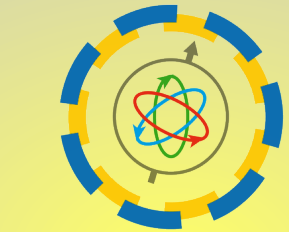
Event building from the data collected in triggerless mode

in J-PET experiment



Krzysztof Kacprzak on behalf of J-PET Collaboration

3rd Symposium on Positron Emission Tomography
Kraków, September 2018

Outline

- About the Task
- Detector, DAQ, storage
- Software Framework
- Data structures and procedures
- Wrokflow summary
- Calibrations and Parameters
- What is next?
- Summary

About the Task

Goals:

- offline preparation of raw binary data for physics analyses
- establishing standardized data format resembling physical events
- preparation of common analysis tools

- side quest: keep it user friendly :)

Detector, DAQ, storage

Event reconstruction starts with sets of time slots from triggerless DAQ and saved as binary data files.

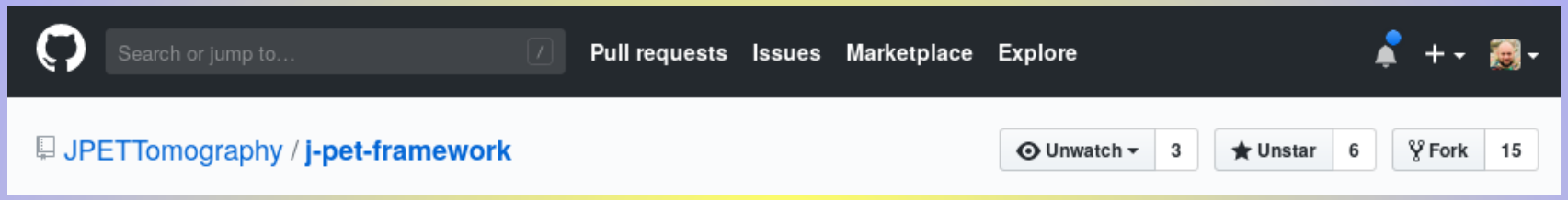
▶ Time slots - consecutive readouts from FEE, parameterized amount of time of measurement, suitable for short response time of polymer scintillators for γ quanta.

See more:

Triggerless DAQ: Bio-Algorithms & Med-Systems, Vol. 10, No. 1, 37-40 (2014)
$\rightarrow$ Presentation by Grzegorz Korcyl;
Data storage: $\rightarrow$ Presentation by Eryk Czerwiński.

Software Framework

- Dedicated software is being developed collaboratively by J-PET team, maintained on GitHub



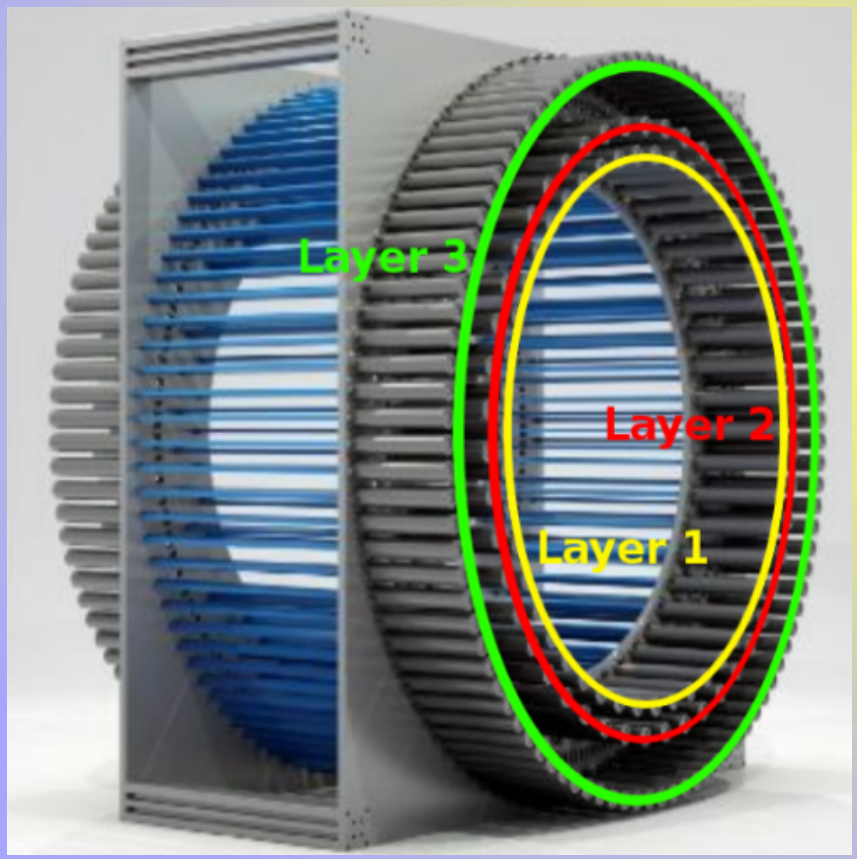
www.github.com/JPETTomography/j-pet-framework-examples

- Repository contains the example dubbed Large Barrel Analysis - data reconstruction for current detector setup

- Other programs perform calibrations, basic data selection, analyze data from different setups

Data structures and procedures (1)

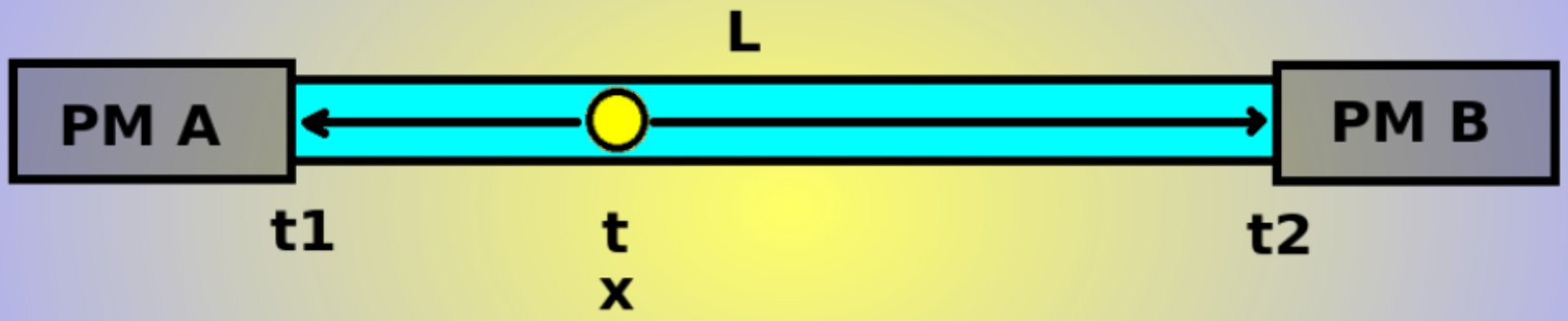
- Framework is designed to represent with C++ classes the physical elements of the detector and each step of data reconstruction
- Naming convention `JPet*`, from top to bottom level description:



`Frame`	
`Layer`	3
Barrel Slot	192 (48+48+96)
Scintillator	192
(one for each `BarrelSlot`)	
Photomultiplier	384
(two for each `Scin`)	
`Channel`	1536
(four for each `PM`)	

Data structures and procedures (2)

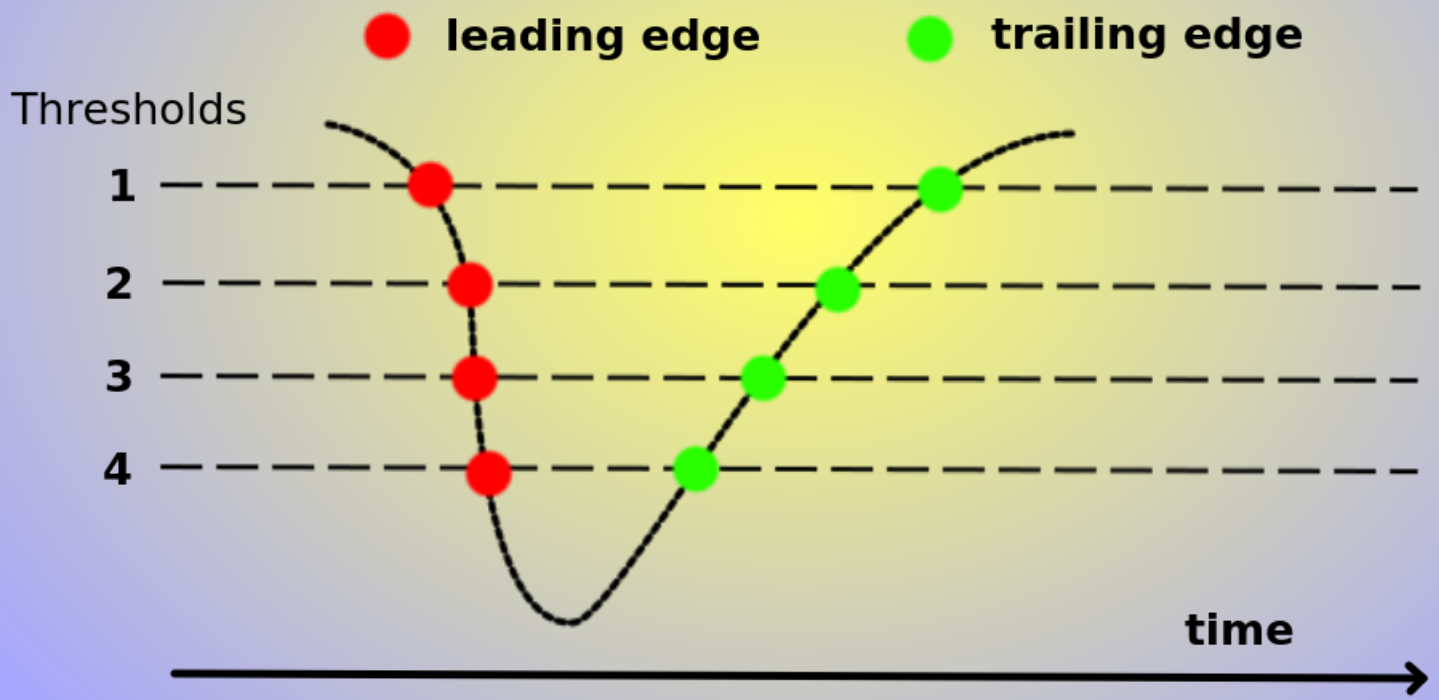
- Time slot of DAQ (represented by `JPetTimeWindow`) is a container for all data objects created



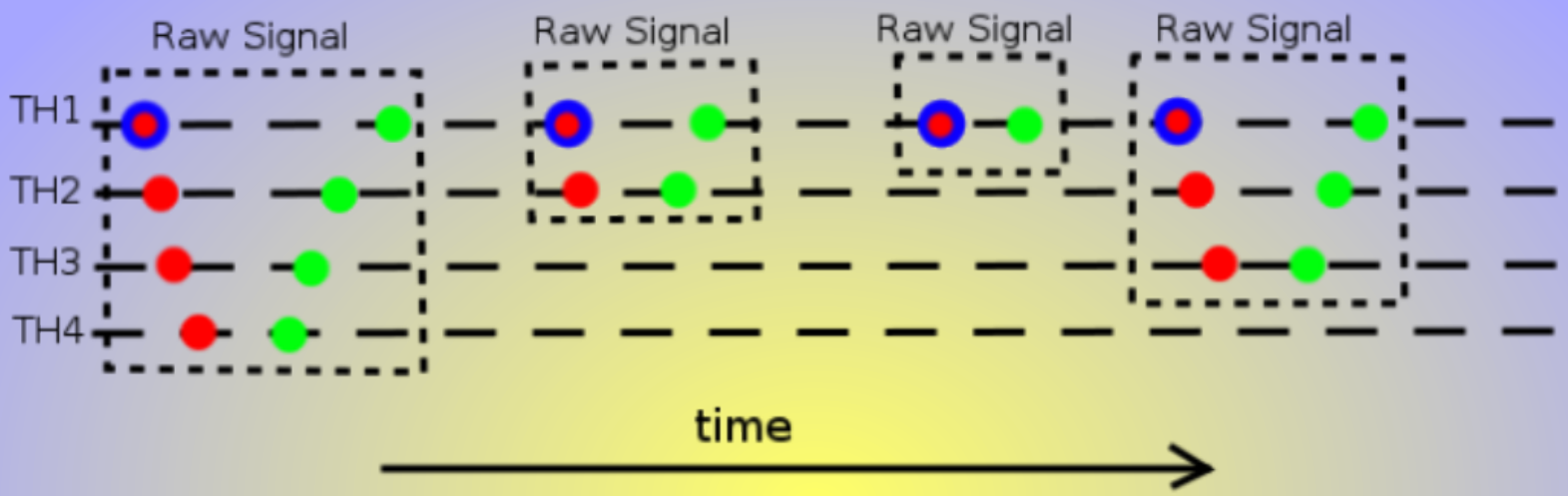
- a particle arrives at a scintillator, deposits energy via Compton effect
- Signal propagates in the scintillator to the photomultipliers on both sides

Data structures and procedures (3)

- Data is transformed from simplest objects to higher level types
- Starting from points in time on one edge of two types, registered on DAQ channels



Data structures and procedures (3)



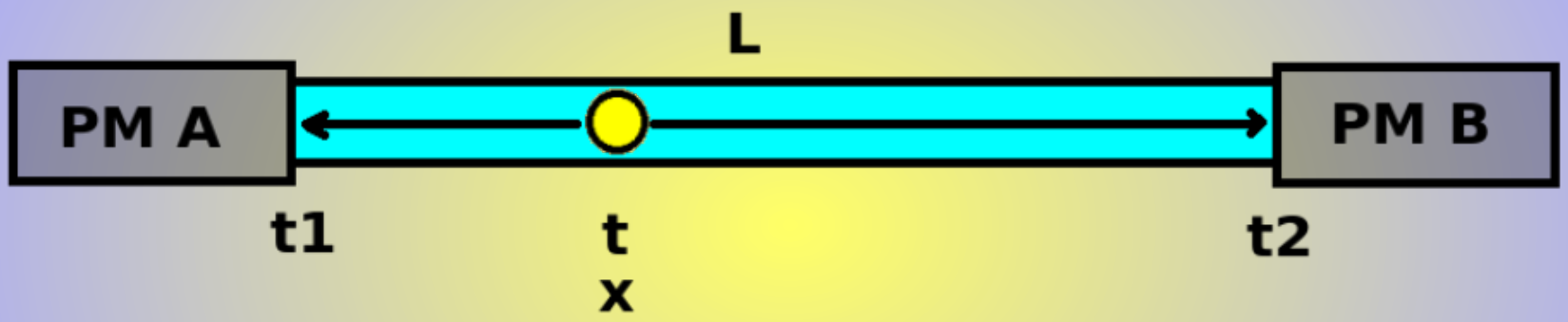
- For created signals (`JPetRawSignal` and `JPetPhysSignal`), arrival time and time over threshold (TOT) can be calculated
- TOT can be used for deposited energy estimation

→ see presentation by Sushil Sharma

- Using the information about Photomultiplier and Barrel Slot, it is possible to pair signals in order to create a hit data structure (`JPetHit`)

Data structures and procedures (4)

- Signal matching condition - opposite sides of the same scintillator in a time window

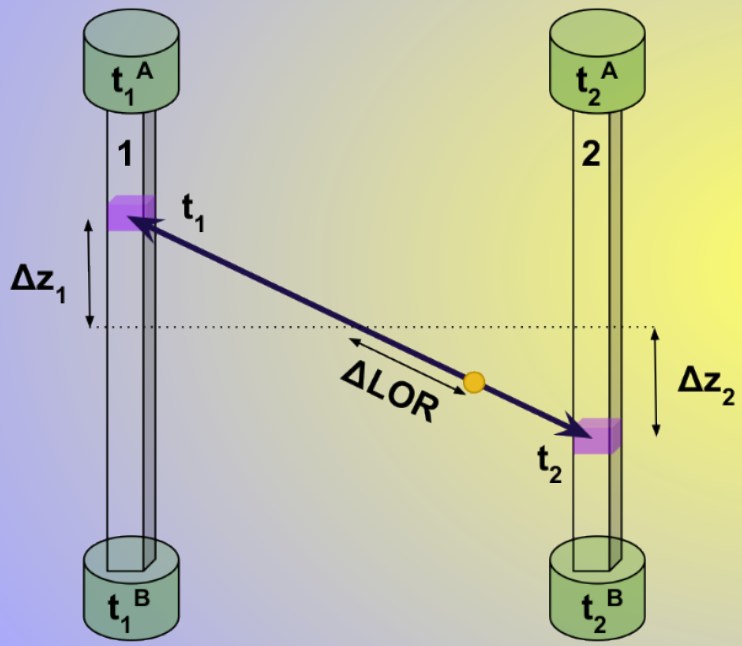


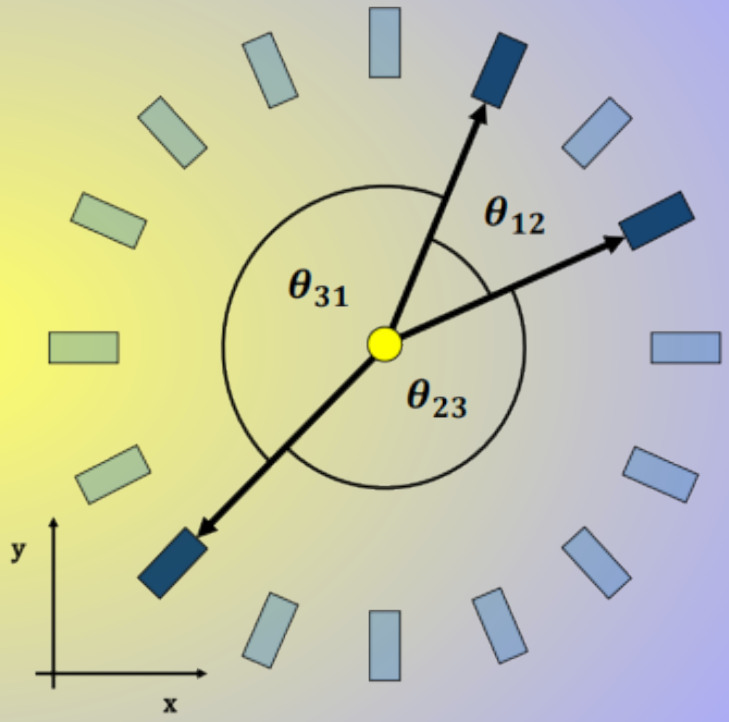
- `time difference` $\Delta t = |t_{signalB} - t_{signalA}|$
- `hit time` $= (t_{signalA} + t_{signalB})/2$
- `hit z-position` $= \Delta t \cdot c_{eff}/2$

Data structures and procedures (5)

Created hits can be used to build next structures

- Lines of Response (`JPetLOR`)
- Events (`JPetEvets`)





adapted from:

Sz. Niedźwiecki et al. Acta Phys. Polon. B48 no. 10, 1567 (2017)

E. Czerwiński et al. Acta Phys. Polon. B48 no. 10, 1961 (2017)

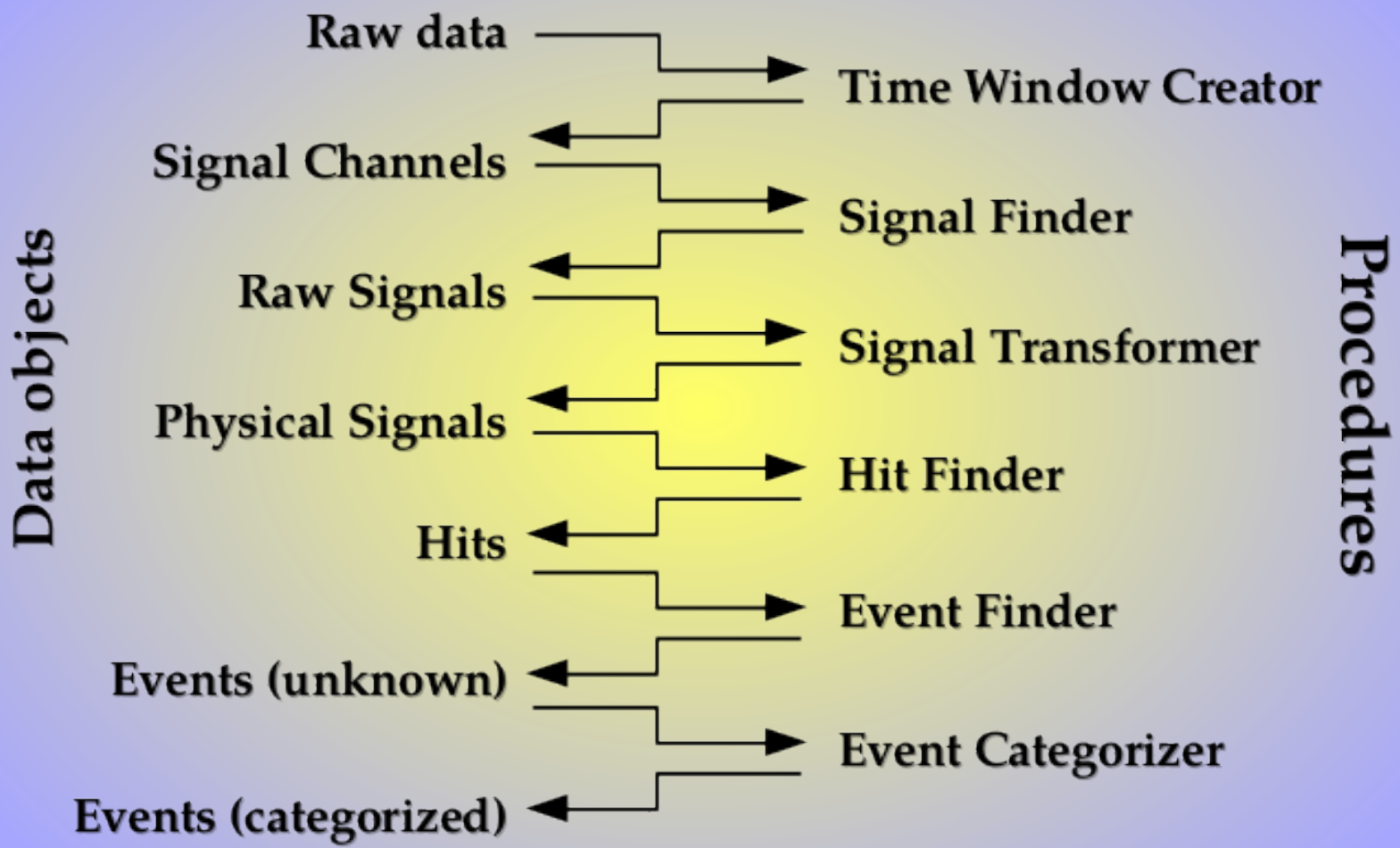
Data structures and procedures (6)

- Events are categorized by investigating basic traits of contained hits: multiplicity, absolute angles of barrel slots, relative angles, distances between hits, distances from the center, TOT, relative arrival times.

- Events are marked with labels (i.e. 2γ, 3γ, scattering) and are candidates for i.e. positronium decays

- Further determination of physical nature of events are to be done by next - end of the reconstruction is a beginning of a analysis

Workflow summary



Calibrations and Parameters (1)

- During execution of reconstruction procedures, various calibrations can - should be applied.

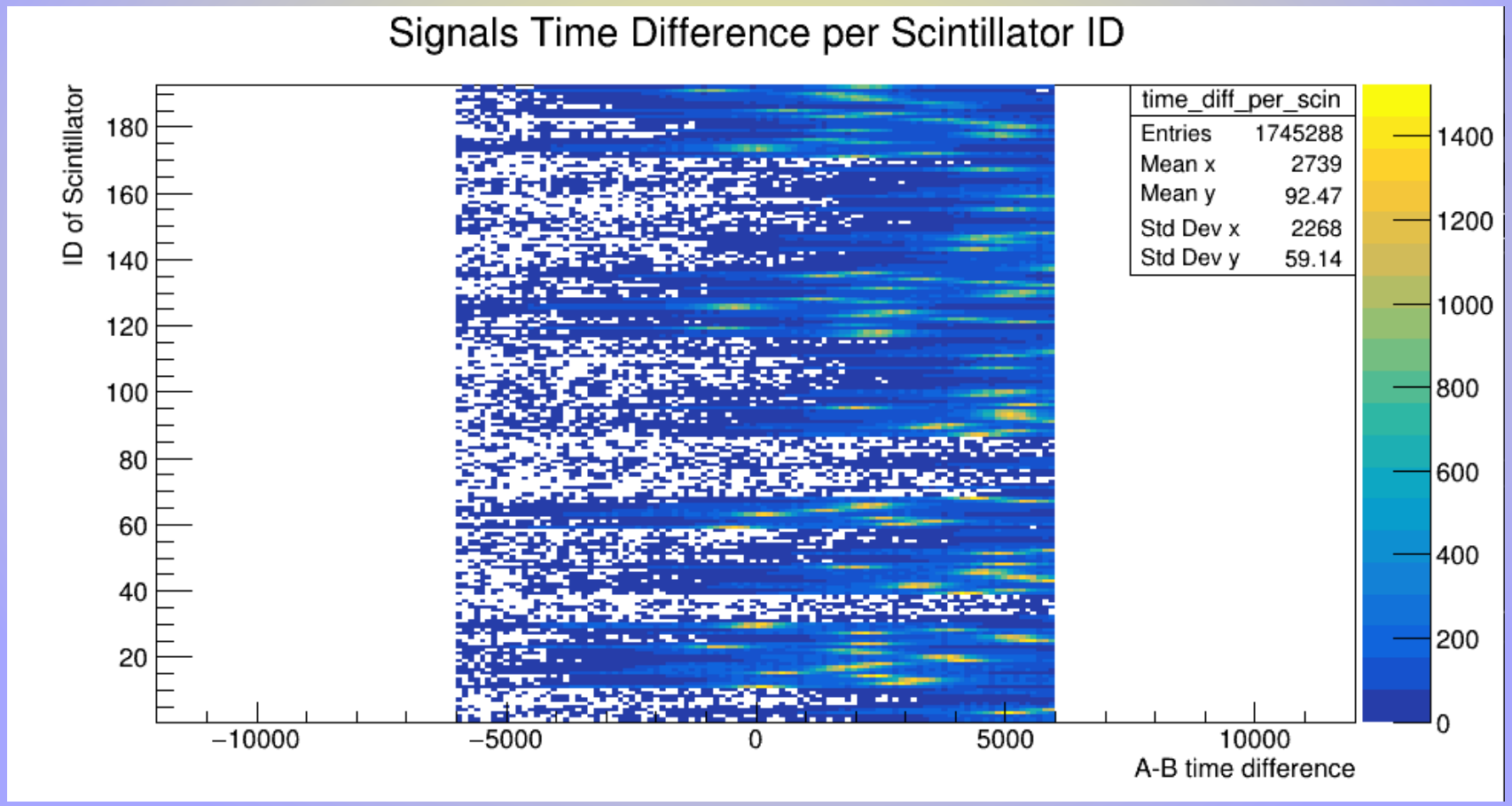
- Results from calibration measurements are prepared separately and read from the standardized format.

- Currently used calibrations: Time-over-Threshold stretching, channel time synchronization, effective speed of light values, TDC non-linearity corrections.

- User-analyst can set up own values of common parameters without need of recompiling programs. These parameters are i.e. values of time windows for signal, hit, event matching; multiplicity cut, relative angle cut; TOT cut...

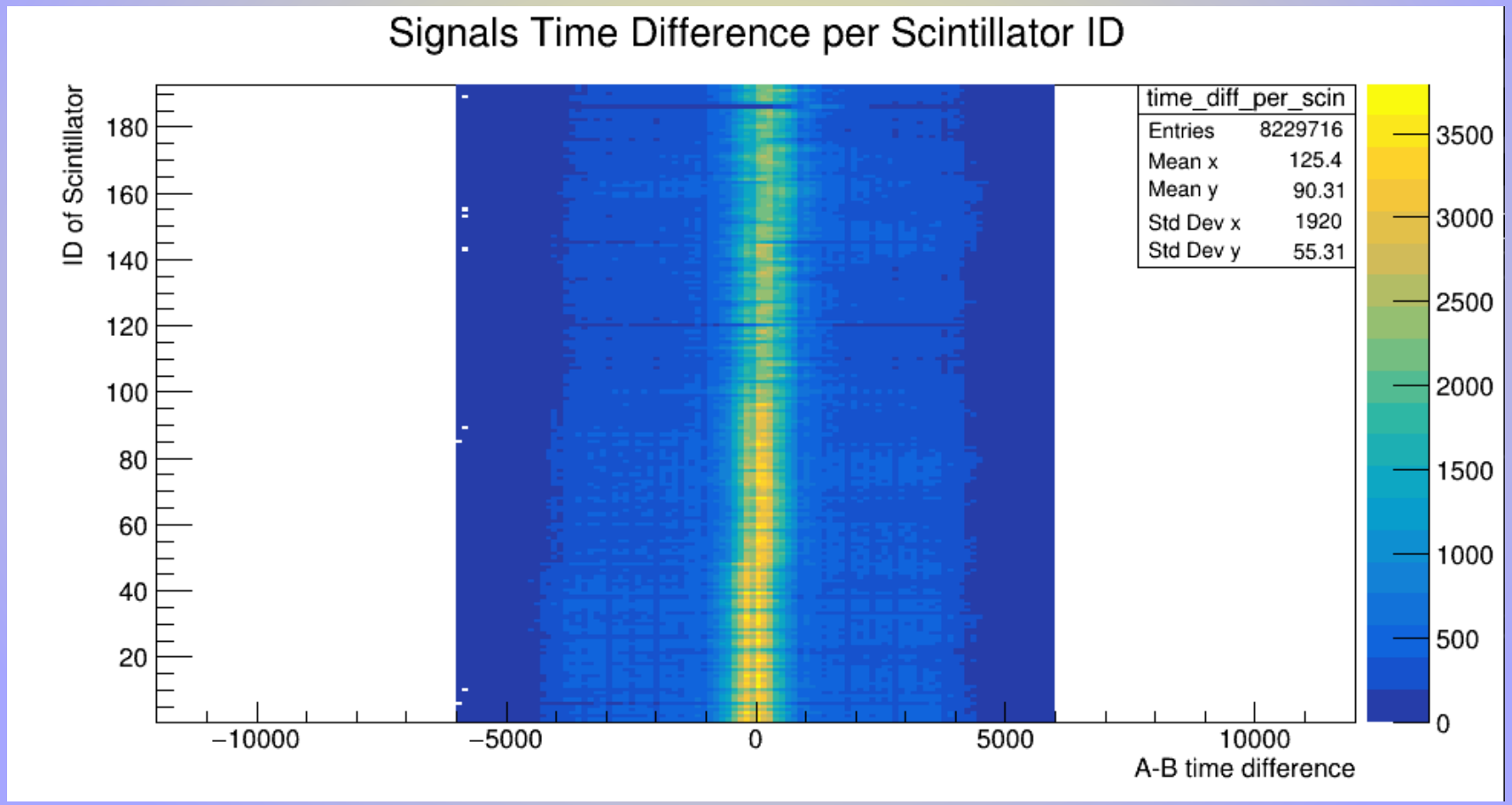
Calibrations and Parameters (2)

- Example - A-B signal time difference before application of calibration



Calibrations and Parameters (3)

- Example - A-B signal time difference after application of calibration



Calibrations and Parameters (4)

More about J-PET calibrations:

→ presentation by Sushil Sharma

→ presentation by Magdalena Skurzok

→ presentation by Shivani

M. Skurzok, M. Silarski et al.
Acta Phys. Polon. A 132, no. 5, 1641 (2017)

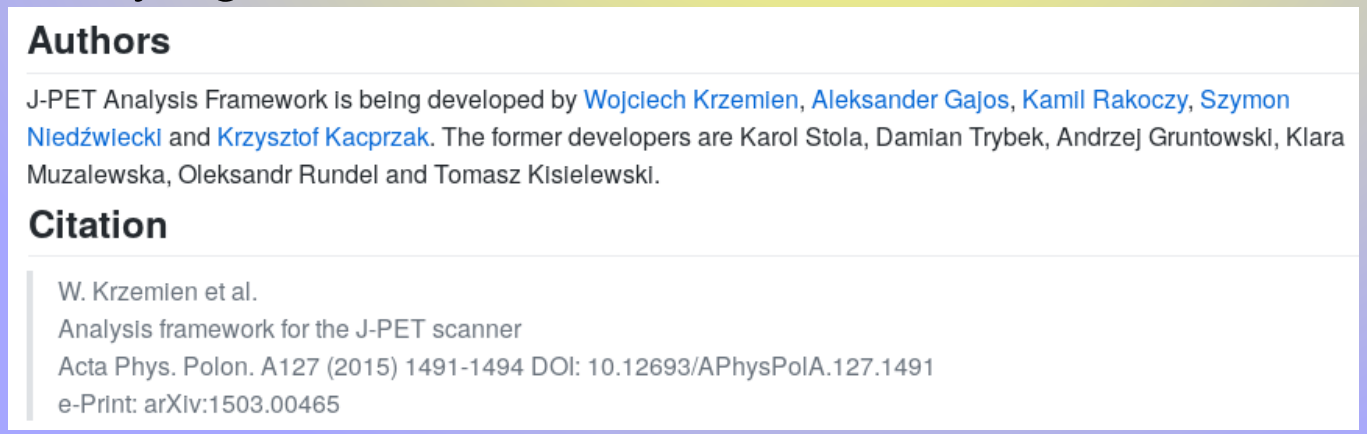
What is next?

- Release of new Framework and Examples versions.
Current - 6.1, soon* - 7.0

- Improvement of tools and implementation of new ideas i.e. new layer of modular J-PET

- Streaming approach - various categorization scenarios (last module versions) for medical imaging, cosmic radiation selection, deeper categorization for physics.

- Buying coffee for the authors - we need lot of it :)



Authors

J-PET Analysis Framework is being developed by Wojciech Krzemien, Aleksander Gajos, Kamil Rakoczy, Szymon Niedźwiecki and Krzysztof Kacprzak. The former developers are Karol Stola, Damian Trybek, Andrzej Gruntowski, Klara Muzalewska, Oleksandr Rundel and Tomasz Kisielewski.

Citation

W. Krzemien et al.
Analysis framework for the J-PET scanner
Acta Phys. Polon. A127 (2015) 1491-1494 DOI: 10.12693/APhysPolA.127.1491
e-Print: arXiv:1503.00465

Summary

- Data analysis Framework for J-PET experiment is a flexible environment for offline reconstruction, physics analyses, medical imaging, detector calibration.
- Object-oriented software design follows modern day programming practices and is constantly developed and maintained
- Final step of implemented event building procedures is a starting point for variety of investigations on the spectrum interests of J-PET collaboration

End

Thank you for your attention