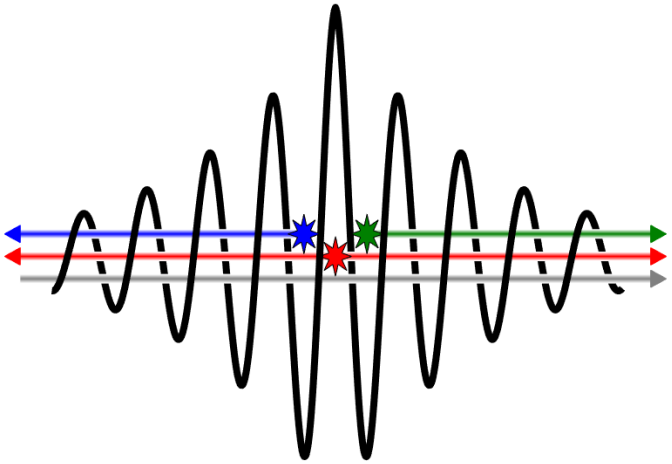

PET Rapid Image Reconstruction Workshop @ IEEE MIC 2024

Charalampos Tsoumpas (RU Groningen)

Christoph Kolbitsch (PTB)

Matthias Ehrhardt (U Bath)

Kris Thielemans (UCL)

Agenda

14:00	K. Thielemans: PET Rapid Image Reconstruction Challenge
14:15	C. O. da Costa-Luis: Competition cloud infrastructure
14:30	A. J. Reader: Advancing PET image reconstruction: from MAP to generative AI
15:00	J. Fessler: Patch-based diffusion models for image reconstruction
15:30	Coffee Break
16:00	M. Ehrhardt[1], Z. Kereta[2], G. Schramm: Efficient optimization of Poisson log likelihood and relative difference prior for PET using preconditioned SVRG
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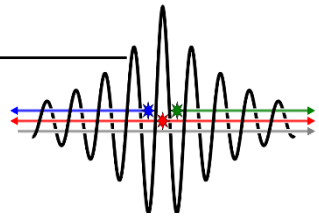
16:45	Awards Ceremony
17:00	D. R. McGowan: Clinical Implementation of New PET Reconstruction Methods
17:30	C. Tsoumpas: Closing Remarks



CCP in Synergistic Reconstruction for Biomedical Imaging (SyneRBI)

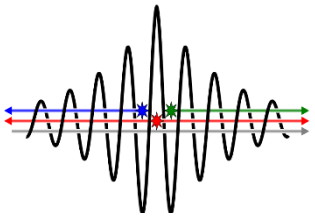
5 year funding (April 2020 – March 2025)

Engineering and Physical Sciences Research Council

Aims:

- Networking and training
- Expanding open source software (OSS) infrastructure
- Translation towards clinical practice

Renewed until Oct 2026



PET Rapid Image reconstruction Challenge

PETRIC

https://github.com/SyneRBI/PETRIC/wiki

Scientific committee:

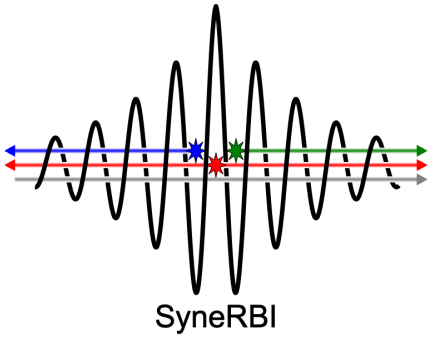
Ch. Tsoumpas (RU Groningen), C. Kolbitsch (PTB),
M. Ehrhardt (U Bath), K. Thielemans (UCL)

Technical support and advice:

Edoardo Pasca, Casper da Costa-Luis (CoSeC, UKRI STFC)

Advisory committee:

CCP SyneRBI Steering Panel



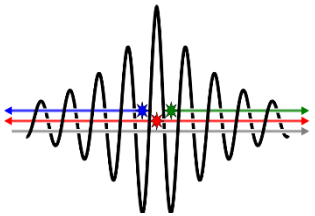
PETRIC

What was it?

- Open challenge
- Target: fast **MAP** reconstruction of phantom data of different scanners
  - Fixed objective function
  - Metrics are related to “distance” to converged solution
- Encourage open-source contributions

What was it not?

- Best image quality
- Distance to “ground truth”
- Comparison of different scanners



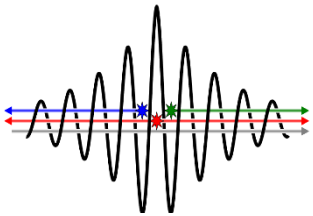
Aims

Primary:

- Stimulate research into the development of fast PET image reconstruction algorithms applicable to real world data

Secondary:

- Grow open database of phantom data (*including* raw data)
- Basis for future challenges

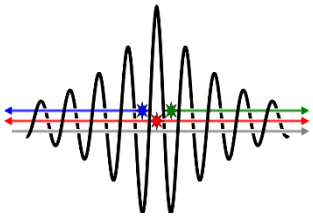


How to measure “fast”?

- Standard software environment
  => frozen version of SIRF

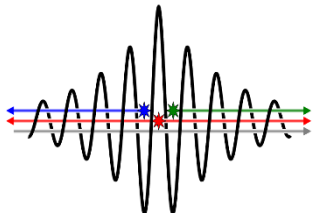
- Standard computational platform
  => VM on STFC Cloud

- Wall-clock time to achieve “practical” convergence



Overall summary

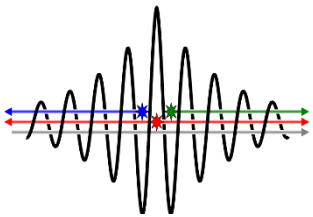
- Participants had access to
  - Open source software (github, docker, VM,…)
    - CIL (optimisation)
    - SIRF (reconstruction framework)
    - STIR (PET/SPECT reconstruction)
    - Parallelproj (GPU projector)
  - Demo implementations: OSEM and 2 MAP recon algorithms
  - Software that computes metrics
  - Training data (~5 data-sets from different phantoms and scanners)
  - Access to “leaderboard”
- Evaluation on unseen phantom data



Optimisation problem

- $\hat{x} = \underset{x}{\operatorname{argmax}}\, L(x) - R(x)$
- $L(\boldsymbol{y}; \hat{\boldsymbol{y}}) = \sum_k y_k \log \hat{y}_k - \hat{y}_k$
- $\hat{\boldsymbol{y}} = D(\boldsymbol{m})(A\boldsymbol{x} + \boldsymbol{a})$
- $R(\boldsymbol{x}) = \sum_{i=1}^{N} \sum_{j \in N_i} w_{ij} \sqrt{\kappa_i \kappa_j}\, \frac{(x_i - x_j)^2}{x_i + x_j + \gamma |x_i - x_j| + \epsilon}$

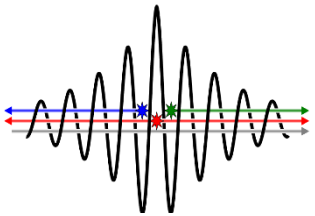
  (κ determined via $H.1$)



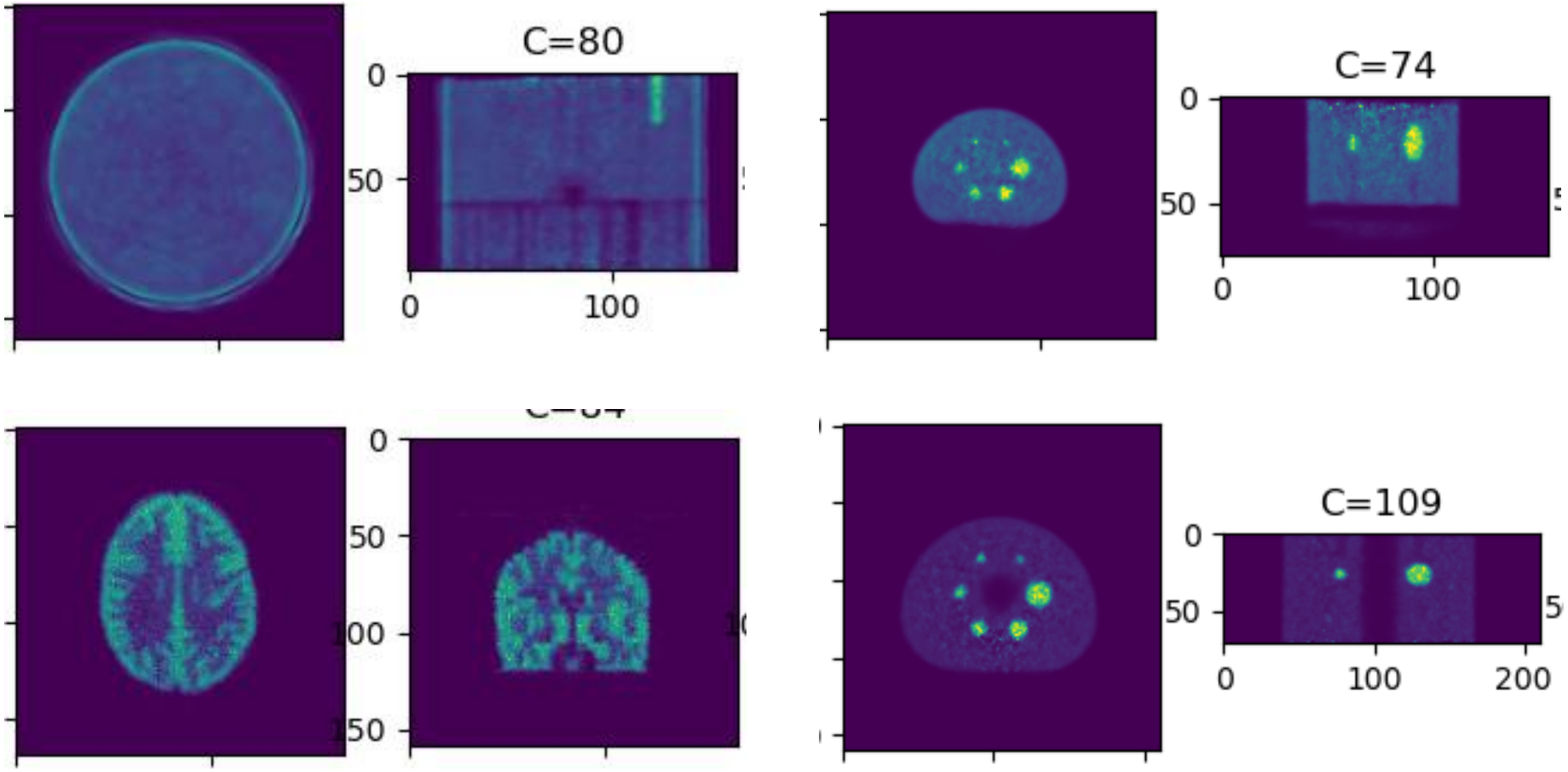
Data

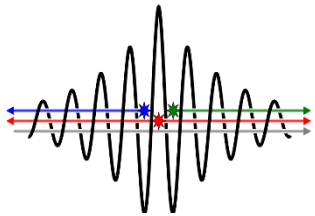
- Training
- Various phantoms
  - Torso with inserts
  - NEMA (low and high count)
  - ACR
  - Hoffman
  - Thorax
- Various scanners
  - GE DMI3
  - Mediso Anyscan Trio
  - Siemens Biograph mMR
  - Positrigo NeuroLF
  - Siemens Vision 600

- Evaluation
- Various phantoms
  - NEMA (low count)
  - Hoffman
  - NEMA (Zr)
  - Esser
- Various scanners
  - GE D690
  - GE DMI4
  - Mediso Anyscan Trio
  - Positrigo NeuroLF
  - Siemens Vision 600



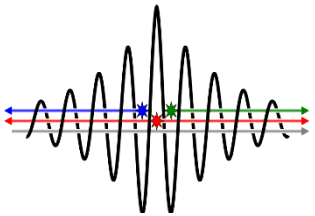
Data





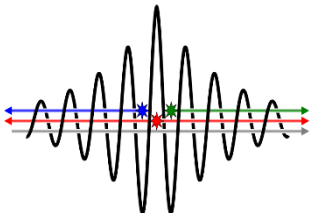
Metrics

- Distance to the reference (i.e. converged) image $\boldsymbol{r}$
  - NRMSE on whole phantom
  - NRMSE on background region
  - Normalised absolute difference in VOI-mean



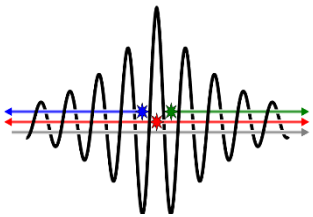
Ranking

- For every data-set:
  - Compute wall-clock time at which **all metrics** are smaller than threshold (for a few updates)
  - If wall-clock time larger than 1 hour, stop, and add average distance of metric to threshold.
- Rank all submissions
- Add ranking over all data-sets to get overall score
- Run this 3 times and compute median rank



Awards

- The highest ranked 3 teams will present their contributions today
- The highest ranked 3 teams that provide an *open-source solution* will get a monetary award for the whole group (£500, £300, £150)



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