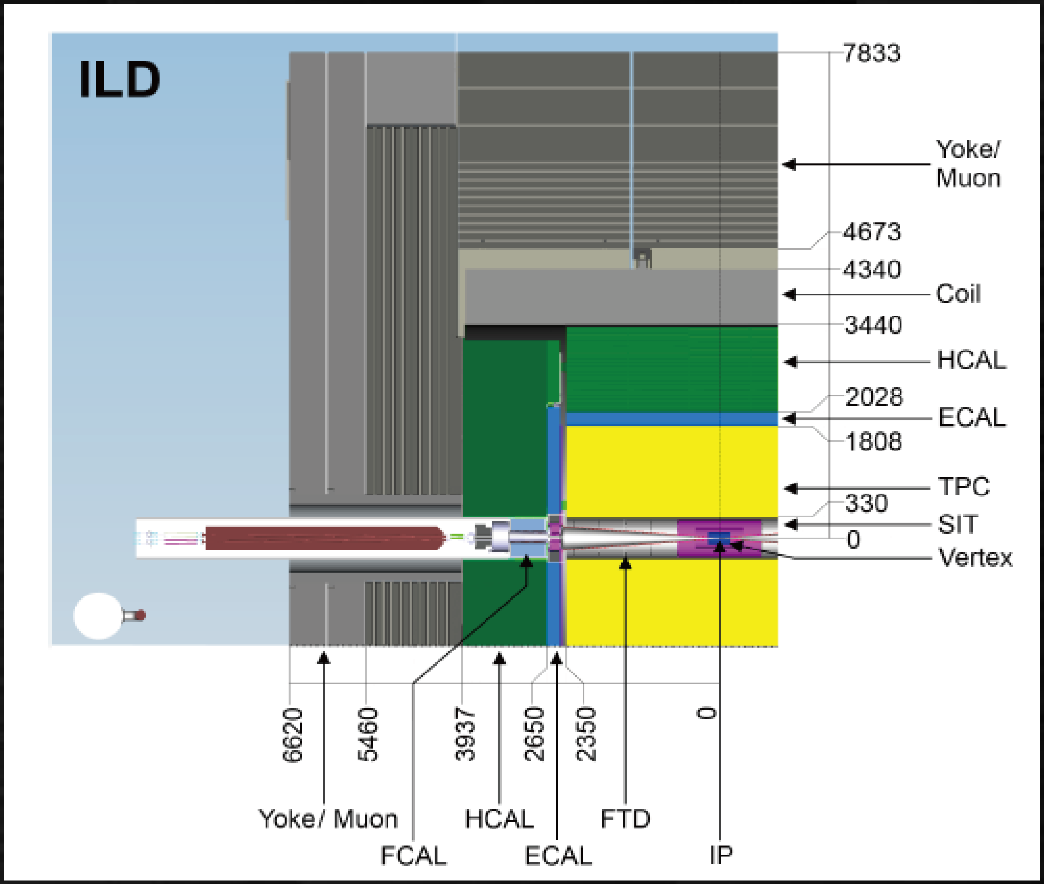
ILC SiW-ECAL開発
現状

Taikan Suehara
(Kyushu University)

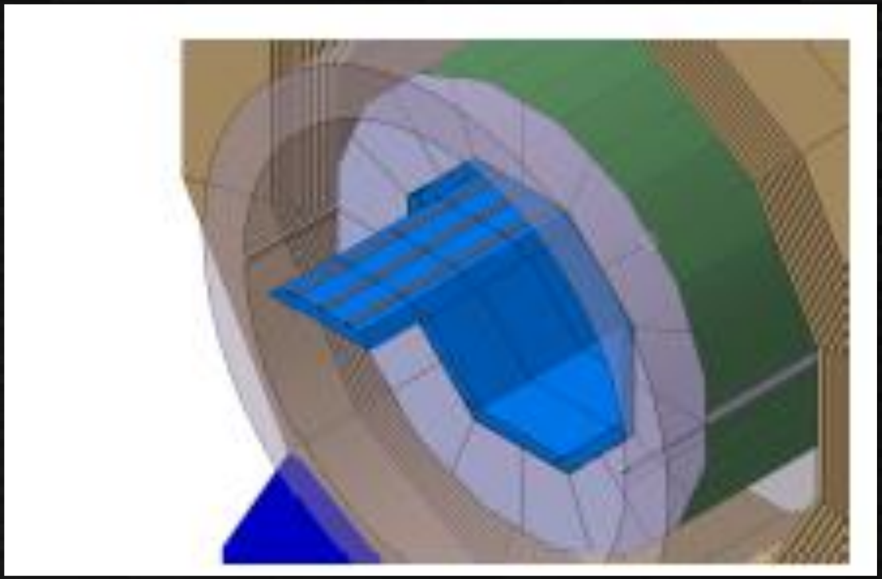
※ すみません。ほぼ既存のスライドをかき集めただけです

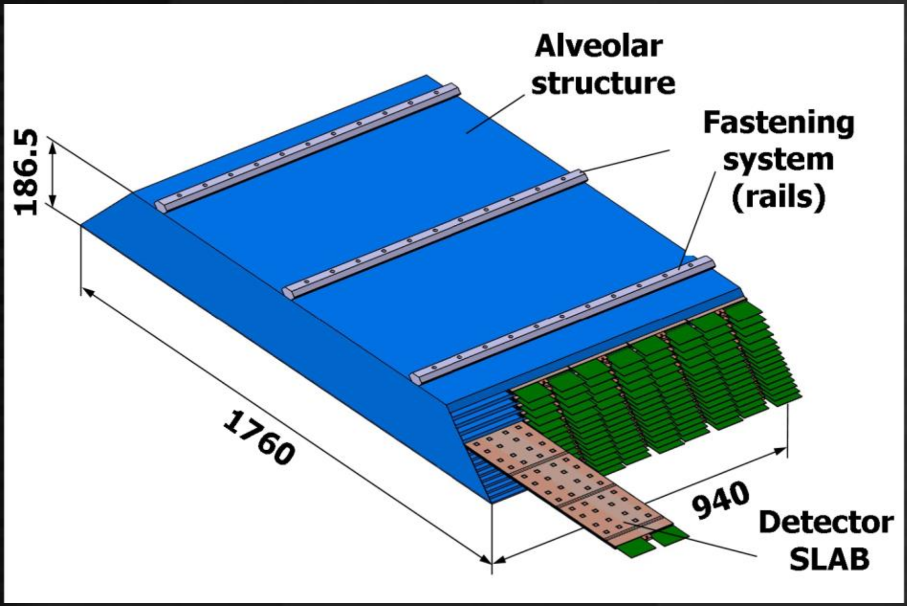
ILD 測定器

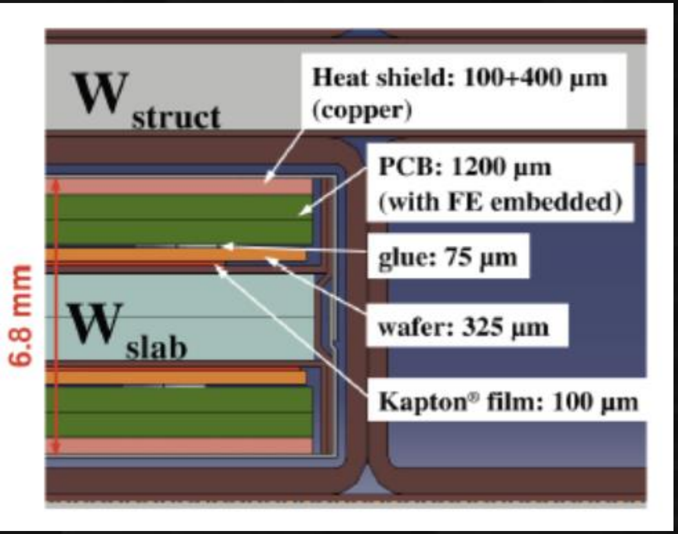


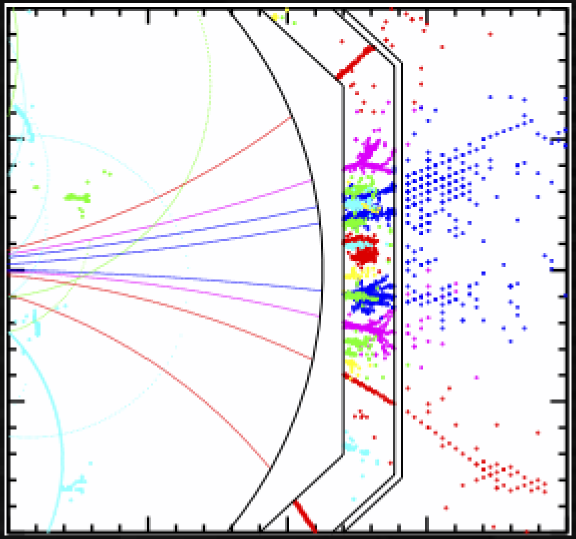
- 崩壊点検出器 (VTX)
  - CMOS, FPCCD, ...
- シリコン飛跡検出器
  - SIT, SET
- 中央飛跡検出器 (TPC)
- 電磁カロリメータ (Si/Sc)
- ハドロンカロリメータ
- ミューオン検出器
- 前方検出器

シリコン電磁カロリメータ (ILD)









20-30層
内径1.4-1.8m

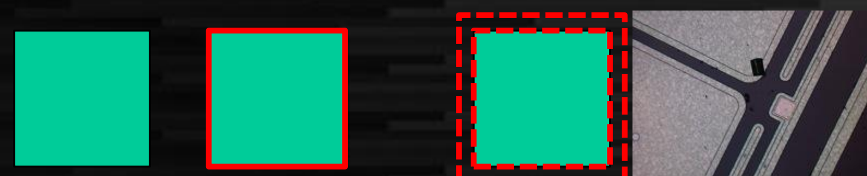
4 x 9 x 5 x 30 x 8 x 5 = 216000 (max.)

Sensor studies

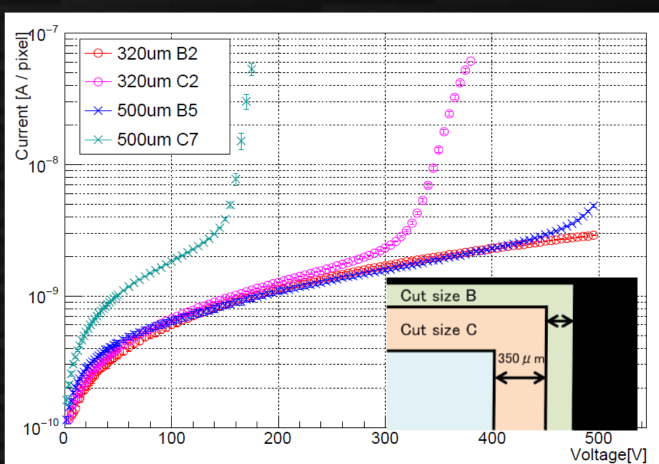
Sensor w/ 5.5 x 5.5 mm^2 cells

To avoid ring events from guard rings, we tested several guard-ring structures using 3x3 or 4x4 pixels baby sensors and infrared laser

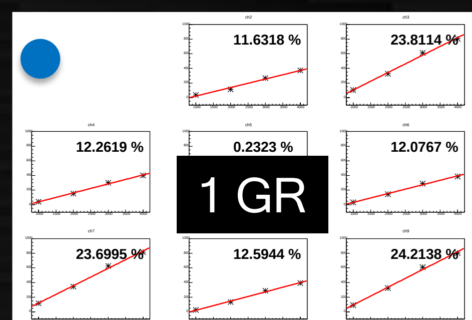
(Floating) guard ring structures

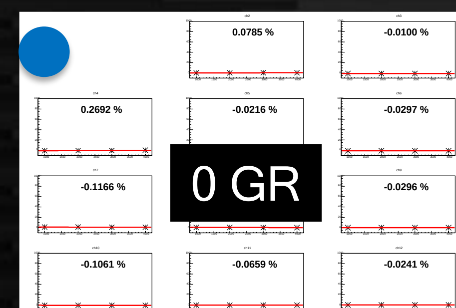


No GR 1 GR Split GR (2/4 GR)



Leakage current 0 GR



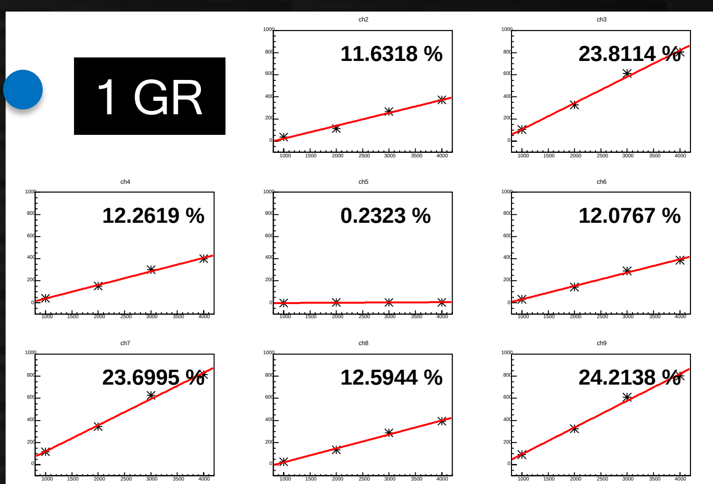


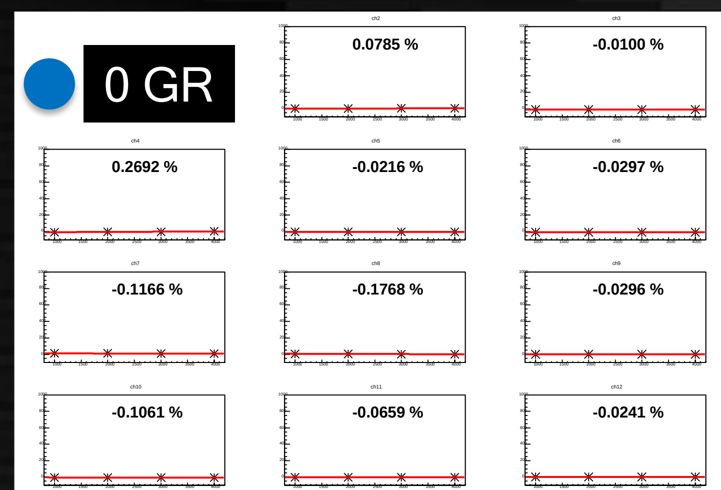
Ring crosstalk seen only with GR

0 GR big sensor produced, will be tested

センサー: これまでのstudy

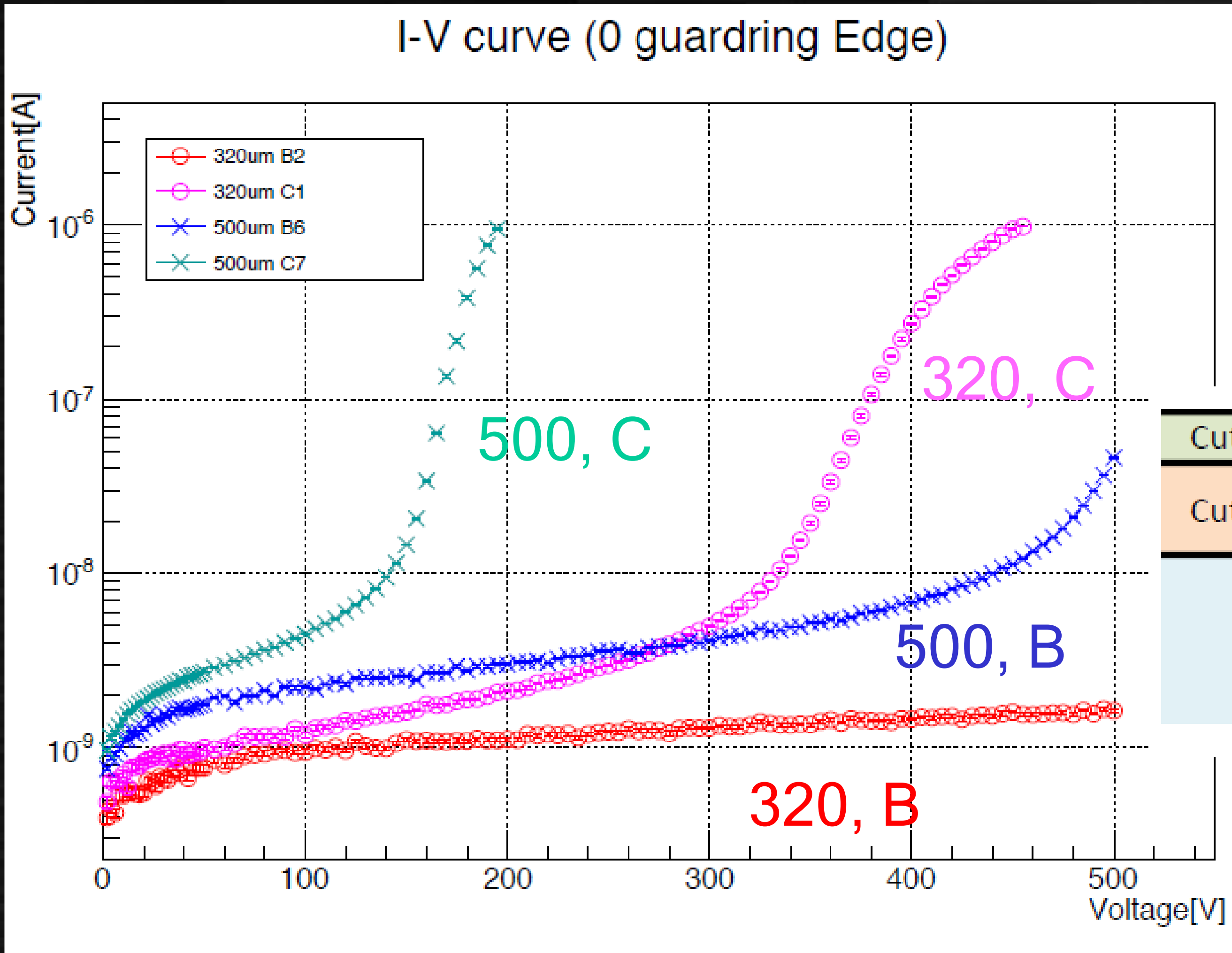
- (floating)ガードリングの効果
- ガードリングなしのセンサーの特性
- 放射線耐性
- PSDサンプル

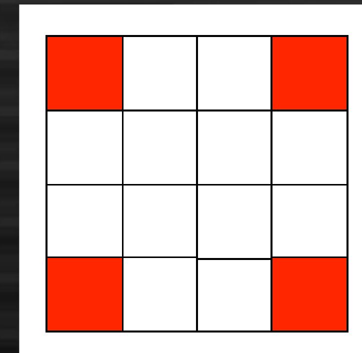


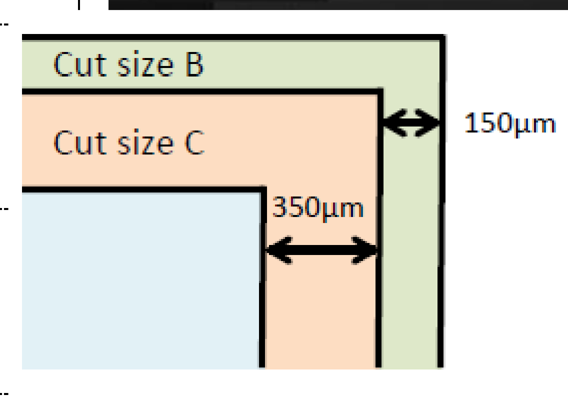


Ring crosstalk with laser seen only with GR

I/V curve at the edge pixels

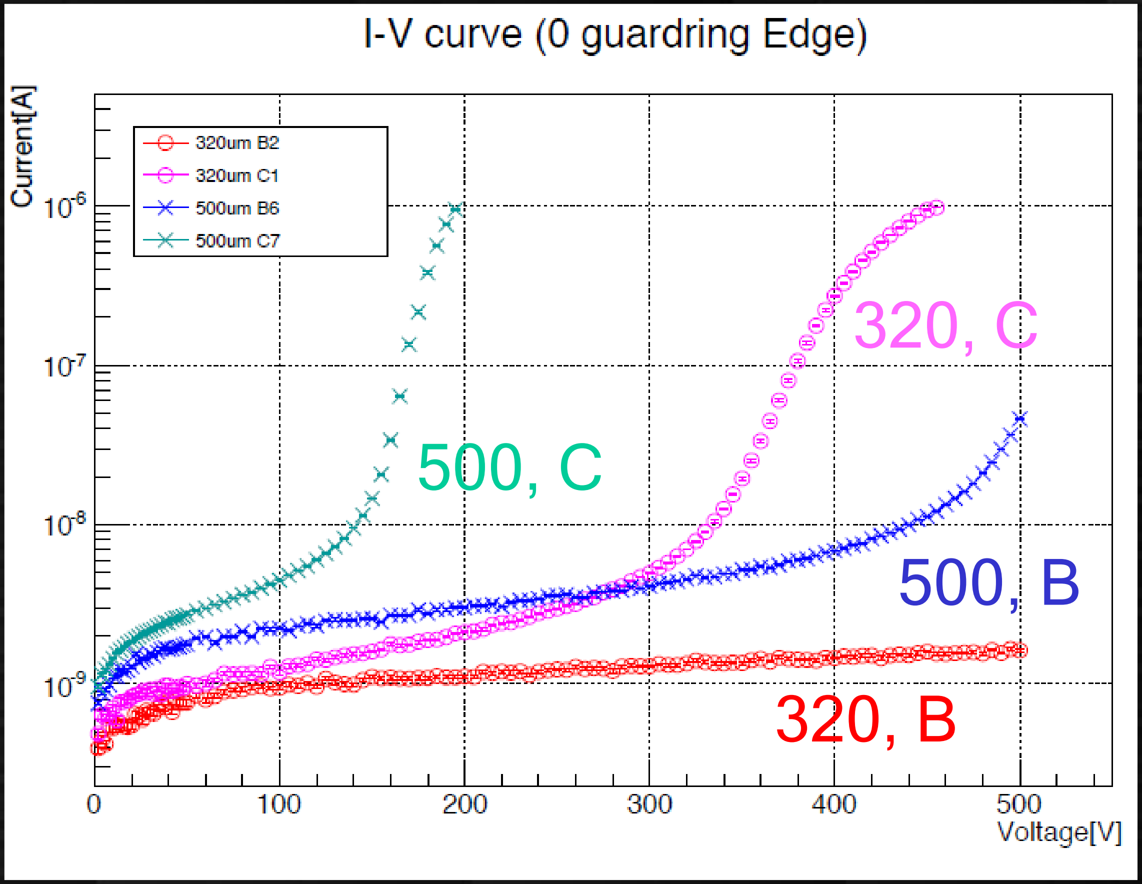




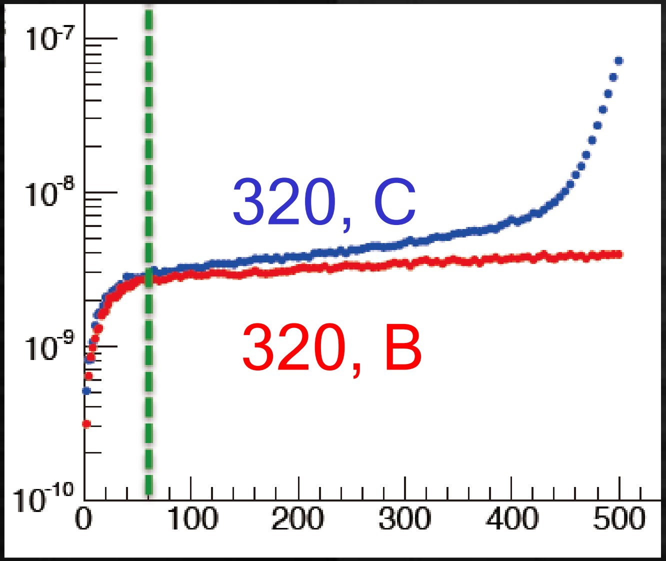


Cut size B is preferred; 500 μm is OK with cut size B

Compared with lower R sensor

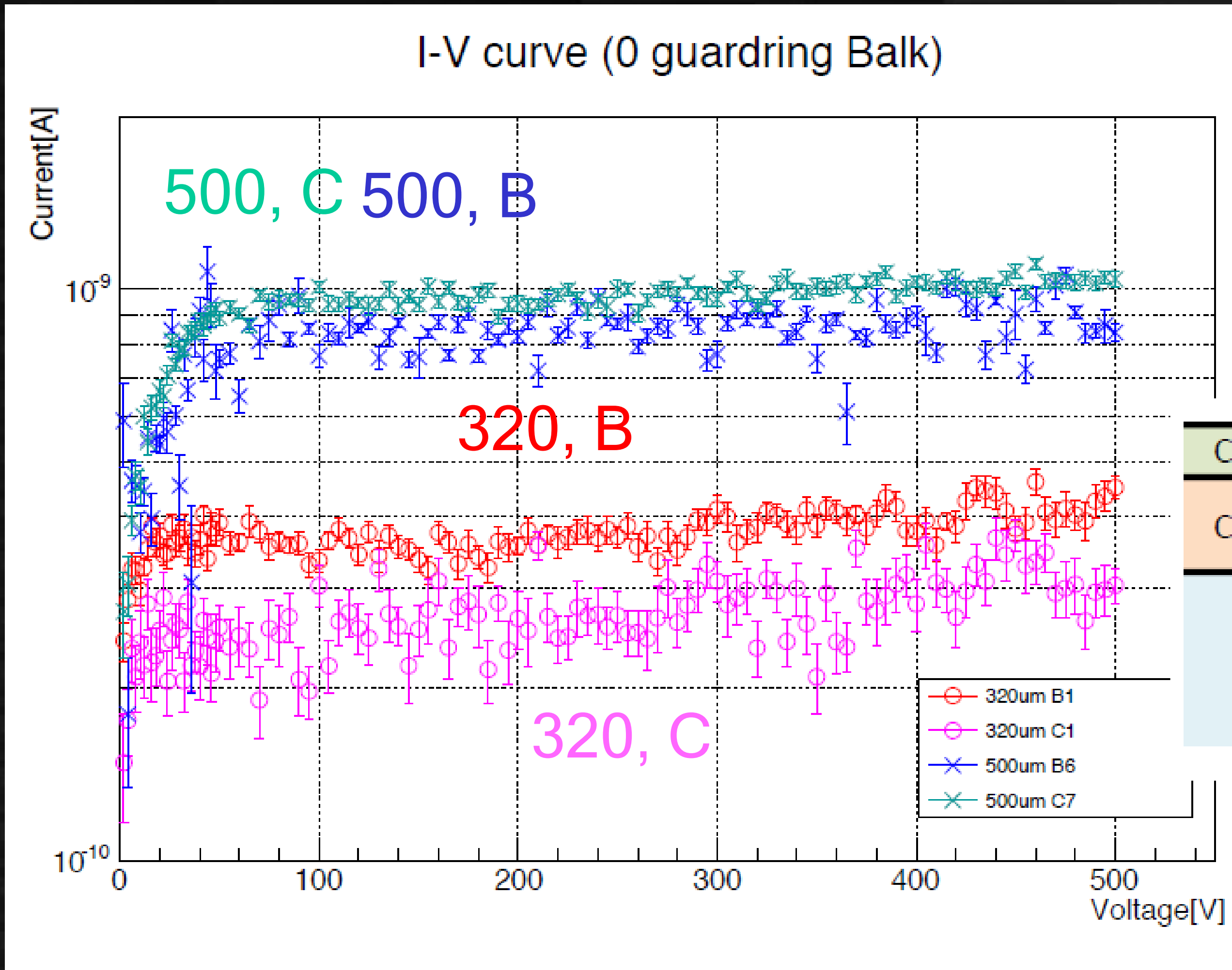


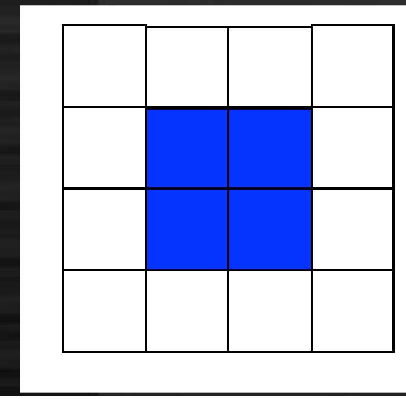
Old sensor
with lower resistivity

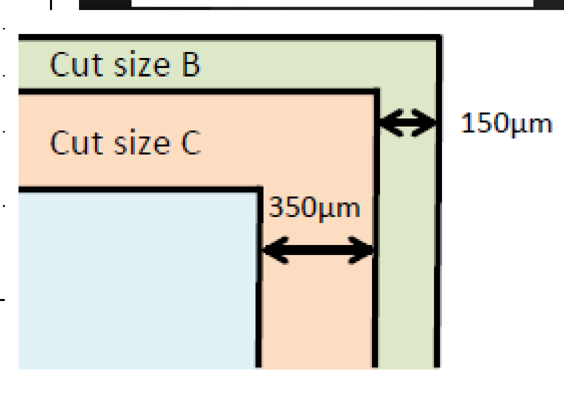


Slightly lower leakage current seen in new sensor
(breakdown voltage lower, but this has sample dependence)

I/V curve at the center pixels

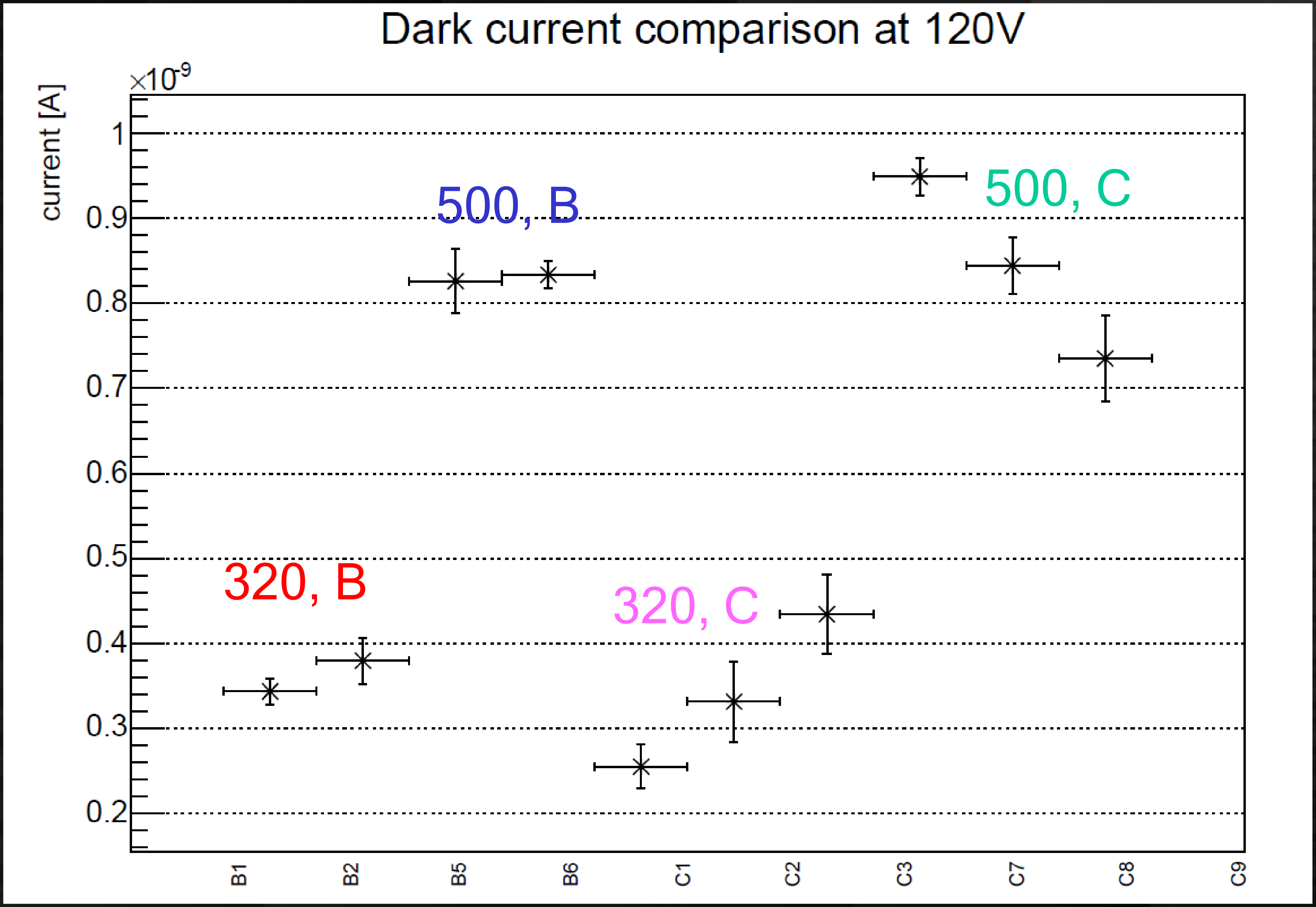




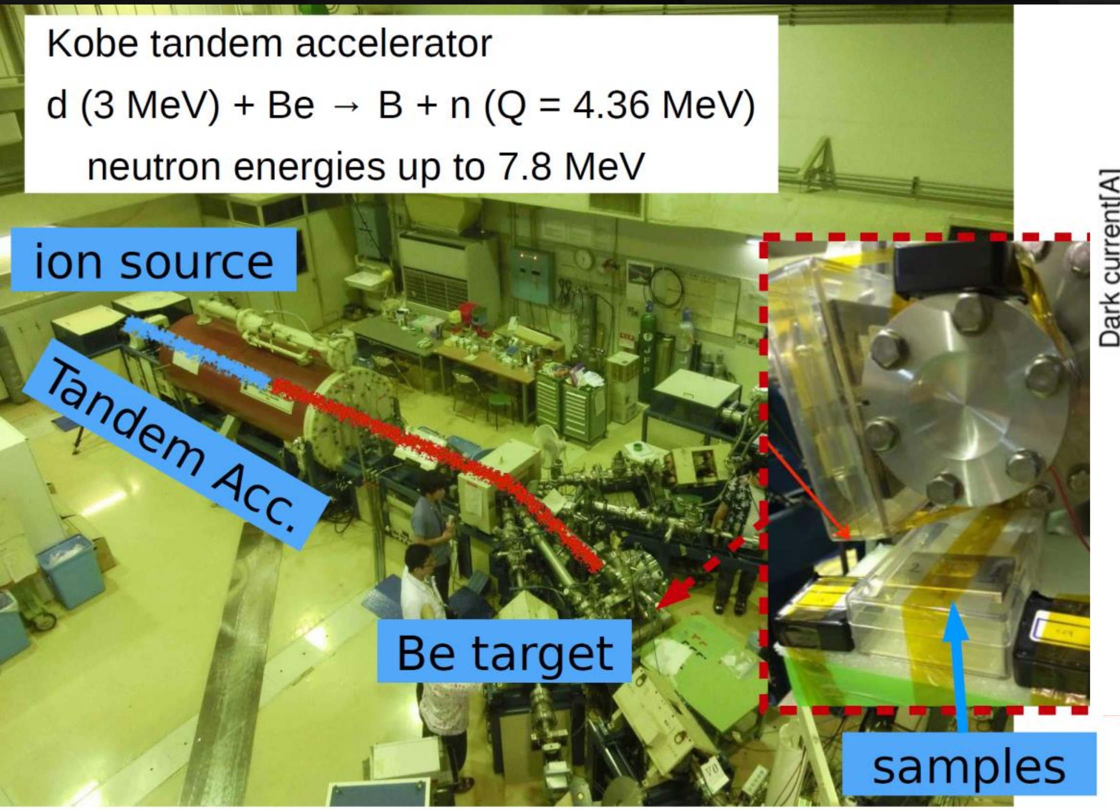


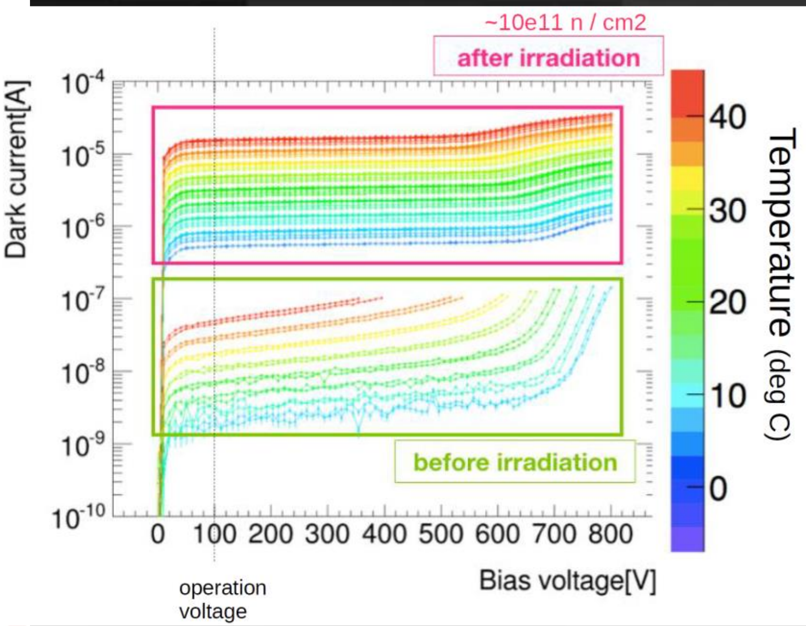
500 μm have ~3 times higher current, no difference on B/C

Statistics

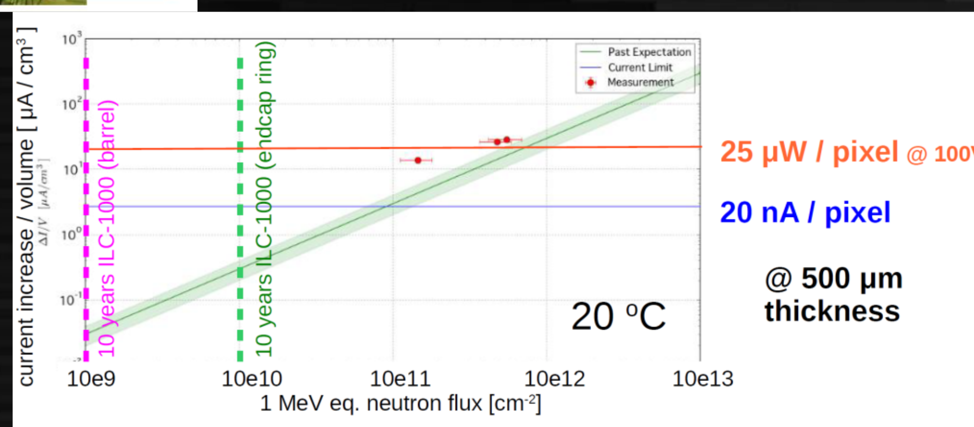

Dark current comparison at 120V
current [A]
×10-9
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
500, B
500, C
320, B
320, C
B1
B2
B5
B6
C1
C2
C3
C7
C8
C9

Neutron irradiation tests



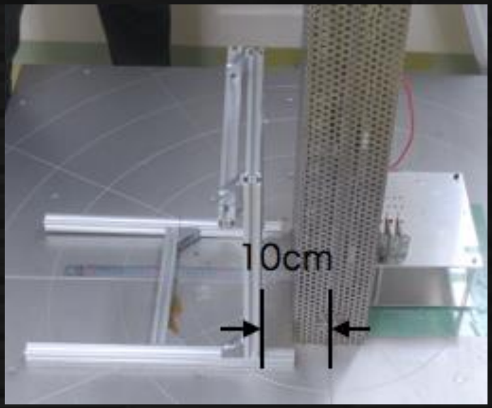


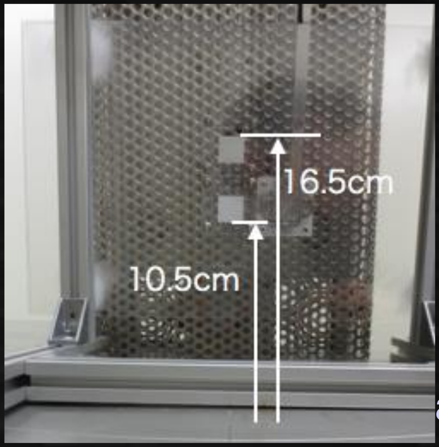
Irradiation of neutrons on baby sensor
Increase on dark current is acceptable considering ILC-1 TeV 10 year radiation dose estimation



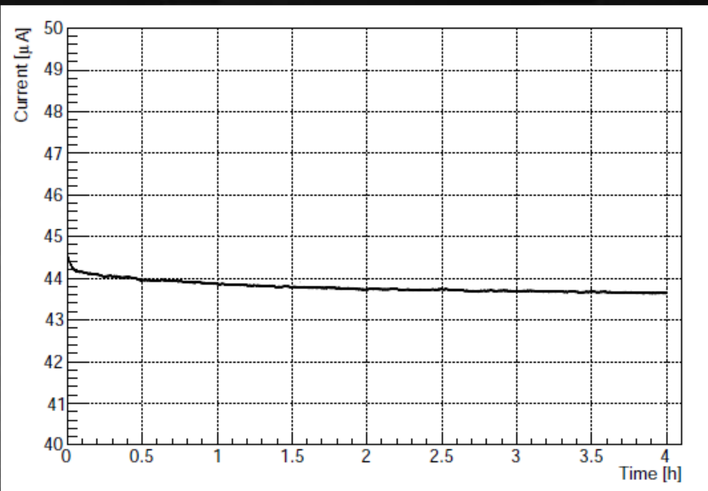
Gamma irradiation: Setup

- Facility & source
  - Gamma from 60Co, 82.3 TBq, Kyushu University
- Sensor: 500 μm, 4 GR, 3 x 3 baby
- Irradiation (too big for ILC detectors)
  - 1.1 kGy, no voltage applied during irradiation
  - 10.2 kGy, no voltage
  - 10.2 kGy, 100 V applied during irradiation (4 hours)

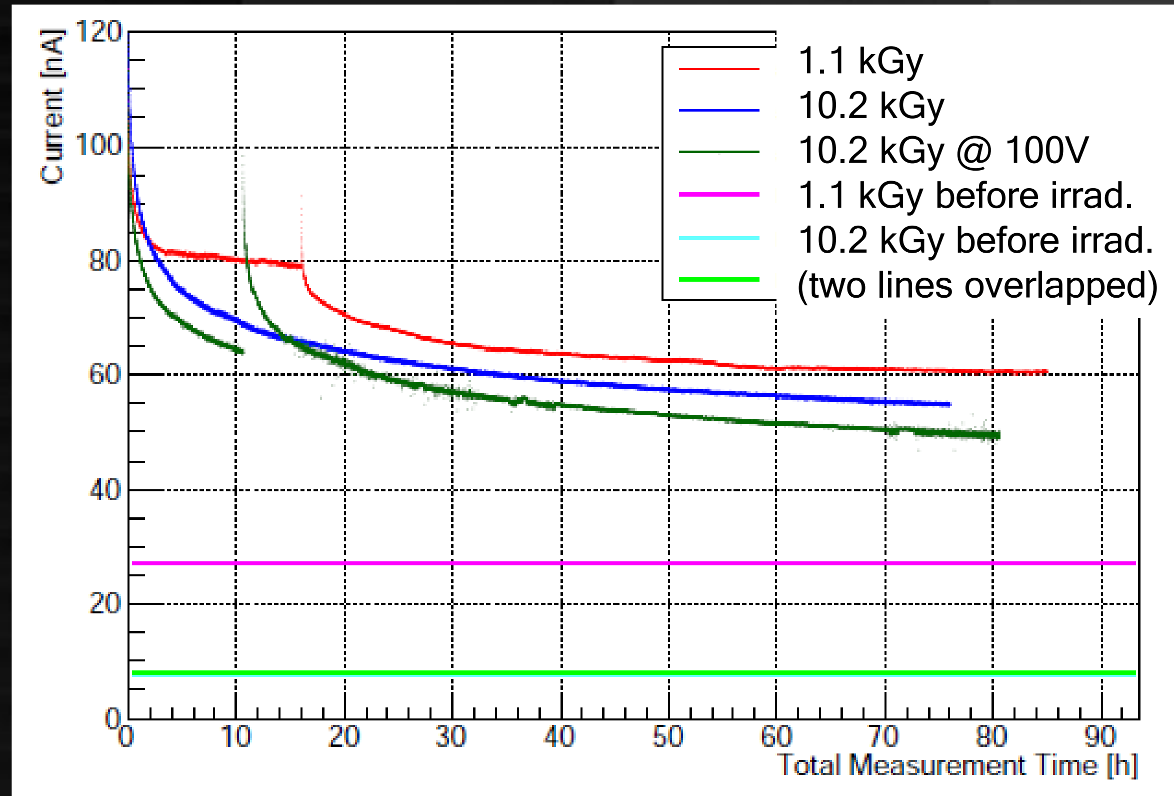




Dark current



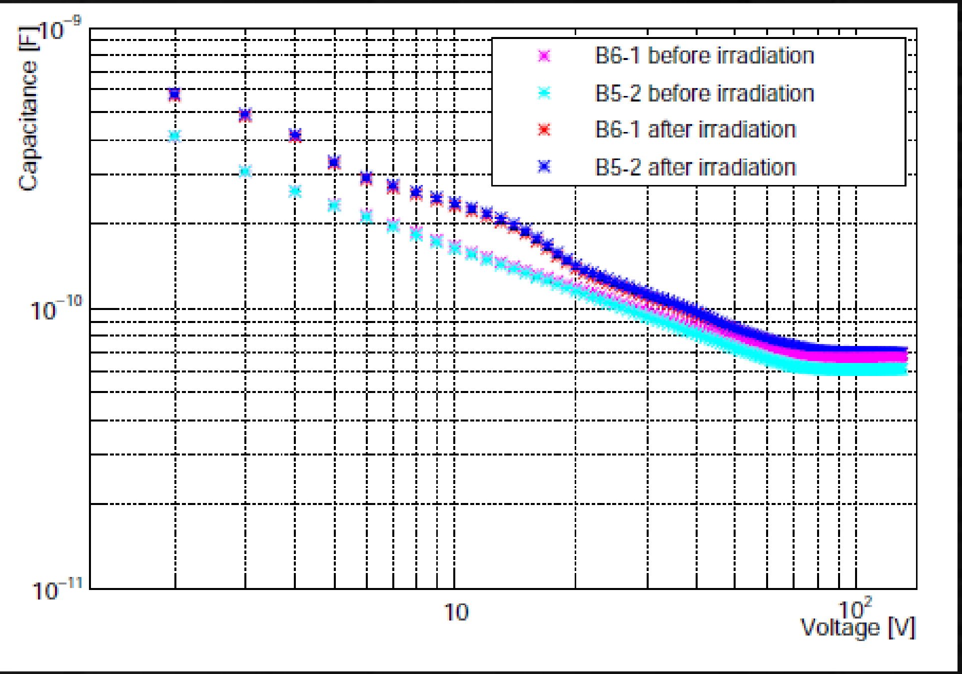
Current during irradiation (including current from gamma energy deposit)

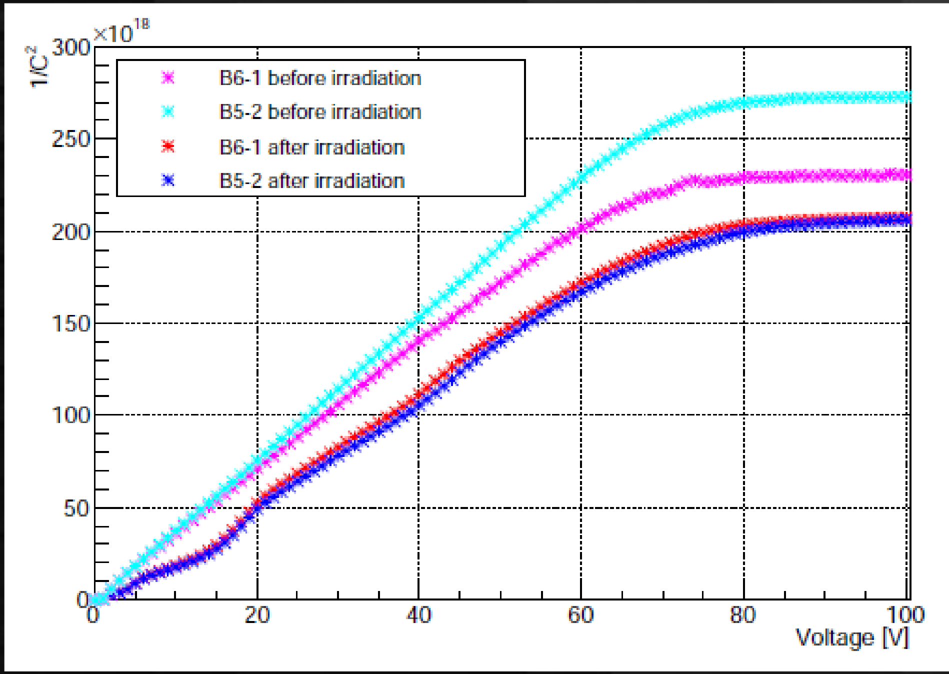


Dark current after irradiation

- No big difference on voltage
- Damage not proportional? (maybe sample dependence)
- 10 kGy damage almost consistent with displacement

C/V characteristics

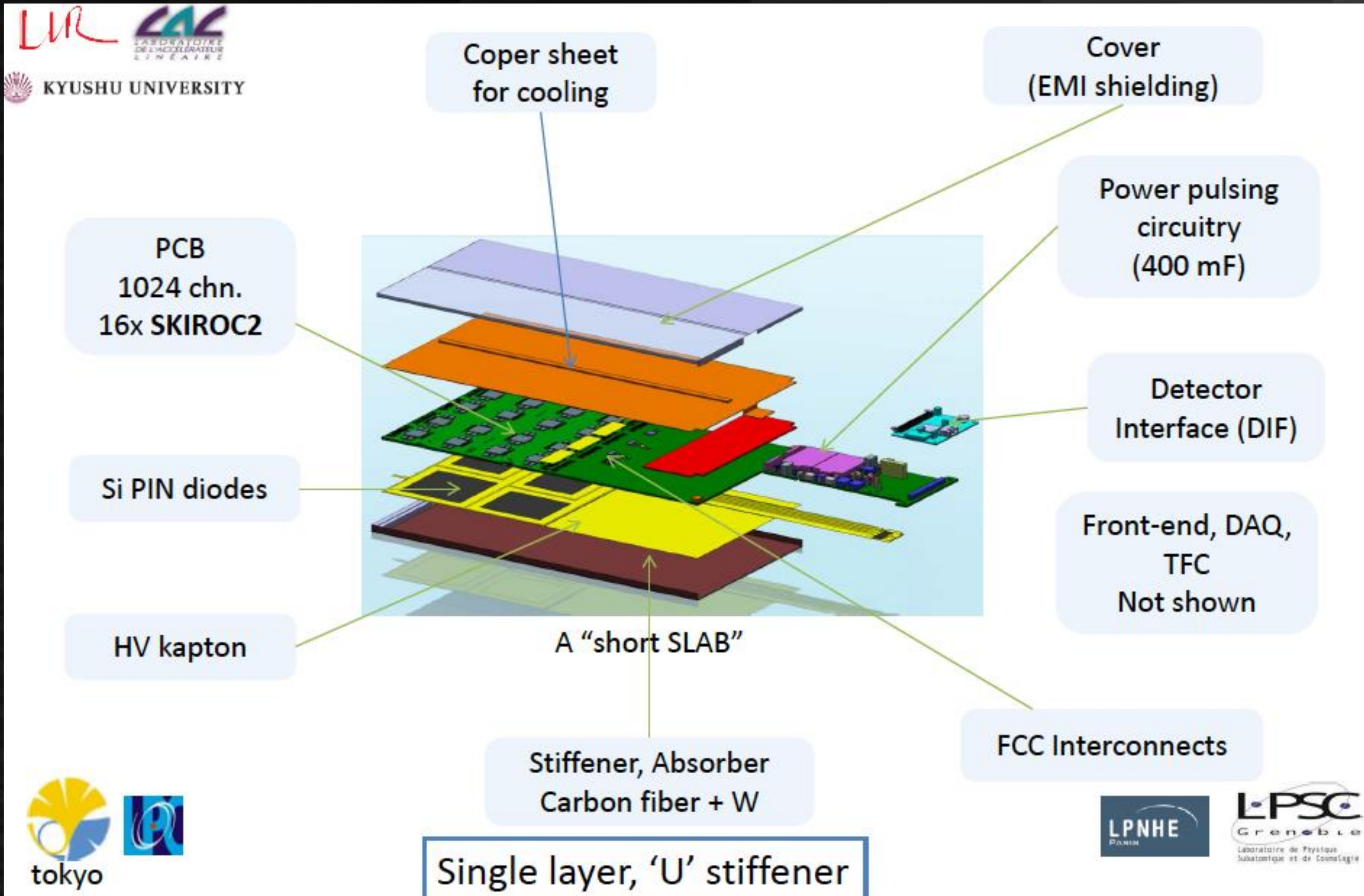




No big difference in capacitance

Strange shape seen ~ 10 V after irradiation

Detector module



SKIROC2

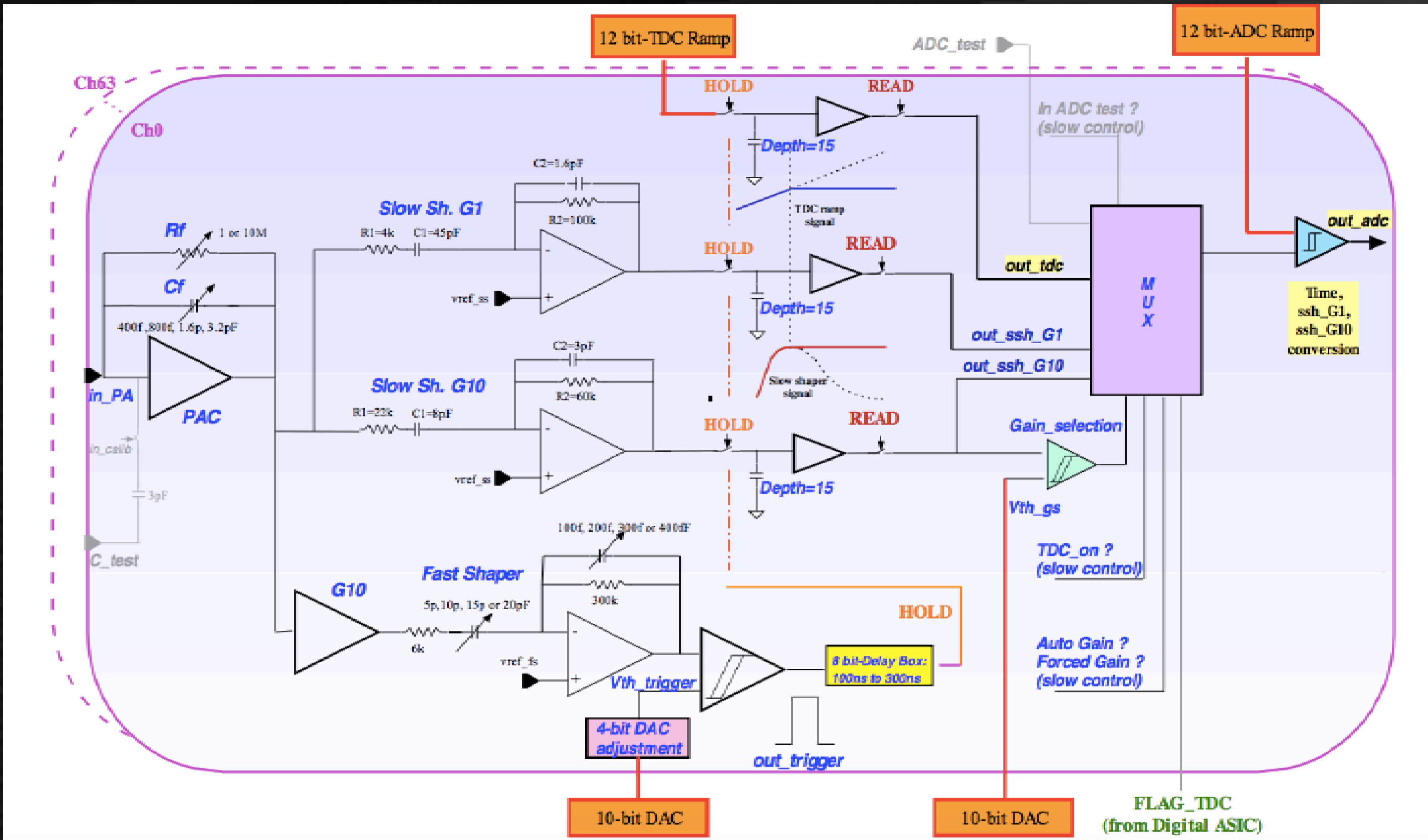
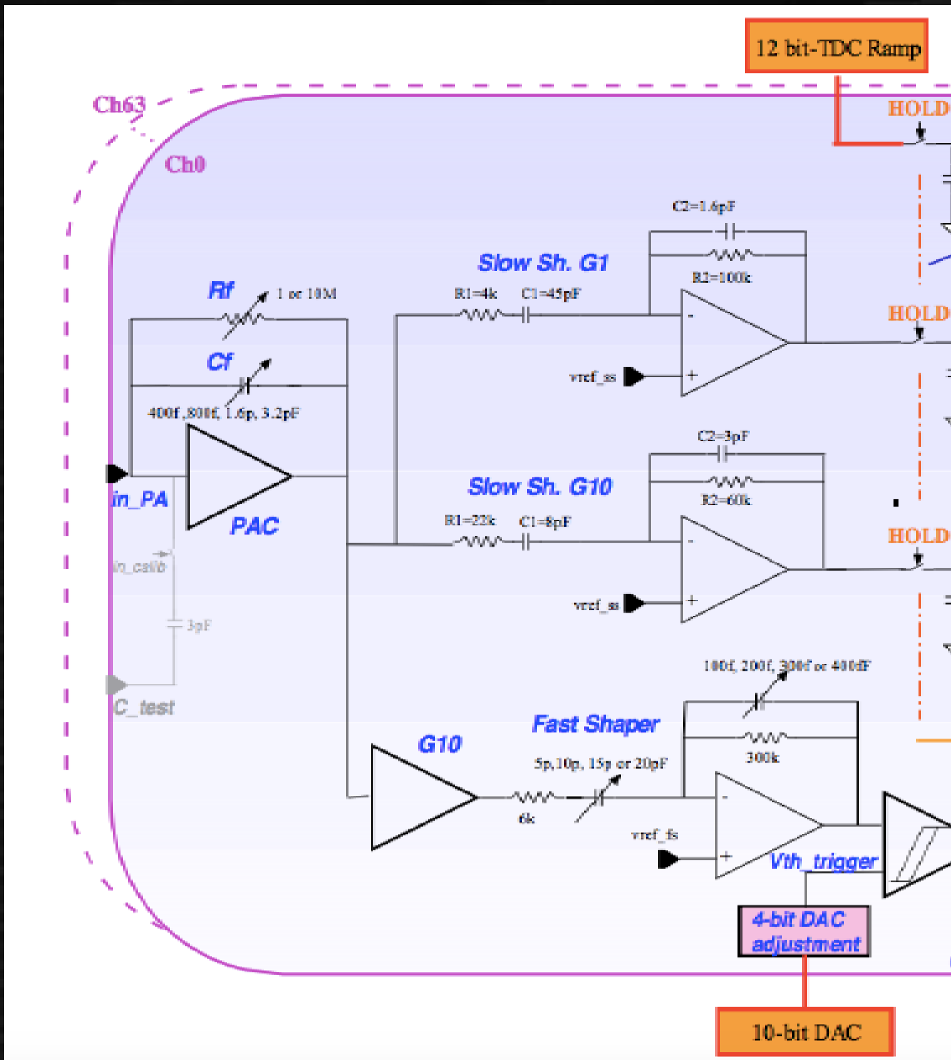


Diagram of analog part of SKIROC2

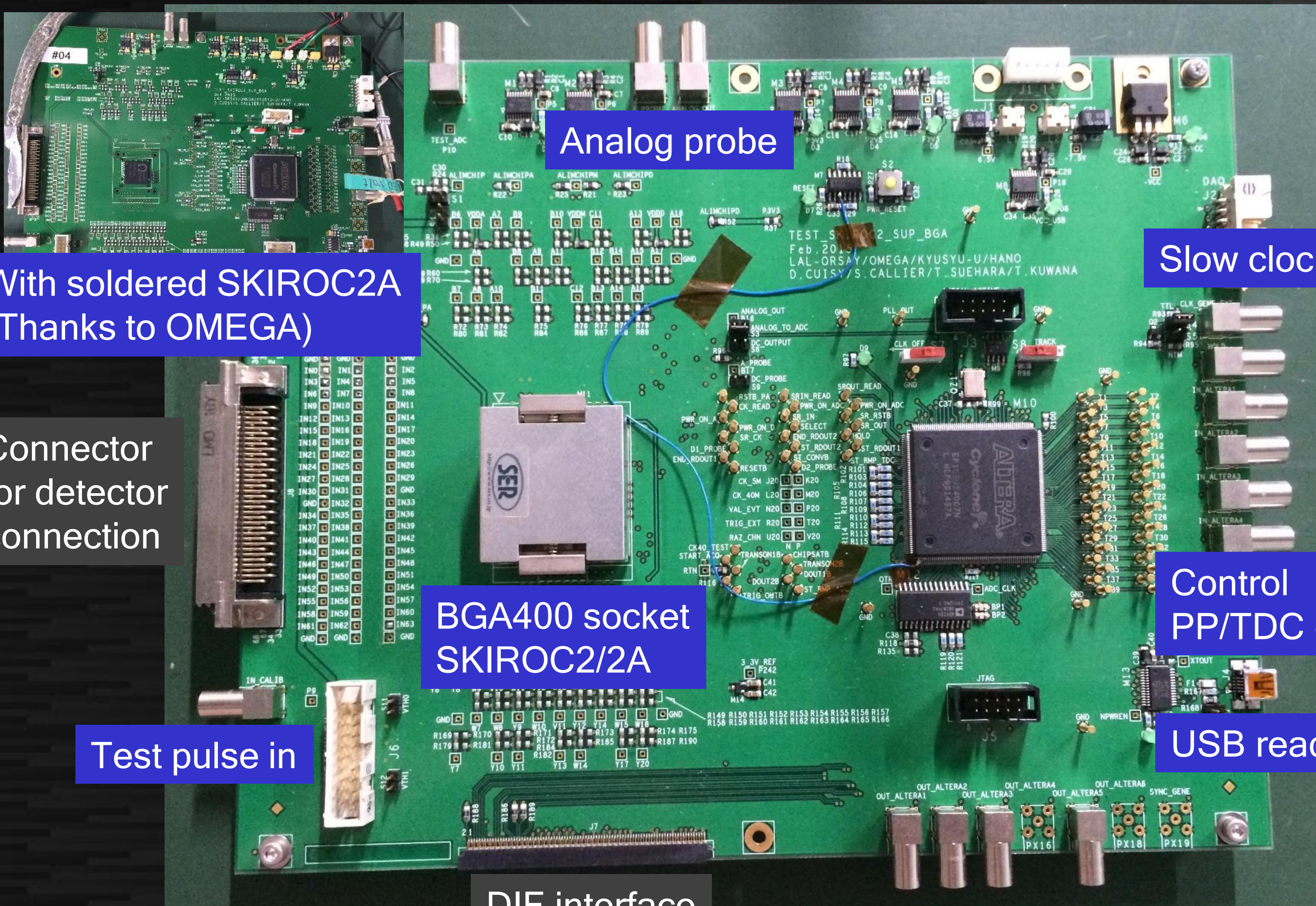
SKIROC2



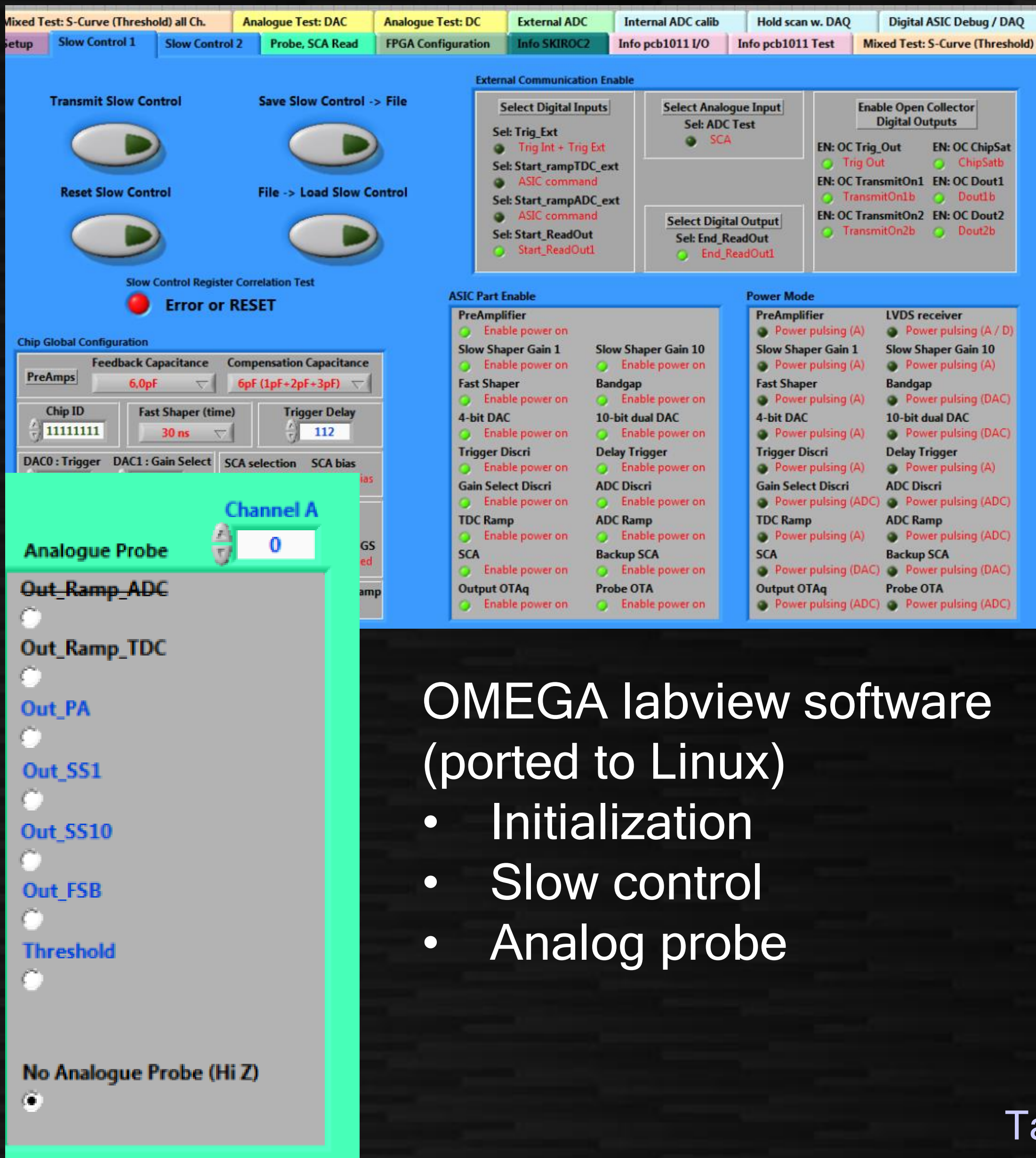
- 64 ch / chip
- 15 analog memories / ch with 12 bit BX counting by BX clock
- 12 bit ADC (G1 and G10)
- Internal trigger (1BX shift seen)
- Power pulsing
- TDC (large noise) within one BX
- External trigger (not working)

Diagram of analog part of SKIROC2

SKIROC2/2A testboard



Readout and DAQ



OMEGA labview software (ported to Linux)

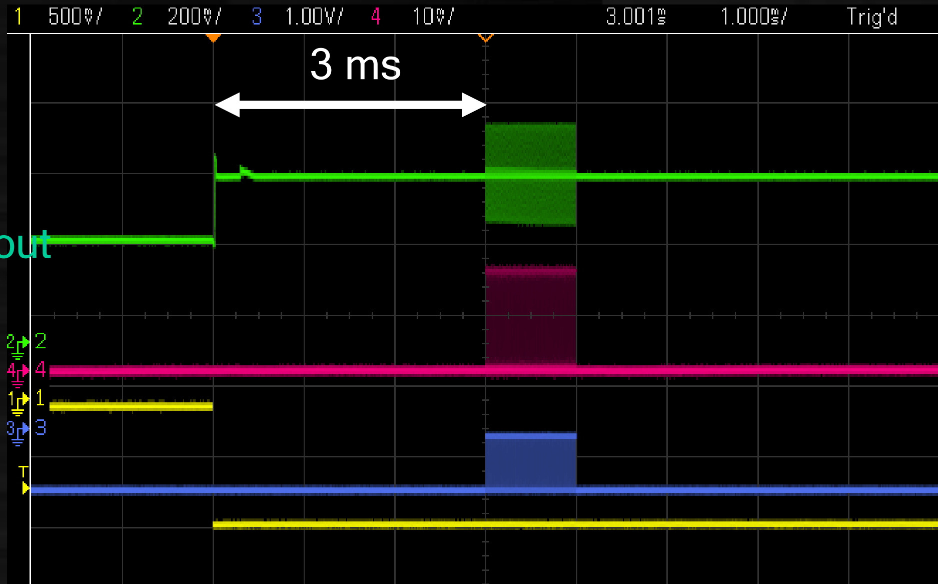
- Initialization
- Slow control
- Analog probe

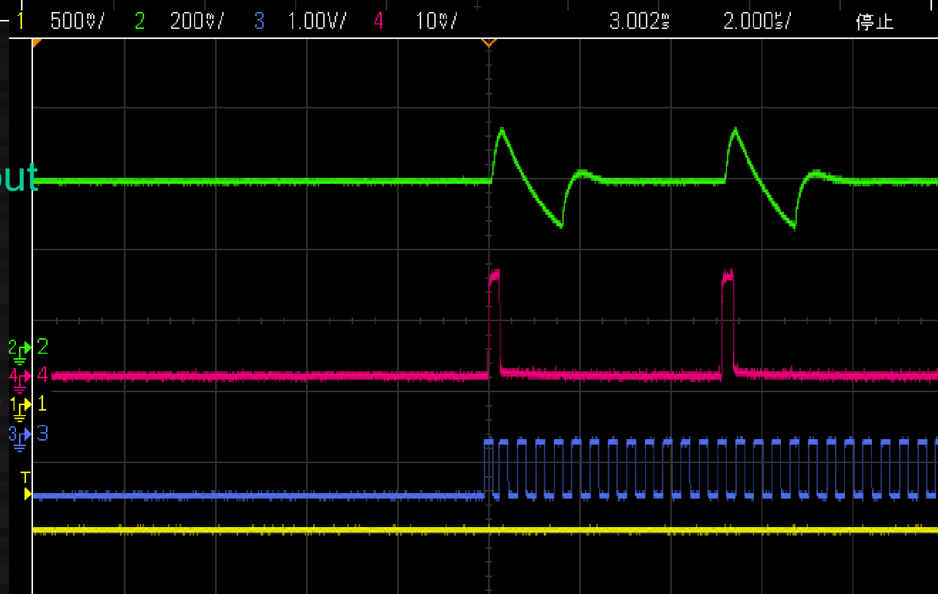
C++ DAQ (original)

- Based on labview DAQ (snip of source diagram)
- DIF-compatible output (raw2root process-able)

Procedure		reg.	bit
ASIC reset	WC	1	2
Start acq.	W	2	0
(200 ms wait)			
Stop acq.	C	2	0
Start readout	WC	2	2
Wait readout	R	4	3
(wait till bit on)			
Obtain # bytes	R	13,14	
Obtain data	Rn	15	

Power pulsing in testboard



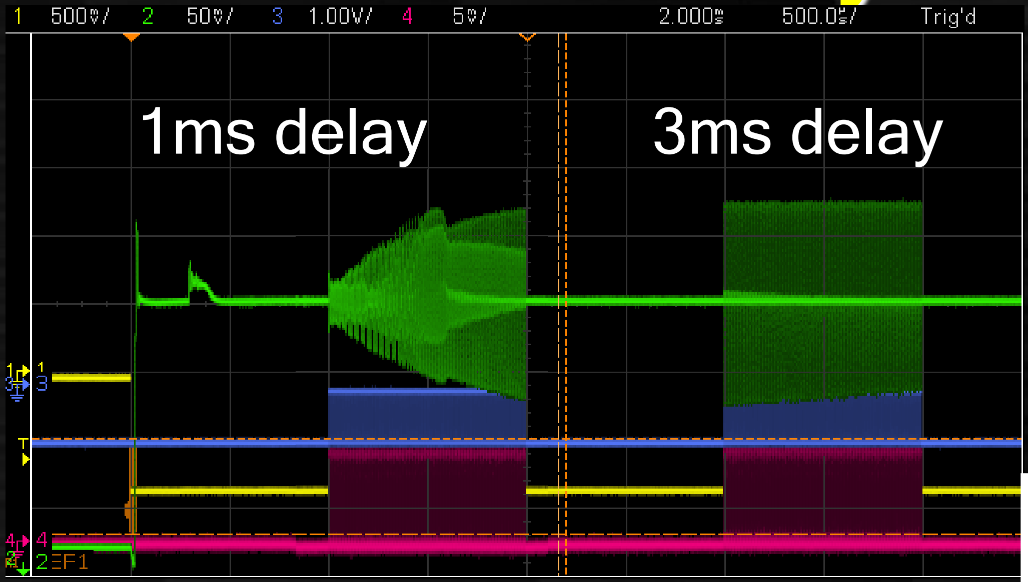


One of power lines can be controlled from outside (this time Analog is tested)

Slow clock will be provided
Problem: readout also depends on the clock: slow down due to inactive 99.5% of time

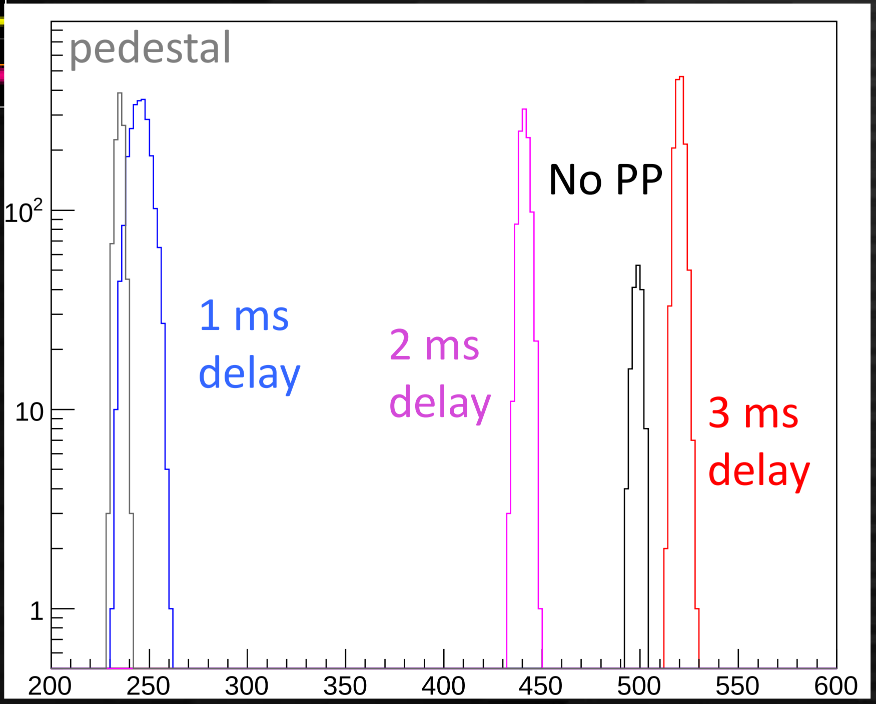
Start of slow clock delayed several ms from power_on_a

Delay vs. gain



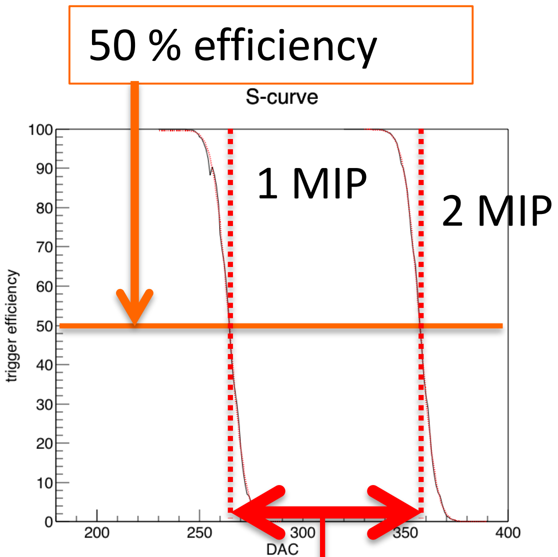
~ 3 ms delay is needed
to ensure typical gain in PP

Next BX is affected
(triggered & negative shift)



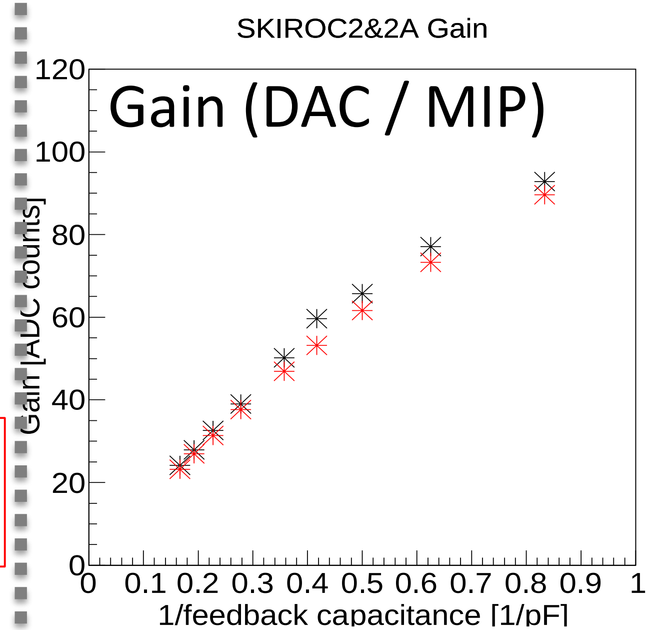
Fast shaper & triggering @SKIROC2,2A

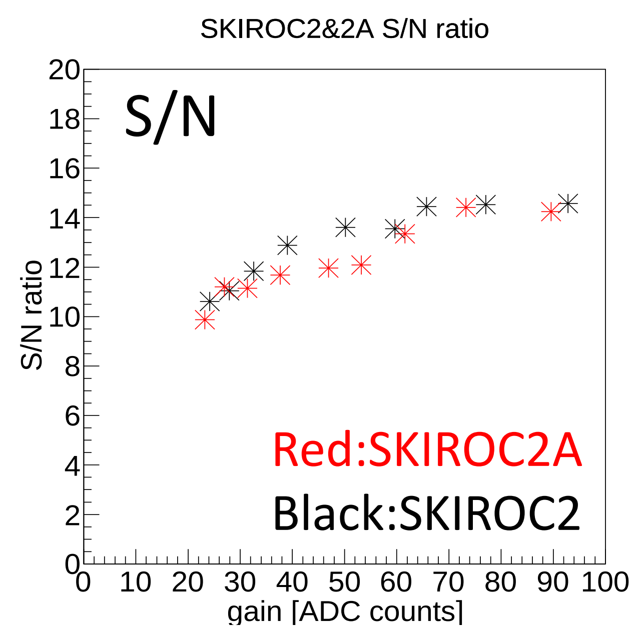
S-curve



Gain : DAC count of 1-2 MIP (50% point)

- Test pulse in ch10
- Preamp of all ch active
- Trigger of all ch active
- Dependence on gain by feedback capacitance
- Socket version of testboard is used





S/N=13~14, no difference seen between SKIROC2/A

Fast shaper@SKIROC2,2A

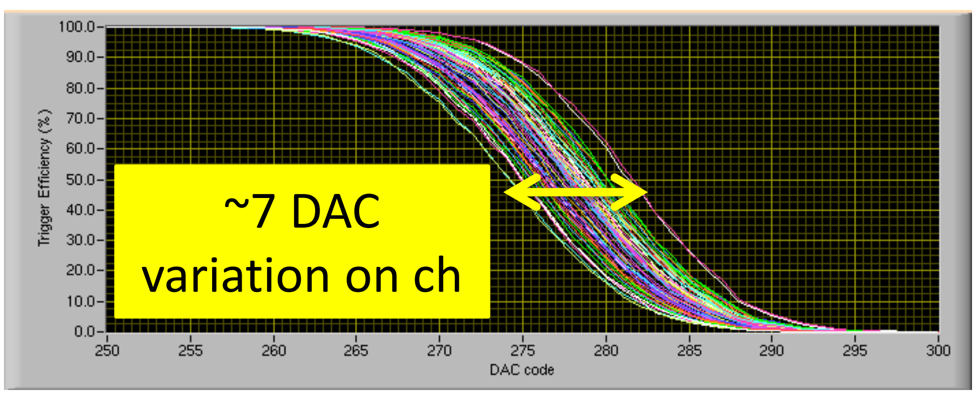
Soldered version (SKIROC2A)

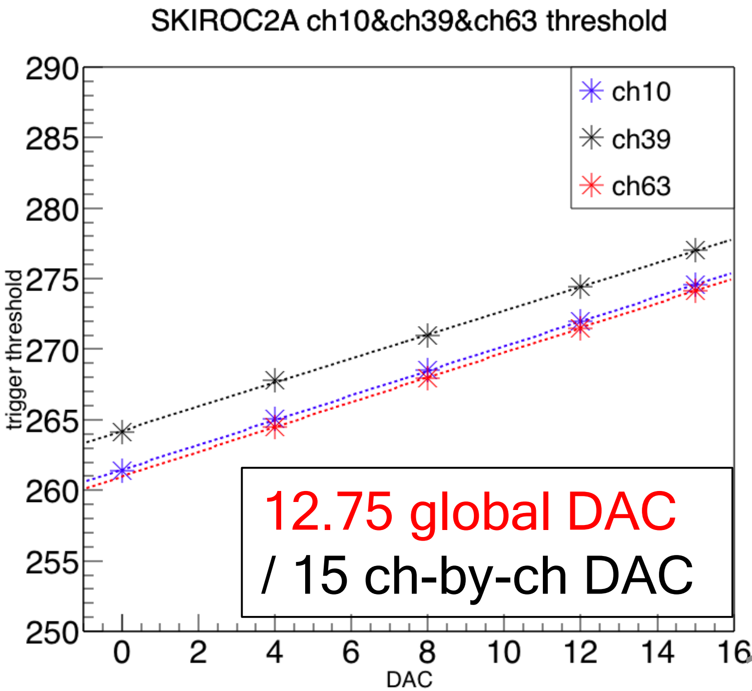
All 64ch s-curve @SKIROC2A

channel	Gain	width @ 1MIP	S/N
10	86.12	5.46	15.76
39	87.58	5.29	16.58
63	86.79	5.64	15.38

feedback capacitance: 1.2 pF
compensation capacitance: 6 pF

Slightly better than socket version (result should be confirmed)





Individual trigger threshold is checked: dynamic range of 13 DAC

Slow shaper @ SKIROC2A

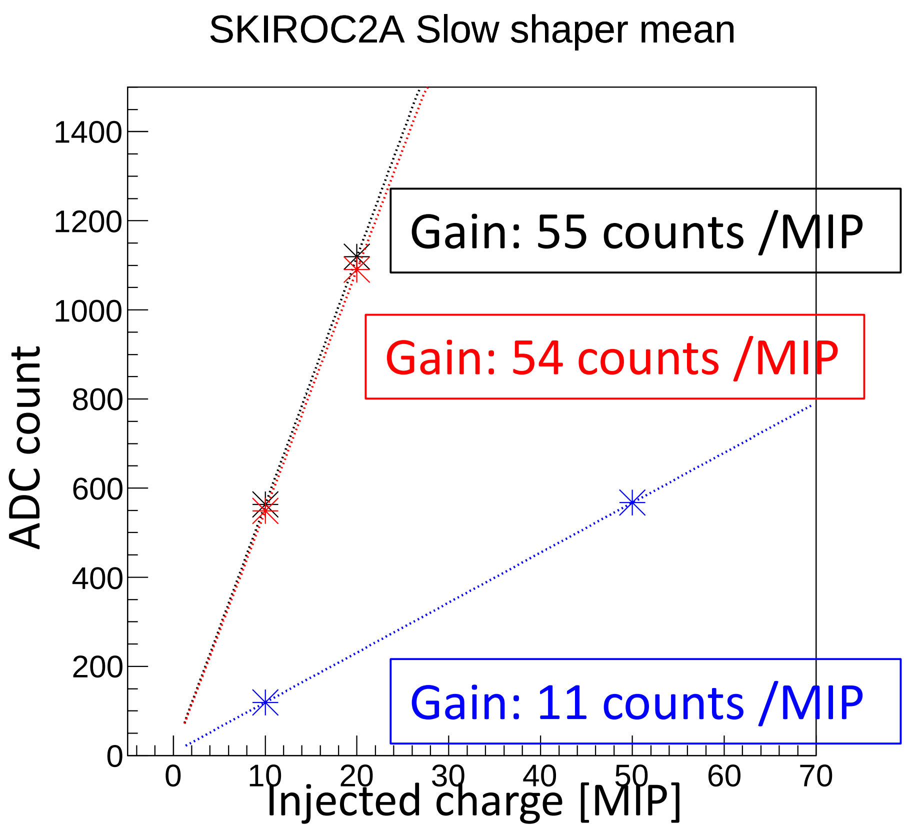
- Test pulse(100 kHz,1-100 MIP)
- power pulsing: 3 ms delay

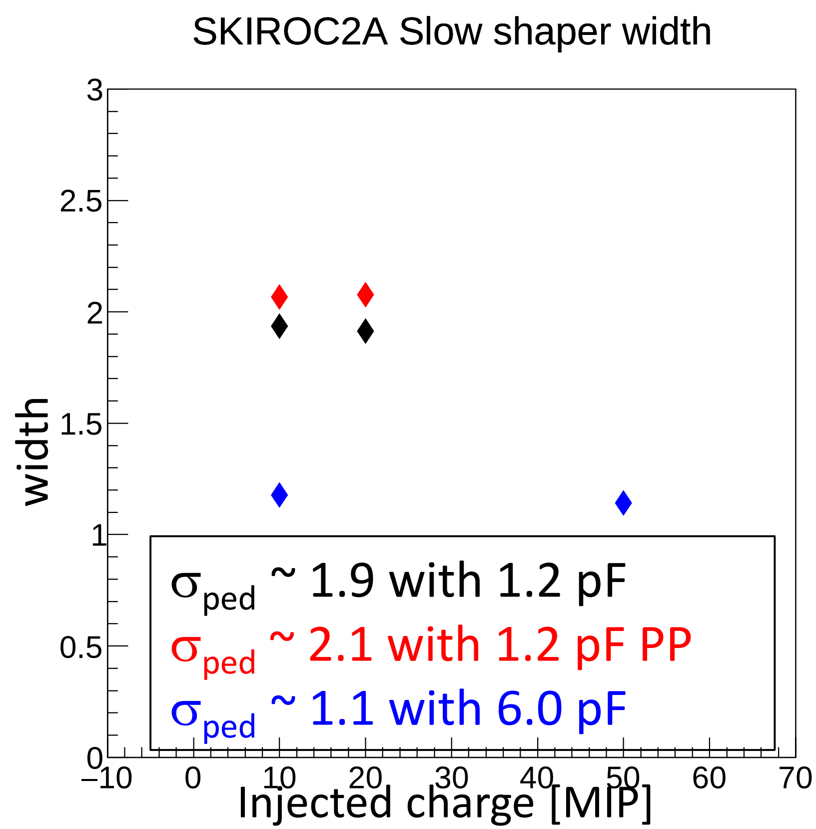
Testboard 2

Black: 1.2 pF fb. cap.

Blue: 6.0 pF fb. cap.

Red: 1.2 pF fb. cap. with power pulsing



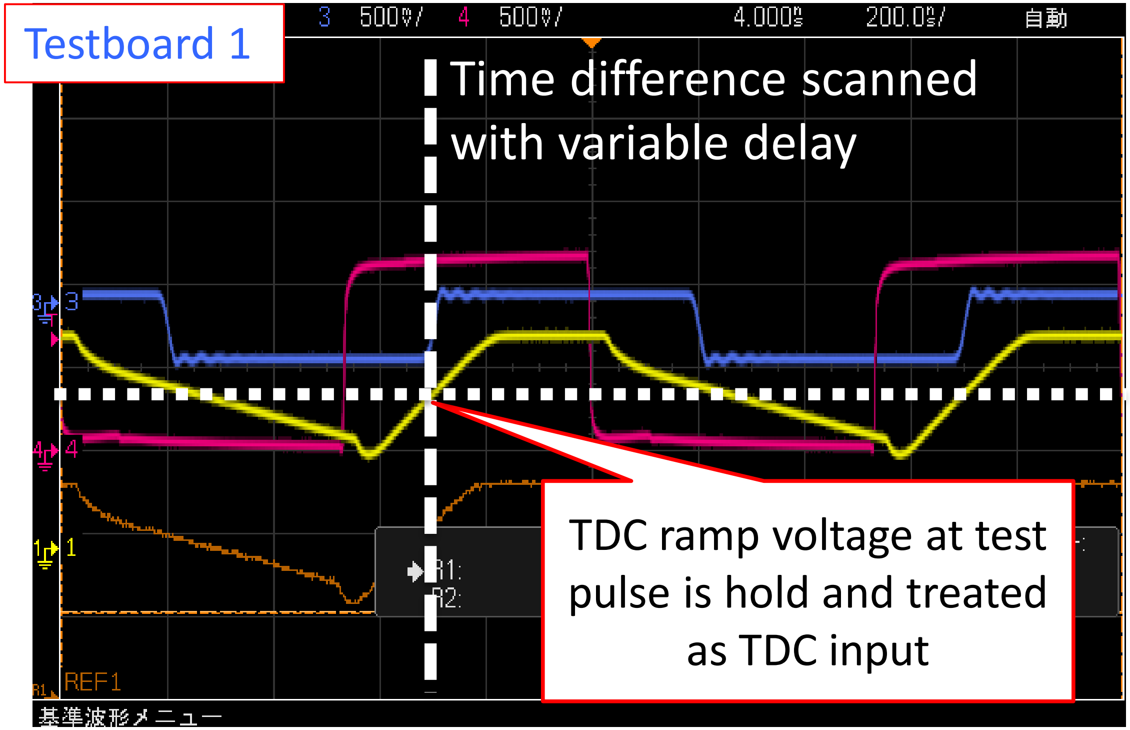


Gain ~ 55 counts / MIP, σ_{ped} ~ 1.9 , S/N ~ 29 with 1.2 pF

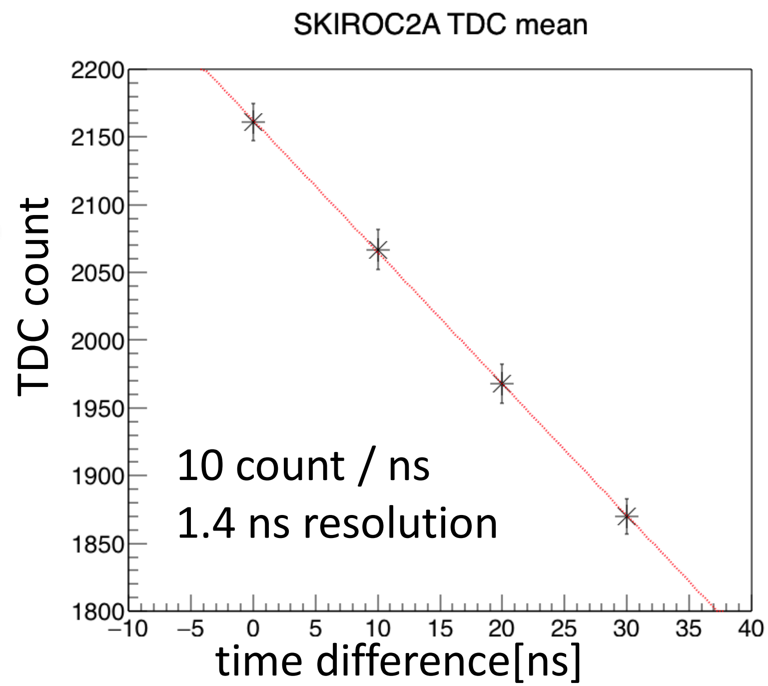
Gain ~ 54 counts / MIP, σ_{ped} ~ 2.1 , S/N ~ 26 with 1.2 pF

Gain ~ 11 counts / MIP, σ_{ped} ~ 1.1 , S/N ~ 10 with 6.0 pF

Time measurement with TDC on SKIROC2A



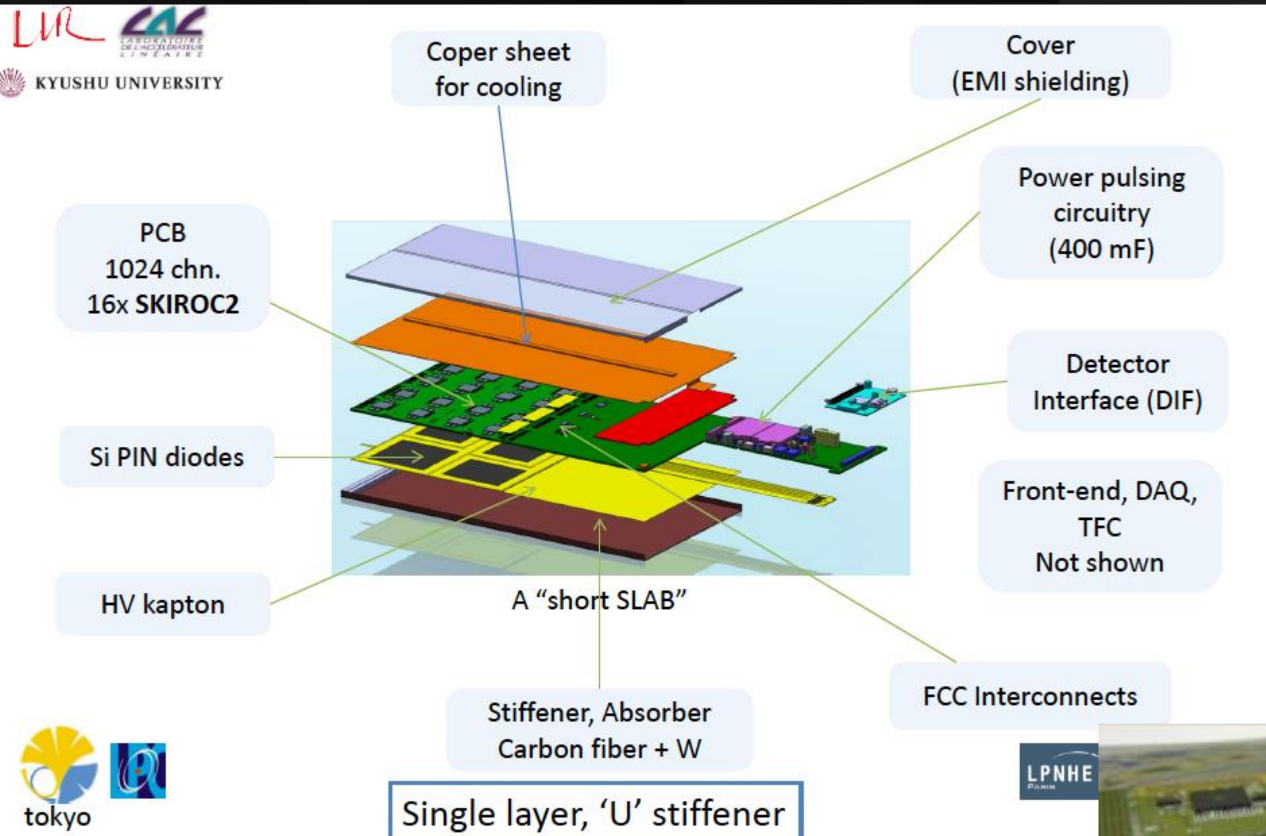
feedback capacitance: 1.2pF
Compensation capacitance: 6.0pF



Blue: Test pulse
(1MHz,10MIP)
Red: Clock for TDC
(1MHz,1.0V)
Yellow: TDC ramp voltage
- 2.5MHz clock
- fast trigger: 30 ns shaping time

10 count / ns TDC slope
1.4 ns resolution @SKIROC2A

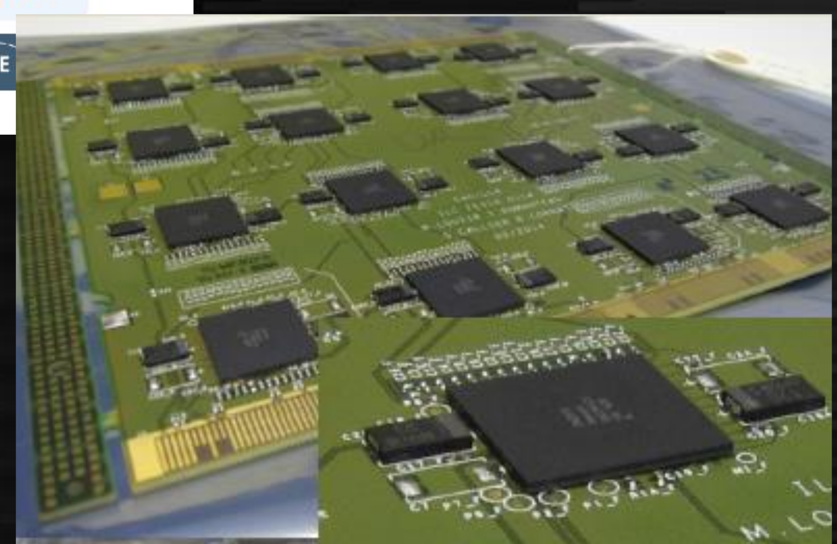
Packaging & PCB



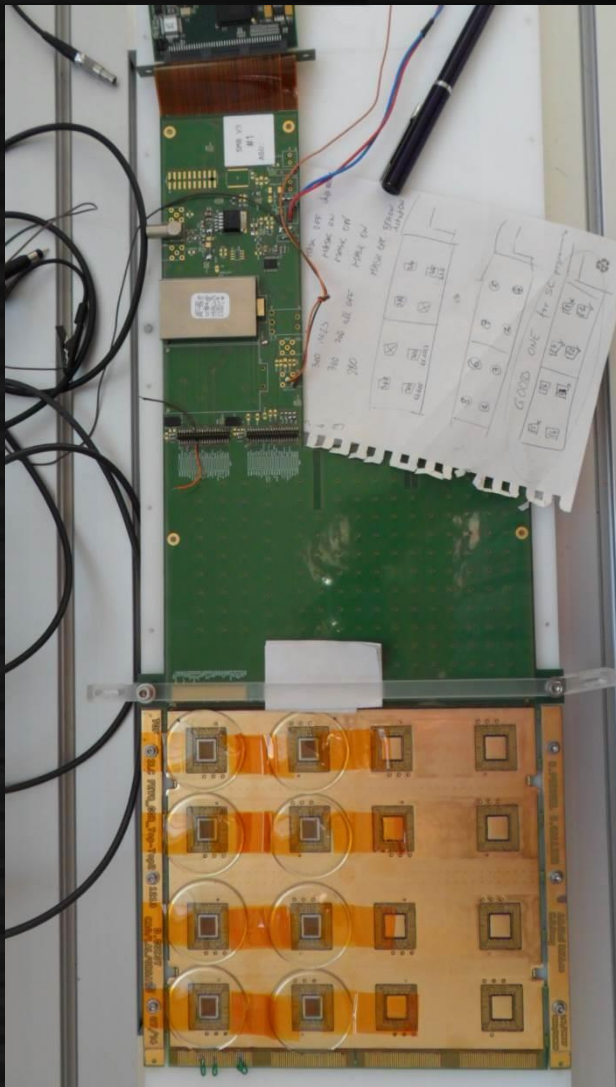
In the second tech. prototype, we used BGA400 for package

- Smaller footprint
- Availability of thinner package is better

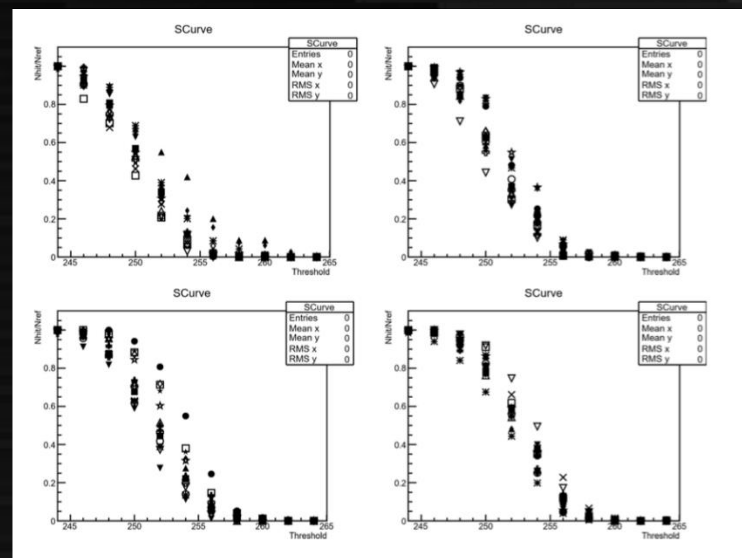
4 sensors / 16 ASICs / PCB



Another form: Chip On Board



Non-packaged chips with direct wire-bonding to PCBs
Much thinner than packaged PCB
More fragile / sensitive to outside noise



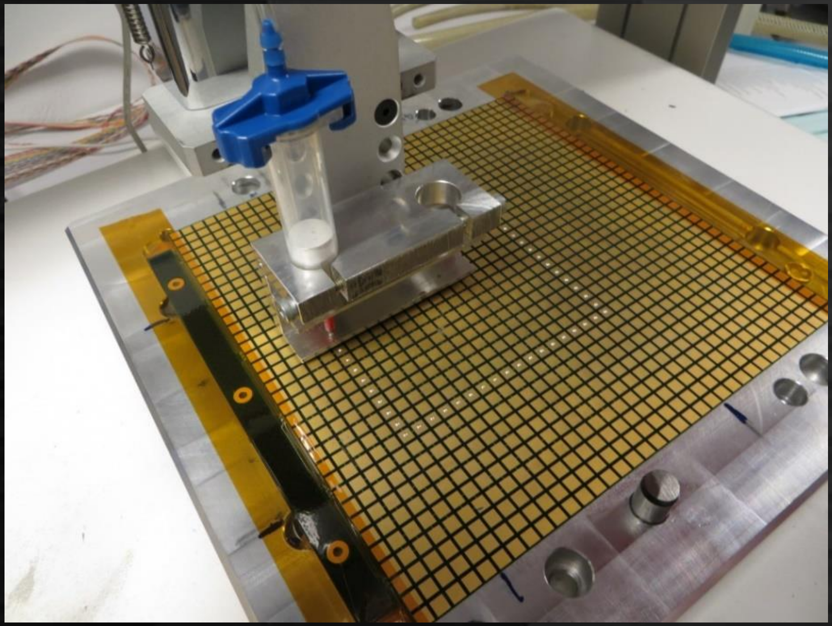
SUNG KYUN KWAN UNIVERSITY

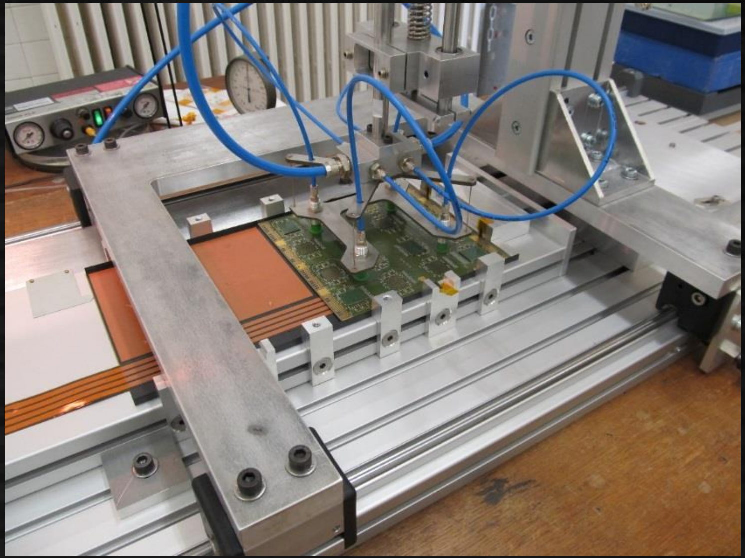
S-Curve with 5 MIP charge injection

Better flatness needed to glue sensors

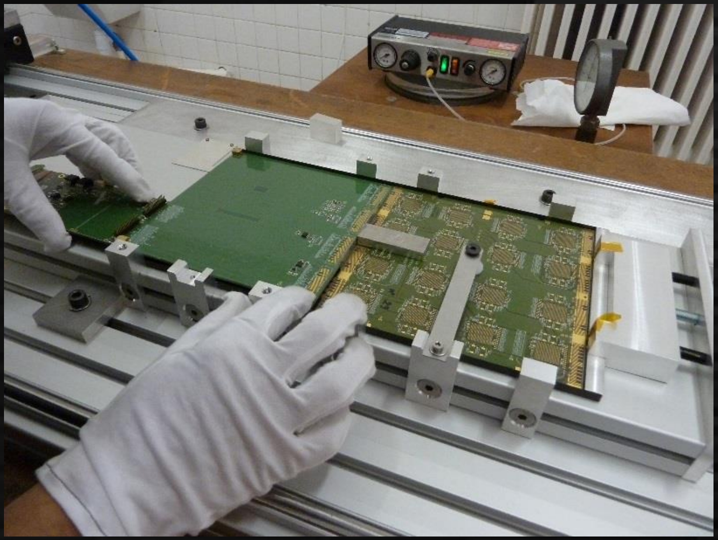
Assembly

Gluing robot was developed for room-temperature conductive glue between sensors and PCBs (to avoid bending by heat)

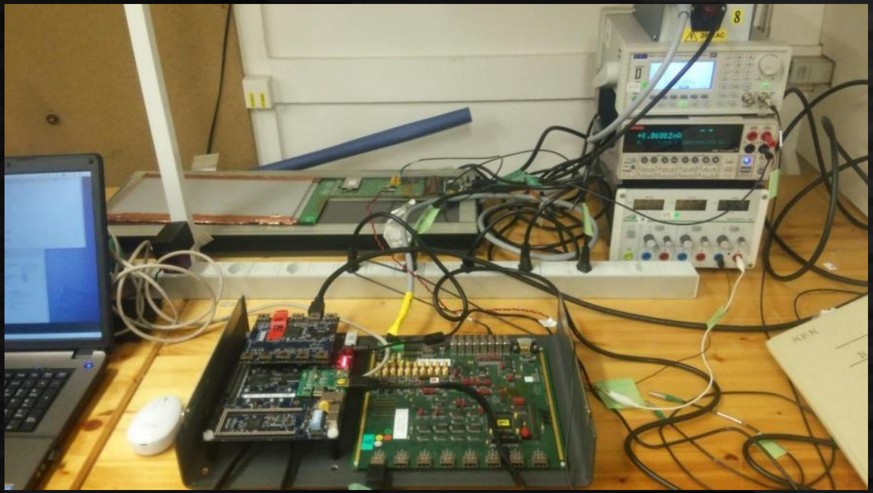




Assembly procedure of the slabs is prepared



Readout Electronics



SKIROC2

Si DIFs

HDMI

GDCC/LDA — Si CCC

ethernet

PC (calicoes)

Si CCC → Busy

Clock, Acquisition cycle → Si CCC

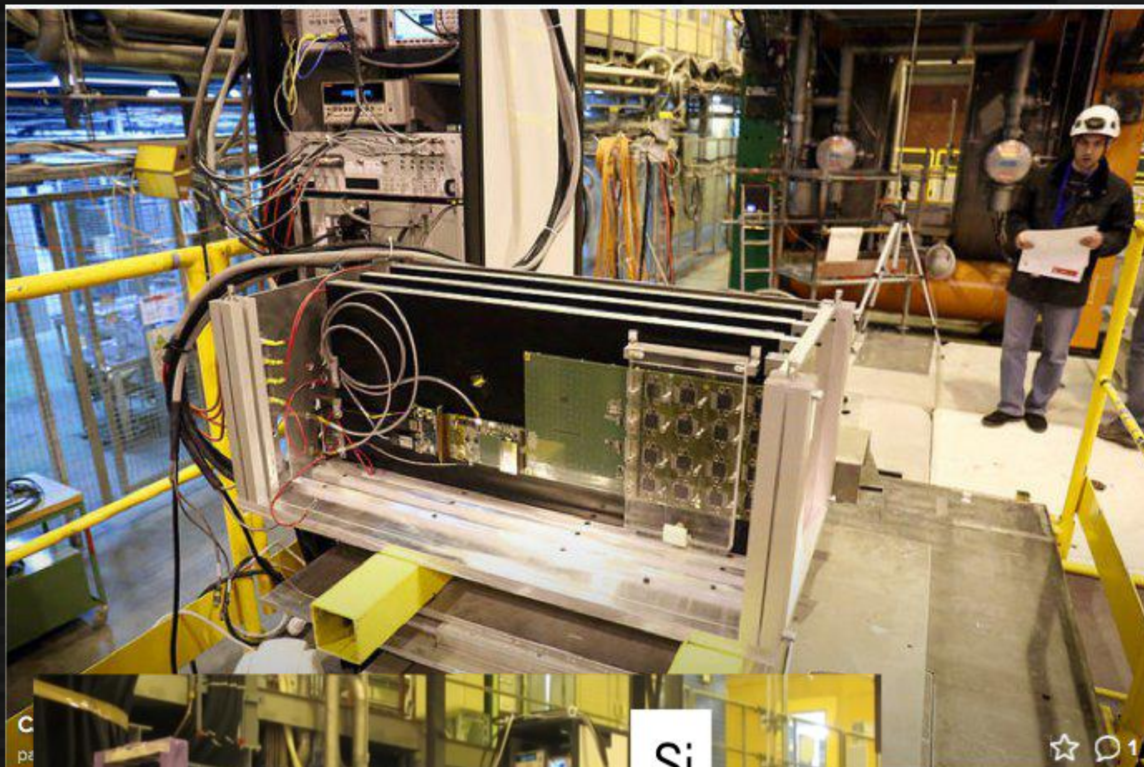
Start/stop acquisition, Run number → PC (calicoes)

Second Tech. Prototype

- 2 x 2 sensor / unit, 16 BGA ASICs
- Assembled from 2015
- New version of readout hardware (GDCC) and software (new CALICOES)

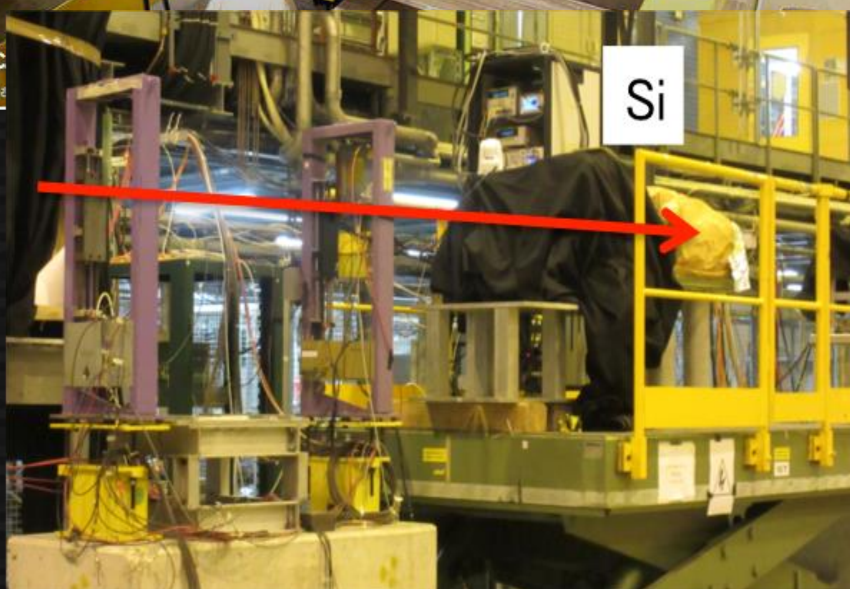
Going to test beam…

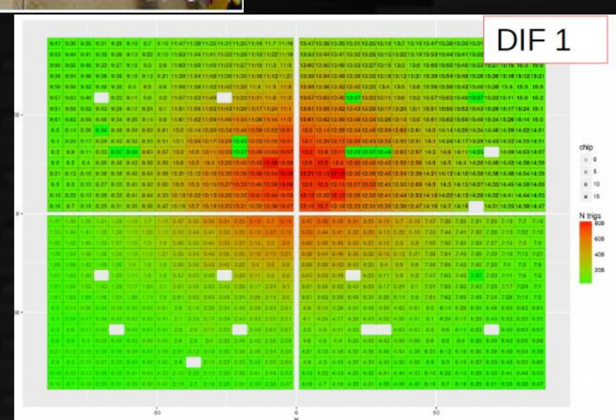
Test beam at CERN SPS 2015



Three layers of second tech. prototype was on CERN SPS and tested with 10-150 GeV electrons, pions, and muons

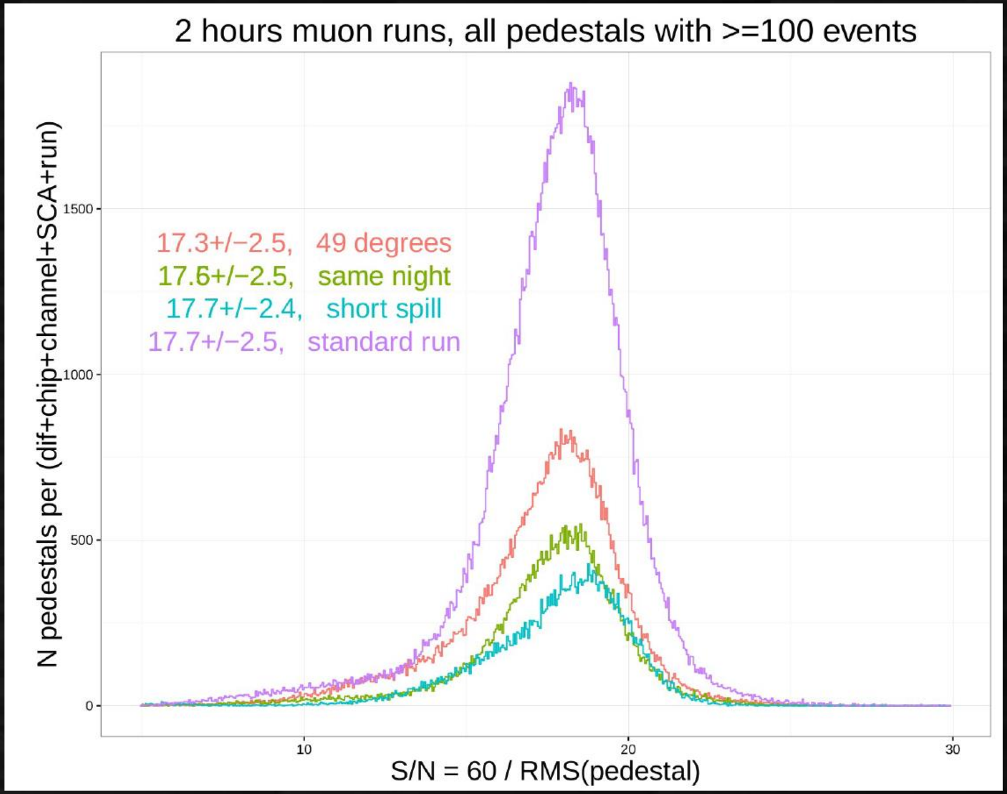
Temporary connection between sensor PCB and adapter to DAQ





Hitmap masked channel: ~2.2%

Signal-to-noise ratio



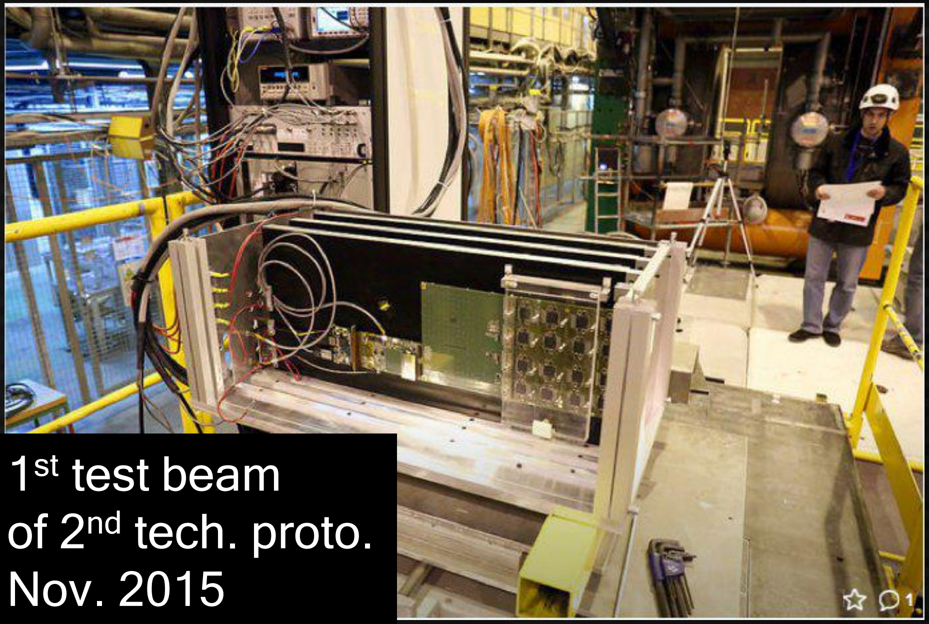
Higher gain with 1.2 pF feedback cap. (nominal: 6.0pF)

S/N 15-20 obtained on most of channels

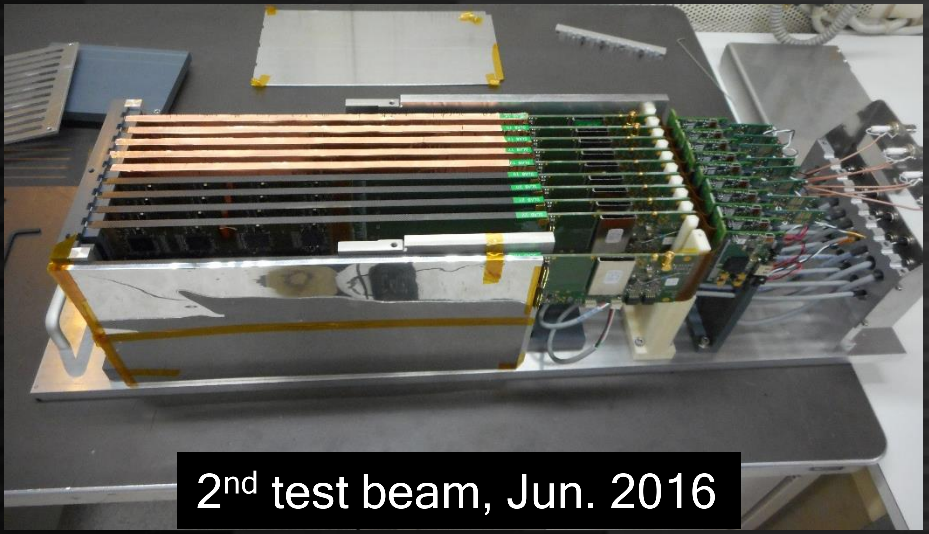
OK for 0.5 MIP threshold with practically no noise

Analysis is still ongoing, more to come…

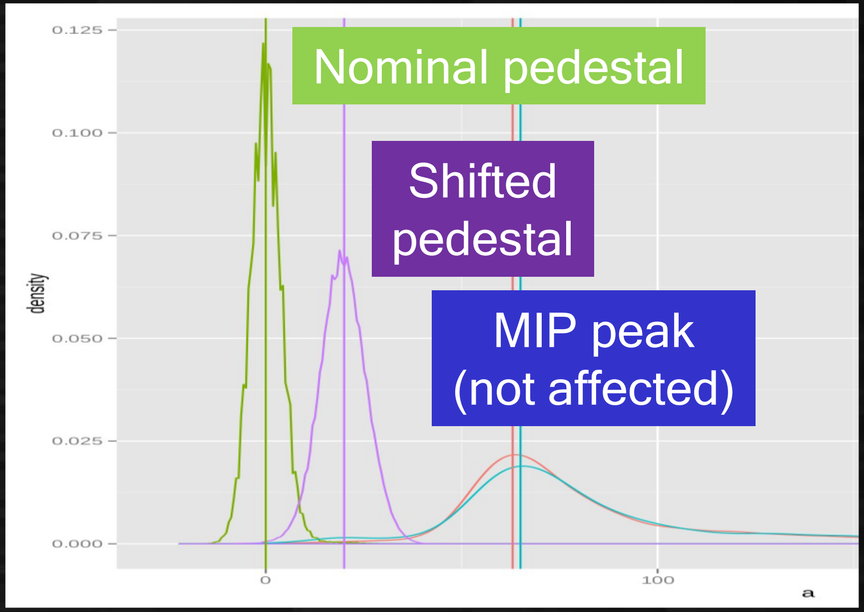
Test beams



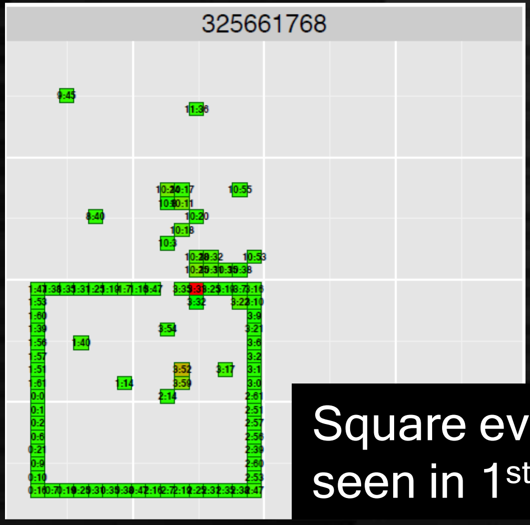
1st test beam of 2nd tech. proto. Nov. 2015



2nd test beam, Jun. 2016

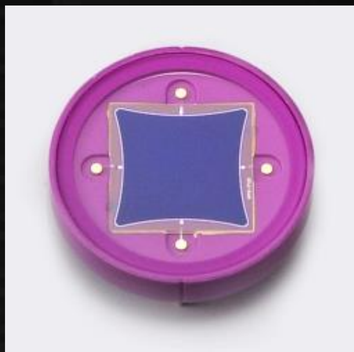


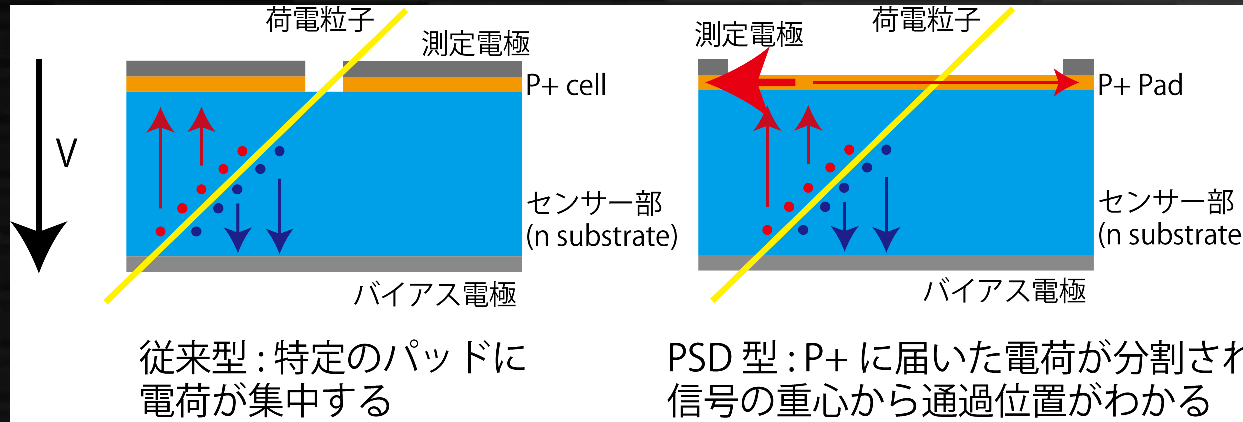
Retrigger and pedestal shift seen in 1st TB



Square event seen in 1st TB

Position Sensitive Detector

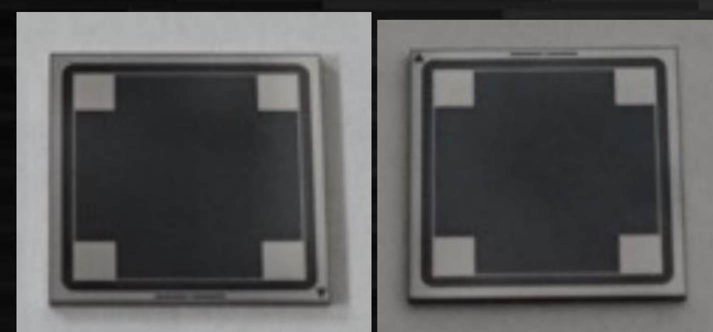




Multiple electrodes in one cell
to obtain particle position
Popular technique in laser optics

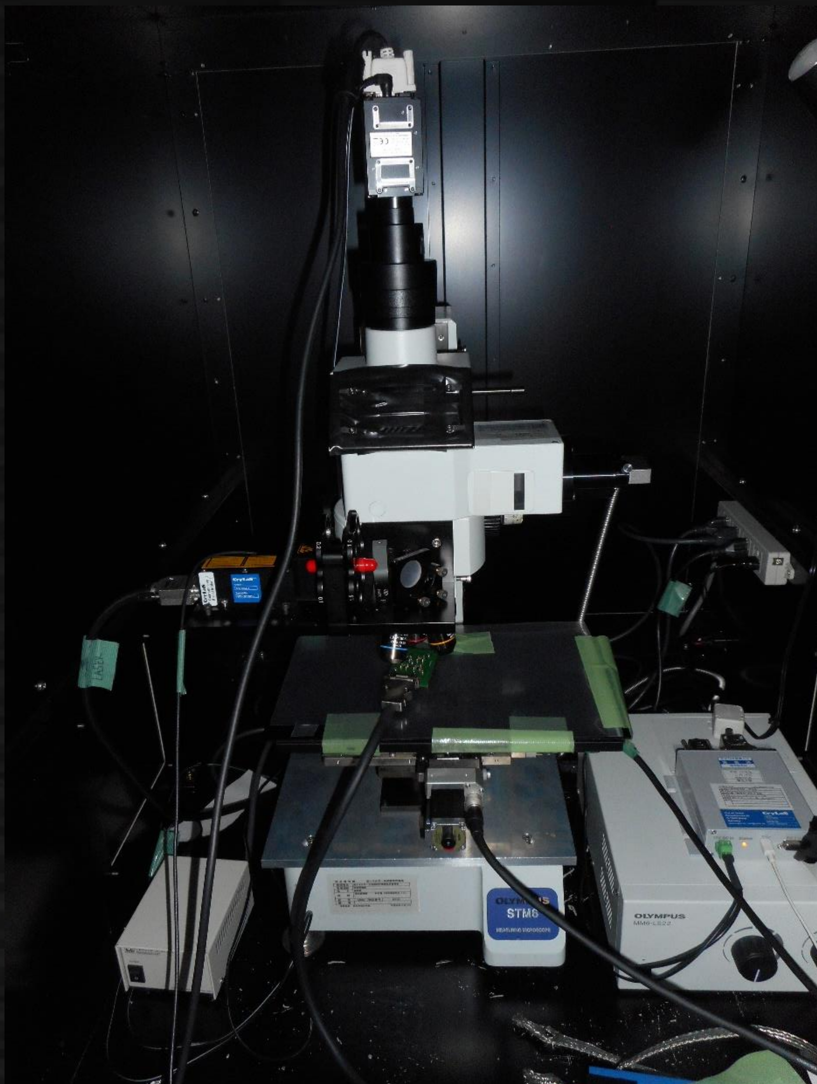
First PSDs arrived
Measurement will be done with
testboard readout within FY2016

- Linearity / Stability (laser)
- Position resolution (cosmic?)

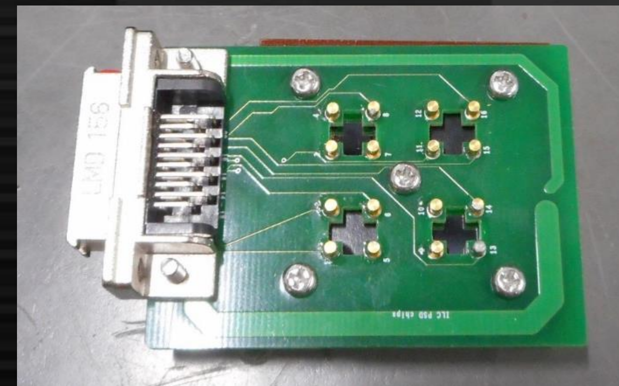


First PSD sample in Kyushu
meshed (left) and unmeshed
8 mm one side, 1 mm electrodes

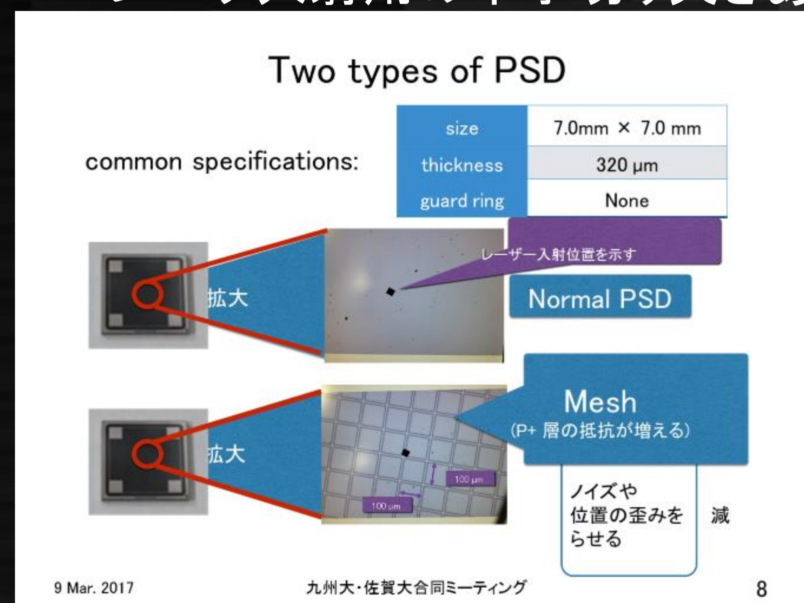
PSD赤外線レーザ測定



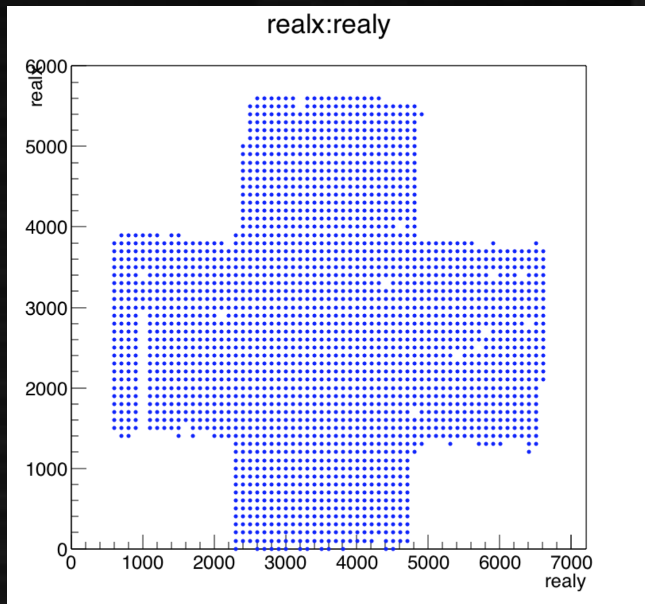
1064 nm パルスYAGレーザ



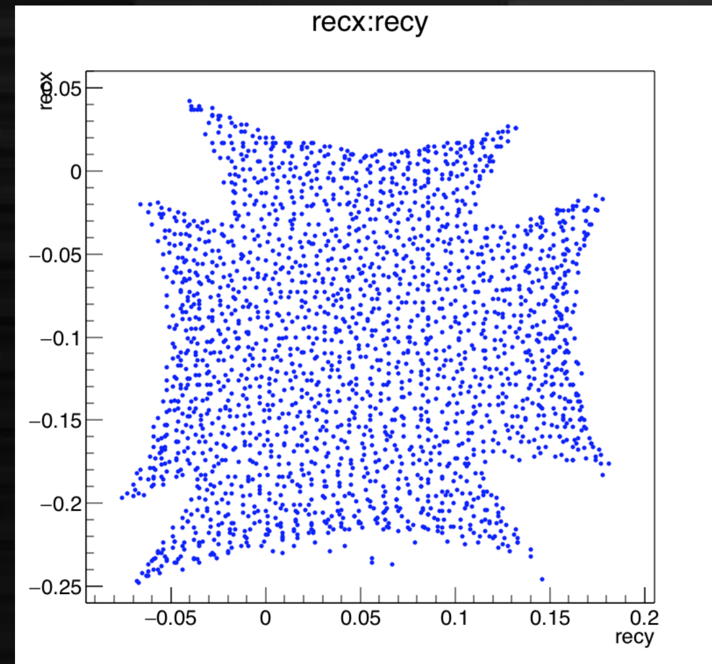
PSD保持具 preampにつなぐ
レーザ入射用の十字切り欠きあり

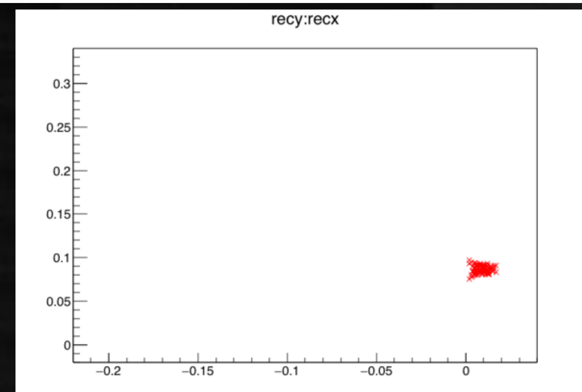


レーザによる位置ゆがみ測定



メッシュありの結果





メッシュなしの結果

電極を工夫して歪みを減らす必要がある
ダイナミックレンジが課題
本質的には、ノイズで制約
→ avalancheに期待

Summary

- Sensor study
  - 大量試験
  - コストダウン
  - 8インチ化?
- Electronics
  - ASIC/PCBの問題解決
  - 国内生産・改良
  - フルレイヤ(20～30層)ビーム試験
- PSD
  - アバランシェゲイン付きセンサーのテスト