Scintillator ECAL for ILC

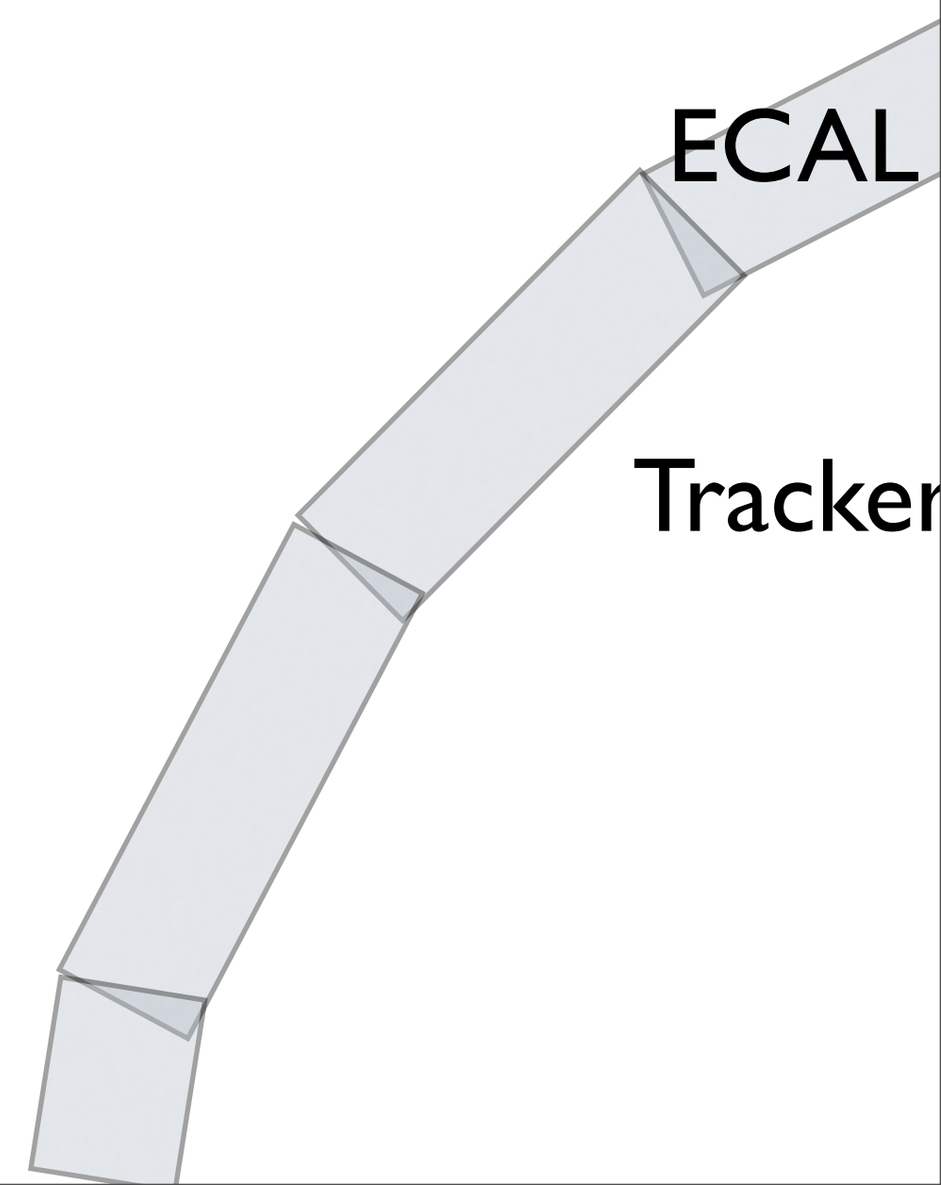
for Calorimeter Review
DESY May2007

Tohru Takeshita (CALICE-Shinshu)

Idea
implementation
current status
future mile stones

ECAL in ILC

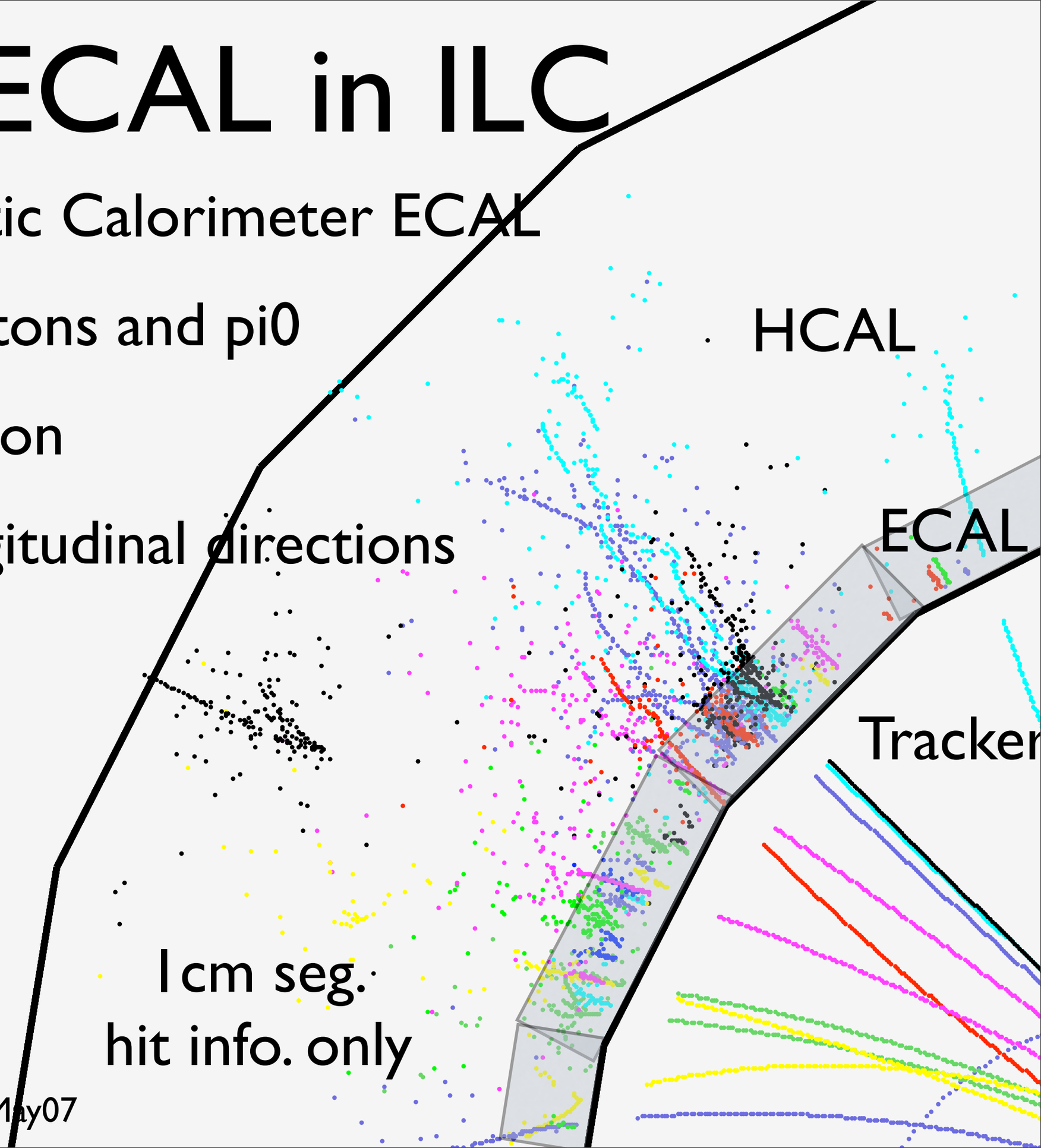
- Electro-Magnetic Calorimeter ECAL
- to identify photons and pi0
- fine segmentation
- lateral and longitudinal directions



1cm seg.
hit info. only

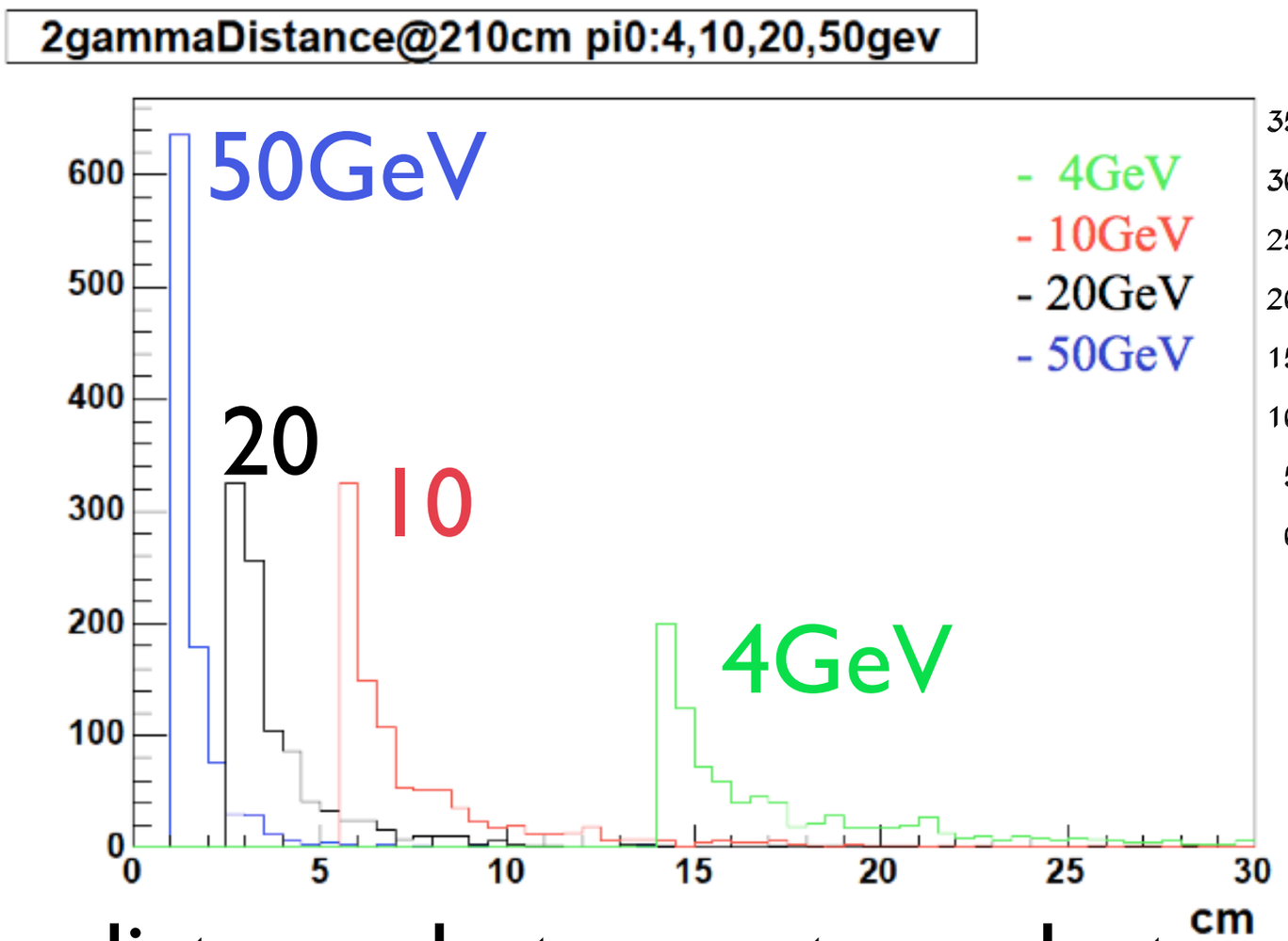
ECAL in ILC

- Electro-Magnetic Calorimeter ECAL
- to identify photons and pi0
- fine segmentation
- lateral and longitudinal directions



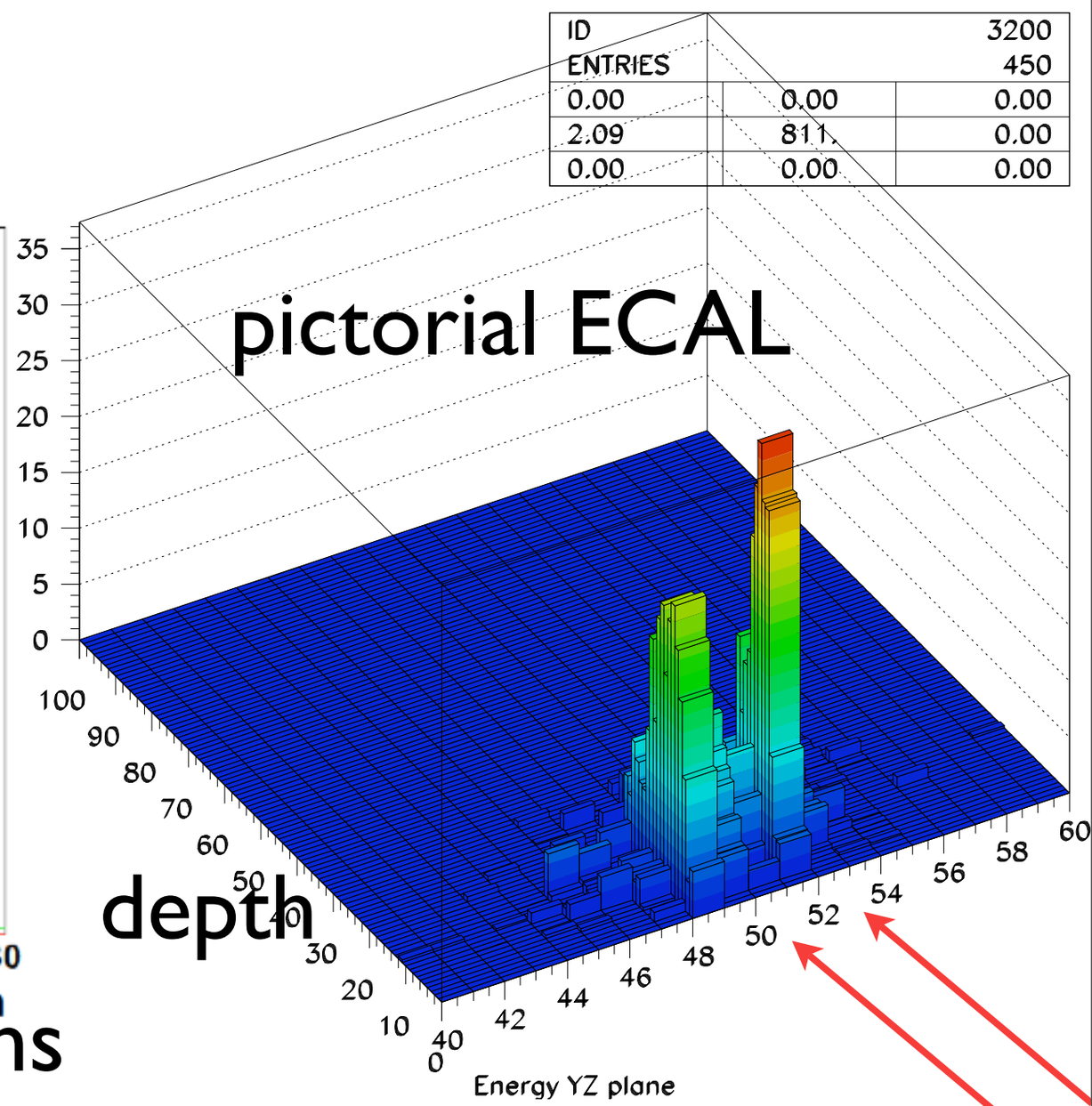
identify pi0

- two photon reconstruction



distance between two photons

ECAL 210cm from IP



1cm seg.

20GeV pi0

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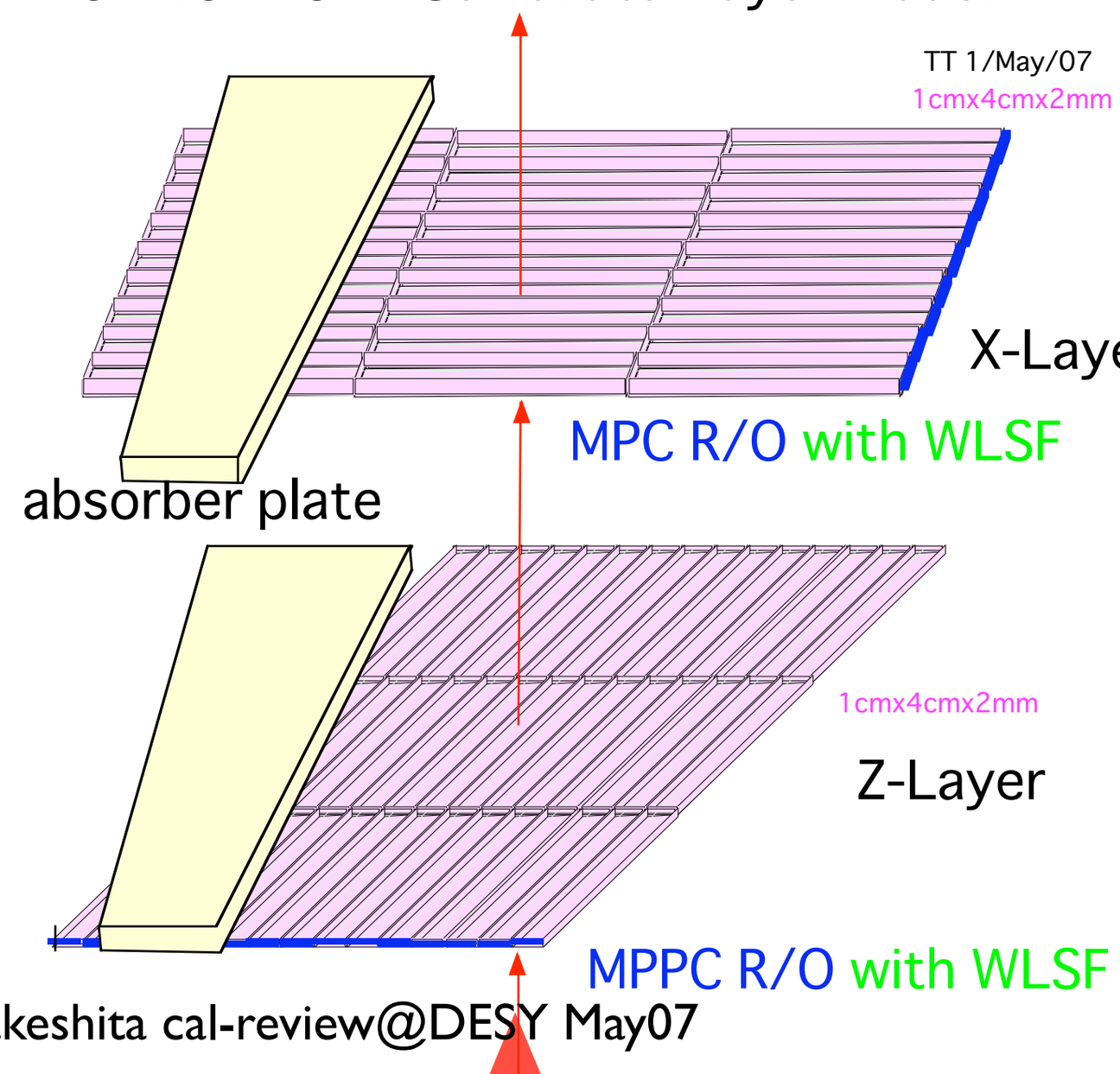
Scintillator strip ECAL

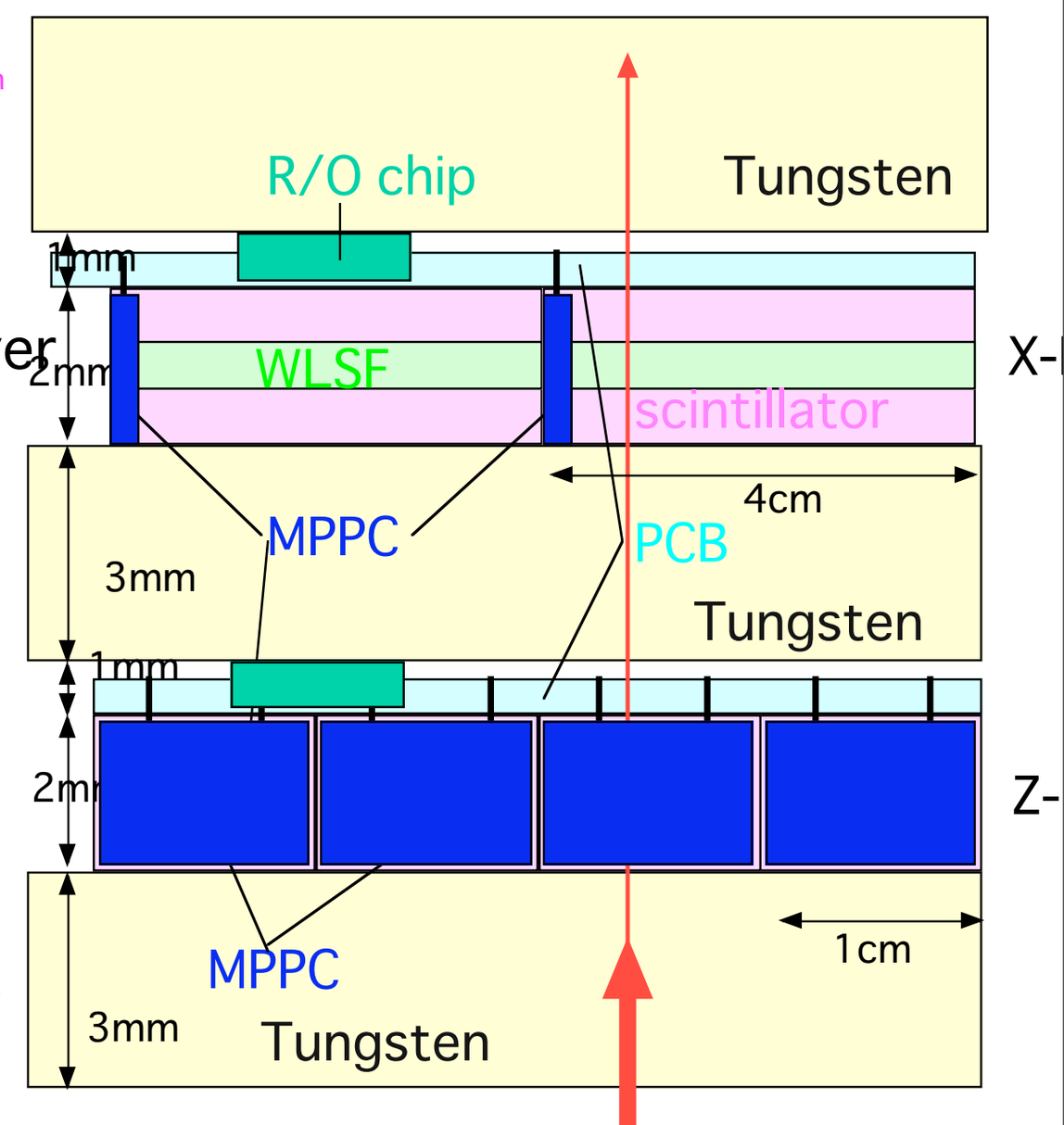
- to reduce the number of readout channels
- orthogonal strips
- effective 1cm x 1cm area

CALICE ECAL-Scintillator-layer model



EM-Scintillator-layer model

Cross section



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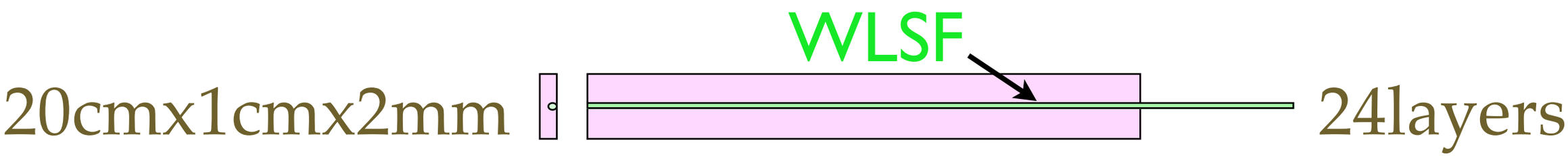
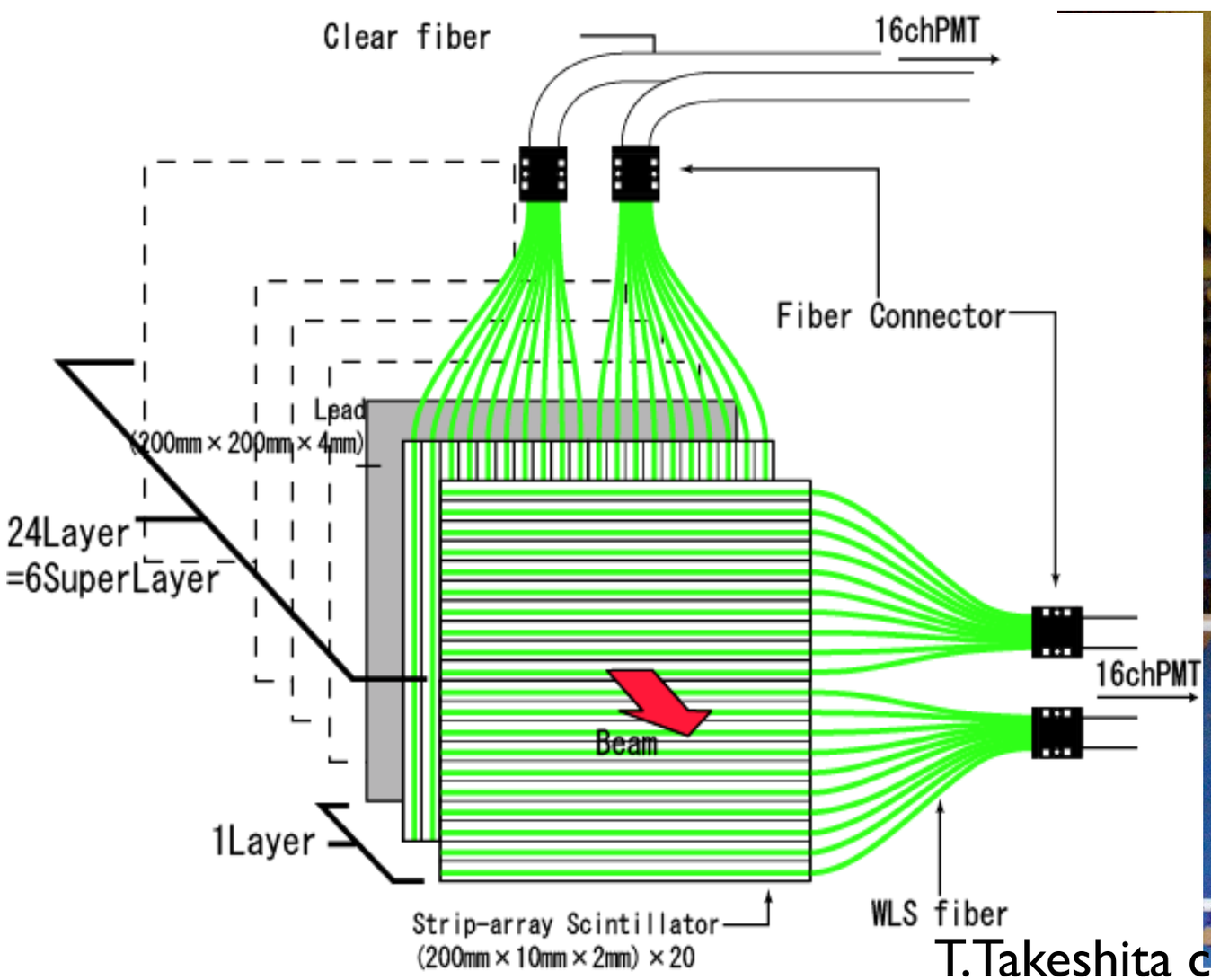
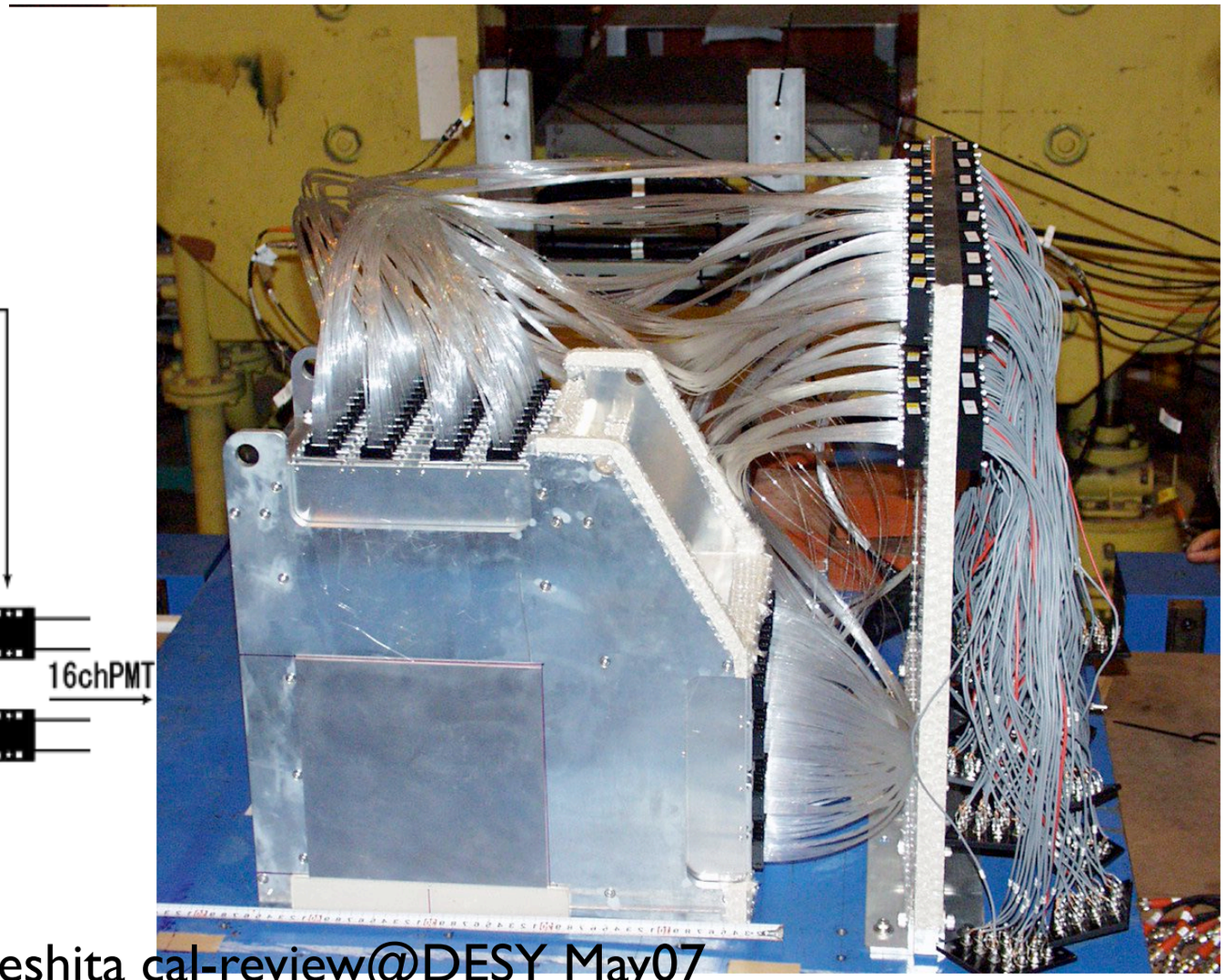
strip experience (det.)

- 20 cm long scintillator strips with Wave Length Shifting Fire read out (MAPMT)



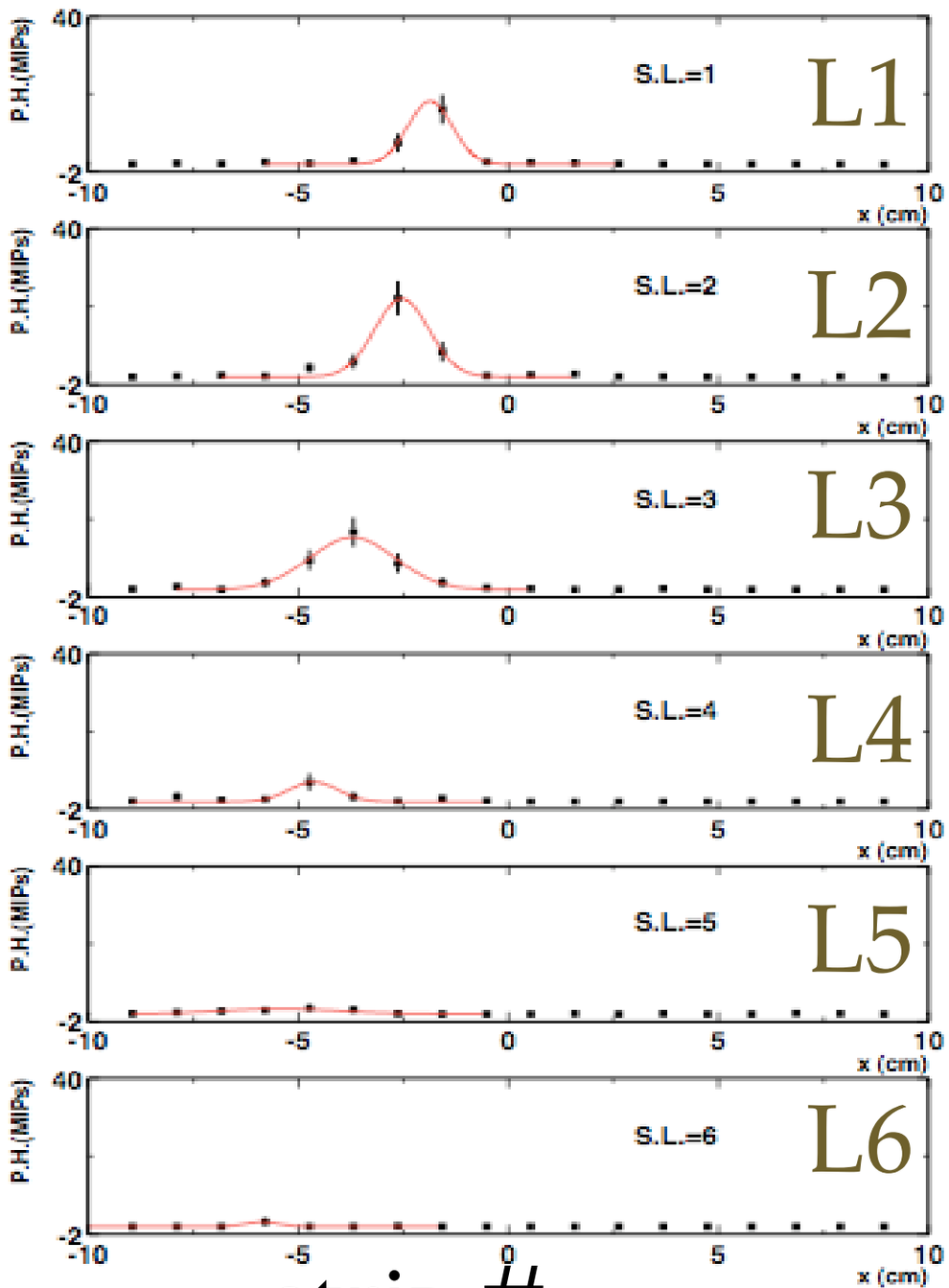




strip experience (res.)

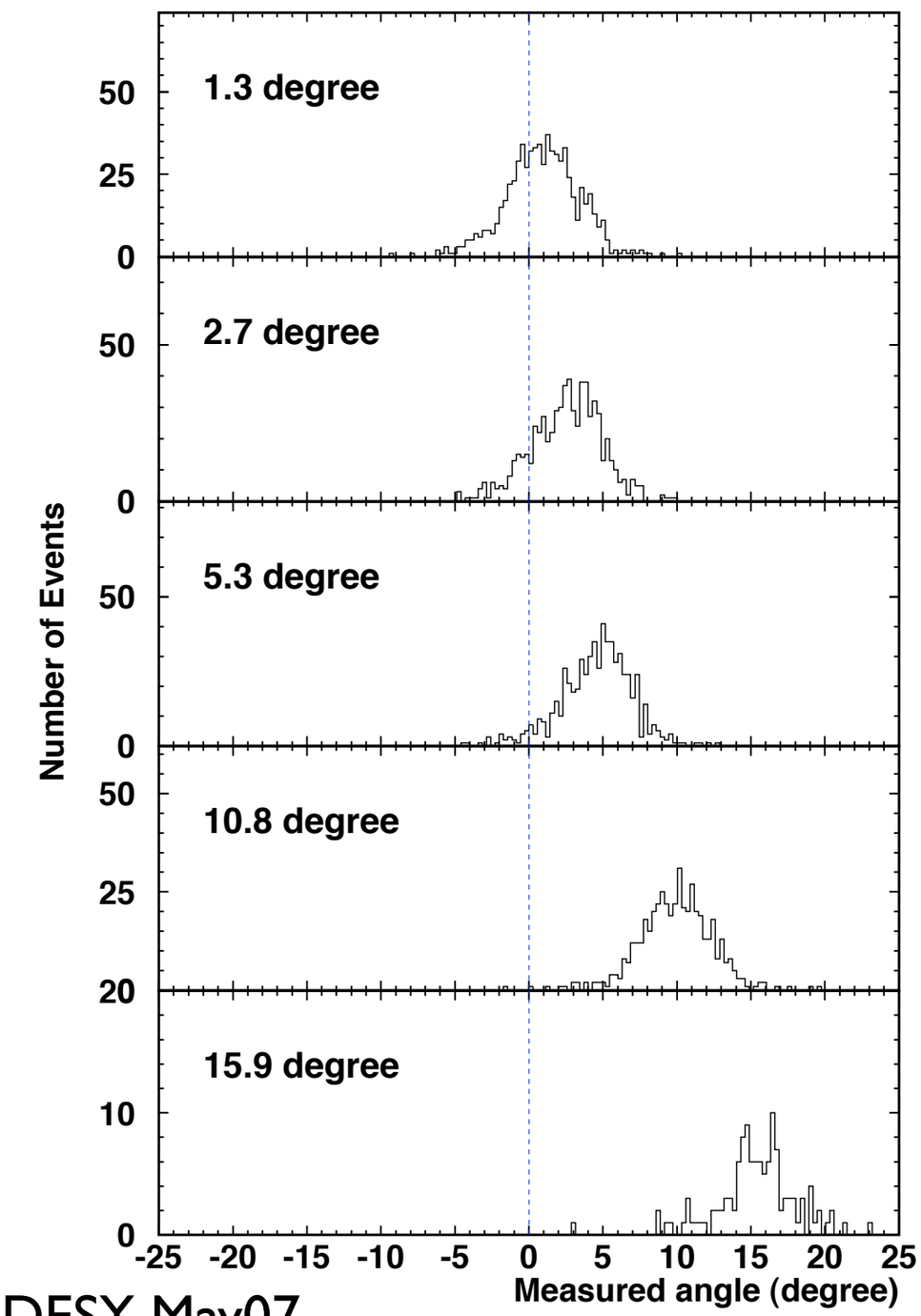
- pictorial calorimeter

4 GeV e, θ=15.9 degree



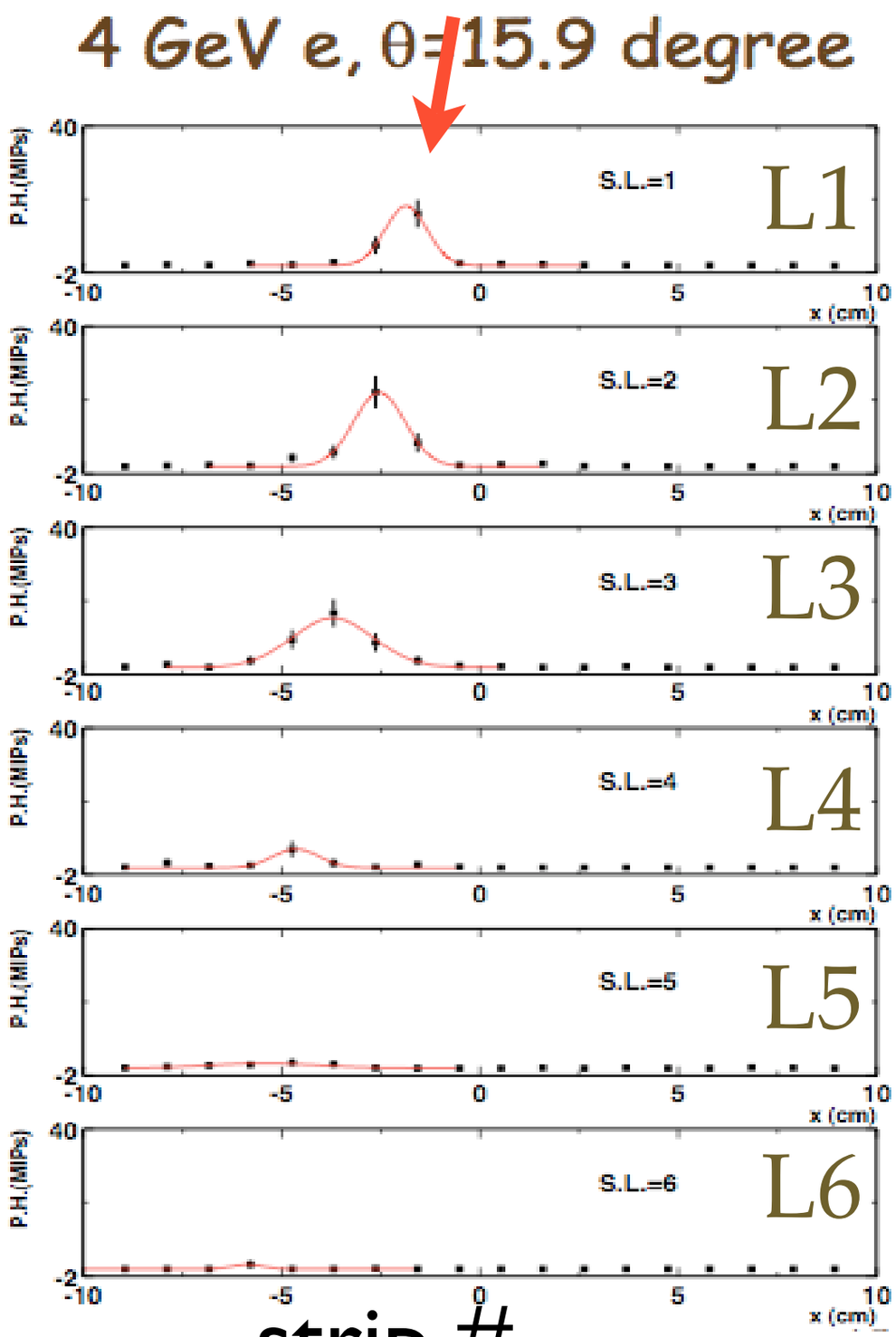
strip #

angle resolution

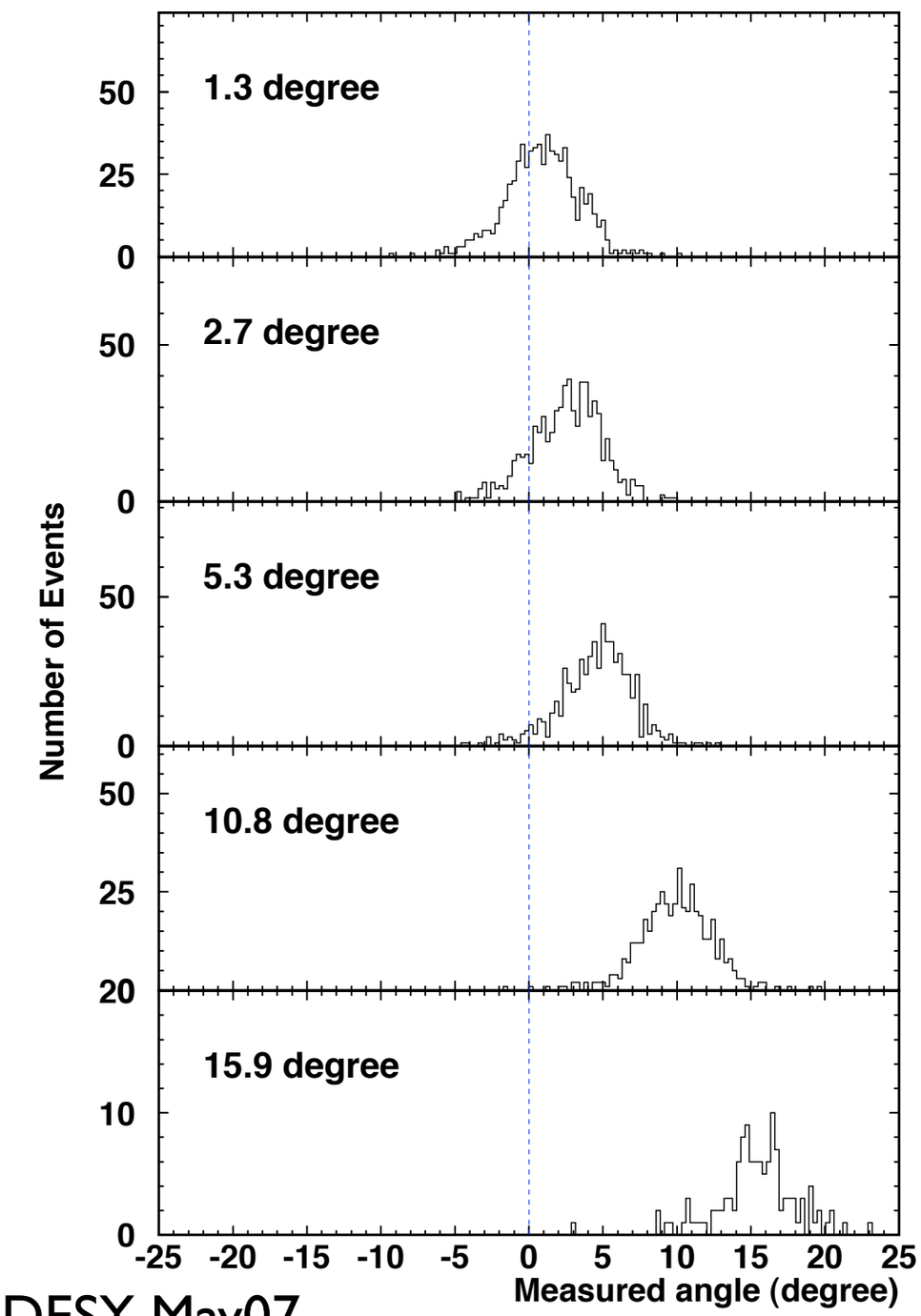


strip experience (res.)

- pictorial calorimeter



angle resolution



strip experience (res.)

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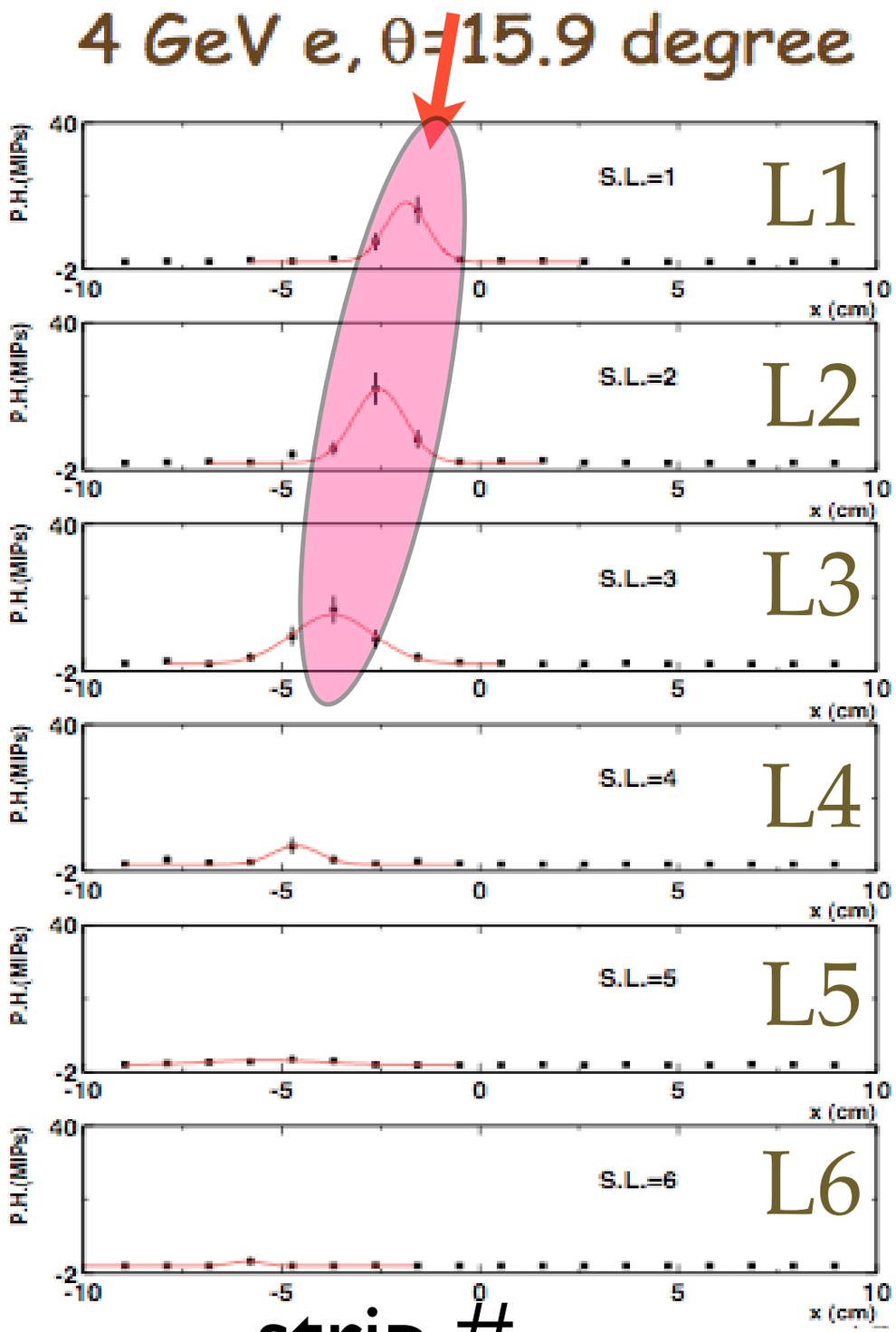
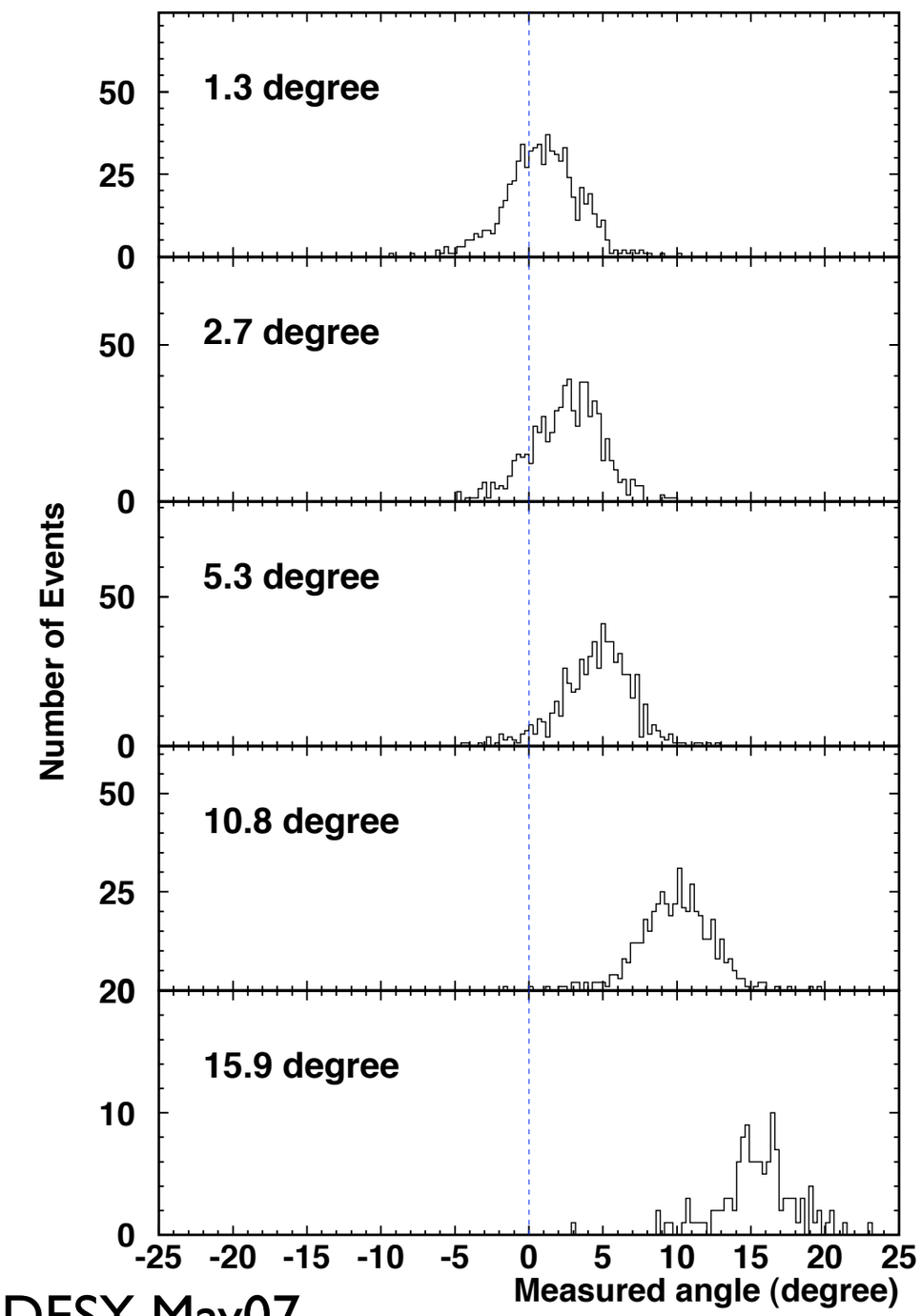
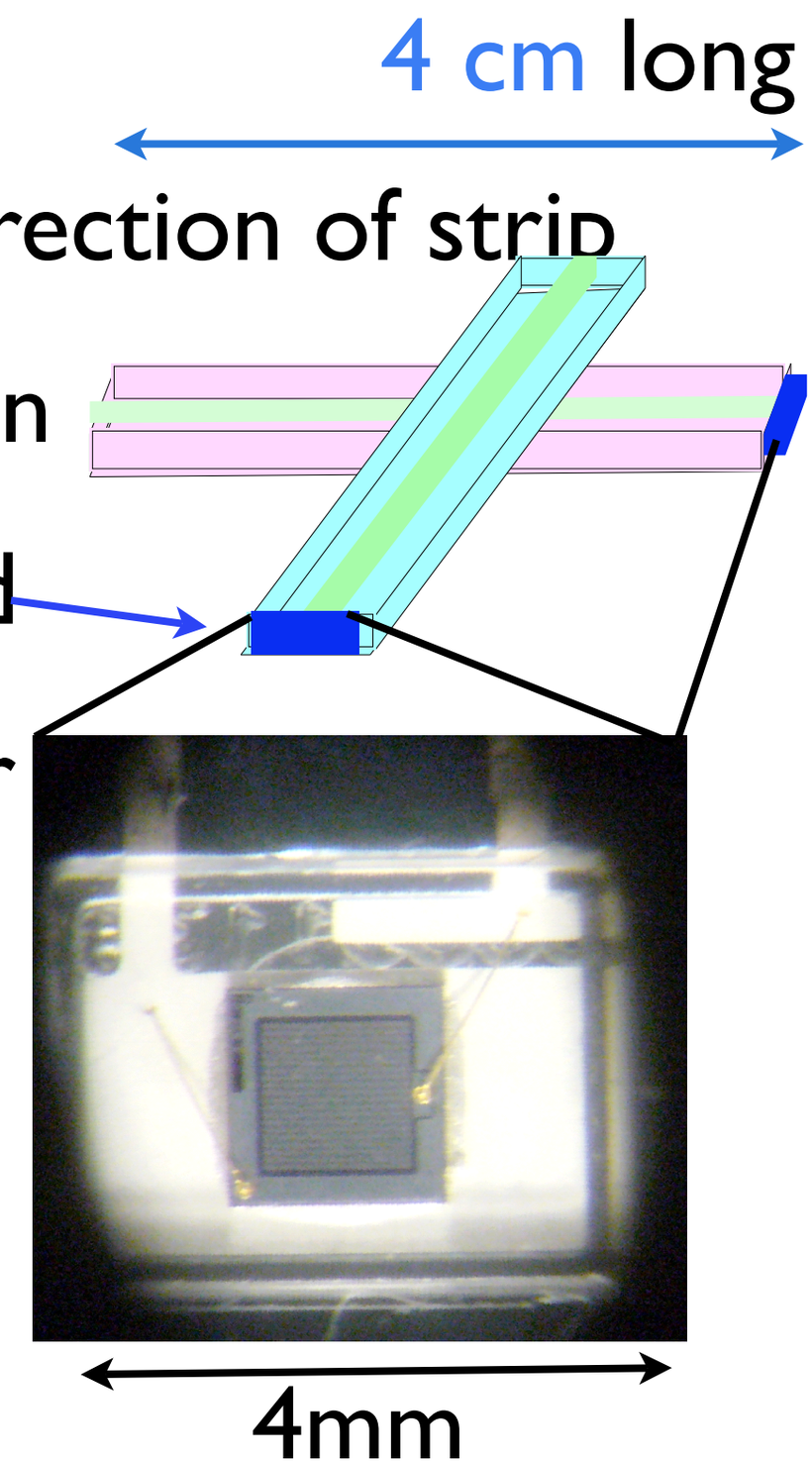


angle resolution



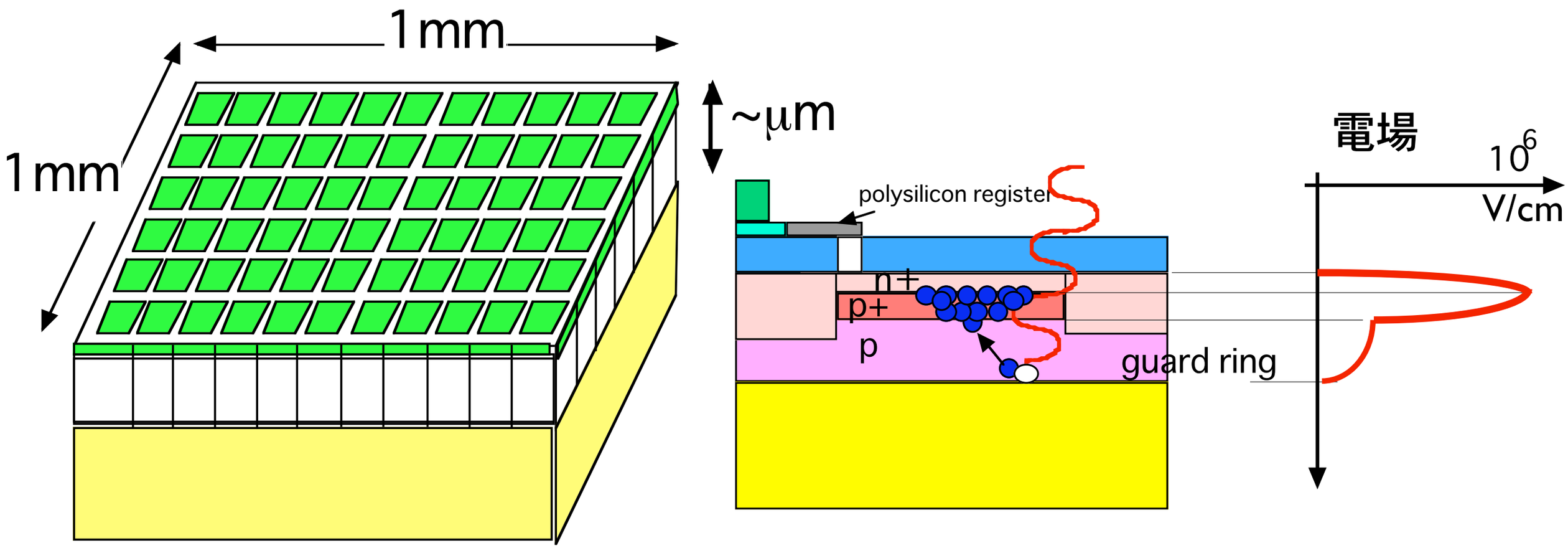
short strip ECAL for ILC

- to have less overlap of showers and charged particles in Jet environment
- for each layer, perpendicular direction of strip
  - effective 1cm x 1cm resolution
- MPPC read out : direct attached
  - semi-conductor photo-sensor
  - 1mmx1mm 1600 pixels
- Tungsten absorber :
- to reduce Moliere R.



MPPC

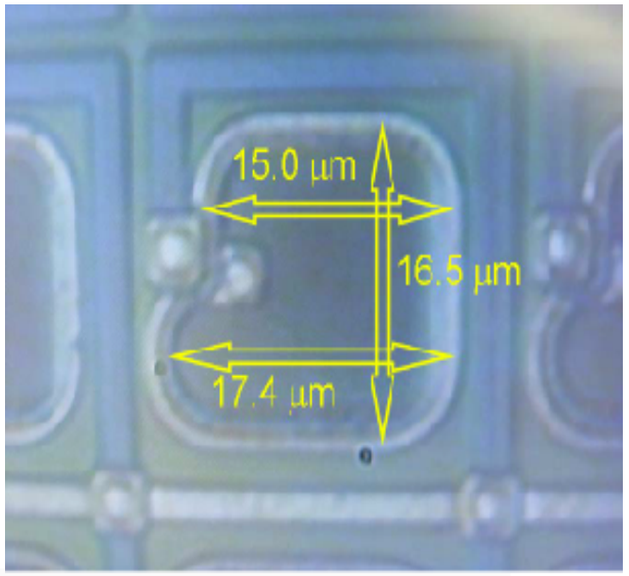
- Geiger Mode pixel Photon sensor
- independent development by us and Hamamatsu Photonics Inc. from SiPM
- 100, 400 and 1600 pixels in 1mm x 1mm

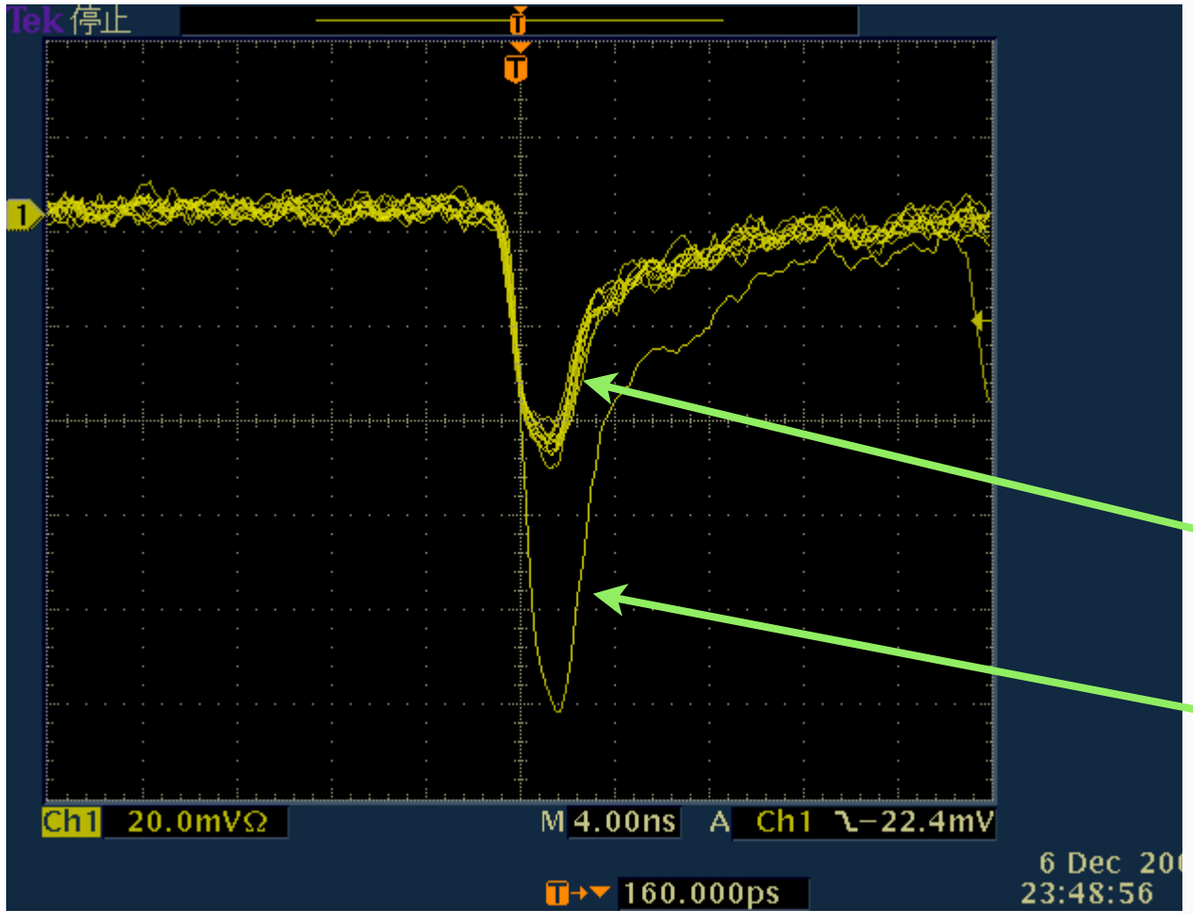


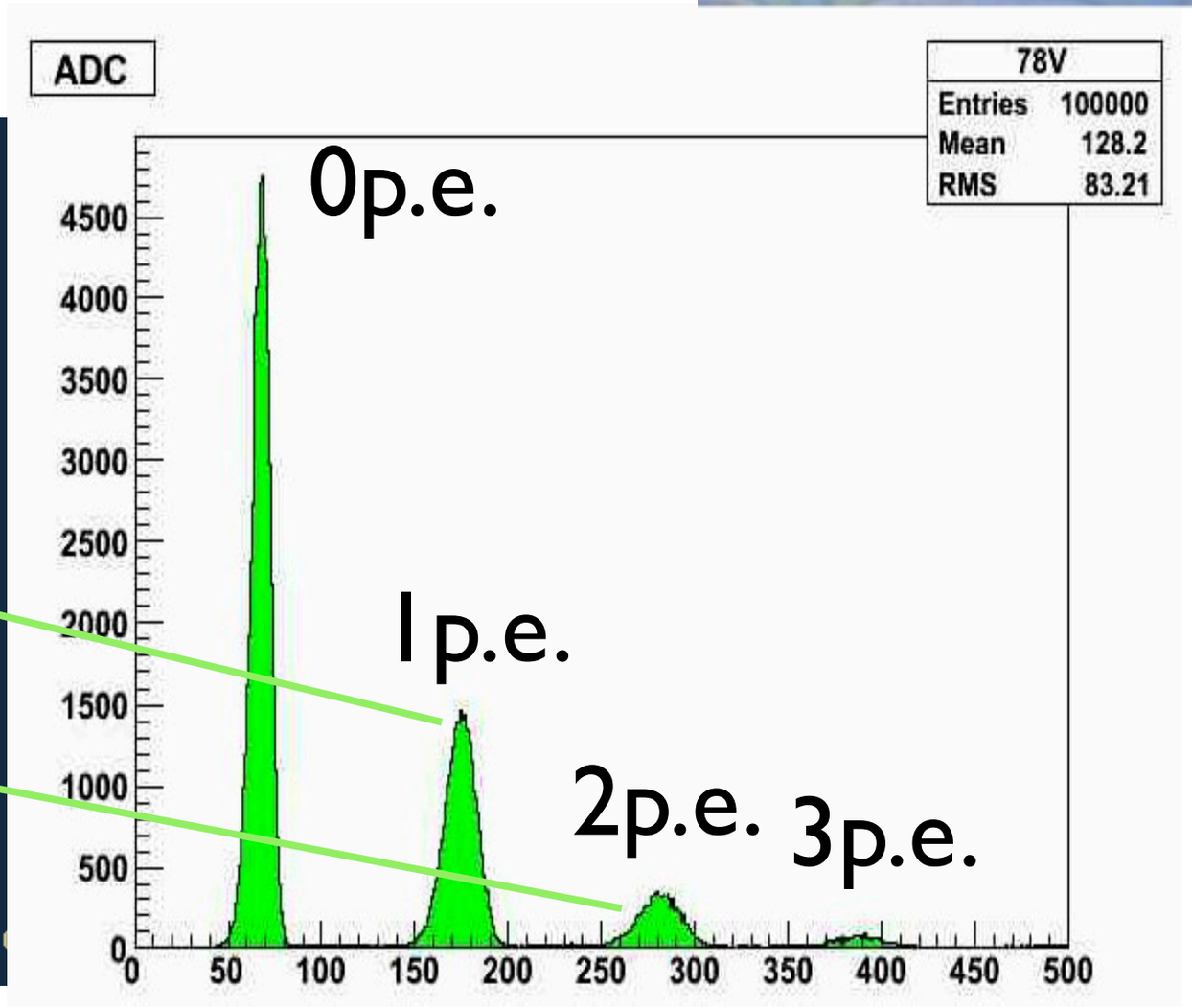
1600pix

MPPC cont.

- digital response of each pixel



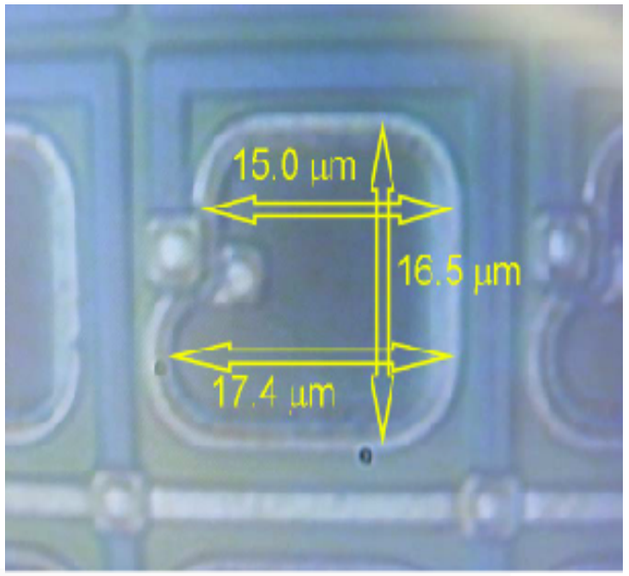




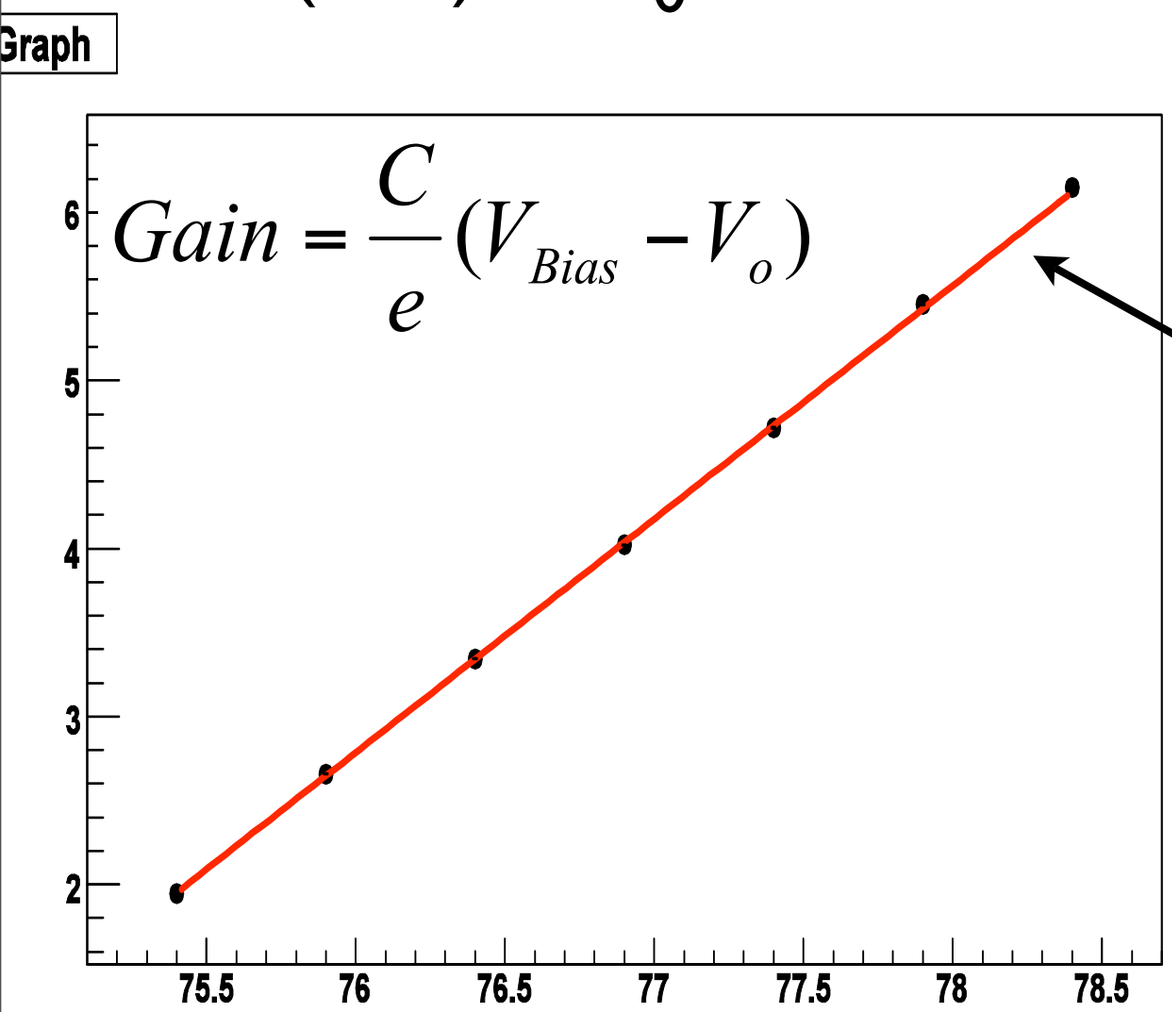
1600pix

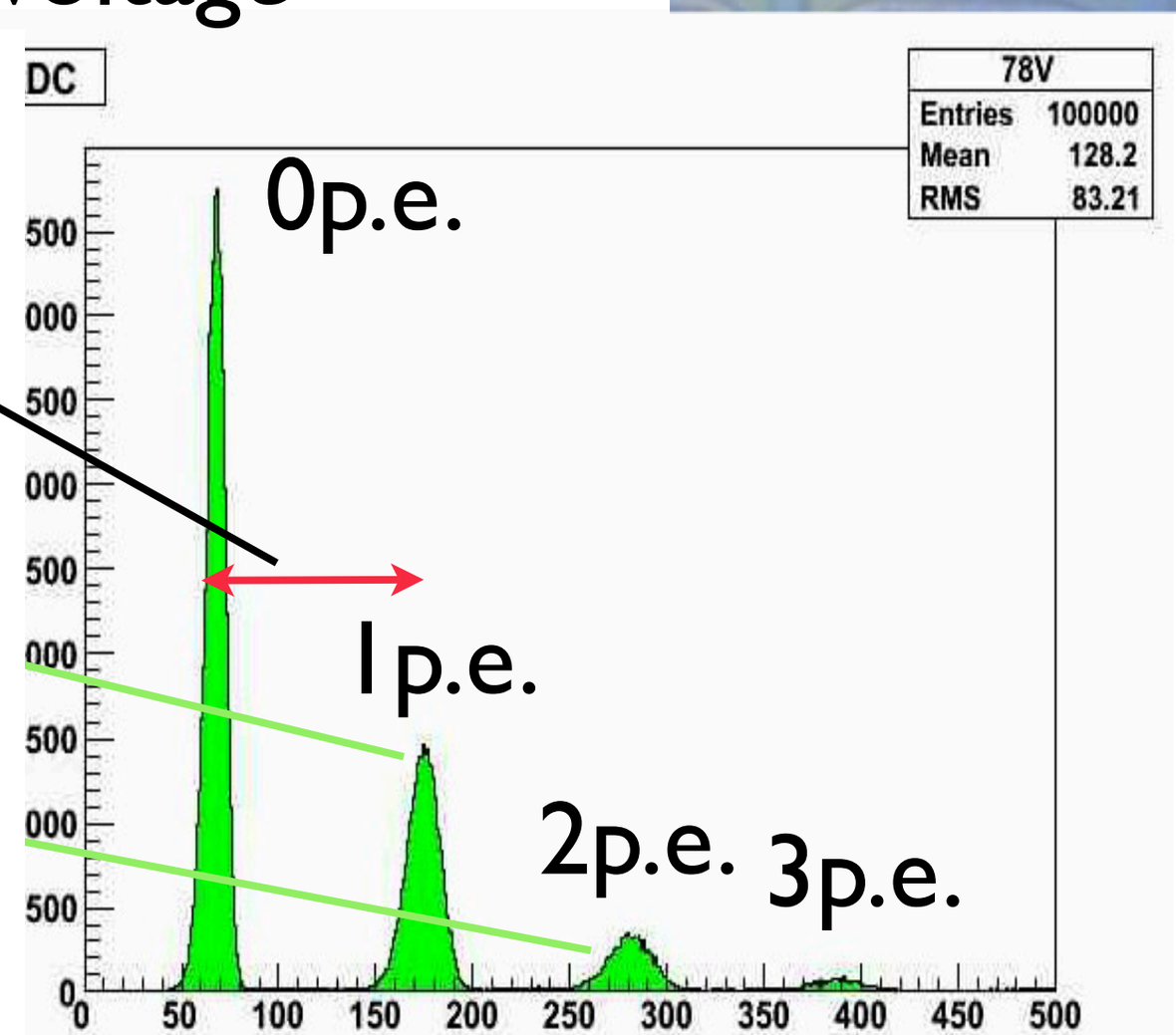
MPPC cont.

- digital response of each pixel



Gain (10^5) V_0 : breakdown voltage





Vbias (V)

C : capacitance of a pixel

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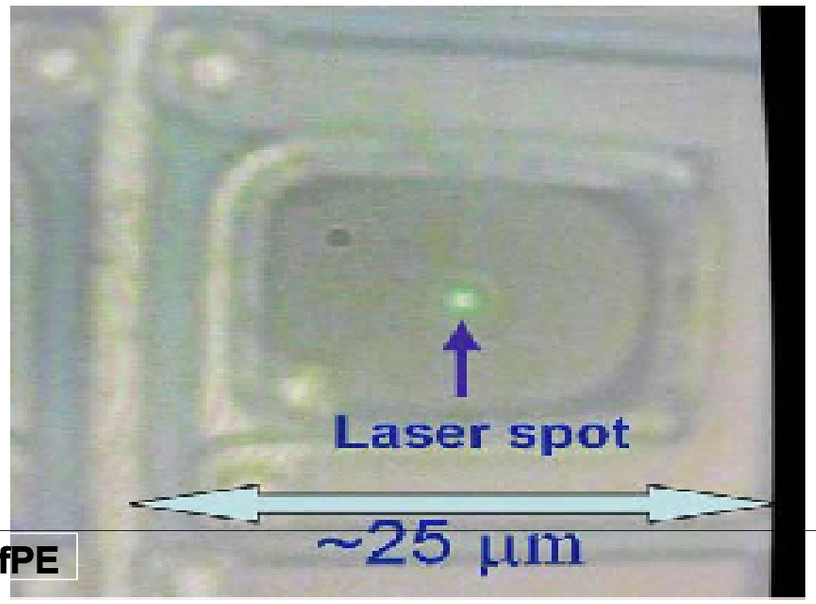
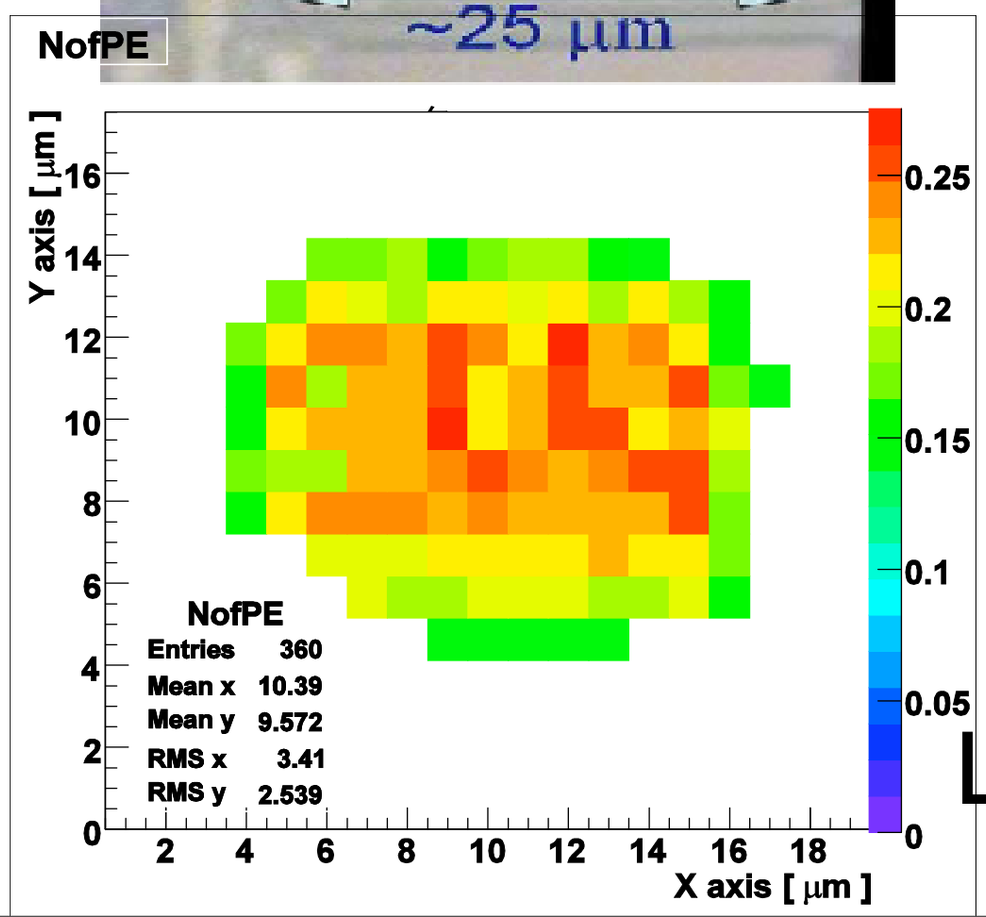
MPPC development

- joint work going on with Hamamatsu

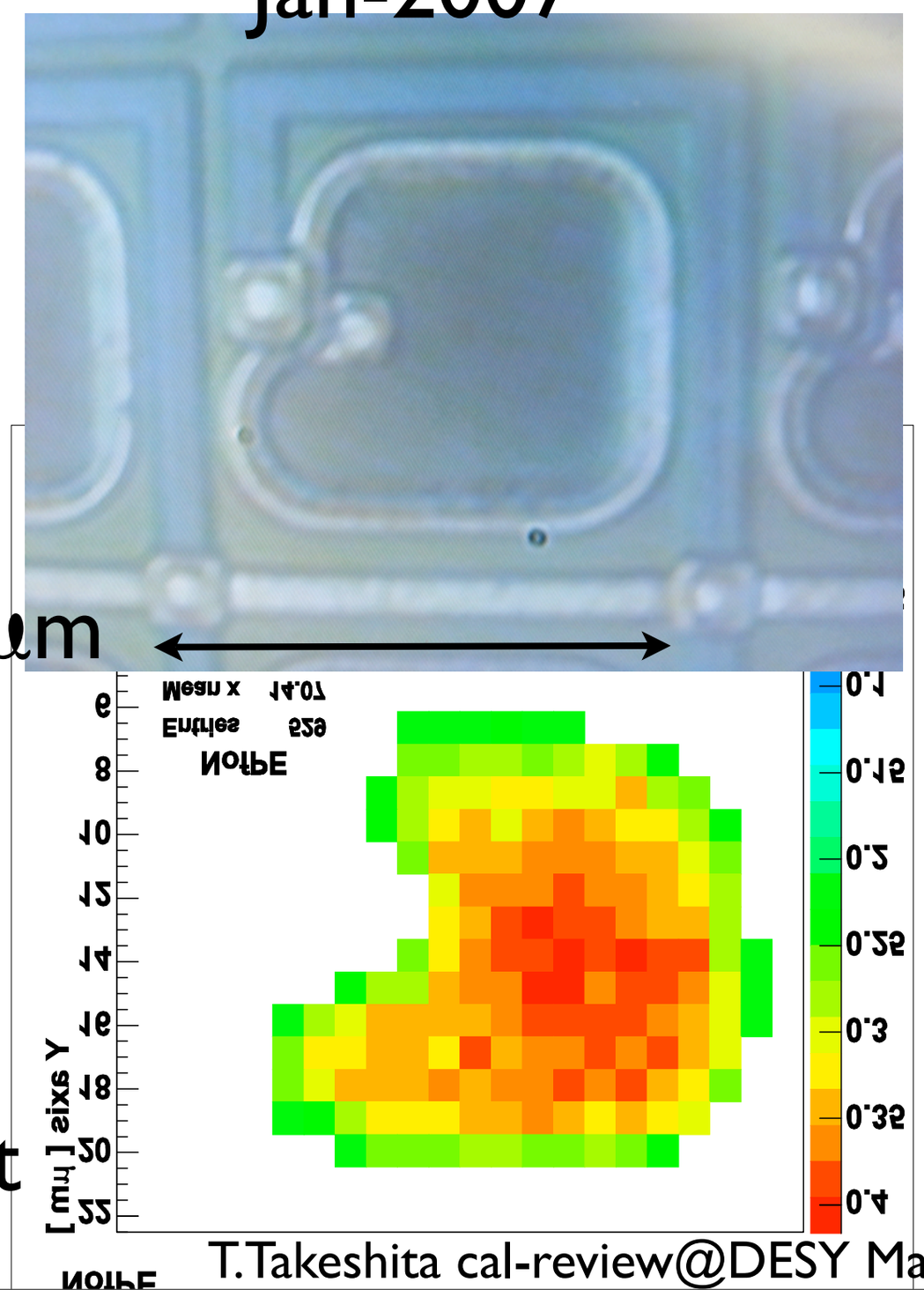
Dec-2005





1600pix

Jan-2007



Laser test

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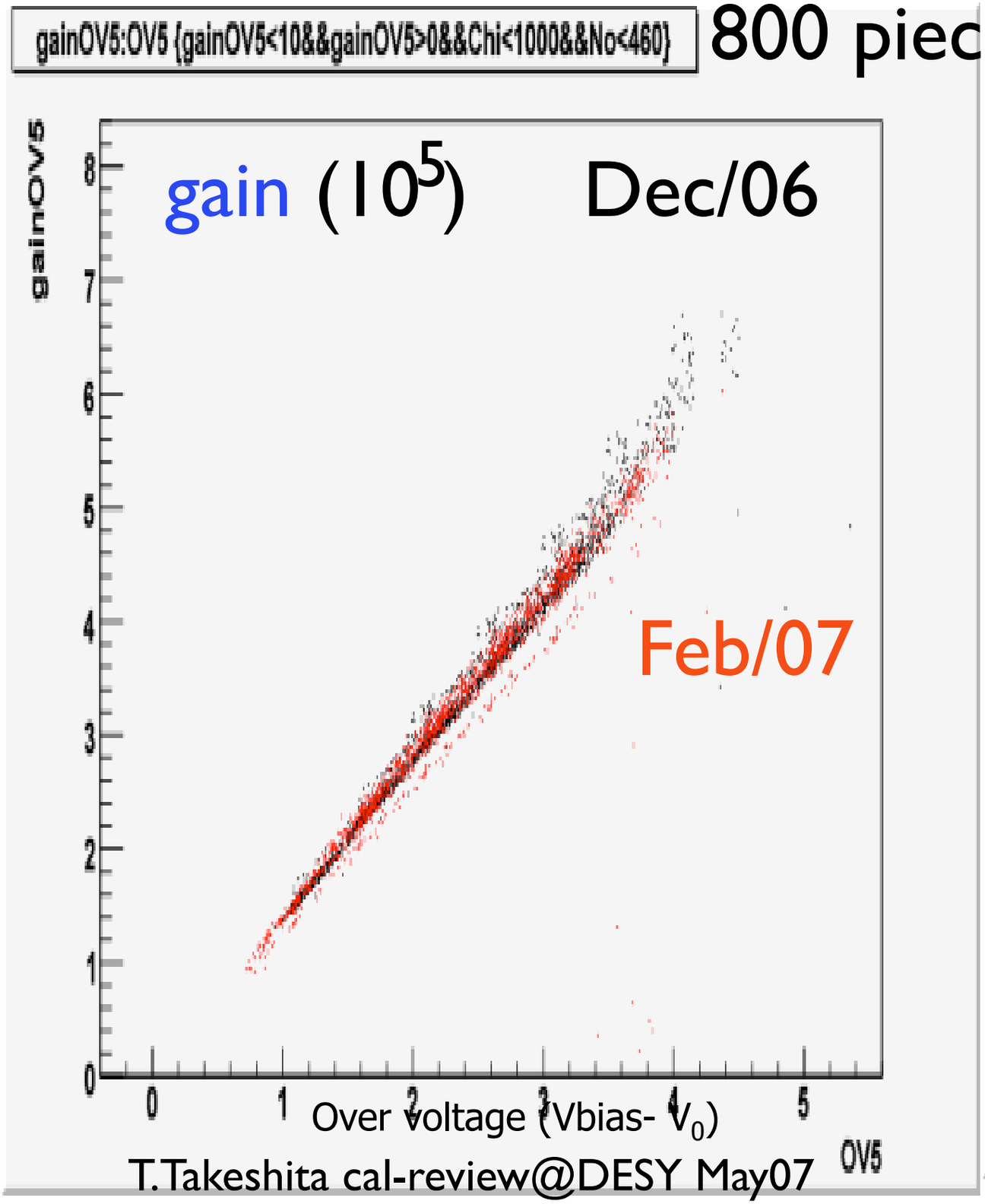
MPPC cont.

1600pix

800 pieces of MPPC tested



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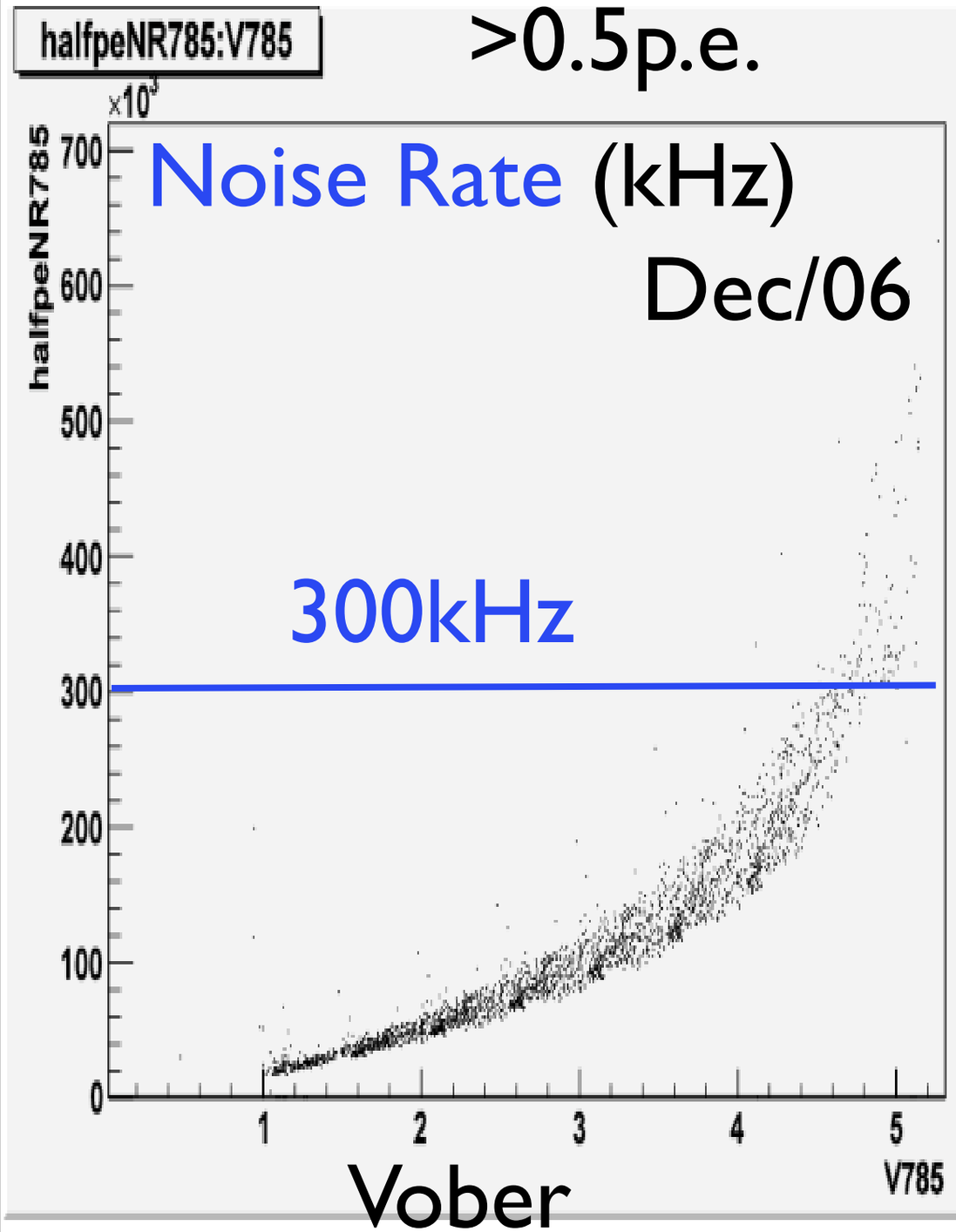
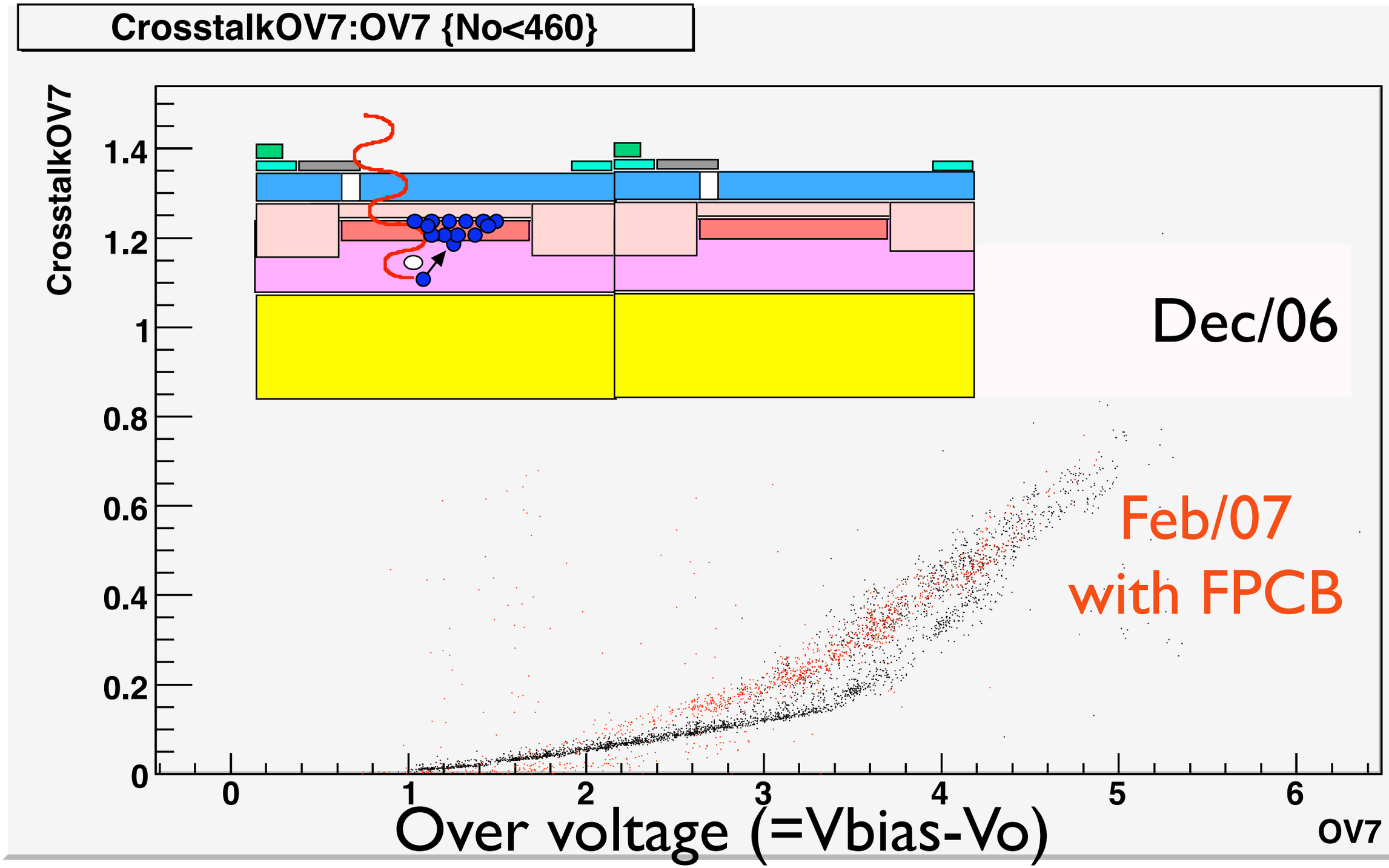
>0.5p.e.



MPPC cont.: cross talk

an avalanche photon reaches neighboring pixel



MPPC cont.: cross talk

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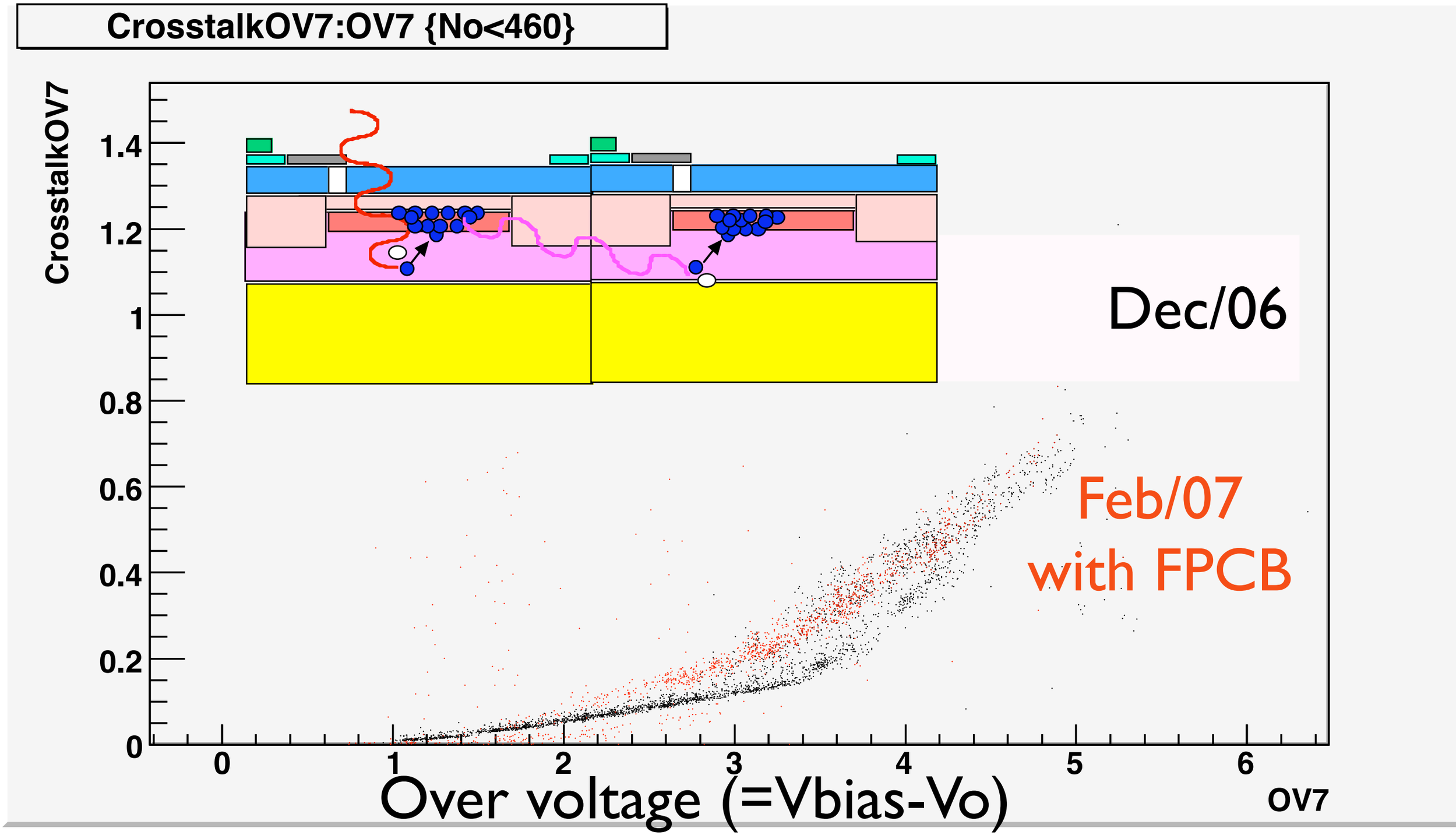
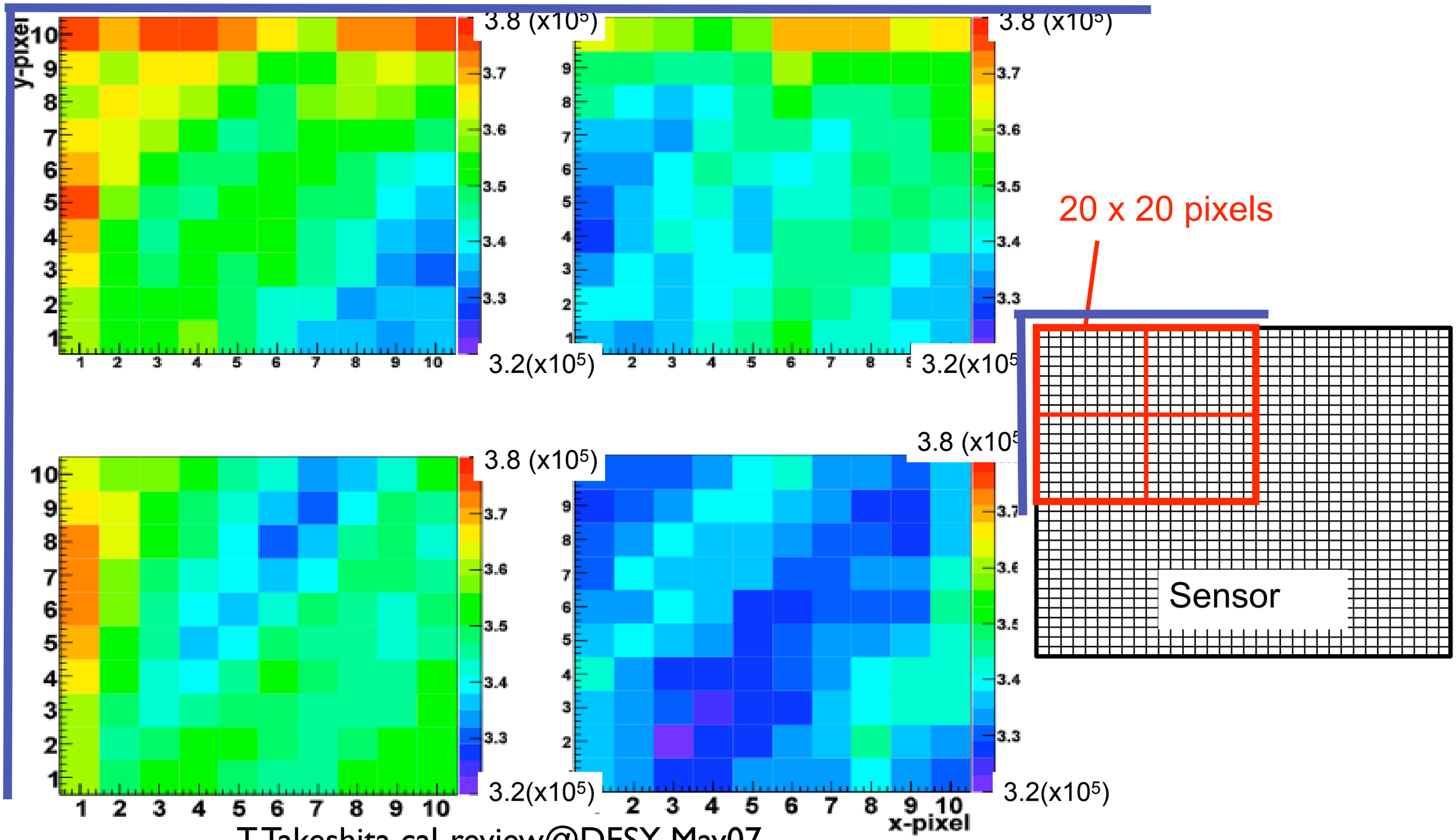


MPPC cont. : pix uniformity

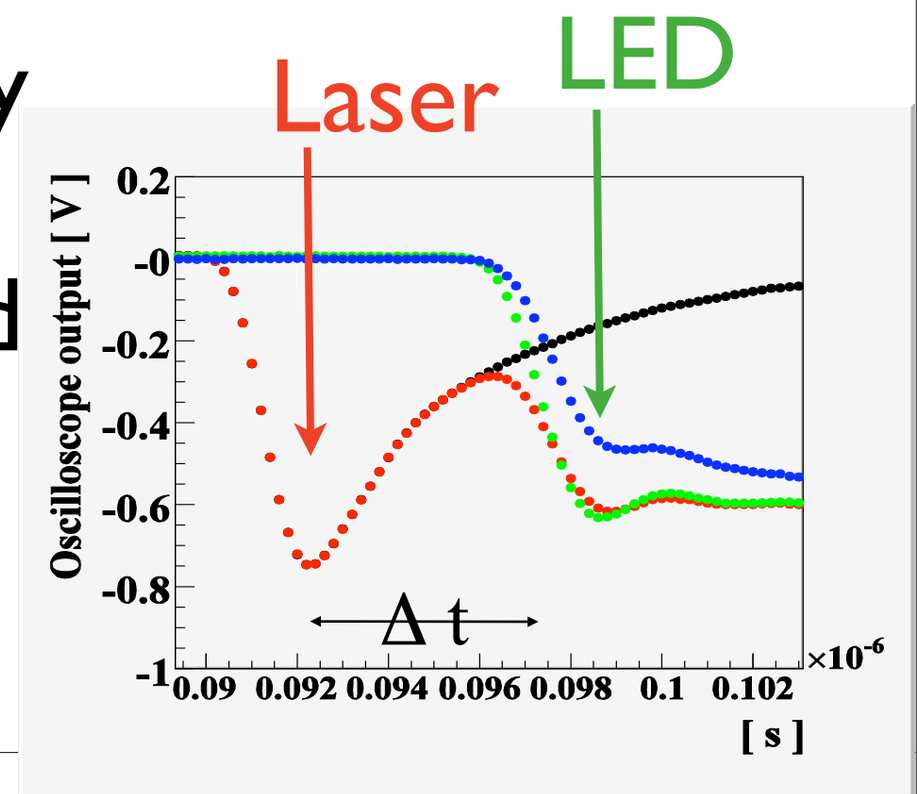
- laser shot at the center of each pixel

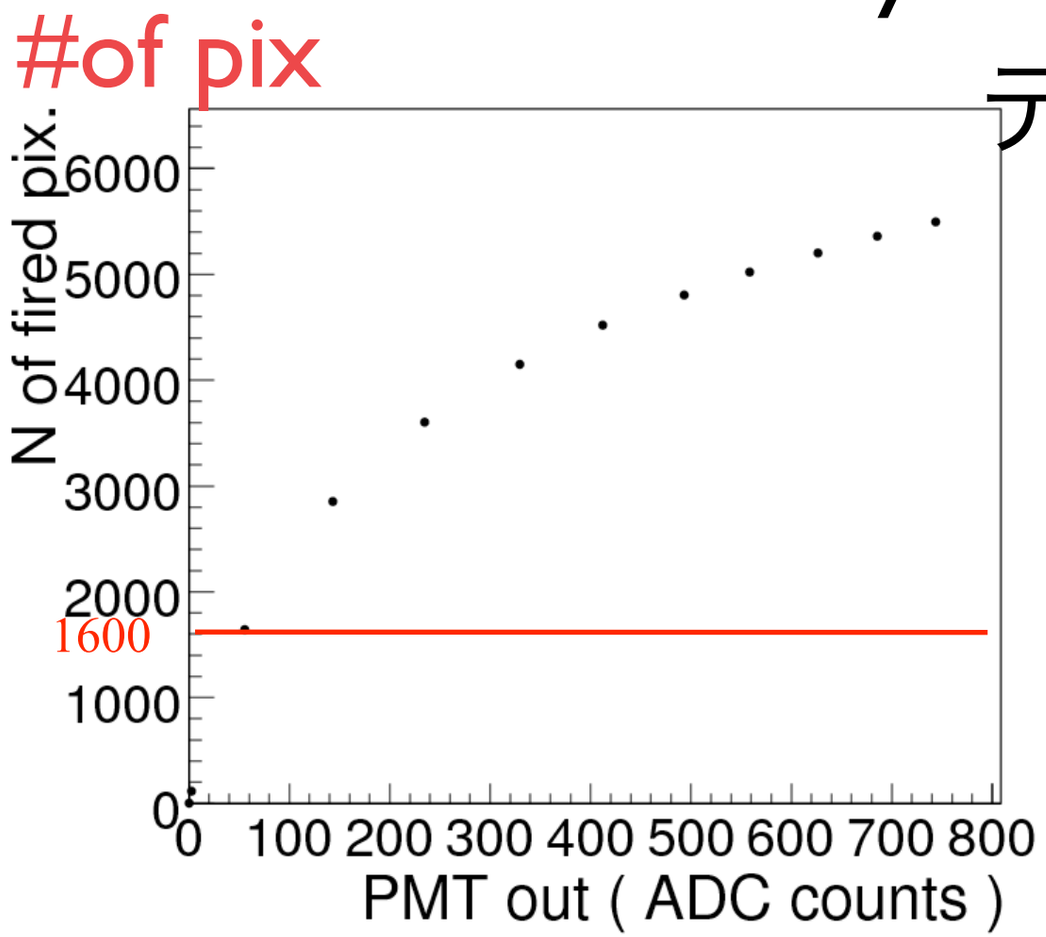


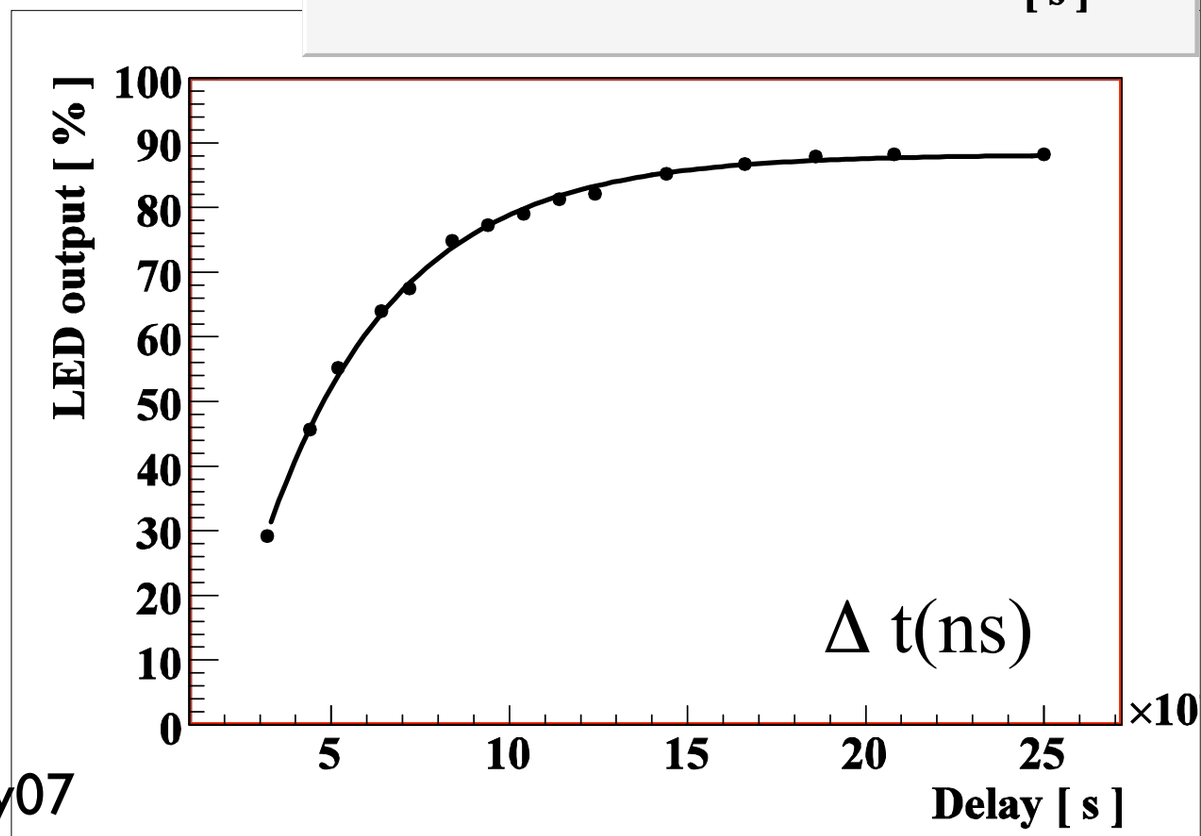
MPPC current dev.

- Linearity is a key for the calorimeter
- MPPC has principle limit of linearity by number of pixels
- significant linear behavior measured
- due to fast recovery time

テキスト

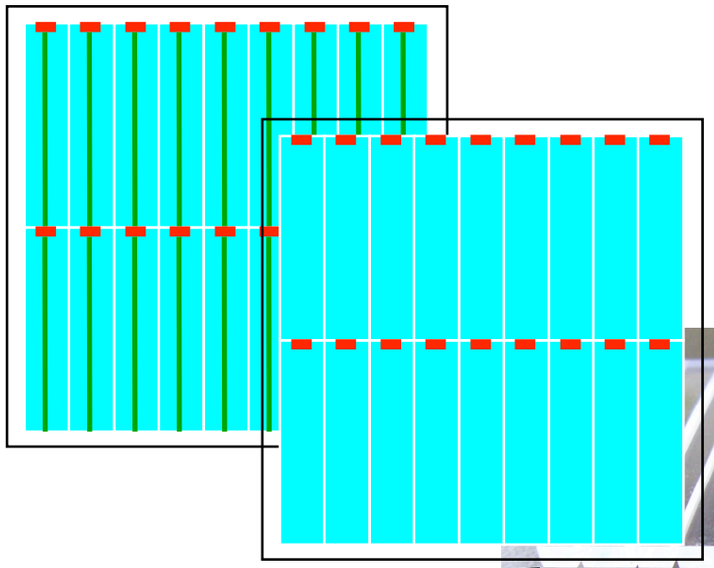




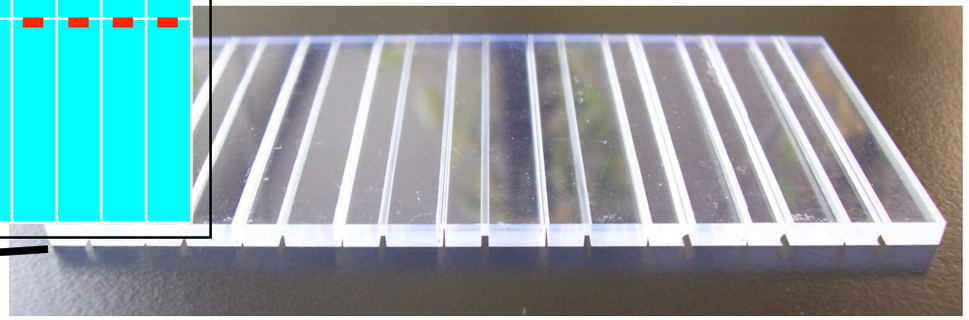


scintillator strip

- two mega-strip and extruded strip
- with and without Wave Length Shifting Fibre
- 26 layers 468ch
- 17X0

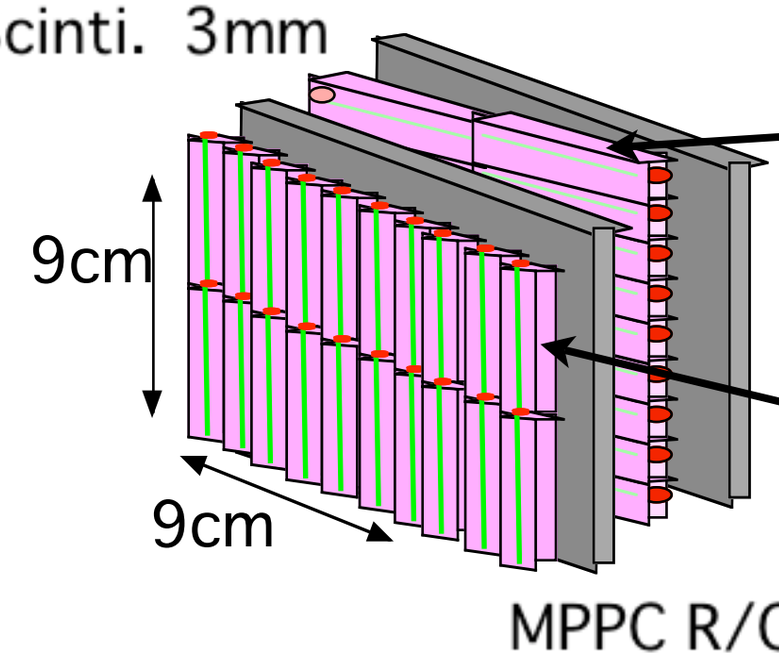


Cast-Mega-strip



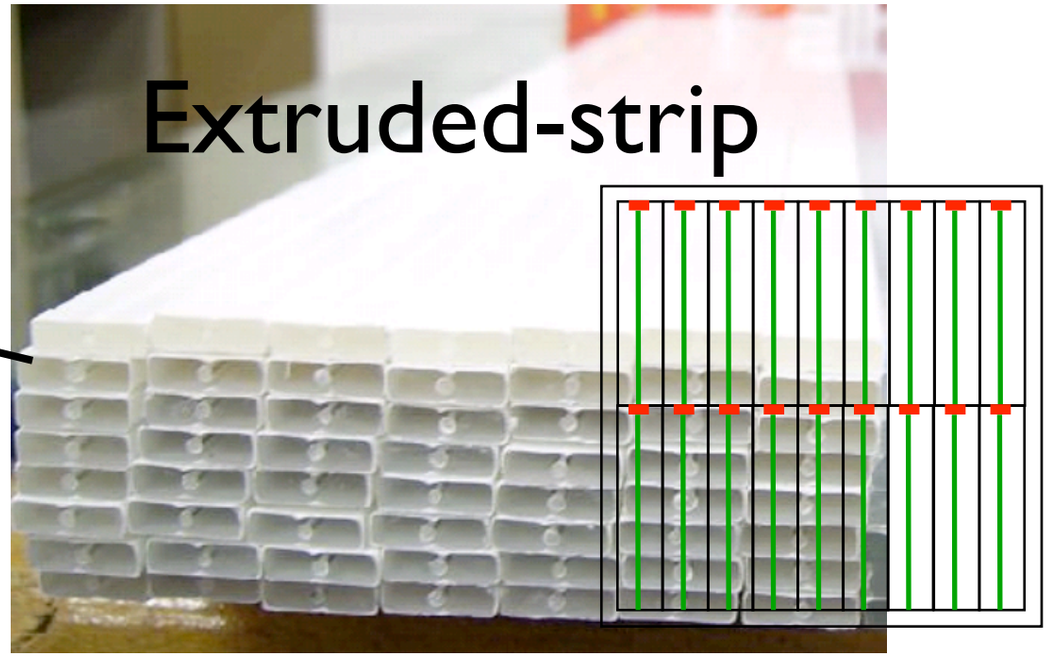
W 3.5mm

Scinti. 3mm

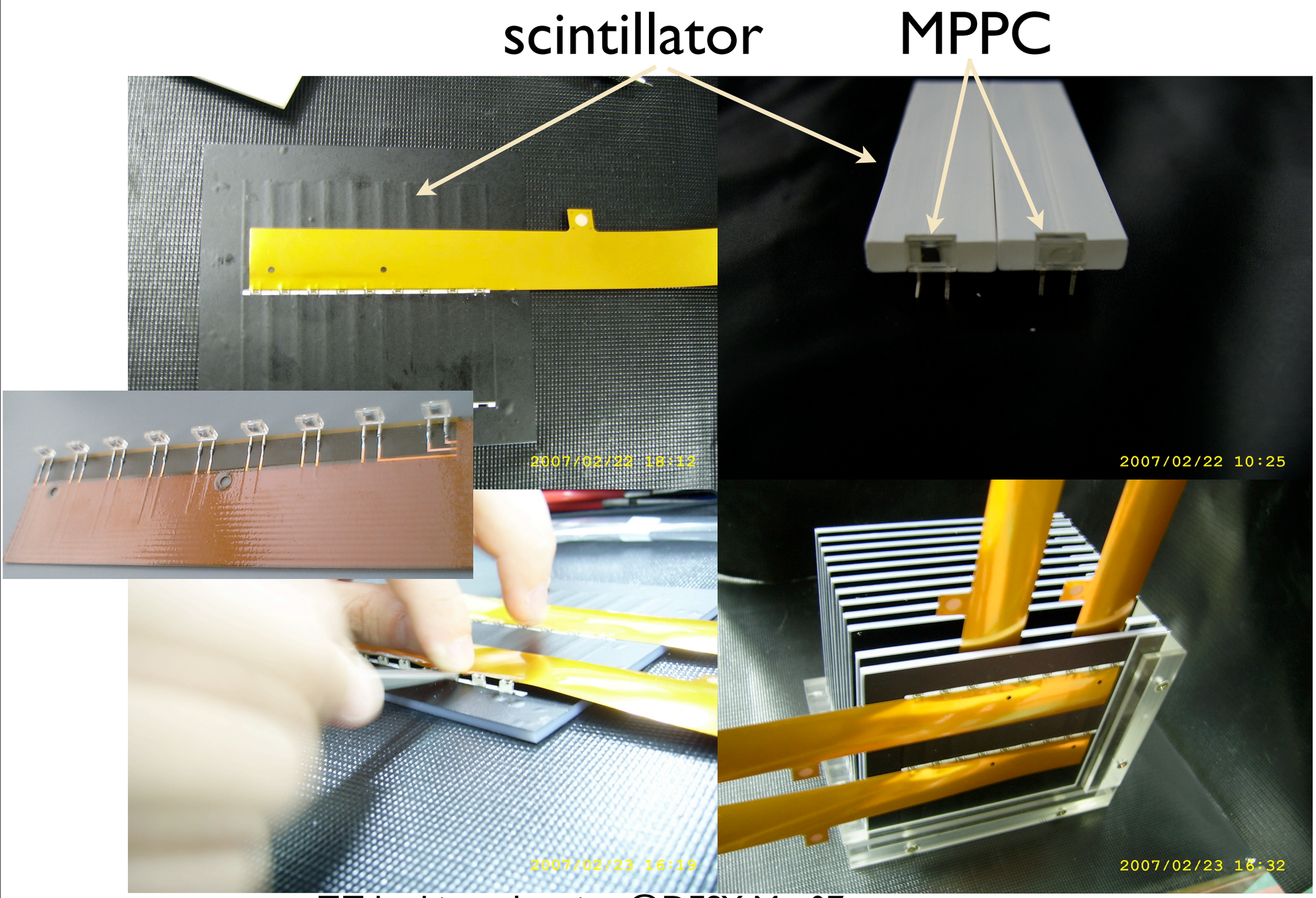


hole with TiO2 outer shield

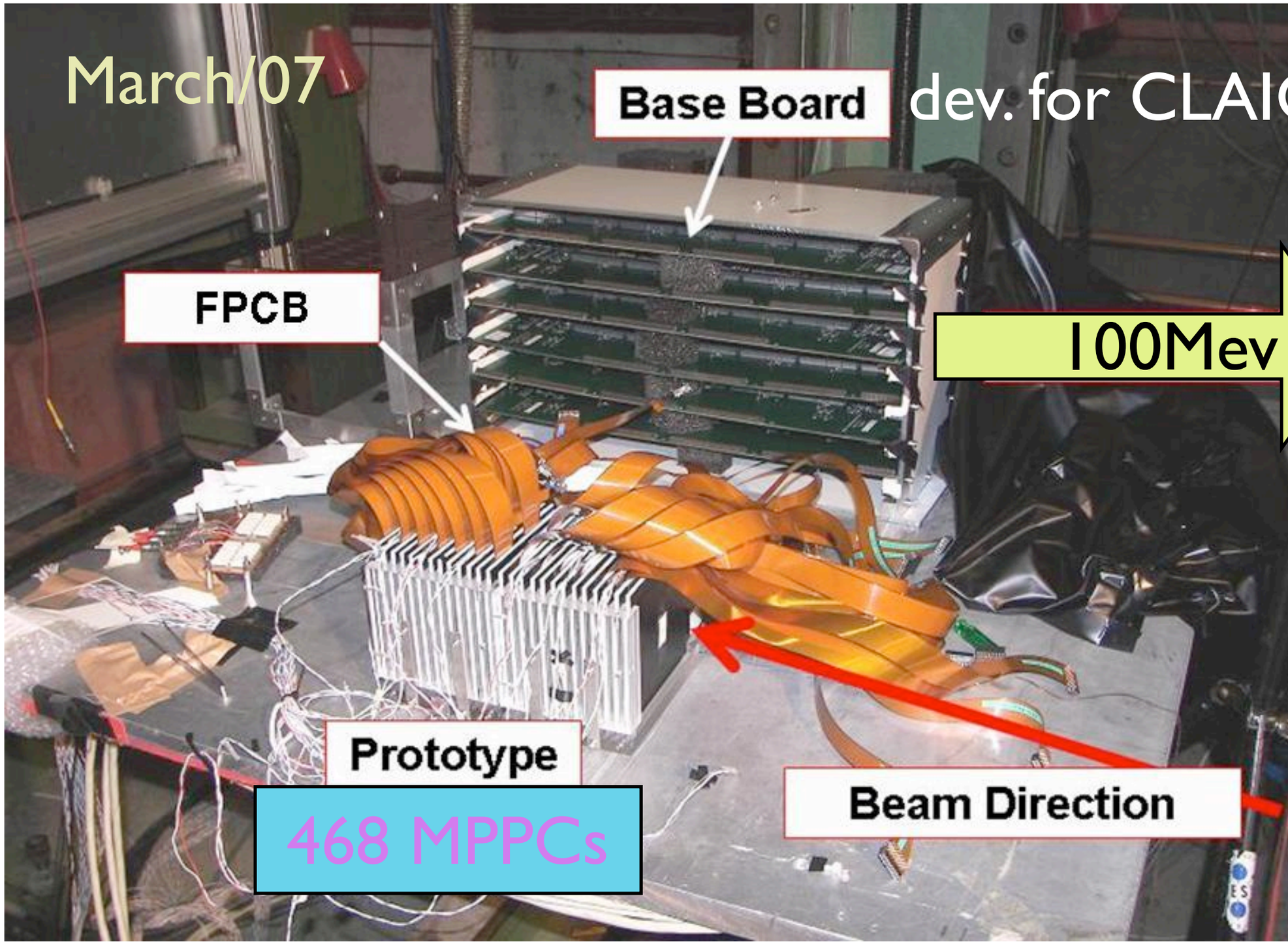
Extruded-strip



Fabrication of ECAL



prototype ECAL at DESY



dev. for CLAIC E AHCAL

SiPM

100Mev

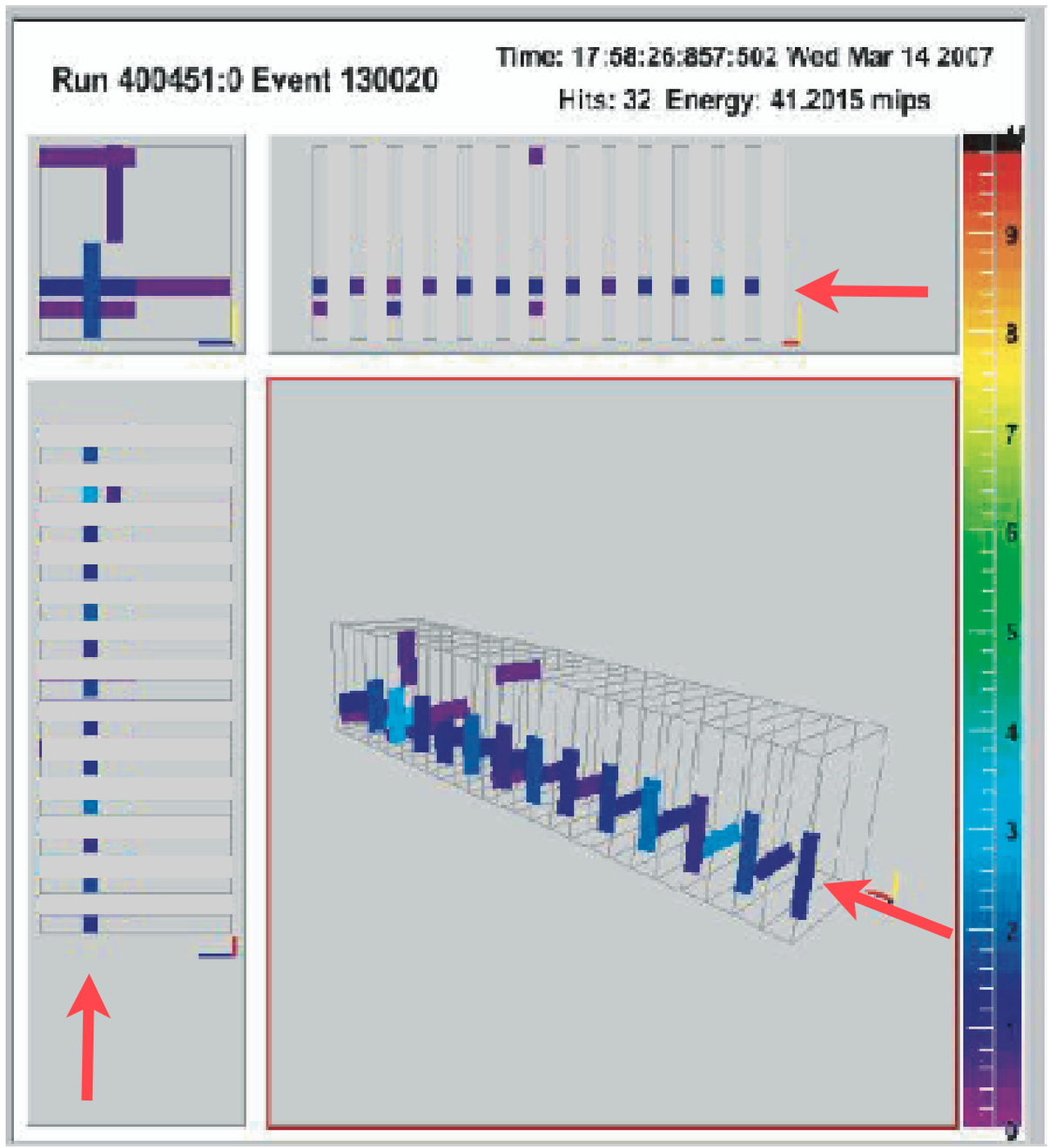
DAQ

GRID
VO
CALICE

DESY BT online

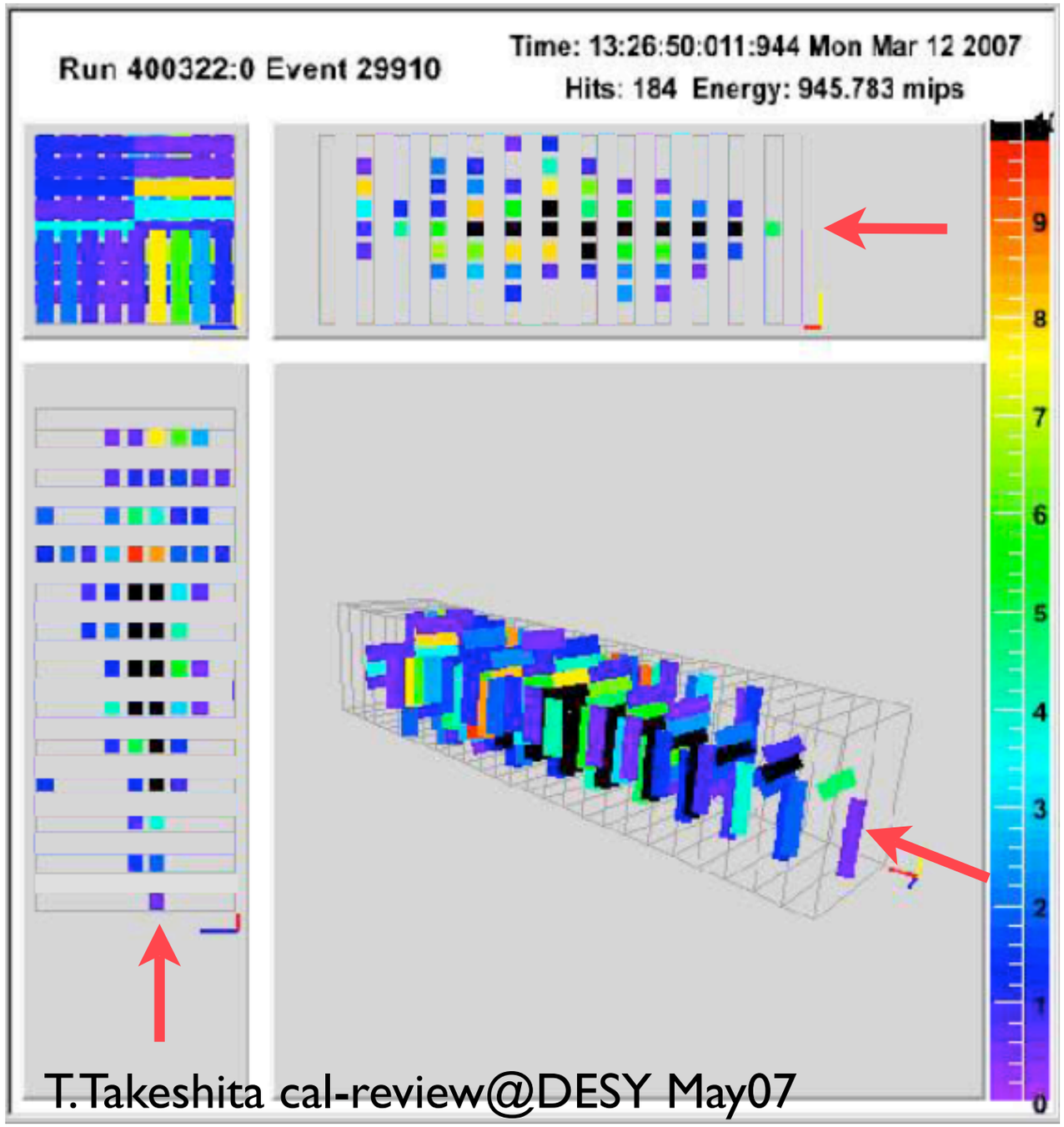
without Tungsten plates

3GeV e



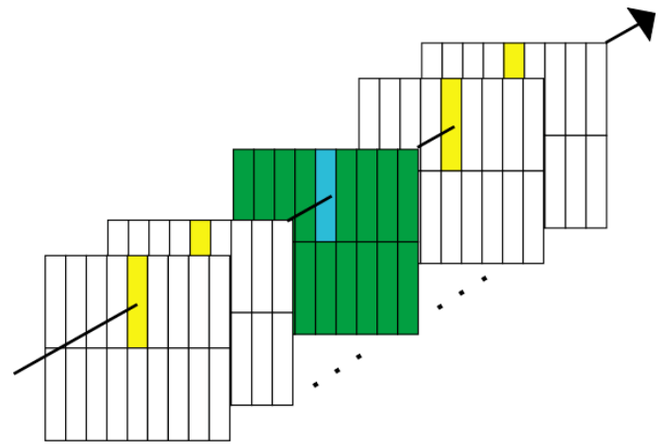
with Tungsten plates

6GeV e

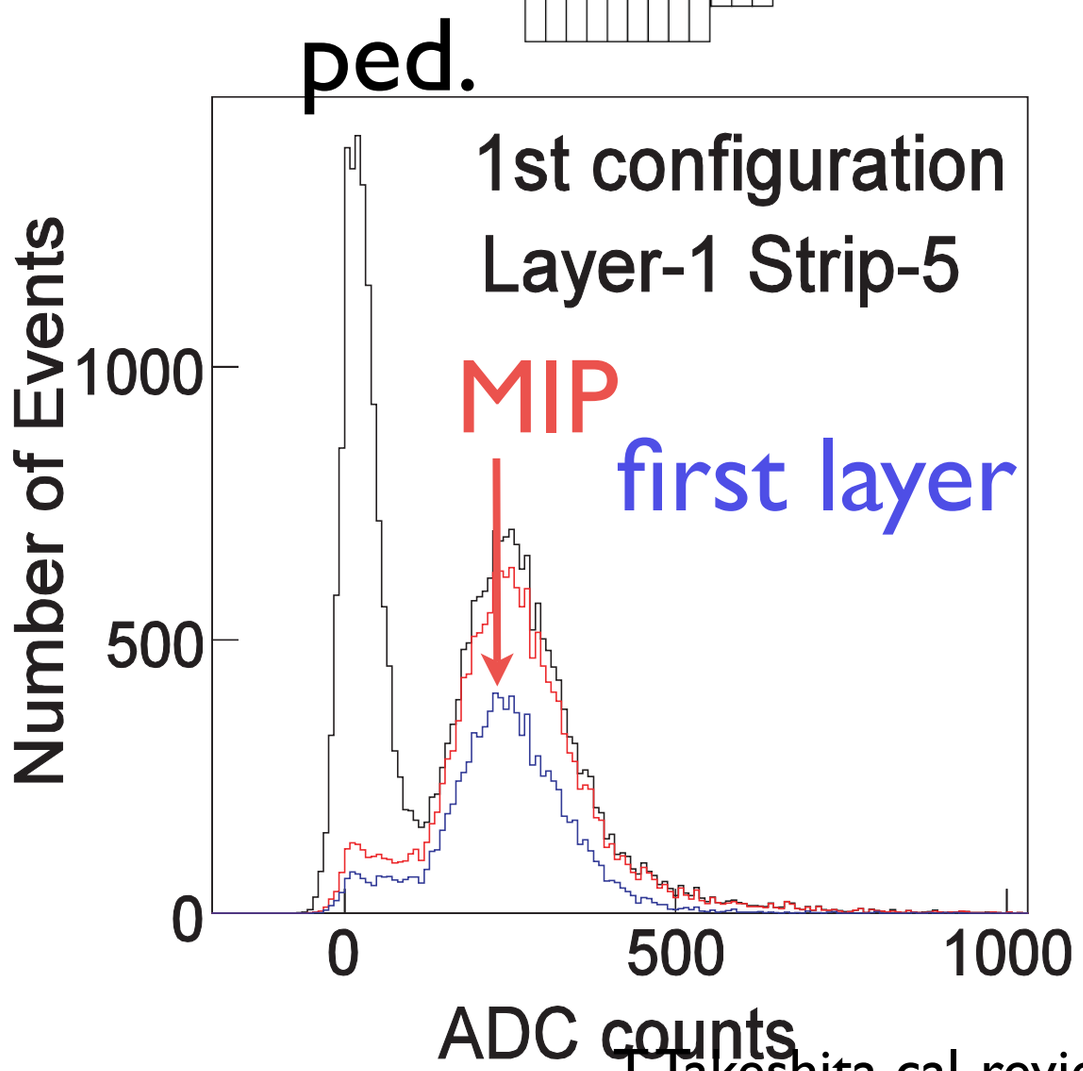


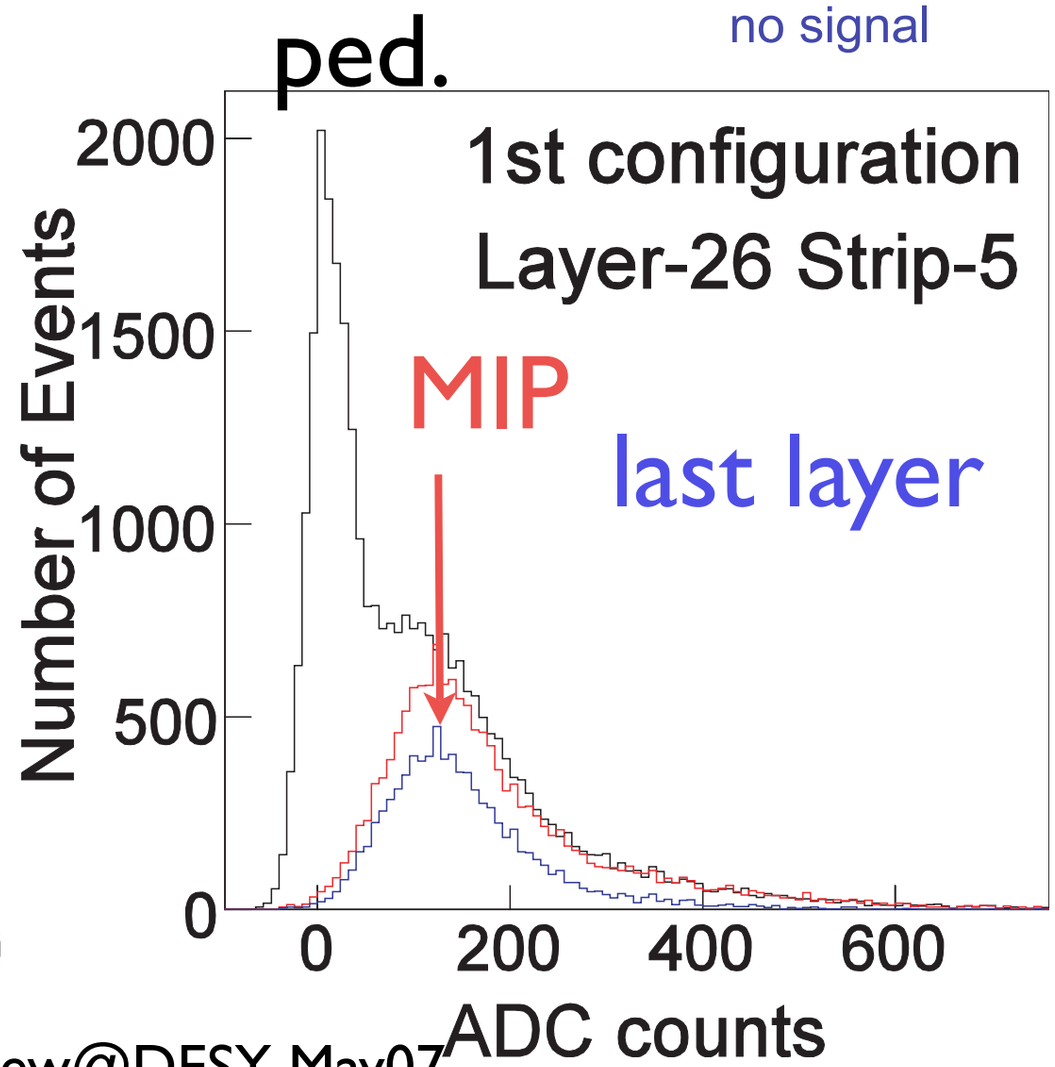
DESY BT calibration

extracting Tungsten plate MIP=3GeV electron



Black … trigger/veto cuts
Red … Yellow strips have non-pedestal signal
Blue … Green strips have no signal

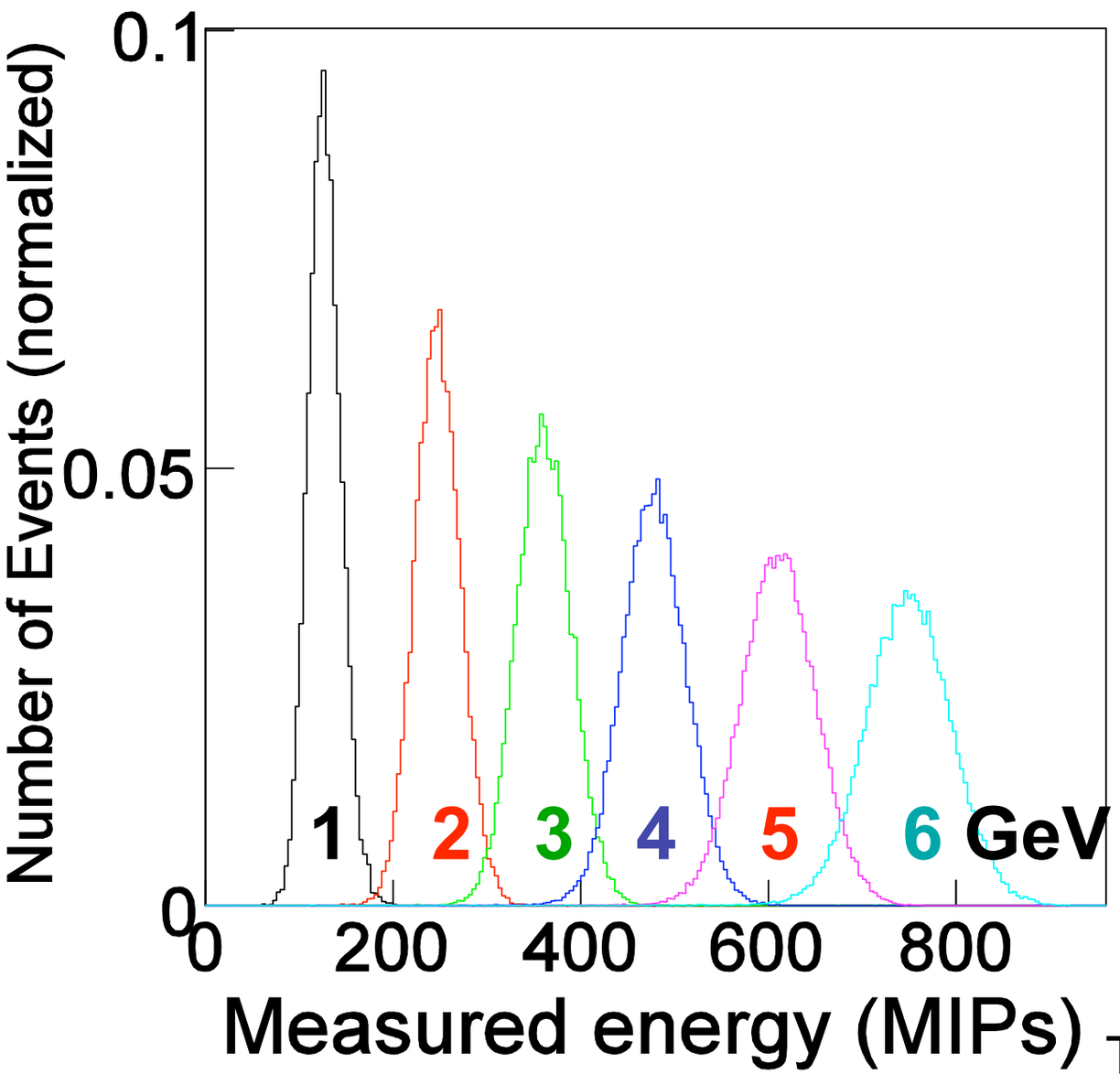




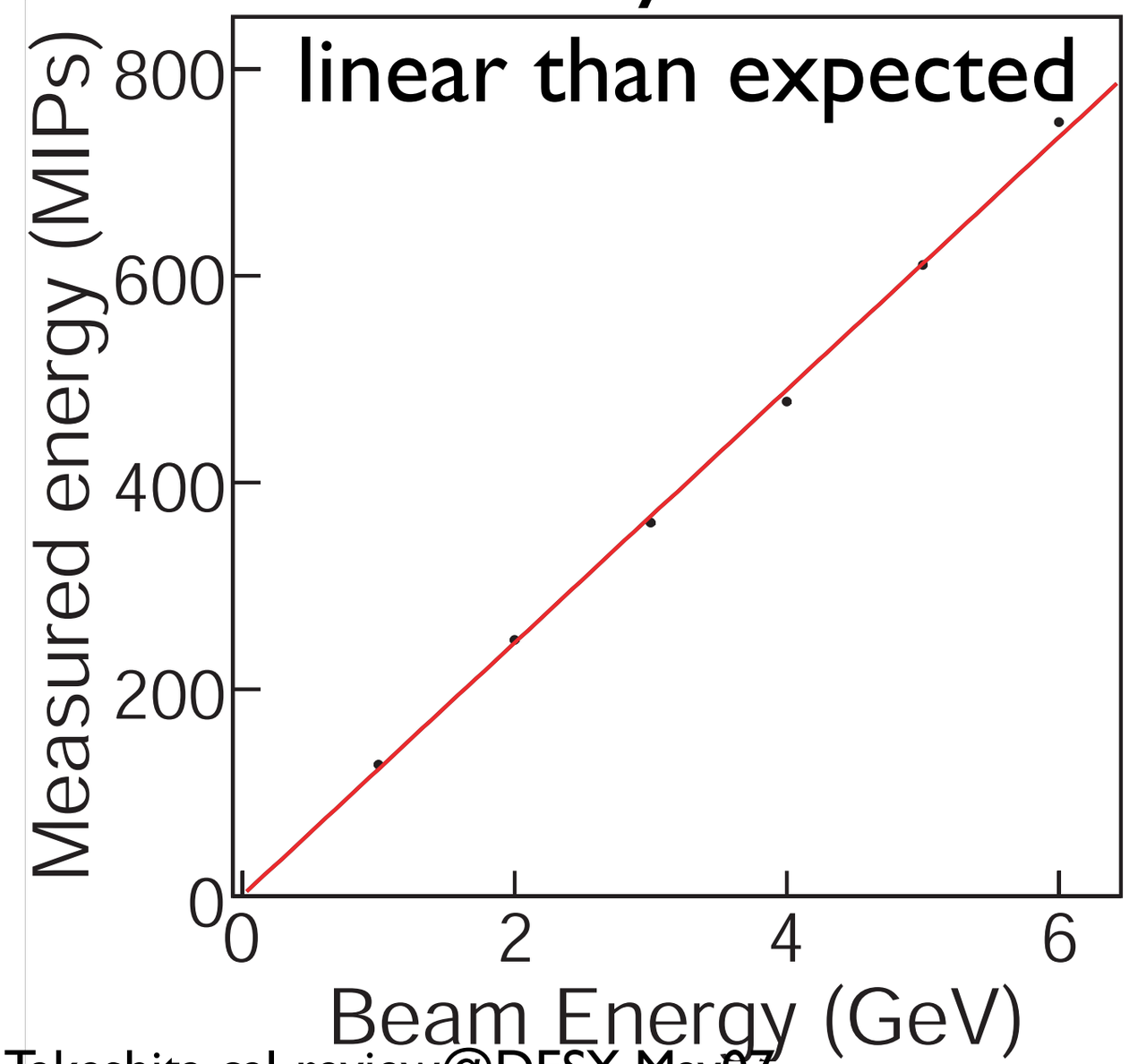
SC-ECAL DESY results (preliminary)

with WLSF

energy measurement

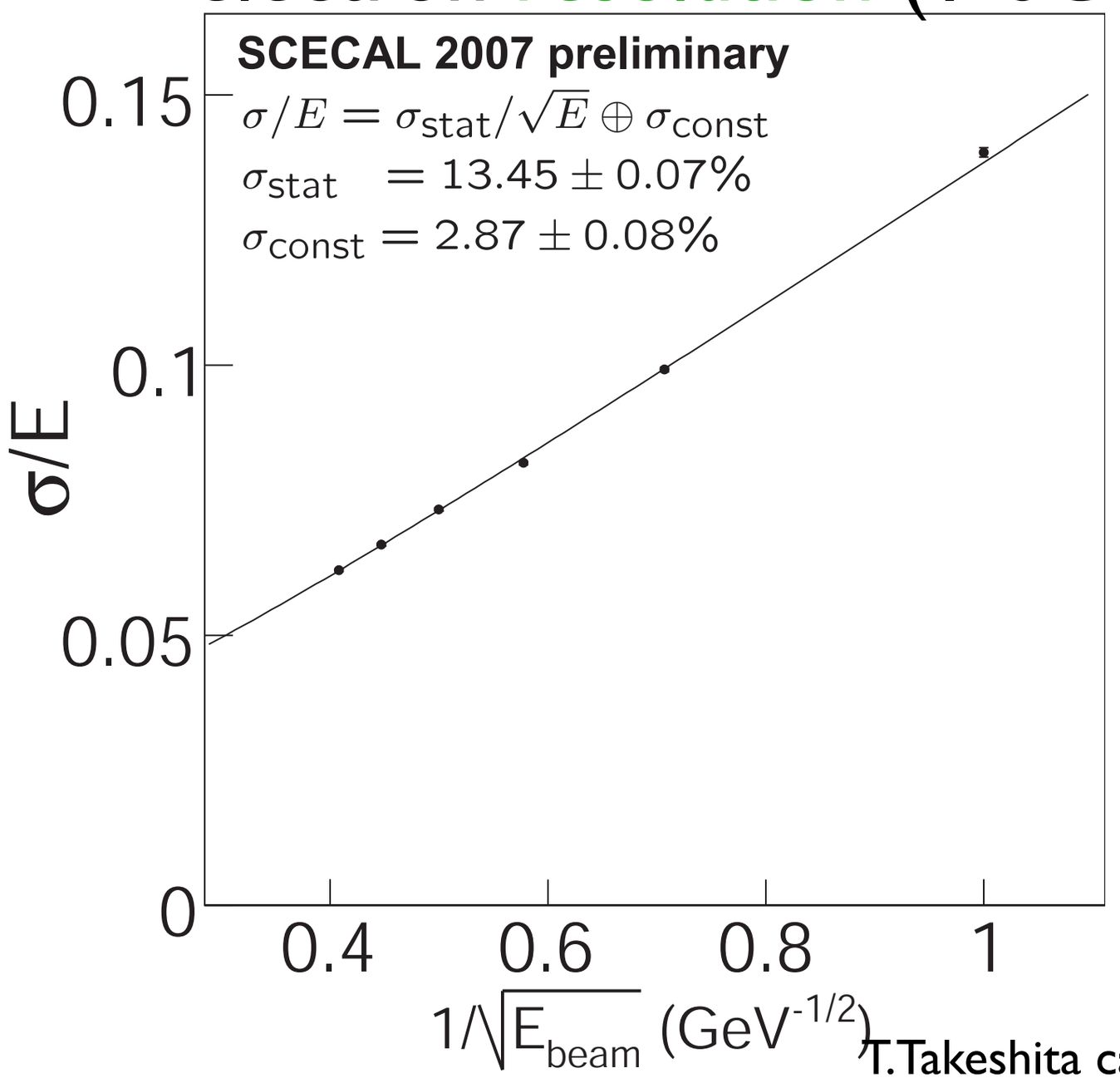


linearity 1-6GeV

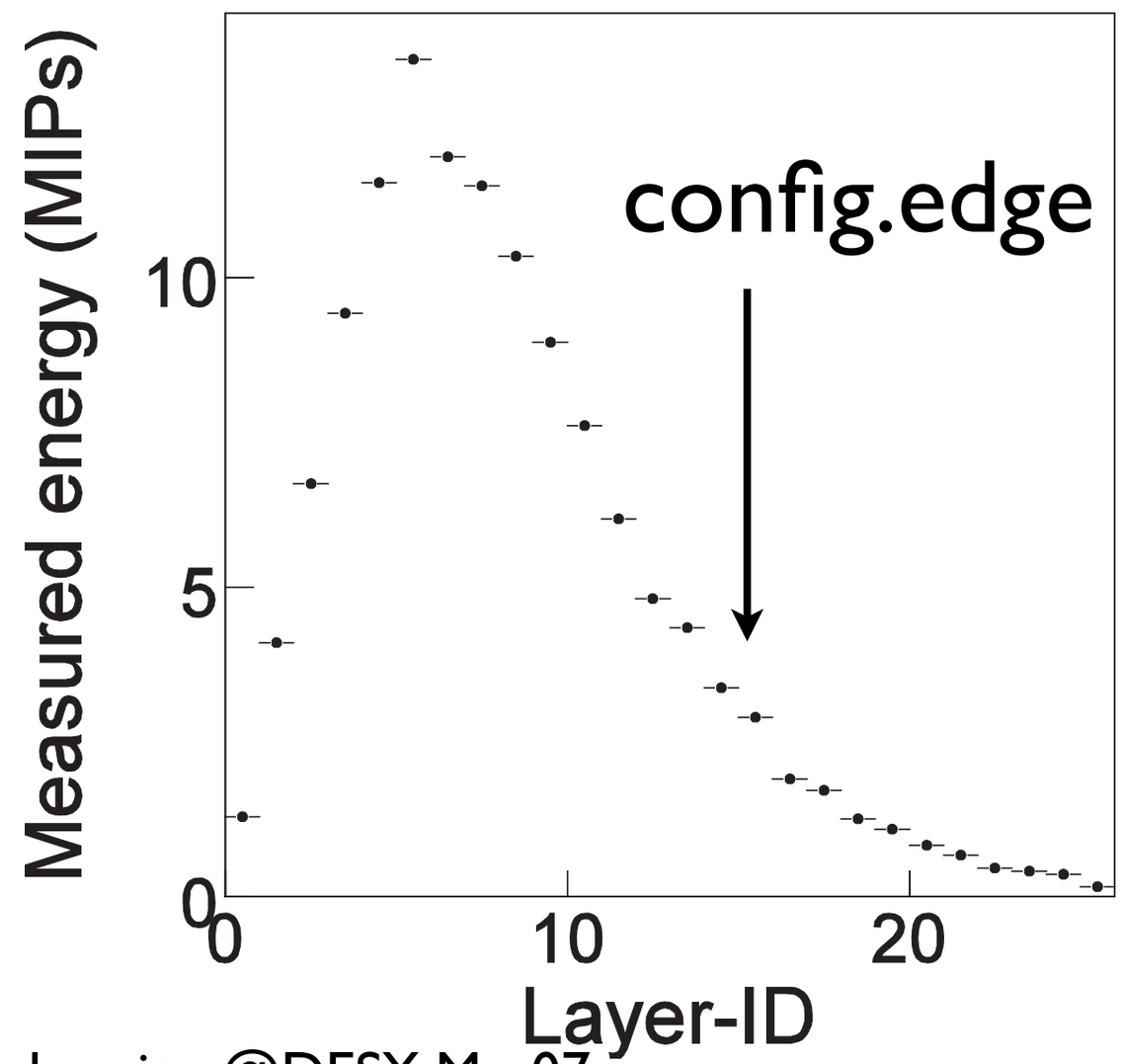


SC-ECAL DESY results (preliminary) with WLSF

electron resolution (1-6GeV)



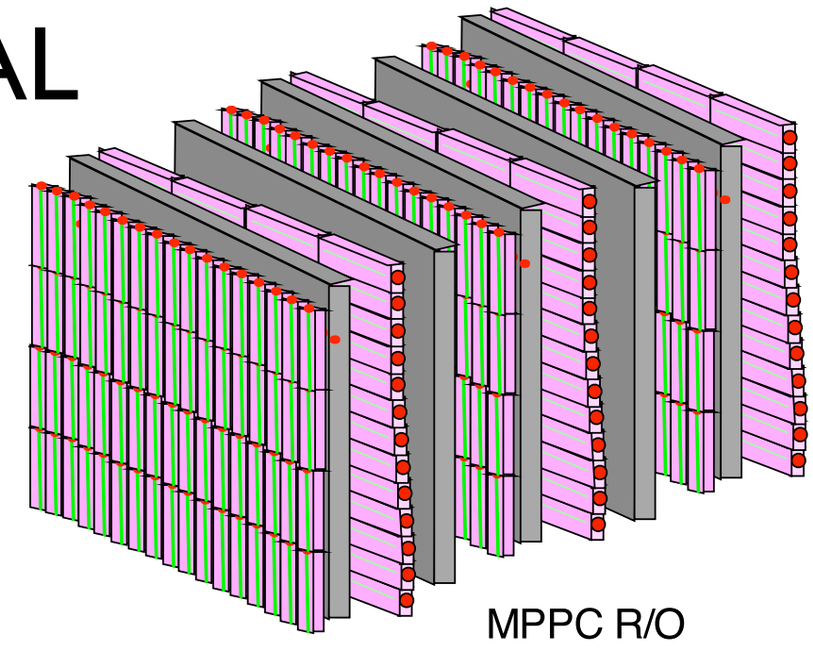
longitudinal shower profile

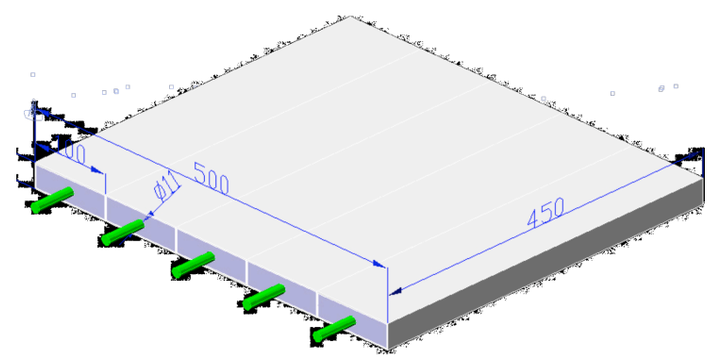


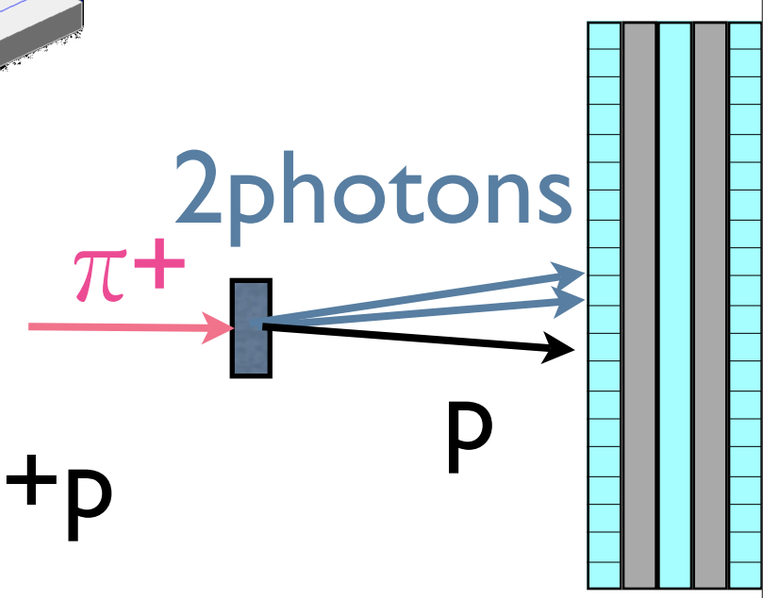
Mile stones

desy data analysis

- const. 4 times bigger Scintillator ECAL
  - MPPC dev. and 2.5k prod.
  - extrusion scintillator prod.
    - embedded WLS fiber to strip
    - Mega-extrusion
- electronics
- 2008 Beam test at Fermilab w HCAL
  - to test pi0 reconstruction : π+n>π0+p







summary & outlook

- scintillator ECAL in CALICE project
- with strip structure
- very much progress : DESY-BT
  - MPPC : photo-sensor
  - scintillator
- 2008 TB at Fermilab
- engineering work for ILC calorimeter
- further development of MPPC with HPK
  - linearity