Status and News from the ECAL

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ECAL

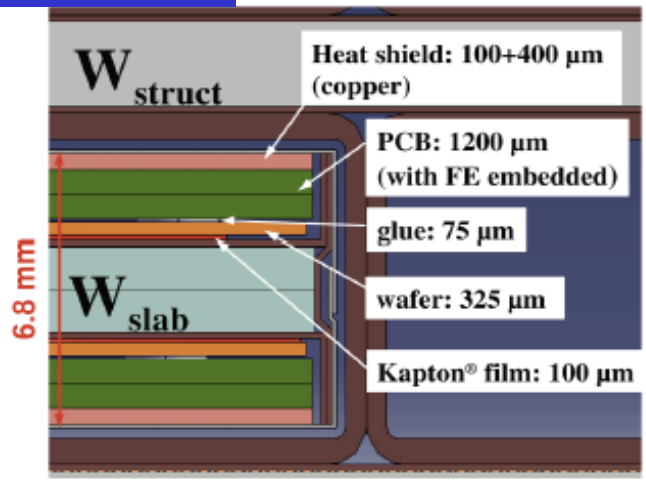
DBD configuration:
180 mm inner radius
Absorber: W

- 2.1 mm ($0.6X_0$) x 20
- 4.2 mm ($1.2X_0$) x 9
- 22.8 X_0 in total

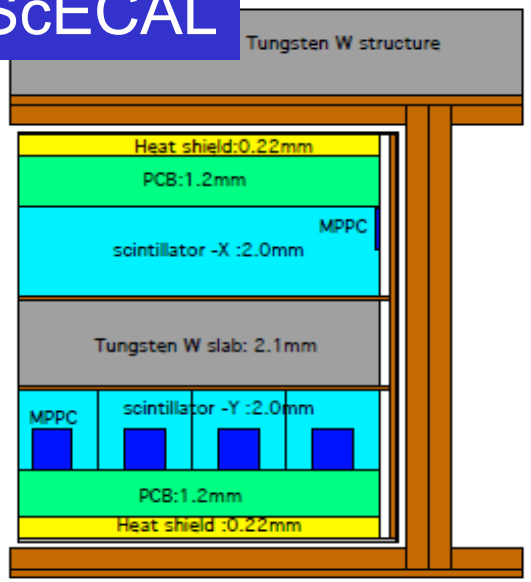
Readout
several options:

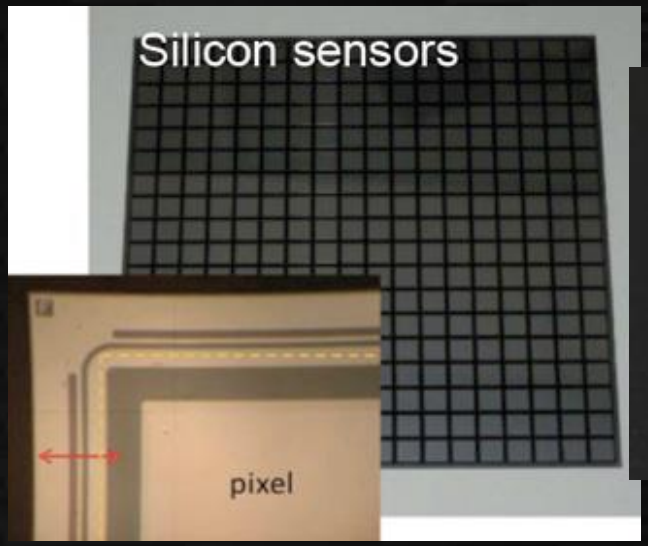
- Silicon ECAL
- Scintillator ECAL with SiPM
- Hybrid (Si + Sc)
- MAPS (digital readout, 50 x 50 μm pixel)

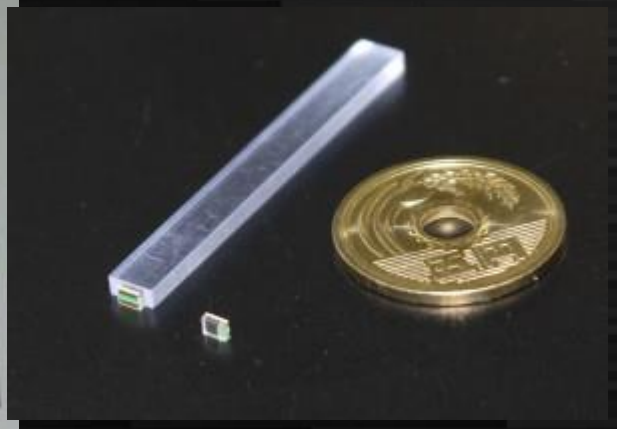
SiECAL



ScECAL







ECAL topics

- SiW-ECAL
- ScW-ECAL
- others
- Optimization

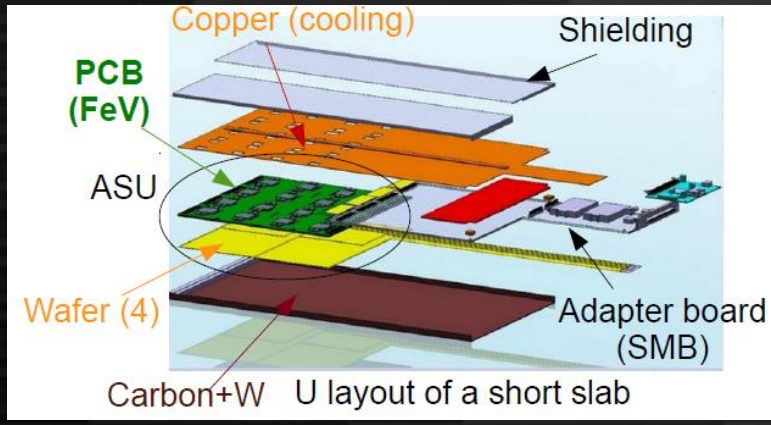
SiW-ECAL topics

- Test beam @ CERN SPS with CMS November 4-16 (ongoing!)
- First test of Chip-on-board
- 500 μm sensor arrived
- Radiation tests
- Hexagonal sensor
- Integration issue

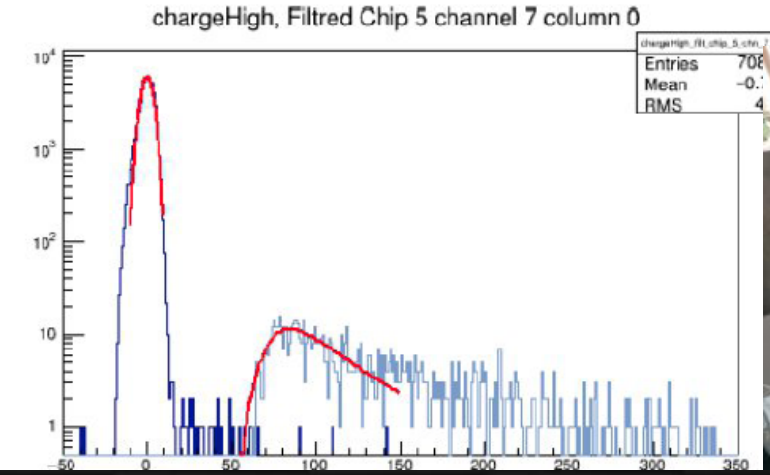
FEV11

FEB11 features

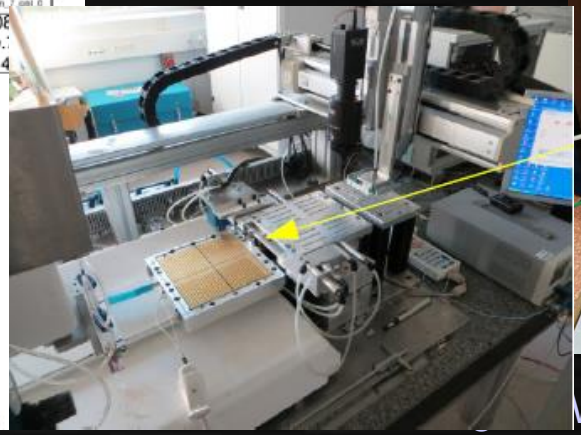
- One board / four wafers, 16 ASICS
- Long slab tested on 4 FEV daisy-chained
- Fixed the problem on afterpulsing
- Fully compatible with power-pulsing



Example of Cosmics for 1st glued ASU, Not et assembled (not fully shielded)

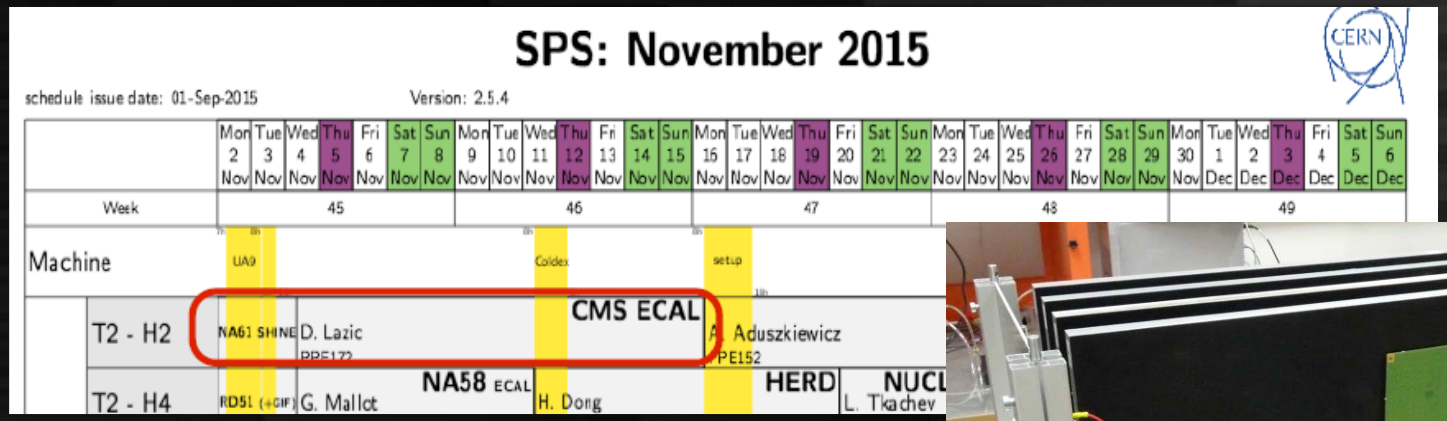


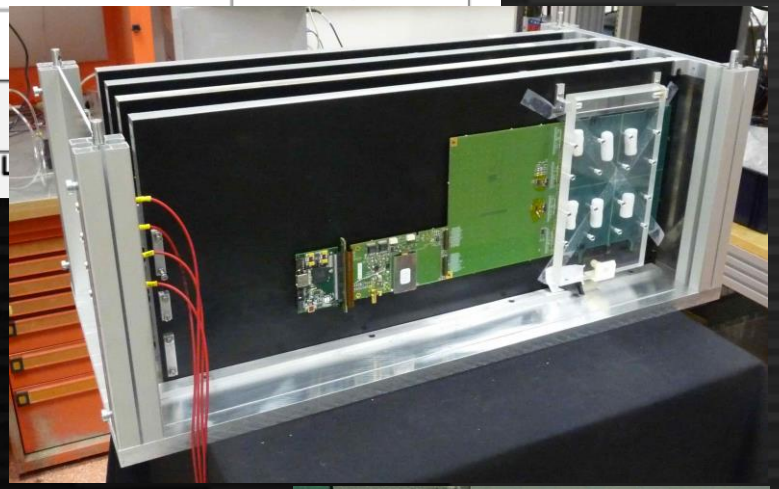
Gluing machine used for FEV11



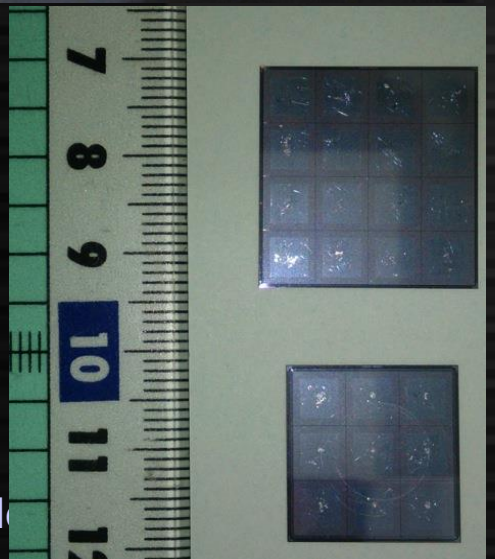
Glued FEV11 on cosmic test

Test beam plan





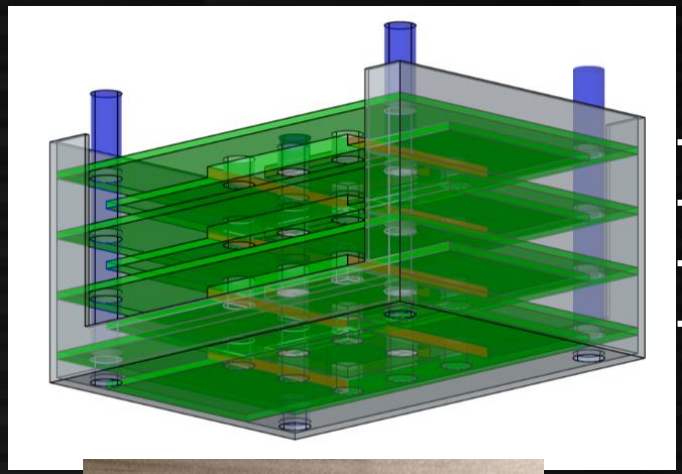
- SPS north area, H2 beamline, “CMS ECAL”
- Nov. 4 – 16, ~20 participants support from AIDA2020 TNA
- Four FEV11 slabs + babies FEV with temporary setup babies include 0/1/2 GR

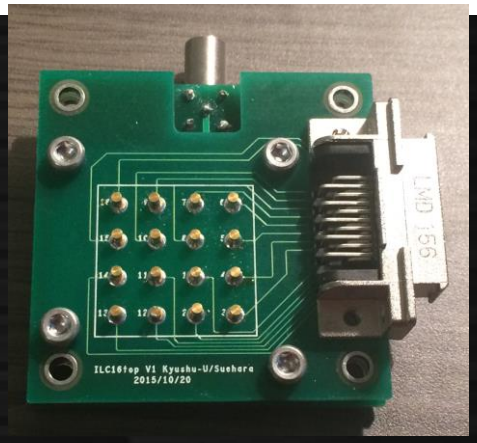


Baby sensor readout at testbeam

CALICOES-compatible raw data format

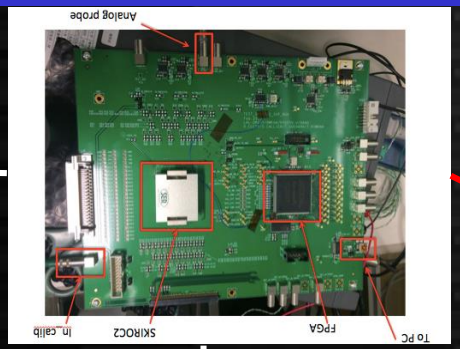
Sensor box (4 x baby(4x4/3x3))





PCB assembly with pins
Silicon inside two PCBs

test board input (64 ch)



USB readout (C++, not LabView)

PC

slow clock

Ethernet (acq_stop)

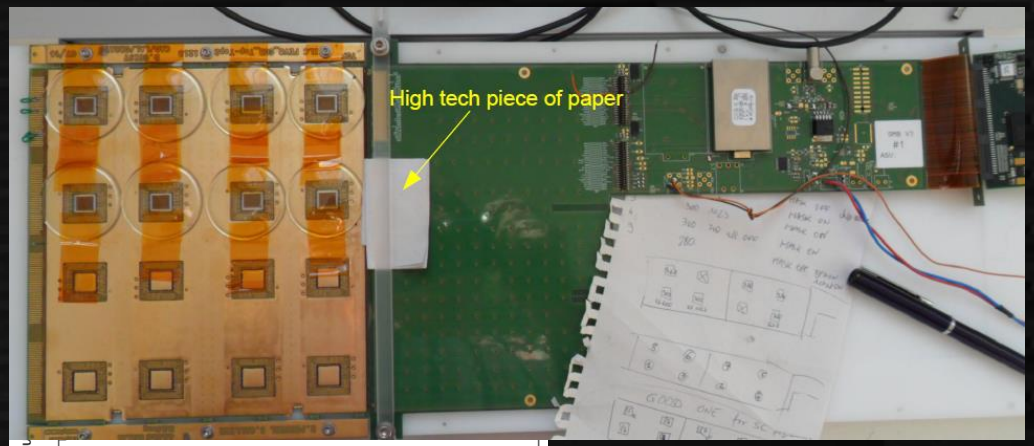
Adapter board

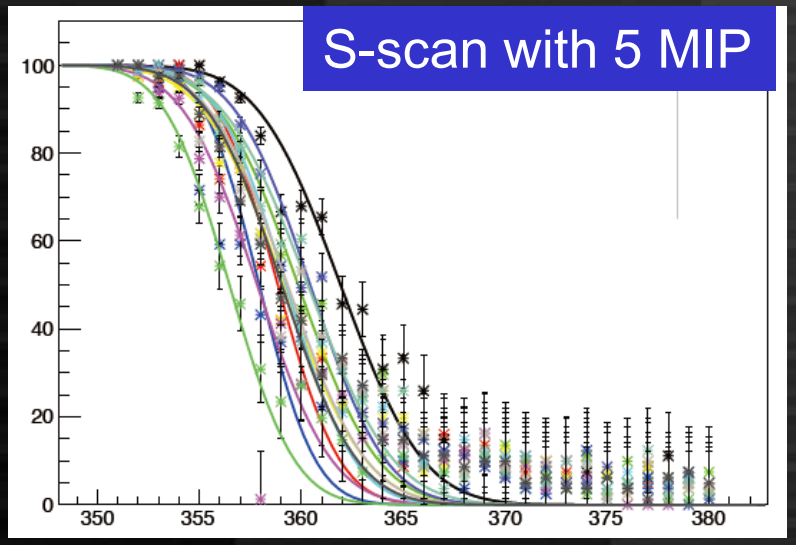
HDMI

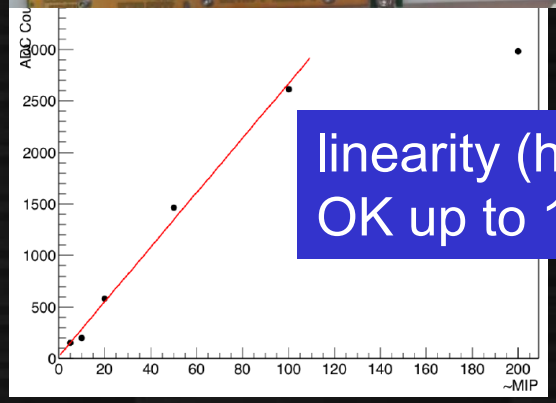
CCC

- Shower extension (with FEV)
- Guard ring effects (0/1/2)

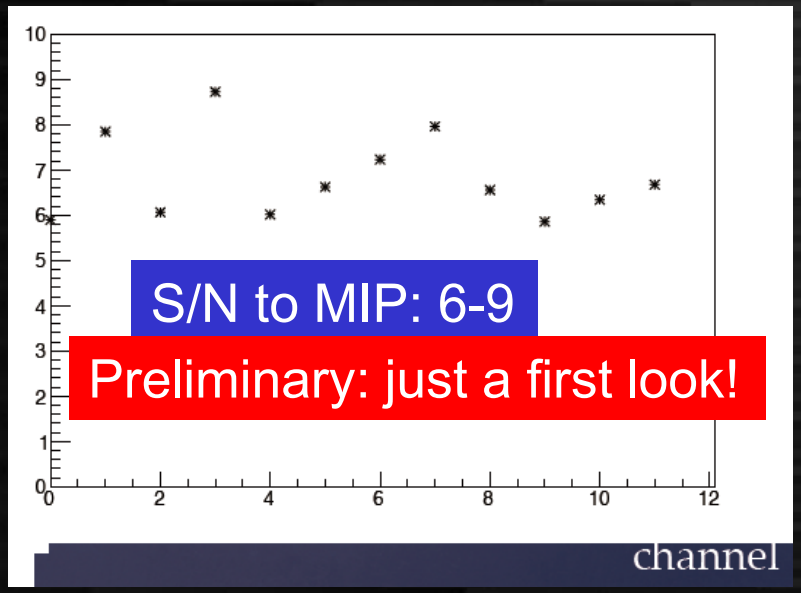
First test on Chip-on-Board





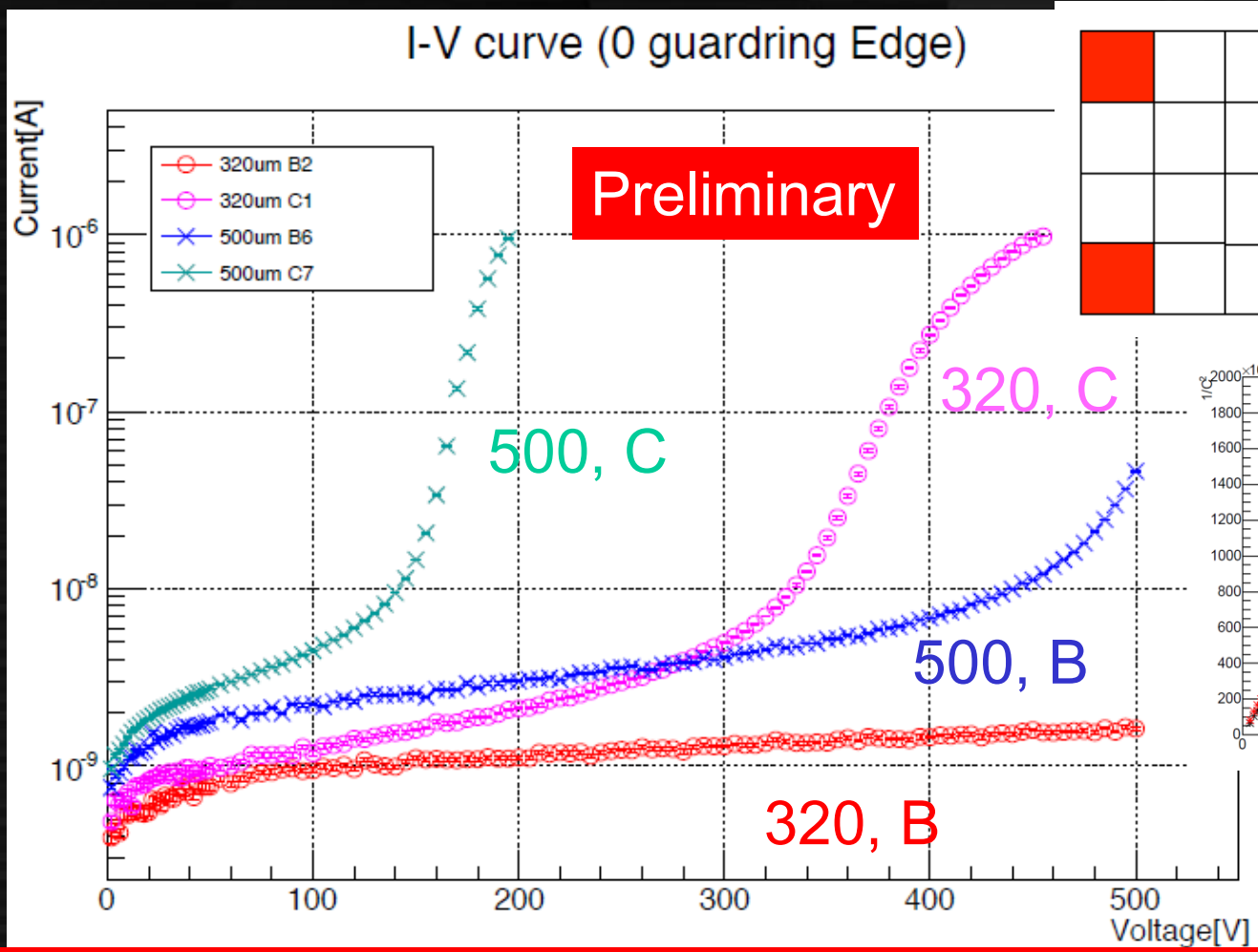


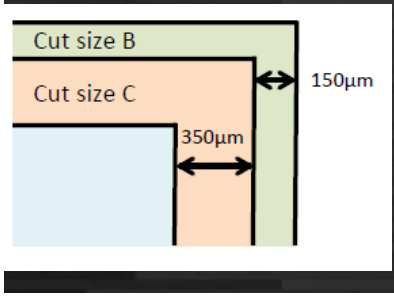
linearity (high gain)
OK up to 100 MIPs

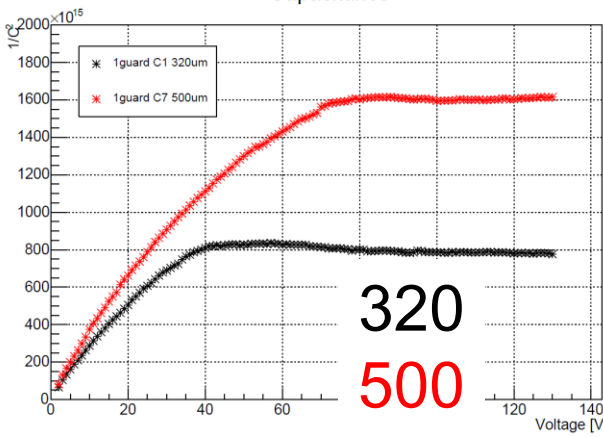


- Relatively in good shape (at least working)
- Noise reduction needed (better grounding etc.)

A new results of 500 μm sensor







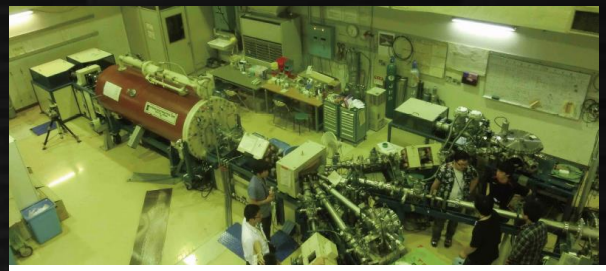
Full-dep. voltage
~40V in 320 μm
~80V in 500 μm

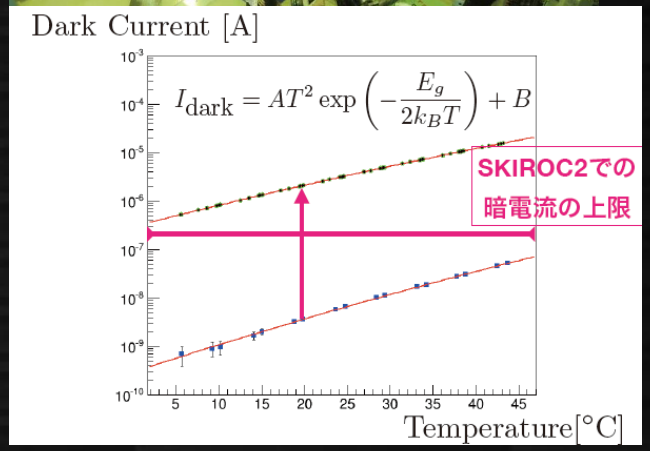
Cut size B - 500 μm is OK → go to test beam

Another investigation, non-Hamamatsu, 8 inch, 700 μm ongoing

Irradiation test

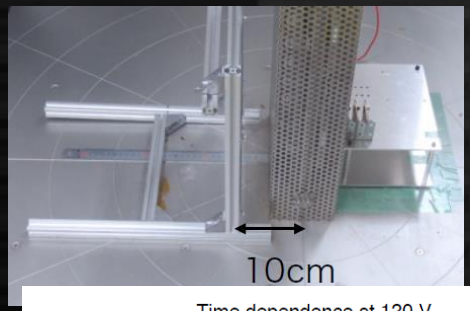
Neutron @ Kobe U, Jul-Aug 2015



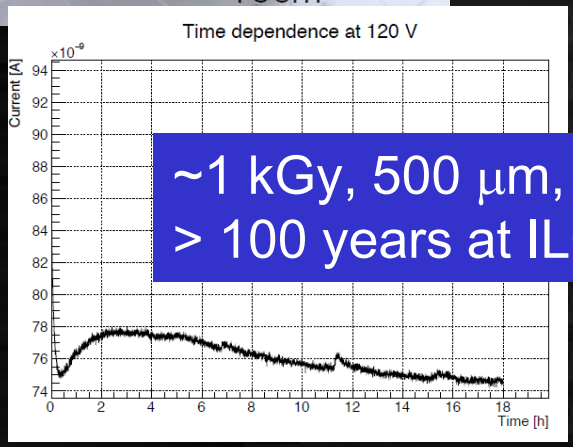


~1000 times more dark current on
~7.5 x 10^{11} neq/cm^2
acceptable in ~10^{10} neutrons
capacitor & glue OK on 10^{12}

Gamma @ Kyushu U, Oct 2015



^{60}Co,
~82 TBq

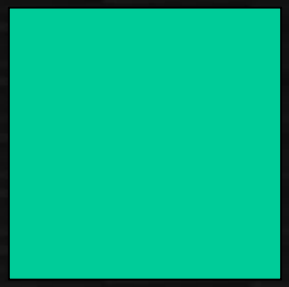


~1 kGy, 500 μm, 4GR
> 100 years at ILC

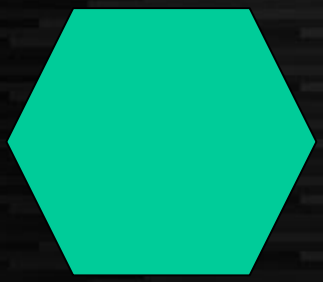
Without bias during irradiation
~5 times larger current seen
Crosstalk should be checked
Continue irradiation on 0/1/2 GR

Silicon is in general robust to radiation: continue investigation

Hexagonal sensors

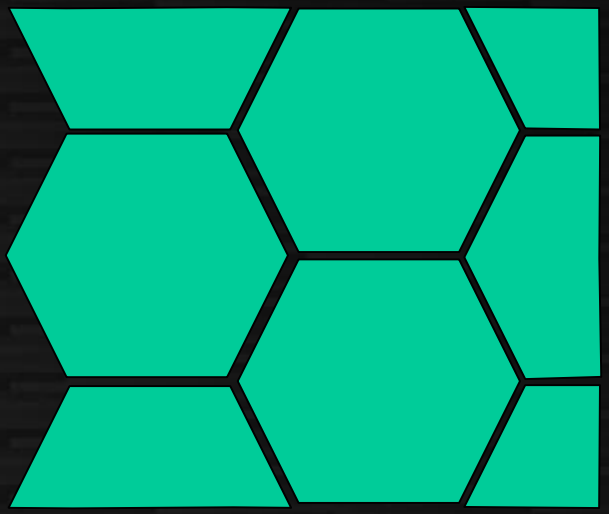


Square
Max. 9.8x9.8 cm^2
Area = 96.04 cm^2

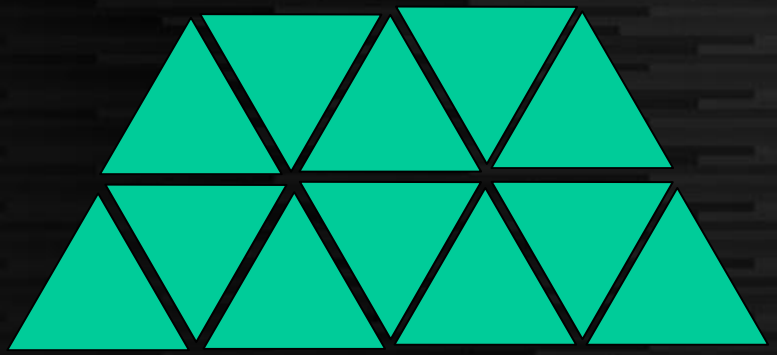


Hexagon
Max. 6.9 cm each edge
Area = 123.69 cm^2
(28.8% larger than square)

28.8% more area per wafer → 22.4% less wafers needed



Preliminary idea
of “Slab for hexagon”



Idea of “triangle pixels”
for hexagonal sensors

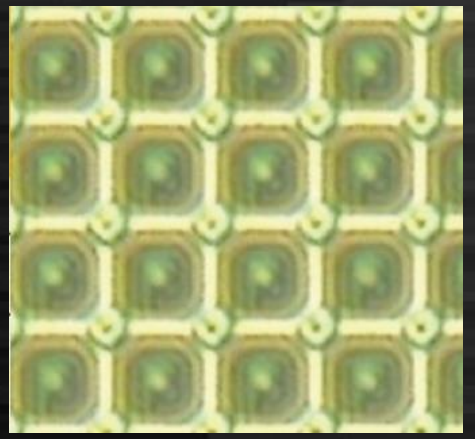
Production of baby submitted:
available in March 2016

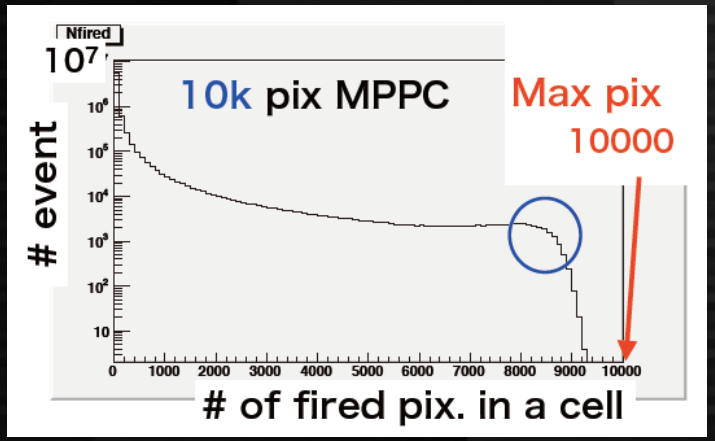
ScW-ECAL topics

- 10 kpix MPPC
- Readout position
- Test beam @ CERN SPS, July & August
- Strip + tile reconstruction

10 kpix MPPC (cf. 1.6k old)

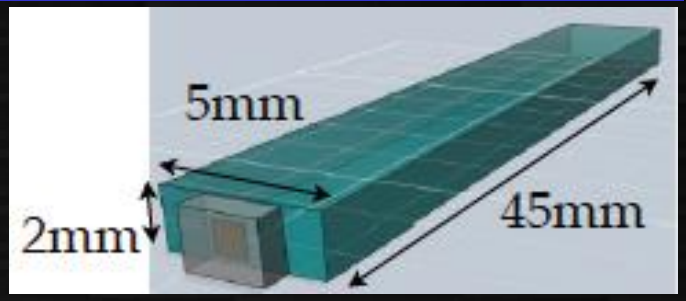
- 1 x 1 mm (10 μm pixel)
- Necessary to avoid saturation in up to 250 GeV electron
- Smaller gain (~1/2?)
- Higher noise
  → better amplifier needed
  (Current SPIROC
  not satisfactory)
- Crosstalk
  - Trench can be implemented by Hamamatsu





Readout position

Vertical readout (default)



- ○ simple shape of scintillator
- ○ good collection efficiency
- × yield depends on position
- × dead volume

Bottom readout

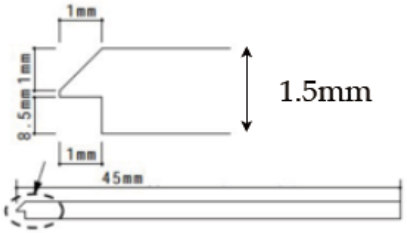
- ○ uniform response on position
- ○ no dead volume
- ○ easy assembly of MPPC
- × yield slightly lower
- × complicated scintillator shape

Long MPPC (under study)

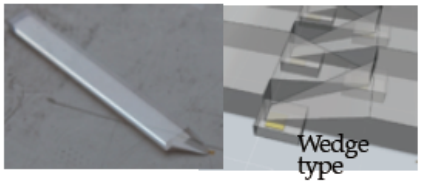
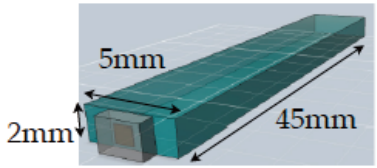
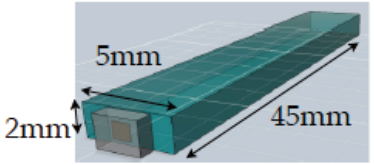
Bottom readout with 4 mm × 0.25 mm MPPC

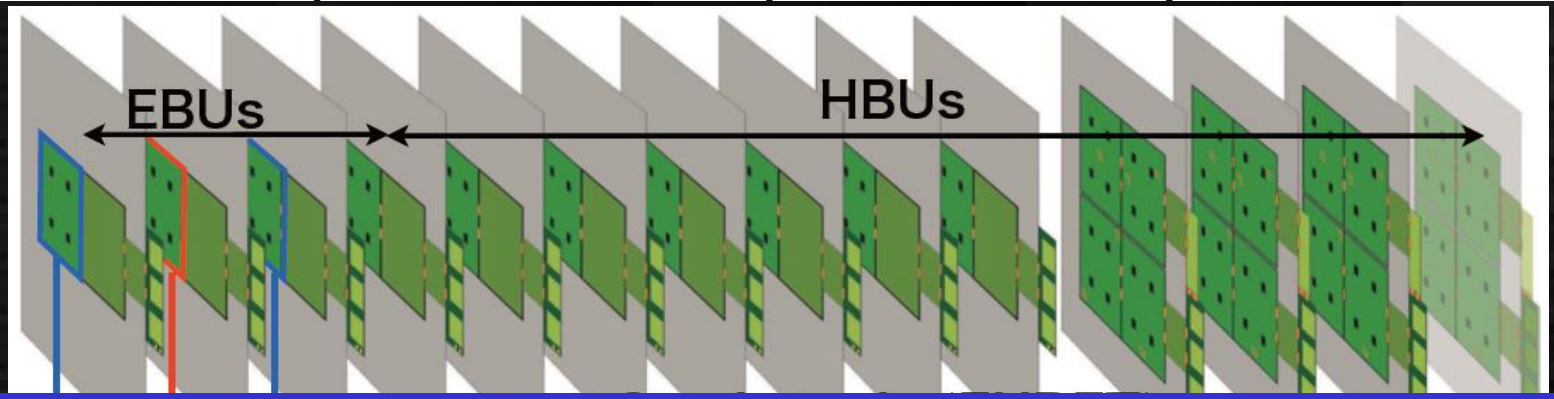
MPPC with shade

Instead of real 4 × 0.25 mm² MPPC, a shade is temporally used.



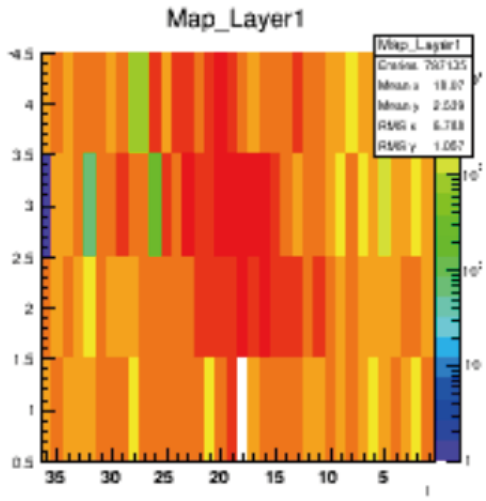
TB in July and August

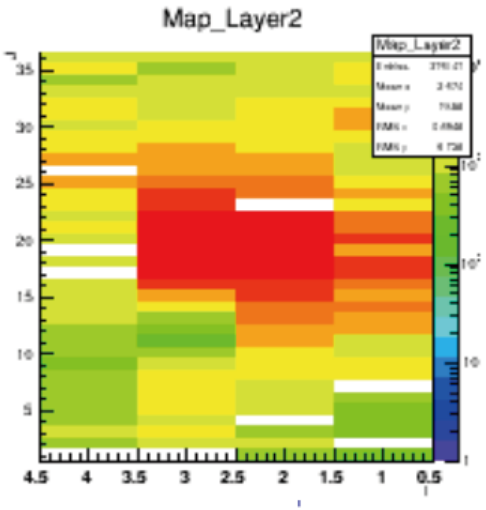
	EBU_0 (1st layer)	EBU_1 (2nd layer)	EBU_2 (3rd layer)
direction of strips	Transverse	Longitudinal	Transverse
MPPC	10 k pixels in 1×1 mm²	10 k pixels in 1×1 mm²	1.6 k pixels in 1×1 mm²
Scintillator	Bottom readout(wedge) 	Default 	Default 

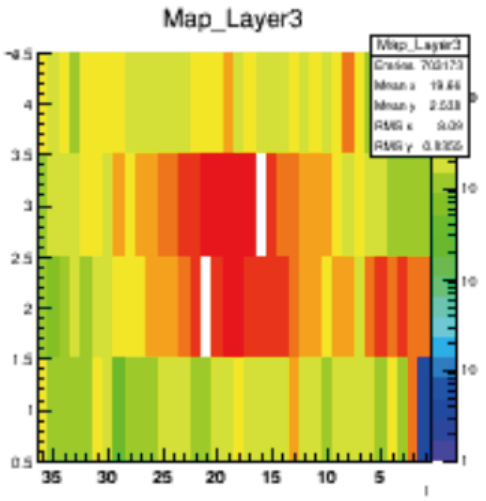


EBU_1 only in August, noise of EBU_0 higher in August

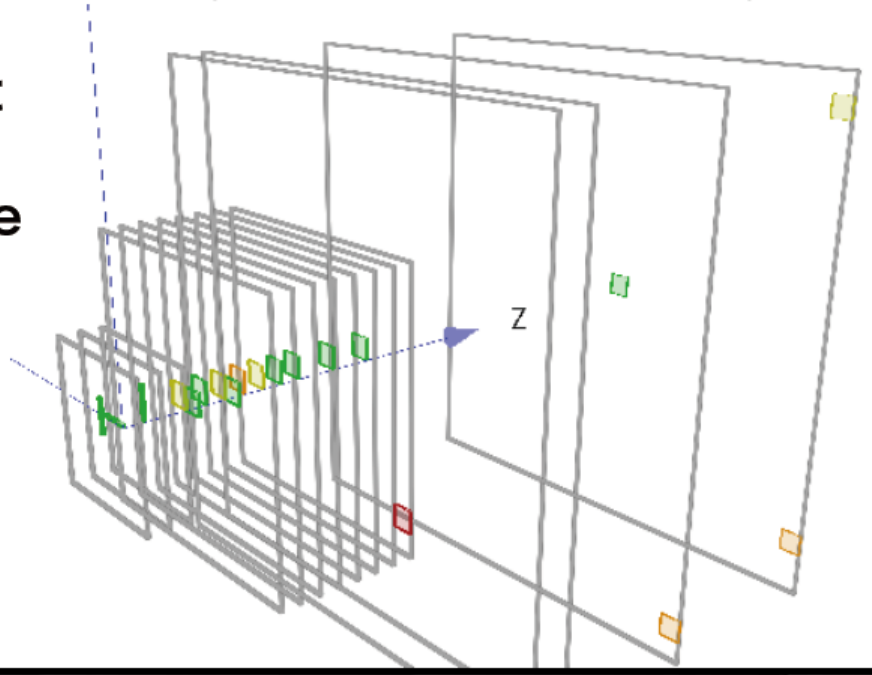
First look of TB (August)





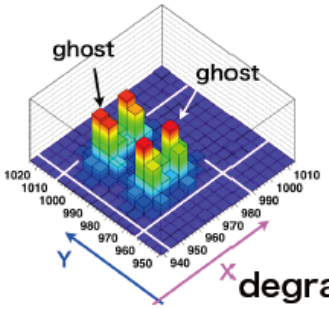


Although first layer is a bit noisy, we have both longitudinal and transverse layer at least.



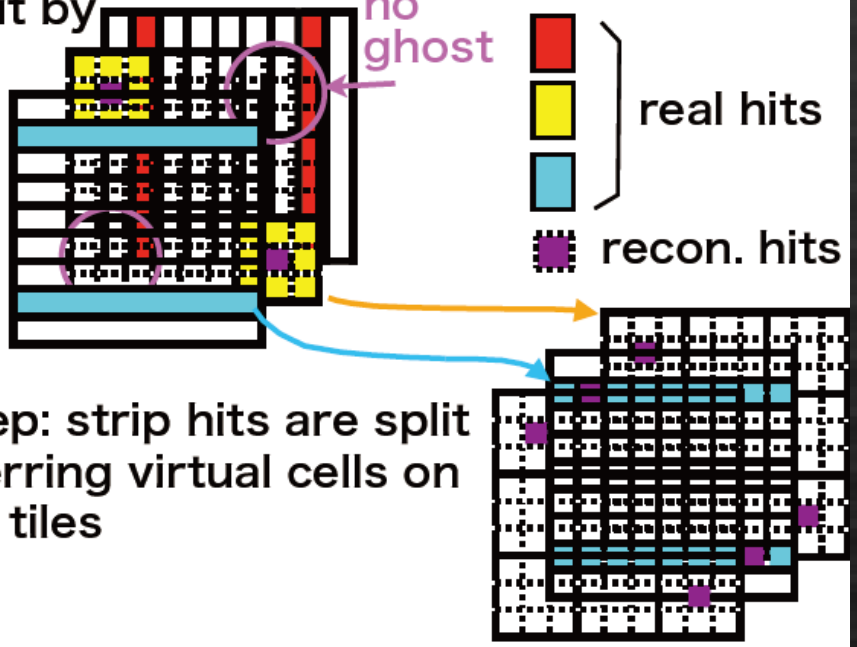
MIP separation is still not good in 10kpix MPPC

Strip + tile reconstruction



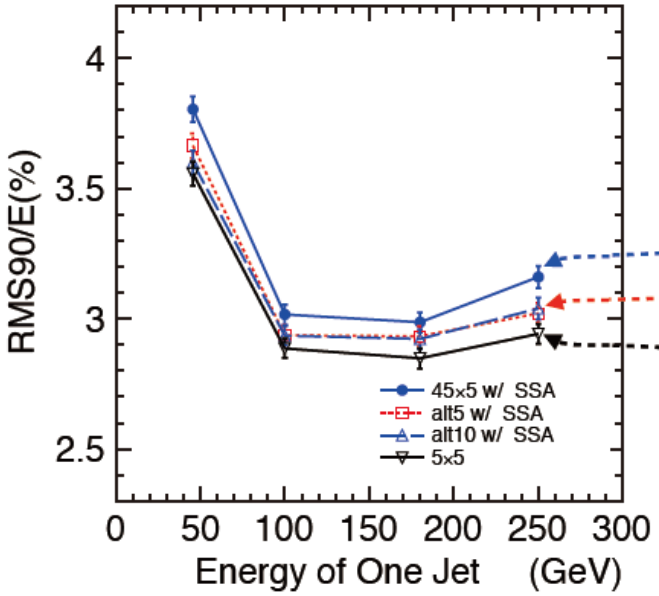
degradation comes from twofold ambiguities

1st step: tile hits are split by referring strip hits



2nd step: strip hits are split by referring virtual cells on square tiles

ECAL case



Strip only (45x5mm²)trip w/ SSA

Strip + tile(5×5mm² or 10×10mm²)

Tile only (5x5mm²)

Strip + tile seems promising

Others – precise shower locator

- Identify “photon direction” precisely
  → shower start finder at inner several X0 in ECAL
- 2+1 options (below)
- Physics should be investigated (eg. H→ττ CP)

MAPS

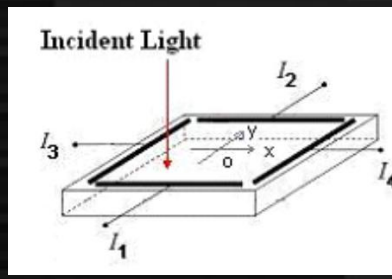
- 50 μm digital ECAL proposed
- ATLAS development?
- Cost? Feasibility?

Si pads with smaller pixels

- 2 mm possible?
- ASIC, COB needed? (for space)

Position sensitive silicon

- Several pads / cell
  pads at the edges
- Popular in optics
- Signal divided:
  require more S/N
- Issue on multiple hits
- Test production submitted



Optimization

- Cost – DBD ECAL cost is "average" of Silicon and Scintillator
  → Si-only ECAL has intrinsic "30%" increase
- Keeping cost is important (cf. accelerator)
  → aim to reduce cost by 30%!

Small ILD

- ECAL inner radius: 1.8 → 1.6m
  → 11% reduction (or 21%)
  + more (HCAL, coil, yoke...)
- # of layers: eg. 30 → 26
  → 13% reduction

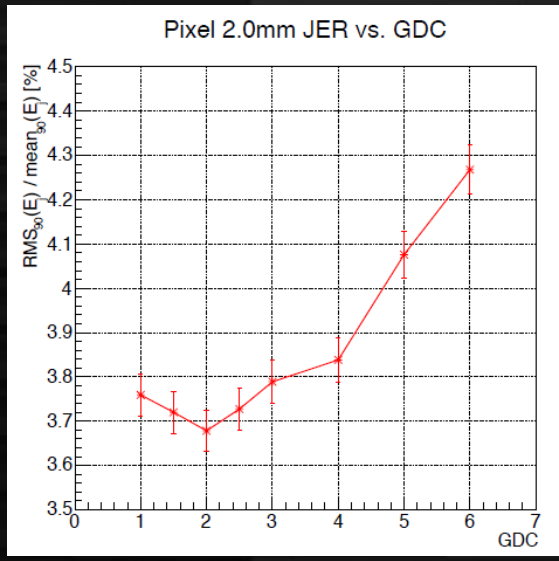
Hybrid ECAL

- Natural idea – average of Si and Sc – half & half
- ~15 layer of Si, ~15 Sc
- Inner Si + outer Sc?
  or (partially) alternate?

Detailed performance comparison needed

Optimization – things to consider

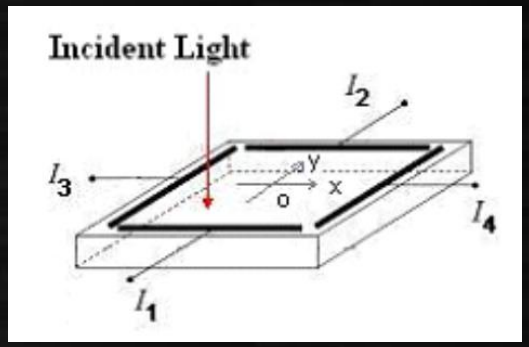
- Detailed optimization
  - Absorber thickness:
    currently 0.6 X_0 x 20 + 1.2X_0 x 9 = 22.8X_0
    → why two configuration? why 1:2?
  - Software optimization
    → SSA? Generic distance cut? ...
  - Pixel size at outer layer?
- Reliability of hybrid
  - Calibration?
  - MPPC irradiation (esp. endcap)?

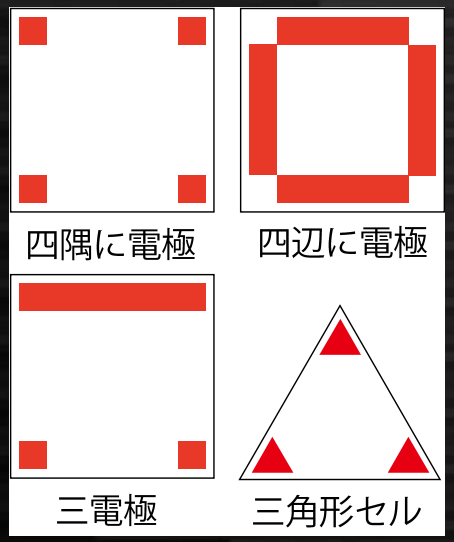


Summary

- Test beams give us much progress
  - From data obtained
  - From time constraint that pushes us(!)
- Hardware optimization still ongoing
- Should consider “edge”
- Optimization: still lot to be done

New idea – position sensitive det.

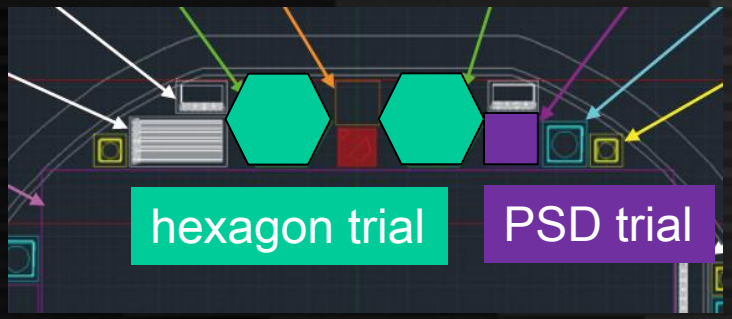




ideas on electrodes

Position sensitive detector (PSD) popular in laser measurement (produced by Hamamatsu)
Application on heavy-ion exists

Divide signal into several electrodes
→ less S/N expected
No much difference on electronics
For “precision shower start finder” to be used in inner layers of ECAL



Hexagons and PSD submitted along with other experiments
~50 sensors on March 2016
(~300 on 2016-2017)