COMPET a high-resolution, high-sensitivity pre-clinical PET scanner

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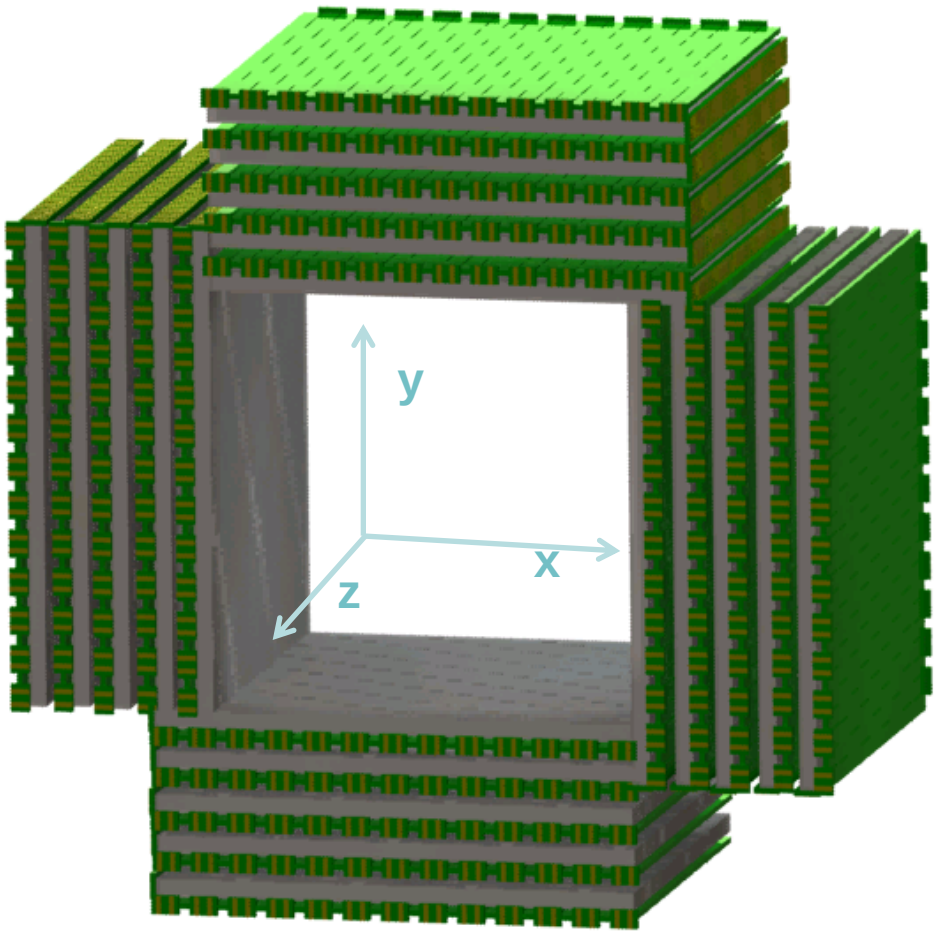
Outline

- COMPET overview
- DAQ system
- COMPET status
- Latest results
- First images
- Summary & outlook

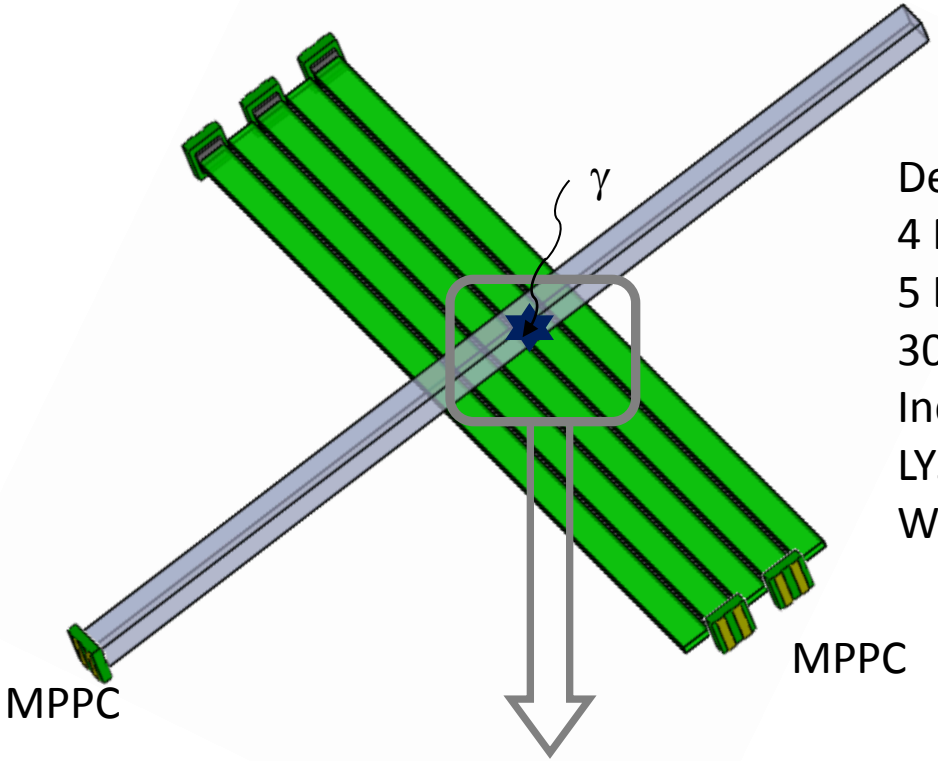
COMPET – Quick overview



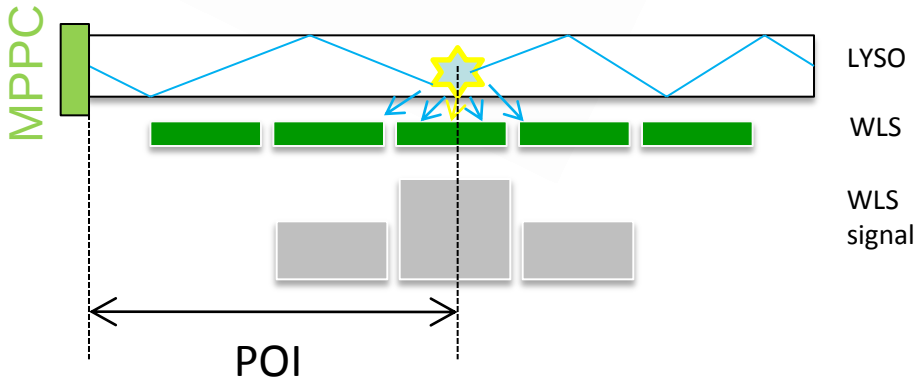
- 4-8 cm adjustable bore opening with 8cm axial view
- very high sensitivity (16%)
- high resolution (~1 mm)
- 3D event reconstruction
- no inter module or inter crystal gap
- High data throughput FPGA/Ethernet readout (~Mevents/sec)
- Back-end computer farm for data acquisition and image reconstruction
- MRI compatibility

COMPET

COMPET: POI Measurement Concept



Detector consists of:
4 Modules, where 1 module is
5 Layers, and 1 layer consists
30 LYSO crystals and 24 Wavelength shifters
Individually read out
LYSO: 80x3x2 mm
WLS: 80x3x1 mm

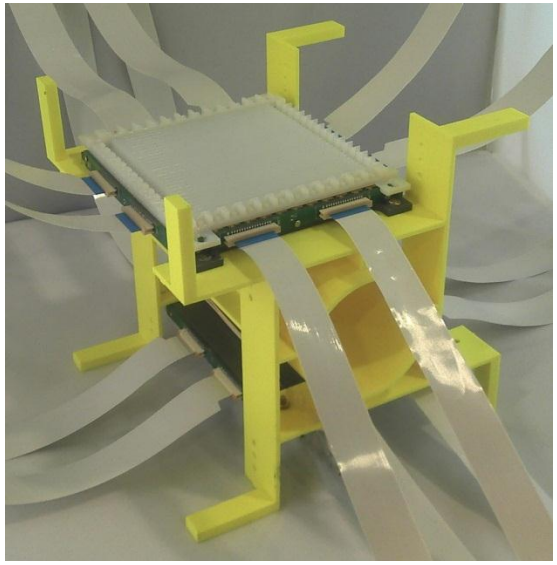


First proposed by AxPET.
See: [The AX-PET experiment: A demonstrator for an axial Positron Emission Tomography]

Read-Out System Front-End (1)

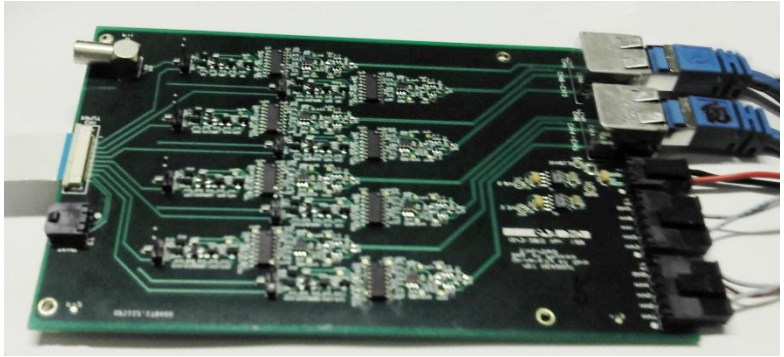
FFC cable from LYSO or WLS layer: →

- A flat cable carries HV and signal for 8 SiPMs
- Ground seperation between each channel
- Cable length 1 meter (will be extended)
- Temperature sensor near MPPCs



Analog Pre-amplifier: →

- 8 channels per card
- Time-over-Threshold from charge integration and linear decay from constant current source
- LVDS output through shielded CAT-5
- 4 channels per CAT-5



Read-Out System Front-End (2)

Digitalization:

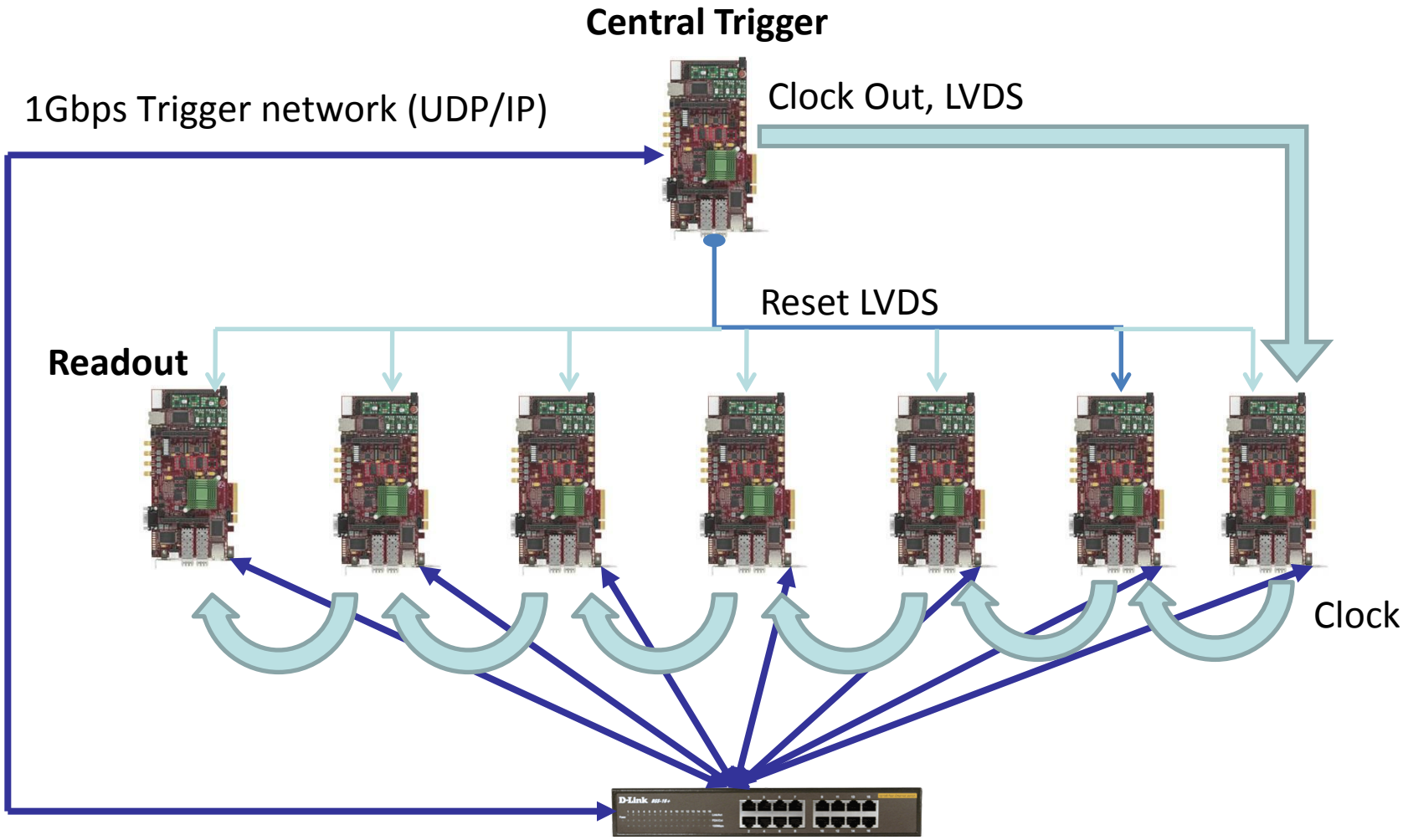
- A Virtex-5 Dev. Board using 54 deserializers digitizes one full layer (30 LYSO, 24 WLS)
- 20 read-out cards + 1 centralized trigger needed for a full scanner
- Deserializers run at 1 Gbps for a timing resolution of 1 ns
- Data output as synchronized UDP streams through a switched 1 Gbps network

→

Computer Storage:

- An arbitrary number of multi-core computers can be used
- Events are stored as HDF5

Trigger & Reset system



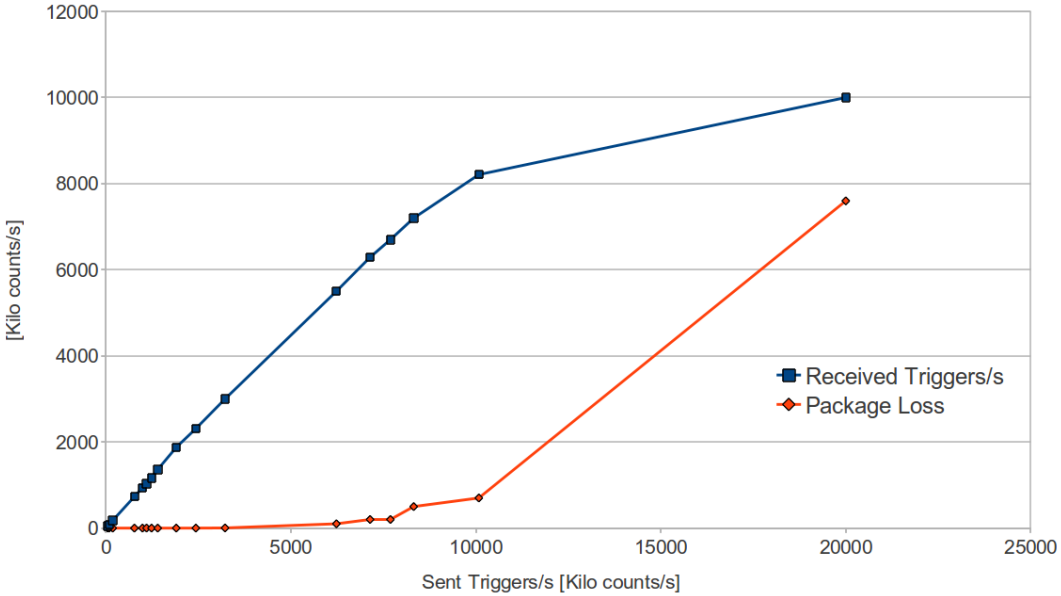
Trigger & Reset system

Trigger:

- Event times are sent as 32bit Integers to the CTU using UDP-IP over 1 Gbps Ethernet
- The CTU search for coincidences following a given rule and broadcasts coincident times
- Handles coincidence rates of 1.5 Mcps
- Rate from each layer is limited to 1.5 Mcps
- Fully asynchronous
- Handles arbitrary number of layers and read-out cards (scalable)
- Coincidence resolution independent of transfer link

Clock synchronization:

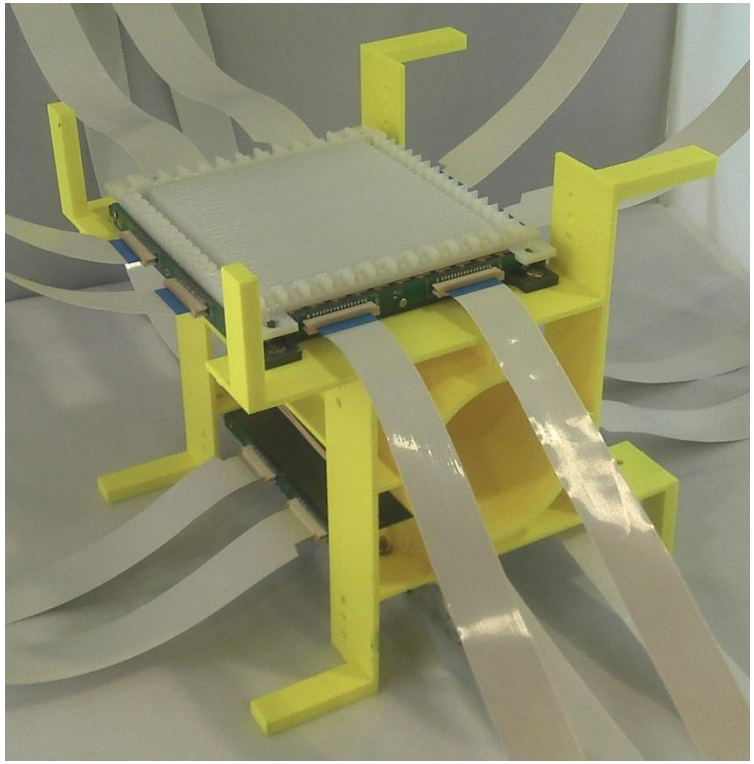
- Read-out cards are synchronized within ~200ps



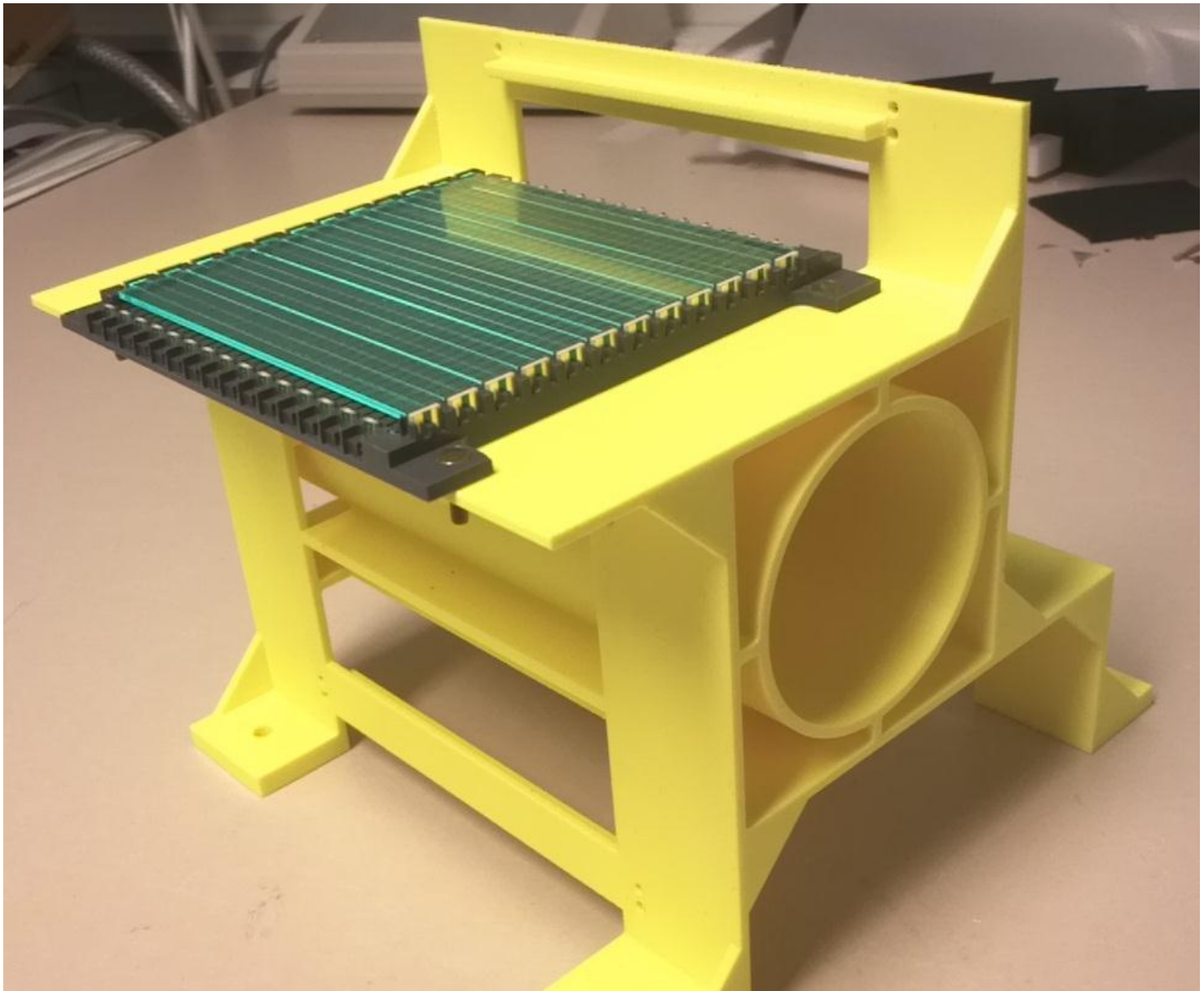
Package loss as a function of rate

COMPET status

- Two layers are fully assembled and connected to DAQ
- Four layers finished by the end of summer
- Two layers used for:
  - DAQ system verification
  - Image reconstruction verification
- Four layers used for:
  - Verification of the simulations
  - Module characterization
- Image reconstruction program (CUDA based) made and verified

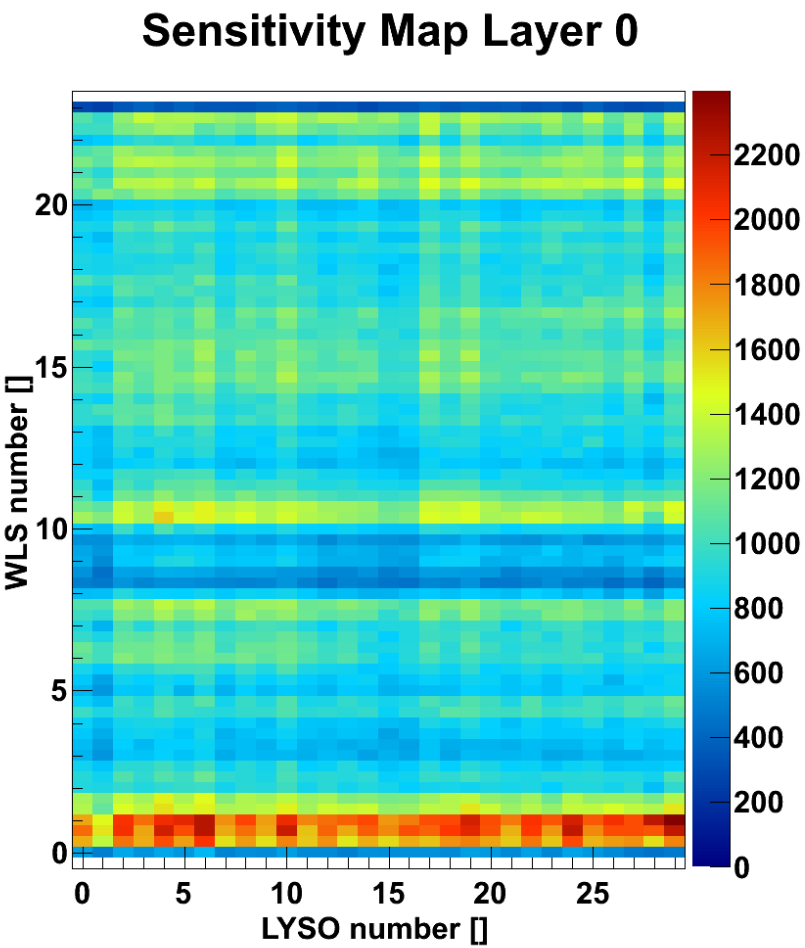


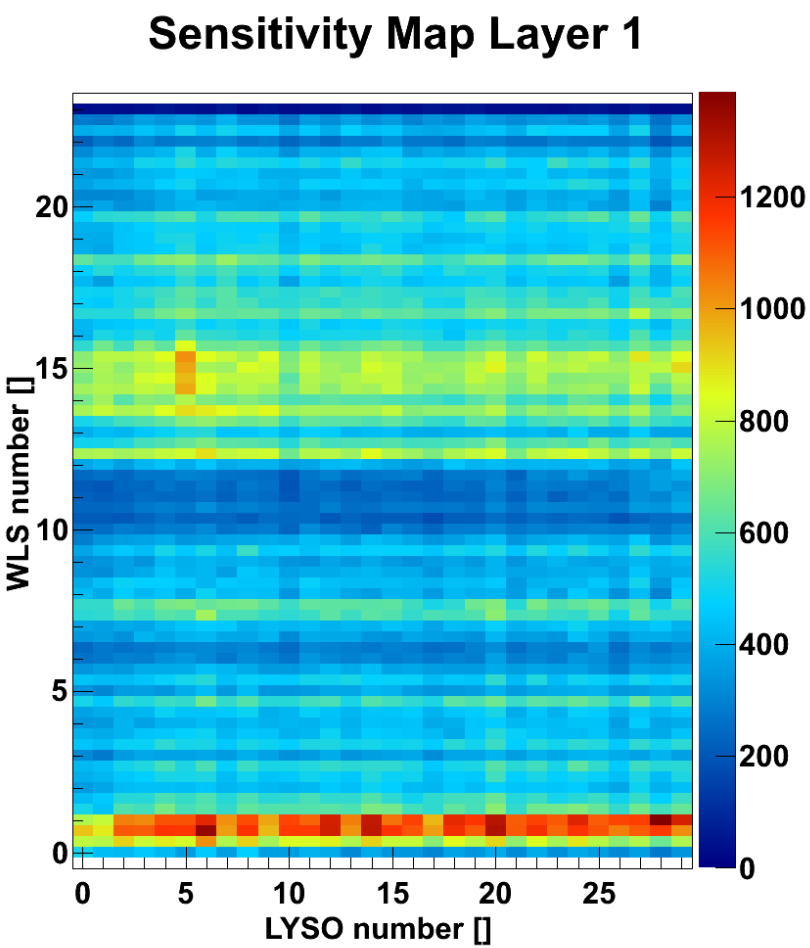
Construction



Sensitivity Map

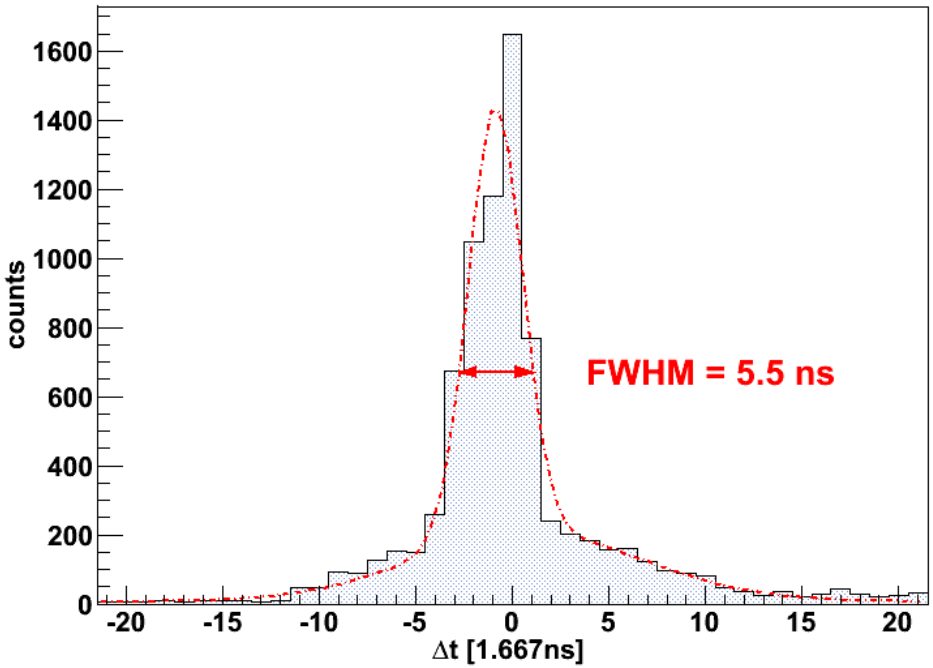
- Made from intrinsic data with a free-running trigger
- Uncalibrated LYSO channels, coarse calibration for WLS channels



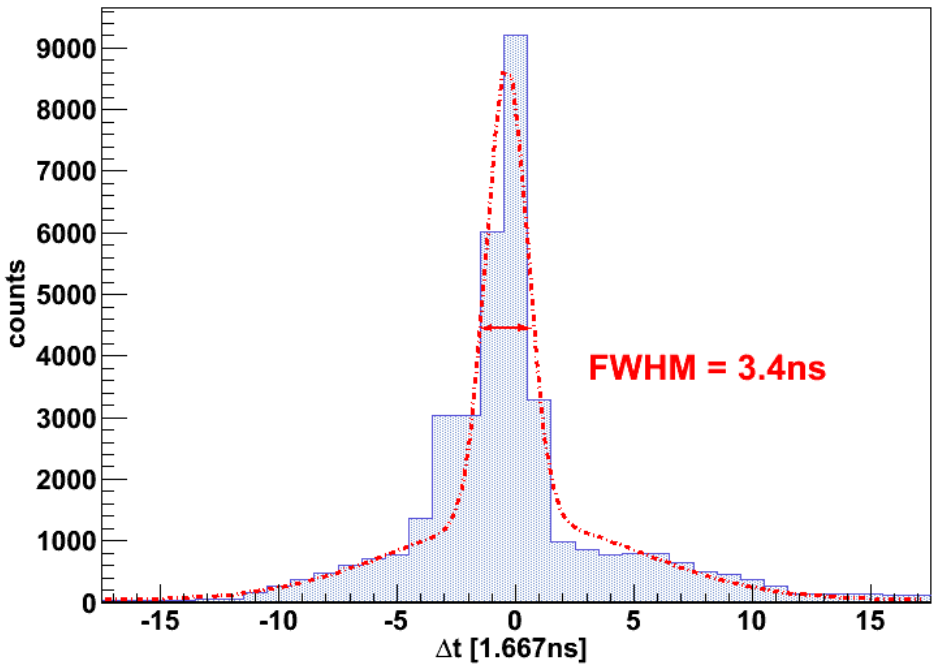


Coincidence Timing

Δt for coincidences between layer 1 and layer 2. Measured with a Na-22 source



No E-cut

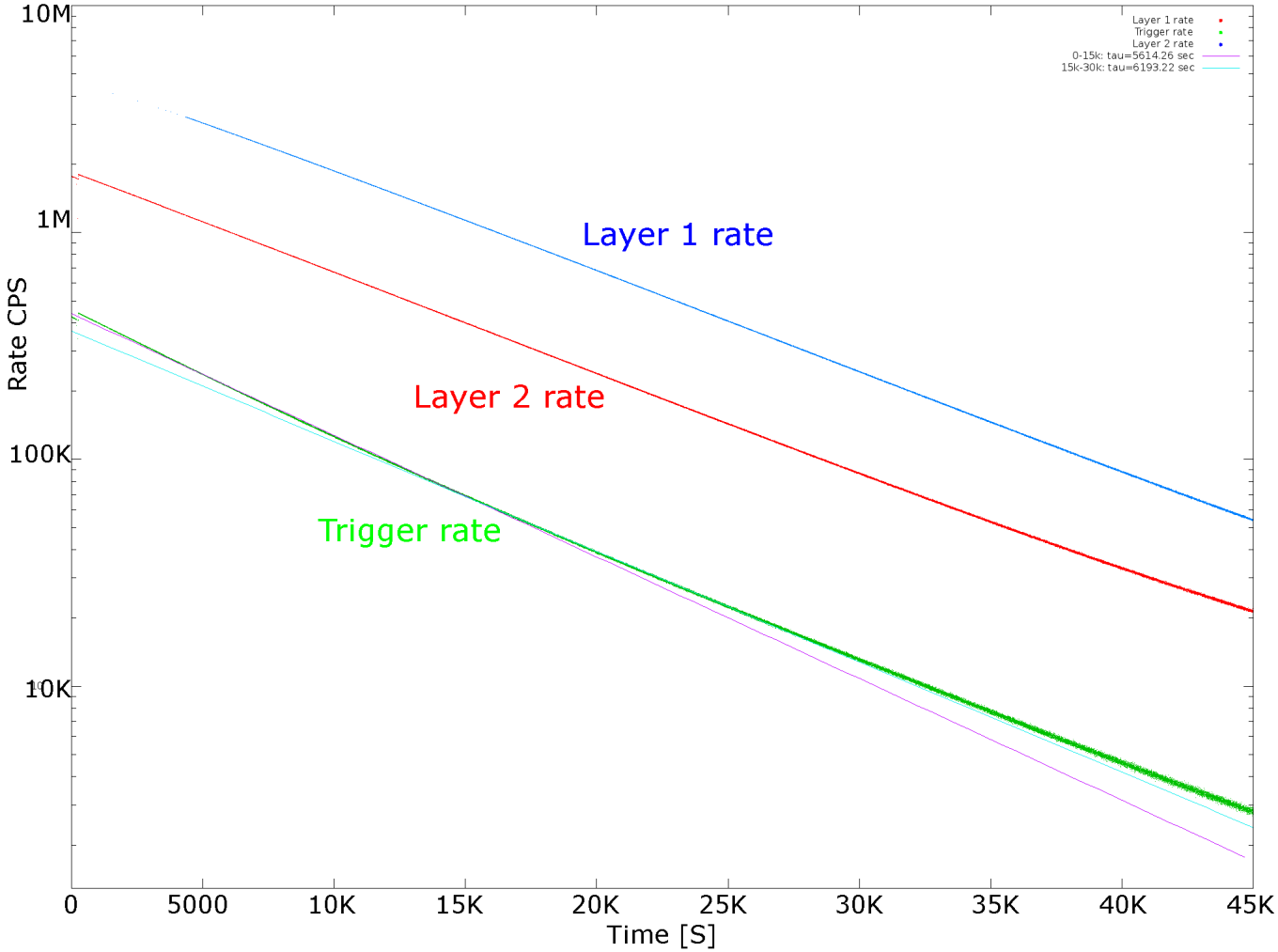


E-cut around 450-560KeV

- Timewalk is not yet accounted for!

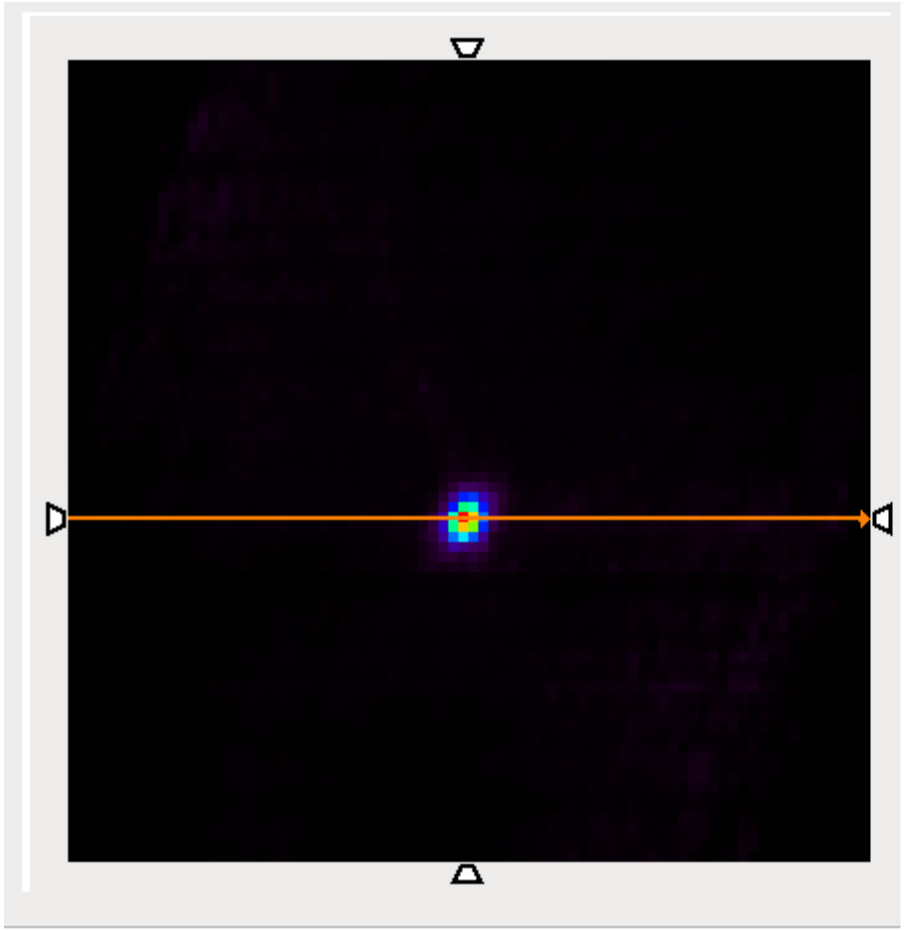
Rate measurements

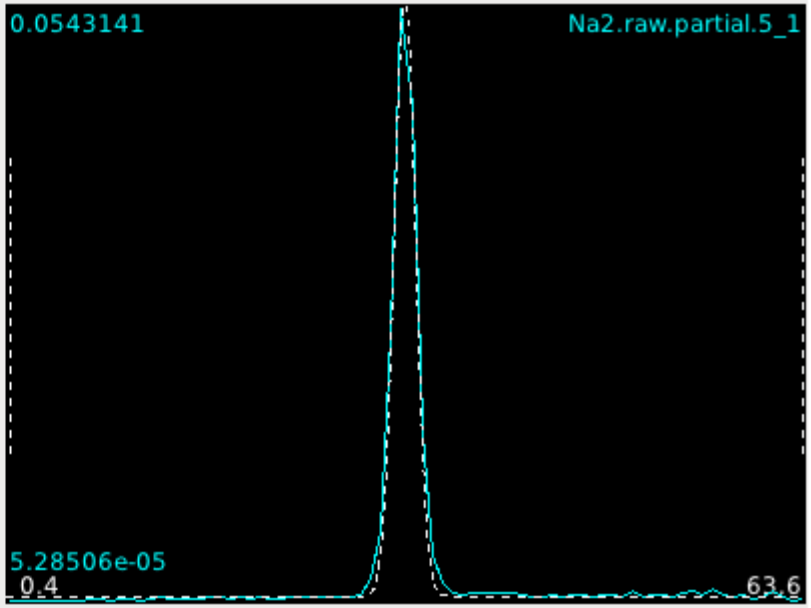
- Taken with a 50 MBq F18 source
- Stored the trigger rate between the two layers and the event rates in both layers
- Coincidence window=20ns
- Trigger dead time=30ns
- Channel dead time=0-500ns (ToT time)



Reconstructed Images

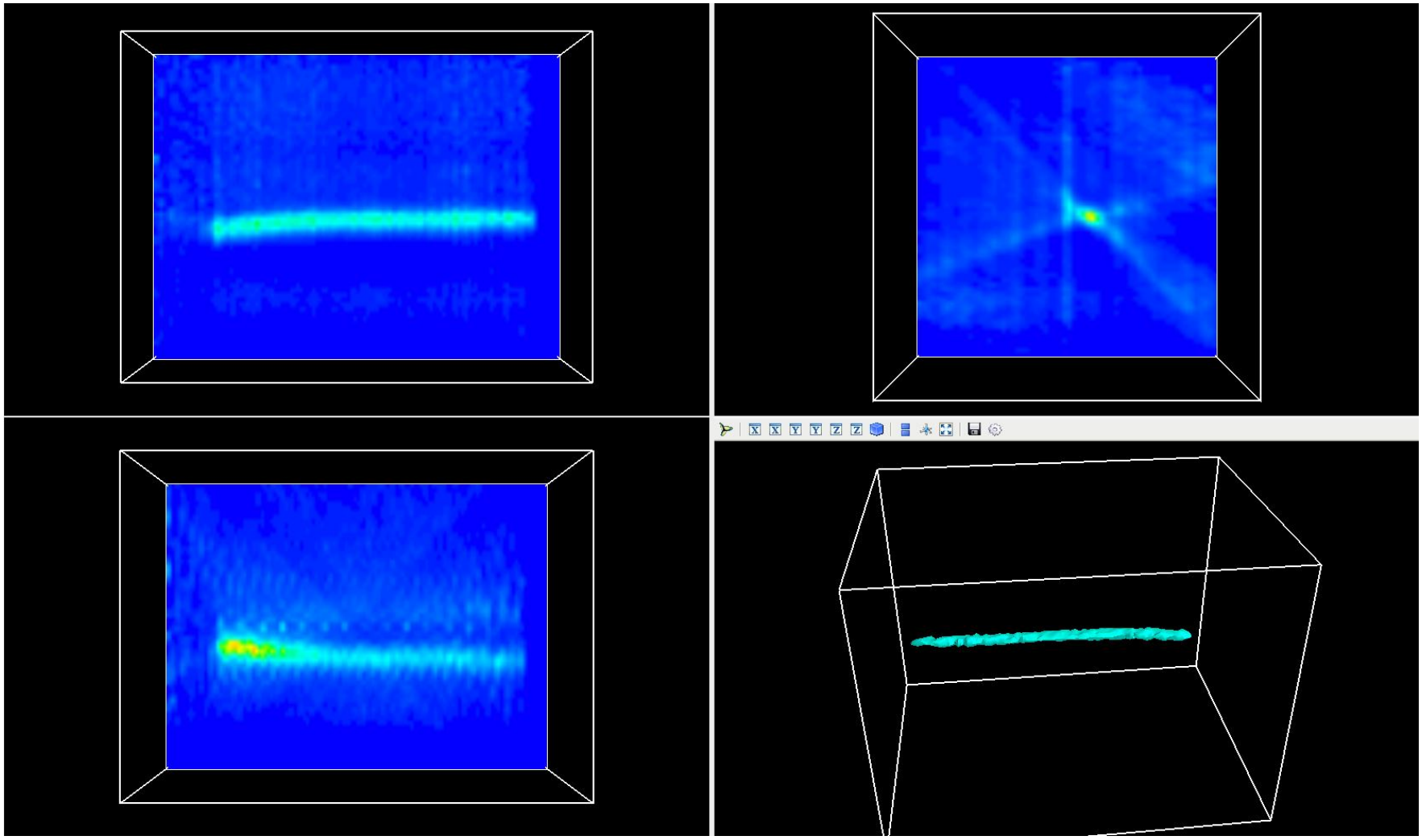
Point-like Na-22 source, D≈1.5mm, 5 iterations



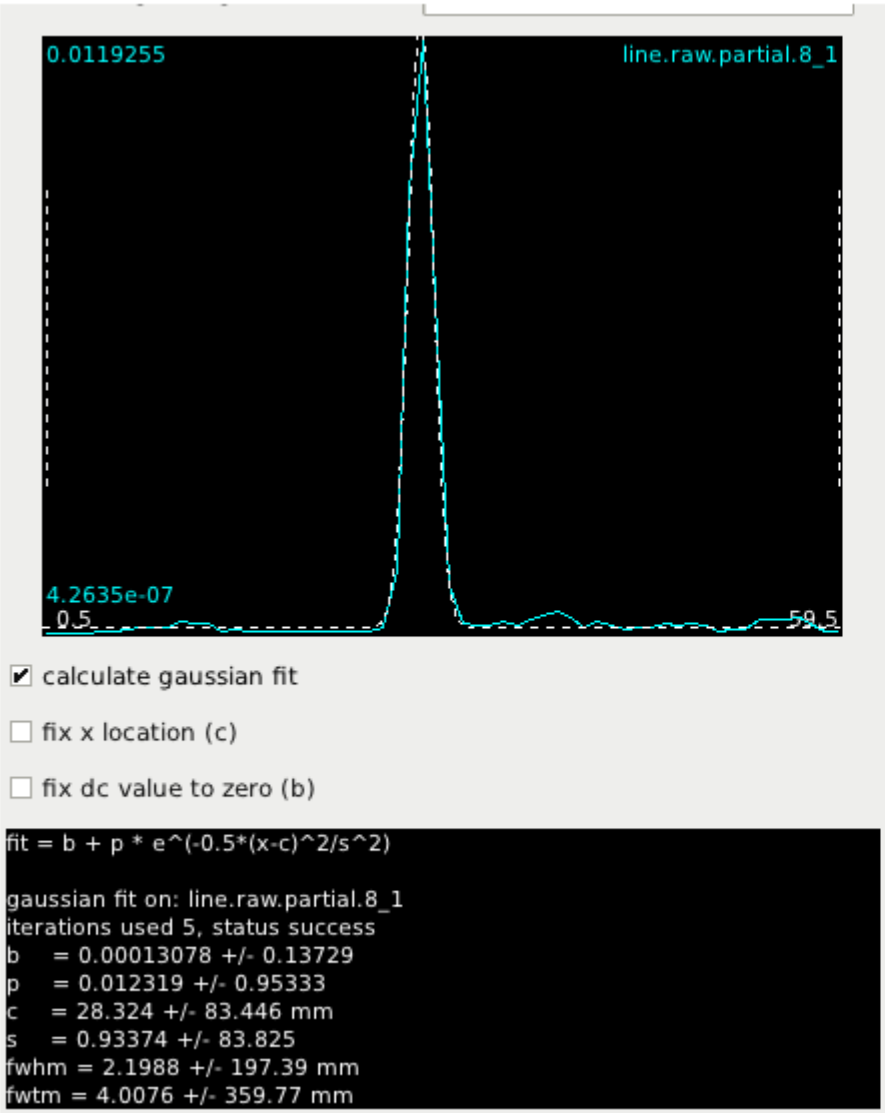


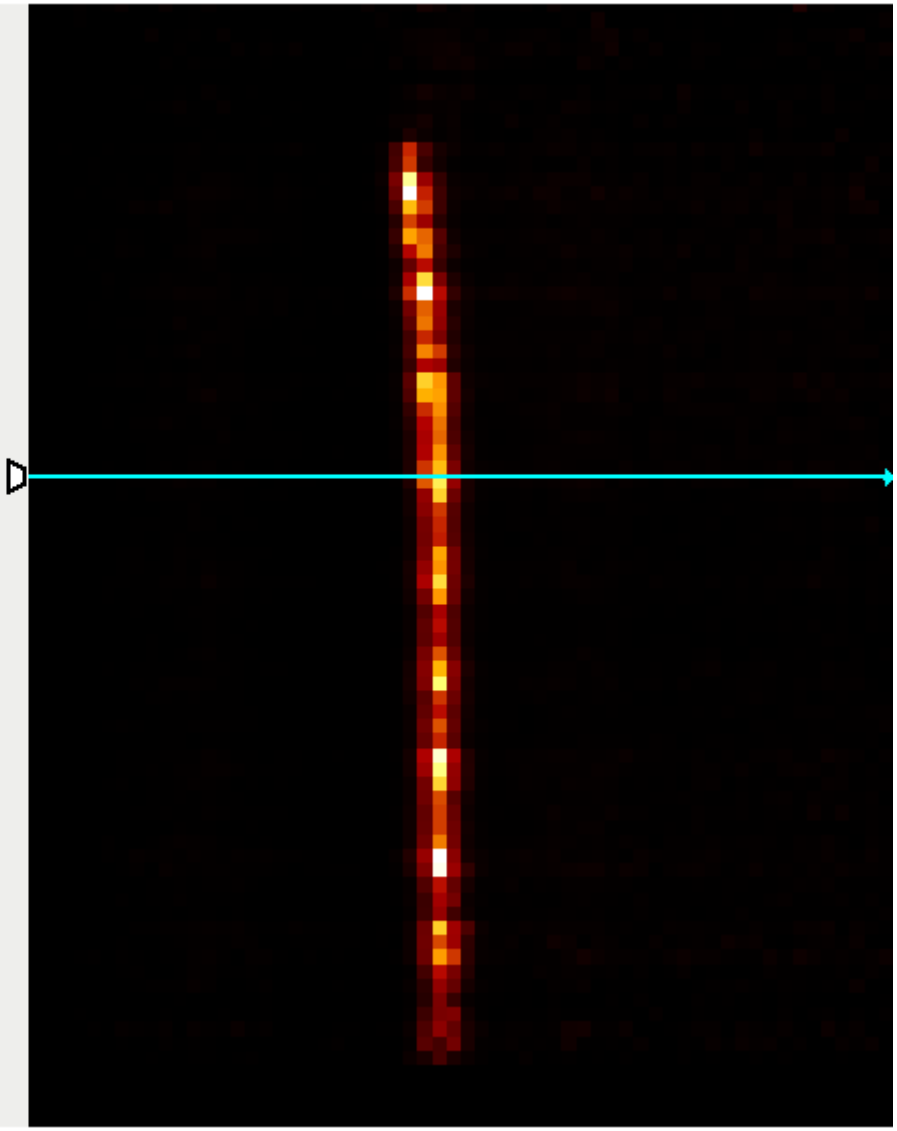
FWHM = 1.97 mm
FWTM = 3.59 mm

Line source (d=0.8 mm, plastic tube)



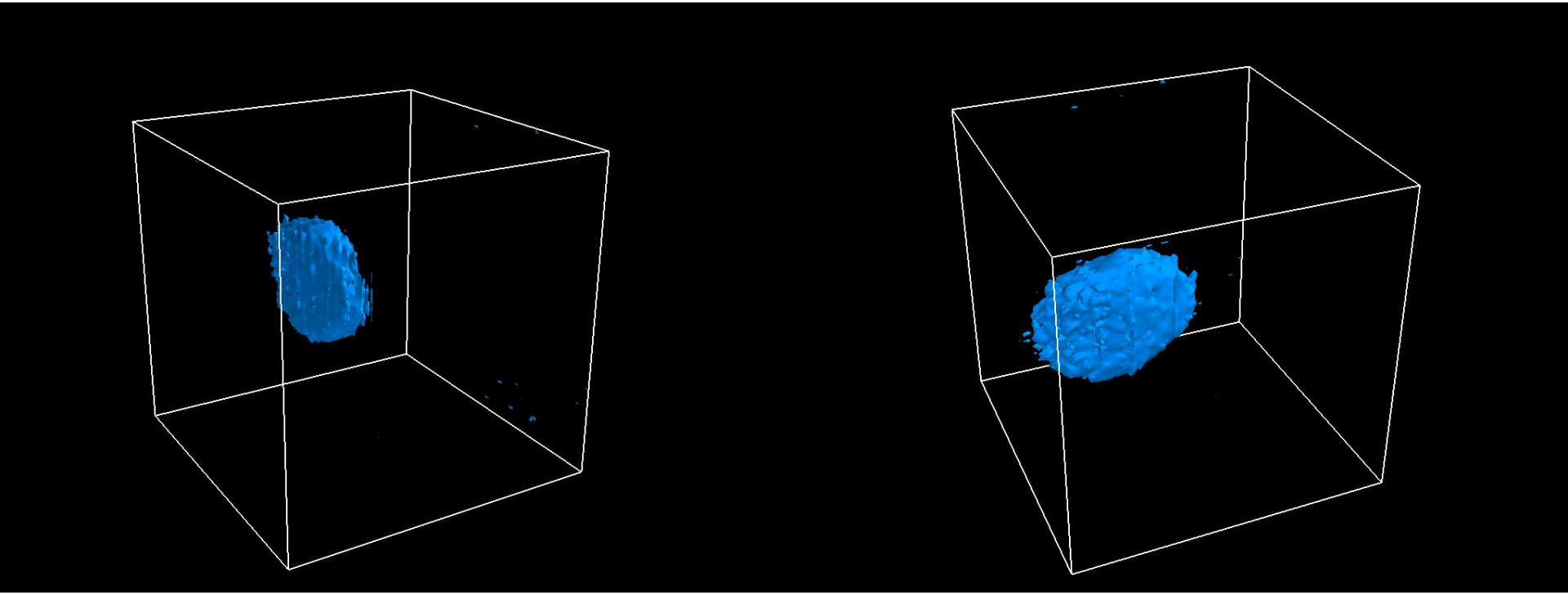
Line source (d=0.8 mm, plastic tube)





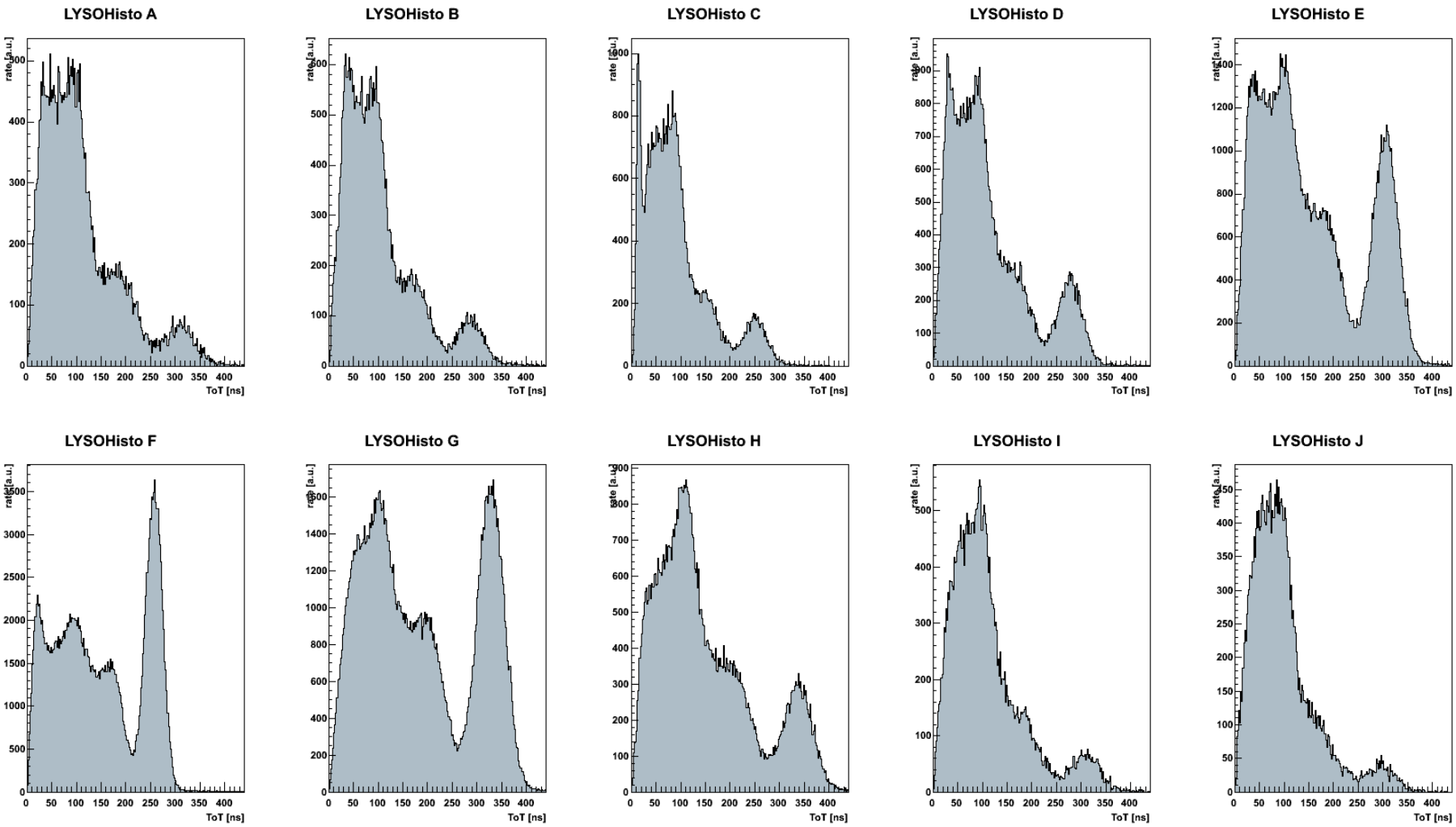
Disk Source

First image produced by COMPET!

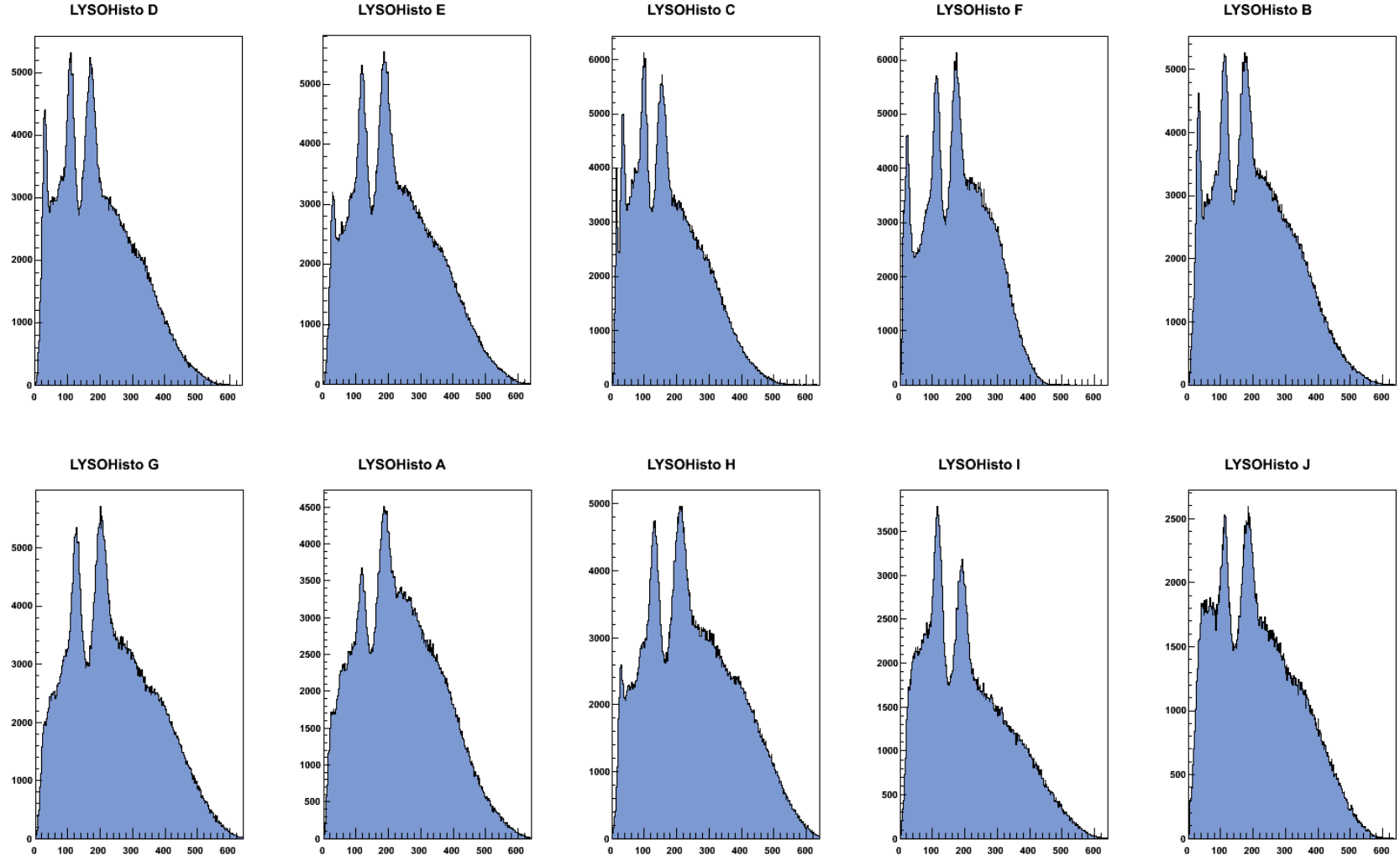


ISO-surface with No E-cut, No time cut, no WLS calibration, around 1 M events

Na-22 Coincident Spectra (LYSO)



Intrinsic Spectra (LYSO)



Peaks at: 202keV, 303keV

Summary

- Two layers assembled
- DAQ proven to work for rates up to MCPS
- First images produced from the COMPET reconstruction program

Outlook

- Assemble 2 more layers for more coverage
- Confirm simulated data
- Module characterization
- Scale up for full scanner

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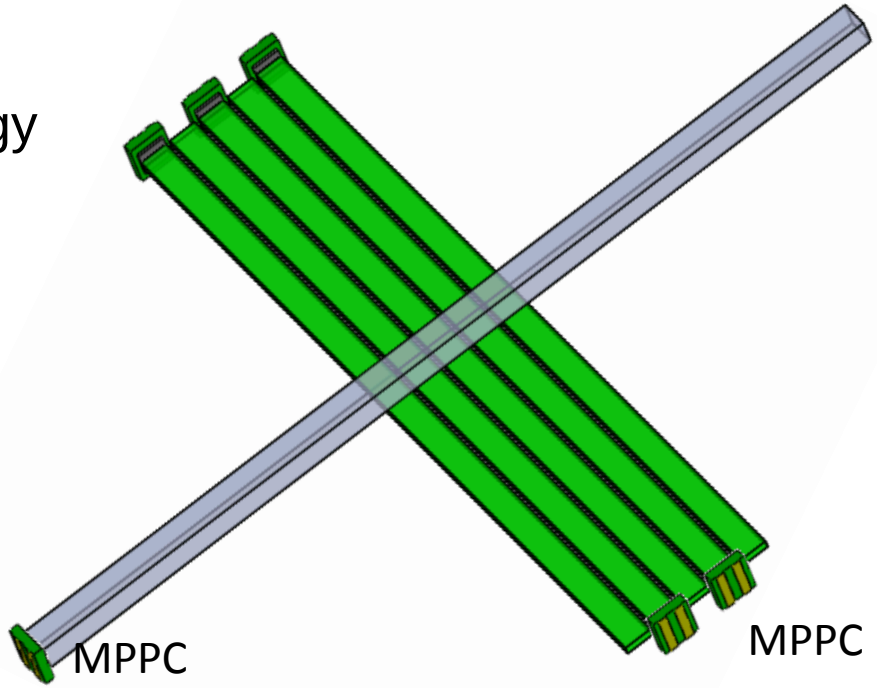
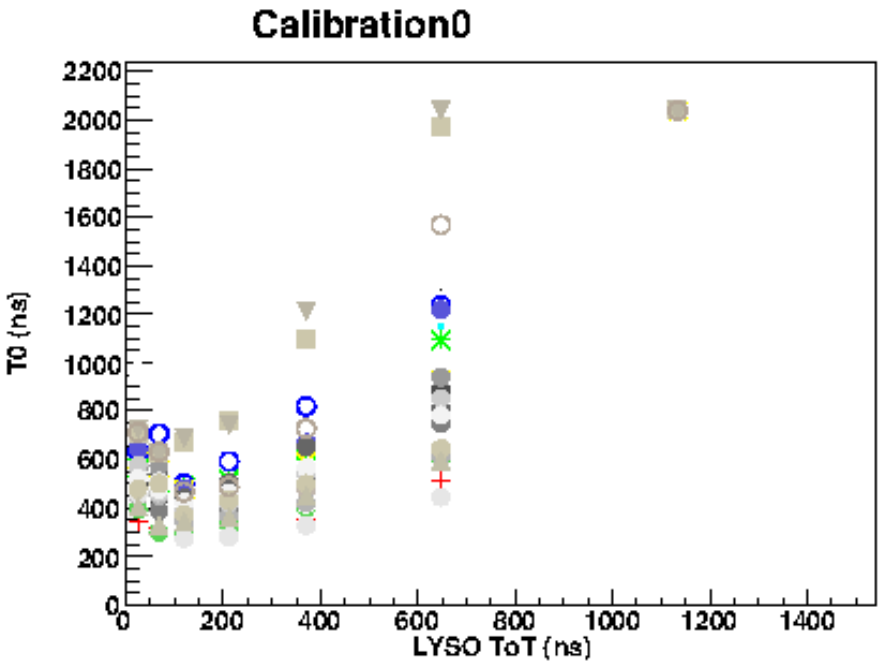
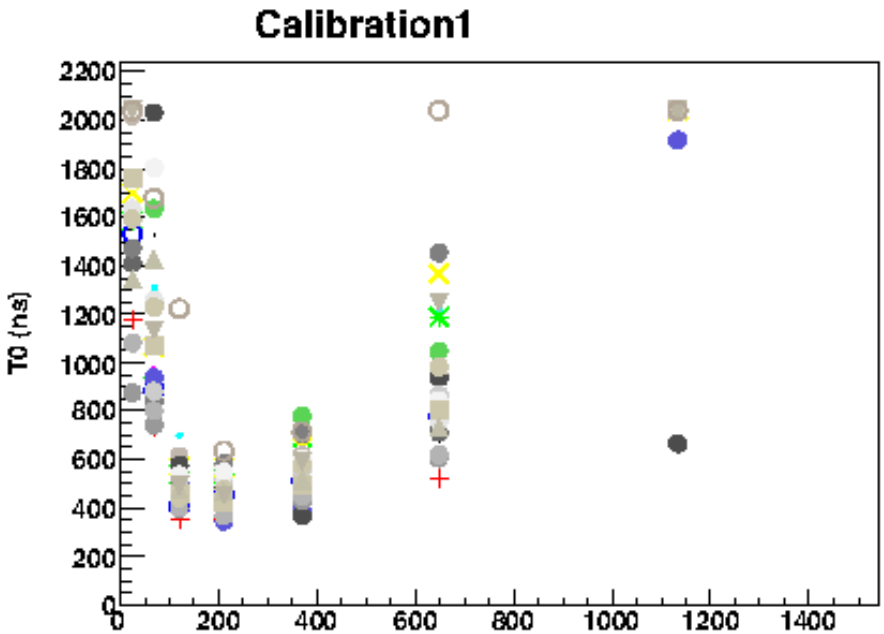
WLS calibration

- Use events from the middle LYSO
- Sum up integrated energy in WLS for different LYSO energy windows
- Pick a “golden wls” and calibrate after this




Calibration0
T0 (ns)
LYSO ToT (ns)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200


Calibration1
T0 (ns)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200

MPPC info, Hamamatsu

- LYSO readout:
  - 40x40um2 pixels
  - 3375 pixels
  - 1,8x3,0 active area
- WLS:
  - 70x70um2 pixels
  - 782 pixels
  - 3,22X1,19mm2 active area