Particle Identification Capability of the PHENIX Experiment

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For PHENIX Collaboration

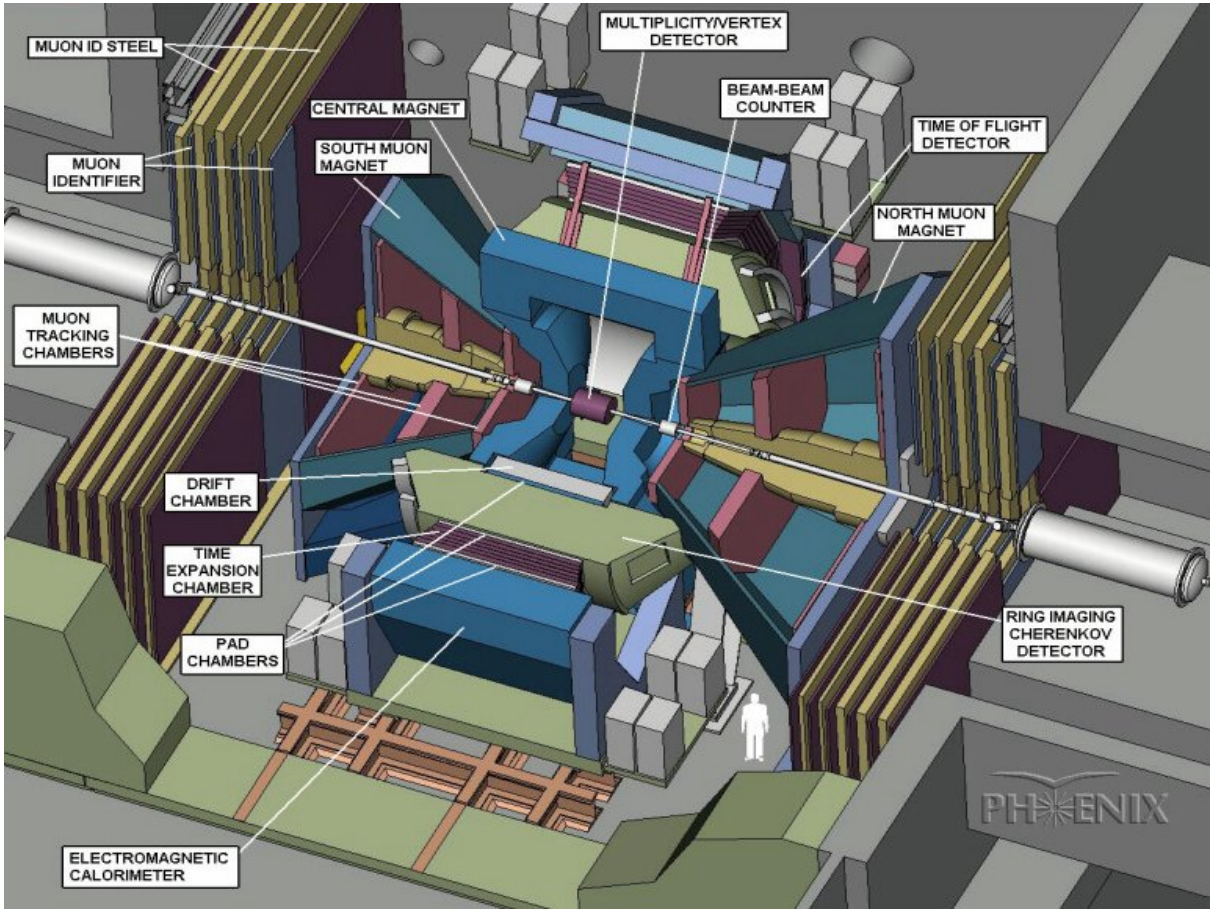
PHENIX Experiment

PHENIX aims to address as many observables as possible, which are relevant to QGP formation

→ Measure photons and leptons, as well as hadrons

Several PID devices
in
Two central arms
-- hadron ID
-- electron ID
-- photon ID

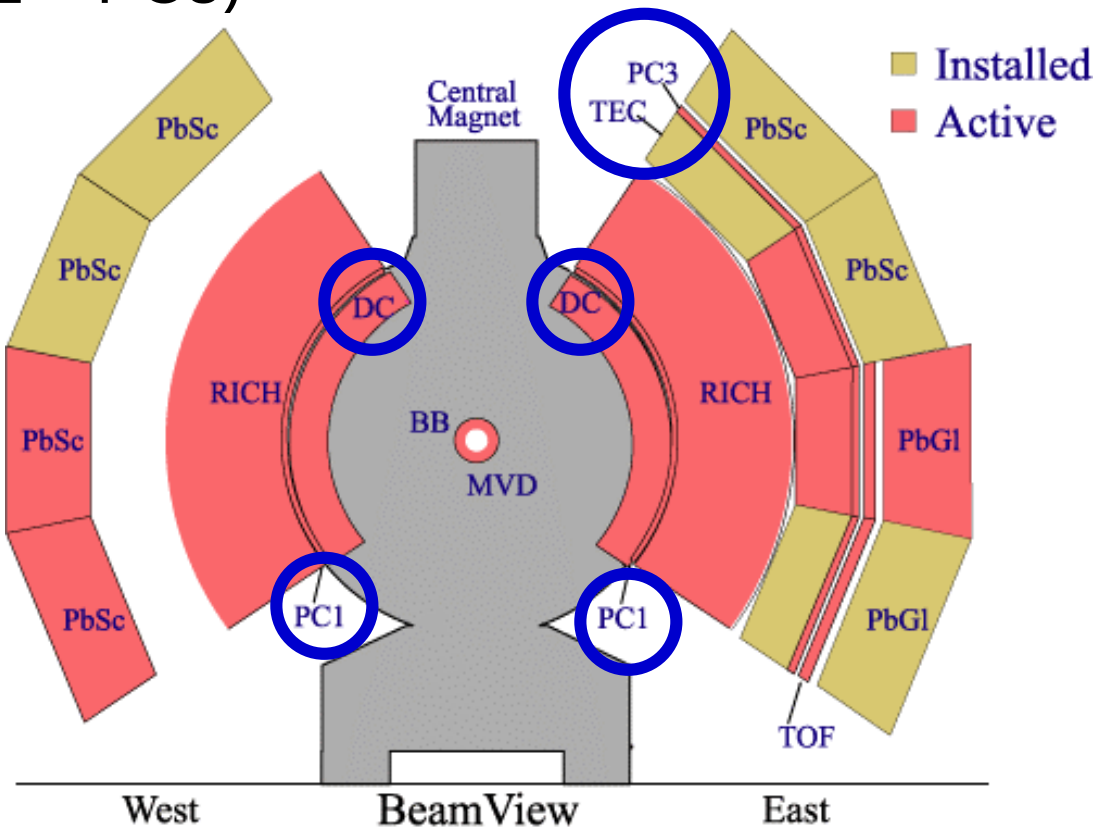
and
Two muon arms
-- muon ID



Tracking in Central-Arms

Track reconstruction → Momentum determination

- East: DC + PC1 + TEC + PC3
- West: DC + PC1 (+ PC2 + PC3)



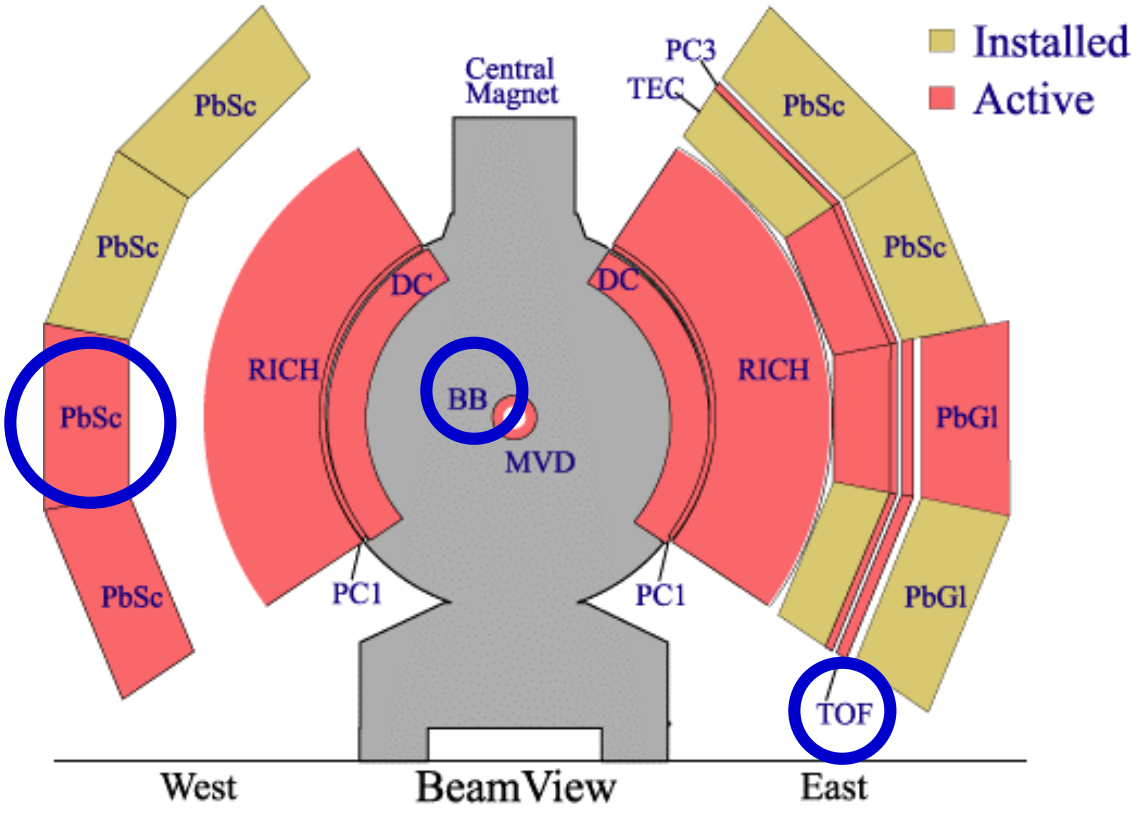
PHENIX Y2000 Configuration

See poster session P223 for details

Hadron ID

Charged Hadron ID --- with Time-of-Flight

- Start: BBC
- Stop: TOF
  EMCAL

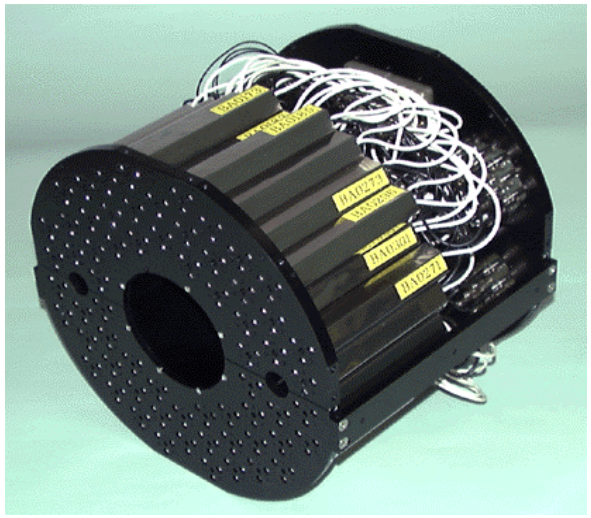


PHENIX Y2000 Configuration

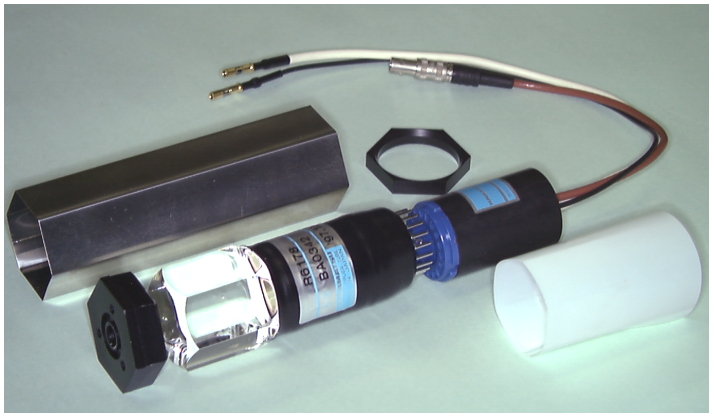
Beam Beam Counter

By Hiroshima Univ, Columbia Univ, LANL, and BNL

- Trigger nuclear interactions
- Determine interaction time and vertex location
- Measure multiplicity in η=3.0-3.9

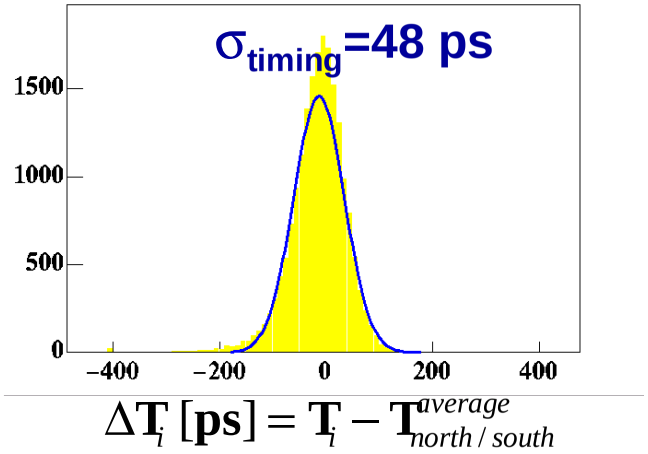


- 2 x 64 mesh-dinode PMT's
- quartz Cherenkov radiator

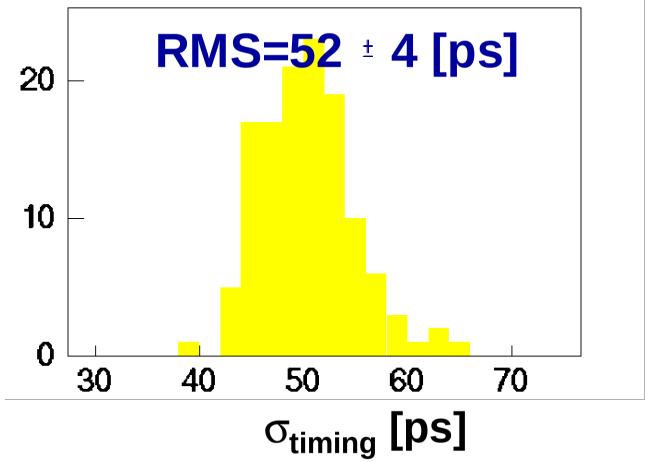


BBC performance in Year-1

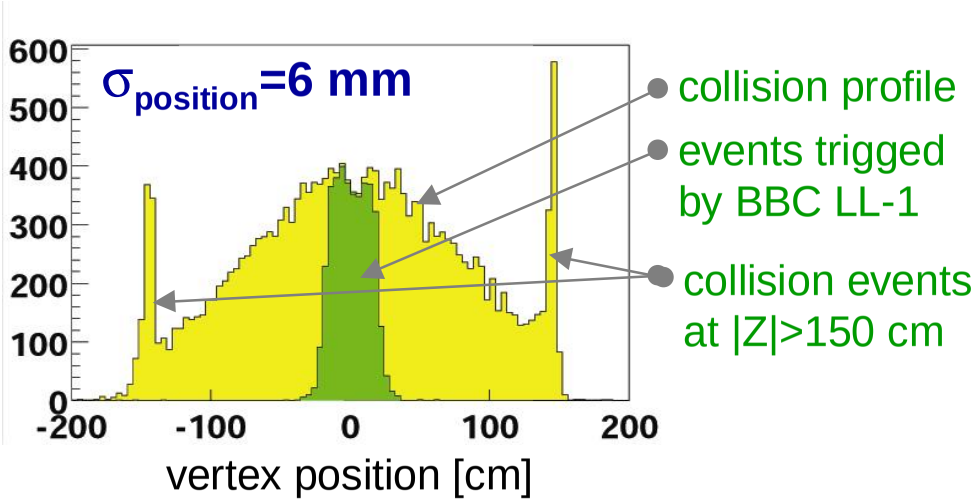
Timing resolution of an element



σ_{timing} profile



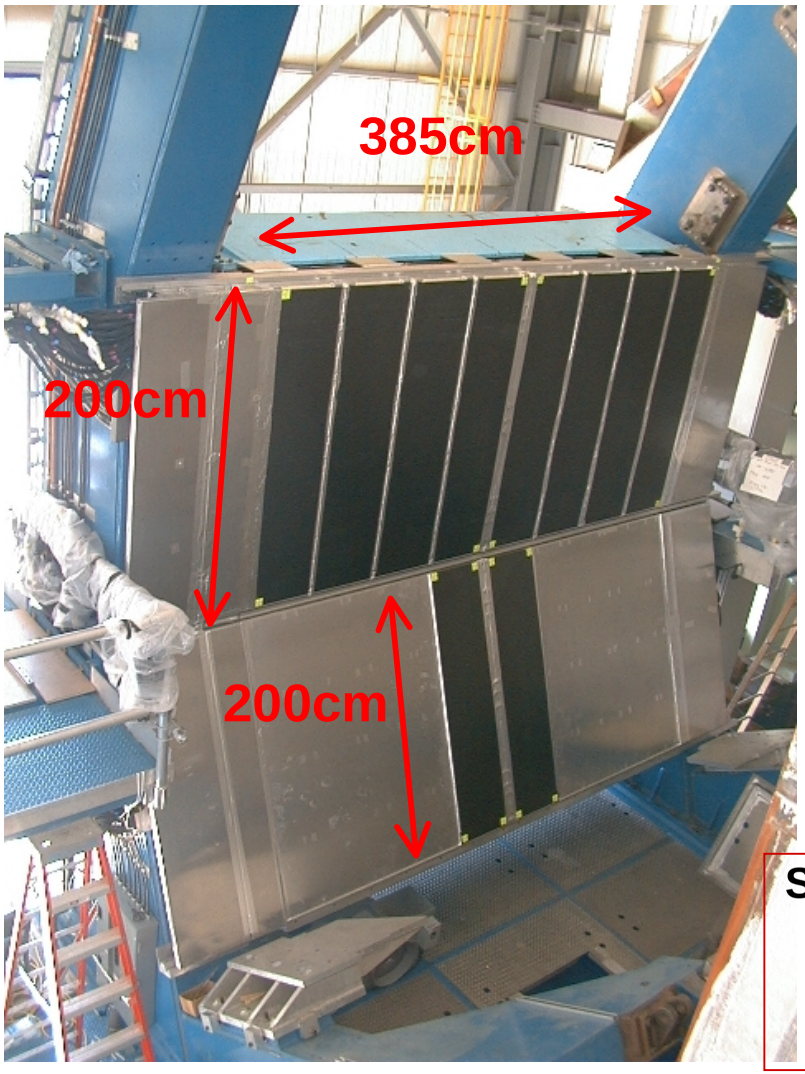
Online Vertex selection in LL-1

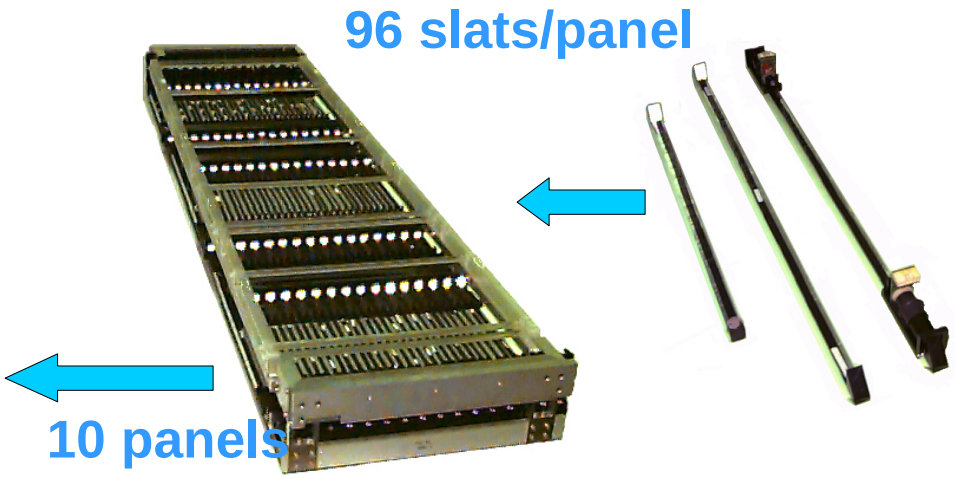


See more details at P229 in the BNL Poster Session

PHENIX-TOF

By U. Tsukuba, NEVIS(Columbia U.) & BNL



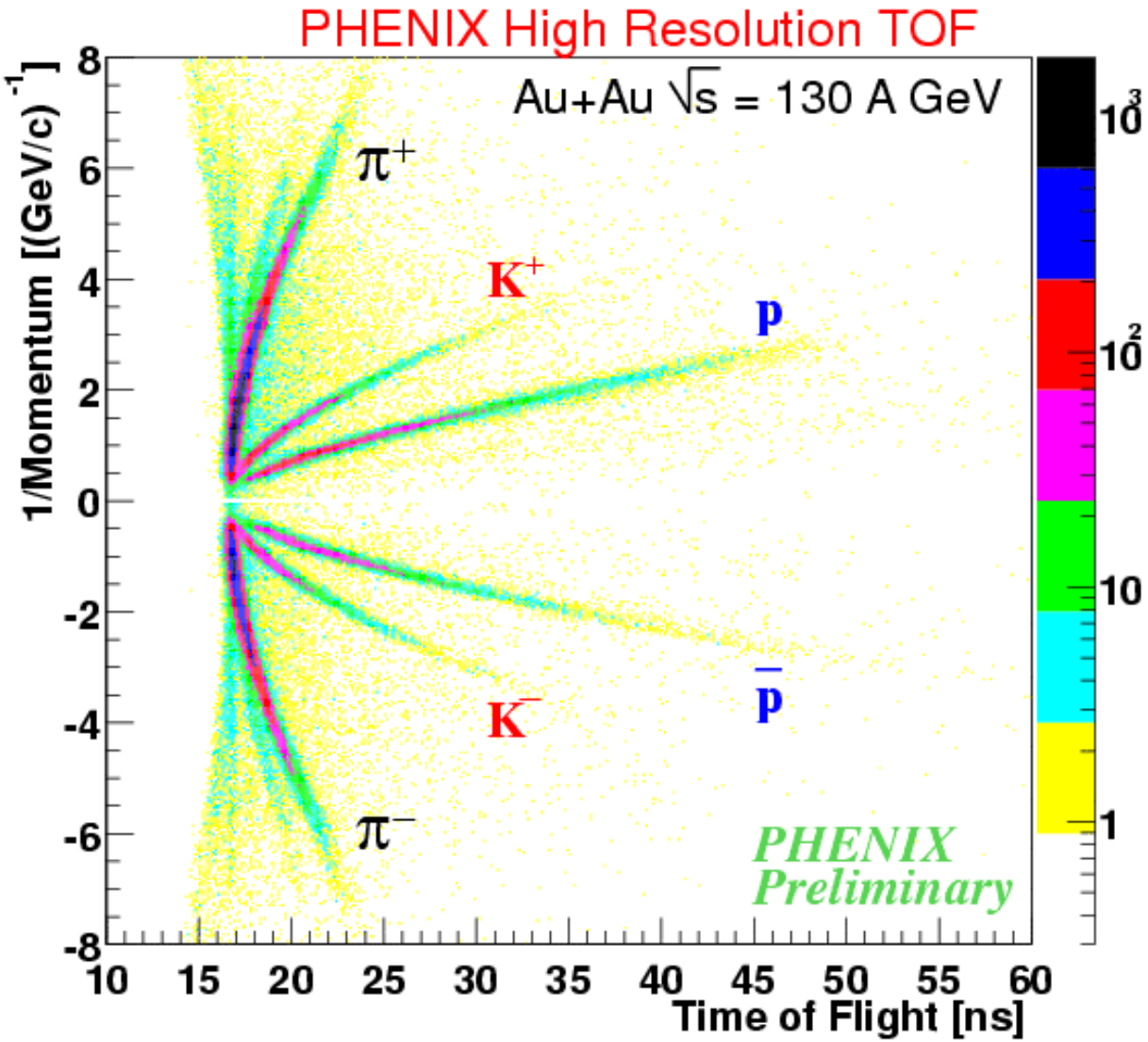


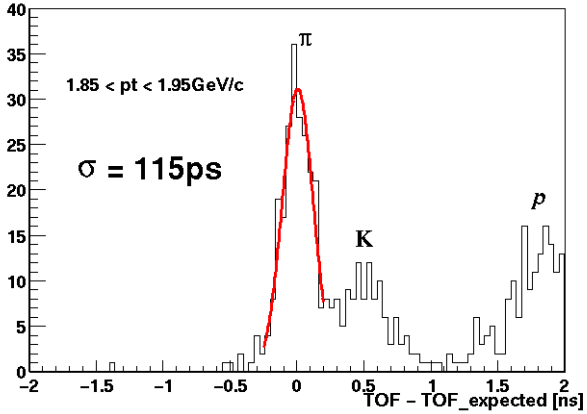
* $\Delta\theta$=40 deg ($\Delta\eta$ = 0.7), $\Delta\phi$=45 deg
  ← HBT and ϕ meson
* 960 plastic scintillators(1920 PMTs)
  ← occupancy less than 10%

Scintillator: Bicron BC404
decay constant : 1.8 ns
attenuation length : 160cm

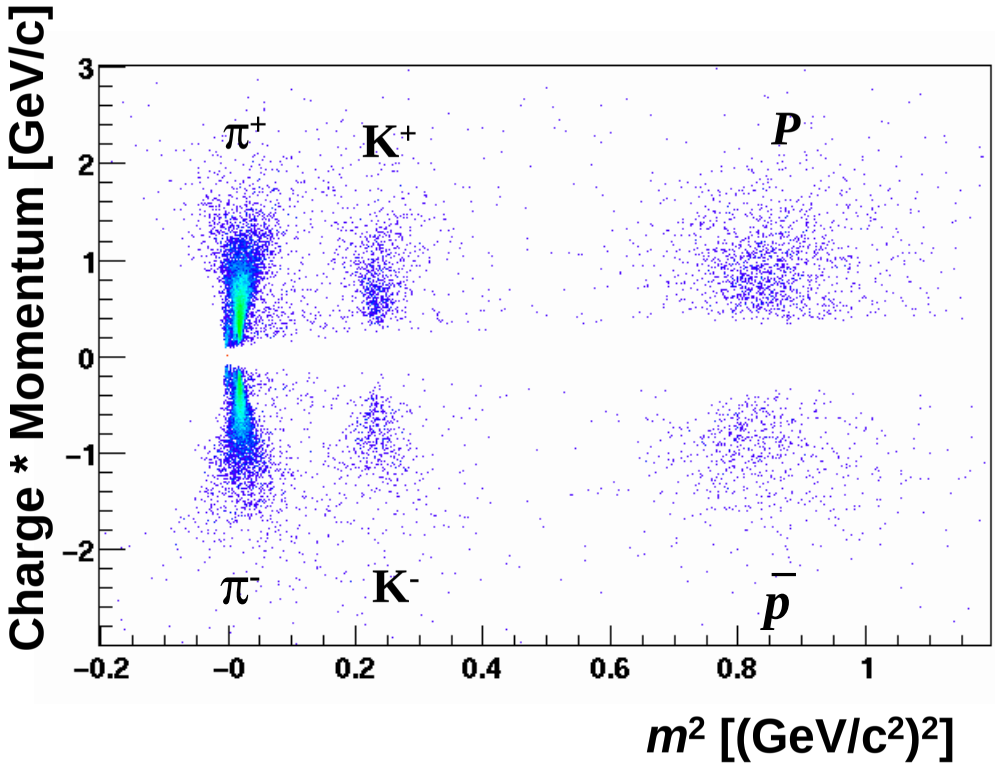
PMT: Hamamatsu R3478S
Rise time : 1.3 ns
Transit time : 14 +-0.36ns

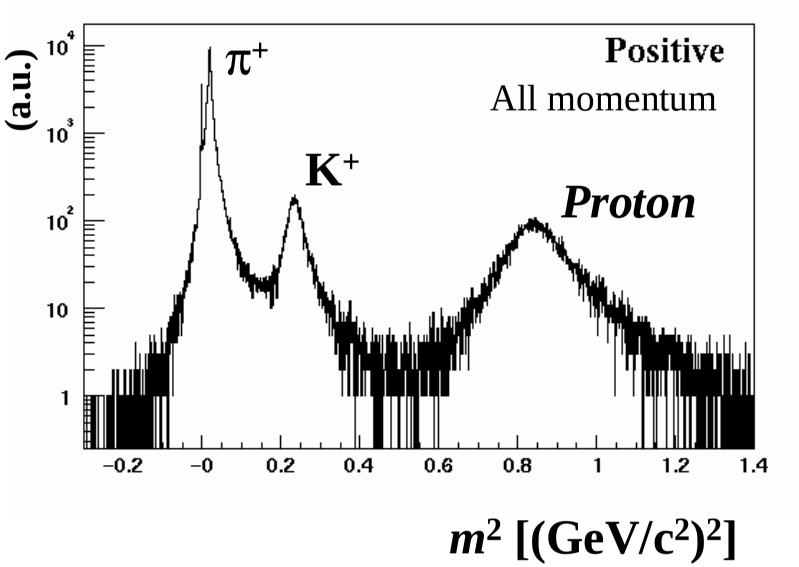
Hadron PID and TOF resolution





Mass Squared Distribution

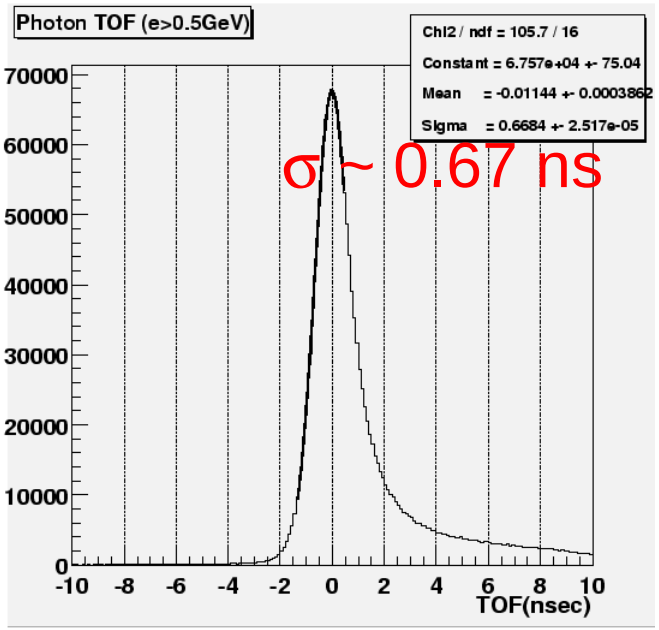




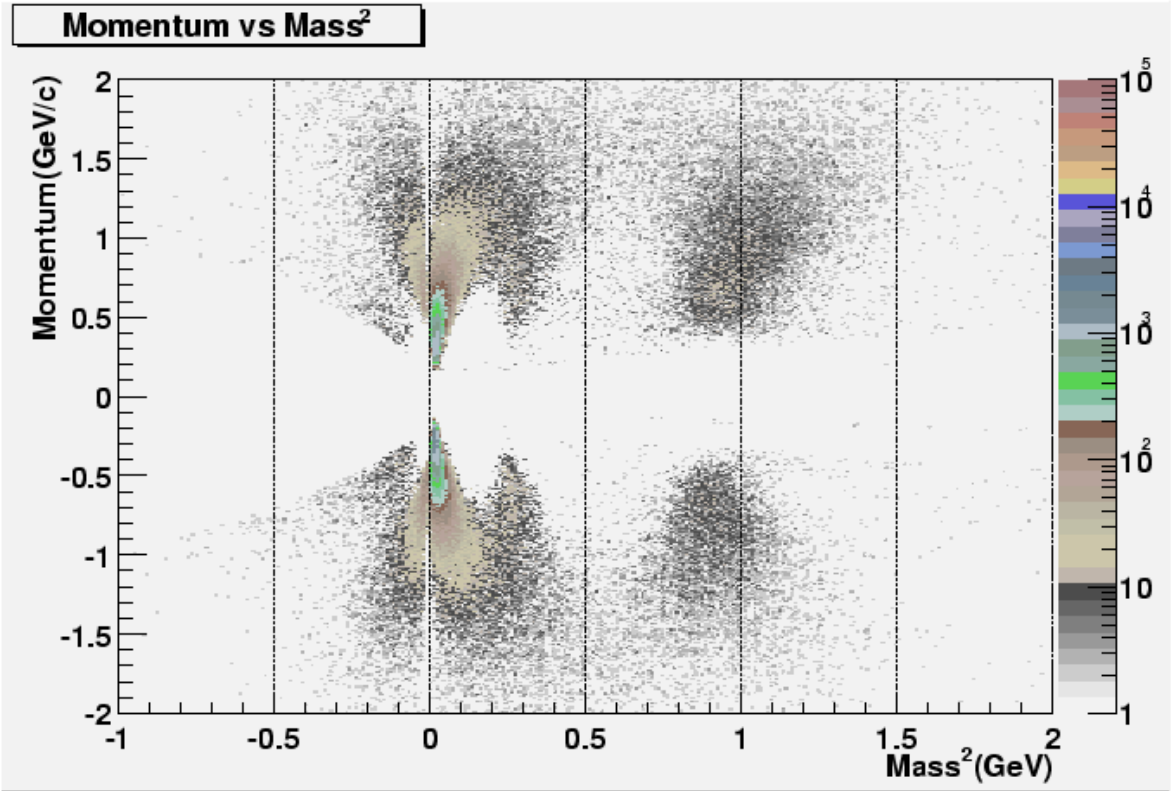
$$m^2 = p^2\left\{\left(\frac{TOF}{L}\right)^2 - 1\right\}$$

See more details at P219 in the BNL Poster Session

EMCAL TOF Performance



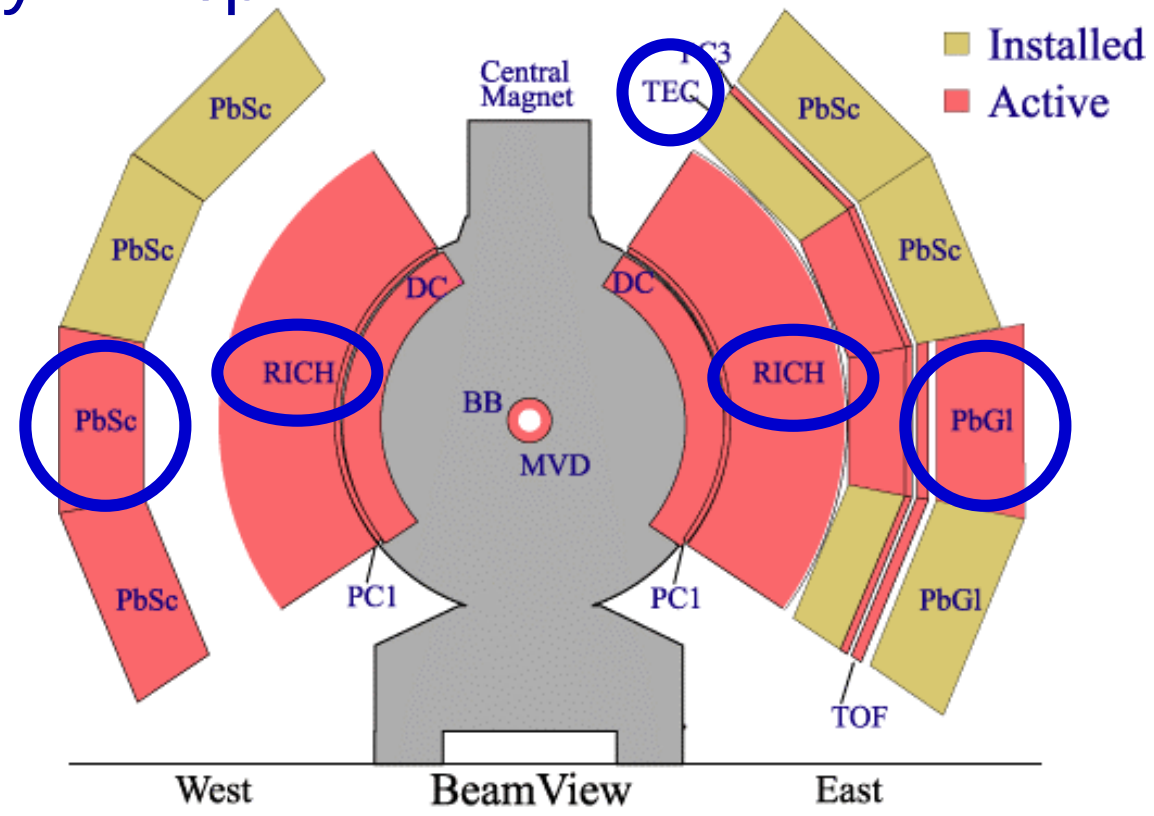
TOF with PbSc
(e > 0.5 GeV)



M**2 vs momentum

Electron ID

- RICH --- gas Cherenkov
- TEC --- dE/dx
- EMCAL --- energy → E/p



PHENIX Y2000 Configuration

PHENIX RICH

By BNL, CNS/U.Tokyo, FSU, KEK, SUNY/SB, NIAS, ORNL, U.Tokyo, Waseda

Primary device for electron ID

gas Cherenkov counter

- C_2H_6 (γ_{th} ~ 25) or CO_2(γ_{th} ~ 35)
- eID p_t range : 0.2 ~ 4 GeV/c

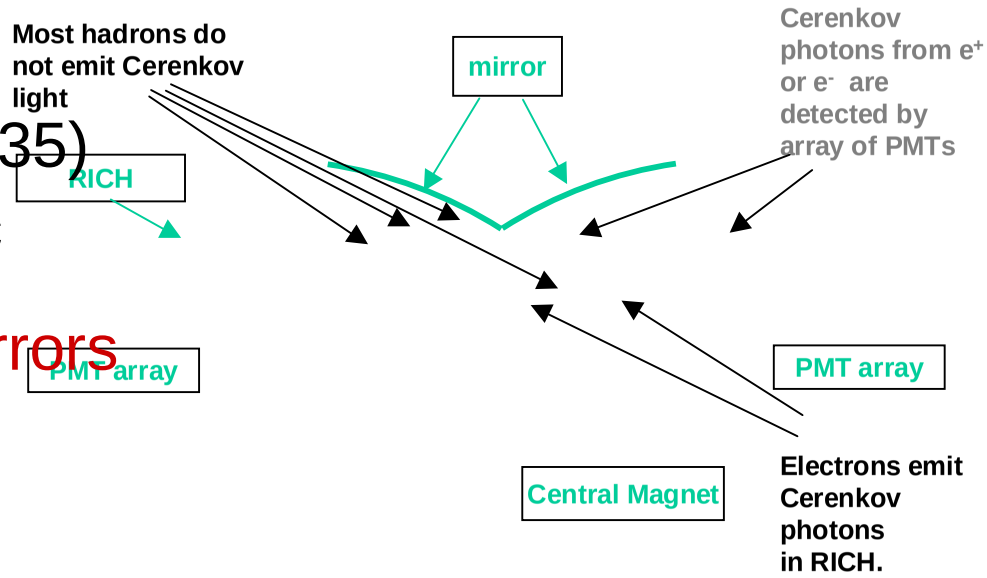
Gull-wing shaped spherical mirrors

Photon detection by PMT's

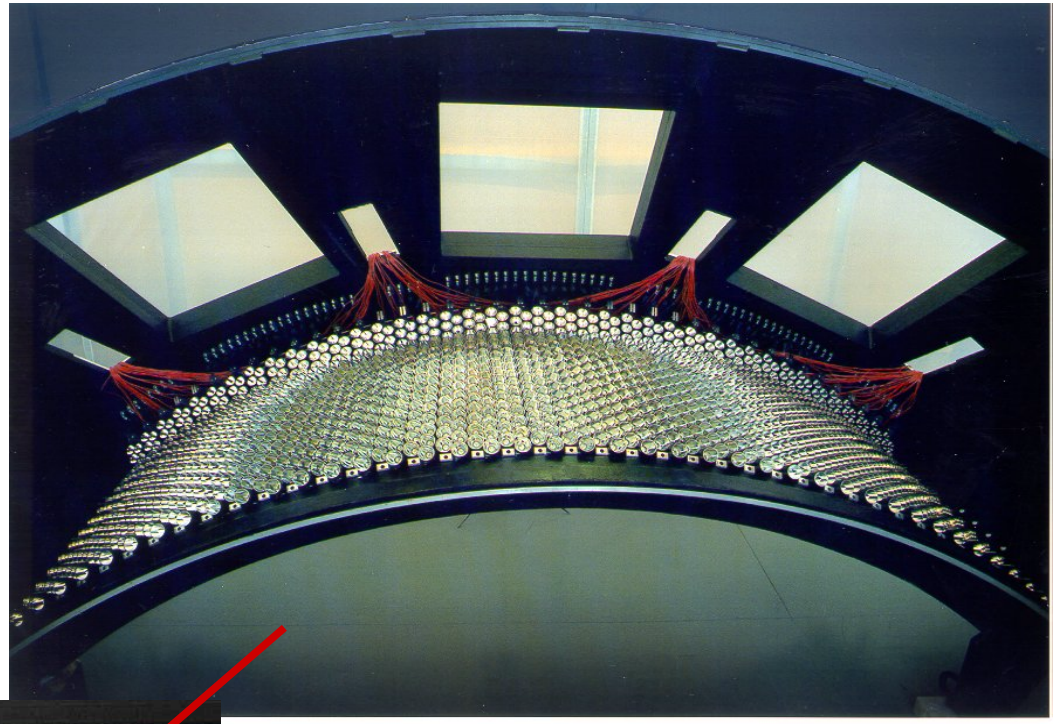
- 5,120 channels in 2 arms

2-D angles (θ,ϕ) of electron tracks

- pixel size ~ 1 degree x 1 degree



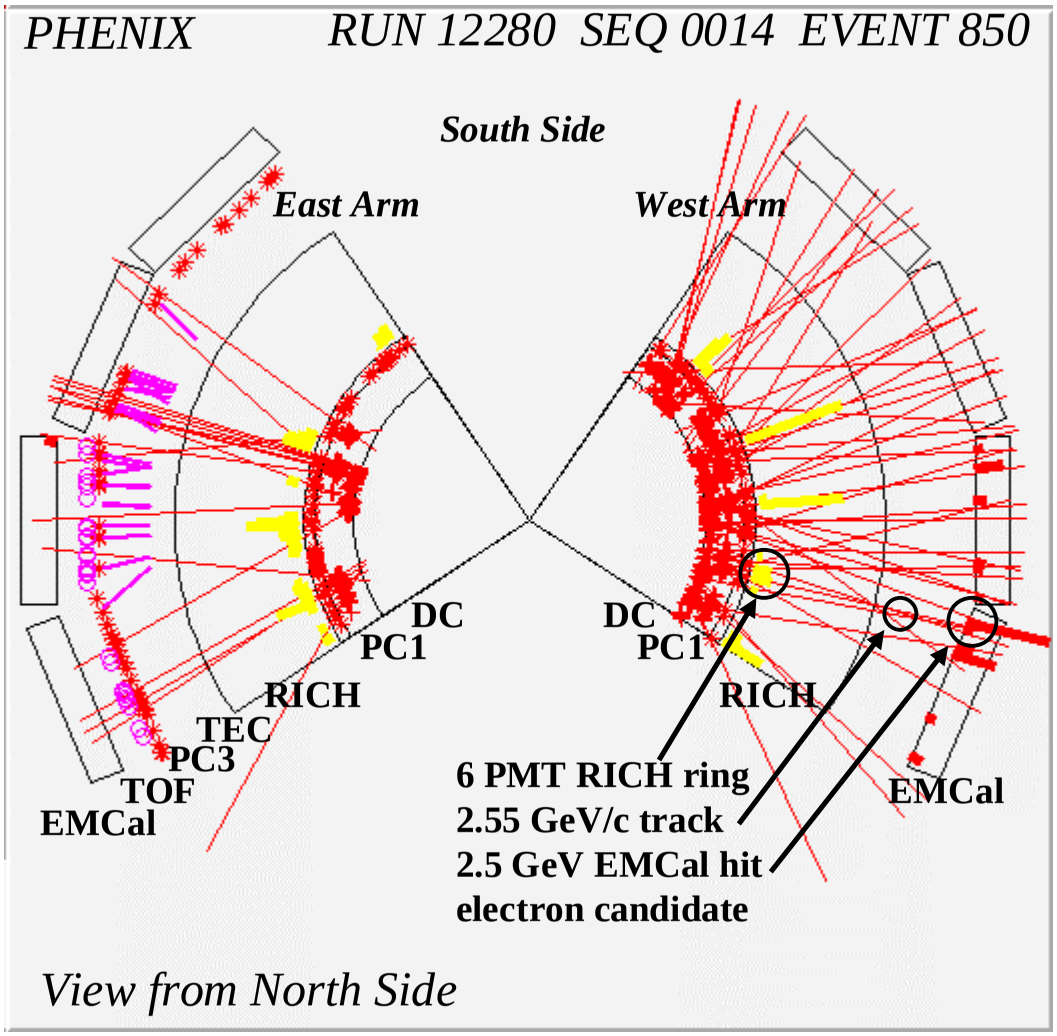
PHENIX



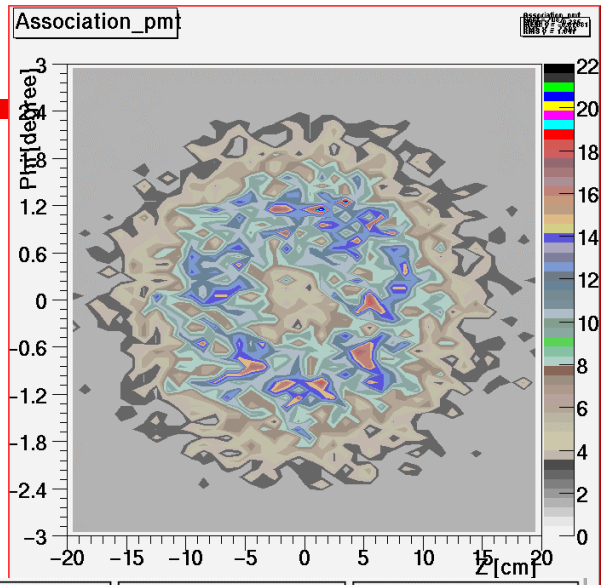
See details on RICH at P226 in the BNL Poster Session

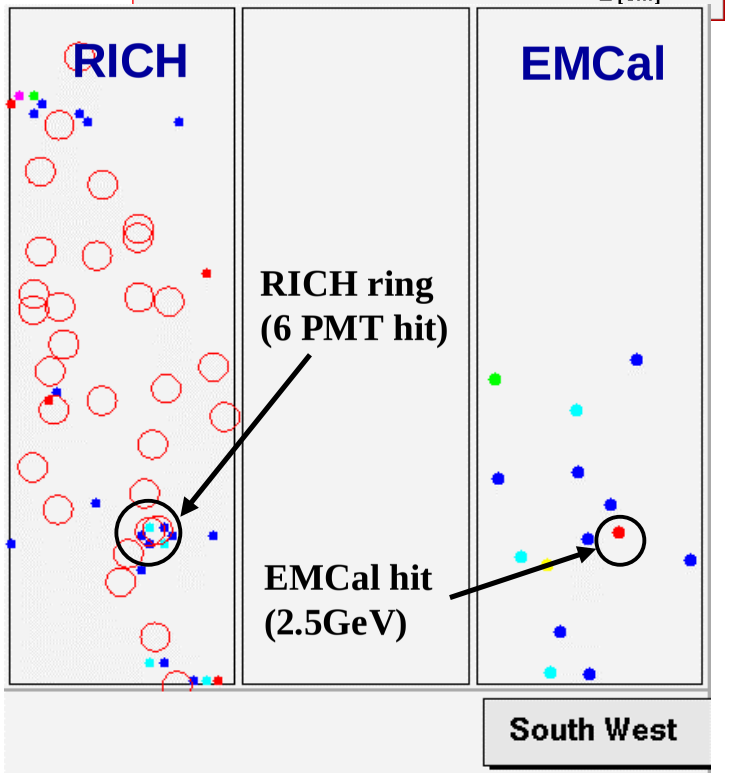
RICH in Operation!

- RICH Rings associated with tracks
- Most of PMT hits are in 3cm < r < 11cm



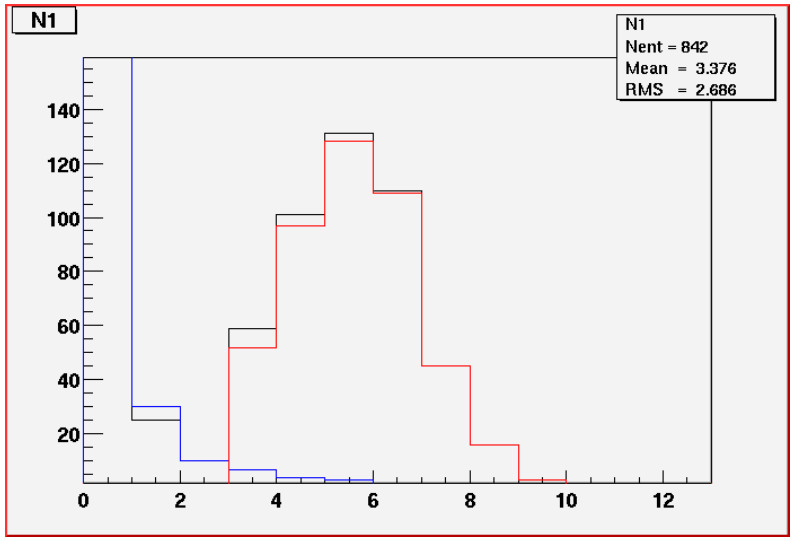
Event Accumulated



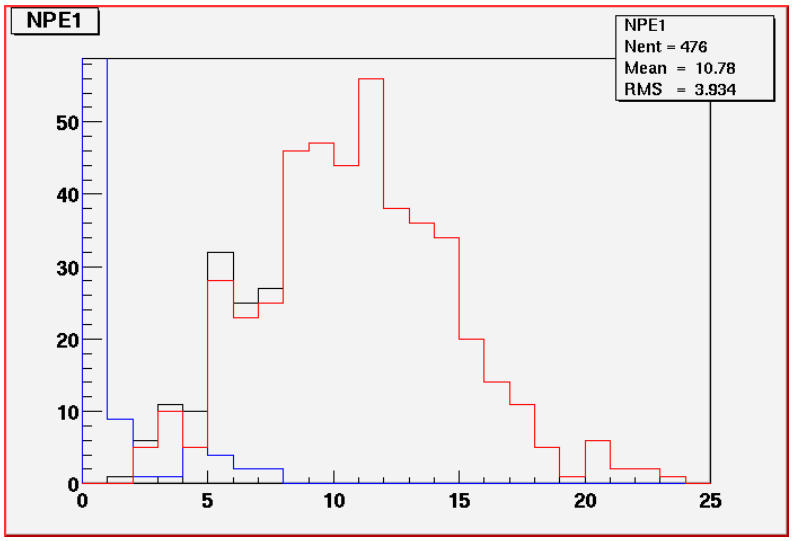


RICH Basic Performance

- Overall Figure of Merit **N_0: 119**
- Timing resolution: **~ 1 nsec**
- Maximum Occupancy : **6.5 %** (Field On), **9.1 %** (Field Off)
- Ring association to reference track: **$\Delta\phi$=0.5°, Δz=3.3cm**



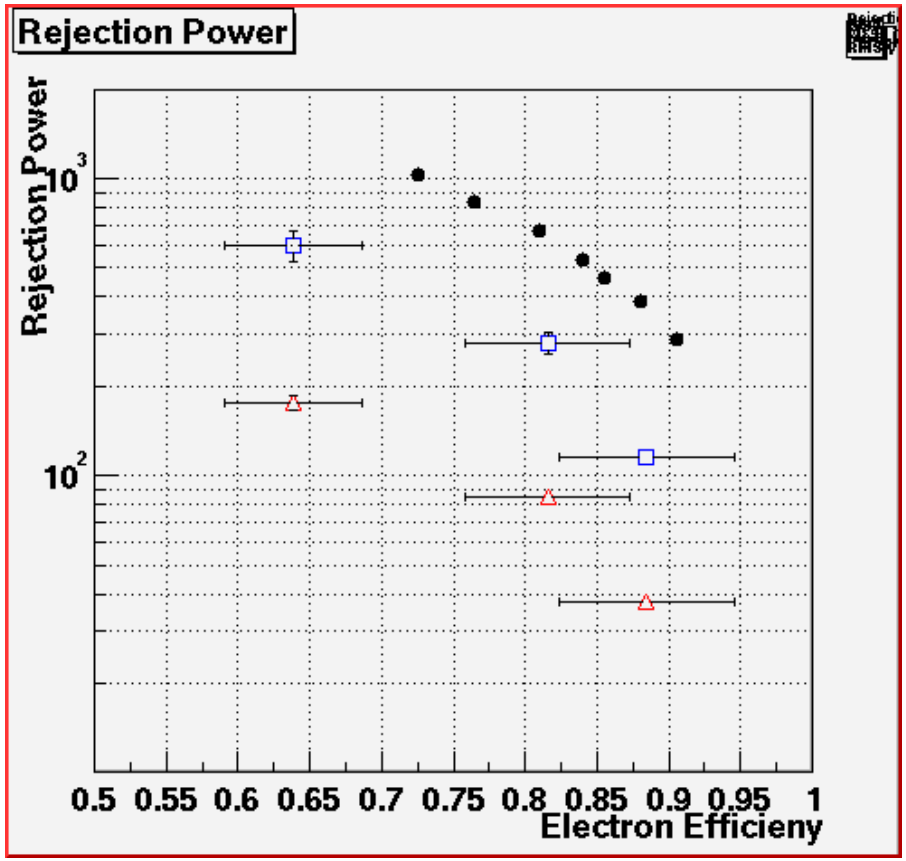
Number of PMT per ring



Number of photoelectron per ring

Black: Raw spectrum, Blue: Background Estimated, Red: Background subtracted

Rejection Power with CO_2 Gas



Black: Simulation for Au+Au Central

Blue: Real data for Au+Au Peripheral

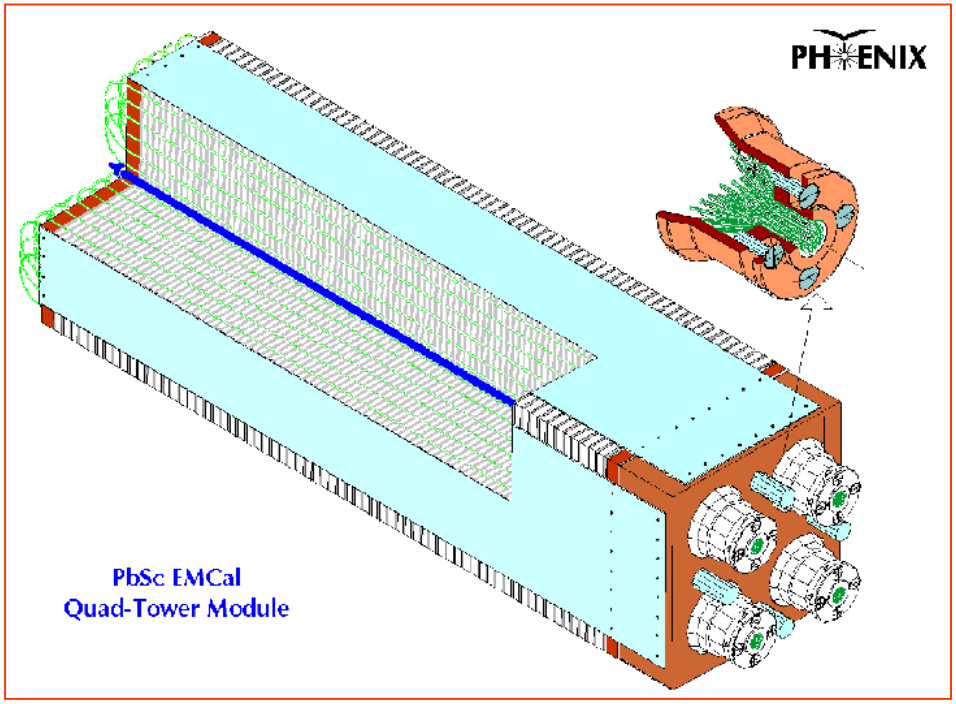
Red: Real data for Au+Au Central

Rejection power: **280** (peripheral), and **85** (central) @ electron efficiency of 82%

- Centrality defined by PC1 Hit:
  Peripheral: (PC1 Hit)<150
  Central: (PC1 Hit)>400
- e and π identified with TOF;
  mom. range 0.3 < p < 0.4 GeV
- Track association: 3.4cm < r < 8.4cm
- Ring shape cut is applied
- Timing cut is not applied
- DC shield was not installed yet

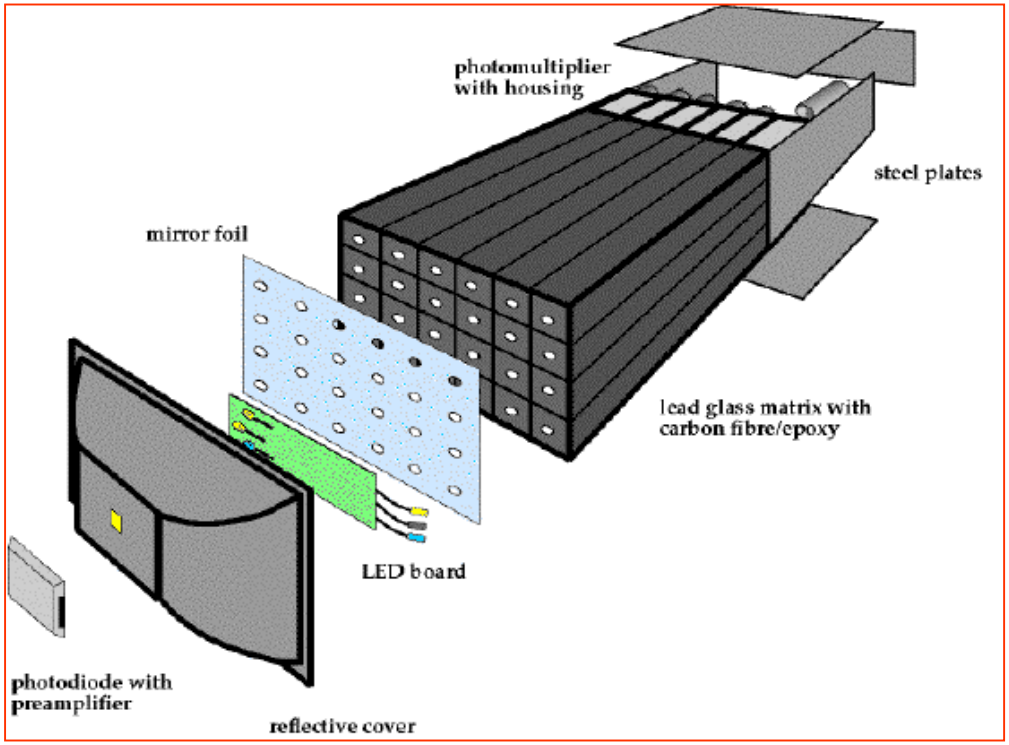
Rejection Power is rather good without DC shield and timing cut

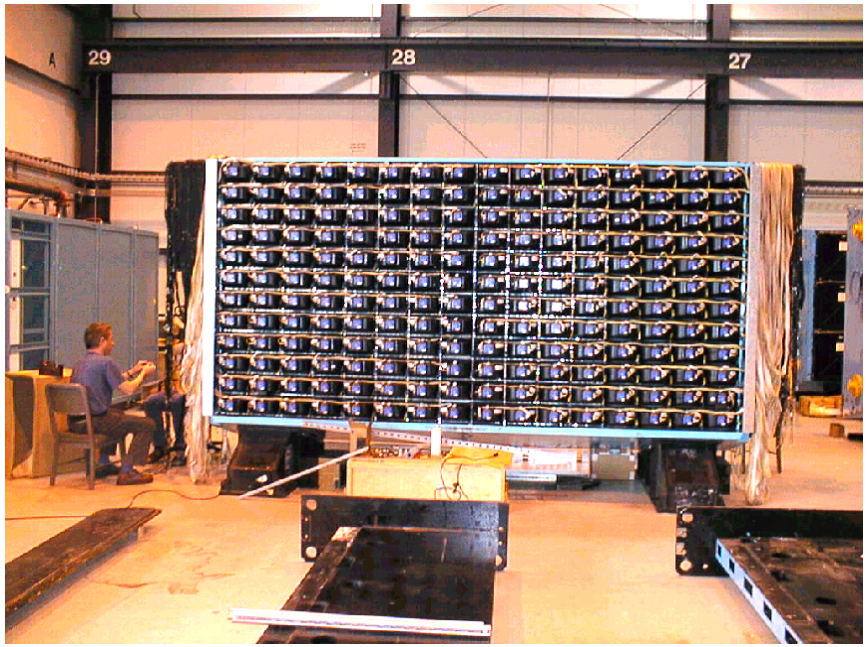
PbSc Calorimeter



	PbSc
Size(cm x cm)	5.52 x 5.52
Depth(cm)	37.5
Number of towers	15552
Sampling fraction	~20%
η cov.	0.7
ϕ cov.	90+45deg
η/mod	0.011
ϕ/mod	0.011
X_0	18
Molière Radius	~3cm

PbGl Calorimeter

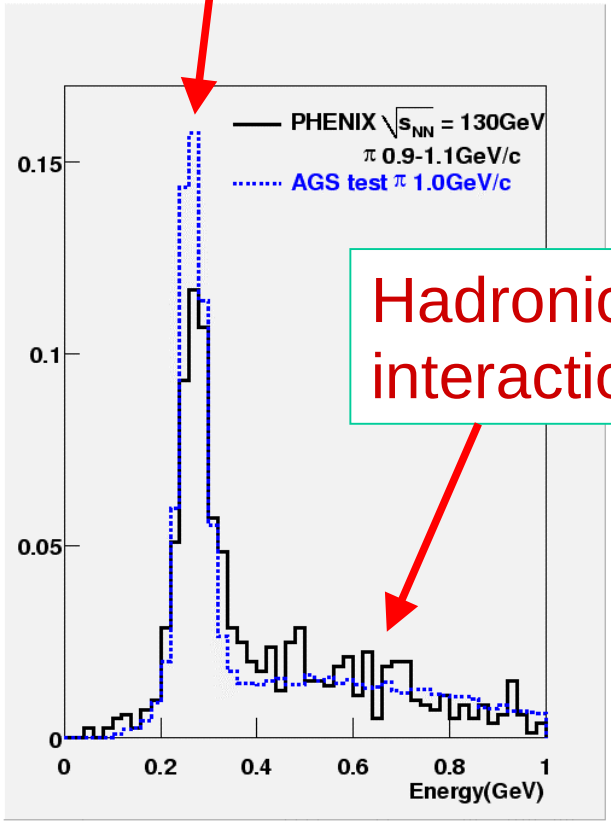




	PbGl
Size(cm x cm)	4.0 x 4.0
Depth(cm)	40
Number of towers	9216
Sampling fraction	100%
η cov.	0.7
ϕ cov.	45deg
η/mod	0.008
ϕ/mod	0.008
X_0	14.4
Molière Radius	3.68cm

Energy Measurement at EMCal

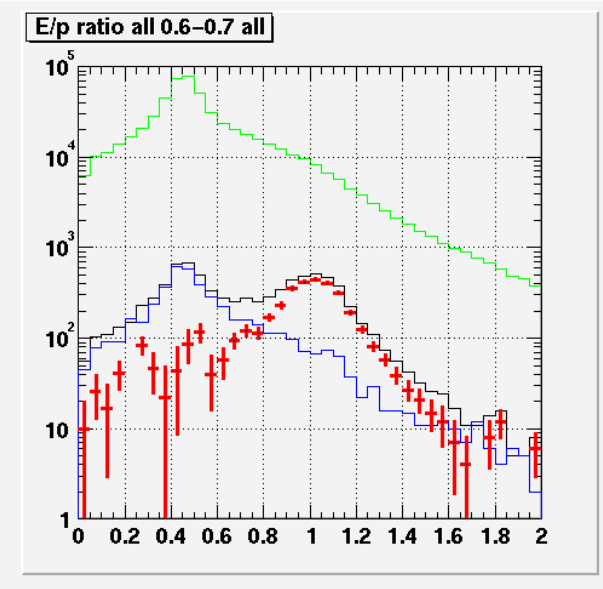
MIP 0.26 GeV

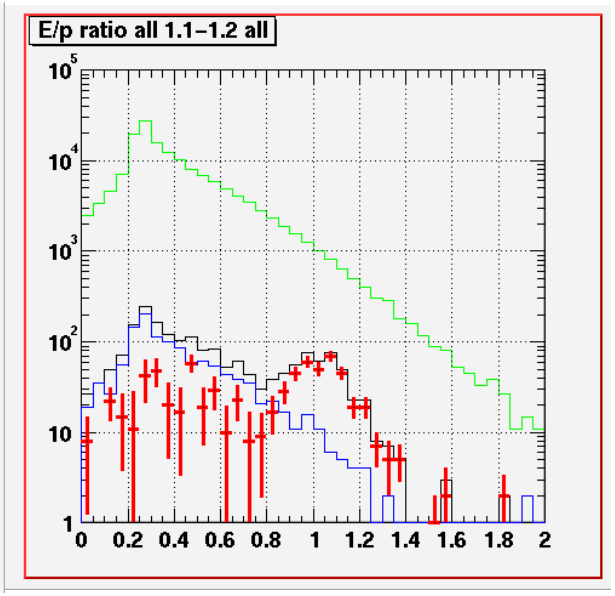


Hadronic interaction

Energy deposit by 0.9 – 1.1 GeV/c π

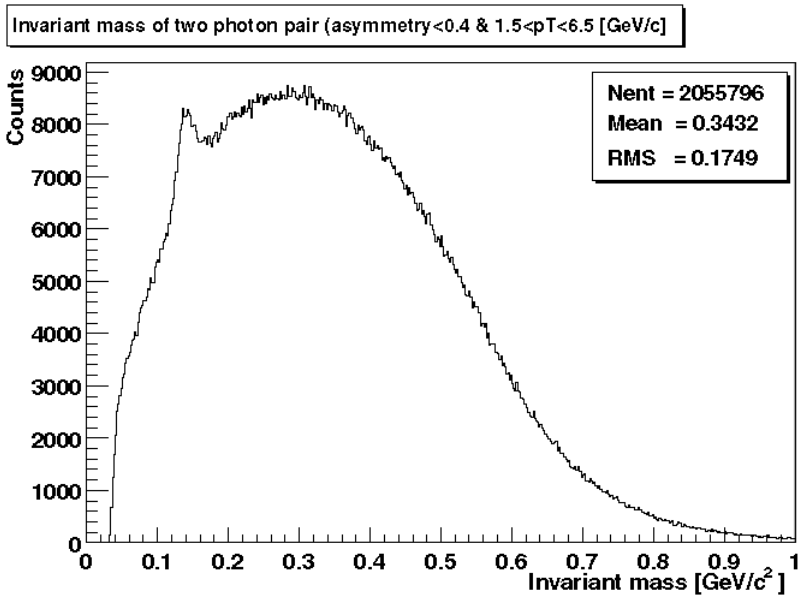
- E/p matching
- Rejection power of RICH



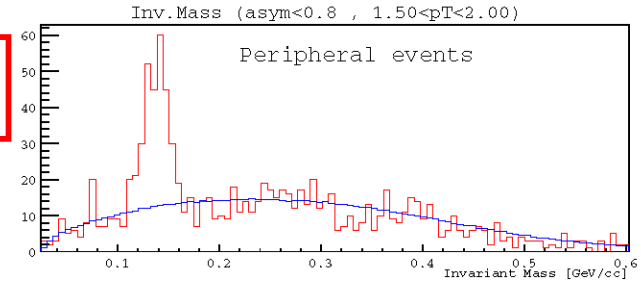


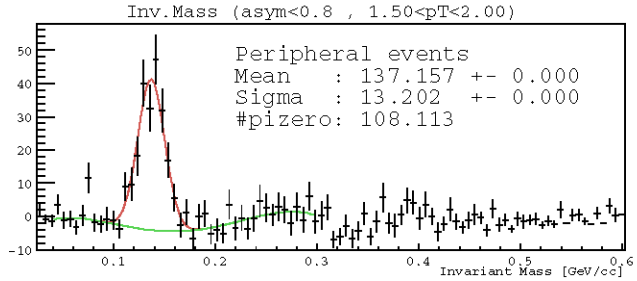
EMCal as π^0 spectrometer

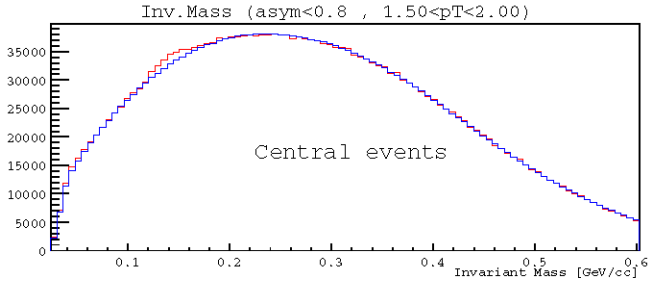
Peripheral:75-92%



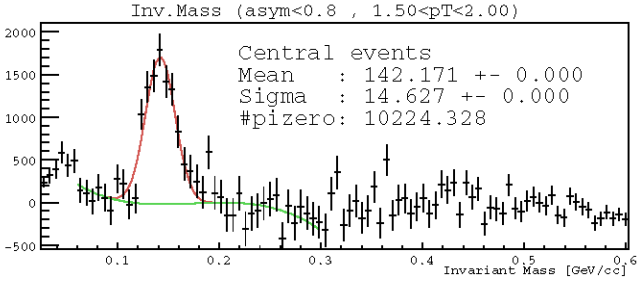
$\gamma\gamma$ **invariant mass**







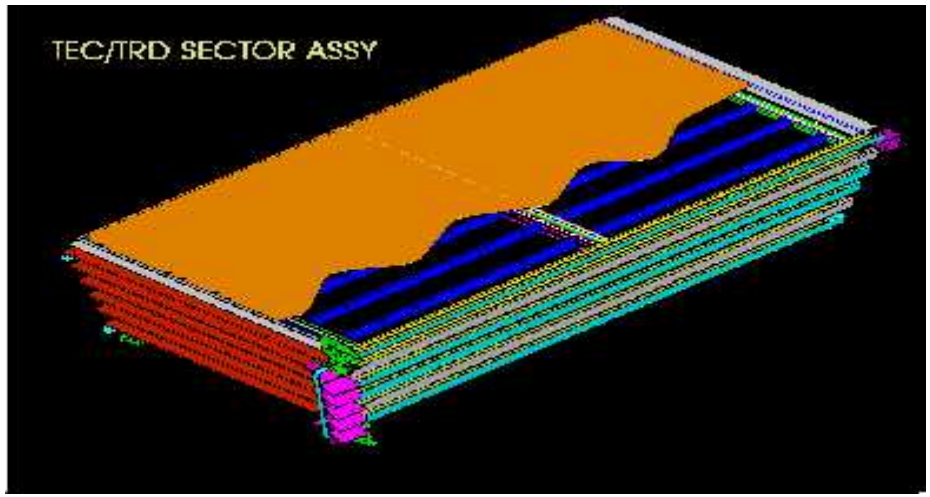
Central:10%

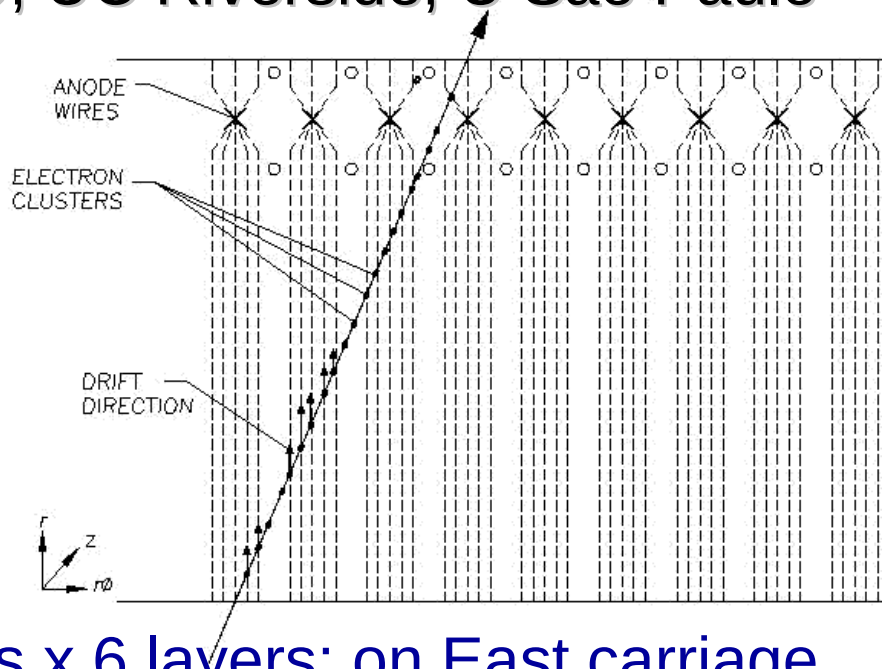


See more details at P230 in the BNL Poster Session

Time Expansion Chamber

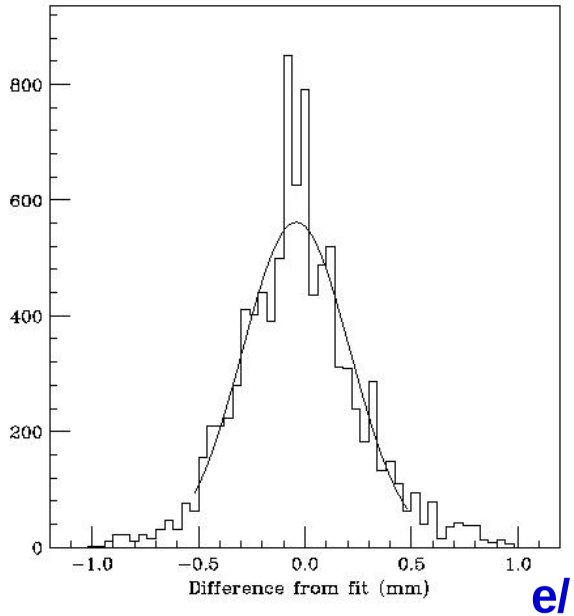
BNL, Academia Sinica(Taiwan), ISU, UC Riverside, U Sao Paulo





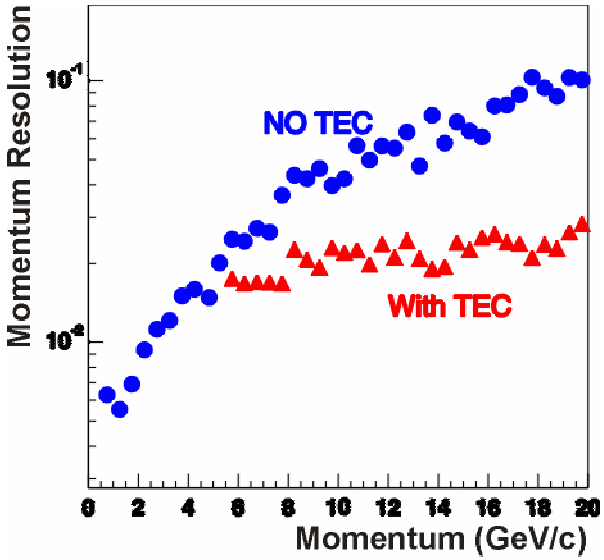
- 24 chambers arranged in 4 sectors x 6 layers; on East carriage
- Each 3.7 m x 2.0 m chamber contains 2700 wires (~900 anodes channels each)
- 2 sectors x 4 layers instrum. RHIC2000
- 4 sectors x 4 layers to be instrum. RHIC2001

TEC Performance

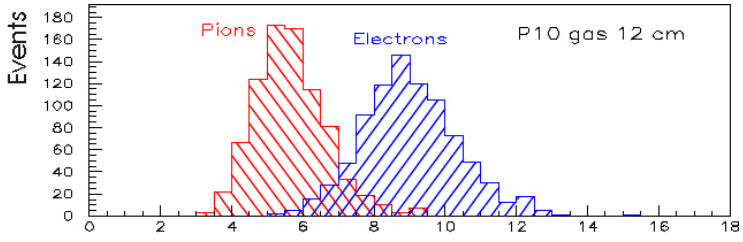


Position Resolution
(Test Beam)
250 μm

Momentum resolution
(Simulation)
Improve Momentum
Resolution at high pT

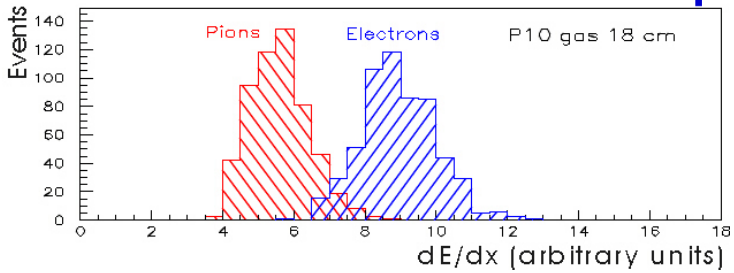


e/π = 5% at 500 MeV/c with 4 planes

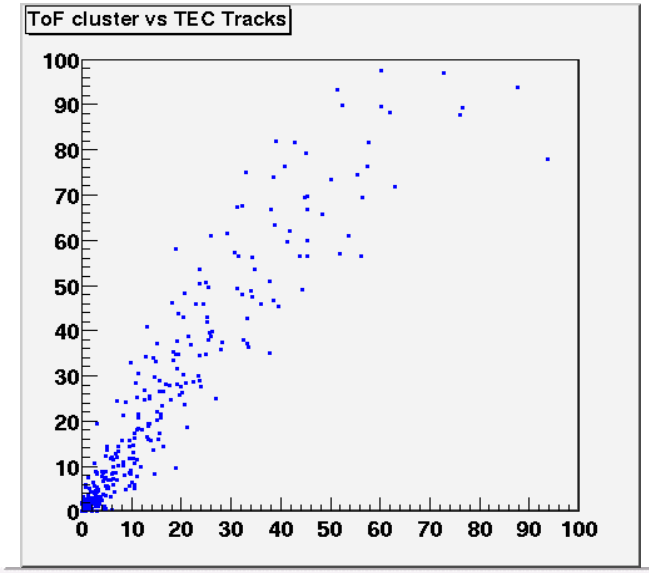


e/π Separation
(Test Beam)

e/π =1. 5% at 500 MeV/c with 6 planes



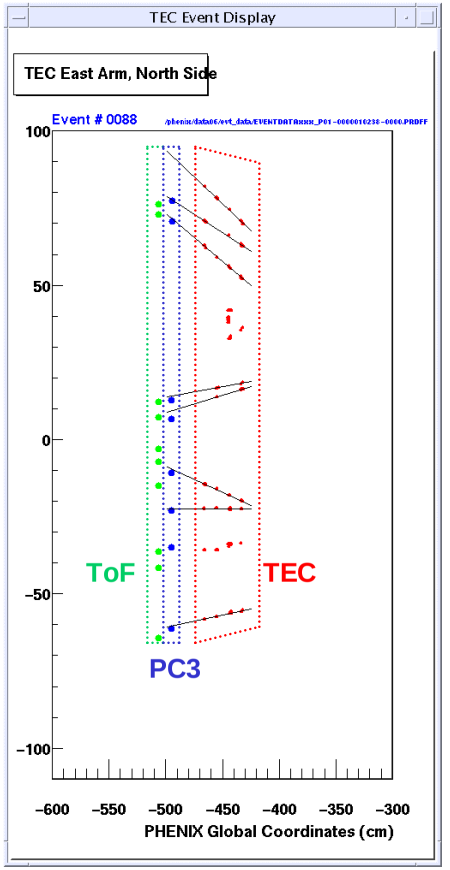
TEC Operation in RHIC 2000 Run

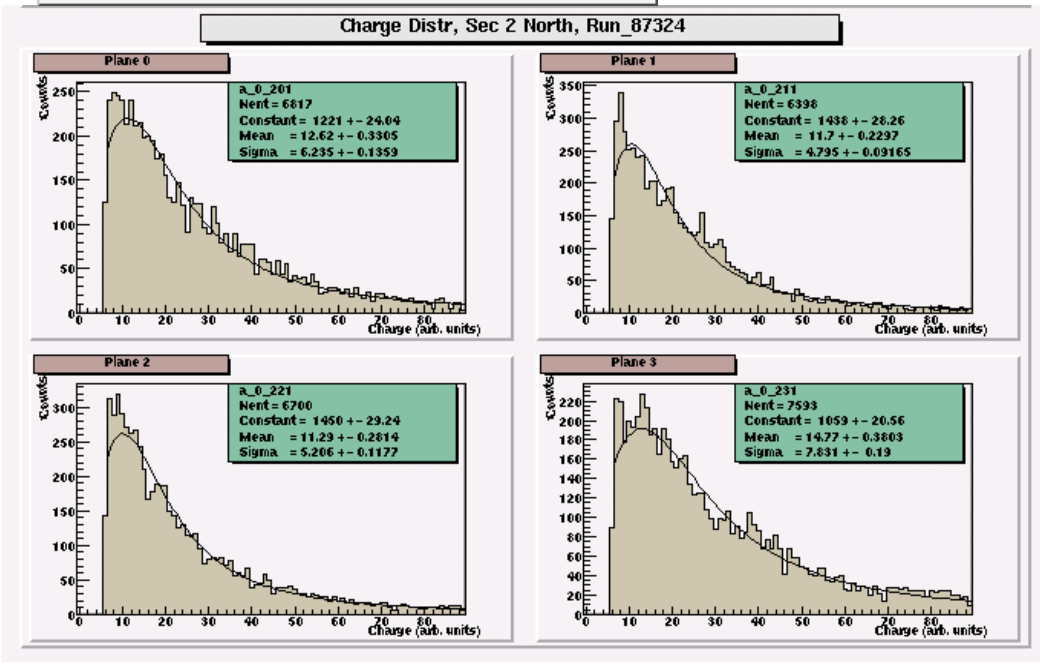


Pattern Recognition

→ Robust track reconstruction at high track densities

TOF clusters
vs.
TEC tracks

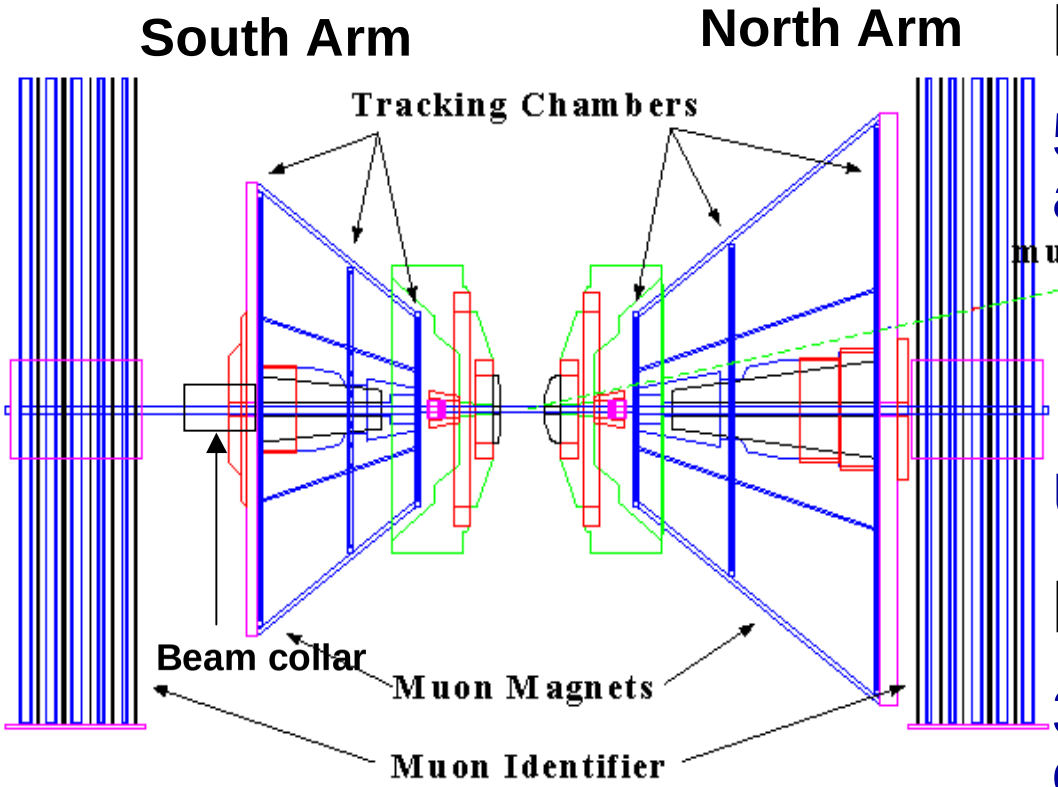




dE/dx in
TEC planes

PHENIX TEC Works Well.
Calibration & Data Analysis is Underway

Muon Arm



Acceptance 1.1<|η|<2.4

South arm will be completed in March 2001

MuID(Muon Identifier)

5 layers; sandwich of steel absorbers and chambers

- absorber ~ 10 λ_{int}
- p_z cut ~ 2GeV/c

Used as Trigger counter

MuTr (Muon Tracking)

3 sets of chambers with cathode-readout

- $\sigma_x \sim 100\mu m$

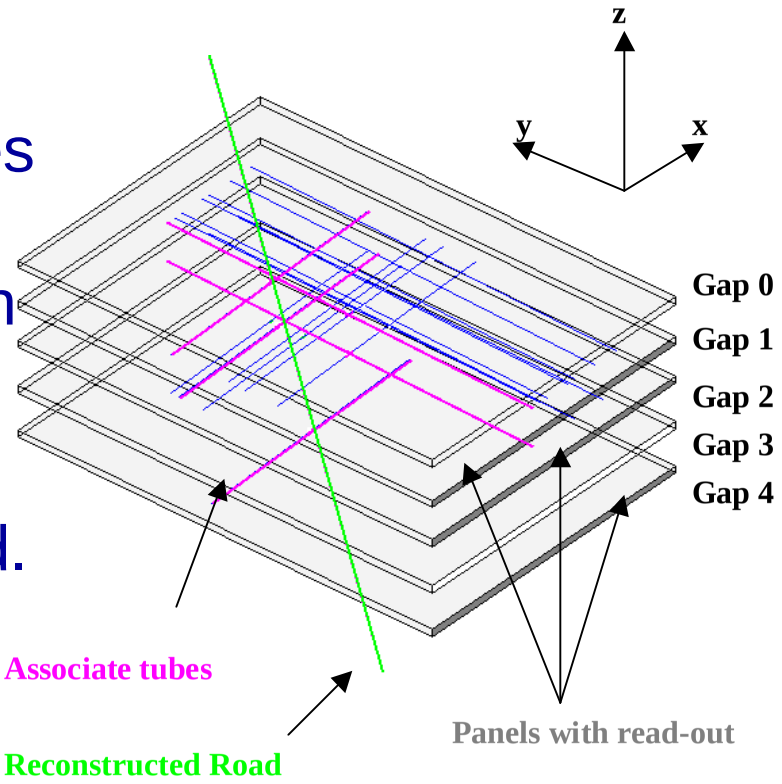
→ $\Delta p/p$ ~3%@3~10 GeV/c

See more details at P214, P215 and P217 in the BNL Poster Session

MuID Test at RHIC 2000 Run

Test Set-up

- South muon identifier
  - readout only 16 horizontal tubes and 13 vertical tubes in lower small panels in gap 1, 2, 4, with using one read-out card (96 channels)
- BBC minimum bias trigger applied.



Tube efficiency

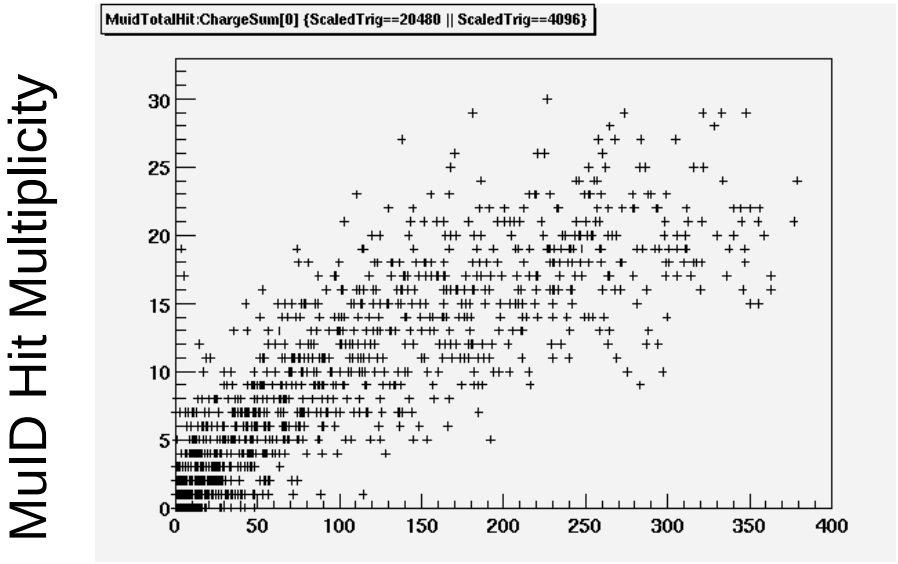
~ 70% @ ~ 4.2kV with CO_2

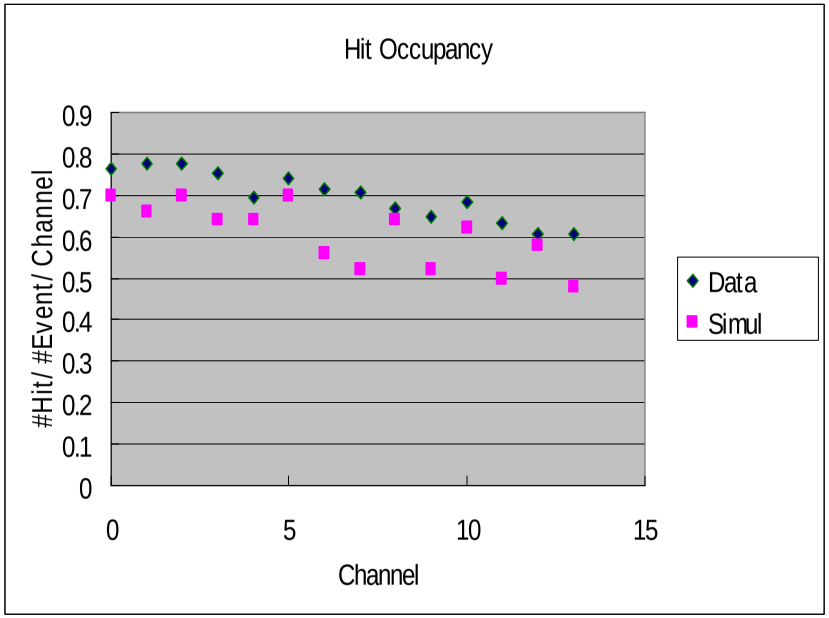
DAQ , online monitoring works fine

Tracks were successfully reconstructed

MuID Results from RHIC 2000

Correlation with BBC(3<h<4)

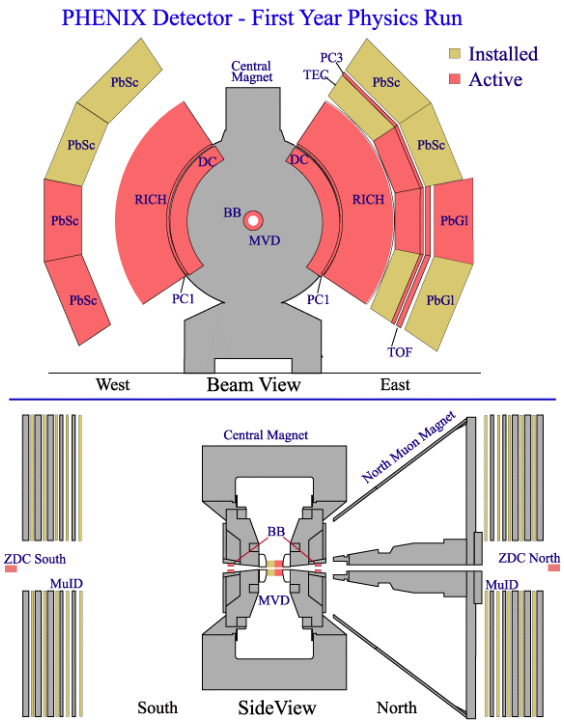


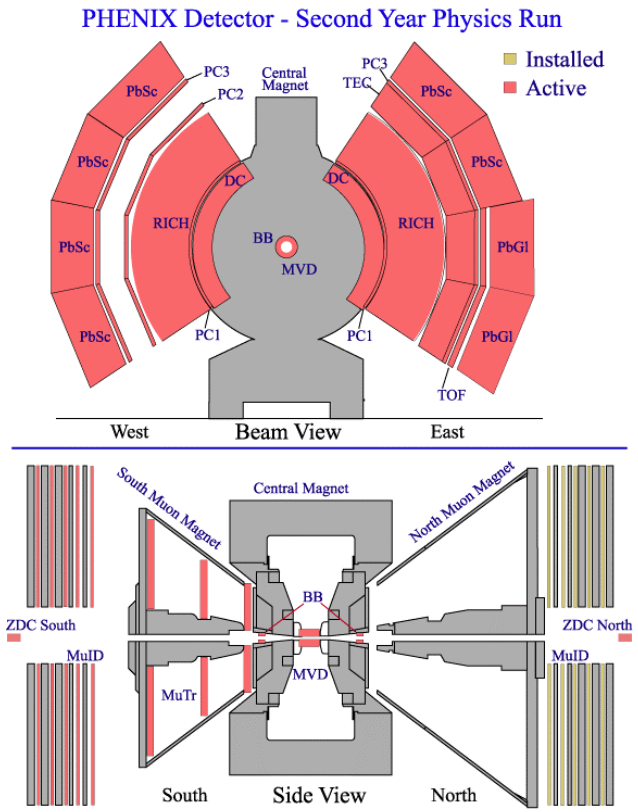


Strong correlation between MuID hit multiplicity and BBC charge sum

- 16 **Horizontal tube in Gap 1**
- **HIJING+GEANT simulation**
- **Most of hit comes from beam pipe.**
- **In next run, MMS and beam collar will stop most of junk.**

Summary and Outlook





- **PID devices → good performance**
- **A lot of works are going on:**
  - to understand characteristics
  - for calibrations, & tuning

  → good and unique physics

At Y2001 Run

- Central Arms
  with full acceptance
- South muon-arm