Overview and Update of SoLID Detector FY22 Beam Test and ECal Update

Michael Nycz (University of Virginia)

SoLID Collaboration Meeting

May 8 2023

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Hao Sun, Shulong Ji, Dong Liu, Cunfeng Feng

Beam Test Overview

<u>SoLID Director's Review (2021)</u>

- Calorimeter and SPD detectors not tested under high rate / high luminosity environment
- Detector test utilizing a full set of SoLID prototype detectors under "realistic SoLID running condition"

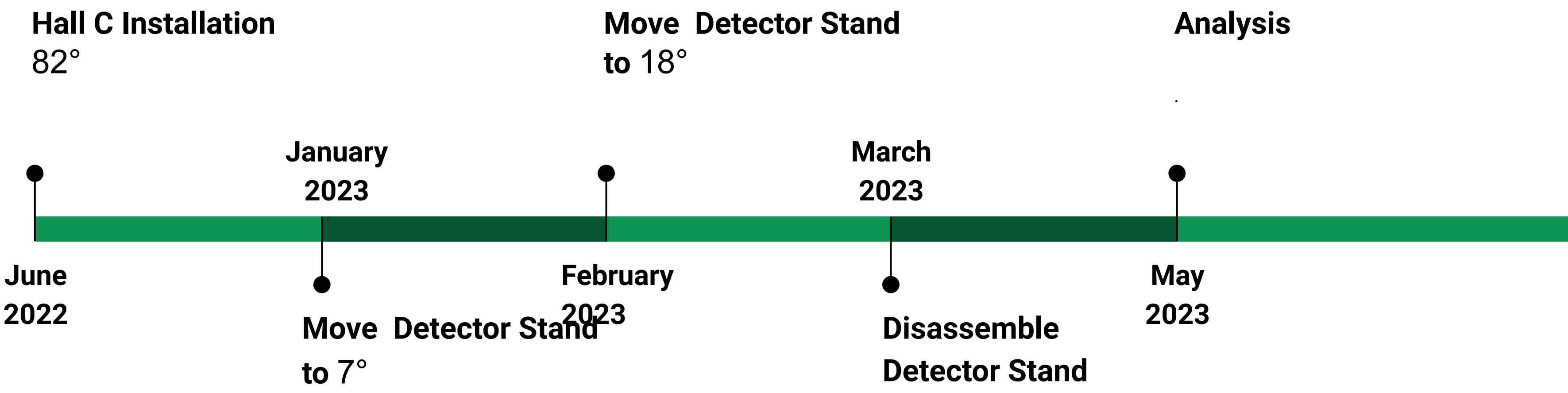
<u>Goals</u>

1. Ensuring scintillators and ECal can trigger at high rates
2. Identifying MIP signals in ECal above background
3. ECal PID meet SoLID requirement under high rate
4. Ensuring GEMs work properly and can find tracks (**see Xinzhan Bai's talk**)
5. Comparison with and benchmark of the SoLID simulation (**see Ye Tian's talk**)

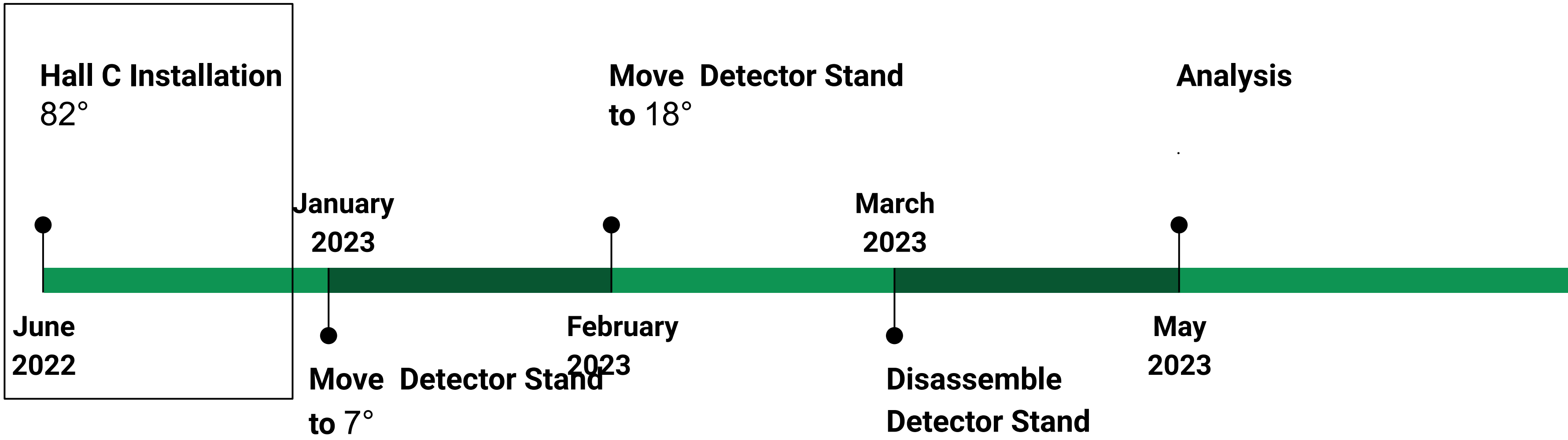
Beam Test **General** Details

- Performed in Hall C
- Utilized existing test stand
  - Modified by Hall C technicians
- NIM / VME electronics located behind green wall
  - ~90 meter signal cables (Mark Jones)
- HV and additional electronics shielded in bunker
  - ~40 meter HV cables (Alexandre Camsonne)
  - 5,10 and 20 meter HDMI cables
- Test stand moved to three angles (82°,7°,18°)
  - Bunker moved three times
- DAQ setup (Jixie Zhang & Alexander Camsonne)
- GEM integration (Xinzhan Bai & Bryan Moffit)
- Survey at 82° and 18°
- Experimental dosimetry at 7° and 18°
- **A lot of changes (and a lot of help)**

Beam Test Timeline



Beam Test Timeline

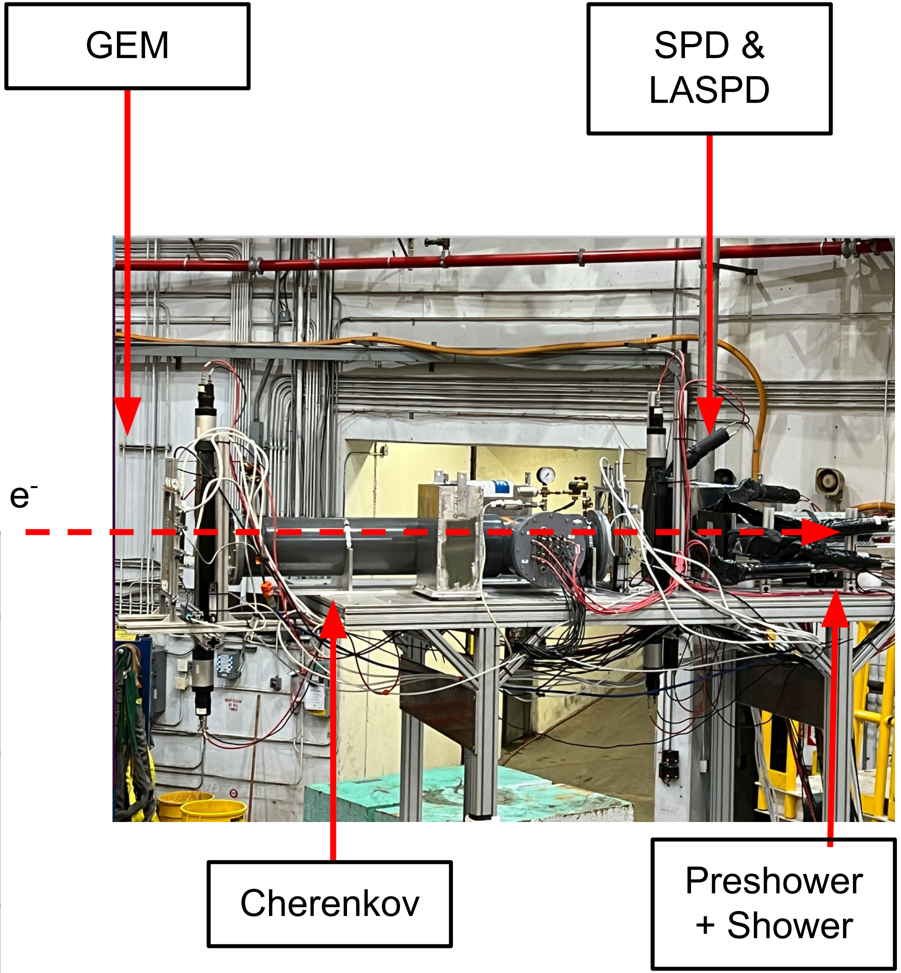


82°: Low Rate Setting

<u>Goals of Low Rate Setting</u>

1. Detector/trigger checkout and optimization
2. GEM setup
    - Only single upstream GEM (no tracking)
    - Used to identify clusters

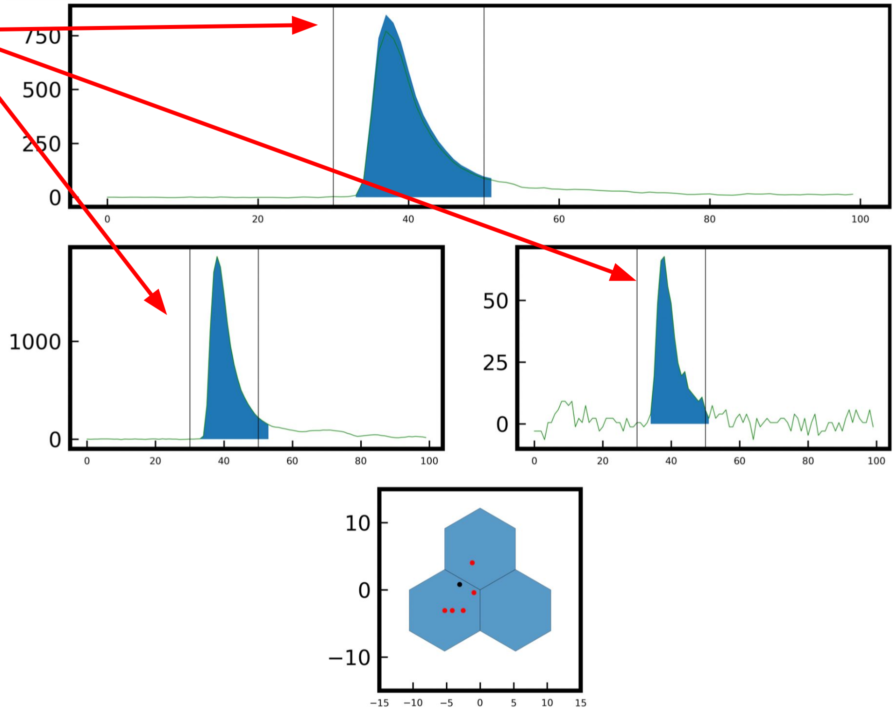
Trigger	Logic	Threshold*	Particle
TS 1	Scin 1 top .and. Scin 2 top	~20 mV	e^-
TS 2	Preshower Top .and. Shower Top	~20 mV	π
TS 3	Shower Sum	~20 mV	e^-



*Minimum NIM module threshold ~ 20 mV

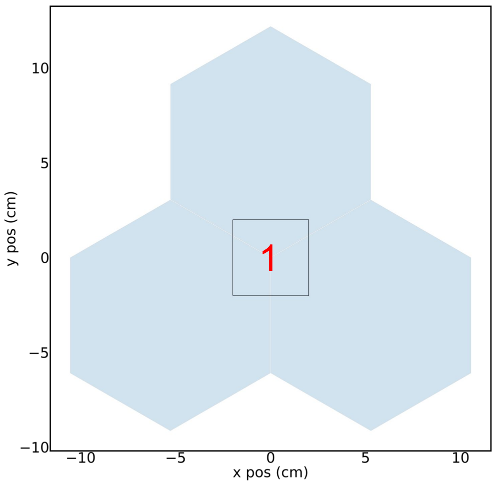
82°: Low Rate Setting

- Recorded waveform information for each event
  - **Offline signal integration** (Jixie Zhang)
- Shower cluster finding algorithm
- Identified MIP in Preshower
  - Scintillators, SPD, and LASPD
- No MIP in Shower at 82°
  - Agreement with simulation
  - Shower spectra used for calibration
- Detectors partially blocked when SHMS was below 15° (majority of the run low rate period)

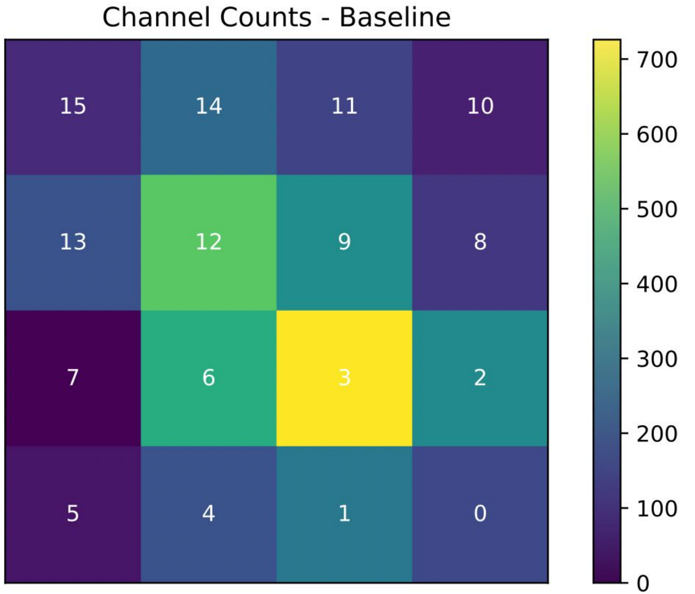


Cherenkov Detector: 82°

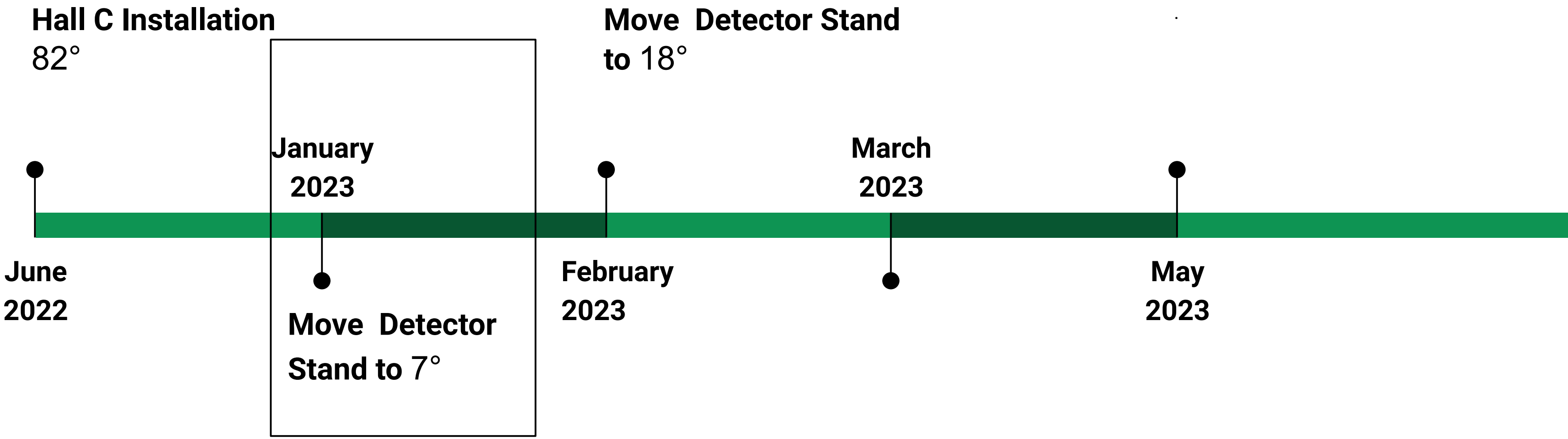
Apply cut on central shower cluster position (-2,2 cm in x and y)



Resulting Heat map of cherenkov channels (after alignment of spe)



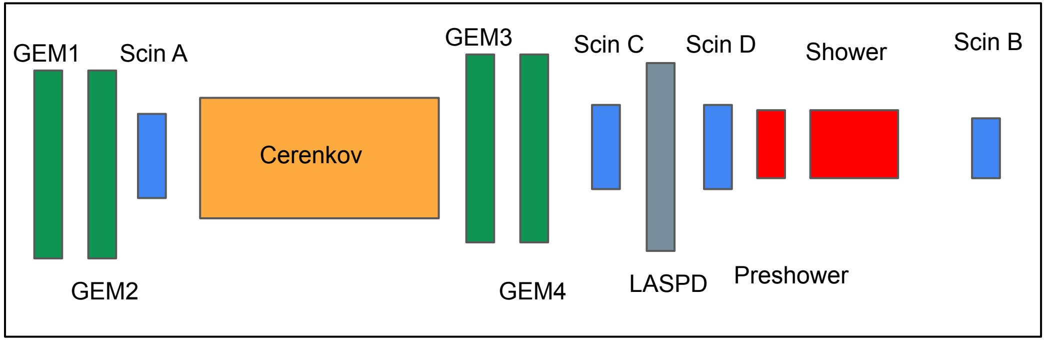
Beam Test Timeline



7°: High Rate Setting 1

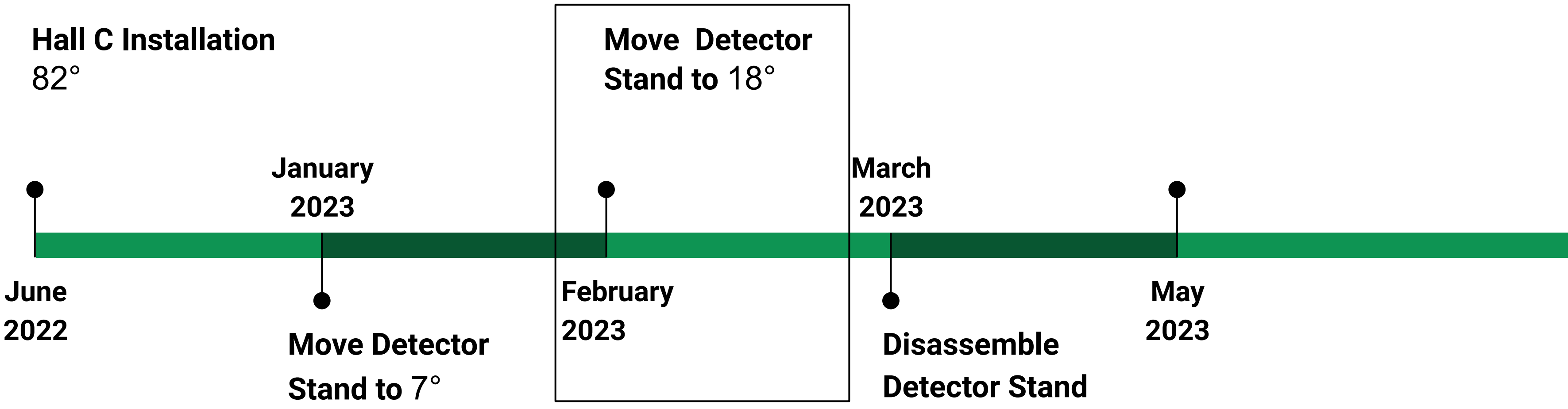
- All 4 GEM layers included
- Removed both scintillators and FASPD
  - **Added 4 smaller scintillators**
- Remotely controllable threshold
- Dedicated 15 minutes runs each week
  - 3-5 μA (Lowest stable current)
  - Limited data with optimized GEMs
- Experimental dosimetry
  - ~150 kRad

Detector layout



Trigger Name	Logic	Particle	
TS 1	Cherenkov Sum + Shower Sum	e^-	SoLID e^- trigger
TS 2	Scin D + Shower Sum + Scin B	π	SoLID π like trigger
TS 3	Cherenkov Sum + Scin D + Shower Sum		⅔ Trigger (efficiency)
TS 4	Shower Sum	“clean” e^- or photon	
TS 5	Scin B	“clean π”	

Beam Test Timeline



18°: High Rate Setting 2

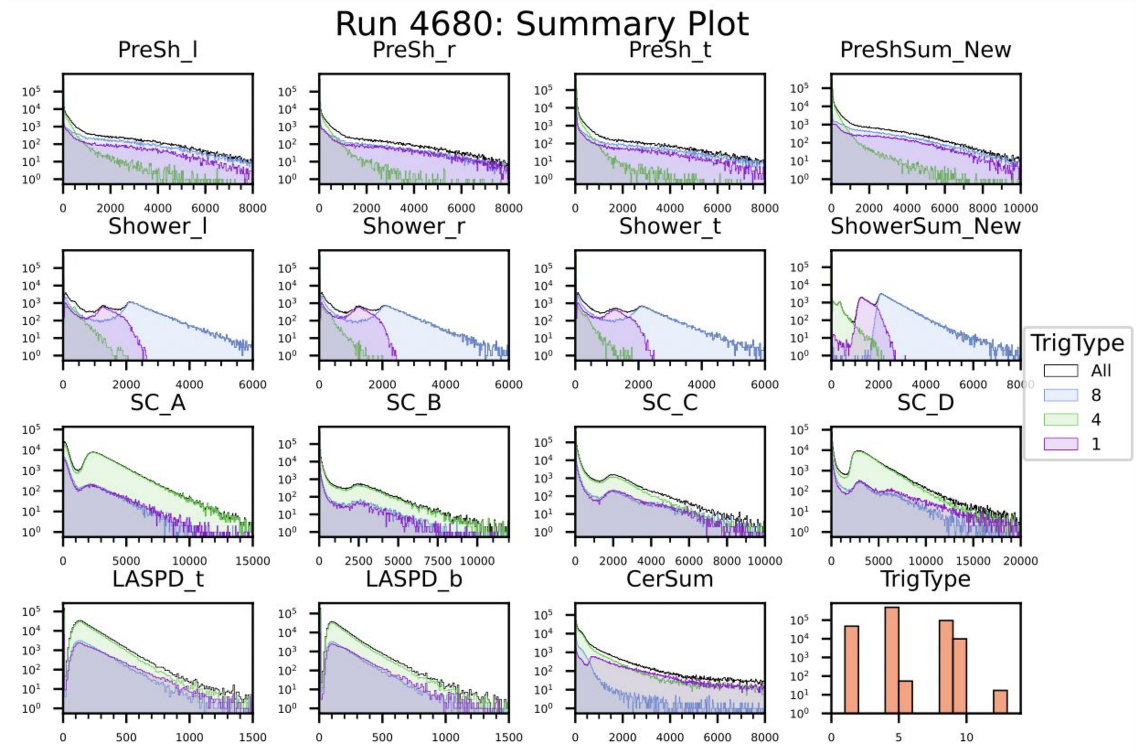
- Added polyethylene before first GEM
- Collected data continuously during experimental running
- Data taken:
    - Deuterium @ 40 - 60 μA
    - **Deuterium @ 10 μA (Boiling study)**
    - Carbon & Dummy @10 μA
- Experimental dosimetry
    - ~70 kRad

Trigger Design: 18°

Trigger Name	Logic	Threshold	Particle
TS 1	Cherenkov Sum + Shower Sum	Cherenkov: 2 pe Shower Sum: 0.5 mip	e
TS 2	Scin D + Scin B	0.5 mip	π
TS 3*	Scin A + Scin D		MIP
TS 4	Shower Sum	Variable	High energy e and γ
TS 5	2 out 16 Cherenkov		

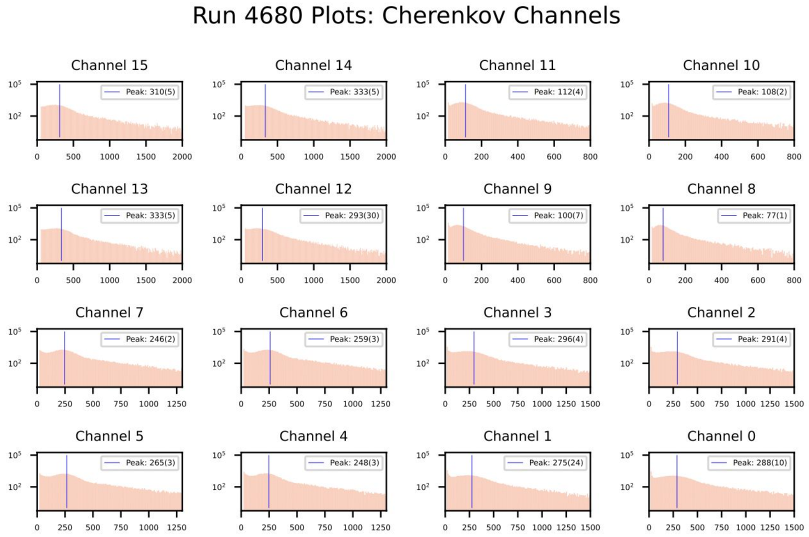
*TS 3 was modified due to the high rate in Scin A
TS 3 = Scin C + Scin D + Shower Sum

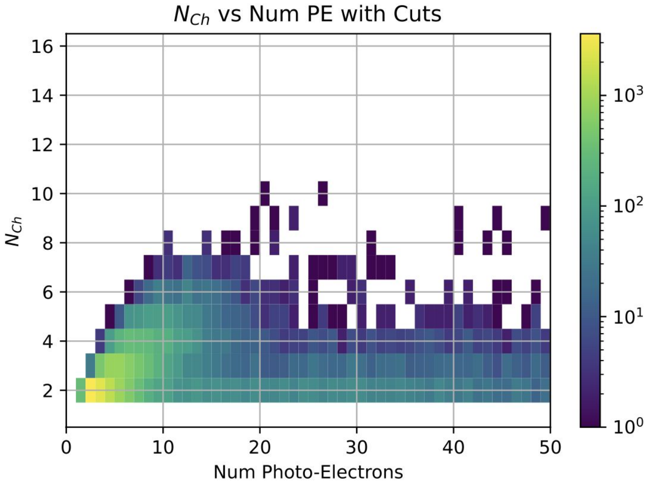
Run 4680
5 μA run
Triggers 1,3, & 4



*Plot from Darren Upton

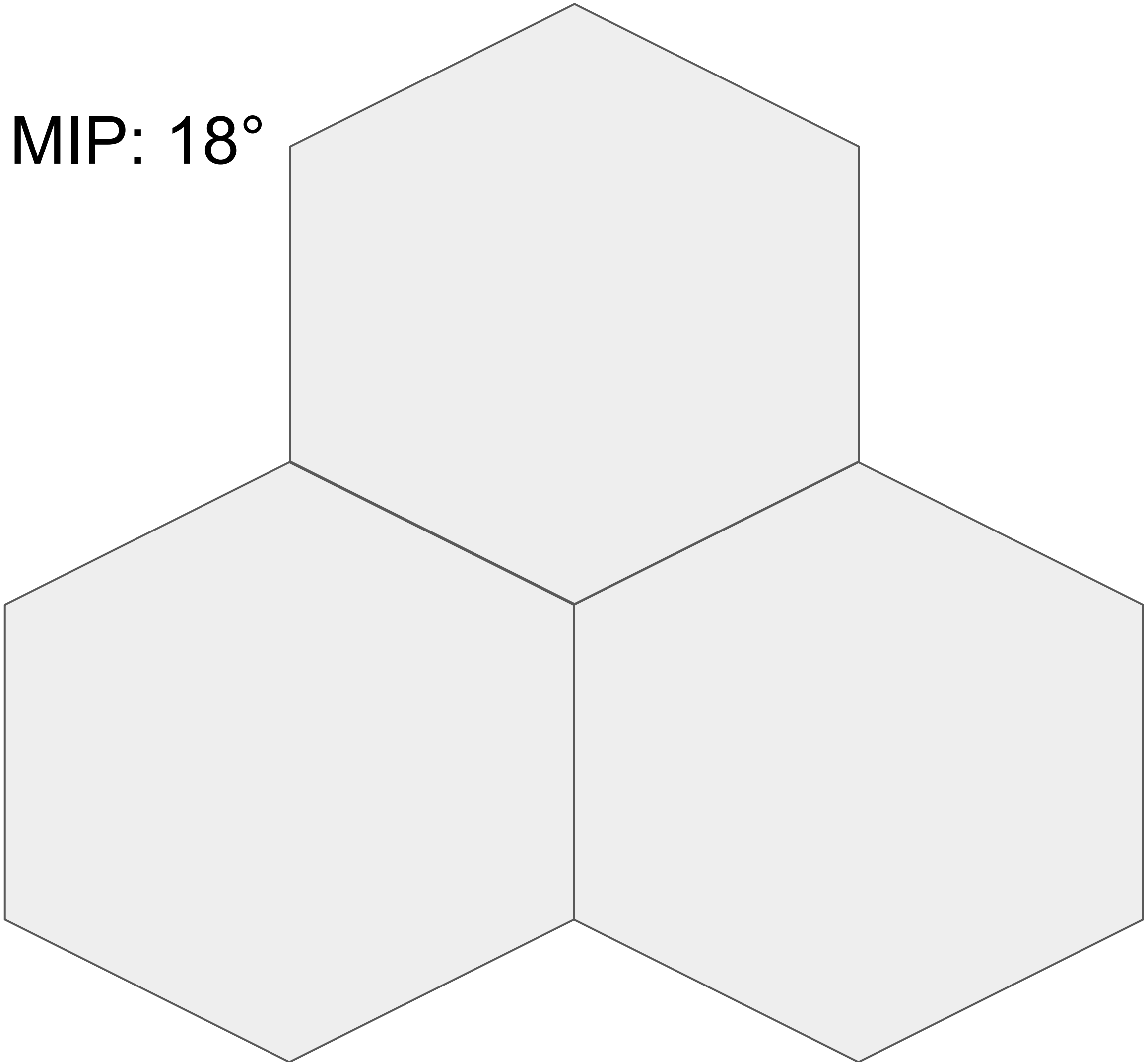
Cherenkov Detector: 18°



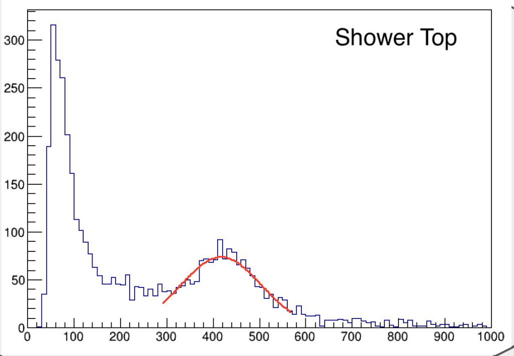


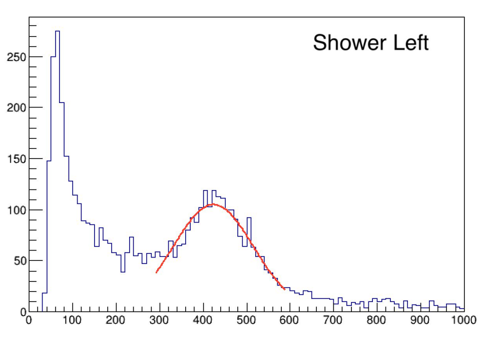
*Plots from Darren Upton

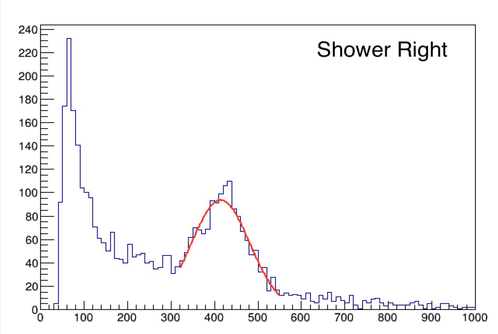
Shower MIP: 18°



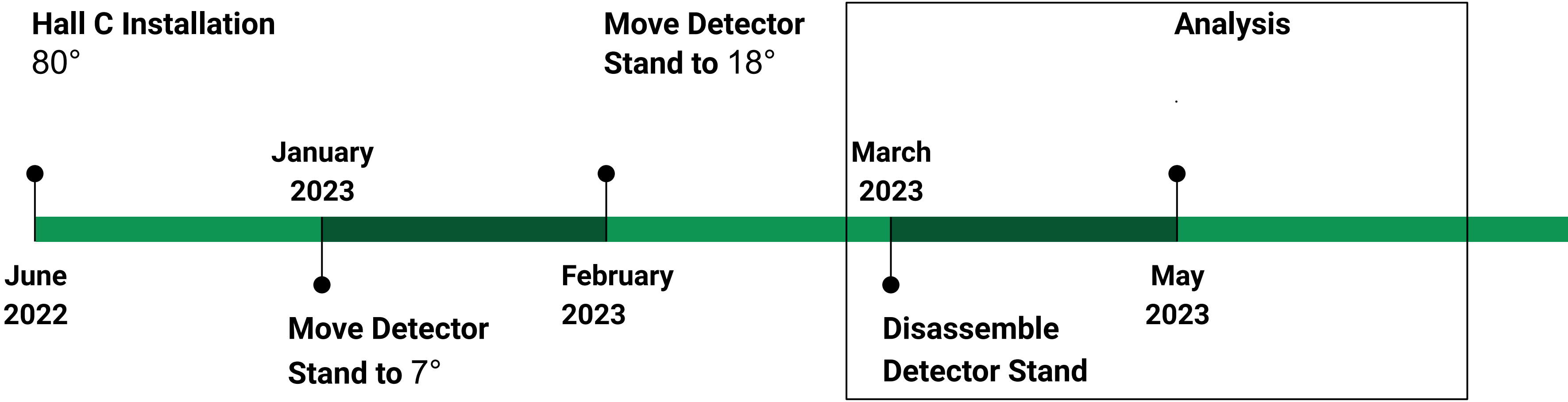
Shower MIP: 18°







Beam Test Timeline



Moving Forward

- Focusing on 18° data
  - Four GEMs (working)
  - Proper GEM latency
  - All Cherenkov channels working
  - Data cover range of currents: 5 - 60 μA
- **Tracking: GEM optimization**
- **PID studies**
  - charged particle and neutral particle identification
- **SPD timing**
- **Comparison with simulation**
- **Pileup at high current**
  - Deconvolution algorithm being adapted/implemented from existing code
- **Technical notes summarizing work and analysis**

ECal Status Update

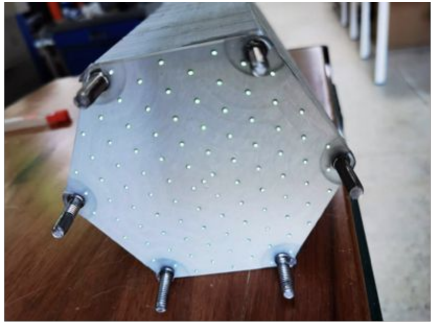
Hao Sun, Shulong Ji, Dong Liu, Cunfeng Feng

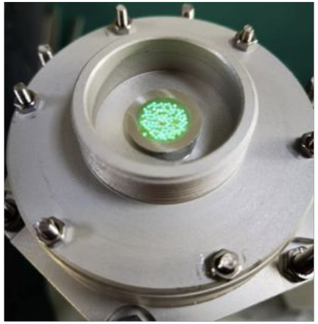
ECal super-module assembly and cosmic ray test

7 Modules assembled painted with TiO_2

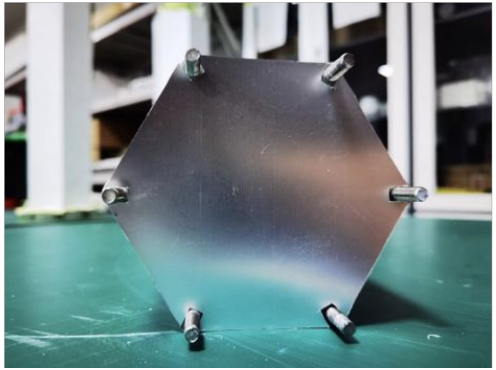
Fiber polishing with CNC

Part	Type/Material
scintillator	KEDI enhanced
WLS fiber	Y11 multi-cladding
outside surface	TiO2
fiber end reflector	ESR film
lead	paint TiO2*





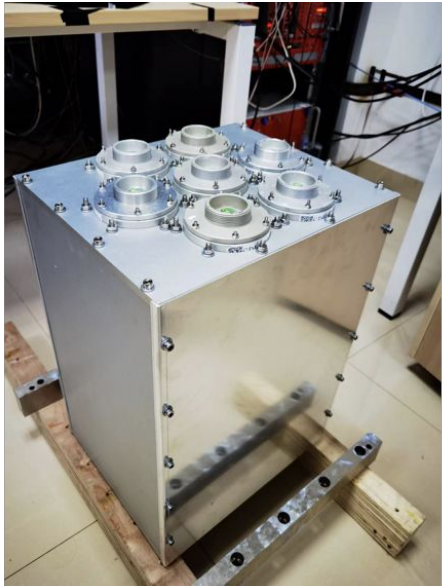
Fiber ends after polishing



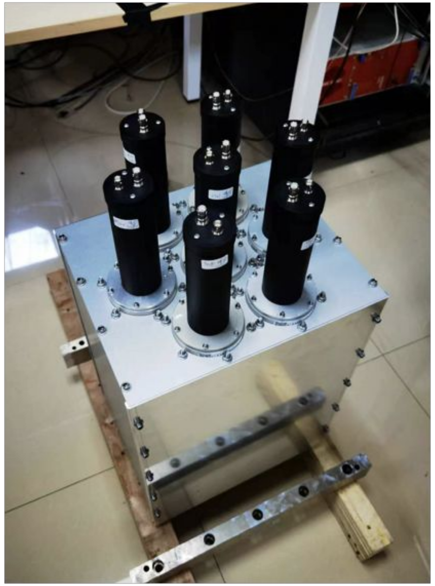
ESR as fiber reflection layer with air coupling

Super Module Assembly

7 modules in frame



7 modules full enclosed in frame



With PMTs

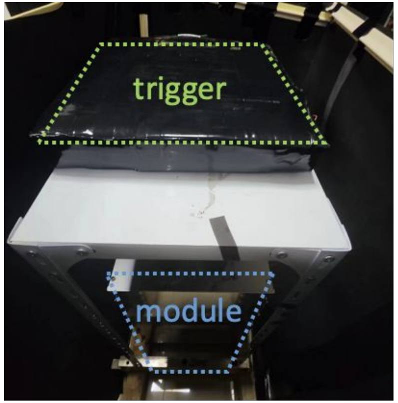
PMTs Gain calibration

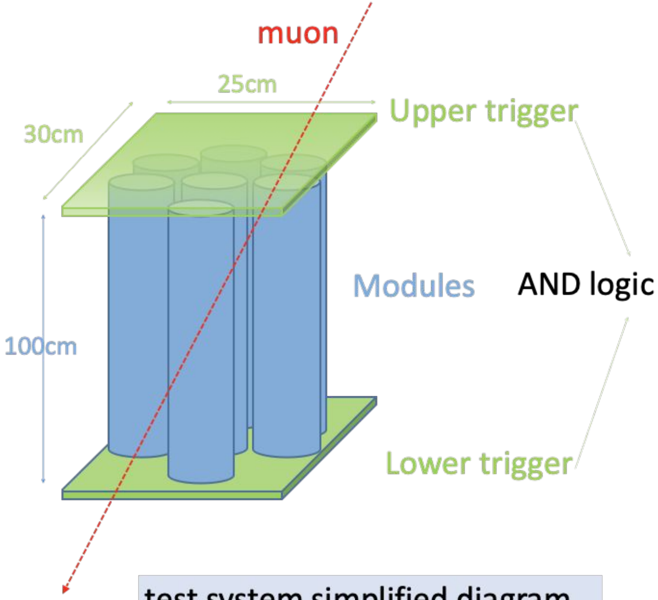
- calibrate with LED and one referenced PMT
- Referenced PMT Gain

  calibrated with Single photon
- Calibrated PMT:

same charge output as the referenced PMT under same LED light.

Cosmic Ray Testing Setup





test system simplified diagram

16 Channel

12bit

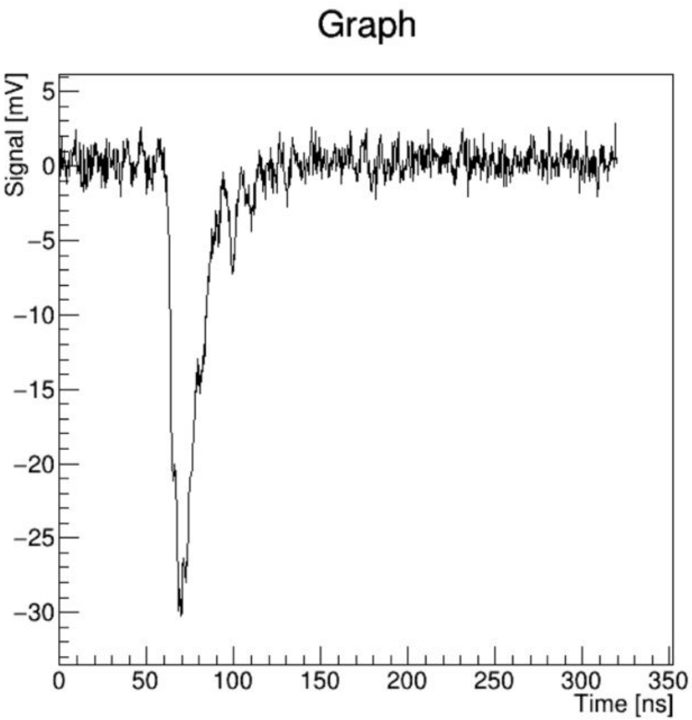
3.2 GS/s

Switched Capacitor Digitizer

Data acquisition: v1743 FADC

X

Preliminary Test Results



Calculate number of photo-electrons(NPE)

- Calculate charge of signal

  1) perform an integral over the entire waveform
  2) subtract the baseline from the waveform integral

- Calculate NPE using NPE = charge / (1.6 * 10^-19) / gain

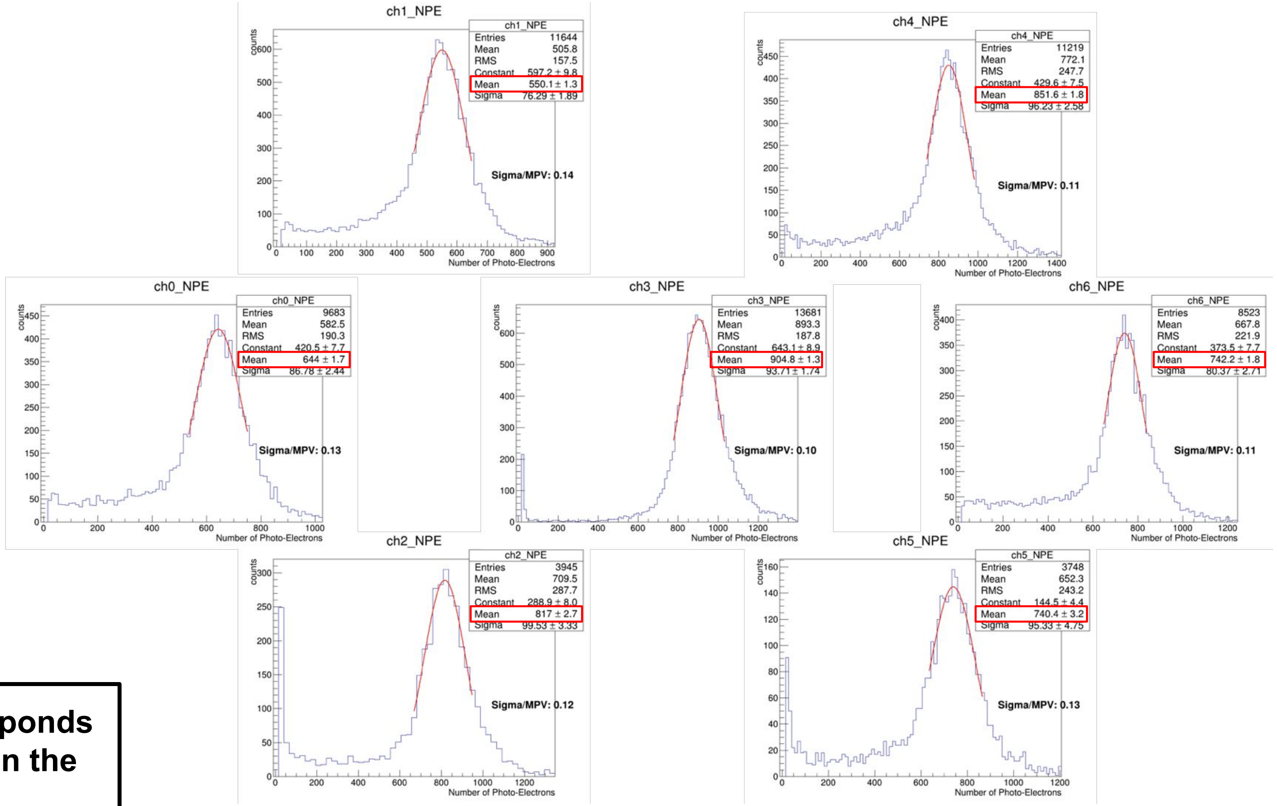
Preliminary Test Results

Number of photoelectrons for vertical incident muons

Vertical muon selection

- Only one module fired with a signal NPE >20

Mean = Fitted # pe



Position of plots corresponds to the module position in the frame

Summary and Conclusions

- Recently completed a high rate beam test in Hall C
  - June 2022 - March 2023
- GEM optimization
  - Utilize track information in offline analysis
- Particle ID studies ongoing
- Preliminary results from super-module assembly and cosmic ray test

Thank You!

Hall A/C staff, Hall C Technical Staff, Hall C Engineering Staff, RADCON, and (all) the running experiments

Thank You

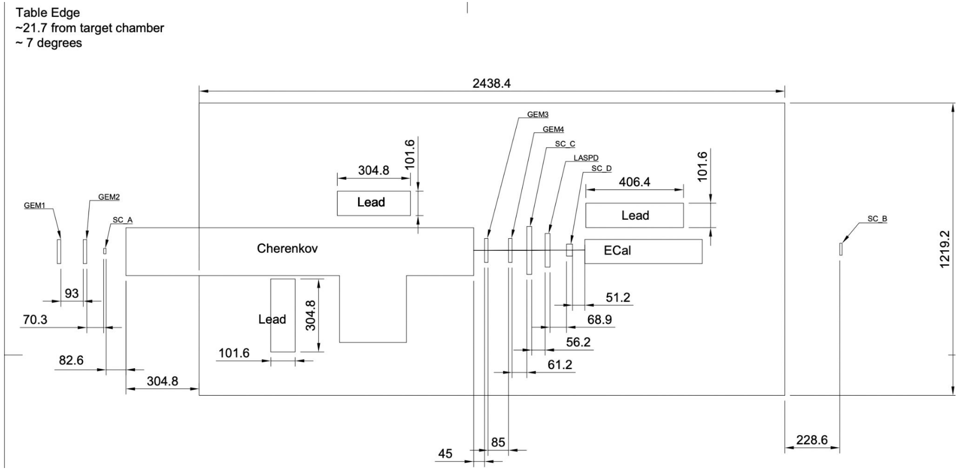
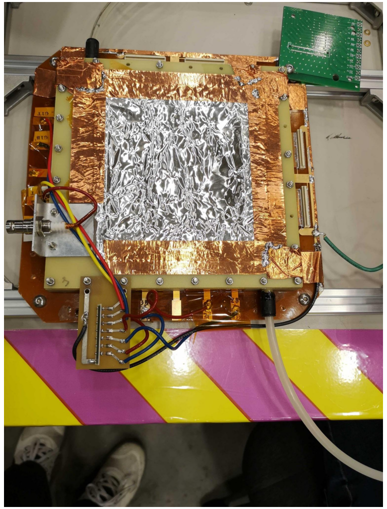


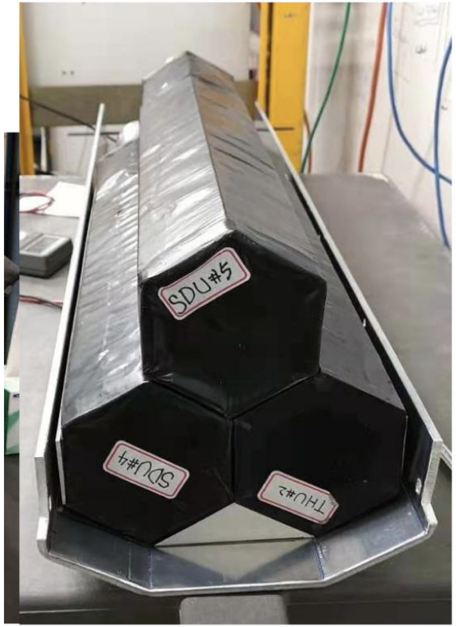
Table Edge
~21.7 from target chamber
~ 7 degrees
2438.4
GEM3
GEM4
SC_C
LASPD
SC_D
304.8
101.6
Lead
406.4
101.6
Lead
GEM1
GEM2
SC_A
Cherenkov
ECal
SC_B
1219.2
93
70.3
Lead
304.8
101.6
82.6
304.8
51.2
68.9
56.2
61.2
85
45
228.6

Detectors

Gas Cherenkov
(Temple)

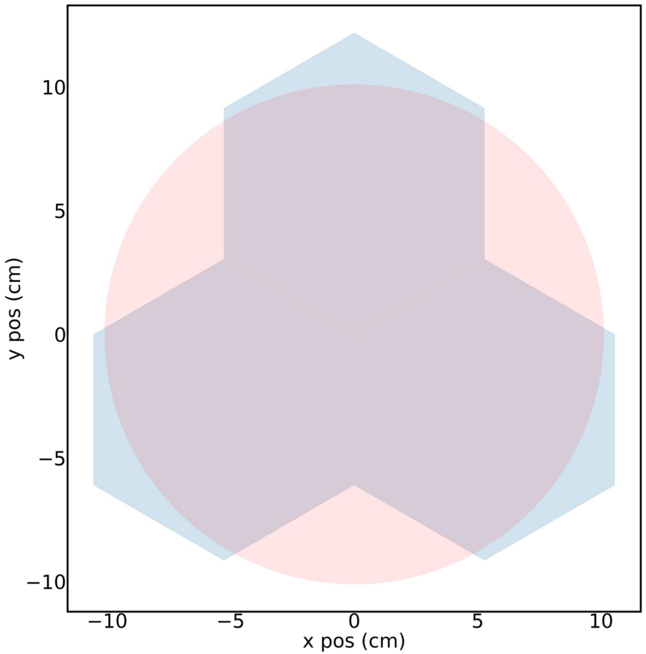
GEMs
(UVa)





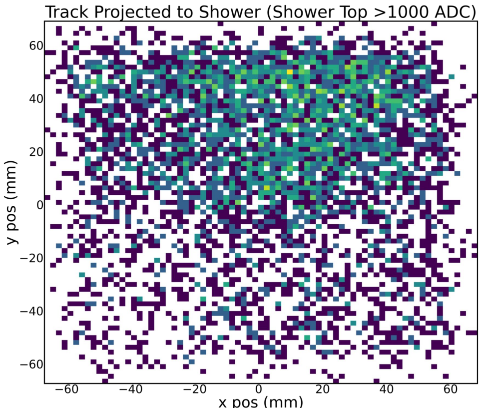
Shashlyk Calorimeter
(UVa)

<u>*Missing Images</u>
LASPD/SPD
Preshower


10
5
0
−5
−10
y pos (cm)
−10
−5
0
5
10
x pos (cm)

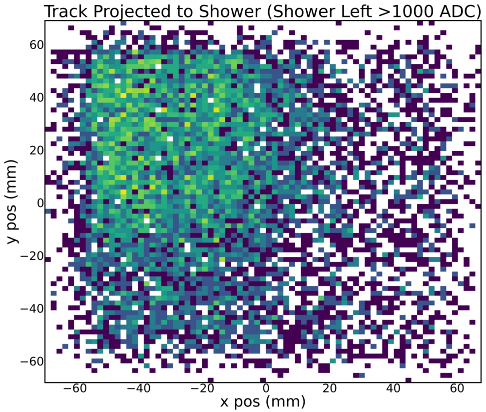
7°: High Rate Setting 1

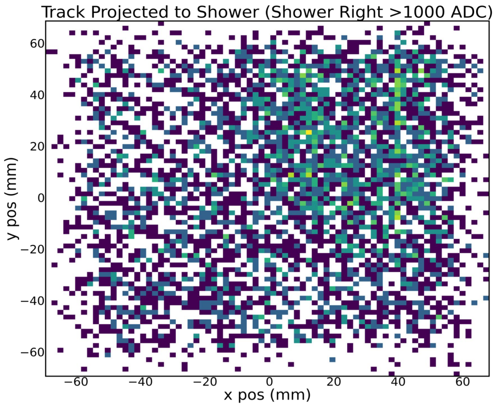
GEM Tracking: 18°



Projection of track from first GEM to Shower

- Large signal in Top, Left, or Right Shower
  - Look at projected track





Trigger Design: 7°

Trigger Name	Logic	Threshold	Particle	
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TS 2	Scin D + Shower Sum + Scin B		π	SoLID π like trigger
TS 3	Cherenkov Sum + Scin D + Shower Sum			⅔ Trigger (efficiency)
TS 4	Shower Sum	Variable	“clean” e^-	
TS 5	Scin B		“clean π”	