

R&D of Small Tile ECAL

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JINR, & DESY
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- Introduction
- Structure of small tile calorimeter
- Beam test at KEK
- Gain calibration
- Energy response linearity and resolution
- Position resolution
- Uniformity
- Small tile calorimeter of JINR
- Summary

Our Base-line design for LC calorimeter

Lead/plastic scintillator sampling calorimeter for both ECAL and HCAL

- Hardware compensation for excellent hadron energy resolution and linearity → Pb/Scinti = 4/1

Good energy resolution for single particle

$$\sigma E/E = 15\%/\sqrt{E} \text{ for ECAL}$$

$$\sigma E/E = 40\%/\sqrt{E} \text{ for HCAL}$$

- Good granularity

Fine transverse/longitudinal granularity for

“particle flow” analysis → 4cmx4cmx1mm tile

- Good hermeticity

- Established technology and Reasonable cost

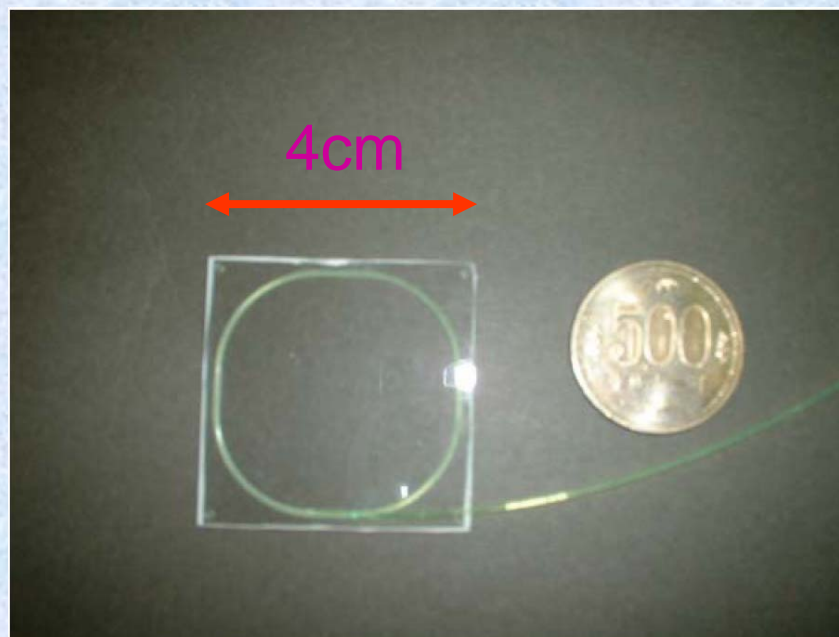
Separate tiles → Mega-tile

Purposes of test beam studies of Tile/fiber ECAL

Fully understand and establish design and performance of tile/fiber calorimeter

- Examine uniformity with staggered WLS layouts
- Energy resolution and linearity
- Position resolution
- Particle ID etc

Beam test was done in **this March 2004**.

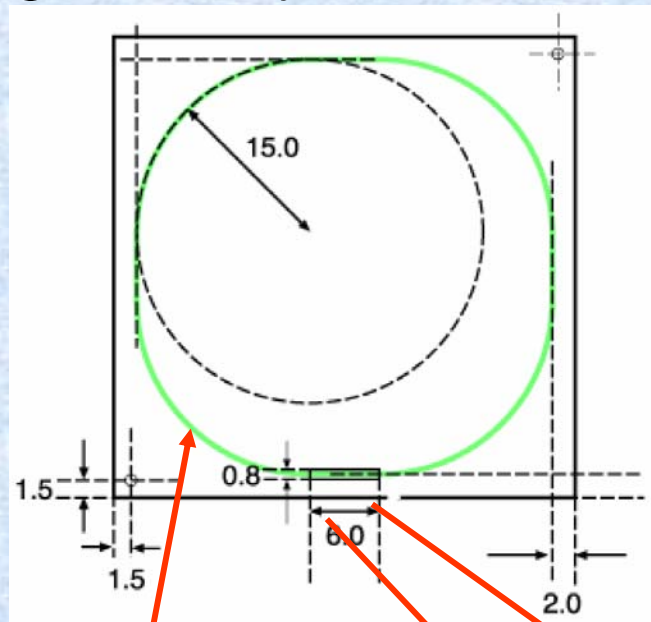


WLS fiber configuration

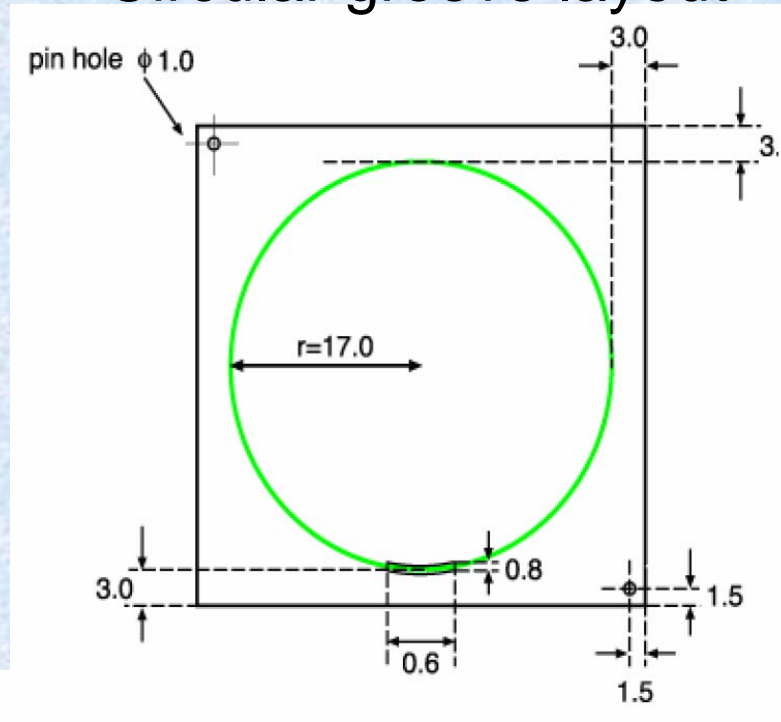
Two types of groove layout to smear non-uniformity

Separate tiles

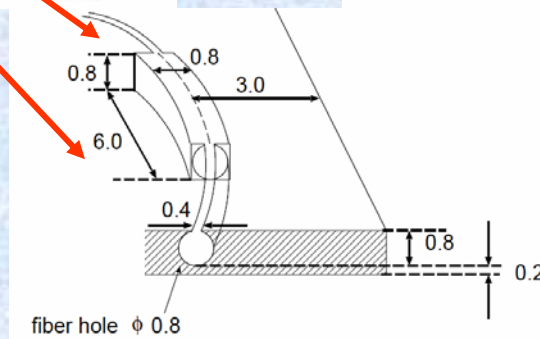
Roundish-square groove layout



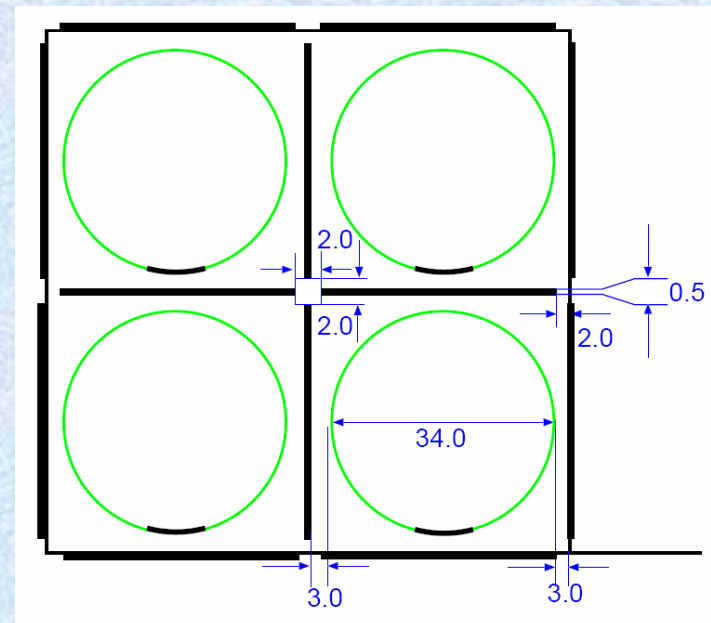
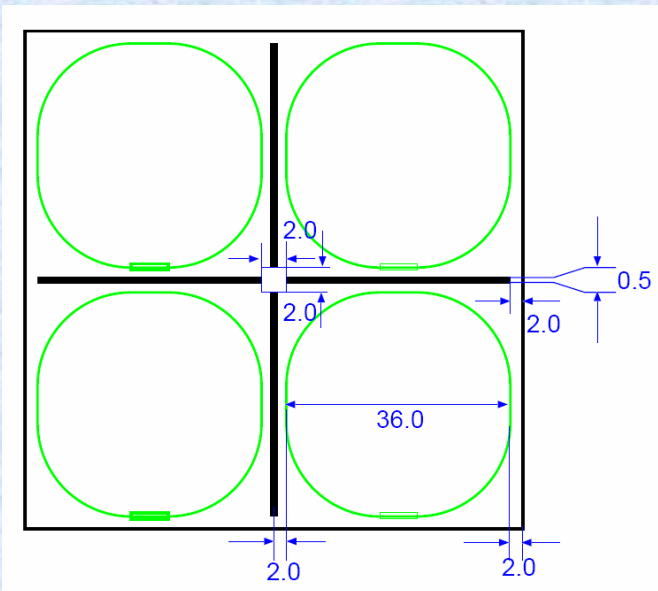
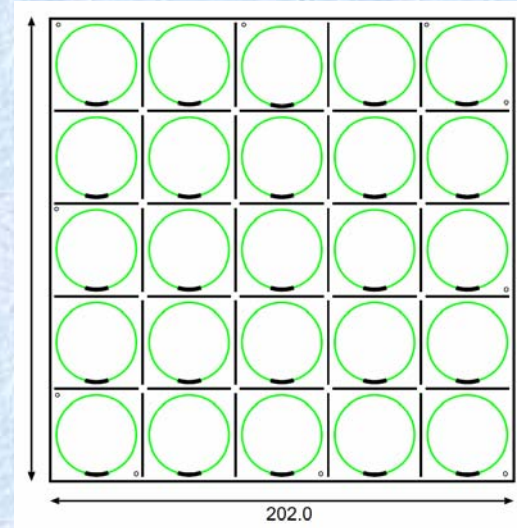
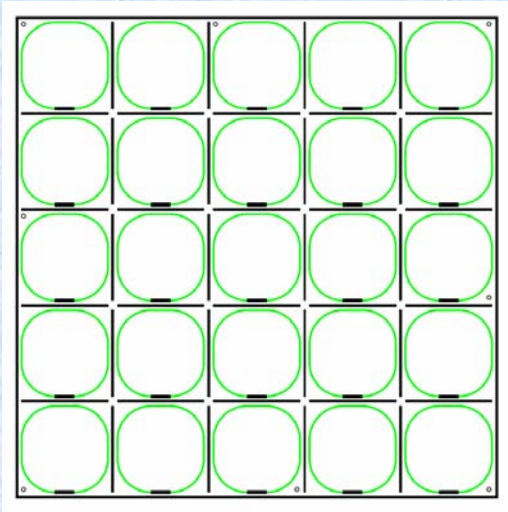
Circular groove layout



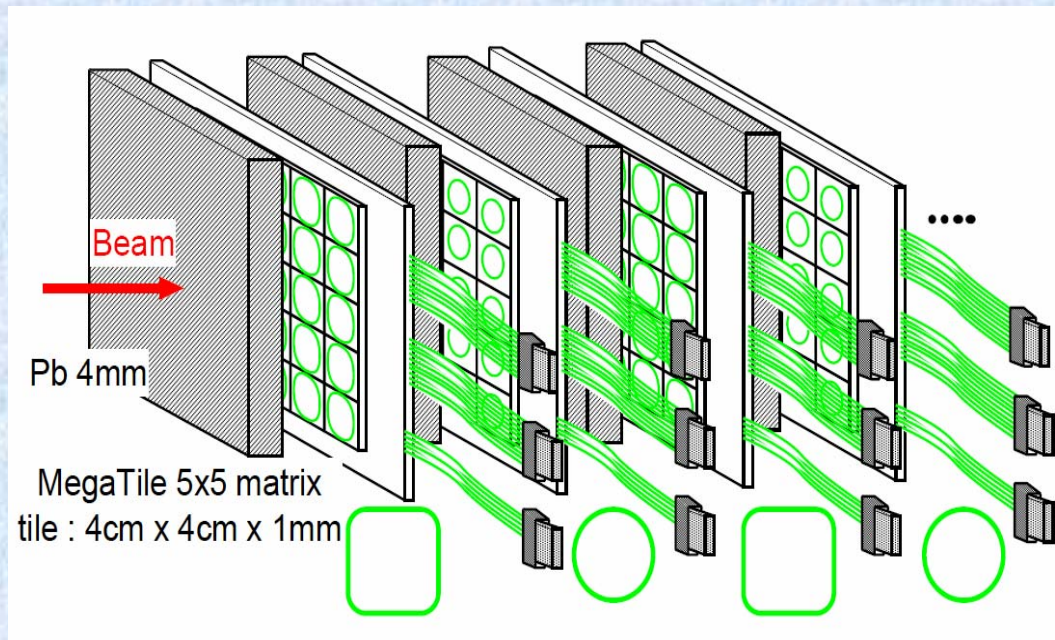
WLS: 0.7mmφ



Mega-tiles



Structure and readout of tile/fiber ECAL

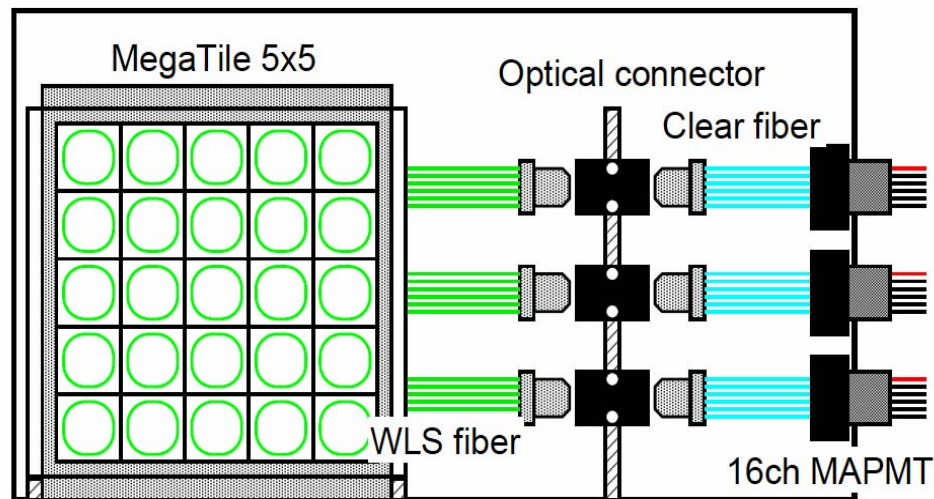


4 Layers = 1 Super Layer

6SL = 17 X_0

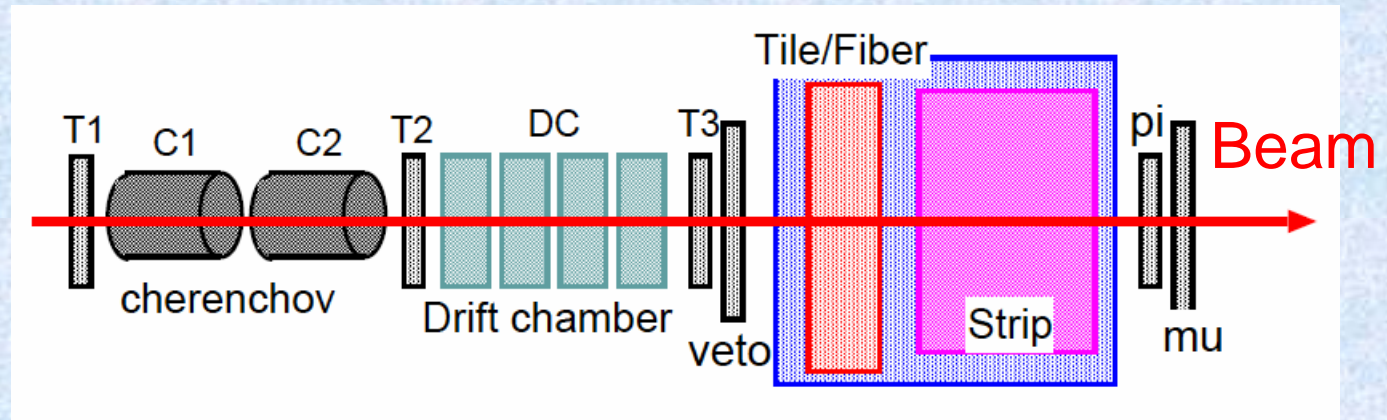
Total No. of R/O Ch:

$5 \times 5 \times 6 = 150$



(H6568)

Beam test
KEK PS
pi2

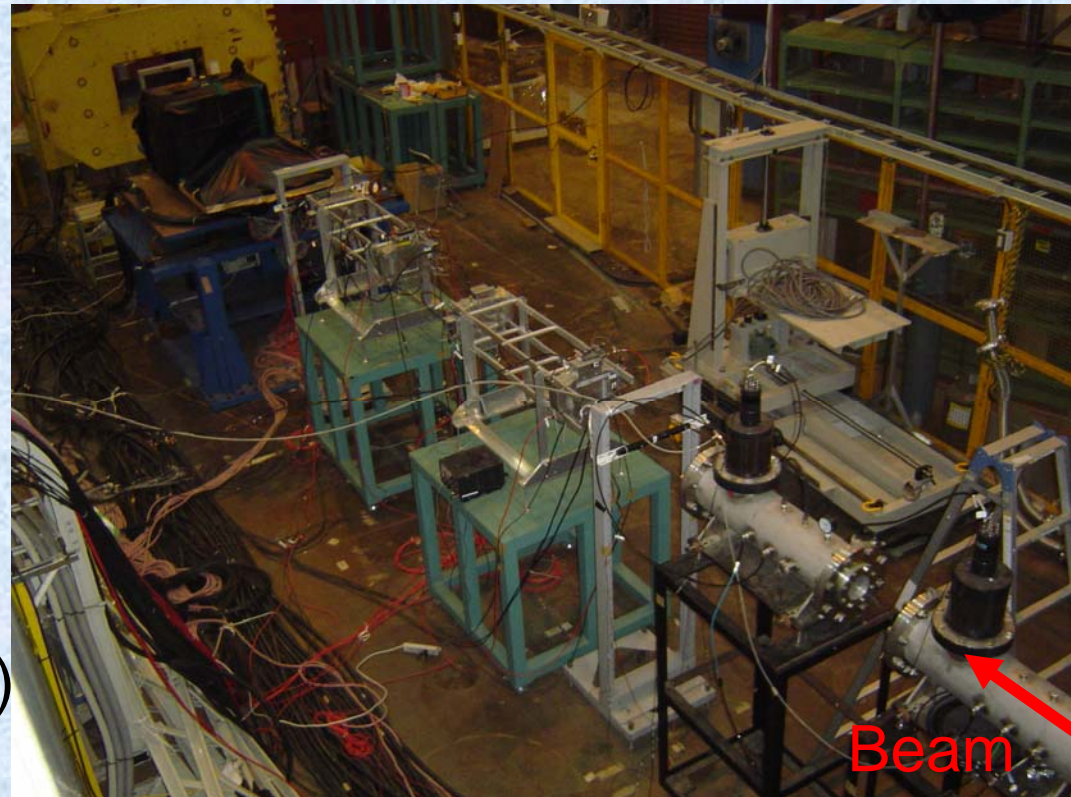


e, pi, mu: 1– 4 GeV/c
Electron-ID:

2 Cherenkov
counters

Tracking:

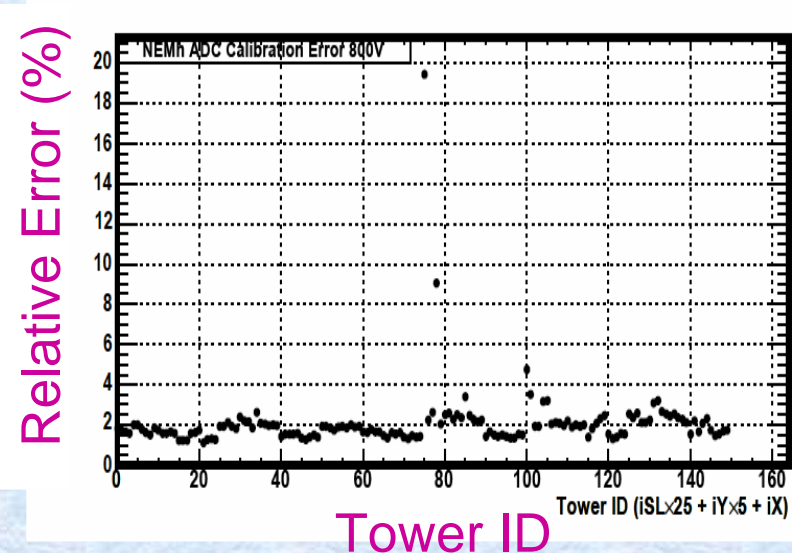
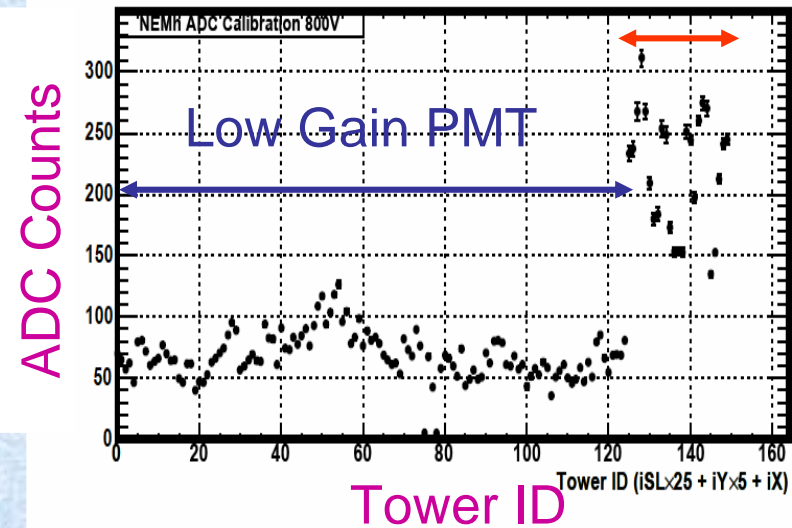
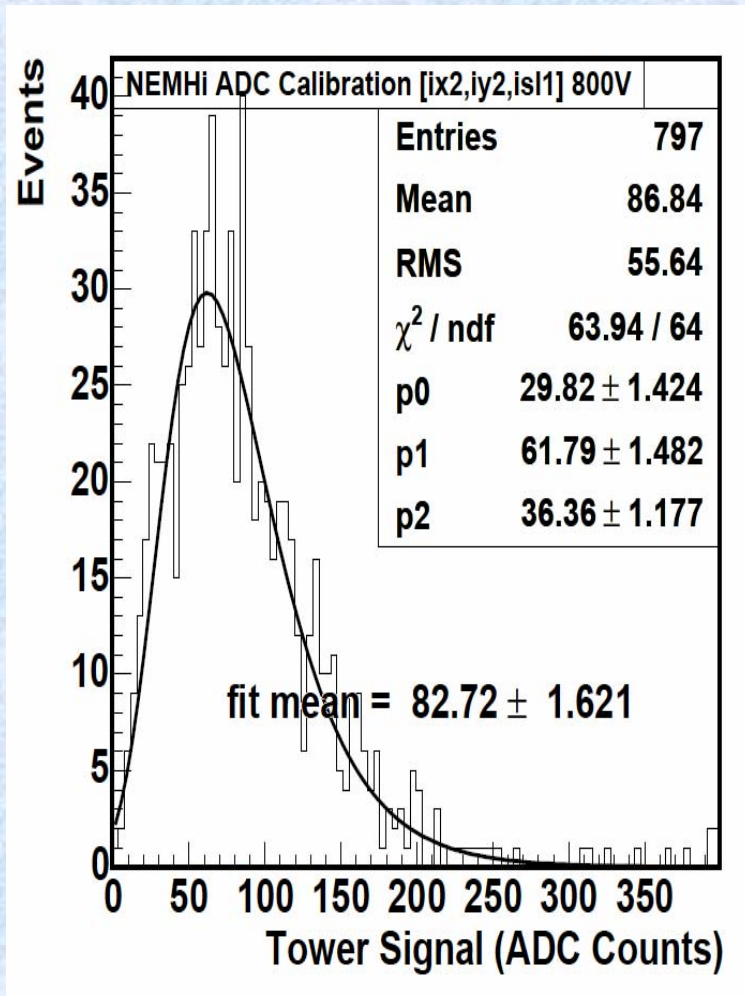
8 Drift chambers
(4X+4Y, $\sigma < 0.3\text{mm}$
at the ECAL surface)



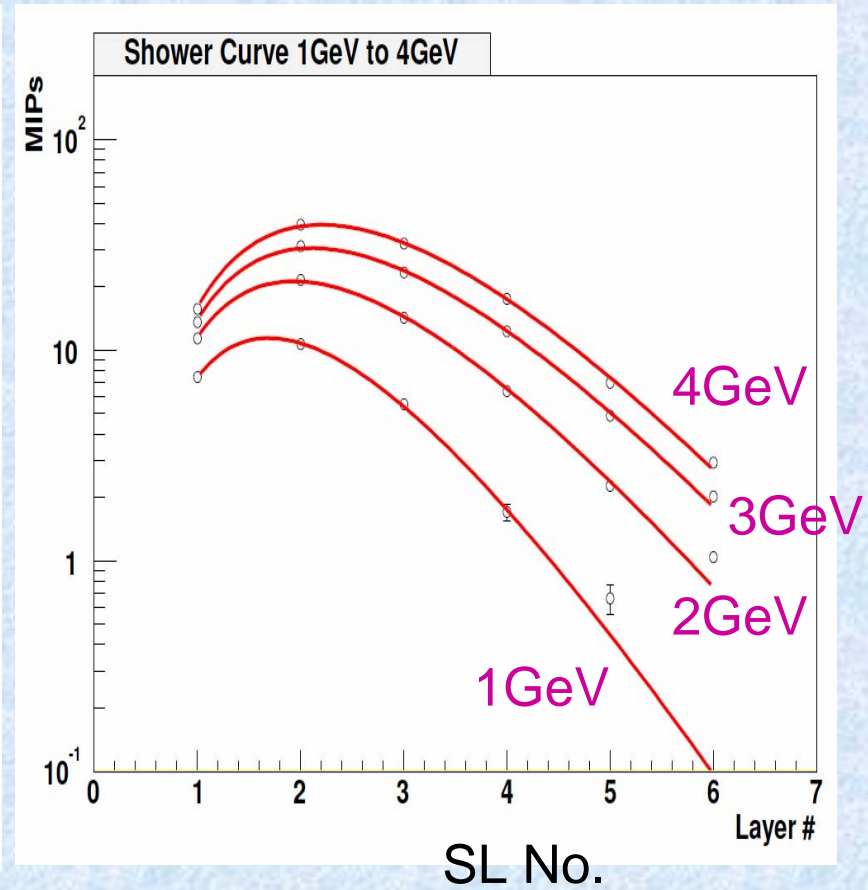
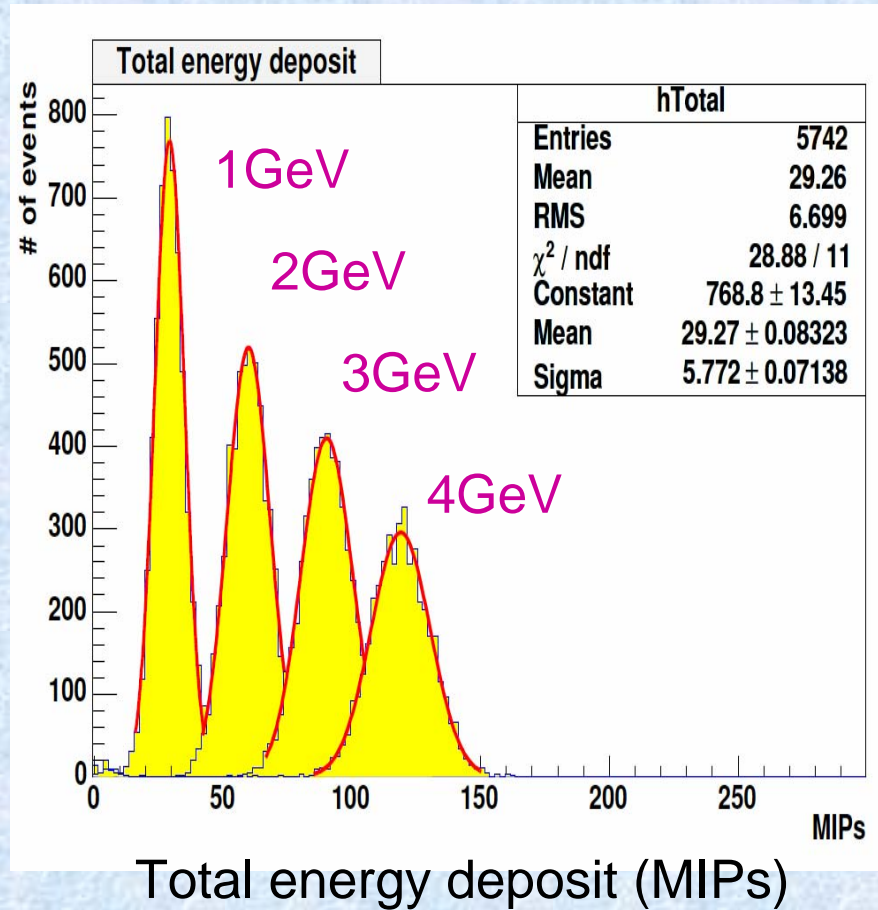
“Preliminary” Results of Data Analysis

Gain calibration with hadron events

High Gain PMT

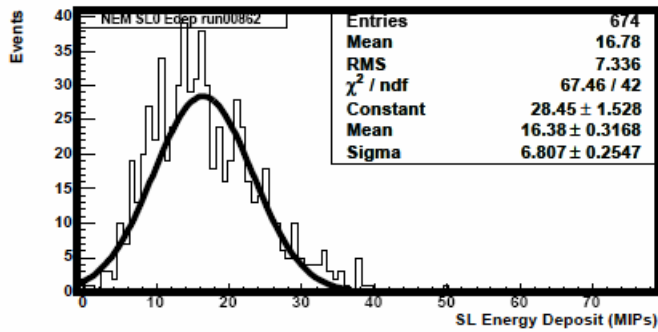


Total energy deposit & Shower curve

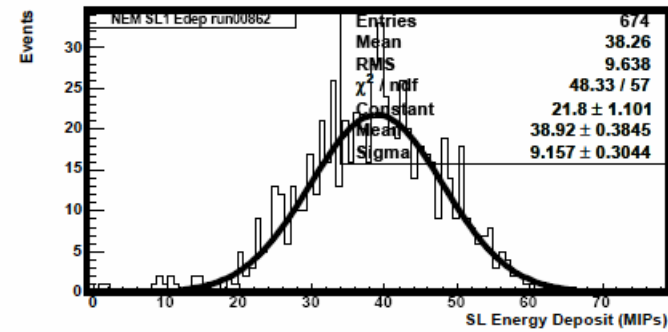


Energy deposits at each Super Layer (4 GeV e)

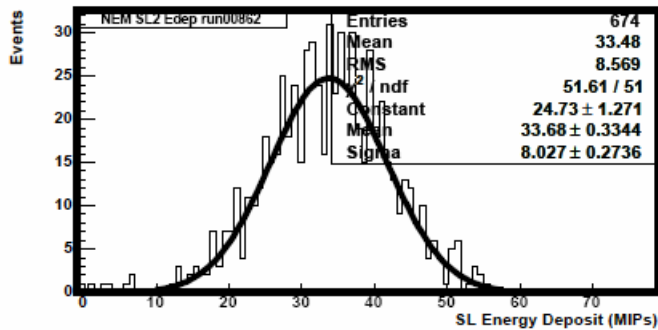
SL1



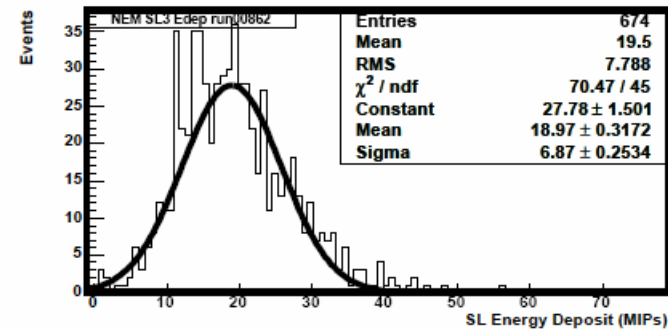
SL2



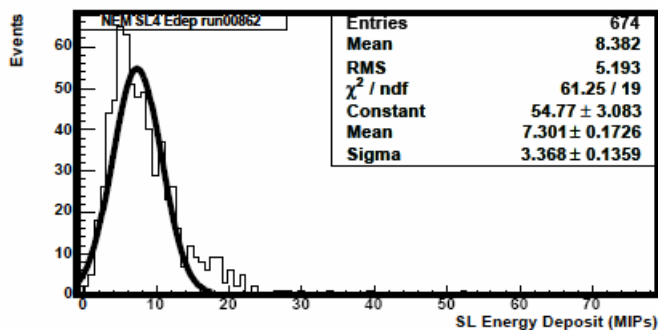
SL3



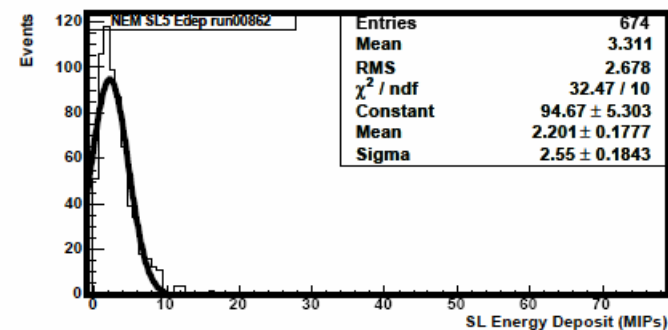
SL4



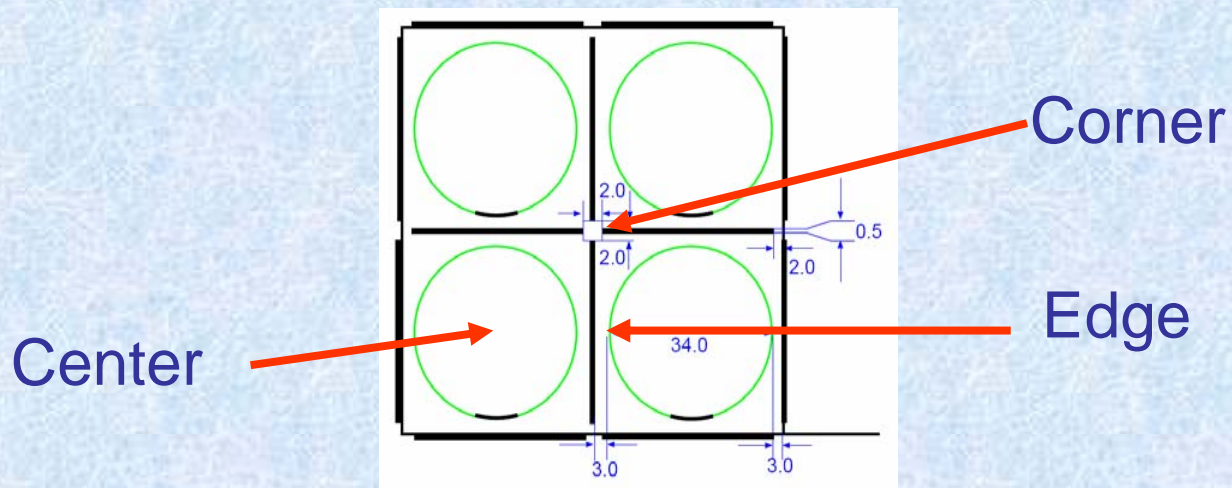
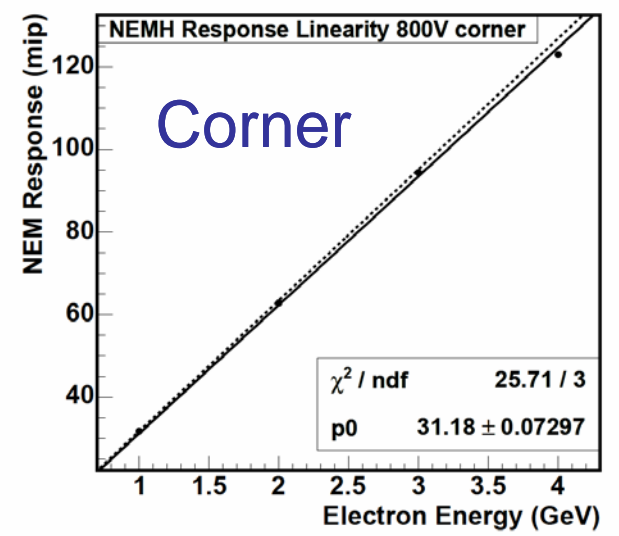
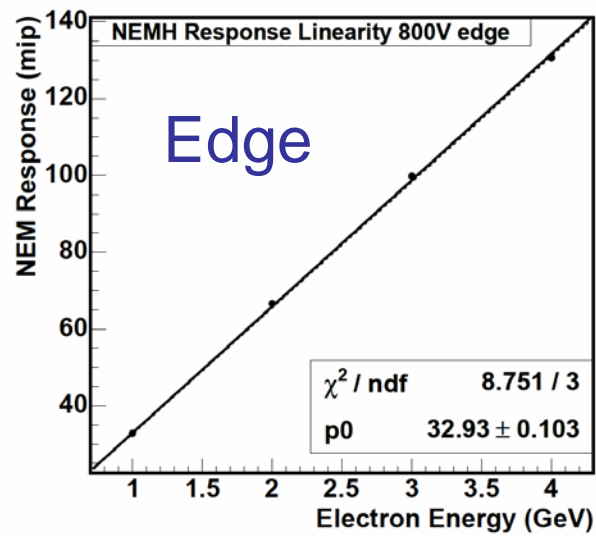
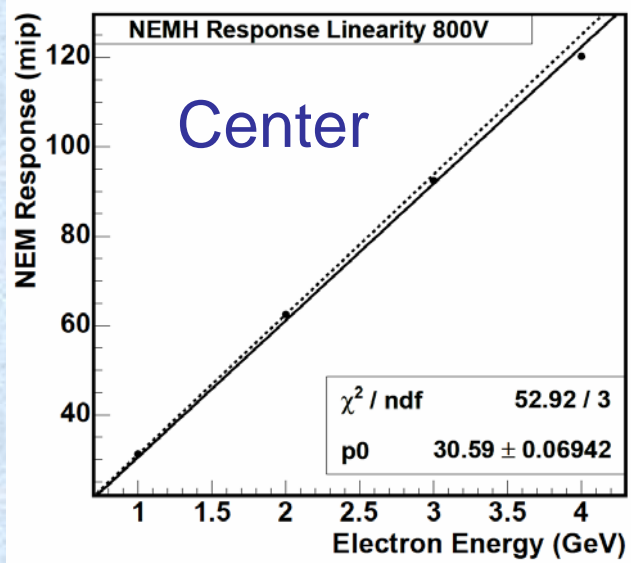
SL5



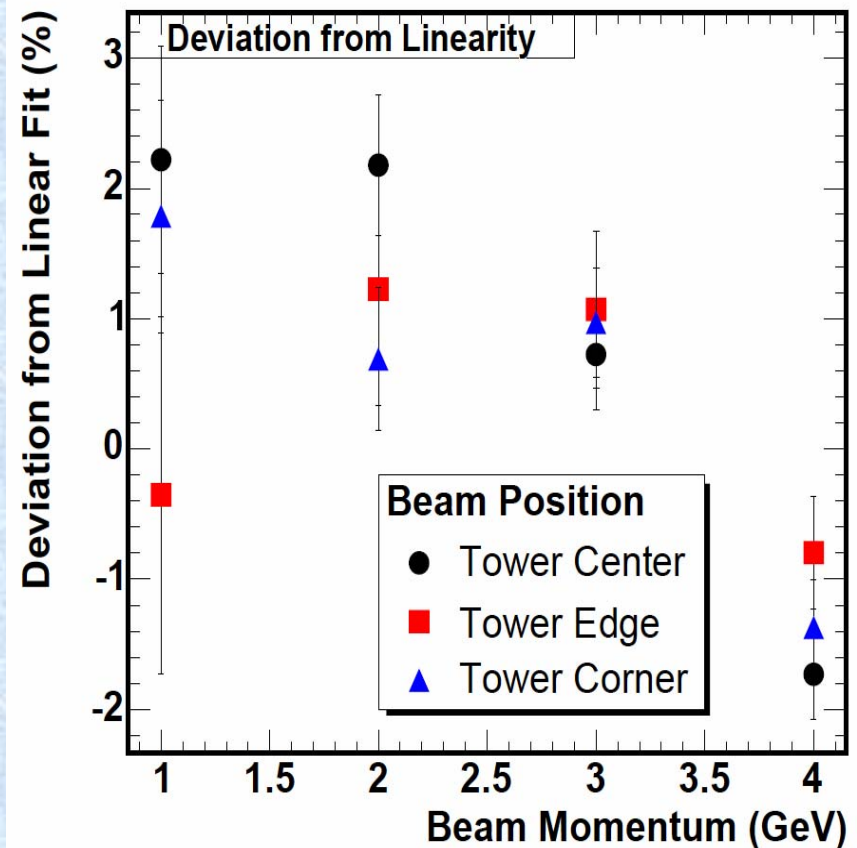
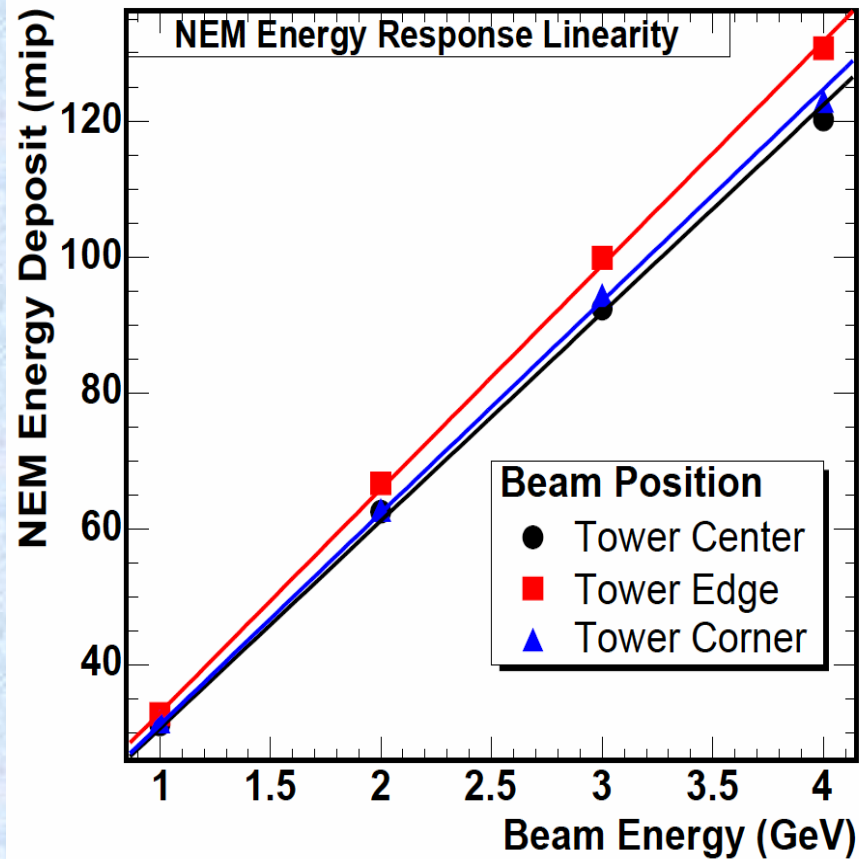
SL6



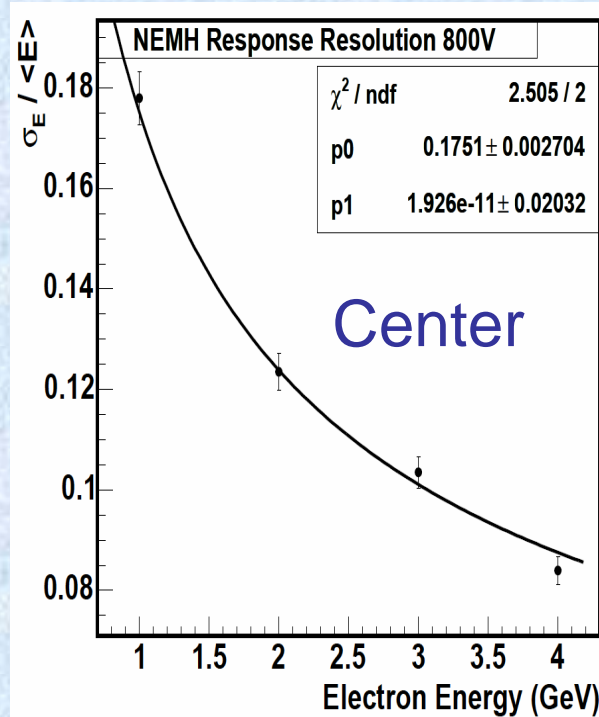
Energy Response Linearity



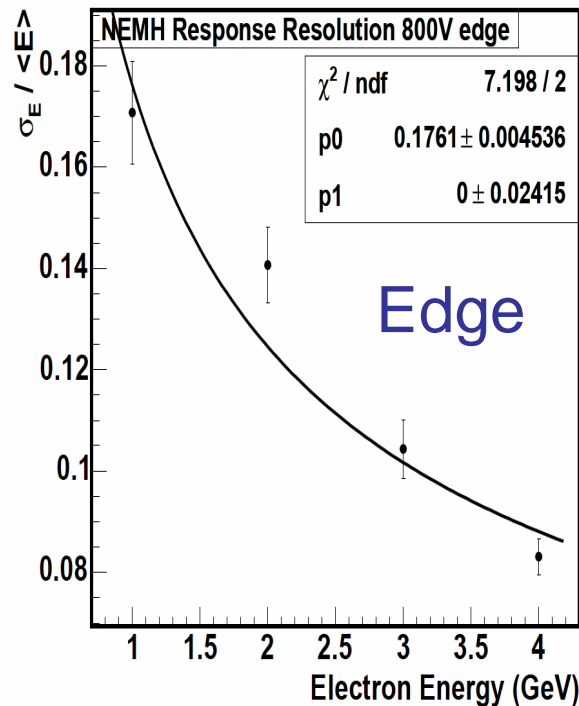
Energy Response Linearity (cont'd)



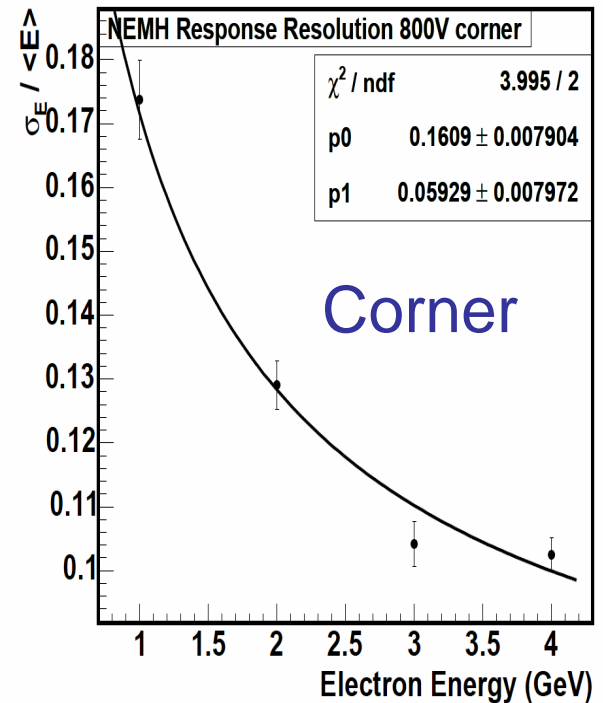
Energy resolution



$\sigma_{\text{stat}} = 17.5\%$



$\sigma_{\text{stat}} = 17.6\%$



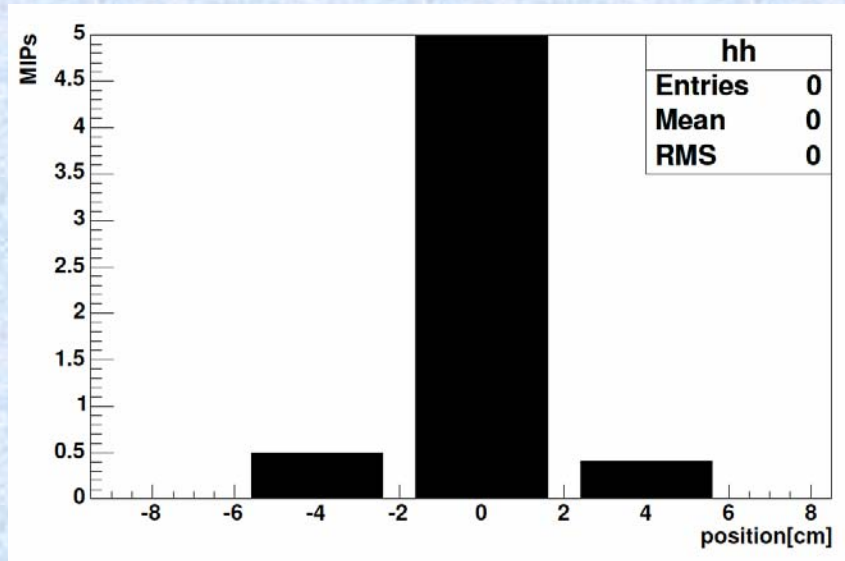
$\sigma_{\text{stat}} = 16.1\%$

$$\frac{\sigma}{E} = \frac{\sigma_{\text{stat}}}{\sqrt{E}} \oplus \sigma_{\text{const}} \quad (A \oplus B = \sqrt{A^2 + B^2})$$

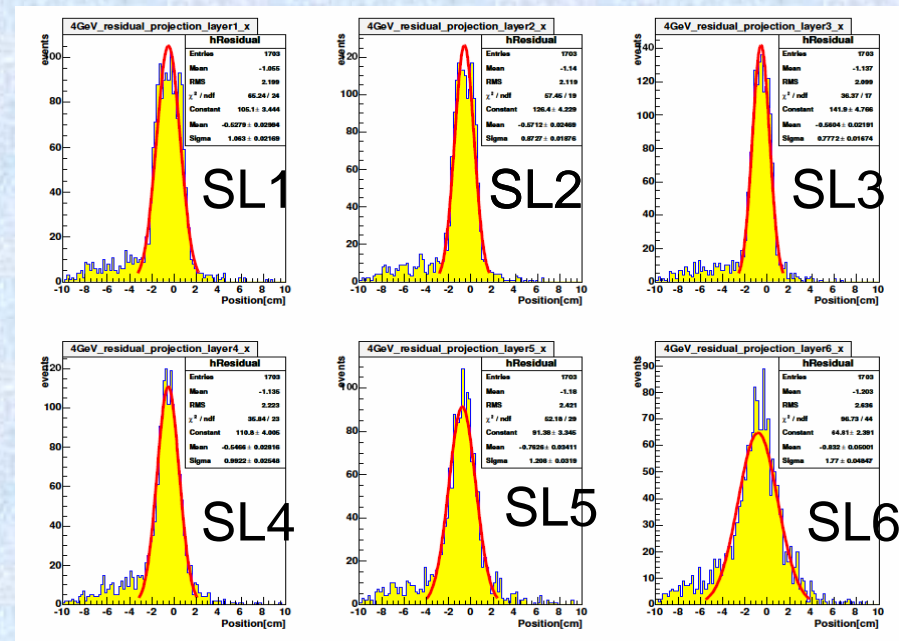
Position resolution

1. Center of gravity position from ECAL towers (Xcal)
2. True hit position from Drift Chamber (Xdrif)
3. Residual distribution ($X_{res} = X_{cal} - X_{drif}$)
4. Position resolution : (σ_x of residual distribution)

Typical electron signal from tiles (1 event)

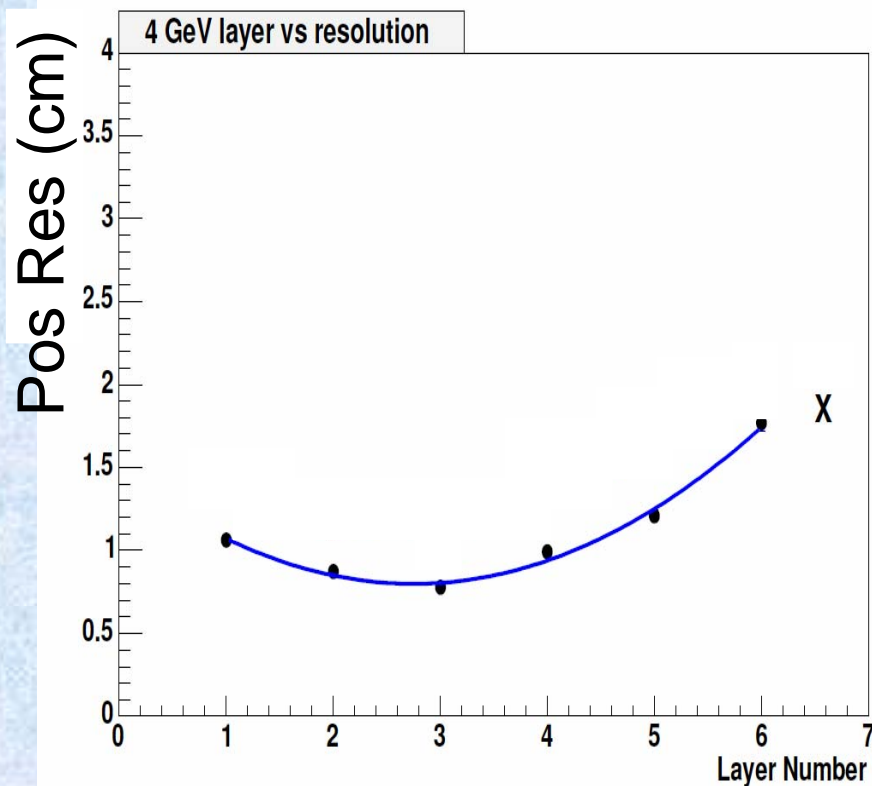


Residual distribution

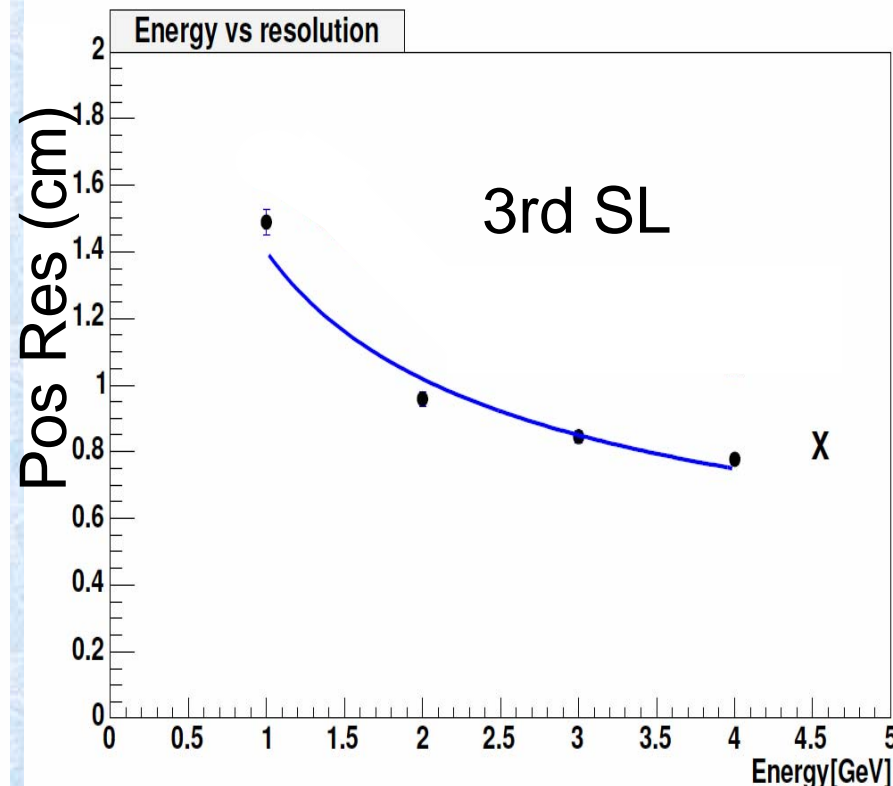


$$X_{res} = X_{cal} - X_{drif}$$

Position resolution vs. SL No. & Energy



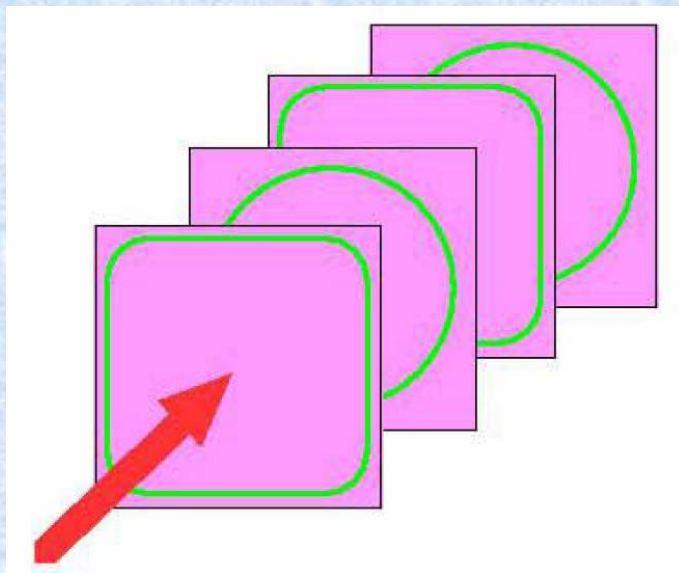
SL No.



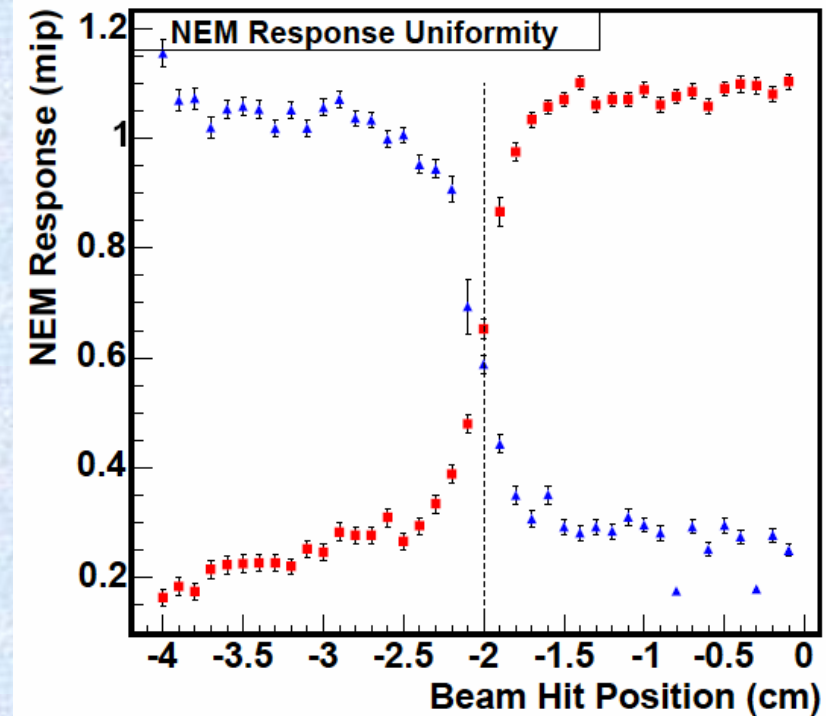
Energy (GeV)

Non-uniformity measurements (Uniformity mapping)

Better uniformity with
alternating layout



X-uniformity scan across
the edge of the tile
(5mmx1mm mesh)

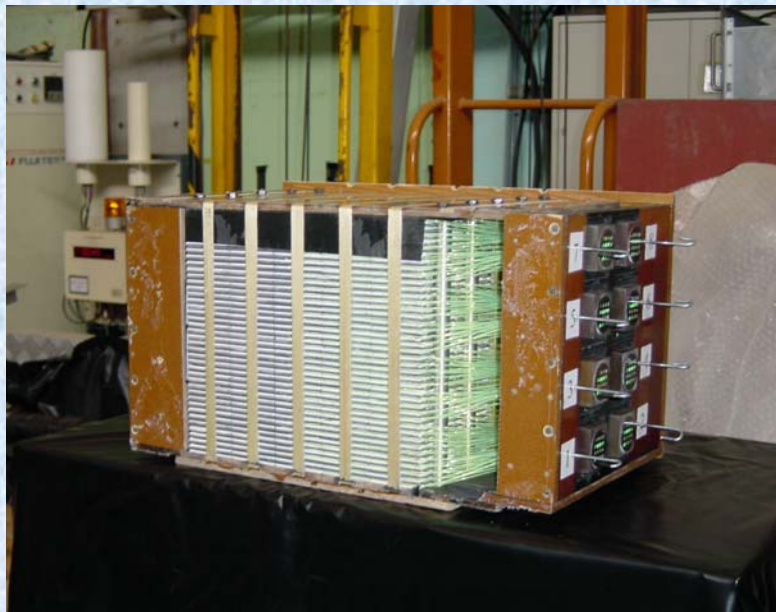


International Collaboration



JEM (JINR EMcal)

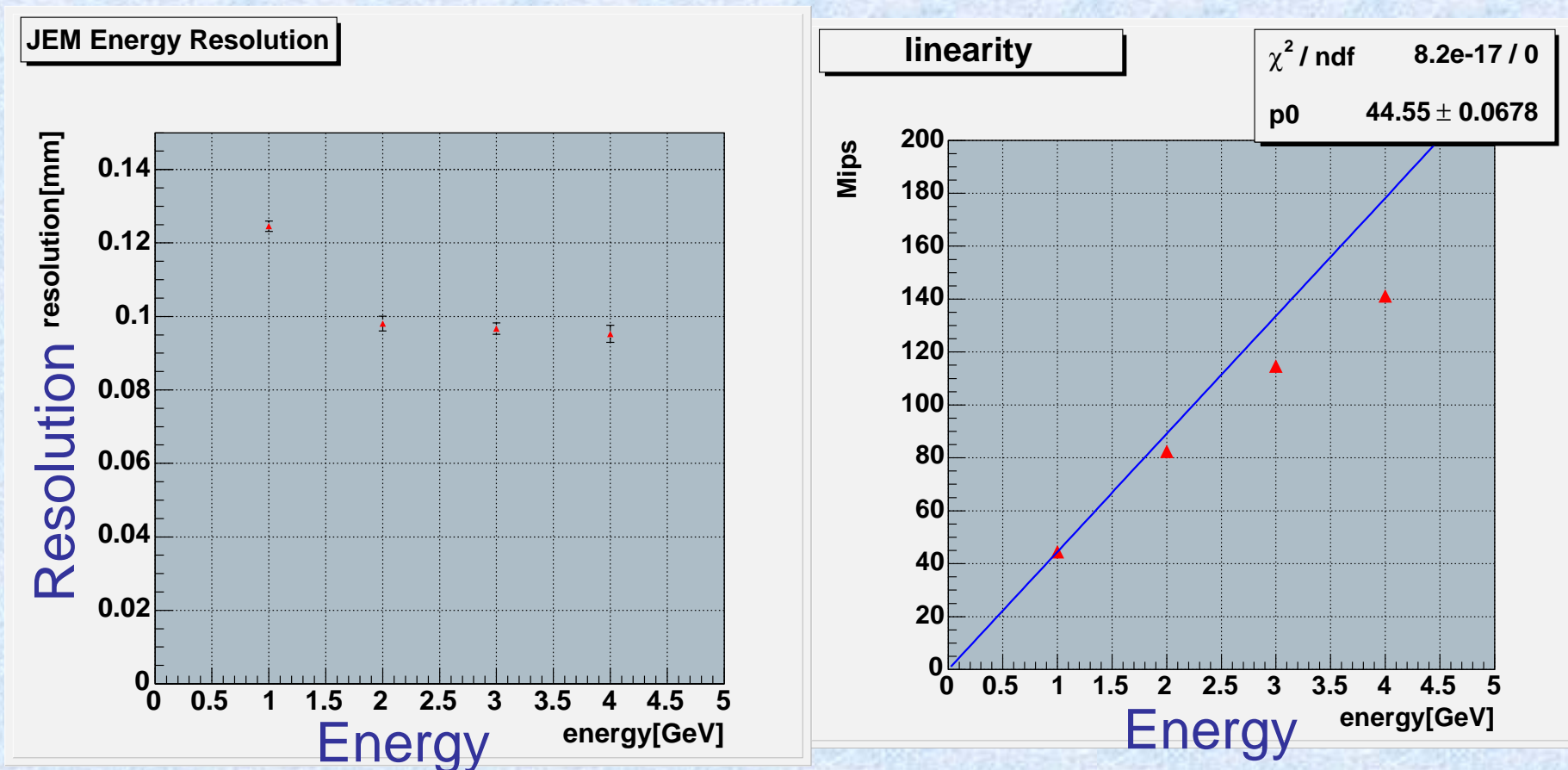
- R&D on Scinti-tile production based on MoU between JINR and KEK
- An EMcal test module made at JINR: similar design, but some differences:



- Scintillator material: made by JINR
- Tiles are made with pressure molding: good accuracy
- WLS fibers glued to rectangular grooves:
- Thinner Pb plate (2mm-thick) : total thickness = $14.4 X_0$

JEM was also tested at KEK:
Detailed analysis and comparison are to be performed.

JEM resolution and linearity



- Resolution for 1 GeV electron is 12.5%, but
- Longitudinal shower leakage (c.f. $14.4X_0$) degrades energy resolution and linearity above 2 GeV.

Comparison of Calorimeter Resolution

Cal Name	Pb t	Sci t	E Res	
Tile Cal (NEM) Preliminary	4mm	1mm	17%	V.
Tile Cal (JEM) Preliminary	2mm	1mm	12%	V.
Strip Cal (TEM)	4mm	4mm	13%	Preliminary

1. $JEM = NEM / \sqrt{2}$
2. TEM \longleftrightarrow NEM : Photo Electron Statistics

Summary

1. Beam test has been done in **this March at KEK** with International collaboration, in order to fully understand and establish design and performance of **tile/fiber calorimeter**.
2. Very preliminary analysis showed reasonable results on
Energy Response Linearity, Energy resolution,
Position resolution
for both Japanese and Russian Calorimeters.
3. We could get reasonably uniform response at the tile edge.
4. Detail analysis including particle ID performance will be done in several months.

おしまい