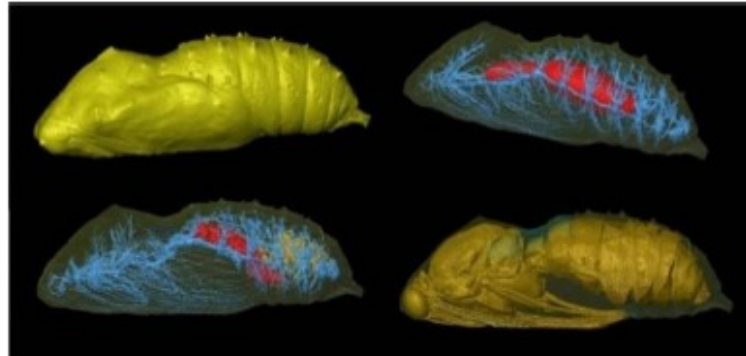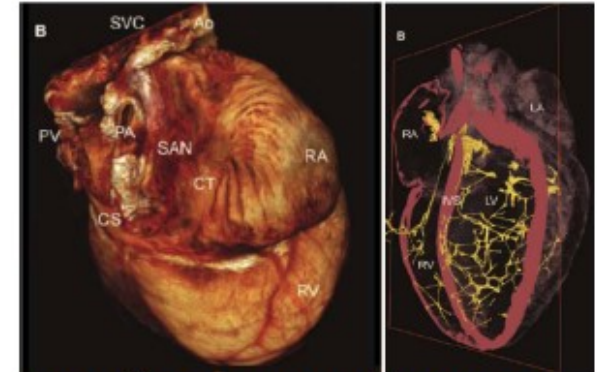# http://www.ccpi.ac.uk/

CCPi
Tomographic
Imaging

Quantifying plant root systems in Soil 3: runner-up in the CCPi sponsored ToScA ©Stefan Mairhofer: CCPi Working Group

Science image runner-up ©Tristan Lowe et al. CCPi member; temporal study of chrysalis development at HMXIF.

Poster 1st prize winner at ToScA Robert Stephenson using 3D imaging for modelling of hearts using CCPi software at HMXIF was supported by CCPi

Collaborative Computational Project in Tomographic Imaging has been funded for the next phase 2015-2020 and…. aims to provide a toolbox of algorithms that increases the quality and level of information that can be extracted by computer tomography.

Prof Phil Withers (Manchester)
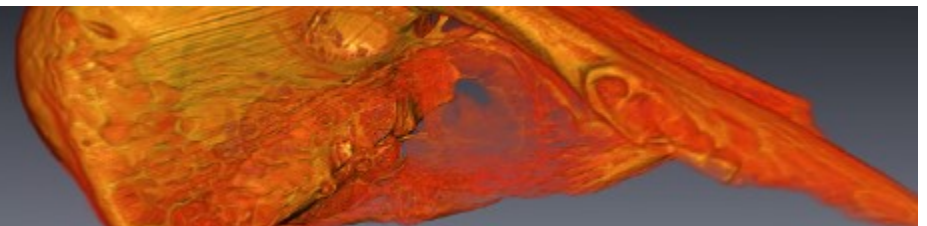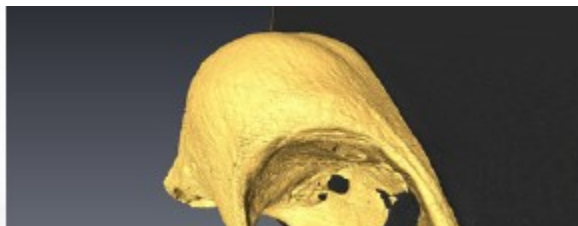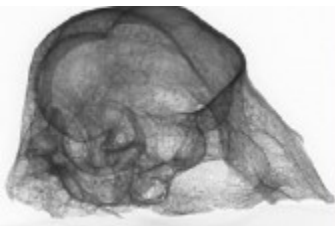
- Pre-processing
- Reconstruction
- Quantification

Framework

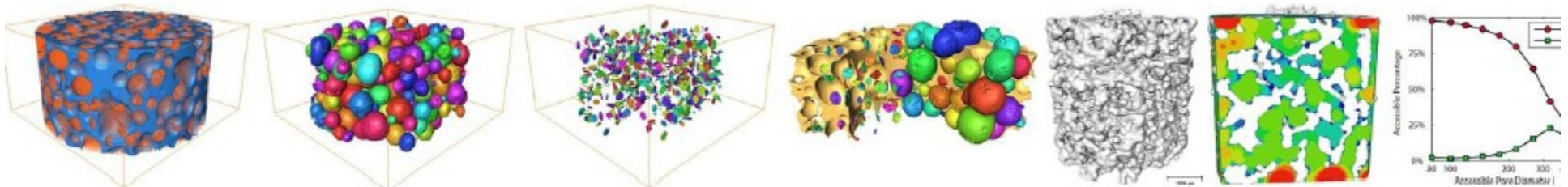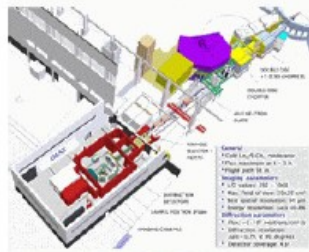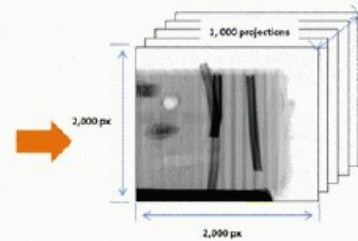ACQUIRE   CALIBRATE/CORRECT   RECONSTRUCT   QUANTIFY & ANALYSE

MLEM   DT   BM   CDT
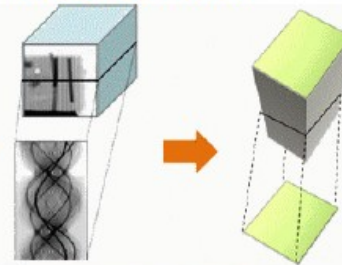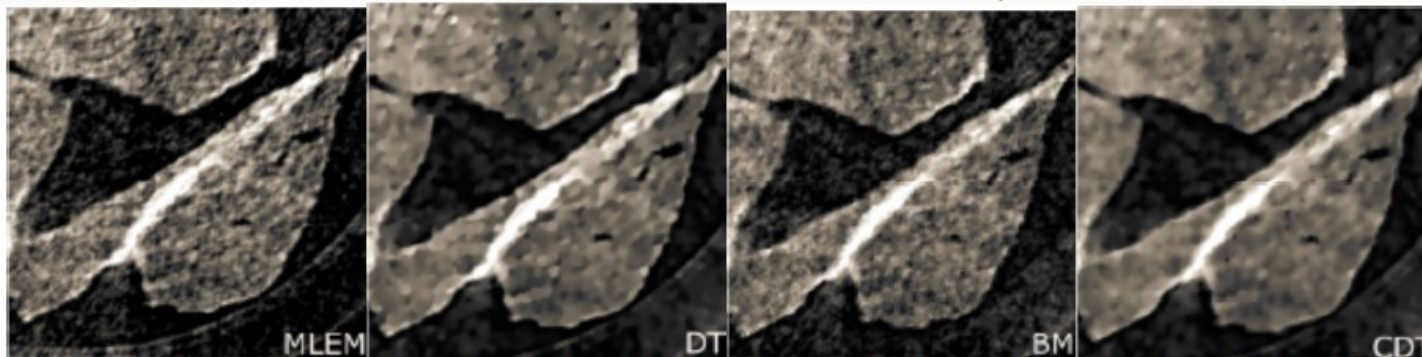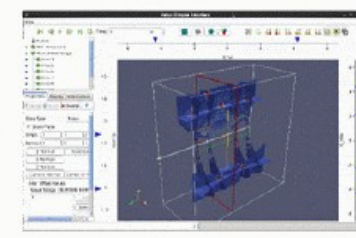
IMAT dataflow schematic showing capture of initial test data from neutron tomography (top). Images below show data from (PSI SLS) bringing together neutron (sensitive to water) and synchrotron imaging (better spatial resolution) utilising CCPi code comparing various hybrid reconstruction algorithms for water ingress into gravel.

CCPi Network Activities

- Funds short term visits and support for collaboration
- Route for Public Engagement
- Shared Repository – Code / Data Sets / Videos / Images
- Coordination and publicity of XCT Events

- As well as cutting edge software development

Contacts

http://tinyurl.com/STFCVis

- martin.turner@stfc.ac.uk
- martin.turner@manchester.ac.uk

http://www.ccpi.ac.uk/

Working Group Meeting, 18 Dec 2019
http://www.ccpi.ac.uk/

Aim of the meetings: strategic positioning - so that we have the current and upcoming plans ready for future grants and networks; proposal for EPSRC case-studies/mid-term report and new bids.

Network targets: # of people / projects to gain impact items - What kind of code and bids: we should be preparing, in terms of best impacts

Menu

1. Update on CIL (Core Imaging Library)
2. Update of Flagship Project
3. Proposals for exchanges/ visits - network events.
4. Networking continues; monthly Lunch-and-Learn sessions, complementing the visitors and software-show-tell events.
5. Industrial Metrology sessions continue culminating with Royce Institute hosting the dimensional-XCT 2020 event. Linked to support for the BSI/ISO standardisation process (ISO/TC 213/WG 10)
6. CCPi is on the governance board for Warwick, WMG "EPSRC Strategic Equipment - High Speed CT" EP/S010076/1 (initial meeting on 5 September 2019 – presentation planned for January 2020)
7. Proposal to support a Royal Society Summer Science Exhibit in July 2020 and Turing Institute Summer School in June 202
8. Supporting ImagingBioPro network https://mecheng.ucl.ac.uk/imagingbiopro/

Planning:next four XCT summer events

- **8-11 June 2020**; Advances in X-ray Imaging workshop; combined with the Turing Summer School on CIL CCPi XCT Fringe meeting, held at Harwell Campus and including Turing sponsorship
- **29 June-2 July 2020**; Dimensional–XCT conference with NPL metrology courses and BSI/ISO standardisation presentations as well as industrial exhibitors
- **7-10 September 2020**: IBFEM-4i 2020: Workshop, https://ibfem.co.uk/ speakers and training for Image based modelling
- **2-4 September 2020** ToScA (The Tomography for Scientific Advancement) main UK User Group conference, now becoming international https://www.toscainternational.org/

Key Items last 6 months

- Four XCT week Summer event
- Synergistic Tomography week – with PETMR
- ISIS / IMAT Beamtime
- Lunch-and-Learn sessions
- Training and Hackathons

- BSI/ISO Standards updates

Extras

- 14-15 May 2019 "Data-Centric Materials Science and Engineering: Microstructure fingerprinting and Digital Twinning for Industry 4.0" Raison d'etre - to bring together data scientists with materials scientists and engineers co-organised with Royce and Turing. (4x oversubscribed)

- Network training activities included; four Avizo courses (22 May, 4-5 June, 5-6 August, 30 September-1 October) three lunch-and-learn events (14 May, 3 June, 9 July) a Summer Research exhibition (2 July 2019) and held two Hackathon events (8-9 April, 12-13 June 2019).
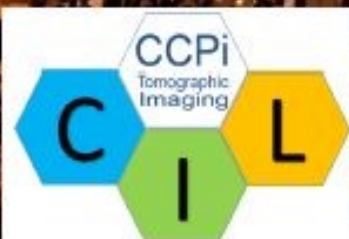
Hackathon

- Jupyter notebook
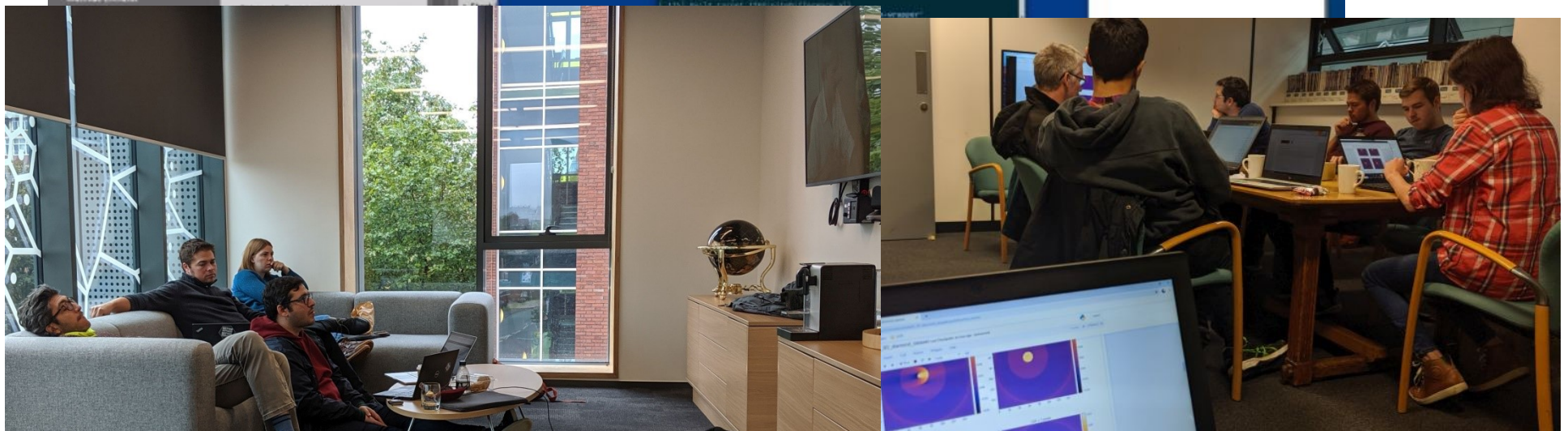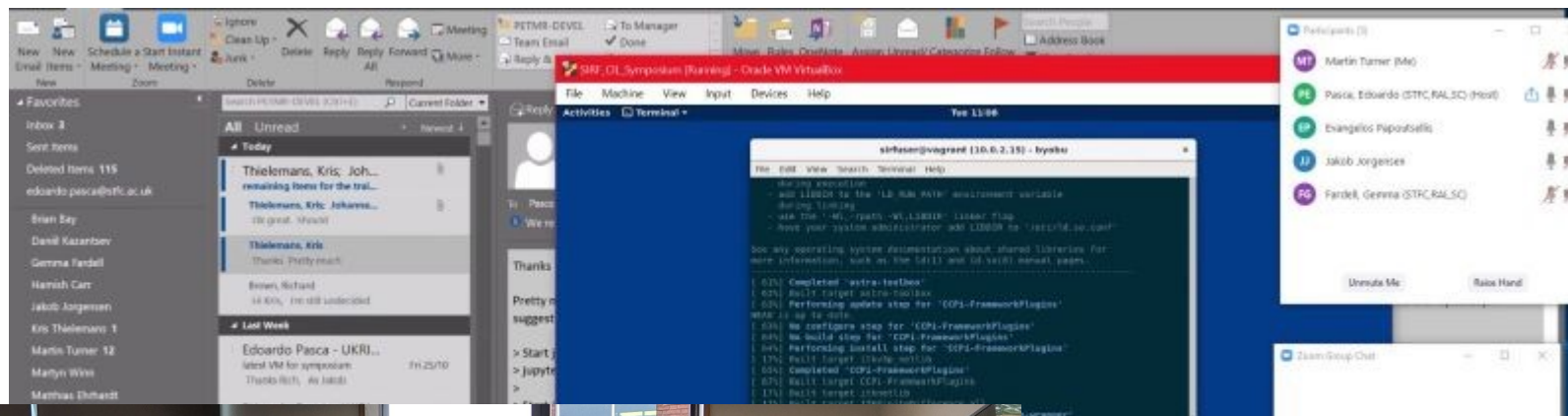
Triangle of Conferences

- Now Four

11-13 September 2019
ToScA https://www.toscainternational.org/

11-12 September 2019 – IBFEM-4i 2019: Workshop with keynotes from Prof Anton du Plessis (Stellenbosch CT Facility, South Africa) and Dr Tristan Lowe (Manchester X-ray Imaging Facility, UK). https://ibfem.co.uk/events

Triangle of Conferences

- Now Four

25-26 June 2019 Dimensional-XCT Conference in the University of Huddersfield.

11 June 2019, 4th Annual Workshop on Advances in X-ray Imaging at DLS

Dimensional-XCT

Dimensional-XCT

Dimensional-XCT
BSI/ISO extra standards gathering

Advances in Imaging Workshop + Fringe + Hackathon

Advances in Imaging Workshop + Fringe + Hackathon
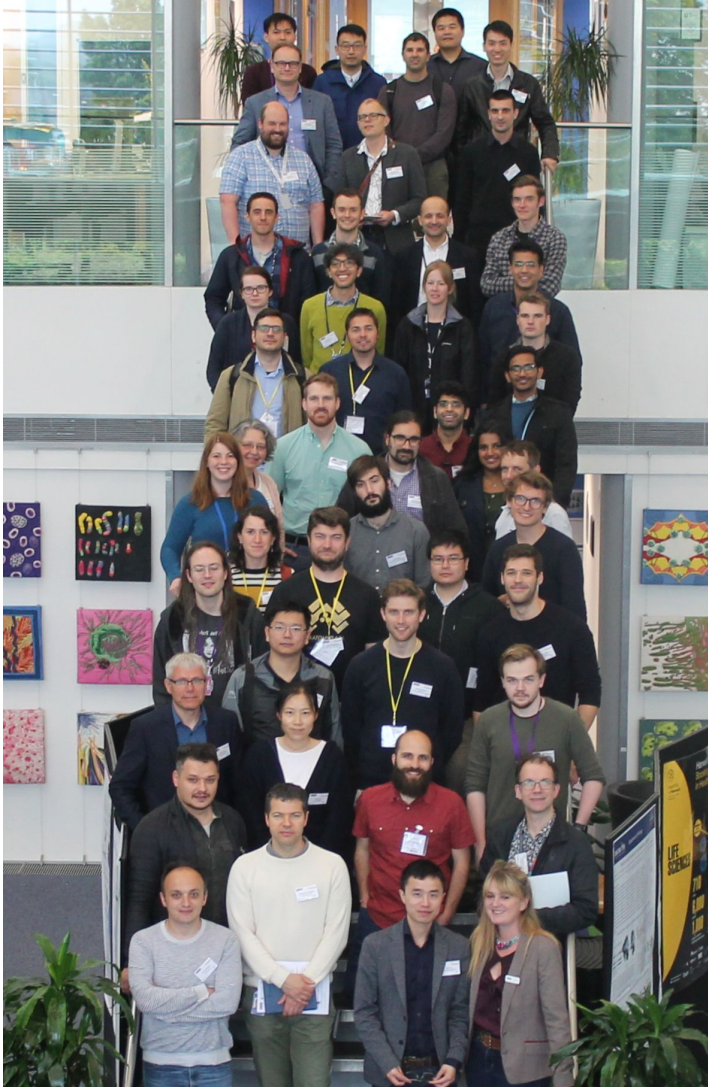
5 September 2019 EPSRC Fast CT scan equipment steering group

First meeting and presentation in January 2020.

Outline Plans 2020/21 (1 April 2020 – 31 March 2021)

- During the years 2017/2019 a large effort has been put in the new development of the iterative reconstruction framework,

- also in collaboration with CCPi flagship.

- We expect a period of lower development activity, more focused on deployment at university labs and facilities like DLS, ISIS/IMAT and CLF/EPAC.

- Also, we will focus on optimisation of the current code base of the DVC tool and distribution to wider community.

- Regarding new development, we will focus on investigation of novel methods based on ML/AI for computed tomography.

Short-Term Fellowships

- David Ryckelynck (ParisTech, Paris)
- Carsten Bellon (BAM Berlin)
- Biao Cai (Birmimgham Uni)
- Azeem Mohammed (Leicetser Uni)
- Chris Simpson (Bristol Uni)
- Anton du Plessis (SA)

- Supported BSI representatives

Lunch-and-Learn

1. 10 December 2019 - **Sarah Fisher** -x-ray back-scatter imaging - **Tristan Lowe** Metrology and dimensional XCT - and ...
2. SQUIDS Maths seminar by Ozan Oktem.
3. 12 November 2019 - **Anton du Plessis** (Stellenbosch CT Facility, South Africa) remote access and **Lindsey Marshall**, Scientific Liaison (Europe) lindsey@syglass.io www.syglass.io (att 22+1)
4. 9 July 2019 - **Mike White** / Bill Lionheart presentation on the Helgason-Ludwig consistency conditions, and Drishti-interface project, **Mario Sandoval Olive** (att 13)
5. 2 July 2019 - Extra special research session: (att 19)
   - Ying Wang In-situ Studies of Damage Mechanisms in Composites
   - Wen Zhang The effect of anisotropic microstructure on the fatigue overload behaviour of ultrafine-grained nickel
   - Shelley Rawson Time-lapse 3D Imaging During The Compression Of Freeze Cast Aerogel By Phase Contrast Synchrotron X-ray Micro-CT
   - Chakri Gudla Initiation and short crack growth behaviour of environmentally induced cracks in AA5083 H131 investigated across time and length scales
   - Sam Johnston Diffraction Constrast Tomography
   - Sam ! McDonald Non-destructive mapping of crystallographic microstructure evolution in 3D by laboratory X-ray diffraction contrast tomography
   - Ryan Warr Developing Techniques in Colour X-ray CT Imaging
   - Evangelos Papoutsellis Multi-Channel tomographic reconstruction and analysis of the CCPi Core Imaging Library
   - James O'Sullivan What microCT can tell us about neglected tropical diseases
   - Parmesh Gajjar Using microCT to understand inhaled pharmaceutical powders
6. **Monday** 10 June 2019 - **Joe Kelleher** *EnginX* - part of the CCPi Working Group meeting (att 26+1+5) (WG att was 14 [11 physically in RAL + Llion, Peter and Bill])
7. **Monday** 3 June 2019 - **Jason Wong** "Challenges of imaging for trauma reconstruction- how you can help" Abstract- The talk will highlight the current state of the clinical art in terms of imaging that guides clinical decision making in trauma, and identifies where there are great unmet needs and opportunities to influence how clinical decision making is made in the trauma reconstruction setting and **Katerina (Kathy) Christofidou** (att 14)

Lunch-and-Learn

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Micro-CT

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Neutron Beamtime

Network Activities

Request for support

- Industrial Metrology sessions continue culminating with Royce Institute hosting the **dimensional-XCT** 2020 event. Linked to support for the BSI/ISO standardisation process (ISO/TC 213/WG 10)

- CCPi is on the governance board for Warwick, WMG "EPSRC Strategic Equipment - High Speed CT" EP/S010076/1 (initial meeting on 5 September 2019 – presentation planned for January 2020)

- Proposal to support a Royal Society Summer Science Exhibit in July 2020

- … and Turing Institute Summer School in June 2020.

- Supporting ImagingBioPro network https://mecheng.ucl.ac.uk/imagingbiopro/

Plans for 2019-2020

1. Website, mailing lists, source code and data archives **Ongoing**
2. Organise exec committee and working group meetings, as well as monthly show-and-tell sessions **Ongoing**
3. Support current training courses and organise developer workshops. Assist in new proposal writing. **Ongoing**
4. Working with CCPi Flagship team in improving Core Imaging Library (CIL) and integrating the codes from flagship into CIL. **Ongoing**
5. Embed CCPi software into DAaS virtual machine to allow facilities users (DLS, ISIS) to perform analysis on their datasets from remote **Ongoing**
6. Release updated version of Simpleflex segmentation algorithm developed together with Hamish Carr (Leeds) and his student. Distribute and collaborate with Diamond i12 staff to test the segmentation on real data **Q2 2019**
7. Help to organise the main ToScA conference; September 2019 **Q3 2019**
8. Embed lab based framework: UoM/ UoS/ UoW **Q3 2019**
9. Collaboration: Working with Brian Bay (USA) on improving the digital volume correlation codes and distributing it to CCPi community **Ongoing**
10. Case Studies: Three case studies will be undertaken with ISIS/Diamond and Universities **Ongoing**
11. Code sharing with CCPPETMR **Ongoing**
12. **Optional**: benchmark the core forward and backprojection code in CCPi - Barry Searle's modification of David Szotten's Jacob's rays - using MPI

19.11.01	Plans for 2019-2020 **Approved** and Potential Software Launch:	EP/MT
	- Website, mailing lists, source code and data archives **Ongoing** - Organise exec committee and working group meetings, as well as monthly show-and-tell sessions **Ongoing** - Support current training courses and organise developer workshops. Assist in new proposal writing **Ongoing** - Working with CCPi Flagship team in improving Core Imaging Library (CIL) and integrating the codes from flagship into CIL **Ongoing** - Embed CCPi software into DAaS virtual machine to allow facilities users (DLS, ISIS) to perform analysis on their datasets from remote **Ongoing** - Release updated version of Simpleflex segmentation algorithm developed together with Hamish Carr (Leeds) and his student. Distribute and collaborate with Diamond i12 staff to test the segmentation on real data **Q2 2019** - Help to organise the main ToScA conference; September 2019 **Q3 2019** - Embed lab based framework: UoM/ UoS/ UoW **Q3 2019** - Collaboration: Working with Brian Bay (USA) on improving the digital volume correlation codes and distributing it to CCPi community **Ongoing** - Case Studies: Three case studies will be undertaken with ISIS/Diamond and Universities **Ongoing**	

	• Code sharing with CCPPETMR **Ongoing** • **Optional**: benchmark the core forward and backprojection code in CCPi - Barry Searle's modification of David Szotten's Jacob's rays - using MPI		
19.11.02	Request for funding • Software grant for Erasmus student in Soton for work on TIGRE/CIL integration - £6k? - £14k? **Rejected with further info** • BL - Multiple axes and tensor/vector tomography in CCPi code: additional resources requested **Further info requested**	EP/MT	
19.11.03	Invited speakers presented • Jay Warnett - WMG new facility • Bob Cernik - Colour bay facility at University of Manchester • Evangelos (Vaggelis) Papoutsellis - Reconstruction software	MT cttee EP/JJ ctte	
19.11.04	Review of Summer Associated Conferences: new cttee member requests • Process Tomography / ToScA (inc International - USA and Asia) / dXCT / RCaH "Advances" workshop EGUK September for 2019 and 2020 • Joint PETMR activities and PETMR joint course at MIC in November 2019 at Manchester	MT to advertise Submit	
19.11.05	Update: TPR/1 (TDW/4) /11 (XCT), Technical product realization (BSI), NPL dXCT User Group event		
19.11.06	Update on International Review of CoSeC. Future grant networks and ... case studies (of networking). For Q3 2019	PW/MT	

	New networks and proposals
	    • Training review – DVC; requires open-source.
	    • Small funds for ToScA USA approved - paper/presentation submitted
	    • BSS Fellowship submitted (Brain Bay, October 2018)
	    • SSI Fellowship, February 2019 "HPC: SCARF18, Archer access: 'constructive critical champion' role."
	    • Leverhulme visiting professor role at UoM
	    • Industrial role in UoM with RAL.
	    • Training course for programming Nikon CT machines - funds for travel to Swansea
		MT

	Location for papers on ccpi.ac.uk - including beamhardening	MT
	Access to IMAT and i12, i13, B24 and industrial grants.	MT
AOB	jiscmail lists and website content etc update	MT/EP
	ATI fellowship applications Roy Regallies and Phil Manning: ICAL facility	
	Next meeting is the: - Exec Meeting on 12 March 2019, 1pm-2pm and - Working Group on 10 June 2019, 11am-1pm.	

Previous Actions: Exec meeting

Minute	Action	Person Responsible	Completion date
29.03.01	Attend WMG equipment governance group	MT	Jan 2019
29.03.02	Summer students to present at lunch and learn[along with Nghia Vo]	EP	Dec 2018
29.03.03	Bill Lionheart to investigate SAXS project - approve travel	BL	Nov 2018
29.03.04	B24 dataset to be investigated (limited angle 150 deg; 500eV to move to 2.5keV) (link DK,EP)	DK EP	Jan 2019
29.03.05	Parmesh Gajjar to attend ToScA USA (and Swansea)	PG	Mar 2019
29.03.06	Thomas Blumensath code to be investigated for CIL inclusion	EP to contact then TL/PG	Jun 2019
29.03.07	DVC to be integrated and BSS Fellowship to be applied for.	BB EP MT DK	Oct 2018
29.03.08	Process Tomography - further integration by invitation to Bergen group ("low count and high speed is the commonality")	BL MS	Jun 2019
29.03.09	New proposal "Rich-and-non-linear tomography operators" (BL et al)	BL et al	Dec 2019

Previous Actions: WG meeting

Minute	Old Actions	Person Responsible	Date due to be completed by
29.03.01	Inform Approved items and liaise	MT	Sep 2018
29.03.02	Stand allocation three events	EP	Sep 2018
29.03.03	CAS Paper	DK	Mar 2019
29.03.04	Informal speakers at Manchester	MT	Dec 2018
29.03.05 .07, .13	Advertise new fellows/ LoS/ meetings	Newsletter ALL	Ongoing
29.03.08	Fringe event coordination	MT	Jun 2018
29.03.09	New staff member	EP/MT	Jun 2018
29.03.10, .12	CIL/Flagship launch and new testers	EP	Jun 2018
29.03.11	Case Study coordination	MT/EP	Ongoing
29.03.14	Brian Bay or student to speak	SN	Jul 2018
15.11.01	Coordinate a CPC paper proposal for 2019	DK	See Above
15.11.02	Coordinate with Nick Brierley/MTC on show and tell for 2018	EP	Done – talk at Manchester
15.11.03	To coordinate the Avizo – Amira software licenses between DLS, RCaH, ISIS and SCD.	EY	
15.11.04	Prepare pull-ups for ToScA/D-XCT roadshow and talks	EP	See Above
15.11.05	Make a small dataset working with DK on phantom dataset for CIL	EP	
15.11.06	Coordinate and organise a CCPi developers' day at University of Huddersfield.	MT	
15.11.07	Coordinate an invitation for Lee Margetts.	MT	Done

Previous Actions: WG meeting

~~15.11.08~~	~~To give update on ISO standard for XCT~~	~~MT~~	~~Done~~
15.11.09	To write up and make available one page documentation on cone beam reconstruction algorithm	SN	
15.11.10	To make a small downloadable open dataset for CIL reconstruction algorithms. Either using Sophia beads dataset	SN	
15.11.11	To estimate efforts to compare the trees and to illustrate the problem in compare two trees of the same images (with different number of projections, limited angle reconstruction)	EP	
15.11.12	To coordinate a programme (whoever interested to involve) to put together a work plan that leads to a paper on comparing the blind spot in CT reconstruction.	EP	
15.11.13	To get in touch with GD to send the paper and code on mesh to projection software.	EP	
15.11.14	To explore how to apply/try NV's denoising/pre-processing algorithms on IMAT data.	SN	
15.11.15	To get in touch with TB for using MapReduce for tomo reconstruction	EY	

Collaborative Computational Project in Tomographic Imaging's Core Imaging Library (CIL) Release

Srikanth Nagella srikanth.nagella@stfc.ac.uk, Edoardo Pasca edoardo.pasca@stfc.ac.uk, Ronald Fowler ronald.fowler@stfc.ac.uk, Martin Turner martin.turner@manchester.ac.uk, Erika Yang erika.yang@stfc.ac.uk

Visual Analytics and Imaging Systems Group
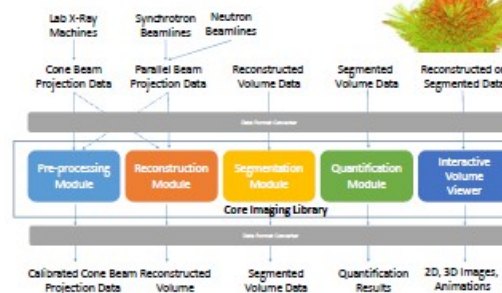Science and Technology Facilities Council (STFC)

INTRODUCTION

The CCPi Core Imaging Library (CIL) is a set of modules for each process involved in the data analysis workflow for Computed Tomography datasets.
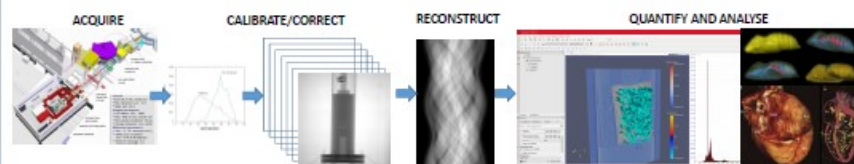
CIL aims to provide the CT imaging community with a set of tools that is easily accessible and that can be integrated into existing workflows.

The algorithms are contributed by the community and the core CCPi staff have reengineered the code to make them scalable, optimized, accessible and maintainable.

The core is developed in C++, with Python/NumPy wrappers to give programmers and scientists more flexible ways to explore and integrate these algorithms into their scripts, such as SAVU, Mantid imaging framework.

Lab X-Ray Machines | Synchrotron Beamlines | Neutron Beamlines

Cone Beam Projection Data | Parallel Beam Projection Data | Reconstructed Volume Data | Segmented Volume Data | Reconstructed or Segmented Data

Data Format Converter

Core Imaging Library
- Pre-processing Module
- Reconstruction Module
- Segmentation Module
- Quantification Module
- Interactive Volume Viewer

Data Format Converter

Calibrated Cone Beam Projection Data | Reconstructed Volume | Segmented Volume Data | Quantification Results | 2D, 3D Images, Animations

CT PROCESS

ACQUIRE → CALIBRATE/CORRECT → RECONSTRUCT → QUANTIFY AND ANALYSE

CURRENT STATUS

Pre-Release 0.1 released in June 2017

- Python (2.7 & 3.5) library binary-only release (linux64, win64)
- ccpi conda channel https://anaconda.org/ccpi
- Documentation https://cil.readthedocs.io
- Website http://www.ccpi.ac.uk/cil
- Mailing list: https://www.ccpi.ac.uk/list

Nightly builds of the Python library available on conda channel.

Available modules
- Pre-processing: Beam hardening[1]
- Iterative reconstruction algorithms (CGLS, SIRT, MLEM and CGLS with 3 regularization methods) for parallel beam
- Topological Segmentation based on Contour Tree [2]
- Quantification: Accessible Volume[3] and Label Quantification[4] algorithms
- Interactive Viewer for 3D volumes and surfaces

FUTURE PLAN

- Release 1.0 October 2017:
  - Python library
  - Plugins for ParaView, Avizo
  - Open Source Apache v2.0 license
  - Iterative reconstruction algorithms for cone beam CT
  - FISTA reconstruction algorithm [5]

- Bi-yearly stable release plan with nightly builds.

- Roadmap to zero installation distribution based on web technology.

[1] DOI: 10.1016/j.ijleo.2014.01.010
[2] DOI: 10.1109/TVCG5.2013.02.009
[3] DOI: 10.1016/s10925-7721(02)00099-7
[4] DOI: 10.1016/j.jnatproten.2014.06.009
[5] DOI: 10.1137/080716542

KEY BENEFITS

Community provided algorithms are re-engineered to scale up the application and for portability and easier distribution, e.g. code is rewritten from Matlab to C++/Python, and/or optimized.

We create and distribute plugins for common open source and commercial image analysis and visualization software, such as Paraview, Fiji/ImageJ or Avizo.

APACHE v2.0 software license compatible with both commercial and academic use.

Maximize the impact of the research by increasing the outreach of your work.

Science & Technology Facilities Council — 10 Years of Impact and Inspiration | UNIVERSITY OF BATH | diamond | UNIVERSITY OF BIRMINGHAM | The University of Nottingham — UNITED KINGDOM · CHINA · MALAYSIA | EPSRC Engineering and Physical Sciences Research Council | WMG THE UNIVERSITY OF WARWICK | Science & Technology Facilities Council ISIS | MANCHESTER 1824 | UNIVERSITY OF Southampton