FOCAL: a FOrward CALorimeter for PHENIX

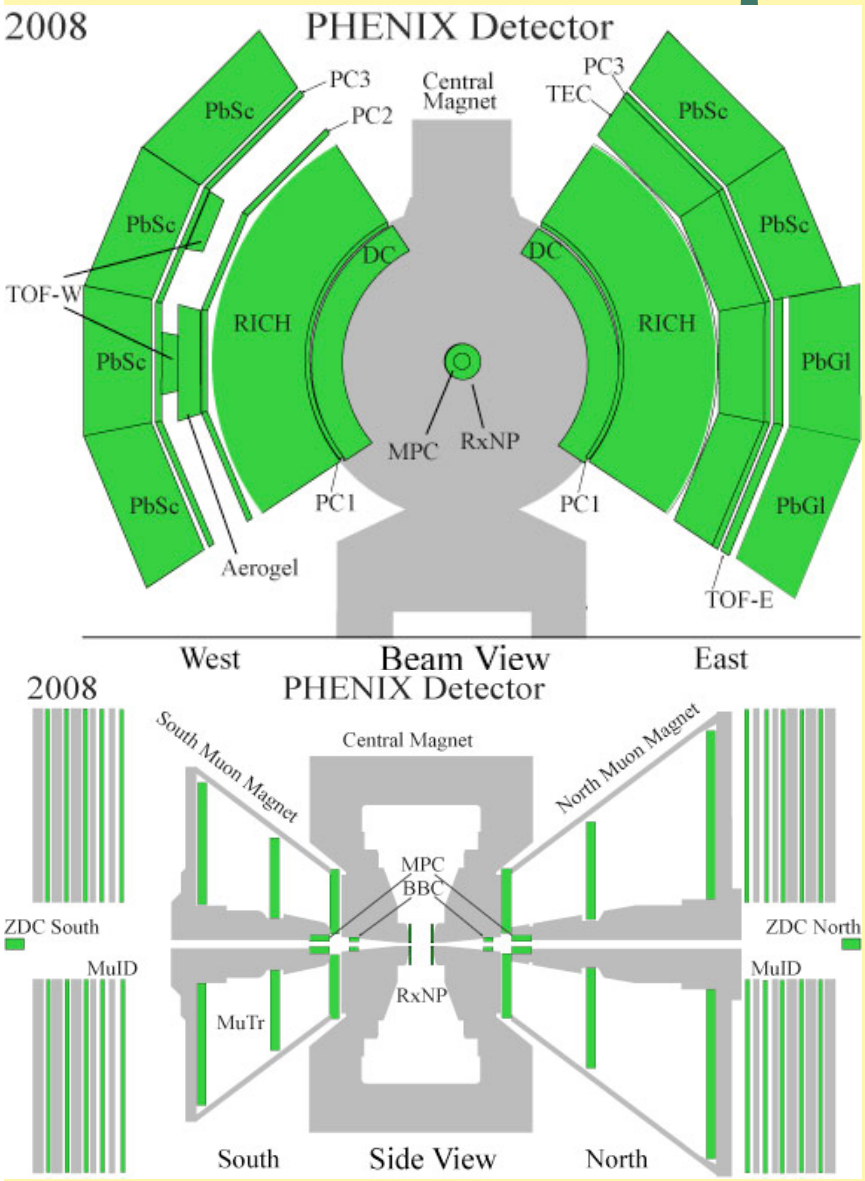
Carla M. Vale, BNL
for the PHENIX Collaboration

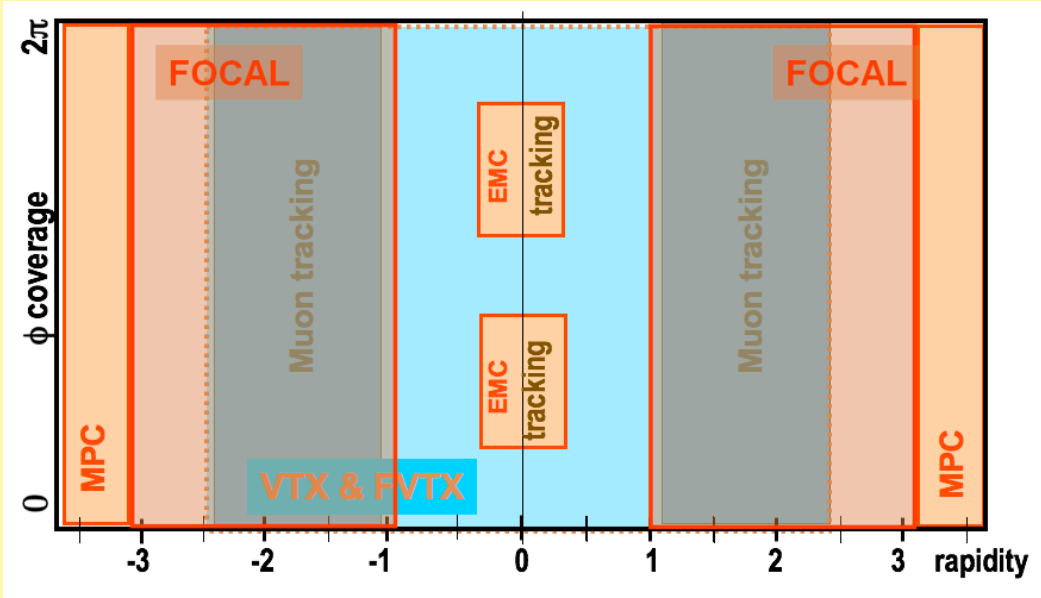
DNP/APS & JPS Meeting '09, Waikoloa, HI

Motivation

- An electromagnetic calorimeter
  - Many recent and exciting RHIC measurements depend on calorimetry
    - π^0, η suppression; single and di-hadron
    - Direct photons
    - γ-jet and full jet reconstruction
- At forward rapidity
  - New area of interest, in particular for d+Au measurements and the spin program

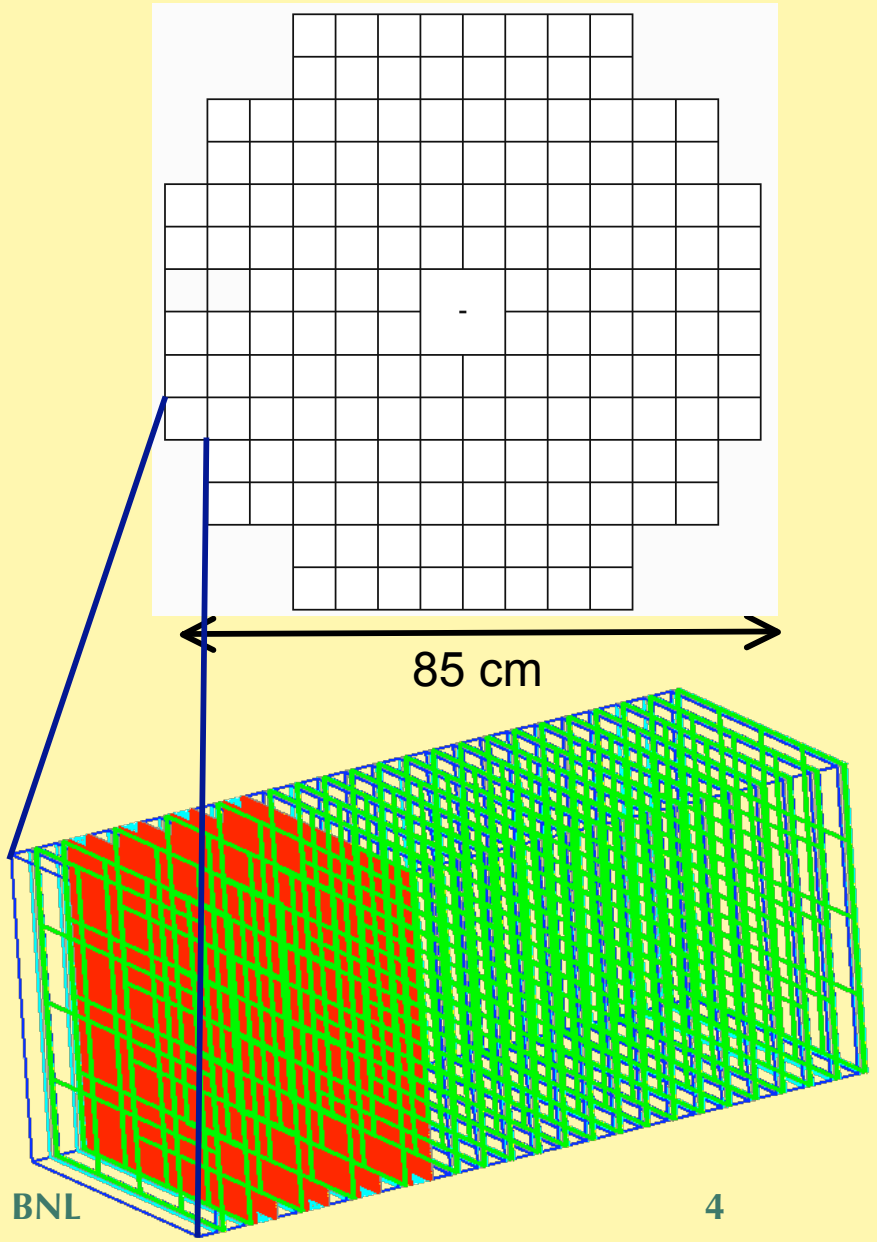
PHENIX: present and future



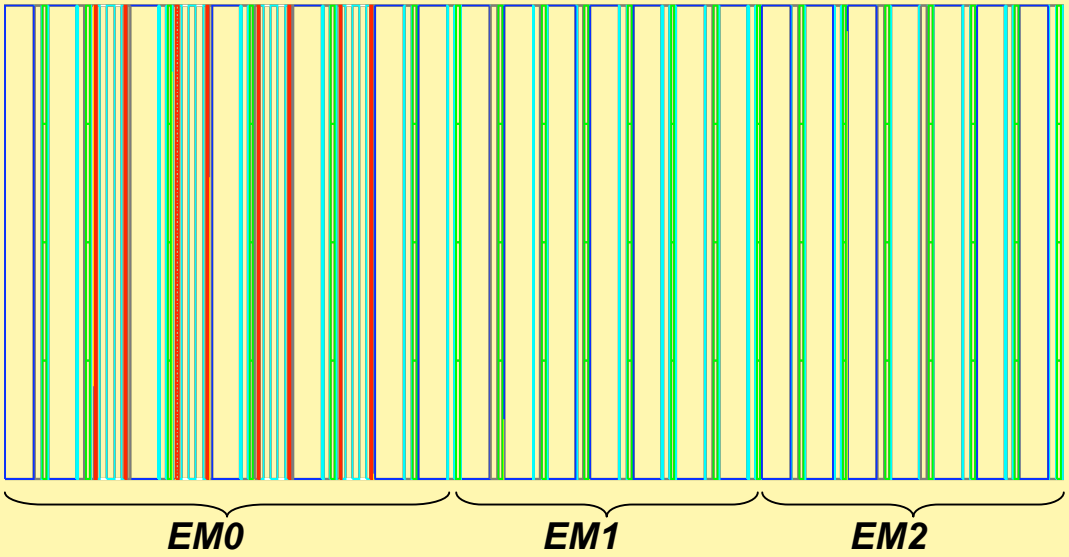


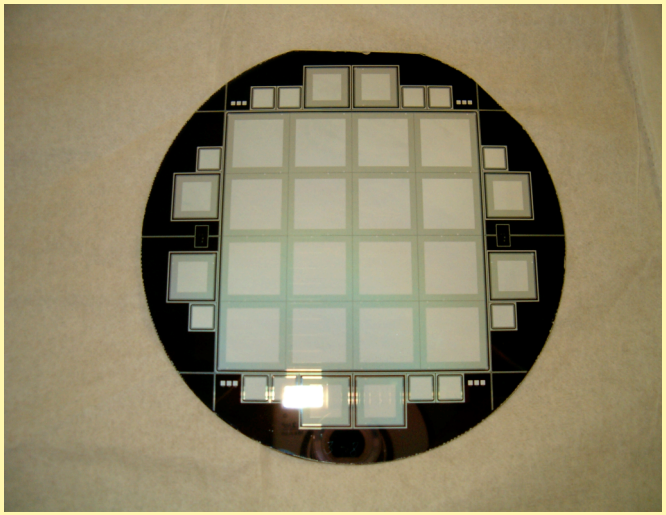
What is the FOCAL?

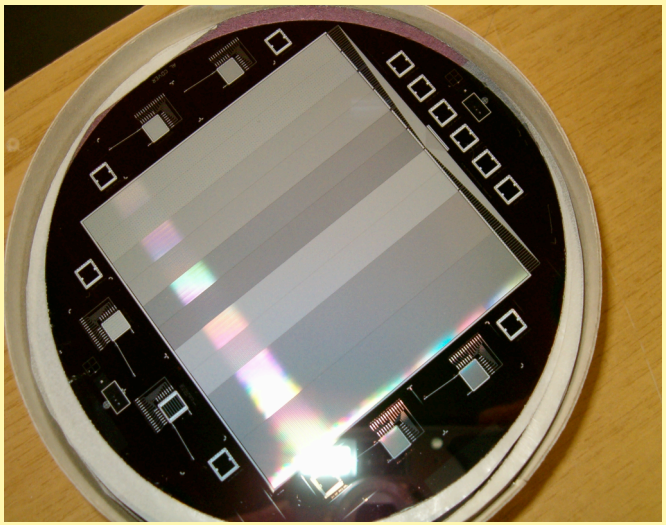
- A compact Silicon-Tungsten (SiW) sampling calorimeter: tungsten absorber plates with silicon pad readout.
  - $1 < \eta < 3$
  - 2π azimuth
  - 24 X_0 deep
- Three longitudinal segments of pad readout, to reconstruct lateral and longitudinal shower profile
- Four layers of Si-strips within the first X_0, for γ/π^0 separation.



Zooming in





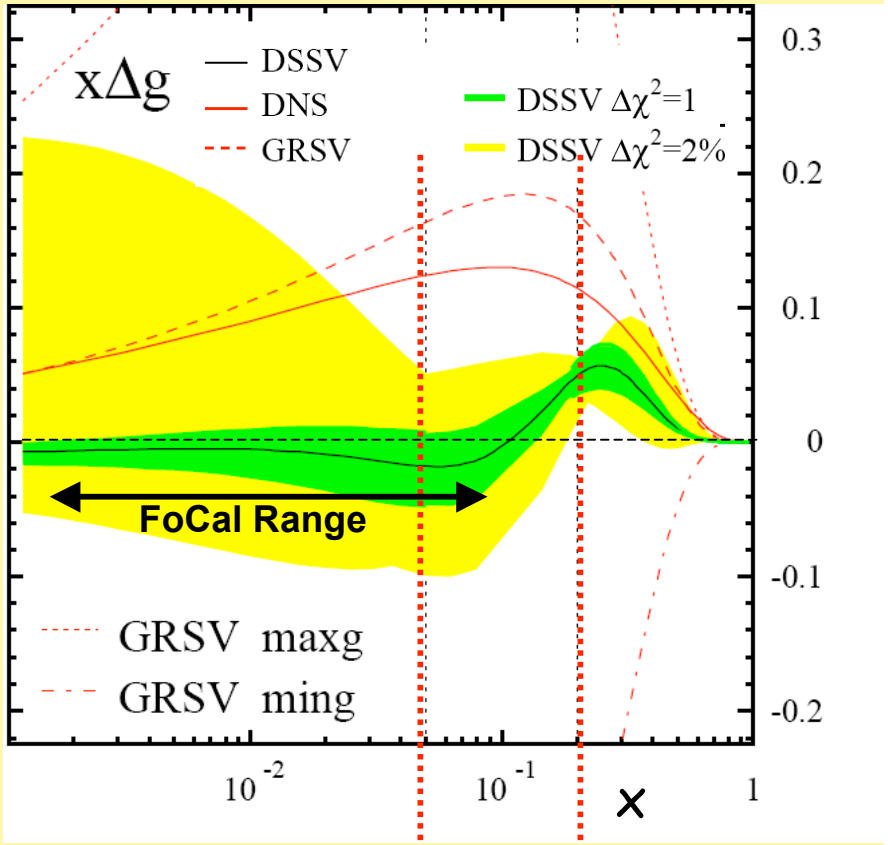


One tower:

- 4 mm thick W plates, ~21 X_0;
- 3x7 = 21 layers of 4x4, 500m thick Si pads
  - 15x15 mm^2 per pad
- 8 layers of 300m thick, 0.5 mm wide Si strips
  - 4 horizontal strip layers + 4 vertical

What we would like to do with FOCAL

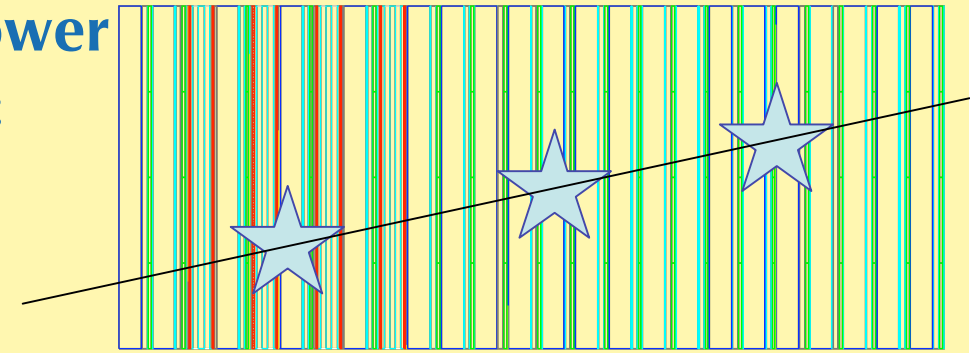
- In p+p
  - Expand ΔG measurements to low-x, via γ-jet and direct photon
  - Study transverse spin physics: Sivers effect, Collins function
- In d+A
  - Nuclear gluon PDFs at low-x
- In A+A
  - Expand coverage for γ-jet and photon measurements
- Overall
  - Increase PHENIX triggering capabilities

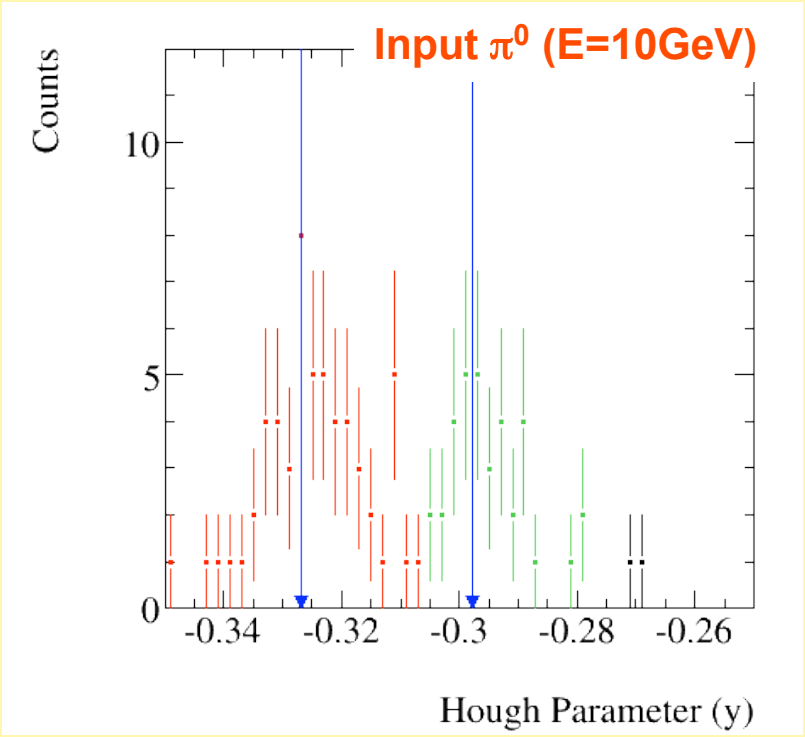


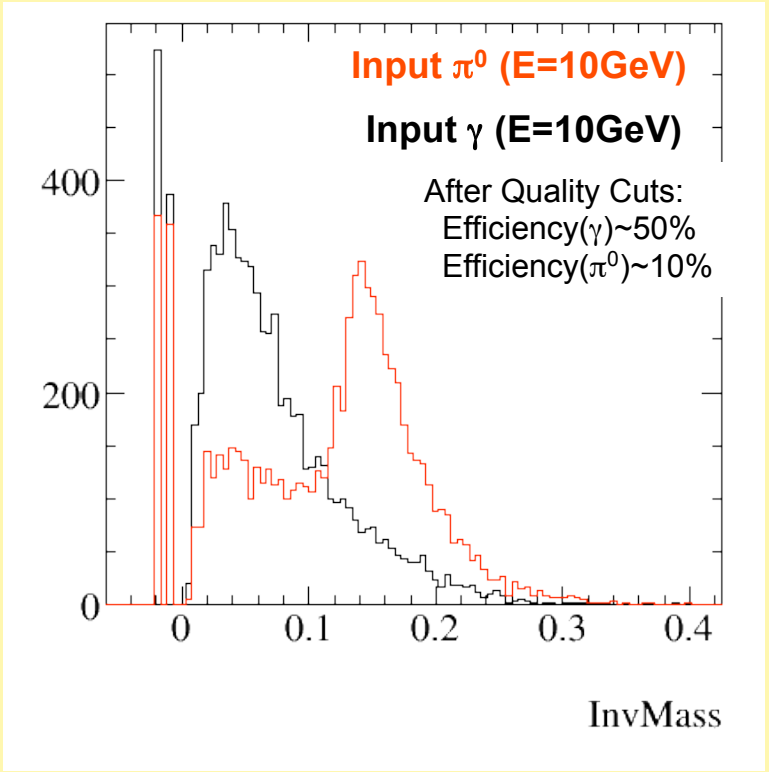
Identifying π^0 and γ

Use strip layers to track early shower development, via hough tracking;

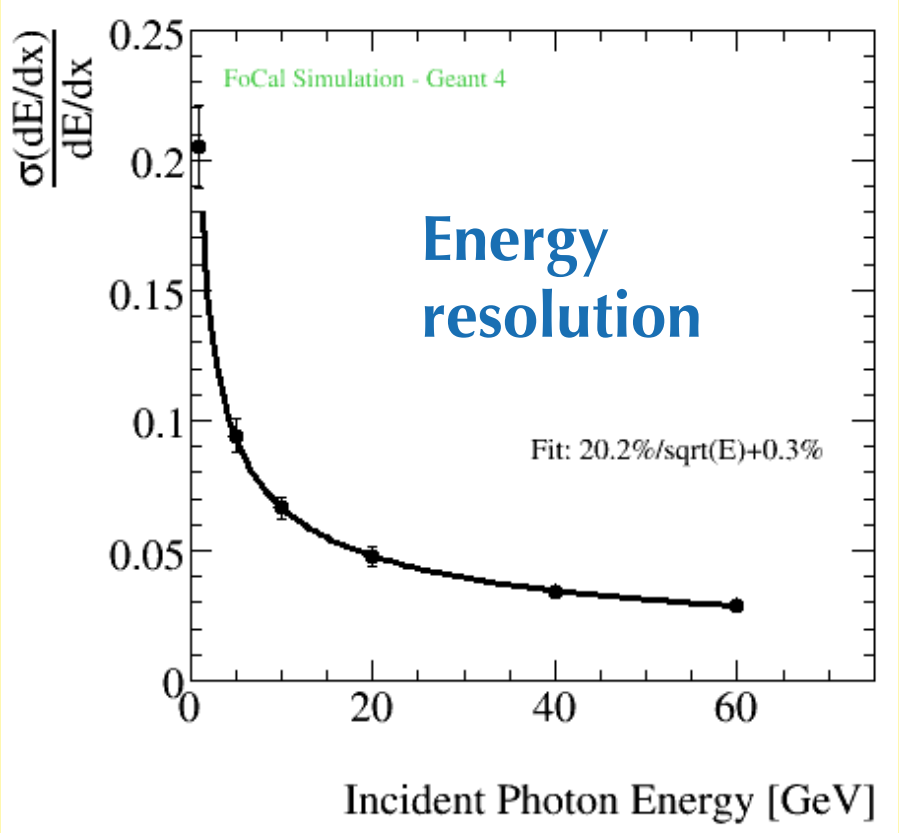
When two tracks are found, reconstruct invariant mass.

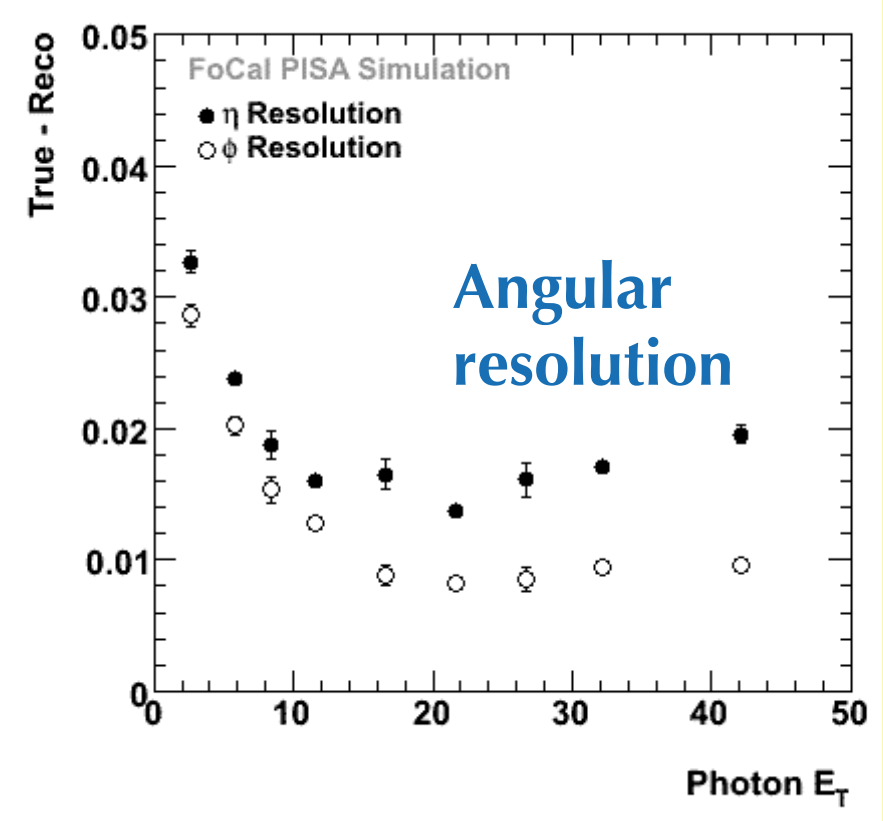






Detector performance studies

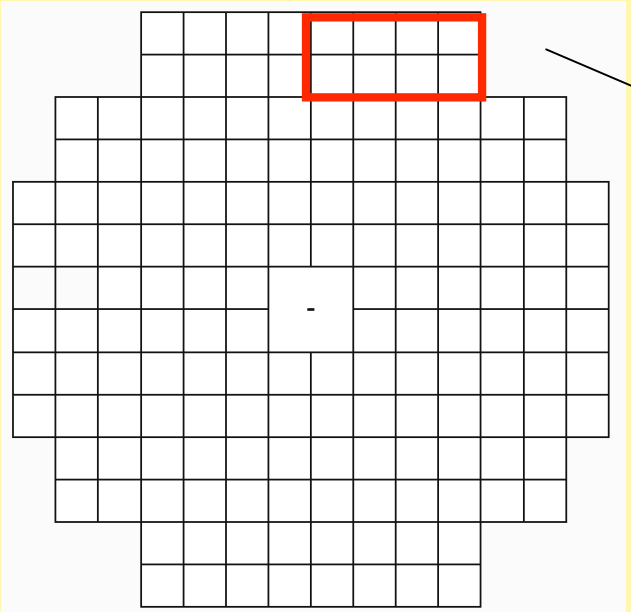




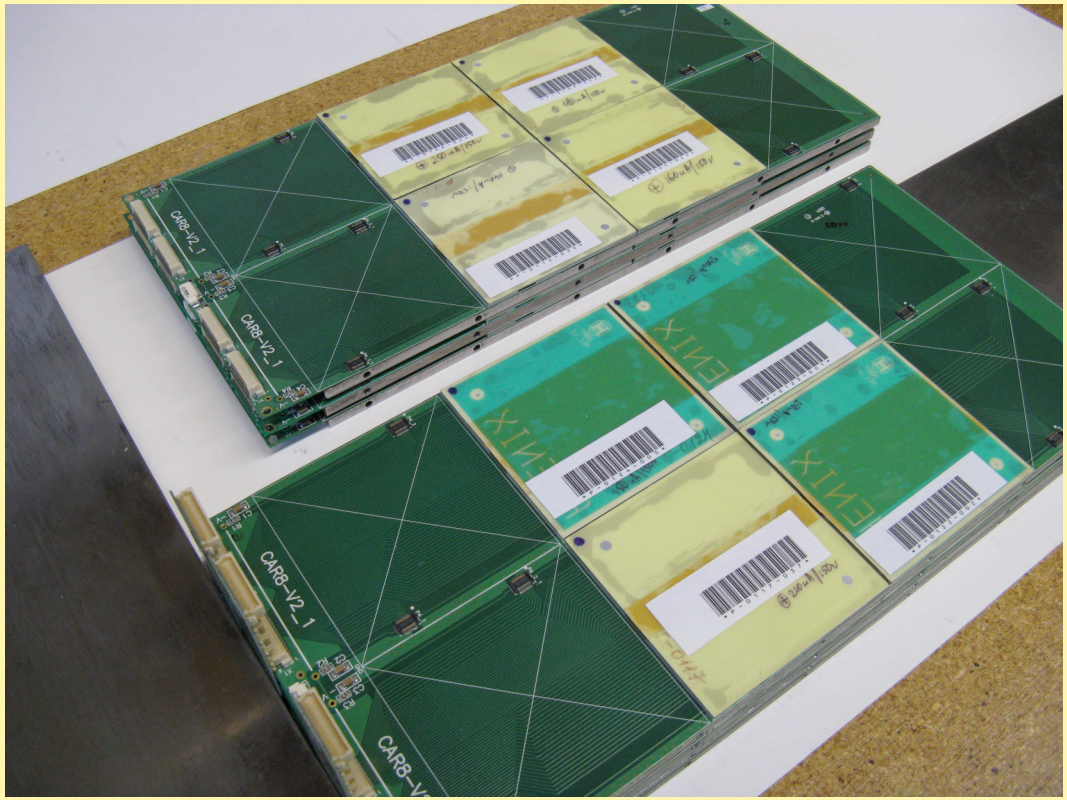
- Photon identification
  - e/γ radiation length: ~21
  - Hadronic rad. length: ~1
- Photon energy determination
  - Sampling fraction ~1.5-2.0%
  - Resolution ~ 20%/√E+0.3

- Good angular resolution is critical for jet measurements;
- Results from simulation studies exceed minimum requirements
- Embedding jet in d+Au events has very small effect on resolution

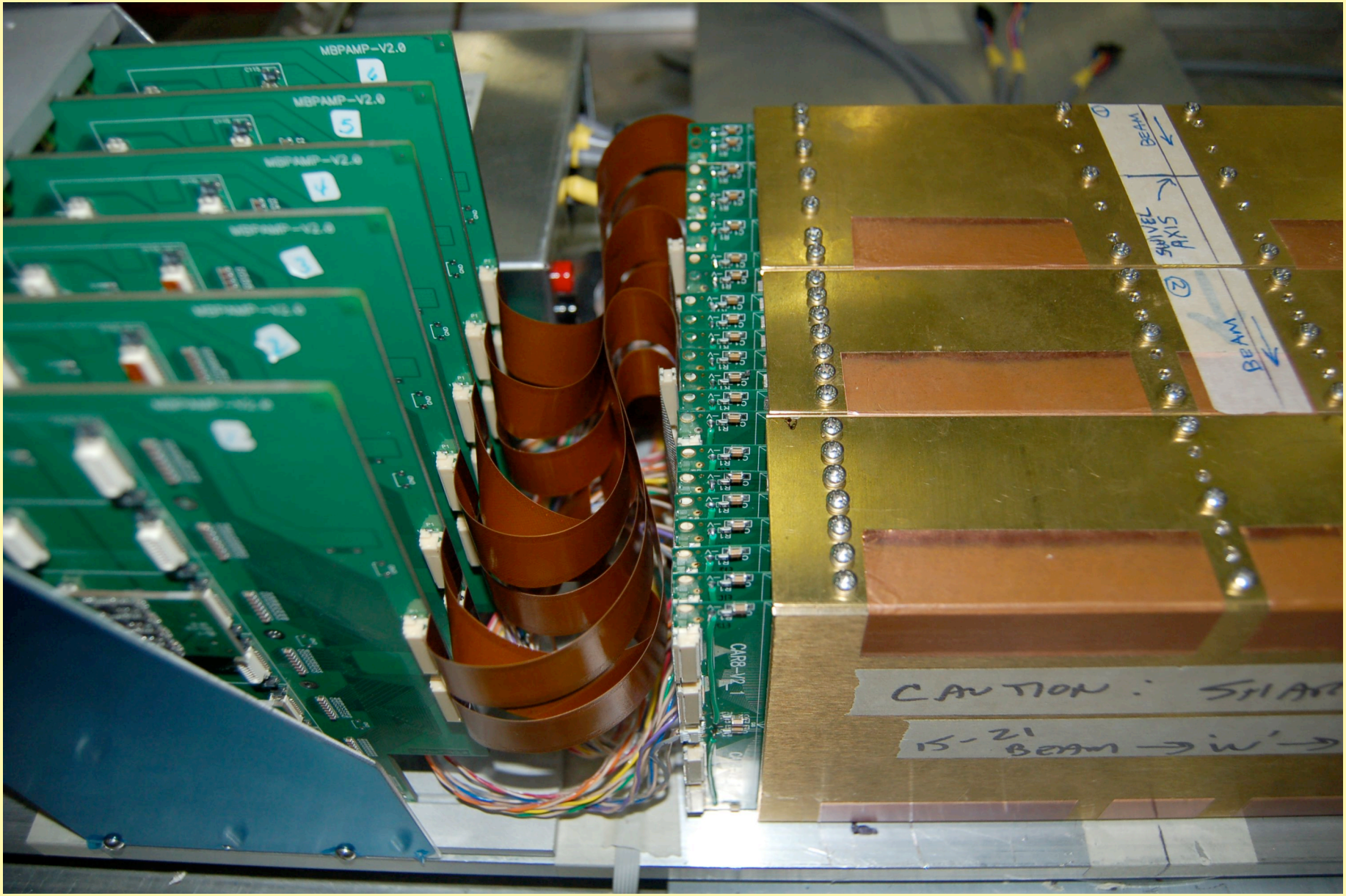
The prototype detector



3-segment brick, with the 4 towers in the center populated with pad sensors.



+ full readout chain, connected to standard PHENIX DAQ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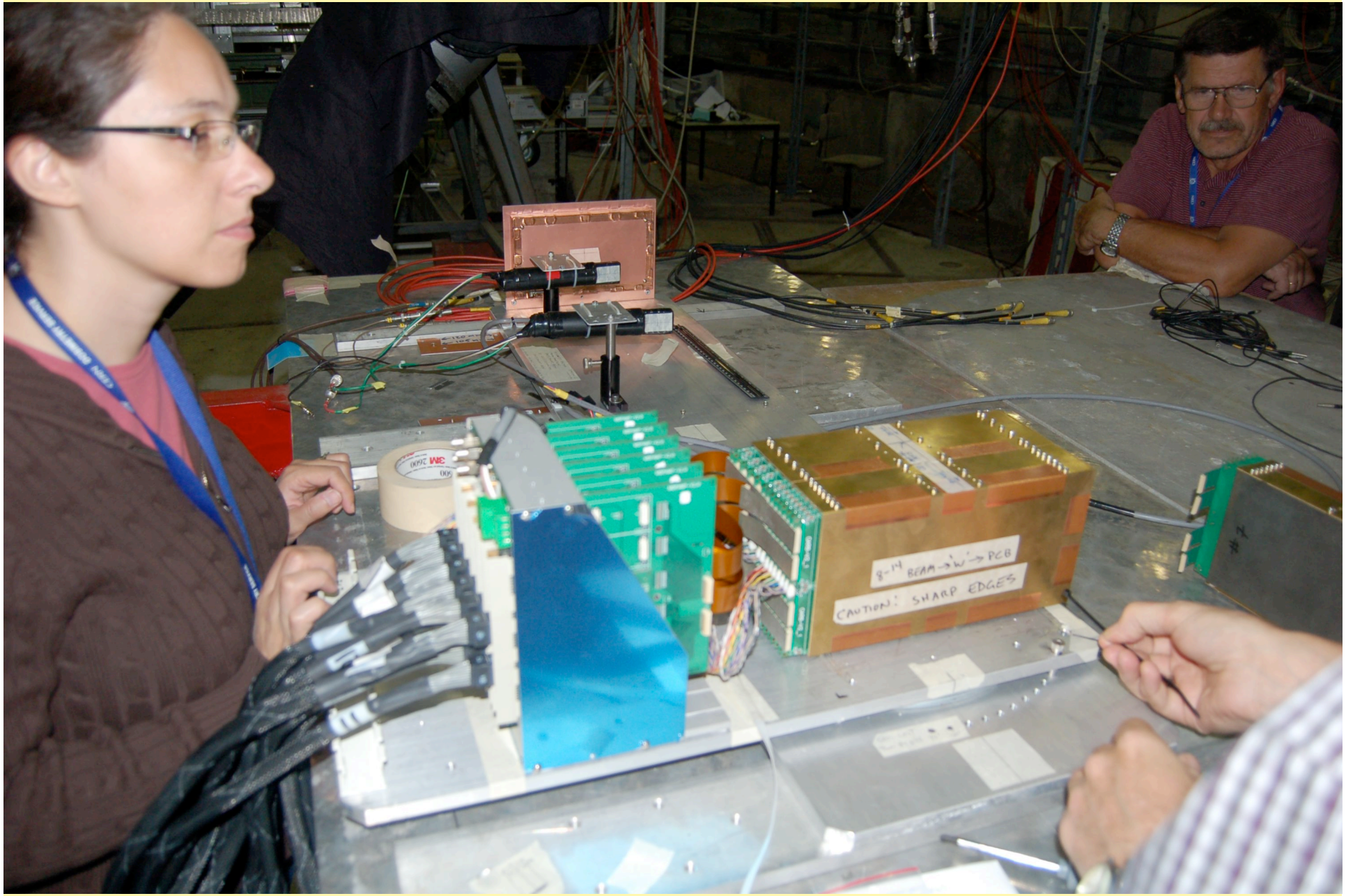
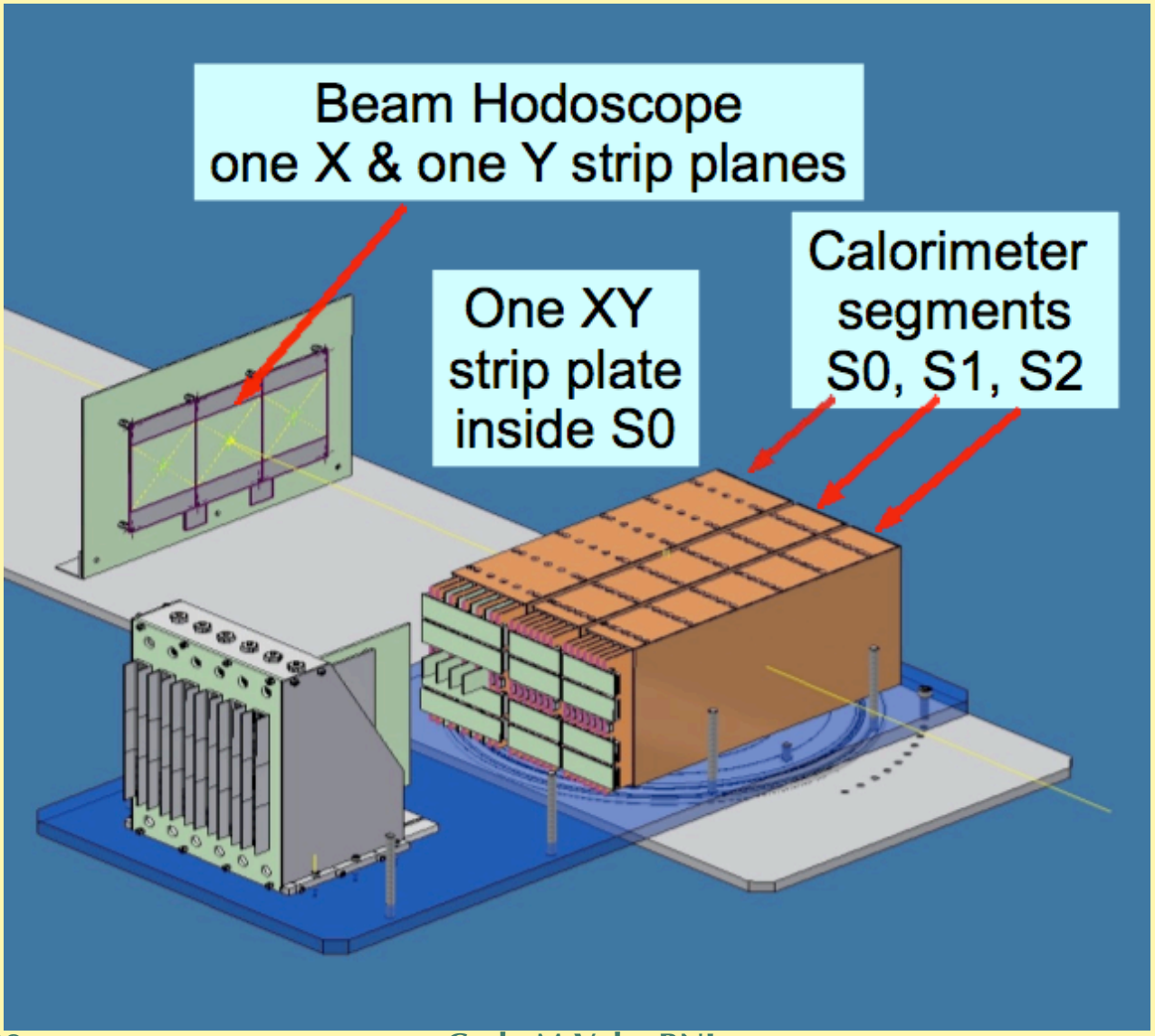
CAUTION :
BEAM


CAUTION: SHARP EDGES

Test-Beam @ CERN 2009

- June 11-30, 2009 at CERN PS and SPS
- Hosted by ALICE group
- Ran at PS T-10 area from June 14-19, with complete PAD system; beam energies of 1-6 GeV, electron, muon and pion beams
- Ran at SPS H-2 area from June 22-29, added first strip plane on June 27; beam energies of 10-100 GeV
- Debugged the entire system and collected lots of useful data, still under analysis

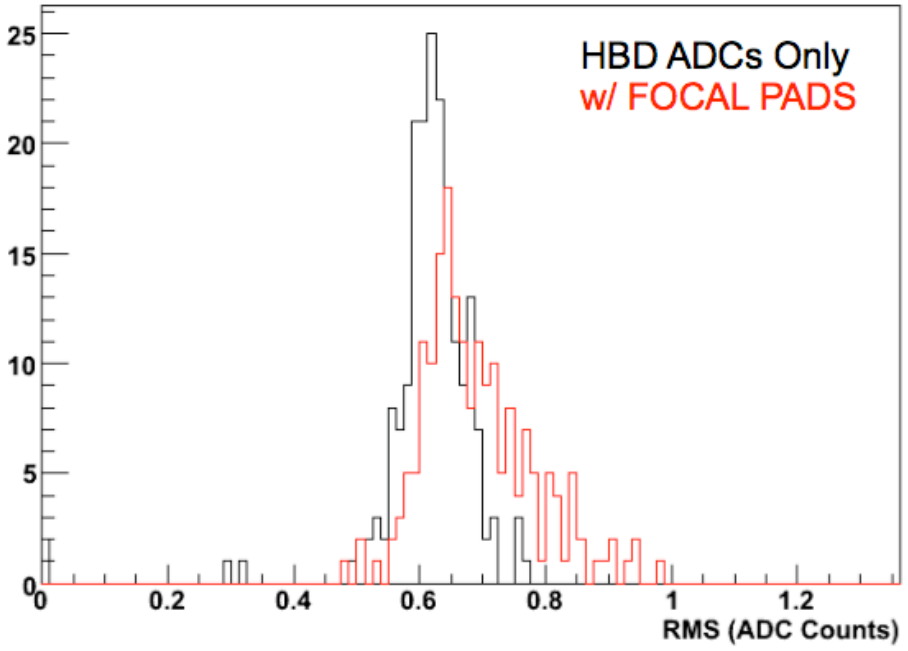
Test Beam setup

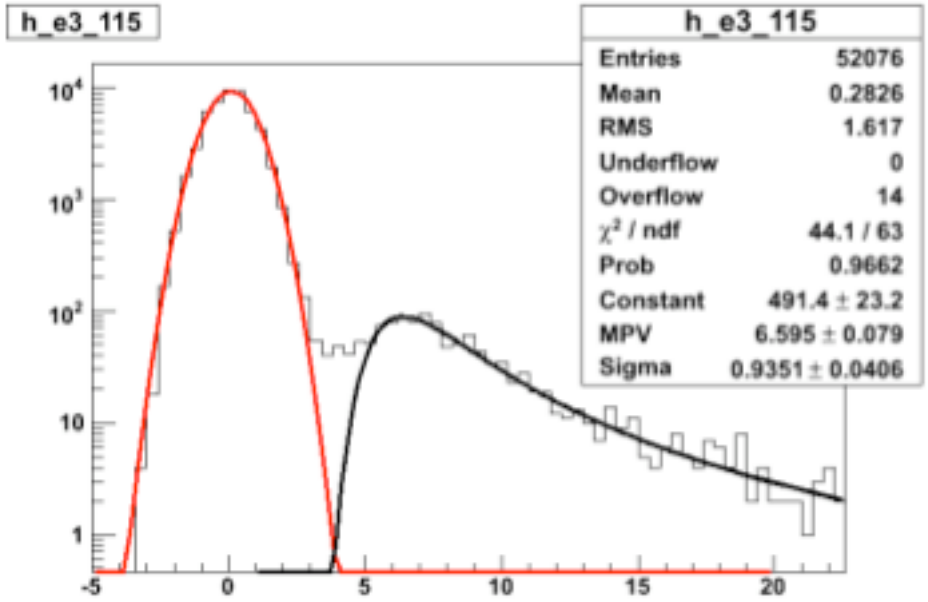


Prototype performance

Pedestals: very low noise,

Connecting the pad modules increases RMS by only ~ 0.2 ADC counts



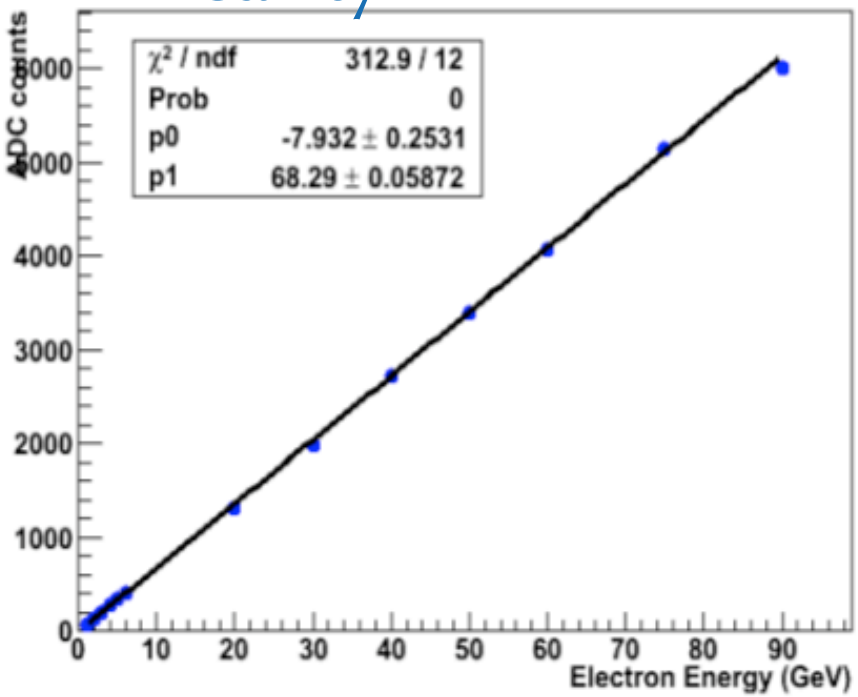


Muon beam: clear MIP peak

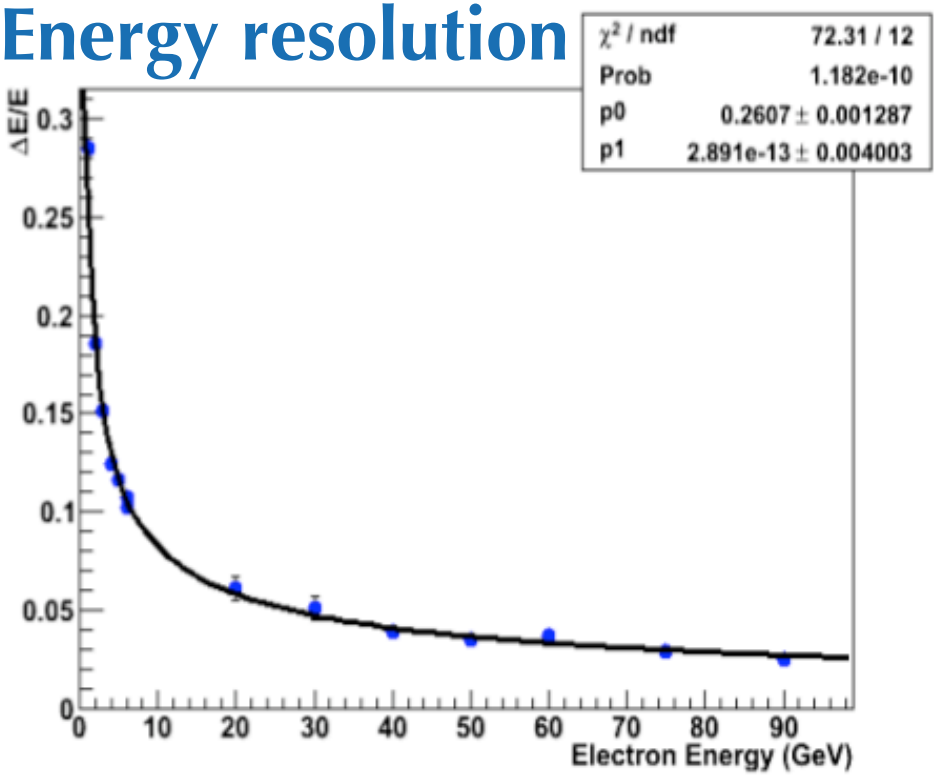
Response well described by Gaussian pedestal + Landau function

Prototype performance: response to electron beams

Linearity



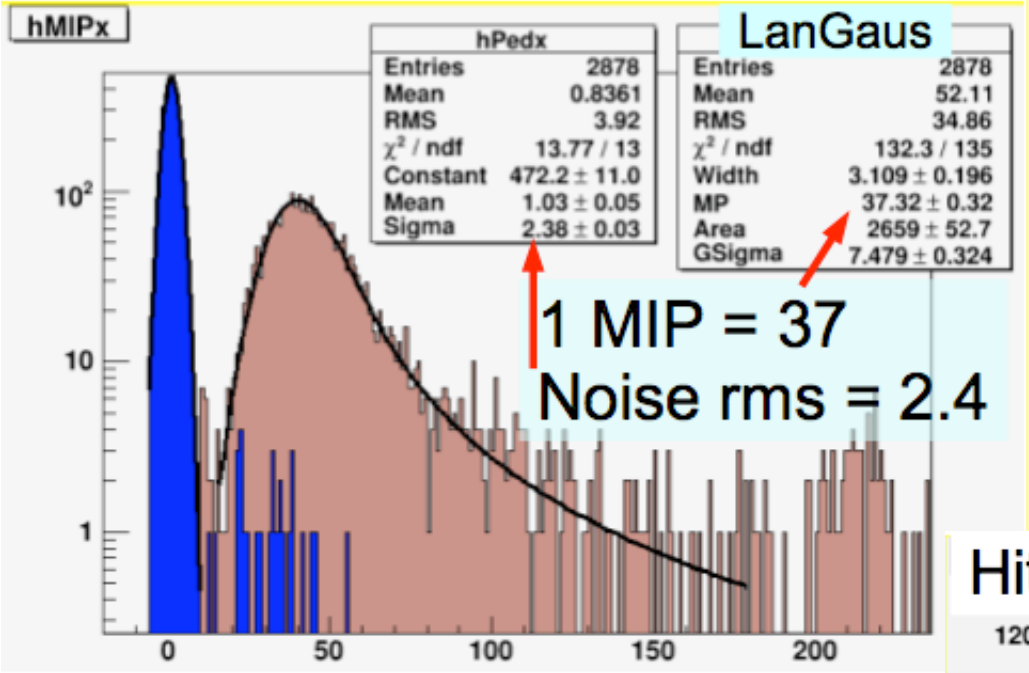
Energy resolution

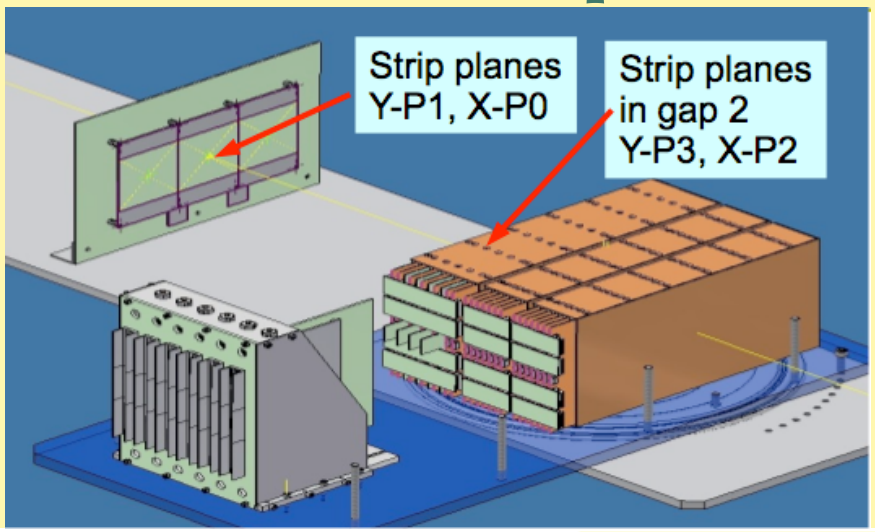


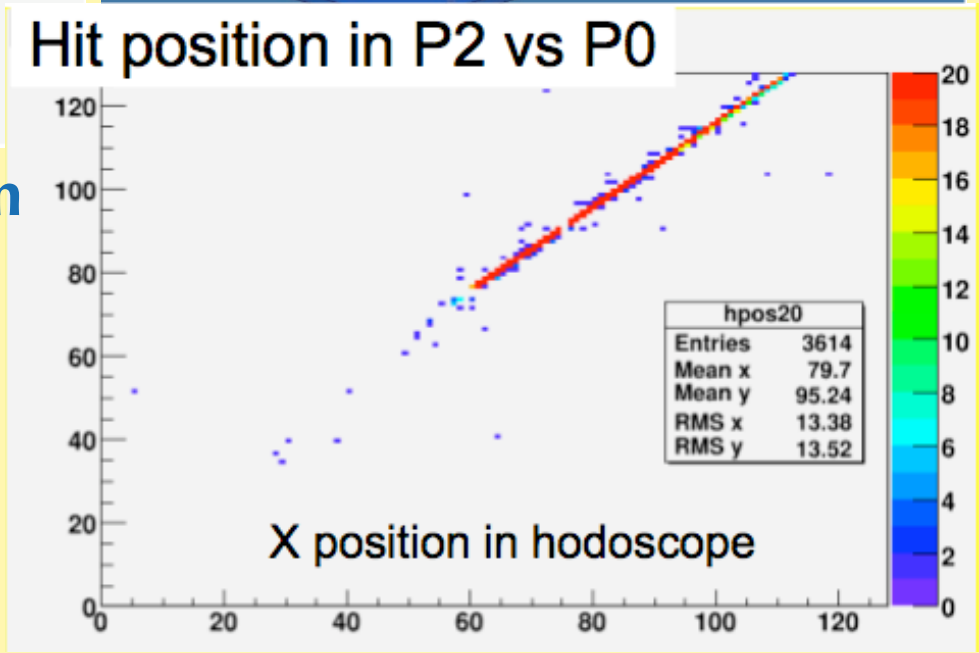
Good linearity up to ~90GeV, and down to very low PS beam energy

Energy resolution currently at ~26%/√E, but this still can be improved; design value is 23% /√E

Prototype performance: strips







MIP peak clearly separated from pedestal; obtained by adding amplitudes of 3 strips around hit.

Good correlation between the two planes of strips

Summary

- The PHENIX and RHIC physics programs can benefit from enhanced electromagnetic calorimetry capabilities, in particular at forward rapidity
- We have a design that is undergoing extensive studies, both at the simulation and hardware levels
- Performance results from the prototype test beam are very encouraging

Stay tuned…

Extras

FoCal Test Beam Run

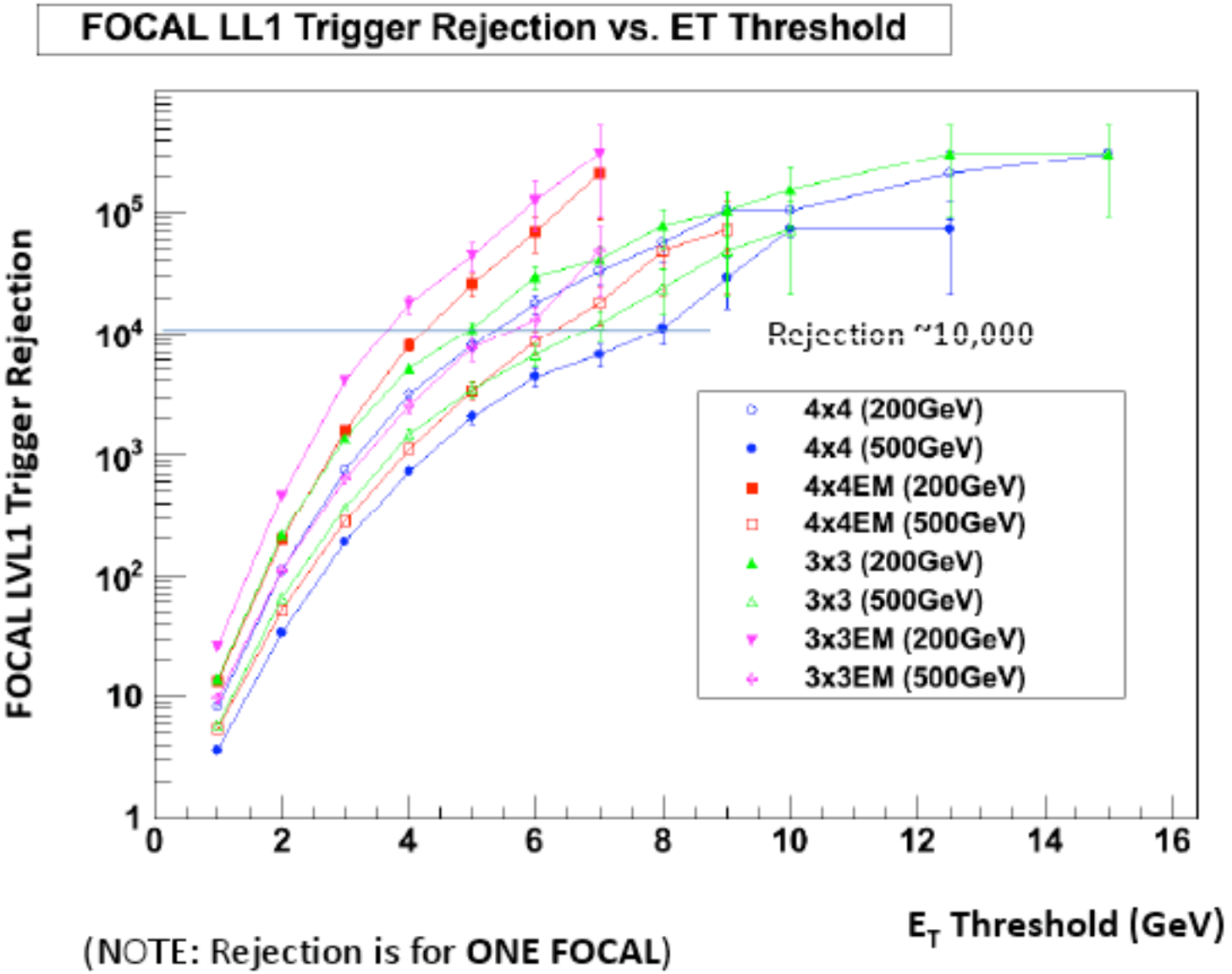
June 11-30, 2009 CERN PS and SPS facility

Participants: 23 total.

Mike Lenz, BNL
Mickey Chiu, BNL
Carla Vale, BNL
Edward Kistenev, BNL
Andrey Sukhanov, BNL
Richard Seto, UCR
Sky Rolnik, UCR
Taku Gunji, ALICE, Tokio
Yasuto Hori, Tokio
Michal Tomasek, Prague
Miloslav Slunecka, Prague
Nikolay Zamiatin, Dubna.

Yongil Kwon, Korea
Eunah Joo, Korea
Heonjoo Kim, Korea
Soonrye Lee, Korea
Myunggeun Song, Korea
Hyejin Moon, Korea
Jan Rak, ALICE
Jiri Kral, ALICE
Norbert Novitzky, ALICE
Jussy ViiniKainen, ALICE.
Terry Awes, our host from ALICE.

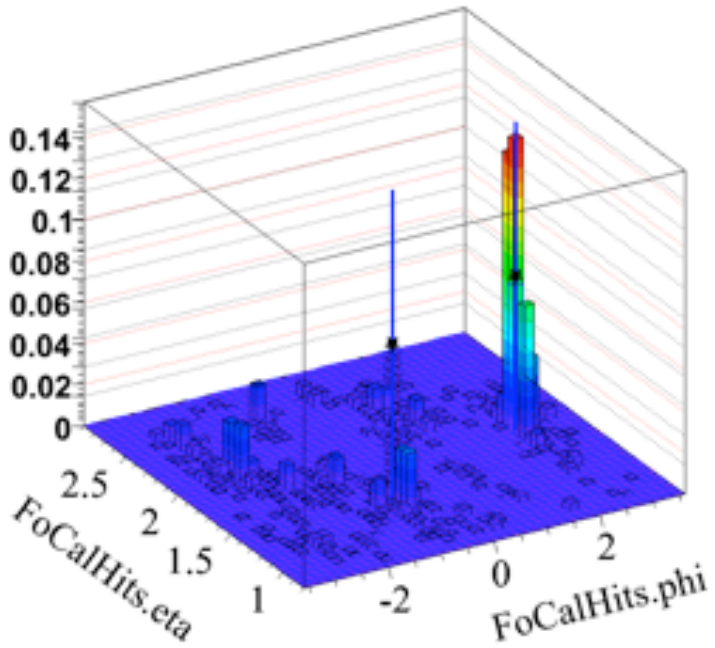
Rejection at 200GeV and 500GeV



(NOTE: Rejection is for **ONE FOCAL**)

J. Lajoie

Input: E~30 GeV → E_T~10 GeV



Pythia jet embedded into d+Au event at dst level