EM-CAL beam test at KEK

Tohru Takeshita (Shinshu University)
for the JLC-CAL group
(KEK,Kobe,Konan,Niigata,Shinshu and Tsukuba)

introduction
beam test at kek
results
summary and plans

Introduction

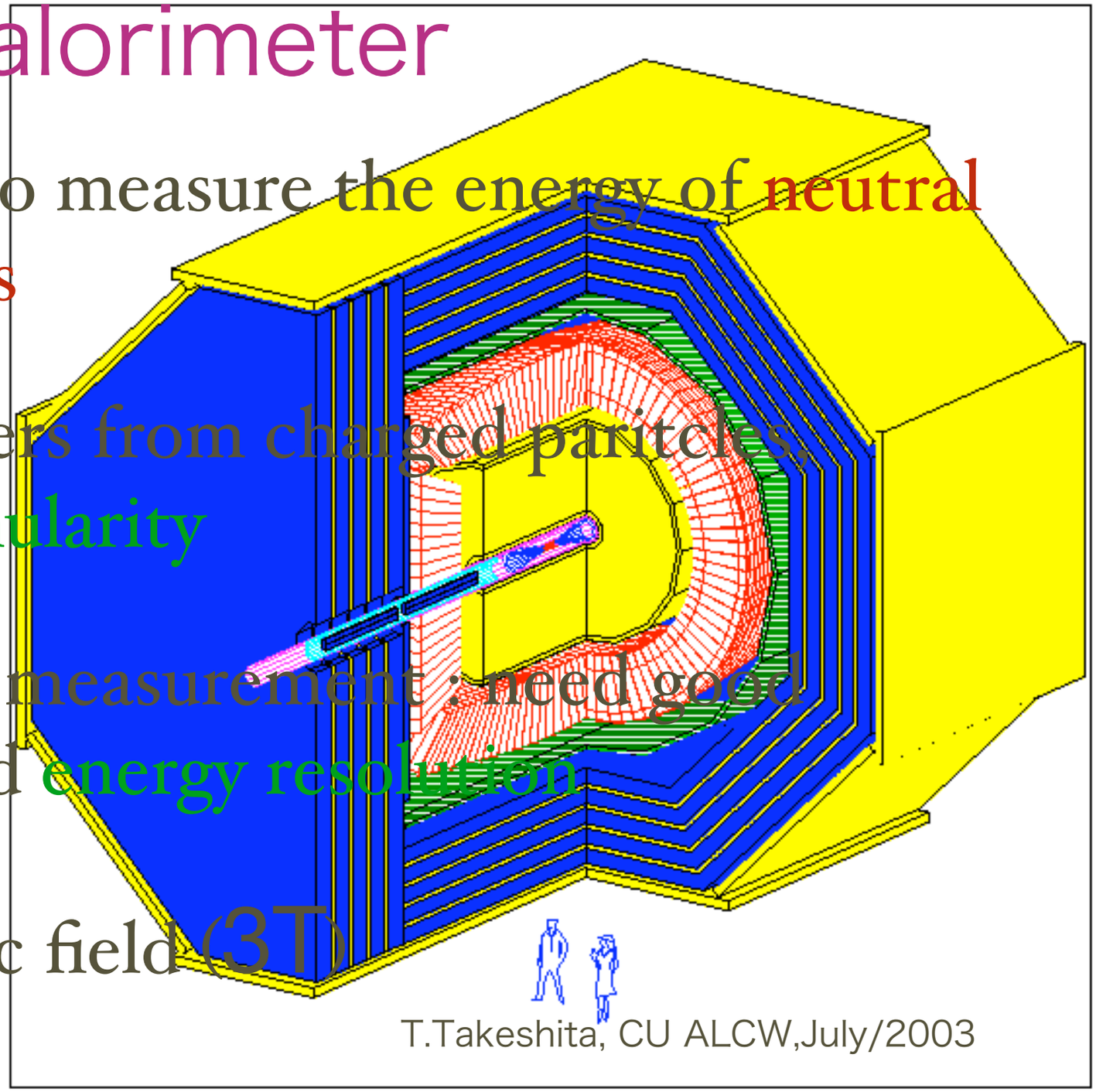
For the future linear collider calorimeter

- calorimeter is to measure the energy of neutral particles in jets

- eliminate clusters from charged paritcles.
  : need fine granularity

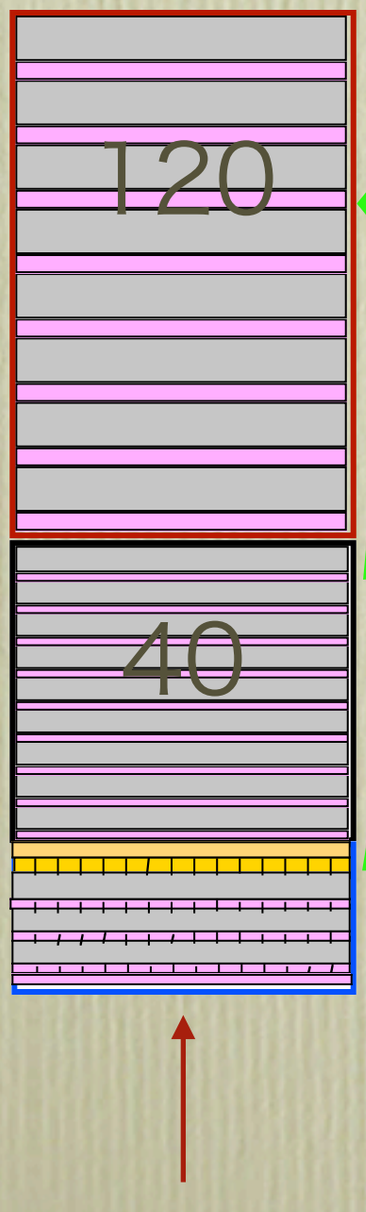
- missing energy measurement ; need good hermeticity and energy resolution

- In the magnetic field (3T)



Detector Design

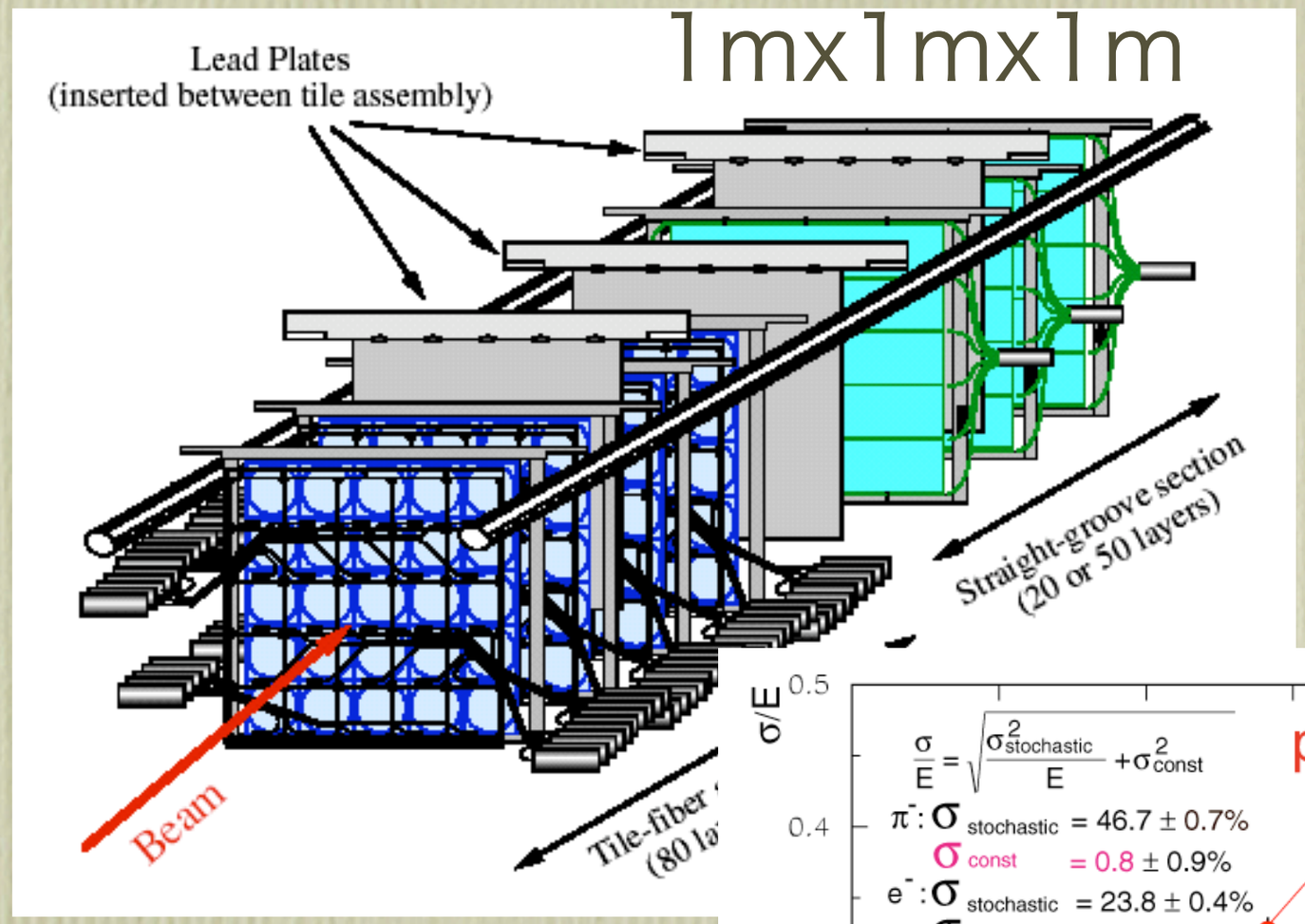
Base line Idea: sandwich calorimeter of plastic scintillator with Hardware compensation



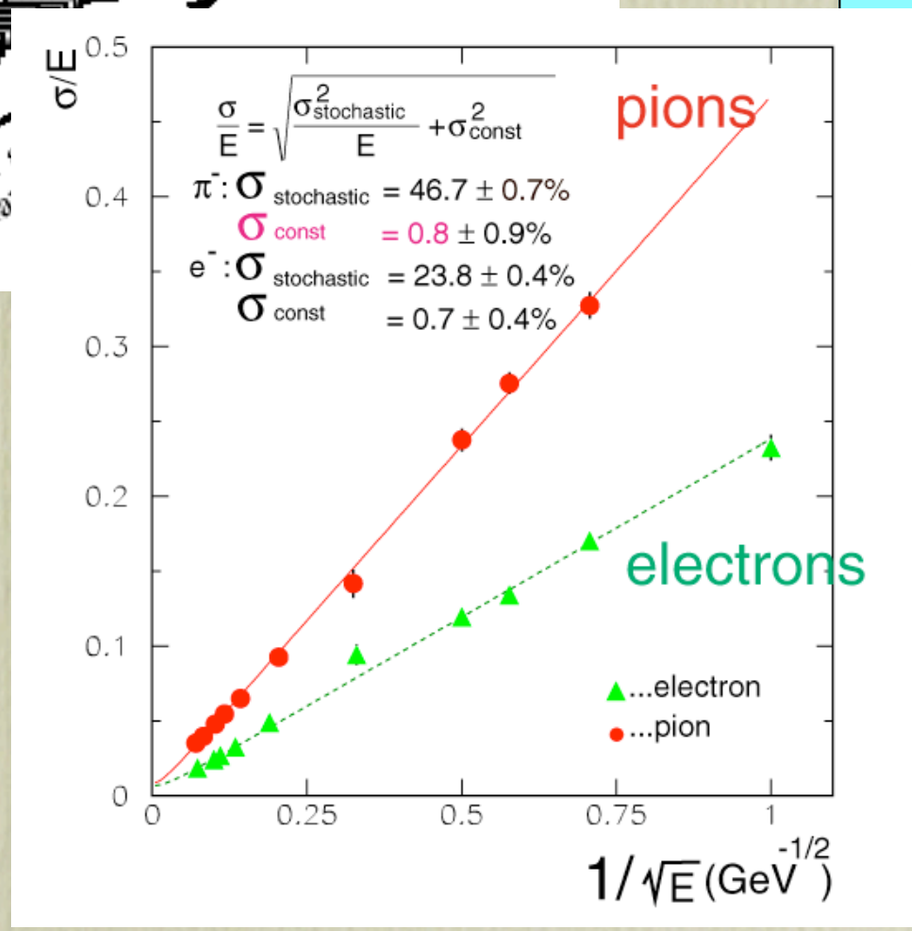
- Hadron cal.: Tile/Fiber of 20cm x 20cm x 2mm-t Pb:8mm
- EM cal.: Tile/Fiber of 4cm x 4cm x 1mm-t or Strip array (x,y) of 1cm-width and 2mm-t Pb:4mm
- Shower Max. detector : Strip-array with fiber readout or direct attached APDs

Tile-Hadron Calorimter

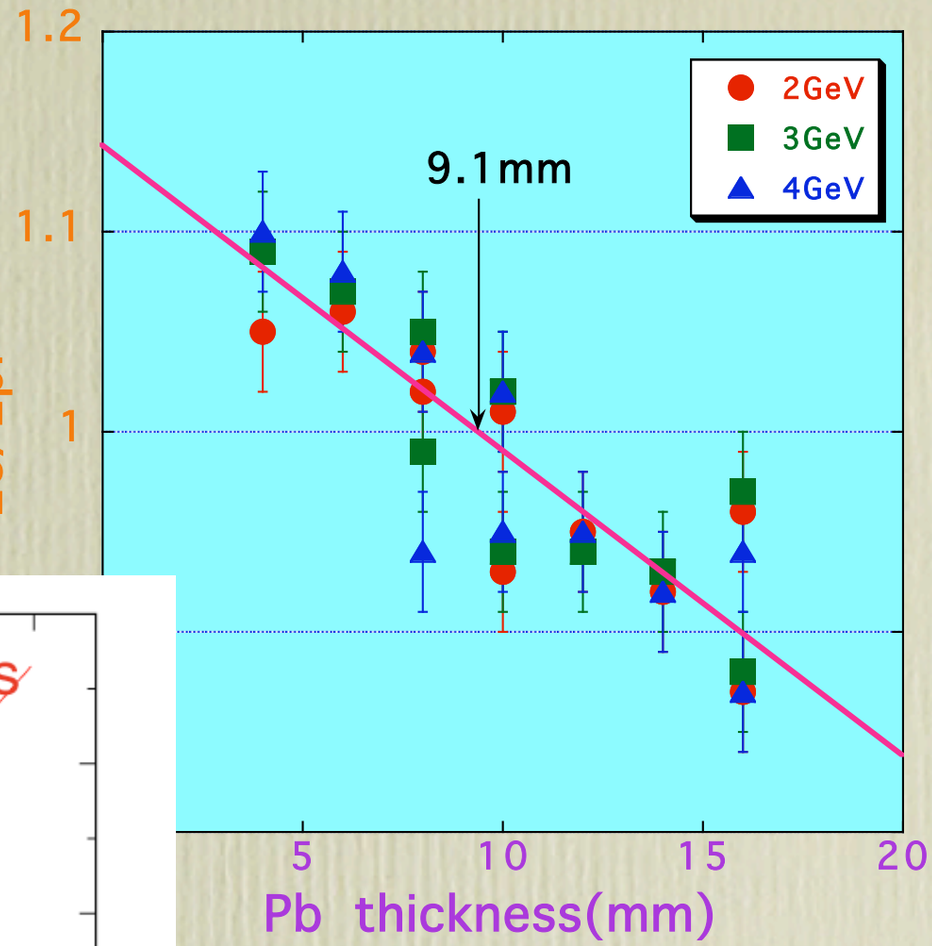
1mx1mx1m



8mmPb+Plastic scinti. 2mm



2mm scintillator



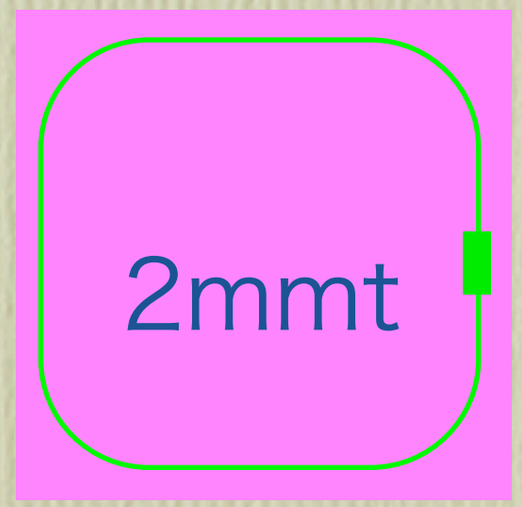
compensating

'98-'00

T.Takeshita, CU ALCW,July/2003

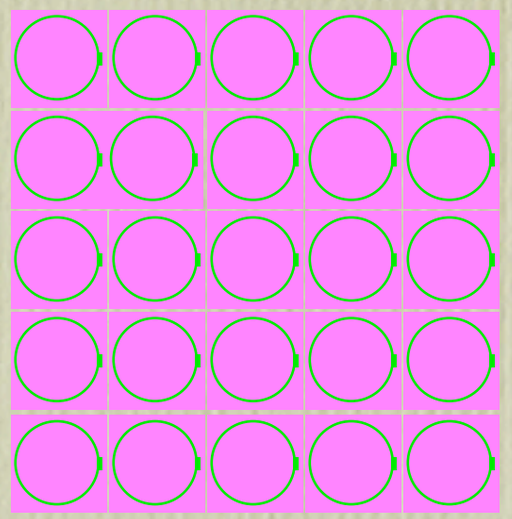
EM-Calorimeter

Hadron Tile



20cmx20cm

EM Tile EM-Tile-cal.

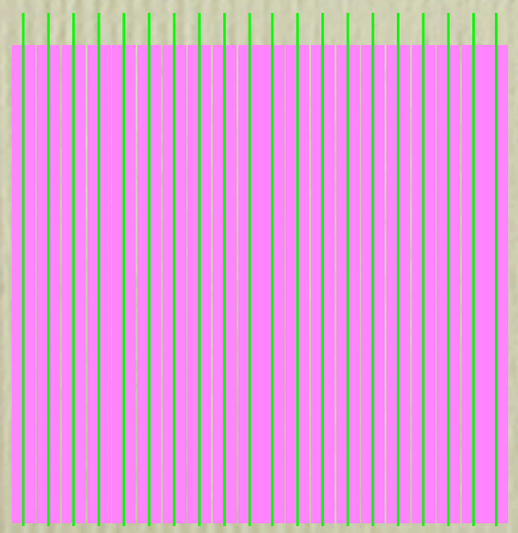


4cmx4cm 2.2pe/MIP/tile

1mmt compensation

+4mmPb

EM Strip

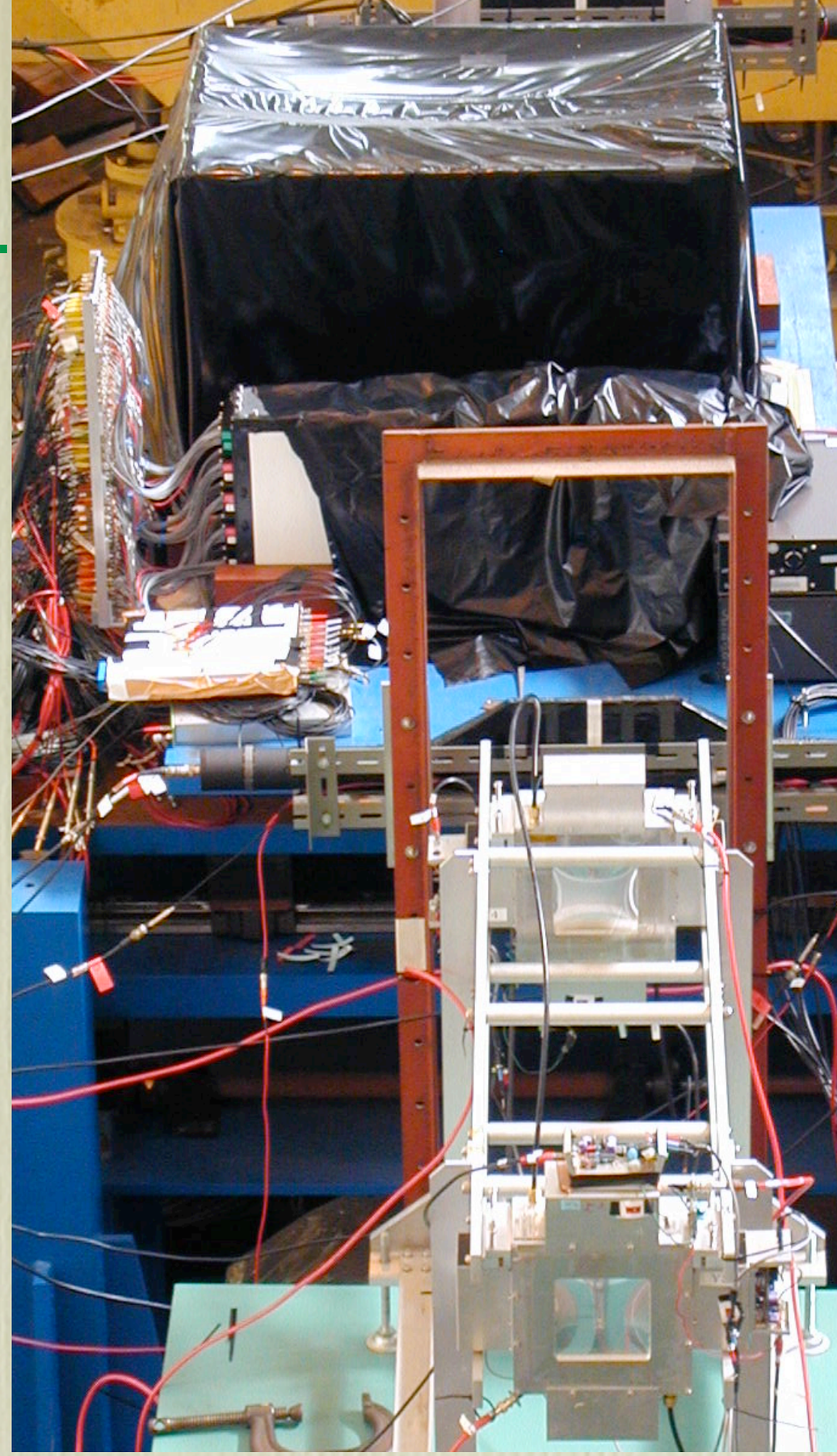


1cmx20

EM-Strip cal.

4pe/MIP/strip

2mmt +4mmPb



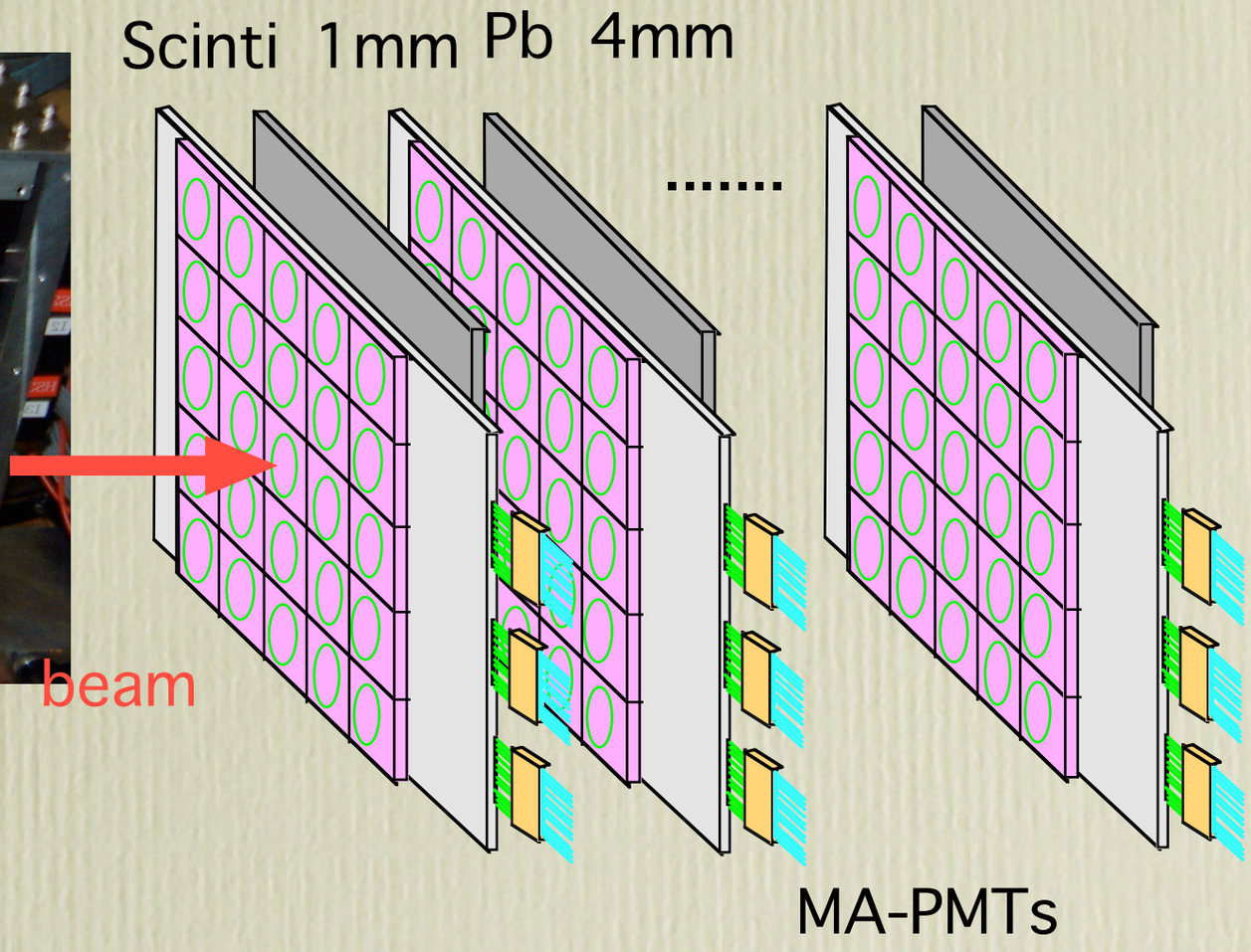
T.Takeshita, CU ALCW,July/2003

EM Tile-cal. tested at the beam

structure

1layer=4cmx4cmx1mm Tiles x 25 + 4mmPb

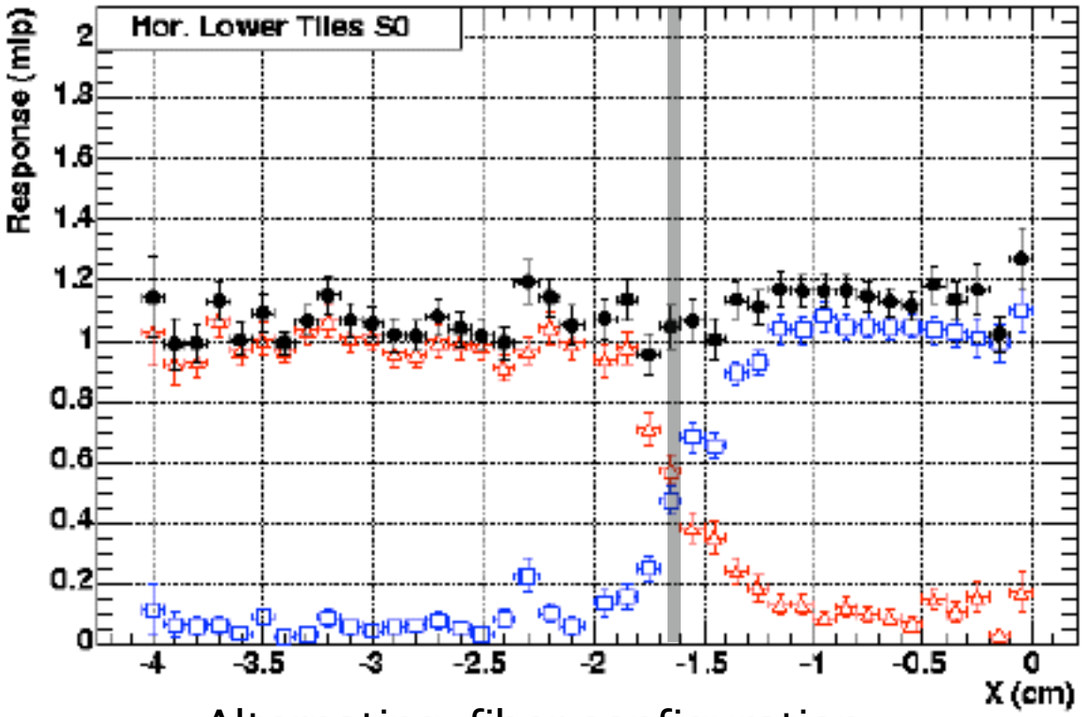
2 Super Layers (7.1X_0) 5layers=1SL



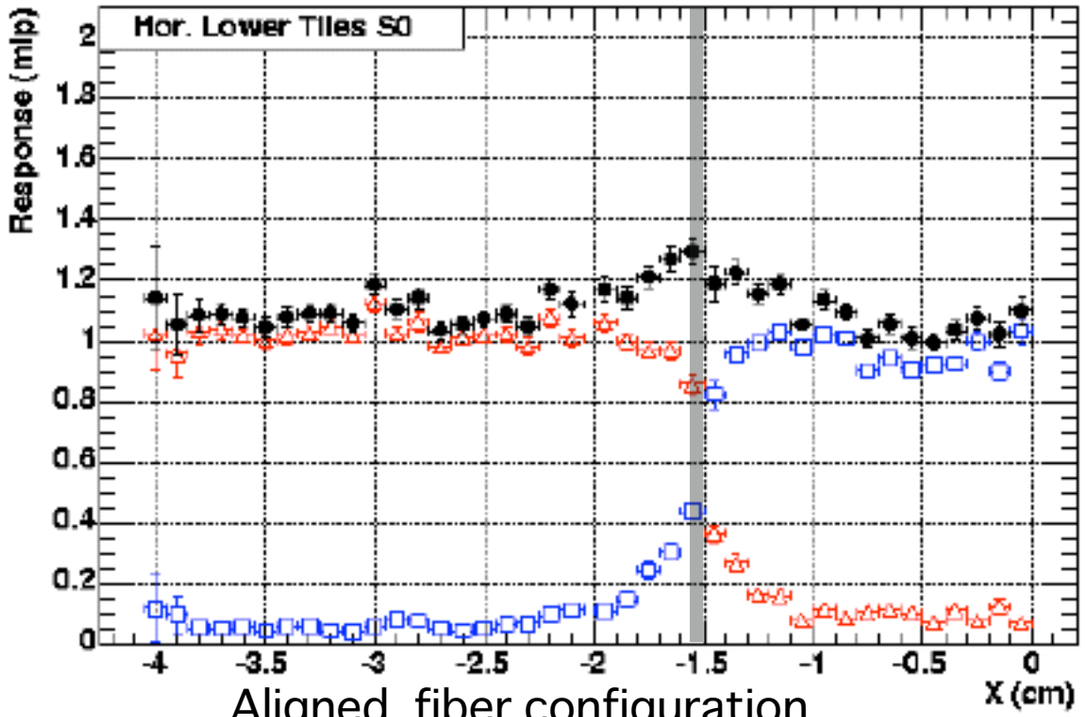
EM Tile-cal. tested at the beam

response around the tile boundary

Alternating WLS for 1SL Aligned WLS

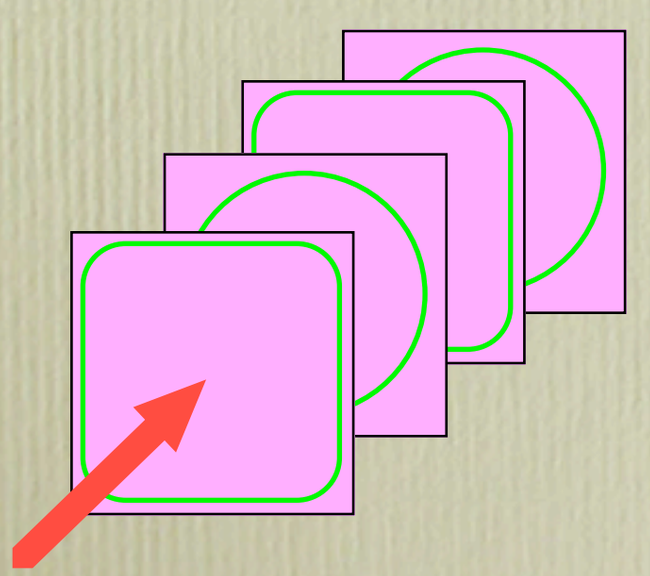


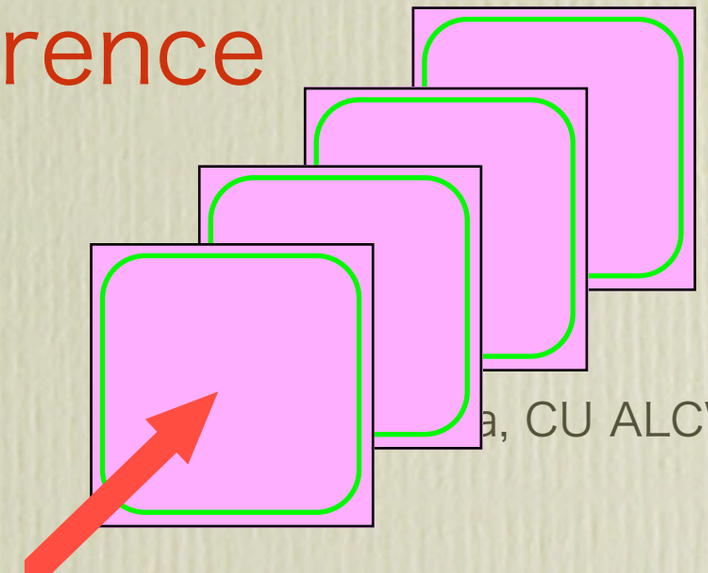
Alternating fiber configuration



Aligned fiber configuration

no big difference

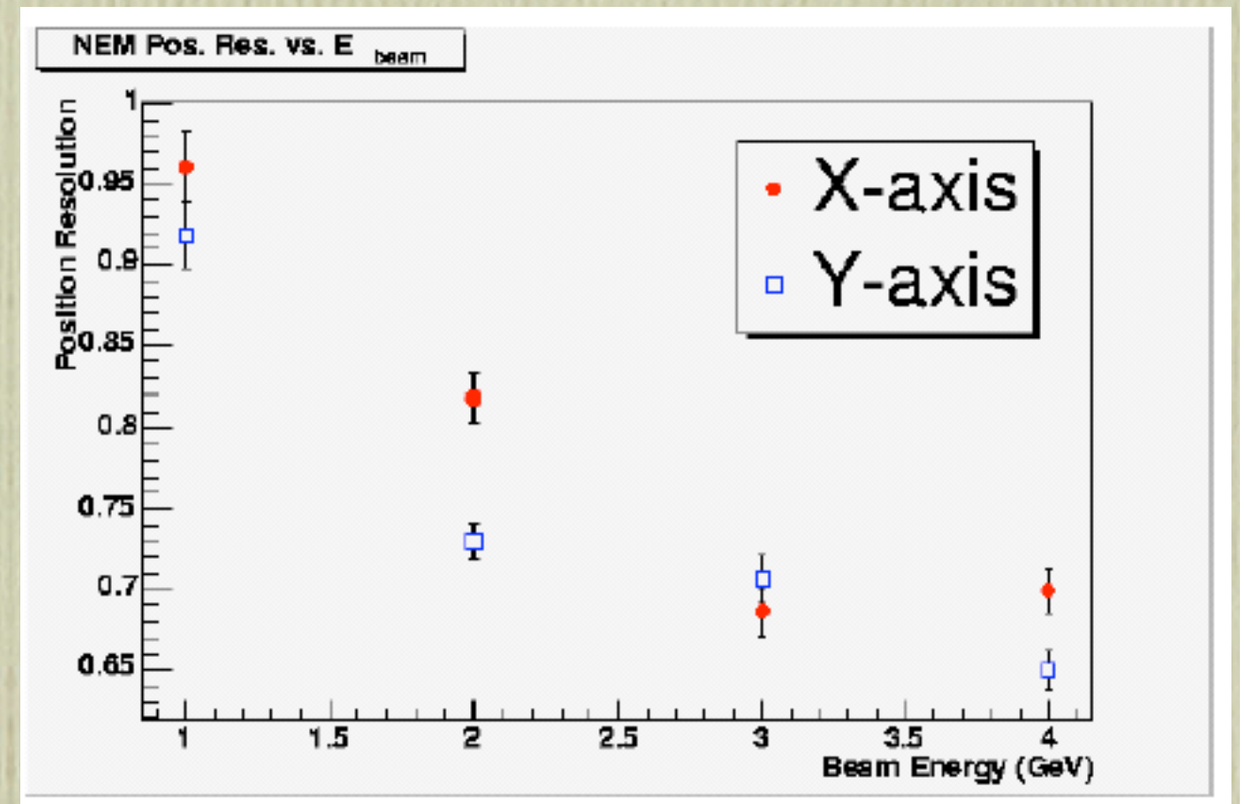




a, CU ALCW,July/2003

EM Tile-cal. tested at the beam

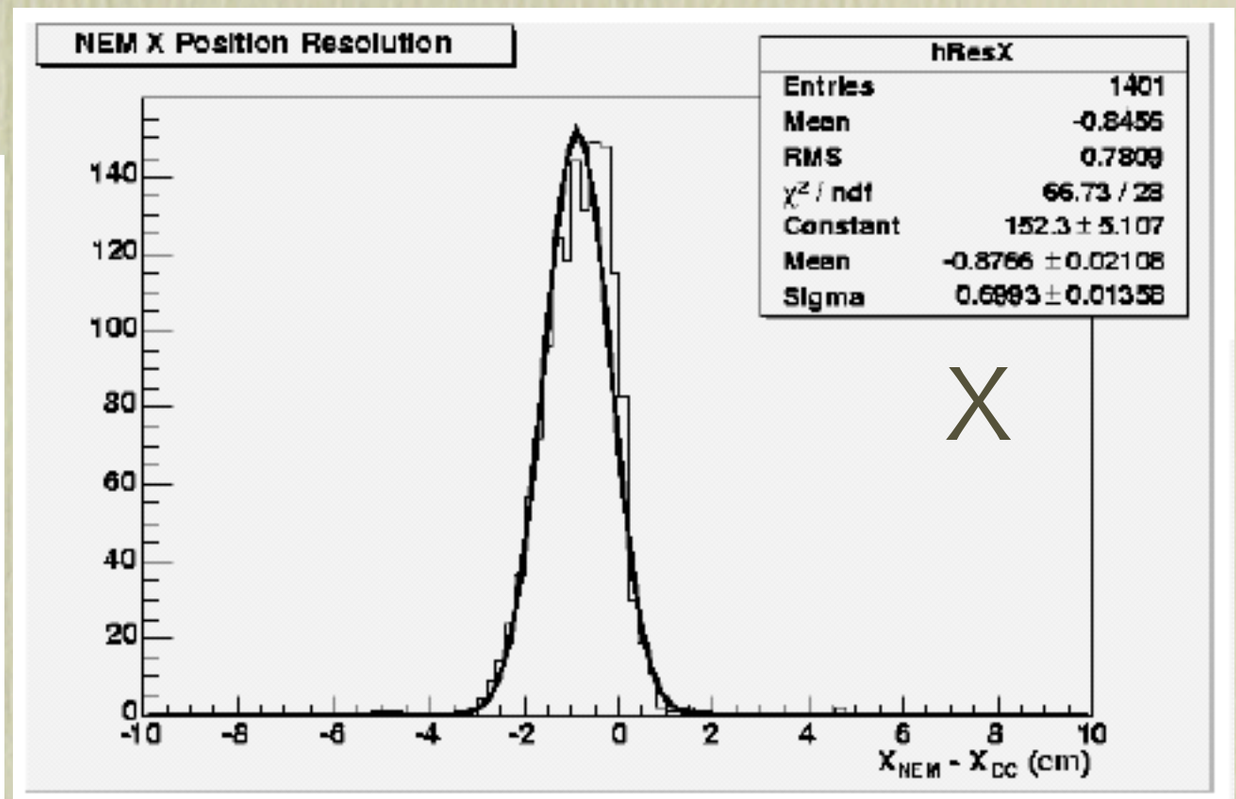
Spatial resolutions

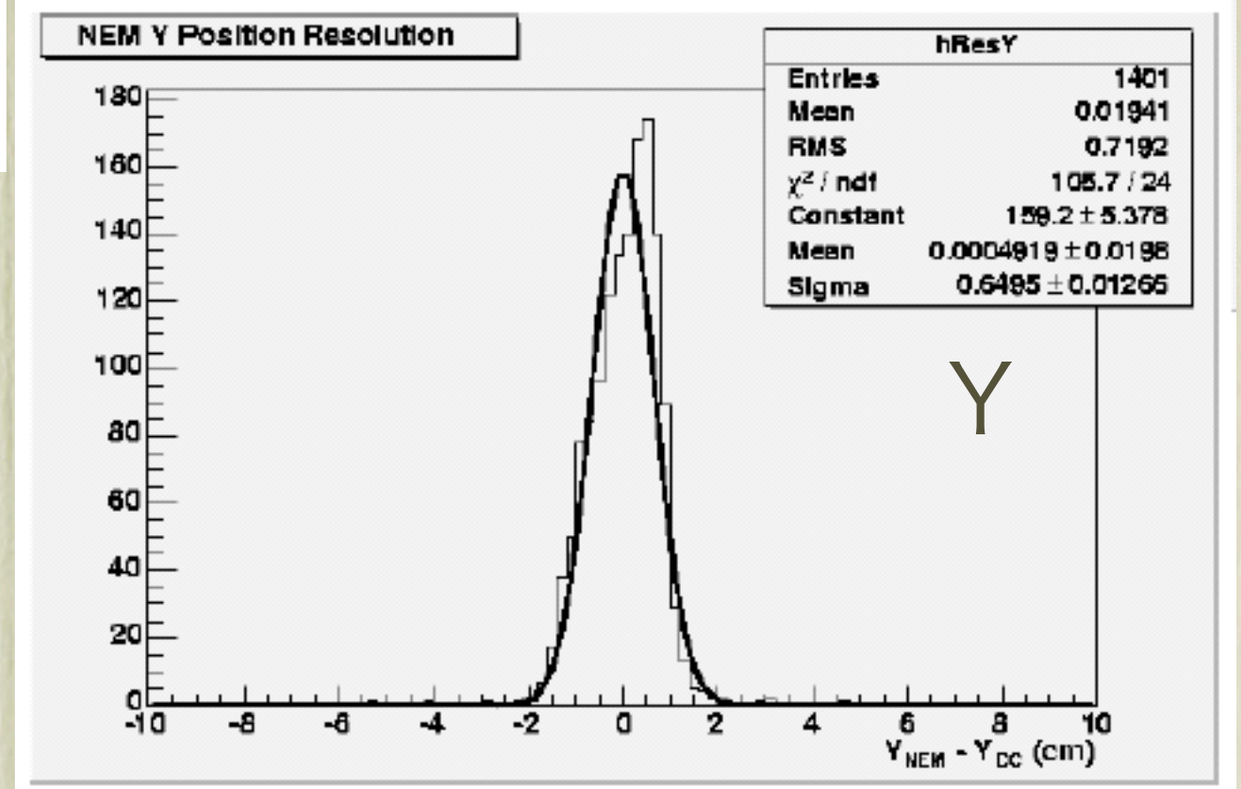


$\sigma_{X,Y}$ =0.7cm

Tile size

=4cmx4cm

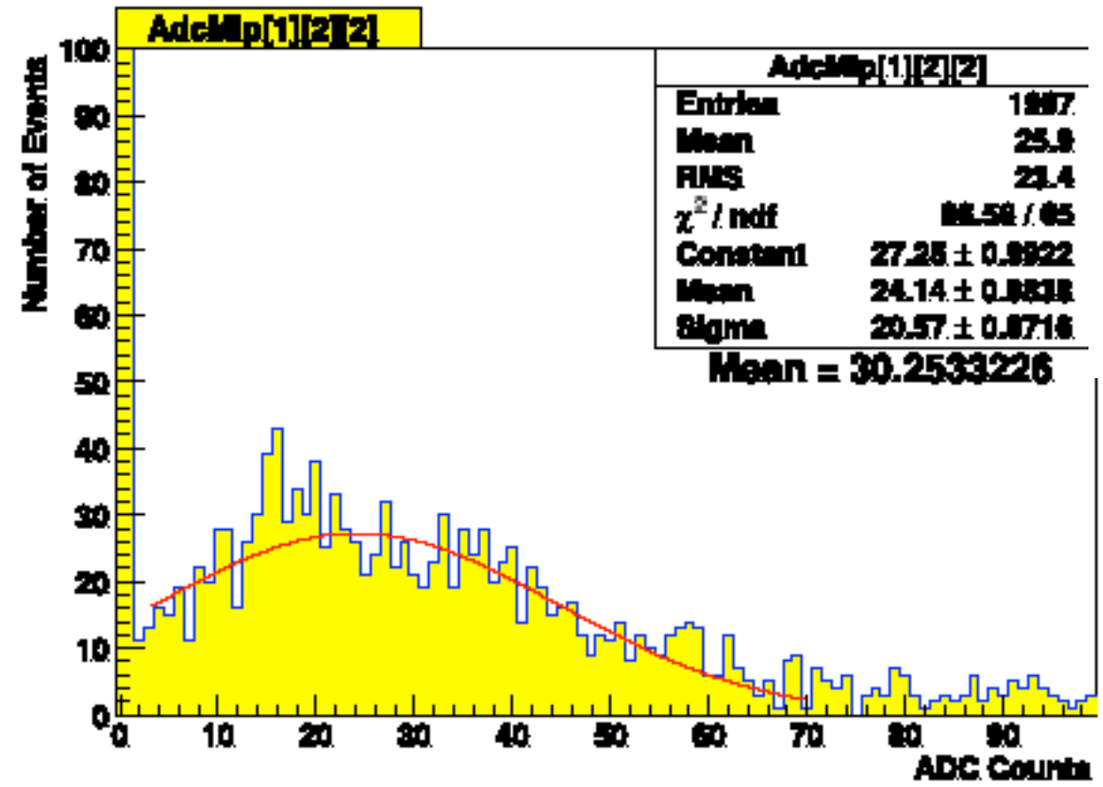


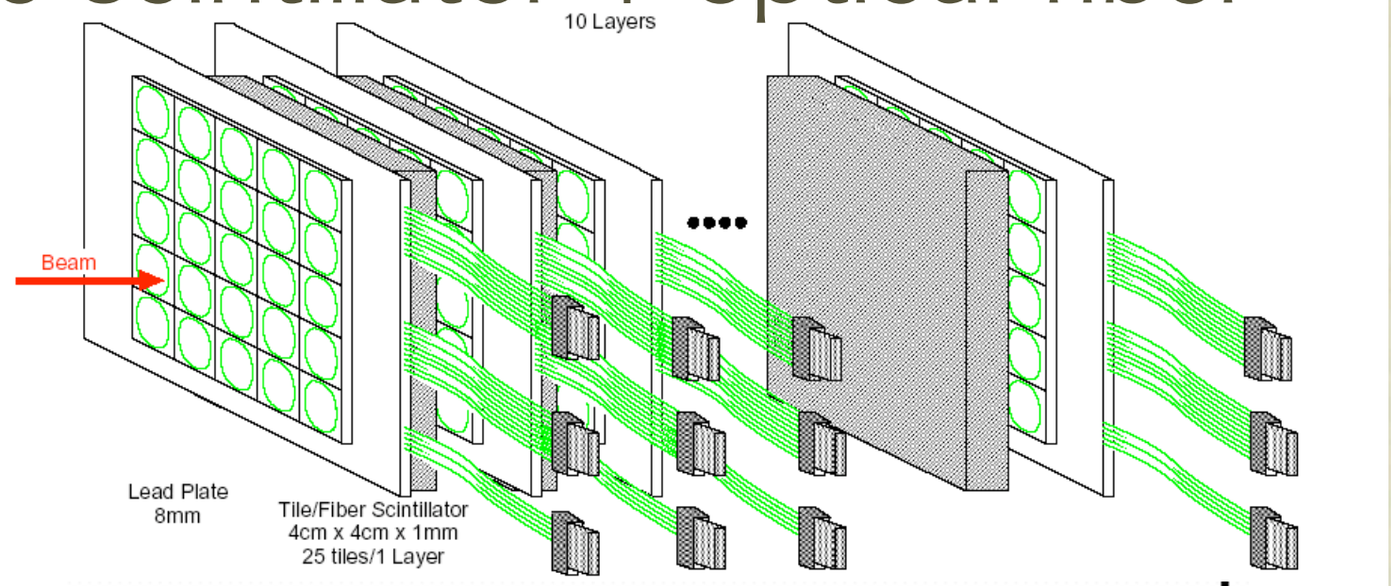


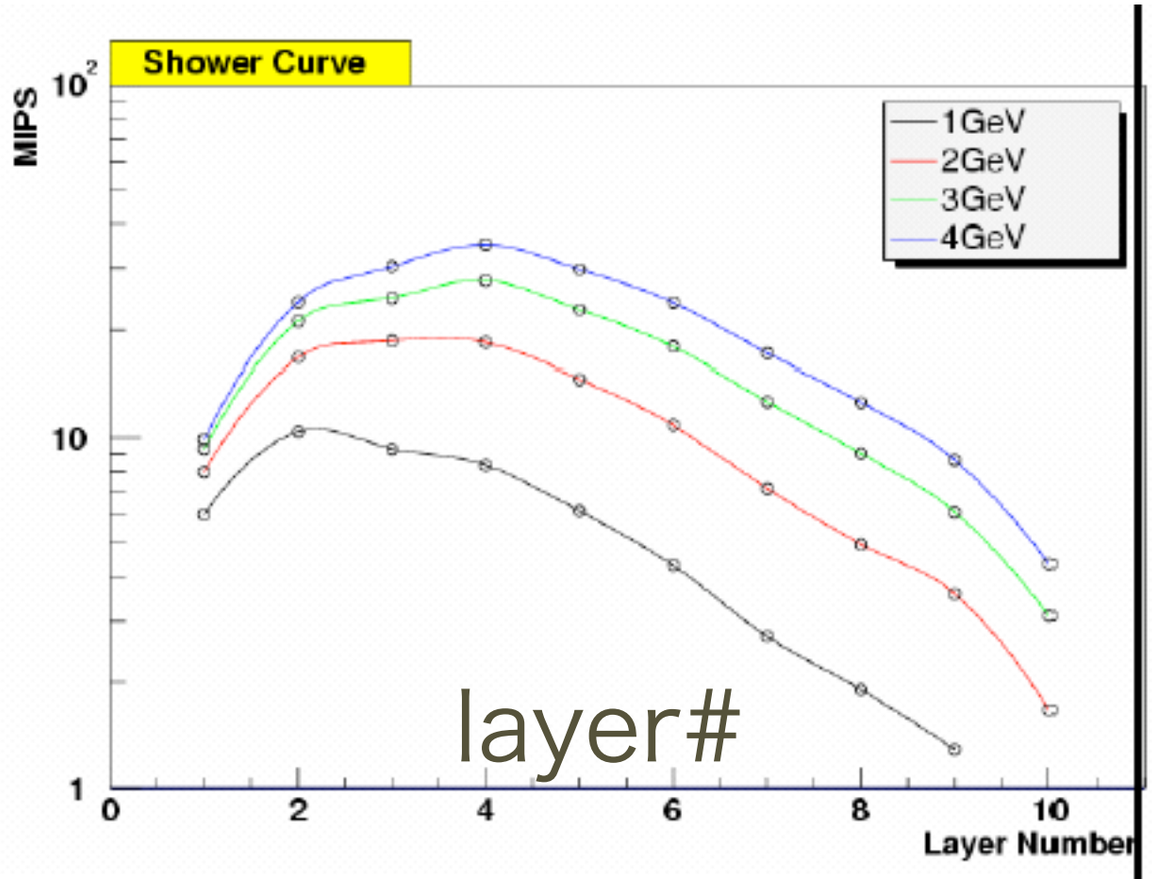
EM Tile-cal. tested at the beam

layer by layer read out

1 mm thick plastic scintillator + optical fiber





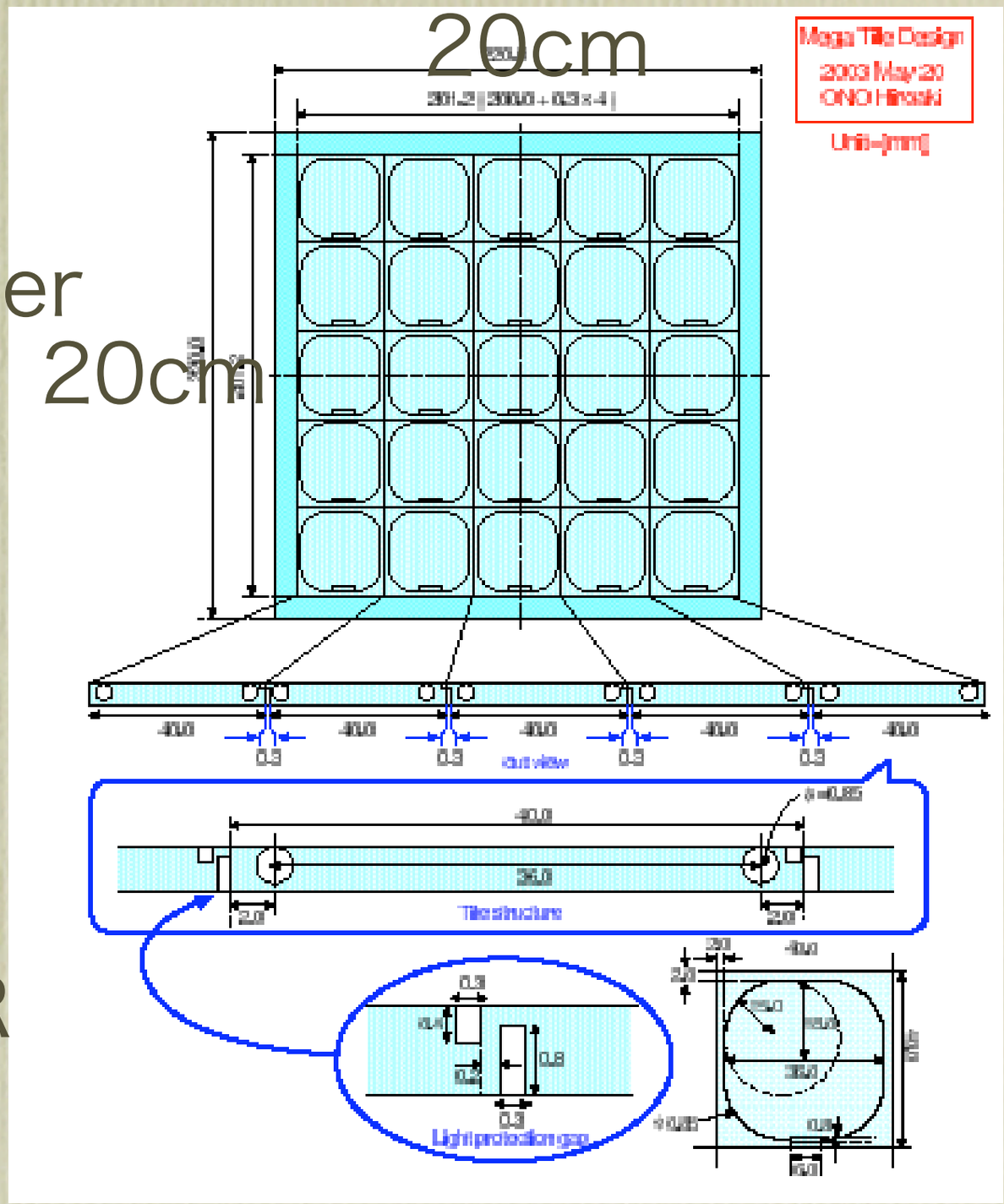


EM Tile-cal. next

Mega-Tile

mass production easier

Megatile fabrication will be done in collaboration with JINR



T.Takeshita, CU ALCW,July/2003

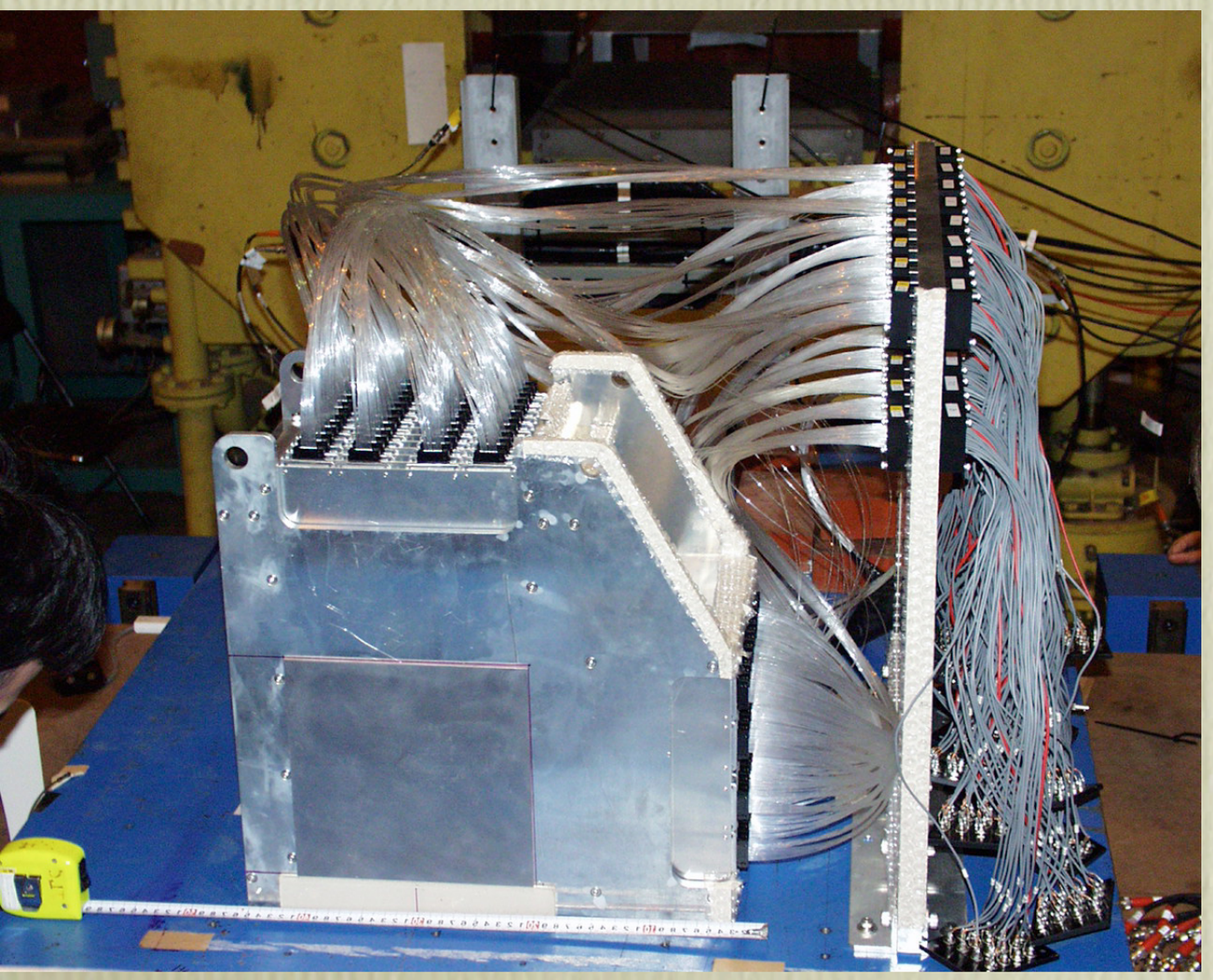
EM Strip-cal. tested

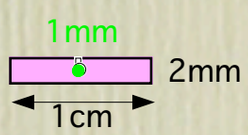
structure

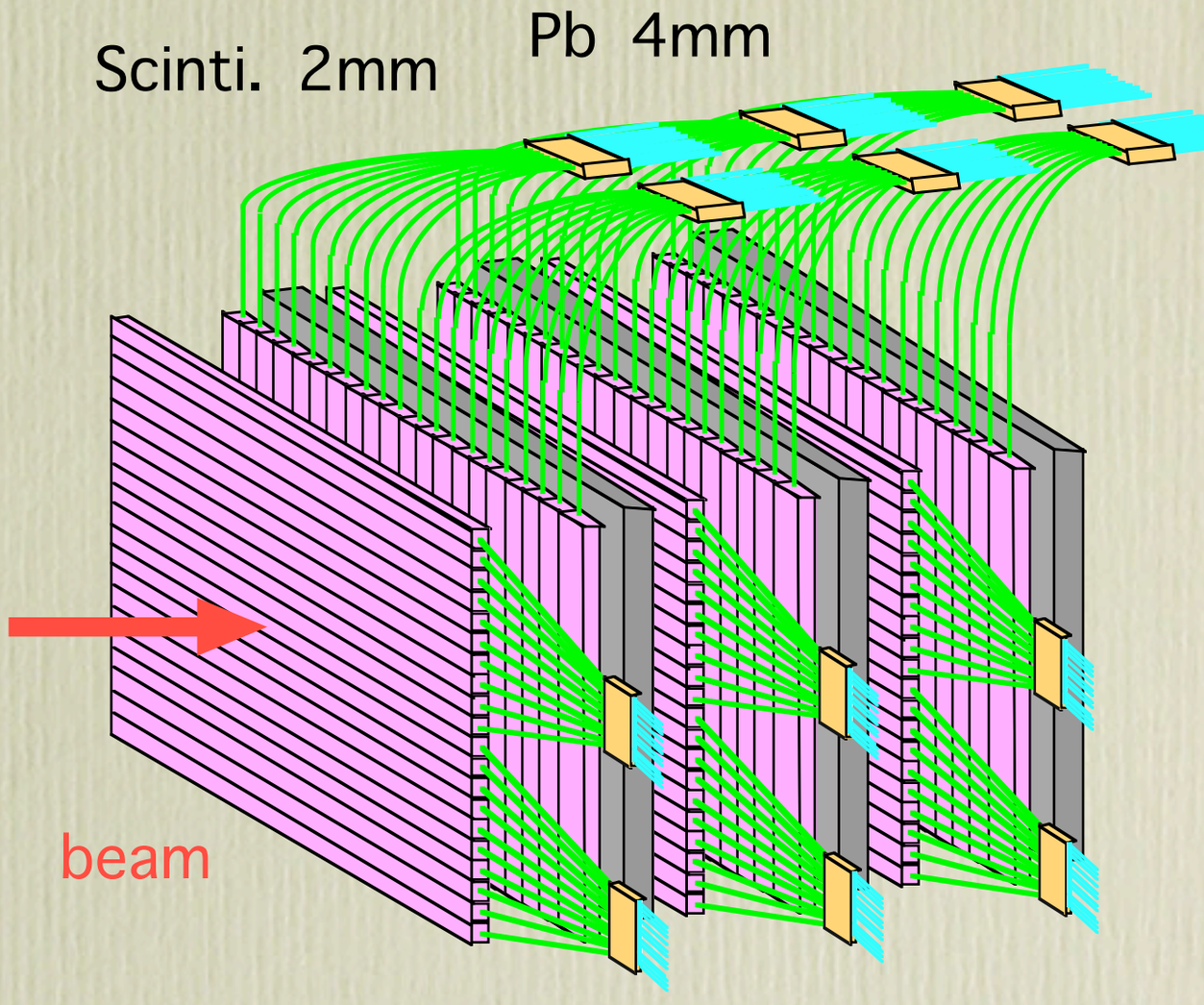
1layer=1cmwx20cmlx2mmt X+Y Strips x 20 + 4mmPb

6 Super Layers (17X_0) 4layers=1SL

Wave length Shifter- fiber ReadOut

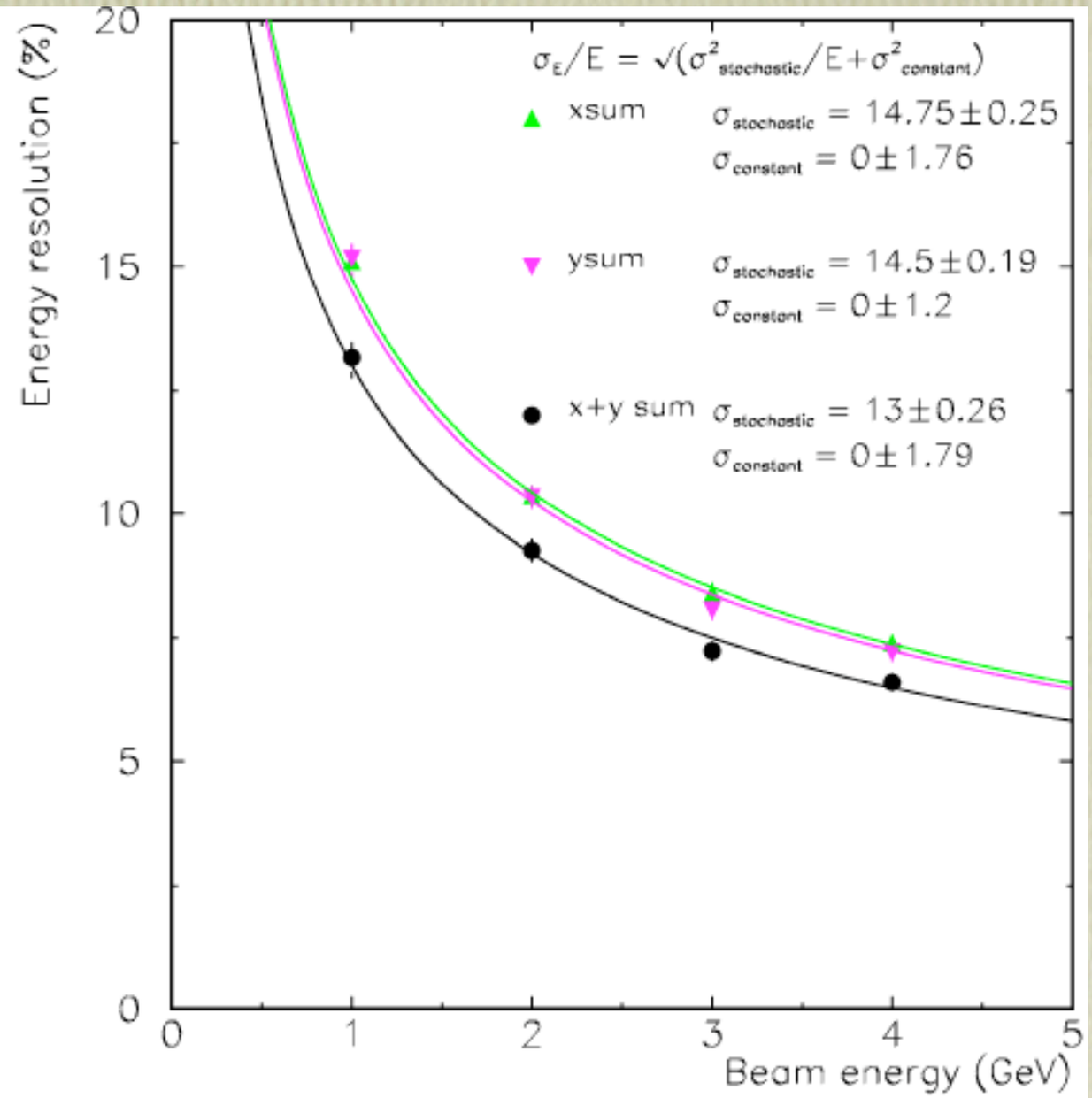




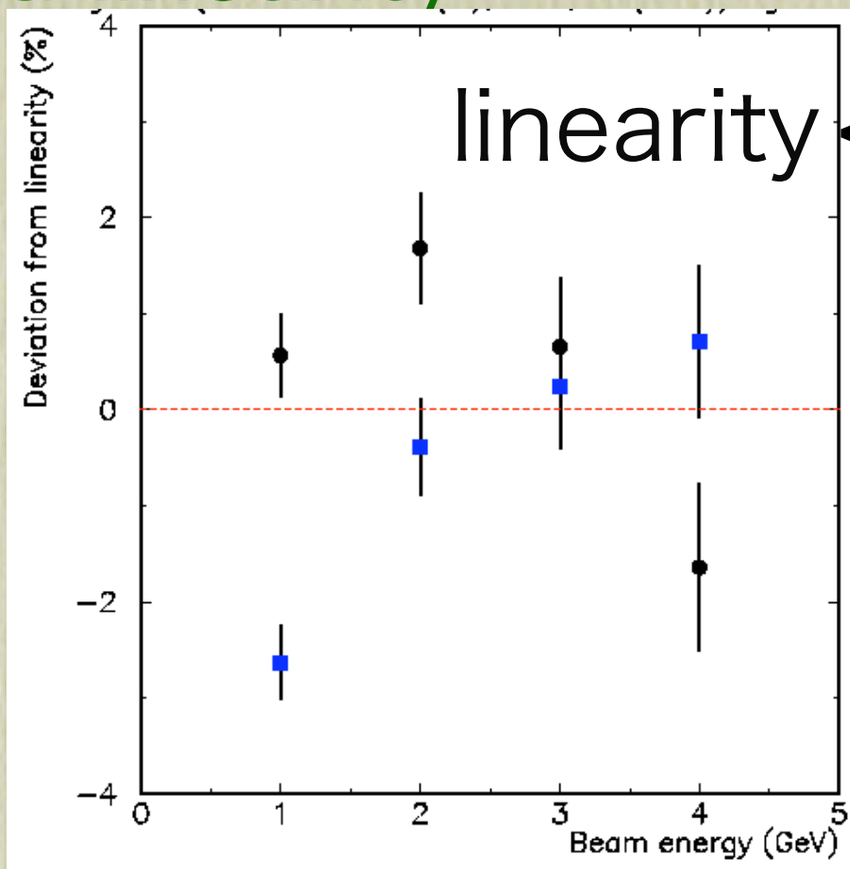


EM Strip-cal. tested

Energy Resolution and linearity



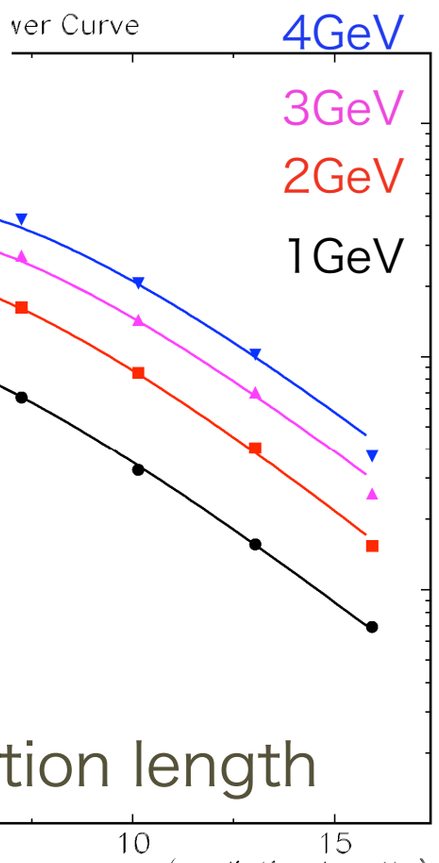
$$\frac{13\%}{\sqrt{E}} \oplus 0\%$$



linearity < ±2%

Beam

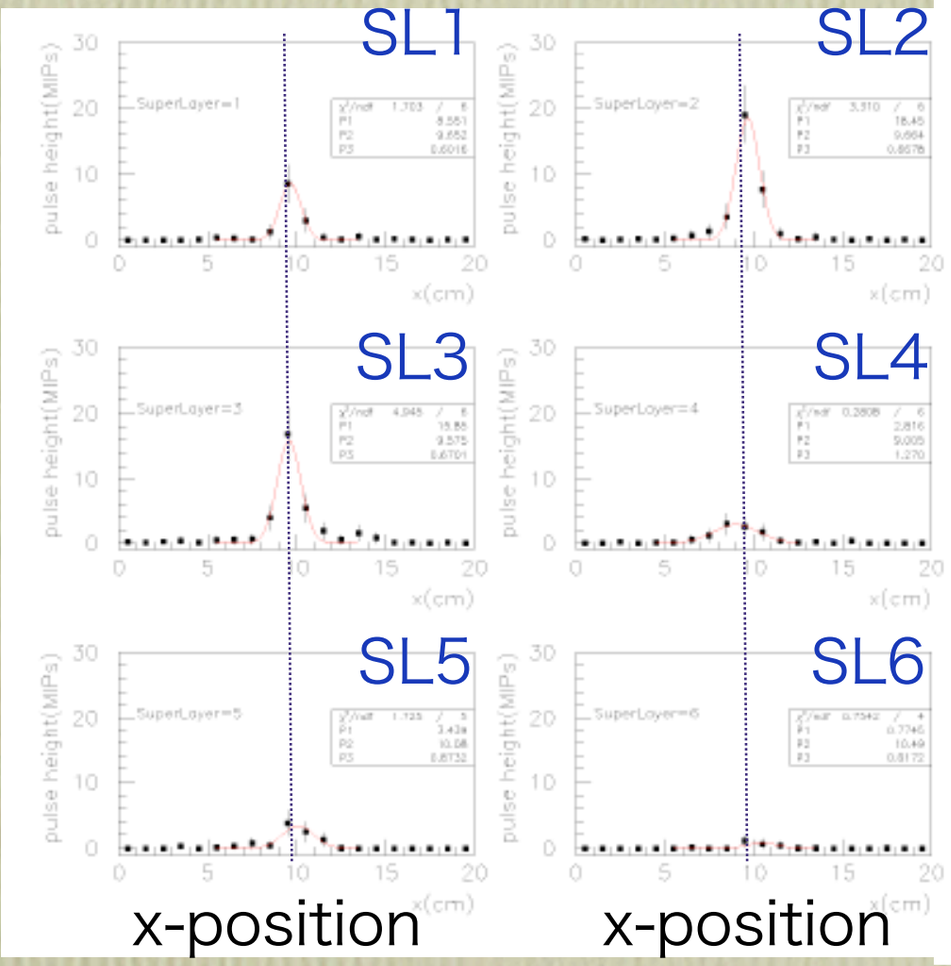
Geant

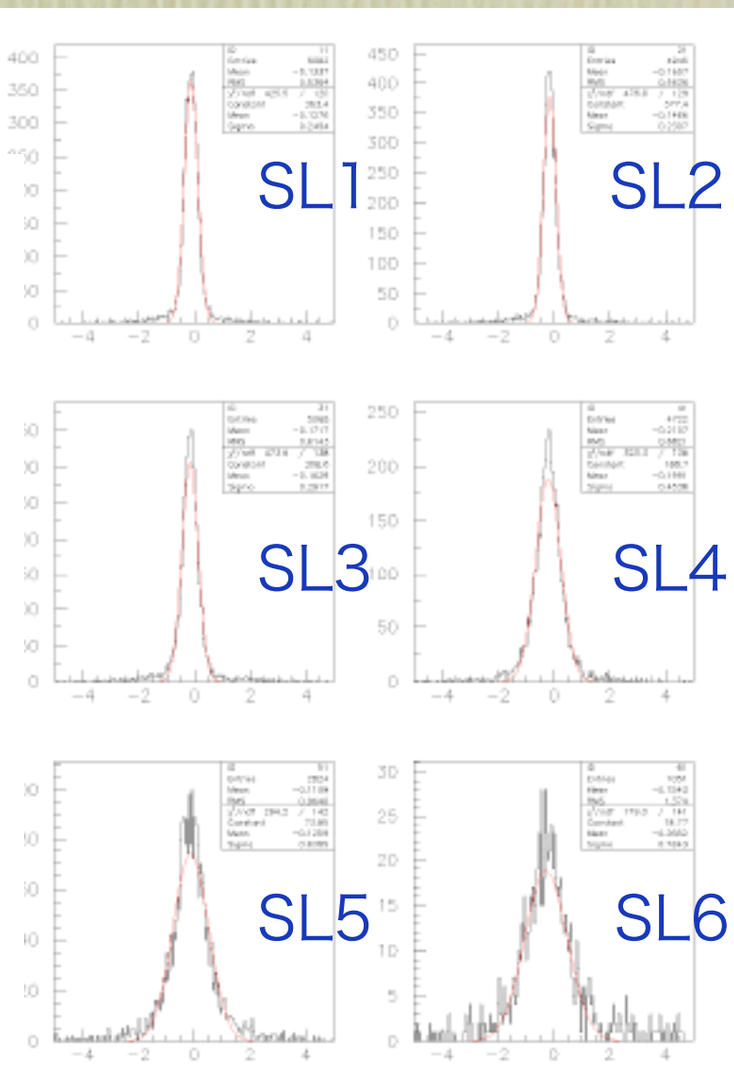


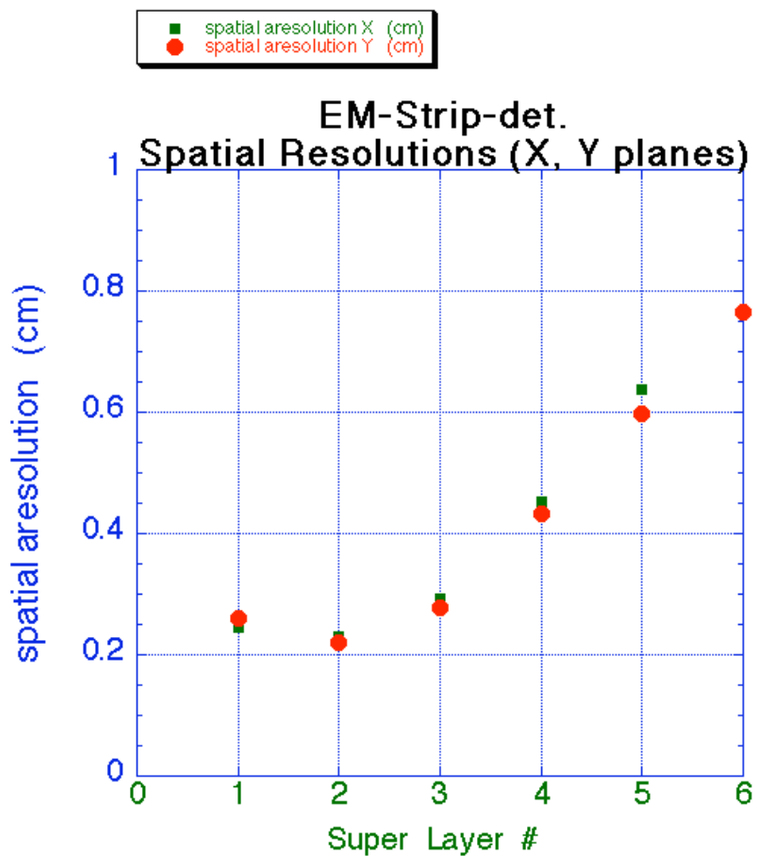
EM Strip-cal. tested

Spatial resolution

4GeV-electron







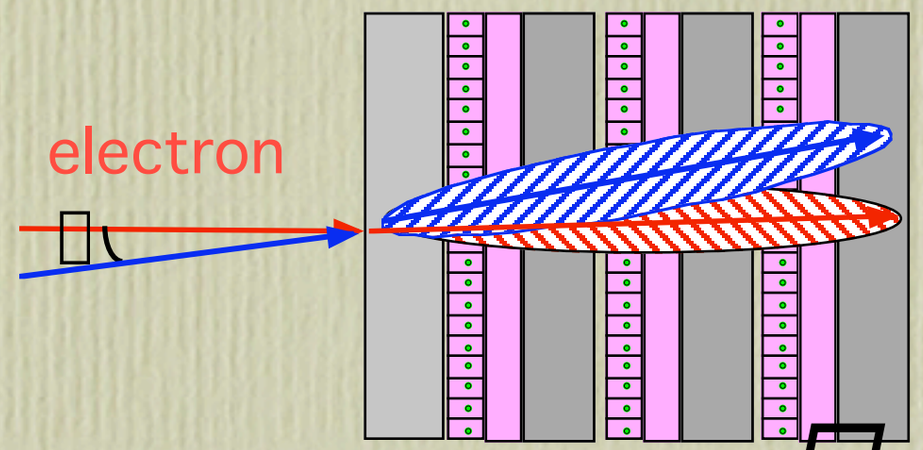
a 4GeV electron event

residual dist. X

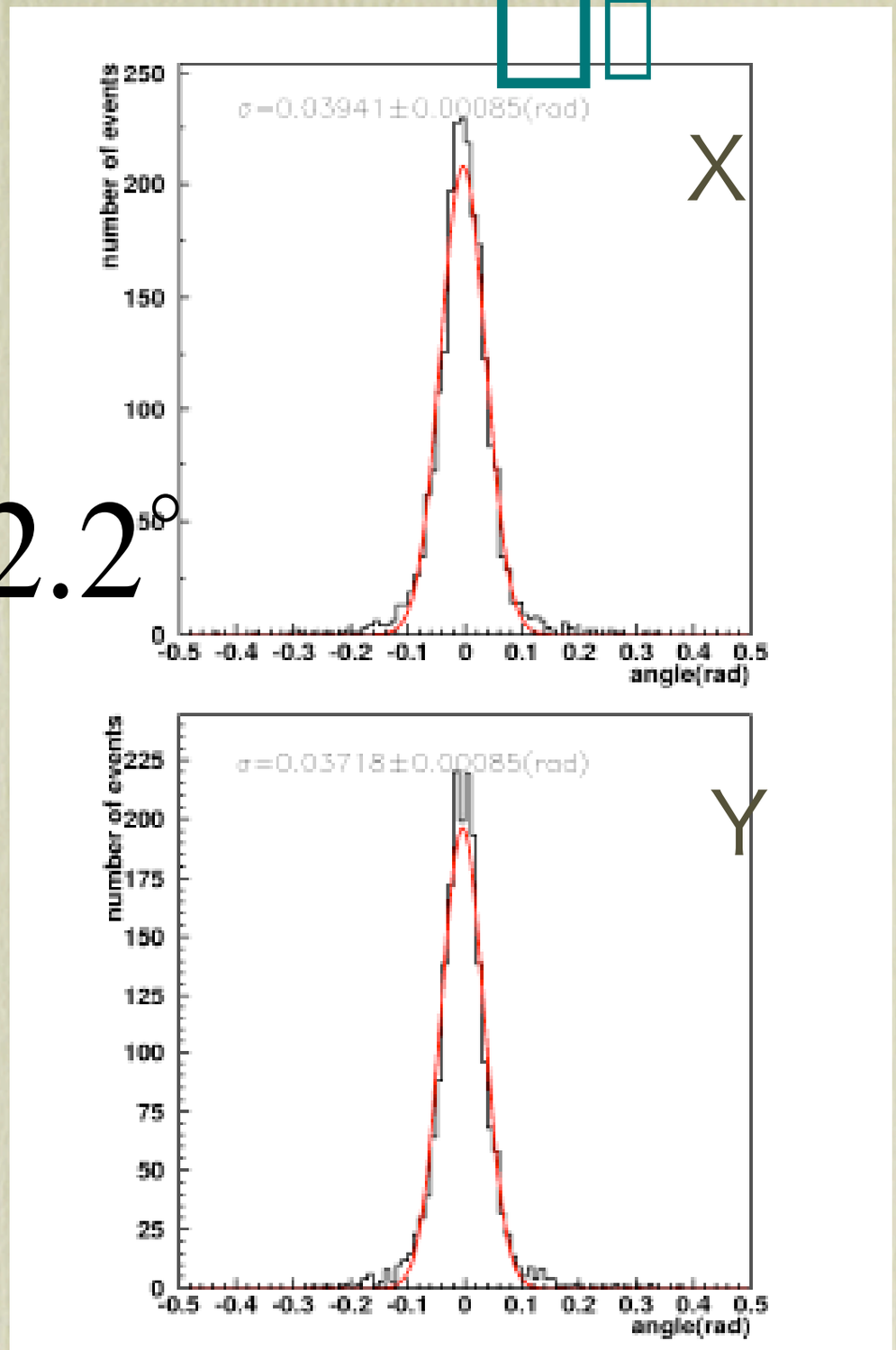
best resolution = 0.22cm

EM Strip-cal. tested

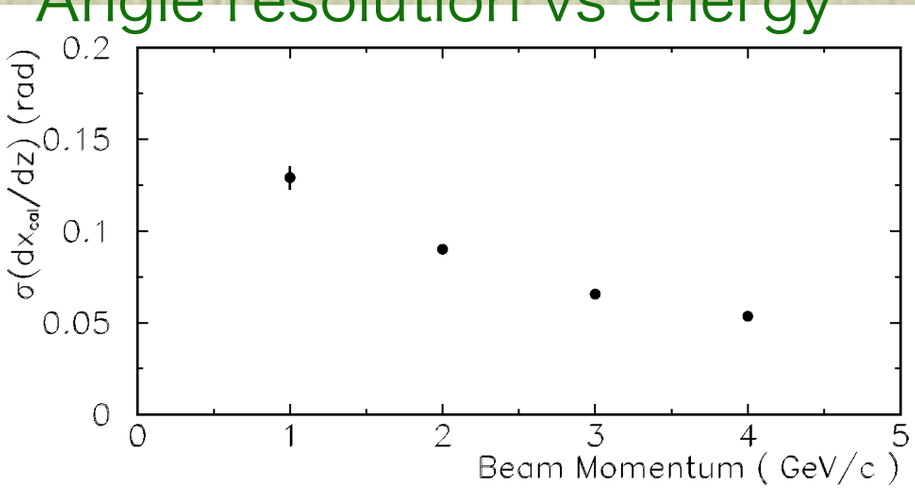
Angle resolution



$$\theta_{X,Y} = 2.2^\circ$$



Angle resolution vs energy

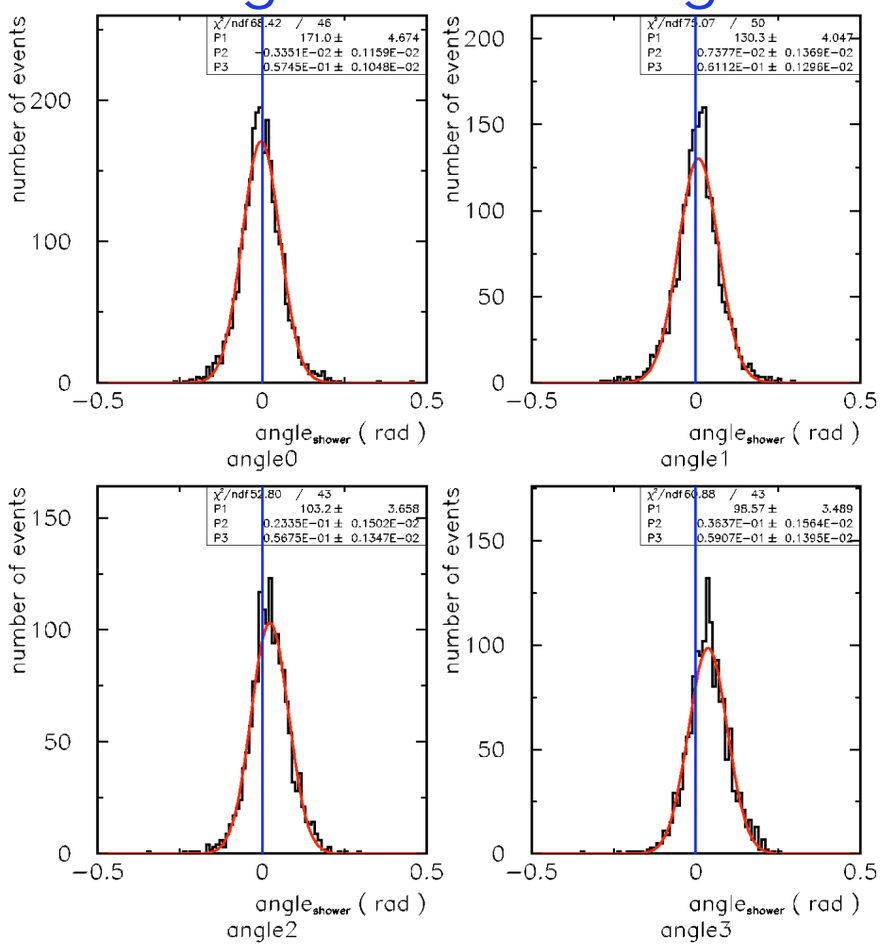


T.Takeshita, CU ALCW,July/2003

EM Strip-cal. tested

Angle resolution 2

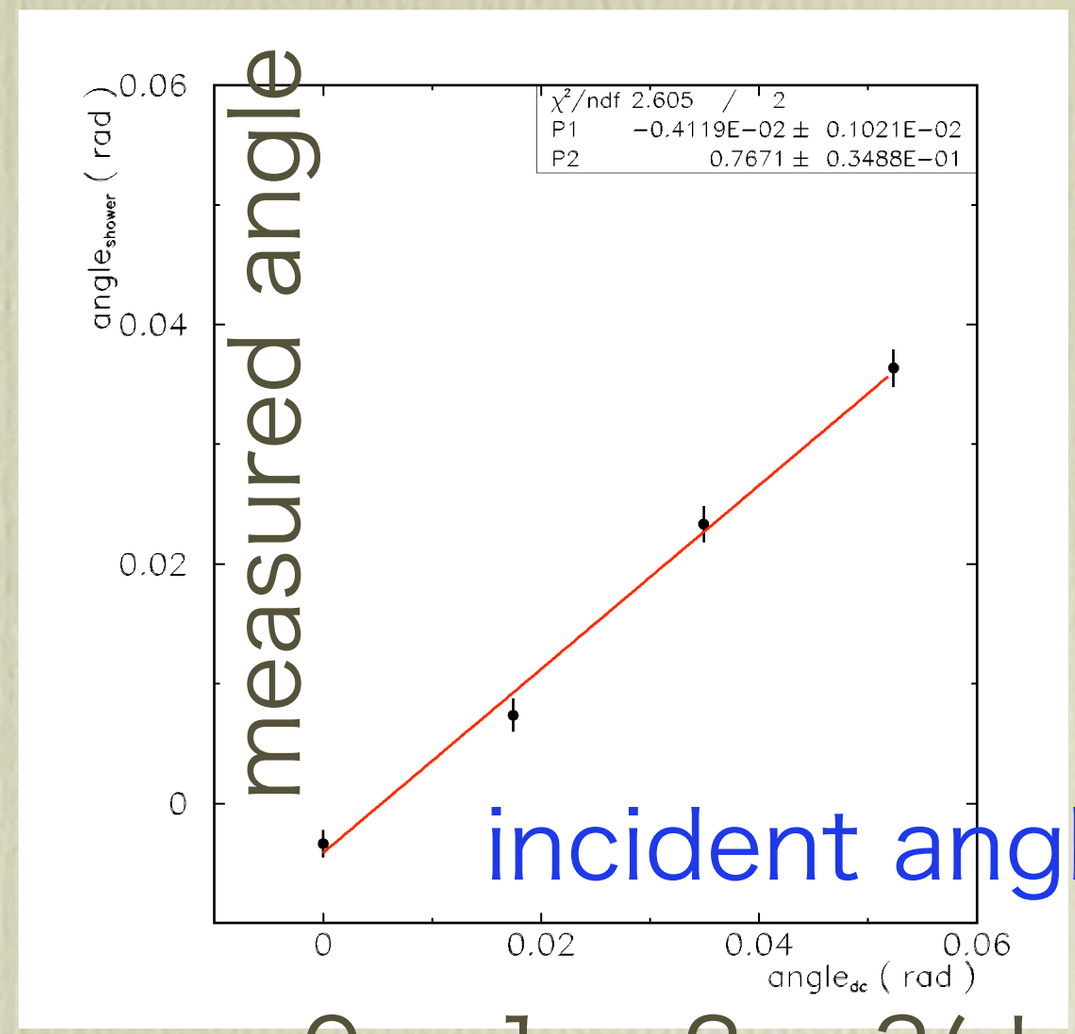
0degree



1degree

2degree

3degree

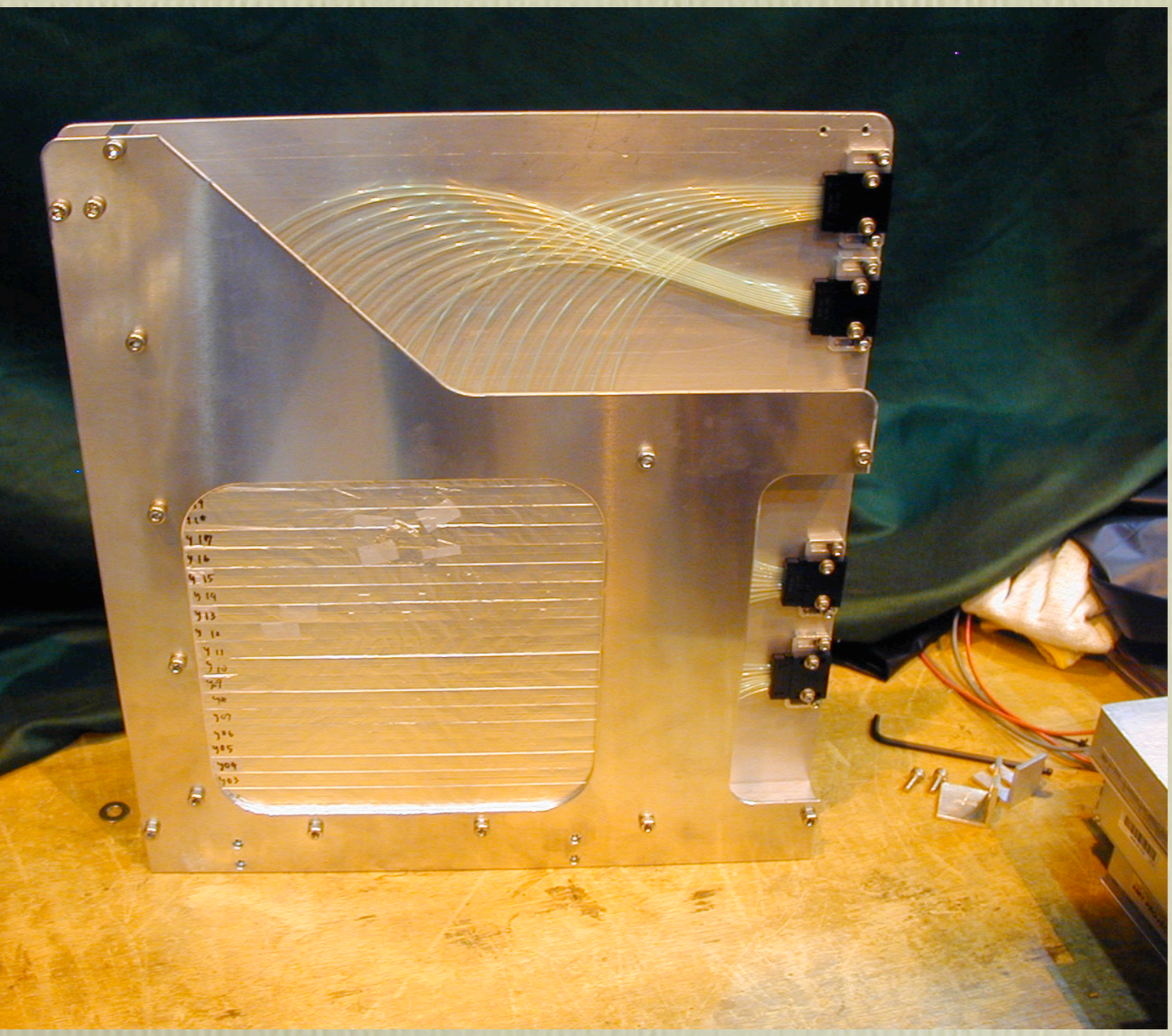


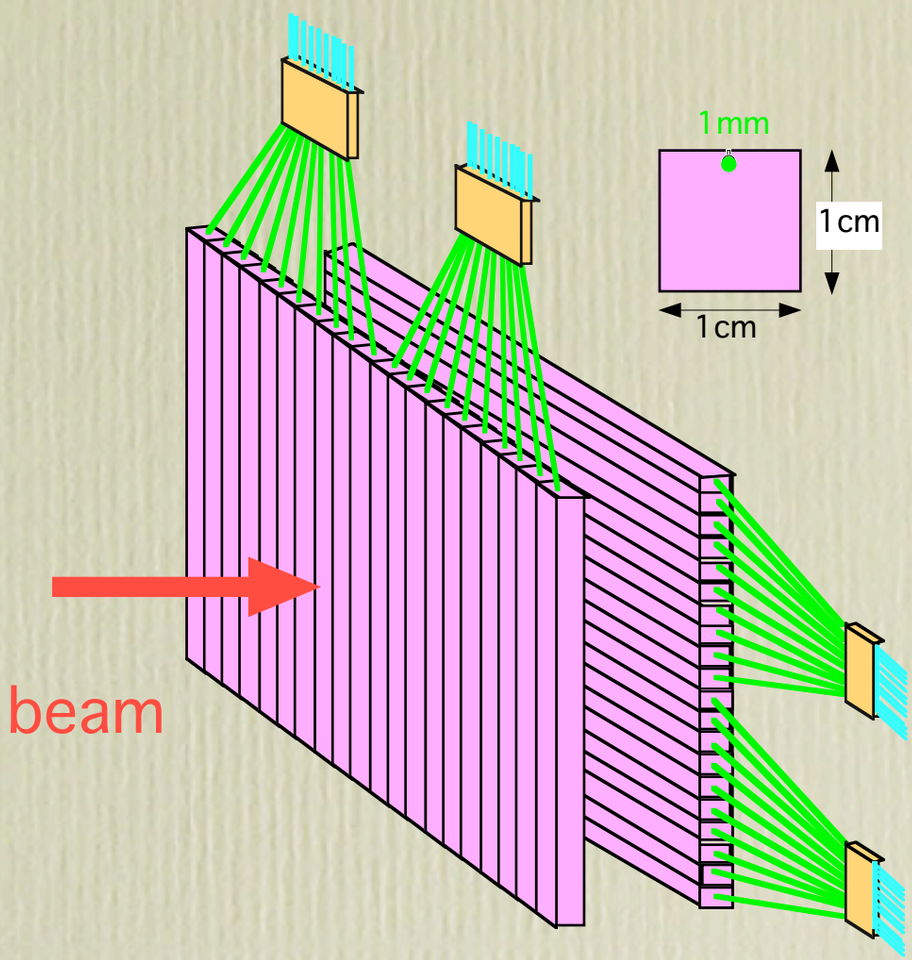
0 1 2 3(degre

2GeV electrons

Strip Shower -Max det. tested

structures



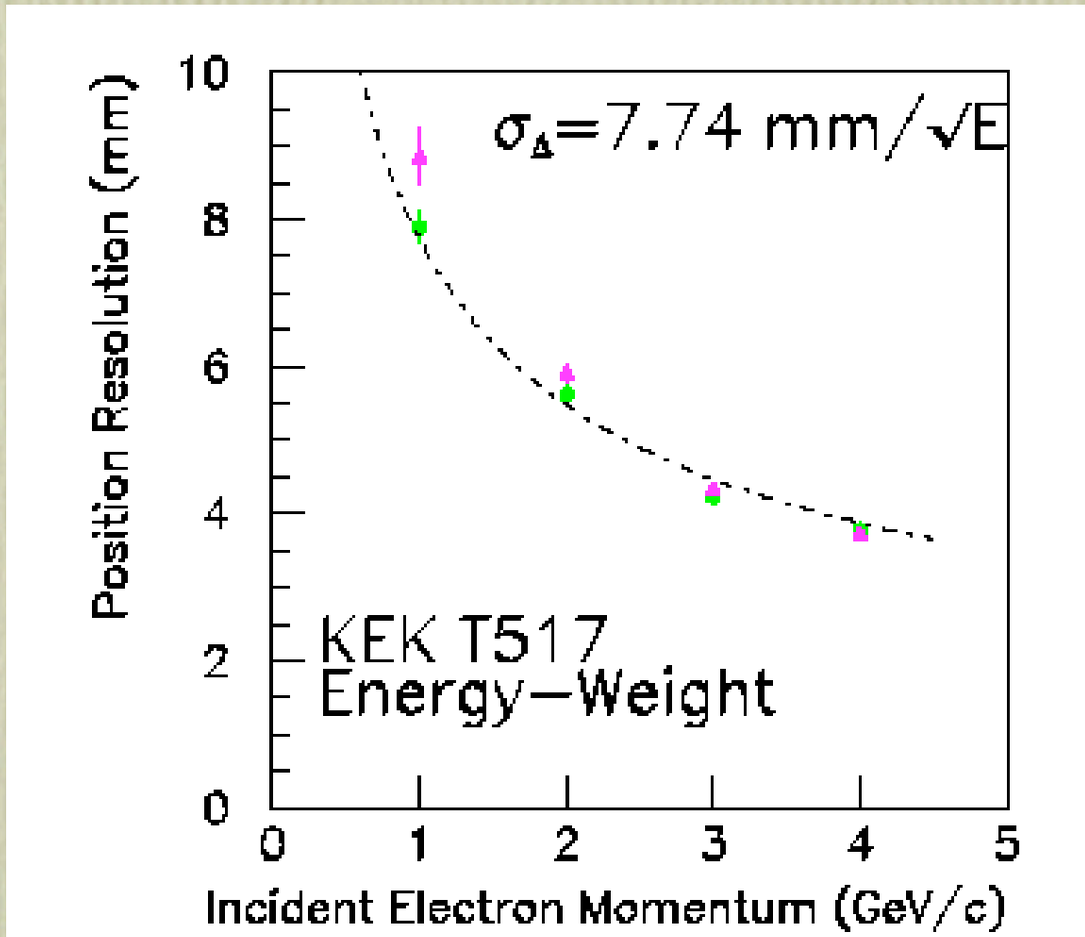


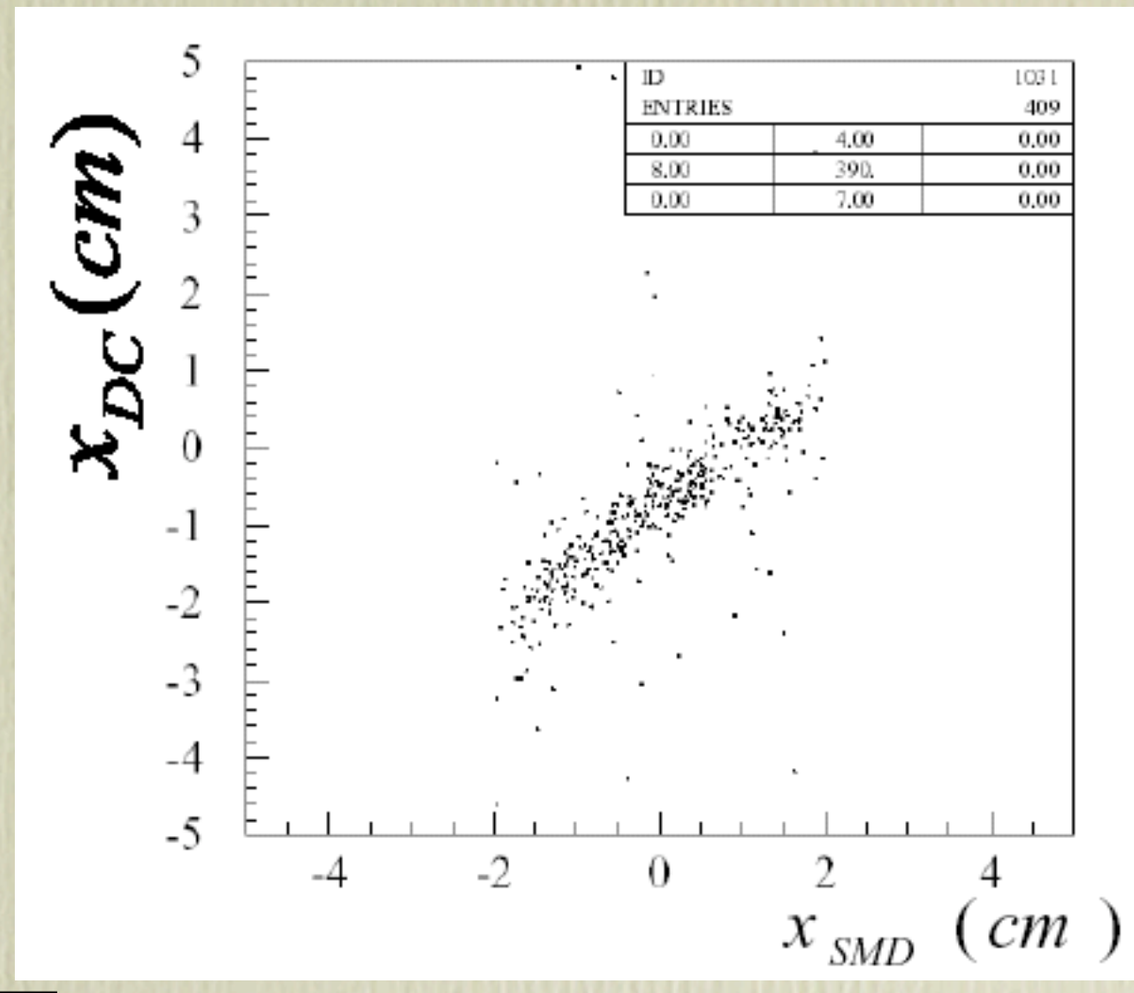
Scinti. 10mmt MA-PMTs

10pe/MIP

Strip Shower -Max det. tested 2

spatial resolution





X Y $\sigma_{X,Y} \sim 3.7mm$

Strip Showe-Max det. tested 3

e/pion separation

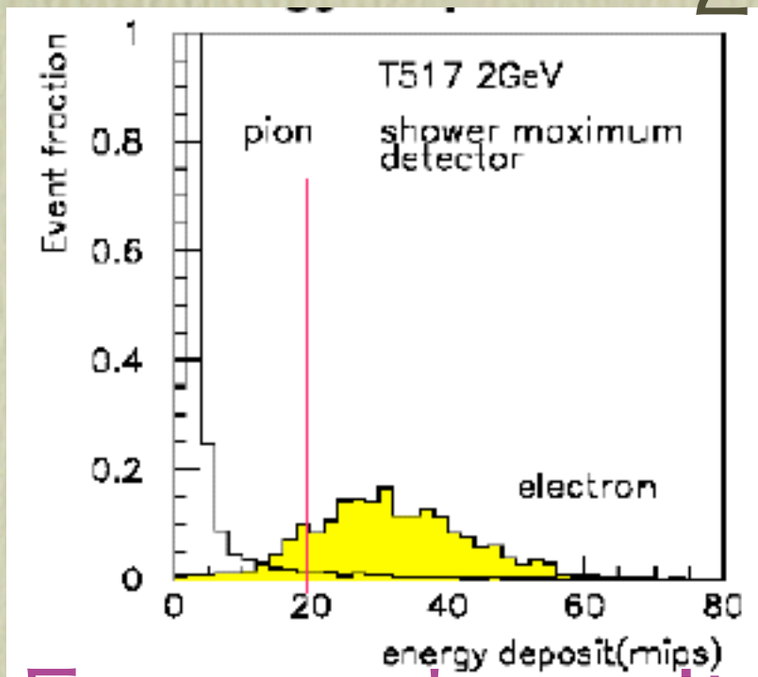
Energy deposit

85% eff.

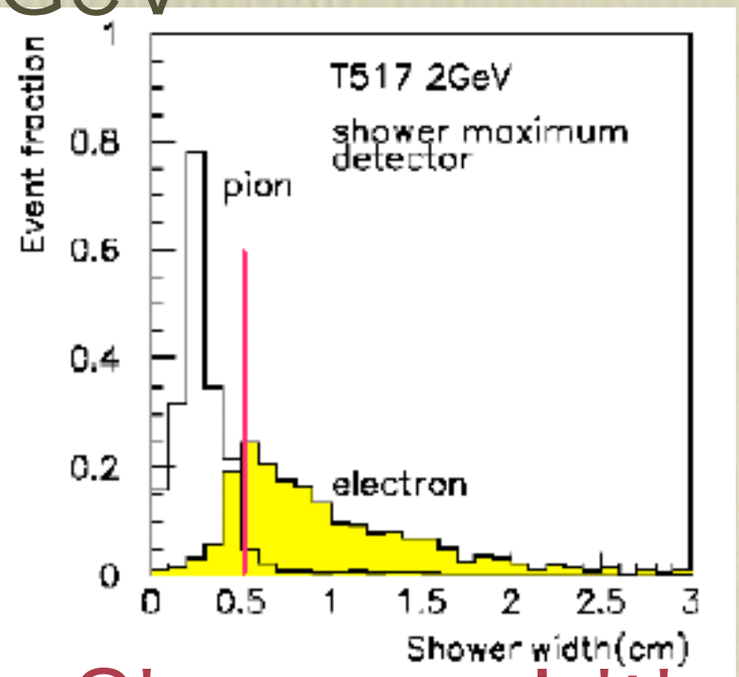
5% contamination

Photo-devices:
EBCCD or
SiPM will be
tested

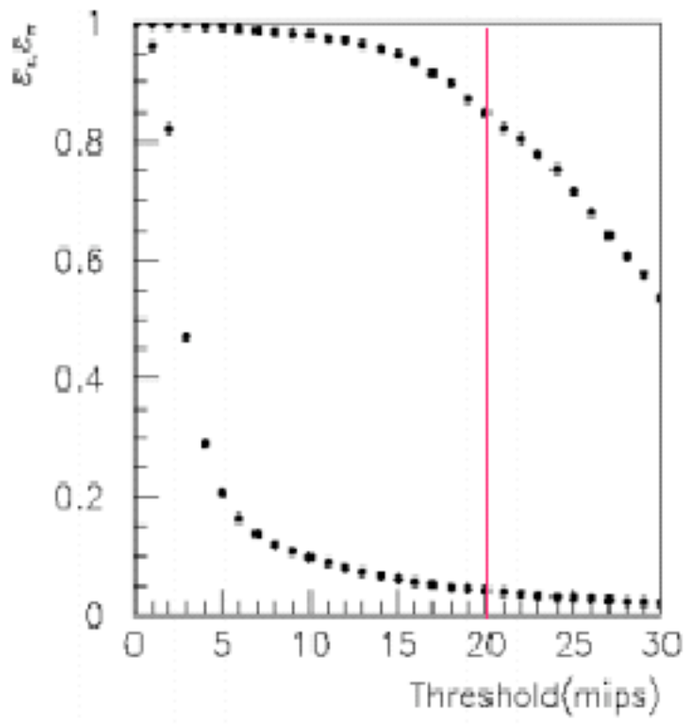
2GeV

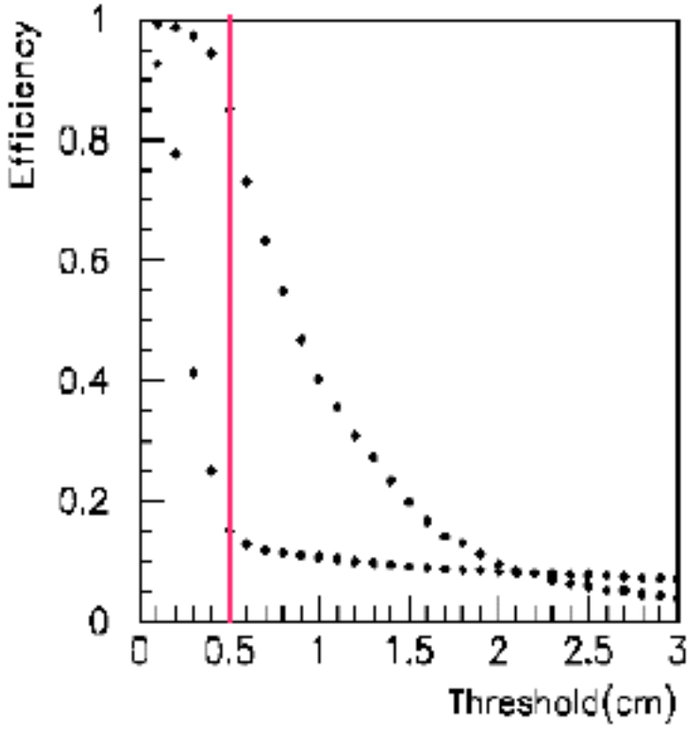


Energy deposit



Shower width

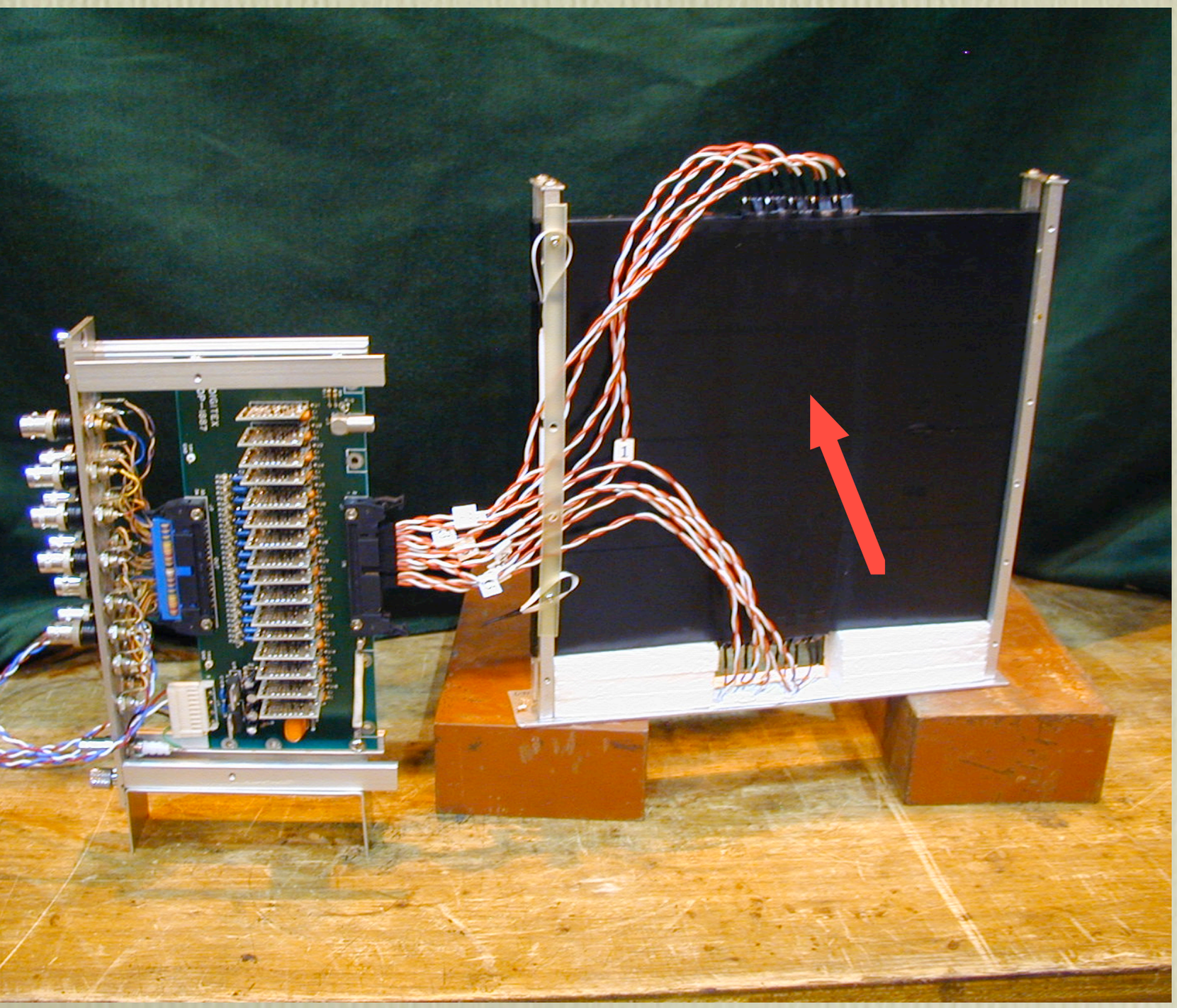




Strip Shower -Max det.

APD Read Out

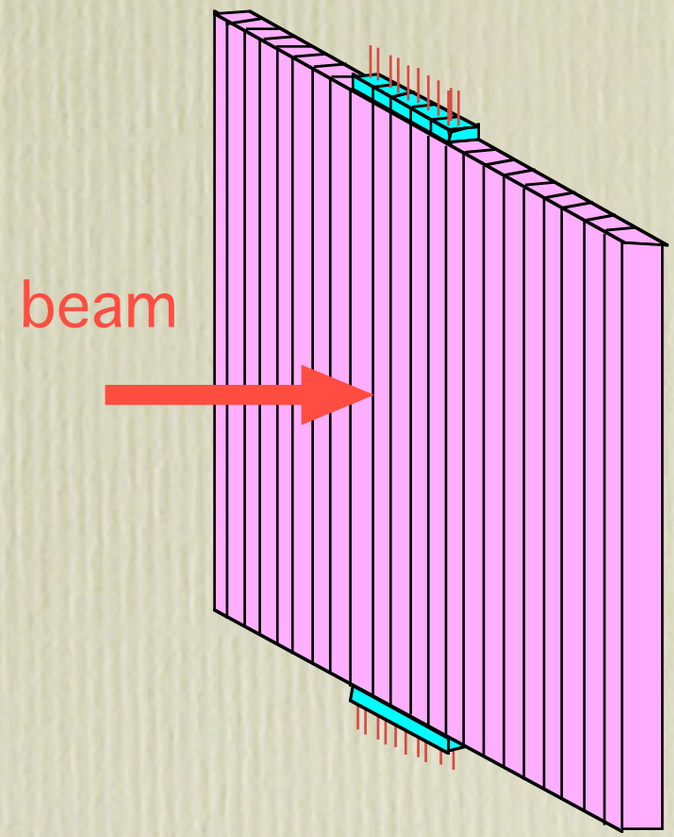
Structure



HPK 8664-55

5x5 mm^2

x10

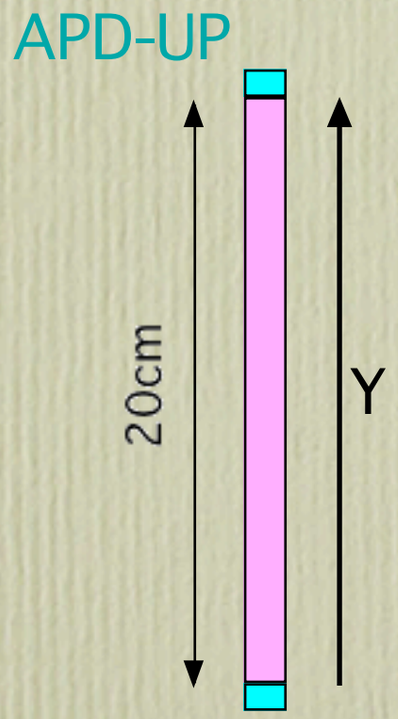


Scinti. 10mmx10mmx20cm

at room temp.

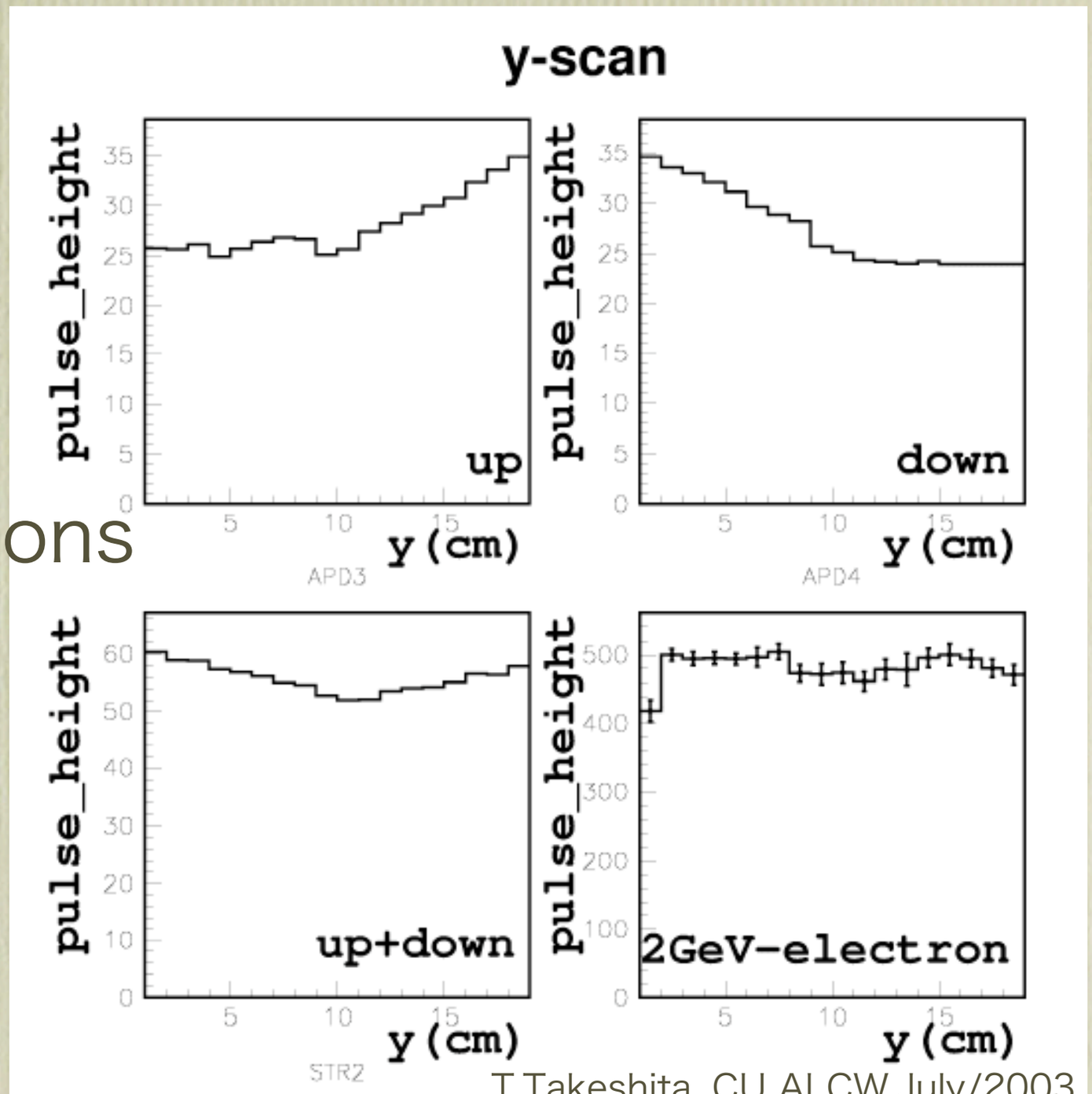
Strip Shower -Max det. APD Read Out

light yield for strip direction (Y)



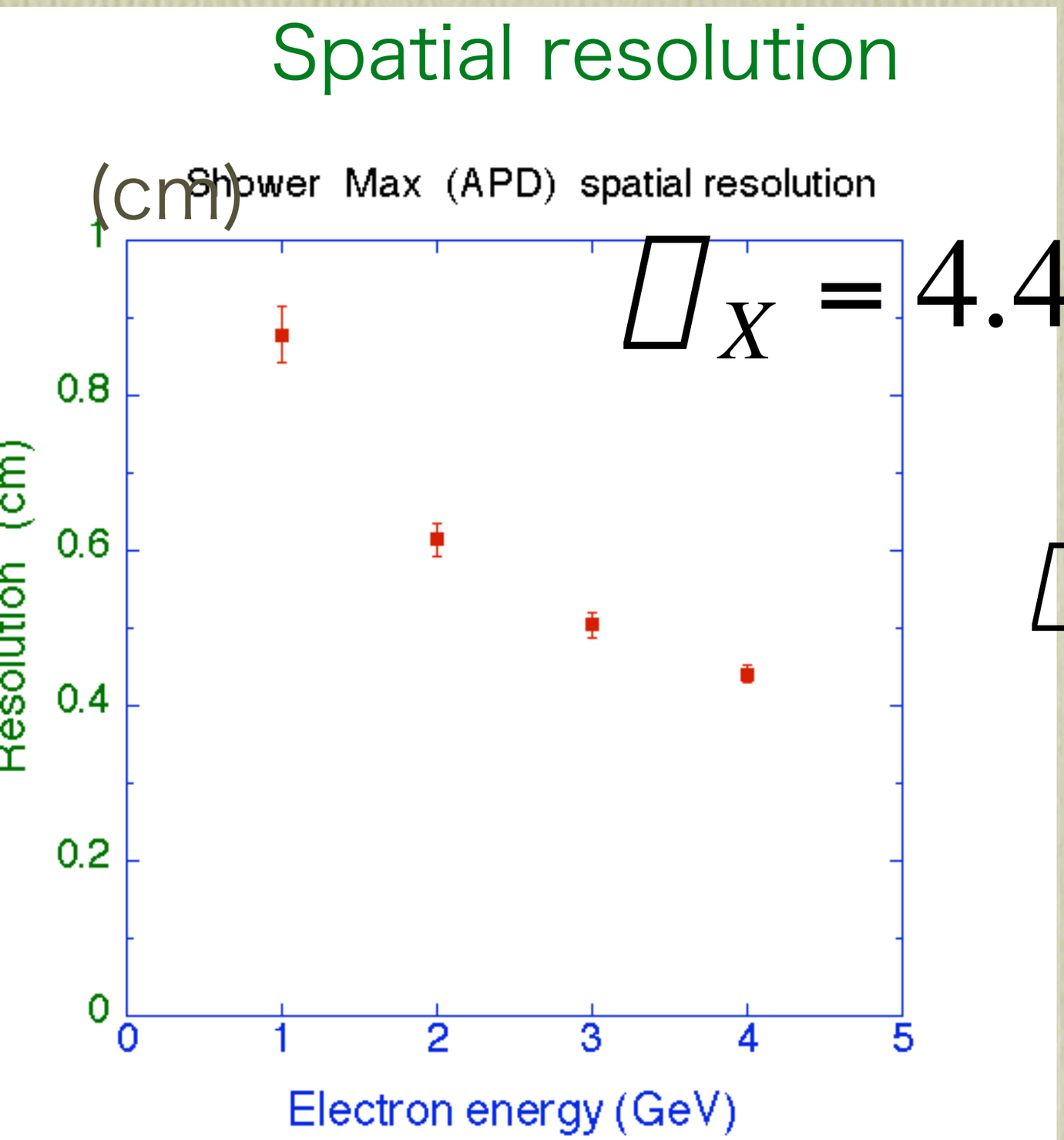
for pions

adding up and down APDs, uniform response

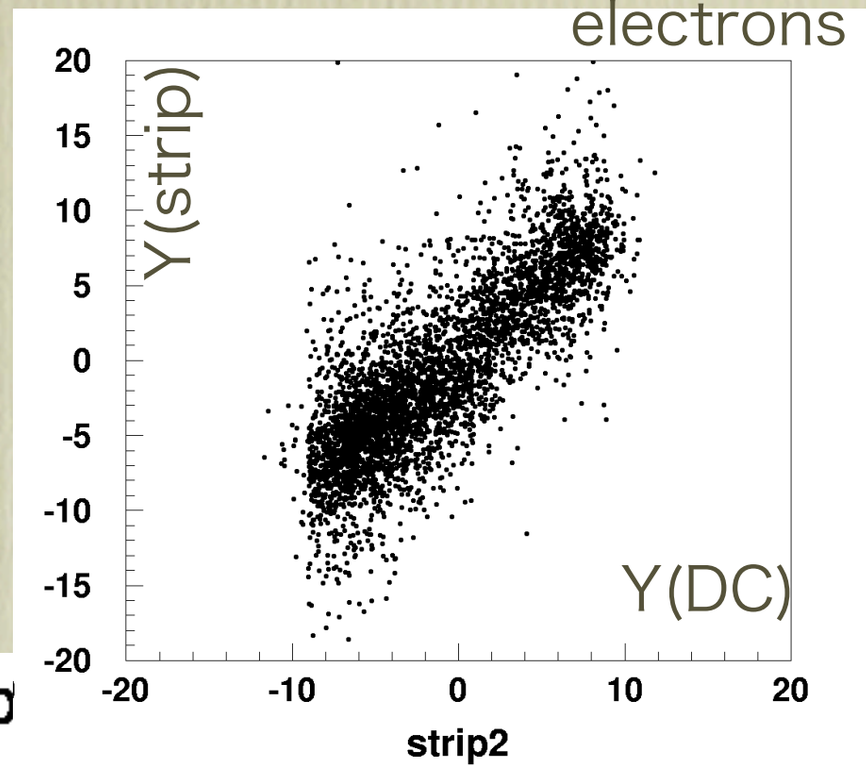


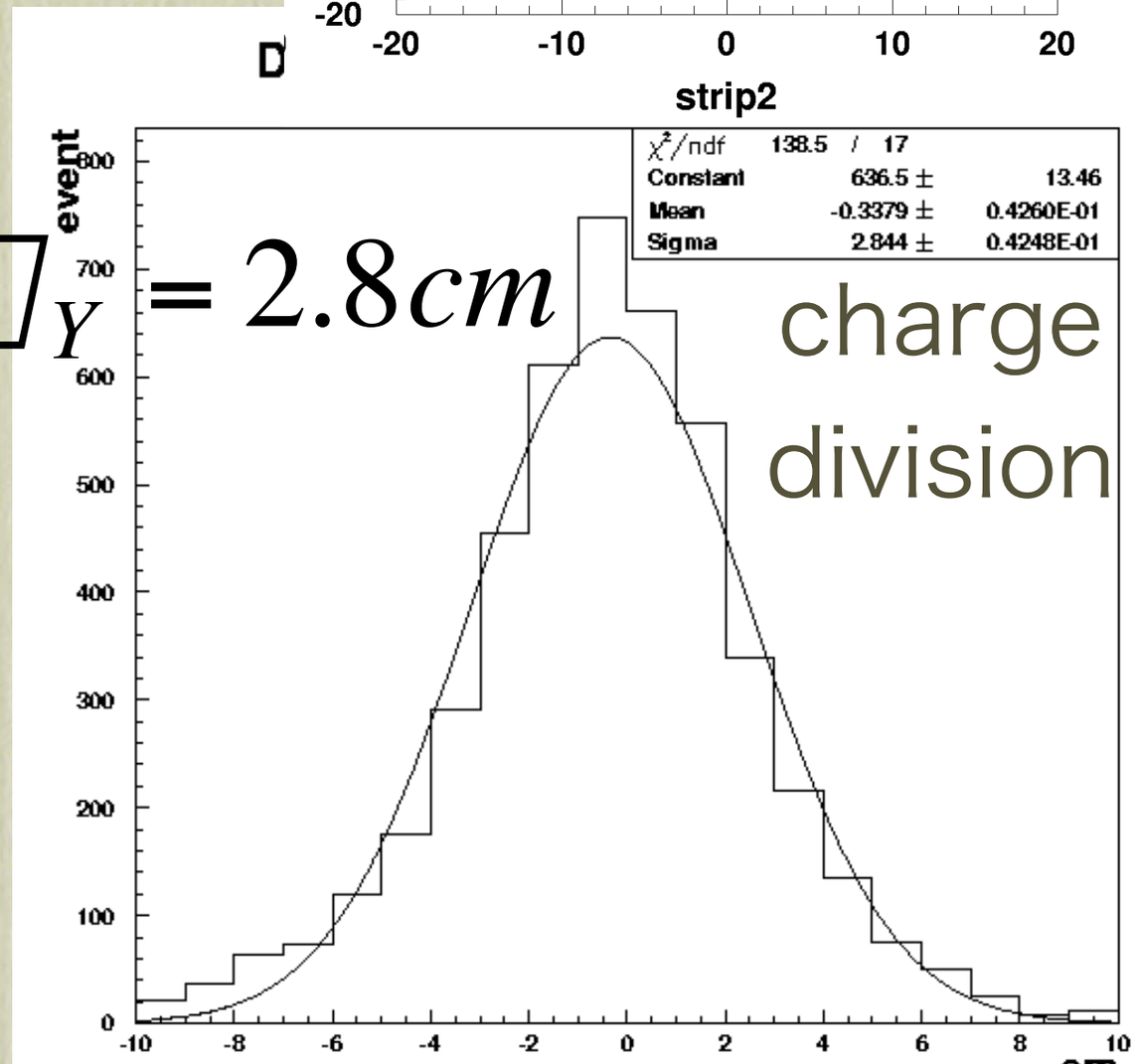
Strip Shower -Max det. APD Read Out

Spatial resolution



$$\sigma_X = 4.4mm$$





$$\sigma_Y = 2.8cm$$

charge division

Summary and plans

- EM CAL. detectors are tested at the beam
- Tile EM: boundary check → megatiles
- Strip EM: E-resolution **13**% → HPD R/O
  Spatical resolution 2.2mm
- Strip Shower Max : spatial resolution 3.7mm
  → EBCCD/SiPM
- Strip Shower Max + APD: spatial resolution 4.4mm
  → add more APDs
- Strip Shower Max detectors: DESY beam Sep/2003
- beam test 2004 Feb/March at KEK