International NR Newsletter

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International Society for Neutron Radiography

(www.isnr.de)

Content

Editorial

Dear colleagues,

conferences, meetings, workshops etc. are always a big challenge for the organizers. Venue, date, budget, accommodation, "urgent" requests of possible participants …, all this is handled by a local organization committee, most time being volunteers whose contribution to the success of an event is often not realized and hence not really recognized by participants. And there is the selection of accepted abstracts for oral and poster presentations, of keynote speakers and invited talks. Here, the (international) scientific program committee comes into the game. As the name indicates, it has to evaluate the abstracts according to their scientific relevance and hand over a suggestion for the program to the organizers. But this is not the end of the game. The organizers themselves may have further criteria for the selection, like reasonable gender, regional equilibrium, ethnical diversity …, sometimes denoted as "political correctness". As stated in the section "About us" of the ISNR webpage, *the "International Society for Neutron Radiology – ISNR" is the main and only platform world-wide for the interaction and communication of experts and users involved into the field of the neutron usage for radiographic and imaging purposes. It was built mainly to establish a democratic structure for the organization of international conferences…* To my personal opinion, this already prohibits any kind of exclusion of participants, as long as human values are met. What does this mean for organizers and the suggestion of a scientific program committee and what are the implications for ISNR members? First, the organizers are finally responsible for the program (and the success) of the meeting, i.e. they will do their best to set-up an interesting and well-balanced program based on the suggested list of accepted abstracts. Second, it's in the responsibility of all members of ISNR to share their knowledge on neutron imaging with others, independent of gender, provenance etc. and especially - within the realms of possibility - by educating and training interested (young) people. In doing so with open minds, the discussions on gender, ethnics etc. hopefully will become obsolete in the near future.

As a small contribution to education, we selected "tomographic reconstruction software" as the main topic of this issue. It is intended in giving information for newcomers as well as for experienced users. After a general introduction we have a look on the trends for the reconstruction of neutron tomography data in the next decade with focus on the software packages MuhRec and iMars3D. A look how data reconstruction is actually handled at a running facility (DINGO) and a few more words on iMars3D complete the section. In addition the contribution of Sergey Kichanov in NR Newsletter No. 12 entitled "The first steps in neutron tomography processing: a freeware solution" is also giving helpful information. At WCNR-11 in Sydney it was realized that fast neutron imaging (FNI) is of increasing interest. Based on an ad hoc meeting a "fast neutron mailing list" was initiated becoming a very active forum for discussion of different topics related to FNI contributing to information exchange, education (by following the discussions) and help. These two examples may hopefully give you ideas how to actively contribute in the dissemination of knowledge on NI. So, what's about a New Year's pledge to write an article for the next NR Newsletter or for the ISNR webpage, to actively participate in the discussion via mailing lists, maybe initiate new mailing liste etc.

Wishing you all the best for 2020

Thomas Bücherl

Words from the ISNR President

These are truly exciting times in the neutron imaging community. There are many reasons for optimism. User facilities are continuing to support researchers. High quality papers are published in peer-reviewed journals daily. We read and hear about many upgrades to neutron imaging facilities and instruments. New instruments are coming online. Instruments that are being decommissioned are quickly being integrated into facilities elsewhere. Applications neutron imaging are expanding into new scientific and industrial applications. Modern accelerator sources are being developed that yield useful neutron beam flux and collimation capable of producing high quality radiographs. New standards are being developed for modern techniques beyond film-based neutron radiography. Yes, there is much reason for optimism!

This newsletter contains multiple contributions on tomographic reconstruction software. Octopus Reconstruction software has long been a common CT reconstruction tool used by the neutron imaging community. Unfortunately for some in our community that use this software, Octopus announced in September 2019 that they decided to discontinue sales of their software so they can focus their efforts on supporting X-ray micro-CT systems. Fortunately, there are many replacement options for CT reconstruction software, some of which are highlighted and described in this newsletter and on the ISNR website (www.isnr.de). It is an indication of a strong community that there are many alternatives available when a common resource becomes unavailable.

Perhaps the most important role of the ISNR is to organize conferences and topical meetings where the neutron imaging community can interact and communicate. This newsletter includes a summary of recent meetings: NEUWAVE-10 held at Paul Scherrer Institut, Switzerland in May of 2019; Experts Meeting on Fast Neutron Imaging held at Technische Universität München, Germany in October of 2019; X-ray and Neutron Phase Imaging with Gratings in Shendai, Japan in October 2019; and a Software Imaging Workshop at Oak Ridge National Laboratory, USA in October 2019.

This Newsletter also includes information on one of the ISNR's main international meetings, the International Topical Meeting on Neutron Radiography (ITMNR-9) which will be held in Buenos Aires, Argentina.

The 12th World Conference for Neutron Radiography (WCNR-12) will be hosted by Idaho National Laboratory in 2022. Planning for WCNR-12 is already well underway, and we are currently considering dates in June of 2022. We look forward to seeing all of you.

I offer all of you my encouragement with your work, and many thanks to all of you who are actively working towards the advancement of our neutron imaging community.

Aaron Craft

Methods and programs for reconstruction of CT data

General introduction to CT reconstruction on a neutron source

(Several segments of this text are taken from [1])

Beam shape and collimation

An X-ray tube is a quasi-point source (the size of the focal spot) that emits radiation in a cone. The resulting projection magnifies the sample onto the detector (Fig.1a). Pictures of the sample 180 degrees apart are obviously not the same even when one image is flipped.

Since neutron sources like nuclear reactors or accelerators deliver weak neutron intensities compared to an X-ray tube or synchrotron source, making a point source is not possible. Flight tubes are used to extract neutrons from the extended source area. Comparatively large openings are used to get a neutron beam, resulting in geometric unsharpness of the neutron radiography projection of a sample, caused by bad beam collimation. The same is true for the use of neutron guides, where the maximum angle of reflection on the mirrors defines the beam collimation. The only way to generate a quasi-parallel neutron beam is to use a small pinhole opening of a few mm to cm size close to the source and in large distance to sample and detector. The diameter of this pinhole of course limits the total available neutron flux at the sample position.

Using an X-ray tube, the focal spot size of the electron beam on the anode limits the achievable spatial resolution. The emitted come beam projects a magnified image of the sample onto the detector, so even large detector pixels can depict fine details of the magnified sample (Fig 1a).

In a perfectly parallel beam like at a synchrotron, the sample is projected onto the detector with its original size, so the detector resolution limits the achievable spatial resolution.

For neutrons, the beam geometry is an approximation to a parallel beam (Figure 1b), so there is no inherent magnification.

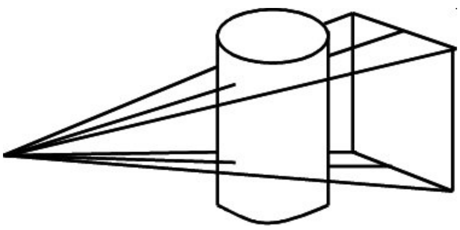
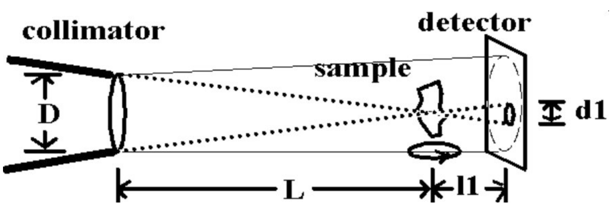


Figure 1. (a) This is a figure magnifying cone beam projection,



(b) beam geometry for neutron imaging: Approximation to parallel beam.

The smallest diameter D of the collimator acts like a pinhole camera that projects the source area onto the detector. But the collimator also acts as an effective source area (compared to the focal spot in an X-ray tube) that determines the achievable spatial resolution by the angular range of neutrons that hit the sample. Collimation is defined – (this is currently under discussion) as the ratio of the sample to source distance L and the smallest collimator Diameter D (Fig 1b). Since L is usually rather large (several meters) in the neutron case, L is often also defined as the distance to the detector, provided the sample is placed close to the detector. Due to the size of the effective source area – the diaphragm of the collimator – each point of the sample sees incoming neutrons from a beam cone that again projects the point onto a blurred disk on the detection screen. To keep the blur to a minimum, the diameter D of the diaphragm should be small, the distance L between diaphragm and sample should be large, and the distance d between sample and screen should be small. As a rule of thumb, for imaging (and rotating) small samples of several centimeter size, the collimation should be no smaller than L/D=100 as an absolute minimum. For a perfectly parallel beam, an image of the sample is identical to an image rotated by 180 degree, and flipped horizontally.

CT Recording Strategy

The best explanation of computed tomography known to us is given in Kak and Slaney's book Principles of Computerized Tomographic Imaging [2]. From this, we learn that mathematically exact, a CT reconstruction requires Pi/2 times as many projections as the maximum width of the sample in pixels. However, this seems to be an asymptotic curve, and with other sources of unsharpness, much less projections deliver good results. In a quasi-parallel neutron beam, about 900 projections for a 2048 pixel camera deliver very good results. Using 1200 projections shows an improvement in quality that is noticeable, but usually not worth the extra measurement time. For a parallel beam (opposed to the cone beam from X-ray tubes), the second half of a full rotation is identical to the first half, save for a flip and shift of the image, and does not introduce additional angular information. Although a range of 180 degrees would be sufficient for a parallel beam CT, doing a full rotation is desirable to reduce beam hardening artefacts: A dense sample attenuates the lower neutron energies more than the higher energies of the spectrum. Thus, higher energies penetrate the sample better, the effective neutron spectrum has a higher average energy behind the sample, because the lower energies were absorbed more. The assumption of a monochromatic neutron beam which undergoes exponential attenuation is no longer valid, the reconstruction of the sample shows an artefact of a dense semi-ring of higher attenuation, since low-energy neutrons are absorbed close to the surface of the material. The other half of the circle shows a weakly defined surface. This effect is much reduced when using a 360 degree scan, and in addition, reconstruction can still be performed when the measurement stops for technical reasons (computer crash etc.) after at least acquiring 180 degrees.

To avoid doing a repetition of images in the second half of the rotation which would not introduce additional angular information, we use an odd number of increments to reach 360 degrees, so the position 180 degrees is never reached exactly, and the projections of the second half do not coincide with the projections of the first half of the full rotation. The exact 180 degree position is still required for the determination of the rotation axis and its tilt, so we record the 180 degree image first, then rotate back to zero degrees to begin the full CT scan. To avoid contouring errors by the gearbox of the turntable (if no absolute feedback is given by encoders), the table may turn back beyond zero degrees to a negative value, then switch direction to approach zero degrees from the same side as the 180 degree position.

Data Processing of Raw Images

All Images need to be normalized to the beam profile, i.e. divided by an open beam image that contains the intensity distribution of the beam. In addition, every camera has a little fixed offset from zero so that the analog-to-digital converter never gets fed negative values which might arise from noise symmetrical around zero. The camera chip also produces thermal charges that cause additional offset and noise. To correct for that, dark frames of identical exposure time without an image signal are subtracted from both the projections and open beam images before the normalization.

The corrected projections are divided by the corrected open beam images.

Depending on the employed software, these steps may be performed by the reconstruction software (like MuhRec, [3]) itself, but most X-ray software or the new Module TomoJ [4] in ImageJ/Fiji requires the preprocessing steps done by hand.

Then, the center of rotation and a potential tilt of the rotation axis must be determined. If the rotation axis was perfectly centered and upright, the zero- and 180-degree images would be identical, save for a horizontal flip of the 180 degree image.

Subtracting the flipped 180-degree image from the zero degree image will thus result in an image close to zero. If the rotation axis is not aligned, dark and bright edges will appear. With the width of these edges measured, half as many columns need to be cut off the original images on either the left or right side until the subtraction delivers near-zero and the edges disappear. Similarly, if the rotation axis is tilted, both original images need to be rotated until the subtraction delivers near-zero.

Finally, –log must be performed on the data, since the image signal I corresponds to the open beam signal I_0 as $I=I_0 \cdot \exp(-\mu x)$, so the attenuation coefficient μ is calculated as $\mu = -1/x \cdot \log(I/I_0)$.

The resulting data may be fed to any reconstruction program.

The most commonly used commercial reconstruction software 'Octopus' is soon no longer sold and supported, several freeware solutions were examined in [5], but new solutions have emerged that are treated in consecutive articles in this issue.

References

1. *B. Schillinger, An affordable image detector and a low-cost evaluation system for computed tomography using neutrons, X-rays or visible light, https://www.mdpi.com/2412-382X/3/4/21*
2. *Principles of Computerized Tomographic Imaging. Available online: http://www.slaney.org/pct/pct-toc.html*
3. *http://www.imagingscience.ch/tools/*
4. *http://www.cmib.fr/en/download/softwares/TomoJ.html*
5. *Schillinger, B.; Craft, A.E. A freeware path to neutron computed tomography. Phys. Procedia 2017, 88, 348–353.*

Burkhard Schillinger

Reconstructing neutron tomography data in the next decade

Introduction

Tomography has today become a standard technique at most neutron imaging stations worldwide. The method is continuously evolving intending to allow shorter scan times or to increase the spatial resolution. The progress is made using improved hardware such as better optics, new detector techniques, and revised sample environments. In addition to the hardware development, there have also been considerable efforts in improving the image quality using new reconstruction techniques and image processing workflows to improve the information output also for data with poor signal to noise ratio.

Tomography reconstruction software is a central component of the experiment workflow. Its task is to transform the raw projection data from the instrument into volume images representing the three-dimensional structure of the investigated sample. In the last decade, it has been a de facto standard in the neutron imaging community to use the commercial software Octopus for this task. Late this summer, many of you probably received an email announcing the end-of-sale for Octopus. This announcement faces us with the question; What happens when Octopus is not sold or even updated anymore? Fortunately, there are many alternatives to fill the gap and to replace Octopus in our workflows. In this article, we will give you an overview of the available open-source options and give you some guidance in the choice of your primary tool for tomography reconstruction in the future.

Guide to the choice

Choosing the right tool can be hard, and the first step is to identify your needs, ability to work with the different alternatives. You also have to decide the amount of time you are ready to invest in learning. In particular, when you decide to work with some of the more advanced techniques.

Today, there are two main categories of reconstruction software; (1) script-based frameworks (CLI) using libraries that can be imported in, for example, Python or Matlab and (2) tools with a full graphical user interface (GUI). Both options are well motivated and will also co-exist in parallel as they target different use-cases. CLI tools are ideal for experiments that require high flexibility in configuring the reconstruction chain and for reconstructing multiple data sets with the same geometry, e.g., time-series or wavelength resolved data. CLI tools also allow using the latest development in iterative reconstruction techniques earlier and more flexible than in GUI based tools. The backside of these tools is that the user has to have some programming skills to be able to work with the scripting language and also understand the used techniques on a more detailed level. These tools are also less convenient for occasional reconstruction tasks of single samples. This is the niche of GUI based reconstruction tools. By providing direct visual feedback to the user, these tools are more suited for single specimen reconstructions. Features like selecting regions of interest using mouse operations and wizards to help the user to tune the reconstruction make the instruction task much easier for the instrument scientist who is supporting the experiment user. These tools are easier to learn but do not provide the flexibility of CLI tools. There are also hybrids between CLI and GUI based tools that aim at offering the benefits from the two approaches while the disadvantages are kept to a minimum. Finally, we would also like to mention a third option: start your own development. The advantage is that you can tailor your tool to your needs. This is, however, a very resource-demanding choice, and it is most likely better to join the development of existing open-source projects and, in these projects, focus on the specific feature you want to add.

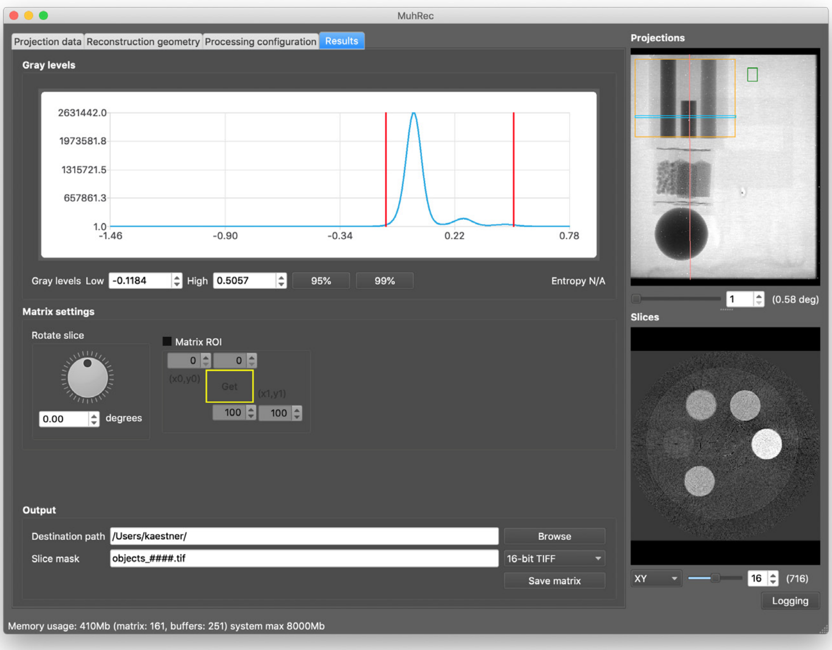
Tool overview

The tools we report here are based on open source development and can be used without any commercial base platform. This is an important aspect in a future where open science is becoming increasingly important.

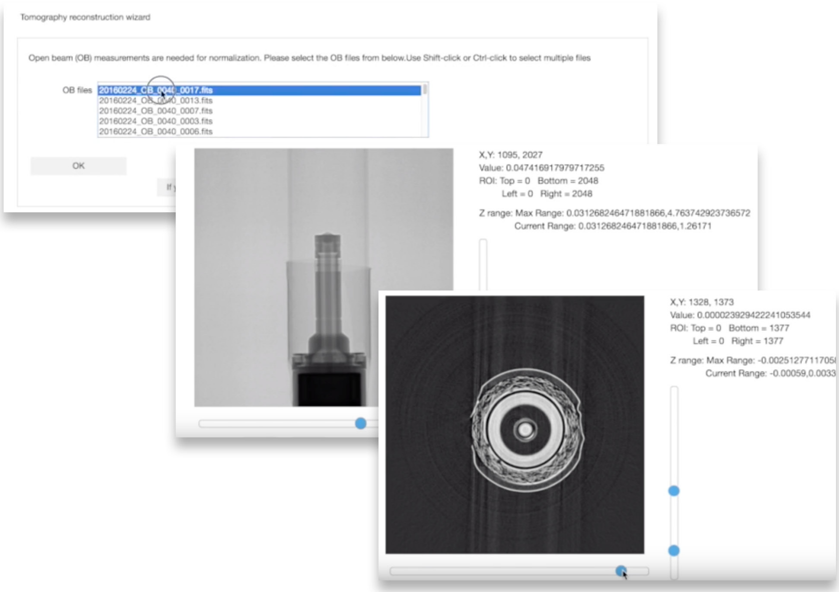
The most known CLI tools are the ASTRA toolbox originating from the University of Antwerp and provide a collection of analytic and iterative reconstruction techniques with a backend implemented on the GPU to speed up the reconstruction. The ASTRA toolbox can be used directly with the native C++ interface, but most users prefer to use the toolkit in Python or Matlab. Tomopy and NeuTomPy are two high-level toolkits that provide additional tools to estimate the reconstruction center and filters to reduce artifacts. Both toolkits provide a binding to ASTRA to benefit from the advanced methods provided there. Currently, Tomopy has a more active community and also has a greater user community than the more recent NeuTomPy.

For those who prefer to work with their data with more interaction, there are currently two alternatives with long development history and active development that provide GUIs to guide the configuration of the reconstruction task; these are MuhRec and iMars3D. The tools have different approaches and are also developed in different programming languages. MuhRec is a GUI based tool, which is developed at Paul Scherrer Institut, Switzerland, and now also is part of the tool suite for the European Spallation Source in Sweden is developed in C++. It is released as self-contained binaries that run on the leading operating systems. iMars3D is python-based and requires a python installation to run. The UI is provided via a Jupyter notebook that contains widgets to guide the users through the workflow. The fact that it is running under python makes it available on any system where a python installation is possible. The current state of the program is tailored to work on the file system used at the Oak Ridge National Laboratory, but a few minor modifications would allow it to work on any file system.

MuhRec currently supports filtered back-projection for parallel and divergent beam and has a collection of pre-processing filters and algorithms to correct for common artifacts and also scattering correction. Correcting for biases caused by scattering is essential for quantitative neutron imaging. Without this correction, the reconstructed data suffers



Screenshot of MuhRec



Screenshot of iMars3D

from radial intensity gradients that make analysis harder, and the attenuation coefficients are usually underestimated. The user interface of MuhRec has evolved into a tool that guides the user through the different tuning steps required to perform the reconstruction. MuhRec is designed to run under various conditions. It can be used with limited hardware resources; e.g., a full volume can be even reconstructed on a laptop computer for test reconstructions. On the other extreme, it can be called in scripts to allow mass-reconstruction of time-series or wavelength resolved tomographies. MuhRec also comes with user documentation in the form of a wiki. We also have a project to produce tutorial videos for those who are not able to participate in schools where the tool is demonstrated and used. We are currently in the process of preparing the next release of MuhRec, which will be available in January 2020.

iMars3D provides a user interface to the reconstruction and filter features provided in TomoPy. Therefore, it also offers the option to use iterative reconstruction techniques in addition to the filtered back-projection options.

Conclusion

Today, there are several open-source alternatives to reconstruct tomography data set that, depending on your needs and experience, will allow you to reconstruct the data from your experiments. With the options presented here, we believe there are sustainable solutions to reconstruct tomography data from neutron imaging experiments. There are further ongoing local development projects in the neutron imaging community. We would, however, like invite the developers of these projects to join our efforts to develop a few tool suites. The benefit of joint development is better utilization of developer resources, in particular, when many projects already are based on the same core technology for the reconstruction. A further very important argument for reducing the number of projects doing the same work is that it increases the interoperability between different facilities, and the experiment users will recognize the analysis workflow when they perform experiments at neutron imaging facilities worldwide.

Links

https://www.astra-toolbox.com/
https://tomopy.readthedocs.io/
https://pypi.org/project/neutompy/
https://neutronimaging.github.io/
https://github.com/ornlneutronimaging/imars3d

Anders Kaestner, Chiara Carminati, and Jean Bilheux

DINGO exploration of Python packages for tomographic data reconstruction

The increased demand for free software solution to reconstruct neutron tomography data by the user community, and the necessity to have a better control over the computation process has led to implementation of existing python packages on the neutron imaging beamline DINGO at Australia's Nuclear Science and Technology Organisation (ANSTO).

In order to simplify package management and deployment, Anaconda [1] has been used. Anaconda is a free and open-source distribution of the Python [2] and R programming [3] languages for scientific computing that can be installed on Linux, Windows, and Mac OS X.

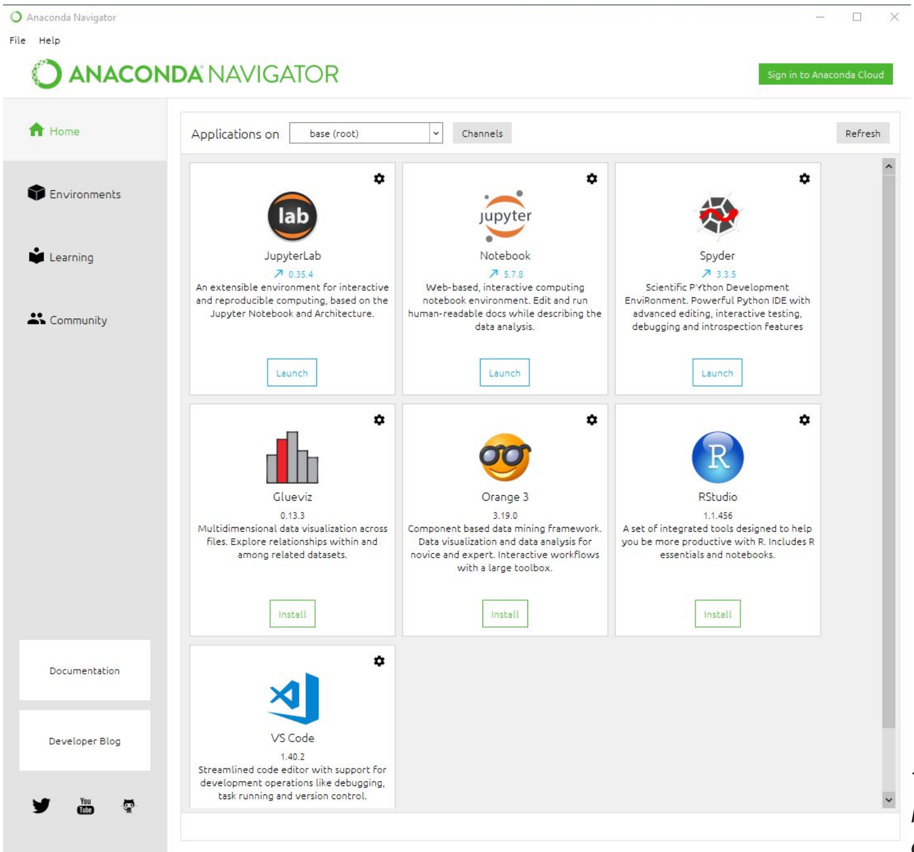
As well as Python and hundreds of scientific open-source packages, Anaconda Distribution includes conda and Anaconda Navigator. Conda is the package management system and environment management system that works on command line interface such as Anaconda Prompt on Windows and terminal on macOS and Linux. Navigator is a graphical user interface that allows you to launch applications and easily manage conda without using command-line commands. Further documentation can be found here [4].

At DINGO we have deployed Anaconda 2019.10 with Python 3.7 thought the downloadable installer on machines operating Windows or Linux.

Different toolboxes and packages are currently available that contains 2D parallel and fan beam geometries, and 3D parallel and cone beam as well as a large number of 2D and 3D reconstruction and filter algorithms. To name a few ASTRA [5], TomoPy [6] and NeuTomPy [7]. Different toolboxes can be also installed and used together, to exploit the advantages of a flexible and integrated environment [8]. To install NeuTomPy[7] with Pyhton 3.7 you have to use the development package for ASTRA-Toolbox and you have to install opencv via PIP instead of using conda. The rest works according to the installation instruction for Python 3.6.

We have first set the NeuTomPy toolbox because of a more user friendly procedure to select a region of interest and a centre of rotation. As mentioned it is important to pre-install the listed dependencies via Anaconda prompt on Windows or terminal on Linux and only after the toolbox. It is recommended to install the whole package in a separate environment (please read Anaconda documentation).

Although several different options are available, after installation of NeuTomPy, Spyder [10] has been chosen as development environment for editing, analysis, debugging and interactive testing, etc ... Typically there is no need to install it since is already pre-set in Anaconda Navigator.



Typical Anaconda Navigator graphical interface

Now everything is ready for coding your data treatment and reconstruction procedure according to your local settings. See the example script for DINGO below.

```
#!/usr/bin/env python
# coding: utf-8
# In[ ]:
# -------------------------------------------------------------------
# This script performs a complete reconstruction workflow.
# The reconstruction algorithm used is the FBP performed on a GPU.
# -------------------------------------------------------------------
import numpy as np
import neutompy as ntp

# set pixel size in cm()
pixel_size  = 0.0015

# set the last angle value of the CT scan: np.pi or np.pi*(angle/180)

last_angle = np.pi*(180/180)

# read dataset containg projection, dark-field, flat-
field images and the projection at 180 degree
proj, dark, flat, proj_180 = ntp.read_dataset()

# normalize the projections to dark-field, flat-field images and neutron dose
norm, norm_180 = ntp.normalize_proj(proj, dark, flat,
proj_180=proj_180, dose_draw=True, crop_draw=True)

# rotation axis tilt correction
```

```
norm = ntp.correction_COR(norm, norm[0], norm_180)

# clean up memory
del dark; del flat; del proj; del proj_180

# remove outliers, set the optimal radius and threshold
norm = ntp.remove_outliers_stack(norm, radius=2,
threshold='local', outliers='dark', out=norm)
norm = ntp.remove_outliers_stack(norm, radius=6,
threshold='local', outliers='bright', out=norm)

# perform minus-log transform
norm =  ntp.log_transform(norm, out=norm)

# remove stripes in sinograms
norm = ntp.remove_stripe_stack(norm, level=7, wname='db25', sigma=2.5, out=norm)

# define the array of the angle views in radians
angles = np.linspace(0, last_angle, norm.shape[0], endpoint=False)

# FBP reconstruction with the hamming filter using GPU
print('> Reconstruction...')

rec0    = ntp.reconstruct(norm, angles, 'FBP_CUDA', paramete
rs={"FilterType":"hamming"}, pixel_size=pixel_size)

# select the directory and the prefix file name of the reconstructed images to save.
recon_dir0 = ntp.save_filename_gui('', message = 'Select the fold-
er and the prefix name for the reconstructed images...')

# write the reconstructed images to disk
ntp.write_tiff_stack(recon_dir0, rec0,overwrite='true')
```

The integration of different toolboxes in the same environment is still work in progress. Eventually this will allow to exploit the most advantageous features provided by different packages, such as GPU offloading useful especially for iterative reconstruction methods, access a border variety of algorithms and so on (Gridrec in TomoPy [11]).

References

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[2] https://www.python.org/
[3] https://www.r-project.org/about.html
[4] https://docs.anaconda.com/
[5] https://www.astra-toolbox.com/
[6] https://tomopy.readthedocs.io/en/latest/
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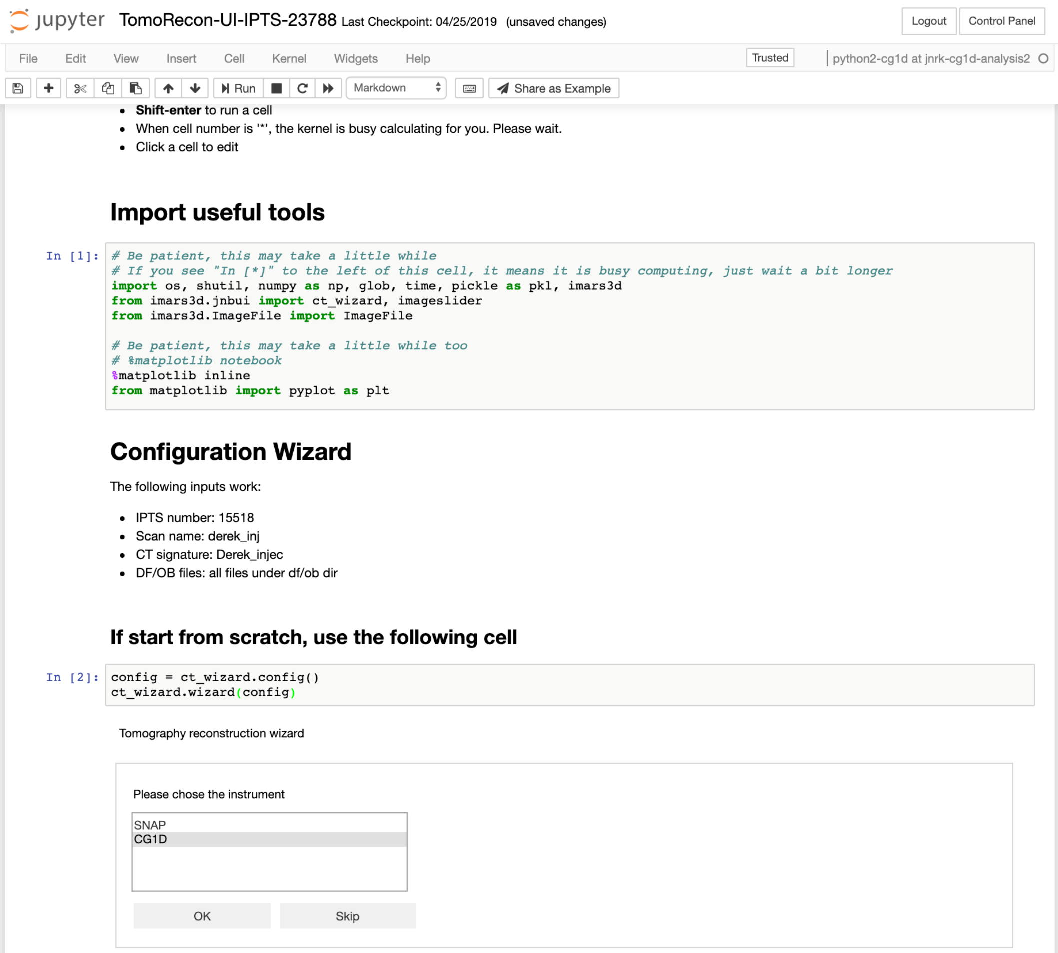
[9] https://pypi.org/project/neutompy/
[10] https://anaconda.org/anaconda/spyder
[11] https://tomopy.readthedocs.io/en/latest/ipynb/tomopy.html

Ulf Garbe, Floriana Salvemini

iMars3D - CT reconstruction python package for neutron imaging

iMars3D is a python package we developed for the normalization, correction and reconstruction of the neutron tomography data measured at beam lines at the HFIR and SNS facilities. imars3D leverages the tomopy library (https://tomopy.readthedocs.io/en/latest/) and can be run via the command line or via the Jupyter notebooks. In order to facilitate inputs such as sample, open beam, dark field, selection of region of interest, we take advantage of an extended jupyter widget library. In addition to the intuitive workflow provided by the notebook, we also have a few tutorials (videos, wiki and in our instrument web page) that guide neutron imaging users in the reconstruction of his/her datasets (https://neutronimaging.pages.ornl.gov/tutorial/how_to_run_imars3d/).



The workflow of iMars3D can be divided as follow:

Preprocessing

gamma-filtering
normalization
intensity fluctuation correction
cropping
smoothing
tilt correction

Reconstruction

- build sinograms
- find rotation center
- reconstruct

Want to give it a try? The GitHub and wiki pages give a detail description of the installation process.

https://github.com/ornlneutronimaging/iMars3D

Jiao Lin, Jean Bilheux

News from the Lab and Out of Practice

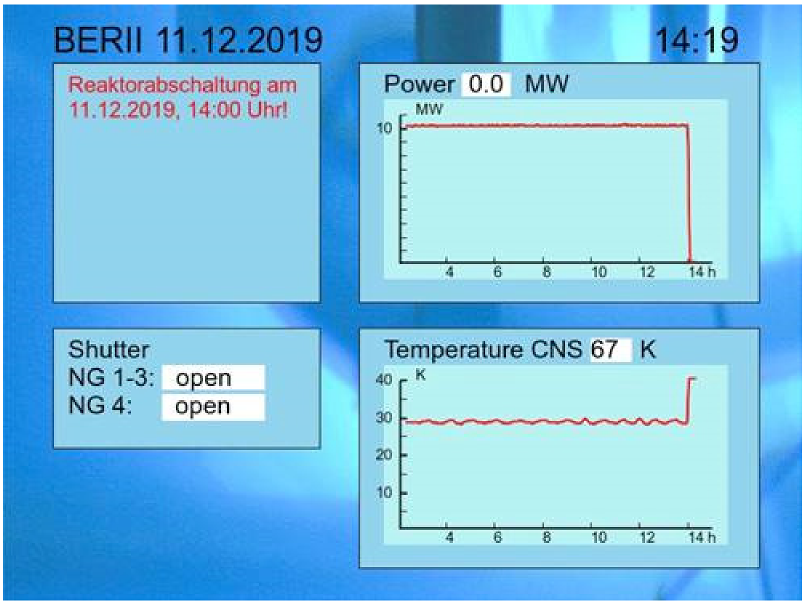
Bye-bye BER-II - an e-mail by Nikolay Kardjilov dated 12. December 2019

Dear Colleagues,

Yesterday was the last operation day of the research reactor BER-II.

It was shutdown on 11.12.2019 at 14 o'clock and with this the neutron research in Berlin has finished. I would like to thank you for the instantaneous support and close collaboration which we had through the years! For sure we will stay in contact for the future and continue to work in the field of neutron imaging.

Nikolay Kardjilov



Introduction of new NR facility at Aomori prefecture Quantum Science Center (QSC)

Background

Aomori prefecture Quantum Science Center (QSC) is located at Rokkasho in Aomori prefecture, as shown in Fig.1. There are many plants related to nuclear fuel reprocessing and also to fusion energy development. The QSC has been built in 2017 with the aim of human resource development and R&D in quantum science field.

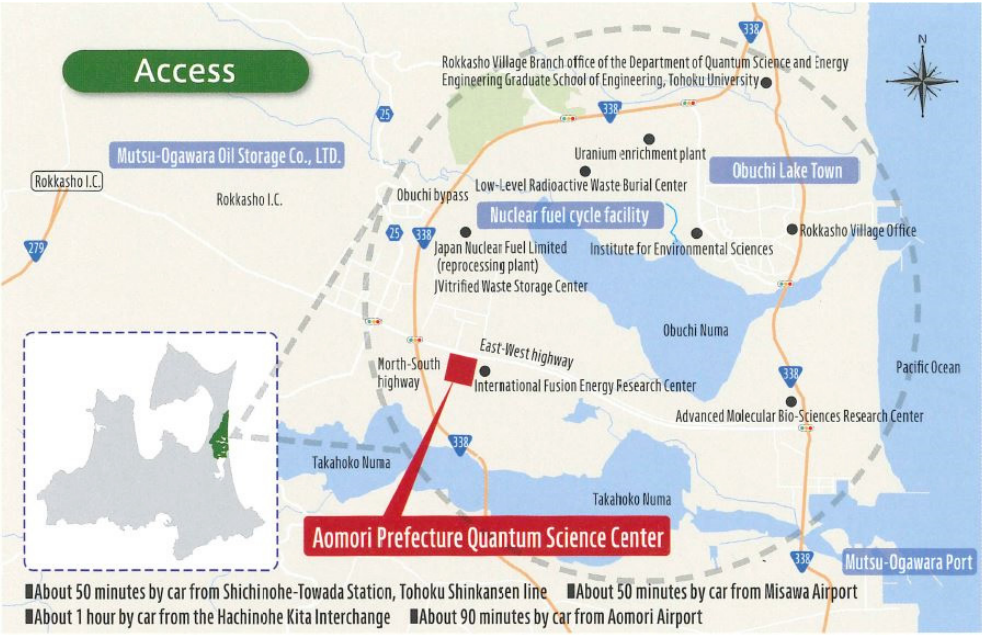


Fig.1: Location of QSC.

One of the main facilities at the QSC is a cyclotron accelerator (Sumitomo Heavy Industry, HM-20V), whose specifications are listed in Table 1. Neutron beam is utilized for Neutron Radiography Testing (NRT) and Boron Neutron Capture Therapy (BNCT). Figure 2 shows the NRT and BNCT setup. The facility can be used also for RI production for Positron Emission Tomography (PET) and for trace element analysis using Particle Induced X-ray Emission (PIXE).

Table 1 Operation Conditions of Cyclotron

Accelerated Particles	*Proton*	*Deuteron*
Energy	14MeV or 20MeV	10MeV
Maximum Current	100μA	50μA

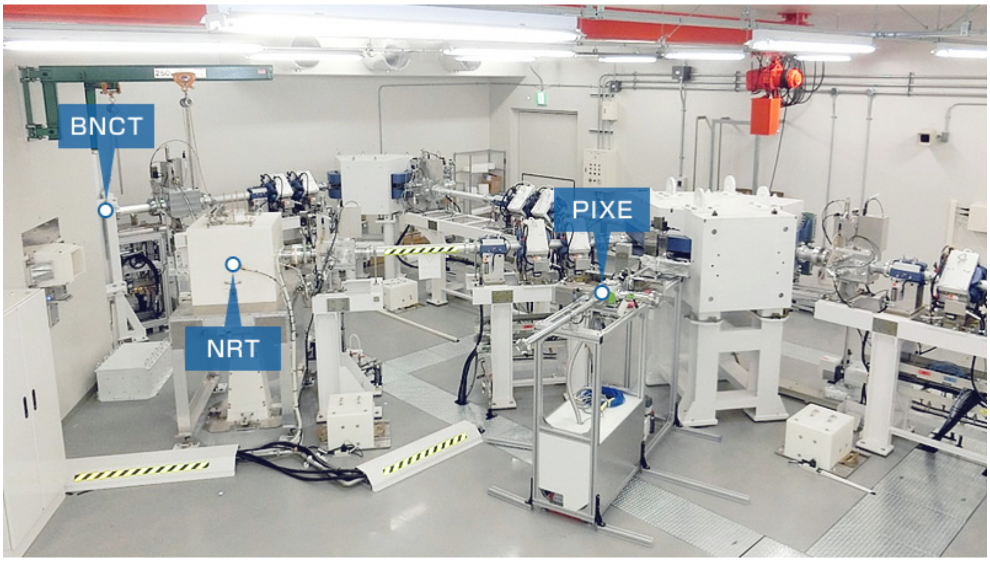


Fig.2: Setup of each component of neutron source.

General description of NRT in QSC

The detailed specification of NRT are shown in Table 2. The neutron beam can be irradiated in the horizontal and in the vertical directions. The horizontal port is shown in Fig.3(a). Imaging area is 43cm x 36cm for the horizontal port and 30cm x 30cm for the vertical port, A preliminary neutron transmission image is shown in Figure 3(c), where H_2O, D_2O, Hexane, and Octane capsuled in a metallic tube can be clearly observed.

Table 2: Specifications of NRT facility

Thermal Neutron Flux	$6.06 \cdot 10^5$ n/cm^{2}s (Horizontal port)
L/D ratio	44 (Horizontal port)
Imaging area	43cm x 36cm

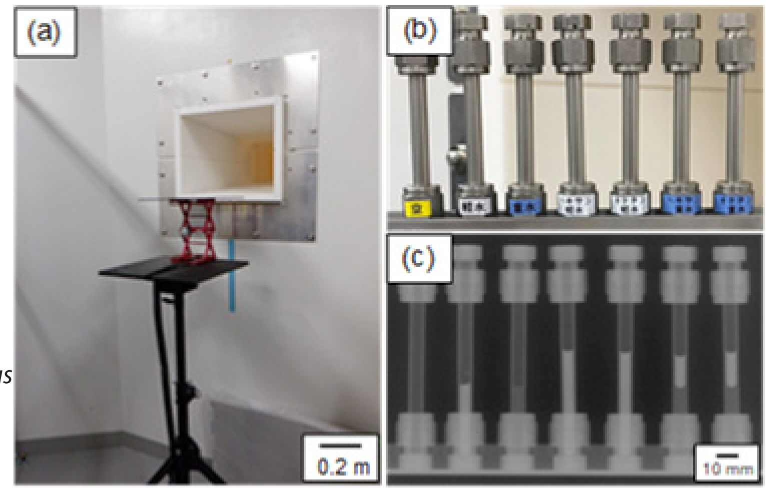


Fig.3 (a) Horizontal port of NRT Facility, (b) Test peace for various liquids, and (c) Neutron transmission image of the liquids.

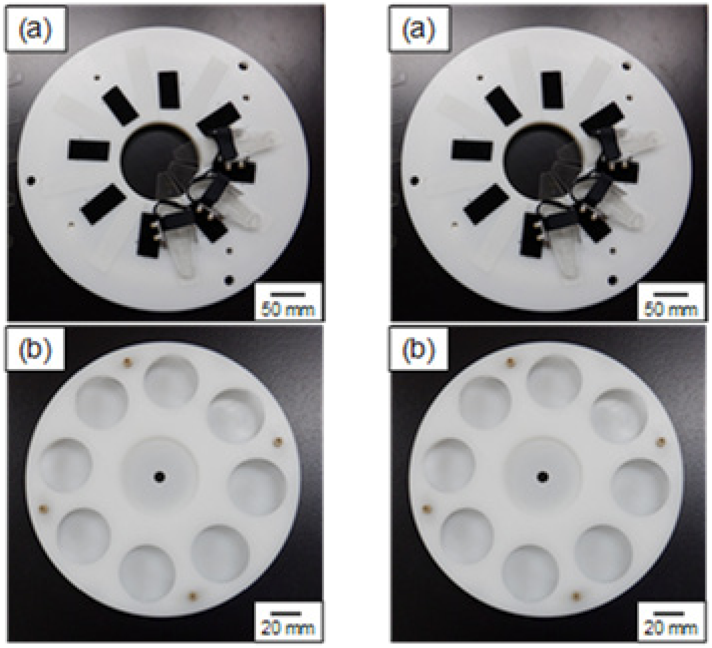


Fig.4 (a) Fixing holder for rat sample,
(b) Fixing holder for cell sample.

General description of BNCT in QSC

At the QSC, neutron beam can be generated by irradiating proton beam (20MeV, 100μA) to Be target for BNCT experiment. The main targets of BNCT at the QSC are cells and small animals like mouse or rat. Such samples can be irradiated by using special fixing holder showing in Fig.4. The thermal neutron flux at the sample position is $1.14 \cdot 10^{9}$n/cm^{2}s.

Summary

QSC is one of the Japanese neutron source facilities open for general use. QSC is equipped with accommodation facility and general experimental facilities for materials and chemistry. More detail information can be found at https://www.aomori-qsc.jp/.

Yasushi Saito

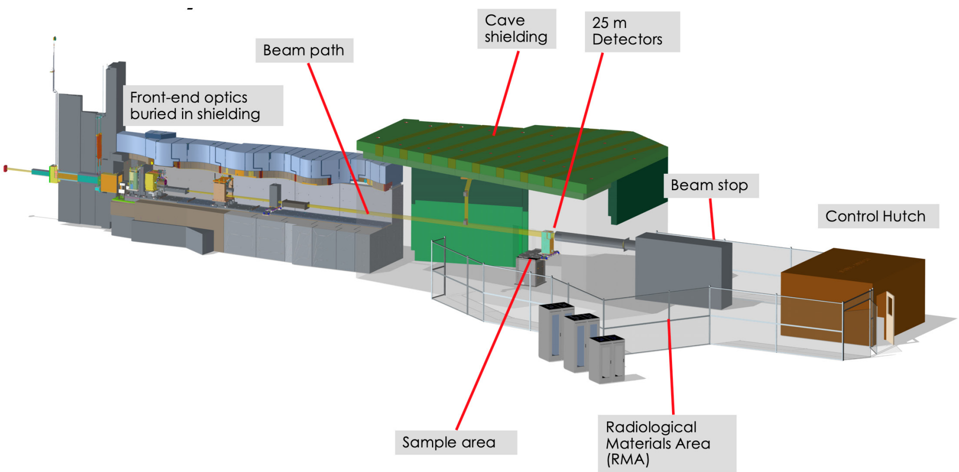
The VENUS Project: an update

Under construction at the Oak Ridge National Laboratory's Spallation Neutron Source's (SNS) First Target Station, VENUS will be a state-of-the-art neutron radiography and computed tomography facility, capable of exploiting the unique intrinsic time-of-flight properties of the SNS. VENUS will provide Bragg-edge and resonance imaging capabilities with field-of-views of 20 cm x 20 cm and 4 cm x 4 cm, respectively. The instrument is equipped with variable apertures that define different collimation ratios (from 400 to 2000), a suite of choppers, and adaptive beam scrapers to reduce instrument background. VENUS will be equipped with a charge-coupled device (CCD) detector and a micro-channel-plate (MCP) detector positioned 25 m from the source. The figure below illustrates the overall design and footprint of the VENUS beamline located on beam line 10, which views the decoupled para hydrogen moderator.

The ORNL project team are supported by an international VENUS Advisory Committee (VAC) charged with regularly reviewing the instrument project and providing recommendations on the beamline design, contingency spending, and future upgrade paths. The committee is chaired by Dr. Anton Tremsin from the University of California-Berkeley, and comprises the following worldwide experts: Dr. Aaron Craft, Idaho National Laboratory, USA; Dr. Daniel Hussey, National Institute of Standards and Technology, USA; Dr. Winfried Kockelmann, ISIS Facility, Rutherford Appleton Laboratory, UK; Dr. Javier Santisteban, Centro Atomico Bariloche, Argentina; Dr. Burkhard Schillinger, Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRM-II), Germany; Dr. Takenao Shinohara, Japanese Atomic Energy Agency (J-PARC). The VAC first convened in May this year to review the VENUS preliminary design and the second review meeting is scheduled for December.

Installation activities for VENUS begin in February 2020 and will comprise installation of the bulk shield insert, a component located on the target station wall, followed by poured-in-place concrete to form the chopper shelf also located at the upstream end of the beam line.

While VENUS is being constructed, the imaging team welcomes proposals submitted to the SNS SNAP beamline, where an MCP detector is utilized to performed wavelength-dependent imaging in the cold (Bragg edge) and epithermal (resonance) neutron ranges. For more information about the future VENUS and/or access to SNS' current imaging capabilities, please contact Dr. Hassina Z. Bilheux at bilheuxhn@ornl.gov .



Layout of the VENUS beamline, depicting the front-end optics (with choppers and apertures), the cave or bunker area where the sample and detector sit at 25 m, followed by a beam stop and radiological materials area and control hutch.

Jean Bilheux, *Hassina* Bilheux

New sample container for the high resolution neutron imaging of spent nuclear fuel cladding sections and other highly radioactive materials

Here we report on the development of a small but rather useful tool that allows for the high-resolution neutron imaging of highly radioactive materials.

Hydrogen/hydrides distribution in zirconium based nuclear fuel cladding materials has long been one of the key applications of neutron imaging [1,2]. Hydrogen concentrations in the zirconium-based claddings can often be non-uniform because of the high mobility of hydrogen interstitial atoms. When the hydrogen concentration in zirconium alloys reaches the solubility limit, the hydrogen precipitates into platelet-like zirconium-hydrides. Hydrides are brittle and their accumulation or unfavorable orientation can pose a risk to the nuclear fuel rod integrity.

The enhancement of the spatial resolution of neutron imaging to sub-5-micrometres domain using the 'PSI Neutron Microscope' [3] detector allowed for the visualization of individual hydride packets and provided the hydrogen quantification [4] across the nuclear fuel cladding [5]. However, none of the mentioned high-resolution investigations were performed on real samples that would have been operated in nuclear power plants.

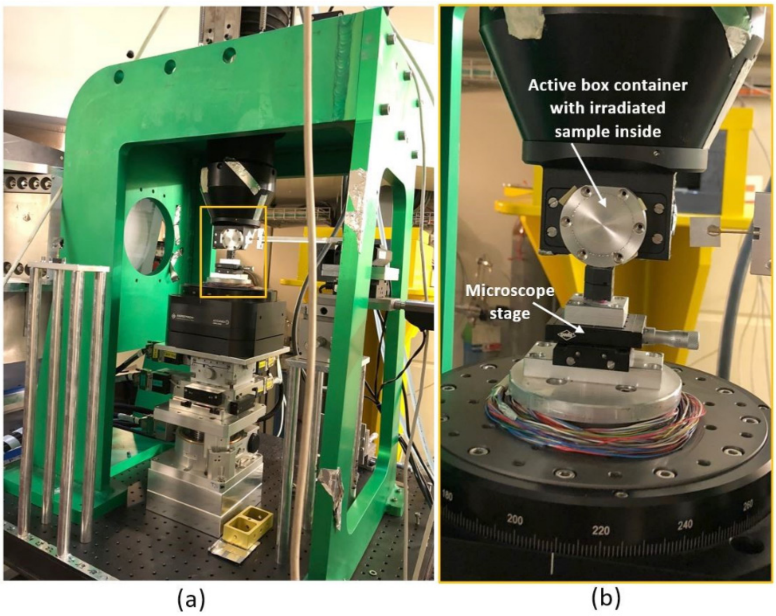


Fig. 1: Photograph of (a) neutron microscope overview and (b) the 'Active Box' sample container placed in front of the scintillator screen of 'PSI Neutron Microscope' detector.

We developed a gas-tight, contamination-free container -referred to as 'Active Box'- that can be loaded in a hotlab facility and handled outside a hotlab facility. Figure 1 shows the Active Box sample container placed on the sample stage in front of the scintillator screen of the PSI Neutron Microscope detector. We demonstrate [6] that the container itself -thanks to its design- has hardly any negative influence on the quality of the acquired high resolution neutron images.

Figures 2a and 2b show, respectively, the high-resolution neutron radiographies of the unirradiated sample in air (as a reference) and enclosed in the Active Box. Figure 2c presents the high resolution image of an active sample that was operated in a Swiss nuclear power plant exhibiting approximately about 2.5 mSv/h dose rate at 5 cm distance.

We trust that the new sample cell offers a large potential for high resolution neutron imaging not only of irradiated nuclear fuel cladding samples of various power and thermo-mechanical histories, but also of other small but highly radioactive objects.

On behalf of all the co-authors of the recently submitted manuscript [6]

References

[1] M. Grosse, et al., NIM-A, 651, (2011)
[2] N.L. Buitrago et al., J Nucl. Mater., 503 (2018)
[3] P. Trtik and E. H. Lehmann, J. Phys. Conf. Ser. 746, (2016)
[4] W. Gong, et al., J. Nucl. Mater. 508, 459-464 (2018)
[5] W. Gong, et al., J. Nucl. Mater. 526, 151757 (2019).

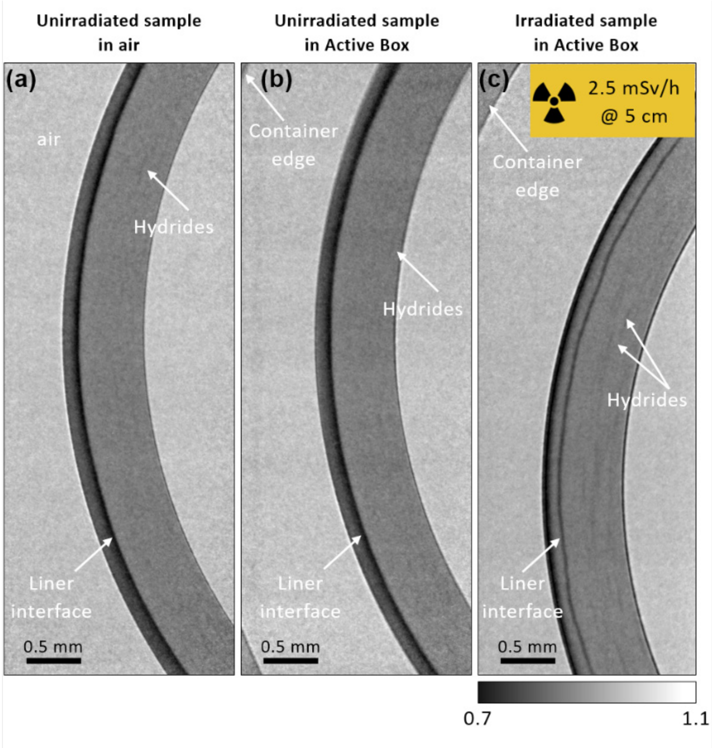


Fig. 2: High-resolution neutron radiographs of segments of nuclear fuel cladding tubes. (a) inactive sample in air as a reference image, (b) the same inactive sample enclosed in the Active Box, (c) radioactive sample exhibiting about 2.5 mSv/h dose rate at 5 cm distance enclosed in the 'Active Box' sample container.

[6] *Pavel Trtik, Robert Zubler, Weijia Gong , Robin Grabherr, Johannes Bertsch, Liliana I. Duarte, Sample container for high-resolution neutron imaging of spent nuclear fuel cladding sections, submitted (2019)*

Pavel Trtik, Liliana Duarte

An Affordable Image Detector and a Low-Cost Evaluation System for Computed Tomography Using Neutrons, X-rays, or Visible Light

Neutron computed tomography (nCT) has been established at many major neutron sources worldwide, using high-end equipment requiring major investment and development. Many older and smaller reactors would also be capable of doing nCT, but cannot afford the investment before feasibility is proven. We have developed a compact low-cost but high-quality detection system using a new cooled CMOS camera that can either be fully integrated into a sophisticated setup, or used with a rudimentary CT control and motion system to quickly evaluate feasibility of neutron CT at a given beam line facility. Exchanging the scintillation screen makes it feasible for X-rays as well, even for visible light (and transparent samples) using a matte screen. The control system uses a hack to combine motion control with existing imaging software so it can be used to test several dozen different cameras without writing specific drivers. Freeware software can do reconstruction and 3D imaging.

https://www.mdpi.com/2412-382X/3/4/21

Burkhard Schillinger

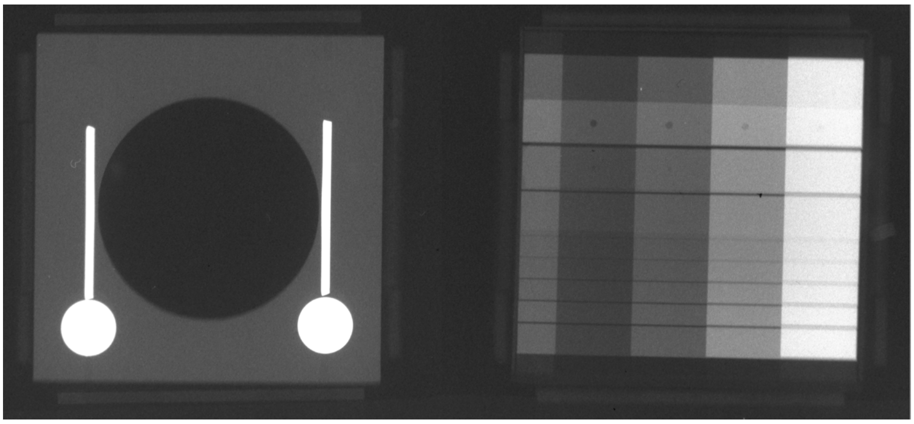
Industry

Neutron Radiography at Phoenix, LLC

Exciting things are happening to the world of neutron imaging in Wisconsin! Phoenix, LLC., a nuclear technology company founded in Madison, WI in 2005, has announced that it has now demonstrated the capability to take ASTM Category I neutron radiographs at its new accelerator-based industrial radiography facility, the Phoenix Neutron Imaging Center (PNIC) in Fitchburg, which opened in October of this year. ASTM Category I images are the highest image quality level specified by ASTM E545-19, the gold standard for defining the quality of neutron radiographs. With this breakthrough, PNIC is now the first non-reactor facility capable of producing Category I images.

Unlike in fission reactor facilities, in which neutron imaging has typically been done for decades, the neutrons in Phoenix's system are generated with the use of a high-current ion source and are moderated to thermal energies. The collimation ratio is variable between 75 and 105, with a cadmium ratio above 4.5. The system is flexible in detection techniques; neutron images can be acquired using film with appropriate neutron conversion screens, digital detector arrays, and computed radiography image plates with effective imaging times ranging from several seconds up to 10 minutes. The beamlines will also be useful for thermal neutron computed tomography. The neutron flux has been measured at above 1×10^5 $cm^{-2}s^{-1}$ but will more than double over the coming weeks during commissioning.

Phoenix has also taken their first 2D fast neutron images at PNIC, as well as completed reconstruction of fast neutron computed tomography. Their fast neutron source is operational now with a source strength of approximately 1.5×10^{12} n/s and an L/D of 450 to achieve a neutron flux at the image plane of approximately 5×10^5 $cm^{-2}s^{-1}$. Over the next few weeks, Phoenix will be increasing the beam current and expects to reach full power and have a source strength of 3×10^{13} n/s and a neutron flux at the image plane of approximately 1×10^7 $cm^{-2}s^{-1}$. The system currently uses a 16-inch by 16-inch field of view digital detector array but could accommodate other digital neutron cameras as well.



The Phoenix Neutron Imaging Center is also equipped with a 450 kV X-Ray system that will allow comparison studies between X-Ray and N-Ray images. The system has been in use for several months and has proven to be a very useful tool for side-by-side studies. The system has a 360° rotational turntable with a weight capacity of 1500 lbs and an imaging area 32 inches in the horizontal and 48 inches in the vertical; it is also equipped with a 16-inch field of view digital detector array with 200 µm pixels. Other imaging modalities are available as well to increase the field of view and resolution.

The ability to produce ASTM Category I neutron radiographs is an important milestone for both Phoenix and for the field of neutron radiography as a whole. Phoenix's goal since its first neutron imaging system was developed in 2012 has been to advance the accessibility of neutron radiography by providing an alternative neutron source to nuclear reactor facilities, which are few in number and dwindling as the years go by. These metrics are heartening for the Phoenix team, as it shows that PNIC and future facilities like it can match the quality and throughput of reactor facilities and thus act as viable alternatives.

Michael Taylor

Reviews on conferences and workshops

NeuWave 10 2019

The 10th edition of the NeuWave workshop series was held 26th to 29th May 2019 at Paul Scherrer Institut in Switzerland. The workshop started with the traditional Sunday walking-discussion which led the participants from the small town of Brugg in Aargau to the Habsburg castle, the cradle of the empire on which the sun never set, and from there on to the hot springs of Bad Schinznach for a relaxing evening after inspiring exchanges on the way.

The scientific program started on Monday and was carried by 55 participants from 14 countries, 24 institutions and 13 neutron sources. The main topics of the workshop program conveyed instruments and methods, applied Bragg edge imaging, grating interferometry, technology and software as well as polarized neutron imaging. Despite an impressive number of 36 oral presentations the program left ample space for discussions and in addition featured poster sessions. The first day focused on instrumentation and

Group photo in front of the lecture hall building at PSI in a coinciding session and rain break on the second workshop day

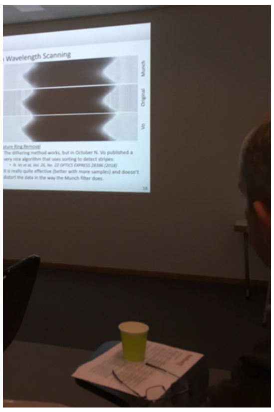
applied Bragg edge imaging. The meanwhile established first dedicated time-of-flight (ToF) imaging instruments at pulsed sources, namely RADEN at JPARC and IMAT at STFC alongside the imaging beamlines at LANSCE, reported on their progress and scientific program, while the instrument projects at SNS (VENUS), ESS (ODIN) and at CSNS in China outlined the status of their projects allowing the community to look forward to additional ToF instruments and capabilities in the years to come.

In addition, the well-established beamlines at continuous sources such as the HZB, TUM, PSI and NIST gave an impression of their rich activities in wavelength resolved neutron imaging, while new imaging instrument projects at ILL and by CNEA in Argentina have been introduced promising future applications of wavelength resolved neutron imaging, while unfortunately the neutron source of the HZB in Berlin, BER2, will shut down Dec. 2019, loosing the community one instrument that has been productive with regards to the workshop topic in the past.

In addition, at least one initiative for investigating the potential of wavelength resolved neutron imaging at a small scale neutron source, a photoneutron source, has been introduced and might spur interest to consider stronger in the future a number of small scale sources, such existing and in particular such currently in a planning phase, also for neutron imaging.

Left: Extended lively discussions at the workshop dinner Tuesday evening in the Trotte of the wine village Villigen next to PSI, where traditionally wine was produced;

Bottom: Focused concentration on numerous valuable contributions and exciting talks during the scientific sessions.



A large number of following talks throughout the workshop did not only address developments but in particular also successful applications of the new imaging modalities and methods to subjects such as crystal growth, additive manufacturing, laser shock peening and energy research, especially for Li-ion batteries and fuel cells. Additional applications of Bragg edge imaging reported studies ranging from cultural heritage to meteorites and characterization of Ni super-alloys. Magnetic phenomena studies by wavelength resolved neutron imaging were the topics not only in the polarized neutron imaging session but also for grating interferometric imaging, for which also a broad range of applications could be demonstrated including magnetism, energy research but also engineering materials science.

Some novel approaches and methodical advancements presented conveyed e.g. quantitative 2D small angle scattering dark-field contrast imaging, multi-probe measurements combining different radiation fields, grain mapping approaches for ToF and continuous beams as well as high duty cycle ToF studies notably profiting from inelastic scattering contrast contributions and continuous sources.

In another session the 10th "anniversary" of the NeuWave workshop series has been taken as an occasion for a retrospective of the events and developments they have accompanied and a discussion was held concerning the current judgement of the potentials of Bragg edge imaging and critical topics such as texture. It was also decided during the workshop to change the frequency of the workshop, which was initially held annually with two one year breaks though, to a regular bi-annual frequency aligned with the rhythm of the WCNR and ITMNR conferences, filling the gaps between those. This also reflects the somewhat changed nature of the workshop which originated in discussing the then novel opportunities of instrumentation and application of wavelength resolved neutron imaging to a meeting of experts in these methods focused on applications and more detailed and focused developments with relevance to an ever growing stakeholder community.

Finally, another dedicated session commemorated the work and companionship in our community of M. Arif, who very sadly had passed away some months before, but lives on in our best memories.

In Memoriam Muhammad Arif

Our great friend and colleague Arif passed away 27 November 2018 and was commemorated at the NeuWave10 meeting, reminding us of many great occasions and achievements that we shared with him.

The program was rounded off by a lively workshop dinner at the Trotte in Villigen, a wine village next to PSI, and the last day of the meeting offered the opportunity not only to visit the neutron imaging and scattering installations at SINQ but also at the Swiss Light Source and the SwissFEL at PSI. We are looking forward to the next NeuWave-11 meeting in 2021 in Japan!

Markus Strobl

Report on XNPIG conference in Sendai

The 5th international conference on X-ray and Neutron Phase Imaging with Gratings (XNPIG2019) has been held in Sendai, the largest city in the North-East province of Japan, on October 20-24, 2019. There were 146 participants from 13 countries, Japan, Germany, USA, Switzerland, and China, and so on. The conference has 12 oral sessions (49 contributions including 12 invited talks) and one poster session (53 posters) covering topics on not only technical developments, such as instrumentation, grating fabrication, devices, data analysis, etc., but also application studies including medical diagnostics. The conference has started from the opening address by Prof. A. Momose of Tohoku University, the chair of the conference and the following invited talk by Prof. F. Pfeiffer about the first patient results of X-ray dark field imaging. The remarkable achievement will be that the medical application of the X-ray dark field imaging method is in the stage of clinical application. The TUM researchers are collaborating with the Munich School of BioEngineering and applied the dark field chest X-ray radiography for patients with/without lung diseases by using a specially developed scanner.

Prof. A. Momose (left) and Prof. F. Pfeiffer (right). Two important pioneers in the grating based phase imaging.

Regarding the neutron phase imaging, there were 4 oral presentations and 6 posters. D. Pushin of University of Waterloo gave an invited talk about the neutron interferometry. He presented the recent study on phase-grating moire interferometry with three phase-grating conducted at NIST and future application to fundamental physics especially to precision measurement of the big "G". Then, presentations on the recent studies of neutron grating interferometer have been given. T. Shinohara of J-PARC presented wavelength dependent analysis of phase contrast imaging and dark field imaging using pulsed neutrons conducted at RADEN. Then, T. Neuwirth of Technical University Munchen (TUM) discussed upgrade of the grating interferometer setup at ANTARES facility of FRM-II and the results of application study using the new apparatus. L. Butler of Louisiana State University applied dark field imaging to investigate plant roots. In this study, he has tested a new grating fabricated by 3D printing of UV-cured polymer using thermal neutrons at TRIGA reactor facility in McClellan Nuclear Research Center. In addition, another type of dark-field imaging using an edge-illumination approach has been demonstrated by M. Endrizzi using IMAT facility at ISIS.

A scene from Matsushima-bay cruise.

On the day before the main conference, a tutorial session has been set for the first time consisting of rudimentary lectures on X-ray and neuron radiography, phase imaging techniques, and tomography. On the third day, Matsushima-bay cruise was held as the conference excursion. Matsushima is known as one of the three most scenic views of Japan and is composed of 260 small islands covered in pine groves. The participants enjoyed the beautiful sunset scene on the boat.

The next XNPIG conference will take place in Kunming of China in September of 2021 hosted by Shanghai Light Source.

Takenao Shinohara

Software Imaging Workshop held at ORNL in October.

A first Software Imaging Workshop took place in Oak Ridge on October 8 and 9. The goal of the workshop was to bring closer the X-Ray and neutron software communities. During this 2 days workshop, various speakers from Brookhaven National Laboratory, Argonne

National Laboratory, Paul-Scherrer Institute, KitWare company and Oak Ridge National Laboratory presented their research and tools they were using or needed. Morning speakers were scientists and afternoon sessions were software developers. An off-site dinner took place at the end of the first day to encourage and stimulate collaborations between participants. The 20 participants share thoughts about tools to share, to look at or to use during afternoon brain-storming sessions.

Jean Bilheux

1st Experts Meeting on Fast Neutron Imaging

On October 20-23, 2019, the Neutron Imaging Group at the Technische Universität München, Forschungs-Neutronenquelle Heinz Maier-Leibnitz (FRMII), was hosting the 1st Experts Meeting on Fast Neutron Imaging. The meeting featured presentations and discussions on the latest advancements and applications of fast neutron imaging with 32 international participants from industry and research facilities. Fast neutrons are an invaluable probe and provide information for non-destructive inspection of large and dense objects where thermal neutrons or X-rays face limitations due to their comparatively low penetration. Only few facilities around the world provide access to fast neutrons with NECTAR at the FRMII being the only beamline that has a dedicated user program for fast neutron imaging. The meeting brought the experts in the field from around the world together and provided a pathway for quantification and standardization of imaging setups at different facilities, as well as for improving resolution and efficiency of the technique in a collaborative effort. With an overwhelmingly positive outcome of the 1st Experts Meeting on Fast Neutron Imaging, the continuation of this event was confirmed with updates being posted at the International Society for Neutron Radiography (ISNR) website.

Adrian Losko

News from the Board

Task Groups

Task Group on Characterisation and Standardization

Standards are important for applications where the customer or user require that testing be performed according to a standard. The American Society for Testing and Materials (ASTM) International is, as the name states, an international committee for setting standards, similar in many ways to ISO (The International Organization for Standardization). There are many colleagues from Germany, France and other European countries that are actively involved with Committee E07 on Nondestructive Testing, through which the E07.05 Subcommittee for Neutron Radiology resides. If this area is of interest to you, please consider joining this subcommittee and working with us to continue a strong and relevant set of standards that out community needs to perform quality-level measurements. Membership is free. The E07.05 Subcommittee meets every January and June. More information can be found at www.astm.org.

The American Society for Testing and Materials (ASTM) International E07.05 Subcommittee on Neutron Radiology is developing a new standard to measure basic spatial resolution with a line-pair gauge that will be applicable to neutron radiography with both film and digital methods. This is work item number WK55633 on the website. A first prototype was fabricated and tested through a round robin series that included eight facilities, the results of which were reported in a presentation at WCNR-11 in Sydney, Australia. Based on the lessons learned from these first tests, a second prototype gauge was designed and eight gauges have been fabricated. The new prototype gauges will be distributed for a second series of round robin testing. If you are interested in participating in the round robin testing of the new gauge, please contact Aaron Craft.

Additionally, the E07.05 Committee is developing a Guide to Digital Neutron Radiography under the leadership of Michael Taylor. This is work item WK68570 on the website. Monthly meetings have been useful in developing the scope of the Guide, which will be a major topic of discussion at the biannual ASTM E07 meeting in January 2020.

The current standards that the E07.05 Subcommittee are developing are for digital neutron radiography, for which there are no existing standards. Successful development of these standards would represent a step into a new era where digital techniques would be able to be applied with the pedigree of an international standard, which is required for many applications desired by industrial users. Please consider getting involved in these exciting efforts, whether joining the committee or simply participating in round robin testing.

Aaron Craft

TG Characterization and Standardization

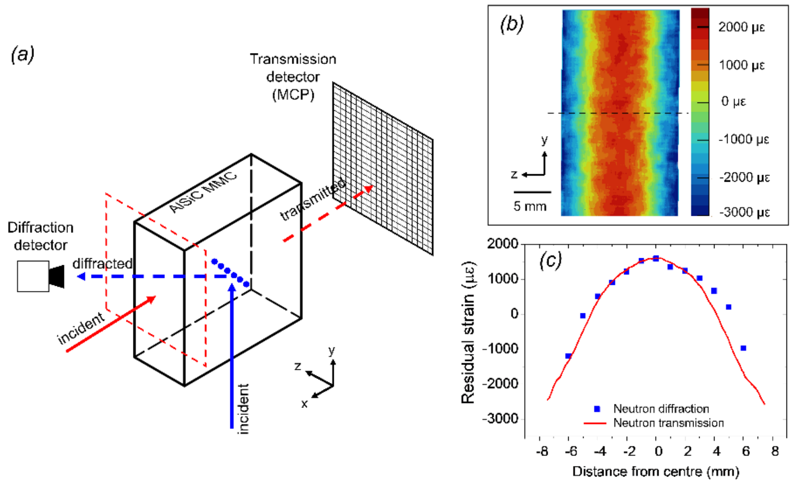
Proposal for a Bragg edge analysis round robin

We wish to propose a round robin on Bragg edge analysis and we wish to invite instrument scientists and users of neutron imaging beamlines and neutron strain scanners. The purpose of the proposed round robin is to share a set of test samples and software, as well as information on data collection protocols and analysis strategies for strain analysis and phase composition analysis from transmission and diffraction measurements.

In recent years, the ISNR Task Group Characterisation and Standardisation pursued a round robin exercise to measure resolution and contrast phantoms using white beam instruments for radiography and tomography, an effort led by A. Kaestner and N. Kardjilov. That round robin did not yet involve energy-selective and energy-dispersive neutron imaging. A sizable number of proof-of-concept and materials science studies using energy-resolving imaging methods have been published and discussed at Neuwave workshops. The majority of energy-resolved neutron imaging applications are concerned with Bragg edge techniques. Although Bragg edge transmission analysis is around for more than 20 years, it was only recently that such methods have become attractive, mostly due to sub-millimetre spatial resolutions that are achieved nowadays (Figure 1), either using time of flight setups or crystal monochromators for energy discrimination.

Understandably, there are no standard tests for Bragg edge analysis yet, let alone certified standards, such as the ISO/TS 21432:2005 standard for determining residual stresses by neutron diffraction. The latter standard was developed initially with the VAMAS TWA 20 round robin (G.A. Webster, M.R. Daymond) using an aluminium ring and plug sample. Because of the close relations between scattering and transmission techniques in this application area, it is important for any exercise on transmission data to establish the context with conventional neutron strain and stress methods. Thorough characterisation and standardisation of the Bragg edge setups and techniques is particularly relevant because of potential commercial, industrial, users at the large scale facilities. The Bragg edge round robin for energy-resolving imaging addresses the deficit. It might likely be more limited in scope than the VAMAS round robin 20 years ago, as the number of participating partners and instruments is probably smaller.

We are conscious of concerns that a Bragg edge round robin happening now may be too early for several major imaging facilities which are currently in design or construction stages. However, we think the time is right to start planning for such an exercise, considering that several beamlines at pulsed and steady state sources are available now and that useful information and data can be gathered already. Also, as it happened with many round robins in various areas in the past: samples and exercises must usually be significantly refined after a first round of experiments.



Comparison of residual strains in an AlSiC metal matrix composite determined by Bragg edge imaging and neutron diffraction. R. Ramadhan, Thesis Coventry University 2019.

In view of the recent advances in Bragg edge imaging and of the close relation of the science areas between neutron imaging instruments and strain scanners, we propose a round robin to benchmark the known and new capabilities on both types of instruments. We propose to do this for quantitative crystallographic phase on engineering samples and for residual strain analysis from Bragg edge and Bragg peak data. The purposes of a round robin could include:

- To assess levels of accuracy, precision, and detection limits of Bragg edge transmission and neutron diffraction for residual strain and phase composition analysis in 1D, 2D and 3D

- To come up with recommendations and best practices for data collection and data analysis.

The selection of samples and specific tasks will be discussed in due course between interested participants but will likely include the original VAMAS sample. There is no funding as yet. This means interested parties will need to find beamtime on their beamlines and will analyse the data themselves.

The round robin will be an opportunity to share samples and ideas about how to run and analyse Bragg edge spectra. This exercise may be an important development step towards standardisation. For participants from existing beamlines there is the opportunity to test their analysis procedures against other beamlines. For participants from planned neutron imaging beamlines at pulsed and steady state sources there will be an opportunity either to participate at existing instruments or to work on downloaded data from the round robin. For participants from neutron diffraction strain scanners there will be opportunity to test their beamlines once more or for the first time, as many will not have been around at the time of the VAMAS round robin 20 years ago.

If you are interested in par¬ticipating in the round robin testing of the new gauge, please contact one of us.

Winfried Kockelmann (ISIS),
Ranggi Ramadhan (ILL),
Markus Strobl (PSI),
Aaron Craft (INL)

Upcoming conferences and workshops

Status of ITMNR in Argentina in 2020

The 9th International Topical Meeting on Neutron Radiography (ITMNR-9) will be held in Buenos Aires, Argentina, from October 12-16, 2020. This will be the 9th conference in the ITMNR series being coordinated by the International Society for Neutron Radiography (ISNR) and in this occasion it will be organized by the Atomic Energy Commission of Argentina (CNEA).

View of Puerto Madero quarters in Buenos Aires

Each meeting of the ITMNR has a specific topic. The special focus of ITMNR-9 is on Neutron Imaging for "Applications of Neutron Imaging for Science, Industry and Heritage".

The meeting will be a forum for scientists working with neutron imaging techniques to share their experiences and expertise. The aim is that participants will return home with new ideas for their work, by learning about the latest advances on the application of neutron imaging techniques to an ever increase number of problems in science and technology. Topics include:

Buenos Aires Architecture (http://www.openhousebsas.org)

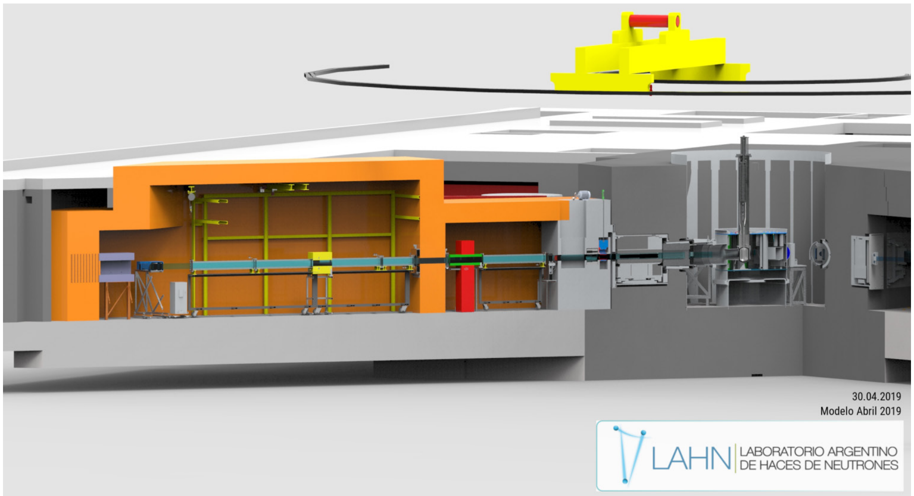
View of the Obelisk in 9 de Julio street, main artery of Buenos Aires.

- Materials science and engineering
- Cultural heritage, Art and Conservation
- Solid state physics and magnetism
- Paleontology
- Botanic and wood science and technology
- Materials degradation
- Nuclear materials and fuels
- Archaeometry
- Technologies for the Hydrogen economy (storage, fuel cells, batteries)
- Concrete technology
-New imaging instruments and techniques

The meeting will share the venue with ART'20, the 13th International Conference on non-destructive investigation and microanalysis for the diagnostic and conservation of cultural and environmental heritage. Some sessions will include audience from both events, enhancing the opportunities of sharing the applications of neutron radiography as a non-destructive tool in cultural heritage research. We particularly promote contributions within this field.

The meeting will include a visit to the site of RA-10, a 30 MW multi-purpose research reactor being built by CNEA near Buenos Aires, which will host the Argentine Neutron Beam Laboratory (LAHN), and ASTOR, a state-of-the-art neutron imaging instrument for cold neutrons.

Artistic view of CNEA RA-10 reactor complex in Centro Atómico Ezeiza, near Buenos Aires [1].



3D model of ASTOR (in orange), the cold neutron imaging beamline to be installed at the Argentine Neutron Beam Laboratory (LAHN) of RA-10, showing the experimental room on the left, and the beam conformation room on the right [2].

As a satellite event to ITMNR-9, we will host an International School on Neutron Imaging for young scientists and students, in the Patagonian city of San Carlos de Bariloche from October 19-23.

We hope this conference will further promote the applications of neutron imaging technology around the world.

Looking forward to seeing you in Buenos Aires,

Dr. Javier Santisteban *Chair of ITMNR-9 Scientific Committee*
Eng. Karina Pierpauli *Chair of ITMNR-9 Organizing Committee*

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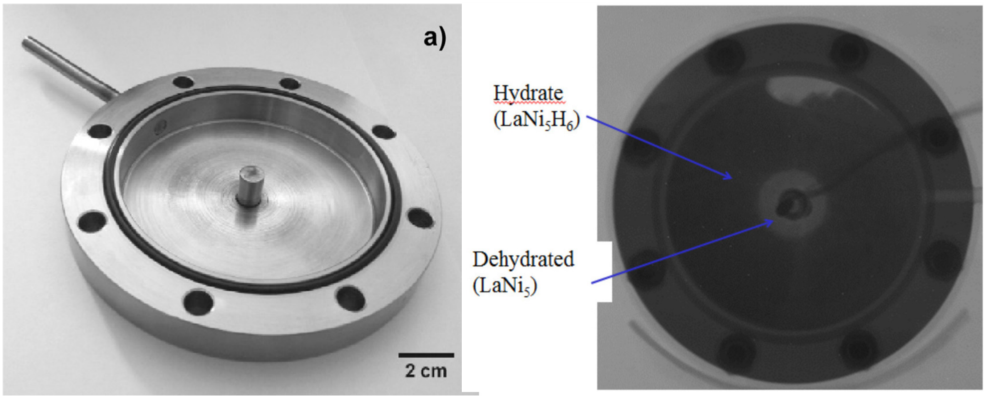
IMPORTANT DATES AND CONTACTS

15/1/2019 to 3º/3/2020: CALL FOR ABSTRACTS
30/4/2020: SUBMIT REVIEW OF ABSTRACTS
1/5/2020 to 16/8/2020: EARLY REGISTRATION
17/8/2020 to 12/10/2020: REGISTRATION
28/09/2020 to 9/10/2020: ETNA: Argentine School on Applied Neutron Techniques
12/10/2020 to 16/10/2020: ITMNR-9 IN BUENOS AIRES
19/10/2020 to 23/10/2020: ITMNR-9 SATELLITE IMAGING SCHOOL IN BARILOCHE
1/12/2020: DEADLINE SUBMISSION OF PAPERS

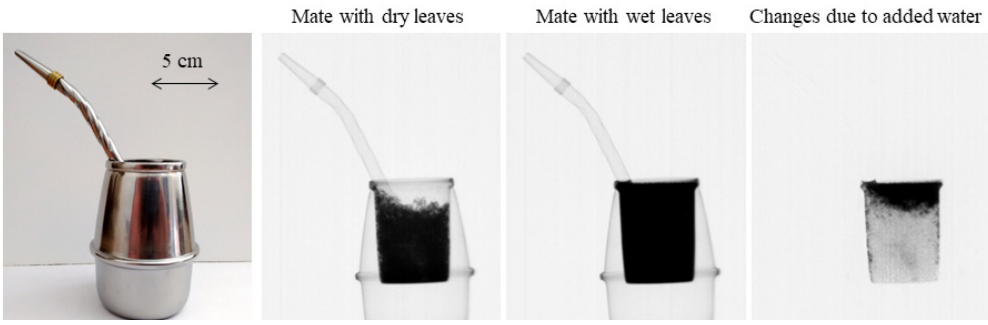
Email: itmnr2020@cnea.gov.ar

Website: coming soon.

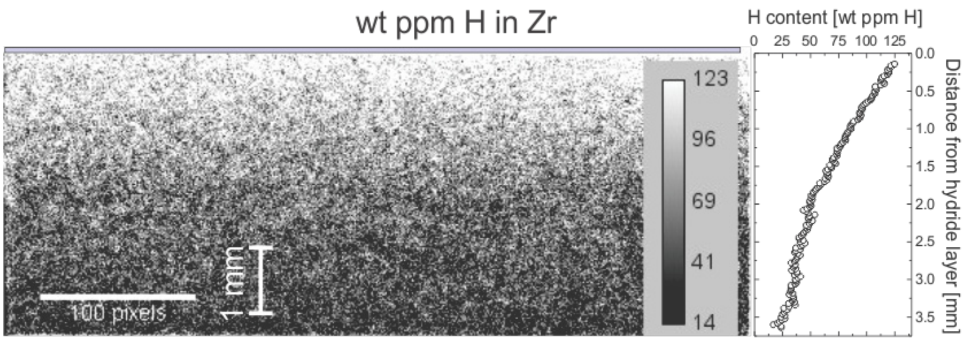
On the next page you will find some neutron images from Argentine groups.



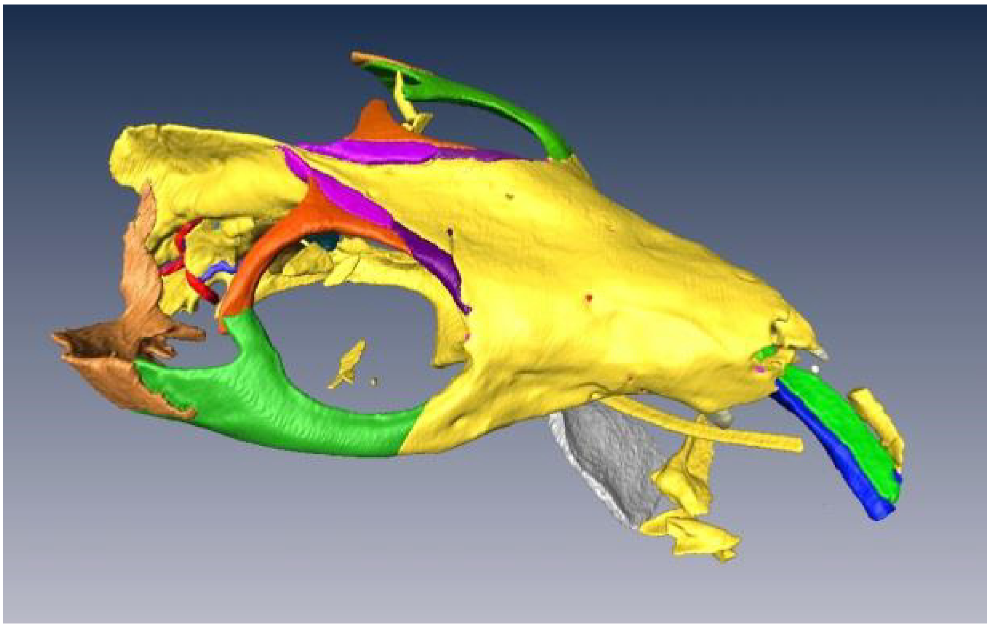
In-situ studies of a hydride-based hydrogen storage system at the imaging beamline of the RA-6 reactor in Bariloche, Argentina [3].



Neutron images of a "mate", a typical Argentinean tea drunk from a straw, taken at the imaging beamline of the RA-6 reactor in Bariloche, Argentina [4].



Quantitative map of hydrogen diffused out of a hydride layer on Zircaloy-2 after a thermal treatment at 350°C, measured at the ANTARES beamline of FRM-II [5]



Neutron tomography of a tetrapode skull from Middle Triassic Formation, from Los Chañares", at Talampaya National Park in the north-western province of La Rioja in Argentina, from experiments performed at at the ANTARES beamline of FRM-II [6]

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[5] [1]N.L. Buitrago, J.R. Santisteban, A. Tartaglione, J. Marín, L. Barrow, M.R. Daymond, M. Schulz, M. Grosse, A. Tremsin, E. Lehmann, A. Kaestner, J. Kelleher, S. Kabra, Determination of very low concentrations of hydrogen in zirconium alloys by neutron imaging, Journal of Nuclear Materials. 503 (2018) 98–109. https://doi.org/10.1016/j.jnucmat.2018.02.048.

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Javier Santisteban

ITMNR-9
9th International Topical Meeting on Neutron Radiography
12-16 October, 2020, Buenos Aires, Argentina

WCNR-12
currently considering dates in June of 2022

... and finally

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Editor

Thomas Bücherl
TU München
Walther-Meissner-Str. 3
85748 Garching
Germany
thomas.buecherl@tum.de
secretary@isnr.de