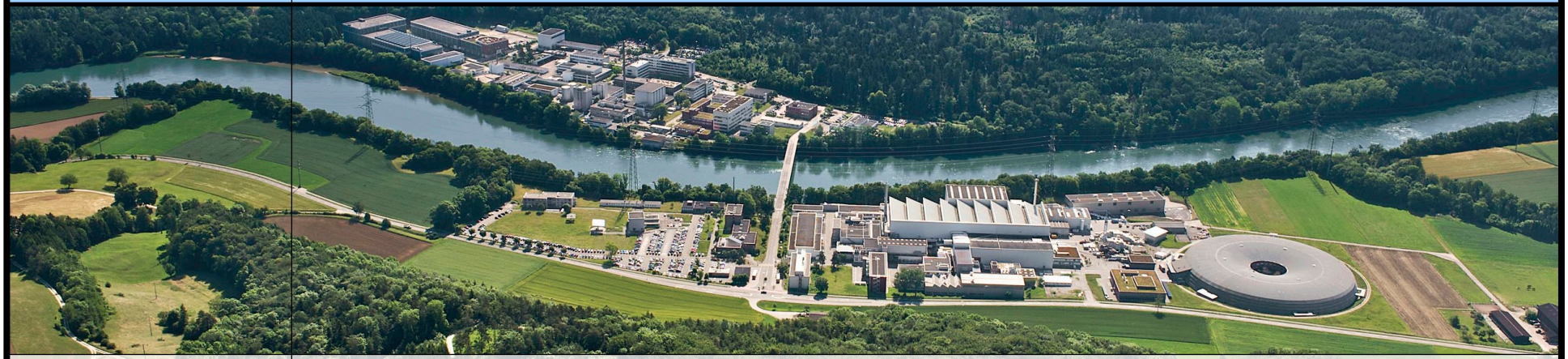
PAUL SCHERRER INSTITUT

PSI



Wir schaffen Wissen – heute für morgen

Swiss Spallation Neutron Source SINQ and ESS

Christian Rüegg

Laboratory for Neutron Scattering, Paul Scherrer Institute

Sigtunahöjden, 30 January 2012

Outline

Swiss Spallation Neutron Source SINQ and ESS

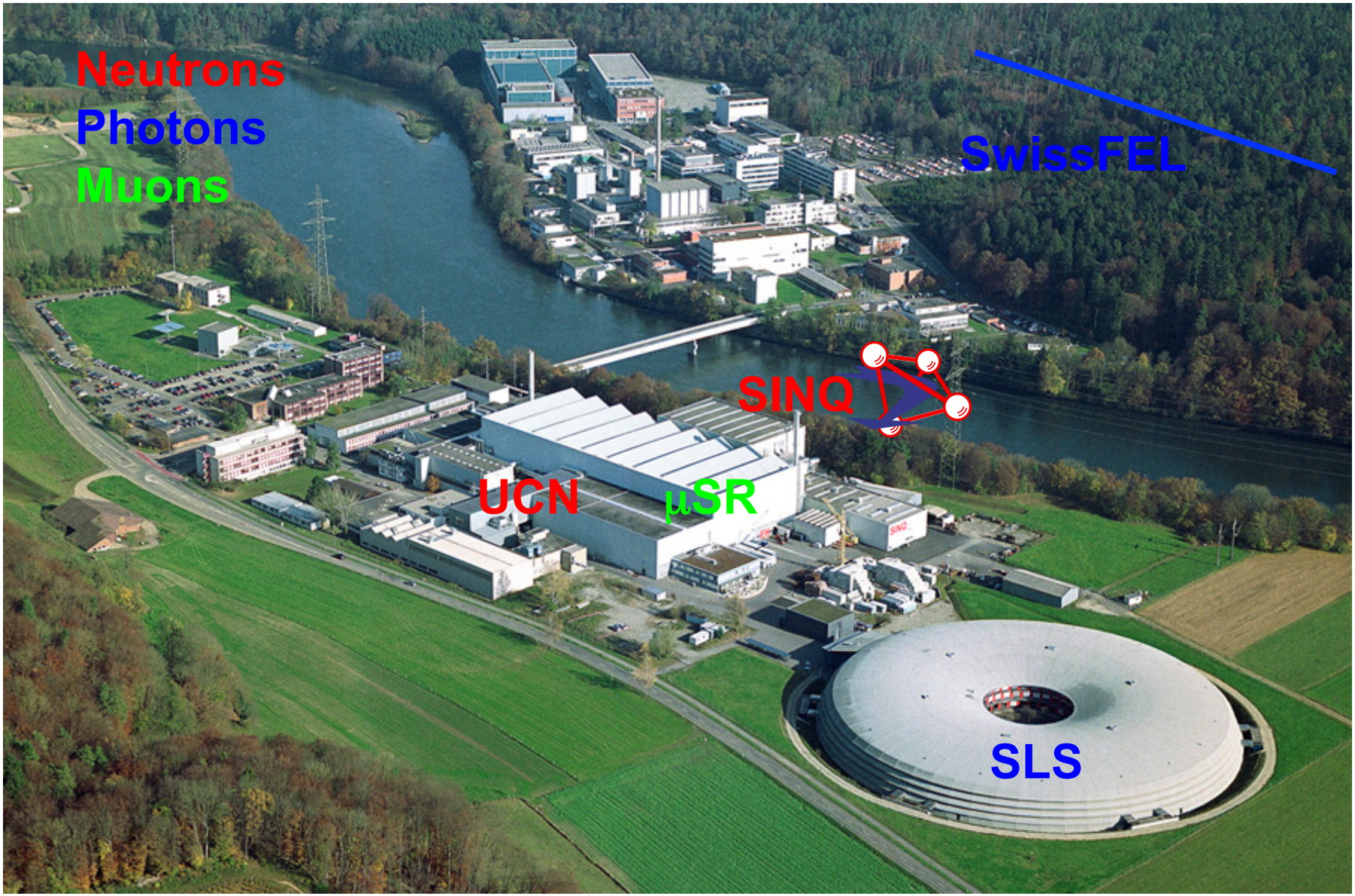
I: Swiss Spallation Neutron Source SINQ
- proton accelerator, source and instruments
- user program

II: Science News from SINQ
- material science (energy, technology)
- soft matter (health)

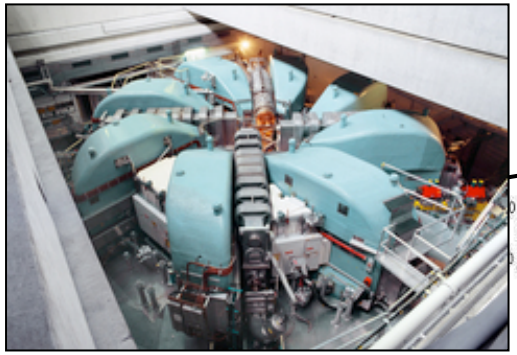
III: ESS:
- the Swiss contributions to the ESS (instrumentation, target)

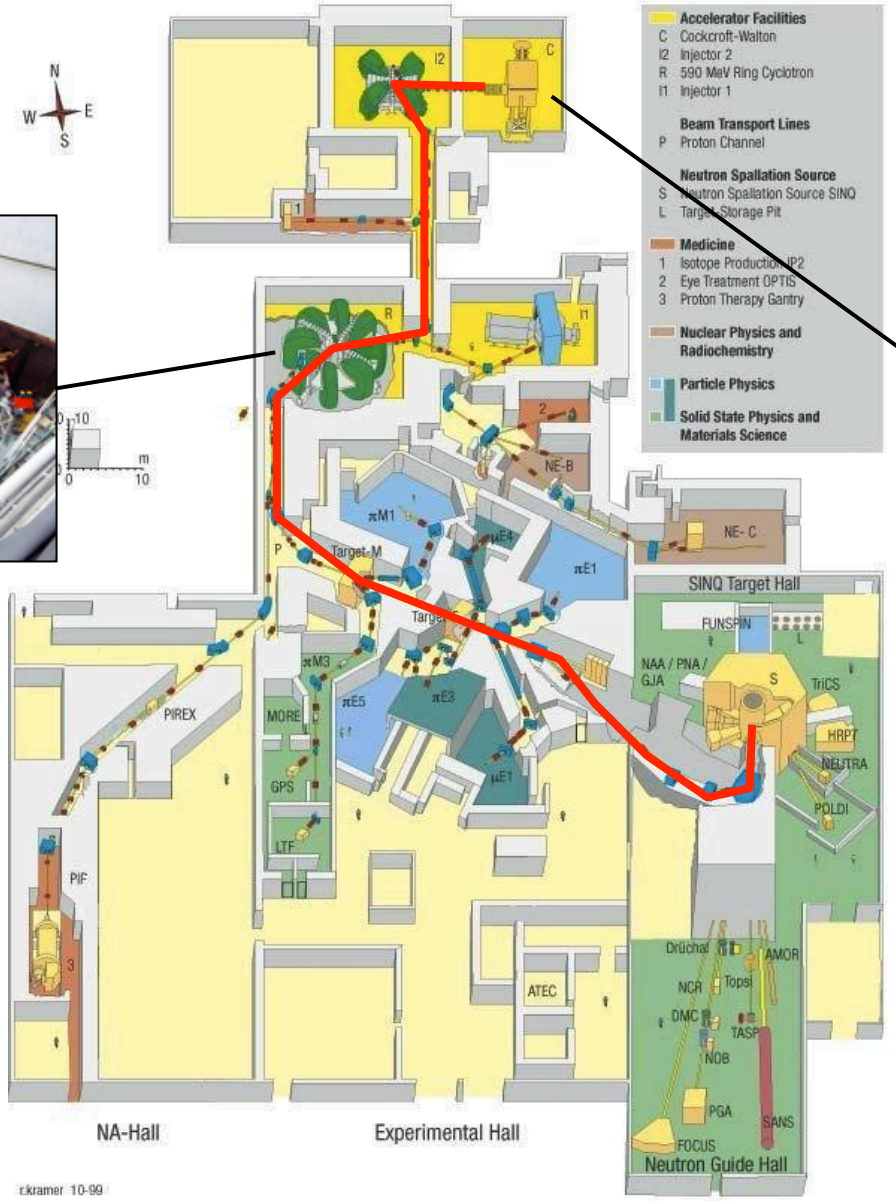
IV: Future Collaborations:
- neutron technology and education
- science projects (new sources for funding)

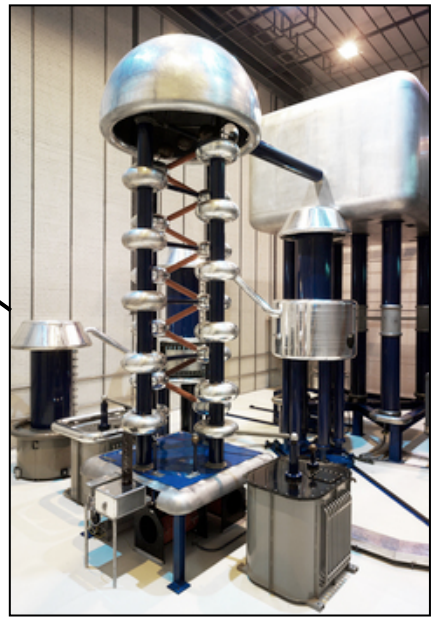
Paul Scherrer Institute



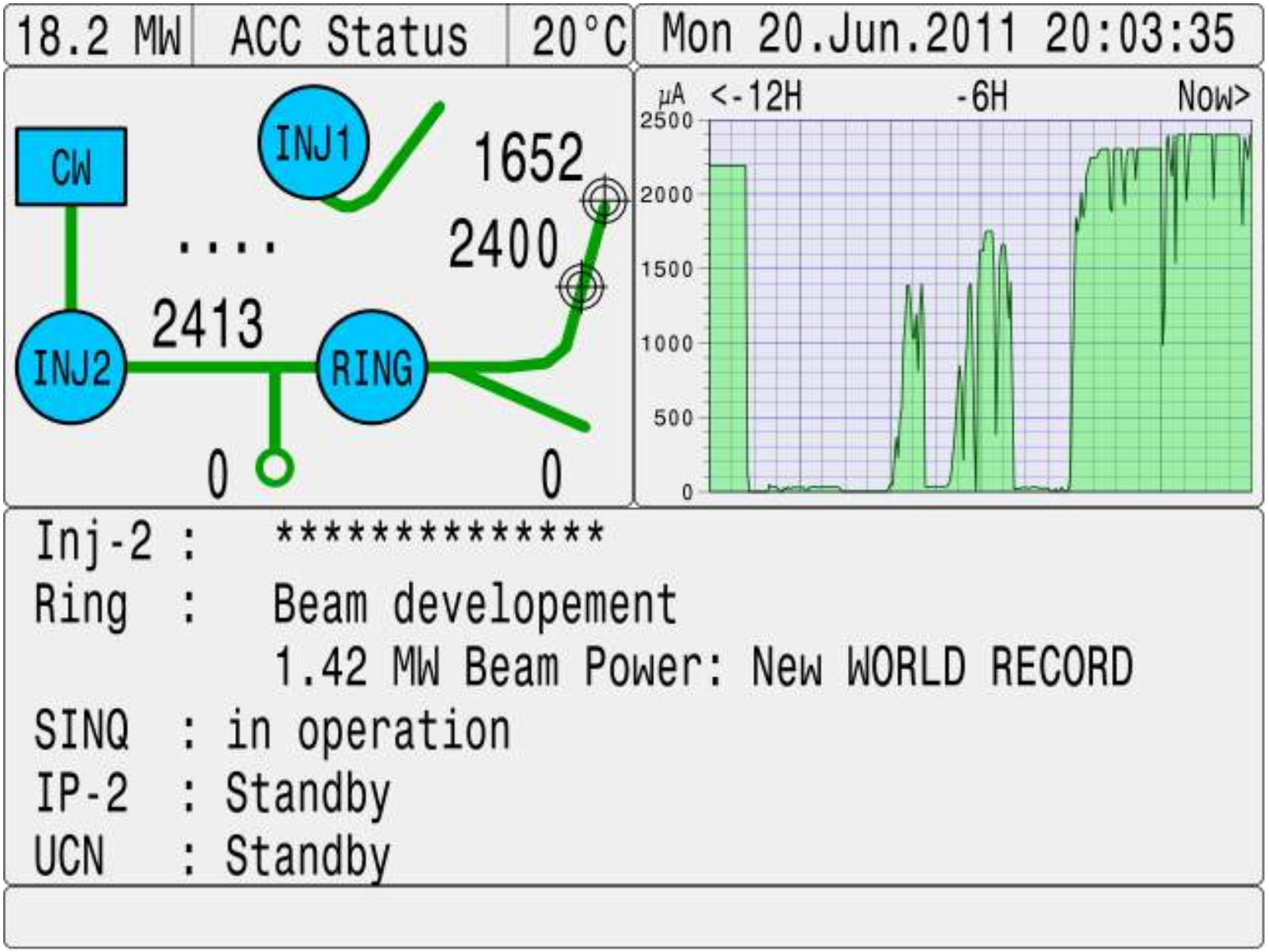
Proton Accelerator (590 MeV, 1.42 MW, 2.4 mA)



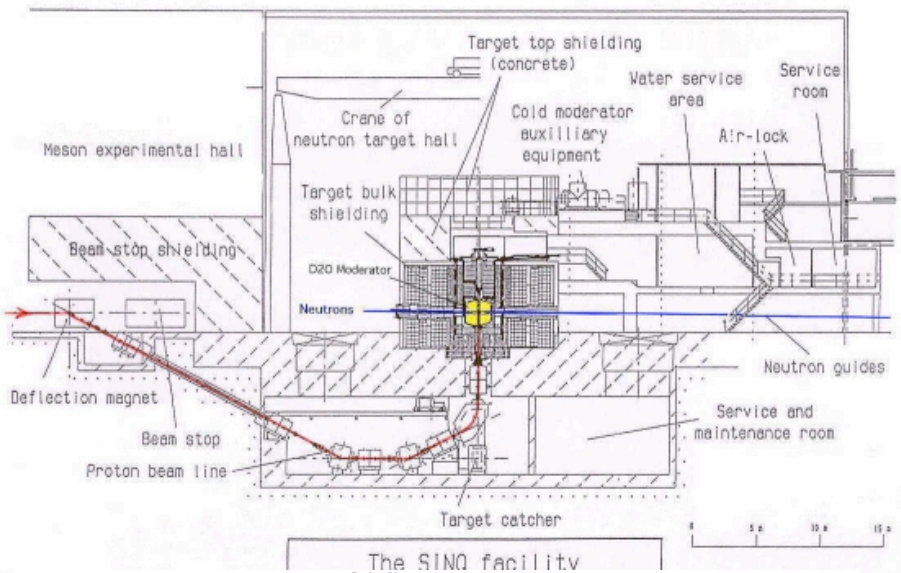


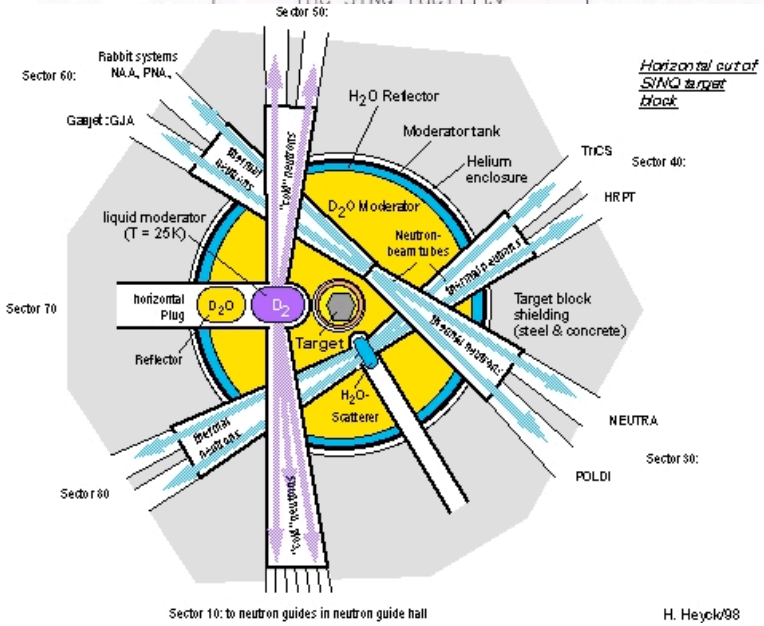


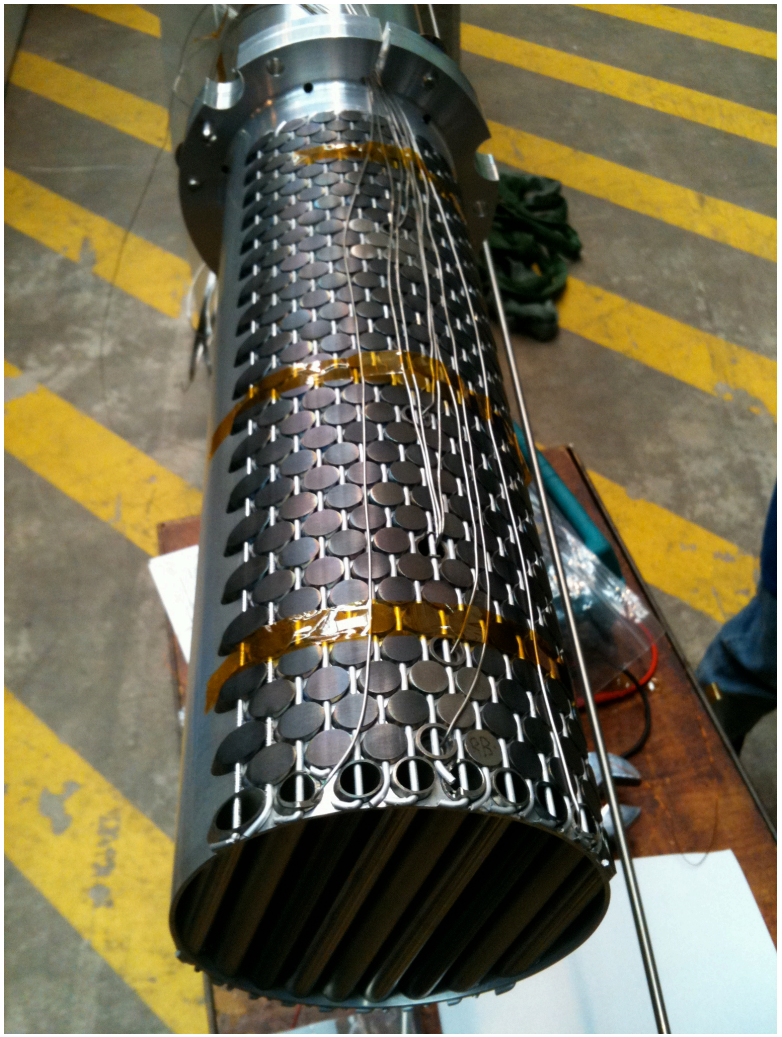
Proton Accelerator (590 MeV, 1.42 MW, 2.4 mA)



Swiss Spallation Neutron Source SINQ



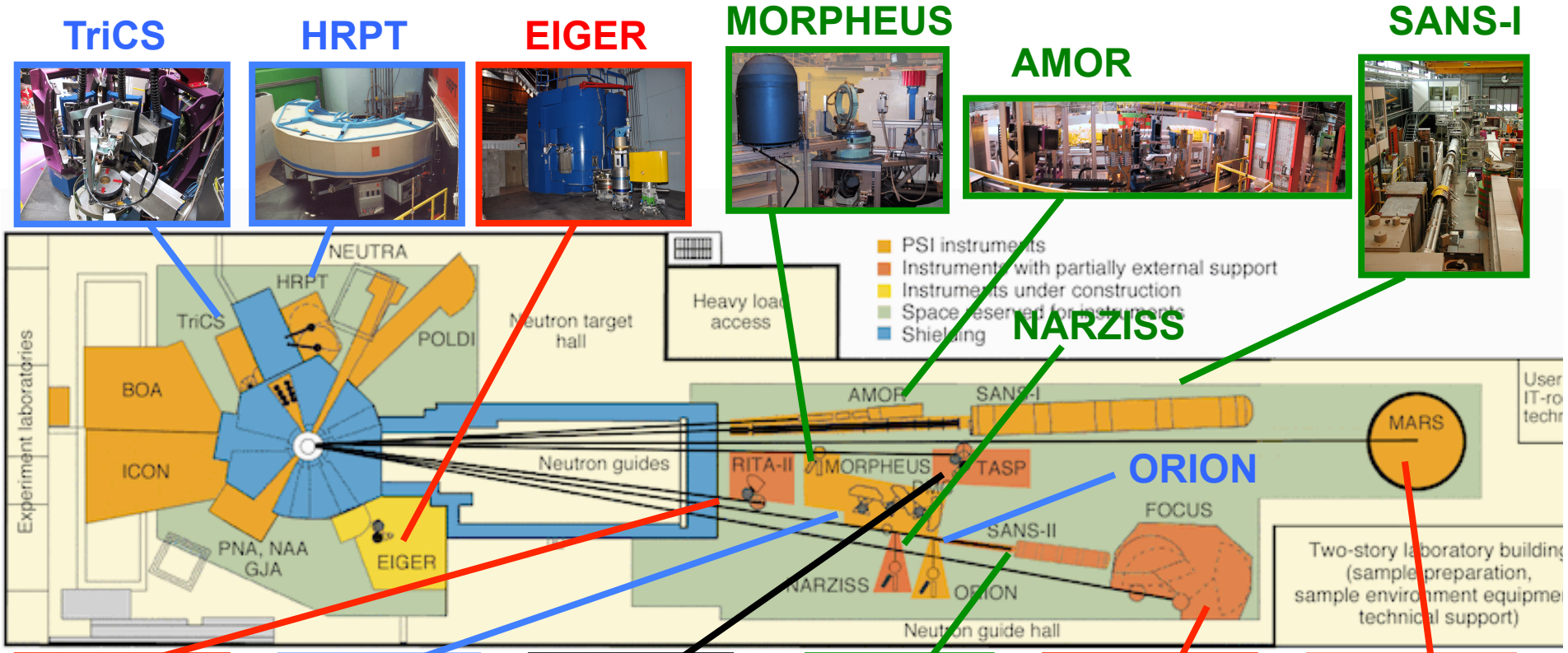


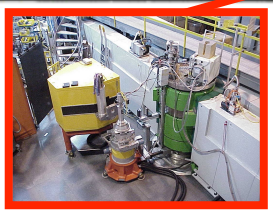


- W. Wagner, ASQ, Paul Scherrer Institute

Swiss Spallation Neutron Source SINQ

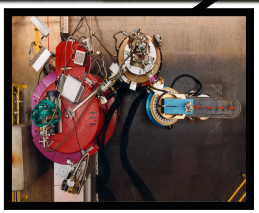
LNS Instruments at SINQ





RITA-II

DMC



TASP
(ETHZ)

SANS-II

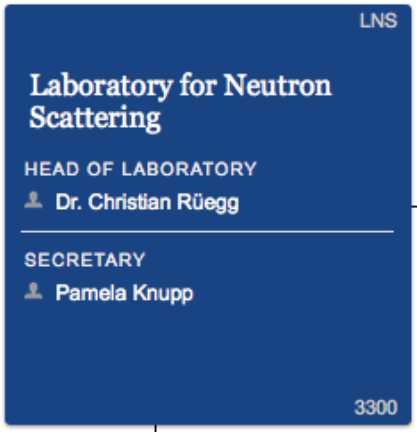
FOCUS

MARS

Diffraction | **Spectroscopy** | **SANS + Ref.**

PAUL SCHERRER INSTITUT

Laboratory for Neutron Scattering (LNS)



NEUTRON POLARIMETRY
Dr. B. Roessli

Diffraction

Dr. J. Schefer

SCIENTISTS / STAFF
- Dr. N. Aliouane
- Dr. D. Cheptiakov
- Dr. L. Keller
- Dr. V. Pomjakushin
- Dr. O. Zaharko

PHDS
- R. Sura
- W. Wallace

Spectroscopy

Dr. C. Niedermayer

SCIENTISTS / STAFF
- Dr. J.P. Embs
- Dr. T. Fennell
- Dr. F. Juranyi
- Dr. M. Laver
- Dr. S. Ochsenbein
- Dr. A. Poole
- Dr. M. Skoulatos
- Dr. U. Stuhr
- Dr. J. White

PHDS
- M. Bestel
- T. Burankova
- E. Hirtenlechner
- M. Mena
- P. Merchant
- S. Ward

SANS + Ref.

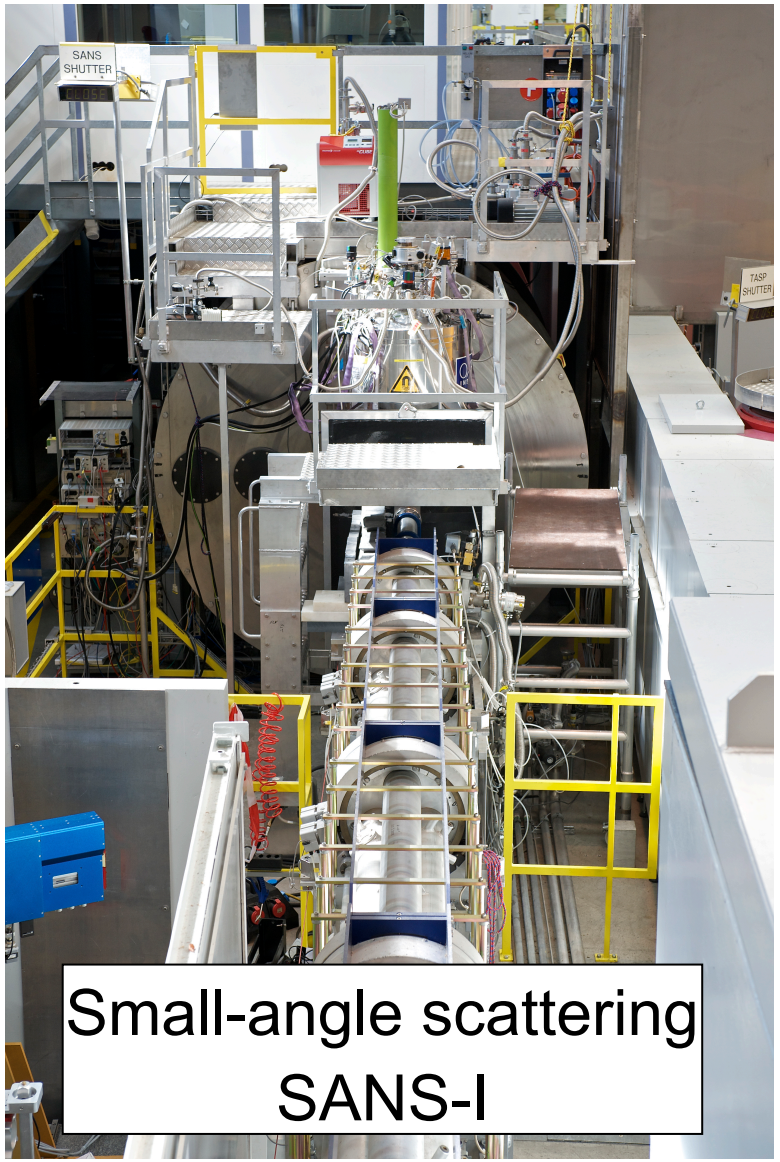
Dr. J. Kohlbrecher

SCIENTISTS / STAFF
- Dr. S. Balog
- Dr. U. Gasser
- Dr. J. Gavilano
- Dr. T. Geue
- Dr. J. Stahn

PHDS
- N. Egetenmeyer
- S. Gerber
- A. Scotti
- V. Städele

Swiss Spallation Neutron Source SINQ

Triple-axis spectrometer
RITA-II

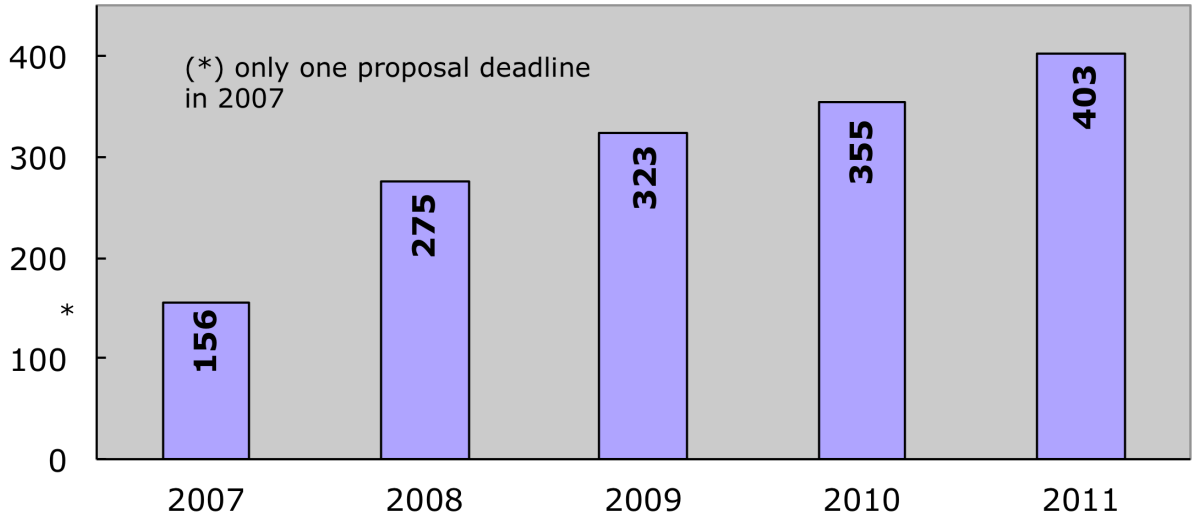


Small-angle scattering
SANS-I

SINQ User Program

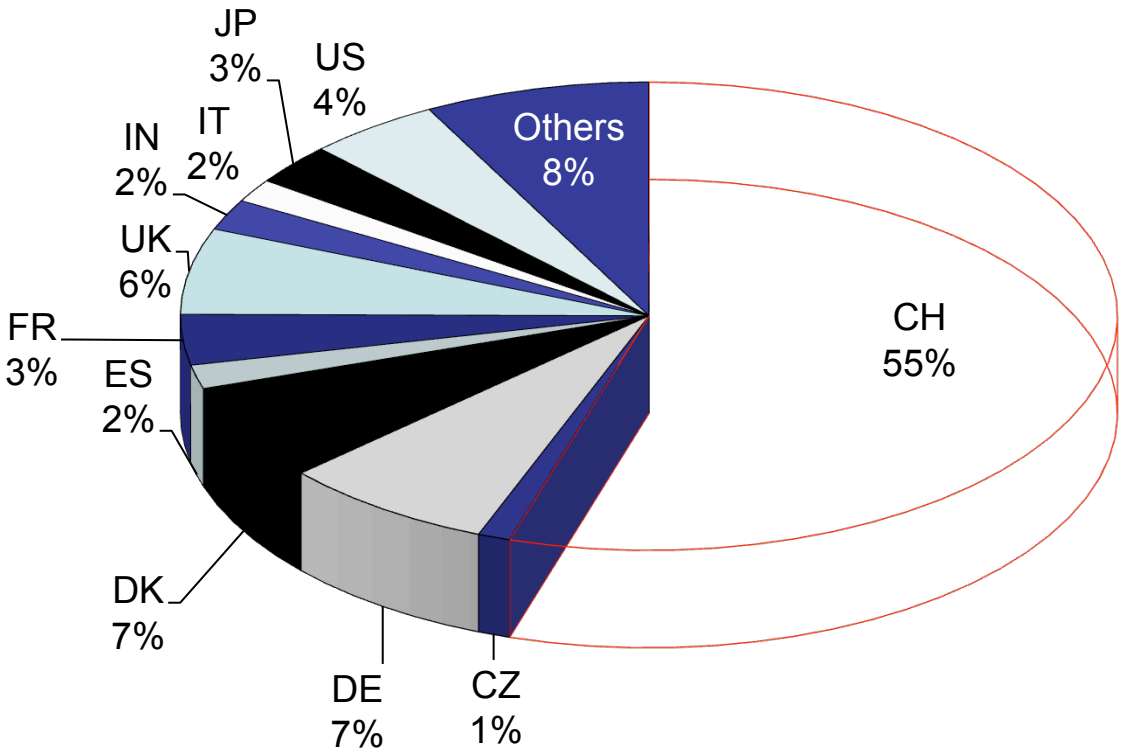
SINQ key numbers 2011 (2010)

New Proposals	:	403 (355)
Visits	:	826 (945)
Individual Users	:	441 (465)
Experiments	:	439 (483)
Experimental days	:	1939 (1954)



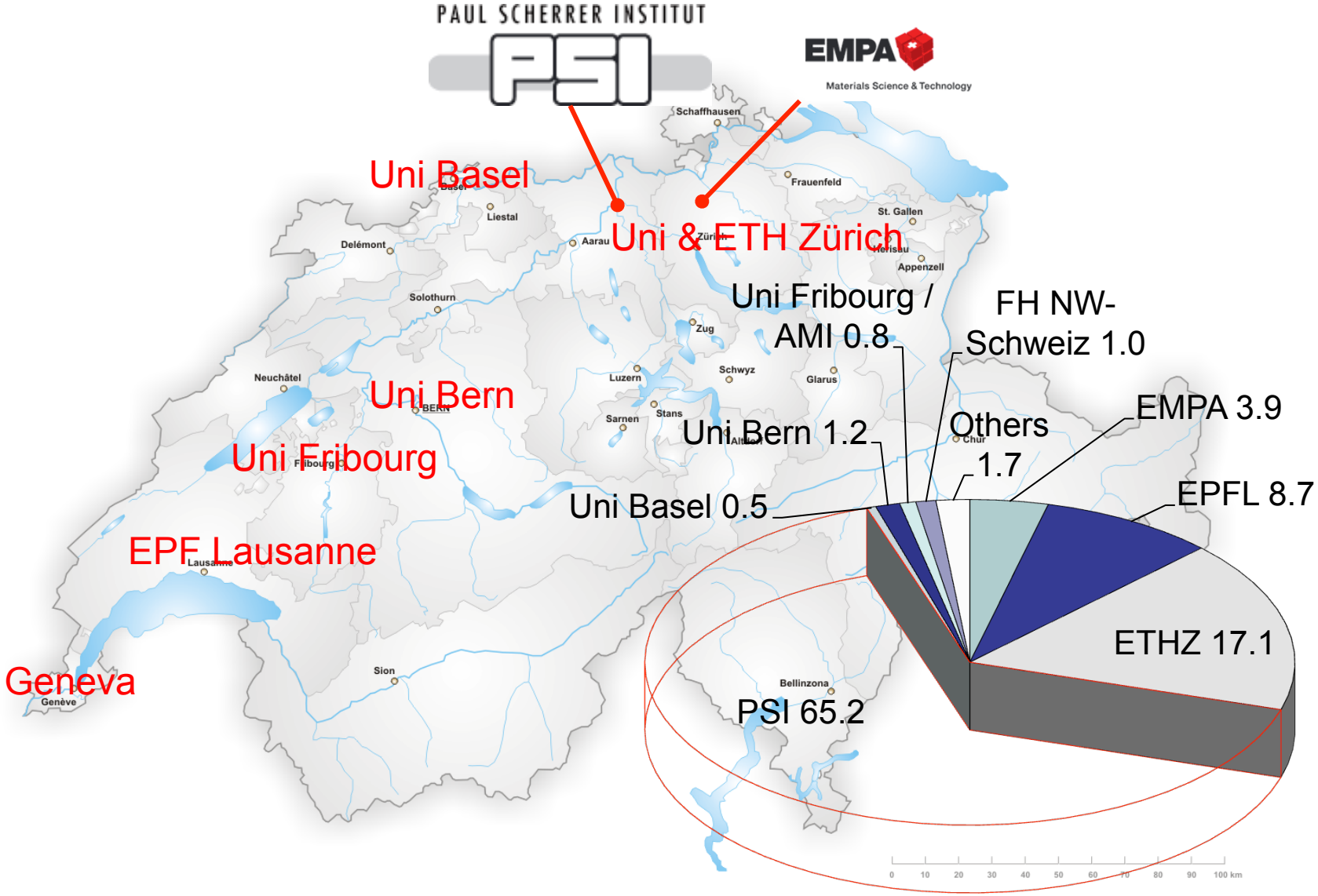
• Source: S. Janssen, PSI User office

Distribution of SINQ users in 2011



- Source: S. Janssen, PSI User office

Swiss SINQ users



• Source: S. Janssen, PSI User office

DANSCATT – PSI Collaboration

DK:

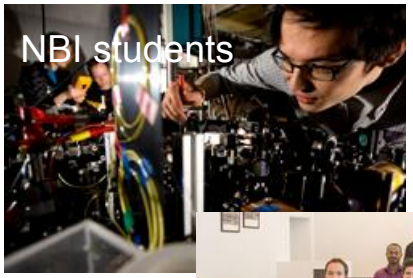
DANSCATT, Niels Bohr Institute, University of Copenhagen, Technical University of Denmark

CH:

Paul Scherrer Institute, Laboratory for Neutron Scattering

Practicals:

2-3 per year (1 week each) with DTU and NBI, as part of scattering courses for Undergraduate and Masters students



Joint student projects:

Jacob Larsen (DTU/Christof Niedermayer) – magnetism and superconductivity (PhD)
Rasmus Toft-Petersen (DTU/Mark Laver) – flux line lattices (PhD)
Sonja Holm (NBI/Christof Niedermayer) – LSCO (PhD)
Gitte Stieper (NBI/Christof Niedermayer) – iron pnictide superconductors (Masters)

Joint operation of RITA-II spectrometer at SINQ:

Mark Laver (DANSCATT postdoc working at PSI)

Outline

Swiss Spallation Neutron Source SINQ and ESS

I: Swiss Spallation Neutron Source SINQ
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- user program

II: Science News from SINQ
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III: ESS:
- the Swiss contributions to the ESS (instrumentation, target)

IV: Future Collaborations:
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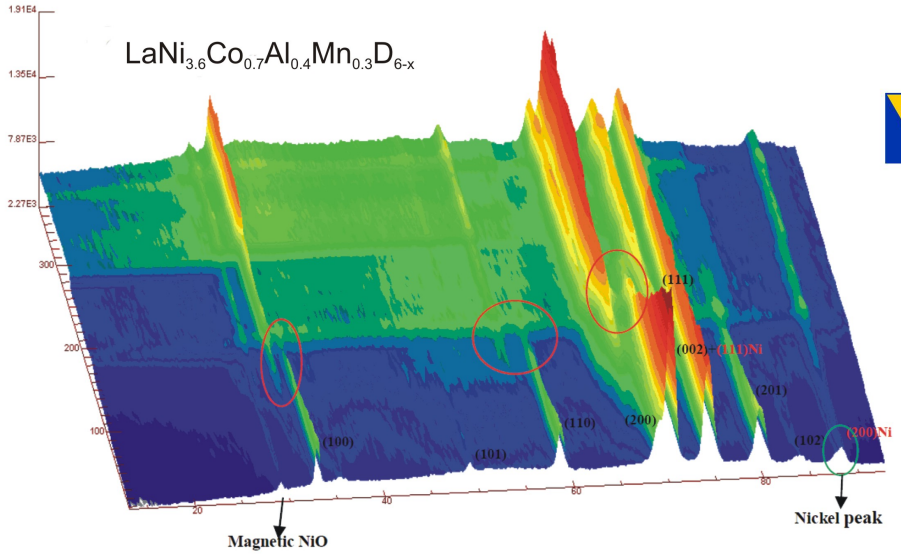
- science projects (new sources for funding)

Materials for energy storage – H-battery research

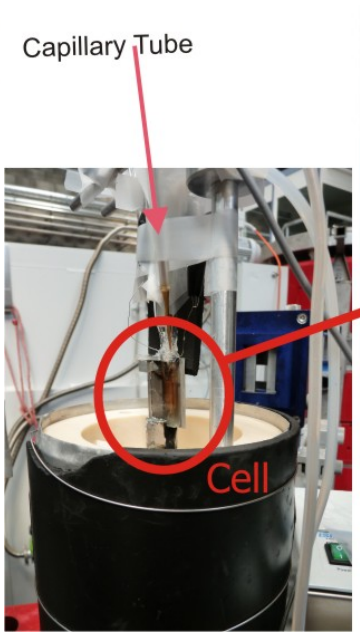
$LaNi_5$-based hydrides in micro-cell-batteries



Submitted to Int. J. Hydrogen Energy (2012)

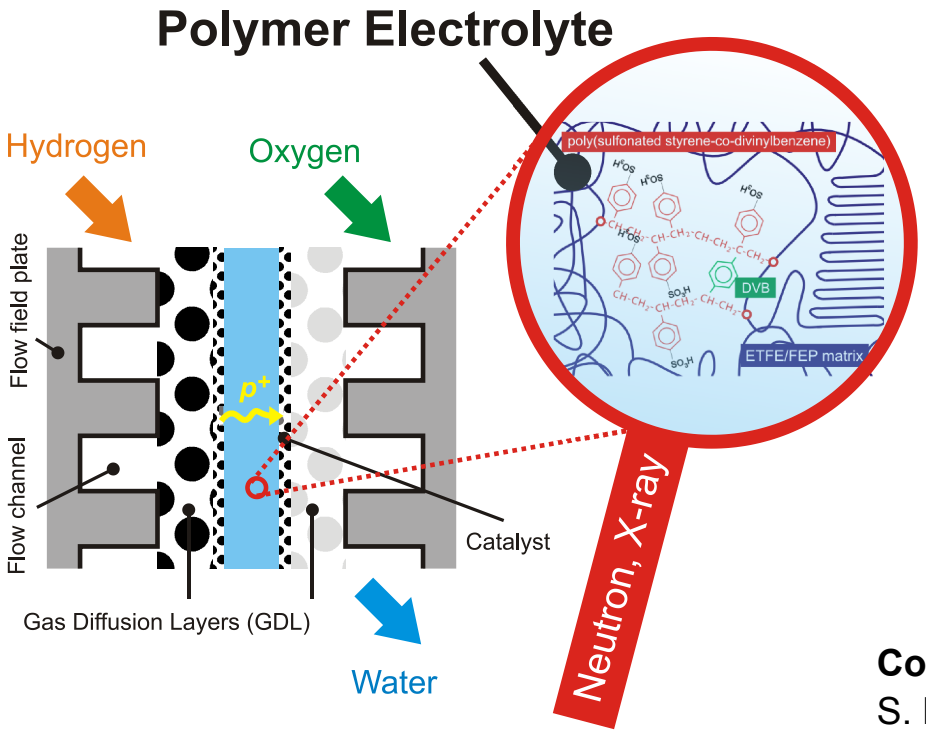
Collaboration:
Univ. Rennes, Paul Scherrer Institute, Varta Microbattery

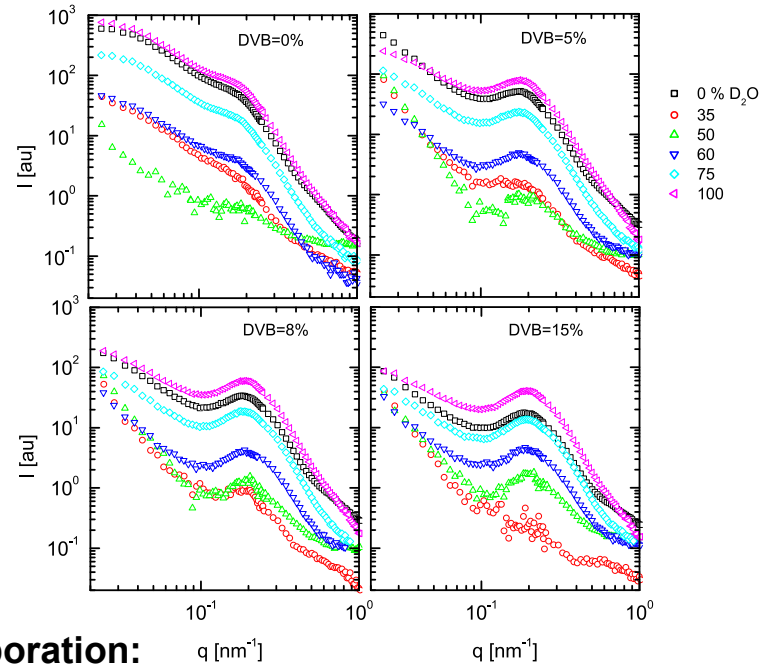
Battery research:
Volume expansion during loading of micro-cell batteries has to be compensated during the operation to keep the chemical process running safely.



DMC:
In-situ powder diffraction, fully deuterated electrolyte

Novel Polymer Electrolytes for Fuel Cells: Structure-property relationships of radiation-grafted block copolymers



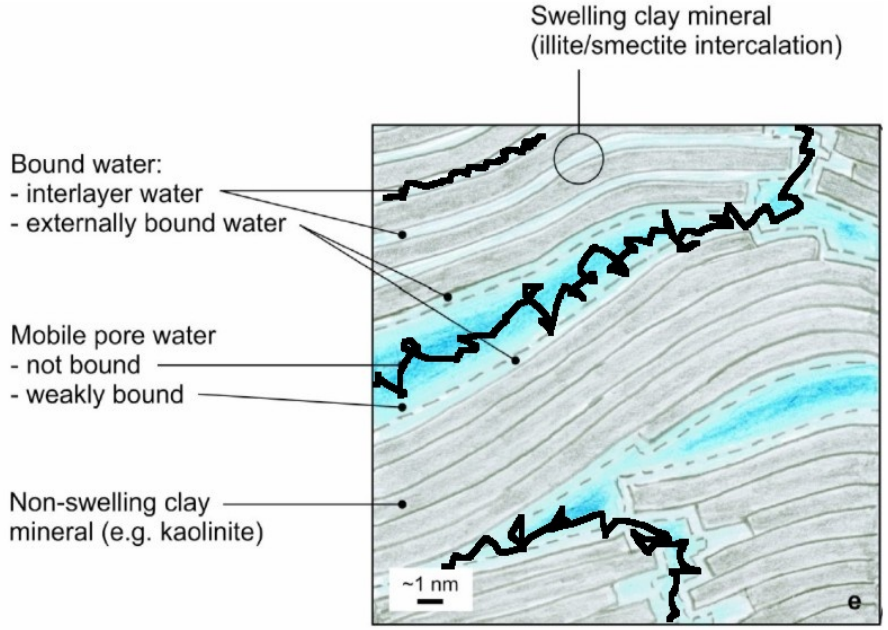


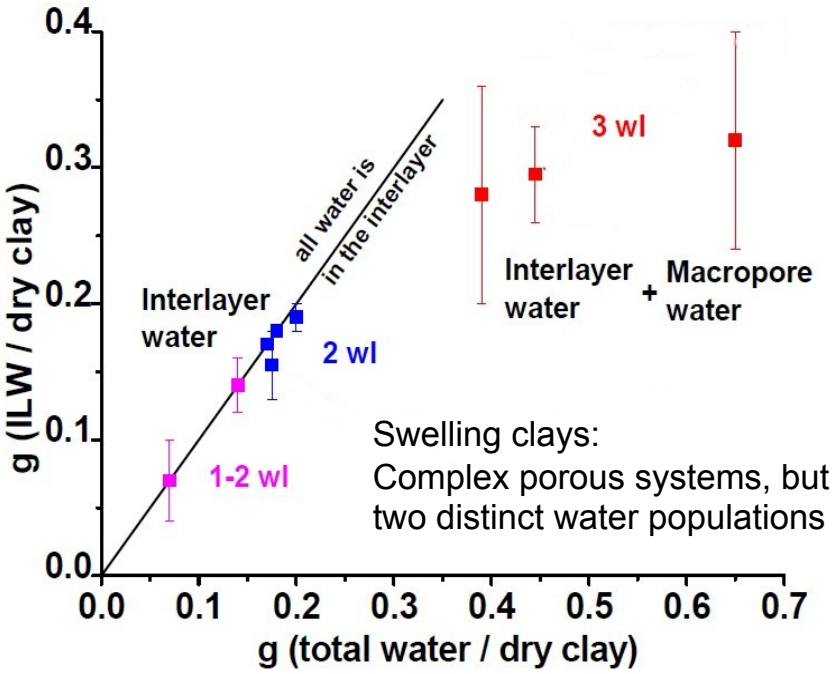
Publications:

Macromol. Chem. Phys. **211**, 635-643 (2010)
Journal of Membrane Science **383**, 50-59 (2011)
Polymer **53**, 175-182 (2012)

Collaboration:
S. Balog, U. Gasser
Lab. for Neutron Scattering, Paul Scherrer Institute
G. G. Scherer, L. Gubler, K. Jetsrisuparb, H. Benyoucef
Electrochemistry Lab., Paul Scherrer Institute
K. Mortensen
Department of Nat. Sciences, Univ. of Copenhagen
Supported by SNF Grant

Water diffusion in clays at different scales



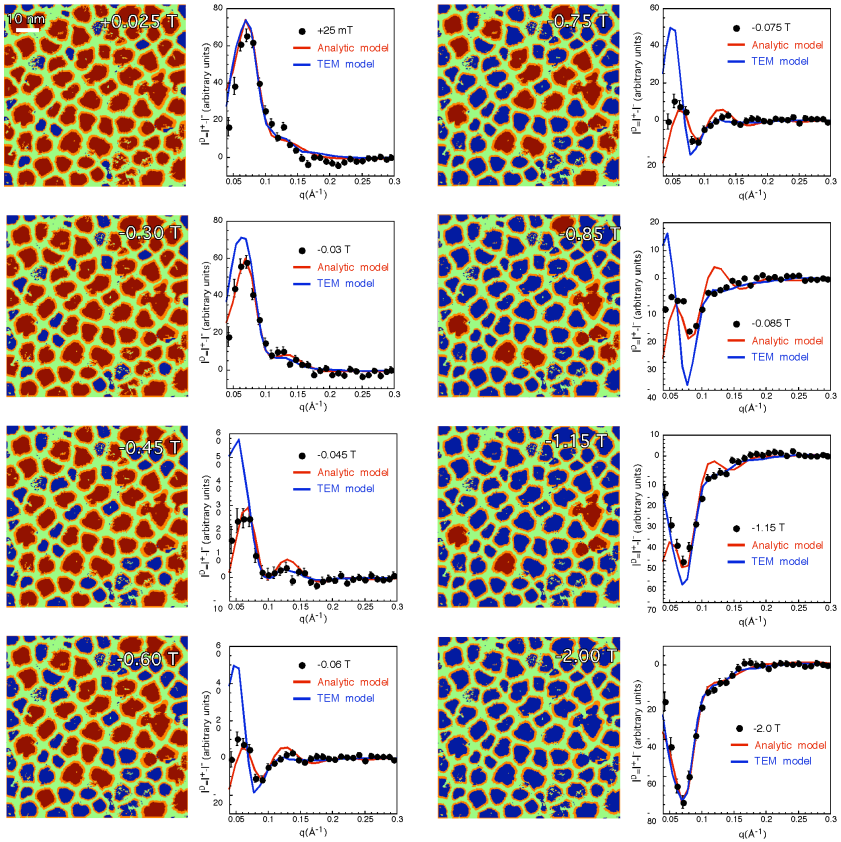


Quasi-elastic neutron scattering: Å / ps
(Multi)Tracer through-diffusion: cm / weeks

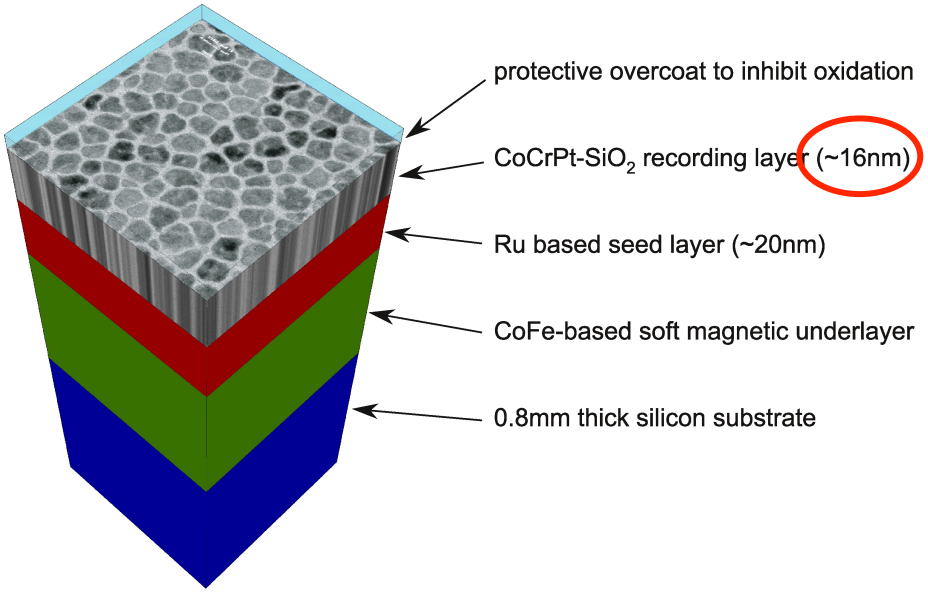
→ Separation of geometrical and chemical effects
→ Test of upscaling models
(observation time dependent diffusion coefficient)
→ Role of compensating cations

Collaboration:
Prof. L. Diamond
University of Berne, Switzerland
M. Bestel, M. Wattson, F. González
F. Juranyi, L. Van Loon, T. Gimmi,
G. Kosakowski, M. Glaus
Paul Scherrer Institute, Switzerland
Supported by SNF Grant

Polarised small-angle neutron scattering study of the switching response of perpendicular magnetic recording media



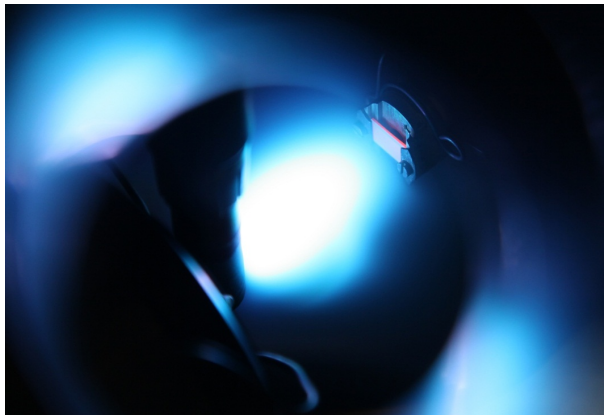
J. Appl. Phys. **106**, 063908 (2009),
Appl. Phys. Lett. **97**, 112503 (2010).

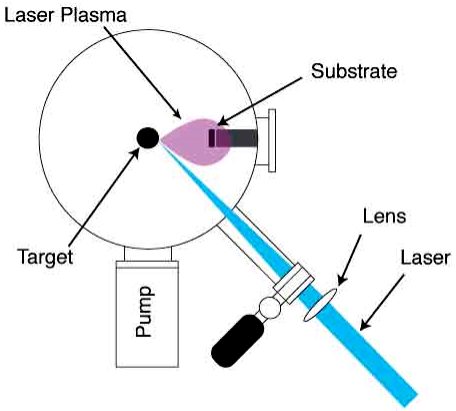


Collaboration:
S.J.S. Lister, V. Venkataramana, M. A. de Vries, and S. L. Lee
University of St Andrews, UK
Tom Thomson
University of Manchester, UK
Joachim Kohlbrecher
Paul Scherrer Institute, Switzerland

$REMnO_3$ thin films – Targeted tuning of the multiferroic ground state

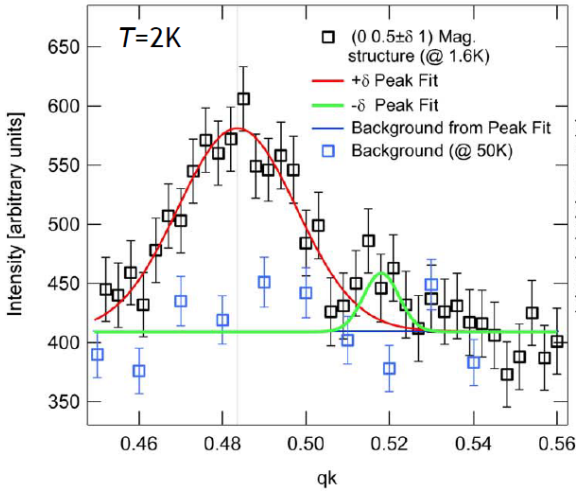
Pulsed Laser Deposition (ENE)





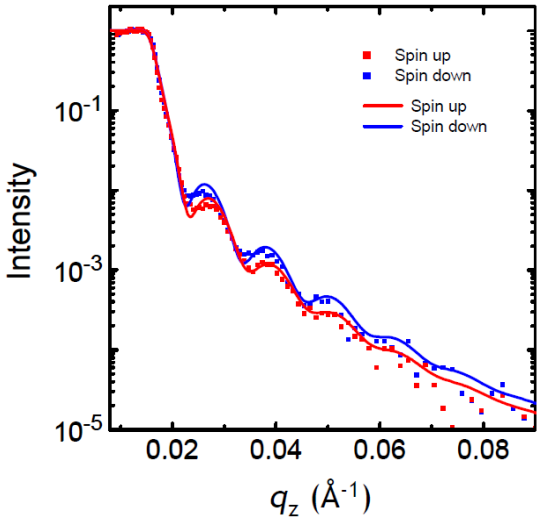
Y. Hu et al., Applied Surface Science (2011).

Neutron Diffraction (RITA2)



IC order in MF film 90 nm

Reflectometry (AMOR)



FM order (stress)

Collaboration:

M. Bator, Y. Hu, T. Lippert, C.W. Schneider

Materials Group, ENE, PSI

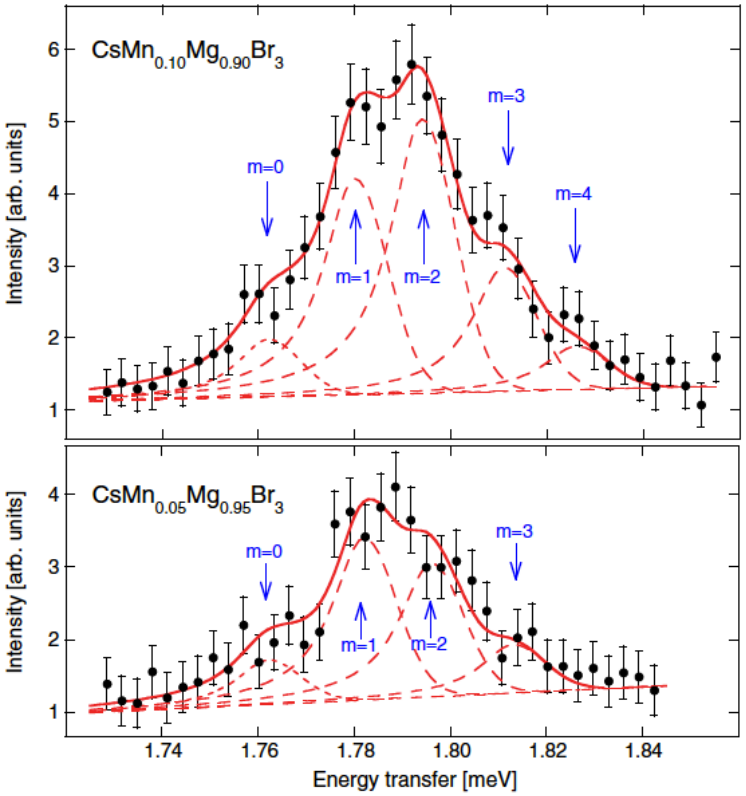
H. Luettkens

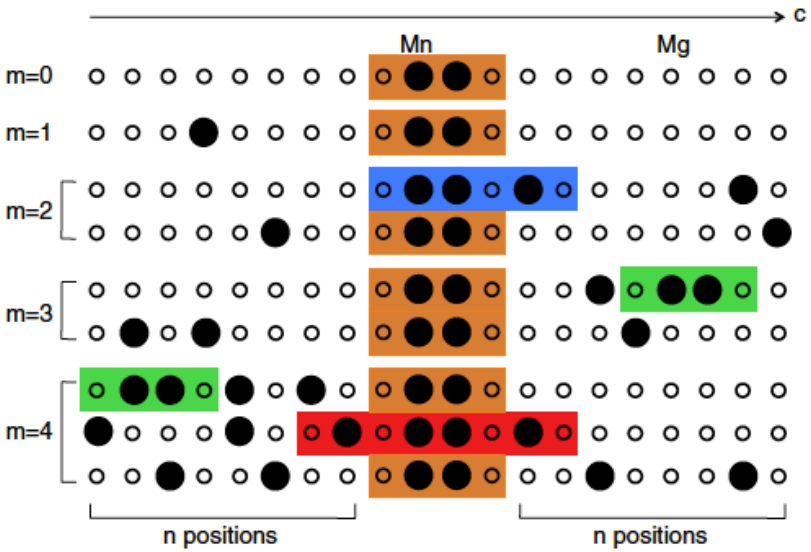
Laboratory for Muon spectroscopy, PSI

C. Niedermayer, J. White, J. Stahn

Laboratory for Neutron Scattering, PSI

Direct Observation of Local Mn-Mn Distances in the Paramagnetic Compound $CsMn_xMg_{1-x}Br_3$

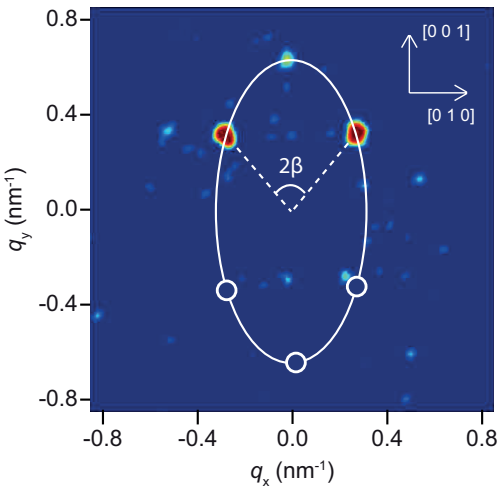


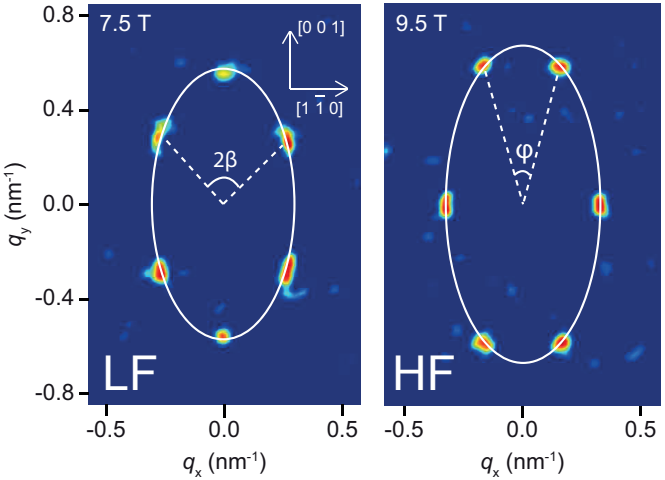


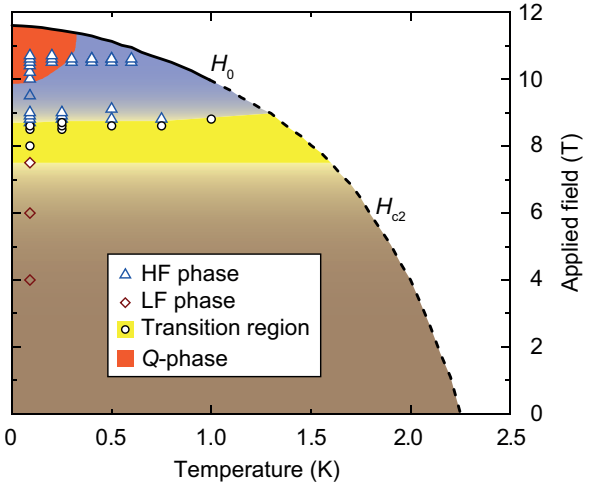
High-resolution spectroscopy on MARS: Phys. Rev. Lett. **107**, 115502 (2011).

Collaboration:
A.Furrer, Th.Strässle, J.P.Embs, F.Juranyi, V.Pomjakushin, M.Schneider,
LNS, Paul Scherrer Institute
K.W.Kramer
University of Berne

SANS of the vortex lattice (VL) in $CeCoIn_5$ with magnetic fields *H* applied parallel to the antinodal [100] and nodal [110] directions







H || [100]
single VL orientation

H || [110]
90º VL reorientation

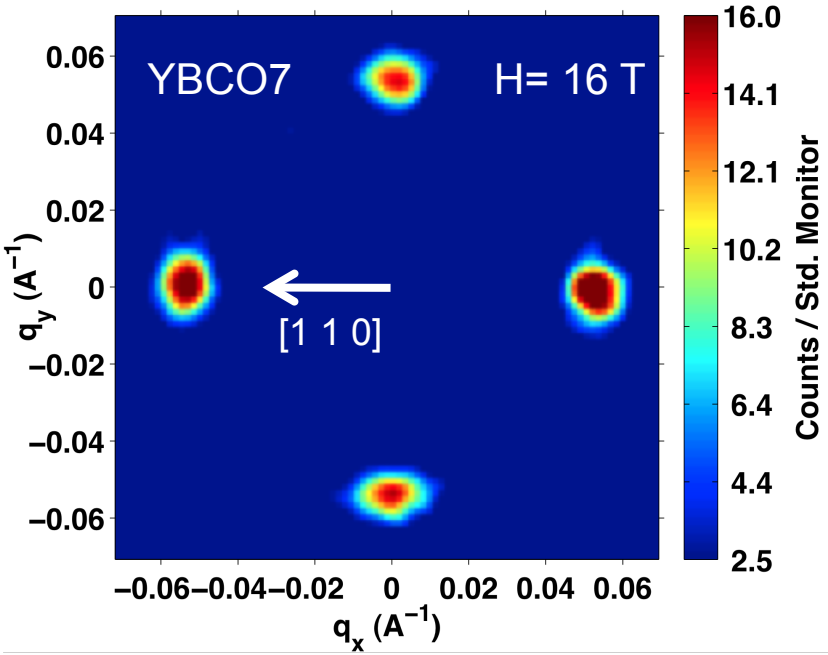
- **Strong Pauli paramagnetic effects**
- **Increased VL disordering above H_0**
- **No coupling to the *Q*-phase**

Phys. Rev. Lett., accepted, *arXiv:1201.1880v1*

Das & Eskildsen, **University of Notre Dame, USA**
Holmes & Forgan, **University of Birmingham, UK**
Bianchi, **University of Montréal, CA**
Bauer & Sarrao, **Los Alamos NL, USA**
Petrovic, **Brookhaven NL, USA**
White, Gerber, Kenzelmann, Zolliker & Gavilano, **Paul Scherrer Institute, CH**

New 17T Magnet Tested for Small Angle Neutron Scattering

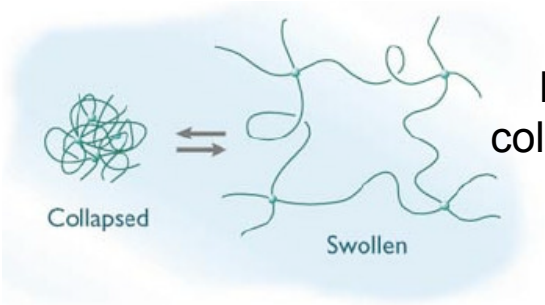
- Superconducting solenoid (University of Birmingham, Cryogenic Ltd, EPSRC UK)
- 17 T maximum field, 10 deg opening angle
- July and Aug 2011: first experiments at SINQ (SANS-I)
- Used for hard and soft matter (HTC, fd virus)
- It will be available for future user experiments at SINQ



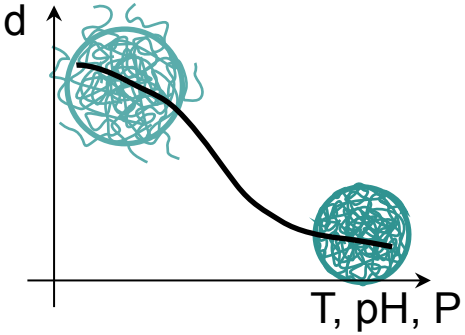
Flux lattice in a twinned YBCO7 crystal locking into a square VL at fields above 11 T (previous max field at SINQ). In an untwinned crystal (not shown) the VL moves through the square shape as a function of field.

Materials for future technology - Microgels

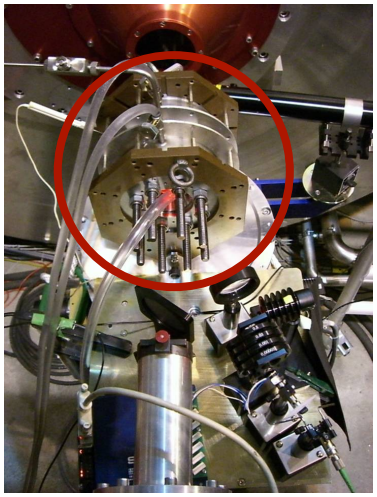
Small-angle neutron and light scattering study of the volume-transition of pNIPAM microgel colloidal particles with pressure



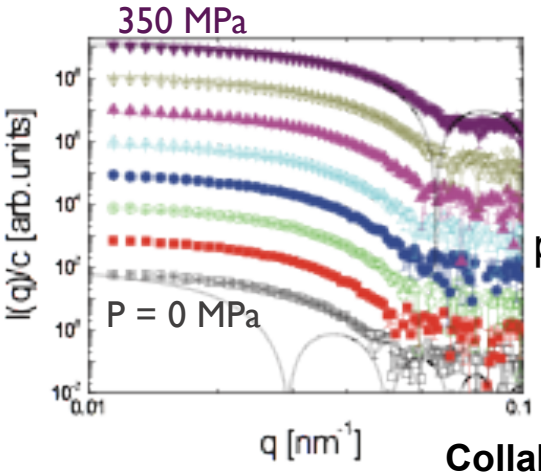
Microgels swell or collapse in response to changes in their environment



pressure cell (5 kbar)

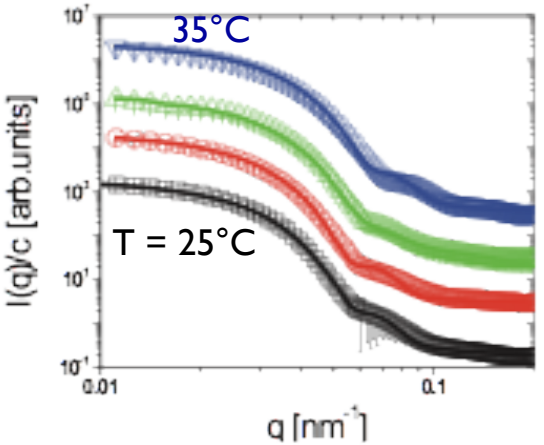


form factor with pressure



analogous change of Flory-parameter χ with P and T

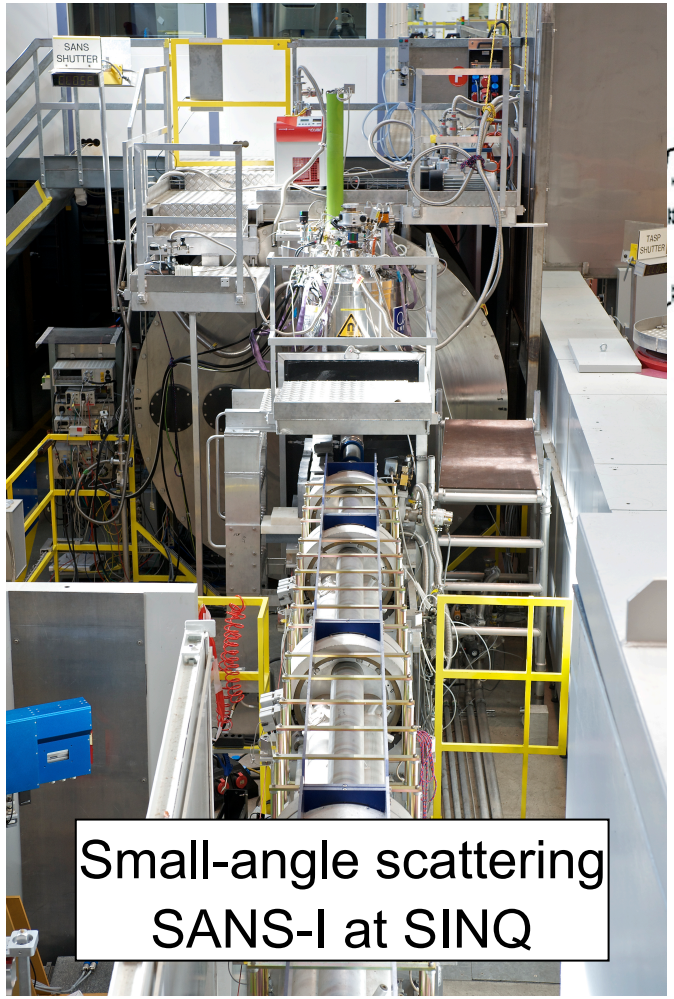
form factor with temperature

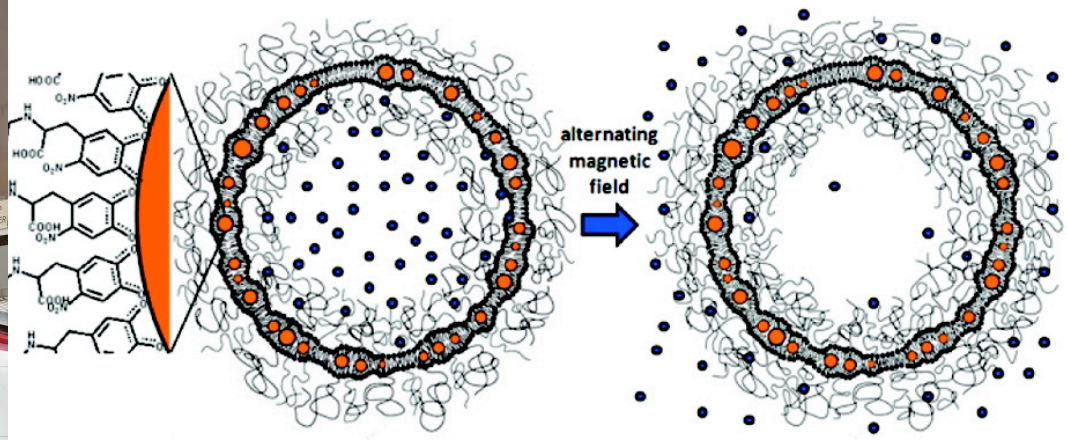


Macromolecules **42**, 6225-6230 (2009)
J. Chem. Phys. **133**, 034901 (2010)
Soft Matter **7**, 6370-6374 (2011)

Collaboration:
J.-J. Lietor-Santos, B. Sierra-Martin, A. Fernandez-Nieves
Georgia Institute of Technology, USA
U. Gasser, R. Vavrin
Paul Scherrer Institute, Switzerland

Triggered Drug Release from Liposomes through Magnetic Actuation of Membranes





Nano Lett. **11**, 1664 (2011)

Collaboration:
E. Amstadt, E. Müller, T. Schweizer, M. Textor, and E. Reimhult
ETH Zürich, Switzerland
Joachim Kohlbrecher
Paul Scherrer Institute, Switzerland

Outline

Swiss Spallation Neutron Source SINQ and ESS

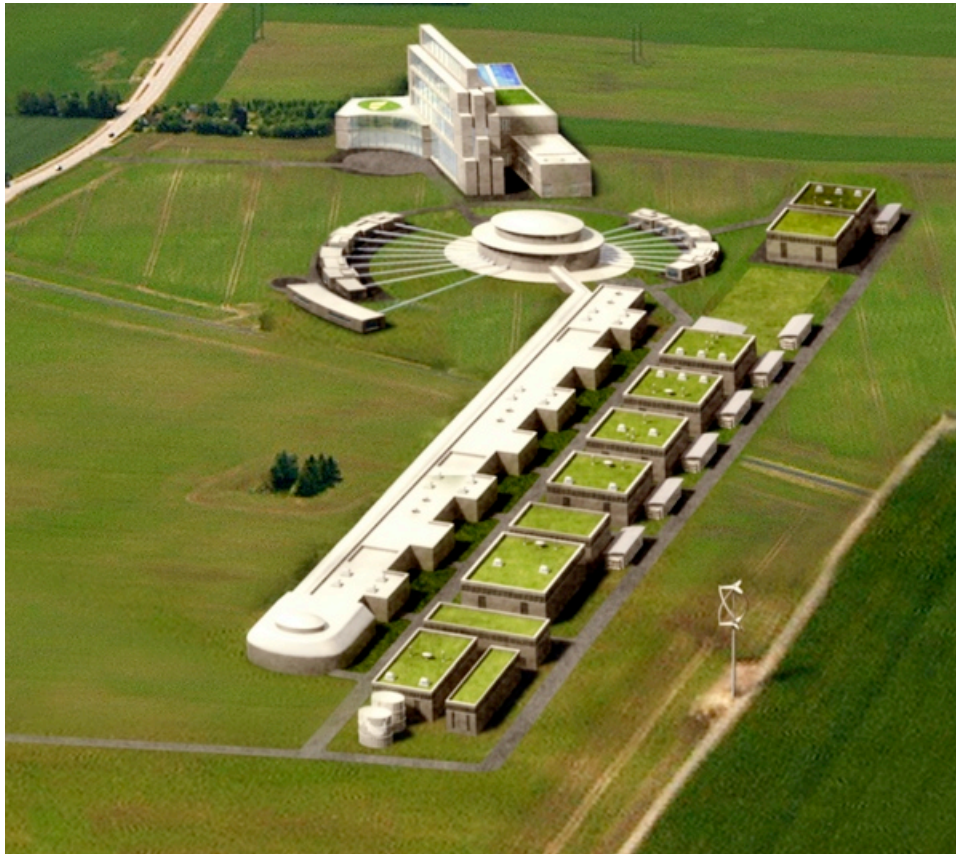
I: Swiss Spallation Neutron Source SINQ
- proton accelerator, source and instruments
- user program

II: Science News from SINQ
- material science (energy, technology)
- soft matter (health)

III: ESS:
- the Swiss contributions to the ESS (instrumentation, target)

IV: Future Collaborations:
- neutron technology and education
- science projects (new sources for funding)

European Spallation Source ESS



EUROPEAN SPALLATION SOURCE

European Spallation Source ESS

- to be built in Lund, Sweden
- 17 European countries
- operational by 2019
- 22 instruments by 2025
- 1.6 BEuro project
- the future of neutron scattering!

Swiss Contributions to the ESS

- CH-DK work packages Instrumentation (with ESS Science Directorate, 5 WPs)
- CH-D work package Imaging (with ESS Science Directorate, 1 WP)
- CH work packages Moderators & Shielding (with ESS Target Directorate, 3 WPs)

ESS Steering Committee Meeting at PSI 19/20 Sept:

signing of MoU by Switzerland

Schweiz beteiligt sich an Neutronenquelle der Zukunft

19. September 2011

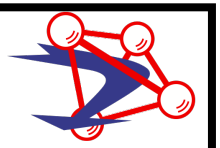
Unterzeichung aus Anlass eines Treffens am Paul Scherrer Institut.

Mauro Dell'Ambrogio, Staatssekretär für Bildung und Forschung unterzeichnete heute die Absichtserklärung der Schweiz, sich an der neuen europäischen Neutronenquelle ESS (European Spallation Source) zu beteiligen. Darin bekennt sich die Schweiz zu dem Ziel, die ESS in Lund (Südschweden) zu bauen und verpflichtet sich, am Konzept mitzuarbeiten, in dem der endgültige Plan für die Anlage festgelegt wird. Kurz nach Fertigstellung des Konzepts im Frühjahr 2013 soll die Entscheidung für den Bau der ESS fallen. Die Schweizer Beiträge zur Entwicklung der Anlage werden durch das Paul Scherrer Institut, das langjährige Erfahrung in der Forschung mit Neutronen hat, sowie durch Schweizer Universitäten und die Schweizer Industrie erbracht.

Mit Hilfe von Neutronen können Forschende Einblicke in verschiedene Materialien oder biologische Strukturen gewinnen und so Grundlagen für neue technische Geräte oder Medikamente schaffen. Für Schweizer Forschende wird die ESS vor allem die Möglichkeit eröffnen, Experimente durchzuführen, die am PSI nicht möglich sind und so die Schweizer Neutronenquelle ergänzen. Sie soll 2019 die ersten Neutronen produzieren und 2025 voll betriebsbereit sein. Insgesamt sind 17 europäische Länder an dem Projekt beteiligt. Die Gesamtkosten betragen 1,5 Milliarden Euro (in Preisen von 2008).

Visualisierung der ESS in Lund, Quelle: ESS AB, http://ess-scandinavia.eu/

Switzerland and ESS



In Switzerland: Four phases (SGN, Universities, PSI, SBF):

1) Last year (2011)
   0.1 MCHF available for work on ESS instrumentation (1 MY)

2) Design-update phase (2012)
   1.88 MCHF approved, 1.2 Mio CHF for ESS instrumentation (>7 MY)

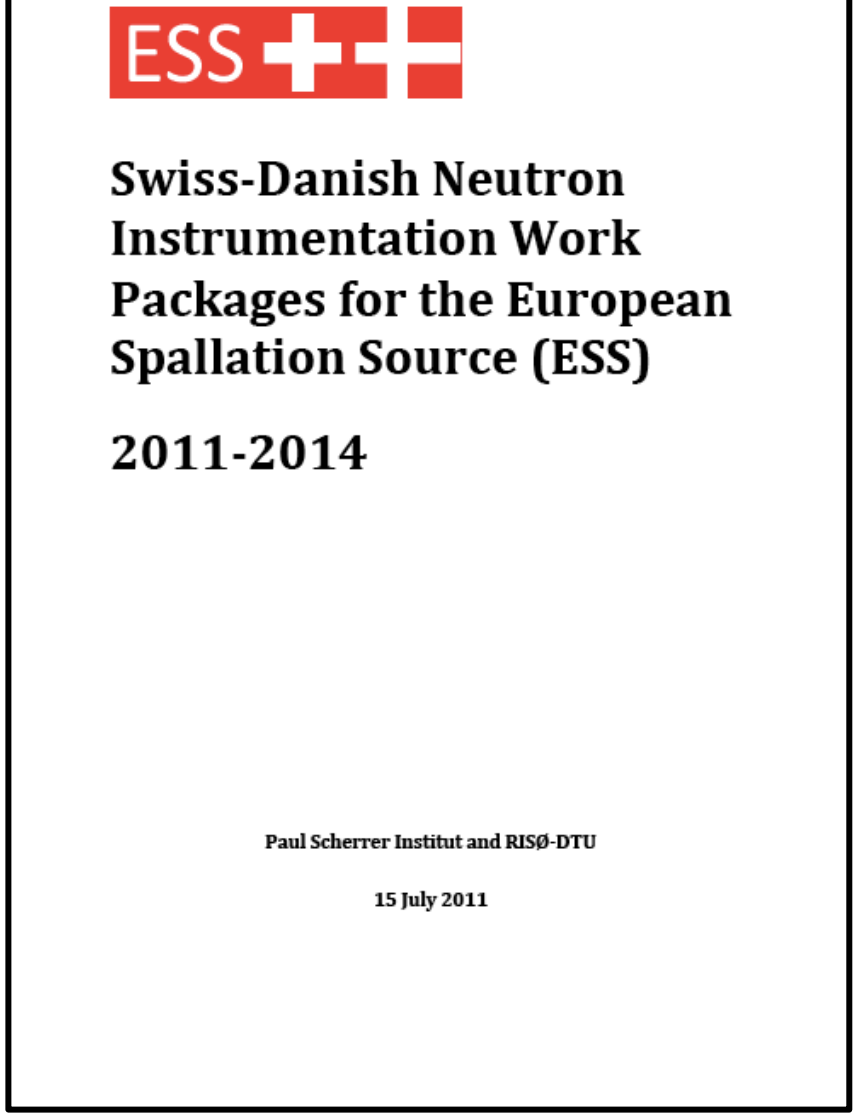
3) Construction phase (2013-2016), …
   total 20 MCHF in budget

4) Operation (20XX-20YY)
   CH is member (expect ILL level 3-4 %)

In Denmark: Design-update phase (2012)

- Strong links to PSI, similar size of community and share research interests
- Co-host of ESS (12%), 6.6 MDKK for instrumentation (approved Dec 2011)

CH-DK ESS Instrumentation WPs



CH-DK Instrumentation WPs

- National coordinators: Niels B. Christensen and Christian Rüegg
- 5 areas of common interests and activities
- in CH: PSI and EPF Lausanne
- in DK: RISO and major universities
- tests with prototypes done at SINQ
- collaboration with simulation centre in DK (K. Lefmann)
- 5 new postdocs at PSI, 2 tech/eng

CH-DK ESS Instrumentation WPs

WP 1: Extreme Environment Spectrometer
Kim Lefmann, Henrik Ronnow, Christof Niedermayer

WP 2: Focusing Reflectometer
Jochen Stahn, Beate Klösgen, Marite Cardenas

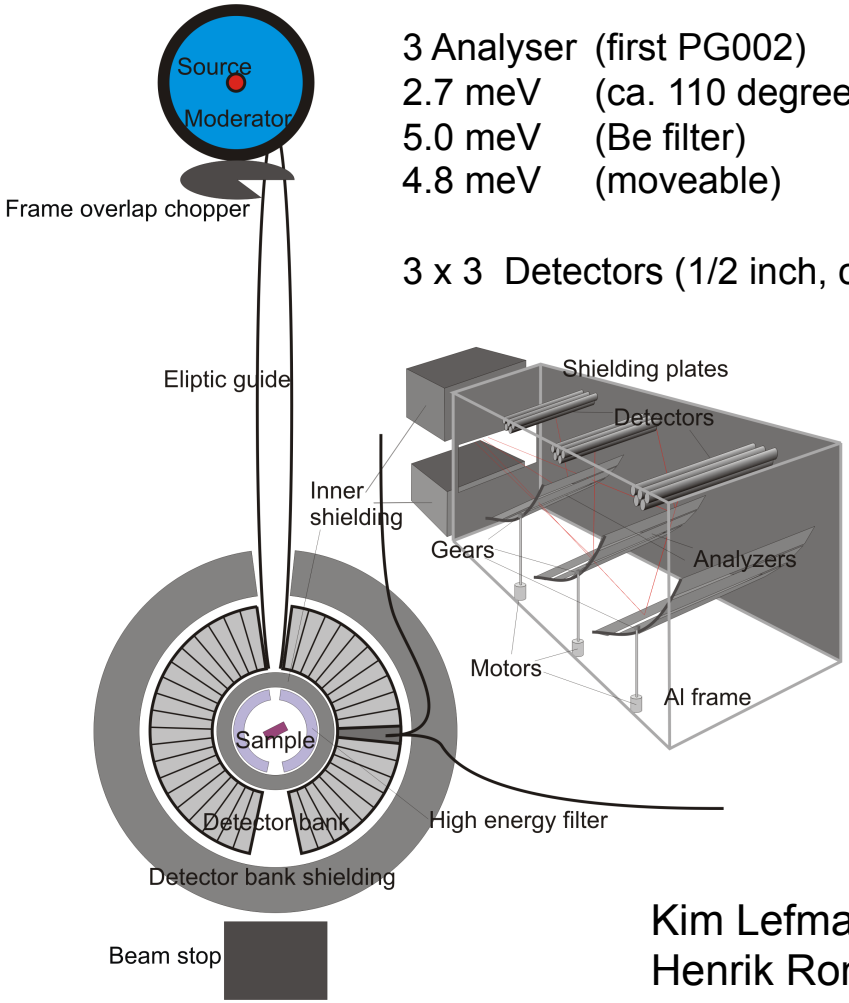
WP 3: Compact Chopped SANS – BioSANS
Lise Arleth, Kim Lefmann, Kell Mortensen, Joachim Kohlbrecher

WP 4: Hybrid Diffraction-SANS-Imaging Instrument
Mogens Christensen, Jürg Schefer, Kim Lefmann

WP 5: Neutron Optics
Uwe Filges, Henning Poulsen

CH: PSI and EPF Lausanne
DK: RISO and major universities

Design and test of a prototype of Extreme Environment Spectrometer



3 Analyser (first PG002)
2.7 meV (ca. 110 degrees)
5.0 meV (Be filter)
4.8 meV (moveable)

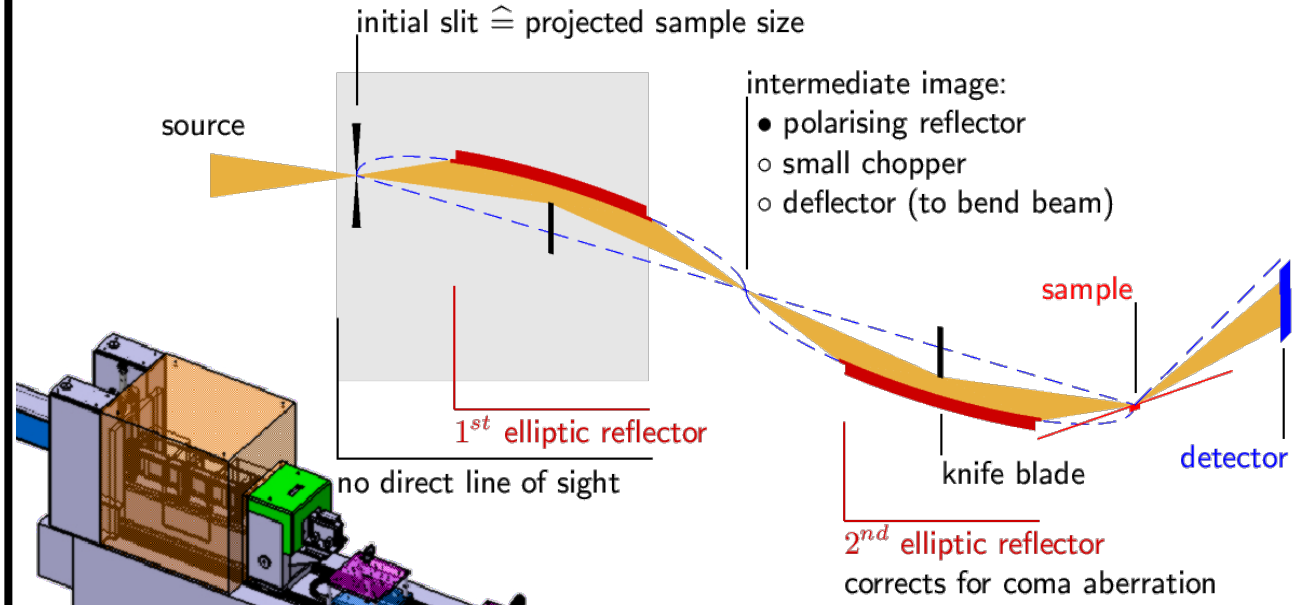
3 x 3 Detectors (1/2 inch, ca. 40 cm)

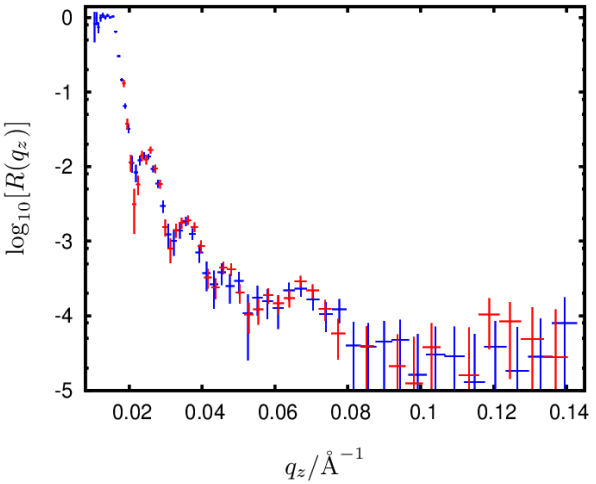
Installation in MARS tank

Kim Lefmann, DK
Henrik Ronnow, EPFL
Christof Niedermayer, LNS
Niels Christensen, DK

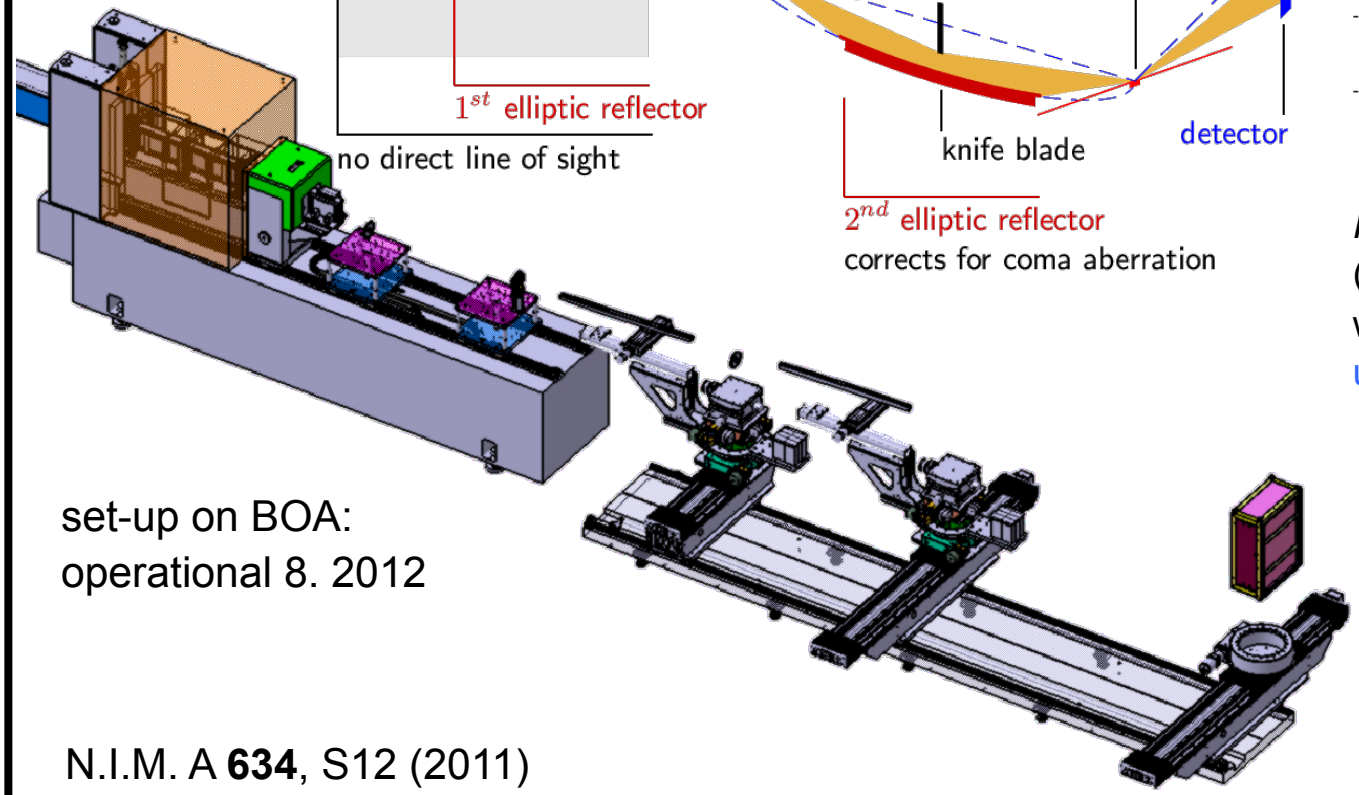
WP 2: Focusing Reflectometer

Installation of a prototype (*Selene*) and testing on BOA





$R(q_z)$ of a perowskie multilayer (4x5 mm^2) measured on AMOR with conventional set-up and with using focusing in 12% of the time.



set-up on BOA:
operational 8. 2012

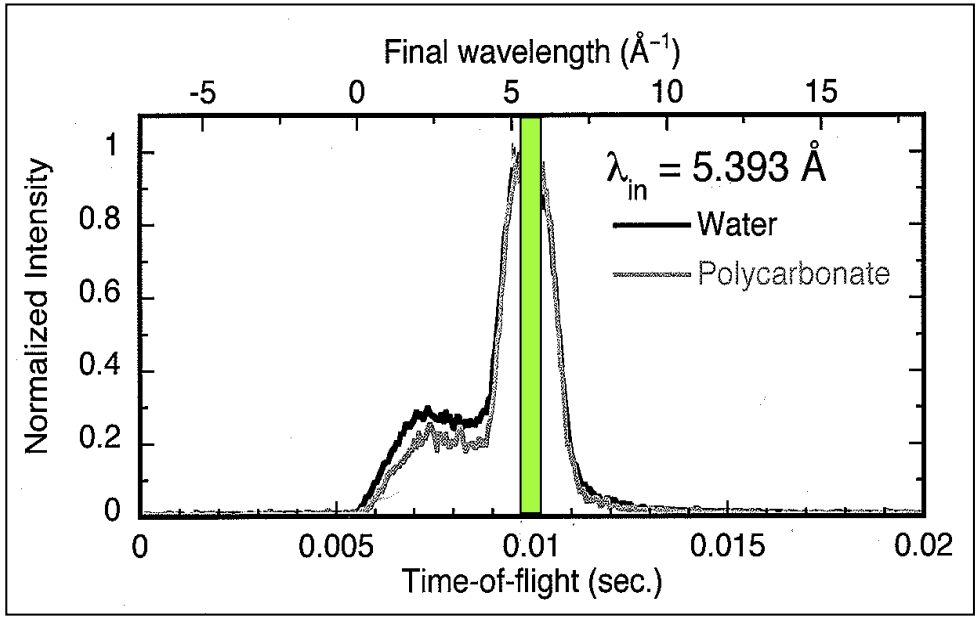
N.I.M. A **634**, S12 (2011)

Jochen Stahn, LNS
Uwe Filges, LDM
Tobias Panzner, LDM
Beate Klösgen, DK
Marite Cardenas, DK

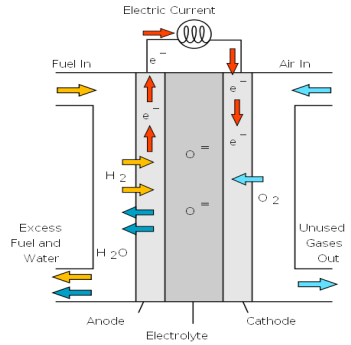
Suppression of incoherent inelastic scattering for SANS

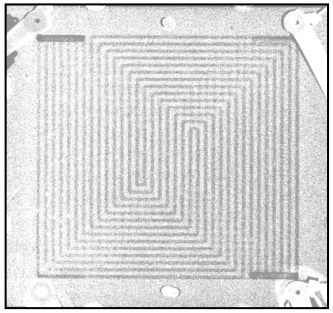
- Monochromatic pulsed beam: separate coherent small angle scattering from quasi-elastic incoherent scattering of H
- Reduction of flux and dynamic Q-range per geometry
- Quasi-elastic scattering is Q-dependent (requires calibration measurements)
- No special requirements on sample conditions (ambient conditions)
- Can be used to extract inelastic information

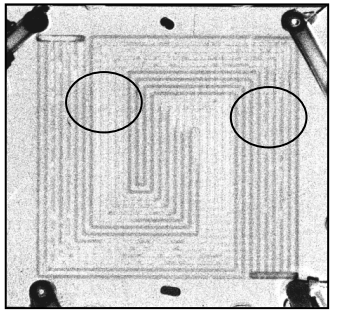
Lise Arleth, DK
Kim Lefmann, DK
Kell Mortensen, DK
Joachim Kohlbrecher, LNS



Development of new materials and devices requires in-situ information on different length scales



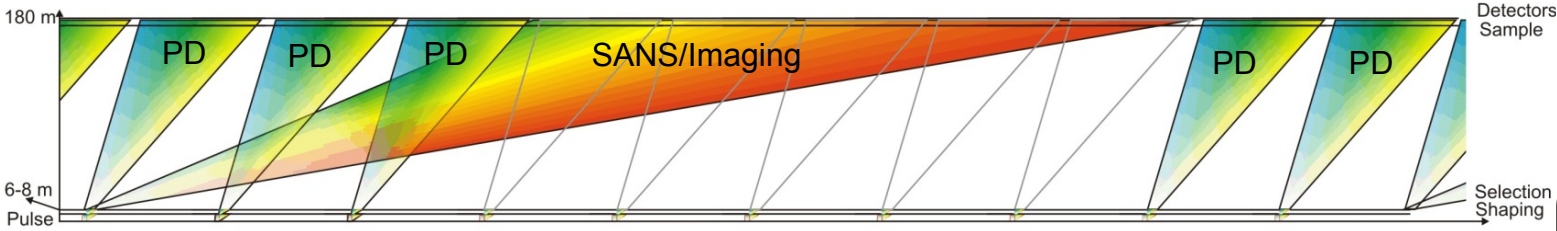


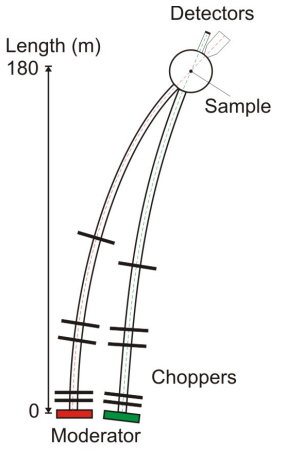


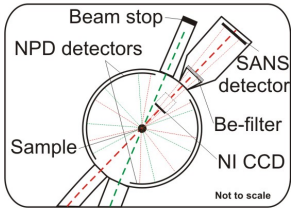
Example: loaded-unloaded fuel cell areas

Approach: instrument combining SANS, Diffraction and Imaging

TIPSI-concept: 3 thermal pulses followed by a 1 cold pulse
2 guides
Imaging station (resolution 200 µm scale)





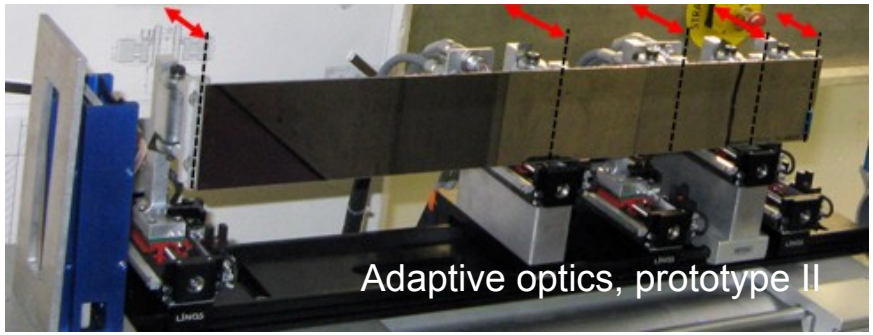


Mogens Christensen, DK
Jürg Schefer, LNS
Kim Lefmann, DK

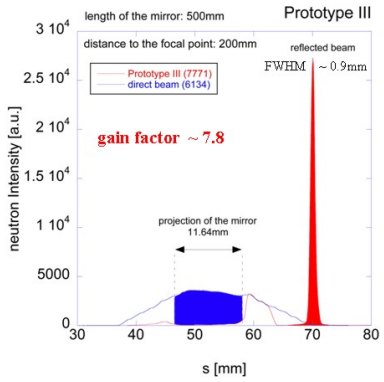
Focusing neutrons on small samples and polarisation

Adaptive neutron optics

- adjusting the focal spot by means of actuators
- variable sample sizes are possible without loosing performance
- focal point can be adjusted to sample environment



Uwe Filges, LDM
Henning Friis Poulsen, DK

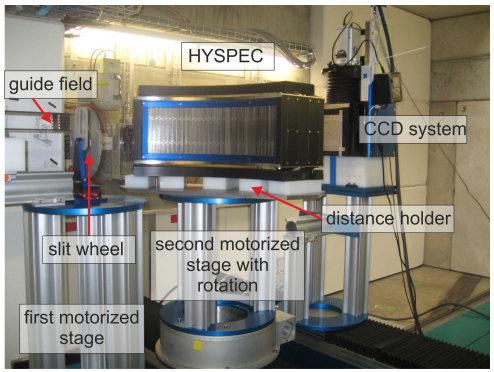


Remanent supermirror polarizers & Compound refractive (CR) lenses

(a) Improving performance of FeCoV polarizers

- exchanging the nonmagnetic layer TiNx by alternatives
- investigation of magnetic anisotropic sputtering
- exchanging Co-60 by Co-61 (activation)

(b) Evaluating of X-ray optics : mainly CR lenses



HYSPEC analyzer measurement setup on BOA; analyzer based on FeCoV polarizers

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Future Collaborations with Sweden

SINQ and ESS:

Switzerland is a partner and heavily involved in the ESS project:

- neutron technology (target, materials) and instrumentation (with DK)
- happy to contribute to training of next generation of SE neutron scatterers
  (PSI summer school, SE training course at SINQ ?, postdocs at PSI ?)
- junior appointments are essential to establish a solid user base
  (agreement to use instrumentation at SINQ for some years ?)

Science:

Strong and broad in-house science program at the Paul Scherrer Institute:

- material science (energy, technology, magnetism, superconductivity)
- soft matter (polymers, health care)
- use of complementary experimental methods (neutrons, muons, photons)
- materials synthesis, nano-fabrication, thin films

It seems to be the right time to apply for funding for common SE-CH projects!