Measurement of Basic Characteristics of Si-pad for ILD ECAL

Oishi Kou

Kyushu University

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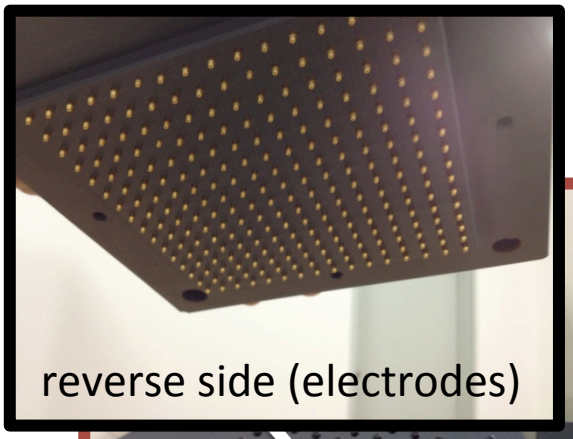
Motivation

- The Si-pad would be the best for PFA Calorimetry for Linear Collider Experiments.
  - Therefore the study of the Si-pad is important.
- We started the Si-pad study.
  - Until now French team has been working.
  - Kyushu University is becoming a new core of the Si-pad study with the strong connection with the French team.
- We are setting up a test bench for basic measurements (I-V curve, etc.) in Kyushu University.

Si-pad & box



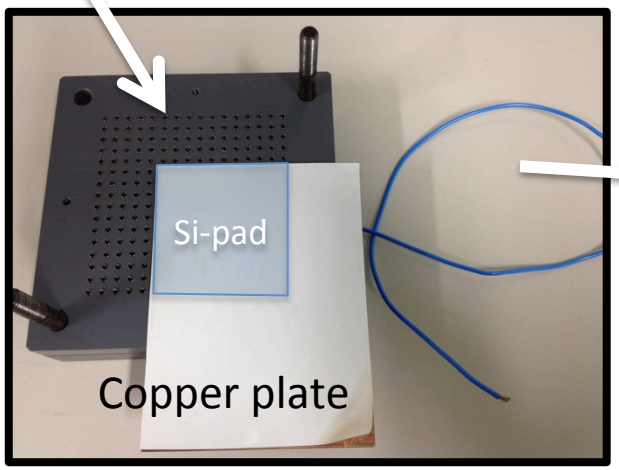
Si-pad

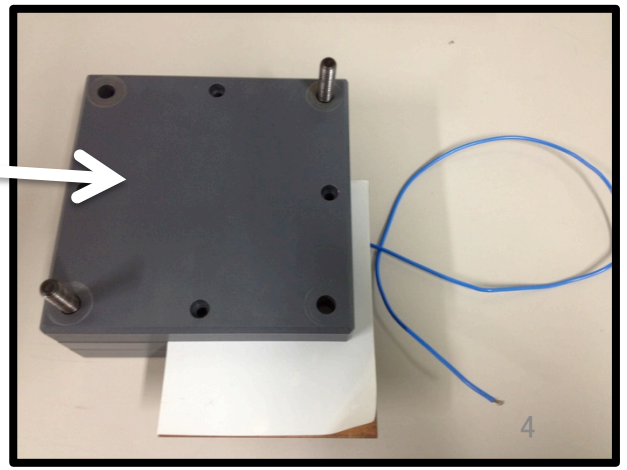
6x6 pixels
1 pixel size is 1cm x 1cm

This type is a physics prototype
used for a previous beam test.

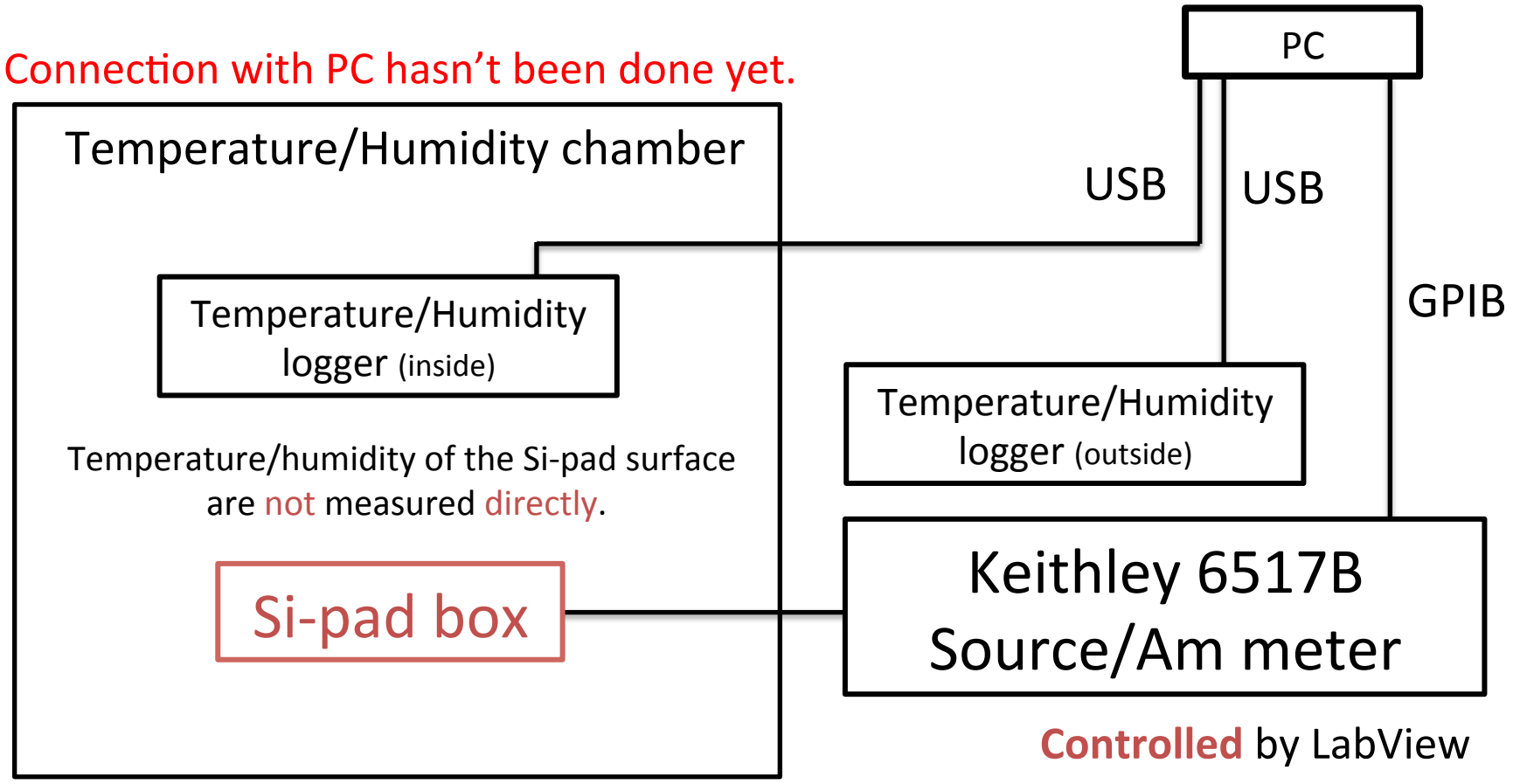
Measurement BOX

All-pixel currents are ganged by a copper plate.



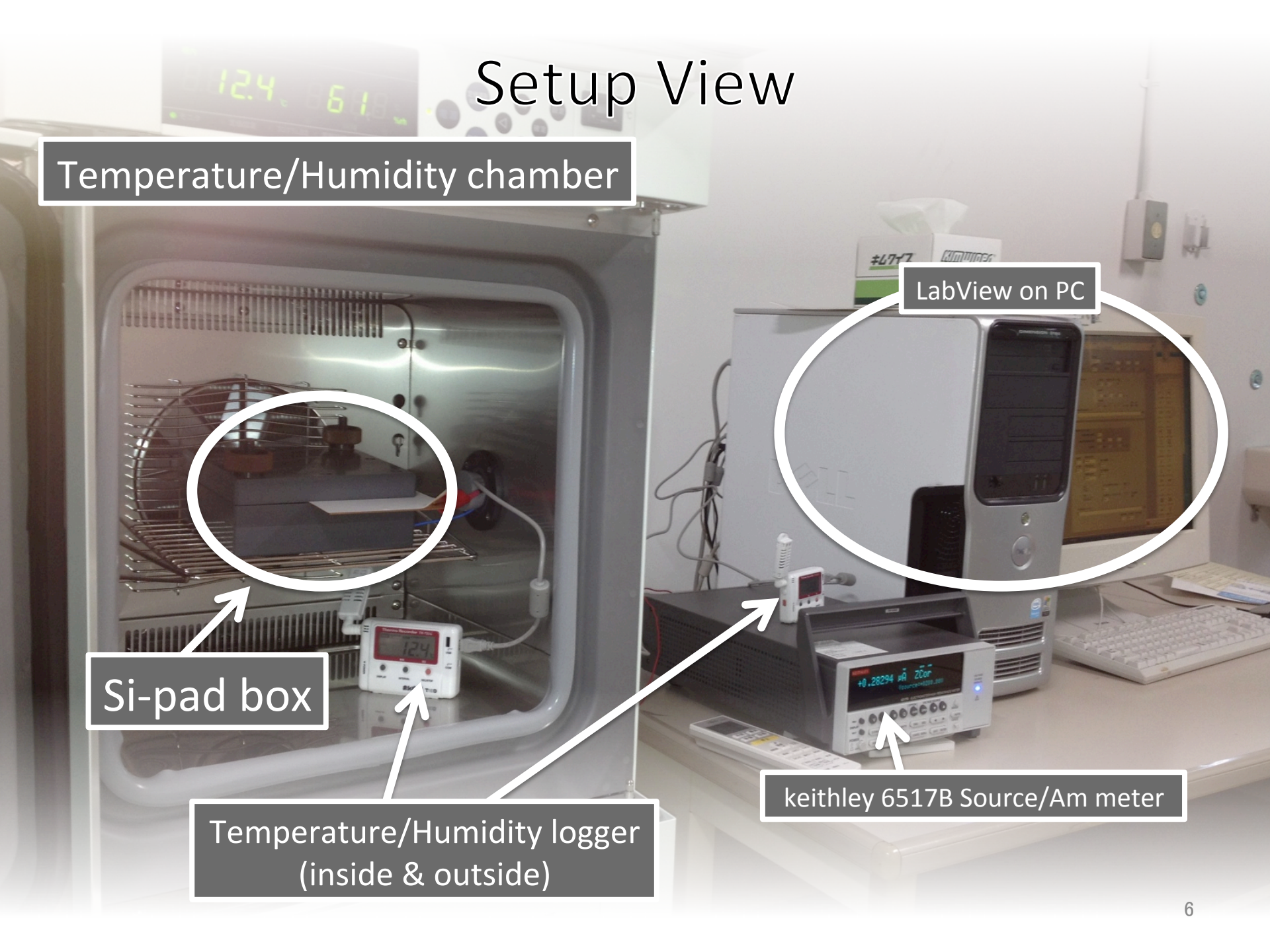


Setup of the measurement

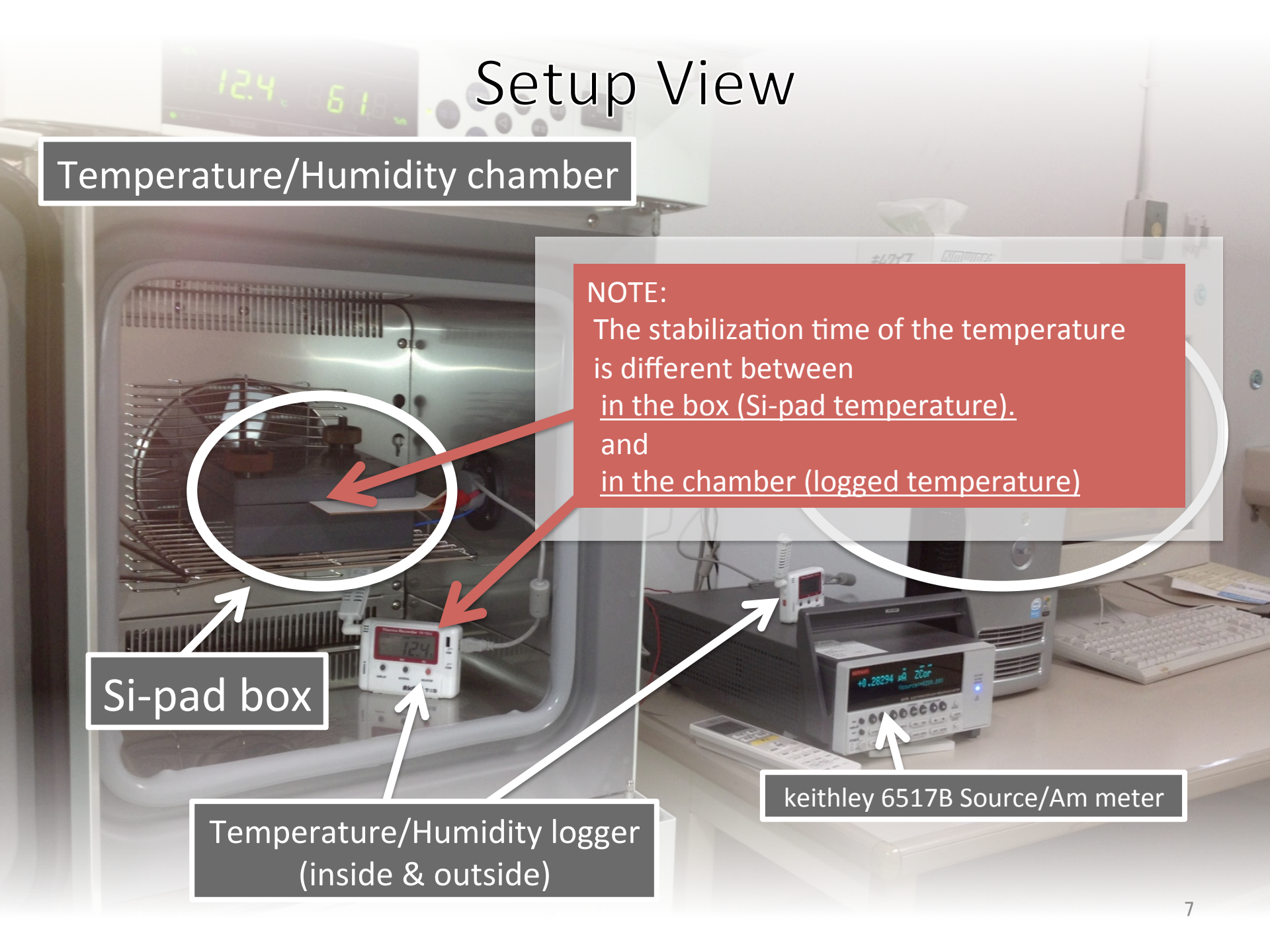


I-V curves are measured by controlling temperature and humidity.

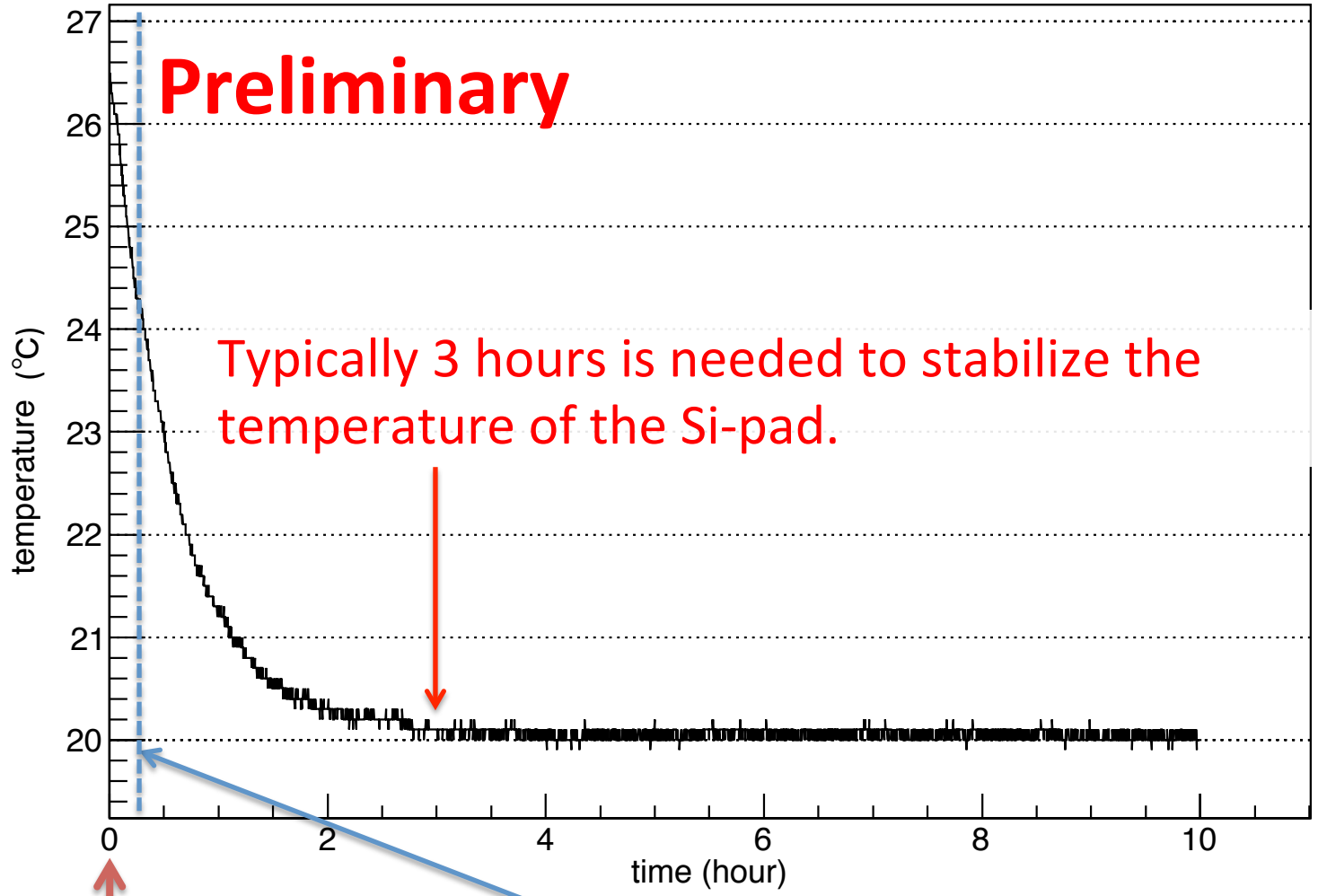
Setup View


Temperature/Humidity chamber
LabView on PC
Si-pad box
Temperature/Humidity logger
(inside & outside)
keithley 6517B Source/Am meter

Setup View


Temperature/Humidity chamber
NOTE:
The stabilization time of the temperature is different between
in the box (Si-pad temperature).
and
in the chamber (logged temperature)
Si-pad box
Temperature/Humidity logger (inside & outside)
keithley 6517B Source/Am meter

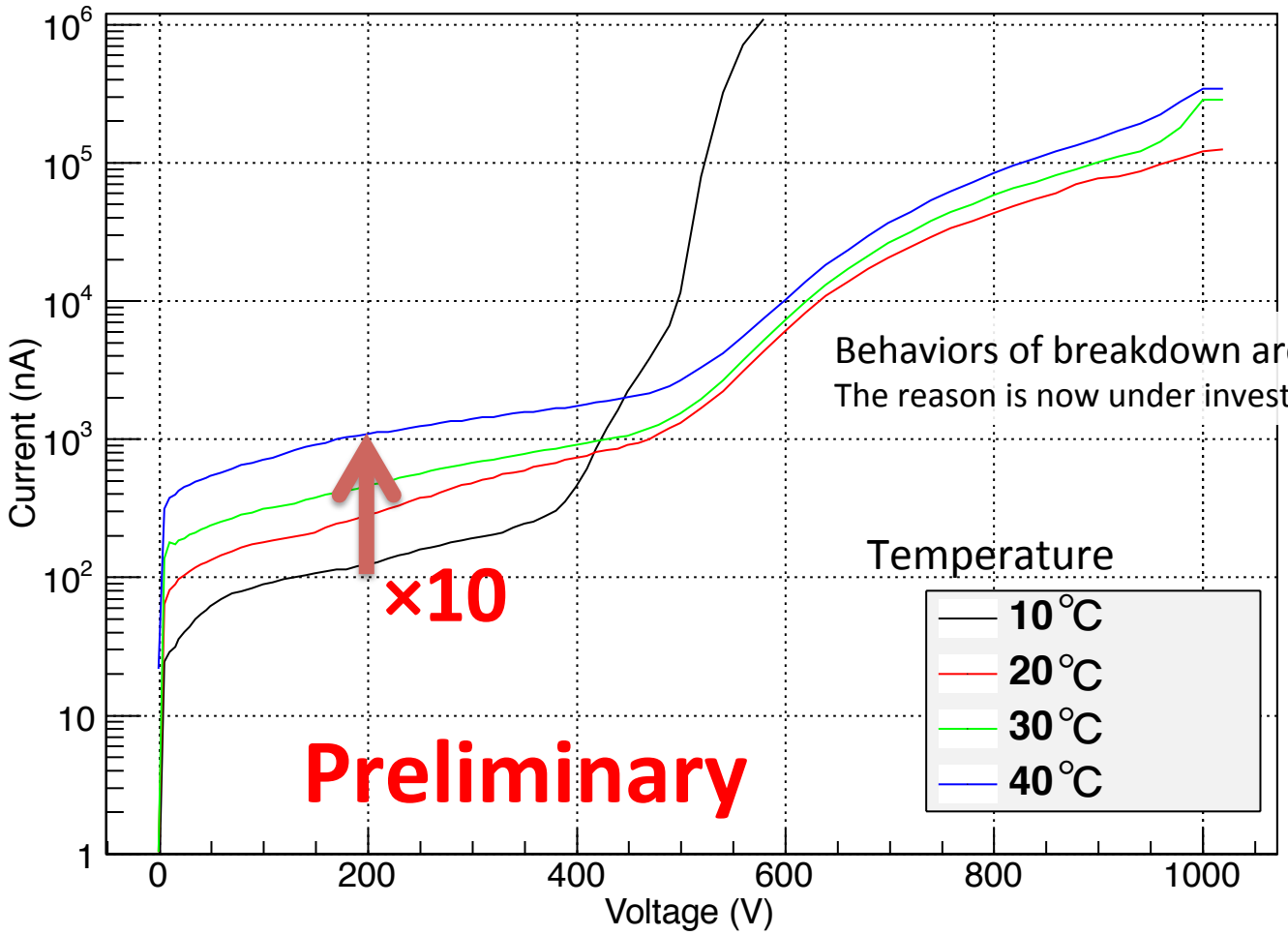
The temperature in the box



In contrast, the time of the chamber is about 15 min.

Temperature dependence

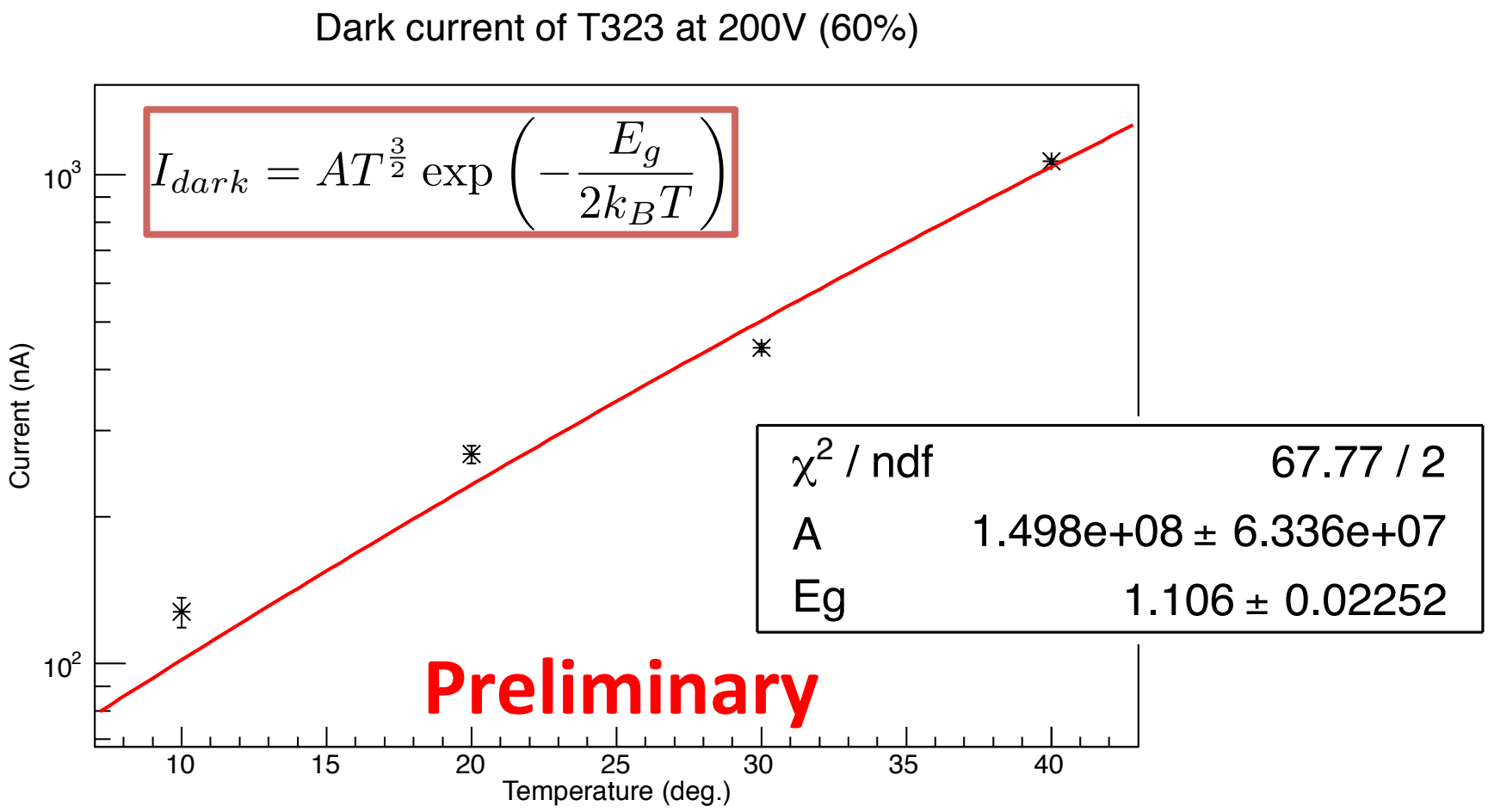
Dark current of T323 at 60% RH



Behaviors of breakdown are strange and not uniform.
The reason is now under investigation…

The I-V curves were measured at least 2.5 hours after changing the temperature setting to stabilize the surface temperature.

Temperature dependence



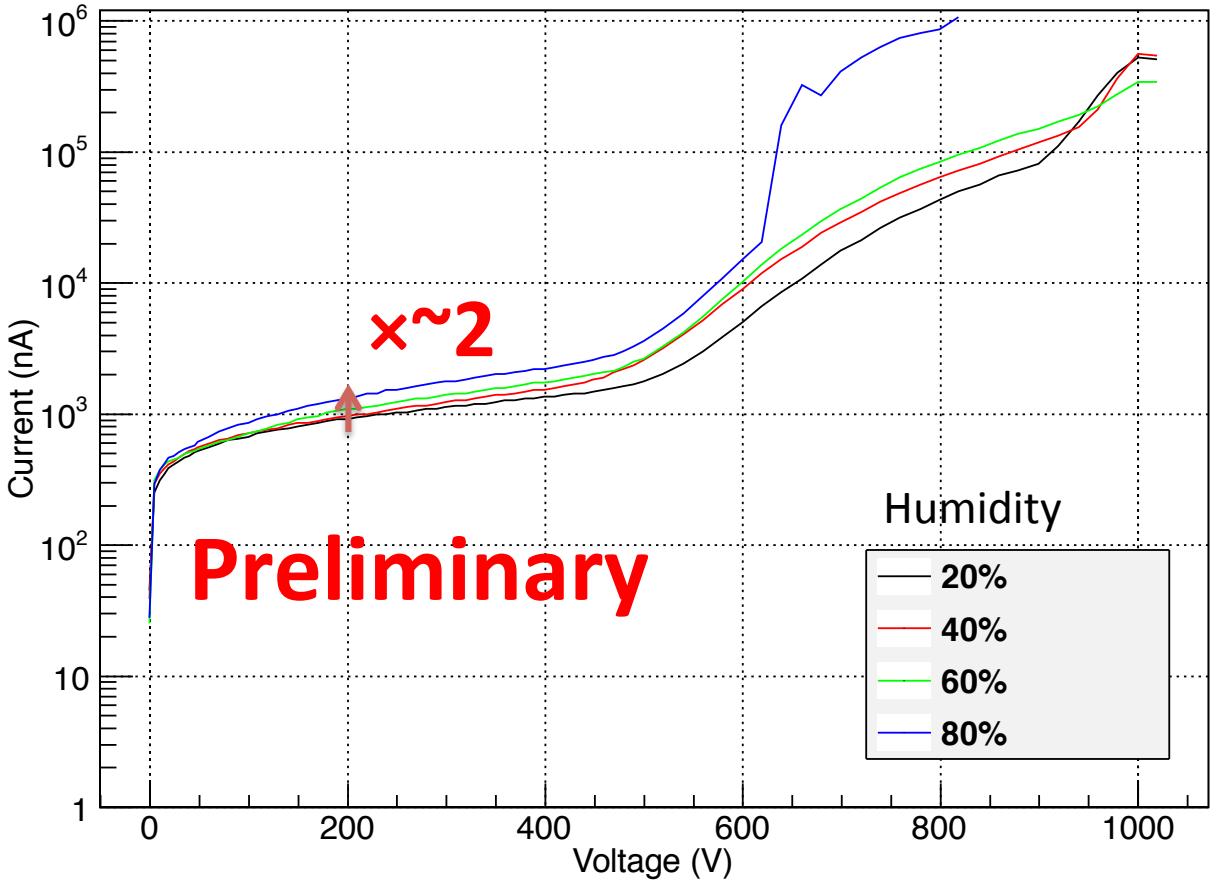
- The Band-gap, Eg, is nearly equal to Si's 1.11 eV.

(The temperature is measured in the chamber, not on the Si-pad surface.)

Humidity dependence

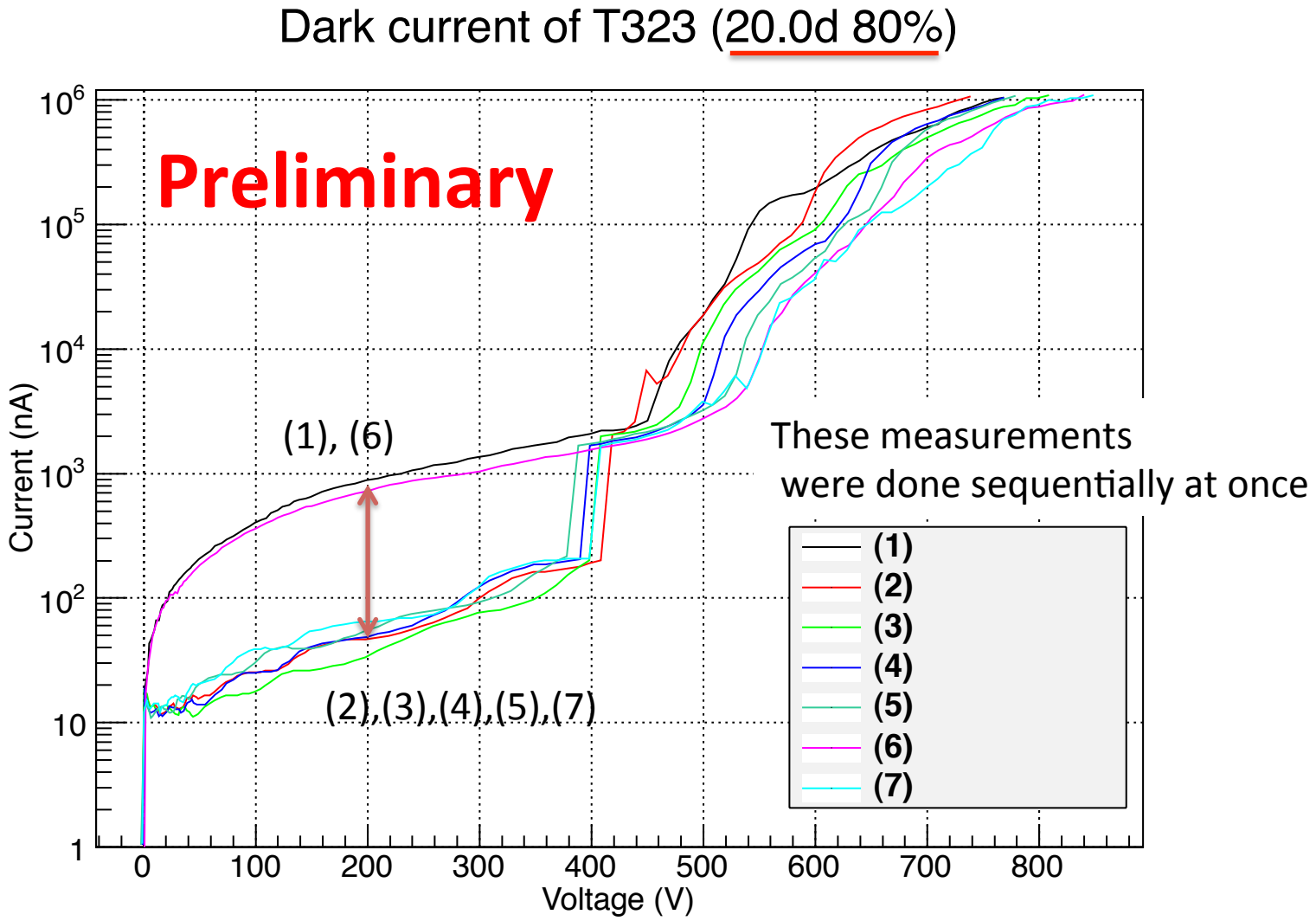
It's a little unstable to control humidity in lower temperature.

Dark current of T323 at 40℃.



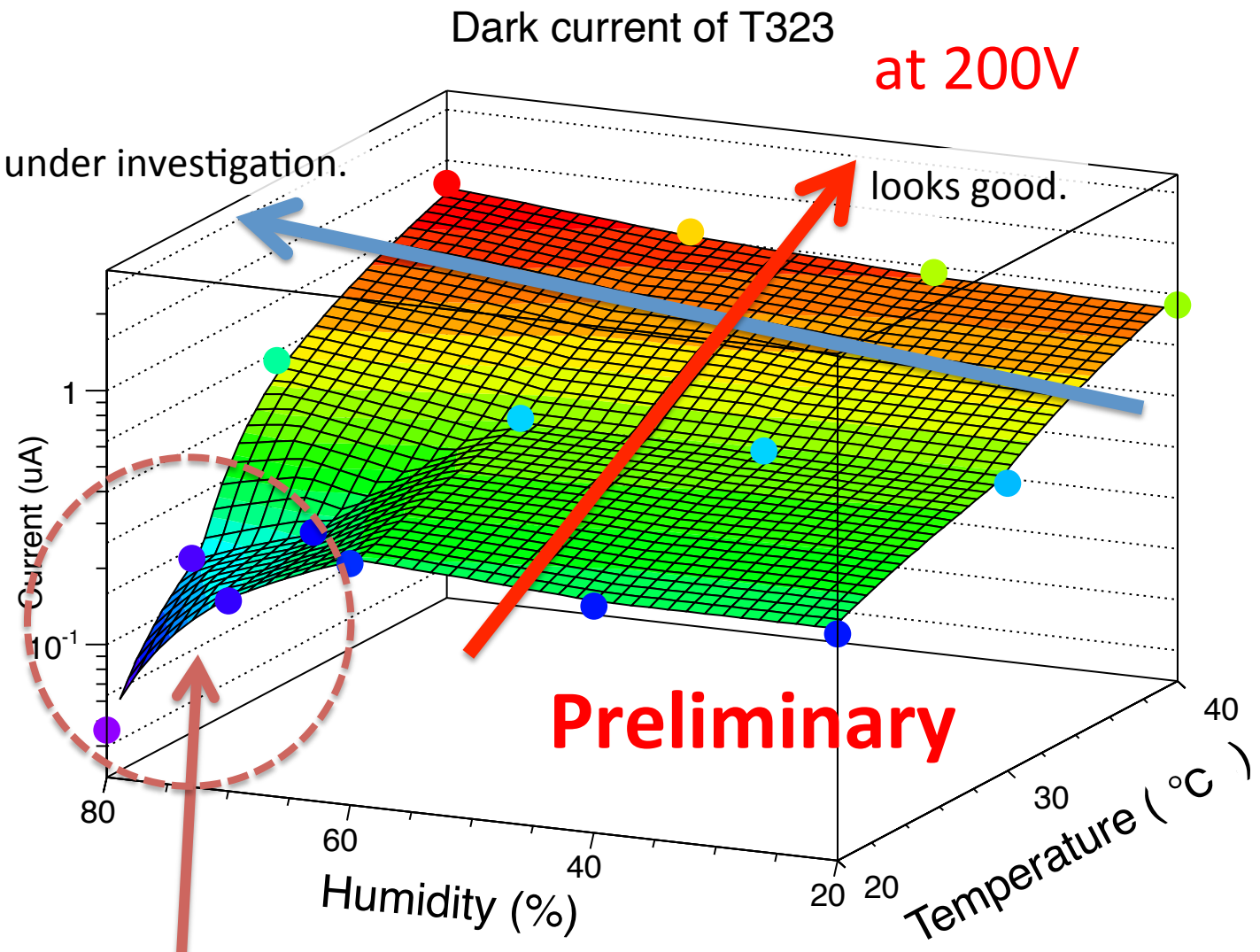
The origin of the dependence is under investigation.

Some bad reproducibility



Some strange behavior (reproducibility is not good)

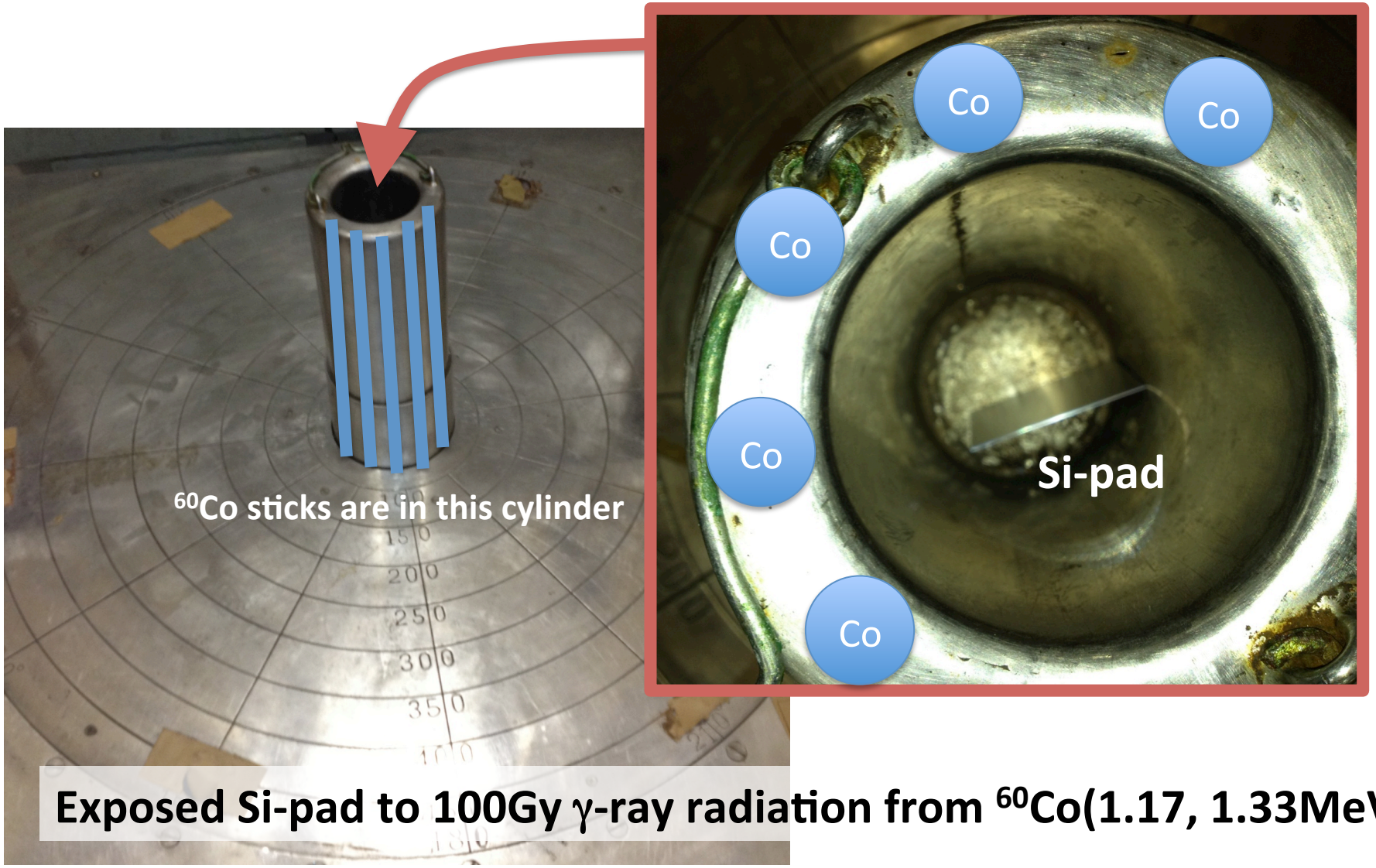
Temperature/Humidity dependence



Bad reproducibility is included.

Each value is the average of sequential measurements under the corresponding condition.

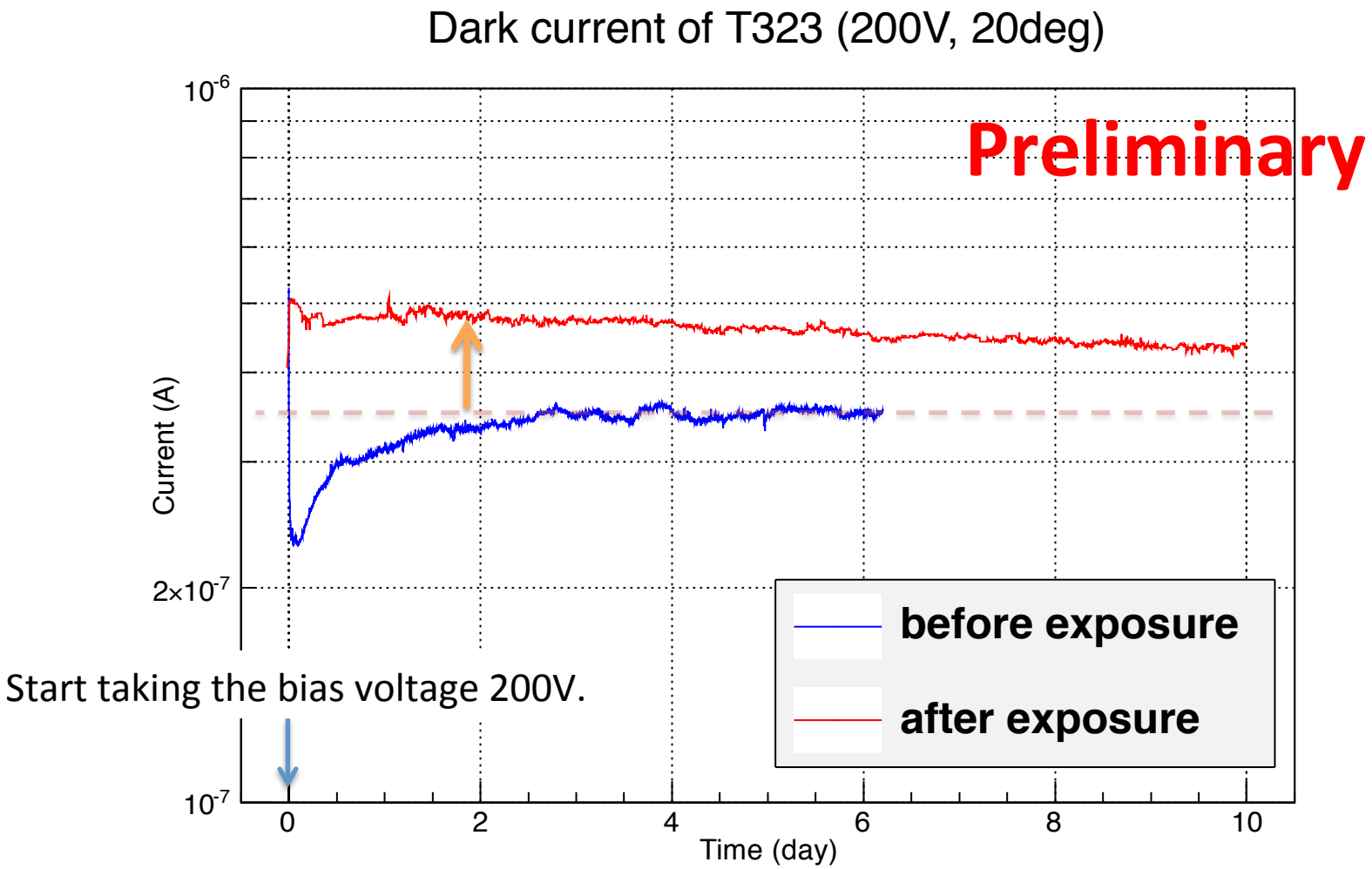
Study of radiation hardness



Exposed Si-pad to 100Gy γ-ray radiation from ^{60}Co(1.17, 1.33MeV)

@ γ-ray irradiation institute, Kyushu University.

Result



- The dark current actually increases after exposure.
- 100Gy corresponds to more than ~million years for ILC operation.
- The effect is small (~ ×1.5). -> GOOD hardness.

Summary

- We have been setting up a system to measure basic properties of the Si-pad sensors.
  - The chamber can control temperature/humidity.
  - Temperature/humidity logging is complete.
  - Several automatic measurements by LabView are completed.
    - Bias voltage control.
    - Current monitoring and recording.
- We have measured.
  - Temperature dependence. (looks good)
  - Humidity dependence. (now under investigation)
  - Radiation hardness. (good hardness)

Prospects

- Measurements of basic properties
  - Capacitance
  - Other samples with the same way mentioned above.

    Each model's pixel size = 10mm x 10mm and 5mm x 5mm.
- Improvements of the system
  - Temperature and Humidity monitoring
    - Thermocouple to measure the surface temperature
    - Improvement of humidity monitoring is to be considered…
  - PC control of the chamber for complete automatic system.
    - RS-485 cable is to be introduced for the connection.
    - To be controlled by LabView.

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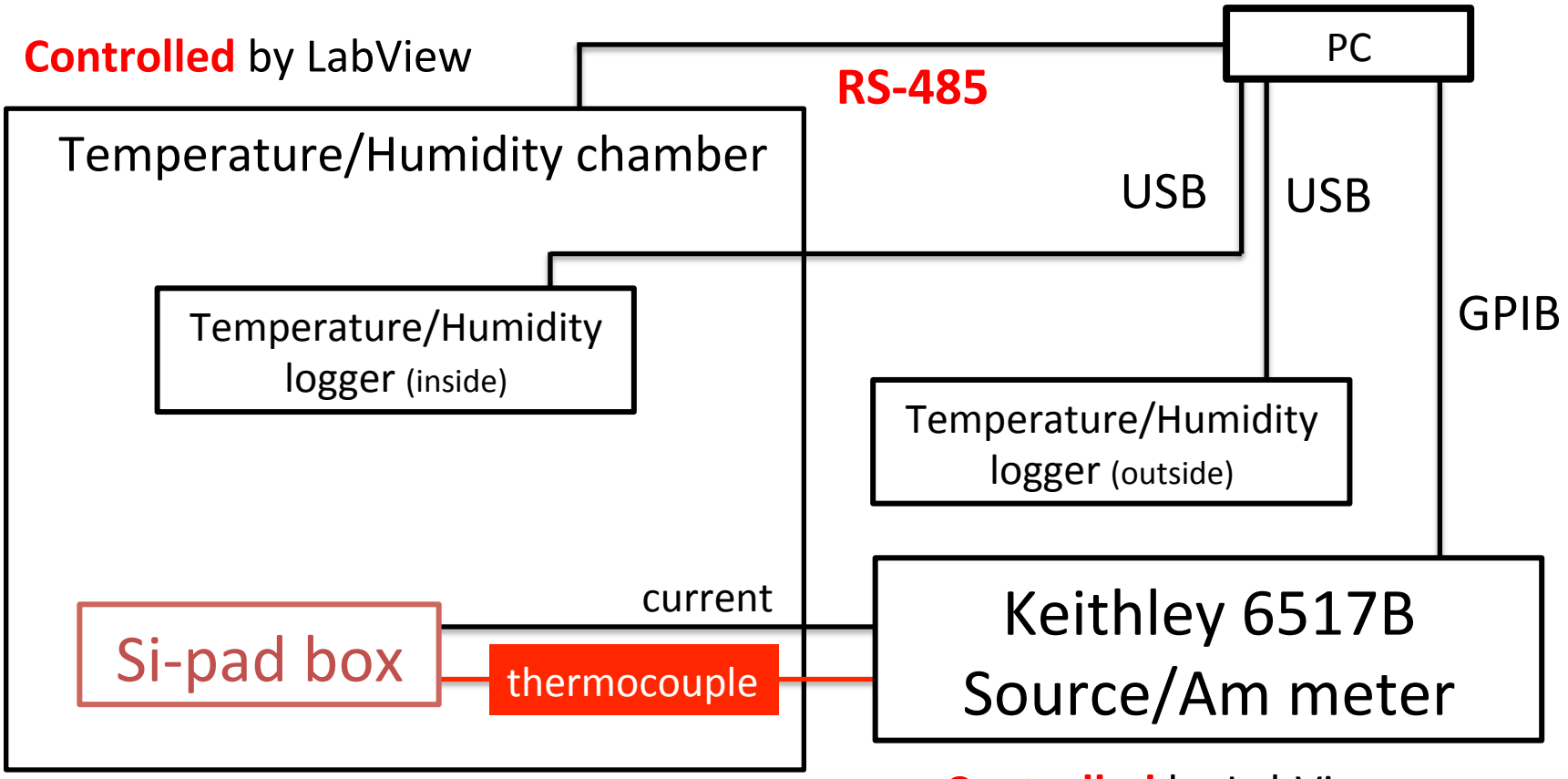
The improved system



A thermocouple is installed into the box
to directly monitor the temperature of Si-pad.

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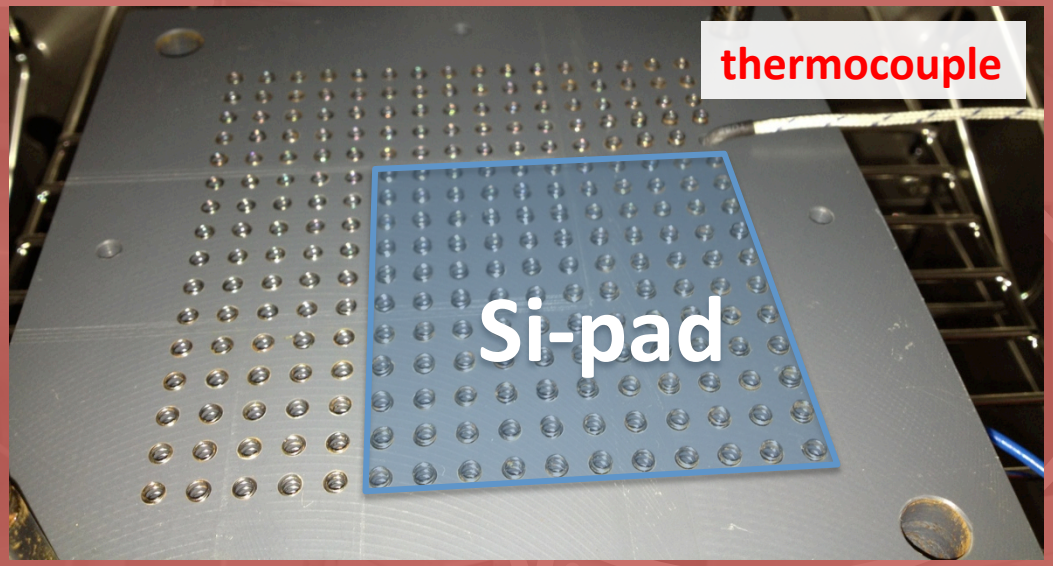
Setup View

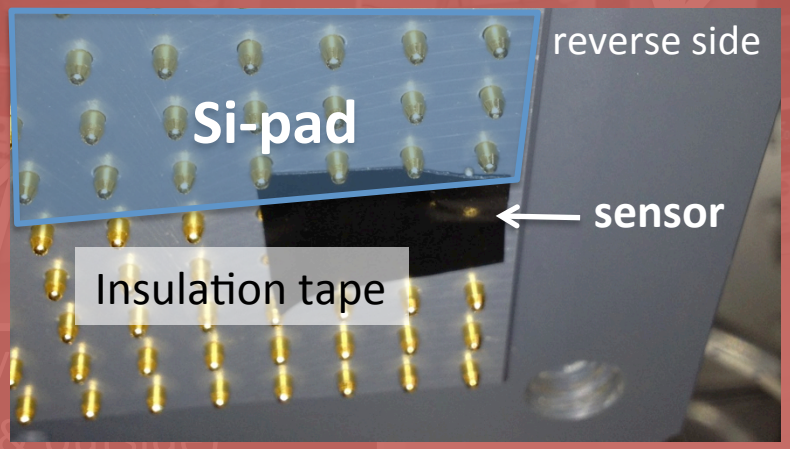
Temperature/Humidity chamber

Si-pad box

Temperature
(inside & outside)

A thermocouple is installed





measure the temperature at very near the Si-pad

Prospects

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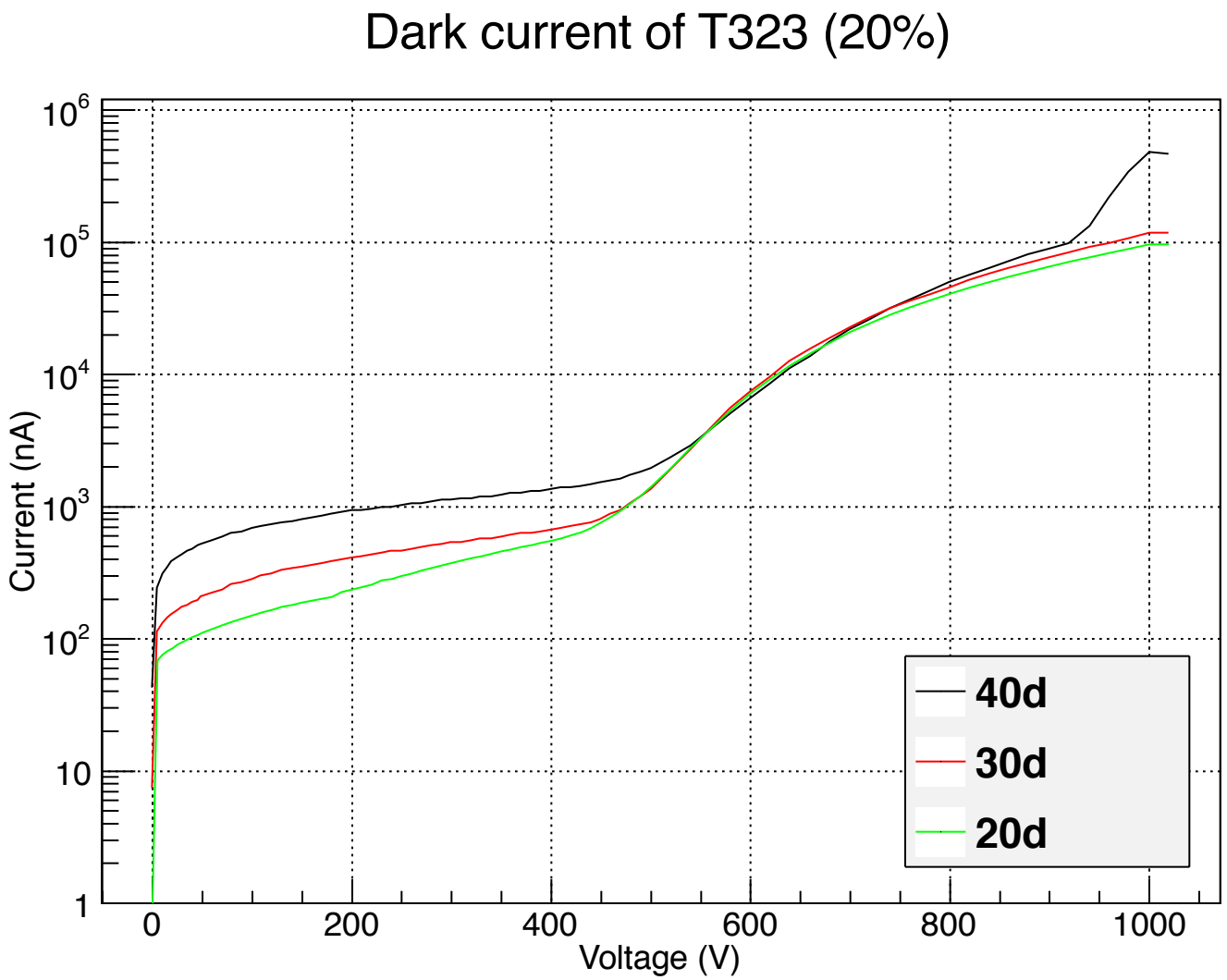
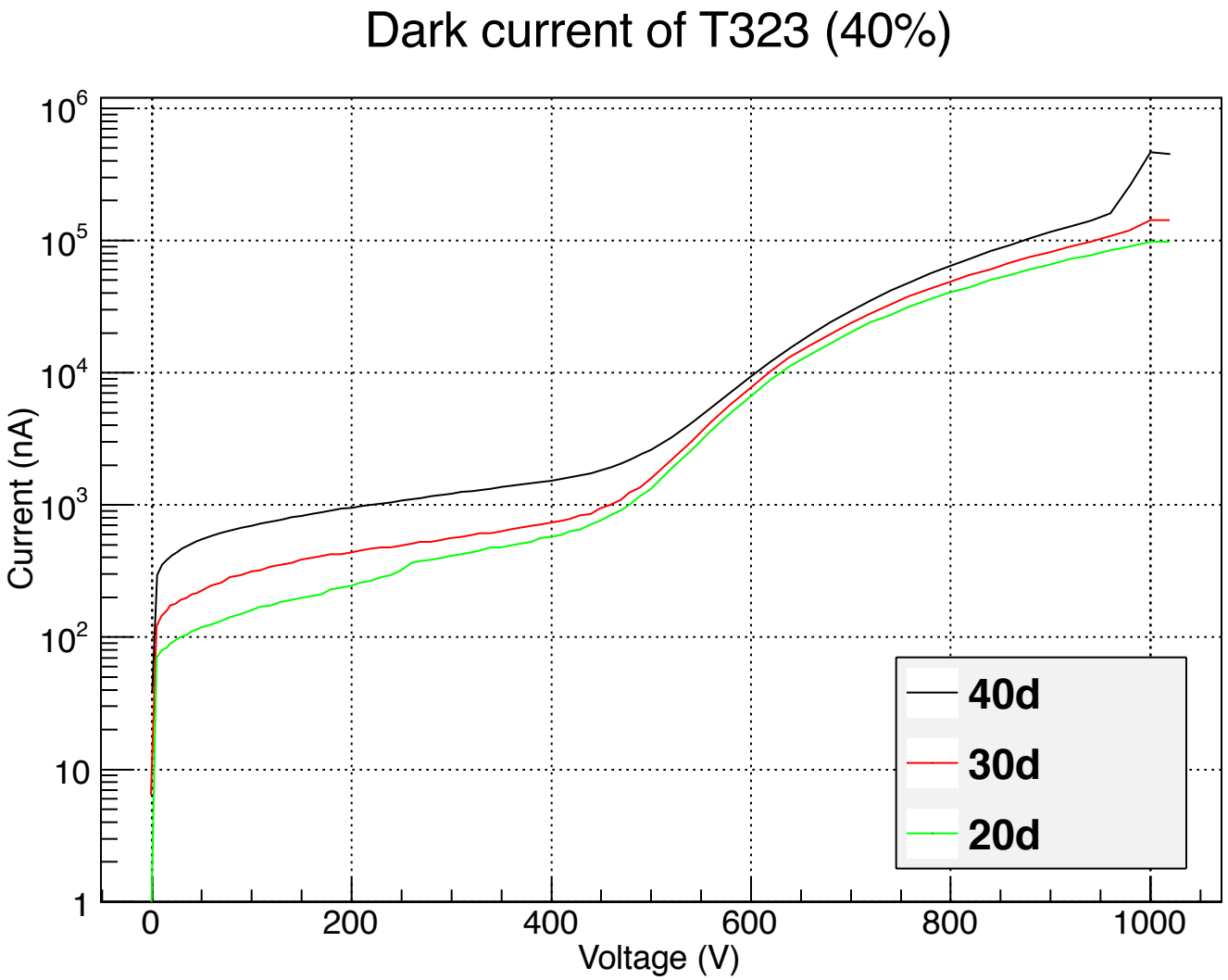
Back up

Other measurement samples

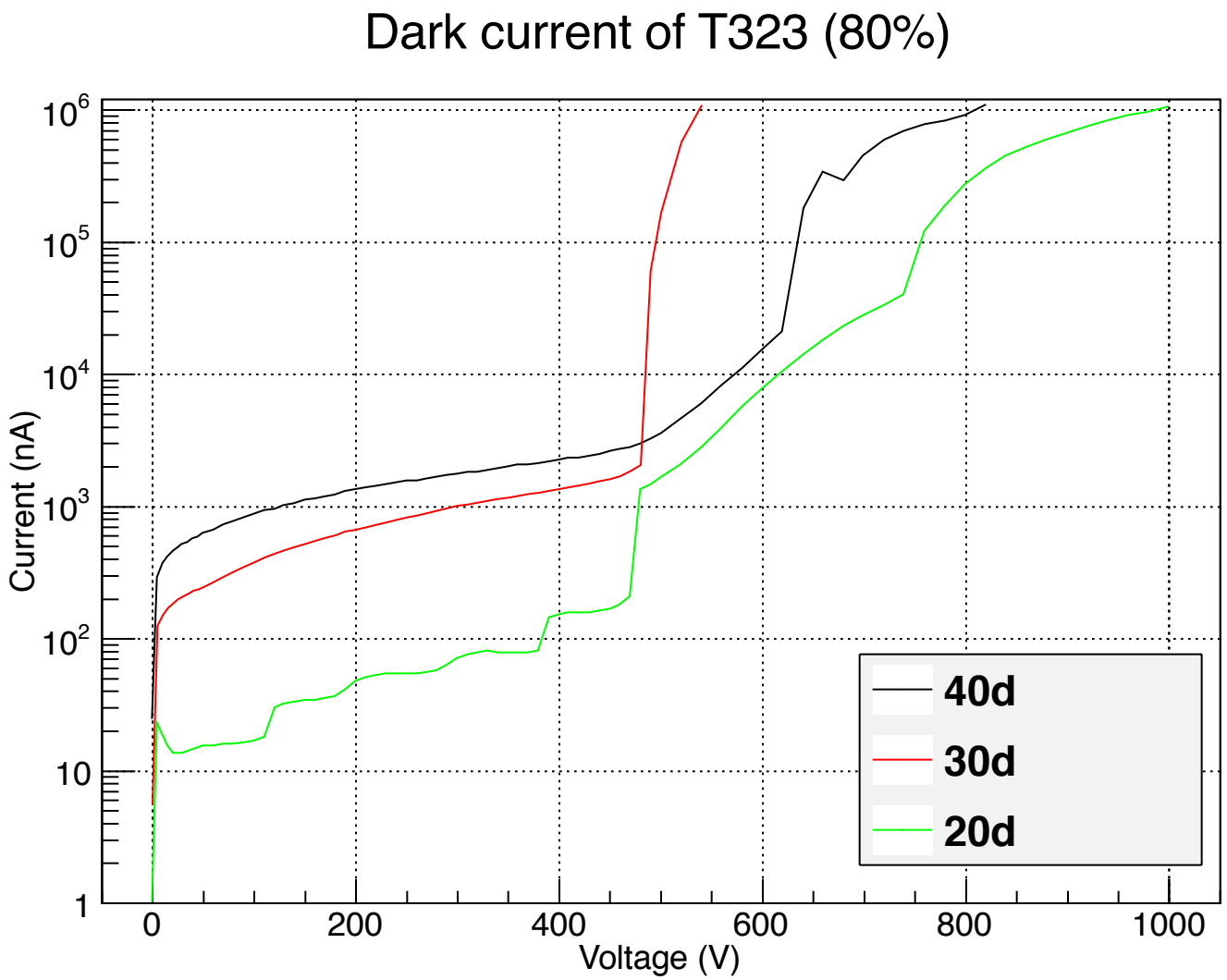
Temperature dependence



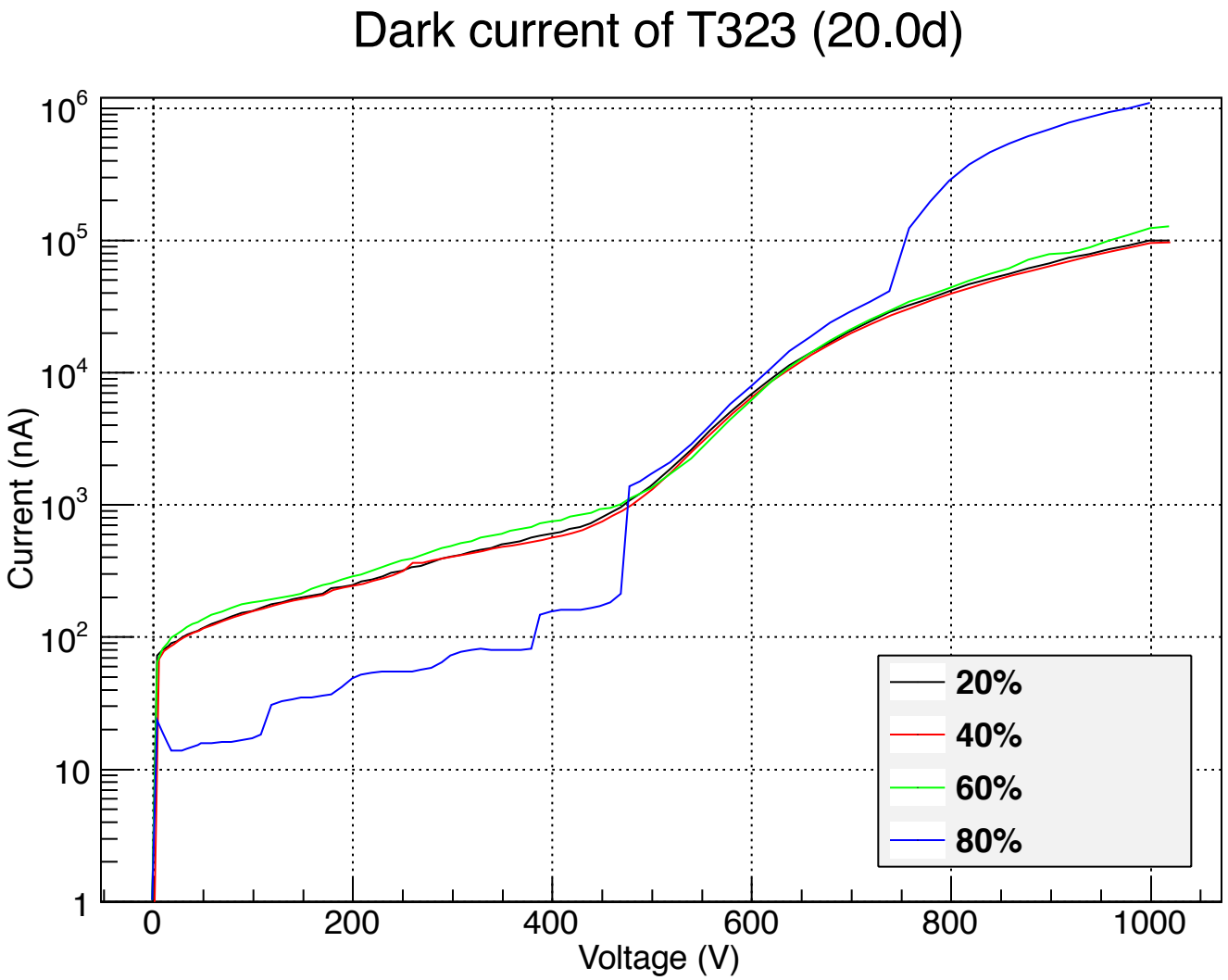
Temperature dependence



Temperature dependence



Humidity dependence



Humidity dependence