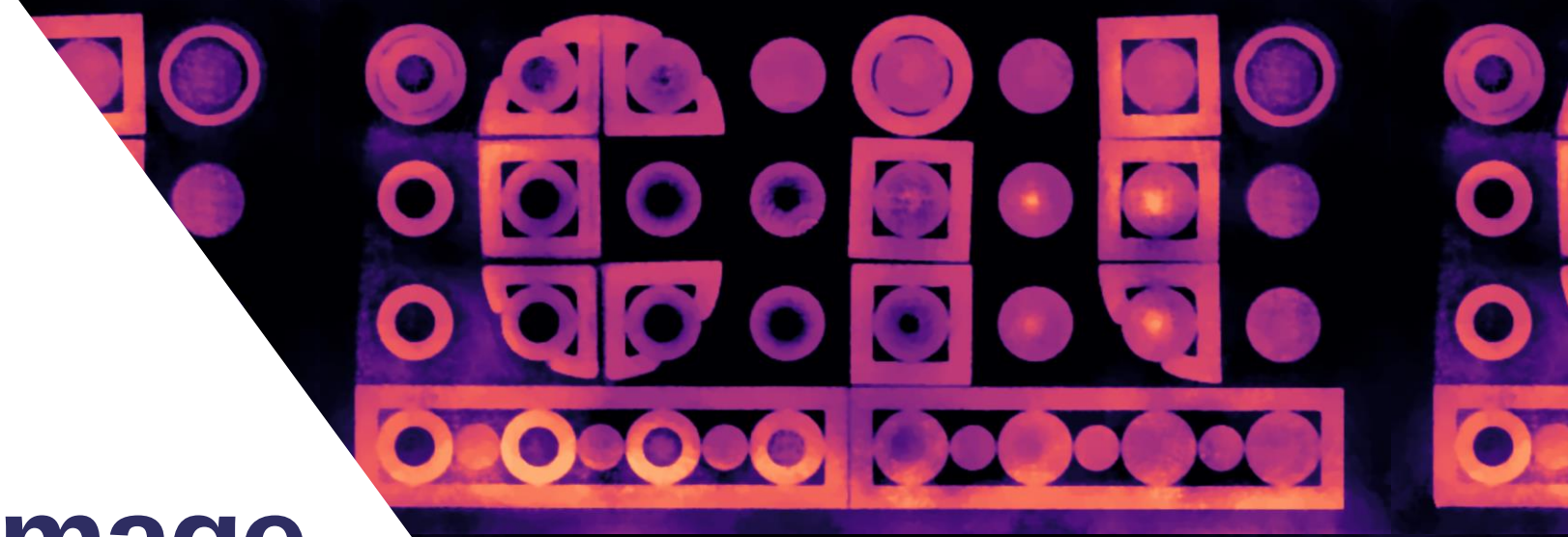
CoSeC
Computational Science Centre for Research Communities



Reproducible Tomographic Image Processing with CIL

Laura Murgatroyd
Tomography group, Scientific Computing, STFC

UKRI Science and Technology Facilities Council
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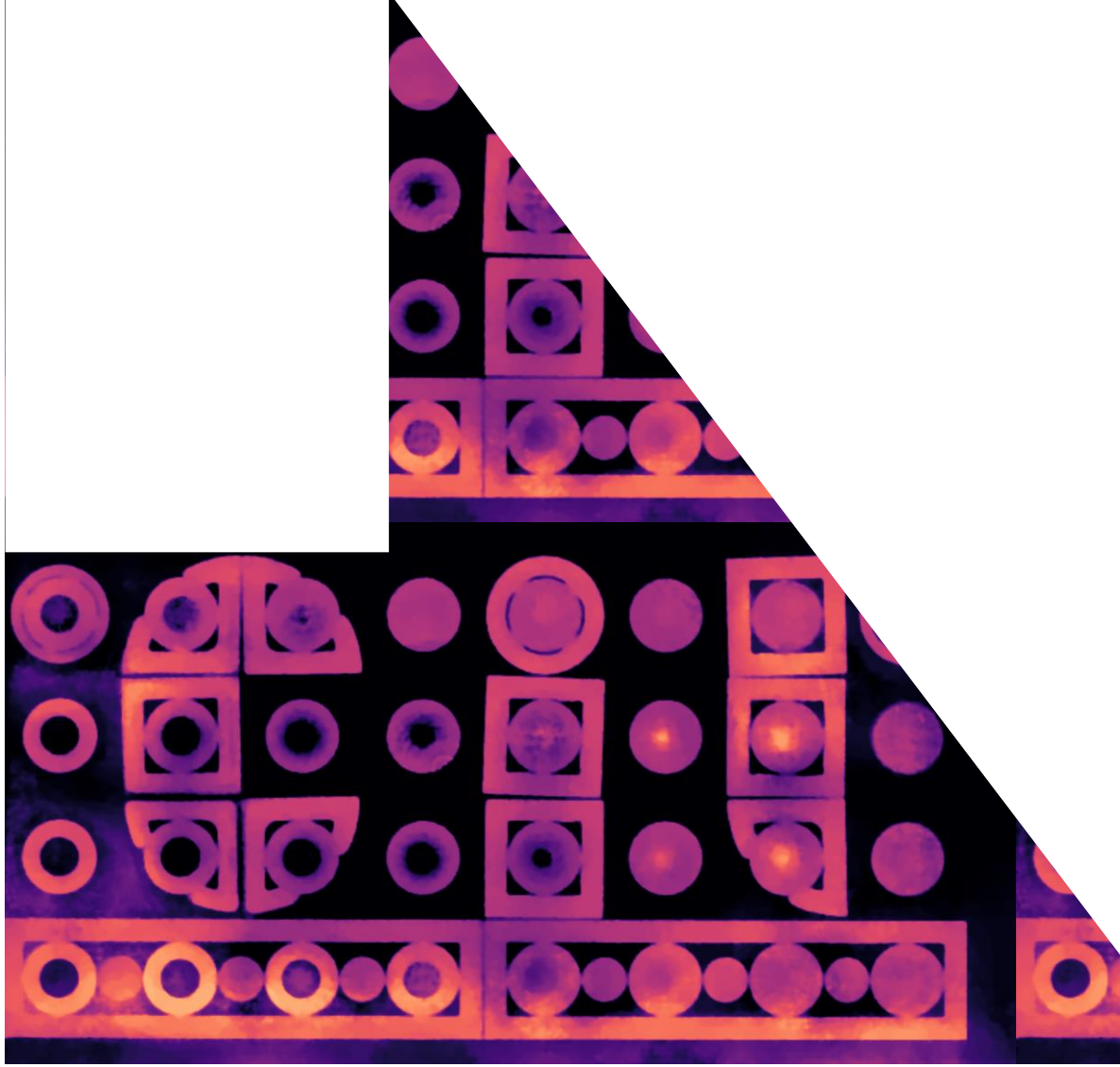
Agenda

1 Introduction to Tomography

2 Introduction to CCPi, CCPSyneRBI & CIL

3 CoSeC Award Winner Case Studies

4 Outcomes of CIL User Meeting



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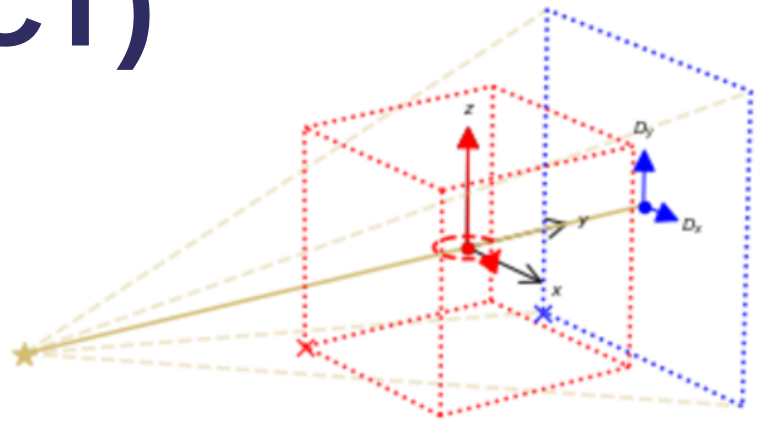
What is Tomography?

Computed Tomography (CT)



A non-destructive imaging technique for studying the interior of samples.

Available in 200+ universities, industrial labs, large facilities at RAL and beyond!

reconstruction

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Generates a 3D representation of a sample for analysis

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CCPi, CCPSyneRBI & CIL

The Collaborative Computational Project in Tomographic Imaging

Supports UK Tomographic Imaging community:

User-driven Software:

CIL, CIL-GUI, Regularisation Toolkit, DVC

Training Courses

User support Network

Processing Pipelines for Facilities

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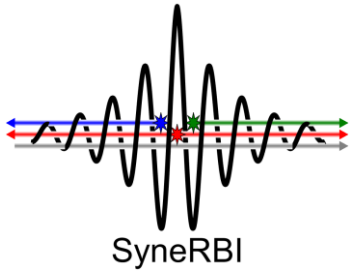

CCPSyneRBI - Synergistic Reconstruction for Biomedical Imaging

Includes SPECT, PET and MR reconstruction

SIRF (Synergistic Image Reconstruction Framework)

CIL and SIRF are being designed to work in Synergy!

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CIL - The Core Imaging Library

A **python library for pre-processing, reconstruction and visualisation of tomographic data**

Emphasis on **challenging data**…

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github.com/TomographicImaging/CIL

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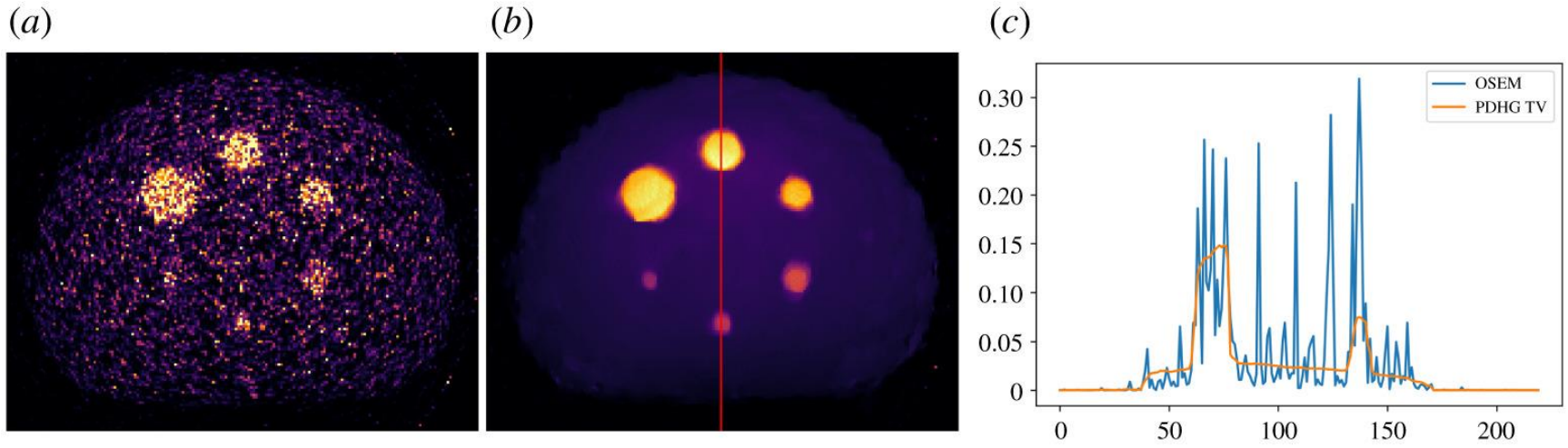

Noisy

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A **python library for pre-processing, reconstruction and visualisation of tomographic data**

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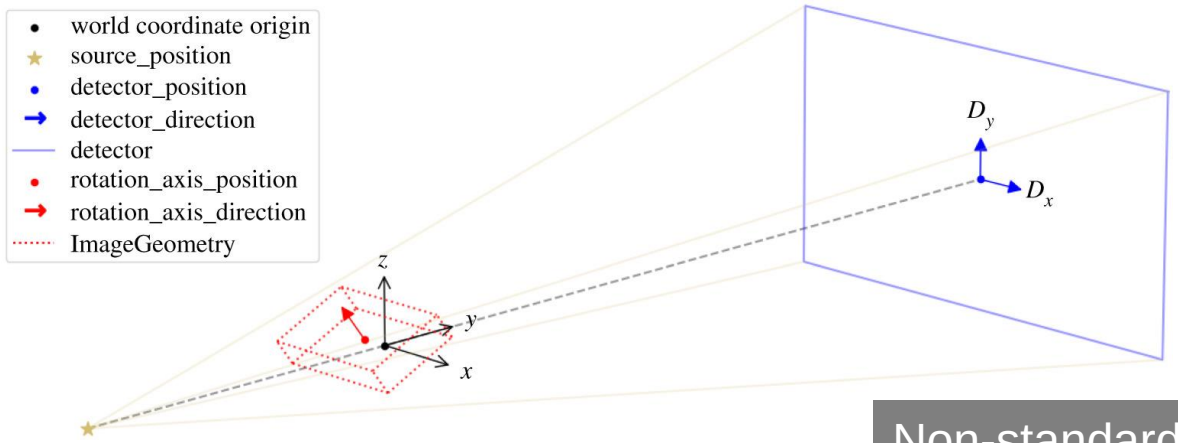

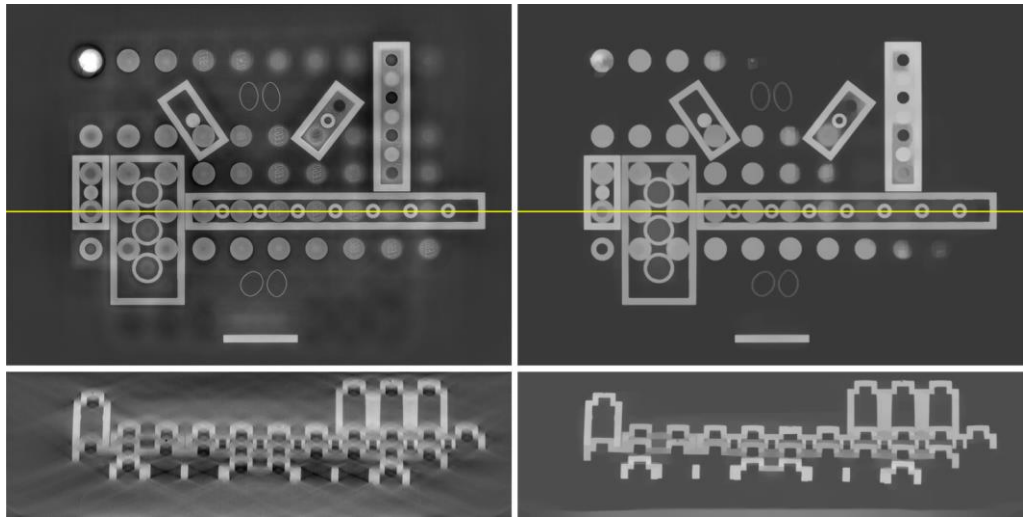

Non-standard Geometries

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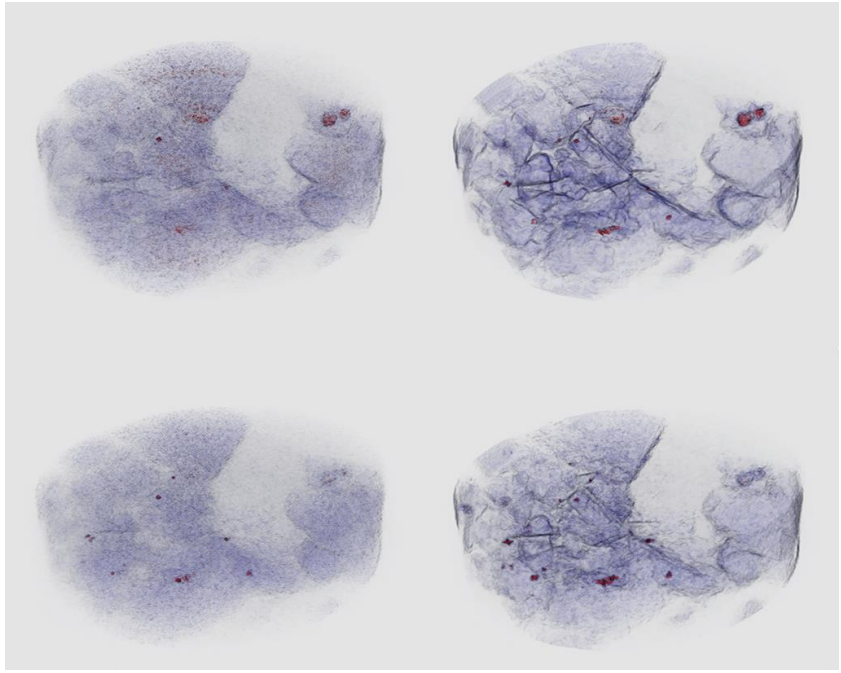
Multi-channel



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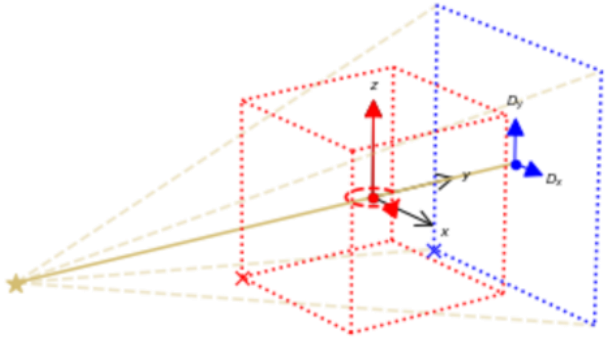
github.com/TomographicImaging/CIL

CIL for CT experimentalists



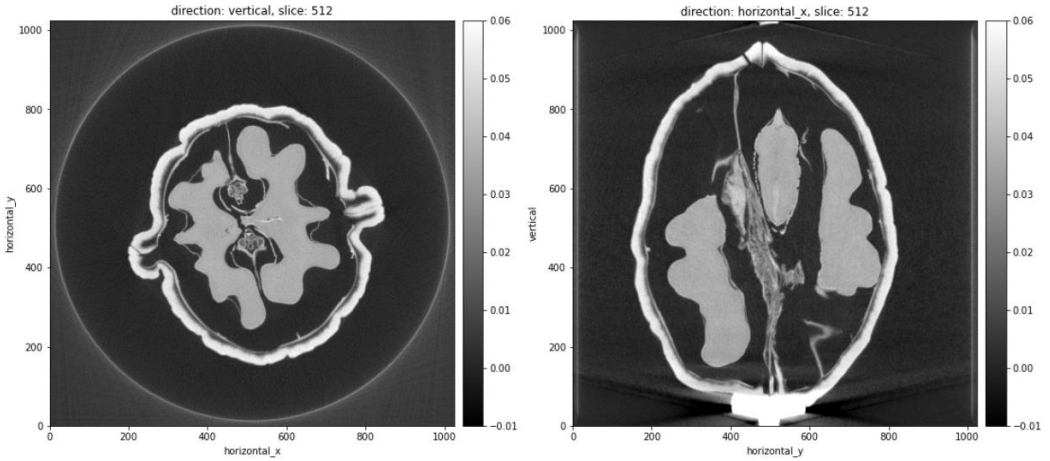
Simple to configure a standard processing pipeline

Accelerated with TIGRE or ASTRA toolboxes

Optimised standard algorithms for large data

State-of-the-art iterative algorithms for challenging data

```
data = ZEISSDataReader(filename).read()
data = TransmissionAbsorptionConverter()(data)
show_geometry(data.geometry)
recon = FBP(data).run()
show2D(recon)
```



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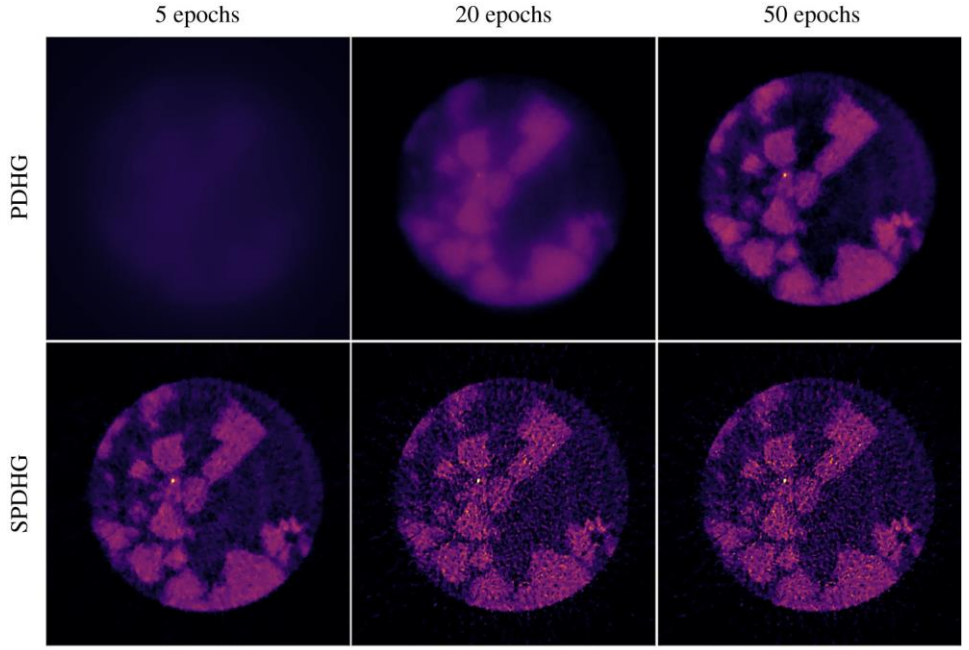
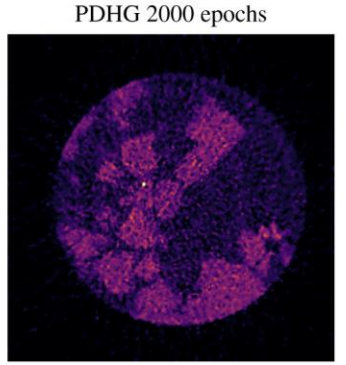
TIGRE: A MATLAB-GPU toolbox for CBCT image reconstruction Ander Biguri, Manjit Dosanjh, Steven Hancock and Manuchehr Soleimani Biomedical Physics & Engineering Express, Volume 2, Number 5 Read the article (open access)
W. van Aarle, W. J. Palenstijn, J. Cant, E. Janssens, F. Bleichrodt, A. Dabravolski, J. De Beenhouwer, K. J. Batenburg, and J. Sijbers, "Fast and Flexible X-ray Tomography Using the ASTRA Toolbox", Optics Express, 24(22), 25129-25147, (2016), http://dx.doi.org/10.1364/OE.24.025129

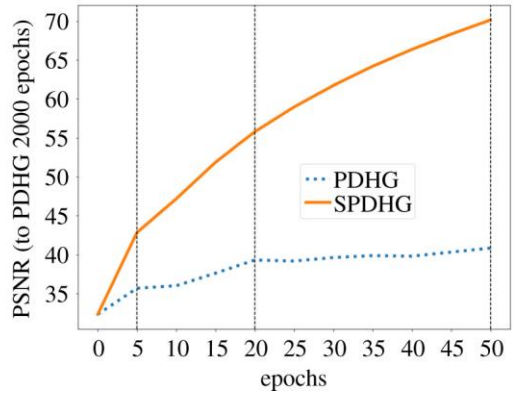
Iterative Recon in CIL

CIL provides plug and play framework, with the flexibility to construct different iterative algorithms.

Near-maths interface makes it easy for image processing specialists to use CIL to develop new algorithms and assess them against existing ones.







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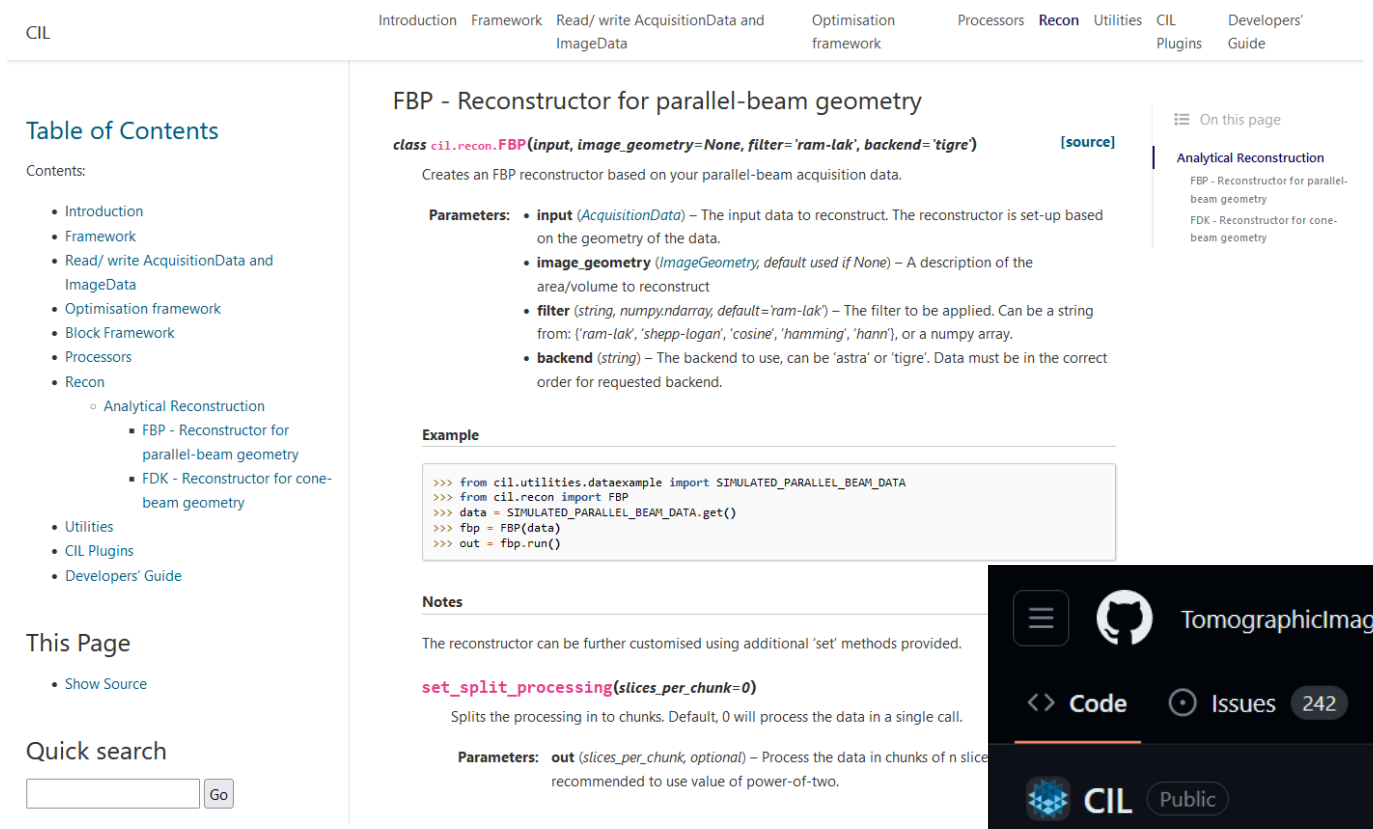
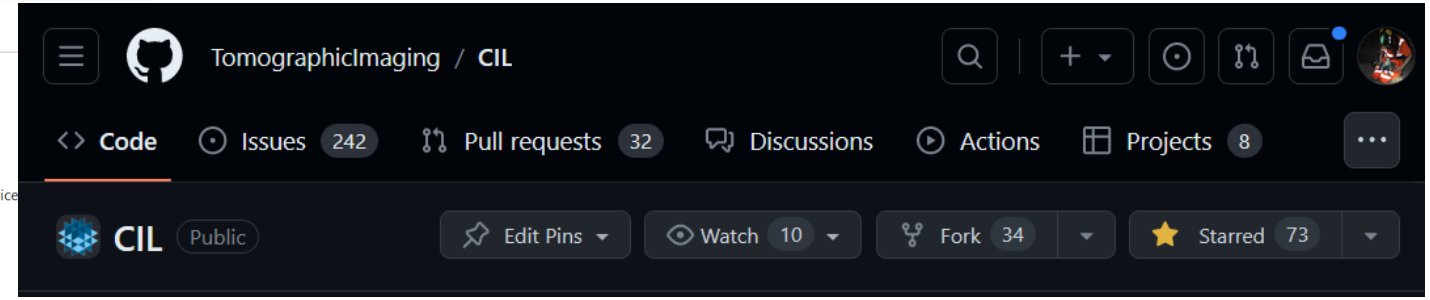
https://royalsocietypublishing.org/doi/10.1098/rsta.2020.0193

CIL is Open Source



Apache v2 License

Extensive unit tests



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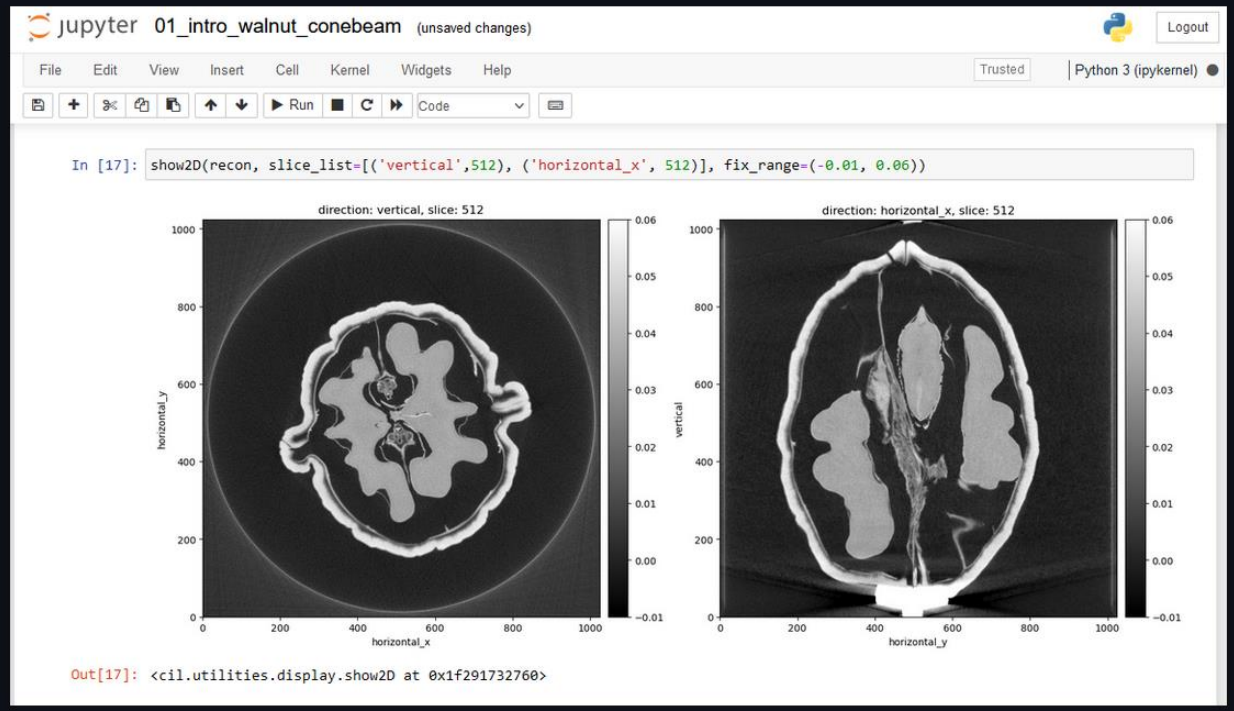
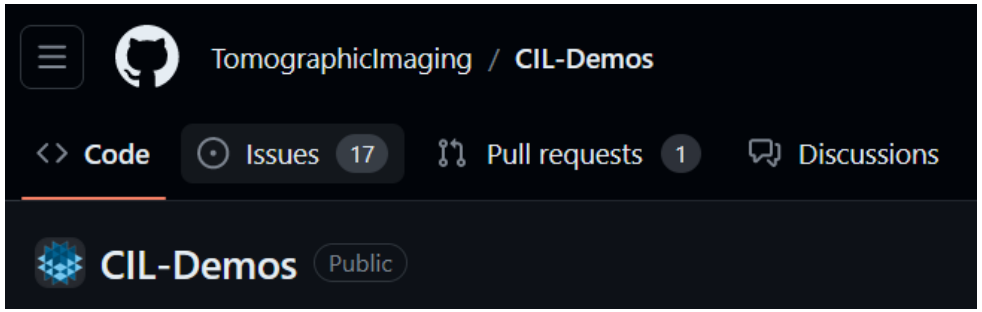
github.com/TomographicImaging/CIL

CIL Demos

CIL-Demos is a collection of jupyter notebooks, designed to introduce you to the Core Imaging Library (CIL).

The demos can be found in the demos folder, and the README.md in this folder provides some info about the notebooks, including the additional datasets which are required to run them.





github.com/TomographicImaging/CIL-Demos

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CIL Papers

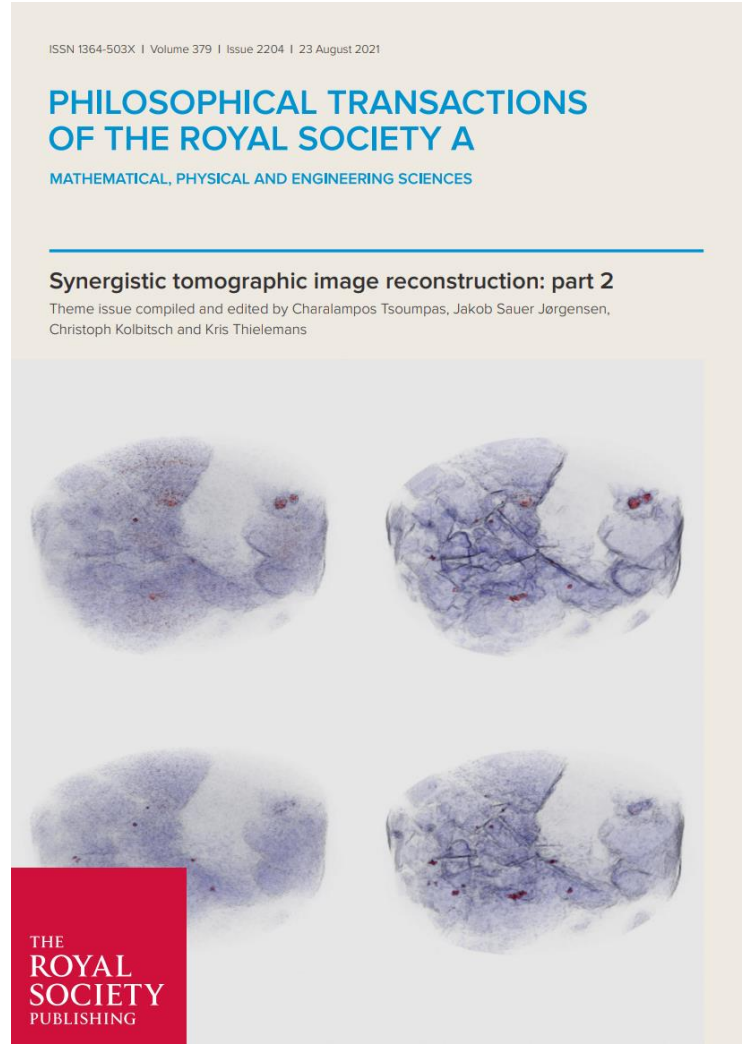
Jørgensen et al.: *Core Imaging Library - Part I: a versatile Python framework for tomographic imaging* Phil. Trans. R. Soc. A. **379** 20200192 (2021) DOI: 10.1098/rsta.2020.0192

Papoutsellis et al.: *Core Imaging Library - Part II: multichannel reconstruction for dynamic and spectral tomography* Phil. Trans. R. Soc. A.**379**20200193 (2021) DOI*:* 10.1098/rsta.2020.0193

Ametova et al.: *Crystalline phase discriminating neutron tomography using advanced reconstruction methods*, J. Phys. D: Appl. Phys. **54** 325502 (2021) DOI 10.1088/1361-6463/ac02f9

Warr R. et al.: *Enhanced hyperspectral tomography for bioimaging by spatiospectral reconstruction* Sci Rep **11,** 20818 (2021) DOI: 10.1038/s41598-021-00146-4

Brown R. et al: *Motion estimation and correction for simultaneous PET/MR using SIRF and CIL* Phil. Trans. R. Soc. A.**379** 20200208 (2021) DOI:10.1098/rsta.2020.0208



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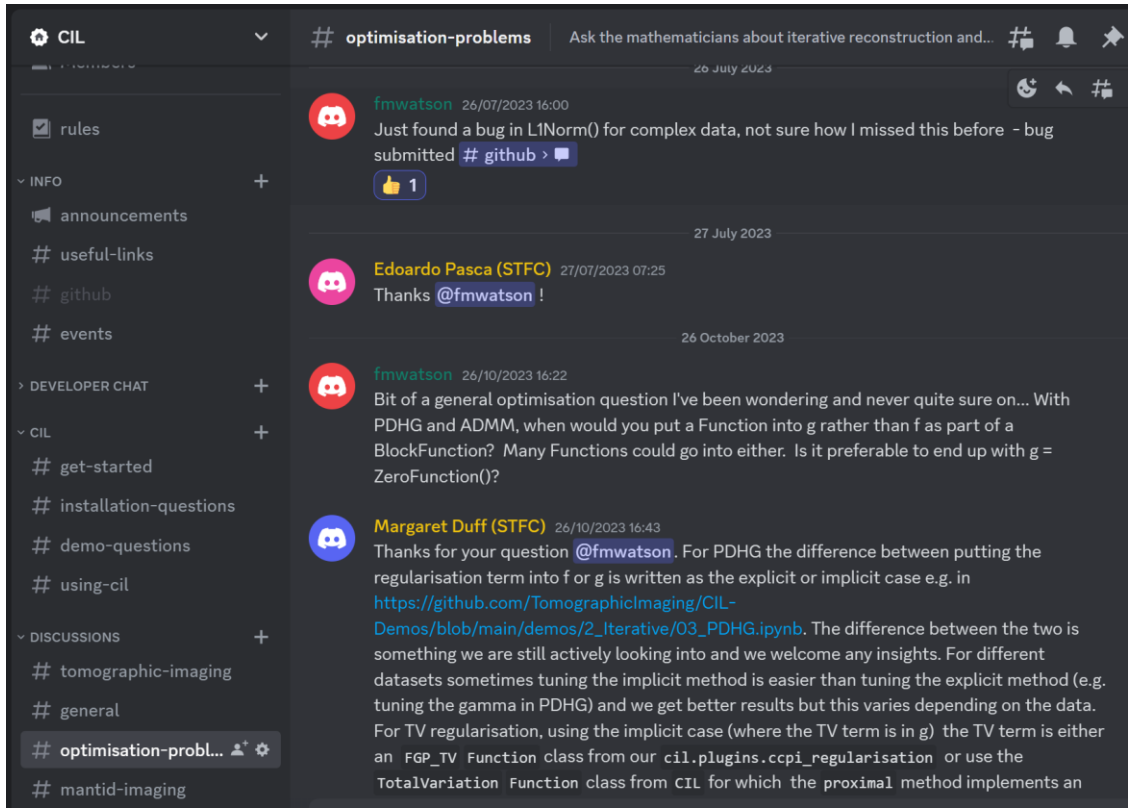
CIL User Community



CIL discord with 160 users!

Weekly user drop-ins

Fortnightly Developer meetings

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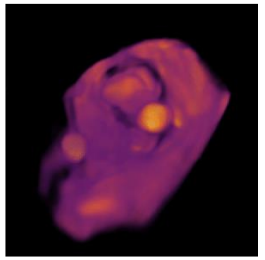
CoSeC Award Winners

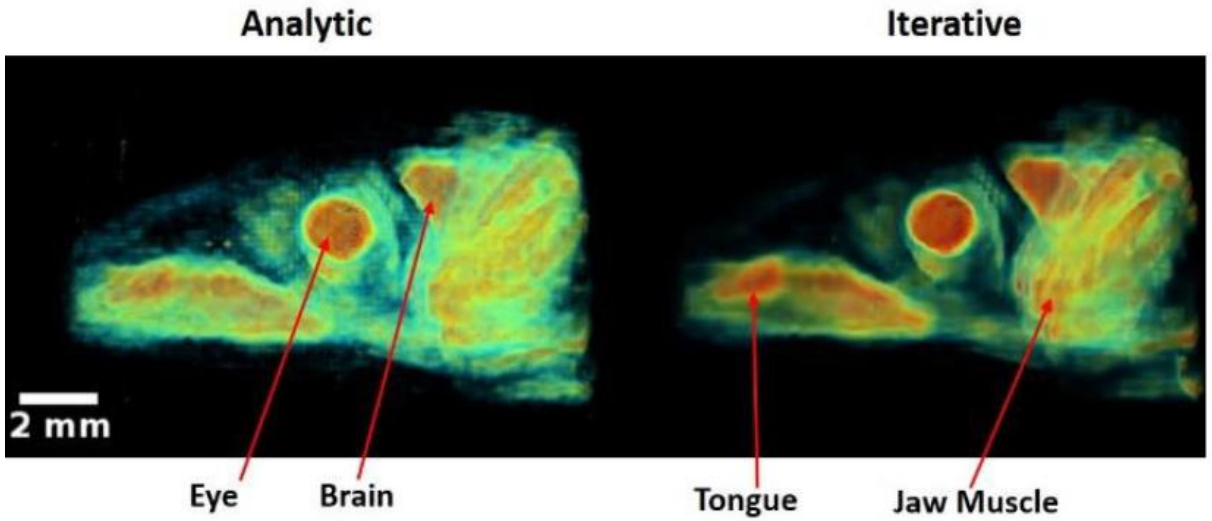
2021: Ryan Warr - Hyperspectral X-ray CT

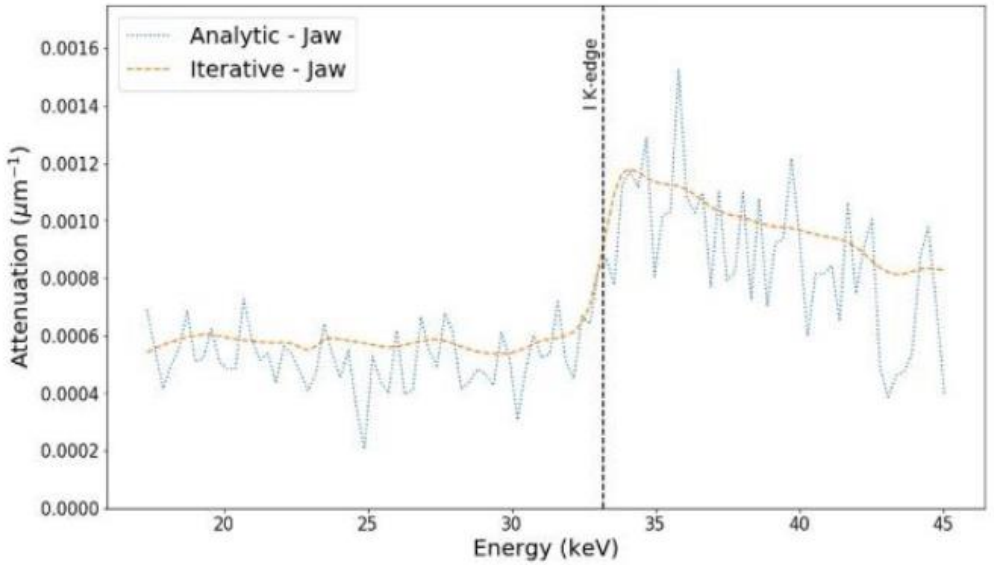
PhD student in the Henry Moseley X-ray Imaging Facility at the University of Manchester



Hyperspectral CT: also measures X-ray energy profile, allowing elemental ID.

Challenges: Limited data per energy channel – poor signal to noise ratio





Comparison of reconstructions with FDK and with a **novel iterative algorithm** developed using CIL

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[1] SCD CoSeC Impact Award 2021: Case Studies, https://www.scd.stfc.ac.uk/Pages/CoSeC_Impact_award_Oct2021.aspx

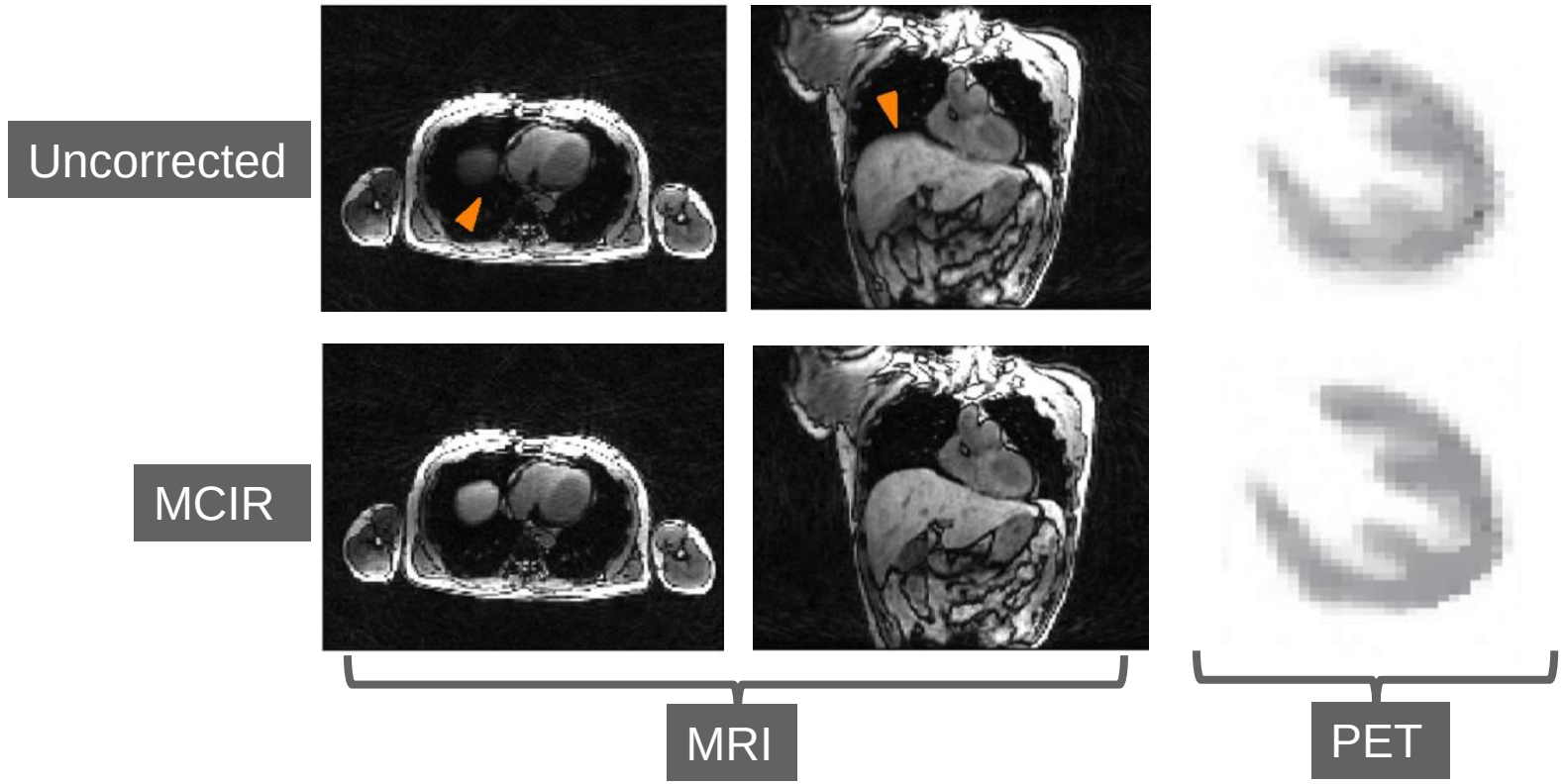
[2] Warr, R., Ametova, E., Cernik, R.J. *et al.* Enhanced hyperspectral tomography for bioimaging by spatiospectral reconstruction. *Sci Rep* **11**, 20818 (2021). https://doi.org/10.1038/s41598-021-00146-4

2022: Claire Delplancke – PET with CIL & SIRF

Research Associate in the Department of Mathematical Sciences, University of Bath

Development of iterative algorithms in CIL and their application to PET/MR imaging

Motion Compensated Image Reconstruction using SIRF & CIL



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SyneRBI

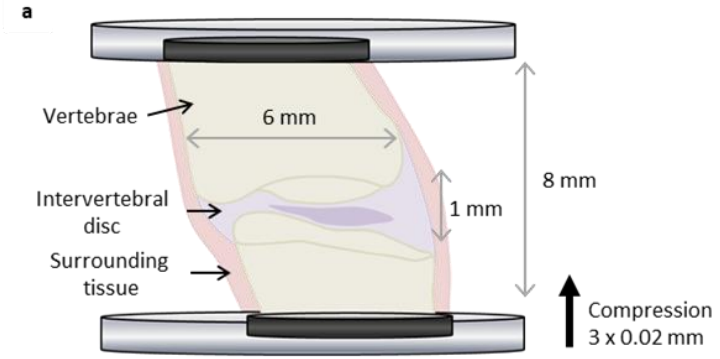
Brown R *et al.* 2021 Motion estimation and correction for simultaneous PET/MR using SIRF and CIL. **Phil. Trans. R. Soc. A 379**, 20200208. (doi:10.1098/rsta.2020.0208)

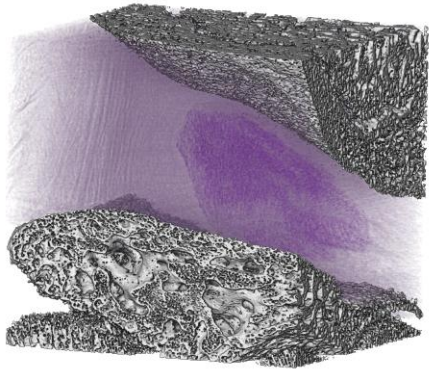
2022: Catherine Disney – Microstructure-guided Digital Volume Correlation

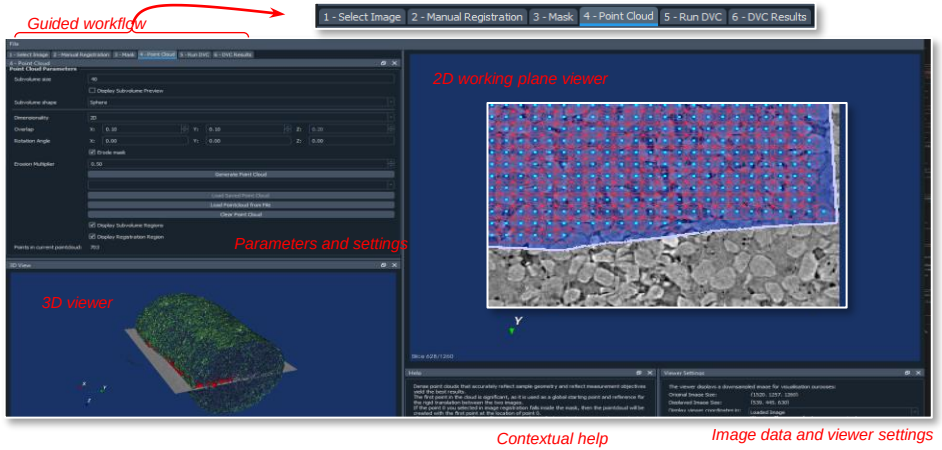
Research Fellow in the Department of Mechanical Engineering at University College London

DVC between two CT scans, with and without compression applied.

Examining intervertebral disc microstructural dynamics of collagen fibres.







Software Support
Core DVC code developed by Brian Bay, Oregon State University and maintained by CCPi.
iDVC GUI developed by CCPi team.

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[1] Disney *et al.*, 2019, *Acta Biomat.* 92, pp.290-304
[2] https://github.com/TomographicImaging/iDVC

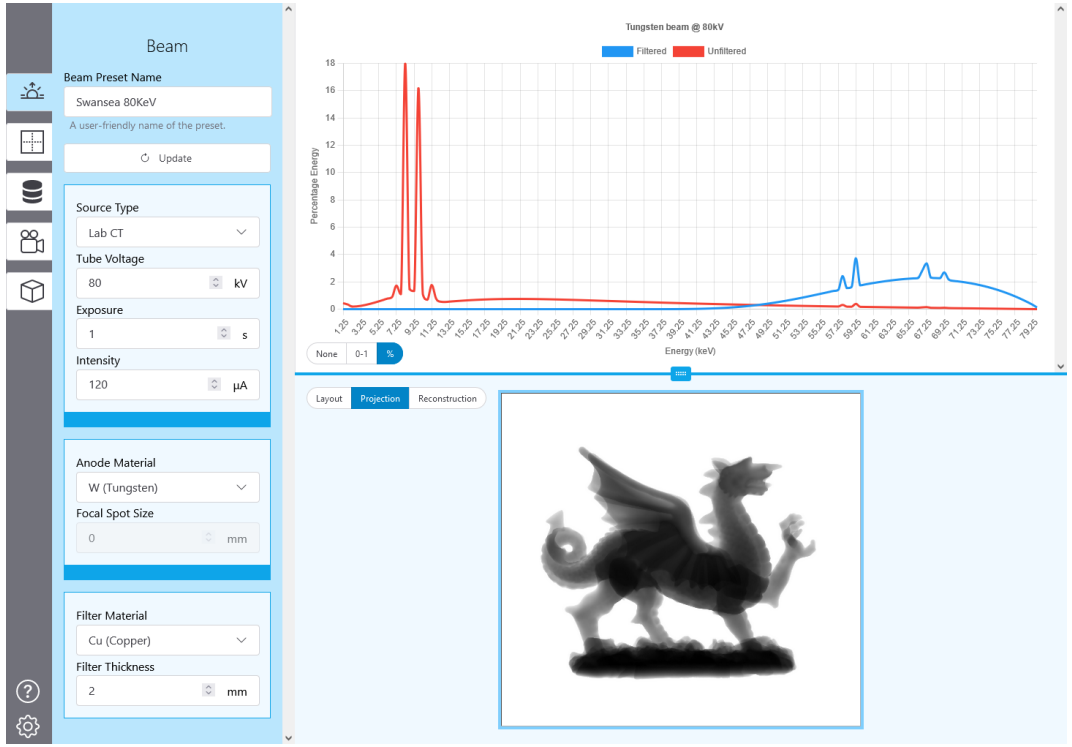
2023: Iwan Mitchell: Producing Digital Twins of Industrial XCT Scanners

PhD Student, Bangor University

1st fully open-source non-destructive testing workflow!

Use of CIL to reconstruct simulated CT volumes.

WebCT - browser-based X-ray simulation and reconstruction



Impact

- Training without access to scanners
- Optimisation of experimental parameters
- Reduction in required beamtime

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https://www.scd.stfc.ac.uk/Pages/CoSeC-Impact-Award-2023.aspx

https://webct.io/

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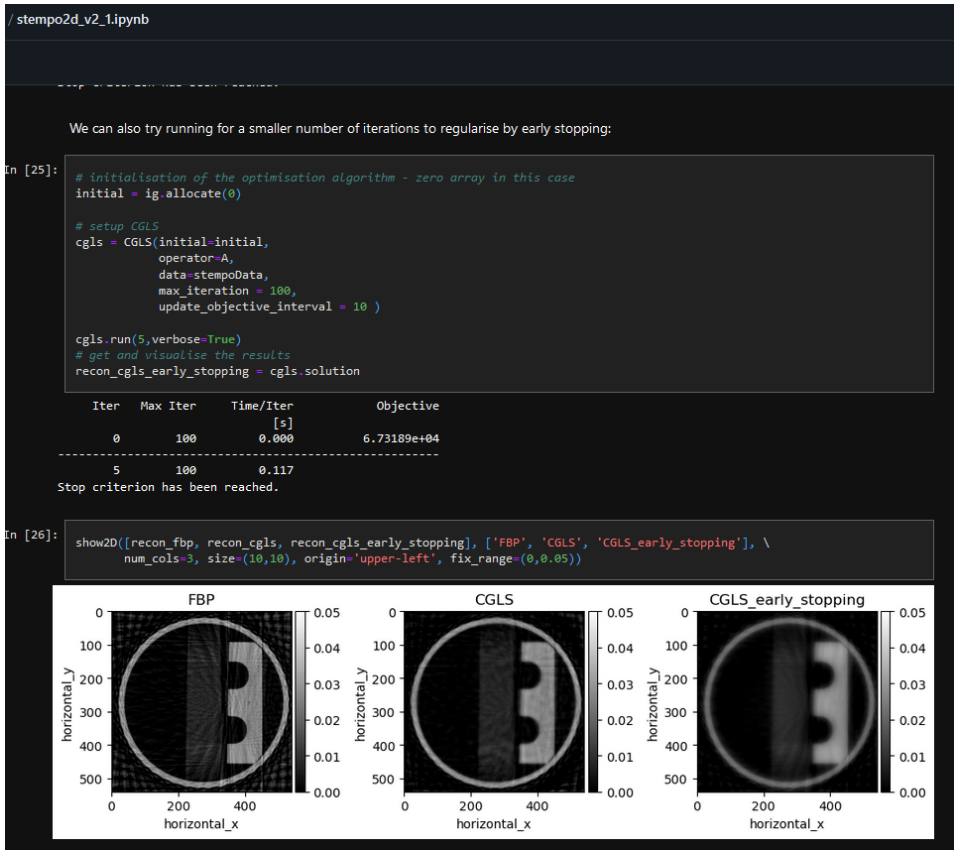
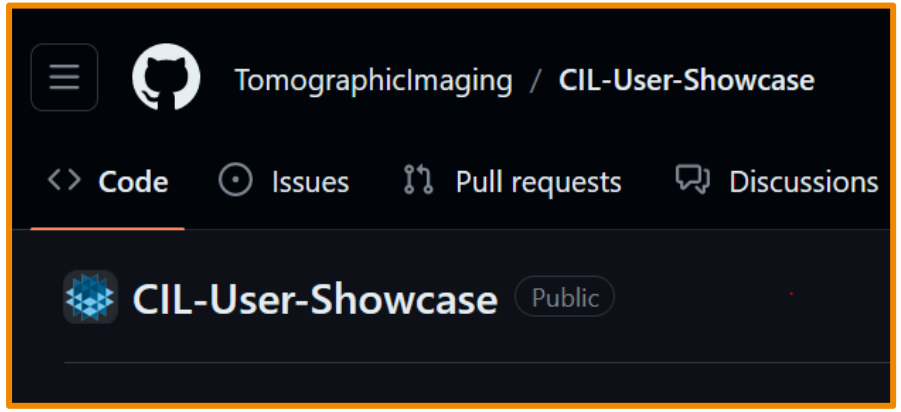
The First CIL User Meeting

CIL User Showcase





9 contributed notebooks from different users!

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Trained 18 users

Presentations from 10 users on their use of CIL in their research, ranging from PhD students to professors.

Town hall meeting, gathering feedback

Hackathon solving issues with real data!

WMG THE UNIVERSITY OF WARWICK

MANCHESTER 1824 The University of Manchester

UNIVERSITY OF HELSINKI

UKRI Science and Technology Facilities Council
ISIS Neutron and Muon Source

Queen Mary University of London

UNIVERSITY OF Southampton

diamond

UNIVERSITÄT GÖTTINGEN

PRIFYSGOL BANGOR UNIVERSITY

DTU

UCL

Western Norway University of Applied Sciences

Finden

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What events would be useful to you?

Advanced workshops with a deeper dive into iterative/specific imaging modalities

What are the barriers to you/others using CIL more frequently?

Expand documentation with more examples

Quick demo videos for getting started with CIL

How do we make it attractive for users to contribute to CIL?

Develop clear and friendly contributor guide for:
- Reporting bugs
- Updating docs
- Adding code

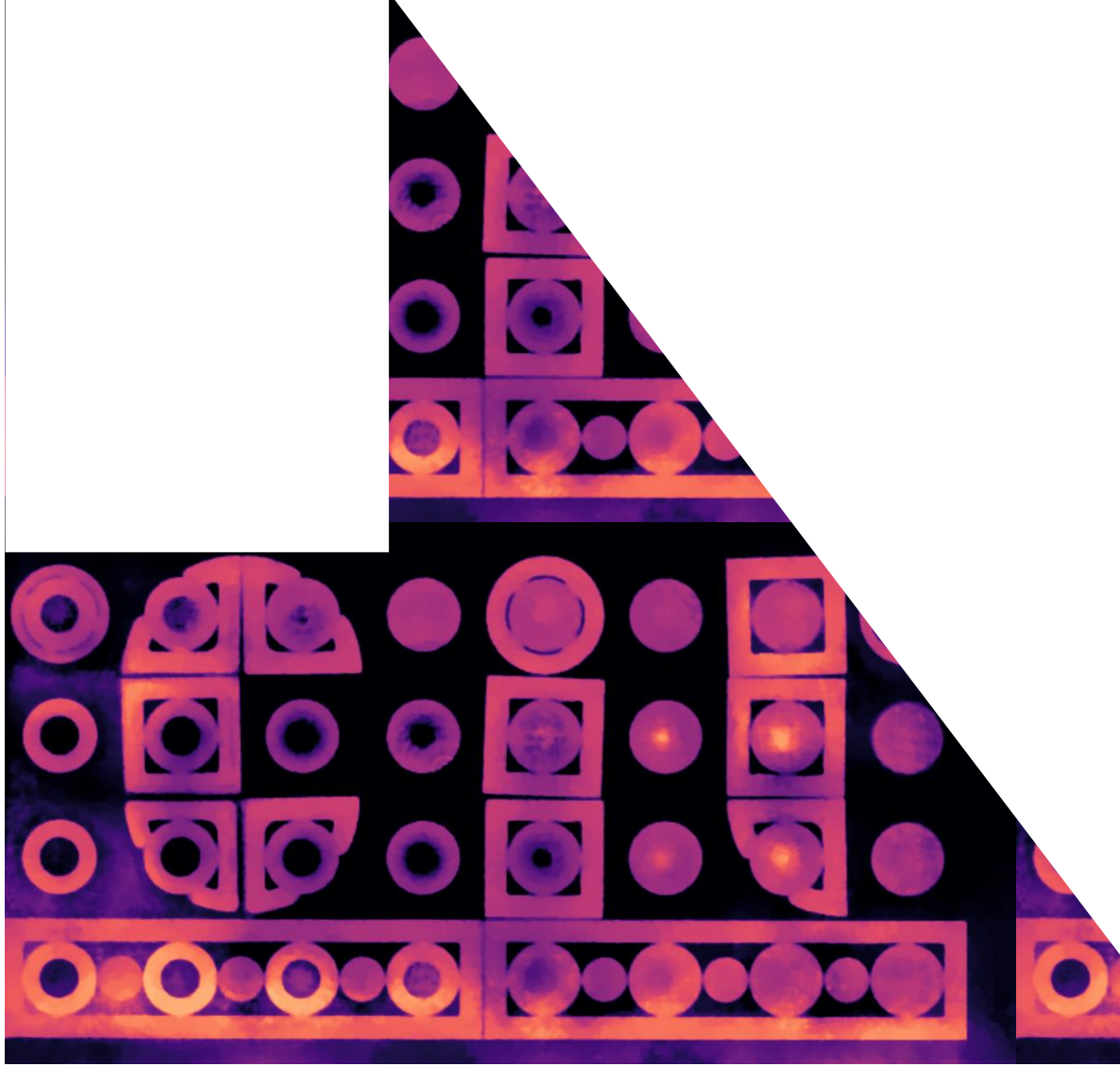
Recap

1 Introduction to Tomography

2 Introduction to CCPi, CCPSyneRBI & CIL

3 CoSeC Award Winner Case Studies

4 Outcomes of CIL User Meeting



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