



Scintillator ECAL



for ILC

T. Takeshita (Shinshu & CALICE)

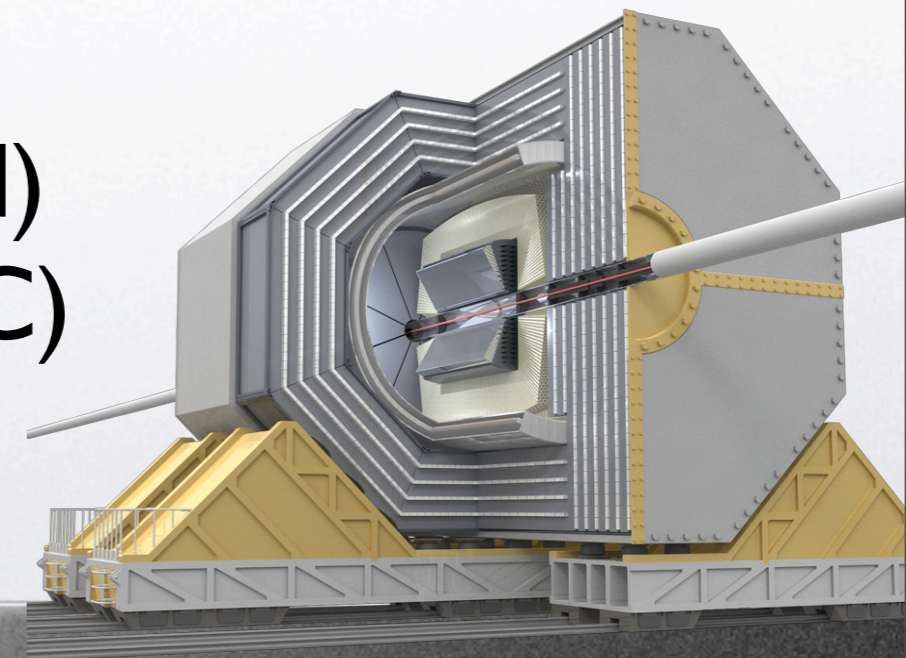


for calorimeter school at Tsinghua & CCAST 2009

竹下徹 (信州大学)



ILC Physics and Calorimeter
scintillator ECAL
scintillator (extruded)
photon sensor (MPPC)
ECAL



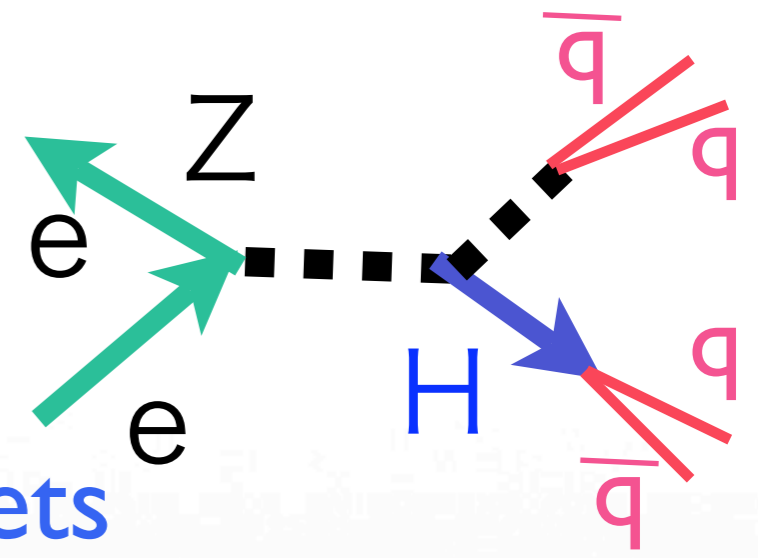
by S. Numazawa



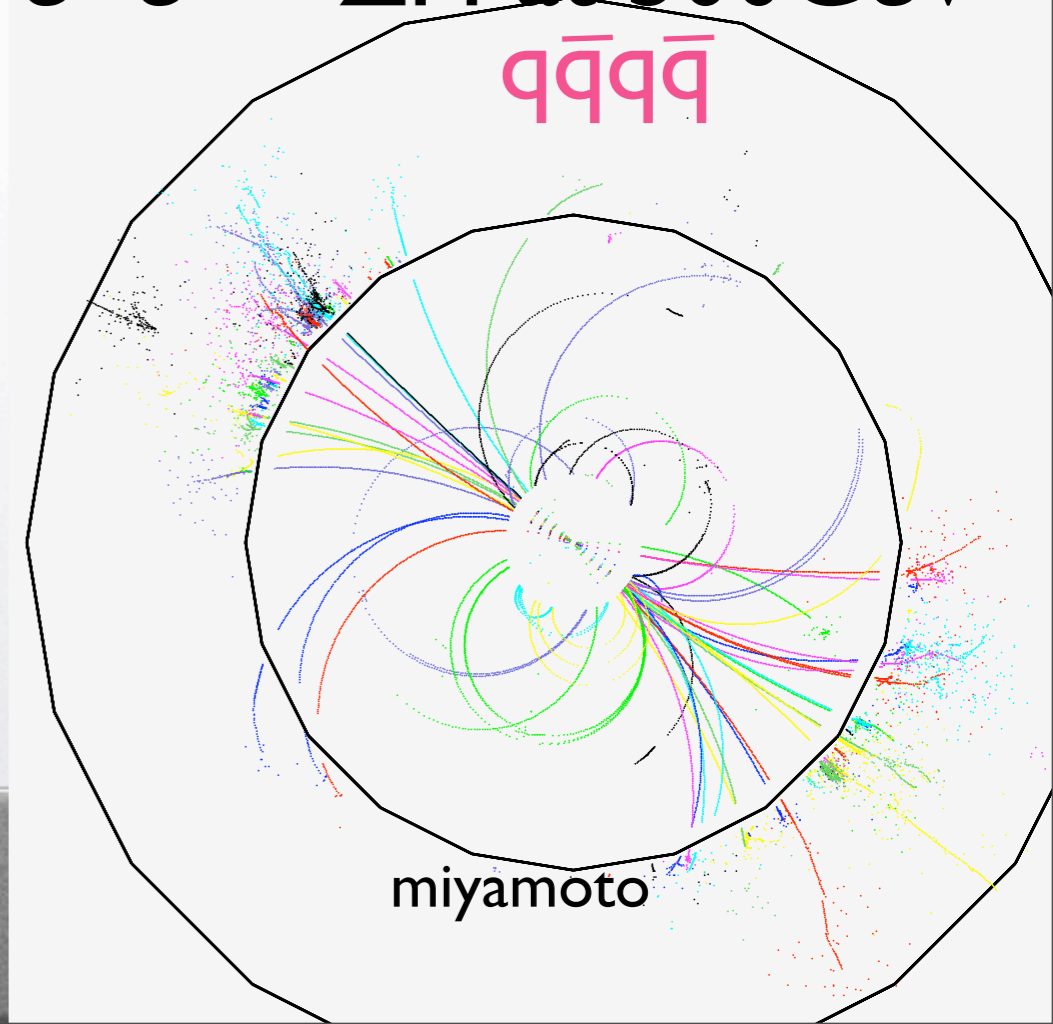
ILC Physics & events



- High Energy $e^+ e^-$ collision (~ 1 TeV)
- relevant physics final states
 - $W/Z/H$ /top which emerges as **jets**
- need to identify its **origin**
- required $30\%/\sqrt{E_{jet}}$
- guiding principle : PFA
- PFA requires optimal detector



$e^+e^- \rightarrow ZH$ at 500 GeV
 $q\bar{q}q\bar{q}$





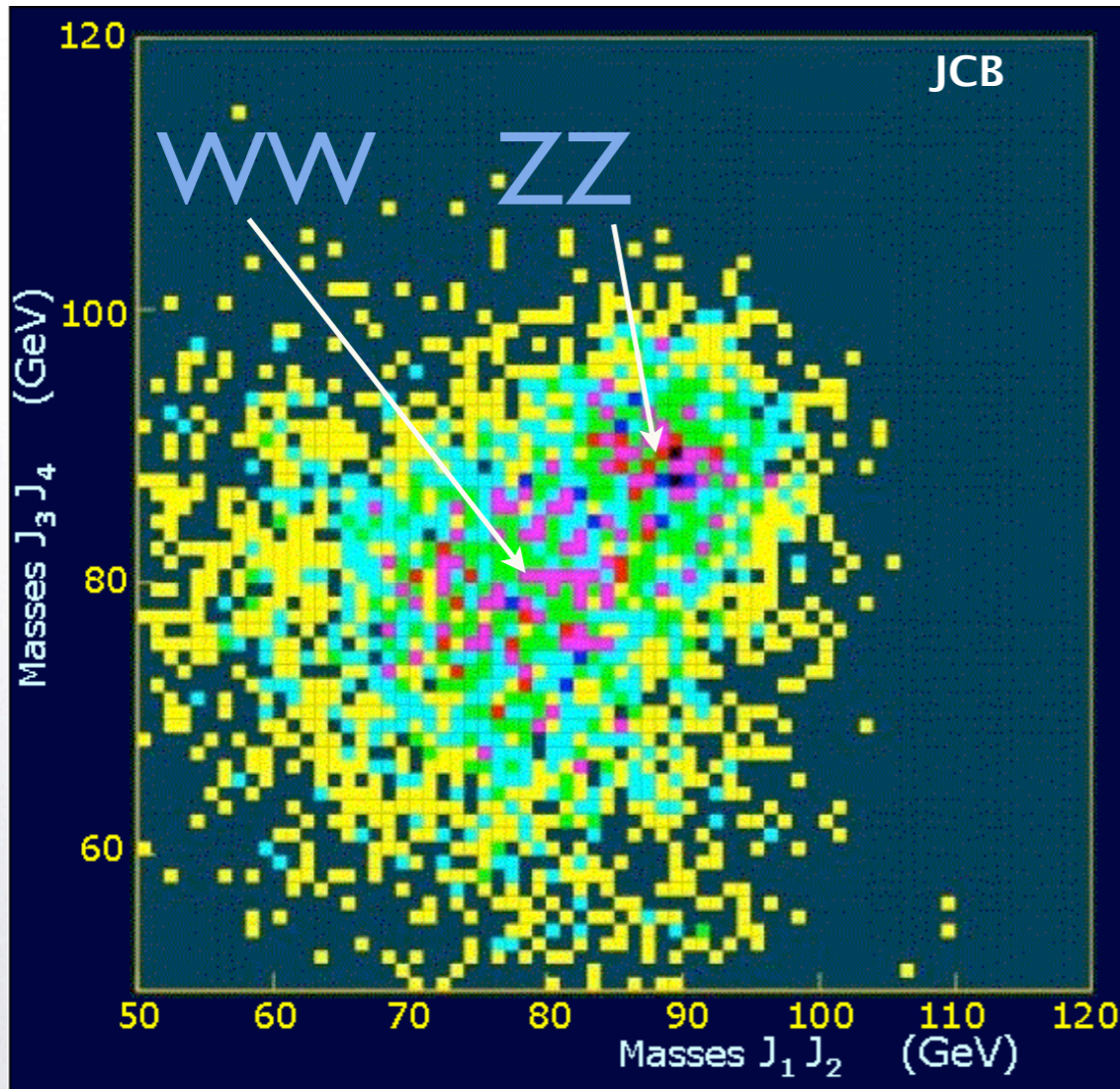
JET energy resolution required to resolve W, Z & H

$$e^+ e^- \rightarrow \nu\bar{\nu}WW/\nu\bar{\nu}ZZ \rightarrow qq'qq' \rightarrow 4jets$$

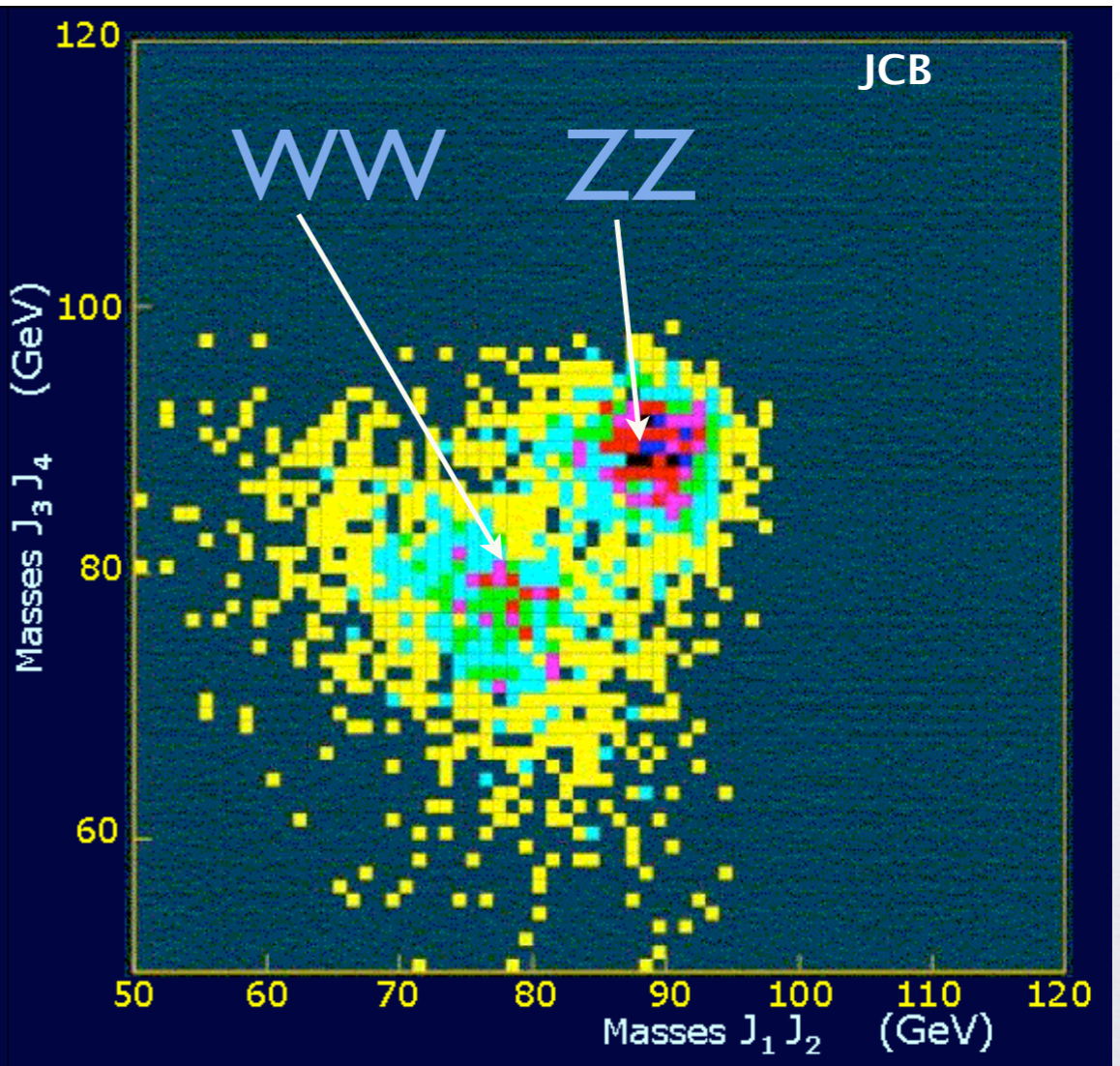
$$\sigma_{Ejet} / E_{jet} = 60\% / \sqrt{Ejet}$$

$$\sigma_{Ejet} / E_{jet} = 30\% / \sqrt{Ejet}$$

2jet-mass(GeV)



2jet-mass(GeV)

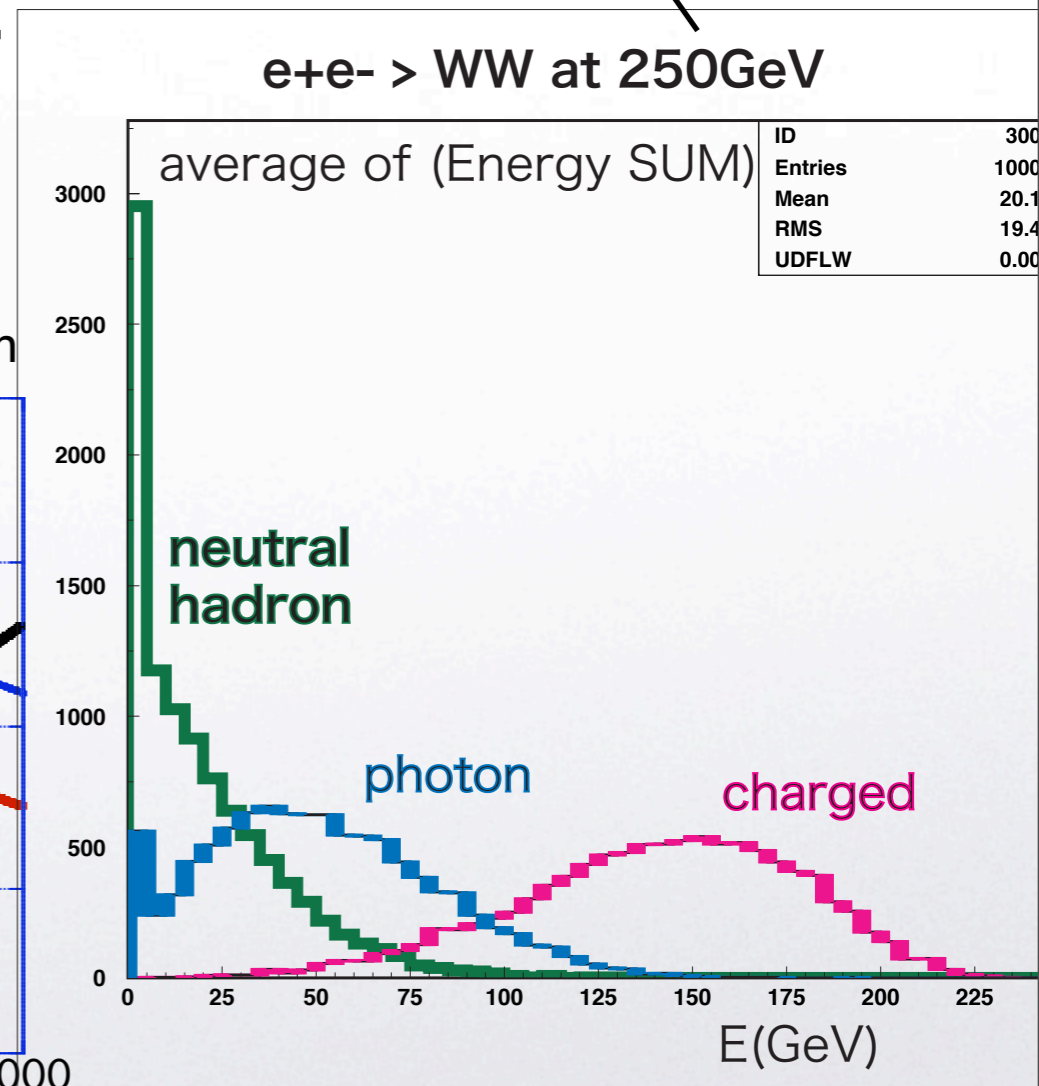
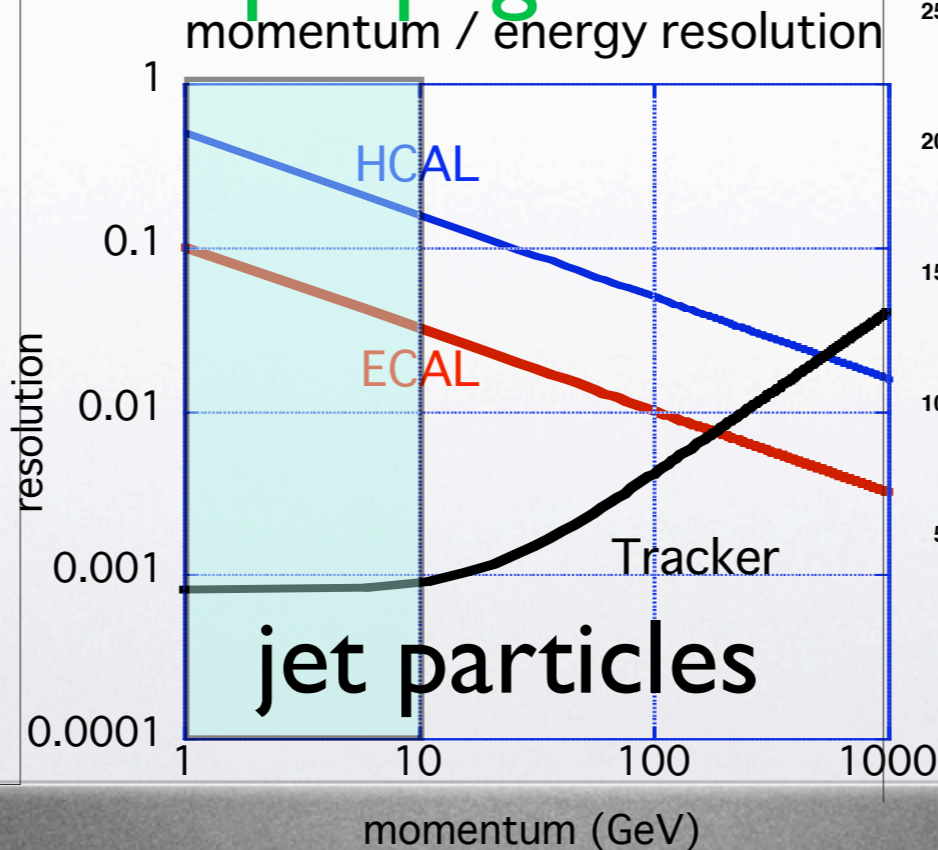
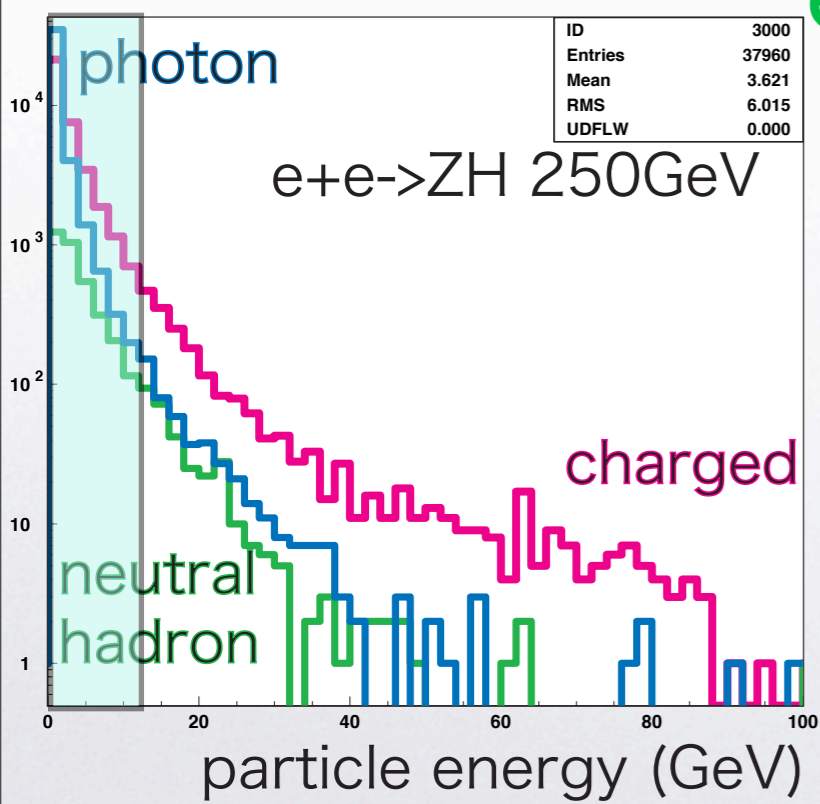


2jet-mass(GeV)

JCBrient

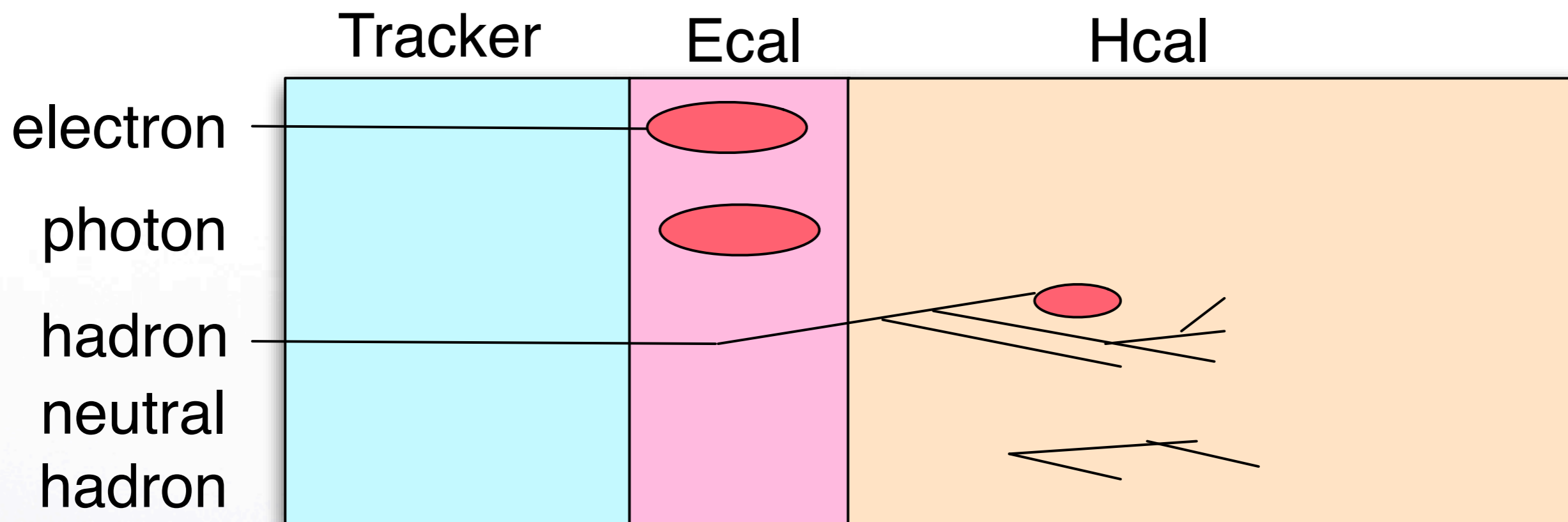
Particle Flow Algorithm

- Charged particle : pion, Kaon: Tracker : 65% of Ejet
0.001 @ 10 GeV
- neutral : photon: ECAL : 25% of Ejet
0.05 @ 10 GeV
- neutral: Ko,n: HCAL: 10% of Ejet
0.2 @ 10 GeV
- jet energy resolution : HCAL
error propagation





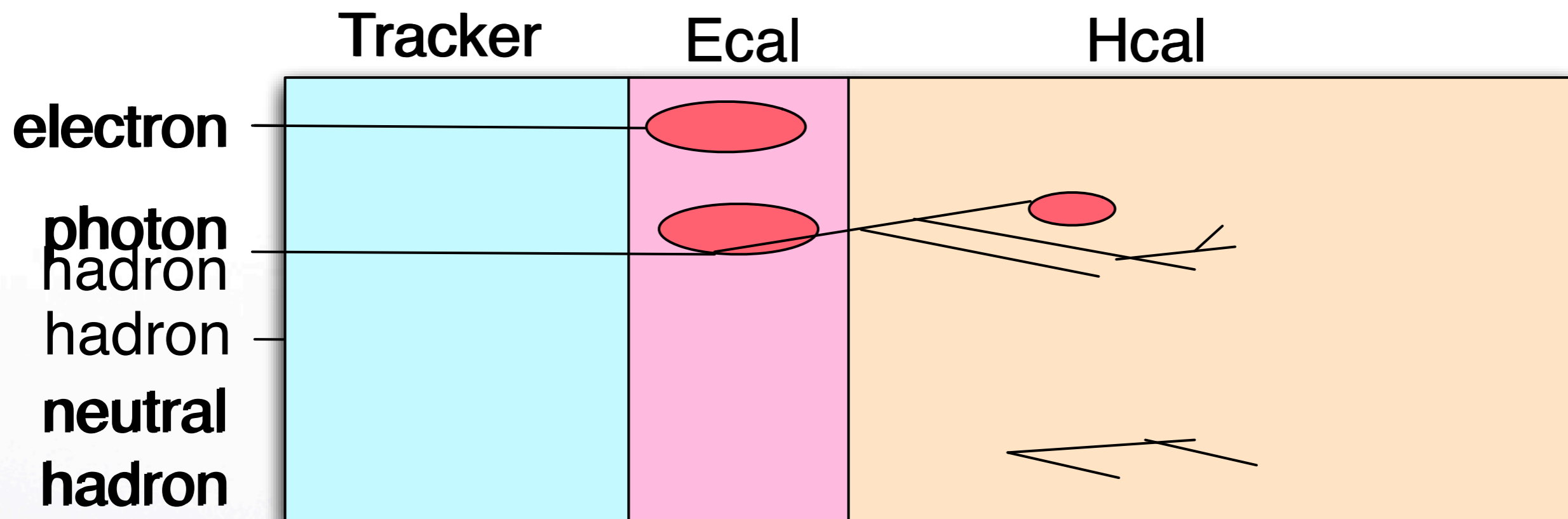
PFA detector



$$E_{jet} = \sum_{\text{charged}} p_i + \sum_{\text{photon}} E_i + \sum_{\text{neutral hadron}} E_i$$



PFA detector



$$E_{jet} = \sum_{\text{charged}} p_i + \sum_{\text{photon}} E_i + \sum_{\text{neutral hadron}} E_i$$

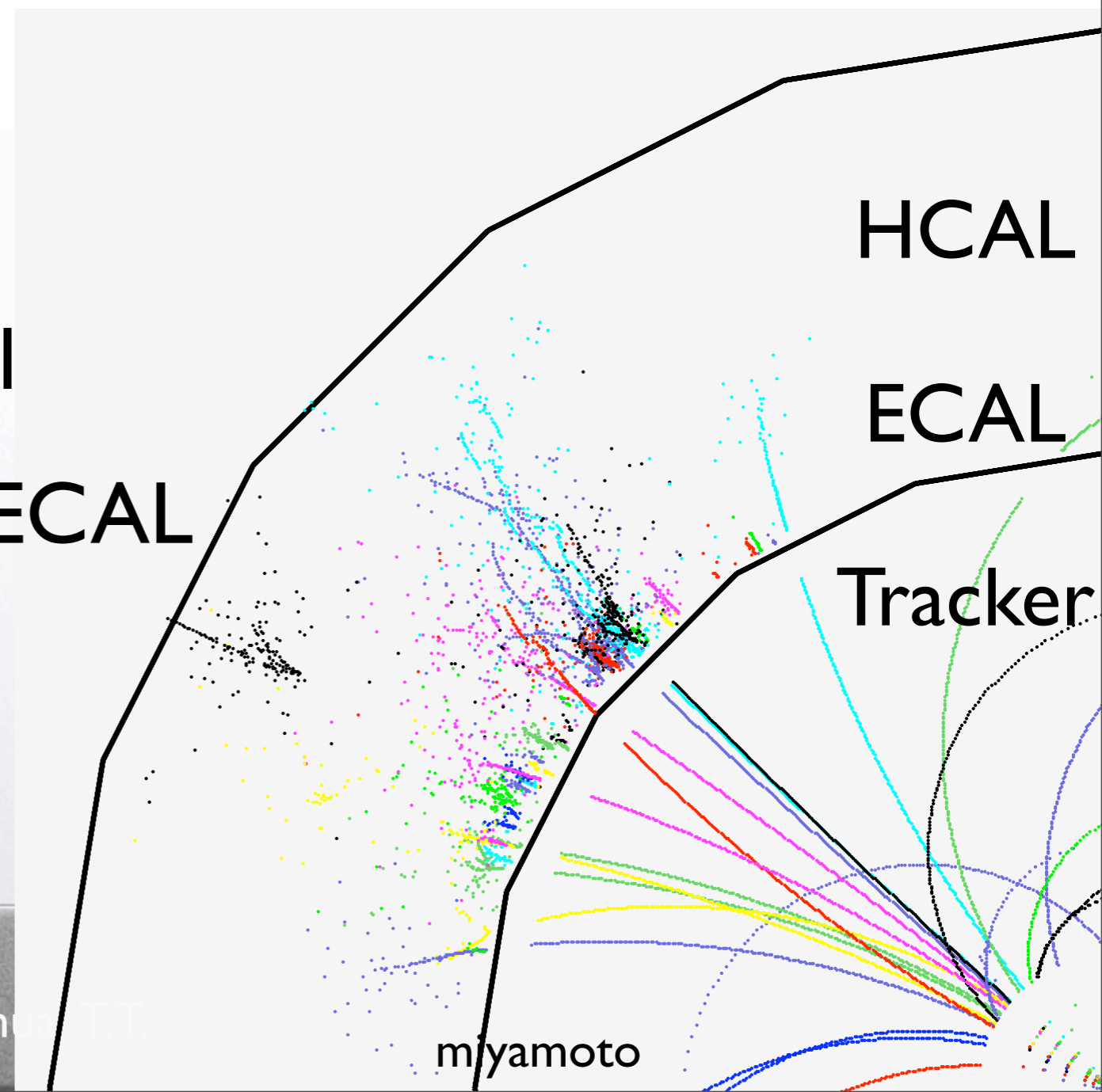


PFA Calorimeter



- need to **separate** charged and neutrals in calorimeter
- cluster overlapping in 3D.
- tracking in CAL
- fine segmentation
- longitudinal and lateral
- photon separation in ECAL
- neutral hadron isolation
- in the magnetic field

$e^+e^- \rightarrow ZH$ at 500GeV

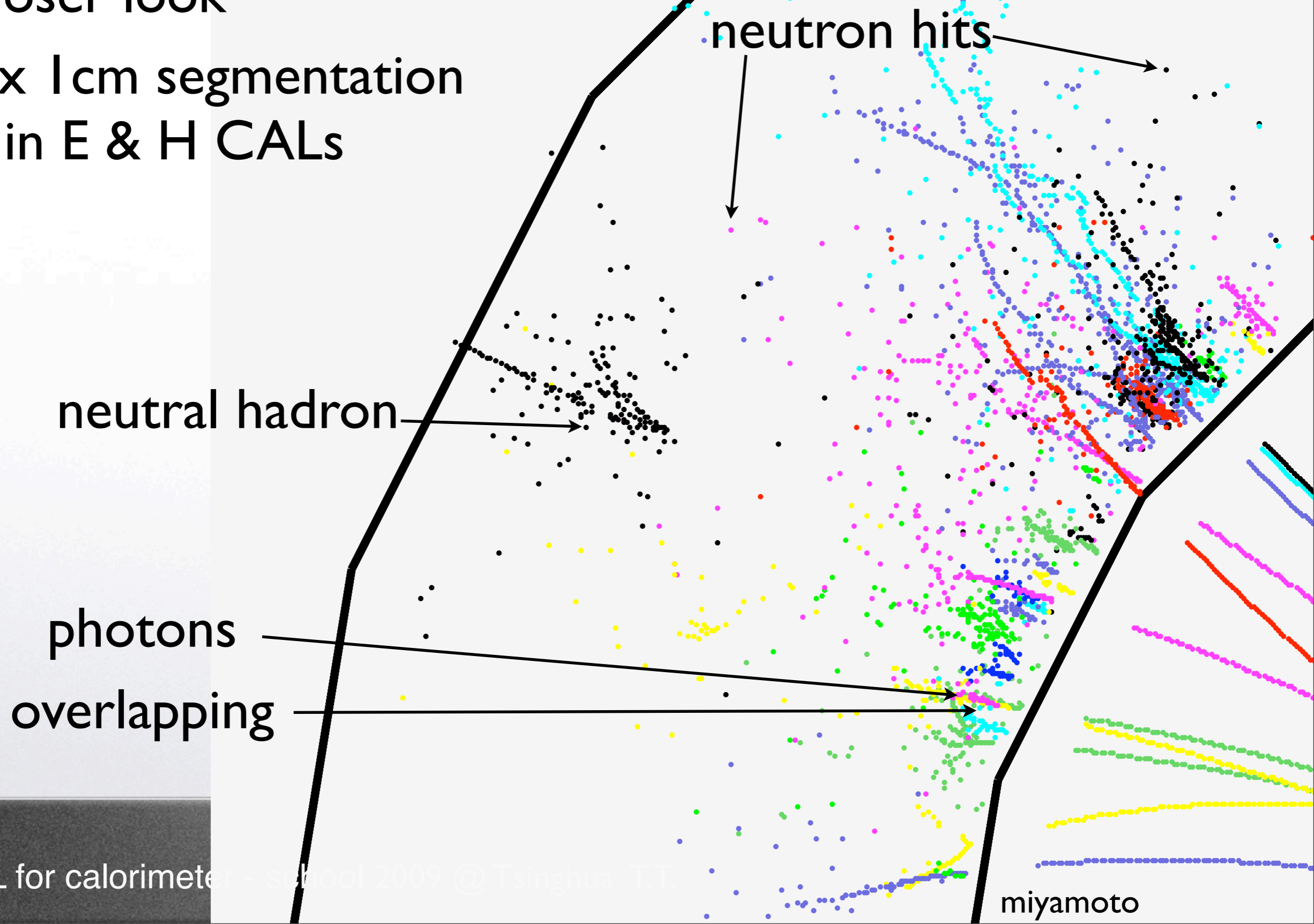




PFA CAL-more

A closer look

1cm x 1cm segmentation
in E & H CALs

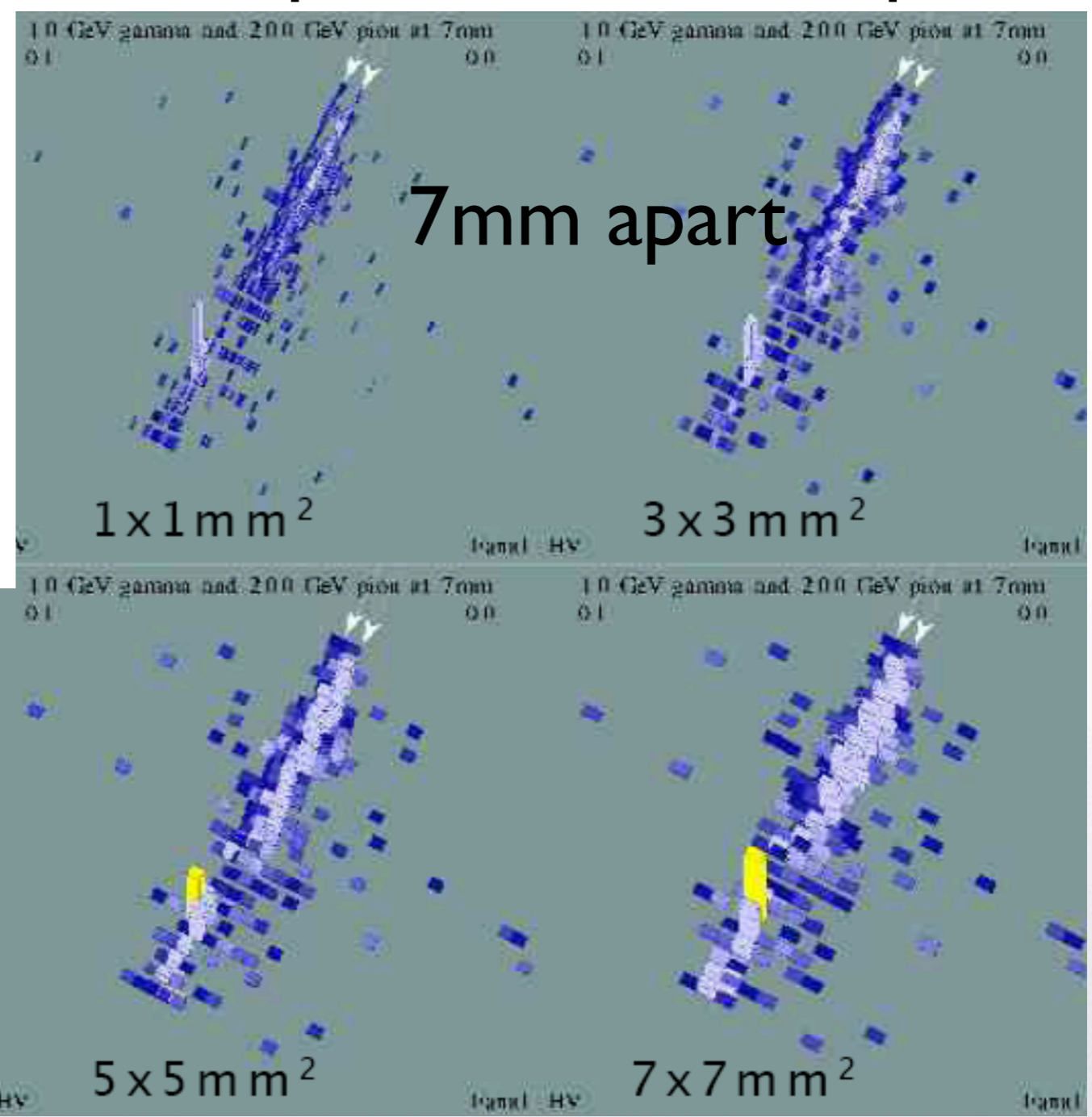
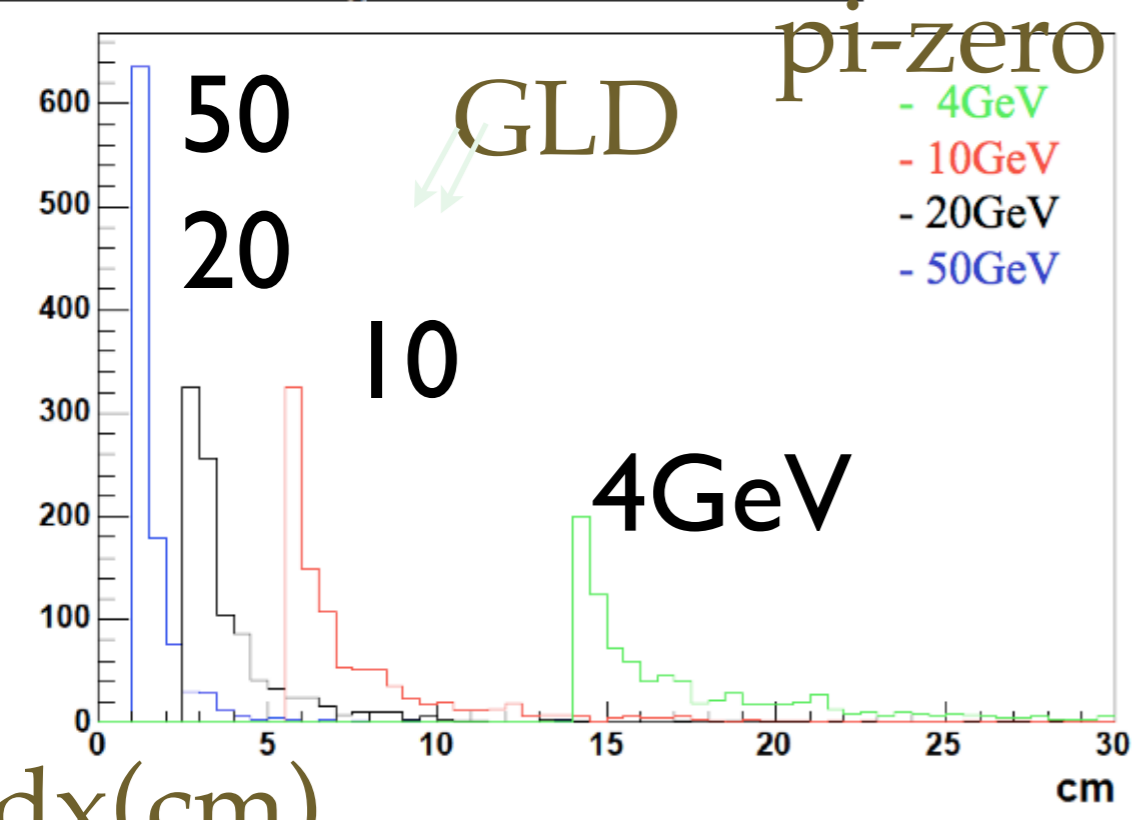


granularity ECAL

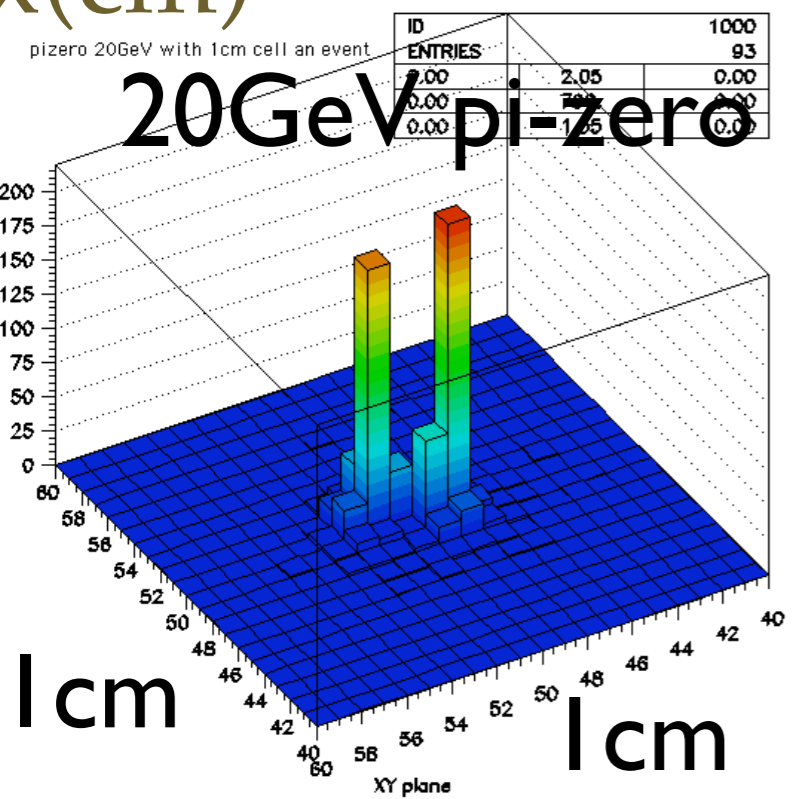


tau decays into
10GeV photon & 20GeV pion

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



dx(cm)





implementation



- How to reconstruct a jet with sampling cal. for PFA
- longitudinal segmentation everywhere
 - to separate particle from shower profile
- lateral segmentation
 - due to technological reasons
 - Silicon/WV 15~100Mch , $\sim T_{ch}$ (digital)
 - analog ($<(1)\text{cm}^2 \text{seg.}$) and digital ($\sim (50)\mu\text{m}^2 \text{seg.}$)
 - Scintillator/WV ($\sim <(1)\text{cm}^2 \text{seg.}$ 5~10Mch)
 - sensor size



ECAL for ILC

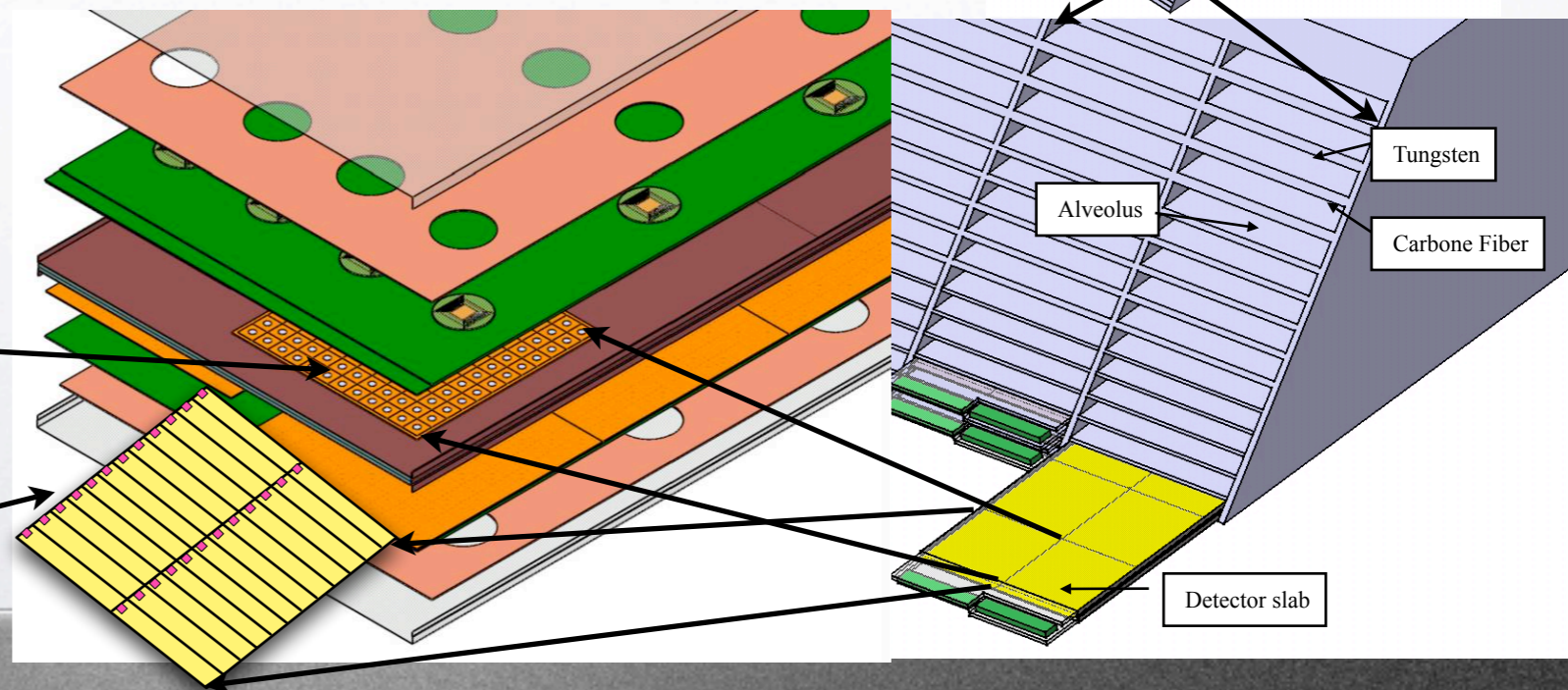


- Tungsten : small Moliere radius ~ 1 cm
- need less gap between layers
- read out elex. within layers
 - Amp, Shaper + 15 bit ADC
 - power pulsing : $1/1000 \sim \mu\text{W}/\text{ch}$

- sensor :

- Silicon Pad

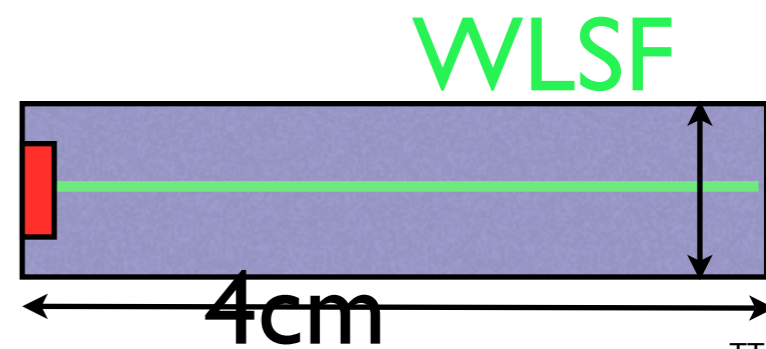
- Scintillator strip





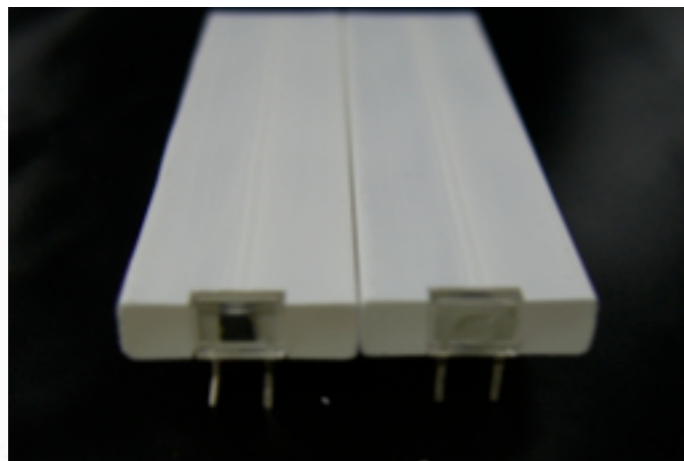
ECAL-scintillator strip

- scintillator : 1cm x 4cm x 2mm
- MPPC read out w/wo WLSF **MPPC**
- effective 1cm x 1cm resolution

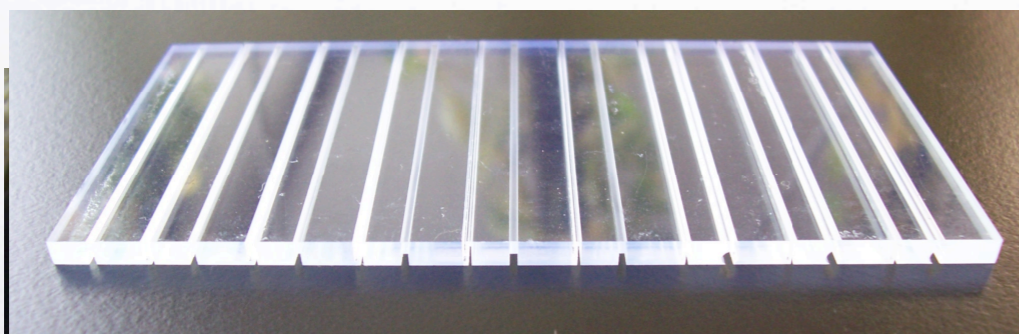


TT Oct 07

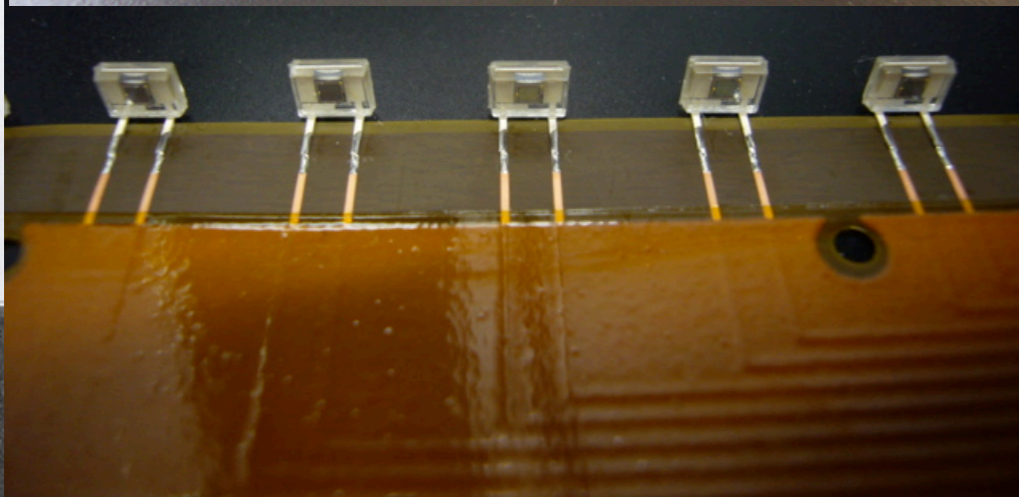
Cross section



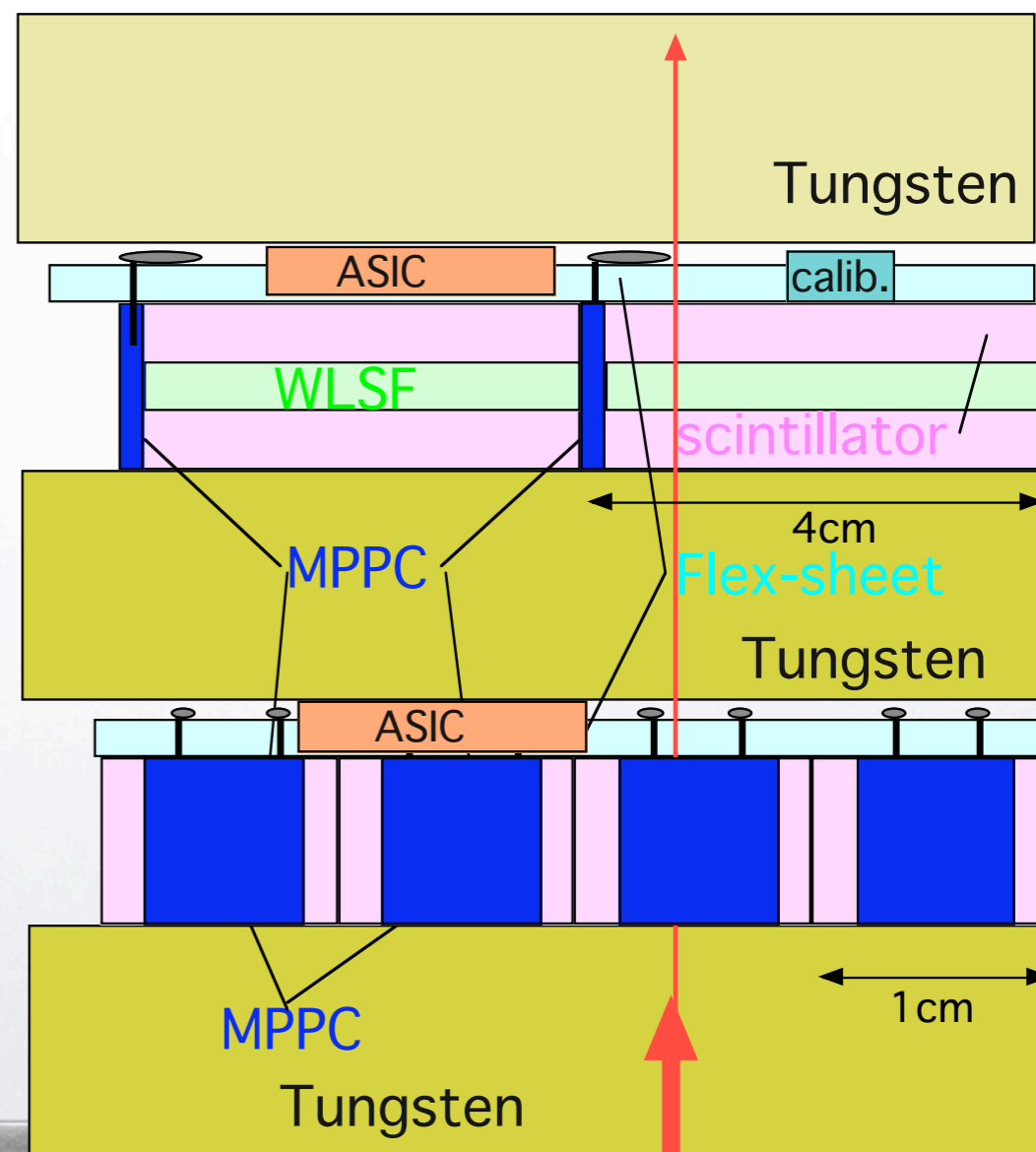
extruded with TiO2



casted



MPPC



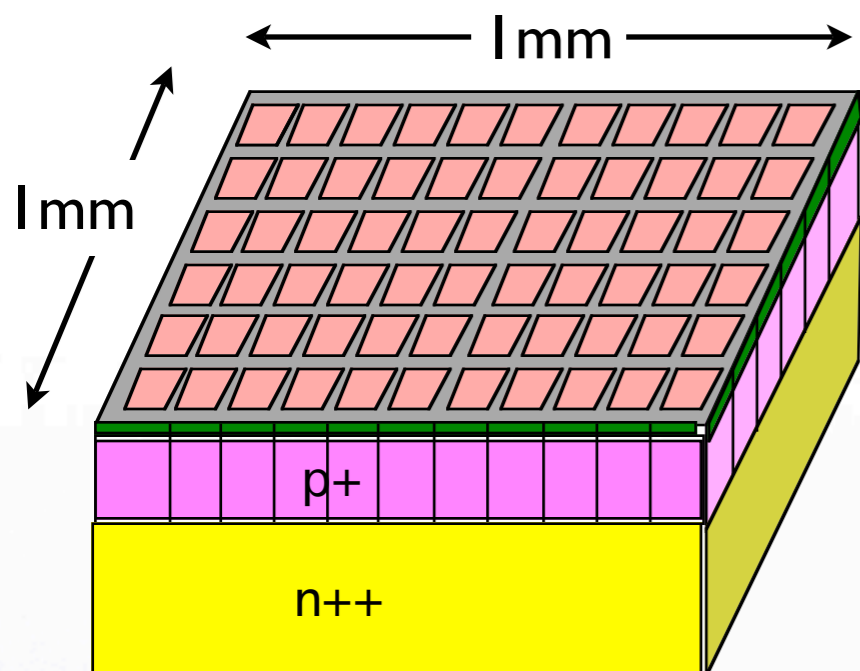
particle



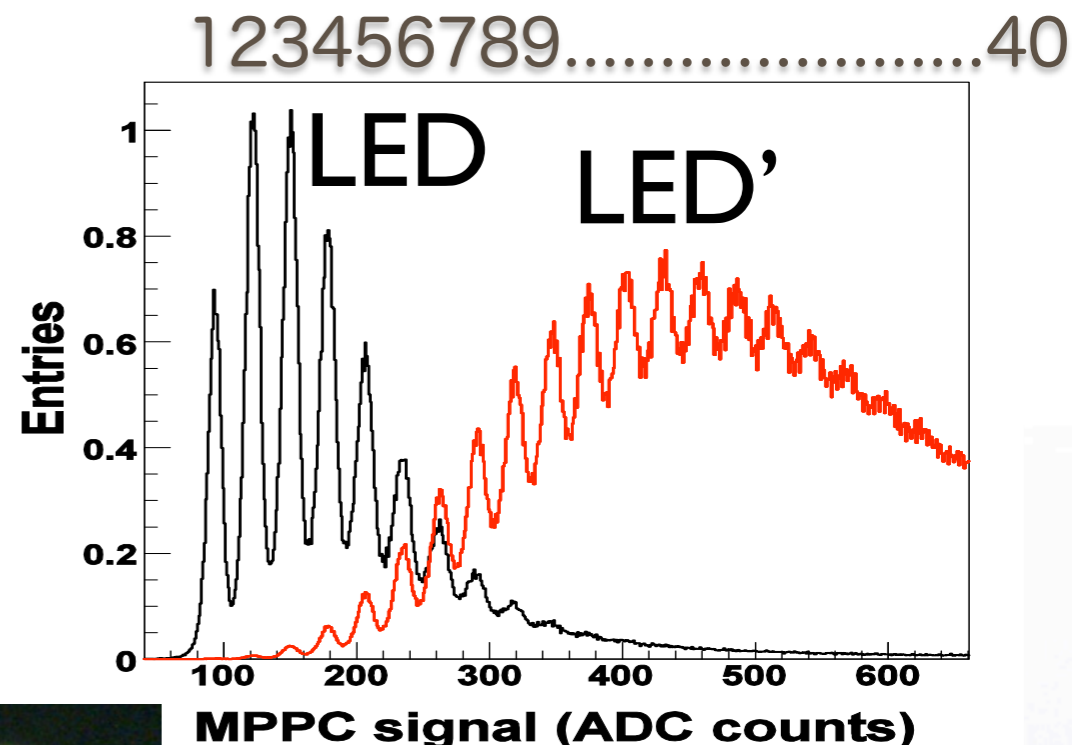
MPPC HPK



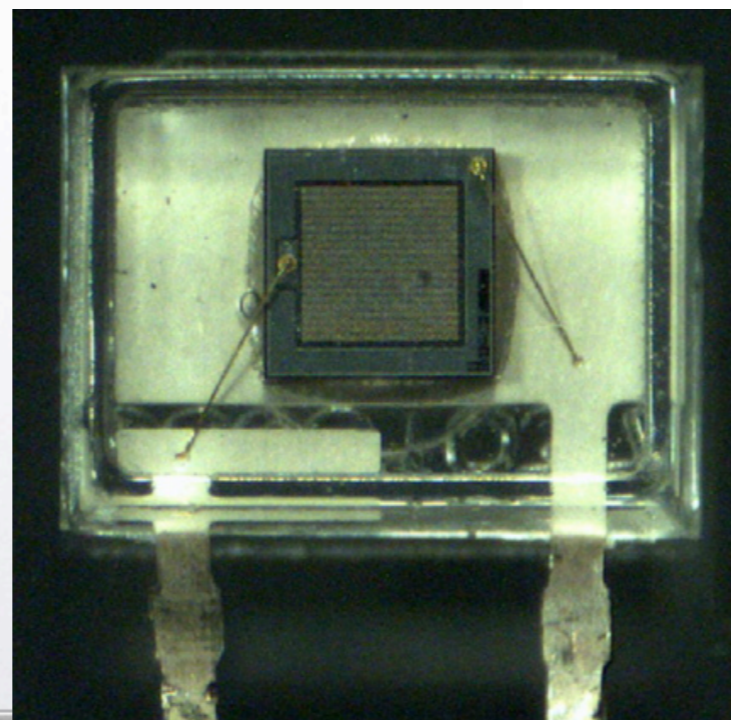
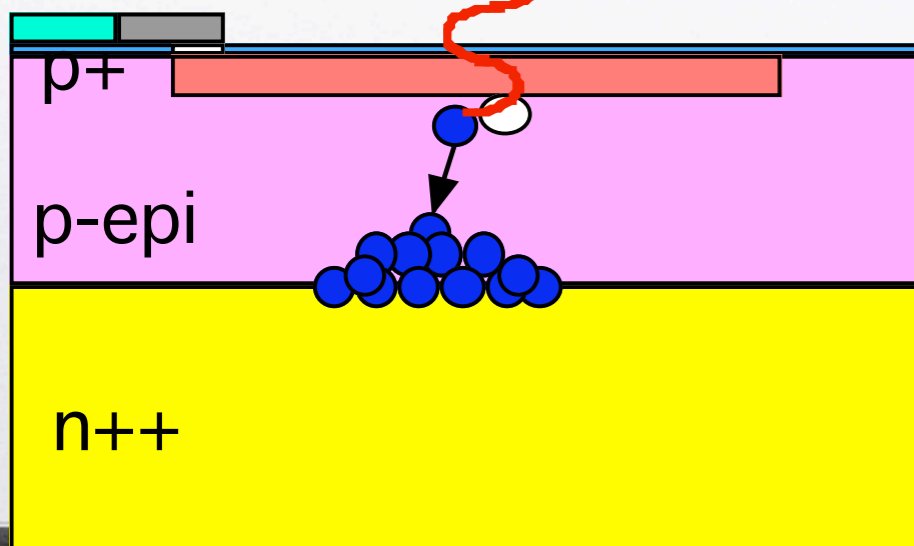
- new type of photon sensor : Geiger Mode



of p. e.
= # of pix



a pixel



MPPC signal (ADC counts)

high gain $\sim 10^{5\sim6}$
 blue sensitive
 low Voltage $\sim < 100V$
 small $\sim 1\text{mm}^2$
 insensitive to mag.



Scintillator strip : H-CAL

HCAL-Scintillator-layer model

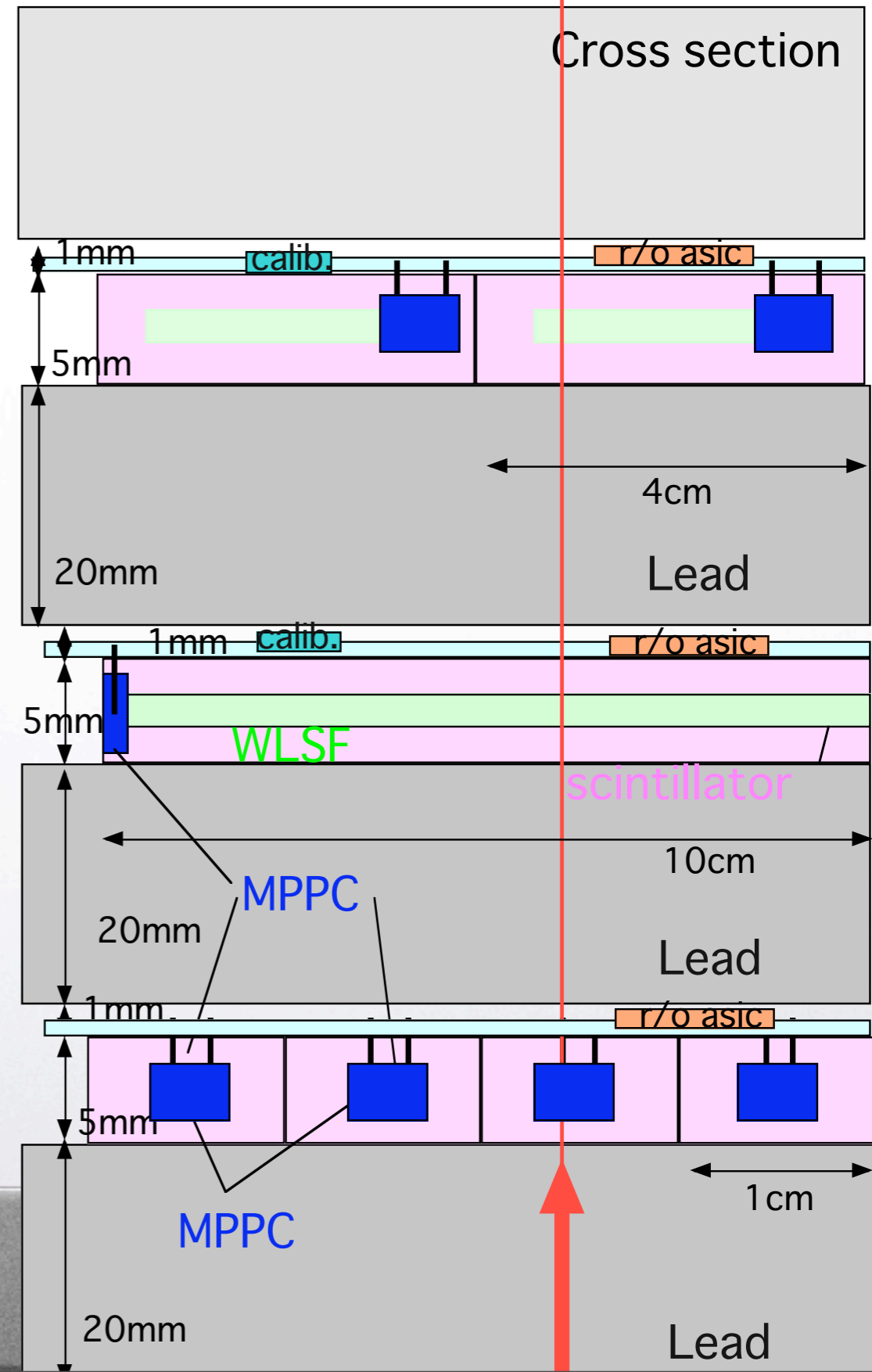
idea

1 cm x (10~20)cm strip (X,Y)+

4 cm x 4 cm tile

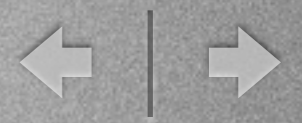
MPPC read out with WLSF

possible absorber : Pb
for hardware
compensation

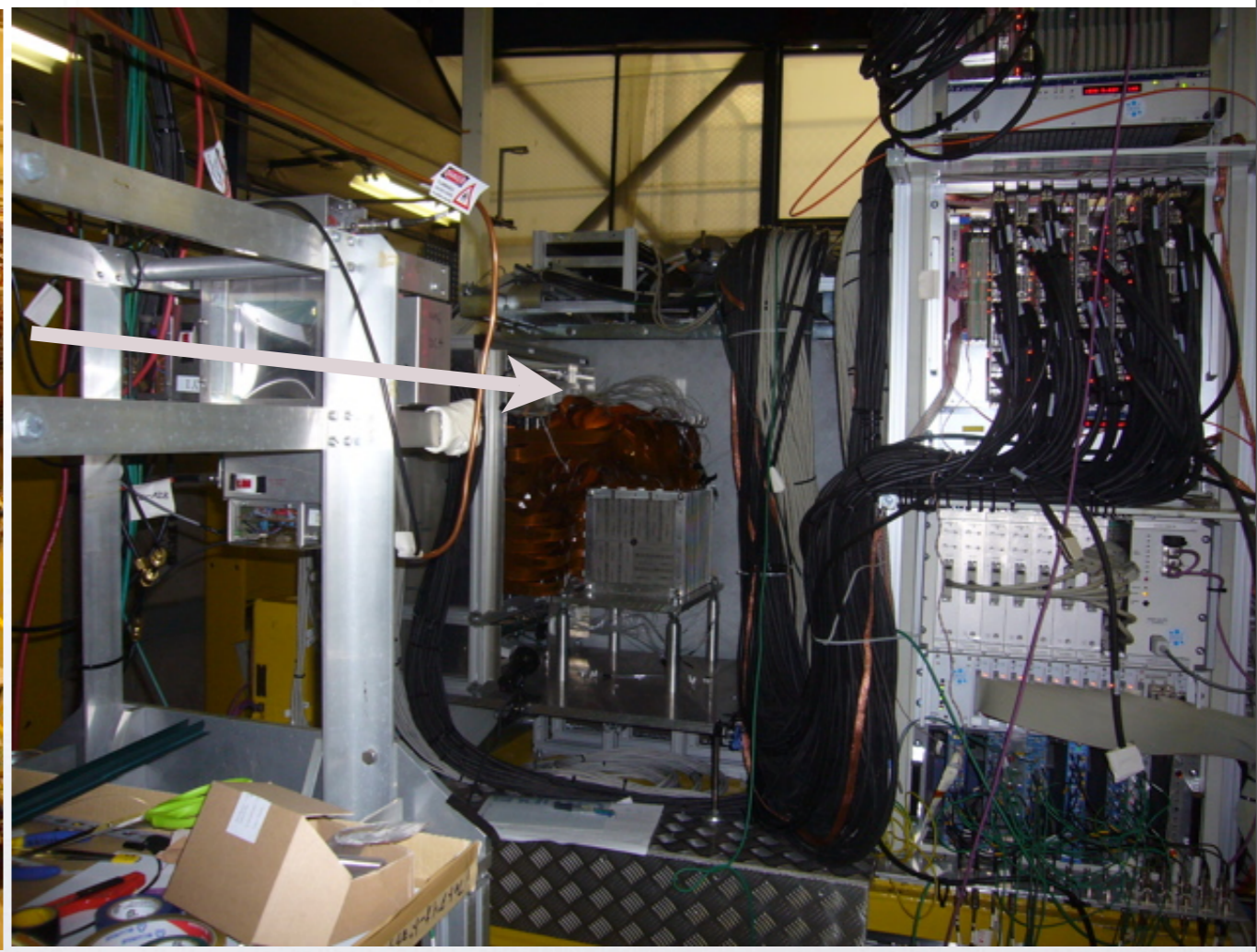
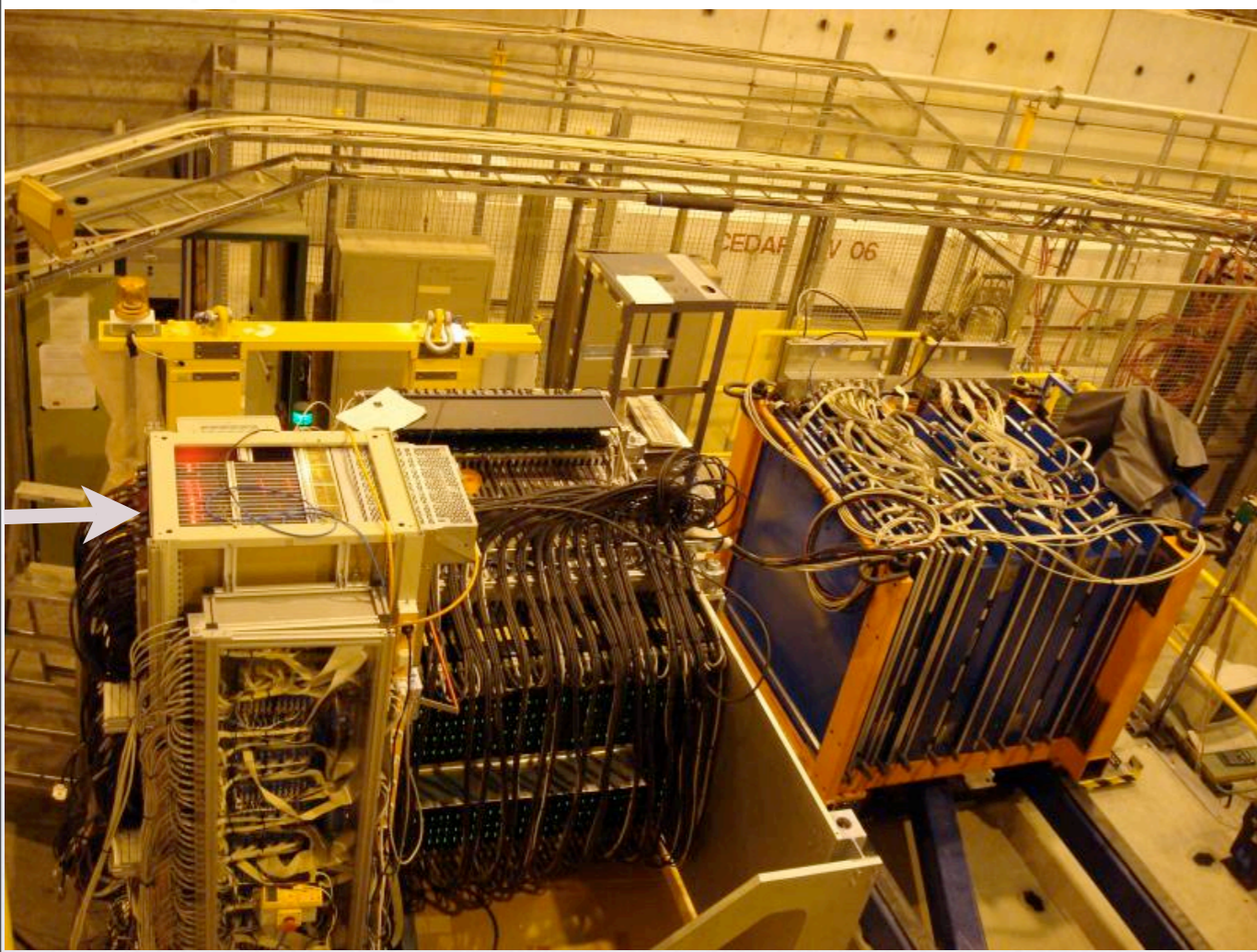




CALICE



- validate technologies, including read out
 - ECAI Silicon/W & **Scintillator**/W
 - HCAL :Analog (scintillator) & Digital
- CERN06-07 Fermilab 2008-

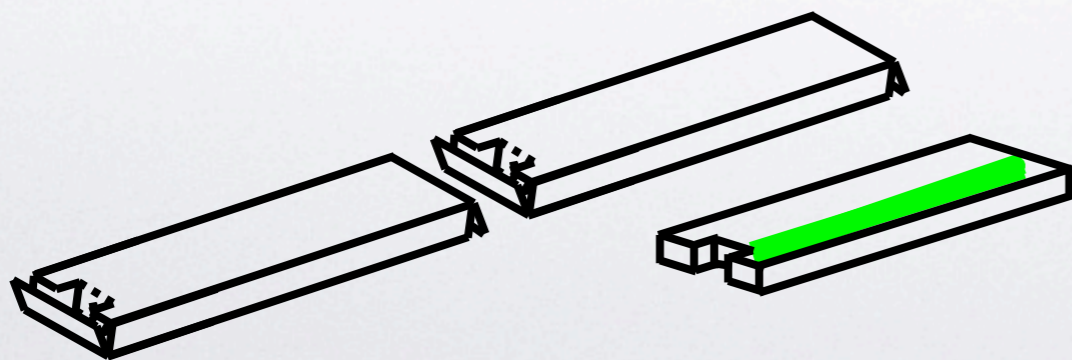
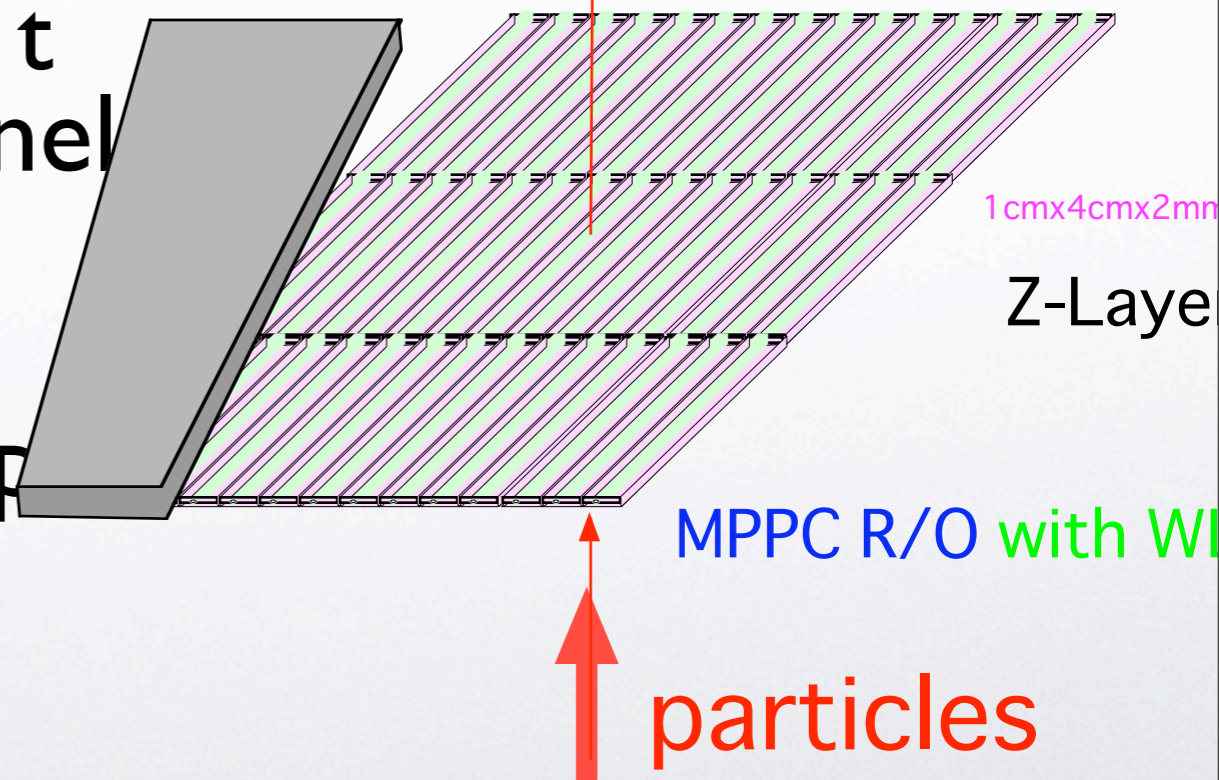
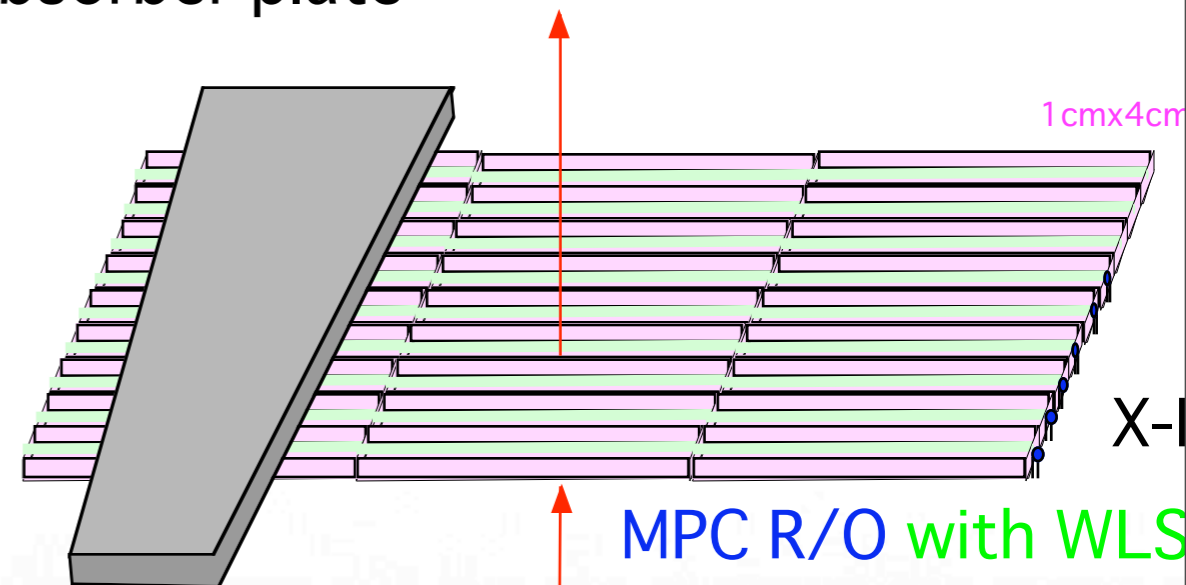
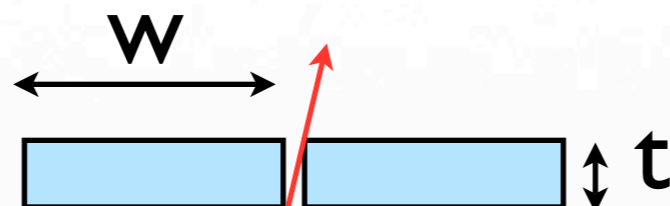




Strip scECAL

absorber plate

- strip
- width : segmentation
- thickness : charged track insensitive
- length : to reduce # of channel but not so long
- reflector sheet for each strip





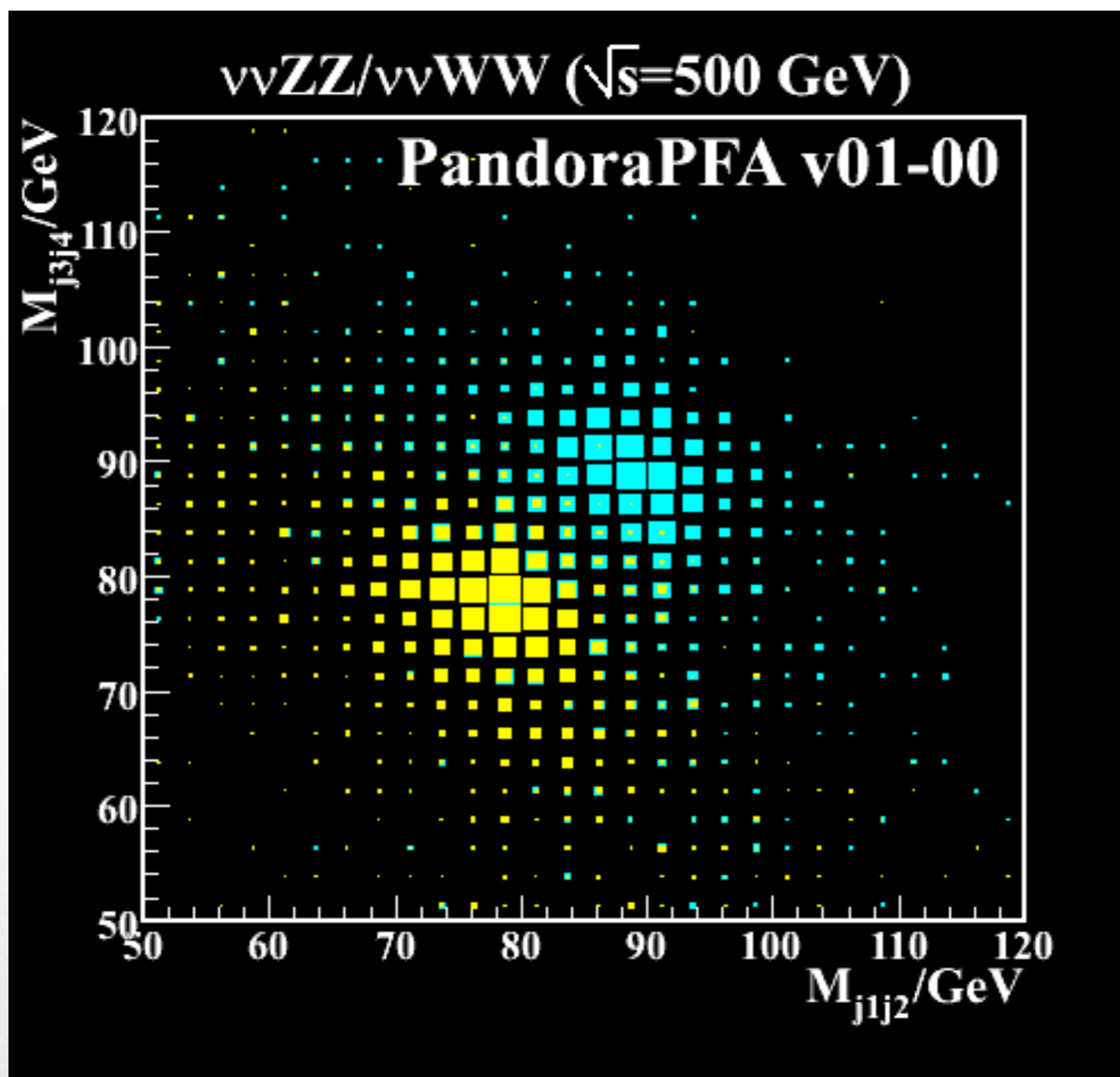
summary I



- PFA oriented calorimeters for ILC
 - fine segmented (1 cm) cell for ECAL & HCAL
- need verification for both E/H CAL
 - Technology (electronics ASIC)
- non-PFA : Dream project
- we are waiting for good ideas,
- still room for you to work/study



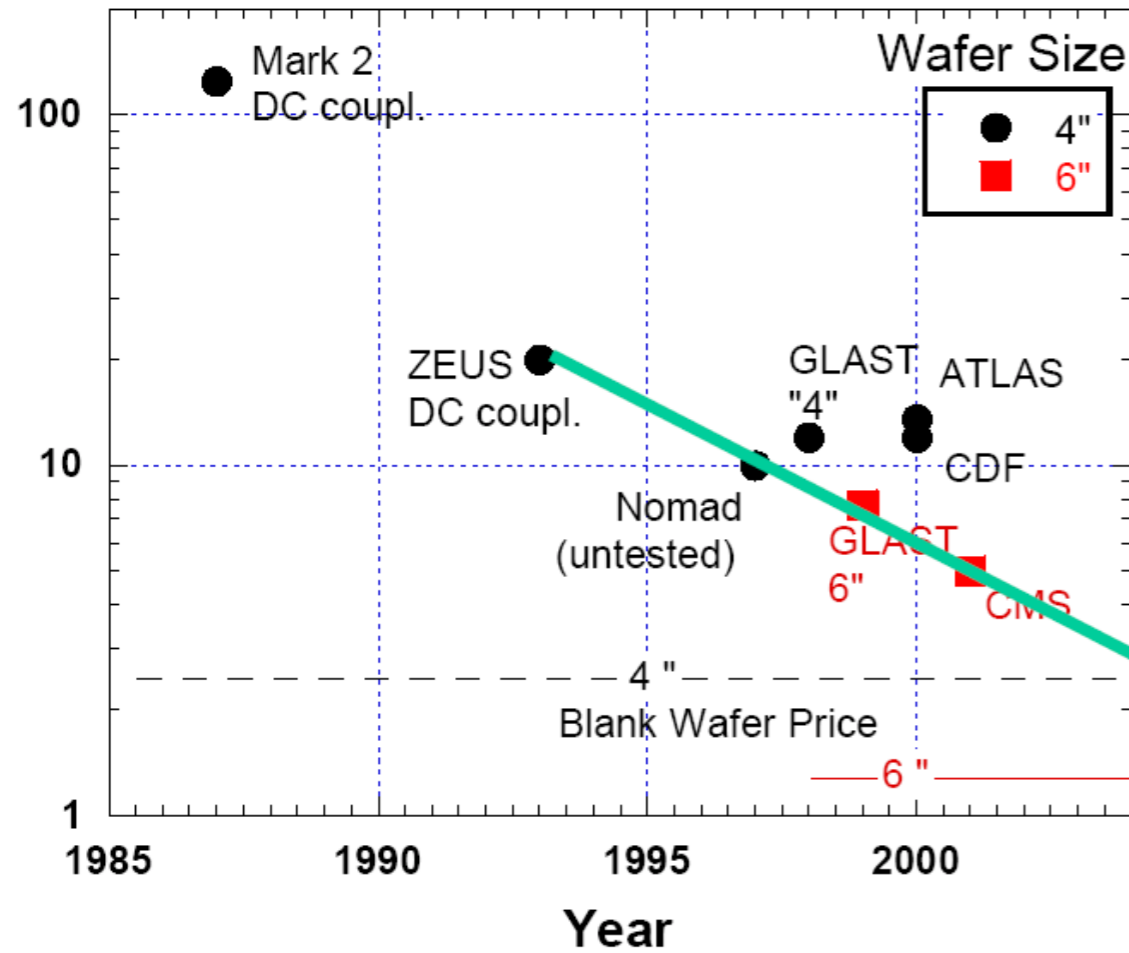
best PFA with LDC



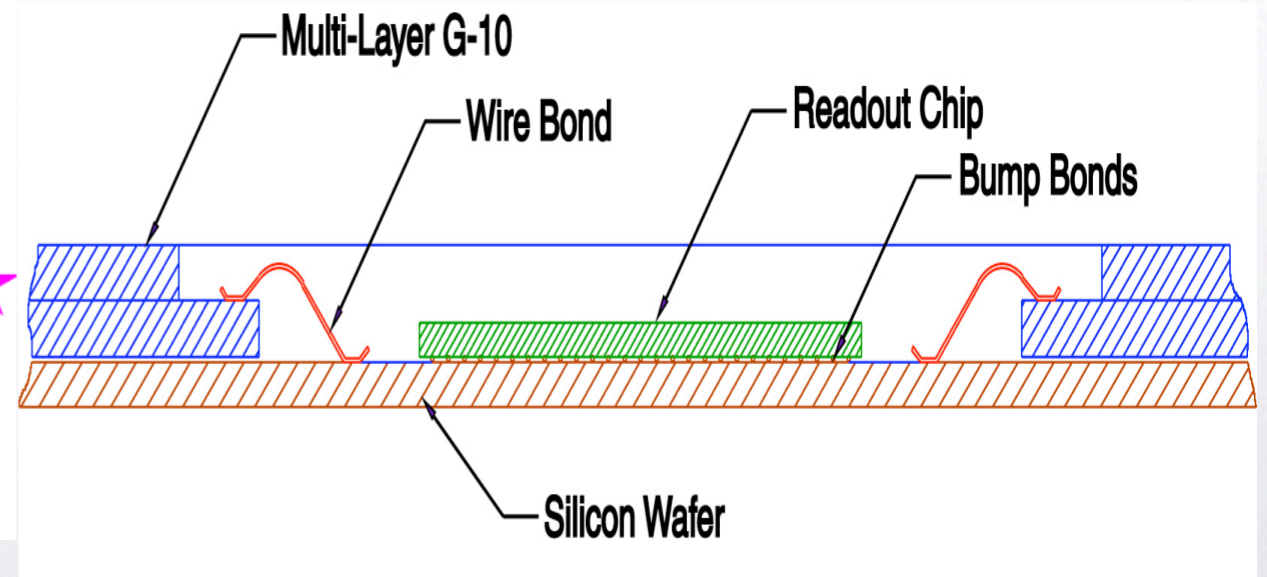
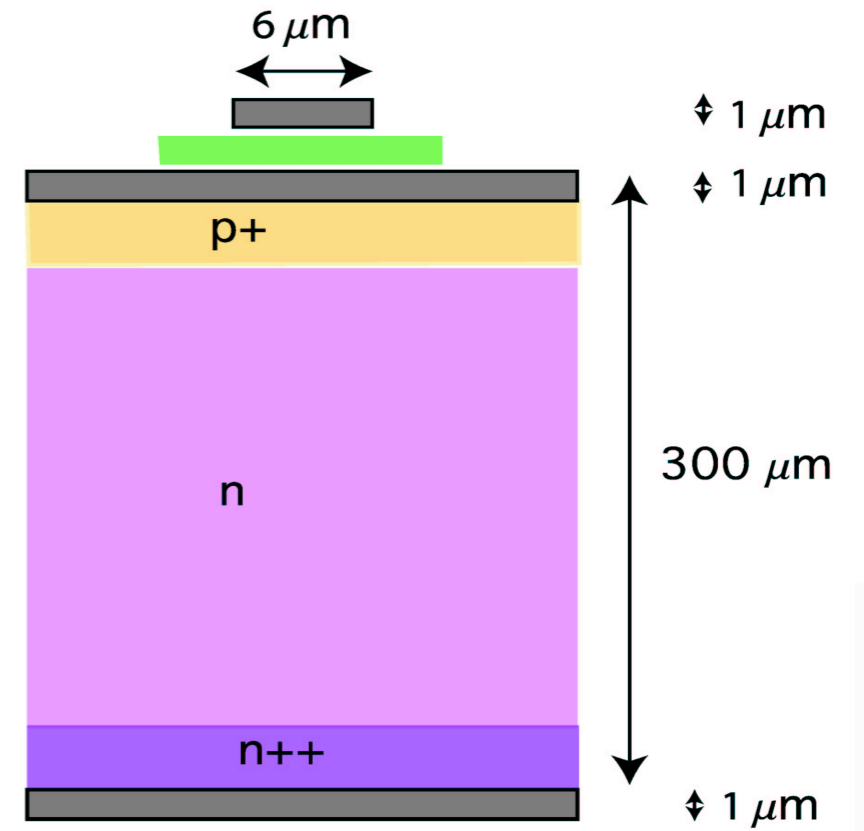


US-Si-ECAL

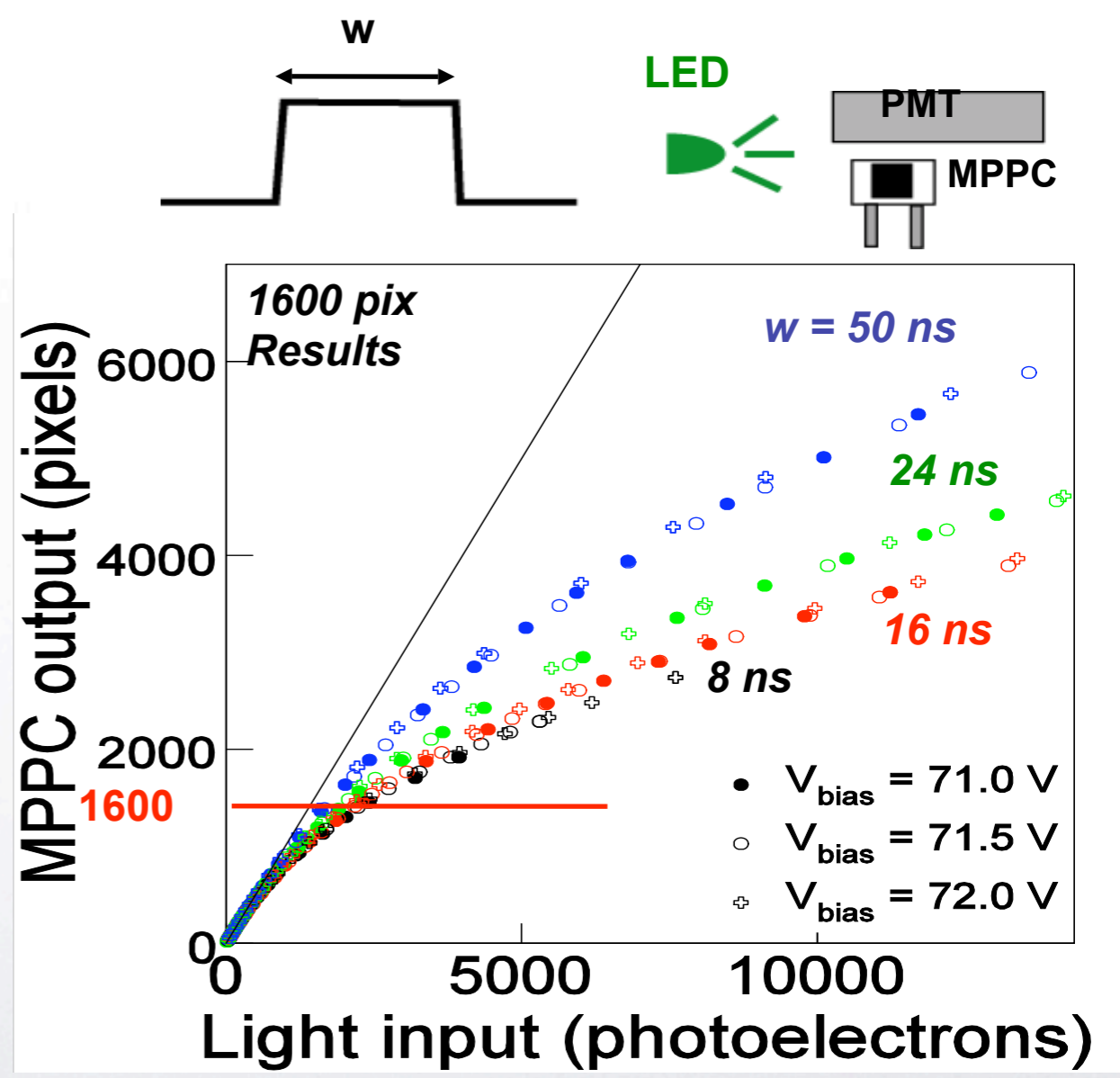
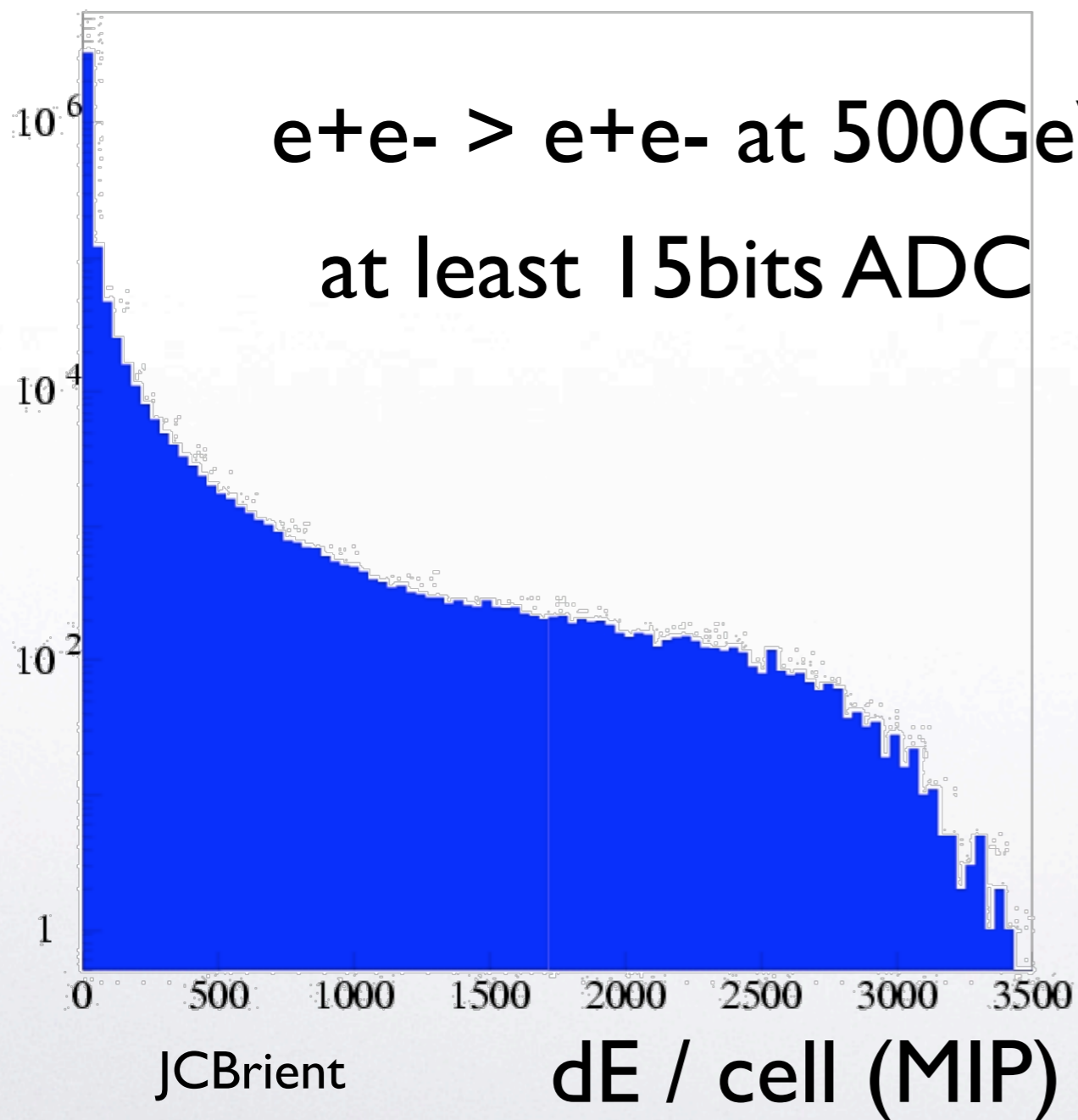
Silicon cost vs year



Bridenbach



- Dynamic range : electronics & Photon sensor
MPPC non linearity





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