Calibration of the PHENIX Lead Scintillator Calorimeter

H.Torii for the PHENIX Collaboration

Kyoto Univ./RIKEN

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Lead Scintillator Calorimeter(PbSc)

Shashlik type calorimeter

Scintillator plates 55.2x55.2x1.5mm

Lead plates 110.4x110.4x4mm

Shish-kebab geometry wave shifter fiber readout

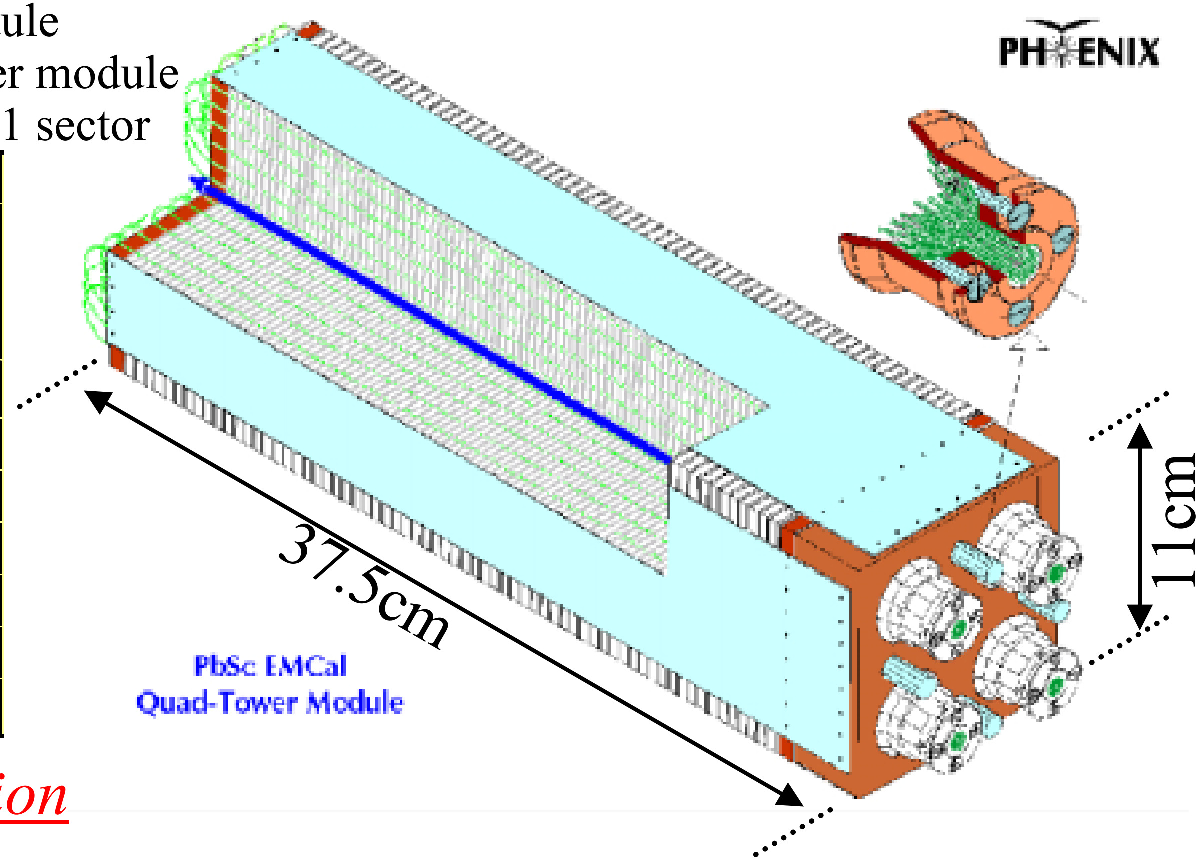
6x6 fibers → 1 PMT = 1 tower

2 x 2 towers = 1 module

6 x 6 module = 1 super module

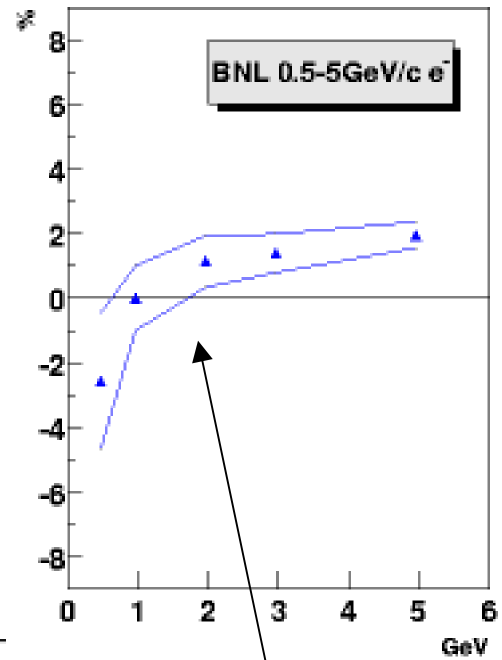
6 x 3 super module = 1 sector

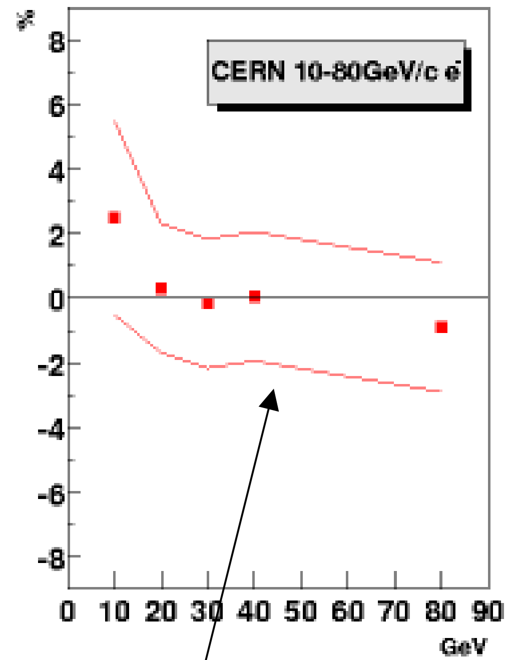
	PbSc
Size(cm x cm)	5.52 x 5.52
Depth(cm)	37.5
Number of towers	15552
Sampling fraction	~20%
η cov.	0.7
ϕ cov.	90+45deg
η/mod	0.011
ϕ/mod	0.011
X_0	18
Molière Radius	~3cm



Very fine segmentation

Energy linearity and resolution





Energy resolution

$2.1\% \oplus 8.1\%/\sqrt{E(\text{GeV})}$

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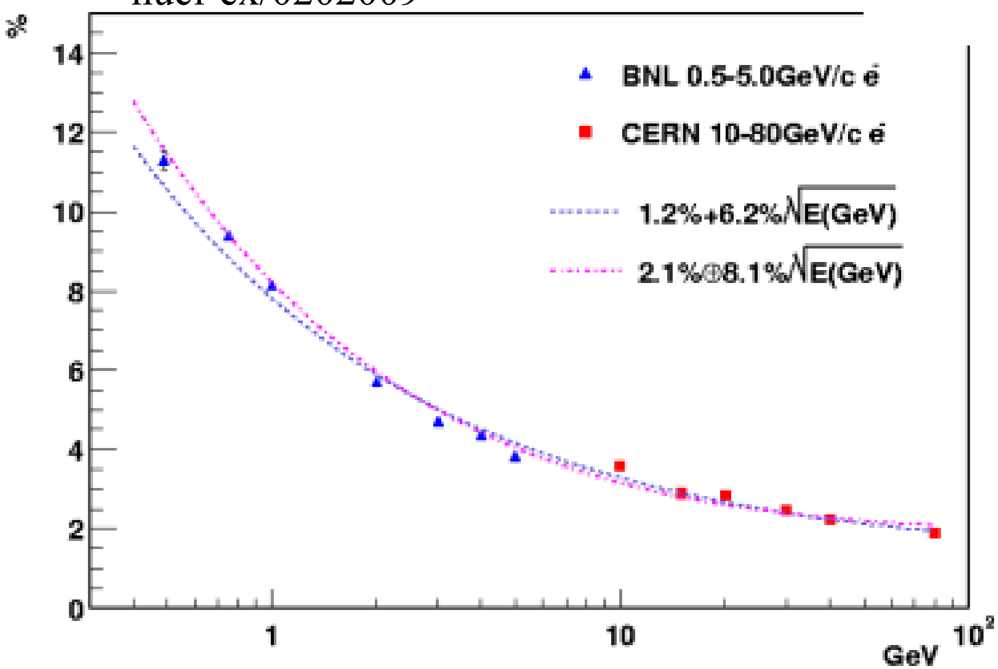

Energy leackage

Light attenuation in the WLS fibers (effective L_{att}~100cm)

Timing and Position resolution

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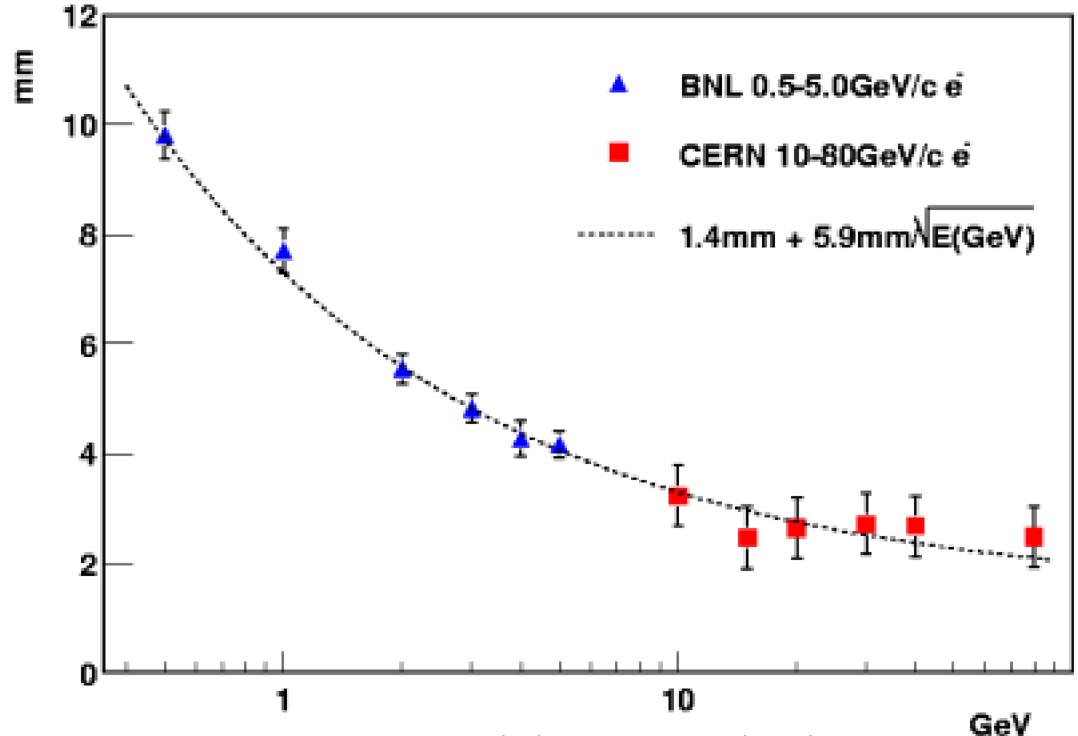
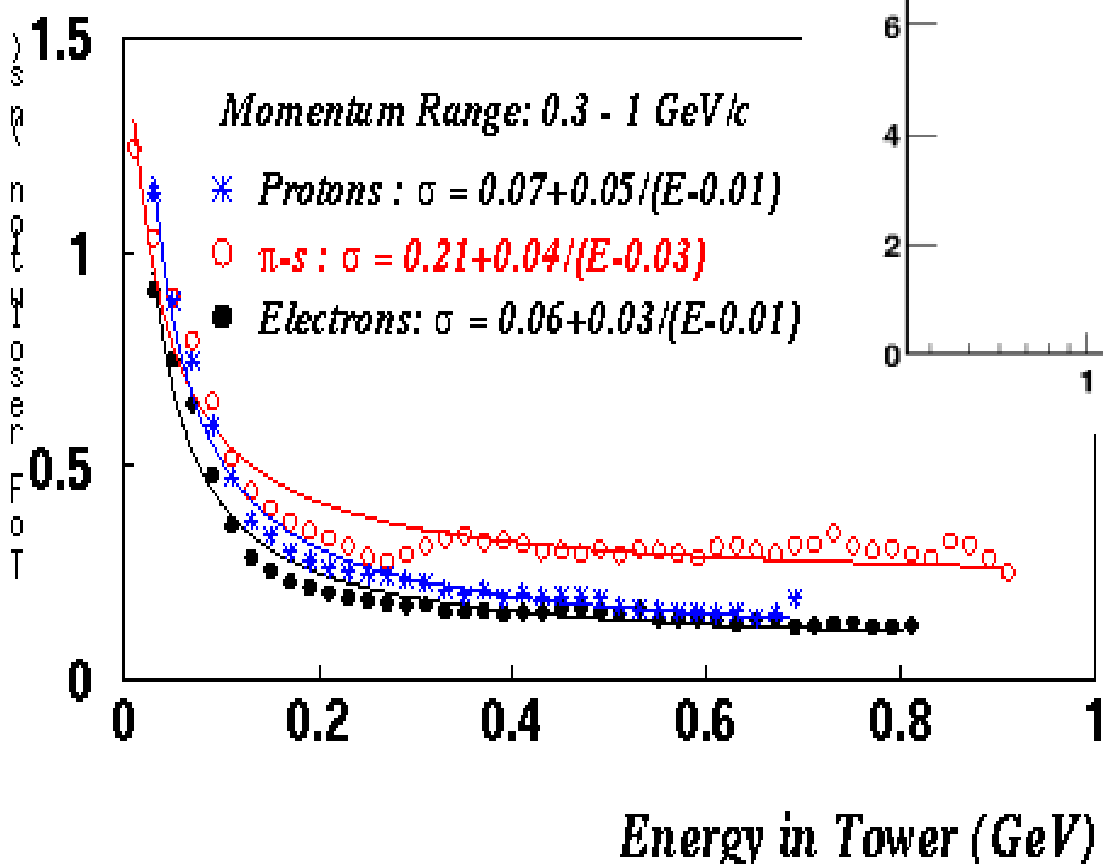


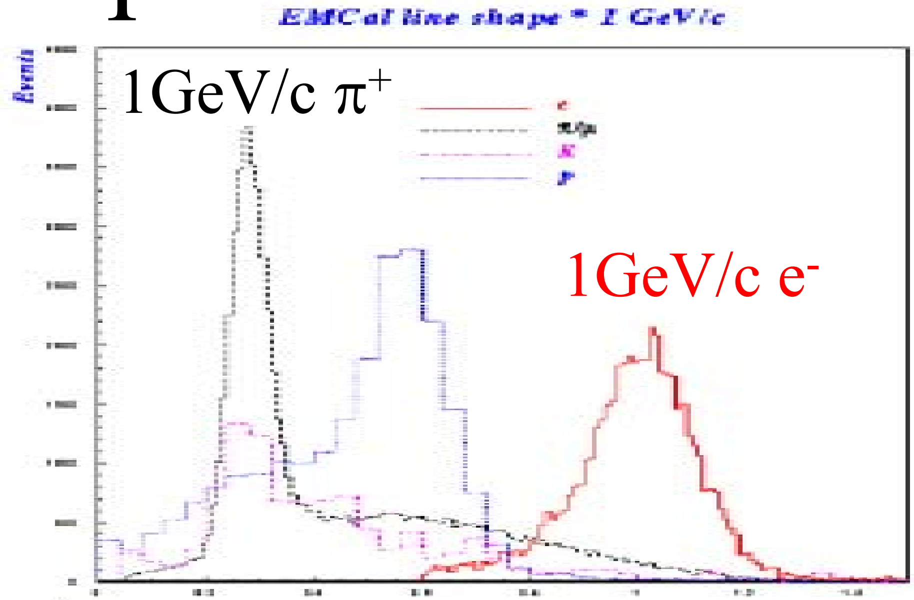
Position resolution

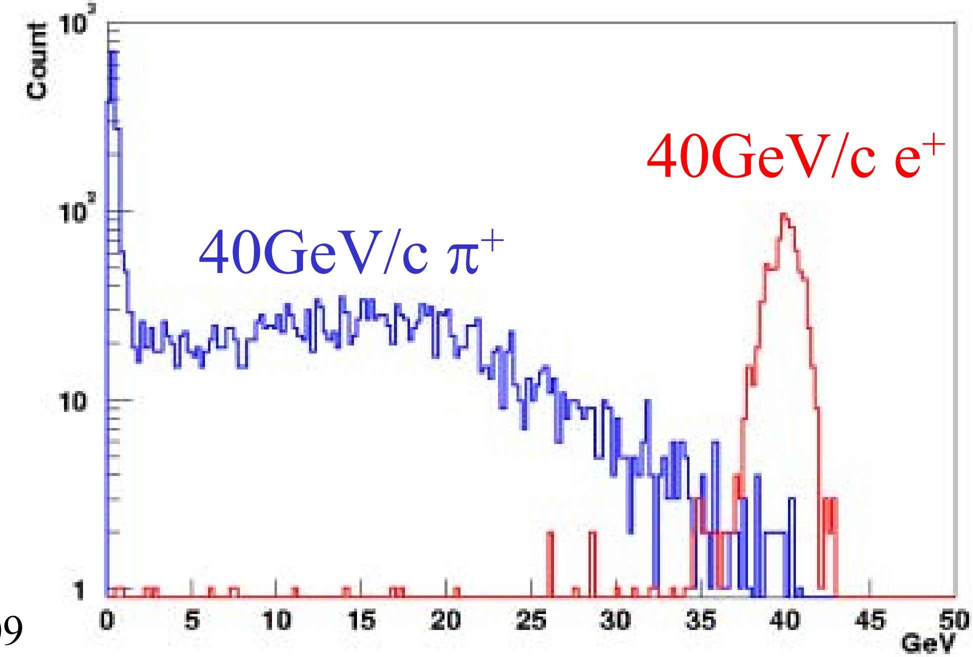
- Timing resolution



Hadron response

- We measured hadron energy response at test beam
  - 0.3-2GeV/c π,K,p
  - 40GeV/c π^+
- Two structure
  - Ionization
    - 270MeV for 1GeV/c pi
  - Hadronic shower
    - Distribution from the ionization energy to its kinematics energy.
- The measured energy of electromagnetic shower is well separated from that of hadronic shower.





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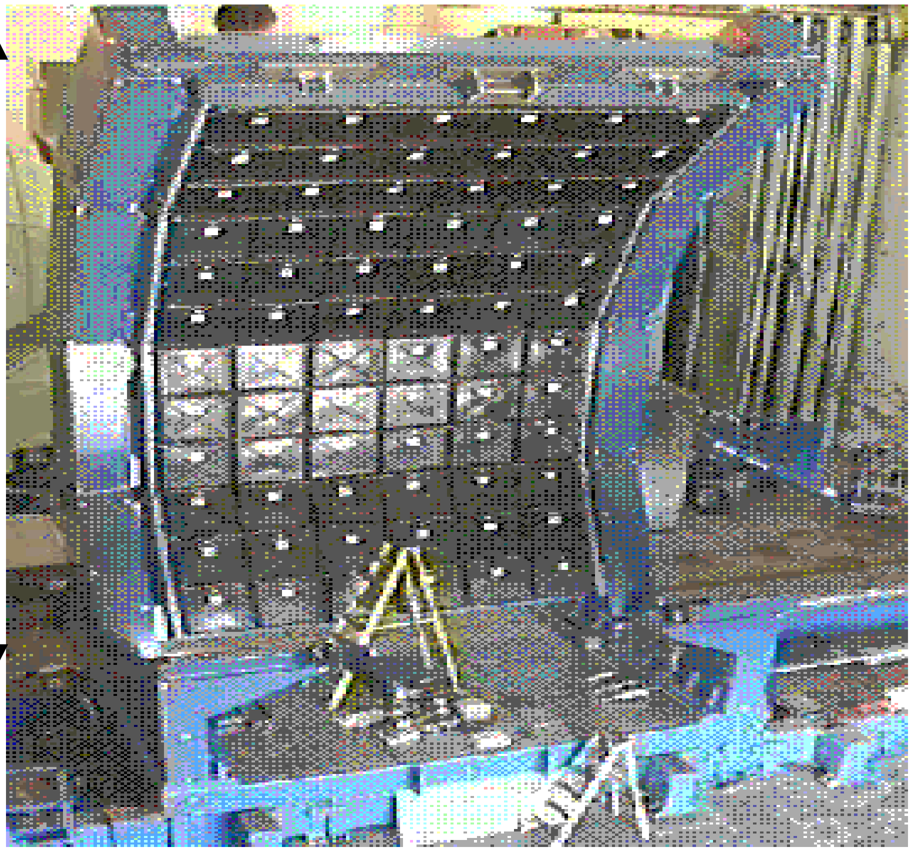
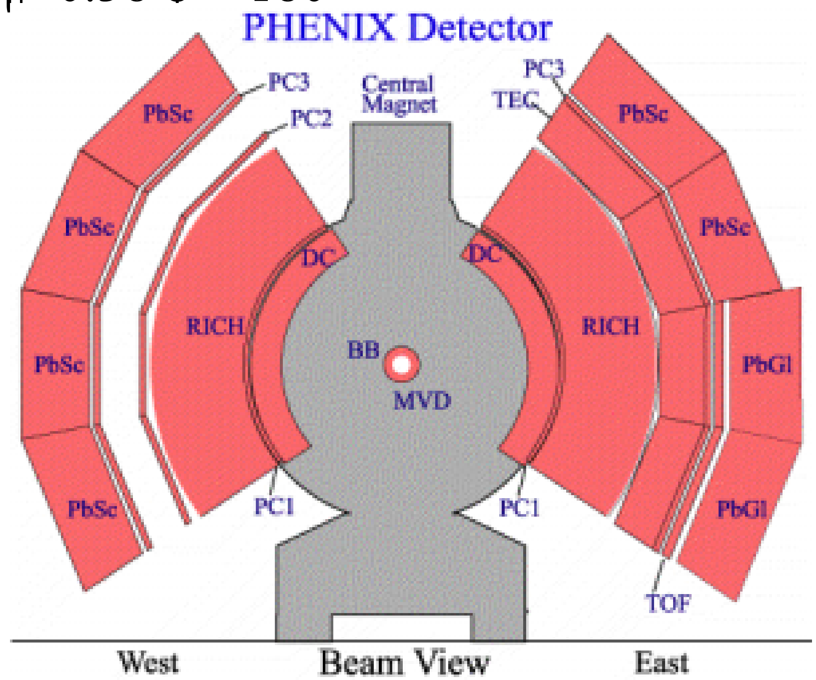
PHENIX Configuration

4m (72 towers)

7m (144 towers)



- 2 Arm × 4 sectors
  - Lead Scintillator(PbSc)
    6 sectors(15552 channels)
  - Lead Glass (PbGl)
    2sectors (9216 channels)
- ~5m distance from collision point
- $|\eta|<0.38$ $\phi = 180°$

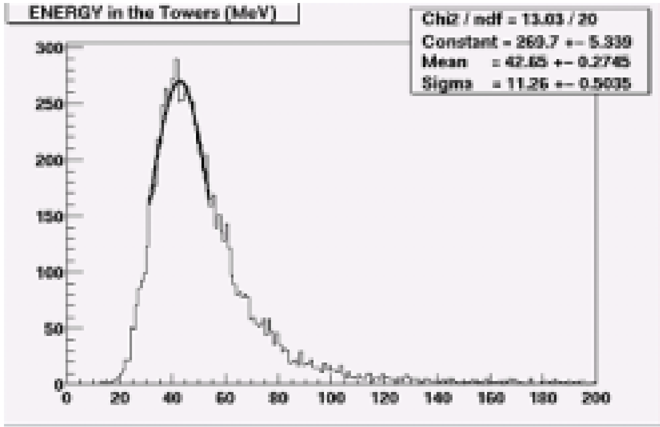


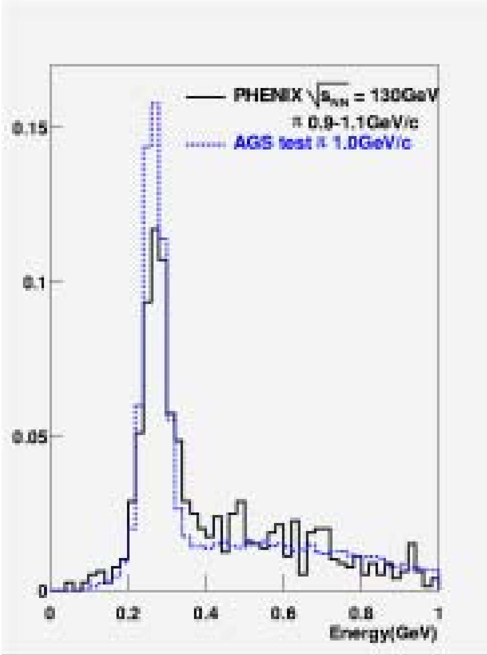
Energy Calibration Strategy in PHENIX configuration

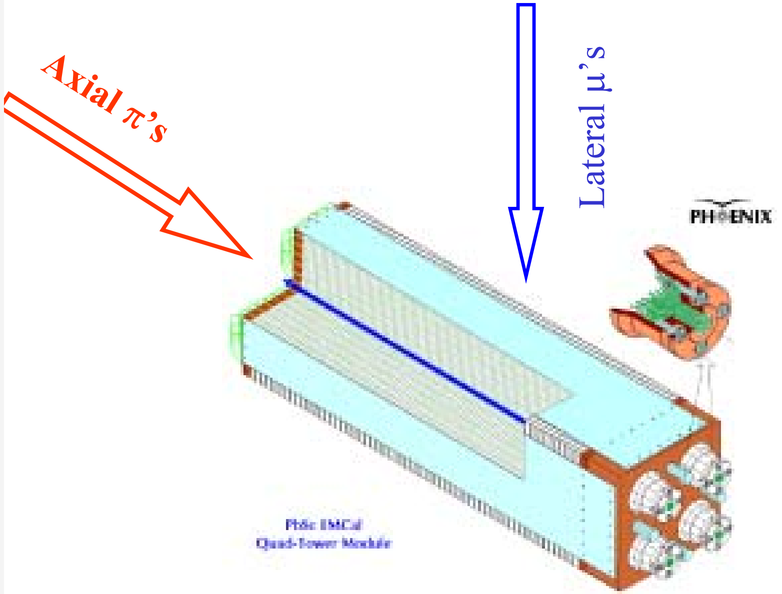
- Before installing into PHENIX configuration, all towers are calibrated using cosmic muon traversing laterally.(1998??)
- The calibration parameters are transported into PHENIX configuration by laser monitoring system.
  - The procedure is well established through several beam test
- Remained misalignment is corrected using charged particle from collision traversing lengthwise
- The absolute energy scale is obtained by physics signal
  - π^0 mass
  - E/p
  - Ionization energy

Energy calibration

- All towers calibrated by ionization energy of cosmic muon traversing laterally
  - 42MeV
- Additional misalignment is calibrated by charged π traversing lengthwise
  - 270MeV

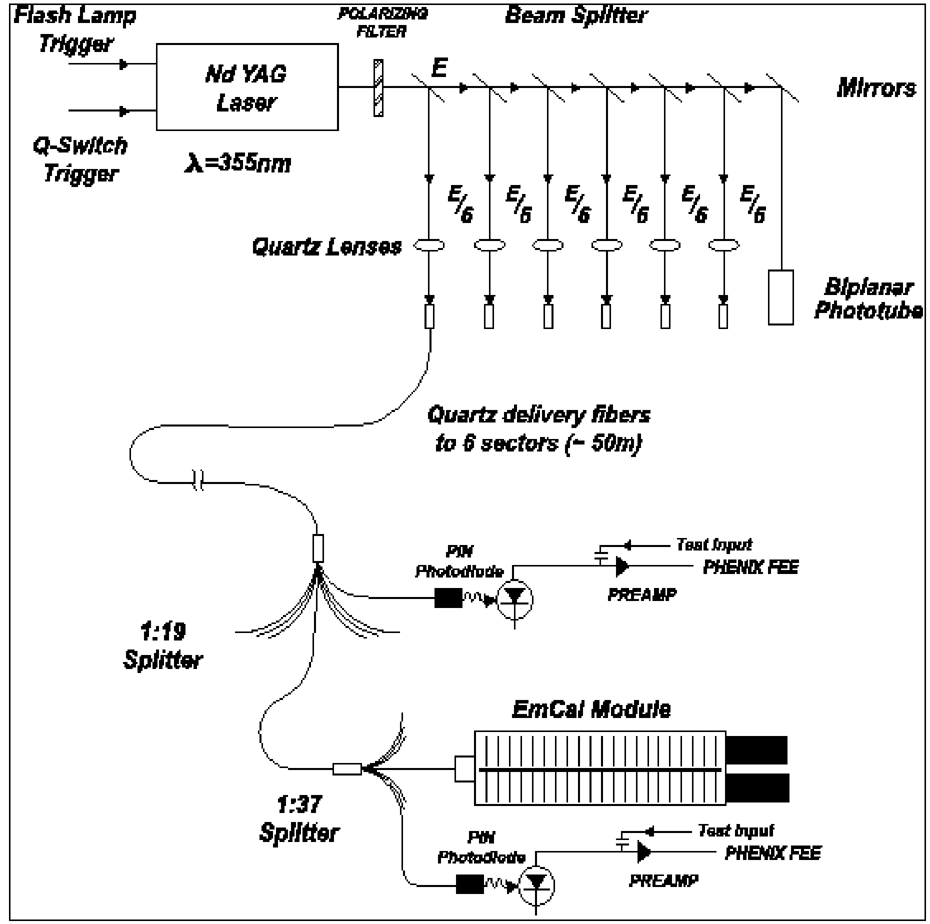






Laser monitoring system

- UV laser (YAG laser) is used for calibration and monitoring system
  - The light intensity is monitored with PIN diodes at each intermediate splitter that are used for normalization.
  - Light is injected into each module through a “leaky fiber” to simulates an electromagnetic shower
- Laser monitoring system works for
  - Transportation from cosmic muon calibration into PHENIX configuration
  - Trace of time drift



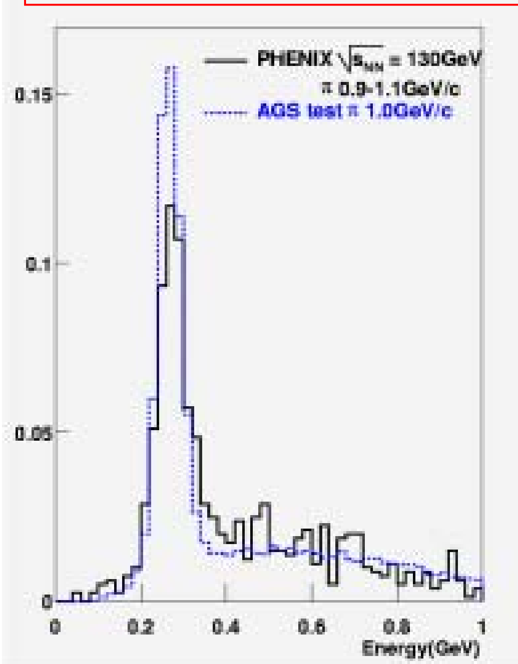
Absolute energy calibration

Three independent measurement results in

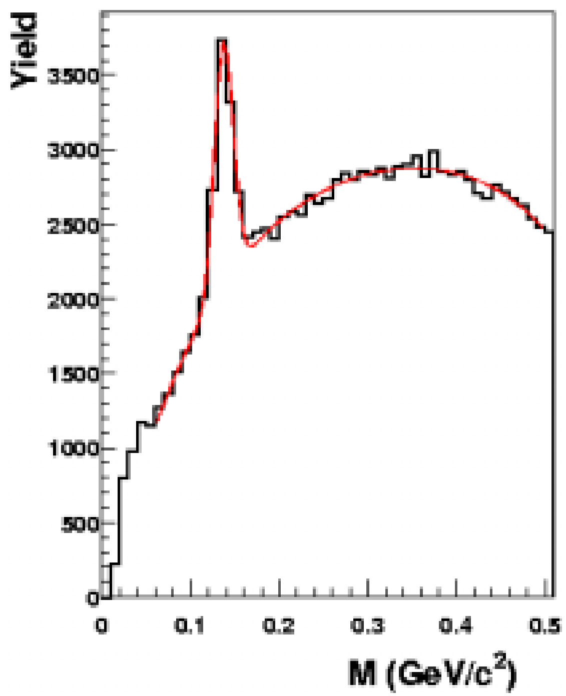
2%

accuracy of absolute energy calibration

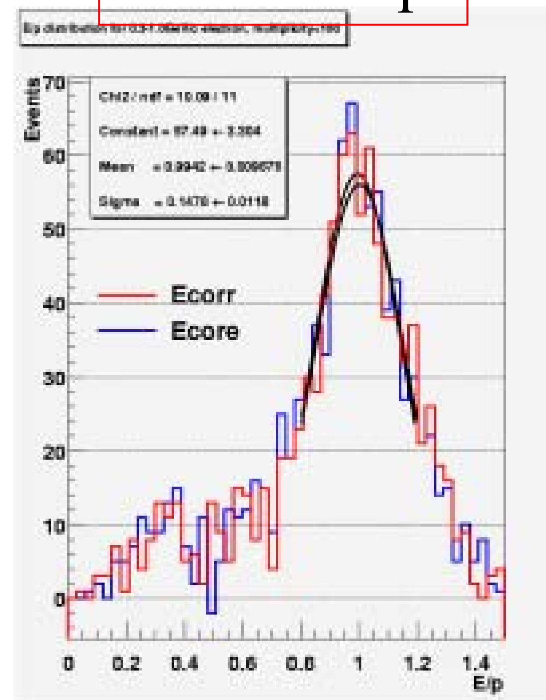
Ionization energy



π^0 mass



electron E/p



Timing calibration

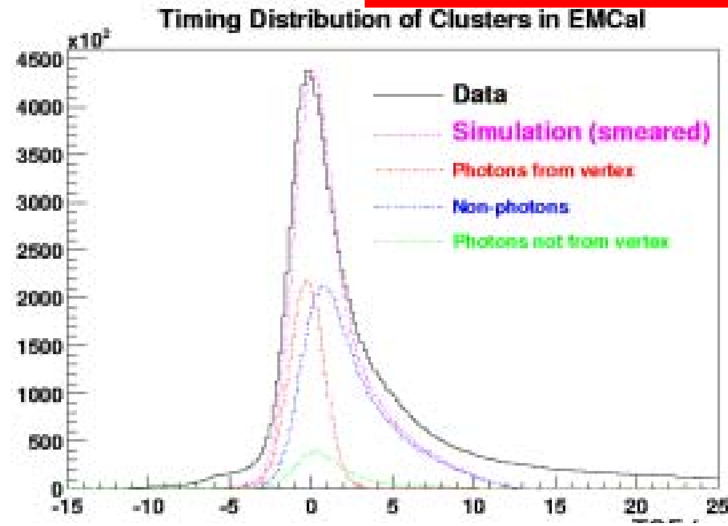
- Strategy
  – Slewing correction is obtained by laser and photon.
  – Time zero is adjusted using photon sample purified by shower shape cut.
- Timing measurement is very important in heavy ion collision
  – to reduce slow hadron contribution

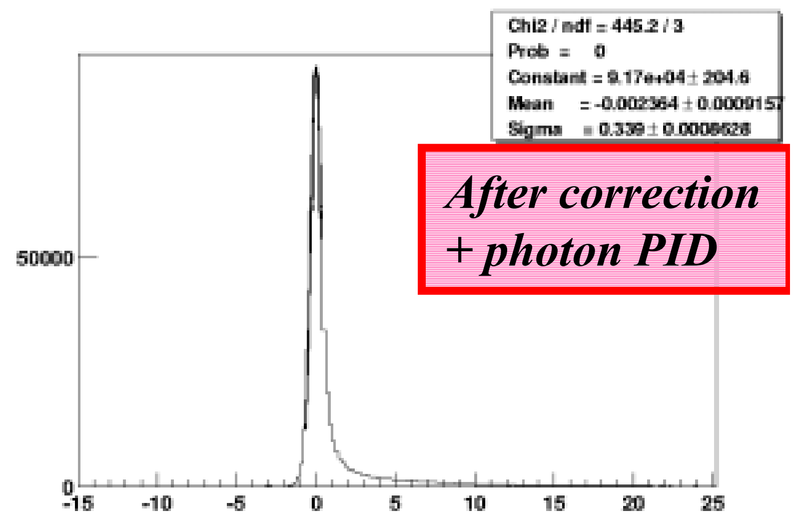
Currently, time resolution is

~400psec for 0.5GeV γ

work in progress

Before correction

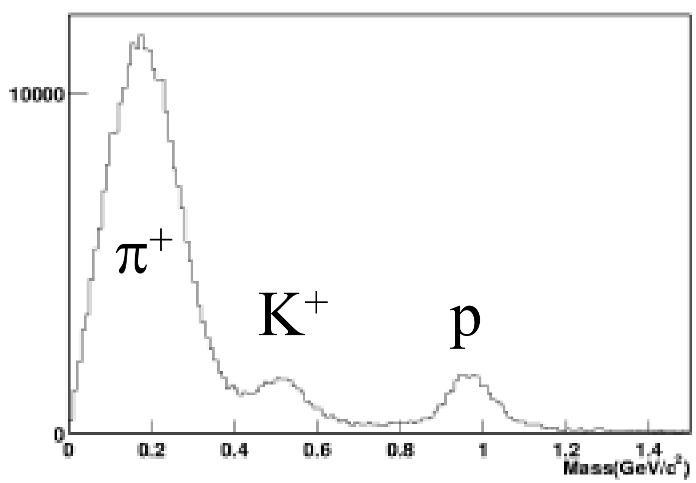


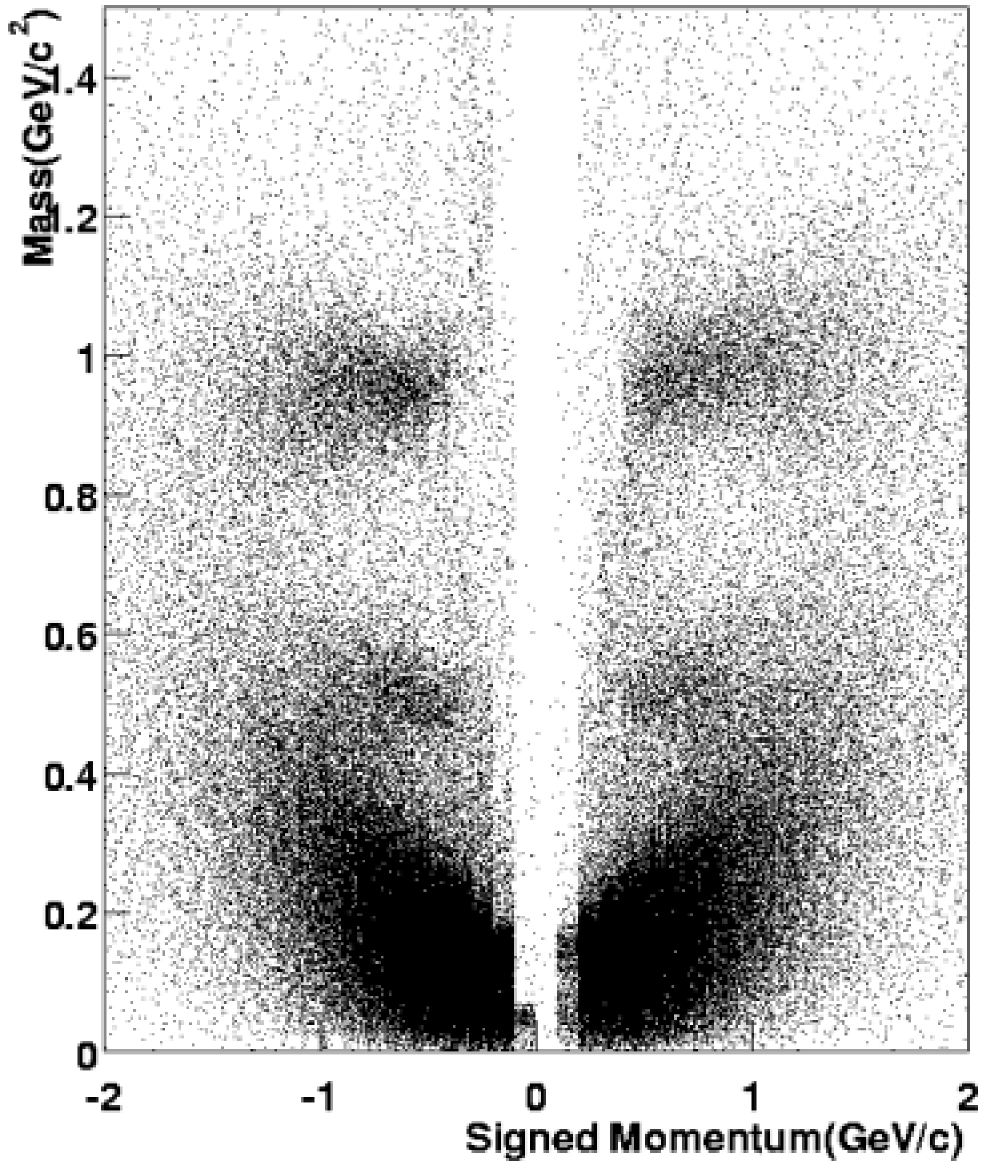


Hadron PID

- Timing measurement is also important for hadron physics
  - For run1, π-K separation up to 0.8GeV/c

0.7-0.8GeV/c

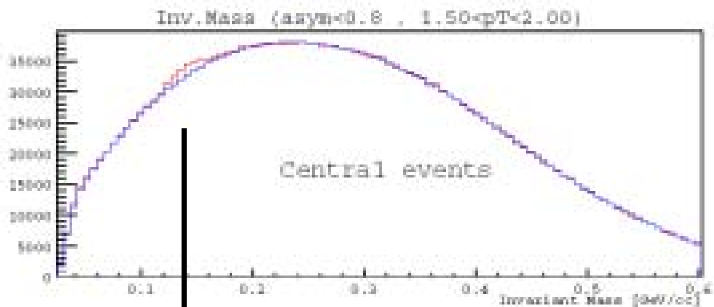




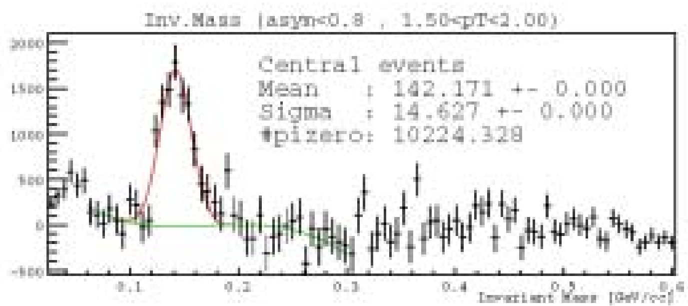
π^0 measurement

Run1 Au+Au $\sqrt{s_{NN}}$ =130GeV

10% Central events



Subtraction by event mixing

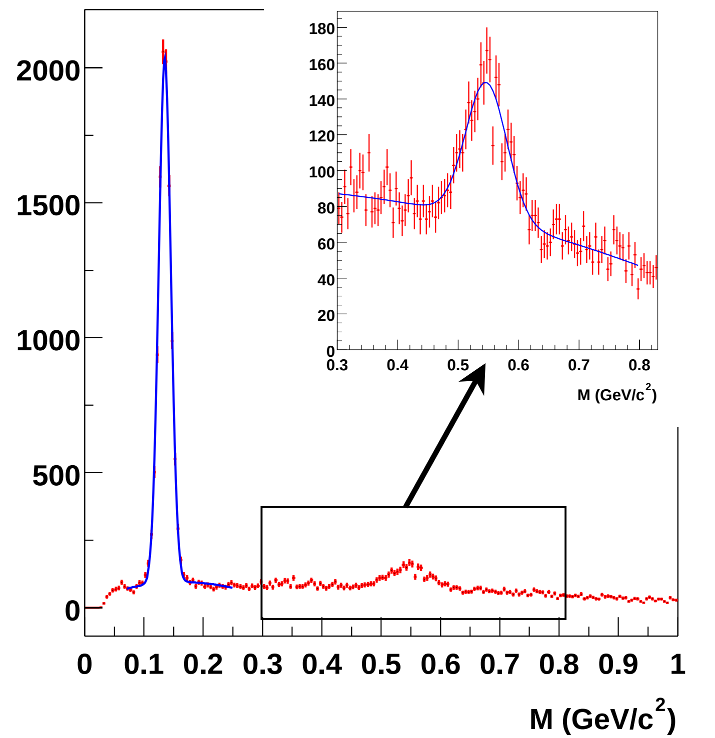


pT = 1.5 – 2.0Gev/c

Run2 p+p $\sqrt{s_{NN}}$ =200GeV

$m(\pi^0)$ = 135.1 MeV/c^2 $\quad$ $m(\eta)$ = 547 MeV/c^2

$\sigma_m(\pi^0)$ = 10.3 MeV/c^2 $\quad$ $\sigma_m(\eta)$ = 34 MeV/c^2



pT = >3.5Gev/c

Pi0 measurement is successful from p+p to Au+Au collision

Summary

- Test beam results
  - Energy linearity and resolution($2.1\% \oplus 8.1\%/\sqrt{E}$)
  - Timing resolution, Position resolution($1.4mm+5.9mm/\sqrt{E}$), Hadron rejection
- PHENIX configuration
  - The relative energy for all towers is calibrated using the ionization energy of a cosmic muon traversing laterally and that of a charged pi traversing lengthwise
  - Gain drift during run is corrected by laser monitoring system.
  - The absolute energy scale is 2% accuracy from
    - E/p
    - π^0 mass
    - Ionization energy
  - Time measurement
    - Hadron PID shows π/K separation up to 0.8GeV/c in Run1