Si-sensor tests

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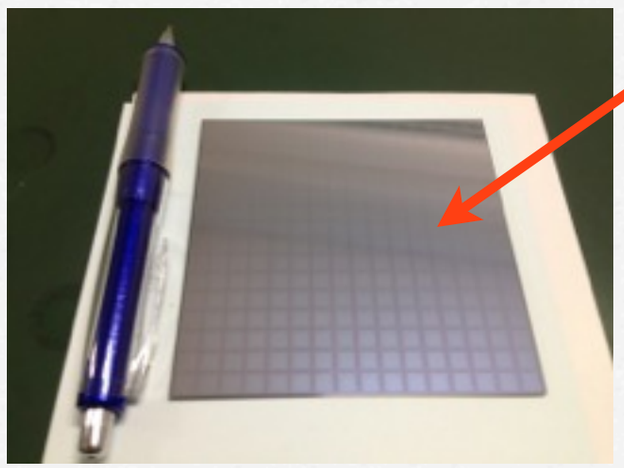
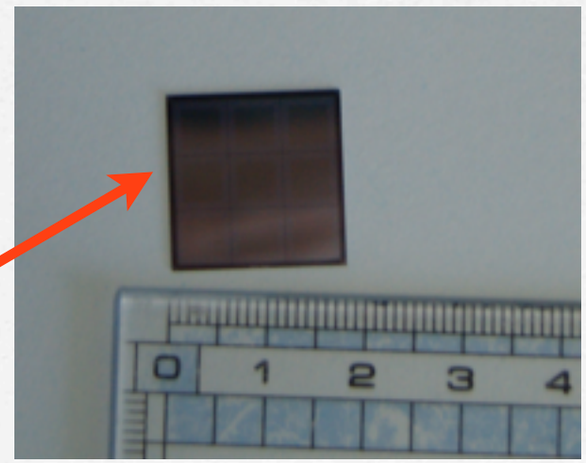
Motivation

- **The Si-sensor (Silicon pixel sensor) would be the best for PFA.**
- **Kyushu University aims to be a center of the Si-ECAL study in Japan.**
- **It is very important to develop a system to examine many Si-sensor samples uniformly and efficiently in a same way.**

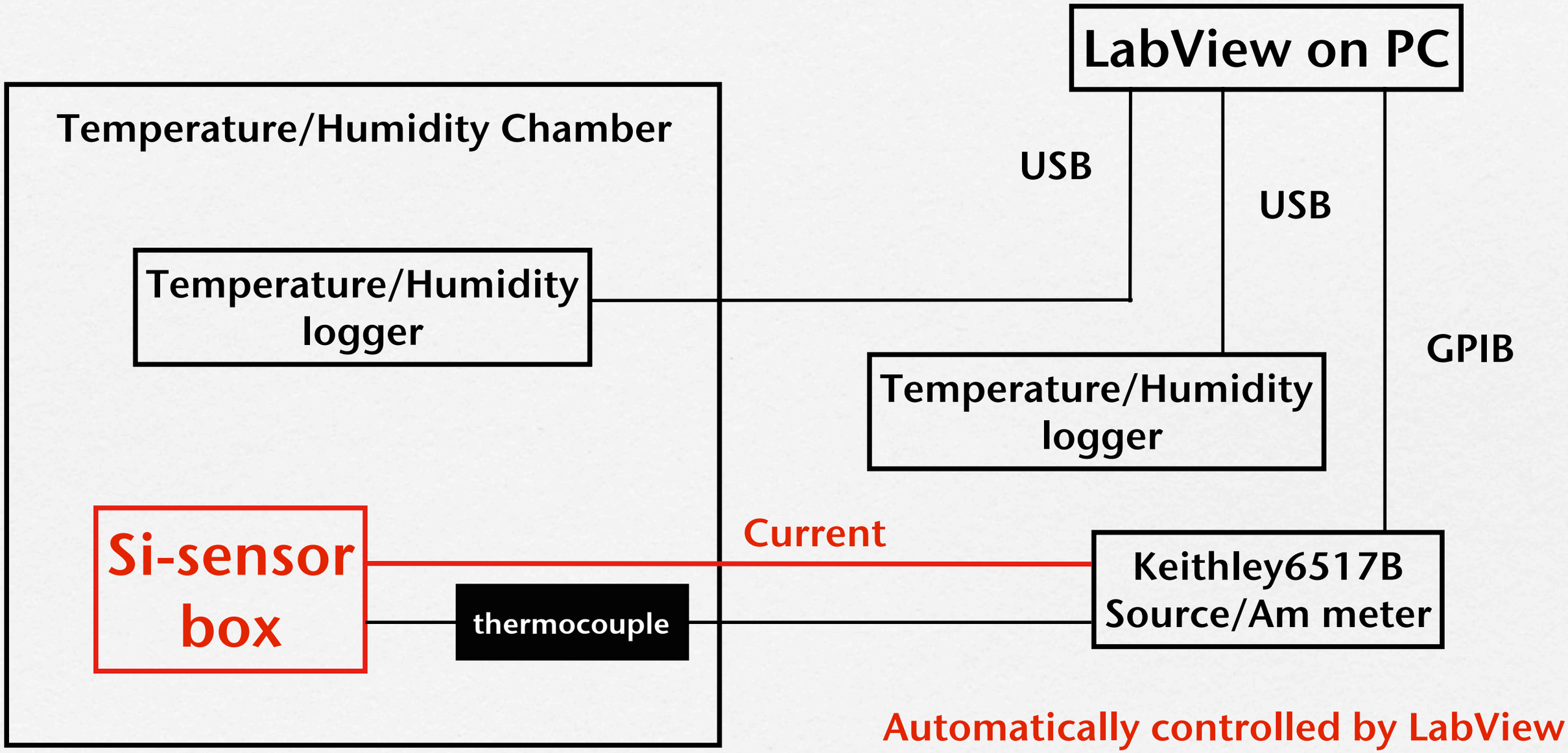
Si-sensor samples

- **We measured five types of Si-sensors manufactured by HPK**
  - **mainchip (16×16 pixels)**
    - **type B (8.97×8.97 cm^2) : 12 samples**
    - **type C (8.94×8.94 cm^2) : 4 samples**
  - **babychip (3×3 pixels)**
    - **guard rings same as the mainchip Cut size C : 24 samples**
    - **split guard rings (4rings) Cut size B : 8 samples**
    - **split guard rings (4rings) Cut size C : 6 samples**





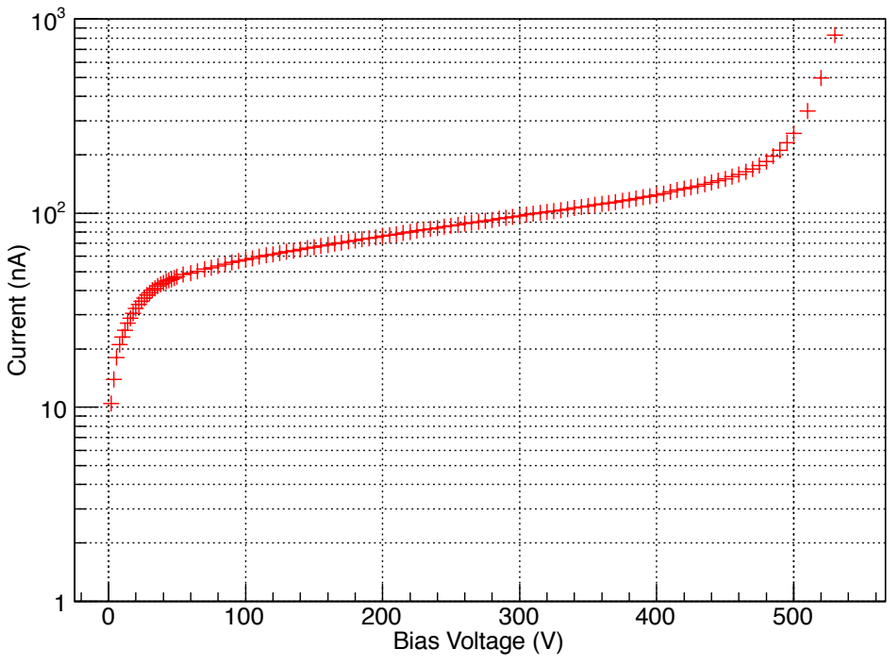
I-V Measurement Setup

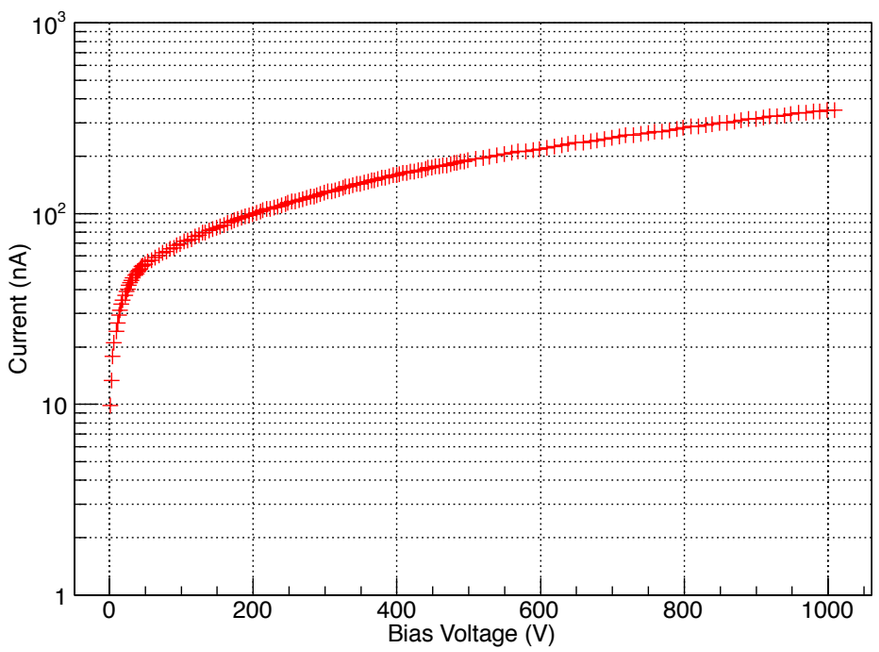


Thermocouple is installed in the box to directly monitor the Si-sensor's temperature

I-V Measurement

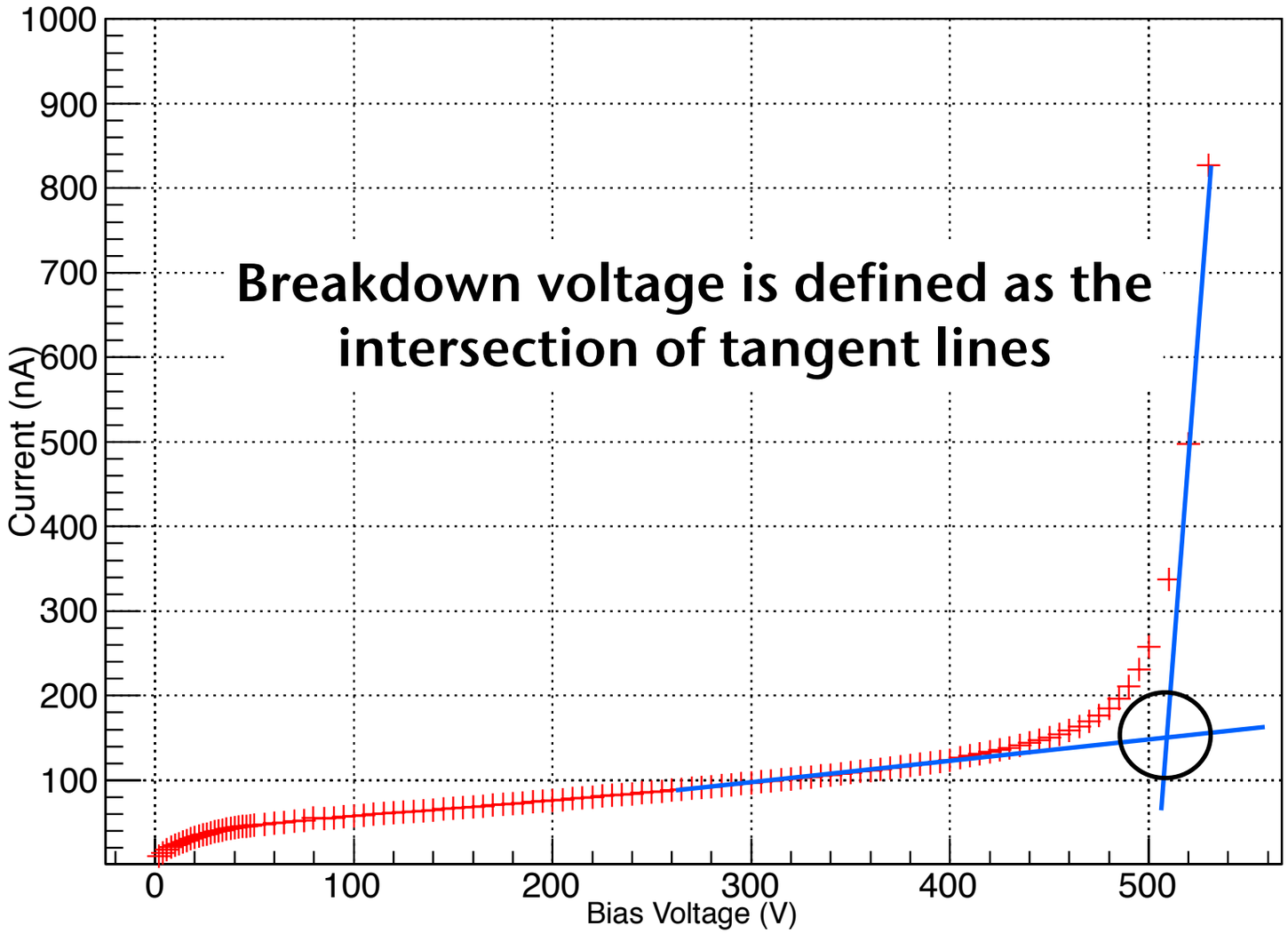
- **We measured the I-V curve for each sample at 20°C, 60% humidity**





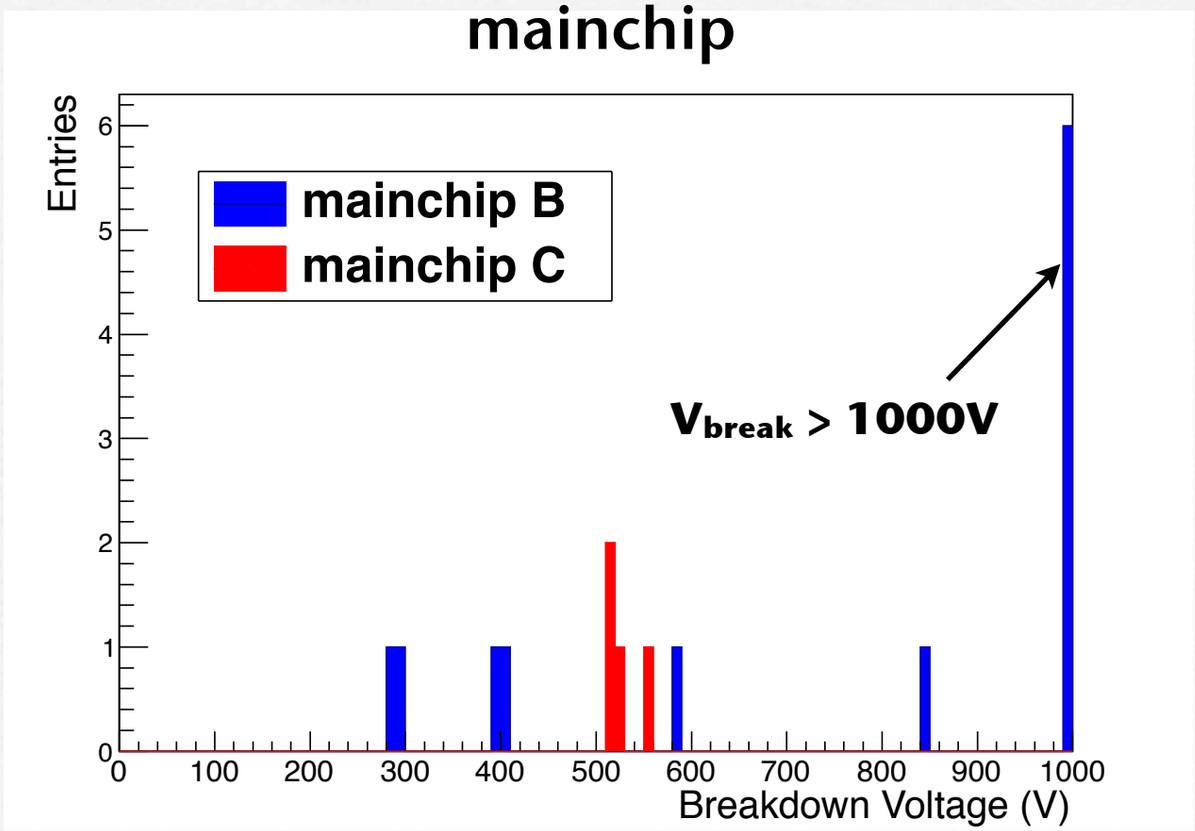
Breakdown occurs for some samples, but not for others.

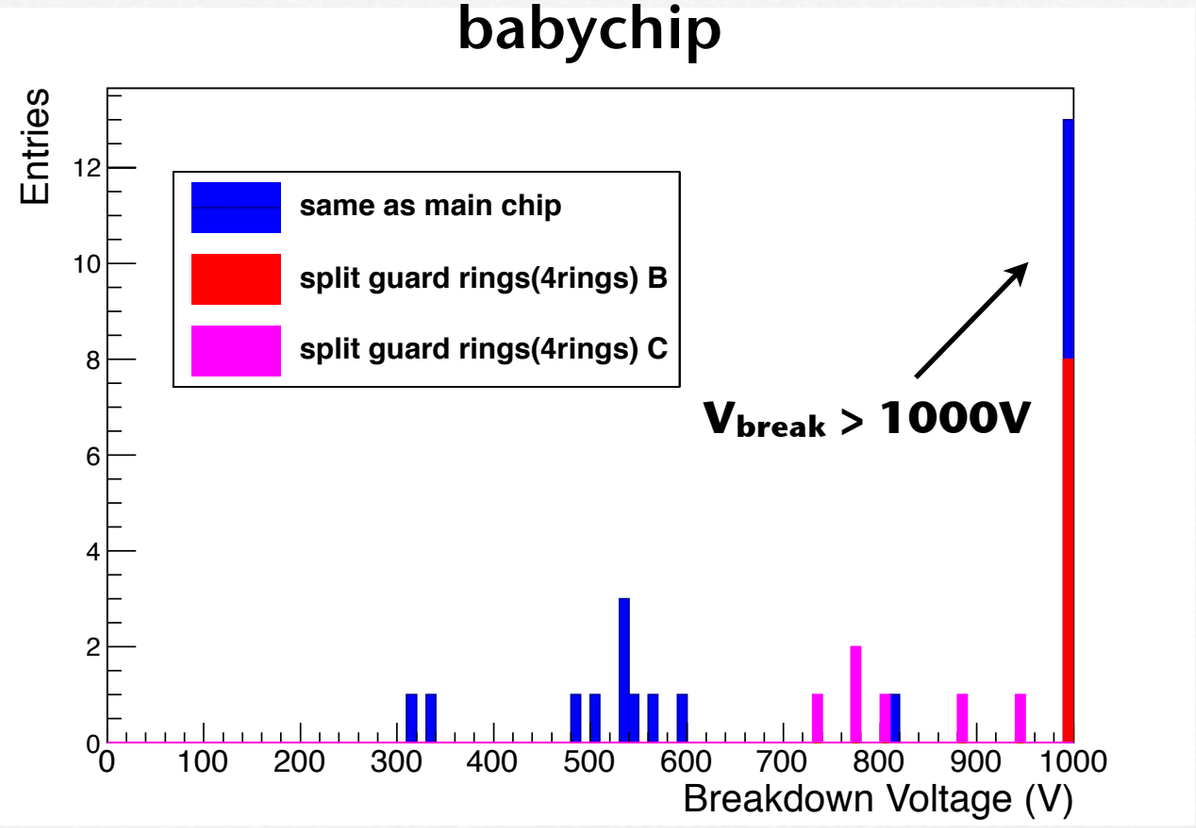
I-V Measurement



We measured the breakdown voltage for each sample.

Breakdown Voltage





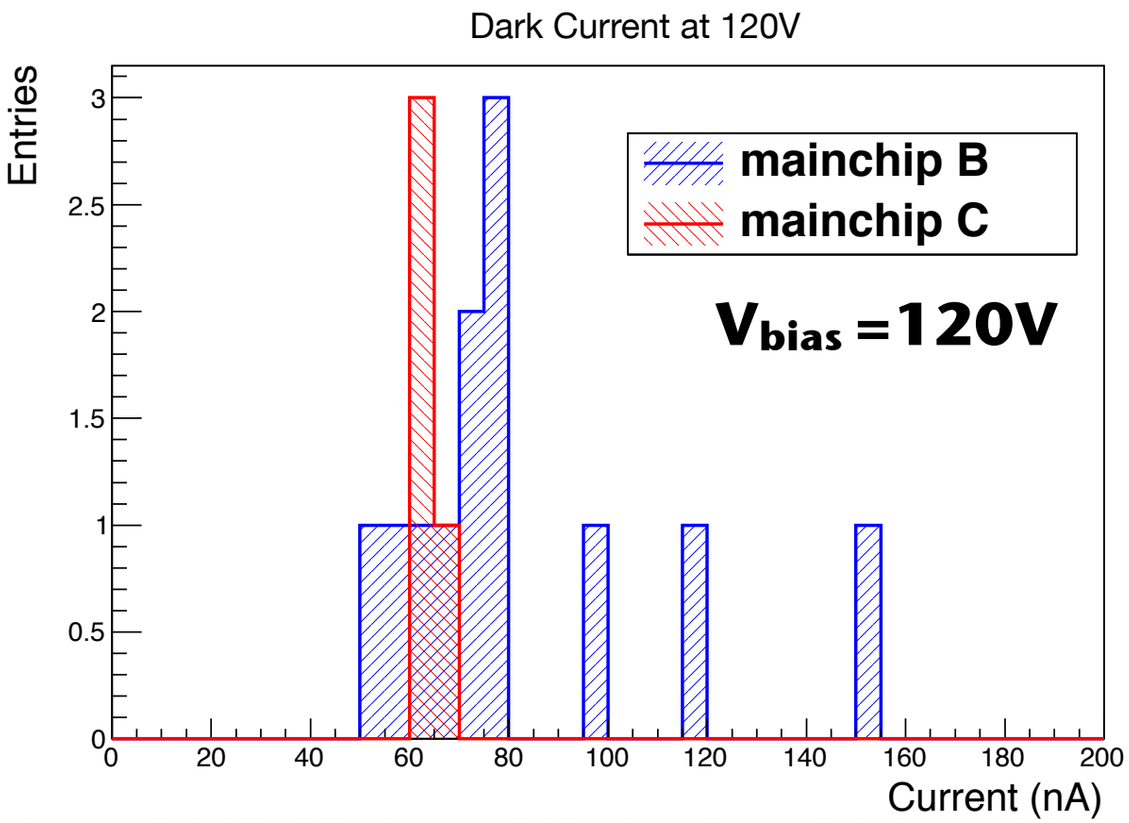
Samples in last bin don't reach breakdown voltage by 1000V.

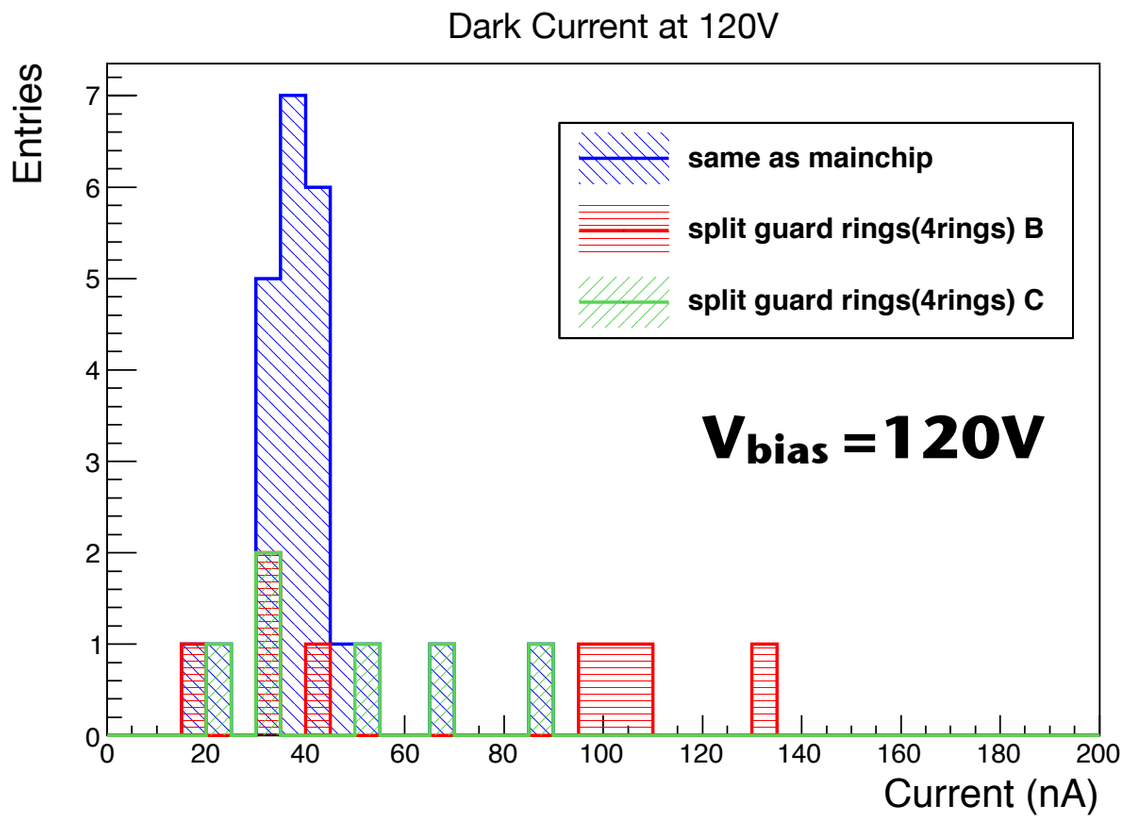
We can operate all mainchips stably at V_{bias} < 300V.

Samples with split guard rings have larger breakdown voltage.

Dark current at 120V

- **We measured the dark current at 120 V**





C-V Measurement

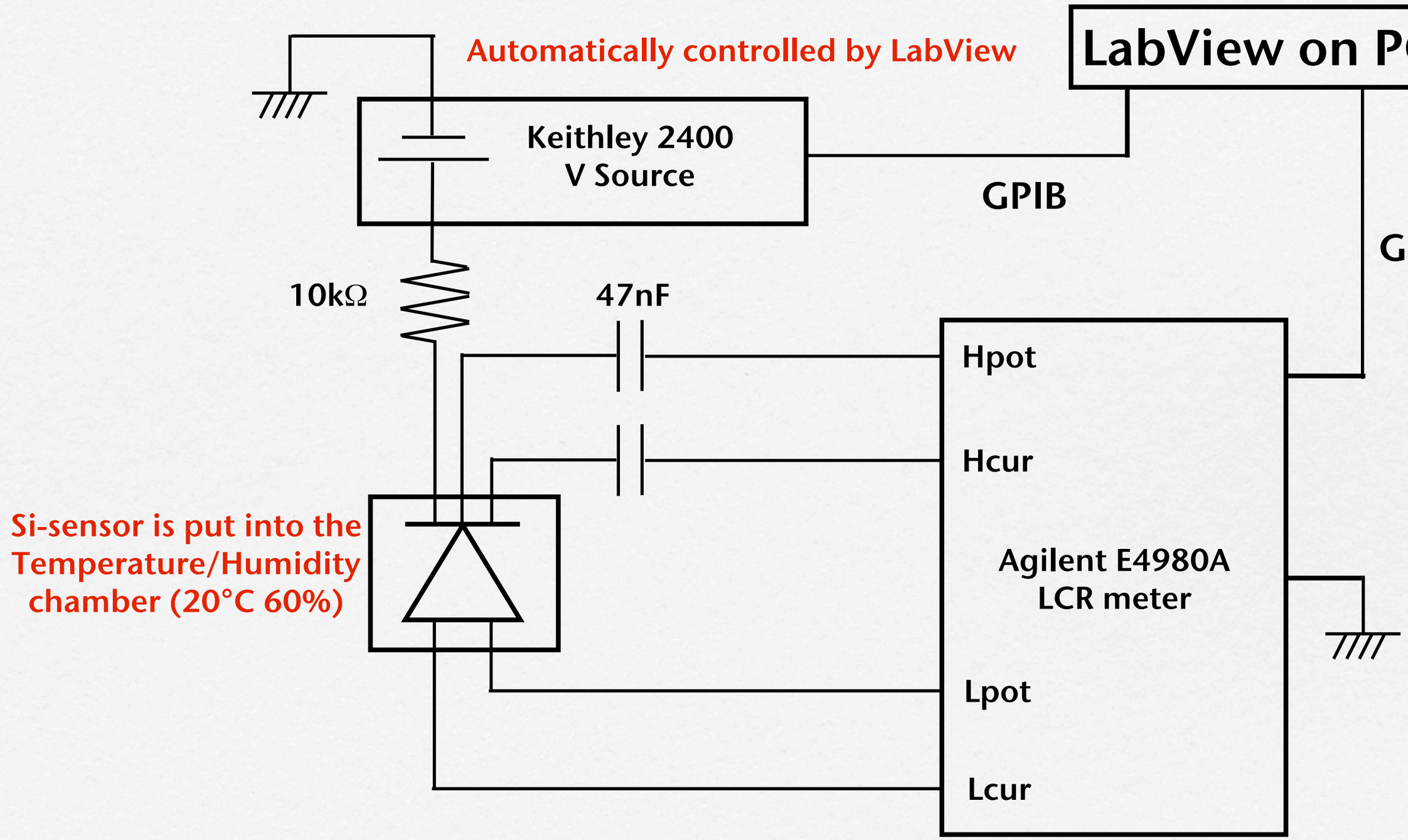
- **We measured the capacitance of all mainchips at 20°C, 60 % humidity.**
- **Increasing bias voltage, decreasing capacitance.**
- **As bias voltage reaches to full depletion voltage, capacitance becomes constant.**
- **Depth of the full Depletion region should be identical to thickness of the Si-sensor.**

$$C = \frac{\epsilon_{\mathrm{si}} S}{d} \approx 2.4\mathrm{nF}$$

$$d \approx 350\mu\mathrm{m}$$

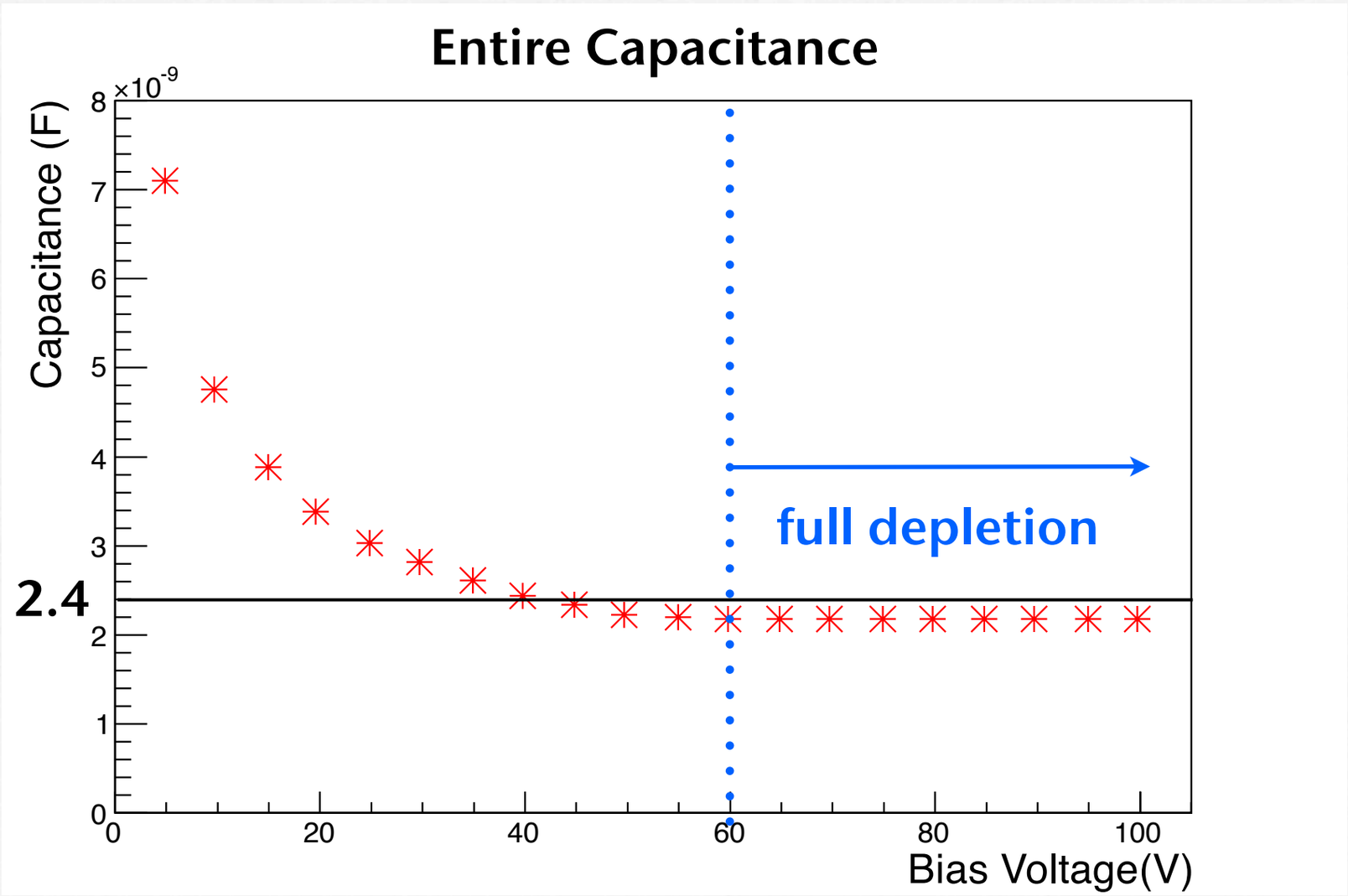
$$\epsilon_{\mathrm{si}} = 1.03 \times 10^{-10}\mathrm{F/m}$$

C-V Measurement Setup



Changing the Voltage automatically, measure the capacitance

Results



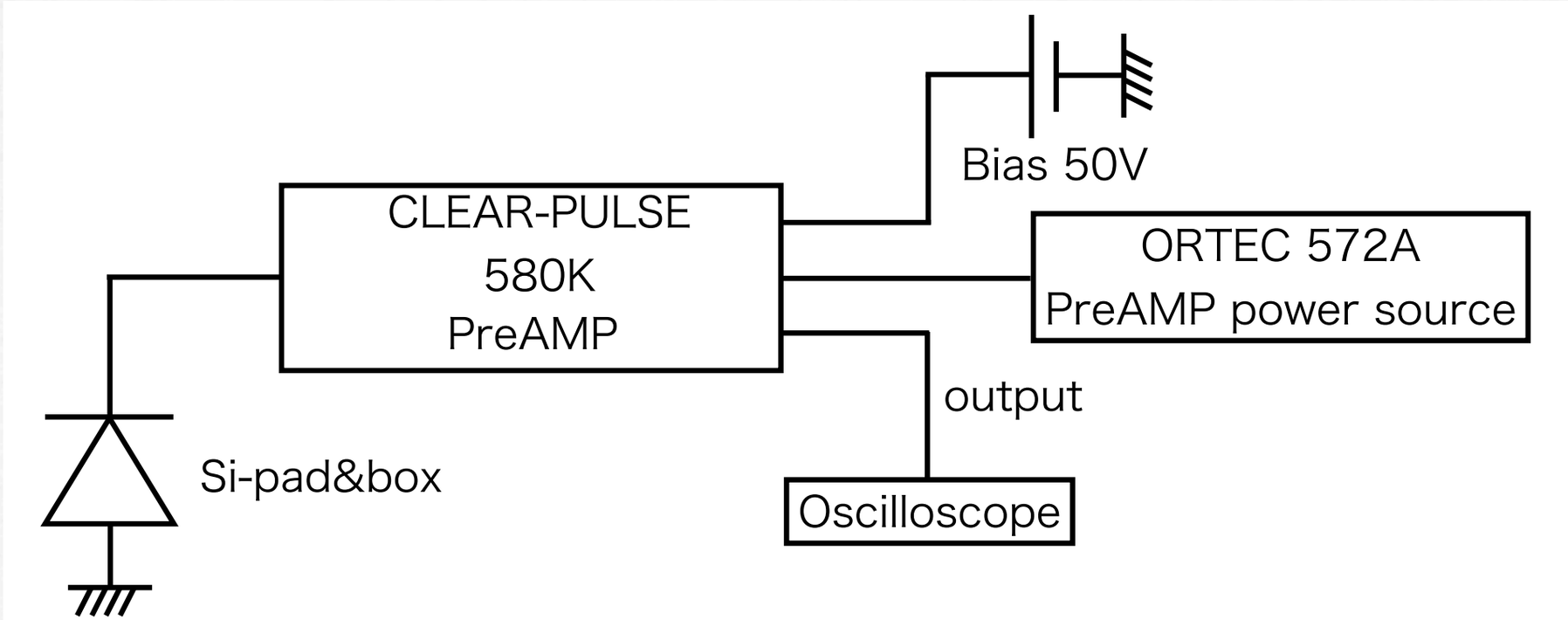
Full depletion voltage of all mainchips distributed around 60V.

Read out signals

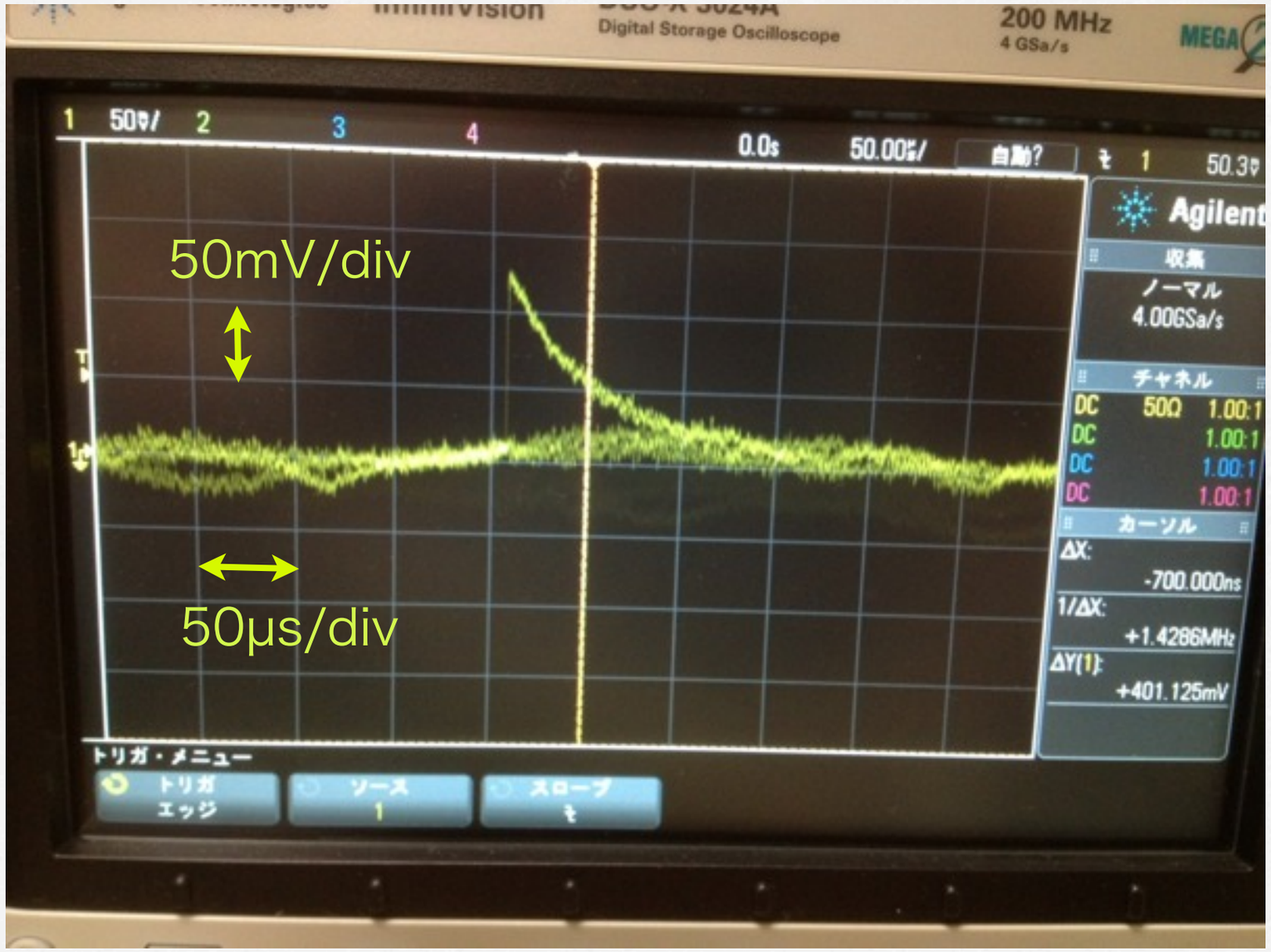
- We made a signal read out system for total pixels.
- We observed gamma-ray signals (^{60}Co,1.17MeV) using babychips
- Conversion coefficient of the PreAMP is 2V/pc
- Assuming that the ionization energy is 3eV, generated charge is

$$Q = 1.6\times10^{-19} \times (1.17MeV/3eV) = 0.0624pC$$

$$V = 0.0624 \times 2 = 124.8mV$$



Signal Waveform



We can observe gamma-ray signals, with large noise.

We will try to reduce the noise.

Summary

- **We constructed automatic system to measure I-V curve and C-V curve.**
- **I-V curve**
  - **We can operate stably at V_{bias} < 300V**
- **C-V curve**
  - **Full depletion occurs around 60V.**
- **Read out gamma-ray signals using a babychip**
  - **Signal observed, but noise was large**

Prospects

- **C-V measurement**
  - **1 pixel capacitance measurement.**
- **Signal test**
  - **Improve measuring circuit.**
  - **noise reduction.**
  - **read out IR laser signals from 1 pixel.**
    - **to check crosstalk and behavior of sensor edge.**