

# SIRF-CIL Training School

SIRF:

Synergistic Image Reconstruction Framework

CIL:

Core Imaging Library

Kris Thielemans

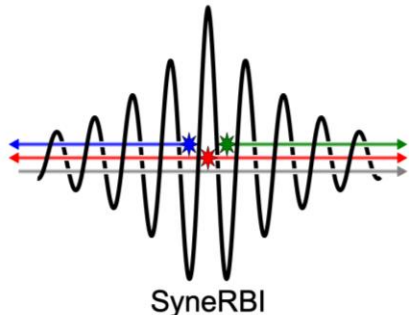
University College London, UK

on behalf of the

*Collaborative Computational Projects on*

*Synergistic Reconstruction for Biomedical Imaging (CCP SyneRBI)*

*Tomographic Imaging (CCPi)*



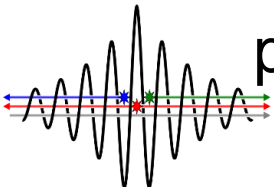
<http://www.ccpsynerbi.ac.uk>

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

**CCPi**  
Tomographic  
Imaging

# ***Zoom info***

- Zoom session will be recorded
  - Recording will be made available to participants
  - Main information sessions will be shared openly via the website
- Zoom users
  - Mute microphone as much as possible (either your device or via the zoom interface)
  - Do not enable video (but do so during discussion)
  - Use “chat” facility for short communications (e.g. to notify you want to ask a question, note about problems with sound, etc)



# *Schedule for today*

- Introduction

Kris Thielemans & Christoph Kolbitsch

- Demonstration on tools used

Edoardo Pasca & Ander Biguri

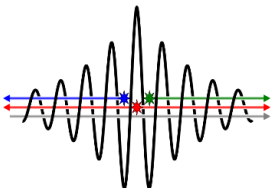
Short break

- Software concepts per modality

– 15:00-15:30 MR (SIRF)      *Christoph Kolbitsch*

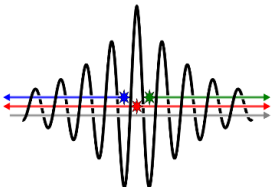
– 15:30-16:00 PET (SIRF)      *Kris Thielemans*

– 16:00-16:30 CT (CIL)      *Jakob Jørgensen*

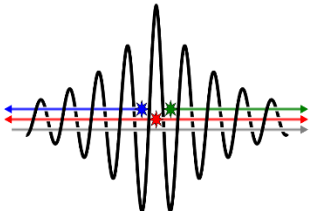


# Overview

- Training school aims and structure
- SIRF and CIL description
- Practicalities
  - Schedule
  - Where to find information
  - Ways to interact



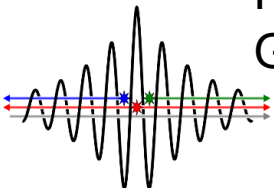
# AIMS AND STRUCTURE



# *Aims*

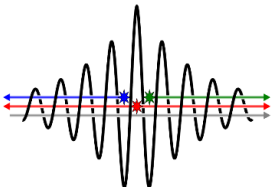
For you to gain

- basic understanding of imaging
  - physics processes behind x-ray CT, MR and PET
  - the image formation process and in particular image reconstruction methods
- hands-on experience
  - SIRF and CIL software
    - use and evaluate existing algorithms
    - Implement your own, or combine existing ones
  - modern data-processing tools and resources  
Python, Jupyter, Zenodo, docker, VirtualBox, HackMD (markdown), GitHub and git,...



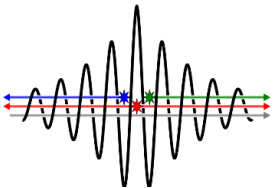
# ***Additional aims***

- Join/grow a community of researchers improving image quality and willing to *share* experience and software
  - sharing between modalities as well as fields (medical and material science)
  - international
- Accelerate research and translation into practice



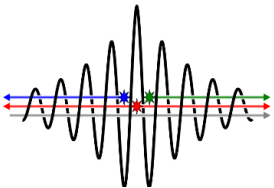
# ***How to do all of that in an online context across most time zones?***

*Self-taught* with  
orientation sessions + “office hours”



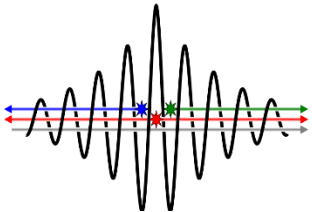


- Use existing online material
  - Recorded lectures
  - Papers
- Live sessions (which will be recorded)
  - Opportunity to ask questions (use chat or “raise hand”)
- Asynchronous interaction via HackMD  
anonymous or via registration on HackMD



# SIRF AND CIL DESCRIPTION

- Project background
- Software overview
- Example results



# ***Background: what are CPPs?***

*Collaborative Computational Projects* (CCPs) are UK-funded networking grants with Research Software Engineering support



Engineering and  
Physical Sciences  
Research Council



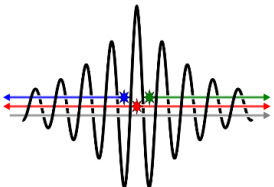
## **Timelines**

- CCP in Synergistic PET-MR Reconstruction  
2015-2020
- CCP in Synergistic Reconstruction for Biomedical Imaging (SyneRBI)  
2020-2025

<http://www.ccpsynerbi.ac.uk>

- CCP in Tomographic Imaging 2010-2025

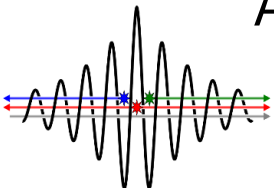
<http://www.ccp.ac.uk>



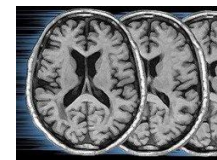
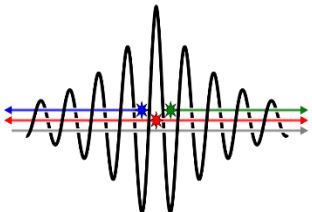
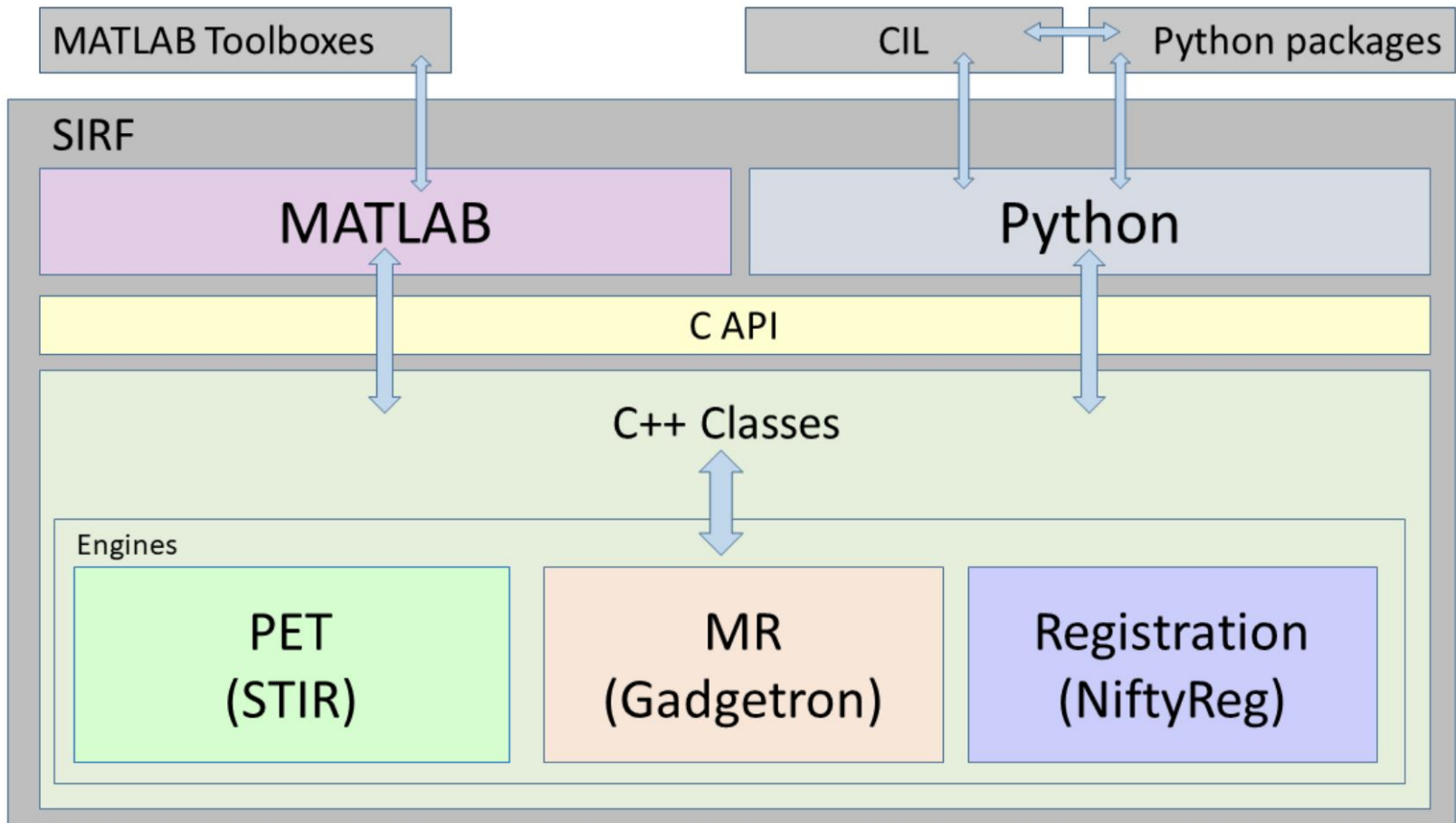
**CCPi**  
Tomographic  
Imaging

# ***Synergistic Image Reconstruction Framework***

- Aims
    - ***powerful*** enough to handle real data,
    - ***simple*** enough to be used for training and fast prototyping
    - ***robust*** enough to be incorporated into real-world pipelines
  - Open source
    - Apache 2.0 license
- Actual distribution is GPL due to use of FFTW



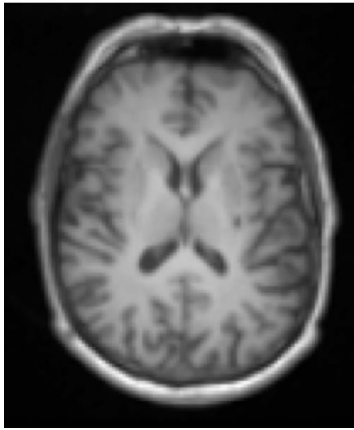
# SIRF SOFTWARE ARCHITECTURE



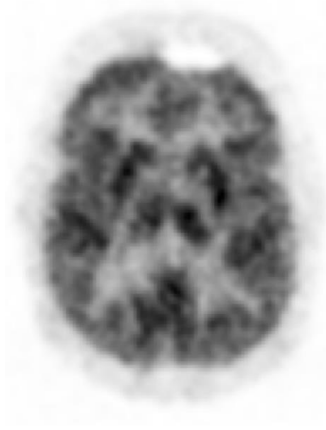
NiftyReg

# Example SIRF reconstructions

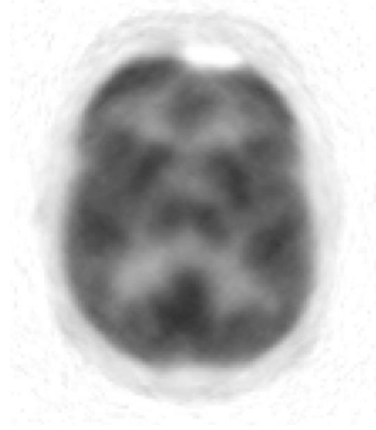
(epilepsy study, PET-FDG)



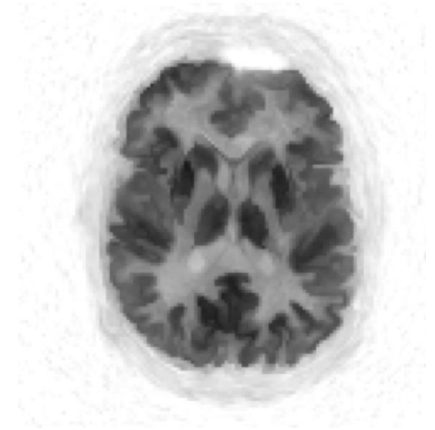
T1-weighted  
MR



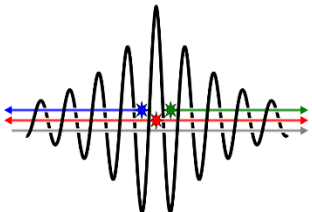
OSEM



Uniform-weighted  
quadratic MAP



Bowsher-weighted  
quadratic MAP



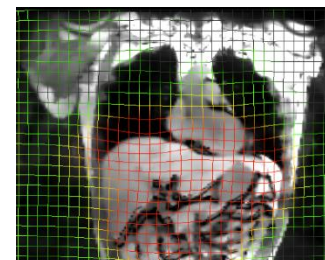
See week 3

# Siemens mMR: respiratory gated PET/MR

- Motion compensation to reduce artefacts and noise
- Workflow:
  1. Gated MR recon (FISTA+TV)
  2. Image registration
  3. MCIR of gated MR with GTV
  4. MCIR of gated PET (OSSPS)

No TV

With TV



No MC

With MC



MCIR =  
Motion Compensated Image Reconstruction

# CIL <https://github.com/TomographicImaging/CIL>

Open Source Python framework for tomographic imaging with emphasis on challenging datasets where conventional filtered back-projection fail.  
Apache 2.0 license

CIL aims to combine the best of the two worlds of:

**Tomography**

**Optimisation software**

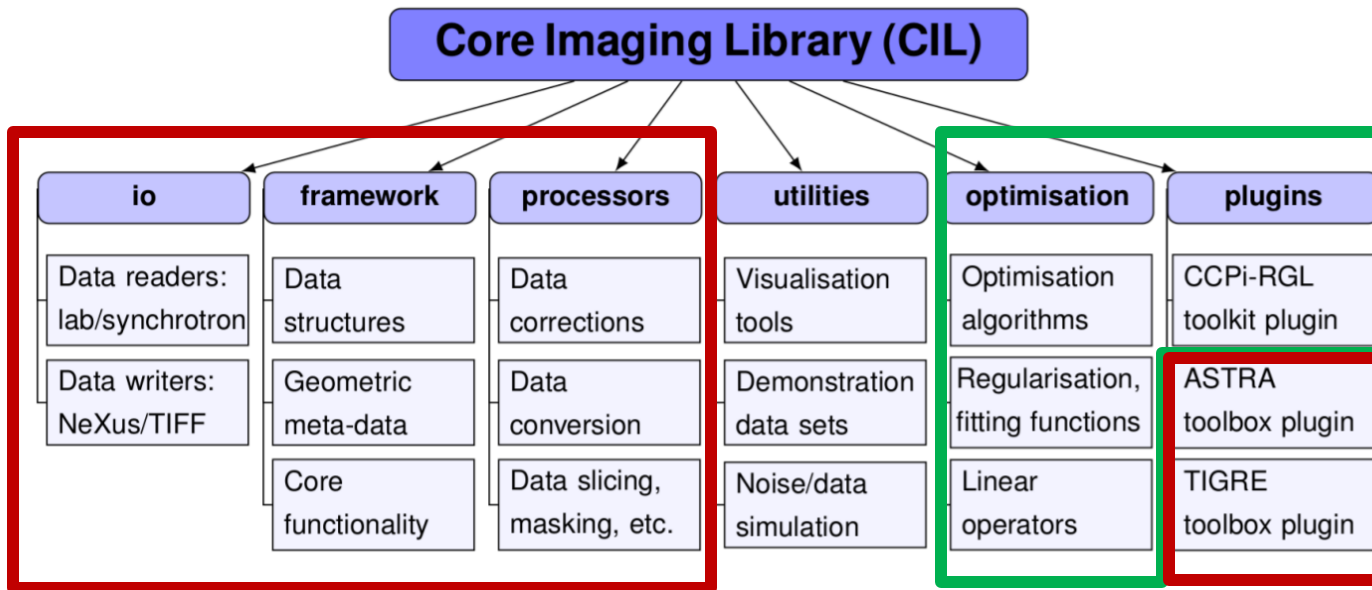
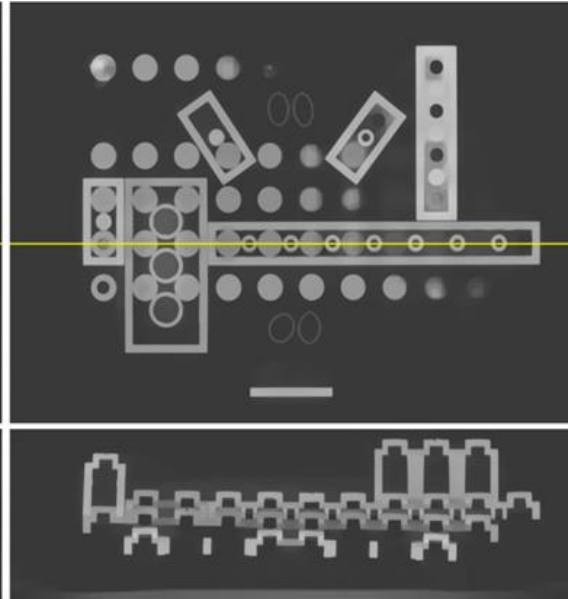
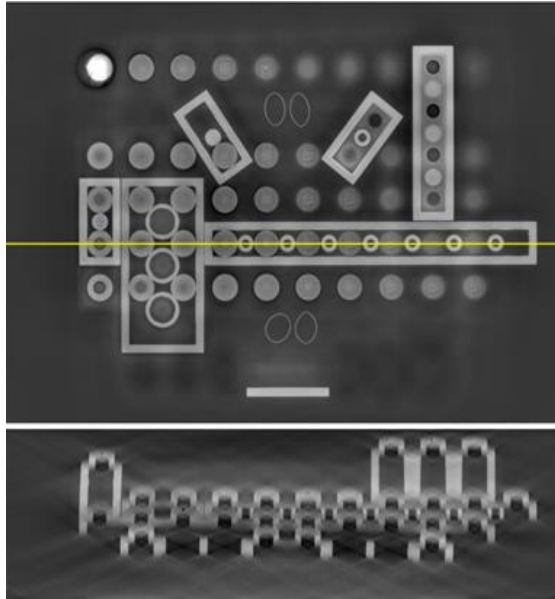
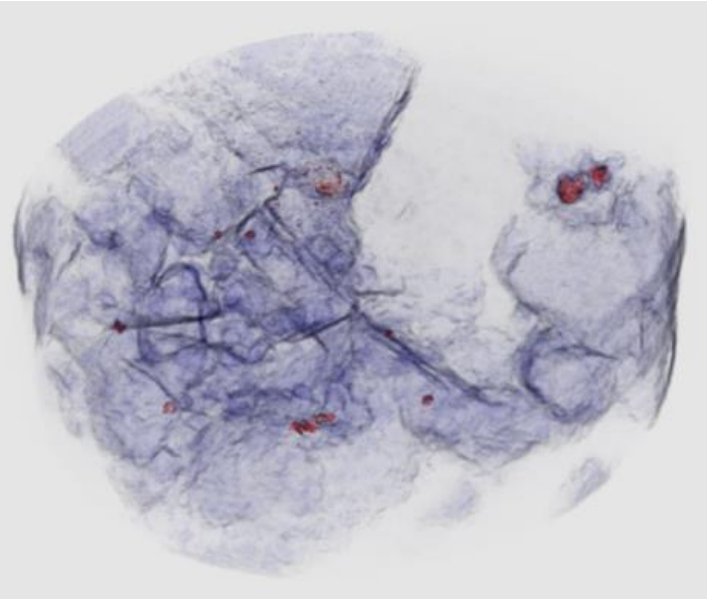


Figure 1: Overview of CIL module structure and contents. The `cil.plugins` module contains wrapper code for other software and third-party libraries that need to be installed separately to be used by CIL.



# Example *CLL* reconstructions

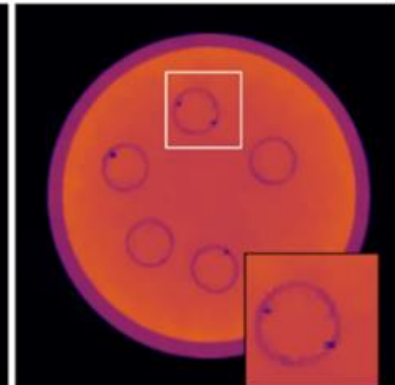
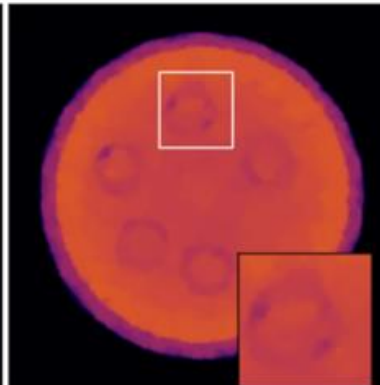
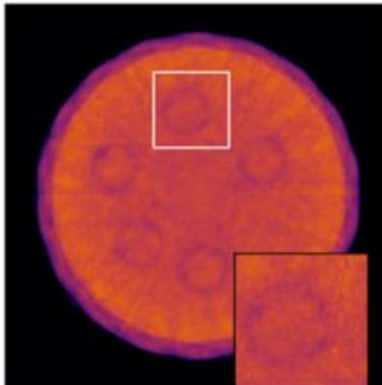
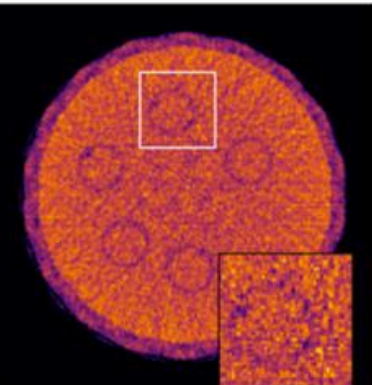


FBP  
18 projections

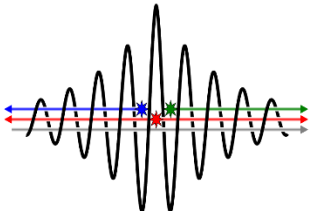
Tikhonov  
18 projections

TV  
18 projections

dTV  
18 projections



# PRACTICALITIES



# Overall time-table

- **Week 1 Basic concepts**

- Image display, acquisition models, forward projections, back (adjoint) projections, simple reconstruction, basic input/output
- Familiarity with Python, Jupyter notebooks, other tools

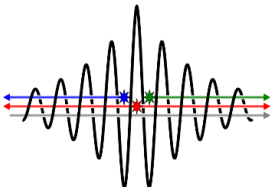
- **Week 2 Iterative Reconstruction and Regularisation**

- General and modality-specific optimisation
- Smooth and non-smooth regularisers

- **Week 3 Advanced Topics**

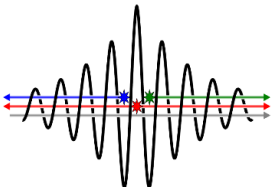
- Guided and Synergistic reconstruction
- Post-reconstruction deep learning

**social session** on the last Friday “night”



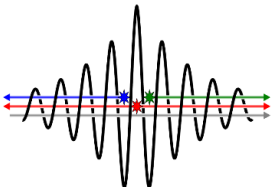
# ***Weekly schedule***

- **Monday 14:00 – ~16:30: Orientation**  
joint session
- **Wednesday 14:00 – 16:00: Live support**  
partially overlapping sessions  
(use overlap for unsolved problems, but ideally join next session)
  - Address any questions posted on HackMD
  - Zoom interaction
  - Zoom breakout rooms for detailed topic or group work
- **Friday 14:00 – ~16:00: Summary and outlook**  
joint session
  - Address unresolved questions posted on HackMD
  - Participant participation: you show your solutions
  - What happens next week?



# *How to participate?*

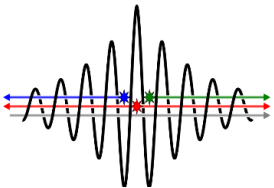
- Join live sessions if you can, or watch them later (**essential**)
- In your own time:
  - Brush up/expand your knowledge via the supporting material (**recommended**)
  - Use the software and exercises (**essential**)
  - Ask (and answer!) questions via HackMD (**recommended**)



# *How to get/install the software?*

- STFC Cloud:  
<https://training.jupyter.stfc.ac.uk/>
- Your own installation:
  - Virtual Machine
  - Docker
  - (self-built)

More detail on the HackMD site, and see sessions later.



# ***Information and interaction***

- Overall schedule and information on website

<https://www.ccpsynerbi.ac.uk/SIRFCIL2021>

- During zoom sessions:

**use zoom chat to ask questions**

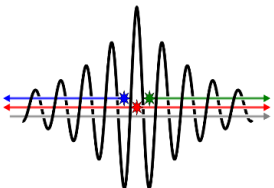
- Otherwise:

**ask (or answer!) questions via HackMD**

<https://hackmd.io/@SIRF-CIL-Fully3D>

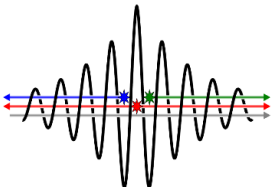
**Emergency or feedback:**

**SCD\_EVENTS@stfc.ac.uk**



# *Final notes*

- Our first online training school
  - Bear with us
  - Provide feedback and suggestions while we go



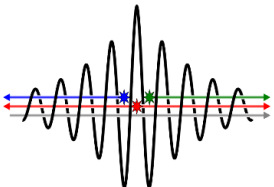


# Acknowledgements

- **CCP SyneRBI and CCPi Executive Committees**
  - Kris Thielemans (UCL)
  - Phil Withers (Manchester)
- **CoSeC staff**
  - Edoardo Pasca in particular for this training school
- **Many volunteers**

sites: Bath, CSIRO Brisbane, KCL, Manchester, PTB Berlin, UCL, ...

  - Christoph Kolbitsch (PTB)
- **Underlying open source projects**
  - Gadgetron, STIR, NiftyReg, Astra
  - CMake, Jupyter, python, gcc ...
- **Funding**
  - CCP SyneRBI (EP/T026693/1).
  - CCP PET-MR (EP/M022587/1) and the associated Software Flagship project (EP/P022200/1)
  - CCPi (EP/P02226X/1, EP/V007742/1, EP/M022498/, EP/T026677/1)



# *Schedule for today*

- Introduction

- School and project overview (Kris Thielemans)
- Notebook overview (Christoph Kolbitsch)

- Demonstration of tools used

Edoardo Pasca & Ander Biguri

Short break

- Software concepts per modality

- 15:00-15:30 MR (SIRF)      *Christoph Kolbitsch*
- 15:30-16:00 PET (SIRF)      *Kris Thielemans*
- 16:00-16:30 CT (CIL)      *Jakob Jørgensen*

