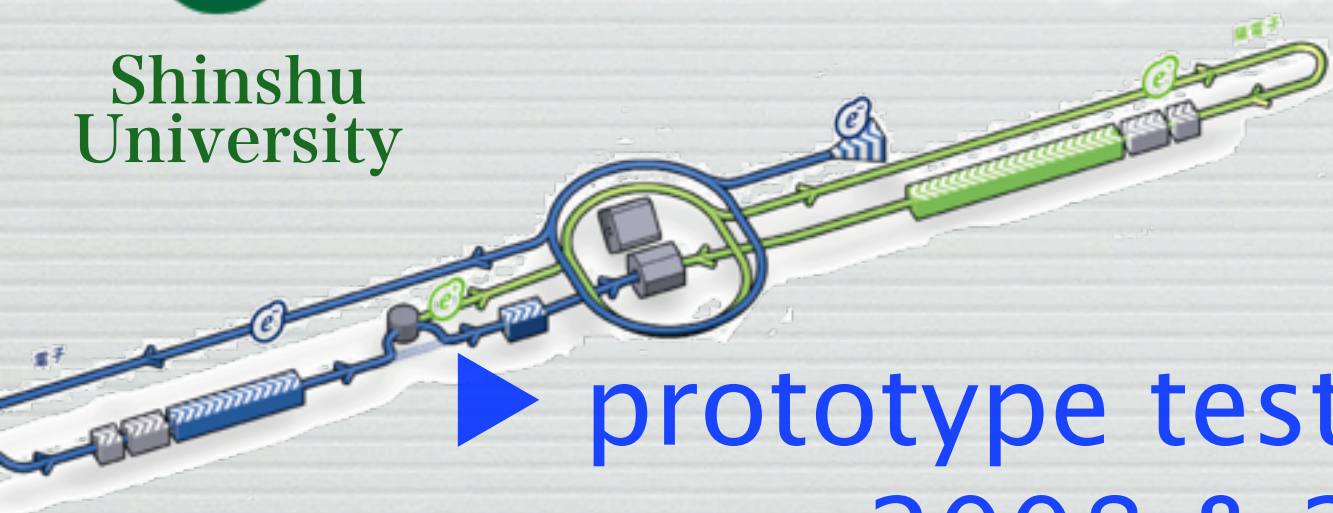
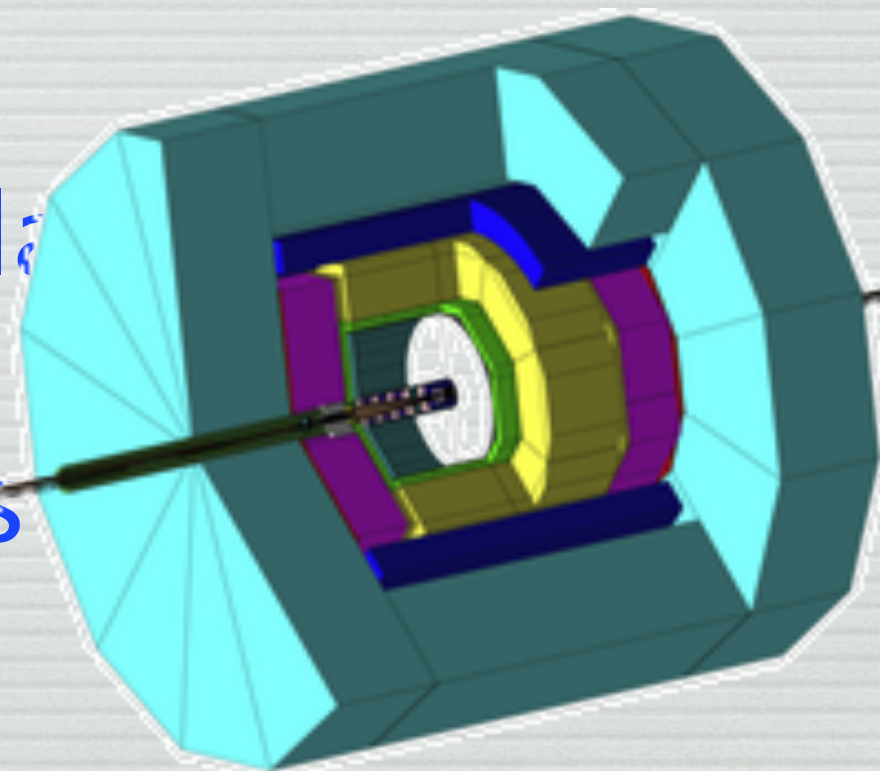


Scintillator ECAL beam test results

LCWS2012 @ Texas
Tohru Takeshita (Shinshu)
for CALCIE

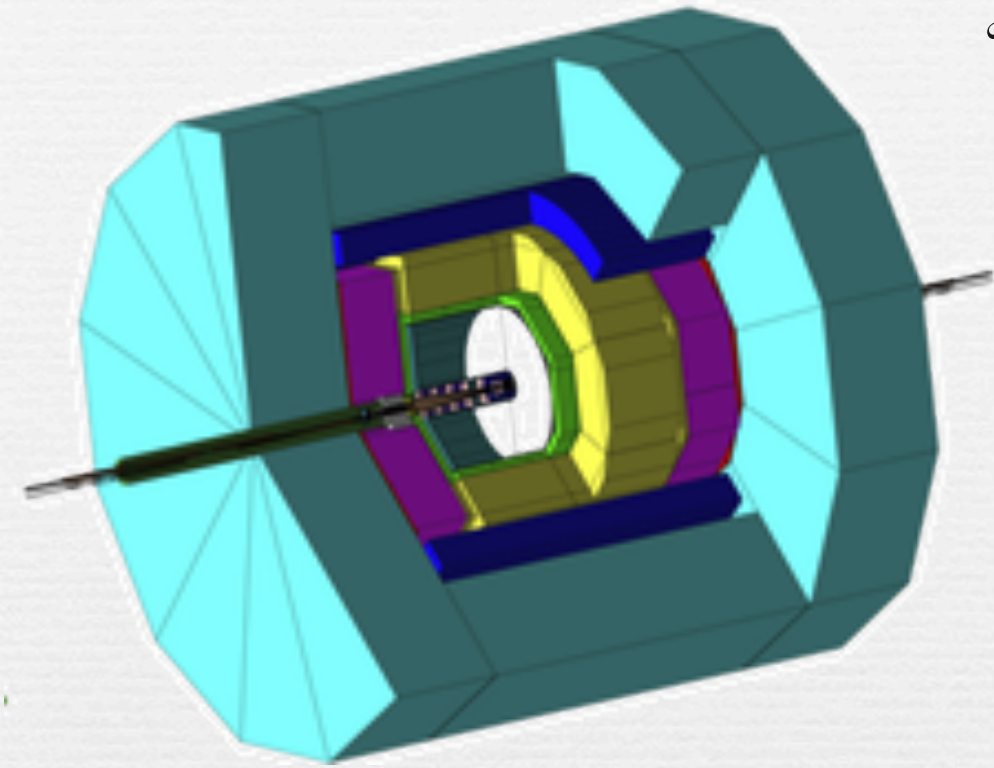


▶ prototype test at Fermilab
2008 & 2009
systematic uncertainties
energy resolution
linearity



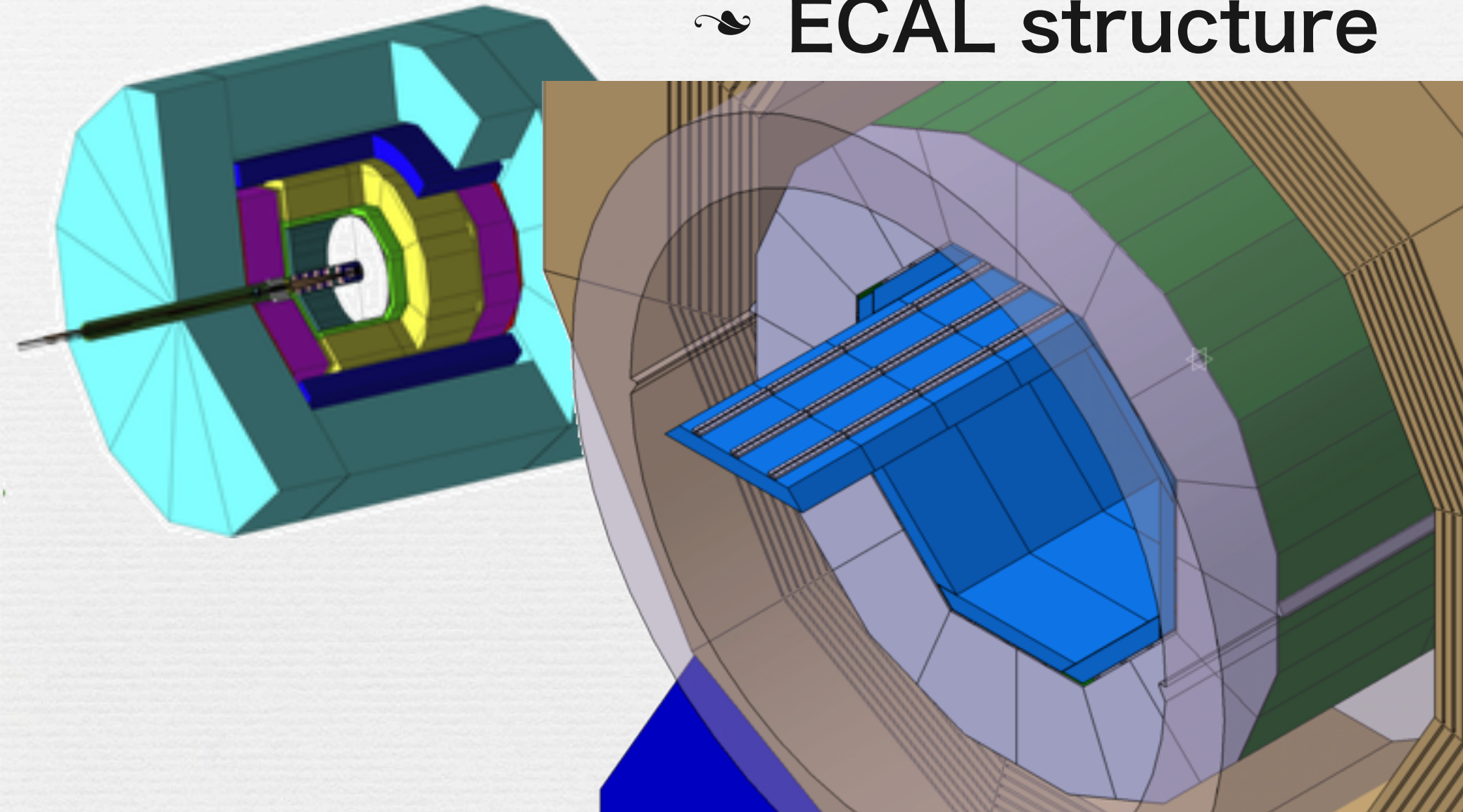
ECAL in e^+e^- collider

↪ ECAL structure



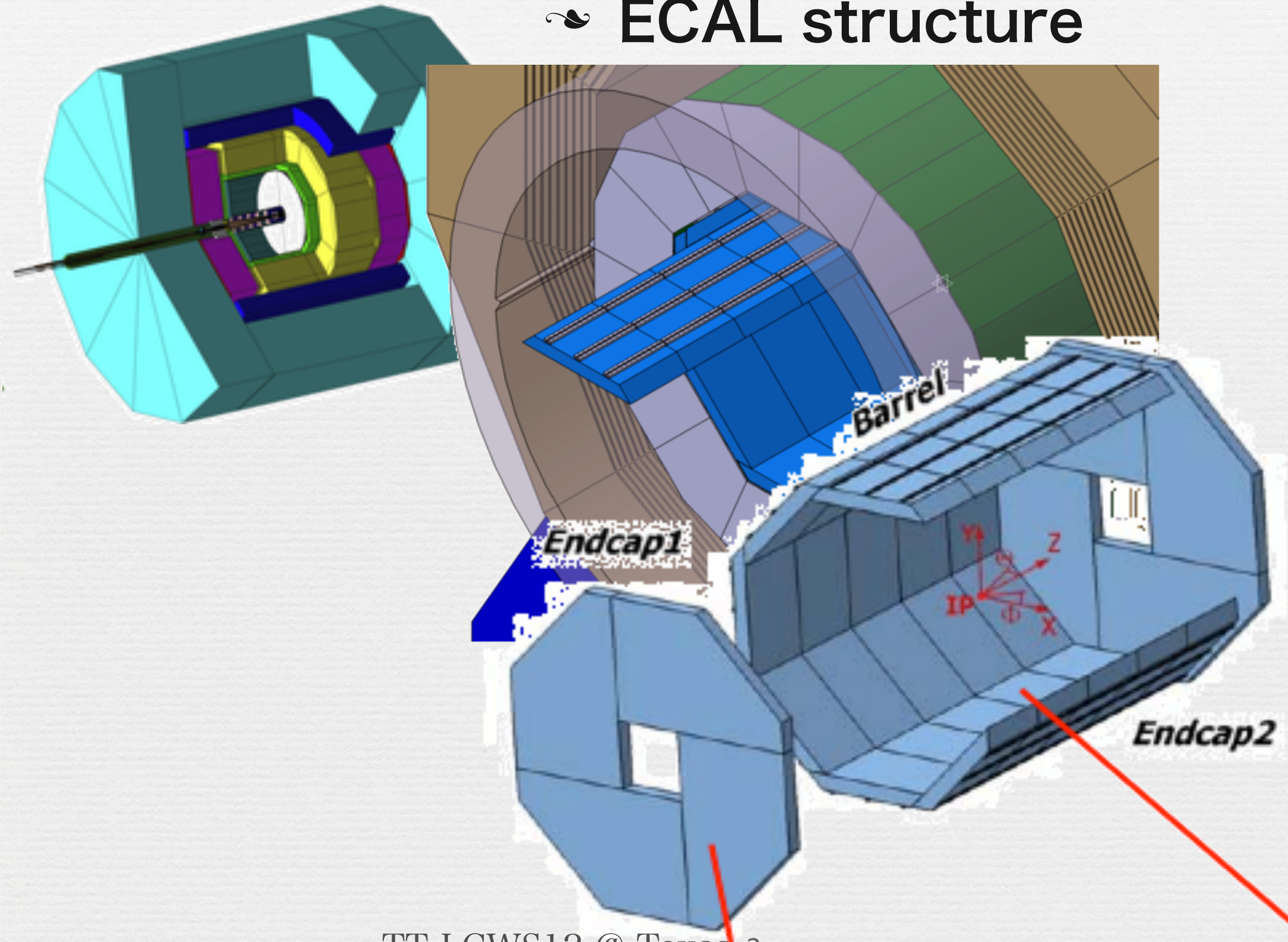
ECAL in e⁺e⁻ collider

↪ ECAL structure



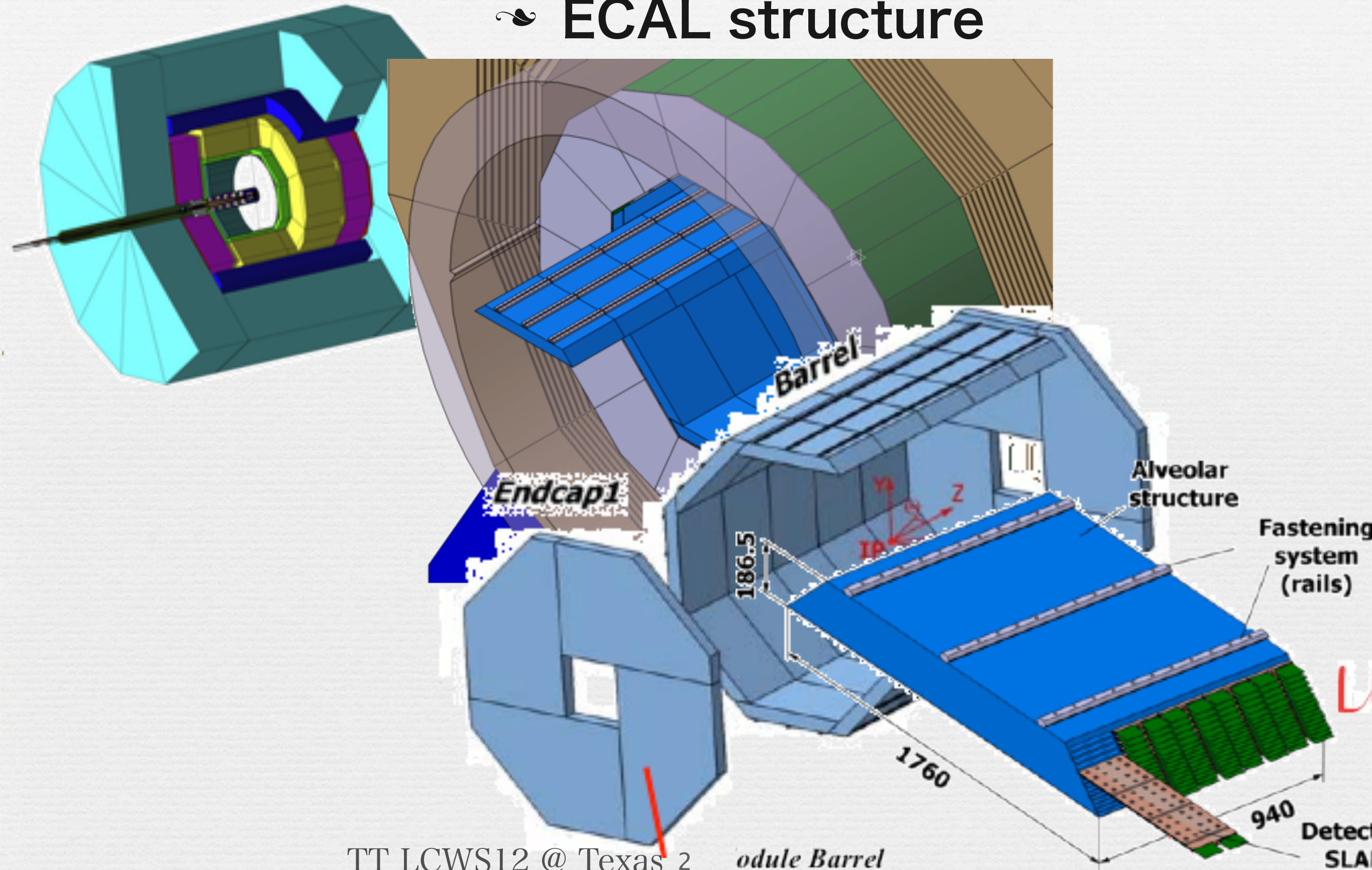
ECAL in e⁺e⁻ collider

• ECAL structure



ECAL in e⁺e⁻ collider

ECAL structure



scintillator ECAL

→ to satisfy 5~10mm granularity

→ required by PFA

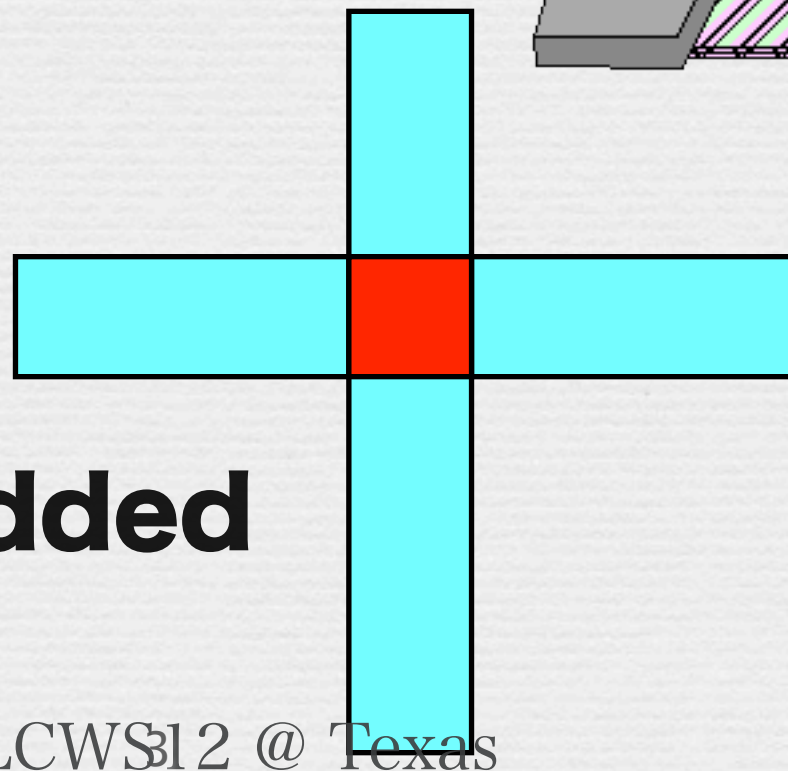
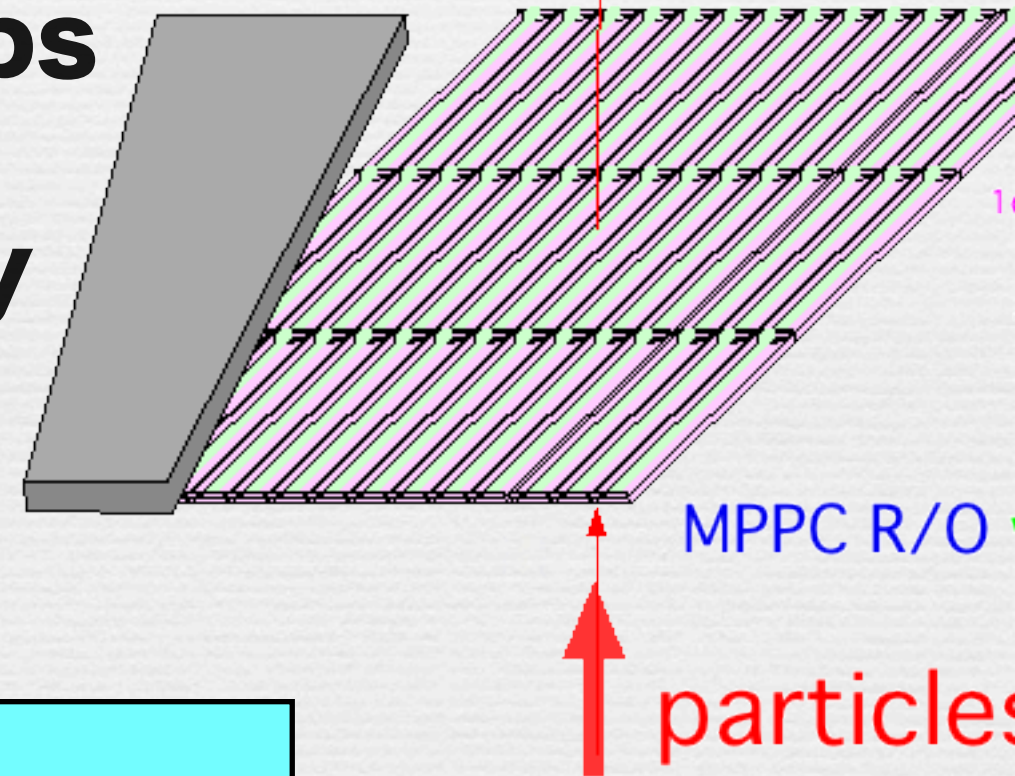
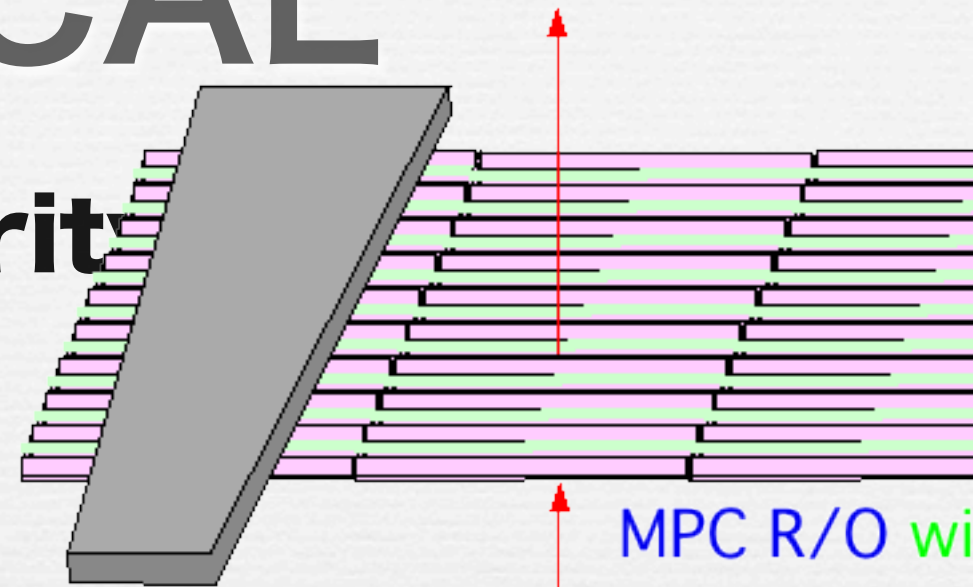
→ orthogonal scintillator strips

→ high granularity effectively

→ thinner layers

→ MPPC read out

→ electronics embedded



scintillator ECAL

→ to satisfy 5~10mm granularity

→ required by PFA

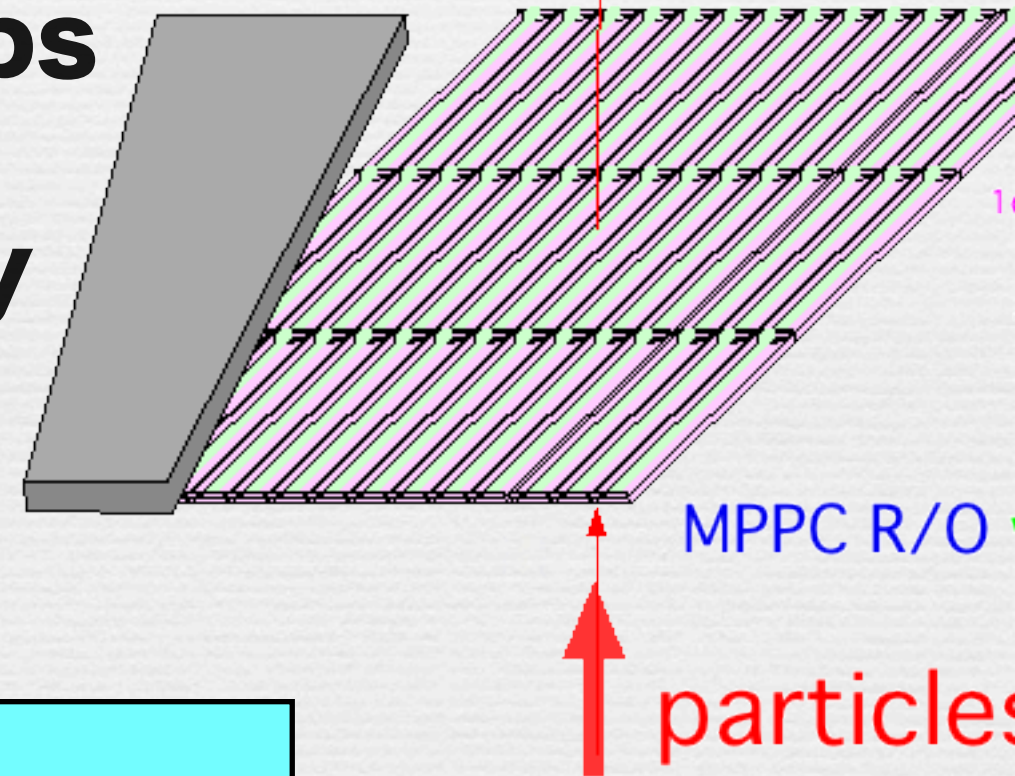
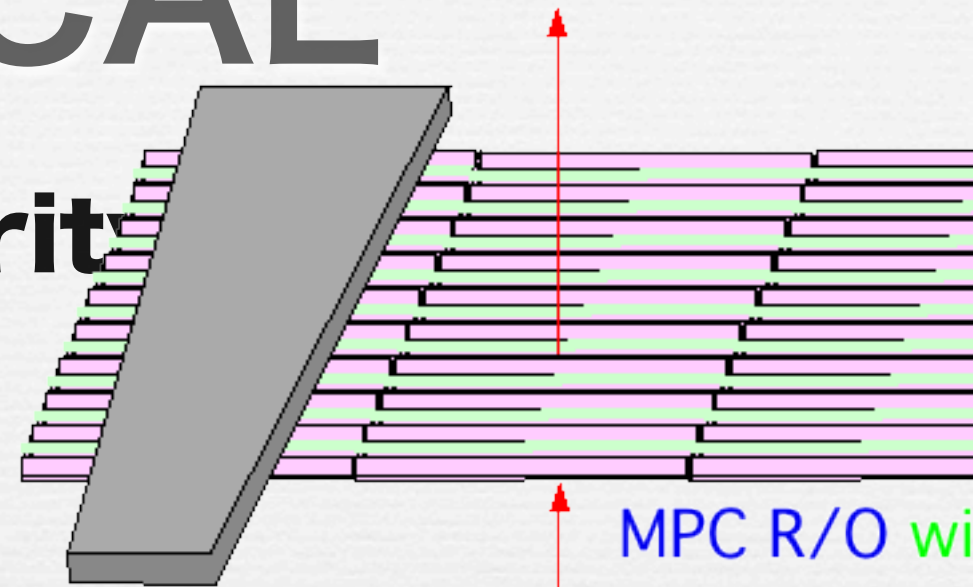
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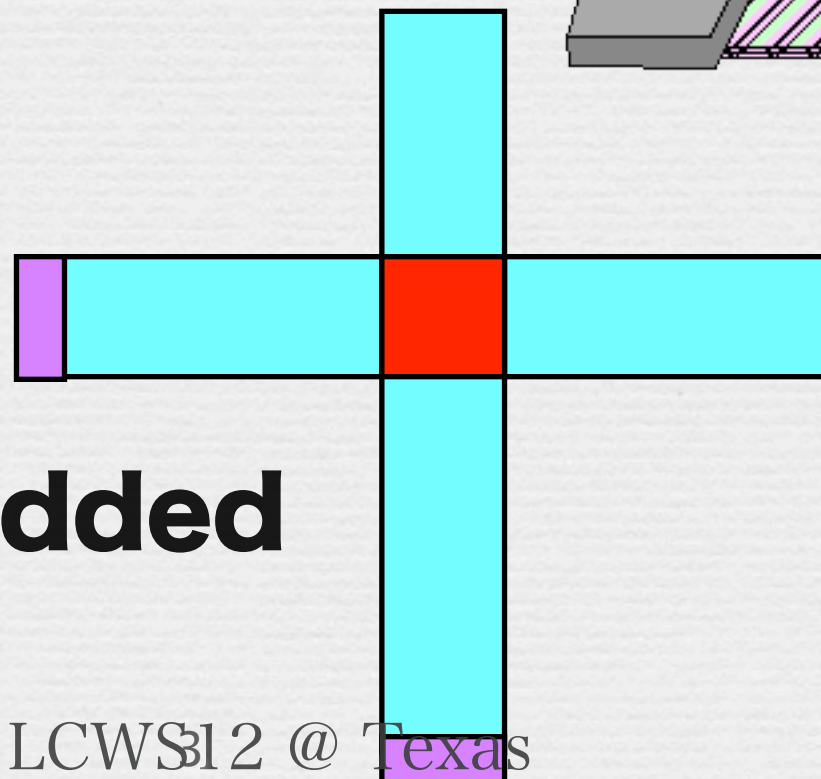
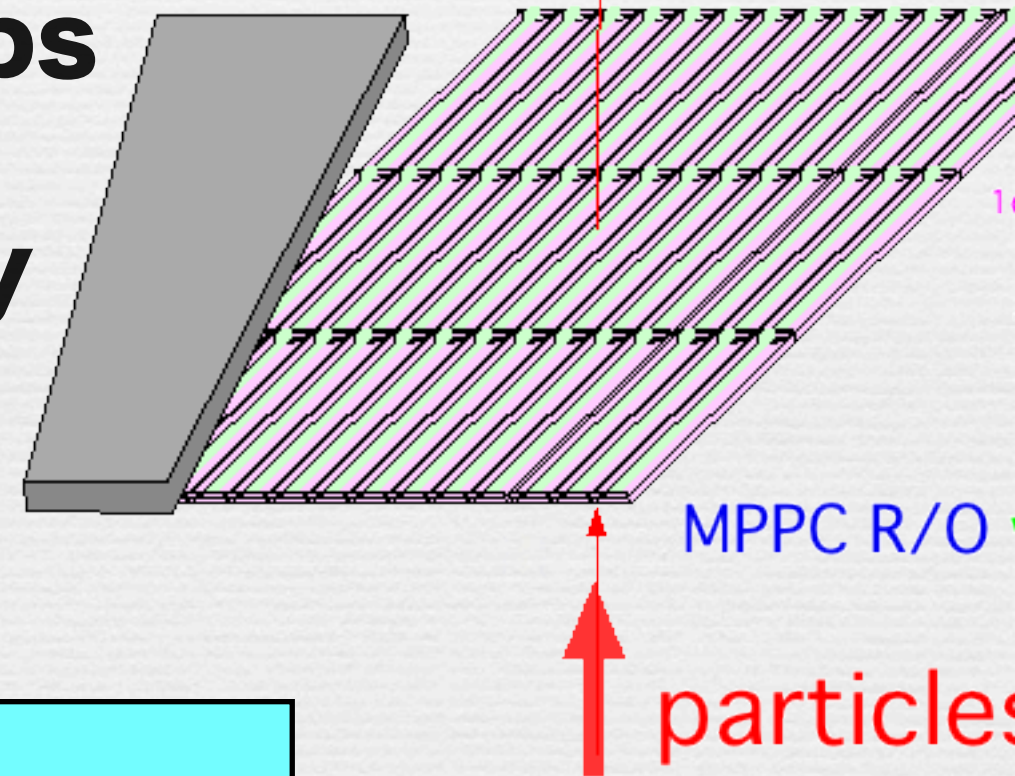
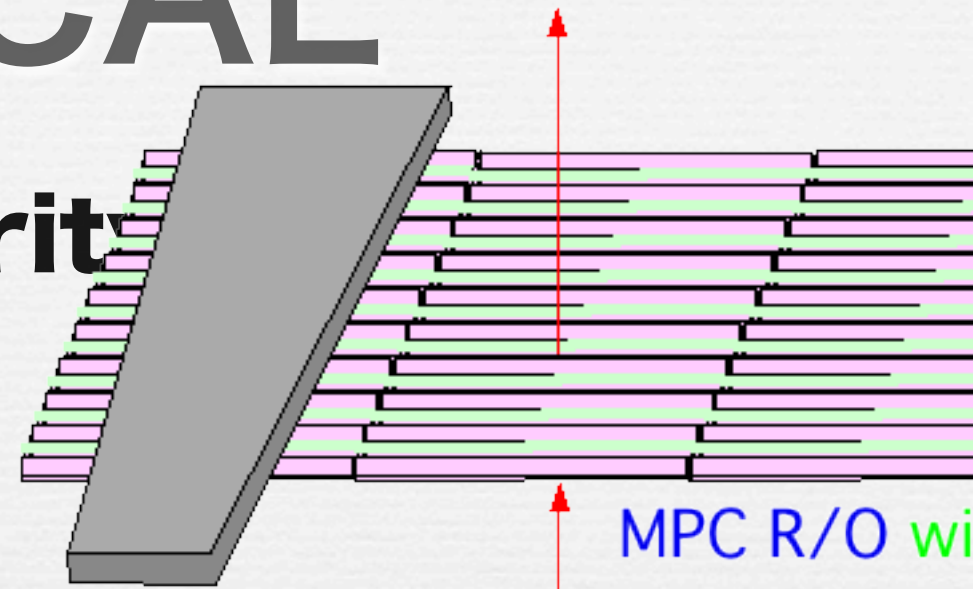
→ orthogonal scintillator strips

→ high granularity effectively

→ thinner layers

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→ electronics embedded



scintillator ECAL

→ to satisfy 5~10mm granularity

→ required by PFA

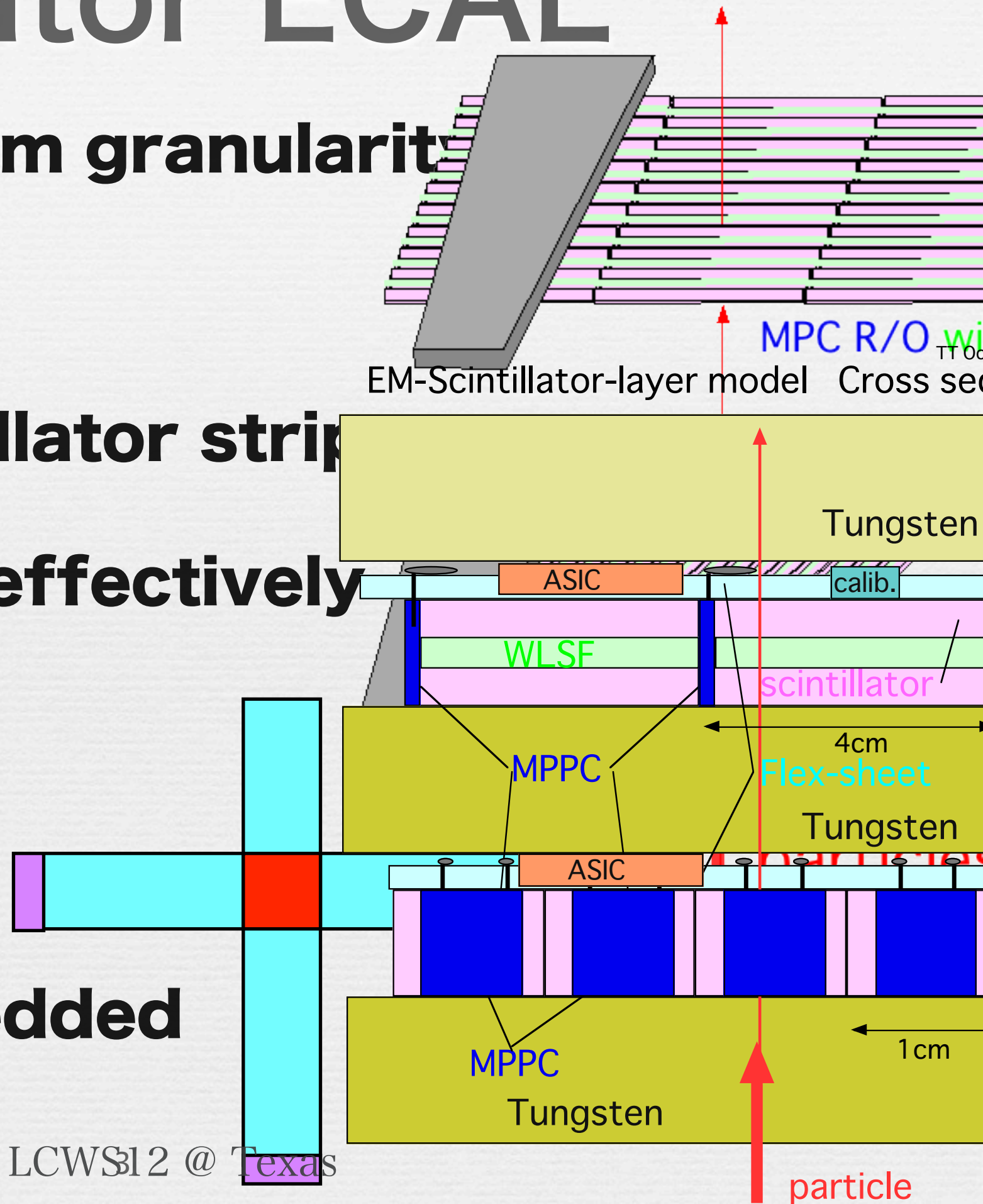
→ orthogonal scintillator strips

→ high granularity effectively

→ thinner layers

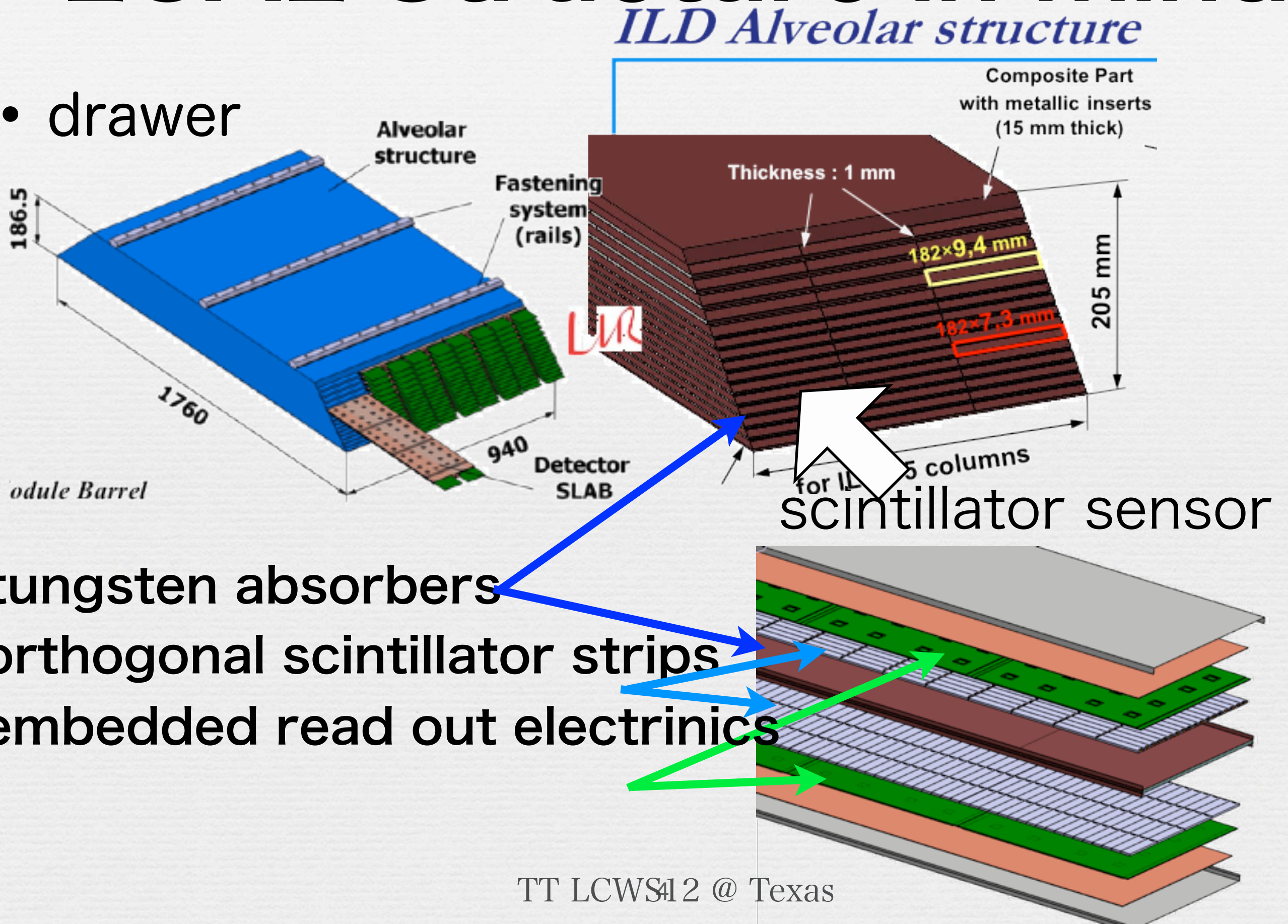
→ MPPC read out

→ electronics embedded



ECAL Structure in mind

- drawer



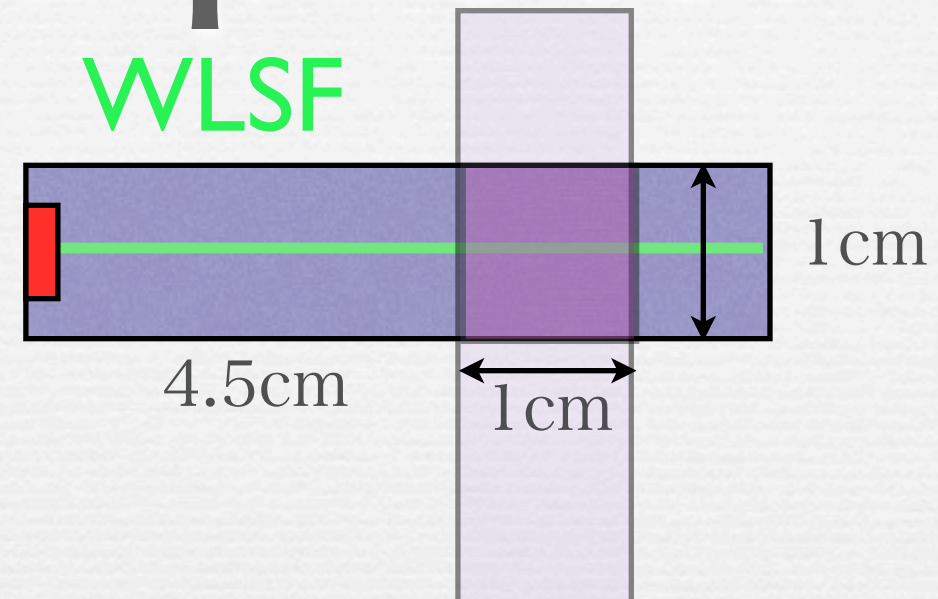
scintillator ECAL proto.

extruded by KNU

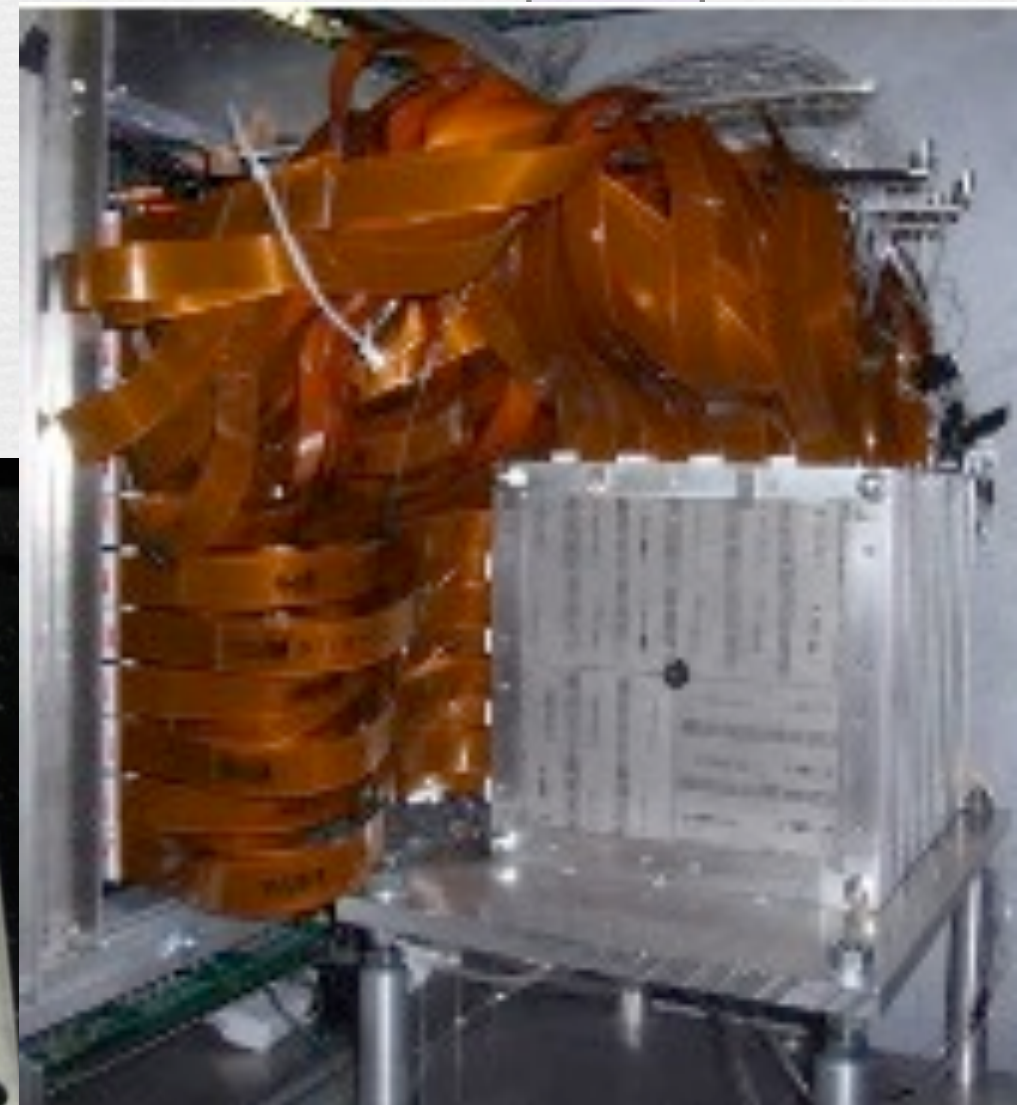
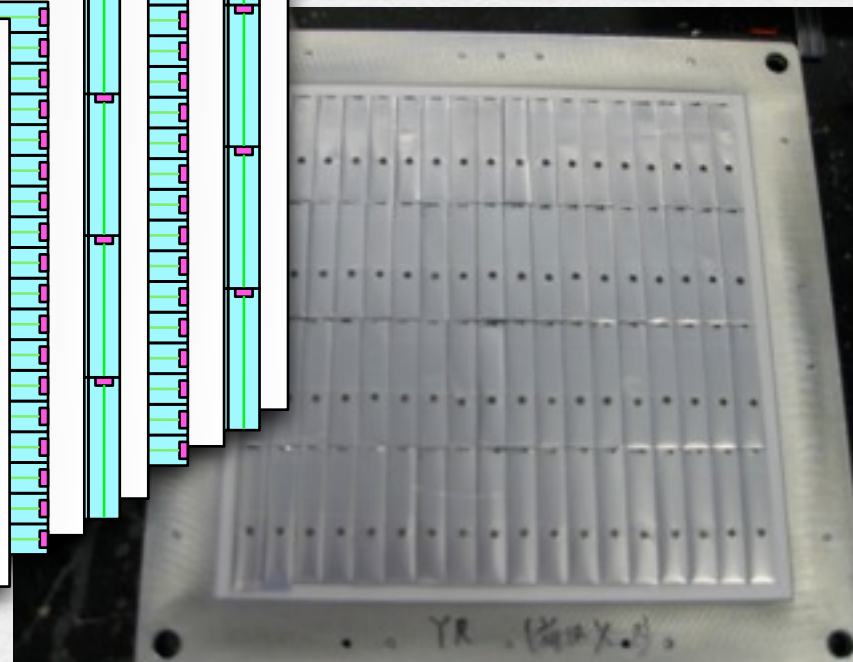
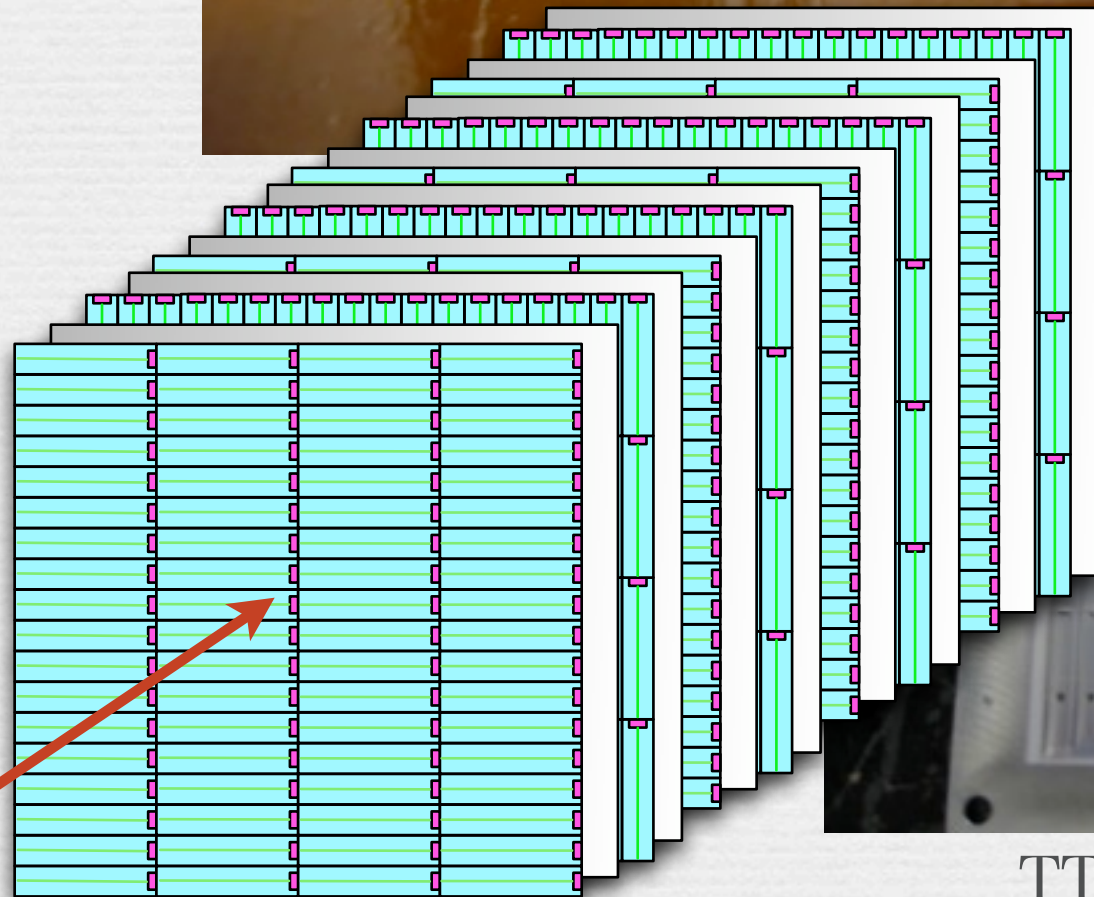
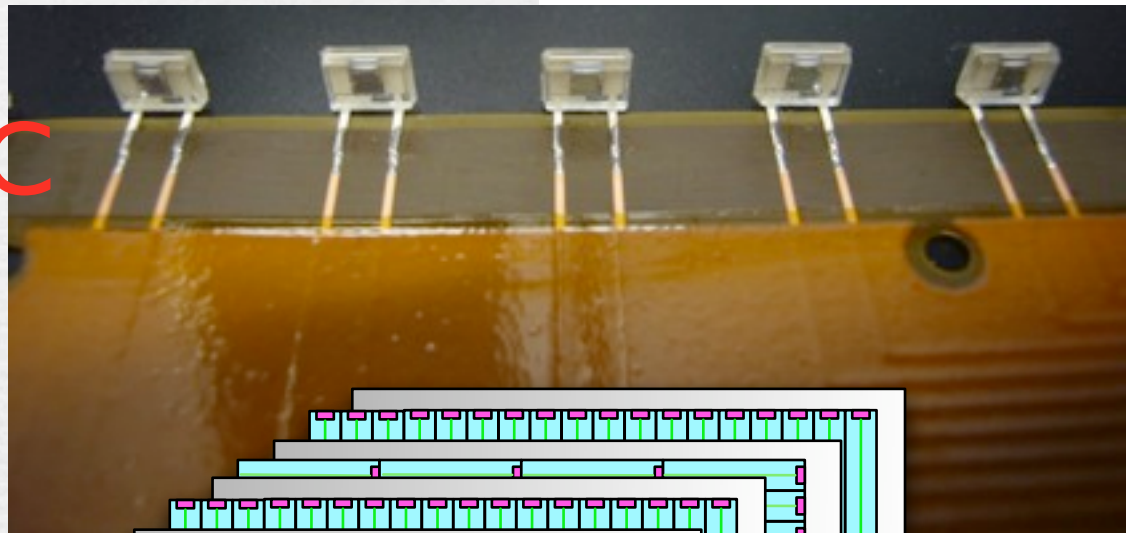
MPPC read out

MPPC

WLSF



MPPC

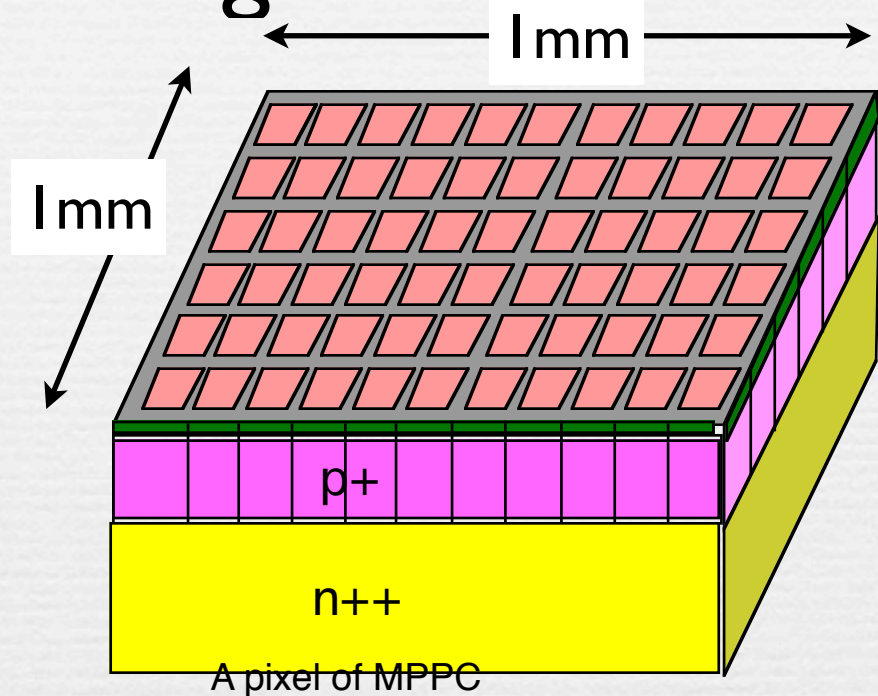


TT LCWS12 @ Texas

photo-sensor

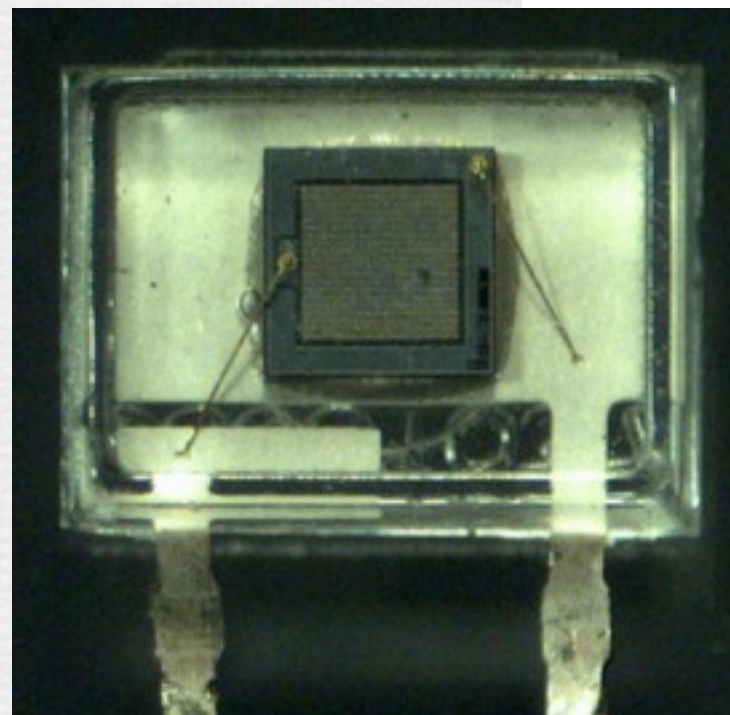
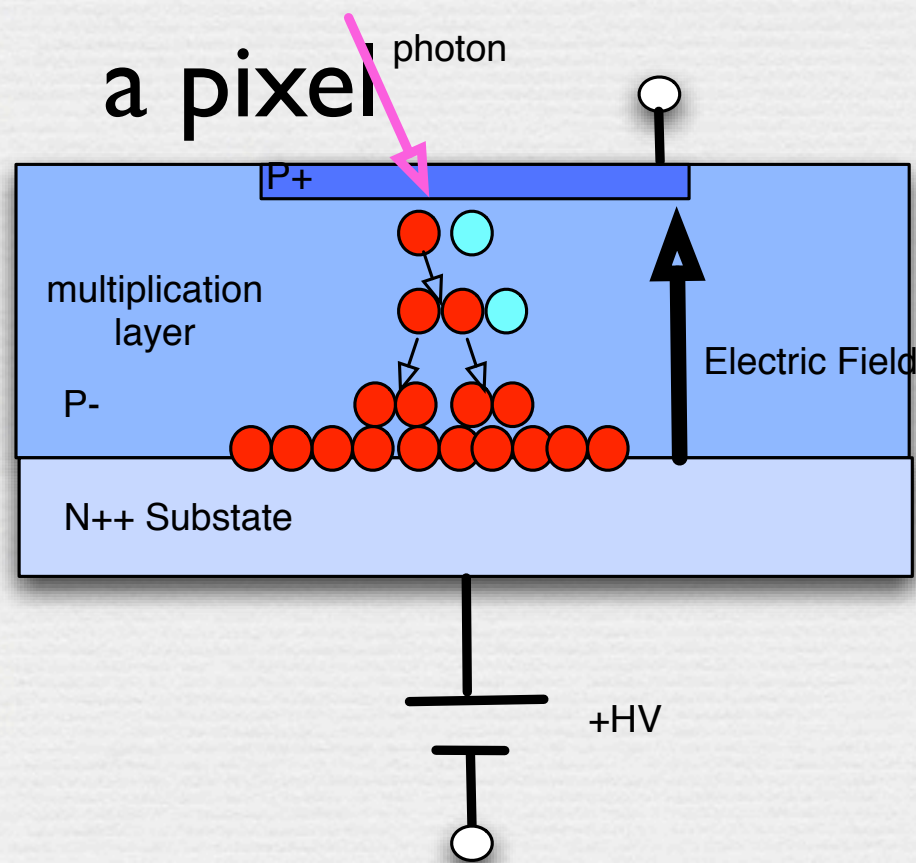
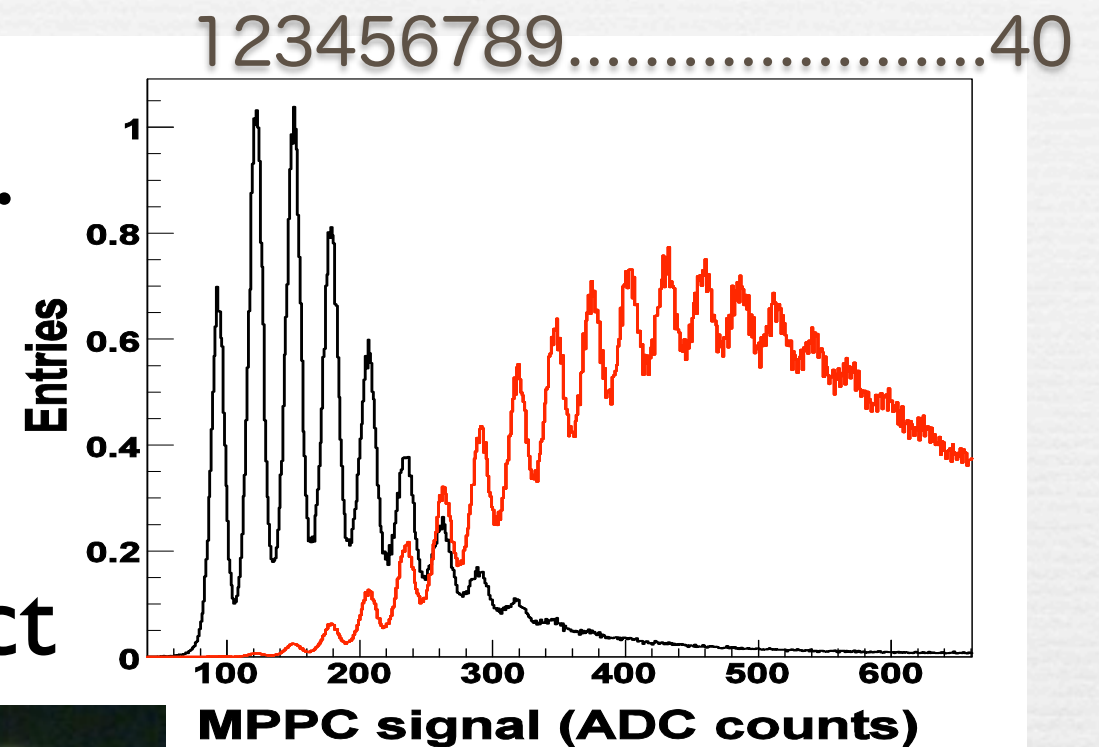
- MPPC: new type of photon sensor : Pixlated

Geiger Mode APD



of p. e.
= # of pix

MPPC pict



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

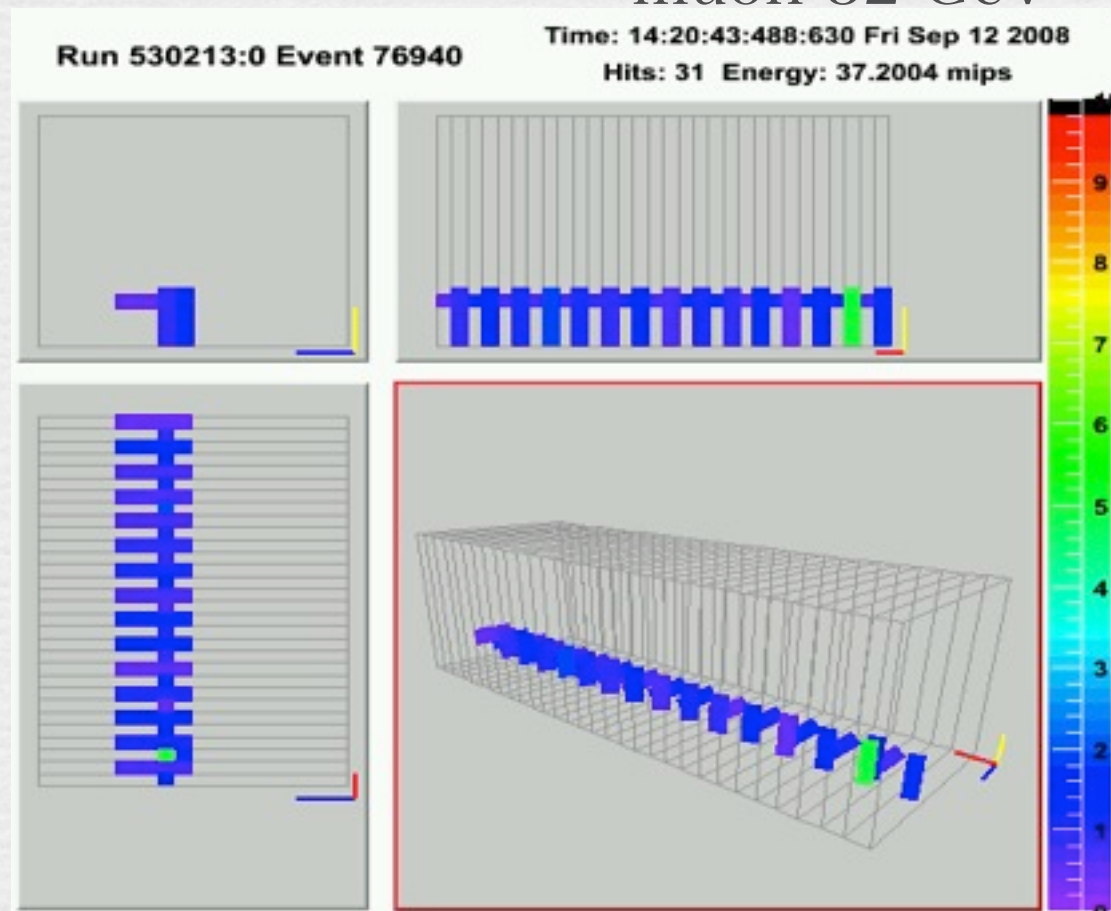
CALICE Fermilab BT

❧ **scintillator ECAL tested at Fermilab
2008 & 2009 in MT6**

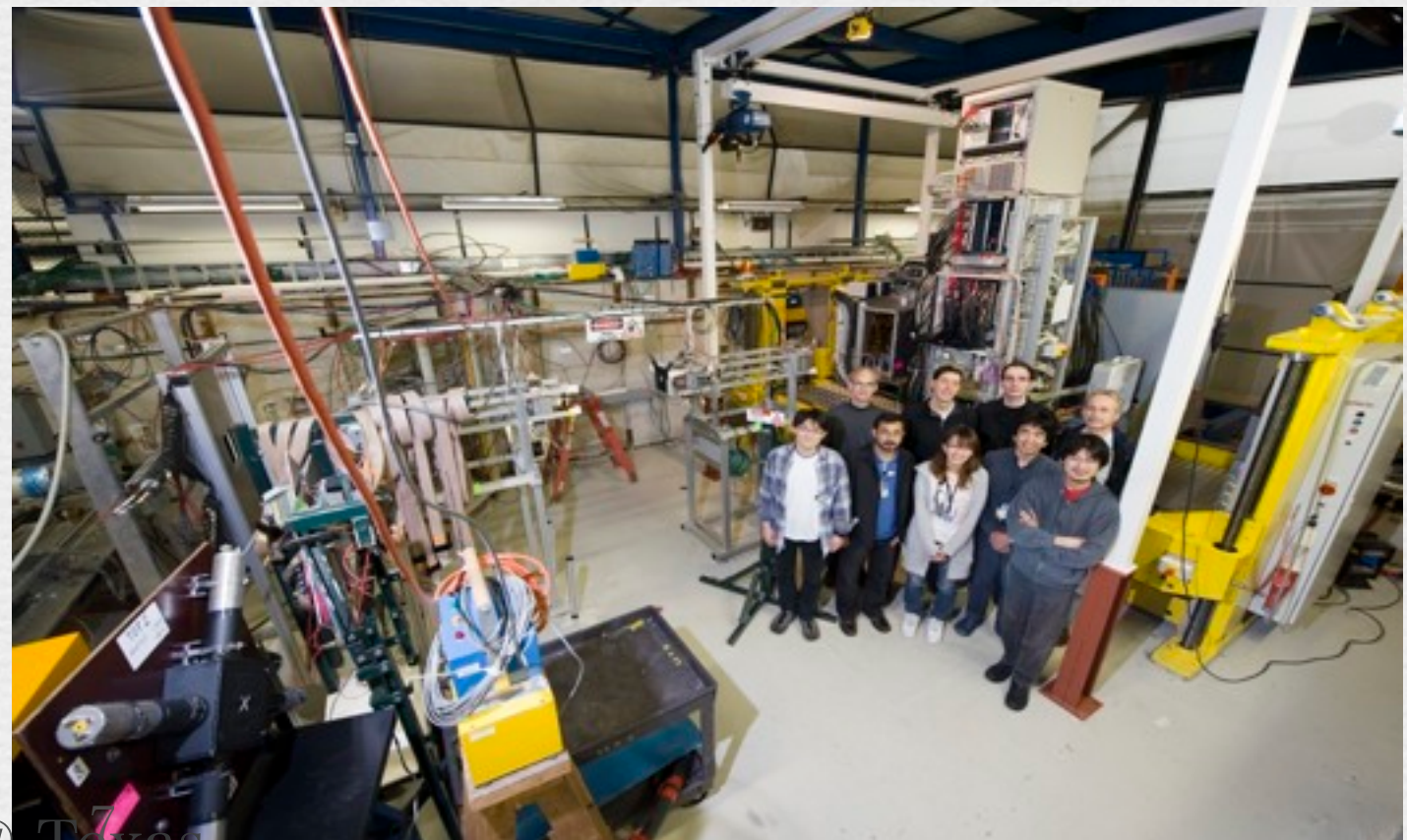
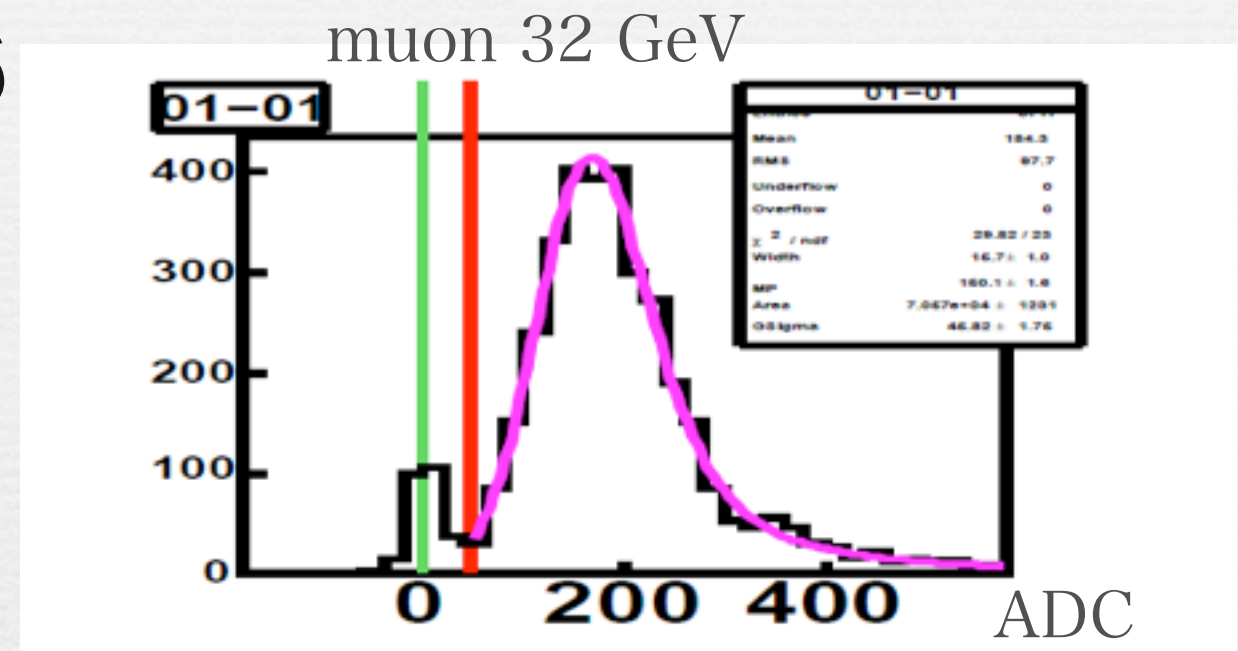
❧ **18 x 18 x 26 cm³**

❧ **2160 ch.**

muon 32 GeV

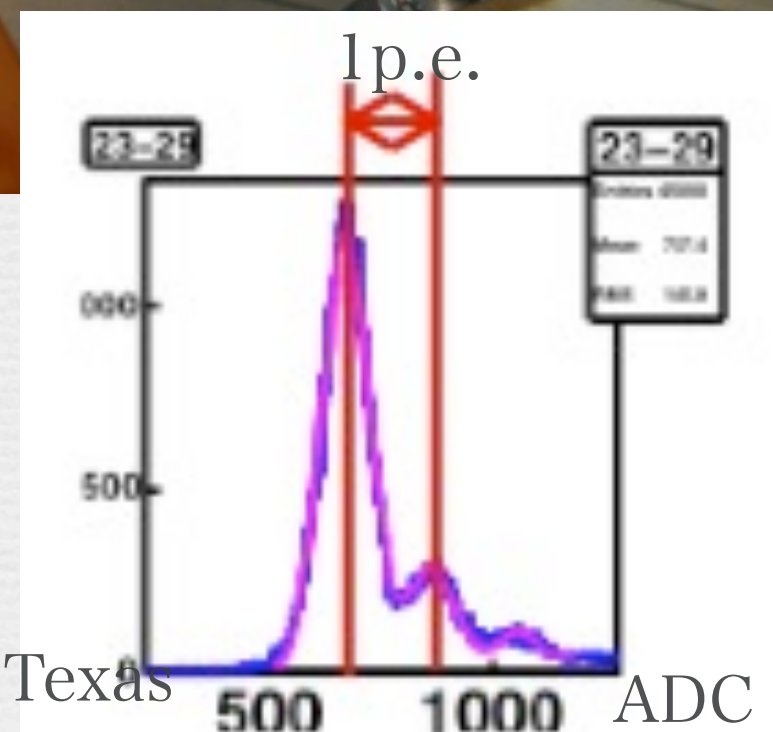
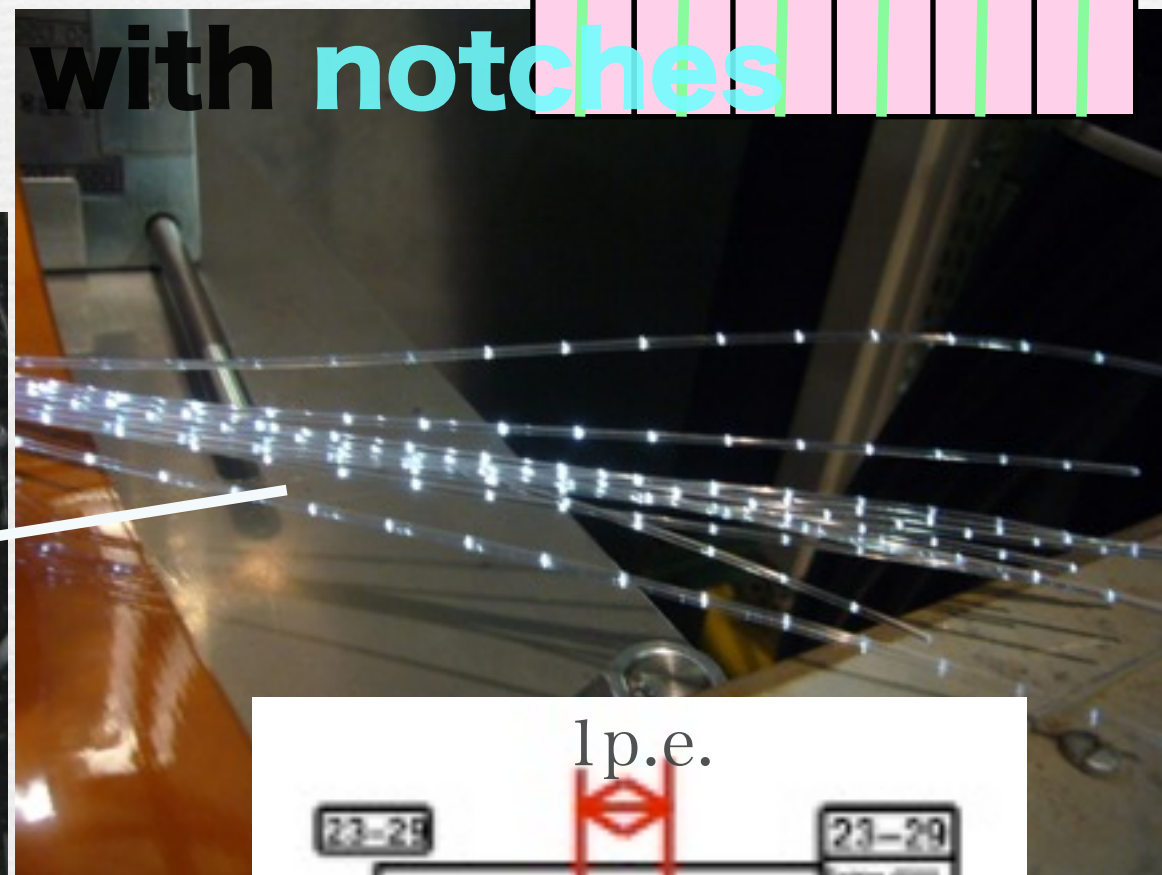
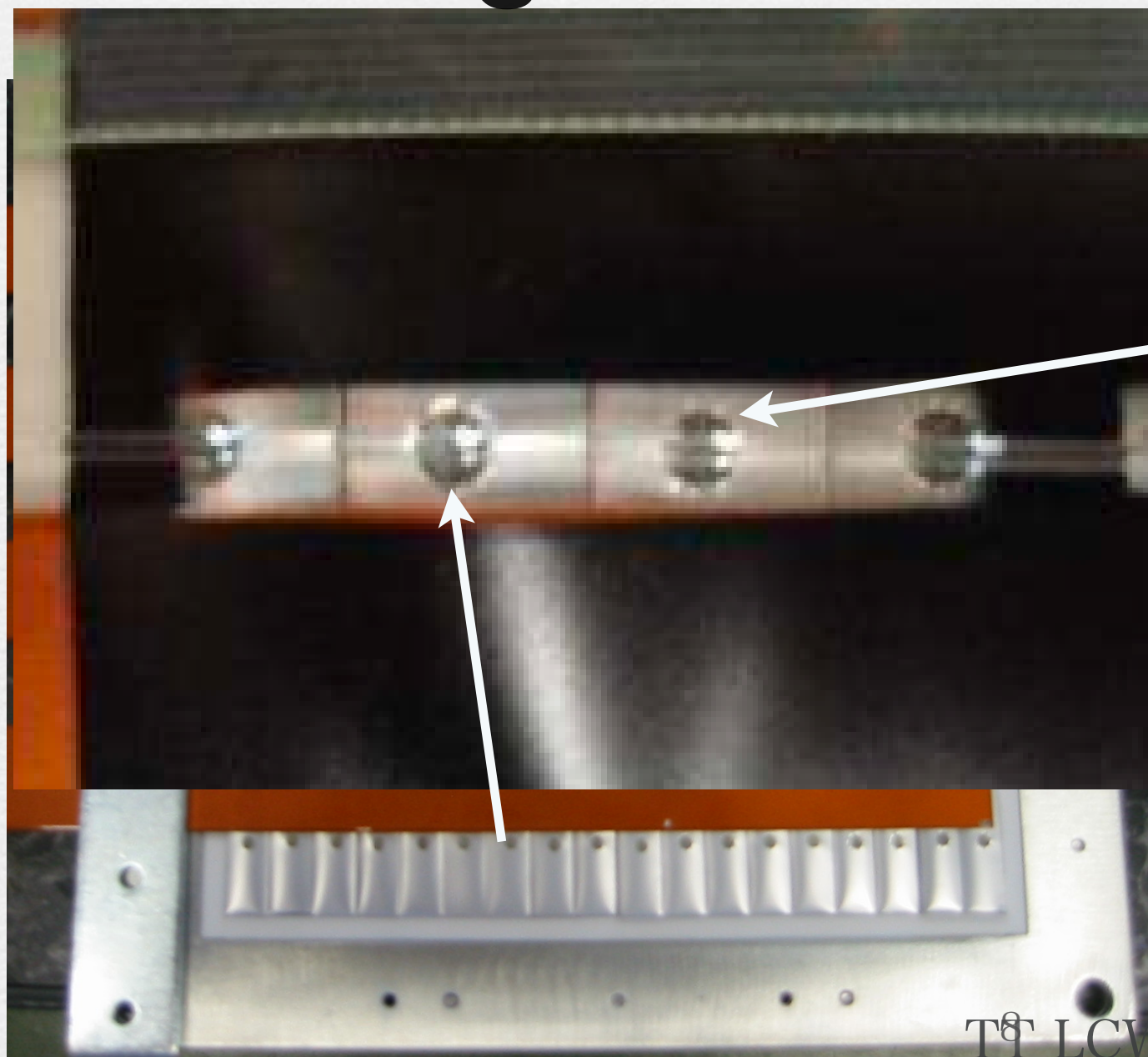
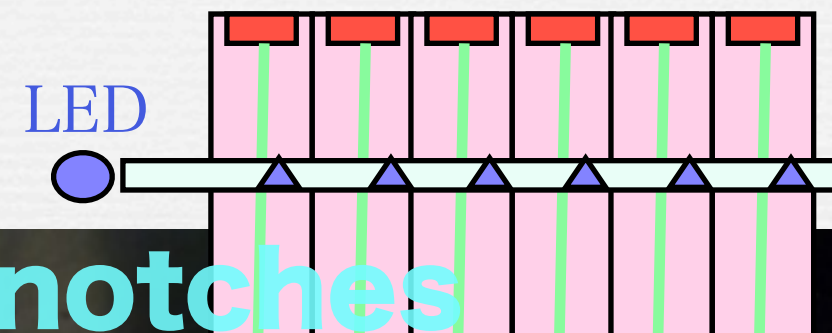


a muon event TT LCWS12 @ Texas



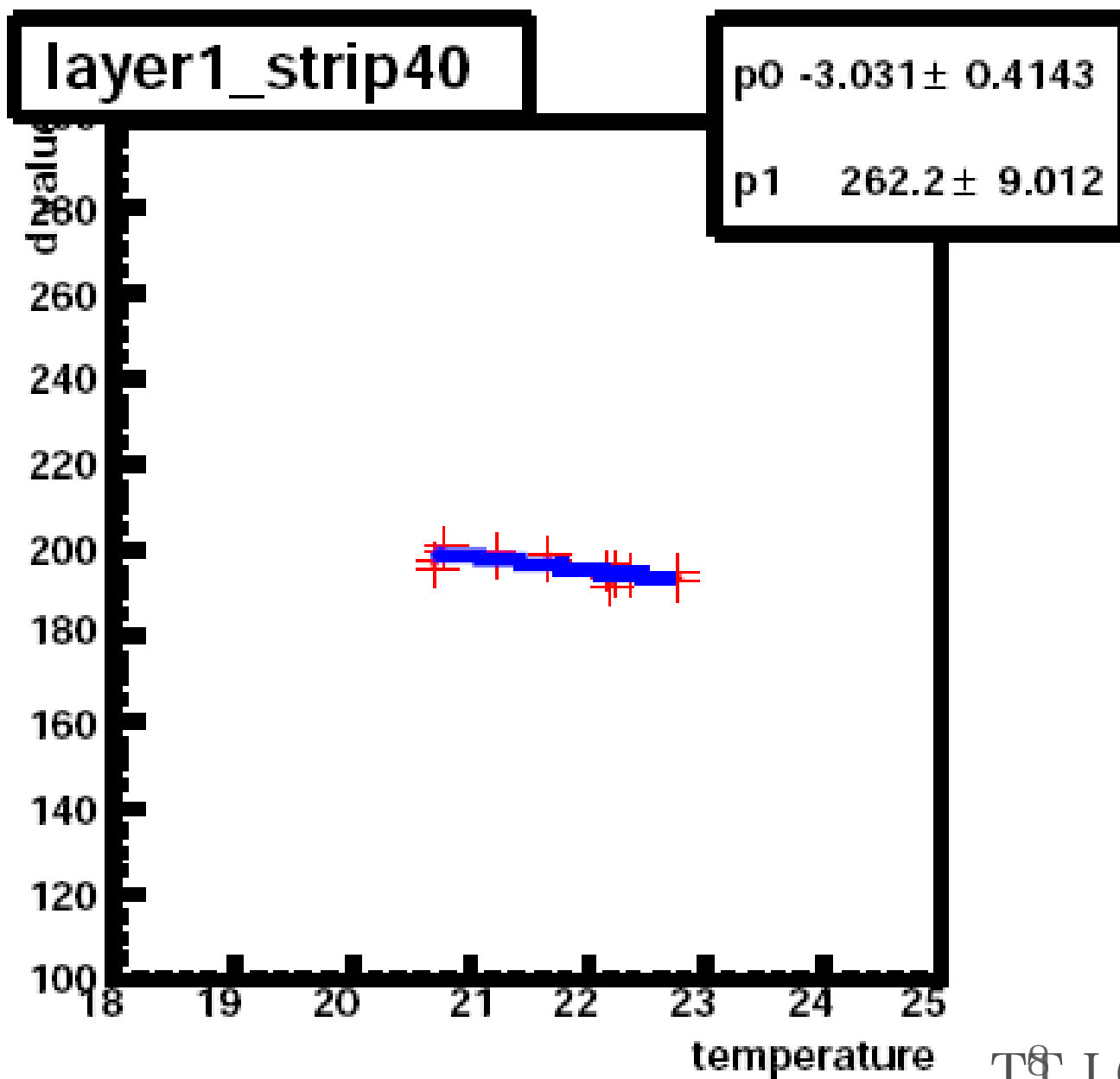
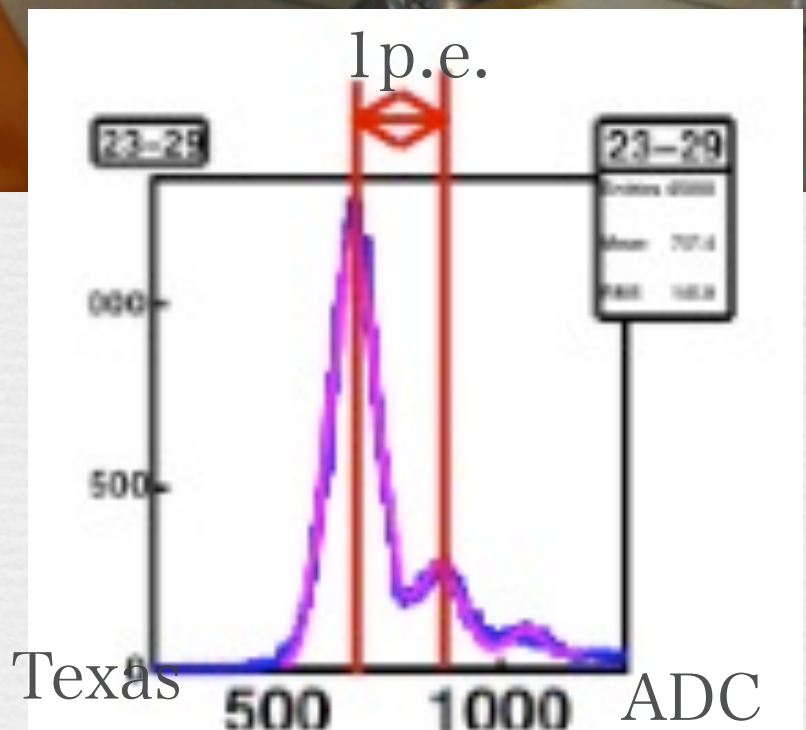
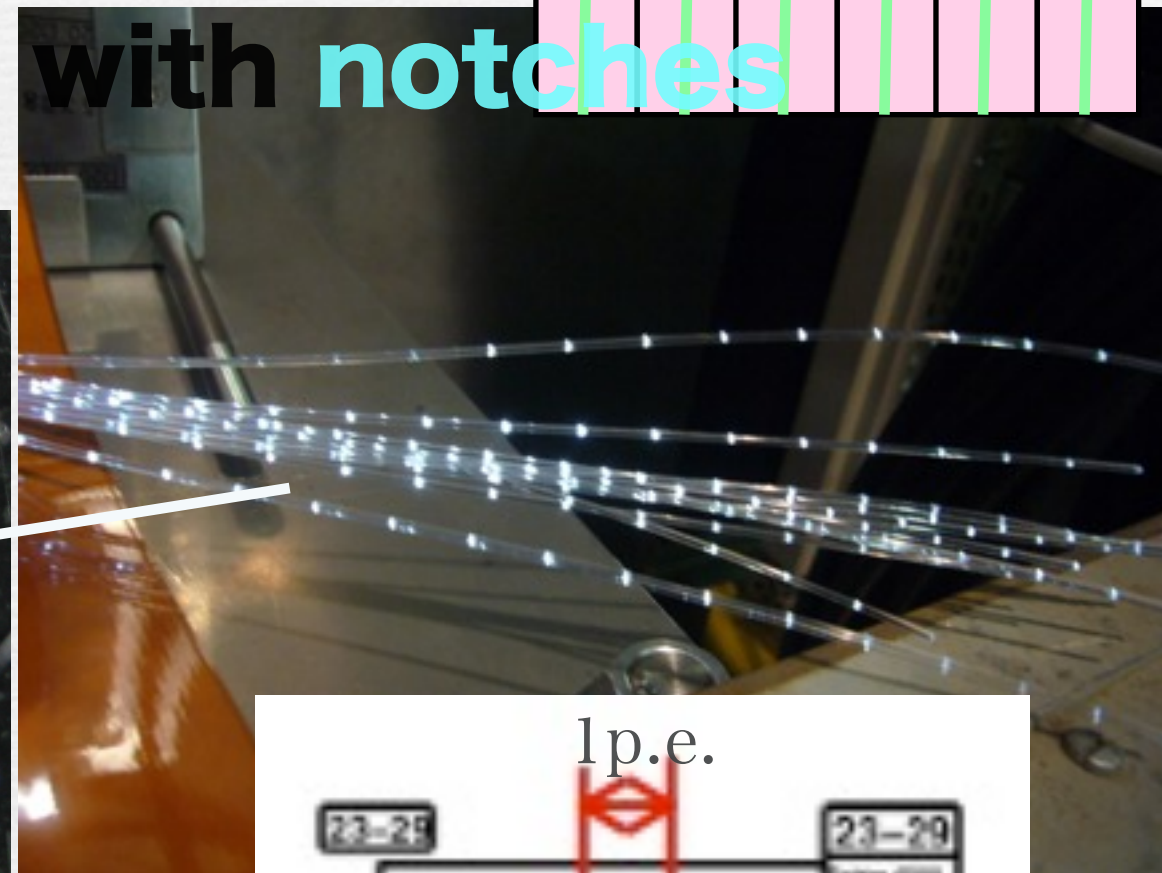
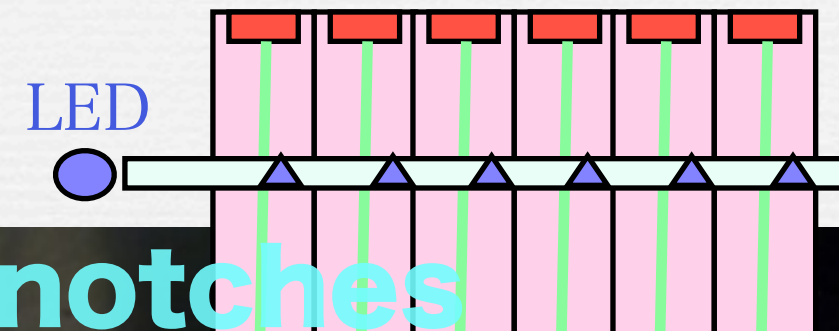
monitoring system

- MPPC has gain calibration capability
- to monitor 1 p.e.
- **LED** through clear fiber with notches

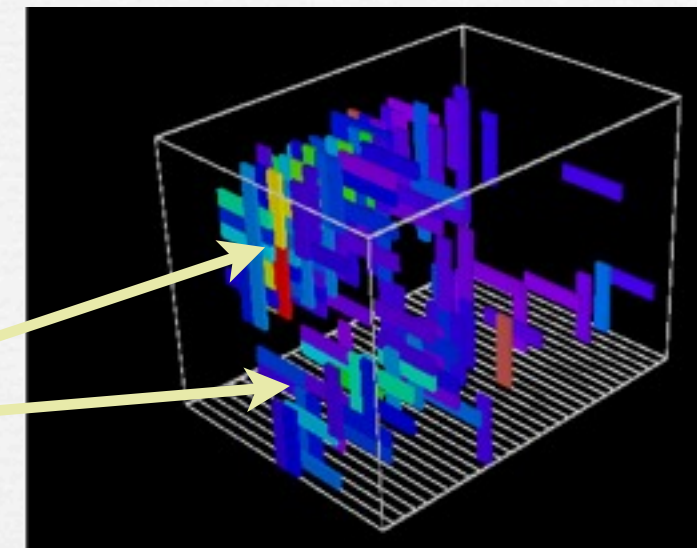


monitoring system

- MPPC has gain calibration capability
- to monitor 1 p.e.
- **LED** through clear fiber with notches



π^0 reconstruction

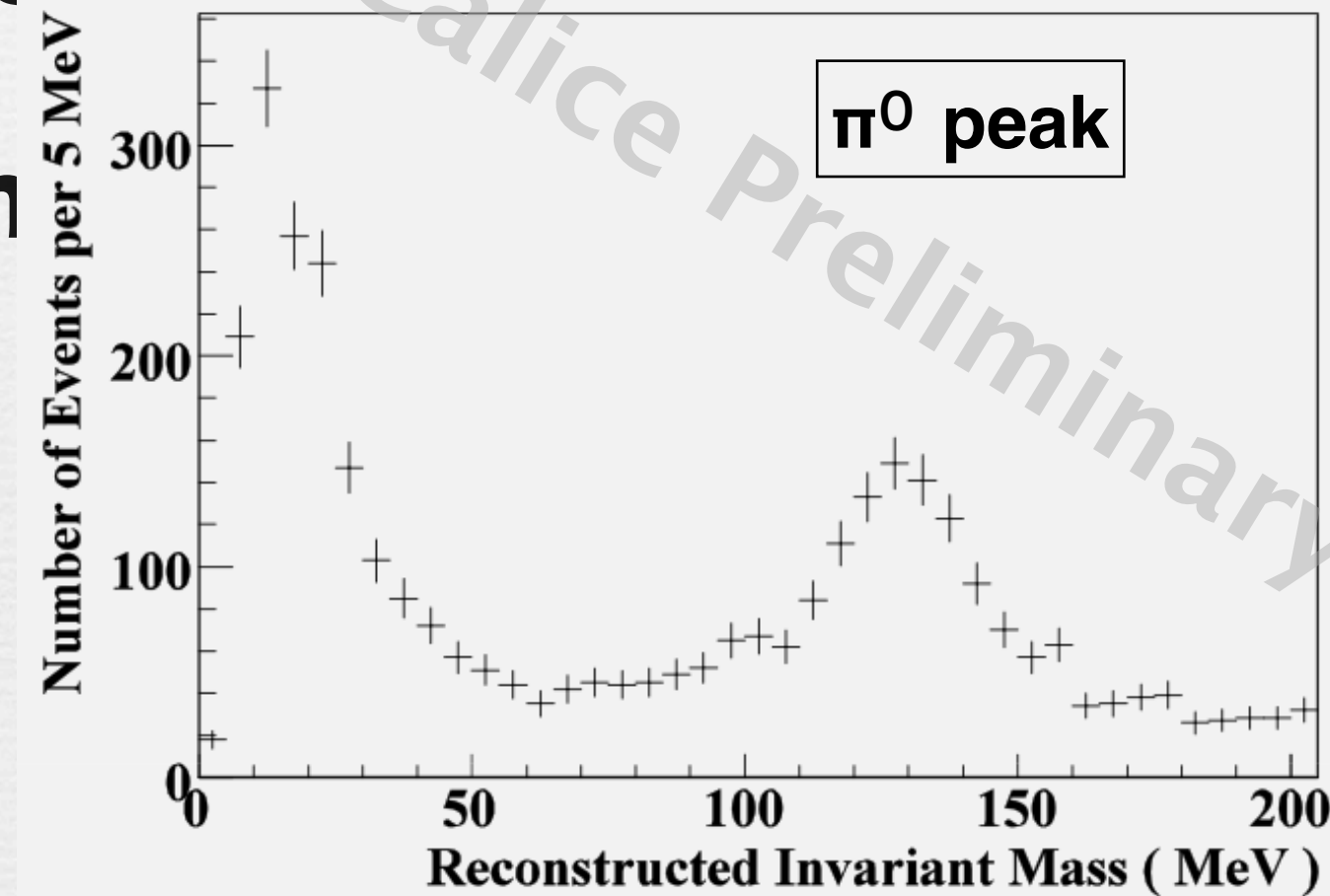
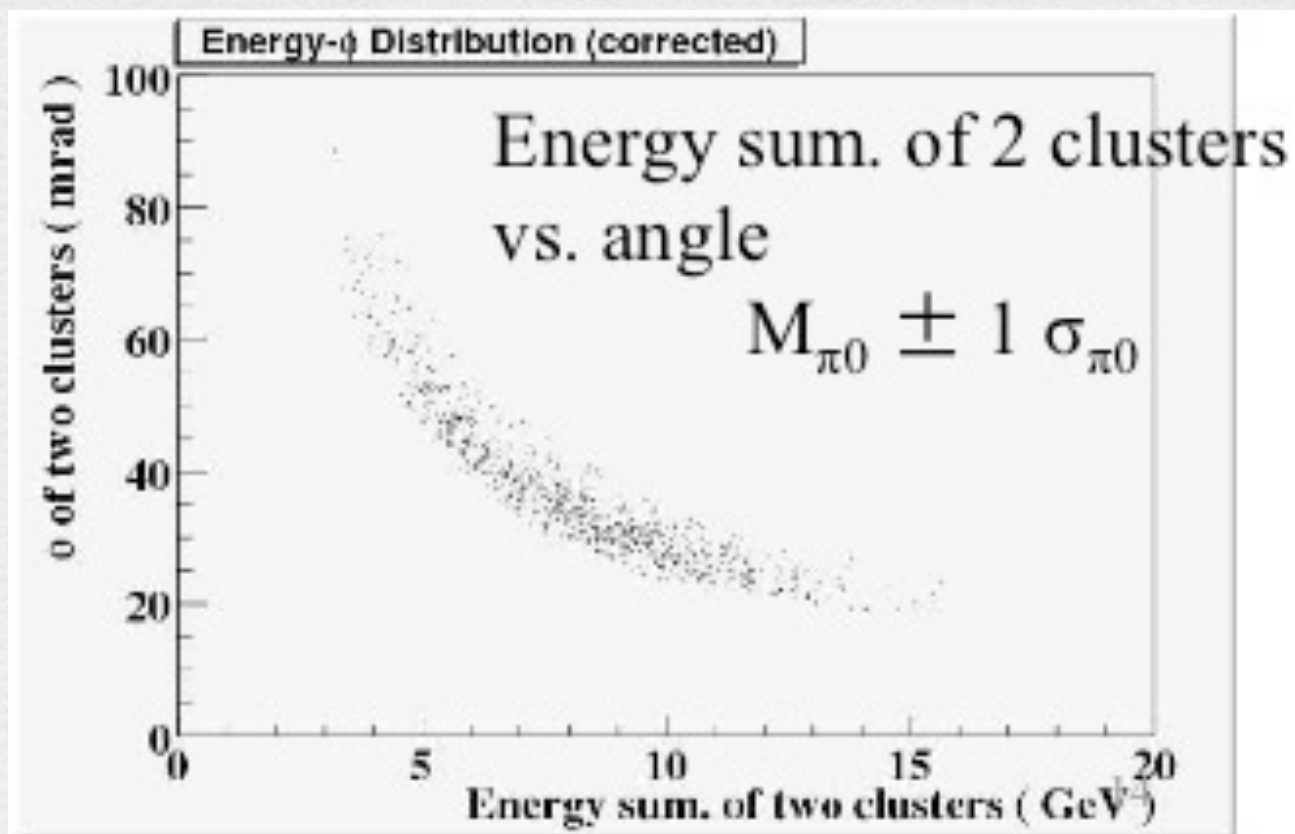


• **target in pion beam to make π^0**

• **find two isolated clusters**

• **calculate invariant mass**

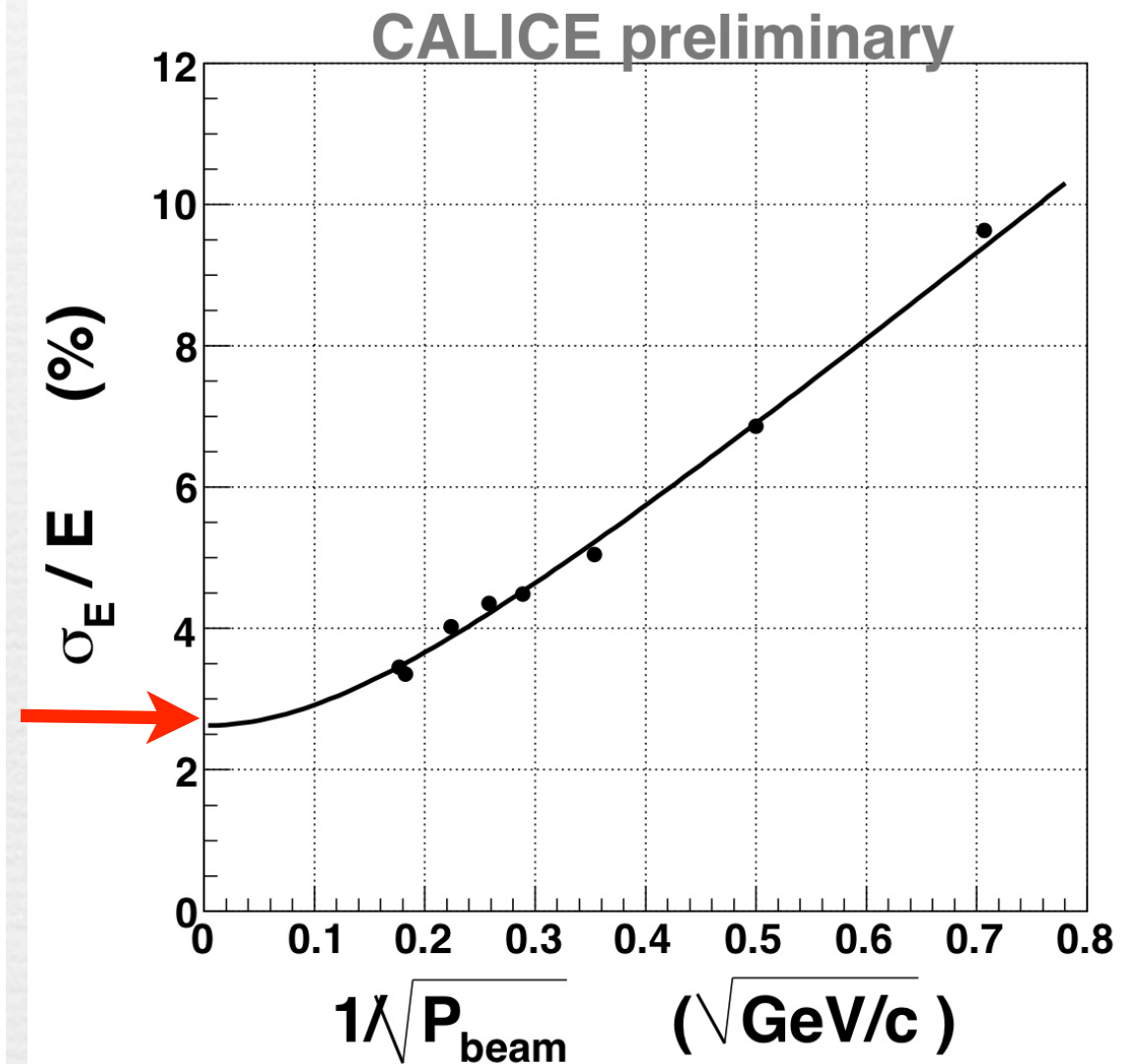
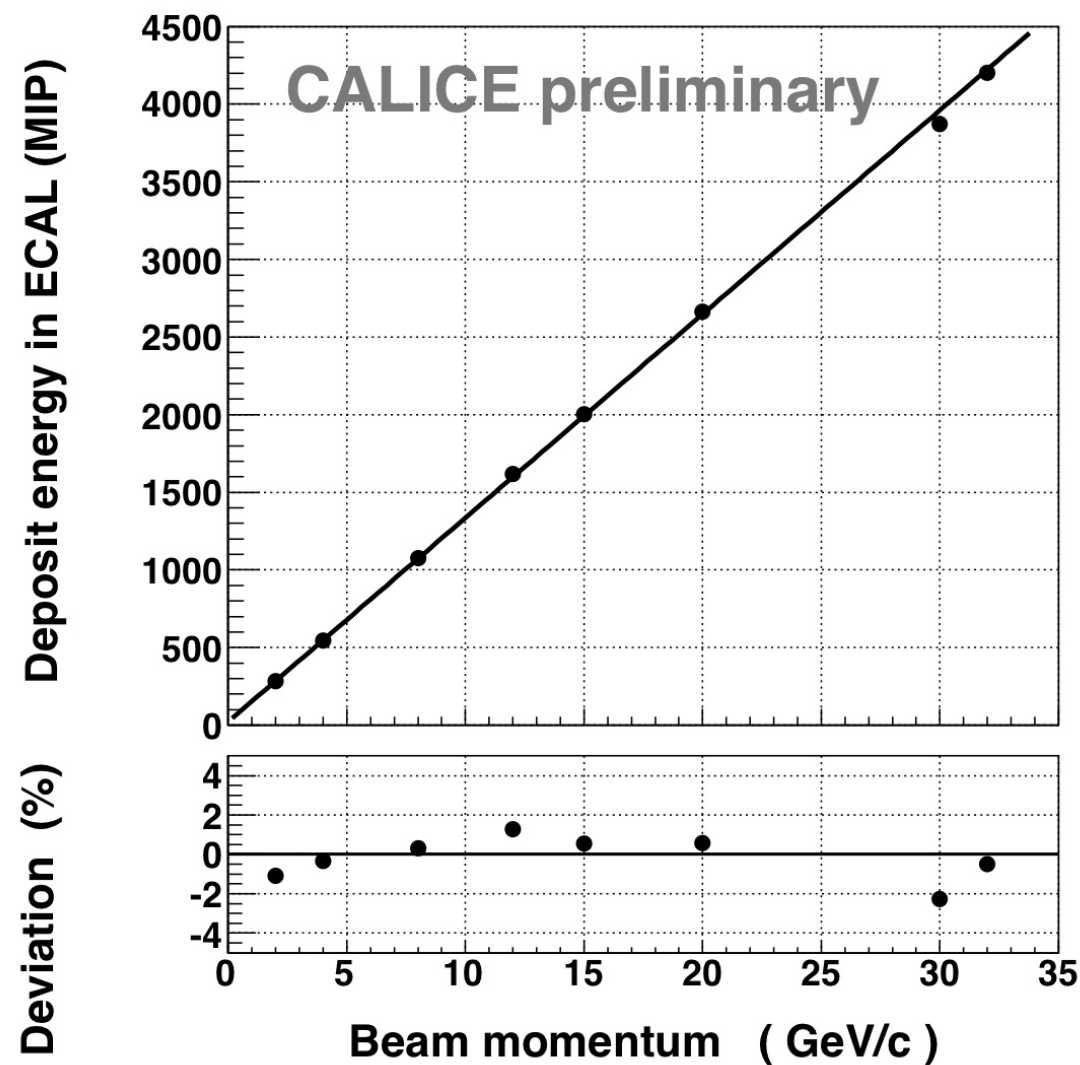
• **with different E_r**



results of ECAL prototype

scintillator ECAL

• linearity and resolution for electrons

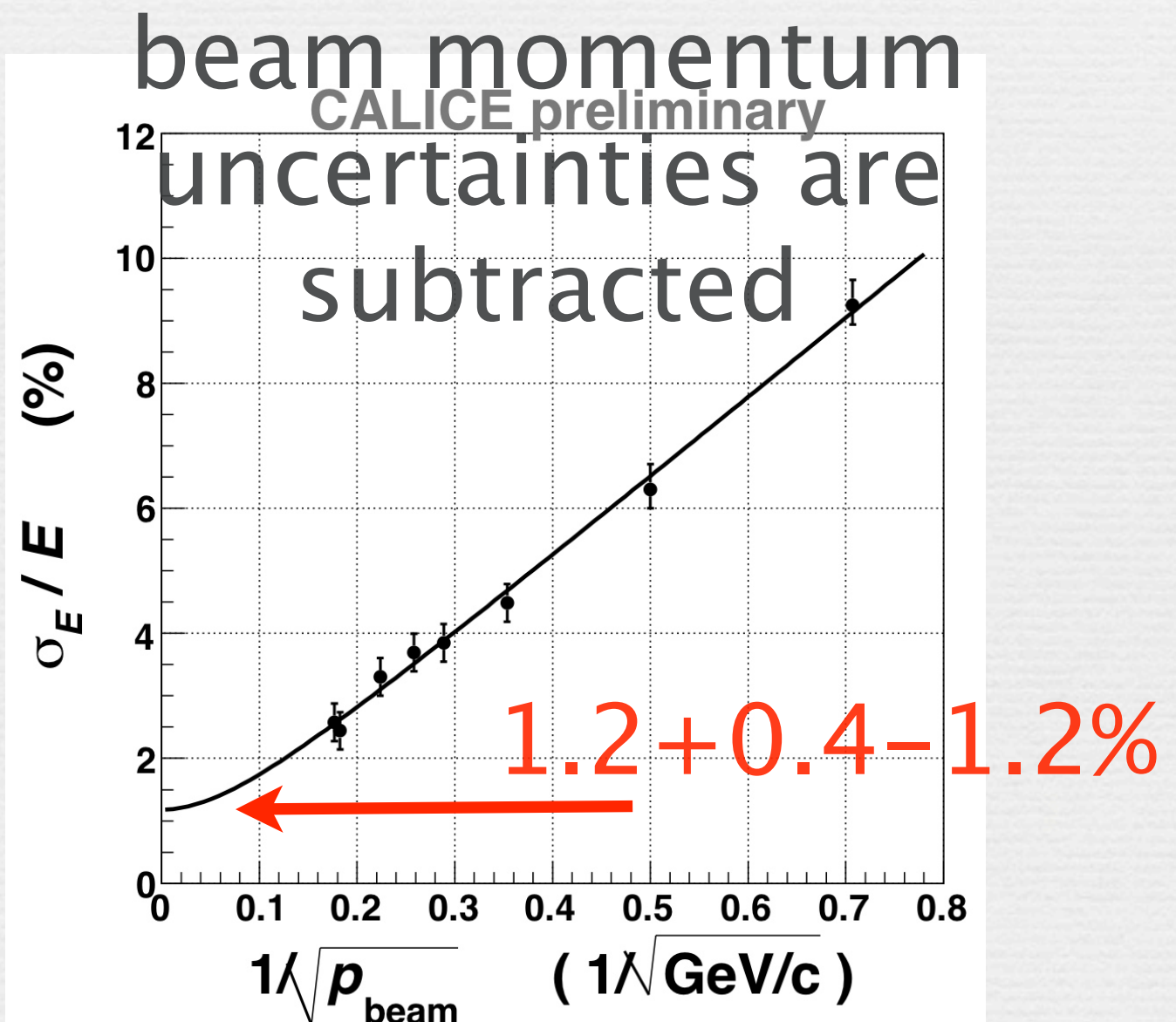
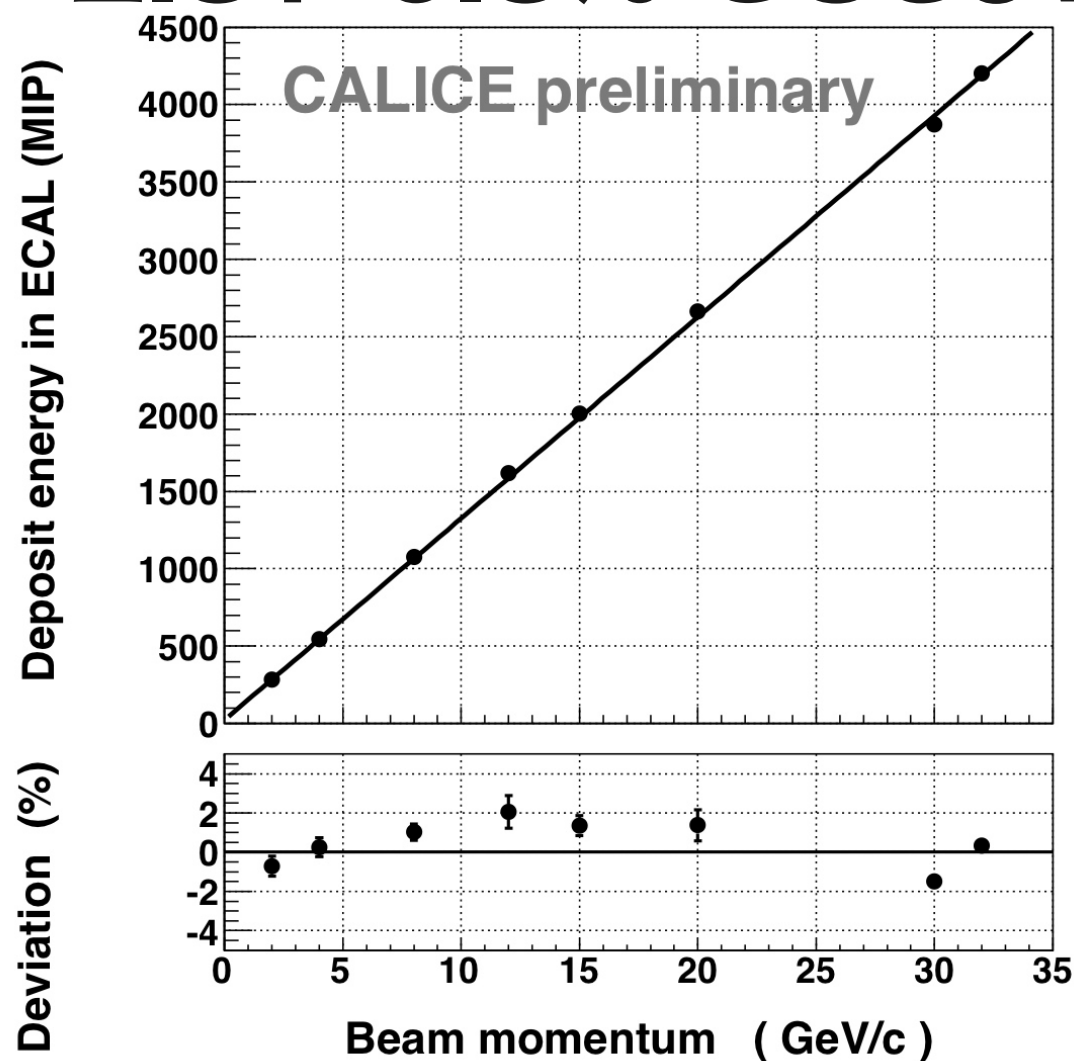


saturation effects of MPPC are corrected
linearity is less than +2%

constant term in the energy resolution is 2.6%

Beam momentum uncertainty

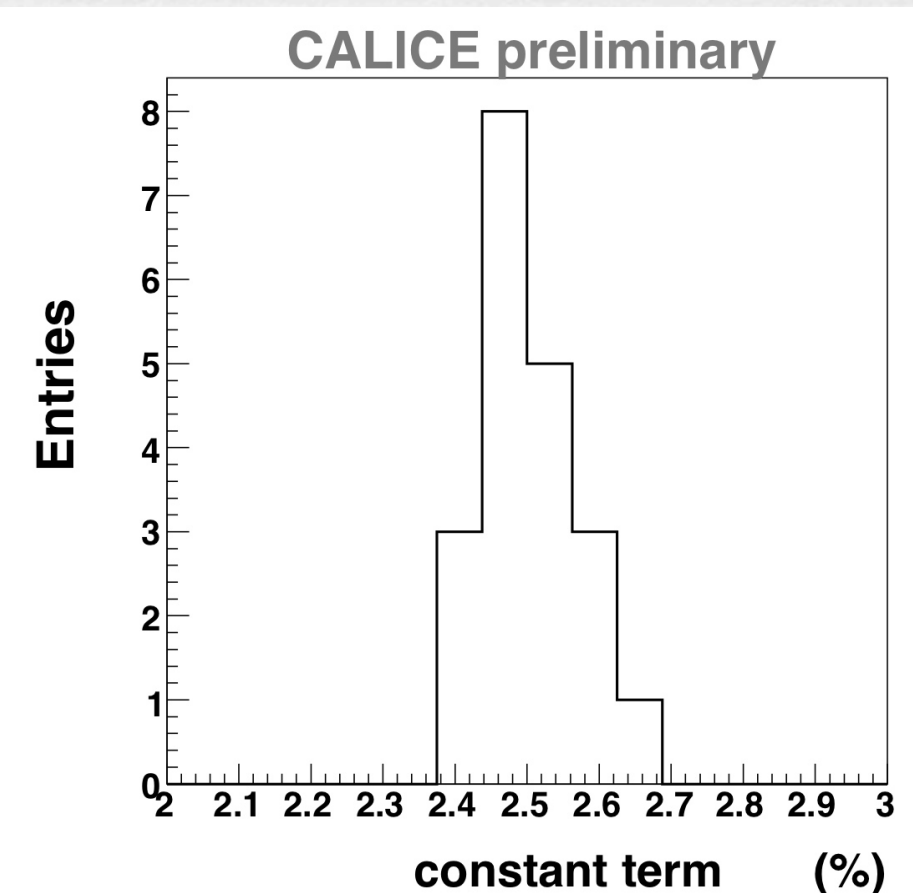
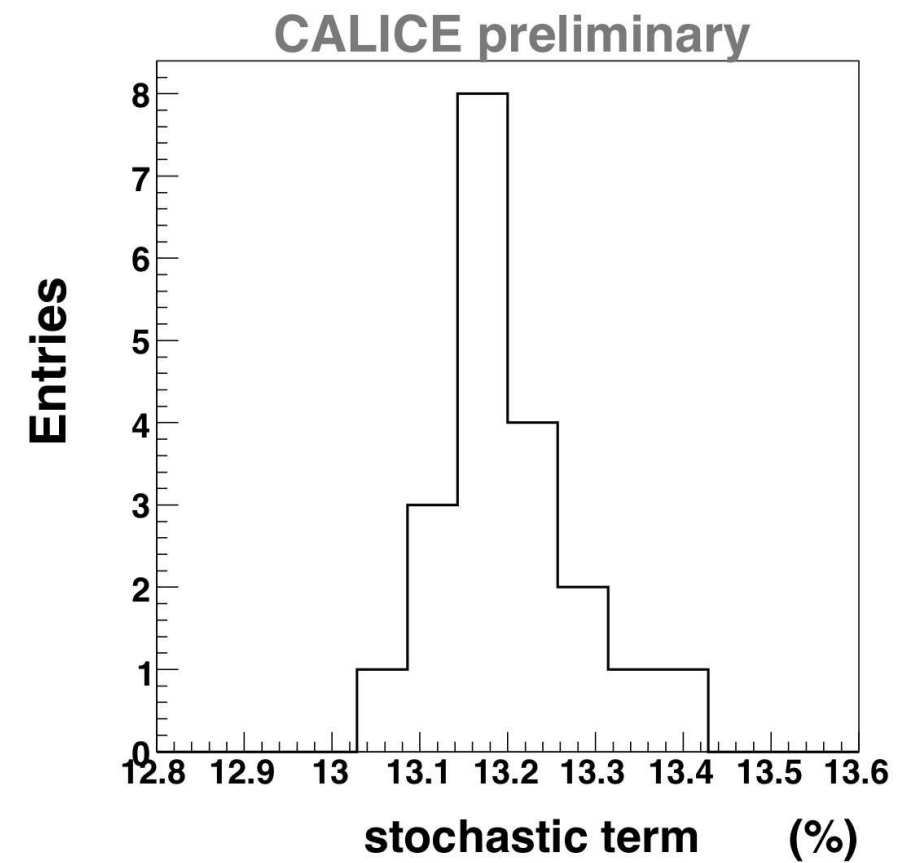
- designed beam momentum spread at MT6 ~2%
- measurements : $2.7 \pm 0.3\%$ @1-4 GeV & $2.3 \pm 0.3\%$ @8GeV



systematic uncertainties

for stochastic term

- **electron E : temperature corrections $\pm 0.07\%$**
- **ADC to gain conversion $\pm 0.08\%$**
- **saturation effects with temperature $\pm 0.07\%$**
- **run by run $< 0.3\%$ at low E**
- **event selection $< 0.01\%$**
- **beam momentum fluct. $\pm 0.41\%$**



prototype II

→ scintillator width: 10 > 5mm

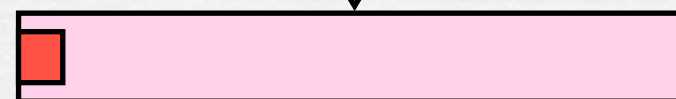
→ without WLS fiber

→ uniformity studied

→ scintillator thickness: 2 > 1mm

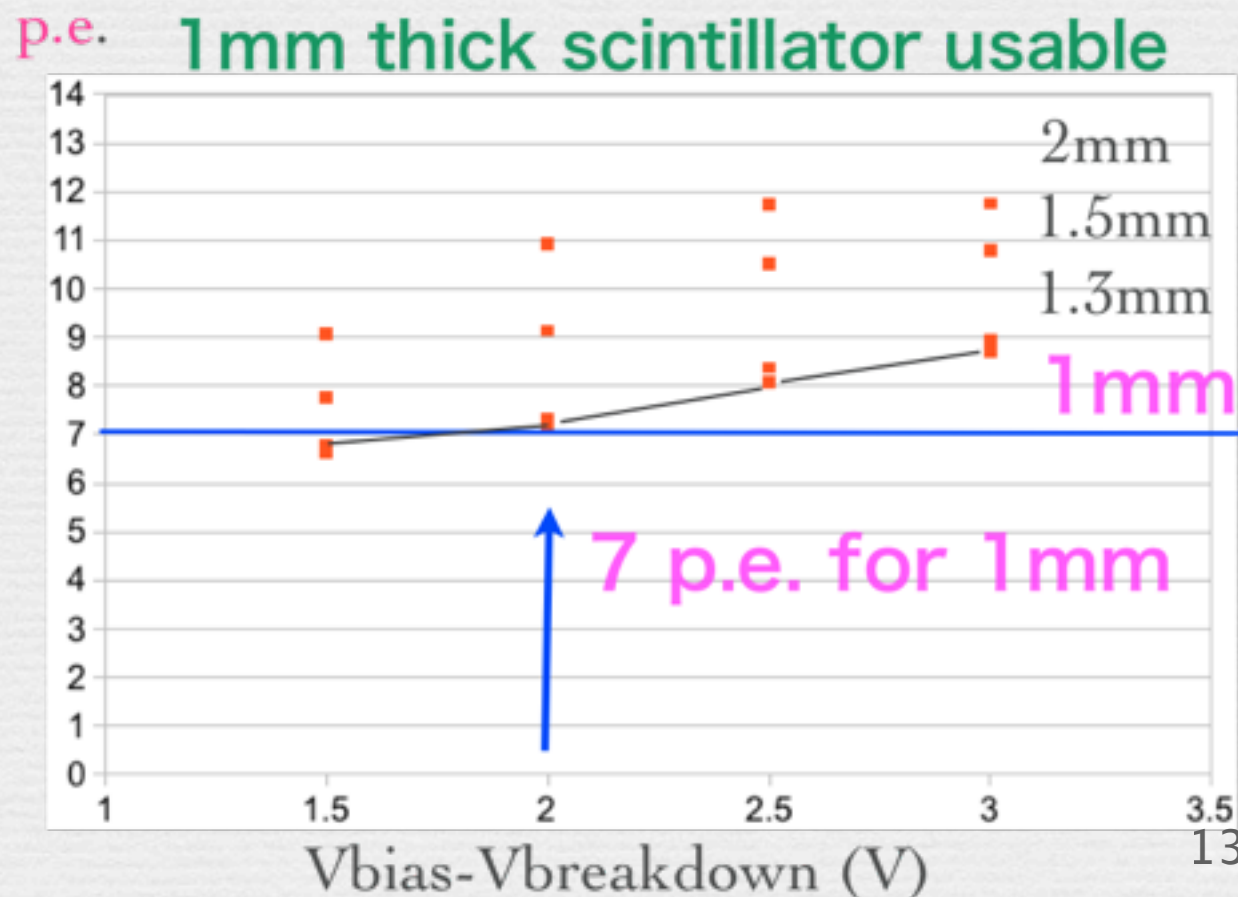
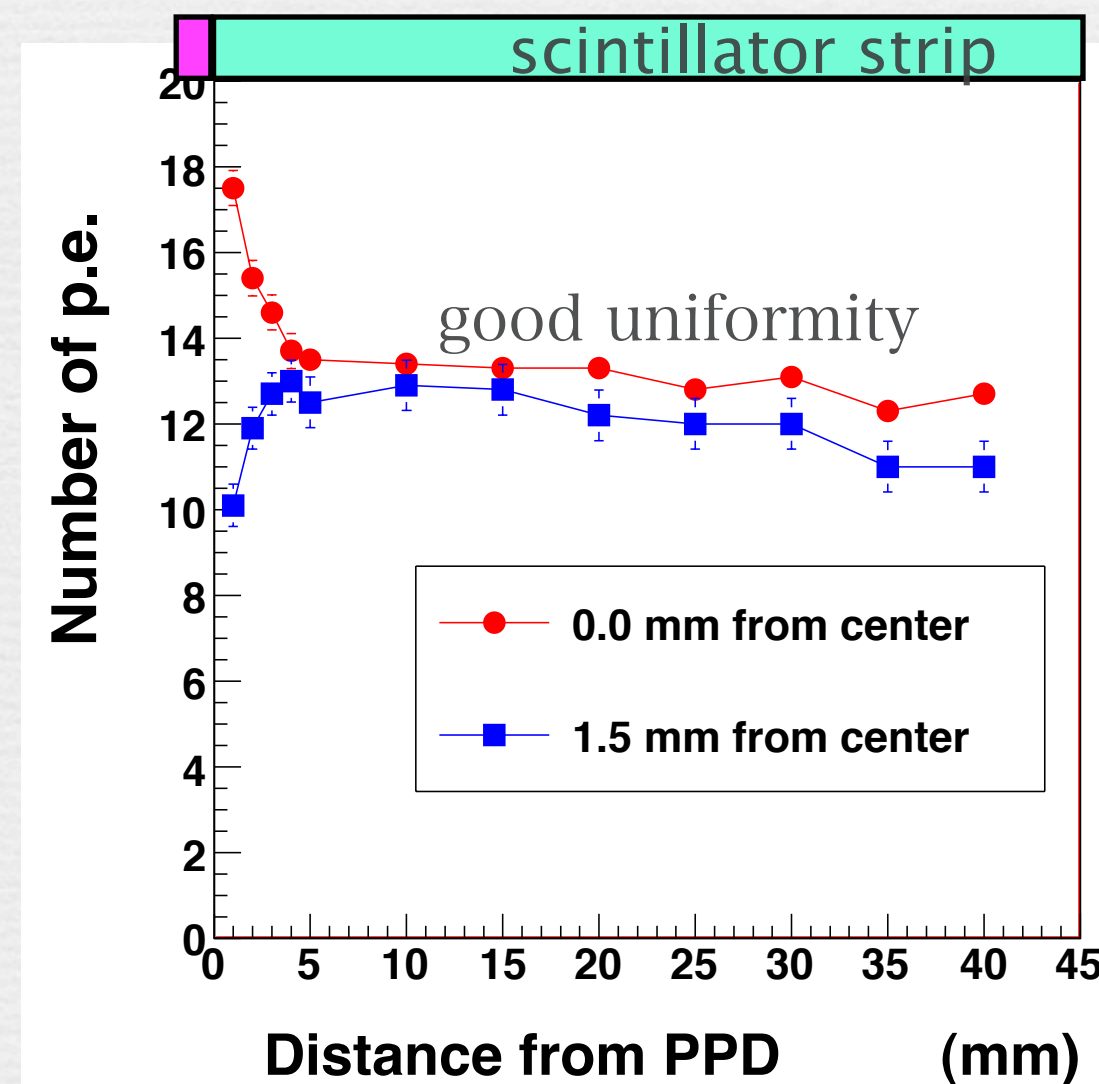


no precise alignment required



5mm wide strip bench test

MPPC 25 μ m



Prototype II

- ❖ **Absorber layer**

20x20cm²

- ❖ **scintillator layer**

4 lows x 36 strips = 144 strips

- ❖ **read-out electronics**

- EBU layer**

4 SPIROC asics

- ❖ **combined as one super layer**

Prototype II

- ❖ **Absorber layer**

20x20cm²

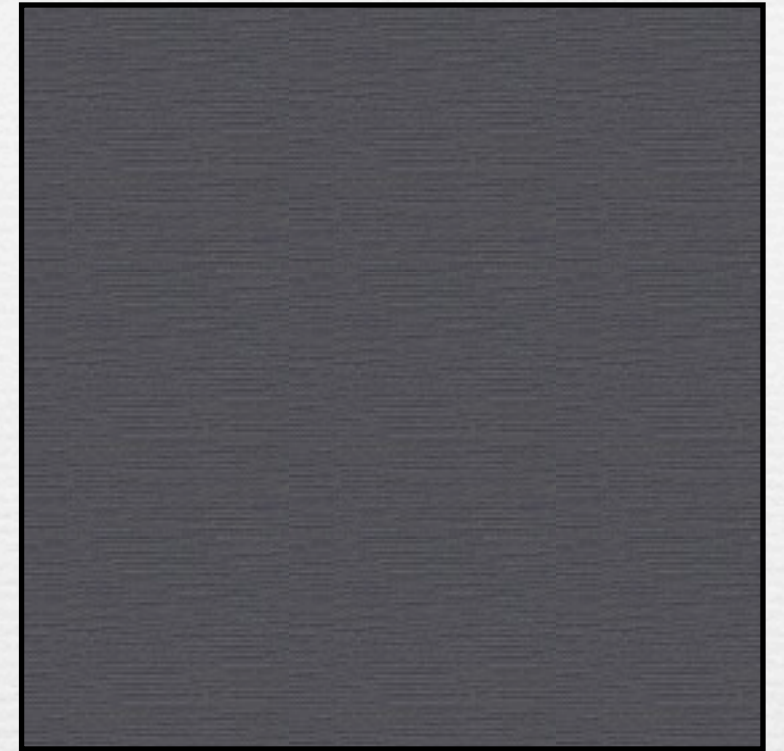
- ❖ **scintillator layer**

4 lows x 36 strips = 144 strips

- ❖ **read-out electronics**
EBU layer

4 SPIROC asics

- ❖ **combined as one super layer**



Prototype II

- ❖ **Absorber layer**

20x20cm²

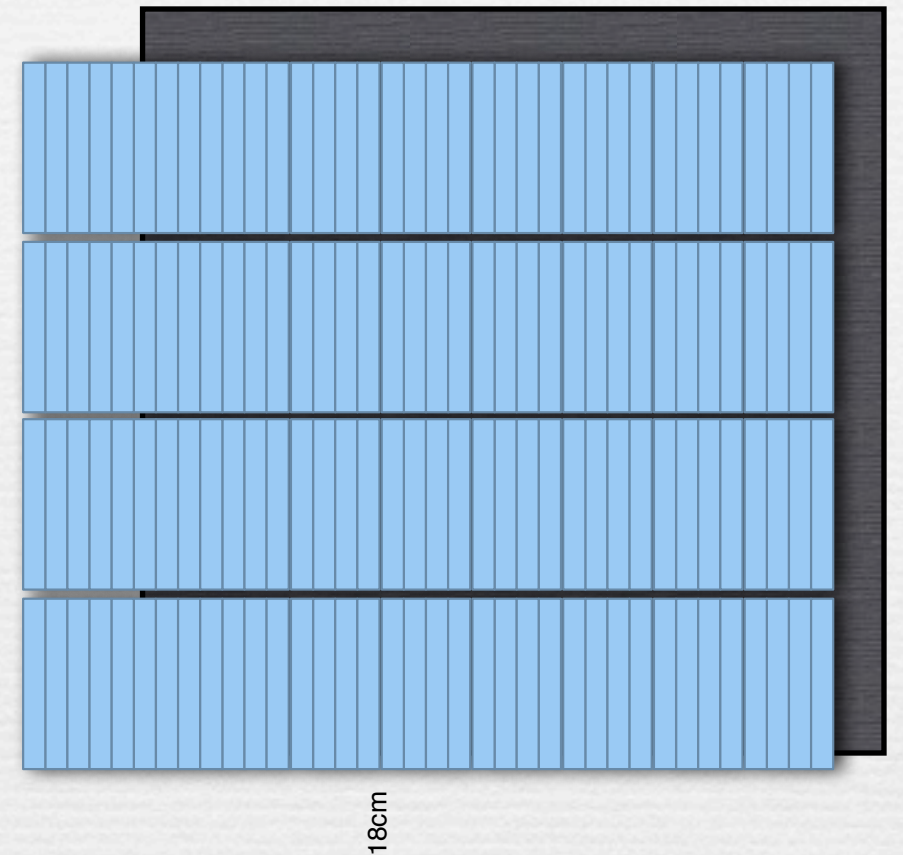
- ❖ **scintillator layer**

4 lows x 36 strips = 144 strips

- ❖ **read-out electronics
EBU layer**

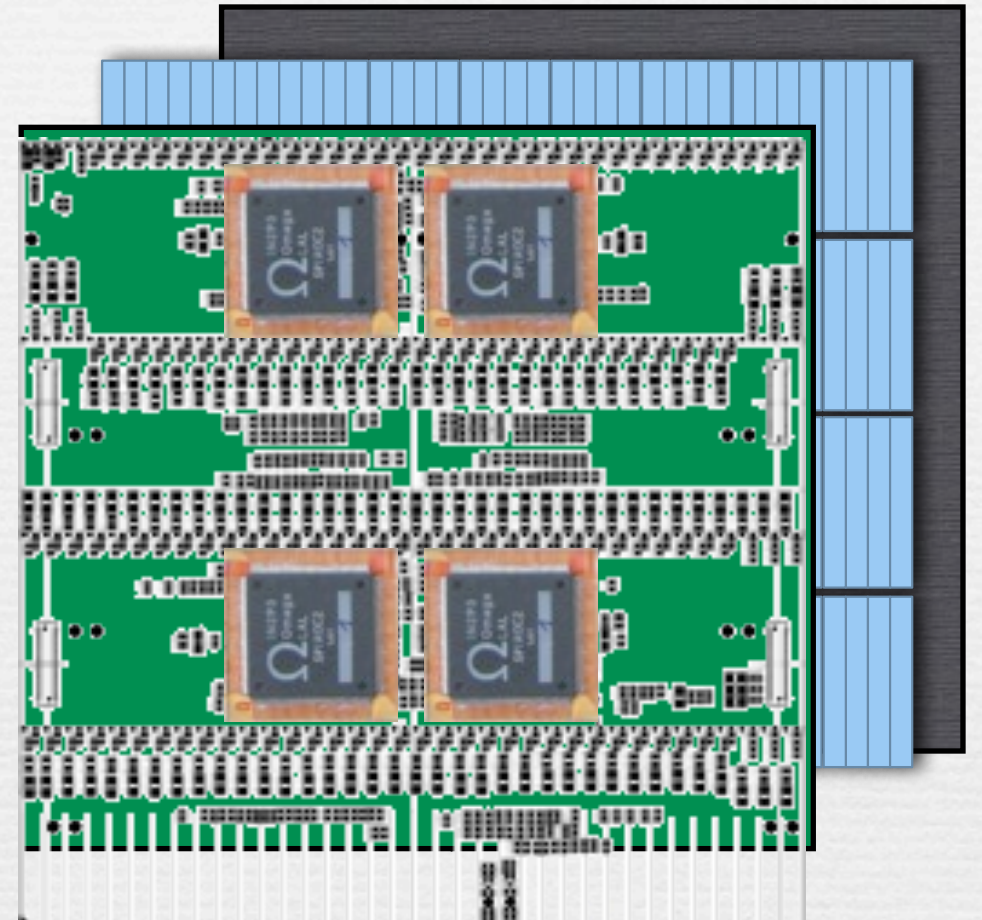
4 SPIROC asics

- ❖ **combined as one super
layer**



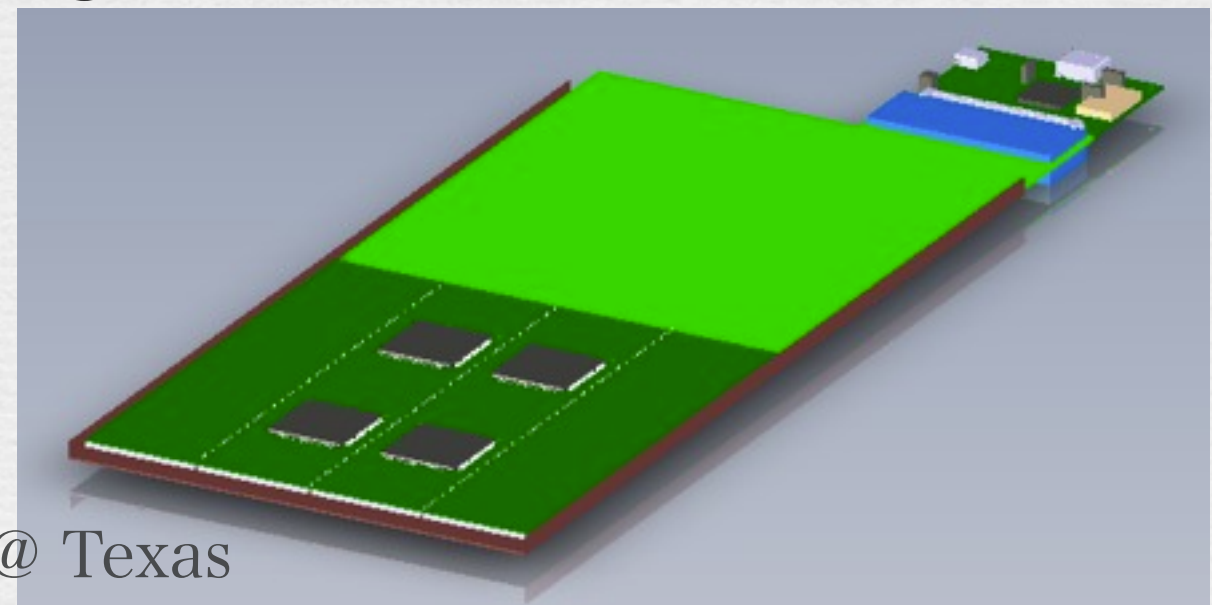
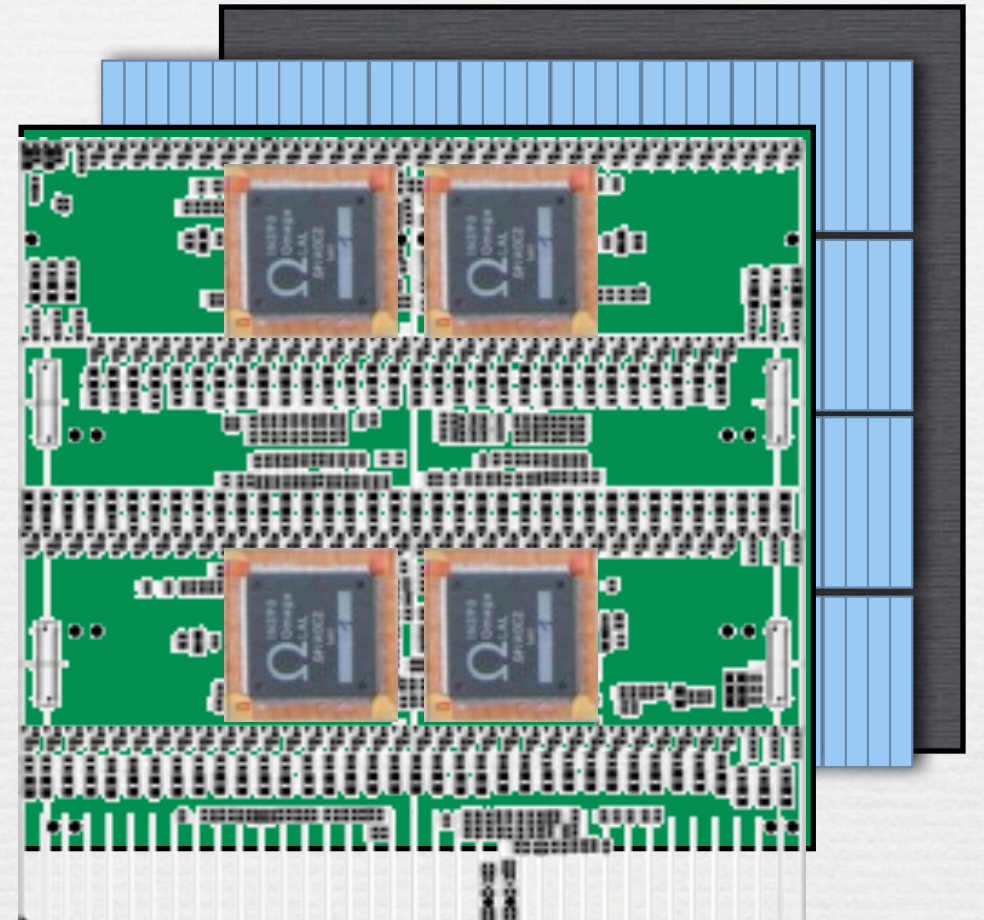
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Prototype II

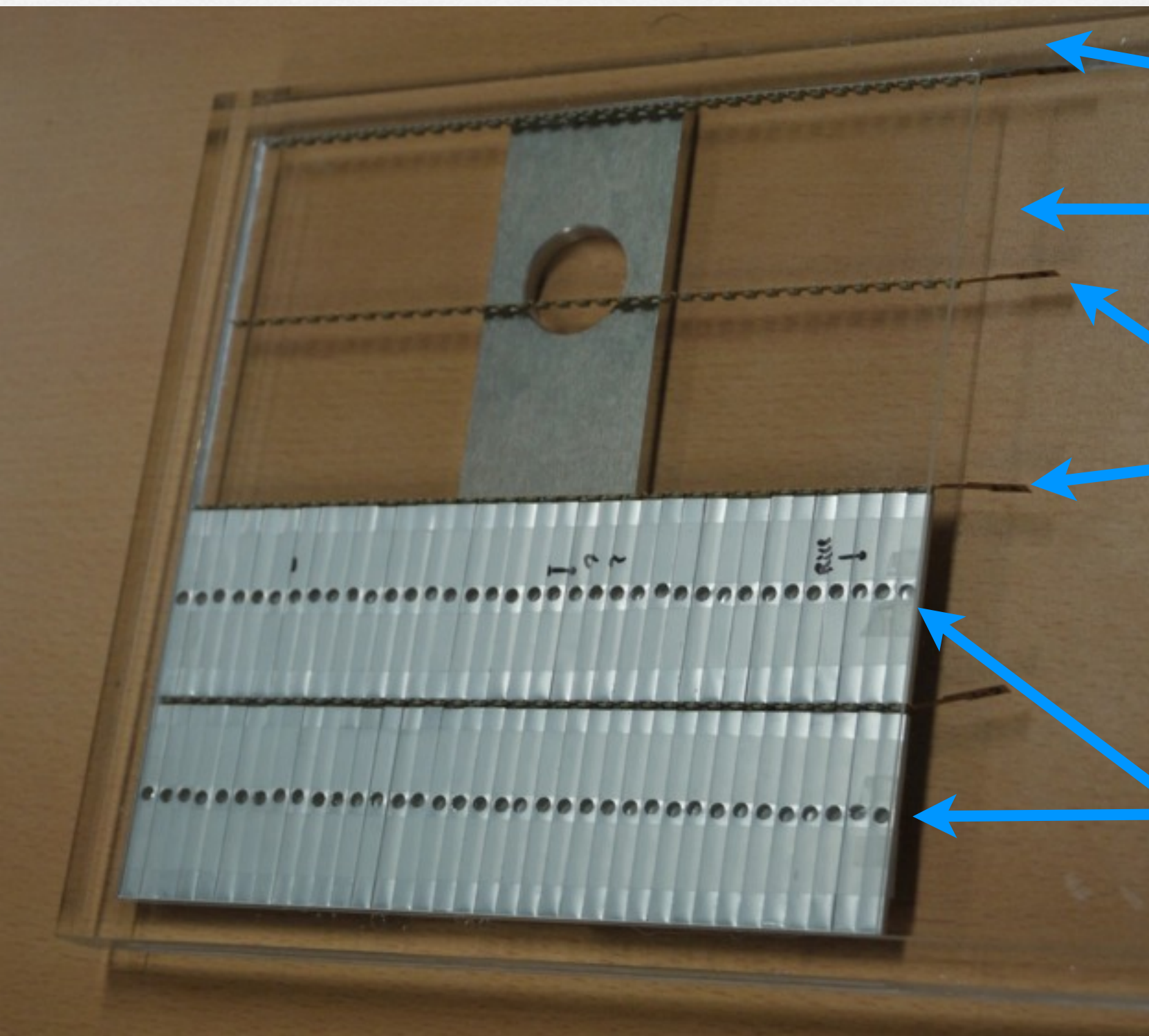
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- ❖ **scintillator layer**
4 lows x 36 strips = 144 strips
- ❖ **read-out electronics**
EBU layer
4 SPIROC asics
- ❖ **combined as one super layer**



A strip layer

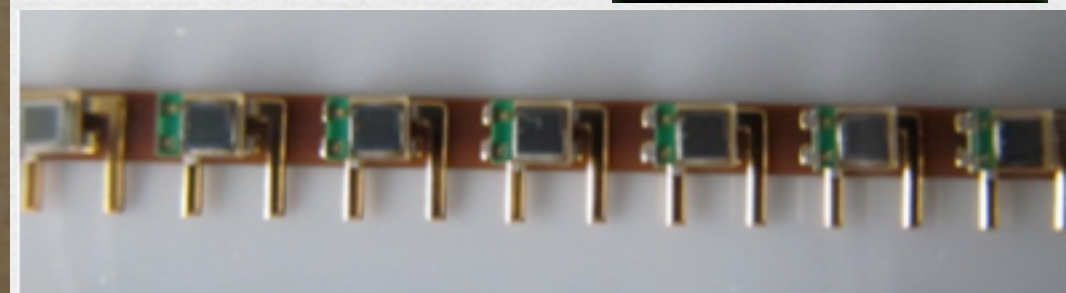
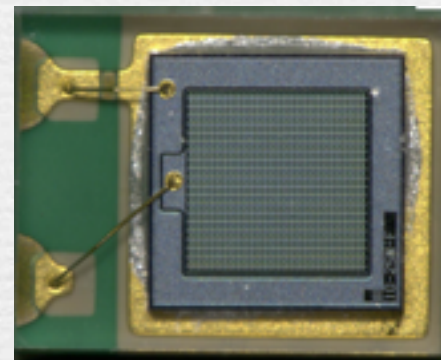
180x180mm²

36x4=144ch



Alveolar mockup
dummy read
out layer

MPPCs

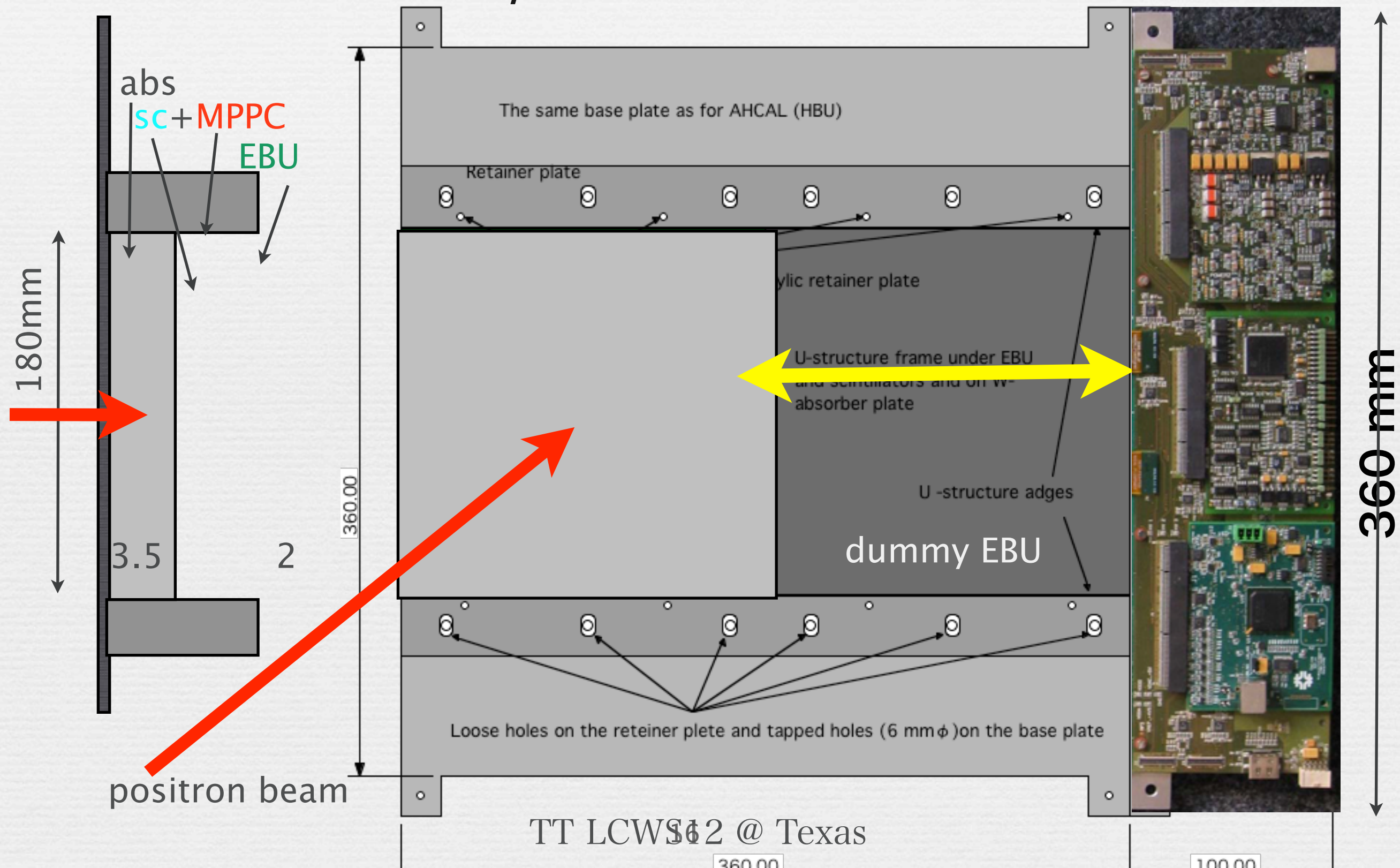


strip
stacks
need another two
rows

At the beam

Oct/2012 at DESY

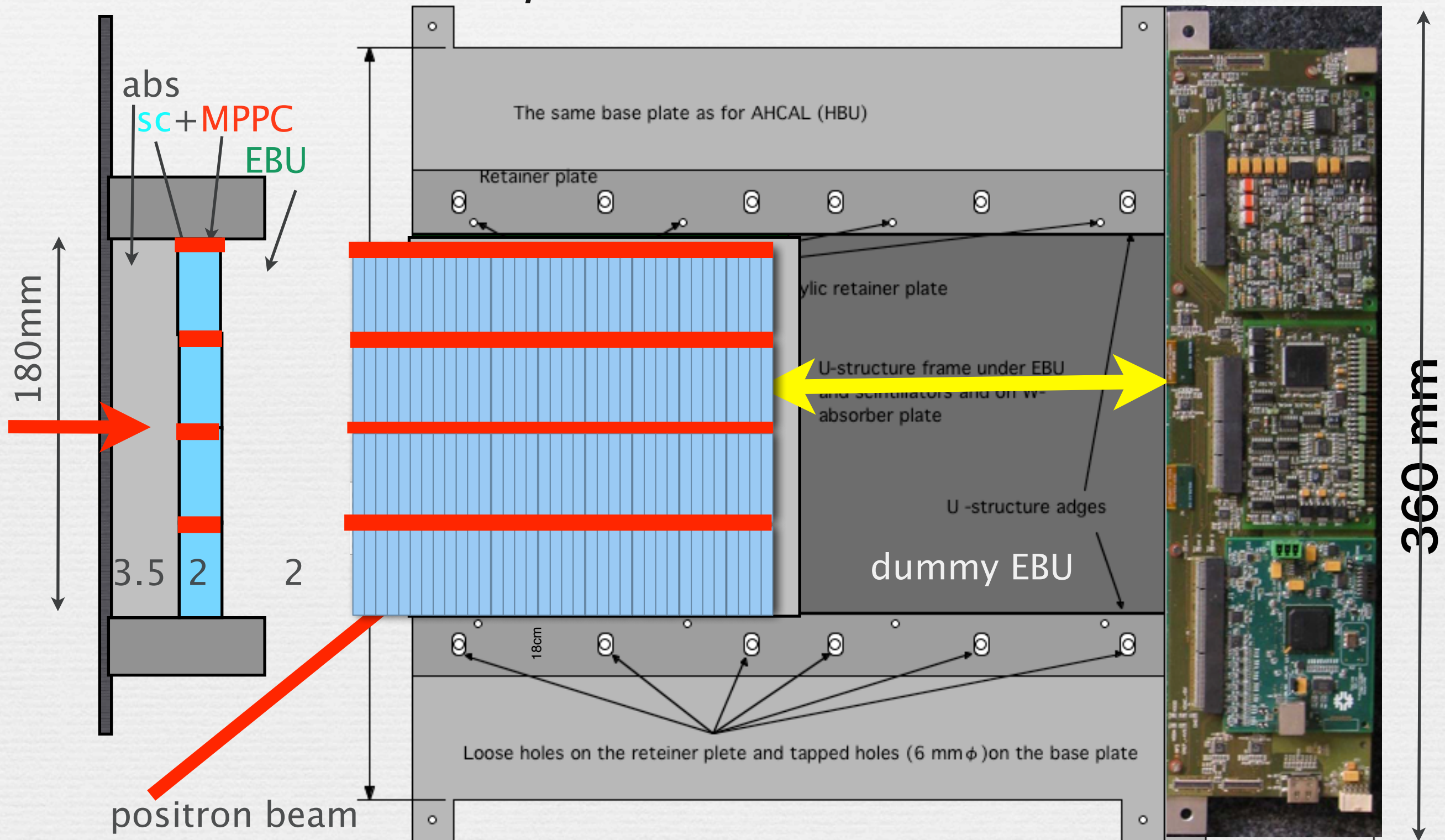
DIF
AHCAL



At the beam

Oct/2012 at DESY

DIF
AHCAL



TT LCWS\$12 @ Texas

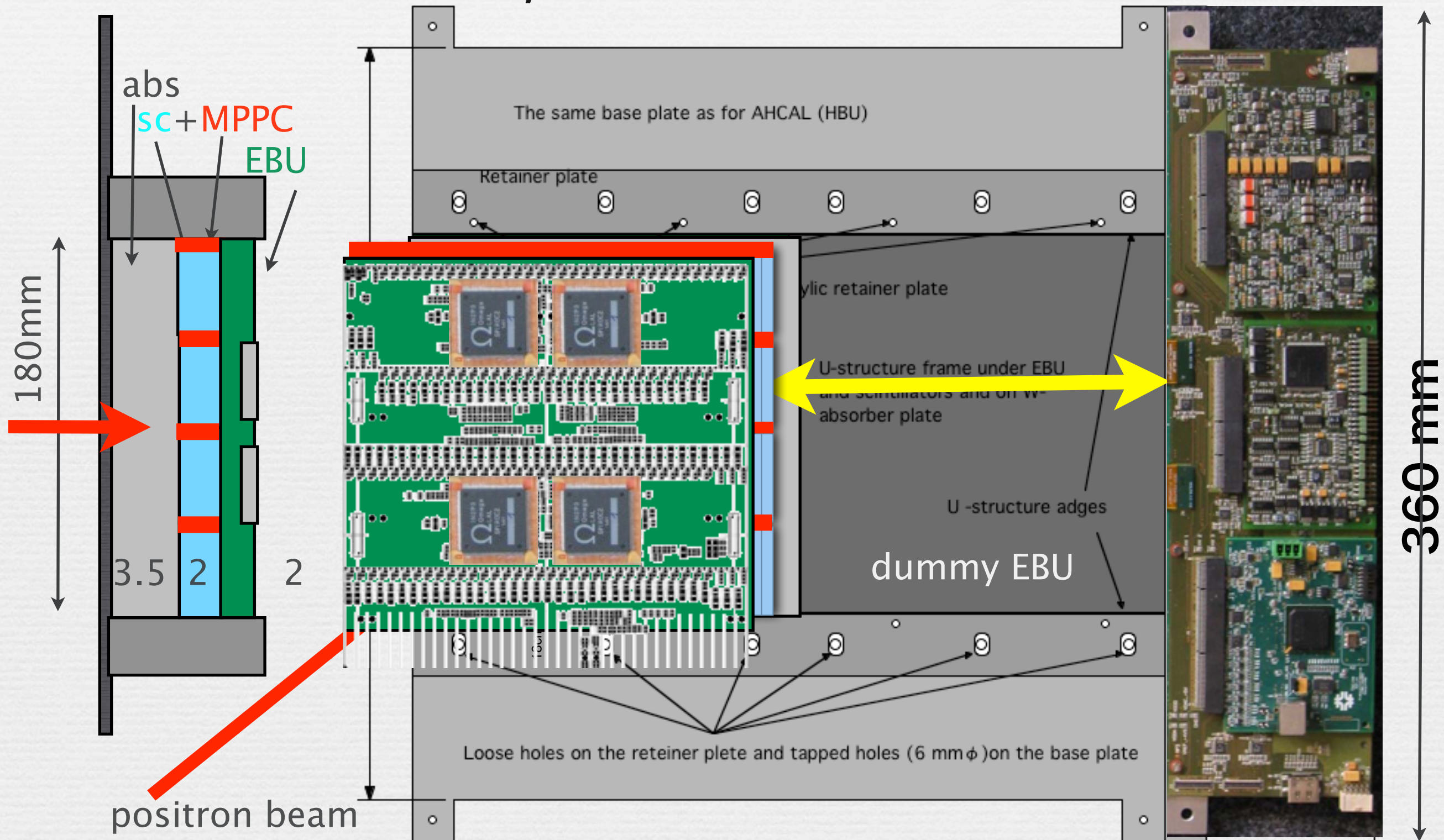
360.00

100.00

At the beam

Oct/2012 at DESY

DIF
AHCAL



TT LCWS12 @ Texas

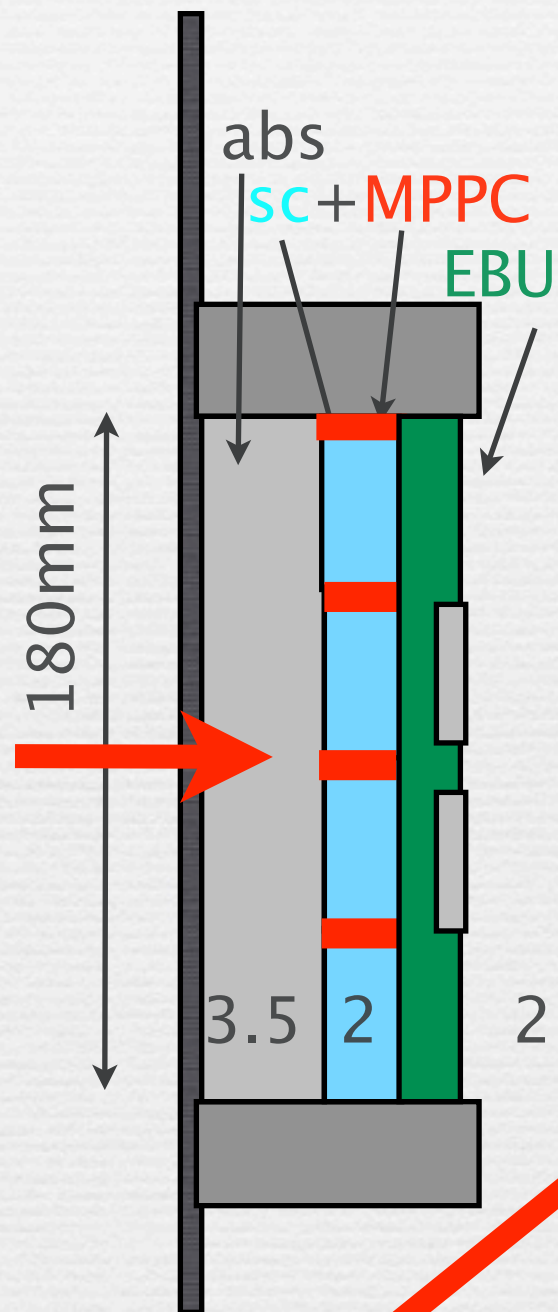
360.00

100.00

At the beam

Oct/2012 at DESY

DIF
AHCAL



positron beam



TT LCWS\$12 @ Texas

360.00

100.00

results of DESY BT

Oct/2012

- an integrated layer (absorber, scintillator, photo-sensor, and read out electronics combined in 5mm thick) is being tested

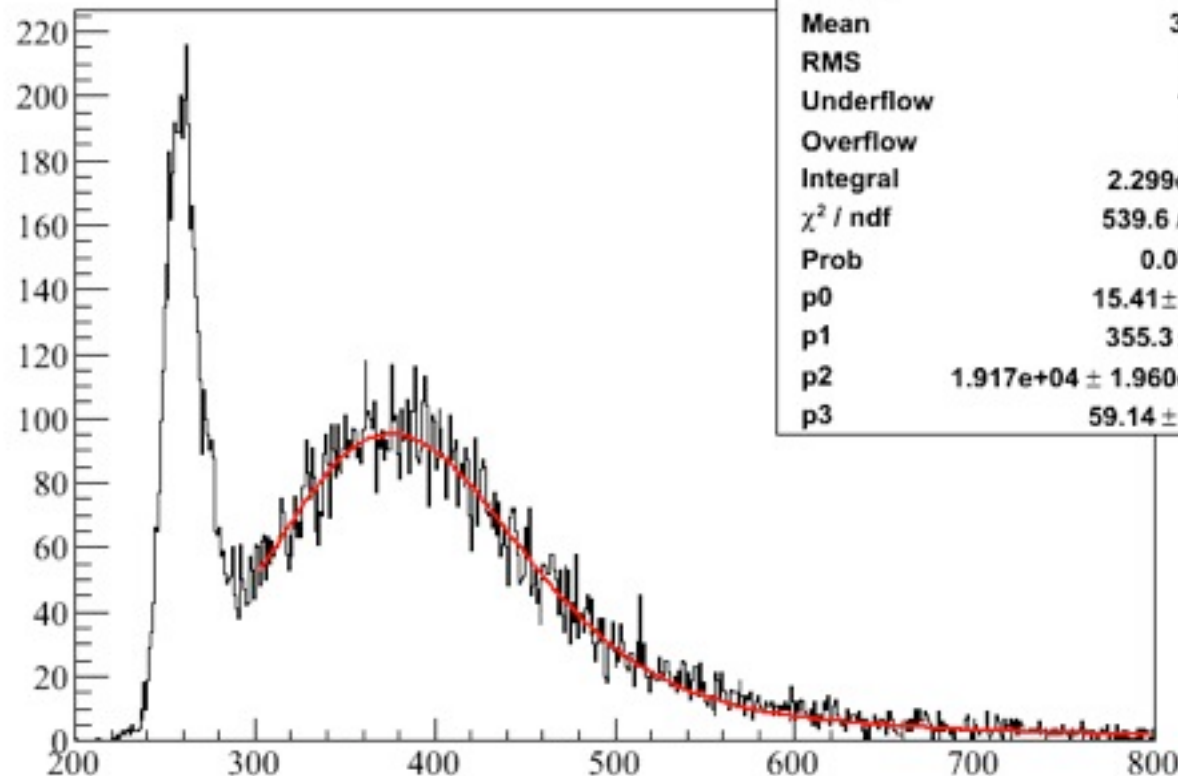
ADC dist. fro MIP

MPV-MIP(ADC) for 25 ch.

ADCData {ChipID==132&&ChannelNumber==8}

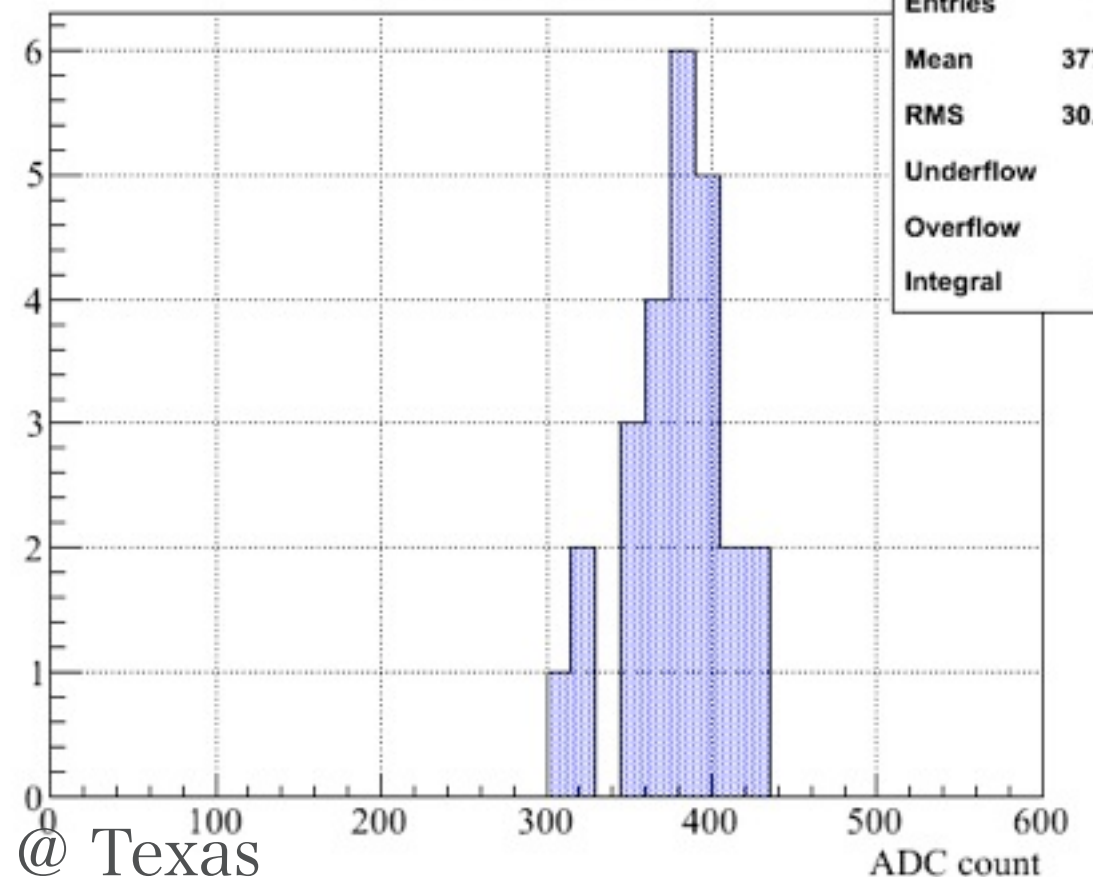
ADCData

Entries	25181
Mean	379.6
RMS	104
Underflow	1937
Overflow	252
Integral	2.299e+04
χ^2 / ndf	539.6 / 493
Prob	0.07187
p0	15.41 ± 0.57
p1	355.3 ± 1.1
p2	$1.917e+04 \pm 1.960e+02$
p3	59.14 ± 1.75



TT LCWS12 @ Texas

Entries



MPV

Entries	36
Mean	377.7
RMS	30.39
Underflow	0
Overflow	11
Integral	25

SCECAL summary

- ❖ **scintillator strip ECAL**
- ❖ **tested at Fermilab at 2008 & 2009**
- ❖ **good linearity and resolution**
 $12.9/\sqrt{E} + 1.2\%$
- ❖ **next generation prototype being constructed and tested**
- ❖ **will be a good candidate for ILC - ECAL**