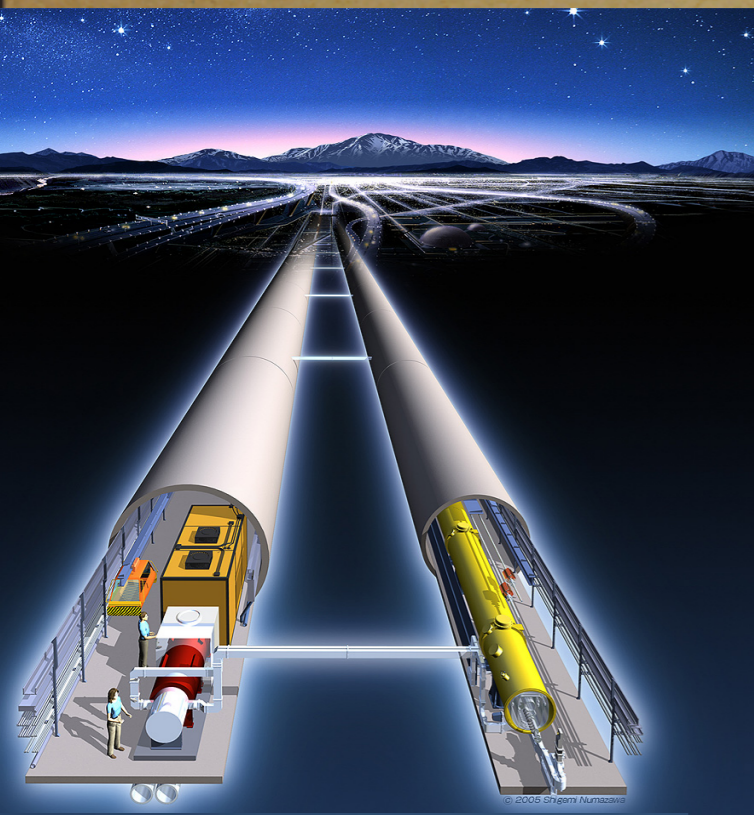# GLD Calorimeter

Tohru Takeshita
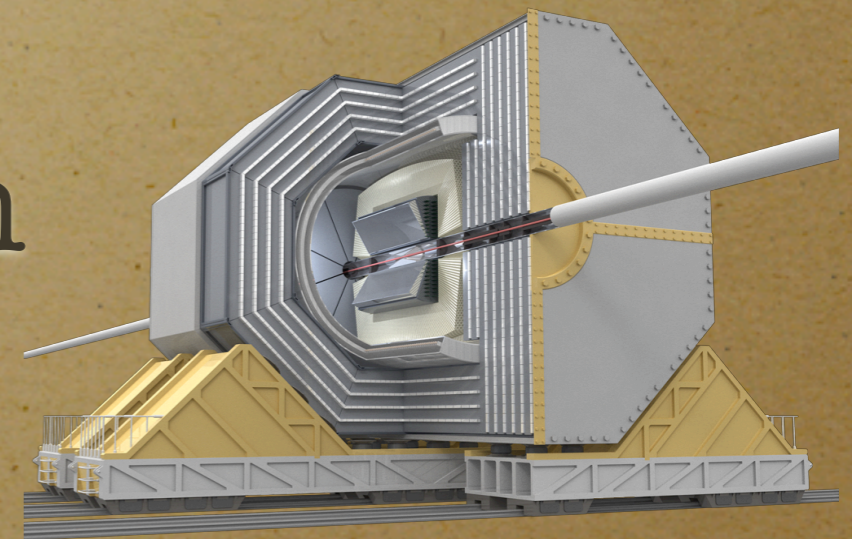## Shinshu U. for GLD-CAL group

ILC

GLD

outline
concept
implementation
experience
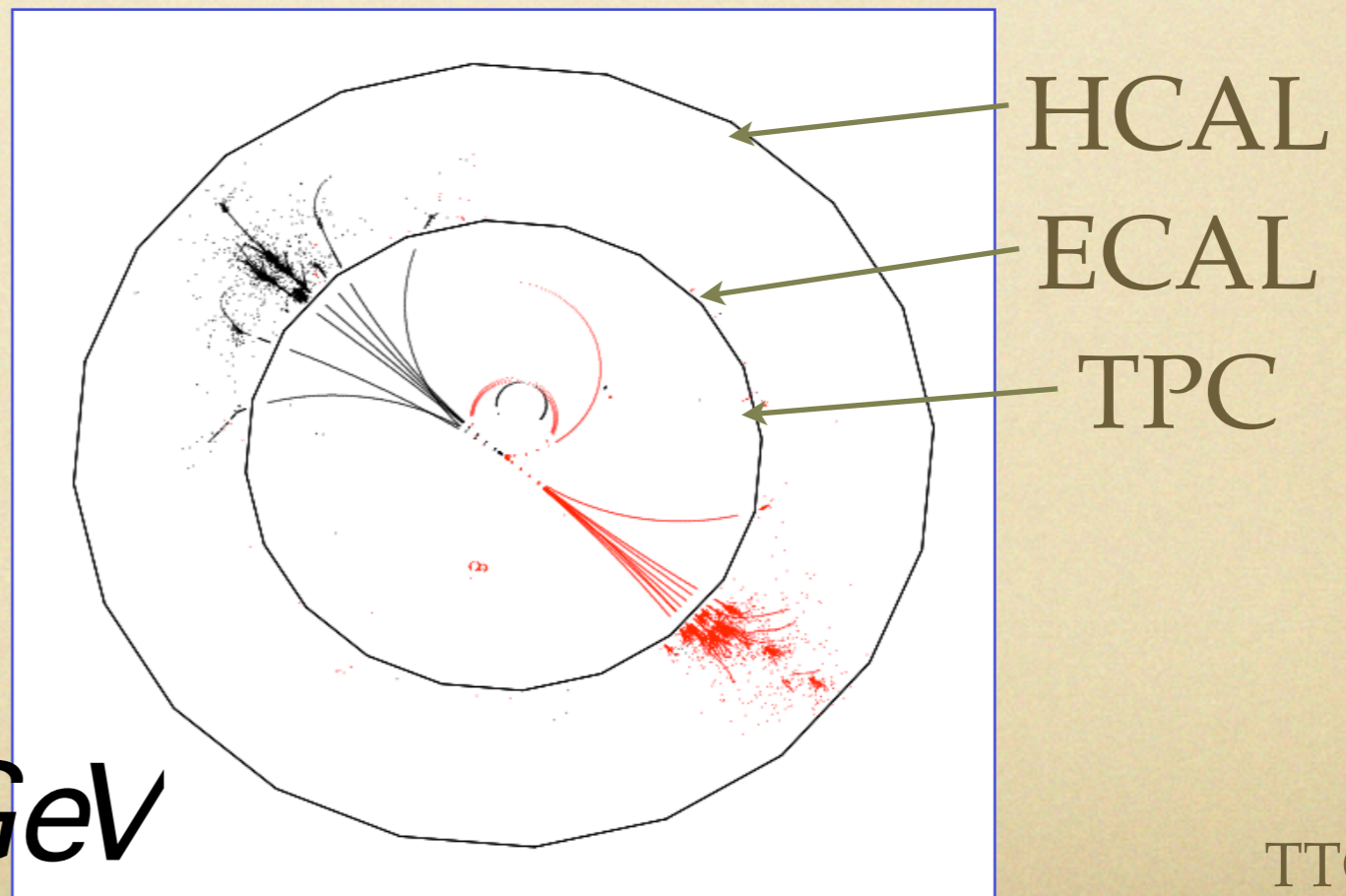outlook

© illustrated Shigemi Numazawa

ILC and its Physics

© illustrated Shigemi Numazawa

- e+e- collision with ~1TeV Linear Collider

- Final states will be dominated by narrow jets

- Jets come from W/Z/g/q
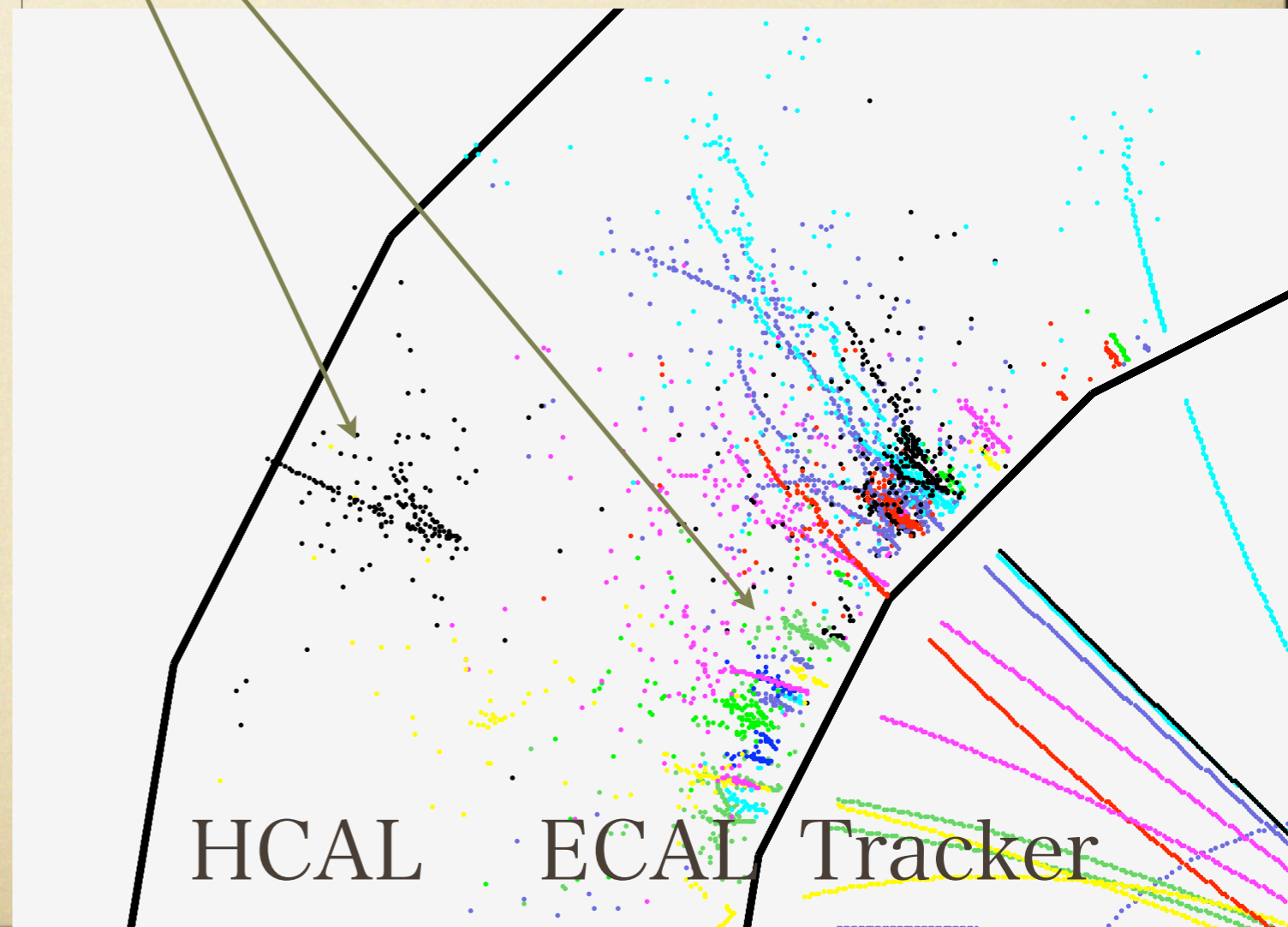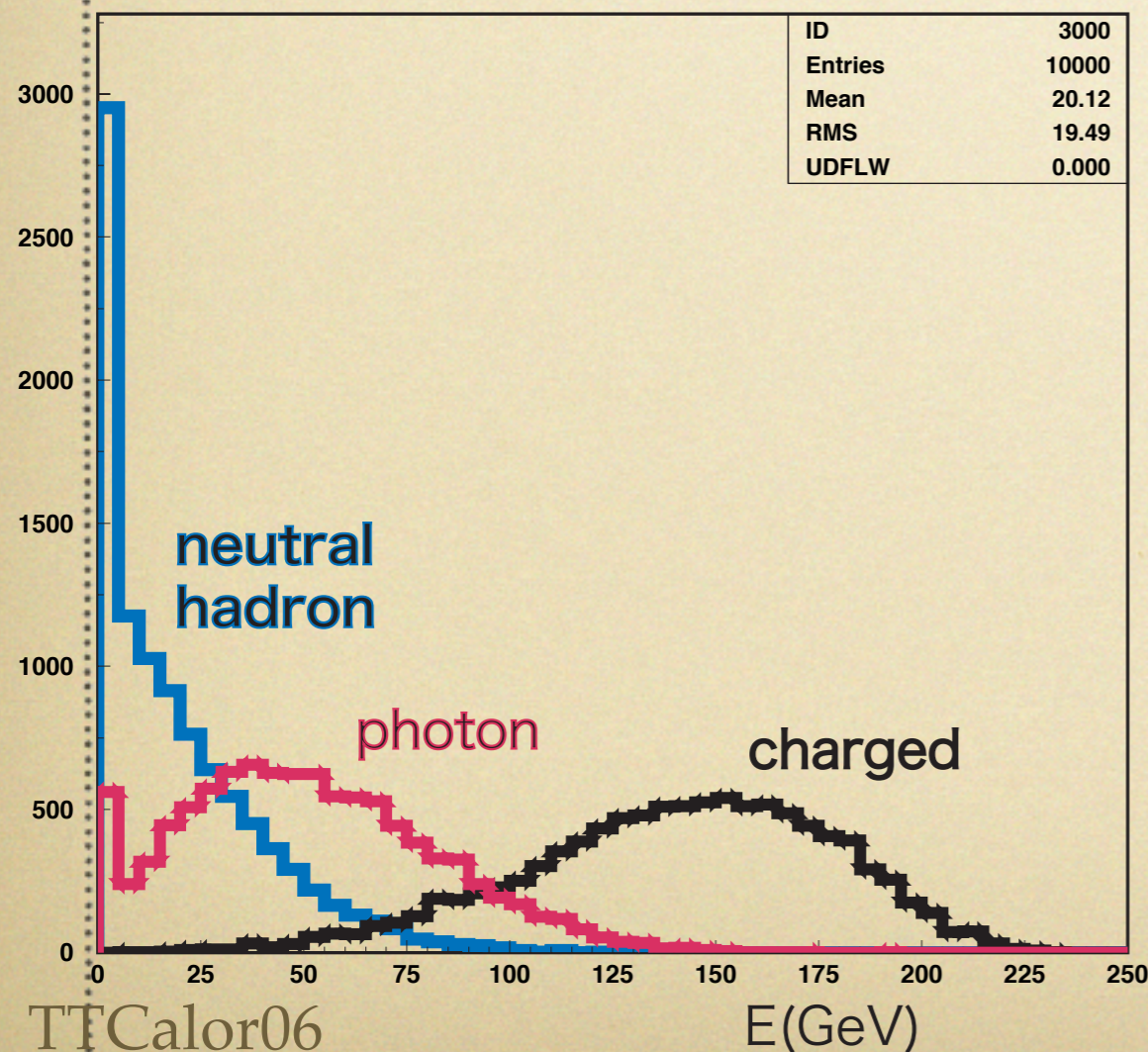
- Task : identify these partons/gauges boson from Jets

HCAL

ECAL
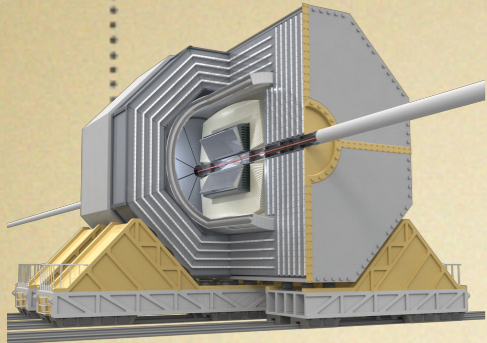
TPC

$e^+e^- \rightarrow q\bar{q} @ 350 GeV$

TTCalor06

Particle Flow oriented

Jet is measured by

- Tracker : charged 65% in a jet
- ECAL : photon 25 % in a jet
- HCAL : neutral hadron 10% in a jet

e+e- > WW at 250GeV

ID	3000
Entries	10000
Mean	20.12
RMS	19.49
UDFLW	0.000

neutral hadron

photon

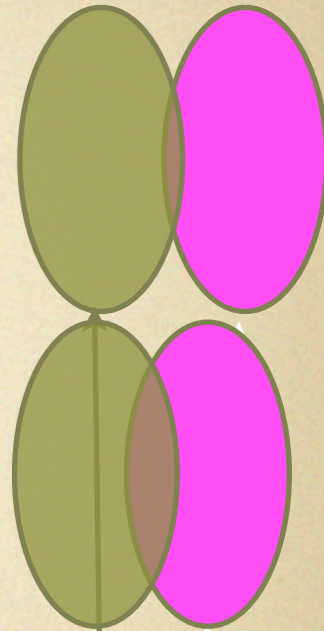charged

TTCalor06

E(GeV)

HCAL   ECAL Tracker

GLD Concepts

- Large detector
  - to measure neutral pion (ECAL)
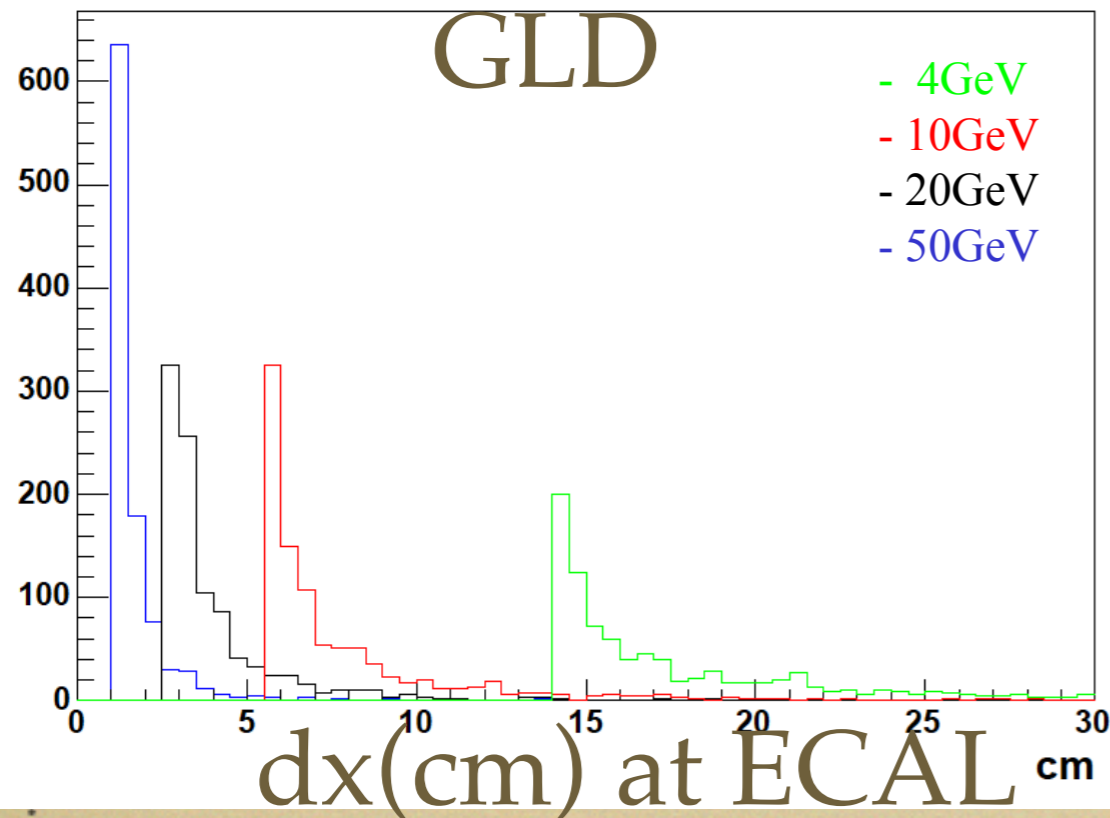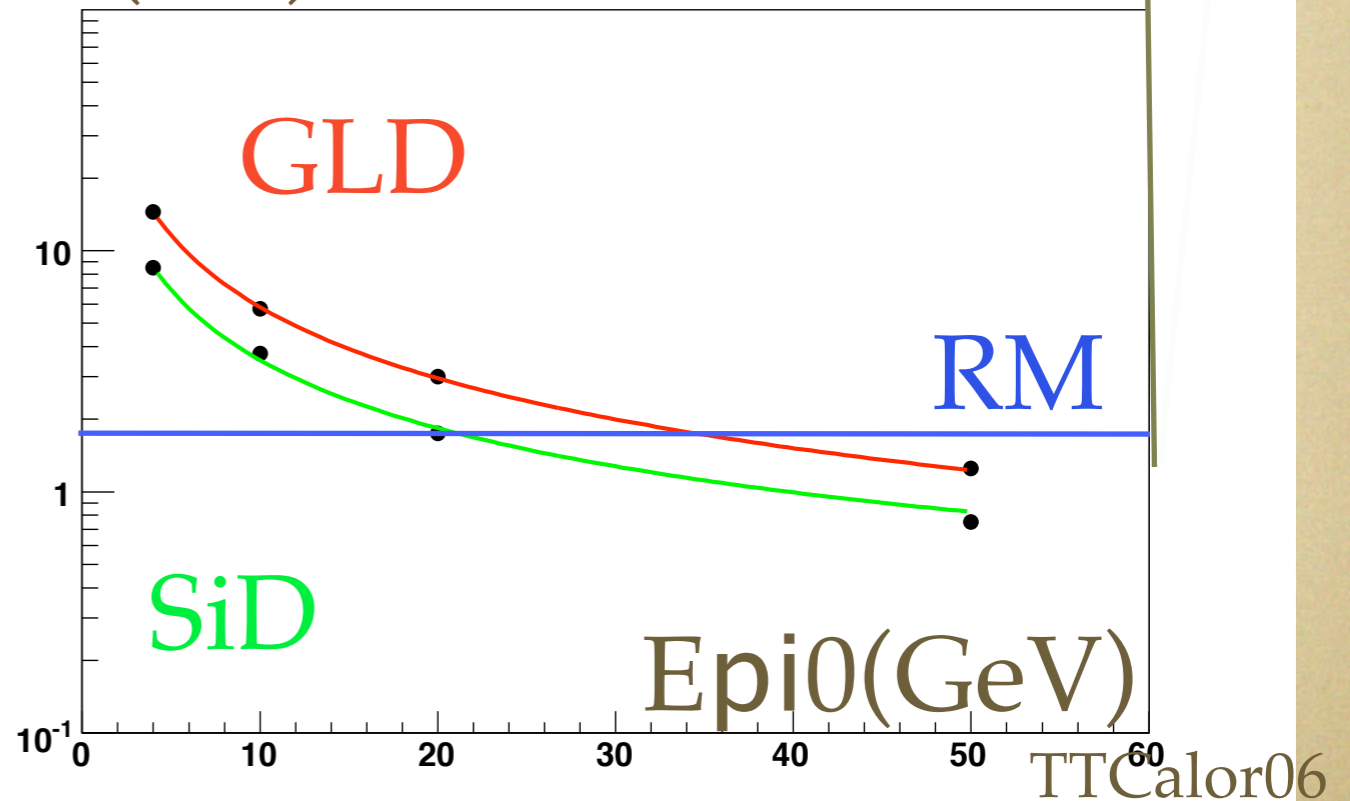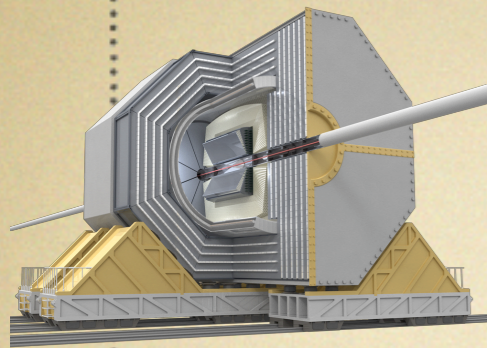 - to measure neutral hadrons (HCAL)
- smaller segmentation

Large

Small
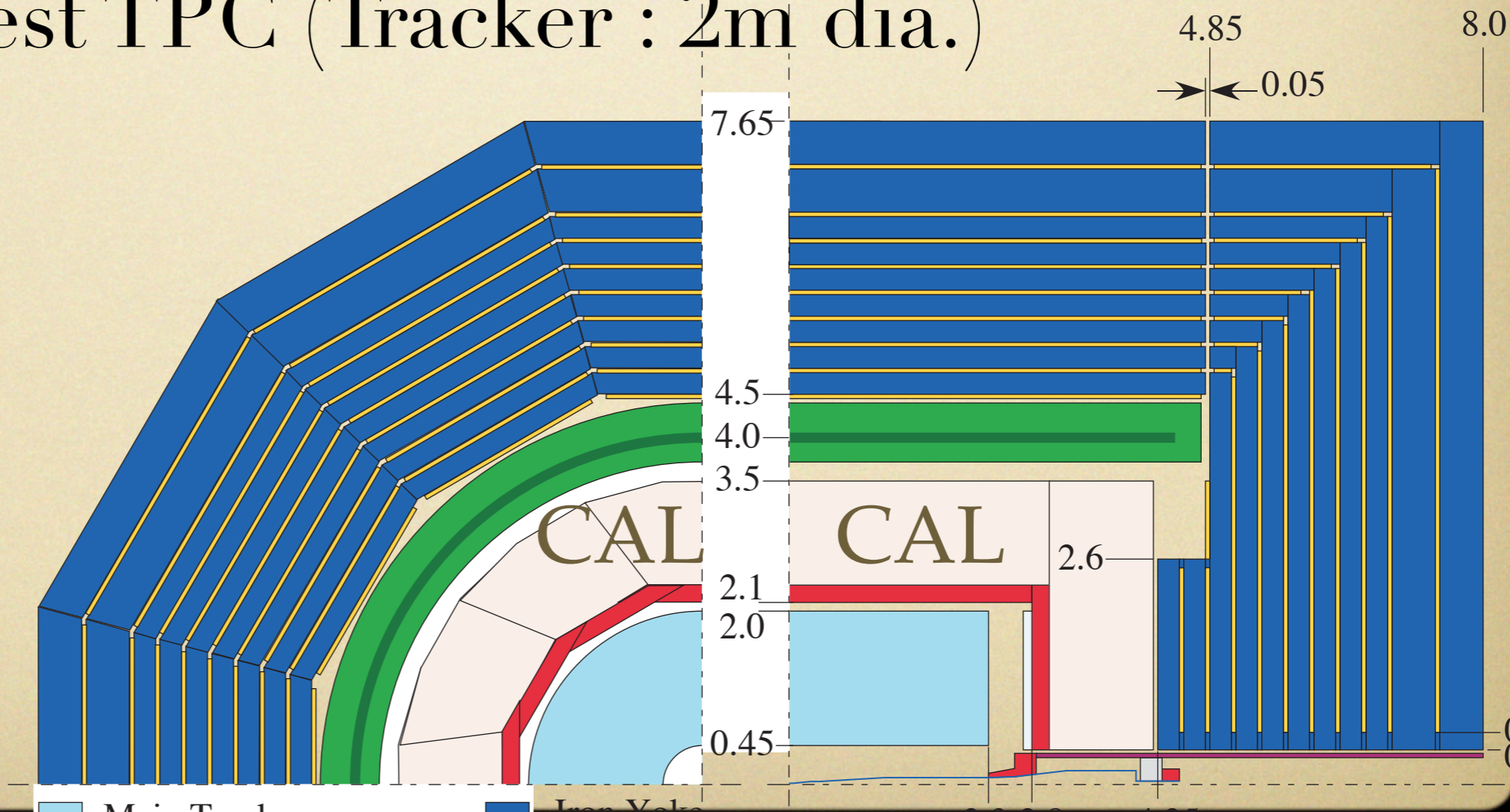
pi-zero

2gammaDistance@210cm pi0:4,10,20,50gev

GLD

- 4GeV
- 10GeV
- 20GeV
- 50GeV

dx(cm) at ECAL cm

dx(cm)

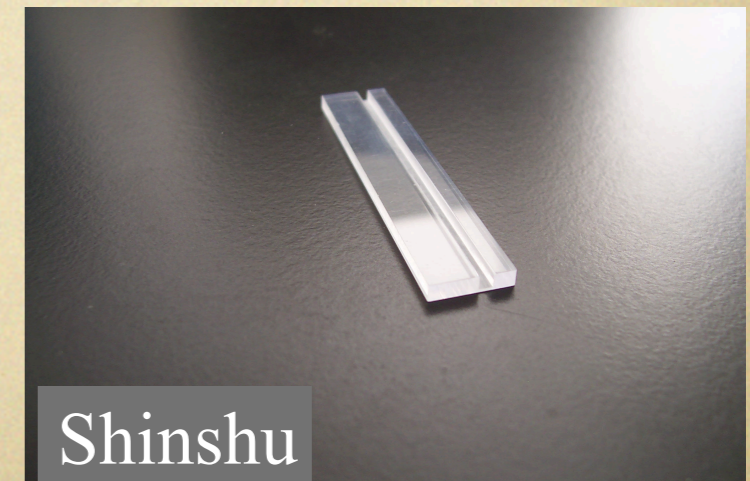GLD

RM

SiD

Epi0(GeV)
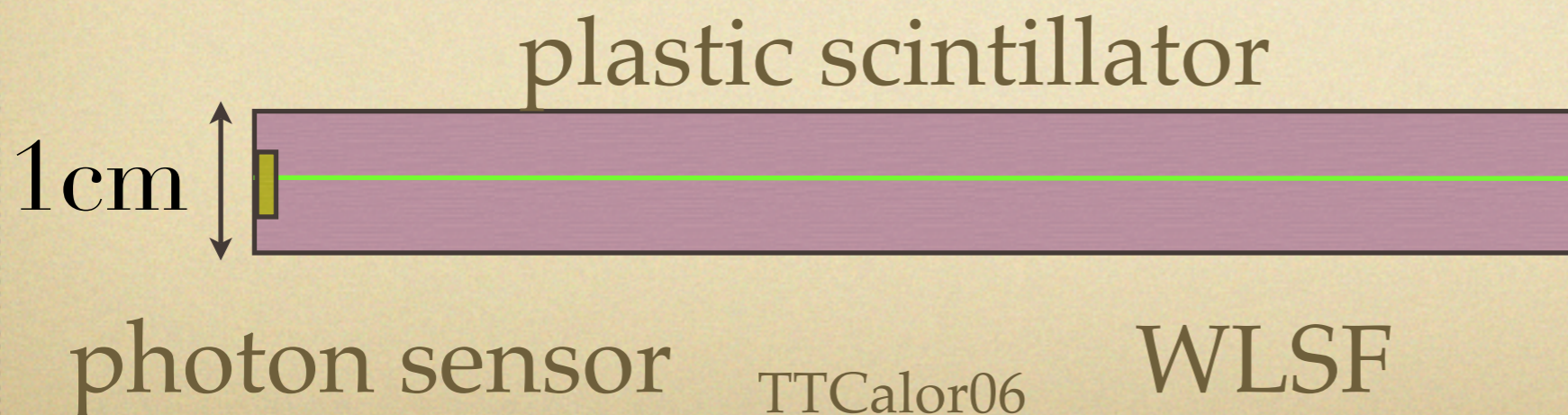
TTCalor06

4

GLD features

- to identify and measure particles in a jet

  - Large detector + super conducting magnet

    - HCAL inside coil (3.5m diameter max)
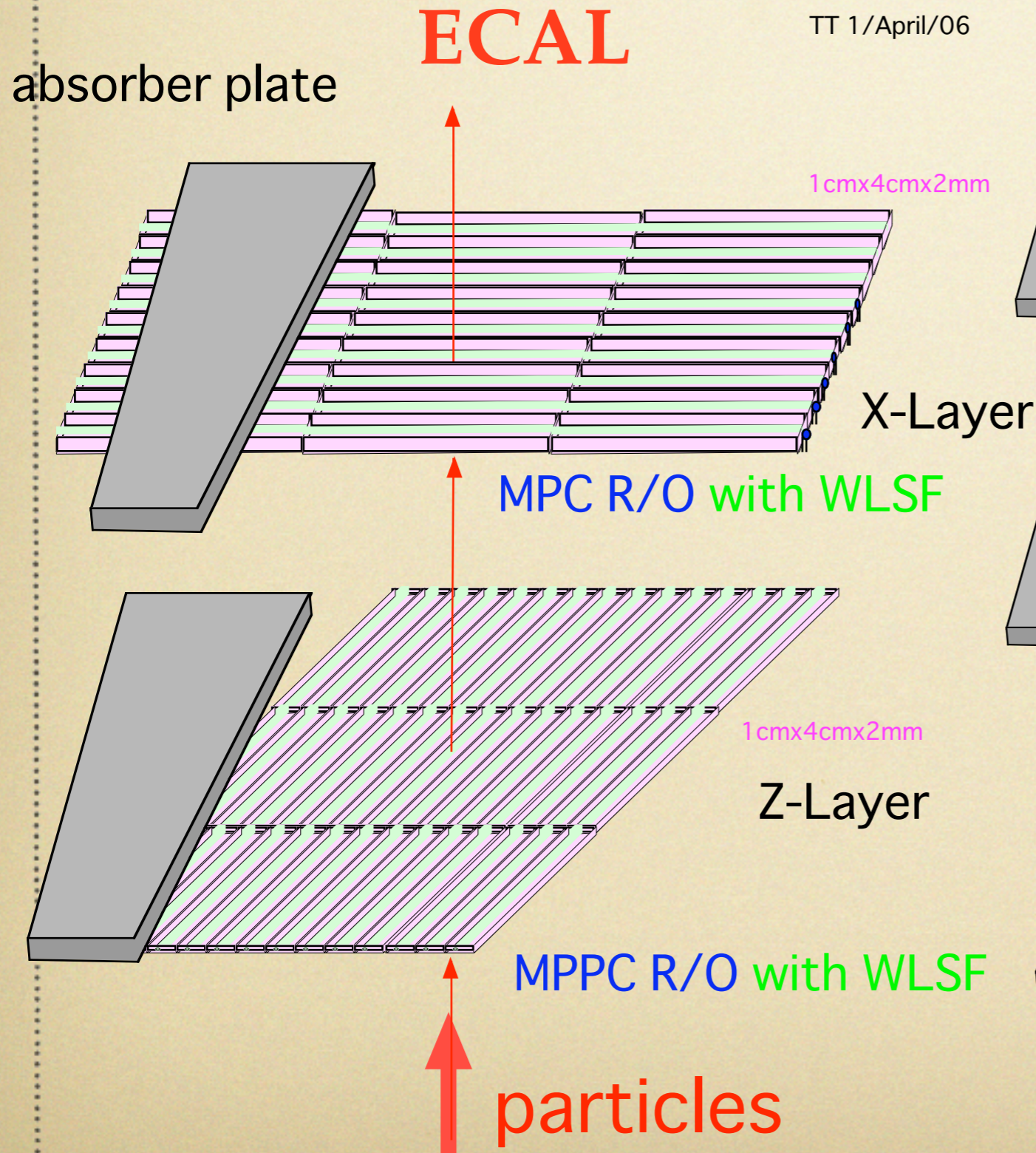
    - Largest TPC (Tracker : 2m dia.)

4.85   8.0

0.05

7.65

4.5
4.0
3.5

CAL   CAL

2.6

2.1
2.0

0.45

GLD-Calorimeter

- **scintillator strip calorimeter**
- ECAL : R = 2.1 ~ 2.3 m (0.2m) :
  - 6 mm/layer (3 + **2** + 1)mm
    - 33 layers, 28X0
- HCAL : R = 2.3 ~ 3.5 m (1.2m) :
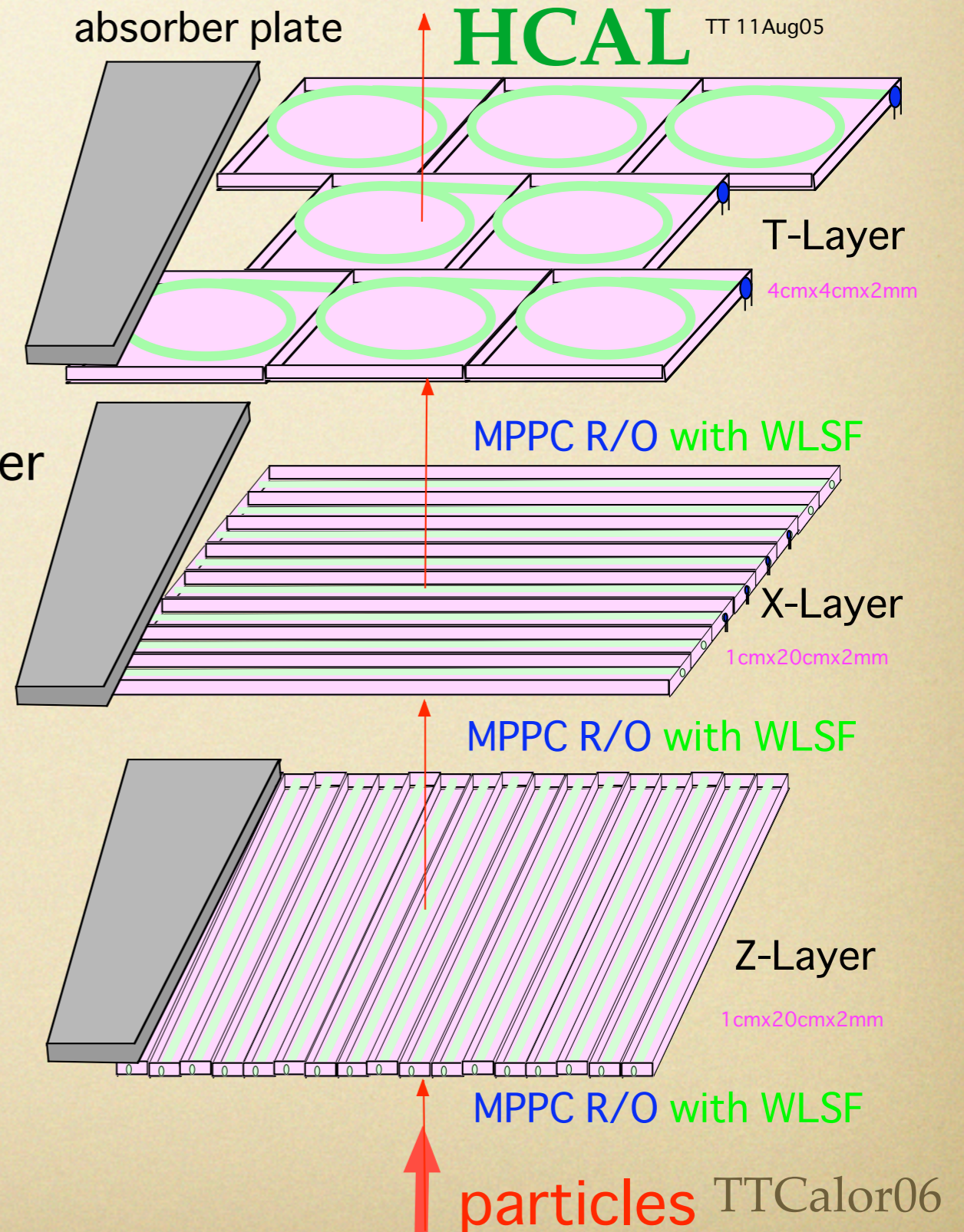 - 26 mm/layer (20 + **5** + 1)mm
    - 46 layers , 5.5 mint

plastic scintillator

1cm

photon sensor   WLSF

TTCalor06

Shinshu

GLD-Calorimeter cont.

GLD-ECAL-Scintillator-layer model

ECAL

TT 1/April/06

absorber plate

1cmx4cmx2mm

X-Layer

MPC R/O with WLSF

1cmx4cmx2mm

Z-Layer

MPPC R/O with WLSF

particles

HCAL-Scintillator-layer model

absorber plate

HCAL TT 11Aug05

T-Layer

4cmx4cmx2mm

MPPC R/O with WLSF

X-Layer

1cmx20cmx2mm

MPPC R/O with WLSF

Z-Layer

1cmx20cmx2mm

MPPC R/O with WLSF

particles TTCalor06

GLD-Calorimeter cont.

TT 01April06

ECAL

EM-Scintillator-layer model

Cross section

TT 1April06

Tungsten

1mm

2mm   WLSF   scintillator   X-Layer

MPPC   4cm

3mm   Flex-sheet   R/O chip

Tungsten

1mm

2mm   Z-Layer

MPPC   1cm

3mm   Tungsten

particle

HCAL

Cross section

1mm

5mm   Tile-Layer

4cm

20mm   Lead

1mm

5mm   WLSF   scintillator   X-Layer

MPPC   4cm   Flex-sheet   R/O chip

20mm   Lead

1mm

5mm   Z-Layer

MPPC   1cm

20mm   Lead   TTCalor06

8
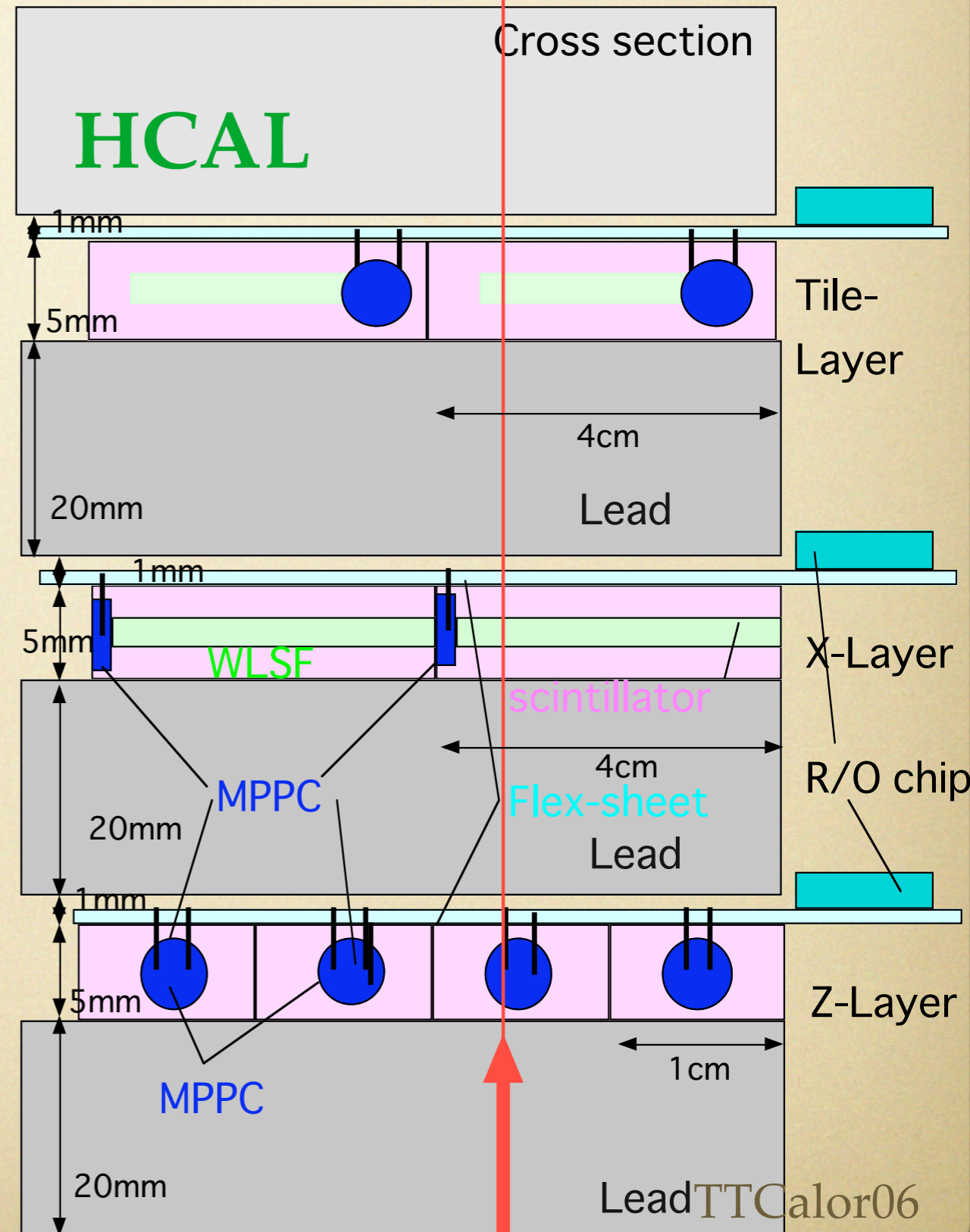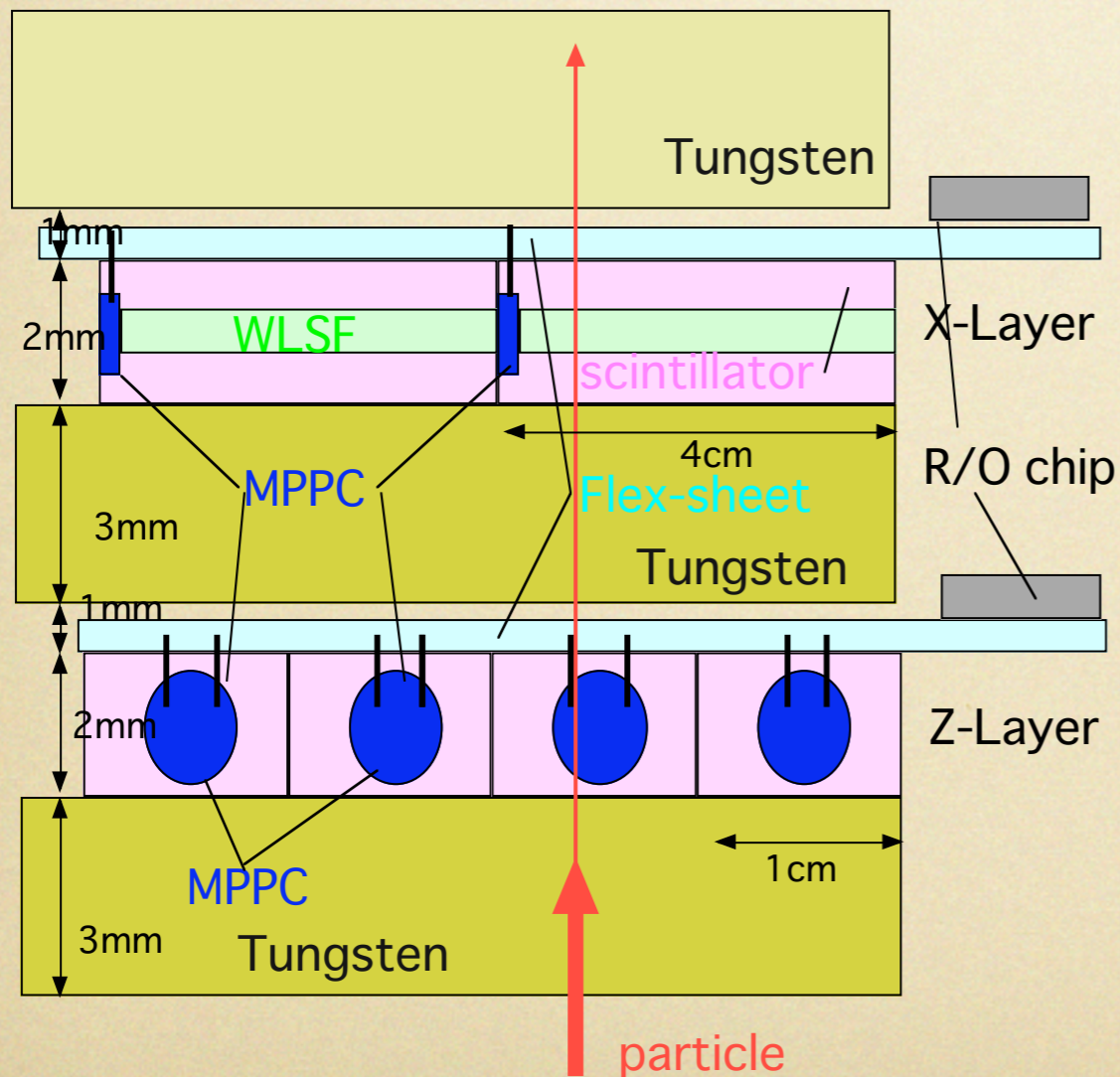
GLC-CAL parameters

	absorber	active material	Layers barrel/ec	strip length	N. R/O
ECAL	W 3mm	scintillator 2mm	33/ 33	5cm?	~10M ch
HCAL	Pb 20mm **compensating**	scintillator 5mm	46/ 48	20cm?	~4M ch

scintillator strip CAL. experience
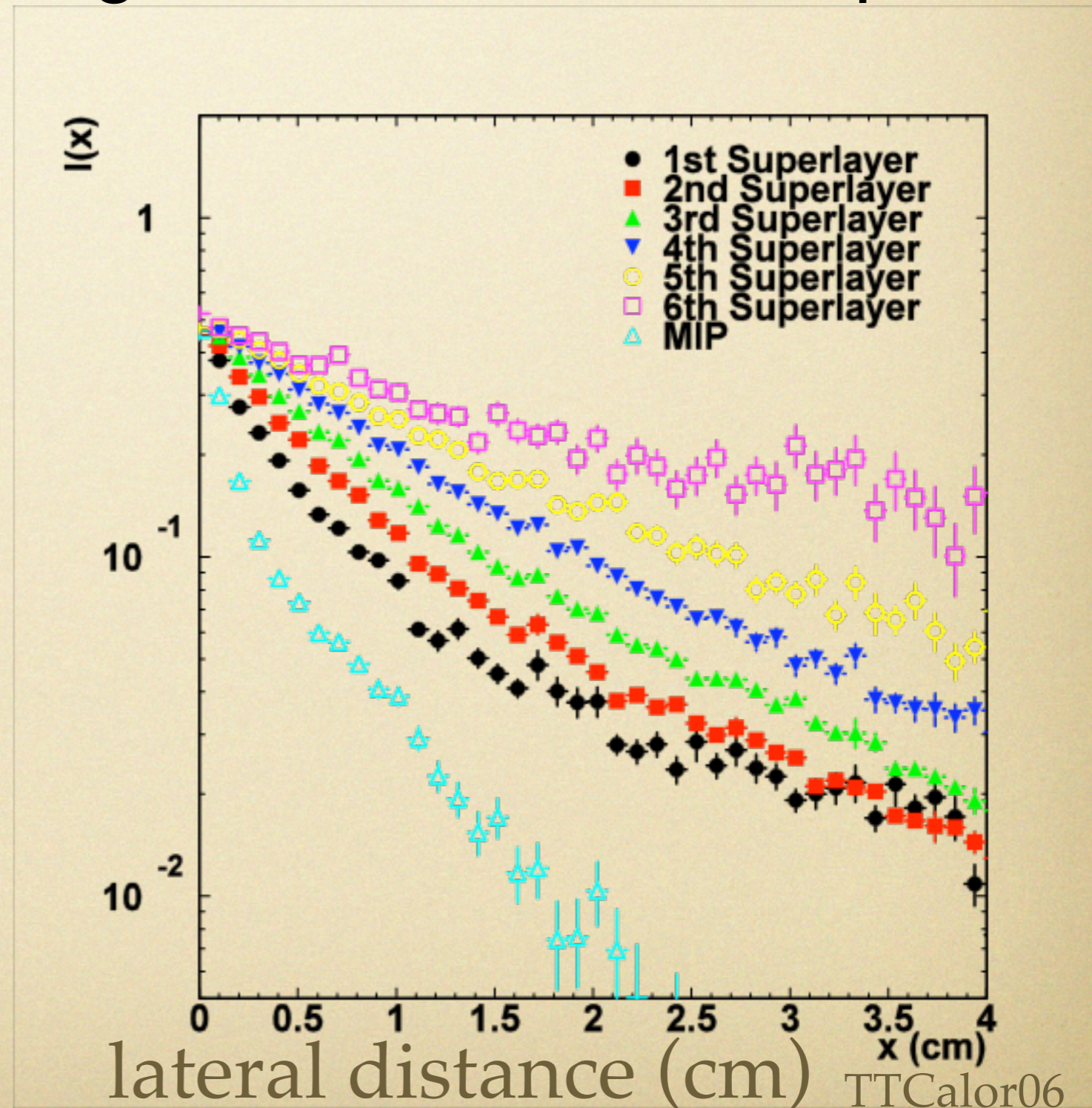
ECAL test with MAPMT
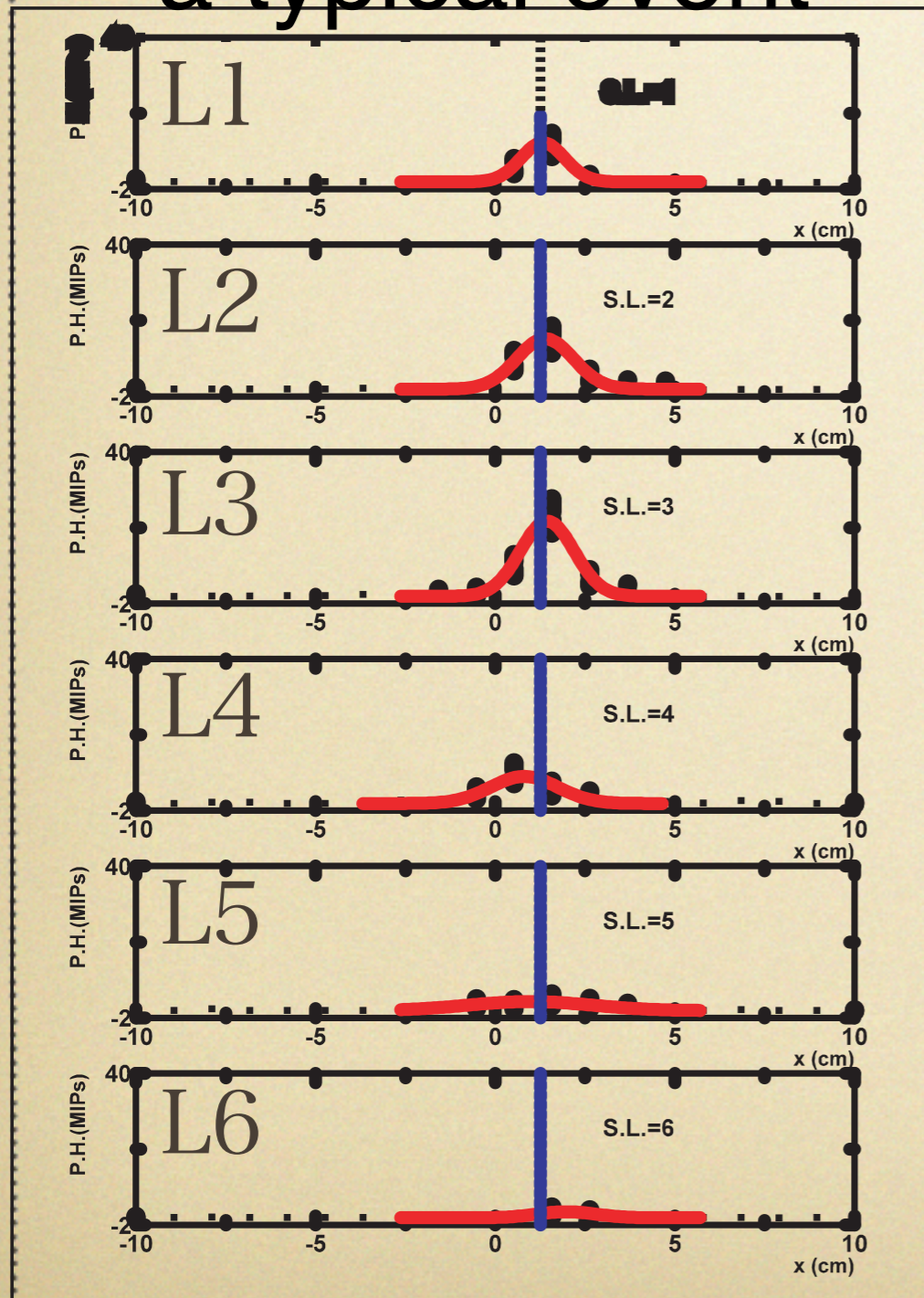
20cmx1cmx2mm

24layers
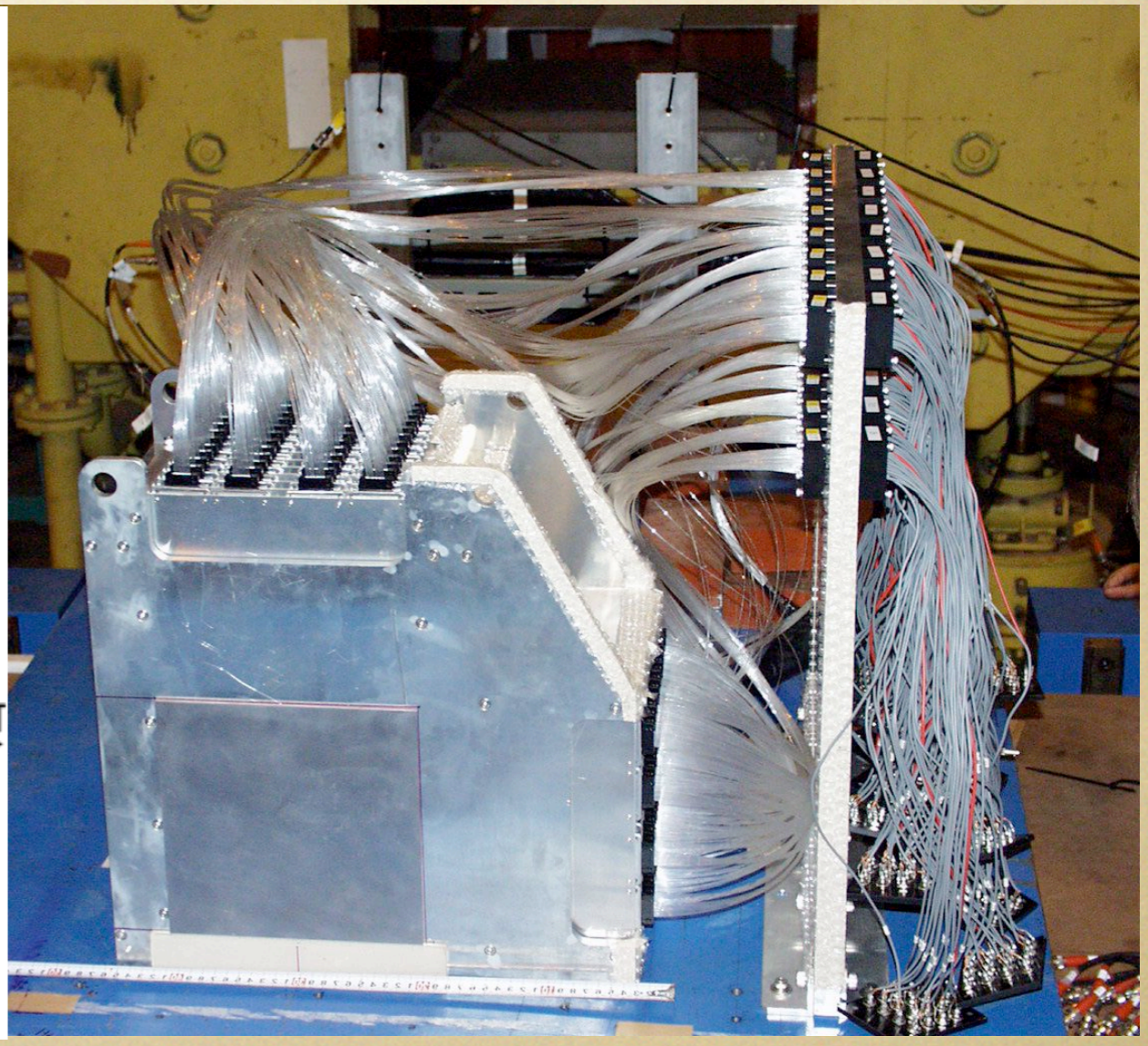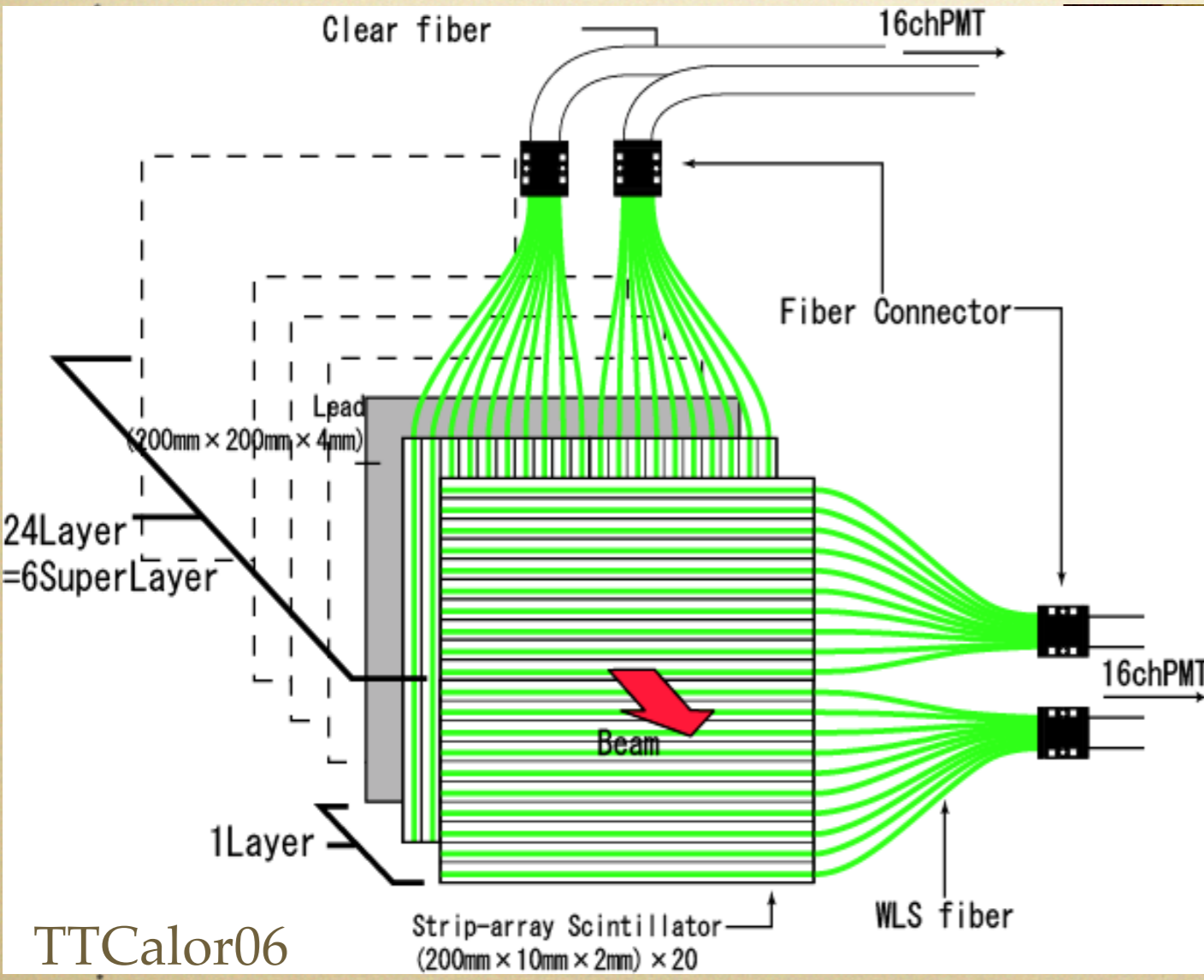
TTCalor06

SSCAL experince cont.

pictorial detector
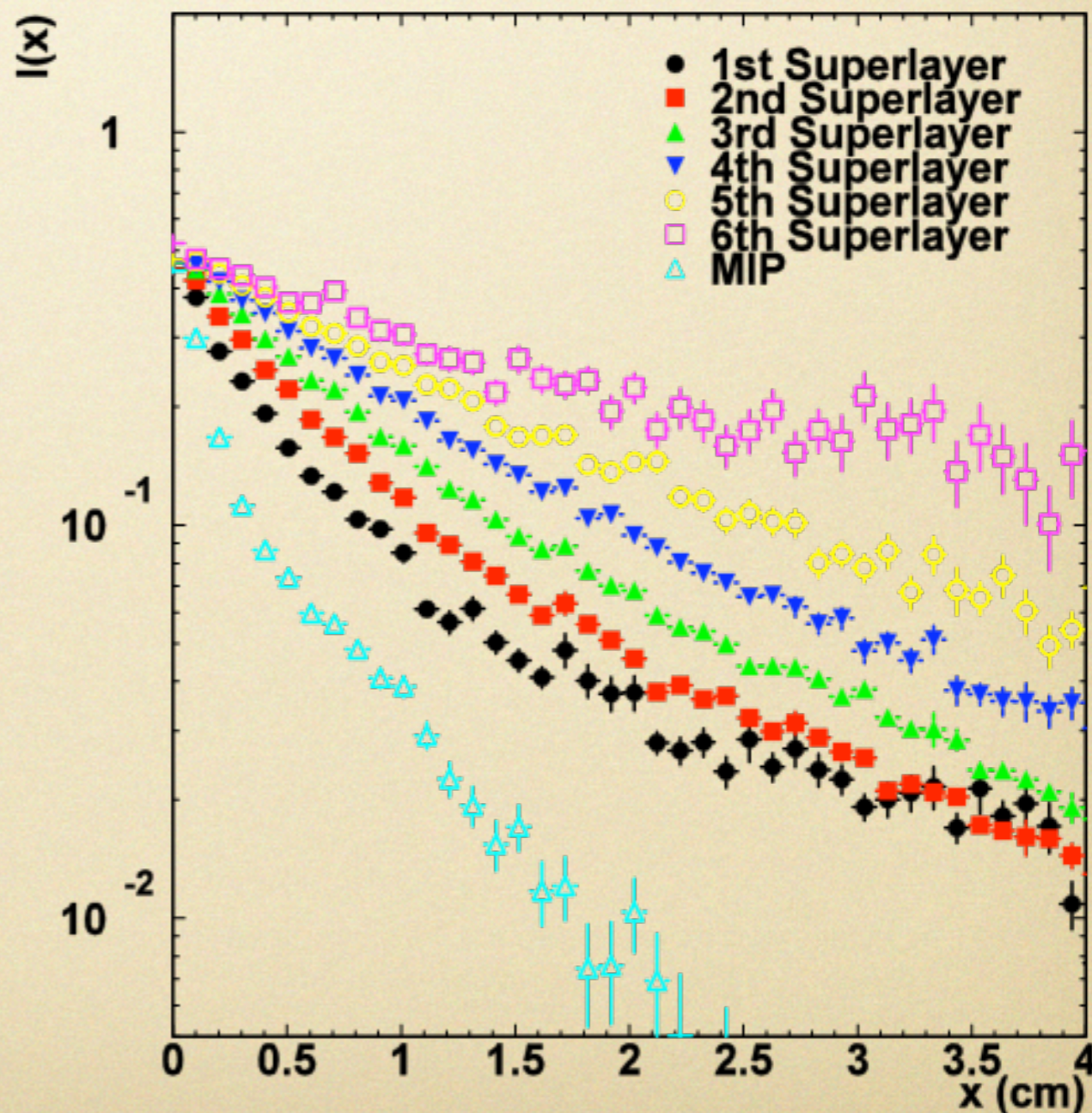## a typical event

Integrated lateral shower profile
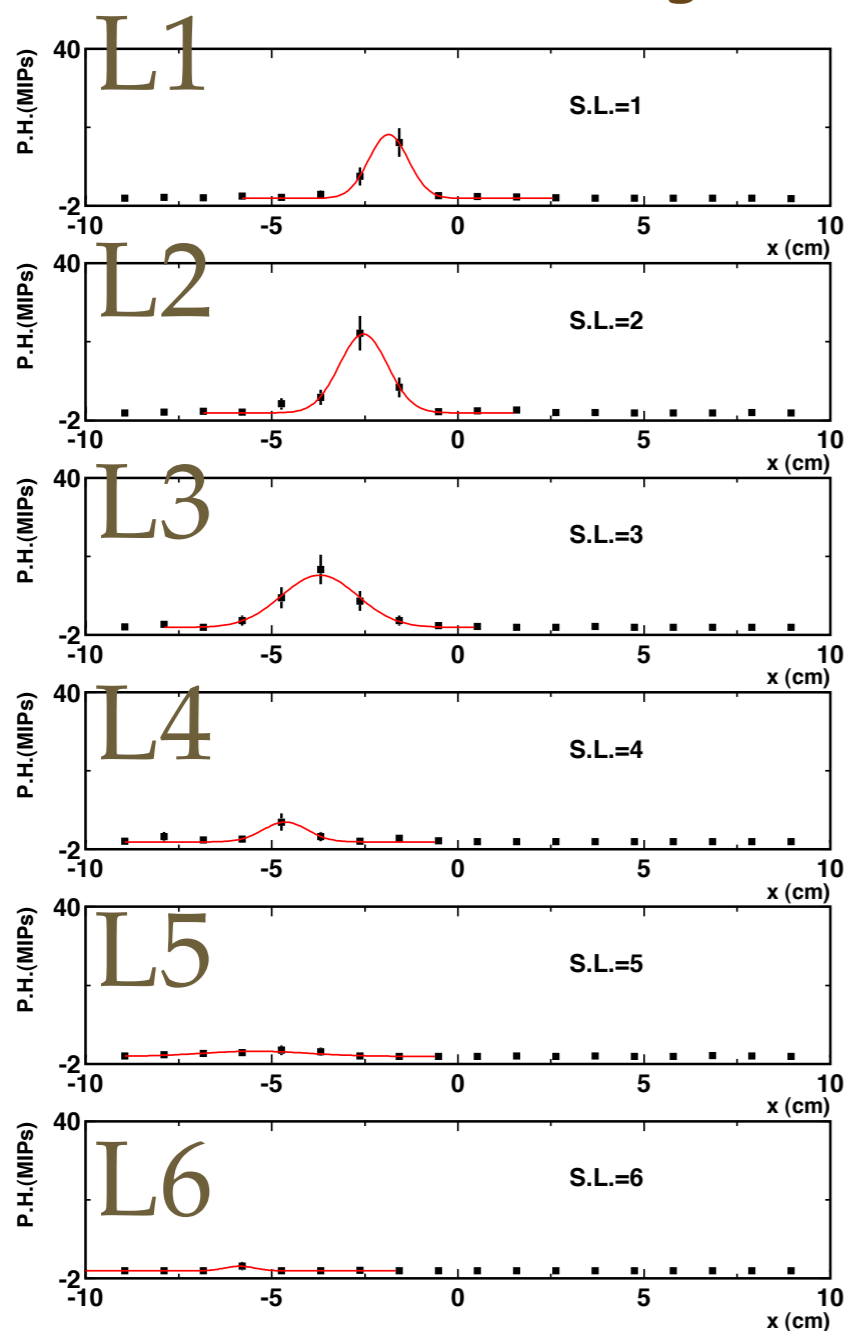

lateral distance (cm)
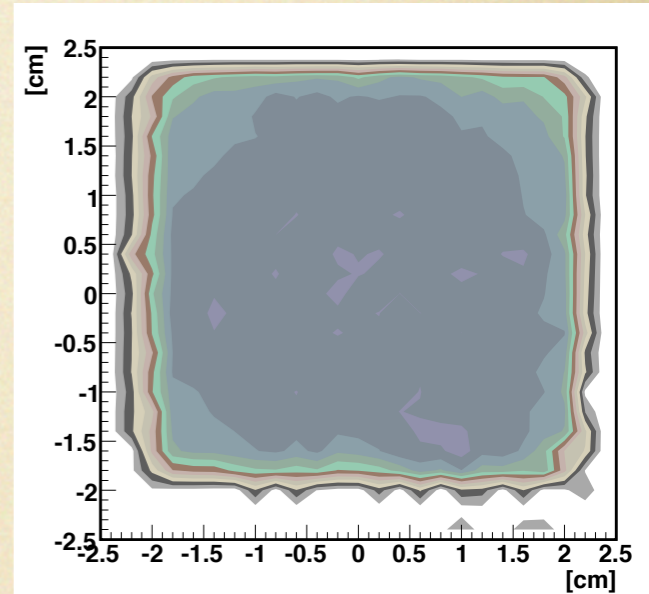
TTCalor06

SSCAL experince cont.

pictorial detector

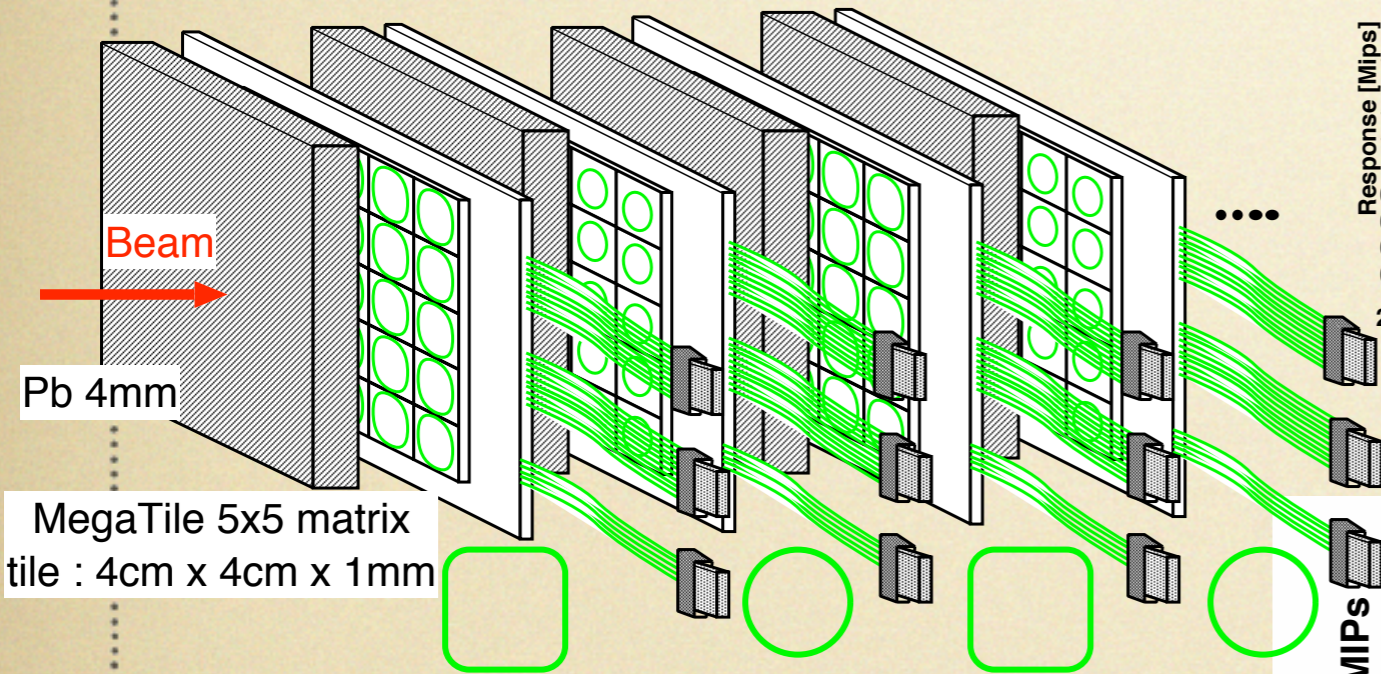## Integrated lateral shower profil

4 GeV e, θ=15.9 degree
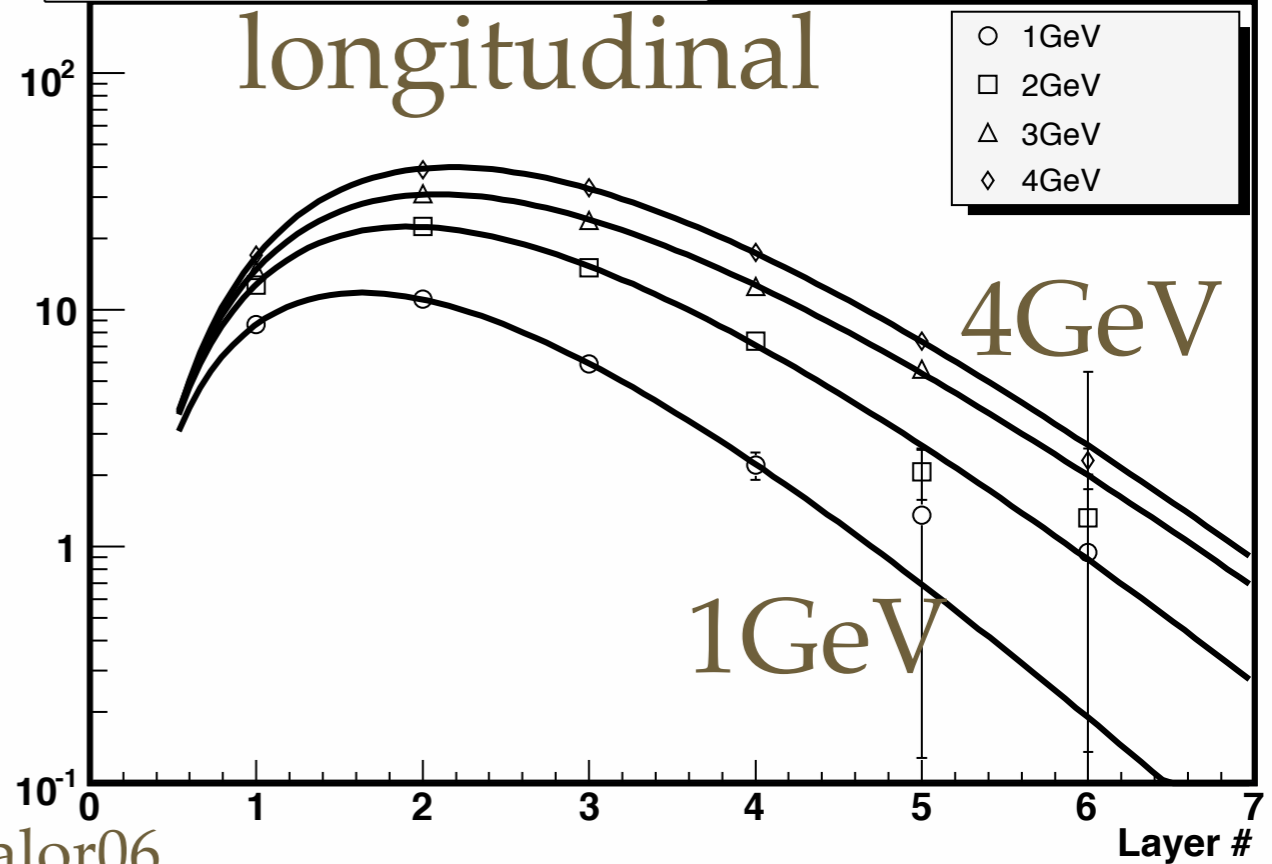
L1
L2
L3
L4
L5
L6

scintillator Tile CAL. experience

Beam

Pb 4mm

MegaTile 5x5 matrix
tile : 4cm x 4cm x 1mm

....

Response [Mips]

MIPs
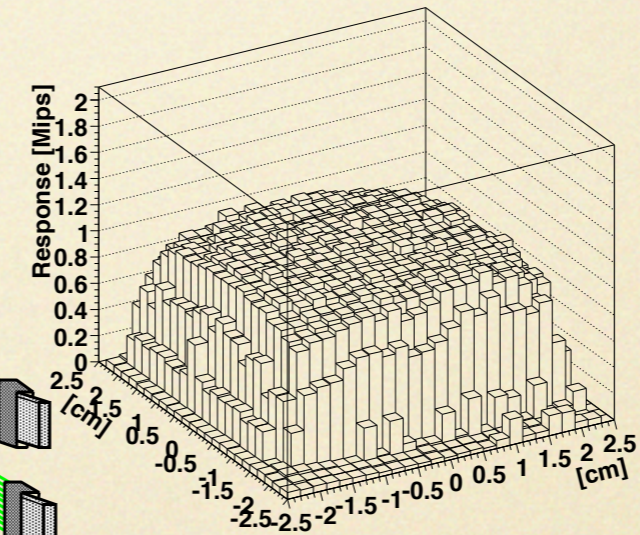
Shower Curve 1GeV to 4GeV

longitudinal

- ○ 1GeV
- □ 2GeV
- △ 3GeV
- ◇ 4GeV

4GeV

1GeV

Layer #

TTCalor06

13

netural pion finnding in ECAL

1cm width assumed

Y strips   X strips
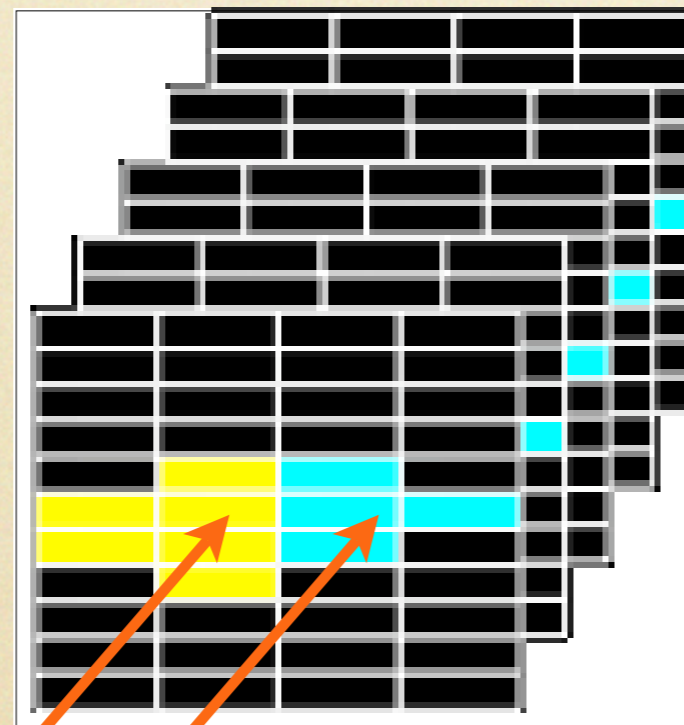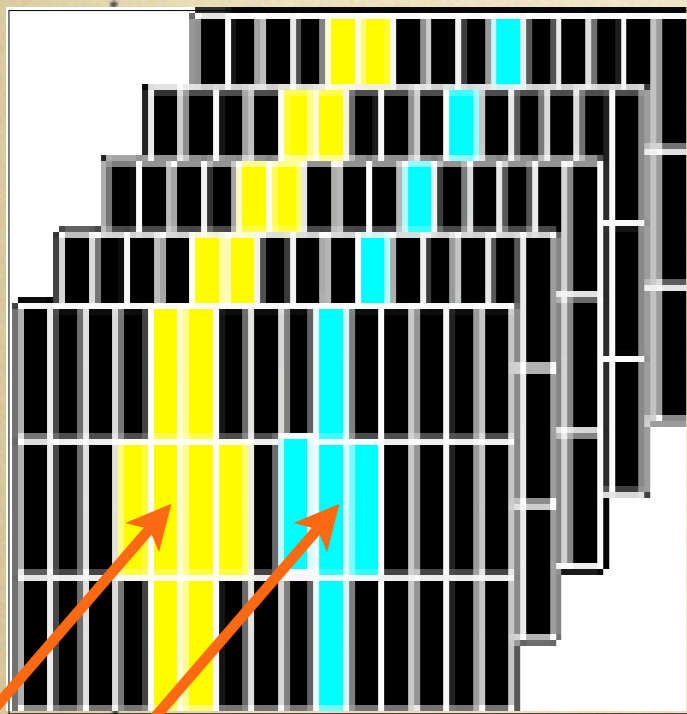
two photons from pizero

finding effciency $*10^3$
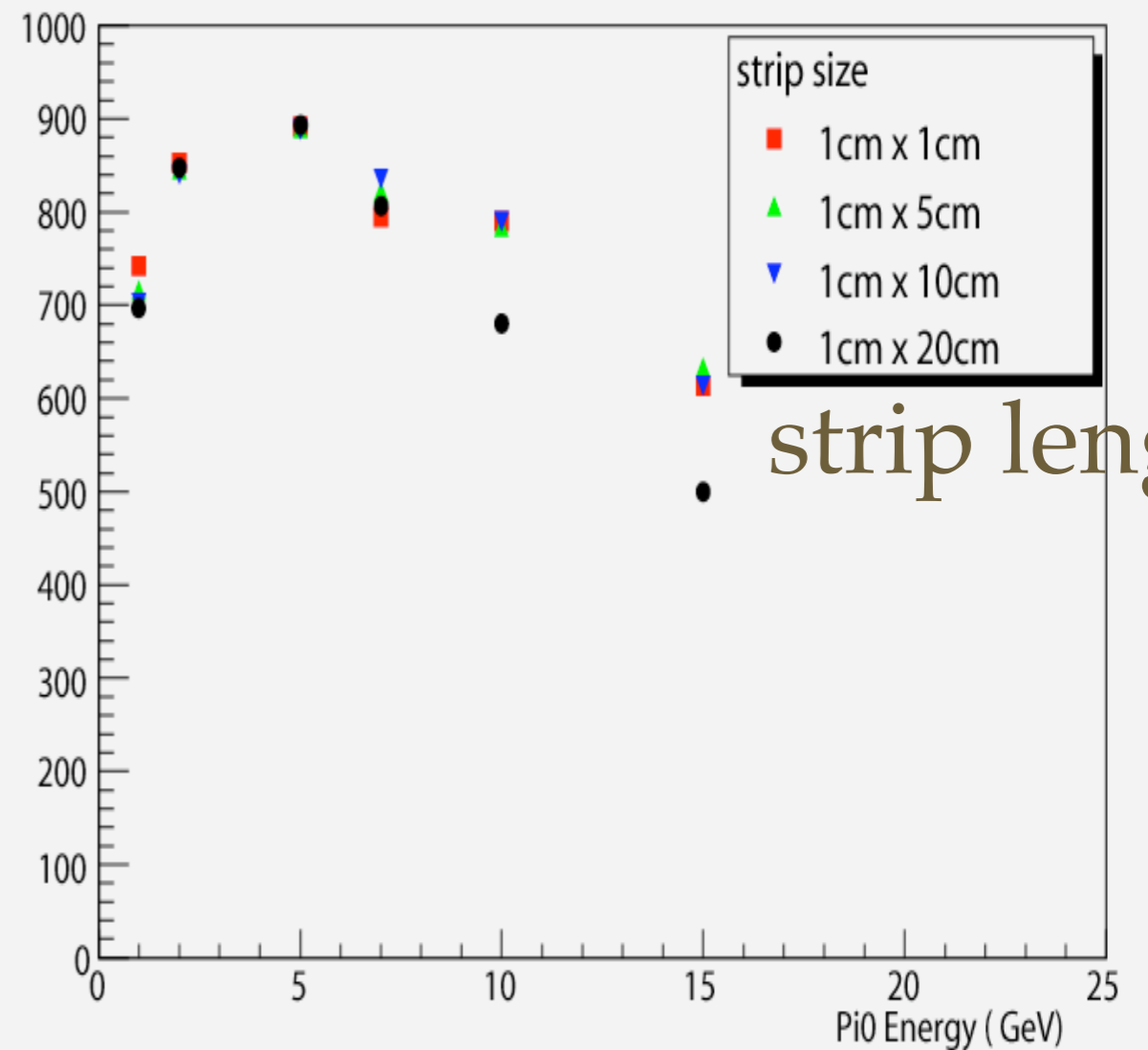
strip length

Epi-zero (GeV)

TTCalor06

scintillator HCAL

neutron sensitive

timing info.

a pion event
digitized hits

Pb/Sci

pi-
4GeV

1cm x 1cm
glanurality
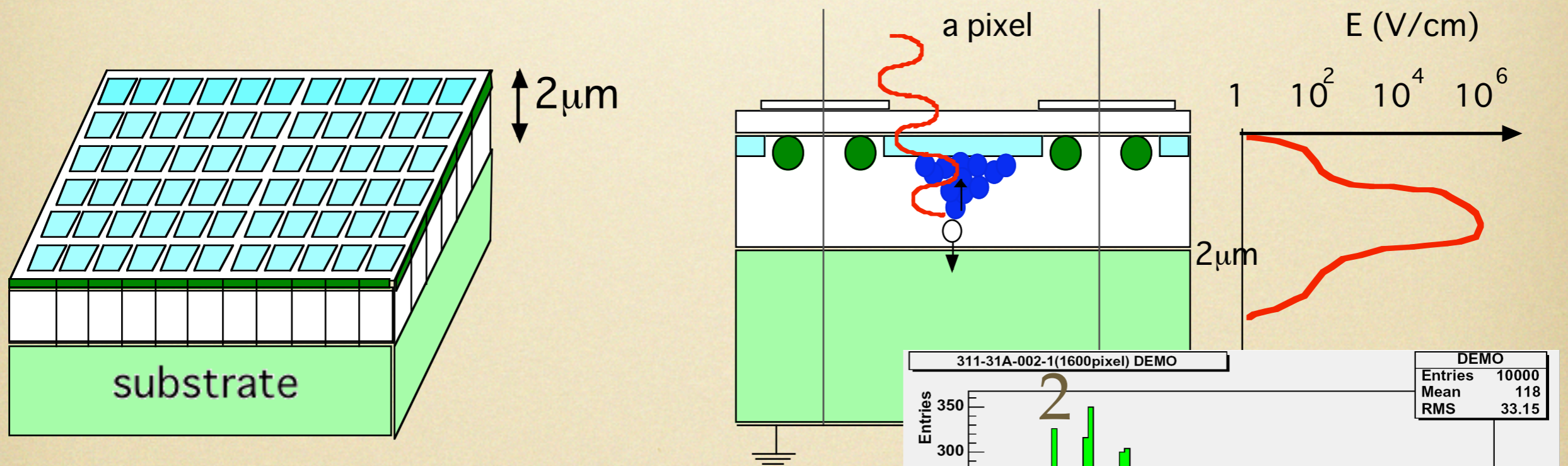with 8mm lead

a pion interaction in HCAL layers
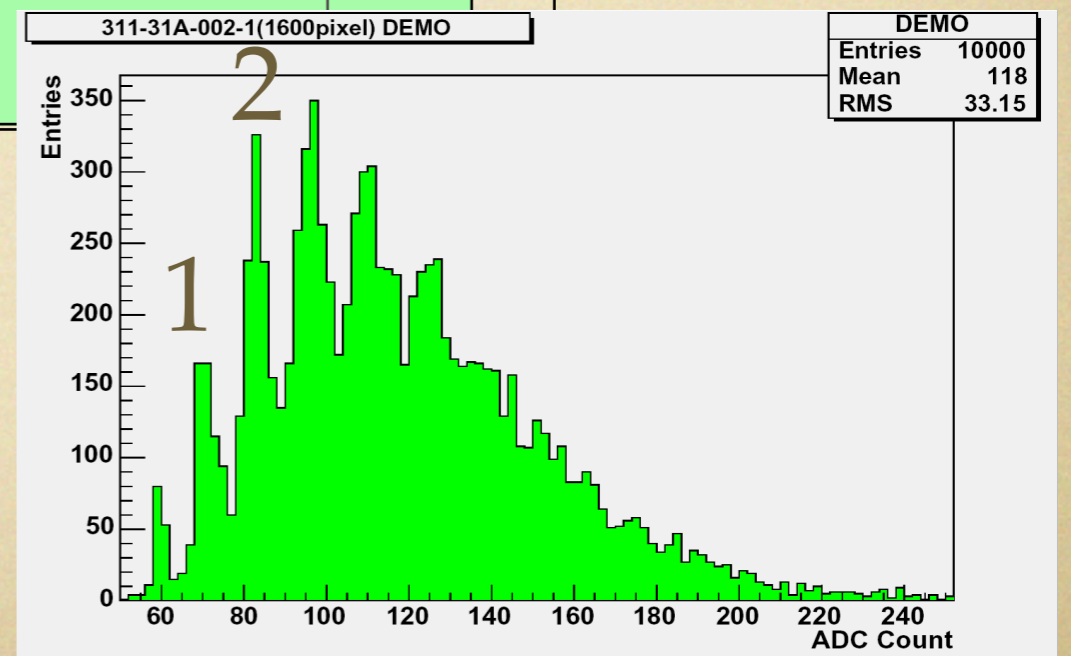

20% of energy

neutron
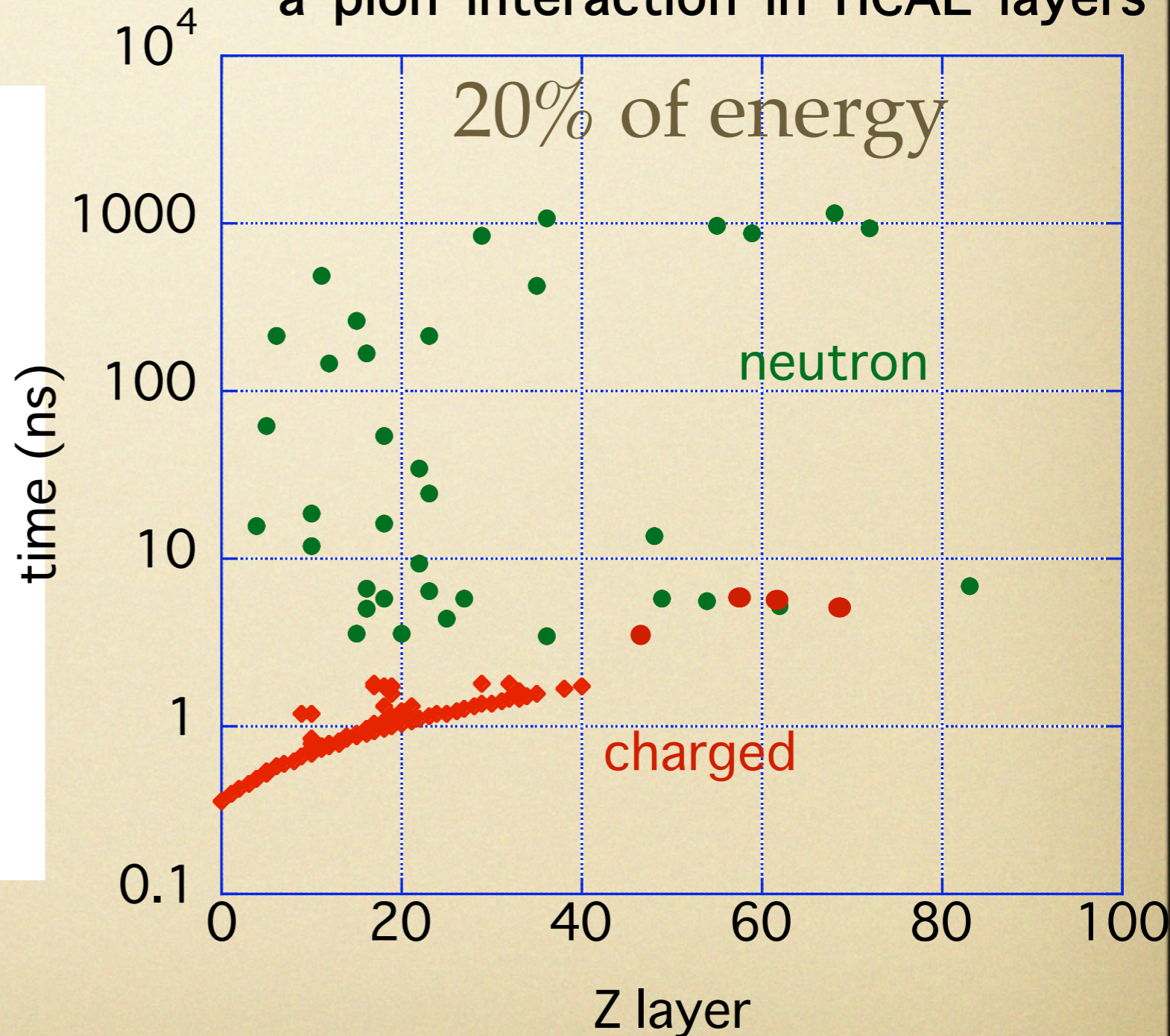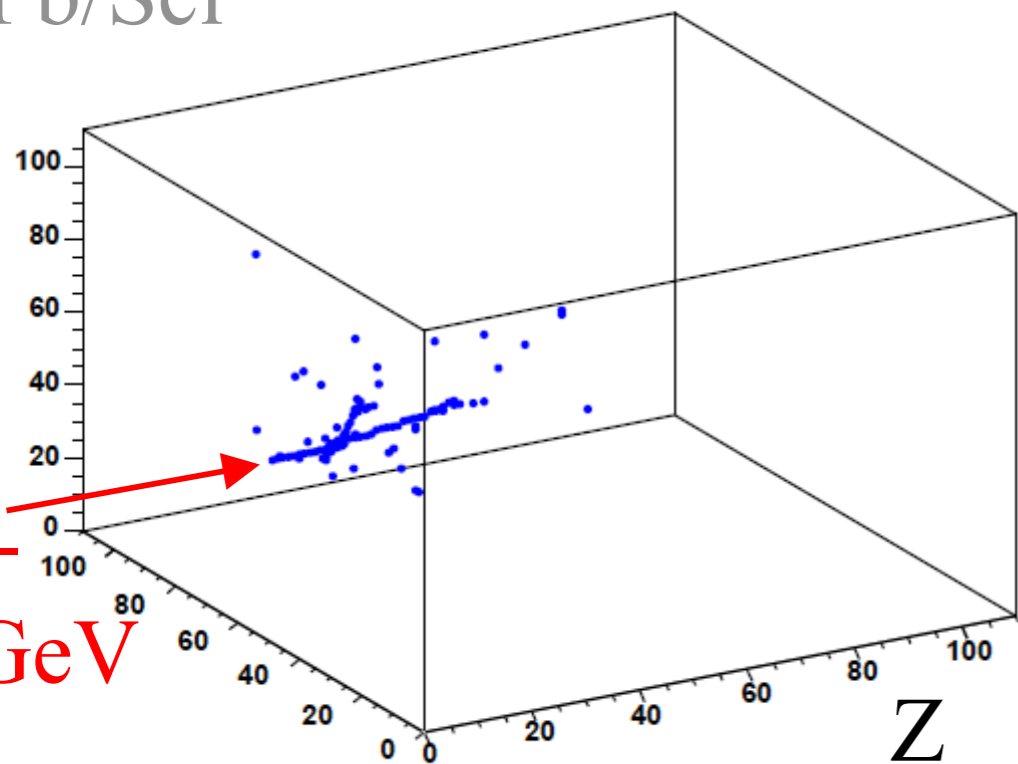
charged

current R&D issues

- **Photon sensor (MPPC) and prototype test at beam**

MPPC semiconductor pixel photon sensor
with Geiger or Limited Geiger Mode

a pixel

E (V/cm)

$1 \quad 10^2 \quad 10^4 \quad 10^6$

$2\mu m$

$2\mu m$

substrate

photon counting capability

311-31A-002-1(1600pixel) DEMO

DEMO	
Entries	10000
Mean	118
RMS	33.15

Entries

2

1

350

300

250

200

150

100

50

0

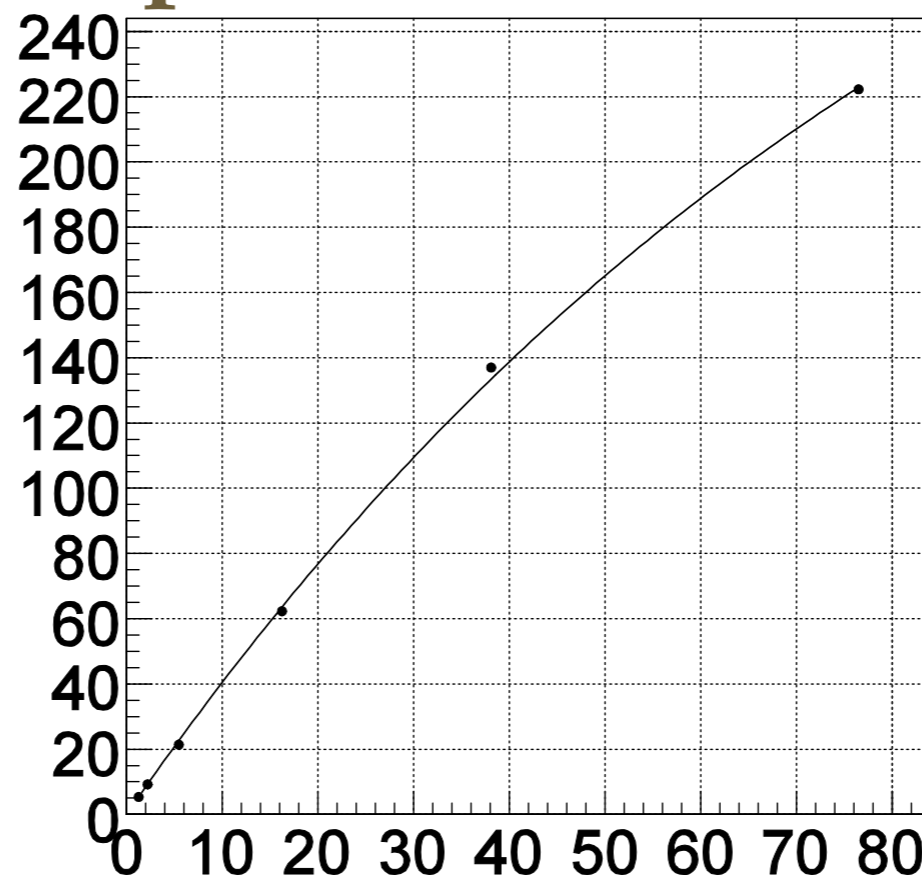60 80 100 120 140 160 180 200 220 240

ADC Count

MPPC (Multi Pixel Photon Counter) by HPK

- **linearity is relevant for calorimeter however, limited by number of pixels**

- **fixed to a fiber diameter (~1mm)**
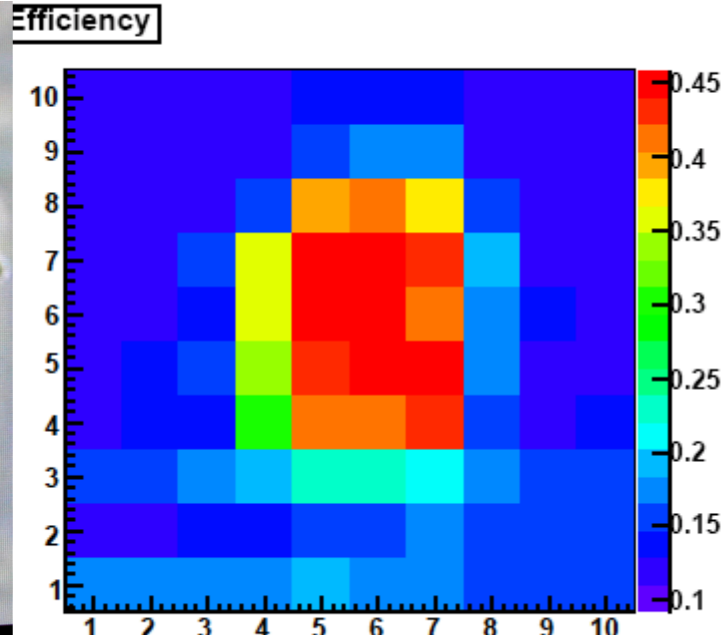
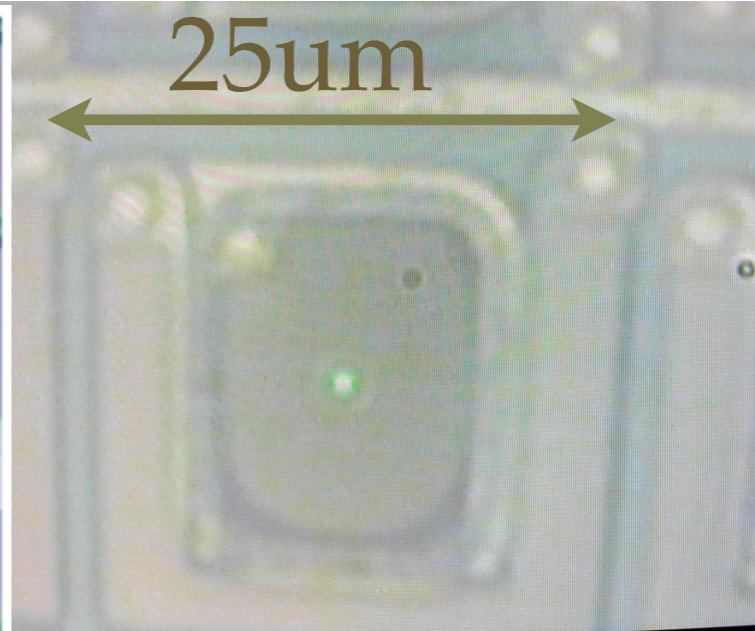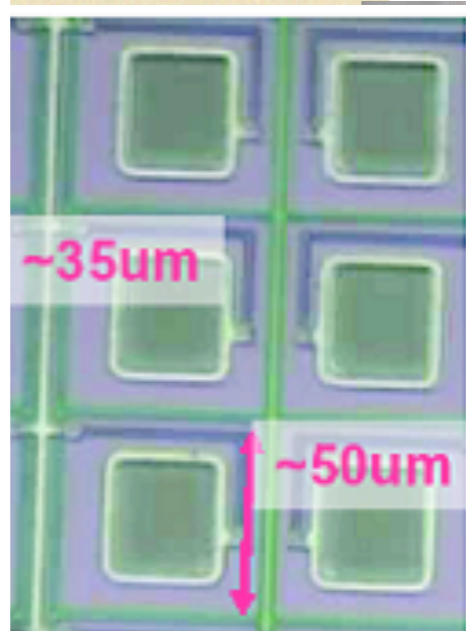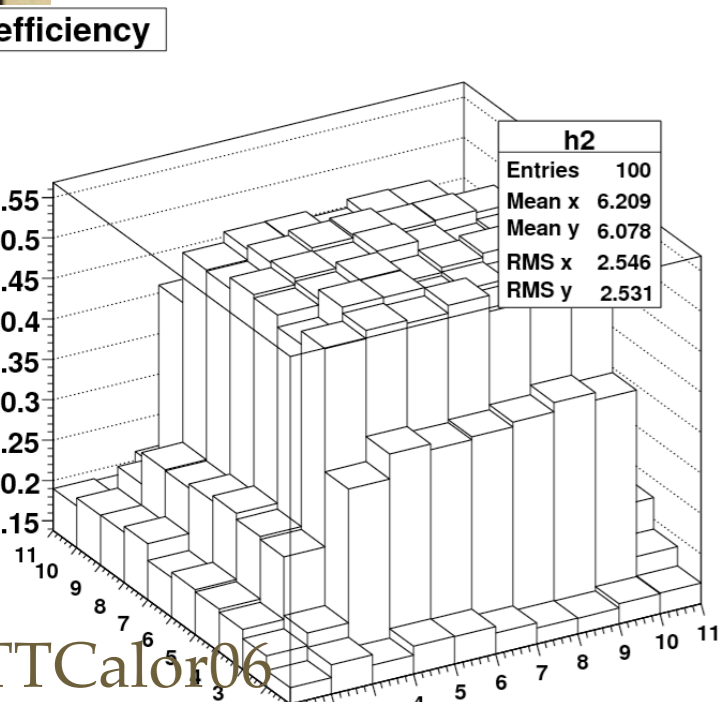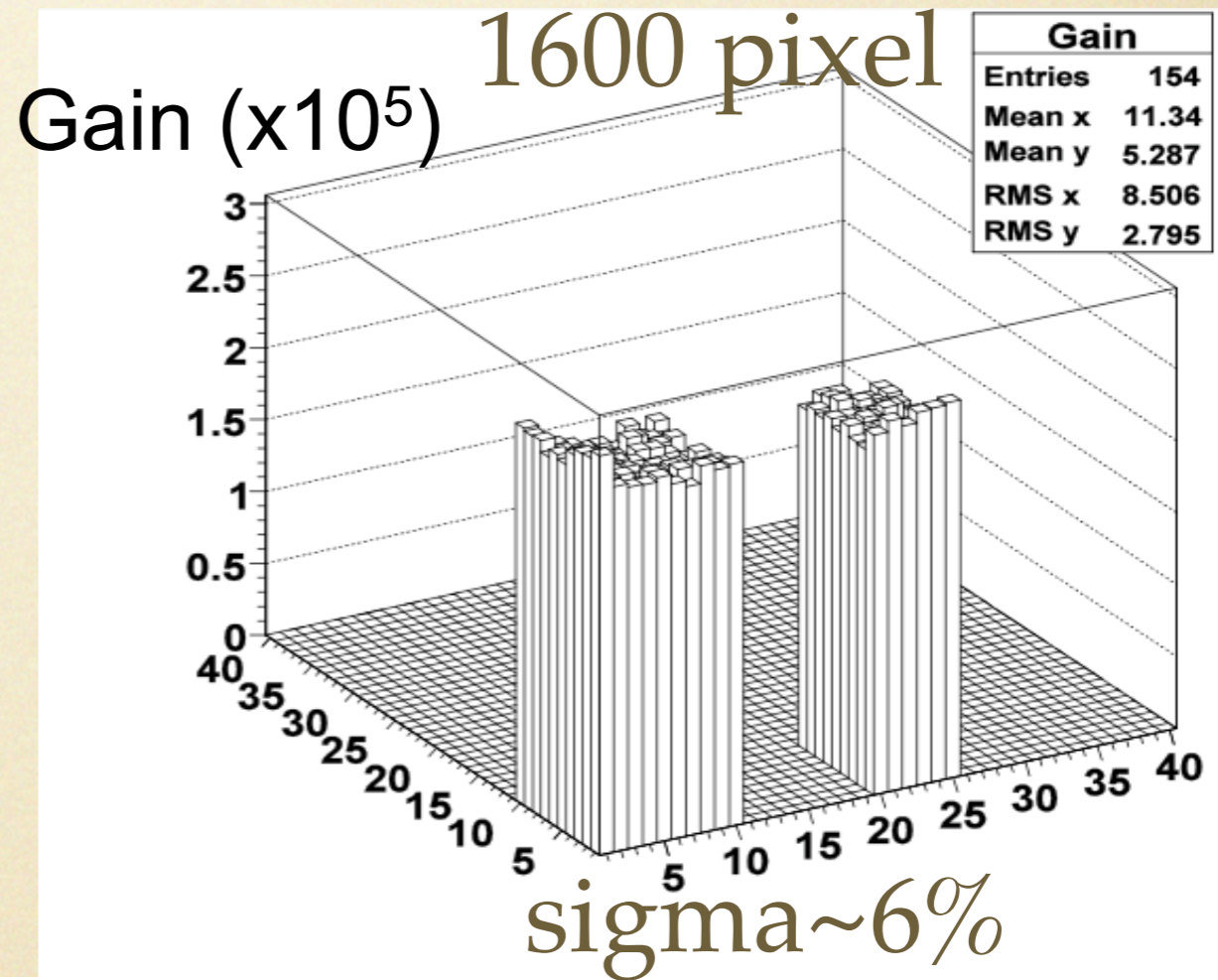number of fired pixels   400pix sample

pmt ADC   TTCalor06

MPPC (HPK)

pixel test by laser scanner

400 pixel

Gain (x10)

gain	
h2	
Entries	400
Mean x	10.98
Mean y	10.88
RMS x	5.767
RMS y	5.777

sigma~3%

1600 pixel

Gain (x10^5)

Gain	
Entries	154
Mean x	11.34
Mean y	5.287
RMS x	8.506
RMS y	2.795

sigma~6%

efficiency

h2	
Entries	100
Mean x	6.209
Mean y	6.078
RMS x	2.546
RMS y	2.531

~35um

~50um

25um

Efficiency
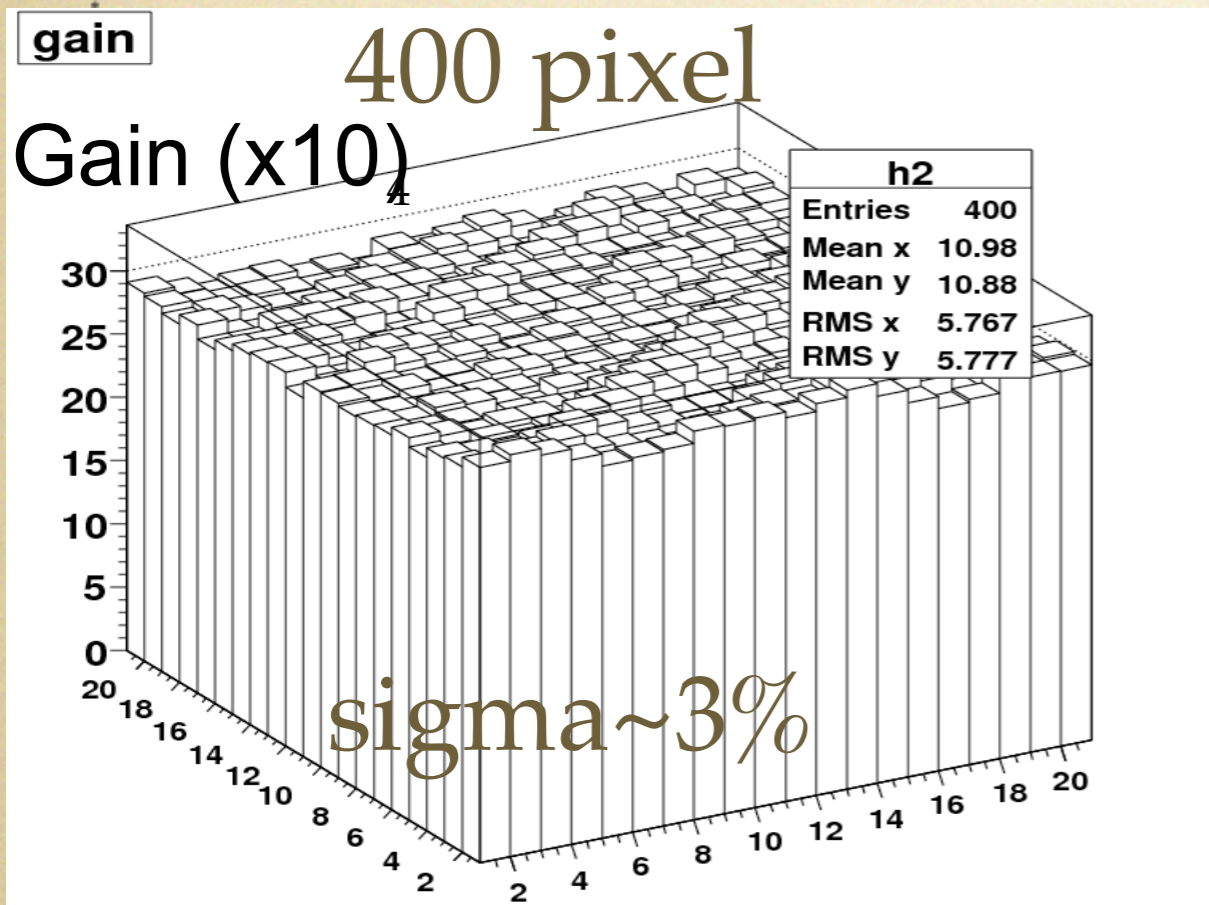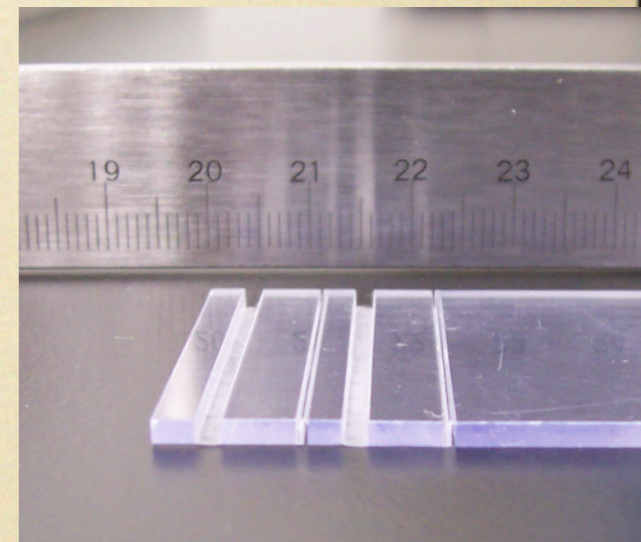
TCalor06

prototype ECAL

we will test the prototype at DESY 2006/2007

Scinti. 2mm   W 3mm

Mega-strip

20cm

20cm
32layers

1cm

2mm

33layers

MPC R/O

20cm
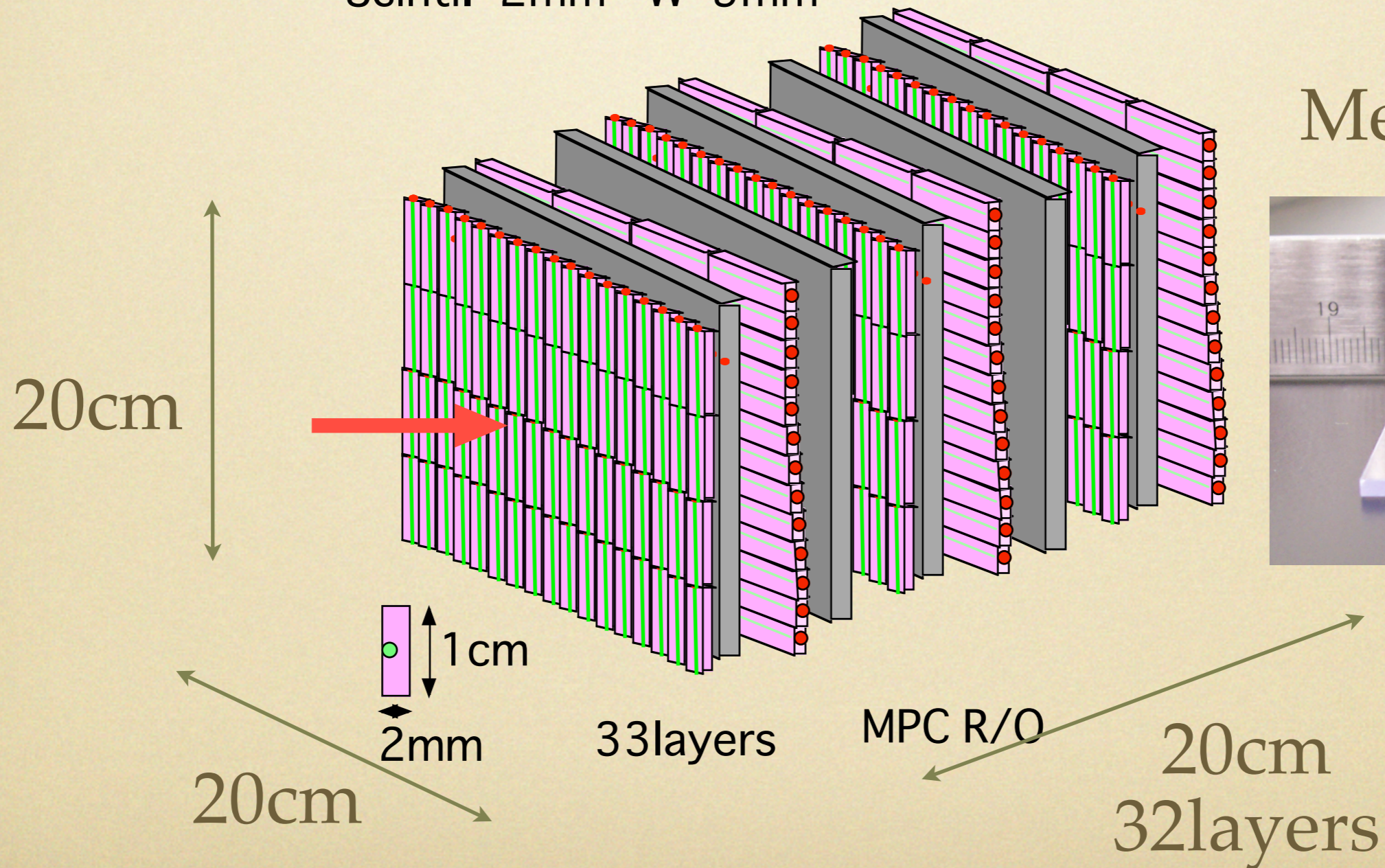
prototype HCAL

we will test the prototype at Fermilab 2008

Pb/scintillator sandwich HCAL

1m

1m

1m

Hadron model dep.

hadron shower radius

G3-GCALOR
G3-GHSLAC
G3-FLUKA+MI
G3-FLUKA+GH
G3-GHEISHA

G4-QGSP-BIC
G4-QGSP-BERT
G4-QGSP
G4-QGSC
G4-LHEP-HP
G4-LHEP-GN
G4-LHEP-BIC
G4-LHEP-BERT
G4-LHEP
c -FTFP

RPC

scintillator

normalized

0.9   1.0   1.5
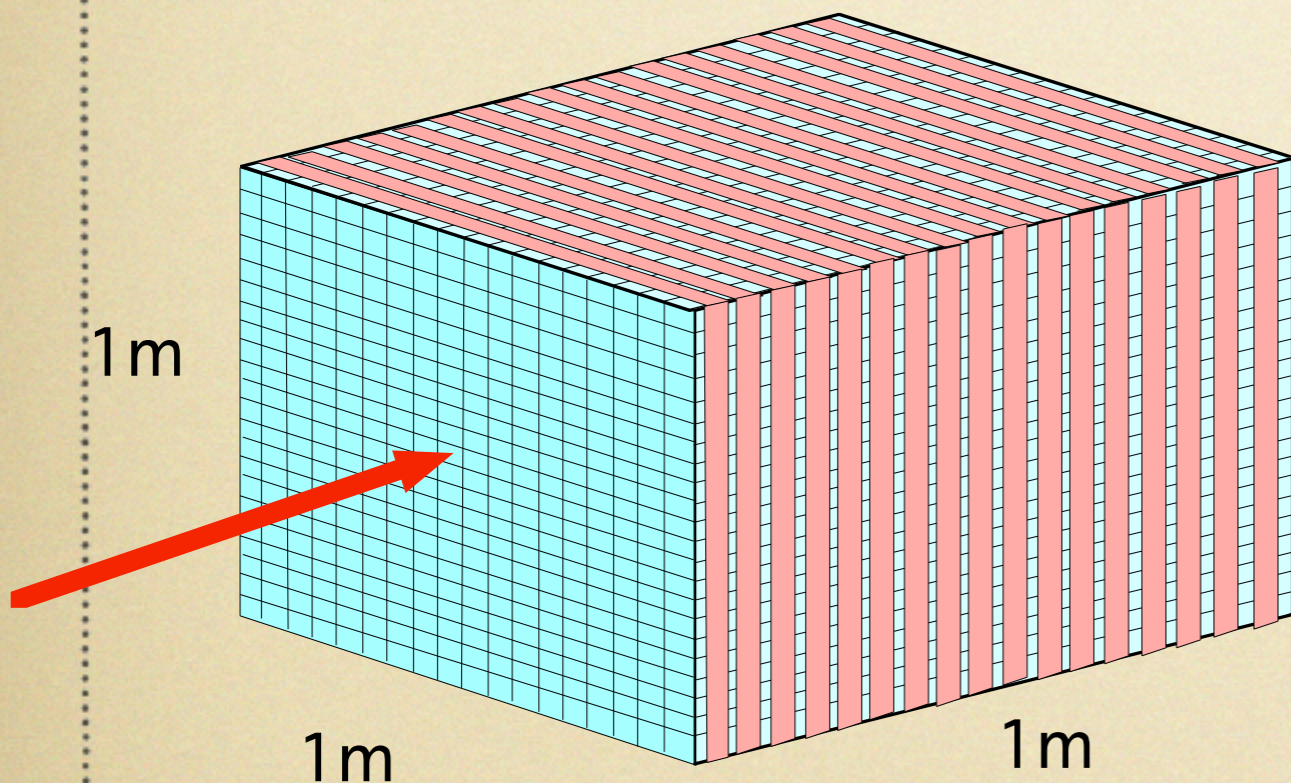
relative ratio

TTCalor06

open issues

- **optimization of detector parameters by PF**

  - **strip length/width (ECAL and HCAL)**

  - **electronics development**

  - **number of channels**

summary and outlook

- **GLD calorimeter**

  - **scintillator based calorimeter**

- **under development**

  - **MPPC & tools (PFA)**

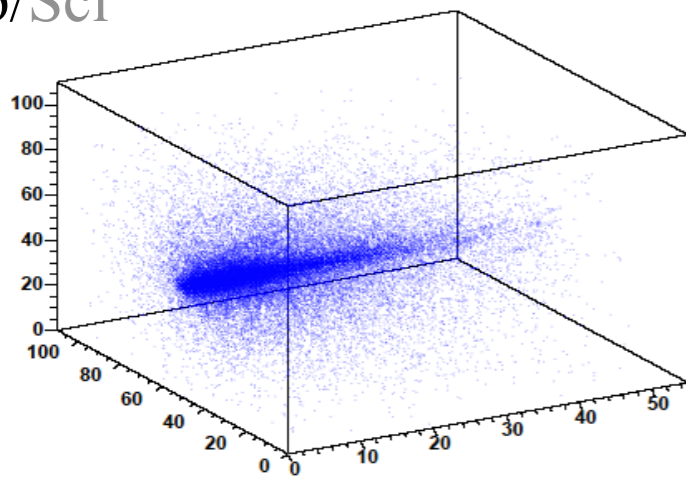- **beam test to verify PFA**

- **ILC-CAL**
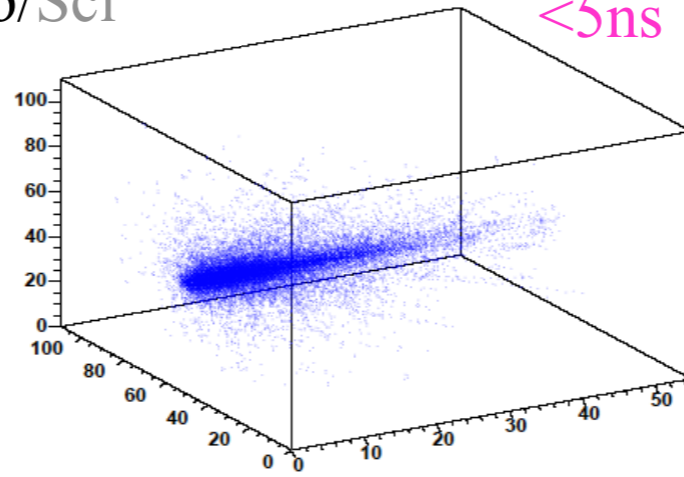
backups

- compensation in HCAL

-

compensation

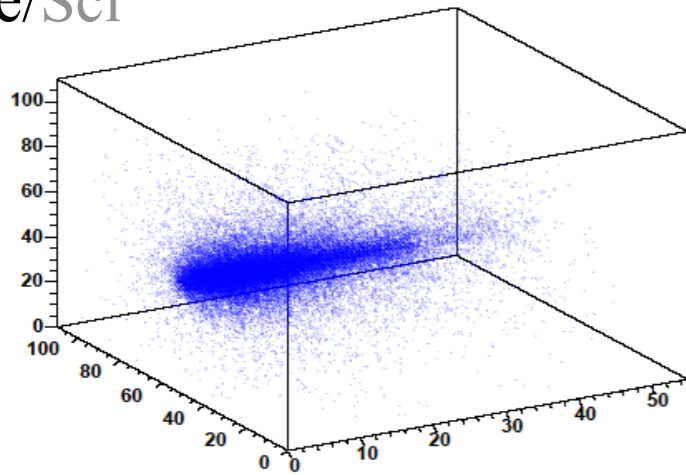## transverse spread of EM shower