Silicon sensor study for ILD ECAL

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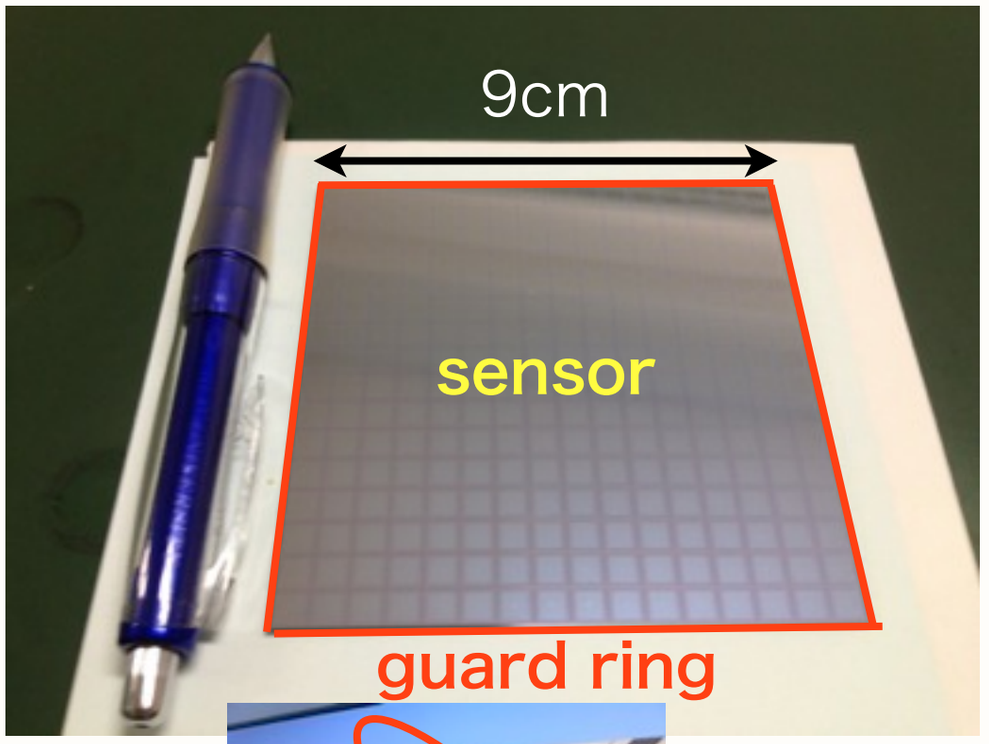
CALICE
Calorimeter for ILC

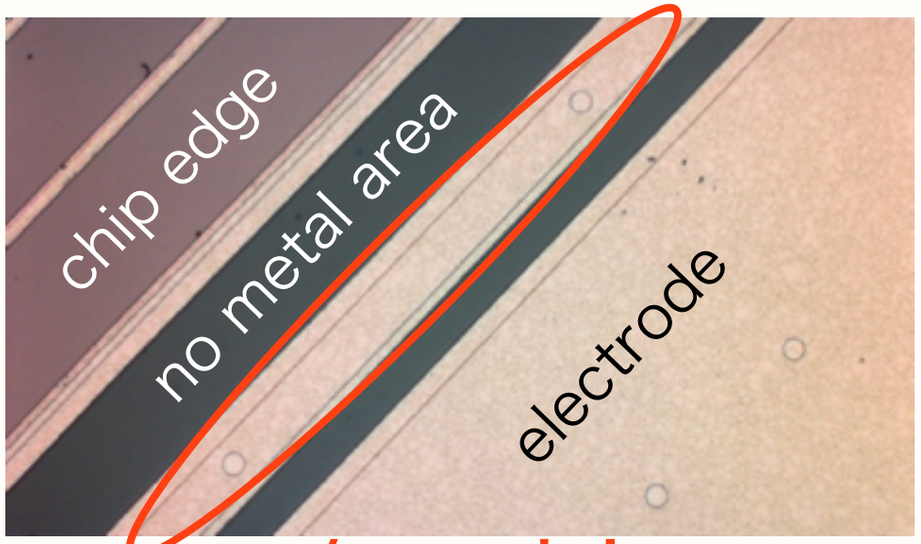
Outline

- Silicon sensor for ILD ECAL
- Motivation
- Result from measurements
  - Leakage current
  - Capacitance
  - Response to laser
- Summary & Prospect

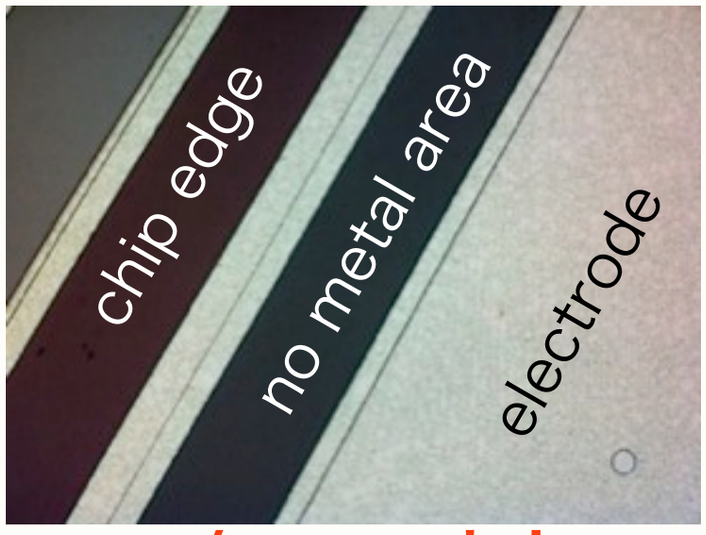
Silicon sensor

- Produced by Hamamatsu.
- 1pixel = 5.5mm x 5.5mm
- 16 x 16 = 256 pixels
- Thickness of sensor : 320 μm
- Guard ring width :
  80μm(1GR),20μm(2,4-GR)

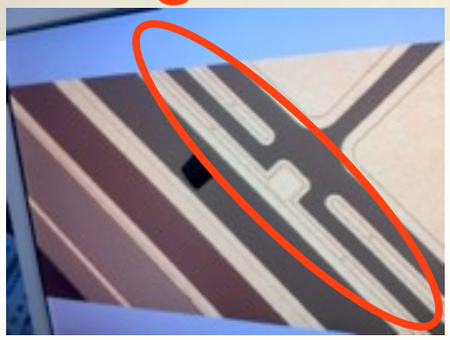




w/ guard ring



w/o guard ring



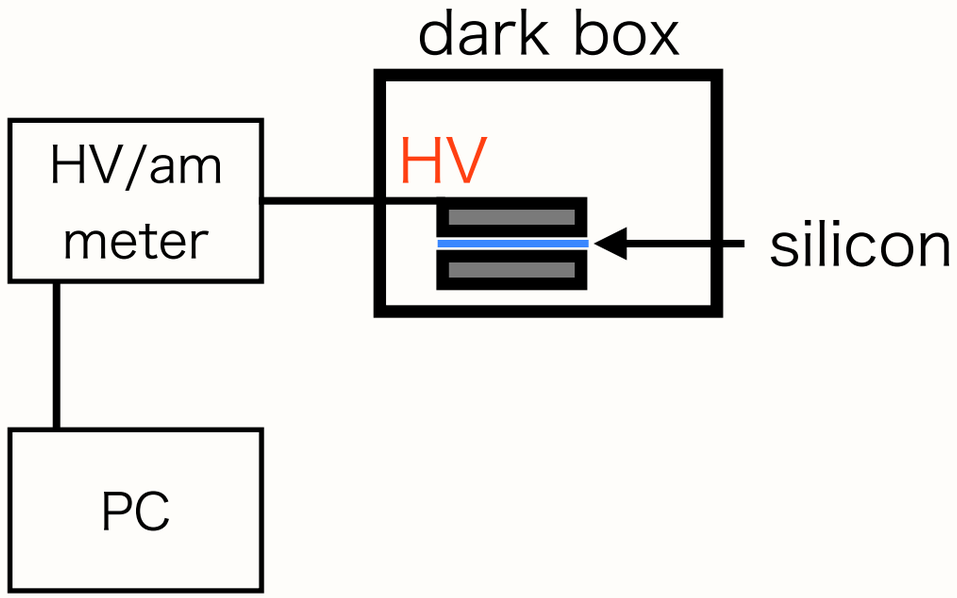
2-split GR

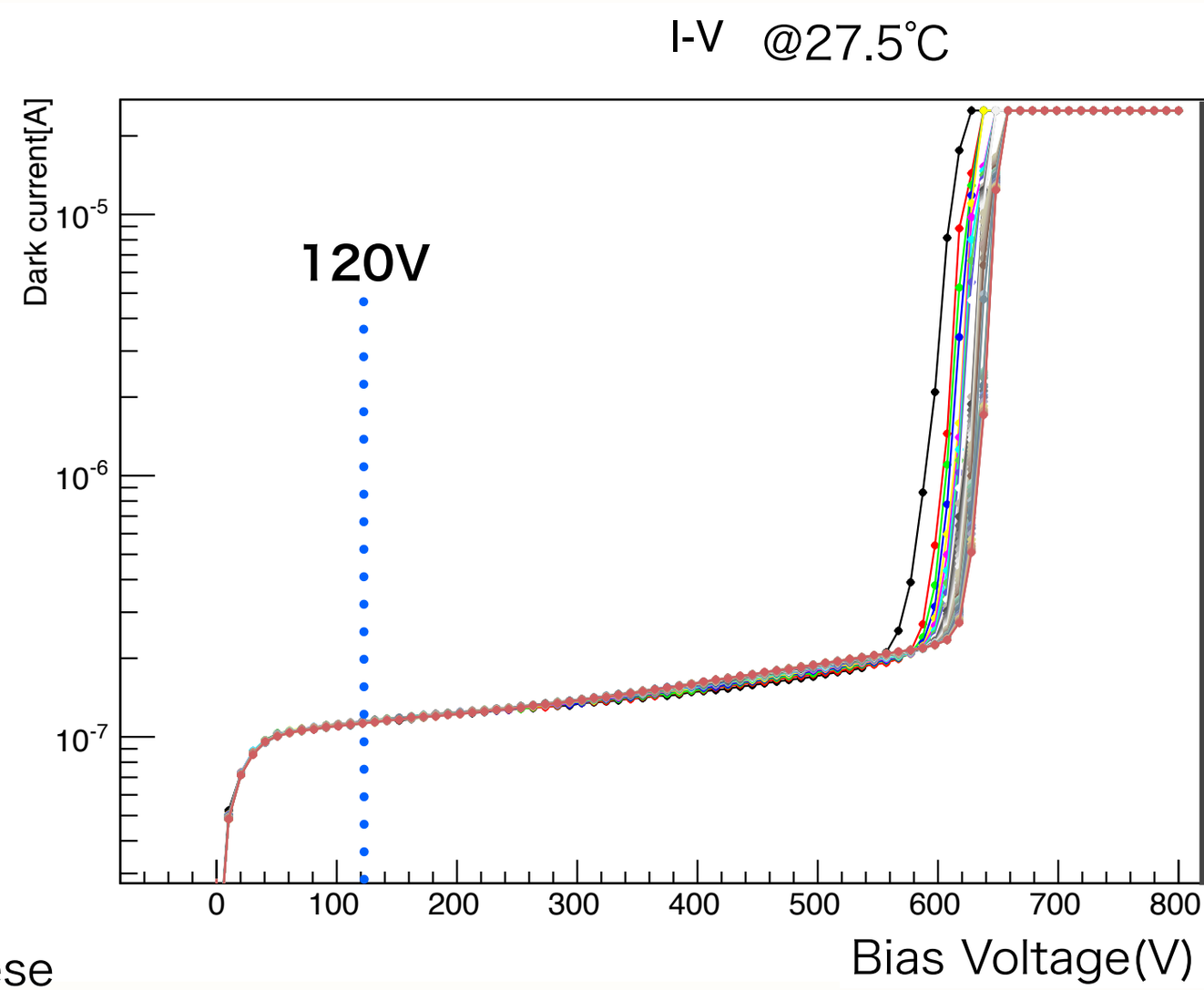
4-split GR

Motivation

- Measurements of properties
  - To understand basic properties of Si sensor,
    and establish Si sensor test bench system for quality control.
- Response to laser
  - To study the response of sensor.
  - We need to investigate the effect of guard ring to decide sensor design.

Leakage current



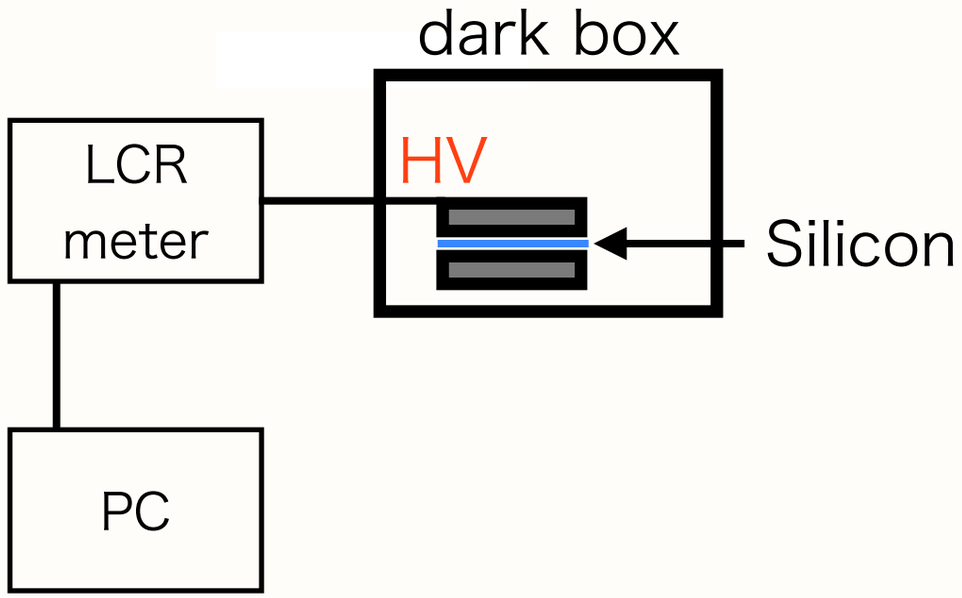


The leakage current around 120V(operation V) is low and stable.

Until 4 or 5 times measurements,
break down voltage went higher by each step.
(This behavior is now under investigation)

From this result, the good chip should have these low and stable leakage current around 120V.

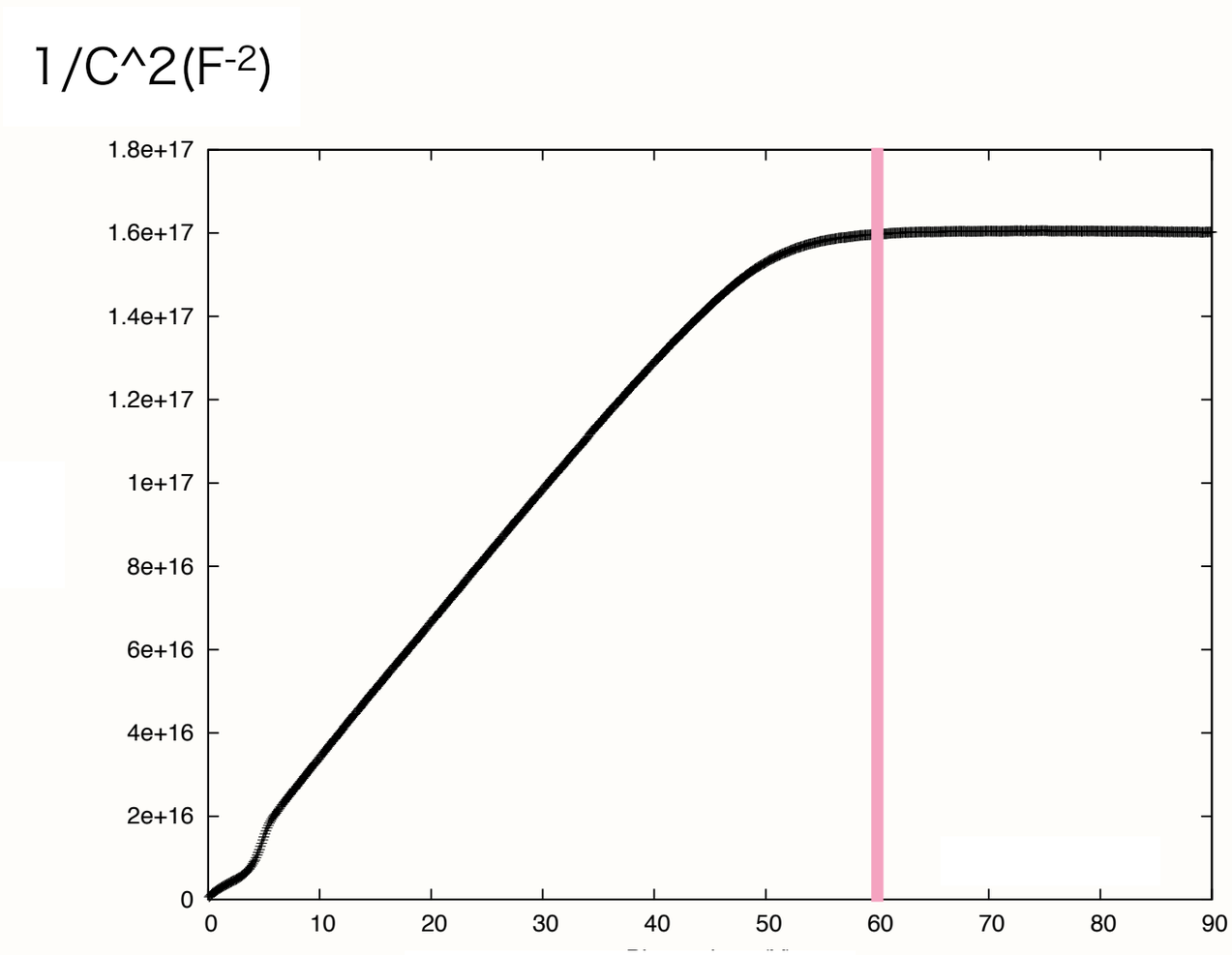
Capacitance



1/C^2 has very good linearity.

> 60V : saturated because chip is fully depleted.

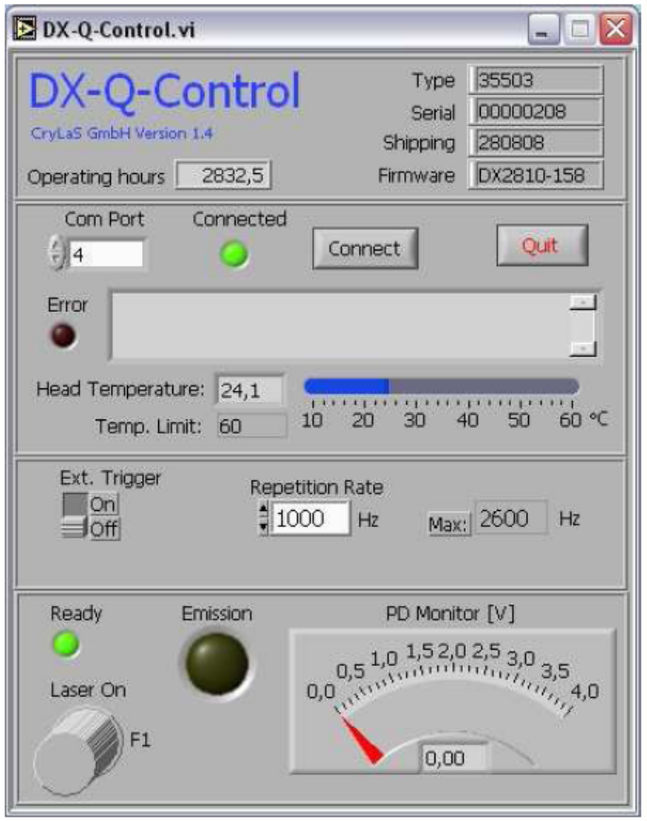
Chip can be fully depleted before 120V.



Laser System

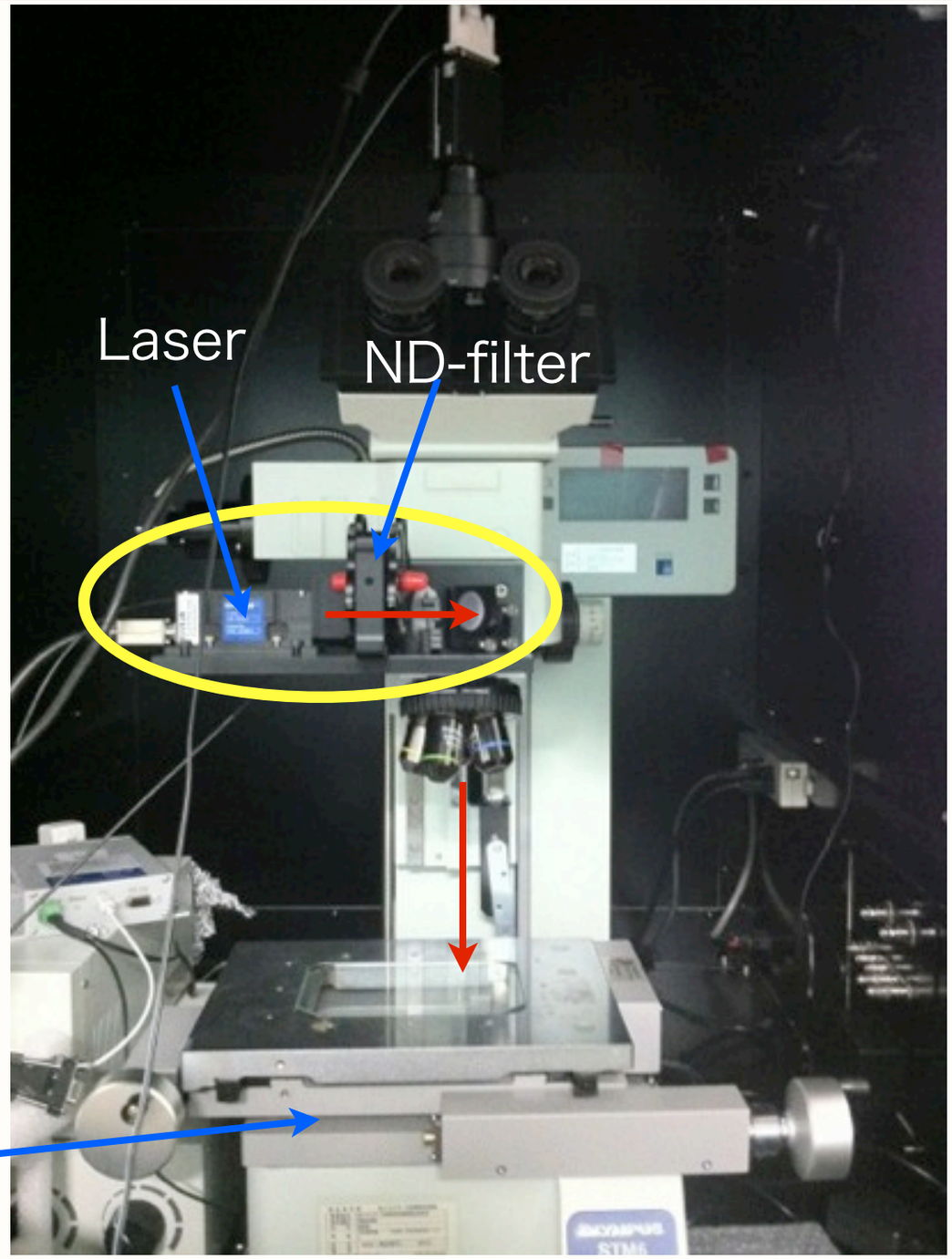
CRYLAS GmbH
DSS1064-Q2 (Class 3B)
Wave length : 1064 nm
Pulse width : ~ 1.5 ns

Interface of the control software



We can control
Repetition Rate
from PC

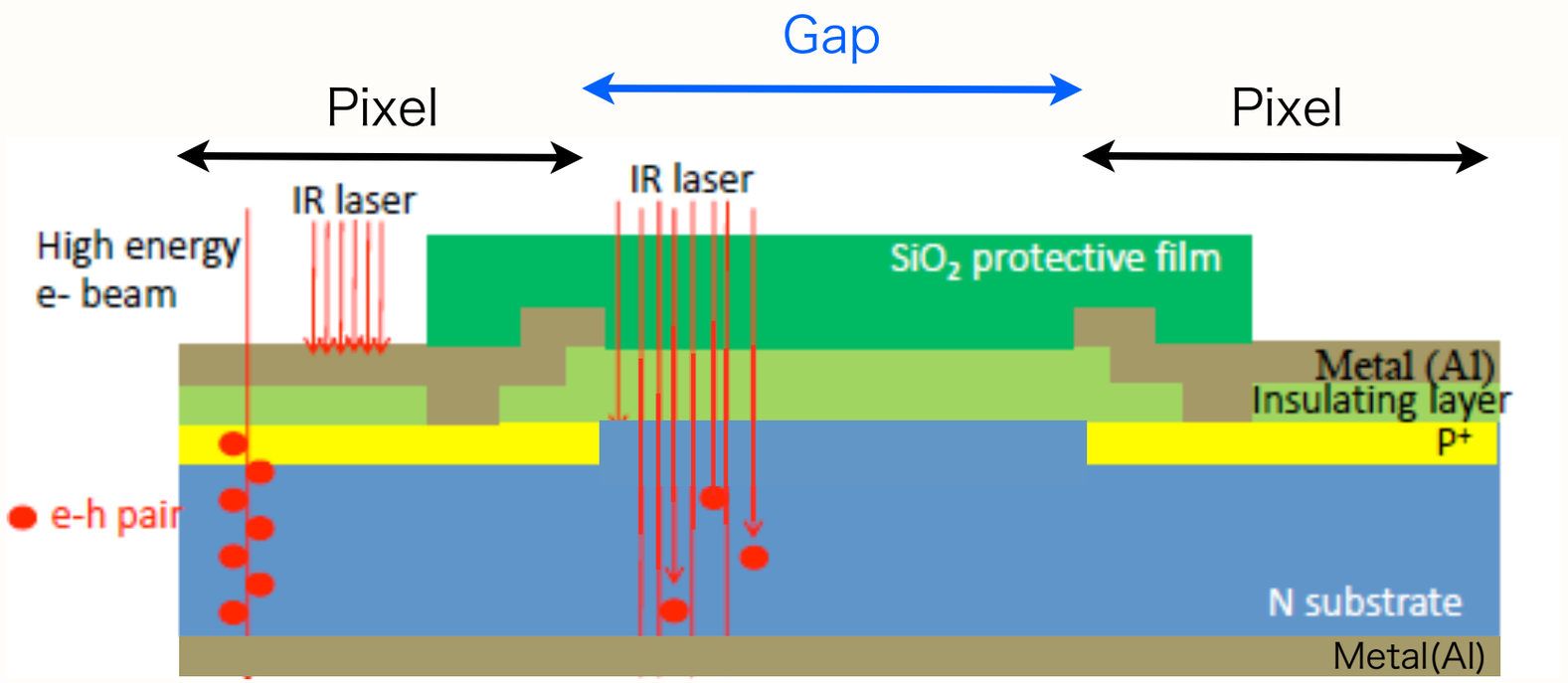
x-y stage



Infrared laser

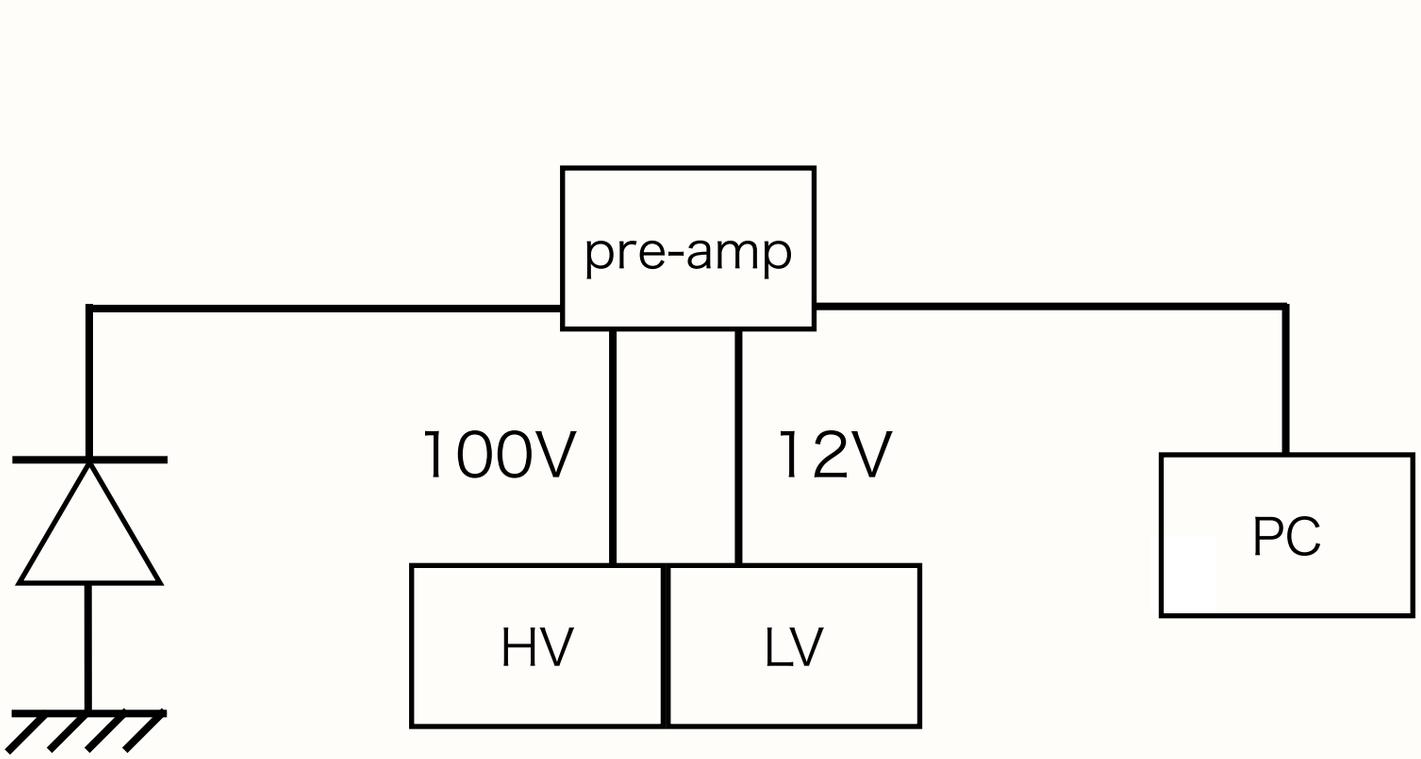
- Wave length -> 1064 nm = 1.16 eV
  Band gap energy of Si = 1.12 eV

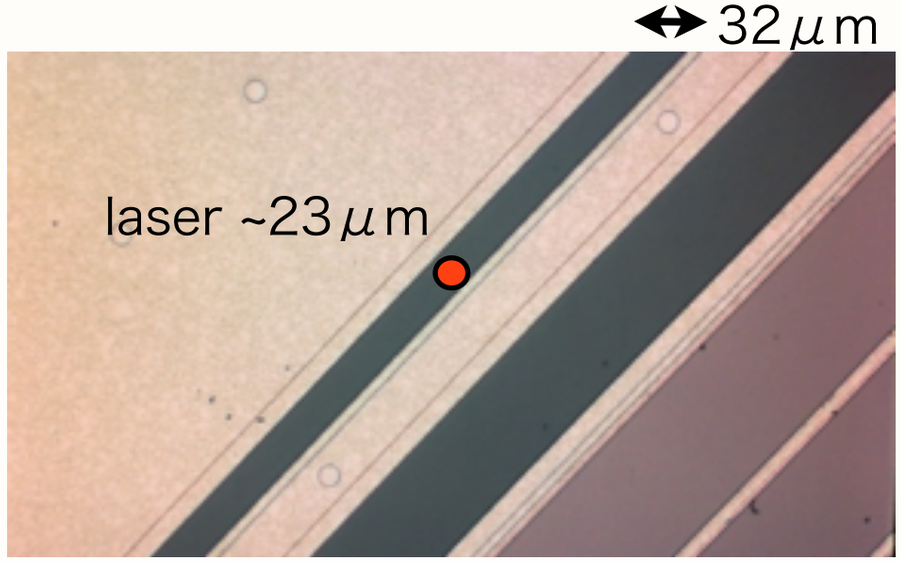
- To investigate the guard ring effect, we shoot the laser into the gap.
  (between pixel and pixel, guard ring and pixel)



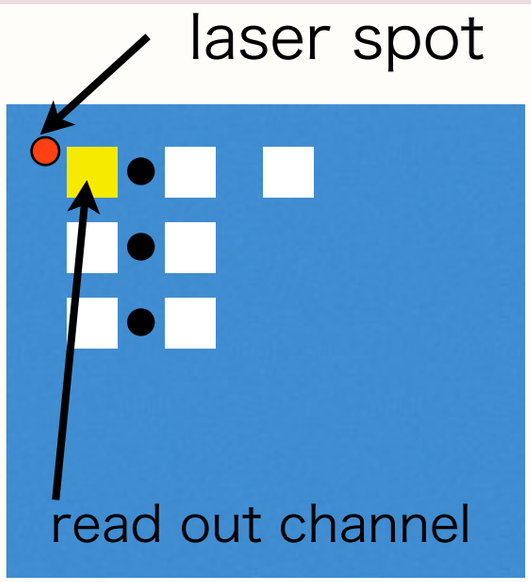
Setup

- The diameter of laser at focus point ~23μm.
- The width between gap and pixel ~39μm.
  Laser is small enough to shoot into gap.

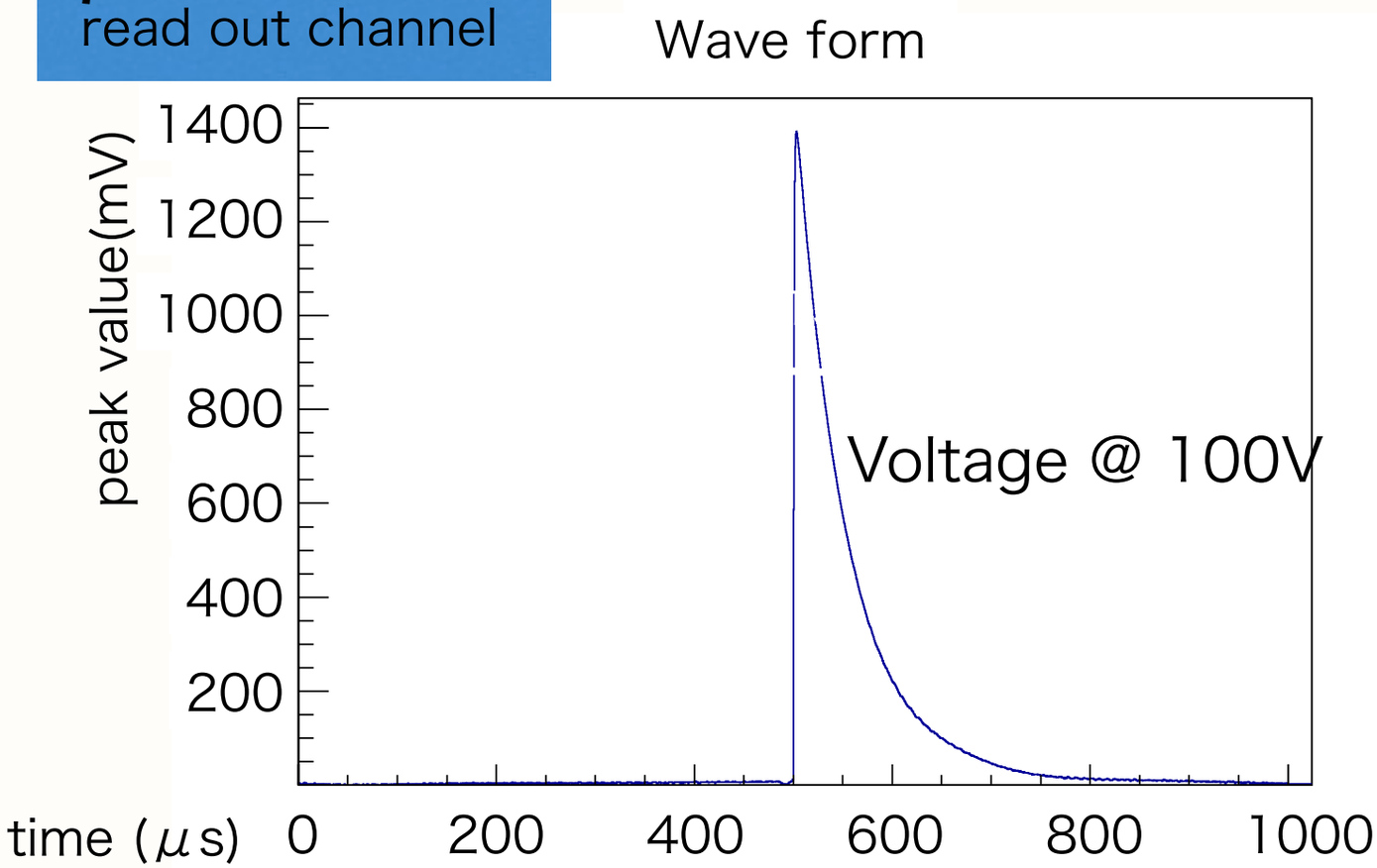


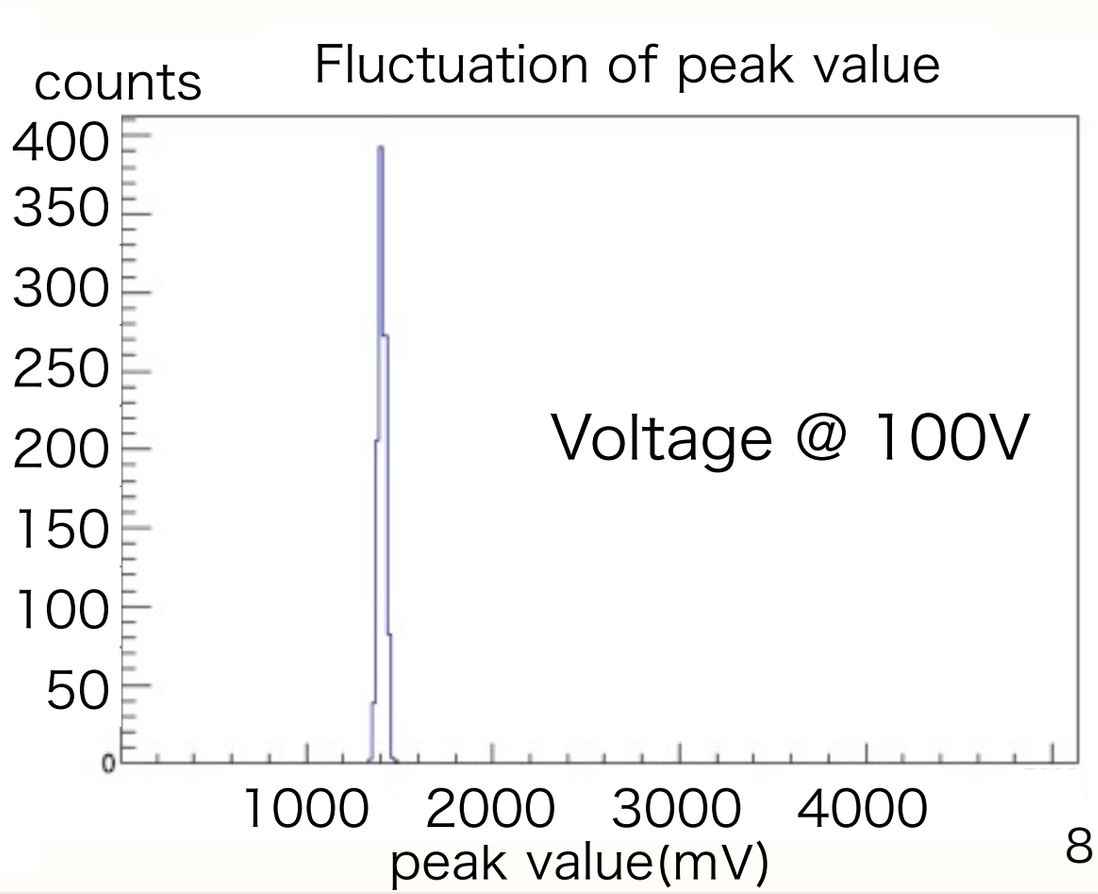


Response to laser



- Wave form was obtained from oscilloscope
- Fluctuation of peak value ~3%

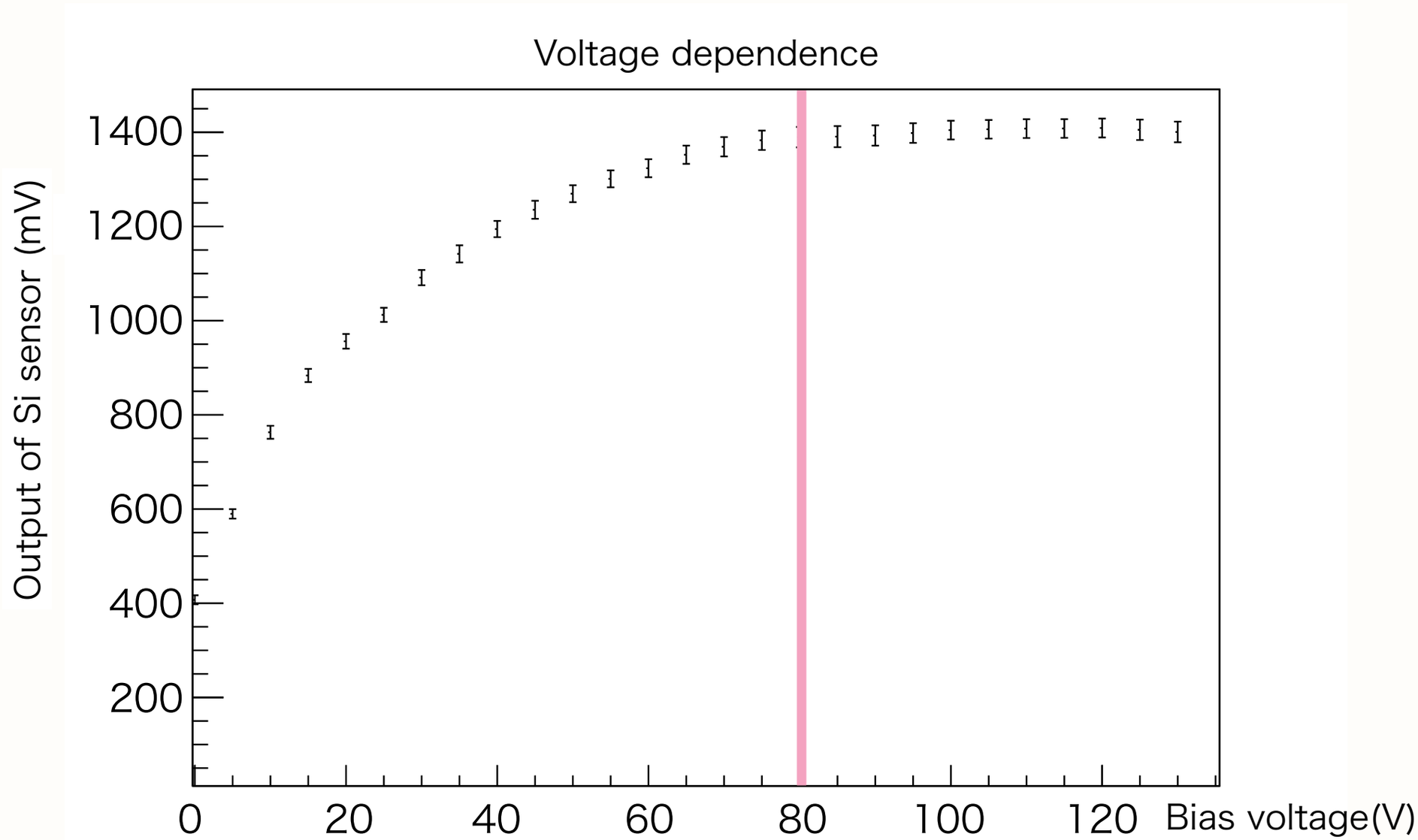




Voltage dependence

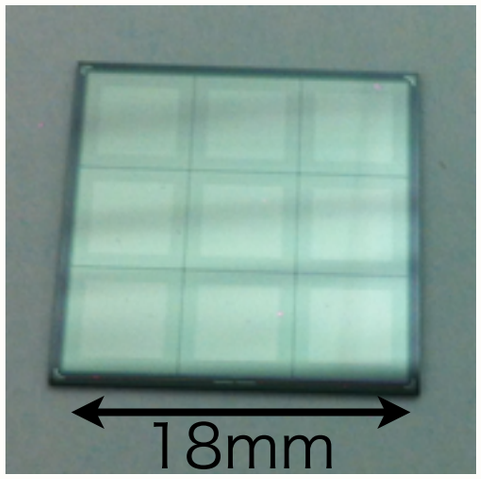
The response saturated when chip reach full depletion. (>80V)

We are investigating the difference between $1/C^2$(60V) and this result (80V).

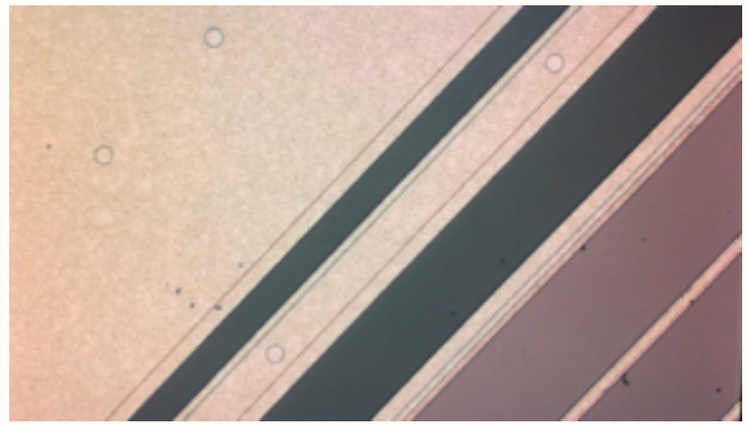


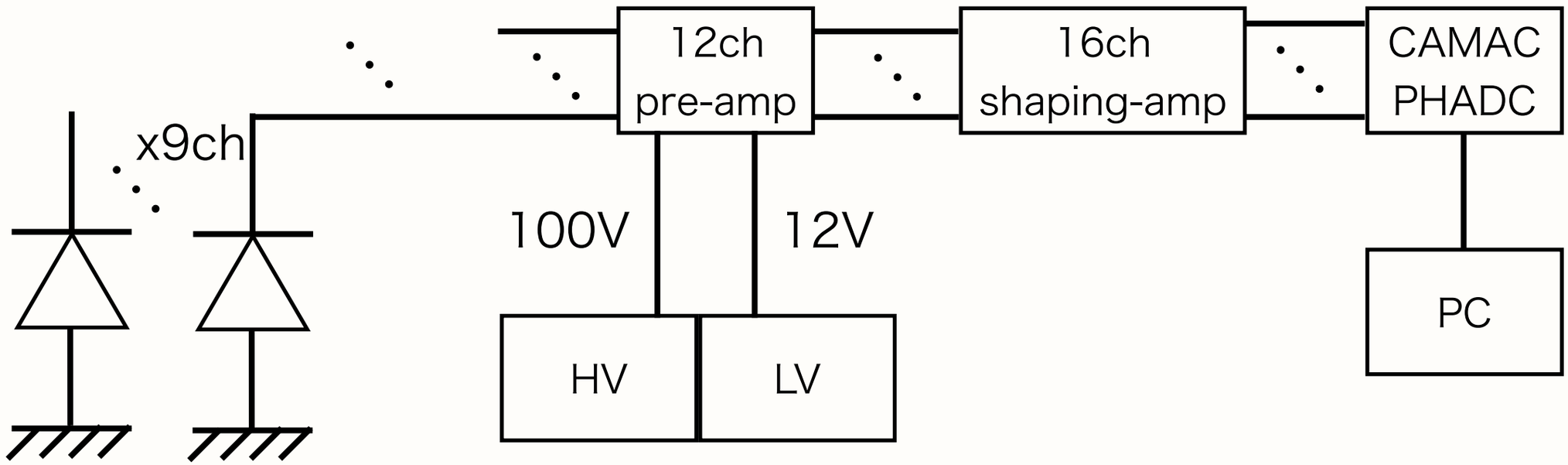
Multi pixel read out

We used the smaller chip to read out every channel.

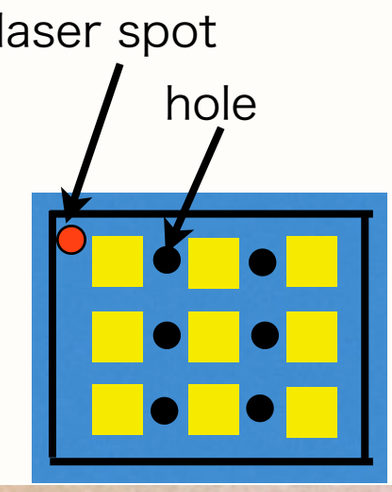


Smaller chip has
- same pixel size
- same thickness
- same guard ring

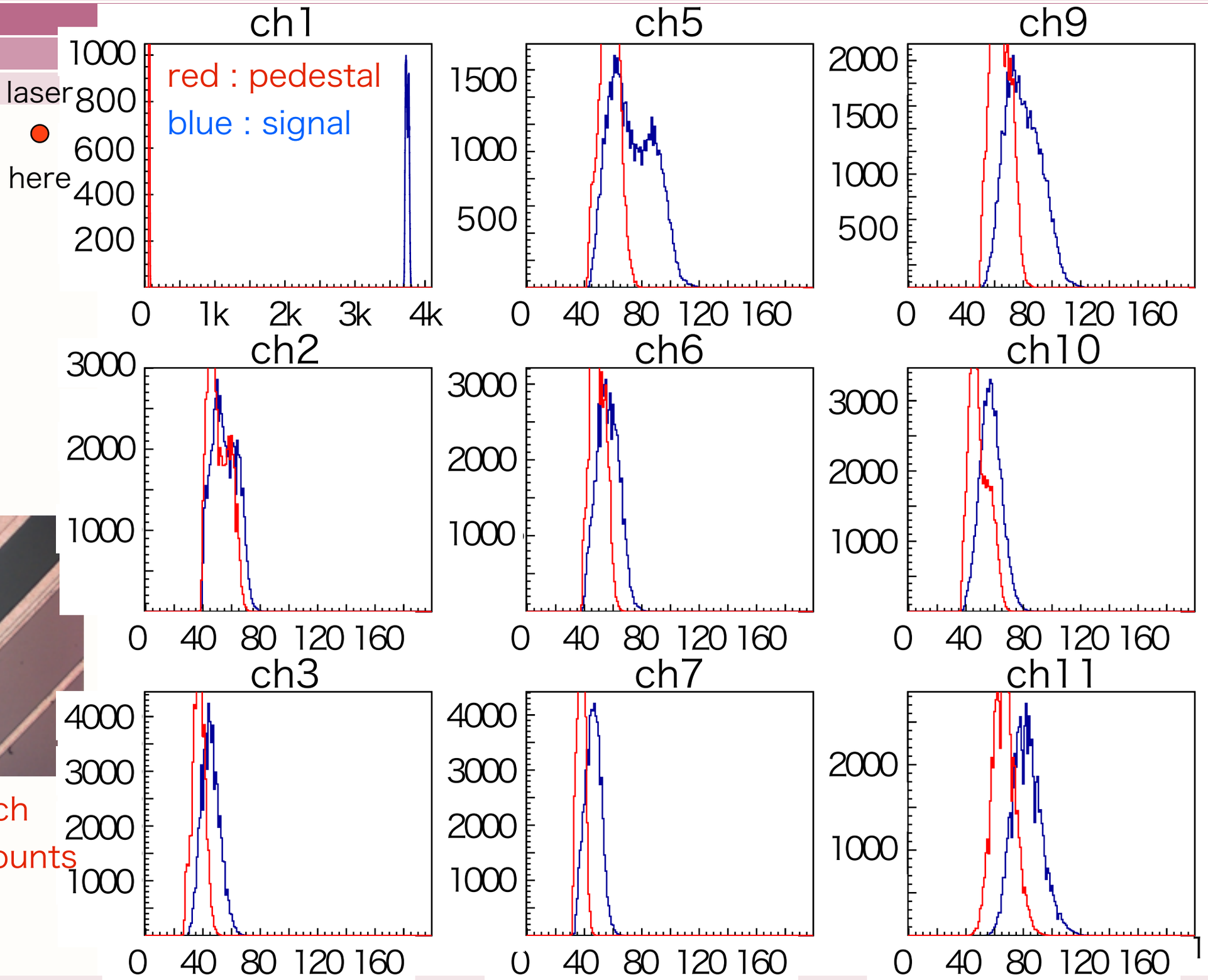




Cross talk study



pedestal : 40~80 ADC ch
horizontal axis : ADC counts
vertical axis : counts
@ 100V



Summary & Prospect

Summary

- We established the Si chip test-bench system.
  - We can measure leakage current and capacitance of chip.
  - We started cross talk study using laser system.

    → The preparation for quality control is satisfactorily.

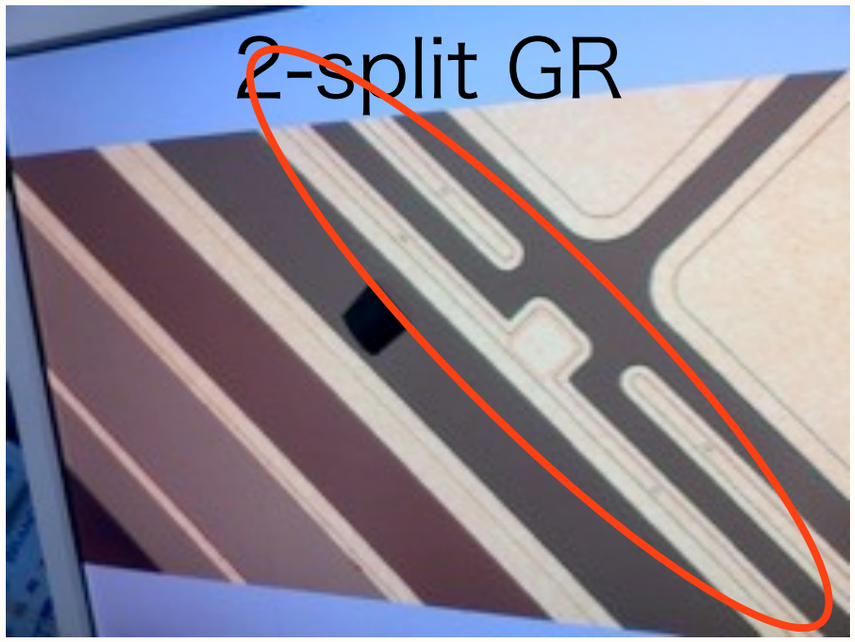
Prospect

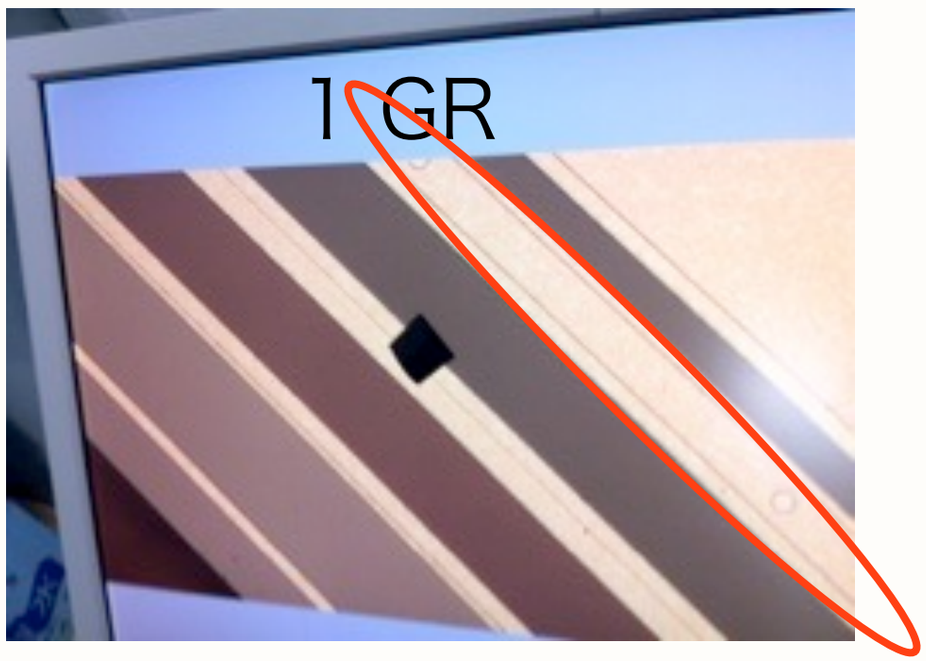
- Radiation test is now preparing.
- Compare each type of guard ring and decide chip design.

Thank you for listening!!

back up slides

type of guard ring





recombination time

Recombination time is calculated from constants A, B.

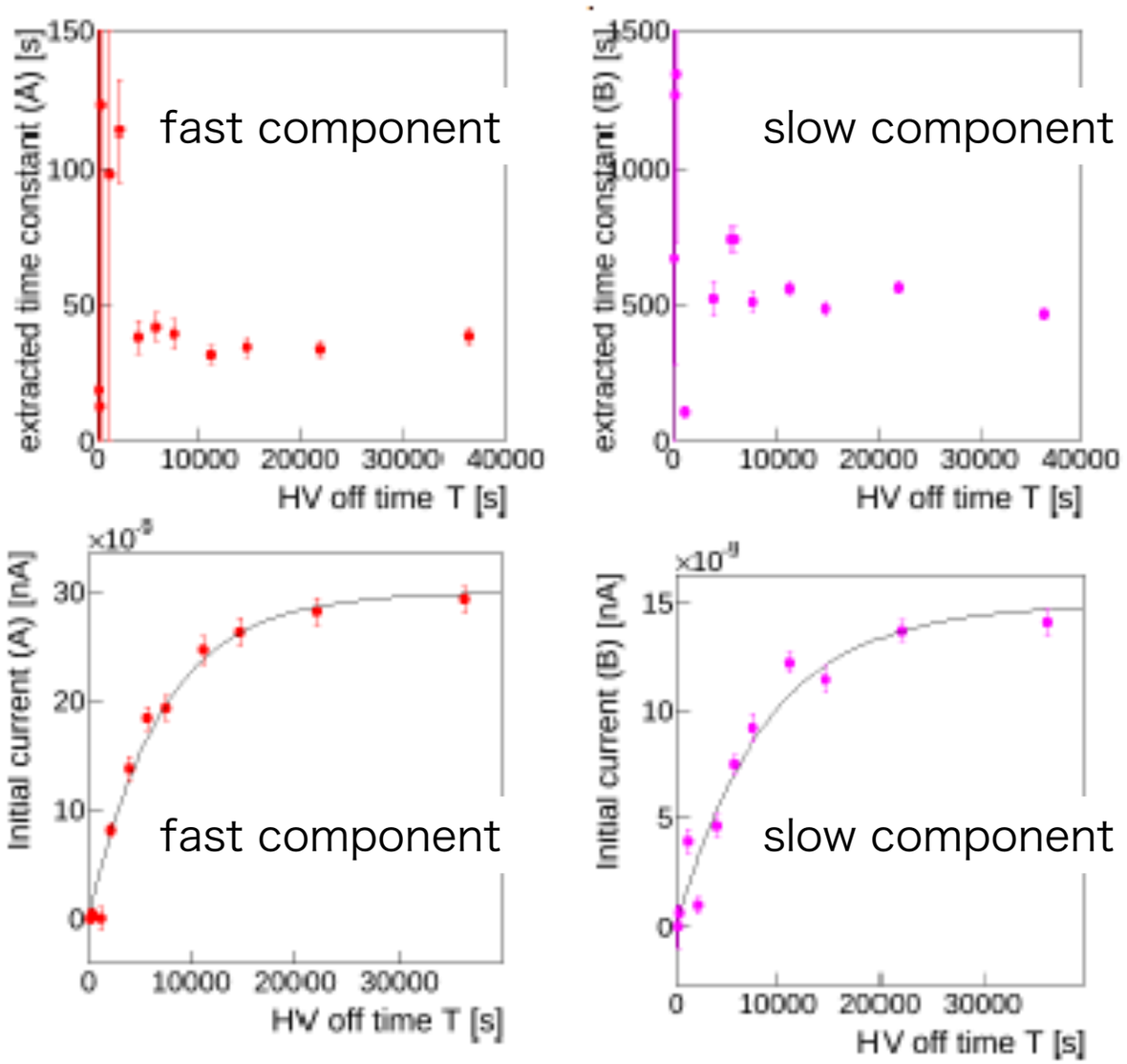
$$A = C_A(1 - \exp(-T/\tau_T))$$

C_A showed A at infinity region.

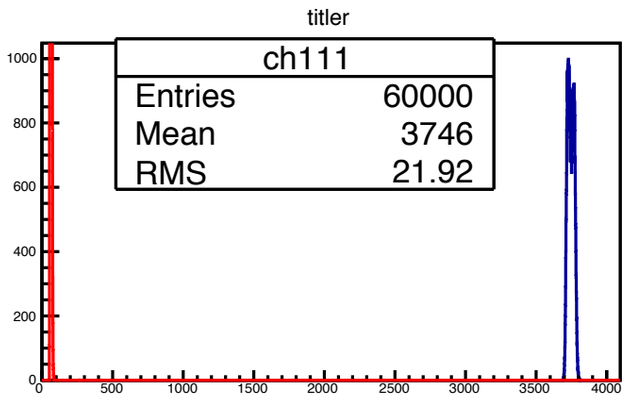
fitted by...

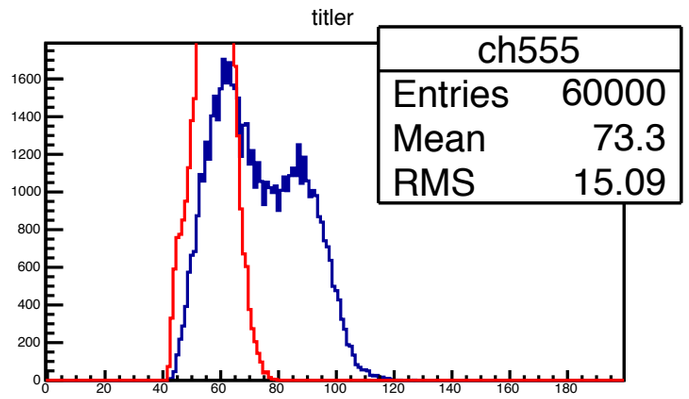
$$I = A\exp(-t/\tau_1) + B\exp(-t/\tau_2) + const$$

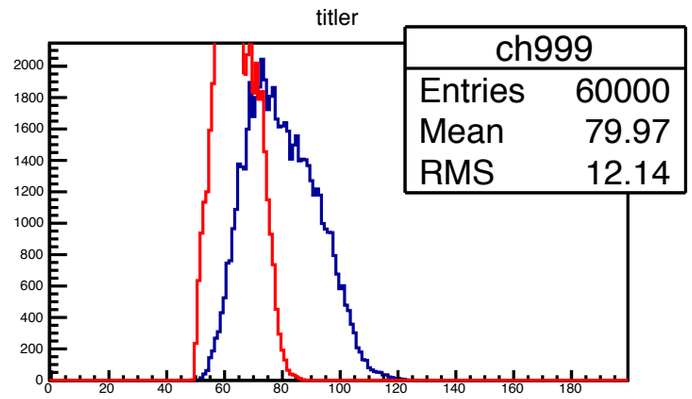
	fast component(τ_1)	slow component(τ_2)
generation time @ 250V	40 s	600 s
recombination te @ 0V	7000 s	9000 s

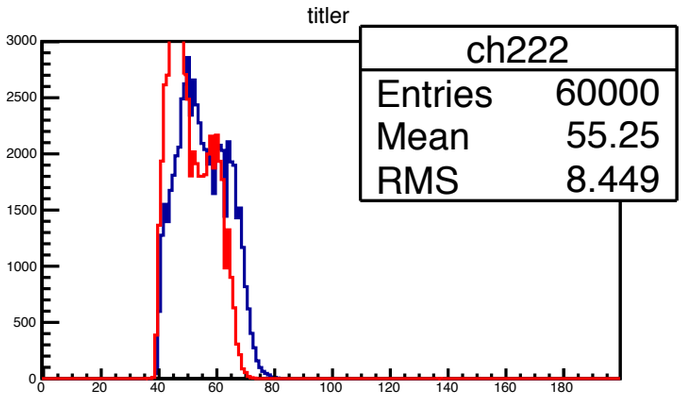


pedestal+gr


titler
ch111
Entries 60000
Mean 3746
RMS 21.92


titler
ch555
Entries 60000
Mean 73.3
RMS 15.09


titler
ch999
Entries 60000
Mean 79.97
RMS 12.14


titler
ch222
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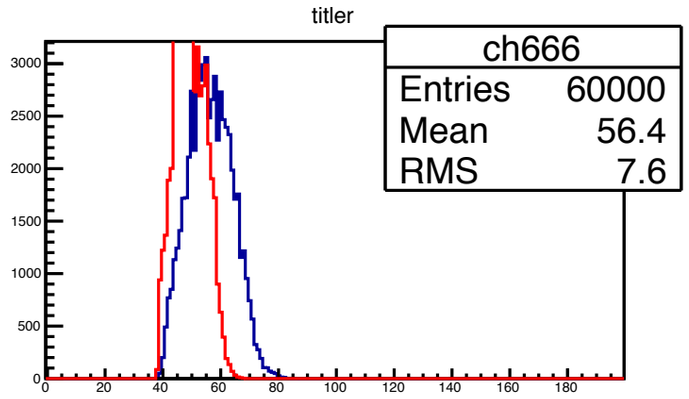
Mean 55.25
RMS 8.449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ch666
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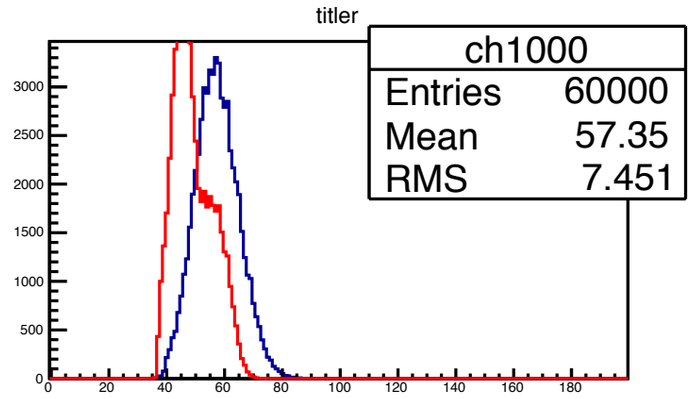
Mean 56.4
RMS 7.6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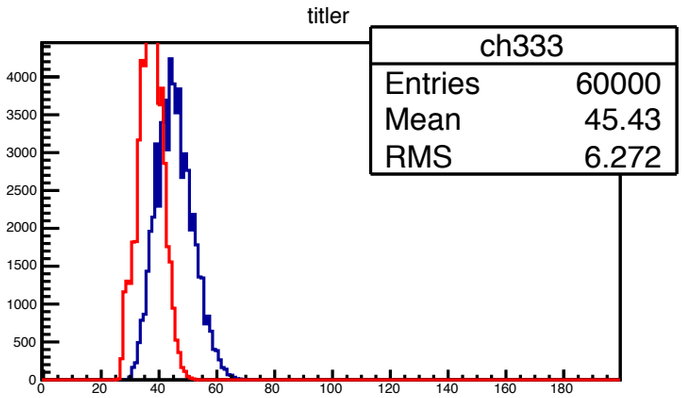
RMS 7.451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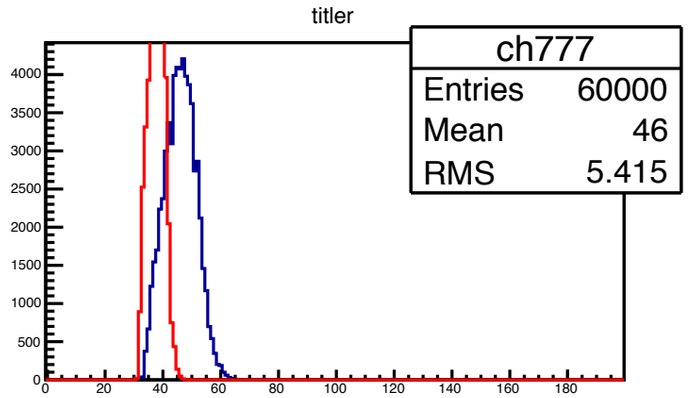
RMS 6.272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ch777
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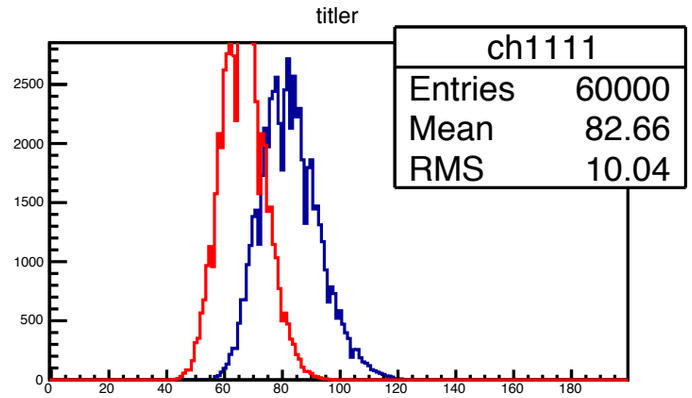
RMS 5.415


titler
ch1111
Entries 60000
Mean 82.66
RMS 10.04