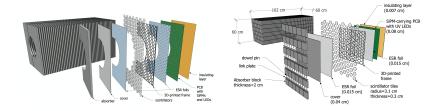
## Status and Plans for Insert/ZDC Test at RHIC

Weibin Zhang

UC Riverside

2024-07-08

## SiPM-on-Tile Calorimetry



- Developed by the CALICE Collaboration for  $e^+e^-$  colliders
- Deployed at scale at the LHC and the EIC
- Chosen for the LFHCAL, CALI and ZDC for the ePIC detector

# Hexagonal Layer



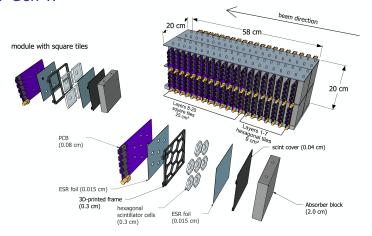






3

#### CALI: Gen-II



- First beam test at JLab in 2023 (Instruments)
- ullet 20 sampling layers: 4 hexagonal layers + 16 square layers
- Iron absorber + scintillator tile + SiPM (on tile) + CAEN unit
- 20 cm × 20 cm transverse active area.

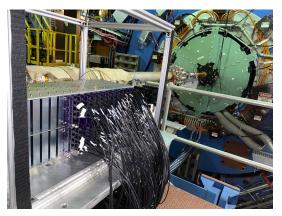
#### Beam Test at BNL



- Operating and calibrating the prototype in realistic conditions, as well as quantifying system degradation due to radiation damage
- Measurement of MIP response using isolated tagged charged hadron
- Measurement of core of hadronic shower using isolated tagged charged hadron
- Measuring  $\pi^0$  invariant mass and spectra to verify calibration and showcase the separation of two showers with a fine 3D shower shape

#### Installation in the STAR Hall





- East platform of the STAR detector, parallel to the beampipe
- $3.2 < \eta < 3.6$
- 192 (268)/368 channels readout (connected)
- · Hodoscope installed, but not in use yet

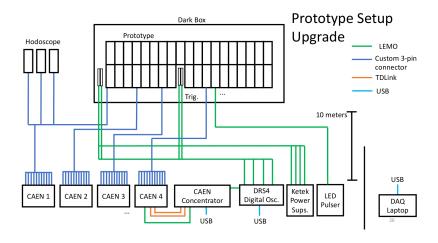
### Trigger and Data Collection





- 4 trigger tiles: 2 in front and 2 at the showermax
- One radiation monitoring tile on the bottom right
- CAEN unit to bias and read out SiPM signals (CITIROC 1A ASIC), will test HGROC once the Oak Ridge group shares their boards
- Multiple CAEN units, requires external trigger DRS4
- Concentrator to distribute the trigger signal and collect the readout
- Janus for software configuration

## Trigger Logic (Slide by Sean Preins)



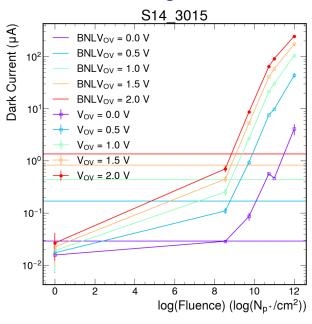
## Radiation Monitoring





- A SiPM in front of the prototype for radiation monitoring, readout by a Keithley unit
- Perform I-V characterization with the Keithley unit

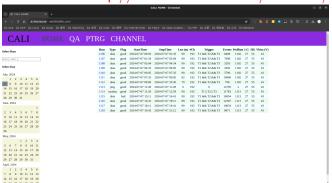
## Radiation Monitoring



- Irradiation test at UC Davis last month as reference to calculate fluence for the BNL test
- Since RHIC Run24, the radiation received by the prototype is about  $10^8-10^9$  p/cm<sup>2</sup>

### **Daily Operation**

Our website: http://138.23.151.181:8080/BNL\_test/



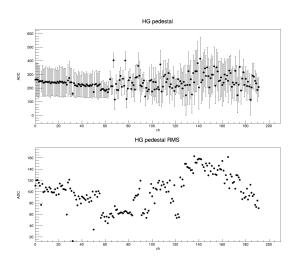
- Automate most work for data taking and analysis with scripts
- Analysis framework is developed (github)
- At least one pedestal run every day
- Cosmic data on maintenance day and scheduled beam off time
- Power cycle the CAEN unit and concentrator through a NPS

#### **Database**

Run	Type	Flag	StartTime	StopTime	Len (m)	#Ch	Trigger	Events	PedRun
692	data	good	2024-06-13 00:47	2024-06-13 02:17	90	192	T1 && T2 && T3	7353	683
693	data	good	2024-06-13 02:17	2024-06-13 03:47	90	192	T1 && T2 && T3	6069	683
694	data	good	2024-06-13 03:48	2024-06-13 05:18	90	192	T1 && T2 && T3	5563	683
695	data	good	2024-06-13 05:18	2024-06-13 06:48	69	192	T1 && T2 && T3	3939	683
696	data	good	2024-06-13 06:49	2024-06-13 08:19	89	192	T1 && T2 && T3	174	683
697	data	good	2024-06-13 08:19	2024-06-13 09:49	90	192	T1 && T2 && T3	6186	683
698	data	good	2024-06-13 09:49	2024-06-13 10:25	17	192	T1 && T2 && T3	1344	683
699	ptrg	good	2024-06-13 10:25	2024-06-13 10:25	0	192	0	12904	-1
700	cosmic	good	2024-06-13 10:44	2024-06-13 11:03	17	192	T1 && T2 && T3	6	699
701	cosmic	good	2024-06-13 11:03	2024-06-13 12:33	89	192	T1 && T2 && T3	205	699
702	cosmic	good	2024-06-13 12:33	2024-06-13 14:03	89	192	-2	61	699
703	data	good	2024-06-13 14:04	2024-06-13 15:34	88	192	-2	9949	699
704	data	good	2024-06-13 15:34	2024-06-13 17:04	90	192	-2	2575	699
705	data	good	2024-06-13 17:04	2024-06-13 18:34	90	192	-2	172737	699
706	data	good	2024-06-13 18:35	2024-06-13 20:05	90	192	-2	385395	699
707	data	good	2024-06-13 21:29	2024-06-13 22:59	90	192	T1 && T2 && T3	2087	699
708	data	good	2024-06-13 22:59	2024-06-14 00:29	90	192	T1 && T2 && T3	2345	699

- Run information is stored in a database
- The database is accessible from the cali website

#### Pedestal

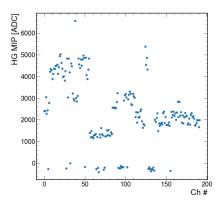


- HG pedestal from run 941 (2024-06-25)
- The pedestal is fluctuating in CAEN unit 2 and 3
- Increament of the pedestal RMS value (Imon) along time

## Cosmic

		High-gain ADC spe	ctra									
Only X Notes X Notes	X X Posts X Nets	× × Peals ×	Cho Pada X X Pada KCE	X X Peaks X	Y Posts	X X Feets	Ch 13 Phake HDE	Ch 11 Plaks HDC	Ch 12 Feels NCC	X Peaks	X X Posts	X X Peaks
10-3 X	- X	- / \- \-	×	-\x	\x	×	×	Vx.	X	\x_	X	×
0 10 <sup>-3</sup> × × Page × × Page × 10 <sup>-17</sup>	X X Pouts X Pouts	× × × × ×	ta X Pedra	X X Profit	X Photo	X X Peas	Ch 26 X Peaks H26	Chi27 X Peaks XDS	Ch 28	Ch.29 X Profes X26	X X Pouts	X X Peans
10 <sup>-3</sup> X	- x - x		~ X	\x_ \	×	×	X	\	×	X	×	×
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10 <sup>-5</sup> ×	- X	- x	×	X_	×	×	×	×	×	×	X	×
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8 10 <sup>-3</sup> × × 10 to 10 t	X X Number X X Number 1			X X Produ	X Peaks	X X Feets 2	X Peace.	× Peaks	X Peasa HSG	X Paulis 125	X Posts KSS	X Peass.
10-4	×	×		×	×	×	*	×	×	×	×	×
8 10 <sup>-3</sup> × feet × feet × feet	× Posts	X X Point X X Po		× × Peaks ×	Y Posts	X X Pessa	Ch So Phase	X Peaks	Cn 52 Posts HCK	Cn 95 Pasks HDE	X On 94 X Peaks	X Ca so Pasks HDC
10-5 X	×	×	×	×	X.	×	×	×	×	×	×	×
On N 10 <sup>-3</sup> × × Note × × Note × Note × Note Note Note Note Note Note Note Note	X X Posts X On 18	X X Nada X X Na		X X Pedro X	Ch 104 Pholio KDE	X X Peeks	X Produ	X Presis	Ch 100 X Pesks	X Peels	X X Photo	X X Pests
10-4	× ×	×	- ×	×	X_	×	X	×	×	×	×	×
8 10-3 × × Pass × × Pass × × Pass	X X Plans X Plans (Ch.118)	X X Page X X Page 100 NO		X X Paula X	X Peaks HDG	X X Feeta.	X Pushs 125	Ch 122 Pushs 125	Ch till Plaks KCC	X Page 1	X X Peaks	X X Pasks
10-8 X	* *	×	- ×	×	X_	×	××	×	×	×	×	×
8 10-3 × × On 128 × × Feature NCC	X X Peda X X Ped		On 133 Peaks X X Peaks KCC XCC	× × in tis	X Posts HDE -	× × Pesta	× × On 138 Posito KDE	X X Posics	× × Cn 140	× Peaks	X X Posts	× × Pooks
10-3-	+\ +\	+/ +/	+	<u> </u>	UX	×	×	×	×	×	×	×
O 10-3 × × hele × × hele	× × Prote × × Prote	X X Predict X X Pre	AS X Peaks	× × Pede ×	X Prodo	X X Peaks	X Paulo	X Prode	X X Peodo	X Preds	Co 158 Y Photo	X X Photo
10-4 X	- X	- X	×	×	×	×	×	×	×	×	×	×
8 10-3 × × Nata × × Nata × × Nata	X X Pluss X Pluss X Pluss 606	X X Pade X X Pad	S X X Peans	X X Produ	X Peaks	X X Page 2	X Peaks 1256	X Peaks	Ch TIZ Planta KSI	X Pedis XXE	X Years	X X Photo
10-3 X	- X	- Lx	_ \x_	×	X	×	×	×	×	V	×	×
8 10-3 × × heles × × heles × xce	X Notes X Notes	X X Peds X X Ped		X X Peda	X Pode -	× × Ch 105	X Peaks	X Peaks	Cn 100 Pooks HDC	× Profes	X Photo	X Pools HDC
10-5 X	- X	- X	_ \x	×	X	×	×	×	×	Vx	UX	×
0 5000 0 5000 ADC AD	0 5000 0 5000 G ADC AI	0 5000 0 50 DC ADC	ADC ADC	0 5000 0 ADC	5000 ADC	0 5000 C	5000 ADC	5000 ADC	5000 ADC	9000 ADC	0 5000 ADC	5000 ADC

### **MIP**



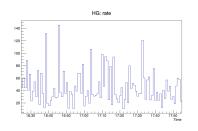
- 1.3 mm and 3 mm SiPMs; Hexagonal and sqaure tiles
- Small hexagon cells show very clear MIPs while small SiPMs with large tiles can barely see the MIP (even biased at 5V)
- MIP analysis with beam data is under development

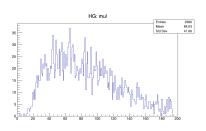
### Parallel Test at UCR



• Optimize bias/gain setting

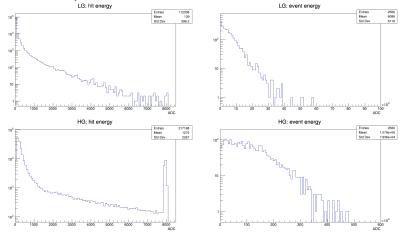
## Data: Rate and Hit Multiplicity





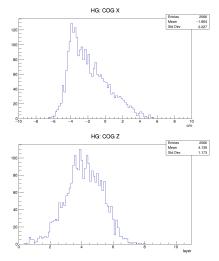
- Event rate at a few Hz
- Most are low energy particles

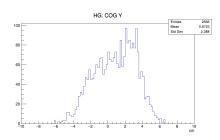
### Data: ADC Spectrum



- HG for MIP analysis
- LG for high energy particles
- Monitoring total energy along time

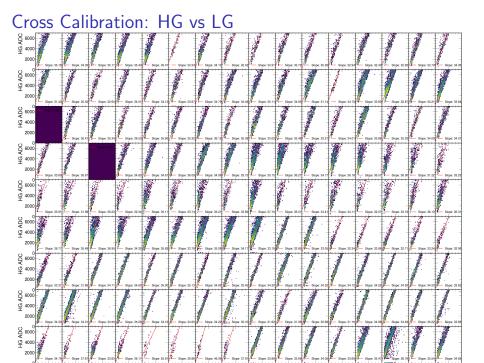
## Data: Center-of-Gravity (COG)

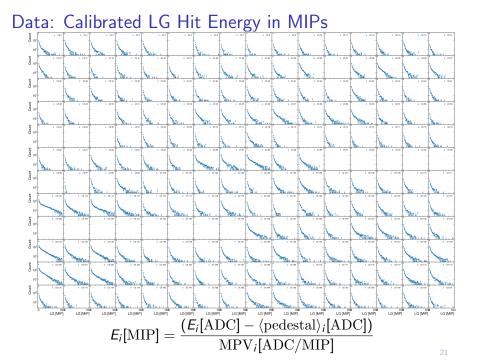




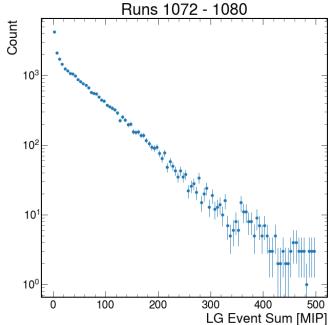
$$COG = \frac{\sum_{i} E_{i} \cdot \vec{X}}{\sum_{i} E_{i}}$$

- Shower shape analysis is under development
- Aims at separating the two photons from  $\pi^0$





# Data: Calibrated LG Event Energy in MIPs



### Summary

- The first operation of a SiPM-on-tile calorimeter in a collider ever
- Will run it until next year (the end of RHIC), including both pp and AA collisions
- The goal: maintain stable performance along time under harsh radiation environment – radiation effect, MIP response, shower shape analysis and particle reconstruction
- The experiment is still in the commissioning phase
- More cables, SiPM boards and CAEN units (HGROC) will be added
- Shower shape analysis is under development
- Pythia simulation is coming