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# The First International Workshop on Neutron and X-Ray Imaging Applications in Life Sciences and Biology (NXLSB1)

Milton Hill House, Steventon

18-19 February 2020

G Burca (editor)

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# The First International Workshop on Neutron and X-Ray Imaging Applications in Life Sciences and Biology (NXLSB1)

*Editor: Dr Genoveva Burca*

*Dear Colleagues,*

Imaging instrumentation at large-scale facilities such as ISIS, neutron and muon spallation source from the Rutherford Appleton Laboratory or Diamond Light Source, synchrotron facility, UK, are designed to offer the best possible environment for performing top quality scientific experiments which otherwise could not be done at university-based laboratories, covering a broad range of science topics. Of particular interest is the applicability of combining neutron, X-ray imaging and modelling in life sciences and biology. To discuss and share ideas on the employment of the current capabilities, future development and scientific projects, ISIS and Diamond collaborated to organise the first edition of an international workshop with 67 participants from 7 different countries focussing on the use of neutrons and X-ray imaging to provide a new approach for research into life sciences, palaeontology, geoscience and biology.

**Organising Committee**

*Dr Genoveva Burca, Dr Joe Kelleher* - ISIS Beamline Scientists

*Prof Steve Hull* - ISIS Crystallography Group Leader

*Mrs Emma Roberts, Mrs Lisa Wiltshire* - ISIS User Office

*Dr Oxana Magdysyuk, Dr Silvia Cipiccia* - Diamond Light Source beamline scientists

**Workshop aims**

Selected expert members of the life sciences and biology communities, postdoctoral researchers, PhD students, consultants from different companies together with instrument scientists from ISIS neutron and muon source and Diamond Light Source gathered for a lunchtime-to-lunchtime international workshop held at the Milton Hill House, Steventon, Oxfordshire on 18-19th February 2020. The meeting offered the opportunity for future and current users to meet the scientists from ISIS, Diamond and CLF, as well as present, discuss and share their work. The instrument scientists from IMAT neutron imaging and diffraction beamline, ISIS, Diamond imaging beamlines (I12, I13, DIAD, B16) and CLF laser-driven accelerators presented the capabilities of their instruments and various applications in many areas of research including life sciences and biology and showed the benefits of using these imaging techniques to the workshop participants. A particularity of this meeting was the novelty of the research, and the wealth of results already acquired showed the potential of interdisciplinary research projects, which brought together scientists from different fields. The necessity of developing new imaging techniques and improving instrumentation was another important topic discussed during the meeting.

**Summary of the presentations and posters**

The workshop started with a welcome address to the participants by Dr Philip King, Head of ISIS Spectroscopy and Support Division, who summarised for the audience the opportunities offered by ISIS Facility and Dr Paul Quinn, Diamond Science Imaging and Microscopy Group Leader who outlined the imaging capabilities Diamond offers to users.

The Tuesday afternoon continued with a series of presentations (see abstracts) from instrument scientists (ISIS – IMAT, Diamond – I12, I13 and CLF) and users from both ISIS and Diamond facilities, covering a wide range of topics from root systems, beetle scales, geoscience and soil characterisation. The day ended with a poster session, giving researchers a further chance to present and discuss about their work.

A panel of experts judged the posters and selected *Micro-tomography of teeth following demineralisation* from University of Oxford based on the quality of research, contribution to the field and presentation, for the best poster award.

The workshop resumed on Wednesday morning with a second round of talks (see abstracts) showing the broad range of the complementary X-ray and neutron imaging

applications in the current life sciences and biology studies including but not limited to the preservation of archaeological bone, the analyses of fossils and moisture sorption of nanocellulose treated painting canvases.

All participants agreed that the potential of combining neutron and X-ray imaging applications in life sciences is tremendous opening the way for a new and exciting cutting-edge research.

**Conclusions**

The workshop programme covered both scientific and technical developments, offering the possibility of open and constructive knowledge exchange concerning issues such as the performance of presently available instruments at ISIS, Diamond and CLF. The participants have also addressed the current limitations of the neutron imaging techniques available on IMAT.

Whilst IMAT has already proved its role in the advancement of soil-plants systems, geoscience or palaeontology research it was argued that an improvement of the spatial resolution (e.g. detectors developments, neutron optics) or sample environment would significantly boost the quality of the research done on IMAT.

Moreover, a CT X-ray machine installed in immediate vicinity of IMAT would be beneficial for users with short life span samples when access to Diamond imaging beamlines (e.g. I12) is not available.

The discussion that followed focussed on identifying viable solutions to overcome the challenges of combining neutron and X-ray imaging measurements on the same samples but on different beamlines from two different facilities ISIS and Diamond.

The advantage of preparing the samples in our own research greenhouse installed at ISIS was emphasised by IMAT/ I12 users who already successfully used it during their experiments.

Some of the workshop participants suggested that ISIS should prioritise the development of software for imaging data analysis and eventually provide access to users to analyse acquired data even after they finished their experiments. The collaboration with Diamond facility in software development was strongly encouraged.

# Workshop Poster

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ISIS Neutron and Muon Source

diamond

## WORKSHOP ON NEUTRON AND X-RAY IMAGING IN LIFE SCIENCES AND BIOLOGY

Milton Hill House, Steventon, Oxfordshire OX13 6AF
18th – 19th February 2020
(Lunchtime – Lunchtime)

**Register at https://tinyurl.com/NXLSB**

Topics include, but are not limited to:

Updates from IMAT (ISIS), I12 and I13 (Diamond) imaging beamlines
Plant-soil research
Geoscience/ Palaeontology/ Palaeobotany
Biology/ Forensic Sciences
Student poster session

**Group photo (Milton Hill House garden, 18th February 2020)**

**The 1st Workshop on Neutron and X-Ray Imaging Applications in Life Sciences and Biology (NXLSB1)**

**Milton Hill House, UK – February 18-19th, 2020**

# PROGRAMME

## *Tuesday 18th February*

| | |
|---|---|
| **13:00 - 13:10** | **Philip King** - Welcome @ ISIS<br>(Head of ISIS Spectroscopy and Support Division, ISIS Neutron and Muon Source, UK) |
| **13:10 - 13:20** | **Paul Quinn** - Welcome @Diamond<br>(Science Group Leader – The Imaging and Microscopy Group, Diamond Light Source) |
| **13:20 - 13:40** | **Genoveva Burca** - IMAT: neutron imaging and diffraction beamline<br>(ISIS Neutron and Muon Source, UK) |
| **13:40 - 14:00** | **Oxana Magdysyuk** - Tomography capabilities of the Beamline I12 for the Life Science and Biology research<br>(Diamond Light Source, UK) |
| **14:00 - 14:20** | **Ceri Brenner** - Laser-driven accelerators for ultra-short pulsed beams of X-rays and neutrons<br>(Central Laser Facility, UK) |
| **14:20 - 14:40** | **Thomas Clark** - Correlative X-ray and Neutron Tomography of Root Systems<br>(University of Southampton, UK) |
| **14:40 - 15:00** | **Andrew Parnell** - The 3D nanostructure of Ultra-white beetle scales and how to make this nanostructure synthetically<br>(The University of Sheffield, UK) |
| **15:00 - 15:30** | **Coffee Break** |
| **15:30 - 15:50** | **Darren Battey** - Imaging with X-rays: A multiscale, multimodal approach from I13<br>(Diamond Light Source, UK) |
| **15:50 - 16:10** | **John Koestel** - Combined Neutron and X-ray tomography for soil material characterization<br>(Swedish University of Agricultural Sciences, Uppsala, Sweden) |
| **16:10 - 16:30** | **Frikkie de Beer** - The role the neutron and X-ray radiography/tomography experimental facilities at Necsa (South Africa) play to enhance palaeoscience, geoscience and bioscience research<br>(The South African Nuclear Energy Corporation SOC Ltd, South Africa) |
| **16:30 – 16:50** | **Amer Syed** - 3D fracture planes in weakly consolidated sandstone under axial loading<br>(University of Aberdeen, UK) |
| **17:00 – 18:00** | **Poster Session** |
| **18:00** | **Dinner** |

## *Wednesday 19th February*

| | |
|---|---|
| **09:00 - 09:20** | **Hongchang Wang** - From geological science to medical imaging: fast X-ray phase tomography at B16<br>(Diamond Light Source, UK) |
| **09:20 - 09:40** | **Chloe Pearce** - Neutron tomography as a non-destructive tool for determining the preservation of archaeological bone<br>(Birbeck, University of London, UK) |
| **09:40 - 10:00** | **Manoj Menon** - Progress and prospects of neutron imaging in soil-plant systems<br>(The University of Sheffield, UK) |
| **10:00 - 10:20** | **Imran Rahman** - Complementary X-ray and neutron tomography of exceptionally preserved fossils<br>(University of Oxford, UK) |
| **10:20 - 10:40** | **Morteza Aminnaji** - Interplay of biofilm growth and NAPL biodegradation in natural attenuation of aquifers: A pore network modelling study<br>(The University of Manchester, UK) |
| **10:40 - 11:00** | **Xavier Portell** - Image-based modelling of microbiologically driven soil processes<br>(Cranfield University, UK) |
| **11:00 - 11:30** | **Coffee break** |
| **11:30 - 11:50** | **Ahmed Sharif** - DIAD: A new Dual Imaging and Diffraction beamline at Diamond<br>(Diamond Light Source, UK) |
| **11:50 - 12:10** | **Richard Johnston** - Imaging mineralised and soft tissues using lab X-ray tomography<br>(Swansea University, UK) |
| **12:10 - 12:30** | **Marianne Odlyha** - Neutron radiography studies of moisture sorption of nanocellulose treated painting canvases<br>(Birbeck, University of London, UK) |
| **12:30 - 12:50** | **Tinashe Mawodza** - Revealing root system architecture and soil moisture distribution in an aggregated soil using neutron computed tomography<br>(The University of Sheffield, UK) |
| **12:50 - 13:00** | Closing Remarks and Feedback |
| **13:00** | **Lunch** |

# ABSTRACTS

**IMAT: neutron imaging and diffraction beamline in life sciences and biology**

*Genoveva Burca, ISIS Neutron and Muon Source, UK*
*(genoveva.burca@stfc.ac.uk)*

Neutron imaging has been employed in life sciences in recent years and has proven to be a viable technique for studying internal features without compromising integrity and internal structure of samples in addition to being complementary to other methods such as X-ray or magnetic resonance imaging. Within the last decade, the IMAT neutron imaging and diffraction beamline was designed and built at the ISIS Neutron and Muon Source, UK to meet the increasing demand for neutron imaging applications in various fields spanning from materials engineering to agriculture (soil-plants systems), palaeontology, geoscience and biology.

**Tomography capabilities of the Beamline I12 for the Life Science and Biology research**

*Oxana Magdysyuk, Diamond Light Source, UK*
*(oxana.magdysyuk@diamond.ac.uk)*

The high-energy beamline I12 provides the unique tomography capabilities for biomechanics, plant-soil research, geoscience and palaeontology. Measurements of the large sample with high spatial resolution are possible allowing the investigation of the various processes and objects at realistic conditions.

**Laser-driven accelerators for ultra-short pulsed beams of X-rays and neutrons**

*Ceri Brenner, Central Laser Facility, UK*
*(ceri.brenner@stfc.ac.uk)*

Laser-driven accelerators provide high brightness, ultra-short (10's fs) pulsed beams of photons, ions and neutrons. Laser-driven x-ray beams have been utilised for micro-CT imaging of biological samples and have shown phase-contrast enhancement capability within a short (2 m) stand off from the source. A new facility is now being constructed onsite, which will realise a 10 Hz laser-driven accelerator beamline, providing X-rays (from keV up to MeV) and fast neutrons for academic and industry users.

**Correlative X-ray and Neutron Tomography of Root Systems**

*Thomas Clark, University of Southampton, UK*
*(tjc3q13@soton.ac.uk)*

The interactions between plant roots and soil are an area of active research, particularly in terms of water and nutrient uptake. A X-ray imaging gives clear insight to soil structure and composition; however, water is comparatively transparent to X-rays and biological matter also displays poor contrast with respect to the pores between soil particles. Neutron imaging presents a complementary view where water and biological matter are better distinguished but the soil minerals are not imaged as clearly as they would be with X-rays. This work aims to develop robust methods for complementary X-ray/neutron tomographic imaging of plant root samples, which should lead to new insight into water and nutrient transport in soil. The key challenges of this project are to develop experiments that will meet the requirements of

both imaging modalities as well as the biological requirements of the plant samples and to develop ways to register a pair of reconstructed volume images of a sample that will typically have been produced with entirely separate facilities.

**The 3D nanostructure of Ultra-white beetle scales and how to make this nanostructure synthetically**

*Andrew Parnell, University of Sheffield, UK*
*(a.j.parnell@sheffield.ac.uk)*

Cyphochilus beetle scales are amongst the brightest structural whites in nature, being highly opacifying whilst extremely thin. Using 3D x-ray nanotomography toileting study the scales of Cyphochilus and Lepidiota stigma we have been able to confirm the structure formation mechanism and create optically equivalent materials. These possess a comparable density of voids of similar size and strongly scatter light.

**Imaging with X-rays: A multiscale, multimodal approach from I13**

*Darren Batey, Diamond Light Source, UK*
*(darren.batey@diamond.ac.uk)*

Neutrons provide X-ray microscopy with complimentary information, especially where samples contain both high and low z materials. I will discuss the various methods applied in a recent cross instrument examination of plant roots, involving direct-space micro-tomography, reciprocal-space nano-tomography, and X-ray fluorescence.

**Combined Neutron and X-ray tomography for soil material characterization**

*John Koestel, Swedish University of Agricultural Sciences, Sweden*
*(John.Koestel@slu.se)*

Non-invasive imaging methods provide unprecedented means to link soil structure to bulk soil properties. This study investigates the potential and limitations of combined neutron and X-ray imaging to quantify mineral and carbon contents in undisturbed soil.

**The role the neutron and X-ray radiography/tomography experimental facilities at Necsa (South Africa) play to enhance palaeoscience, geoscience and bioscience research**

*Frikkie de Beer, The South African Nuclear Energy Corporation SOC Ltd, South Africa*
*(frikkie.debeer@necsa.co.za)*

The South African Nuclear Energy Corporation (Necsa) is located within the Cradle of Humankind, near the platinum rich Marensky Reef and is also enclosed by nearby Universities with anatomical and bioscience research Departments. With its Micro-focus XCT and neutron radiography (currently in upgrade phase) facilities, Necsa plays a significant role in human source development and knowledge generation by serving the National System of Innovation of South Africa but also the international research community. Experience in generation of results in interesting but important collaborating research activities will be highlighted to showcase our capabilities in the palaeosciences, geosciences and biosciences research fields.

**3D fracture planes in weakly consolidated sandstone under axial loading**

*Amer Syed, University of Aberdeen, UK*
*(a.syed@abdn.ac.uk)*

Damage mechanics of weakly consolidated rocks is of interest for various fields of engineering such as ground engineering, hydrocarbon production etc to assess the integrity of geoengineering operations. This talk will discuss the damage mechanics in weakly consolidated sandstones based on the recent experiments at IMAT aimed at acquiring fracture morphology in Lochaline sandstone under axial stress.

**From geological science to medical imaging: fast X-ray phase tomography at B16**

*Hongchang Wang, Diamond Light Source, UK*
*(Hongchang.Wang@diamond.ac.uk)*

Ever since the speckle technique was introduced into the X-ray imaging community, attention has been immediately attracted since it can provide the quantitative phase information by tracking the displacements of speckle patterns generated with a piece of membrane filter or sandpaper. It offers alternative solution to perform the phase contrast imaging without sophisticated experimental conditions or stringent beam properties. To improve the spatial resolution, a generalized method has been developed to retrieve the phase image by performing a 2D raster scan of the phase/absorption object. Recently, the fast 1D speckle scanning technique has been proposed, in addition to the phase contrast image, both absorption and dark field image can be simultaneously extracted from same data set. Moreover, the speckle based technique has been demonstrated to perform high energy X-ray imaging with random absorption mask. Importantly, it has been extended from high brilliant synchrotron radiation source to the micro-focus laboratory source for wide application. An overview of the speckle based technique for the application in advanced X-ray imaging will be given in this talk with representative examples.

**Neutron tomography as a non-destructive tool for determining the preservation of archaeological bone**

*Chloe Pearce, Birkbeck, University of London, UK*
*(cpearc03@mail.bbk.ac.uk)*

Archaeological bone is a finite resource that holds much data about our past, however, conditions of display and storage in museums pose risk of deterioration due to fluctuations in environmental conditions. To improve our understanding of the state of preservation of selected archaeological bones from English Heritage collections, neutron tomography was performed for the first time at the IMAT facility at ISIS. Our aim was to evaluate their condition without compromising their integrity, and so preserving their research potential. Results have highlighted areas of weakness, such as cracks below the surface. Attenuation intensity data produced by transmittance variation was used to map distribution of residual collagen. This was shown to correlate with collagen content as determined from FTIR data. Neutron tomography has therefore provided a method of non-invasive analysis that includes information on both physical and chemical state of preservation, as well providing a digital legacy for the archaeological bones.

**Progress and prospects of neutron imaging in soil-plant systems**

*Manoj Menon, The University of Sheffield, UK*
*(m.menon@sheffield.ac.uk)*

Neutron imaging is an in situ method which is available to researchers at various neutron facilities across the world. In contrast with X-rays, neutrons attenuate with hydrogen

(abundant in water and plant organs), and this principle was used in detecting field soil moisture was first developed in the 1950s in the form of a neutron moisture meter. However, its application to the image root system *in situ* was only realised in 1978. Since then, this non-destructive imaging has revolutionised our understanding of root growth and its architecture as well as its interactions with various soil conditions. Over the past decade, neutron image acquisition technology have developed considerably, which has resulted in an increased use of neutron radiography (2D) and tomography (3D) methods in plant-root system research. In this presentation, selected case studies from the last 10 years literature will be presented. These examples will include seed germination, early root growth in different plant species, dynamic water uptake, and root system responses to imposed soil stresses. Finally, significant challenges and prospects in using neutron imaging will be considered.

**Complementary X-ray and neutron tomography of exceptionally preserved fossils**

*Imran Rahman, University of Oxford, UK*
*(imran.rahman@oum.ox.ac.uk)*

Tomographic techniques are widely used to study the internal anatomy of exceptionally preserved fossils, greatly improving our understanding of the history of life. I will discuss the strengths and weaknesses of X-ray and neutron tomography in palaeontology, presenting examples of fossil specimens imaged with both methods.

**Interplay of biofilm growth and NAPL biodegradation in natural attenuation of aquifers: A pore network modelling study**

*Morteza Aminnaji, University of Manchester, UK*
*(morteza.aminnaji@manchester.ac.uk)*

The impact of an additional phase (biofilm) on transport and NAPL dissolution is dynamically implemented in the pore network model. The results indicate that as correlation length increases, the biofilm growth decreases resulting in a reduction of NAPL bioremediation and dissolution.

**Image-based modelling of microbiologically driven soil processes**

*Xavier Portell, Cranfield University, UK*
*(xavier.portell@cranfield.ac.uk)*

Soils are central to a number of issues of great societal concern, related to climate change, environmental pollution, or feeding the growing world population. Soil is mostly opaque to most experimental techniques but advances in non-invasive imaging are now offering new ways of studying soil functioning. Neutron and X-ray 3D images describe soil architecture and water distribution, unravelling the diversity of soil microhabitats where microorganisms evolve. This informs bio physicochemical models that can be used to test alternative hypothesis and ultimately provide new mechanistic knowledge of this complex system. This presentation provides two concise case examples of the integration of biophysical modelling and non-invasive imaging. The first example illustrates the study of mechanism generating bacterial diversity in soils and uses the Individual-based model Ib-LBioS (Portell et al. 2018, Front. Microbiol. 9:1583). The second example investigates microscale mechanisms explaining experimental variability and non-linearity in the mineralisation process of the soil organic matter and uses the fungal model mFUN (Falconer et al. 2015, PLoS ONE 10(5): e0123774).

**DIAD: A new Dual Imaging and Diffraction beamline at Diamond**

*Ahmed Sharif, Diamond Light Source, UK*
*(sharif.ahmed@diamond.ac.uk)*

DIAD has been designed for the concurrent use of XCT and XRD on the same sample position. It will offer users unprecedented levels of automation for unattended intelligent data collection and pseudo- real-time decision making for in situ/operando experiments.

**Imaging mineralised and soft tissues using lab X-ray tomography**

*Richard Johnston, Swansea University, UK*
*(r.johnston@swansea.ac.uk)*

Lab-based X-ray microscopy (µCT/XRM) can reveal previously undiscovered internal microarchitectures, as well as generating 3D representations of complex surface structures. Traditionally this would be most useful for mineralised or relatively dense structures. However, diffusible iodine-based contrast-enhanced (DICE) CT where higher-density stains bind to soft tissues enables imaging of non-mineralised biological structures such as muscles, bridging the hard/soft material interface, crucial for a holistic biomechanical understanding. From this work we have demonstrated how even small-scale and often overlooked organisms demonstrate naturally occurring bioengineering. The work demonstrates that correlative methods that span different platforms and techniques enable the extension of the fundamental basics of material science to broaden the application of bio-inspiration in human-made engineering applications.

**Neutron radiography studies of moisture sorption of nanocellulose treated painting canvases**

*Marianne Odlyha, Birkbeck, University of London, UK*
*(m.odlyha@bbk.ac.uk)*

The degradation of an easel painting typically results in canvas loss in strength and elasticity so that it does not effectively support the paint structure. Lining of the painting was done almost as a routine procedure until awareness was raised in 1974 regarding the risks associated with the procedure of application and the stability and invasiveness of the glues used. The aim of our work was to investigate the efficacy of novel nanocellulose-based consolidants for modern easel paintings as a possible alternative to lining and to the use of common adhesives. To test the efficacy of this treatment the response of the treated canvases on exposure to programmed cycles of relative humidity (20-80%RH) was measured by mechanical analysis and neutron imaging of canvases in a custom-built chamber.

**Revealing root system architecture and soil moisture distribution in an aggregated soil using neutron computed tomography**

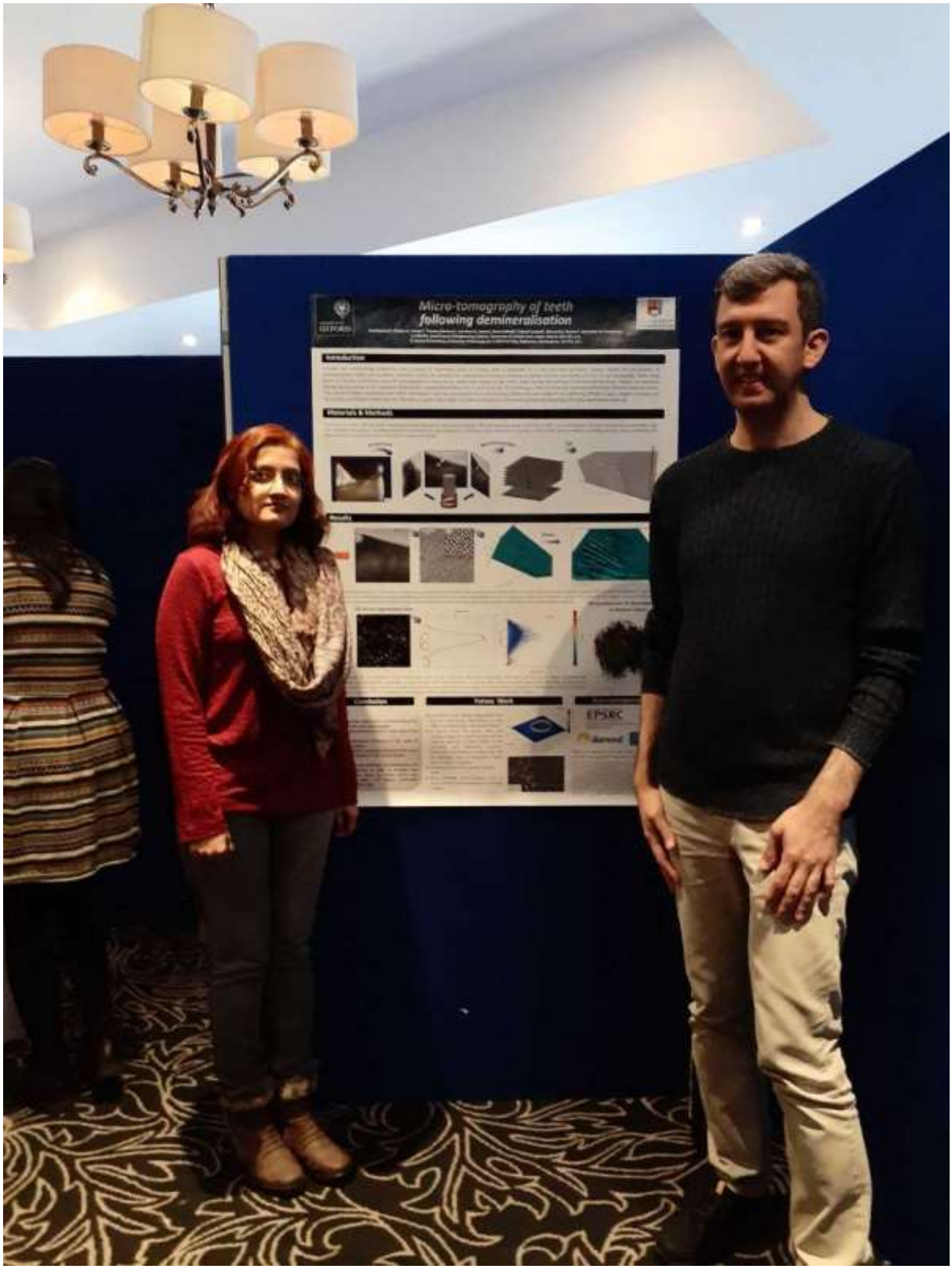
*Tinashe Mawodza, University of Sheffield, UK*
*(t.mawodza@sheffield.ac.uk)*

Neutron computed tomography (NCT) is a powerful imaging tool that can be used to visualise root system architecture and soil water distribution non-destructively. In this presentation, we show results of a recently published work explaining the advantages and disadvantages of NCT in in-situ plant root imaging. The main aims of this research were (1) to unravel wheat (Triticum aestivum cv. Fielder) root system architecture (RSA) when grown in an aggregated

sandy loam soil (<4mm) with 4% SOM content, (2) 3D mapping of soil water distribution after a brief drying period and (3) to understand how the root system interacts with soil moisture distribution brought about by soil structural heterogeneity.

# POSTERS

| | |
|---|---|
| Robert Barker (University of Kent) | Opportunities in Forensic Science and Bioengineering |
| Jakobus Hoffman (NECSA, South Africa) | Developing a method to quantify material density from volumetric data with micro-focus X-ray tomography |
| Flavia Pinzari (Natural History Museum, London) | Fungal strategies to obtain potassium from silicates |
| Alexander Korsunsky (University of Oxford) | Micro-tomography of teeth following demineralisation |
| Gunjan Das (University of Leeds) | X-ray Phase-Contrast Imaging (XPCI) Swiss Army Tool for Early Stage Process Design, Development and Control |
| Ben Callow (University of Southampton) | From Field- to Fine-Scale Fluid Flow Unearthing the science behind the art of X-ray micro-CT image-based modelling |
| Andrew Bodey (Diamond Light Source) | Optimising complementary soft tissue synchrotron X-ray microtomography for reversibly-stained central nervous system samples |
| Sara Nonni (University of Manchester at Harwell) | Looking at the past: X-ray tomography of archaeological and paleontological objects |
| Marianne Odlyha (Birkbeck, University of London) | Neutron radiography studies of moisture sorption of nanocellulose treated painting canvases |
| Julia Parker (Diamond Light Source) | Nano-Bioimaging: Exciting Stories from Diamond's Hard X-ray Nanoprobe |
| Takshak Shende (University of Manchester) | Water cluster in partially saturated tight sandstone |
| Jiayi Zhang (Diamond Light Source) | From geological science to medical imaging: fast X-ray phase tomography at B16 |
| Alexander Liptak (University of York) | Developments towards Bragg edge imaging for a strain mapping implementation on the IMAT beamline at the ISIS Pulsed Neutron and Muon Source: BEAn (Bragg Edge Analysis) |
| Genoveva Burca (ISIS) | Neutron imaging in Life Sciences and Biology |
| Fernando Alvarez-Borges (Diamond Light Source) | Application of X-ray CT to investigate rock-structure interaction on piled foundations for marine areogenerators |
| Thomas Clark (University of Southampton) | Correlative X-ray and neutron tomography of root systems using cadmium fiducial markers |




**Best Poster (University of Oxford)**

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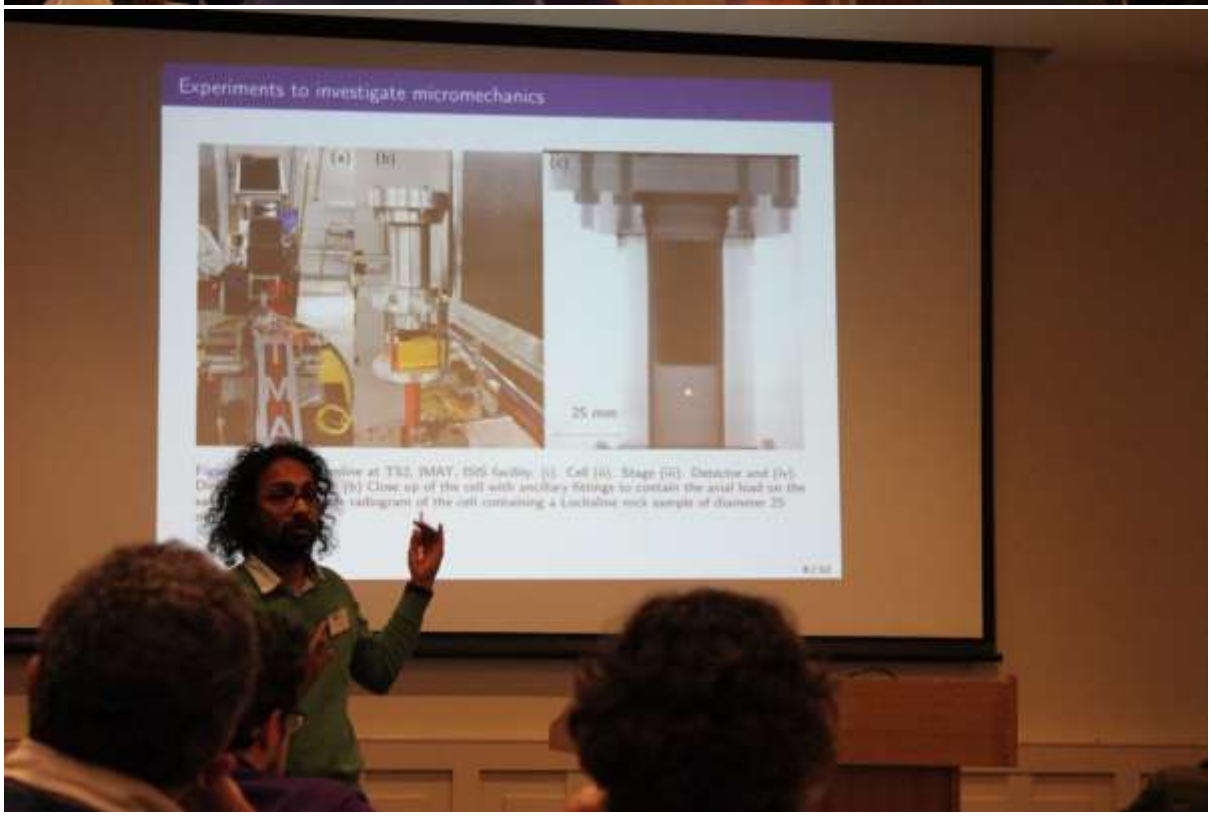
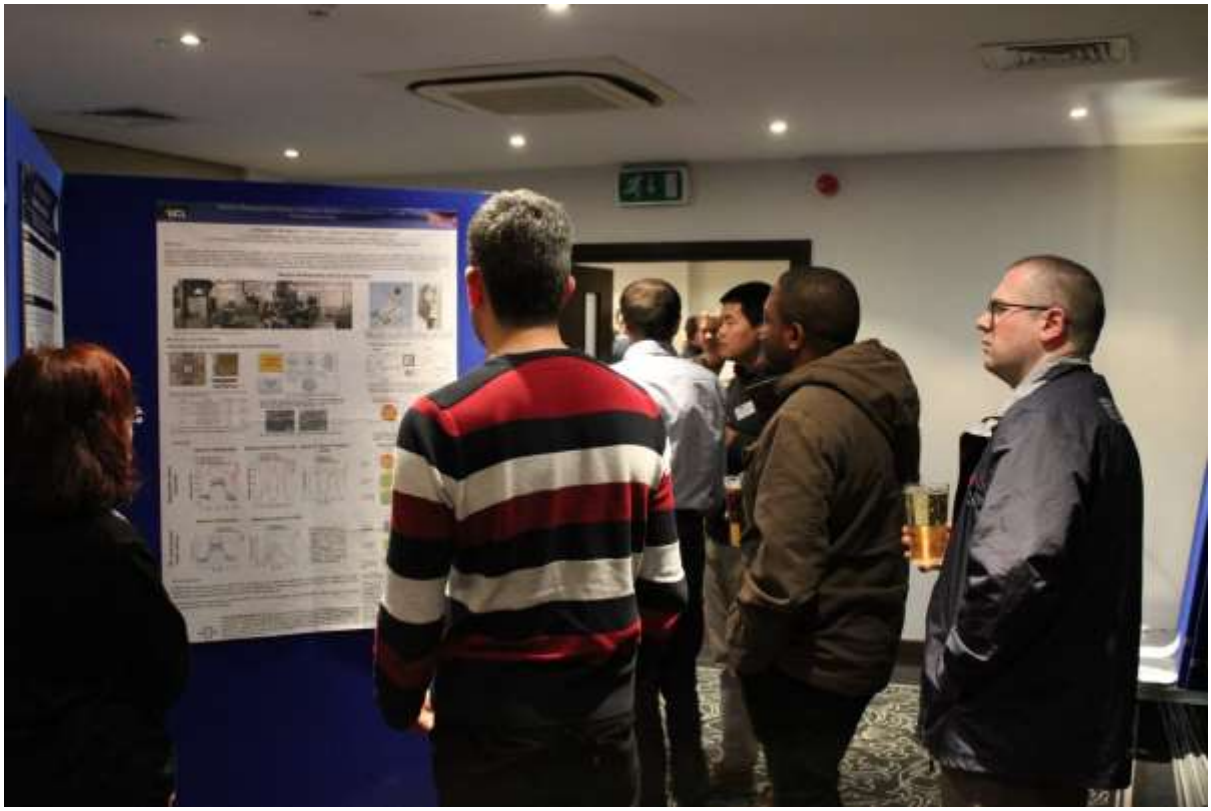
Welcome!


Welcome!


Palaeontology on I12: internal structures revealed by tomography


Ultra white beetles and learning design rules from nature
Andrew Parnell


Experiments to investigate micromechanics
(a)
(b)
(c)
25 mm




Acknowledgements
ISIS Neutron and Muon Source
diamond


Results
Combined 3-D neutron and X-ray im
X-ray-Neutron composite image

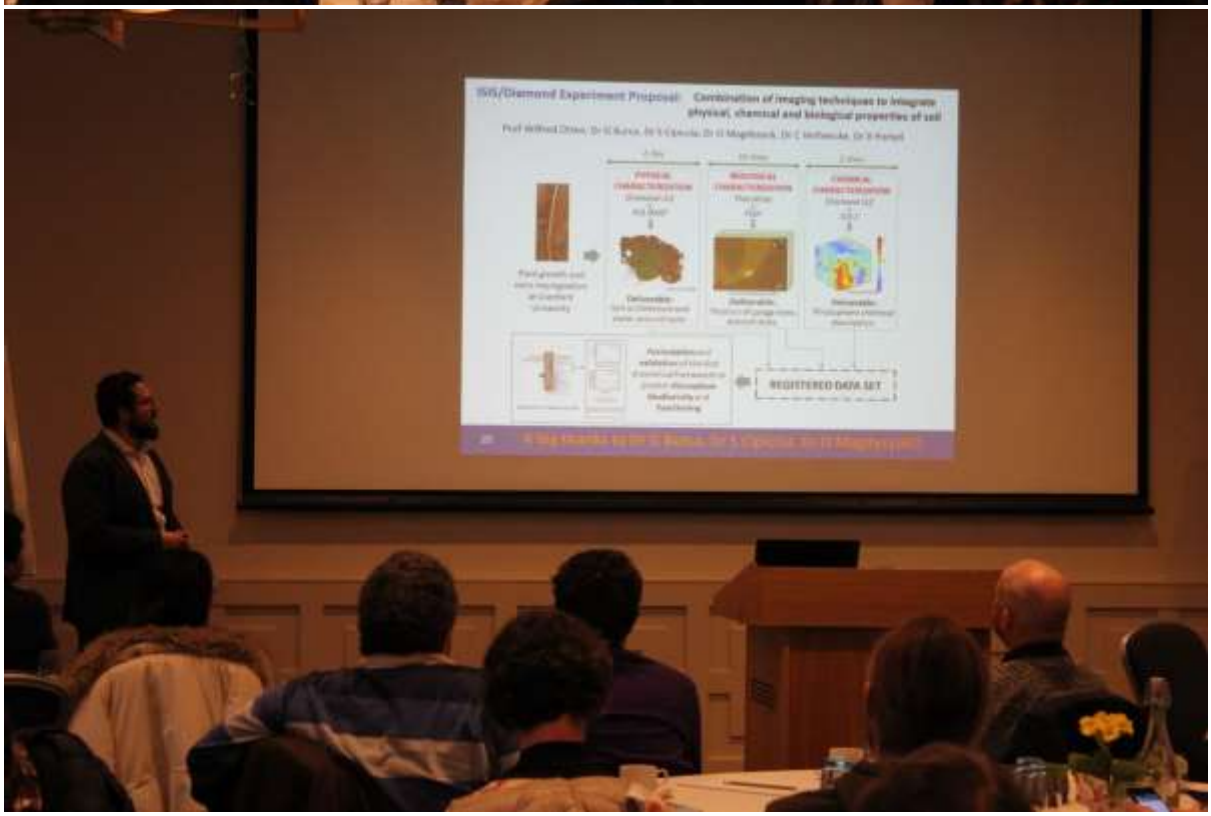

Development and Application of speckle phase contrast imaging
Hongchang Wang
Optics & Metrology Group, Diamond Light Source
diamond


NEUTRON TOMOGRAPHY AS A NON-
DESTRUCTIVE TOOL FOR DETERMINING THE
PRESERVATION OF ARCHAEOLOGICAL
BONE

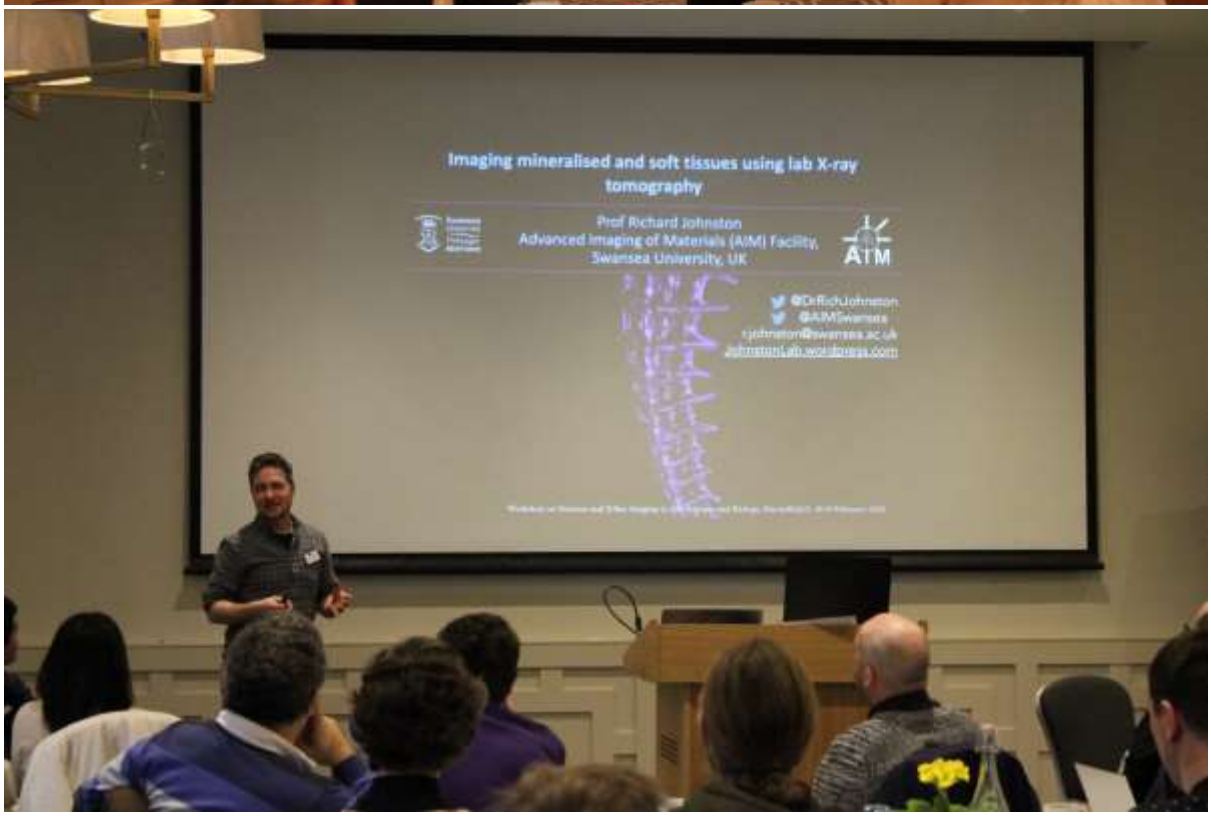

Our work with ISIS-IMAT


Imperial College London
Complementary X-ray and Neutron Tomography of Exceptionally Preserved Fossils
Imran Rahman, Alan Spencer, Russell Garwood & Genoveva Burca


Pore network modelling of interface biofilm: NAPL biodegradation and dissolution
Morteza Aminnaji
Masoud Babaei
Feb 2020


ISIS/Diamond Experiment Proposal: Combination of imaging techniques to integrate physical, chemical and biological properties of soil
REGISTERED DATA SET


DIAD: A new Dual Imaging and Diffraction beamline at Diamond


Imaging mineralised and soft tissues using lab X-ray tomography
Prof Richard Johnston
Advanced Imaging of Materials (AIM) Facility,
Swansea University, UK
AIM


UCL
Neutron Radiography Studies of Moisture Sorption of Nanocellulose Treated Painting Canvases


Wheat root system architecture and soil moisture distribution using Neutron computed tomography
Tinashe Mawodza
Sheffield University