SE needs for imaging/engineering:
Expectations and Experiences

Presenter:
Malcom Guthrie (ESS)

Presentation prepared by:

ODIN:
Michael Lerche (TUM)
Manuel Morgano (PSI)
Markus Strobl (PSI)

BEER:
Přemysl Beran (NPI)
Jan Šaroun (NPI)
Jochen Fenske (HZG)
Gregor Nowak (HZG)

Instrument class coordinator
Robin Woracek (ESS)

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SE needs for imaging/engineering

Overview

- **BEER**
  - Status SE + Envisioned User cases
- **ODIN**
  - Status SE + Envisioned User cases

The next slides will outline:

- There is a **large variety** (and only few standard) sample environments in applications that use **imaging & engineering diffraction**
- Even if the instruments have world-leading performance, they are not readily usable for all academic and industrial needs – **many applications require suitable environment!**
  - Explore possibilities to built SE's for Imaging & Engineering ahead of time (ensure scientific/industrial drivers and motivation: close collaboration with instruments!)
- **A lot of SE is custom built (by users and beamlines),** typically due to:
  - Imaging: specific requirements due to transmission geometry and a very broad variety of applications
  - Engineering: A lot of different processes are of high interest: require very specialized SE
  - **Integration of such equipment needs to be ensured**

SE needs for imaging/engineering

BEER: The Engineering Diffractometer at ESS

BEER: Beamline for **E**uropean Materials **E**ngineering **R**esearch

Helmholtz-Zentrum Geesthacht
Centre for Materials and Coastal Research

GEMS
German Engineering Materials Science Centre

Nuclear Physics Institute CAS
Czech Republic

Přemysl Beran
Jan Šaroun
Petr Lukáš
Petr Šittner

ESS coordinator
Robin Woracek

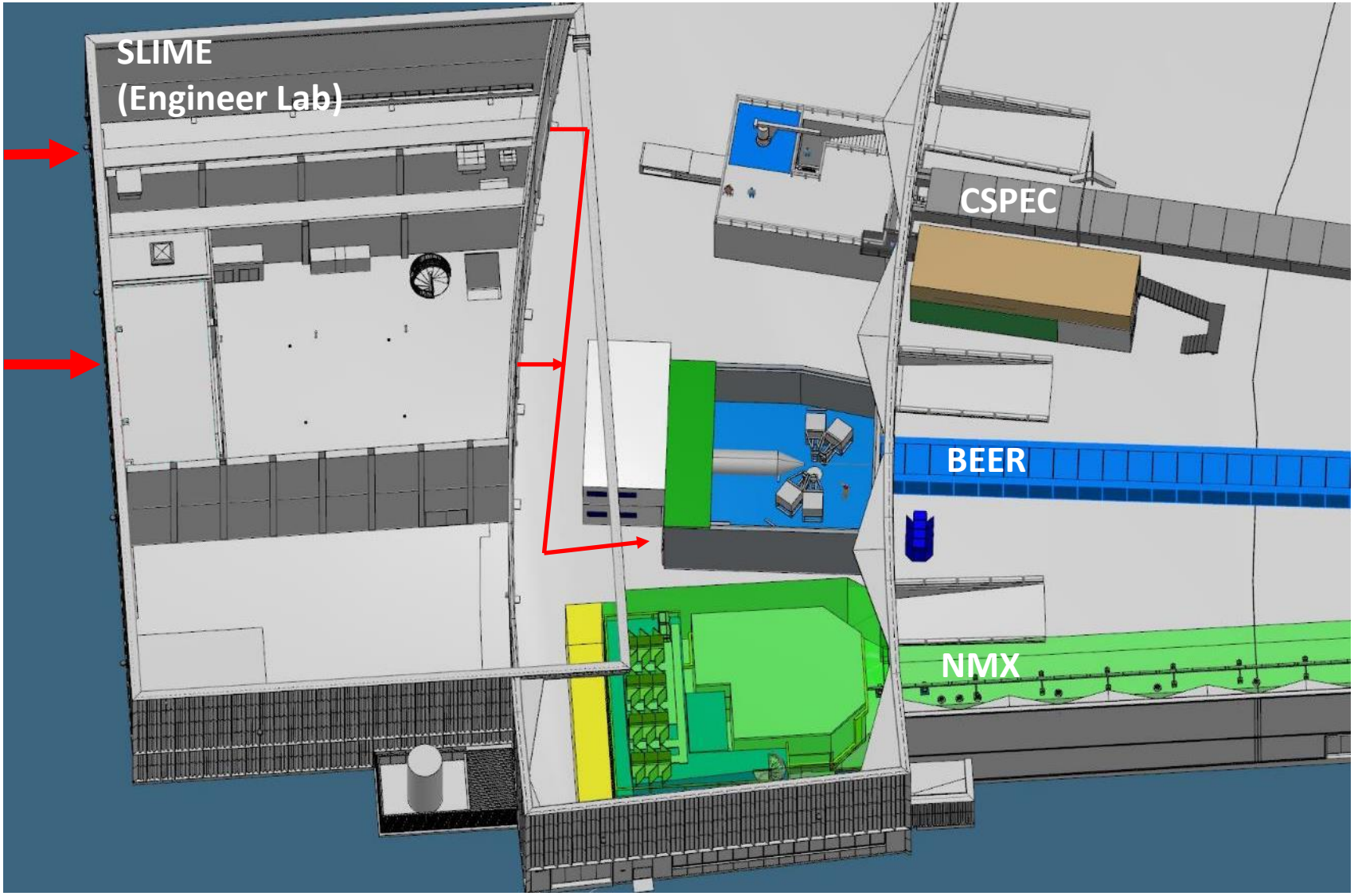
Helmholtz-Zentrum Geesthacht
Germany

Jochen Fenske
Gregor Nowak
Dirk Jan Siemers
Rüdiger Kiehn
John Hedde
Peter Staron
Martin Müller

Budget: ~ 14.99 Mio €
TG2 approval 05.05.2017
Approved for first 8 instrument

SE needs for imaging/engineering

BEER: The Engineering Diffractometer at ESS



SE needs for imaging/engineering

BEER: The Engineering Diffractometer at ESS

Included within BEER Budget:

Hexapod:

- payload 2 t
- x, y: ±110 mm
- z: ±150 mm

six axis robot:

- payload 14 kg
- repatability: ±0.06 mm

Sample Environment included in SAD Budget:

deformation rig:

- furnace 1200 °C
- max. load 60 kN

Dilatometer:

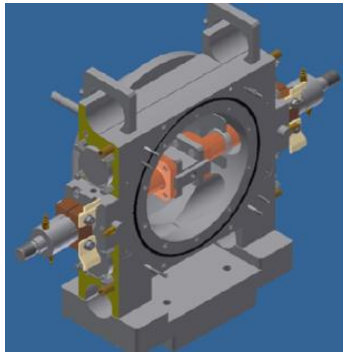
Only partly funded

- induction heating:
  - max. heating rate 4000 K/s
  - max. cooling rate 2500 K/s (hollow samples)
- DSC unit
- deformation units (compr., tension; 25 kN)

SE needs for imaging/engineering

BEER: The Engineering Diffractometer at ESS

Sample Environment with external funding:



Ultra high temperature furnace for stress rig:

- payload 2 t
- x, y: ±110 mm
- z: ±150 mm
- Collaboration between NPI & Chalmers (magnus.colliander@chalmers.se)
- ~9.5 MSEK over 4 years (2017–2020) funded by Vetenskapsrådet
- Simultaneous access to as many of the planned detector banks as possible (including imaging)
- Preferably, it should be transferable to other beamlines (ODIN and SKADI)

Sample Environment (expected that users + in-kind partners bring it)

- It can be expected that users will bring and or design their custom sample environment
- There are very many industrial processes that could be studied at BEER (and it won't be possible to provide suitable devices for everything): We should be prepared to integrate these!
- However: Some key SE devices could be identified

Sample Environment workshop 2-3 May

http://chem.au.dk/en/research/conferences-and-workshops/neutron-and-synchrotron-sample-environment-workshop/

SE needs for imaging/engineering

BEER: User case 1 – Tensile testing with heating

Before the experiment:

- User needs a specs (dimension depends on specific grips): need standards that are compatible with standard mechanical testing
- User needs to define requirements (max. load, loading sequence, temperature curves)
- In the preparatory lab: welding of thermocouples, strain gauges, other potential sensors (acoustic emission, resistivity measurement, etc.)
- Pre-alignment can be useful in a preparatory lab, especially when SE is not yet installed on the sample position

Requirements:

- Control over the rig to maintain stress values during the temperature changes
- Sample can be sensitive to air, so it needs vacuum or inert atmosphere

Be aware:

- Be aware of bending and misalignment issues! (especially with self built rigs)
- Free orientation might be necessary to access scattering vectors freely! *(compare large rig at VULCAN where restricted vs portable rigs by FRM2 and UTK allowing for tilting)*

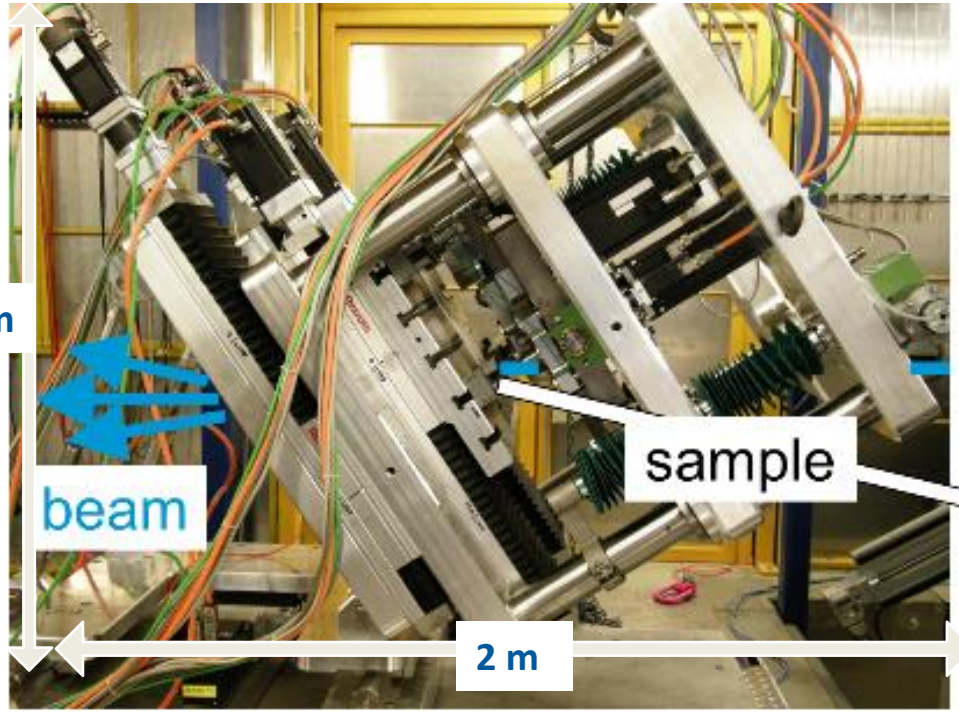
After:

- The return of samples back for further analysis is necessary

SE needs for imaging/engineering

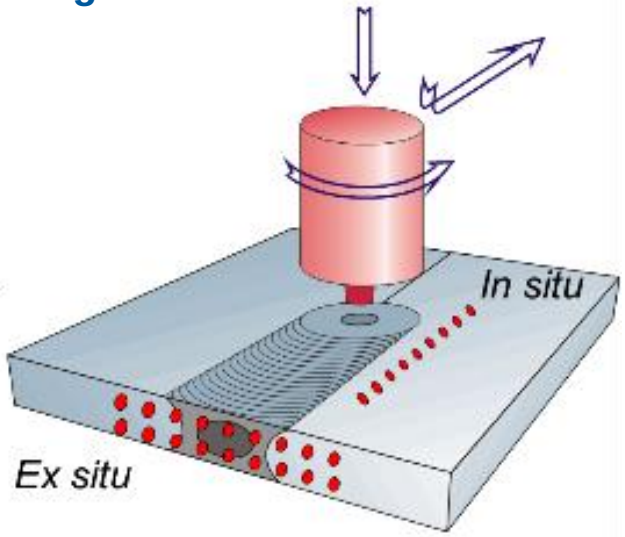
BEER: User case 2 – Friction stir welding

***In situ* studies of the friction stir welding (FSW) process:**



FlexiStir at the HZG high-energy X-ray beamline
HARWI II@DESY

mass:
1400 kg



Before the experiment:

- Communication between user and instrument team + SAD + DMSC + ICS
- Integrate the SE software into ESS control/DAQ software
- Develop long-term plan if SE will be used many times

SE needs for imaging/engineering

BEER: User case 3 – custom strain scanning

custom strain scanning of a complex sample

- user needs the access to a 3D scanning tool which transfers the sample coordinate system to the instrument coordinate system (example Strain Scanning Simulation Software: SScanSS)
- the description of mounting stages (hexapod plate, robot arm interface, etc.) has to be known to prepare the sample fixing routine
- Option to import CAD and/or 3D sample volume from tomography experiment

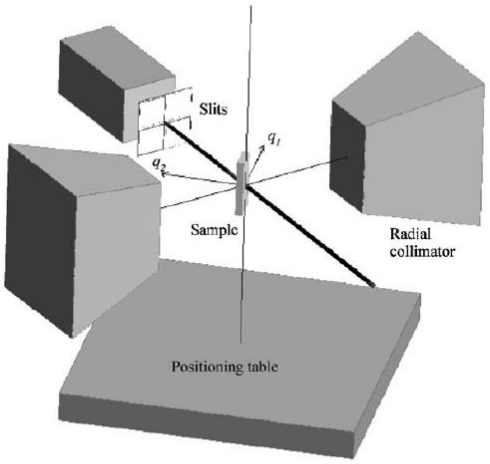
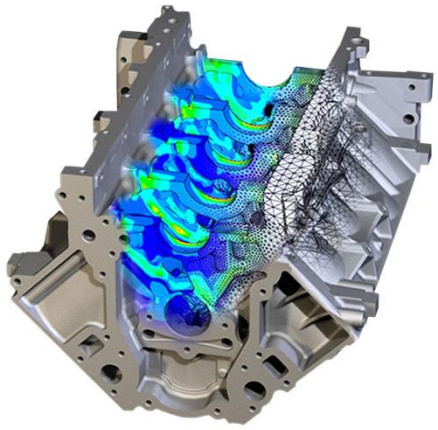


Fig. 2. 3D model of ENGIN-X generated by the software, q_1 and q_2 indicate the strain directions measured by the instrument.



Laser tracker alignment

SE needs for imaging/engineering

ODIN: The Neutron Imaging Instrument at ESS

ODIN: Optical and Diffraction Imaging with Neutrons

Technische Universität München

PAUL SCHERRER INSTITUT PSI

Technische Universität München
Germany

Michael Lerche
Elbio Calzada
Burkhard Schillinger
Michael Schulz

Paul Scherrer Institut
Switzerland

Manuel Morgano
Markus Strobl

ESS coordinator
Robin Woracek

Budget: ~ 11.6 Mio €
TG2 approval 31.05.2017
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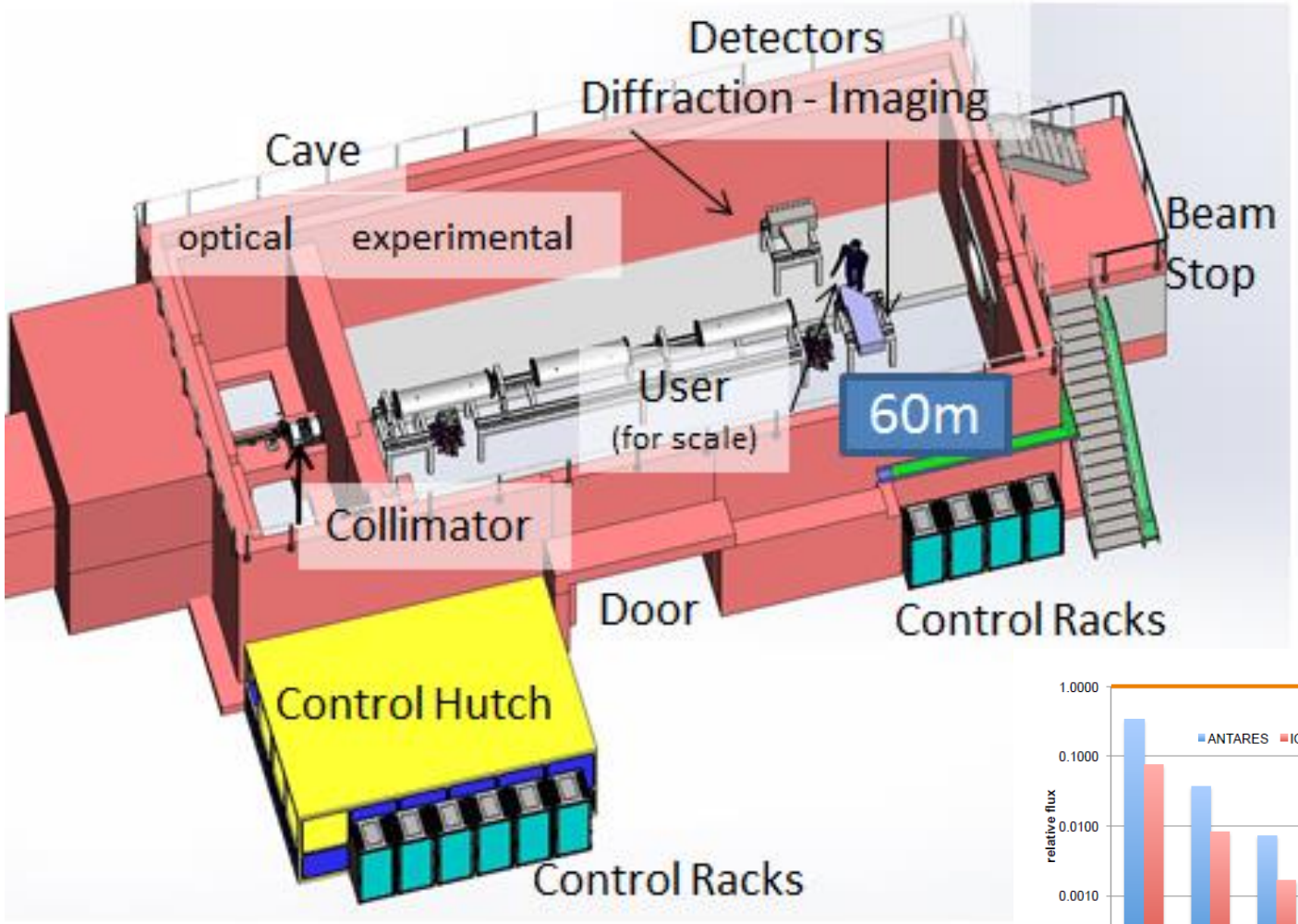
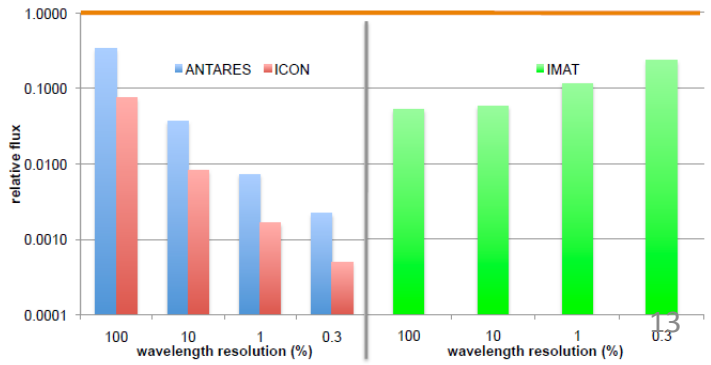
SE needs for imaging/engineering

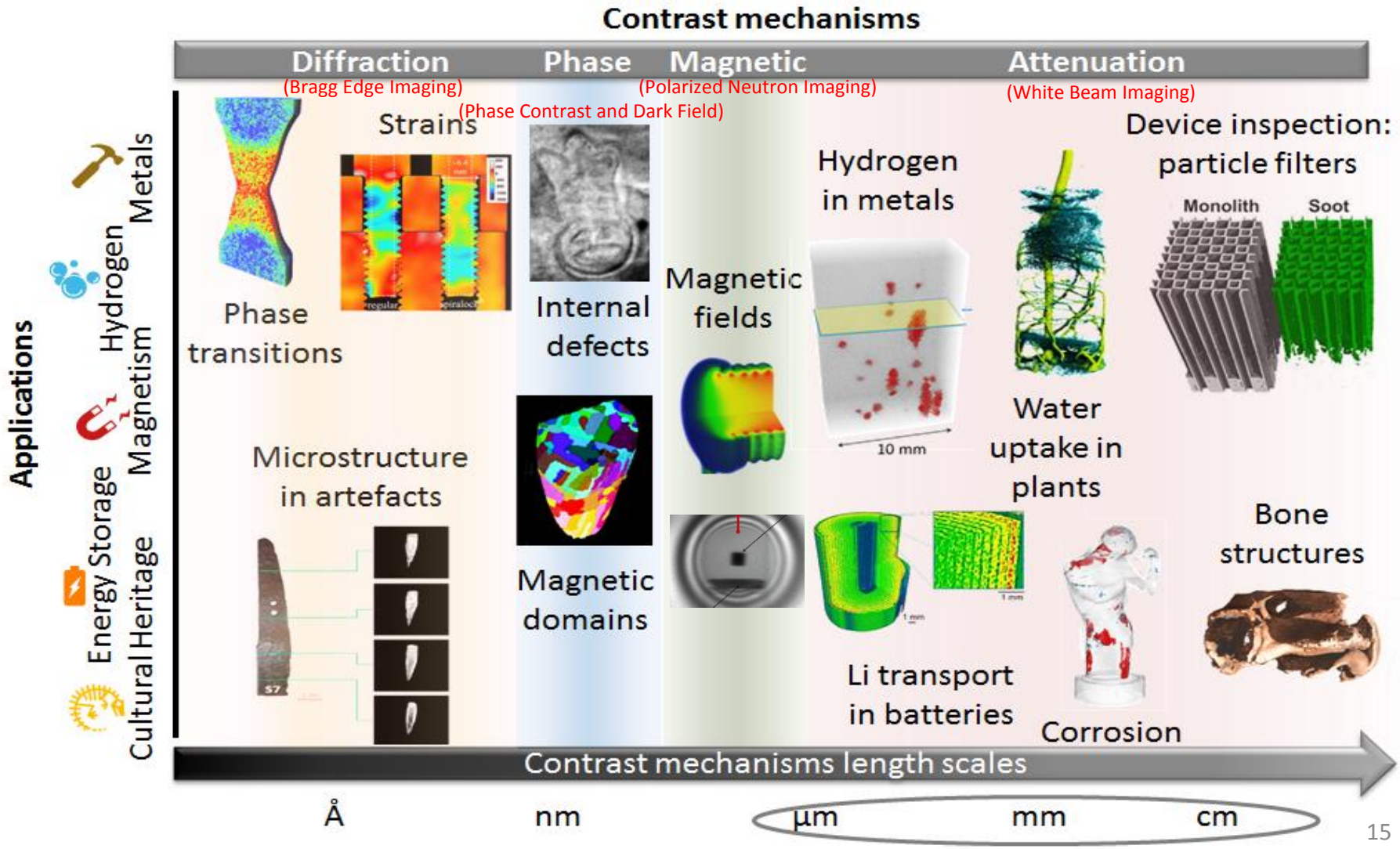
ODIN: The Neutron Imaging Instrument at ESS





SE needs for imaging/engineering

ODIN: Scientific requirements



Kardjilov et al., Advances in Neutron Imaging, Materials Today, accepted (2018)

SE needs for imaging/engineering

ODIN: General remarks on SE

- **Imaging is unique compared to other techniques**
  - transmission based: samples need to be as close to the detector as possible
- **Imaging SE usually has requirements differing from scattering techniques**
  - Little involvement in general ESS sample-environment pool
  - Many “one of” solutions with third party funding in the community, Only few standards so far
- Instrument project focus currently clearly is WU 02, 05 and 11 (Guide, Choppers, Shielding)
- **Nonetheless ODIN was designed with potentially large SE systems in mind**

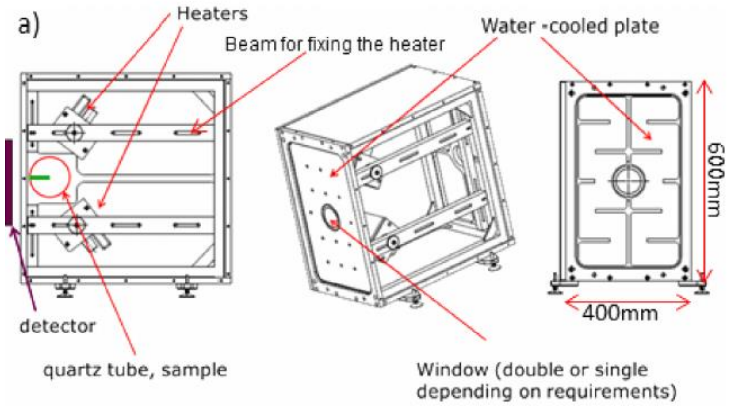
- **Imaging users often come from very broad disciplines, e.g.**
  - Biology (plant growth, H-D water exchangers)
  - Electrochemistry (charging/discharging devices for batteries, fuel cell operation stands)
  - Physics (magnetic fields and spin manipulations)
  - Engineering (in-situ welding, thermo-/mechanical testing)
  - Industry (often specific requirements)
- **Experience from existing neutron imaging beamlines:**
  - Most of the times, users bring their SE equipment to the beamlines
  - Key is integration (mechanical and software!) for flawless user experience and successful experiment

SE needs for imaging/engineering

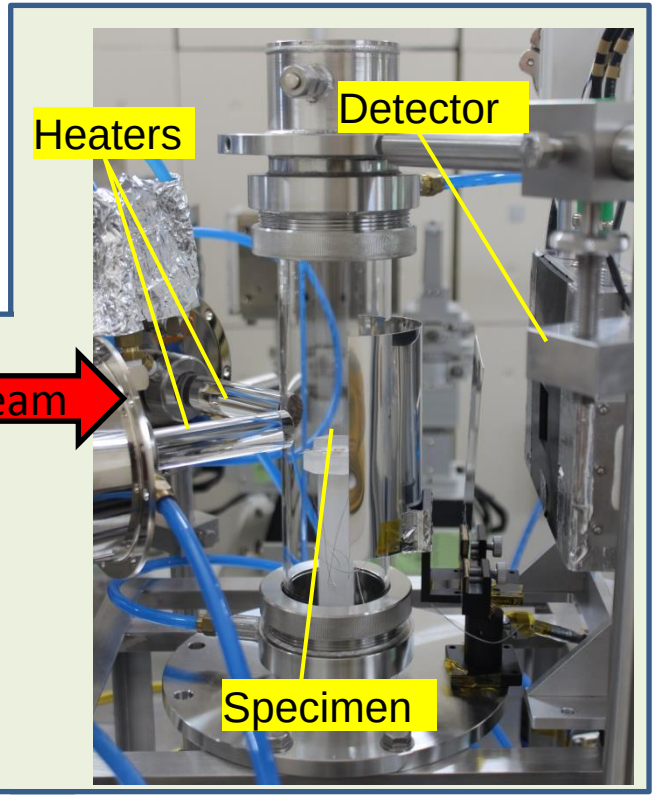
ODIN: User case 1 – Annealing

A typical example from the imaging community:

- This furnace was developed during PhD project at DTU (in collaboration with ESS)
- Control via LabView (furnace is still used at beamline, including V20): needs integration



Makowska, Małgorzata G., et al. "Flexible sample environment for high resolution neutron imaging at high temperatures in controlled atmosphere." Review of Scientific Instruments 86.12 (2015)



The state of the-art ToF imaging beamline is **RADEN** at JPARC:

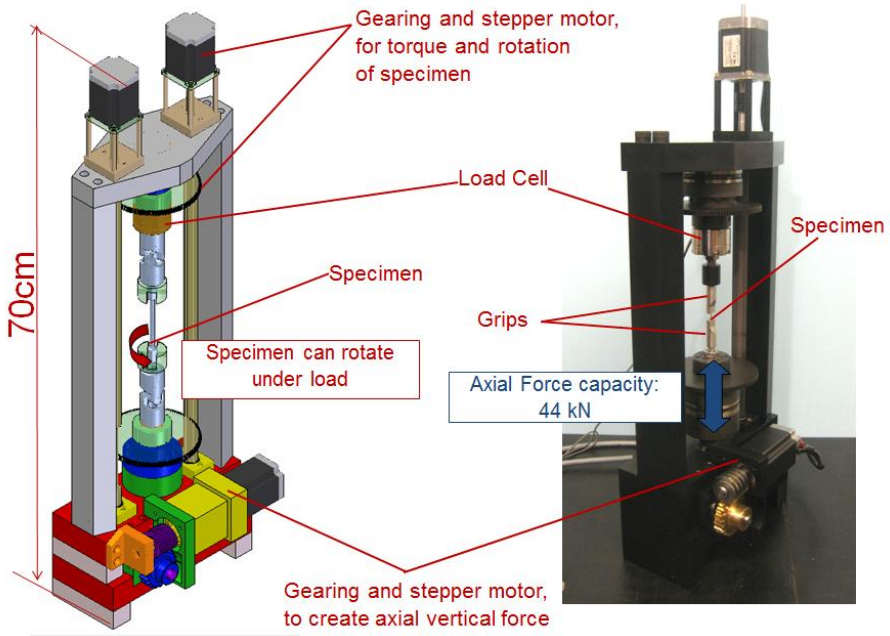
- They recently commissioned a new furnace (partly based on experiences with the DTU furnace) and offer it in their SE-pool
- Optimized for transmission, but also suitable for diffraction

SE needs for imaging/engineering

ODIN: User case 2 – stress rig for tomography

Another typical example (naturally applicable to BEER):

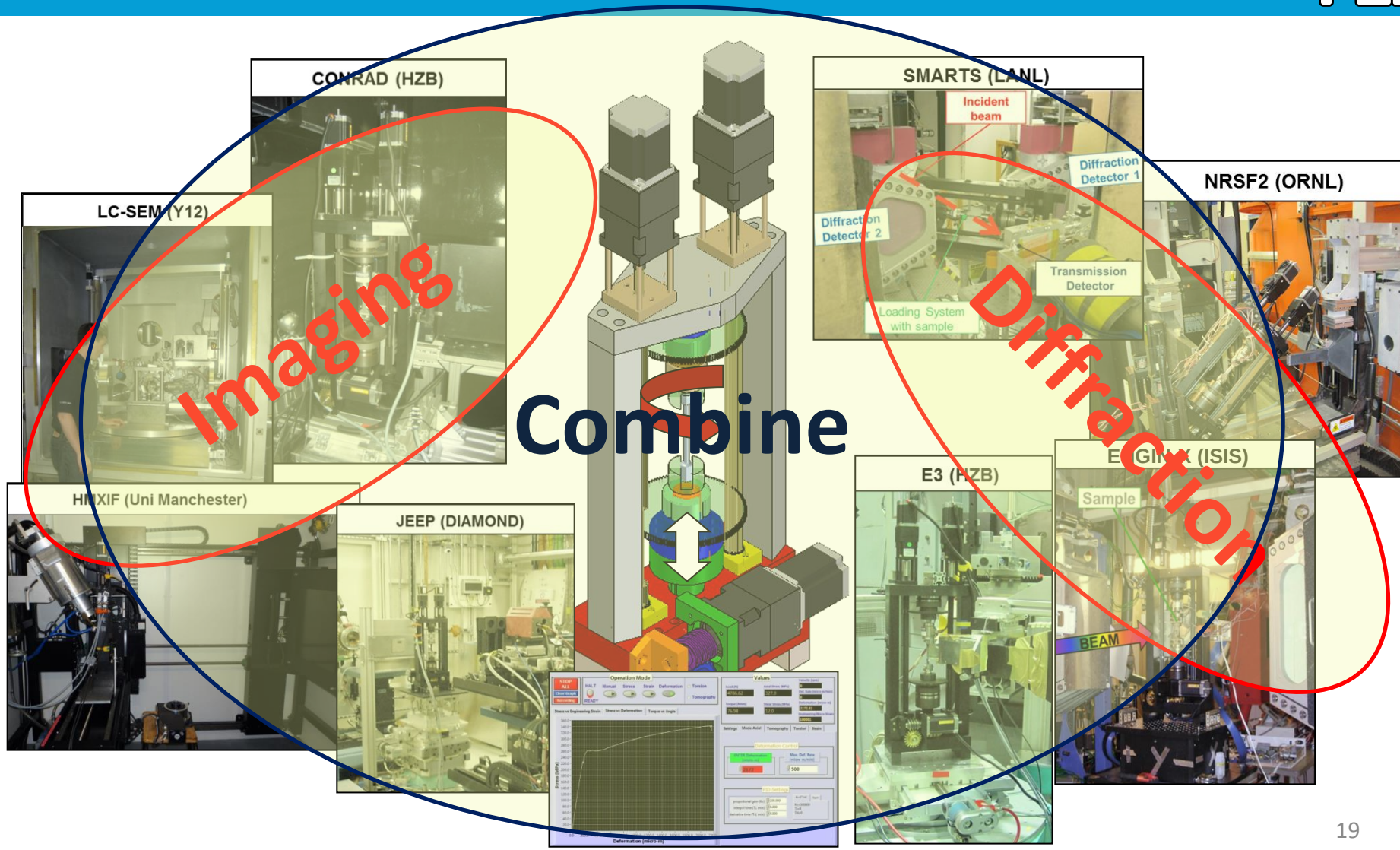
- Custom designed and build mechanical loading system (The University of Tennessee, Knoxville, USA)
- 3 systems operational and used (1 x ORNL, 1 x UTK, 1 x HZB/ESS: at V20)
- Control via LabView (furnace is still used at beamline, including V20): needs integration
- One system currently used at JPARC by ESS/DTU/NPI/PSI for '3D-ND/diffraction-tomography' (CZ-ESS infrastructure project)
- Could a simlar a system be built by ESS/in-kind partner?



- Tension: up to 44kN
- Compression: Up to 10kN
- Tomography: sample rotates freely under load
- Flexibility to test different specimens (materials, shapes) using custom grips
- Mobility of the system (Dimensions: 70 cm x 26 cm x 17 cm, Weight: approx 32 kg)
- proper alignment: protocol + samples + software

SE needs for imaging/engineering

ODIN: User case 2 – stress rig for tomography



Woracek, R., et al. "Method to determine hkl strains and shear moduli under torsion using neutron diffraction." APL 100.19 (2012)

SE needs for imaging/engineering

ODIN: User case 3 – climate chamber

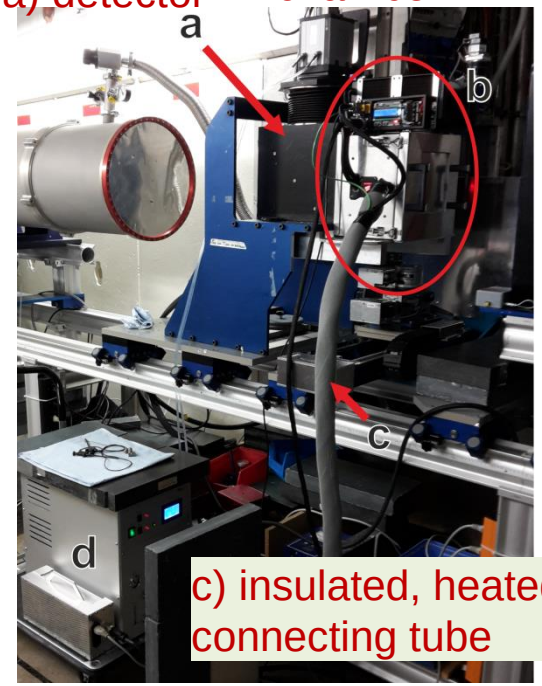
Another typical example :

- Custom designed climate chamber for in-sity neutron imaging (by PSI)
- Moisture generator providing air with adjustable temperature and relative humidity
- Suitable for radiography + tomography

Applications:

quantification of moisture contents or moisture related dynamic processes:

- Building materials (e.g. wood, concrete, etc.)
- Food science (e.g. fruit drying, etc.)
- Electrochemistry (e.g. battery duty cycles under varying temperature conditions)
- Cultural heritage / conservation science (e.g. development of conservation treatments)

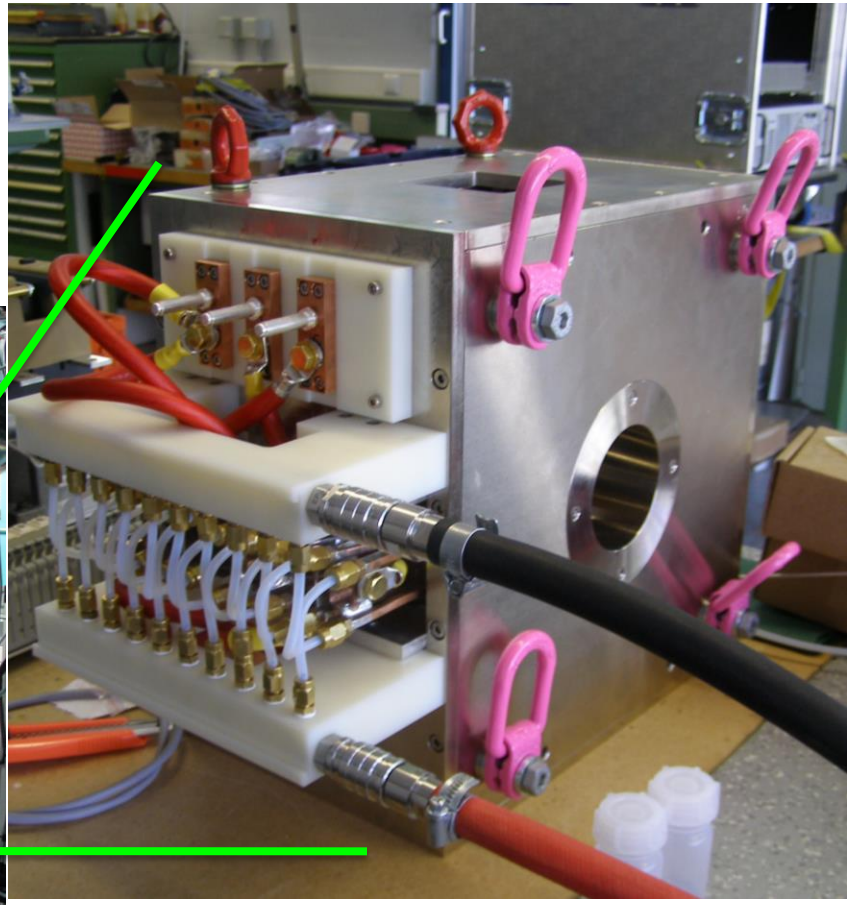


SE needs for imaging/engineering

ODIN: User case 4 – custom magnet

Another typical example :

- Custom designed non-cryogenic magnet ~0.3T (by TUM/FRM2)
- small profile along the beam
- B parallel or perpendicular to beam
- can host small diameter cryo-sample

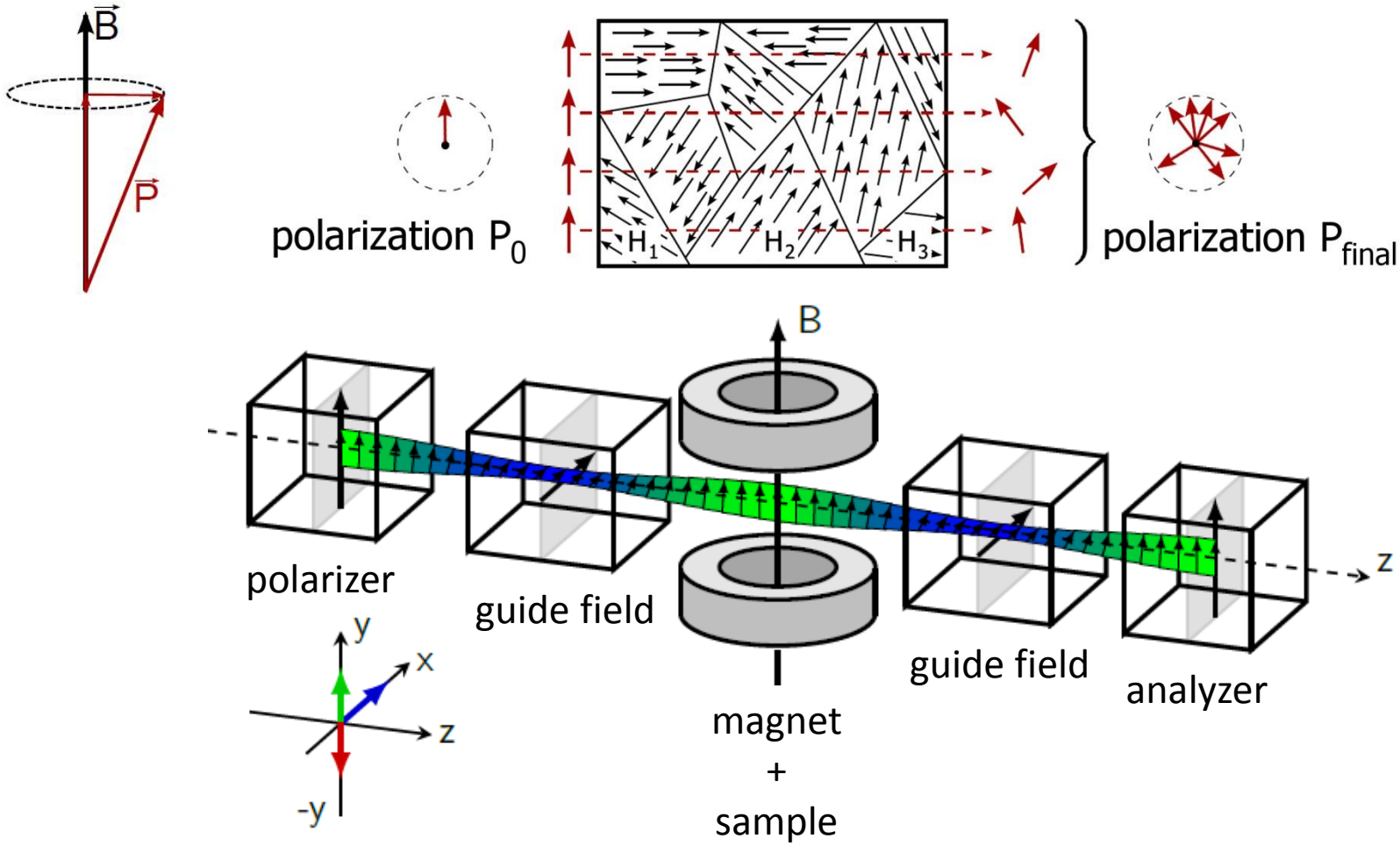


Custom magnet at FRM2, ANTARES

SE needs for imaging/engineering

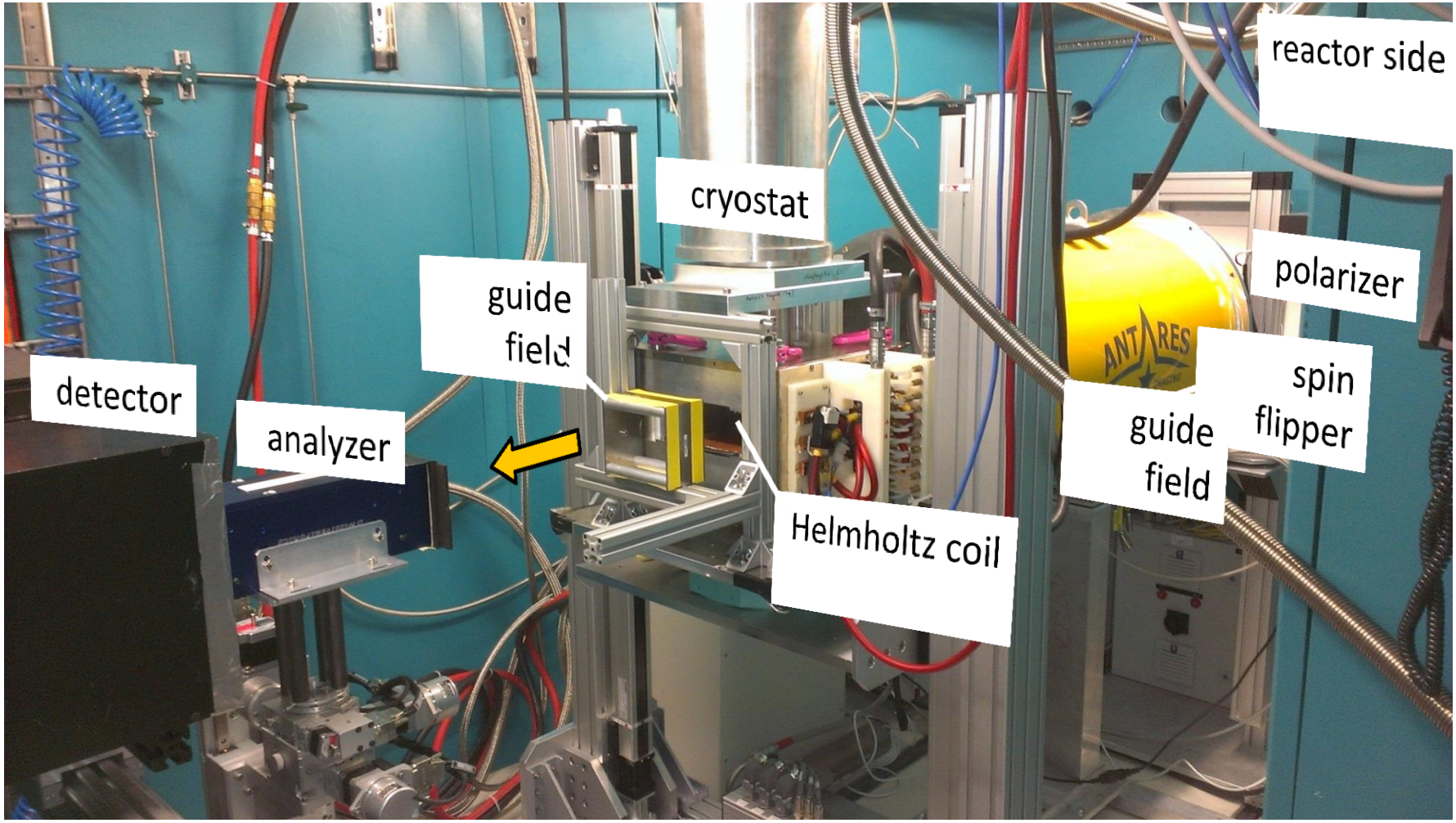
ODIN: User case 4 – custom magnet

Experimental Setup



SE needs for imaging/engineering

ODIN: User case 4 – custom magnet



SE needs for imaging/engineering

Overview

The previous slides outlined:

- There is a **large variety** (and only few standard) sample environments in applications that use **imaging & engineering diffraction**
- Even if the instruments have world-leading performance, they are not readily usable for all academic and industrial needs – **many applications require suitable environment!**
  - Explore possibilities to built SE's for Imaging & Engineering ahead of time (ensure scientific/industrial drivers and motivation: close collaboration with instruments!)
- **A lot of SE is custom built (by users and beamlines),** typically due to:
  - Imaging: specific requirements due to transmission geometry and a very broad variety of applications
  - Engineering: A lot of different processes are of high interest: require very specialized SE
  - **Integration of such equipment needs to be ensured**
- This overview is **by far** not complete
- **Some** of the herein shown **SE** can be **expected to be available in collaboration** with the in-kind partners/instrument teams and/or collaboration
- Dedicated SE that is available within ESS would be desirable

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THANK YOU!