Readout systems for GEMINI CHIP

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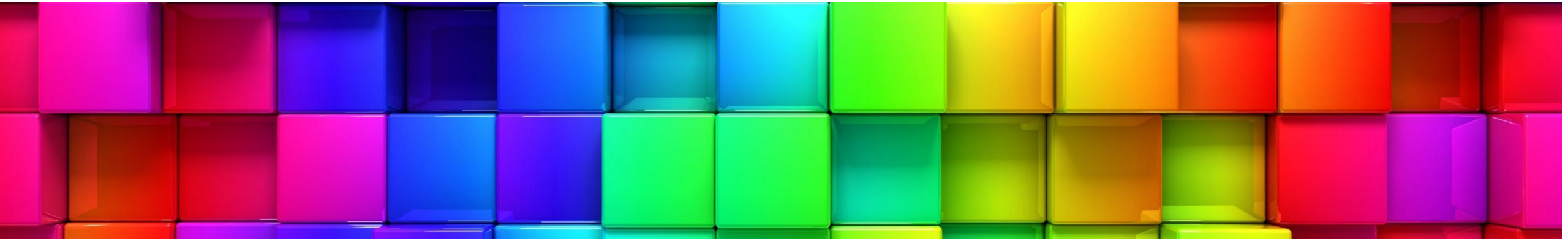
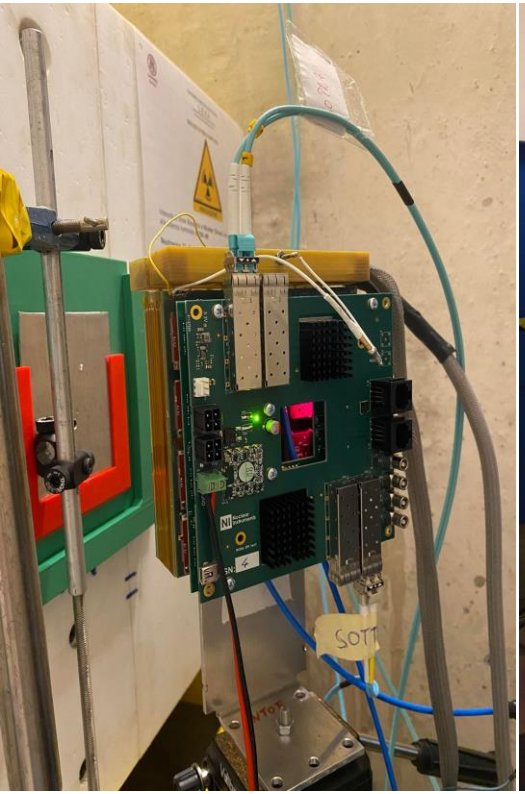
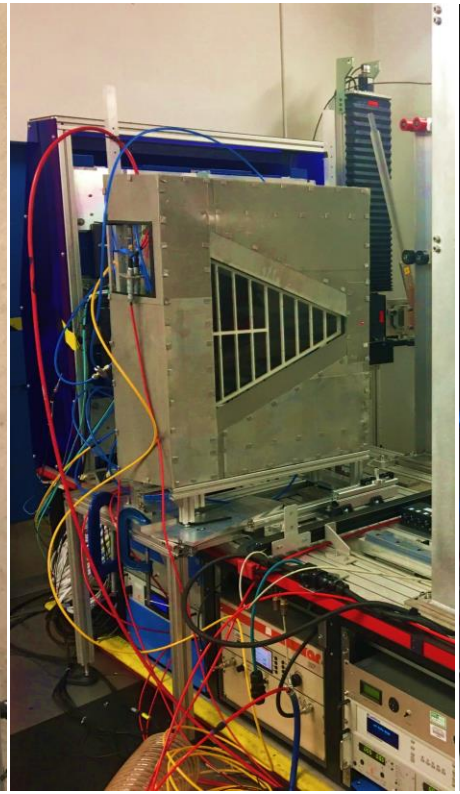
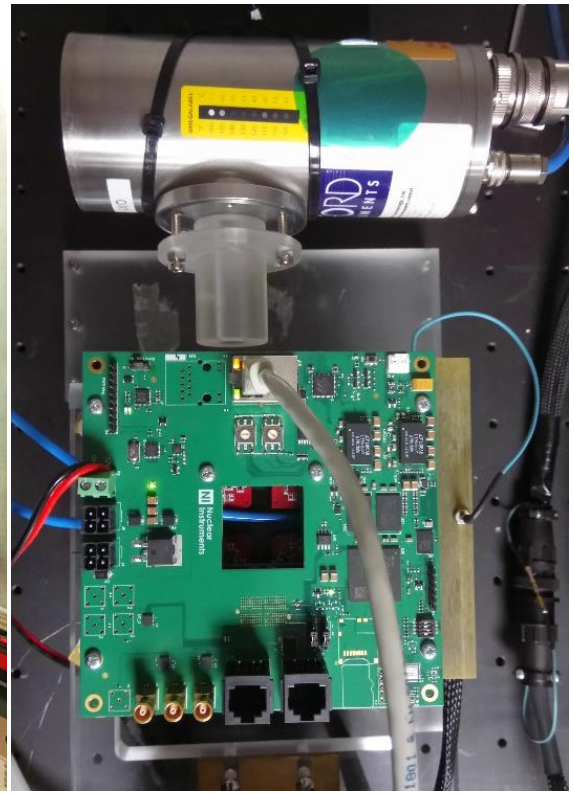
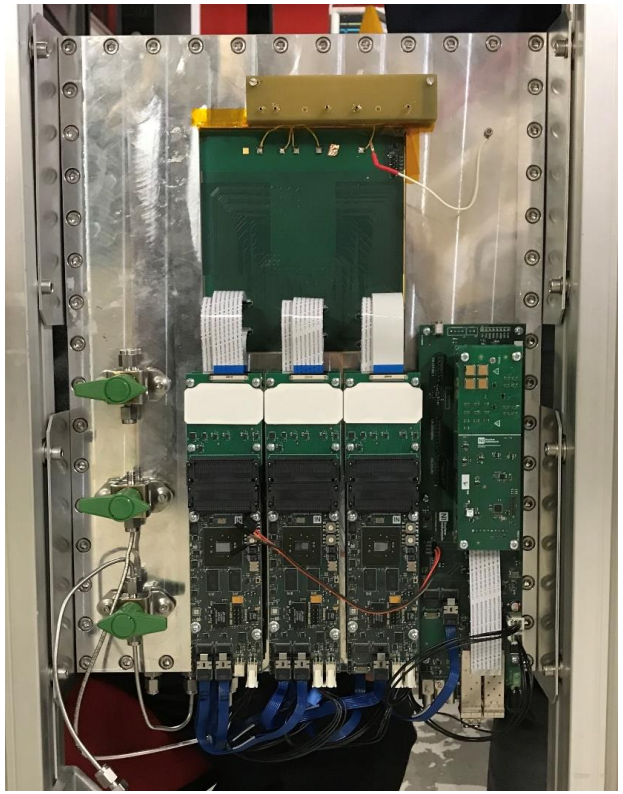
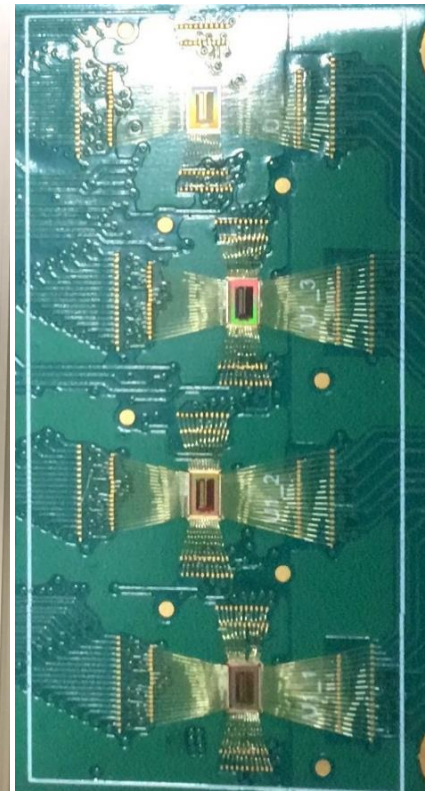
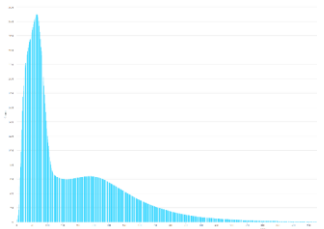
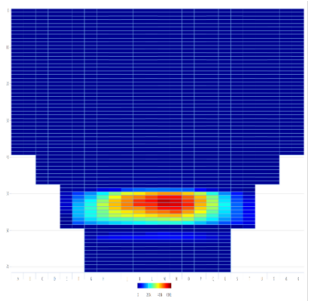
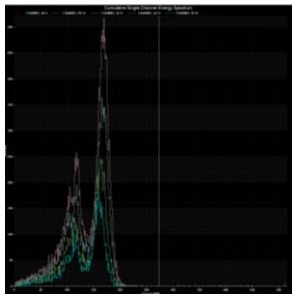
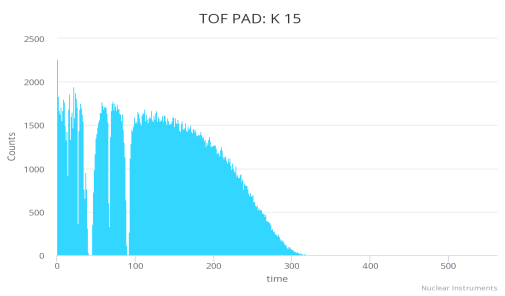
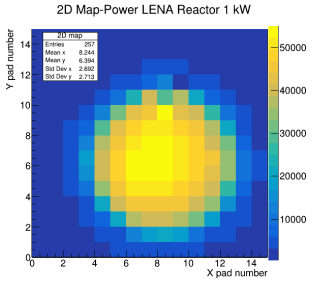


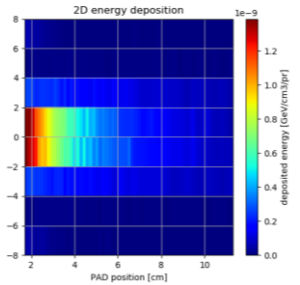
1. Nuclear Instruments SRL
2. Università degli studi Milano Bicocca
3. ENEA - Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile
4. CERN
5. ISTP – Consiglio Nazionale delle Ricerche
6. ISIS Neutron and Muon Source – STFC
7. INFN – Istituto Nazionale Fisica Nucleare

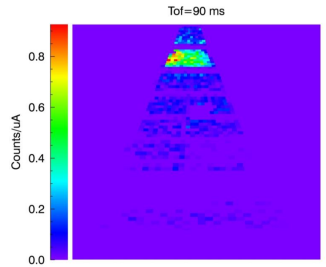
Readout system for GEM/TH-GEM/MICROMEGAS/MSGC

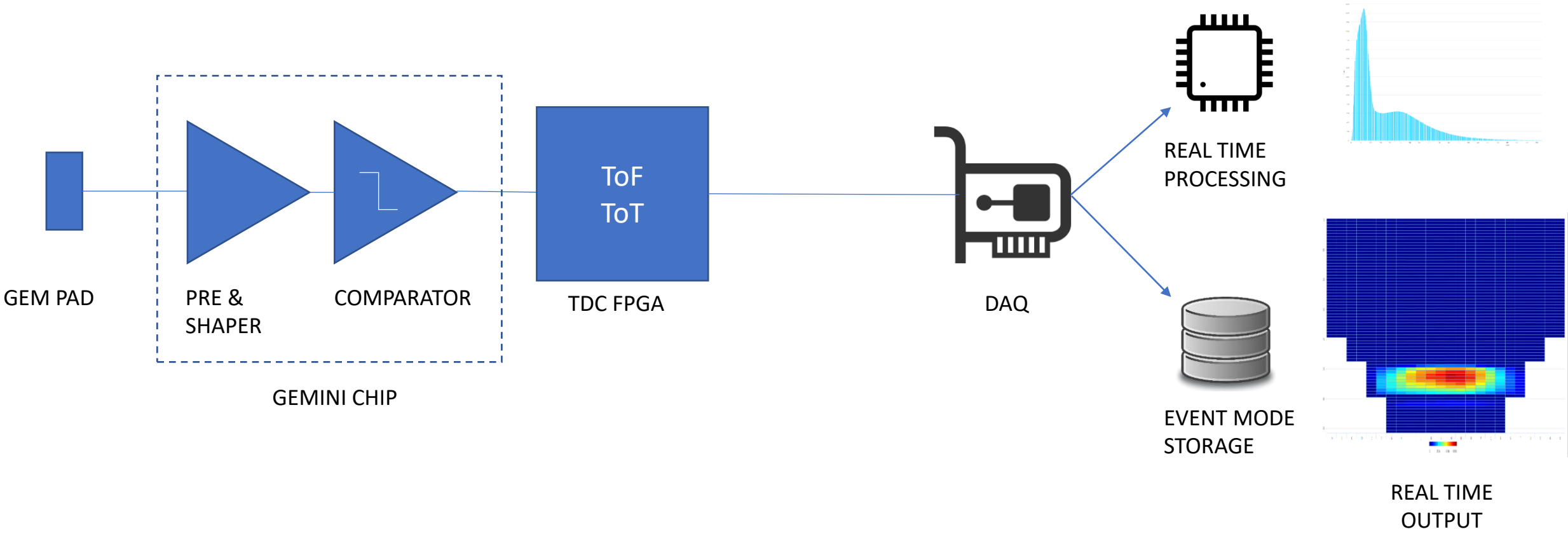









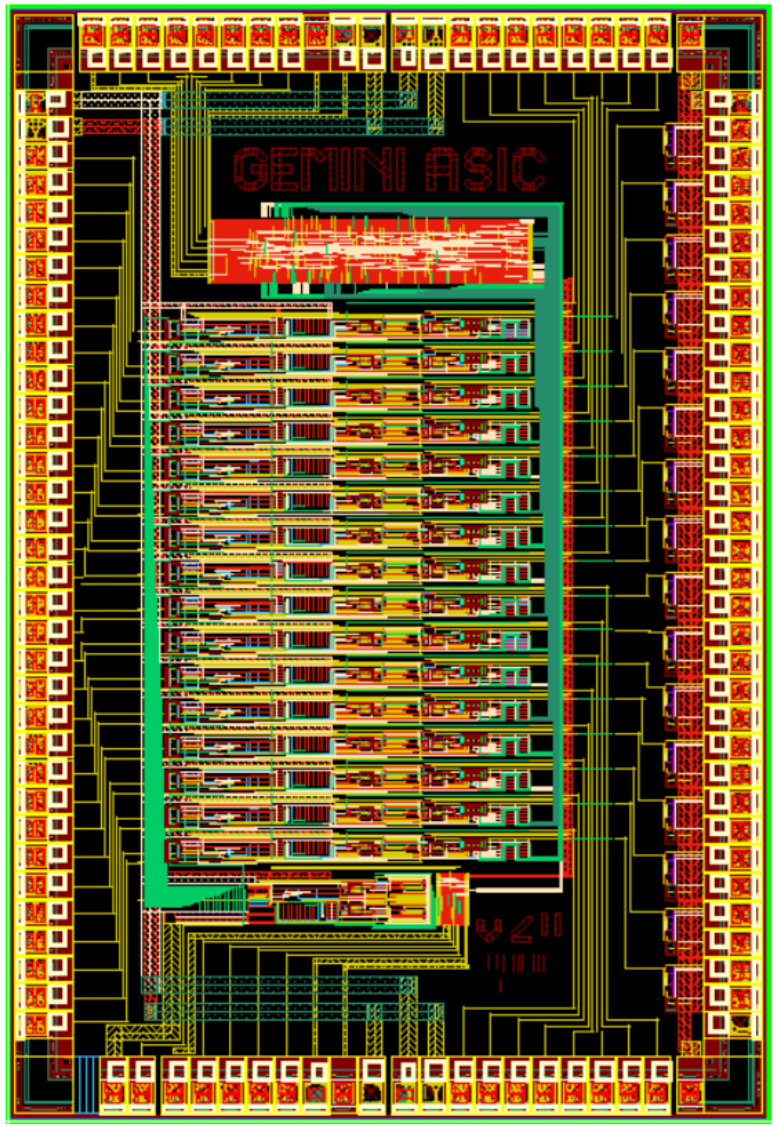


Introduction



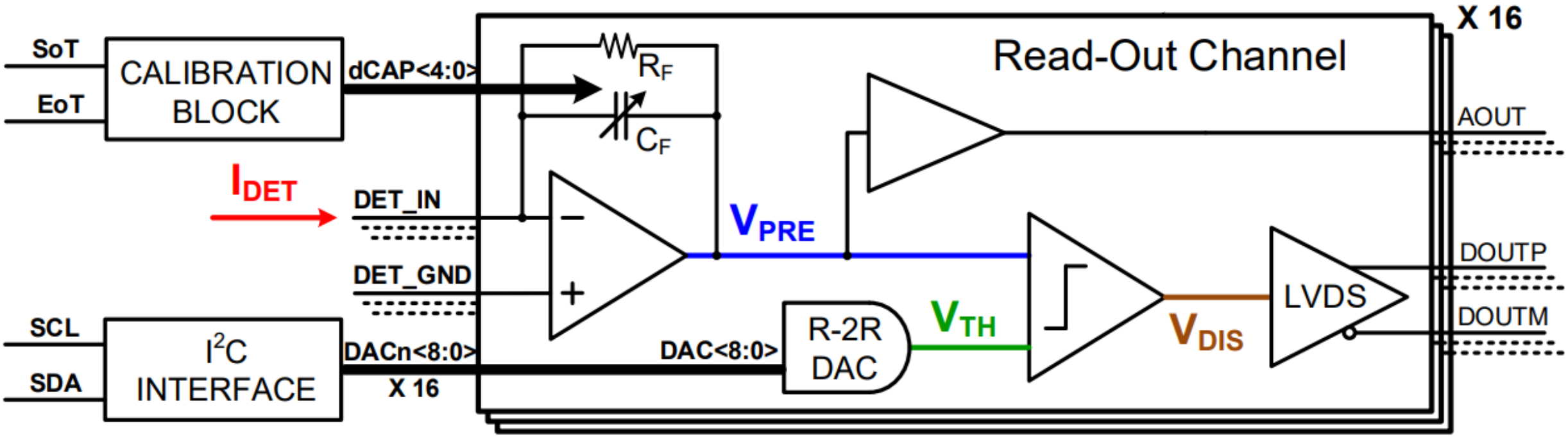
GEMINI CHIP AND CARRIER BOARDS

GEMINI CHIP



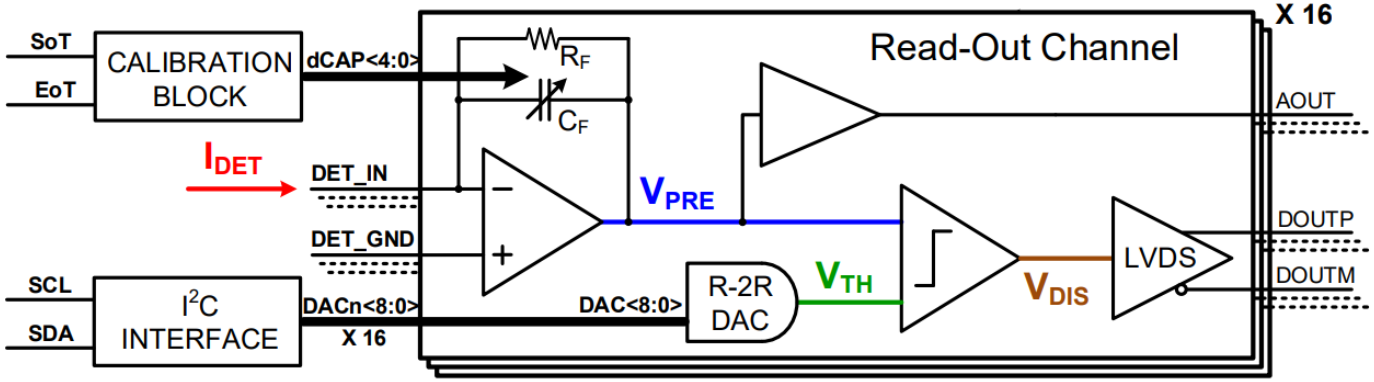
Parameter	Value
CMOS Technology	AMS IBM 180 nm
# of Channels	16
Max. Pixel Capacitance	40 pF
Max. Count Rate	5 Mcps
Sensitivity	2.5 fC
Power Consumption	2.7 mW/ch (With LVDS Driver: 10.7 mW/ch)
Analog Outputs	Preamp Output (for each channel)
Digital Outputs	LVDS Event Detection (for each channel)
Max. Digital Output Jitter	6.2 ns
Q-V Gain	1 mV/fC
Dynamic Range	From 30 fC to 500 fC
CSP Common Mode Voltage	1 V
Reset Mode	Event-Triggered or External

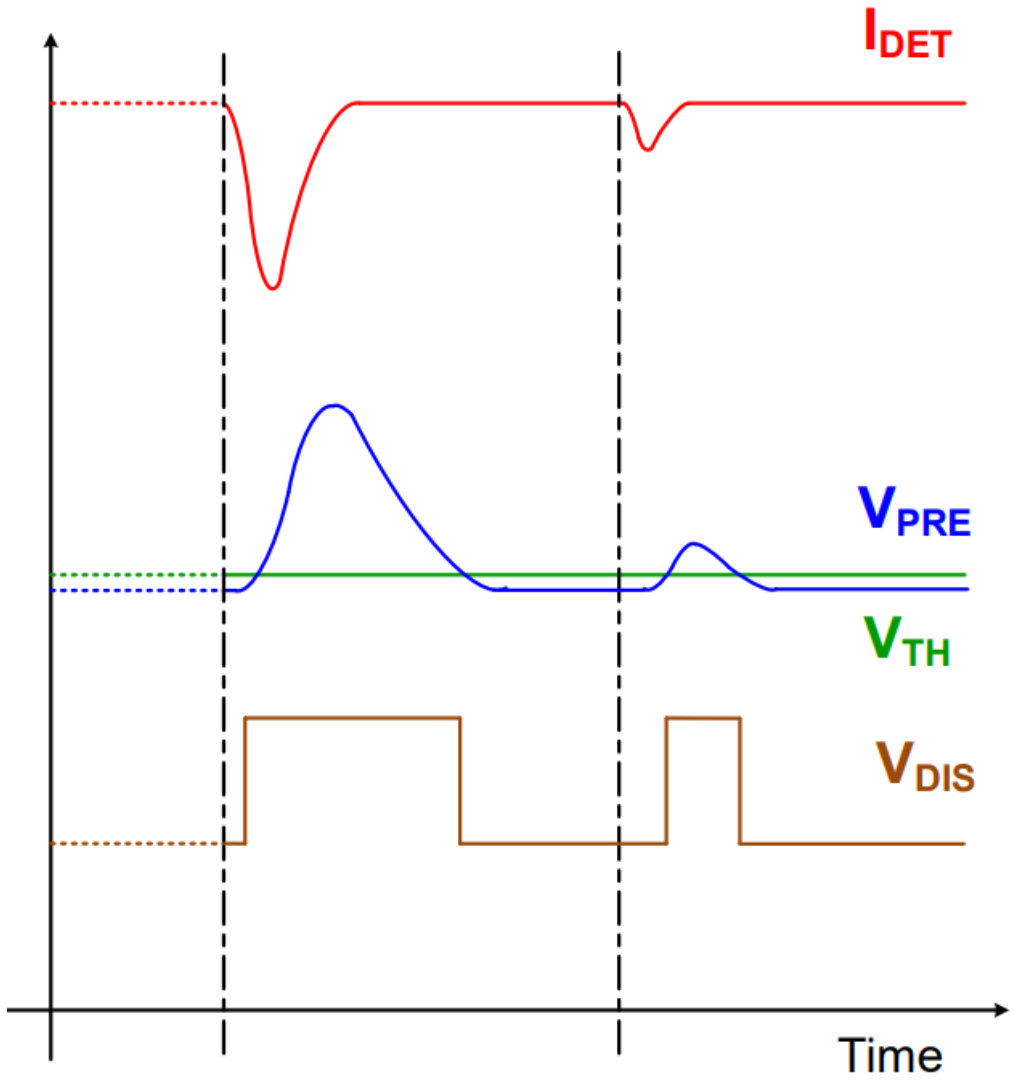
GEMINI CHIP



https://indico.cern.ch/event/697988/contributions/3055898/contribution.pdf

GEMINI CHIP



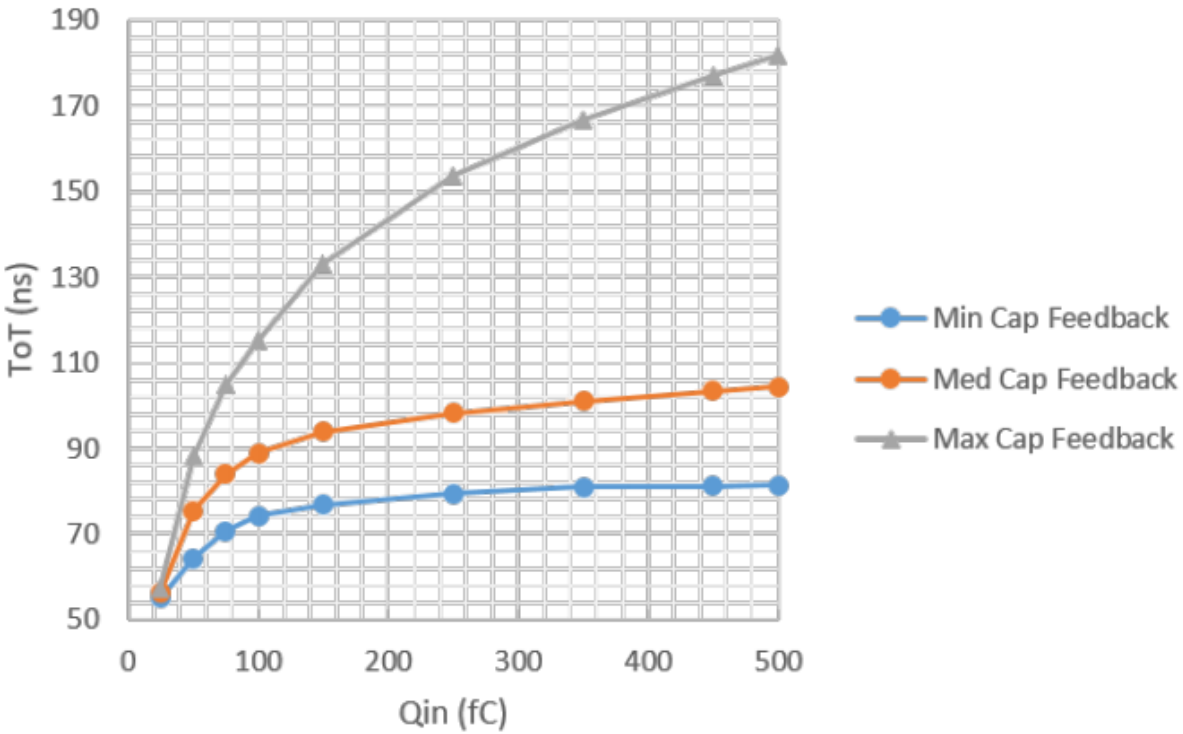


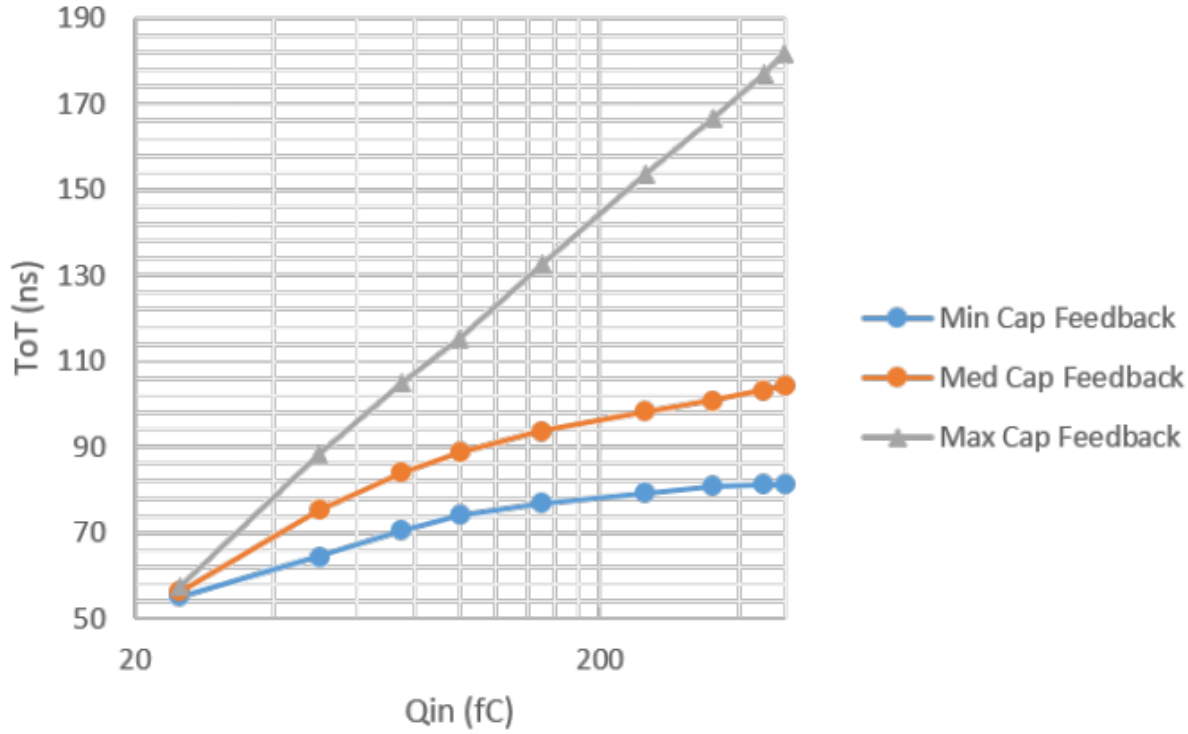
A. Pezzotta, G. Corradi, G. Croci, M. Matteis, F. Murtas, G. Gorini, A. Baschirotto

GEMINI: A triple-GEM detector read-out mixed-signal ASIC in 180nm CMOS

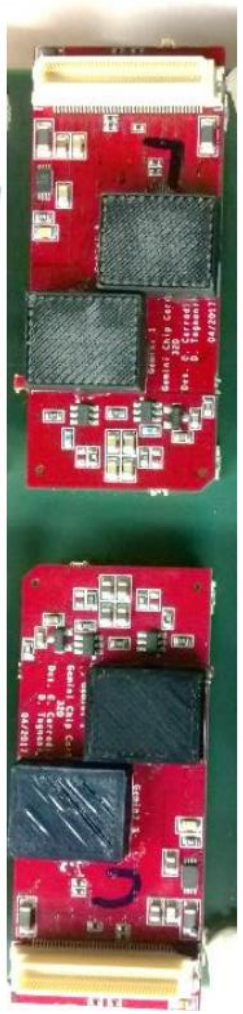
DOI:10.1109/ISCAS.2015.7168984
https://ieeexplore.ieee.org/document/7168984

GEMINI CHIP


190
170
150
130
110
90
70
50
ToT (ns)
0
100
200
300
400
500
Qin (fC)
Min Cap Feedback
Med Cap Feedback
Max Cap Feedback

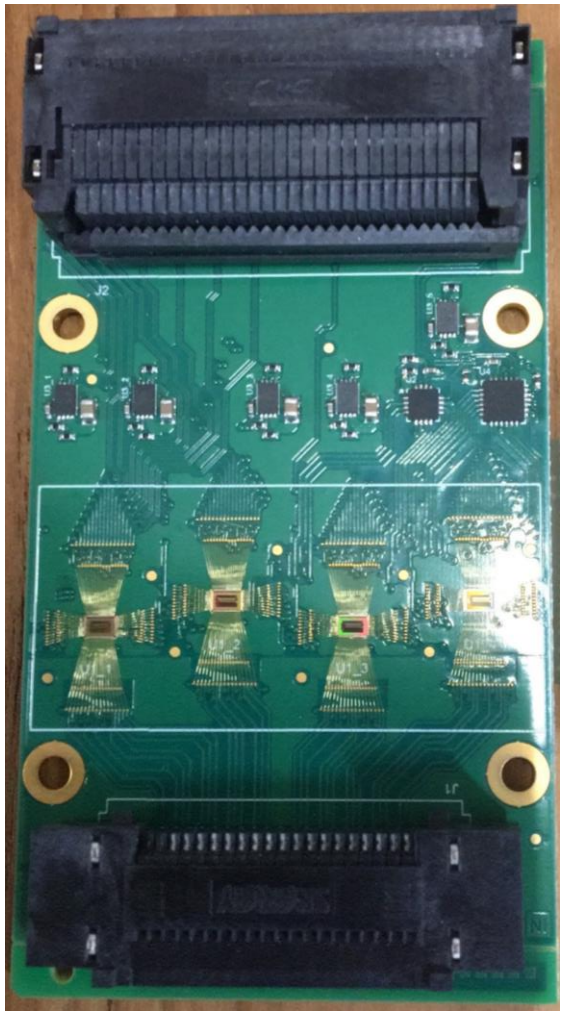

190
170
150
130
110
90
70
50
ToT (ns)
20
200
Qin (fC)
Min Cap Feedback
Med Cap Feedback
Max Cap Feedback

GEMINI ASIC BOARD



32-D

2 ASIC x BOARD

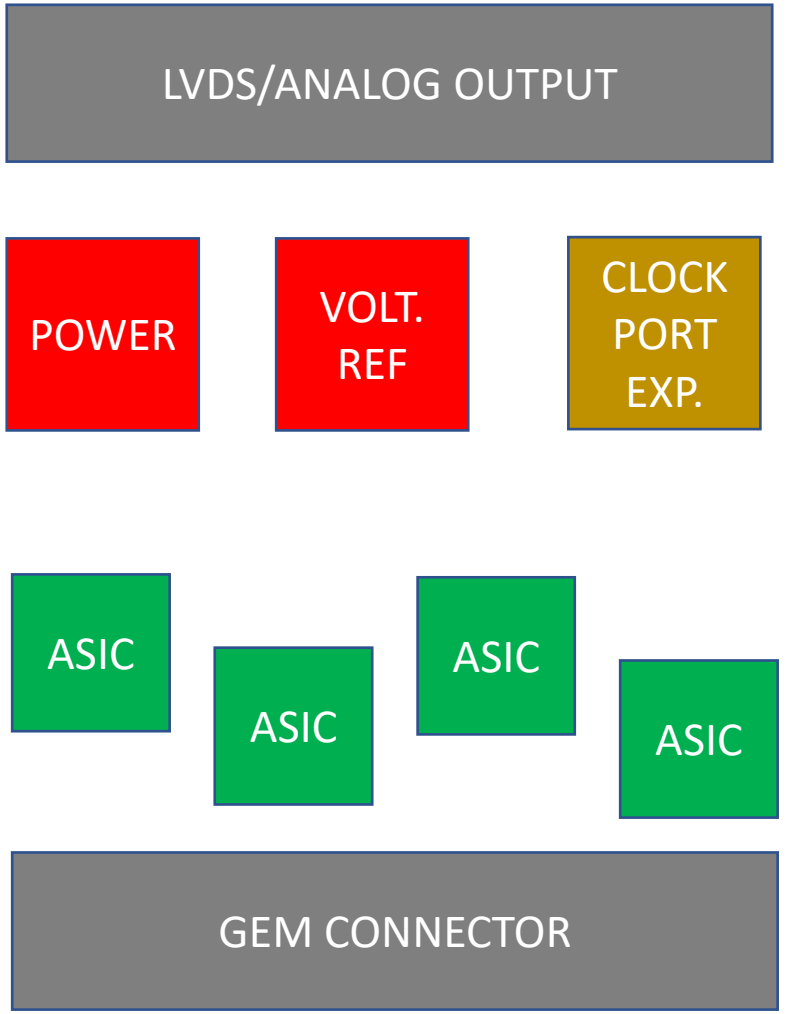


64-D

4 ASIC x BOARD

32-A

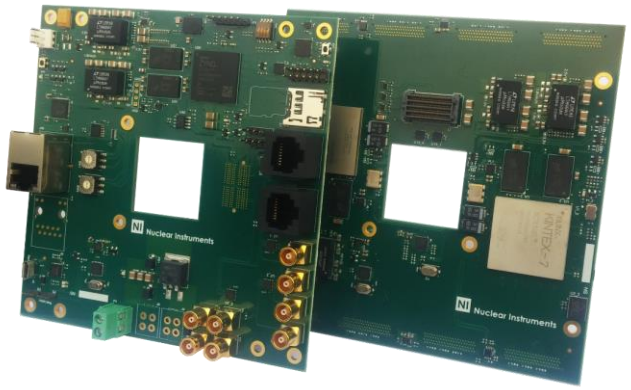
2 ASIC x BOARD (32Digital+32Analog)



FPGA READOUT FOR GEMINI BOARD

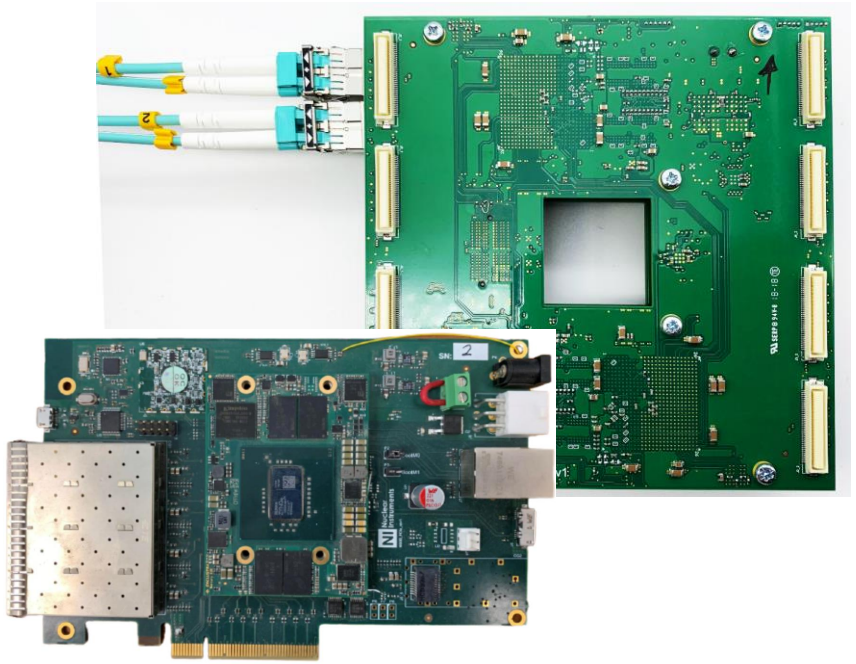
Scalable solutions for large area GEM detector

PORTABLE SYSTEM



- 256 channels Board
- Ethernet readout

ULTRA HIGH RATE

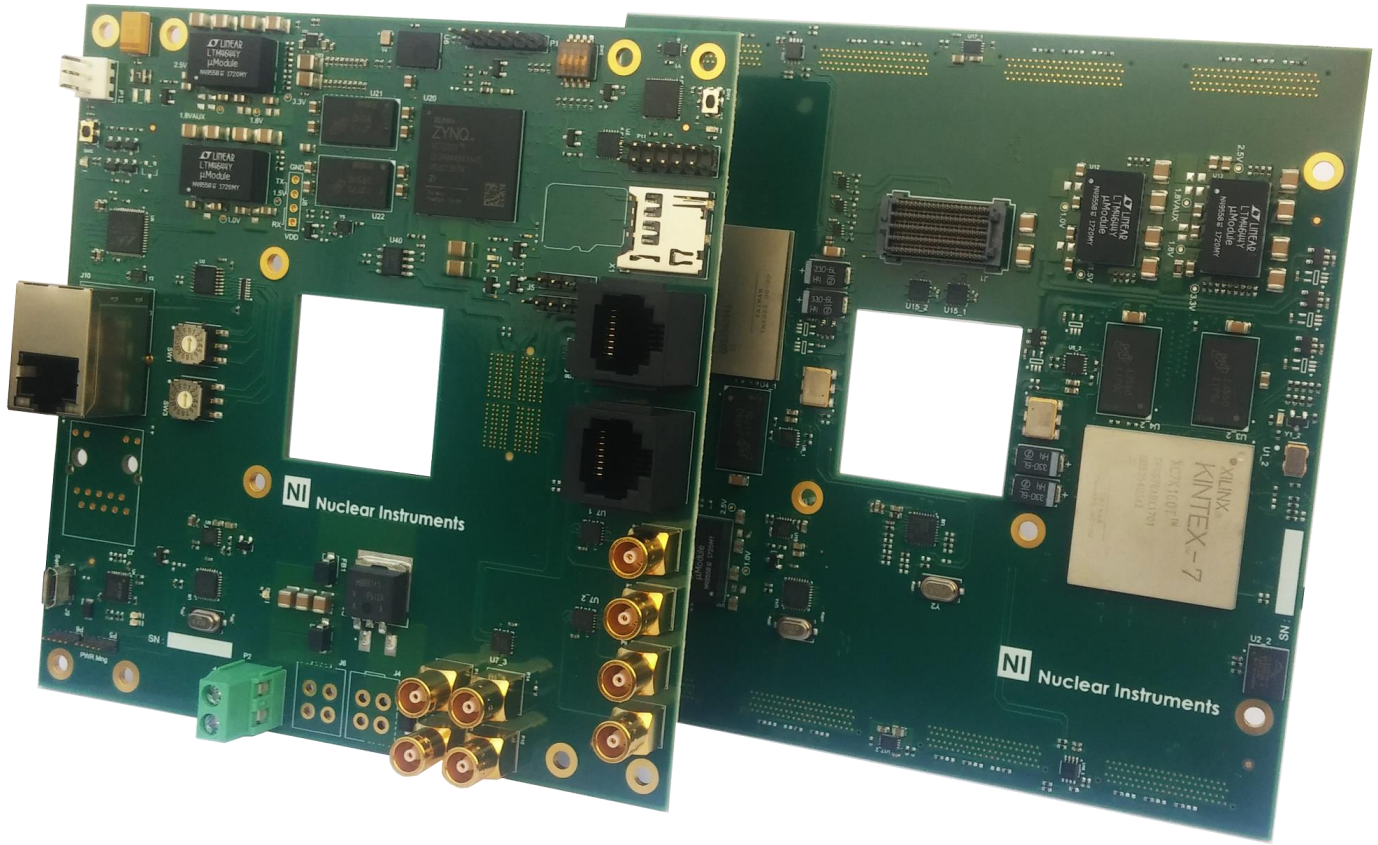


- 256 channels per board, no limit to total number of channels
- Operate in parallel and daisy chain
- Ultra high rate: 625 Mevent/s per board
- PCIe readout via optical link

SCALABLE SOLUTION FOR HIGH CHANEL COUNT

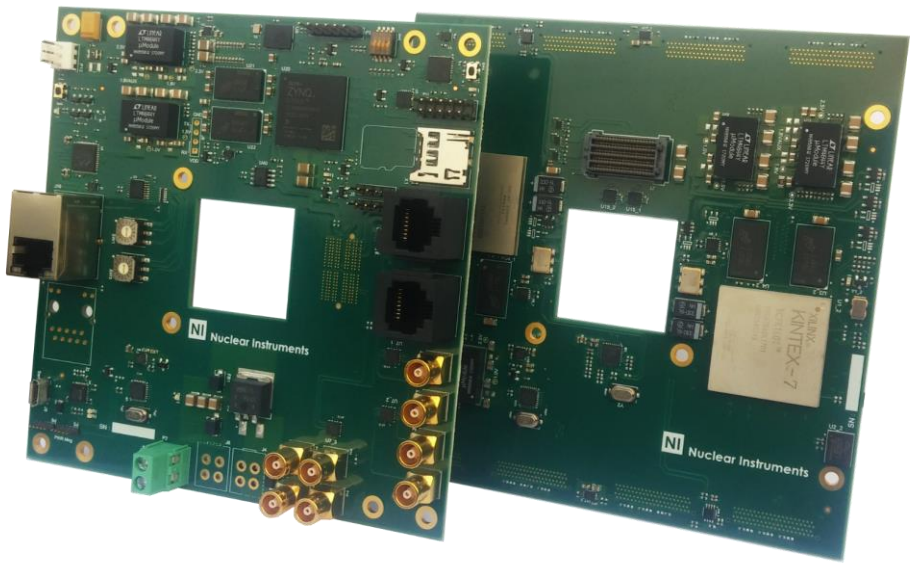
- 64 channels per board, no limit to total number of channels
- Operate in daisy chain
- Ultra high rate: 100 Mevent/s per link
- Compact form factor for (5cm width)
- Ideal to cover large area detector with reduced cabling

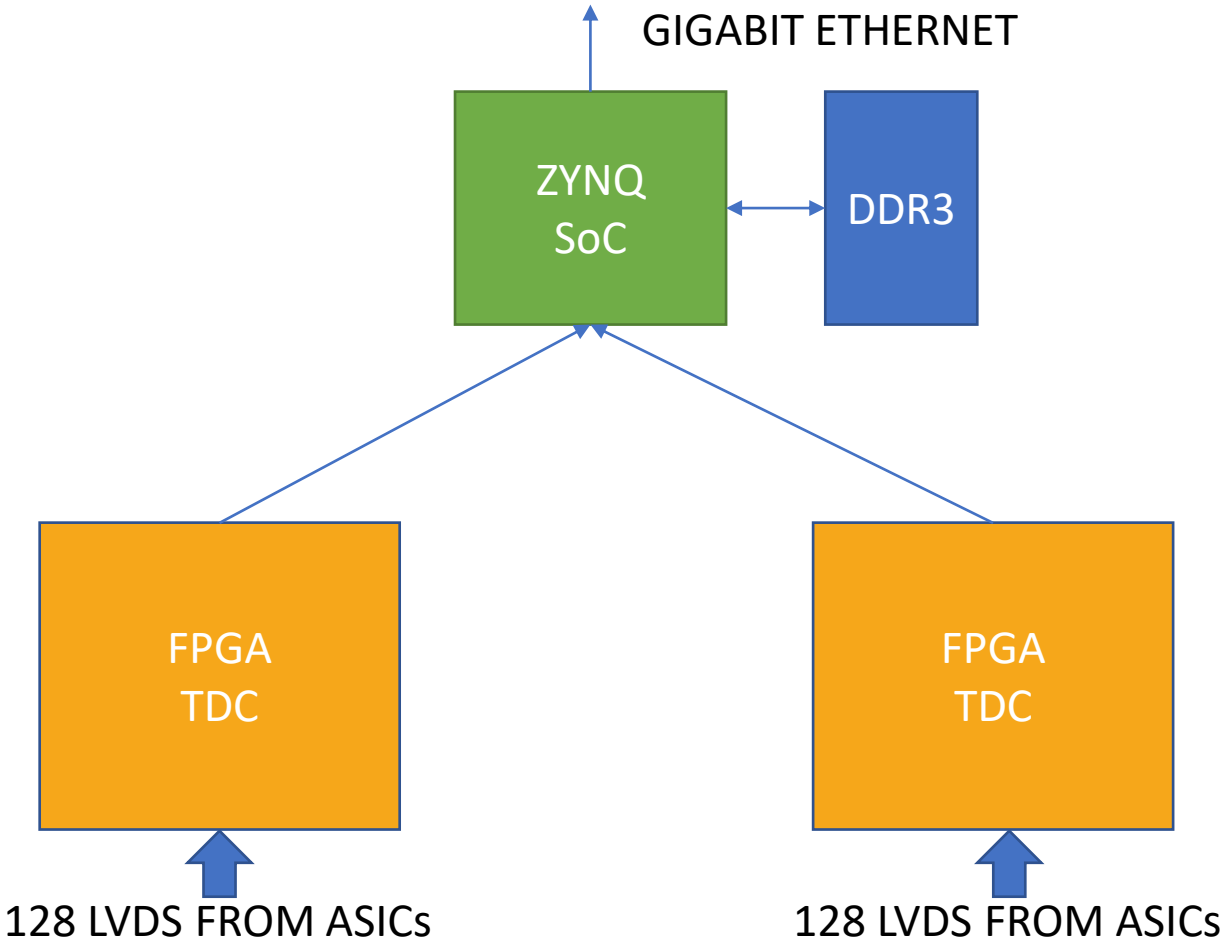
GEMINI 256 – ETHERNET READOUT



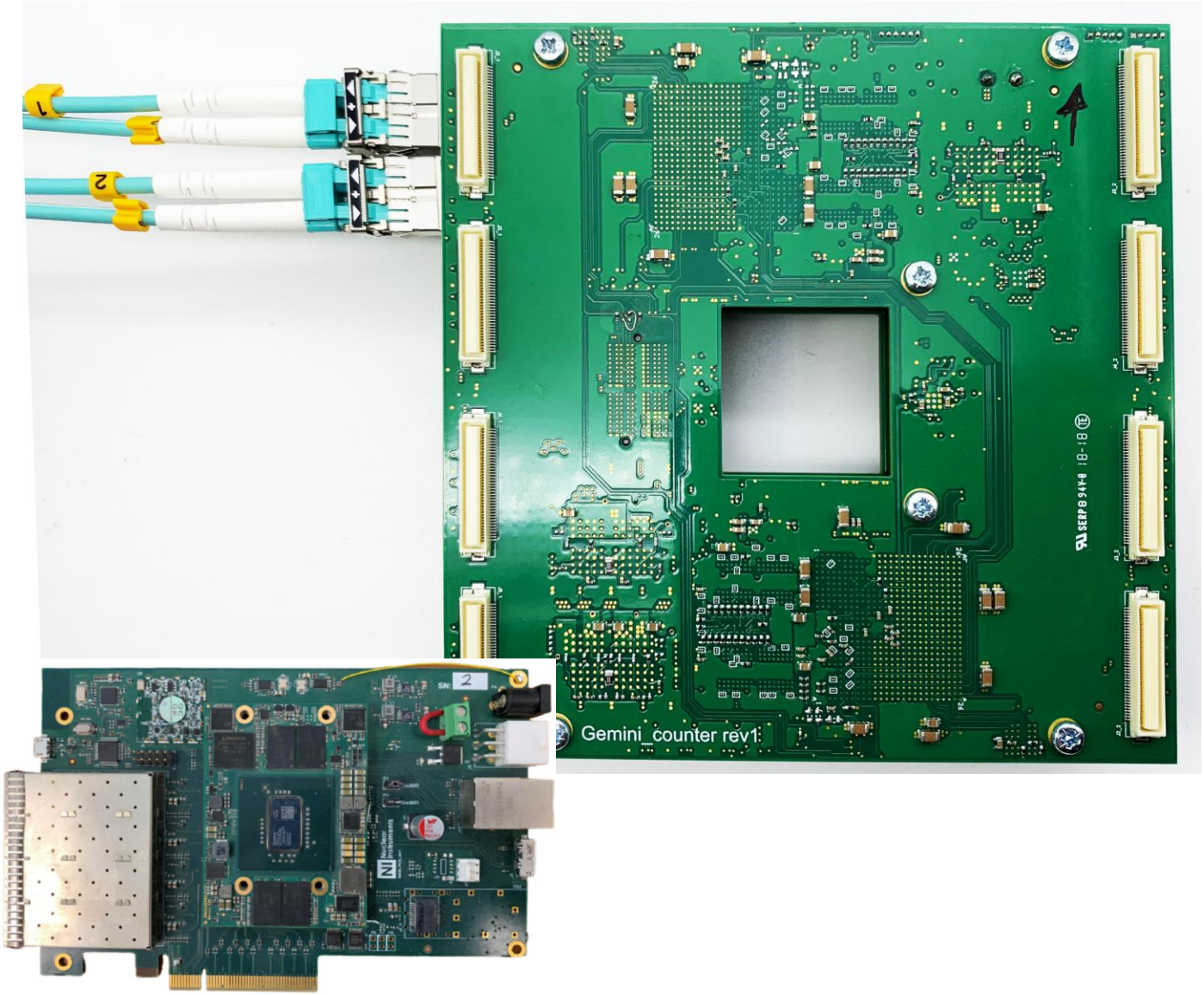
- Stand-alone unit
- Easy to interface to any PC/LAPTOP
- Single Ethernet cable
- Possibility to sync with external T0
- Windows full-featured software
- Up to 8 Mcps on full detector
- Low cost system (just the board)
- List Readout mode
- ToT, ToF and channel indexing

GEMINI 256 ETHERNET



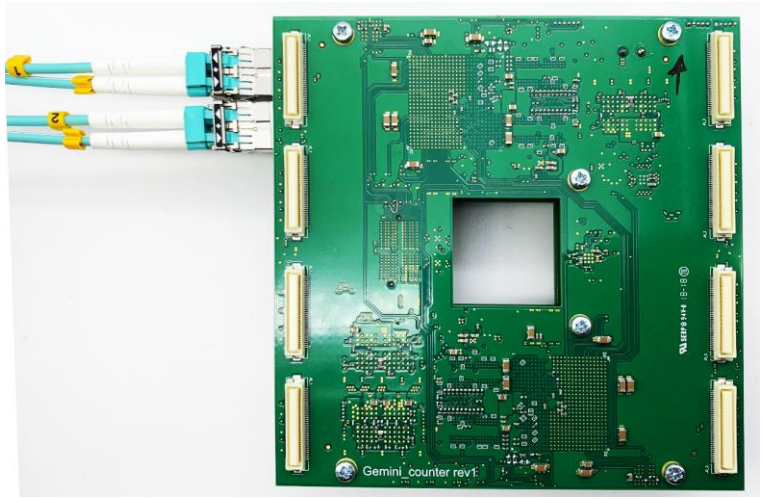


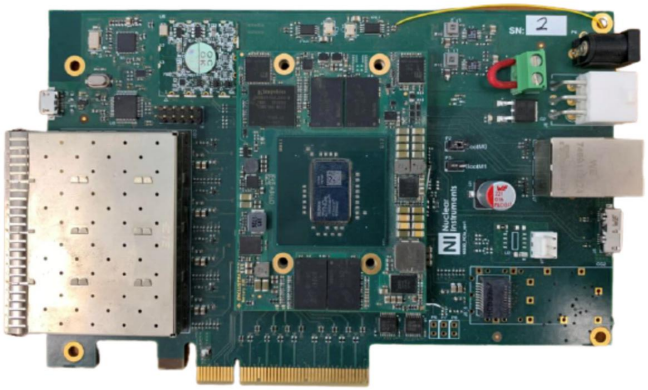
GEMINI 256 – FIBER READOUT

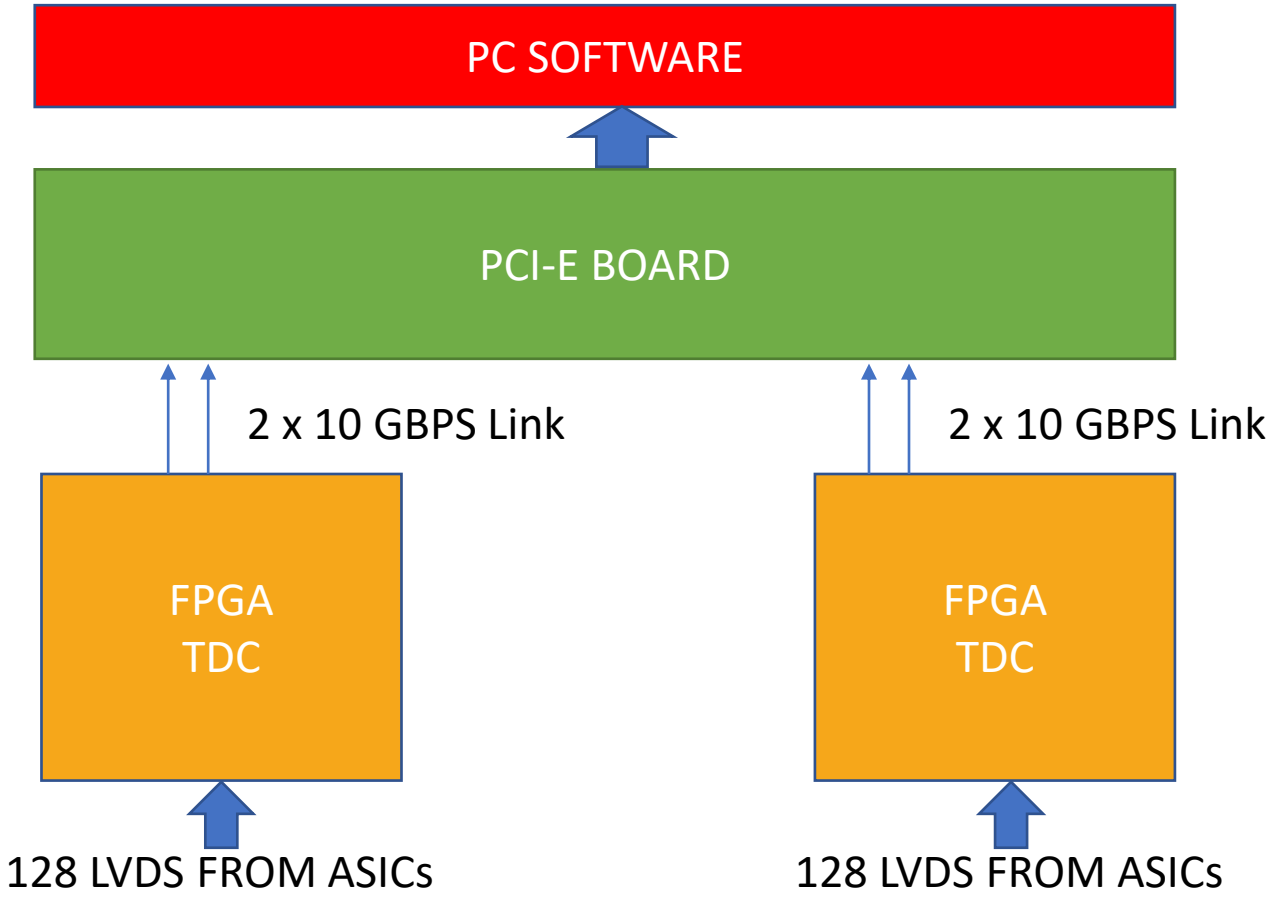


- Designed for high-performance
- 4x optical link @ 40 Gbps
- Tested at 400 Mevent/s per board in list mode
- PCI-E readout board
- ToT, ToF and channel indexing
- Synchronization between multiple board
- Hardware accelerated online monitor

GEMINI 256 FIBER

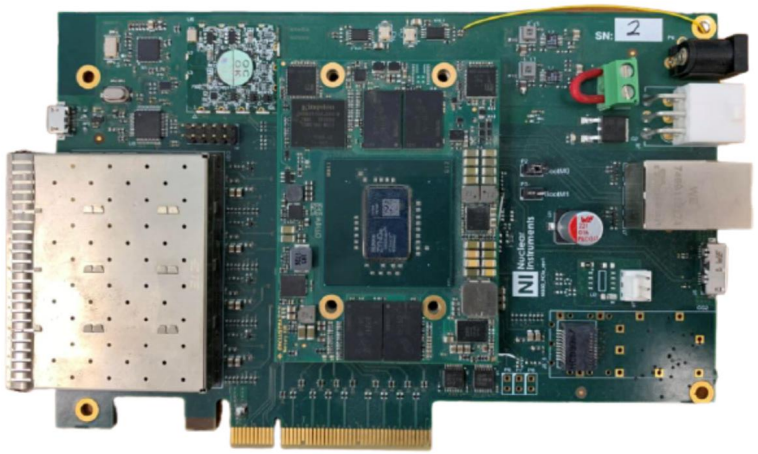


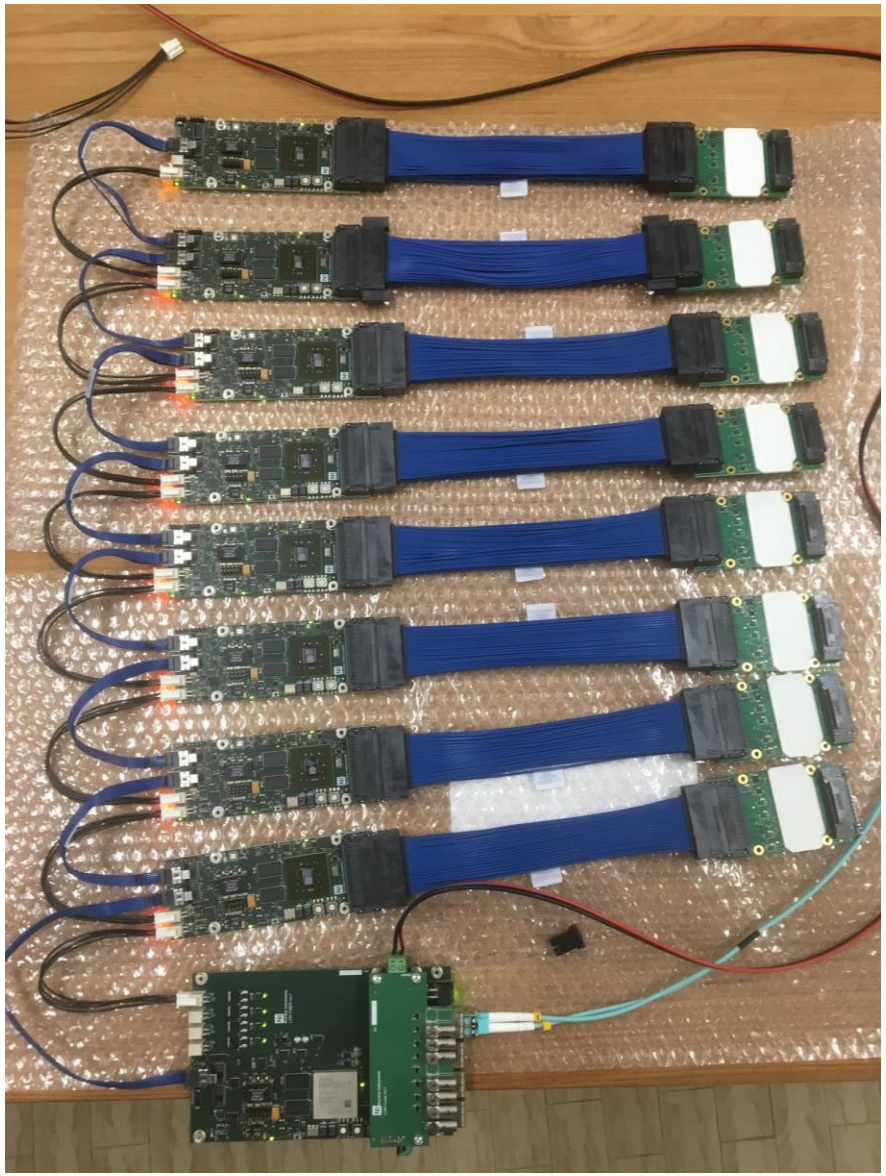




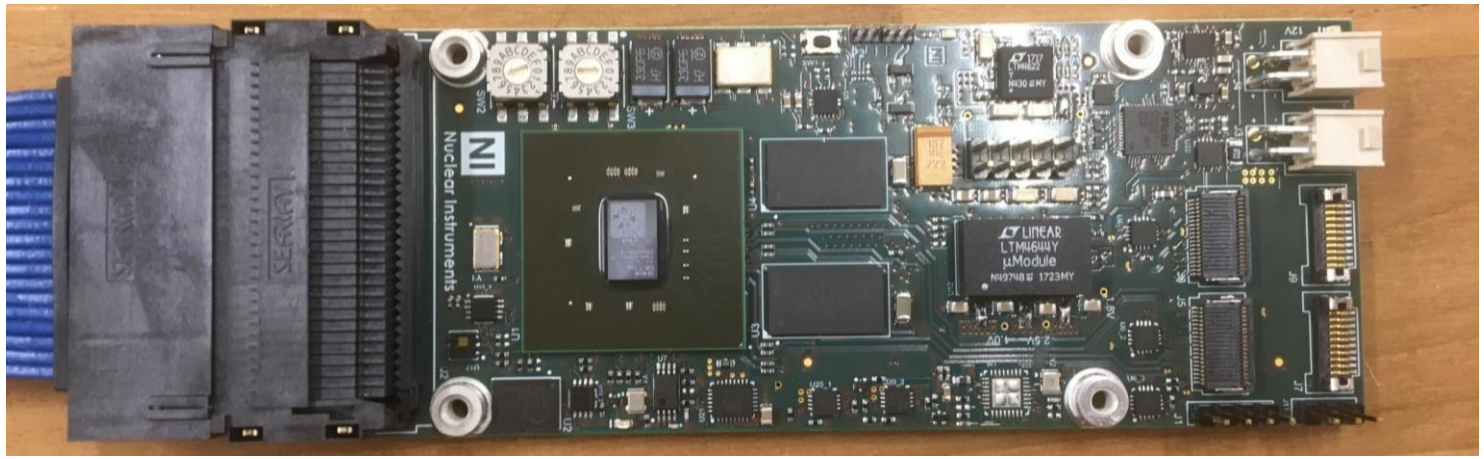
GEMINI 64 – DISTRIBUTED SYSTEM

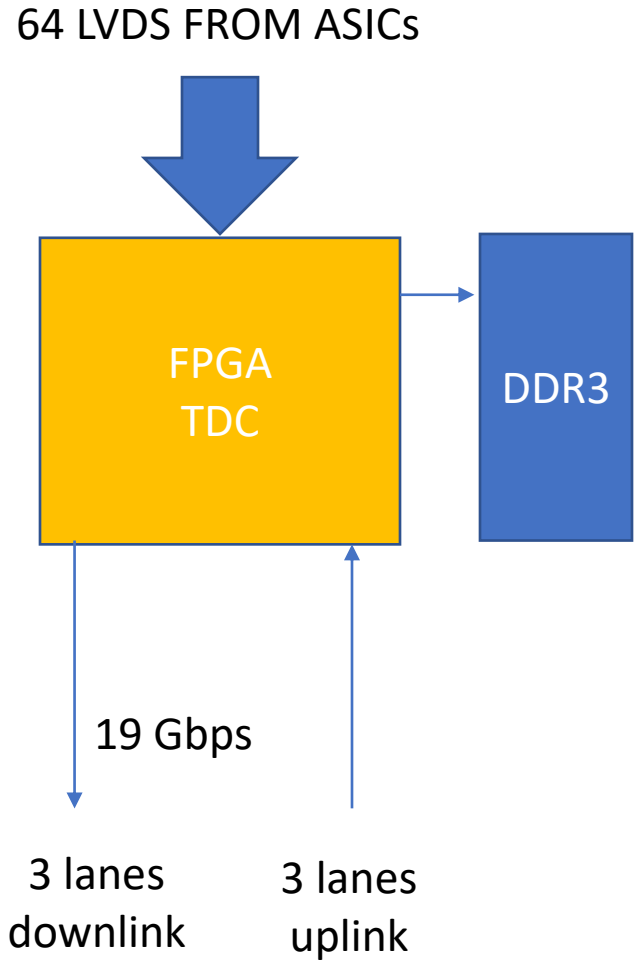
- Designed for very large area detector 1000+ (no upper limit channel)
- Timestamp syncronization
- Copper-Fiber mixed solution
- Intrinsic daisy chain
- Hi-speed (>125 Mcps) per daisy chain
- Remote upgrade and system load monitor
- Realtime online monitor in the readout PCIE DAQ



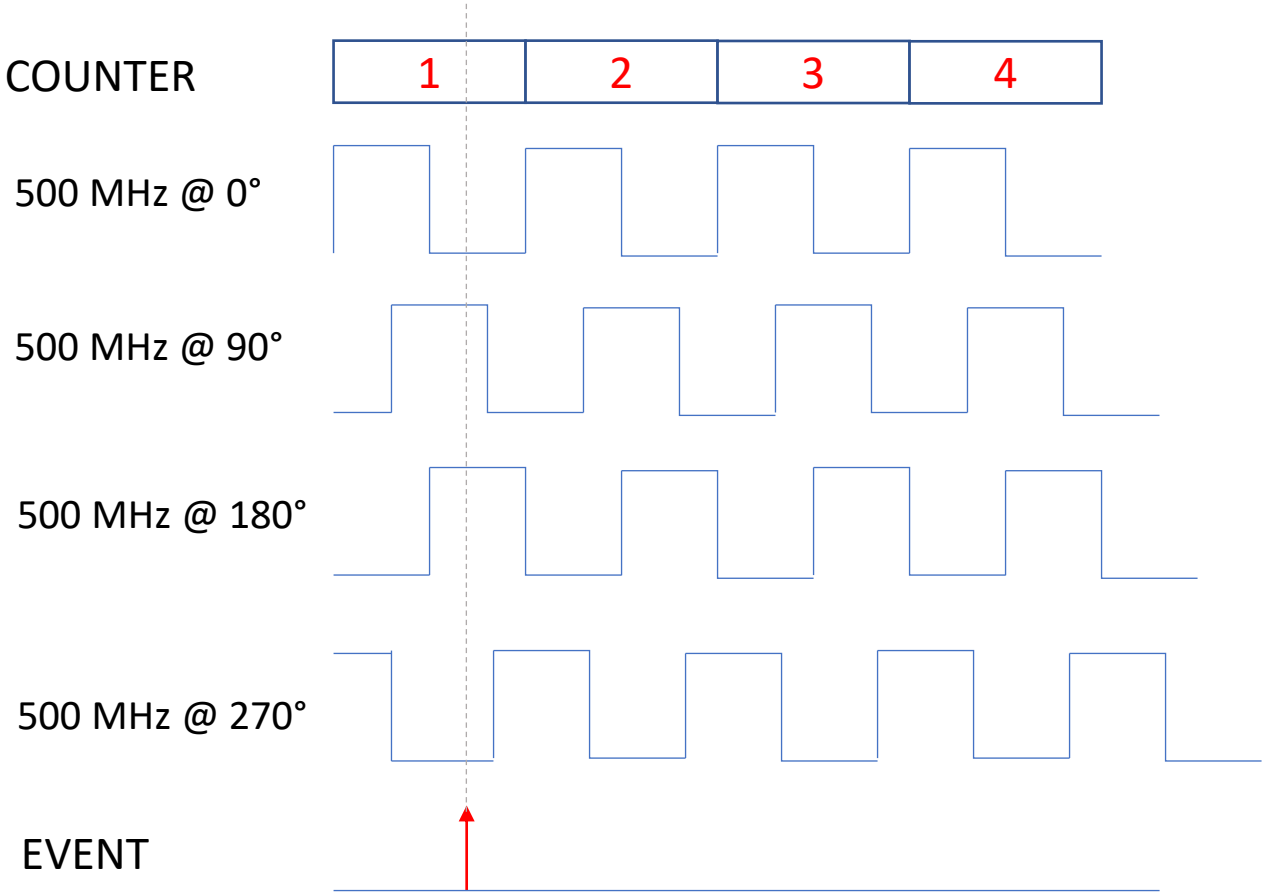


GEMINI 64 – TDC FPGA BOARD



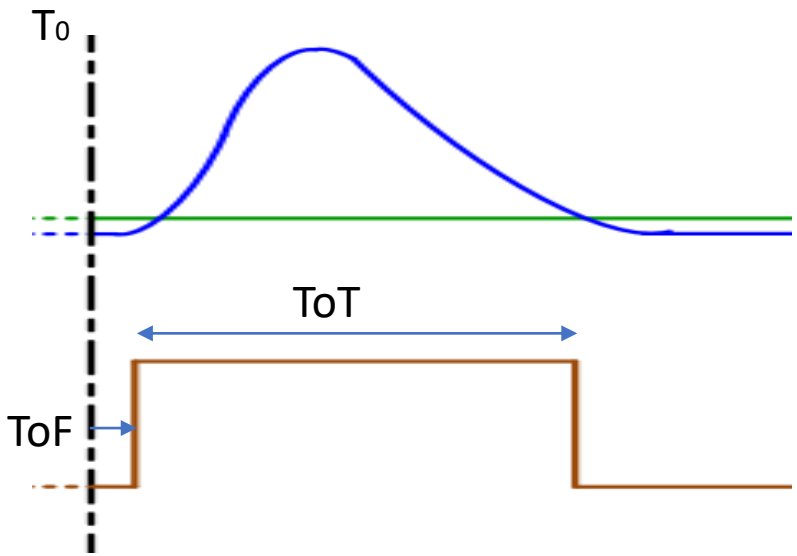


4 PHASE TDC

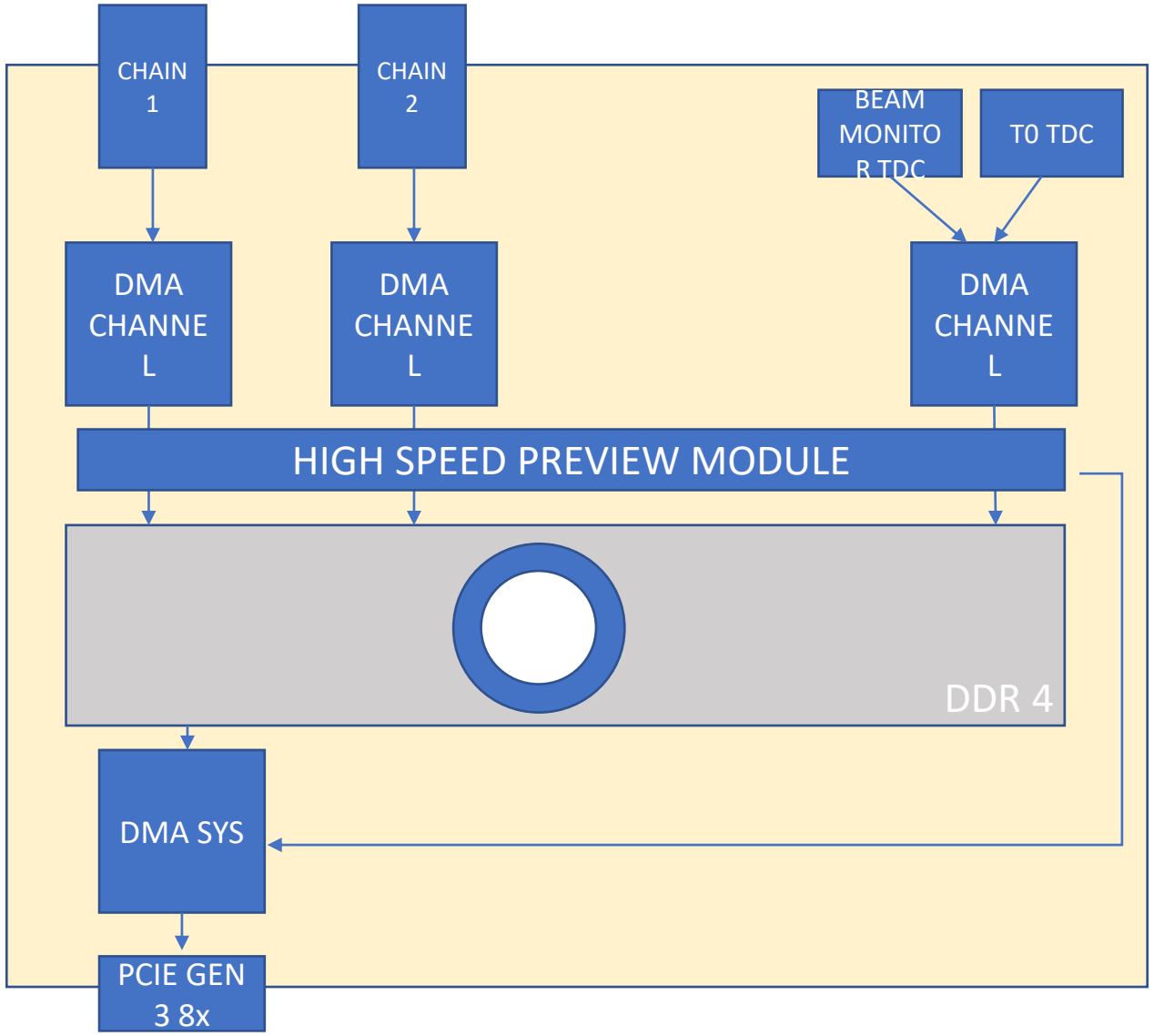


Tout = (2 * 2ns) – 0.5ns = 3.5ns

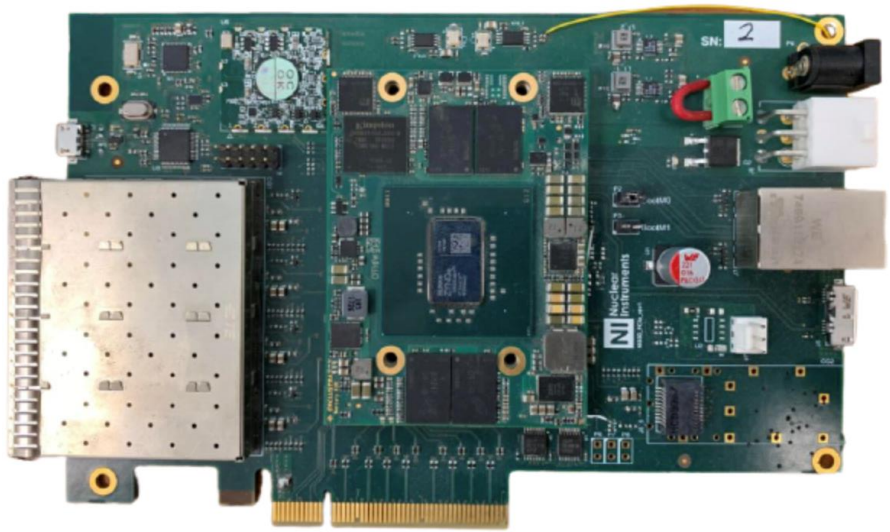
500 ps RESOLUTION WITH 500 MHz clock AND 4 PHASE



PCI-E DAQ FIRMWARE FOR HIGH RATE



- Up to 600 Mcps per PCI-E board
- On line monitor, hardware accellerated:
  - TOF/TOA (Time of flight spectrum on all channels)
  - TOT (Charge spectrum on all channels)
  - Imaging



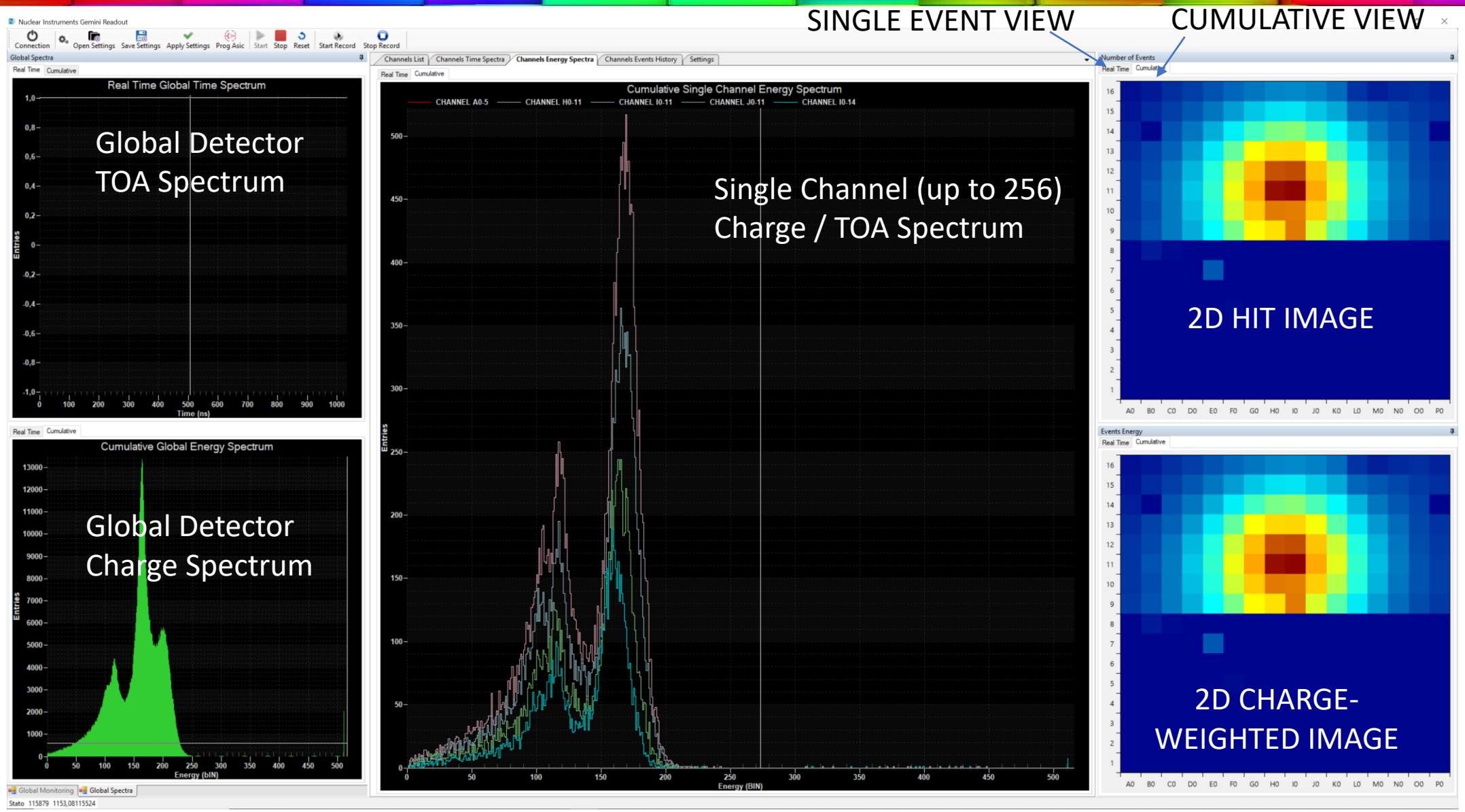
ONLINE MONITORING SOFTWARE

GEMINI READOUT

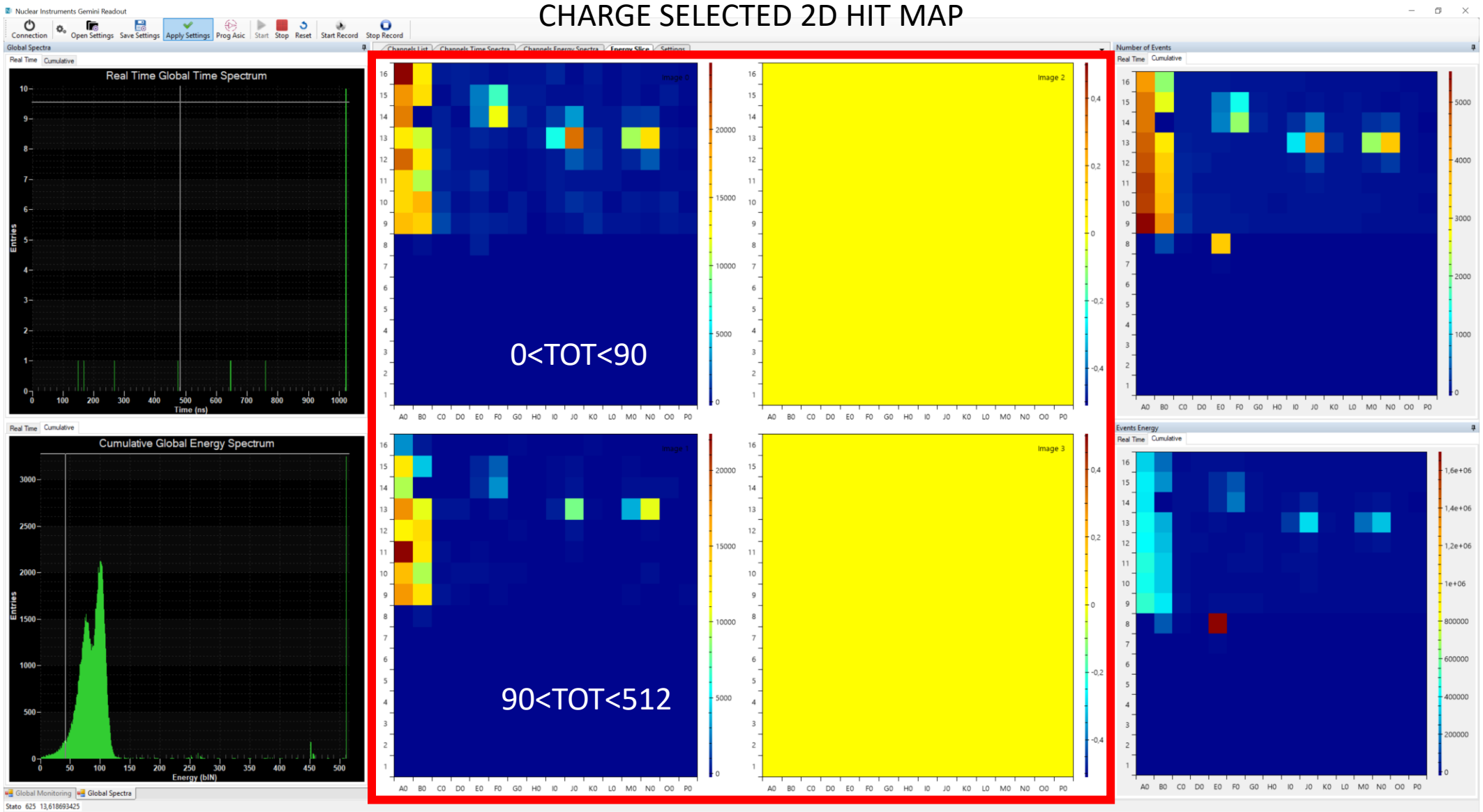
Two software realses:

- Laboratory version (Windows)
- Experiment version (Linux)

LAB SOFTWARE – Real Time Monitor

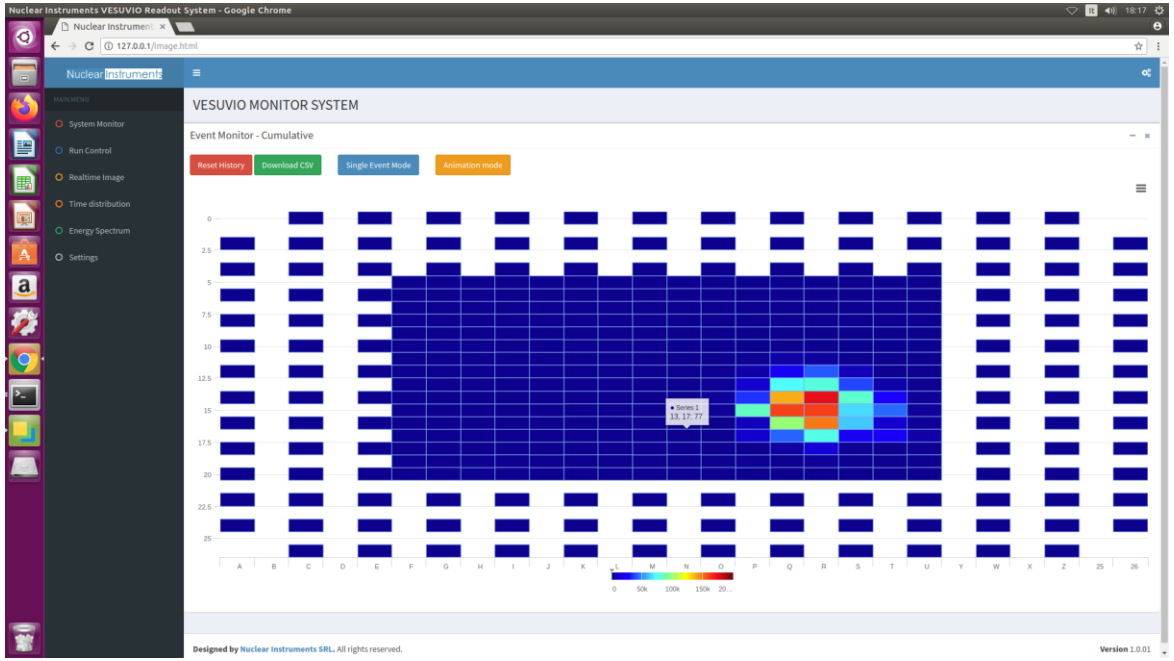


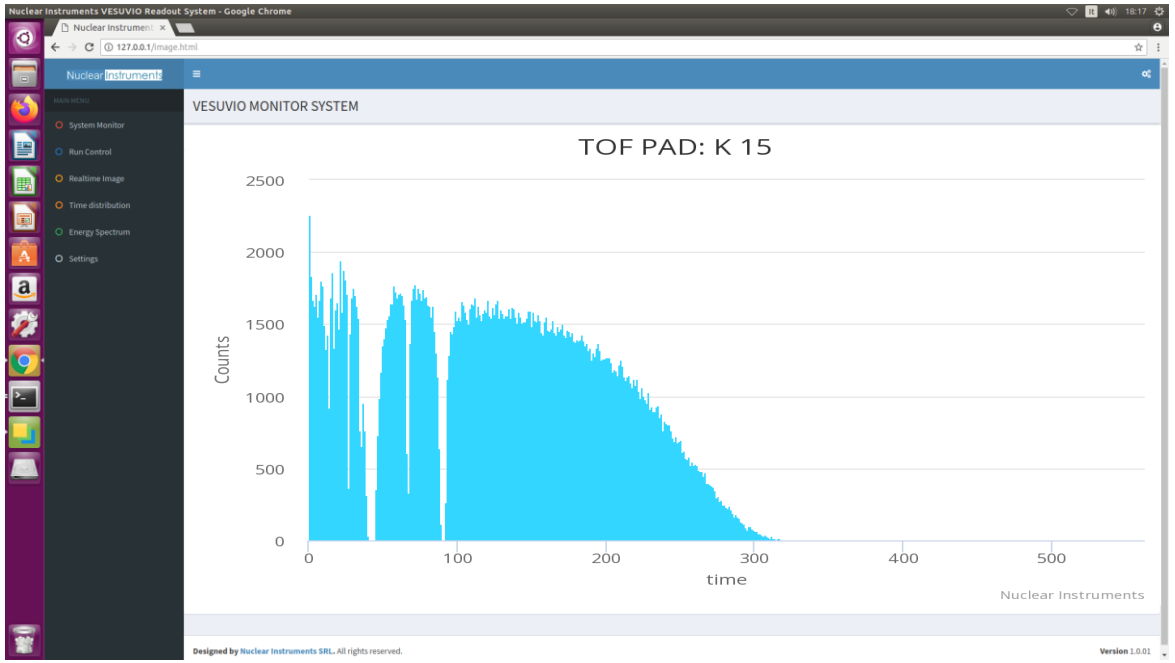
LAB SOFTWARE – Real Time Monitor



Usefull for localization of radioactive waste hot spot by radionuclide

SCALABLE WEB BASED READOUT SOFTWARE FOR EXPERIMENT



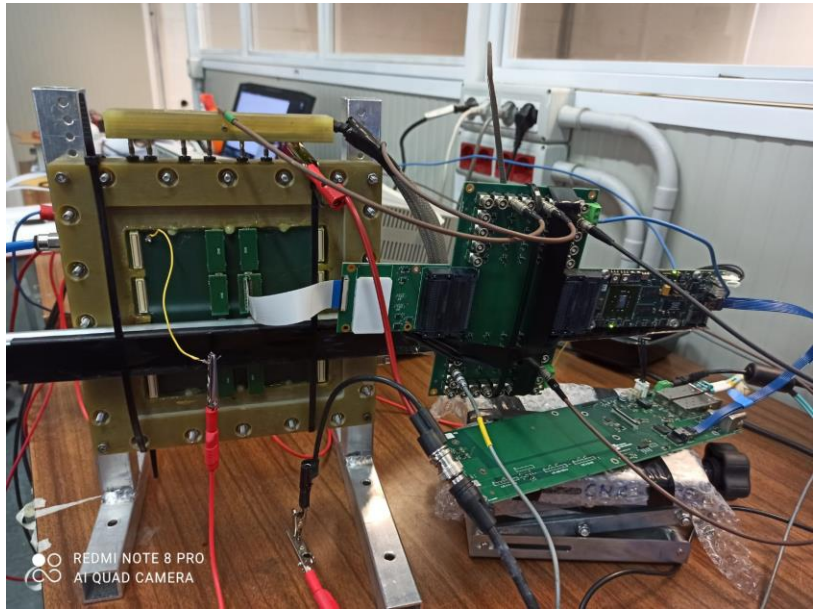


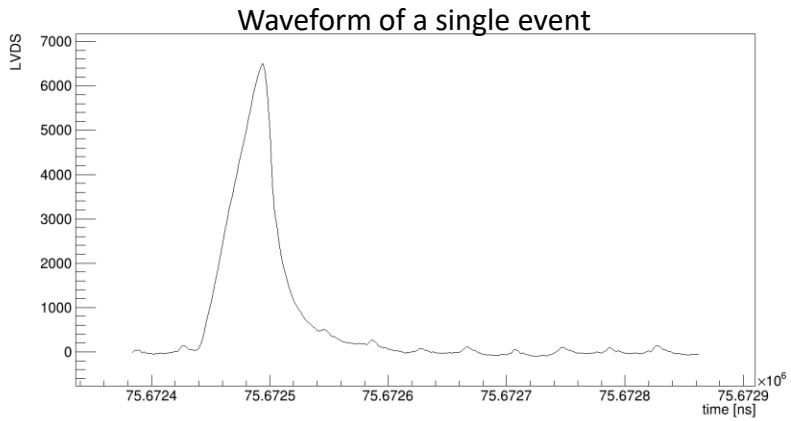
TOT CHARACTERIZATION

ToT vs PHA characterization

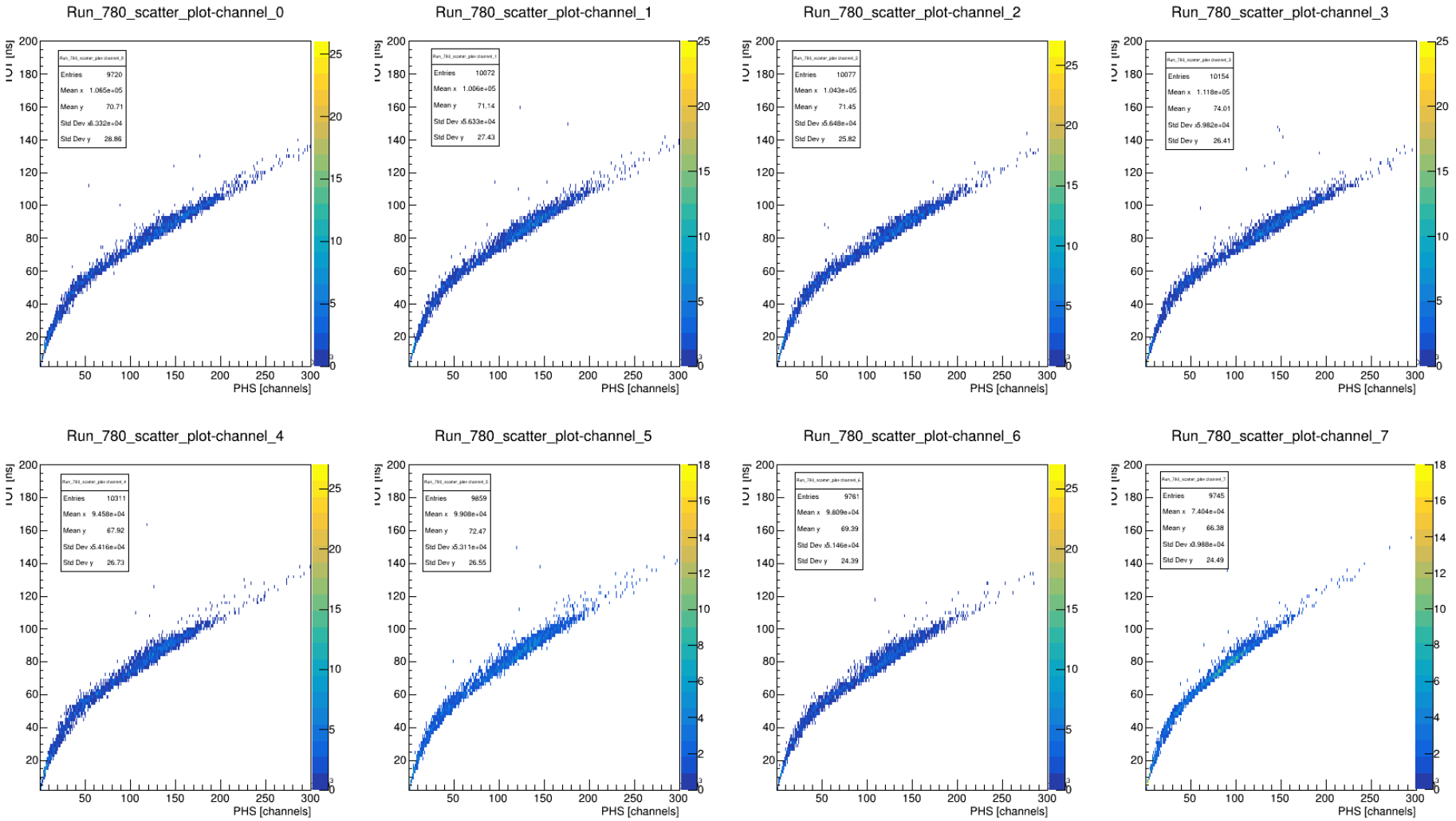
GEMINI 32A

- Comparison between TOT spectra and Pulse Height (PH) Spectra.
- The analog signal of 8 channels from GEMINI is read by CAEN module.
- Use of GEM detector with Alluminium GEM foils, irradiated with a RX source at ISTP-CNR.





ToT vs PHA characterization



GEMINI 32A

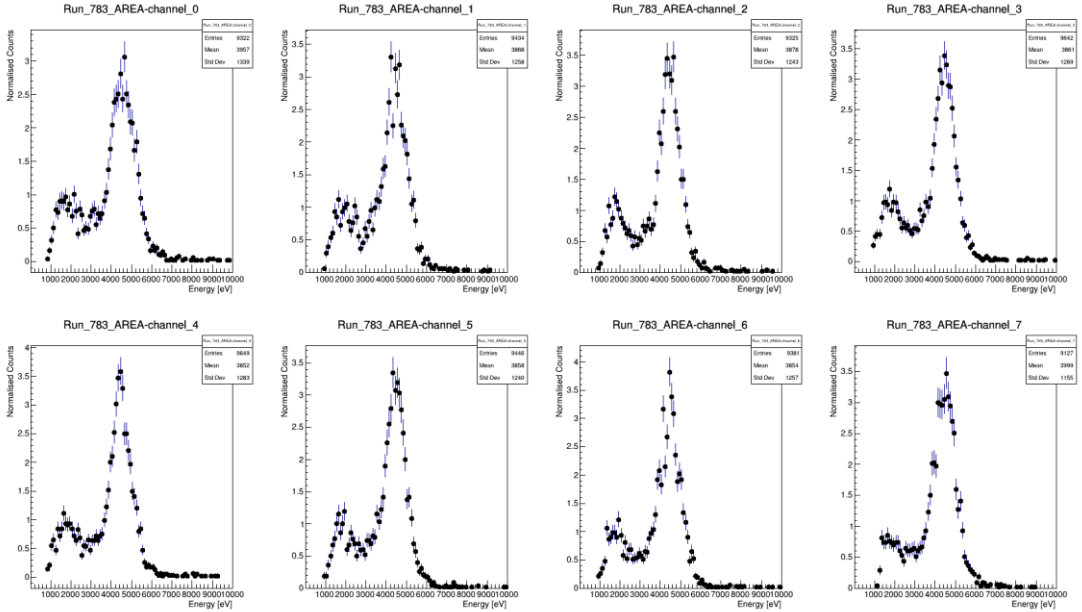
TOT vs CHARGE CALIBRATION CURVE

GOOD MATCH BETWEEN DIFFERENT CHANNELS AND ASICS

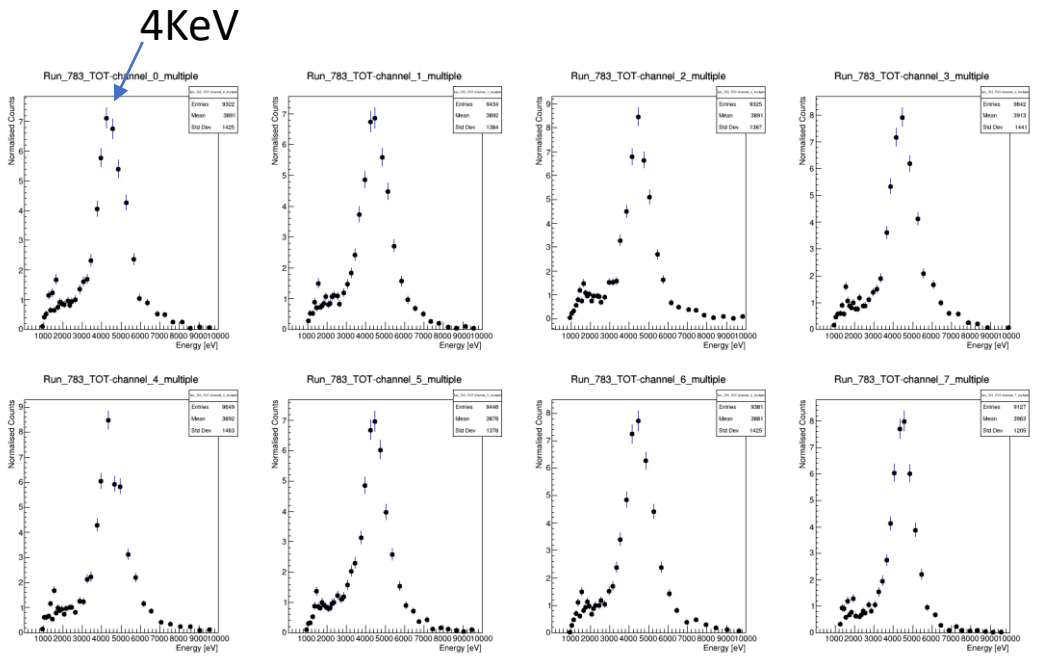
APPLICABLE TO ALL 32D AND 64D

ToT vs PHA characterization

Energy spectra of a Titanium target, obtained both in TOT and Pulse Height mode.



Pulse Height spectra obtained with the use of CAEN QDC – DT5630B



TOT Spectrum using Gemini Readout Board

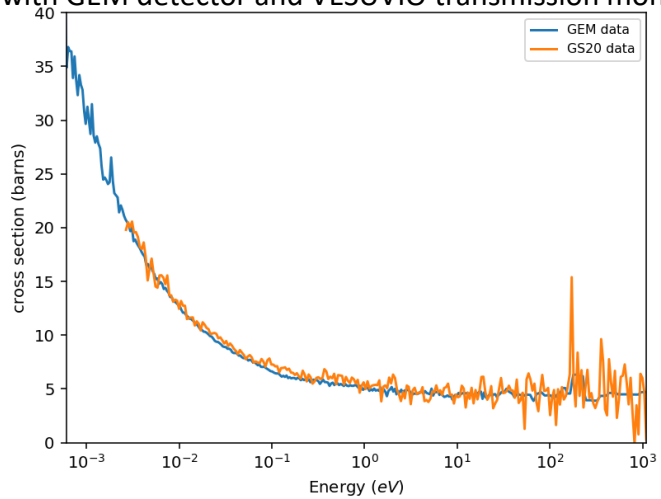
APPLICATIONS

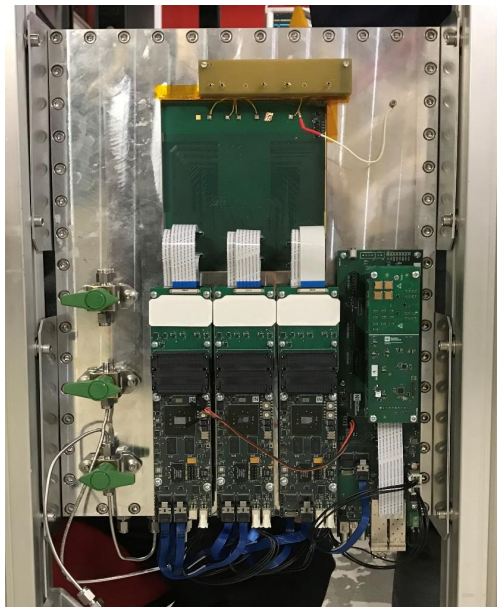
ISIS VESUVIO TRASMISSION BEAM MONITOR

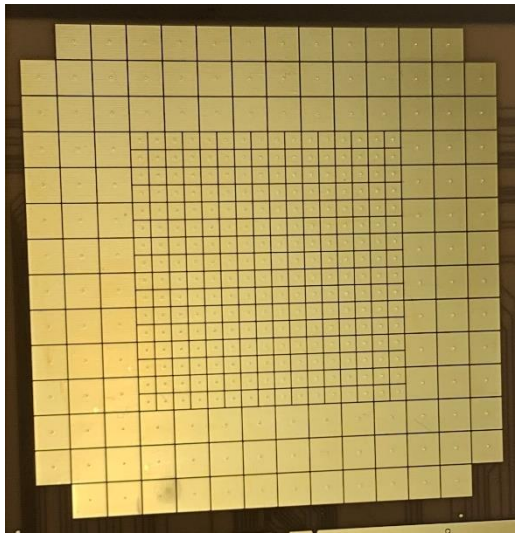
GEMINI 64D

- 16 detecting channel for each ASIC
- GEMINI ASICS can operate in ToT and ToA mode at the same time.
- DAQ is made of a custom FPGA and a Linux server.
- Test made at the **VESUVIO beamline at RAL/ISIS**.
- GEM detector located in trasmissione position.
- Study of thermal and epithermal neutron cross section of samples.
- Permanent installation integrated in the Vesuvio readout system based

Thermal neutron cross section of a Vanadium sample obtained with GEM detector and VESUVIO transmission monitor







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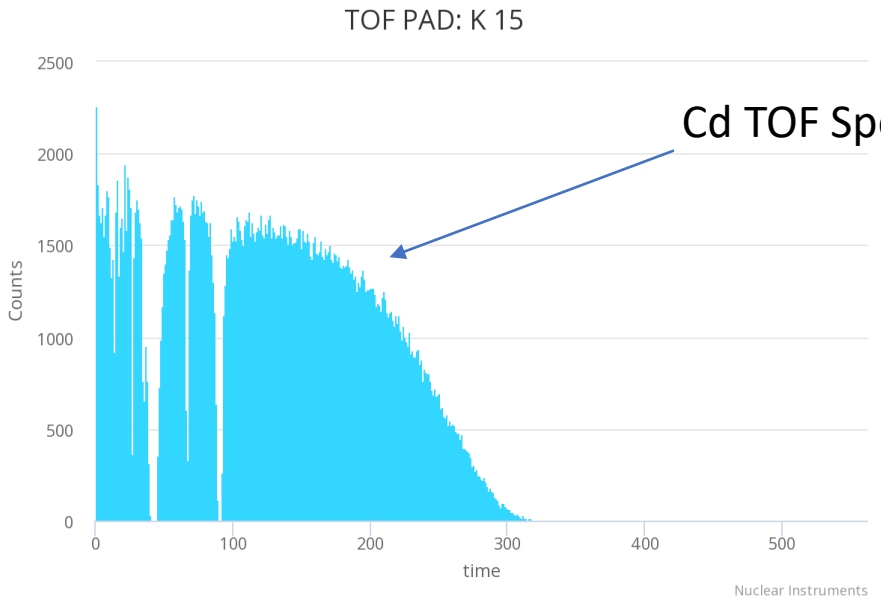
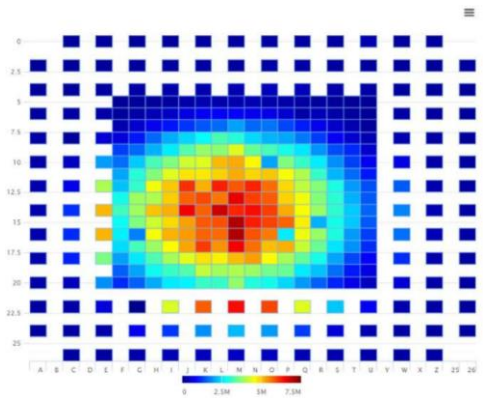
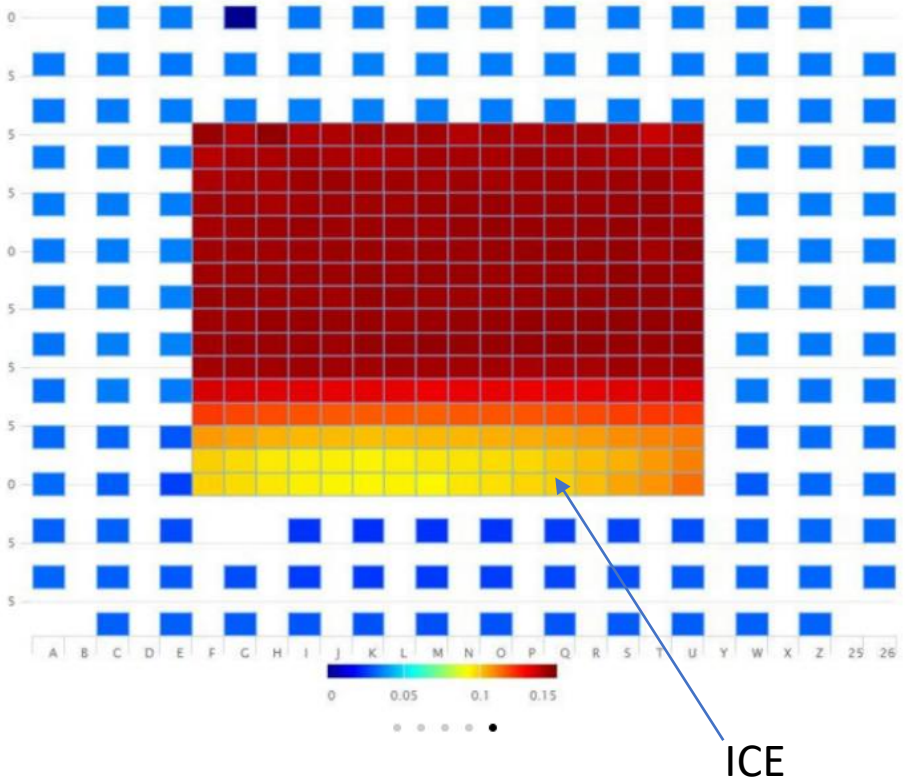
ISIS VESUVIO TRASMISSION BEAM MONITOR





BEAM SPOT

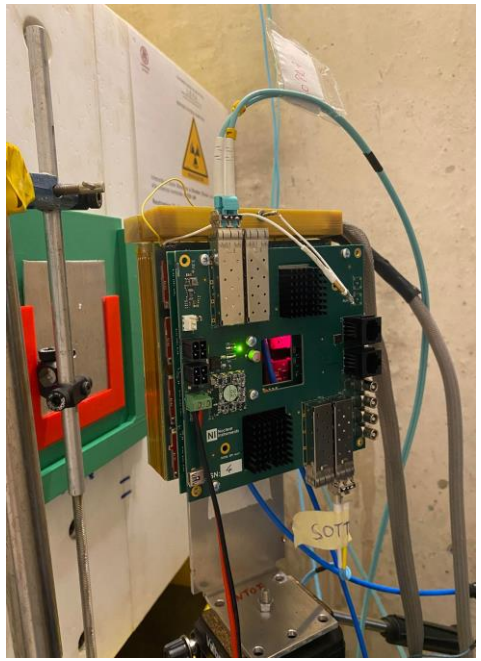


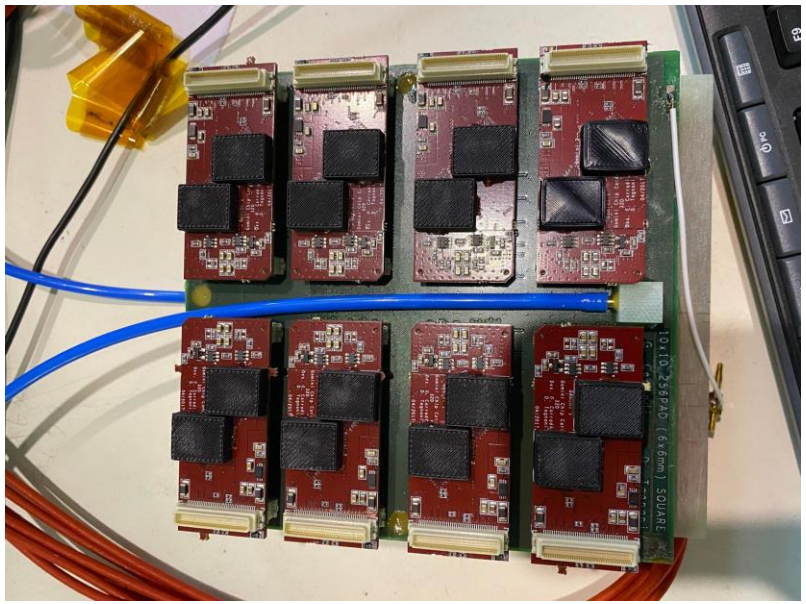
Online data from the web interface based monitor software

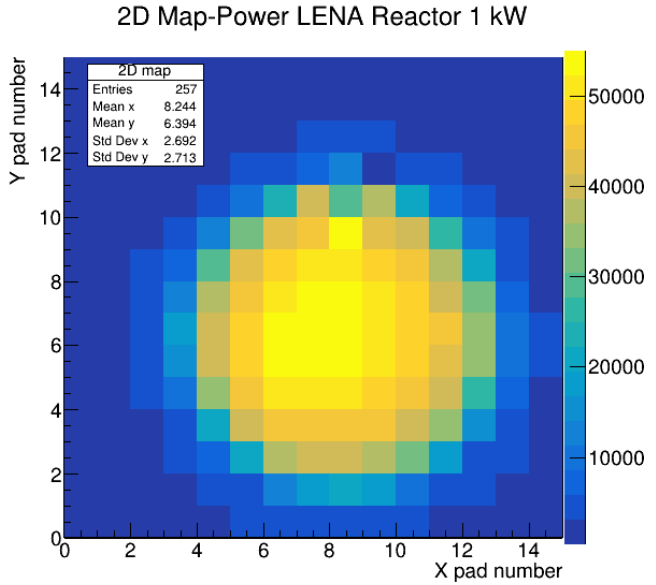
MULTI-BOARATED GEM DETECTOR FOR L.E.N.A. REACTOR

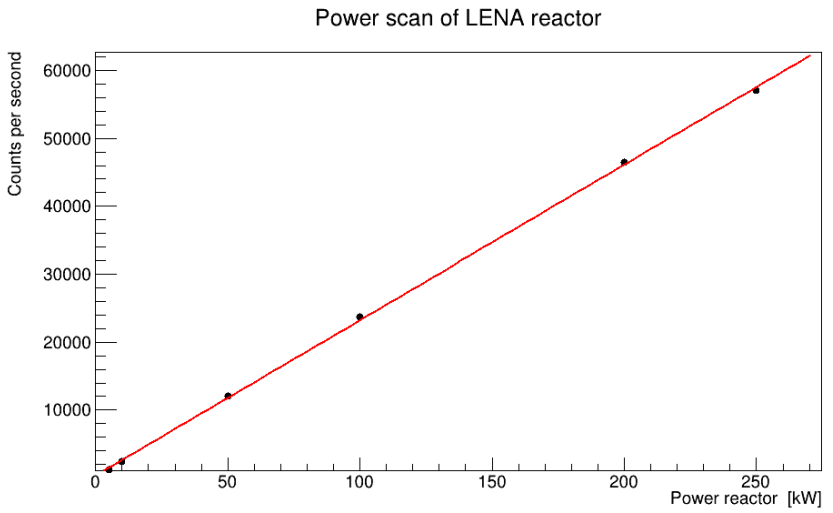
GEMINI 32D

- Study of multi-boron GEM detector(triple GEM detector plus three GEM foils coated with ^{10}B).
- Test at LENA reactor (Pavia).
- Maximum power of reactor: 250 kW.
- Thermal neutron flux of 10^6 n/s*cm^2





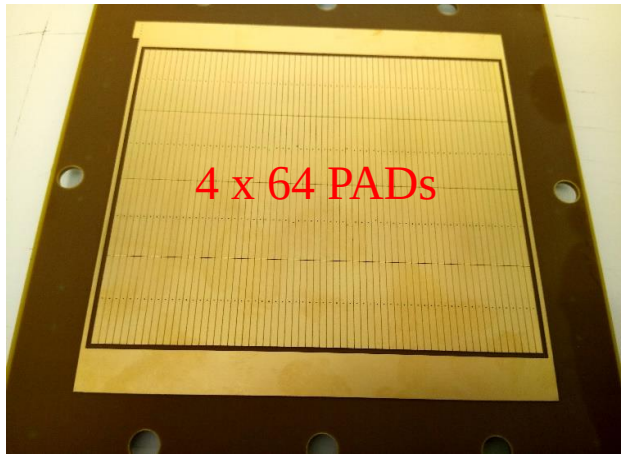


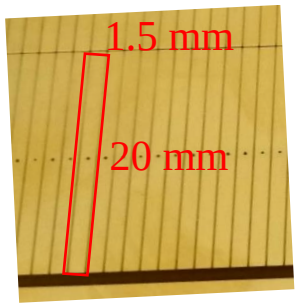


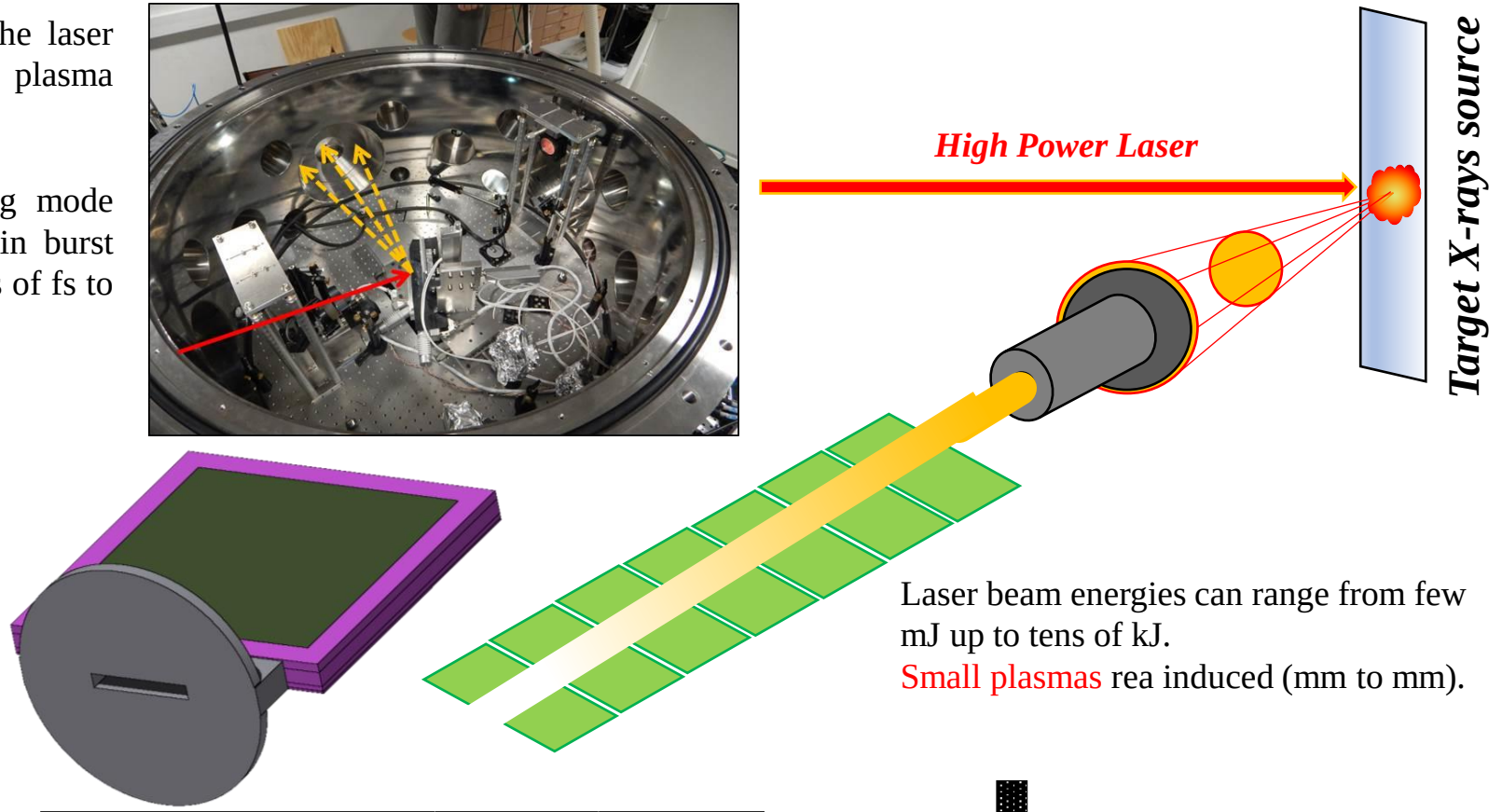
SIDE-ON GEM detector for X-ray spectroscopy on Laser Produced Plasmas

A measure of the X-rays spectrum from the laser induced plasma is important to calculate plasma temperature and other parameters

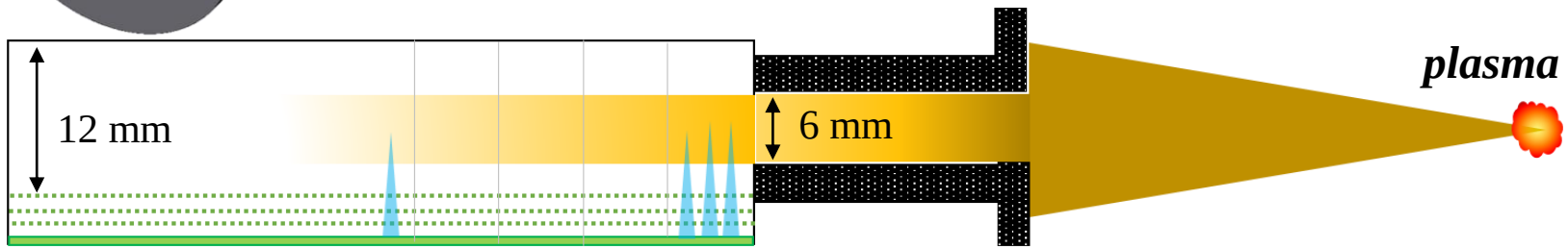
Measure cannot be performed in counting mode because because X-rays are concentrated in burst which lasts as the laser pulse (from few tens of fs to few ns)







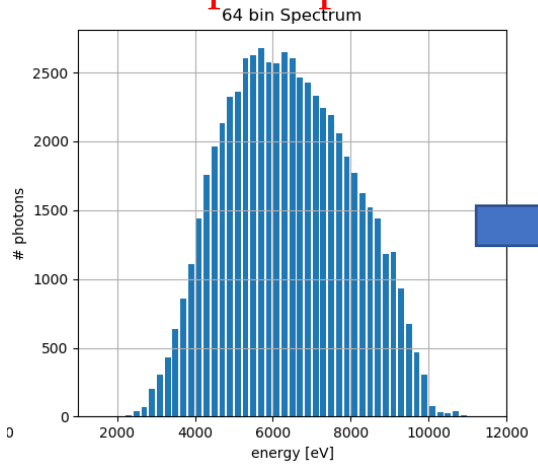
Laser beam energies can range from few mJ up to tens of kJ.
Small plasmas rea induced (mm to mm).



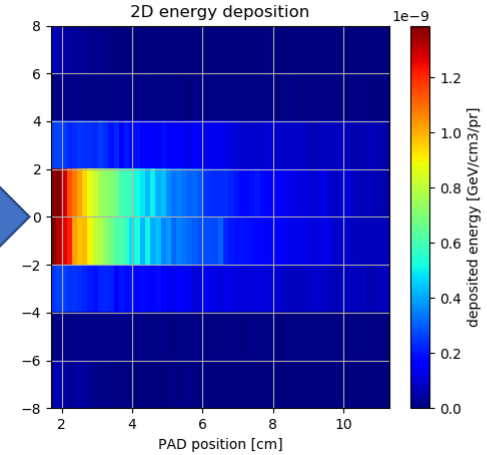
SIDE-ON GEM detector for X-ray spectroscopy on Laser Produced Plasmas

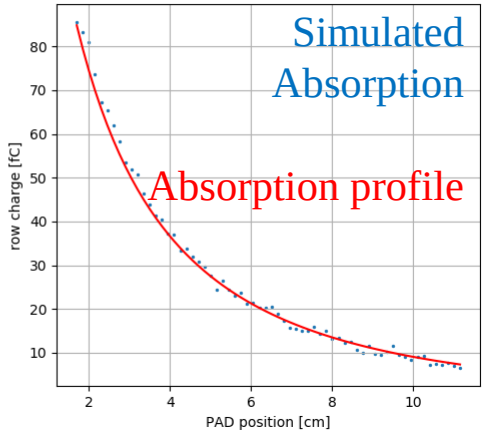
Simulations

Input Spectrum

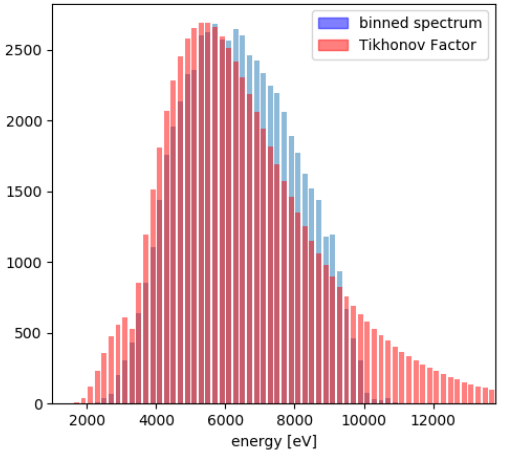


Charge Absorption profile

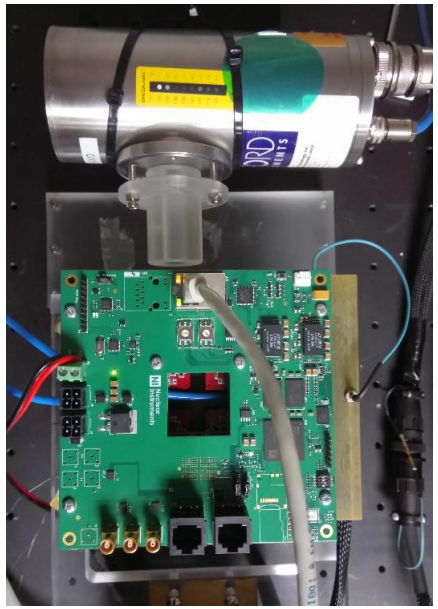


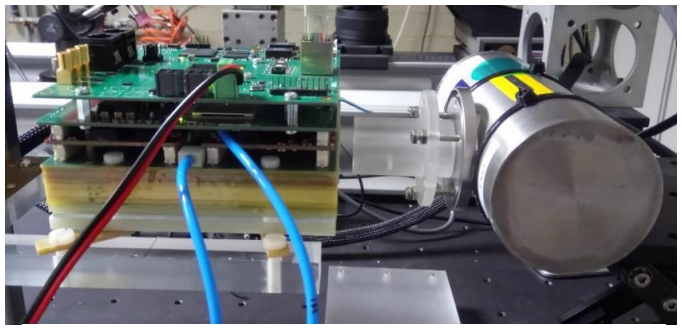


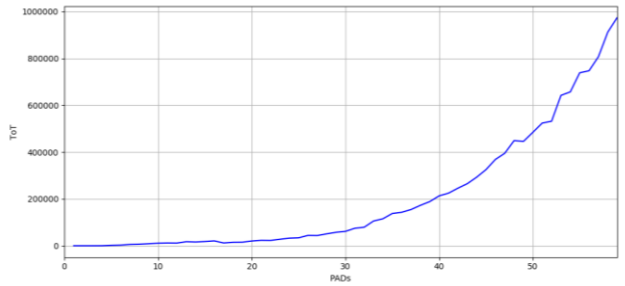
Spectrum Reconstruction

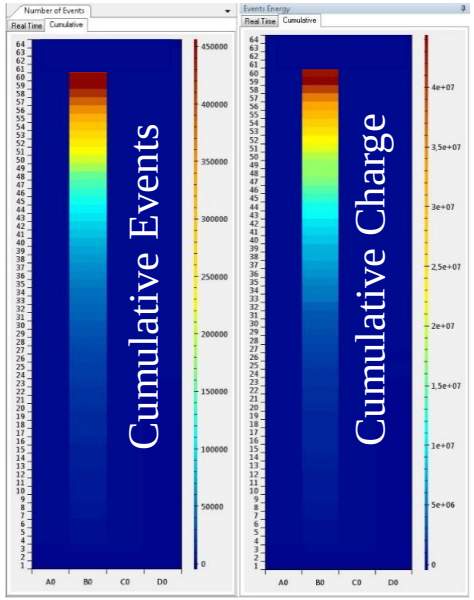


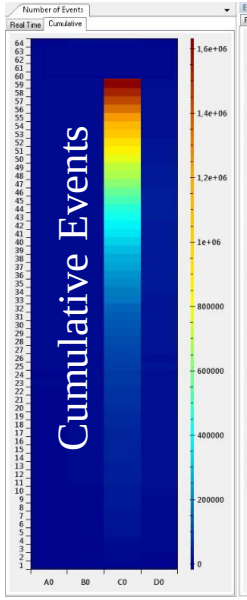
Preliminary Lab Tests

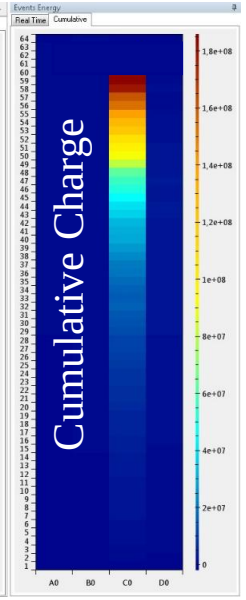












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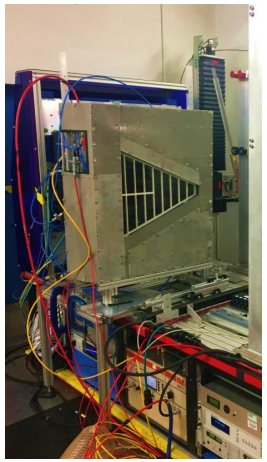
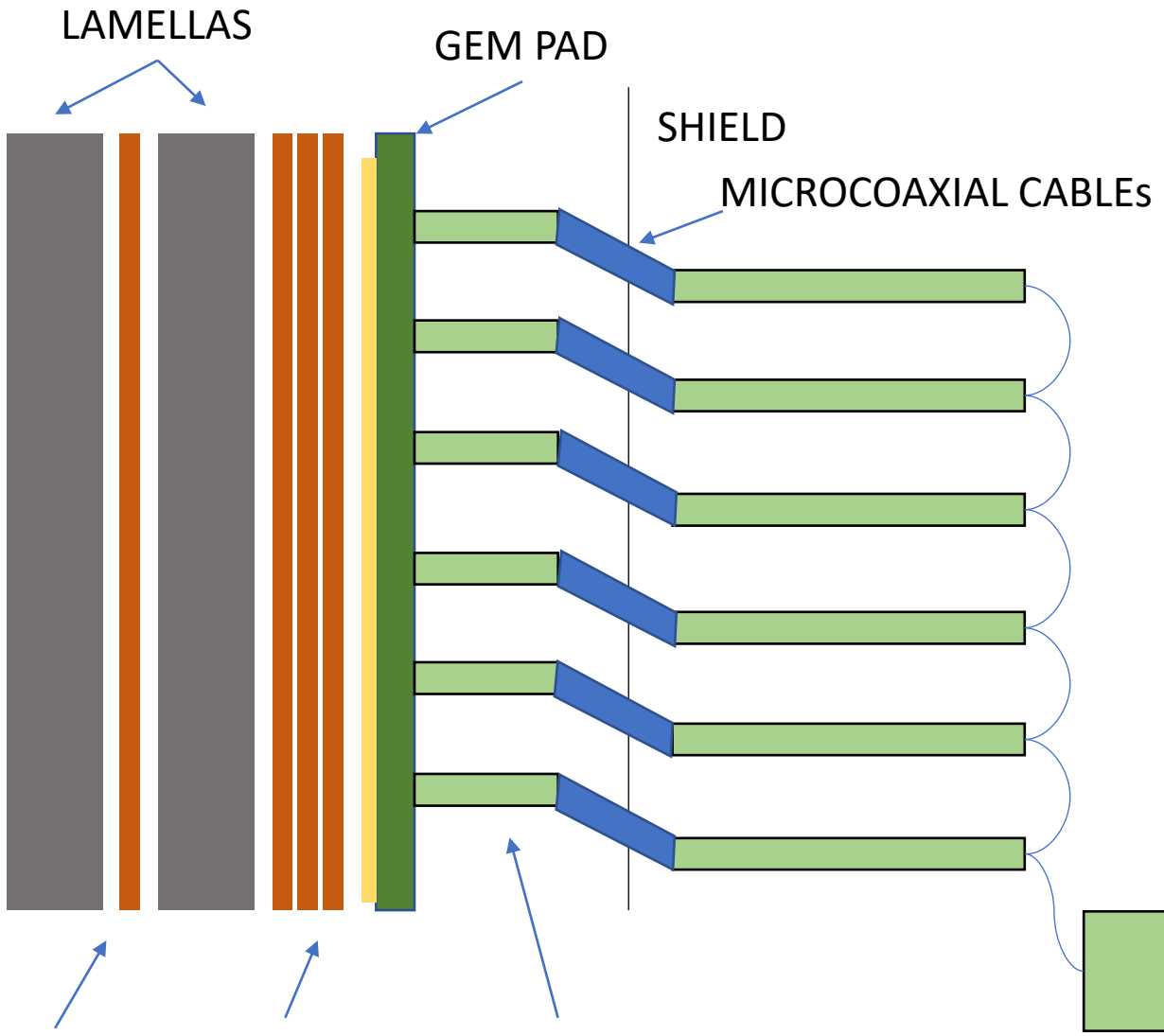
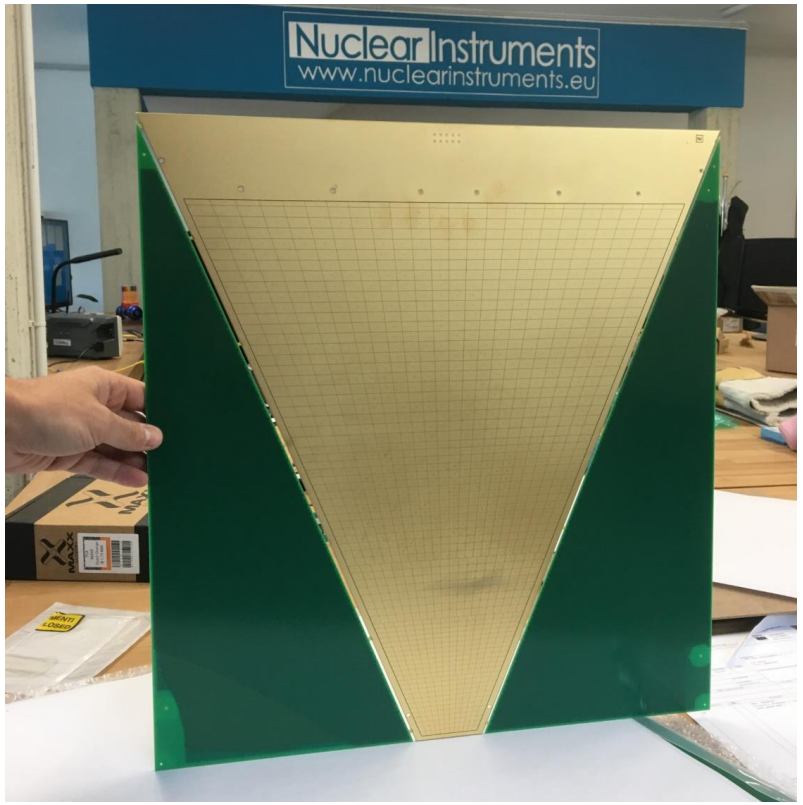
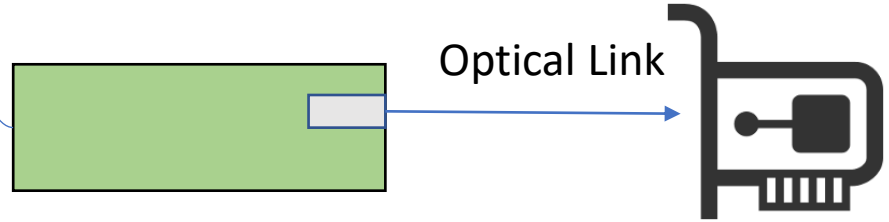
Borated lamellas Triple-GEM detector for SANS for NSS



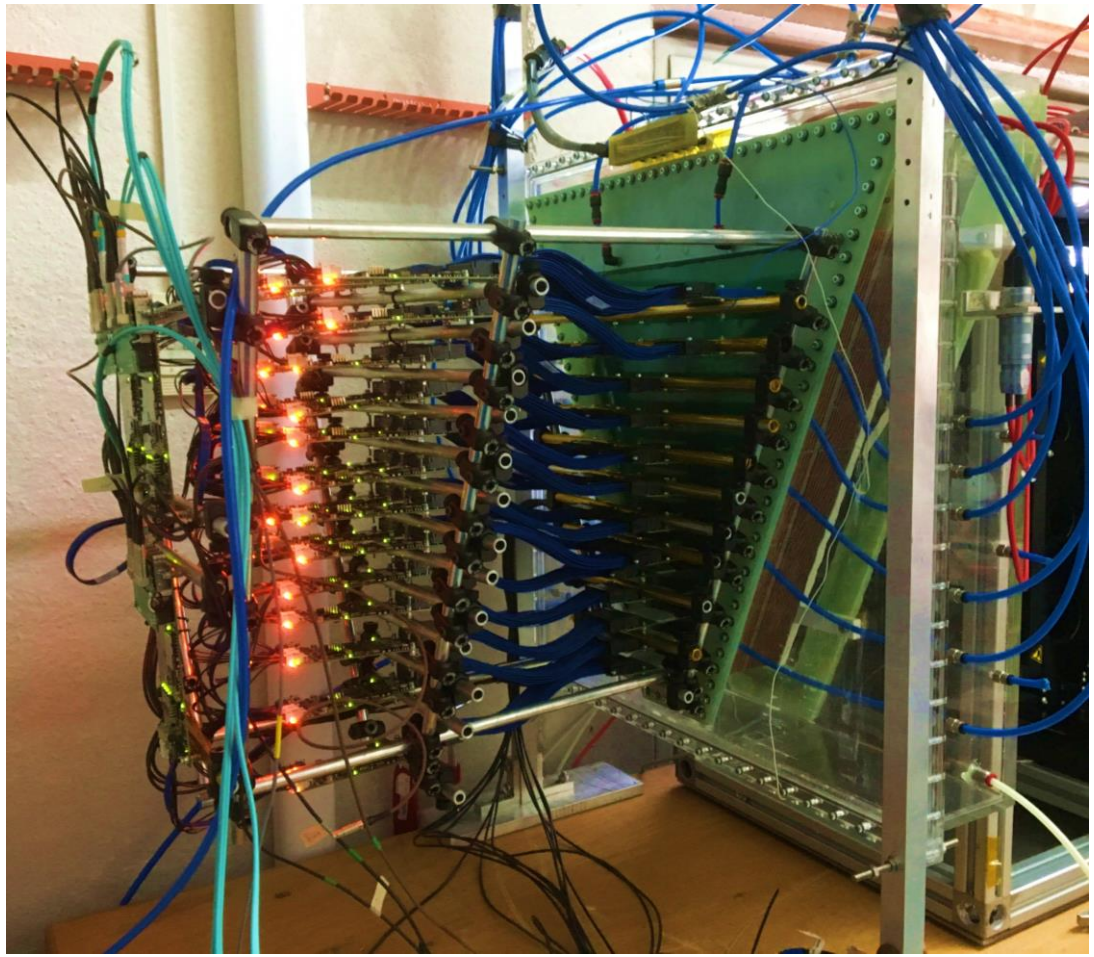




* Tested on LARMOR SANS – ISIS STFC



Borated lamellas Triple-GEM detector for SANS for NSS

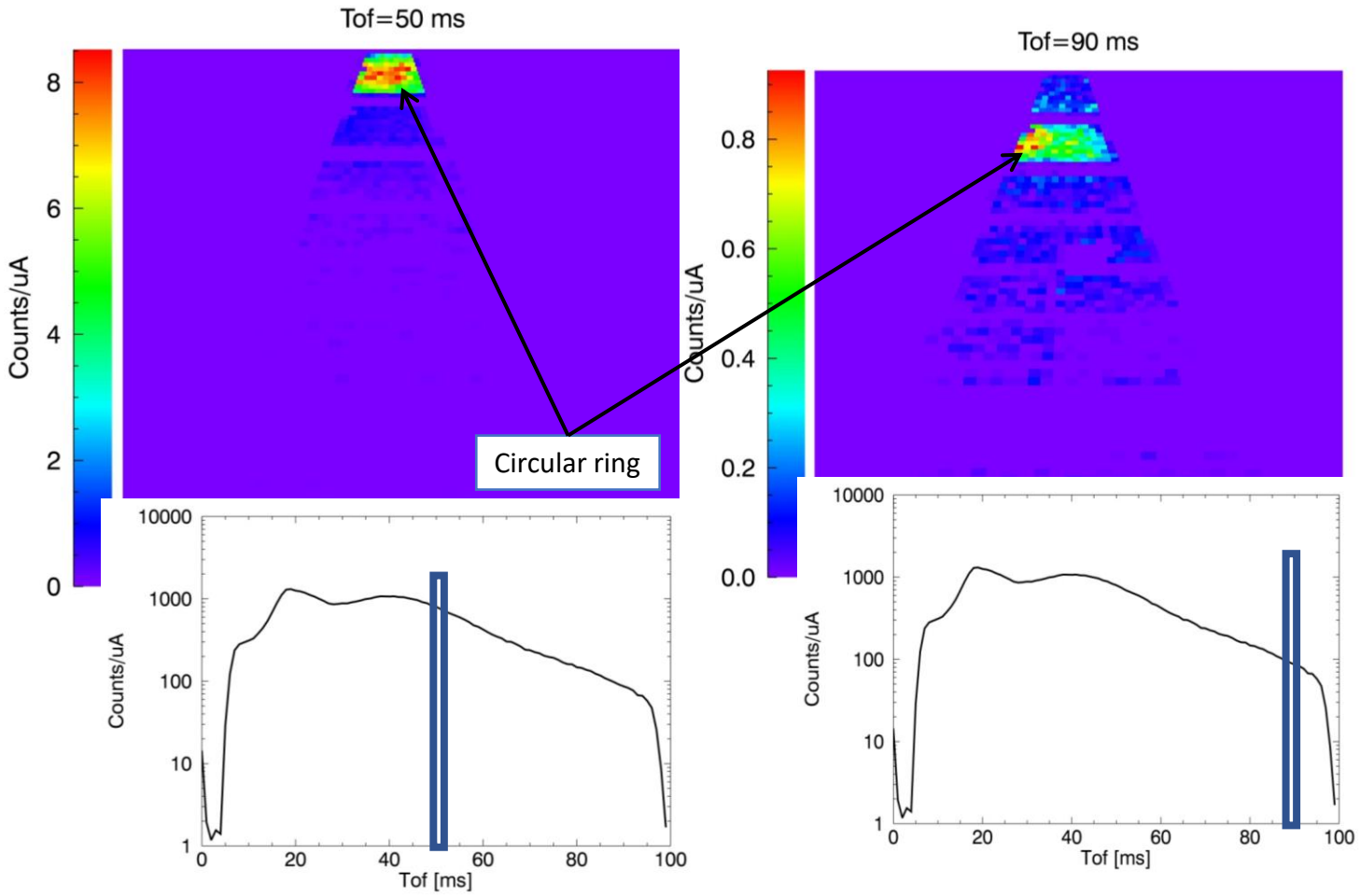


READOUT HIGHLIGHTS:

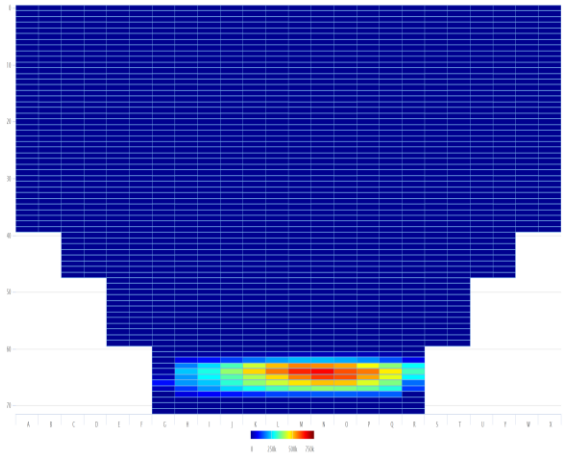
- Based on dedicated GEMINI chip capable to operate at very high rate (up to 5 MCPS per channel)
- Scalable to unlimited number of channels (1496 in currente config)
- System distributed across several FPGA capable to measure position of interaction ToF and amplitue of the signal (Time over threshold)
- Up to 110 Mcps on a single board (tested @ MLZ reactor at 25 Mcps)
- 10 Gbps multiple Optical link to connect the detector to DAQ
- DAQ system based with FPGA accelerator for realtime event reconstruction.

Borated lamellas Triple-GEM detector for SANS for NSS

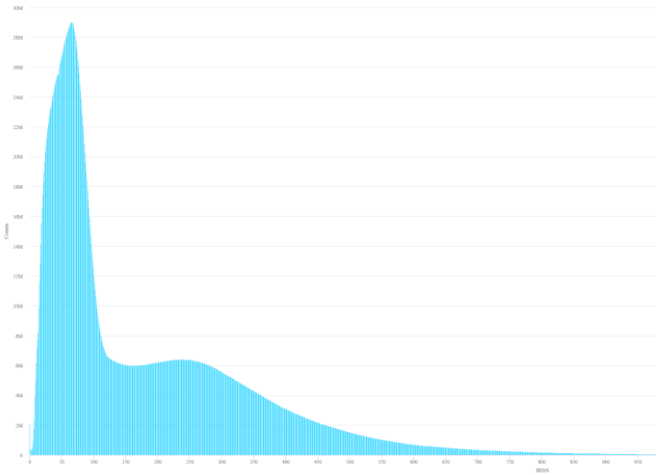
TIME RESOLVED SANS → Larmor/ISIS



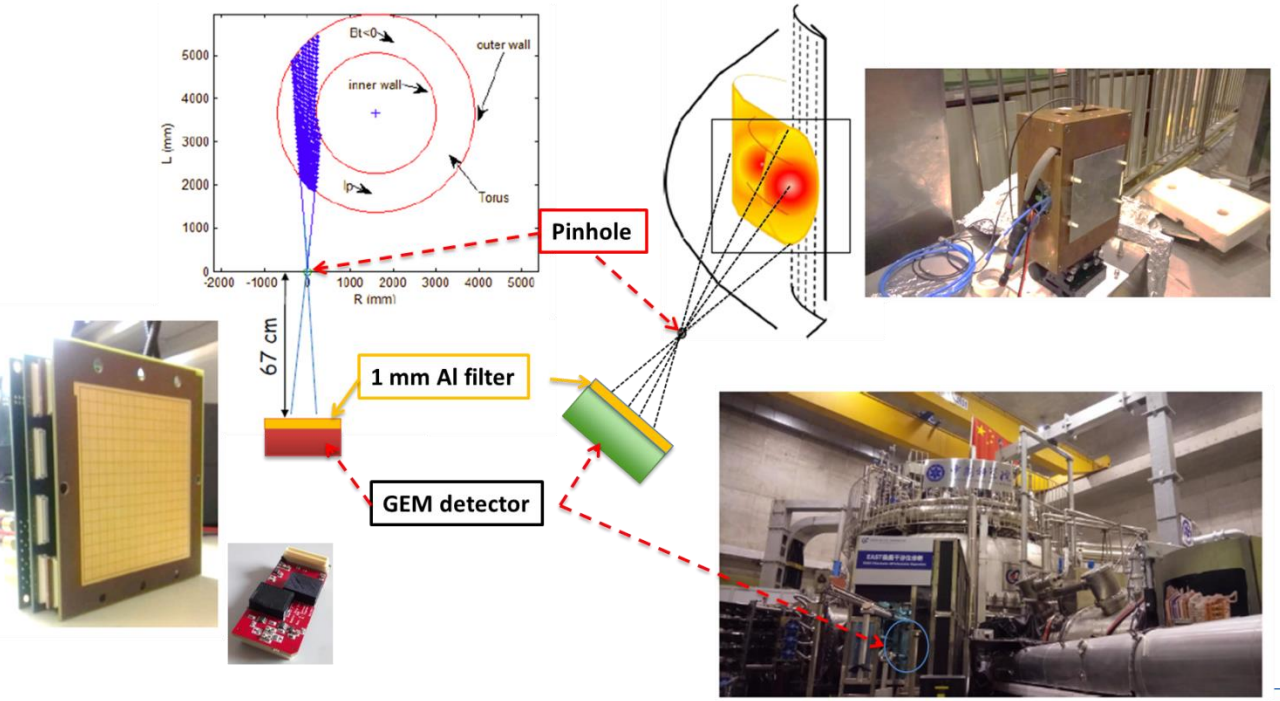
2D – Detector Plot (FRM II Reactor)



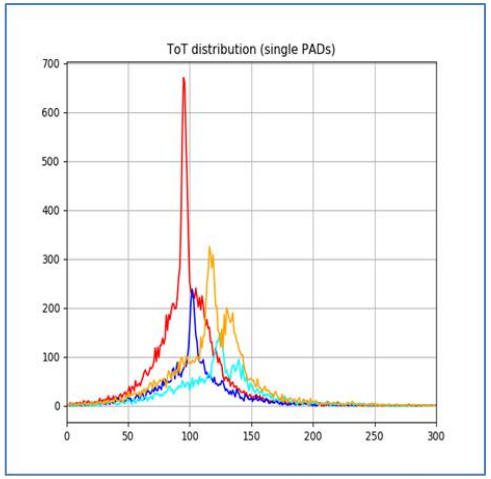
ISIS NEUTRON TIME OF FLIGHT SPECTRUM (EMMA)



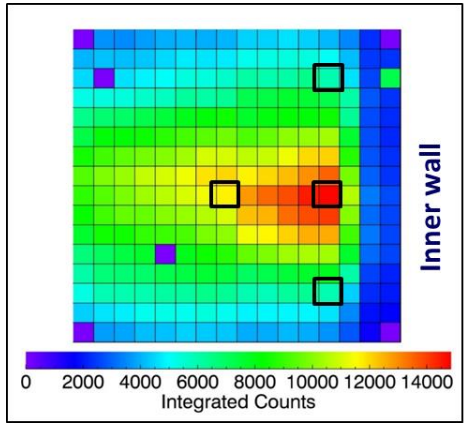
X-rays Monitor for plasmas in EAST tokamak

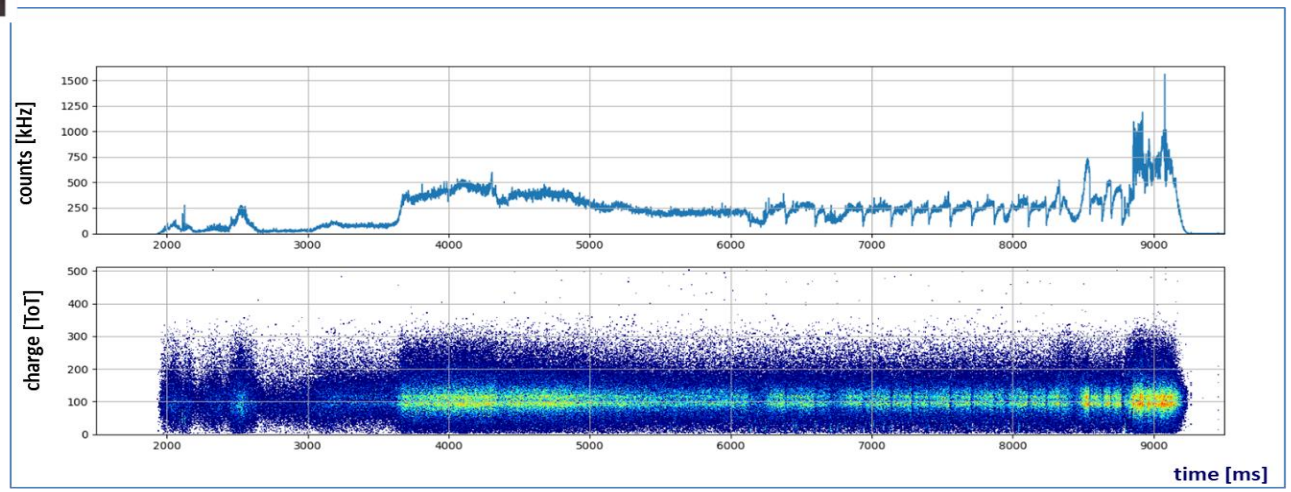


Plasma Profile reconstruction using Soft X-Rays



energy spectra pad by pad



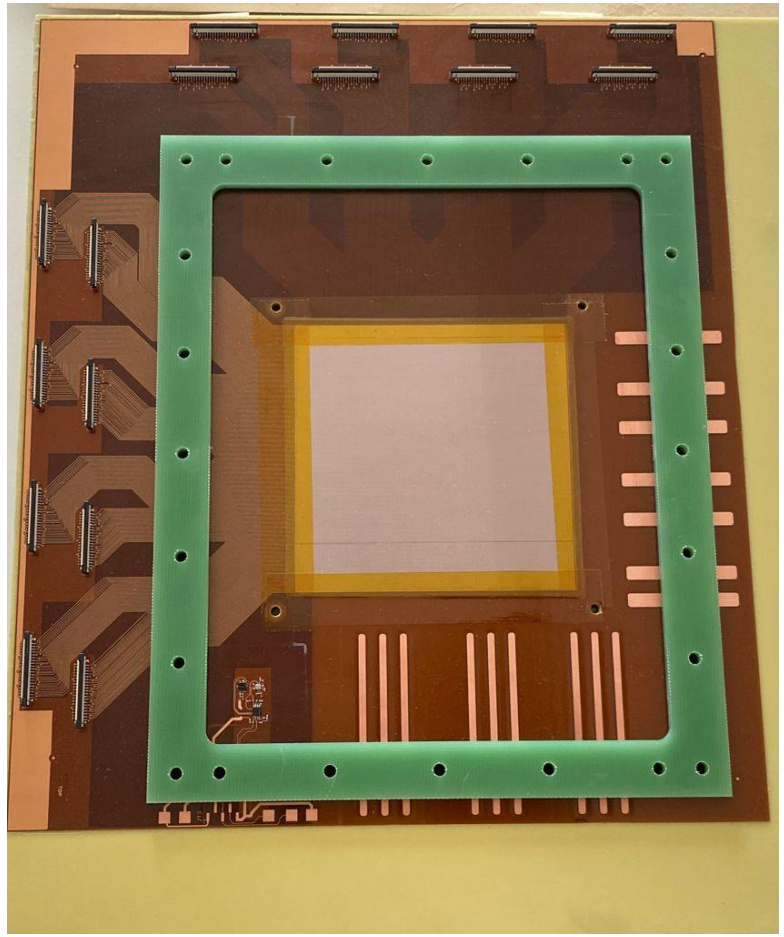


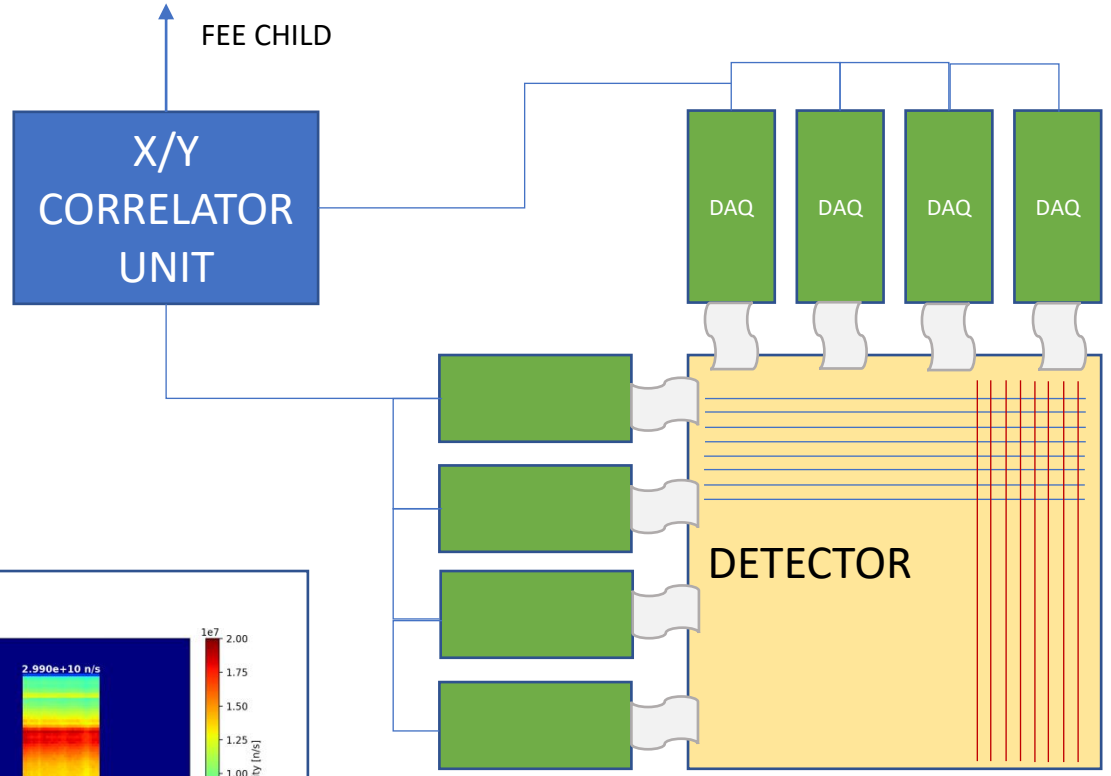
In collaboration with:

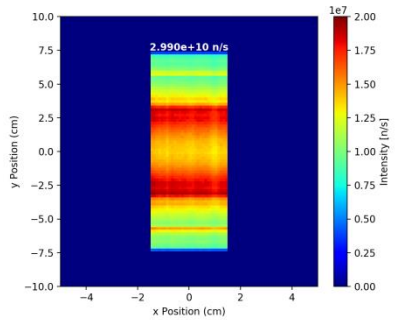
EAST
Hefei, China

abba@nuclearinstruments.eu

Neutron beam monitor based on GEM strip detector for ESS (RD51 common project)







simulation of expected beam profile for FREIA

CONCLUSIONS

Conclusions

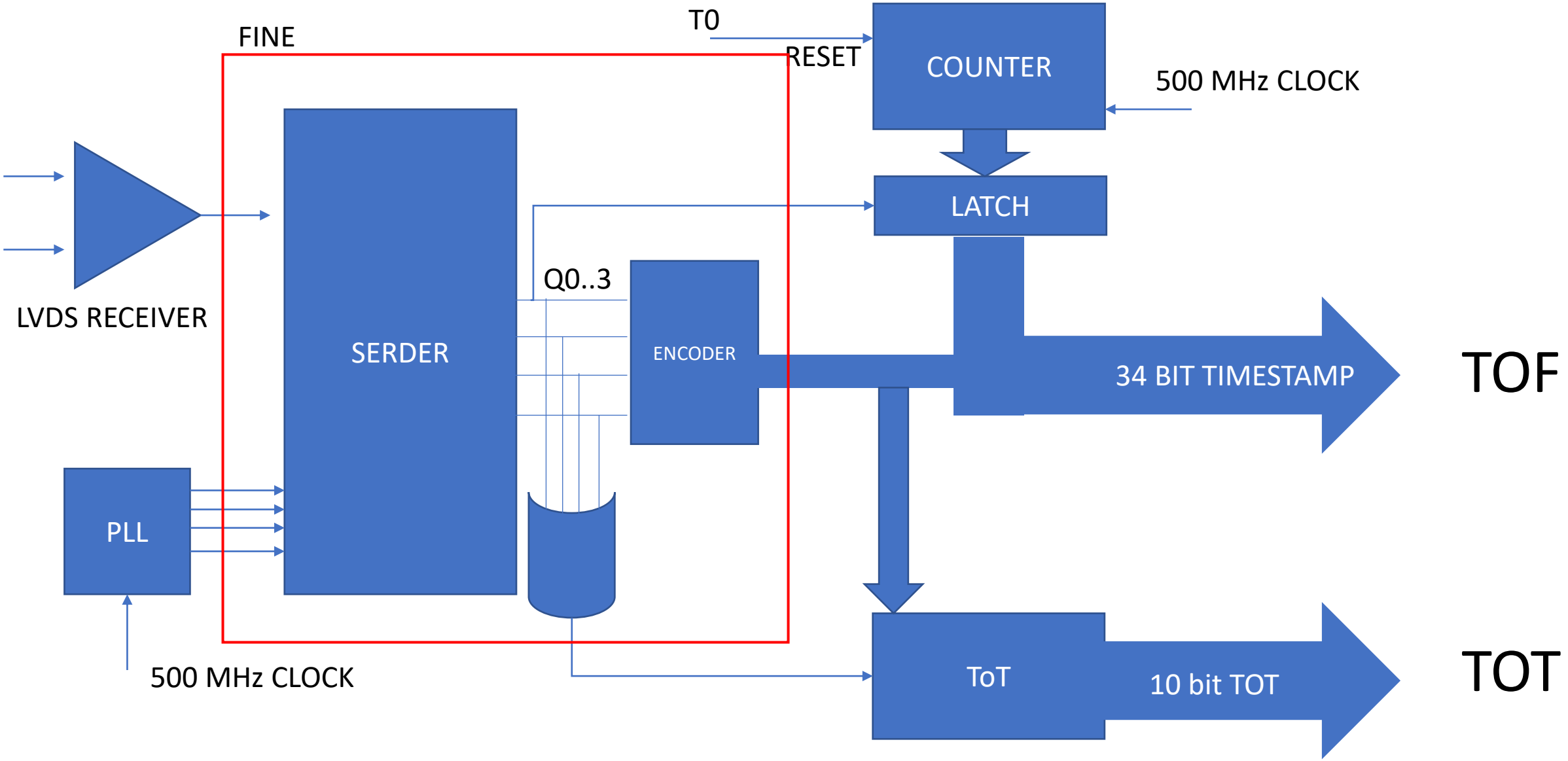
- Gemini chip has been widely tested and fully characterizated in charge and time
- 0.5 ns time resolution
- 2k chip already produced and in stock by the Gemini collaboration
- Few carrier board already designed: 32D/64D/32A
- Readout system for both laboratory and experiment
- Readout solution based on ethernet or dedicated optical fiber from 8MCPS to 600MCPS
- Already used in several application beyond high physics

- Commercial Company support for full system customization and experiment long term support (Nuclear Instruments)

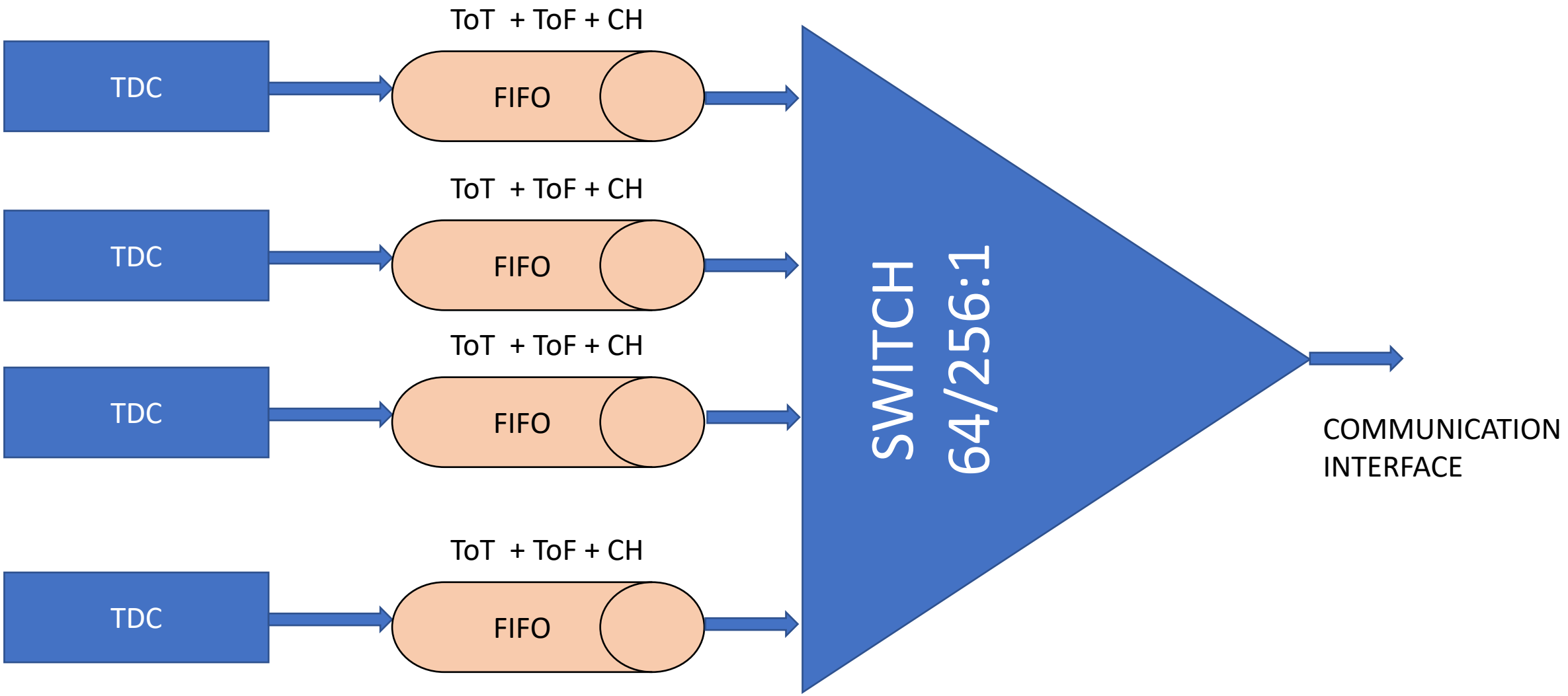
Looking for founding for the desing of a fully digital new chip integrating actual GEMINI front-end, TDC and fast readout

BACKUP SLIDES

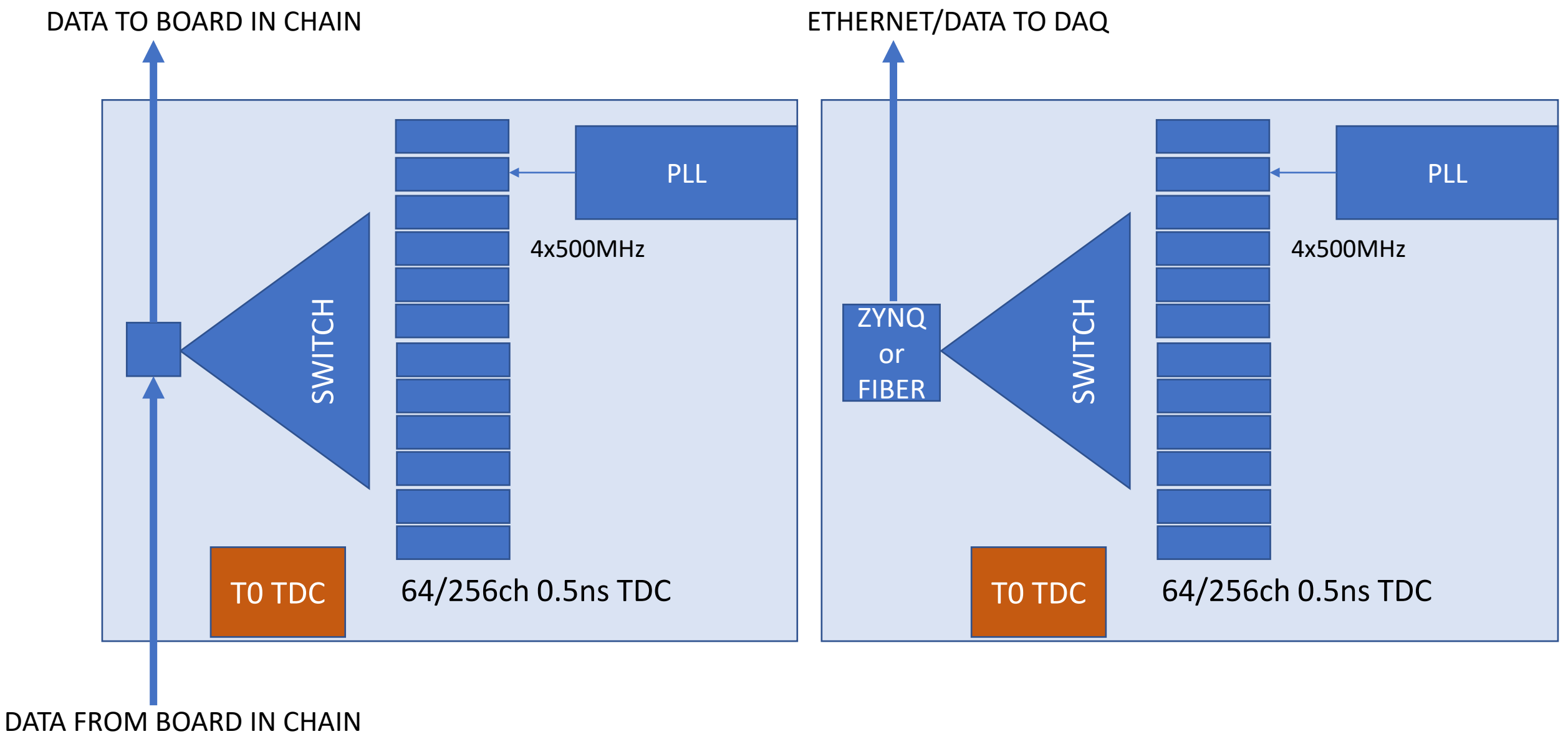
4 PHASE TDC – FINE + COARSE



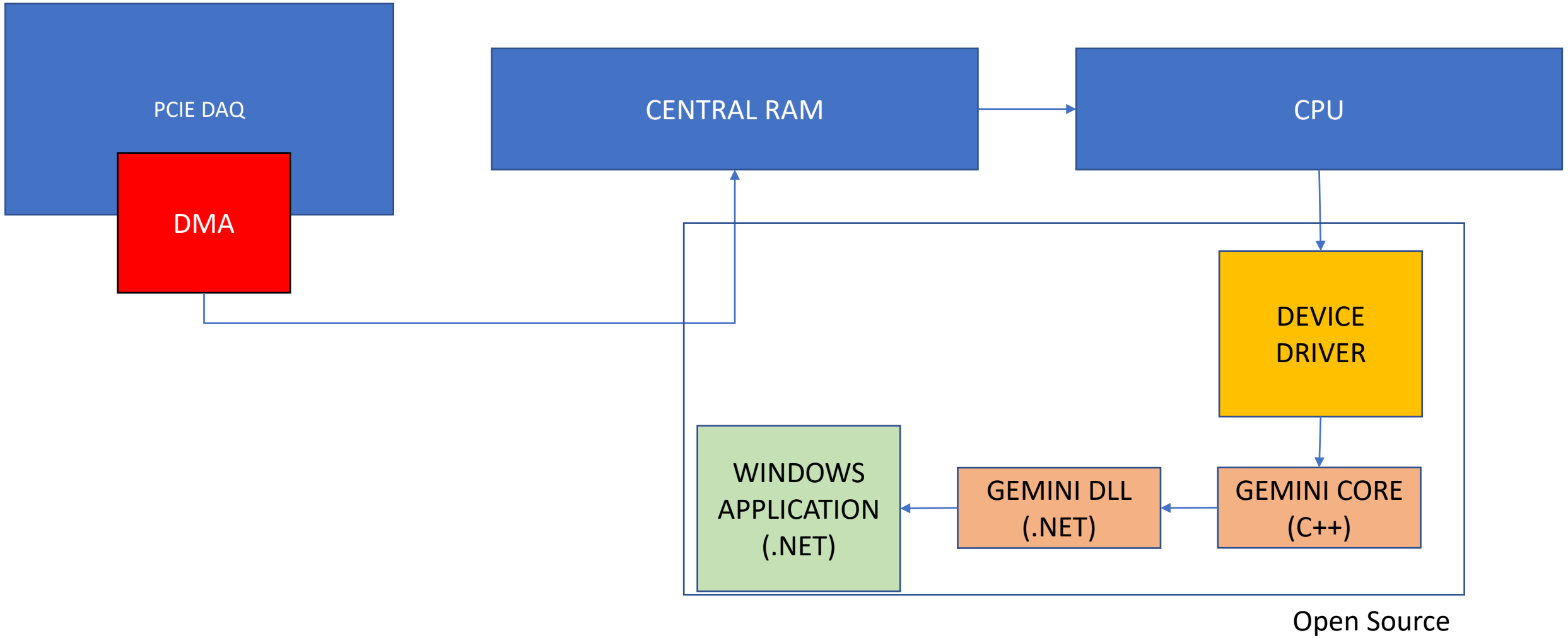
4 PHASE TDC – TDC SWITCH



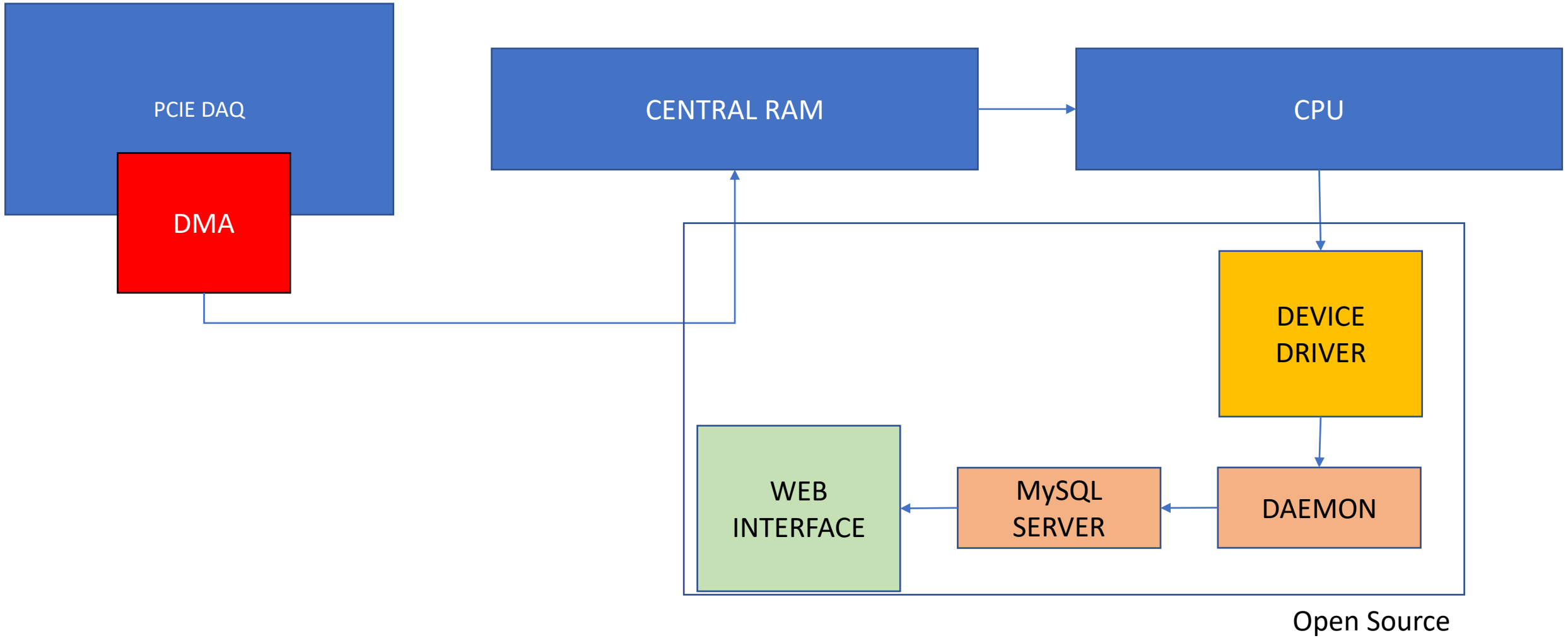
TDC FPGA BOARD



GEMINI 256 – WINDOWS BASED SYSTEM



GEMINI 64 – LINUX BASED SYSTEM



Applications: Boron coated Triple-GEM