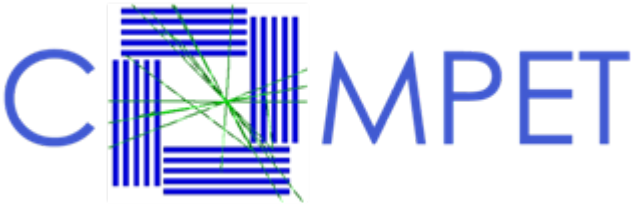

COMPET- Characterization of a High Resolution and High Sensitivity Pre-Clinical PET Scanner with 3D Event Reconstruction

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UNIVERSITY OF OSLO

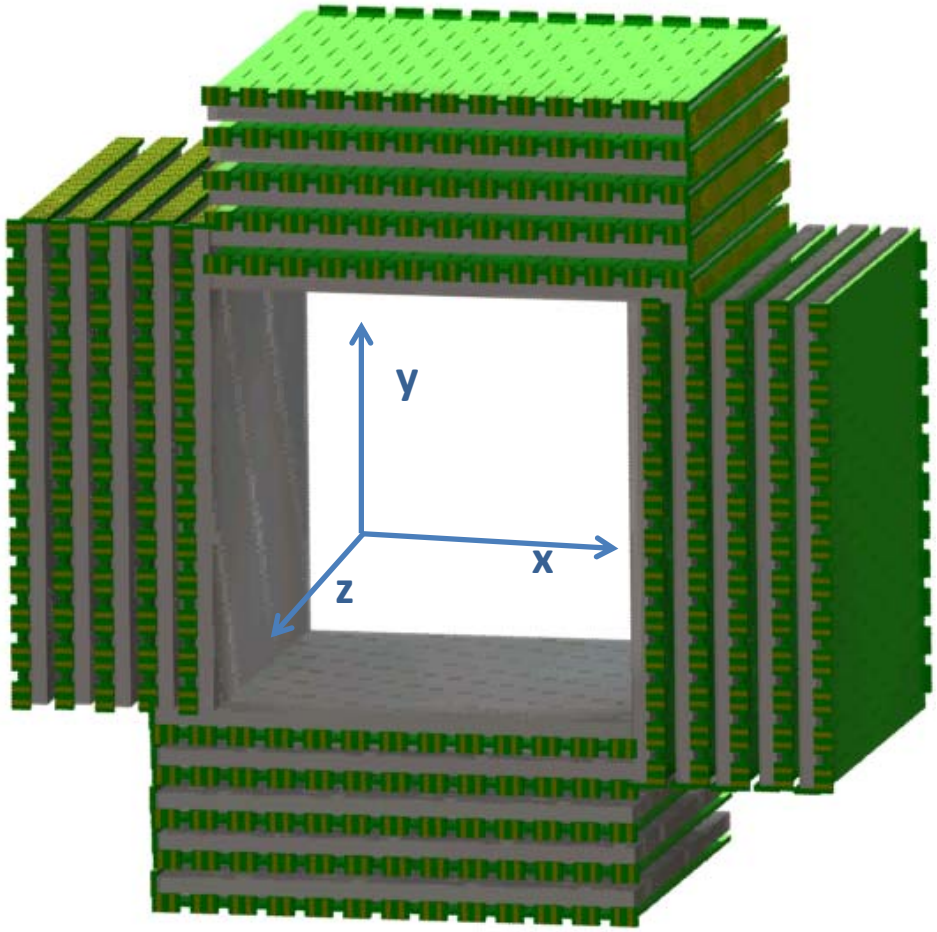
FACULTY OF MATHEMATICS AND NATURAL SCIENCES

The Research Council of Norway

FNSNF

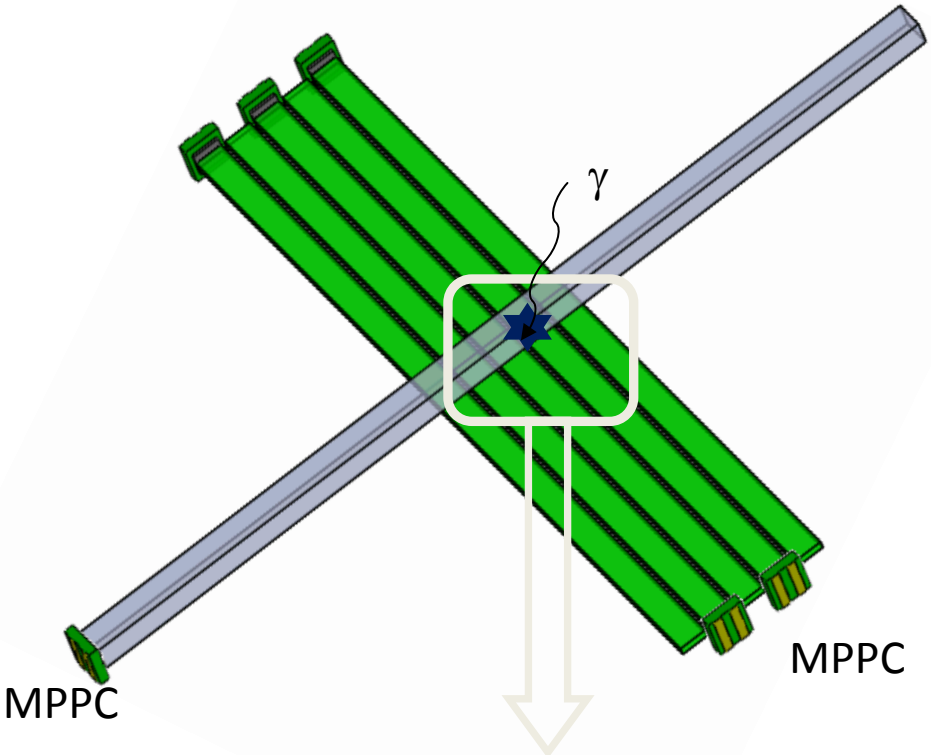
Swiss National Science Foundation

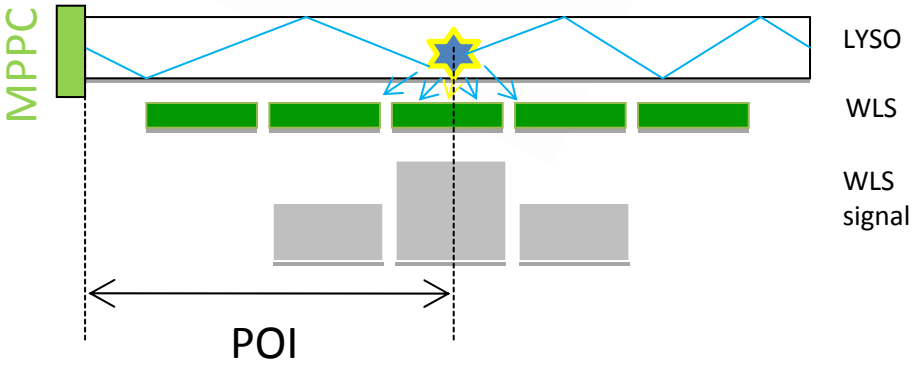
COMPET - Facts



- 4-8cm bore opening (adjustable) with 8cm axial view
- very high sensitivity (16%)
- high resolution (sub-millimeter)
- 3D event reconstruction
- no inter module and inter crystal gap
- High data throughput FPGA/ethernet readout (~Mevents/sec)
- Backend computer farm for data taking and image reconstruction
- MRI compability

COMPET: POI Measurement Concept

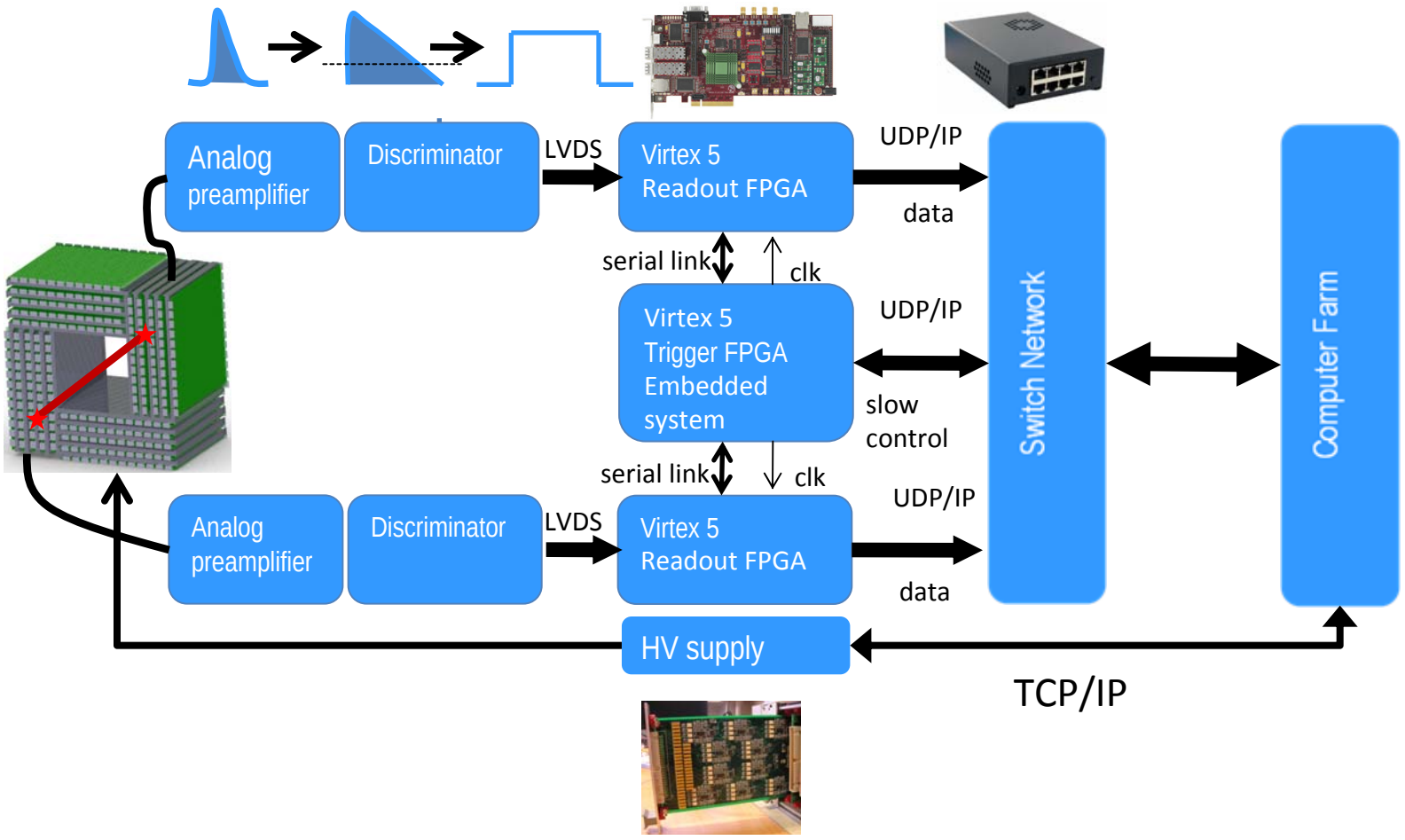




Number of detector elements: 1080
Classical scanner with similar resolution and sensitivity: 20000 - 30000

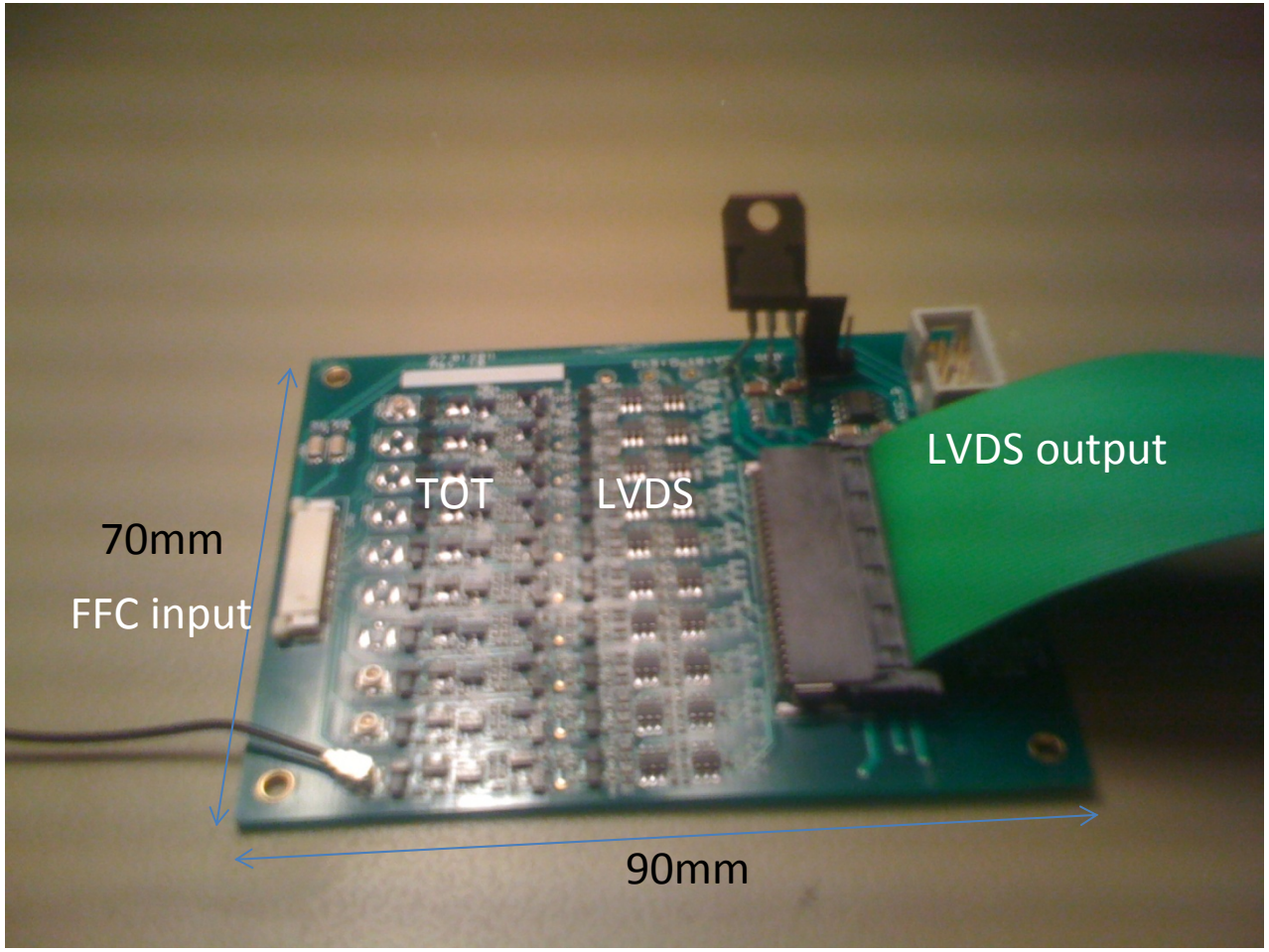
See also AxPET (this session)
The AX-PET demonstrator—Design, construction and characterization
doi:10.1016/j.nima.2011.06.059

Readout Scheme



600 LYSO channels, 480 WLS

PreAmp

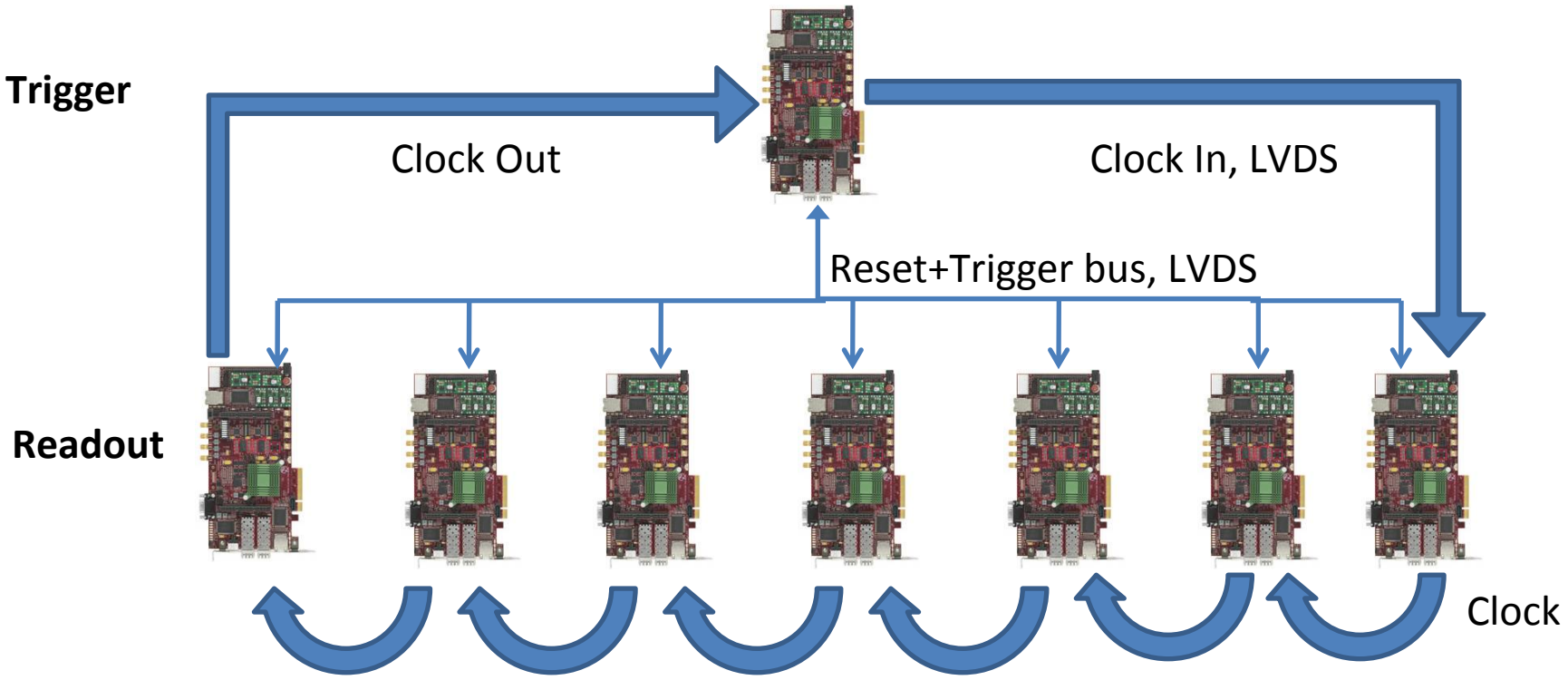


channels: 10
cards: ~150

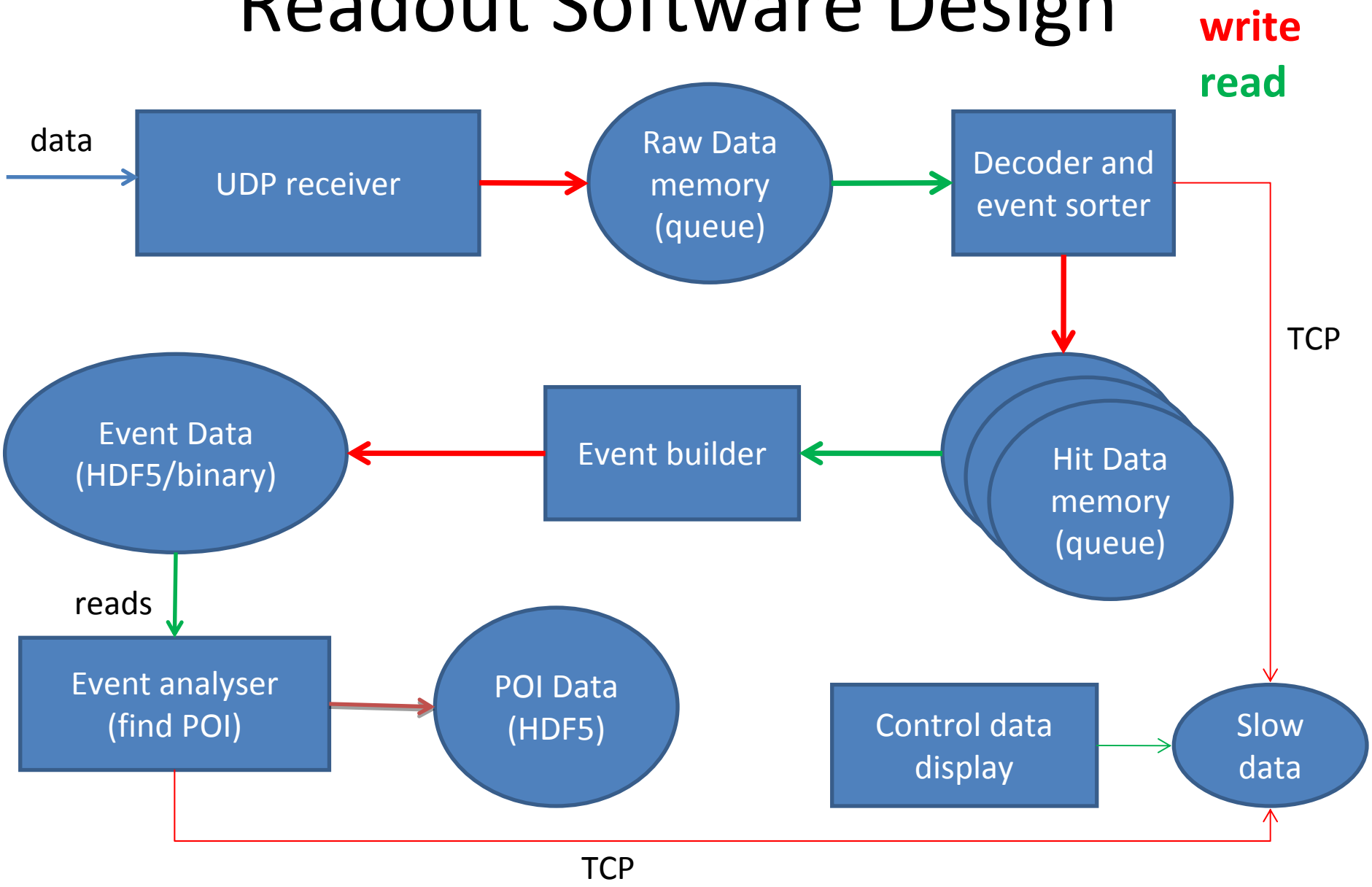
Readout Scheme: FPGA

Fast Digitizer	Parameterization Filter	Event Builder	Ethernet
• 1Gs sampling rate • Continuously sampling • No external trigger needed!	• Extract time and amplitude information • TDC/QDC	• Incremented with each global coincidence • All events tagged with global event number	• 1Gb/s link • UDP data packets

Clock Distribution / Trigger / Reset



Readout Software Design

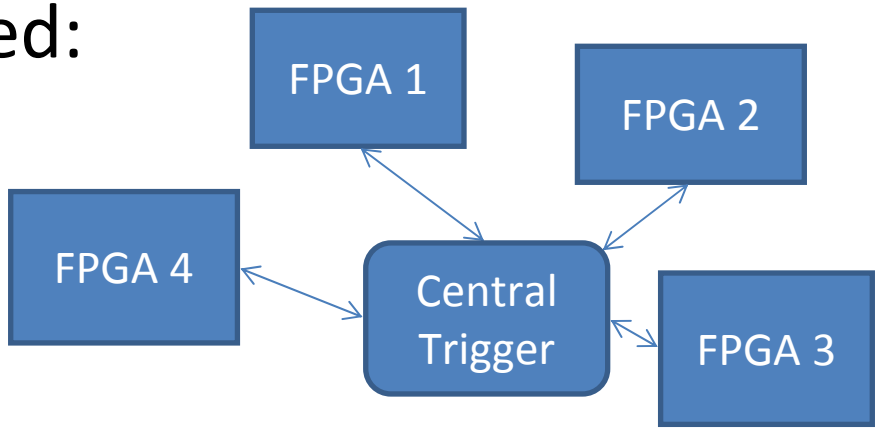


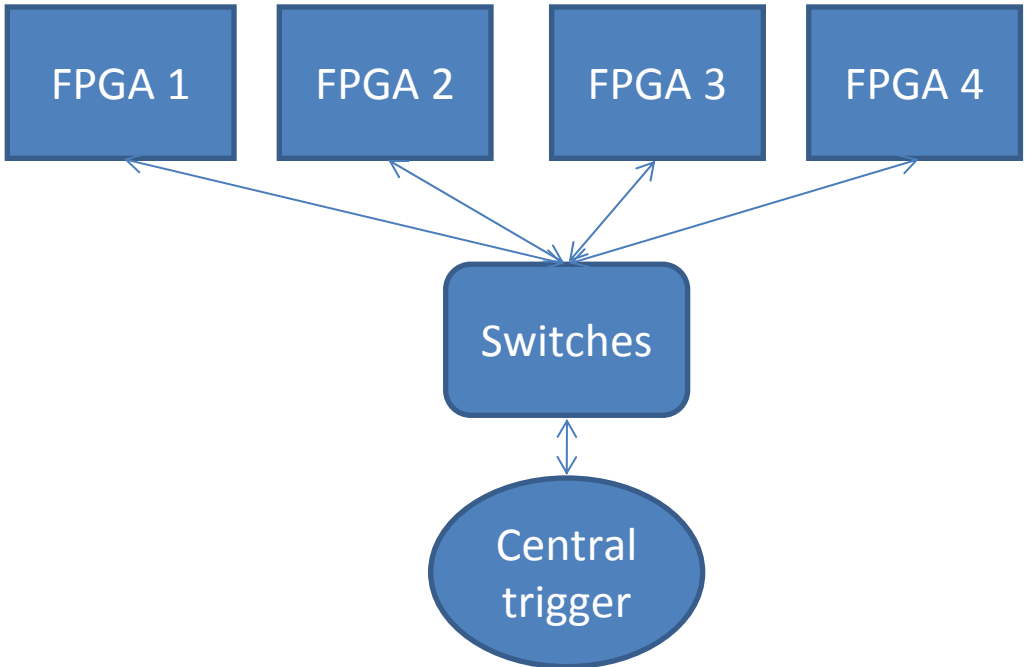
Readout Software Design

- 4 independent threads:
  - UDP receiver
  - Decoder: Decodes and sorts the hits to events
  - Event generator: build HDF5 tables consisting of the same event number
  - Event analyser: clusters the event data, finds corresponding WLS+LYSO data, finds the POI.
- Thread safety:
  - Mutexes/condition variables for access to queues (FIFOs) and slot memory.
- Maximal coincidence rate/computer with test pulser: 200 kcps

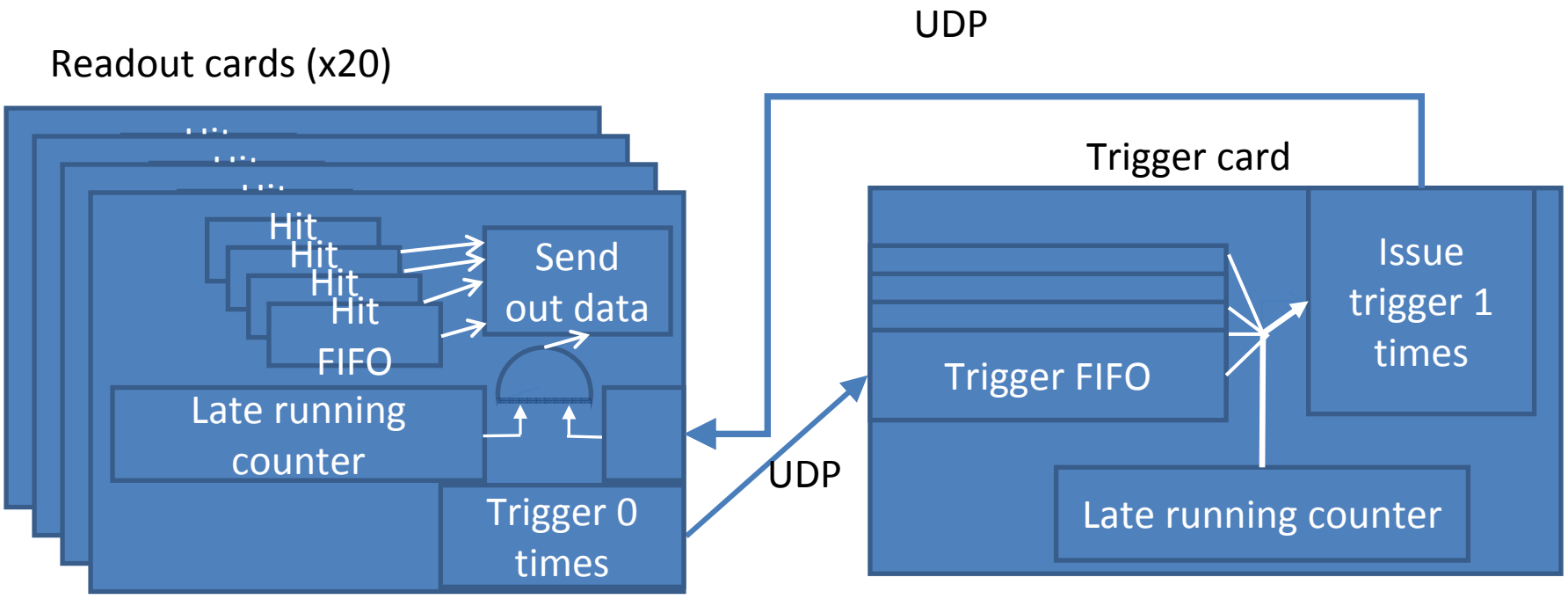
Trigger Scheme

- 2 Trigger to be implemented:
  - Synchronous trigger in real time through direct links:
    implemented, working
  - Asynchronous trigger through Ethernet (UDP/IP)
    50% implemented





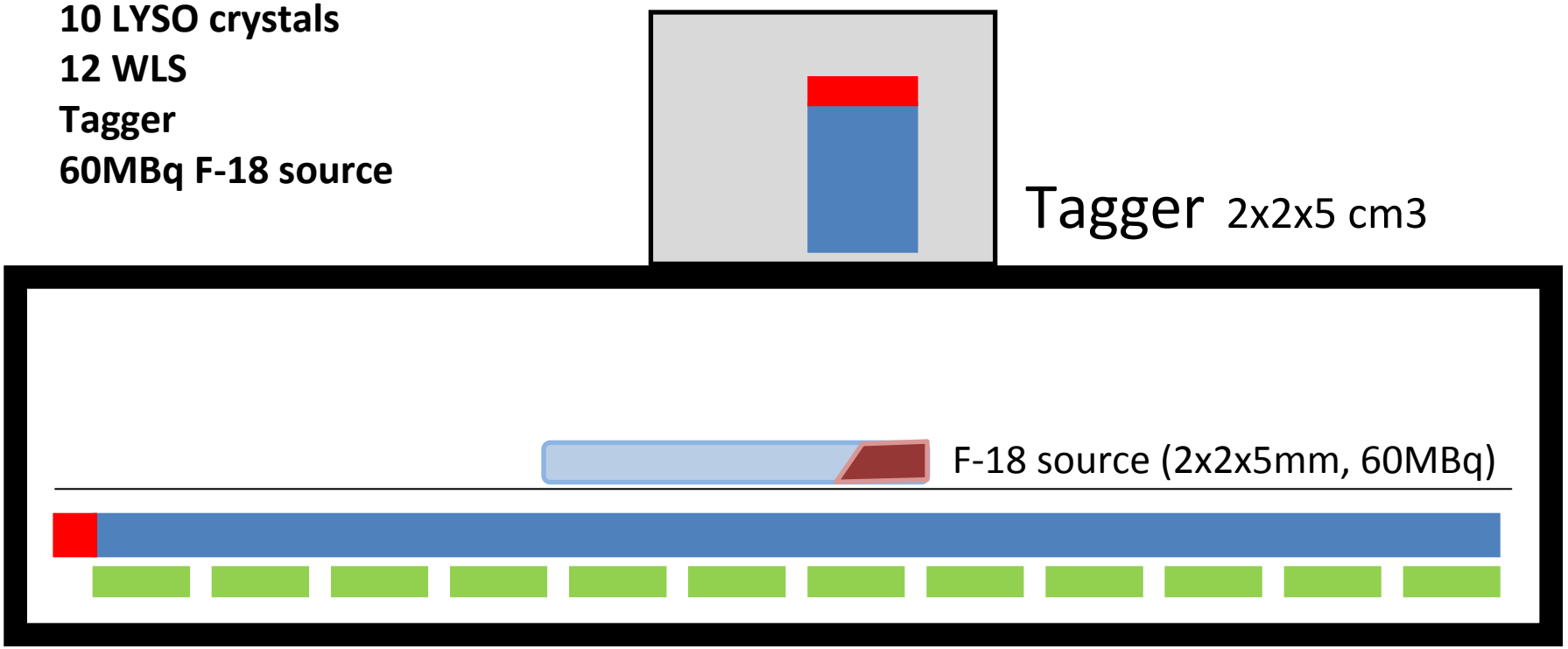
ETHERNET/UDP Trigger



Good to scale, uses only standard network components
Bottleneck: Network capacity, FIFO sizes

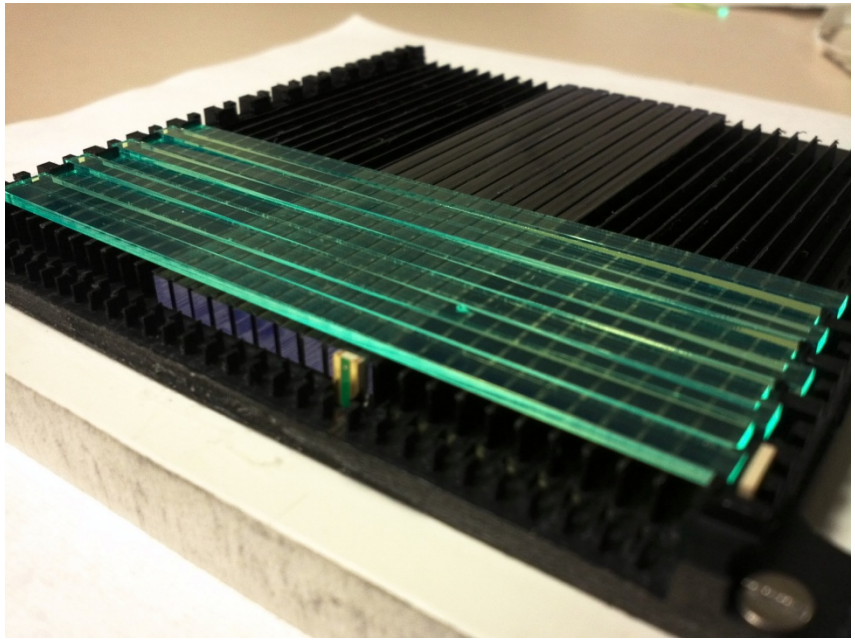
First Module Test Results: One Layer + Tagger

Setup:
10 LYSO crystals
12 WLS
Tagger
60MBq F-18 source



Tagger rate: 6.2 kcps
LYSO rate (10 channels): 1.3 Mcps
Trigger/readout rate: 500 cps

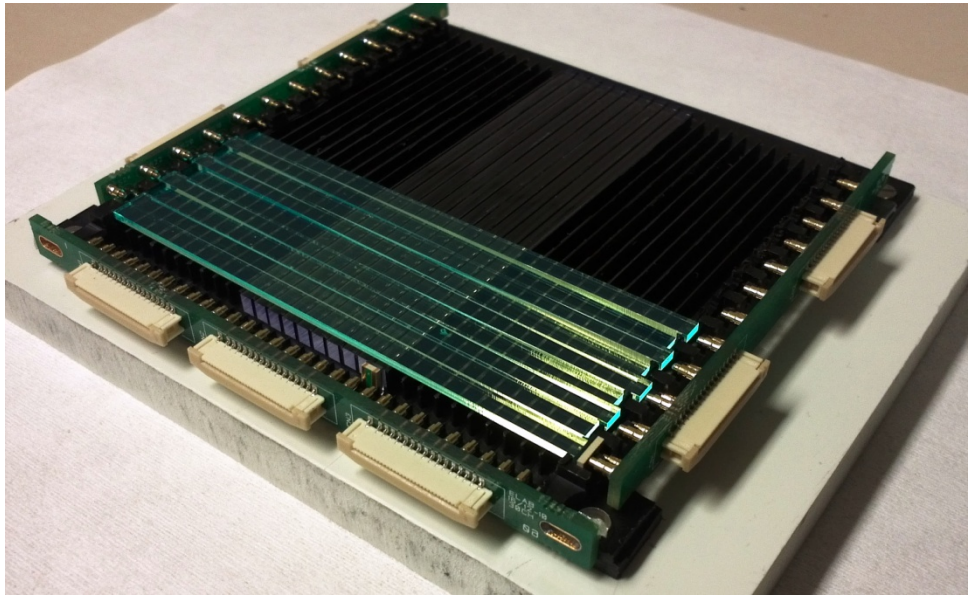
Assembly of the First Layer



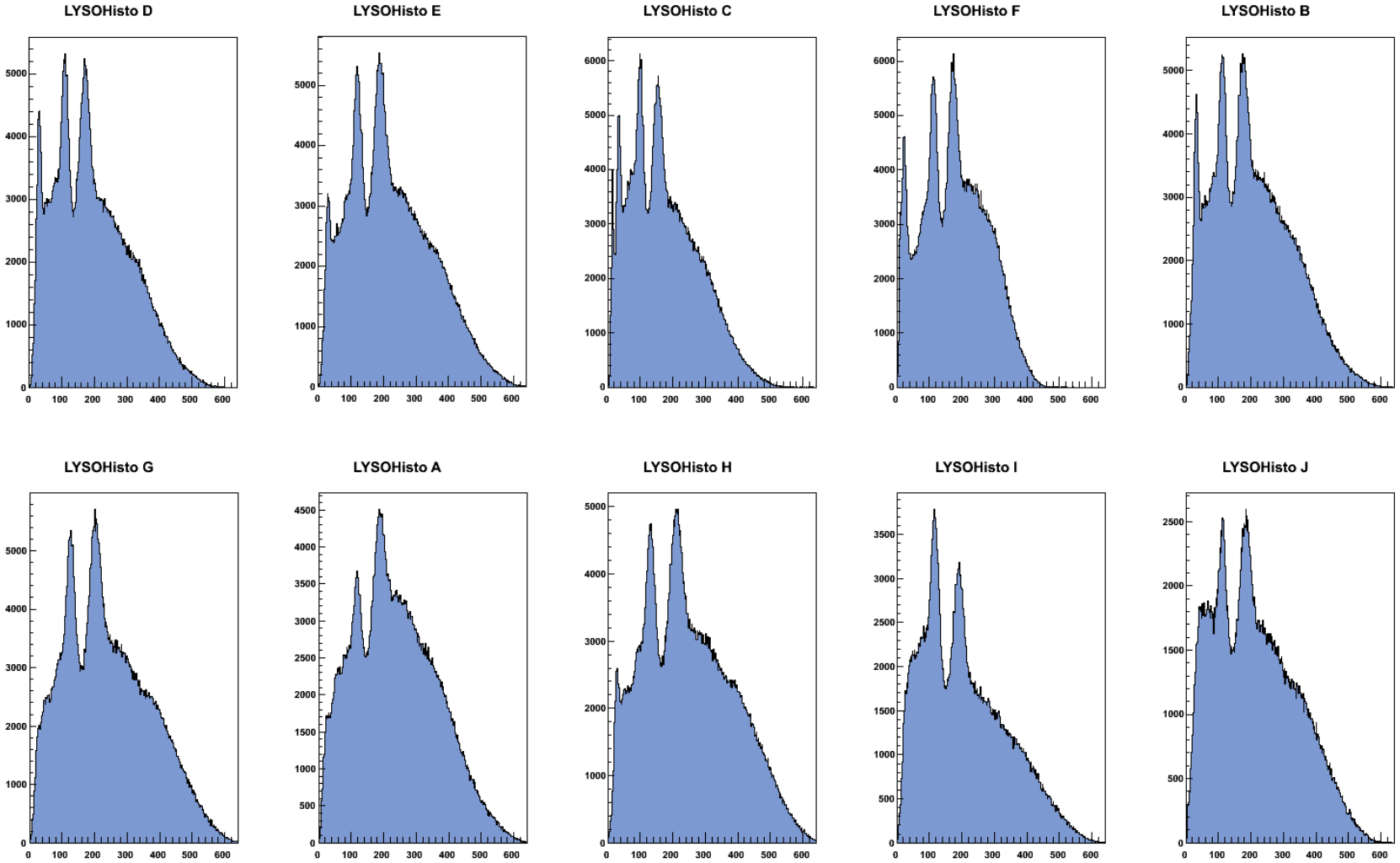
12 WLS

10 LYSO

Connected to COMPET readout

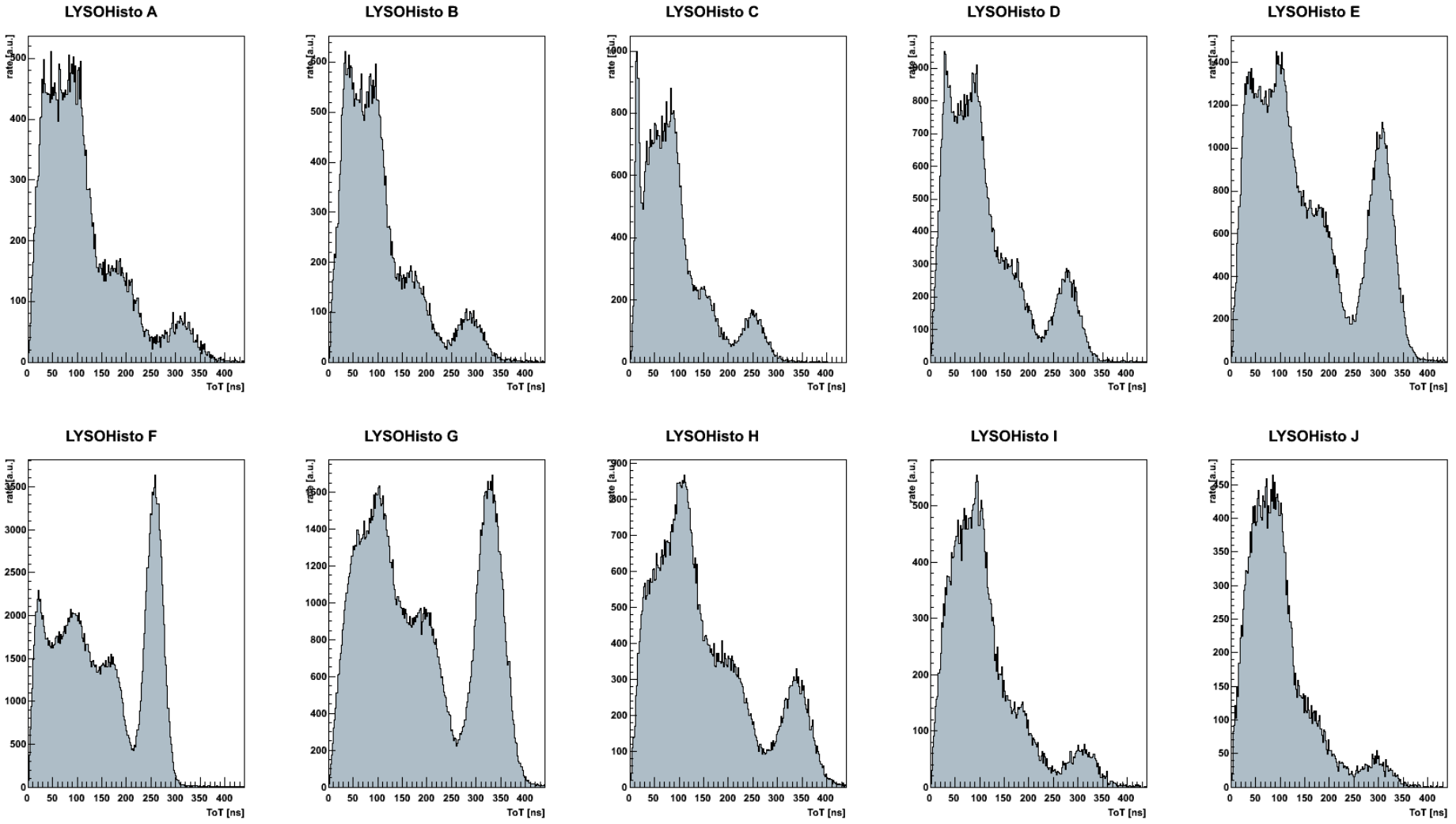


Intrinsic Spectra (LYSO)



Peaks at: 202keV, 303keV

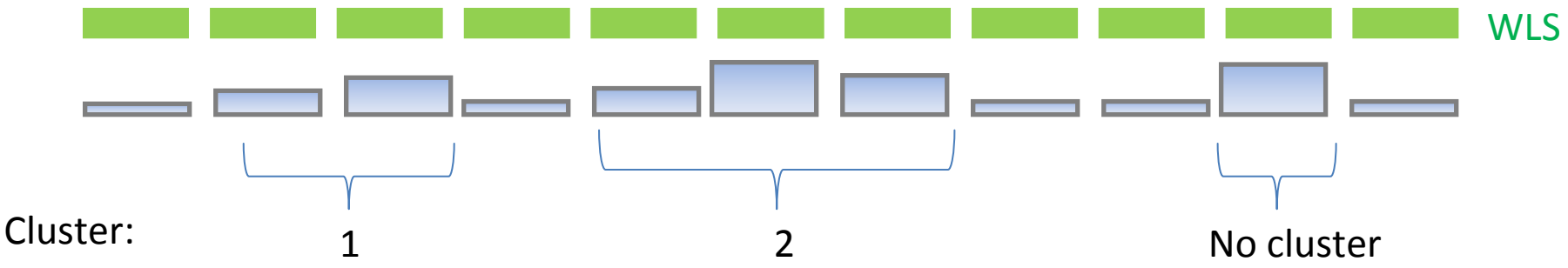
Coincidence LYSO Spectra



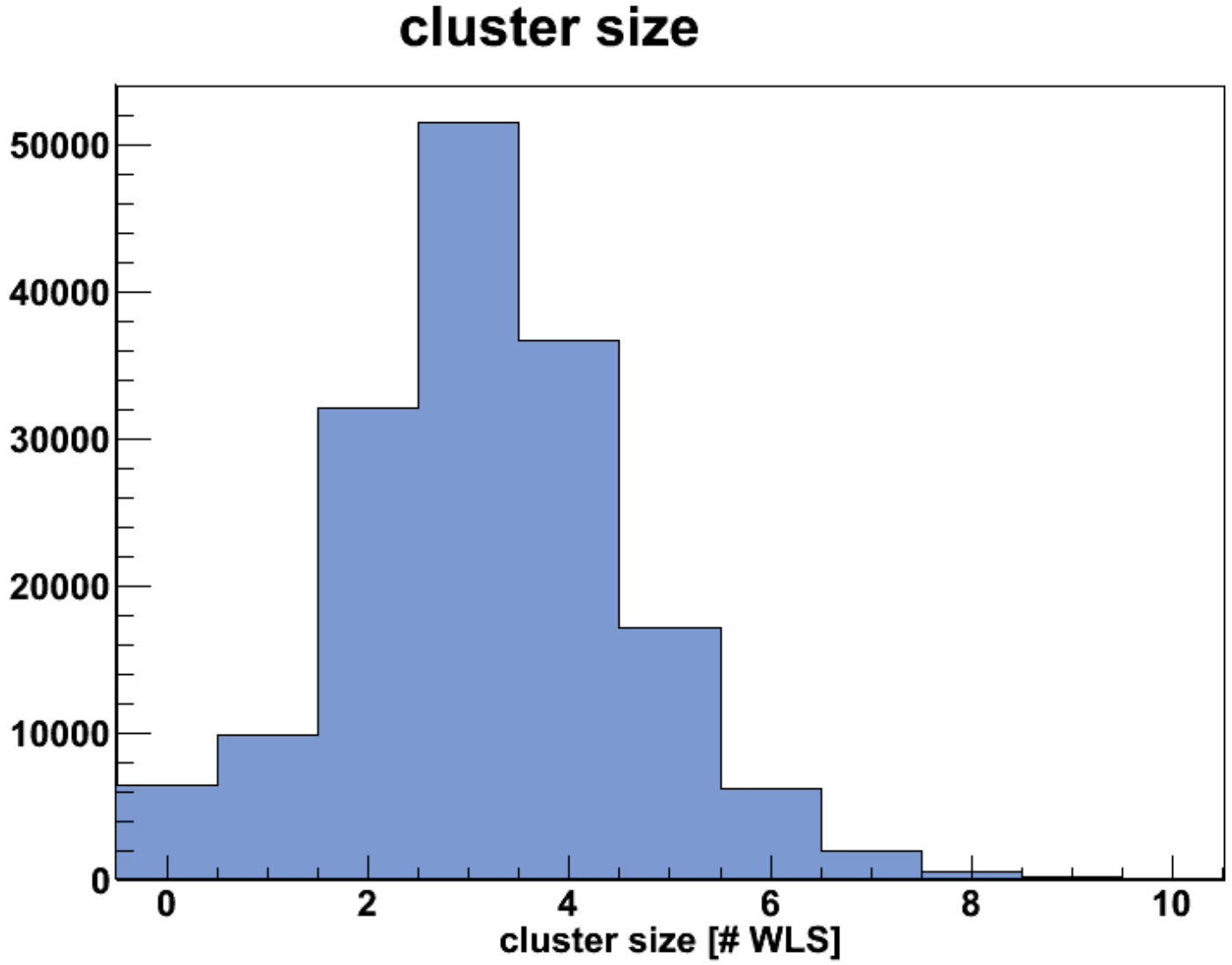
Energy resolution (@511keV**):** **13% (FWHM)** , zero point calibration with intrinsic spectrum

Analysis

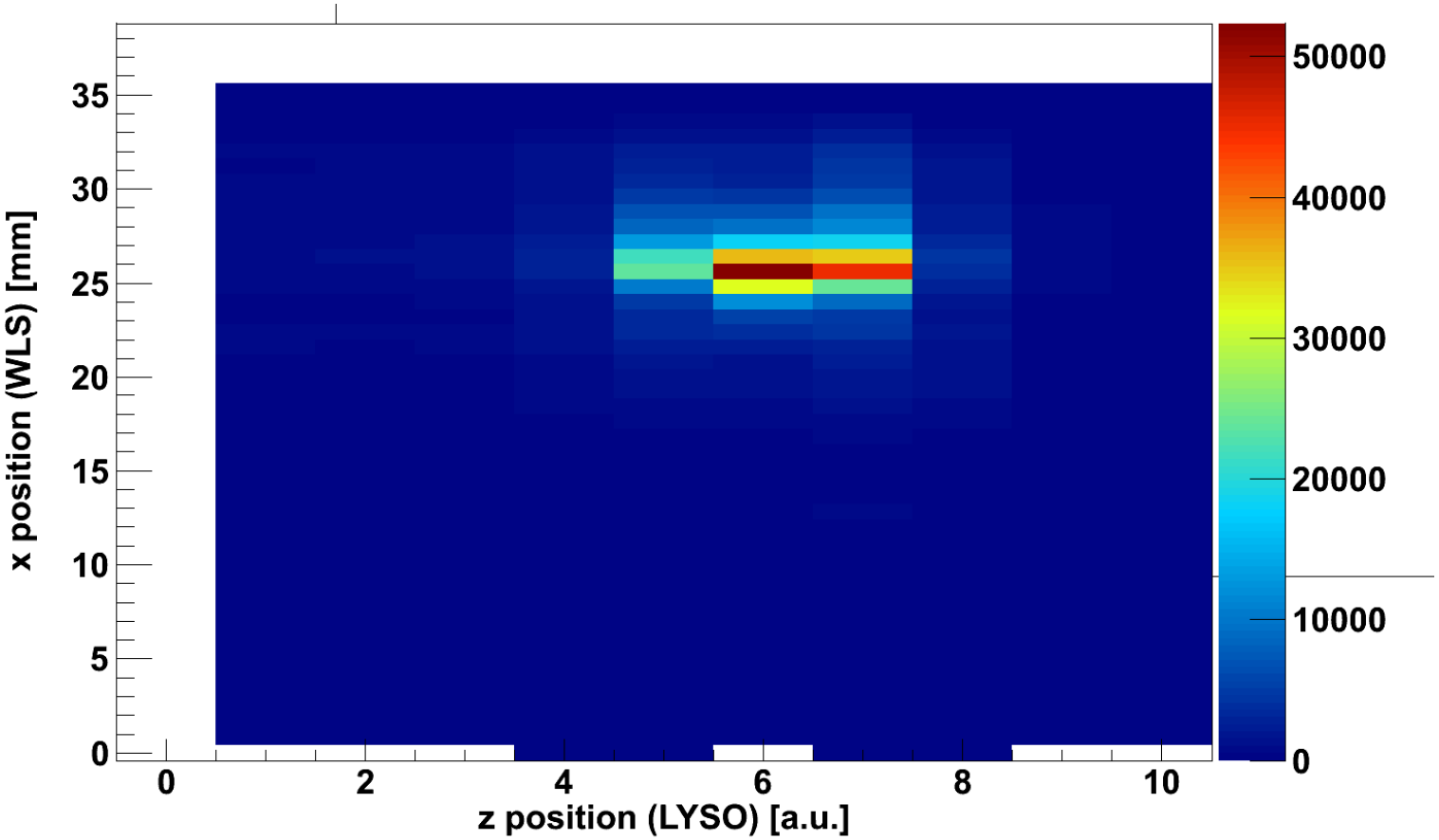
- For each hit in a LYSO crystal search for WLS hits.
- A WLS cluster consists of at least 2 adjacent WLS
- Compute the center of gravity for the cluster with the largest integrated signal



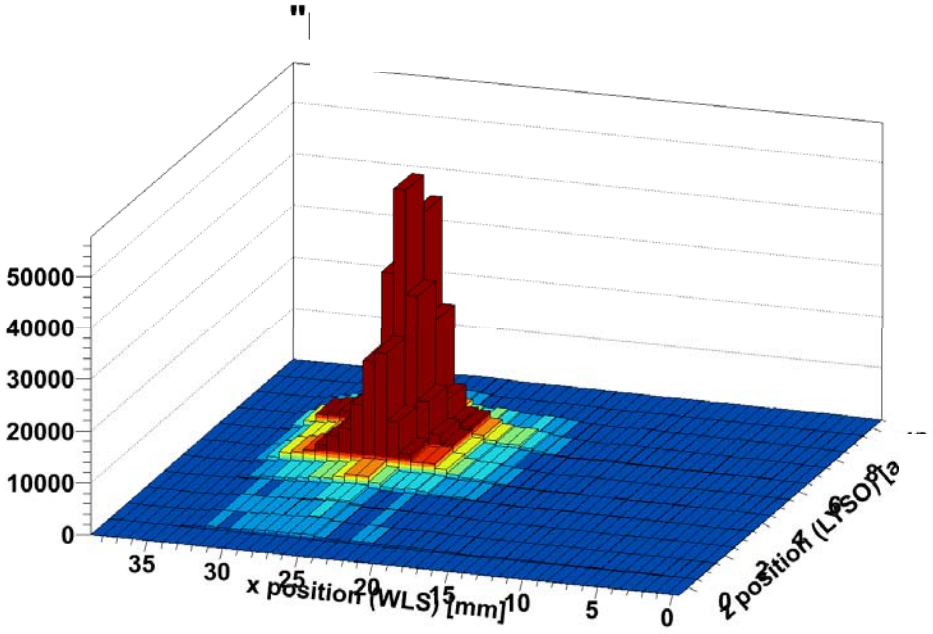
Cluster Size Distribution, E>400keV



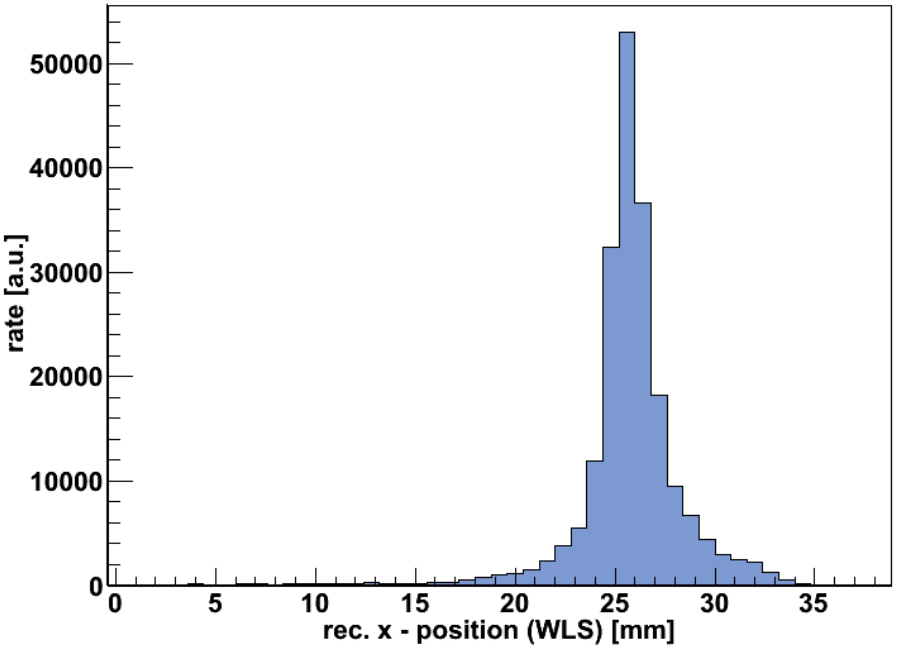
Results: Hit Map



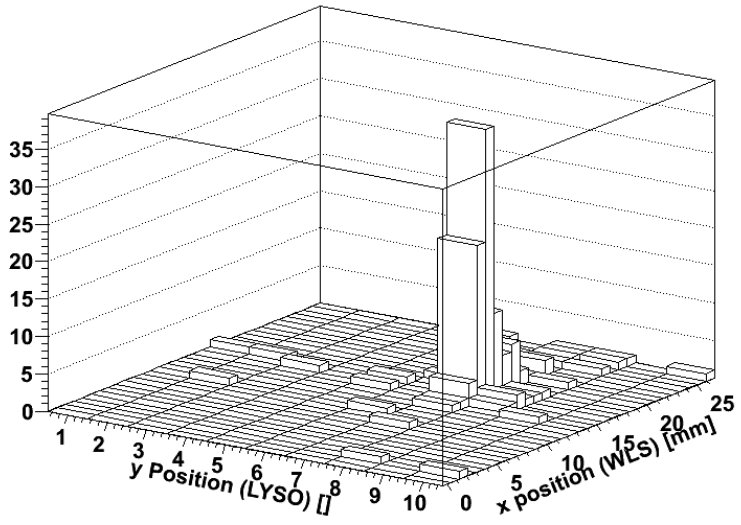
Results: Hit Map



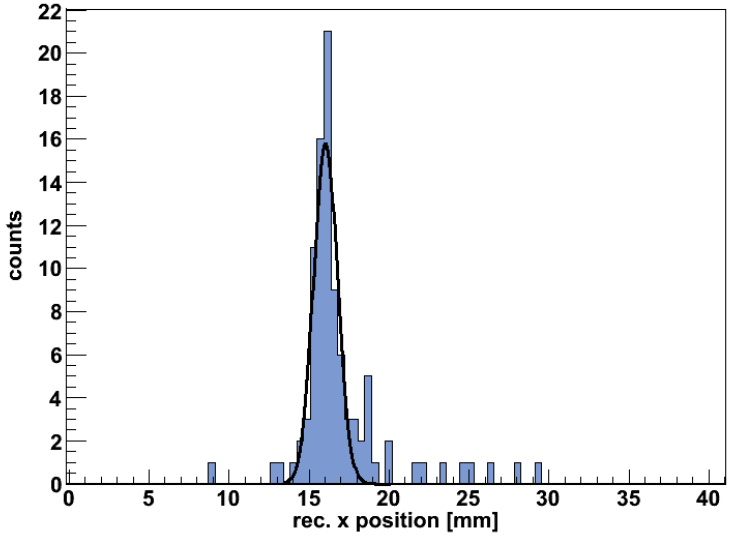
FWHM: 2.5 mm
~ source size



Source 2: Weak Na-22



FWHM: 1.8 mm
~ source size



Summary

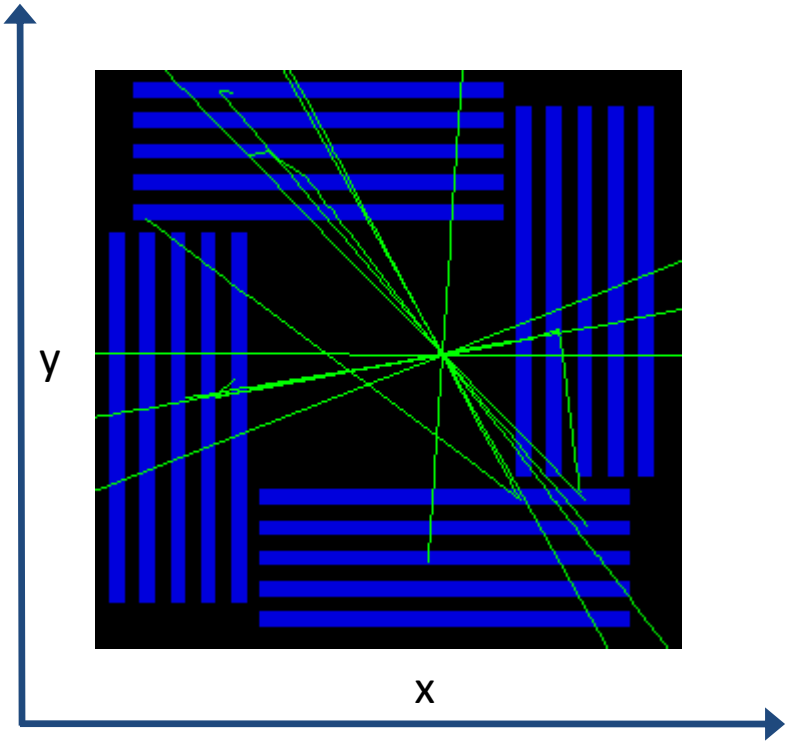
- A high resolution + high sensitivity scanner is being implemented
- Readout scheme (ToT + FPGA-QDC + trigger + readout software) works.
  Bottleneck: Write speed to disk. Maximal rate/computer: 200kcps
- One half-layer assembled.

Backup: Simulations

Simulations: Setup

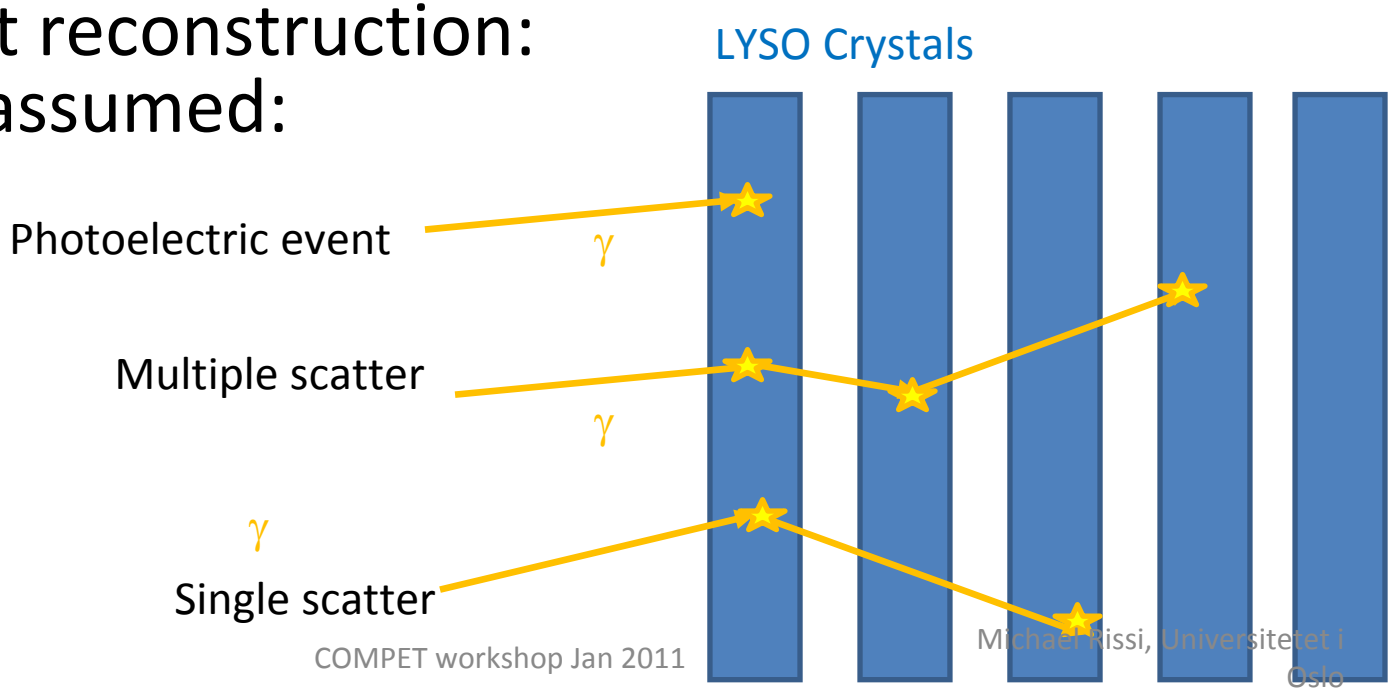
- Gate v5.0.0p01
- Readout based on hits
- List Mode output (ROOT)
- trigger condition:
  - **Total** deposed energy in 2 modules > 450 keV

Simulation of back-to-back gamma rays (511 keV) and ^{18}F in water.

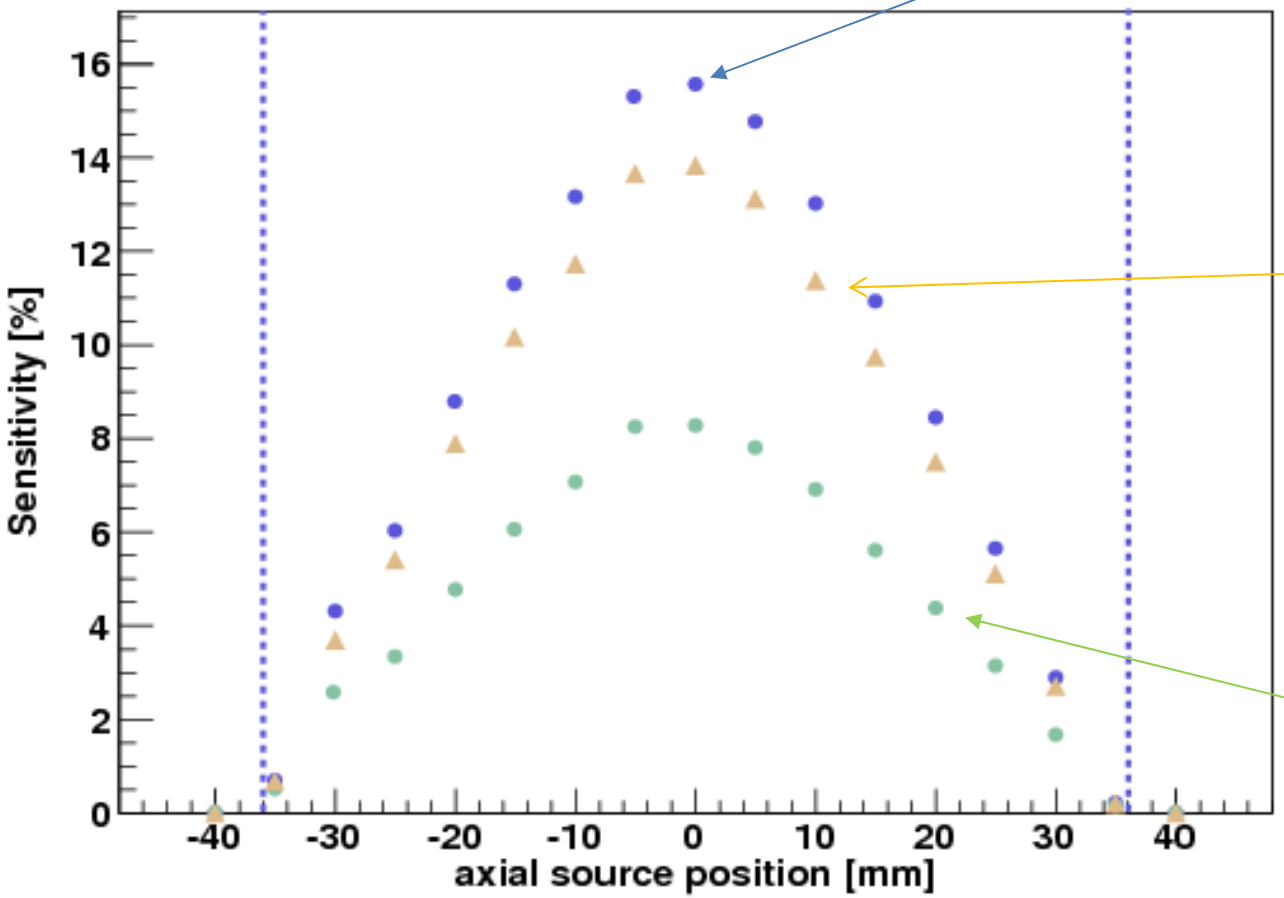


Detector Sensitivity Simulation

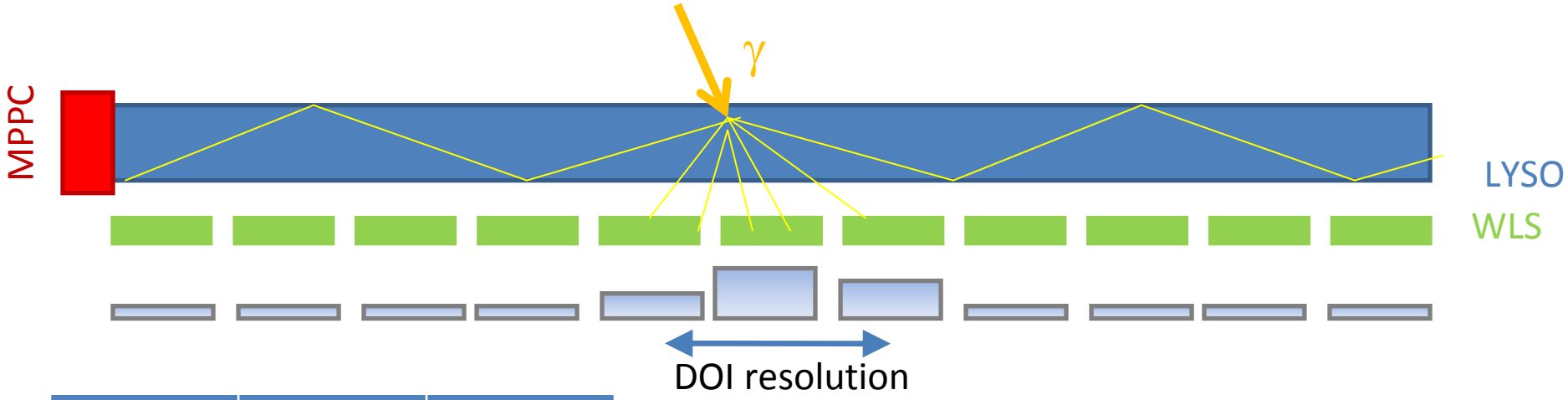
- Source for sensitivity simulations: back to back gammas (511 keV)
- 5 layers, 4 modules
- Diameter: 50 mm, Length: 72 mm
- 3D event reconstruction:
  3 cases assumed:



Detector Sensitivity



Central Point Source Resolution



σ(DOI) [mm]	FWHM$_x$ [mm]	FWHM$_y$ [mm]
0.3	0.75	0.76
0.4	0.82	0.80
0.5	0.86	0.86
0.6	0.93	0.94
0.7	0.96	0.99
0.8	1.18	1.22