



**EUROPEAN
SPALLATION
SOURCE**



The European Spallation source

A giant microscope for a more sustainable future

Jo Lewis

2023-09-08



In 2009 Sweden and Denmark won the bid to be home to a new giant microscope



We're building a global science hub in Lund



ESS, MAX IV, Science Village Scandinavia

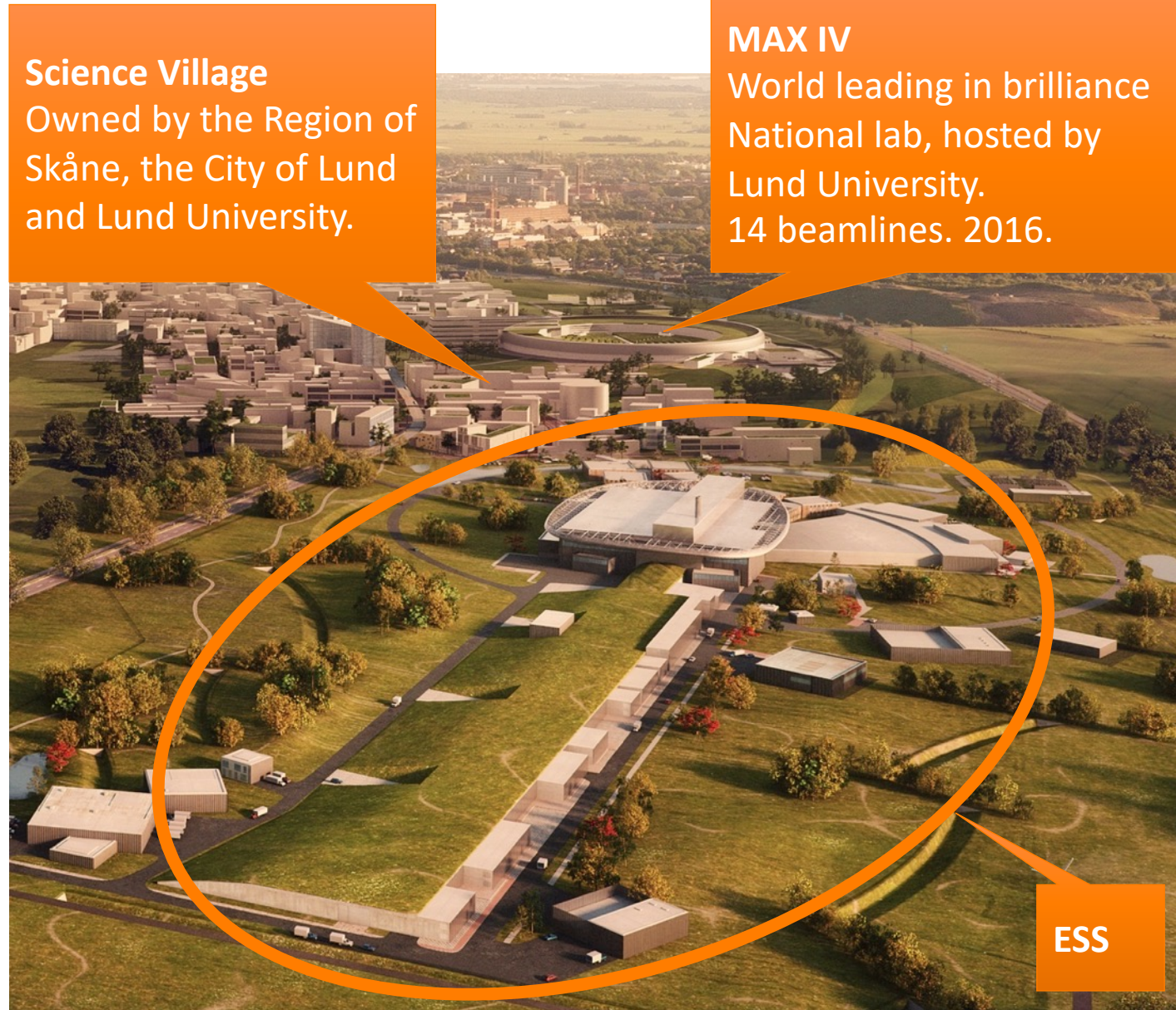


Science Village

Owned by the Region of Skåne, the City of Lund and Lund University.

MAX IV

World leading in brilliance
National lab, hosted by
Lund University.
14 beamlines. 2016.



ESS

ESS today



Photo taken
Feb 2022



ESS is owned and
being built by 13
member countries
and partners



Organisation and People

519

Employees



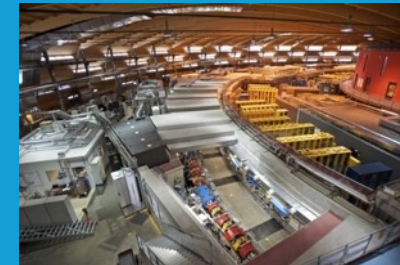
56

Nationalities



> 100

Collaborating Institutions





What is it for?

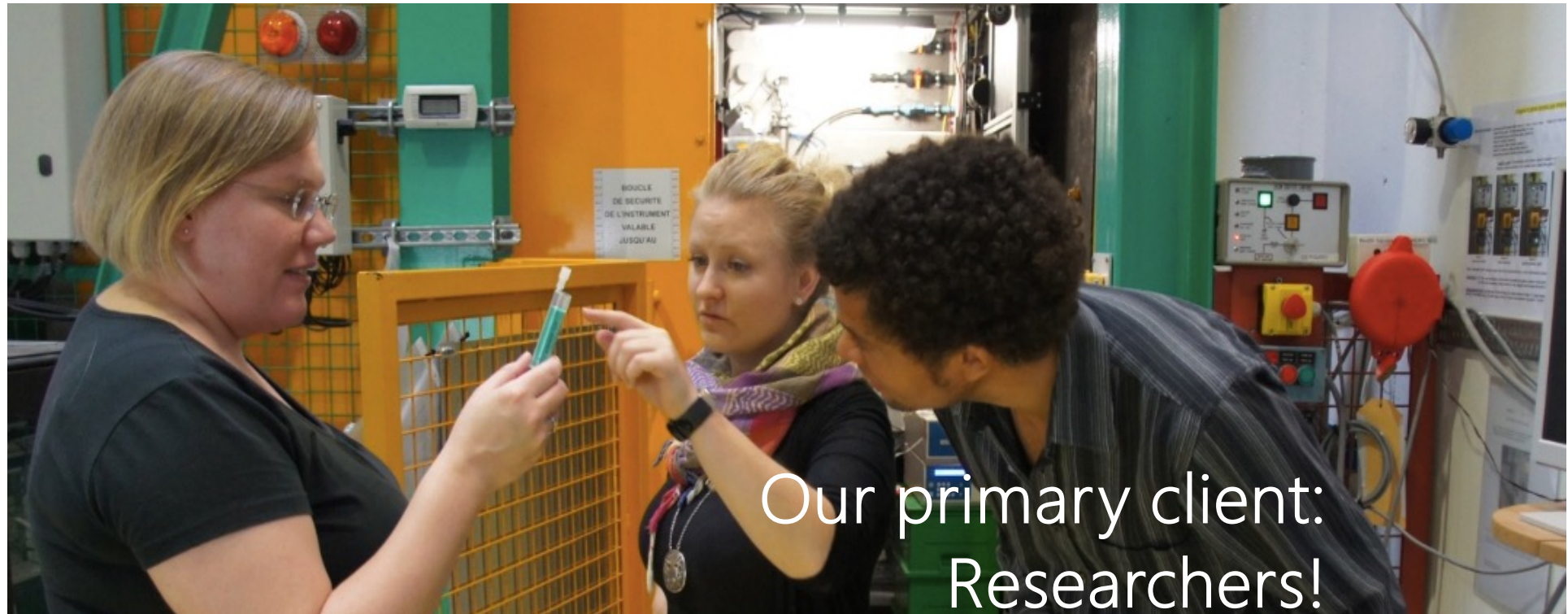
Fundamental science and research are crucial for improved quality of life





ESS will be a user facility

- Researchers who need neutrons for their experiments.
- From universities, institutes, industry.
- We provide tools & support; they bring their projects and perform the experiments.
- 2000-3000 visiting users/year. A stay can be days or weeks.
- Many different disciplines: materials research, physics, chemistry, life science...



Our primary client:
Researchers!

We are creating...



...KNOWLEDGE



life sciences



magnetism & superconductivity



soft condensed matter



engineering & geosciences



chemistry of materials



archeology & heritage conservation



energy research

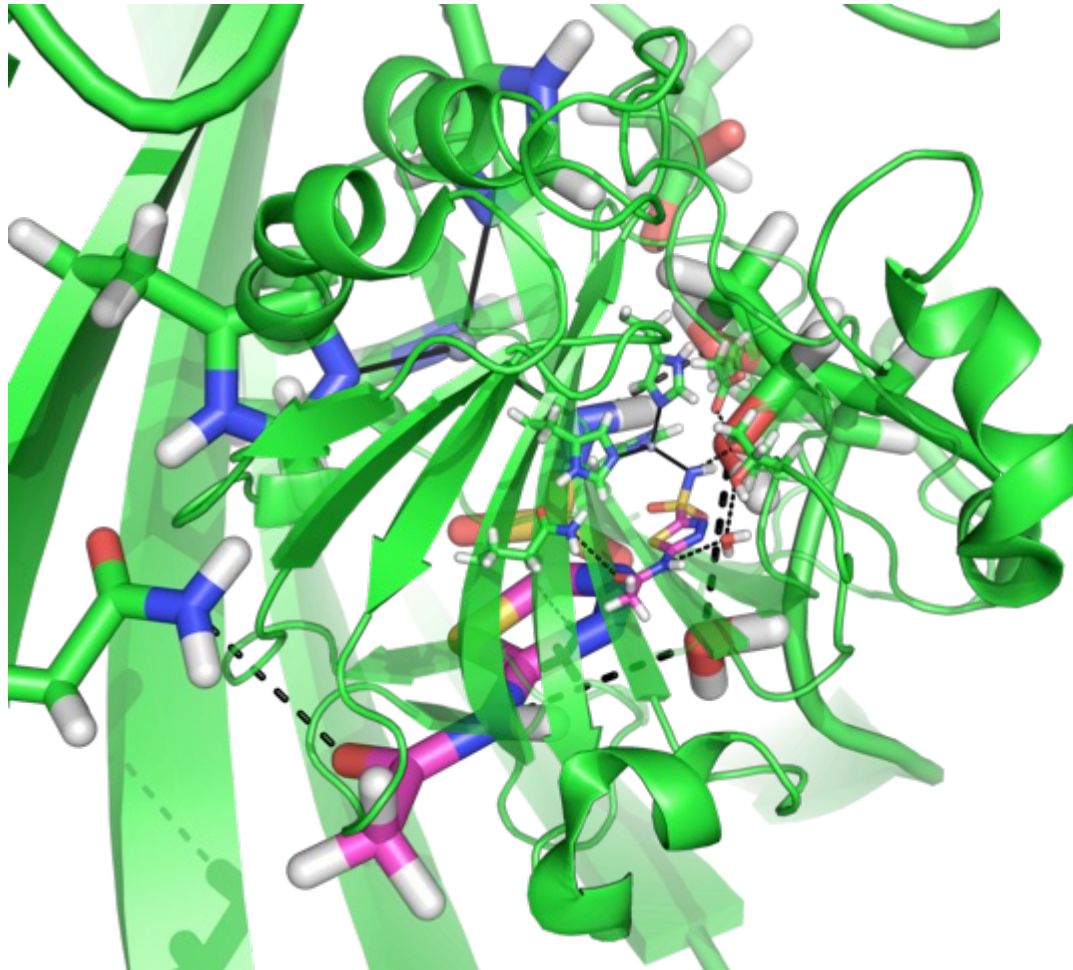


fundamental & particle physics



Neutrons reveal how drugs interact with drug targets

Life sciences



Carbonic anhydrase

- Enzyme
- Transports CO₂
- Regulates blood acidity

Scientists are studying its role in some cancers, glaucoma, obesity and high blood pressure

Neutron crystallography pinpoints protons and waters in the active site, showing how the drug Acetazolamide binds to this enzyme

Neutrons for a sustainable energy economy



Energy research



Wind turbines:

- strong, light, flexible materials
- better magnets

Solar panels:

- Economically feasible, robust solutions
- Neutron reflectivity probes surface action

Cars:

- Fuel cells
- Long-range batteries
- Lighter materials





How do we store the renewable energy?

The Royal Swedish Academy of Sciences awarded the Nobel Prize in Chemistry 2019 to John B. Goodenough
M. Stanley Whittingham
Akira Yoshino



"for the development of lithium-ion batteries"



Energy research



By increasing the Li^+ content, the energy density can be improved

BUT this affects cost and safety.

Use neutrons to monitor Li^+ directly in battery systems during charge and discharge.



Li-ion battery during discharge. Li^+ ions move from anode to cathode inside the battery while electrons move through a wire.



“Machine forensics” using neutrons

Engineering & geo-sciences



Neutrons can penetrate massive metal parts easily.
Neutrons see the hydrogen-rich soot
The technical problem was understood using neutron tomography.

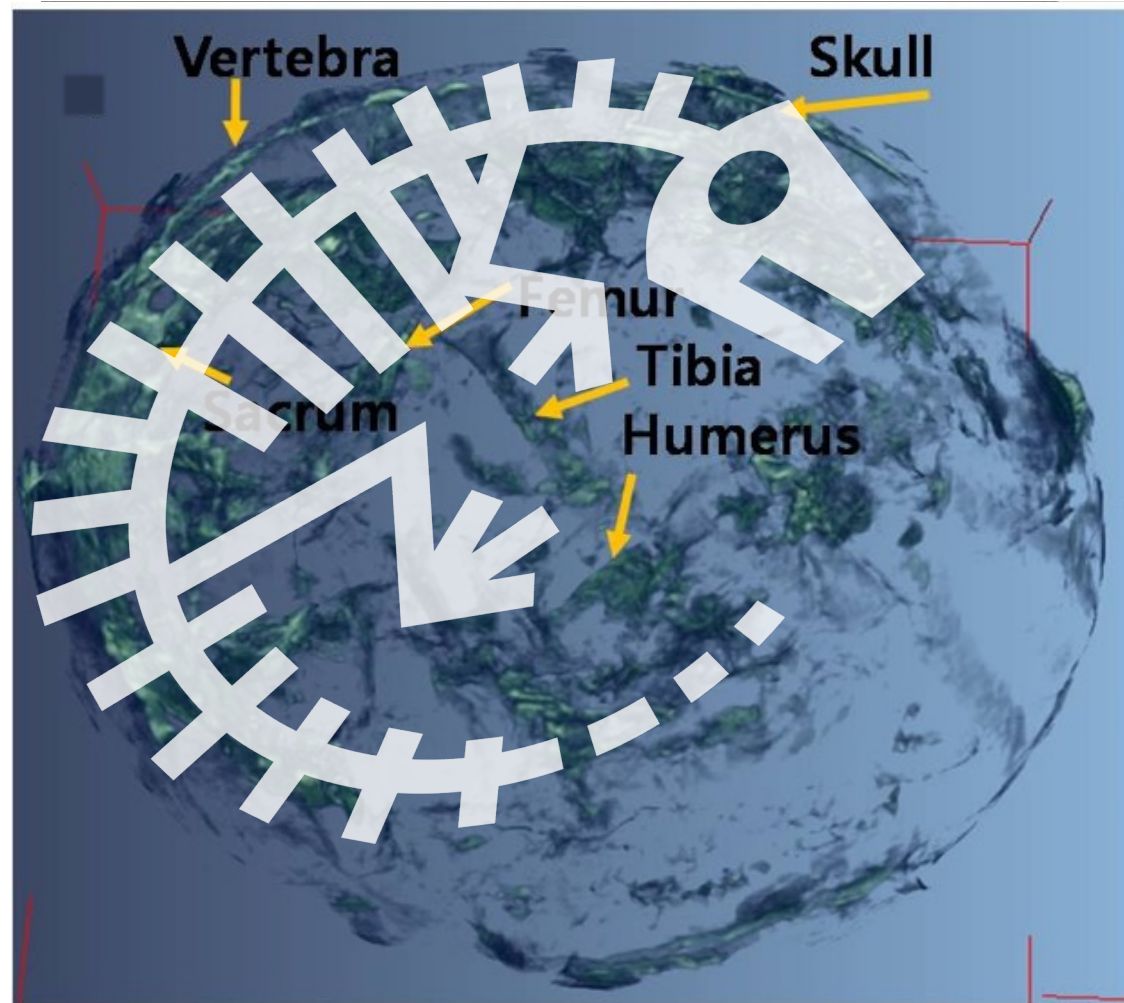


Neutrons for Archaeology

Looking inside a dinosaur egg

[Gondwana
Research 20 \(2011\),
621-629](#)

Sindra Petersson Årsköld





How does it work?

How does a giant microscope work?



1. Protons are generated at the ion source

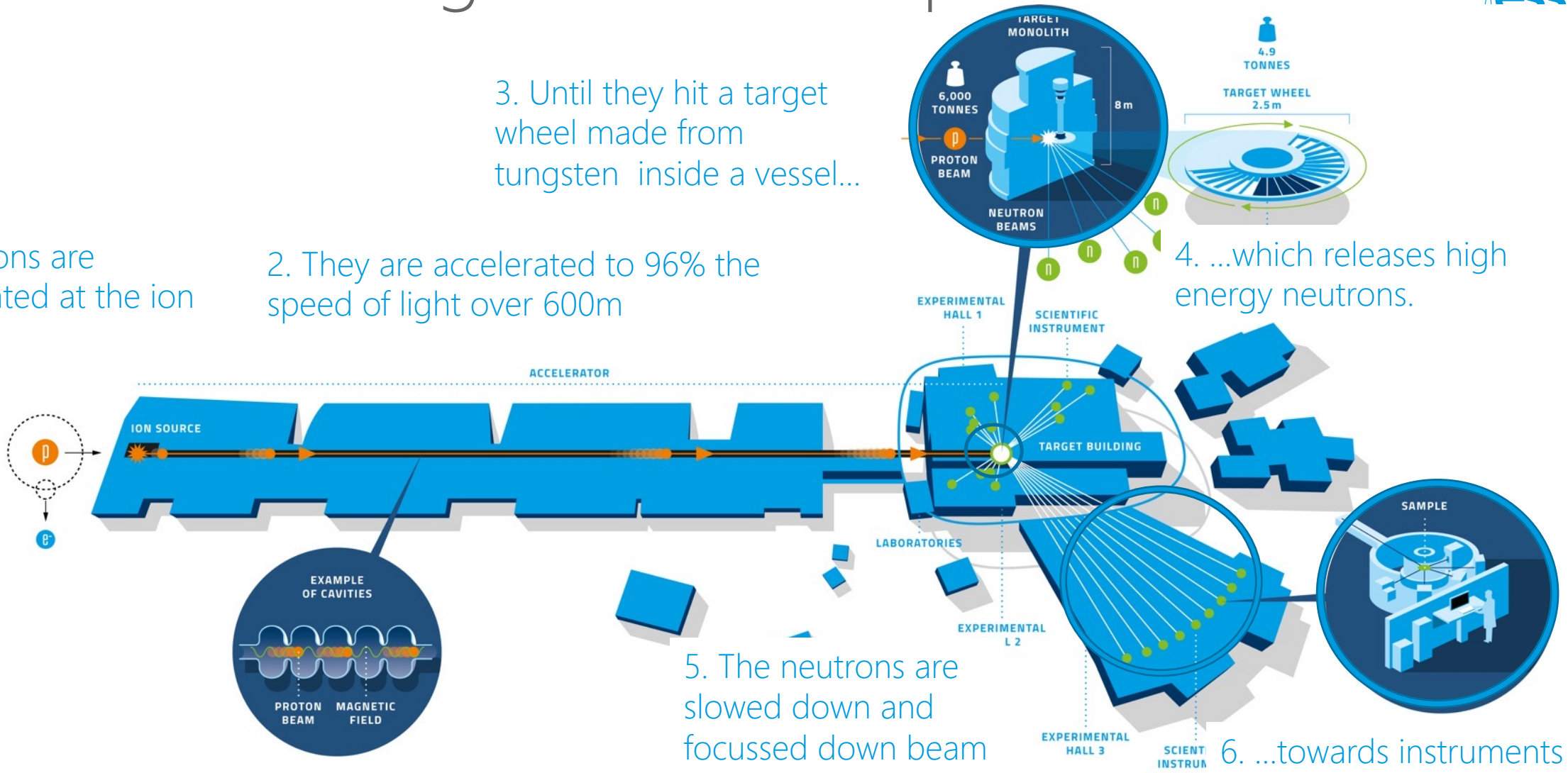
2. They are accelerated to 96% the speed of light over 600m

3. Until they hit a target wheel made from tungsten inside a vessel...

4. ...which releases high energy neutrons.

5. The neutrons are slowed down and focussed down beam guides...

6. ...towards instruments where researchers use the neutrons to explore materials down to an atomic level.

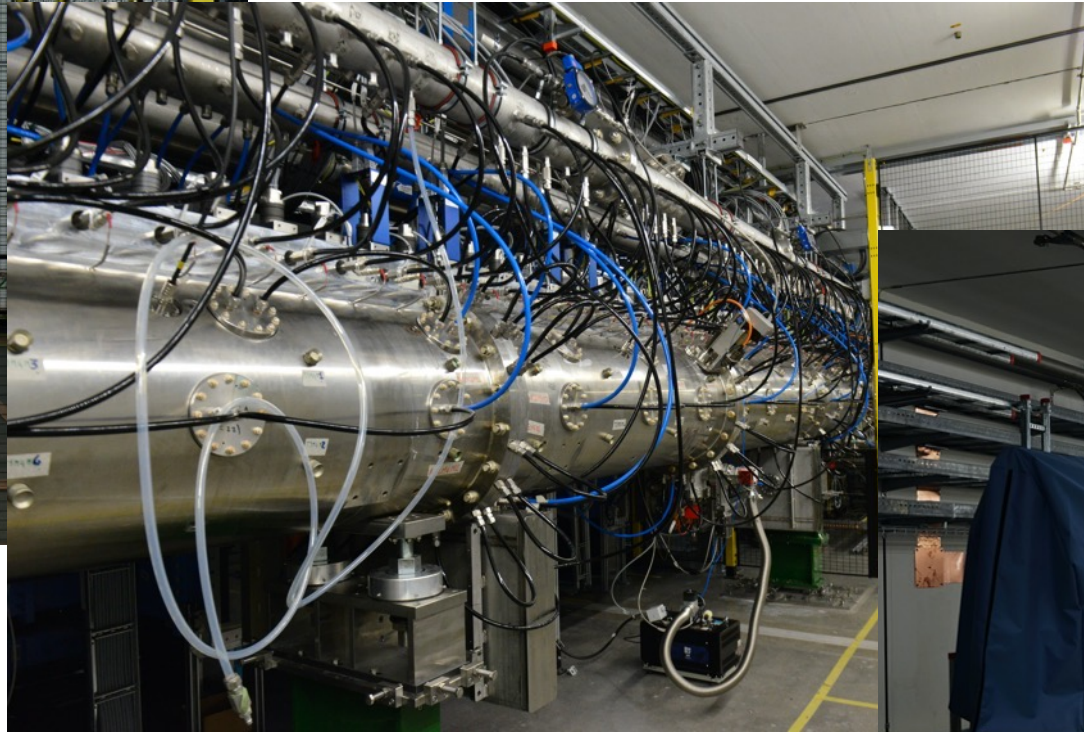


Accelerator

Ion source



Normal conducting linac

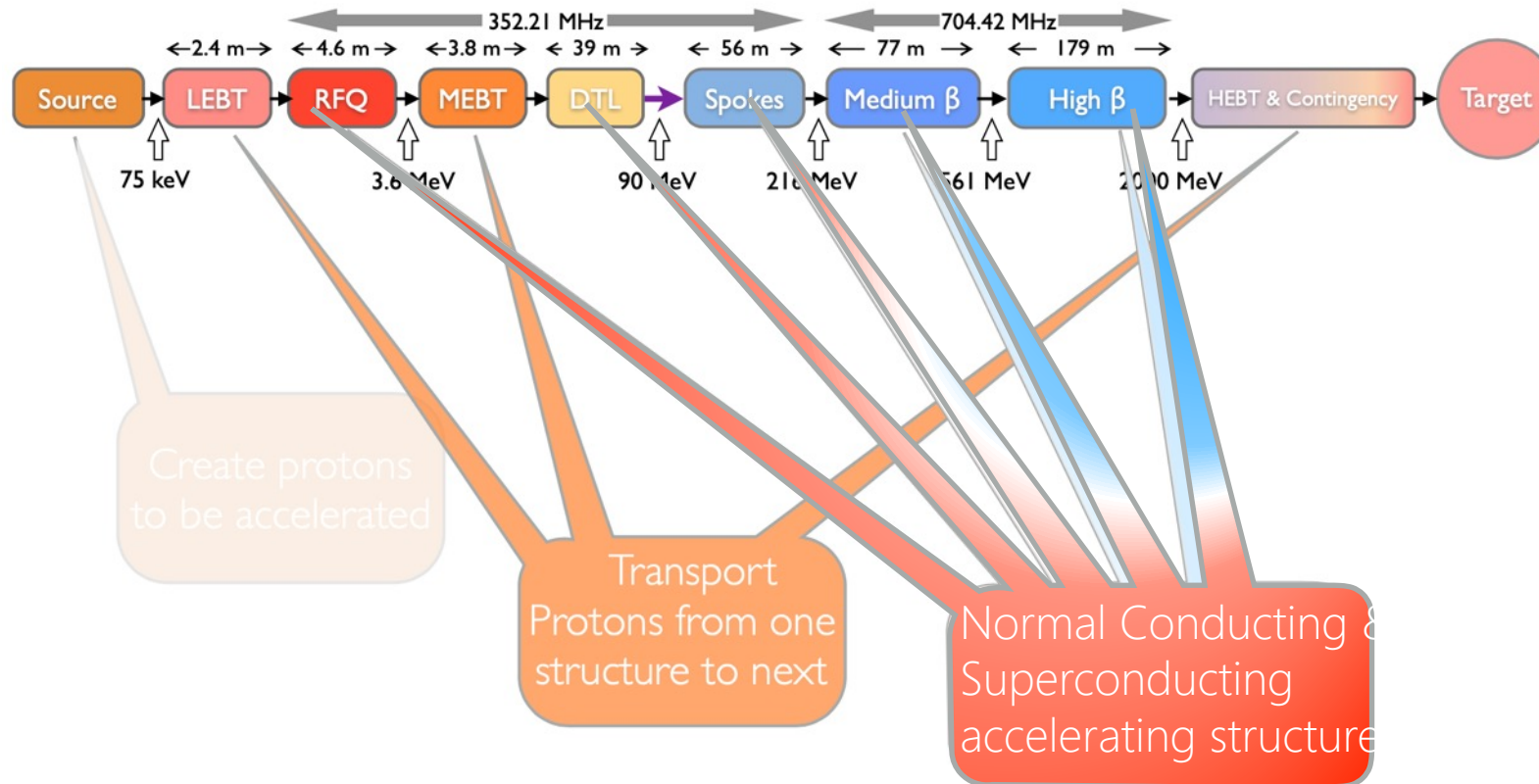


Super conducting linac



A Linear Accelerator has many components

Protons are guided, focussed and accelerated down a 600m tunnel

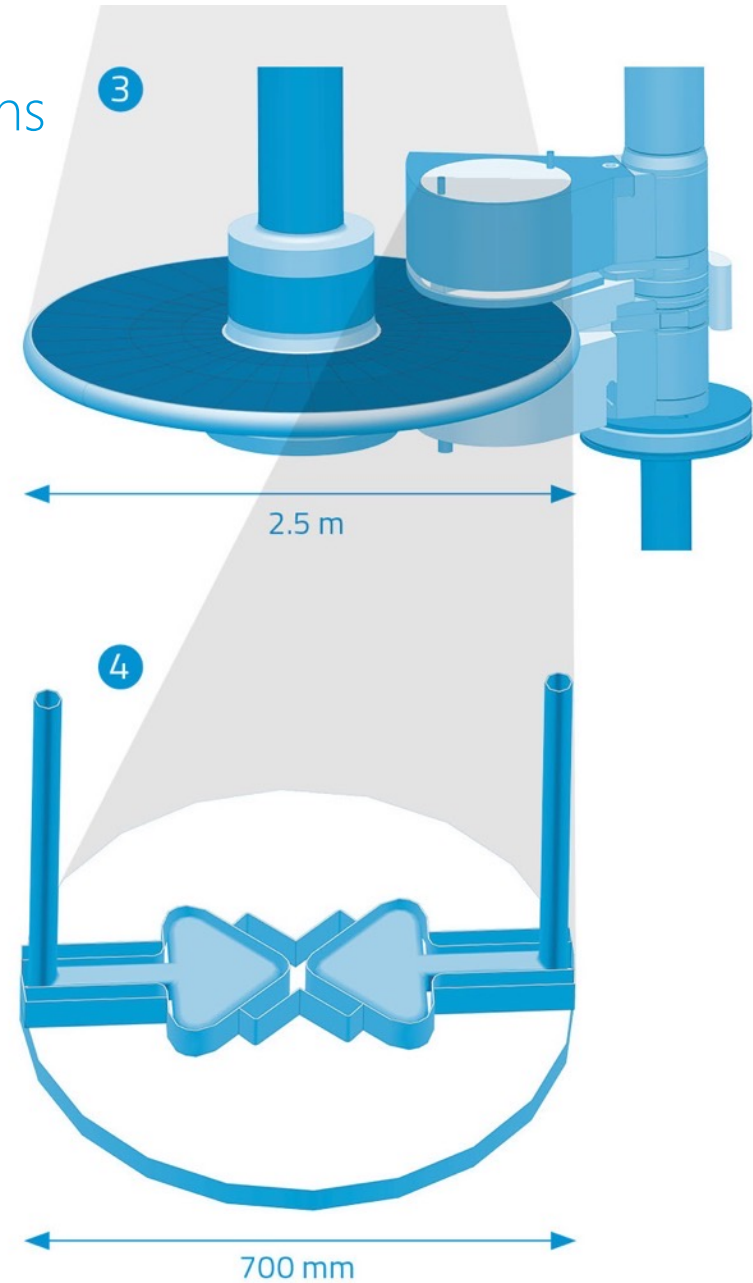
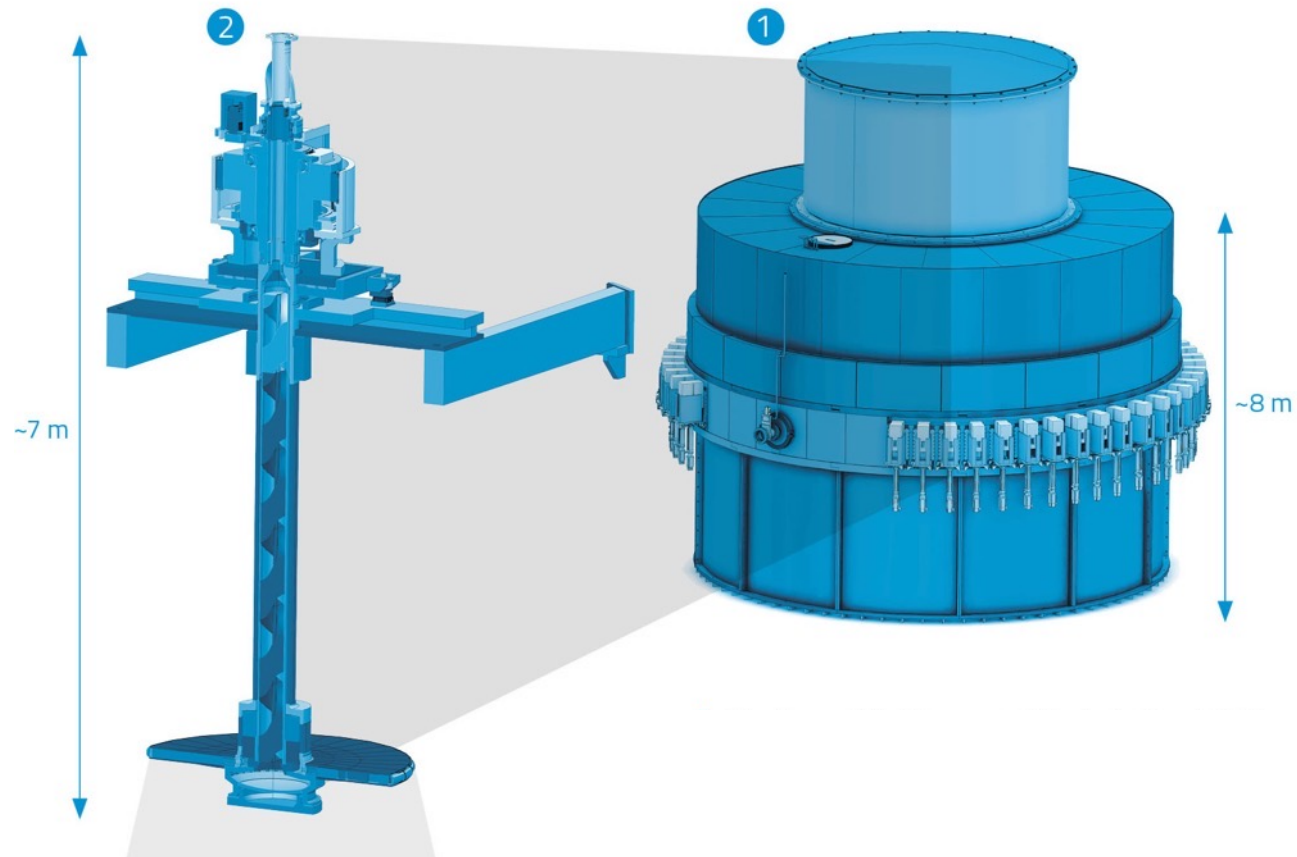


- Ion source
- Normal conducting and superconducting accelerating structures
- Beam Transport Units
- Vacuum
- Cryogenics
- Monitoring & control systems

Target station

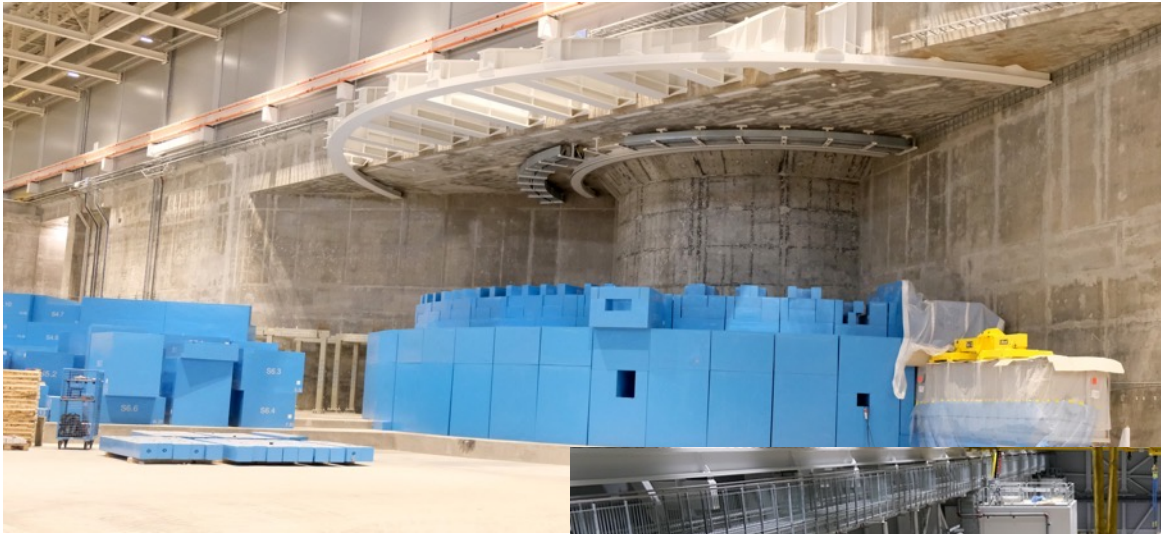
Where spallation occurs – the production of neutrons

Target Station Components



Target Bunker

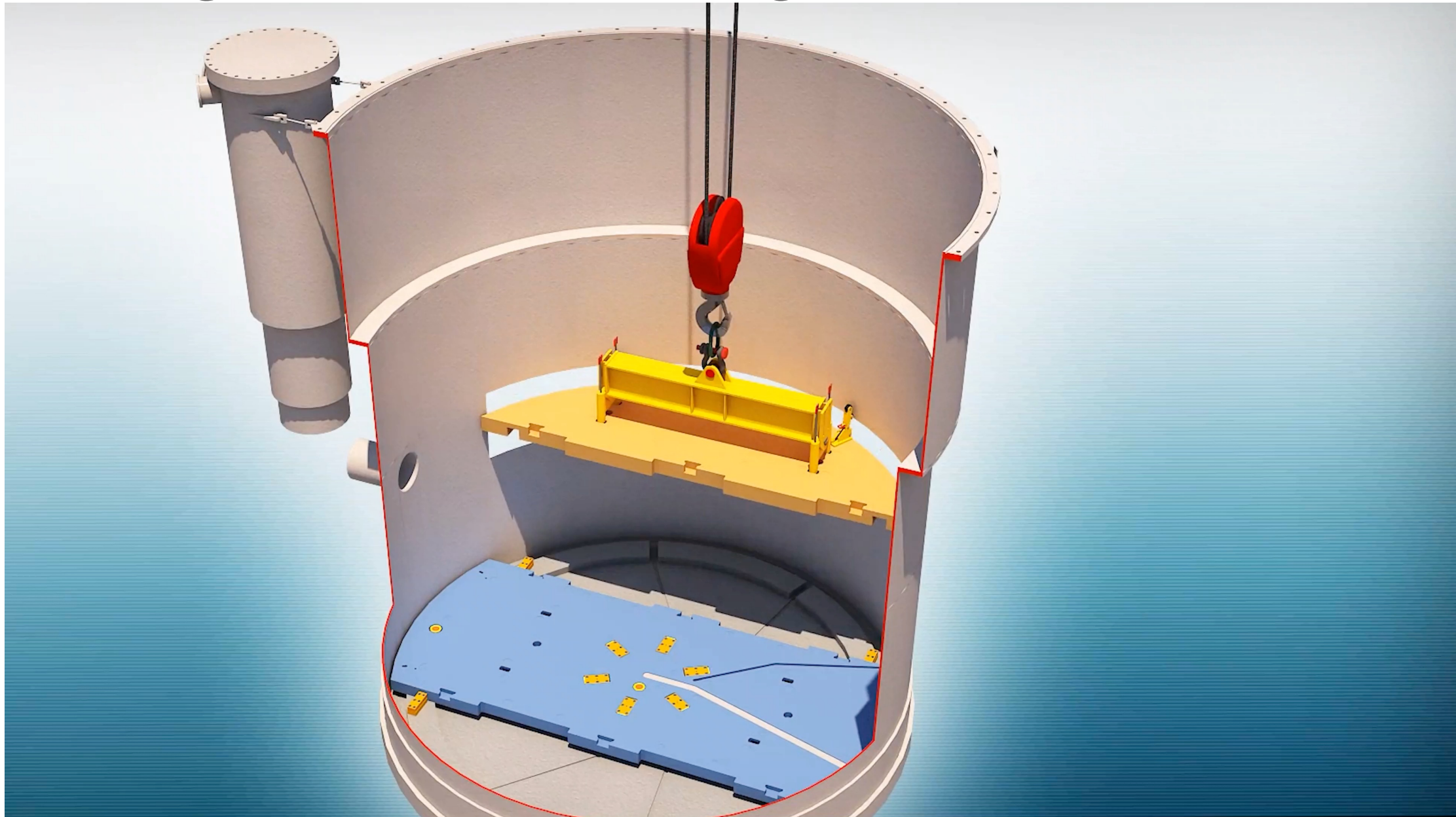
Target Wheel



Monolith



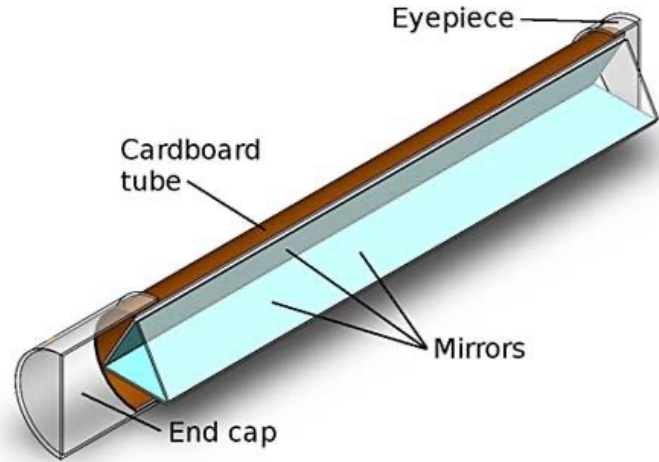
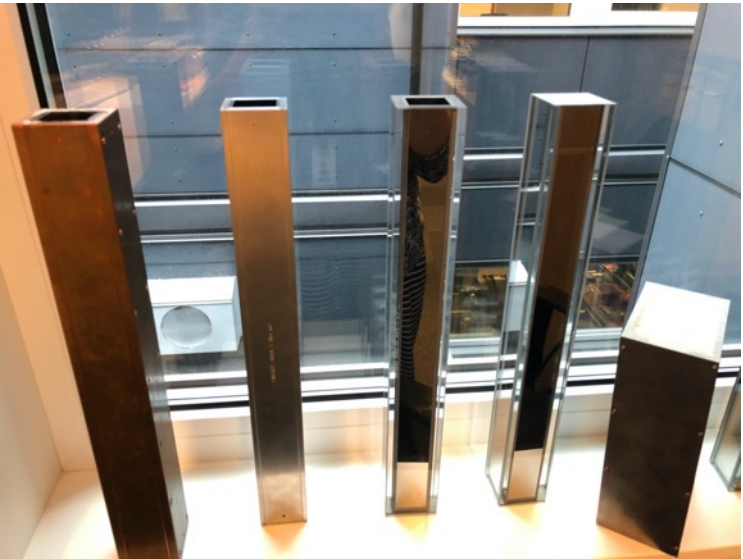
Target station shielding



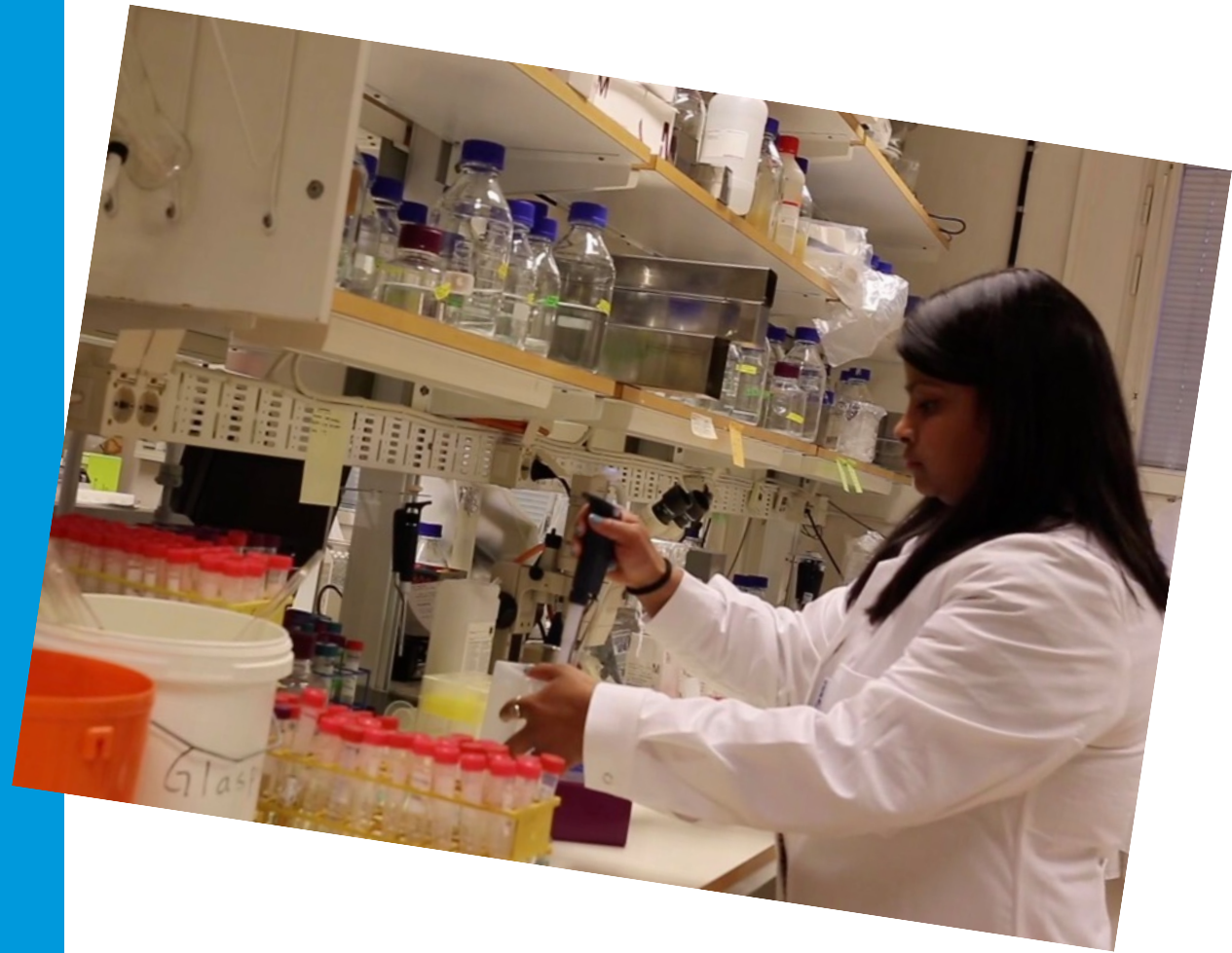
Neutrons are guided down beamlines

Until they interact with the sample in a particular instrument

Beamguides are a bit like very long, highly reflective, kaleidoscopes

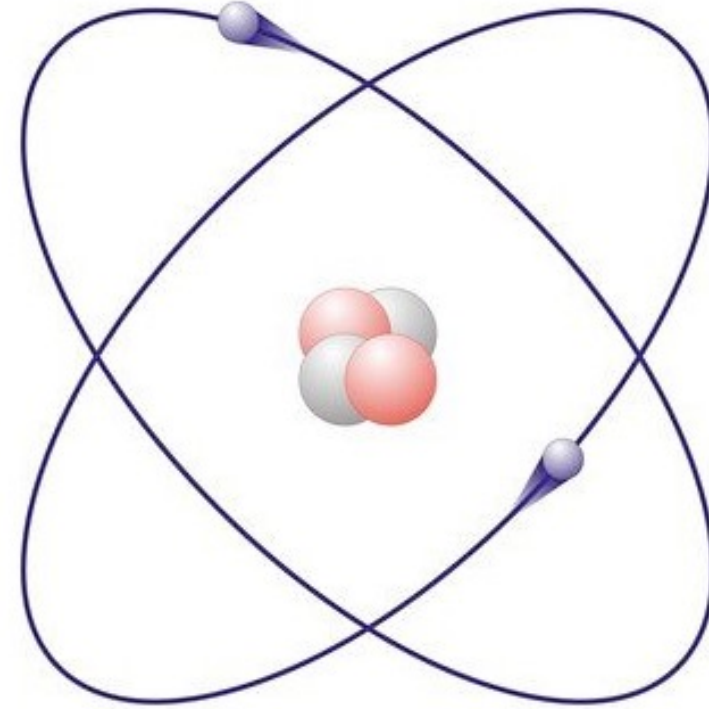


How do neutrons
help researchers
see inside stuff?



What's special about Neutrons?

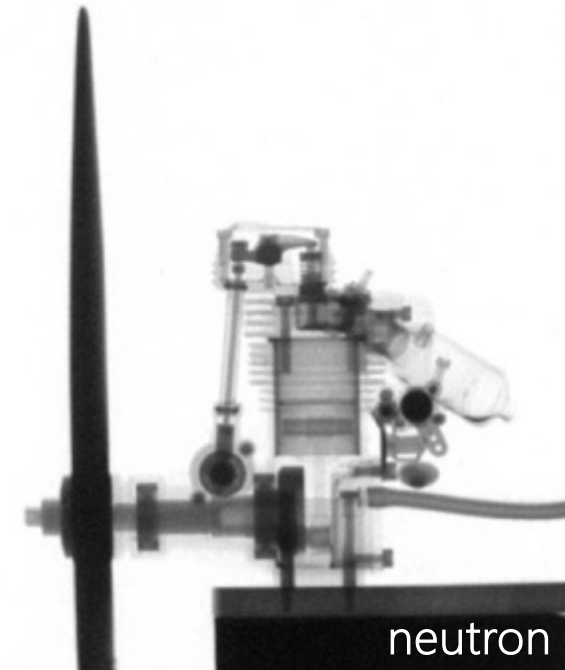
1. Neutral charge
2. Interact with the nucleus
3. Wavelengths are similar to atomic distances
4. Energies are similar to atomic and electronic processes
5. Have a magnetic moment



Neutrons See the Light Elements



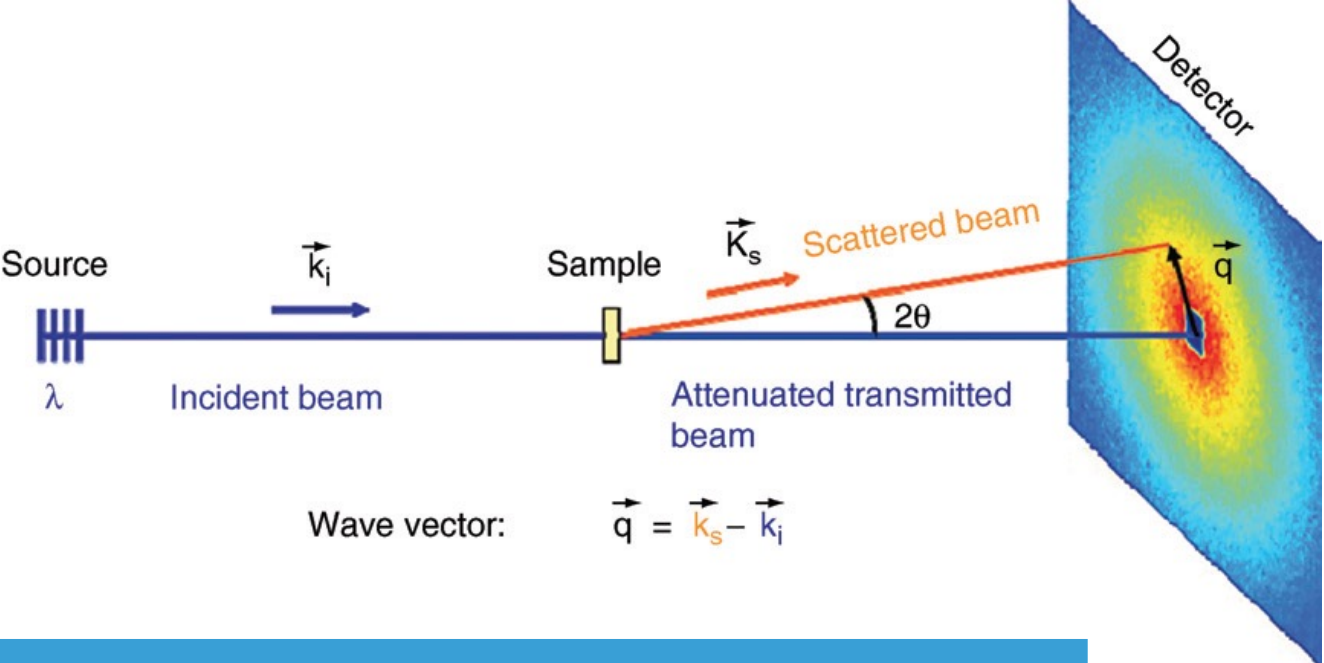
Courtesy of the NIAG group, PSI, Switzerland.





Neutron scattering shows the molecules and atoms inside a sample

Wavelength of a neutron = distance between atoms in a material
This produces a diffraction pattern

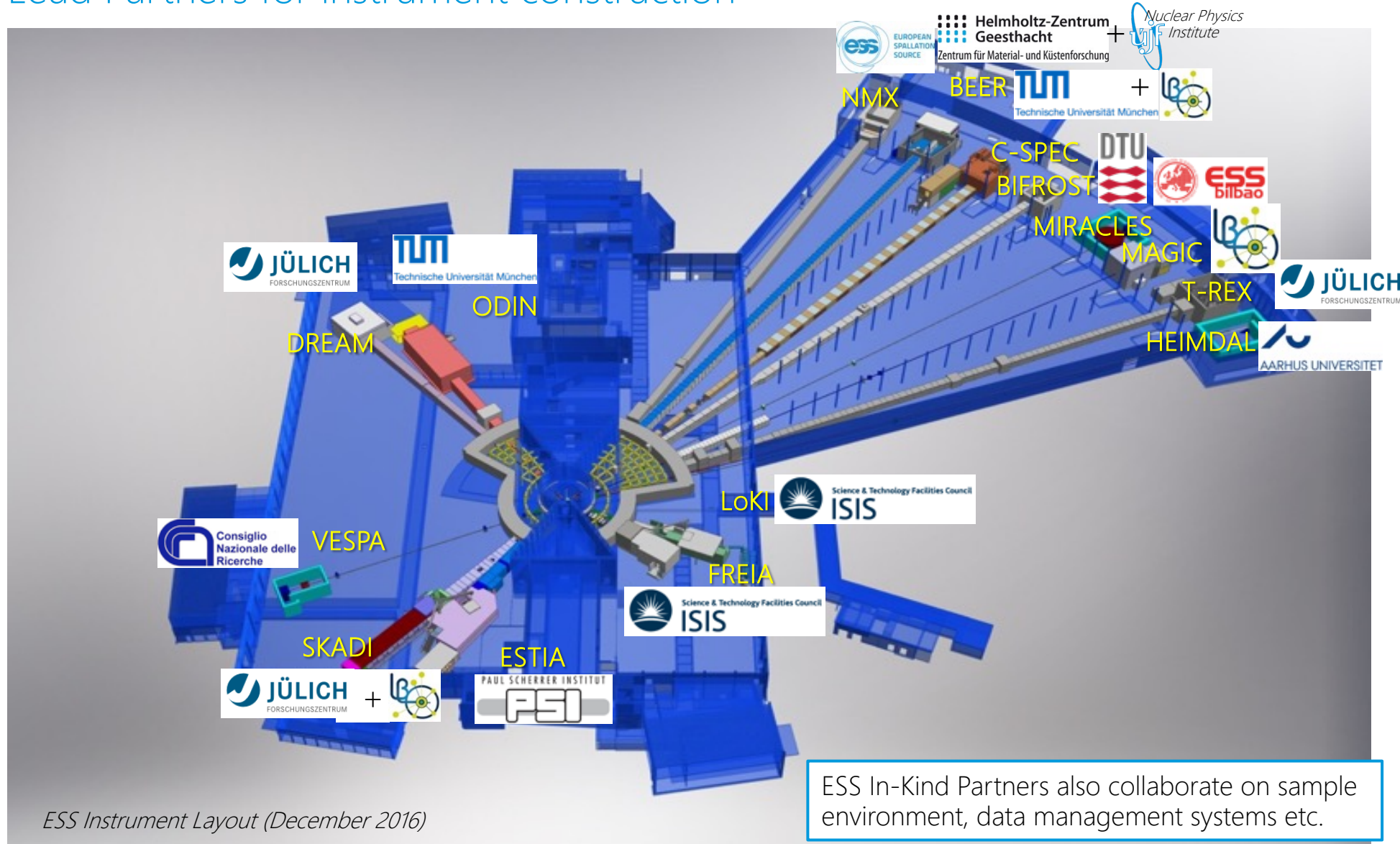


Neutrons tell us: Where are the atoms, and what are they doing?

Different instruments for different science



ESS Lead Partners for instrument construction



ESS Instrument Layout (December 2016)

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

Different instruments for different areas of science

15 Instruments funded. Space for at least 7 more in the future



Large-Scale Structures

ODIN imaging					
SKADI GP-SANS					
LOKI Broadband SANS					
Surface Scattering					
FREIA Hor. Refl.					
ESTIA Ver. Refl.					

Diffraction

HEIMDAL Pow. Diffr.				
DREAM Pow. Diffr.				
Monochromatic Powder Diffractometer				
BEER Eng. Diffr.				
Extreme Conditions Diffractometer				
MAGIC Magn. Diffr.				
NMX Macromol. Diffr.				

Spectroscopy

CSPEC ColdChopSp				
BroadbandSp				
T-REX ThChopSpec				
BIFROST Xana Spec				
VESPA Vibr.Spec.				
MIRACLES BckScatt				
High-Resolution Spin-Echo				
Wide-Angle Spin-Echo				
Fundamental & Particle Physics				

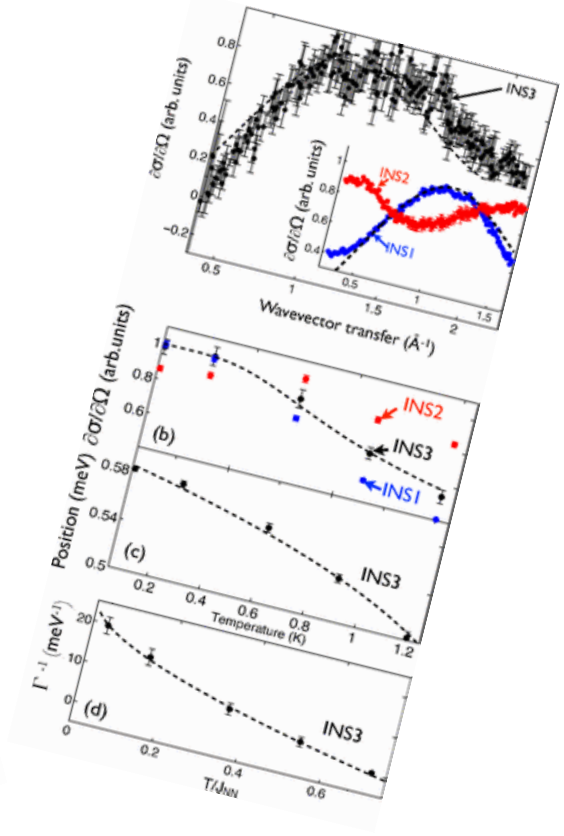
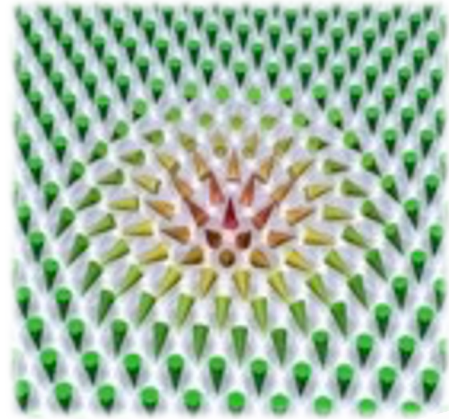
	life sciences		magnetism & superconductivity
	soft condensed matter		engineering & geo-sciences
	chemistry of materials		archeology & heritage conservation
	energy research		fundamental & particle physics

Then we turn all that data into meaningful results to share

A single set of experiments could produce a **terabyte** of data

About 500 hours of movies!

1. Sorted
2. Visualised
3. Analysed by the researchers



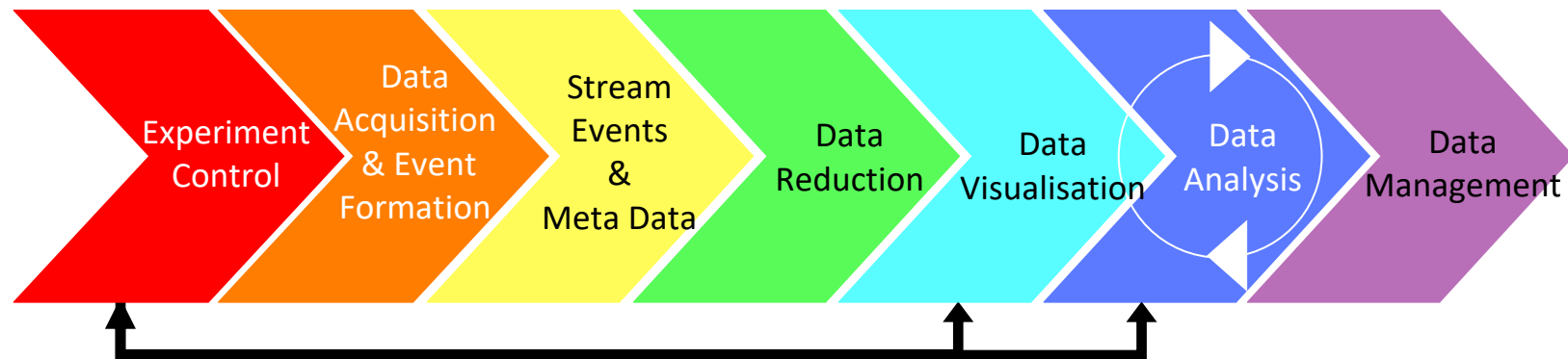
P. P. Deen, Phys Rev B ,ASP

Data Management and Software Centre

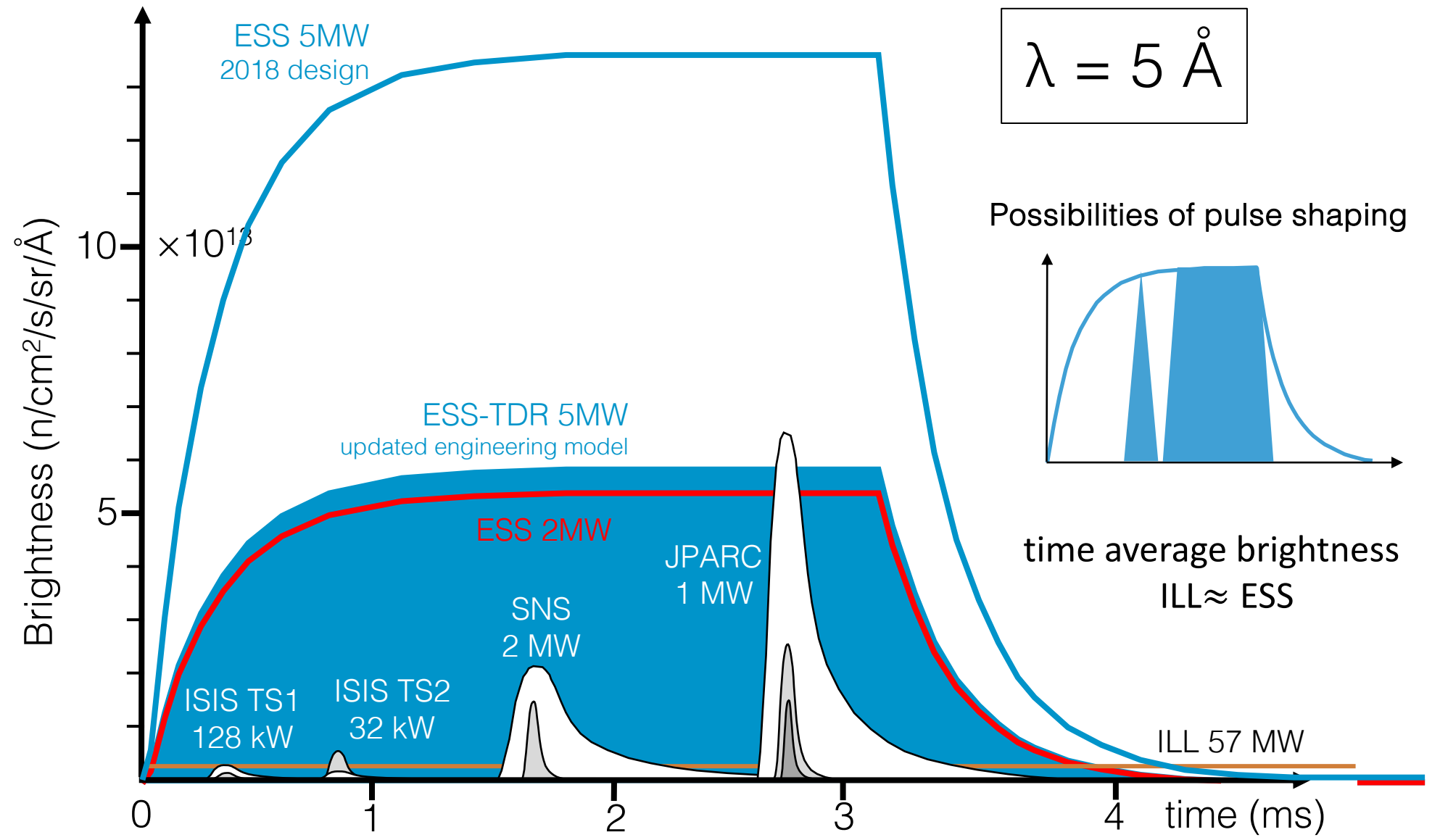


Based at Copenhagen University

Provide scientific software and computing support for researchers doing neutron scattering at ESS



Long-pulse performance



Everybody can
have a virtual
look

ess.eu/explore

The screenshot shows the ESS website interface. At the top right, there are links for CONTACT, PRESS, PRIVACY, and BEHIND ESS. The main navigation menu includes About ESS, Science & Instruments, Technology, Building ESS, Partners & Industry, and Careers. The central banner features a large image of a construction site with the heading "Webcams" and the text "There are four construction site webcams, updated at 10-minute intervals." Below this is a "Weekly Updates" button. To the left, there is a weather forecast section with the heading "Current co... More at Dark Sky" and a table of daily weather data. To the right, there is a section titled "Take a video tour of ESS under construction" with a video player thumbnail.

Day	Weather	High	Low
Today	* ❄️	6°	-2°
Sat	☂️	7°	1°
Sun	☂️	6°	3°
Mon	☂️	5°	3°
Tue	☂️	6°	2°

Information
Videos
Photos


Take a look at one our scientist's TEDx Talks



← ⓘ 🔒 https://www.youtube.com/watch?v=YBiWDJILtVU

☰ YouTube^{SE} Search

Youtube tag: YBiWDJILtVU



SINDRA PETERSSON ÅRSKÖLD

▶ ⏪ 🔊 0:25 / 16:06 CC ⚙️ 📺 🗑️

'Texts, drugs and dinosaurs-neutrons show the way'
| Sindra Petersson Årsköld | TEDxLundUniversity

The image shows a screenshot of a YouTube video player. At the top, there is a browser address bar with the URL 'https://www.youtube.com/watch?v=YBiWDJILtVU'. Below that is the YouTube logo with 'SE' and a search bar. The video player itself shows a woman with long brown hair, Sindra Petersson Årsköld, adjusting her sunglasses. The video title 'SINDRA PETERSSON ÅRSKÖLD' is overlaid on the bottom of the video frame. Below the video frame is a control bar with play, previous, volume, and progress indicators (0:25 / 16:06), along with icons for closed captions, settings, full screen, and a refresh icon. At the bottom of the player, the video title and speaker information are displayed: ''Texts, drugs and dinosaurs-neutrons show the way' | Sindra Petersson Årsköld | TEDxLundUniversity'.

<https://youtu.be/YBiWDJILtVU>



Thank you

Joanna.Lewis@ess.eu