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


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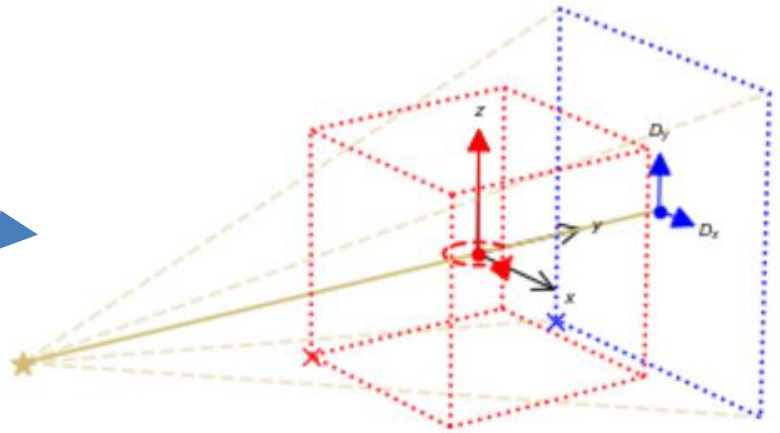
# What is the Core Imaging Library?

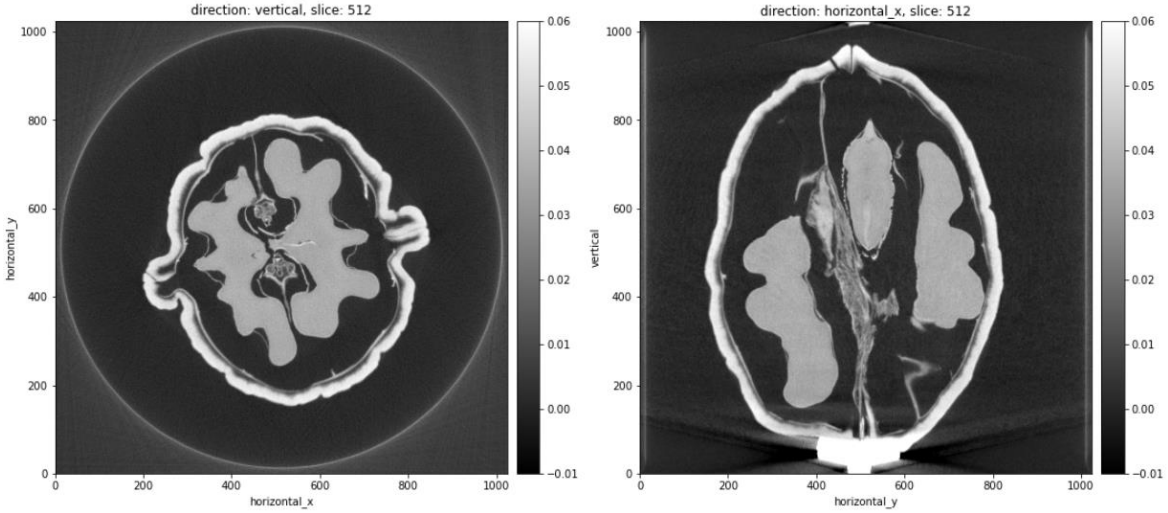
- A Python library for processing and reconstruction of tomography data.
- Special emphasis on ”challenging data sets”: noisy, non-standard, incomplete, multi-channel, ...
- Optimised standard methods: FBP, FDK
- Highly modular to allow creation of bespoke pipelines.
- Range of iterative reconstruction 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)
```

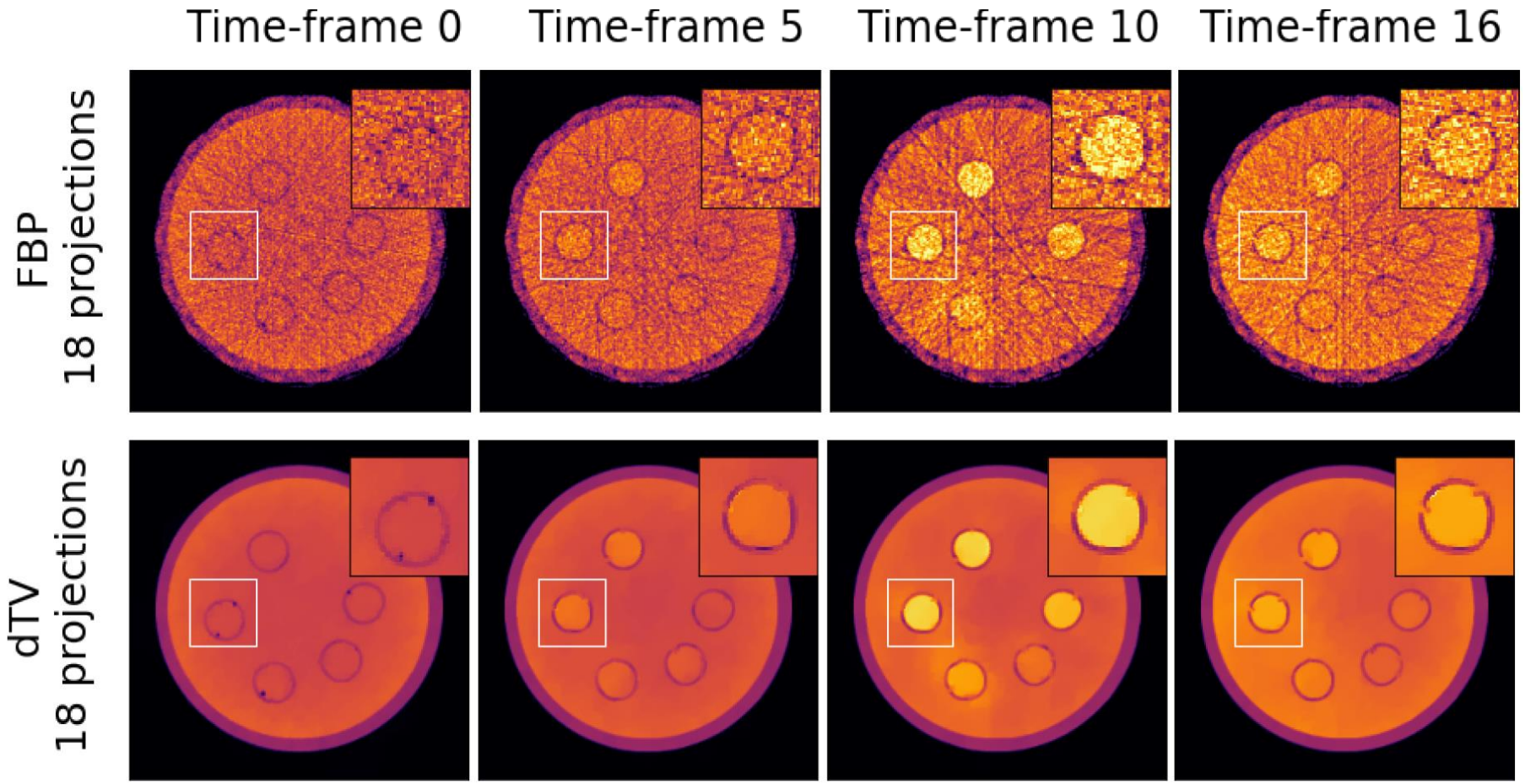



- Data readers/writers
- Pre-processing tools
- TIGRE and ASTRA backend
- 2D, 3D and 4D data
- *Near math* optimisation syntax
- Visualisation




[ccpi.ac.uk/CIL](ccpi.ac.uk/CIL)

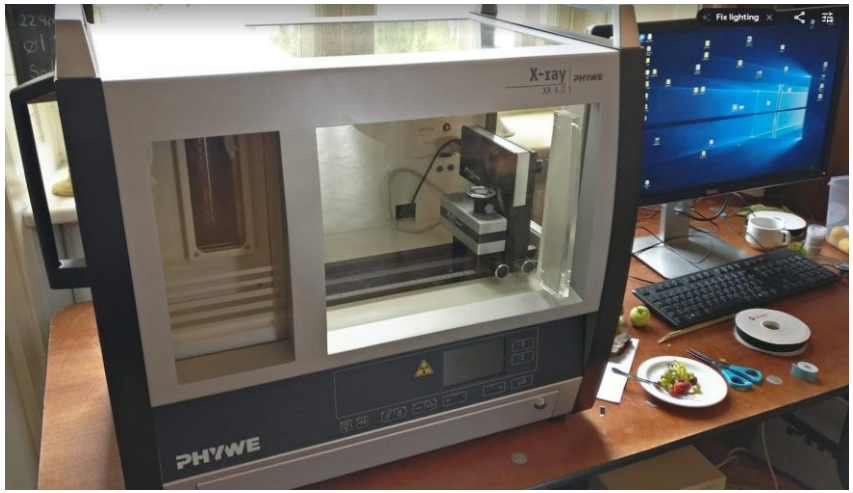
# Example: Fast dynamic CT

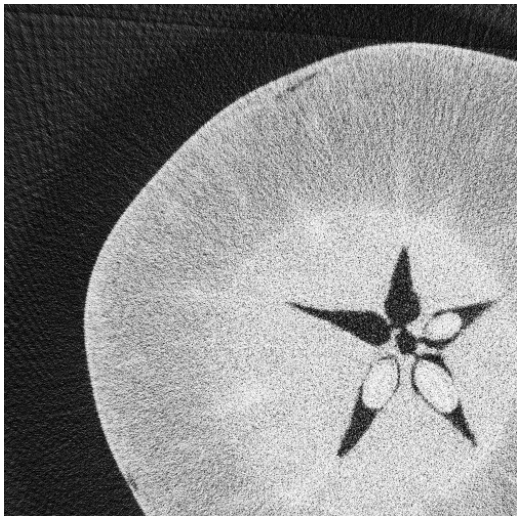



Papoutsellis et al. 2021: *Core Imaging Library - Part II: multichannel reconstruction for dynamic and spectral tomography*, Phil. Trans. R. Soc. A, **379**, 20200193: https://doi.org/10.1098/rsta.2020.0193

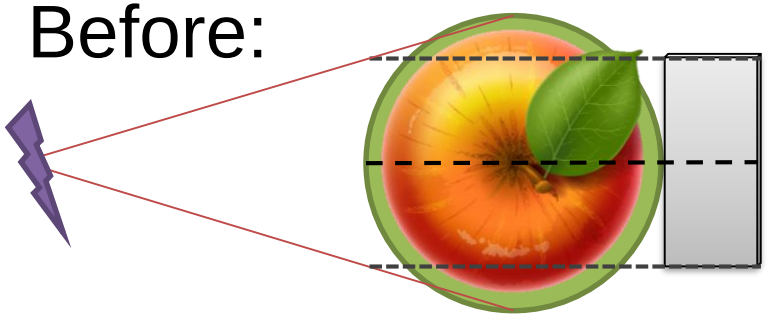
FIPS dataset: Tommi Heikkilä, Hanna Help and Alexander Meaney: "Gel phantom data for dynamic X-ray tomography" https://doi.org/10.5281/zenodo.4540623

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

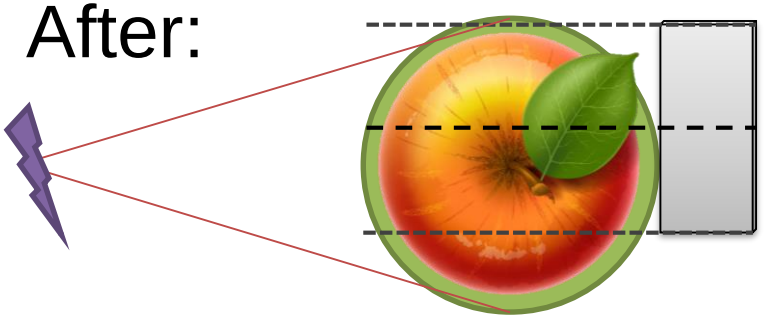


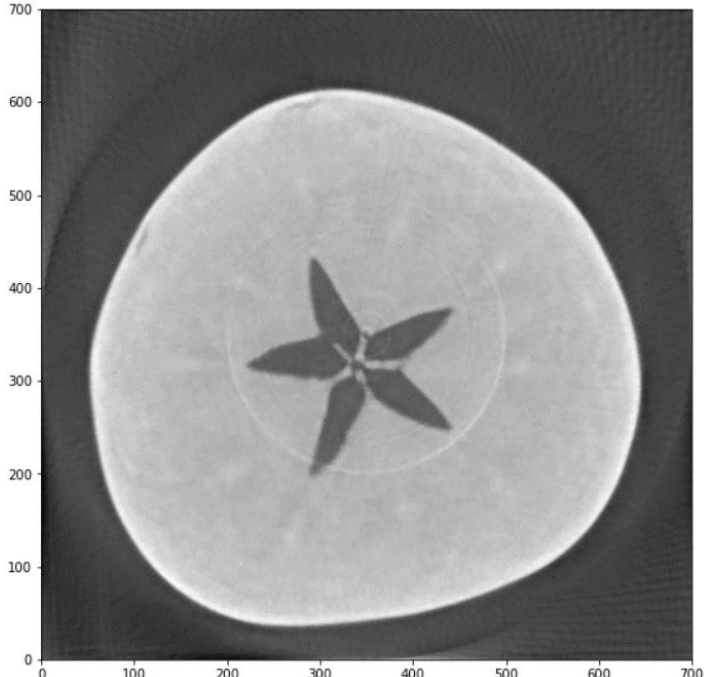



Before:



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

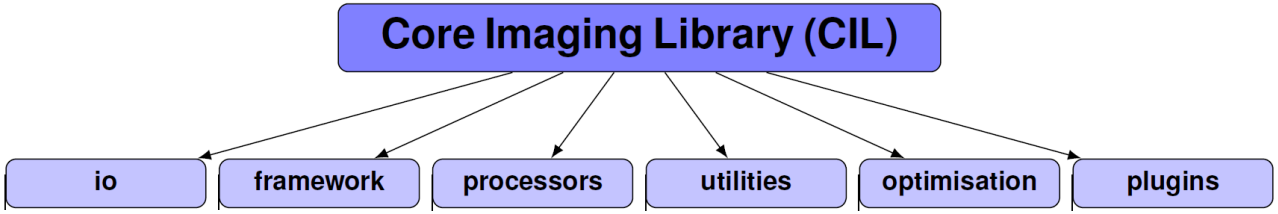
# The beginning of CIL

- 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.

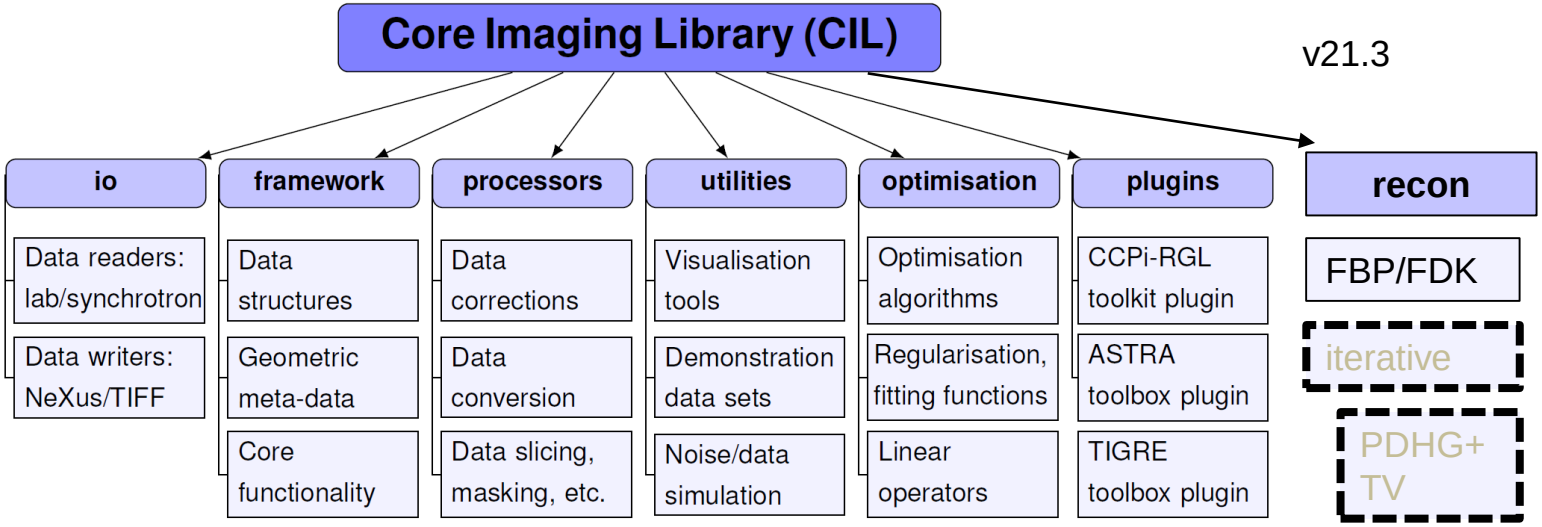
# Module organization and contents




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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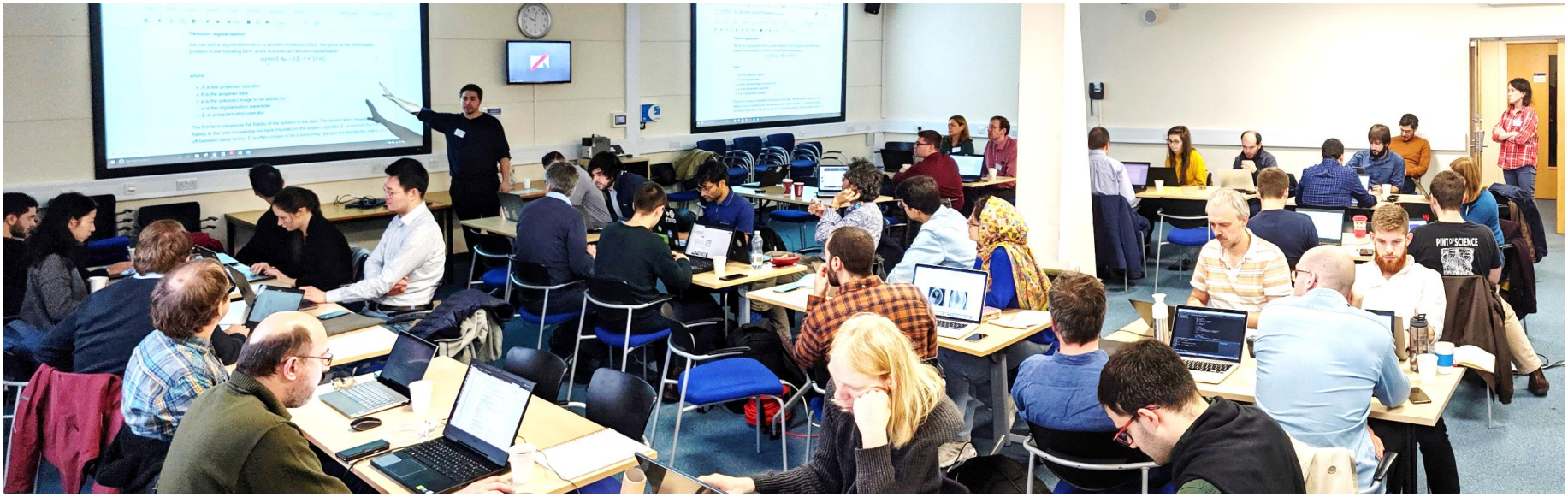
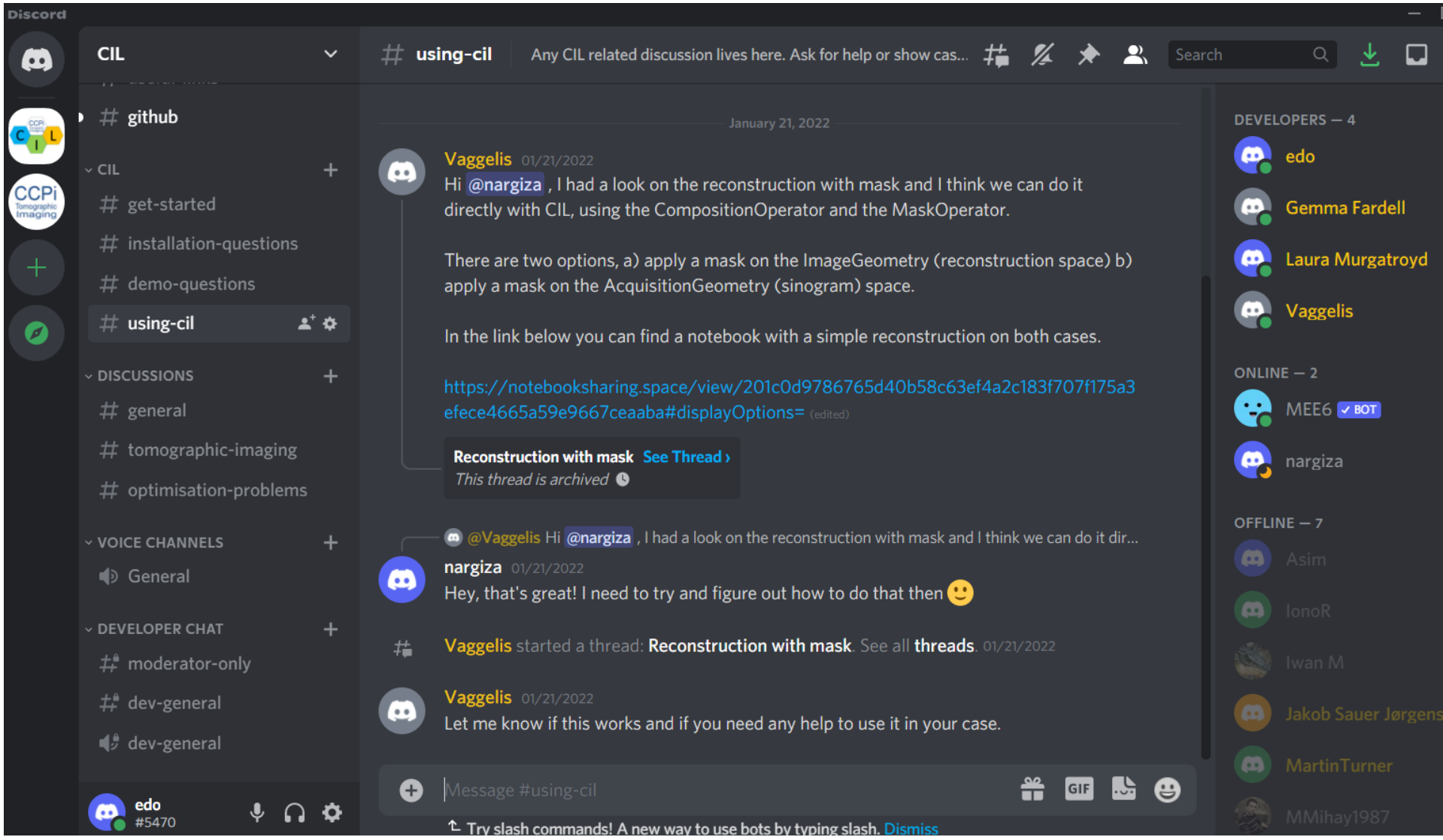
# Training events

- 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



# 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
- Papoutsellis et al. 2021, Phil. Trans. R. Soc. A, **379**, 20200193: *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 spatiospectral 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

CIL
CORE IMAGING LIBRARY

# 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