HZB Helmholtz Zentrum Berlin

HELMHOLTZ-ASSOCIATION

Mission of the Helmholtz-Association

We contribute to solving grand challenges which face society, science and industry by performing **top-rate research in strategic programmes** in the fields of Aeronautics, Space and Transport, Earth and Environment, Energy, Health, Key Technologies as well as Matter.

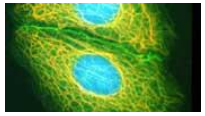
We research systems of great complexity with our **large-scale facilities and scientific infrastructure**, cooperating closely with national and international partners.

We contribute to shaping our future by combining research and technology development with perspectives for **innovative applications** and provisions for tomorrow's world.

The six Helmholtz Research Fields:
Cutting-Edge Science in Networks

Energy

Earth & Environment



Health

Aeronautics, Space and Transport

Key Technologies

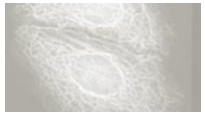
Matter

- **18 legally independent Centres**
- **Total Budget: 3,8 billion EUR**
- **36.000 Staff**

The Helmholtz-Zentrum Berlin für Materialien und Energie: *Energy Materials Research & Large-scale Infrastructures*

Energy

Earth & Environment



Health

Aeronautics, Space and Transport

Key Technologies

Matter

- **18 legally independent Centres**
- **Total Budget: 3,8 billion EUR**
- **36.000 Staff**

The Berlin Research Reactor BER II

Neutrons and Instrumentation for condensed Matter Research

Prof Anke Rita Kaysser-Pyzalla
Scientific Director, CEO

Vision

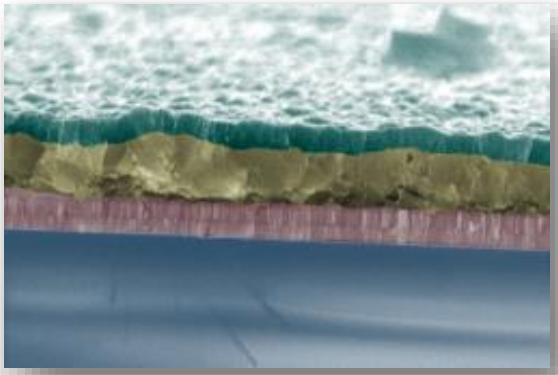
HZB is a world class research center for **Energy Materials Research**, thus contributing to **knowledge-based solutions** to great societal challenges.

HZB provides world class **large-scale research infrastructures** for the national and international scientific community and industry.

HZB exploits **synergies** by integrating excellent research with the operation of dedicated infrastructures, thus creating a unique **research environment**.

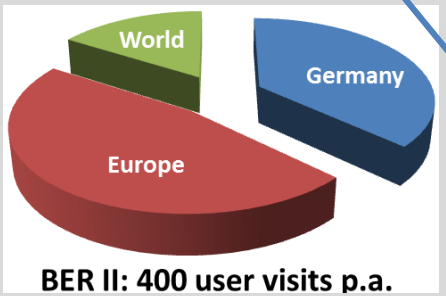
Two Large Infrastructures, Energy Materials Research

Neutron Source BER II
Berlin-Wannsee

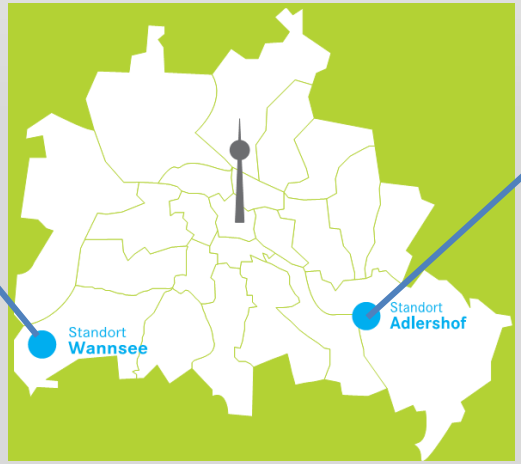


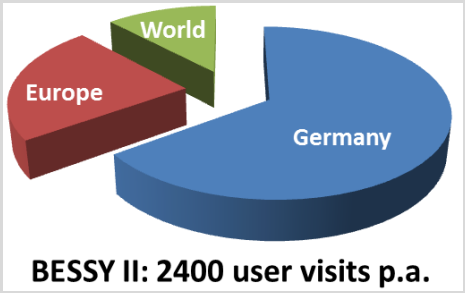
Energy Materials Research

Photon Source BESSY II
Berlin-Adlershof



BER II: 400 user visits p.a.





BESSY II: 2400 user visits p.a.

Complentarity of Neutrons and Photons

Neutrons

- interact with atomic nuclei via the very short-range strong nuclear forces;
- interact with unpaired electronic spins via the magnetic dipole interaction.

X-Rays

- interact with the electrons of the atom via the electromagnetic interaction;
- (interact extremely weakly with the spin).

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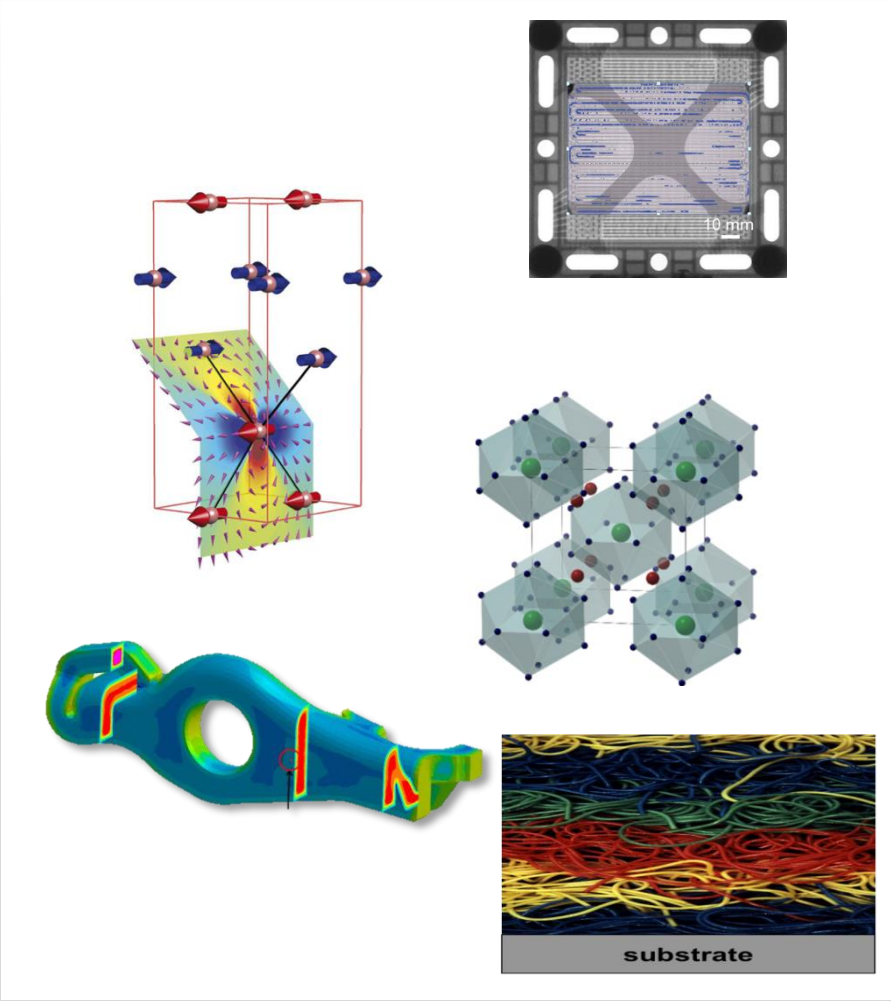
Science with Neutrons

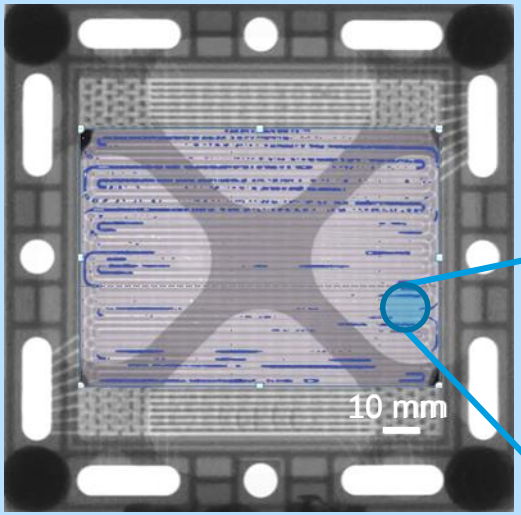
Neutron Science Drivers

- **Energy Conversion & Storage**
- **Quantum Materials**
- **Energy-efficient Information Technology**
- **Materials Science**
- **Medicine & Health**



Neutron Science Drivers: Energy Storage

How to optimize water management in a PEM fuel cell?



synchrotron tomography

- Neutron Imaging @ V7(CONRAD-2)
- *In-operando* visualization of water distribution

Diffusion dynamics revealed with D-H contrast

Photons: tailor-made microporosity improves water transport

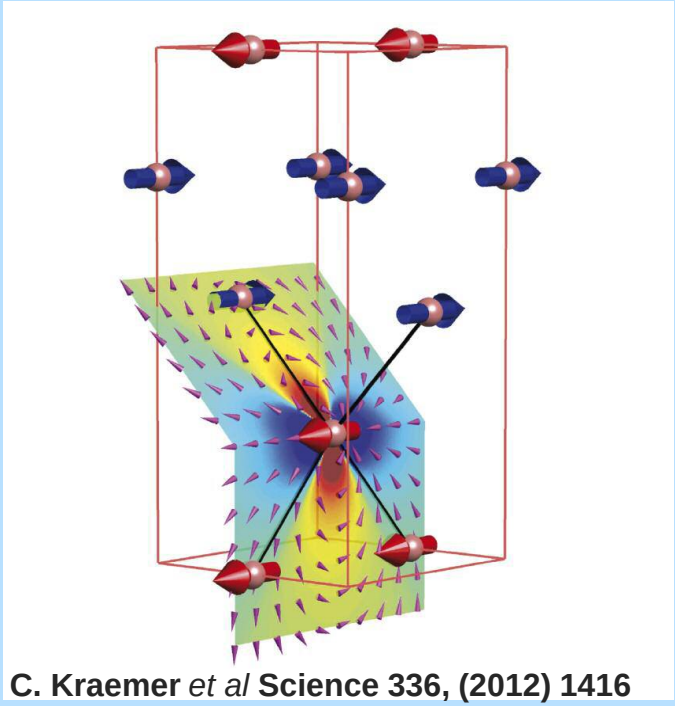
M. Klages *et al* Journal of Power Sources 239 (2013) 596

➔ **Optimized flow field design**

➔ **Handling of water accumulation**

Neutron Science Drivers: Quantum Materials

Can real quantum spins interact like large bar magnets?



C. Kraemer *et al* Science 336, (2012) 1416

- Single crystal neutron diffraction @ E4 and SINQ
- Determination of magnetic structure

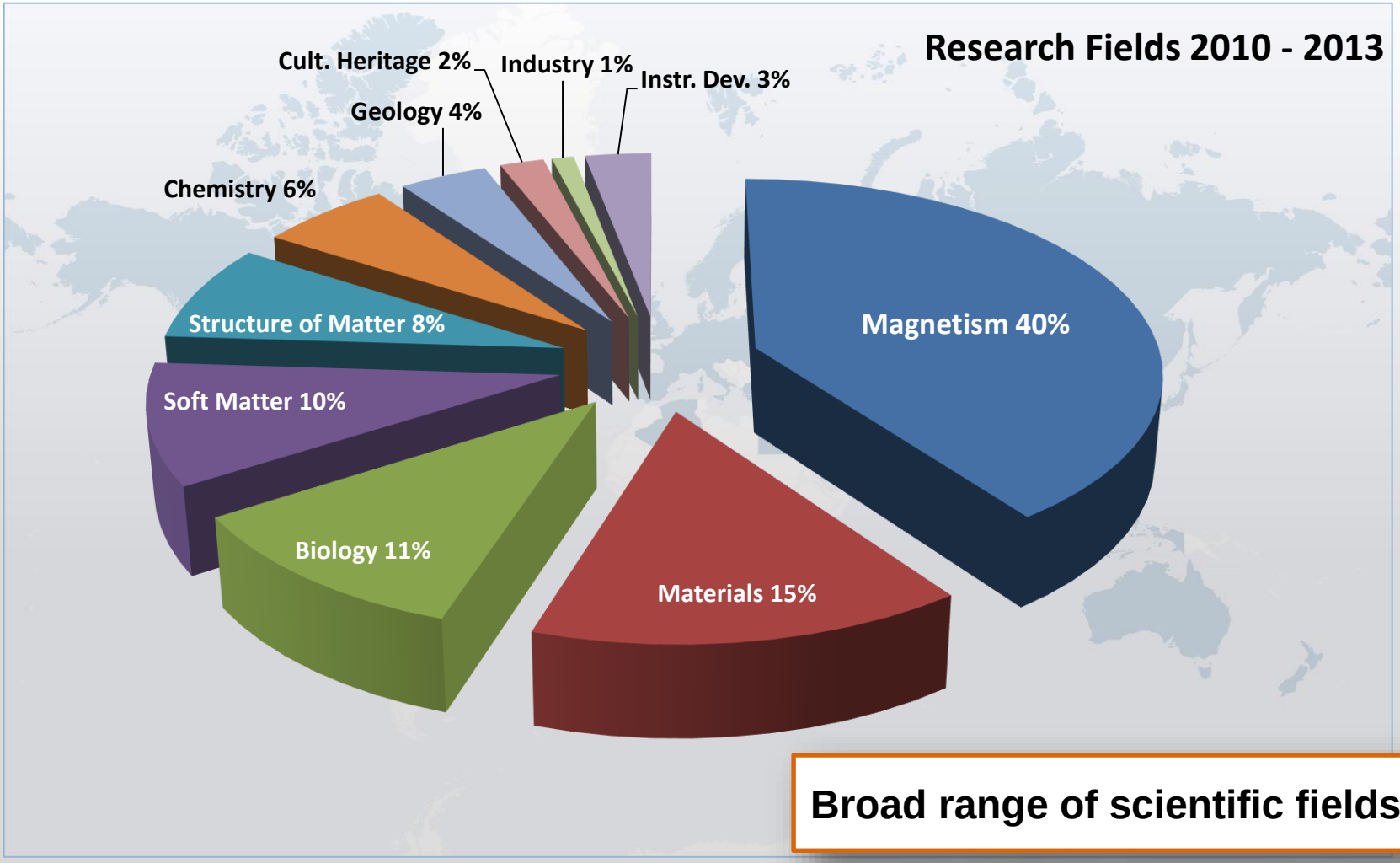
Heat capacity measurements @ MagLab

Vertical magnet & dilution refrigerator

➔ $LiErF_4$ established as a model dipolar-coupled antiferromagnet

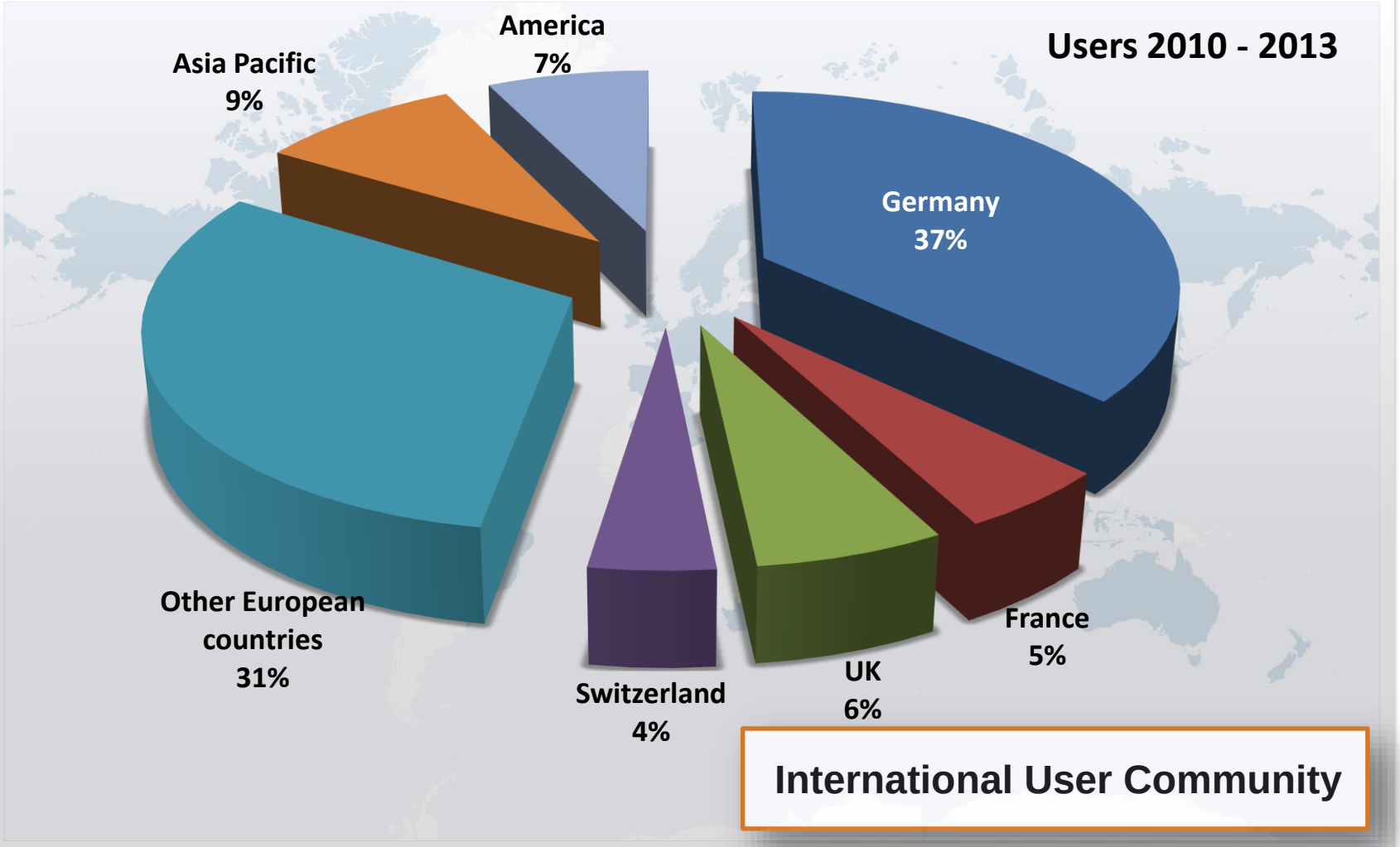
➔ Insights into the fundamental science of quantum dipolar antiferromagnetism

Research Fields at BER II



Broad range of scientific fields

Neutron Users at BER II



International User Community

HZB Helmholtz Zentrum Berlin

The BER II Facility

HZB Helmholtz Zentrum Berlin

Profile of Neutron Activities

Cutting Edge Instrumentation

Unique Measurement Capabilities

Outstanding Support for Science

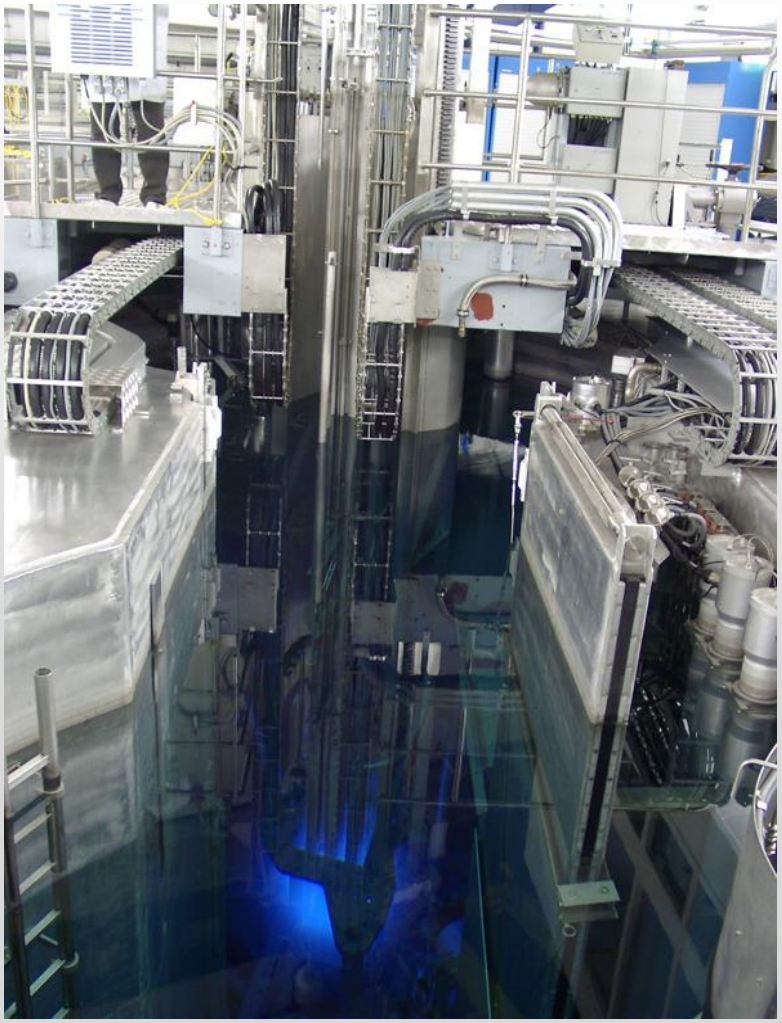
BER II

Broad Range of Sample Environments

Strong In-House Research on Energy Materials

BESSY II & BER II - world class sources

The BER II Neutron Source



Data:

Thermal power	10 MW
Neutron flux	$1.2 \cdot 10^{14}$ $n \cdot cm^{-2} \cdot s^{-1}$
Cold source	(hydrogen at 25 K)

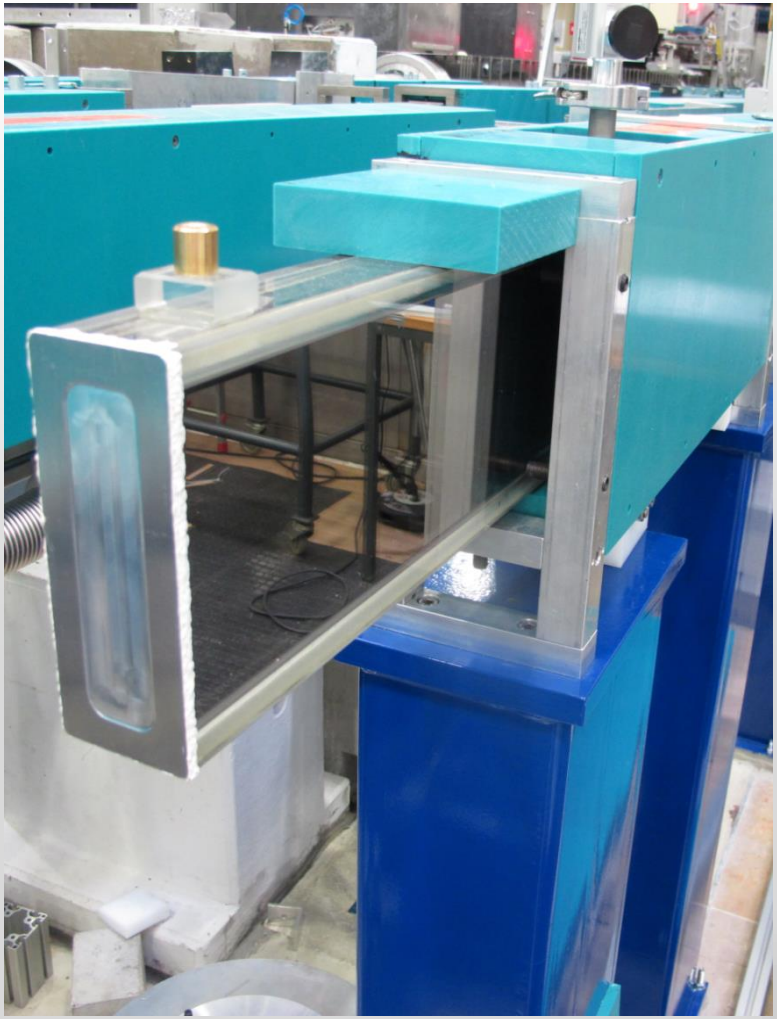
9 beam tubes for thermal neutrons

4 (+4) neutron guides for cold neutrons

History

1973 - 1985: BER II at 5 MW
1985 - 1991: Upgrading -
10 times more flux
plus cold source
1998 - 2000: Conversion to
low enriched uranium
2010 - 2012: New cold source
moderator cell and
instrument upgrade program
end of 2019: End of scientific service

The BER II Upgrade



Measures:

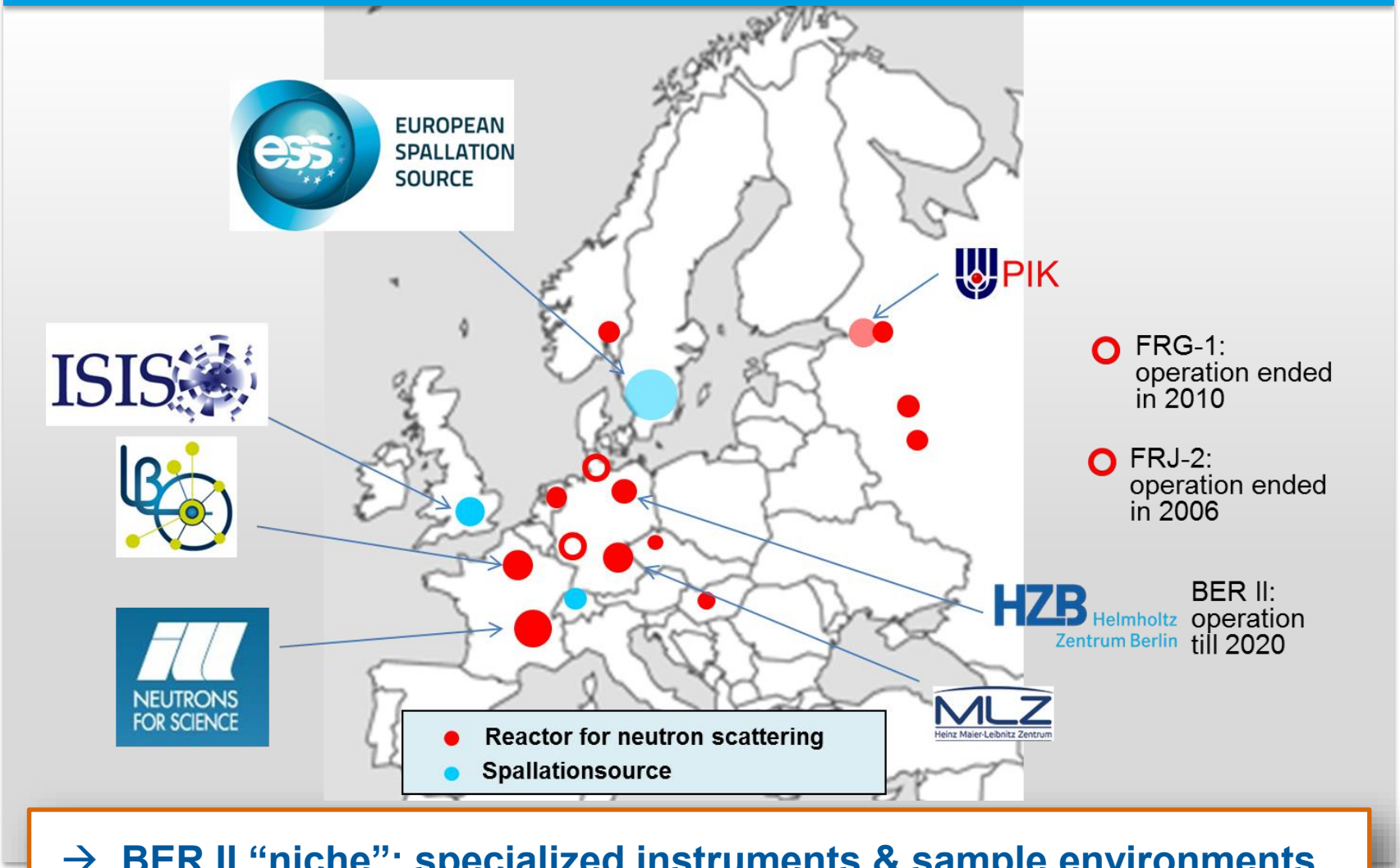
- New cold source / moderator cell
- New in-pile part
- New neutron guides
- New shieldings
- New instrument positions
- New instrument components

Facts & Figures

Costs	10 M€
Guides	142 m
Shieldings	485 t

→ Intensity gain 2 – 10

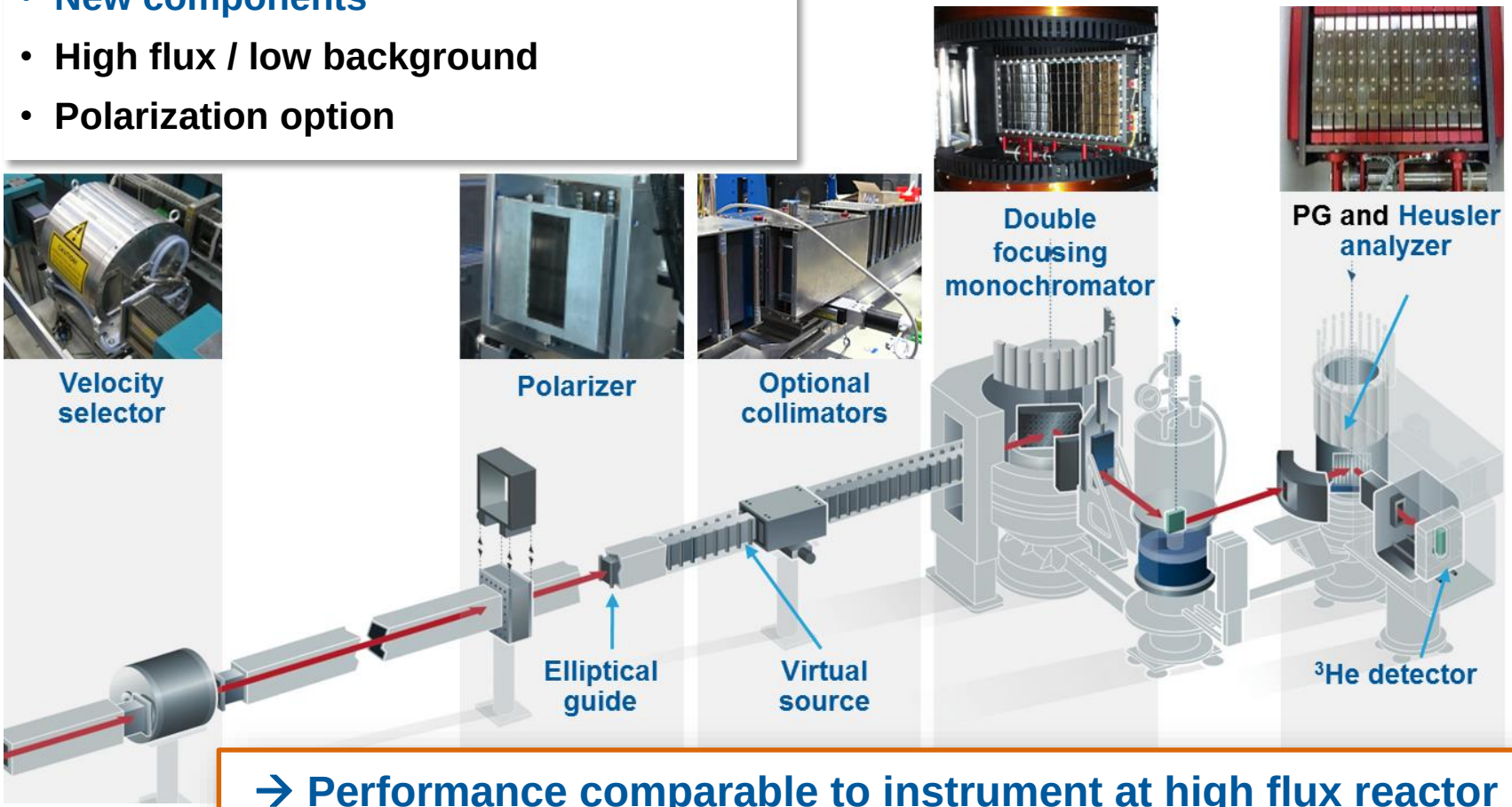
BER II in the European Landscape



→ **BER II "niche": specialized instruments & sample environments**

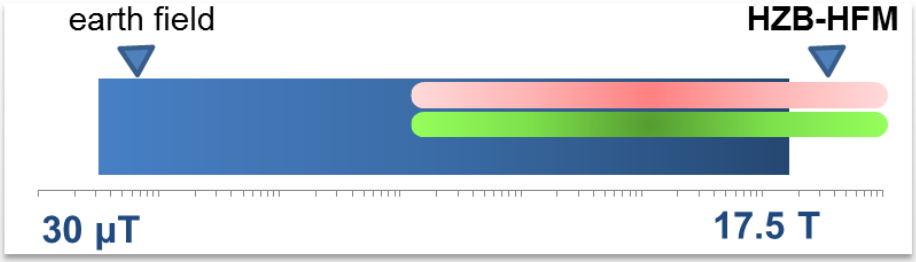
Instrument Optimization

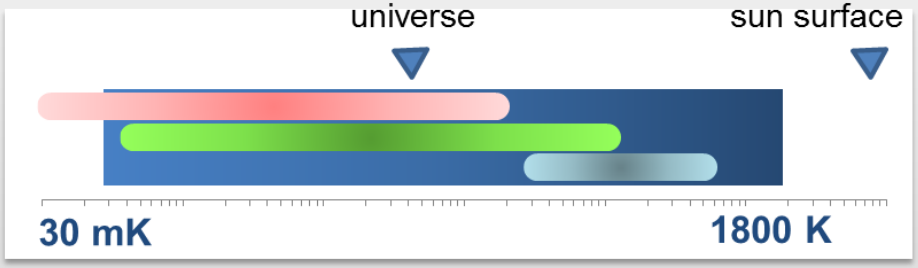
- New design (Monte Carlo simulations)
- New components
- High flux / low background
- Polarization option

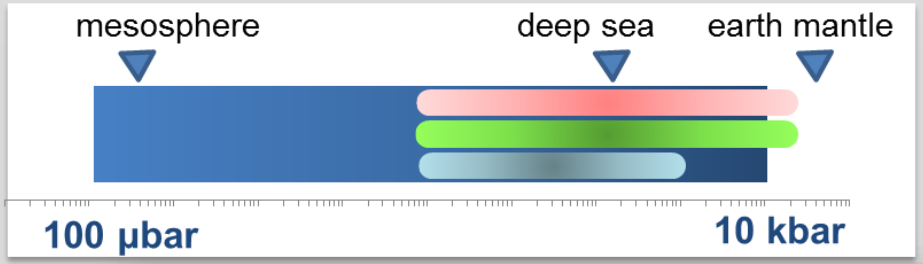


→ Performance comparable to instrument at high flux reactor

Specialized Sample Environments

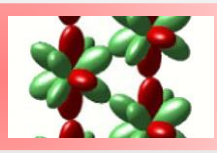






Science applications, e.g. in

Quantum magnetism



Super-conductivity

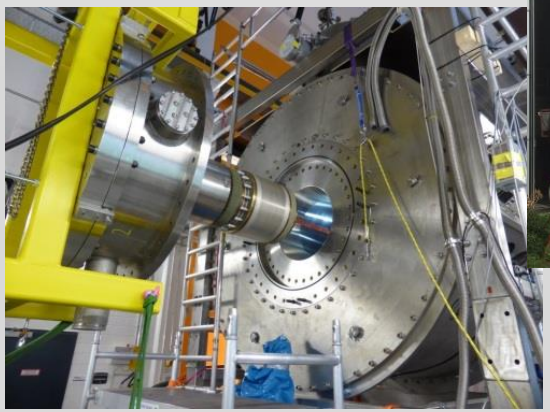
Hydrogen storage

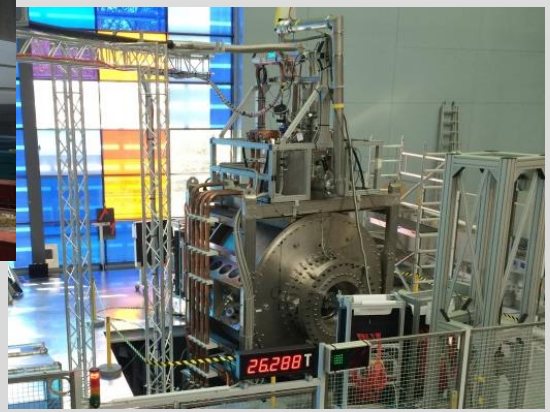
→ **Extreme environments (*H, T, p*) and custom-made *in-situ* / *in-operando* cells for science at BER II and BESSY II**

Flagship High Field Magnet

The HZB High Field Magnet (HFM) - a "first of its kind" hybrid magnet system

- Strongest magnet for neutron scattering experiments in the world
- Project completed within time schedule and budget
- Specification exceeded (**26,3 T**)
- User operation started in July 2015 for elastic scattering
- Inelastic and improved elastic modes available from 2016 on





Complementary Lab Cluster

User Lab Cluster

- Sample preparation
- Sample characterization

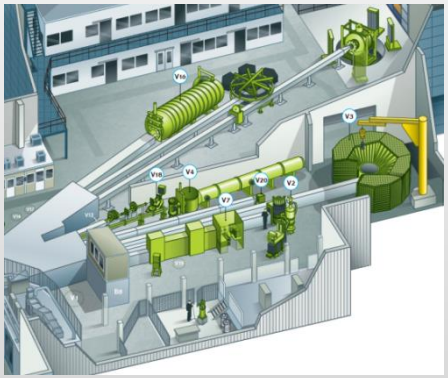
- Supported by scientific staff
- Complementary to experiments at BER II / BESSY II

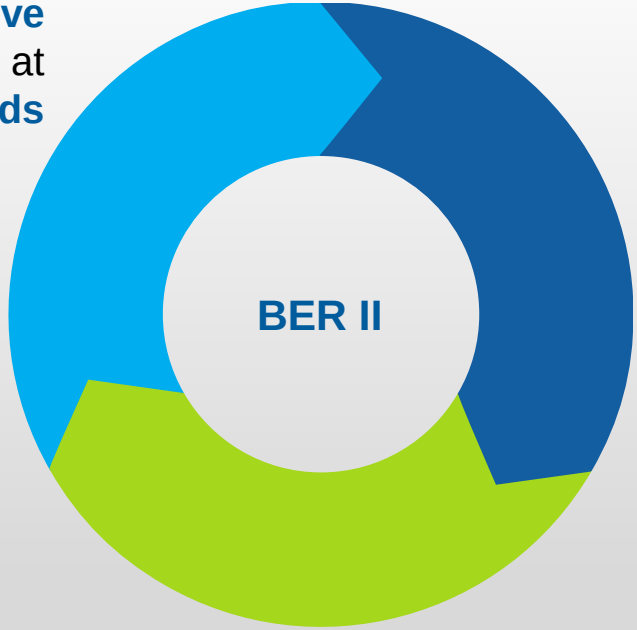
…booking via
user access portal GATE

→ 50% of the users access the Lab Cluster

Goals of Neutron Activities until 2019

Operate selected suite of internationally **competitive instruments** for users at **highest possible standards**





Scientifically exploit the large-scale projects **HFM** and **NEAT** for user service

HFM–EXED

NEAT II

Strengthen energy materials research and foster **scientific collaborations**

Establish collaborations with focus on **training opportunities** and possible **instrument transfers**

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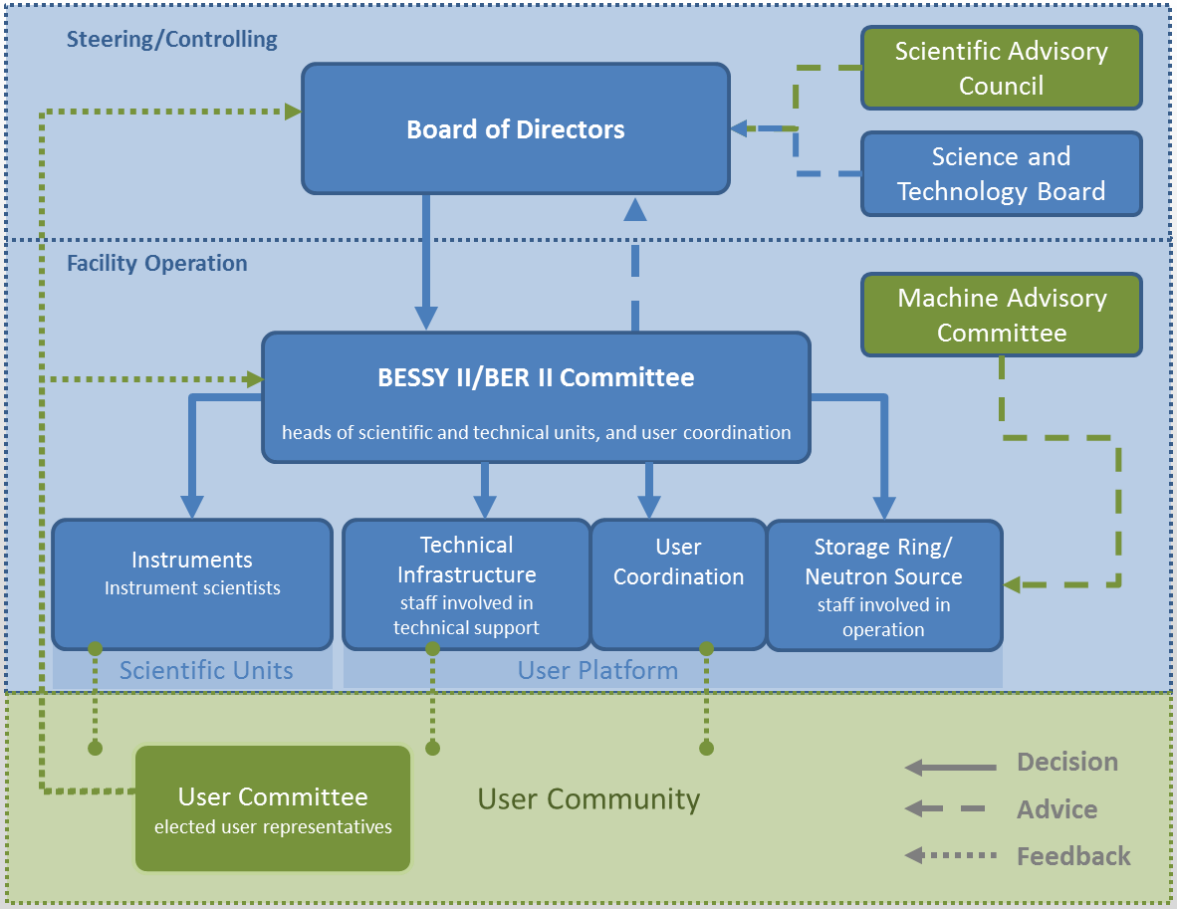
User Service

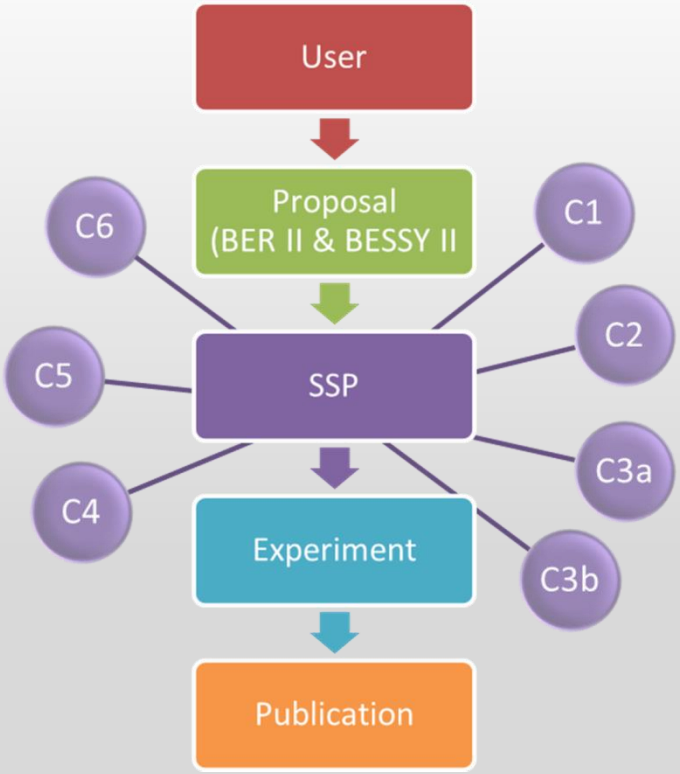
Organization



→ **Scientific units deeply involved in User Service**

Peer Review

Common Scientific Selection Panel (SSP) for BER II & BESSY II



College	Scientific field
C1	Soft Condensed Matter, Biology, Life and Health Science
C2	Macromolecular Crystallography (MX)
C3a	Surfaces and Interfaces, thin films (non magnetic, no catalysis)
C3b	Chemistry, Catalysis and Diluted Matter Research
C4	Electronic Structure (not magnetism)
C5	Magnetism and Superconductivity
C6	Material Sciences and Hard Condensed Matter

→ **Proposals ranked for beamtime allocation**

Proposal Handling

Web-based single user entry point GATE

Proposal submission

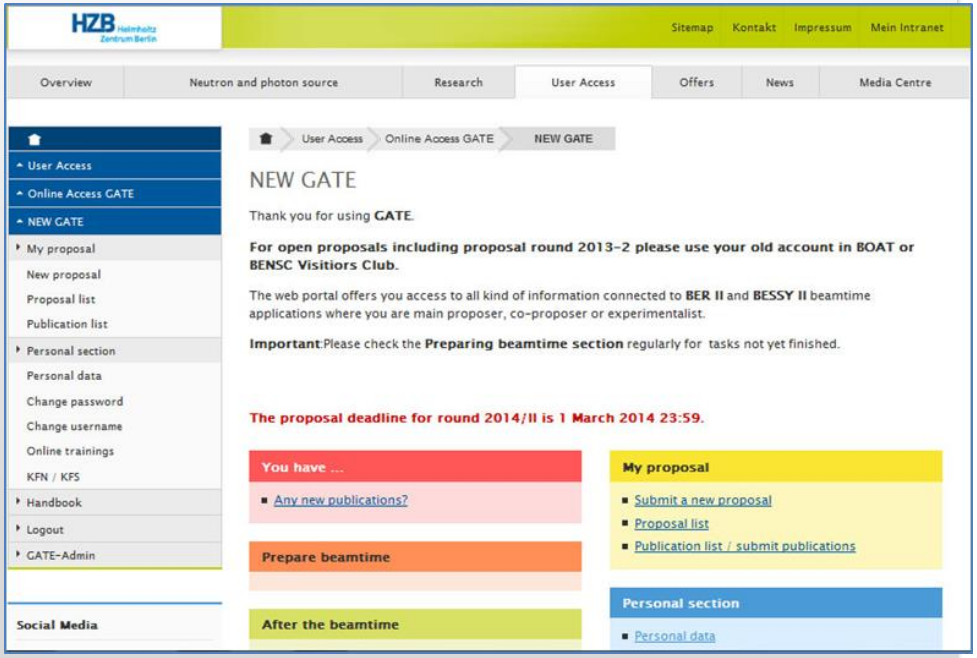
Handling of all formalities

- radiation safety
- safety procedures
- access registration
- guest house reservation
- travel reimbursement

Feedback tools

Publication records

Reporting



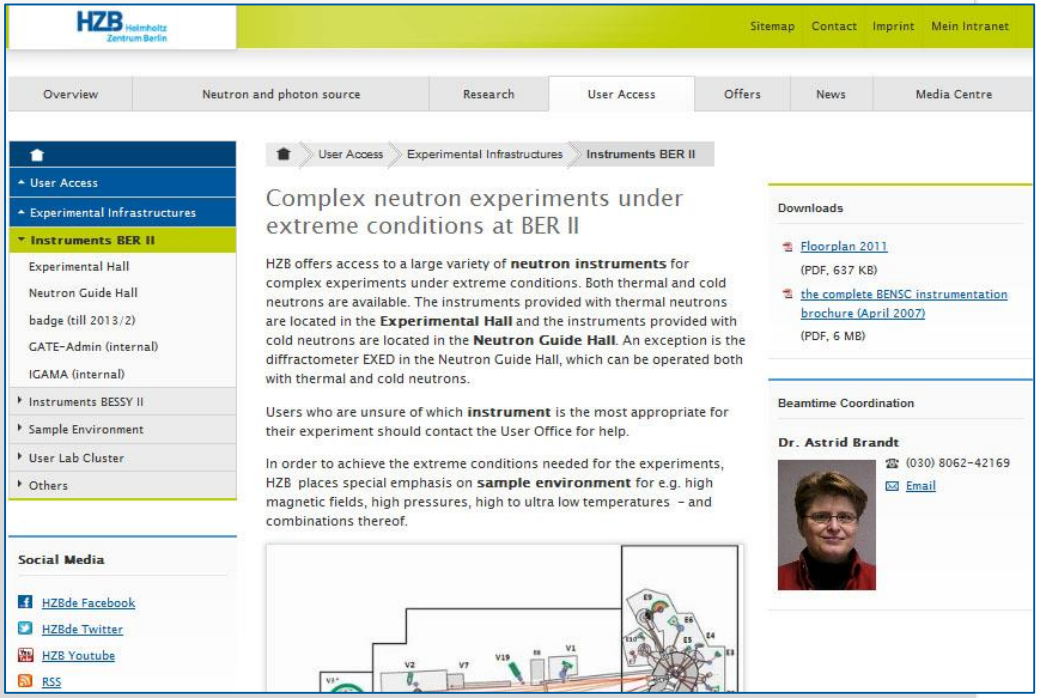
→ **Web-based tool ensures well-defined, structured workflow**

Proposal Handling

IGAMA Instrument Information Tool

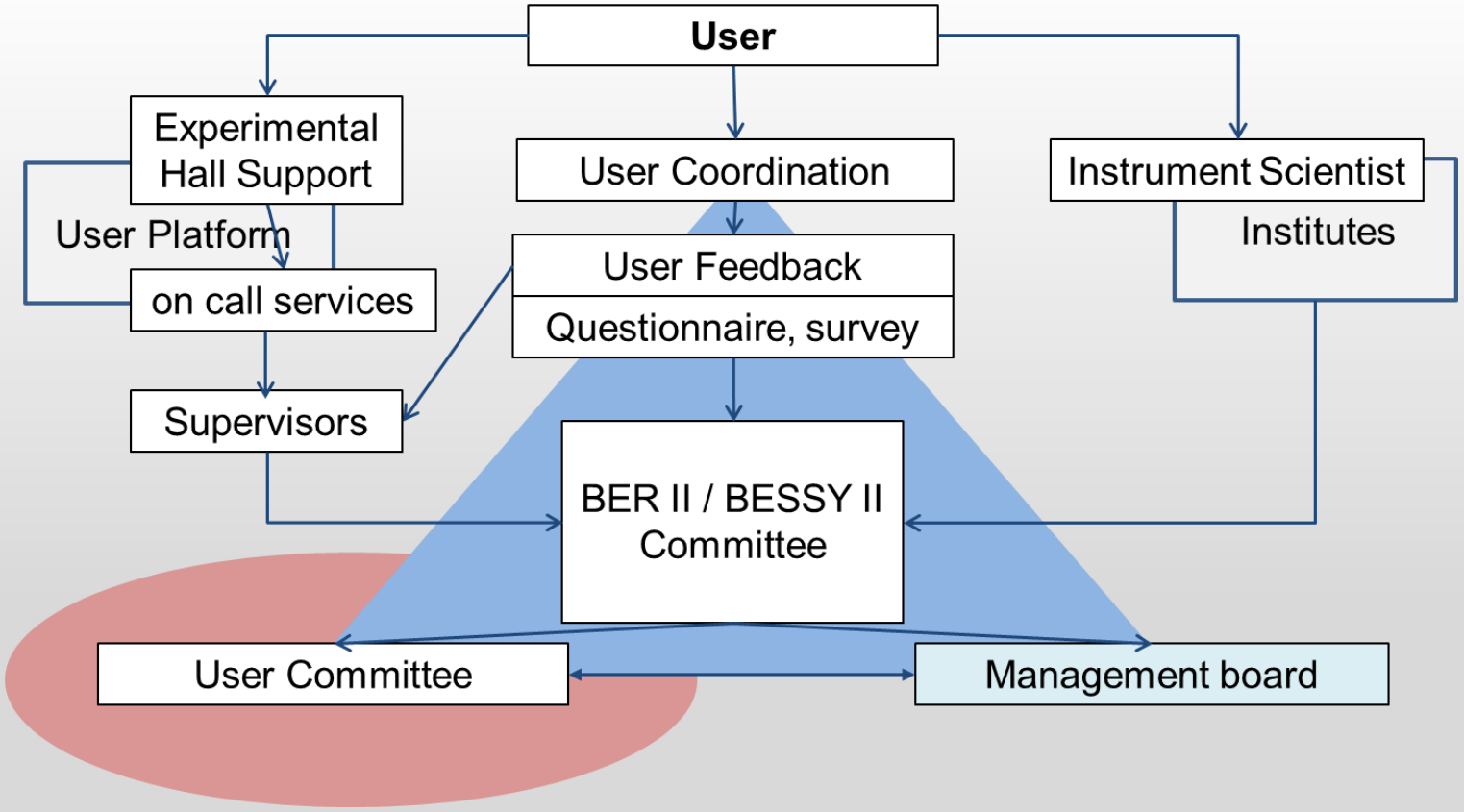
Database of al instruments, sample environments and labs at HZB

- Instrument Parameters
- Instrument Scientist
- User Contact Points
- Search fields (e.g. experimental method)



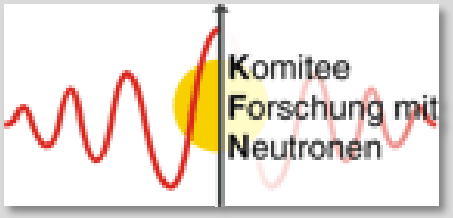
→ **Database directly linked to GATE for maximum efficacy**

Quality Management



→ **Structured quality management for maximum user satisfaction**

Networks



- European Integrating Activities
  - Transnational Access funding
  - Fostering of Industrial use
  - Joint Research Activities
  - Training & Education
- European Neutron Scattering Association (ENSA)
- International Society for Sample Environment (ISSE)
- German Committee Research with Neutrons (KFN)

→ Embedment in networks ensures awareness of user needs & trends

Community Building

- Involvement of external Partners
  - Joint Operation of Instruments
  - Joint Labs
  - Joint Research Programs
- Users‘ Meeting
- Thematic Workshops
- Foresight Workshops
- Training schools, e.g.
  - BER II Neutron School
  - Hydrogen Storage Materials
  - Neutron Scattering for Crystallographers

→ **Community building ensures users’ awareness of the facility**

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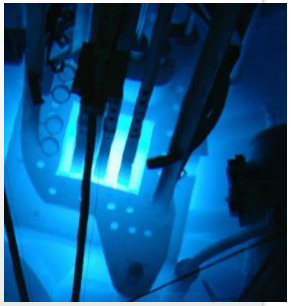
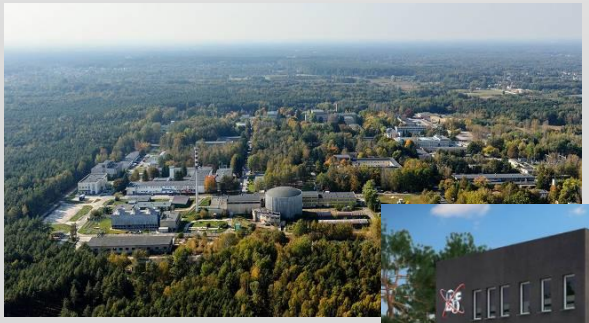
BER II – Preparing for decommissioning

Project established at HZB

Work Packages



- **Compilation of the documentation** for the application
- **Spent fuel management**
- **Radioactive waste management**
- **Follow-up use of instrumentation and sample environments**
  - Training activities
  - Instrument transfers before 2020
  - Instrument transfers 2020ff



National Centre for Nuclear Research (NCBJ), Poland

Opportunities for Latin America

- **MoUs on Cooperation in the field of neutron scattering**
  - IPEN, Peru *(signed)*
  - CNEA, Argentina *(ready for signature)*
  - IPEN, Brazil *(in preparation)*

- **Training activities**

  E.g. BER II **Instrument Workshop** in October attended by staff from
  - CNEA, Argentina
  - IPEN, Brazil
  - IPEN, Peru
  - Pontifical Catholic University of Peru

- **Coordinated instrument transfer**

Summary

- Unique neutron scattering opportunities
- Upgraded suite of state-of-the-art instruments
- Complementary methods and lab environment
- Competetive user service for the international community

Collaborations with focus on training opportunities at BER II neutron scattering instrumentation for mutual benefit

Perspectives for instrument transfers

Thank you for your attention!

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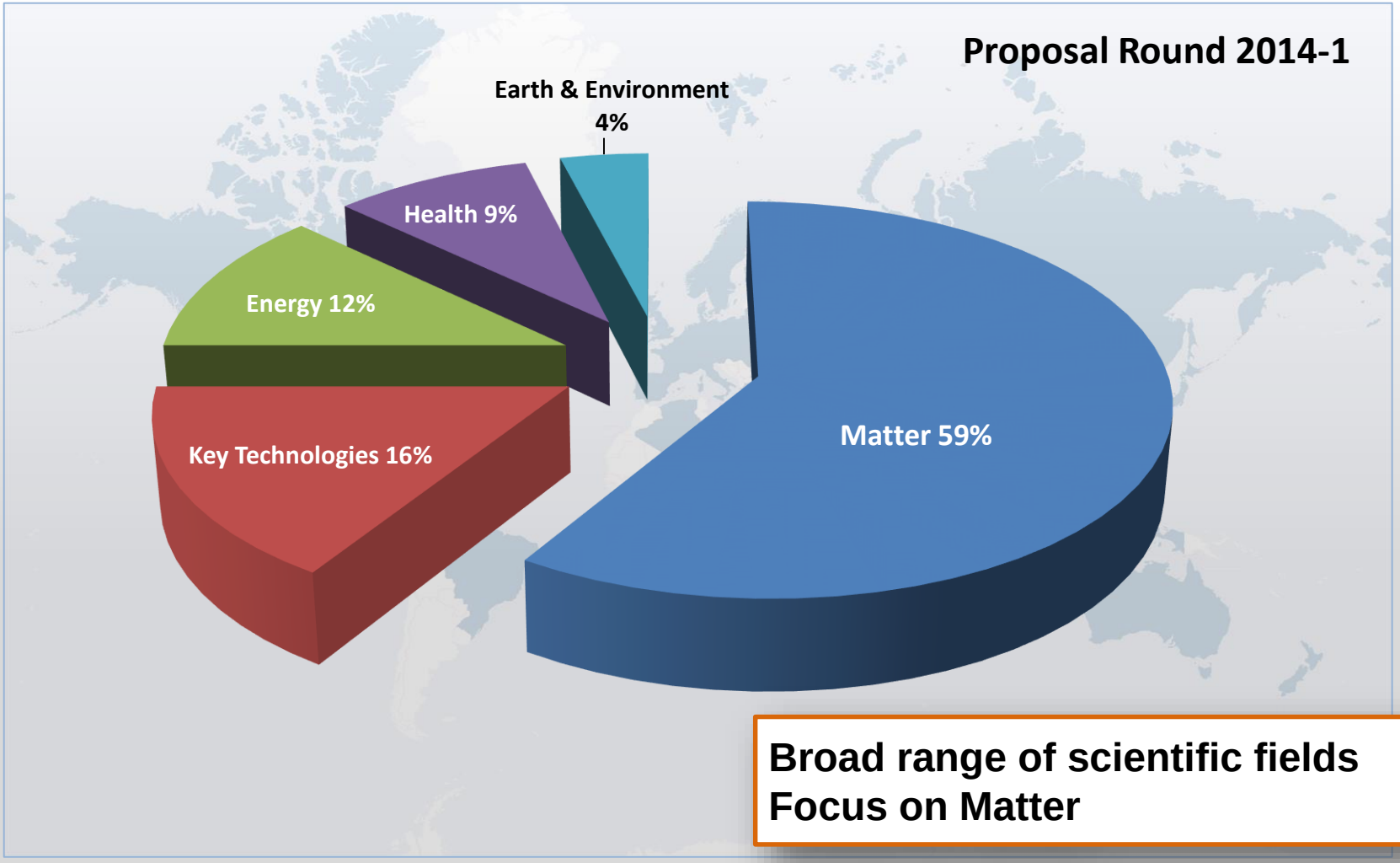
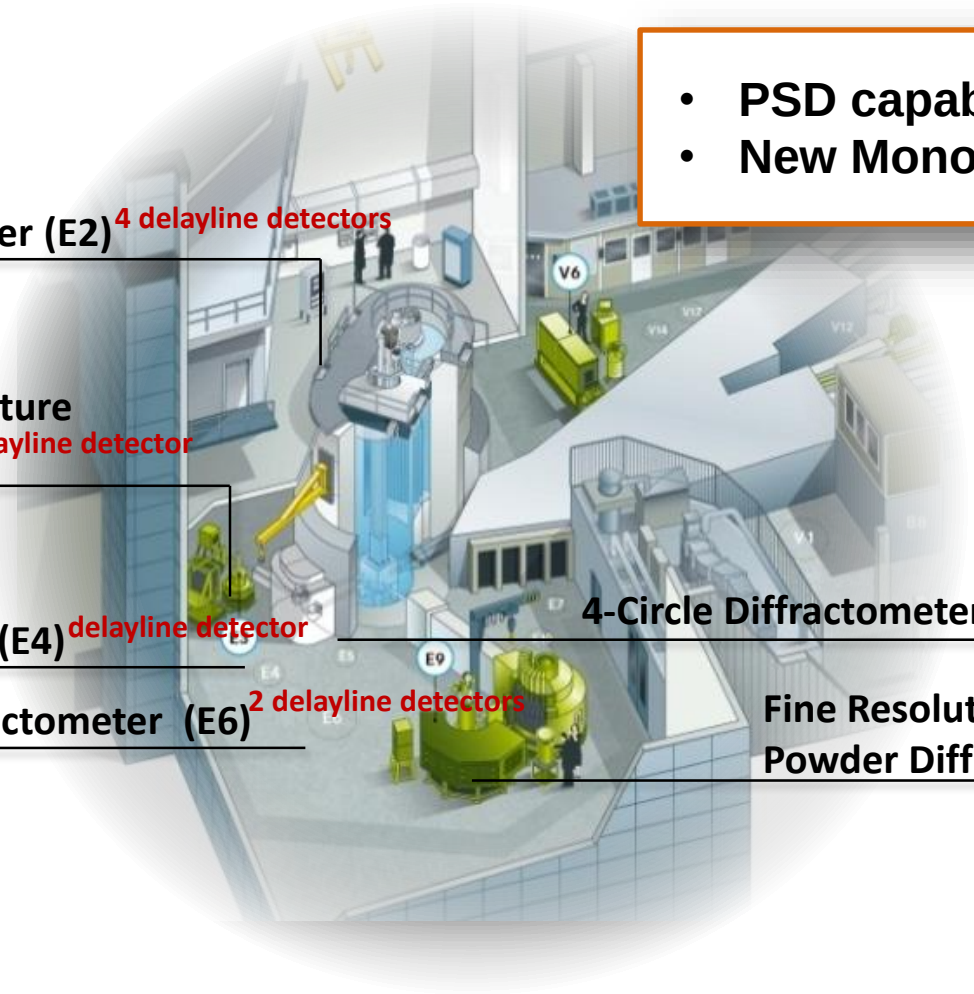
Grand Challenges



Broad range of scientific fields
Focus on Matter

Thermal Neutrons Instrumentation Upgrade

- PSD capabilities
- New Monochromators



Flat-Cone Diffractometer (E2) 4 delayline detectors

Stress Analysis and Texture Diffractometer (E3) delayline detector

2-Axis-Diffractometer (E4) delayline detector

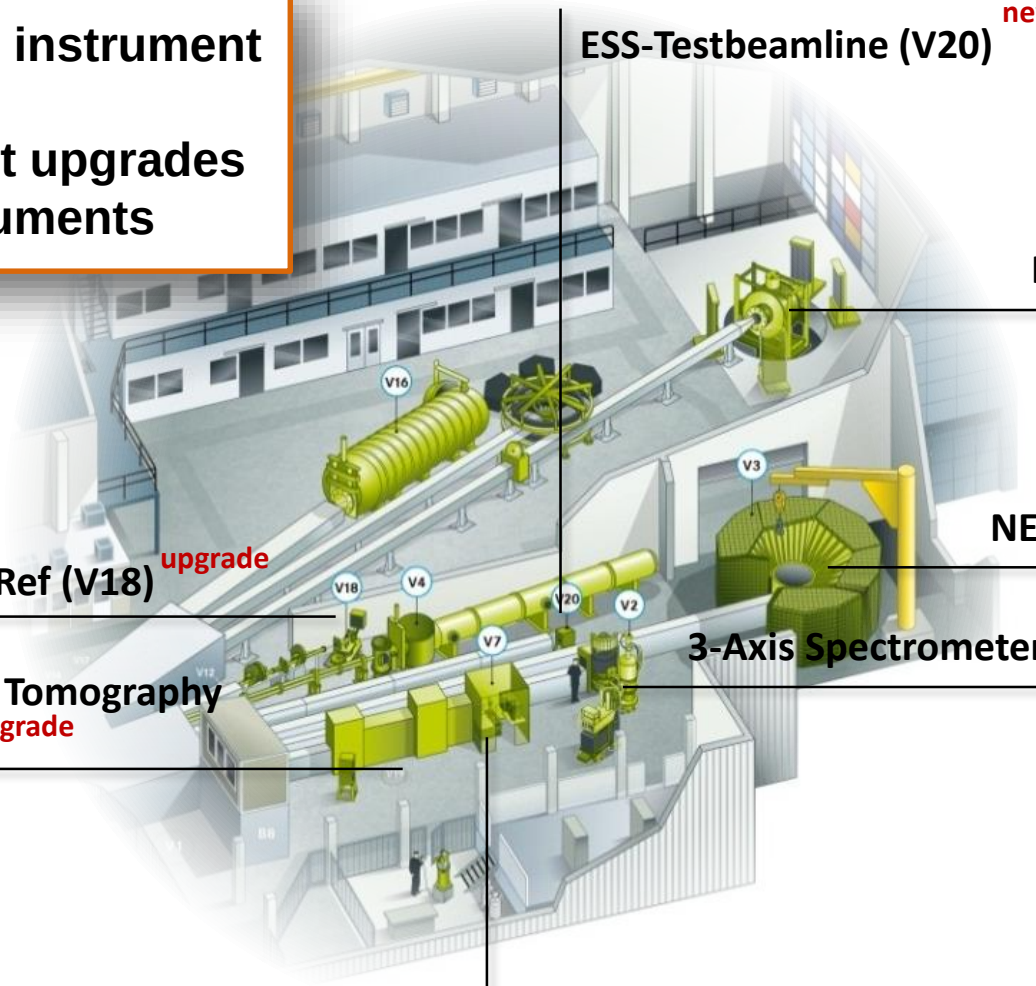
Focusing Powder Diffractometer (E6) 2 delayline detectors

4-Circle Diffractometer (E5) delayline detector

Fine Resolution Powder Diffractometer (E9) 8 delayline detectors

Cold Neutrons Instrumentation Upgrade

- Optimized instrument positions
- Instrument upgrades
- New Instruments



ESS-Testbeamline (V20) new

HFM-EXED (V15) new

NEAT TOF (V3) new

Reflectometer BioRef (V18) upgrade

3-Axis Spectrometer FLEXX (V2) upgrade

Polarized Neutron Tomography PONTO II (V19) upgrade

Neutron Tomography CONRAD-2 (V7) upgrade