



EUROPEAN
SPALLATION
SOURCE

The European Spallation Source



Andreas Jansson
ESS AB



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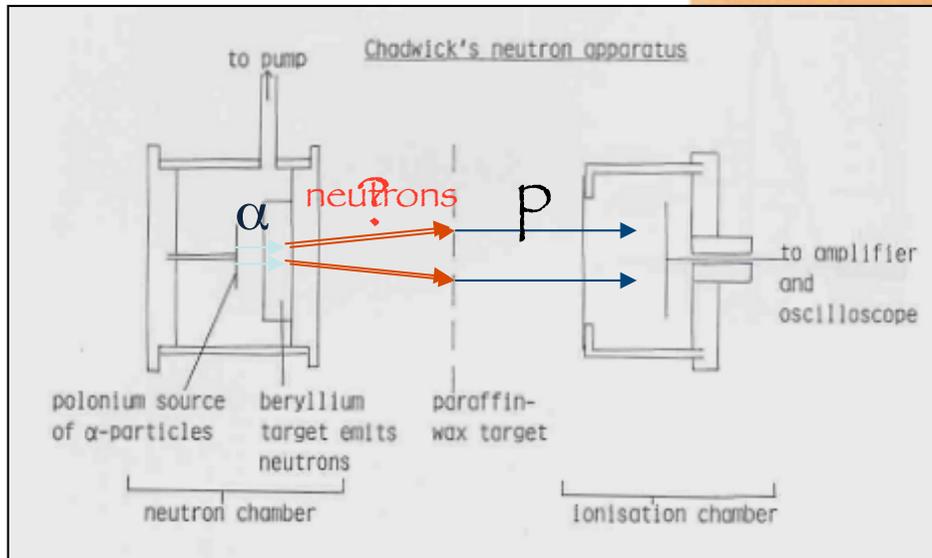
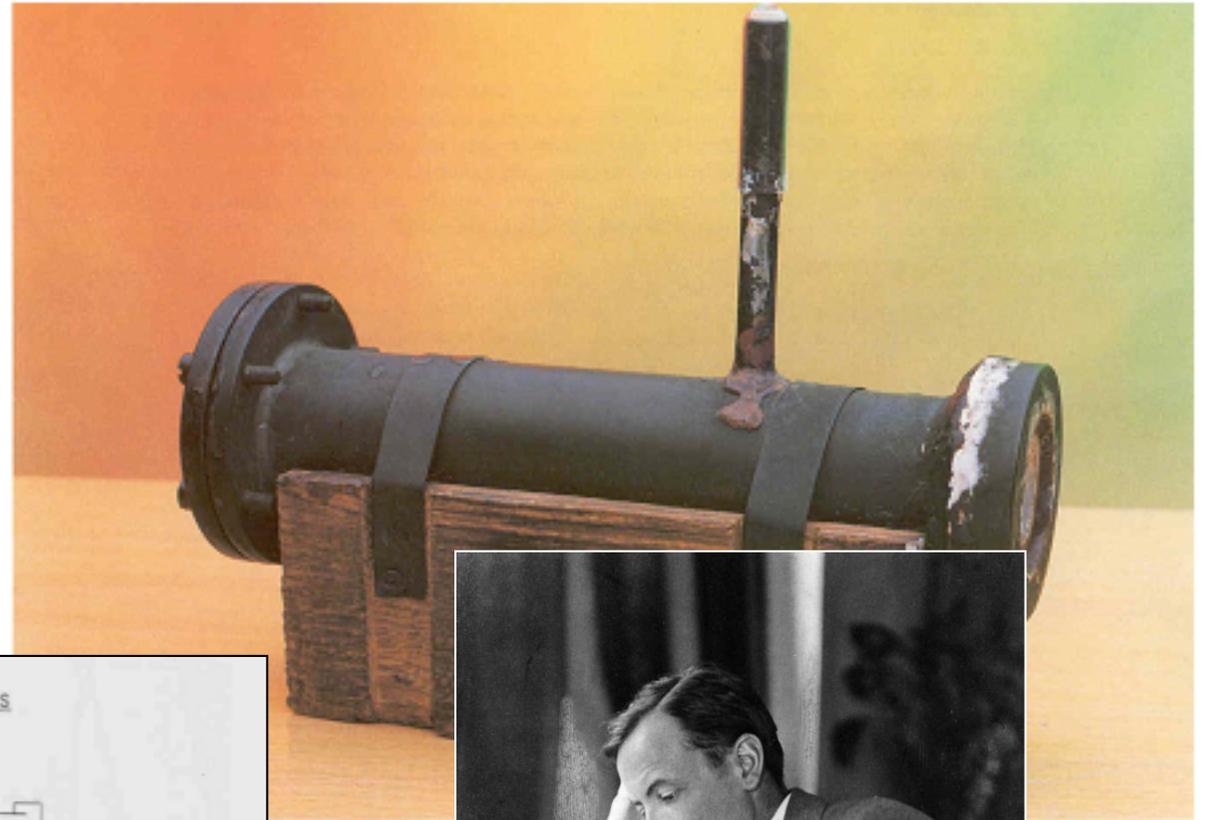
ESS in Lund





Something about Neutrons

Its discovery
James Chadwick
1932
(α, n) reaction





“Whatever the radiation from Be may be, it has most remarkable properties”

Cavendish Laboratory,
Cambridge.

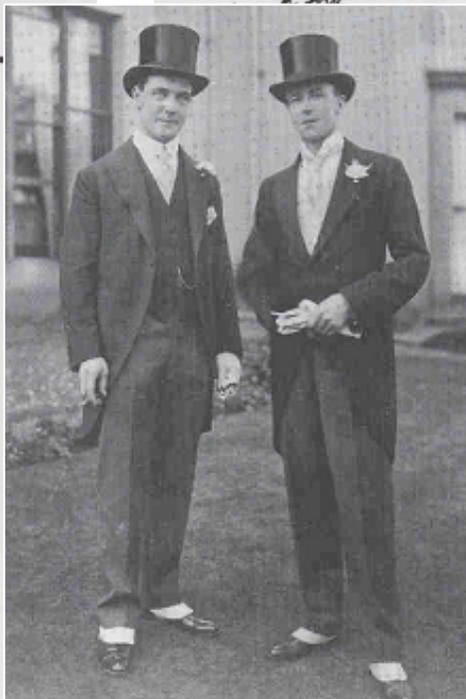
24 February 1932.

Dear Bohr.

I enclose the proof of a letter I have written to "Nature" and which will appear either this week or next. I thought you might like to know about it beforehand.

The suggestion is that α particles eject from beryllium (and also from boron) particles which have no net charge, and which probably have a mass ^{about} $\frac{1}{2}$ equal to that of the proton. As you will see, I put this forward rather cautiously, but I think the evidence is really rather strong. Whatever the radiation from Be may be, it has most remarkable properties. I have made many experiments which I do not mention in the

letter to "Nature" and they can all be interpreted readily on the assumption that the particles are neutrons. Feather has taken some pictures in the diffusion chamber and we have already found about 20 cases of recoil atoms. About 4 of these show an abrupt



almost certain that ~~this~~ one arm presents a recoil atom and the other is, probably an α particle. They are due to the capture of the neutron. I enclose two photographs: the simple recoil atom, and the other is a disintegration. The first is very good but they were printed

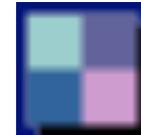
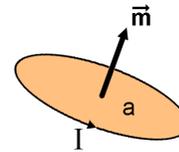
With best regards
Yours sincerely
J. Chadwick.



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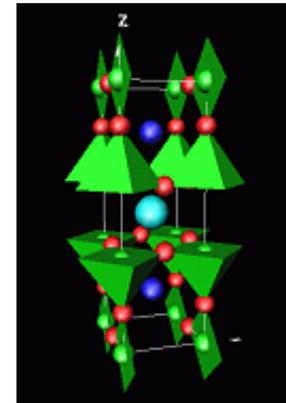
Neutrons are beautiful!

Wave Particle Magnetic moment Neutral



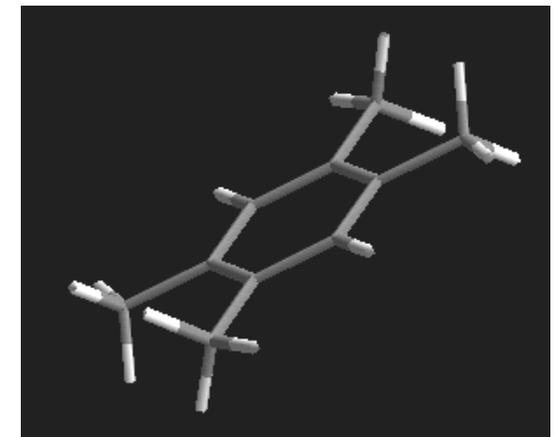
Diffraction meters - Measure structures
- Where atoms and molecules are

1 - 10 Ångström



Spectrometers - Measure dynamics
- What atoms and molecules do

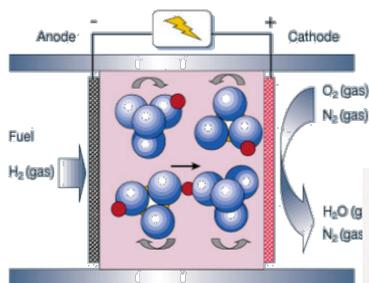
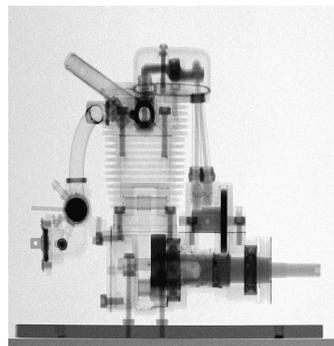
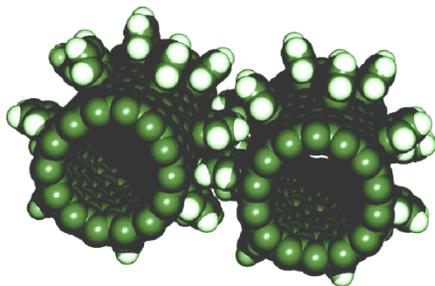
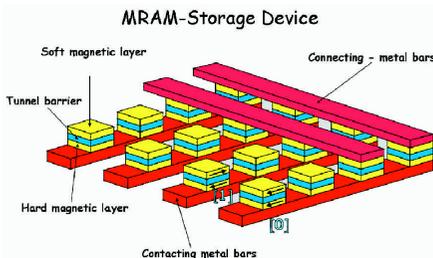
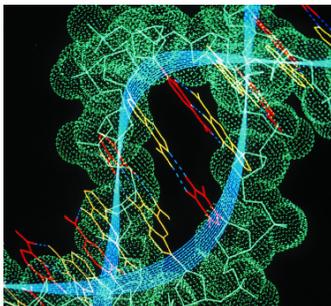
1 - 80 meV





ESS – multi-science with neutrons

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



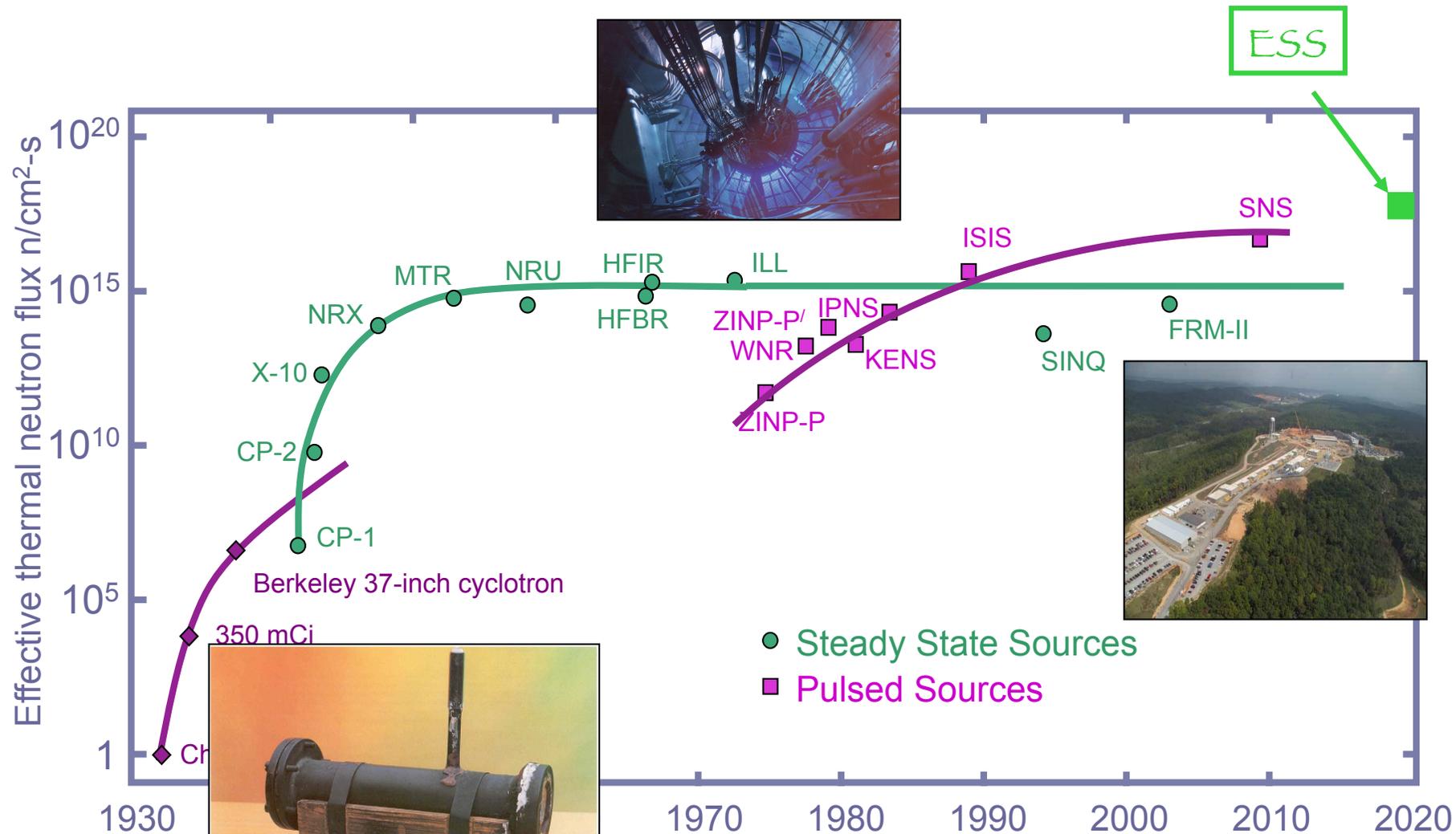
- Neutrons can provide unique and information on almost all materials.
- Information on both structure and dynamics simultaneously. "Where are the atoms and what are they doing?"
- 5000 users in Europe today
Access based on peer review.
- Science with neutrons is limited by the intensity of today's sources

NB. Neutrons and synchrotron light are very complementary methods, often used together. ESS will be sited next to MAX IV, a fourth generation synchrotron light source



Why ESS? - High time average and peak flux

Evolution of the performance of neutron sources



Neutron Scattering, K. Skold and D. L. Price, eds., Academic Press, 1986)



Intensity opens new possibilities

Complexity/
Count-rate

ESS intensity allows studies of

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



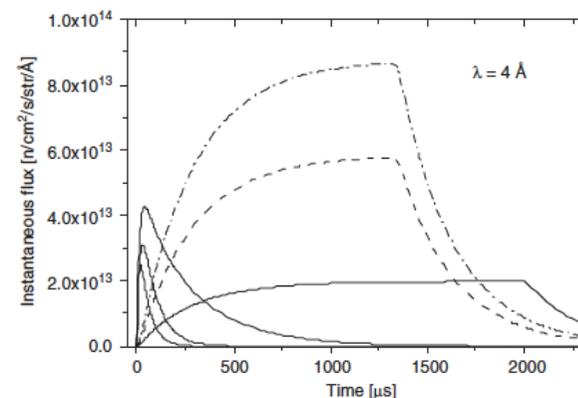
Details/Resolution



Why ESS? – Cold neutrons

- Many research reactors in Europe are aging and will be closed before 2020
 - Up to 90% of the use is with cold neutrons
- There is a urgent need for a new **high flux cold neutron** source in Europe
 - The vast majority will profit from a pulsed structure
 - A large fraction (70%) are fully satisfied by a long pulse source (approx 2 ms, 20 Hz)
 - Existing short pulse sources (ISIS, JPARC and SNS) can supply the present and imminent future need of short pulse users
 - Construction must start now for use in 2018-2019

“Pulsed cold neutrons will always be long pulsed as a result of the moderation process”



F. Mezei, NIM A, 2006



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Why Lund?

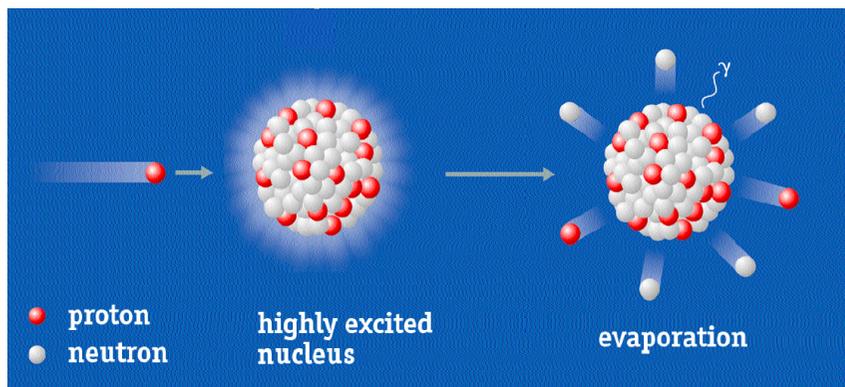
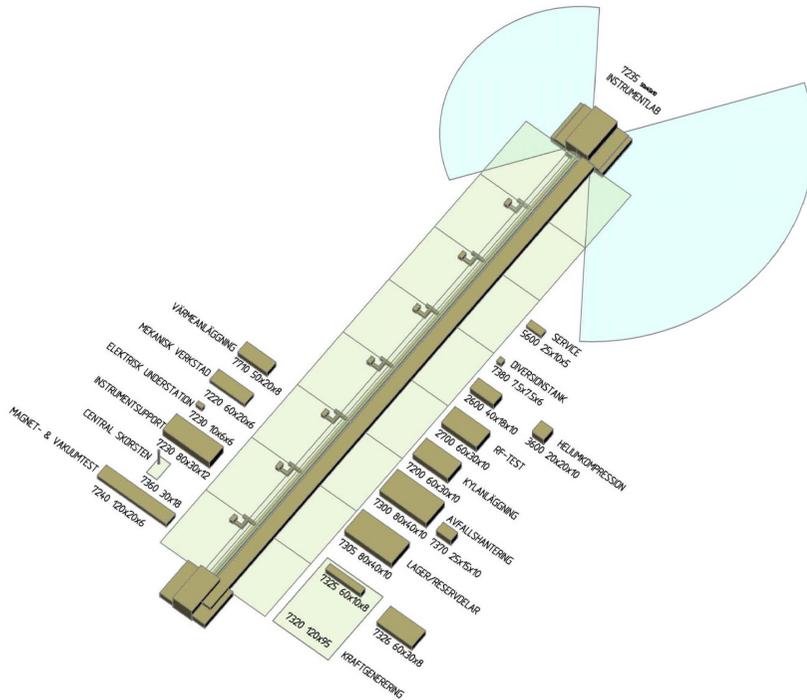
- Neutrons and SR at the same site
 - MAX-IV and ESS
- A World-leading cluster of science facilities
 - XFEL, ESS, PETRA and MAX-IV
- Excellent Communications
 - 41 minutes to airport
 - 125 direct destinations
 - A cross-roads for 10 European countries
- Intellectual capital
 - 10,000 scientists - 140,000 students
 - 3rd biopole in Europe
 - Lund University 3rd largest attractor of EU R&D funds
 - IDEON





How does ESS work?

- An ion source creates positive hydrogen ions (protons).
- Pulses of protons are accelerated into a target with neutron rich atoms.
- In the target neutrons are liberated by a spallation reaction.
- The neutrons are then guided to instruments where they are used for materials studies.



Spallation: A nuclear process in which a high energy proton excites a neutron rich nucleus which decays sending out neutrons (and other particles).

* There are several target concepts under study:

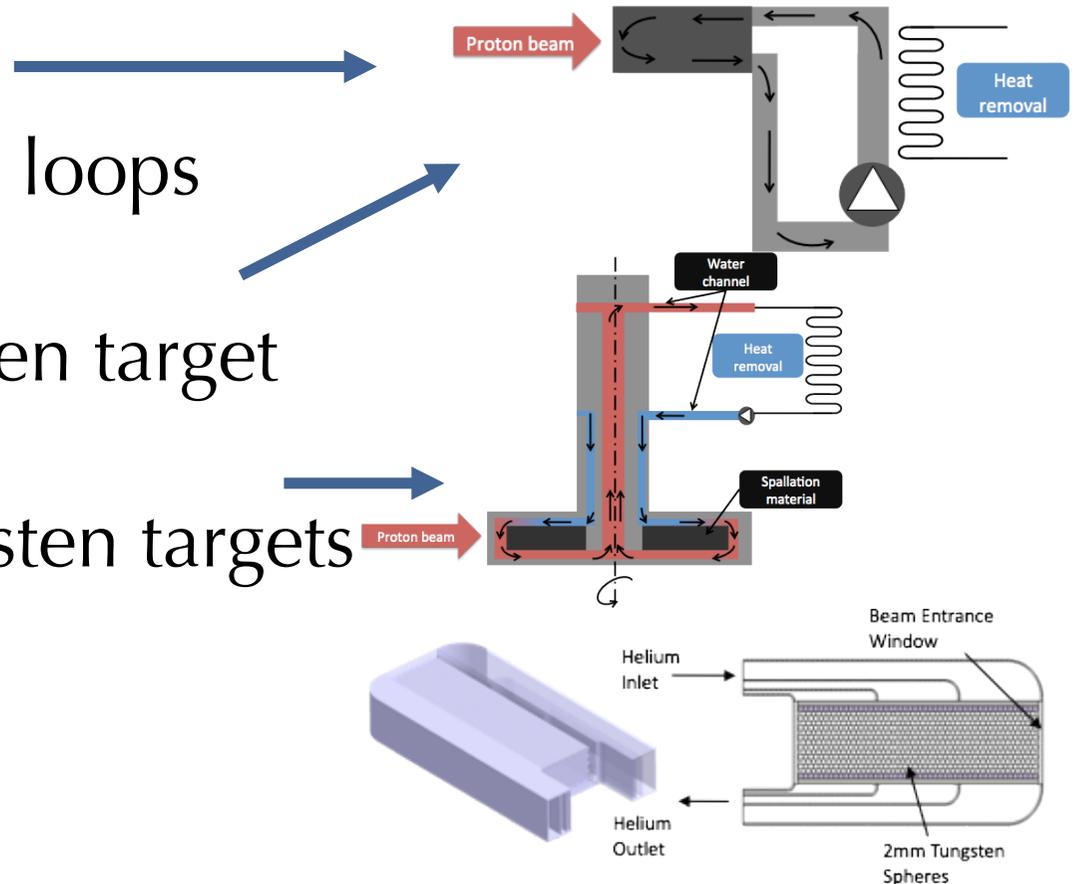
1: Mercury loops

2: Lead and Lead alloys loops

3: Water cooled Tungsten target

4: Helium cooled Tungsten targets

5: *Windowless* targets





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ESS accelerator high-level technical objectives:

5 MW long pulse source

≤ 2 ms pulses

≤ 20 Hz

Protons (H^+)

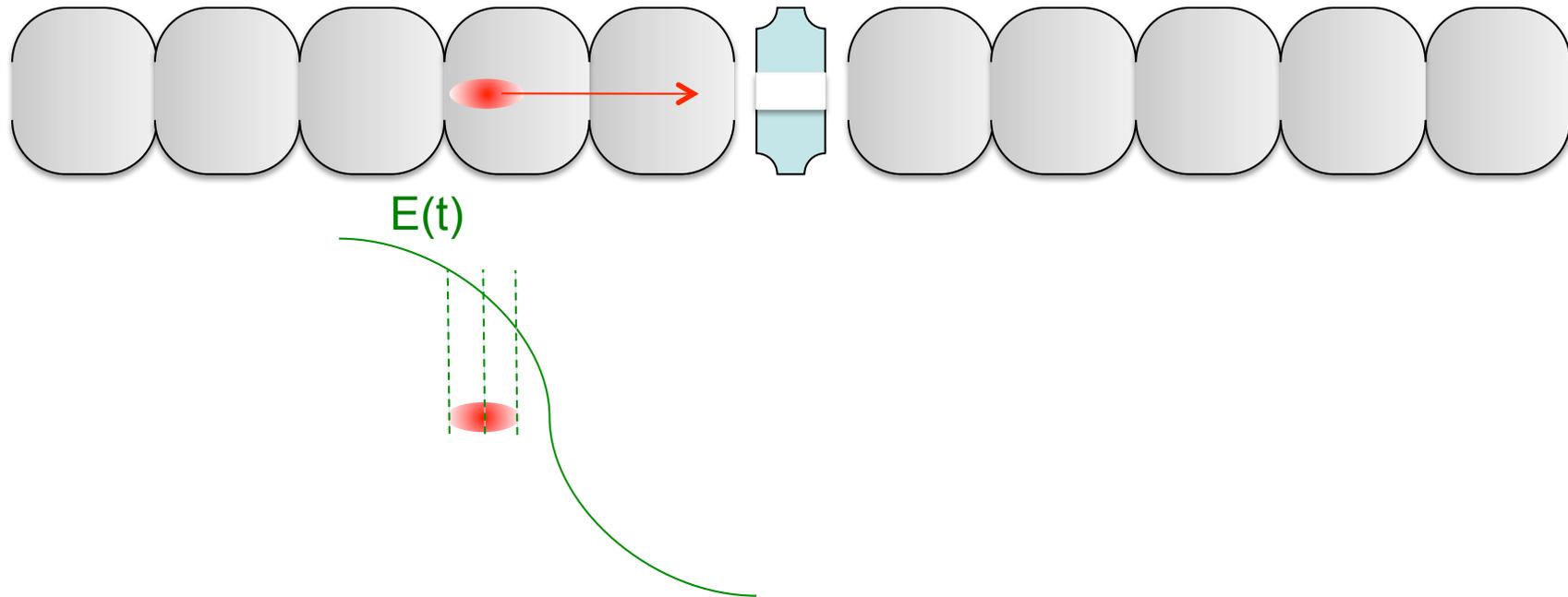
Low losses

High reliability, $>95\%$





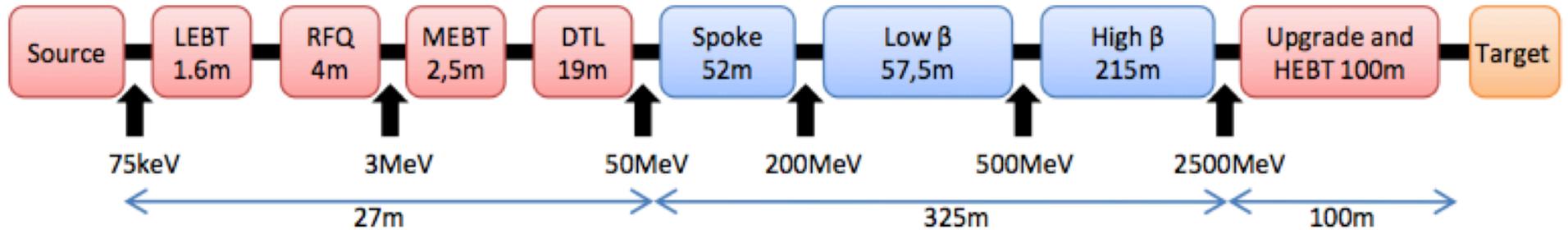
How a linear accelerator works



- RF cavities accelerate and focus longitudinally
- Quadrupole magnets focus beam transversely



LINAC layout

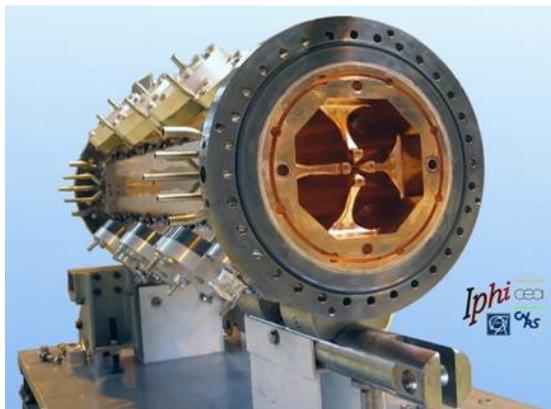


	Length (m)	Input Energy (MeV)	Frequency (MHz)	Geometric β	# of Sections	Temp (K)
RFQ	4	75×10^{-3}	352.2	--	1	≈ 300
DTL	19	3	352.2	--	3	≈ 300
Spoke	52	50	352.2	0.45	14 (3c)	≈ 2
Low Beta	57.5	200	704.4	0.63	10 (4c)	≈ 2
High Beta	215	500	704.4	0.75	19 (8c)	≈ 2
HEBT	100	2500	--	--	--	--

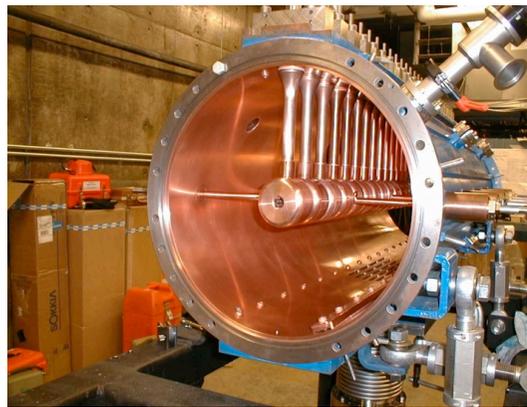


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Linac R&D in progress



IPHI RFQ at CEA-Saclay



[http://
www.jpaw.com](http://www.jpaw.com)



SC triple spoke cavity, ANL



SC 5 cell cavity for 704 MHz, CEA and CNRS



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Preconstruction phase

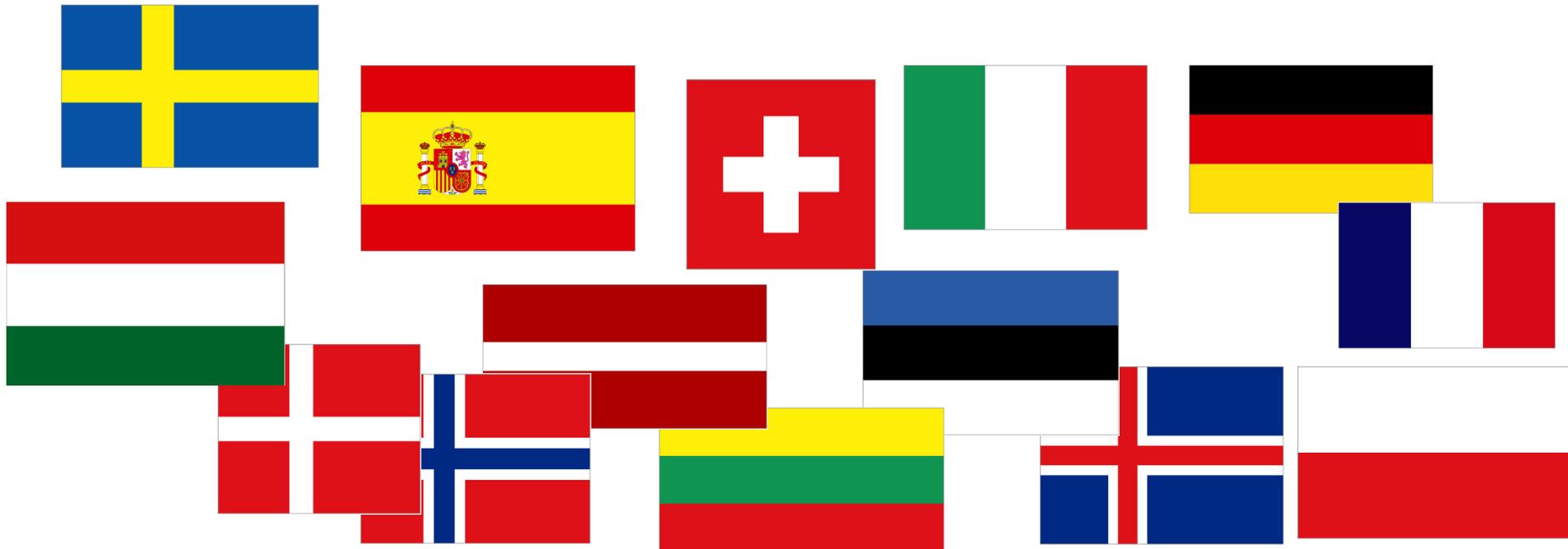
Site decision May 2009 - Brussels

1st ESS Steering Committee October 2009 - Copenhagen

strong support from 13 countries to:

- to engage in the ESS Design Update
- to prepare organisation aimed for construction

Now 16 member states and others on the way...





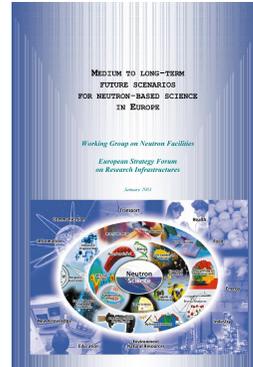
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Time lines



first design
2002-2003

ESFRI Report
2003



site
decision
2009

ESS Pre-construction phase

2010-2012

ESS Construction phase

2013-2018

Completion phase

2018-2025

Operations phase

2026-2066

My retirement

~2037

Decommissioning phase !!!

2067-2071





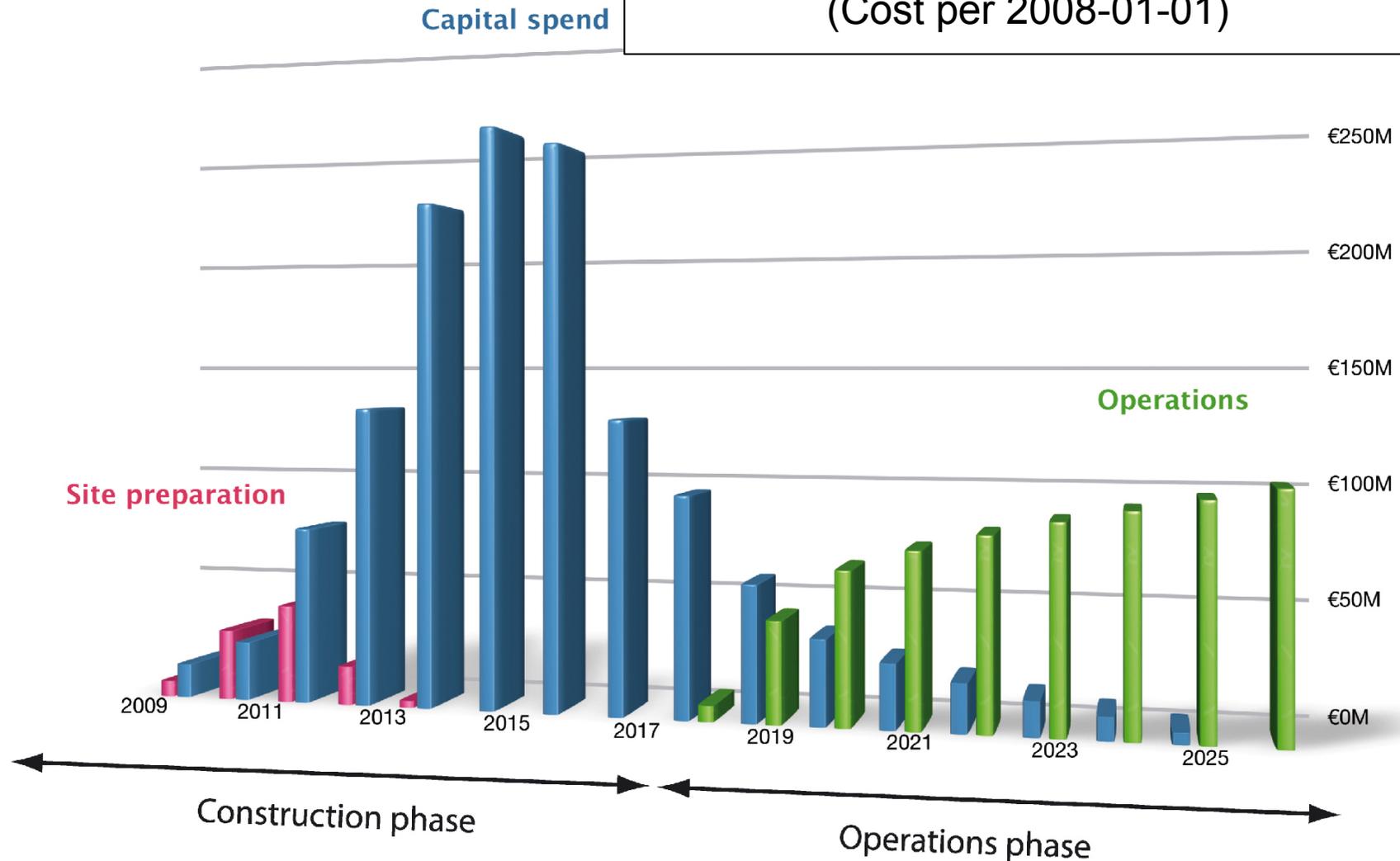
ESS cost estimates

Investment: 1478 M€ / ~10y

Operations: 89 M€ / y

Decomm. : 346 M€

(Cost per 2008-01-01)





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What can you get for 1.5B€ today ?

You could buy four A380 airbuses...



or, 28% of the Fehmarn Bridge



or, you could pay the bonuses of US bankers for...

24 days



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The Sustainable Research Centre

Responsible – Recyclable – Renewable



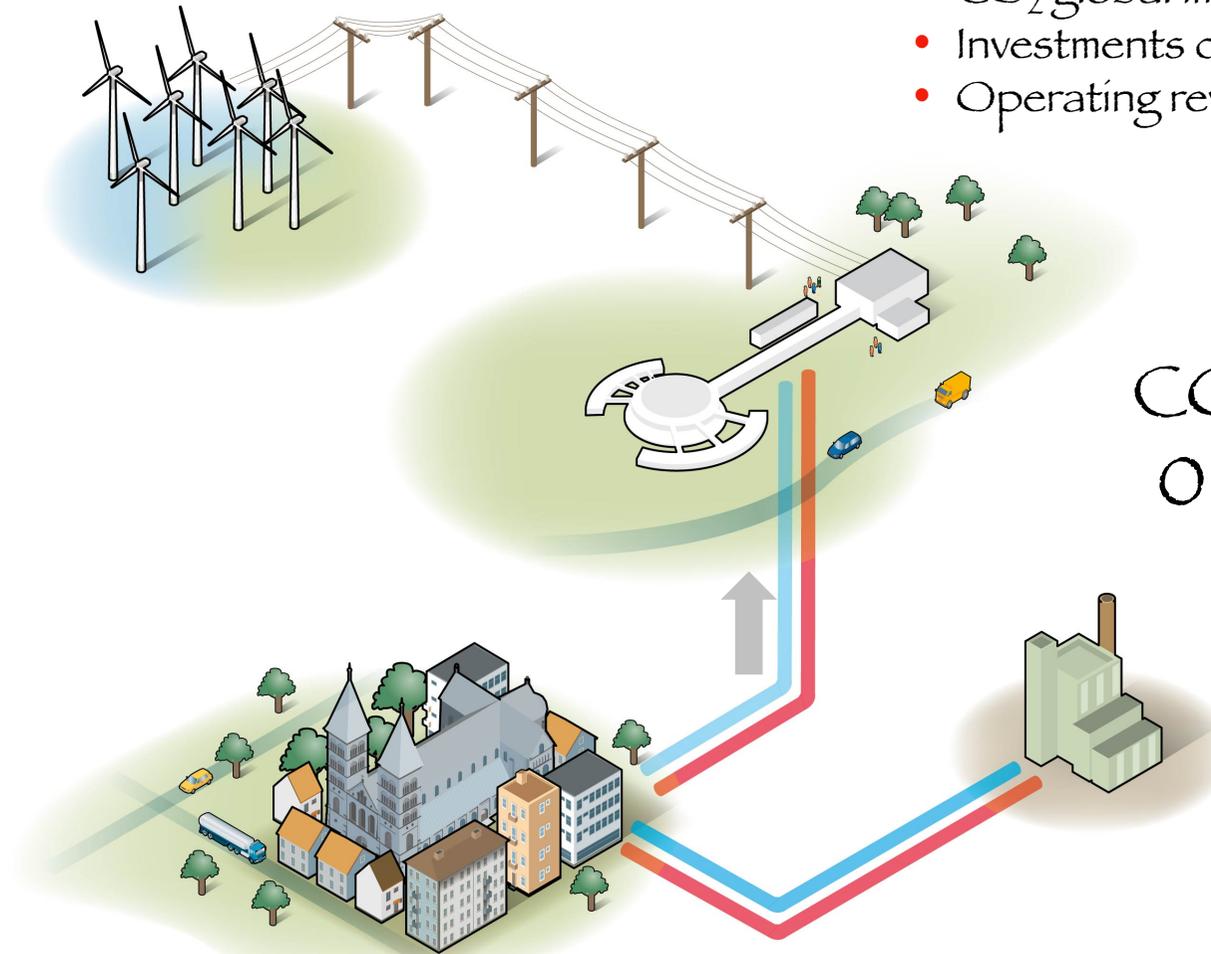
To be carbon dioxide neutral over the lifetime of the facility, including transportation to and from the site.



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ESS Energy Solution - Economy and Sustainability Advantage

- Energy savings in improved efficiency equipment: 20 %
- CO₂ global impact: 0 ton/year
- Investments connection DH: 1 M€
- Operating revenue : -1,5 M€

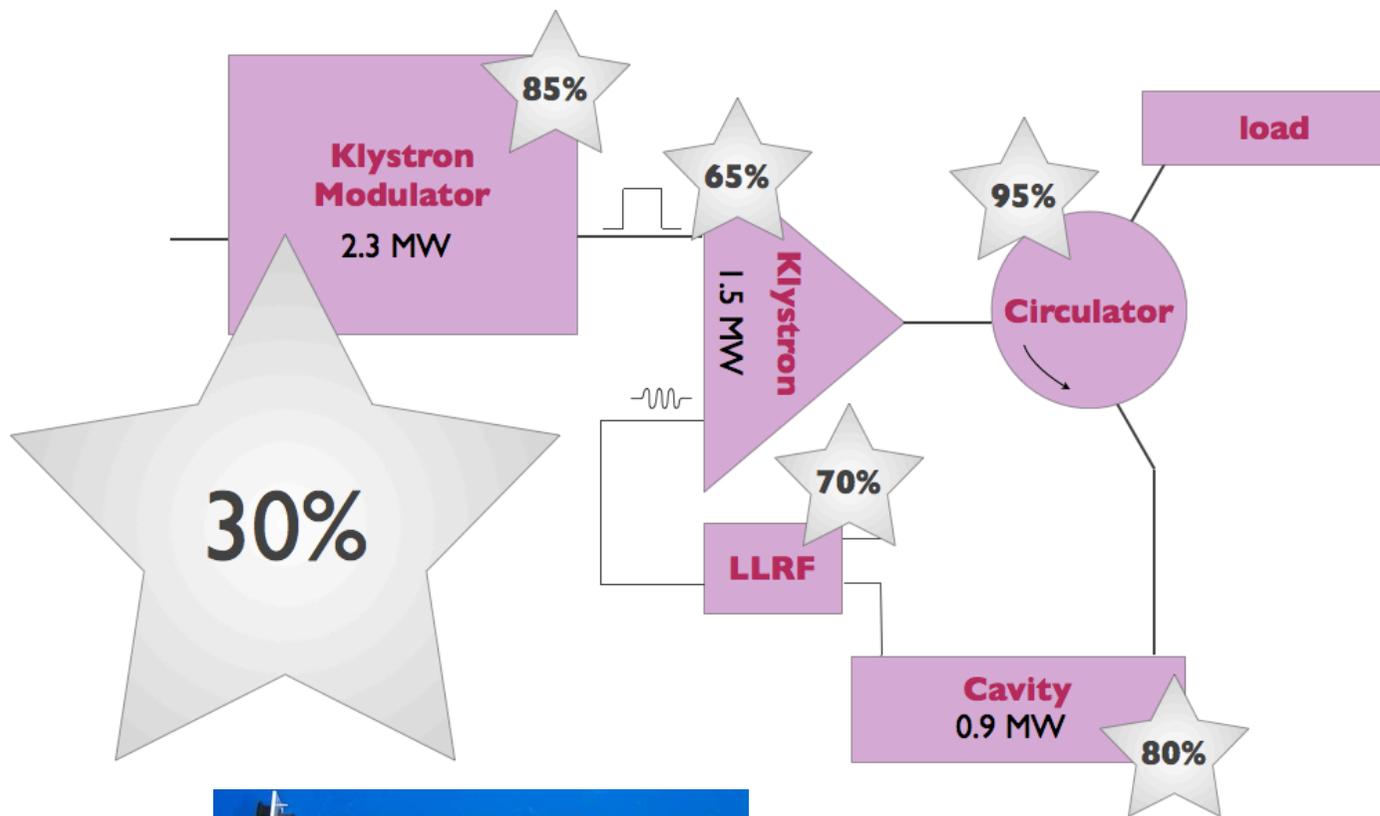


CO₂ production
0 tonnes/year

Income 1.5 M€



Energy efficiency example: RF System



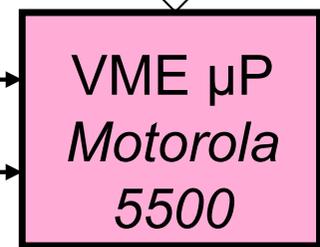
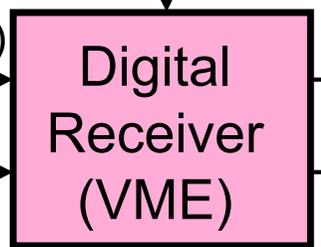
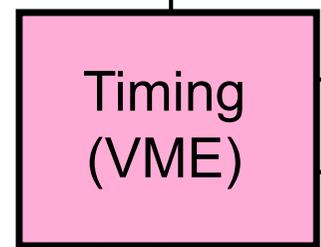
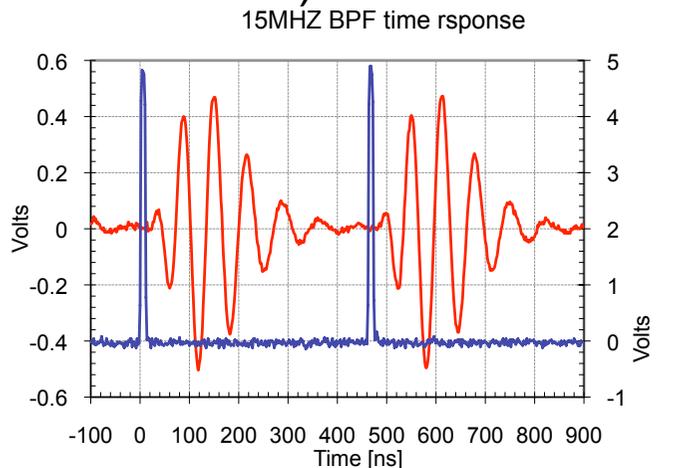
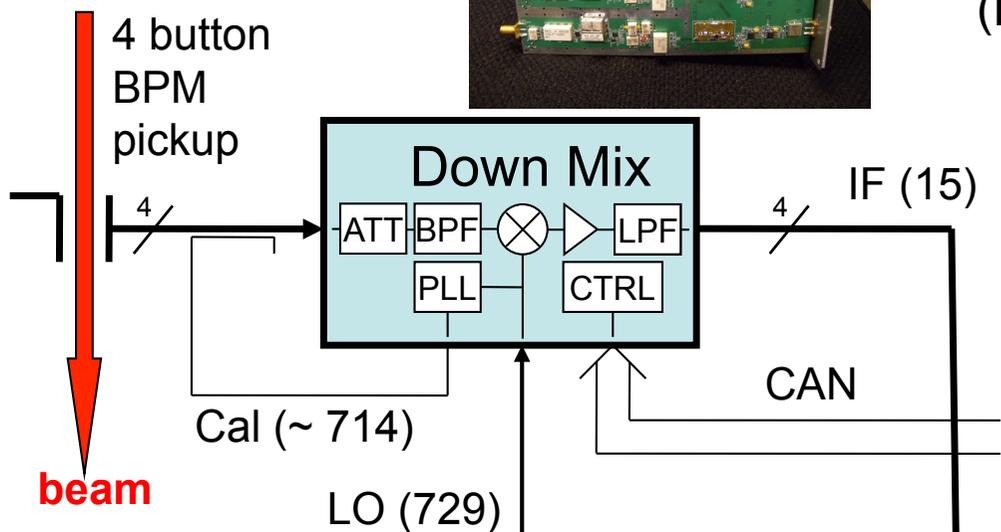
Example: SNS Front end LLRF board (ADC – FPGA – DAC, L. Doolittle et al)



Beam Position Monitors



Example:
Fermilab/ATF BPM System
(M Wendt et al)



position

LAN



Conclusions

- The European Spallation Source will be built in Lund
- The Design will permit a long life with many upgrades
- Neutron “scatterers” using cold neutrons are a major user group but only your imagination puts limits on other use of ESS
- Welcome to back to LUND as users!
- Many Thanks to Mats Lindroos, Colin Carlile, Christian Vettier, Axel Steuwer, Patrik Carlsson, Francois Plewinski, Ference Mezei, Enrico Chiaveri and all other Colleagues at ESS for all the slides I have “borrowed”.

Blue skies research on a truly a green field site
<http://ess-scandinavia.eu/jobs>

