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International Society for Neutron Radiology

(www.isnr.de)

ITMNR-8
Participants at Peking University

Content

Editorial

"The society is to foster and promote actively the field of neutron radiology." This first sentence of the section "Mandate" of our constitution exactly expresses the basic idea of our society. While in times of globalization nearly unrestricted information exchange was one of its pillars actual tendencies worldwide thwarts this valuable achievement.

Thus it is extremely important that we foster the exchange of information and support within our neutron imaging (NI) community, which not only includes our society but also other groups. None of us is setting up a new facility, is improving an existing one or writing a new data evaluation program without considering information and often help from other groups or individuals worldwide. The challenge is to finally add a small individual part on top to get a better result than the others. This may be the point of departure for the next group for further improvement. This "competition" helps our community to make NI more attractive to new users. But it only works with extensive collaboration and information exchange, both by personal contacts and within our community in general, not considering artificial and cultural borders. In this spirit let's foster collaboration!

The NR Newsletter, as well as the website of ISNR, are forums for providing information. In this issue you can read about latest news about our next "World Conference on Neutron Radiography (WCNR-11)" in Down Under (page 3) and about a summary on a stimulating consultancy meeting on NI-facilities (page 4). The section "New and ongoing projects" (page 6 ff.) presents activities of our members, especially mentioning the contribution "Where neutron imaging meets small angle neutron scattering" (page 9) showing quite plainly that nowadays NI is by far more than "simply" taking radiographs. In "News from the Lab and Out of Practice" (page 13) a freeware solution for "newbies" for first steps in neutron tomography processing is presented, but may being interesting for those well settled in data evaluation, too.

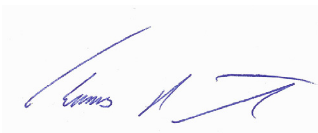
The highlight for ISNR in 2016 was the "International Topical Meeting on Neutron Radiography (ITMNR-8)" in Beijing (page 18 ff.). Read a review on this event, the prior Neutron Imaging School and the subsequent Review Workshop.

Results of the work of two Task Groups initiated by the Board of Members on the Constitution (page 25 ff.) and on Terminology (page 29 ff.) are presented and open for discussion. It is highly recommended that all members of ISNR actively (!) contribute on their further progress.

Last, I personally want to draw your attention to an interesting article I got mailed as an user of Joomla!, the content management system the ISNR website is based on (https://magazine.joomla.org/issues/issue-feb-2017/item/3218-how-do-you-express-a-disagreement). Although related to software development it may be considered for many other cases, like contributions in the NR Newsletter, work and/or manuscripts of colleagues, the ISNR website etc. too!

I hope you enjoy this NR Newsletter, get many new ideas and actively contribute to the discussions. Please feel free to distribute it to your colleagues and send me your feedback.

Wishing you all the best



Thomas Bücherl (Secretary ISNR)

Some Words from Down Under

I would like to thank all members of the ISNR for their contributions to neutron radiology in general and the ITMNR-8 organising group at Peking University (PKU), Beijing, China, for hosting the major event for the neutron imaging community on September 4-8, 2016 in particular. Unfortunately I wasn't able to join the conference, but I heard lots of positive feedback.

Here at ASNTO we made some big steps forward to host the world conference in 2018 in Sydney. We got our organisational committee together and started work on the conference homepage and logo design. The WCNR-11 conference website is now online. We are now in the final stage of negotiating with venue and service providers. The final results will be announced within the next few months on our webpage and through email lists. In addition to the world conference we plan to host a workshop on industrial engagement.

WCNR-11: For more information see www.ansto.gov.au/Events/WCNR-11/index.htm

As part of our user community program, ANSTO started a Cultural Heritage Project which interfaces and synergizes the suite of nuclear methods available across site to provide a non-invasive approach for the study and conservation of heritage materials. The project is led by Dr. Floriana Salvemini and works in close collaboration with the cultural heritage community; the research is focused on several areas ranging from the characterization of Museum exhibits, through the chronology, origin and conservation of Australian Aboriginal Art, to the study of archaeometallurgy.

DINGO is playing a key role in the development of this research project with more than the 20% of the beamtime allocated to the growing Cultural Heritage user community. During last year, results have been disseminated through participation at International and National conferences, and publication on peer-reviewed journals.

The overall performance and demand on DINGO shows that there is a large potential for further grows on the southern hemisphere, which should motivate LAHN-project in Argentina and South Africa (SAFARI-1) in their efforts to build and/or upgrade neutron imaging facilities. Current major research foci on DINGO are in the areas of material science, engineering, geo science, palaeontology, with a strong industrial engagement.

Finally I would like to bring your attention conferences and workshops on neutron imaging for 2017. The next NEUWAVE (June 12-14, 2017, NIST) and ICNS in Korea which runs a neutron radiography and imaging session.

I am looking forward for experiencing another exciting year of neutron imaging / radiography / tomography / radiology.

Ulf Garbe

WCNR-11:	*www.ansto.gov.au/Events/WCNR-11/index.htm*
Cultural Heritage Project:	*www.ansto.gov.au/ResearchHub/OurInfrastructure/ACNS/CurrentResearch/ScientificProjects/CulturalHeritage/index.htm*
Museum exhibits:	*www.abc.net.au/news/2016-02-06/opalised-pearls-found-coober-pedy-south-australia/7145890*
Australian Aboriginal Art:	*neutronsources.org/news/scientific-highlights/seeing-inside-an-ancient-australian-indigenous-artefact-non-invasively.html*
archaeometallurgy:	*www.ansto.gov.au/AboutANSTO/MediaCentre/News/ACS065532*

Results and recommendations of the Consultancy Meeting on "Neutron Imaging Facilities (New Installations and Upgrade)"

During March 1st-4th 2016 a Consultancy Meeting was held with the aim to support upcoming installation projects for neutron imaging facilities by experts from the neutron imaging community.

The meeting was organized by the IAEA, Physics Section (Dr. D. Ridikas), and was held in the Vienna International Centre after nominative invitation of the 17 experts from 12 countries. Representatives from South Korea, France and Morocco were unable to join the meeting due to the last minute cancellation, but delivered some information about their facilities.

The participants were grouped into "learning partners", "reporting partners" and "experienced facility operators". In this manner an efficient knowledge transfer was enabled where the statuses and plans of reported projects were communicated in open and professional manner.

In particular, the results and recommendations for the particular projects are summarized in the following for the learning and some reporting partners:

1. **Argentina:** This project starts in an ideal situation – to build a complete "virgin" new neutron imaging facility at a new reactor in Buenos Aires with high priority. In this manner, all recommendations for the best suitable options can be taken over. Since the design is not yet completed, the establishment of an "Advisory Board" of experienced partners was recommended and a further direct dialog with experts was advised. The participation of involved persons from Argentina in the next upcoming workshops and conferences seems to be required to raise the expertise and to increase the networking. Some detailed technical options and solutions were suggested and will be taken into account in the future design options of the new facility.

2. **Czech Republic:** The reported option at the empty beam port in the very right corner of the 10 MW LVR-15 reactor in Rez was seen to be sub-optimal. The permanent access of underneath holes by the reactor operators and the narrow space are reasons not to build a future user facility. Since the beam port has no option to build a useful in-pile collimator, there is no chance to improve the image quality

even if a large Si filter insert was found useful to reduce the gamma background. Instead, it was proposed to use the port at the thermal column, were currently the BNCT project is allocated with very small coverage of the user community in this particular field. A design of this option can be considered during further consultancy meeting or bilateral discussions with experts.

3. **China:** The CARR reactor is the host of future 2 imaging stations, where the principle design is already discussed and presented during previous conferences. Due to the lack of funding, the installation and the commissioning is postponed although the team with sufficient manpower has been available. Some persons were sent abroad and their experience can be used for update of the project after the delay. A tight contact to the NI community is recommended to build the best possible options at this powerful neutron source. In the format of a user facility, the imaging stations might play an important role in the future research in China and internationally.

4. **Netherlands:** Unfortunately, an application for funding of a comfortable imaging station at the University Delft reactor (2 MW) was not successful, even if the evaluation reports were quite positive. Nevertheless, the team at this reactor will continue its efforts to build a pragmatic imaging station. In this manner, they might become a good example to build a very dedicated and low cost installation which can be taken over to other research reactor facilities in different countries, including developing countries. It was recommended to install an advisory board after the first layout considerations are fixed for discussion. The involvement of a postdoc into this project looks very promising and the user potential around the reactor site is considered high.

5. **Norway:** The reactor in Kjeller has traditions in the inspection of nuclear fuel from the Halden reactor program by means of the established transfer techniques. In addition to this narrow and well-shielded installation it is intended to build another imaging station for research and other industrial applications. Fortunately, a funding is already allocated and the focus is now on the design of the new facility under the limited conditions in space. After first layout attempts, an advisory board should assist and comment with the knowhow and experience.

6. **France (ILL):** ILL started a project at the cold guide D50 as a combination of a reflectometer and an imaging station for industrial applications. With the help of external funding, the reflectometer with an imaging-type detector was technically completed at end of 2015 and first results were produced. Now, the second step for the creation of the imaging station has started. With additional funding, a system will be built for a high-resolution option and the combination with a complementary X-ray option. Driving application is geo-science, but other research partners are invited. It is recommended to present the layout of the facility during the future meetings of the neutron imaging community, e.g. NEUWAVE-8 and ITMNR-8. The detector of the reflectometer cannot be used directly for neutron imaging for different technical reasons.

7. **Australia:** The DINGO facility was implemented successfully and is in operation since 2014 in the OPAL user program. In the discussion of the routine operation it became clear that the limited manpower is responsible for unsatisfactory data post-processing and high-quality outputs. Since DINGO is heavily booked, some more support in the user operation and the professional data analysis was required.

8. **Russia:** The new imaging beam line is well operational and already collected some imaging data, including tomography sets. Further improvements of the detector and the usage of the pulsed structure of the beam were recommended. The facility

has also a great potential as test bench for ESS-like imaging systems, if the access and cooperation is organized.

9. **South Africa:** The process of the upgrade of the new versatile neutron radiography facility (SANRAD) at the SAFARI-1 nuclear research reactor located at Necsa, continues. Final documentation is being compiled for the acceptance by the National Nuclear Regulator and approval to continue with the physical erection of the facility. It is envisaged to apply fast neutron, thermal neutron, gamma-ray and dynamic neutron radiography/tomography at the new facility as from Q3 of 2018. Funding is available to finalize the facility including a high resolution detector system for smaller samples. Unique neutron tomography applications within the palaeosciences is envisaged to scan breccia blocks containing fossils as Necsa is located within the "Cradle of Humankind" which is believed to be the origin of man.

Eberhard Lehmann

New and/or ongoing projects

Testing neutron imaging system at CSNS

China Spallation Neutron Source

China Spallation Neutron Source (CSNS) is located in the southern city of Dongguan, Guangdong province. The final technical parameters for the CSNS were approved in 2008. The construction started in May 2012 and will be completed in March 2018. It will provide users a neutron scattering platform for advanced researches in physics, chemistry, biology, materials science, new energy, materials engineering, as well as in industrial applications.

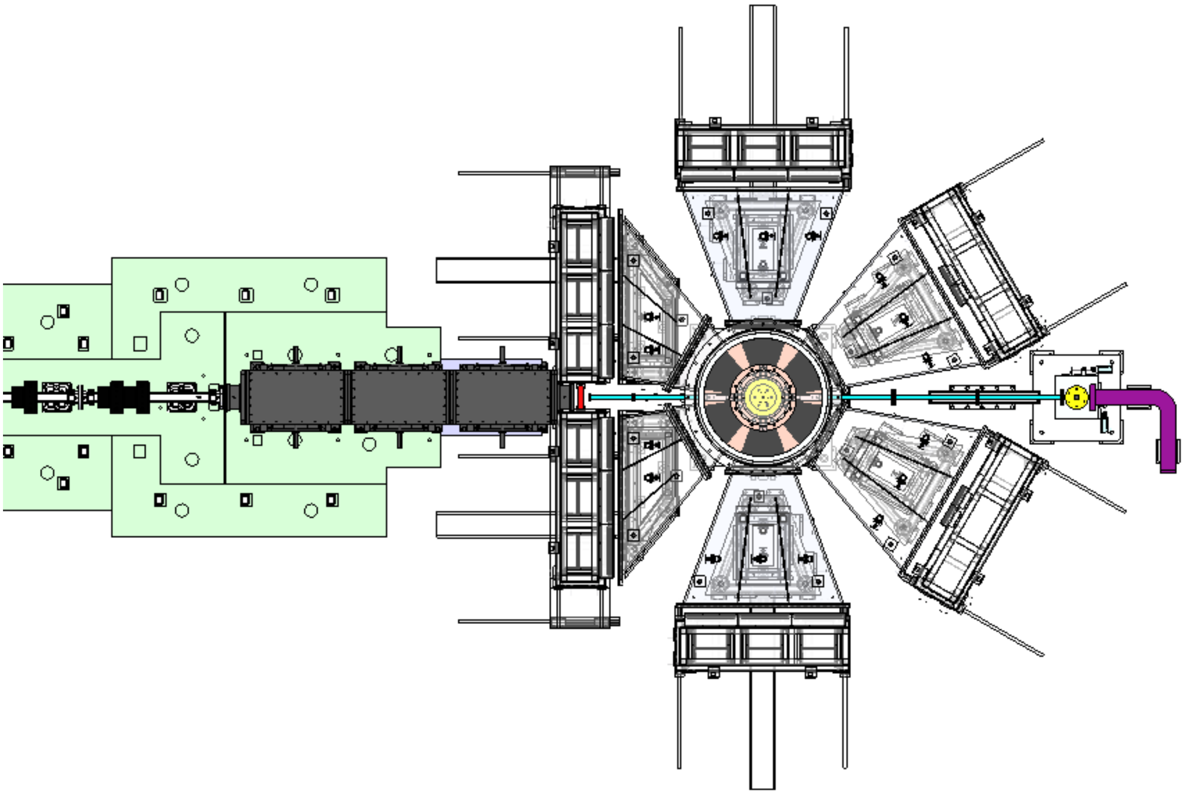
CSNS mainly consists of an H^--linac, a proton rapid cycling synchrotron, and a tungsten target station. The proton beam pulses are accelerated to 1.6 GeV kinetic energy at 25 Hz repetition rate, which strike the target to produce spallation neutrons. The accelerator is designed to deliver a beam power of 100 kW with the upgrade capability to 500 kW by raising the linac output energy and increasing the beam intensity. CSNS' first target station accommodates 20 neutron scattering instruments. Three day-one instruments have been planned: a general purpose powder diffractometer (GPPD), a small angle diffractometer, and a multi-purpose reflectometer.

Aerial photo of the China Spallation Neutron Source taken in 2016

Testing neutron imaging system project

In order to serve a growing multidisciplinary community beyond the traditional scattering areas, an energy-selective neutron imaging instrument has been proposed in future phase II construction project at CSNS. And a testing neutron imaging (NI) system has been decided to build on day-one instrument GPPD. A good news is that we just get funds for the testing NI system, from Chinese Academy of Sciences, and Ministry of Science and Technology of the People´s Republic of China.

The testing NI system is planned to provide analytical techniques such as energy-selective neutron imaging, neutron radiography, tomography, and grating imaging. Decoupled poisoned hydrogen moderator as neutron source for GPPD and a flight path of 30 m from moderator to sample will provide good energy resolution better than ~0.2% for imaging. The best spatial resolution will be 50 µm. Different types of detectors will be used including high spatial resolution CCD camera and TOF detector.



Conceptual design of the testing neutron imaging system on GPPD

The detailed physical design of the testing system is being carried out. A regular workshop will be held every quarter with detector and software groups at CSNS to work on the project. As one main aim of this project is to gain experience, help and cooperation from international neutron imaging community will be appreciated.

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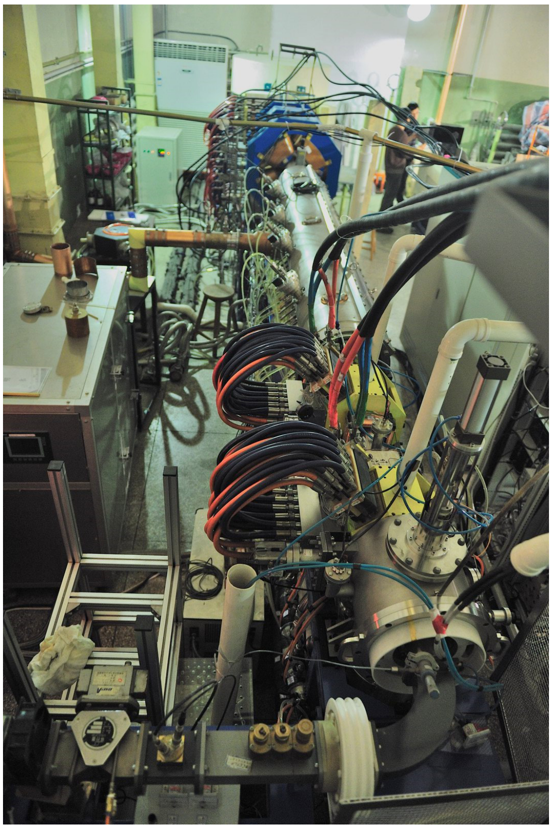
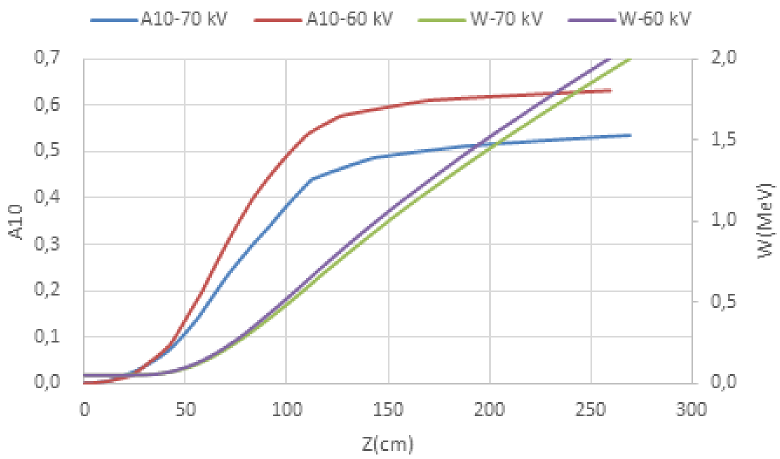
Proposal for PKUNIFTY Upgrade

Peking University neutron imaging facility (PKUNIFTY), is a compact accelerator-driven neutron source (CANS), based on mini-vane 4-Rod RFQ linac [1] (see figure to the right). The 201.5 MHz RFQ accelerates deuteron ions up to the energy of 2 MeV in a length of 2.7 m. The entire length of the whole facility is no more than 10 m. It has been tested for output beam currents about 12 mA. The pulse duration is 1 ms at present, and the duty factor could be adjusted from 1% to 10%. The source could deliver a fast neutron yield of 2.4×10^{11} n/s via the deuteron-beryllium reaction. The thermal neutron beam emitted from the moderator through a collimator with L/D = 50, has a thermal neutron flux of 2.35×10^4 n/cm²/s at the imaging plane. NR experiments have been carried out, since the first neutron beam was obtained on Feb. 2, 2012. In the half year of 2016, the neutron imaging of turbine blade has been performed, and the NR results are favorable.



A bird's-eye view of the PKUNIFTY facility.

However, in the past four year, our facility suffers from some problems, such as full power level instability of RF transmitter, RF sparking for the RFQ high power operation, and the misalignment of RFQ electrodes assembling and deformation. The available power is the bottleneck in operation. So the RFQ & NR group intends to upgrade the facility in an economic way, by replacing the current RFQ electrodes @ U = 70 kV design with new beam dynamics design @ U = 60 kV, while other components of the RFQ accelerator will just be kept intact and the output energy of deuteron beam is still up to 2 MeV [2]. Doubtless it is a more challenging design. Usually, a longer accelerator length is preferred, since the inter-vane voltage lowered from 70 kV to 60 kV. The Figure below



Comparison of the acceleration efficiency and kinetic energy between the 70 kV design and the 60 kV design.

clearly shows that the averaged accelerator gradient in the 60 kV design is higher than that of 70 kV design, which accounts for the D+ beam accelerated up to 2 MeV.

The averaged deuteron beam will be around 3 mA. The source will deliver a fast neutron yield of 2.5×10^{12} n/s in the D-Be reaction, which is about 10 times higher than the current status. The expected thermal neutron flux at the detector plane is more than 10^5 n/cm^2/s.

References
[1] Guo, Z., Lu, Y., Zou, Y., Zhu, K., Peng, S., Zhao, J.s & Ren, H. (2013). Progress of PKUNIFTY–a RFQ Accelerator based Neutron Imaging Facility at Peking University. Physics Procedia, 43, 79-85.
[2] Xiao-Wen, Z., Yuan-Rong, L., Kun, Z., Xue-Qing, Y., Hu, W., Shu-Li, G. & Zhi-Yu, G. Four-Rod RFQ Beam Dynamics Design of PKUNIFTY Upgrade. Chinese Physics Letters, 34(01), 12901.

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When neutron imaging meets small-angle scattering

Neutron diffraction imaging is an advanced method in neutron radiography. Contrary to neutron transmission imaging, in which the attenuation of the neutron beam provides the imaging contrast, only the scattered neutron beam is evaluated in diffraction imaging. This approach has been proven to be particularly useful for the determination of crystal grain shapes, structures and orientations in polycrystalline material, as well as for the inspection of single crystals in terms of homogeneity and mosaicity. The shape and homogeneity of the crystallites can be evaluated from the scattered image itself while, according to Bragg's law, the structure and orientation result from the position of the diffracted images around the sample. Diffraction imaging is thus one possibility to extend the size range which can be probed by neutron radiography to the atomic scale.

Fascinating crystalline patterns do however not only exist on the atomic level. Periodic, crystal-like structures also emerge on larger length scales in a huge variety of systems like e.g. in type-II superconductors or in different kinds of magnetic materials. Belonging to the latter category, the Skyrmion lattice has recently been the subject of highest interest. Skyrmions are whirls in the magnetization of a material. They have firstly been detected

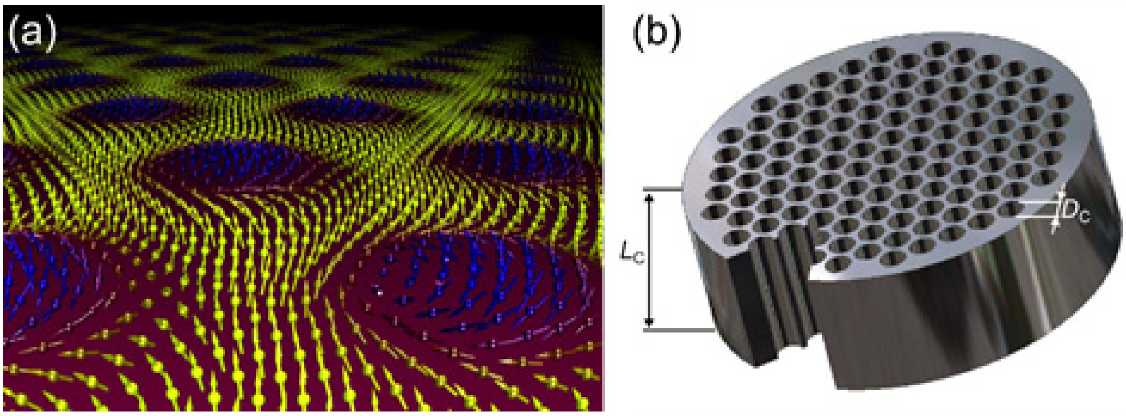

Fig. 1: (a) Illustration of the magnetic Skyrmion lattice (with courtesy of S. Mühlbauer).
(b) Schematic of the used MCP (L_c=2 mm, D_c=8 µm).

in the compound MnSi where they form a two-dimensional hexagonal lattice of 18 nm periodicity (Fig. 1 a). Since these whirls are stable but still easy to manipulate, Skyrmions are candidates for future applications in data storage.

In order to investigate the nucleation of the Skyrmion lattice, diffraction imaging can be applied. However, the involved scattering angles are ten to one hundred times smaller than for a crystal lattice. In contrast to the diffraction imaging of real crystals, where the involved large Bragg angles spatially separate the attenuation from the scattered image, both of these images are hence superimposed on the detector in case of the Skyrmion lattice. The direct beam consequentially has to be blocked behind the sample in order to map the Skyrmion distribution.

A simple experimental approach to perform this task has recently been demonstrated at the ANTARES beamline (MLZ) in collaboration with colleagues from the Paul Scherrer Institut and the University of Berkley. The approach is based on the usage of a borated micro-channel plate (MCP) as thin neutron collimator (Fig. 1b). By rotating the MCP to the Bragg angle of the Skyrmion lattice (Fig. 2), only neutrons which have been Bragg scattered under small-angles can reach the detector and generate a diffraction image of the Skyrmion distribution. Although the setup could easily be realized with slit collimators, only the implementation of the thin MCP collimator enables an imaging with high spatial resolution and without any parasitic streak artefacts.

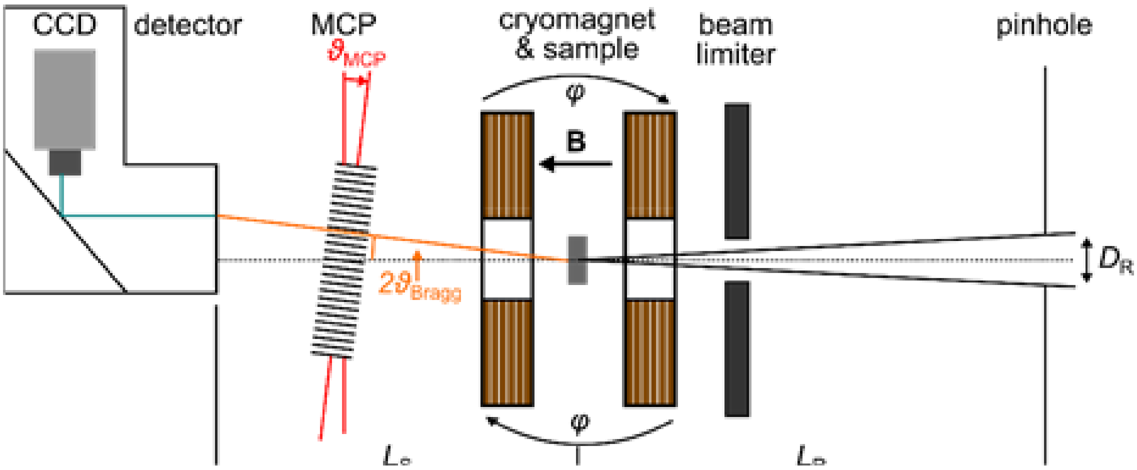

Fig. 2: Illustration of the used setup for diffractive imaging. The sample is placed in a cryomagnet in order to nucleate Skyrmions. The direct beam is blocked by the MCP, while neutrons which were scattered off the Skyrmion lattice can reach the detector. The fulfilment of the Bragg condition is controlled by the rocking angle φ.

By means of this diffraction imaging approach, the distribution of the Skyrmion lattice in a small disc of MnSi has been recorded for different applied magnetic fields (Fig. 3 a). A peculiar ring-like penetration of the Skyrmion lattice could be unambiguously attributed to demagnetization effects. By rotating the sample perpendicular to the beam (rocking scan around φ) the mosaicity of the Skyrmion lattice could moreover be quantified (Fig. 3 b). Hence, the performed experiment provides one of the first data quantifying the influence of the sample geometry onto the magnetic Skyrmion system. The simple approach of scattering selection by means of the usage of an MCP collimator can furthermore be extended in order to study the rich variety of spatially inhomogeneous, nanometer structures which are characterized by Bragg scattering.

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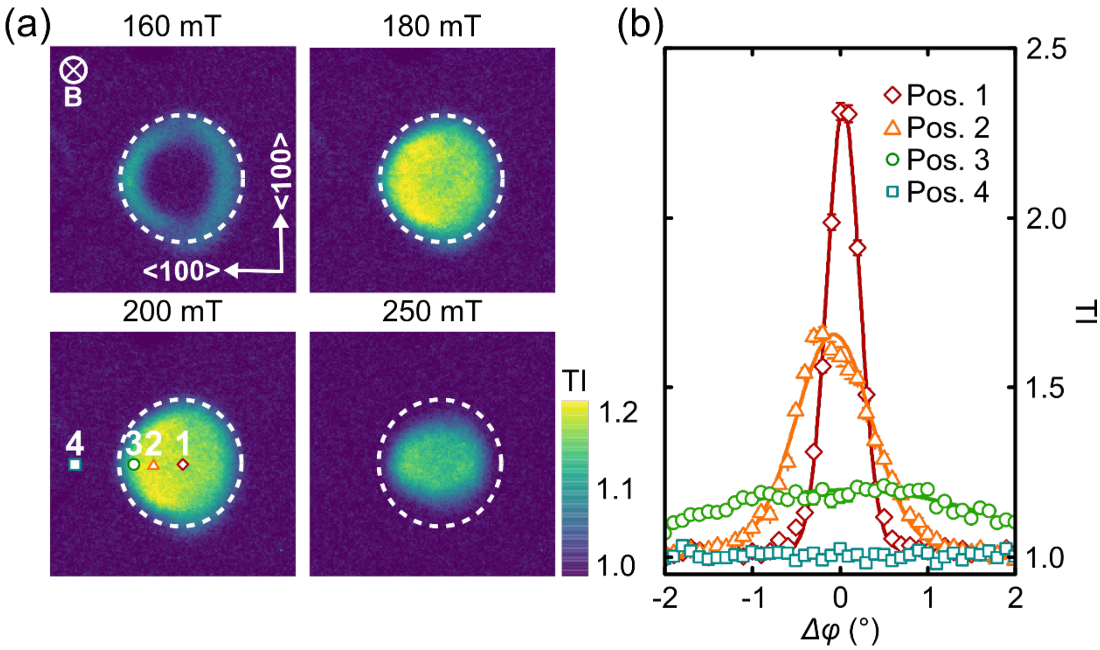
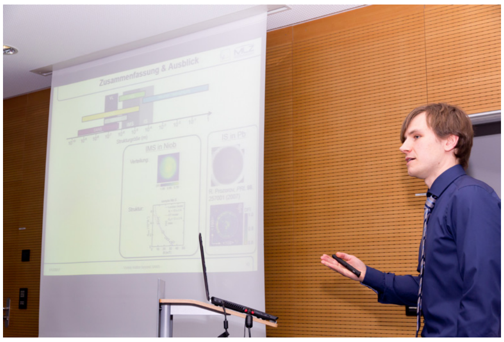


Fig. 3: (a) Diffraction images of the Skyrmion distribution within the disc-shaped sample for different fields at T = 28 K. The sample radius is marked by the white circle. (b) Intensity for the positions 1-4 as function of the rocking angle φ. Neutrons are only scattered if the Bragg condition between the incoming neutrons and the Skyrmion lattice is fulfilled. The width of the curve is therefore a measure of the local bending of the Skyrmion lattice and hence of its mosaicity. Clearly the Skyrmion lattice is strongly distorted at the sample edges.



Impressions during and after the defense of his thesis.

We congratulate Tommy Reimann on the successful defense of his thesis at the Technical University of Munich, Germany.

Old Russian treasures meet with neutrons in Dubna

The one of the most important tasks of archeology and other human sciences are comprehensive studies of the cultural heritage items, which takes us into the deep past and allows understanding a formation and development of civilizations and ethnic groups. The special value and uniqueness of such items requires using of advanced non-destructive methods for their studies. The one of such method is a neutron radiography and tomography, which gives detailed information about the internal structure of the investigated objects.

Recently, in Joint institute for Nuclear Research (Dubna, Russia) the neutron radiography and tomography facility on the 14th beamline of the IBR-2 high-flux pulsed reactor started operating. The engineering and paleontological objects, astrophysical and construction materials have been non-destructive tested by means of this facility. Last year was marked by sign of the Ancient Russian Historical science. The agreement on cooperation between Frank Laboratory of Neutron Physics and Institute of Archaeology of the Russian Academy of Sciences were signed.

A large number of archaeological finds were studied by means of neutron radiography and tomography method. Neutrons look inside ancient artifacts of the times of the Bosporan Kingdom, from Scythian burial places, from pre-Mongolian treasures with old Russian jewelry crafts. Reconstructed from neutron tomography data the three-dimension models of ancient coins, bracelets, colts, brooches, golden pots were obtained.

Here, as examples, the results of the studies of cultural heritage items found in 2014 within the Tver treasure: fragments of two-leafed bracelet and radial colt are presented. For the studies of the internal structure of the archaeological items, the series of neutron radiography experiments were prepared. The virtual three-dimensional model of the object obtained after tomographic reconstruction from the individual neutron radiographic images allows visualizing an internal structure of the objects, including the assembly of individual parts or internal structural of fasteners elements.

A photography of the fragment of the radial colt is shown in Fig. 1a. The virtual three-dimensional model of the object obtained after tomographic reconstruction from the

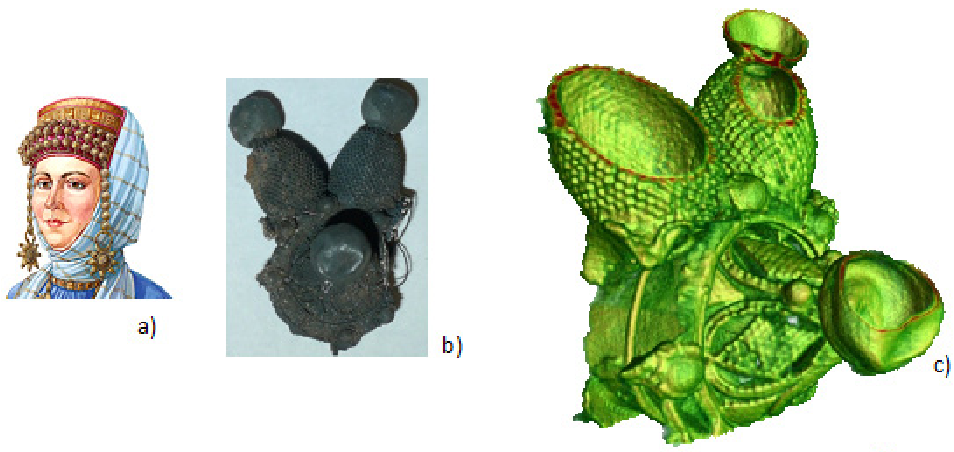


Fig. 1. a) The star-like radial colt in headdress of old Russian ancient women . b) The photo of the remaining of the fragment of a radial colt. The height of the fragment is 5 cm. c) The reconstructed from the neutron tomography data a three-dimensional model of the fragment of a radial colt. The mounting ring, grooving and patterns on the colt rays and a supporting wire are visible. The virtual slice of models demonstrate a hollow structure of radial beam of colt.

a)

b)

Fig. 2. a) A photo of the fragment of the bracelet. The height of bracelet part is 6 cm. Bracelet are covered a corrosion and slag. b) The three-dimensional model of a fragment of the bracelet reconstructed from the neutron tomography data. Gilding areas and their placing on the arches and grooving wires of the bracelet are visible. The recovered from neutron tomography data gilding and blackening patterns on the plane of the bracelet are distinguish.

individual neutron radiography projections is presented in Fig. 1b. The ornamental elements of the central medallion and the radial shafts were attached to the ring. The wire around the outer perimeter of the ring provides the rigidity of the colt structure.

The second studied item is a fragment of a wide two-leafed bracelet, which was a poorly preserved plane between the wired arches before the restoration (Fig. 2a). The results of neutron tomography experiments are data about gilding areas and those distributions on the arches and grooving wires. In addition, it was possible to identify a gilding and blackening tracery on the plane of the bracelet (Fig. 2b). In agreement with the observed neutron data, the studied fragment of the two-leafed bracelet was made in the technique and the style of the First Kiev workshop, which elevates the Tver treasure to the rank of other unique and composition rich treasures dating of the pre-Mongol period.

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News from the Lab and Out of Practice

The first steps in neutron tomography processing: a freeware solution for newbies

One fine day you have joined the neutron radiographic society through neutron measurements of your unique and wonderful material by means of a neutron tomography method. You had obtain the sets of radiography images, open beam and dark field patterns and hard question: “What should I do with all this?”

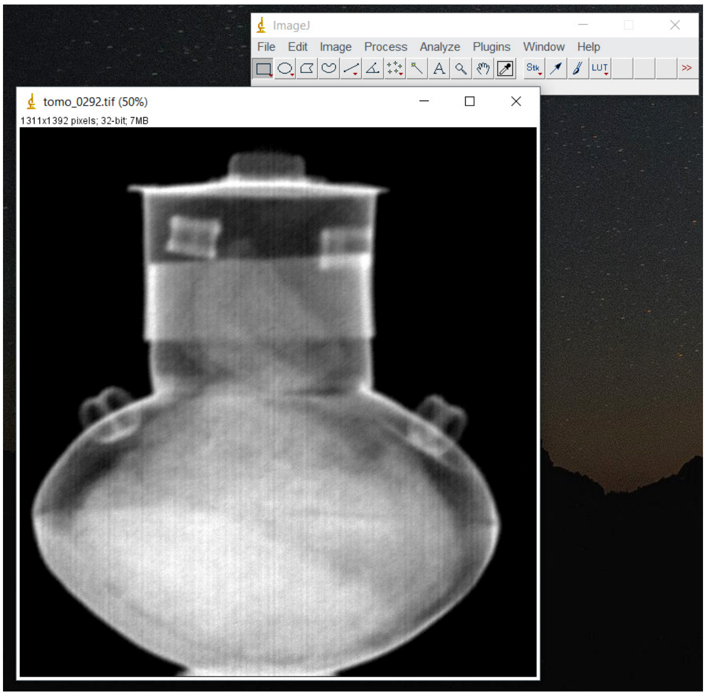
Here, I want to show some easy steps in a neutron tomography processing and short review of free available software for this. My tips are not strict rules for action, but, in my opinion, set the starting point for newbies in the neutron tomography. ….Oh, yes, I remember a time when I was collecting information about the software algorithms, bit by bit, with many unnecessary data filtering…

1. Firstly, we need some software for visualization our imaging data and performing simple operations: denoising, summing, background corrections ant etc. A leader in my private rating is ImageJ software. Easy using, a great extension by plugins, great and helpful community distinguish this software.

   Do you have some "exotic" image format? Do not worry – install additional plugin. Do you want to prepare useful script? Do not worry – the powerful script writing system, python, Ruby, java code support are waiting you. It is tons of possibilities. It is fast and furious. In my opinion, the ImageJ have no competitors.

   You can download this from *https://imagej.nih.gov/ij/download.htm*

   Alternatively, an inflated by plugins FIJI: *http://fiji.sc*, with nice slogan: "Fiji is just ImageJ"



ImageJ can open great images formats easy. Oh, no, it is VERY EASY. The modest interface hides a powerful stuffing.

   Ok, you can load your set of projection data "File → Import → Image Sequence". Now you have image stack and can push "play" button to watch movie "How my object rotates in neutron beam". This is a funny comedy.

   Seriously, you can perform many operations in batch: denoising ("Process → Noise → Despeckle"), filtering ("Process → Filters → "As you like filter") and etc. However, in our case, it is useful for open beam and dark field correction. In additional, open "open beam" file, "dark field" file and perform normalization:

$$Normalized\ image(x,y) = \frac{tomography\ image\ (x,y) - \overline{dark\ current\ image\ (x,y)}}{\overline{open\ beam\ image\ (x,y)} - \overline{dark\ current\ image\ (x,y)}}$$

   Read more: *http://www.sciencedirect.com/science/article/pii/S1110016815000952* or other literary source.

It can be done via "Process → Image Calculator".

So many steps? "Plugins → Macros → Record" and after only one treatment you can obtain ready script for subsequent automatic treatments.

After normalization procedure, we can pass to tomography reconstruction.

2. The tomography reconstruction procedure.

   In simple words, we want convert our angular projections to planar slices perpendicular to rotation axes OR a 3D model of neutron attention mapping.

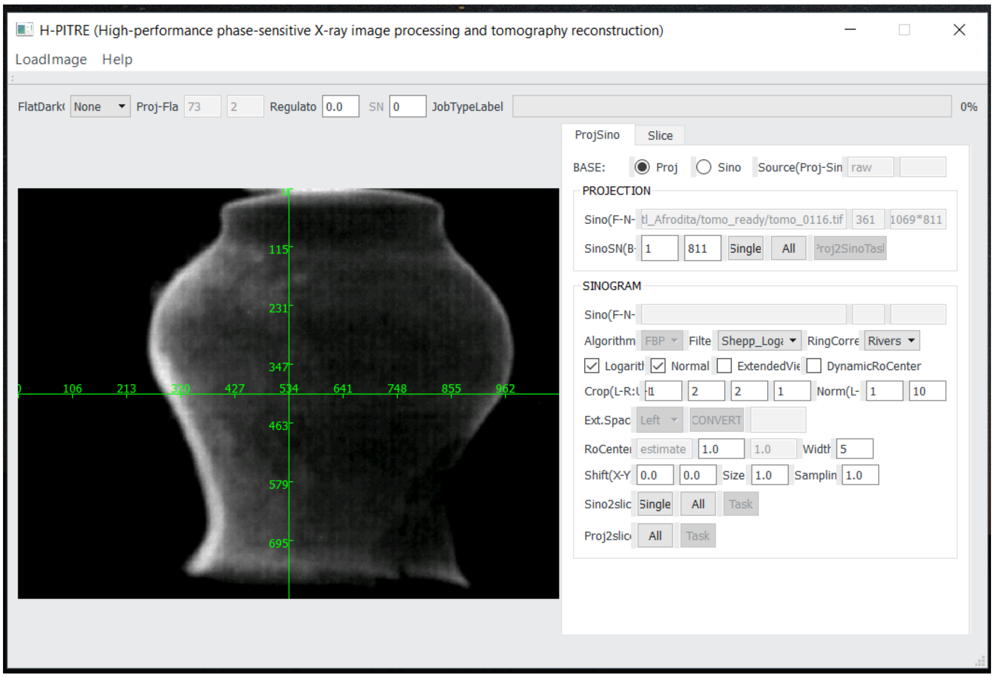
   Here, I recommended use H-PITRE software. *https://webint.ts.infn.it/en/research/exp/beats2/h-pitre-beta-version.html*

   It is high-level software. Really. This software use the CUDA technology *https://developer.nvidia.com/about-cuda*. Therefore, you should use NVIDIA graphic card. Please, download a recent driver for you card. Download and install CUDA libraries. It is of ~1.2 Gb of hard drive space. Nevertheless, CUDA is working.

   Now, the tomography reconstruction of big data is available on personal PC!

   If you have no NVIDIA card or others causing, you can use PITRE: *https://webint.ts.infn.it/en/research/exp/beats2/pitre.html*. Install only IDL Virtual Machine.

   Ok, load you angular images into H-PITRE. Don't forget rename you file name to demanded names for PITRE: "tomo_***.tif". Check parameters, input correct center of rotation. I calculate rotation center in ImageJ: add first and last projection and searching for center of this hybrid image.



The H-PITRE is waiting of our mouse click for tomography reconstruction start. Please, do not make it wait long… The GPU chips should not idle.

After start process, you should take a cup of tea (the cup of coffee would work too) and wait. In finish, we should obtain a directory with slices images. That is all.

I recommend paying attention on other tomography reconstruction software:

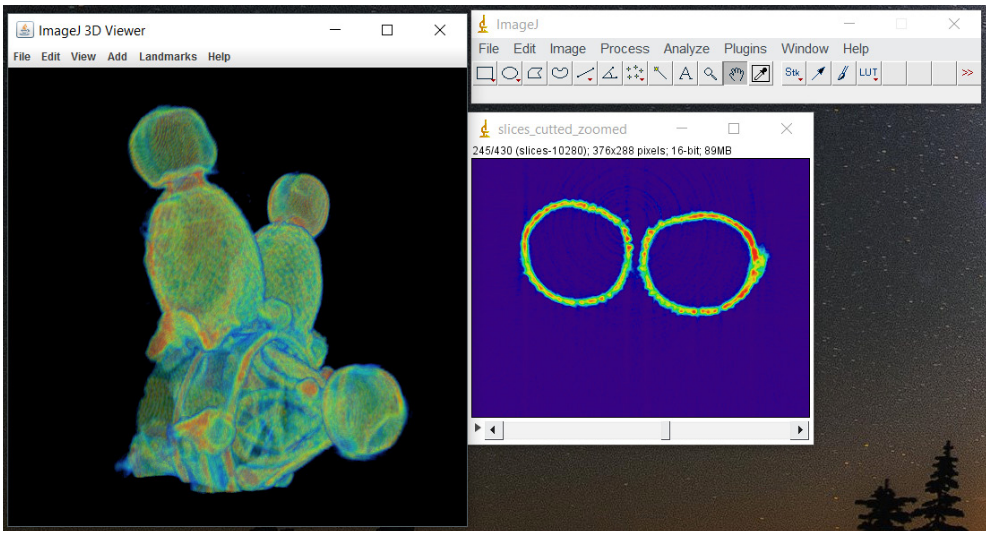
TomoPy: *http://tomopy.readthedocs.io/en/latest/*. It is powerful software package and it includes the great algorithms from initial data loading to outstanding tomography reconstruction cases: GRIDREC, SIRT, ART and others. It demands Python or Matlab. However, version for Windows do not work. In Linux OS (I try it in Ubunta) it is able to work. For users friendly with the programming.

The ASTRA Toolbox: *http://www.astra-toolbox.com*. The CUDA support. But only reconstruction algorithms. I have not known how to load my own imaging data. May be someone will pass this way to the end…

3. The 3D model presentation and calculation something.

In my opinion, the software for 3D visualization and analysis is presented in freeware segment very poor.

The first useful software is …# drumroll#... ImageJ. Get the 3D viewer plugin *https://imagej.nih.gov/ij/plugins/3d-viewer/* and load your slices inside. The rotation, zooming, moviemaker is possible.



The ImageJ is powerful not only in 2D world but also 3D rendering is able

For ImageJ there are great number plugins for 3D model treatment: Local Thickness, 3D particle calculator and etc. You can find everything your heart desires.

Keep your attention to Drishti: *http://anusf.anu.edu.au/Vizlab/drishti/* However, I have no experience to work with software.

Of course, for more professional 3D data treatment you can buy commercial software: FEI Avizo® or Volume Graphics VGStudio®. But they are expensive.

Ok, above I described briefly some software for neutron imaging and tomography. If you uses other soft or you have own code or scripts, please, share them. If you wants. But it is well known:

If you have an apple and I have an apple and we exchange apples then you and I will still each have one apple. But if you have an idea and I have an idea and we exchange these ideas, then each of us will have two ideas.

George Bernard Shaw

Kichanov Sergey

Review on conferences and workshops

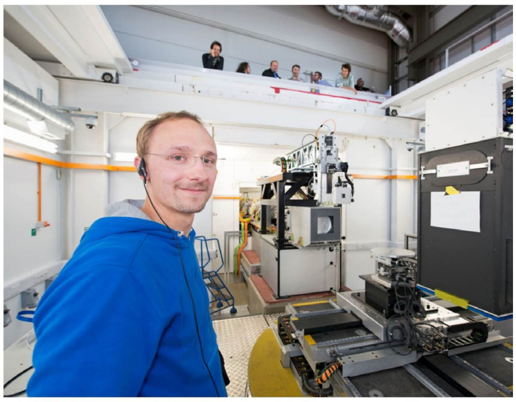
NEUWAVE-8 workshop held in Abingdon in June 2016

The 8th NEUWAVE workshop was held in Abingdon near Oxford from 12 - 15 June 2016. More than 50 participants from 10 countries had lively discussions on applications and future prospects of energy-selective neutron radiography. Topics ranged from Bragg edge mapping applications, resonance transmission analysis to latest developments in dark-field and magnetic imaging. Since the first NEUWAVE workshop in Garching in 2008, neutron radiography began, much more than before, to consider wavelength-dependent effects and to take advantage of the wealth of spectral information in transmission data. Back then, first imaging facilities at pulsed spallation sources were only just being considered. Now, eight years later in Abingdon, stress and strain studies on additive manufactured components and fuel cell materials, magnetic field mapping in superconductors, and isotope mappings via neutron resonances are being reported. The pulsed neutron imaging facility RADEN at J-PARC is operational, IMAT at ISIS is being commissioned, a new far-field interferometer at NIST demonstrated polarized neutron imaging, the VENUS and ODIN projects at SNS and ESS are well underway, and the imaging facility at LANSCE, Los Alamos, is delivering high-quality neutron resonance data on nuclear fuel materials. A significant portion of the progress and increasing appeal of energy-selective neutron imaging over the past few years can be clearly attributed to the high-resolution microchannel plate detector development at Berkeley, led by A.S. Tremsin who received a special recognition award at the Abingdon workshop.

The NEUWAVE participants in the garden of Cosener's House in Abingdon.

The first day held the traditional 'walking discussion', this time along the River Thames, and partly on it, when a boat trip concluded the tour. The walk gave plenty of opportunity for participants to discuss new ideas and projects. The weather on the day offered the whole range of British experience, from sunshine to pouring rain. After three days of presentations and discussions in a tight workshop program the participants of NEUWAVE-8 had the opportunity to visit the target station 2 at the ISIS pulsed neutron spallation source of

'Walking Discussion' **IMAT Tour**



NEUWAVE hikers finding shelter from the rain on the river boat (left). Tour of the IMAT facility (right).

the Rutherford Appleton Laboratory at Harwell, where the nearly completed IMAT facility was of particular interest. It sets a benchmark in performance and costs for other projects at ESS and SNS, ODIN and VENUS, respectively. The local organisers would like to thank ANDOR for supporting the ISIS visit of the workshop participants.

The series of NEUWAVE workshops will be continued in 2017 at NIST in Gaithersburg, USA. The community is looking forward to another exiting NEUWAVE workshop, where participants will have the opportunity to exchange information, experience and solution about current technical developments as well as new science in the fast evolving field of energy-selective neutron imaging.

Winfried Kockelmann (ISIS, UK)
Burkhard Schillinger (TUM, D)
Eberhard Lehmann (PSI, CH)

8th International Topical Meeting on Neutron Radiography (ITMNR-8)

Neutron Imaging School in the framework of the ITMNR-8 conference

In advance to the ITMNR-8 conference the Peking University (in collaboration with the Tsinghua University, China Institute of Atomic Energy and China Academy of Engineering Physics organized two trainings school days, mainly for the Chinese community: a national one (in Chinese language) and an international one (in English language) with some participants from the Asian region and USA. On two days (3rd – 4th September 2016) talks were given about the common practice in neutron imaging, including advanced methodical aspects and facility layout.

This event was organized in similarity to the approach in South Africa next to the WCNR-9, where a one-day school was held in Johannesburg.

Even on this weekend, the participation of the school on 4th September was high with 57 people – and the 8 international speakers in addition: E. Lehmann, P. Trtik (both Switzerland), B. Schillinger (Germany), D. Hussey (USA), M. Strobl (Sweden), M. Furusaka, T. Kamiyama (both Japan) and Y. Zou (China).

Participants and lecturers in front of the conference building on the campus of the Peking University.

The selected topic of the one hour lectures were the following:

- Fundamentals of Neutron Imaging (Lehmann)
- Neutron Imaging Facility and Neutron Tomography (Schillinger)
- Resolution and Standardization of Neutron Imaging (Trtik)
- Industrial Application of Neutron Imaging (Hussey)
- Advanced Technology of Neutron Imaging (Strobl)
- Accelerator based Neutron Source (Furusaka)
- Energy Selective Neutron Imaging (Kamiyama)
- Video Show – neutron imaging experiments (Zou)

Before the English courses some Chinese courses were arranged on 3rd September for 47 Chinese students for their better understanding of English courses:

- Technological Foundation for Neutron Imaging (Z. Guo, PKU)
- Neutron Imaging Facilities (D. Chen, CIAE)
- Application Overview of Neutron Imaging (H. Ho, CAEP)

The preparation of the school was done very carefully: material printed as handout and in digital format on a memory stick. The venue was well selected in size, technical infrastructure and comfort. The participants were highly motivated and used the lecture time with questions and communication. Also with a tighter program for participants, such a "kick-off" is important to attract new members of the neutron imaging community. It should be taken as template in future conference in the hosting countries like Australia (WCNR-11, 2018) or Argentina (ITMNR-9, 2020).

Zhiyu Guo
Eberhard Lehmann

ITMNR-8 conference

The 8th International Topical Meeting on Neutron Radiography (ITMNR-8) was held at Peking University (PKU), Beijing, China, on September 4-8, 2016. It followed the traditions of previous ITMNRs and was focused on "Neutron Imaging for Applications in Industry and Science".

The successful meeting was attended by 114 registered participants, 70 coming from outside of China from more than 20 different countries. In total 60 oral presentations of consistently very high quality on the topics industrial applications, scientific applications, software and simulation, facilities and instrumentation, and (new) methods in Neutron Imaging (NI) were presented. The applicability of NI not only for non-destructive characterization of materials but also as a valuable, if not even a unique tool to solve top scientific questions was impressively demonstrated by some presentations, e. g. by diffraction imaging of Skyrmion nucleation, and by neutron depolarization imaging of weak ferromagnets, respectively.

ITMNR-8: Conference photo

Venue of ITMNR-8 at PKU.

Impressions from ITMNR-8

Prof. Guo, the organizer of ITMNR-8, introducing the next speaker.

Well-stocked audience even in the late afternoon, listening the presentations.

Pavel Trtik (left), substituting the absent president Ulf Garbe from Down Under for his presentation perfectly dressed, obviously impressing the session chair Arif (right).

Discussion and food, both essential for a successful conference.

Poster presentation during coffee breaks.

Laboratory tours to the China Advanced Research Reactor (left) and PKUNIFTY (right).

The oral presentations were supplemented by 54 poster presentations of remarkably high quality in content and layout, both.

During the meeting optional laboratory tours to PKUNIFTY and to the China Advanced Research Reactor (CARR) were arranged and accepted by a large number of participants.

The ISNR Board of Members used the ITMNR-8 for two meetings.

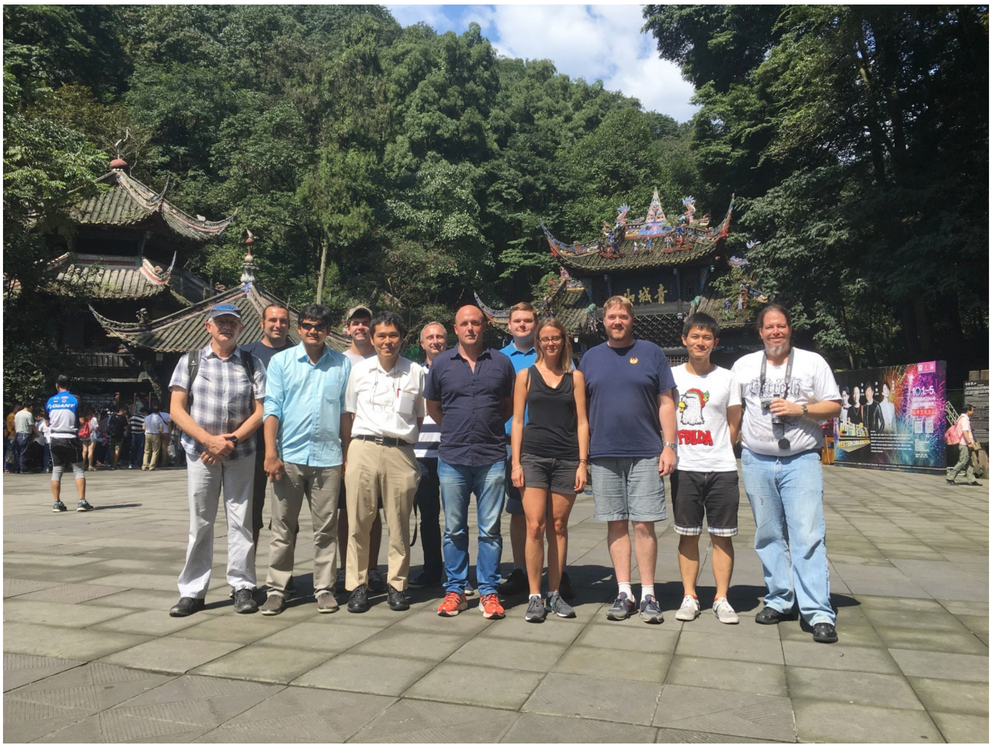
The ITMNR-8 was a successful and outstandingly well-organized meeting. We would like to thank the organizers, just to name Zhiyu Guo and DongFeng Chen as representatives of their teams, for their large efforts and the great hospitality all participants enjoyed.

Thomas Bücherl

Review Workshop after the ITMNR-8 conference in China

The ITMNR-8 conference took place in Peking between Sept. 4rd and 8th 2016 with 106 participants from 18 countries. Since China is not very easily accessible (visa, long-distance flights, costs) and the problem of air pollution is not negligible, this impressive participation indicated the high interest in the exchange of knowledge and the growing activities of the neutron imaging community.

The organizers did their very best to make the stay in China as comfortable as possible (e.g. excursion to the great wall, excellent meals, well acclimatized conference rooms, comfortable lodging for reasonable prices, visits to the facilities).



Participants of the Review Workshop during the excursion to Chengdu's historical sites.

In this framework, the Review Workshop was another highlight to learn more about neutron imaging in China – and the life in China in general. Unfortunately, only 12 persons took the opportunity to extend the stay for this workshop (see below).

The flight from Peking to Mianyang (4.6 million people) took about 2 hours in the morning of Sept. 9th 2016 with China Airlines. Guided by Hu Wang (Peking University) we arrived safely and were welcomed by Hang Li (CAEP). He prepared the visit to the research reactor facility in his institute by a special badging for all participants who sent a passport copy in advance. In this institute we were welcomed by Bin Tang, the neutron imaging project leader. Two imaging stations were shown: a thermal one, just under installation and another one at a cold guide, which was built by J. Rogers and his UK company about 3 years ago. This beam line was obviously under operation and results were shown on

Good food in China at the rotating round table for sharing all meals among the participants.

posters and video screens. The visit in this institute was concluded by a talk given by N. Kardjilov about the latest activities at his CONRAD facility in HZB, Berlin, Germany. Unfortunately, no photo taking was allowed during this visit – no demonstration is possible within this report.

After a great dinner, the tour continued on the next morning with a car ride to Chengdu, a city with 22 million inhabitants. On the way between Mianyang and Chengdu we learned a lot about the country by the excursion guide, in particular during the visits to Mount Qingcheng and Dujiangyan irrigation system (UNESCO world heritage). … and also what happens if a car fails …

Soup for "survival" during the tour through the country under "supervision" by our guide.

During the stay we were able to establish very intensive communication in particular with respect to a future collaboration between institutes and individual researchers. Also the dialog to the Chinese colleagues was very open and creative. We hope it will be continued in the future.

We thank the organizers for the great and unforgettable time in China and hope for further interaction with them. All participants returned safely home, even if thunderstorms around Peking requested an extra train ride of 450 km (within 1.5 hours) by N. Kardjilov.

Zhiyu Guo
Eberhard Lehmann

News from the Board

Board Meetings in Peking

The Board of Members of the ISNR took the opportunity to meet twice during the ITMNR-8 conference in Beijing. The first meeting was on September 4th 2016, one day before the start of the conference, the second on September 6th 2016.

Some of the topics presented and/or discussed were:

- Status of the organization of the upcoming ITMNR-8.
- Update of the list of members.
- Report of the conveners of the different Task Groups initiated at the last WCNR-10 at Grindelwald, Switzerland, report on their activities.
- Presentation of candidates for hosting the next International Topical Meeting at the second meeting (the Board voted for Buenos Aires, Argentina, to organize ITMNR-9 in 2020).
- Nominations for honorary members.

In the next paragraphs the actual status of the Task Groups "Constitution" and "Terminology" are presented. Please read them carefully and participate actively in the discussion. Comments can be send to the conveners of the Task Groups directly or to the secretary of ISNR who will forward them to the conveners.

Thomas Bücherl
(secretary ISNR)

Task Group "Constitution"

The constitution of ISNR serves as a framework for cooperation among its individual members working in the field of Neutron Radiology and Neutron Imaging[1]. Created by John Barton, it first came operational in June, 1996. Although the constitution was defined in a most general sense, its application showed some ambiguities in the wording and allowed different interpretations. This should be remediated by the work of the Task Group *Constitution*, convened by Les Bennett, whose result, a draft revised version of the constitution is presented below. All members of the ISNR are requested to comment. Please send them to Les Bennett or to Thomas Bücherl (secretary of ISNR). Your comments will be discussed by the Board of Members and may be considered in the final version. Shortly before WCNR-11 in 2018 the final version will be distributed among the members of ISNR and at WCNR-11 the attendees may set it operational by voting. A 2/3 majority is required.

Thomas Bücherl

[1]A first trial of a definition of the terms Neutron Radiography and Neutron Imaging is given in the article Terminology on page 29.

Draft Constitution of the International Society for Neutron Radiology (ISNR)

ARTICLE

1. ORGANISATION

The ISNR shall consist of individual members involved in the scientific and educational progress and application of neutron radiography. Some members will be elected or appointed members of a Board, which has the responsibility of meeting the society's mandate.

2. MANDATE

The society is to foster and promote actively the field of neutron radiology. Specifically, the Board

(i) organises a World Conference on Neutron Radiography (WCNR) as a broad, inclusive conference, and an International Topical Meeting on Neutron Radiography (ITMNR) focused on particular topics, each on a nominal four-year interval, with a 2-year spacing in between;

(ii) organizes the voting for the Board at every WCNR;

(iii) maintains an ISNR webpage;

(iv) produces a Neutron Radiography Newsletter periodically;

(v) keeps a Neutron Radiography Directory of Members;

(vi) keeps abreast of developments in this field by undertaking tasks assigned by the Board and reporting on their progress;

(vii) handles nominations for, decides on and awards honorary memberships; and

(viii) undertakes any other activities, as may be proposed and voted.

3. MEMBERSHIP

3.1 Regular

All interested attendees to a WCNR or ITMNR and all others whose application form is submitted in writing to the Secretary and approved by the Board. See By-law 1.

3.2 Honorary

An individual who has made outstanding contributions in the field of neutron radiology throughout their career may be awarded Honorary Membership by the Board. The Board will evaluate nominations from ISNR members every two years with the award being presented to the successful nominees at the next WCNR. See By-law 2.

3.3 Fees

No fees exist for Membership. Costs such as Conference and Meeting organization and any other administration shall be covered voluntarily.

4. BOARD

4.1 Responsibilities

The Board shall be responsible for the mandate of this Society, shall meet at the beginning and before the end of each WCNR and ITMNR as well as communicate on matters between meetings, shall consider motions and vote on proposed changes to this Constitution (by 2/3 majority), and shall consider and vote on other specific proposals, e.g. honorary membership (by simple majority). Most business should be conducted by consensus and not brought to a vote.

4.2 Composition

The Board shall consist of three Officers (President, Vice President & Secretary) and up to thirteen Members. One of these members is the past President and will hold that position until the end of the next WCNR. One of these Members can be selected by the incoming President to assist in organising the next WCNR, may not necessarily be elected and will hold the position until the end of that WCNR. One other of the Board Members has the responsibility to organize the next ITMNR, may not necessarily be elected, as the host of the ITMNR will be selected by the Board, and will hold the position until the end of the next WCNR.

4.3. Election

A general election for the three Officers and ten available Board Member positions shall be organized, held during every WCNR and voted on by the attendees of that WCNR. Their term will last until the end of the next WCNR. For the Board Members, no more than three may be from the country with the most papers at the present WCNR, no more than two may be from the next country, and no more than one may be from each other country. To determine the paper count, only the country of the first author is counted. See By-laws 3, 4 & 5.

5. OFFICERS

5.1 President

The President shall chair the Board meetings and correspond with the Board between meetings, and shall be responsible for and ensure satisfactory organization of the next WCNR. The President may also select a deputy (Article 6), from the Board members or not, for assistance in organizing the next WCNR. The President will organise the voting for the next President by the end of his or her WCNR.

5.2 Vice President

The Vice President should be from a different geographical region than the President as it is intended that the following WCNR will be held there and organized by the Vice President. However, the Vice President may not necessarily be the Chair of the following WCNR, because of the long interval between the present election, the next WCNR, and the following WCNR (nominally, in 8 years time).

5.3 Secretary

The Secretary shall be responsible for maintaining an ISNR webpage, producing a Neutron Radiography Newsletter periodically, maintaining contact with ISNR members, adding new Members, keeping a Directory of Members, and publishing the Agenda and recording the Minutes for the ISNR Board meetings.

6. OPERATION

The ISNR Constitution became operational in June, 1996, and has had several amendments since then, which are now incorporated in this version along with additions to reflect on present activities. This Constitution and its By-Laws may be amended by two-thirds majority of the Board at their meetings. Proposed amendments with reasoning must be submitted in writing to the Secretary two months before the next Board meeting.

7. BY-LAWS

Details for the operation of the Board and of the Society are attached here as By-Laws to the Constitution. By-Laws may be amended by suggestions from all members of the Board. The Board will consider them and change the By-Laws by consensus or by (2/3) majority vote, for example, if a major change affects the Society by the Constitution.

By-Law 1 Regular Membership

Those wishing to become a member of ISNR shall submit the following information to the Secretary: First & Last Names; Organisation & Department; Full Postal, Email & URL Addresses; and Phone & Fax Numbers. In a brief paragraph, they are to indicate their relation to neutron radiology and explain why they wish to become a member. The Secretary will email the names to the Board members requesting any objections to be returned within two weeks. If none are received, membership is granted.

By-Law 2 Honorary Membership

The Secretary will ask via email to all members for nominations before the Board meeting two years in advance of the next WCNR, which is typically the preceding ITMNR. All submissions should be received by the Secretary two months before this Board meeting. The Secretary will pass the nominations to Board members at least one month before this Board meeting.

At the discretion of the Secretary, this schedule may be altered to allow nominations after the ITMNR Board meeting and before the next WCNR. In such cases, the nominations will be vetted via email communication amongst the Board members.

Members wishing to nominate a member must submit their reasons in writing indicating person’s contribution to neutron radiology.

By-Law 3 Board Membership

The Secretary will ask via email to the members for candidates before the next WCNR. All submissions should be received by the Secretary two months before this Board meeting. Members may nominate another member or put forward their name. The Secretary will pass the nominations to Board members at least one month before this Board meeting.

By-Law 4 Voting for Board Membership

The President will conduct the voting and present the results in front of the full membership at the WCNR. The slate of candidates and ballots will have been prepared by the Secretary. The Secretary will receive and tabulate the ballots with one other Board member present and any observer. If any member handling the ballots is a candidate for re-election, other members will be asked to perform these tasks.

By-Law 5 Office or Board Member Resignation

Resignation should be in writing to the President and the Secretary. A member may be removed for cause by a two-thirds vote of the remaining Board Members.

5.1 Officer

If any Officer leaves the Board for any reason, that position should be filled by any Board member willing to assume the vacant position and agreed upon by the remaining Board members.

5.2 Board Member

If any Board member leaves the Board for any reason, that position may remain vacant until the next election or be filled with any Regular Member agreed upon by the Board. Candidates who have the highest ranking in the previous election, but did not make the Board, should be considered.

Constitution Committee, FEB 2017
Les Bennett (Convener), Markus Strobl, Thomas Bücherl

Please send your comments on the draft constitution to Les Bennett (bennett_l@rmc.ca) and/or Thomas Bücherl (thomas.buecherl@tum.de).

Task Group "Terminology"

1 Preface

A broadly shared, agreed and well-defined terminology is of outstanding importance for efficient communication within and outside an organization as well as for every related scientific and applied context in a specific field of activity. The ISNR as a scientific society concerned with neutron radiography/imaging and its applications considers itself responsible to provide and update a concise and complete set of terms describing corresponding activities and methodology.

The ISNR is a scientific interest group/organisation without legal binding framework and reliabilities. Hence, the ISNR might publish recommendations for their members as well as for the general public but has not and does not aim for the authority to implement rules. The ISNR might expect "officials" of the ISNR, i.e. voted members like the board etc. to follow recommendations, but cannot and does not want to enforce such conduct on others. An ISNR task group is working on a guideline of recommended terminology in order to enable stringent and concise use of terms in publications and communications for obvious merits. The task group is however aware and acknowledges that terminology, like language in general, changes with time and progress, and that hence definitions of terminology require reassessment and adaptation on a regular basis in order to be meaningful in a longterm perspective. The first edition shall be accomplished within a single term of presidency of the ISNR (2014-2018). Broad agreement on recommendations published by the ISNR is achieved by a staged (2 step) implementation of definitions of terminology: 1) the task group elaborates definitions and decides upon proposals by majority vote (if consensus cannot be reached with respect to the timeline) and 2) the proposed definitions and terminology recommendations are approved and implemented by the board through a majority vote.

2 Introduction – Scope and Aim

This first edition of ISNR terminology is the first attempt by the society to establish a terminology on its own, for its very own framework and concerns. This is undertaken in the light of growing dissents on terminology, which before has been lent from strongly related fields such as X-ray radiology (medical and scientific), non-destructive testing and neutron science communities. As fast progress in all these fields and in particular also related to more scientific impact has led to inconsistent use of terminology within and among the related communities, this has led to ambiguity, contradicting use of terms and lack of conciseness also in the field represented by ISNR.

An outstanding example for this issue is the name of the society, characterizing the field with the term RADIOLOGY. Radiology as defined in general, apart from its medical definition, is extremely broad and includes all science related to radiation, in this case neutron radiation. Although historically it might have been more limited and taking radiographic images being a more dominating and early application, this has changed tremendously, and while the name of our society has been sustained, in contrast to its meaning the society does not serve and represent major fields within such definition like fundamental neutron science, neutron scattering etc. The diversification might be a reason why the term is hardly applied with respect to neutrons at all anymore, leaving it as an artifact to the limited scope of this society with distorted or invalid definition.

Against this background it has become necessary for our community to develop an own scheme of terminology that clarifies the use of high level terminology as much as it defines an extensive set of terms to concisely describe and reflect the diversity of established methodology and applications and to enable extensions in developing and evolving fields.

It is essential for such terminology to be as much as possible consistent with definitions in related fields but also with the general public use of terms in order to enable best possible interdisciplinary communications as well as broad public impact. Indeed in the light of established inconsistencies such endeavor poses some challenges and will not always allow for full equivalence of terms and definitions.

3 High Level Terms and Context: Neutron Radiology, Neutron Radiography and Neutron Imaging.

First this section will investigate and discuss terms which are broader and of higher level and thus including but not defining the subject of this document. Such terms are in general defined elsewhere and are beyond the scope of this document, however, they provide the context of the terminology developed here. Subsequently this section will define the highest level terms of the field that is subject to the activities of the ISNR. The structure is such that first a term is defined, while the lead number will refer to the basic hierarchy of terms and hence its specific position and relation to the matters of ISNR. The definitions will be followed by discussions of the context in relation to other fields of science and applications including such not subject to the ISNR objectives.

3.1 General umbrella terms

The highest level terms are naturally such, describing a general field of which the subject of the ISNR and hence the here defined terminology is a sub-category of. Such terms can be expected to be defined already elsewhere and that such definitions leave room for the specific field in the focus here to be part of these. These terms are listed here and available definitions or the general use of these terms are discussed with respect to how they serve or include and provide a context for the subject in the focus of this document and ISNR.

The terms identified are:

A. Radiology
B. Imaging
C. Radiography
D. Neutron Radiology
E. Neutron Science

3.1.1 Definitions of general umbrella terms

Although these highest level terms are used very frequently in the context and environment of ISNR it was found that not all of them seem to be properly defined. Therefore either a collection of definitions that could be found as well as their sources or self-formulated definitions as close as possible to the known utilization of terms are provided here and discussed below.

A. Radiology

Etymology

1900, "medical use of X-rays," later extended to "scientific study of radiation," from radio-, comb. form of radiation, + Greek-based scientific suffix –(o)logy, branch of knowledge, science (1500, since app. 1800 in nonce formations)
rad, radio-: from radius, Latin, originally: shaft, rod, spoke of wheel, beam of light; radius of circle (1600); potentially related to radix: root
-logy, -ology: from lego/logia/ logos Greek (later Latin), originally: speak, word, speech, account, story

Definition(s)

Encyclopedia Britannica: A branch of medicine that uses some forms of radiation (such as X-rays) to diagnose and treat diseases
Oxford Dictionary: The science dealing with X-rays and other high-energy radiation, especially the use of such radiation for the diagnosis and treatment of disease.
Marriam Webster Dictionary: 1: a branch of medicine concerned with the use of radiant energy (as X-rays) or radioactive material in the diagnosis and treatment of disease. 2: the science of radioactive substances and high-energy radiations
ASTM/E1316: The science and application of X rays, gamma rays, neutrons, and other penetrating radiations

Discussion

Extended research of definitions for the term Radiology underlined the dominance of medicine for the usage of the term. Hence, without providing a specific other context, most definitions found refer to the medical dimension of Radiology. Only in a limited number of cases other dimensions of Radiology and therefore more general definitions, mostly put behind the medical one, are available. In this context the definitions provided by Oxford Dictionary and ASTM are the most general and seemingly least biased by the dominance of a specific field of the highest public relevance. While the Oxford definition points such out, the ASTM definition remains most neutral.

However, already in the Etymology the origin of the term is traced to the discovery and (medical) application of X-rays, while an extension of the meaning has obviously been implied by the discovery of other forms of (penetrating) radiation, which already provides the correct historic context for the term.

Attention has to be paid to the repeatedly used term of "high-energy radiation", for which, however, hardly a definition can be found. It can be concluded, that this term is with high probability mainly used to describe the penetrating nature of the radiation referred to, but does not so much refer to the ionizing or non-ionizing nature or a specific energy limit. (Also Sonography is part of Medical Radiology for example.) This is important because the neutron spectra used cannot in general be characterized as "high- energy" spectra and neutrons are only indirectly ionizing.

It has to be further noted that general definitions of the term Radiology do not refer to a nature of the term related specifically to the production of images, although again, within the medical field radiography, tomography and other forms of imaging are clearly dominant.

Covers of the journal Radiology underlining the dominance of imaging in medical context.

Adopted Definition and Conclusion

In conclusion the topical focus of ISNR as concerned with the science and application of neutron radiation lies within the field of Radiology defined as

3.1.1.A. Radiology: The science and application of penetrating radiation.

B. Imaging

Etymology

20th century, from verb image: make a visual/mental representation, make a copy, from Latin imago, (related to English imitate); root: from Proto-Indo-European aim-, aiem-, iem- : similarity, resemblance; cognate with Sanskrit yamá: pair, twin, Old English emn, efn: equal, level, even;

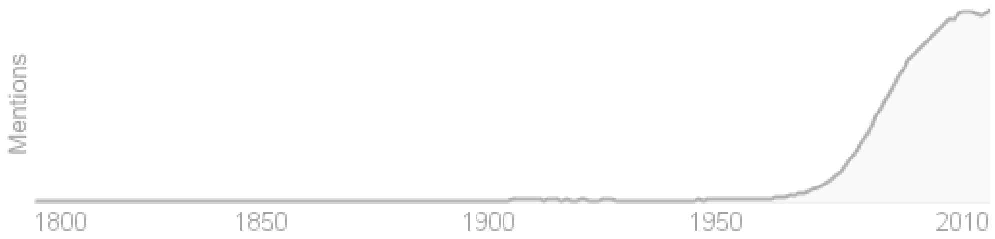
Definition(s)

Cambridge dictionary: The process of producing an exact picture of something, especially on a computer screen;
Encyclopaedia Britannica: The action or process of producing an image especially of a part of the body by radiographic techniques

Imaging in multimedia: Imaging is the capture, storage, manipulation, and display of images (image: the optical counterpart of an object produced by an optical device (as a lens or mirror) or an electronic device)
Oxford Learner's dictionary: The process of capturing, storing and showing an image on a computer screen
(Oxford Dictionary: *Image:* A visible impression obtained by a camera, telescope, microscope, or other device, or displayed on a computer or video screen. *Medical imaging:* The use of electromagnetic or ultrasonic radiation to produce images of organs and tissues within the body for diagnostic or screening purposes.)
Medical Dictionary: The use of computerized axial tomography, sonography, or other specialized techniques and instruments to obtain pictures of the interior of the body, especially those including soft tissues
American Heritage dictionary: Visual representation of an object, such as a body part or celestial body, for the purpose of medical diagnosis or data collection, using any of a variety of techniques, such as ultrasonography or spectroscopy (*medical:* (medicine) obtaining pictures of the interior of the body)

Discussion

Imaging appears to be a very young term (compare figure below). While it is as such not available yet in the standard Oxford dictionary (but only in a form entitled Oxford Learner's Dictionary), on the one hand again strong reference to the Medical field (Oxford Dictionary has imaging only in the combination "Medical Imaging") is found in definitions and on the other hand definitions sometimes imply the involvement of computers to be a characterizing feature.



Use of term "Imaging"

The late establishment of the term might be explained by the corresponding progress of technologies for a broad production and availability of images, first by photography and medical x-ray imaging entering and finally through digital technology becoming an integrated part of our daily life.

It may be concluded, that only the definitions taken together provide a clear picture of what the term Imaging refers to in the most general usage of the word.

Adopted Definition and Conclusion

In conclusion the topical focus of ISNR as concerned with the production of images of the interior of objects lies within a field properly described by the relatively young term of Imaging defined as

3.1.1.B Imaging: The process, science and application of producing images (physically or in the form of data) of objects and phenomena

Where the term Image is defined as

3.1.1.b Image: A real space representation of an object or phenomenon in 1, 2 or 3 dimensions.

C. Radiography (Radiograph)

Etymology

1896, from radiograph (1880), originally a device to measure sunshine; from radio-, comb. form of radiation, + -graph. As a type of image-making device;
rad, radio-: from radius, Latin, originally: shaft, rod, spoke of wheel, beam of light; radius of circle (1600); potentially related to radix: root
- graphy: via Latin from Greek graphos, graphein: something written, to write, to draw, indicating (i) a form or process of writing, representing, etc. (calligraphy, photography) or (ii) an art or descriptive science (choreography, oceanography)

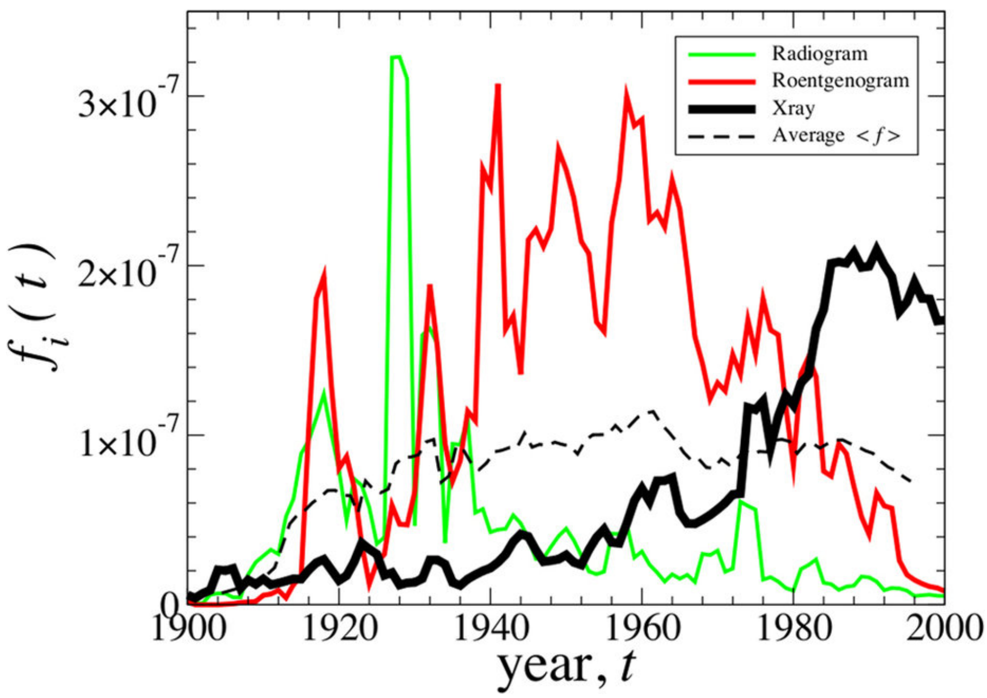


Figure from A.M. Petersen et al., "Statistical Laws Governing Fluctuations in Word Use from Word Birth to Word Death" Scientific Reports 2, 313 (2012), doi:10.1038/srep00313: The English word "Roentgenogram" derives from the Nobel prize winning scientist and discoverer of the X-ray, Wilhelm Röntgen (1845–1923). The prevalence of this word was quickly challenged by two main competitors, "X-ray" (recorded as "Xray" in the database) and "Radiogram." The arithmetic mean frequency of these three time series is relatively constant over the 80-year period 1920–2000, $< f > \approx 10^{-7}$, illustrating the limited linguistic "market share" that can be achieved by any competitor. We conjecture that the main reason "Xray" has a higher frequency is due to the "fitness gain" from its efficient short word length and also due to the fact that English has become the base language for scientific publication.

The definition of the term Radiography is investigated in combination with terms like Radiograph and where needed a few other related terms, as such are used in definitions and hence required for the readability of the first. It has to be noted, that also in correspondence with Etymology the different endings –graph, -graphy and –gram have the same origin. While they all originate in the same Greek term graphos, the ending –graph generally refers to a device or product of the device (Telegraph, Photograph, Monograph), -graphy refers to the process, the product or a field of knowledge (Photography, Telegraphy, Oceanography) and –gram finally mainly to a product (Telegram, Photogram, Radiogram, Monogram).

Definition(s)

Oxford Dictionary: The process or occupation of taking radiographs to assist in medical examinations. *Radiograph:* an image produced on a sensitive plate or film by X-rays, gamma rays, or similar radiation, and typically used in medical examination

Thesaurus dictionary: A photographic image produced by the action of x-rays or nuclear radiation. Also called shadowgraph. *Radiogram:* a photographic image produced on a radiosensitive surface by radiation other than visible light (especially by X-rays or gamma rays)

Medical Dictionaries: The making of film records (radiographs) of internal structures of the body by exposure of film specially sensitized to x-rays or gamma rays

The production of shadow images on photographic emulsion through the action of ionizing radiation; the image is the result of the differential attenuation of the radiation in its passage through the object being radiographed.

The art, act, or process of making radiographs

The recording of an image of a region placed in a beam of radiation; also: Roentgenography, Radiographic Imaging, Imaging

Radiogram: another name for radiograph

ASTM/E1316 definitions: The art, act, or process of making radiographs; *Radiograph:* a permanent, visible image on a recording medium produced by penetrating radiation passing through the material being tested.

Discussion

It becomes obvious, that most definitions originate from times before the availability of digital image recording and hence clearly refer to film and permanent images. The addition of the terms computerized or digital to refer to modern digital techniques seems to be required.

On the other hand the focus is not necessarily on medical imaging, but many definitions are more general concerning the radiation used and objects exposed. The context of Imaging appears regularly.

Several terms seem to be in use alternatively to Radiography and Radiograph. (The study represented in the above Figure suggests that in general language use the term Xray for an X-ray radiograph is dominating nowadays. This is similar to many other cases of unprecisely customized language use in the medical context, like e.g. "Ultrasound is a type of imaging". Or: "neutron radiography: that in which a narrow beam of neutrons from a nuclear reactor is passed through tissues; especially useful in visualizing bony tissue.")

In general no hints are found that the term Radiography would contain also tomography as a technique producing three dimensional or cross sectional images in contrast to e.g. the medical definitions for Imaging. Definitions that assume all kinds of (medical) imaging techniques included in the term (digital/computerized) Radiography are absolute exceptions.

Adopted Definition and Conclusion

In conclusion the topical focus of ISNR as concerned with the production of images of the interior of objects utilizing neutron radiation, i.e. Radiographs/Radiograms has a strong overlap and is at least partly contained in the field described by the term Radiography defined as

3.1.1.C Radiography: The process, science and application of producing a projection image (Radiographs, Radiograms) by means of penetrating radiation.

Where Radiograph/Radiogram shall be defined as

3.1.1.c Radiograph/Radiogram: A one- or two-dimensional projection image recorded by means of penetrating radiation.

D. Neutron Radiology

Definition

As compared to (A) Radiology, here just the word Neutron is added, which commonly means nothing else but that the meaning of the word is here further specified and the frame of reference limited to a specific kind of Radiology, namely the one concerned with Neutron radiation. Consequently Neutron Radiology is a subfield of Radiology defined as:

3.1.1.D Neutron Radiology: The Radiology concerned with neutron radiation

or

3.1.1.D Neutron Radiology: The science and application of neutron radiation

This, however, implies, that Neutron Radiology is not only concerned with the production of images utilizing neutron radiation or with Radiography using neutrons, but also with the study of the neutron itself or its application in many fields of material science, like neutron diffraction and spectroscopy. It has to be further noted, that the term Neutron Radiology is not very much in use in the context of Neutron Science and Physics in general. One reason might be that the term Radiology is very much publicly occupied by the specific medical meaning. Another reason might be that it does not refer to science in particular. It seems to be nowadays to be mainly used in the context of real space investigations with neutrons in particular in the context of ISNR. Therefore the term Neutron Science shall be discussed below in addition.

E. Neutron Science

Etymology Science

Science: from Latin scire, to know to Latin scientia via old French to English: science

Definition Science

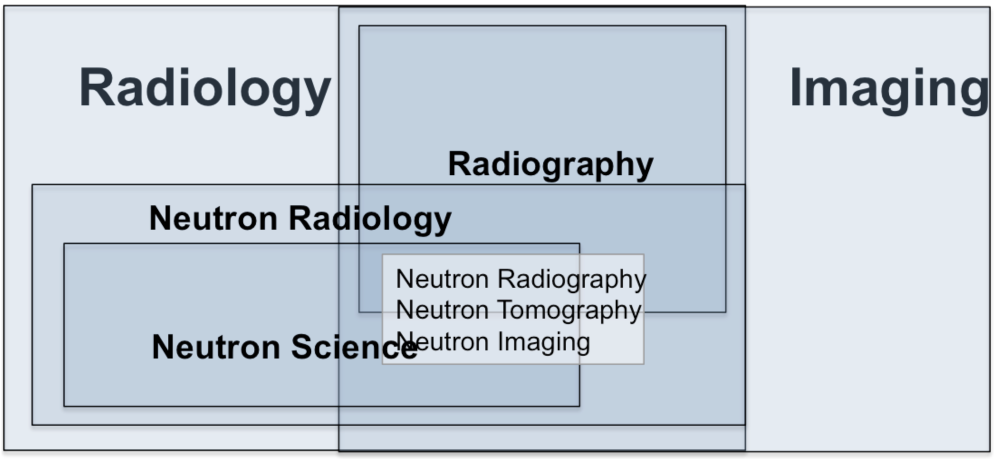
Oxford Dictionaries: The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment

Definition and conclusion

Again the word Neutron acts to classify a specific sub-field. Hence, though there is no specific definition of Neutron Science to be found elsewhere it can be defined as:

3.1.1.E Neutron Science: The science involving neutrons/ neutron radiation (as a subject or a probe)

It can be concluded that the subject matters of the ISNR are strongly overlapping with the field of Neutron Science, but only to the degree that Science as Science is concerned, not when well established or even standardized techniques are simply applied for non-destructive testing or other industrial/commercial applications. The pure application of neutron radiation without any added scientific value, which is included in Neutron Radiology but not in Neutron Science distinguishes these two fields and terms and makes Neutron Science a sub-category of Neutron Radiology.



Context of Terminology for ISNR with respect to higher-level general umbrella terms like Radiology, Imaging, Radiography etc.

3.1.2 Discussion and Conclusion

The above discussed and defined high level umbrella terms provide the framework for the terminology developed here for the requirements of the ISNR and its subject that include on a high level terms like Neutron Radiography, Neutron Tomography and Neutron Imaging. A schematic of this context and framework corresponding to the above is sketched in the Figure above.

According to the definitions derived the terminology, which is the main subject of this document, is to be located in the context and as a part of the overlap of the lead terms Radiology and Imaging but also Neutron Radiology, which it self is a sub-category of Radiology. Furthermore there is a strong overlap with the big fields of Radiography and Neutron Science. While Neutron Science does not include non-scientific areas of the subject matter, whether Radiography is suited to fully host the subject requires more detailed considerations and discussions of the definitions.

Radiography is largely still defined as producing physical images and terms acting to extend these definitions towards digital or electronic data collection are applied. In any case the nature of the hitherto defined images seems to be 2-dimensional projection images. No definition of Radiography is e.g. to be found which would include Tomography, as the production of cross sectional or 3D images. In contrast to the term Imaging, which implies physical, electronic (Radioscopy, comp. ASTM (STSM) E1314) and digital image data and also hosts tomographic techniques. In addition this seems to be particular also the case for any earlier approaches to characterize the terminology with respect to neutron techniques. However, it has to be also stressed that the term Imaging in contrast to Radiography does not seem to refer to penetrating radiation only, and can hence also host conventional Photography or Microscopy.

It is therefore concluded for this terminology, that the term Radiography relates to any form of up to 2D imaging with penetrating radiation, but is different from Tomography and imaging with visible light. Consequently the term Radiography does not fully convey the subject of the ISNR and its terminology but is strongly overlapping with it. However, it has to be also noted, that the process of producing e.g. Tomograms might still be considered a Radiographic process, because recording plain images is to some extend essentially the basis of producing Tomographic data sets and images.

The term Neutron Radiology on the other hand must appear to wide to specify the content in the remit of ISNR and its members sufficiently as it defines a much wider field of techniques and expertise not represented in the ISNR. However, ISNR carries the term Neutron Radiology in its name. Hence, if the name shall be kept there appear only two possibilities, either (i) to deviate from the general definition of Radiology for Neutron Radiology and create an own one only relating to the own matters, or (ii) to significantly increase the scope of ISNR and try to collect all Neutron Science and Application in this framework. The latter does neither seem promising, as the field has grown very large and has its own societies for specific technologies and applications, which the current members of ISNR would loose in this case. The first would be a measure hard to justify in a scientific environment. It is therefore proposed to replace the term Radiology in name of ISNR. Potential alternatives shall be discussed after lying down the high level terms of the subject matter of ISNR below.

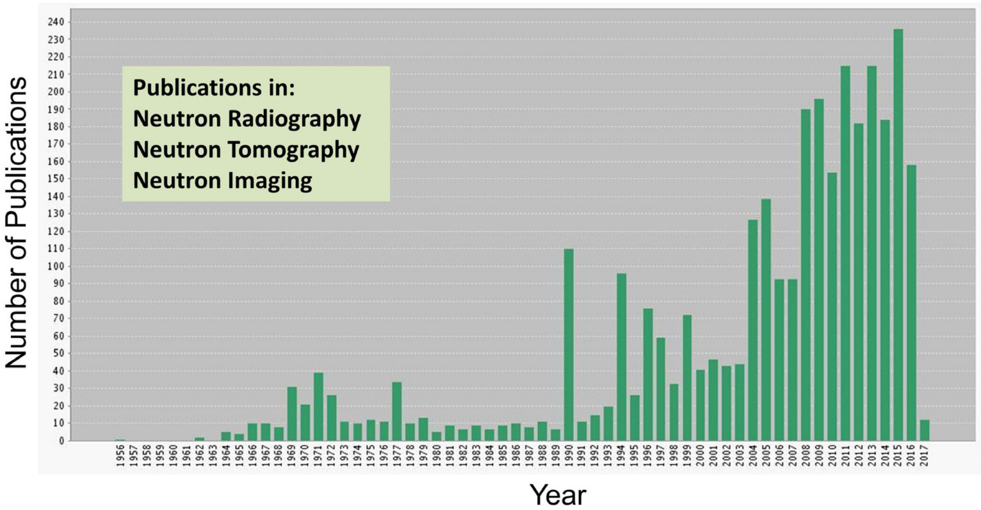
Markus Strobl (convener)
Eberhard Lehmann, Frikiie de Beer, Ulf Garbe, Dan Hussey, Thomas Bücherl

This work on terminology is put up for discussion. Comments can be mailed to the convener Markus Strobl (markus.strobl@esss.se), directly, or to Thomas Bücherl (Thomas.buecherl@tum.de) who will forward the comments to the Task Group members.

Actually the Task Group is working on the definition of the high level terms like Neutron Imaging, Neutron Radgraphy and Neutron Gauging. The results will be presented in the next issue of the NR Newsletter and on the ISNR webpage.

Task Group "Publications"

The working group considers setting up a neutron imaging publication database on the ISNR website to help members and users of neutron imaging facilities keeping track of neutron imaging studies and of work of colleagues. The number of publications on neutron imaging has noticeably increased over the past decade (see Figure below); there are nowadays up to 200 papers per year of applications, technique development and instrumentation of neutron imaging.



Number of neutron imaging publications between 1956 and 2017, based on the search of the following keywords: 'neutron radiography', 'neutron tomography', 'neutron imaging' (Source: Web of ScienceTM).

A basic version of a neutron radiography publications database already exists on the RadSci Consultancy website (*http://www.radsci.co.uk*). We encourage ISNR members to submit reference of papers, book and thesis references to John Rogers (john@radsci.co.uk). Please note that the RadSci database lists publications that may not be found with bibliographic search engines; i.e. papers in conference proceedings, and work published in PhD and master theses.

Winfried Kockelmann

Publications

Two open-access journals of possible interest to neutron imaging community

Pavel Trtik (Neutron Imaging and Activation Group. Paul Scherrer Institut, Switzerland: link: *https://www.psi.ch/lns/pavel-trtik*) would like to draw the attention of the neutron imaging community to two open-access journals.

MehtodsX ISSN: 2215-0161 (online)

https://www.journals.elsevier.com/methodsx

MethodsX is a peer-reviewed open access online journal that publishes important customizations experimentalists (e.g. beamline scientists) make to their methods on every day basis. It focusses on the publication of the essential details of the tweaks scientists have made to a method, without necessity of spending time on writing up a traditional article, with detailed background and contextual information.

A MethodsX article features:

- an abstract to outline the customization
- a graphical abstract to illustrate visually the customization
- the method(s) in sufficient detail to help others replicate it, including any relevant figures, tables etc
- up to 25 references to the original description of the method

Current price for publications: about 460 Euros

Examples of MethodsX publications relevant to the neutron imaging community are here (*http://www.sciencedirect.com/science/article/pii/S2215016116300103*) and here (*http://www.sciencedirect.com/science/article/pii/S2215016116300346*).

Acta Polytechnica ISSN 1210-2709 (Print) ISSN 1805-2363 (Online)

https://ojs.cvut.cz/ojs/index.php/ap

ACTA POLYTECHNICA, Journal of Advanced Engineering, is a peer-reviewed Open Access scientific journal published by the Czech Technical University (CTU) in Prague. It aims to be a high-quality, multi-disciplinary journal presenting both basic theoretical research and experimental research findings in the area of engineering, physics and mathematics.

Current price for publications: 0 (zero) Euros

For Acta Polytechnica is subsidized by the Czech Technical University in Prague, it is one of few open access journals that do not collect any fees from the authors for the publication.

Both the journals are indexed by Scopus database.

Pavel Trtik is member of the Editorial Boards of both the MethodsX and Acta Polytechnica.

In case of any further queries, do not hesitate to contact him directly (pavel.trtik@psi.ch, ptrtik@gmail.com).

Pavel Trtik

New publications

If you are aware of some new publications related to neutron radiography, imaging etc. please send the references and a (short) version of papers (modified abstracts with one or two different images, graphs etc. to Winfried Kockelmann (winfried.kockelmann@stfc.ac.uk) or Thomas Bücherl (thomas.buecherl@tum.de), who will forward your e-mail to Winfried. Please take care of copyright!

Until the database on publications on the ISNR website is completed please refer to the website of John Rogers (*www.radsci.co.uk*).

Upcoming conferences and workshops

Other Conferences

NEUWAVE-9
9th NEUtron WAVElength-dependent Imaging workshop
11-14 June 2017 at NIST in Gaithersburg, MD, USA
https://www.nist.gov/news-events/events/2017/06/neuwave-9

ICNS Korea
International Conference on Neutron Scattering 2017
9-13 July 2017, Daejeon Convention Center, Daejeon, Republic of Korea
http://www.icns2017.org/

AccApp'17
13th International Topical Meeting on the Applications of Accelerators
July 31-August 4, 2017, Hilton Québec Hotel, in Québec City, Québec, Canada

WCNR-11
11th World Conference on Neutron Radiography
September 2018, Sydney, Australia
www.ansto.gov.au/Events/WCNR-11/index.htm

WCNDT 2020
20th World Conference on Non-Destructive Testing
June 8-12, 2020, Seaoul, Korea
www.wcndt2020.com

ITMNR-9
9th International Topical Meeting on Neutron Radiography
2020, Argentina

Call for bids

Candidates for hosting the **12th World Conference on Neutron Radiography** (WCNR-12) in 2022 are asked to send their interest to the secretary of ISNR Thomas Bücherl.

Call for contributions for the next **NR Newsletter** (Deadline 31. October 2017)

... and finally

please review your data on the website (*www.isnr.de/index.php/about-us/list-of-members*) and inform me on errors and / or changes.

Editor

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