European Spallation Source

- status with focus on the accelerator -

TIARA
Madrid 2012-06-14
Patrik Carlsson

ESS in Lund

Almost a green field site. Hotspot for Education, Science, Industry and Innovation, Synchrotron lab, but no large proton accelerator laboratory or neutron source.

ESS is a joint European project and European collaboration is essential.

European Spallation Source

- The world's leading source for slow neutrons
- Neutrons before the decade is out
- Outstanding scientific performance

Main headlines

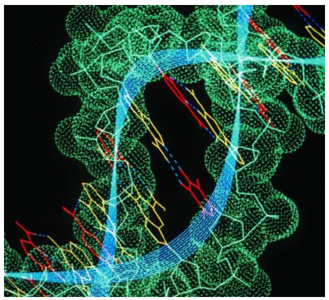
- A long pulse source (ms)
- High intensity 5 MW
- High reliability > 95%
- High safety
- Low risk
- Environmentally friendly
- Good economy

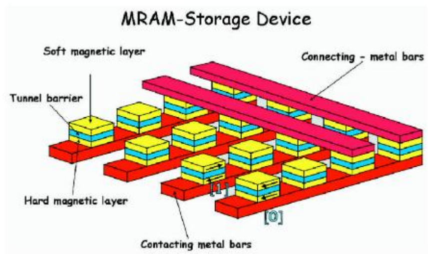
European Spallation Source

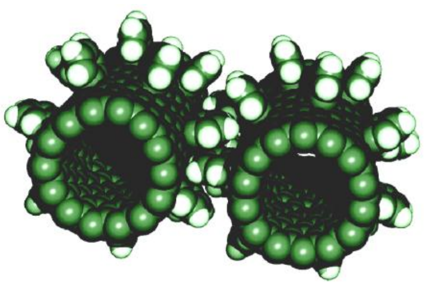
- 5 MW long pulse spallation source
  2.86 ms, 14 Hz, pulses of protons
- Cold or thermal /cold moderators
- Target decision: Rotating W,
  He gas cooling
  (water as backup)
- 22 instruments,
  could have up to 48 beam ports
- 1.479 B€ to build,
  103 M€/ y to operate (2008 prices)
- 450 - 500 employees
- Receiving 2000-3000 users / y

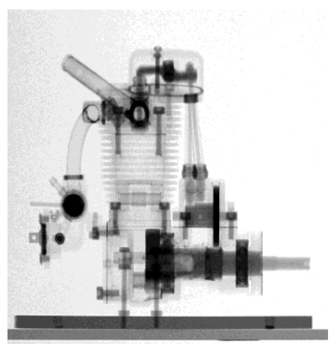
ESS – multi-science with neutrons

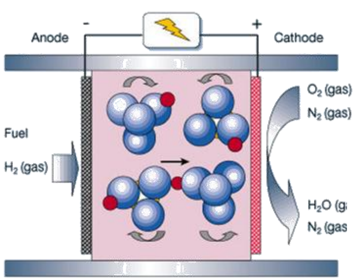
Materials science	Bio-technology	Nano science
Energy Technology	Hardware for IT	Engineering science











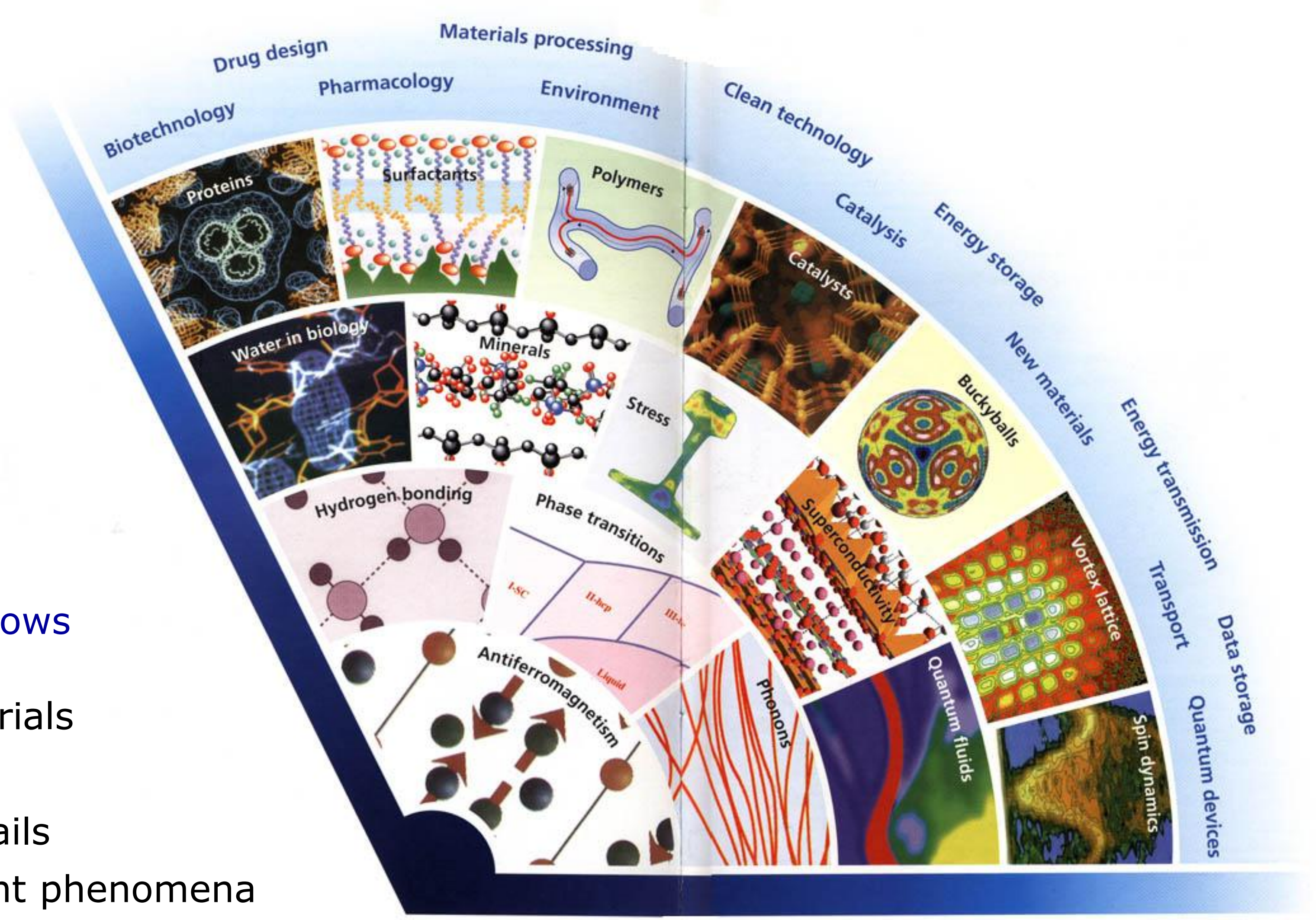
- Unique and important information on almost all materials.

- Information on both structure and dynamics simultaneously.

- Science with neutrons is limited by performance of today's neutron sources

Intensity opens new possibilities

Complexity/
Count-rate



ESS intensity allows studies of

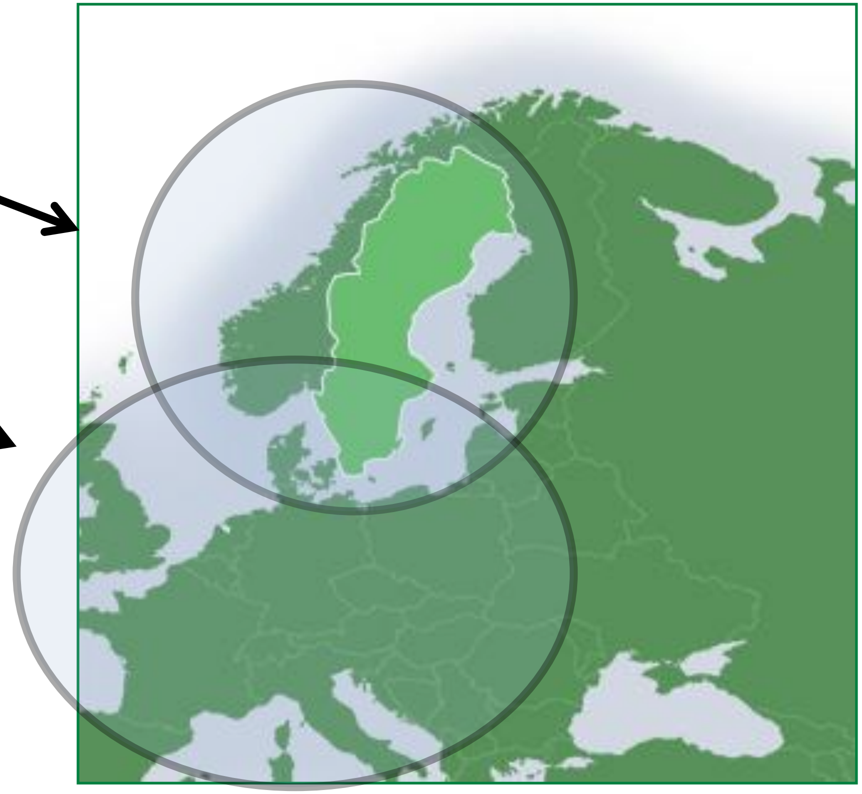
- complex materials
- weak signals
- important details
- time dependent phenomena

Details/Resolution

ESS partner countries

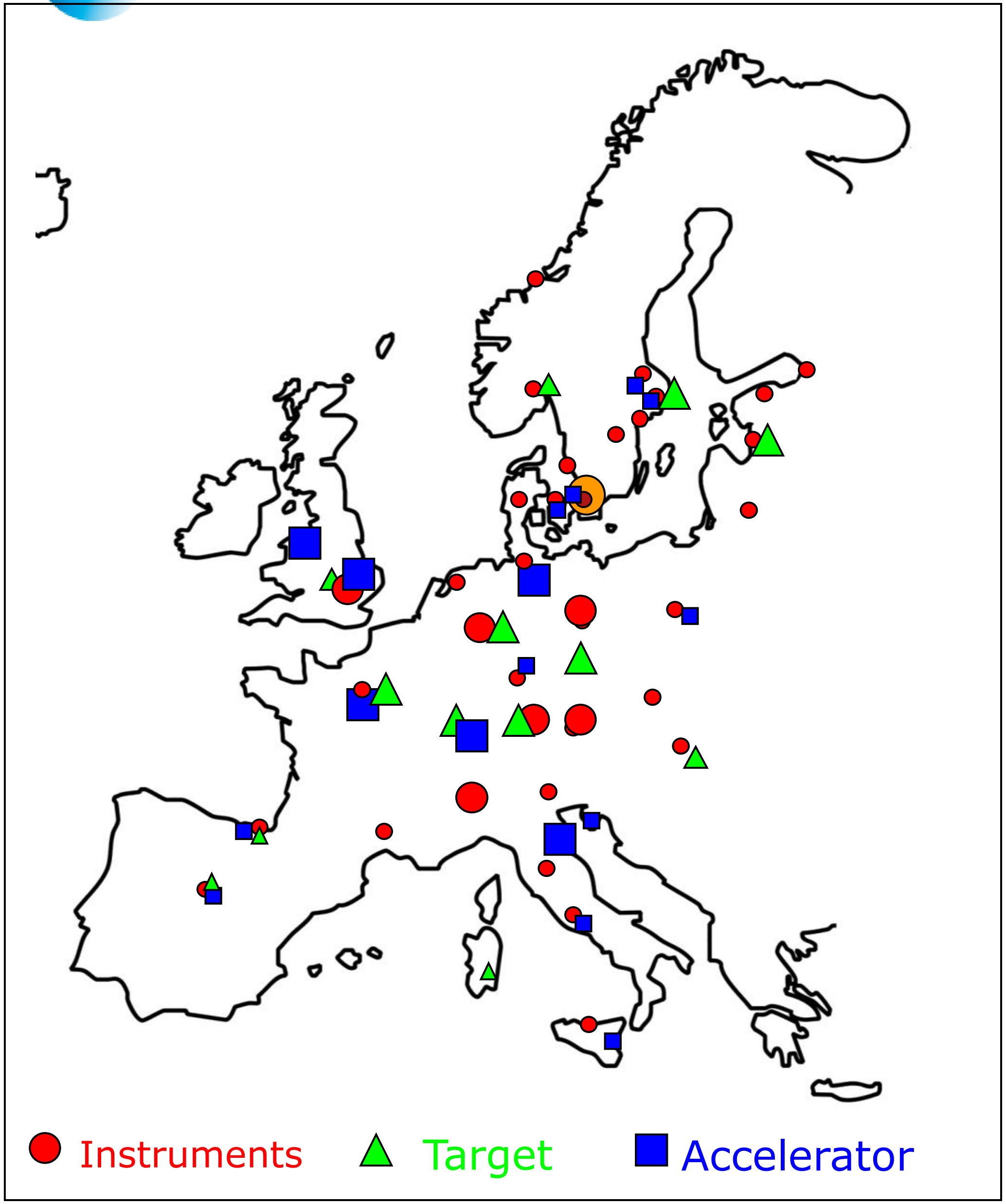
Sweden, Denmark and Norway, 50% of construction and 20% of operations costs

European partners pays the rest



- Letter of Intents from 17 countries
- Multilateral MoU for pre-construction signed in Paris February 11
- ESS AB owned by Sweden & Denmark
- "We have go the money"

ESS - a European collaboration



– Collaborations with labs and universities in partner countries.

– Technically and scientifically challenging work/parts in kind

– Access to infrastructure workshops, test stands, …

– Collaboration model based on CERN and industrial models

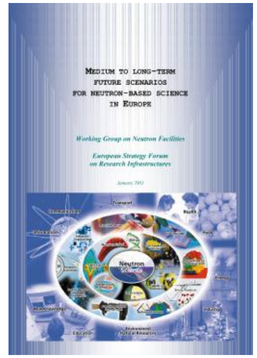
– International collaborations with SNS, J-PARC, BNL, Jlab, Fermilab, RRCAT (India)

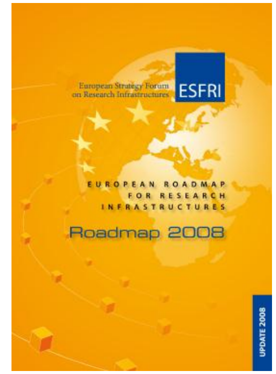
Time lines

first design

2002-2003

ESFRI Report
2003





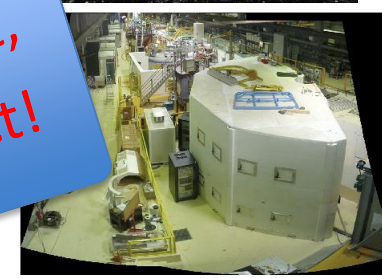
site
decision
2009

Pre-construction phase 2010-2013

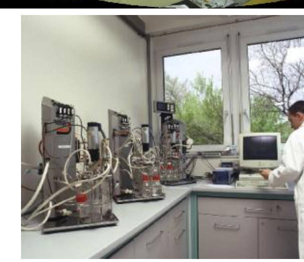
Construction phase 2013-201

Completion phase

Operations phase

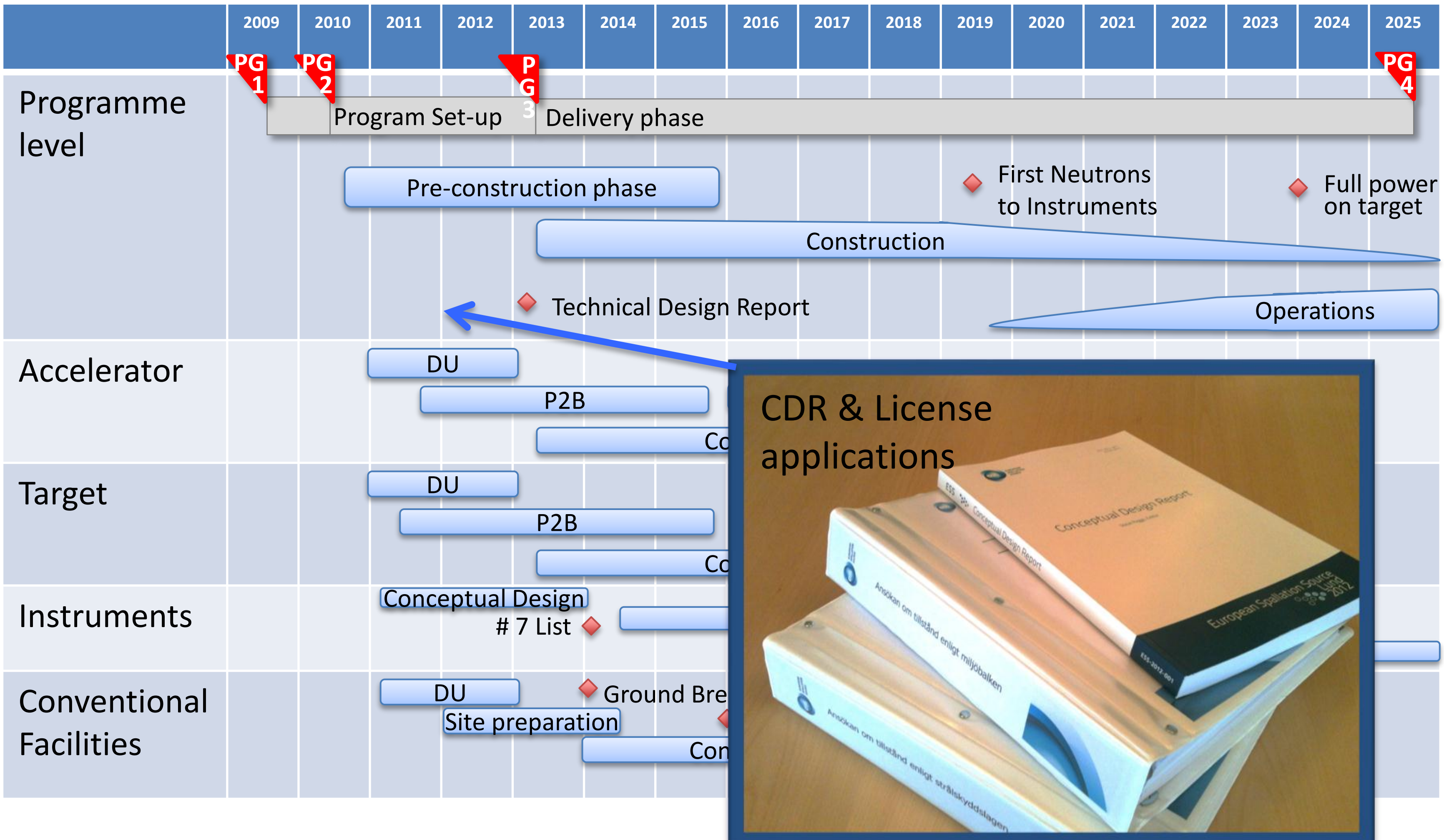


ESS is a construction project,
not a design or R&D project!



Decommissioning phase 2067-2071

ESS Master Programme Schedule



Overall Impression

Review June 2012
Close - out

- What ESS has achieved so far is very impressive and the Swedish and Danish Government are to be congratulated on supporting
- The timetable is very aggressive but should be pursued. However political buy in and the ability to recruit suitable staff in time might mean time overrun.
- The staff hired in the last year are highly motivated and bring in important expertise

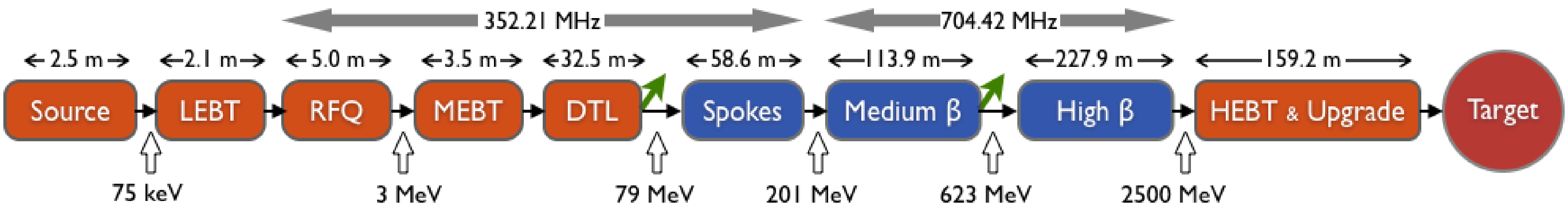
Final Conclusion

Review June 2012
Close - out

- The project is about to go critical and it is in good shape
- There are no show stoppers
- There is much to do
- Be prepared for future demands and storms will lie ahead
- Focus on quality and excellence not the cheapest option. Downtime is expensive and skimping early causes big problems downstream

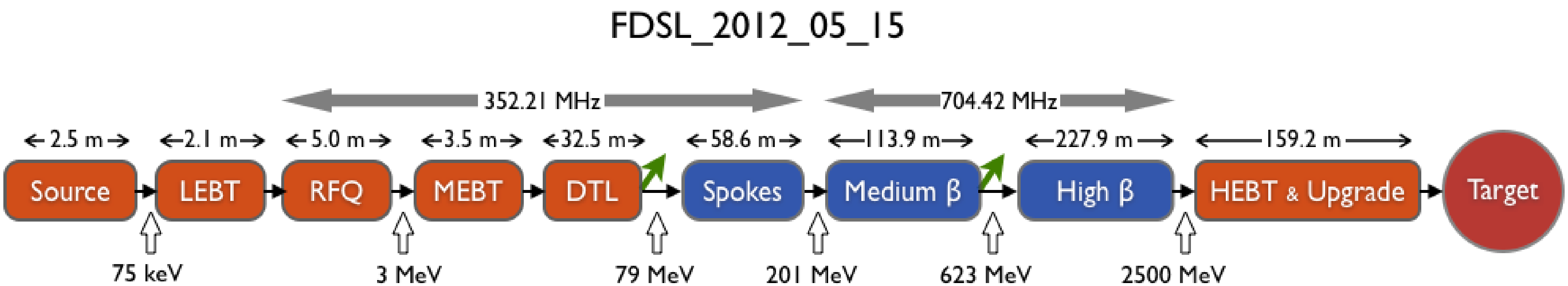
The ESS Accelerator

FDSL_2012_05_15



	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric β	# of Sections	Temp (K)
LEBT	2.05	75×10^{-3}	--	--	--	≈ 300
RFQ	4.95	75×10^{-3}	352.21	--	1	≈ 300
MEBT	3.53	3	352.21	--	--	≈ 300
DTL	32.58	3	352.21	--	4	≈ 300
Spoke	58.46	79	352.21	0.50	14 (2C)	≈ 2
Medium Beta	113.84	201	704.42	0.67	15 (4C)	≈ 2
High Beta	227.86	623	704.42	0.92	15 × 2 (4C)	≈ 2
HEBT (Projection)	158.66	2500	--	--	--	--

The ESS Accelerator



- High reliability at high power–
  - high maintainability and fault tolerance
  - low losses
  - low peak current 50 mA and SC technology
- One measured technical risk : Spoke cavities – fall back available LINAC4
- A reasonable, just beyond state of the art, non-controversial design

  Very similar technology to other HPPA:s such as Project X, SPL, …

  Prototyping and tests started of cavities, cryomodules, modulators, ….

Accelerator Design Update

Romuald Duperrier
(30 years ago)

Steve Peggs

Cristina Oyon

David McGinnis

Work Package (work areas)

1. Management Coordination – ESS AB (Mats Lindroos)
2. Accelerator Science – ESS AB (Steve Peggs)
(**3.** Infrastructure Services – now ESS AB!)
4. SCRF Spoke cavities – IPN, Orsay (Sebastien Bousson)
5. SCRF Elliptical cavities – CEA, Saclay (Guillaume Devanz)
6. Front End and NC linac – INFN, Catania (Santo Gammino)
7. Beam transport, NC magnets– Århus University (Søren Pape-Møller)
8. RF Systems – ESS AB (Dave McGinnis)
19. P2B: Test stands – Uppsala University (Roger Ruber)

Mats Lindroos

Guillaume Devanz

Roger Ruber

UPPSALA UNIVERSITET

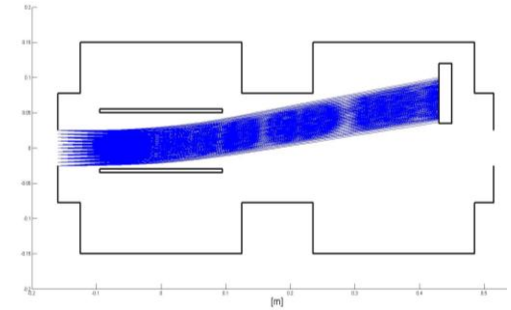
Søren Pape Møller

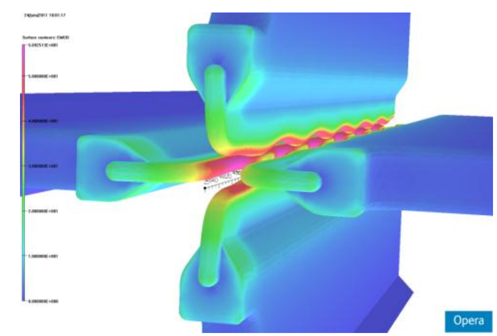
Santo Gammino

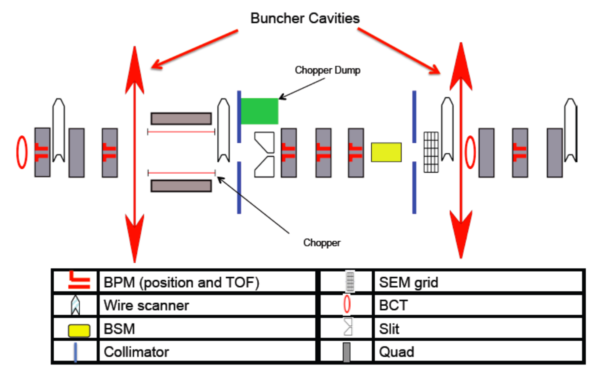
Sebastien Bousson

Ion source and NC linac

- Prototype proton ion source operational (and under further development) Catania
- RFQ tests for ESS conditions at CEA
- RFQ design ready for 5 m IPHI like RFQ
- MEBT design work at ESS Bilbao
- DTL design work at ESS and in Legnaro







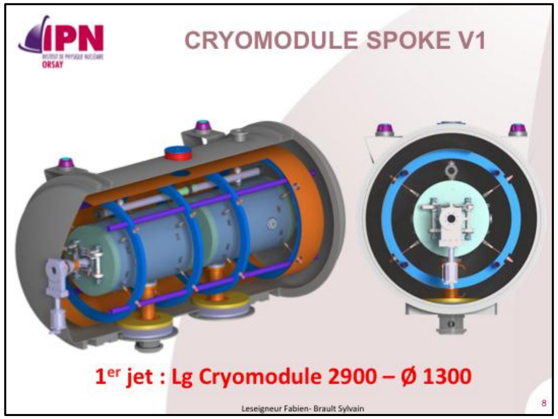
CARE

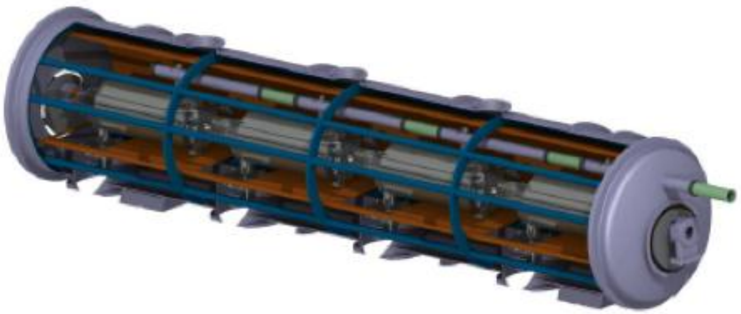
EURISOL Design Study

EuCARD

Cryomodules (Spoke and Elliptical)

Spokes → ESS specific spoke resonator CM design and proto at IPNO





Elliptical → ESS specific design and proto at CEA and IPNO since April 2012
→ R&D oriented design and proto at CERN in collaboration with ESS since 2010
→ Identified the preferred conceptual design
→ Heat load estimate based on the proposed tunnel configuration

EURISOL Design Study EuCARD CRISP The Cluster of Research Infrastructures for Synergies in Physics

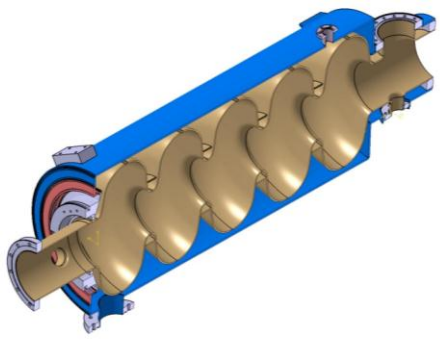
Elliptical cavities

Key Achievements

- Order of two prototype cavities is undergoing
- Nb material for two prototype cavities has been provided
- Clean room tooling design for prototypes 50% completed
- Medium beta PhD started at Lund-U
- CM activities:
  - Combined effort of Orsay/Saclay to design and build a 4-elliptical cavity cryomodule is under discussion
  - Cryoload evaluation(C. Darve presentation)

Planned Key Activities

- Plan cryomodule prototyping activities in Orsay/Saclay



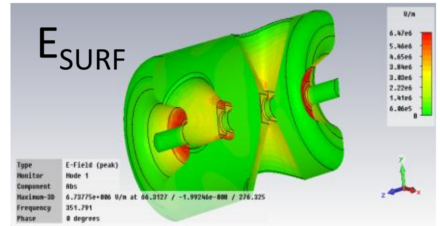
Technical Risks & Issues

- Study of HOM effects on the beam dynamics and RF dissipations not available yet
  - HOM Damping requirements not available to guide the HOM coupler study.
  - No evaluation of HOM cryoload at this stage

beta	Eacc VT (MV/m)	Eacc Linac (MV/m)z	Qo @ nominal Eacc
0.70	17	15	5e9
0.90	20	18	6e9

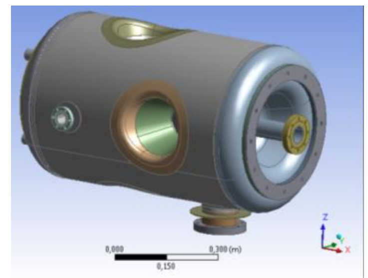
Spoke cavities

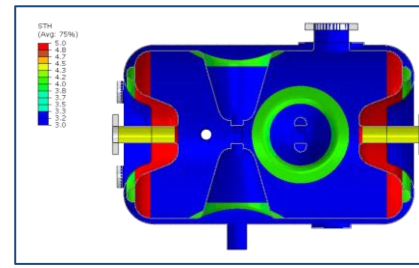
- Spoke cavity RF design:
  - Double spoke beta 0.5
- Spoke cavity mechanical design
- Power coupler
  - EURISOL design

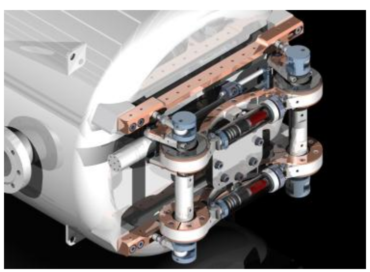


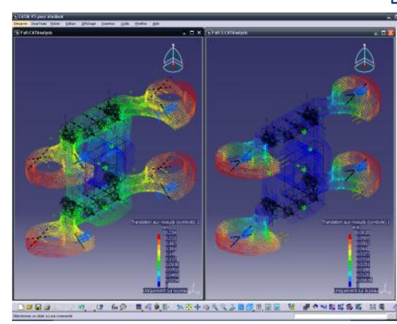
Cavity RF parameters

R/Q	426 Ω
G	130 Ω
Q_o at 4K	$2.6\ 10^9$
Q_o at 2K	$1.2\ 10^{10}$
E_{pk} / E_{acc}	4.43
B_{pk} / E_{acc}	7.08



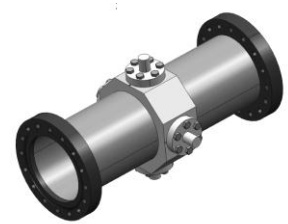






CARE EURISOL Design Study EuCARD Tiara

Beam Diagnostics



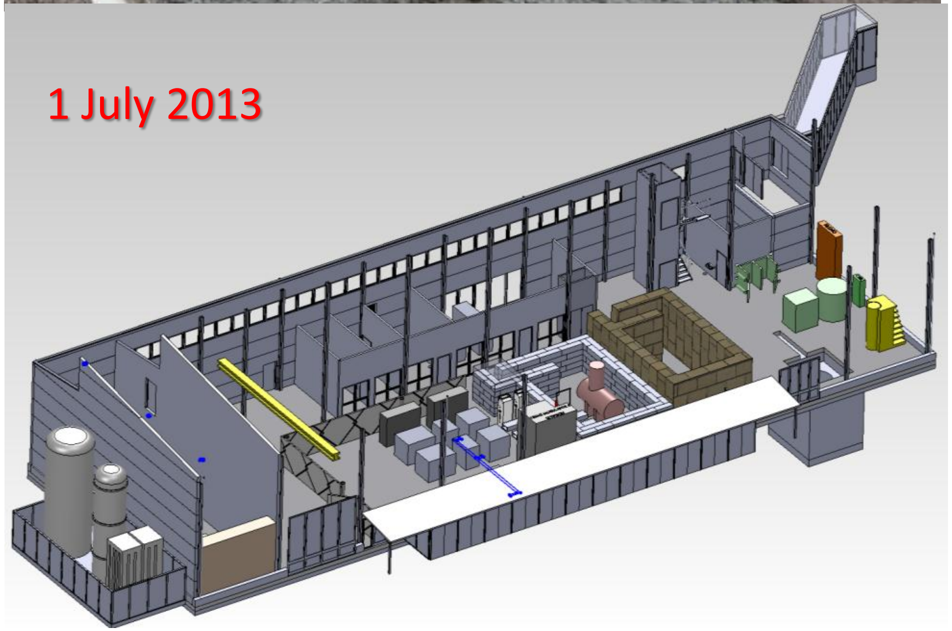
- Built a strong core diagnostics group
  - 6 team members in Lund (one currently on leave)
  - 3 open positions currently being filled (two financed by EC)
  - 1 additional position in 2012 staff plan will be advertised soon.
- Requirements documented (may evolve with linac design)
- Preliminary interfaces with e.g. Machine Protection System defined
- Have system layout (will evolve with linac design)
- Started prototyping activities (e.g. BPMs)

First Compilation Available Test Stands

Name	Institute	Country	Type	Status	Access	Cryostat	Frequency 352 MHz	704 MHz	1.3 GHz	other	Bunker	Cryogenics	Comments
Vertical Cryostat													
DESY	DESY	Germany	cavities	existing	XFEL	vertical			X			yes	
Milan	INFN LASA	Italy	cavities	existing		vertical			X		no	yes	0.5 - 1.3 GHz
Daresbury	STFC	UK	cavities	existing		vertical	??					yes	VTS ID=390mm
SupraTech	CEA Saclay	France	cavities	existing		vertical		200 W CW	200 W CW	80 kW CW, 4.2-8.6GHz		yes	0.35 - 0.7 m
SupraTech	IPN Orsay	France	cavities	existing		vertical	X	X	X			yes	
SM18	CERN	Switzerland	cavities	existing	LHC, SPL	vertical		X		400 MHz		yes	
Horizontal Cryostat													
CHECHIA	DESY	Germany	cavities	existing		horizontal			X			yes	
CryHoLab	CEA Saclay	France	cavities	existing		horizontal		X			yes	yes	
SupraTech	IPN Orsay	France	cavities	existing		horizontal	10 kW CW	80 kW CW				yes	planned 2.8MW@352 MHz
HoBiCat	HZ Berlin	Germany	cavities	existing	closed ??	horizontal			X			yes	
FREIA	UU	Sweden	RF system	2013		horizontal	400 kW				yes	yes	
Cryomodules													
Saclay	CEA Saclay	France	modules	existing			X	X			yes	yes	
CMTB	DESY	Germany	modules	existing	FLASH, open				X		yes	yes	1 bunker
AMT	DESY	Germany	modules	2012	XFEL, open				X		yes	yes	4 bunkers
Legnaro	INFN LNL	Italy	modules	existing			X				yes	no	
Bilbao	ESS Bilbao	Spain	modules	planned			X					no	
Linac4 TS	CERN	Switzerland	modules	existing	Linac4		X				no	no	
SM18	CERN	Switzerland	modules	existing	LHC					400 MHz	yes	yes	
SM18	CERN	Switzerland	modules	2013	SPL			1.5 MW			yes	yes	
Diamond	Diamond	UK	modules	existing	closed					500 MHz	yes	yes	access can be discussed
RAL	RAL	UK	modules	construction	closed		X						ISIS
Others													
IPHI	CEA Saclay	France	proton injector	existing			X				yes	no	100 mA CW, RFQ test
SupraTech	CEA Saclay	France	power couplers	existing			X	80 kW CW	1.5 MW		yes	no	
LAL	LAL Orsay	France	power couplers	existing					X				
Catania	INFN	Italy	ion source	existing								no	

Uppsala Test Stand

- FREIA hall
  - ground breaking 14 May 2012
  - hall ready by 1 July 2013
- 352 MHz source choice
  - report delivered 16 May 2012 (awaiting approval ESS)
  - preparing detailed specs for tendering
- Cryogenics
  - liquefier deadline 20 June 2012
  - starting test cryostat design
- Installation and commissioning
  - preparing detailed planning



Conclusions

- All staff at ESS recruited from Europe have been working with (or even financed through) a European Commission supported project
  - Also to be mentioned are the many Marie-Curie networks which haven't been quoted on previous pages
- The ESS accelerator is based on on-going R&D in Europe, all of it has some link to EC research programs
- The ADU collaboration was set up through a network born out of EC research programs
- ESS is benefitting from increased mobility of staff

ess

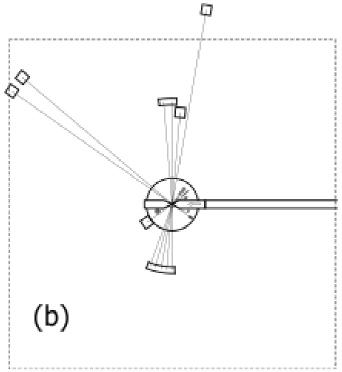
Pulse parameter adjustment

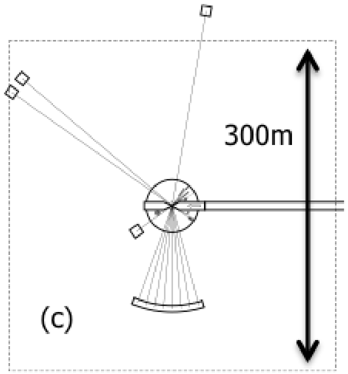
STC Baseline decision Feb 2011: 20 Hz rep rate and 2 ms pulse length, may be adjusted to lower frequencies and longer pulses later.

Optimising for science output: Longer pulses at lower rep rate will increase scientific performance at similar peak current in accelerator.

ESS Studies, advice from SAC/TAC:

- Improved performance for most instruments
- Better instrument layout, simplified/cheaper instruments
- Risk of cost increase for accelerator 15 M€, maintained reliability
- Cost savings on conventional facilities 12 M€

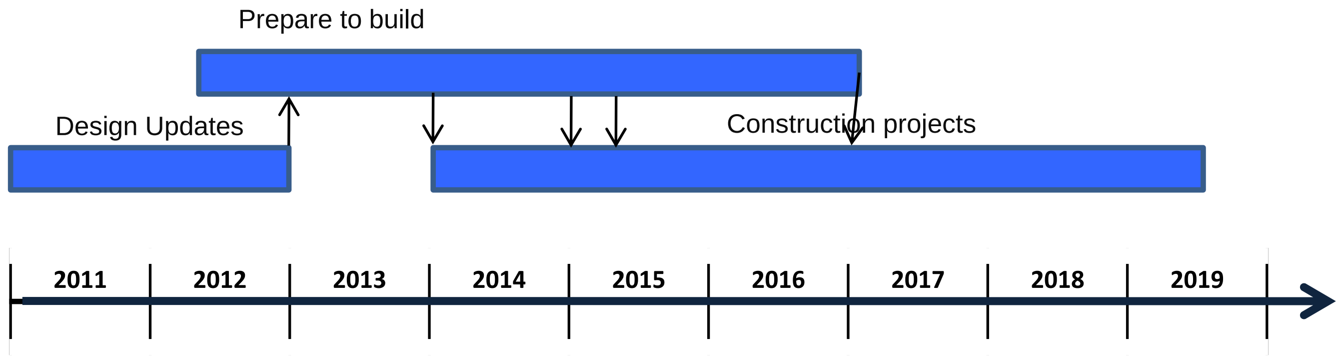




STC Baseline decision Jan 2012: 14 Hz rep rate and 2.86 ms pulse length

Accelerator sub-project goals

- Accelerator Design Update (ADU) sub-project:
  - TDR base on reviewed requirements, draft interface control documents, first cost estimate and a construction plan
- Accelerator Prepare to Build project:
  - Prototyping, Testing, Specifications for construction and Interface Control Documents reviewed
- Accelerator construction project:
  - Construction, testing, installation and commissioning of accelerator up to target



ESS accelerator

ESS **accelerator** high-level technical objectives:

5 MW long pulse source
- -2.86 ms pulses
- -50 mA pulse current
- -14 Hz
- -Protons (H+)
- -Low losses
- -High reliability, >95%
- -Low heat loss cryostats for minimum energy consumption
- -Flexible design for future upgrades

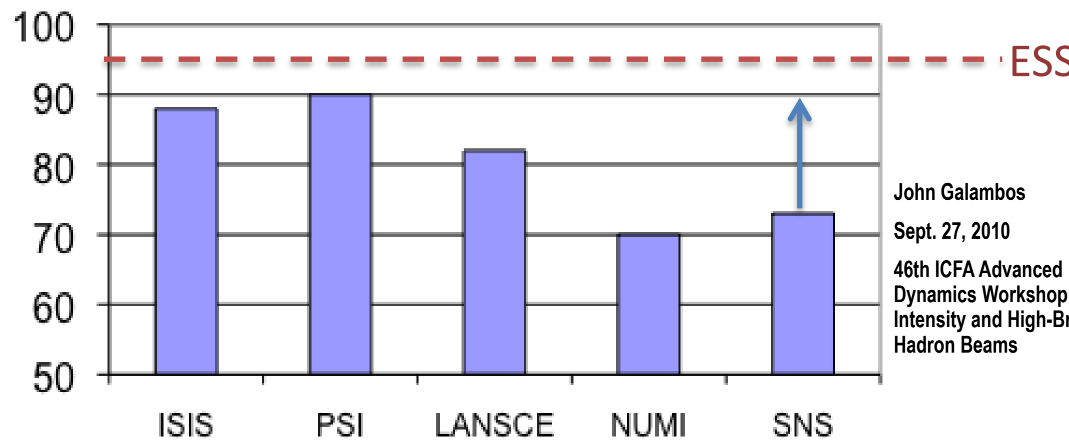
Reliability/Availability

- Achieving *95% availability* is a key goal for ESS

- Working facility wide

- Spend money where it gives users the reliability/availability needed for best science.

Availability of existing facilities

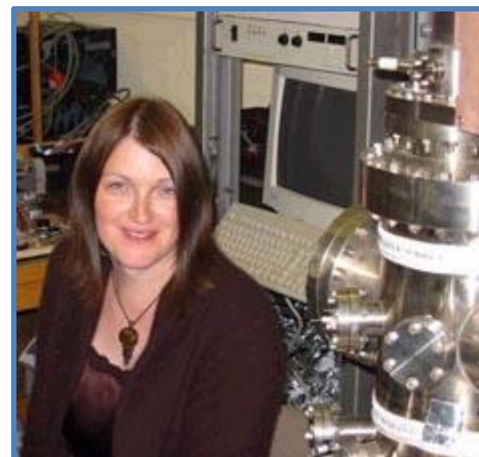


John Galambos
Sept. 27, 2010
46th ICFA Advanced Beam Dynamics Workshop on High-Intensity and High-Brightness Hadron Beams

$$Availability = \frac{Mean\ time\ to\ failure}{Mean\ time\ to\ failure + Mean\ time\ to\ recover}$$

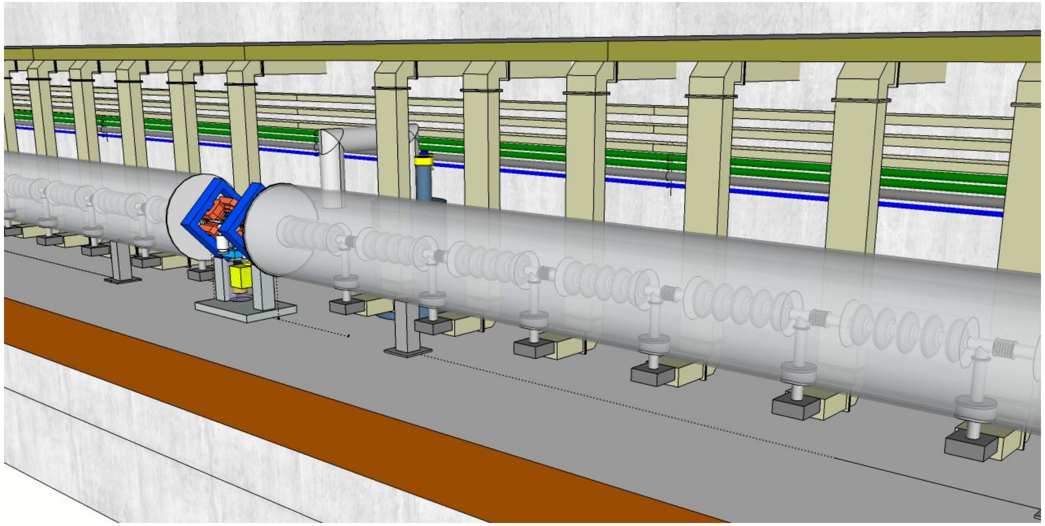
- Fault tolerant system
- Redundancy
- Maintenance/ Operations schedule

- Easy maintenance
- Space in RF gallery
- Spares
- Diagnostics

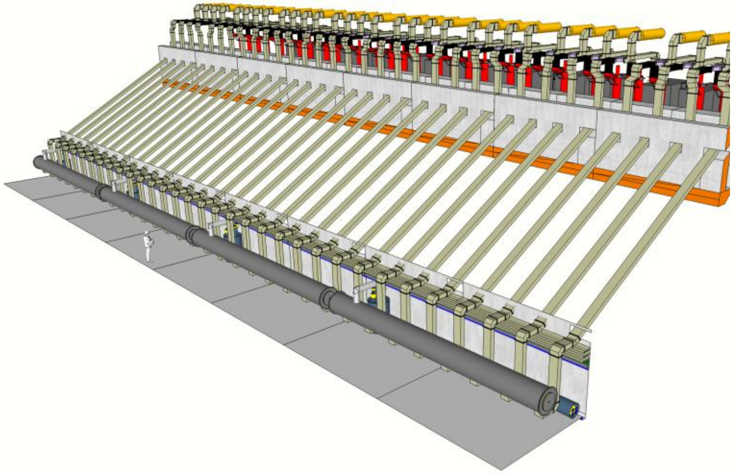


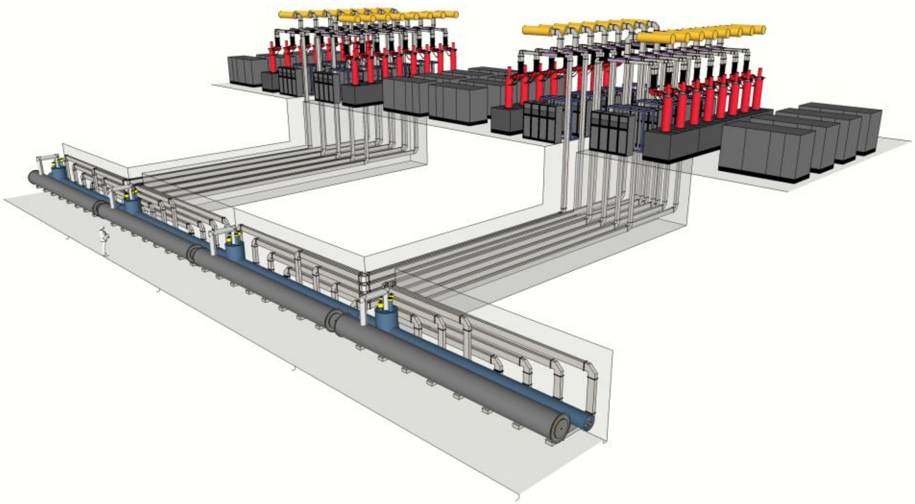
Rebecca Seviour,
RF physicist

Reliability/Availability



- One klystron per cavity for fault tolerance
- Two klystrons per modulator for space
- Minimise radiation to allow repair during operation



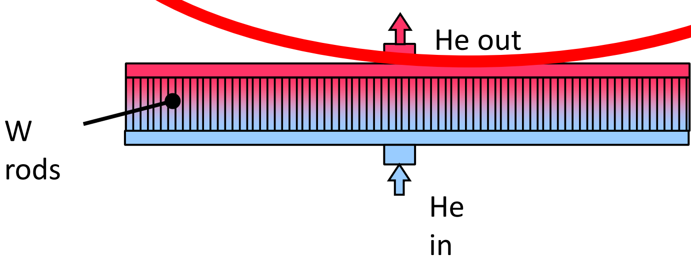


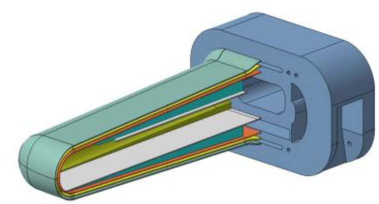
Target Station

Target Station Design Concept: Rotating wheel of tungsten

Rotating Solid		Liquid metal
He-cooled Tungsten	Water-cooled Tungsten	Lead Bismuth Eutectic

Hg as reference





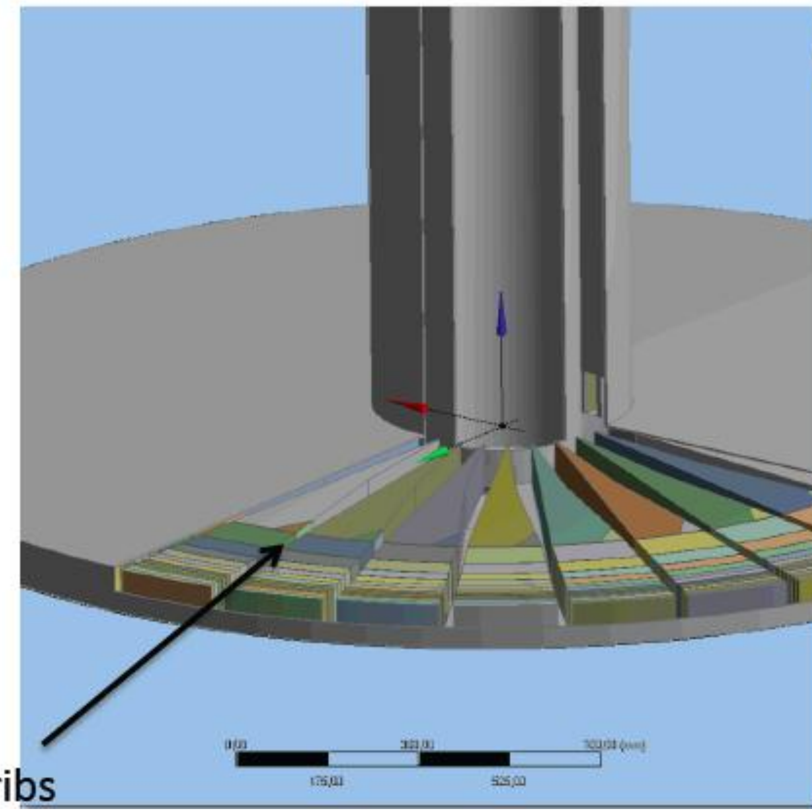
University of Latvia Institute of Physics · PSI · Forschungszentrum Dresden Rossendorf · CRS4 · European Spallation Source · ESS Bilbao · Jülich Forschungszentrum · KIT Karlsruhe Institute of Technology · Science & Technology Facilities Council ISIS

Close to 40 FTE/y, in-house and in collaboration

Target Station

Target Geometry (first baseline)

- 2.5 m diameter
- 33 sectors
- Tungsten vertical plates with cooling channel in between
- Similar for water and helium cooling



Target cooling

Results from studies:

- Both Helium and water cooling options can be made to work at ESS.

- Helium cooling offers best neutronic performance and easiest safety.

Main technical/safety points:

- Helium problems – dust, flow instabilities, leakage – are managable.

- Water has for ~5 MW potential accidents which requires emergency cooling.

Risks are:
- Long and complex licensing
- Nuclear facility classification

Schedule, costs, performance, operations

- Environmental Court: Choose most environmentally friendly of comparable solutions. Water cooling is licensable if helium cooling is shown to be impractical.

Conclusion:

TAC support

- Full speed ahead on helium cooling as baseline.
- Water cooling as backup (develop so that emergency cooling is not required).

Moderators and reflector

- Optimising neutronic performance for best science

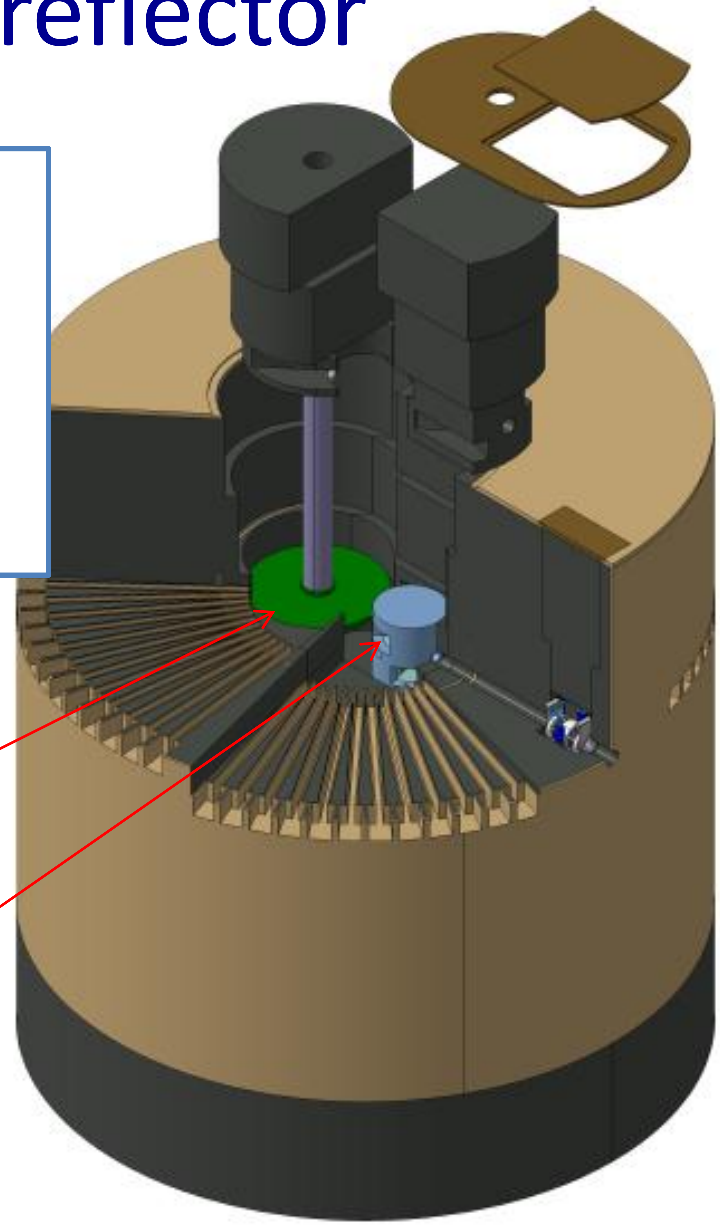
- Cross functional work to reach baseline for
  TMR assembly and beam extraction

- Innovation and optimisation for TMR for
  the lifetime of ESS – large gains possible!

Cut of target monolith during target replacement:

Target wheel (7 t, replaced every ~ 5 y)

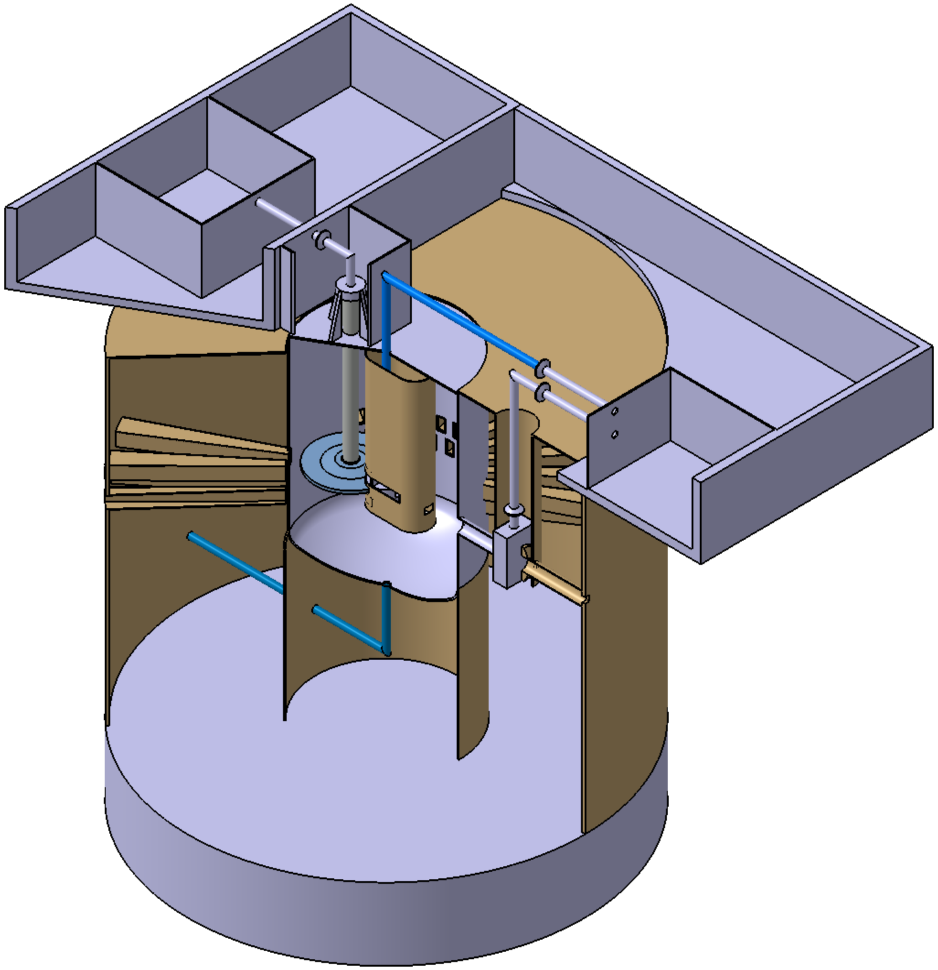
Moderator-reflector plug (10 t, replaced every ~ 1 y, shown in position ready for vertical extraction)



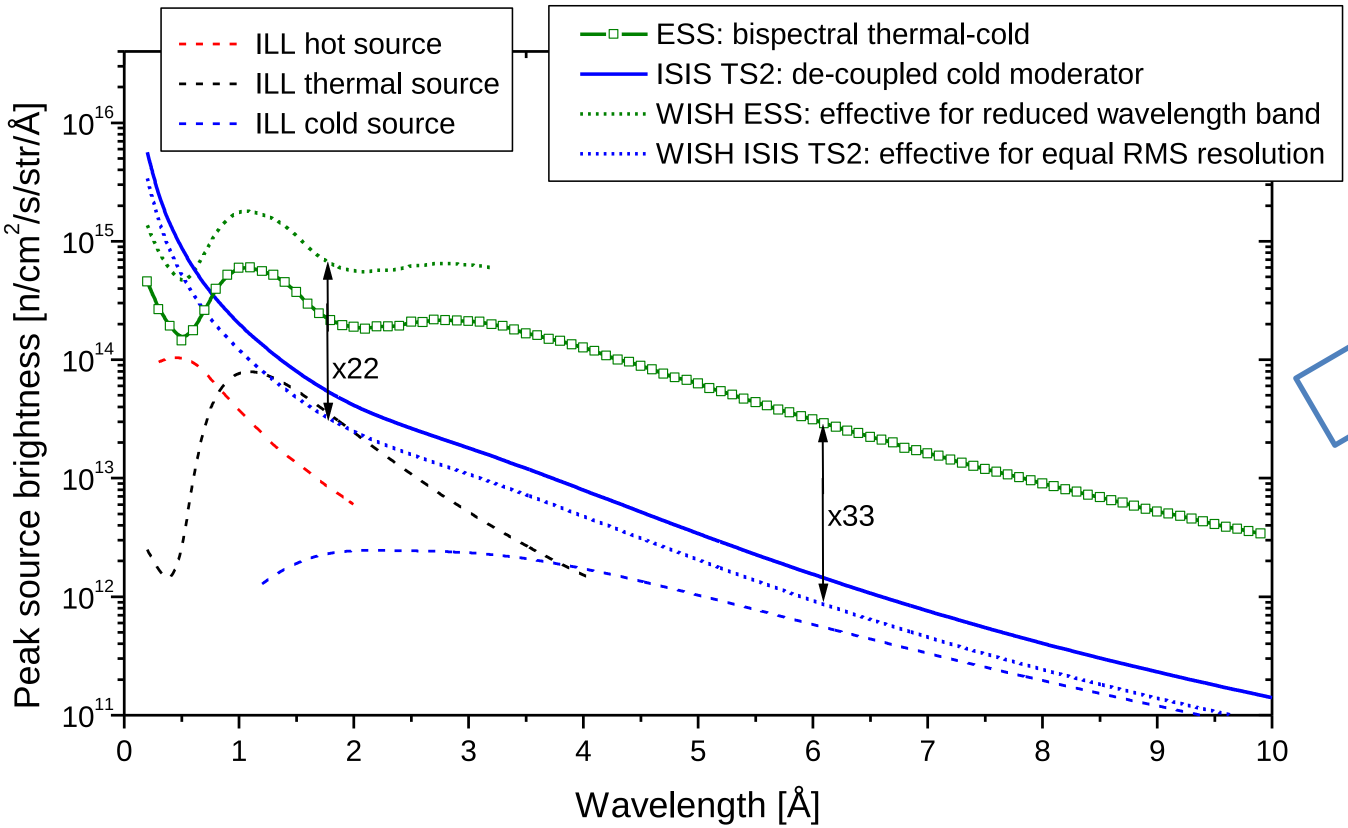
Target Station progress

Future work, main points:

- Design Update launch
- Engineering design
  Detailed safety studies
  Performance optimisation
- Planning for P2B
  - Prototyping
    (He –loops KIT)
  - Mock ups and test stands
- Beam extraction –
  very important for
  scientific performance



Moderators and reflector

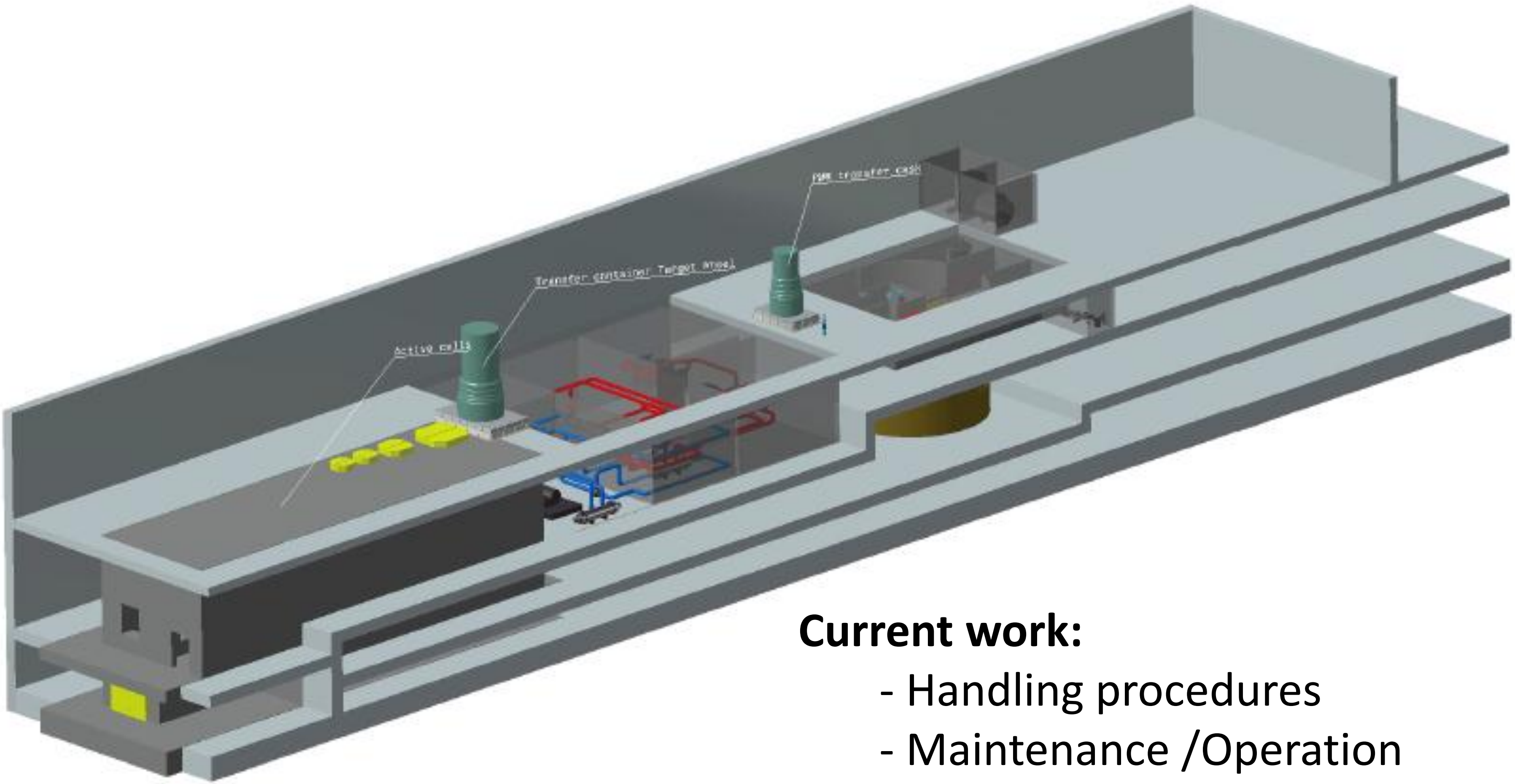


See Feri's poster

- ESS will be world leading for cold and thermal neutrons

- Complementary with other sources - better for hot neutrons.

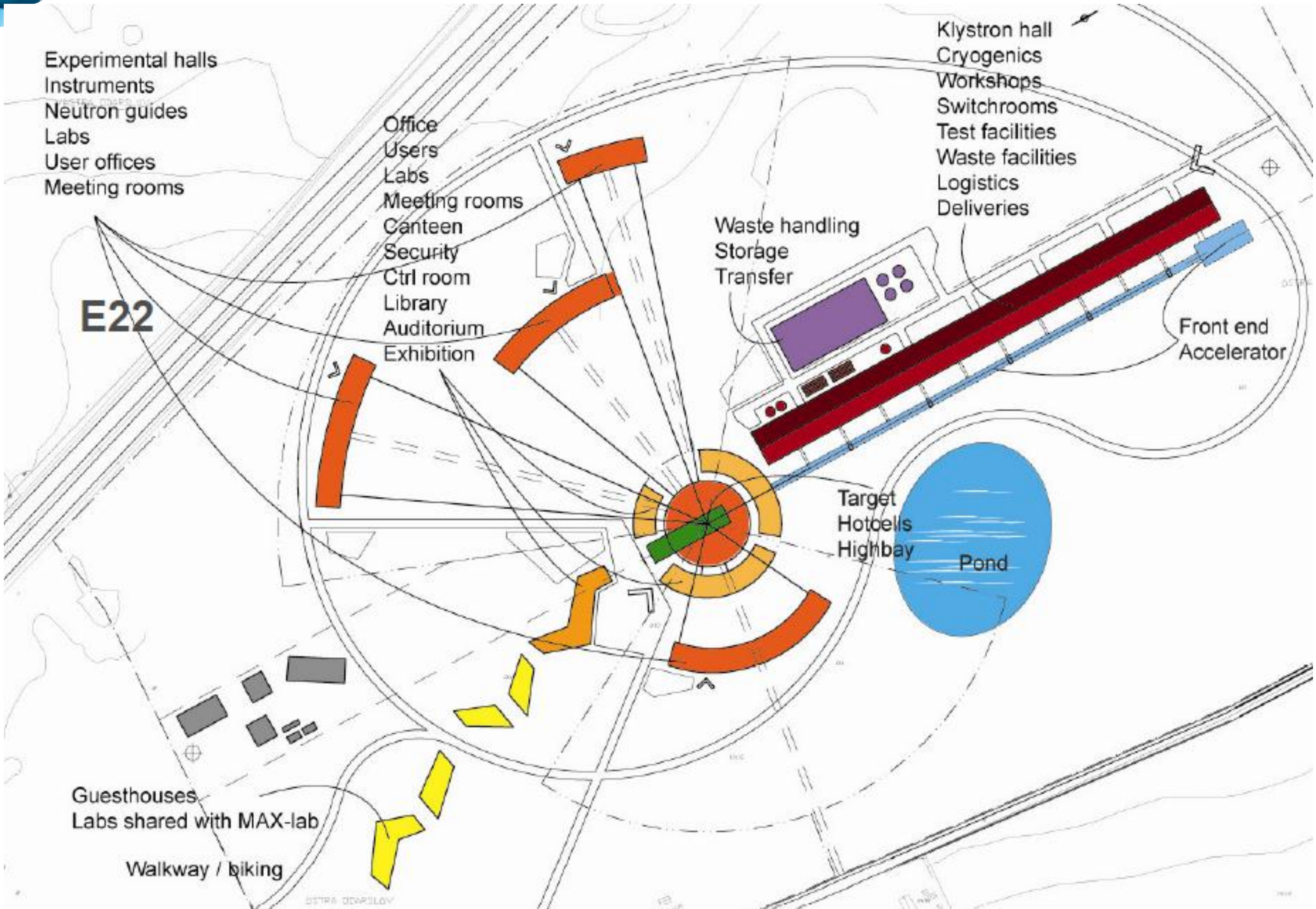
Target station layout



Current work:

- Handling procedures
- Maintenance /Operation
- Handling of active components
- Redundancy of systems
- …

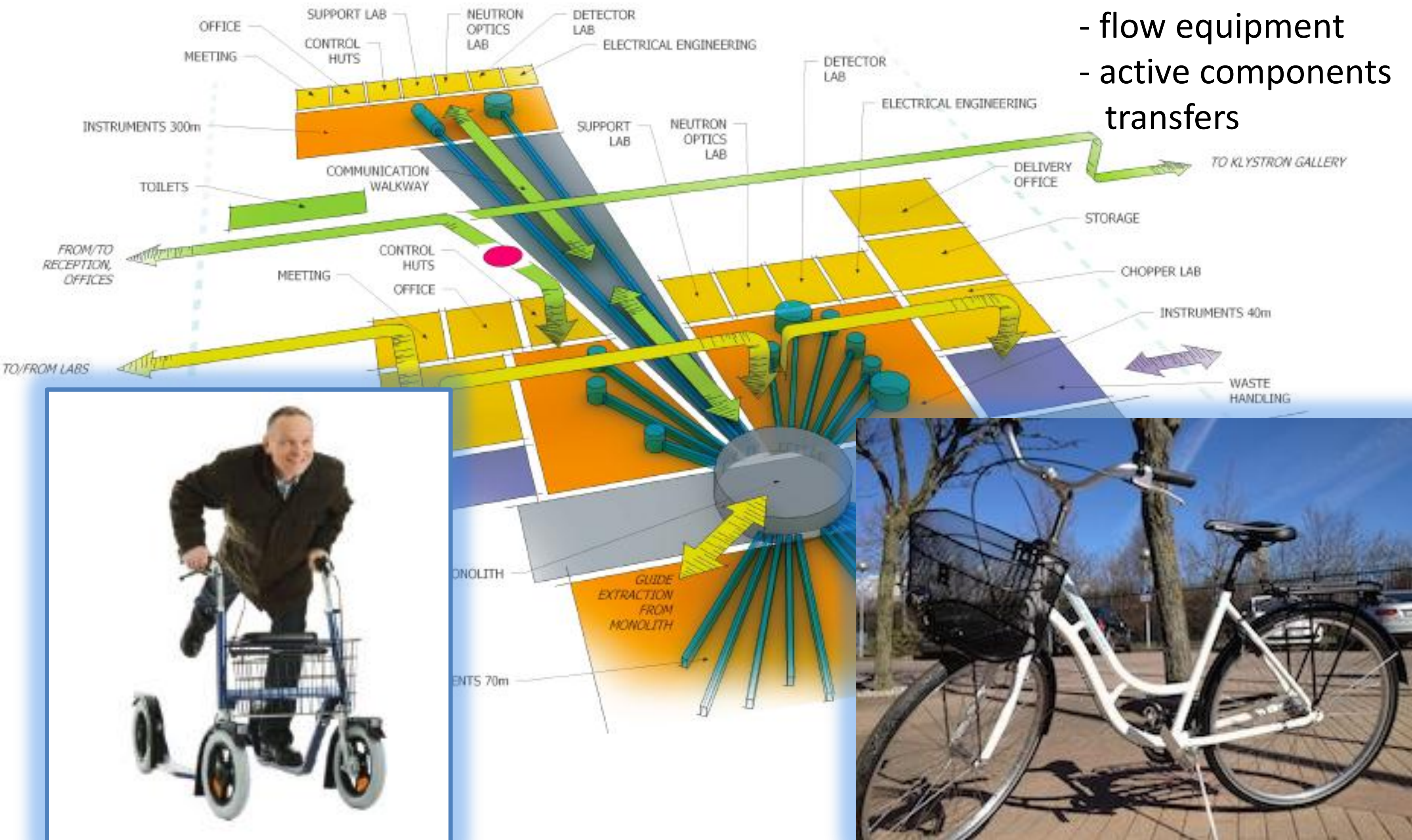
Conventional Facilities: Site layout



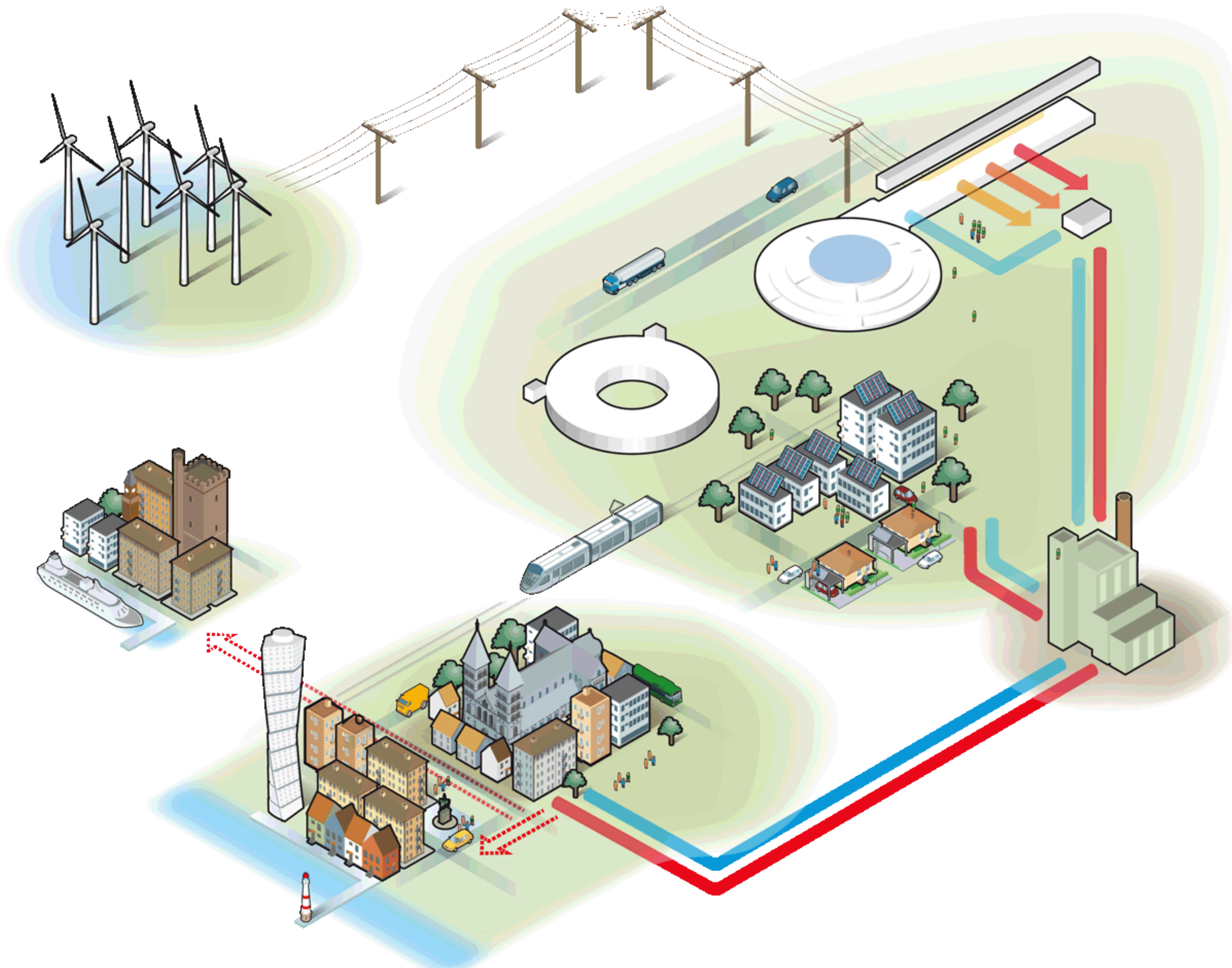
Optimising for Science & Scientists

Building programme 2012

- flow of users
- flow equipment
- active components transfers

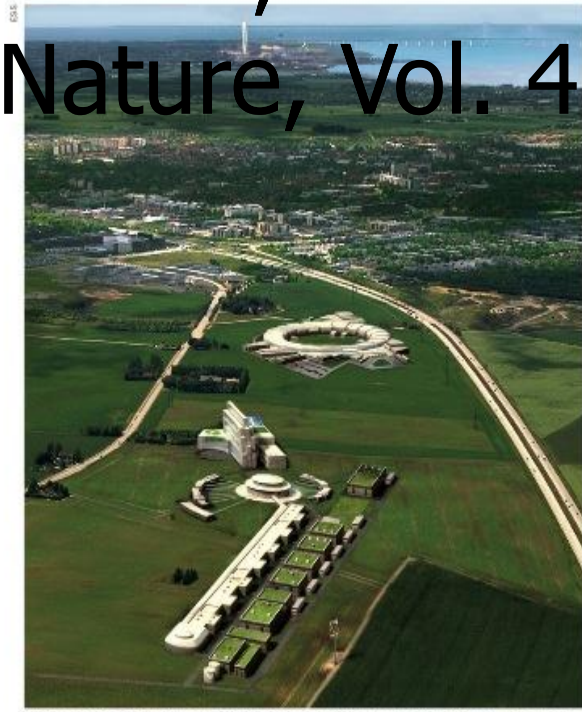


Optimising energy use



Responsible – Renewable – Recyclable

Parker, T. “Cutting science’s electricity bill, Nature, Vol. 480, pp.315-316



The European Spallation Source, to be built in Sweden, will be powered entirely by renewable energy.

Cutting science’s electricity bill

Large-scale research facilities need to reduce their energy consumption and begin moving towards sustainability, says **Thomas Parker**.

Major research facilities such as accelerators and reactors each consume roughly as much electricity as a small town — hundreds of gigawatt hours (GWh) of energy per year or more (see 'Annual energy expenditure'). International and national labs use a total of roughly 3 terawatt hours per year in Europe and 4 terawatt hours (TWh) in the United States, adding up to about the energy consumption of countries such as Estonia or Ghana. This energy use is perhaps these facilities' greatest environmental impact, greater even than the radioactive waste that many produce. Radioactivity can be contained and handled safely; climate change cannot.

The European Spallation Source (ESS) — a neutron source to be built in Lund, Sweden, by 2019, for which I am the energy manager — aims to be the first sustainable such facility. We will use only renewable energy sources to power the accelerator and the lab. We will limit our energy use: so far in the design process we have reduced our energy requirements by more than 20%. And 70% of the energy that we consume will be recovered as usable heat.

Many of the specific solutions that we are adopting at the ESS rely on local conditions, including a liberalized energy market, a well-developed district heating system, a relatively cool climate and public and political support. But the project stands as proof of principle that big science can be sustainable science, and it challenges other facilities to live up to the same standards.

USE IT, DON'T LOSE IT

One area in which there is obvious room for improvement at big labs is the use of waste heat from lab equipment. Water at 40 °C can easily supply buildings with under-floor heating or thermal ventilation, if the right systems are in place. Waste heat of 75 °C can even be used to run cooling air conditioners. But most labs intentionally destroy this resource.

Conventionally, equipment ranging from accelerators to manufacturing machinery is cooled to run at 40 °C or lower. This is in part because early electronics operated best at lukewarm or cool temperatures, and in part to avoid harming aquatic life when the cooling water from hotter systems is discharged into natural systems such as rivers. This target has become so firmly entrenched that manufacturers were surprised two years ago when we began asking them if their modern equipment would work efficiently at higher temperatures. No one else had asked.

It turns out that many modern systems can work at much higher temperatures, allowing the heat to be saved for reuse, with or without conversion to electrical power, rather than being extracted by a heat pump, dissipated in expensive cooling towers, or dumped into the air or water. Sometimes this requires small modifications, such as using sturdier components, or adding adaptable cooling systems that can handle variable heat loads and deal with rare instances of overheating. At the ESS, we are working to design power systems for our accelerators and helium compressors for our cryogenics that can operate at 75–100 °C. One of the challenges is finding the room for extra sets of pipes: some parts of the facility will still need to be cooled to 40 °C for proper operation, so we need parallel cooling systems for parts that are cooled to different temperatures.

Few places recycle their heat. Instead, they burn fossil fuels to meet their heating and cooling needs. For example, CERN, the European high-energy physics laboratory near Geneva, generates waste heat at 40 °C before disposal. This could be used for heating, but its current system uses pressurized 120 °C water instead. Changing CERN's entire heating system retrospectively might be too costly, but new buildings could be designed to use the 40 °C heat. Likewise, the spallation neutron source at Oak Ridge National Laboratory in Tennessee cools its equipment to about 30 °C using a cooling tower, and then uses gas-fired boilers to heat its buildings with no connection between the two systems.

Rather than dumping its leftover heat into cooling towers, the ESS will plug in to the city of Lund's district heating system, which operates a network of hot-water pipes under the entire city and a neighbouring community 20 kilometres away — showing that long distances between the producers and users of heat energy aren't necessarily a problem. We estimate that the ESS will produce about 180 GWh of heat per year, of which about half will be of a suitable temperature to go straight into the district heating system; much of the rest will be warmed electrically so that it doesn't go to waste.

A handful of facilities are taking similar steps. The ESS has a neighbouring synchrotron light facility, Max IV, currently under construction, which plans to cool some of its waste streams only to 75 °C or higher, again to feed into Lund's district heating system. On the other side of the world, a team at the TRIUMF particle accelerator at the University of British Columbia in Vancouver, Canada, is investigating whether it can use its waste heat to warm residential buildings on campus.

REDUNDANT SYSTEMS

TRIUMF demonstrates the problems that such systems can face. The plumbing and heat pumps needed can be costly. And because the surrounding communities don't need heating during summer, a lab such as TRIUMF will have to install back-up cooling devices. In Lund this won't be a problem: the district heating system is being extended, so there will always be sufficient demand for hot water to use up the ESS's waste heat. Conversely, a lab might not provide heat when the community needs it, again requiring a back-up system. If redundant systems are needed on both sides, then there are no savings in investment costs, although there may still be benefits for operating costs.

It is better to be energy efficient in the first place than to recycle: an industry rule of thumb is that electricity is about 2.5 times more valuable than high-grade heat.

Research facilities by their very nature are often pushing the limits of technology and science: cooling to temperatures near absolute zero, for example, or accelerating to near light-speed. Some of these processes are staggeringly inefficient in terms of energy use. Supercooling, for example, uses about 1,000 kWh of energy for every 1 kWh of heat energy that it removes from a system, as it fights to get to ultracold temperatures.

Many labs, including the ESS and CERN, have ongoing projects to improve the efficiency of cryogenics and accelerator power systems, to name two examples. Radio-frequency accelerator power systems have to be tuned to the right frequency for a given beamline, and while that is happening, the electrical energy needs to be diverted. Often it is used to heat water, but it would be more efficient to divert the electricity to somewhere it is needed. CERN in particular is looking into this now.

The ESS has so far managed to reduce its power requirements by 22% in the design update. Nearly two-thirds of this was achieved by using superconductivity in the accelerator power system, which eliminates losses to electrical resistance. Achieving superconductivity requires cooling the equipment to close to absolute zero, with all the inefficiencies that entails. Despite this, there is still a net efficiency gain.

The ESS will build its own renewable-energy-generating facilities to cover all its power needs. This makes the lab more sustainable and hedges against future energy-price volatility. The exact power systems have yet to be decided, although wind power seems the most economical resource in this region. Part of the plan is to have some demonstration plants on site showcasing innovative energy technologies to the public.

There is a funding problem for big facilities that tends to perpetuate energy wastage: facility budgets for initial infrastructure and for ongoing operations often come from different purses, making it hard to justify an initial investment in energy-efficient systems in exchange for long-term savings. The governing bodies of such facilities need to be aware of this issue, and remember that there is more than cash at stake.

In the United States, the national labs are obliged to reduce their emissions to 28% of 2008 levels by 2020. The plans in place to achieve this goal mostly involve increasing energy efficiency or relying on renewables — heat recycling is not mentioned in the Department of Energy's Strategic Sustainability Performance Plan. Ongoing projects include biomass heat and energy co-generation at Savannah River, and biomass steam generation at Oak Ridge.

PRACTICAL VISIONARIES

At a workshop in Lund this October on energy management for large-scale research infrastructures, initiated in part by myself and co-hosted by the ESS, CERN and the European Research Forum (the organization of national laboratories in Europe), it was clear that although many heads of national labs are in favour of greening their facilities, most are in only the earliest stages of changing operations.

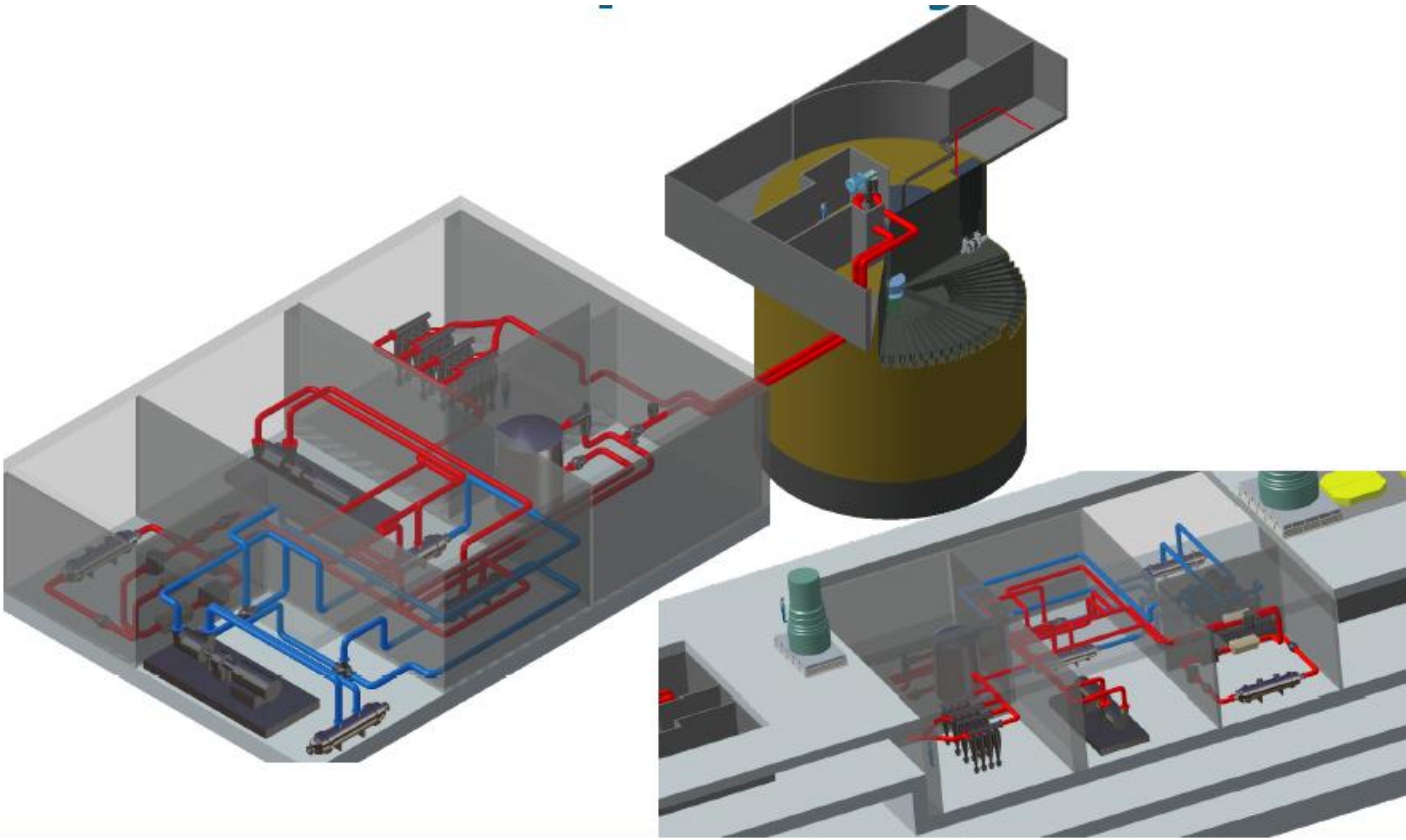
Some larger projects should serve as an inspiration. The DESERTEC project, for example, promotes the construction of solar power plants and wind parks in north Africa, along with transmission lines to high-usage areas in southern Europe. As part of the programme, African nations that supplied facilities with renewable resources would also be given a say in the running of these projects. This promotes not just energy sustainability, but also intellectual sustainability in emerging economies. At our meeting, Helmut Dosch, chair of the board of directors of the German accelerator complex DESY, made an impassioned call for national labs to get involved in making this programme a reality. There is a place for both visionary leadership and practical groundwork.

As the public and its representatives become increasingly aware of the need for energy efficiency, the argument for energy-intensive research becomes weaker. Big science needs to do some housekeeping. The scientists who work at these facilities, perhaps contrary to popular perception, are people with ethical concerns about the environment. They need to translate those concerns into action. ■

ANNUAL ENERGY EXPENDITURE

Large physics facilities, such as CERN, use as much energy as a small town every year. Smaller ones, such as the European Spallation Source (ESS), also consume lots of electricity. All would benefit from going green.

Thomas Parker *is the energy manager of the European Spallation Source.*
e-mail: thomas.parker@esss.se



The ESS Accelerator

Future work main points:

– ADU in full swing
P2B planning advanced

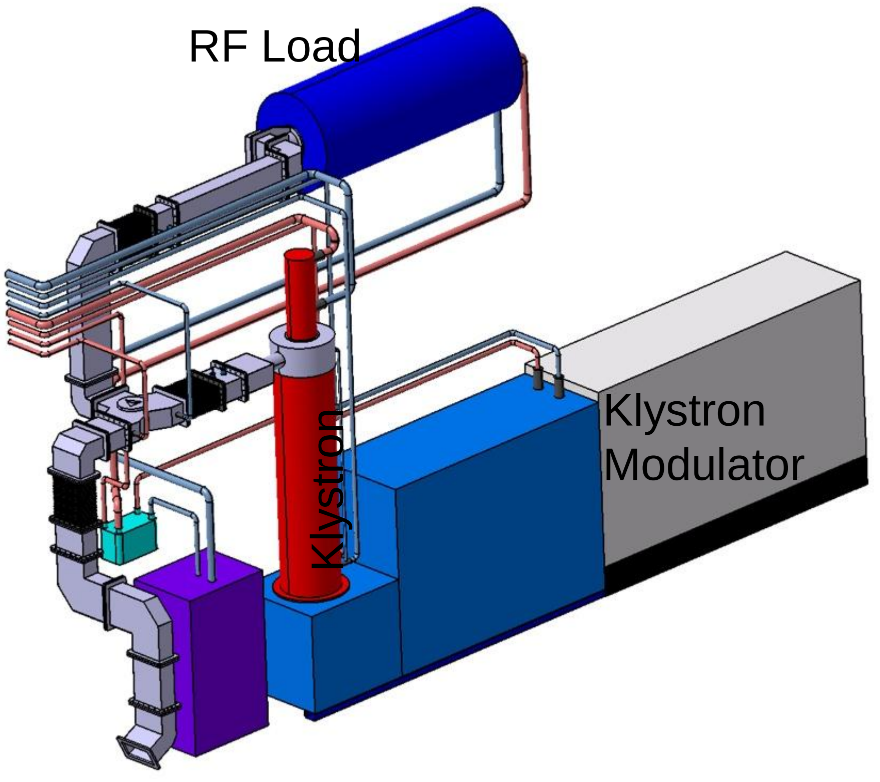
– A complex machine ~500 M€

– A challenging schedule
Fix main parameters now in discussion with Science Directorate

– Prototyping required

– 200 RF power units, procurement is important

– TDR early 2013



Helium cooling

- Many attractive features. Best performance, best safety.

- Experience and solutions developed for fusion, helium cooled reactors, low power targets. Technology needs to be transferred and adapted to spallation source conditions.

- Helium environment at SNS and TS2 target stations.

- Identified challenges:
  - Containment of helium.
  - Some components/ancillary systems are large
  - Possible flow instabilities – density waves
  - …

- Report on He cooling of W components (KIT).

- Test loops available at KIT.

He circulator, 6 x 3 m, 3.75 bar, 6kg/s, ~2M€

Water cooling

- Established technology for cooling targets at lower power and continuous spallation sources. Good performance, some challenges on safety.

- ESS power level and pulse mode creates challenges.

- Identified challenges:
  - Exothermal reaction Vapour + metal -> H_2 + metal oxides (afterheat or beam on may start reaction at 700˚C)
  - Cladding or canning of W required
  - Local boiling/film boiling
  - Water hammer effects
  - …

- Emergency cooling may be required to handle afterheat for loss of cooling accident. Complicates licensing.

  - Could possibly be avoided by developing a new canning technology for W that reduces afterheat. Long R&D project!

  - Could be avoided by choosing a more low performing material than W, where other canning techniques are established.

    Initially, possibly forever, substantially reduced neutronic/scientific performance.

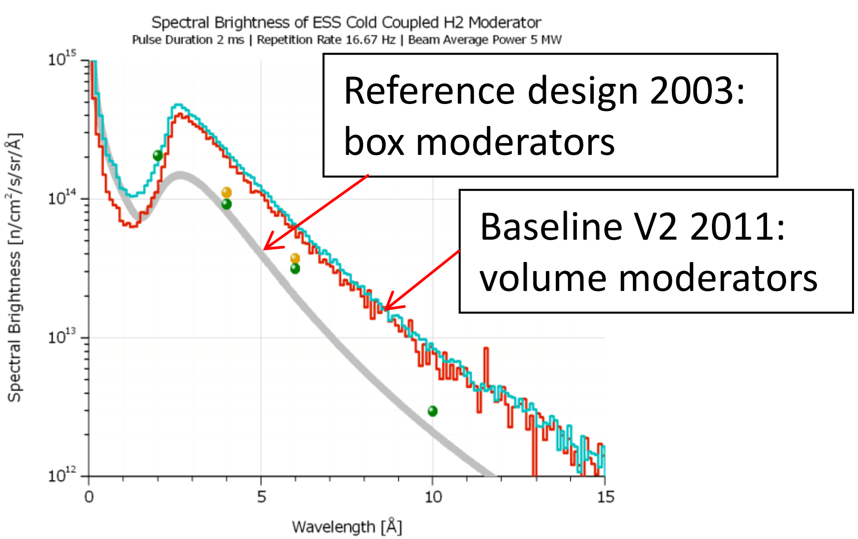
Waste management and decommissioning to green field status

Regular transport of spent targets and reflector-moderator plugs to radioactive repository after 5 years of cool-down

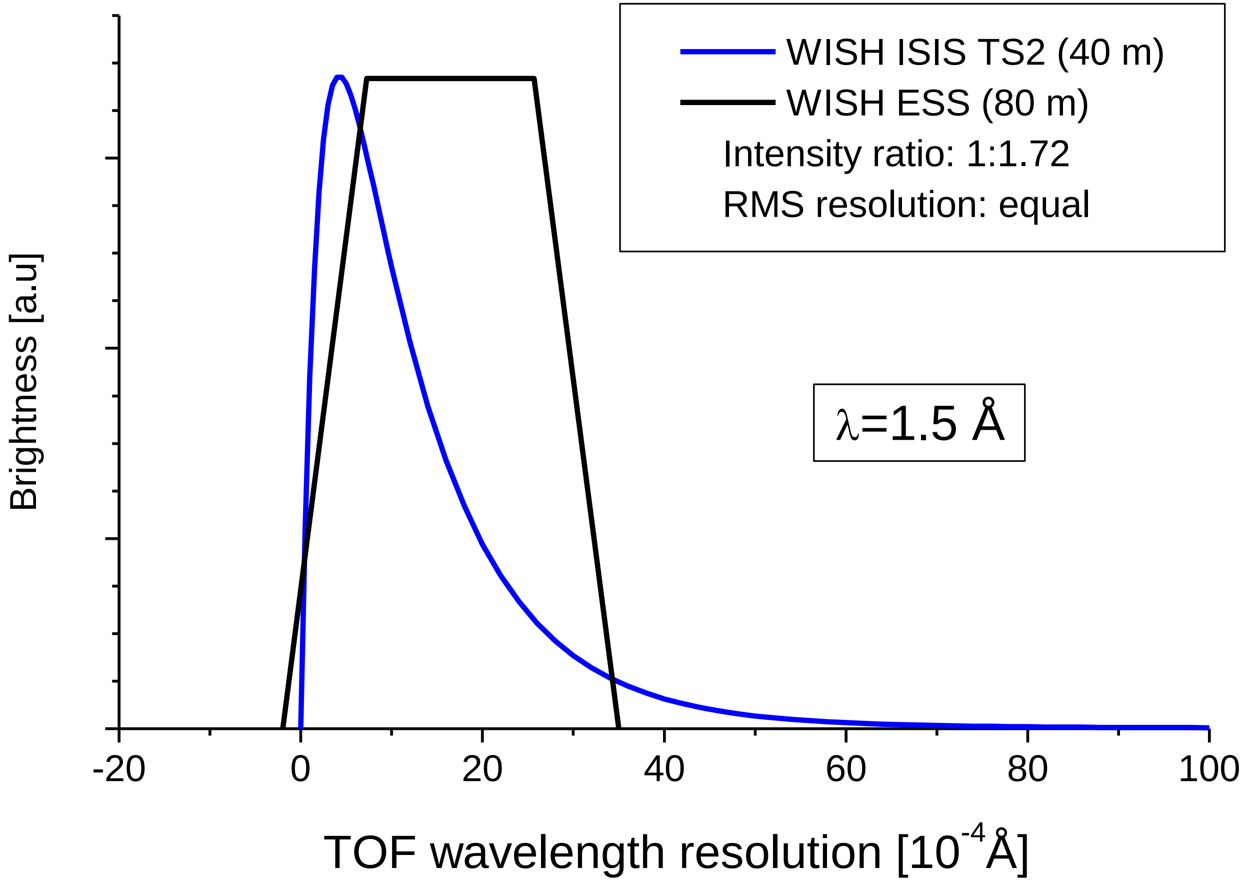
Total weight with shielding steel casks: ~ 50 t.

80 t cask transporter (Studsvik)

Neutronic design group at full strength: beam production optimization in progress



Dresser Roots Helium gas circulator for low pressure, high throughput



Peak flux of long pulses can be used more effectively:

- chopper shaped pulses: enhanced intensity for given peak flux and resolution
- tunable resolution and wavelength band for needs of individual experiment