CASToR: An open-source multi-modal and multi-dimensional tomographic reconstruction platform and its link to GATE

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France Life Imaging

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INVESTISSEMENTS D'AVENIR

CASToR

Customizable and Advanced Software for Tomographic Reconstruction

- Open-source tomographic reconstruction platform
- For Users and Developers
- Generic, modular and extensible
- For now, only PET and SPECT iterative reconstructions are supported
- Future releases: CT, ToF PET, Dynamic and/or gated acquisitions reconstruction, analytical algorithms, analytical simulations

CASToR Collaboration

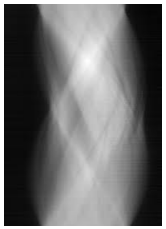
Start of the project: September 2014 - first release: March 2017

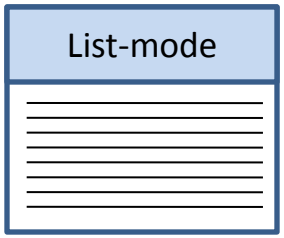
- **LaTIM Brest**: *Didier Benoit, Julien Bert, Thibaut Merlin, Dimitris Visvikis*
  - -PET/SPECT
  - - Projection operators
  - - Dynamic PET (pharmacokinetics, motions)
- **CEA/SHFJ – IMIV, Orsay:** *Claude Comtat, Simon Stute*
  - - General algorithmic conception and architecture
  - - PET
- **INCIA Bordeaux:** *Frédéric Lamare*
  - - PET reconstruction with motion correction
- **CRCNA, Nantes :** *Thomas Carlier*
  - - SPECT

Motivations

Issues:

- Different modalities
- Various studies
- Various data format





⇨ Development of dedicated and non-generic reconstruction codes

Consequences:

- Limited portability of new methods
- Code fusion is difficult
- Comparison between methods is not easy

Proposal

Unified tomographic reconstruction platform

- Flexibility
- Shared components (projector, optimizer, etc..)

Drawbacks

- Compromise (data format, implementation)
- Efficiency / code optimization

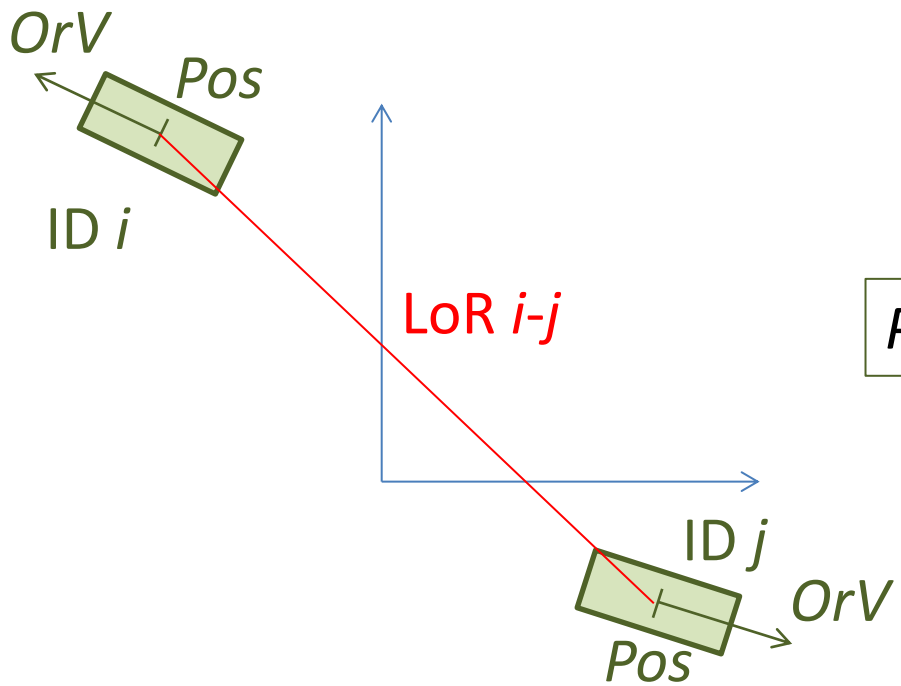
Objectifs

- C++ platform for multi-modal and multi-dimensional tomographic reconstruction
- Generic and unified data organization
- Any detection geometry
- Compromise between genericity and computation efficiency
- Focus on modularity and platform extensibility

Generic PET systems in CASToR

A PET system consists in a collection of *N* elementary detection units (i.e. crystals).

No assumption about their spatial organization

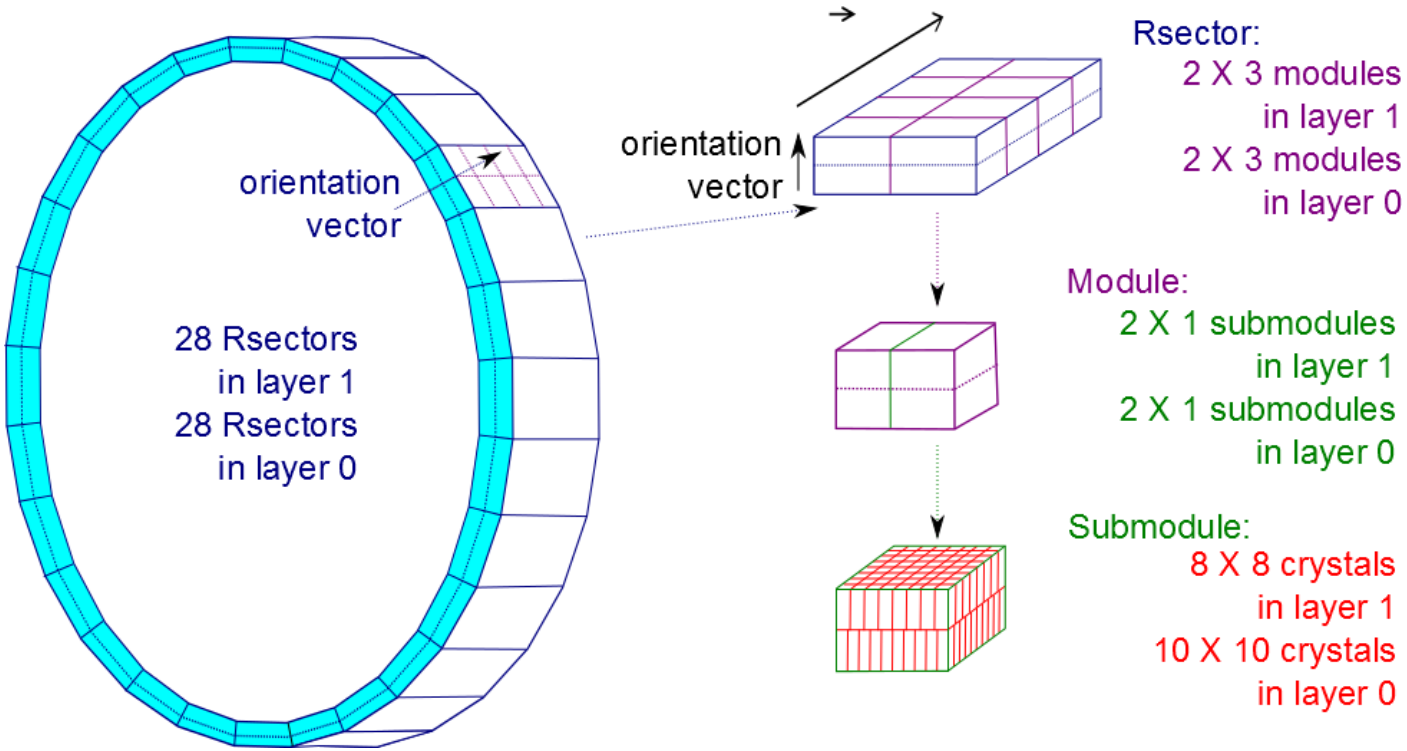


The system is described by a binary look-up-table of *N words*

Posx	*Posy*	*Posz*	*OrVx*	*OrVy*	*OrVz*

Cylindrical PET systems in CASToR

Alternatively, the geometry of cylindrical PET systems can be described *à la GATE* by a generic geometry ASCII file

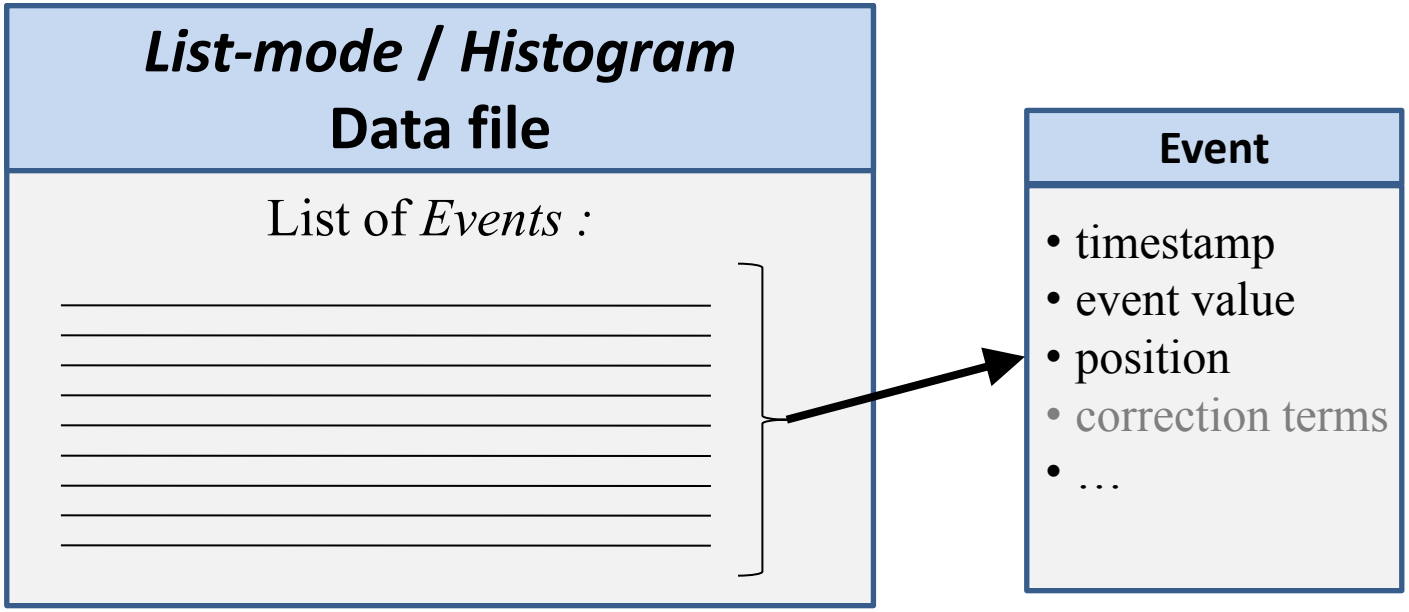


The look-up-table (LUT) is generated at run-time

A tool to convert GATE description files to CASToR is provided

Generic data description

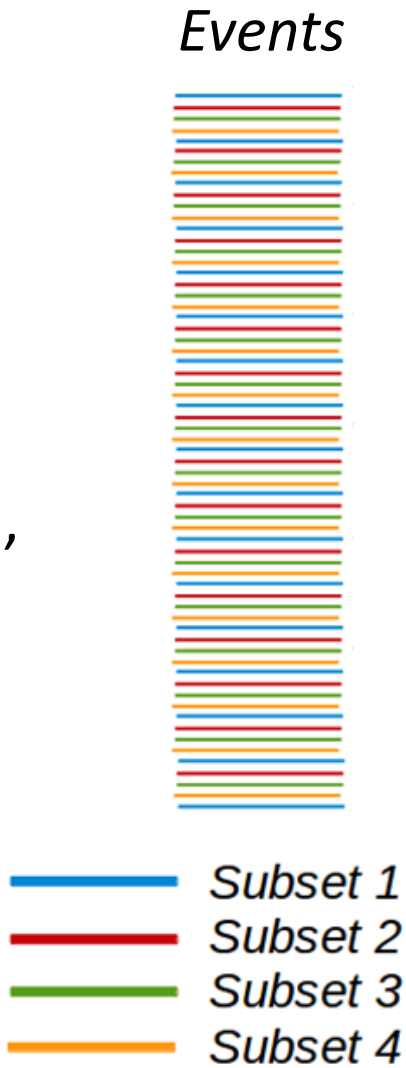
- Generic "*Event*"
- *Event* includes mandatory and optional fields
- Iterative loop based on the *Events*
- No assumption about the ordering / organization of the events



Arbitrary *Event* ordering

OSEM makes no assumption about the organization of the events.

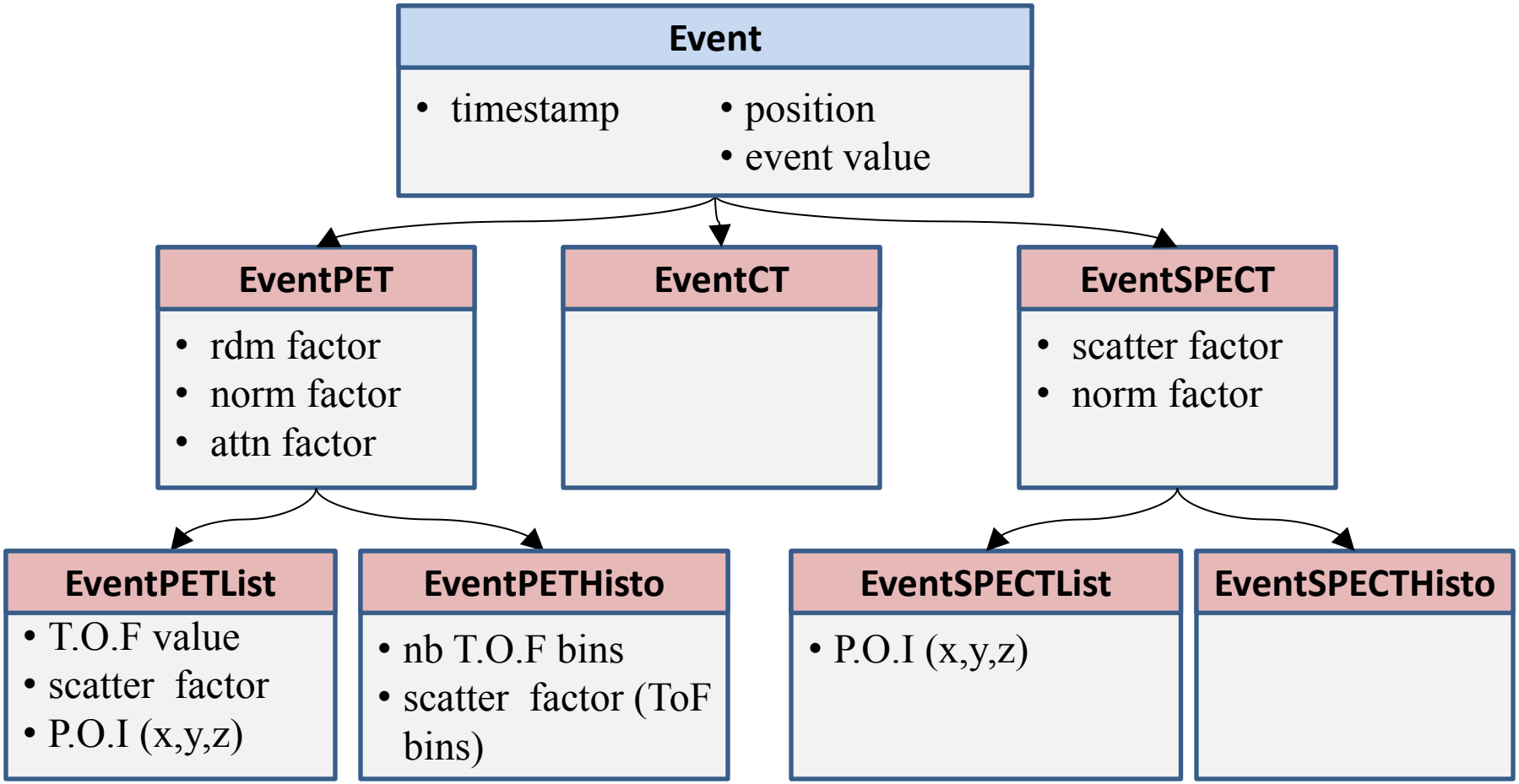
OSEM does not assume that histogram events are stored as a sinogram: *radial bin*, *view*



Generic data description

3 Modalities / 2 *Event* types*:*

- *"list-mode"* (*i.e.* one coincidence)
- *"histogram"* (*i.e.* content of one sinogram bin).



Data description in non ToF PET

PET list-mode event

Time	*ACF*	*SCT*	*RDM*	*NORM*	Detection ID1	Detection ID2

PET histogram event

Time	*ACF*	*RDM*	*NORM*	DATA	*SCT*	Detection ID1	Detection ID2

A tool to convert GATE root data files to CASToR is provided

Optimization

Iterative loop

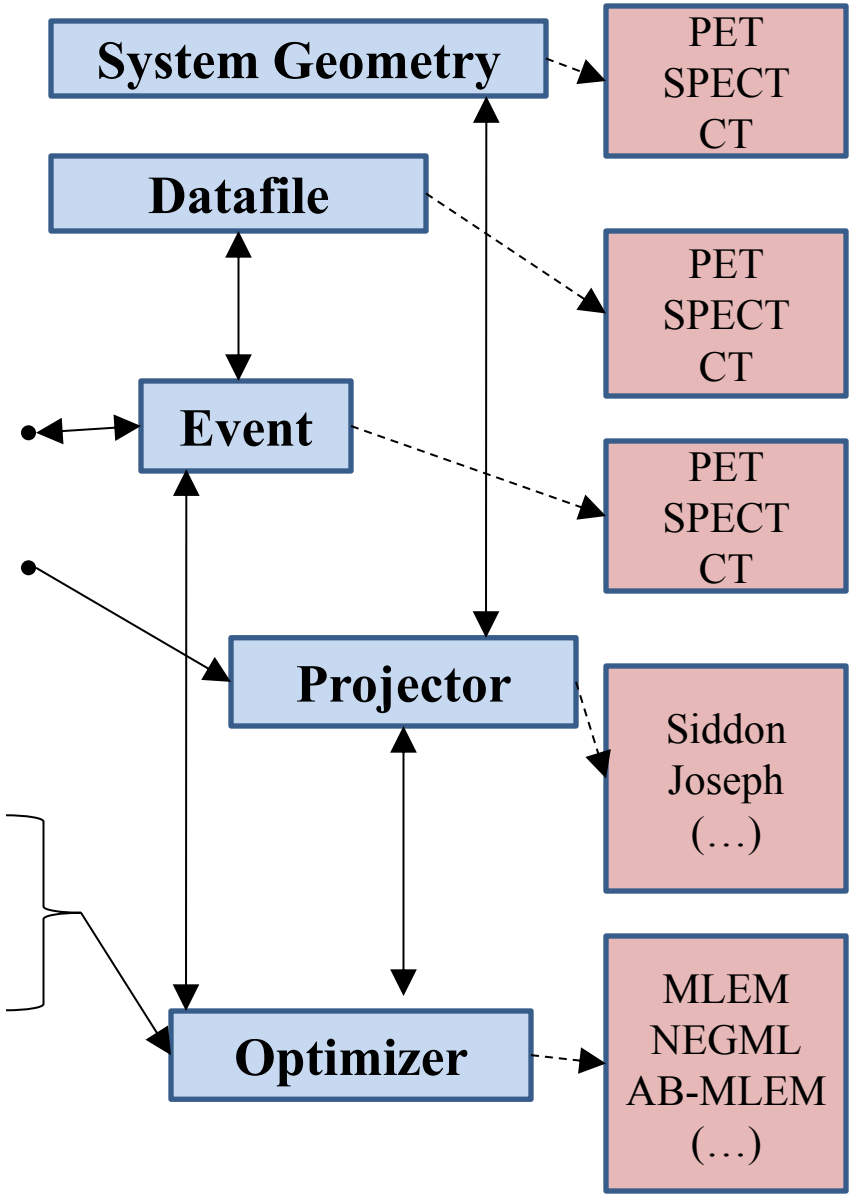
// Loop on Events

do

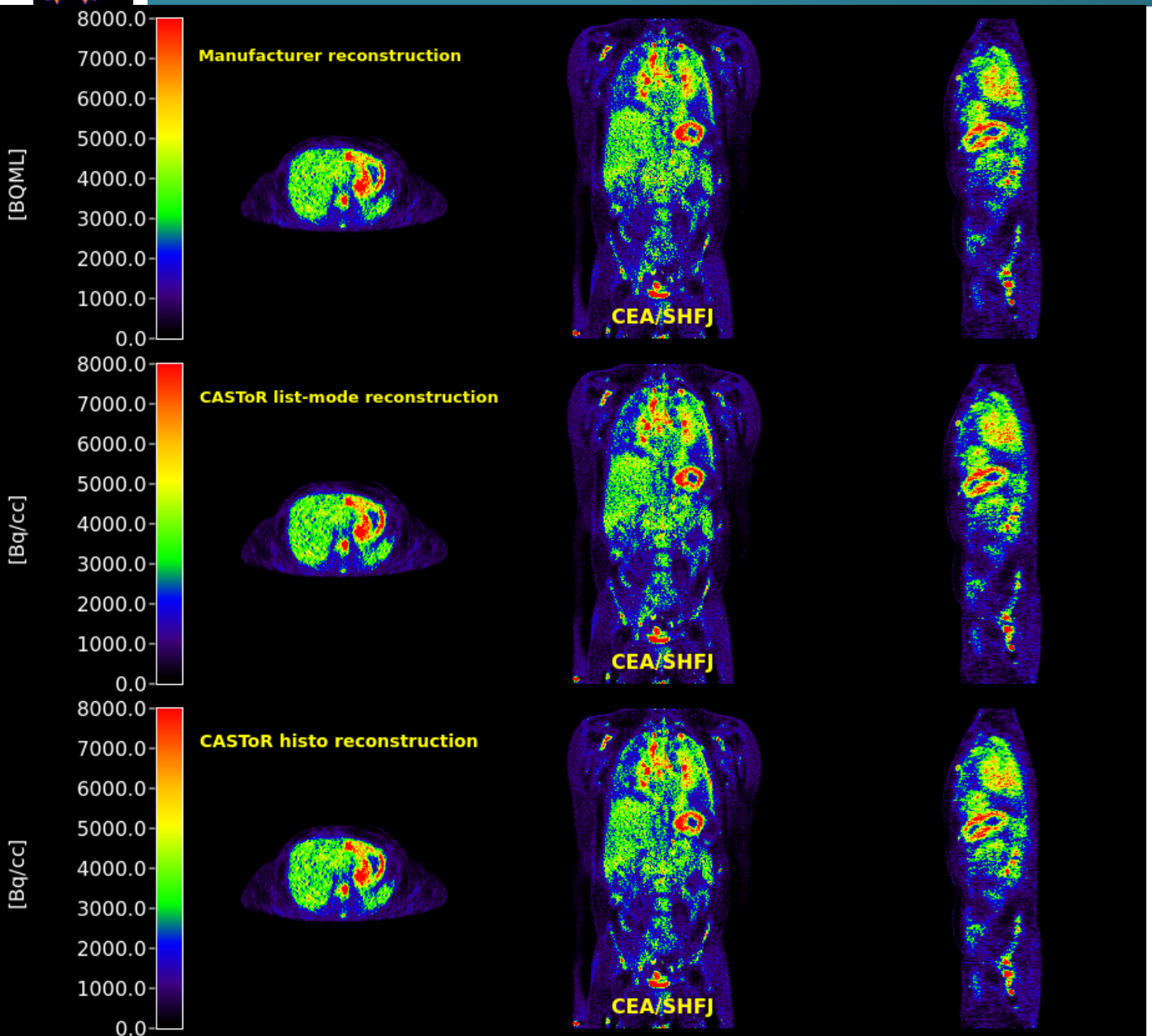
- Get Event ***e*** from Datafile
- Compute/Load system matrix elements associated to ***e***
- *// Compute update term associated to the optimization algorithm*
- Compute forward projection
- Compute values to be back-projected
- Compute the backward projection

end

Only one call to **Projector** per Event



Validation for SIGNA PET/MR



OP-OSEM

- 28 subsets,
- 2 iterations
- All corrections included for quantitative images in Bq/cc

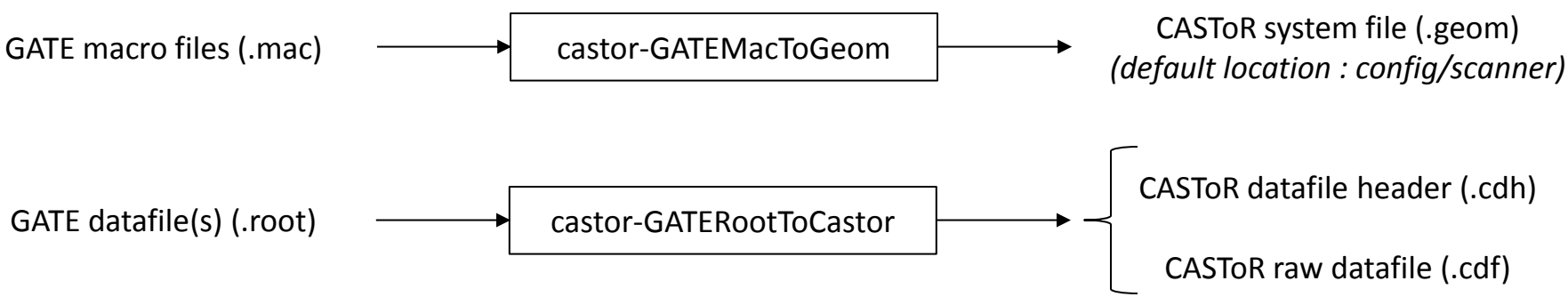
GATE To CASToR utilities

- Tools to convert GATE simple scripts and simulation outputs to CASToR format:

  castor-GATErootToCastor : data file conversion tool

  castor-GATEMacToGeom : geometry description conversion tool

- Currently supported GATE systems: *cylindricalPET* and *ecat*
- Currently supported GATE output format : *root*
- Generate system geometry file and data file from GATE macros and root data file



GATEMacToGeom

- Recover geometry information from macro files
  (numbers, dimensions and layout of *rsectors, modules, crystals*, etc..)
- Generate a CASToR .geom file in the scanner repository
  (system specifications file for the reconstruction code. default location: config/scanner/)
- Main options:

-m main_macro.mac : path to a main GATE macro file

-o output_geom_file : alias for the output geom file

- Limitations:
  - Currently support cylindricalPET and ecat systems
  - Not all GATE commands supported
  - Always double-check consistency of data converted in the *.geom* file!

GATERootToCastor

- Convert the GATE *.root* output in a CASToR datafile

- Main options:

-i data file *.root : input root datafile to convert
-m main_macro.mac : input GATE macro file
-s scanner_alias : give the name of the scanner
-o path_to_out_file : path to the output .cdh/.cdf file

- Optional settings:

-t : only convert true prompts
-oh : output datafile in histogram format (default : List-mode)
-atn img.hdr : compute acf from a provided attenuation image (histogram output only)
-isrc : write image generated from the source (annihilation)
-geo : Generate the CASToR geom

CASToR – version 1.0

- CASToR v1.0 *(Linux & MS Windows)* :
  www.castor-project.org
  castor-users@lists.castor-project.org
- Contents
  - Iterative reconstruction algorithms
  - PET & SPECT
  - C++ plug-in classes
    - projectors
    - optimization algorithms
    - Image based PSF modeling
  - GATE to CASToR conversion utilities

CASToR – perspectives

www.castor-project.org

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- Next
  - C++ plug-in classes
    - Dynamic models
    - Image deformation (motion correction)
  - Dynamic and/or gated acquisitions reconstruction
  - PET Time Of Flight
  - Analytical simulator
  - Transmission tomography

CASToR

www.castor-project.org

Mailing-list : castor-users@lists.castor-project.org