

Hands-on introduction to the CCPi Core Imaging Library (CIL)

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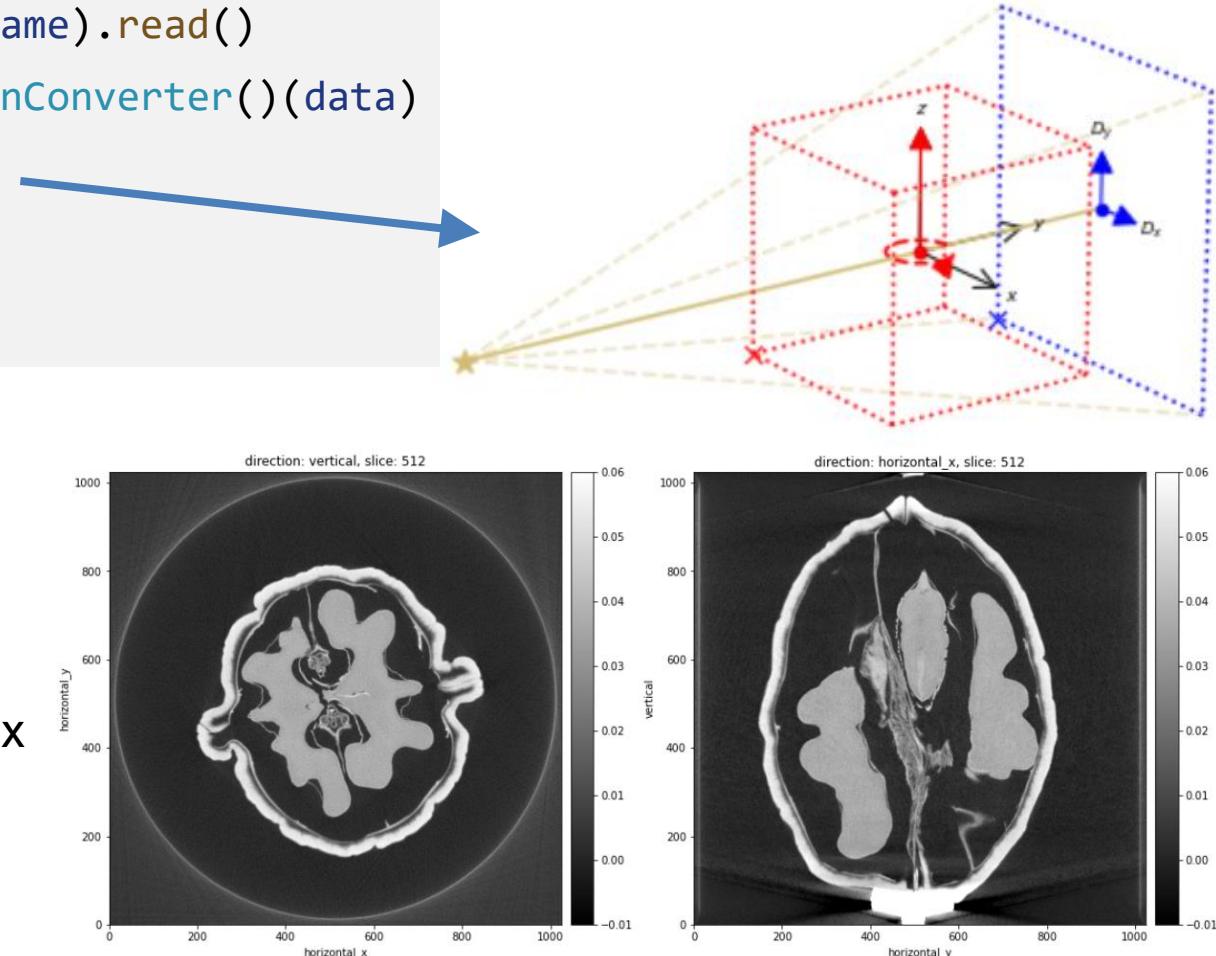
What is the Core Imaging Library?

- A Python library for processing and reconstruction of tomography data.
- Special emphasis on "challenging data sets": noisy, non-standard, incomplete, multi-channel, ...
- Optimised standard methods: FBP, FDK
- Highly modular to allow creation of bespoke pipelines.
- Range of iterative reconstruction methods and building blocks allowing users to create new ones.
- Fully open source under permissive Apache 2 license.
- Actively developed on GitHub:
<https://github.com/TomographicImaging/CIL>

Example CIL code: Cone-beam FBP

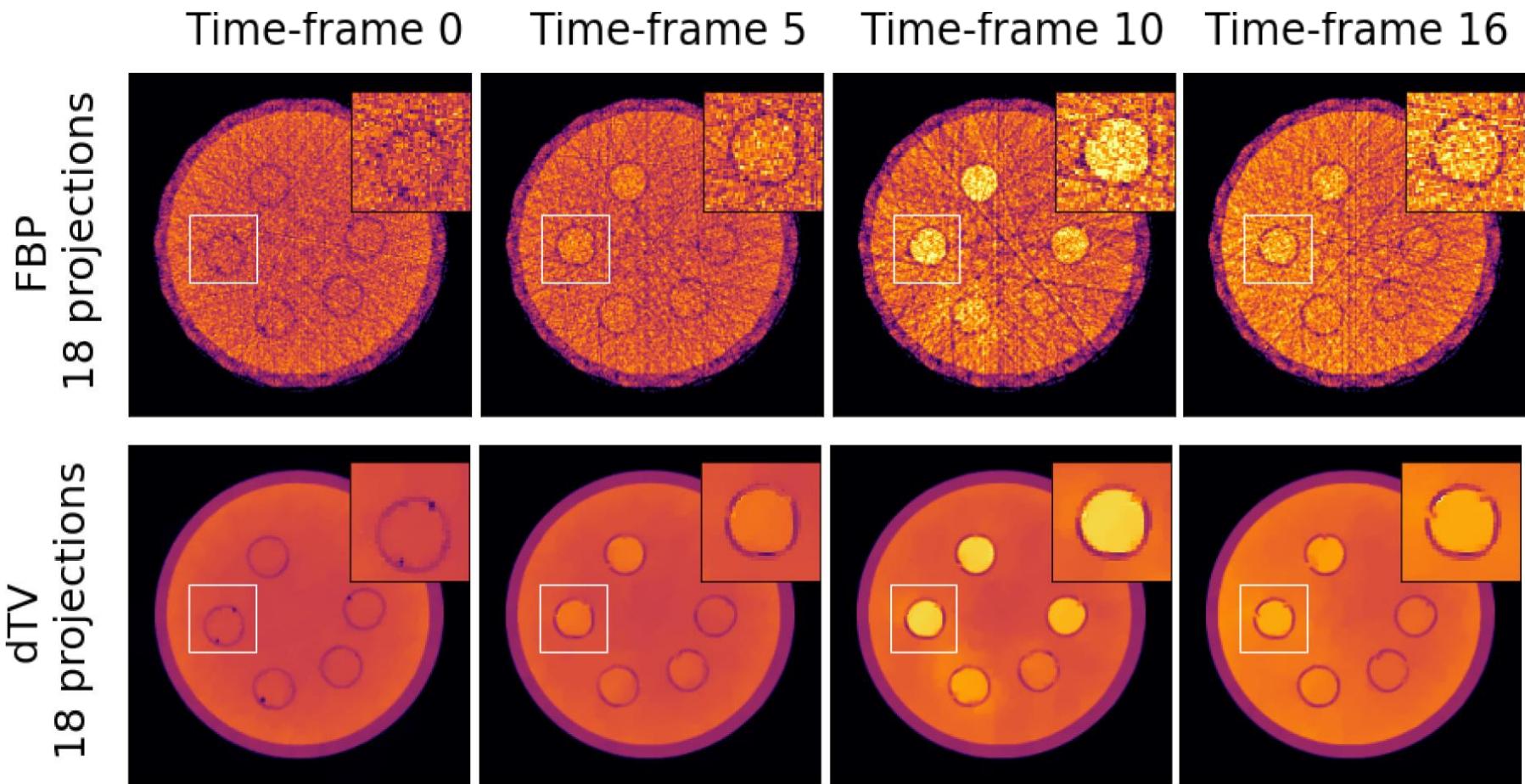
```

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



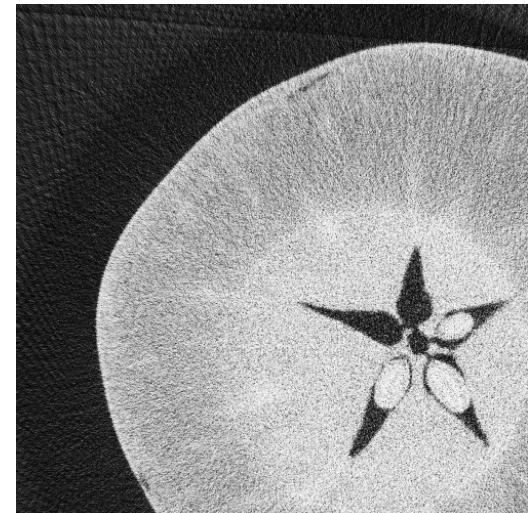
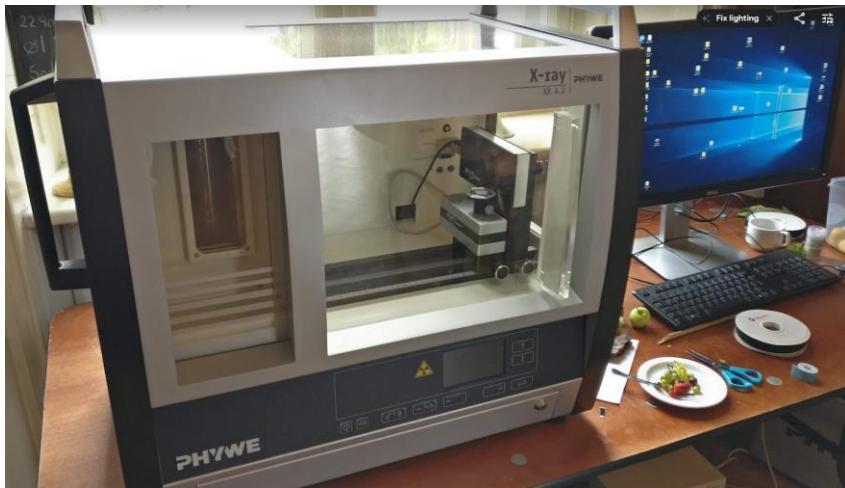
- Data readers/writers
- Pre-processing tools
- TIGRE and ASTRA backend
- 2D, 3D and 4D data
- *Near math* optimisation syntax
- Visualisation

Example: Fast dynamic CT

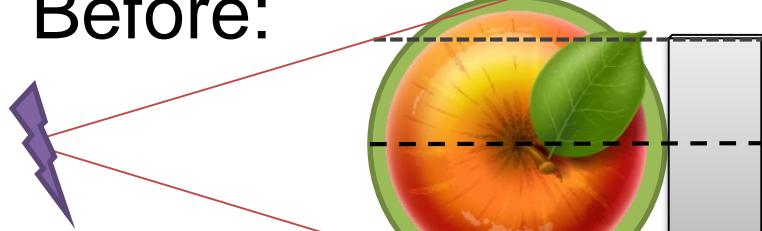


Papoutsellis et al. 2021: *Core Imaging Library - Part II: multichannel reconstruction for dynamic and spectral tomography*, Phil. Trans. R. Soc. A, **379**, 20200193: <https://doi.org/10.1098/rsta.2020.0193>

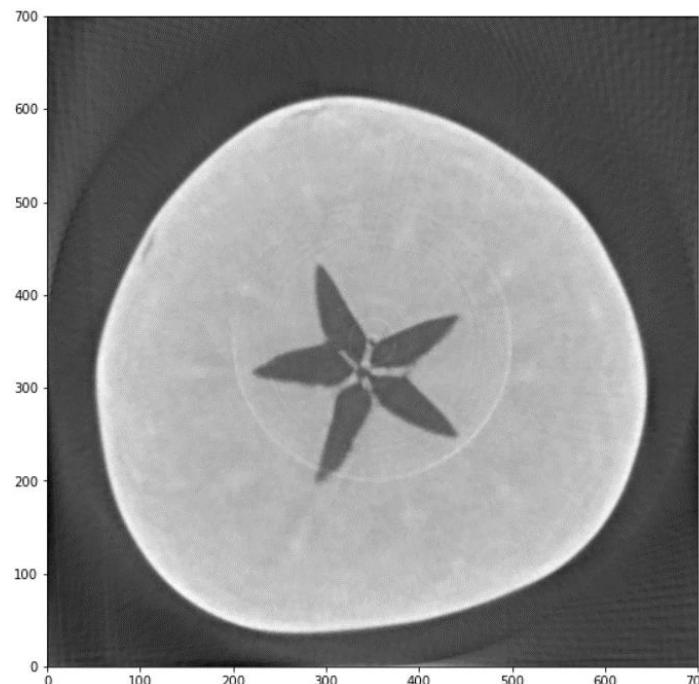
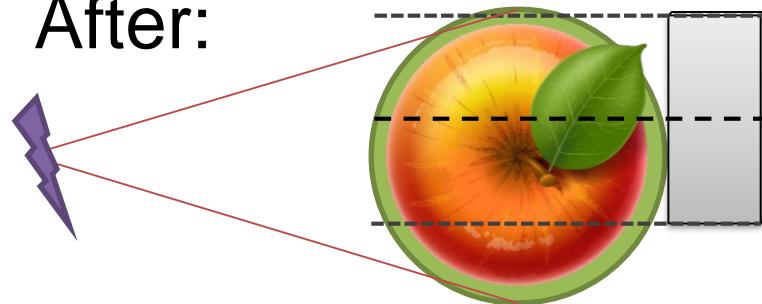
Example: Offset scan on table-top scanner done by CINEMAX summer school students



Before:



After:



What is the CCPi?

The Collaborative Computational Projects (CCPs) bring together leading UK expertise in key fields of computational research to tackle large-scale scientific software development, maintenance and distribution.

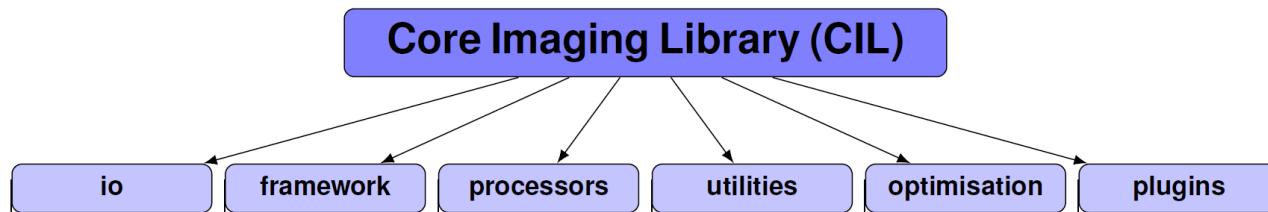


- CCPi – CCP on tomographic imaging
- PI Prof Philip Withers
- Phase III: 2020 – 2025, team of Co-Investigators:
 - Jakob S Jørgensen, University of Manchester (Now DTU)
 - Jay Warnett, Warwick Manufacturing Group
 - Llion Evans, Swansea
- Core Software Developers:
 - Edoardo Pasca, Gemma Fardell, Evangelos Papoutsellis and Laura Murgatroyd @ RAL

The beginning of CIL

- Development started in 2017.
- EPSRC grant "Reconstruction Toolkit for multichannel CT" 2017-2020
- **Goal 1:** Develop reconstruction methods and **software framework** for multichannel data such as dynamic (time-lapse) and multispectral CT.
- **Goal 2:** Handle other "non-standard" data such high-noise, unconventional scan geometries etc.
- **Goal 3:** Common platform to connect existing tomography codes, both CCPi codes and existing packages such as ASTRA and TIGRE.

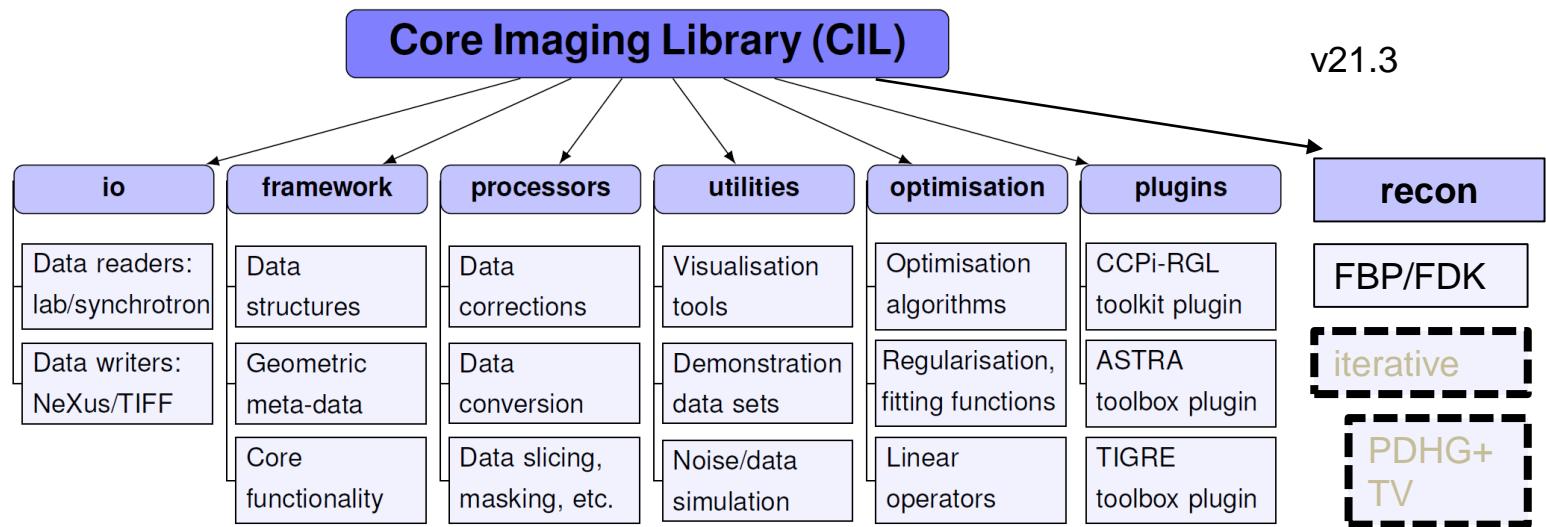
Module organization and contents



Jørgensen et al. 2021: *Core Imaging Library - Part I: a versatile Python framework for tomographic imaging*, Phil. Trans. R. Soc. A, **379**, 20200192: <https://doi.org/10.1098/rsta.2020.0192>

The **cil.plugins** module contains wrapper code for other software and third-party libraries that need to be installed separately to be used by CIL.

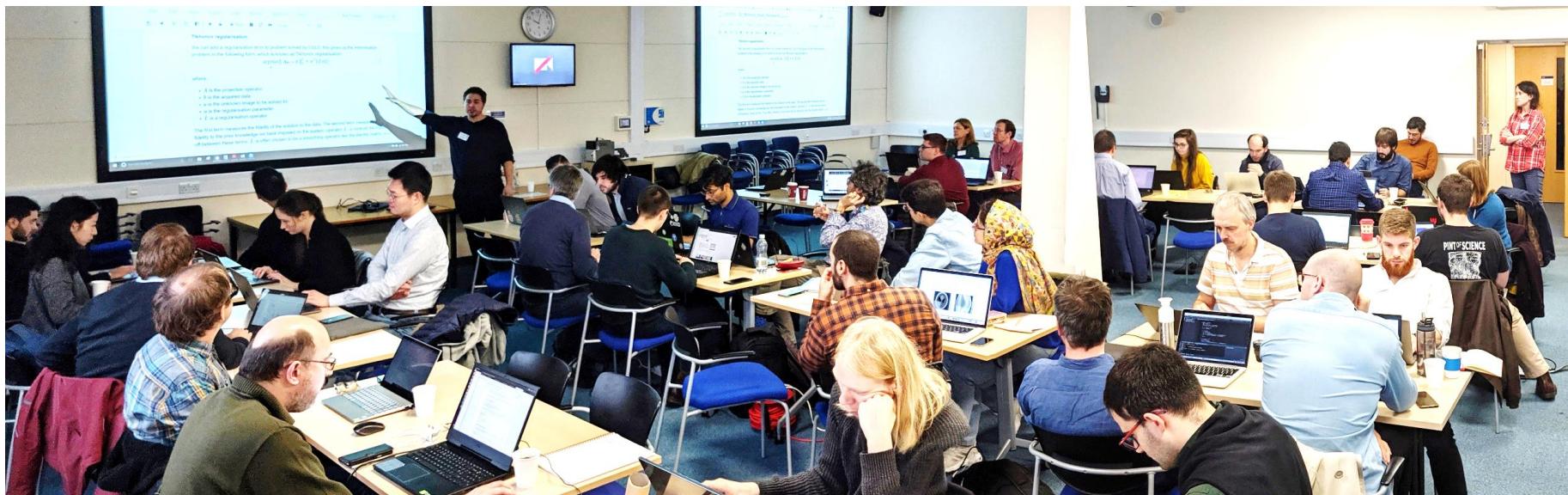
Module organization and contents



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Training events

- 2019: Symposium on synergistic tomographic recon, Chester, UK.
- 2021: Fully3D Conference
- 2021, 2022: CINEMAX VI Summer School
- 2021, 2022: ToScA Conference
- Cloud setup with Jupyter notebooks, example data sets, GPUs
- **20 – 24 March, Cambridge: Training + Hackathon "bring your data"**





Discord community to support CIL users

The screenshot shows the CIL Discord server interface. The left sidebar lists channels: #github, #CIL, #get-started, #installation-questions, #demo-questions, #using-cil (selected), #discussions, #general, #tomographic-imaging, #optimisation-problems, #voice-channels, #general, #developer-chat, #moderator-only, #dev-general, and #dev-general. The right side shows a message from Vaggelis on January 21, 2022, discussing reconstruction with mask using CIL's CompositionOperator and MaskOperator. It includes a link to a notebook sharing space and a note that the thread is archived. Other messages show interactions between Vaggelis and nargiza, and Vaggelis starting a new thread. The right sidebar shows developer profiles for edo, Gemma Fardell, Laura Murgatroyd, and Vaggelis, and lists online users MEE6 (BOT), nargiza, Asim, IonoR, Iwan M, Jakob Sauer Jørgens, MartinTurner, and MMihay1987.

using-cil Any CIL related discussion lives here. Ask for help or show cas... January 21, 2022

Vaggelis 01/21/2022 Hi @nargiza , I had a look on the reconstruction with mask and I think we can do it directly with CIL, using the CompositionOperator and the MaskOperator.

There are two options, a) apply a mask on the ImageGeometry (reconstruction space) b) apply a mask on the AcquisitionGeometry (sinogram) space.

In the link below you can find a notebook with a simple reconstruction on both cases.

[https://notebooksharing.space/view/201c0d9786765d40b58c63ef4a2c183f707f175a3efce4665a59e9667ceaaba#displayOptions=\(edited\)](https://notebooksharing.space/view/201c0d9786765d40b58c63ef4a2c183f707f175a3efce4665a59e9667ceaaba#displayOptions=(edited))

Reconstruction with mask [See Thread](#) This thread is archived

@Vaggelis Hi @nargiza , I had a look on the reconstruction with mask and I think we can do it dir... nargiza 01/21/2022 Hey, that's great! I need to try and figure out how to do that then 😊

Vaggelis started a thread: **Reconstruction with mask**. See all threads. 01/21/2022

Vaggelis 01/21/2022 Let me know if this works and if you need any help to use it in your case.

Message #using-cil

DEVELOPERS — 4

edo

Gemma Fardell

Laura Murgatroyd

Vaggelis

ONLINE — 2

MEE6 ✓ BOT

nargiza

OFFLINE — 7

Asim

IonoR

Iwan M

Jakob Sauer Jørgens

MartinTurner

MMihay1987

Useful links for Core Imaging Library

- Website: <https://www.ccpi.ac.uk/CIL>
- Documentation: <https://tomographicimaging.github.io/CIL>
- Discord community discord.gg/9NTWu9MEGq

Software papers

- J. et al. 2021, Phil. Trans. R. Soc. A, **379**, 20200192:
Core Imaging Library - Part I: a versatile Python framework for tomographic imaging
<https://doi.org/10.1098/rsta.2020.0192>
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Core Imaging Library - Part II: multichannel reconstruction for dynamic and spectral tomography
<https://doi.org/10.1098/rsta.2020.0193>

Useful links for Core Imaging Library

Applications papers using CIL

- Ametova et al. 2021, J. Physics D, **54**, 325502
Crystalline phase discriminating neutron tomography using advanced reconstruction methods
<https://doi.org/10.1088/1361-6463/ac02f9>
- Warr et al. 2021, Scientific Reports, **11**, 20818
Enhanced hyperspectral tomography for bioimaging by spatirospectral reconstruction
<https://www.nature.com/articles/s41598-021-00146-4>
- Brown et al. 2021, Phil. Trans. R. Soc. A, **379**, 20200208
Motion estimation and correction for simultaneous PET/MR using SIRF and CIL
<https://doi.org/10.1098/rsta.2020.0208>



Live demo...

Exercises in Jupyter notebooks

- Hands-on exercises at CIL Jupyter notebook server:
<https://learnmore1.compute.dtu.dk>
<https://learnmore2.compute.dtu.dk>
- To distribute load between servers:
If your birth date is an odd (even) number, use learnmore1 (2)
- Use your DTU or guest login and password
- Assignments -> CINEMAXV_Reconstruction -> 2023_SC_for_CT_week_1
-> Fetch -> Files -> Refresh (hit F5) -> Enter folder 2023_SC_for_CT_week_1

Recommended order of exercises

- 02_intro_sandstone_parallel_roi
(SLS Tomcat synchrotron, parallel 2D)
- 03_preprocessing.ipynb
(DLS synchrotron, parallel 3D, small)
- 01_2D_intro_walnut_conebeam.ipynb
(Zeiss lab, cone **2D**)
- 01_intro_walnut_conebeam.ipynb
(Zeiss lab, cone 3D)
- exercise_A_intro_seeds_conebeam
(Nikon lab, cone 3D)
- exercise_B_preprocessing_seeds_con
(Nikon lab, cone 3D)
- additional_exercises_data_resources
- 00_CIL_geometry