ULTRA: A data analysis platform for neutron (and X-ray) CT reconstruction

Collaborative project between ISIS, SC, DLS, and CCPi

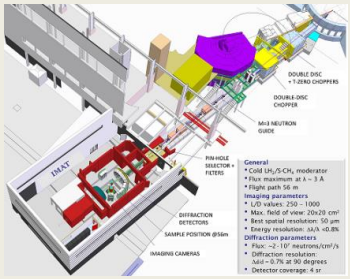
STFC Scientific Computing Department

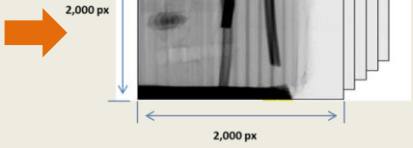
Science & Technology Facilities Council ISIS

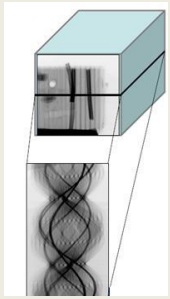
MANTID

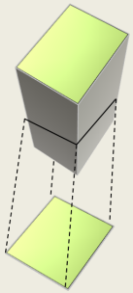
diamond

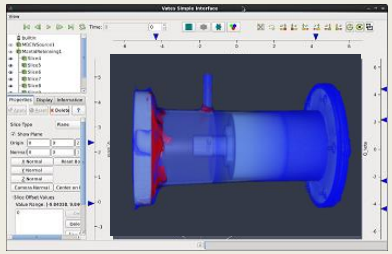
CCPi Tomographic Imaging











IMAT Experiment

In-experiment tomography image reconstruction

Parallel Volumetric Data Visualisation*

UKT0 – 15 March 2018

Winfried.Kockelmann@stfc.ac.uk

What is ULTRA?

Project to develop an open-source CT data processing package to provide facility users with:

- ❑ Tools to cope with the complexity of imaging data (e.g. 4D/colour)
- ❑ Fast reconstruction on HPCs (where desktops fall short)
- ❑ A common tomography pipeline across site (SAVU)
- ❑ Remote access to local beamline resources and HPC clusters

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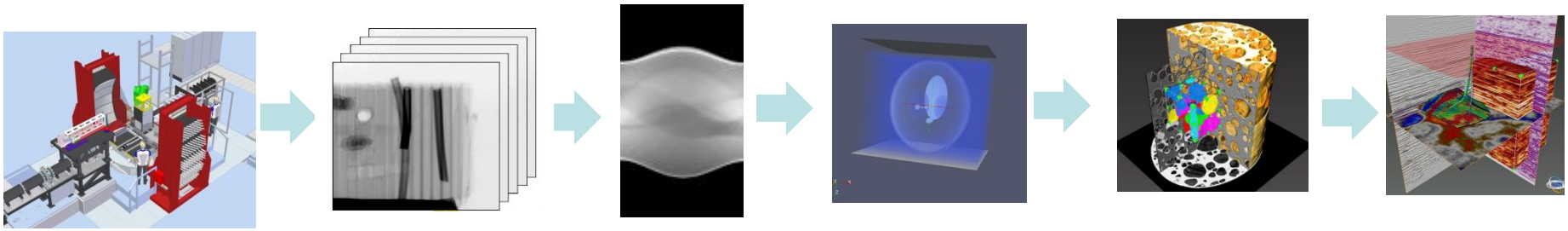


Experiment

Projections
Energy-Selection
Normalisation
Corrections
Filters

Sinograms
Filters

Reconstruction
Post-processing
Filters
De-noising

Segmentation

Quantification

Data collection

User Interactions with reconstructed data

ULTRA: the process

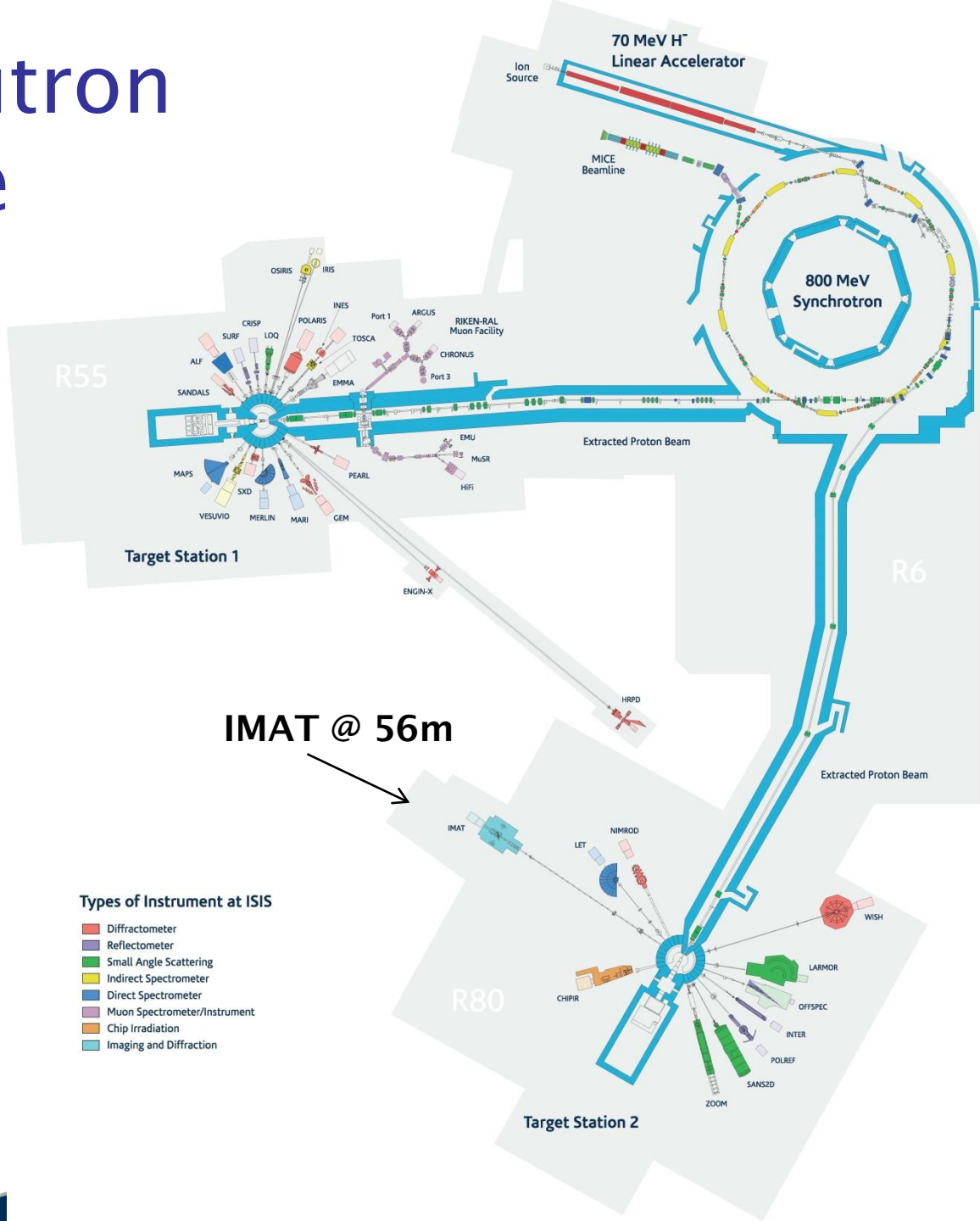
ISIS pulsed neutron & muon source

Proton-accelerator based
Spallation source: 800 MeV

37 neutron+muon beamlines

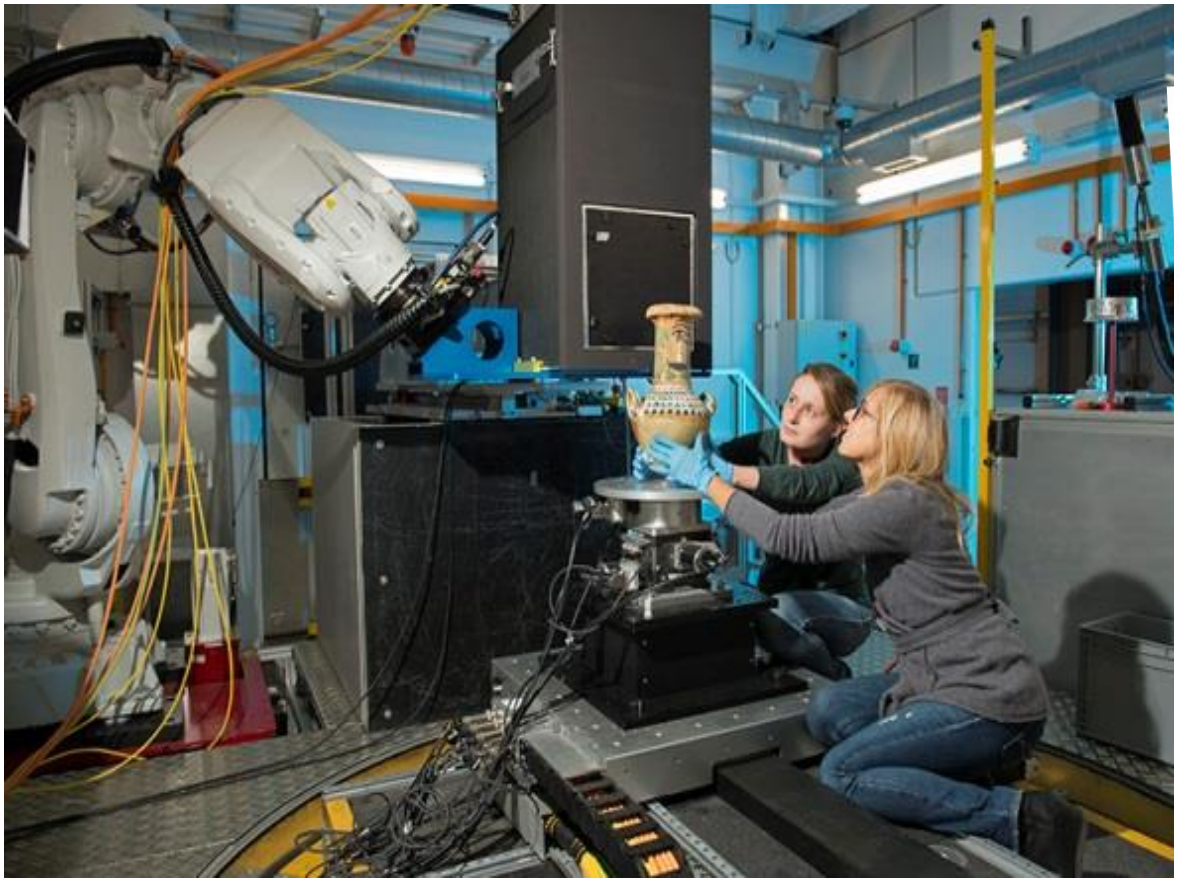
A pulsed neutron source enables effective Time of Flight (ToF) techniques, i.e. for determining neutron velocities and wavelengths:

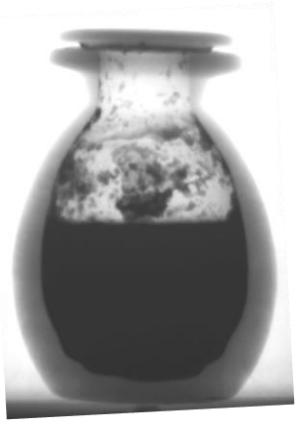
$v = \frac{L}{T} = h/(m*\lambda)$

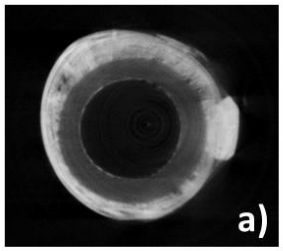


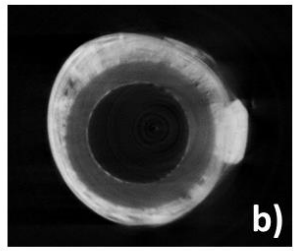
IMAT: Imaging and MATerials science

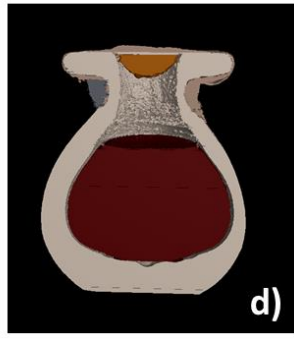
(Imaging & Diffraction)











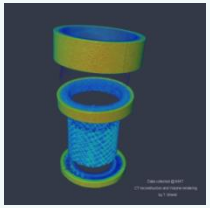
Objects from the Egyptian Museum Turin

Valentina Turina, Museo Egizio di Torino
Matilde Borla, Sopr. Arch. Piemonte

IMAT Methods

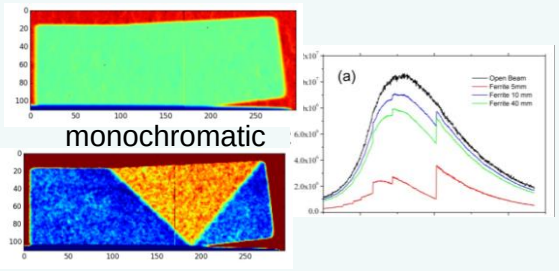
Real-space + TOF Imaging

White beam Radiography/ Tomography



Energy-selective Imaging

White beam



monochromatic

SMA imaging; Saurabh Kabra

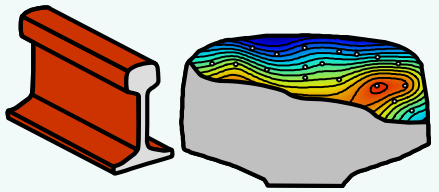
"Tomography guided" diffraction

(ULTRA)

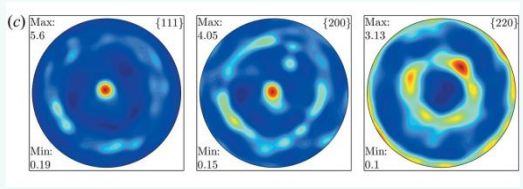
Interprete images

Spatially resolved Diffraction

Phase analysis Strain & Stress



Texture analysis



Napoleonic war copper bolts on ENGIN-X: Melamud, Northover et al. 2017

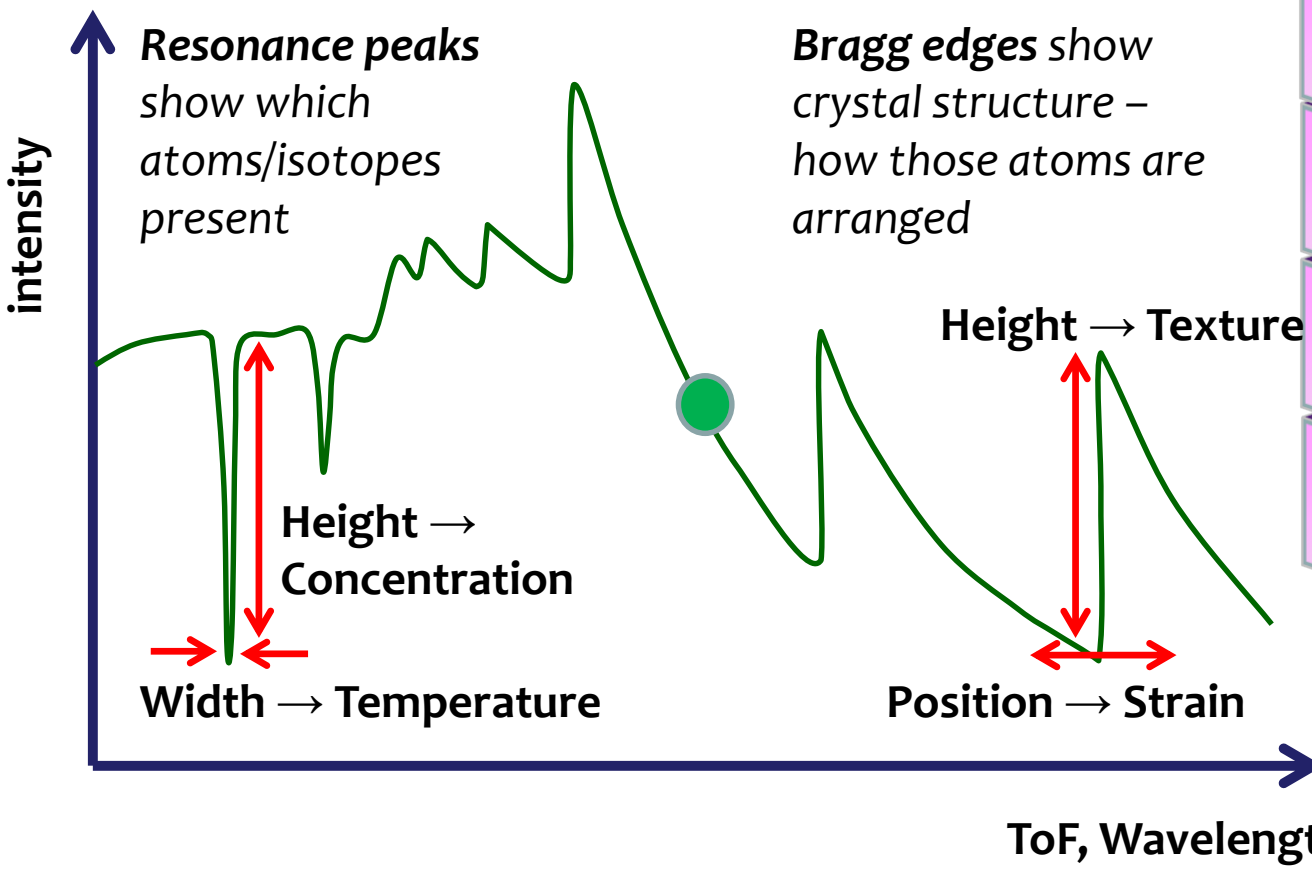
Now available

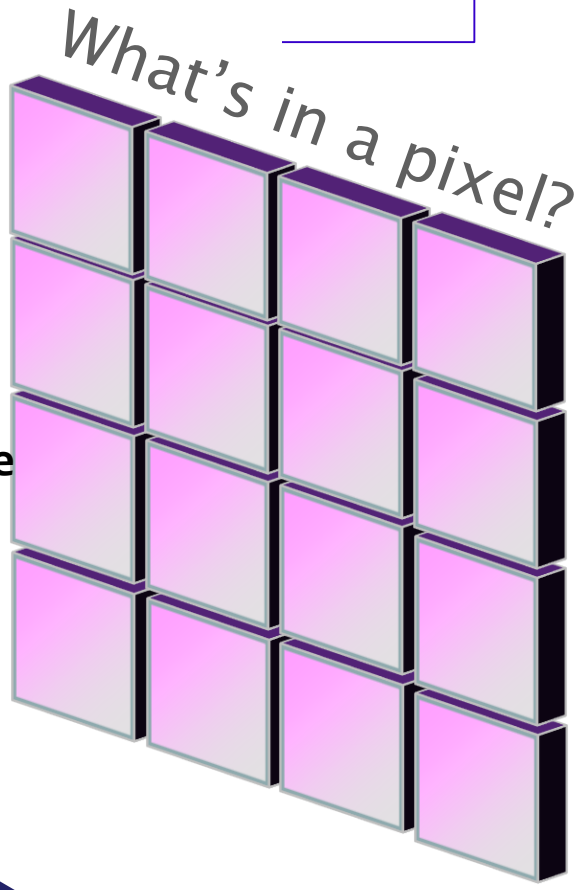
Coming in 2019

Energy-dispersive (colour) neutron radiography

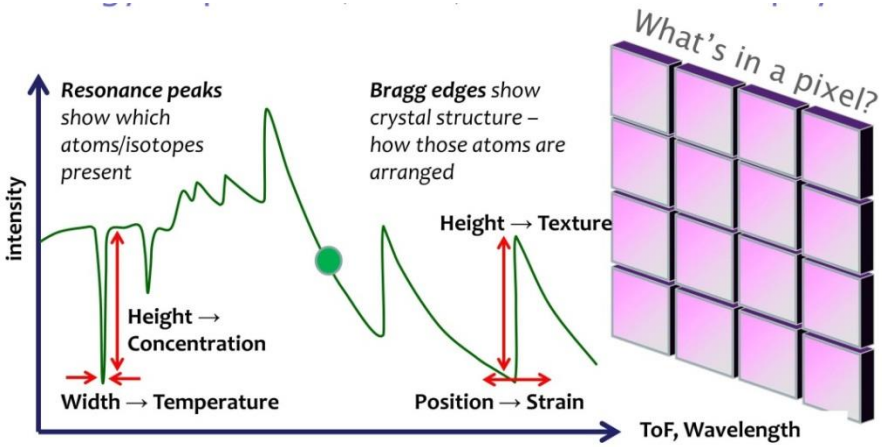
A pulsed neutron source enables effective
Time of Flight (TOF) = wavelength = energy dependent imaging:

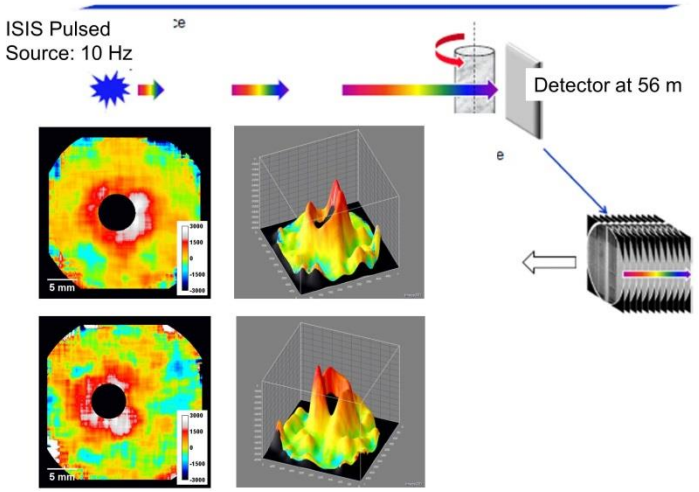
$v = \frac{L}{T} = h/(m*\lambda)$

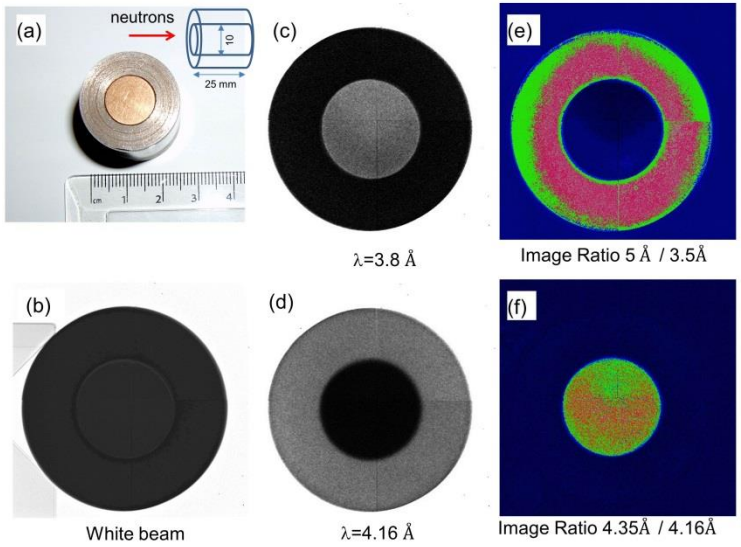


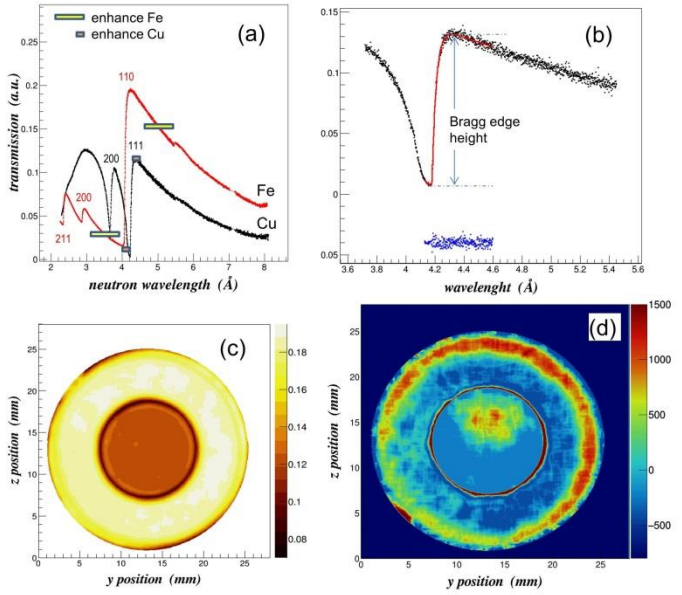


Energy-dispersive (colour) neutron radiography









What do we need from ULTRA?

SCARF/ EMERALD/ "ISIS COMPUTE"

- Computing-intensive reconstructions (e.g. HPCs at SCD)
  - High speed processing of a large number of tomographies: e.g. for contrast optimization via energy selection
  - Dealing with large data volumes (e.g. 0.5 TB/day raw data on IMAT)
  - On-the-fly reconstruction during the experiment
  - Dealing with computing intensive iterative codes

- Neutron User interface and reconstruction control (Mantid)

- Access to latest algorithms / reconstruction codes

  (SAVU @ DLS)

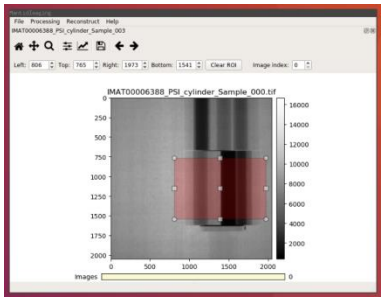
Work in Progress

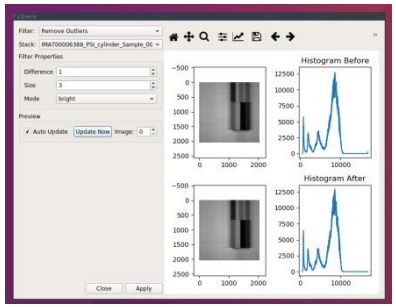
MANTID-Interface (Dan Nixon)

- New Python based GUI
- Supported file formats: TIFF, FITS, NeXus
- Pre and post processing filters (most using NumPy/SciPy and TomoPy)
- Automatic + interactive rotation centre and tilt finding + correction
- Volume reconstruction using TomoPy.
- Data flow link to SAVU

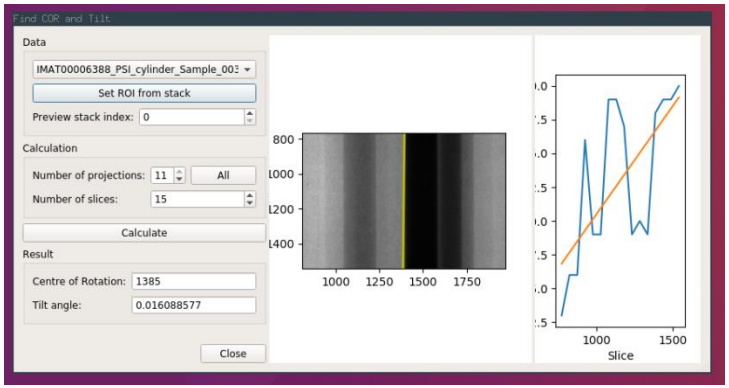
MANTID

Basic image processing steps

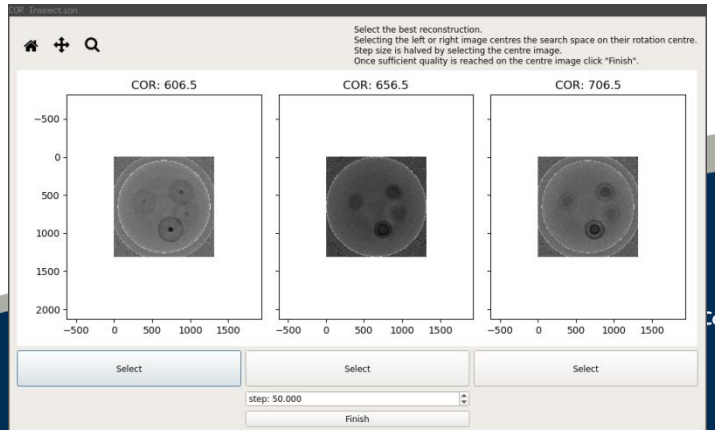




Centre of Rotation / Tilt (auto)



Centre of Rotation / Tilt (manually)



Savu – Tomography Reconstruction and Processing Pipeline

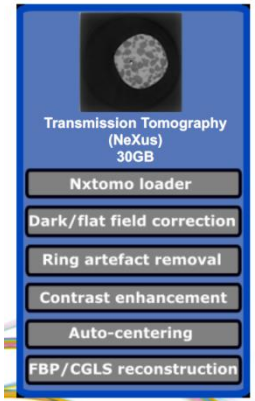
Mark Basham
Nicola Wadeson

Diamond Light Source

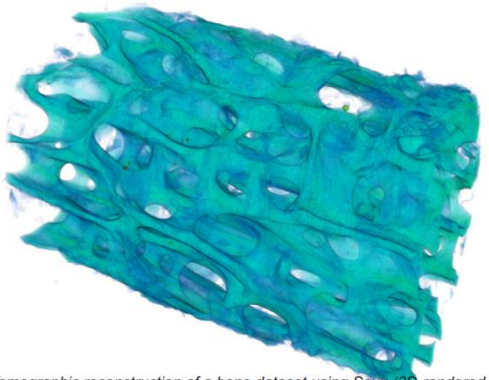
Features:

1. Standard Tools
2. Plugin structure
3. Allows Data Transpose
4. Multidimensional Data
5. Parameter Tuning
6. Multimodal Data

Full-field tomography processing with Savu at DLS



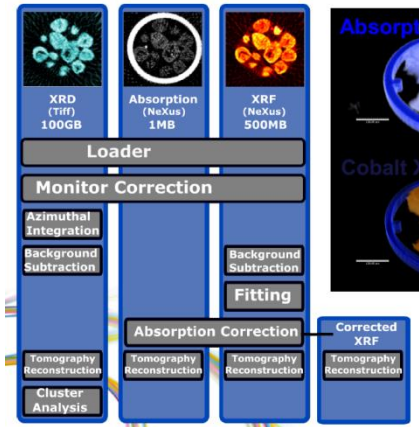
A typical process list for reconstructing full-field tomography data.

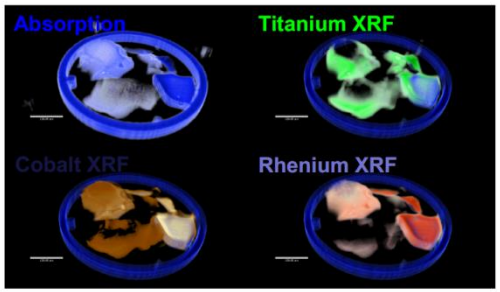


Tomographic reconstruction of a bone dataset using Savu (3D-rendered using VisIt). Courtesy of Gianluca Tozzi, Marta Pena-Fernandez, Rachna Parwani, and Asa H. Barber (2016) from Portsmouth University. Data collected on the Diamond Manchester Imaging Branchline (I13-2) with support from Andrew J. Bodey.

diamond

Multi-modal tomography processing with Savu at DLS





Multimodal chemical tomography: absorption, XRF, XRD (not shown) of Re and Ti promoted Co/SiO_2 catalyst for Fischer Tropsch Synthesis collected at room temperature.

550 x 550 x 50 µm volume imaged
3 x 3 µm spot, raster scan 5 µm translation, 3 ° rotation
13 hr collection. Processing/reconstruction: 2 min absorption, 10 min XRF, 1 hr XRD (5-10 minutes/slice)
1.3 GB absorption/XRF → ca. 10 MB reconstructed volume (fitted XRF)
942 GB XRD → ca. 2 GB reconstructed volume

ULTRA Collaboration

STFC Scientific Computing Department

Erica Yang
Derek Ross
Brian Mathews

CCPi Tomographic Imaging

Srikanth Nagella
Martin Turner

diamond

Mark Basham
Nicola Wadeson
Alun Ashton

MANTID

Dan Nixon
Dimitar Tasev
Anders Markvardsen
Nick Draper

Science & Technology Facilities Council ISIS

Triestino Minniti
Genoveva Burca
Daniel Pooley
Winfried Kockelmann
Chris Moreton-Smith
Tom Griffin

ULTRA

Collaborative Computational Project

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To provide the UK tomography community with a toolbox for image analysis with a range of CT algorithms.