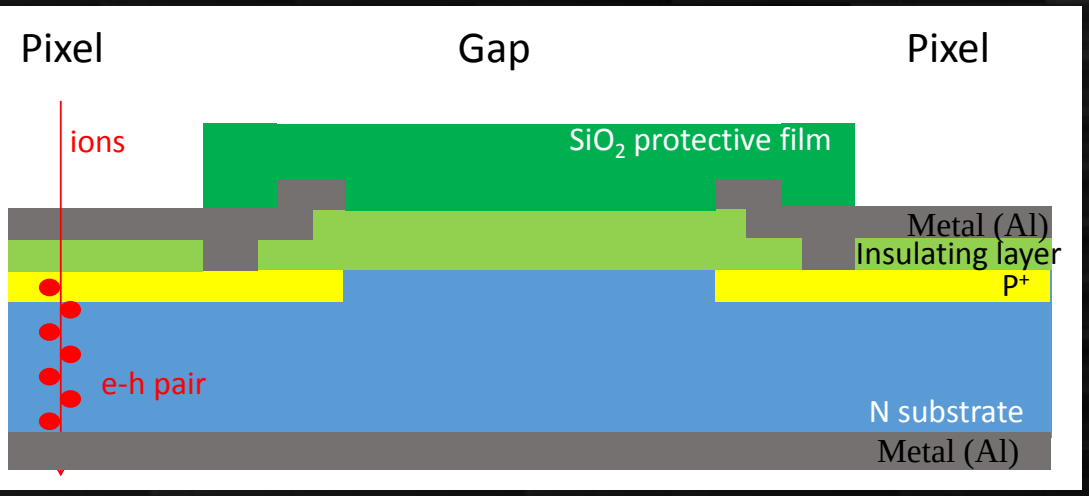
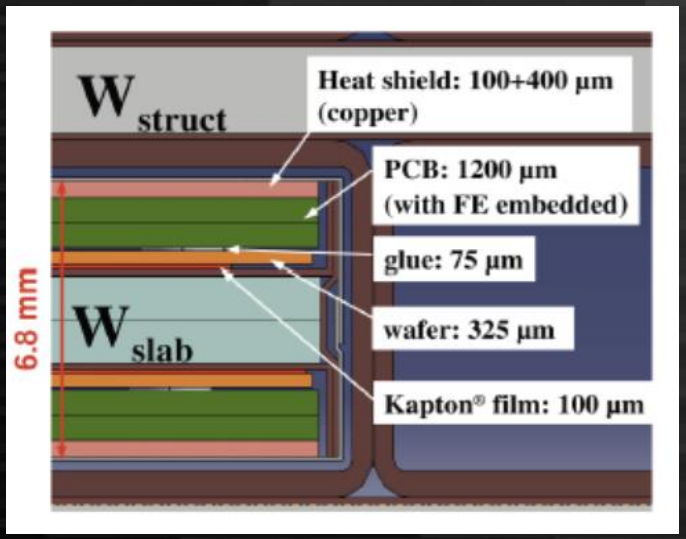
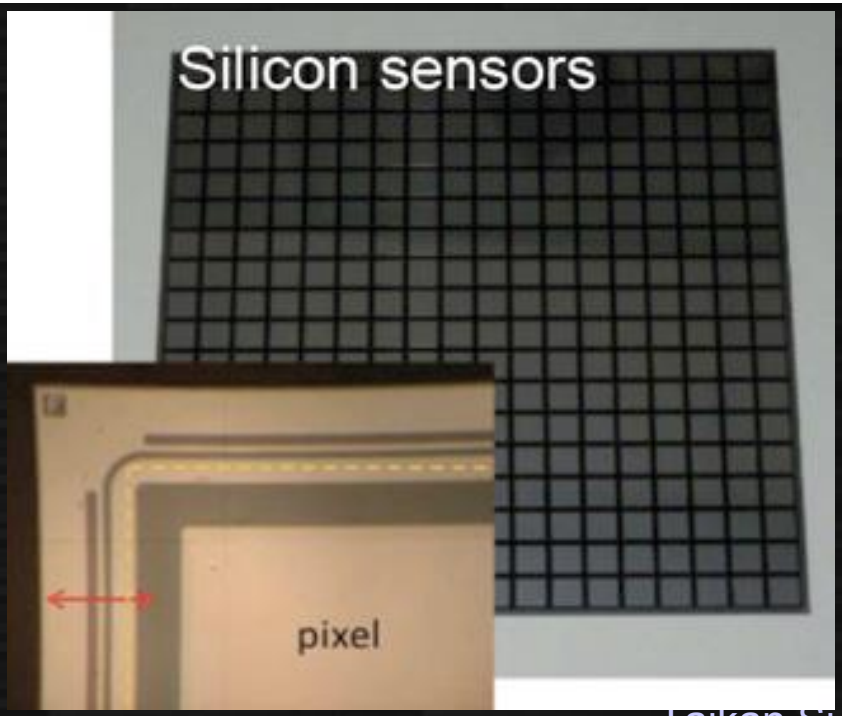
Status of the CALICE SiW ECAL

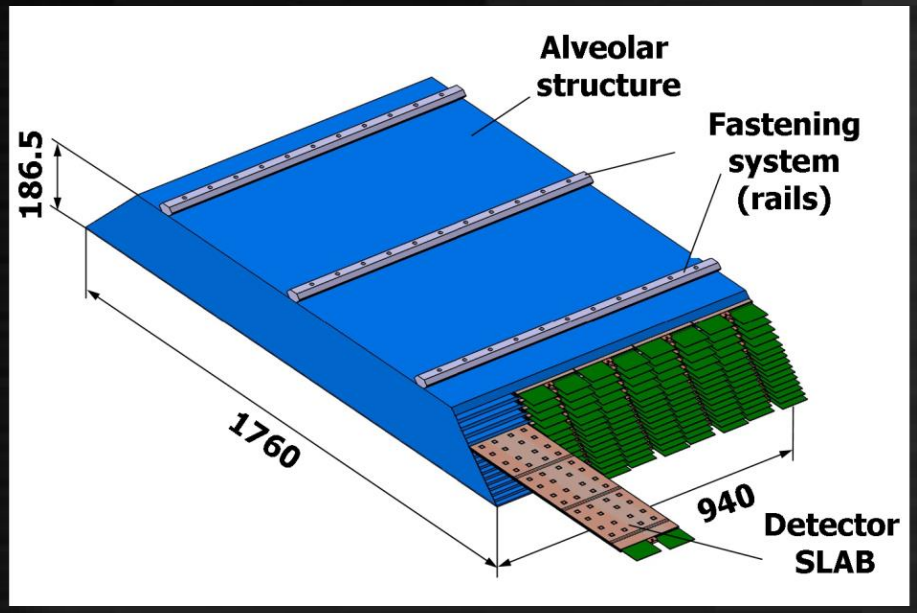
Taikan Suehara
(Kyushu University, Japan)

SiW-ECAL: design









Progress in SiW-ECAL

Electronics & test beam

- FEB11 production
- Test beam plan
- Chip-in-board progress
- SKIROC test board for BGA
- Baby sensor readout

Sensor design

- Resistivity
- Thickness
- Guard-ring, cutting edge
- Hexagonal sensor
- Radiation test
- New idea

Non-ILC activities

- CMS endcap calorimeter
- ATLAS preshower

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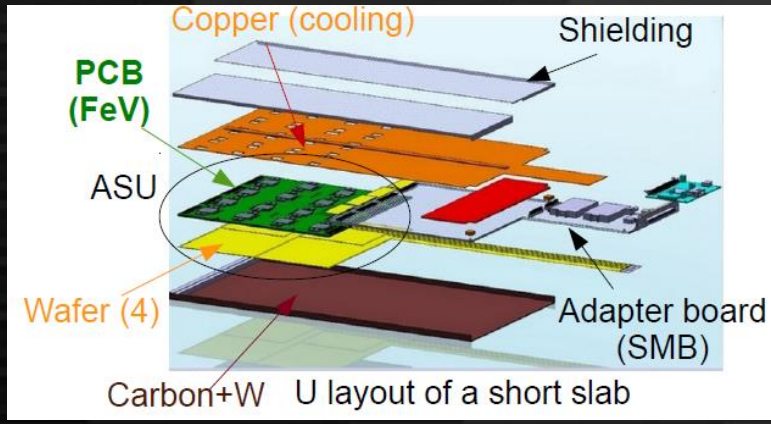
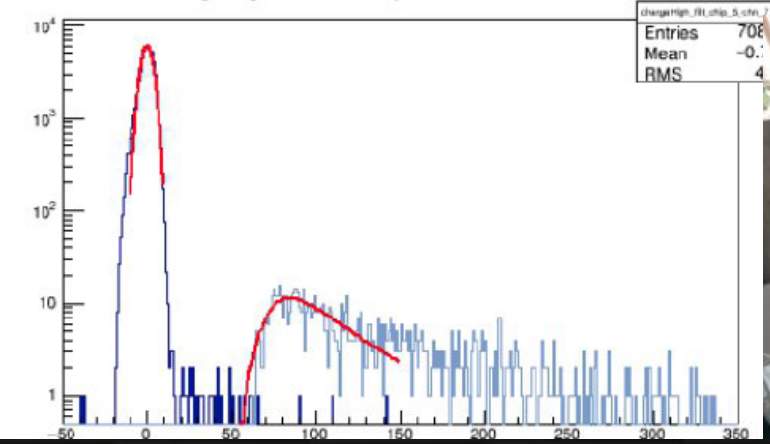
FEB11

FEB11 features

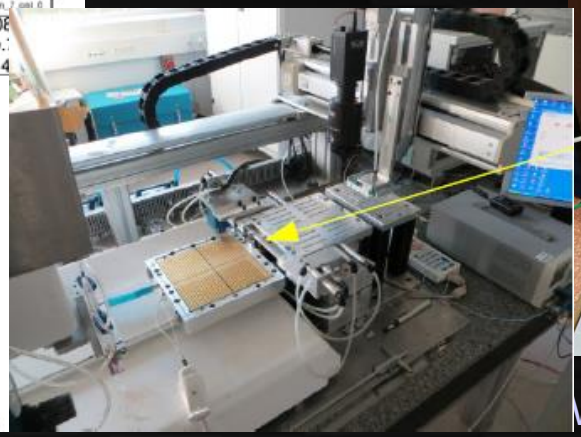
- One board / four wafers, 16 ASICS
- Long slab tested on 4 FEB daisy-chained
- Fixed the problem on afterpulsing
- Fully compatible with power-pulsing



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

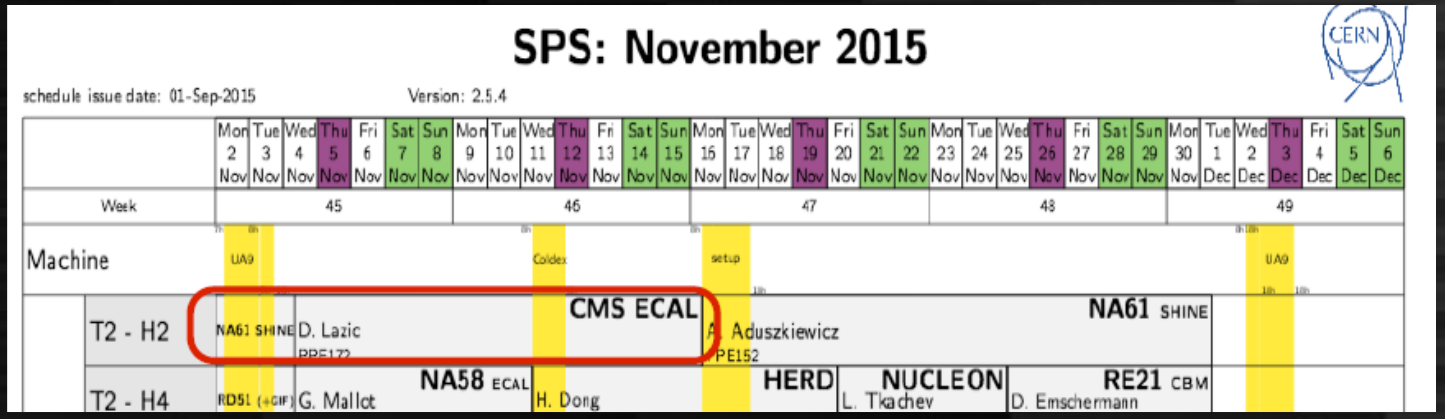


Gluing machine used for FEB11

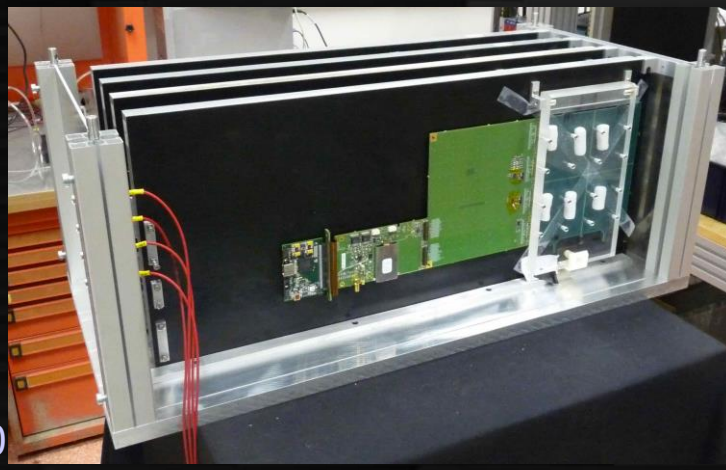


Glued FEB11 on cosmic test

Test beam plan



- SPS north area, H2 beamline, “CMS ECAL”
- Nov. 4 – 16, ~20 participants support from AIDA2020 TNA
- Four FEB11 slabs + babies FEB with temporary setup babies include 0/1/2 GR



(prelim) Physics program

Physics commissioning:

- Check proper running with high intensity μ's (X-check of cosmics)
- Thr. adjustment vs noise environment. (Maybe require shielding).

EM-Core Set-up: All slabs after 5 X_0 of W ⟶ Strong correlation between SLAB's

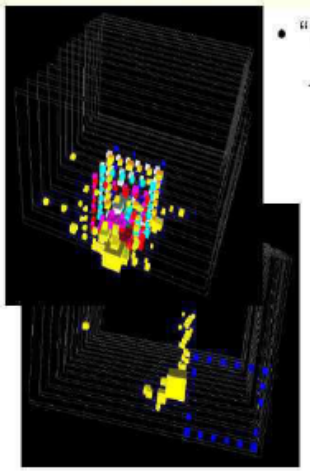
- Response at the core of a EM shower:
  - Explore the full dynamic range (1–2500 mips) using shower profile (for all mem depth).
    - e– runs of all energies, beam rates ⟶ linearity
  - Check the responses at the wafers edges with ≠ types of wafers (square events)
    - Scan in positions

HAD-Core set-up: same as EM-core *or* with 1λ of W / SS

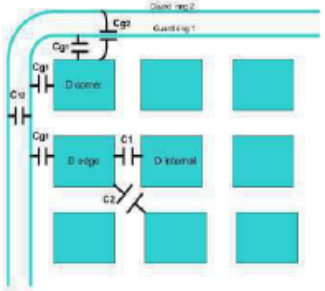
- Response to HE hadrons: look for SEU

Mini-ECAL set-up: Sampling with 3-4 × 2.5 X_0 and 2-3× 5 X_0

- Study of theoretical resolution & simulation tuning.
  - Scan in energy, position (and angle).



- "Square events"
  - cross talk between guard rings and pixels



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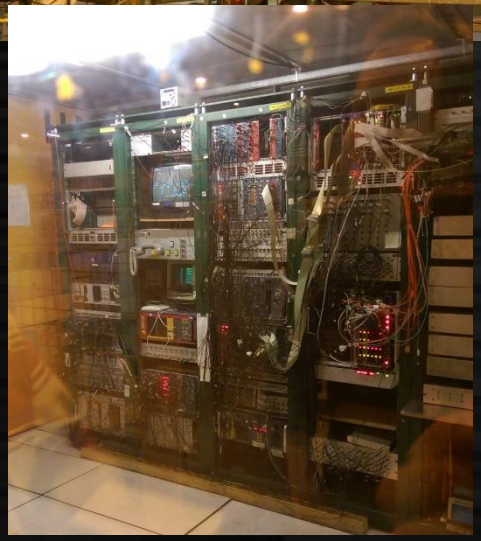
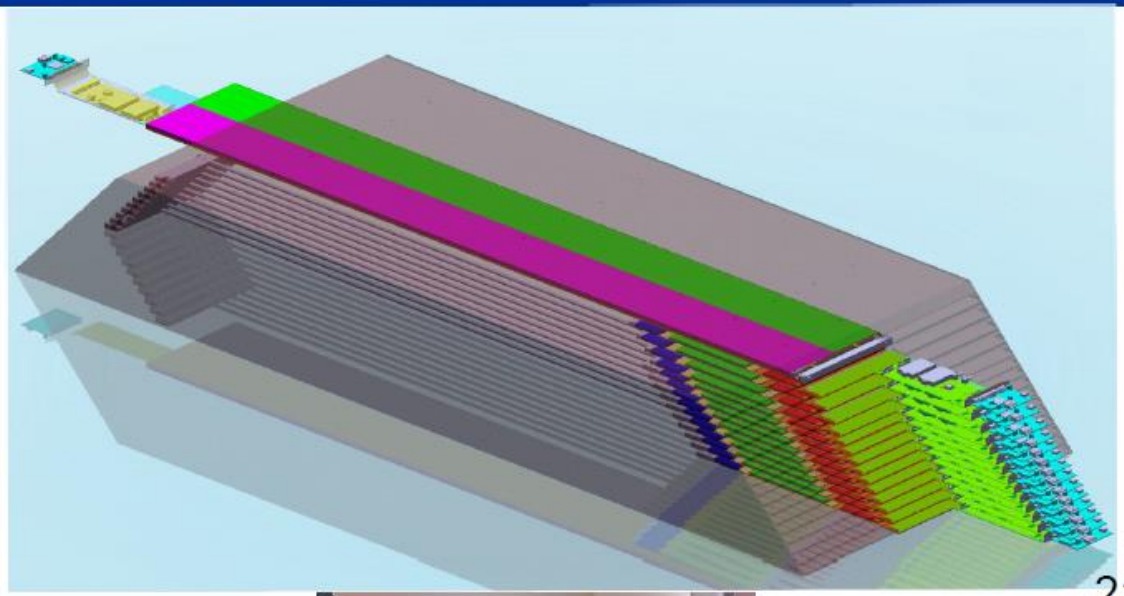
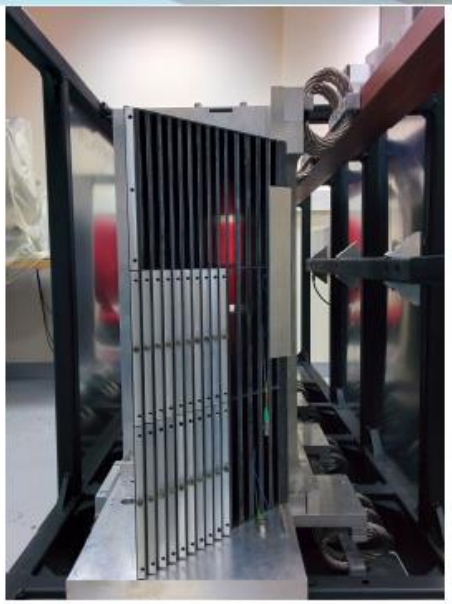
SPS H2 beamline



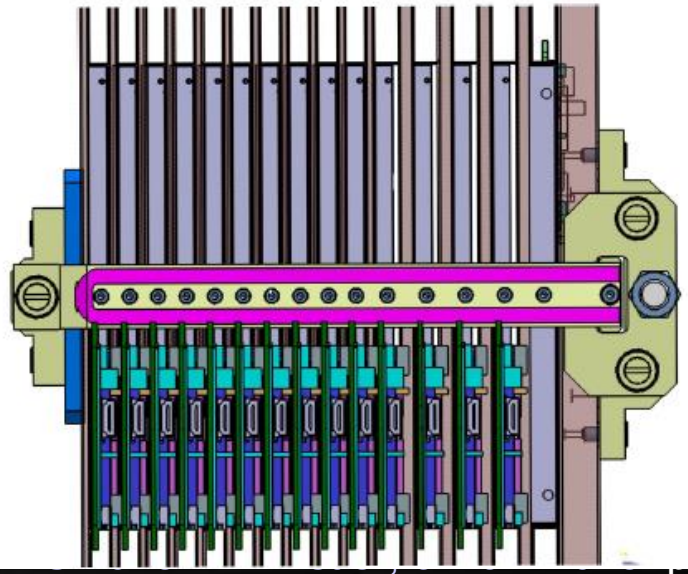
“Final” prototype test (2016+)



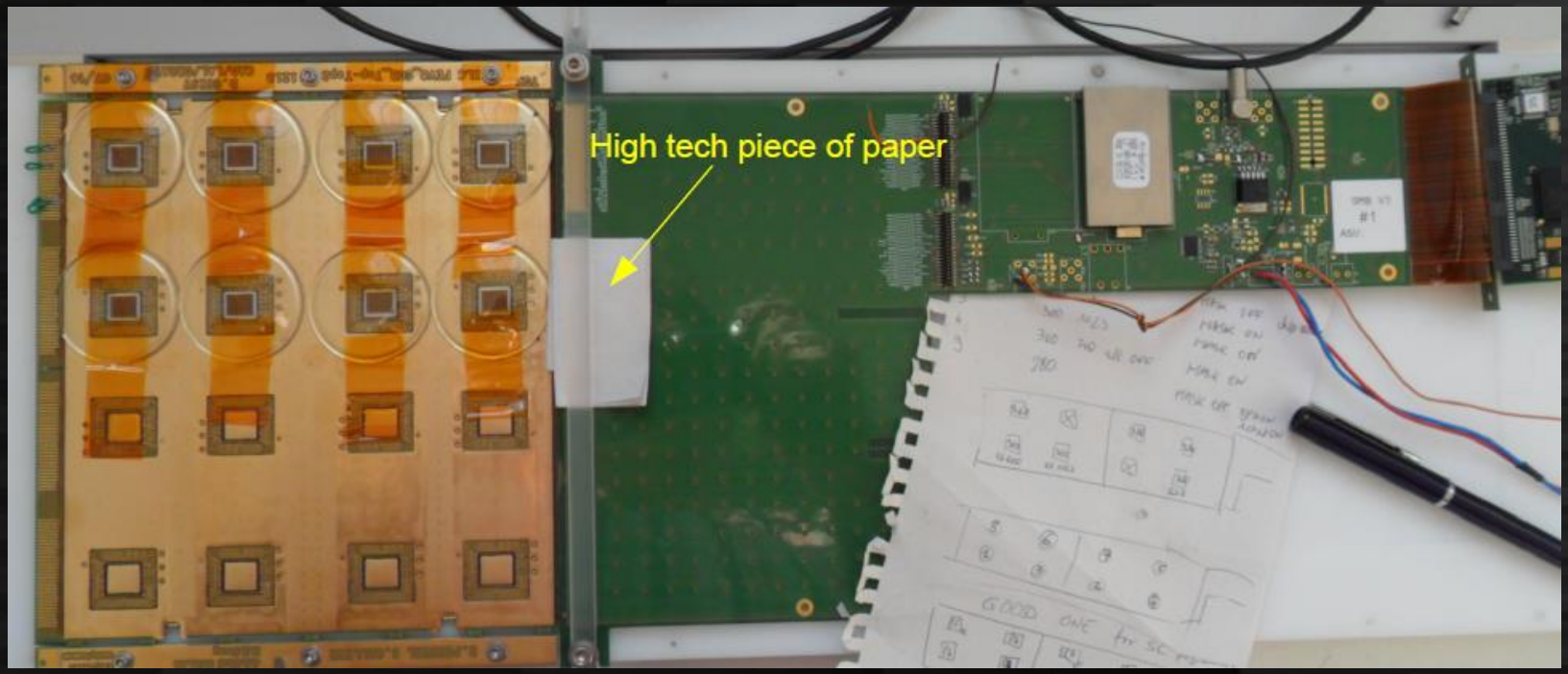
Tower of 18×18 cm² (2×2 wafers)
14 Short SLABs
1 Long SLAB



2×2.1mm/lay 2×4.2mm/lay

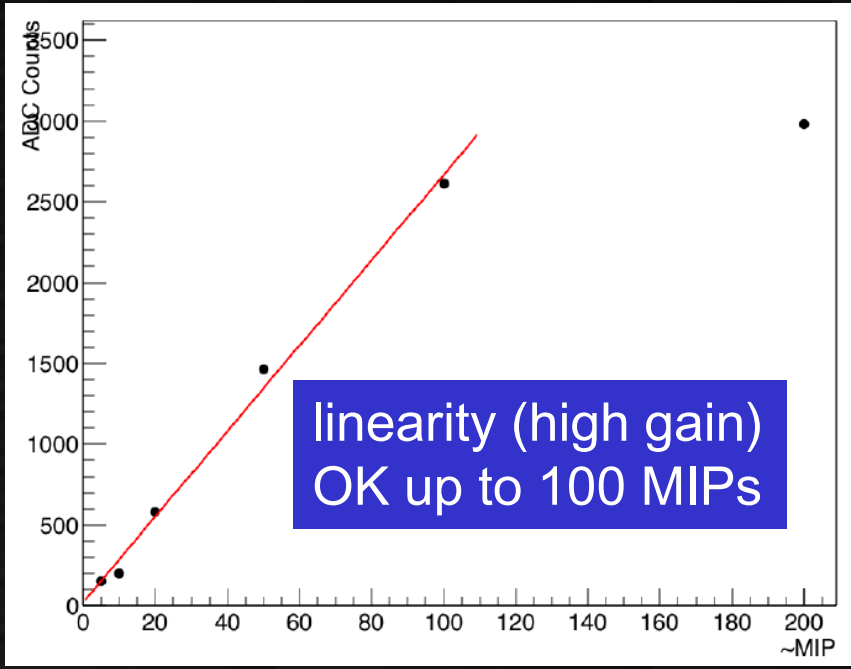


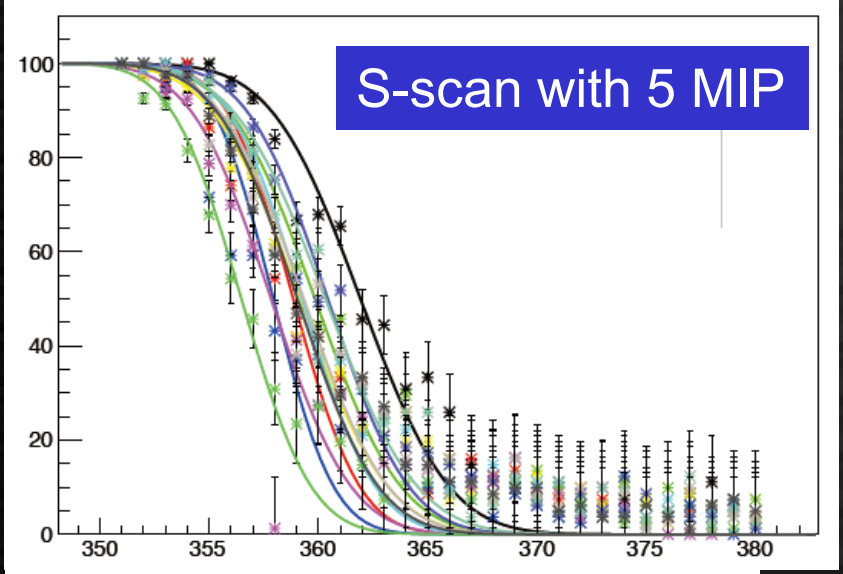
Chip-in-Board progress

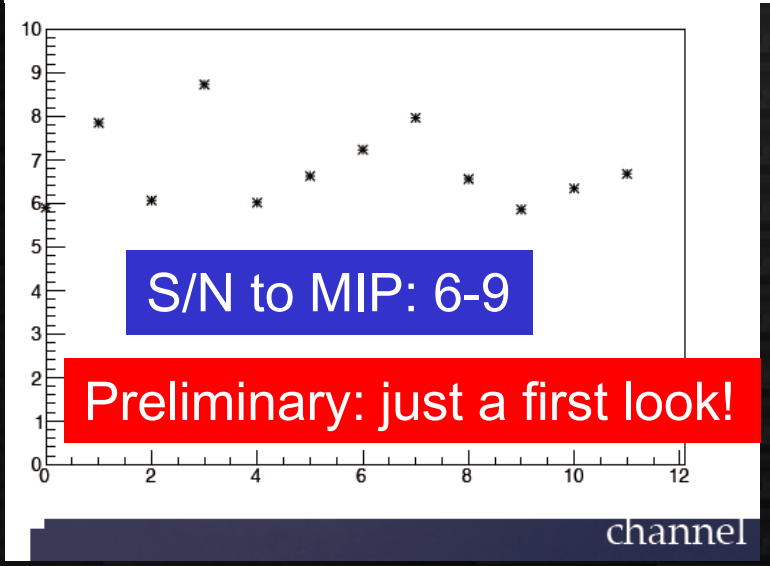


- PCB made in Korea, SKIROC wire-boded at CERN
- FEB8-based
- Optical shield (black plastic bag) needed
- Basic characteristics test done

CIB – measurement results

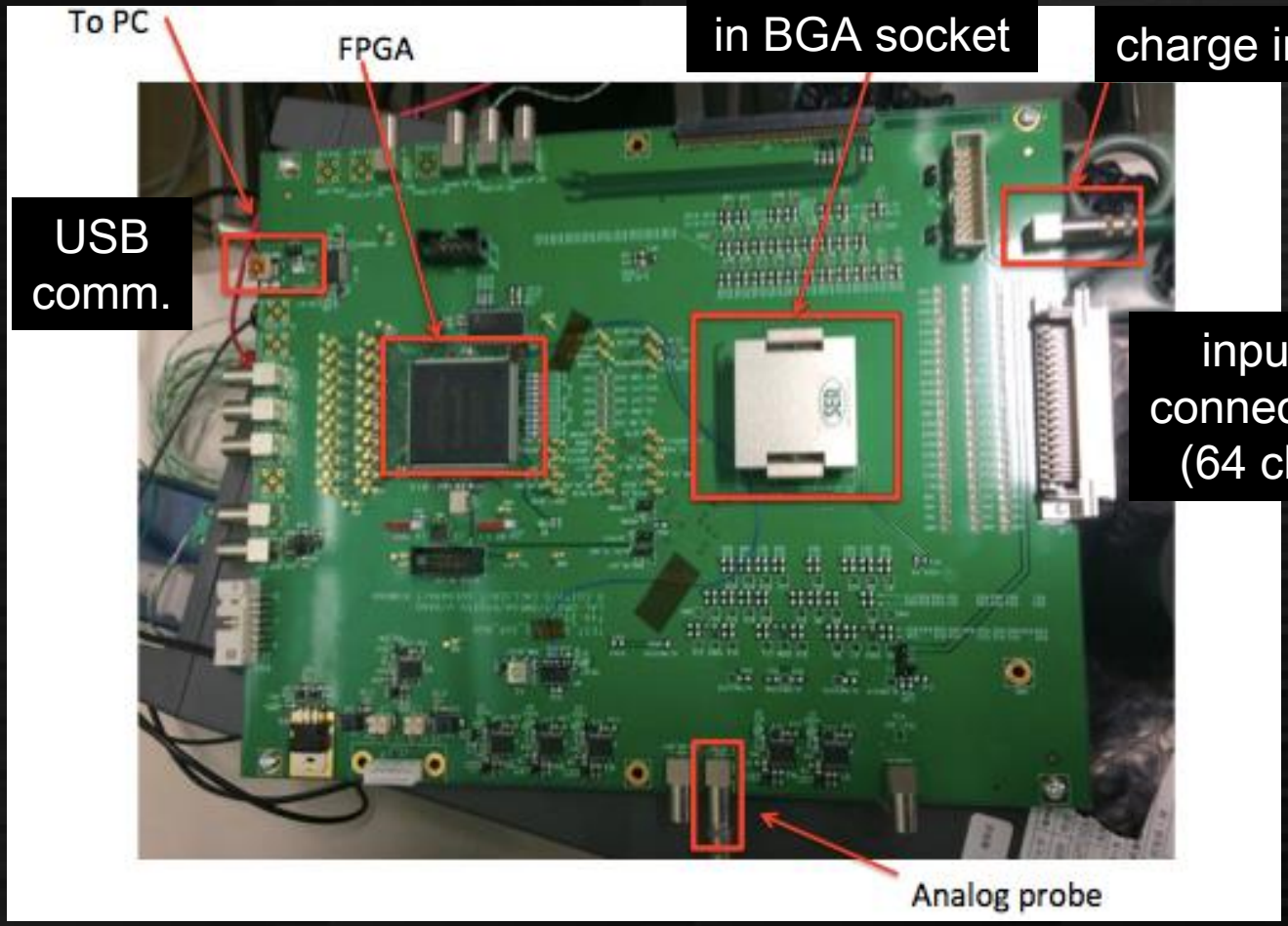






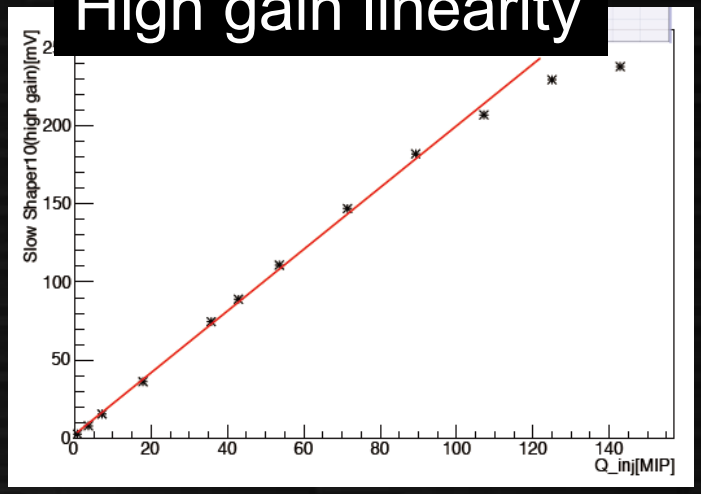
- Relatively in good shape (at least working)
- Noise reduction needed (better grounding etc.)

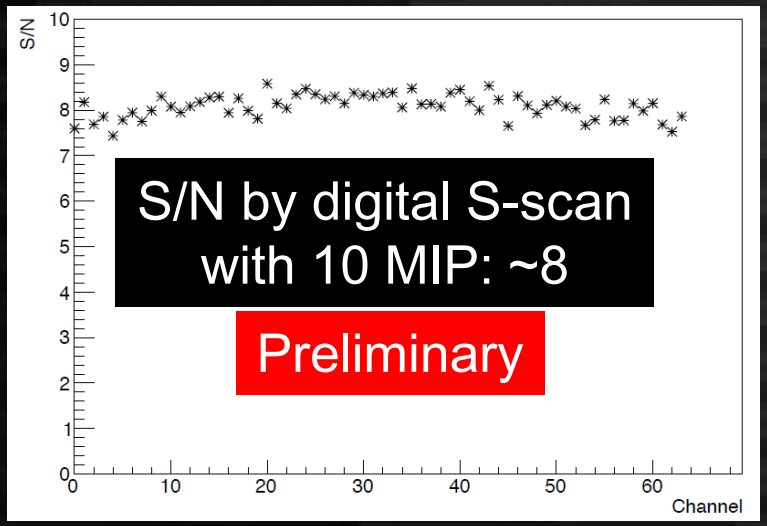
SKIROC test board for BGA

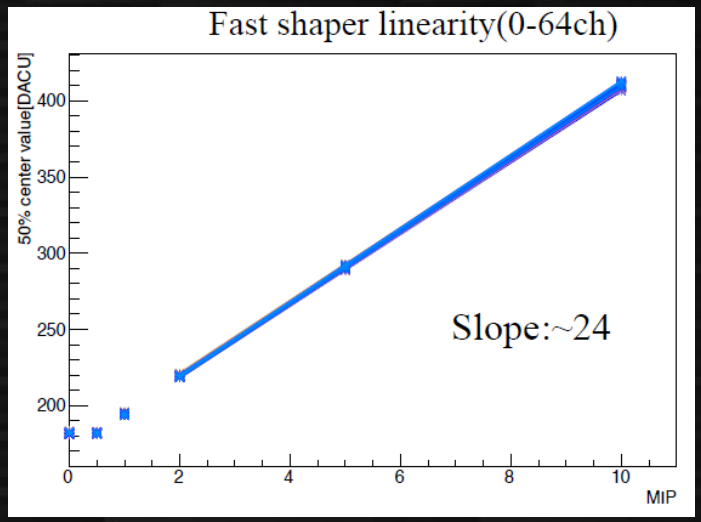


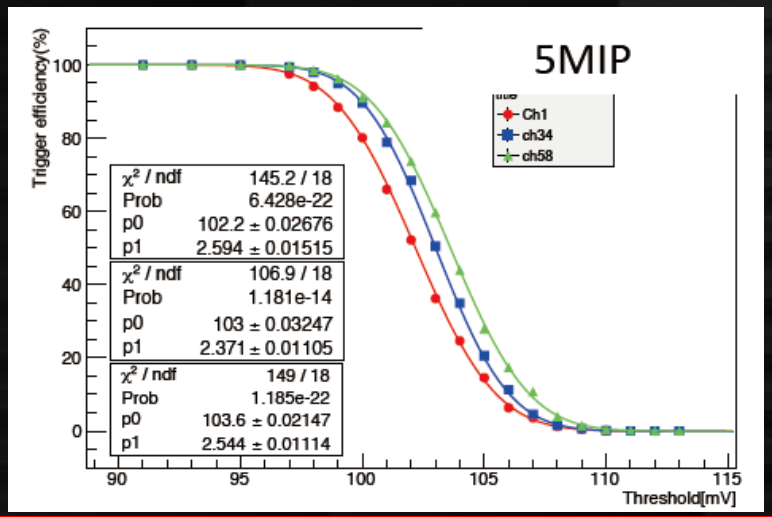
Test board results

High gain linearity







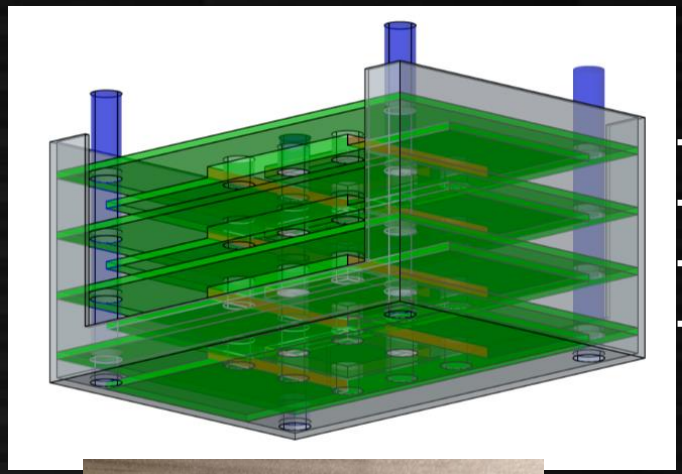


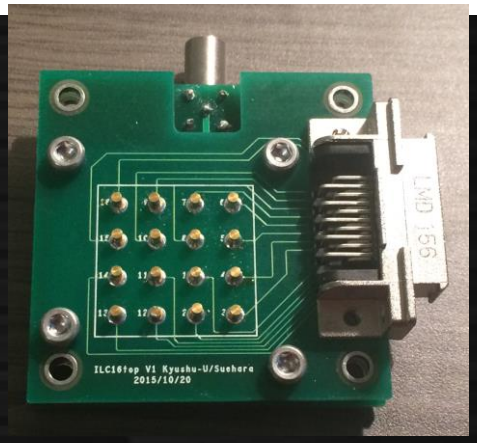
Analog S/N: consistent in several ch

Baby sensor readout at testbeam

CALICOES-compatible raw data format

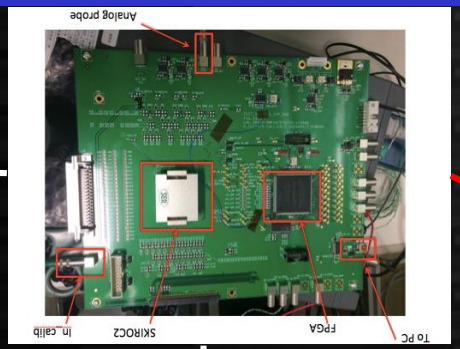
Sensor box (4 x baby(4x4/3x3))





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 FEB)
- Guard ring effects (0/1/2)

Progress in SiW-ECAL

Non-ILC activities

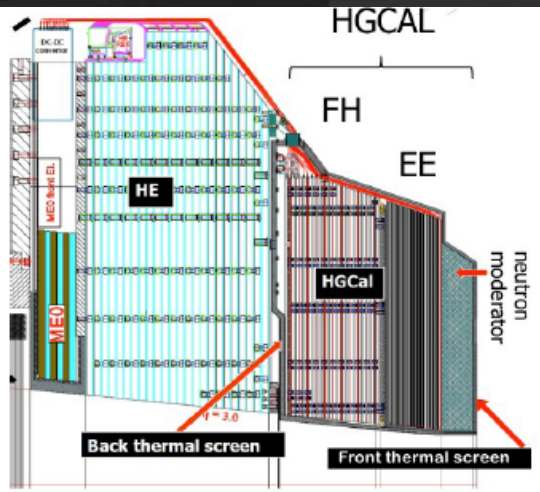
- CMS endcap calorimeter
- ATLAS preshower

Non-ILC activities

CMS High Granularity CALorimeter: phase-2 upgrade of ECAL+HCAL endcaps for High Luminosity LHC
(≥140 pile up evs, up to 10^{16} n/cm^2)

Approved this spring, similar Si active detectors,
inspired by ILC SiECAL, good synergy between two projects.

Common CERN beam tests planned (spring 2016),
common front-end chips production (end 2015)
(SKIROC for HGCAL: much faster, no power pulsing).



EE: 28 layers of W/Cu+Si,
FH: 12 layers of brass+Si

Sep 2015: expression of interest for ATLAS:
High Granularity Timing Detector, Si timing preshower between LAr barrel and end-cap cryostats in $2.5<\eta<4$ (4 layers in Δz=6 cm, δt~50 psec),
also inspired by CALICE SiW ECAL.

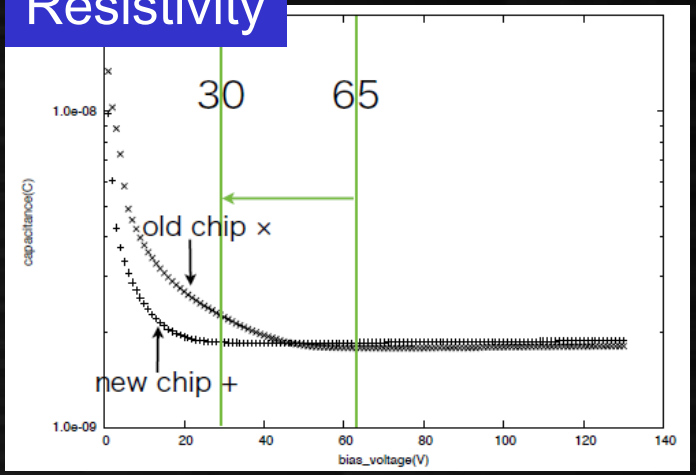
Progress in SiW-ECAL

Sensor design

- Resistivity
- Thickness
- Guard-ring, cutting edge
- Hexagonal sensor
- Radiation test
- New idea

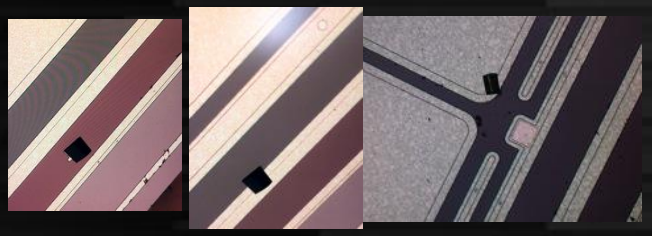
Parameters of sensors

Resistivity

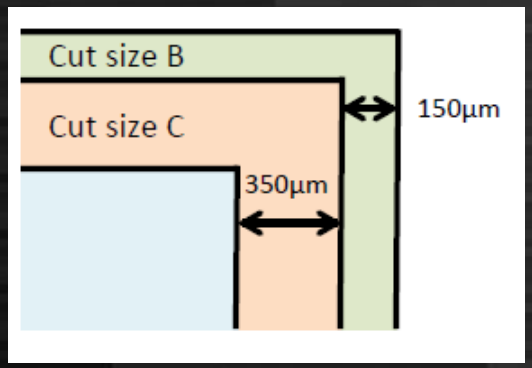


Hamamatsu changed
to higher resistivity
→ lower full-depletion V

Guard-rings & cut sizes



0GR, 1GR & split 2GR
1GR has ring event
→ trying 0GR
Currently no critical
disadvantages found



Cut sizes affect the
breakdown voltage
and leakage current

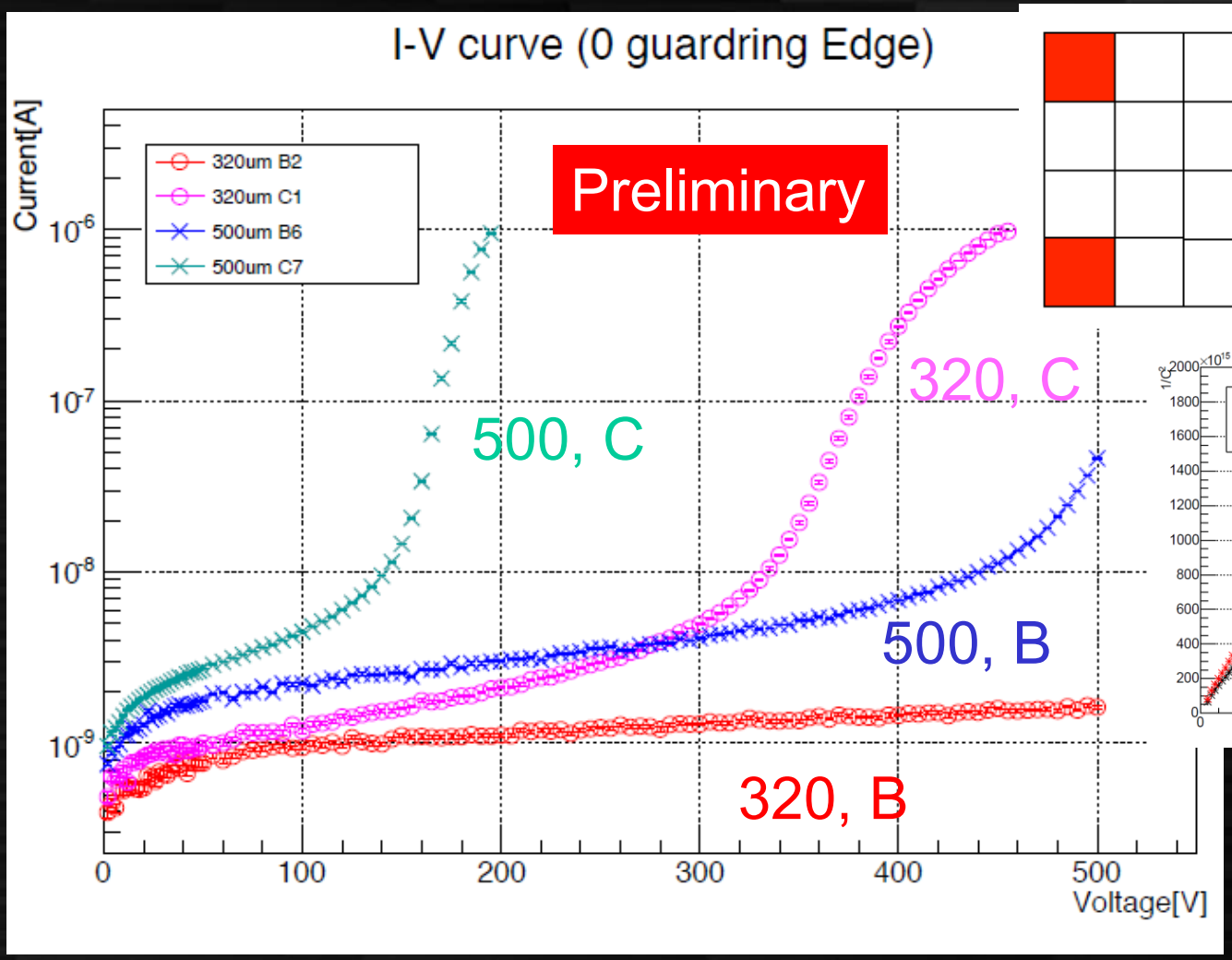
Thickness

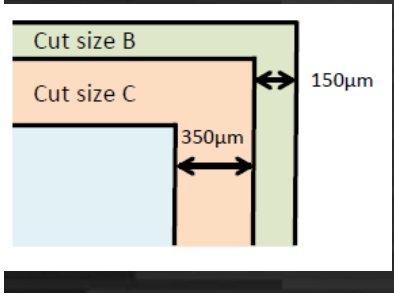
320 μm vs 500 μm
Costs same
More signal strength in 500
More full-dep. voltage in 500
500 μm sample arrived

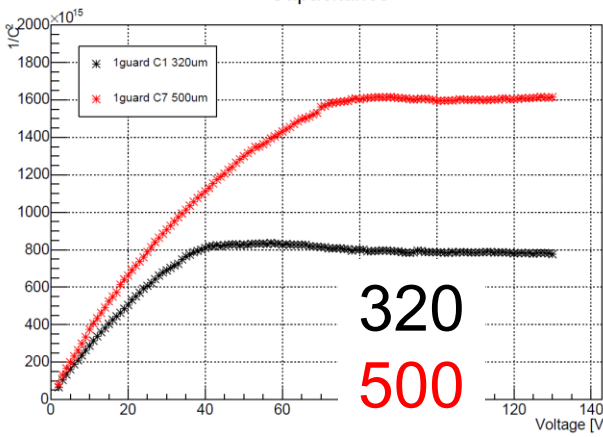
Wafer size and manufacturer

Silicon industry is moving to 8 inch (or even 12)
Hamamatsu recommends 6 inch in their fab.
Consulting to another manufacturer (LFoundry)
→ Sample not yet available

A new results of 500 μm sensor





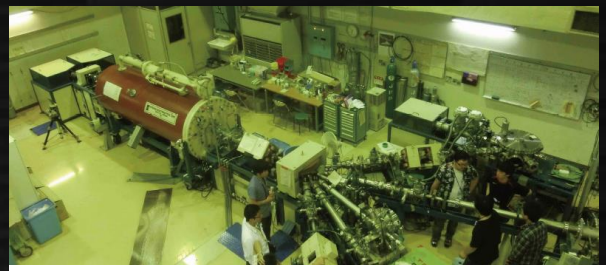


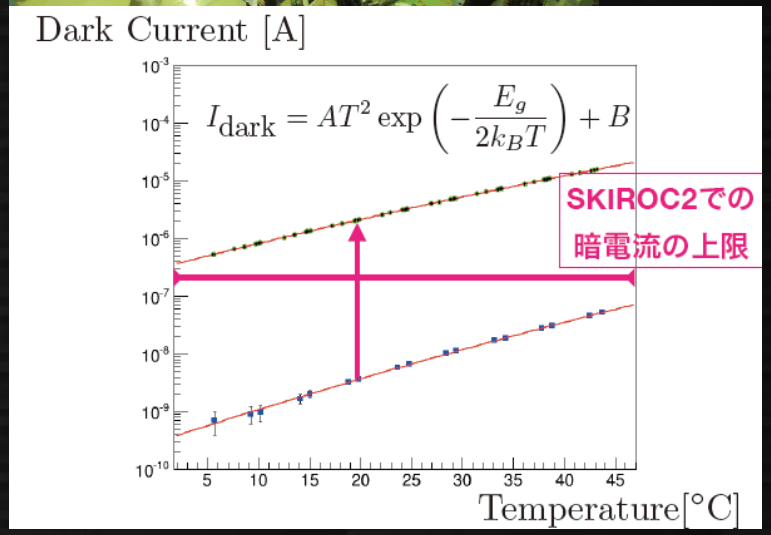
Full-dep. voltage
~40V in 320 μm
~80V in 500 μm

Cut size B is preferred esp. in 500 μm

Irradiation test

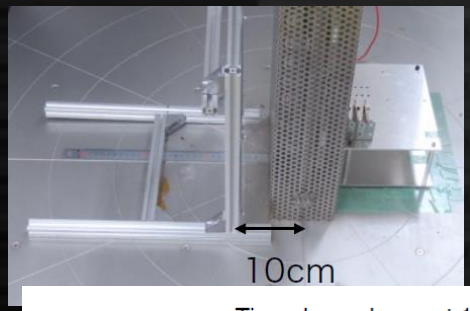
Neutron @ Kobe U, Jul-Aug 2015



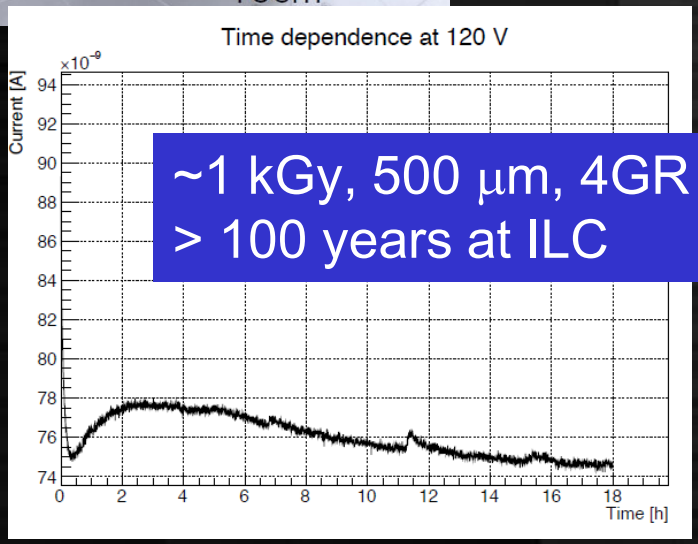


~1000 times more dark current on
~7.5 x 10^{11} neq/cm^2
acceptable in ~10^{10} neutrons
capacitor & glue OK on 10^{12}

Gamma @ Kyushu U, Oct 2015

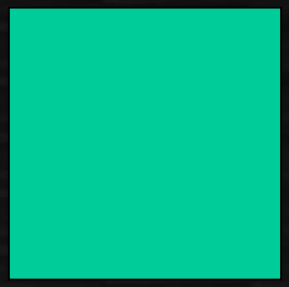


^{60}Co,
~82 TBq

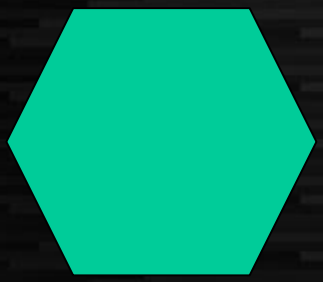


Without bias during irradiation
~5 times larger current seen
Crosstalk should be checked
Continue irradiation on 0/1/2 GR

Hexagonal sensors

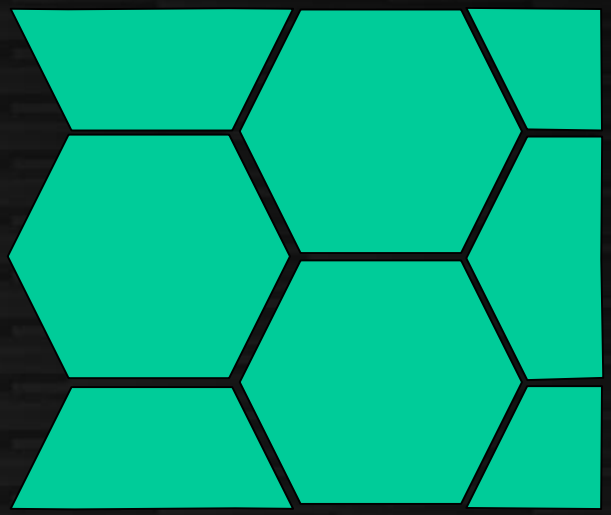


Square
Max. 9.8x9.8 cm^2
Area = 96.04 cm^2

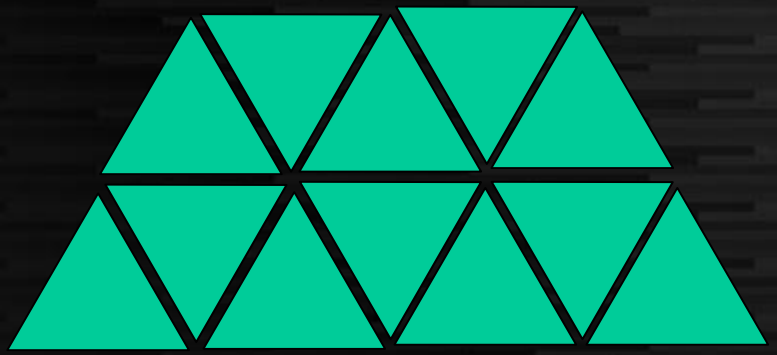


Hexagon
Max. 6.9 cm each edge
Area = 123.69 cm^2
(28.8% larger than square)

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



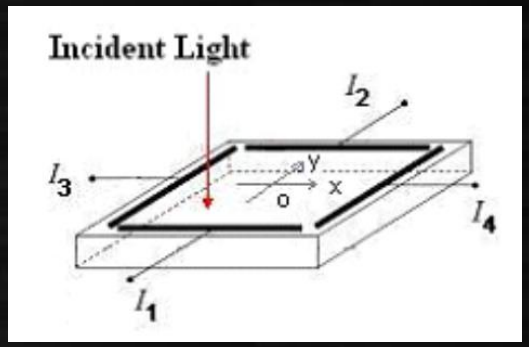
Preliminary idea
of “Slab for hexagon”

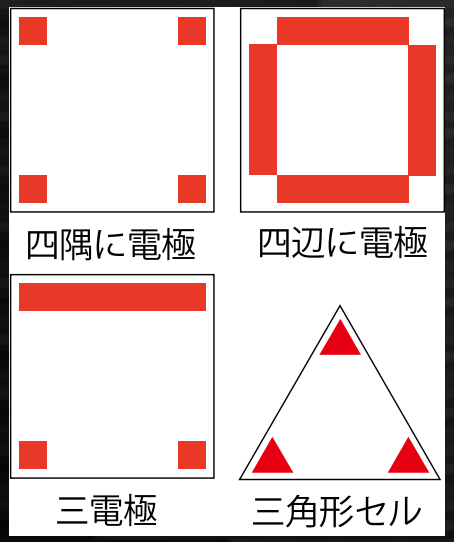


Idea of “triangle pixels”
for hexagonal sensors

Production of baby submitted:
available in March 2016

New idea – position sensitive det.

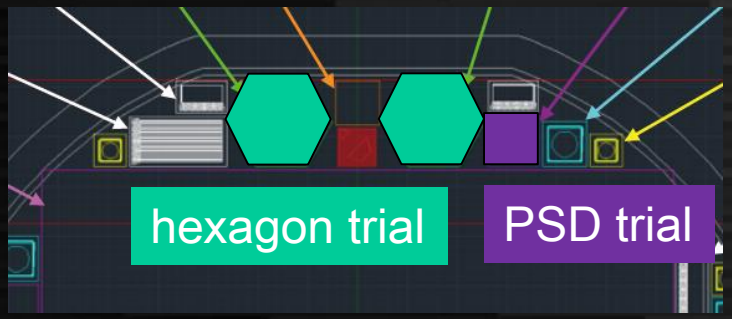




ideas on electrodes

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)

Summary

- Test beam on CERN SPS
  Nov. 4-16 for 4 FEB11 + baby
- CIB measurement started
- Application on CMS and ATLAS
- 500 μm sensor tested
- Idea on hexagon and PSD