STIR

MILANO

2022 IEEE NSS MIC RTSD

IEEE NUCLEAR SCIENCE SYMPOSIUM, MEDICAL IMAGING CONFERENCE
AND ROOM TEMPERATURE SEMICONDUCTOR DETECTOR CONFERENCE

STIR status and future 2022

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Thursday, 10/11/2022

Software for Tomographic Image Reconstruction

- C++ open-source library
- Data/image processing
- SPECT/PET image reconstruction (sinogram and list mode)
- Multiple scanners models
- Python and Matlab interface
- Used as "engine" by the synergistic image reconstruction framework (SIRF)

STIR 5.0 new features (March 2022)

See Summary of changes in STIR release 5.0

Main items:

- Block detectors (and generic location)
  Geometry specification, IO, projectors
- View-offset
- Maximum Likelihood Estimation of normalisation factors
- Virtual crystals for ROOT
- Radionuclide information and calibration
- *Parallelproj* integration

parallelproj

OpenMP and CUDA libraries for 3D Joseph non-TOF and TOF forward and back projectors

gschramm/parallelproj: code for parallel TOF and NONTOF projections (github.com)

Remaining issues with STIR integration:

- copying to/from GPU memory
- bugs for block detector (fixed (?) on master)
- potential for voxels missed
- no tests integrated
- not yet in listmode reconstruction

Some anecdotal timings

PC:

- processor: AMD Ryzen 9 5900 (12 cores)

- GEForce RTX 3070 (24GB memory, 5888 CUDA cores)

- 32GB RAM

- Windows 10 Pro

Compilers:

- Visual Studio 2022

- gcc 9 (under WSL 1)

Data/projector information

- Siemens mMR
  - {127, 344, 344} voxels of size {2.03, 2.08, 2.08}
  - span 1 and 11
- Projectors:
  - parallelproj (v0.8)
    - always single LOR
  - ray tracing matrix
    - 5 tangential LORs
    - Axial LORs: 1 for span 11, 2 for span 1
- Wall-clock timing of forward_project
  - Includes IO
  - Includes set-up time (2nd projection is faster)

Span 11 results

- RT projection matrix
  - VS (with caching) 30.3s
  - VS (no caching): 35.9s
  - gcc (no caching): 23.973s
- Parallelproj
  - gcc OpenMP: 28s
  - VS CUDA:9.1s
    - copy image to device: 1.2s
    - Call to parallel_proj_forward_cuda: 1.9s (2 chunks: 3.2s)

Span 1 results

- RT projection matrix
  - VS (with caching) 329.3s
  - VS (no caching): 321.5s
  - gcc (no caching): 207.7s
- Parallelproj
  - VS CUDA: 41.5s
    - copy image to device: 1.2s
    - Call to parallel_proj_forward_cuda: (2 chunks): 6s
      Note: Georg Schramm’s independent timings imply this should be faster

Some comments

- parallelproj – CUDA is considerably faster (note however, factor 5/10 due to #LORs)
  - overhead due to conversion of STIR objects (avoidable)
  - overhead due to CPU/GPU memory transfer (needs a lot of work)
- for OpenMP performance, your compiler matters
- need for benchmarking tool
  - Repeat projections
  - Different scanners

STIR 5.1features

Summary of changes in STIR release 5.1 (github)

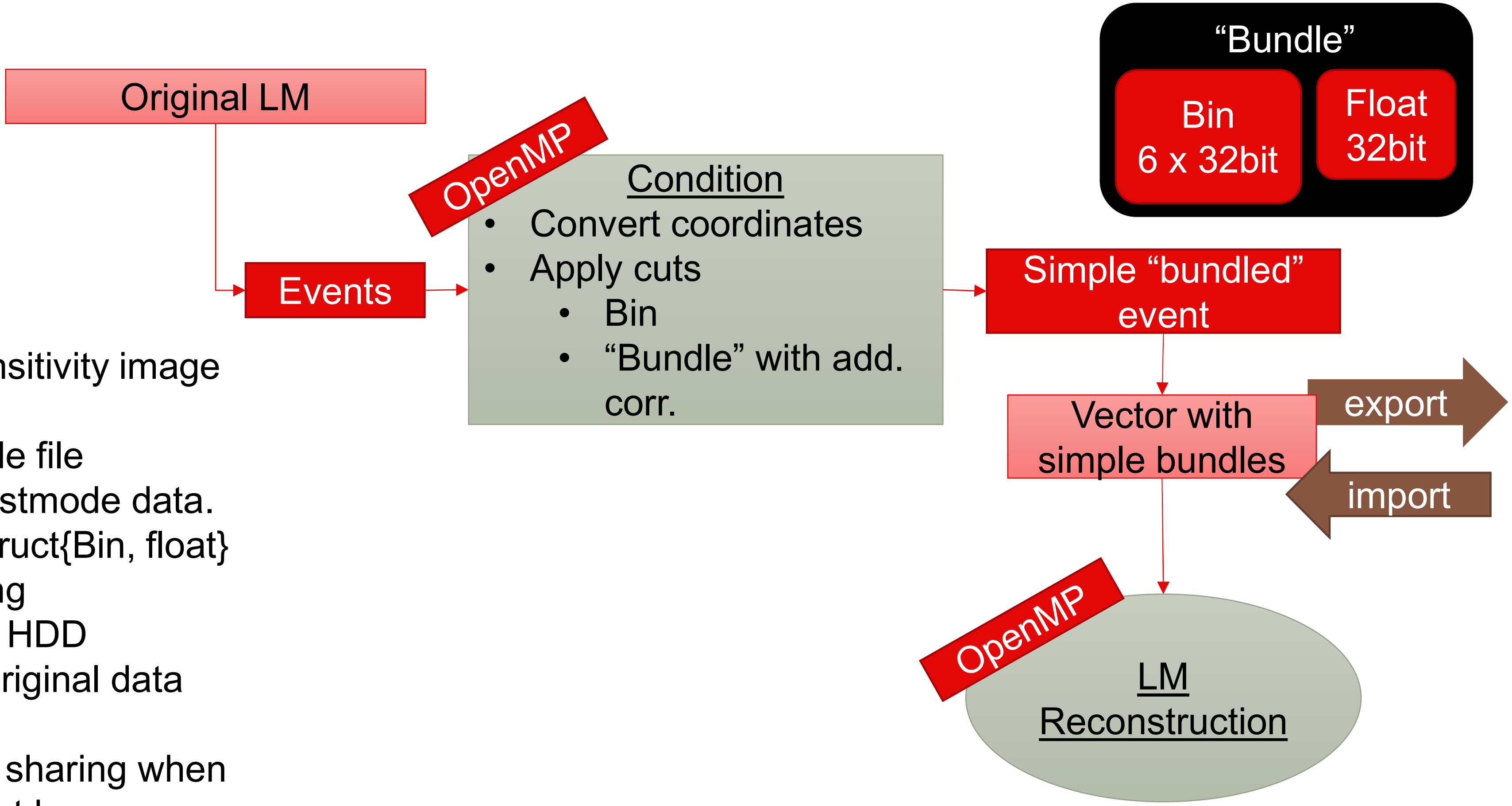
- Improvements to listmode reconstruction (Nikos)
- Support for PENNPET Explorer listmode data (if proprietary libraries are found) (Nikos)
  - Potentially Philips data, too
- Scatter simulation, estimation and down/up-sampling adapted for scanner with Block geometry (Daniel and Kris)
- Various small changes to add functionality to Python interface (Markus Jehl)
- Python projection data visualiser (in examples/python) (Robert Twyman)

To be merged:

- Adaptation of MLE normalisation/randoms code for BlocksOnCylindrical (Daniel)

Listmode improvements

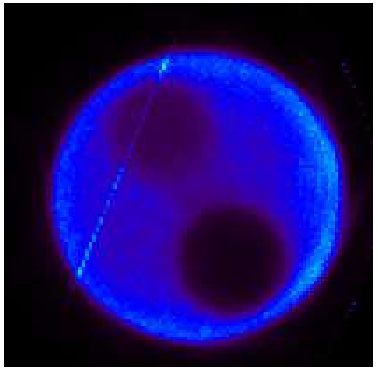
- Use of OpenMP
  - Calculation of sensitivity image
  - Reconstruction
- Cache in RAM listmode file
  - Simplification of listmode data.
  - Event bundles: struct{Bin, float}
  - Parallel processing
  - Write / Load from HDD
    - Agnostic to original data format
    - Permits data sharing when exact IO is not known

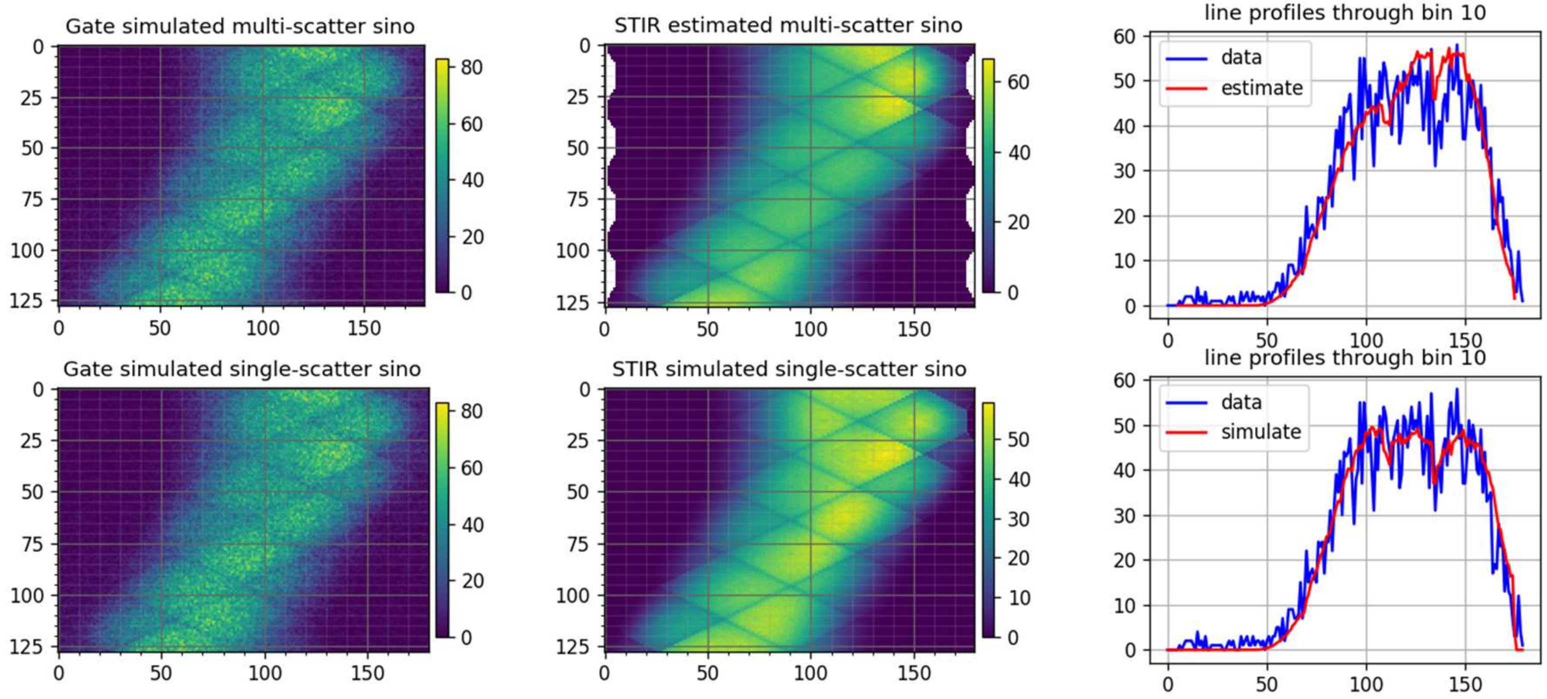


Adapting scatter to BlocksOnCylindrical geometry

- Scatter estimation does not use SSRB to downsample but uses segment 0
- Downsample scanner only in axial direction and remove gaps
- Upsample of m coordinate done via nearest neighbour interpolation -> no need of inverse SSRB

Reconstructed phantom




Gate simulated multi-scatter sino
STIR estimated multi-scatter sino
line profiles through bin 10
data
estimate
Gate simulated single-scatter sino
STIR simulated single-scatter sino
line profiles through bin 10
data
simulate
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150
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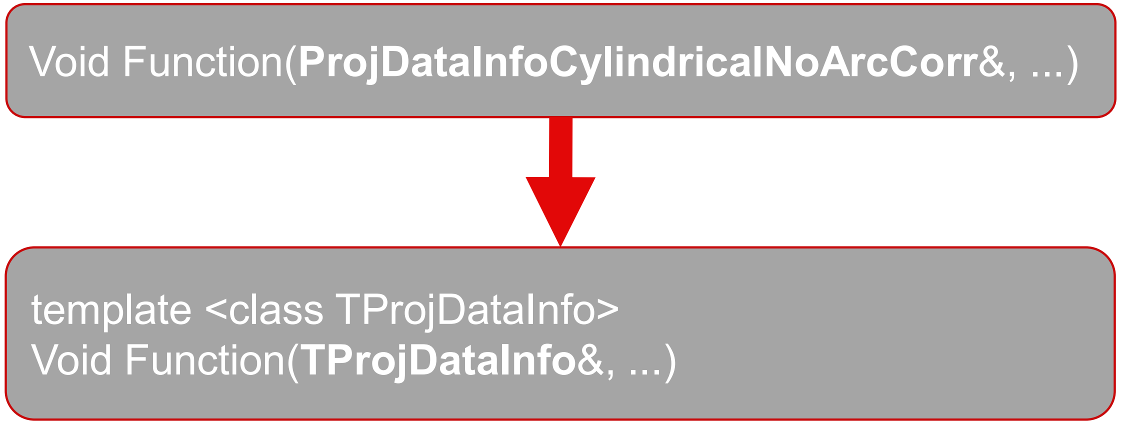
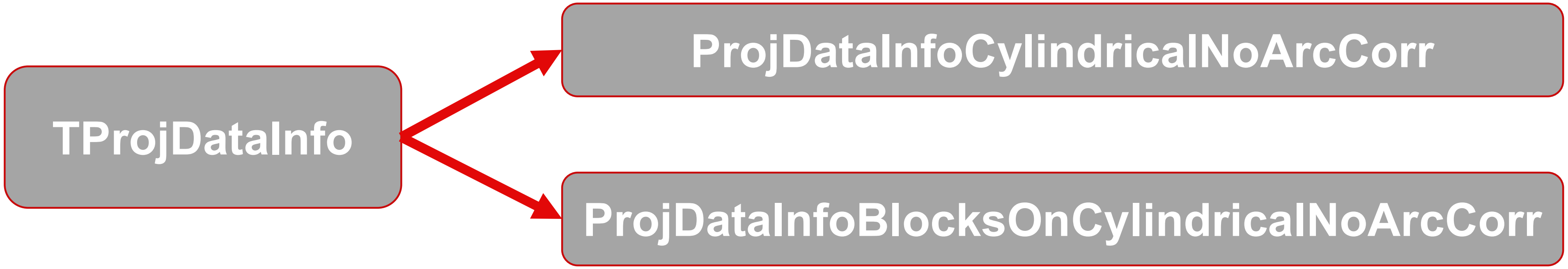
Image courtesy of E. Mikhaylova, Positrigo

Templating function for normalisation



Void Function(**ProjDataInfoCylindricalNoArcCorr**&, ...)

template <class TProjDataInfo>
Void Function(**TProjDataInfo**&, ...)



TProjDataInfo

ProjDataInfoCylindricalNoArcCorr

ProjDataInfoBlocksOnCylindricalNoArcCorr

STIR 6.0

Main feature: TOF (*Nikos Efthimiou, Elise Emond et al.*)

Current status:

- almost up-to-date with master
- recently enabled symmetries and caching
  - resulting in speed-up
    - Most when enabling caching but need lots of memory
- “awkward” loops

Other PRs (in progress)

Pinhole SPECT
Matthew Strugari and Carlés Falcón

Alternative MCIR implementation (using adjoint warping as opposed to inverse)
Richard Brown and Kris Thielemans

Axial effects in ECAT8 normalisation
Kris Thielemans

Multiple bed position support
Ashley Gillman et al.

STIR 7.0 (in progress)

Multiple energy window support for PET
Ludovica Brusaferri et al.

- Data structures
- Scatter simulation
- gradients of projector and scatter estimator w.r.t. emission and attenuation image

  => MLAA using energy information

Other things that we want/need

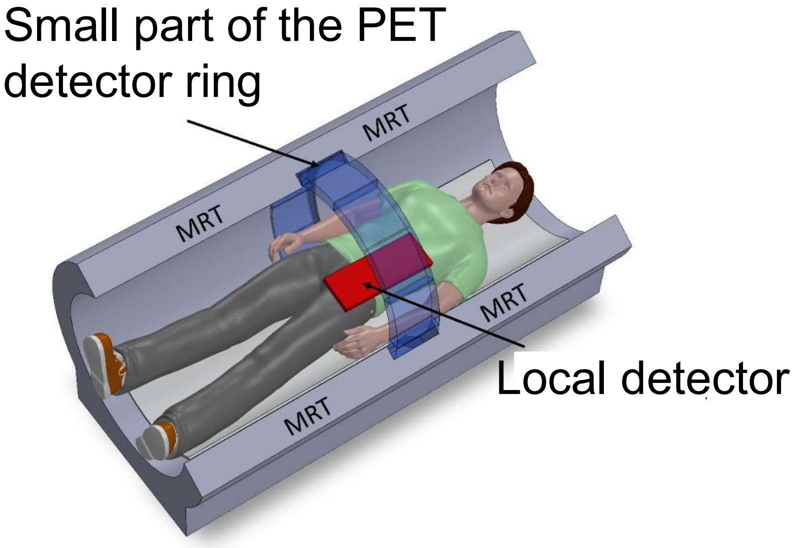
- Finalise calibration to obtain kBq/ml
- Include dead-time modelling for scanners
- Multi-detector layer support
- Easy deployment
  (increasing reliance on dependencies makes this harder)
  - Conda (done)
  - Pip
  - Docker/VM (done via SIRF-SuperBuild, but could be made STIR-specific)
- Updating of STIR-Exercises

HD-MetaPET - LAFOV PET/MRI

RWTH AACHEN UNIVERSITY

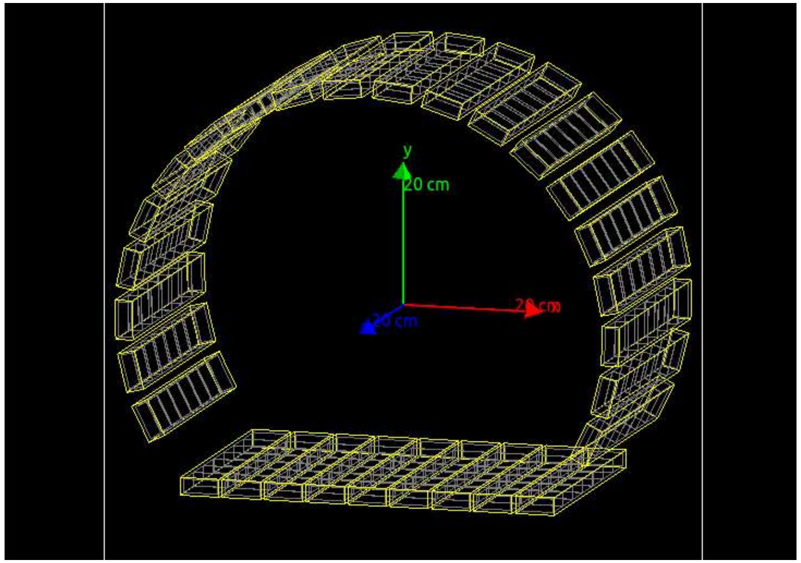
Florian Mueller, Stephan Naunheim & Yannick Kuhl on behalf of the HD-MetaPET Team

- Integration of non-cylindrical PET in a clinical MRI system
- Large axial FOV
- Local detector as “booster” for PET spatial resolution



Small part of the PET detector ring

Local detector



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HD META PET

Hyperion Hybrid Imaging Systems

PMI PHYSICS OF MOLECULAR IMAGING SYSTEMS

Contributing to STIR, SIRF …

- Ask questions
- Answer questions
- Test new (and old) functionality
- File bug reports
- Add use cases to wiki
- Participate in discussions on code, design etc
- Solve some small “issue”
- Join in a (virtual) hackathon
- Contribute a feature

Why contribute to STIR?

- Join a friendly community
- Advance STIR and therefore science
- Feel good about yourself
- Get credit for your work and advance your CV
- Get citations for your contributions
- Get funding for travel and exchanges
- Get one of the yearly SyneRBI awards (£400, £200, £100)

Acknowledgments

File formats

- GE Healthcare
- Siemens Healthineers

EPSRC CCP-SyneRBI provides resources for networking, travel exchanges and research software engineer support (mostly dedicated to SIRF and its ecosystem)

Synergistic PET-MR Reconstruction

Main publication:

Thielemans, Tsoumpas, *et al* (2012) STIR: Software for Tomographic Image Reconstruction Release 2, *Physics in Medicine and Biology*, 57(4):867-83.

But please cite

- relevant papers on STIR features that you use.

- version specific DOI (includes all authors to that version)

[STIR: Software for Tomographic Image Reconstruction | Zenodo]