ESS Science Symposium

Neutron Imaging User Symposium NIUS 2012

Bad Zurzach (Switzerland), April 15th – 18th, 2012

1. Introduction

The ESS Science Symposium 'Neutron Imaging User Symposium' was held to inform existing users at the three prominent neutron-imaging sites in Europe (PSI, TUM, HZB) about the plan to build a dedicated beam line for imaging purposes at the future European Spallation Neutron Source ESS. A feedback based on the content of the discussions and from a prepared Questionnaire was expected from the participants.

A selection of users from the facilities ICON and NEUTRA (PSI), ANTARES (TUM) and CONRAD (HZB) were invited to report about the current research topics and major results obtained at these beam lines. Due to the wide range of applications of the neutron imaging technology 10 topics were identified to be the most relevant – ending up in 10 sessions during the 2½-day symposium. More than 60 participants from 13 countries contributed and participated in the meeting (see the list of participants attached in Appendix 1). 33 oral presentations and 15 posters (additionally presented in short oral contributions) were given and deeply discussed (see the program in Appendix 2).

The meeting was organized to have daily summaries and a global summary on the final day in order to enable a dedicated report to the main sponsor – ESS. The discussions were continued during an excursion to SINQ at PSI. The excursion was done in particular to show the 3 beam lines used for imaging purposes: NEUTRA for thermal neutrons and X-rays, ICON for cold neutrons and BOA for imaging with polarized neutrons.

1. Content of NIUS

The symposium intended to report about and to verify the present user interests regarding their current important research topics and for future needs in respect to facilities upgrade. Even if the ESS activities seems to be far in the future it was well accepted that visions and plans should be considered NOW in order to find the best possible options for neutron imaging under the conditions of the long pulsed source ESS with its highest possible beam intensity.

The presentations during the meeting were structured into the following sessions:

- Introduction – the future ESS imaging beam line
- Plant – Soil interaction
- Building Materials
- POSTER session
- Electro-chemistry: fuel cells, batteries
- Material research / metallurgy
- Cultural Heritage
- Archaeology / Paleontology
- Nuclear engineering
- Water transport
- Porous Media

This broad spectrum of applications in neutron imaging has the consequence that the facilities' operators need to be very flexible in the particular setup, the experimental infrastructure and

the data acquisition strategy. In addition, the image procession and further data evaluation has to be taken into account from the beginning. Since very little practical experience is available with imaging at pulsed neutron sources so far, the brainstorming about the future options at ESS were based on current needs and visions for improvements. A big interest of the community was found towards the ESS imaging instrument project and the corresponding and the attendees expressed the wish to be informed on details and progress also in the future.

2. Main conclusions from the NIUS symposium

The symposium delivered an actual overview about the current interests and the experimental needs for the selected part of the user community. Several open questions have been identified with relevance for the daily work at the 3 sites but also for the future ESS facility. This outcome is based on the discussions during the meeting and the results from the questionnaire.

- Higher spatial resolution: many applications would get higher information level and scientific outcome if the resolution would come closer to the performance at X-ray facilities: below 10 micrometers.
- Energy resolution: this is a new approach in neutron imaging but arise more and more interest for specific applications; with the TOF option at ESS high TOF resolution can be achieved while a high flexibility can be maintained also concerning other parameters (FOV, resolution, polarization, beam intensity, etc.)
- Quantification: there is the need in many applications to derive numbers about the sample content in high accuracy. In particular in the case of hydrogen (water) the neutron scattering in larger samples needs dedicated correction algorithms, which already exist but need to be improved and adapted to the specific application. The potential of energy resolution shall be investigated also in this field.
- If D_2O is applied in replacement processes with H_2O it should be verified in model experiments how the mixing behavior takes place and what are the time lines for that process. In particular the validity of data achieved by substituting H with D has to be examined carefully.
- It was clearly expressed that the time required for image processing can often be 10 times more effort than the data acquisition itself. Since many users have only limited expertise in such analytical work, some support from professionals at the facilities is required. For the more complex image data at ESS this aspect has to be considered from the beginning. The described approaches at ESS and its partners involving schools, virtual experiments and teaching as well as the ideas for an imaging competence centre involving also MAX IV and expertise from universities have been very welcomed.
- Detector development: existing imaging detectors can only use a part of the supplied neutrons from the pulsed source if not the energy integrated flux is used. To efficiently exploit the pulse structure for energy selected studies adequate detection systems have to be developed. The presented MCP system (A. Tremsin) is a clever prototype for perfect beam utilization, but it has still its limitation in the FOV and the usable beam intensity in the high-resolution mode. However, it has been appreciated that many developments in this direction are

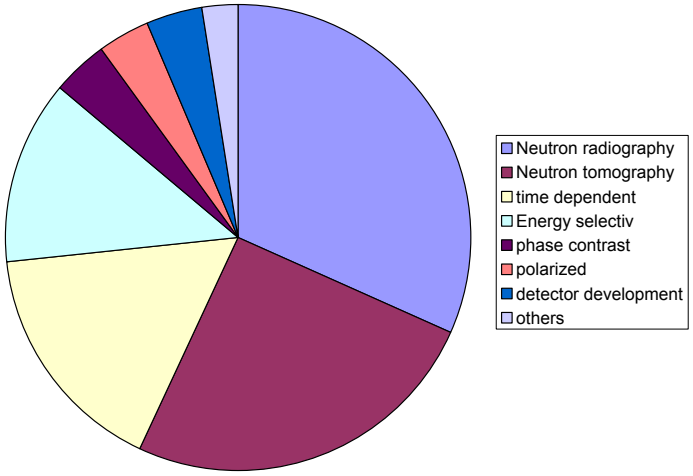
ongoing at different centers and facilities as well as at the ESS and it has been found that these are promising and hence largely no critical obstacles for TOF imaging are expected from this side.

- Combined methods: in addition to more complex experimental infra-structure (magnets, cryogenic devices, heater/furnace, etc.) it is proposed to add alternative techniques next to the neutron imaging setup, such as fluorescence, NMR, X-ray. These options might require significant space at the experimental site. These demands have however been agreed to be investigated and collected in close collaboration with the user community.

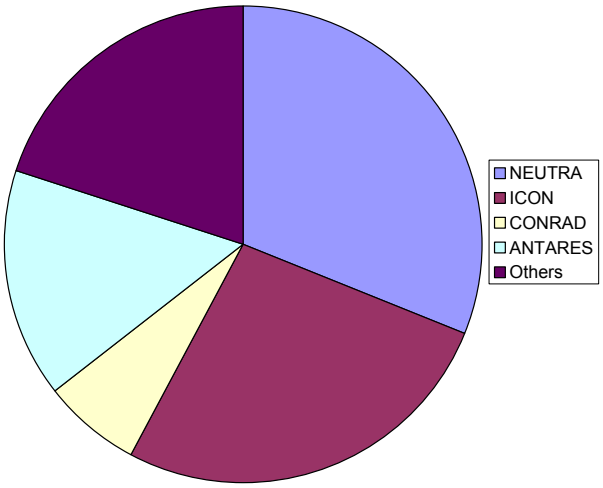
3. Results from the Questionnaire

The template of the Questionnaire is given in Appendix 3. Here we present selected results of this communication.

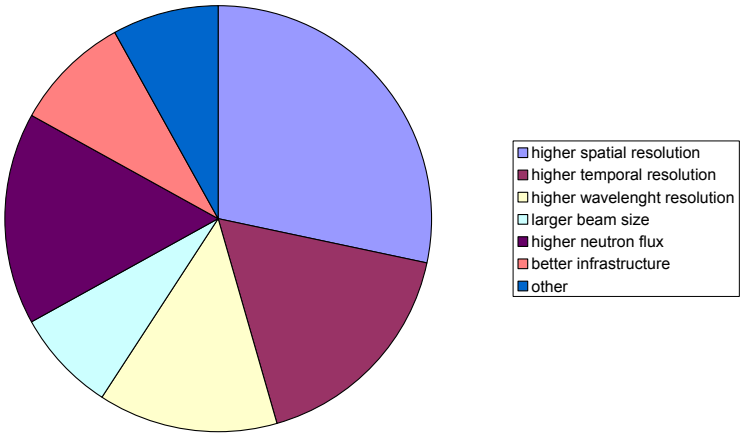
Which methods are used mostly in the present applications?



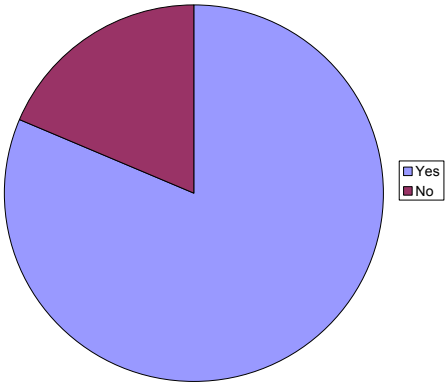
Users of which facilities for neutron imaging have attended the workshop?



What are the specific requests for the improvement of the existing facilities?



Was the principle and purpose of ESS well communicated and understood during NIUS?



Furthermore, the participants hope for more information about ESS and its development by further meetings like NIUS2012. They are in particular interested in information regarding neutron-imaging options. An annularly returning such event was found useful by 73% of the participants.
In the evaluation of the meeting an “excellent” was given by 68% of the participants; a “good” was given by the remaining 32%.

Acknowledgements

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Symposium organizers

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ESS representative

Markus Strobl (European Spallation Source)

Symposium Web Site

www.psi.ch/**nius2012**

APPENDIX 1

List of participants

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APPENDIX 2

Monday, April 16, 2012 Programme

Chair: Nikolay Kardjilov

	Session 01: Introduction	
08:30 – 08.50	Introduction to the ESS NIUS Symposium	E. Lehmann
08:50 – 09:10	Prospects for neutron imaging at the ESS long pulse source	M. Strobl
09:10 – 09:30	IAEA Activities Related to Neutron Imaging	D. Ridikas
09:30 – 09:50	PSI imaging beamlines	C. Grünzweig
09:50 – 10:10	Non-imaging instruments at SINQ – The future may include hybrids	Chr. Rüegg
10:10	COFFEE	
	Session 02: Plant / Soil interaction	
10:30 – 11:00	Imaging water flow in soils and roots	A. Carminati
11:00 – 11:30	Contribution of neutron imaging to assess key processes at the root-soil interface	S. Oswald
11:30 – 12:00	The influence of heterogeneous water and phosphorus supply on root growth in soil	B. Felderer
12:00	LUNCH	

Chair: Markus Strobl

	Session 03: Building materials	
13:30 – 14:00	Moisture movement and durability of cement-based composite materials	F. Wittmann
14:00 – 14:30	Patchy Microstructure of Cement Paste Investigated by Neutron and Synchrotron X-Ray Tomography	P. Trtik
14:30 – 15:00	Neutron imaging of transport in porous materials: rocks, gypsum, asphalt, clay brick, wood, and fruits	D. Derome
15:00 15:30	Short oral presentations poster COFFEE	Postersession
	Session 04: Fuel cells / Battery electro-chemistry	
16:00 – 16:30	Neutron Imaging of Water in Fuel cells – State of the Art and Future Opportunities	P. Boillat
16:30 – 17:00	Modeling of Li-Ion-batteries to optimize the results gained by neutron imaging	M. Mühlbauer
17:00 – 17:30	Neutron imaging into an operating lithium-ion battery	H. Sommer
17:30 – 18:00	Summary & Discussion	

Tuesday, April 17, 2012 Programme

Chair: Burkhard Schillinger

Session 05: Materials research / Metallurgy		
08:30 – 09:00	Chemical diffusion in liquid metallic alloys	F. Kargl
09:00 – 09:30	Combining diffraction and imaging for the study of structural phase transitions	M. Medarde
09:30 – 10:00	Studies of hydrogen diffusion in steels with neutron radiography	T. Kannengiesser
10:00 – 10:30	Neutron epolarization imaging of the Kondo cluster glass formation In CePd(1-x)Rh(x)	P. Schmakat
10:30	COFFEE	
	Session 06: Cultural heritage	
11:00 – 11:30	Neutron imaging, a non destructive method for the study of mobile cultural heritage objects	M. Woerle
11:30 – 12:00	An example of the application of combined use of Neutron Imaging and Time of Flight Neutron Diffraction characterization of Japanese ancient swords	F. Grazzi
12:00 – 12:30	Non-destructive investigation of “The violinist”, a lead sculpture by the Spanish artist Pablo Gargallo, using the neutron imaging facilities of the Paul Scherrer Institute	A. Masalles
12:30	LUNCH	

Chair: Winfried Kockelmann

Session 07: Archeology / Paleontology		
14:00 – 14:30	The IMAT imaging system at ISIS	F. Aliotta
14:30 – 15:00	Natural science meets the humanities – The study of roman bronzes found in Switzerland by the combination of different methods	E. Deschler-Erb
15:00 – 15:30	New insights into hearing of early synapsids	M. Laaß
15:30	COFFEE	
Session 08: Nuclear engineering		
16:00 – 16:30	Investigating the thermalhydraulics of nuclear fuel bundles and functional spacers using cold-neutron tomography at the ICON beamline	R. Zboray
16:30 – 17:00	What happens during nuclear accidents? – Contributions of neutron imaging to nuclear safety	M. Grosse
17:00 – 17:30	Recent developments at the CONRAD instrument at the Helmholtz Centre Berlin	N. Kardjilov
17:30 – 18:00	Summary & Discussion	

Wednesday, April 18, 2012 Programme

Chair: Eberhard Lehmann

	Session 09: Water transport I	
08:30 – 09:00	ANTARES Upgrade – The New Imaging Beam Line at FRM II	M. Schulz
09:00 – 09:30	Quantitative in-situ neutron imaging of non-equilibrium soft and complex matter systems using cold neutrons	H. Hermes
09:30 – 10:00	Influence of pore size and fluid-wall interactions on the imbibition of a fluid in silica mesoporous materials	C. Pantalei
10:00	COFFEE	
	Session 10: Water transport II	
10:30 – 11:00	Imaging Chemistry (and Physics) in Space and Time: New Opportunities by Dynamic Neutron and X-ray micro-Imaging	D. Grolimund
11:00 – 11:30	Neutron imaging of recurrent ponded infiltration into heterogeneous soil	M. Snehota
11:30 – 12:00	High resolution neutron radiography and microtomography with fast MCP-Timepix detector operating at >1Khz frame rates	A. Tremsin
12:00 – 12:30	Summary & Discussion	
12:30	Transport to PSI (for those who are joining the PSI-Tour)	
13:00	Lunch at PSI (TimeOut)	
14:00	Guided tour at PSI	

APPENDIX 3

ESS-NIUS Questionnaire

Research area: …….

1. Which facility are you using most often:

   ☐ NEUTRA@PSI

   ☐ ICON@PSI

   ☐ ANTARES@FRM2

   ☐ CONRAD@HZB

   ☐ Other:……

2. How many days per year do you perform neutron imaging experiments:

   ☐ 0 ☐ 1-5 ☐ 6-10 ☐ more than 10

3. What is the most often used setup/method:

   ☐ Neutron radiography

   ☐ Neutron tomography

   ☐ time-dependent image series

   ☐ Energy-selective imaging / Bragg-edge mapping

   ☐ Phase-contrast / Dark-field imaging

   ☐ Polarized neutron imaging

   ☐ Detector development / High-resolution imaging

   ☐ Others: ……..

4. Do you have a request for more beam time?

   ☐ YES ☐ NO Days: …...

5. Do you perform image processing yourself?

   ☐ YES ☐ NO

6. Do you have ideas how to improve the neutron imaging technology, what are your specific requests for the existing facilities;

   ☐ Higher spatial resolution (down to … µm)

☐ Higher temporal resolution (down to … ms)

☐ Higher wavelength resolution (~ … %)

☐ Larger beam size (up to …. cm)

☐ Higher neutron flux (up to …. n/cm^{2}s)

☐ Better infrastructure and sample environment (temperature (…°C), pressure (… MPa), vacuum (… mbar), gas (…), magnetic fields (… mT), ……)

☐ Other:

……
……

7. ESS: Did you understand the principle and the ideas of the layout for an imaging beam line at the future European Spallation Source in Lund?

☐ YES ☐ NO

Comment:……..

8. Can you imagine using that beam line in 2019?

☐ YES ☐ NO

9. Would you like to contribute actively to the ESS-NI beam line?

☐ YES ☐ NO

About ESS-NIUS?

1. Global comment about usefulness, style, attendance:

☐ Excellent

☐ Good

☐ Need to be improved

2. How often should such an event take place?

☐ twice in a year

☐ once in a year

☐ once in 2 years

☐ never again

3. What can be improved to make the communication between users and facility operators perfect?

☐ better e-mail communication

☐ longer time for discussions

☐ better technical support

☐ other: ……