Irradiation Campaign 2019

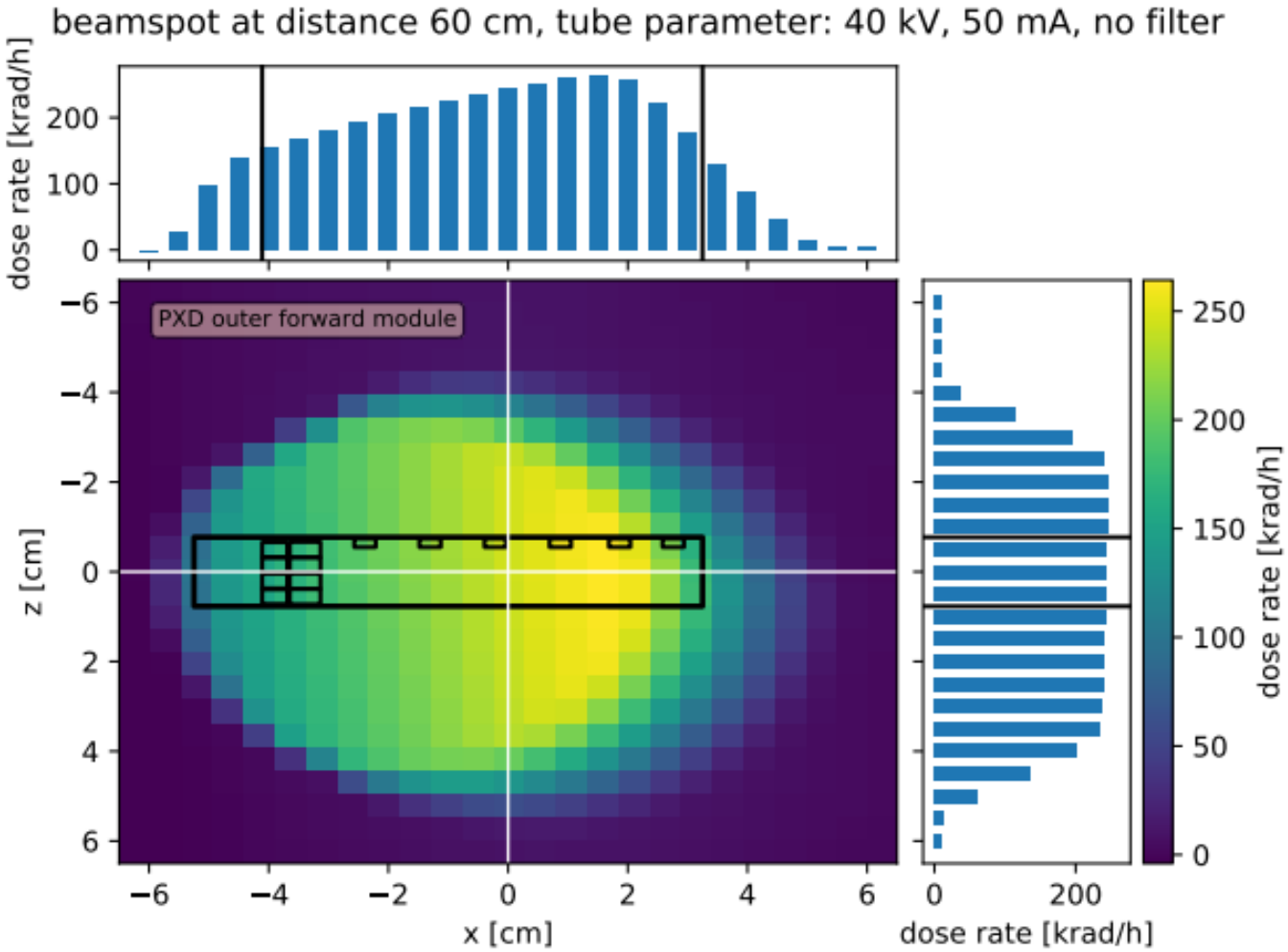
Work in progress

Motivation and Goals

- No irradiation of a final PXD9 module has been performed yet (with final ASICS)
- Cross-Check threshold shifts from phase2
- Go to high doses (>20Mrad) to estimate performance during phase3
- We want to get close to the temperature conditions of Belle2
  - From the thermal mockup we estimate ~35°C on the matrix
  - To replicate this we measure the temperature with a thermal camera and set our cooling temperature in a way that we get ~35°C on the matrix
- If possible we want to measure the x-ray spectrum with the module and calculate the dose based on the detector response

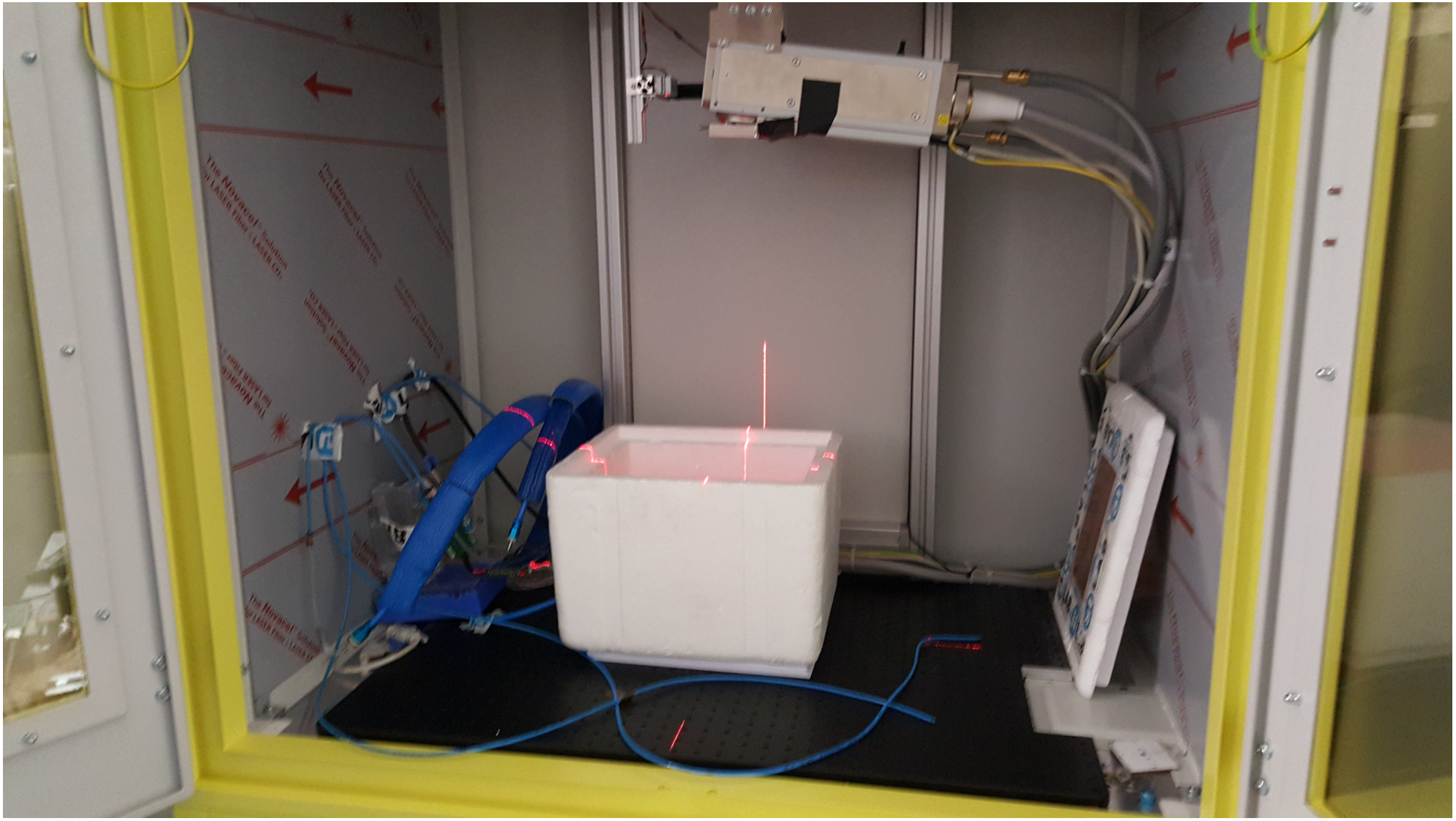
Setup

- X-Ray machine at Bonn, Beamspot was measured in detail.
- Gradient along one axis found

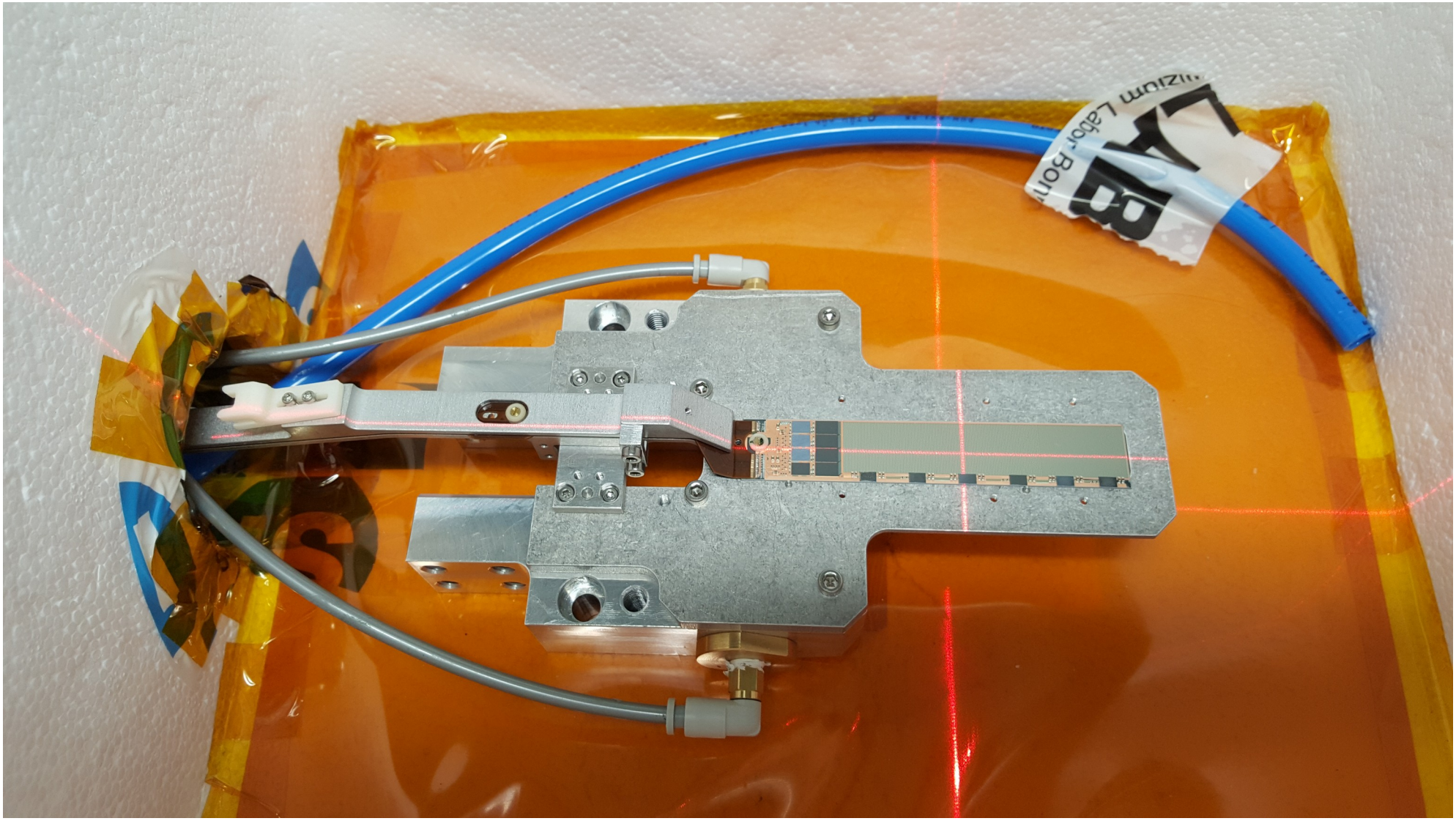


Setup

Setup



Setup

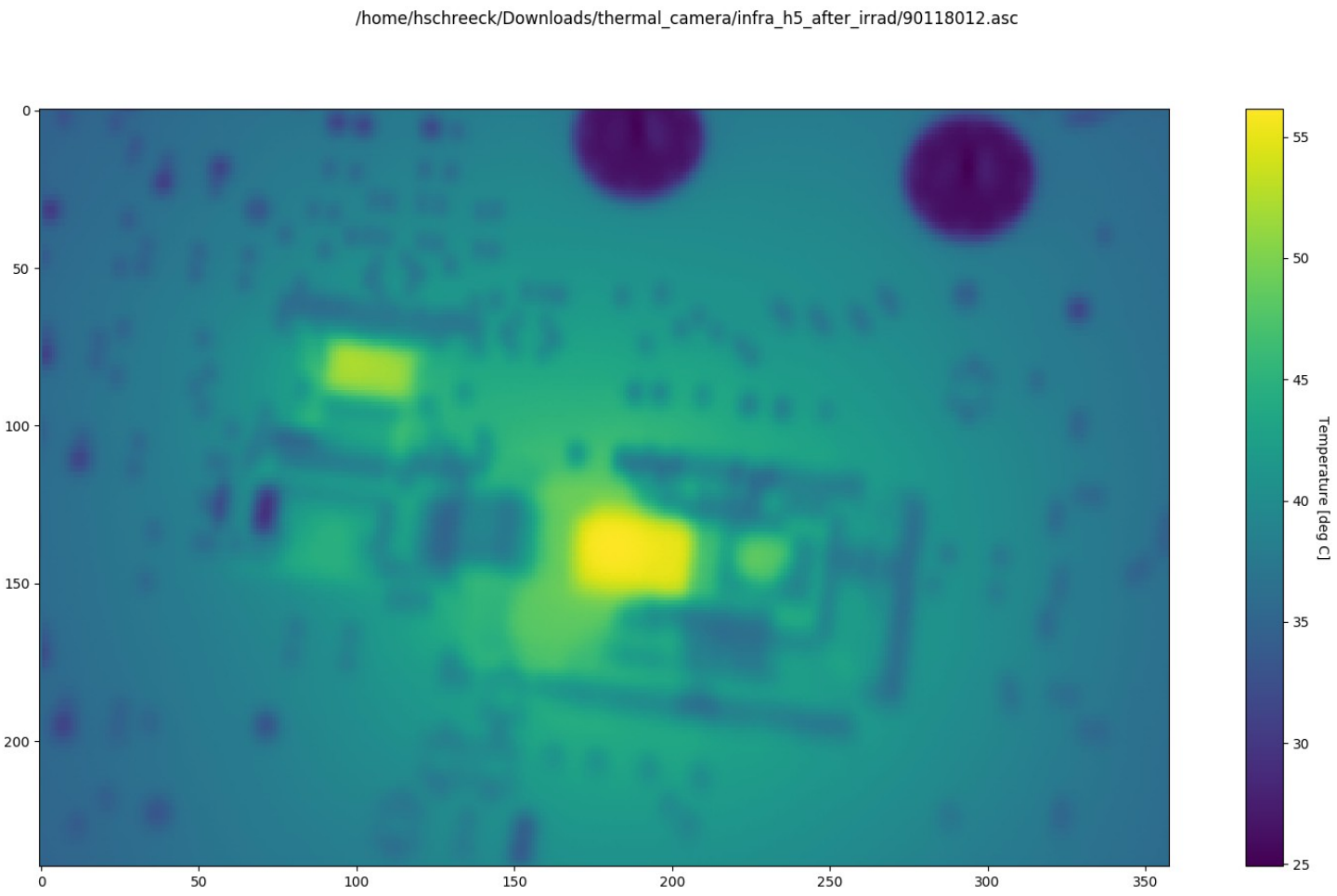


Temperature Measurements

- To get a good temperature measurement we used a thermal camera (cooled with liquid nitrogen)
- To improve this measurement we put black paint on top of the ASICs and the matrix of a Hybrid5 and an EMCM
- We took picturces with the fully powered Hybrid5 before and after our „test irradiation“
- The EMCM was not powered, instead the cooling block was brought to a specific temperature (5°C, 15°C, 30°C, 50°C, 60°C)

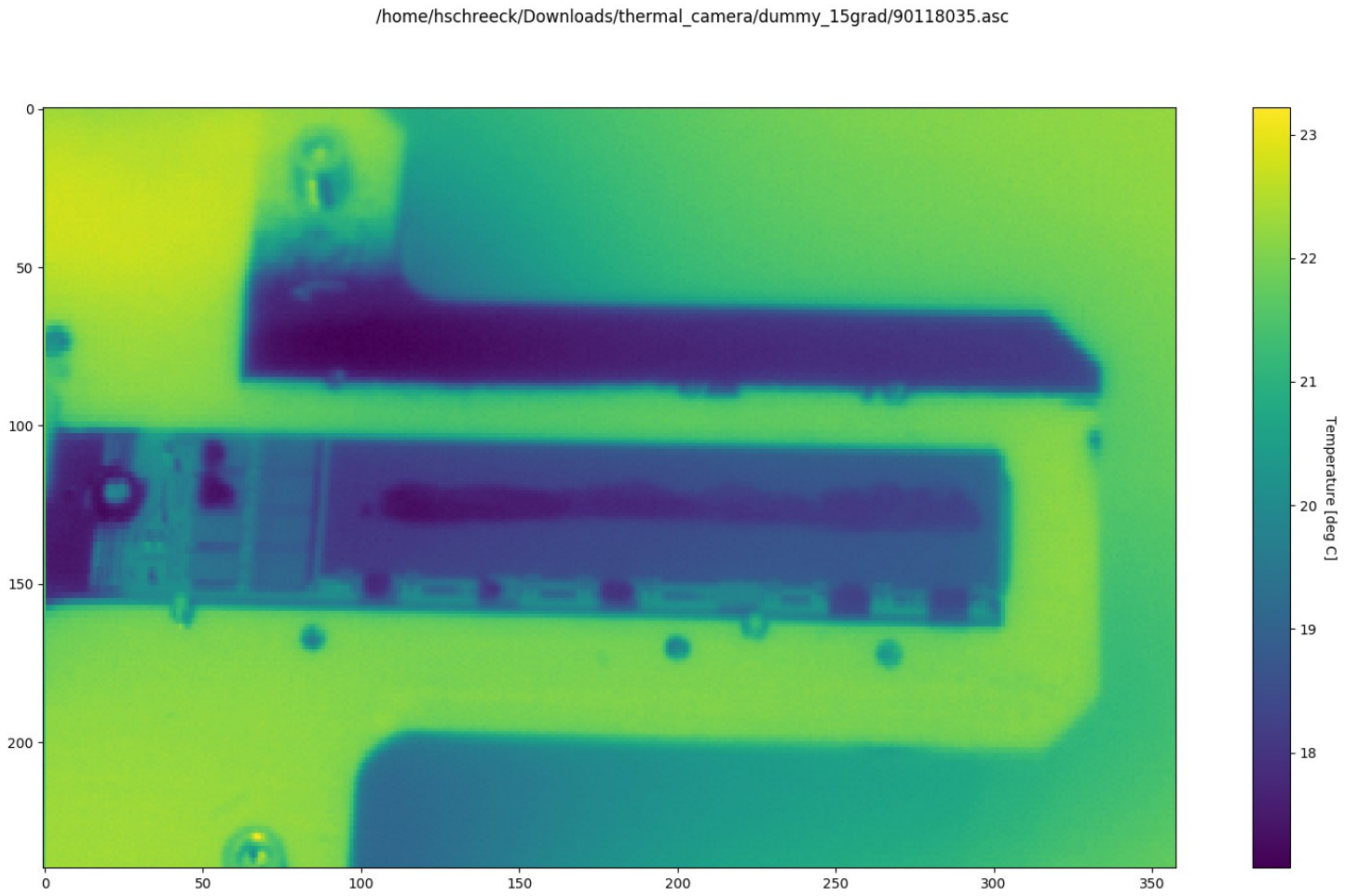
Temperature Measurements

- H5026 after the irradiation



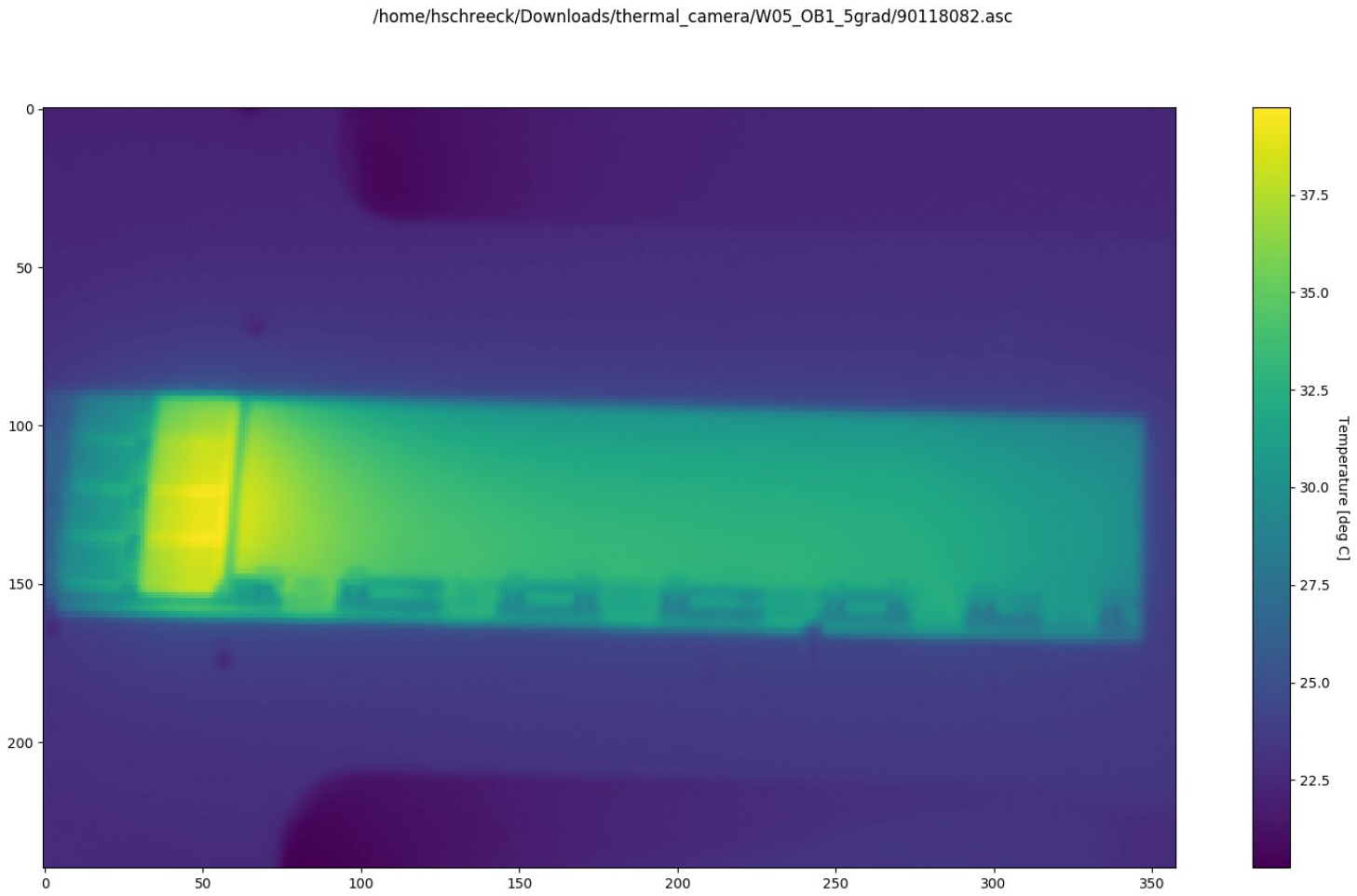
Temperature Measurements

- EMCM, cooling block at 15°C



Temperature Measurements

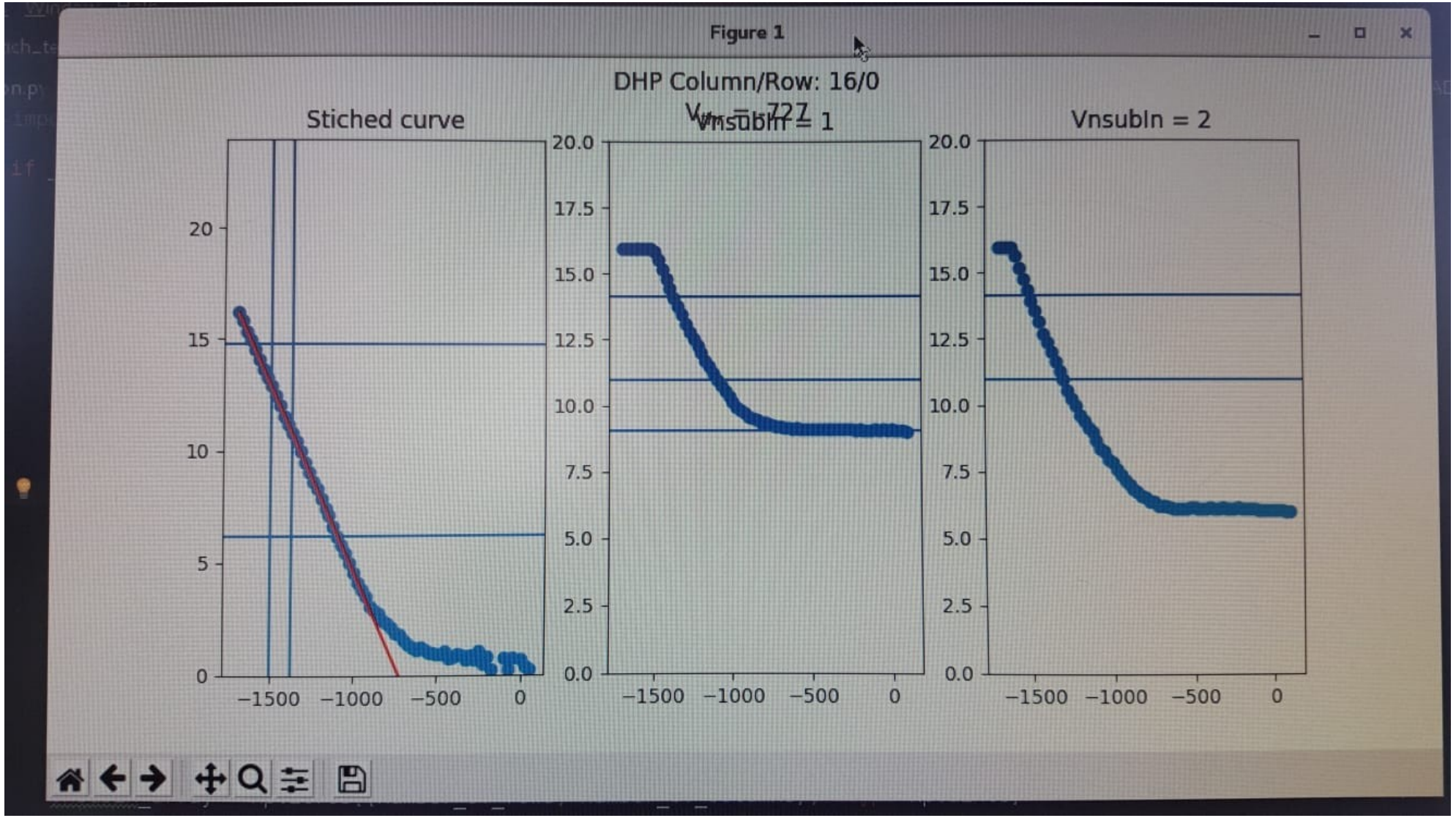
- W05_OB1, cooling block at 5°C



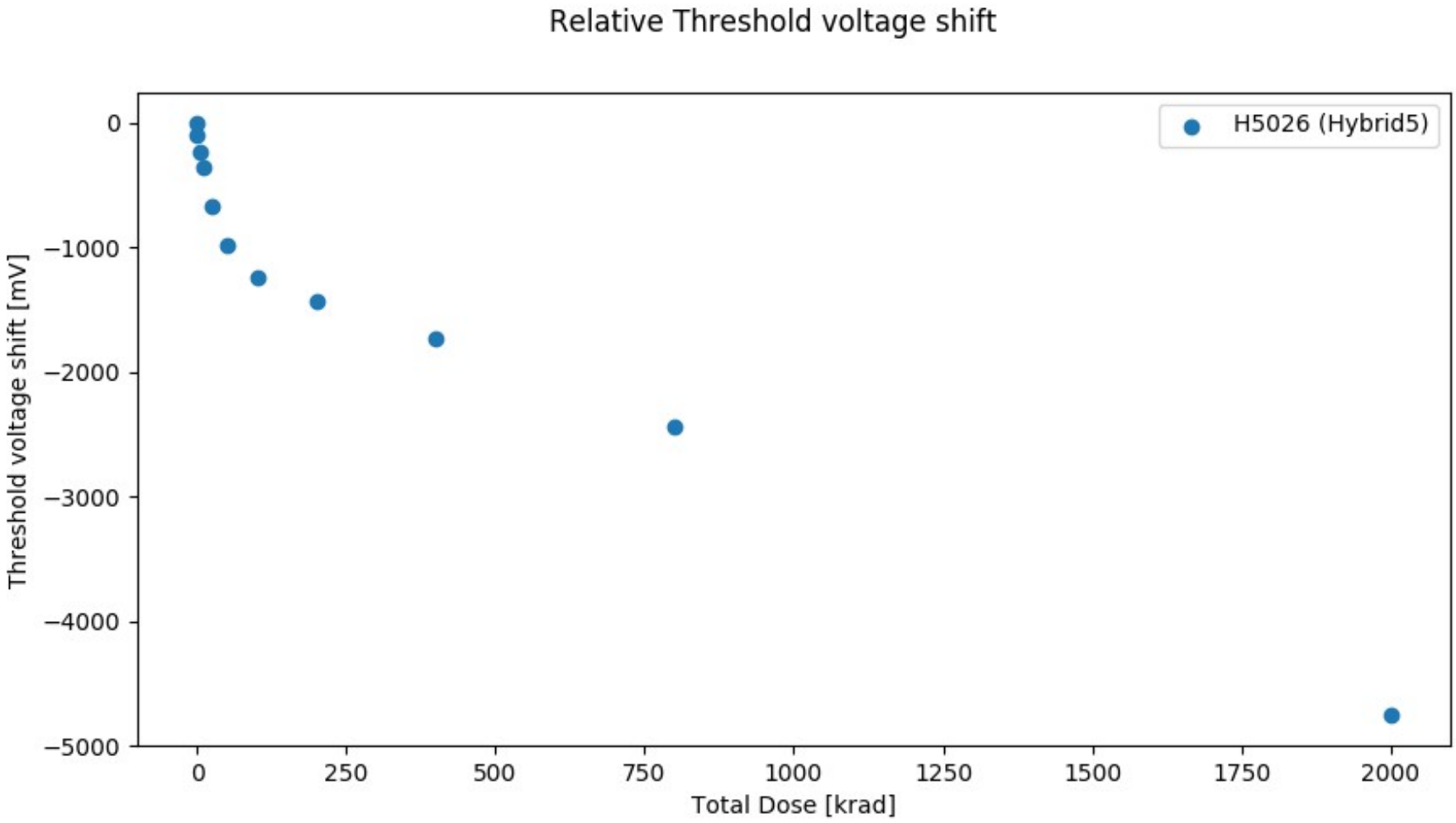
Hybrid5 Pretest

- As a pretest for the irradiation of the PXD9 module, one Hybrid5 (H5026) was irradiated
  - Steps (in krad): 5, 10, 25, 50, 100, 200, 400, 800, 2000
- We took IV Curves every ~10 min after each irradiation step: The shift of the threshold voltage was found to be rather small ~10-30mV after 1 hour → Decided to wait 1 hour for the PXD9 module
- Hardware limits became a problem at one point (Gate-On voltage limit was to restrictive)

Hybrid5 IV Curves



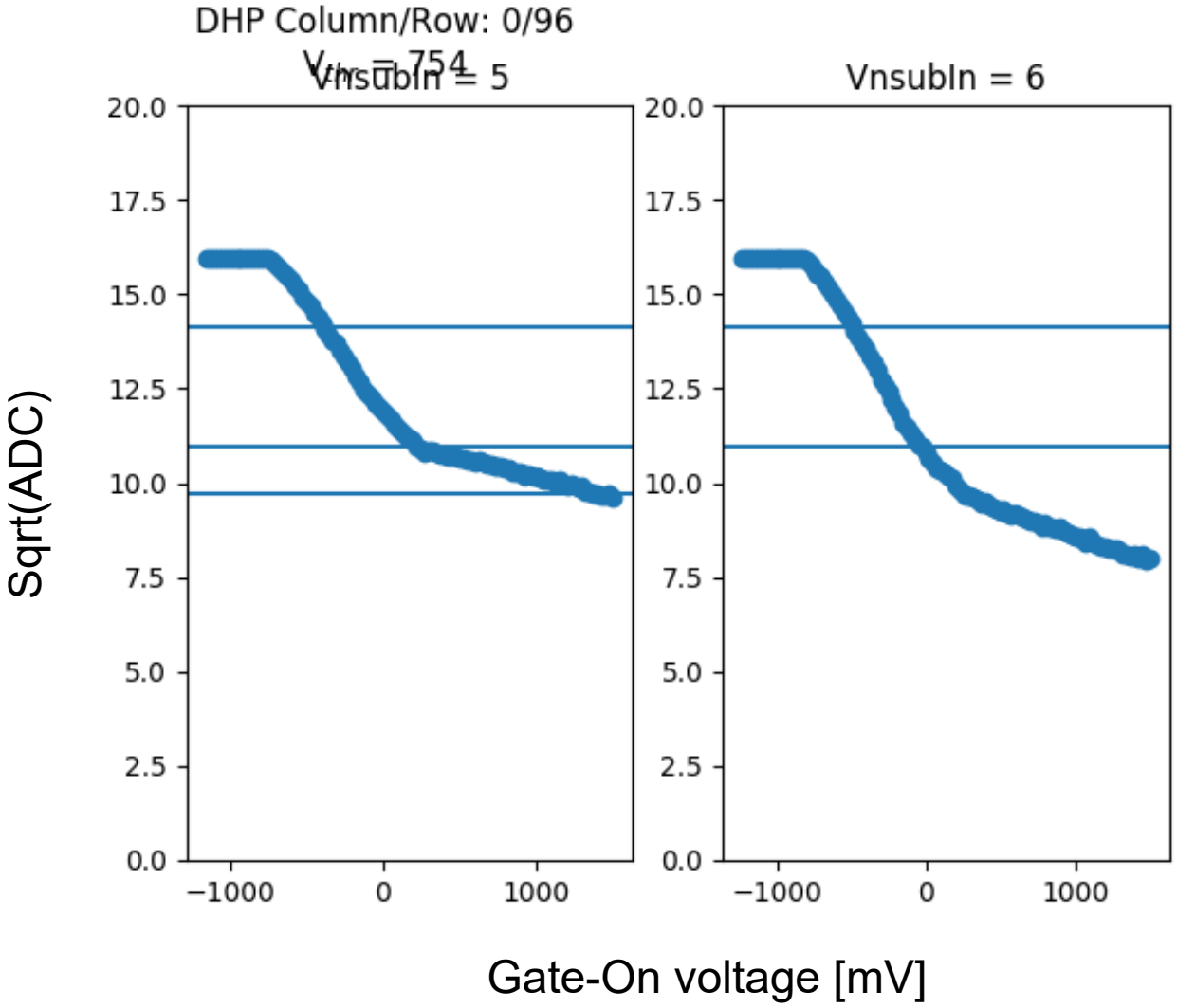
Hybrid5 IV Curves



Measurement protocol

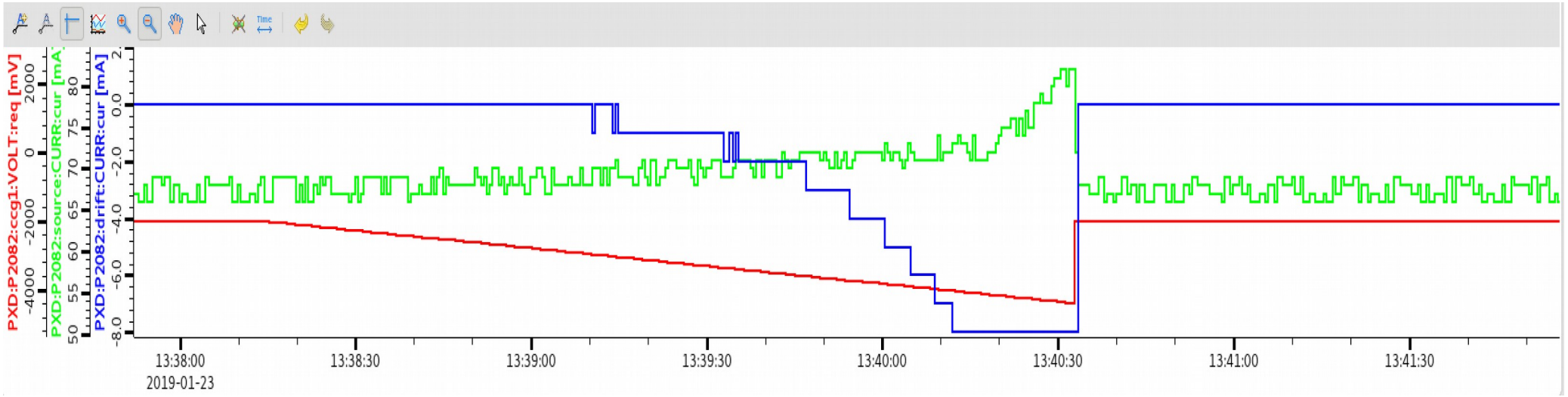
- Irradiate the module (fully powered, ACMC on)
  - Keep the source current constant by adjusting the gate-on voltage (as well as gate-off)
  - Record memdumps during this time (every X sec)
- After the irradiation is complete, wait one hour and leave the module on → Annealing
  - Record memdumps during that time
- Start with the measurements:
  - Delays, IV curves, ADC Curves (no sweep over DCD parameters), CCG Curves, Source measurements (Sr90, Cd109)
- Go to next irradiation step

PXD9 IV Curves

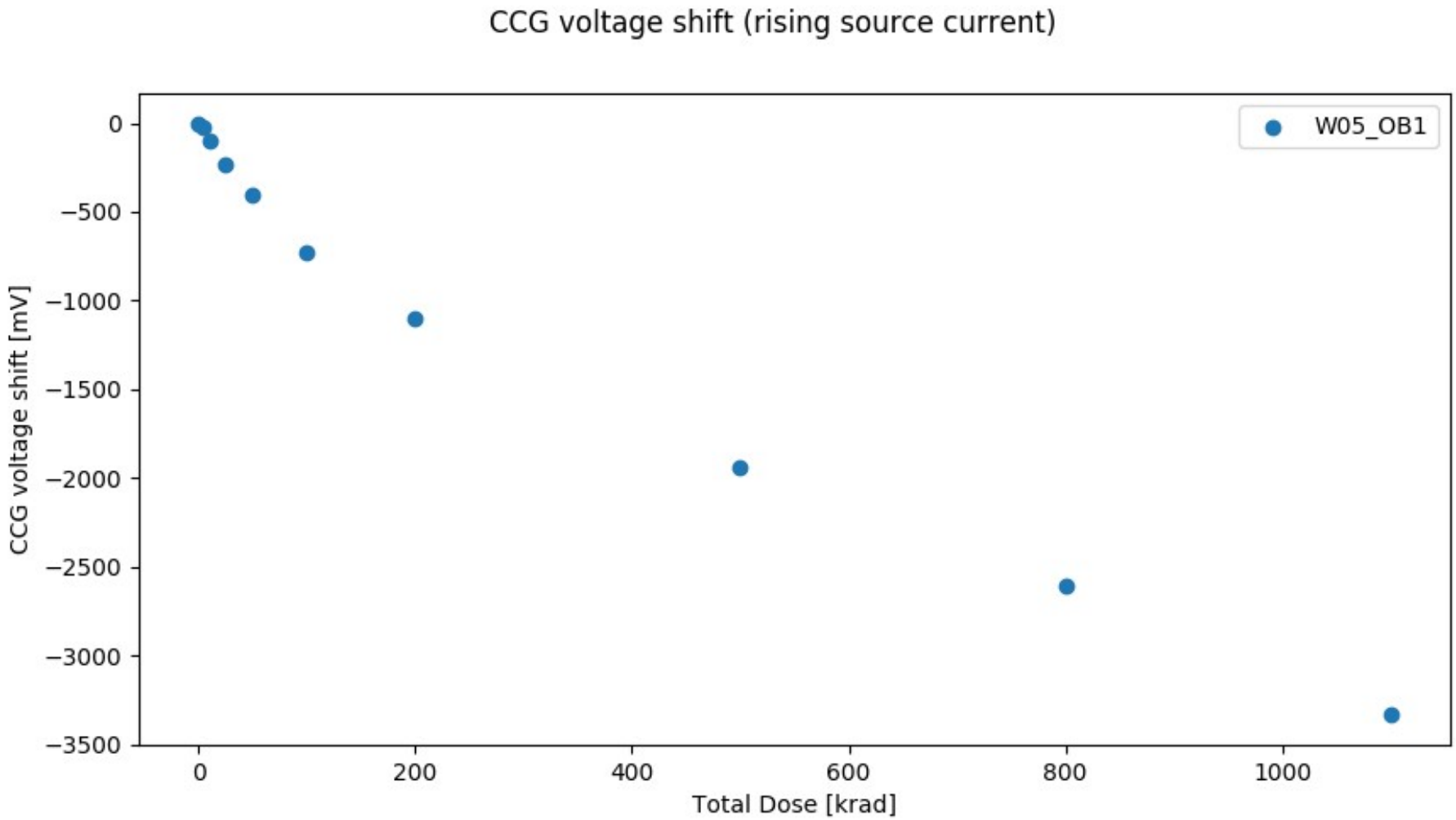


PXD9 CCG Curves

- **Expectation:** When CCG goes to a more negative value, a second drain-source channel is opened → Increase in the source current
- **Observation:** Source current does indeed increase (and pedestals are shifted). In addition we see a current for Drift

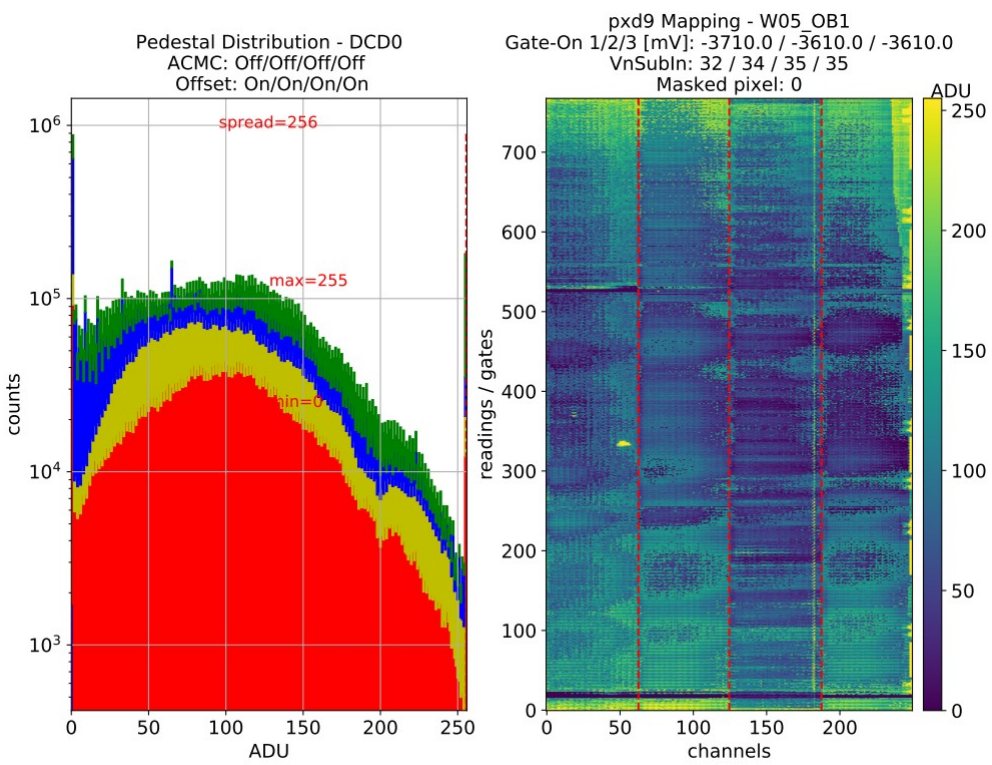


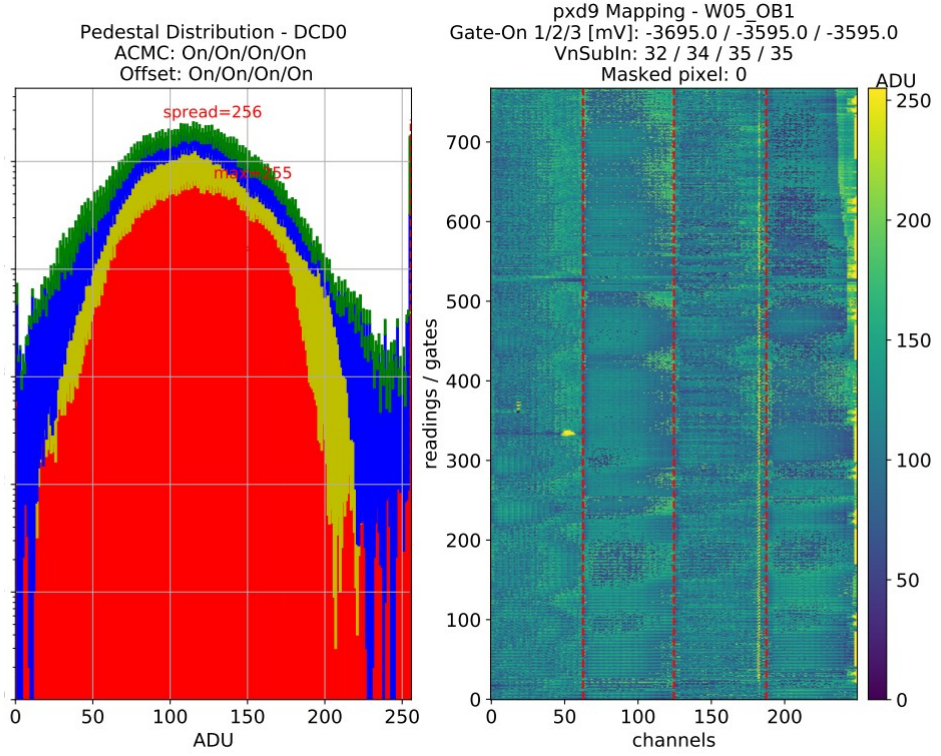
PXD9 CCG Curves



Inhomogeneous Irradiation

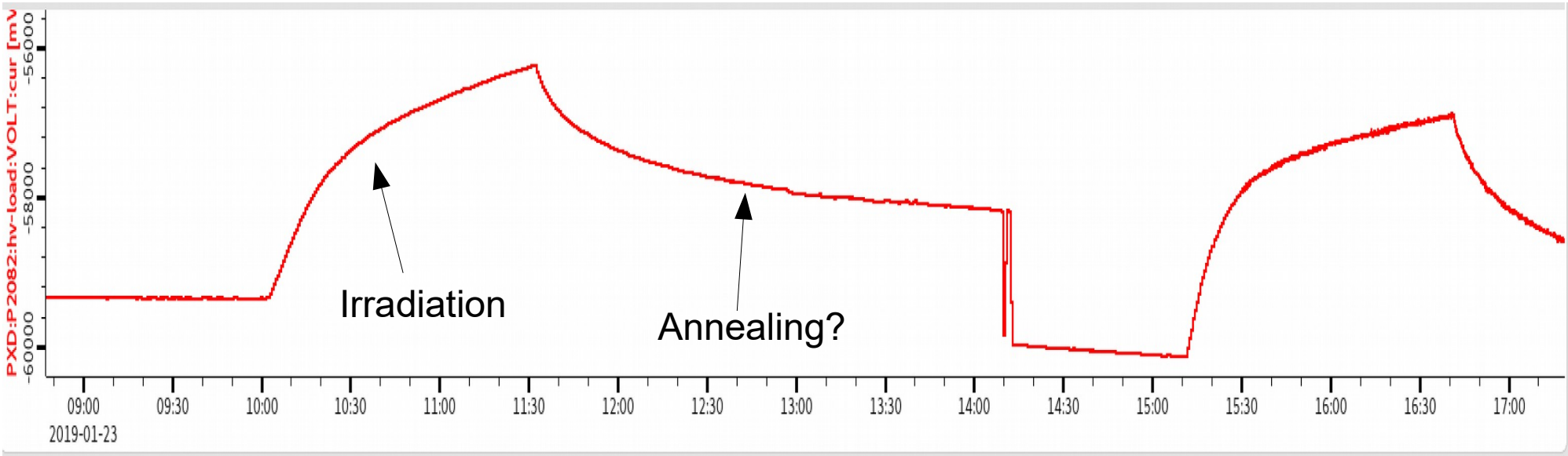
- Due to the inhomogeneous beam spot the pedestal shift is different along the z-axis
- ACMC compensates this very nicely





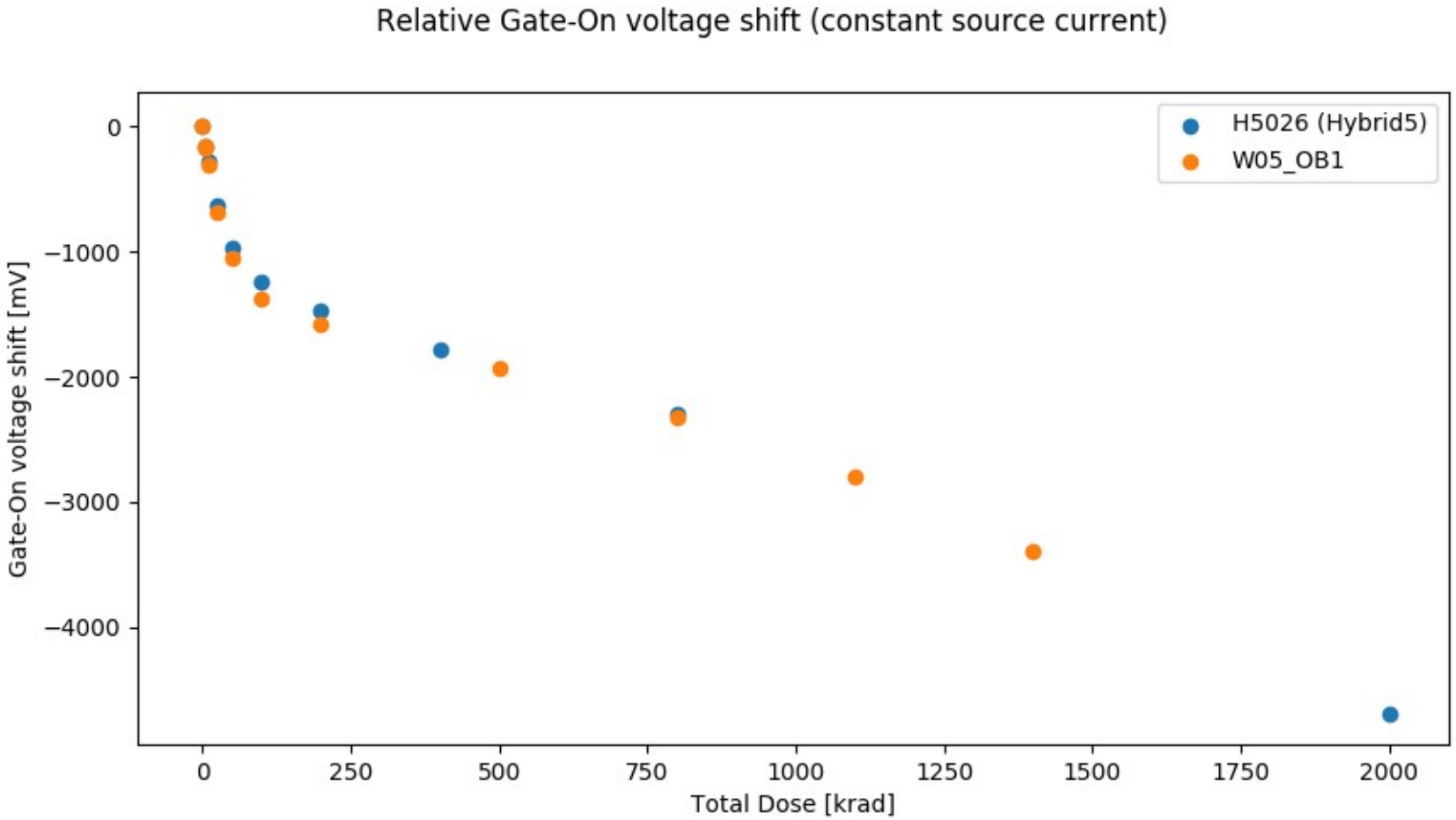
HV voltage drift

- The HV voltage started to drift to positive values during the irradiation
- The LMUPS does **not** compensate this
  - No warning light for the regulator, current limit at 10mA, measured current is 0mA



Gate-On voltage shift

- Until the IV Curve Analysis is complete, we use the Gate-On voltage to determine the shift
- The voltage is chosen so that the source current stays constant



Irradiation Campaign 2019

- 1kGy = 100krad