

GEM commissioning for GEN-RP experiment (UvA GEMs)

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SBS collaboration meeting Jul 14-15

Outline

- SBS GEM trackers for GEN-RP
- Status of the UVa GEM commissioning
- Daq and read out electronics
- Auxiliary systems: Gas System, LV and HV
- Recent cosmic data and the tracking results

SBS GEM trackers for GEN-RP

10 UVA GEM layers

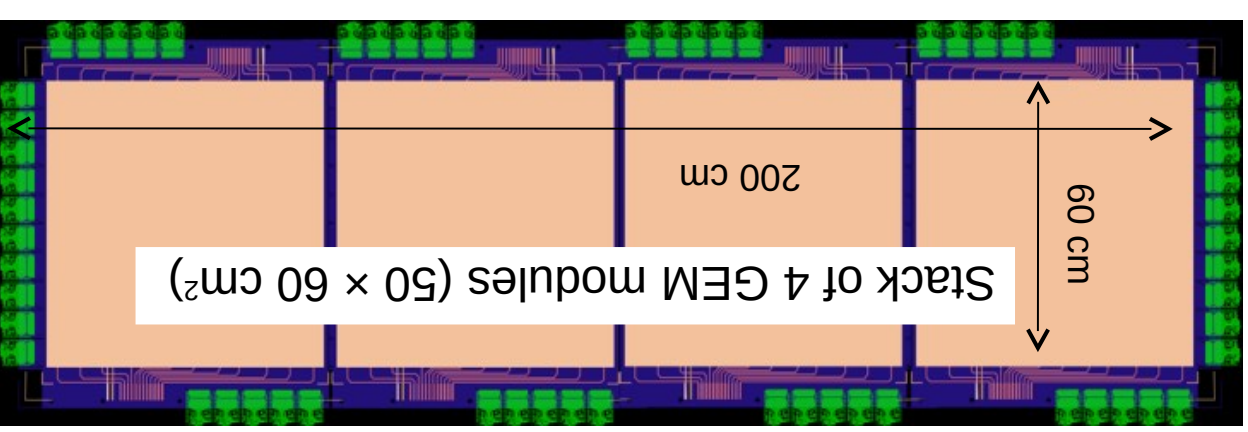
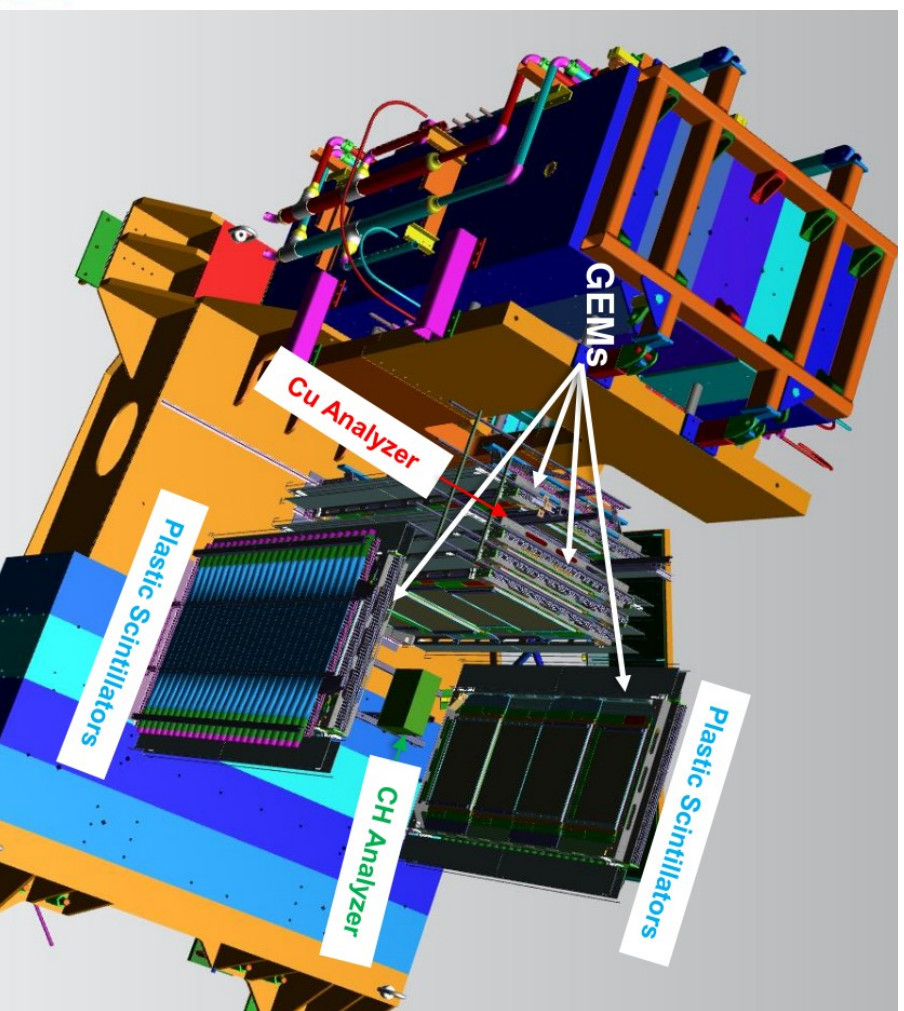
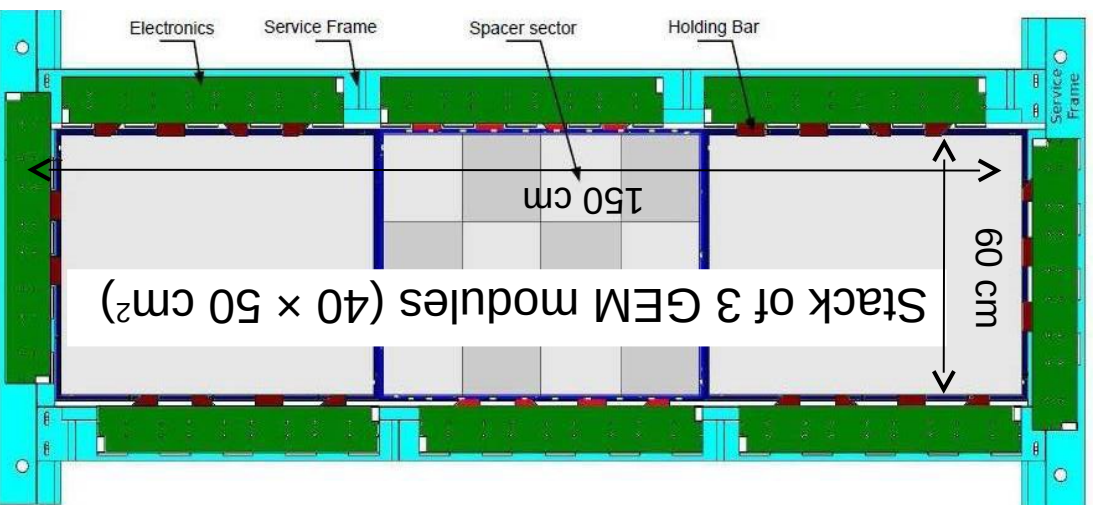
Charge-Exchange (CE) Polarimeter:

- ⇒ 2 INFN + 2 UVA layers, in front of Cu analyzer
- ⇒ 4 UVA layers behind the Cu analyzer

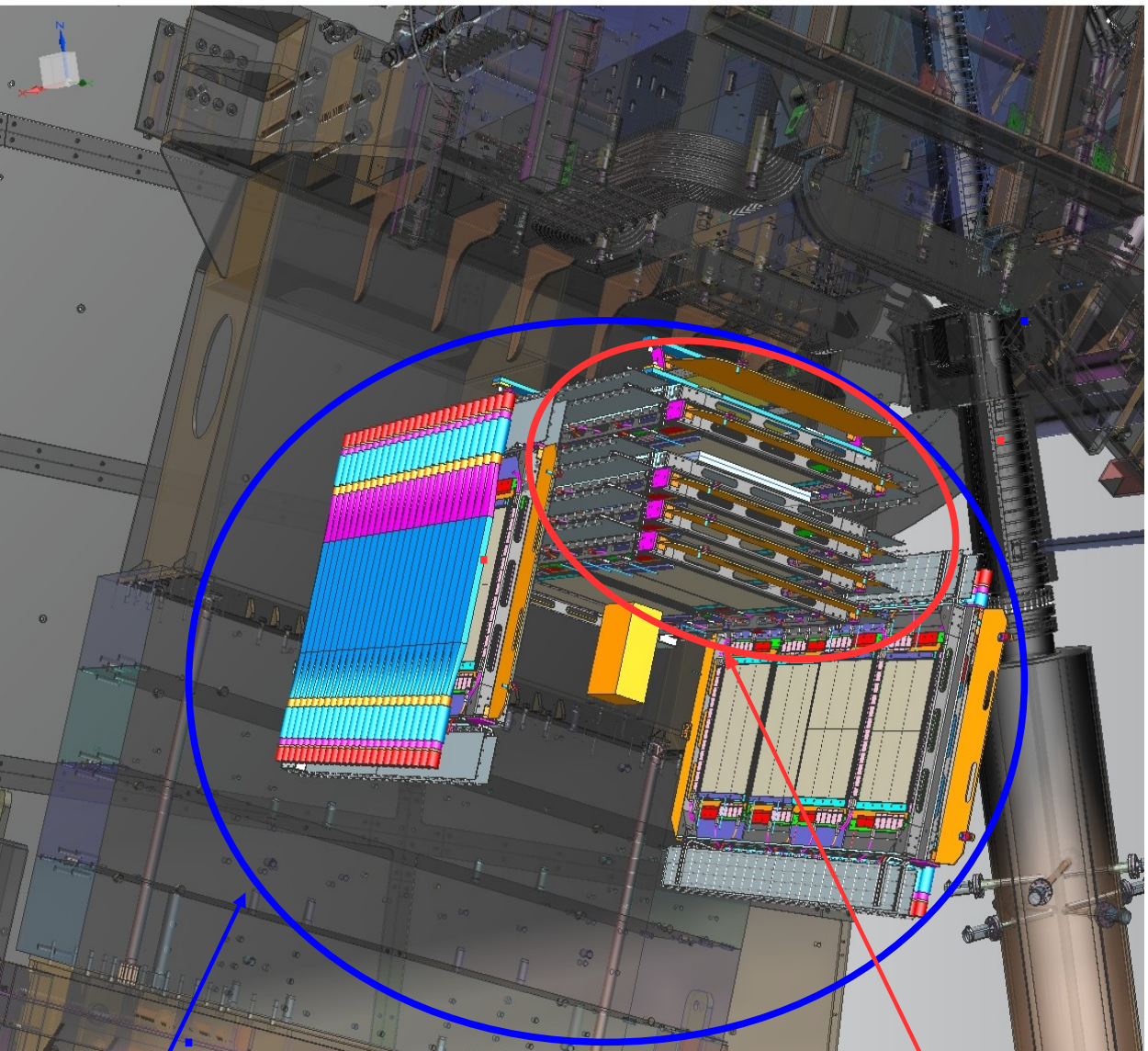
Proton-Recoil (PR) Polarimeter:

- ⇒ 2 Identical arms, 2 UVA GEM layers in each arm

2 INFN GEM layers



SBS Neutron Polarimeter



- **Charge Exchange (CE) Polarimeter**
 - High-momentum forward protons (towards HCAL) after CE $np \rightarrow pn$
 - 2 INFN GEM planes
 - 6 UVa GEM planes
 - 1 steel analyzer
- **Proton Recoil (PR) Polarimeter**
 - Low-momentum large-angle recoiling protons after $np \rightarrow np$
 - Active CH analyzer
 - 2 sections, one each side of CE Polarimeter
 - Each section has 2 UVa GEM planes and 1 plastic scintillator plane

SBS GEM detector commissioning (UVa)

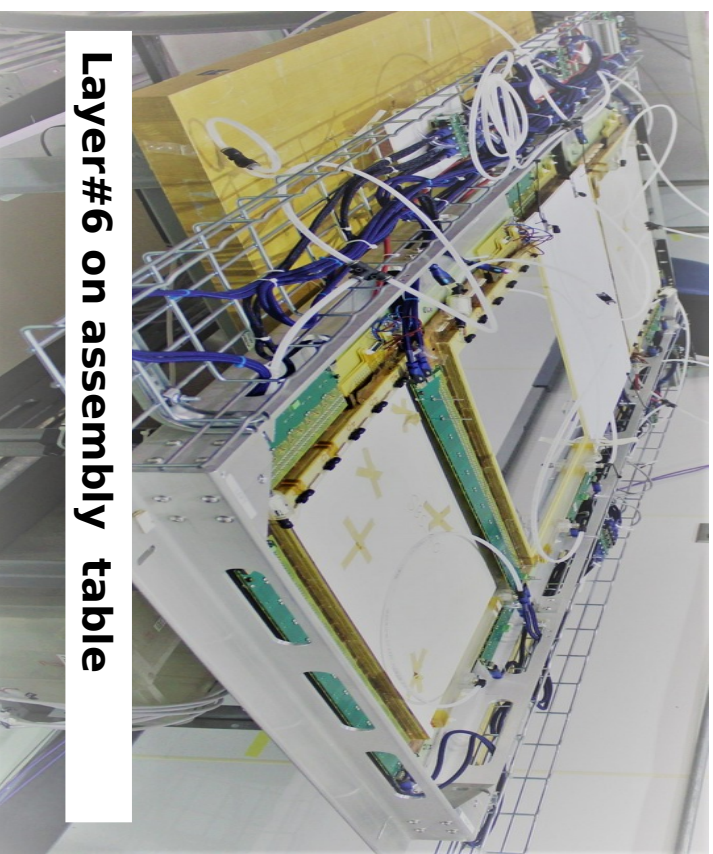


Storage Shelves

- Prepare/test and place each GEM module
- Assembly of Aluminum structure and cable trays
- Prepare and test necessary backplanes : Four 12-slot eight 5-slot backplanes
- Cabling: Blue and white HDMI cables
- Assembly of Auxiliary systems and HV testing

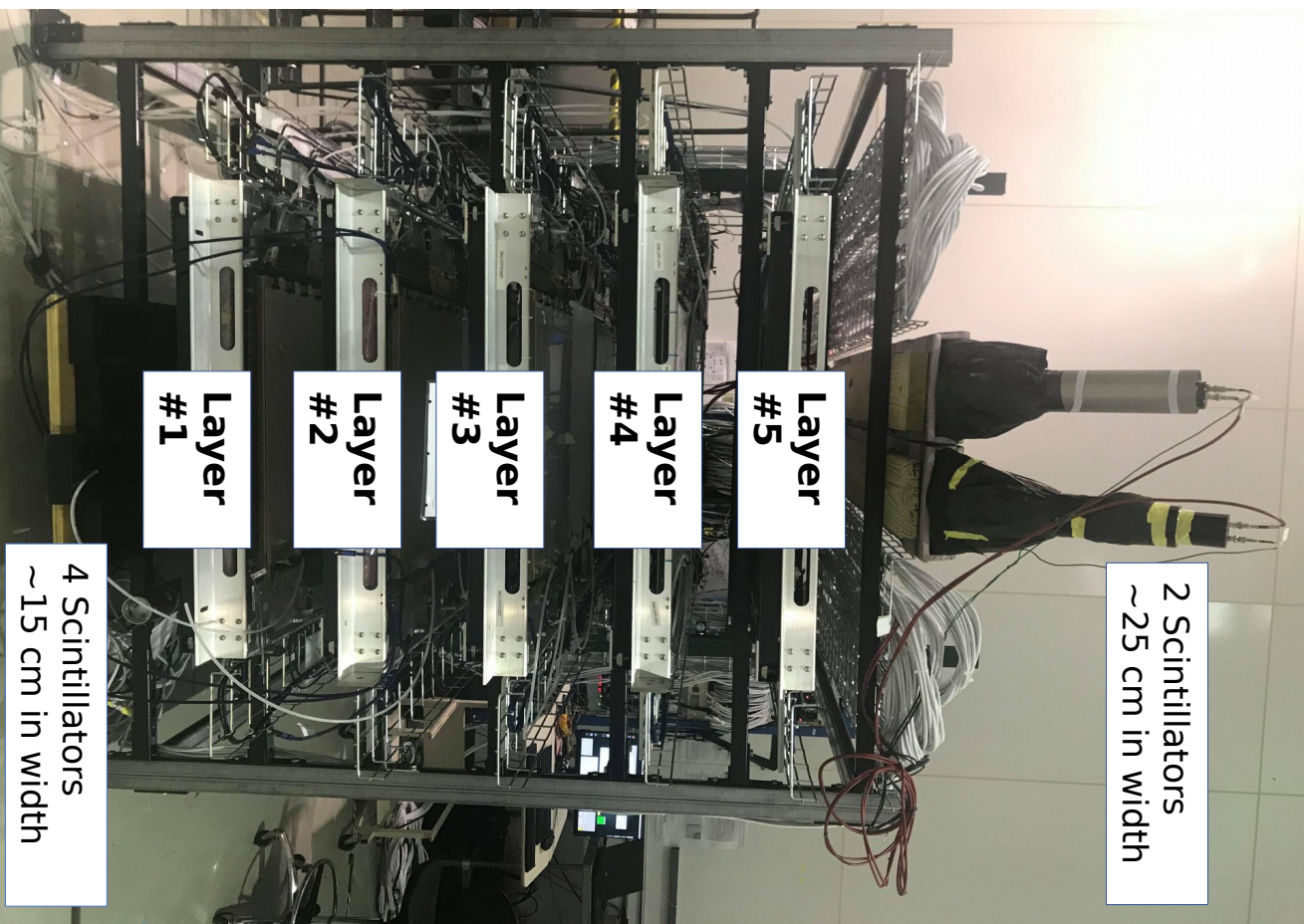


Setup for Individual modules test



Layer#6 on assembly table

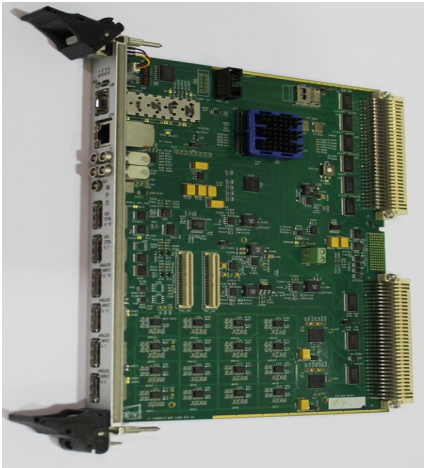
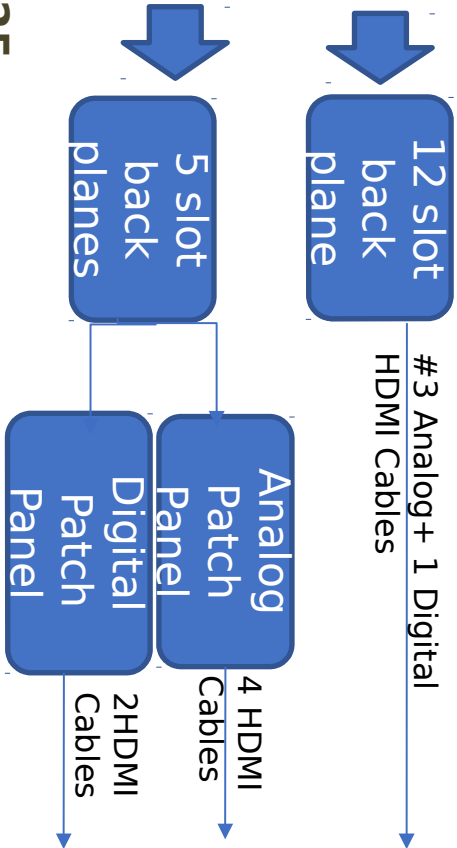
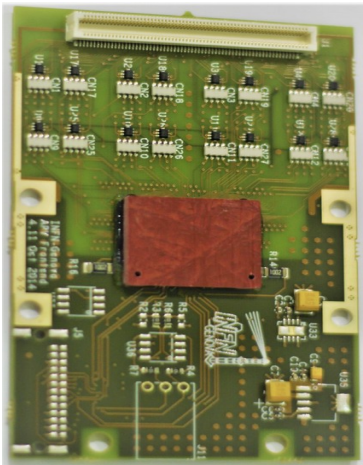
Status of the UVa GEM layers assembly in EEL 124



- All 5 layers on the cosmic stand are tested and validated
- HV test performed regularly.
- We took cosmic data with all the layers on the cosmic stand
- Layers 3, 4 and 5 assembly are ready for the experiment
- Layer 1 and 2 are going to be taken out for some modifications
- Layer 6 is sitting on the assembly table. It has passed the HV tests and readout electronics tests and ready to go to the cosmic stand



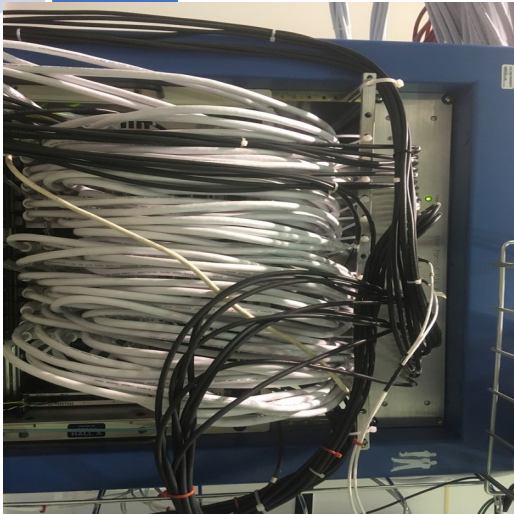
GEM Readout Electronics



128 analog ch / APV25 ASIC

- **3.4 ms trigger latency** (analog pipeline)
- Capable of sampling signal at 40 MHz
- Multiplexed analog output (**100 kHz readout rate**)

	Chanel	APV	MPD
Front Tracker	14000	108	8
Rear Tracker	113000	880	70



HDMI cables connected to MPDs

INFN MPD

- Arriga GX FPGA
- 128 MB DDR2-RAM
- Firmware V4.0 (74% resources):
- FIR Filter (16 param)
- Zero Suppression
- Common mode and pedestal subtraction
- Remote config, ≈ 2 ns trigger time resolution

Daq and readout electronics

MPD Daq and trigger rack 1



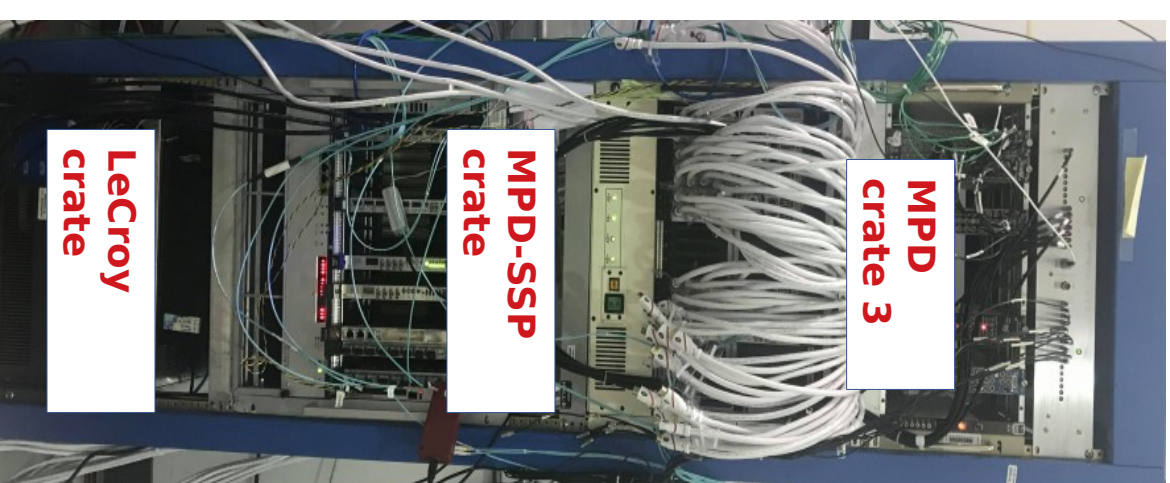
First rack:

- Has 2 standard VME crates for the MPD electronics
- Holding 28 MPDs for 342 APV25 cards
- Configured to read out 4 layers on the cosmic stand
- Trigger signal distribution (Jlab custom module)
- Wiener HV power supply crates for the GEM

Second rack:

- 1 standard VME crate for MPD electronics read out 5th layer & and layer on assembly table
- 1 LeCroy PS crate for the trigger scintillators
- NIM crate for the trigger coincidence logic
- 1 VXS crate test SSP readout mode

MPD Daq and trigger rack 2



Auxiliary Systems

→ Low Voltage System

Power Supply Unit

- Capacity of powering 6 GEM layers
- Output Voltage 5V

Power Regulators

- 8 Required for One layer
- Output Voltage 1.25V & 2.5 V

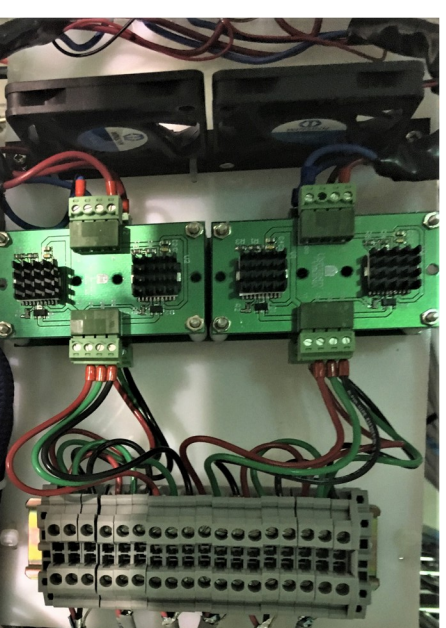
→ High voltage System

- Uva Wiener crate + 3 HV Mpod modules
- Windows Based Software to control HV

→ Gas System

- Ar /CO₂ (75/25) for Data taking
- UHP N₂ used for HV test
- One flow meter to control 2 modules

Heat Sink
Voltage Regulator
Cooling Fan



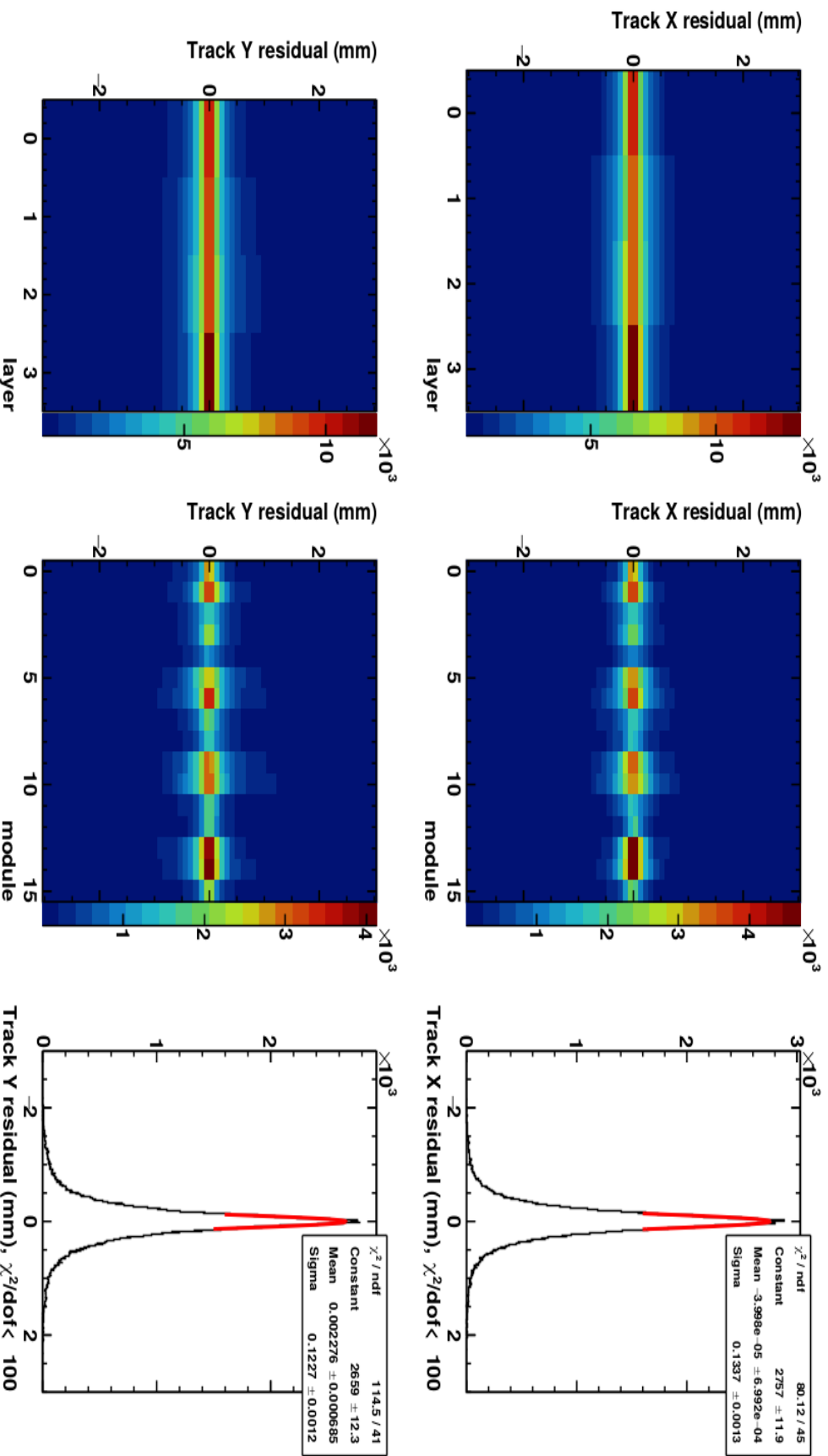
Low Voltage Power Distribution



HV hardware in the crate HV Control user Interface

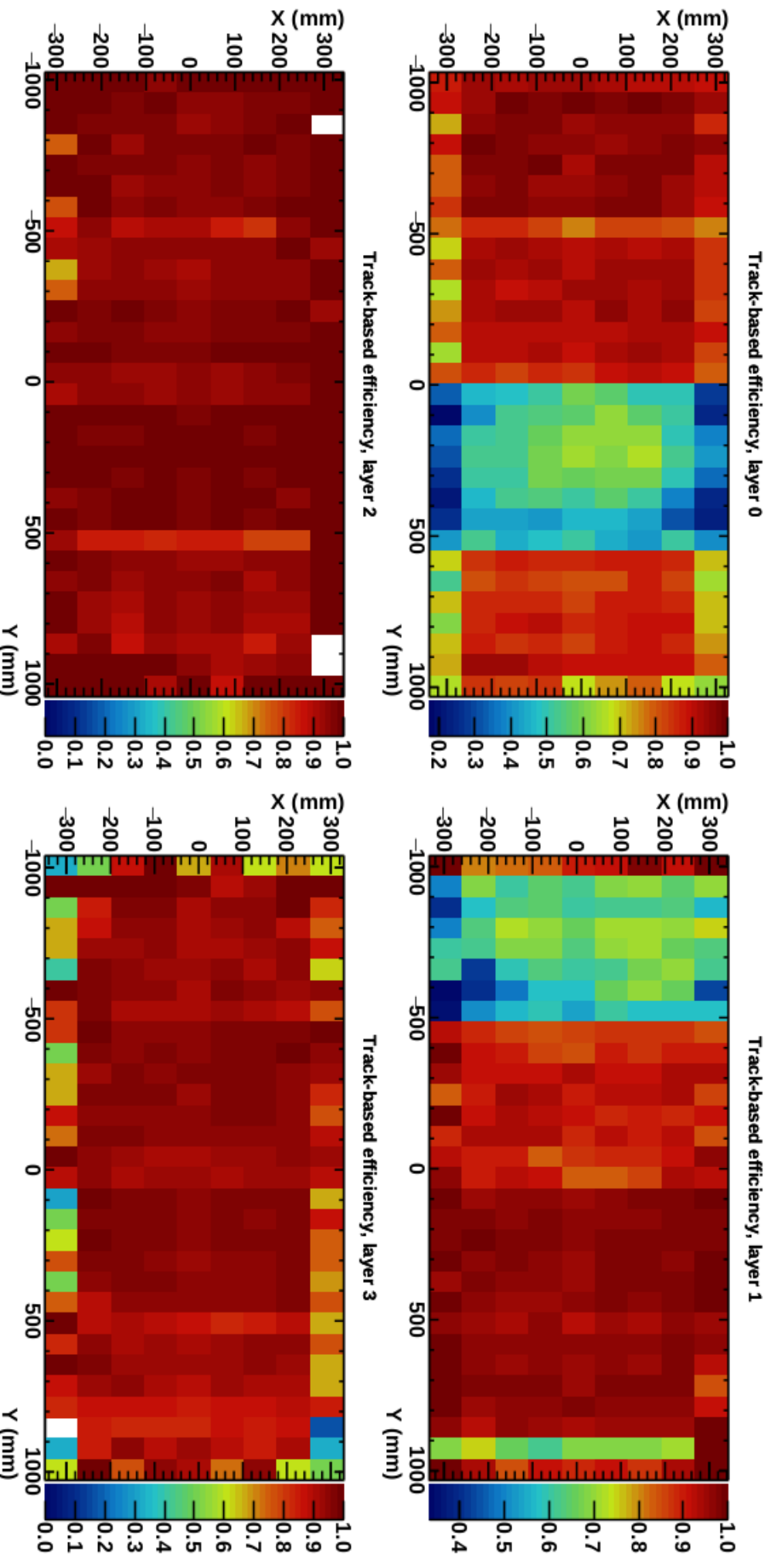
Cosmic data I: Tracking residuals

- First analysis of cosmic data has been done in Feb 2020 with four layers on the cosmic stand
- About 1M data has been collected and performed tracking analysis
- Tracking residual from this data: $(\sigma_x, \sigma_y) = (133 \mu m, 122 \mu m)$



Cosmic data I: Track based efficiency

- Track based efficiency is the ratio of Did hit to should hit
- Above 80% track finding probability with 90% local track based efficiency in most of the module
- Two of the 16 modules have apparently low efficiency in the active area



Cosmic data I: Some issues

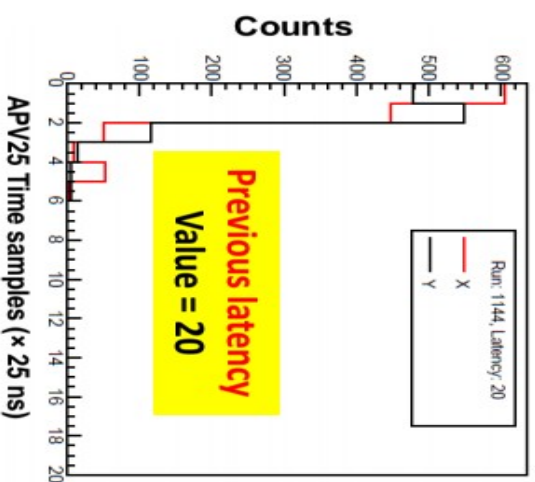
- Low efficiency in two module: Since, they have slightly different GEM hole diameter they need to operate at higher HV. But for the current data we had the same HV on all the modules (except one).
- The signal pulses look a bit early relative to the trigger, as the peak appears to be shifted toward samples 0-1 instead of samples 2-3: Need re-adjustment of trigger latency (next slide)
- The signal/noise ratio looks a bit marginal: We have 2 or 3 modules with high noise that we are working on (probably issue with the FE cards contacts)

Other issues:

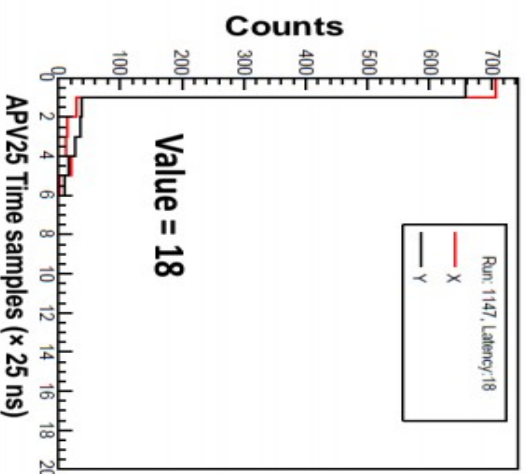
- DAQ stability issue: With some adjustment in APV configuration, it seems to be more stable currently but need more fix
- Spiky (200-300 ADCs from the baseline) strip channels in groups from time to time in even pedestal runs: Could be fixed by grounding in our setup

Cosmic data II: Latency scan

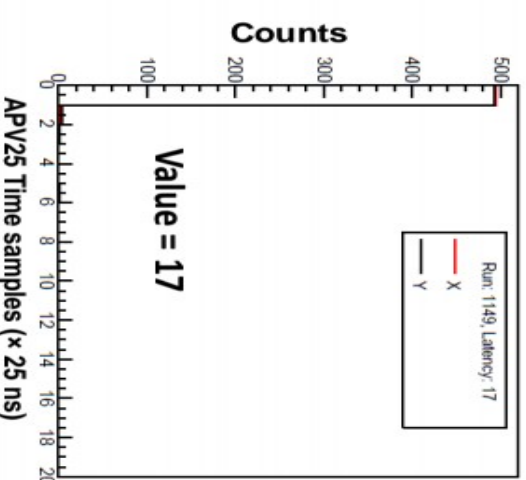
Max Time Bin Cluster Module 13



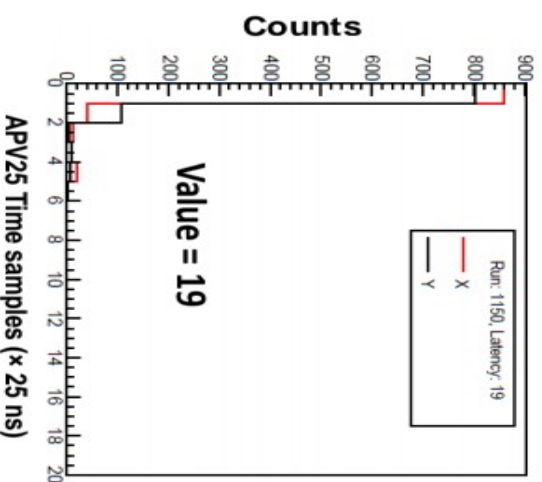
Max Time Bin Cluster Module 13



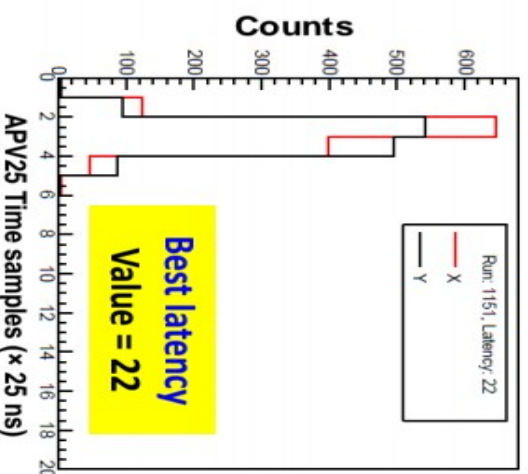
Max Time Bin Cluster Module 13



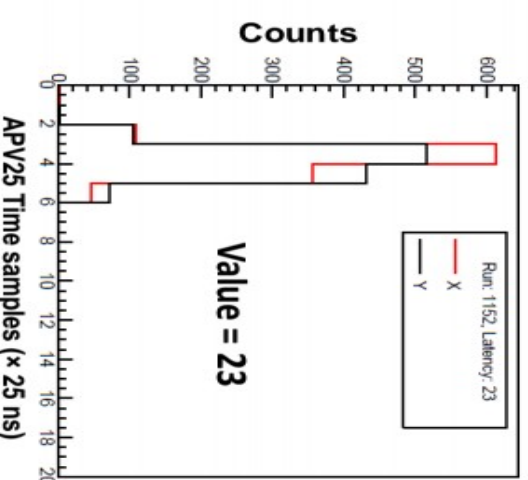
Max Time Bin Cluster Module 13



Max Time Bin Cluster Module 13

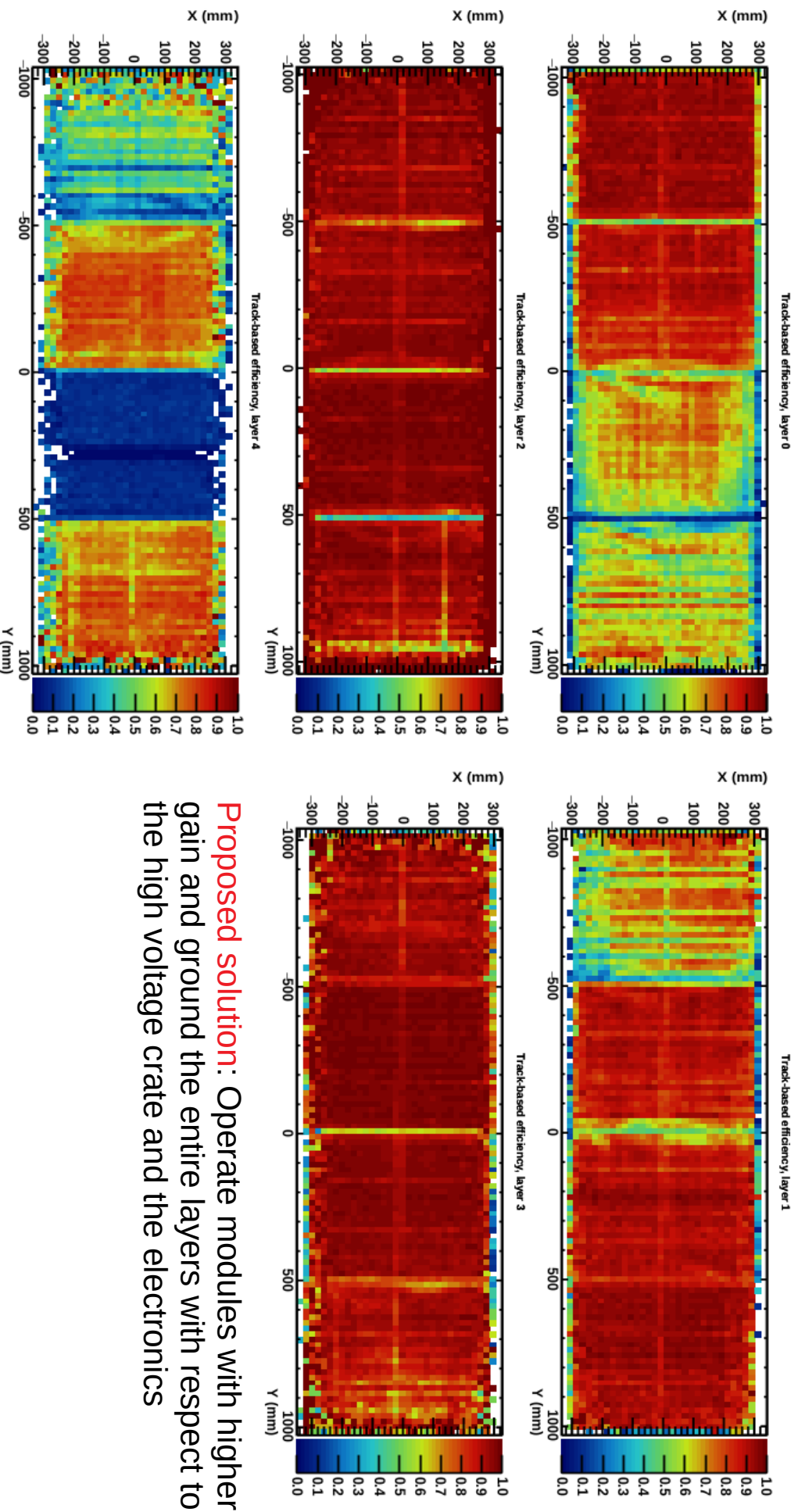


Max Time Bin Cluster Module 13



Cosmic data II

- About 2M cosmic data has been collected and performed tracking analysis
- Major issues: Low efficiency, low signal to noise ratio and low gain for the several modules
- 5th layer had a problem with module 3 during data taking
- First module of 2nd layer has low efficiency than other modules and the 3rd and 4th modules of the first layer shows pretty low gain and efficiency



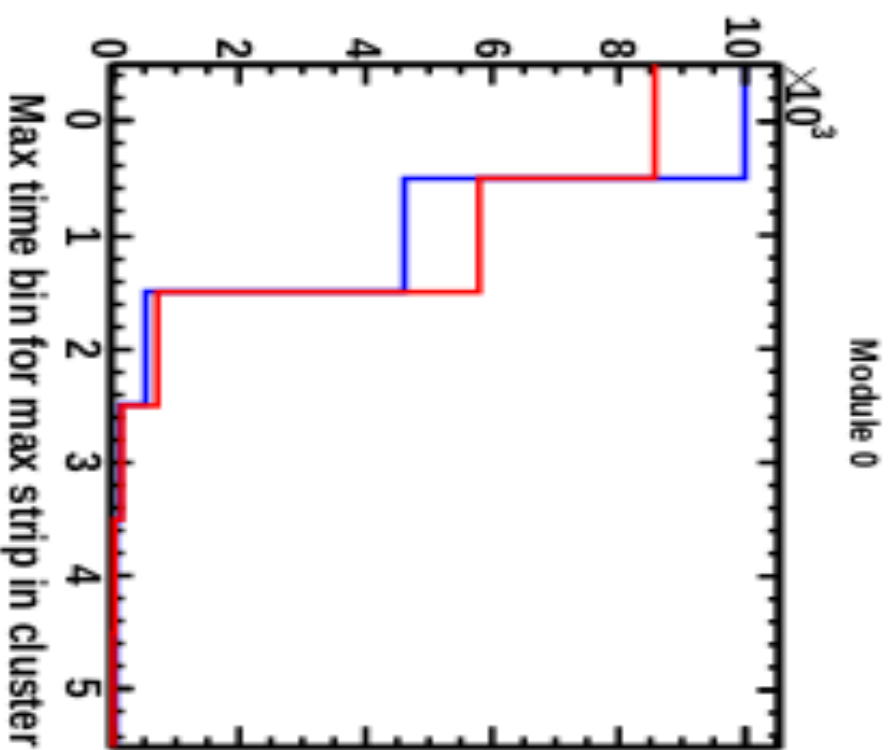
Proposed solution: Operate modules with higher gain and ground the entire layers with respect to the high voltage crate and the electronics

Conclusion

- Five GEM layers are assembled and tested on the UVa GEM cosmic stand
- Sixth layer assembly is in progress
- Assembly of the remaining layers is expected to be done within 6 months
- Preliminary analysis of the cosmic data tracking with four and five layers on the cosmic stand showing promising results with some fixable issues: low signal to noise ratio, low efficiency etc.

Effect of Latency change

Cosmic I : Layer 0, module 0



Cosmic II : Layer 0, module 0

