Energy for Sustainable Science

at the European Spallation Source

John Womersley, Director General

November 2017

EUROPEAN SPALLATION SOURCE

Outline

- Status of ESS
- ESS and Energy for Sustainable Science
- Conclusions

Why Research Infrastructures?

- Scientific and technological innovation is essential to address
  - The economic and societal challenges of stalled productivity and long term wage stagnation
  - The global challenges of energy, climate, environment, healthcare
- Understanding the structure and behaviour of materials and molecules at the atomic level
  - New materials, new processes, new energy storage technologies

Why Research Infrastructures?

- Promote STEM skills
  - Big visionary projects attract young people into science
- Promote interdisciplinarity
- Promote engagement with industry
  - Importance of ‘place’ - science and innovation campuses
- Promote foreign policy goals
  - e.g. SESAME

Why neutron science?

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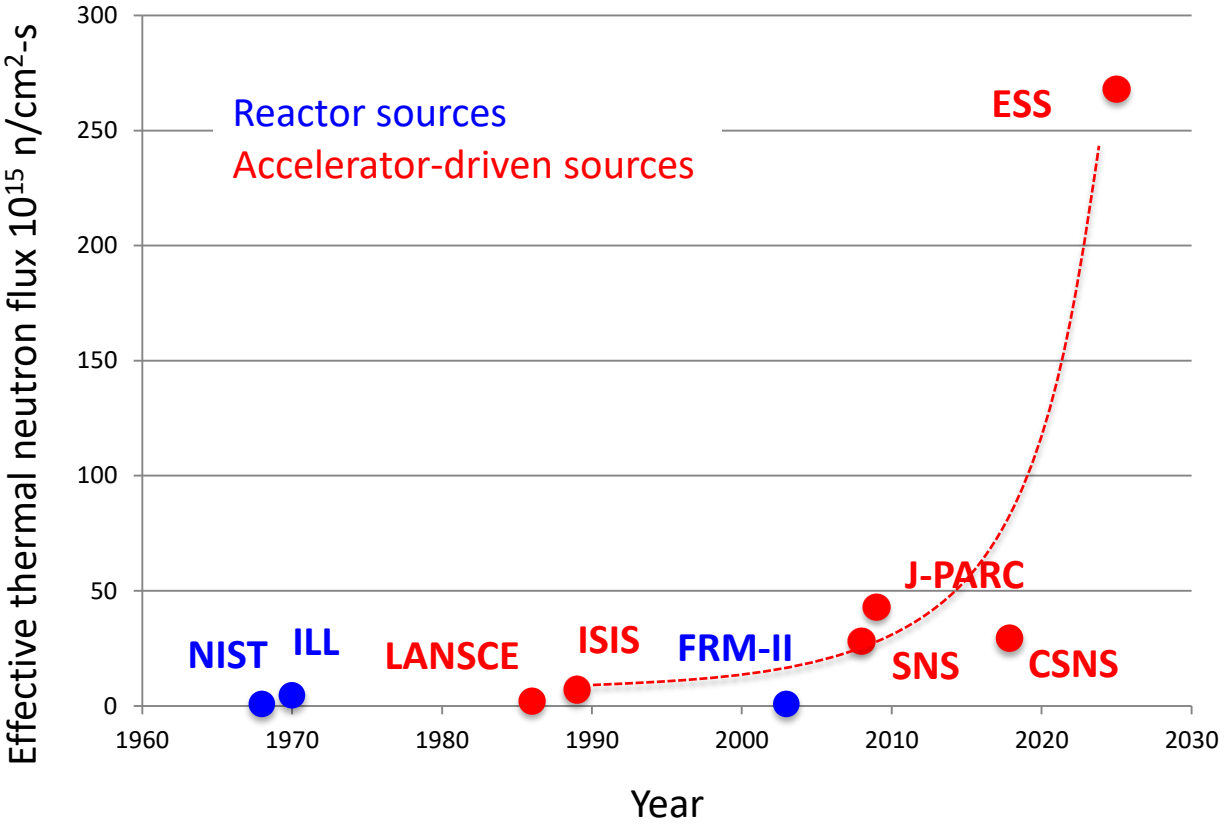
Why ESS?


Effective thermal neutron flux 10^{15} n/cm^2-s
300
250
200
150
100
50
0
1960
1970
1980
1990
2000
2010
2020
2030
Year
Reactor sources
Accelerator-driven sources
ESS
J-PARC
NIST
ILL
LANSCE
ISIS
FRM-II
SNS
CSNS

ESS High level design

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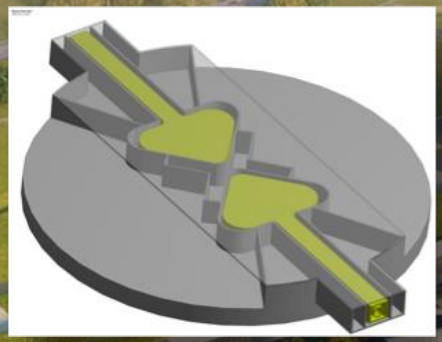
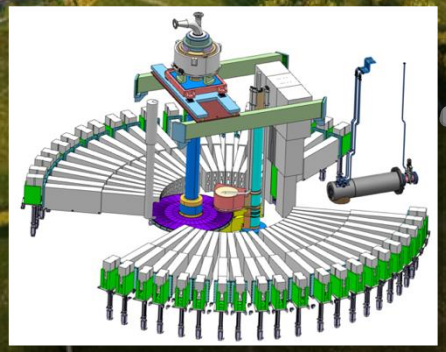
High Power Accelerator means more neutrons

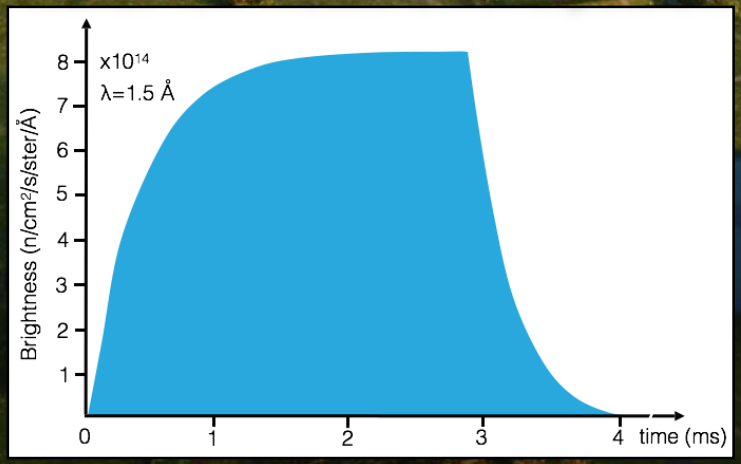
Flat moderator delivering smaller and brighter neutron beams

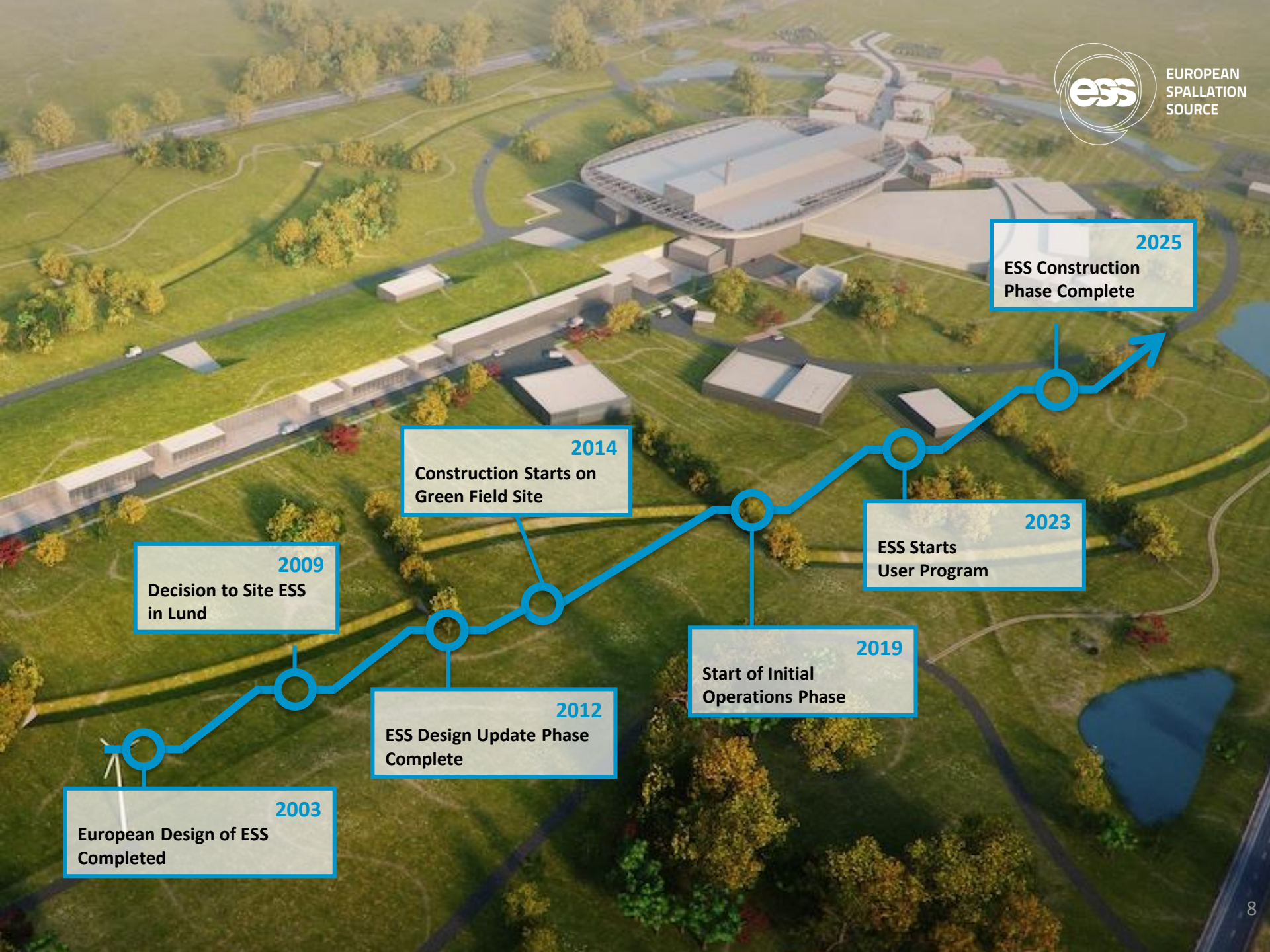




An Innovative Target Station that can host >30 instruments

High brightness and tuneable resolution makes new measurements possible




EUROPEAN SPALLATION SOURCE
2025
ESS Construction Phase Complete
2014
Construction Starts on Green Field Site
2023
ESS Starts User Program
2009
Decision to Site ESS in Lund
2019
Start of Initial Operations Phase
2012
ESS Design Update Phase Complete
2003
European Design of ESS Completed

Financing includes cash and deliverables

The European Spallation Source ERIC established in 2015

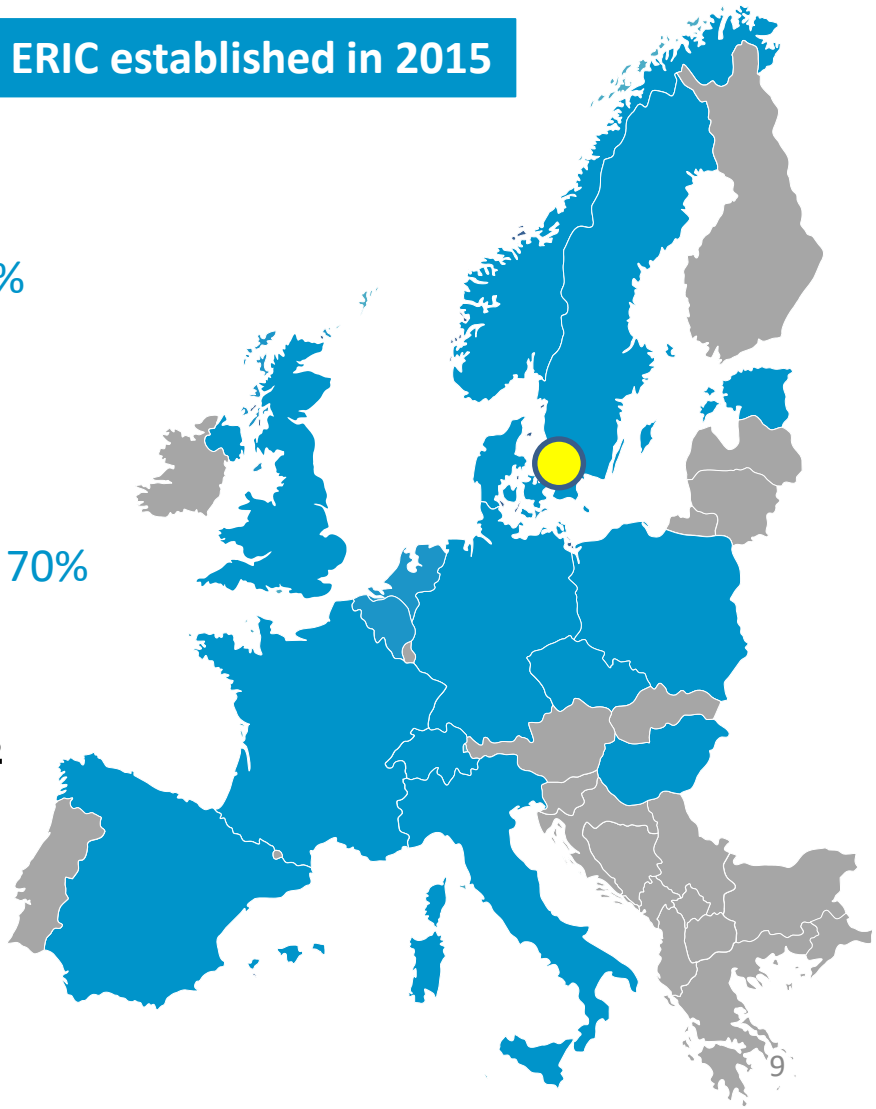
Host Countries Sweden and Denmark

Construction 47.5% Cash Investment ~ 97%
Operations 15%

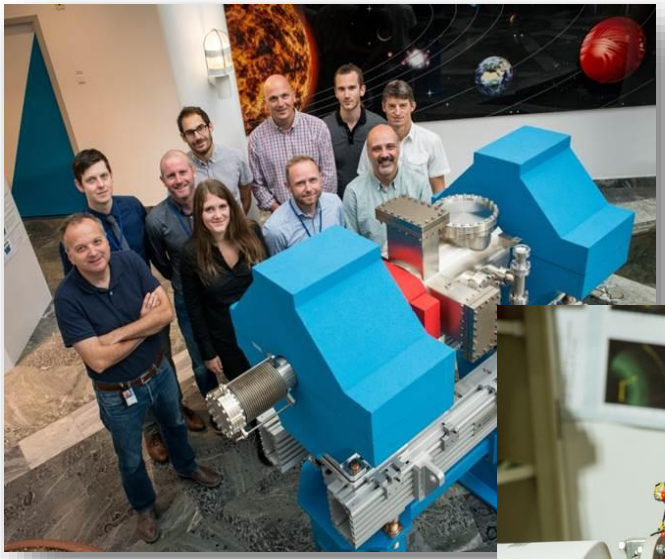
Non Host Member Countries

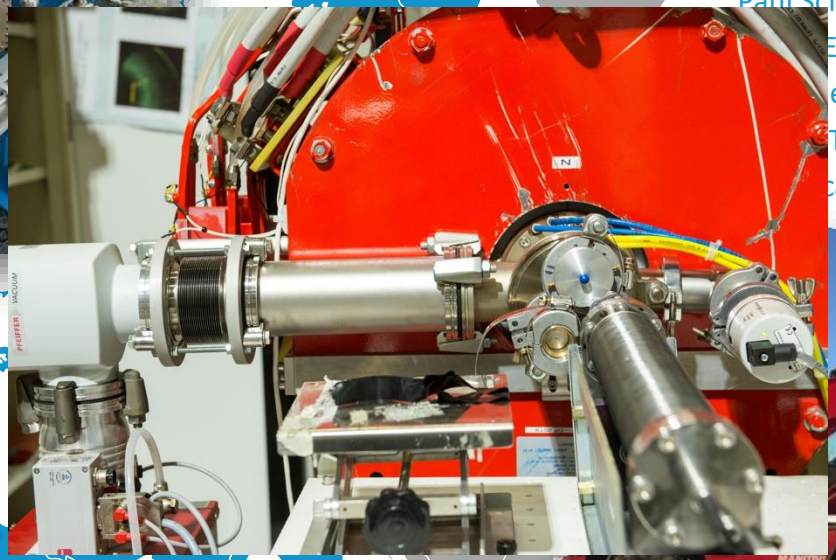
Construction 52.5% In-kind Deliverables ~ 70%
Operations 85%

<u>15 European Member and Observer Countries</u>



ESS In-kind Partners



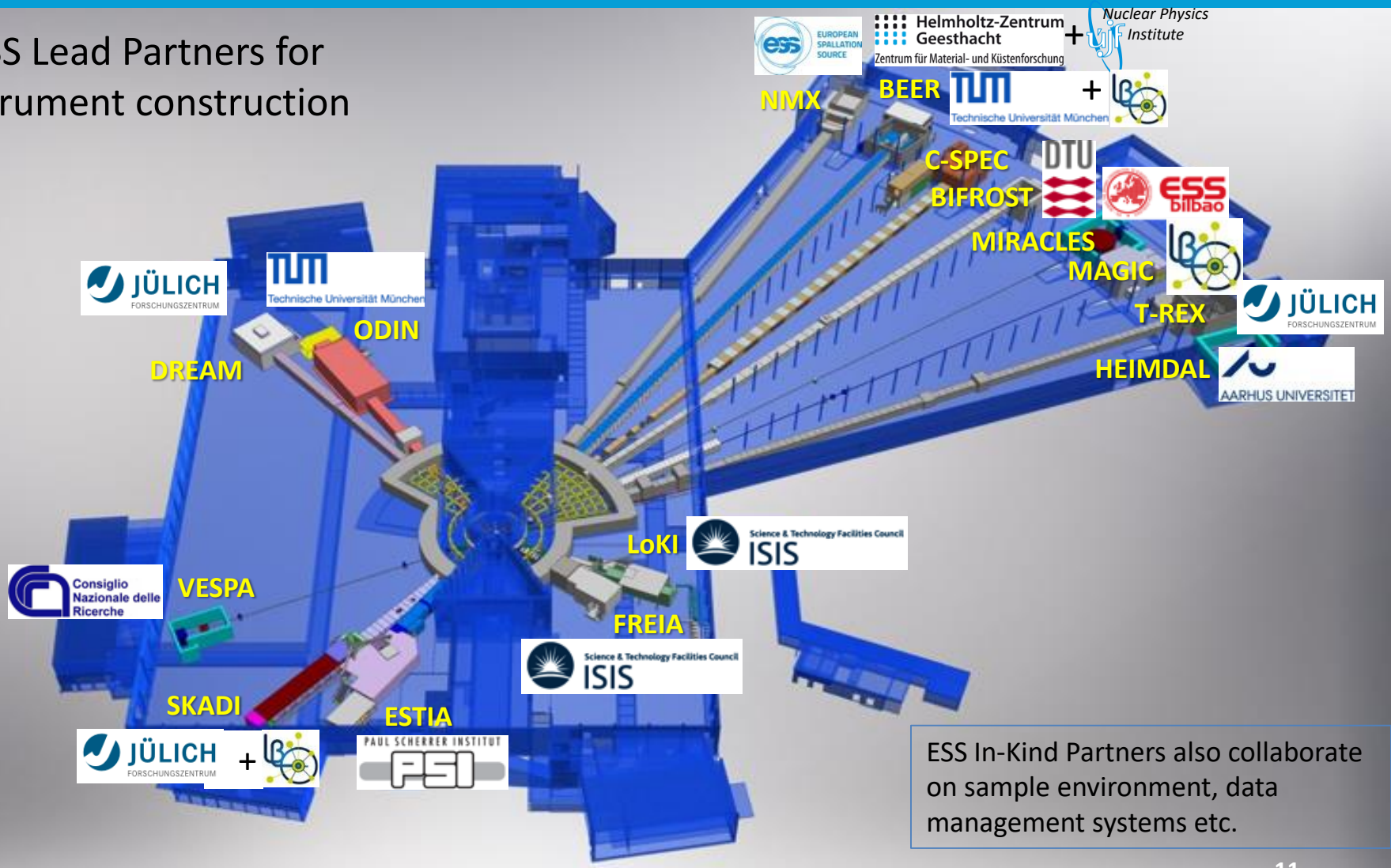


ISIS - Rutherford-Appleton Laboratory, Oxford
Laboratoire Léon Brilouin (LLB)
Lund University
Nuclear Physics Institute of the ASCR
Oslo University
Paul Scherrer Institute (PSI)
Electronic Group (PEG)
e University
Technical University
cal University of Denmark (DTU)

Forschungszentrum Jülich
Helmholtz-Zentrum Geesthacht
Huddersfield University
IFJ PAN, Krakow
INFN, Catania
INFN, Legnaro
INFN, Milan
Institute for Energy Research (IFE)

NSS Neutron Instrument positions

ESS Lead Partners for instrument construction



ESS In-Kind Partners also collaborate on sample environment, data management systems etc.

ESS Instrument Layout (December 2016)

Data Management and Software Centre

COBIS, Copenhagen University North Campus

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Provide world leading scientific software and scientific computing support for neutron scattering at ESS

Scientific Software

ESS experiment control system, Data acquisition, Data correction software, visualization, and software to model and analyze experimental data sets.

Data center operations

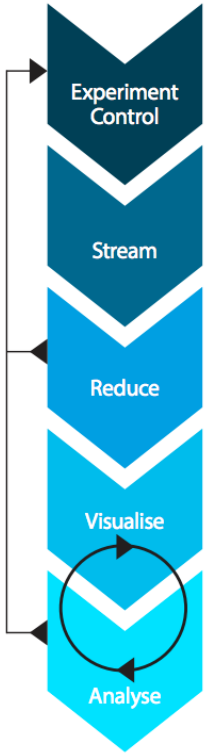
Store and catalogue ESS datasets, provide ESS users remote access to their data, computing for live data correction, and analysis software during and after experiments.

User support

Support ESS users with data treatment and analysis.

From Lund to Copenhagen, and Back Again

The figure illustrates a typical data flow for a neutron scattering experiment. Each arrow in the graphic corresponds to a key area of scope within the DMSC.



The team of users configure the components of the instrument and sample environment using an experiment control system that interfaces with the neutron instrument components through the ESS EPICS network.

Data are taken in event mode whereby the individual detector counts are tagged with useful experimental metadata to create a dataset. The list of events and metadata are aggregated in software and broadcast over a network in a continuous stream of data that external software systems can utilise.

The raw data are transformed and corrected from the base unit of the instrument to a data type that is scientifically useful and valid. One of the key objectives of ESS is to take the large volumes of data and process them in as near to real time as possible.

The representation to the beamline users of a scientifically meaningful display of the corrected data.

A scientific model is generated in order to scientifically interpret the experimental data.

Data Flow / Experiment Control

A key objective is to build in from the start the capability for the interconnected software systems to control the experiment. The lines connecting parts of the data flow to the experiment control represent this functionality.

Iterative Workflow

The circle in the graphic represents the iterative workflow of scientific modelling and visualisation of model and experimental data that is often used.

Civil Construction Groundbreaking

September 2014


EUROPEAN
SPALLATION
SOURCE
September 2015


EUROPEAN
SPALLATION
SOURCE
September 2016


EUROPEAN
SPALLATION
SOURCE
November 2017

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Vision, Mission and Values

ESS Vision

Our vision is to build and operate the world's most powerful neutron source, enabling scientific breakthroughs in research related to materials, energy, health and the environment, and addressing some of the most important societal challenges of our time.

Mission

To do this, we commit to deliver ESS as a facility that:

- Is built safely, on time and on budget
- Produces research outputs that are best-in-class both in terms of scientific quality and in terms of socioeconomic impact
- Supports and develops its user community, fosters a scientific culture of excellence and acts as an international scientific hub
- Operates safely, efficiently and economically, and responds to the needs of its stakeholders, its host states and member states
- Develops innovative ways of working, new technologies, and upgrades to capabilities needed to remain at the cutting edge

Core Values

Excellence • Collaboration • Openness • Sustainability

ESS and Environmental Sustainability

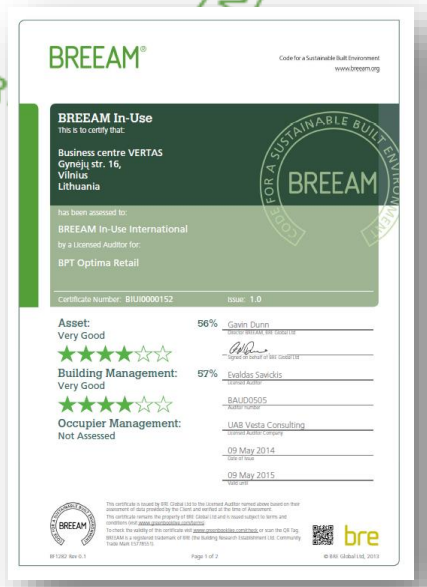
Sustainability is a core value

Initial dreams of what might be demonstrated at ESS have needed to be reconciled with what is technically achievable and affordable within a firm cost cap

- Buildings certification
- Construction site
- Energy supply
- Waste heat recovery

Buildings Certification

- Build in accordance with good environmental standards
  - insulation, low energy usage, etc.
- Original aspiration was to certify all structures according to BREEAM standards
  - However - process is quite work-intensive and not well adapted to industrial facilities
- Now pursuing certification only for offices
  - Same approach as MAX IV



“Green” Construction Site

Skanska ESS CONSTRUCTION

- Compliance with Environmental Court, water runoff, noise regulations, machines, traffic, biodiversity etc.
- No waste to landfill
- Supply chain – environmental assessment of materials

PVC

FSC

“Green” Construction Site

Skanska ESS CONSTRUCTION

- Diesel fuel 100% from renewable sources
- Community and public engagement, schools programme
- Promote increased biodiversity on finished site

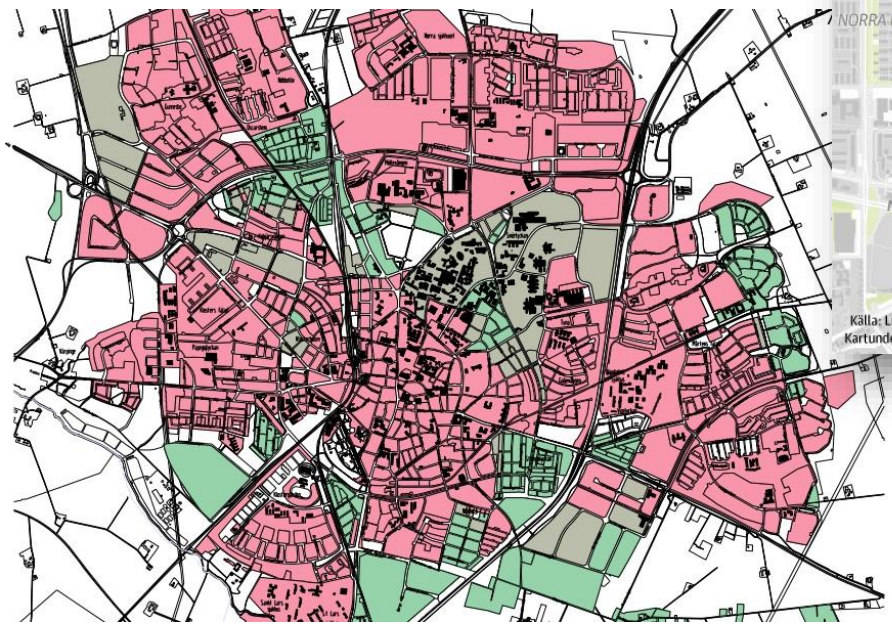
Energy Supply

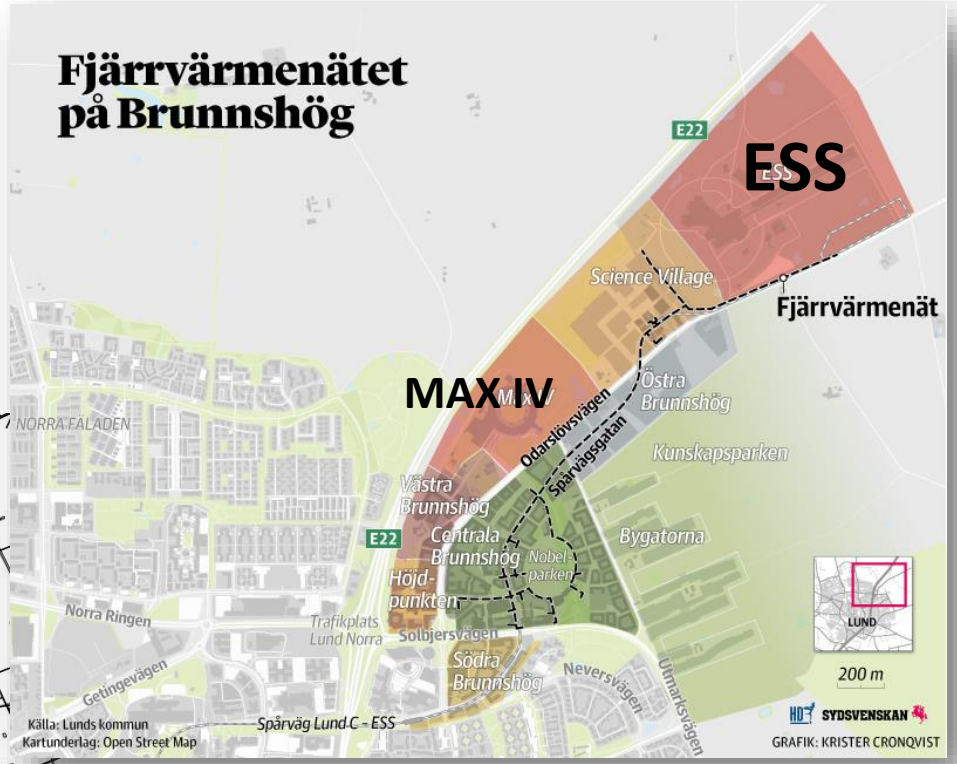
- Total grid power ~ 30MW
  (5MW accelerator power)
- Committed to purchase from 100% renewable sources
  - But makes no sense to generate our own power with a vibrant market in Sweden
  - 52% of Swedish electricity from renewable sources (highest in EU)

Waste Heat Recovery

District heating in Lund

Pink areas in map = district heating

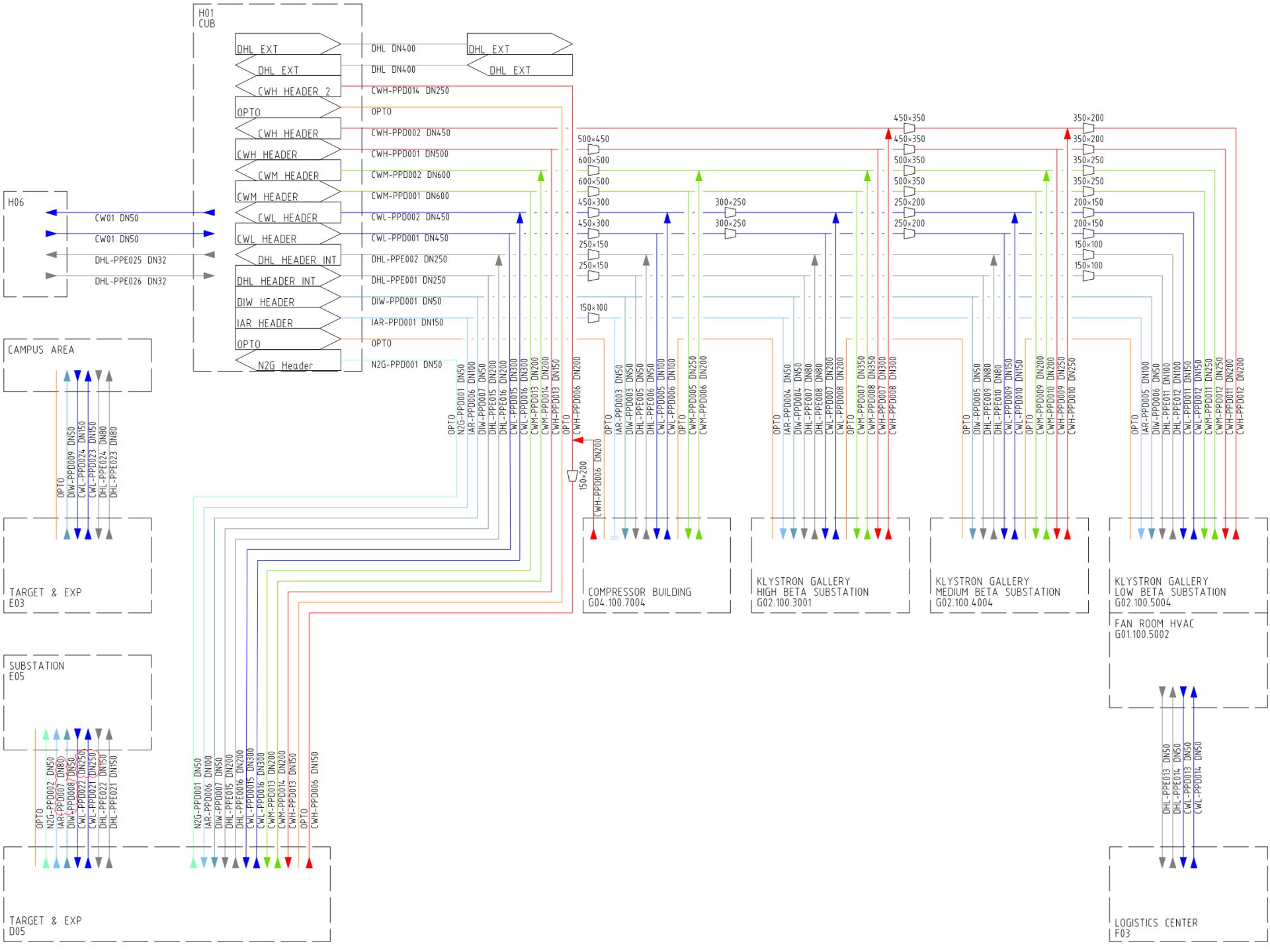




kraftringen

Waste Heat Recovery

- Industrial cooling water from accelerator, target etc.
- Primary goal – efficient operation of ESS
- Secondary goal – recovery of waste heat
- Basis of design:
  - 50% of waste heat must be recovered
  - 50% of recovered heat must be usefully transferred to district heating
  - Minimum extra power
  - Low Temperature Heat Recovery is favored
  - Requirements on water flow, purity, operations modes, etc.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DIW-PPD003 DN50
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DHL-PPE006 DN50
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CWL-PPD006 DN100
OPTO
CWM-PPD005 DN250
CWM-PPD006 DN200
COMPRESSOR BUILDING
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300×250
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IAR-PPD004 DN50
DIW-PPD004 DN50
DHL-PPE007 DN80
DHL-PPE008 DN80
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CWL-PPD008 DN200
OPTO
CWM-PPD007 DN350
CWM-PPD008 DN350
CWH-PPD007 DN300
CWH-PPD008 DN300
KLYSTRON GALLERY
HIGH BETA SUBSTATION
G02.100.3001
450×350
450×350
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DIW-PPD005 DN50
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CWH-PPD009 DN250
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MEDIUM BETA SUBSTATION
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CWH-PPD011 DN200
CWH-PPD012 DN200
KLYSTRON GALLERY
LOW BETA SUBSTATION
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FAN ROOM HVAC
G01.100.5002
DHL-PPE013 DN50
DHL-PPE014 DN50
CWL-PPD013 DN50
CWL-PPD014 DN50
LOGISTICS CENTER
F03

Technical Requirements 15/11/17

Cooling Water System

Option now adopted as Basis of Design

System	Supply temp	Return temp	Max cooling capacity
CWL	8°C	16°C (15-22 °C)	2025: 6 MW (at return temp 16°C) 2019-2025: Ramp-up 2 – 6 MW)
CWM	25°C	40°C (26-45 °C)	2025: 13 MW (at return temp 40°C) 2019-2025: Ramp-up 5 – 13 MW
CWH	25°C	80°C	2025: 5 MW 2019-2025: Ramp-up 3 – 5 MW

Implementation

- Plan to award a 40-year contract for design, construction and operation of “Central Process Systems”
- Vendor identified
- Now in technical design phase
- Will be interactive between vendor and ESS
- ESS has established a technical review team including outside experts (DESY and CERN)
- Conceptual design now signed off
- Preliminary Design in progress, review Q2-2018
- Final design will be reviewed a few months later

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Conclusions

- We have reconciled big initial ‘dreams’ with construction reality, while maintaining sustainability as a core value at ESS
  - Green construction site
  - Good environmental building standards
  - Purchase all electrical power from renewable sources
  - Waste heat recovery into district heating system
- Good examples of what is sensible and possible

- ESS is on schedule for science in 2023
- We are confident that the research done at ESS will also go on to have a major impact on the energy sector