Calibration of the sPHENIX hadronic calorimeter system

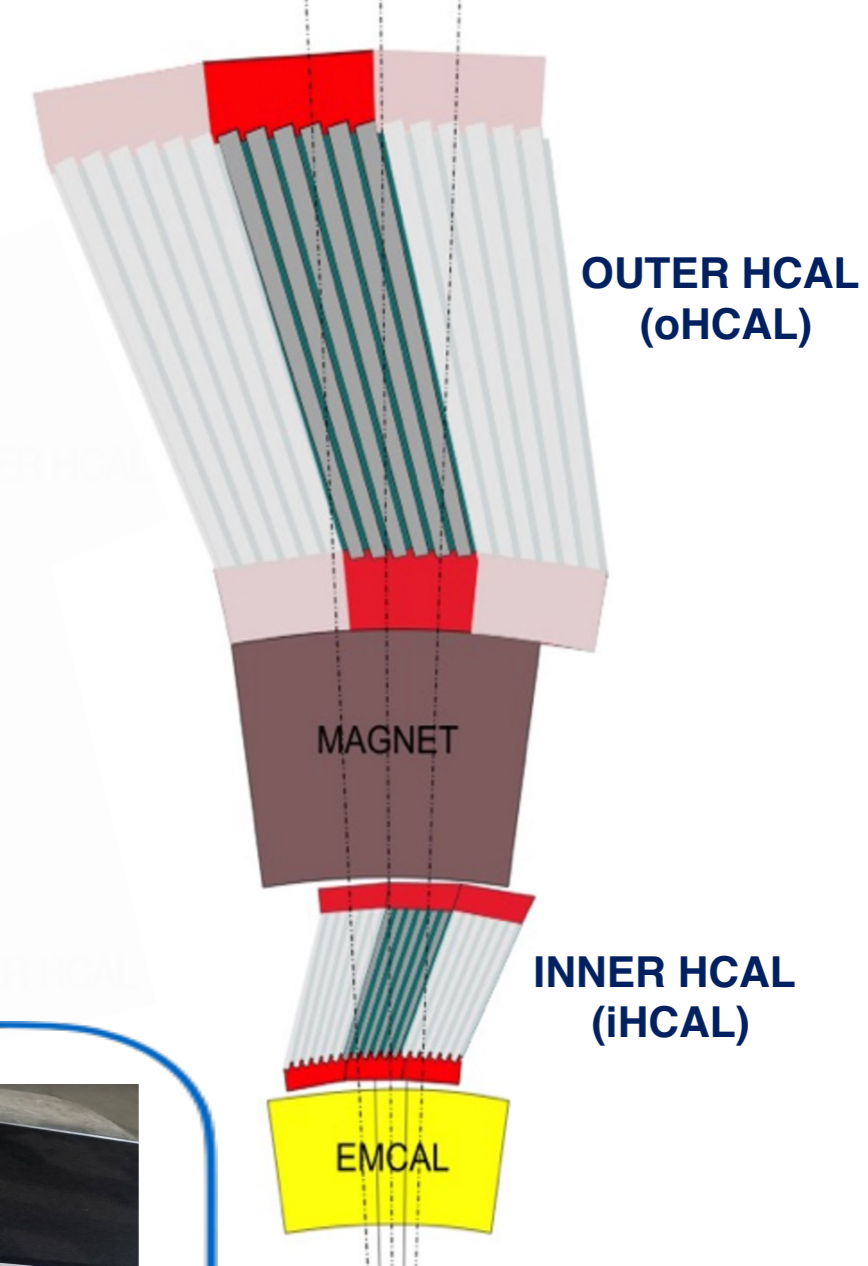**Ejiro Umaka[1], Hanpu Jiang[2], Shuhang Li[2]**
1. Iowa State University, 2. Columbia University
on behalf of the **sPHENIX** collaboration

Quark Matter 2022 - the 29th International Conference on Ultra-relativistic Nucleus-Nucleus Collisions
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Brookhaven National Laboratory

sPHENIX

sPHENIX Hadronic calorimetry (HCAL)

- **First at RHIC at mid-rapidity**
  - Coverage: $|\eta| < 1.1$, 2π in ϕ
- Plastic scintillating tiles with embedded WLS fibers + tilted (steel) aluminum plates (oHCAL) iHCAL
- Hadrons traversing the HCALs shower due to the plates. The deposited energy in the tiles are directed to silicon photomultipliers (SiPMs)
- The signal from the SiPMs is then aggregated into towers
- **HCAL geometry**
  - 32 sectors
  - 48 towers/sector
  - 24 towers in η, 2 towers in ϕ
  - 4 tiles/tower (iHCAL); 5 tiles/tower oHCAL
 - Overall tile segmentation of $\Delta\eta \times \Delta\phi \approx 0.1 \times 0.1$

Transverse view of one sector of the (i+o)HCAL

OUTER HCAL (oHCAL)

MAGNET

INNER HCAL (iHCAL)

EMCAL

Single tower

ϕ

η

A section of iHCAL sector with tiles and SiPMs

# Cosmic muon data taking with HCAL Sectors

- **Cosmic muon event selection**
  - A sector is divided into thirds (shown in teal, yellow & magenta in the plot below)
  - Each third has the same trigger for cosmics. The sum of the signal of a third of the towers must surpass a given threshold.

- **Offline cuts**
  - Vertical towers, i.e., 2 towers in ϕ are hit
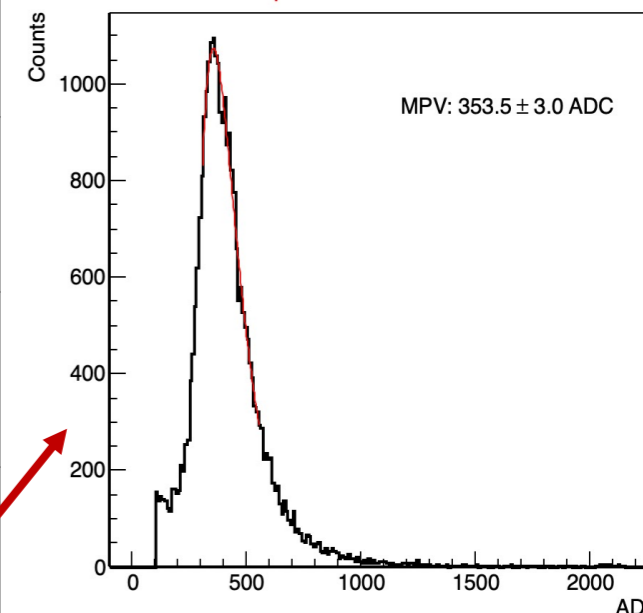 - No horizontally neighbor towers are hit (i.e., immediate towers in η)

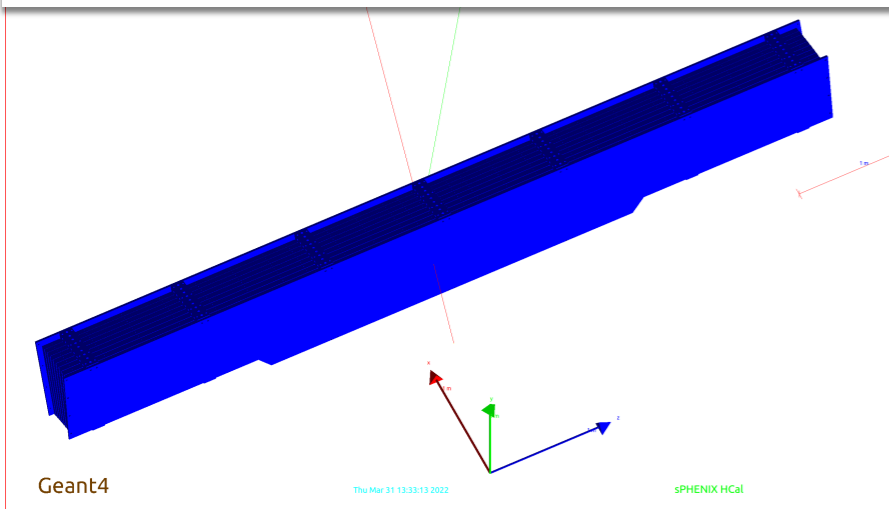**oHCal sectors at BNL's AGS Fixed-Target Exp. Hall**
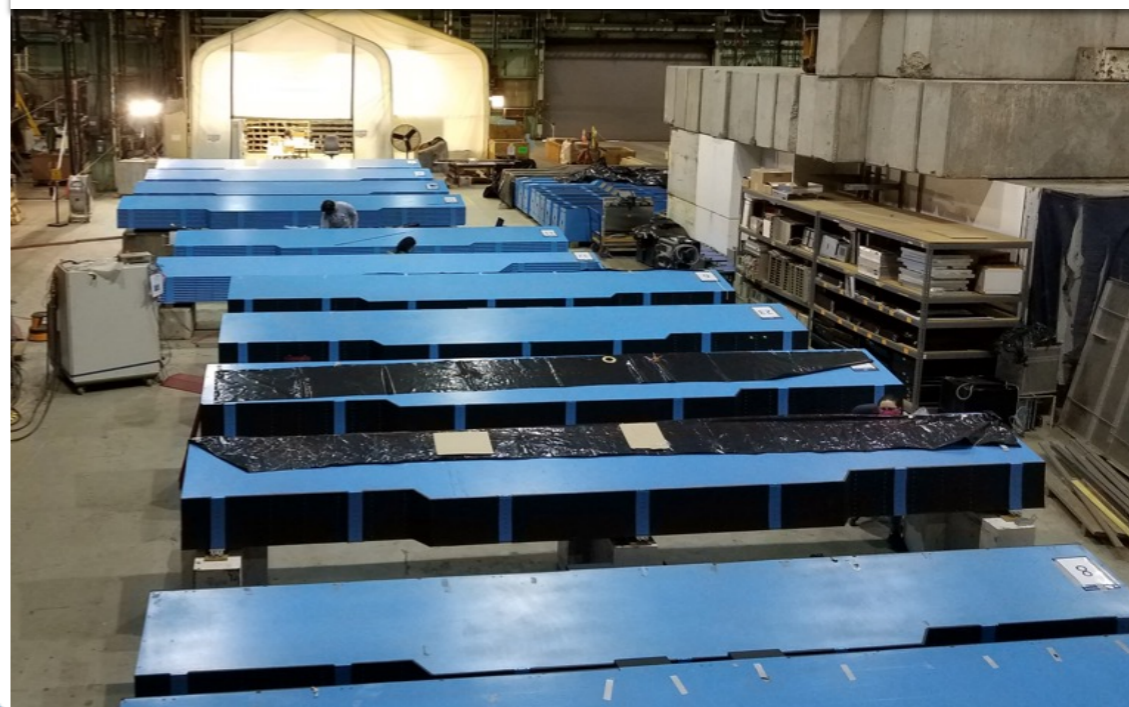
**Cosmic muon data for all towers in 1 HCAL sector over the course of 1 hour
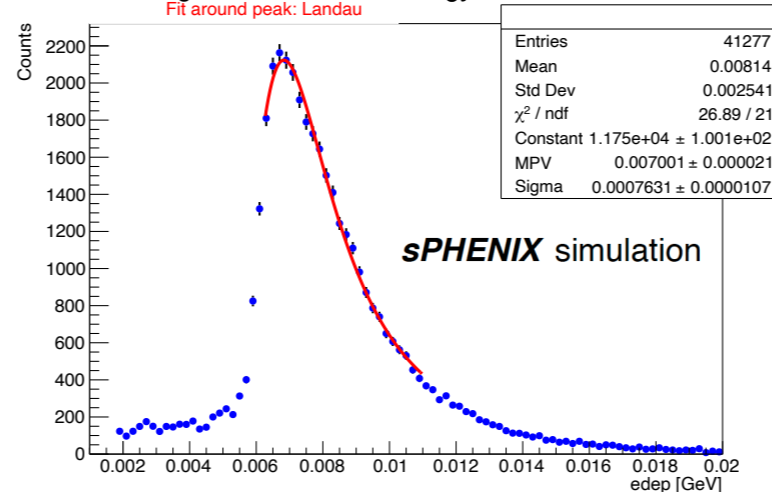(black = no offline cuts; red = with offline cuts)**
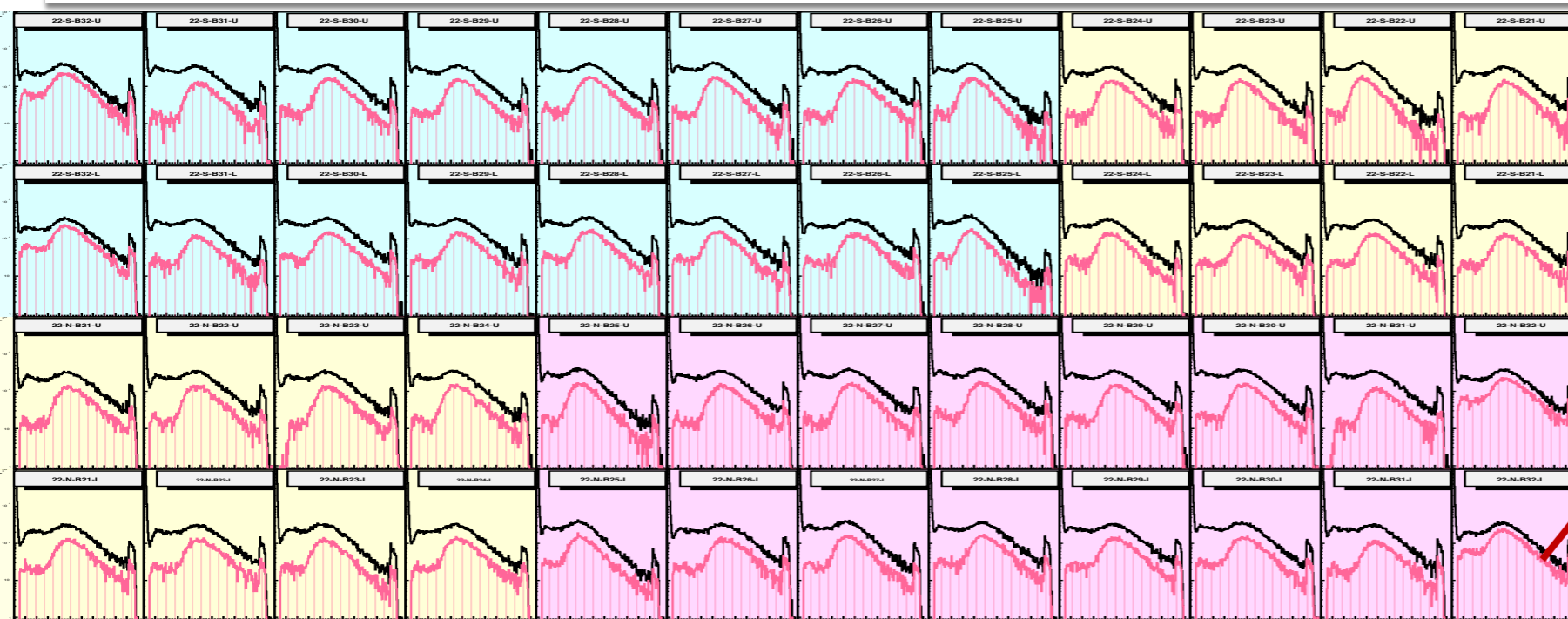
Single oHCAL Tower ADC Distribution
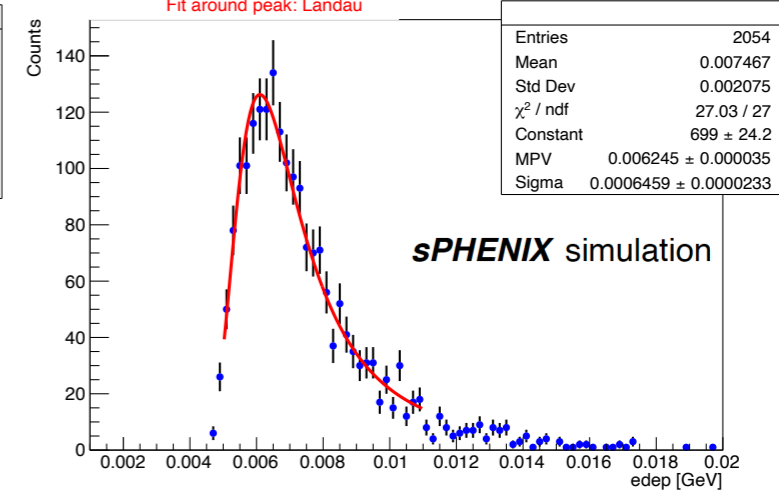Fit around peak: Gamma + linear function

MPV: 353.5 ± 3.0 ADC

HCAL sector cosmic muon simulation

Simulated single μ^- event on 1 HCAL sector

Geant4   Thu Mar 31 13:33:13 2022   sPHENIX HCal

Single oHCAL Tower Energy Loss Distribution
Fit around peak: Landau

Entries	41277
Mean	0.00814
Std Dev	0.002541
χ^2 / ndf	26.89 / 21
Constant	1.175e+04 ± 1.001e+02
MPV	0.007001 ± 0.000021
Sigma	0.0007631 ± 0.0000107

sPHENIX simulation

Single iHCAL Tower Energy Loss Distribution
Fit around peak: Landau

Entries	2054
Mean	0.007467
Std Dev	0.002075
χ^2 / ndf	27.03 / 27
Constant	699 ± 24.2
MPV	0.006245 ± 0.000035
Sigma	0.0006459 ± 0.0000233

sPHENIX simulation

- A muon is simulated going through one sector with energy and angular dependence described in arXiv:1606.06907
- The energy loss distribution is then extracted for each tower
- This simulation result is used to calibrate the ADC signal peak in each tower with:

$$C = \frac{E_{dep}^{cosmic}}{E_{dep}^{ADC} \times SF(muon)}$$

- Where, E_{dep}^{cosmic} is the peak of the eloss distribution extracted from GEANT4 cosmic simulation, E_{dep}^{ADC} is the ADC peak measured from the cosmic data, and $SF(muon)$ is the muon sampling fraction

E_{dep}^{cosmic} and initial calibration constants, C, for the HCAL sectors
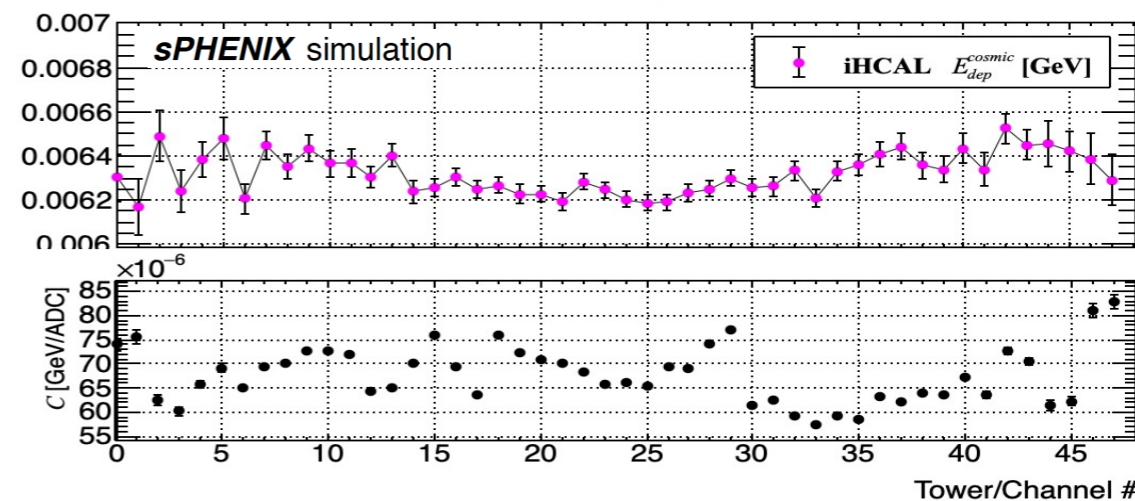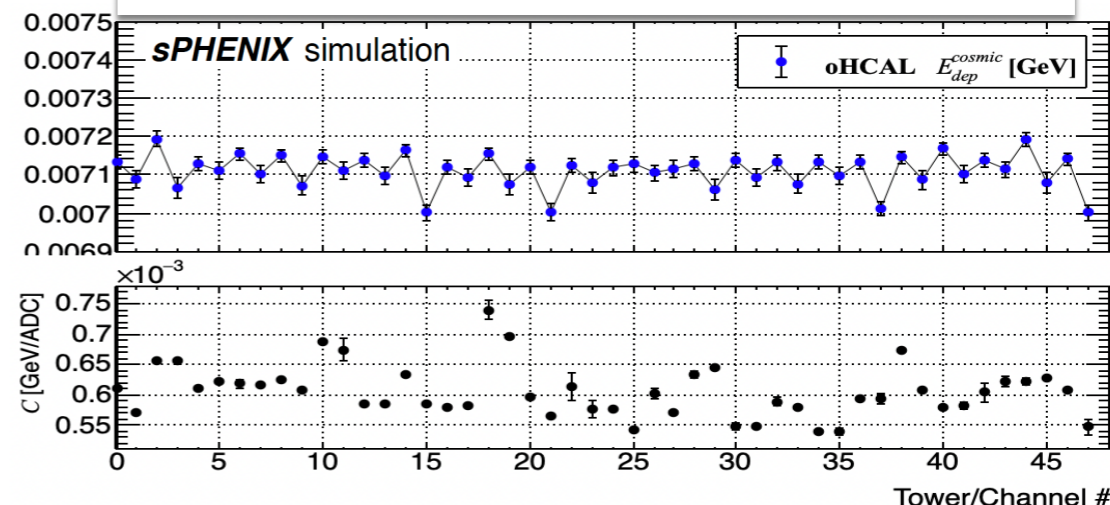
- **sPHENIX** will be the first new collider detector at RHIC in over 20 years!
  - First hadronic calorimetry at RHIC at mid-rapidity
- The outer and inner HCAL sectors are now fully assembled at BNL!
  - Future calibrations will include the sectors in their fully assembled configuration

oHCAL Installation Complete!

iHCAL Barrel Complete!

sPHENIX is supported by

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