Veto Updates

BULLKID digest meeting 9/22/25

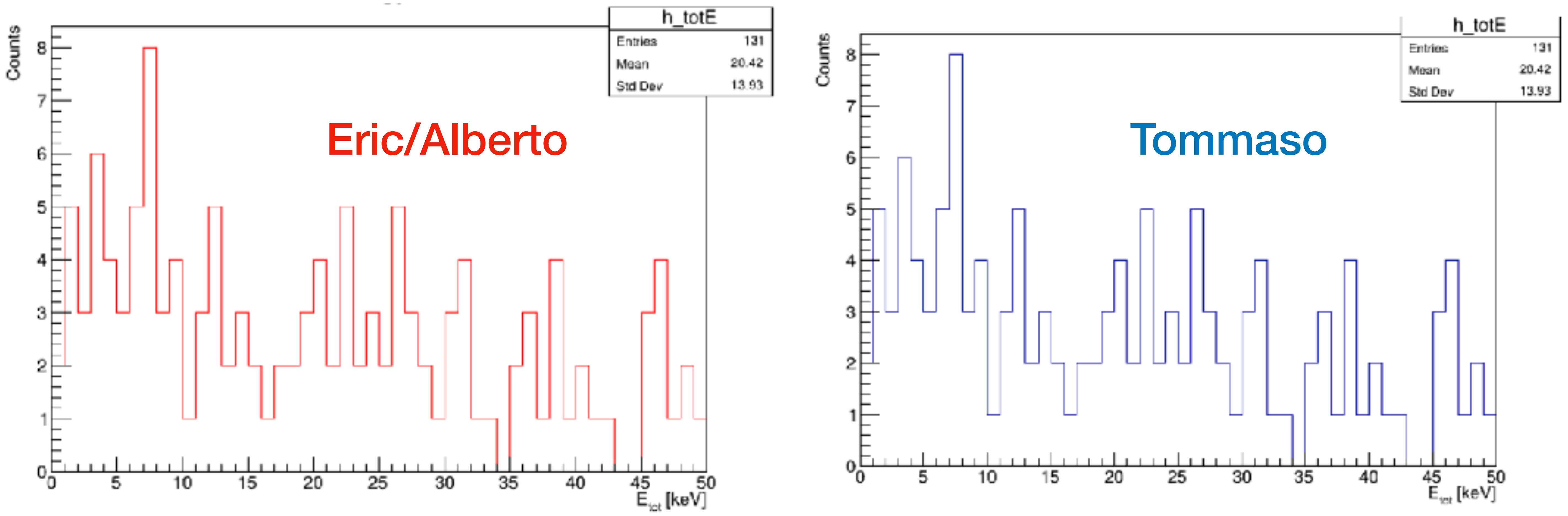
Tommaso Lari

Simulations:

Comparison with Unam group:

- Previously:
  - My event rates differed from those obtained by the Unam group, especially for gamma backgrounds.
  - Only relatives rates, when simulating the background suppression of the veto.
- Updates:
  - Now: after several cross-checks, our results are in good agreement
  - Validated with a 2.6 MeV gamma line, without shields
- Next steps:
  - simulate the full shielding setup

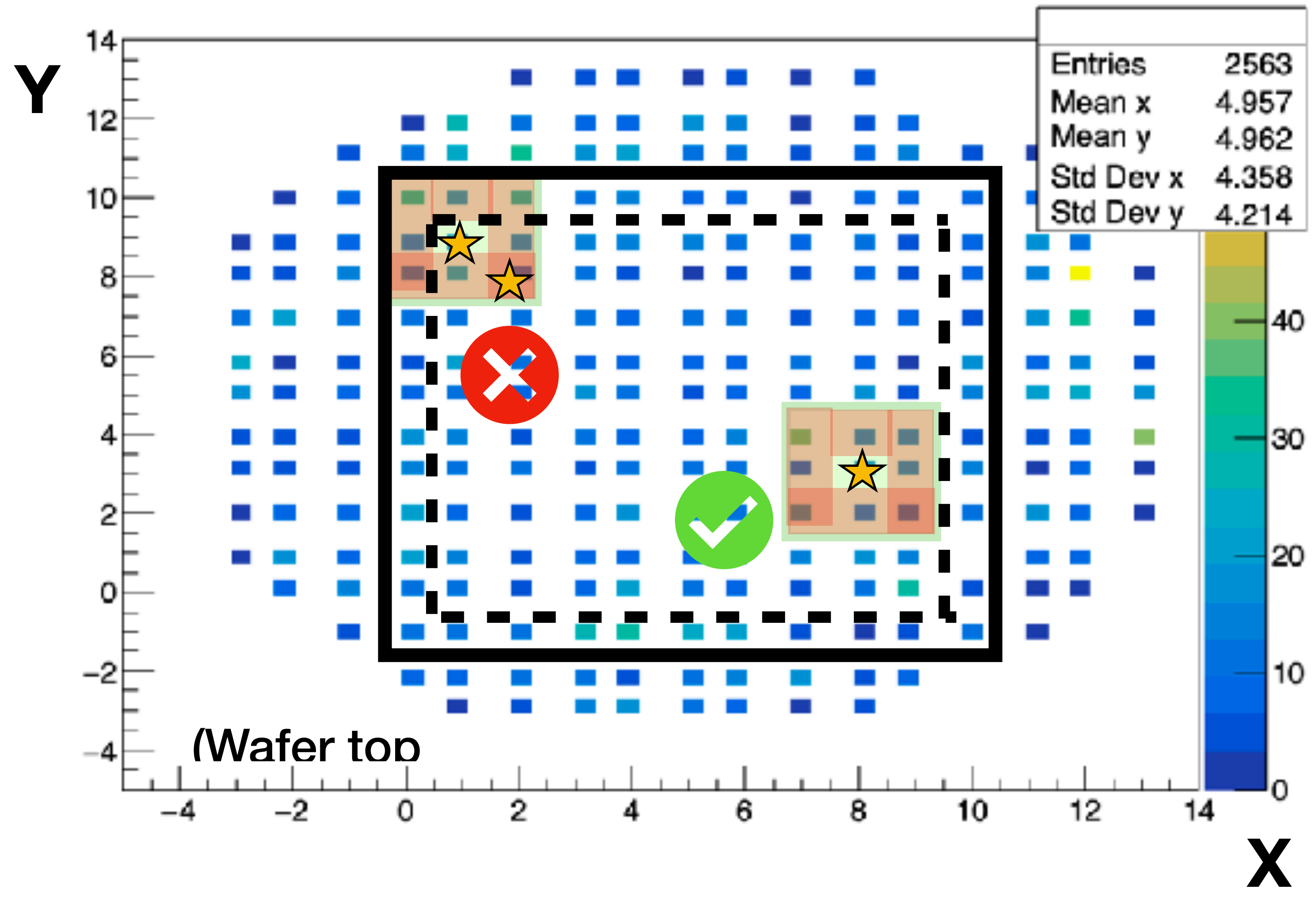
Tl 2.6 MeV gamma line no shields



Event selection in simulations:

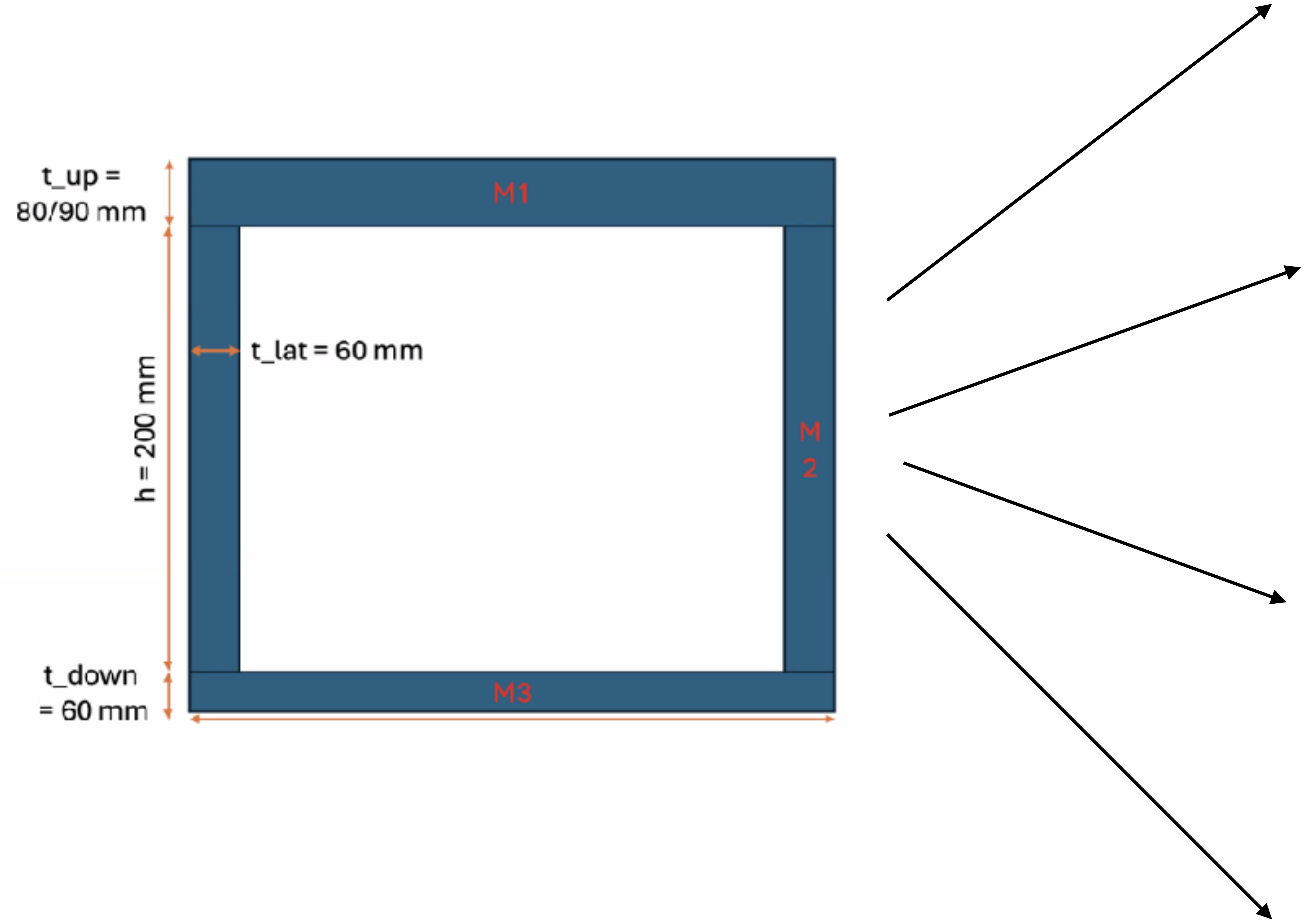
- Convert energy deposits in BULLKID-DM wafers into event counts.
- Reproduce the background-reduction strategy.
- Two approaches:
  - **Conservative:** use only first-neighboring dice as anticoincidence.
  - **Stringent:** use the entire wafer stack as anticoincidence.

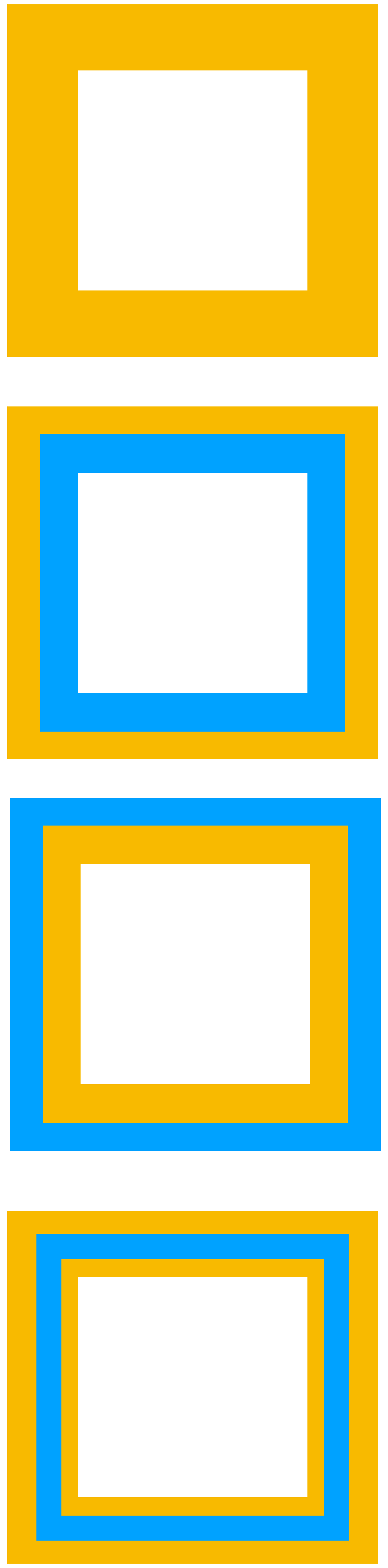
Example of event reconstruction in a BULLKID-DM wafer



Simulations:

Updated Configurations of cryogenic shields





Configuration # 3:
Shields (side): 60 mm Cu
Mass= 238 kg

Configuration # 4:
Shields (side): 30 mm BGO Veto +30 mm Cu
Mass= 219 kg
Veto Mass= 74 kg

Configuration # 5:
Shields (side): 30 mm Cu + 30 mm BGO Veto
Mass= 208 kg
Veto Mass= 115 kg

Configuration # 6:
Shields (side): 20 mm Cu +
+20 mm BGO Veto+ 20 mm Cu
Mass= 222 kg
Veto Mass= 62 kg

BGO:
Density=7.13 g/cm^3

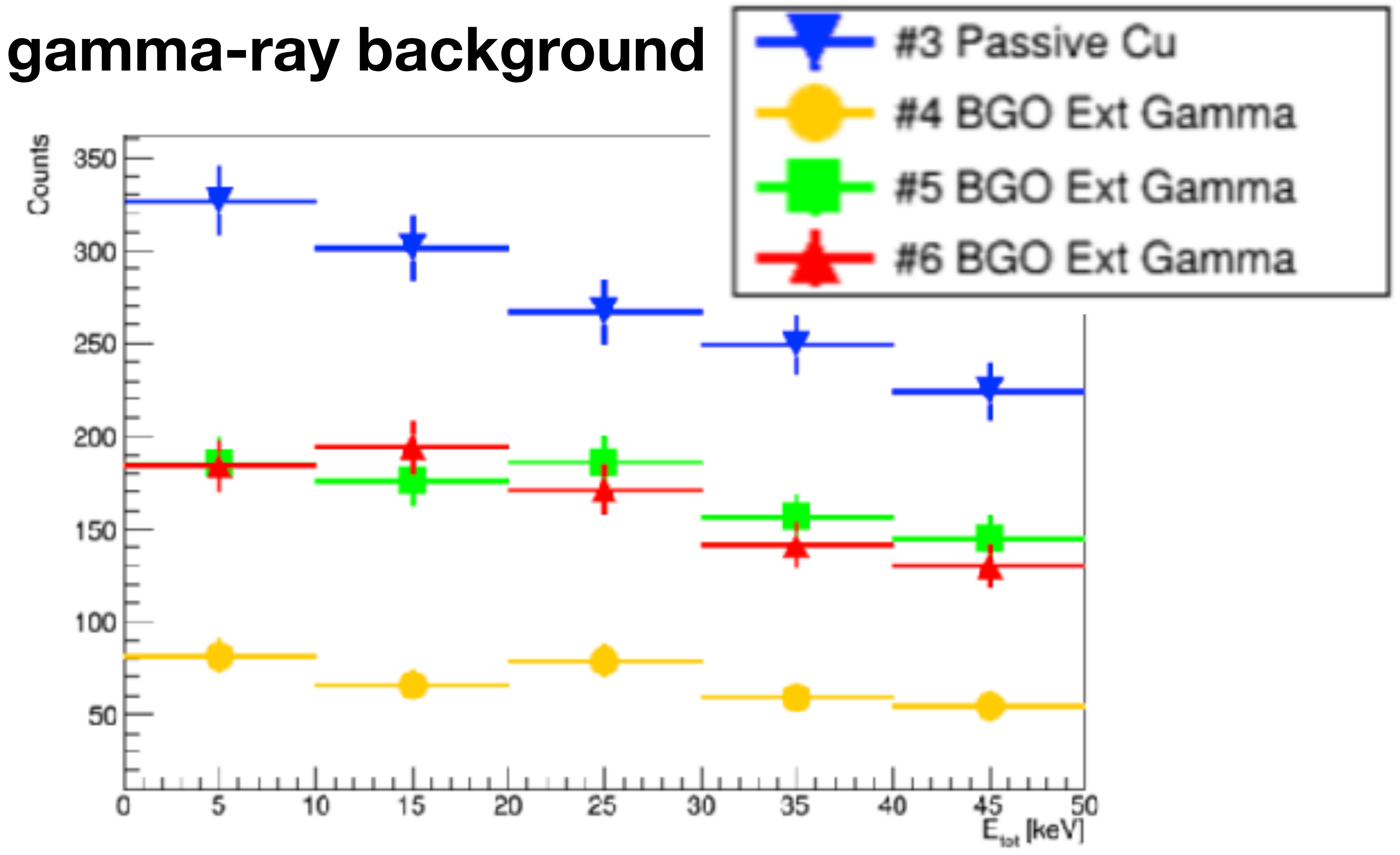
Simulations:

Suppression of External gamma-rays:

- Updates:
  - Evaluated suppression of external gamma rays for different shielding configurations.
    - Veto inside: better performance (background reduction ×4–5)
    - Veto outside: still effective (background reduction ×2).

- Next steps:
  - Evaluate neutron background.
  - Test alternative configurations discussed in the simulation meeting, e.g. using a **GAGG veto as neutron absorber** instead of B_4C.

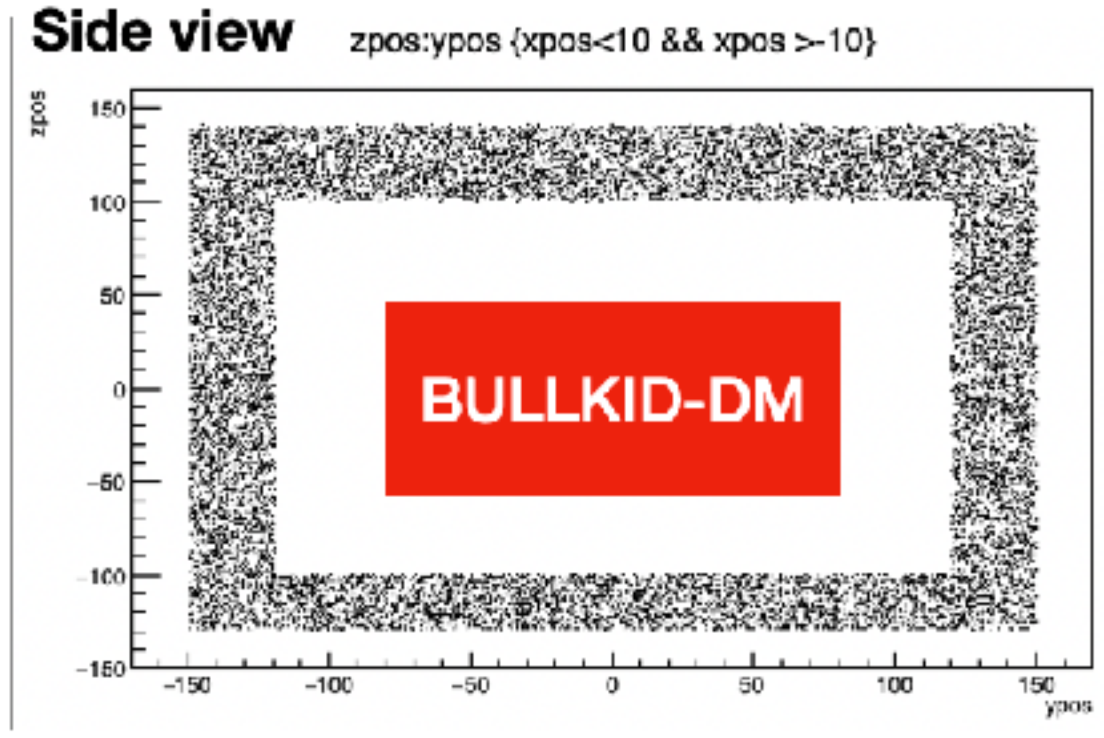
External gamma-ray background

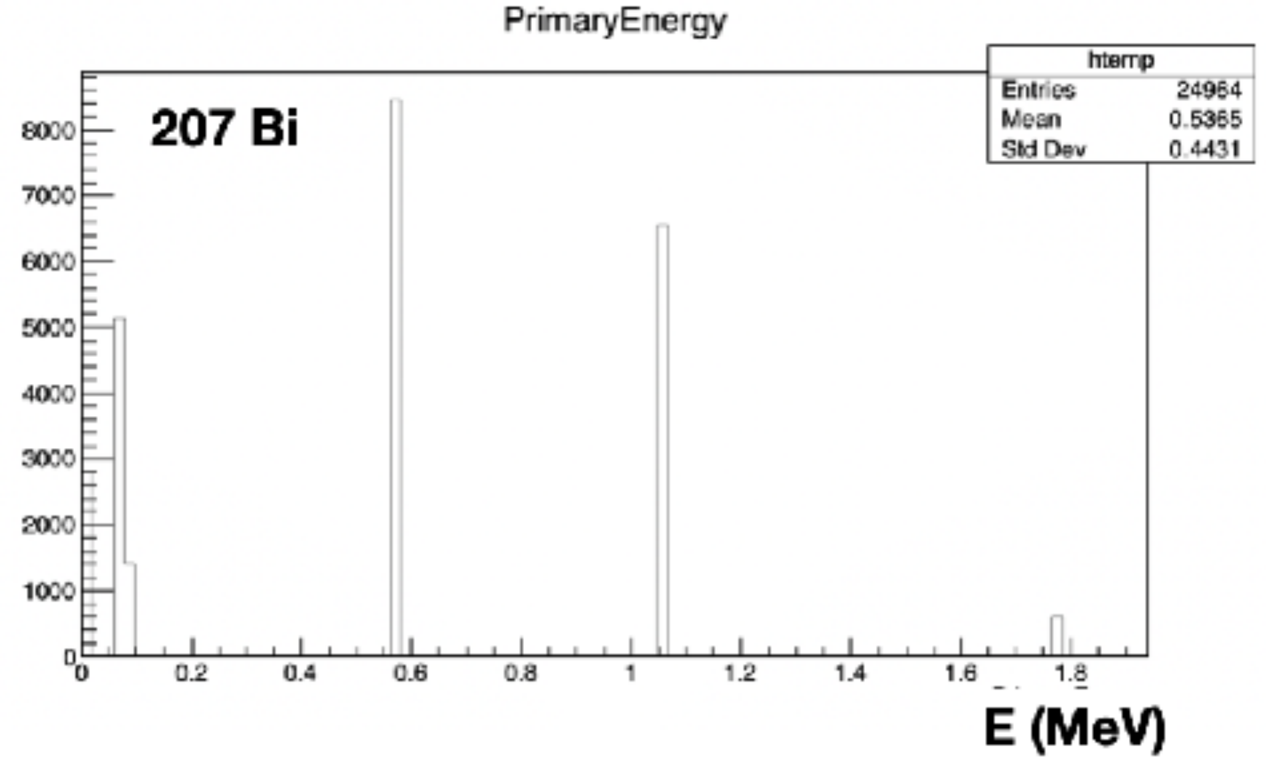


Configuration #3: 60 mm Cu
Configuration #4: 30 mm BGO Veto +30 mm Cu
Configuration #5: 30 mm Cu + 30 mm BGO Veto
Configuration # 6: 20 mm Cu +20 mm BGO Veto+ 20 mm Cu

Contamination of veto material:

- Started evaluating background induced by contaminations from ^{238}U, ^{234}Th and ^{207}Bi.
- Considered the characteristic gamma spectra.
- Not yet included associated alpha and beta emissions
  - → important for veto tagging capability.
- **Next step:**
  - reproduce the full decay chains.
  - Still in progress

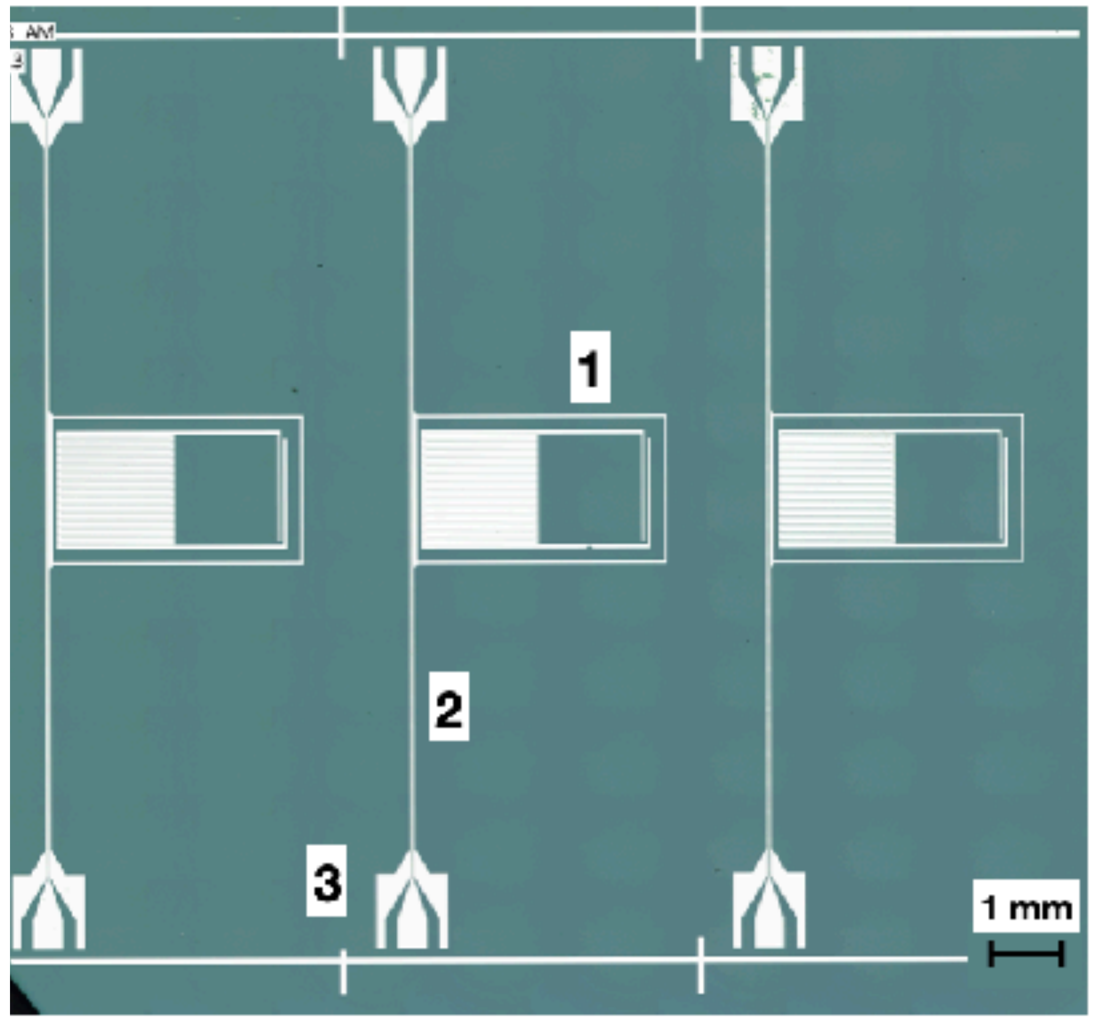


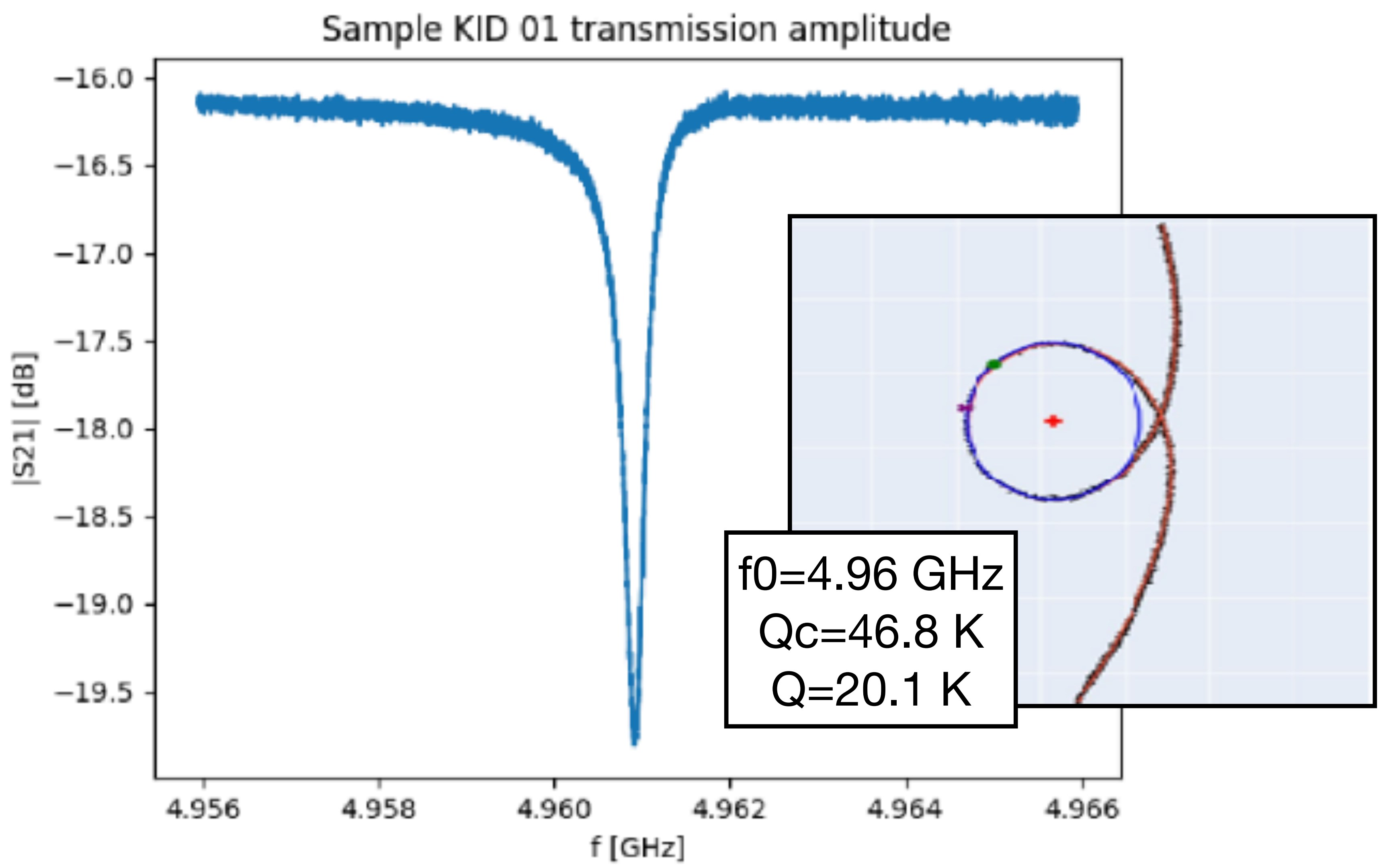


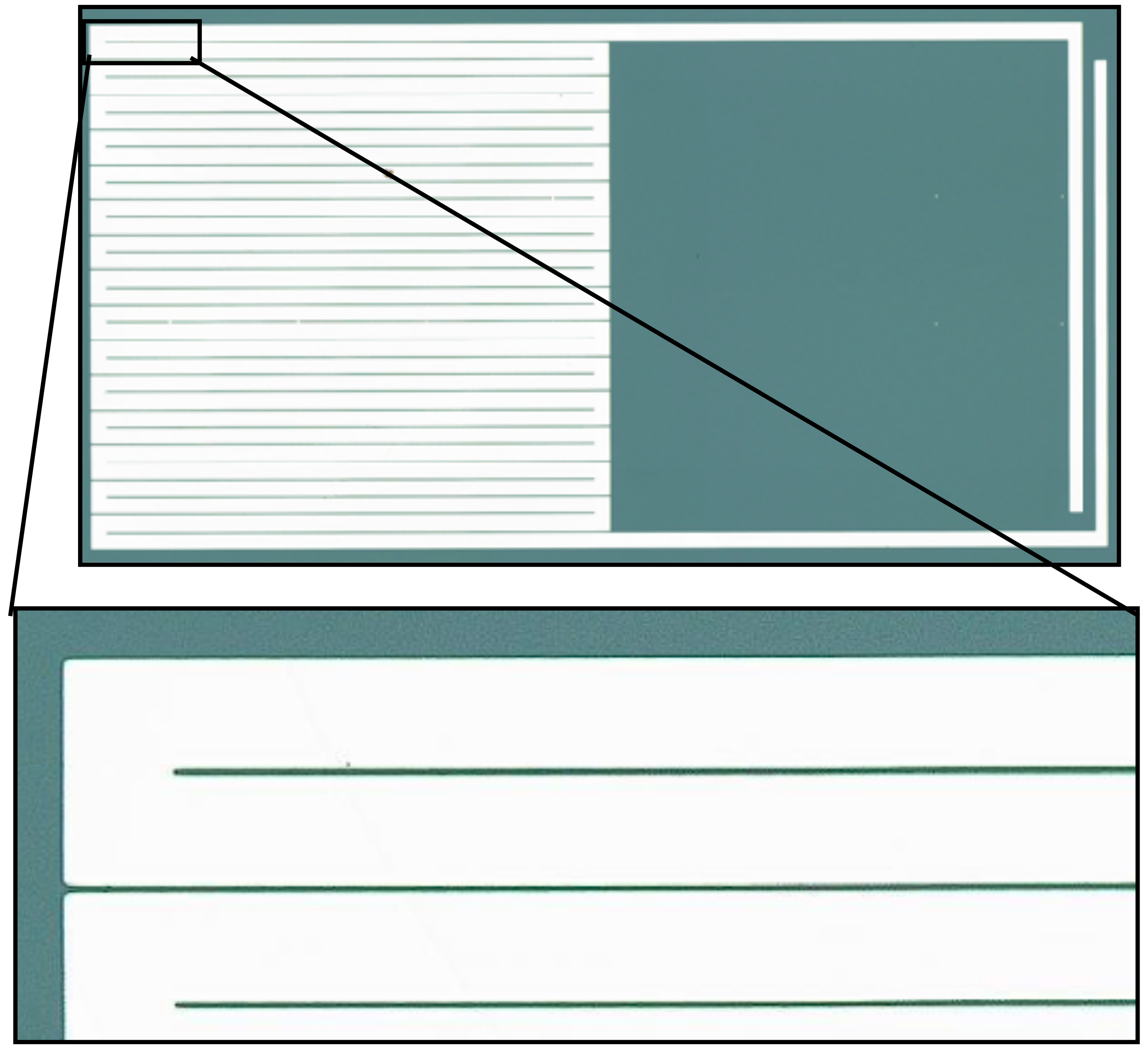
KID fabrication:

First Fabrication test of a CALDER-style KID:

- Details
  - 40 nm aluminum
  - Lift-off
  - Substrate: intrinsic Si, 350 nm SiO_2 (not removed in this sample)
- Results
  - Resonance observed, but frequency higher than expected (5 GHz vs 2.5 GHz).
  - Sonnet simulations suggest this is the second-order mode of the resonator.
- Next Steps:
  - Review fabrication process.
  - Continue design studies with Sonnet
  - New fabrication test with oxide removal



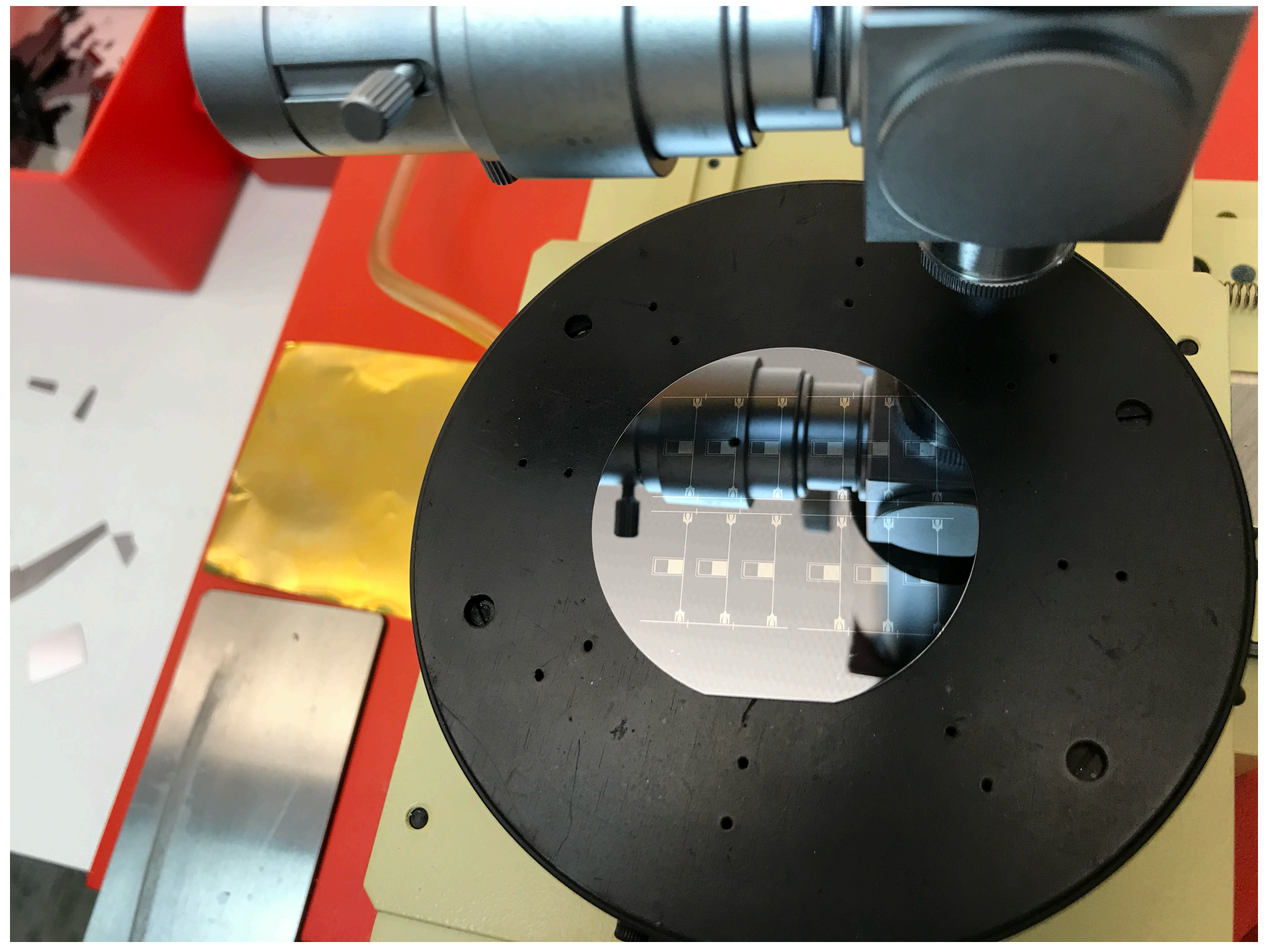




Next Steps:

- Fabrication of a BULLKID-style KID
- Fabrication of the full light sensor
  - Fabrication on a double side polished wafer
  - Wafer cut

Test of wafer cut with cleaving machine



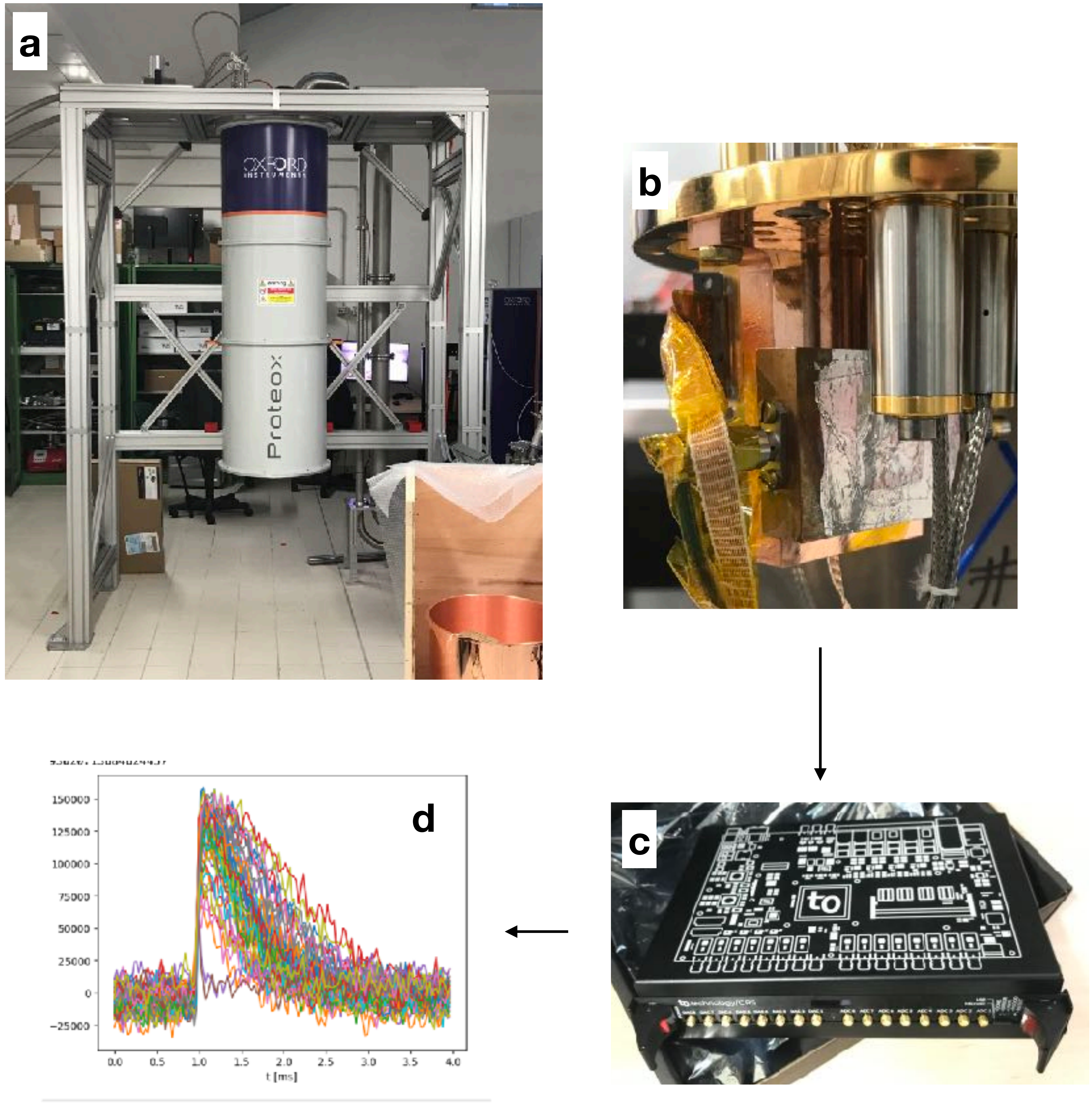
Demonstration of veto module:

Goal:

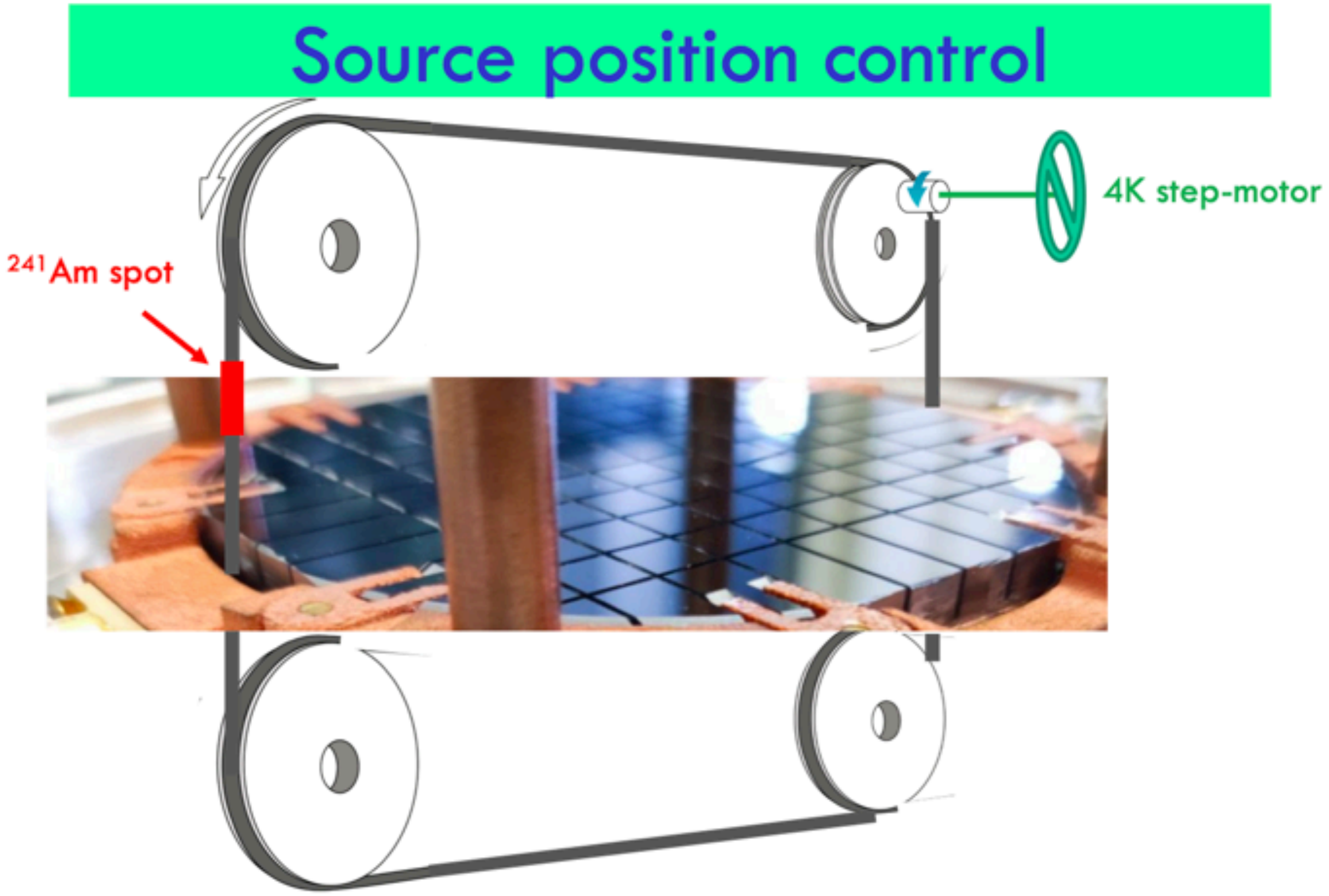
- Demonstrate the operation of a detector composed of KID-based light detector coupled to scintillating crystal:
  - (2.5x2.5x1) cm^3 GAGG
  - (2.5x2.5x1) cm^3 BGO
  - Simultaneous operation of two modules

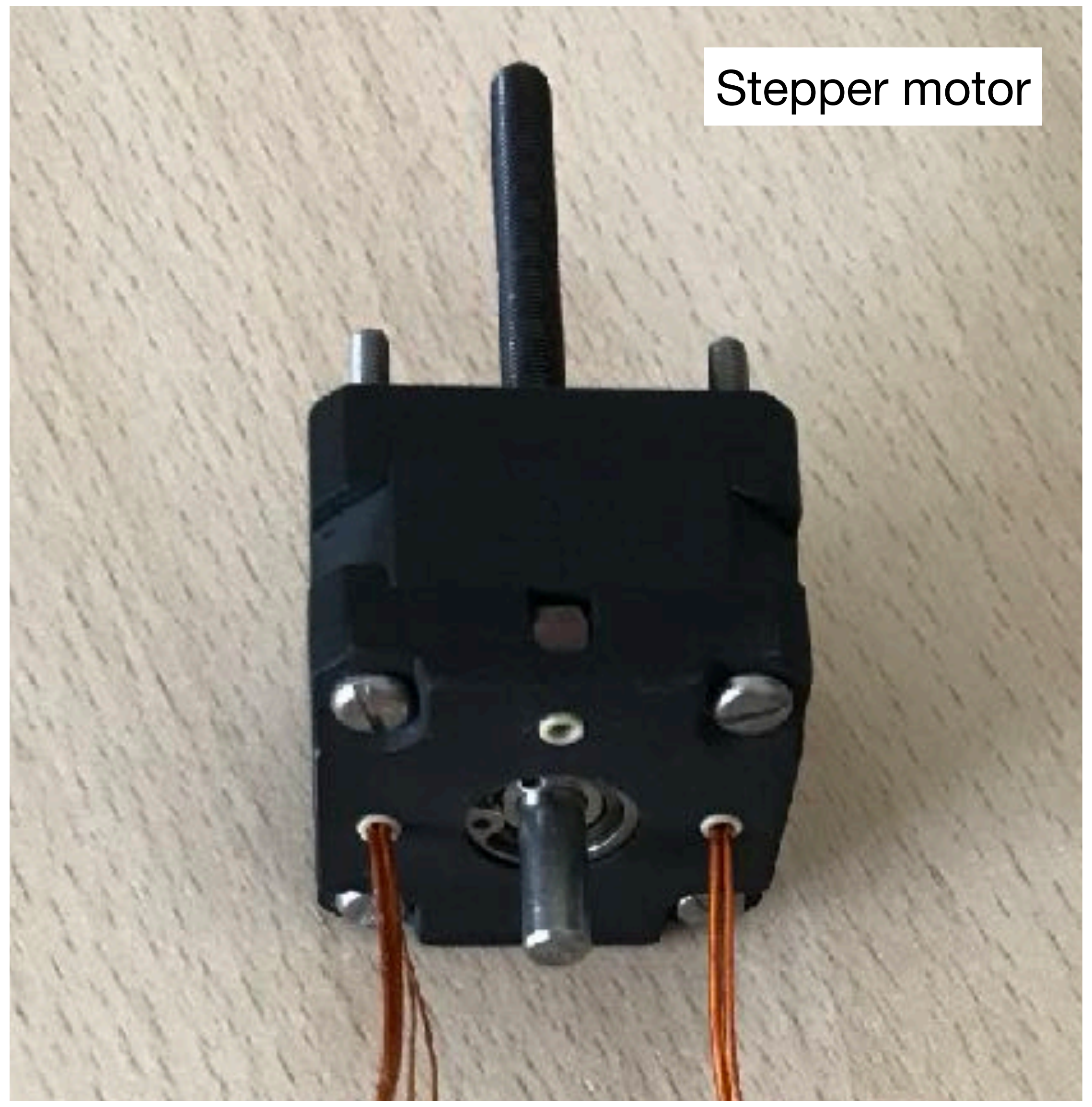
Setup Updates:

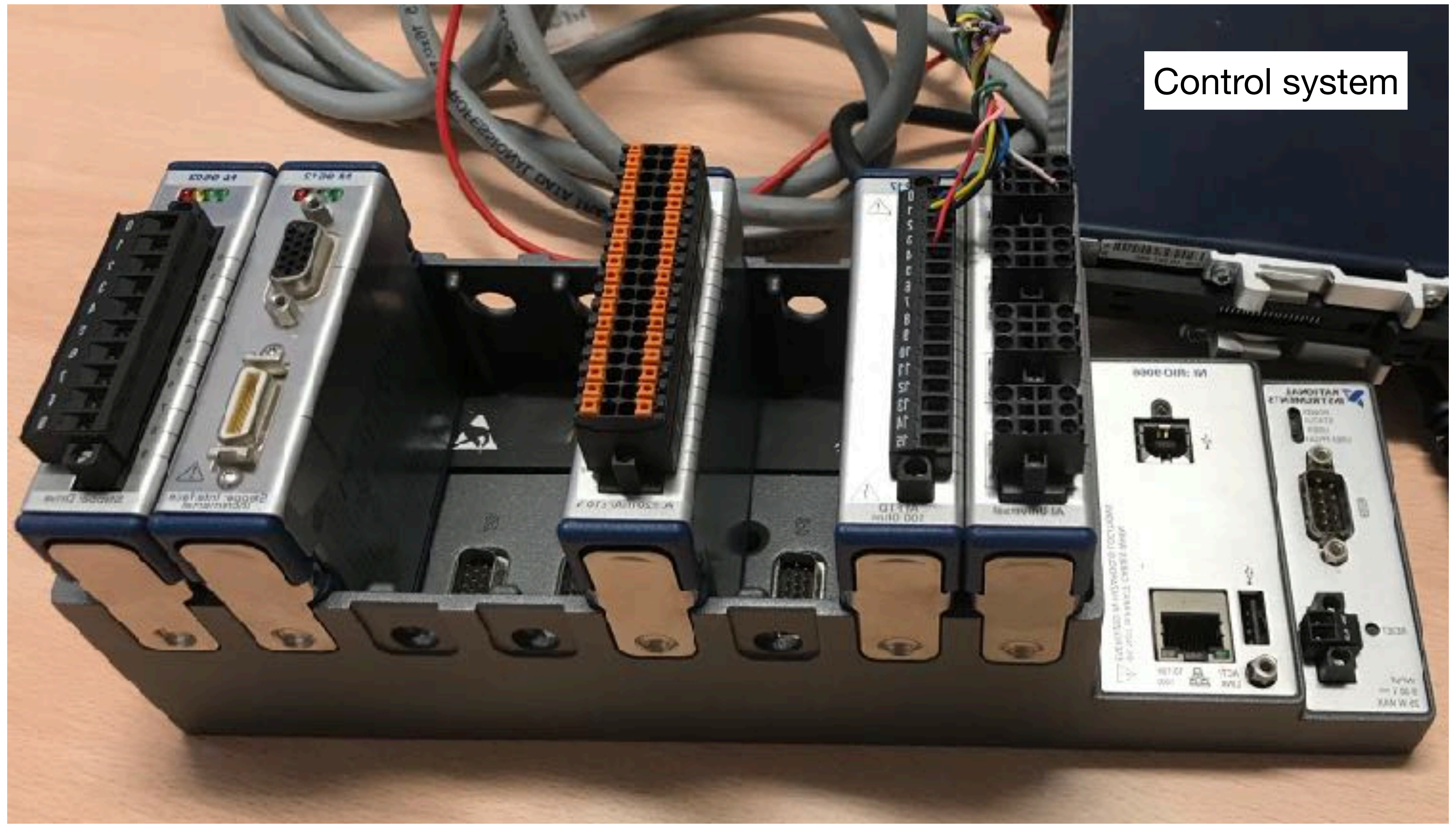
- New Cryostat
- Readout Board:
  - Zynq™ RFSoC ZCU216 purchased but delivered February/26
  - Backup KID readout board borrowed from LiteBIRD collaborators:
    - Tested with AlTiAl (2x2) cm^2 CALDER KID
    - No optimal detector operation (~1.6 dB resonance)
    - Capable of acquiring pulses from cosmic ray interactions
- LED + fibre calibration system purchased (all components available, installation pending)
- Design of new KID and crystal holders to improve thermalization ongoing.



Calibration system







Updates:

- Cryogenic stepper motor:
  - Stepper motor borrowed from Virgo
  - Control system available in the lab

Next steps:

- Understand communication protocol
- Develop control software
- Room temperature and then cryogenic tests

Thank you for your attention

Tommaso Lari