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Jülich Centre for Neutron Science

Neutron Science and Instruments @ ESS

Research Centre Jülich (FZJ)

Andreas Wischnewski || 22nd January 2014

ESS: An Opportunity for German Organisations and Companies – BMU, Bonn, Germany

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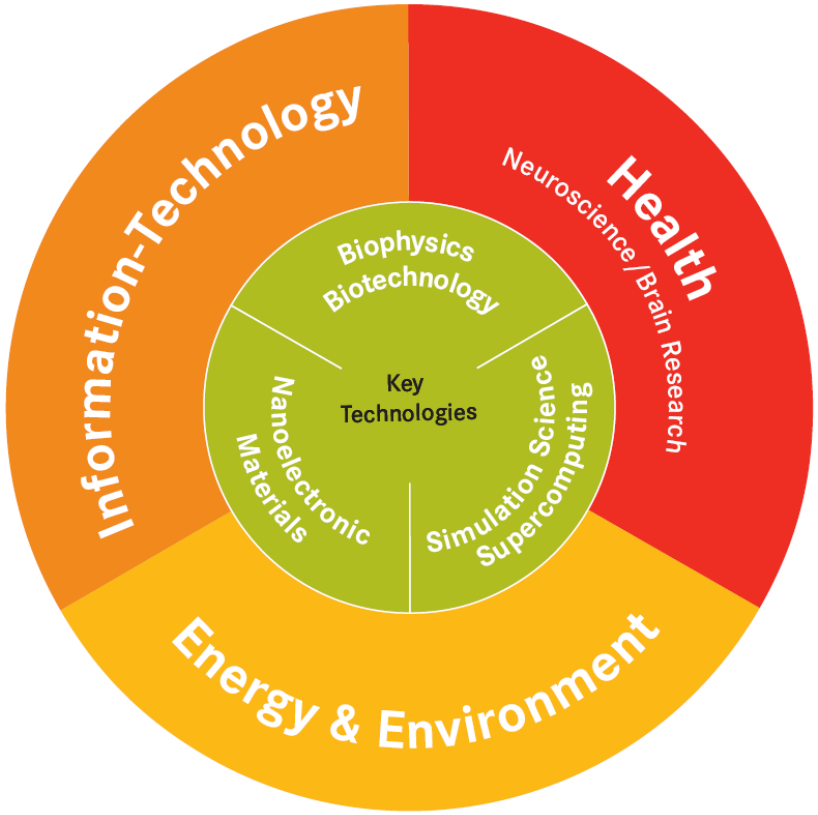
Jülich Centre for Neutron Science

Science Campus Jülich



Staff: 5236 (reference date: 31.12.2012)

thereof:
Scientists: 1658
(incl. 469 PhD – Students)

Technical staff: 1662

Revenue: 557 Mio. €
incl. 172 Mio. € third party funding

Research for generic key technologies of the next generation

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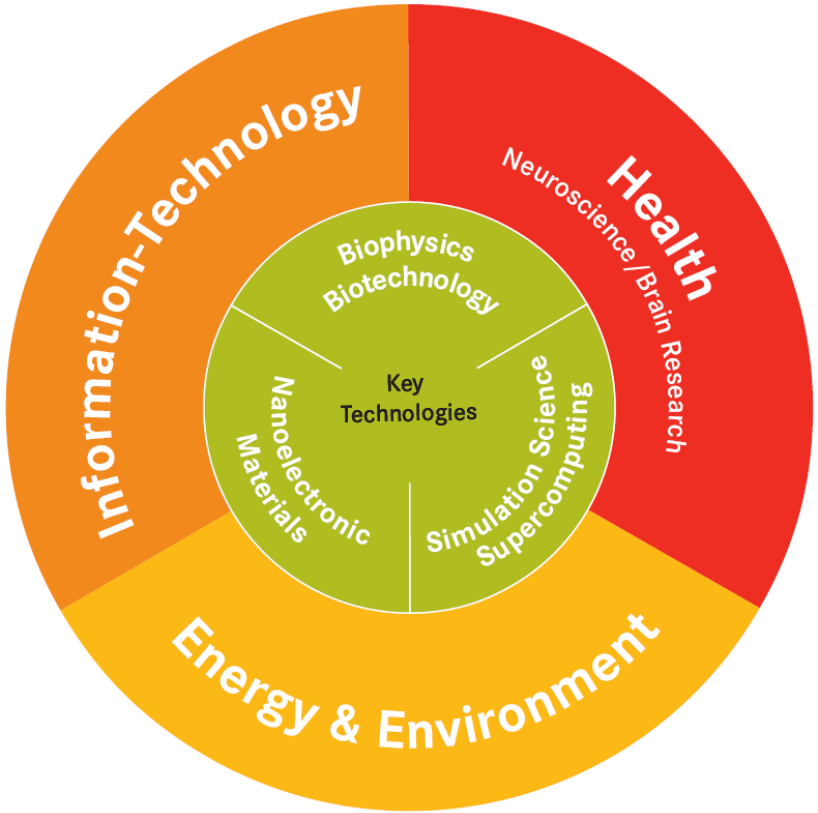
Jülich Centre for Neutron Science

Science Campus Jülich



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... long tradition in Neutron Science, Neutron Sources, Instrumentation, Instrument Components ...

Research for generic key technologies of the next generation

JÜLICH
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Jülich Centre for Neutron Science

13 instruments

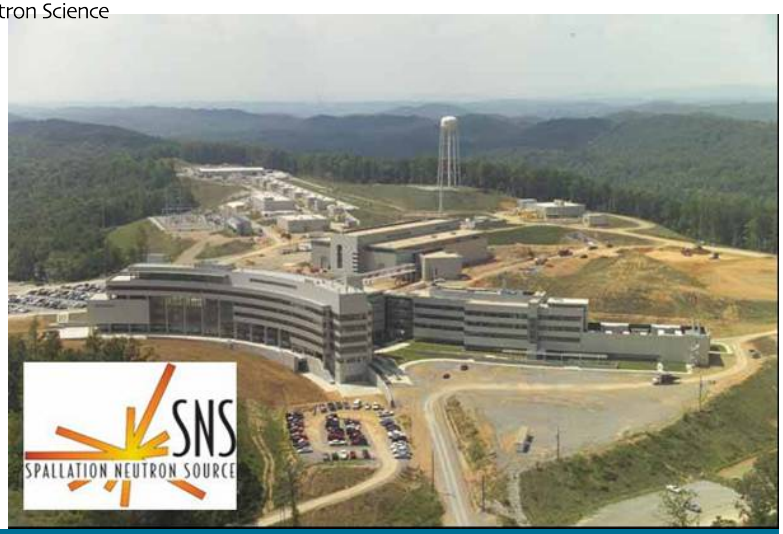
Design – Construction – Operation

of First Class Instruments

and Instrument Components

Jülich Centre for Neutron Science

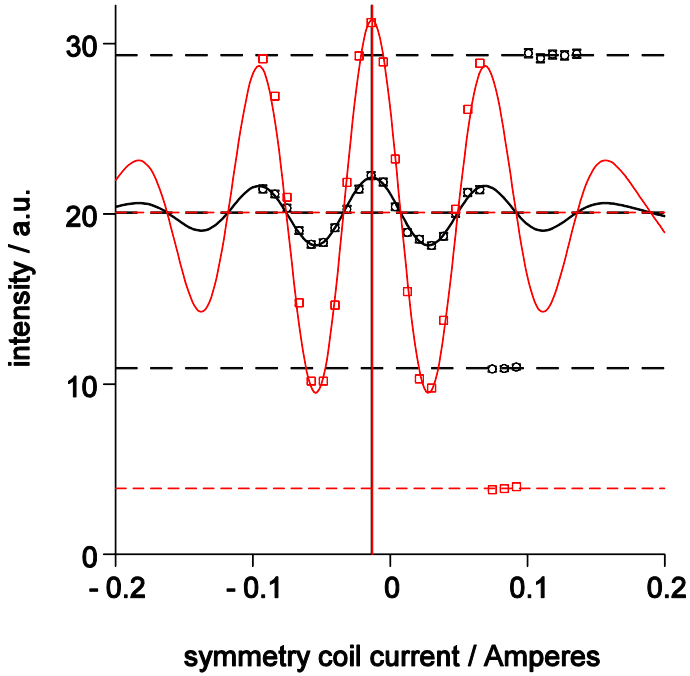
contr. to 4+1 instruments



MLZ, Garching – ILL, Grenoble – SNS, Oak Ridge

JCNS Outstation @ SNS

first echo: end 2009



JCNS Outstation: 7 persons (scientists, engineers, postdocs)

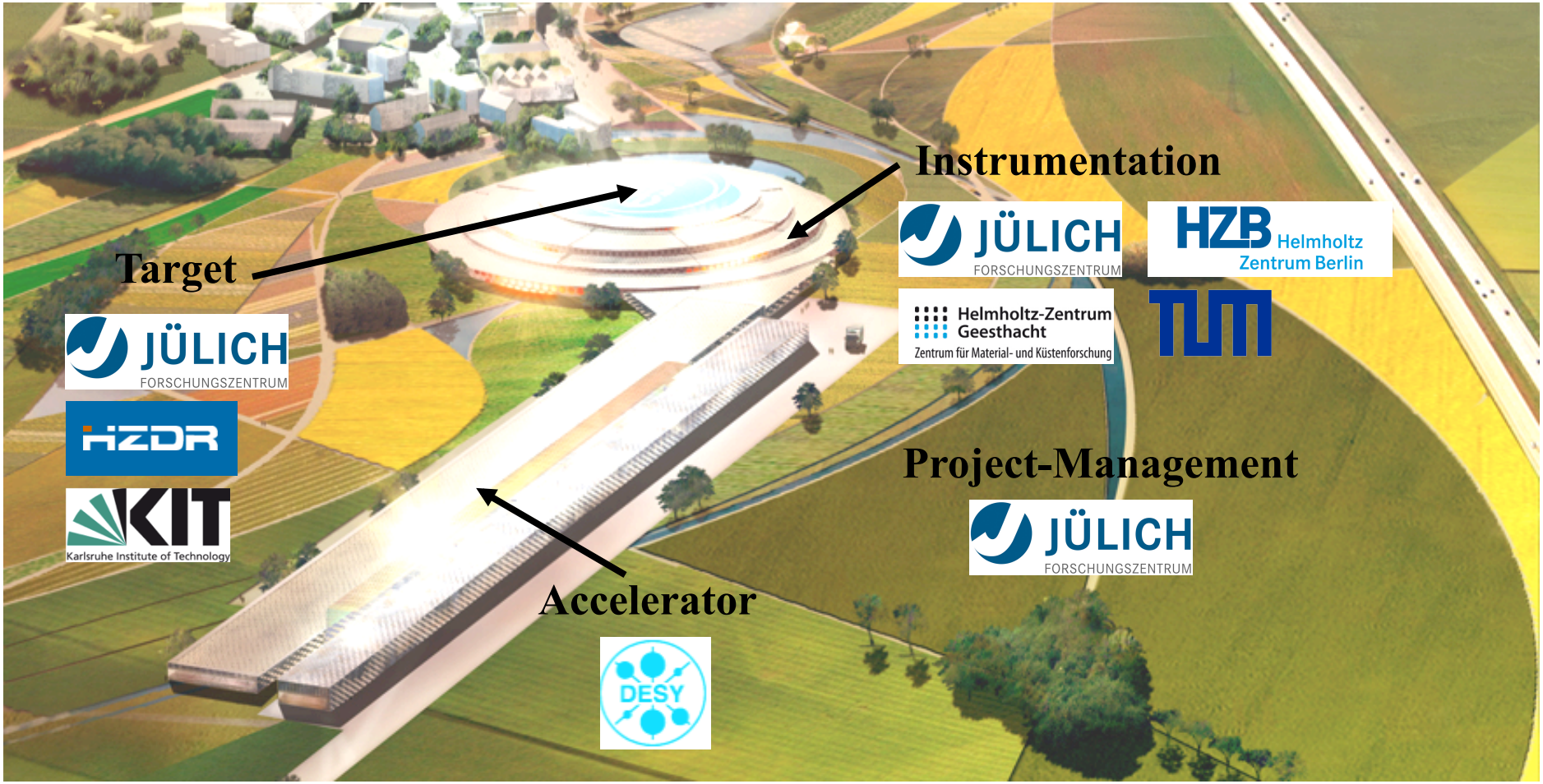
overbooking factor ≈ 2

10% POWGEN (powder diffractometer)
10% BASIS (backscattering spectrometer)
25% NSE

collaboration with companies:
(sc) coils, magnetic shielding, sample environment,
(detectors, neutron guides, chopper)

First time operation of NSE at a spallation source

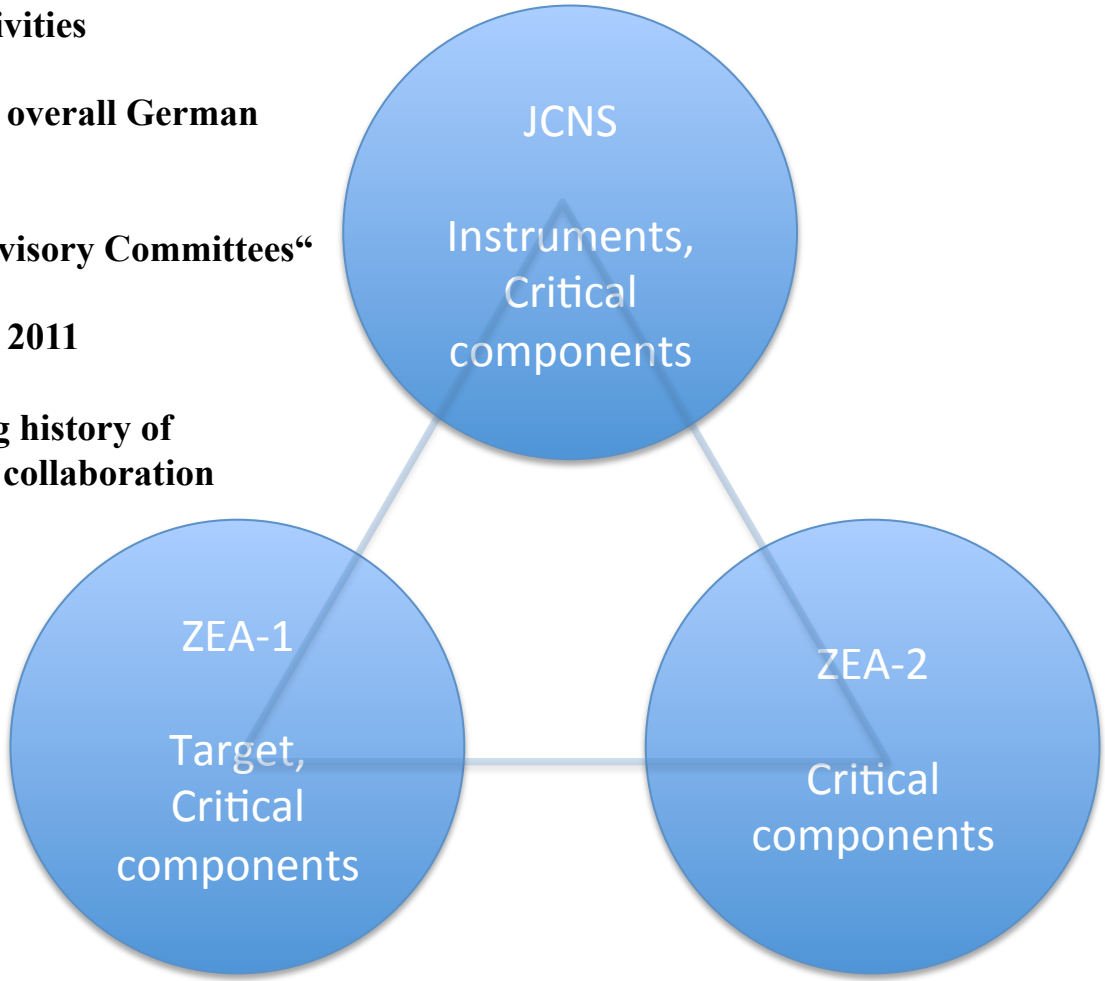
German ESS Design Update Project



Contributions to all major parts of the ESS

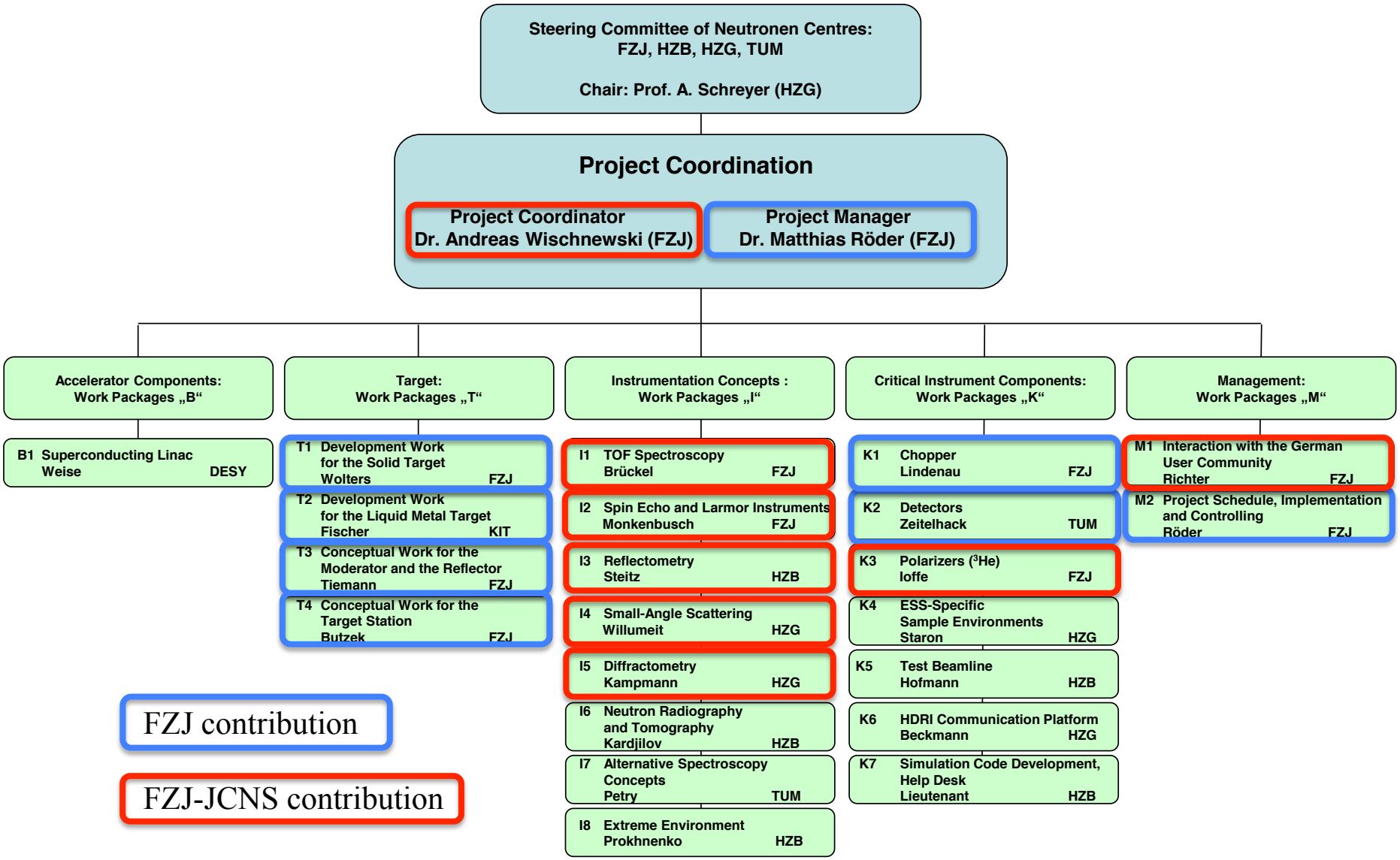
ESS: FZ Jülich Activities

- **FZ Jülich coordinates German ESS activities**
- **Prof. Schmidt is the coordinator for the overall German project and member of the ESS STC**
- **Jülich scientists are member of the „Advisory Committees“**
- **ESS competence centre established mid 2011**
- **FZ Jülich competence is based on a long history of interdisciplinary and inter-institutional collaboration**



ZEA-1: Central Institute for Technology
ZEA-2: Central Institute for Electronics

German ESS Design Update Project



German Design Update Project

Management:
Work Packages „M“

M1 Interaction with the German User Community
Richter FZJ

M2 Project Schedule, Implementation and Controlling
Schroeder FZJ

- **General approach (“bottom-up”)**
- **Evaluation of user demands, requests, feedback**
- **Close contact to KFN**
- **Large number of user workshops on the “instrument level”**
- **Workshop Bad Reichenhall**

  - **Organized by KFN, ESS AB, FZ Jülich**
  - **150 participants**
  - **Scientists & Instrument experts**
  - **Outcome documented in a report**

German ESS Design Update Project
October, 2010 – December, 2014

Instrument Design, Evaluation of Science Case and User Requests

Submission of 7 Instrument Proposals
September, 2013

Review Process in 2014
STAP, SAC, STC

FZJ : 5
HZG: 1
TUM: 1

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Jülich Centre for Neutron Science

Vertical Sample Reflectometer

Time-of-flight Reciprocal space Explorer

TREX: A bispectral chopper spectrometer for magnetism and material science

Bi-spectral powder diffractometer: POWHOW

High-Resolution Spin Echo Spectrometer

High Intensity SANS with optional focusing optics

SKADI: Small K Advanced Diffractometer

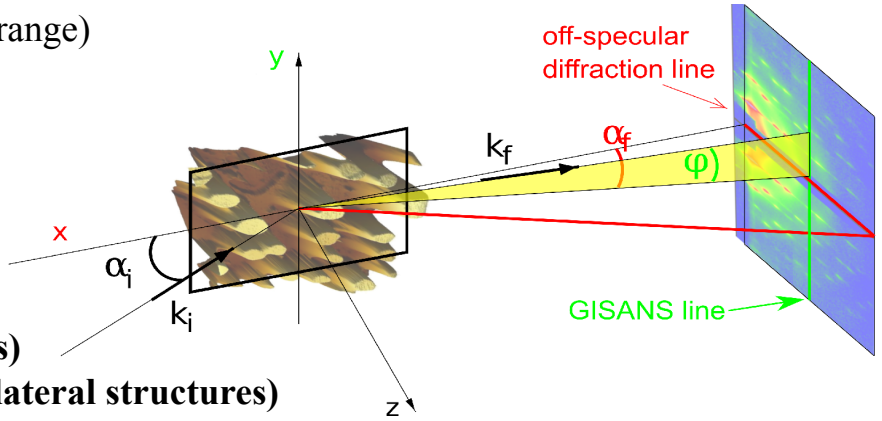
Instrument Proposals submitted September, 2013

Vertical Sample Reflectometer

The most urgent common request from both communities:

- increase the **sensitivity to thin layers, interfacial regimes** in the **sub nm region**
- **high intensity** (relaxed Q resolution)
- **high dynamic Q range** (low background)
- **implemented GISANS option** (lateral structures in the nm range)

- **Low resolution reflectometer**
  with high Q range and high dynamical range (≥8 orders)



Optimised modes of the instrument:

- **Un- / Polarised specular reflectivity (thin interfaces areas)**
- **Un- / Polarised off-specular scattering / GISANS mode (lateral structures)**

Add on's (NOT COMPROMISING main modes)

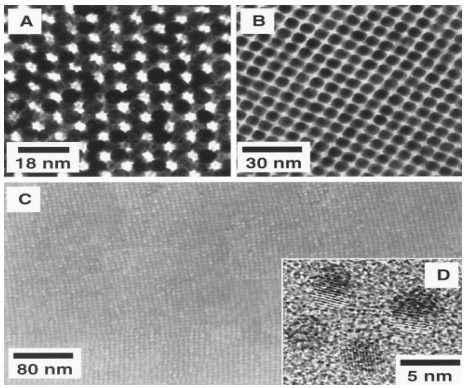
- High wavelength resolution 1% and 3%
- Small samples with 1 x 1mm^2

Stefan Mattauch (FZJ)
Alexander Ioffe (FZJ)
Jean-Francois Moulin (HZG)
Dieter Lott (LLB)
H. Wacklin (ESS coordinator)

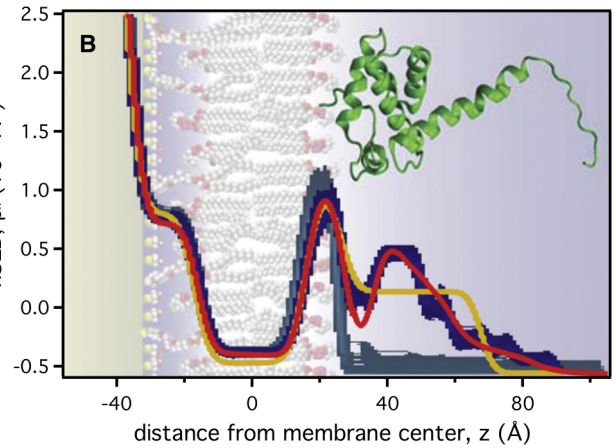
FZJ Instrument Proposal 2013

Vertical Sample Reflectometer

3D assembly of $Fe_{50}Pt_{50}$ particles



S. Sun et al., Science 287 (2000) 1989



Hirsh Nanda et al., Biophysical Journal 99 (2010) 2516
nSLD, ρ_n (10^{-6} Å^{-2})

The illustration provides a molecular interpretation of the SLD profile

Examples: Understanding and controlling interfacial structures and interactions in the 1-10 nm regime

Properties at interfaces between oxide materials:

- Superconductivity between insulating materials
- Magnetism between non-magnetic layers
- Ferromagnetism between anti-ferromagnetic layers

Pattern Formation in the Nanoworld:

- Due to competition between exchange interactions, dipolar interactions and anisotropies
- Non-collinear magnetism at the surface
- Influence of the substrate
- Dynamics (spin waves)

- **Biology of membranes and associated proteins**
- **Hybrid materials**
- **Materials in confined geometry**

Science Case

JÜLICH
FORSCHUNGSZENTRUM

Jülich Centre for Neutron Science

Vertical Sample Reflectometer

Time-of-flight Reciprocal space Explorer

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Instrument Proposals submitted September, 2013

JÜLICH FORSCHUNGSZENTRUM

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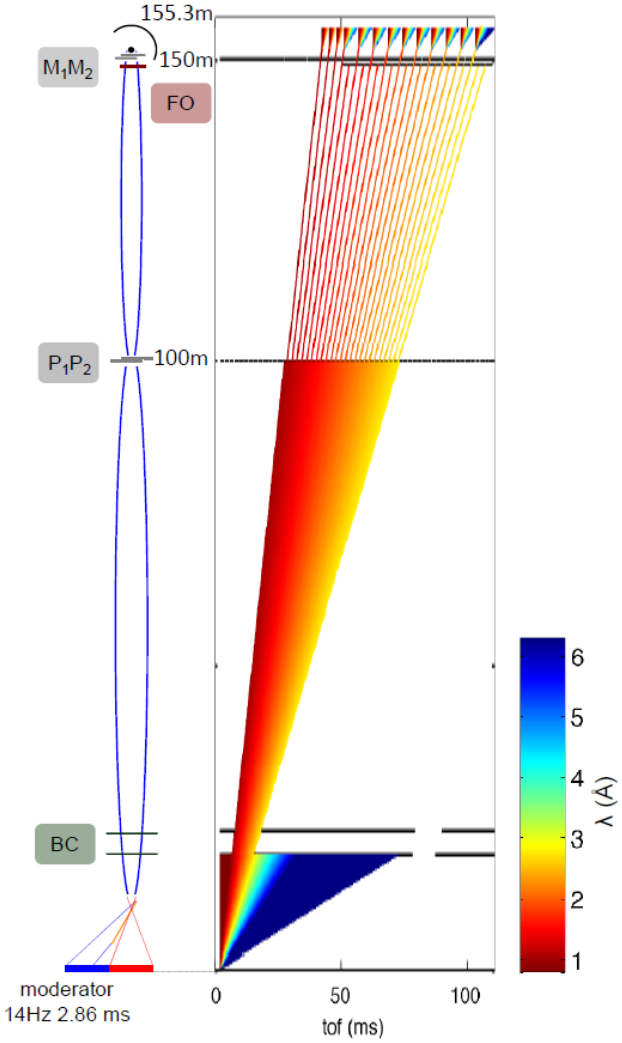
Time-of-flight Reciprocal space Explorer

TREX: A bispectral chopper spectrometer for magnetism and material science

- Multispectral spectrometer for magnetism + material science
  - From extreme energy resolution to very high flux
  - 4 decades in energy/time on **one** instrument
- Polarization analysis
- Taking full advantage of Repitition Rate Multiplication (RRM)
- Pixel power
  - Adaptive collimation
  - $\Delta Q \geq 0.01$ Å^{-1} for small angle region
  - $Q \leq 12$ Å^{-1}
  - Mapping of coherent excitations



Jörg Voigt (FZJ)
Nicolo Violini (FZJ)
Thomas Brückel (FZJ)
P. Deen (ESS coordinator)

FZJ Instrument Proposal 2013

JÜLICH FORSCHUNGSZENTRUM

Jülich Centre for Neutron Science

Time-of-flight Reciprocal space Explorer

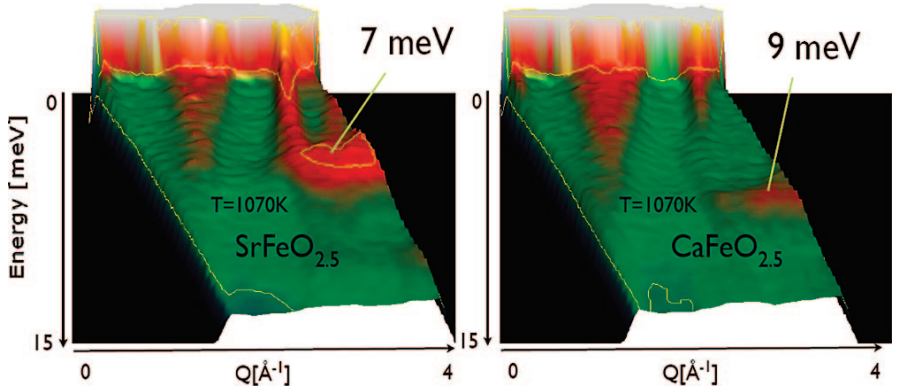
TREX: A bispectral chopper spectrometer for magnetism and material science

High T_C Superconductivity

Multiferroics

Molecular magnets

Quantum phase transitions

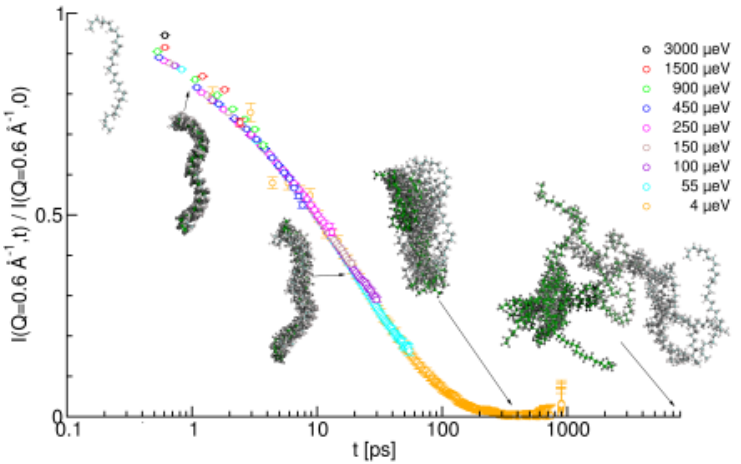


Energy research

- Diffusive motion, acoustic and optical branches at once
- Thermo-electrics
- Ion transport

Dynamics in polymers and biomaterials

- Proteins, hydration water
- Bio-catalysts, bio-sensors
- Polymers, Glasses



Science Case

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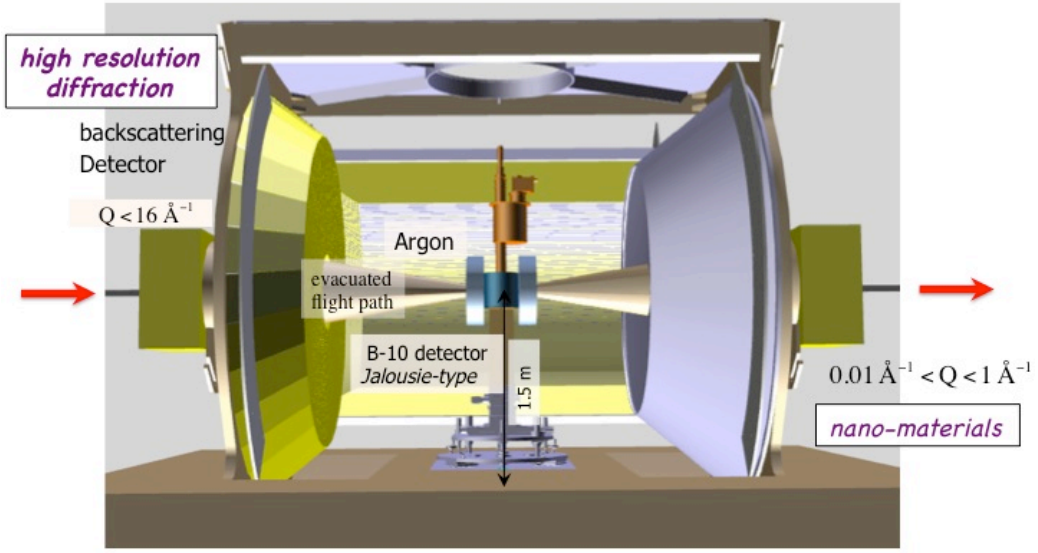
Bi-spectral powder diffractometer: POWHOW

High flexibility in trading resolution versus intensity
High resolution in backscattering $\Delta d \approx 10^{-4}\ (\propto 1/\lambda)$
High intensity single shot: approx. a few ms resolution



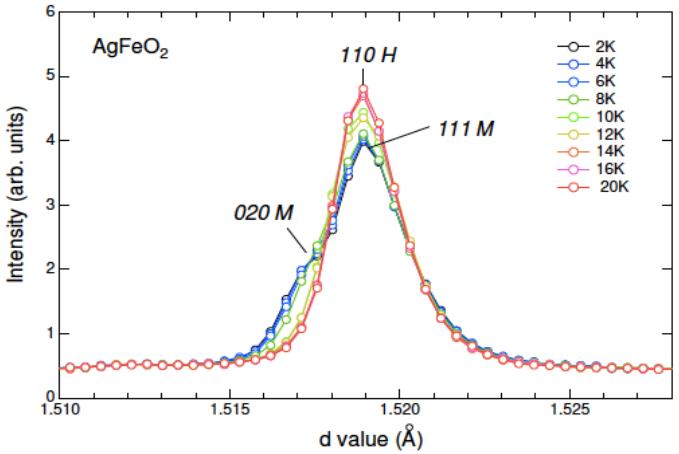
W. Schweika (FZJ)
N. Violini (FZJ)
K. Lieutenant (HZB)
A. Houben (RWTH Aachen)
P. Henry (ESS coordinator)

FZJ Instrument Proposal 2013

Bi-spectral powder diffractometer: POWHOW

- magnetism
- low T physics, multiferroics
- multiple phases and length scales
- large unit cells
- ...

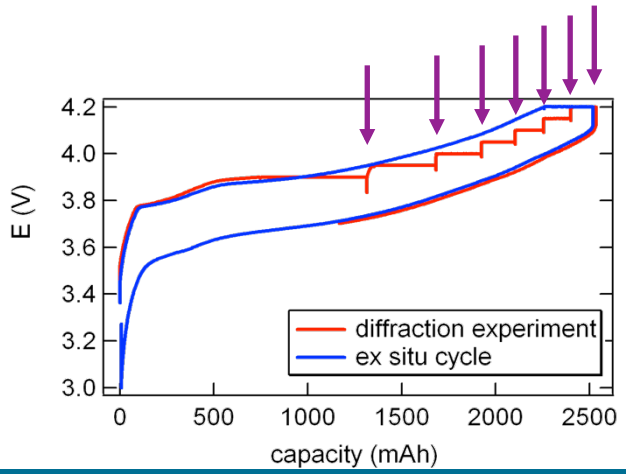
- Magnetic nano-particles:
  atomic and magnetic structure
  spatial magnetization distribution



high resolution @ HRPD (ISIS)

observation of magnetic phase transition associated with lattice distortions

Noriki Terada et al., EPJ Web of Conferences 40 , 15008 (2013)



Neutron powder diffraction on commercial Li-ion battery
($LiCoO_2$ based, 18650 type) „in operando“

A. Senyshyn, W. Schmahl (LMU Munich)

Science Case

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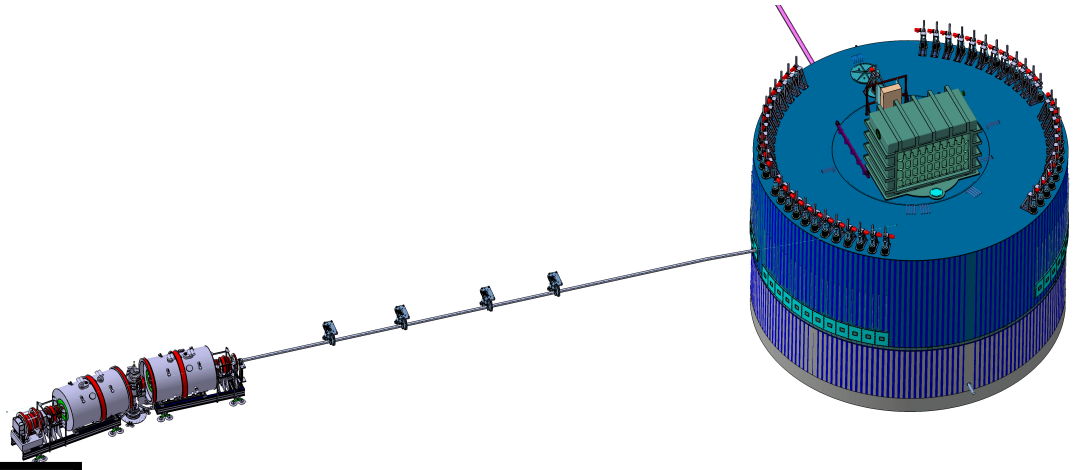
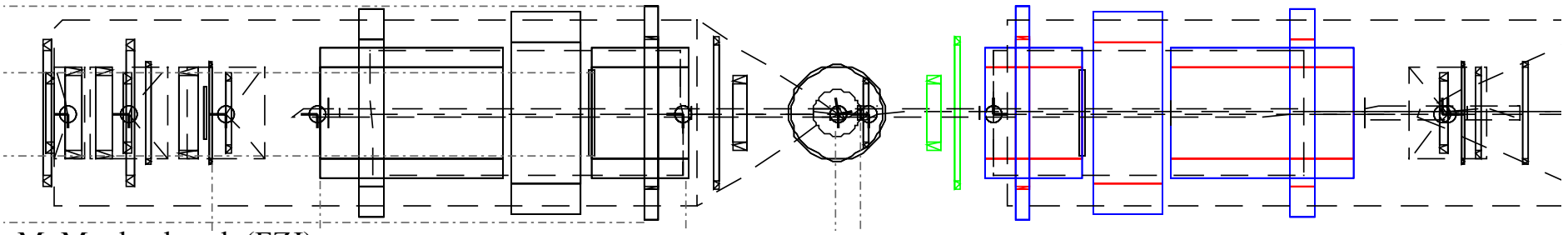


New superconducting coils,
fully compensated

2-2.5 times improved resolution



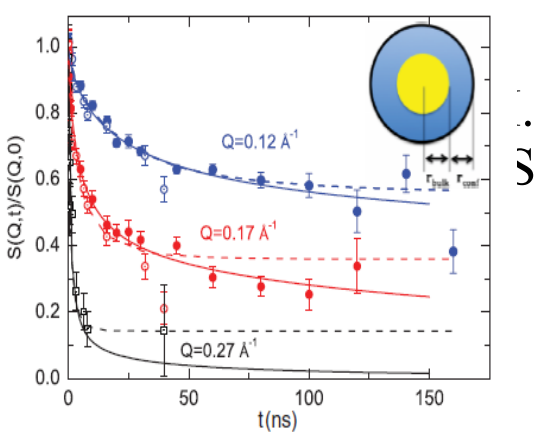
M. Monkenbusch (FZJ)
S. Pasini (FZJ)
M. Sharp (ESS coordinator)

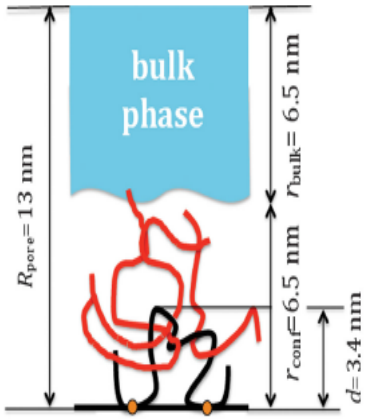
FZJ Instrument Proposal 2013

High-Resolution Spin Echo Spectrometer

Dense polymeric systems

- polymer rings, star polymers
- self-healing materials
- polymers in confinement, e.g. pores





Krutyeva et al., PRL 110, 108303 (2013)

Proteins and biomolecules

- Functional domain motions
- Emerging topic: nanodiscs

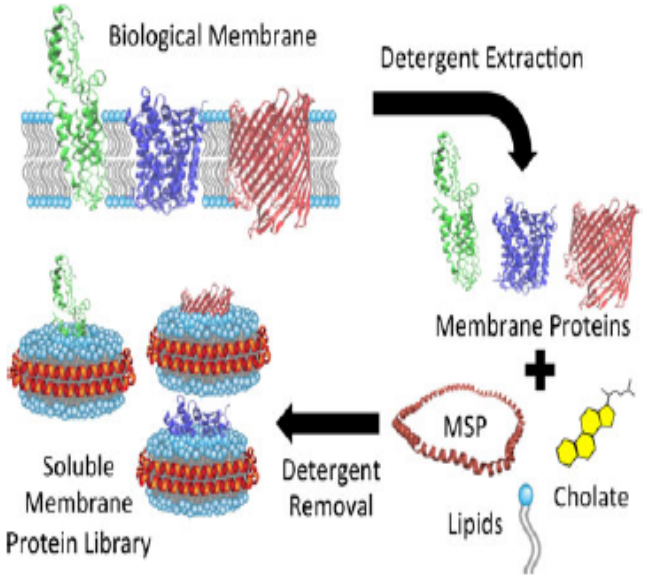
Glass physics

Complex fluids and diffusion in crowded (protein) soluti

Challenge: diffusion in cell/ionic liquids

Research in energy materials

Electrolytes and storage materials



Science Case

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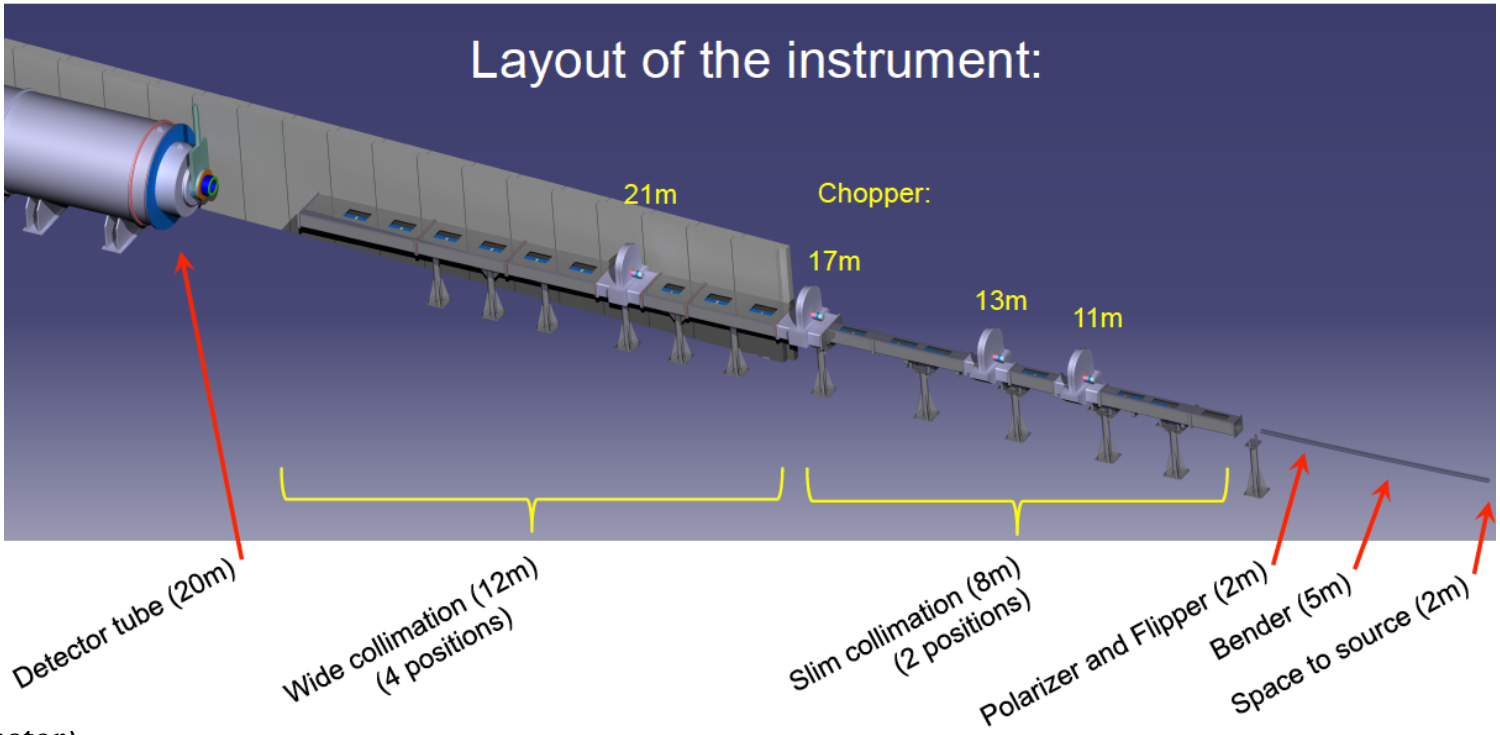
Jülich Centre for Neutron Science

High Intensity SANS with optional focusing optics
SKADI: Small K Advanced Diffractometer

- Highest possible intensities
- Polarization
- Wide Q-range 10^{-3}Å^{-1} – 2 Å^{-1}
- Extended Q-range to few 10^{-5} Å^{-1} (VSANS) and 10^{-6}Å^{-1} (SESANS)
- Large customized sample environment



H. Frielinghaus (FZJ)
S. Jaksch (FZJ)
J. Jestin (LLB)
A. Jackson (ESS coordinator)

FZJ Instrument Proposal 2013

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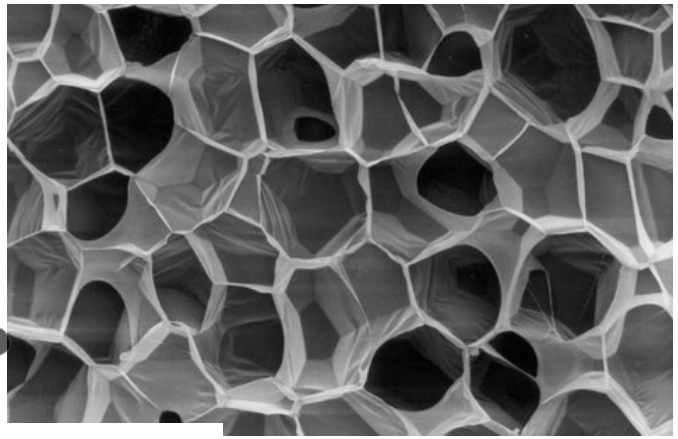
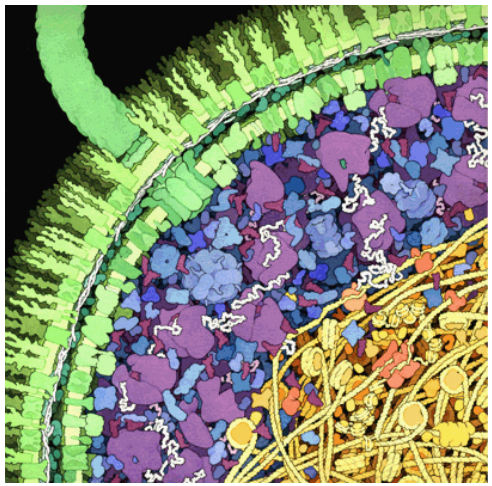
Jülich Centre for Neutron Science

High Intensity SANS with optional focusing optics
SKADI: Small K Advanced Diffractometer

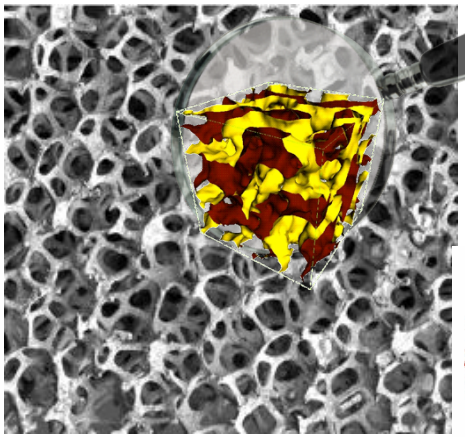
- Fast Kinetics
- Crowded Systems (Multiple length scales)
- Magnetic Systems
- Detect smallest amounts of additives

Nanofoams



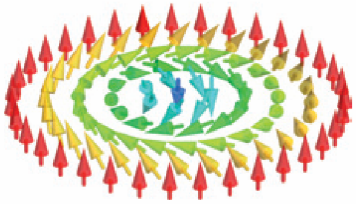


E. coli
(Goodsell)



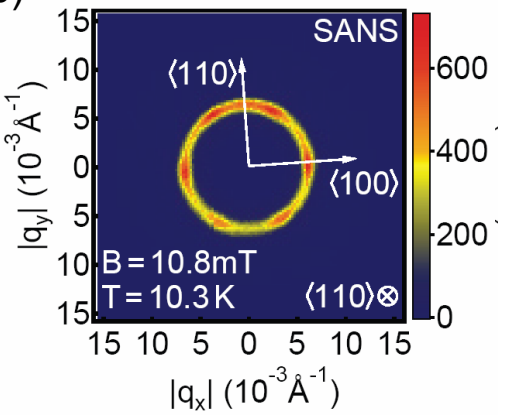
μE in Pores

a)



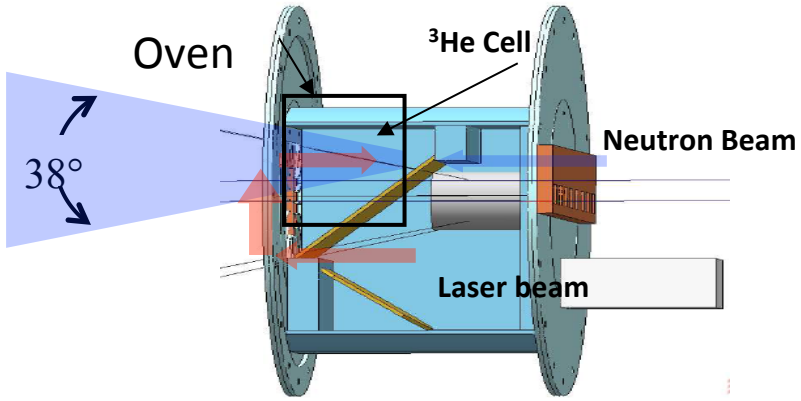
Skyrmions

b)

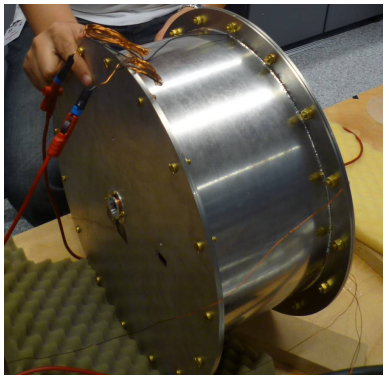


Science Case

Critical instrument components

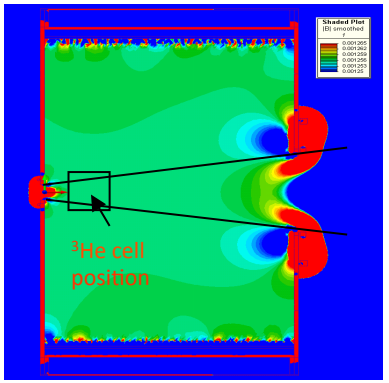


The prototype device



Design of a compact on-beam **SEOP analyzer** for SANS

- Allows standard sample environment
- Online polarization



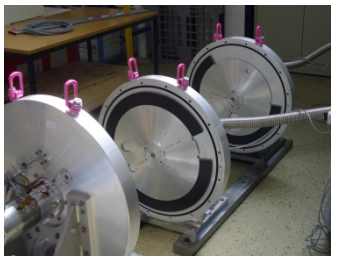
Polarization Analysis studies

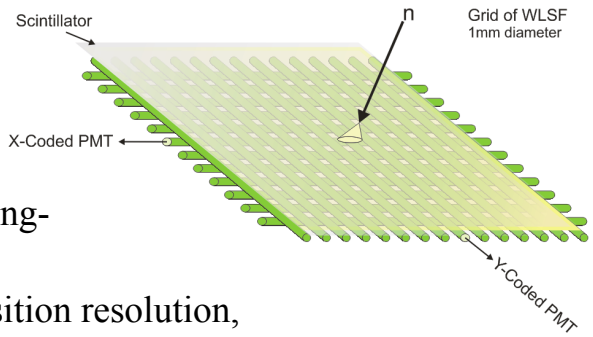
- Large solid-angle **^{3}He spin-filter** cell
- Separation of coherent, incoherent and magnetic scattering

Novel components for novel instrumentation

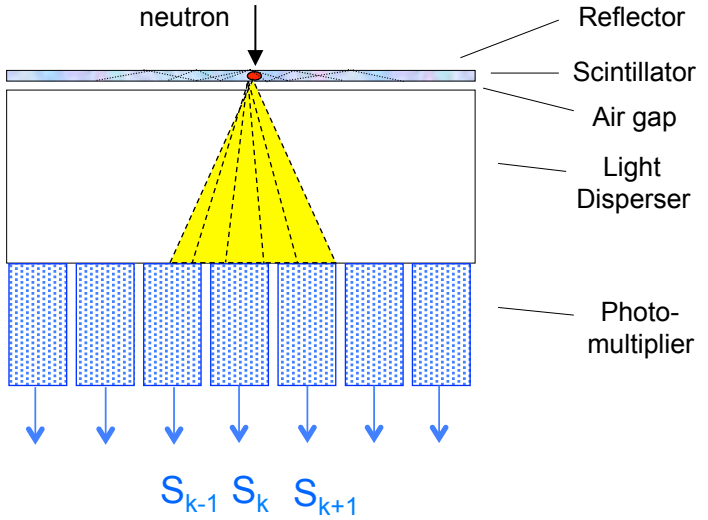
Choppers & Detectors for the ESS

- Disk choppers with beamline specific housings and disk designs
- Customized absorber coatings
- Fermi choppers with rotor weights up to 50 kg
- Chopper control electronics





- Detectors with wavelength-shifting-fibre light readout
- Large area, low γ-sensitivity, position resolution, detection efficiency



- Detectors based on Anger camera principle
- Large area, light detection devices, low γ-sensitivity, position reconstruction, count rate capability

JCNS – ZEA-1 – ZEA-2 collaboration

Thank you !