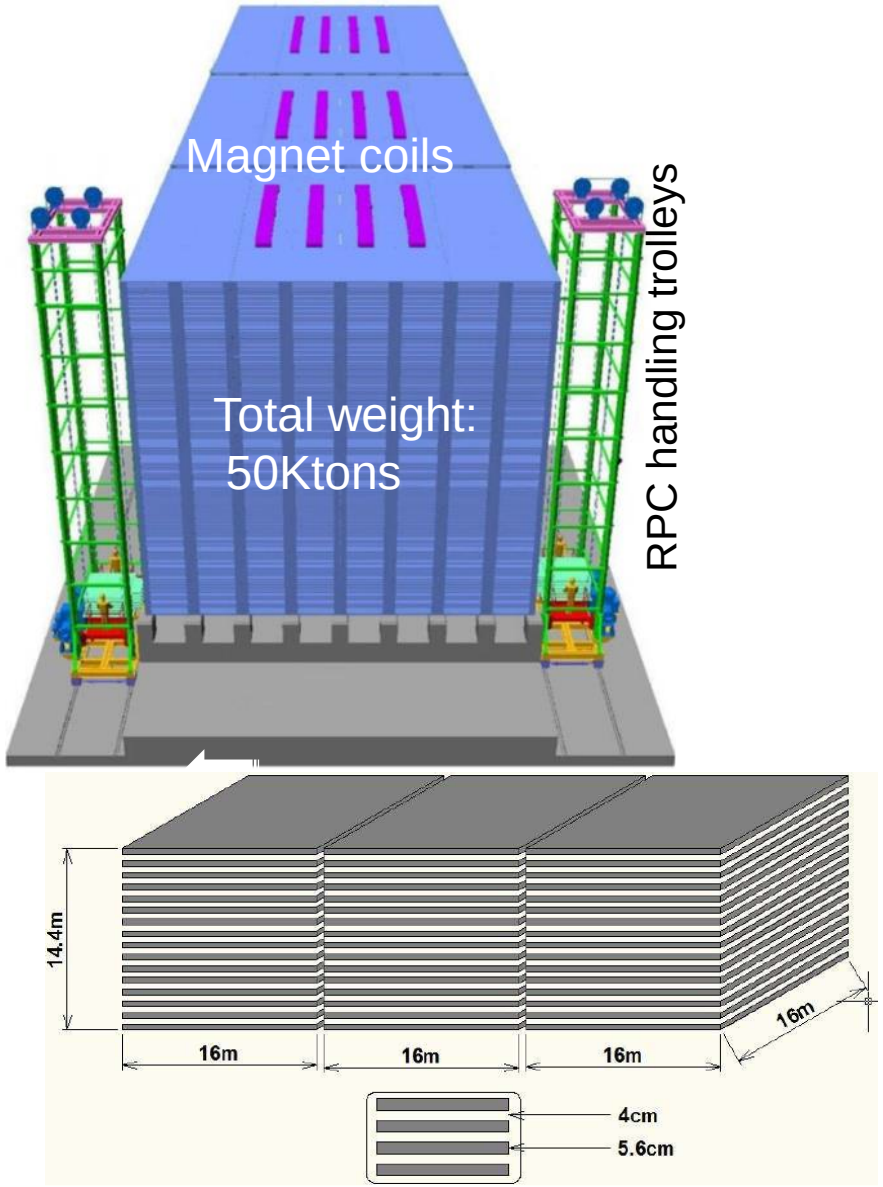
Mini ICAL Electronics

(S.S.Upadhya On behalf of INO Team)

- ICAL introduction
- Min ICAL & its progress
- Other potential developments (TIFR associated)
- Madurai stack result

ICAL detector and numbers



No. of modules	3
Module dimensions	16m × 16m × 14.5m
Detector dimensions	48.4m × 16m × 14.5m
No. of layers	150
Iron plate thickness	56mm
Gap for RPC trays	40mm
Magnetic field	1.3Tesla
RPC dimensions	1,950mm × 1,840mm × 24mm
Readout strip pitch	3 0mm
No. of RPCs/Road/Layer	8
No. of Roads/Layer/Module	8
No. of RPC units/Layer	192
No. of RPC units	28,800 (97,505m^2)
No. of readout strips	3,686,400

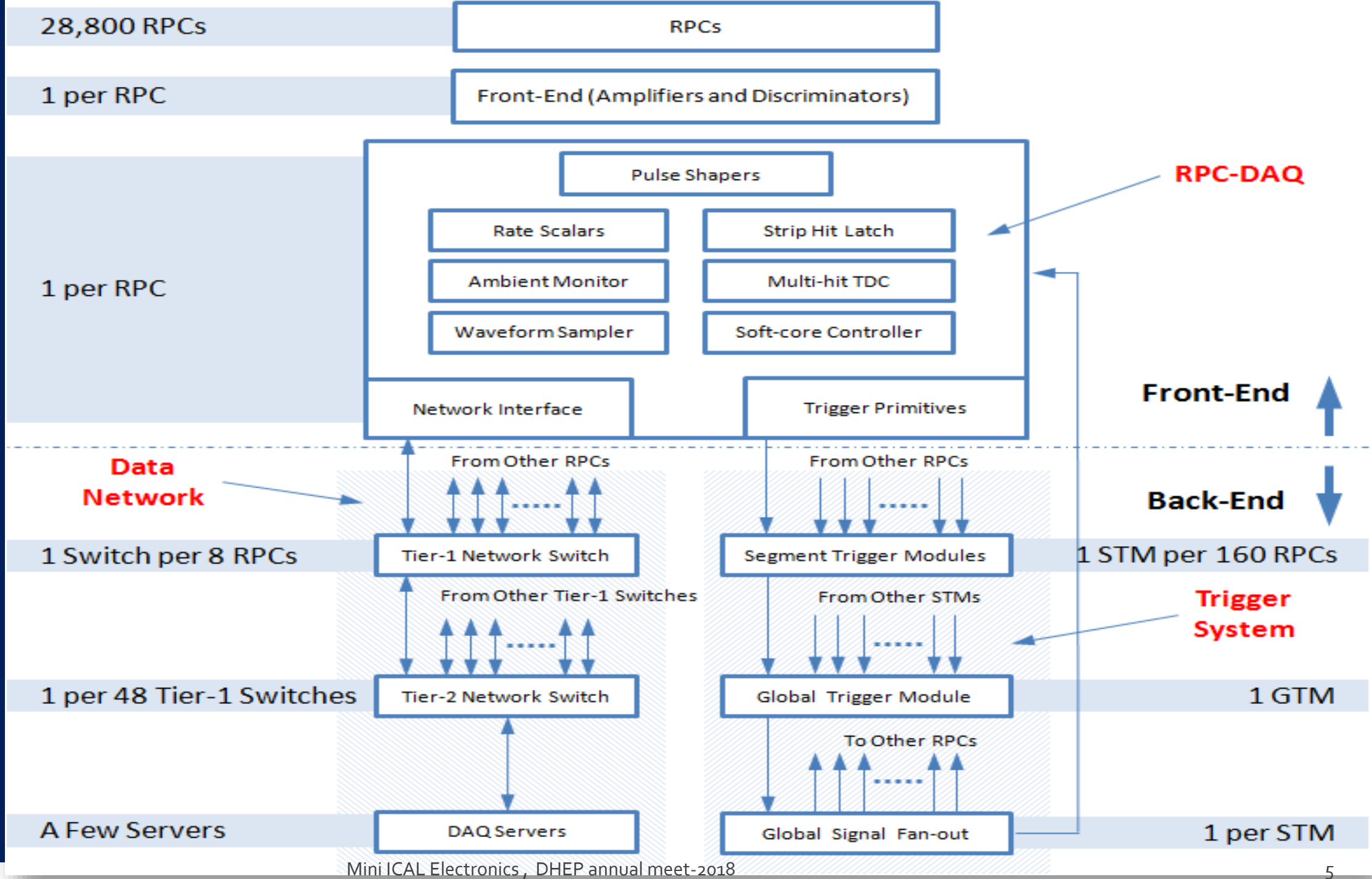
ICAL, e-ICAL and m-ICAL

Parameter	ICAL	e-ICAL	m-ICAL
No. of modules	3	1	1
Module dimensions	16.2m×16m×14.5m	8m×8mx2m	4m×4mx1m
Detector dimensions	49m×16m×14.5m	8m×8mx2m	4m×4mx1m
No. of layers	150	20	10
Iron plate thickness	56mm	56mm	56mm
Gap for RPC trays	40mm	40mm	45mm
Magnetic field	1.3Tesla	1.3Tesla	1.3Tesla
RPC dimensions	1,950mm×1,910mm×24mm	1,950mm×1,910mm×24mm	1,950mm×1,910mm×24mm
Readout strip pitch	30mm	30mm	30mm
No. of RPCs/Road/Layer	8	4	2
No. of Roads/Layer/Module	8	4	1
No. of RPC units/Layer	192	16	2
No. of RPC units	28,800 (107,266m^2)	320 (1,192m^2)	20 (74.5m^2)
No. of readout strips	3,686,400	40,960	2,560

Madurai stack to m-ICAL

Parameter	Madurai stack	m-ICAL
Gap for the RPC tray	160mm	32 mm
Maximum height for RPC/FE/HV	25mm ++	≤ 25mm
Tray dimensions	2112mm×1979mm×38mm	1950m×1910mmx33.2mm
RPC gas gap size	1906mm×1806mm	1851mm × 1746mm
Gas nozzle orientation	Rear side	Front side
Number of RPCs per layer	One, less concerns	Two, necessary considerations
AFE	HMC/NINO	NINO/Anusparsh
DFE	RPCDAQ v1	RPCDAQ v1++
HV supply solution	Commercial	Commercial/INO's module
HV supply location	Front-left side	Rear-right side
Trigger system	Almost the same (except for the number of RPCs)	
Backend system	Almost the same (except for the number of RPCs)	
Magnetic field	0Tesla	1.3Tesla
Thermal and shielding issues	Exists	Will be better?

Scheme of ICAL DAQ electronics



Madurai Detector Stack with old Electronics (without Magnet)



Madurai Detector Stack with the new Electronics without magnet



Mini ICAL (Magnetized)

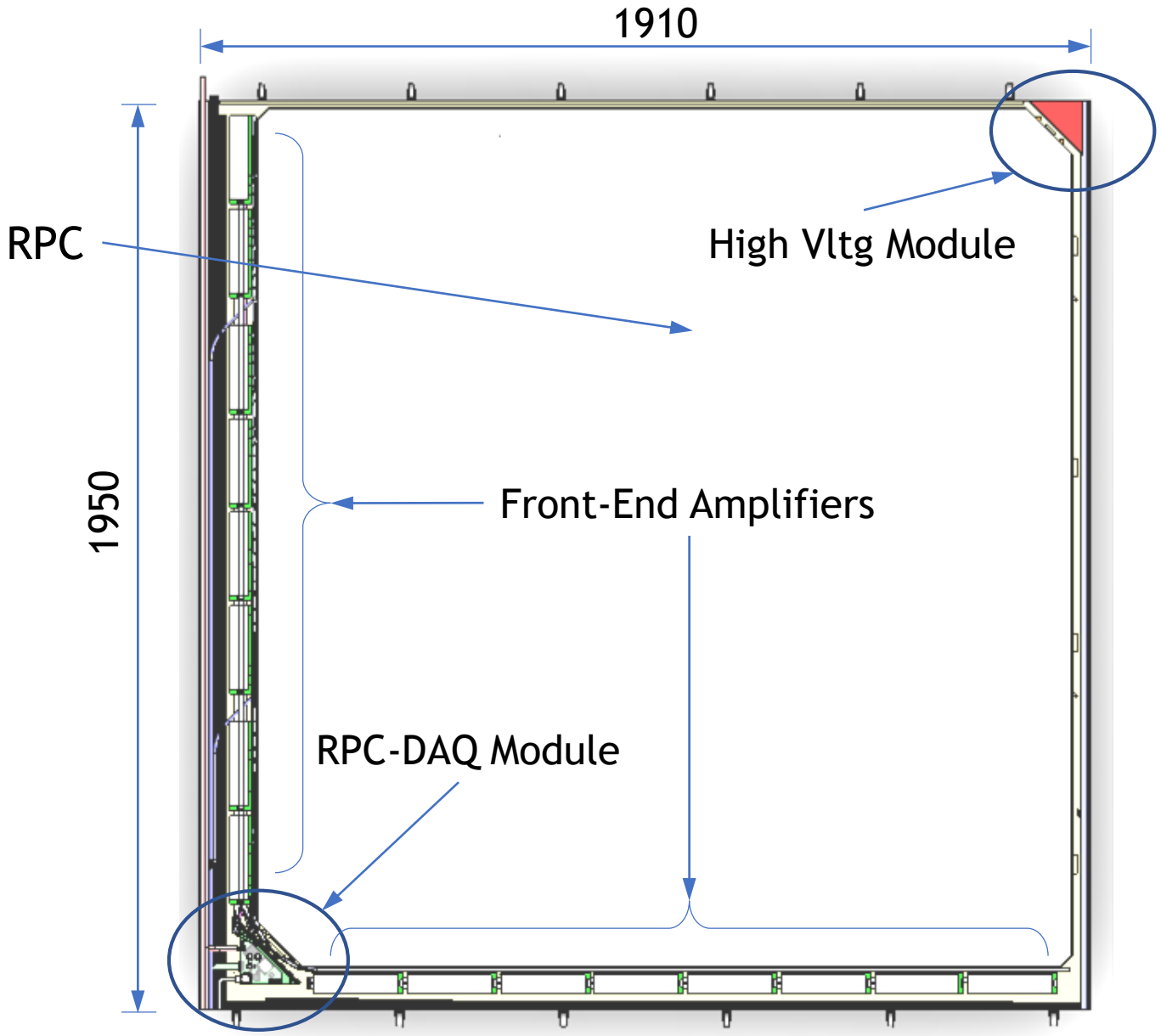


Re

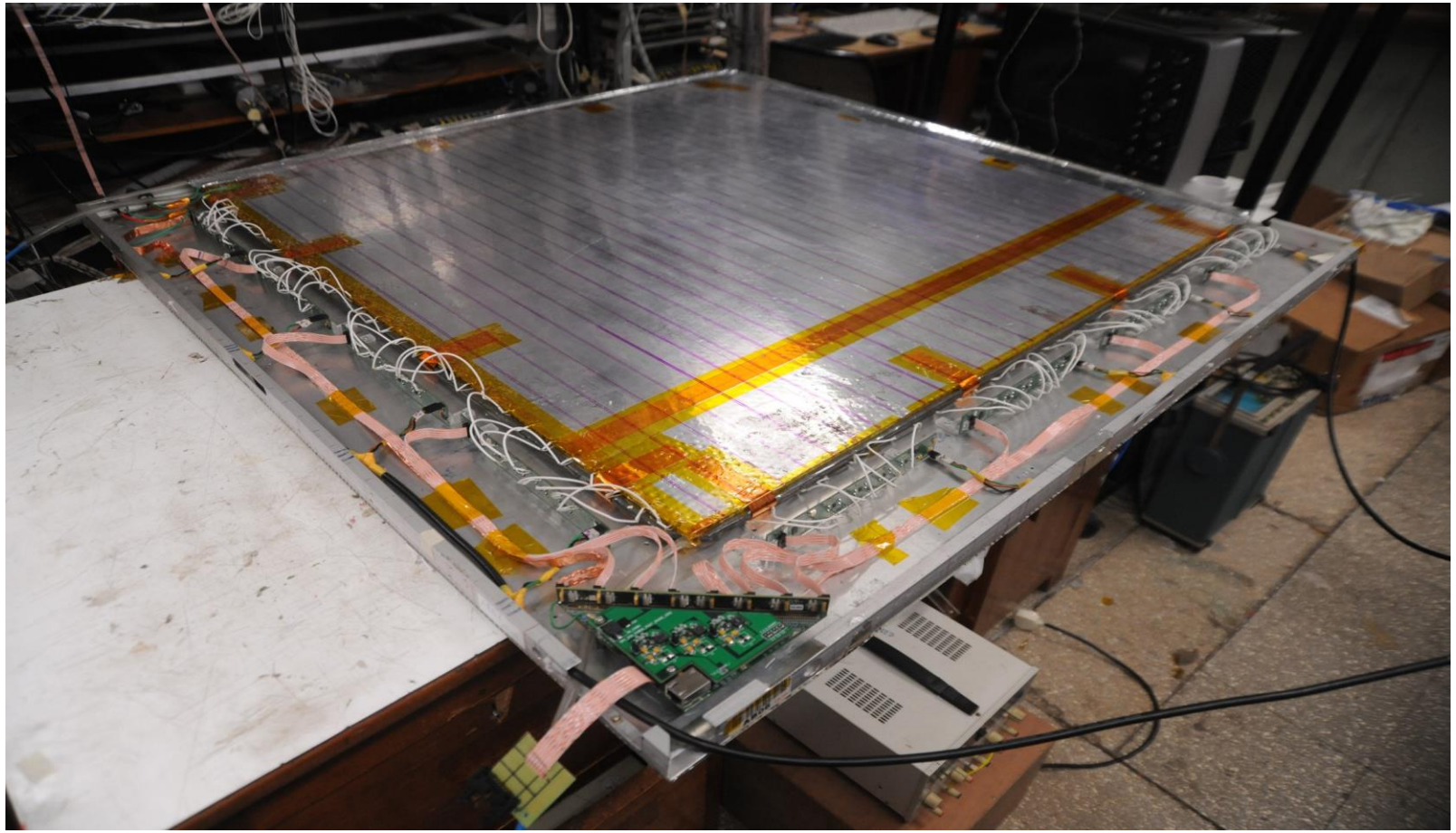




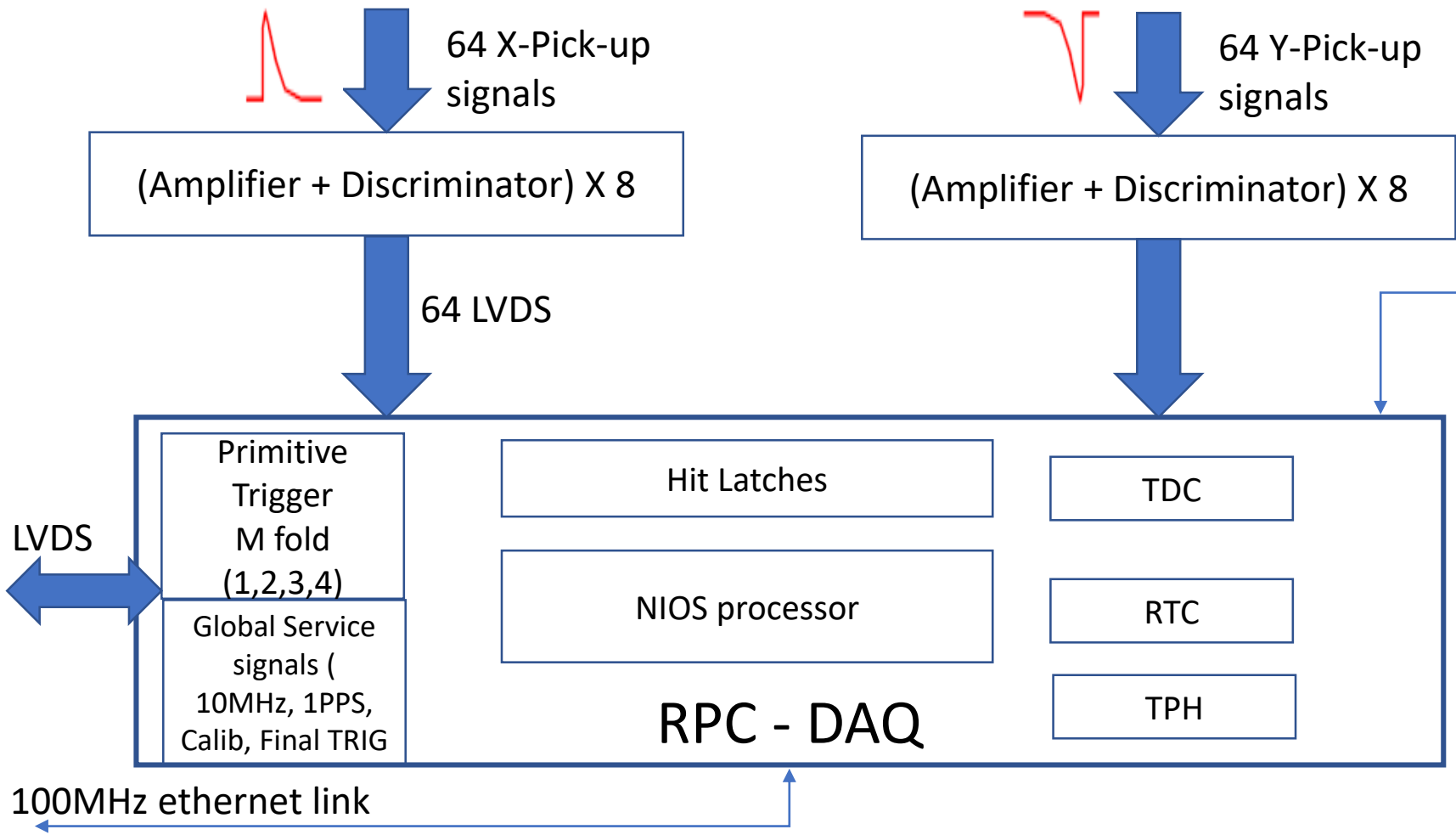
RPC Tray Assembly



Typical tray of the Madurai stack



RPC Embedded Electronics



MAIN TASKS

- Pre Trigger Generations Mfold in X & Y
- Event Recording (DT-300us)
  - Event time stamp
  - Strip Hit data(128)
  - TOF (TDC) wrt FTRIG arrival
- Monitoring
  - Pick-up signal rates
  - HV , TPH
- HV setting
- Command execution and Data transfer over LAN

Analog Front-End: NINO and Anusparsh-III

NINO: Installed in 11 layers(TIFR)

- 8 Channel preamplifier board.
- Common threshold contol for all channels.
- Size of Board is 200 mm x 23 mm
- LVDS Outputs
- Power consumption 70 mW/ch

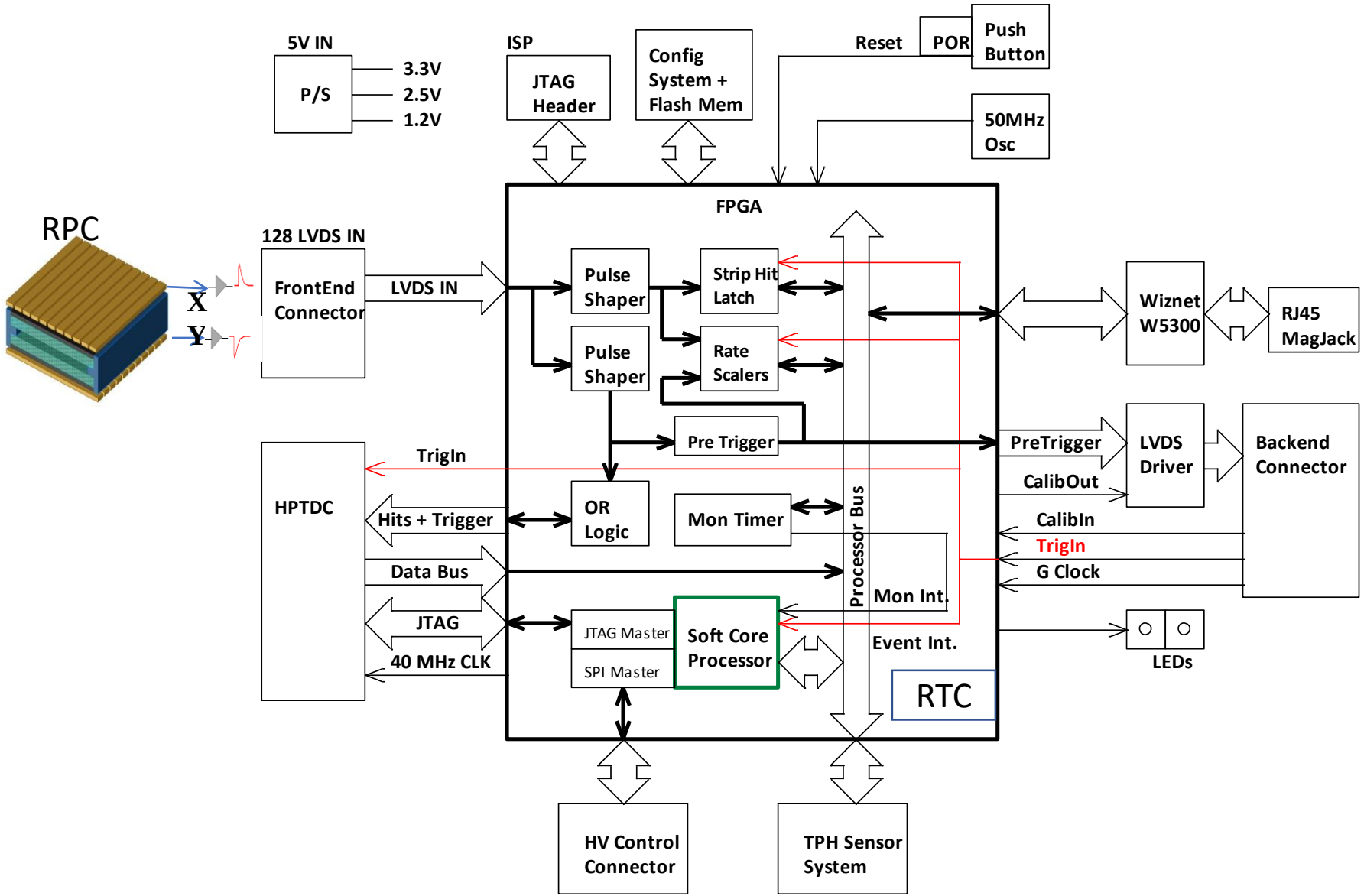
Anusparsh-III: Installed in 1 Layer(BARC)

- 8 Channel preamplifier board
- Size of Board is 200 mm x 45 mm
- LVDS Outputs + 1 Multiplexed Analog output
- Power consumption 32 mW/ch

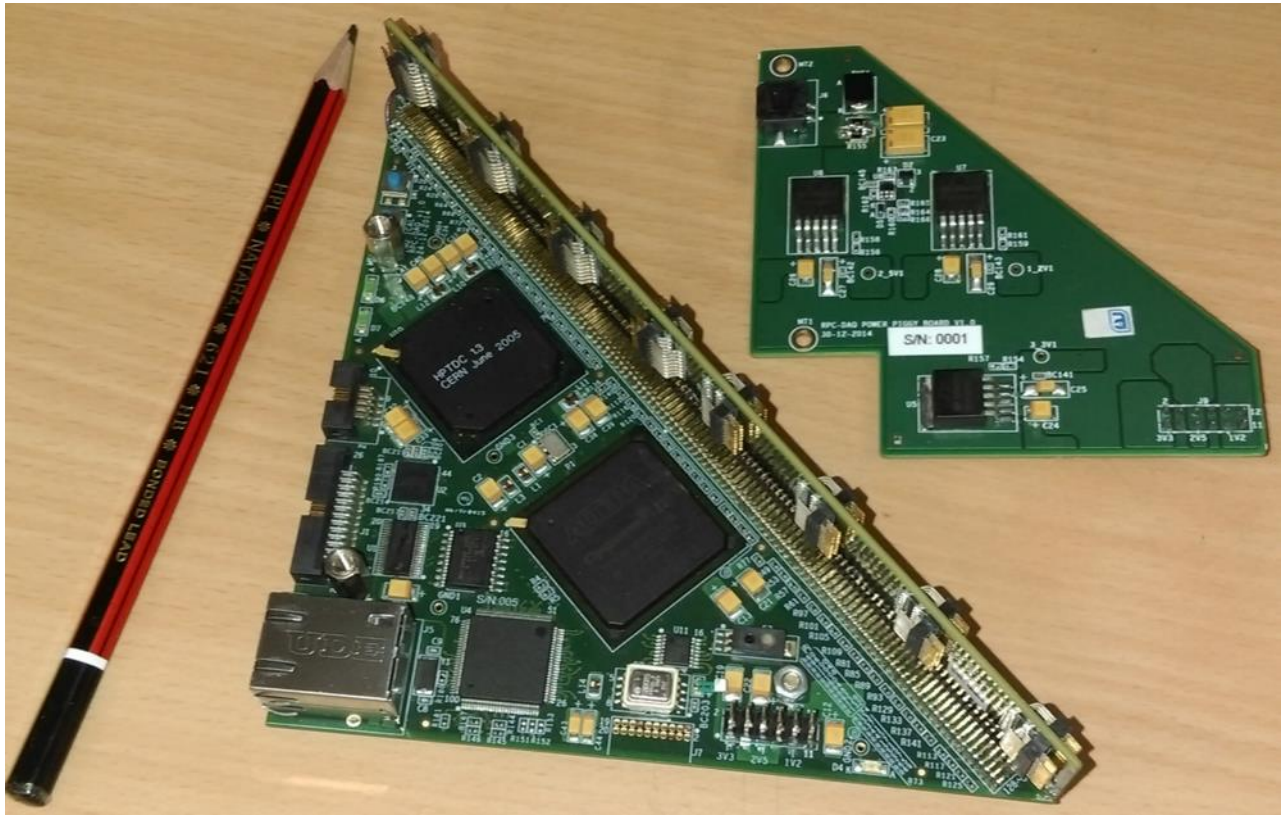




RPC-DAQ Block Diagram

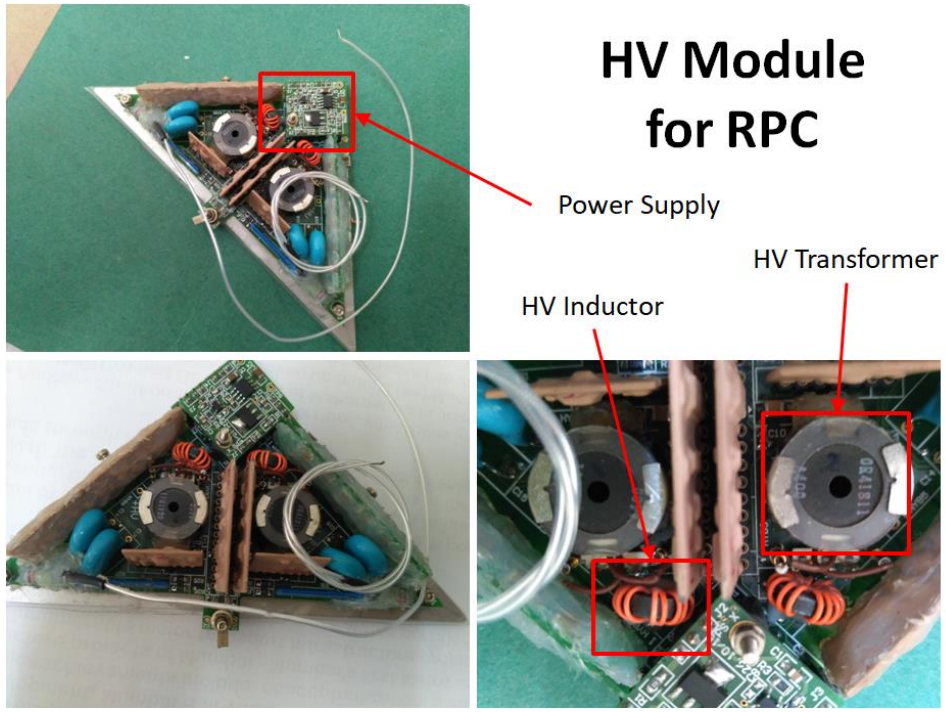


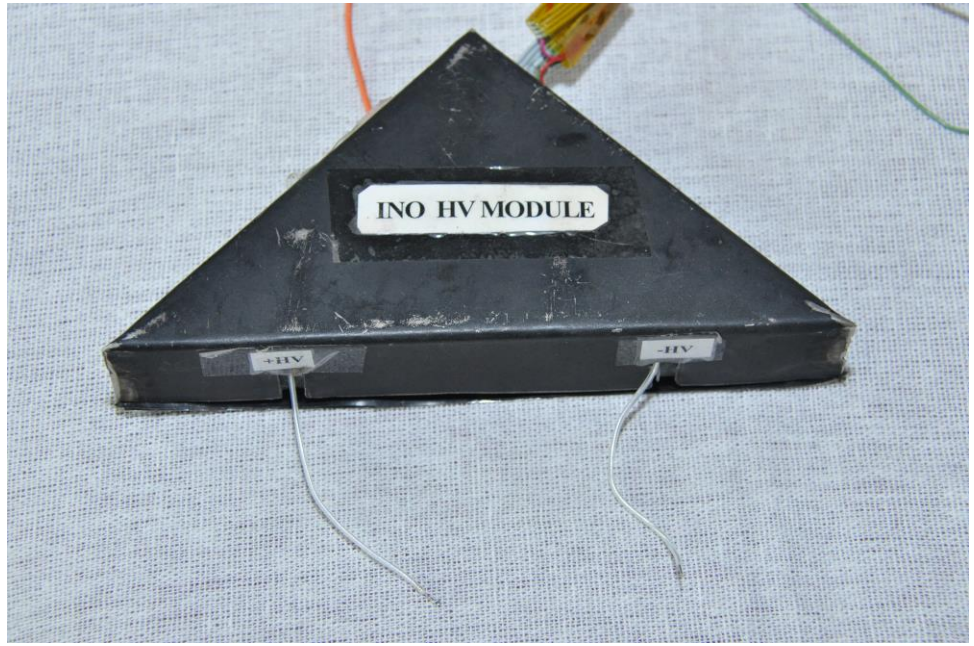
RPC-DAQ



125mm X 125mm
Right angle triangle
Power =5W

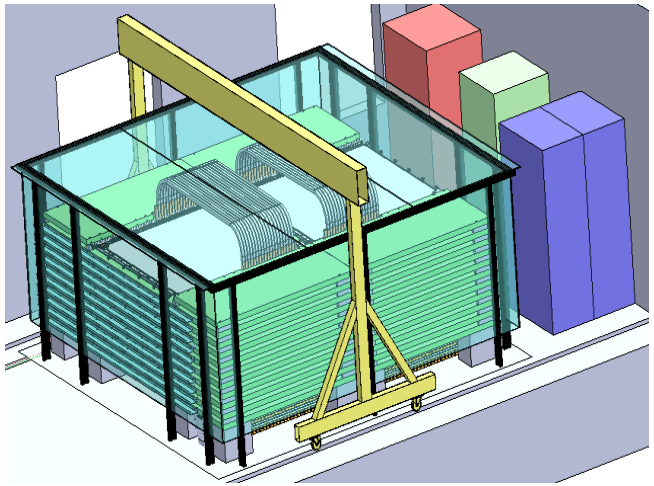
DC-DC HV module (+ - 6KV, 2uA)(BARC/TIFR)

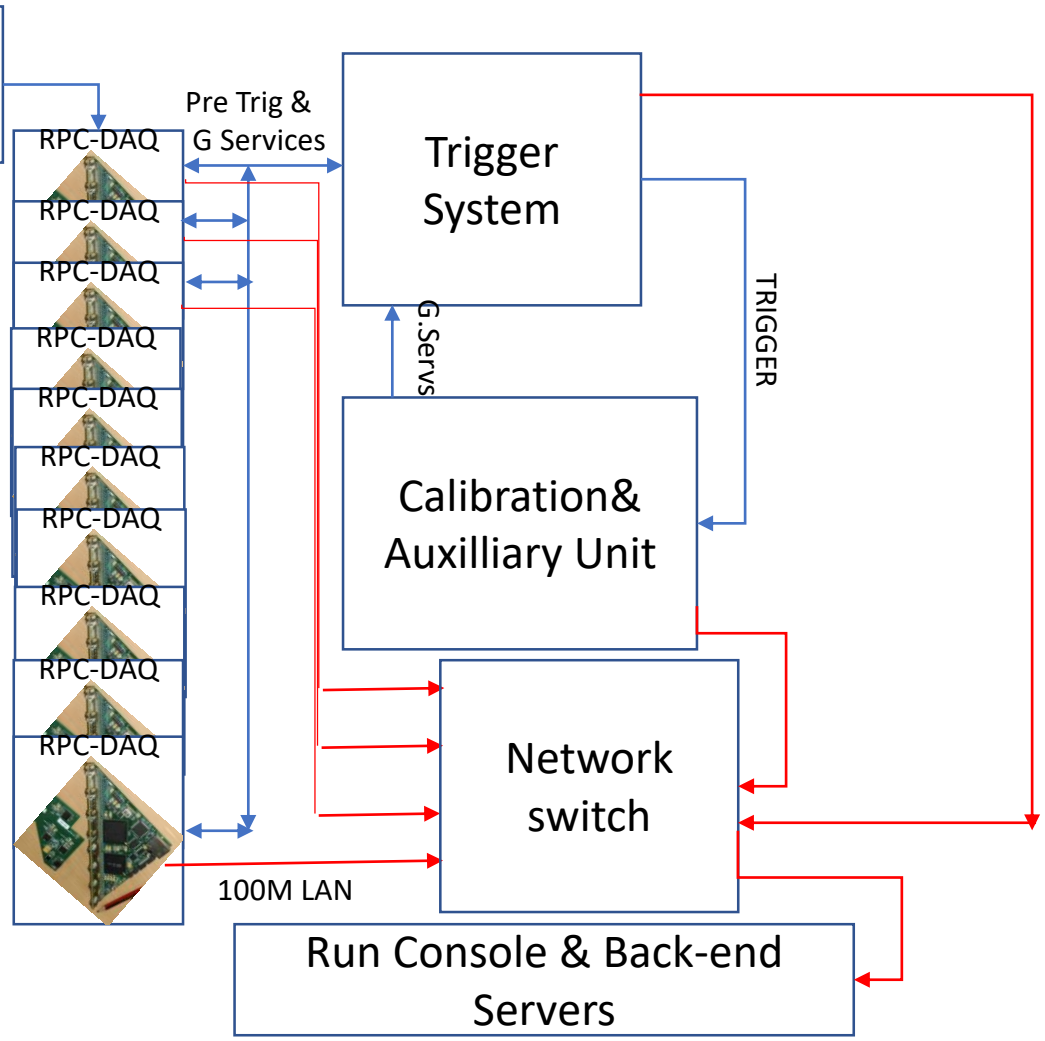




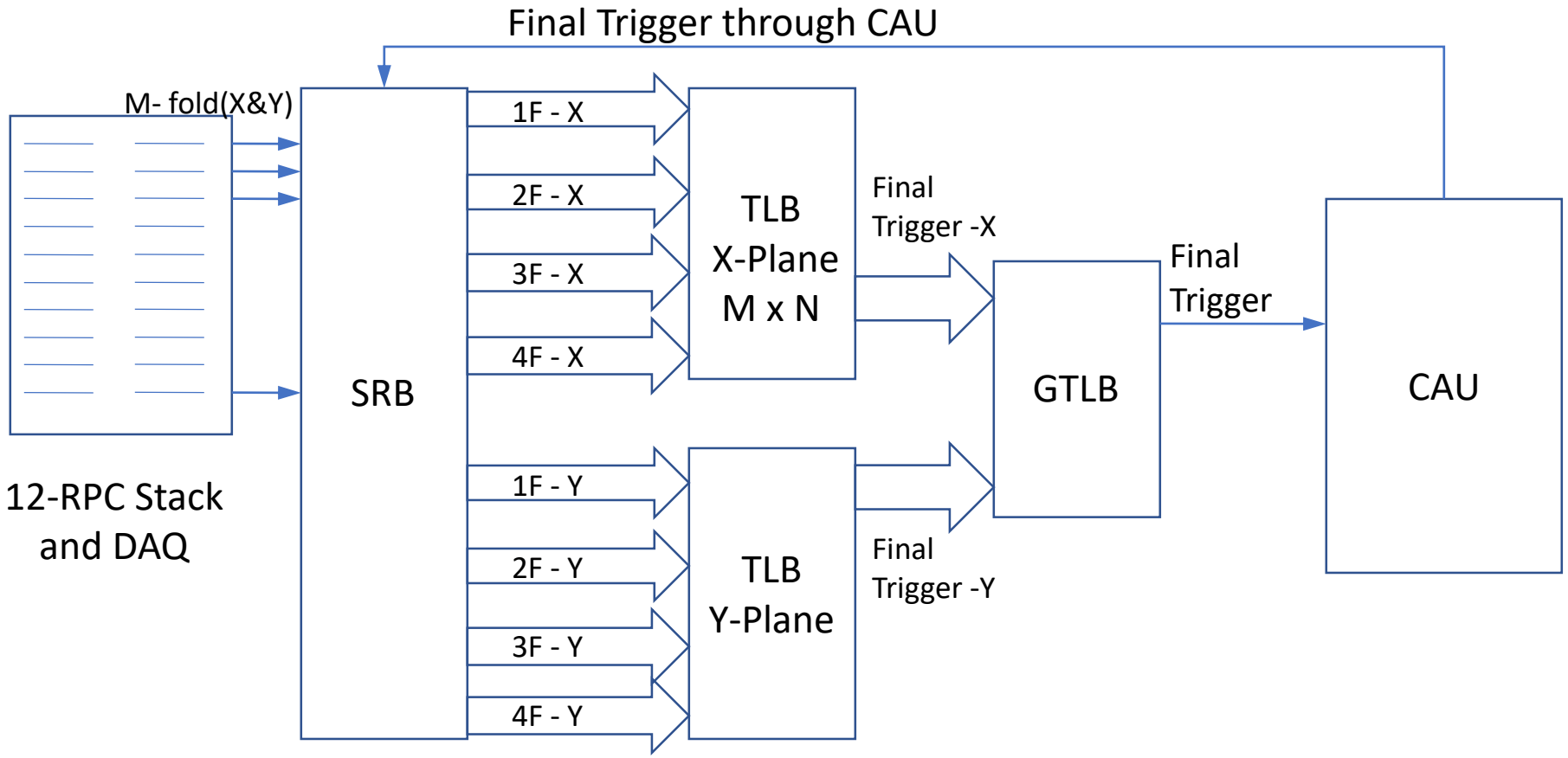
Mini-ICAL at Madurai

- GAU generates Global services like FTRIG,10MHz,1PPS,Calib IN/OUT
- Trigger System generates MxN trigger over layers
- CAU controls Final Trigger and Calibration trigger. Records Final trigger delay offsets to all RPC DAQs and time stamp on each Calibration trigger
- Trigger system generates Trigger Packet and RPC DAQ generates event packet on a normal trigger. Calibration packet on Calibration Trigger.
- Run Console controls over all operation
- Back-end servers records Event Data, Monitor data and calibration data

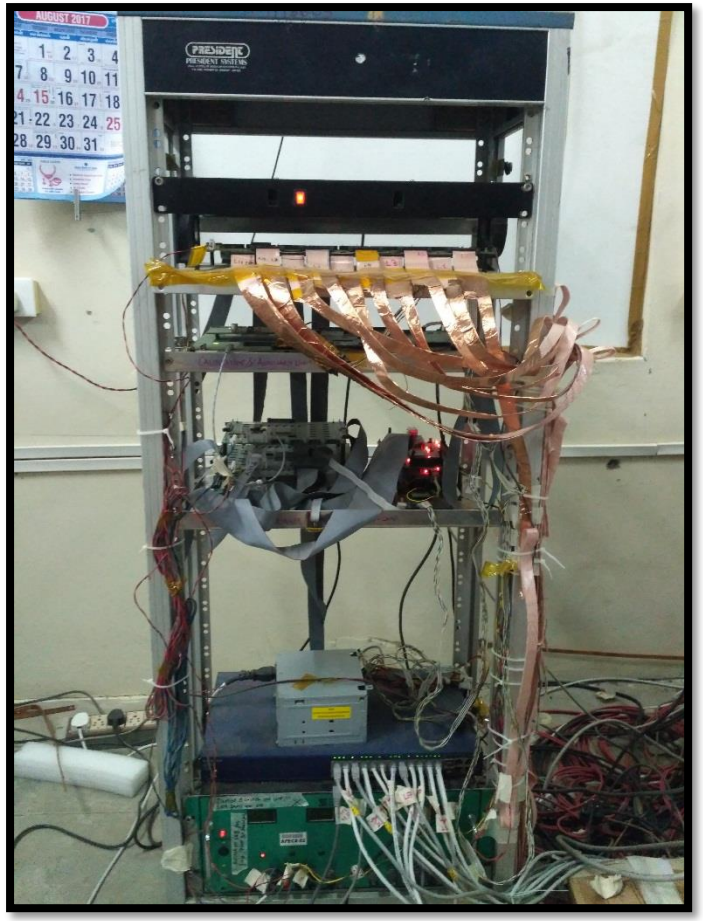


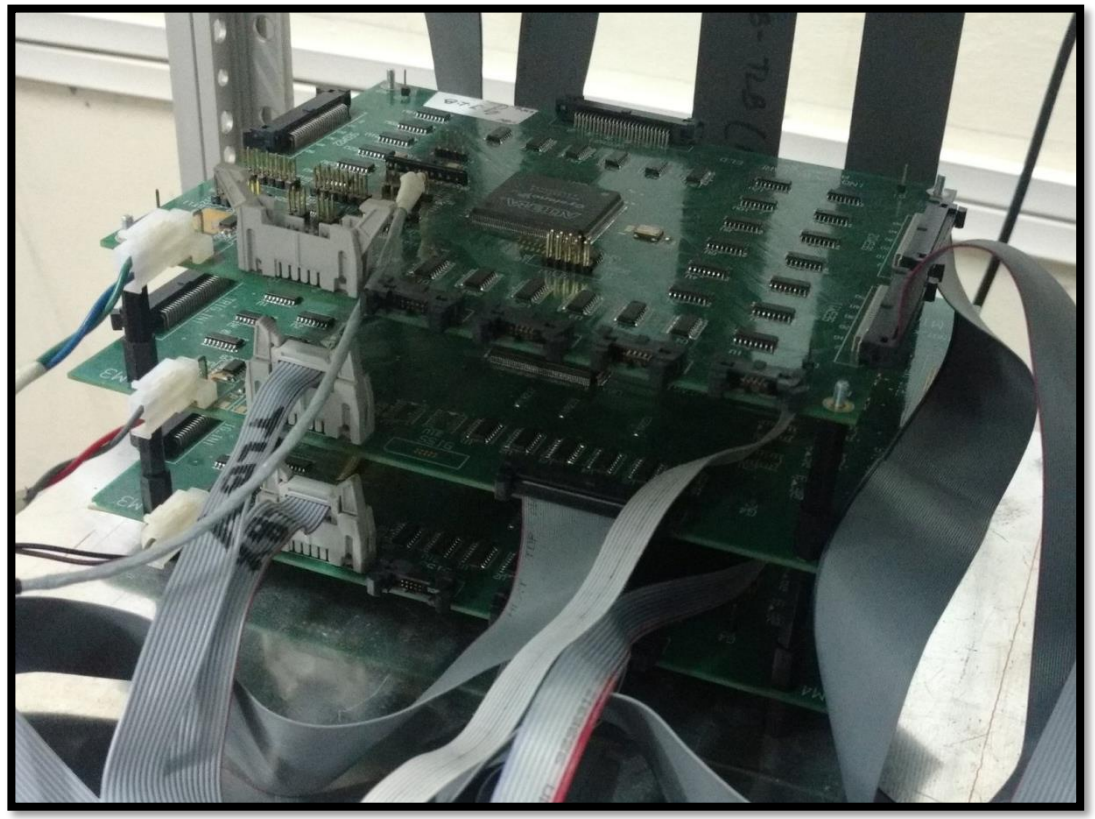


The Trigger System for mini-ICAL(BARC/TIFR)



The mini-ICAL Trigger System(BARC/TIFR)

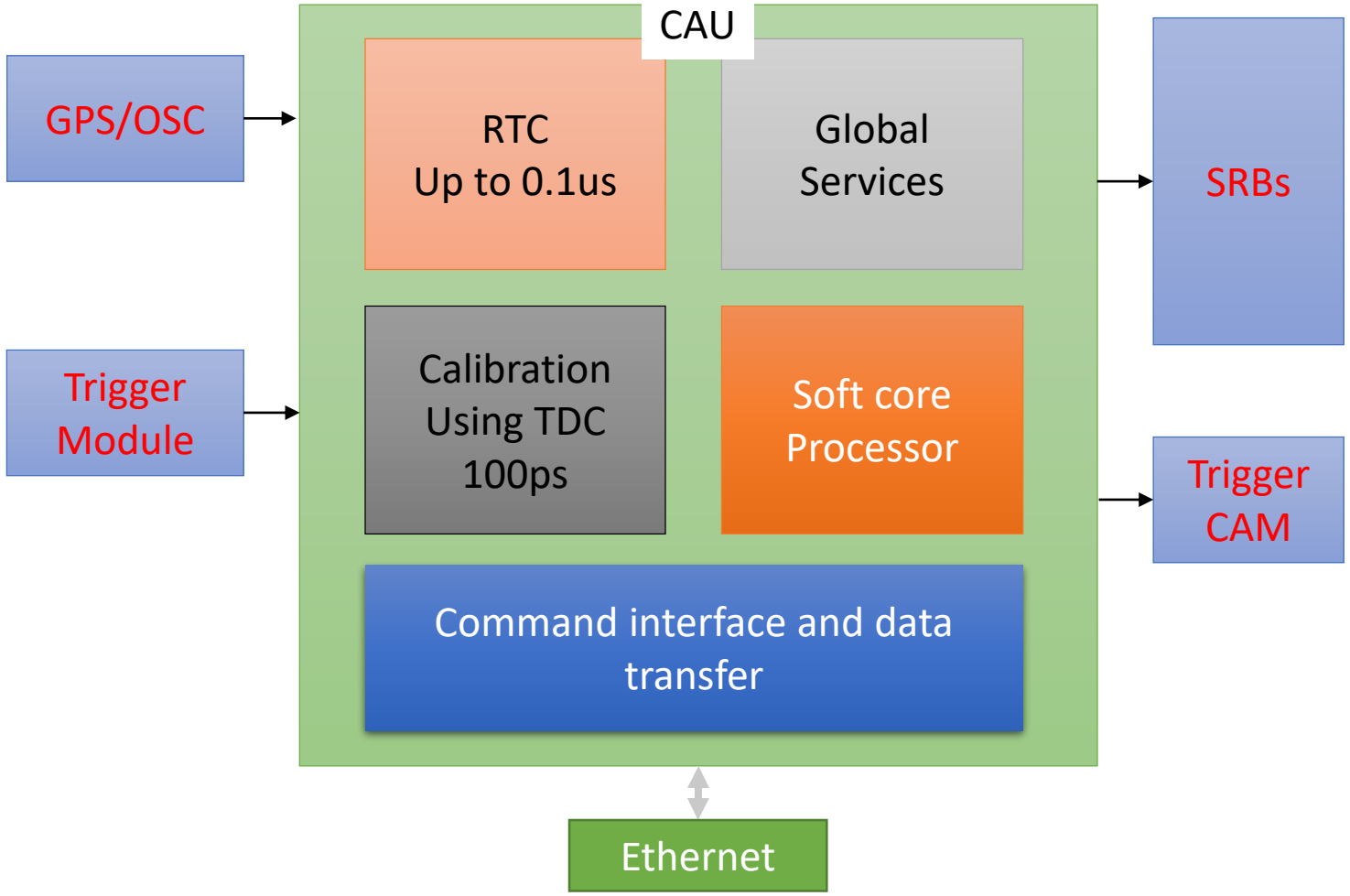




CALIBRATION & AUXILIARY UNIT

Main Tasks

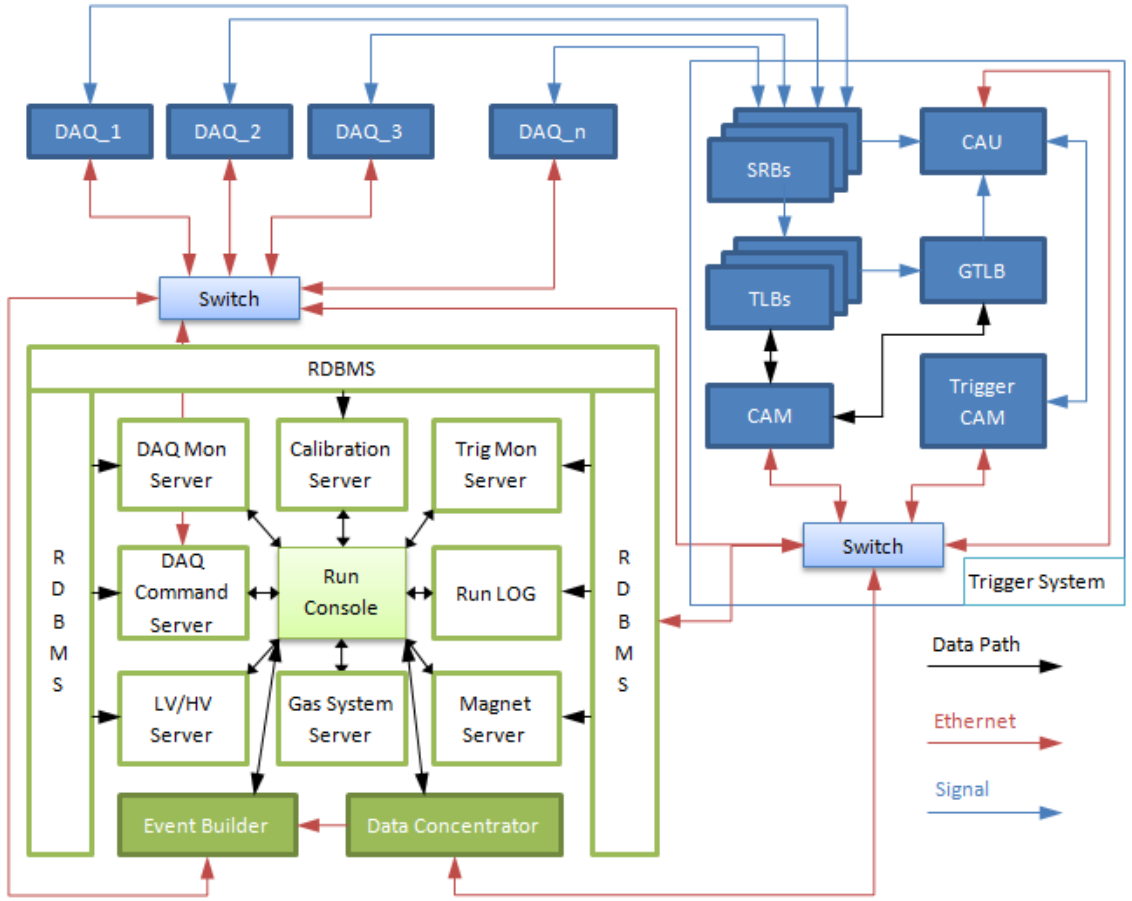
- Global services to all Nodes
- RTC time setting and Synchronization to GPS
- Trigger & Calibration control
- Calibration Data packet (RTC time stamp + final Trigger path delays to RPCs (TDC)
- Calibrate trigger delay paths for timing data



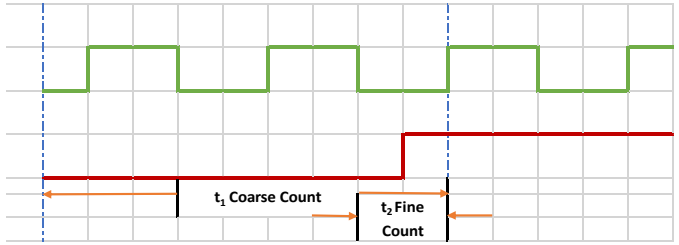
mini-ICAL system integration

Back-end tasks

- DC- collects event packet
- Event builder
- Monitoring Server
- Calibration server
- Trigger Mon Server
- Command Server
- Run Console



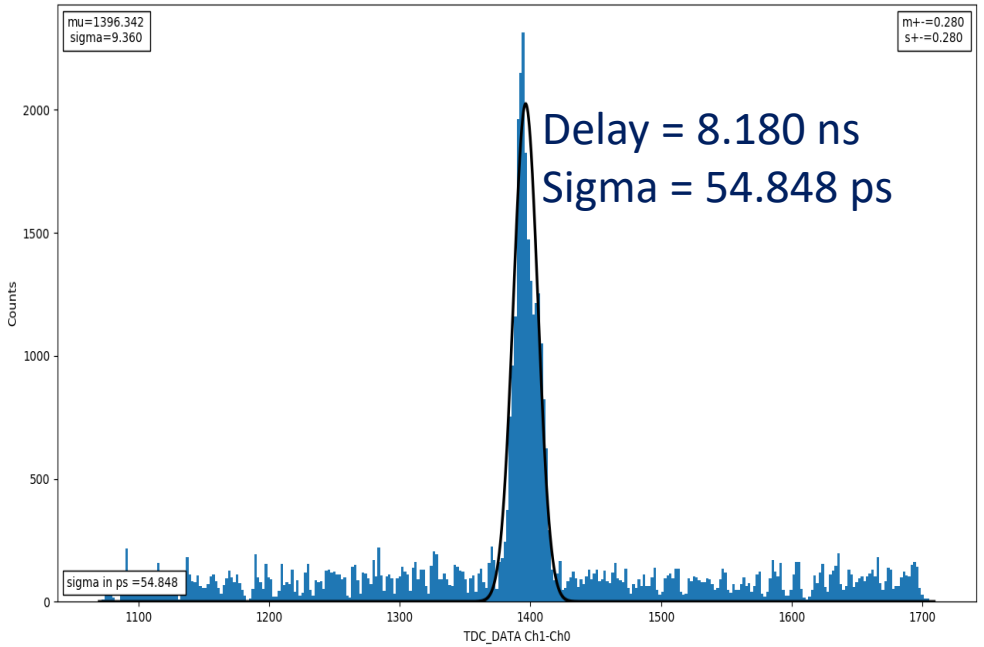
Attempt to make FPGA based TDC (TIFR)



TIMESTAMP = $t_1 - t_2$

- No. of Channels -2
- Coarse Count bits – 22
- Fine Count – 10 (8 Bit Raw Count –2extra hist bits)
- Precision – expected better than 50ps
- Dynamic Range – 25.165 ms
  Coarse Clock – 175 MHz

- Each Hit is fed to delay line.
- **Delay Line** Implemented using fast **Carry Chain**
- 400 Carry Elements used per Chain for 6ns delay
- Encoding of 400 tapped register values to 10bit gives us fine count

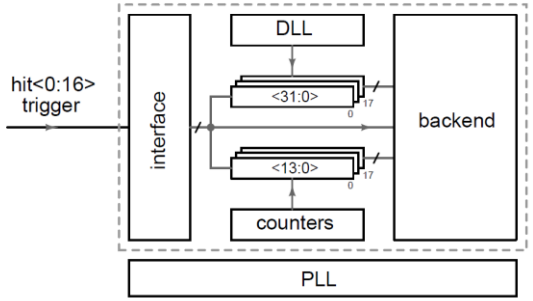


status of IITM TDC v3 (IITM-TIFR)

Specifications

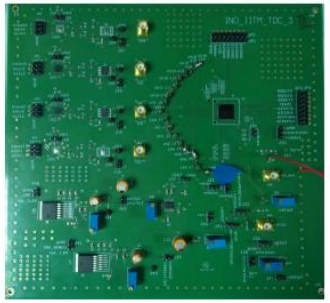
- 17 inputs + Trigger (4 hits)
- L. Edge- 125ps, 65.5us
- width (250ps, 64ns)
- SPI read out

TDC3v1





(c) Packaged chips



(d) PCB for testing

- Packaged in QFN64
- Testing began in May 2017

TDC3v1 - debugging

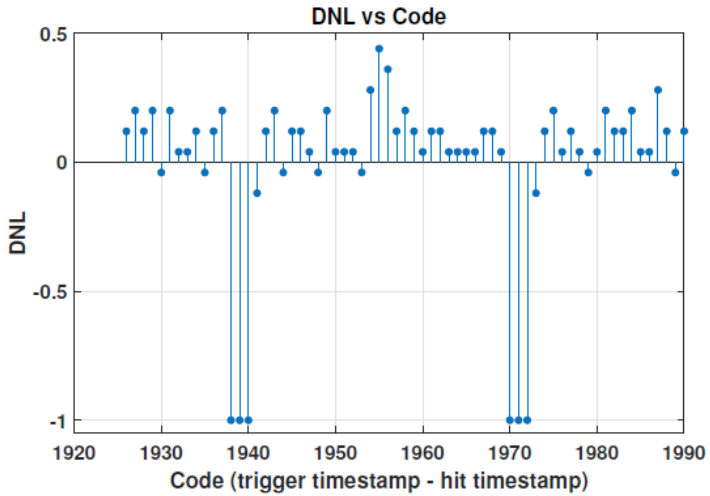
* Analog input/output behaviour as expected
* Digital outputs not as expected

* Digital inputs not reaching core
* Issues with digital IO cells (?)

- Incorrect IO cell replacement by IMEC during pre-processing for fabrication
- All digital inputs/outputs floating within chip

- IMEC offered free fabrication of the same gds in September 2017
- Testing began mid January 2018

DNL vs Code



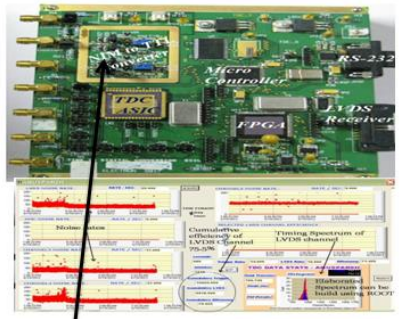
- Worst case DNL = -1 LSB
  - Testing
    - Characterize all channels
    - Verify the programmable parameters

Testing of TDC3v2 in the Madurai stack

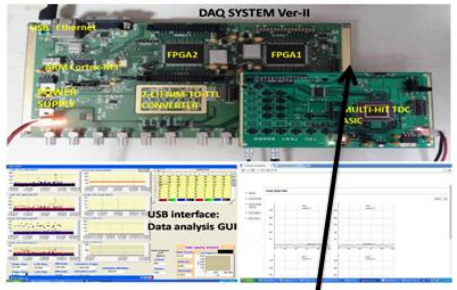
- Next tapeout: June 25, 2018
  - Fix bugs in core
  - Design inbuilt selftest block

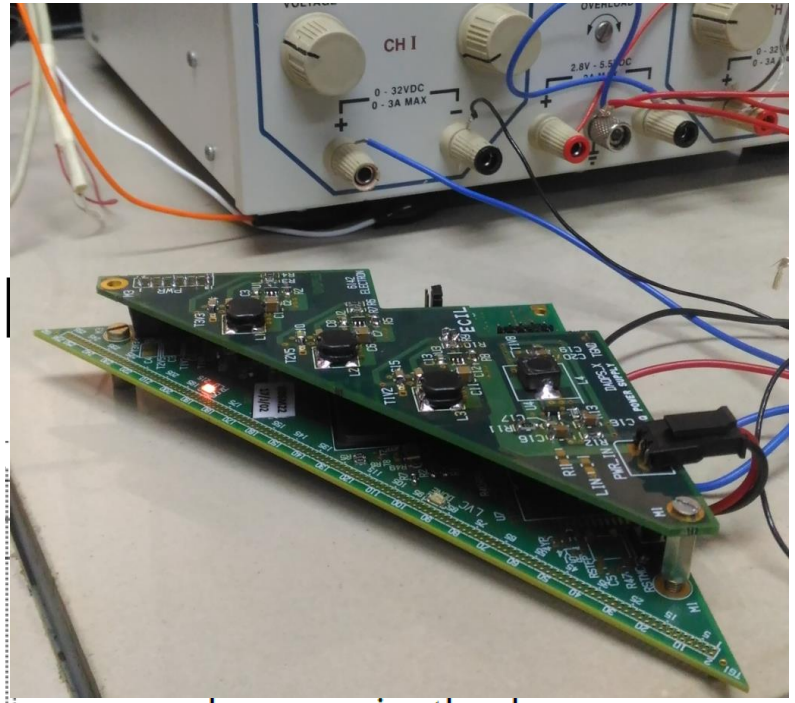
More ICAL TDC/RPC-DAQ candidates(BARC)

8-CHANNEL DAQ SYSTEM

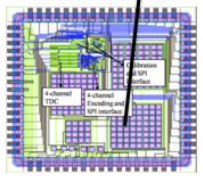


64-CHANNEL DAQ SYSTEM



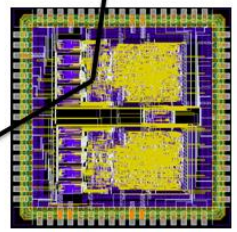


128-CHANNEL DAQ SYSTEM



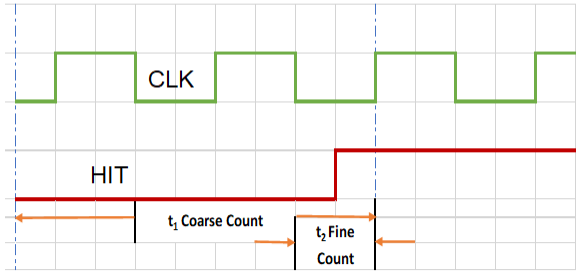
4-CH, Single Hit TDC



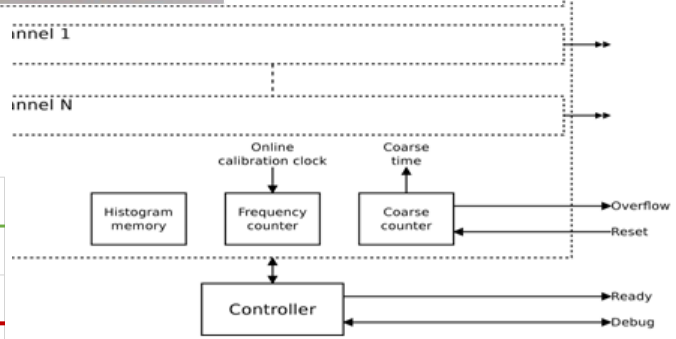


8-CH, 4-hits/CH TDC

CONCEPT



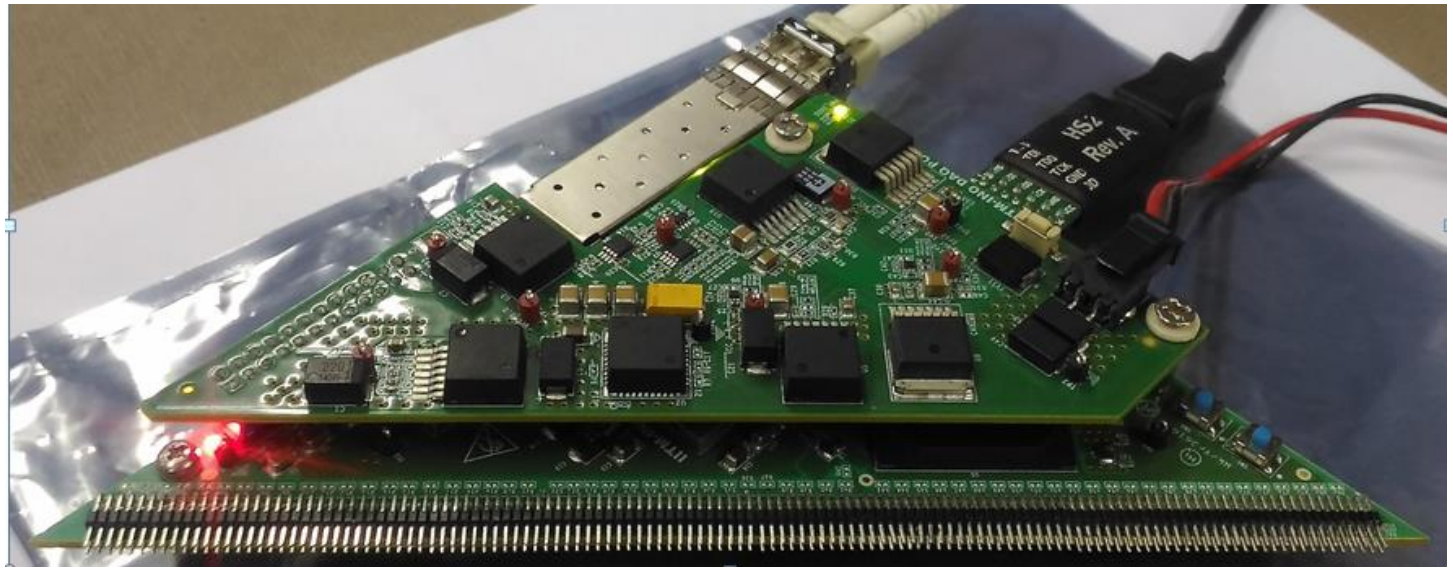
TIMESTAMP = $t_1 - t_2$



by measuring the change in frequency of a ring oscillator and updating histogram memory to compensate for PVT variations

ARXIV:1303.6840V1 [PHYSICS.INS-DET] 27 MAR 2013

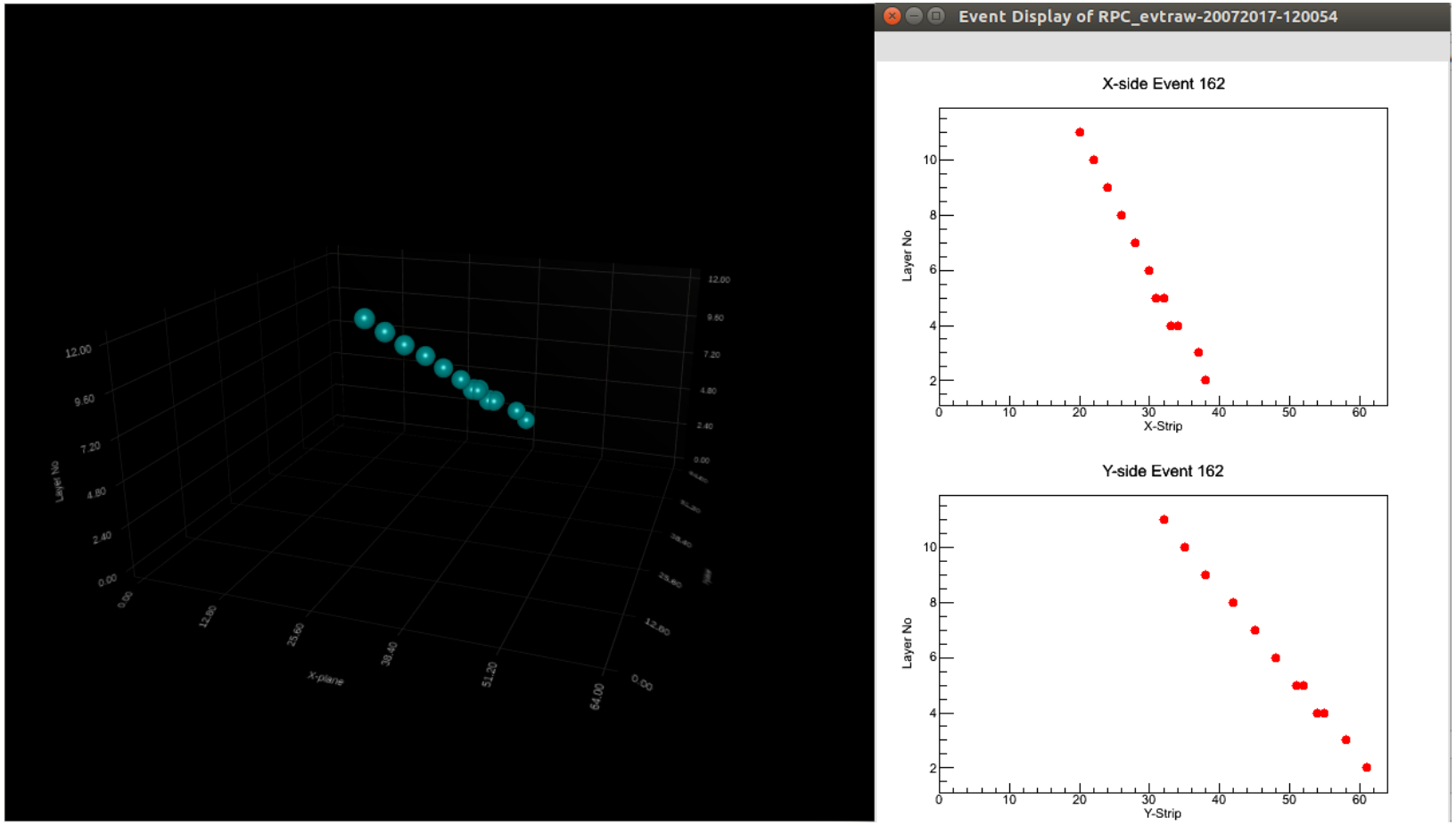
RPCDAQ with fiber link instead of present copper(IITM-TIFR)



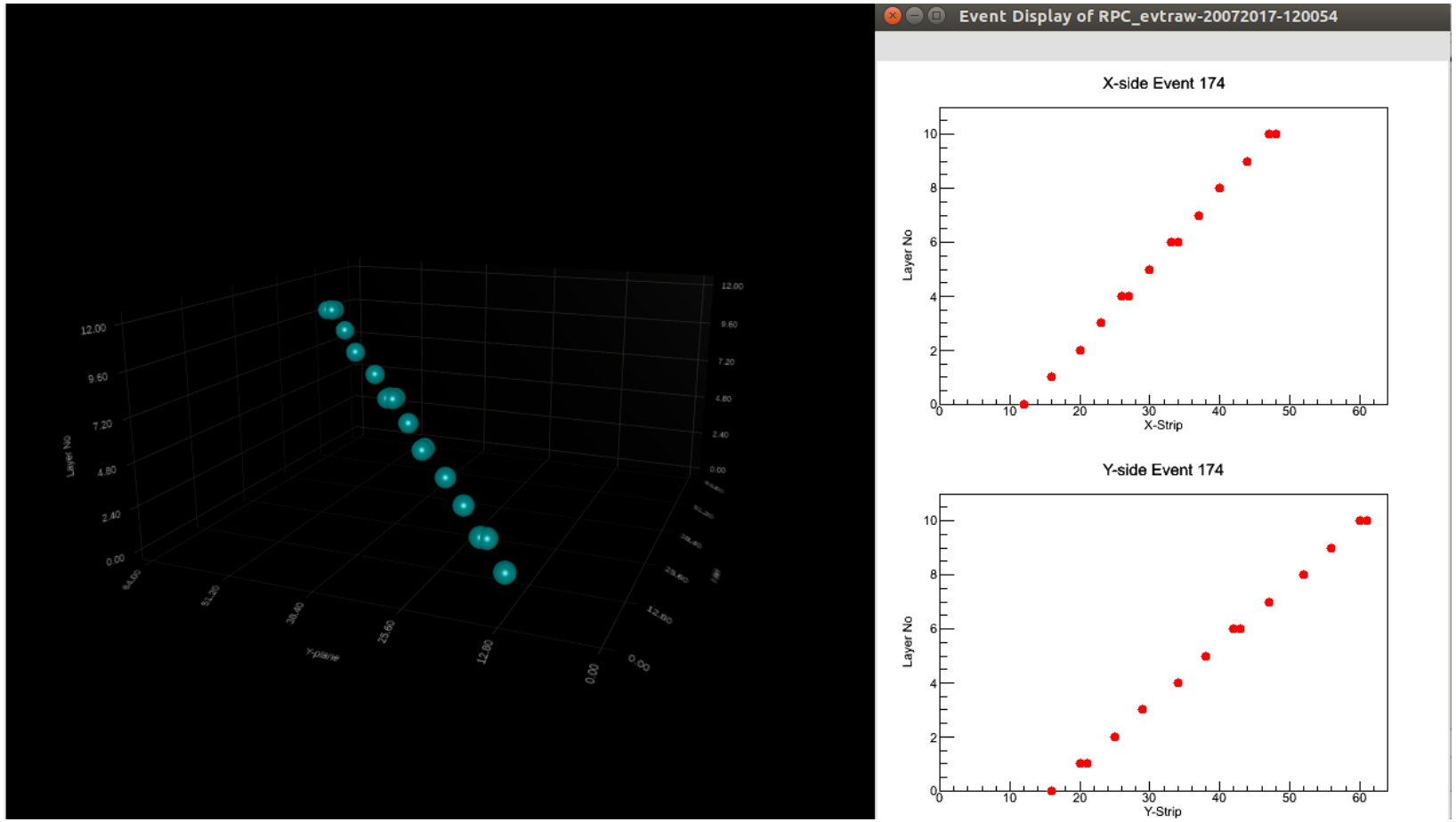
- **Lightweight IP (lwIP) is an open source TCP/IP networking stack**
- **Data captured at PC using Hercules Setup**
- **Data received from DAQ is mapped to lwIP on Kintext evaluation board KC705**
- **Test it at IICHEP soon**



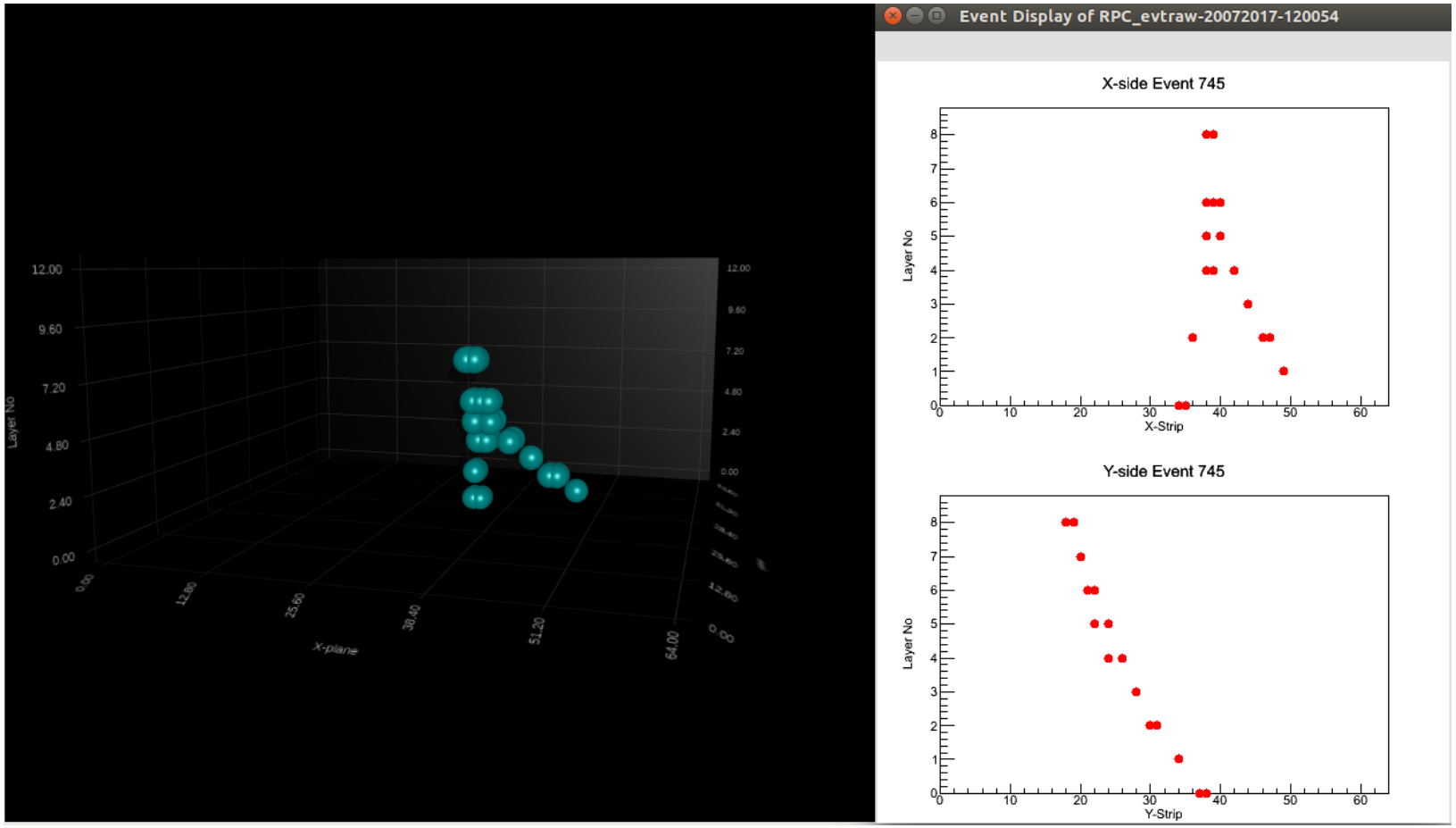
Results: Tracks



Results: Tracks



Results: Tracks



Thank you - INO team