

### ISIS Neutron and Muon Source

### MANTID Imaging

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# **Neutron imaging**



### IMAT at ISIS



10.1016/j.nima.2018.01.037





Object



Projections



#### Reconstruction

# Tomography

Input: Nexus or TIFF/FITS

- List of 2D images (3D array) ٠
- Projections ۲
- Flat and dark frames .
- 180 projection •
- Reconstructed volume •
- Float32 or Float64
- 2k x 2k x 1.5k (20GB)

### Output: TIFF/FITS (Nexus soon)

- **3D** voxels
- Attenuation coefficient









- **Filtered Back Projection** (FBP) ٠
  - ASTRA ۲
  - GPU •
- **Simultaneous Iterative** • **Reconstruction Technique** (SIRT)
  - ASTRA •
  - GPU •
- **Total Variation with Primal-Dual** • **Hybrid Gradient** (TV-PDHG)
  - Core Imaging Library ٠
  - GPU •
  - Resilient to noise
  - Gridrec

٠

- TomoPy ۲
- CPU

\*Wikipedia: Prolineserver

# MANTID Imaging

### User friendly interface for neutron imaging





Image data from experiments





Apply preprocessing



#### Tomographic reconstruction

Distinct from Mantid: No shared code

### **Features**

### High performance UI







#### Preprocessing



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- **Crop Coordinates** Median
- Flat-fielding

۰

٠

- **Remove Outliers** 
  - **ROI** Normalisation Rescale
- Circular Mask
- **Clip Values**
- Arithmetic .
- Gaussian ٠

Tomographic Reconstruction



•Astra:

•FBP CUDA - Filtered Back Projection •SIRT\_CUDA - Simultaneous Iterative **Reconstruction Technique** 

TomoPy

•Gridrec •Core Imaging Library – CCPi •TV-PDHG - Total Variation with Primal-Dual Hybrid Gradient

- •
- **Ring Removal Rotate Stack** •

Rebin

Stripe Removal

Monitor Normalisation

### Development



Your Workspaces





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python

powered

TomoPy





m Dan William

Dan William Samue Nixon Taylor Stock  $\mathbf{O}$ 

#### a mantidproject / mantidimagin <> Code () Issues 36 11 Pull requests 2 Discussions រះ master 🗸 Go to file Add file -Graphical toolkit for × yesterday 🕲 3,161 DolicaAkelloEgwel Merge pull request #861 fro. neutron imaging emove leftover curly braces in git pr Use environment-dev.yml for conda gith. 5 days ago .github 2 months add .vscode Fix test expectation Readme huildscript Move Jenkinsfile to buildscripts directory 3 years ago GPL-3.0 License 53 conda Merge branch 'master' into update pyth .. 2 months ag Set url in dockerfile to master docker vesterda Releases docs Update documentation for new depende. vesterda 🕟 Mantid Imagi Move icons to qui/ui/images 2 months ago images on 15 Jan mantidimaging Merge pull request #856 from mantidpr 7 days ago + 4 release

Pulls Issues Marketplace Explore

🛆 + 🕶 😥

Agile development Test driven Continuous integration Open Source (GPL3) Close partnership with users Regular releases

ISIS Computer Division Scientific Software Data Reduction Imaging team

Currently 3 core developers

Built on strengths of existing tools

CuPv

Iomographic

Imaging





# History

- 2015: Initially part of Mantid, C++ GUI
- 2017: Extracted from Mantid and rewritten as a Python GUI
- 2019: Effort picked up, as Octopus\* replacement for IMAT
- 2021 Jan: 2.0 first end user release
- 2021-22: 2.1 -> 2.4 Releases







Used by IMAT until 2021 Commercial tomograph package End of Life start of 2021 Proprietary restrictive licence





### 2021

### 2022

#### Release 2.0

- First end user release
- Tomography workflow for IMAT

#### Release 2.1 Usability improvements

- New user wizard
- Better histograms
- Auto colouring
- Drag and drop loading
- Fixed many annoyances

### Release 2.2 New features

- TV-PDHG reconstruction (Core Imaging Library)
- Nexus loading
- Filter improvements







### Release 2.3 GUI improvements

- Dataset viewer
- Bad data indicators & overlays
- Beam hardening correction



### Release 2.4

- Windows support
- Auto-sinograms
- Nexus output
- Line profiles
- Spectrum viewer
- Non-negativity constraint



Recon: 0.000918



# **Bad data handling**

- Bad pixel values
  - Missing/corrupt data
  - Noise
  - Artefacts from preprocessing
- Finding
  - Warnings
  - Overlays
- Fixing
  - Keep user in control
  - Tools to fix
  - Might indicate problem at collection
- Before reconstruction









## **Sustainability**

- Advanced reconstruction algorithms
  - Total Variation with Primal-Dual Hybrid Gradient (TV-PDHG) - Core Imaging Library
  - More robust
    - Noise
    - Reduced projection angles
- Golden angle scanning
  - Normal: Step = 360°/N
  - Golden: Step = 137.508°
  - Allows stopping a scan after any number of projections
- Improving testing/benchmarking
  - Allows optimising algorithms



### **Future**



### Tomography

- 1. Energy-selective tomography
  - Select several energy bands
  - Reconstruct
- 2. Energy-resolved tomography 3D
  - Spectrum to scalar quantity
  - Reconstruct in scalar
- 3. Energy-resolved tomography 4D
  - Reconstruct each energy slice
  - Analysis spectrum of each voxel







### **Energy resolved imaging**

- TOF gives energy
- Can record absorption spectrum at each pixel
- Sensitive to
  - Resonances peaks
  - Bragg edges material, concentration, temperature, strain, texture
  - Large increase in data sizes
  - Ongoing investigation into options
    - Tomography driven diffraction
    - Cross platform
    - Image stitching
    - New algorithms
    - New data format support
    - GUI/visulisation improvements

# Summary

- User friendly GUI for neutron imaging and tomography
- Ready to use
- Being used by IMAT at ISIS
- Range of tools and algorithms
  - Preprocessing
  - Tomography
- Agile development, driven by user needs



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https://github.com/mantidproject/mantidimaging https://doi.org/10.5281/zenodo.4728059 mantidimagingsupport@stfc365.onmicrosoft.com



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# Thankyou

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