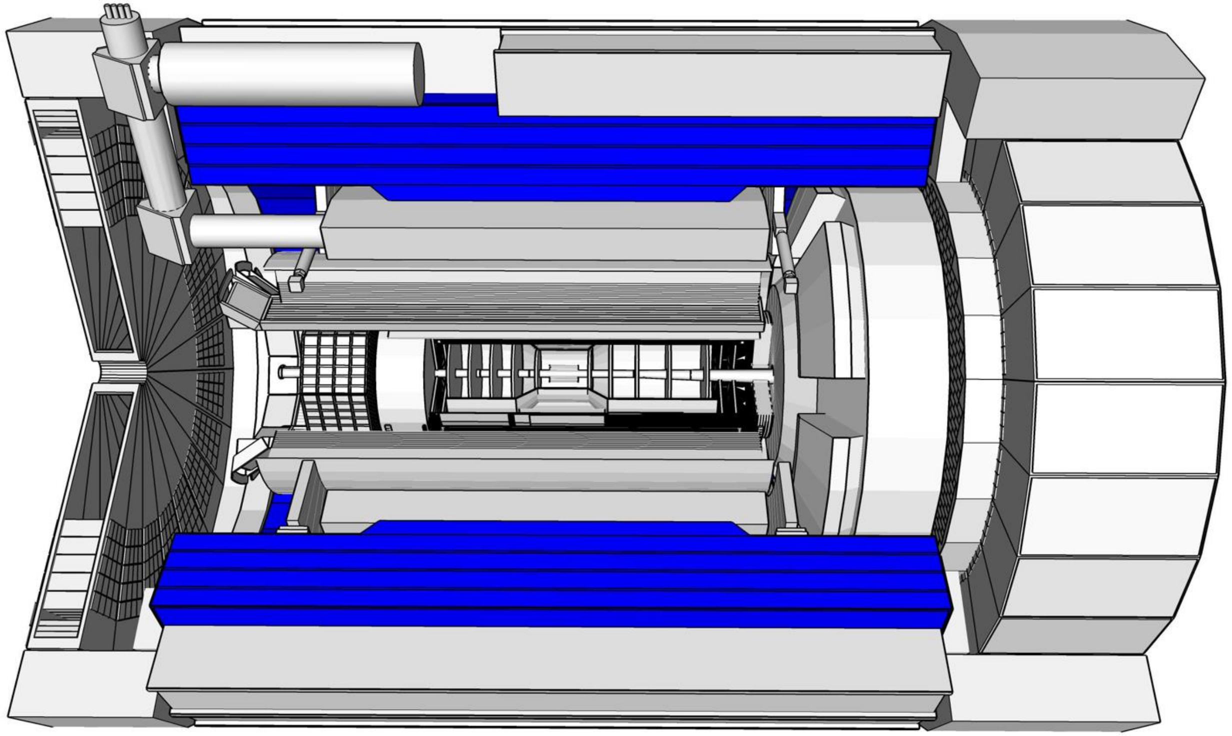
The Barrel Hadronic Calorimeter - BHCal



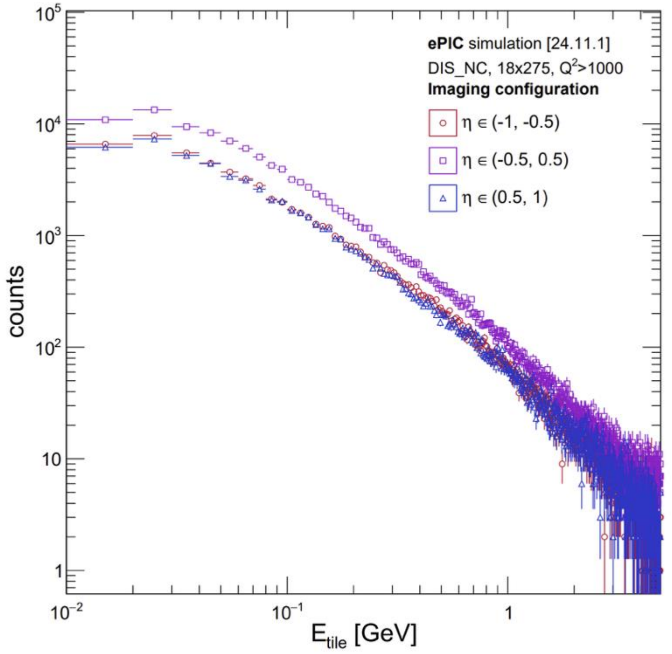
DSLs: S. Bathe (Baruch) & M. Sarsour (GSU)

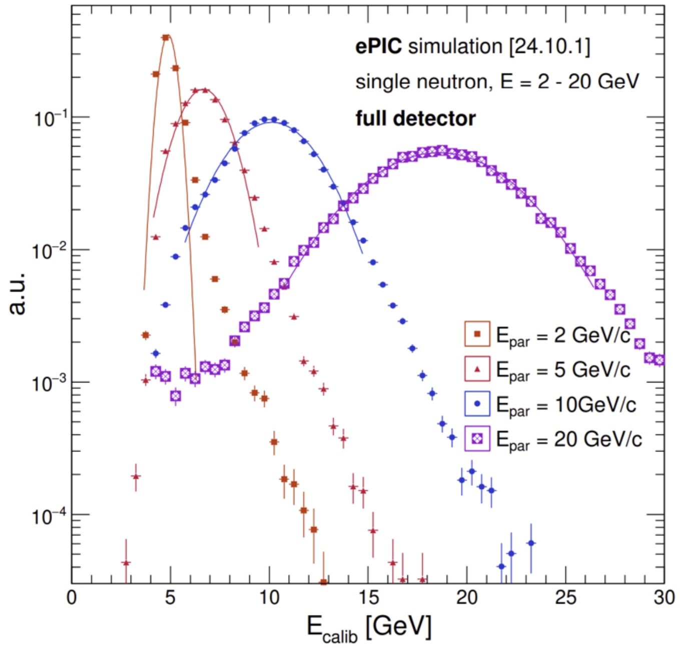
Team: ANNL, Baruch, BNL, GSU, ISU, ORNL , UNH

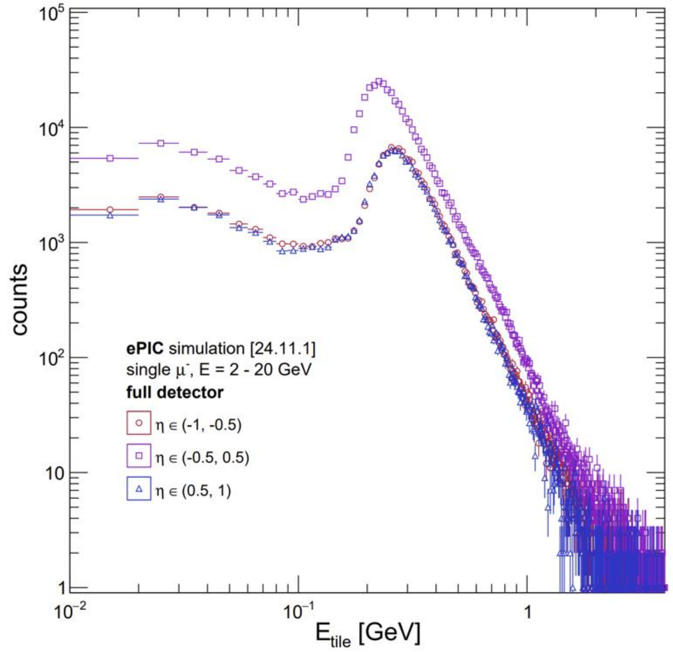
The Barrel Hadronic Calorimeter - BHCal

❖ **Why HCal at midrapidity in ePIC:**

- Account for contributions from neutral particles for precise jet energy reconstruction
- Charged-current DIS
- Hadronic final state and $\mu^{\pm}$ identification
- Solenoid flux return





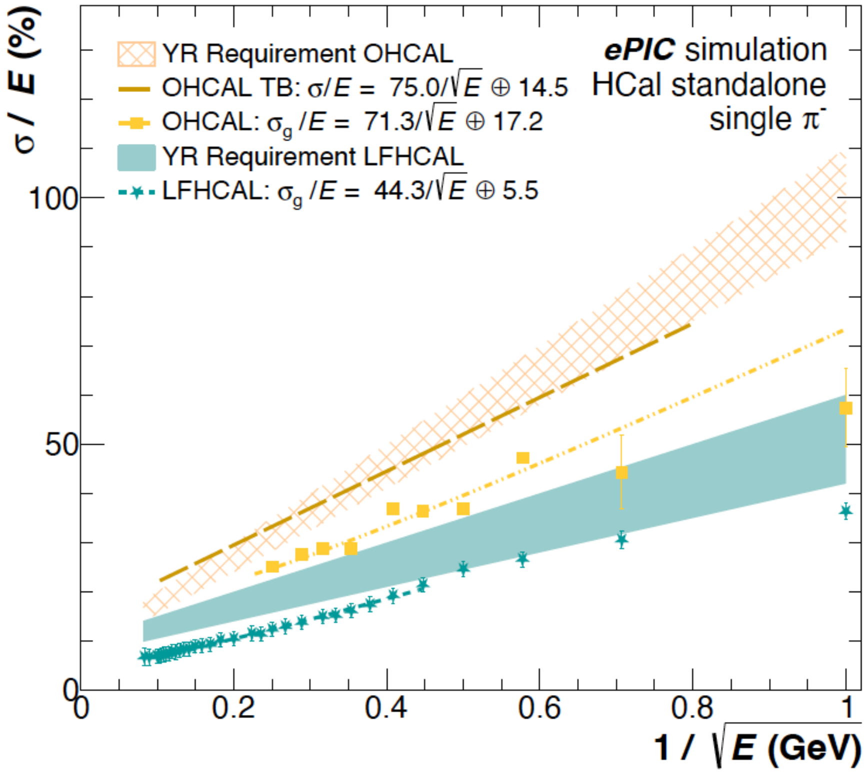


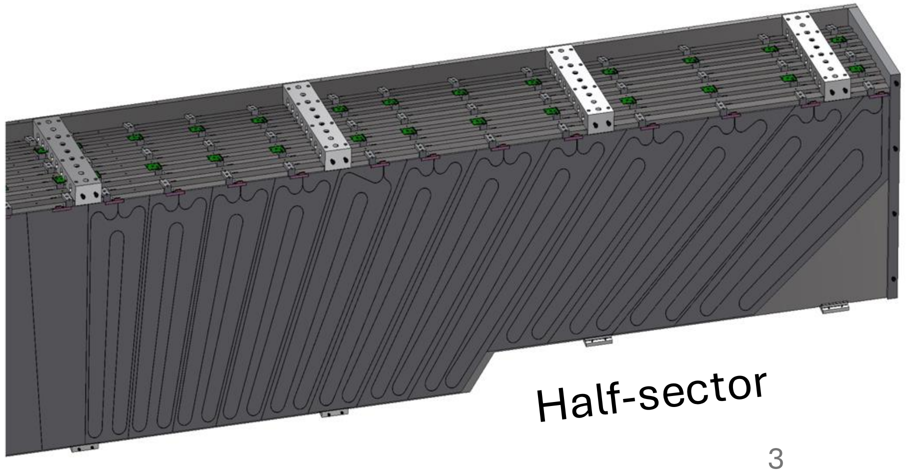
BHCal Requirements

- The Yellow Report indicates that $\frac{\sigma_E}{E} \approx \frac{(80-100)\%}{\sqrt{E}} \oplus (7-10)\%$ will be adequate.

- sPHENIX Outer Hadronic Cal. (OHCAL) with $\frac{\sigma_E}{E} \approx \frac{75\%}{\sqrt{E}} \oplus 14.5\%$
  - Tilted-plate: alternating steel & scintillating tile (+ WLS fibers)
  - $|\eta| < 1.1$ & 2π coverage.
  - 32 sectors – 6 m long, 16 tons each
  - 48 towers/sector @ 5 tiles/tower ($\Delta\eta \times \Delta\varphi \sim 0.1 \times 0.1$)

→ **ePIC** will refurbish sPHENIX OHCal, but read out each tile ($\Delta\eta \times \Delta\varphi \sim 0.1 \times 0.02$)

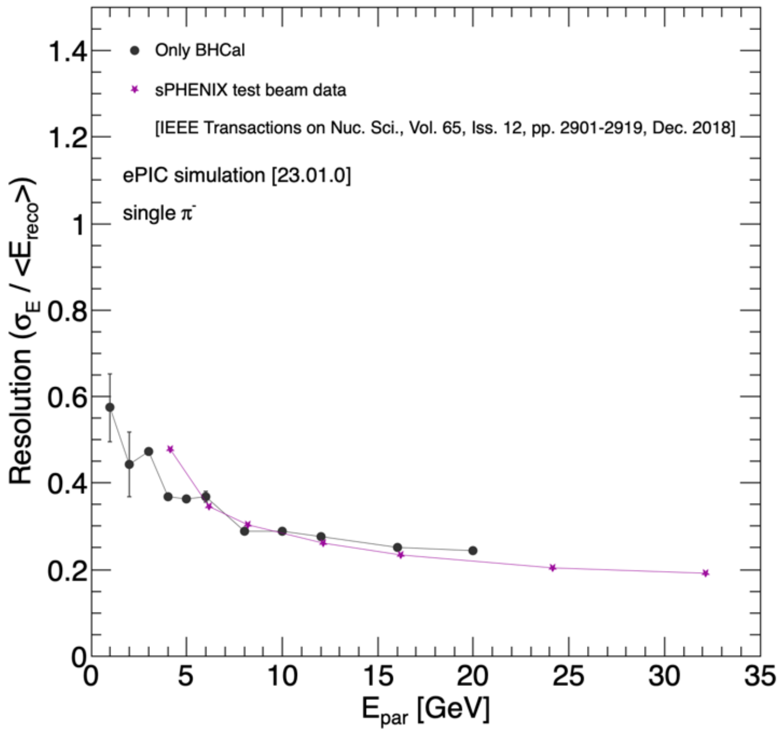




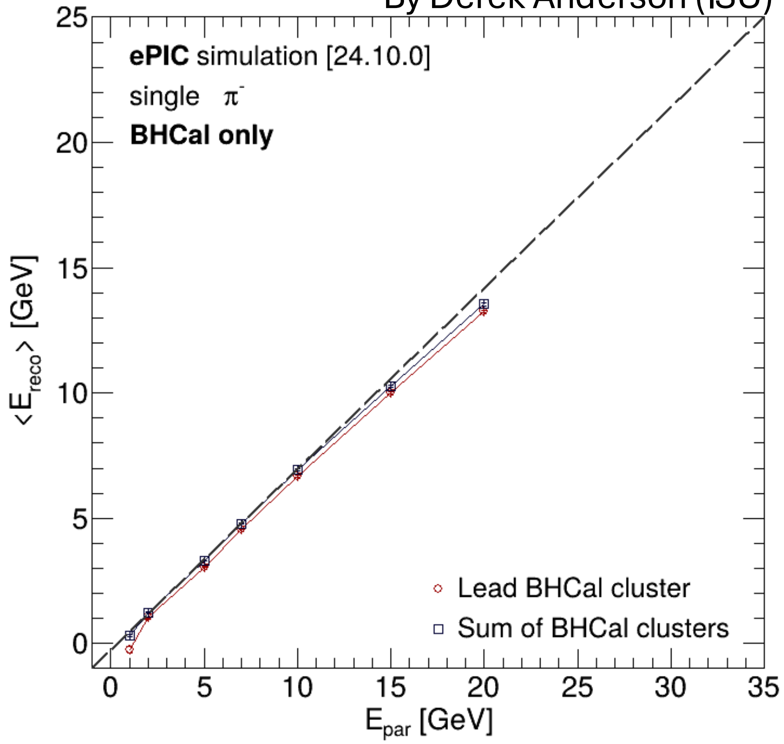
BHCal in ePIC Simulation Framework

❑ BHCal implemented in DD4hep simulation of ePIC

- Resolution&Linearity from ePIC simulation vs. sPHENIX test beam data (*IEEE Transactions on Nuc. Sci., Vol. **65**, 2901 – 2919 (2018)*)



By Derek Anderson (ISU)



❖ The simulation results are done with towers.

❖ Ongoing: include CAD geom. through GDML files + per-tile simulations (clustering, ... etc).

Refurbishing sPHENIX Barrel HCal

- ❑ Parts to be reused
  - Steel sectors
  - Scintillating tiles
    - Have few spares (of order 8 per shape)
  - fiber system to distribute LED light
    - intended to be reused
    - LED system is being developed

Refurbishing sPHENIX Barrel HCal

New parts

- SiPMs
- Read-out boards
- Coax cables to read-out board
- Bias & LV supplies
- LED monitoring system

Labor

- sPHENIX outer HCal assembly was 5-person-year effort, e.g. if done in a year, it needs 5 people working each day
- Setting up the factory takes time:
    - Space lay-out
    - Set up of test racks
    - Establishing testing procedures
- In sPHENIX, started this two years early

Lessons Learned

- Have as many sectors set up for assembly simultaneously as possible
  - ➢ doubling the space used for sPHENIX in 912
- Do most of the labor with students and postdocs
  - ➢ Some 50 people worked in the sPHENIX HCal factory
- Dedicated technician support essential (electrical/mechanical work)
- Heavy need for rigging

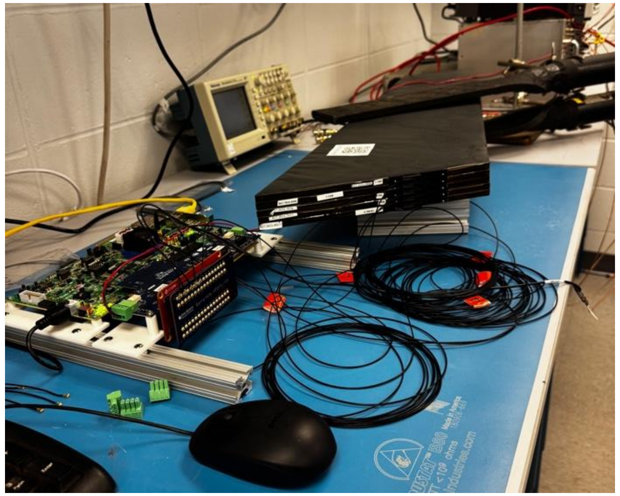
Beam Test

- Desired to characterize all components and calibrate simulations

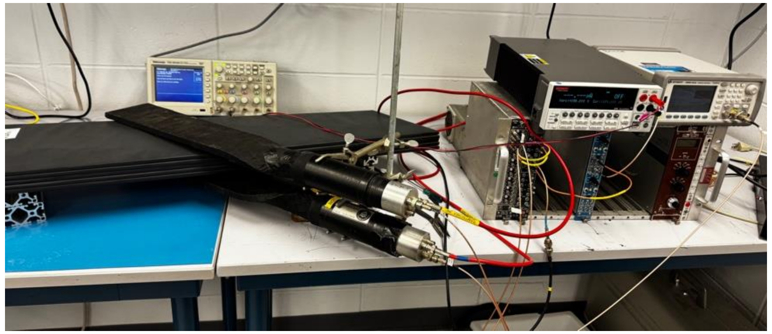
- Plan
  - Refurbish sPHENIX old prototype steel
  - 80 spare tiles
  - 120 new ePIC SiPMs
  - H2GCROCv3 board from Norbert Novitzky (ORNL)

Beam Test

- What do we have?
  - Test-stand in the HCal Lab at BNL (5 OHCal tiles read individually with H2GCROCv3 board with RCDAQ.)
  - Similar test stands are planned at UNH and GSU to gain hands-on experience with the readout system and DAQ.



- Where?
  - FermiLab (pending schedule)
  - CERN



Summary

- Reuse sPHENIX BHCAL
  - Generally satisfies Yellow-Report energy resolution requirements and plan to read single tiles to improve constat term
  - Performance already measured in a test beam as well as in sPHENIX

- Plan for BHCal test beam
  - Reading single tiles with the new H2GCROC based electronics chain
  - Have all components and plan to put it together over the summer

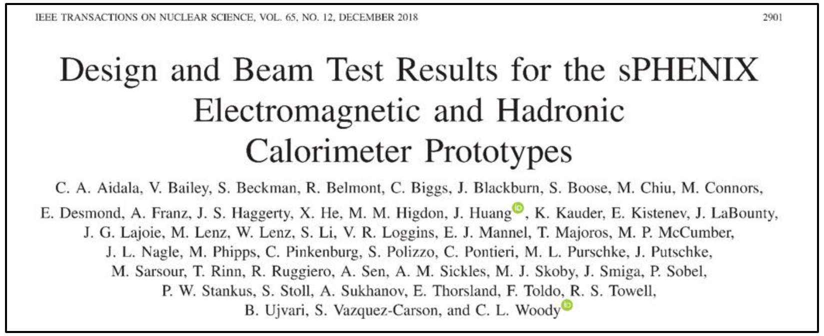
- It is critical to have time to refurbish the Barrel HCal for the reuse at ePIC. The refurbishment is estimated to take **1.5 years** with one team redoing the work done constructing the HCal.

Backup Slides

Charge Questions Addressed

- Is the design of the ePIC detector and its sub-systems appropriate and progressing well?
- Are the remaining work and technical, cost and schedule risks adequately understood? Are there opportunities?
- Will the detector be technically ready for baselining by late 2025?
- Are the detector integration and planning for installation and maintenance progressing well? Are there areas where further ideas should be pursued?
- Will the detector be ready for start of construction by late 2026?

Prior Test Beam Results

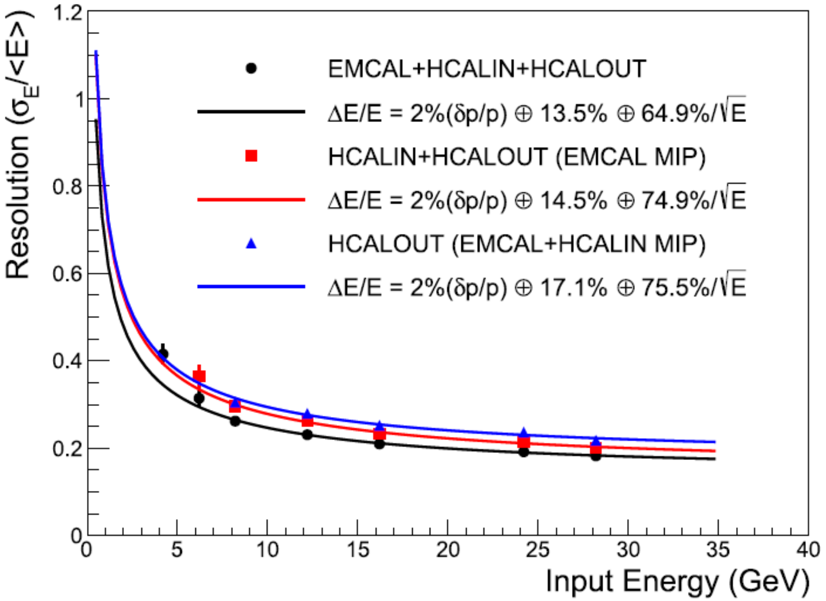


IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 65, NO. 12, DECEMBER 2018 2901

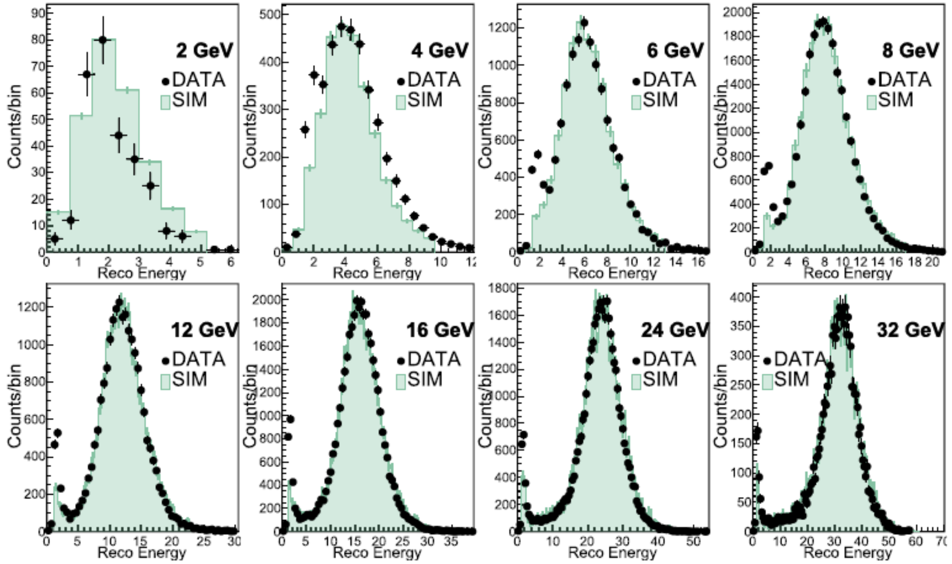
Design and Beam Test Results for the sPHENIX Electromagnetic and Hadronic Calorimeter Prototypes

C. A. Aidala, V. Bailey, S. Beckman, R. Belmont, C. Biggs, J. Blackburn, S. Boose, M. Chiu, M. Connors, E. Desmond, A. Franz, J. S. Haggerty, X. He, M. M. Higdon, J. Huang, K. Kauder, E. Kistenev, J. LaBounty, J. G. Lajoie, M. Lenz, W. Lenz, S. Li, V. R. Loggins, E. J. Mannel, T. Majoros, M. P. McCumber, J. L. Nagle, M. Phipps, C. Pinkenburg, S. Polizzo, C. Pontieri, M. L. Purschke, J. Putschke, M. Sarsour, T. Rinn, R. Ruggiero, A. Sen, A. M. Sickles, M. J. Skoby, J. Smiga, P. Sobel, P. W. Stankus, S. Stoll, A. Sukhanov, E. Thorsland, F. Toldo, R. S. Towell, B. Ujvari, S. Vazquez-Carson, and C. L. Woody

- Detailed studies of performance and comparison with simulations done in test beam (T-1044).
- Performance of full device will be measured in sPHENIX. We should achieve a reduced constant term due to tighter control on the scintillator variation in a tower for production sectors.



Data vs. Monte-Carlo comparison



Initial studies: Log Likelihood Difference Using Barrel HCal E/p and Shower Radius