedish supplier networks, skills, and expertise are moving forward and continuing to develop.

The companies in the guide are presented according to technology and expertise sectors, making it easy for you to find companies in areas in which you are particularly interested. You will also find information about 87 Swedish academic contributions to various research facilities. We welcome the collaboration and knowledge exchange between universities, institutes, and industry, and observe how boundaries can be extended with high-tech content in large national and international collaborations.

We can see that the network around Big Science Sweden is blooming. Swedish companies are receiving orders from both Swedish and international research facilities, such as ESS, MAX IV, CERN, ESO, and FAIR. Sweden is deepening collaboration with several research facilities, and our industrial return is increasing significantly.

Working closely with the research facilities, we also see potential for technology and knowledge transfer from the research facilities to industry and society. This year, we have started a collaboration programme with CERN in which we are exploring how Swedish companies can work more closely with CERN's experts. We see great opportunities for collaboration in fields such as digital solutions for tomorrow's industry, solutions for sustainable transportation, and materials science.

At the end of 2019, we arranged an AIMday with the aim to foster collaborations between Swedish industry, academia, and international research facilities. The day generated no fewer than five feasibility studies exploring solutions to challenges identified by the research facilities. One such study led to the formation of a Småland cluster to work on superconducting 'cold' magnets. The feasibility study concluded with a project application for which funding of SEK 19 million has recently been awarded. Three high-tech companies and two universities will now be working together.

We look forward to continuing our work with pioneering solutions. Please don't hesitate to ask us more about Swedish collaboration partners, and please contact me or any of our team members if you have any questions.

Best wishes
Anna Hall
Programme Director, Big Science Sweden


EISCAT


ESS


MAX IV


XFEL


DESY


ISIS


FAIR


ESRF


CERN

LOCATED IN CHILE

ESO


ILL

ITER

AUSTRALIA/ SOUTH AFRICA
UNDER CONSTRUCTION

SKA

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ESS

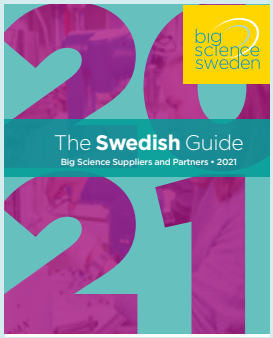

MAX IV

## BIG IN RESEARCH



## SWEDEN'S OFFICIAL ILO






## THE SWEDISH GUIDE

### SUPPLIERS AND PARTNERS



### ACADEMIC CONTRIBUTIONS





## SUCCESS STORIES



## ACTIVITY REPORTS

# Sweden – a Big Science nation

Big Science Sweden is Sweden's official Industrial Liaison Office (ILO) and the link between Swedish high-tech industry, academia, institutes, and the large-scale research facilities in which Sweden is a member. In practical terms, we help Sweden supply equipment, materials, and services to Big Science research facilities around the world.



Two of the world's most powerful and renowned research facilities are located in Sweden.

Big Science Sweden is mandated by the Swedish Government, and funded by Vinnova (Sweden's Innovation Agency) and The Swedish Research Council (Vetenskapsrådet).


Superconducting magnet technology is the backbone of the PET/MR scanner, and this technology has evolved thanks to research centres like CERN and within industry teams like General Electric.

Photo: GE Healthcare




# Swedish Knowledge Transfer Office

The cutting-edge expertise and infrastructures of Big Science facilities represent a unique opportunity to advance technology with great potential for commercial exploitation.

Our Knowledge Transfer Office (KTO) is making scientific and technological development accessible to a wider range of users, both in academia and industry.

# AIMday Big Science Technology

AIMday Big Science Technology is a challenge-driven innovation process involving a workshop. Research facilities are given an opportunity to discuss their challenges with scientists at Swedish universities and institutes and with representatives from high-tech companies that deliver to Big Science.

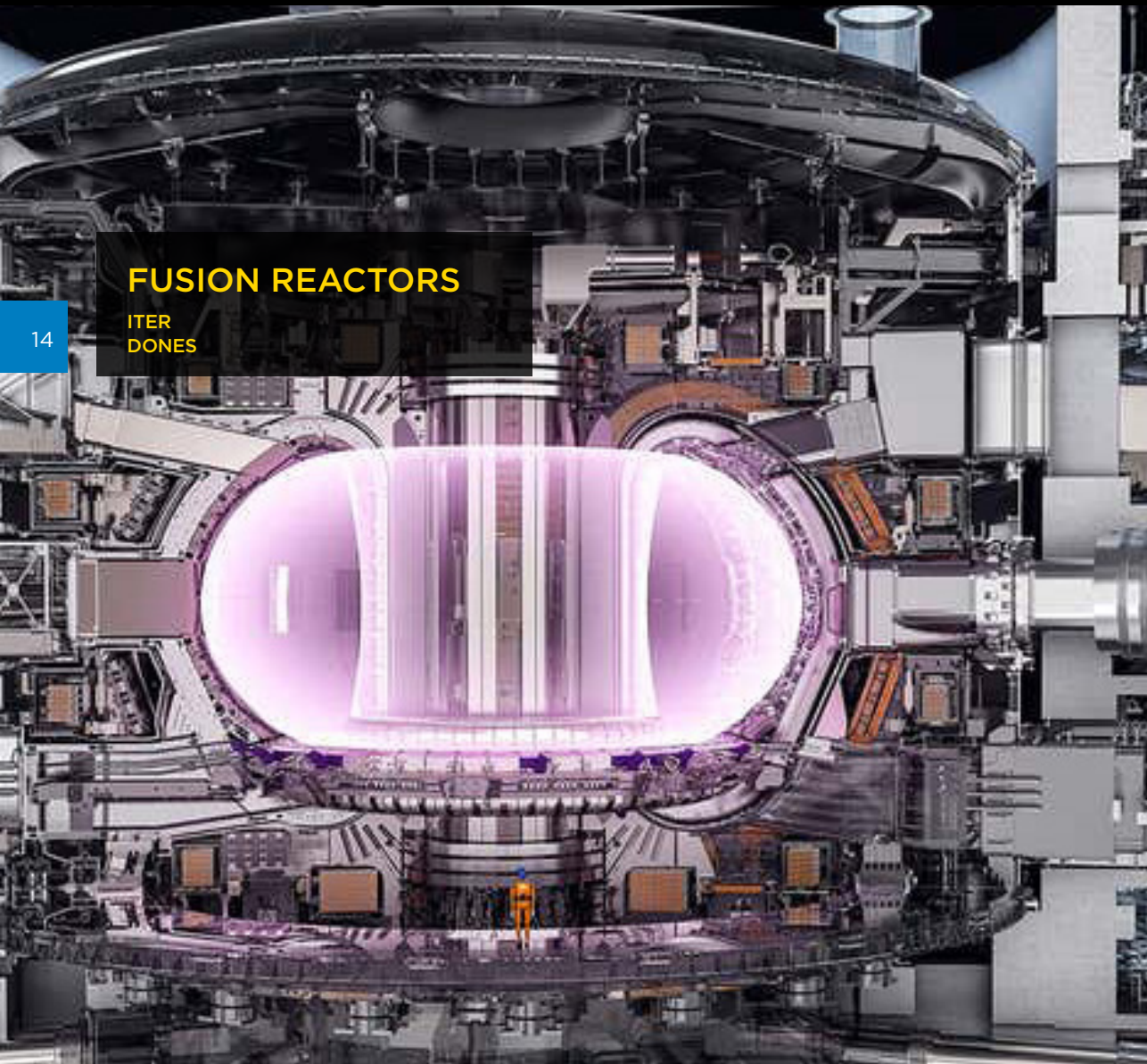
Ahead of the event, the research facilities identify the challenges they are facing in a number of categories, and submit them to Big Science Sweden. Workshop teams with the relevant expertise for each category are then put together to discuss the challenges.

Photo: Kennet Ruona

## BIG SCIENCE

# Official Swedish Industrial Liaison Office (ILO)

An important part of the ILO work is to build networks between Swedish companies and relevant contacts at the research facilities. Big Science Sweden works actively to match Swedish companies with tangible needs and current procurements at the facilities.



## FUSION REACTORS

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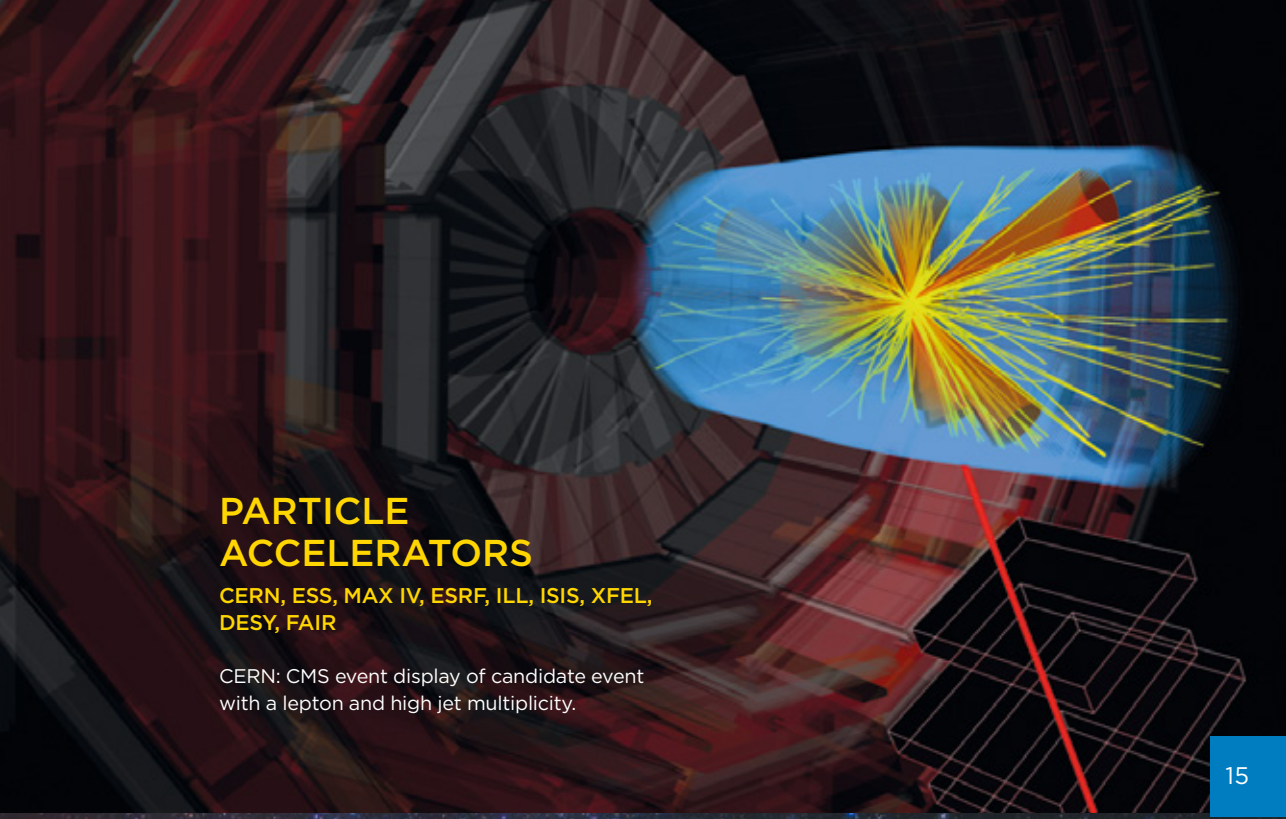
DONES



## PARTICLE ACCELERATORS

**CERN, ESS, MAX IV, ESRF, ILL, ISIS, XFEL, DESY, FAIR**

CERN: CMS event display of candidate event with a lepton and high jet multiplicity.



## SPACE RESEARCH FACILITIES

**ESO, SKA, EISCAT**

The antennas of the Atacama Large Millimeter/ submillimeter Array (ALMA), set against the splendour of the Milky Way.

Photo: ESO/B. Tafreshi

**LUND, SWEDEN**

# ESS – a world leading science and technology infrastructure

The multi-disciplinary research facility European Spallation Source, ESS, based on the world's most powerful neutron source, will enable scientific breakthroughs in a wide range of areas, such as environment, health, materials and energy. ESS is a European partnership, with member countries all over Europe that have committed to collectively build and operate the world's leading facility for research using neutrons. The facility is currently under construction in Lund, Sweden, and will deliver world-class science from 2023.



**World's most powerful neutron source**
**Lund, Sweden (data centre in Denmark)**

**First science:** Pre-Covid-19 planned for 2023 (TBD)
**Full operation:** Pre-Covid-19 planned for 2025 (TBD)
**Construction budget:** EUR 1,8 billion
**Estimated operation cost:** EUR 140 million/year (TBC)
**Employees:** 550
**Users/researchers:** 3000 per year
**No. of member countries:** 13

**Host countries:** Sweden and Denmark
**Construction** 47.5% **Cash investment** ~ 97%
**Operation** 15% (TBD)
**Other member countries**
**Construction** 52.5% **In-kind contribution** ~ 70%
**Operation** 85% (TBD)

Photo: Roger Eriksson/ESS

**LUND, SWEDEN**

# MAX IV makes the invisible visible

The MAX Laboratory is a synchrotron light facility that has been in operation for more than 35 years, and construction of the new synchrotron facility was completed in 2016. Hosted by Lund University, it is the world's most brilliant synchrotron light source, capable of viewing material structures atom by atom. MAX IV facilitates discoveries of new structures at nanolevel, and scientists are able to monitor chemical processes in real time. The facility can house up to 26 beamlines.

**Operational start:** 2016
**Construction cost:** SEK 4.5 billion
**Operational budget:** SEK 530 million/year
**Employees:** 280
**Guest researchers:** 2000 per year
**No. of member countries:** N/A (Swedish national facility, hosted by Lund University).

The world's most advanced SKA telescope in South Africa will consist of 197 dish antennas, each with a diameter of 15 m.
Photo: SKA

**Co-located in South Africa and Australia**

# The Square Kilometre Array (SKA)

The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, with a square kilometre (one million square metres) of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development towards building and delivering a unique instrument, with the detailed design and preparation now well under way. As one of the largest scientific endeavours in history, the SKA will bring together a wealth of the world's finest scientists, engineers and policy makers to bring the project to fruition.

**Representing Sweden in the SKA project**

Onsala Space Observatory is Sweden's national infrastructure for radio astronomy, giving scientists access to equipment for studying the Earth and the rest of the universe. Run by Chalmers University of Technology, the observatory operates radio telescopes and other instruments for both astronomy and geodesy.

**FINLAND, NORWAY AND SWEDEN**

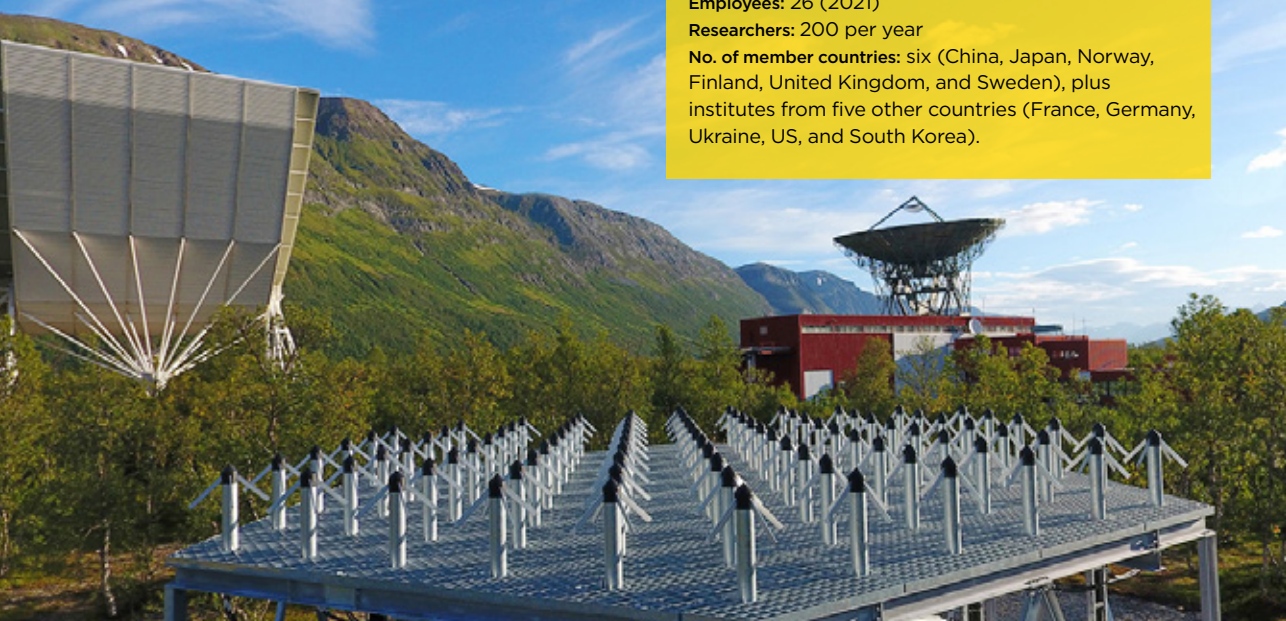
# EISCAT – ionospheric and atmospheric measurements

EISCAT is an international scientific association that conducts ionospheric and atmospheric measurements using a technique called 'incoherent scatter radar'. An example is studies of the Northern Lights.

The association operates equipment in three countries – Finland (Sodankylä), Norway (Tromsø and Longyearbyen), and Sweden (Kiruna) – and all the facilities are located north of the Arctic circle. In Tromsø the facility comprises a combined ionospheric heating and short-wave radar facility.

EISCAT is currently building a next-generation research radar facility, called EISCAT_3D. The radar will replace the systems in Sodankylä, Tromsø, and Kiruna. EISCAT_3D will also be located in the three countries.

**Operational start:** 1981
**Construction cost** (current systems): SEK 300 million (1976-1998). EISCAT_3D: SEK 650 million (2017-2022)
**Operational budget:** SEK 8 million (1981) SEK 26 million (2021)
**Employees:** 26 (2021)
**Researchers:** 200 per year
**No. of member countries:** six (China, Japan, Norway, Finland, United Kingdom, and Sweden), plus institutes from five other countries (France, Germany, Ukraine, US, and South Korea).



# Welcome to Big Science Sweden

### Funding bodies

Big Science Sweden is funded by Sweden's largest and most important organisations for supporting and funding Swedish research and high-tech research and growth: Vinnova (Sweden's Innovation Agency) and The Swedish Research Council (Vetenskapsrådet).

Natasa Pahlm is Strategic Programme Manager, International Cooperation, at Vinnova.

"It's vital that Swedish companies have the necessary expertise and skills to deliver services and products to research facilities, both nationally and globally," she says. "Big Science Sweden opens doors and creates new contacts, enabling us to to establish Swedish innovation on a global market."

### Management

Big Science Sweden is led by a consortium comprising the Association of Swedish Engineering Industries (Teknikföretagen), the industrial development centre (Industrikluster IUC Syd), Chalmers University of Technology, Lund University, Luleå University of Technology, Uppsala University, RISE, and Region Skåne.

"A company may feel that entering the Big Science market and contacting research facilities would be too big a step," says Kjell Möller, Chair of the Big Science Sweden Steering Committee and representing the Association of Swedish Engineering Industries.

"However, many Swedish companies definitely have both the expertise and the capacity to meet the requirements of the facilities. Big Science Sweden provides guidance, and facilitates the first important contacts that can lead to a business relationship."

### ILO

Big Science Sweden is Sweden's official ILO (Industry Liaison Office), which means it has the national responsibility for facilitating contacts and business between Swedish companies and the European research facilities that Sweden is involved in funding. An important part of the ILO work is to build networks between Swedish companies and relevant contacts at the research facilities. Big Science Sweden works actively to match Swedish companies with tangible needs and current procurements at the facilities.

A designated member of the Big Science Sweden team is responsible for each facility, maintaining contacts, building relationships, and getting to know the facility's organisation and needs.

Fredrik Engelmark, Business Development and Project Management, Big Science Sweden, is responsible for contacts with CERN.

"By networking with representatives at the research facilities, I can match a facility with a relevant Swedish company, and with researchers who can complement the company's existing expertise," he explains. "In this way, we put together a team that can run high-tech innovation projects."

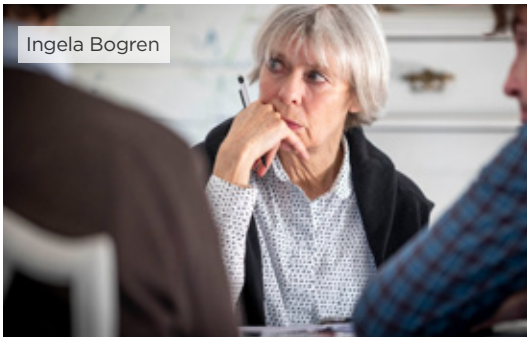


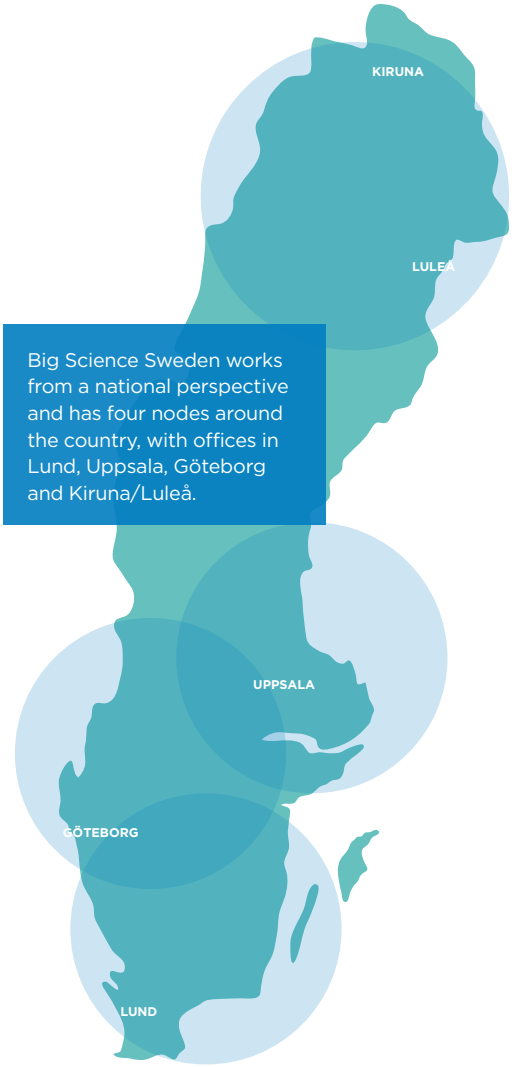
The Big Science Sweden National Team, here during the Strategy Days in Luleå, spring 2020. Fredrik Engelmark, Frida Tibblin Citron.


Sven-Christian Ebenhag


Ekaterina Osipova


Adam Wikström


Ingela Bogren




Big Science Sweden works from a national perspective and has four nodes around the country, with offices in Lund, Uppsala, Göteborg and Kiruna/Luleå.



## Industrial Liaison Officers and Purchasing Advisors – Support and Contact Points

**Anna Hall**
ILO: CERN, ESS, MAX IV, FAIR, ESRF, ILL
Contact point: EISCAT, ISIS, DESY, XFEL
**Patrik Carlsson**
ILO: ITER, ESO, SKA
**Fredrik Engelmark**
ILO: CERN

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Several of our part-time staff are shared with universities and institutes, which gives us a broad coverage.

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The Swedish ILOs, Patrik Carlsson, Anna Hall and Fredrik Engelmark, and Håkan Nilsson, discussing collaborations between the Swedish company Studsvik and various research facilities. In the background, Niklas Snis, General Laboratory Manager at Studsvik.

# European research facilities

**We are Sweden's official ILO organisation, serving European Big Science research facilities in which Sweden is a member. The focus is on Big Science facilities and fields important for Swedish science, innovation, technology and business.**



## ESS

**Lund, Sweden**

ESS (European Spallation Source) will be a world-leading multi-disciplinary research facility, based on the world's most powerful spallation source. ESS will enable scientific breakthroughs in research related to materials, energy, health and the environment, addressing some of the most important societal challenges of our time. ESS, currently under construction and hosted by Sweden and Denmark, is a collaboration between 13 European countries that are building and will operate the facility jointly. ESS expects to welcome its first researchers in 2023.

## MAX IV

**Lund, Sweden**

MAX IV is a synchrotron light facility that began operations in 2016. Hosted by Lund University, it is the world's most brilliant synchrotron light source, capable of viewing material structures atom by atom. MAX IV facilitates discoveries of new structures at nanolevel, and scientists are able to monitor chemical processes in real time. The facility can house up to 26 beamlines. At full capacity, more than 2000 scientists are expected to conduct experiments at MAX IV every year.

## CERN

**Geneva, on the border between Switzerland and France**

CERN (Conseil Européen pour la Recherche Nucléaire) is a European research facility set up in 1954 by 12 founder states, one of which was Sweden. CERN now has 23 Member States and a number of Associate Member States. At CERN, 2500 staff and some 15,000 external scientists advance the boundaries of knowledge regarding the origins of our universe and its smallest building blocks, subatomic particles. The heart of the CERN facility is the Large Hadron Collider (LHC), a 27-kilometre circular particle accelerator. The High Luminosity project, due to come into operation in 2025, will increase the luminosity of the LHC by a power of ten. The materials budget of the High Luminosity project is nearly CHF 950 million.

## ITER

**Cadarache, France; European procurement organisation F4E in Barcelona, Spain**

ITER (International Thermonuclear Experimental Reactor) is a global cooperation project, funded by 35 nations, to build the world's largest Tokamak reactor for research into fusion energy. It will be the largest fusion experiment facility in the world and the first to produce net energy, producing 500 MW of power from an input of 50 MW. It will be the first plant that integrates all the various technologies needed to operate a fusion reactor. Experiments at ITER are scheduled to begin in 2025, and the construction budget is EUR 20 billion. F4E (Fusion for Energy) is the EU organisation responsible for the EU contribution to ITER.

## ILL

**Grenoble, France**

The Institut Laue-Langevin (ILL) is an existing spallation facility that has been in operation for more than 45 years. ILL was founded in 1972 by France, Germany, and the UK, and there are ten further Scientific Member countries. Sixty percent of the capacity of ILL is dedicated to fundamental research and 40% is dedicated to research into societal challenges. The facility is undergoing a modernisation programme that has increased the detection rate of the instruments by a factor of 25, and the programme is about to move into its second phase.

## ESRF

**Grenoble, France**

ESRF (European Synchrotron Radiation Facility), opened in 1989, is operated as a partnership between 22 countries. The facility welcomes almost 9000 visiting scientists every year, conducting research using the X-ray beams that are 100 billion times more powerful than the X-rays used in hospitals. An extensive upgrade, the Extremely Brilliant Source, is under way, with a budget of EUR 330 billion. This will provide new storage rings that can produce more intense, coherent, and stable X-ray beams.

## DESY

**Hamburg, Germany**

DESY (Deutsches Elektronen Synchrotron), set up in 1959, is a national research centre in Germany, operating particle accelerators used to investigate the structure of matter. Three thousand guest scientists from 40 countries conduct research at the facility each year. Three large accelerators dominate the DESY site: PETRA III, Flash and XFEL. Research ranges from nanomaterials and semi-conductors to pharmaceuticals and materials for solar panels. Technologies developed at DESY can also be used for detailed diagnosis of tumours and for developing less invasive cancer therapies.

## European XFEL

**Hamburg, Germany**

European XFEL (X-ray Free Electron Laser) is the world's most powerful X-ray laser facility, opened in 2017. The project is funded by 12 European countries. The facility is powered by a 3.4-km linear accelerator, which can generate 27,000 flashes of light per second, each of a duration of less than 100 quadrillionths of a second.

## FAIR

**Darmstadt, Germany**

FAIR (The Facility for Antiproton and Ion Research) is currently under construction in Darmstadt at a cost of EUR 1.7 billion. At the facility, matter that only exists in outer space will be produced in a lab for research, and it will be possible to accelerate ions of all the natural elements in the periodic table, as well as antiprotons. Ten countries are shareholders of FAIR and more countries are partners. Three thousand scientists will visit and use FAIR each year.

## ISIS

**Harwell, UK**

ISIS Neutron and Muon Source is a national spallation source financed by the Science and Technology Facilities Council, and is based at the Rutherford Appleton Laboratory in Harwell, near Oxford. Research at ISIS spans a wide range of disciplines, from magnetism to cultural heritage, engineering to food science, and from chemistry to environmental science. The facility houses 32 instruments.

## ESO

**HQ Munich, Germany and telescopes in Chile**

ESO (The European Southern Observatory) consists of telescopes at three sites in the Atacama Desert in Chile. The Very Large Telescope can view objects at the edge of our universe and help answer fundamental questions, such as whether we are alone. A new Extremely Large Telescope (ELT) with a 39-m mirror is under construction, with a budget of EUR 1.2 billion. It will be the world's largest telescope and will address some of the most pressing unresolved issues in astronomy.

## EISCAT

**Kiruna, Sweden**

EISCAT (European Incoherent SCATter) is a facility for astronomy research using radar. A new facility, EISCAT 3D, is under development. This will comprise three sites in the north of Sweden, Norway, and Finland, each consisting of 10,000 antenna elements. The facility will be used for research, for example, into how the earth's upper atmosphere is connected to space, and also for forecasting space weather and for detecting and tracking space debris. The EISCAT system will use several different measurement techniques that have never before been combined in one system.

## SKA

**Co-located in South Africa and Australia**

The Square Kilometre Array (SKA) project is an international effort to build the world's largest radio telescope, with a square kilometre (one million square metres) of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development towards building and delivering a unique instrument, with the detailed design and preparation now well under way. As one of the largest scientific endeavours in history, the SKA will bring together a wealth of the world's finest scientists, engineers and policy makers to bring the project to fruition.

# ACADEMIC CONTRIBUTIONS TO BIG SCIENCE

# QUICK GUIDE: HOW TO NAVIGATE

The following is a selection of current Swedish academic contributions to Big Science. Is there anything you want to update, or are you a researcher in Sweden and want your contribution to Big Science included in The Swedish Guide? Don't hesitate to get in touch!

**This is a quick guide to make it easier for you to learn about the Academic Contributions**
Feel free to browse around and learn about more about the 70+ academic projects presented in the guide. There are different ways to search, depending on your preferences. We are using the procurement codes developed and used by CERN.

**BIG SCIENCE FACILITY**

**1** Search for academic projects by Big Science facility.

**COORDINATING UNIVERSITY**

**2** Search for academic projects by coordinating university.

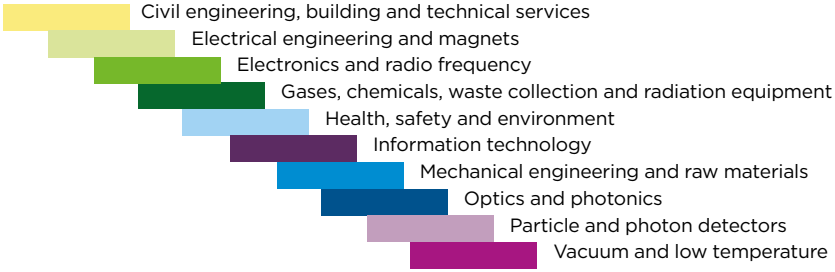
**AT HOMEPAGE**

**3** Search at **www.bigsciencesweden.se**



# INDEX PROCUREMENT CODES

To facilitate and make it easier to find right supplier we are using procurement codes according to CERN.



# Index sorted by Big Science facility

# Index sorted by coordinating university

**MID SWEDEN UNIVERSITY**

The MEDIPIX Collaboration

Brightness

**RISE**

FINESSE – Fiber optic sensing systems

EUROfusion WPENS

Square Kilometre Array

EUROfusion DIVERTOR work package, ITER

High Voltage Reference Divider

**STOCKHOLM UNIVERSITY**

Temperature measurement system for undulators

Characterization and Fiducialization of Undulator quadrupoles

**SWERIM AB**

MassDiff: Development of post-processing tools for time-resolved data

**UNIVERSITY OF GOTHENBURG**

Instrument to increase the capacity for life-science studies SFX at XFEL

**UNIVERSITY WEST**

Luminescent coatings

**UPPSALA UNIVERSITY**

Laser Heater system for the injector; design, production, test, delivery, and commissioning

Solid State Power Amplifier – development of the next 400 kW power station for ESS

CERN Superconducting Cables Connection Cryostats (Cold Boxes)

Cold Spark System for Clic

Development of CERN superconducting Canted Cosine Theta magnet prototype

Quench Study and RF Characterization of Crab Cavities

Silicon Detector Modules for ATLAS Experiment

Testing of Superconducting Orbit Corrector Dipole Magnets

Micro Accelerator Structure center MAS in Uppsala

Extremely Large Telescope Instrumentation: HIRES and MOSAIC

Acceptance Tests of Cryo Modules

Design Study of Accumulator Ring

Test of the ESS High Voltage Pulse Modulator

Testing of the ESS superconducting Elliptical cavity

Testing of the ESS tetrode 352 MHz radiofrequency power source

Testing of the ESS superconducting Spoke cavity Prototype

Electromagnetic Calorimeter for the PANDA Experiment

Super ADAM @ ILL

Veritas

Laser Heaters

Mass spectrometer and cell sorter for biology infrastructure

NIR Spectrometer for European XFEL

Sample injector and diagnostic system

Neutron diagnostics for fusion power plants

IceCube extension

# CERN

CERN
Coordinating university: Lund University, www.lu.se

# ADVANCED RESOURCE CONNECTOR SOFTWARE FOR ATLAS AND LHC COMPUTING

LUNDS UNIVERSITET

## Project description
ATLAS is the biggest instrument at the biggest machine on Earth, the Large Hadron Collider (LHC). It is 46 meters long and weighs 7000 tonnes, working like a huge camera, taking very detailed "pictures" of particle collisions. With a spacial resolution of microns, the raw size of one "picture" is 1.6 Mbytes, and with data taking rates of Megahertzs, it collects several Petabytes of raw data a year. The challenge is to store this data, process it to create samples ready for analysis, and to make it available to physicists around the world in real-time. No single supercomputer exists meet this challenge, so the solution is to use the global network of supercomputers, for which our team develops software.

## Team
Lund University:
- Oxana Smirnova, Doctor, team leader, specialist in scientific computing
- Balazs Konya, Doctor, specialist in distributing computing
- Florido Paganelli, systems expert, computer scientist

## Core deliverables
Advanced Resource Connector (ARC) software

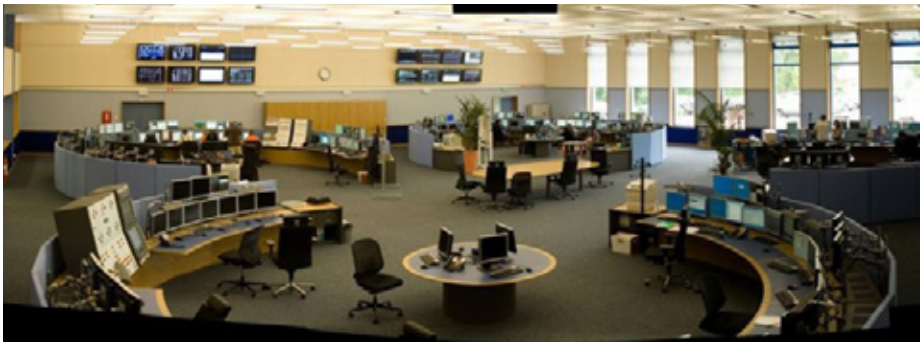
## Industry involvement
Industry involvement in the distributed computing project comes indirectly, through high-performance computing and storage hardware, and partially through open source software.

## Year
2001 –

## Total budget
EUR 2 million

## Collaboration(s)
- Lund University
- Uppsala University
- University of Oslo
- University of Copenhagen
- Jozef Stefan Institut
- University of Bern
- Taras Shevchenko National University of Kyiv

## Hyperlink(s)
www.nordugrid.org



**Procurement code(s)**
Information technology

CERN
**Coordinating university: Lund University, www.lu.se**

# AUTONOMOUS AIRSHIP FOR INDOOR INSPECTIONS

LUNDS UNIVERSITET

## Project description
Efficient use of Unmanned aerial vehicles (UAV) in terms of flying time and having them work autonomously for monitoring in accelerator tunnels and other hostile environments, and at the same time avoiding contaminated dust being moved into different facilities regions. We are taking into account the radioactive environment and are improving the performance of positioning systems for autonomous navigation, operation, sensors and processing of collected data. We see that the results obtained are of interest to the research infrastructures ESS and MAX IV, which also expresses the need for autonomous radiation inspection.

## Team
Lund University, Faculty of Engineering
- Anders Robertsson, Team leader, Professor, Department of Automatic Control
- Marcus Greiff, Doctoral student, Department of Automatic Control
- Rikard Tyllström, Lecturer in Aeronautical Sciences, TFHS
- Emil Rofors, Postgraduate, Department of Physics
- Kalle Åström, Professor, Department of Mathematics

## Core deliverables
- Autonomous Radiation Mapping
- Isotope Composition Identification
- Mobile Gamma Spectroscopy

## Year
2019-

## Total budget
EUR 200,000

## Collaboration(s)
Lund University

## Hyperlink(s)
http://uav.lu.se



**Procurement code(s)**
Electrical engineering and magnets
Health, safety and environment
Gases, chemicals, waste collection and radiation equipment

**CERN**
**Coordinating university: Uppsala University, www.uu.se**

# CERN SUPERCONDUCTING CABLES CONNECTION CRYOSTATS (COLD BOXES)

UPPSALA UNIVERSITET

## Project description

The High Luminosity Large Hadron Collider (HL-LHC) at CERN is an upgrade of the LHC to achieve instantaneous luminosities a factor of five larger than the LHC nominal value. More powerful superconducting magnets are needed and their powering relies on essential and critical connections between MgB2 cable and a high temperature superconductor current lead. These connections need to be cooled by cryogens and must be able to carry an unprecedented current capacity of up to 100 kA each. The devices where these connections are made have to be cryogenic and high current compatible as well as compact.

## Team

Uppsala University:
- R. Santiago Kern, Research Engineer, cryogenics and vacuum
- Roger Ruber, Researcher, cryogenics and superconductivity
- Tord Ekelöf, Professor, project leader

CERN:
- Vittorio Parma, Research Engineer, project engineer

## Core deliverables

- Design of the different components of the cryostats
- Manufacturing
- Assembly
- Qualification testing
- All documentation pertaining to the project, such as manufacturing drawings and test reports

## Year

2018–2023

## Total budget

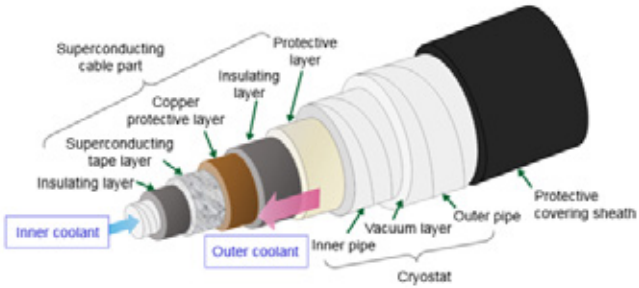
EUR 2 million

## Industry involvement

RFR Solutions

## Hyperlink(s)

http://hilumilhc.web.cern.ch




**Procurement code(s)**
Electrical engineering and magnets
Electronics and radio frequency
Vacuum and low temperature

**CERN**
**Coordinating university: Uppsala University, www.uu.se**

# COLD SPARK SYSTEM FOR CLIC

UPPSALA UNIVERSITET

## Project description

A particle accelerator is an important tool of modern science and medicine. The use of the accelerators is limited to bigger research centers and larger hospitals due to their often large size and cost. The size is limited by phenomena of vacuum breakdowns where significant increase of the accelerating voltage inside the accelerator will cause an electric discharge which can destroy the machine. For safe operation we keep the accelerator longer and stay at lower voltages. Uppsala University is building a system with large planar electrodes for studies of the fundamental physics of high-fields in vacuum, important for development of accelerating technologies. The system is cooled to cryogenic temperatures and operated in a wide range of temperatures.

## Team

Uppsala University:

- Marek Jacewicz, Doctor, detectors and control systems
- Johan Eriksson, Senior Lecturer, mechanical engineering
- Roger Ruber, Docent, cryogenics.

## Core deliverables

- System design and requirement gathering
- Acquisition of hardware
- Manufacturing of components
- System integration and commissioning

## Year

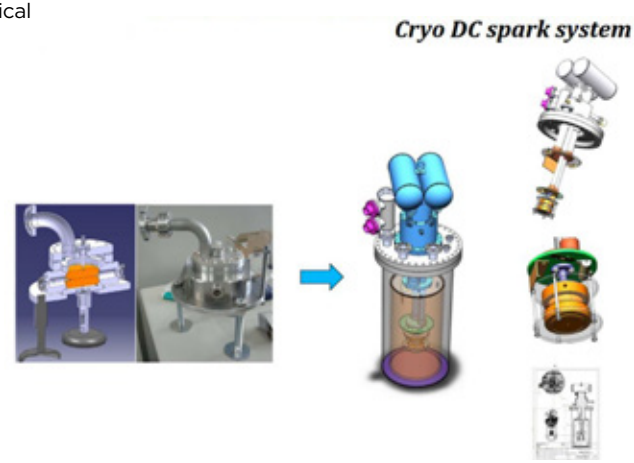
2018–

## Total budget

EUR 150,000

## Industry involvement

- Innovatec Ceramics
- VAQTEC
- Omega Engineering




**Procurement code(s)**
Mechanical engineering and raw materials
Vacuum and low temperature

**CERN**
**Coordinating university: Lund University, www.lu.se**

# CONSTRUCTION OF THE TIME PROJECTION CHAMBER IN ALICE AT LHC

LUNDS UNIVERSITET

## Project description

The ALICE Experiment (s)ee figure) at LHC at CERN is designed to study collisions between Heavy nuclei at extremely high energy, a new state of matter named Quark Gluon Plasma is created where protons and neutrons do not exist but their constituents, quarks and gluons form a large volume system like in the first millionth of a second of the Big Bang. Several thousand particles are produced when the plasma expands and cools off. The ALICE experiment with its ca 1000 collaborators is designed to measure these. The main subdetector is the TPC, which records the track of ionized atoms due to passing charged particles. The TPC is read out with about 500 000 electronic channels. Each channel is a preamp/shaper 10 bit sampling ADC and 1000 samples memory. Half a million channels of digital oscilloscope in simple words. The Lund group covered prototyping and fabrication of the digital ASIC, performed robotic testing and calibration of 100000 ASICs and Manufactured 5000 circuit boards together with NOTE AB in Lund.

## Team

Lund University:

- Hans Åke Gustafsson, Professor, physicist, project leader, detector expert
- Anders Oskarsson, Professor, physicist, deputy project leader, detector expert
- Lennart Österman, Research engineer, electronics, specification, circuit board design and board layout, CAD, R&D, robotic ASIC testing, quality control

## Core deliverables

- Prototyping and fabrication of ALTRO ASIC (s)T microelectronics)
- Robotic testing of 50000 ALTRO ADC chips (in house)
- Robotic testing of 50000 PASA (preamp-shaping amplifier ASIC) (in house)
- Assembly of 5000 Front End boards (NOTE)

## Industry involvement

NOTE

## Year

2003–2005

## Total budget

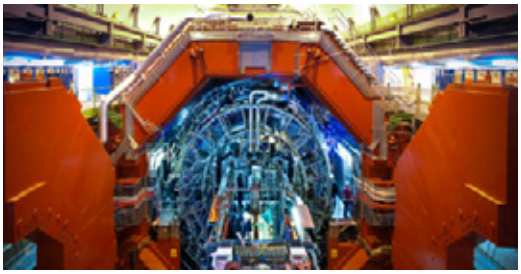
EUR 2.1 million

## Collaboration(s)

- Lund University
- CERN
- GSI Darmstadt
- Frankfurt University
- University of Heidelberg

## Hyperlink(s)

- http://alice-collaboration.web.cern.ch/
- http://alice-tpc.web.cern.ch/content/tpc-frond-end-electronics
- http://cdsweb.cern.ch/record/940643



**Procurement code(s)**
Electronics and radio frequency
Particle and photon detectors

**CERN**
**Coordinating university: Lund University, www.lu.se**

# CONTRIBUTION TO THE ISOLDE-EXPERIMENT AT CERN

LUNDS UNIVERSITET

## Project description

The project concerns the Swedish membership in the ISOLDE collaboration at CERN. ISOLDE, CERN:s radioactive beam facility, provides beams for experiments in nuclear physics and atomic physics, including applications in nuclear astrophysics and fundamental physics, as well as in solid-state physics, biophysics and medical physics. The experimental activities at ISOLDE are governed by a memorandum of understanding between CERN and the members of the ISOLDE collaboration represented by the respective funding agencies. The collaboration currently includes 15 countries and CERN. Sweden has been member of ISOLDE since it inception in 1967. ISOLDE is a part of CERNs general organization. It includes a user group of ca 500 university physicists with research activities at the facility. The contribution delivers support for the optimization of the daily operation of the accelerator and separator infrastructure of the facility. The collaboration also provides support to assist approved experiments.

## Core deliverables

- Research infrastructure optimization
- Infrastructure assistance
- Collaboration Organisation

## Team

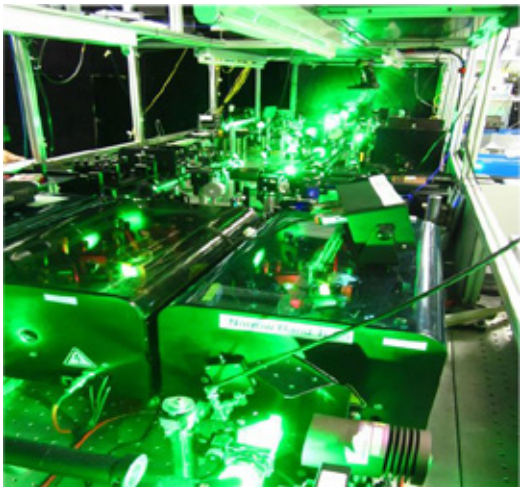
Lund University:
Joakim Cederkäll, Professor, Nuclear Physics, Faculty of Science, Department of Physics

## Year

2018-2022

## Budget

EUR 270,000





**Procurement code(s)**
Particle and photon detectors
Optics and photons

**CERN**
**Coordinating university: Lund University, www.lu.se**

# DARKJETS

LUNDS UNIVERSITET

## Project description

For experiments at the Large Hadron Collider (LHC) at CERN, proton-proton collisions occur up to 30 million times per second. One cannot record all information related to each of these collisions, since the size of each "event" can surpass 1 MB. Experiment therefore select only a subset of these collision events, record them to storage and then analyze them afterwards. Novel techniques are needed in order to make the most of data that is not selected and would otherwise be discarded. The DARKJETS project delivers such a technique for the ATLAS experiment, called Trigger-object Level Analysis (TLA). In this technique, higher-level insight is obtained from a fast data analysis done in milliseconds, so that only a small subset of the information can be stored for each event. This greatly reduces the event size and allows for a much larger dataset to be recorded for e.g. searches for new physics phenomena. This project has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No GA679305)"

## Team

Lund University, Faculty of Sciences:

- Caterina Doglioni, Senior Lecturer, specialist in data selection and data analysis, particle physics
- William Kalderon (now at Brookhaven National Lab) and Jannik Geisen, Postdocs, specialist in data selection and data analysis, particle physics
- Oxana Smirnova, Senior Lecturer, specialist in scientific computing and data processing
- Florido Paganelli, Researcher, computer scientist, system expert
- Eva Hansen, Eric Corrigan, PhD students

## Core deliverables

- Novel technique for the ATLAS detector to record more data than traditional techniques in searches for new particle
- Commissioning of FPGA-based board for event selection in the upcoming LHC Run
- Scientific and technical peer-reviewed publications

## Year

2016–2021

## Total budget

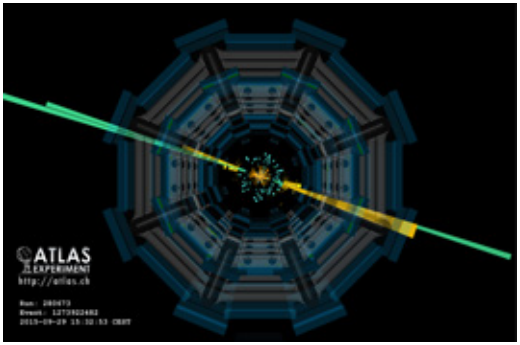
EUR 1.27 million

## Collaboration(s)

- Lund University
- Ohio State University
- Heidelberg University
- University of Oregon
- University of Geneva
- CERN

## Hyperlink(s)

www.hep.lu.se/staff/doglioni/darkjets.html

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**Procurement code(s)**
Information technology

CERN
**Coordinating university: Uppsala University, www.uu.se**

# DEVELOPMENT OF CERN SUPERCONDUCTING CANTED COSINE THETA MAGNET PROTOTYPE

UPPSALA UNIVERSITET

## Project description
CERN is currently upgrading its Large Hadron Collider to increase its collision frequency (luminosity) by an order of magnitude. To do so a new type of superconducting orbit corrector dipole magnet based on the Canted Cosine Theta (CCT) design is being developed. FREIA Laboratory is aiming at signing a so called K-contract with CERN for the fabrication of a series such magnets.

## Team
Uppsala University, Department of Physics and Astronomy, FREIA:
- Tord Ekelöf, Professor, project manager
- Roger Ruber, Docent, accelerator systems
- Kevin Pepitone, Research engineer

Scanditronix:
- Mikael Vieweg

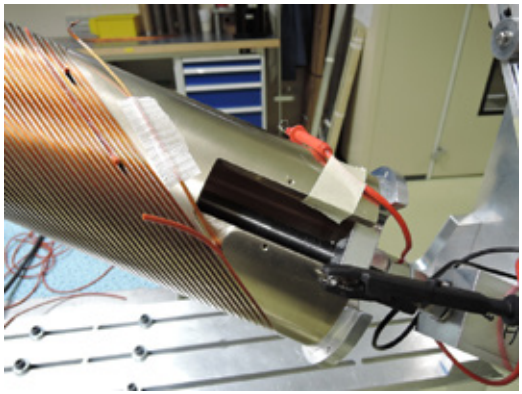
CERN:
Glyn Kirby

## Core deliverables
- Design of the CCT magnet
- Fabrication of the prototype
- Tests of the prototype
- Report on the test results

## Year
2017-2019

## Total budget
EUR 500,000

## Industry involvement
- Uppsala University
- Scanditronix



**Procurement code(s)**
Electrical engineering and magnets
Mechanical engineering and raw materials
Vacuum and low temperature

**CERN**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# DEVELOPMENT OF THE RILIS/LARIS-ISOLDE LABORATORIES AT CERN

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

Today ISOLDE is a major CERN installation with a user community of about 300 researchers from 80 institutions in 21countries. The scientific program is broad and includes experiments in low-energy nuclear physics, nuclear solid-state physics, atomic-and molecular physics, nuclear astrophysics, particle physics and nuclear medicine. The research program focuses on further development of the RILIS (Resonance Ionization Laser Ion Source)-ISOLDE ionization laboratory. The RILIS-ISOLDE facility produces radioactive isotopes using the Isotope Separator On Line (ISOL) technique whereby a driver beam impinges upon a fixed target. The reaction products are ionized, extracted and then mass separated during their flight towards the experimental setup. On account of its high efficiency, speed and unmatched selectivity, the preferred method for ionizing the nuclear reaction products at the ISOLDE on-line isotope separator facility. By exploiting the unique electronic energy level fingerprint of a chosen element, the RILIS process of laser step-wise resonance ionization enables an ion beam of high chemical purity to be sent through the mass selective separator magnet. The isobaric purity of a beam of a chosen isotope is therefore greatly increased. We developed the RILIS facility further to a "state-of-the-art" system together with the newly developed pre-RILIS laboratory in order to make a reliable, ion producing CERN facility for the ISOLDE community.

## Team

Lund University:

- Joakim Cederkäll, Professor, Nuclear Physics, Faculty of Science, Department of Physics
- Claes Falander, Professor, Nuclear Physics, Faculty of Science, Department of Physics

## Core deliverables

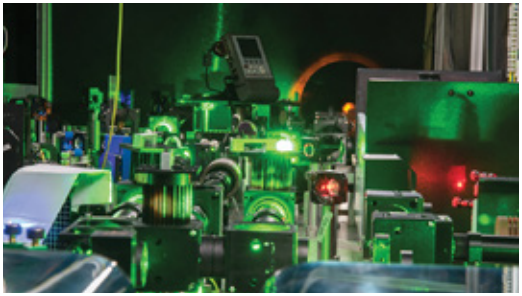
Electronic energy level “fingerprinting”
RILIS (Resonance Ionization Laser Ion Source)

## Year

2011-2015

## Budget

EUR 200,000





**Procurement code(s)**
Particle and photon detectors
Optics and photons

CERN

**Coordinating institute: RISE Research Institutes of Sweden, www.ri.se**

# FINESSE – FIBER OPTIC SENSING SYSTEMS

## Project description

FINESSE is a collaborative research and training network, gathering 26 European universities, research centers and industrial partners with complementary expertise in distributed optical fibre sensor systems for a safer society.
One activity within FINESSE involved evaluating the use of fibre optic sensors for monitoring in harsh radiative environment. Indeed, any sensor to be installed in a silicon detector at CERN's LHC should ideally fulfil the requirements of being radiation resistant and insensitive to magnetic fields, while having small dimensions, reliable reading across long distances, and ease of multiplexing to form large network of sensors. Thanks to their inherent properties, fibre optics sensors have been identified as candidates to monitor relative humidity inside the detector enclosure. In this work, humidity measurement was performed every 70 cm over a single 1 km fibre using phase-sensitive Optical Time Domain Reflectometry, an advanced fibre optic sensing technique.

## Team

RISE, Research Institutes of Sweden
- Kenny Hey Tow, Researcher, Fibre optic unit
- Åsa Claesson, Researcher, Fibre optic unit

## Core deliverables

The optical fibers used in the study were developed and produced by RISE Fiberlab. These fibers, and the sensors built from them, were evaluated for distributed relative humidity sensing in terms of response time and sensitivity.

## Year

2019

## Total budget

In kind

## Collaboration(s)

EPFL, Swiss Federal Institute of Technology

## Hyperlink(s)

- http://itn-finesse.eu/
- https://www.ri.se/en/what-we-do/expertises/fiber-optic-sensors
- https://www.ri.se/en/what-we-do/expertises/specialty-optical-fiber

**Procurement code(s)**

Optics and photonics

**CERN**
**Coordinating university: Lund University, www.lu.se**

# HELIOS

## Project description
The Helmholtz-Lund International graduate School (HELIOS) on "Intelligent instrumentation for exploring matter at different time and length scales" connects major knowledge hubs in the Baltic Sea Region: Hamburg University, DESY, and Lund University. HELIOS started in early 2021 and includes scientists from Particle Physics, Molecular Physics, Nano(bio) Science, and Ultrafast Photon Science. The aim of HELIOS is to develop the instrumentation and data acquisition systems for the next generation of photon sources and particle accelerators, in collaboration with industrial partners that we will seek within Big Science Sweden. HELIOS also aims to connect with the Hanseatic League of Science (HALOS) project for life sciences, to enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Team
Lund University
- Mathieu Gisselbrecht, Associate professor, Physics
- Caterina Doglioni, Associate professor, Physics, Particle physics
- Anders Mikkelsen, Professor, Physics, NanoLund

## Core deliverables
Individual projects investigate novel solutions for (e.g.):
- Real-time data acquisition and analysis
- Image processing techniques
- Feedback control loops
- On chips miniaturization using nanotechnology for biosensing

## Year
2021-2026

## Total budget
EUR 7.9 million

## Collaboration(s)
University of Hamburg

## Hyperlink(s)
https://www.heliosgraduateschool.org

**Procurement code(s)**
Electronics and radio frequency
Information technology
Vacuum and low temperature
Optics and photonics
Particle and photon detectors

CERN
**Coordinating institute: RISE Research Institutes of Sweden, www.ri.se**

# HIGH VOLTAGE REFERENCE DIVIDER

## Project description

The large Hadron Collider at (CERN, was upgraded in 2014 with a new linear accelerator Linac4. Radio-frequency (RF) power requirements for the new accelerator translated into new requirements for the high-voltage measurements at the level of the klystron power supplies: Cathode and anode voltages are pulsed at –110 and –50 kV, respectively, with a repetition rate of 1.1 Hz. Voltage rise and fall times are in the range of 150 $\mu$s, and pulse width is approximately 1700 $\mu$s. The new reference system built by SP Technical Research Institute of Sweden proved to be able to calibrate the measurement of the flat-top voltage with an uncertainty of 0.05 %, thus ensuring that DUT performance requirement of 0.5 % could be fulfilled.
Since 2017 SP Technical Research Institute of Sweden is a part of Research Institutes of Sweden, RISE.

## Team

RISE:
- Anders Bergman, Doctor, senior researcher in High-voltage Metrology
- Maria Hammarquist, Researcher in high-voltage metrology

CERN:
- M.C. Bastos, Calibration Specialist

## Core deliverables

- Define the principle and modelling of the measurement system
- Purchase components
- Building a complete measuring system incl software
- Characterise the measuring system in-house at RISE´s high voltage lab
- Deliver and perform final calibration of reference system at CERN

## Year

2009–2010

## Total budget

EUR 55,000

## Collaboration(s)

- RISE
- CERN

## Hyperlink(s)

https://ieeexplore.ieee.org/document/5682402

**Procurement code(s)**
Civil engineering, building and technical services
Electrical engineering and magnets

CERN
Coordinating university: Chalmers University of Technology, www.chalmers.se

# ON INTEGRITY ASSESSMENT OF IGBT-BASED POWER STACKS USED IN MAGNET POWER SUPPLIES FOR PARTICLE ACCELERATORS

CHALMERS

## Project description
The aim of this research project was to prevent malfunctions and downtime of particle accelerators at CERN caused by failures of power electronic converters. Thousands of power electronic converters are used at CERN to supply electromagnets with current. A critical requirement is the long lifetime of at least 20 years. A failure of a power electronic converter may have a detrimental impact to the conduction of experiments and the operating cost. A method was proposed to detect the aging due to thermal stressing of the Insulated Gate Bipolar Transistor (IGBT) that is widely used in new converters' generations at CERN. This method for the IGBTs' health evaluation is applied during the converters' testing phase and during scheduled service stops.

## Team
Chalmers University of Technology
- Torbjörn Thiringer, Professor
- Massimo Bongiorno, Professor

CERN
- Panagiotis Asimakopoulos, Dr, Power Electronics Engineer at Technology Department
- Konstantinos Papastergiou, Dr, Power Electronics Engineer at Technology Department
- Gilles Le Godec, Section Leader of the Medium Power Converters section

## Core deliverables
- A method for the health assessment of IGBT-based power electronic converters.
- A measuring system for the application of the method.
- Power converter control strategies for thermal stressing mitigation of the IGBT switches to prolong their lifetime.

## Industry involvement
ABB semiconductors, Lenzburg, offered uncovered IGBT modules to facilitate thermal measurements.

## Year
2014-2018

## Total budget
EUR 220,000

## Collaboration(s)
Chalmers University of Technology

**Procurement code(s)**
Electrical engineering and magnets

CERN
**Coordinating university: Uppsala University, www.uu.se**

# QUENCH STUDY AND RF CHARACTERIZATION OF CRAB CAVITIES

UPPSALA UNIVERSITET

## Project description

The High Luminosity LHC (HL-LHC) is an upgrade of the LHC to achieve instantaneous luminosities a factor of five larger than the LHC nominal value, thereby enabling the experiments to enlarge their data sample by one order of magnitude compared with the LHC baseline programme. The HL-LHC will rely on a number of key innovative technologies, including cutting-edge compact superconducting crab cavities with ultra-precise phase control for beam rotation.

The FREIA Laboratory will be responsible for studying the quench characteristics at full RF power of a string of two crab cavities in a horizontal cryostat. In addition the FREIA laboratory shall study the RF characteristics of several other crab cavities at low RF power in a vertical cryostat.

## Team

Uppsala University:

- Roger Ruber, Docent, accelerator systems
- Han Li, Doctor, superconducting cavities

## Core deliverables

- Test system integration and commissioning
- High and low power RF generator and LLRF control
- Electronic acquisition hardware
- Data analysis

## Year

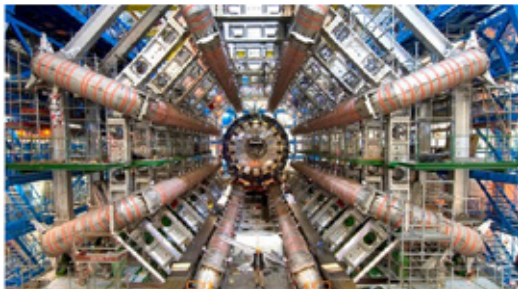
2016–2020

## Total budget

EUR 2 million

## Hyperlink(s)

http://hilumilhc.web.cern.ch/





**Procurement code(s)**
Electronics and radio frequency
Information technology
Particle and photon detectors

**CERN**
**Coordinating university: Uppsala University, www.uu.se**

# SILICON DETECTOR MODULES FOR ATLAS EXPERIMENT

UPPSALA UNIVERSITET

## Project description

Production of ~1000 silicon semiconductor detector modules/hybrids in Sweden. A module consist of silicon strip sensors readout electronics and data transmission. The sensor module is assembled with high precision (<10 micrometer) using UV and chemical curing glue. Electronics is wire bonded to sensor and readout with 25 micrometer wires. Each module has in total about 4000 wire connections.

The Swedish production is an in-kind contribution to an international collaboration with several partners. The Scandinavian contribution is done together with groups from Denmark and Norway. The assembly and testing is done in clean room facilities. The work is done in collaboration between industry and academia.
Expertise and production tooling is produced by university. Assembly of modules are done in industry. Wire bonding both in industry and university. Testing done at university.

## Team

Uppsala University:
- Richard Brenner, Professor specialist in: particle physics instrumentation
- Lars-Erik Lindquist, Maintenance superintendent, specialist in micro-mechanics and micro-electronics, Department of Physics and Astronomy, high energy physics

Lund University, :
- Geoffrey Mullier. Postdoc at particle physics specialist in particle physics instrumentation, Faculty of Engineering

NOTE
- Johnny Goncalves, Senior technical project manager, specialist in microelectronics production

## Core deliverables

Silicon detector modules

## Year

2017-

## Total budget

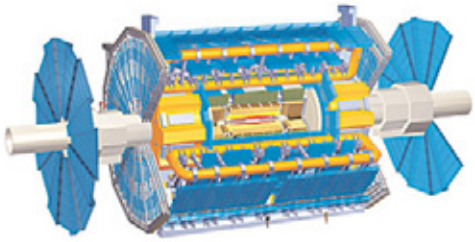
EUR 2 million

## Industry involvement

NOTE

## Collaboration(s)

- Uppsala University
- Lund University
- Note



**Procurement code(s)**
Electronics and radio frequency

**CERN**
**Coordinating university: Uppsala University, www.uu.se**

# TESTING OF SUPERCONDUCTING ORBIT CORRECTOR DIPOLE MAGNETS

UPPSALA UNIVERSITET

## Project description

Between 2023-2024, the LHC will be upgraded to increase the beam luminosity by a factor of five. Many new magnets will have to be installed. Before going to the tunnel, each magnet must be trained. The training consists of powering the superconducting magnet to an ultimate current which corresponds to 110% of the nominal current. To save space, magnets consist of two perpendicularly and coaxially arranged dipole coils. FREIA's task is to train single aperture superconducting dipoles with a length of 2.5 and 1.5 m and an internal magnetic field of 2.5 and 4.5 T.m, They will be tested in the new vertical cryostat currently being installed at FREIA.

## Team

Uppsala University, FREIA:

- Kévin Pepitone, Research Engineer, Department of Physics and Astronomy
- Roger Ruber, Researcher, Department of Physics and Astronomy

## Core deliverables

- Training superconducting orbit corrector dipoles to the ultimate current
- Ramp rate test studies
- Thermal cycle and memory verification
- Simultaneous powering of vertical and horizontal coils

## Year

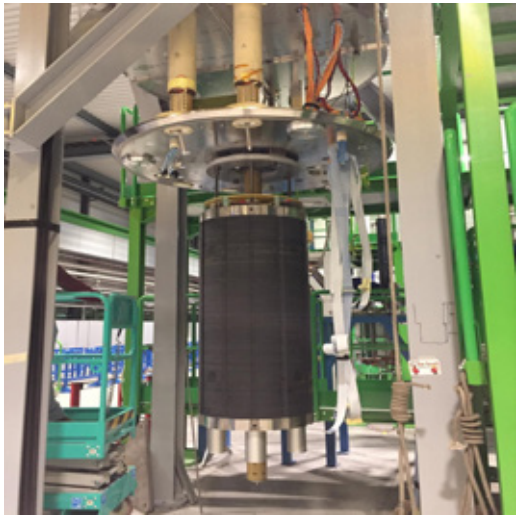
2018–

## Total budget

EUR 2 million

## Hyperlink(s)

https://espace.cern.ch/HiLumi/wp3/



**Procurement code(s)**

Electrical engineering and magnets
Electronics and radio frequency
Mechanical engineering and raw materials
Vacuum and low temperature

**CERN**
**Coordinating university: Mid Sweden University, www.miun.se**

# THE MEDIPIX COLLABORATION

## Project description

The MEDIPIX collaboration, coordinated by CERN, is developing readout electronics for single photon processing pixel detectors. The objective is to make detectors for spectral X-ray imaging as well as for particle tracking. Applications outside of high-energy physics can for example be found in medical imaging and material science. Current resolution is in the keV and ns range.

## Team

Mid Sweden University:

- Christer Fröjdh, Professor, radiation detection and imaging
- David Krapohl, Doctor, radiation detection and imaging
- Göran Thungström, Docent, semiconductor and radiation physics
- Börje Norlin, Doctor, spectral X-ray imaging

## Core deliverables

- Detector electronics and readout systems
- Sensors for different types of radiation
- Theory for spectral imaging and tracking

## Year

1999–

## Hyperlink(s)

www.cern.ch/MEDIPIX



**Procurement code(s)**

Civil engineering, building and technical services
Information technology
Particle and photon detectors
Optics and photons
Health, safety and environment

CERN
Coordinating university: Lund University, www.lu.se

# UPGRADE OF THE ALICE TPC, THE GEM UPGRADE, STEP 2

LUNDS UNIVERSITET

## Project description

Project description
The exploratory phase of Quark Gluon Plasma Studies with nuclear collisions at LHC is over and focused studies on specific aspects can commence with an upgraded detector with about 100 times higher sensitivity than the baseline ALICE. Step 1 of the upgrade was made in 2015 resulting in a factor 3 larger data rate which allowed to finish the science program planned for the baseline detector 6 years earlier and to take the large upgrade step with another factor 30 increase in sensitivity to be installed 2019-2020. This Involves a major change in the TPC detector technology and all readout electronics has to be replaced. All functionality of a readout chain both analog and digital is now in the same 32 channel ASIC named SAMPA. All circuit boards are new and the readout architecture is changed to have 10000 bidirectional optical links operating at 4.8Gbit/s. Lund University is involved in the SAMPA development and performs robotic testing and calibration of 90000 SAMPA chips for the final circuit board production (which has just started in the US).

## Team

Lund University, Physics Department:
- David Silvermyr, Doctor, Associate Professor, Physicist, detector expert, project leader, software development
- Anders Oskarsson, Professor, Physicist, detector expert, project leader
- Lennart Österman, Research Engineer, electronics, electronics design, CAD, quality assurance robotics and automation expert
- Ulf Mjörnmark, Doctor, Research Engineer, software and data acquisition expert

## Core deliverables

- Characterization and evaluation of SAMPA chip prototypes.
- Robotic testing and calibration of 90 000 SAMPA chips.
- Installation and commissioning in ALICE.

## Year

2014–2020

## Total budget

EUR 450,000

## Collaboration(s)

- Lund University
- Bergen University
- Oslo University
- Sao Paolo University
- Knoxville University
- Houston University
- Orsay University
- CERN
- GSI
- Oak Ridge National Laboratory
- Saclay

## Hyperlink(s)

http://alice-collaboration.web.cern.ch/
www.youtube.com/watch?v=3tnqPbMWzqQ&feature=youtu.be

**Procurement code(s)**
Electronics and radio frequency
Particle and photon detectors

**CERN**
**Coordinating university: Lund University, www.lu.se**

# UPGRADE OF THE ALICE TPC DETECTOR, RCU2 STEP

LUNDS UNIVERSITET

## Project description
Experiments in high energy physics run for several decades. Electronic components of higher performance become available over time. This motivated an upgrade of the readout electronics of the TPC detector in ALICE improving the data collection rate by a factor of 3. The figure shows reconstructed tracks in the TPC which produces huge data volumes. A science program expected to take 9 years could thus be finished in 2018 after 3 years, which translates to a saving of 600 person years just in operation of the experiment, not counting the 1000 collaborators who can complete their studies much earlier. The modernization involved new Field Programmable Gate Arrays (FPGA) for data collection which were replaced by the latest version and the readout architecture was made more parallel. The changes included massive firmware engineering and circuit board design/ fabrication.

## Team
Lund University:
- Anders Oskarsson, Professor, physicist, project leader, detector expert
- Lennart Österman, Research engineer, electronics lead engineer, specification, quality control, electronics design
- Mohammad Khorramnejadi, CAD engineer. PCB layout

## Core deliverables
Halogen free circuit boards housing the 40 bit wide data bus for data readout.

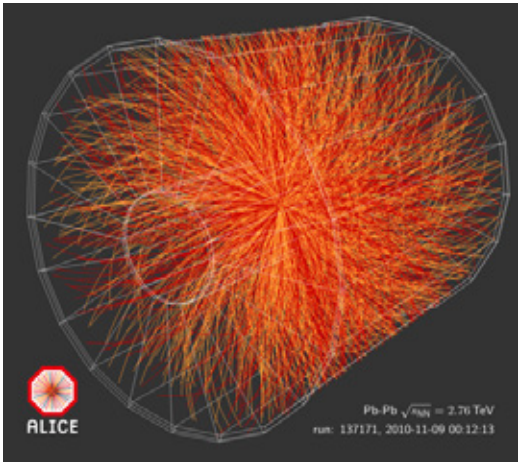
## Industry involvement
- Cervitrol
- MEPCB

## Year
2013–2015

## Total budget
EUR 220,000

## Collaboration(s)
- Lund University
- Bergen Technical High School
- KFI
- GSI
- CERN

## Hyperlink(s)
http://alice-collaboration.web.cern.ch/






**Procurement code(s)**
Electronics and radio frequency
Particle and photon detectors

# DESY

**DESY**
**Coordinating university: Lund University, www.lu.se**

# HANSEATIC LEAGUE OF SCIENCE (HALOS)

LUNDS UNIVERSITET

## Project description
By bringing new life science users together with researchers from the large regional photon and neutron infrastructures HALOS facilitates the development of new measurement methods and instrumentation. For example the ongoing development of X-ray fluorescence imaging applications in tissue imaging and time-resolved crystallography to study protein mechanisms at PETRA III. HALOS also aims to connect with the The Helmholtz-Lund International graduate School (HELIOS) project, to further enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Year
2019-2022

## Team
Includes among others
- Kajsa Paulsson, PhD, Lund University, Faculty of Medicine
- Michael Gajhede, Professor, UCPH
- Arwen Pearson, Professor, UHH
- Marite Cardenas, Professor, Malmö University
- Anders Bjorholm Dahl, Professor, DTU

## Core deliverables
HALOS will build a unique collaboration between Hamburg and South-West Scandinavia, bring together the four unique research facilities MAX IV, ESS, DESY and European XFEL, and create a centre for integrated, world-leading Life Science innovation and research. In the work package for Cross Border Research different activities are arranged such as seminars, webinars, workshops, summer/winter schools, match-making and not least funding of 6 month projects. The funding of 6 month projects is given to only projects with industry outreach plans and of high innovation potential. The work in the WP will result in increased awareness, competence development and increased use of large scale facilities in Life Science research and innovation. In the workpackage Regional Development the HALOS community in Hamburg and Southwest Scandinavia work to improve the conditions for using the large scale Research Infrastructures including topics mobility, remote access, innovation and tech-transfer and science cities and develop joint key messages and strategies, bi- and multi-lateral agreements.

## Industry involvement
Companies involved or selected for targeted out-reach activities include: ReceptorPharma, ImplexionPharma, Leo Pharma, Lundbeck, Avilex Pharma, Acesion Pharma, Borregaard, Colloidal Resources Competence, Axiom Insights, Thermofisher, Abbott, NIOM, Corticalis, Catalyst Biosciences.

## Total budget
EUR 3.6 million

## Collaboration(s)
- Lund University
- Universität Hamburg
- University of Copenhagen
- MAX IV
- ESS
- Malmö University
- Region Skåne
- DESY
- European XFEL
- City of Hamburg
- Technical University of Denmark
- Aarhus University
- Capital Region of Denmark
- Medicon Valley
- Alliance EMBL

## Hyperlink(s)
www.halos.lu.se

**Procurement code(s)**
Electrical engineering and magnets
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Optics and photonics
Particle and photon detectors
Health, safety and environment

DESY

**Coordinating university: KTH Royal Institute of Technology, www.kth.se**

# CENTRE FOR X-RAYS IN SWEDISH MATERIAL SCIENCE

## Project description

The PETRA III Swedish Node is distinctive in its capability to obtain signals deep inside materials with high measurement time resolution. The PETRA III Swedish Node comprises i) the Swedish Material Science (s)MS) beamline at the PETRA III synchrotron in Hamburg and ii) the Center for X-rays in Swedish Material Science (CeXS). CeXS safeguards Swedish interests at PETRA III and acts as the academic host of the SMS beamline. CeXS activities include: i) raising awareness about research possibilities; ii) providing training and support about why, when and how to use high-energy x-rays; and, iii) disseminating results. A key contribution of CeXS is ensuring a use perspective is taken in decision making about ongoing operational developments and upgrade planning.

## Team

Royal Institute of Technology, KTH

- Peter Hedström, Professor, Team leader, Department Materials Science and Engineering, Director of CeXS, specialist in high-energy x-rays for metals
- Linköping University
- Fredrik Eriksson, Professor, Department of Physics, Chemistry and Biology, Vice-Director of CeXS. Specialist in high-energy x-rays for thin films.
- CeXS
- Denise McCluskey, Manager of CeXS.

## Core deliverables

- Events
- Training
- Reports

## Industry involvement

Swedish companies are being engaged in projects using the facilities at PETRA III, DESY. Projects can be internal to the company or in collaboration with universities or research institutes.

## Year

2019-2024

## Total budget

EUR 100,000

## Collaboration(s)

- CeXS is hosted at KTH Royal Institute of Technology
- CeXS is supported by Linköping University
- All Swedish universities are welcome to request information and support from CeXS

## Hyperlink(s)

www.cexs.kth.se

**Procurement code(s)**

Civil engineering, building and technical services

**DESY**
**Coordinating university: Lund University, www.lu.se**

# HELIOS

## Project description
The Helmholtz-Lund International graduate School (HELIOS) on "Intelligent instrumentation for exploring matter at different time and length scales" connects major knowledge hubs in the Baltic Sea Region: Hamburg University, DESY, and Lund University. HELIOS started in early 2021 and includes scientists from Particle Physics, Molecular Physics, Nano(bio) Science, and Ultrafast Photon Science. The aim of HELIOS is to develop the instrumentation and data acquisition systems for the next generation of photon sources and particle accelerators, in collaboration with industrial partners that we will seek within Big Science Sweden. HELIOS also aims to connect with the Hanseatic League of Science (HALOS) project for life sciences, to enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Team
Lund University
- Mathieu Gisselbrecht, Associate professor, Physics
- Caterina Doglioni, Associate professor, Physics, Particle physics
- Anders Mikkelsen, Professor, Physics, NanoLund

## Core deliverables
Individual projects investigate novel solutions for (e.g.):
- Real-time data acquisition and analysis
- Image processing techniques
- Feedback control loops
- On chips miniaturization using nanotechnology for biosensing

## Year
2021-2026

## Total budget
EUR 7.9 million

## Collaboration(s)
University of Hamburg

## Hyperlink(s)
https://www.heliosgraduateschool.org

**Procurement code(s)**
Electronics and radio frequency
Information technology
Vacuum and low temperature
Optics and photonics
Particle and photon detectors

DESY
Coordinating institute: Swerim AB Swedish Research Institute for Mining, Metallurgy and Materials), www.swerim.se

# MASSDIFF: DEVELOPMENT OF POST-PROCESSING TOOLS FOR TIME-RESOLVED DATA

## Project description

The project started with Vinnova funding based on industrial needs to analyze existing time-resolved diffraction experiments and continued with internal resources from Swerim.
Within the project, a program tool was developed for visualization and fitting of diffraction peaks. The tool can be used to convert data type, visualize, and inspect many data sets and perform quantitative analysis after performing peak fitting operations. The program enables single and multi-peak fitting using the internal engine, and LeBail/Pawly/ Rietveld analysis by using Topas or Topas-Academic (and currently being developed for MAUD). The standalone version of the program is user-friendly and does not require any programming skills. For experienced users who need new functionalities or modification, the source code is also available.
The program tool has continued to be developed and tested within several diffraction projects e.g. Vinnova-funded projects for data collected at different photon and neutron facilities as well as laboratory-based diffraction data.

## Team

Swerim, Stainless steels & non-ferrous metals:
- Shirin Nouhi, Ph.D., Researcher
- Tuerdi Maimaitiyili, Ph.D., Researcher
- Johannes Brask, M.Sc., Researcher
- David Lindell, Ph.D., Group manager

## Core deliverables

- Simple and user-friendly software package to visualize high number of diffraction data.
- Simple analysis using single/multiple peak fitting for residual stress and phase analysis.
- A simple interface to prepare and run more complex and comprehensive analysis of diffraction data e.g. Rietveld analysis.

## Industry involvement

- Outokumpu, Alfa Laval

## Year

2019-2020

## Total budget

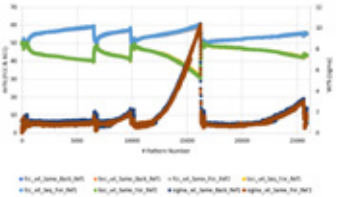
EUR 200,000

## Collaboration(s)

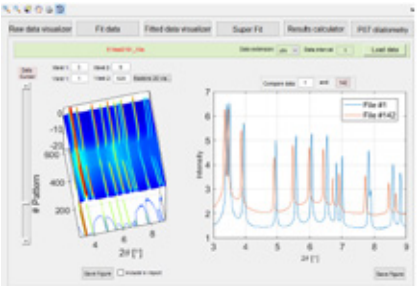
Data from P07 high energy material science beamline at PETRA III have been used.

## Hyperlink(s)

- https://www.vinnova.se/p/utveckling-av-programvara-for-efterbehandling-av-in-situ-diffraktionsmatningar-i-metalliska-material/
- https://www.swerim.se/en/services/analyses-testing-studies/large-scale-facilities



*Phase quantity extracted from >25000 diffraction patterns after Rietveld analysis.*



*Screenshot from the developed toolbox: raw data visualisation window .*

**Procurement code(s)**
Information technology
Mechanical engineering and raw materials

DESY
**Coordinating university: Uppsala University, www.uu.se**

# MICRO ACCELERATOR STRUCTURE CENTER MAS IN UPPSALA

UPPSALA UNIVERSITET

## Project description

To meet new demands from accelerator physics strategies on the rise the Micro Accelerator Structure center (MAS) in Uppsala was founded. It will aid Big Science facilities around the world in constructing microfabricated devices utilizing e.g. lithography methods in clean room environments. The first collaboration for delivering such hardware are with DESY in Germany which currently are constructing a test accelerator setup, Sinbad where the centre will play a vital part in producing micro machined structures, sample holders, controllers and setups.

## Team

Uppsala University:
- Mathias Hamberg, Researcher, Department of Physics and Astronomy, FREIA
- Mikael Karlsson, Senior Lecturer, Department of Engineering Sciences, Applied Materials Science
- Pontus Forsberg, Researcher, Department of Engineering Sciences, Applied Materials Science
- Anders Rydberg, Professor at Department of Engineering Sciences, Solid State Electronics

DESY:
- Ulrich Dorda

## Core deliverables

- Micro fabricated structures of various nature
- Sample mounts
- Test and evaluation setup
- Laser routing system
- Vacuum chamber design
- Hexapod implementation
- PLC control systems design
- Design of system
- Fabrication in Cleanroom environment
- Installation of setup
- Tests and Improvements

## Year

2015-2025

## Total budget

EUR 1 million

## Collaboration(s)

- Uppsala University
- FAU
- PECS
- DESY Research Centre

**Procurement code(s)**
Electronics and radio frequency
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Particle and photon detectors
Optics and photons

# EISCAT

**EISCAT**
**Coordinating University: Luleå University of Technology, www.ltu.se**

# EISCAT 3D DESIGN OF ANTENNA ELEMENTS

## Project description

EISCAT 3D is a radar system that will consist of five phased-array antenna fields located in the northernmost areas of Finland, Norway and Sweden. It will be operated by EISCAT Scientific Association. LTU also worked on possible configurations of the antenna array with respect to the hardware and electromagnetic properties. The work also led to electrical and mechanical front end design, and included an investigation of timing solutions and antenna calibration methods.

## Team

Luleå Technical University, Industrial Electronics:

- Jonny Johansson, Associate Professor
- Johan Borg, Senior lecturer
- Gunnar Isaksson, Research engineer
- Tore Lindgren, Research assistant

## Core deliverables

- Antenna element specifications
- Antenna array configurations
- Front end electronics
- Antenna timing and calibration

## Industry involvement

- National Instruments
- WSI
- Gäddede Elektronik
- Gelab
- Microbit

## Year

2010–2014

## Total budget

EUR 1 million

EISCAT 3D test array on the EISCAT site in Tromsø.
Photo: Craig Heinselman Heinselman

**Procurement code(s)**
Electrical engineering and magnets
Electronics and radio frequency
Information technology

300

# ESO

**ESO**

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# ALMA BAND5 RECEIVERS

## Project description

The ALMA (Atacama Large Millimeter/ SubMillimeter Array) Observatory is the world's largest radio-astronomy observatory consisting of 66 radio telescopes, with a 12-metre diameter, working as an interferometer with largest baseline of 16 km. All telescopes are placed at approximately 5000 m altitude, at Chajnanto Plato in the Chilean Andes. For optimal performance of the observatory, each telescope is equipped with an identical receiver system with ultimate sensitivity. To meet the expectations of the astronomers, especially in their search for water in the universe and understanding of the origins of life in the Solar system, the consortium led by the Chalmers Group of Advanced Receiver Development, developed and deployed the most sensitive radio-astronomy receiver system operating between 158 and 211 GHz also known as ALMA Band 5. The Band 5 receivers operate at cryogenic temperatures of around 4 K using superconducting components as well as advanced circuits and systems, resulting in a sensitivity close to the quantum limit (35 K, SSB noise temperature). The Band 5 receiver has the lowest noise temperature out of all other ALMA bands to date.

## Team

Chalmers University of Technology, GARD, Onsala Space Observatory:

- V. Belitsky, Professor, Department of Space, Earth and Environment, advanced receiver development
- V. Desmaris, Associate Professor, Department of Space, Earth and Environment, advanced receiver development
- A.Pavolotsky, Senior Research Engineer, Department of Space, Earth and Environment, advanced receiver development

## Core deliverables

- 6 prototype receivers after Phase I (2012)
- 70 receivers + 10 spares after Phase II (2018)

## Year

2006-2018

## Total budget

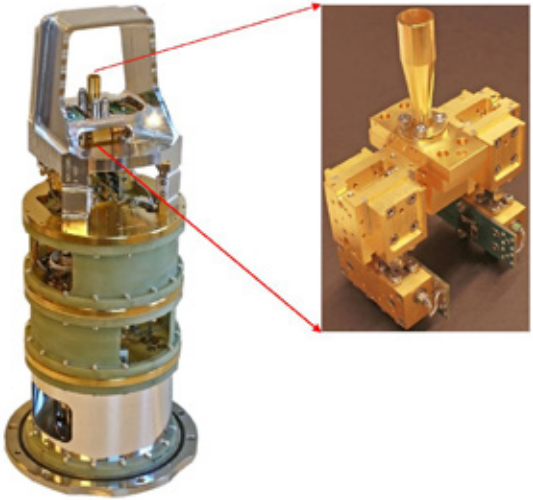
EUR 10.7 million

## Collaboration(s)

- Chalmers University of Technology
- Netherlands Research School for Astronomy, (NOVA),
- National Radio Astronomy Observatory,
- European Southern Observatory (ESO)

## Hyperlink(s)

https://www.aanda.org/articles/aa/abs/2018/03/aa31883-17/aa31883-17.html



**Procurement code(s)**

Electronics and radio frequency

**ESO**
**Coordinating university: Uppsala University, www.uu.se**

# EXTREMELY LARGE TELESCOPE INSTRUMENTATION: HIRES AND MOSAIC

UPPSALA UNIVERSITET

## Project description

The 39m ELT will be the largest astronomical telescope ever built. For spectroscopic analysis, the light collected by the ELT will be carried by optical fibers to the spectrometers called HIRES and MOSAIC. Three major Swedish universities (Lund, Stockholm and Uppsala) take active parts in design and construction of these instruments. The coupling of fibers with other optical elements is crucial for efficiency and stability. The new instruments will measure the values of fundamental physical constants back in time, the expansion rate of the Universe etc. They will also search for atmospheres around Earth, -such as exoplanets, and make chemical analysis in order to detect signatures of life.

The project also involved the developement of a unique technology for CO2 laser fusion of fiber cores with other optical components that matches high requirements of astronomical instrumentation and repeatedly delivers excellent quality.

## Team

Uppsala University:
Nikolai Piskunov, professor, specialist in stars and exoplanets, astronomical spectroscopy

## Core deliverables

- For HIRES: 32 optical bundles with 64 or 96 fibers each coupled to microlens arrays on both sides.
- For MOSAIC: 2000 bundles with 7 fibers each coupled to re-imaging optics on one side and to image slicer on the other.

## Year

2018–2027

## Total budget

EUR 4.5 million

## Industry involvement

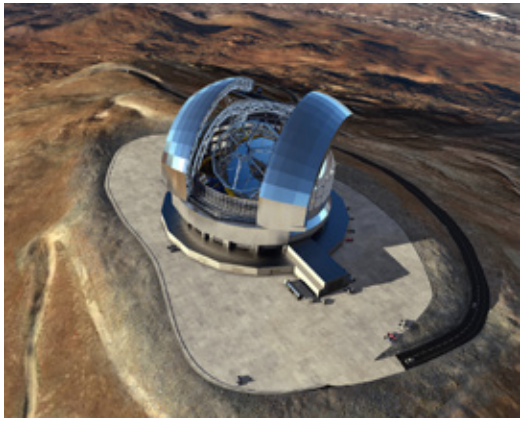
- Nyfors
- ELT instruments

## Collaboration(s)

- Uppsala University
- Stockholm University
- Lund Universitiy

## Hyperlink(s)

http://www.arcetri.astro.it/~hires



**Procurement code(s)**
Information technology
Mechanical engineering and raw materials
Optics and photons

**ESS**
**Coordinating university: Chalmers University of Technology,**

# A NEW METHOD TO MODEL THE DYNAMIC STRUCTURE FACTOR BY MOLECULAR DYNAMICS SIMULATIONS

## Project description

In this collaborative project between Chalmers, ESS, ISIS and the Niels Bohr Institute we aimed to overcome the difficulty to interpret and understand inelastic and quasielastic neutron scattering data (information about molecular and atomic motions) by developing a new computer modelling method to model the dynamic structurefactor, S(Q,w). The method is a dynamical correspondence to the Empirical Potential Structure Refinement (EPSR) method used to produce structural models of materials in quantitative agreement with neutron and x-ray diffraction data. The developed tool is a computer-based simulation tool that can then model the dynamic data (how atoms and molecules move) from neutron scattering by refining the model potentials in a molecular dynamics simulation until the simulation can reproduce the experimentally measured data.

## Team

- Jan Swenson, Professor, Chalmers University of Technology, Department of Physics
- Heloisa Bordallo, Associate professor, Niels Bohr Institute, Condensed Matter Physics
- Anders Markvardsen, Researcher, ISIS Neutron and Muon Source, STFC
- Thomas Holm Rod, Researcher, European Spallation Source

## Core deliverables

- A software package for modelling the dynamics of basically all types of molecular systems.
- New computer modelling method to model the dynamic structure factor, S(Q,Ð), by molecular dynamics (MD) simulations.
- The computer simulation community get a unique possibility to refine their interatomic model potentials (or force-fields) for ordinary MC and MD simulations.
- This method provides new possibilities to interpret and understand inelastic and quasielastic neutron scattering data.

## Year

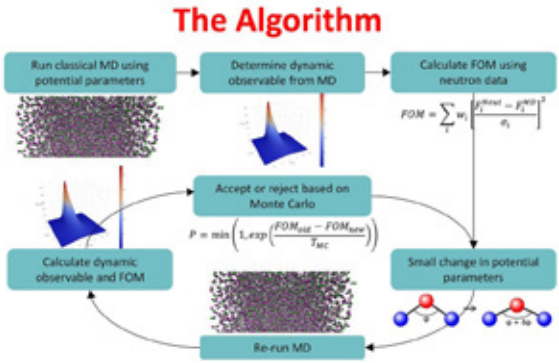
2017-2022

## Total budget

EUR 850,000

## Collaboration(s)

- Chalmers University of Technology
- Niels Bohr Institute
- ISIS Neutron and Muon Source
- European Spallation Source




**Procurement code(s)**
Information technology

ESS

**Coordinating university: Uppsala University, www.uu.se**

# ACCEPTANCE TESTS OF CRYO-MODULES

UPPSALA UNIVERSITET

## Project description

A part of the linear accelerator for the European Spallation Source being built in Lund will contain thirteen cryo-modules that host two superconducting spoke cavities each. Before lowering them into the tunnel for the final assembly, they need to be fully tested and validated under cryogenic conditions and at high power to ensure they will meet the requirements once they are in operation.

## Team

Uppsala University:

- R. Santiago Kern, Research engineer, cryogenics and vacuum
- Han Li, Researcher, radio-frequency and cavity testing
- Rolf Wedberg, Research engineer, radio-frequency power amplifiers
- Roger Ruber, Researcher, project leader

## Core deliverables

- Definition of a test plan
- Procedure for formal acceptance of a cryo-module
- Mechanical, electrical and vacuum checks of each cryo-module after arrival
- Cryogenic cooldown
- High power radio-frequency tests
- Radiation monitoring
- All pertaining documentation such as test reports

## Year

2018–2020

## Total budget

EUR 5 million

## Hyperlink(s)

https://europeanspallationsource.se/accelerator

**Procurement code(s)**

Civil engineering, building and technical services
Electrical engineering and magnets
Electronics and radio frequency
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Particle and photon detectors
Gases, chemicals, waste collection and radiation equipment
Health, safety and environment

ESS

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# ANALYSIS TOOLS FOR ANALYSIS OF IN-SITU TIME-RESOLVED NEUTRON DIFFRACTION

CHALMERS

## Project description

The unprecedented neutron flux at the engineering diffractometer BEER at ESS will enable in-situ diffraction to be performed during thermomechanical loading approaching industrial processes and/or service conditions. In order to fully exploit this possibility, computational tools capable of reverse modelling of competing deformation mechanisms in complex materials are required. Such models are not publicly available. The project will develop and implement a state-of-the-art elastic-viscoplastic self-consistent (EVPSC) crystal plasticity model for analysis and prediction of grain scale response in complex engineering materials during conditions of simultaneously varying load and temperature. In a separate project, this will be made publicly available as a user friendly web application through the ESS data management center. Notably, the models are equally applicable for experiments carried out at constant wavelength neutron sources and monochromatic or energy dispersive X-ray diffraction stations at synchrotrons.

## Team

Chalmers University of Technology:

- Magnus Hörnqvist Colliander, Docent, senior researcher, Department of Physics
- Hongjia Li, Doctor, Postdoc
- Magnus Ekh, Professor, Industrial and Materials Sciences
- Fredrik Larsson, Professor, Industrial and Materials Sciences

## Core deliverables

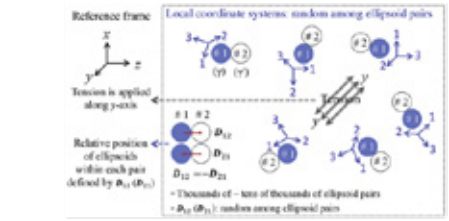
Development and implementation of a finite strain elastic-viscoplastic self-consistent crystal plasticity model for temperature dependent simulation of multiphase materials with or without crystallographic relationships and lattice coherency, including optimization engine for calibration against in-situ neutron scattering data.

## Year

2017–2019

## Total budget

EUR 200,000




**Procurement code(s)**

Information technology

**ESS**
**Coordinating university: Lund University, www.lu.se**

# AUTONOMOUS RADIATION MAPPING

LUNDS UNIVERSITET

## Project description
During commissioning, operation and decommissioning of nuclear power plants, particle accelerators and industries dealing with radioactive materials, there is a need to monitor radiation levels and isotope composition over large swathes of land surrounding the facilities. Ideally, this would be done regularly by an automated system which we are developing.

## Year
2019-

## Team
Lund University, Faculty of Engineering
- Emil Rofors, Postgraduate, Department of Physics
- Rolf Johansson, Professor, Department of Automatic Control
- Anders Robertsson, Team leader, Professor, Department of Automatic Control
- Marcus Greiff, Doctoral student, Department of Automatic Control
- Rikard Tyllström, Lecturer in Aeronautical Sciences, TFHS
- Christopher Rääf, Professor, Department of Translational Medicine

## Core deliverables
- Autonomous Radiation Mapping
- Isotope Composition Identification
- Mobile Gamma Spectroscopy

## Industry involvement
- Barsebäck Nuclear Power Plant
- European Spallation Source

## Total budget
EUR 200,000

## Hyperlink(s)
http://uav.lu.se



**Procurement code(s)**
Electrical engineering and magnets
Gases, chemicals, waste collection and radiation equipment
Health, safety and environment

**ESS**

**Coordinating university: Mid Sweden University, www.miun.se**

# BRIGHTNESS

## Project description

BrightnESS is a large infrastructure project within HORIZON2020. Part of the project concerned addressing the resolution challenge. In this activity, we developed neutron detectors based on MEIXPIX-type readout electronics using silicon sensors coated with a suitable neutron converter. Resolutions below 100 um can then be achieved.

## Team

Mid Sweden University:

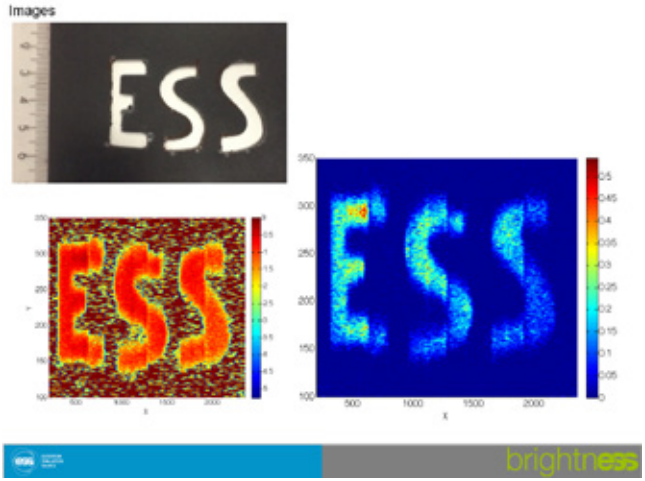
- Christer Fröjdh, Professor, radiation detection and imaging
- David Krapohl, Doctor. radiation detection and imaging

## Core deliverables

Pixel detectors for high resolution neutron imaging.

## Year

2016–2019






**Procurement code(s)**

Information technology

Particle and photon detectors

**ESS**
**Coordinating university: Lund University, www.lu.se**

# COST-EFFECTIVE AND VERSATILE TESTBED FOR NOVEL NEUTRON DETECTORS

LUNDS UNIVERSITET

## Project description

ESS aspires to be the world's brightest neutron source. With this ambition comes the need for novel, highly sophisticated instrumentation able to handle record-breaking neutron fluxes. Such development, however, requires frequent and affordable access to neutrons.
This need is addressed by the Source Testing Facility (s)TF) at Lund University. Operated by the SONNIG group, the STF is a fully functioning user facility. It boasts a complete range of gamma-ray and neutron sources and is equipped with advanced nuclear physics infrastructure for characterizations of detectors. As there are no reactors or accelerators involved, the STF provides a round-the-clock available locale for prototype development and commissioning to its ESS users.

## Team

Lund University, Division of Nuclear Physics:
- Kevin Fissum, Doctor, senior lecturer in nuclear physics
- Francesco Messi, Doctor, researcher in neutron instrumentation
- Hanno Perrey, Doctor, researcher in neutron metrology

## Core deliverables

- Provide laboratory space
- Design and construction of the facility
- Purchasing of equipment
- Commissioning of infrastructure
- User support

## Year

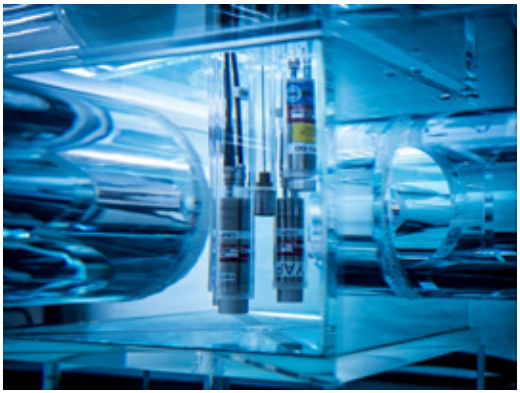
2015–

## Total budget

EUR 400,000

## Hyperlink(s)

www.nuclear.lu.se/forskning/neutronfysik





**Procurement code(s)**
Civil engineering, building and technical services
Information technology
Particle and photon detectors
Optics and photons
Gases, chemicals, waste collection and radiation equipment

**ESS**
**Coordinating university: Uppsala University, www.uu.se**

# DESIGN STUDY OF ACCUMULATOR RING

UPPSALA UNIVERSITET

## Project description

An EU/H2020 supported Design Study is being carried out with the objective to use the powerful ESS linear accelerator to generate a very intense neutrino beam, for the study of neutrino oscillations using a very large underground water Cherenkov neutrino detector. For this a ca 400 m circumference accumulator ring will be needed, with the purpose to compress the ESS linac pulse from 3 ms to 1.3 microsecond duration. The FREIA laboratory is leading the work to design this ring, which will contain magnets, vacuum chambers, collimators and other beam transport equipment. The design work, which will be based on computer simulations, is made particularly challenging by the exceptionally high beam charge to be stored in the accumulator ring.

## Team

Uppsala University, Department of Physics and Astronomy, FREIA:
- Maja Olvegård, Researcher
- Tord Ekelöf, Project Manager
- Ye Zou, Postdoc

CERN:
- Elena Wildner
- Horst Schönauer

IPHC Strasbourg:
- Elian Bouquerel

## Core deliverables

- Formulation of the ESSnuSB accumulator requirements
- Elaboration of the ESSnuSB accumulator design using different computer codes to simulate the performance iteratively
- Written report on the optimized ESSnuSB accumulator design

## Potential industry involvement

Scanditronix

## Year

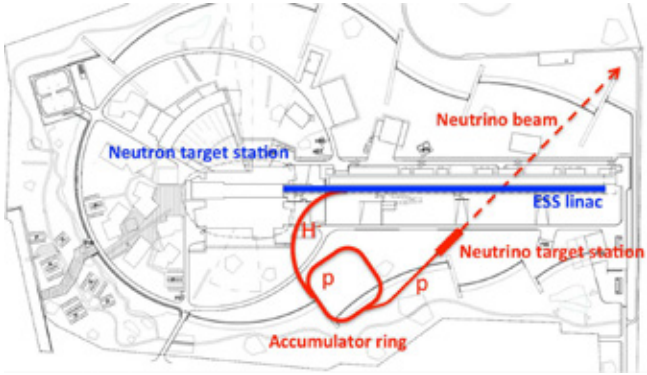
2017–2021

## Total budget

EUR 500,000

## Hyperlink(s)

http://essnusb.eu/site/wp3




**Procurement code(s)**
Electrical engineering and magnets
Vacuum and low temperature
Particle and photon detectors

**ESS**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# GRID AND APERTURE MONITOR ELECTRONICS

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

The European Spallation Source (ESS) is generating neutrons by hitting a tungsten target with proton beam pulses. The energy of the pulses needs to be spread out in order not to destroy the target. This is done by a rastering system. Crucial components are the measurement devices used to make sure that the beam is spread out sufficiently and that it is still in the right place. The task of Lund University is to design the electronic part of these measurement systems, including the algorithms that analyze the position of the beam and reports the results to the ESS control and protection systems. This places high demand on accuracy and reliability on the system developed.

## Team

Lund University: Faculty of Engineering:

- Anders J Johansson, Docent, RF and accelerator systems, communications engineering,
- Markus Törmänen, Docent, RF electroninics, electrical engineering,
- Liang Liu, Docent, high speed signal processing, communications engineering

## Core deliverables

- System design and requirement gathering
- Electronic acquisition hardware design
- High speed data analysis in FPGA hardware
- System integration and commissioning

## Years

2018–

## Total budget

EUR 130,000

## Collaboration(s)

- Lund University
- ESS (ERIC)
- Institute of Modern Physics, China
- Japan Proton Accelerator Research Complex, Japan



**Procurement code(s)**
Electronics and radio frequency Information technology

**ESS**
**Coordinating university: Lund University, www.lu.se**

# HANSEATIC LEAGUE OF SCIENCE (HALOS)

LUNDS UNIVERSITET

## Project description
By bringing new life science users together with researchers from the large regional photon and neutron infrastructures HALOS facilitates the development of new measurement methods and instrumentation. For example the ongoing development of X-ray fluorescence imaging applications in tissue imaging and time-resolved crystallography to study protein mechanisms at PETRA III. HALOS also aims to connect with the The Helmholtz-Lund International graduate School (HELIOS) project, to further enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Year
2019-2022

## Team
Includes among others
- Kajsa Paulsson, PhD, Lund University, Faculty of Medicine
- Michael Gajhede, Professor, UCPH
- Arwen Pearson, Professor, UHH
- Marite Cardenas, Professor, Malmö University
- Anders Bjorholm Dahl, Professor, DTU

## Core deliverables
HALOS will build a unique collaboration between Hamburg and South-West Scandinavia, bring together the four unique research facilities MAX IV, ESS, DESY and European XFEL, and create a centre for integrated, world-leading Life Science innovation and research. In the work package for Cross Border Research different activities are arranged such as seminars, webinars, workshops, summer/winter schools, match-making and not least funding of 6 month projects. The funding of 6 month projects is given to only projects with industry outreach plans and of high innovation potential. The work in the WP will result in increased awareness, competence development and increased use of large scale facilities in Life Science research and innovation.
In the workpackage Regional Development the HALOS community in Hamburg and Southwest Scandinavia work to improve the conditions for using the large scale Research Infrastructures including topics mobility, remote access, innovation and tech-transfer and science cities and develop joint key messages and strategies, bi- and multi-lateral agreements.

## Industry involvement
Companies involved or selected for targeted out-reach activities include: ReceptorPharma, ImplexionPharma, Leo Pharma, Lundbeck, Avilex Pharma, Acesion Pharma, Borregaard, Colloidal Resources Competence, Axiom Insights, Thermofisher, Abbott, NIOM, Corticalis, Catalyst Biosciences.

## Total budget
EUR 3.6 million

## Collaboration(s)
- Lund University
- Universität Hamburg
- University of Copenhagen
- MAX IV
- ESS
- Malmö University
- Region Skåne
- DESY
- European XFEL
- City of Hamburg
- Technical University of Denmark
- Aarhus University
- Capital Region of Denmark
- Medicon Valley
- Alliance EMBL

## Hyperlink(s)
www.halos.lu.se

**Procurement code(s)**
Electrical engineering and magnets
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Optics and photonics
Particle and photon detectors
Health, safety and environment

**ESS**

**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# HIGH POWER MODULATORS DESIGN FOR THE ESS LINAC

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

Following the project for the development of the reduced scale modulator prototype, the Faculty of Engineering of Lund University (LTH) was a key partner in the design of the full scale modulator units on a build-to-print basis. A total quantity of 33 modulators will be required to power up the ESS accelerator to an average beam power of 5MW. Each modulator delivers very high quality pulsed power at 115kV/100A amplitude with pulse widths of 3.5ms and pulse repetition rates of 14Hz. Altogether, they will constitute a park with total installed pulse power of 380MW and will represent more than 300 ton of the worldwide most sophisticated power electronics. Other than pulse quality, the quality of the power consumed from the AC electrical network needed to comply with the relevant standards, in order to not disturb the whole electrical grid in Lund area. This feature was achieved thanks to the utilization of Active Front End devices in combination with a constant power capacitor charging scheme, a subsystem well researched previously by LTH for several industrial applications. Compactness, reliability and cost effectiveness were also very important advantages of the proposed topology and design.
The complexity of their design and its unprecedented level of requirements put this development at the forefront of modulator developments at a worldwide scale and will be part of a new state of the art reference.

## Team

Lund University, Faculty of Engineering

- Carlos A. Martins, Team leader, Senior lecturer, Industrial Electrical Engineering and Automation
- Max Collins, PhD student, Industrial Electrical Engineering and Automation
- Mats Alakula, Prof. and head of department, Industrial Electrical Engineering and Automation
- Getachew Darge, Research assistant, Industrial Electrical Engineering and Automation

## Core deliverables

High Voltage power electronics expertise

- Magnetostatic and Electrostatic design of the High Voltage modules with Finite Element Analysis
- Global optimization studies of the complete modulator system in Matlab
- Simulation studies of the electrical circuits and control algorithms
- 3D CAD design of the complete modulator unit on a build-to-print basis. Development of control and Human Machine Interface software

## Industry involvement

- LM Halvarsson Consulting AB, has delivered the complete 3D CAD mechanical design of the modulators on a build-to-print basis
- Loayza Dynamics AB, has delivered the complete software package for the modulator control and Human Machine Interface in Labview/CompactRIO NI environment

## Year

2016-2020

## Total budget

EUR 1.1 million

**Procurement code(s)**

Electrical engineering and magnets
Mechanical engineering and raw materials
Electronics and radio frequency

**ESS**
**Coordinating university: Lund University, www.lu.se**

# HIGH-RATE READ-OUT ELECTRONICS AND DATA ACQUISITION SYSTEM

LUNDS UNIVERSITET

## Project description

The novel neutron detectors developed for reflectometry at ESS require dedicated high-speed electronics as well as custom-made data-acquisition (DAQ) software to process and store the record-breaking amount of data produced at such instruments. The SONNIG group of Lund University, in collaboration with the Detector Group of ESS and the Data Management and Software Centre of ESS, have been assigned the task of designing and commissioning a high-performing DAQ system.
Lund University has delivered front-end electronics capable of high rates as well as a scalable and modular DAQ software to acquire and save data almost one thousand times faster than the state-of-the-art in the field.

## Team

Lund University, Division of Nuclear Physics:
- Francesco Messi, Doctor, Researcher
- Hanno Perrey, Doctor, Researcher

ESS:
- Francesco Piscitelli, Doctor, Detector Scientist

Niels Bohr Institute
- Troels Blum, Doctor, Researcher

## Core deliverables

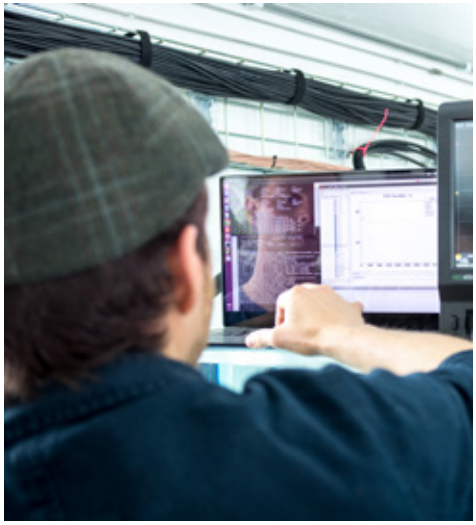
- Design, production and commissioning of electronics cards
- Conceptualization and implementation of software
- Providing development resources
- Integration and commissioning of complete systems

## Year

2018

## Total budget

EUR 500,000



**Procurement code(s)**
Electronics and radio frequency
Information technology

**ESS**

**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# LOW-LEVEL RF SYSTEM

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

We have designed and developed the low-level RF system for ESS, which is the system that controls the acceleration of the particles. It is a very sensitive process, which requires the highest precision in all parts of the design, both electronics and software. After an in-depth analysis of the requirements and the solutions used at other facilities, we designed a tailored solution for ESS. To fulfill all requirements, including availability, we required newly developed hardware. This was developed in collaboration with our partners in Poland, Germany and Spain, thanks to the in-kind form of the ESS project. During the whole process, the distributed development process has been coordinated by LU. Today the system is in production and will be installed in 2019.

## Team

Lund University, Faculty of Engineering,

- Anders J Johansson, Docent, RF system design, LLRF systems
- Bo Bernhardsson, Professor, automation control
- Markus Törmänen, Docent, RF design
- Anders Svensson, M.Sc., RF electronics
- Olof Troäng, M.Sc., control for LLRF systems

## Core deliverables

- System design
- Automatic control algorithms
- Test benches
- LLRF test systems
- Project coordination

## Industry involvement

Struck

## Years

2011–2019

## Total budget

EUR 4 million

## Collaboration(s)

- Lund University
- The Polish Electronics Group
- DESY
- ESS Bilbao



**Procurement code(s)**

Electronics and radio frequency
Information technology

ESS
**Coordinating university: University West, www.hv.se**

# LUMINESCENT COATINGS

## Project description

ESS is the world's most powerful neutron source and acts as a giant microscope where neutrons are used to analyze samples at atomic and molecular levels. Simply described, 5 megawatt strong proton beams are shot at a very high speed on a target that looks like a rotating wheel. University West has been selected as an ESS partner to develop a luminescent coating that will light up when the strong proton beam hits the "target wheel" in the ESS facility. The coating is of crucial importance in order to be able to ensure and verify that the profile of the proton beam meets the target, and that the neutrons are delivered correctly to the instruments in the plant

## Team

University West
- Professor Shrikant Joshi, Team leader, University West
- Research engineer Stefan Björklund

## Core deliverables

- Development of Luminescent Coatings for critical parts of the ESS installation.
- Development of the thermal spray application of these coatings.
- Investigation of how the process might have an effect on material properties of the ESS parts.
- Coating the real parts.

## Industry involvement

We have started to involve TSE AB (Thermal Spray Engineering AB, tse.se) since we have the goal together with ESS that the Company TSE would be the one to do the actual spray work on the real parts for ESS.

## Year

2017-

## Total budget

EUR 200,000

**Procurement code(s)**
Mechanical engineering and raw materials

**ESS**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# MASTER OSCILLATOR FOR ESS

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

To work properly the European Spallation Source is dependent on accurate timing and synchronization. The accelerator is pulsed 14 times a second, and every part of the 600 meter machine must work in pico-second synchronization with the internal structure of the pulses. In addition, the target wheel and the scientific experimental stations must also be synchronized to the pulses. Lund University developed the timing strategy for ESS, and have designed the master oscillator that will drive all the different timing systems utilized. This includes a specially designed dielectric resonator housed in a cavity delivered by the local industry, and the electronic circuitry needed to run it and to distribute the signals to the facility.

## Team

Lund University, Faculty of Engineering:

- Anders J Johansson, Docent, RF system design
- Anders Svensson, Master of science, RF electronics

## Core deliverables

- Design of master oscillator
- Protoype and tests

## Industry involvement

Cervitrol

## Year

2012-2018

## Total budget

EUR 50,000


**Procurement code(s)**
Electronics and radio frequency

**ESS**

**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# MODULATOR DESIGN AND DEVELOPMENT

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

ESS will be the world's most powerful neutron source. This source has at its heart a linear accelerator which fires protons at a tungsten target, producing the powerful neutron beam. The linear accelerator is fed, at the first stage of the powering chain, by 33 modulators which have to deliver, each one, 11,5 megawatts peak and 600 kilowatts average power, at a rate of 14 pulses per second. While this should be possible by scaling up standard technology, it quickly became clear that there was not enough budget and space. Furthermore, the impact of such huge amount of pulse power in the local electrical power network in Lund municipality would have been seriously affected by flicker and harmonic distortions.

The research group, led by Carlos Martins, performed critical work together with the power converter team at ESS, designing, testing and commissioning critical parts for the ESS modulator following a novel topology. The final engineered solution reduced budgeted costs of modulator components by 70% and the space requirements by 80%, while factors like reliability, the quality of both the output pulse and of the power absorbed from the electrical network reached unprecedented performance.

## Team

Lund University, Faculty of Engineering:

- Carlos Martins, Senior lecturer, power converters high-voltage modulator design, Industrial electrical engineering and automation
- Mats Alaküla, Professor, power converters high-voltage modulator design, industrial electrical engineering and automation
- Max Collins, Doctoral student, Industrial electrical engineering and automation
- Avo Reinap, Assistant professor, power converters high-voltage modulator design, Industrial electrical engineering and automation

## Core deliverables

- High voltage power electronics
- Power converters for physics applications
- New solid state high power modulator system design
- High voltage pulse transformer design
- Complete prototype system design and construction
- Test, commissioning and verification
- Full system design specifications, build-to-print instructions, procurement documentation, follow up of series production contract

## Industry involvement

AQ Elautomatik, Herman Anderssons Plåt, Plåtmekano, Carlsson & Möller

## Year

2013–2018

## Total budget

EUR 1.2 million

## Hyperlink(s):

https://europeanspallationsource.se/article/how-do-you-power-worlds-most-powerful-linacs

**Procurement code(s)**

Electrical engineering and magnets
Electronics and radio frequency
Mechanical engineering and raw materials

**ESS**
**Coordinating university: Lund University, www.lu.se**

# NEUTRON REFLECTOMETRY DETECTORS

## Project description

ESS will be the most powerful neutron source in the world. The unprecedented neutron flux has made the development of new detector technology necessary. In particular, Neutron Reflectometry is facing a huge challenge: the required instantaneous rate capability is on the order of one thousand times higher than what current state-of-the-art detectors can achieve, and the spatial resolution needs to improve fourfold.

After three years of intense development, the Multi-Blade detector fulfills all the above requirements and has been accepted to be the detector used on the two reflectometry instruments built at ESS: ESTIA and FREIA.

## Team

Lund University, Division of Nuclear Physics:
- Francesco Messi, Doctor, Researcher

ESS:
- Francesco Piscitelli, Doctor, Detector Scientist

University of Perugia:
- Giacomo Mauri, Master of Science

## Core deliverables

Neutron detector for cold and thermal neutrons

## Year

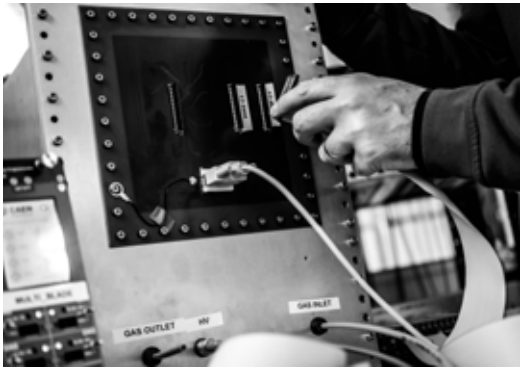
2016-2020

## Total budget

EUR 400,000

## Hyperlink(s)

- Journal of Instrumentation, vol. 13, no. 03, p. P05009, 2018. doi:10.1088/1748-0221/13/05/P05009
- Journal of Instrumentation, vol. 13, no. 03, p. P03004 2018. doi:10.1088/1748-0221/13/03/P03004




**Procurement code(s)**
Particle and photon detectors

**ESS**

**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# PHASE REFERENCE LINE

## Project description

The linear accelerator at ESS is dependent on high precision synchronization between the different acceleration stages. The stages have to be within 0.1 degree of each other at 704 MHz, which equals sub-picoseconds accuracy. One important part of achieving this is to have a highly stable time, or in this case phase, reference distribution. This is done by a thermally controlled coaxial cable where we have designed the algorithms and thermal system that keeps it to within 0.1 degree Celsius for a length of 600 meters.

## Team

Lund University, Faculty of Engineering:

- Bo Bernhardsson, Professor
- Björn Olofsson, Professor
- Pontus Andersson, Master of Science
- Rolf Johansson, Professor

ESS:

- Rihua Zeng

## Core deliverables

- Design of thermal system
- Design of automatic control algorithms
- Test bench and tests

## Industry involvement

- Eurotherm
- Beckhoff
- Pentronic AB
- KIMA

## Years

2015–2017

## Total budget

EUR 65,000

**Procurement code(s)**

Electronics and radio frequency
Mechanical engineering and raw materials

**ESS**

**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# REMOTE HANDLING WITHIN THE ACTIVE CELLS FACILITY AT THE EUROPEAN SPALLATION SOURCE, USING DIGITAL REALITY TECHNIQUES

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

This project aimed to show possibilities of using Digital Reality (Augmented Reality and Virtual Reality) techniques in the remote handling within the Active Cells Facility at the European Spallation Source. The remote handling within similar environments as the Active Cells Facility has normally been performed using radiation shielding windows. As the operations get more complex, and both Virtual Reality and Augmented Reality technologies get cheaper, more advanced, more robust, and easier to use, there is a growing interest in trying to apply these technologies for better control and monitoring within these environments. This project was set to test requirements on hardware and software these kinds of solutions would have, and which designs would be most promising as these technologies get better. Different ideas were explored by researching existing documentation and exploring existing solutions and products. Experiments on these ideas were conducted on different products that were commercially available at the time. Different solutions were tried using these products and were then evaluated using both informal and formal user tests. The results from these tests indicated that the application of Digital Reality techniques to the remote handling within the Active Cells Facility could indeed prove to be very useful. The Active Cells Facility at the European Spallation Source are now built without radiation shielding windows as a result of this project.

## Team

Lund University

- Joakim Eriksson, Team leader, Research engineer, Head of VR lab
- Emil Boman, Student, Department of Design Science
- Lukas Smisovsky, Student, Department of Design Science
- Günter Alce, Reseracher, Ergonomics and Aerosol Technology

## Core deliverables

Augmented Reality (AR) Virtual Reality (VR) replacing windows in Active Cell Facilities
Interface development

## Year

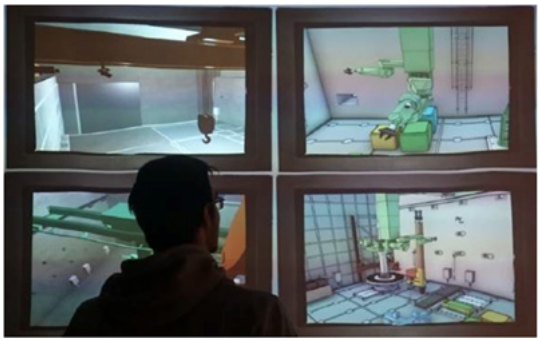
2016

## Total budget

EUR 25,000

## Hyperlink(s)

http://lup.lub.lu.se/luur/



**Procurement code(s)**

Information technology

**ESS**

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# SAMPLE ENVIRONMENT FOR IN-SITU ULTRA-HIGH TEMPERATURE MECHANICAL TESTING

CHALMERS

## Project description

There is a large societal need for structural materials capable of withstanding temperatures in the ultra-high temperature (UHT) range, here defined as temperatures above 1100°C. Development of such materials poses significant scientific and technological challenges and in order to address these challenges, it is vital to understand the deformation mechanisms at the operating temperatures. The unprecedented neutron flux and intended detector combination at the engineering diffractometer BEER at ESS will provide a unique tool for this purpose. Within the project, a sample environment, in the form of a furnace adapted for mounting on the BEER stress rig, will be developed. The furnace will allow in-situ mechanical testing during neutron diffraction experiments to be performed at temperatures up to at least 1600°C, and will be a part of the standard sample environment pool for BEER.

## Team

Chalmers University of Technology:
- Magnus Hörnqvist Colliander, Docent, senior researcher in physics

Linköping University:
- Ru Lin Peng, Professor, Engineering Materials

KTH Royal Institute of Technology:
- Peter Hedström, Docent, Materials Science and Engineering

Nucelar Physics institute Prague:
- Premysl Beran, Doctor, Instrument Scientist at BEER at ESS

## Year

2017–2020

## Total budget

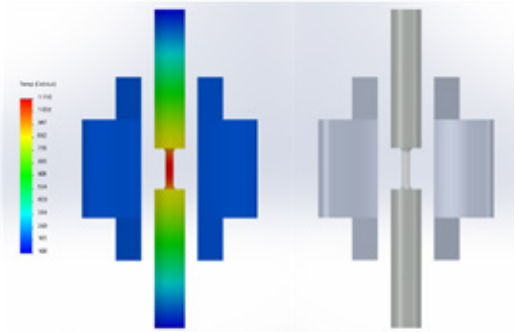
EUR 940,000

## Collaboration(s)

- Conceptual and detailed design of sample environment
- Manufacturing and testing of sample environment prototype
- Delivery of final hardware to BEER at ESS

## Universities involved

- Chalmers University of Technology
- Linköping University
- KTH Royal Institute of Technology
- Nucelar Physics Institute Prague





**Procurement code(s)**

Mechanical engineering and raw materials

**ESS**
**Coordinating university: Uppsala University, www.uu.se**

# SOLID STATE POWER AMPLIFIER – DEVELOPMENT OF THE NEXT 400 KW POWER STATION FOR ESS

UPPSALA UNIVERSITET

## Project description

To ensure a continuous improvement of the operations at ESS in the long term and, to benefit from cutting edge technology, the FREIA laboratory at Uppsala University has undertaken the development of a Radio Frequency (RF) Solid State Power Amplifier (s)SPA) station of 400 kW at 352 MHz. SSPA offers many advantages compared to vacuum tube technology, such as: (i) longer lifetime and longer mean time between failures (MTBF) considering more than 10 years operation 24/7, (ii) additional safety using much lower voltages i.e. 50 V v.s. 16 kV, (iii) additional redundancy in operation by combining many SSPAs, (iv) support from a mature and growing semiconductor industry while (v) vacuum tube manufacturers suffer from obsolescence and their number is continuously decreasing. The output power of SSPA modules is relatively low (i.e. 1 kW) and many SSPAs need to be combined in order to produce the peak power levels required. Power combination is key for enabling the economic viability of the system. In the same time, we develop adaptive control mechanisms to make hundreds of amplifier pulse in concert with optimal energy efficiency. ESS will operate 26 power stations, each of 400 kW peak power at 352 MHz.

## Year

2017 - ongoing

## Team

Uppsala University

- Dragos Dancila, Associate professor, Department of physics and astronomy
- Kristiaan Pelckmans, Associate professor, IT, Division of Systems and Control
- Anders Rydberg, Professor, Department of physics and astronomy, FREIA
- Alireza Kasaee, Postdoc, Department of physics and astronomy, FREIA
- Renbin Tong, Student, Department of Electrical Engineering, Solid state electronics

## Core deliverables

Solid State power amplifier modules at kilowatt level and high power combiners development up to 400 kW and up to 300:1 combination ratio. Adaptive control procedure for up to 400 amplifiers optimization. Specific design for superconductive cavity particle accelerators. System design and specifications. High speed data analysis and control using FPGA. System integration and commissioning. High power testing bench and continuous development.

## Industry involvement

- ESS, Sweden
- ESRF, France
- CERN, Switzerland
- GE Healthcare – collaboration on SSPA for cyclotrons
- Exir AB – waveguides and combiners
- Percyroc AB – signal generators and adaptive control

## Total budget

EUR 1 million

**Procurement code(s)**
Electronics and radio frequency
Electrical engineering and magnets
Information technology
Mechanical engineering and raw materials

ESS

# TEST OF THE ESS HIGH VOLTAGE PULSE MODULATOR

UPPSALA UNIVERSITET

**Coordinating university: Uppsala University, www.uu.se**

## Project description

The high beta cavities of ESS use Klystrons as power sources. The klystrons are powered by HV modulators. We will work towards improving the overall reliability of the system.

## Team

Uppsala University, FREIA:

- Rolf Wedberg, Research engineer, Department of Physics and Astronomy
- Dragos Dancila, Docent, Department of Engineering Sciences, Solid State Electronics
- Tord Peterson, Research engineer, Department of Physics and Astronomy
- Long Huang Duc, PhD student, Department of Engineering Sciences, Solid State Electronics
- Han Li, Researcher Department of Physics and Astronomy

## Core deliverables

- System design
- System characterization

## Industry involvement

Ampegon

## Year

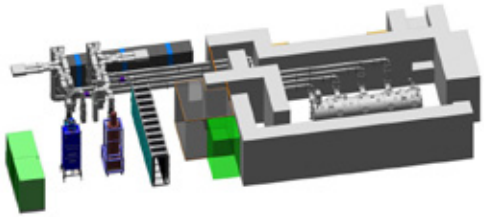
2017–

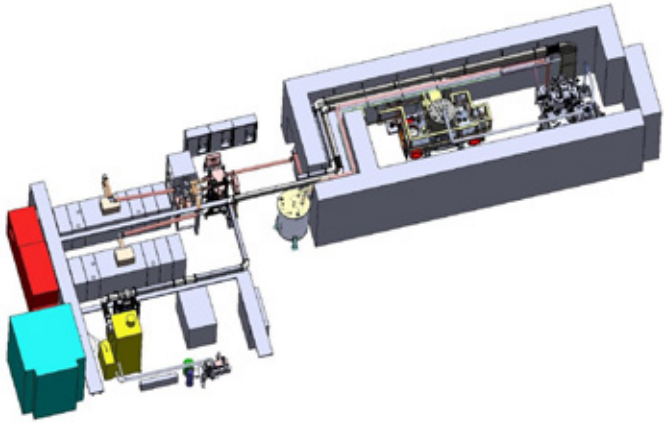
## Total budget

EUR 1 million

## Collaboration(s)

- Uppsala University
- Lund University





**Procurement code(s)**

Electronics and radio frequency

**ESS**
**Coordinating university: Lund University, www.lu.se**

# TEST OF THE FAST-NEUTRON ATTENUATION OF NOVEL SHIELDING MATERIALS

LUNDS UNIVERSITET

## Project description

The process of neutron creation at ESS results in an intensive radiation field consisting of many different types of particles. Therefore, effective shielding is absolutely essential at such facilities for both radiation safety and for minimizing unwanted background noise in the scientific instruments.

Specialized bulk shielding concretes have been developed at ESS for this purpose. The materials were then tested at the Source Testing Facility at Lund University. The specialized infrastructure present there allowed to characterize the energy-dependent attenuation of fast neutrons by the different concretes as well as by reference samples. The results were then used to successfully validate simulations of the materials.

## Team

Lund University, Division of Nuclear Physics:
- Kevin Fissum, Doctor, Senior Lecturer in Nuclear Physics
- Hanno Perrey, Doctor, Researcher in Neutron Metrology

ESS:
- Douglas DiJulio, Doctor, Radiation Physicist

## Core deliverables

- Design and tuning of the experimental setup
- Performing the measurement
- Data analysis

## Year

2016

## Total budget

EUR 3,500

## Hyperlink(s)

https://doi.org/10.1016/j.nima.2017.03.064



**Procurement code(s)**
Information technology
Particle and photon detectors

**ESS**

**Coordinating university: Uppsala University, www.uu.se**

# TESTING OF THE ESS SUPERCONDUCTING ELLIPTICAL CAVITY

UPPSALA UNIVERSITET

## Project description

ESS will adopt elliptical multi-cell superconducting cavities with a beta value of 0.86 to accelerate the proton beam up to 2 GeV at the last section of the linac. A 5-cell high-beta cavity for the ESS project was tested with high power at FREIA Laboratory. A pulse mode test stand based on a self-excited loop was used in this test. The qualification of the cavity package involved a 5-cell elliptical cavity, a fundamental power coupler, a cold tuning system, LLRF system and an RF station. These tests represented an important verification before the series production. Fruitful studies of the test chain, RF conditioning, high power performance and experience of this cavity have been done in this test.

## Team

Uppsala University:

- Han Li, researcher RF and accelerator systems
- Rolf Wedberg, Researcher high power RF system
- Rocio Santiago-Kern, Engineer researcher cryogenic system
- Tor Lofnes, Engineer LLRF system

## Core deliverables

- Test stand based on self-excited loop development
- Test method and algorithm design
- Data acquisition and control software development
- Coupler RF conditioning
- RF test in high vacuum and cryogenic system
- Data analysis
- Test result report

## Year

2018

## Total budget

EUR 50,000

## Collaboration(s)

- Uppsala University
- Saclay



**Procurement code(s)**

Electrical engineering and magnets
Electronics and radio frequency

**ESS**
**Coordinating university: Uppsala University, www.uu.se**

# TESTING OF THE ESS TETRODE 352 MHZ RADIOFREQUENCY POWER SOURCE

UPPSALA UNIVERSITET

## Project description
The 26 spoke cavities of ESS are powered by tetrode amplifiers at 352 MHz.
In Freia Laboratory we have two prototypes from different manufacturers to work with.
We will describe the modifications which had to be made and what the consequence it will make.

## Team
Uppsala University, FREIA:
- Rolf Wedberg, Research engineer Department of Physics and Astronomy
- Dragos Dancila Docent, Department of Engineering Sciences, Solid State Electronics
- Tord Peterson, Research engineer, Department of Physics and Astronomy
- Long Huang Duc, PhD student Department of Engineering Sciences, Solid State Electronics
- Han Li, Researcher, Department of Physics and Astronomy

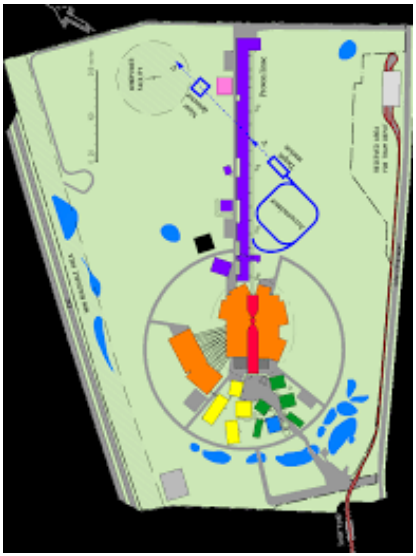
## Core deliverables
System design

## Industry involvement
- Thales
- Itelco
- DB Elletronica

## Year
2017–

## Total budget
EUR 1 million

## Collaboration(s)
- Uppsala University
- Lund University





**Procurement code(s)**
Electronics and radio frequency

**ESS**

**Coordinating university: Uppsala University, www.uu.se**

# TESTING OF THE ESS SUPERCONDUCTING SPOKE CAVITY PROTOTYPE

UPPSALA UNIVERSITET

## Project description

ESS is an accelerator-driven neutron spallation source, which will use spoke cavities in its superconducting linac. Since this type of cavity is new and the study of its performance is still ongoing, it becomes the key challenge of the whole project. The testing of the double-spoke prototype cavity for the ESS project at high power has been conceded to Uppsala University, Sweden. The qualification of the prototype cavity, involving a superconducting spoke cavity, a fundamental power coupler, cryogenic system, LLRF system and RF station, represents an important verification before the module assembly. The study of the test configuration, RF conditioning history and first high power performance of this cavity provides an important input for ESS.

## Team

Uppsala University:

- Han Li, Researcher RF and accelerator systems
- Rolf Wedberg, researcher high power RF system,
- Rocio Santiago-kern, Engineer researcher cryogenic system
- Tor Lofnes, Engineer LLRF system

## Core deliverables

- Test stand design and building up
- Test method and algorithm design
- Data acquisition and control software development
- Coupler RF conditioning
- RF test in high vacuum and cryogenic system
- Data analysis
- Test result report

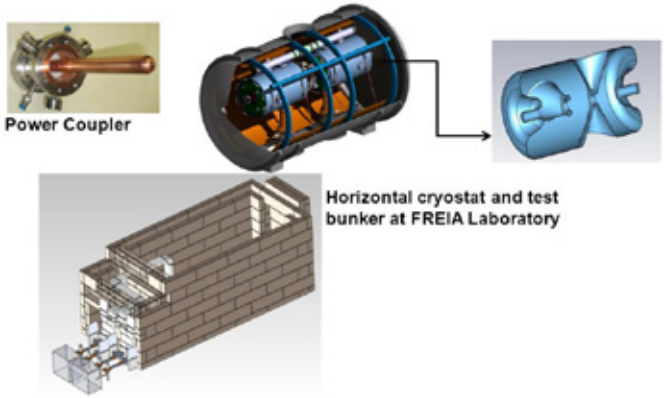
## Year

2017

## Total budget

EUR 70,000






**Procurement code(s)**

Electronics and radio frequency
Mechanical engineering and raw materials

**ESS**
**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# UNIAXIAL STRESS DEVICE FOR QUANTUM MATTER RESEARCH

CHALMERS

## Project description
Quantum matter is a class of materials having great potential for technological applications, ranging from MRIs at hospitals to hard disk drives. Understanding their fundamental properties in various environmental conditions is essential to implement them in our everyday lives. In this regard, a new uniaxial stress device for neutron scattering experiments is being developed for the BIFROST instrument at the future European Spallation Source (ESS) in Lund – Sweden. The aim is to explore, with exceptional precision, quantum materials on the molecular level under extreme conditions.

## Team
Chalmers University of Technology
- Yasmine Sassa, Assistant professor, Department of Physics

KTH (Royal Institute of Technology)
- Martin Månsson, Associate professor, Department of Applied Physics

DTU (Technical University of Denmark) / ESS (European Spallation Source)
- Rasmus Toft-Petersen, Researcher, ESS and DTU

Paul Scherrer Institute, Switzerland
- Marc Janoschek, Associate professor,Laboratory for Neutron and Muon Instrumentation (LIN)
- Gediminas Simutis, Postdoc, Laboratory for Neutron and Muon Instrumentation (LIN)

## Core deliverables
Develop and test uniaxial stress device for inelastic neutron scattering experiments. At the end of the developmental period, the goal is to have the pressure device available for users at the BIFROST instrument.

## Year
2021-2023

## Total budget
EUR 475,000

## Collaboration(s)
- Chalmers University of Technology
- KTH Royal Institute of Technology
- European Spallation Source
- Paul Scherrer Institute, Switzerland



**Procurement code(s)**
Mechanical engineering and raw materials

330

# FAIR

FAIR

**Coordinating university: Lund University, www.lu.se**

# CONTRIBUTION TO THE CALIFA BARREL R3B EXPERIMENT AT FAIR

LUNDS UNIVERSITET

## Project description

This project concerns investment for the CALIFA barrel detector of the R3B experiment at FAIR (the Facility for Antiproton and Ion Research) in Darmstadt, Germany. In 2010 Sweden signed the FAIR agreement and thereby became member of the new facility. The laboratory is planned to be the main user laboratory for Swedish nuclear physics for the coming 15-20 years. This specific application comes as part of the in-kind contributions to detector systems at FAIR that has been developed in dialogue between the Swedish FAIR consortium (s)FAIR) and the research council. It consists of a contribution to scintillator crystals and readout devices to the barrel part of the calorimeter for the R3B experiment. The technical design report (TDR) for the detector was completed in 2011 following a period of R&D on detector design. The Lund, Chalmers and KTH groups are the main Swedish participants in this detector development program where the Lund group has the responsibility in Sweden for scintillator and readout devices for the CALIFA barrel. The main purpose of CALIFA is to detect charged particles and gamma-rays from reactions with exotic ion beams at relativistic energies. The CALIFA barrel consists of CsI(Tl) crystals of varying geometry coupled to readout devices. The funding requested in this application will be dedicated to purchase of detector units as described in the TDR. FAIR is currently under construction and this investment is part of the Swedish contribution to FAIR.

## Team

Lund University:

- Joakim Cederkäll, Professor, Nuclear Physics, Faculty of Science, Department of Physics,
- Bo Jakobsson, Professor, Nuclear Physics, Faculty of Science, Department of Physics,
- Pavel Golubev, Senior Lecturer, Nuclear Physics, Faculty of Science, Department of Physics

KTH Royal Institute of Technology:

- Torbjörn Bäck, Associate professor, Nuclear Physics

Chalmers University of Technology:

- Thomas Nilsson, Professor, subatomic and plasma Physics, Department of Physics

## Year

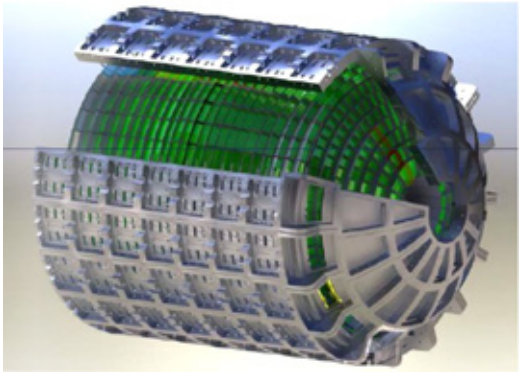
2013-2017

## Total budget

EUR 340,000

## Collaboration(s)

- Lund University
- KTH Royal Institute of Technology
- Chalmers University of Technology



**Procurment codes**

Particle and photon detectors
Optics and photons

**FAIR**
**Coordinating university: Lund University, www.lu.se**

# LUND-YORK-COLOGNE CALORIMETER (LYCCA)

LUNDS UNIVERSITET

## Project description

LYCCA is a core detector of the HISPEC experiment within NUSTAR-FAIR. The main objective is to uniquely identify exotic nuclear reaction products by their mass *A* and charge *Z*. These nuclei are produced in nuclear reactions induced by relativistic radioactive ion beams. These beams are going to be provided by the new Super-Fragment Separator. Typical kinetic energies of the reaction products of interest are some 100-300 MeV/u, which corresponds to some 30-40% of the speed of light. The identification of the exotic nuclei is based upon event-by-event time-of-flight, energy loss (*ΔE*), and total energy (*E*) measurements, eventually in conjunction with a magnetic spectrometer. R&D and provision of the *ΔE-E* detector modules is the main Swedish contribution to LYCCA.

## Team

Lund University
- Pavel Golubev, Team leader, Division of Nuclear Physics
- Dirk Rudolph, Division of Nuclear Physics

Universität zu Köln
- Peter Reiter, Institut für Kernphysik
- Stefan Thiel, Institut für Kernphysik

University of York
- Mike Bentley, Department of Physics

## Core deliverables

- Thirty (30) LYCCA DSSSD-CsI *ΔE-E* detector modules (tailor-made)
- The LYCCA CsI read-out electronics (GSI-EE development)
- The LYCCA high- and low-voltage supplies (commercial NIM modules)

## Year

2010-2019

## Total budget

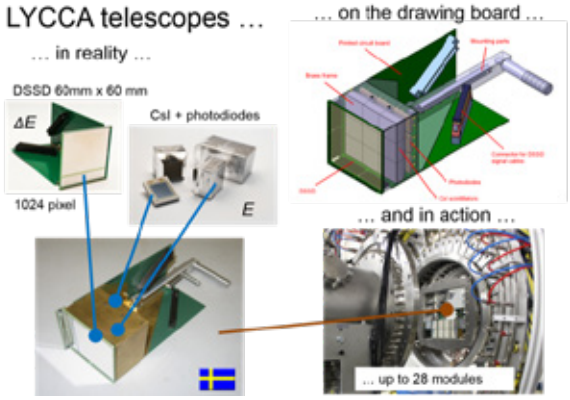
EUR 250,000

## Collaboration(s)

- Lund University, Sweden
- Universität zu Köln, Germany
- University of York, United Kingdom
- GSI Darmstadt, Germany

## Hyperlink(s)

www.nuclear.lu.se/english/research/basic-nuclear-physics/nustar/lycca/




**Procurement code(s)**
Particle and photon detectors

FAIR

**Coordinating university: Uppsala University, www.uu.se**

# ELECTROMAGNETIC CALORIMETER FOR THE PANDA EXPERIMENT

UPPSALA UNIVERSITET

## Project description

PANDA is an experiment at FAIR, Darmstadt, Germany, which uses a beam of antiprotons to study the strong force. A key element of the PANDA detector is its electromagnetic calorimeter (EMC) consisting of about
16 000 PWO crystals to measure photons from antiproton induced interactions. Uppsala is responsible for developing and producing read out electronics for the EMC:

- Sampling analog-to-digital converters (s)ADCs) with built-in intelligence for feature extraction from the signals (time and energy) using FPGAs.
- Data Concentrators that synchronize the data from the SADCs, build events and perform first level analysis. These units are also based on FPGAs

## Team

Uppsala University:
Pawel Marcienewski, Doctor, digital electronics design

## Core deliverables

- Electronics hardware design, testing and production.
- Radiation resistance tests of electronics
- Electronic acquisition hardware design
- High speed data analysis in FPGA hardware
- System integration and commissioning

## Industry involvement

- Semicon
- Crytur

## Year

2016–

## Total budget

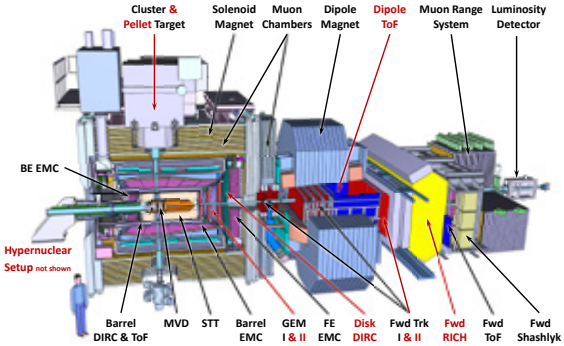
EUR 2.6 million

## Collaboration(s)

- Uppsala University
- Stockholm University

## Hyperlink(s)

https://panda.gsi.de/article/electromagnetic-calorimetry




**Procurement code(s)**

Electronics and radio frequency
Information technology
Particle and photon detectors

**FAIR**
**Coordinating university: Lund University, www.lu.se**

# HIGH VOLTAGE PULSE TRANSFORMER SYSTEMS FOR THE FAIR KLYSTRON MODULATORS

LUNDS UNIVERSITET

## Project description

To generate the required antiproton beam intensity for the FAIR PANDA experiment, a dedicated proton LINAC (pLINAC) for the FAIR accelerator chain is being constructed. Klystron modulators are power converters within the high power RF system of the pLINAC. Here, seven modulator systems with a nominal pulse power amplitude of 115 kV / 54 A, an effective pulse width of 360 μs and a pulse repetition rate of up to 5 Hz are required. These modulators are to be based on pulse transformers whose characteristics largely determine the modulator output pulse quality. This project has considered electromagnetic modeling and optimal design of pulse transformers to deliver a compact system ensuring the RF power requirements of the FAIR pLINAC are met.

## Team

Lund University:

- Max Collins, PhD, Industrial Electrical Engineering and Automation

FAIR:

- Sven Pütz, Engineer for High Voltage, Power Electronics and Pulsed Power Systems, Accelerator Operations - Linac RF (ACC - LRF)

## Core deliverables

- Global optimization study of high voltage pulse transformer and auxiliary systems accounting for pre-existing klystron modulator primary stage.
- Complete electromagnetic design of high voltage pulse transformer.
- Circuit simulation and Multiphysics simulation of FAIR klystron modulator system.
- Production of a full scale prototype device.
- Experimental verification of prototype device and the design procedure.

## Industry involvement

Production of the full scale prototype device will be contracted to industrial partners.

## Year

2019-2021

## Total budget

EUR 120,000

**Procurement code(s)**
Electrical engineering and magnets
Electronics and radio frequency
Mechanical engineering and raw materials

FAIR

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# PHOTON- AND PARTICLE CALORIMETER CALIFA – FRONT END SYSTEM

CHALMERS

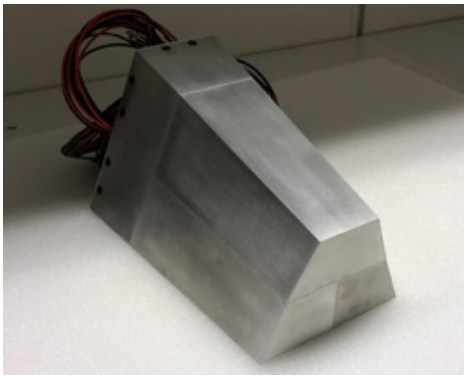
## Project description

The CALIFA photon and particle calorimeter is a part of the experimental set up for Reactions with Relativistic Radioactive Beams (R3B) at the FAIR facility. It is one of the key detectors and will detect gamma rays and light charged particles. Chalmers is contributing R&D on the forward end-cap of the CALIFA – including the hybrid LaBr3-LaCl3 phoswich detector and the associated slow control and readout electronics. The work included the technical design, prototyping, pre-series, procurement and delivery of the system.

## Team

Chalmers University of Technology:

- Thomas Nilsson, Professor, experimental subatomic physics
- Håkan T. Johansson, Research engineer, advanced software and computing hardware
- Andreas Martin Heinz, Associate professor subatomic physics



## Core deliverables

- Research and Development of detector system in line with scientific requirements
- Detector specification and design
- System integration
- Detector system production
- DAQ and controls, signal processing computers/ FPGAs
- Integration, prototyping, pre-series, procurement and delivery of system

## Industry involvement

Saint-Gobain Cristeaux et Detecteurs

## Year

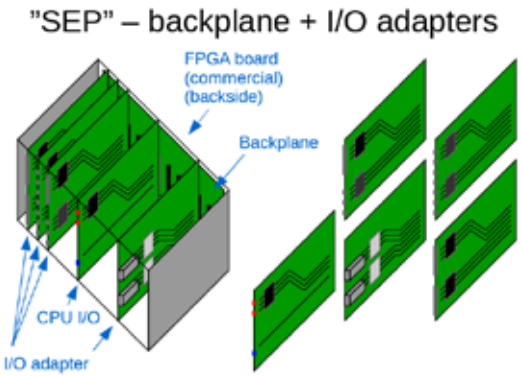
2010-2023

## Total budget

EUR 850,000

## Collaboration(s)

- Chalmers University of Technology
- SFAIR consortium




**Procurement code(s)**

Electronics and radio frequency
Information technology
Particle and photon detectors

# ILL

**ILL**
**Coordinating university: Uppsala University, www.uu.se**

# SUPER ADAM @ ILL

UPPSALA UNIVERSITET

## Project description

The Super ADAM instrument is a state of the art neutron reflectometer located at the highest neutron flux research reactor worldwide. At the facility scientists conduct both cutting edge fundamental science and applied research for industrial projects.
Super ADAM offers unique information not available by any other research tool in such areas as:

- magnetic layers, superlattices, heterostructures and magnetic meta-materials
- self-assembly of surfactants, polymers, lipids and proteins at solid and liquid interfacets
- rearrangement processes in thin films (e.g. diffusion, annealing, exchange, swelling etc.)
- encapsulation in and release from thin films e.g. drug delivery materials
- chemical and biochemical surface interactions and reactions
- hydrogen in metals
- ionic and magnetic liquids

## Team

Uppsala University:

- Alexei Vorobiev, Doctor. infrastructure manager,
- Björgvin Hjörvarsson, Professor, magnetism, hydrogen in metals, AM,

Lund University, Faculty of Engineering:

- Tommy Nylander, Professor, soft matter and bio-science

Linköping University:

- Jens Birch, Professor, advanced materials, thin films

## Core deliverables

Unique information on structure (e.g. composition, thickness and roughness, density, interfusion, crystalline state, magnetic state) and properties (e.g. phase transitions, reactivity, durability) of:

- solid-state and soft-matter ultrathin films and multilayers
- bared solid-liquid and solid-solid interfaces
- 2D artificially patterned and self-ordered structures

## Year

2013–

## Total budget

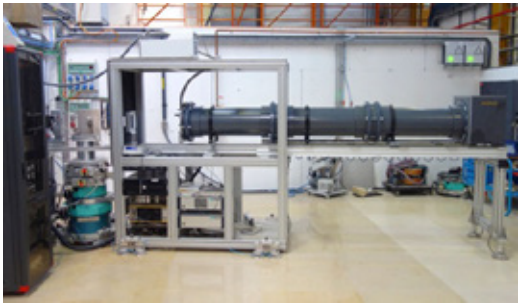
EUR 10 million

## Collaboration(s)

- Uppsala University
- Lund University
- Linköping University

## Hyperlink(s)

- https://www.ill.eu/users/instruments/instruments-list/superadam/description/instrument-layout/
- http://www.physics.uu.se/research/materials-physics+/super-adam/



**Procurement code(s)**
Electrical engineering and magnets
Mechanical engineering and raw materials

338 ISIS

**ISIS**
**Coordinating university: Chalmers University of Technology,**

# A NEW METHOD TO MODEL THE DYNAMIC STRUCTURE FACTOR BY MOLECULAR DYNAMICS SIMULATIONS

CHALMERS

## Project description

In this collaborative project between Chalmers, ESS, ISIS and the Niels Bohr Institute we aimed to overcome the difficulty to interpret and understand inelastic and quasielastic neutron scattering data (information about molecular and atomic motions) by developing a new computer modelling method to model the dynamic structurefactor, S(Q,w). The method is a dynamical correspondence to the Empirical Potential Structure Refinement (EPSR) method used to produce structural models of materials in quantitative agreement with neutron and x-ray diffraction data. The developed tool is a computer-based simulation tool that can then model the dynamic data (how atoms and molecules move) from neutron scattering by refining the model potentials in a molecular dynamics simulation until the simulation can reproduce the experimentally measured data.

## Team

- Jan Swenson, Professor, Chalmers University of Technology, Department of Physics
- Heloisa Bordallo, Associate professor, Niels Bohr Institute, Condensed Matter Physics
- Anders Markvardsen, Researcher, ISIS Neutron and Muon Source, STFC
- Thomas Holm Rod, Researcher, European Spallation Source

## Core deliverables

- A software package for modelling the dynamics of basically all types of molecular systems.
- New computer modelling method to model the dynamic structure factor, S(Q,Ð), by molecular dynamics (MD) simulations.
- The computer simulation community get a unique possibility to refine their interatomic model potentials (or force-fields) for ordinary MC and MD simulations.
- This method provides new possibilities to interpret and understand inelastic and quasielastic neutron scattering data.

## Year

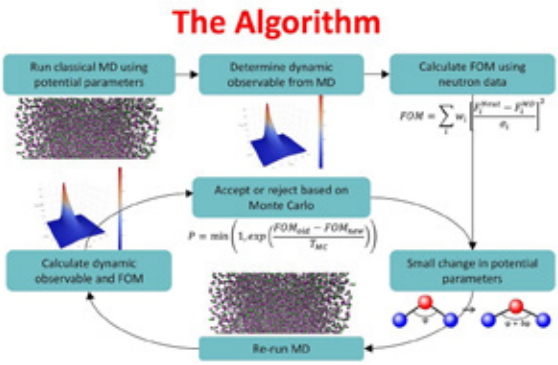
2017-2022

## Total budget

EUR 850,000

## Collaboration(s)

- Chalmers University of Technology
- Niels Bohr Institute
- ISIS Neutron and Muon Source
- European Spallation Source




**Procurement code(s)**
Information technology

**ISIS**
**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# IMAT: IMAGING AND MATERIALS SCIENCE INSTRUMENT

CHALMERS

## Project description

IMAT (Imaging and Materials Science & Engineering) is a neutron imaging and diffraction instrument for studies of a broad range of materials science related problems. IMAT will offer a combination of imaging and spatially resolved diffraction modes such as standard neutron radiography, neutron tomography, energy-dispersive imaging, neutron strain scanning, crystallographic structure and phase analysis, texture analysis, and non-destructive testing. Examples of fields of study include the non-destructive and in-situ testing of materials for applications in aerospace and transportation, civil engineering, energy storage, geoscience, biology, soil-plant systems, palaeontology and cultural heritage.

## Team

Chalmers University of Technology, Department of Chemistry and Chemical Engineering

- Sten Eriksson, Professor
- Maths Karlsson, Associate professor
- Dariusz Wardecki, postdoc
- ISIS Neutron and Muon Source
- Stephen Hull, Professor, Crystallography Group Leader
- Genoveva Burca, Researcher, Instrument Scientists at IMAT
- Winfried Kockelmann, Researcher, Instrument Scientists at IMAT
- Nigel Rhodes
- Jeff Sykora, ISIS Detector Group
- David McPhail, ISIS Detector Group
- Francesco Zuddas, ISIS Instrument Design Group

## Core deliverables

- Design, procurement, manufacturing, testing and installation of large diffraction detector arrays at 90 degrees
- Design, specifications, mounting system, shielding, purchasing and installation of radial collimators at 90 degrees
- Community building and transferring of know-how to the Swedish community

## Year

2014-2021

## Total budget

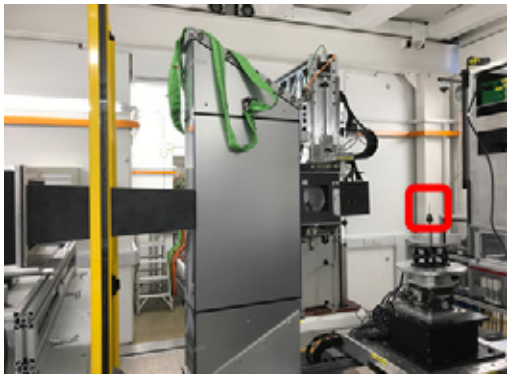
EUR 1.3 million

## Collaboration(s)

- Chalmers University of Technology
- ISIS Neutron and Muon Spallation Source

## Hyperlink(s)

www.isis.stfc.ac.uk/Pages/Imat.aspx



**Procurement code(s)**
Optics and photonics
Particle and photon detectors

**ISIS**

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# NEUTRON RAY-TRACING SIMULATIONS FOR THE UPGRADE OF THE OSIRIS SPECTROMETER

CHALMERS

## Project description

OSIRIS is a cold-neutron high-flux near-backscattering neutron spectrometer combined with a long-wavelength diffractometer, located at the ISIS Neutron and Muon Source. In this project we designed a new silicon analyzer and detector system for OSIRIS, with the use of neutron ray-tracing simulations as well as analytical calculations, which will improve the resolution and increase the dynamic range of the instrument. We further designed a new elliptic super-mirror neutron guide for OSIRIS that will significantly increase the flux and focus of the neutron beam on sample position, which will allow the routine measurement of smaller samples. These developments will facilitate challenging studies of novel materials and ensure that OSIRIS remains a highly competitive instrument.

## Team

- Maths Karlsson, Associate professor, Chalmers University of Technology, Department of Chemistry and Chemical Engineering
- Max Wolff, Professor, Uppsala University, Department of Physics and Astronomy
- Adrien Perrichon, Postdoc, Uppsala University, Department of Physics and Astronomy
- Felix Fernandez-Alonso, Professor, ISIS Neutron and Muon Source, Group Leader in Molecular Spectroscopy
- Franz Demmel, Researcher, ISIS Neutron and Muon Source, Instrument Scientist on OSIRIS

## Core deliverables

- Design study supported by ray-tracing simulations of a new silicon analyzer and detector system for OSIRIS
- Design study supported by ray-tracing simulations of an elliptic super-mirror guide for OSIRIS

## Year

2017-2021

## Total budget

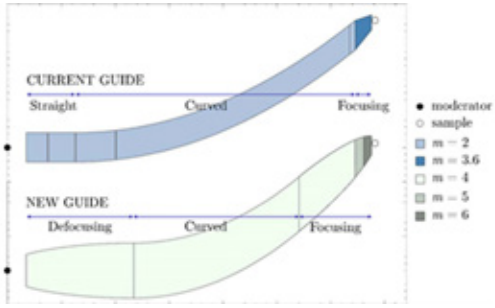
EUR 700,000

## Collaboration(s)

- Chalmers University of Technology
- Uppsala University
- ISIS Neutron and Muon Source

## Hyperlink(s)

www.isis.stfc.ac.uk/Pages/osiris.aspx




**Procurement code(s)**

Information technology
Particle and photon detectors
Optics and photonics

# ITER

**ITER**

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# ADDITIVE MANUFACTURING FOR FABRICATION OF 316L-GRADE COMPONENTS

CHALMERS

## Project description

The main objective is to demonstrate how a subdivision of a final structure could be produced in stainless steel 316L(N)-IG-grade with electron beam melting (EBM) followed by post-EBM hot isostatic pressing (HIP). As alternative way, selective melting (LS/SLM) has also been explored. The characteristics of raw materials and processing have been explored in detail and the quality control of the powder material, process and optimized parameters to achieve a fully dense material have been clarified. A large number of block specimens have been fabricated and delivered for testing. The approach to manufacture a large section by sub-division and subsequent joining using hot isostatic pressing (HIP) has been explored. The surface preparation and optimization of post-EBM joining of parts by HIP has been addressed and parameters to achieve successful joints with good metallurgical bonding have been developed.

## Team

Chalmers University of Technology:

- Lars Nyborg, Professor, specialist in materials design, powder technology and additive manufacturing, surface technology
- Eduard Hryha, Professor, specialist in materials design, powder technology and additive manufacturing, divison of materials and manufacturing, industrial and materials science

Mid-Sweden University:

- Lars-Erik Rännar, Docent, specialist in EBM technology, additive manufacturing, Quality management and mechanical engineering

Stockholm University:

- Zhijian James Shen, Professsor, specialist in SLM technology, department of materials and environmental chemistry

Swerim:

- Hans Magnusson, Specialist in HIP and powder technology, materials modelling

## Core deliverables

- Certification and assessment of high quality metal powder for intended application
- Development and delivery of test specimens for mechanical testing and radiation testing
- Development of design for AM-fabrication of intended product for ITER
- Process development and process optimization for material by AM
- HIP process and surface preparation for optimized HIP-joining of AM-fabricated specimens developed
- Scientific publications
- Patent application

## Industry involvement

- Carpenter Powder Products
- Sandvik Materials Technology

## Year

2015-2017

## Total budget

EUR 510,000

## Collaboration(s)

- Chalmers University of Technology
- Mid Sweden University
- Stockholm University
- Swerim

**Procurement code(s)**

Mechanical engineering and raw materials

ITER

**Coordinating university institute: RISE Research Institutes of Sweden, www.ri.se**

# EUROFUSION DIVERTOR WORK PACKAGE, ITER

## Project description

The divertor is an area of a fusion reactor, where impurities and waste material are removed from the plasma while the reactor is still operating. This allows control over the buildup of fusion products in the fuel and removes impurities in the plasma originating from the vessel lining. The divertor is a geometrically complex design, where the pieces are water-cooled and surface materials are exposed to severe environmental and thermal conditions.

The EUROfusion work package Divertor (WP-DIV) integrates the design and technology R&D of power exhaust solutions for the divertor regions and limiters of the existing devices Wendelstein 7-X stellarator and JT-60SA Tokamak, as well as the future devices I-DTT and DEMO. The RISE mechanical laboratory in Borås will contribute with mechanical testing of materials and components for the divertor designs.

The department of mechanics at RISE is a team of researchers and skilled engineers in solid mechanics with expertise in fracture mechanics, computational material mechanics, fatigue and structural dynamics. Together with skilled personnel in our accredited mechanics laboratory, they serve the needs of both industry clients and publicly funded research projects. In the present project, experts in other parts of RISE contribute special competence in microscopic characterization, fractography and measurement of thermal properties.

## Year

2021-2024

## Team

RISE Research Institutes of Sweden

- Ola Widlund, PhD, Senior researcher, Unit director, Mechanical reliability
- Johan Sandström, PhD, senior researcher, Structural and solid mechanics, Mechanical reliability
- Pooya Tabib, PhD, researcher, Mechanical reliability

## Core deliverables

- Mechanical testing
- Material analysis
- Material properties

## Total budget

EUR 125,000

## Collaboration(s)

- RISE Research Institutes of Sweden
- CEA, Cadarache and Mines St Etienne
- Max-Planck-Institut für Plasmaphysik (MPG-IPP)

**Procurement code(s)**

Mechanical engineering and raw materials

**ITER**
**Coordinating university institute: RISE Research Institutes of Sweden, www.ri.se**

# EUROFUSION WPENS

## Project description

The aim of the project is to investigate Lithium fire safety, in particular relating to the Lithium Loop (LL) facility. LL divertors is a possible solution to outstanding fusion reactor technology issues, while potentially improving reactor plasma performance. There are however risk and safety concerns regarding LL. Risk assessment and fire mitigation scenarios will be investigated in a scenario that contain around 10 m3 of lithium circulating at a rate of 0.104 m3/s at elevated temperatures. Although lithium is the least reactive of the alkali metals, many exothermic reactions chemical reactions are possible in contact with common gases and materials such as oxygen, nitrogen, water, CO2 and concrete.

Experimental approaches on lithium fire safety oriented to prevention of ignition will be developed according to the reference RISE testing apparatus and capabilities. A first draft matrix of experiments to develop in the WPENS frame will be prepared in view of DONES fire safety requirements, which could be review in later stages. First experimental results will be obtained and reported.

The Fire Research unit is a part of Fire Technology at RISE. Fire Research is a team of researchers and skilled engineers in fires with expertise in fire dynamics, fire resistance, forest fires, fire simulations and structural mechanics. Together with skilled personnel in our accredited fire test laboratory, they serve the needs of both industry clients and publicly funded research projects.

## Team

RISE Research Institutes of Sweden

- Johan Anderson, PhD, Senior researcher, Fire Research
- Johan Sjöström, PhD, Senior researcher, Structural and solid mechanics, Fire Research
- Emil Hallberg, Technician, Test engineer, Fire Research
- Fredrik Kahl, Technician, Test engineer, Fire Research

## Core deliverables

- Fire safety of Lithium
- Li ignition prevention experiments
- Risk assessments of Lithium and Lithium fires
- Material analysis

## Year

2021-2024

## Total budget

EUR 542,000

## Collaboration(s)

RISE Research Institutes of Sweden
IFMIF-DONES

## Hyperlink(s)

https://www.ri.se/en/what-we-do/our-areas/fire-safety, https://www.ri.se/en/test-demo/fire-simulation

**Procurement code(s)**

Mechanical engineering and raw materials
Health, safety and environment
Gases, chemicals, waste collection and radiation equipment

**ITER**
**Coordinating university: KTH Royal Institute of Technology, www.kth.se**

# FUSION REACTOR DEVELOPMENT. PARTICULAR PROJECT: PLASMA-WALL INTERACTIONS IN FUSION DEVICES

## Project description

Design and construction of a next step controlled fusion device (ITER) is preceded by development, selection and characterization of materials relevant for plasma-facing components– especially for the first wall and the divertor. Tungsten and beryllium were selected for ITER; results obtained also by the KTH group influenced that choice.

Material erosion, transport and re-deposition leading to the fuel accumulation in wall materials top the list of urgent priority issues to be assessed in present-day devices to provide the best possible predictions for a reactor. Experimental work is carried out at Joint European Torus (JET), ASDEX Upgrade, and WEST, and also in linear simulators of plasma-surface interactions. Materials are examined using a large number of material research techniques.



## Year

2007-

## Team

KTH Royal Institute of Technology, School of Electrical Engineering and Computer Science, Department of Fusion Plasma Physics

- Marek Rubel, Team leader, professor
- Per Brunsell, professor
- Per Petersson, researcher
- Henric Bergsåker, associate professor
- Laura Dittrich, student

Uppsala University, Department of Physics

- Daniel Primetzhofer, professor

## Core deliverables

- Testing of beryllium and tungsten behaviour under plasma operation
- Determination of the impact of material migration and mixing on the wall composition and retention of hydrogen isotopes
- Mechanism of dust generation and detailed characterisation of particles
- Mechanism and efficiency of fuel removal and wall conditions under ion cyclotron-assisted plasma operation
- Development of diagnostic tools and the determination of the plasma impact on diagnostic components

## Total budget

EUR 2.2 million (estimate)

## Collaboration(s)

- KTH Royal Institute of Technology
- Uppsala University
- EURO-fusion Consotrium
- Culham Centre for Fusion Energy, Joint European Torus (JET), UK
- Forschungszentrum Juelich, Germany
- Warsaw University of Technology, Poland

## Hyperlink(s)

www. euro-fusion.org
www.iter.org

**Procurement code(s)**
Particle and photon detectors

**ITER**

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# ITERIS – DESIGN AND IMPLEMENTATION OF AN INTEGRATED MODELLING INFRASTRUCTURE

CHALMERS

## Project description

ITER is the next generation of fusion experiments and is aimed at demonstrating the feasibility of fusion energy as a viable energy source for the future. It is currently under construction with a first plasma expected 2025. The ITERIS consortium was set up to bring the long-term European activity on simulation and modeling as a basis for the future ITER analysis environment. The project defines the data model for ITER, the related access tools and implements a workflow orchestration tool for developing simulations on the modelling platform. The prototype installation has now been adopted by the ITER organization and is promoting this for developments and use of the global fusion community with the continued support from the consortium.

## Team

Chalmers University of Technology:

- Pär Strand, Professor, specialist in plasma physics and fusion, plasma physics and fusion energy group, astronomy and plasma physics, space earth and environment

## Core deliverables

- Schema for data dictionary
- Database structure and access tools
- Workflow orchestration and workflow components
- Physics modules

## Industry involvement

Areva

## Year

2011-

## Total budget

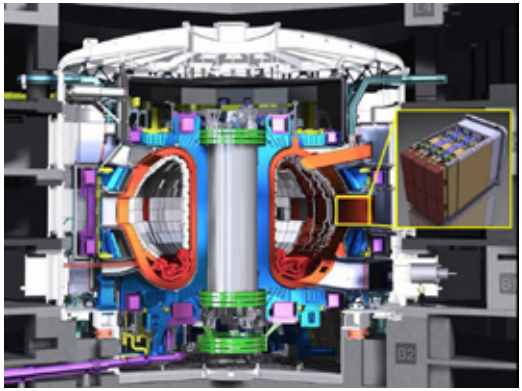
EUR 1.7 million

## Collaboration(s)

- CEA
- Chalmers
- EPFL

## Hyperlink(s)

http://iopscience.iop.org/article/10.1088/0029-5515/55/12/123006





**Procurement code(s)**

Information technology

**ITER**
**Coordinating university: Uppsala University, www.uu.se**

# NEUTRON DIAGNOSTICS FOR FUSION POWER PLANTS

UPPSALA UNIVERSITET

## Project description

ITERs main goal is to demonstrate the feasibility of key technologies for the development of future power plants based on fusion energy. ITER is under construction in Cadarache (France) and it is expected to start operation in 2026. In parallel to ITER, the conceptual design of a Demonstration Fusion Power Plant (DEMO) is underway. DEMO is intended to be the single step between ITER and a commercial reactor: it is expected to deliver electricity to the grid in 2050. The measurement of the 2.5 and 14 MeV neutron yield and energy spectrum is required for the determination of the fusion power produced, for the optimal operation of such devices and, ultimately, for the steady state production of electricity.
Design, construction, installation, commissioning and operation of neutron flux monitors and spectrometers in present day fusion devices such as JET and MAST and development of neutron diagnostics for ITER, DEMO and DTT.



## Team

Team Uppsala University, Department of Physics and Astronomy, Division of Applied Nuclear Physics:

- Göran Ericsson, Team leader, Professor, specialist in neutron diagnostics for fusion plasmas
- Marco Cecconello, Professor, specialist in neutron diagnostics for fusion plasmas
- Sean Conroy, Researcher, specialist in Monte Carlo neutron transport simulations
- Anders Hjalmarsson, Researcher, specialist in neutron diagnostics for fusion plasmas
- Eric Anderson-Sunden, Researcher, specialist in neutron diagnostics for fusion plasmas
- Jacob Eriksson, Researcher, specialist in fusion neutron physics modelling

## Core deliverables

- TOFOR and MPRu2.5 and 14 MeV neutron spectrometers for JET
- Collimated 2.5 MeV neutronflux monitor for MAST
- Design of a High Resolution Neutron Spectrometer and of Radial Neutron Camera for ITER for 14 MeV neutrons
- Conceptual design of neutronflux monitor for DEMO and DTT 14 MeV and 2.5 MeV
- Fast data acquisition (0.2 – 2 GSs) and analysis software
- Suites of interpretative software tools for physics modelling and prediction

## Industry involvement

- Teledyne SPDevices
- Gammadata
- CAEN
- Strängbetong
- Spectrum Instrumentation
- Scionix
- JCS

## Year

1996

## Total budget

EUR 3 million

## Collaboration(s)

- Culham Centre for Fusion Energy, UK
- Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA)
- Institute of Plasma Physics and Laser Microfusion, Warsaw
- Institute for Plasma Science and Technology, CNR, Milan
- Princeton Plasma Physics Laboratory, US

## Hyperlink(s)

www.physics.uu.se/research/applied-nuclear-physics/groups/fusion-diagnostics-group

**Procurement code(s)**
Particle and photon detectors

**ITER**
**Coordinating university: KTH Royal Institute of Technology, www.kth.se**

# MODELLING OF PLASMA-SURFACE INTERACTIONS IN ITER

## Project description

The provision of plasma-facing components (PFC) with a sufficient lifetime is one of the major technological obstacles to be overcome in the development of thermonuclear fusion reactors such as ITER. The PFC integrity is mostly threatened by fast transient power loading on millisecond timescales during which surface melting is essentially inevitable due to the high plasma stored energies. The metallic melt is subject to plasma-induced forces which displace the material and may cause large-scale surface deformations as well as create droplets. Re-solidified droplets are the main source of dust whose amount in ITER is stringently restricted by nuclear licensing. It is, thus, crucial to model the consequences of melt events and droplet survival.

## Team

Royal Institute of Technology, KTH
- S. Ratynskaia, Professor, Plasma Physics
- P. Tolias, Ph.D., Researcher, Plasma Physics
- L. Vignitchouk, Ph.D., Researcher, Computational Plasma Physics

## Core deliverables

- Development and validation of numerical model for macroscopic melt motion (the MEMOS-U code)
- Development and validation of numerical model for dust / droplet transport and life-time (the MIGRAINe code)
- Impact of electron emission on tokamak edge plasmas.
- Theory and experiments of dust remobilization.
- Theory and experiments of dust adhesion.

## Year

2016-

## Total budget

EUR 1.1 million

## Collaboration(s)

- Max Planck Institute for Plasma Physics, Garching, Germany
- Culham Centre for Fusion Energy, UK
- Institute for Plasma Science and Technology - CNR Milano, Italy
- Dutch Institute for Fundamental Energy Research, Netherlands



**Procurement code(s)**
Electrical engineering and magnets

350

# MAX IV LABORATORY

**MAX IV Laboratory**
**Coordinating university: Chalmers University of Technology, www.chalmers.se**

CHALMERS

# CORRELATIVE NANOSTRUCTURE ANALYSIS USING SAXS TENSOR TOMOGRAPHY AND PTYCHOGRAPHIC NANOTOMOGRAPHY

## Project description

The project aims to explore the complementarity of information obtained with SAXS and coherent X-ray imaging on fuel cell electrode materials. Fuel cell electrode materials are porous nanomaterials with structural features across multiple length scales. The goal within this project is to provide a non-invasive structural characterization of porous nanocomposite materials on the meso- and nanoscale in order to gain insights on the structure performance relation in fuel cell electrode materials. The project is set up in a close collaboration between the SAXS beamlines at MAXIV (ForMAX and CoSAXS) and the corresponding cSAXS beamline at the Swiss Light Source at PSI. It includes method transfer of SAXS imaging in 2D and 3D transfer from PSI where it is well established to the beamlines at MAXIV.

## Team

Chalmers University of Technology
- Marianne Liebi, Associate professor, Physics
- Christian Appel, Postdoc, Swiss Light Source / MAXIV
- Manuel Guizar-Sicairos, Researcher, Swiss Light Source

Lund University
- Ann Terry, Researcher, MAX IV Laboratory
- Kim Nygård, Researcher, MAX IV Laboratory

## Core deliverables

- Method development in SAXS imaging in 2D and 3D.
- Correlation of SAXS tensor tomography with high resolution coherent techniques such as ptychography on catalyst composite material.
- Knowledge transfer from PSI to MAXIV for scanning SAXS experiments.
- Implement the scanning SAXS and SAXS tensor tomography analysis scripts to CoSAXS (and ForMAX) pipeline.

## Year

2020-2023

## Total budget

EUR 495,000

## Collaboration(s)

- Chalmers University of Technology
- MAX IV Laboratory, Lund University
- SLS, Paul Scherrer Institute, Villigen, Switzerland

**Procurement code(s)**
Mechanical engineering and raw materials

MAX IV Laboratory
Coordinating university: Chalmers University of Technology, www.chalmers.se

# DETECTOR FOR SIMULTANEOUS X-RAY DIFFRACTION AND ABSORPTION SPECTROSCOPY

## Project description

The Balder beamline is designed for X-ray absorption and emission spectroscopy in the medium and hard X-ray energy range, i.e., 2.4-40 keV. The high brilliance from the 3 GeV storage ring in combination with the beamline construction allows for time resolved measurements down to sub-second time resolution to be performed in operando conditions. The implementation of an additional two-dimensional detector on a robotic arm will provide diffraction (long-range ordering) information truly simultaneous with chemical state and fine structure information for many different materials. The scattered intensity is monitored when the energy is scanned over an absorption edge such that the diffraction becomes anomalous. It is thus possible to determine which of the elements in a material that contribute to certain diffraction peaks. Knowledge about the long-range order also paves the way for more thorough analysis of chemical state and fine structure of complex materials.

## Team

Chalmers University of Technology:
• Per-Anders Carlsson, Professor, Materials and Surface Science, Department of Chemistry and Chemical Engineering
Lund University:
- Konstantin Klementiev, Doctor, Beamline Manager at Balder, MAX IV
- Justus Just, Doctor, postdoc at Balder, MAX IV

## Core deliverables

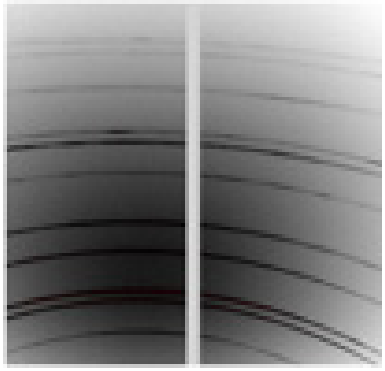
- Specification and purchasing of 2D detector
- Assembling of 2D detector and robotic arm incl. software control
- Software development for synchronous control and acquisition
- Demonstration of synchronous measurements on catalytic materials

## Year

2018–2020

## Total budget

EUR 500,000



First diffraction image of a Cu-block measured at Balder.

**Procurement code(s)**
Particle and photon detectors

**MAX IV Laboratory**
**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# DEVELOPMENT OF A NEW RHEOMETER SYSTEM

CHALMERS

## Project description

A new rheometer system is being developed into a state-of-the-art Rheo-SAXS sample environment at the MAX IV Laboratory in Lund, Sweden. MAX IV Laboratory is a Swedish national laboratory providing scientists from academia and industry with the brightest X-rays available in the world. Thus, the aim is to have a sample environment focused on Swedish academic and industrial strengths as well as have an international appeal through unique testing possibilities.

## Team

Chalmers University of Technology
- Roland Kádár, Team Leader, Associate Professor, Department of Industrial and Materials Science
- Marianne Liebi, Assistant Professor, Department of Physics
- Aleksandar Matic, Professor, Department of Physics

Lund University, MAX IV
- Kim Nygård, Beamline Scientist & Project Manager, MAX Laboratory
- Anne Terry, Beamline Scientist & Group Manager, MAX IV Laboratory

## Core deliverables

Develop and test several unique rheo-SAXS testing possibilities. At the end of the developmental period, the goal is to have the rheometer sample environment available for external users at ForMAX and CoSAXS beamlines.

## Year

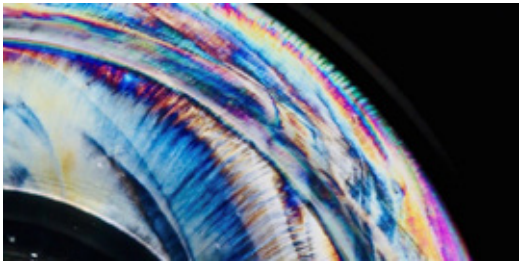
2020-2022

## Total budget

EUR 420,000

## Hyperlink(s)

https://www.chalmers.se/en/departments/ims/news/Pages/New-unique-test-opportunities-in-bio-based-materials-at-MAX-IV.aspx





**Procurement code(s)**
Mechanical engineering and raw materials

**MAX IV Laboratory**
**Coordinating university: Lund University, www.lu.se**

# HANSEATIC LEAGUE OF SCIENCE (HALOS)

LUNDS UNIVERSITET

## Project description

By bringing life science users together with researchers from the large regional photon and neutron infrastructures HALOS facilitates the development of new measurement methods and instrumentation. For example the ongoing development of X-ray fluorescence imaging applications in tissue imaging and time-resolved crystallography to study protein mechanisms at PETRA III. HALOS also aims to connect with the Helmholtz-Lund International graduate School (HELIOS) project, to further enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Year

2019-2022

## Team

Includes among others

- Kajsa Paulsson, PhD, Lund University, Faculty of Medicine
- Michael Gajhede, Professor, UCPH
- Arwen Pearson, Professor, UHH
- Marite Cardenas, Professor, Malmö University
- Anders Bjorholm Dahl, Professor, DTU

## Core deliverables

HALOS will build a unique collaboration between Hamburg and South-West Scandinavia, bring together the four unique research facilities MAX IV, ESS, DESY and European XFEL, and create a centre for integrated, world-leading Life Science innovation and research. In the work package for Cross Border Research different activities are arranged such as seminars, webinars, workshops, summer/winter schools, match-making and not least funding of 6 month projects. The funding of 6 month projects is given to only projects with industry outreach plans and of high innovation potential. The work in the WP will result in increased awareness, competence development and increased use of large scale facilities in Life Science research and innovation.
In the workpackage Regional Development the HALOS community in Hamburg and Southwest Scandinavia work to improve the conditions for using the large scale Research Infrastructures including topics mobility, remote access, innovation and tech-transfer and science cities and develop joint key messages and strategies, bi- and multi-lateral agreements.

## Industry involvement

Companies involved or selected for targeted out-reach activities include: ReceptorPharma, ImplexionPharma, Leo Pharma, Lundbeck, Avilex Pharma, Acesion Pharma, Borregaard, Colloidal Resources Competence, Axiom Insights, Thermofisher, Abbott, NIOM, Corticalis, Catalyst Biosciences.

## Total budget

EUR 3.6 millions

## Collaboration(s)

- Lund University
- Universität Hamburg
- University of Copenhagen
- MAX IV
- ESS
- Malmö University
- Region Skåne
- DESY
- European XFEL
- City of Hamburg
- Technical University of Denmark
- Aarhus University
- Capital Region of Denmark
- Medicon Valley
- Alliance EMBL

## Hyperlink(s)

www.halos.lu.se

**Procurement code(s)**

Electrical engineering and magnets
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Optics and photonics
Particle and photon detectors
Health, safety and environment

**MAX IV Laboratory**
**Coordinating university: Lund University, www.lu.se**

# HELIOS

## Project description

The Helmholtz-Lund International graduate School (HELIOS) on "Intelligent instrumentation for exploring matter at different time and length scales" connects major knowledge hubs in the Baltic Sea Region: Hamburg University, DESY, and Lund University. HELIOS started in early 2021 and includes scientists from Particle Physics, Molecular Physics, Nano(bio) Science, and Ultrafast Photon Science. The aim of HELIOS is to develop the instrumentation and data acquisition systems for the next generation of photon sources and particle accelerators, in collaboration with industrial partners that we will seek within Big Science Sweden. HELIOS also aims to connect with the Hanseatic League of Science (HALOS) project for life sciences, to enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Team

Includes among others

- Kajsa Paulsson, PhD, Lund University, Faculty of Medicine
- Michael Gajhede, Professor, UCPH
- Arwen Pearson, Professor, UHH
- Marite Cardenas, Professor, Malmö University
- Anders Bjorholm Dahl, Professor, DTU

## Core deliverables

Individual projects investigate novel solutions for (e.g.):

- Real-time data acquisition and analysis
- Image processing techniques
- Feedback control loops
- On chips miniaturization using nanotechnology for biosensing

## Year

2021-2026

## Total budget

EUR 7.9 million

## Collaboration(s)

University of Hamburg

## Hyperlink(s)

https://www.heliosgraduateschool.org

**Procurement code(s)**
Electronics and radio frequency
Information technology
Vacuum and low temperature
Optics and photonics
Particle and photon detectors

**MAX IV Laboratory**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# HIGH FIELD/HIGH GRADIENT MAGNETS

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

The MAX IV 3 GeV electron storage ring in Lund, Sweden, represents the new generation of light sources that uses a 20-fold 7-bend achromat lattice to achieve a bare lattice emittance of 330 pm in a relatively short circumference of 528 m. The large number of strong bending magnets per achromat requires a compact magnet design that is achieved by use of small aperture (Ø 25 mm) magnets integrated into one common block i.e. each achromat has 7 magnet blocks.
The project aims at demonstrating the feasibility of use small aperture (Ø 11 mm) and high field/high gradient permanent/hybrid magnets in frame of the upgrade concept for a future diffraction-limited light sources within the constraints of the existing MAX IV 3 GeV ring tunnel.

## Team

Lund University, MAX IV Laboratory:
- Alexey Vorozhtsov, Magnet engineer

## Core deliverables

Electromagnetic & mechanical design, manufacturing and magnetic measurements of the following hybrid magnet prototypes:
- Gradient dipole: aperture H ≥ 15 mm, yoke length ≤ 300 mm, field strength $B_0$=(0.5-0.6) T, gradient up to 70 T/m
- Quadrupole: aperture ø=(11/12) mm, yoke length ≤ 100 mm, gradient up to 250 T/m
- Sextupole: aperture ø ≥ 15 mm, yoke length ≤ 150 mm, gradient B″/2 up to 20 kT/mm2
- Magnet block containing the magnets listed above.

## Potential industry involvement

- Scanditronix
- Danfysik

## Year

2019-2021

## Total budget

EUR 300,000

## Potential Collaboration(s)

Synchrotron SOLEIL, France
ISA, Centre for Storage Ring Facilities, Denmark

## Hyperlink(s)

https://www.maxiv.lu.se/about-us/governance/vision-goals-values/

**Procurement code(s)**
Electrical engineering and magnets
Mechanical engineering and raw materials

**MAX IV Laboratory**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# NANOMAX KB-MIRRORS

LUNDS UNIVERSITET
Lunds Tekniska Högskola

## Project description

NanoMAX is a Hard X-ray monochromatic nanoprobe experimental station at MAX IV. The second experimental station at NanoMAX beamline use two plane-elliptical in Kirkpatrick-Baez configuration to achieve a spot size in the 100-1000 nm range. In order to meet the high demands of stability at MAXIV and high level of accuracy for the attenuation of the mirrors a in-house design was developed. The design is influenced by MAXIV alignment principle with one alignment unit per degree of freedom. Flexure links and a cage made from invar is the backbone of the design with low thermal drift. The mirror supports are designed to exclude the gravitational effect and the mirrors have a figure error of less than 1 nm.

## Team

Lund University MAX IV

- Ulf Johansson, Team leader, Beamline Scientist
- Gerardina Carbone, Beamline Scientist
- Sebastian Kalbfleisch, Instrument Scientist
- Linus Roslund, Mechanical Designer
- Karl Åhnberg, Mechanical Designer

## Core deliverables

- Stability
- Alignment
- Thermal drift
- In-house design and development

## Industry involvement

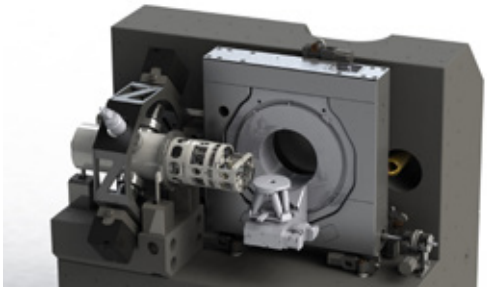
- Jtec
- Arrema Mekano
- FMB Berlin
- Pfeiffer Vacuum

## Year

2016-2017

## Total budget

EUR 350,000





**Procurement code(s)**
Mechanical engineering and raw materials
Optics and photonics

Max IV Laboratory
Coordinating university: Chalmers University of Technology, www.chalmers.se

# SAMPLE ENVIRONMENT FOR COMBINED NANO-MECHANICAL TESTING AND NANODIFFRACTION

## Project description

The purpose of the project is to develop and implement a sample environment for in-situ nanomechanical testing at MAX IV. The set-up will be based on a nanoindenter instrument intended for in-situ operation in scanning electron microscopes (s)EMs), which will be adapted for use on synchrotron beam lines. The sample environment can be transferred to SEMs in order to verify experimental setups before attempts at synchrotron beamlines, and to perform correlative experiments. The setup will be flexible to allow testing of different materials (metals, ceramics, polymers and biological materials such as bone and wood), and the modular design will allow upgrades to accommodate e.g. tensile testing as well as high-temperature, cryogenic and dynamic deformation conditions. The instrument will be part of the standard sample environment pool at MAX IV.

## Team

Chalmers University of Technology:
- Magnus Hörnqvist Colliander, Docent, senior researcher in physics

Lund University, MAX IV Laboratory:
- Gudrun Lotze, Doctor, Postdoc sample environment and detector systems
- Stefan Carlson, Doctor, group manager sample environment and detector systems
- Gerardina Carbone, Doctor, instrument scientist at Nano MAX beamline

## Core deliverables

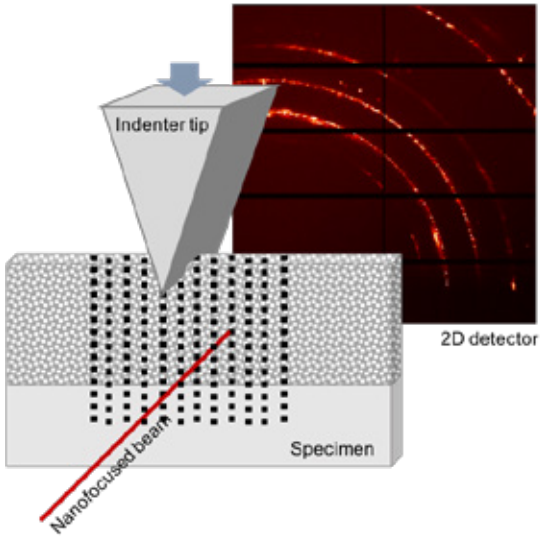
- Definition of requirements and specifications of in-situ nanoindenter equipment.
- Definition and development of approach for integration into MAX IV control and data management system
- Acquisition and installation of nanoindenter, including commissioning at both NanoMAX beamline and Chalmers SEMs.
- Demonstration of correlated tests at MAX IV and Chalmers.

## Year

2017–2019

## Total budget

EUR 370,000




**Procurement code(s)**
Mechanical engineering and raw materials

**MAX IV Laboratory**
**Coordinating university: Lund University, www.lu.se**

# THE VACUUM SYSTEM OF MAX IV 3 GEV STORAGE RING

LUNDS UNIVERSITET

## Project description

Some of the characteristics of recent ultra-low-emittance (fourth generation) storage-ring designs and possibly future diffraction-limited storage rings are a compact lattice combined with small magnet apertures. Such requirements present a challenge for the design and performance of the vacuum system. The vacuum system should provide the required vacuum pressure for machine operation and be able to handle the heat load from synchrotron radiation. Small magnet apertures result in the conductance of the chamber being low. One way to provide the required vacuum level via distributed pumping, which can be realized by the use of a non-evaporable getter (NEG) coating of the chamber walls. In addition, the chamber walls can work as distributed absorbers if they are made of a material with good thermal conductivity, and distributed cooling is used at the location where the synchrotron radiation hits the wall.
The vacuum system of the 3 GeV storage ring of MAX IV is unique, it is has a very small aperture, combined with being 100% NEG coated, a feature which is the first to be implemented in fourth generation storage rings.

## Team

Lund University, MAX IV Laboratory:
- Eshraq Al-Dmour, Vacuum engineer
- Marek Grabski, Vacuum engineer

## Core deliverables

- Implementation of small vacuum aperture all over the storage ring.
- 100% NEG coating as source of pumping down.
- Realizing the technique for the power removal from synchrotron radiation on the chambers wall.

## Industry involvement

FMB Berlin

## Year

2012-2014

## Total budget

EUR 6 million

## Collaboration(s)

- Lund University
- CERN
- ESRF
- ALBA

## Hyperlink(s)

www.maxiv.lu.se



**Procurement code(s)**
Mechanical engineering and raw materials
Vacuum and low temperature

**Max IV Laboratory**
**Coordinating university: Uppsala University, www.uu.se**

# VERITAS

## Project description

The project concerns the design and construction of a high resolution soft x-ray emission beamline for material science at MAX IV. Key parts of the project concern development of components for improved performance, both in collaboration with vendors but also as University in-house development and manufacturing.

The beamline consists of a 57 m +10 m long stretch of vacuum and optical components to shape and transmit soft x-ray photons to a sample where they will interact with the electronic structure of the material being studied.

## Team

Uppsala University:

- Marcus Agåker, Project leader, procurement, instrument design
- Carl-Johan Englund, Senior research engineer, mechanical design
- Pierre Fredriksson, Shop engineer, mechanical manufacturing
- Nial Wassdahl, Researcher, assembly and testing
- Joseph Nordgren, Senior Professor, instrumentation design

## Core deliverables

Project management, design, mechanical part procuction and installation.

## Year

2011–2019

## Budget

EUR 8.7 million

## Industry involvement

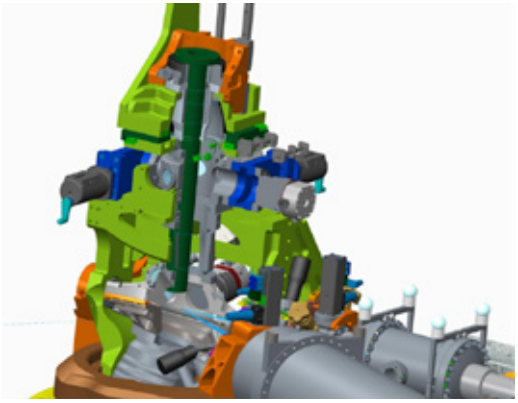
- FMB Berlin
- Toyama
- Jtec
- Piltz Optics
- SKS
- EWCON
- Surface Concepts
- Englund Engineering
- Pfeiffer Vacuum
- Österby Gjuteri

## Collaboration(s)

- Uppsala University
- Lund University
- Linköping University

## Hyperlink(s)

www.maxiv.lu.se/accelerators-beamlines/beamlines/veritas/



**Procurement code(s)**

Mechanical engineering and raw materials
Vacuum and low temperature
Particle and photon detectors
Optics and photons

**XFEL**
**Coordinating university: KTH Royal Institute of Technology in Stockholm, www.kth.se**

# CENTER FOR X-RAYS IN SWEDISH MATERIAL SCIENCE (CEXS)

## Project description

The PETRA III Swedish Node is distinctive in its capability to obtain signals deep inside materials with high measurement time resolution. The PETRA III Swedish Node comprises i) the Swedish Material Science (s)MS) beamline at the PETRA III synchrotron in Hamburg and ii) the Center for X-rays in Swedish Material Science (CeXS). CeXS safeguards Swedish interests at PETRA III and acts as the academic host of the SMS beamline. CeXS activities include: i) raising awareness about research possibilities; ii) providing training and support about why, when and how to use high-energy x-rays; and, iii) disseminating results. A key contribution of CeXS is ensuring a use perspective is taken in decision making about ongoing operational developments and upgrade planning.

## Team

KTH (Royal Institute of Technology) Linköping University

- Peter Hedström, Professor, Material Science and Engineering
- Denise McCluskey, PhD, Material Science and Engineering, Unit of Properties
- Linköping University
- Jens Birch, Professor, Department of Physics, Chemistry and Biology, Thin Film Physics
- Fredrik Eriksson, Associate professor, Department of Physics, Chemistry and Biology, Thin Film Physics

## Core deliverables

- Scientific Direction of the Swedish Material Science beamline at PETRA III
- Scientific overview articles
- Popular science articles
- Education and training
- News about issues related to PETRA III
- Industry involvement
- Research support
- Education and training

## Year

2019-2022

## Total budget

EUR 100,000

## Collaboration(s)

KTH Royal Institute of Technology Linköping University

## Hyperlink(s)

cexs.kth.se


**Procurement code(s)**
Information technology
Particle and photon detectors

**XFEL**
**Coordinating university: Stockholm University, www.su.se**

# CHARACTERIZATION AND FIDUCIALIZATION OF UNDULATOR QUADRUPOLES

## Project description
Control and measurements of magnets for the European XFEL. Measurement of magnetic Axis with 2-micrometer resolution, measurement of distance between magnetic axis and fiducials within 50 micrometers.

## Year
2010

## Total budget
N/A

## Team
Stockholm University, Manne Siegbahn Laboratory
- Anders Hedqvist, Researcher
- Fredrik Hellberg, Researcher

ESS
- Håkan Danared, Researcher

## Core deliverables
Measured specified properties of magnets.



**Procurement code(s)**
Electrical engineering and magnets

**XFEL**
**Coordinating university: Lund University, www.lu.se**

# HANSEATIC LEAGUE OF SCIENCE (HALOS)

LUNDS UNIVERSITET

## Project description

By bringing new life science users together with researchers from the large regional photon and neutron infrastructures HALOS facilitates the development of new measurement methods and instrumentation. For example the ongoing development of X-ray fluorescence imaging applications in tissue imaging and time-resolved crystallography to study protein mechanisms at PETRA III. HALOS also aims to connect with the The Helmholtz-Lund International graduate School (HELIOS) project, to further enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Year

2019-2022

## Team

Includes among others

- Kajsa Paulsson, PhD, Lund University, Faculty of Medicine
- Michael Gajhede, Professor, UCPH
- Arwen Pearson, Professor, UHH
- Marite Cardenas, Professor, Malmö University
- Anders Bjorholm Dahl, Professor, DTU

## Core deliverables

HALOS will build a unique collaboration between Hamburg and South-West Scandinavia, bring together the four unique research facilities MAX IV, ESS, DESY and European XFEL, and create a centre for integrated, world-leading Life Science innovation and research. In the work package for Cross Border Research different activities are arranged such as seminars, webinars, workshops, summer/winter schools, match-making and not least funding of 6 month projects. The funding of 6 month projects is given to only projects with industry outreach plans and of high innovation potential. The work in the WP will result in increased awareness, competence development and increased use of large scale facilities in Life Science research and innovation.
In the workpackage Regional Development the HALOS community in Hamburg and Southwest Scandinavia work to improve the conditions for using the large scale Research Infrastructures including topics mobility, remote access, innovation and tech-transfer and science cities and develop joint key messages and strategies, bi- and multi-lateral agreements.

## Industry involvement

Companies involved or selected for targeted out-reach activities include: ReceptorPharma, ImplexionPharma, Leo Pharma, Lundbeck, Avilex Pharma, Acesion Pharma, Borregaard, Colloidal Resources Competence, Axiom Insights, Thermofisher, Abbott, NIOM, Corticalis, Catalyst Biosciences.

## Total budget

EUR 3.6 million

## Collaboration(s)

- Lund University
- Universität Hamburg
- University of Copenhagen
- MAX IV
- ESS
- Malmö University
- Region Skåne
- DESY
- European XFEL
- City of Hamburg
- Technical University of Denmark
- Aarhus University
- Capital Region of Denmark
- Medicon Valley
- Alliance EMBL

## Hyperlink(s)

www.halos.lu.se

**Procurement code(s)**

Electrical engineering and magnets
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Optics and photonics
Particle and photon detectors
Health, safety and environment

XFEL

**Coordinating university: KTH Royal Institute of Technology in Stockholm, www.kth.se**

# HEAT LOAD INVESTIGATIONS ON DIFFRACTIVE OPTICS: FABRICATION OF 'ZONE PLATE' NANOSTRUCTURES ON DIAMOND SUBSTRATE, SIMULATIONS OF HEAT TRANSPORT, DESIGN OF COOLING SYSTEMS, AND HEAT LOAD TESTS WITH BEAM

## Project description

The heat load on X-ray optics is very high at Free Eelectron Lasers. The purpose of this Project was to develop X-ray optics with effective heat transport and design of cooling systems.

## Team

KTH (Royal Institute of Technology)

- Ulrich Vogt, Professor, Applied Physics

## Core deliverables

X-ray optics with properties suitable for high-intensity Free Electron Lasers, in particular the European XFEL.

## Year

2010

## Total budget

N/A



**Procurement code(s)**

Optics and photonics

XFEL

**Coordinating university: University of Gothenburg, www.gu.se**

# INSTRUMENT TO INCREASE THE CAPACITY FOR LIFE-SCIENCE STUDIES SFX AT XFEL

UNIVERSITY OF GOTHENBURG

## Project description

The aim of the Serial Femtosecond Crystallography (s)FX) instrument is to increase the capacity for life-science studies at the European X-ray Free Electron Laser (EU-XFEL). To this end we have built an instrument that can run parasitically to, or independently of, the Single Particles and Biomolecules (s)PB) instrument that was the first beamline constructed at the European XFEL. To accommodate a second (s)FX) instrument, we refocus the XFEL beam after it passes through the SPB instrument. This is possible because the X-ray beam is essentially unaffected by the very small samples probed in the first instrument. Together, these end stations provide an invaluable resource for screening and measuring single molecules, nano- and micro-crystals, viruses and more.



## Team

University of Gothenburg

- Richard Neutze, Team leader, Professor Department of Chemistry and Molecular Biology
- University of Hamburg
- Henry Chapman, Prof. Dr., Division Director, Center for Free-Electron Laser Science, DESY

University of Oxford

- James H. Naismith, Professor, Structural Biology

European XFEL

- Adrian Mancuso, Professor, Lead Scientist of the Single Particles

## Core deliverables

- In-atmosphere end station including:
- Fixed target sample delivery system (Roadrunner) Jungfrau detector (4 Megapixels)
- Liquid jet sample delivery system
- Optical pump laser technology
- In-vacuum end station including:
- Liquid jet sample delivery system
- AGIPD (detector), 4 Mpx and megahertz rate compatible Optical laser pump technology
- Diagnostic tools including: Wavefront monitor
- Intensity and position monitor(s) Spectrum monitor

## Industry involvement

- FMB Oxford, UK
- JJ X-ray, Denmark
- JTech, Japan
- Pfeiffer Vacuum, Germany Suna Precision, Germany

## Year

2014-2018

## Total budget

EUR 20.5 million

## Collaboration(s)

University of Gothenburg, Sweden, University of Hamburg, Germany, University of St Andrews, UK University of Oxford, UK, La Trobe University, Australia, Uppsala University, Sweden, Stockholm University, Sweden, Lund University, Sweden, Arizona State University, US, University of Lübeck, Germany, Diamond Light Source, UK, Medical Research Council Laboratory of Molecular Biology, UK Karolinska Institute, Sweden, Paul Scherrer Institute, Germany, NSF BioXFEL Science and Technology Center, US, Ministry of Education, Science, Research and Sport of the Slovak Republic DESY, Germany, Max Planck Society, Germany

## Hyperlink(s)

www.xfel.eu/facility/instruments/spb_sfx/sfx_user_consortium/index_eng.html


**Procurement code(s)**

Particle and photon detectors
Vacuum and low temperature

**XFEL**
**Coordinating university: Lund University, www.lu.se,**

# HELIOS

## Project description

The Helmholtz-Lund International graduate School (HELIOS) on "Intelligent instrumentation for exploring matter at different time and length scales" connects major knowledge hubs in the Baltic Sea Region: Hamburg University, DESY, and Lund University. HELIOS started in early 2021 and includes scientists from Particle Physics, Molecular Physics, Nano(bio) Science, and Ultrafast Photon Science. The aim of HELIOS is to develop the instrumentation and data acquisition systems for the next generation of photon sources and particle accelerators, in collaboration with industrial partners that we will seek within Big Science Sweden. HELIOS also aims to connect with the Hanseatic League of Science (HALOS) project for life sciences, to enhance use of the unique research centers in the area (MAX IV, ESS, DESY and XFEL).

## Team

Lund University

- Mathieu Gisselbrecht, Associate professor, Physics
- Caterina Doglioni, Associate professor, Physics, Particle physics
- Anders Mikkelsen, Professor, Physics, NanoLund

## Core deliverables

Individual projects investigate novel solutions for (e.g.):

- Real-time data acquisition and analysis
- Image processing techniques
- Feedback control loops
- On chips miniaturization using nanotechnology for biosensing

## Year

2021-2026

## Total budget

EUR 7.9 million

## Collaboration(s)

University of Hamburg

## Hyperlink(s)

https://www.heliosgraduateschool.org

**Procurement code(s)**
Electronics and radio frequency
Information technology
Vacuum and low temperature
Optics and photonics
Particle and photon detectors

**XFEL**
**Coordinating university: Uppsala University, www.uu.se**

# LASER HEATERS

UPPSALA UNIVERSITET

## Project description

The European XFEL is the world's largest and most brilliant free electron laser. It is located at DESY, Hamburg, Germany and produces high intensity x-ray light pulses used for various state of the art synchrotron light investigations. It consist of a 3,4km long electron accelerator utilizing magnet structures for light creation. XFEL is used an enormous microscope. To overcome potential problems with the distributions of the electrons travelling in bunches a laser heater was implemented. The laser heater is Sweden's largest in-kind contribution into the XFEL project.

## Team

Uppsala University
- Mathias Hamberg, Researcher, Department of Physics and Astronomy, FREIA

DESY
- Frank Brinker
- Christopher Gerth
- Evgeny Schneidmiller
- Lutz Winkelmann

## Core deliverables

- Ultra high vacuum (UHV) electron vacuum chambers, with extreme tolerances regarding magnetic permeability, surface roughness, oxide thickness layering and copper coating.
- Laser transport vacuum system (~40 m).
- Laser routing and stabilization system with micrometer precision.
- PLC control systems.
- Undulator magnet.
- Design of system.
- Installation of setup
- Commissioning
- Improvements and tests

## Year

2007-2018

## Total budget

EUR 1 million

## Industry involvement

- KYMA
- TEM Messtechnik GmbH
- FMB Berlin
- Pfeiffer Vacuum
- VACOM
- Newport optics
- Thorlabs
- Altechna
- PLX
- Owis
- Smaract
- Beckhoff
- UMB
- Edstraco
- Sala Bly

**Procurement code(s)**

Civil engineering, building and technical services
Electrical engineering and magnets
Electronics and radio frequency
Information technology
Mechanical engineering and raw materials
Vacuum and low temperature
Particle and photon detectors
Optics and photons
Gases, chemicals, waste collection and radiation equipment
Health, safety and environment

**XFEL**
**Coordinating university: Uppsala University, www.uu.se**

# LASER HEATER SYSTEM FOR THE INJECTOR; DESIGN, PRODUCTION, TEST, DELIVERY, AND COMMISSIONING

UPPSALA UNIVERSITET

## Project description
X-ray Free Electron Lasers are often driven by high-brilliance photo-cathode radio-frequency guns which generate electron beams. These electron beams are very cold, which can lead to micro-bunching instabilities. The purpose of the laser heater is to gently and in an easily adjustable way heat up the electron beam in order to avoid such instabilities. The laser heater is in constant use at the European XFEL as it alleviates the tuning process and increase the energy of the outgoing light pulses with about 40% (up to 500% demonstrated). Between 2018-2021 the uptime has been 99,8%.

## Team
Uppsala University
- Mathias Hamberg
- Niklas Johansson
- Masih Noor, Simon Fahlström
- Volker Ziemann

## Core deliverables
A laser heater

## Year
2010-2019

## Total budget
N/A



**Procurement code(s)**
Electronics and radio frequency

XFEL

**Coordinating university: Uppsala University, www.uu.se**

# MASS SPECTROMETER AND CELL SORTER FOR BIOLOGY INFRASTRUCTURE

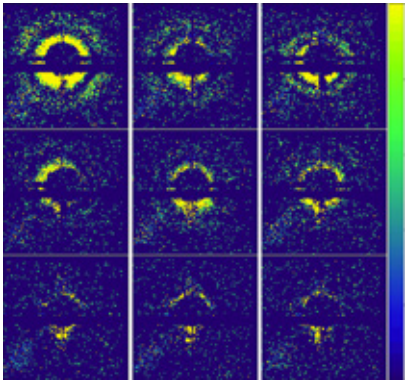
UPPSALA UNIVERSITET

## Project description

The stability of biological samples is limited, and optimal use of beam time at XFEL requires a biological sample infrastructure to provide: (i) support to the Swedish life-science community in generation and handling of challenging samples in the immediate proximity to XFEL instruments; (ii) appropriate selection, quality control and evaluation of samples, including correlative imaging, immediately prior to XFEL experiments; (iii) standardised technology for data interpretation, including computation and validation of structural models. We proposed to establish a collaborative infrastructure, integrated within XFEL, providing open-access facilities for preparation and
sample handling. The Swedish contribution was essential for the realisation of the project at the European XFEL.The XBI facility that was built from this IKC is up and running at XFEL.

## Team

Uppsala University, Laboratory of Molecular Biophysics:
Janos Hajdu, Professor molecular biophysics, specialist in extreme photon science, ultra-fast diffractive imaging, biophysics, structural sciences



## Core deliverables

Construction of the XBI infrastructure at XFEL
Successful user operation of the XBI infrastructure at XFEL

## Year

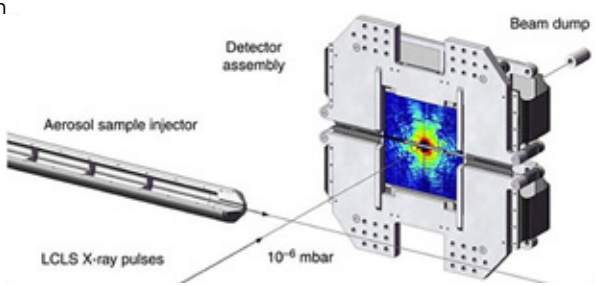
2013-

## Total budget

EUR 1.6 million

## Hyperlink(s)

www.xfel.eu/users/experiment_support/user_labs/the_xfel_biology_infrastructure_xbi_user_consortium/index_eng.html




**Procurement code(s)**

Optics and photonics

**XFEL**
**Coordinating university: Uppsala University, www.uu.se**

# NIR SPECTROMETER FOR EUROPEAN XFEL

UPPSALA UNIVERSITET

## Project description

The European XFEL is the world's largest and most brilliant free electron laser. It is located at DESY, Hamburg, Germany and produces high intensity x-ray light pulses used for various state of the art synchrotron light investigations. It consist of a 3,4km long electron accelerator utilizing magnet structures for light creation. XFEL is used an enormous microscope. Potential problems with the electron bunches can arise in turn affecting the overall outcome of the performance.
In order to better understand the nature of the electron bunches it was decided to implement a continuous shot-to-shot NIR spectrometer who will be sensitive to radiation emitted by upstream pinhole screen. The spectral signature will be a key feature to understand electron bunch behavior and changes. To be able to read out with continuous shot-to-shot ratio of 4.5MHz the KALYPSO detector system is used which enables this to be the world´s fastest NIR spectrometer of such type.

## Team

Uppsala University:
- Mathias Hamberg, Researcher, Department of Physics and Astronomy, FREIA
- Simon Fahlström, Department of Physics and Astronomy, The Svedberg Laboratory

DESY:
- Christopher Gerth
- Nils Lockmann

## Core deliverables

- Optics setup
- Electronics setup for readout including the KALYPSO system

## Year

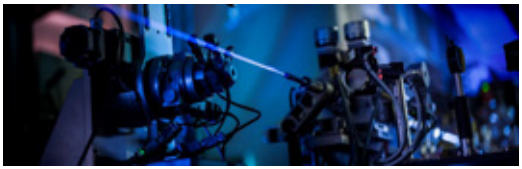
2018-2019

## Total budget

EUR 50,000

## Collaboration(s)

- Uppsala University
- DESY





**Procurement code(s)**
Electronics and radio frequency
Information technology
Mechanical engineering and raw materials
Particle and photon detectors
Optics and photons
Gases, chemicals, waste collection and radiation equipment
Health, safety and environment

XFEL

**Coordinating university: Uppsala University, www.uu.se**

# SAMPLE INJECTOR AND DIAGNOSTIC SYSTEM

UPPSALA UNIVERSITET

## Project description

The Laboratory of Molecular Biophysics at Uppsala University provided parts of the bio-imaging instrumentation as a Swedish in-kind contribution to the European XFEL. The instrumentation will permit ultra-fast coherent diffraction studies on non-crystalline objects, such as single virus particles or biomolecuies. The project included tests of prototypes at FLASH in Hamburg and at the LCLS at Stanford.

## Core deliverables

Uppsala developed a sample injector and diagnostic instrumentation for the European XFEL.

## Year

2011–2015

## Total budget

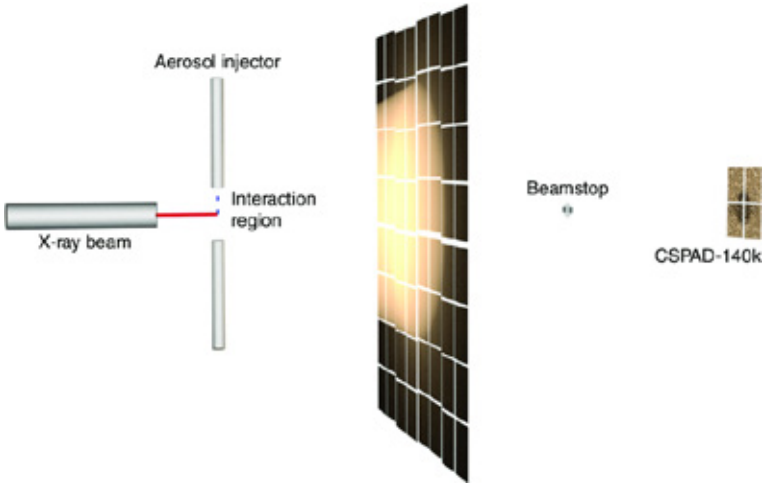
EUR 520,000

## Team

Uppsala University

- Janos Hajdu, Professor, molecular biophysics, specialist in extreme photon science, ultra-fast diffractive imaging, biophysics, structural sciences
- Jakob Andreasson, Specialist in AMO and laser science






**Procurement code(s)**

Optics and photons

**XFEL**
**Coordinating university: Stockholm University, www.su.se**

# TEMPERATURE MEASUREMENT SYSTEM FOR UNDULATORS

## Project description
The second project concerns high precision measurements of the undulator temperature. The SASE radiation intensity depends strongly on the undulator period and the magnetic field strength, which are both sensitive to temperature. Instead of keeping the temperature within 0.1 degrees along the undulator tunnel, a temperature compensation scheme can be applied.

## Team
Stockholm University, Manne Siegbahn Laboratory
- Anders Hedqvist, Researcher
- Fredrik Hellberg, Researcher

ESS
- Håkan Danared, Researcher

## Core deliverables
Temperature compensation scheme and delivery of temperature sensors.

## Year
2010

## Total budget
N/A



**Procurement code(s)**
Electrical engineering and magnets

# SKA

SKA

**Coordinating university: Chalmers University of Technology, www.chalmers.se**

# BAND 1 RECEIVER FOR THE SQUARE KILOMETRE ARRAY

CHALMERS

## Project description

The Square Kilometre Array (s)KA will be the world's largest and most sensitive radio telescope, capable of transforming our understanding of the universe and our place in it. The dish antennas to be built at the SKA site in South Africa need to be sensitive to a broad range of radio frequencies. The Band 1 receiver developed at Onsala Space Observatory, Chalmers, for 350-1050 MHz (wavelengths 30-85 cm) is composed of a specially-designed quad-ridge flared horn (QRFH) and room-temperature low noise amplifiers from Low Noise Factory to minimise noise and maximise sensitivity over the required range. Each of the initial 133 dishes of the SKA will be equipped with one Band 1 receiver.

## Team

Chalmers University of Technology:

- John Conway, Director, Onsala Space Observatory, Department of Space, Earth and Environment
- Jonas Flygare, feed design and testing,
- Magnus Dahlgren, microwave instrument design and testing
- Leif Helldner, mechanical design and testing
- Ulf Kylenfall, microwave instrument layout and circuitry

## Core deliverables

- Pre-study and design of individual RF components for high performance receiver design
- Development and test of demonstration receiver model for proof of concept
- Development and test of receiver design
- Successful qualification tests of the final receiver design on the SKA precursor telescope MeerKAT in South Africa

## Industry involvement

Leax Arkivator, Ventana Group, MegaMeta, Low Noise Factory, Omnisys.

## Year

2013-2018

## Total budget

EUR 6 million

## Collaboration(s)

- Chalmers University of Technology
- EMSS, South Africa
- EMSS Antennas, South Africa
- South African Radio Astronomy Observatory (s) ARAO)
- Chalmers Nanofabrication Laboratory

The project is part of the SKA DISH consortium.

## Hyperlink(s)

https://research.chalmers.se/person/flygarej

One of the 64 antennas in the telescope MeerKAT in the Karoo Desert in South Africa, with a Band 1 receiver installed. Photo: SARAO

**Procurement code(s)**

Electronics and radio frequency

Mechanical engineering and raw materials

SKA
**Coordinating institute: RISE Research Institutes of Sweden, www.ri.se**

# SQUARE KILOMETRE ARRAY

## Project description

The Square Kilometre Array (s)KA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometre (one million square metres) of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research and development towards building and delivering a unique instrument, with the detailed design and preparation now well under way.
The SKA will eventually use thousands of dishes and up to a million low-frequency antennas that will enable astronomers to monitor the sky in unprecedented detail and survey the entire sky much faster than any system 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. South Africa's Karoo region and Western Australia's Murchison Shire have been chosen as co-hosting locations. South Africa's Karoo will host the core of the high and mid frequency dishes, ultimately extending over the African continent. Australia's Murchison Shire will host the low-frequency antennas.
The SKA Signal and Data Transport (s)ADT) Consortium, was led by the University of Manchester, and incorporates the Synchronization and Timing (s)AT) SADT sub-element. SAT aims, inter alia, to provide a highly accurate reference frequency distribution system to both the SKA-Mid and SKA-Low telescopes.

## Team

RISE, Research Institutes of Sweden
- Sven-Christian Ebenhag, PhD, Senior Scientist, Unit Time and Optics
- Per Olof Hedekvist, PhD, Senior Scientist, Unit Time and Optics

## Core deliverables

SAT had two candidates for frequency distribution designs. In order to select a single candidate to go forward to Critical Design Review by the SKA Organization, the Consortium management performed a down selection process. The process involved assessment by an expert panel in which RISE was one of the partners. Using a pre-defined formal process and methodology, the Consortium asked the appointed expert panel to reach a consensual agreement regarding which, if any, of the candidate designs best met the requirements of the SKA-Mid and SKA-Low telescopes.

## Year

2017

## Total budget

In kind

## Collaboration(s)

The project was a part of the SKA SADT consortium.

## Hyperlink(s)

https://skatelescope.org
www.ri.se/en/what-we-do/expertises/position-navigation-and-time

**Procurement code(s)**
Electronics and radio frequency
Optics and photonics

# OTHER

**Brookhaven National Laboratory**
**Coordinating university: Lund University, Faculty of Engineering, www.lth.se**

# PIXEL-PAD DETECTORS

## Project description

By the start of the Relativistic Heavy Ion Collider (RHIC) in year 2000 at Brookhaven National Laboratory in New York the energy for collision of heavy nucleiincreased by a factor 10. The Lund group participates in the PHENIX experiment at RHIC which is designed to study the Quark Gluon Plasma, a very hot (100000 times hotter than the sun) and dense state of matter prevailing in the first microseconds of the Big Bang. This state can be produced by nuclear collisions at high energy and it was found for the first time by PHENIX (and others) at RHIC. The studies continue now at LHC atCERN. The Lund group, invented a new type of detector (named pixel-pad detector) for the trackingof charged particlesand,thanks to close cooperation with Swedish industry,provided a unique solution for electronics construction in extremely thin format. Together with Swedish industrial partners 2integrated circuits (ASICs) were designed and produced. The circuit board consisting of 4 bare silicon diebonded by CHIP ON BOARD technique on 100 micron thin KAPTON. In total 80 square meters of detector was constructed. One part is shown in the picture. Development and construction took place 1995-2000. The system was running until 2016. The techniques used are still unique and competitive.

## Team

Lund University, Faculty of Engineering:

- Anders Oskarsson, Professor, physicist, project leader, detector expert, integration of equipment in PHENIX
- Hans Åke Gustafsson, Professor, physicist, deputy project leader, detector expert, integration of equipment in PHENIX
- Lennart Österman, Research engineer, electronics, specification, circuit board design and board layout, CAD, R&D, quality control

## Core deliverables

- System design
- Design and construction of Digital ASIC for TEC detector
- Design and construction of Digital ASIC for pixel-pad detector
- Design and assembly of 5000 readout cards with Chip on Board on KAPTON
- Test and burn-in of front end electronics
- Assembly and integration in PHENIX at BNL

## Industry involvement

- SiCon
- XiCON

## Year

1995–2000

## Total budget

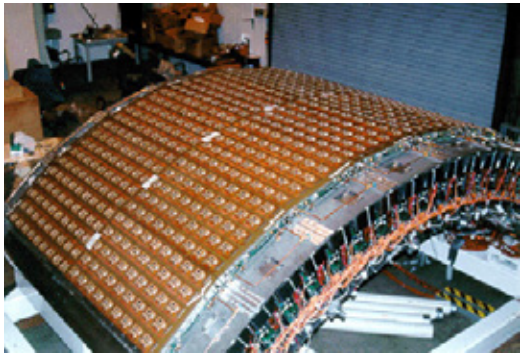
EUR 900,000

## Collaboration

- Lund University
- Vanderbilt University,
- Stony Brook University
- Oak ridge National Laboratory
- Brookhaven National Laboratory
- Weizman Institute

## Hyperlink(s)

www.phenix.bnl.gov



**Procurement code(s)**

Electronics and radio frequency
Particle and photon detectors

**Other**
**Coordinating university: Uppsala University, www.uu.se**

# ICECUBE EXTENSION

UPPSALA UNIVERSITET

## Project description

IceCube is the largest neutrino detector ever built. It is located at the South Pole where 1 $km^3$ of the deep glacier ice has been instrumented with over 5000 optical sensors. The sensors are attached to cables that have been deployed into vertical holes drilled using jets of hot water. The digital optical modules are read out with a timing precision of a few ns.
For a future expansion of IceCube we are now looking for companies that can develop hybrid, fiber-optical cables to exigent specifications, help develop radio technology for neutrino detection or provide wind turbines and batteries for polar conditions. We are also interested in small cameras for deployment into the ice together with optical modules.

## Team

Uppsala University:
- Olga Botner, Team leader, professor, specialist in high-energy physics
- Allan Hallgren, professor, specialist in high-energy physics

## Core deliverables

- Cables with excellent transmission properties over 3 km length
- Radio antennas and electronics
- Wind turbines
- Batteries
- Cameras

## Industry involvement

Hexatronic AB, Hudiksvall

## Year

2020-2025

## Total budget

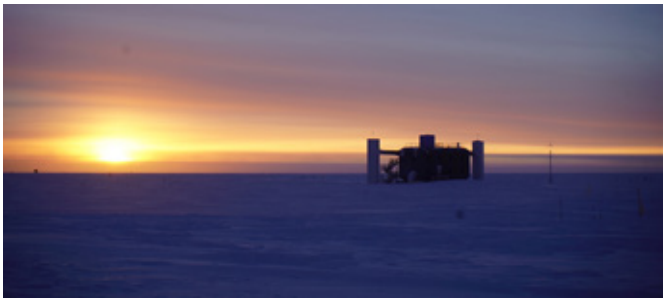
EUR 300 million

## Collaboration(s)

- Stockholm University
- Michigan State University
- 50 collaborating institutions worldwide

## Hyperlink(s)

icecube.wisc.edu

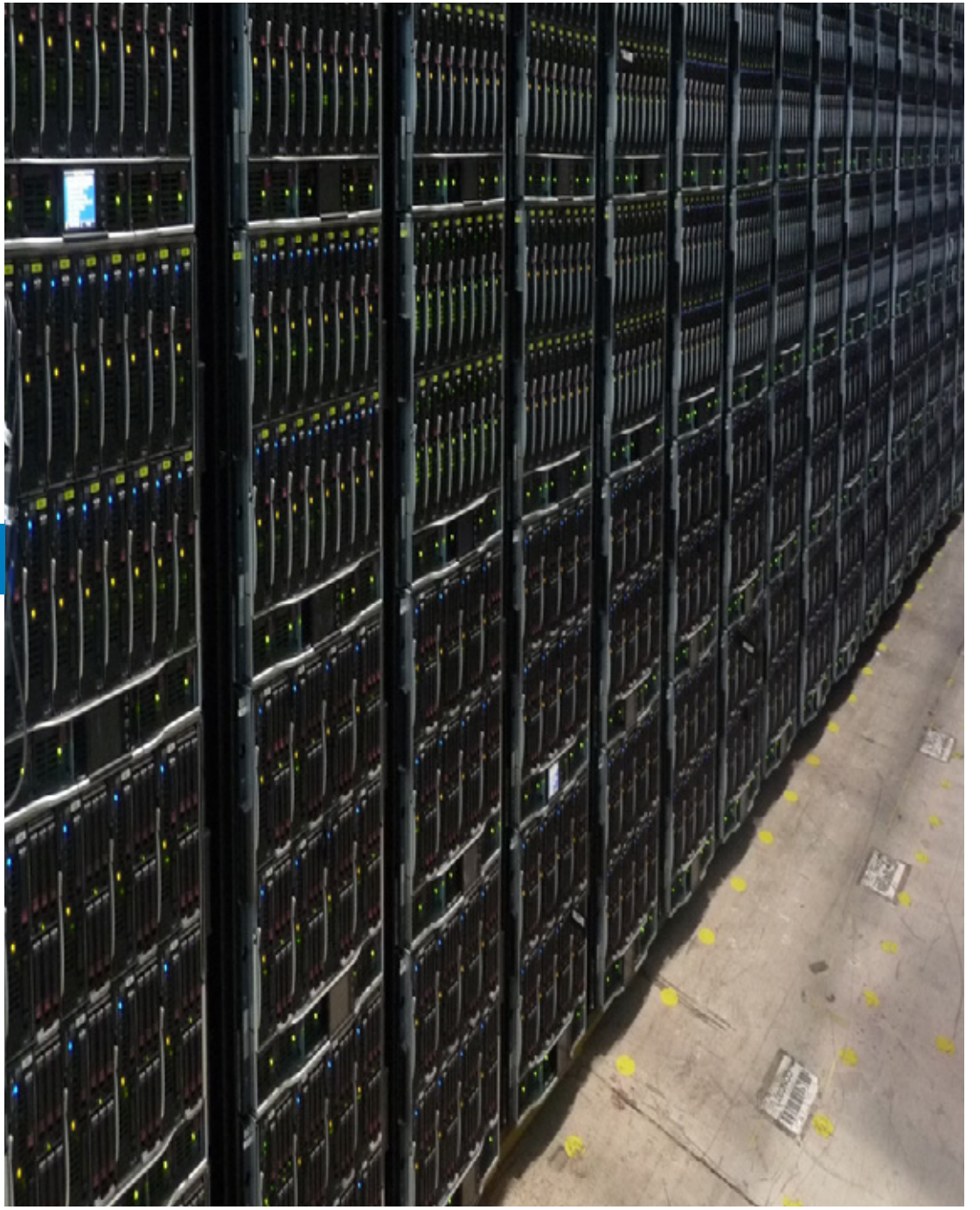


**Procurement code(s)**
Electronics and radio frequency
Particle and photon detectors


# SUCCESS STORIES



More success stories on our homepage.



# GO VIRTUAL NORDIC

## Specialist expertise, experience, and flexibility

The IT company Go Virtual Nordic, with head office in Göteborg, customises cost-effective data solutions with a focus in HPC (High Performance Computing).

With comprehensive expertise in the fields of HPC and AI, the company has forged ahead in the market. The cutting-edge company holds a unique position in areas such as HPC and supercomputers.

### Big order to supply experiment stations at CERN

Research facilities handle vast quantities of data, making them an interesting market for Go Virtual Nordic. In 2020, Big Science Sweden contacted the company and drew their attention to a large upcoming procurement from CERN. They submitted a tender and won the order, which involves extensive deliveries linked to CERN's upgrades of the experiment stations ALICE, LHCb and CMS at CERN's Large Hadron Collider.

"We are HPC architects who build efficient solutions in accordance with customer needs," explains Peter Hjärn, HPC Sales at Go Virtual Nordic. "CERN wanted an upgrade of its network, which is the communication link between the servers that comprise its cluster technology. The network consists of communication components from Mellanox Technologies that are adapted to CERN's needs. Our solution meets the crucial requirement for rapid communication between computers, servers and storage units."

### Experience of complex system solutions

As a small company, Go Virtual Nordic can be flexible and agile, and make quick decisions. The company can stand up against European HPC companies, shown not least by the big order from CERN, which led to increased sales in 2020.

"Go Virtual Nordic is a relatively small company, but we're efficient and understand the customer's needs, and we also have experience of building complex system solutions," continues Peter Hjärn. "Our employees' aggregated experience means we can offer attractive specialist expertise in the HPC field."

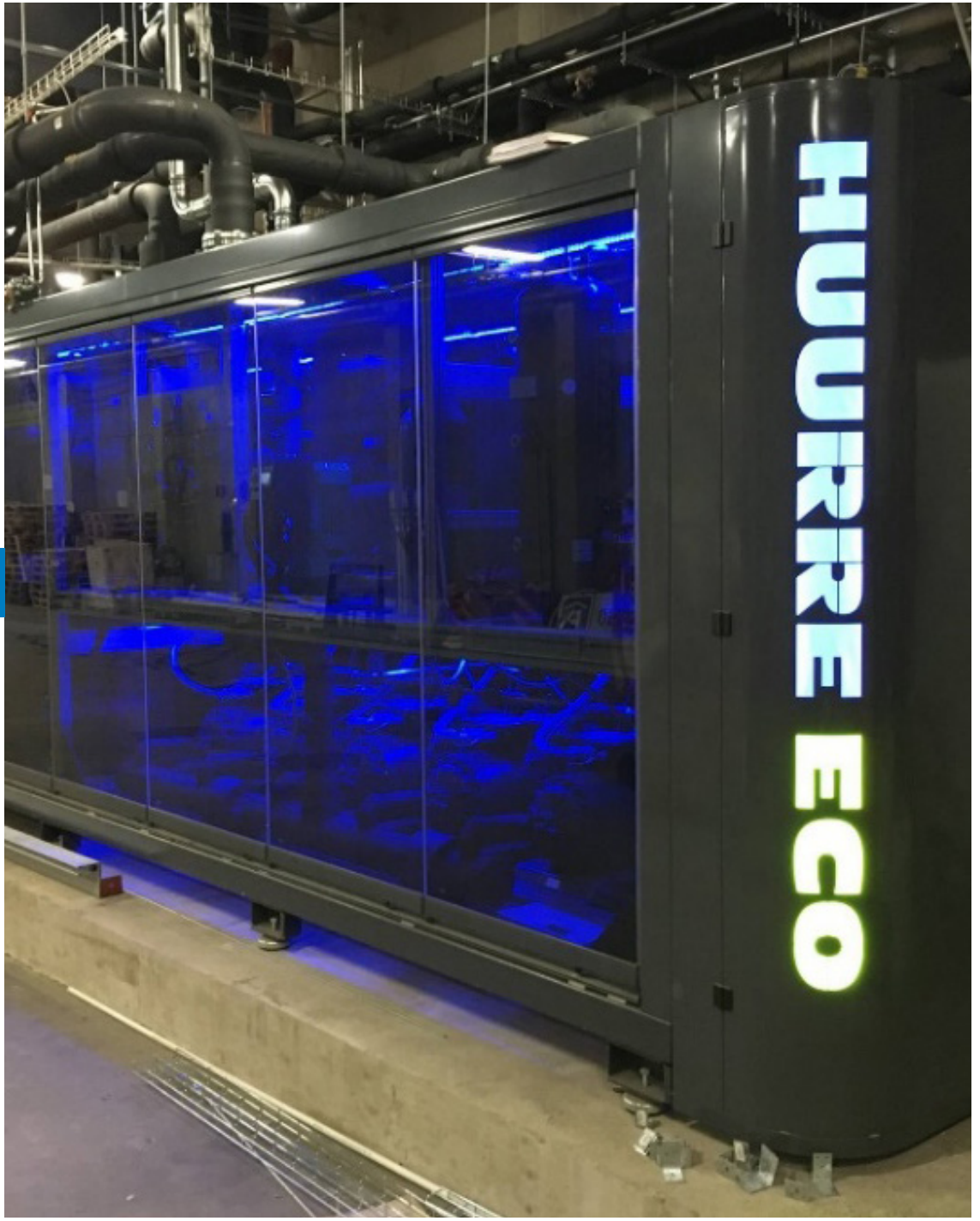
### Good opportunities for new business

Go Virtual Nordic is a well established HPC supplier in Europe, not least to the automotive industry, which is facing many new IT challenges. Self-driving cars and smart products are examples of areas that will require both AI technology and HPC solutions for storage capacity and for handling large data quantities. The research facilities are facing similar challenges.

"We monitor procurements from the facilities in Europe, and see good opportunities for new business in the future," concludes Peter Hjärn.



"Research facilities handle vast quantities of data, making them an interesting market for Go Virtual Nordic."


HUURRE ECO

# HUUREE

## Designs, manufactures and supplies refrigeration units

Huurre is part of the Caverion Group – a leading European group in the refrigeration sector, with a focus on energy-efficient and environmentally friendly refrigeration. Huure Sweden, with 150 employees, is owned by Caverion Sverige.

Huurre designs, manufactures and supplies refrigeration units, and for many years has driven the technology away from fluorinated greenhouse gases to natural coolants, such as carbon dioxide. Sweden and the Nordic region are at the forefront of this technological development, and Huurre is now a world leader in these types of refrigeration units.

Huurre has regular contracts with universities, hospitals, schools, and ice halls, but also supplies commercial customers like shops, properties, process industry, and restaurants. Research facilities offer a promising new market.

### Big order from CERN

CERN is currently undergoing an extensive upgrade, which includes replacing refrigeration systems. In 2020, representatives from CERN participated in a seminar on CO2-cooling arranged by Big Science Sweden at the Ångström Laboratory at Uppsala University. This was where CERN heard about Huurre. Ahead of the procurement of new refrigeration units for the CMS and ATLAS experiments at LHC, CERN contacted Huurre and recommended that the company submit a tender.

"We did so and won the order, and see it as recognition that we have the necessary specialist expertise," explains Fredrik Strengbohm, Technical Manager at Huurre. "We'll be supplying refrigeration units designed and built with extremely stringent requirements in terms of safety, refrigeration, and redundancy. CERN employees visited us digitally during the procurement process. After interviews and a guided tour using cameras in our production environment, they were convinced we had the necessary resources."

### -53 degrees and 100 percent redundancy

In the project Huurre may be supplying a total of 20 units by 2024, assuming practical tests in situ at CERN in the autumn are a success. Huurre is currently working with final project planning, design and construction. The unit will refrigerate down to -53 degrees with 100 percent redundancy.

"The technical demands are extremely high," continues Fredrik Strengbohm. "The accelerators must be able to run at full capacity even when outdoor temperatures are high. Nothing must go wrong and cause disruption while the expensive experiments at CERN are being conducted."

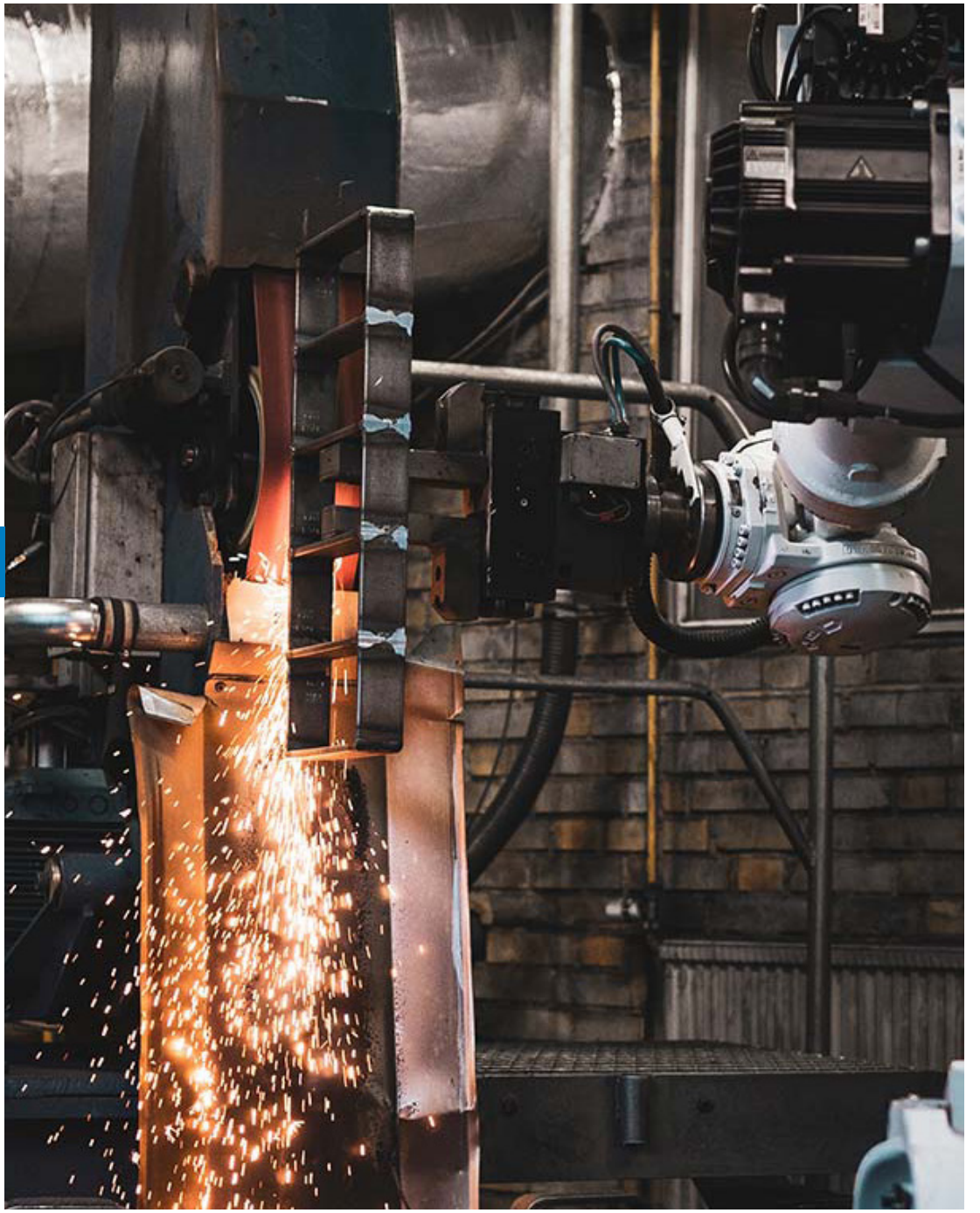
In spring 2021, the unit will be planned and designed at the head office in Västerås. Later, the unit will be built at the Huurre factory in Finland, and then assembled in situ at CERN.

### Technology for the future

Greater requirements for energy-efficient and environmentally friendly refrigeration make Huurre an attractive supplier that works with future-proof technology.

"It's not so common that Swedish companies supply products to southern Europe, but news of our expertise and competencies has spread, and we've put ourselves on the map without marketing. Working in an environmentally friendly way is important today, and will be even more important tomorrow, so our products and services are ideal for the future."

"Research facilities offer a promising new market."



# MCT BRATTBERG

## World leader in development of cable and pipe transits

MCT Brattberg develops and manufactures high-performance cable and pipe transits, used to protect people and property in various application areas in exposed environments.

Within a short period, the company has won two orders, one from ESS and the other from the Jules Horowitz Reactor, a test reactor for water-cooled nuclear power, built in connection with ITER.

The ESS order concerns cable and pipe transits for the target area, a radiation environment requiring specialised cable transits. If all goes according to plan, the order should be completed during 2021.

At the Jules Horowitz Reactor, MCT Brattberg's products will be tested against future requirements. MCT Brattberg is now working on design ahead of an approved quality audit, and will start to supply the equipment during 2021.

### Known products, high quality, and strategic contacts

"We've worked a lot with ITER, and supplied fire protection equipment to the buildings," explains Mats Åfeldt, Sales Manager at MCT Brattberg. "Eventually, we hope to become involved in the fusion part.

"We started to establish contacts at ESS through Skanska already during the design stage of the facility, and we've been making continual deliveries since then. Our products are well known, and are known to be of high quality. For a long time, we've been supplying equipment to nuclear power plants, which also have very exposed environments with very strict requirements."

Already in the 1950s, MCT Brattberg developed a product, the MCT Brattberg system, a modular multi-cable and pipe transit, which over the years has given the company a global reputation.

"Big Science Sweden has given us an effective and rapid way in to new contact networks. This frees up valuable time that we can instead devote to talking with the right people at the right time – that's the sort of thing that can be crucial in future business."

"We've always worked with customers that demand high quality. We've gradually made the right contacts."

# OMNISYS

## Key supplier to the space industry

Omnisys develops and manufactures customised scientific instruments for advanced science applications, and specialises in development and production of high performance electronics hardware for the space industry.

In 2007, Omnisys was awarded the contract as main supplier for detailed design and production of the Water Vapour Radiometers for the ALMA telescope that ESO was constructing in Chile. Omnisys designed the systems almost from scratch, to make them suitable for serial production and to ensure the systems could endure the harsh desert environment at high altitude.

### Corrective maintenance and replacement of obsolete components

The contacts with ESO have continued, and in 2017 Omnisys signed a five-year agreement on corrective maintenance and development of spare parts that had become obsolete. Maintenance agreements are vital for end users when they concern very specialised technology intended for long-term operation.

"Due to the rapid technological development, components to certain subsystems are no longer available, so new replacement systems must be developed after approximately ten years," explains Martin Kores, Managing Director Omnisys.

### New receiver components and spare parts for harsh environments

"Here, we're talking about systems installed in an extremely harsh environment, in a desert in Chile at a height of 5000 metres, with limited opportunities for maintenance and repair on-site," continues Martin Kores. "We don't just carry out traditional maintenance work like troubleshooting and repair – we also identify subsystems that need updating, and we develop and supply new receiver components and spare parts."

Martin Kores is very optimistic about an extension to the five-year contract. Few other companies in Europe have the capacity for this type of contract, and ESO are very satisfied with the equipment that Omnisys has supplied so far. The agreement with ESO also gives the company valuable contacts in the radioastronomy market.

### Omnisys wins big order through consortium

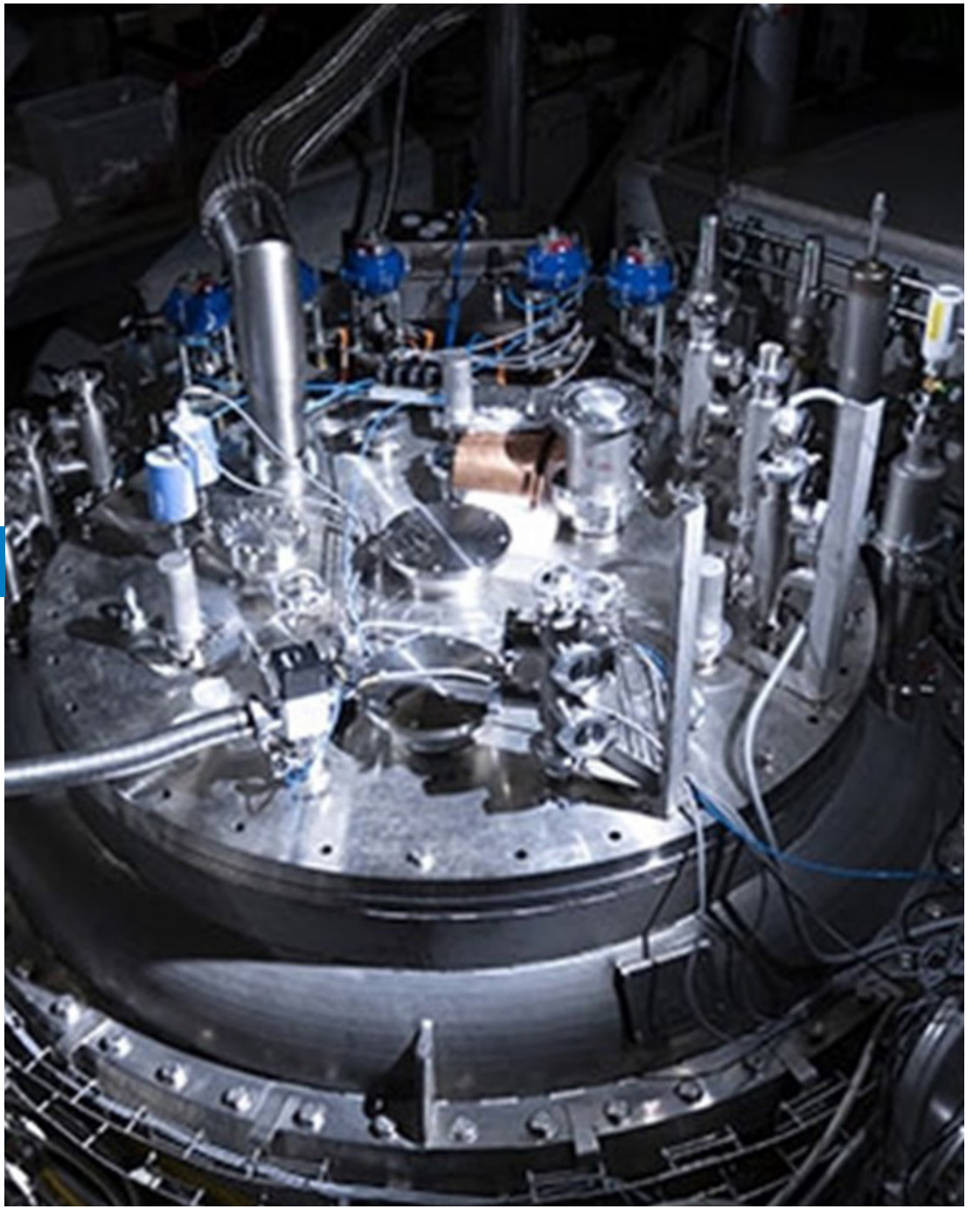
Omnisys is part of the industrial consortium that won an extensive order to develop an Arctic Weather Satellite for ESA (The European Space Agency).

A prototype for a new weather satellite will be developed. The prototype will demonstrate the opportunities afforded by a constellation of smaller weather satellites with a dedicated payload of microwave instruments. These will provide an almost continual flow of data for measurement of temperature and precipitation, with global coverage.

The industrial consortium is led by OHB Sweden, and Omnisys Instruments is the prime contractor of the microwave radiometer. The agreement runs over three years, and is worth over SEK 100 million for Omnisys.



"Few other companies in Europe have the capacity for this type of contract."



Top of the five-metre-deep thermos (vertical cryostat), which will be used to cool down the magnet prototype to –270 degrees Celsius during the tests at the FREIA laboratory.

# SCANDITRONIX MAGNET

## Constructing new superconducting magnet

Scanditronix in Vislanda is a leading manufacturer of magnets for particle accelerators, supplying products to research facilities, major medical companies in the field of cancer treatment, and other industries. The company's experience, engineering know-how and long-term relationships with demanding customers, such as research facilities, has won the company an excellent reputation on the market.

Scanditronix is now entering a new phase of innovative technology, developing 'cold' superconducting magnets in an exciting collaboration project involving both academia and industry. The project aims to develop environmental-friendly and energy-efficient superconducting magnets, combining research and technical development to boost global competitiveness för Swedish companies.

Mikael Vieweg, CEO, Scanditronix, describes how the current project is breaking new ground. "Working with superconducting magnets is nothing new in our industry, but the type of magnet we're currently developing has a design that has never been used before in accelerators. It will be less complicated and thereby easier to manufacture than existing superconducting magnets. The CCT concept, Canted Cosine Theta, is unique."

### Academia and industry working side-by-side

A lot of the preliminary work and research has been done, for example at the FREIA Laboratory at Uppsala University. Industry and academia gathered at a Big Science Sweden AIMday in 2019, where the foundation was laid for the current project*, which involves an intensive exchange of research and industrial expertise. Scanditronix is one of three companies participating, together with Uppsala University and Linnaeus University.

Uppsala University has a leading role, and is designing the magnet in collaboration with experts from CERN. Linnaeus University is producing drawings and performing calculations, and Scanditronix and the two other companies will produce the magnet.

"The process involves a continuous and rewarding exchange of knowledge and expertise," says Mikael Vieweg. "We will make the coil and assemble the magnet. A lot of the technology will be new to us, but still within our field, so it's a suitable project. We're acquiring the equipment and testing new technologies in developing a functional prototype that will be delivered to CERN."

### Further interest expected from CERN and medical research

If everything goes well, and the prototype satisfies CERN's expectations, Mikael Vieweg is optimistic that CERN will be interested in a number of similar magnets within a couple of years. He also believes that the medical market, with ion therapy systems for cancer patients, will see great advantages in a compact magnet at a lower cost.

* The project is funded by the European Regional Development Fund, Kronoberg Region and Uppsala University.

"The type of magnet we're currently developing has a design that has never been used before in accelerators."

# STUDSVIK NUCLEAR

## Working to implement fusion technology

Studsvik Nuclear is a leading supplier of services to the international nuclear power industry. The company's unique specialist expertise built up over the years also includes research and development in the fusion field.

Studsvik has long experience of working with challenging issues in corrosion and materials relating to light water reactors based on the fission principle. The company has been able to adapt its expertise and experimental equipment to solve similar challenges in fusion research. For instance, with a unique testing capacity in flow-accelerated corrosion, Studsvik has successfully established itself in a narrow technological niche. Their experience in materials testing has also helped validate new construction materials for use in future fusion reactors.

The company also has special capacity in its hot cells, where neutron-irradiated, i.e. strongly radioactive material, can be handled remotely. In a hot cell, the material can be tested mechanically and chemically, using various methods. Samples of these materials can be produced for further analysis down to atom level using state-of-the-art microscopy techniques.

### Understanding of quality requirements and scientific challenges

At an early stage, Studsvik contacted ITER, F4E and the research organisation EUROfusion (European Consortium for the Development of Fusion Energy). In the past ten years, Studsvik has been involved in several projects for all three organisations. Studsvik's expertise in nuclear technology has been crucial for the successes.

"Operating within the Big Science arena is on a much larger scale from both a technical and administrative perspective," explains Lotta Nystrand, Key Account Manager in Fusion. "We understand the scientific challenges and the special quality requirements regarding fusion, and we've built up the collaborations needed to work in large international networks like EUROfusion and ITER."

### Specialist knowledge in nuclear technology, materials, and corrosion

Lotta Nystrand emphasises the importance of Studsvik being able to use their existing facilities, and their in-depth knowledge in nuclear technology, materials, and corrosion when entering the high-tech Big Science market. She is also aware of the importance of making the right contacts.

"Studsvik are an SME with a strong reputation within nuclear, built up over many decades of working internationally. We started to build relations at an early stage and participated in technology-oriented conferences and featured in scientific journals. Even with a strong base, it takes a lot of work to become established as a supplier and occupy a natural place in the networks aimed at implementing fusion technology."

"We've built up the collaborations needed to work in large international networks."


SP Devices
ADQ7DC
PWR
SYNC TRIG
IN
USR
STA
IN
RDY
GPIO
SP Devices
ADQ7

# TELEDYNE SP DEVICES

## Cutting-edge instruments for modular data acquisition and signal generation

Teledyne SP Devices designs and manufactures cutting-edge instruments for modular data acquisition and signal generation. Products, employed across a wide variety of industries, include analytical and scientific instruments, and equipment for remote sensing and medical imaging.

The company is a world leader in its field, providing technical solutions that are much in demand for large collaborative projects, including procurements for research facilities such as CERN and ITER.

### Innovative technology and solutions

"As a supplier to a major development project, a high degree of flexibility is required" explains Kacper Matuszyński, Sales Engineer Europe at Teledyne SP Devices. "We contribute expertise for developing technical infrastructure. It's not about mass production but about developing and making single units that must be tested and continuously evaluated and adapted. We work with technology and solutions that no one has done before, so this is genuine research and innovation."

Teledyne SP Devices has worked its way into the Big Science market, for example by gradually building up a network of contacts at universities and research facilities. Kacper has identified key people by searching subject areas in databases at various universities.

"You have to be persistent and work systematically, but it's easy to find information about researchers and their publications," continues Kacper. "I'm interested in research in our field – it gives me an idea of who are the influencers and decision-makers.

"The Big Science world is a community with an extremely high degree of collaboration. Once you've established a good contact, it often leads to further contacts. And if you've done a good job – delivered a high-quality product with support – the word spreads quickly, creating a springboard for new business."

### Recent and forthcoming orders

In addition to completed orders to particle accelerator facilities such as CERN and XFEL/DESY, Teledyne SP Devices has supplied technology for plasma devices like Wendelstein W7-X and JET. Recent projects include a new detector for the DELTA electron storage ring in Dortmund, Germany.

"Teledyne SP Devices delivers highly customised solutions and products requiring intensive R&D."

**Networking continues despite the pandemic**
Our digital events have enabled us to continue activities that bring people together and spread knowledge, but we are looking forward to physical meetings and exciting study trips.

# PARTNERSHIP, BUSINESS, AND KNOWLEDGE TRANSFER

Big Science Sweden is Sweden's official Industrial Liaison Office (ILO), serving as the link between Swedish industry, institutes, academia, and Big Science research facilities.

We promote the build-up of knowledge, skills, and expertise that drive technological development in Swedish companies. We also help research facilities find qualified Swedish suppliers.

Activities arranged by Big Science Sweden offer opportunities for partnerships and collaboration initiatives. Industry, academia, and research facilities regularly participate in our various events, where personal meetings can be the starting point for business and long-term, constructive relationships.

## Big Science Business Trips

Big Science Sweden arranges Business Trips, where Swedish companies visit research facilities around Europe. The companies get valuable information about the facilities' upcoming projects and procurements, make contacts with key personnel, and get the opportunity to present what they can offer in terms of unique expertise, skills, and resources.

Knowledge is also exchanged, and contacts made, when representatives of research facilities come to Sweden and take part in road trips, visiting Swedish companies with the specialist expertise and skills that their facilities are looking for.

## Conferences and other networking events

Large, international trade fairs and conferences within Big Science are important meeting places for research facilities and Swedish companies. The conference programmes usually include seminars in various areas of advanced technology and reports from some of the large-scale facilities. In workshops and personal meetings, representatives from the facilities can form an overall impression of Swedish high-tech capacity, and make important contacts for future cooperation, projects, and business.


## Business Corner

Once a week, every Wednesday morning, we open our Business Corner. This is an effective 30-minute virtual meeting where we go methodically through the new procurements announced by the research facilities, and talk about procurement procedures, contact channels, technical specifications, deadlines, etc.

We regularly invite representatives from the research facilities or other experts to give current information on procurements or other issues relevant for our participants. Suppliers and research facilities can then make important contacts for further discussions.


## Big Science@

Big Science@ is a series of workshops focusing on academic institutions' past, present, and future involvement in delivery to Big Science facilities. When academia delivers technology to Big Science facilities, this generates multiple scientific, technological, and societal benefits.

We arrange the workshops together with leading universities and research institutes in Sweden. A Big Science@ event is characterised by inspiration, networking, and ecosystem building.

### Big Science Morning

At a Big Science Morning, companies that are already, or are interested in becoming, suppliers to research facilities hear about the latest developments and new technologies within the Big Science field and can discuss opportunities for collaboration. Representatives from the research facilities are invited, and we arrange 1-to-1 meetings.

"A morning meeting is a good way for us to communicate business opportunities focusing on, for example, current procurements or different technical challenges. The informal atmosphere is much appreciated and stimulates networking," explains Frida Tibblin Citron, Business Development and Project Management, at Big Science Sweden in Lund.



### Big Science Technology Workshop

Big Science Technology Workshop is a combination of seminar and workshop, where the focus is on a specific field of technology, such as AI, advanced 3D printing, or other areas. The aim is to strengthen the expertise and skills of supplier companies and their abilities to deliver advanced technology. World-class speakers and experts participate in these workshops.

Anna Hall, Programme Director for Big Science Sweden, explains why these events are important. "Technology Workshops have a tremendously important function in driving the development of new advanced technology in the companies. The workshops enable suppliers, researchers from academia, and representatives of research facilities to sit down at the same table and discuss current issues directly, face-to-face."

### Big Science Academy

Suppliers to research facilities need to continually raise their level of expertise, to ensure they remain at the cutting edge in the technological fields where suppliers are needed. Big Science Academy offers continual training in the areas that reflect the facilities' requirements and needs, such as accelerator technology, future AI, ultra-high vacuums and procurement handling.

### Big Science Sweden Conference

The Big Science Sweden Conference is a meeting place for networking and knowledge sharing – a two-day conference for research facilities, companies, academia, and institutes. Participants meet to discuss challenging issues within Big Science and the opportunities in different fields of technology.

At the digital conference in November 2020, 250 delegates from ten different countries met up over two intensive days that offered nine parallel sessions, 300 unique 1-to-1 meetings, roundtable discussions, and some 50 exhibitors. Examples of comments in the concluding evaluation:

*"This is definitively an important hub regarding the connection between industry, researchers and research facilities."*

*"Best conference so far of any Big Science conference I have ever attended."*

### AIMday Big Science Technology

AIMday Big Science Technology is a workshop where research facilities get the chance to discuss their challenges with scientists at Swedish universities and institutes and with representatives from high-tech companies that deliver to Big Science.

Ahead of the workshop, the research facilities identify the challenges they are facing in several categories and submit them to Big Science Sweden. Workshop teams with the relevant expertise for each category are then put together to discuss the challenges at AIMday Big Science Technology.

VINNOVA Sweden's Innovation Agency · Swedish Research Council · Swedish Agency for Economic and Regional Growth

big science sweden

# BIG SCIENCE SWEDEN CONFERENCE 2020

**JOIN US IN BUILDING THE BIG SCIENCE ECOSYSTEM**

**VIRTUAL CONFERENCE**
**NOVEMBER 24, 2020**

## NOVEMBER 24

REGISTER TODAY

Swedish high-tech industry and academia meets with European Big Science facilities

### STATUS AND BUSINESS

08:30 **Join us in building the Big Science Ecosystem**
**Anna Hall, Director Big Science Sweden**
08:45 **Introducing Sweden as a Big Science player,**
Pia Kinhult, Head of Host States Relations at ESS and Anna Hall
09:00 **Creating collaboration and business in the Big Science ecosystem,**
Research facilities giving an update on current status and business plans
09:30
Coffee Break and Interaction
09:45 **Creating collaboration and business in the Big Science ecosystem**
A number of research facilities giving an update on current status and business plans
10:45 Coffee Break and Interaction
11:00 **Creating collaboration and business in the Big Science ecosystem**
A number of research facilities giving an update on current status and business plans
11:30 **CERN Knowledge transfer ecosystem, developing the innovation culture in a Big Science ecosystem**
Why, how and success factors
11:45 **Conclusions**
Anna Hall Director Big Science Sweden
12:00 Lunch Break

### BREAKOUT SESSIONS

13:00 **Breakout session**
Learn more about challenges and needs of research facilities in different technology fields.
13:45 Break
14:00 **Breakout session**
Learn more about challenges and needs of research

- AI, Control Systems & Data Acquisition, Big Data
- Consortium Agreements, why and how
- Diagnostics Part One
- Material and advanced manufacturing
- Remote handling & robotics
- Diagnostics Part two
- Drones applications
- Opportunities for Swedish industry with Tech transfer from Big Science
- Vacuum, Cryogenics & Magnets
- Electronics and RF systems

### 1-1-MATCHMAKING

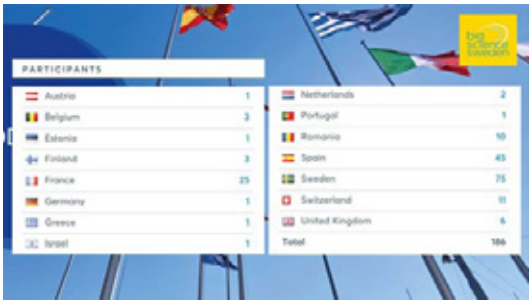
15:15 **1-1 matchmaking meetings**
A matchmaking event is a quick and easy way to meet potential cooperation partners in face-to-face talks. 15 minutes pass quickly but this is usually enough to make an initial connection, then the bell rings and the meeting starts.

www.bigscience sweden.se

Big Science Sweden is led and operated by by a consortium of leading universities, institutes and industrial network organisations:

CHALMERS · UPPSALA UNIVERSITET · LUNDS UNIVERSITET · LULEÅ TEKNISKA UNIVERSITET · Teknikföretagen · RI.SE · JUC SYD · REGION SKÅNE

THE OFFICIAL SWEDISH ILO




Industry event

## Big Science Virtual Workshop

186 participants from 15 European countries connected to the Big Science Virtual Workshop co-hosted with Eureka/Eurostars. High-tech suppliers from all over Europe listened to representatives from CERN, ESS, and Fusion for Energy/ITER.


Knowledge

## Focused Technical Workshop

We gathered industry, academia, and research facilities in virtual technical workshops on remote handling, materials and CO2-cooling systems. The workshops included presentations, 1-to-1 meetings, and updates on the facilities' current challenges and needs.




International networking

## Interactive webinars

BSBF International Organising Committee decided to postpone the BSBF2020 conference. In order to keep the momentum, we engaged in BSBF interactive webinars with the following themes: COVID-19 Pandemic: Impact and Measures on the Big Science and Big Science Organisations: Strategic Plans, 2020-21 Procurements, and Flagship Projects.
The ENRIITC 1st Networking Meeting offered a great chance for participants to get to know one another.


Partner events

## Big Science@events

During 2020, we hosted two different Big Science@ events - one together with Lund University and one with RISE. These were strategy days filled with inspiration, networking, and ecosystem building, involving the research community, with the aim to define areas of strength in Big Science.

Industrial development

## Access Day

Big Science Sweden and the ÅMA Ångström Materials Academy held a seminar where representatives from selected research infrastructures at Uppsala University and industrial companies were invited to share information.

Workshop

## Collaboration ESS and DESY

A new pilot study is strengthening collaboration between the research facilities ESS in Lund and DESY outside Hamburg. Greater collaboration is driving development in exciting areas of technology, such as open data, AI, and machine learning.
ESS is already involved in a pilot study, ESS Data Lab, together with industry and academia, focusing on alarm management. ESS is now entering a new collaboration with the DESY research facility.


Training

## Automation Control

Member companies got the chance to listen to presentations from the EPICS community, with developers and managers from various research facilities that use EPICS tools.
One of Big Science Sweden's key areas is knowledge transfer, making scientific and technological development accessible to a wider range of users. EPICS is an innovation, one in which we see great potential for developing tomorrow's industry.



## **Innovate with CERN** Discovery Day

Big Science Sweden is developing a Knowledge Transfer Office within Big Science, and has set up a collaboration programme with the CERN Knowledge Transfer Group.

CERN and Big Science Sweden hosted their first joint event.

No fewer than 25 experts from CERN and representatives from 13 Swedish companies, e.g. GKN Aerospace, Volvo Cars, ABB, and Alfa Laval, met to discuss future collaboration.

The collaboration programme applies a challenge-driven approach, to identify strategic innovation challenges in Swedish companies and to match them with unique CERN know-how and technology.

*25 experts from CERN and representatives from 13 Swedish companies took part.*

KNOWLEDGE TRANSFER COLLABORATION PROGRAMME SWEDEN

Weekly meetings

## Business Corner

Every Wednesday, member companies can join a short Zoom meeting and learn about current procurements.


Member meetings

## Big Science Mornings

Big Science Morning is our forum where member companies meet with each other, share experiences, and learn more about how to generate business in the Big Science market.




Training event

## Step by step

How can companies boost their chances of winning contracts from research facilities?


Our activities are continuing as normal during the COVID-19 pandemic, but all events are in digital form.

# Big Science Sweden Conference 2020 went digital




# BIG SCIENCE SWEDEN CONFERENCE 2020

**Great atmosphere, fast tempo, and a feeling of almost physical presence when Big Science Sweden Conference 2020 went digital.**
Joining us in building the Big Science ecosystem were no fewer than 245 delegates from 14 countries. This year's conference proved to be an intensive day, with reports from eight research facilities, discussions in nine breakout sessions in various areas of technology, and no fewer than 34 speakers and 179 1-to-1 meetings. During the breaks, participants looked round the virtual exhibition, including video pitches from 18 member companies showing their offers to the research facilities.

### 1-to-1 meetings

An important part of the conference was the dedicated matchmaking session where participants could meet with each other in virtual 1-to-1 meetings.

### Breakout sessions

The challenges and needs of research facilities in different technology fields.

- AI, Control Systems & Data Acquisition, Big Data
- Diagnostics - Upcoming opportunities and Swedish initiatives in diagnostics
- Material and advanced manufacturing
- Remote handling & robotics
- Diagnostics - The European ecosystem for diagnostics: How do we best work together?
- Drones applications
- Electronics and RF system
- Opportunities for Swedish industry with Tech transfer from Big Science
- Vacuum, Cryogenics & Magnets

# BIG SCIENCE SWEDEN CONFERENCE 2020

**Big Science Sweden Influencer: Industry**
Carl Johan Fagerström
Fagerström Industrikonsult AB


**Big Science Sweden Influencer: Newcomer**
Sofia Davidsson
Qtech Group AB


**Big Science Sweden Influencer: University**
Anders J Johansson
Lund University

**Big Science Sweden Influencer: Research Facility**
Jérôme Pierlot
CERN



## BIG SCIENCE SWEDEN 2020 CONFERENCE AWARD

**The Big Science Sweden Award is given in four categories to individuals showing particular engagement in helping to build Sweden as a Big Science nation and in driving Big Science Technology. This year, the award-winners were:**

- Influencer Research Facility: Jerome Pierlot, CERN
- Influencer University: Anders J Johansson, Lund University
- Influencer Industry: Carl Johan Fagerström, Fagerström Industrikonsult
- Influencer Newcomer Sofia Davidsson, Qtech Group

# BIG SCIENCE SWEDEN CONFERENCE 2020

Anna Hall, Director, Big Science Sweden, guided us through the day.

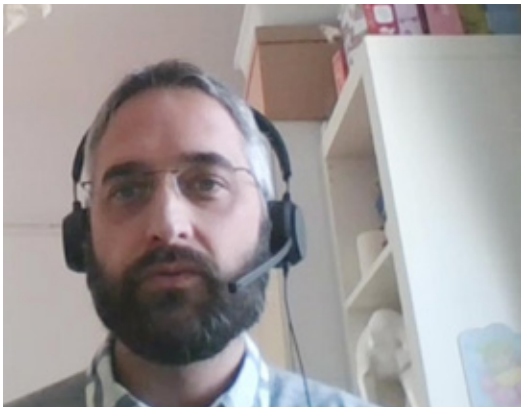
## What was the most important part of the conference?

**Luis Ortega, Procurement Officer/Group Leader Procurement Administration Group at ESS**
The 1-to-1 meetings were the most useful, as they provide the opportunity for a deeper and focused discussion with potential suppliers.

**Fabio Biancat Marchet, ELT Programme Engineer at ESO**
In my view the most interesting subjects were the presentations on the technology transfer and associated discussion.

**Dr. Nicole Elleuche, Managing and Administrative Director at XFEL**
For me the most valuable part was the exchange with my colleagues from the other international facilities and getting closer to them. This will make it easier in the future to network and get collegiate answers to some specialist questions.

# BIG SCIENCE SWEDEN CONFERENCE 2020



**Mehdi Daval, Market Intelligence Group at Fusion for Energy, Barcelona, Spain**
For me it was the opportunity to present our forthcoming Calls For Tender, in the hope that Swedish companies can bid and win some of them. It means that our project could really involve the best of all European countries.

**Ian McKinley, Fuel and Materials Technology – UK Business Development Manager Studsvik Nuclear AB**
The 1-to-1 meetings were most important! I found my participation in the conference to be very worthwhile.



**John Conway, Director at Onsala Space Observatory**
It was good to have a chance to present, to a broad audience, the OSO perspective on how national research infrastructures can play a part in developing industrial return from major international science infrastructures.

**Dr. Sonia Utermann, In-kind and Procurement at FAIR**
Thank you and your team for the Big Science Sweden Conference. I already have three new potential suppliers for FAIR.

# BIG SCIENCE SWEDEN CONFERENCE 2020

## What was the most important part of the conference?

**Han Dols, Head of Business Development Section at CERN**
Great to witness how well the Swedish ecosystem is gearing up to get most out of Big Science. Good for industry, but also good for science!

**Ingrid Milanese, Head of Procurement & Contracts, Administration Division at ESRF**
For me, I believe the best part was when the institutions presented forthcoming opportunities. I also really liked the questions and the use of links when answering, and that you could present the responses live. I found the conference very collaborative.

## What is your greatest challenge within your technology field?

**Jean-Baptiste Haumonte, Sales Manager, Bertin Technologies**
Our greatest challenge was probably the success in the alignment instrumentation design and manufacturing of the 240 lasers for the Laser Mégajoule (LMJ in France) at 7 microns in a 10-m vacuum chamber.

**Anders Wallander, Head of Division, ITER Controls Division**
The greatest challenge for me is not technical but administrative. How to organise Big Science projects with many different stakeholders from different backgrounds/cultures? How to control an in-kind project where stakeholders provide systems and not money? How to control a project without one central point of authority?

# 2020 FACTS & FIGURES

## Virtual Seminars & Conferences

National and international

**18+1000**

**Seminars & conferences** | **Participants**

Seminars, conferences, workshops, and training events in cooperation with universities and international partners.

## AIMDay Big Science Technology

**5** **Big Science Pre-Study Projects**

AIMDAY events enable long-term collaborations, by sharing knowledge, presenting expertise, and acquiring first-hand information about the needs of research facilities and their current and future challenges.



## Big Science Sweden Conference 2020

Meeting place for industry, universities, institutes, and research facilities

**245+179**

**Delegates from 14 countries** | **1-to-1 meetings**

**Did the event meet your expectations?**

**99%** **Yes!**

**10** **Big Science facilities**

Promoting collaboration and business in the Big Science ecosystem, ten research facilities gave an update on their current status and business plans.

**9** **Breakout sessions**

- *AI, Control Systems & Data Acquisition, Big Data*
- *Diagnostics - Upcoming opportunities and Swedish initiatives in diagnostics*
- *Material and advanced manufacturing*
- *Remote handling & robotics*
- *Diagnostics - The European ecosystem for diagnostics: How do we best work together?*
- *Drones applications*
- *Electronics and RF system*
- *Opportunities for Swedish industry with Tech transfer from Big Science*
- *Vacuum, Cryogenics & Magnets*

# 2020 FACTS & FIGURES

## International collaboration

**50** **meetings with system integrators**

We held around 50 meetings with large system integrators in Europe, to build relationships between Swedish players and international companies such as Jacobs, Technetics, CNIM, Assystem and Cybernetics.

## Swedish Big Science Orders

**250** **million SEK**

Value of orders over the first 3-year programme period. During 2020 Swedish companies won orders for around SEK 50 million. Examples of companies winning orders: ABB, AQ Elautomatik, Examec, Carlsson & Möller, GoVirtual, Luma Metall, Omnisys, Qamcom, Qtech Group, Sandvik, and Scanditronix.

## Business Corner

**BUSINESS CORNER EVERY WEDNESDAY 10:00-10:30.**

**14** + **226**

**Business Corners** | **Participants**

A short virtual meeting where our member companies hear the latest news on new procurements.

## Business matchings

**572**

Big Science Sweden matched procurements with suppliers.

2020 FACTS & FIGURES

# Value creation

The process from first contact to a final order is long, but more and more Swedish companies are starting to submit bids and win orders. We see a need for industry to collaborate with academia, and for Sweden to become involved at an earlier stage, as early as prototype development. This will enable our high-tech companies to compete in the Big Science market, estimated to be worth EUR 38.7 million* in the next few years.

* Source: www.bsbf2020.org

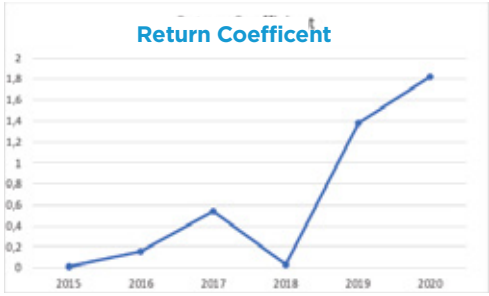
During 2020, the year of the Covid pandemic, the industrial return at CERN decreased to 0.6. One explanation is that there was less networking with people at the facilities.

Our events were largely held in digital form, but we miss meeting people in real life. We are looking forward to visiting the research facilities, and meeting and connecting with people again during 2021.

## INDUSTRIAL RETURN TO SWEDEN 2020 CERN

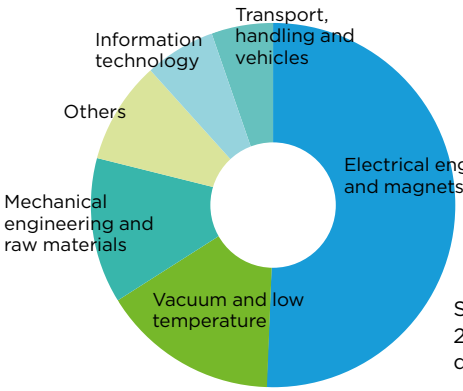

During 2020, the industrial return at CERN decreased to 0.6. One explanation is that there was less networking with people at the facilities.

## INDUSTRIAL RETURN TO SWEDEN 2020 ESO




The Swedish Return Coefficient based on commitments has steadily increased at ESO. However, during the years of large investments around 2016, Sweden was not in a position to participate. The amount committed to Swedish companies 2020 was EUR 2701 thousand, and the return coefficient based on commitments was 1.82 (1 = return is equal to investment).

### Orders by Activity / Procurement Area




Swedish orders at CERN 2020, divided into the different procurement areas.

# AIMDAY BIG SCIENCE TECHNOLOGY 2019

# Looking back

2019

**Get inspiration from the interesting challenges identified by CERN and ESS at the AIMday 2019. Researchers and technical experts immersed themselves in around 30 challenges within categories as Advanced materials, Drones, Data handling and Electronics. As a result, five top-quality pre-studies were initiated.**



## Advanced materials and advanced production methods such as additive manufacturing

- Can we produce thicker sheets or bulk material of grain oriented steel, and steer the grain orientation? (CERN)
- How to produce, cut and polish radiation-hard garnet crystals more efficiently for large detector applications? (CERN)
- How to construct efficiently large and complex detector absorbers from tungsten alloys, whose composition is driven by the physics application? (CERN)
- Radiation hardness on greases: Is there a roller screw/lubricant (dry) system that can withstand the conditions in a radiation environment, and take up to 10MGy? (CERN)
- Is there a method to heavily bend 316L tubes (6mm or 18mm) with nearly no deformation? (CERN)
- Can we design a cooling solution in a vacuum chamber that does not include welded seams? (CERN)

## Drones

- How can we make use of drones more efficient and more compatible in terms of flying time and autonomous operation (CERN)
- How can we use drones for monitoring in the accelerator tunnels and other hostile environments? (ESS)

## Robotics/Remote handling

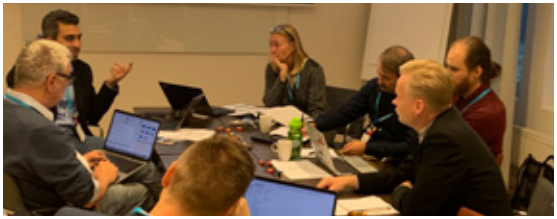
- How can we make industrial robots lighter, while maintaining their precision and dynamics? (CERN)
- How can we increase safety for humans in close human/robot collaborations? (CERN)
- How can we make robots for cryogenic and UHV environments? (CERN)
- How can we make hyper-redundant robots – think for example “snake-like” robots? (CERN)
- How can we use robots for continuous decontamination and cleaning of Big Science facilities? (CERN)
- How can we increase the “human touch” for robots working with humans in Big Science? (CERN)
- How can we increase proprioception in maintenance teleoperation in Big Science facilities? (CERN)

## AI/Big Data/Data handling/Control systems

- How do we optimise the flow of data in machine learning projects? (ESS)
- How do we develop Intelligent Alarm Handling? (ESS)
- How to create a Software Development Ecosystem for Machine Learning (Agile machine learning)?
- How can we develop Artificial Monkey Tuning? (ESS)
- What do tomorrow's control rooms look like? (ESS)
- How do we together drive the development of future Control Systems for Complex Processes (EPICS/Tango)? (ESS)
- How much should we care about integrating all the data from all the legacy systems upfront - instead of starting with some data and developing a culture for continuous analysis involving cross-functional teams? (Lund University)

## Electronics

- How do we meet the needs for Big Science when it comes to TCA development (Micro TCA – hardware) and how can we push for our needs to be part of standard TCAs. Energy-efficient processors? (ESS)
- Magnets and Cryo
- What can Sweden do to help CERN develop a canted-cos-theta dipole magnet for the LHC?
- How can we develop Superconducting Magnet Energy Storage (SMES) for the LHC at CERN?
- How can we fabricate -53 degrees CO2 cooling systems for the experimental setup at the ATLAS experiment?



**RESULT**
**5 top-quality pre-studies**

- Robotic arm in carbon fibre
- SMES – Energy storage
- CO2-cooling down to -53°C
- Developing a Swedish cluster for super conducting magnets
- Drones in harsh environments.

## One of the pre-studies has now advanced into a major project, with funding of SEK 19 million.

**Big Science Sweden and AIMday Big Science Technology helped bring together key partners for an exciting collaboration project involving industry and academia.**

A cluster of technology companies in Småland are collaborating with Uppsala University and Linnaeus University in an EU research and innovation project on superconducting magnets with uses in, for example, Big Science.

The project aims to develop environmentally friendly and energy-efficient superconducting magnets, where research and technical development can be combined to boost global competitiveness.

Magnets and cryotechnology were one of the areas of technology discussed at the Big Science Sweden Conference/AIMday 2019, under the title, "What can Sweden do to help CERN develop a canted-cos-theta dipole magnet for the LHC?".

The discussion during the AIMday initiated a feasibility study on the formation of a Småland cluster to work on superconducting 'cold' magnets. The feasibility study concluded with a project application for which funding has recently been awarded. Three high-tech companies and two universities can now work together on an exciting research and development project. Collaboration partners in the project are Scanditronix Magnet, Ryd-Verken, Vattenskärningsteknik in Vislanda, Uppsala University and Linnaeus University.
The project will run until April 2023, and will combine expertise in research, business, technology, and innovation to compete on a global market.

**Financial support**
The project – Disseminating technology for cold magnets to provide access to a wider international market – will be carried out with financial support from the European Regional Development Fund (ERDF) and Region Kronoberg. Collaboration partners in the project are Uppsala University, Linnaeus University, Scanditronix Magnet, Ryd-Verken, and Vattenskärningsteknik i Vislanda.

### Contacts at AIMday Big Science Technology

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# COMMUNICATION

**Communication plays a key role, enabling us to highlight the achievements of our member companies and partners, and spread news in different channels.**

15 December 2020

Congratulations Load!

13 December 2020

Today's CERN Alumni Advent Calendar window takes us to Sweden

12 December 2020

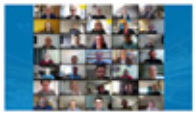
Big Science Sweden Award

11 December 2020

Collaboration between ESS and DESY · Workshop on Intelligent Control Systems

3 December 2020

Focused Technical Workshop: Remote Handling



30 November 2020

Discovery Day – Innovate with CERN · Knowledge transfer event proves popular


26 November 2020

Big Science Sweden Conference 2020


11 November 2020

Positive tones at this year's Big Science@LU on Lund University's role in Big Science



4 November 2020

Big Science Morning – an effective meeting place in the Big Science community


3 November 2020

Information Day on Nuclear Doors (TB20) for ITER, 5 November, 2020

2 November 2020

Welcome to the Big Science Sweden Conference 2020

12 October 2020

2020 Nobel Prize in Physics awarded for research using ESO telescopes

8 October 2020

Qamcom wins order for major space project

1 October 2020

Call for proposals: Innovation projects in SMEs


14 September 2020

BigScience@LU · Academic input in Big Science facilities

7 September 2020

Qtech Group receives order from ESS


26 August 2020

Don't miss procurement opportunities!


25 August 2020

Big Science Sweden in partnership with the CERN Knowledge Transfer Group

23 June 2020

European Strategy for Particle Physics 2020

22 June 2020

Congratulations X-officio


21 June 2020

Notes from the Big Science Business Forum - 1st Webinar


12 June 2020

The Swedish Guide 2020 now published - many thanks to everyone who contributed!


26 May 2020

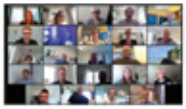
New knowledge, networking, and constructive dialogue at training session on procurement

12 May 2020

Big Science Virtual Workshop - 15 European countries represented

23 April 2020

Grattis Dve! Ett av våra medlemsföretag har inlett ett samarbete med ESS i ett nytt Vinnova-projekt.



22 April 2020

Från hela landet kopplade vi upp oss för att höra det senaste om ESS och aktuella upphandlingar

16 April 2020

Ny pilotstudie ger möjligheter för forskning, tekniköverföring och innovation inom AI, open data och framtidens fabriker


1 April 2020

Träffa forskningsanläggningar och europeiska leverantörer på Big Science Virtual Workshop den 11 maj 2020.

27 March 2020

Go Virtual vinner storordер till CERN på 15 miljoner SEK

12 March 2020

Grattis till Fagerström som fått en mångmiljonorder vid ESO i Chile

12 March 2020

Malmö Mönsterkort gör runt 2000 unika prototyper per år

26 February 2020

Uppsala universitet satsar 80 miljoner på teknikmiljö för avancerad forskningsutrustning

24 February 2020

The Swedish Guide 2020! Vi satsar på att presentera fler akademiska projekt.

7 February 2020

Fagerström med på europeiska SME-spåret på BSBF2020

4 February 2020

Big Science Morning med ITER/Fusion 4 Energy

23 January 2020

Kickoff i Neapel - Big Science Sweden medverkar i ENTRIITC

22 January 2020

Vetenskapsradion - Söker svaren på universums mysterier på CERN

17 January 2020

Big Science Sweden 2019 In Brief