Status of the Ricochet experiment

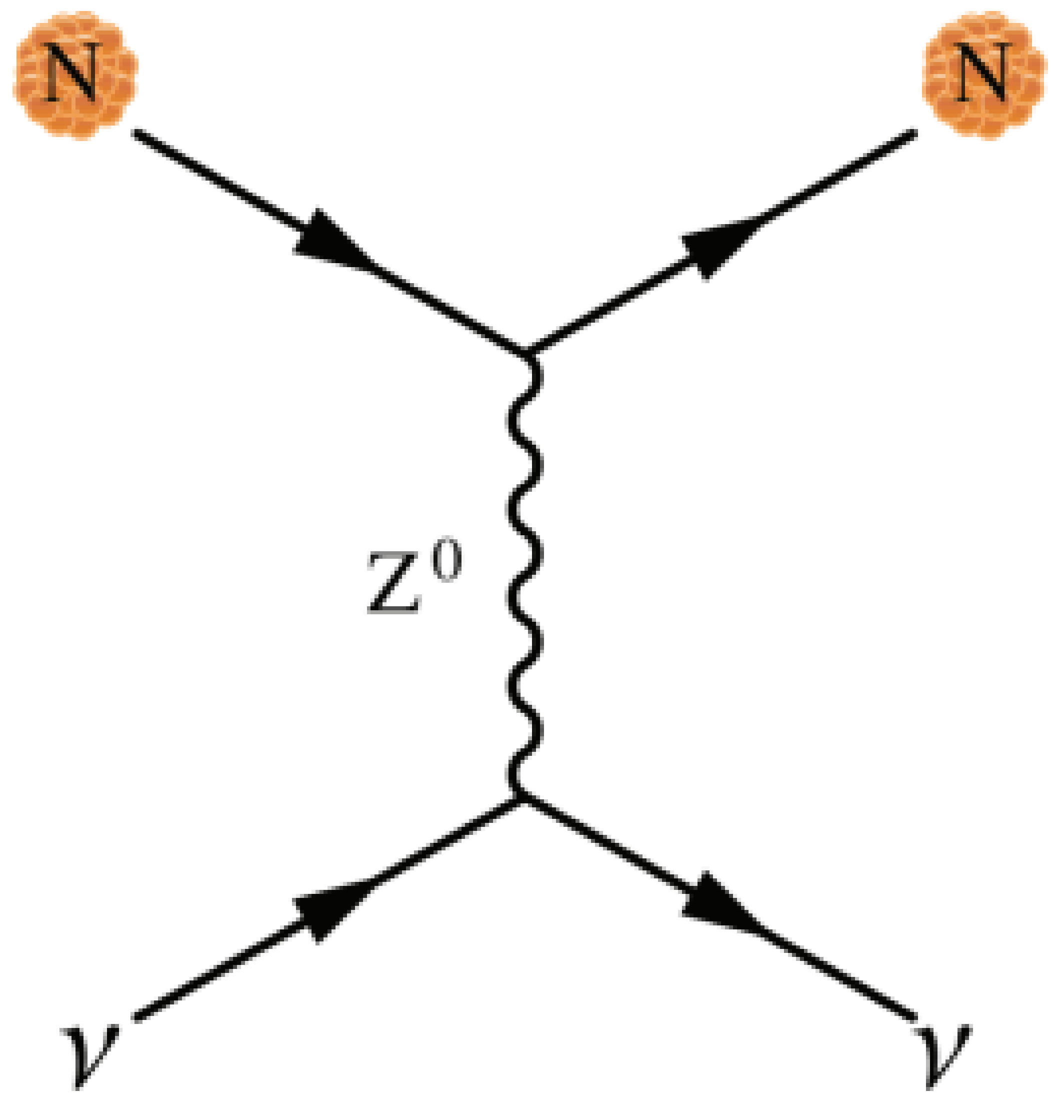
Valentina Novati
on behalf of the Ricochet Collaboration

TAUP XICHANG

GRENOBLE | MODANE

CEνNS

Coherent elastic neutrino-nucleus scattering (CEνNS)



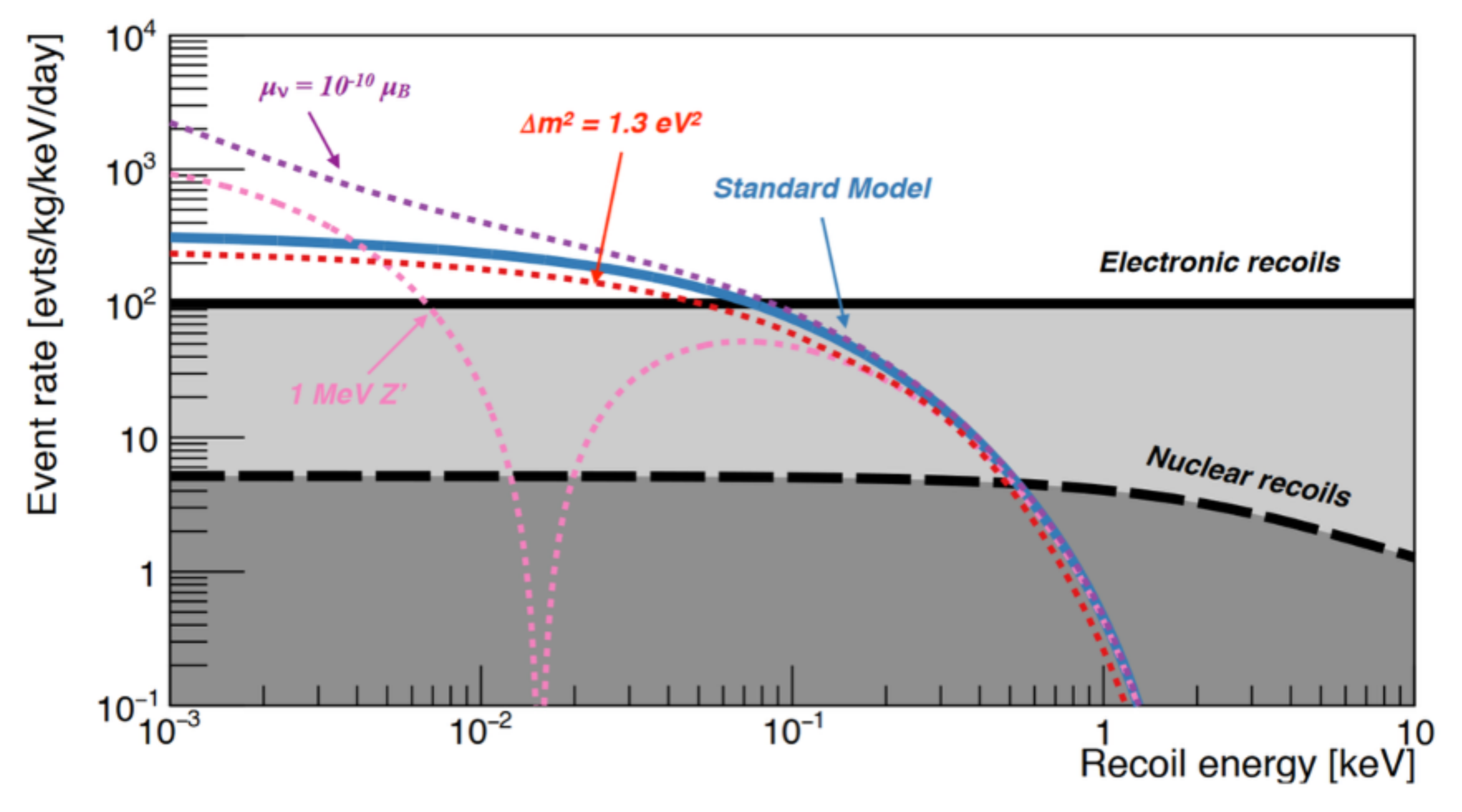
- proposed by Freedman in 1974
- detected by the COHERENT Collaboration 43 years after at the Spallation Neutron Source (SNS)

D. Z. Freedman, Phys. Rev. D 9, 1389 (1974)
D. Akimov et al. (COHERENT Collaboration), Science 357, 1123, (2017) - ArXiv:1708.01294

Physics beyond the Standard Model

Test for physics beyond the Standard Model:

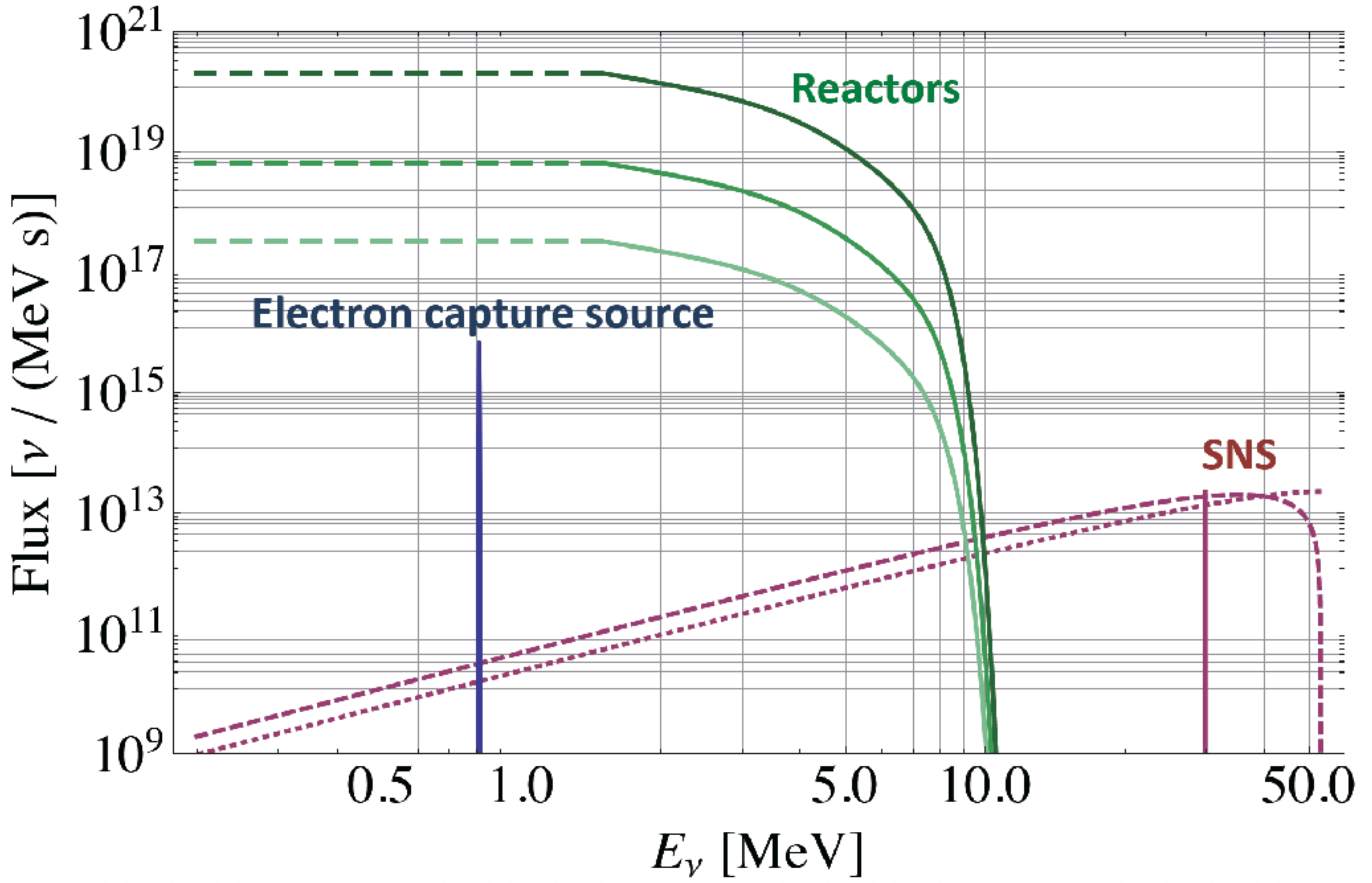
- non-standard interactions of neutrinos and quarks
- neutrino magnetic moment
- neutrino couplings to new mediators
- sterile neutrinos



Need large exposure to be sensitive to physics beyond the Standard Model

x 10^4 times higher
flux than the SNS

Reactor antineutrinos

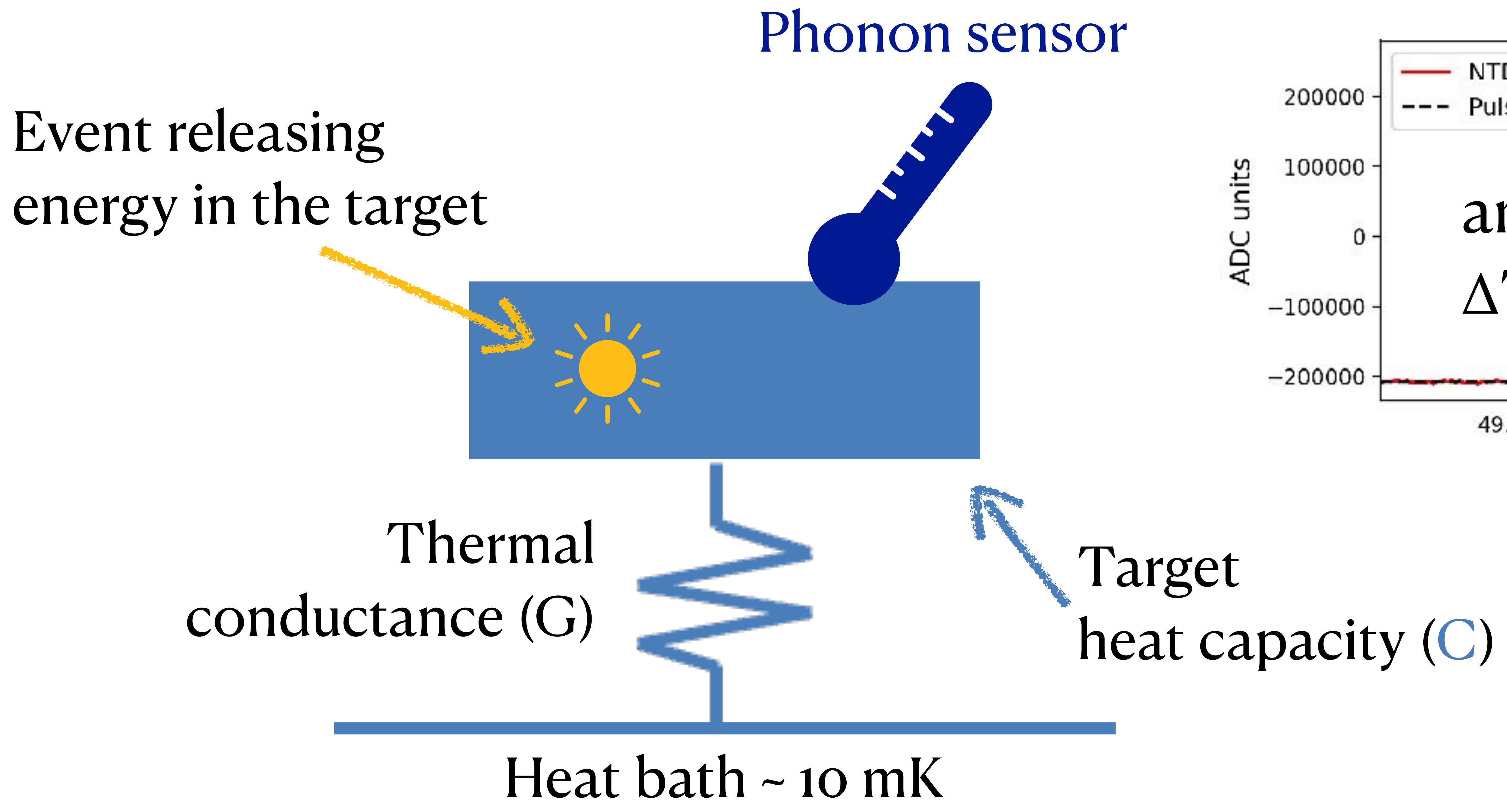


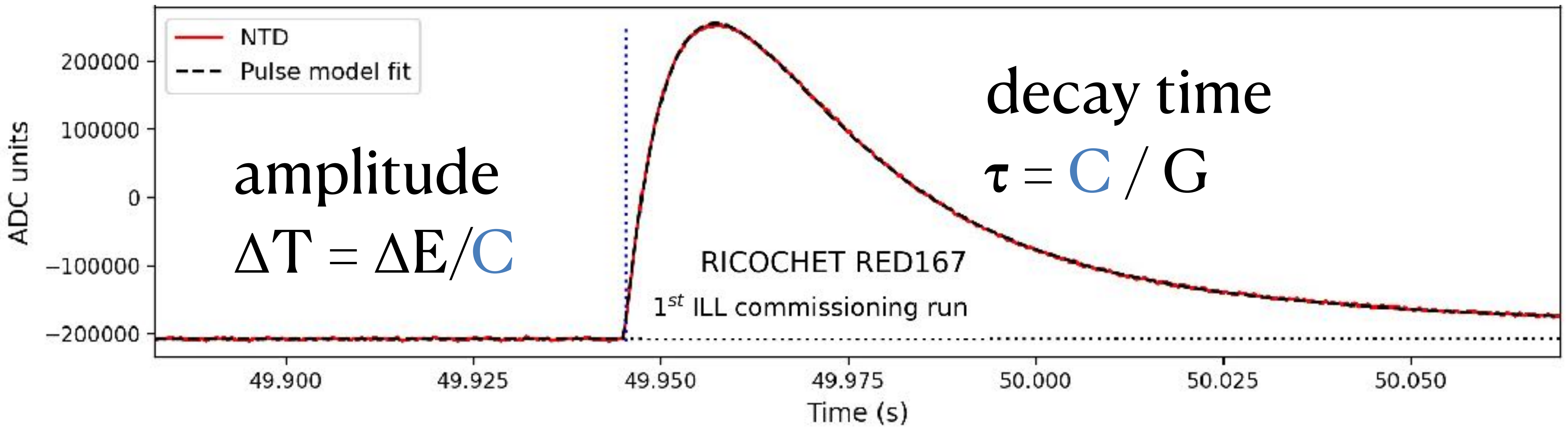
- Reactors are a source of antineutrinos with a larger flux than the SNS
- But a lower energy threshold is required

Despite the high antineutrino flux, the interaction is rare

Cryogenic calorimeters

Cryogenic calorimeters are phonon-mediated detectors



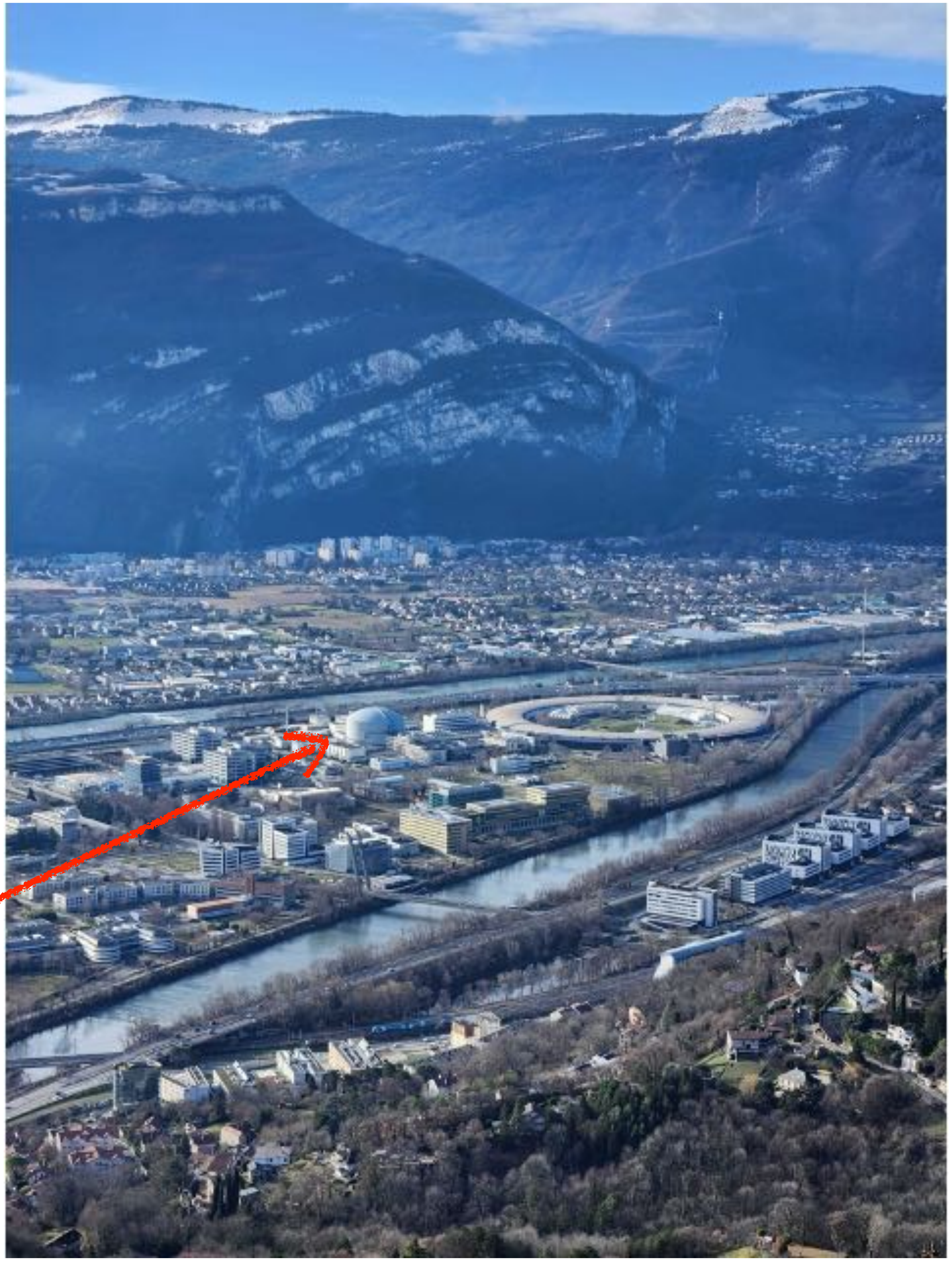


Cryogenic calorimeters have exquisite resolutions and low thresholds

Ricochet at the ILL

Ricochet is located at the **research nuclear reactor** (58 MW power) in the Institut Laue-Langevin (ILL) in Grenoble (France)

The ILL

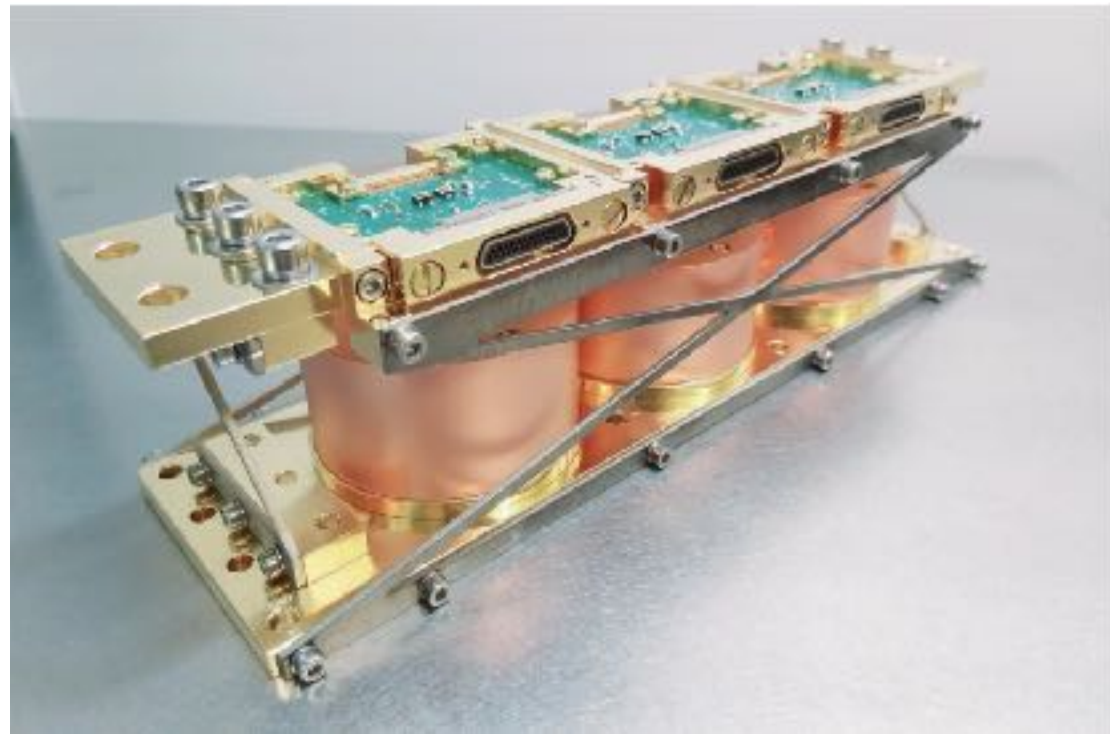


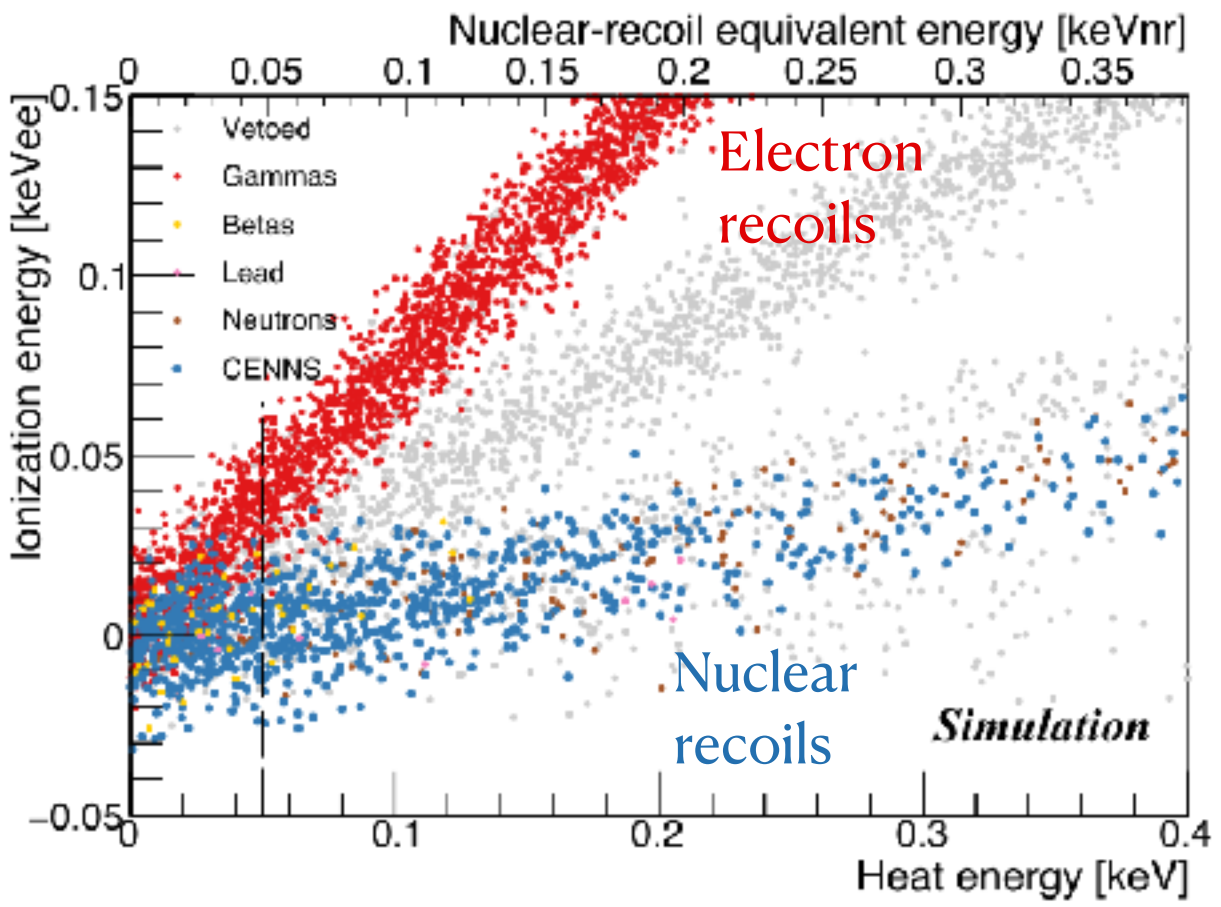
C. Augier *et al.* (Ricochet Collaboration), NIM A, 1057, 168765, (2023) ArXiv:2304.14926
C. Augier *et al.* (Ricochet Collaboration), EPJC, 84, 186, (2024) ArXiv:2306.00166

Two detector technologies

CryoCube

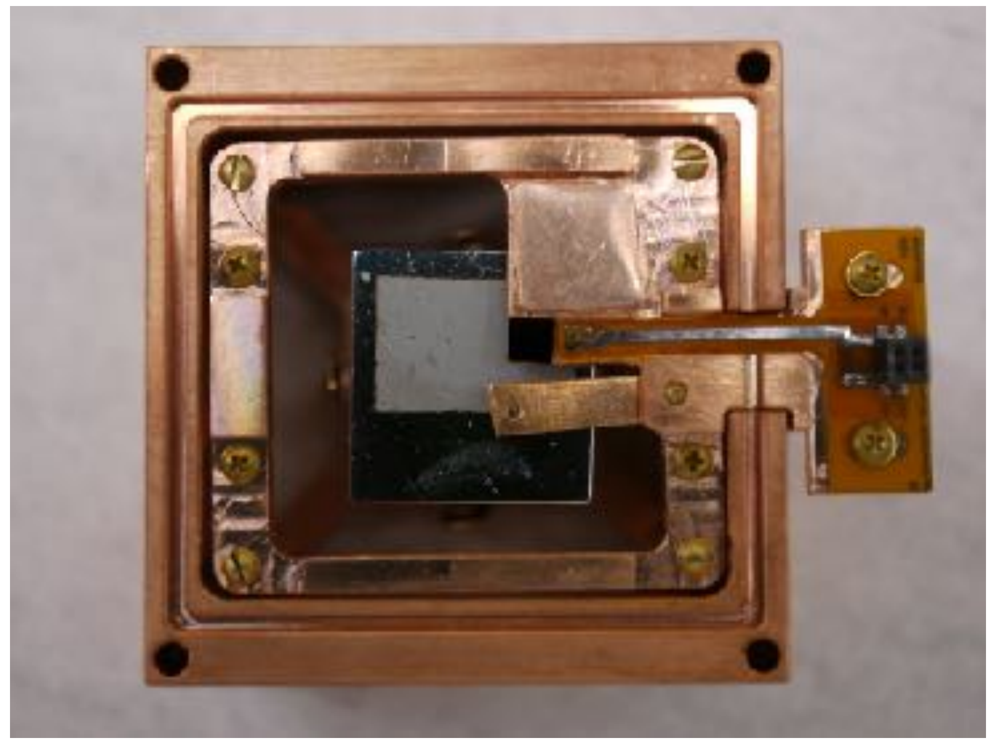
- Neutron-transmutation-doped germanium thermistors for the phonon readout
- Phonon and ionization readout for particle identification
- Germanium targets

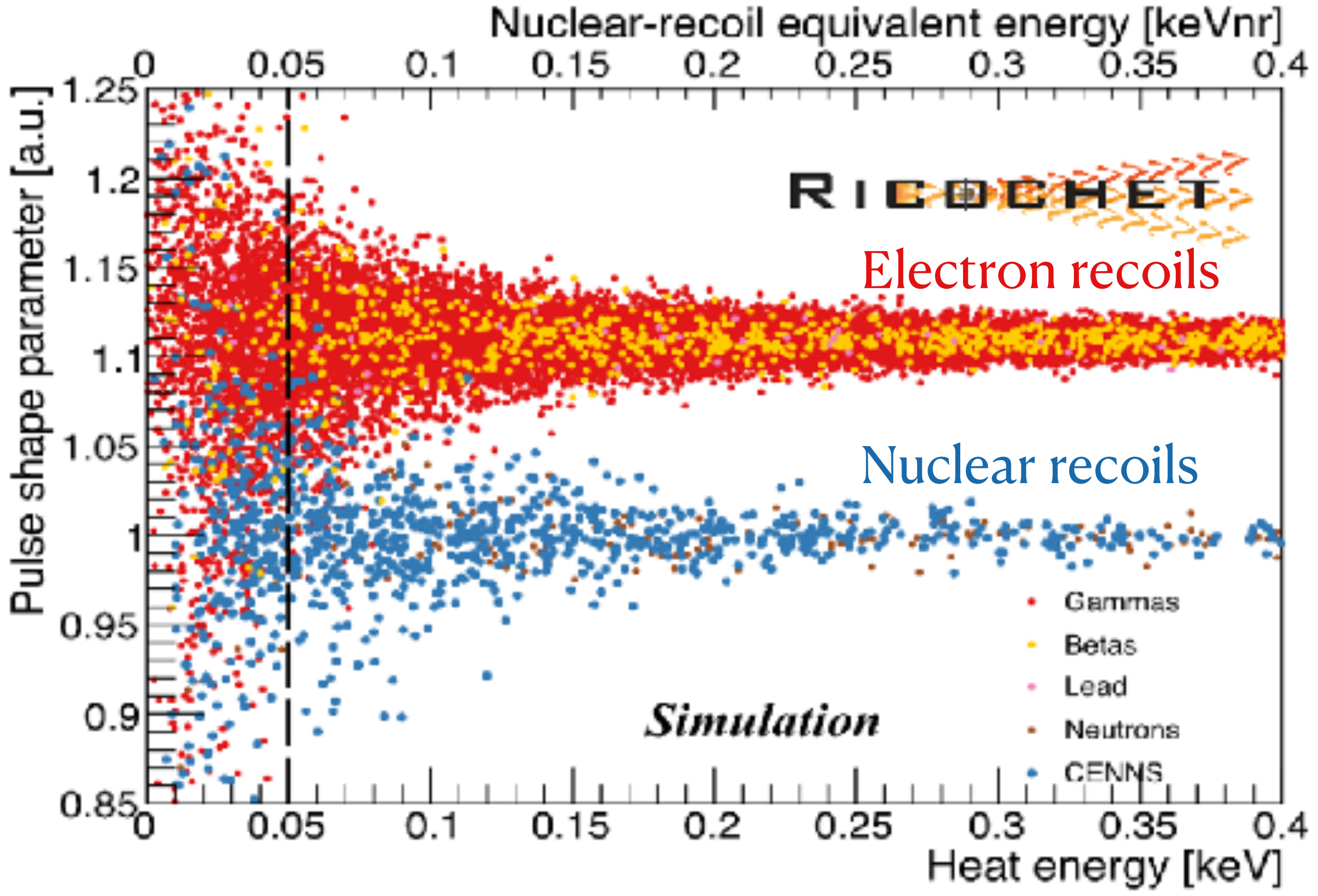




Q-Array

- Transition-Edge Sensor for the phonon readout
- Pulse shape discrimination for particle identification
- Superconducting targets (Zn, Al, Sn)





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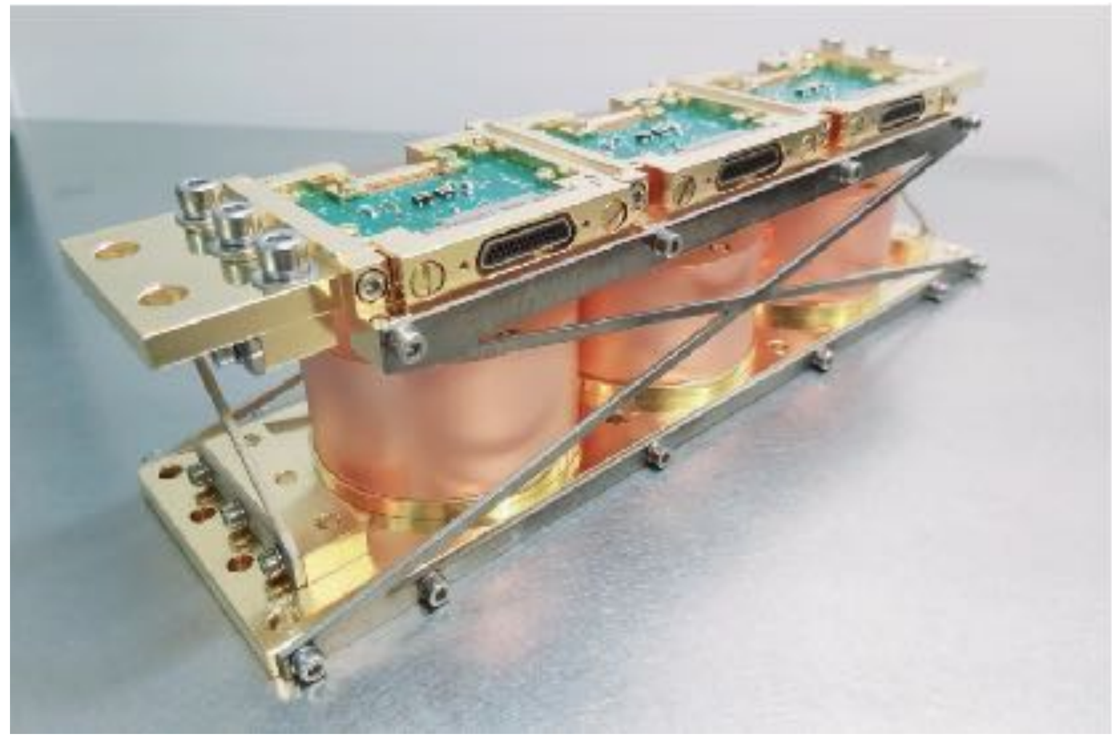

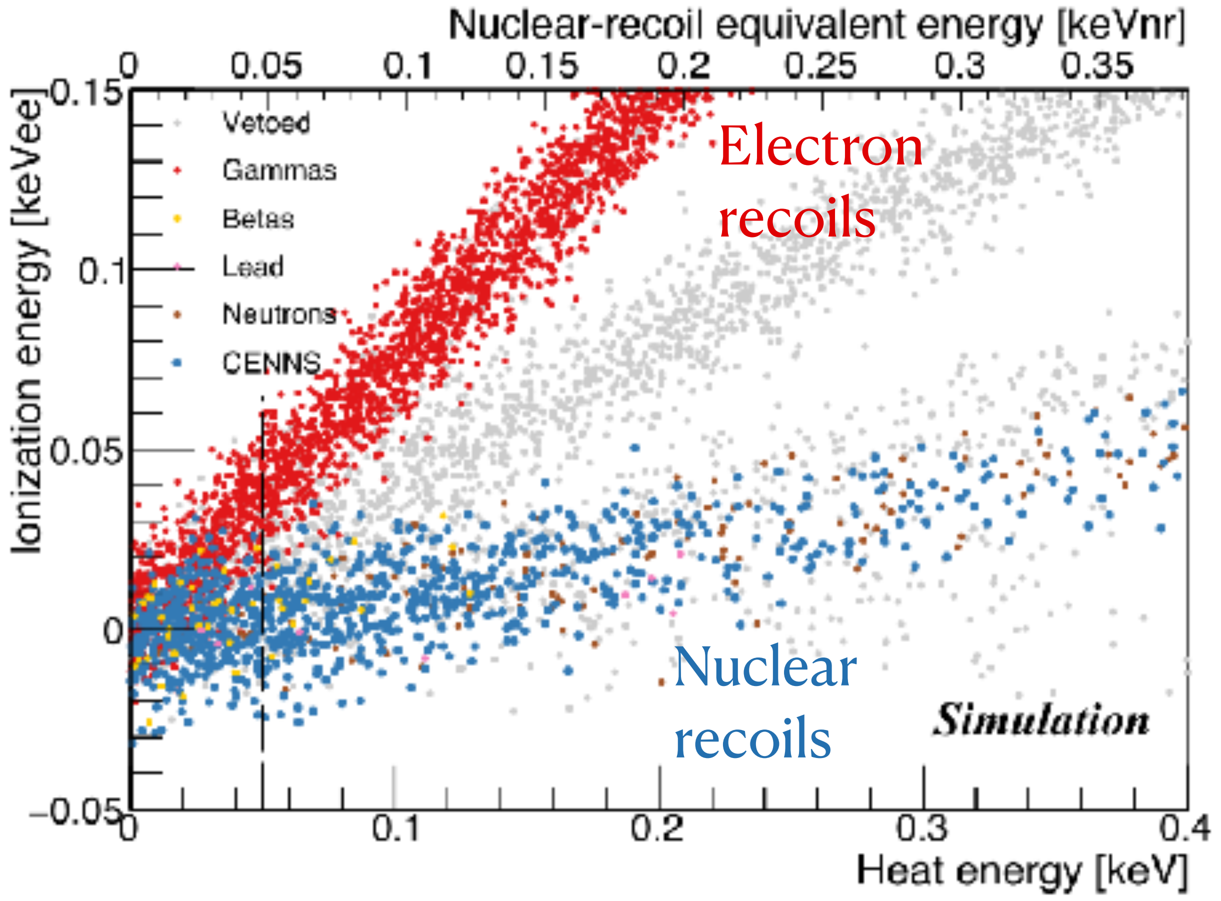

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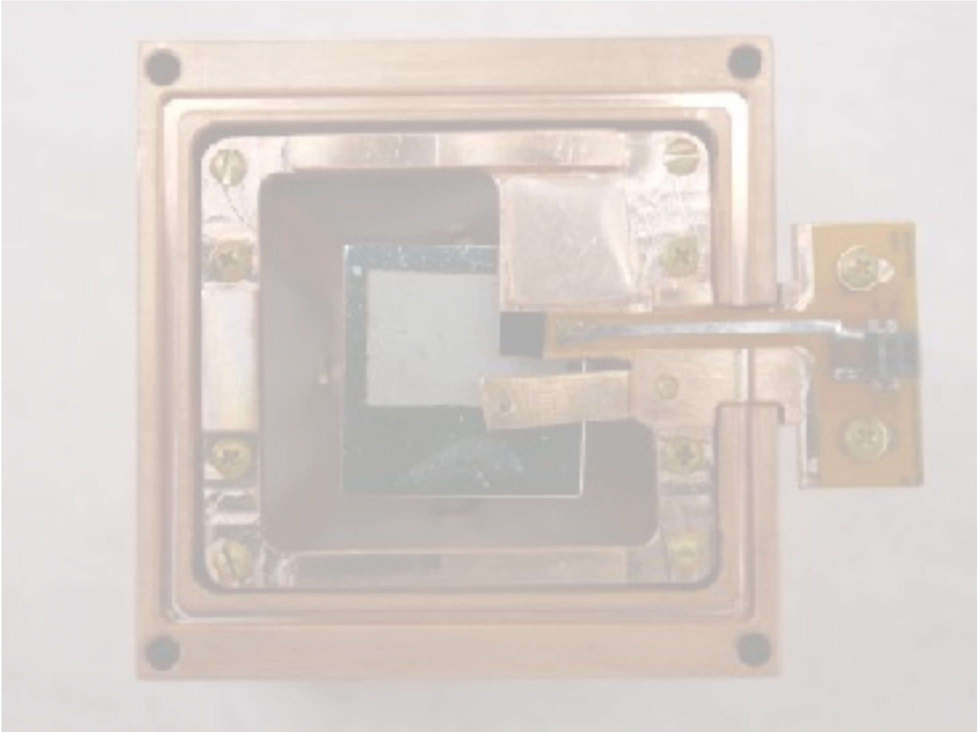
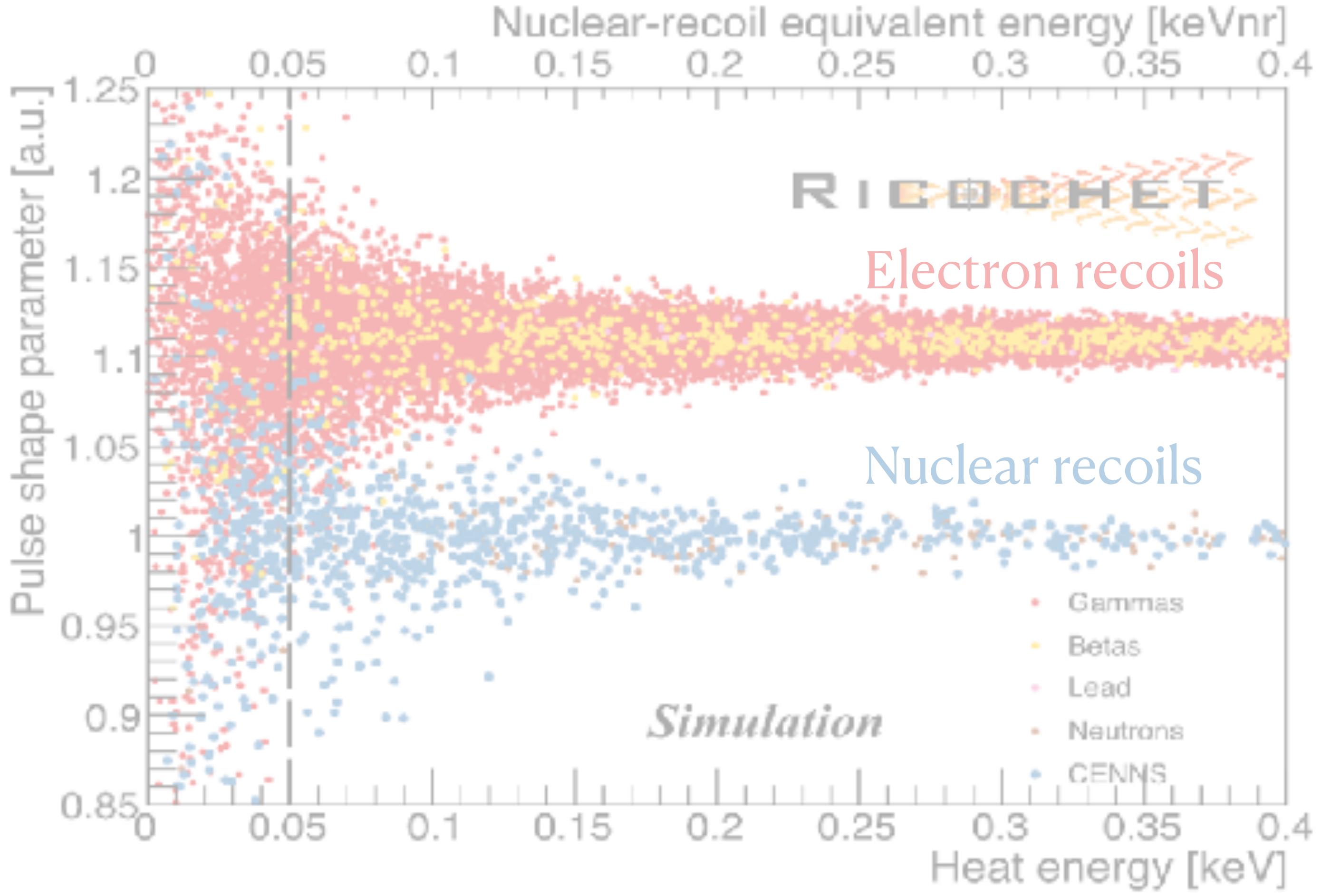
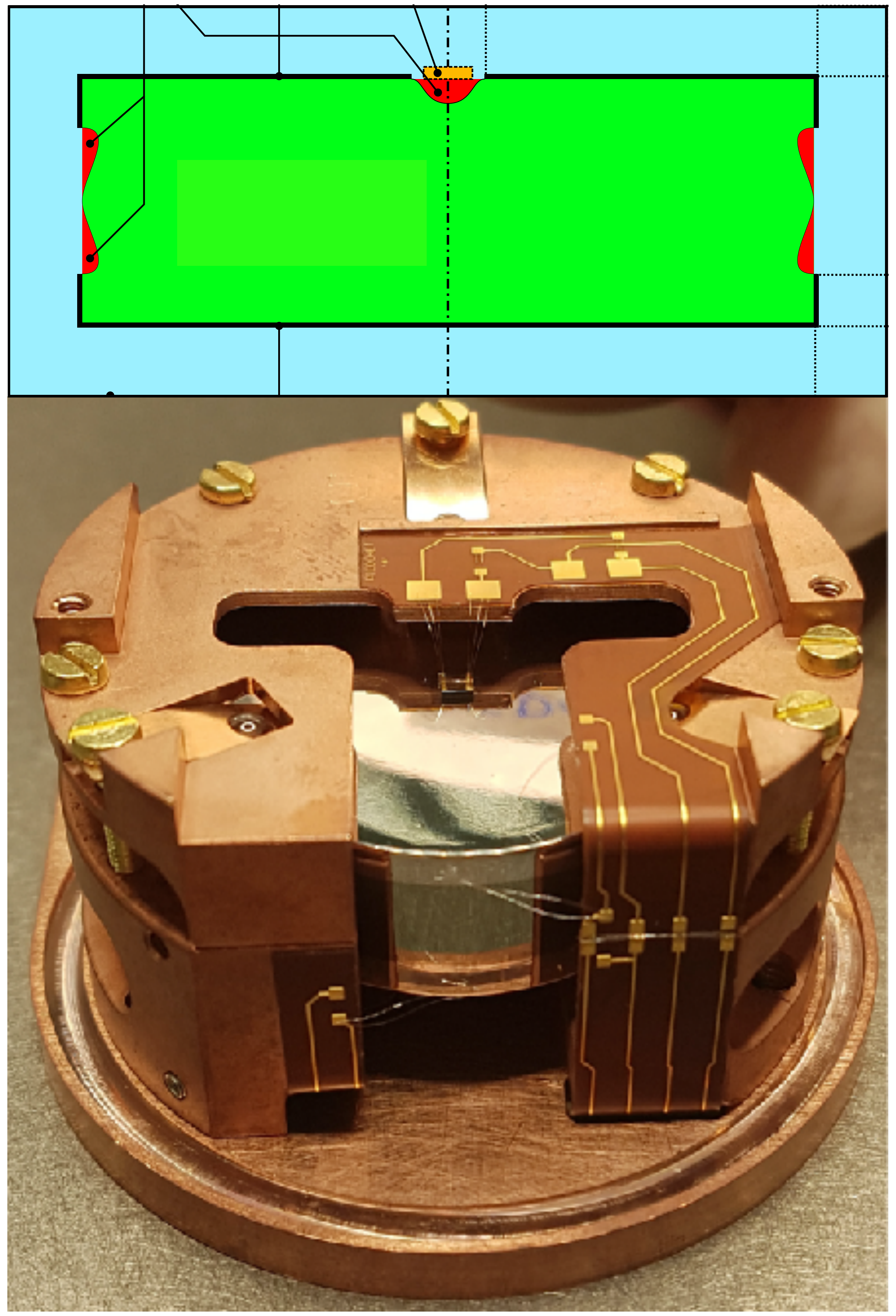


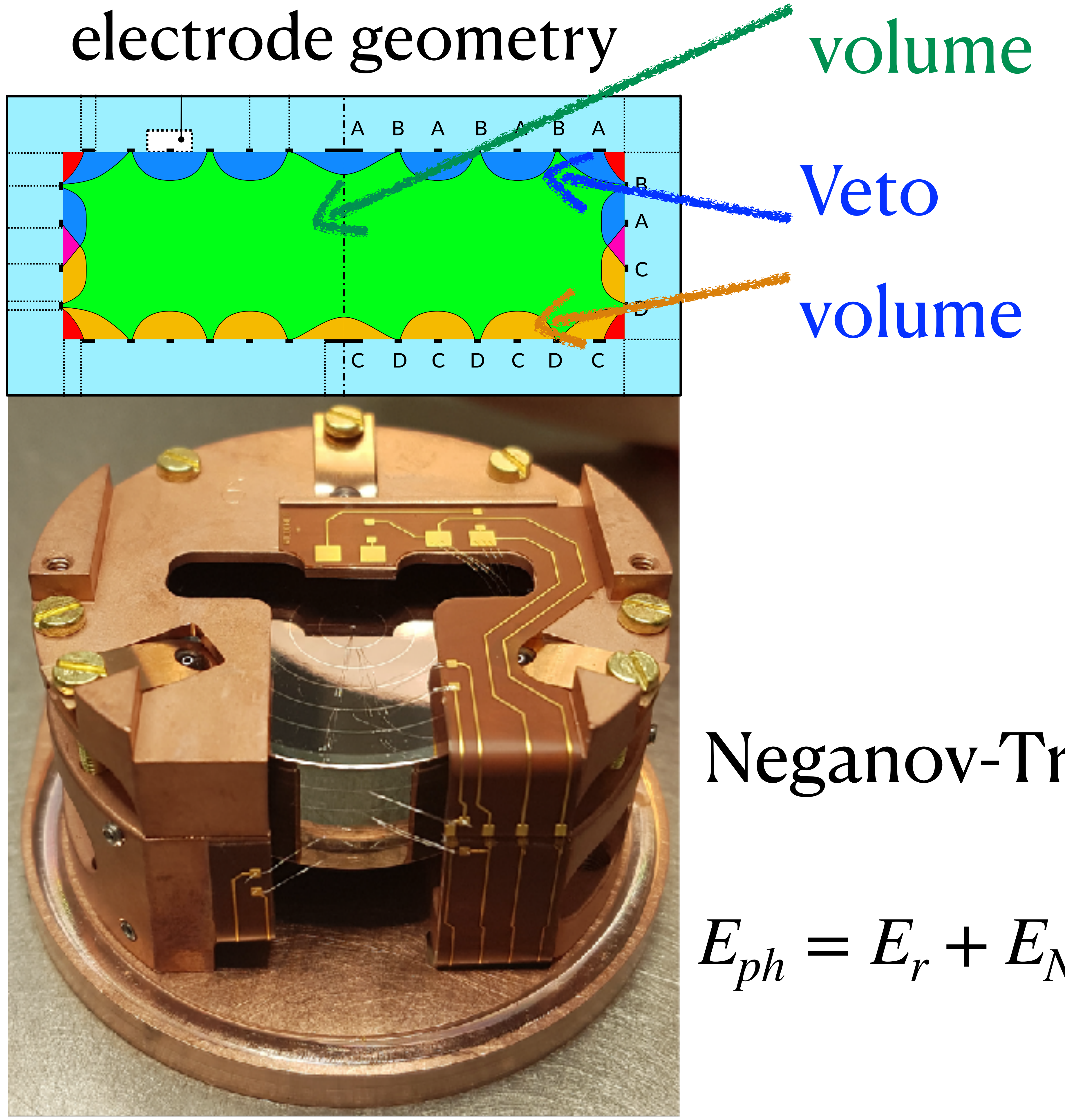


CryoCube: two electrode geometries

Planar
electrode geometry



Fully Inter-Digitized (FID)
electrode geometry



Planar geometry:

- No surface event discrimination
- All the volume is sensitive

FID geometry:

- Surface event discrimination
- Reduced sensitive volume

Neganov-Trofimov-Luke (NTL) effect:

$$E_{ph} = E_r + E_{NTL} = E_r \left(1 + Q\frac{q \cdot V}{\epsilon}\right)$$

I will express phonon energy as the recoil energy plus the NTL gain

Background mitigation

Cosmogenic, reactogenic and radiogenic background rejection:

15 m water equivalent overburden from the water transfer channel

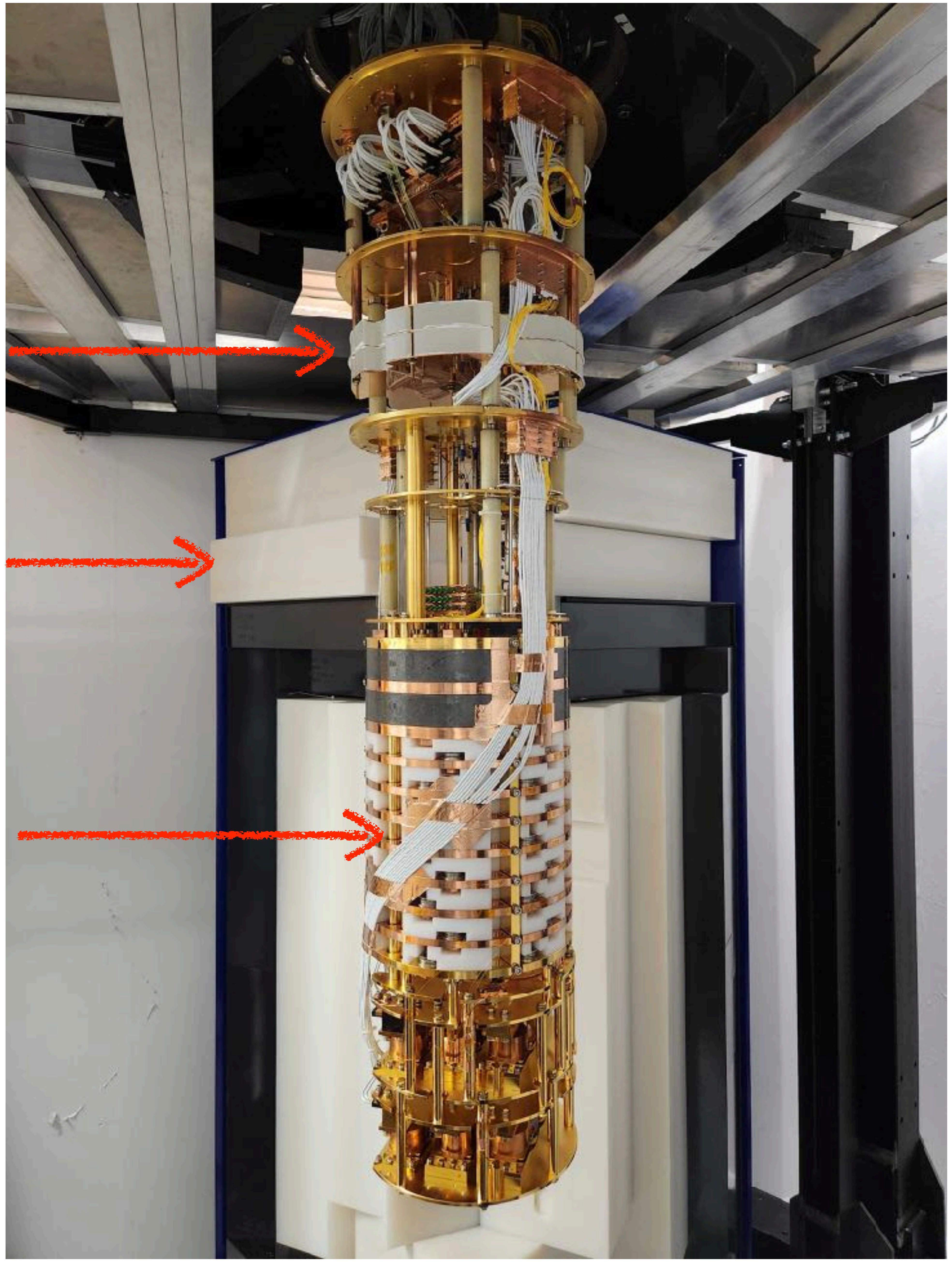
Outer muon veto

HDPE sheets at 1K, 4K and 50K

Cryogenic muon veto

Outer shielding (Pb, HDPE, soft iron)

Inner shielding (Pb, Cu and HDPE)

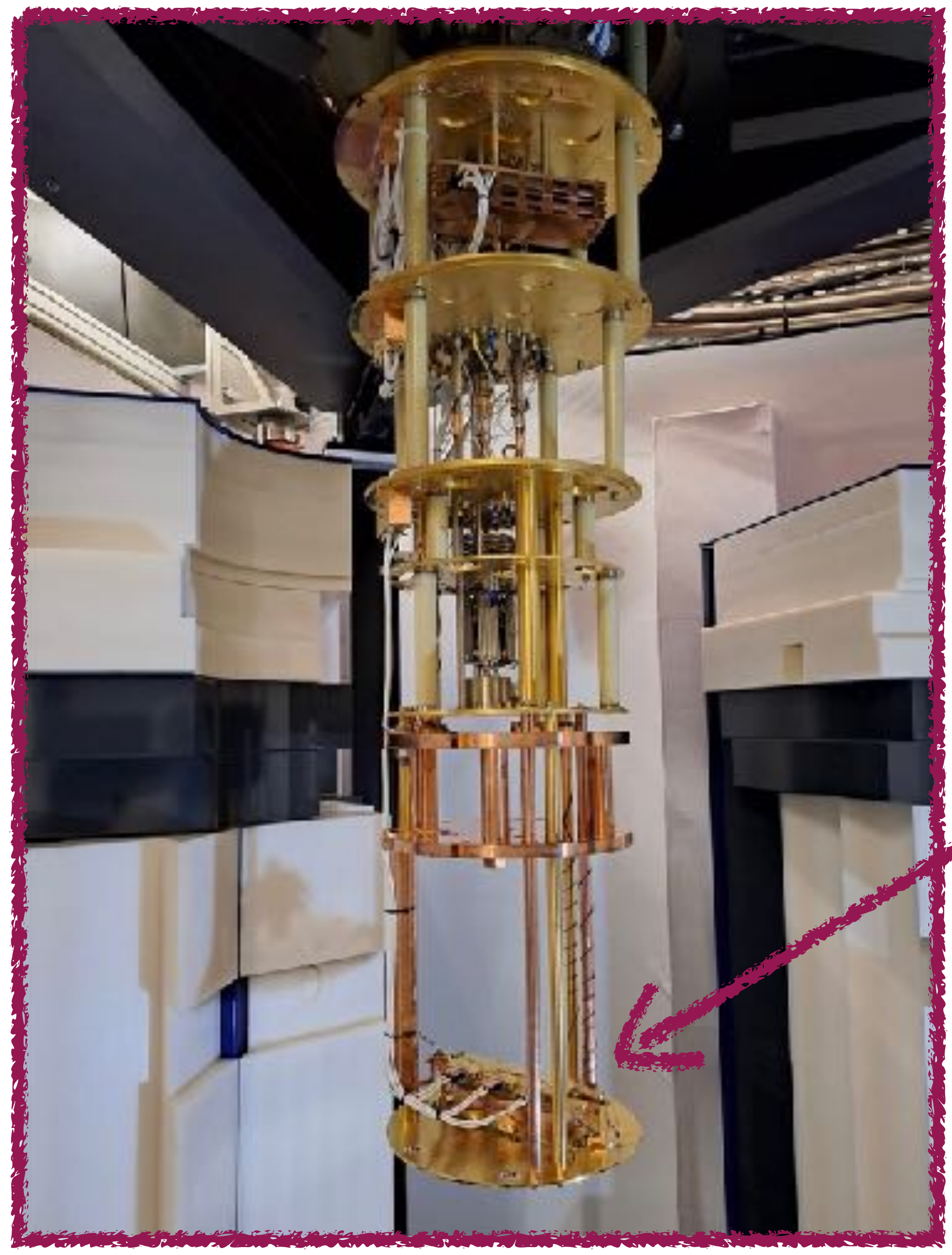


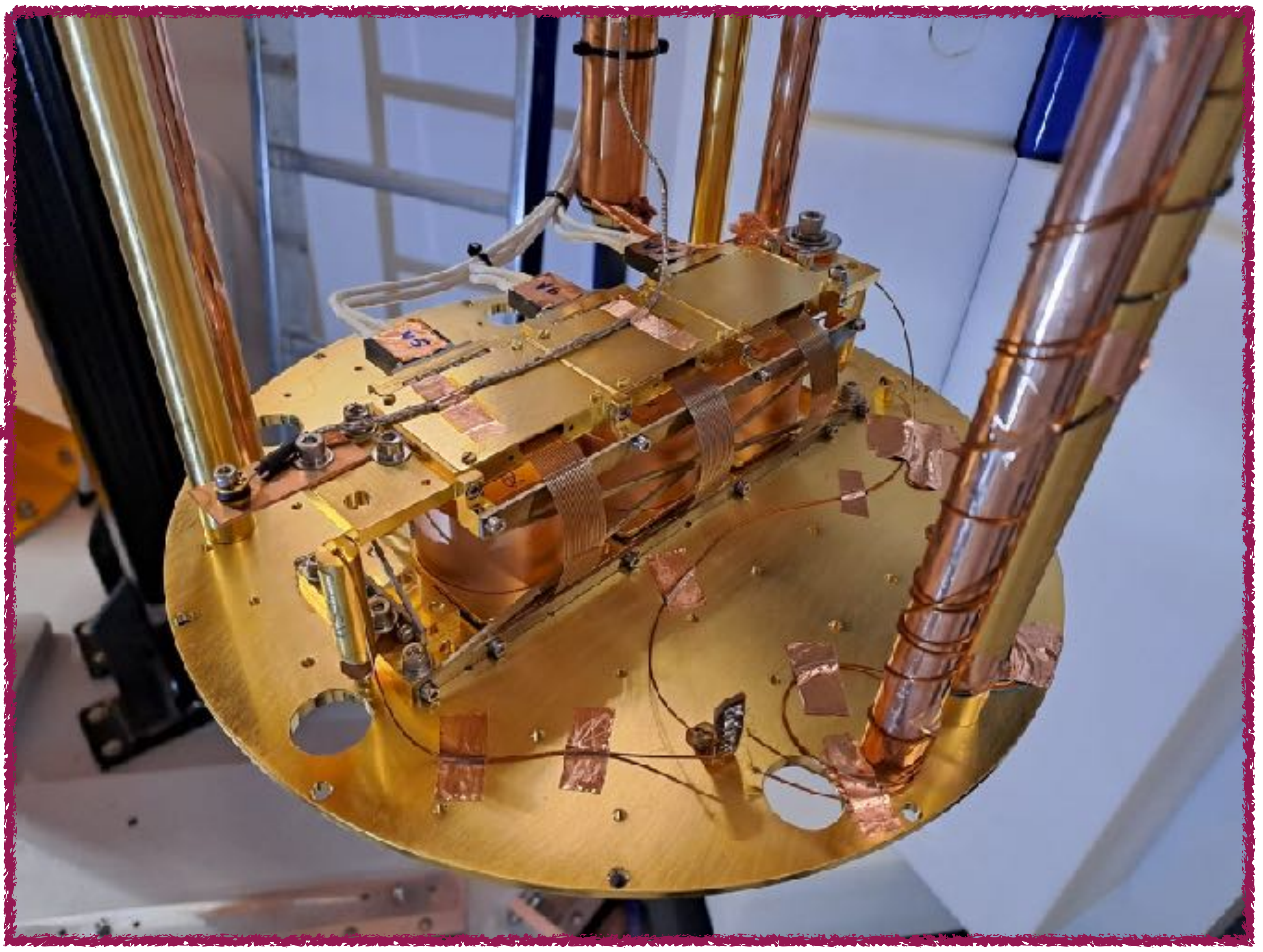
Commissioning at the ILL

Cryogenic commissioning

Detector commissioning

RUN013





3 planar detectors

Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

Commissioning at the ILL

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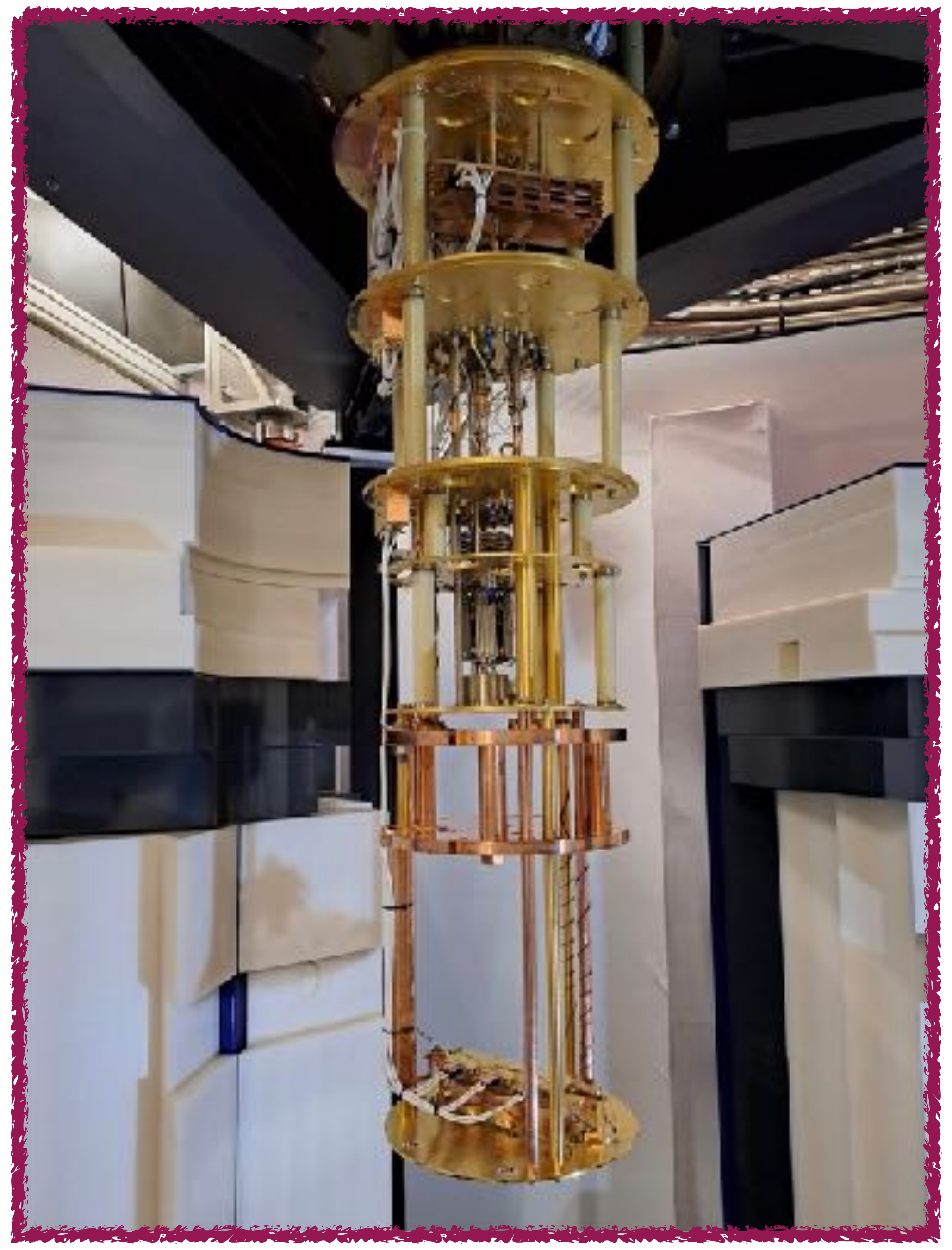
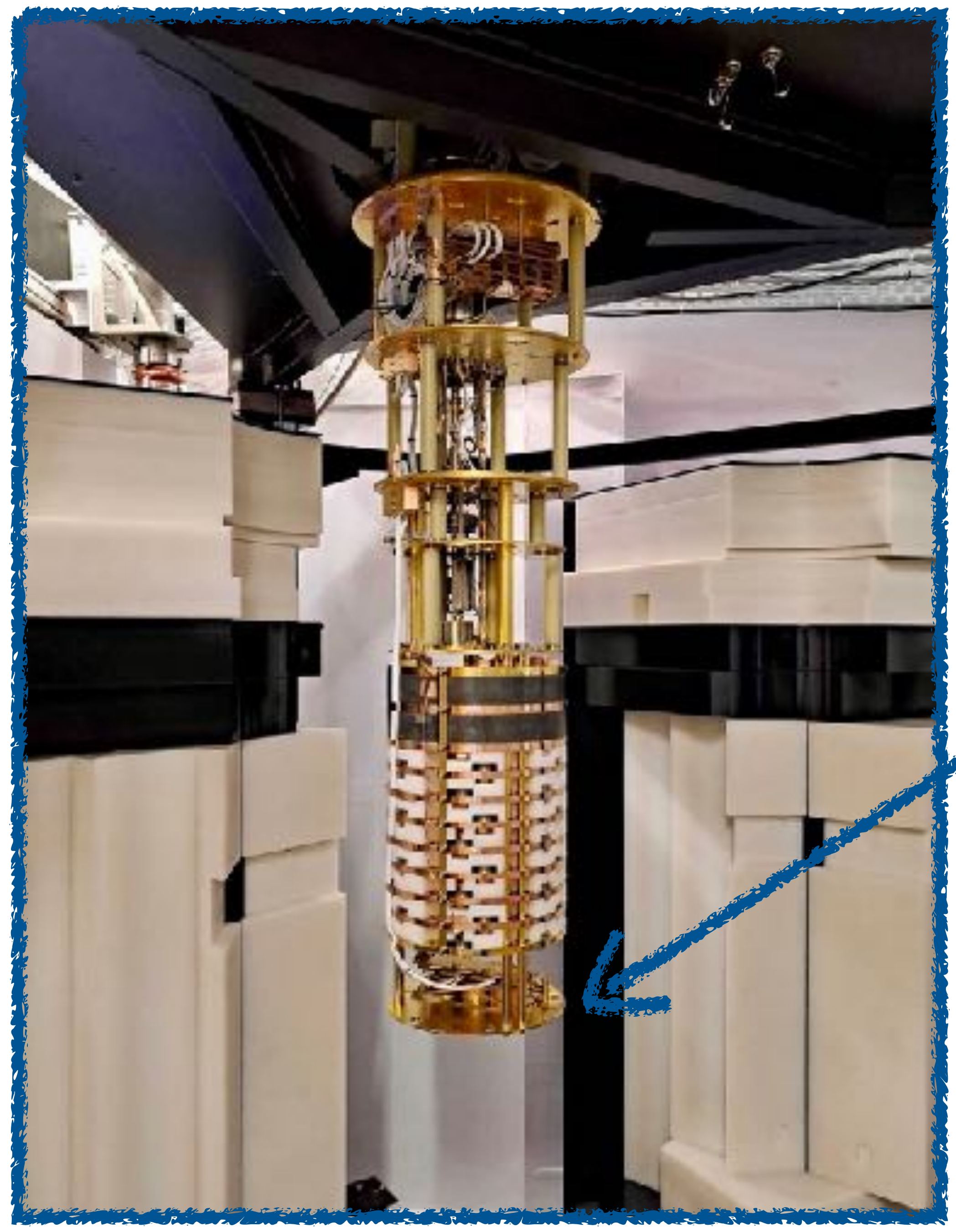
RUN013

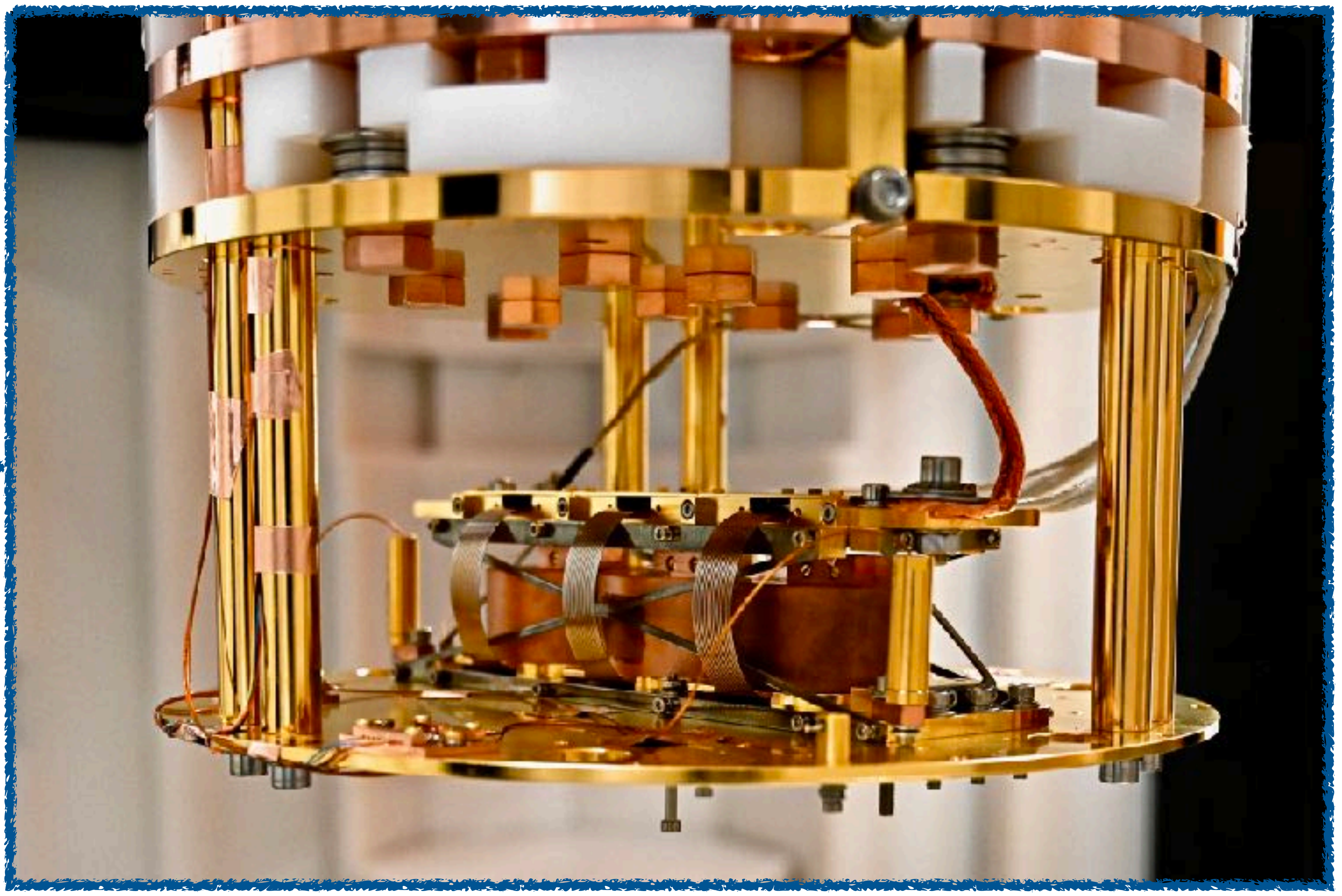


Background commissioning

RUN014



3 planar detectors



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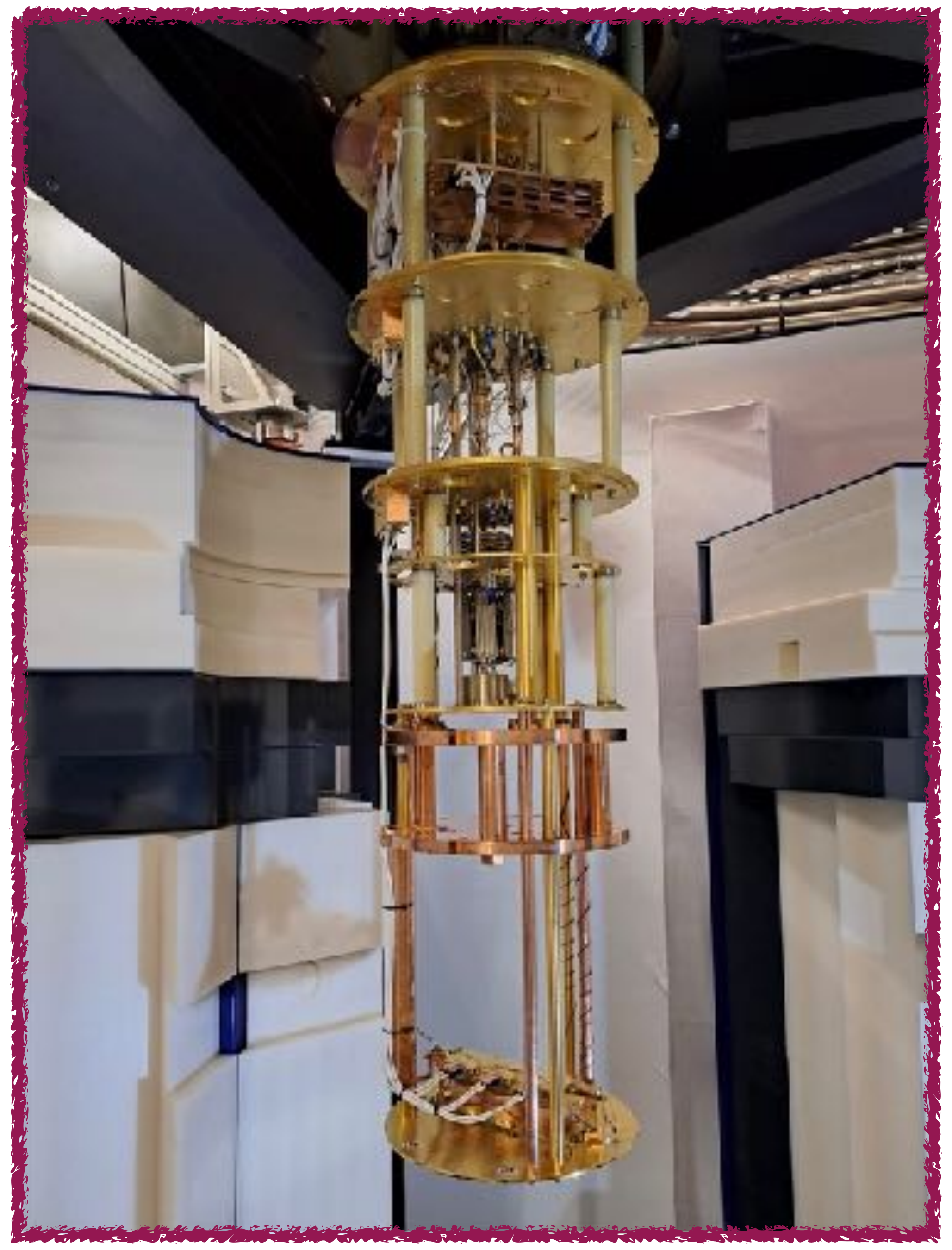
Commissioning at the ILL

Cryogenic commissioning

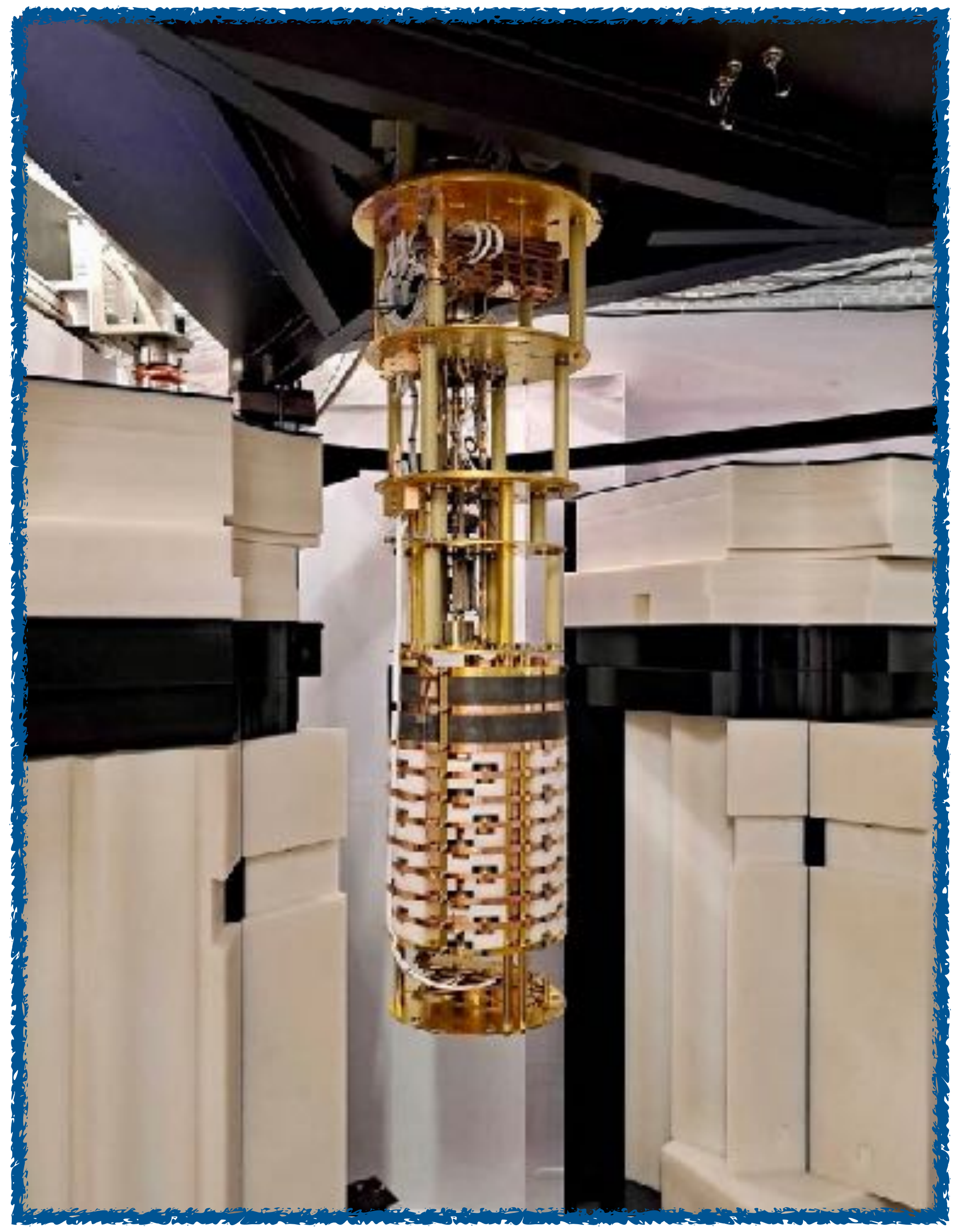
Detector commissioning

RUN013



Background commissioning

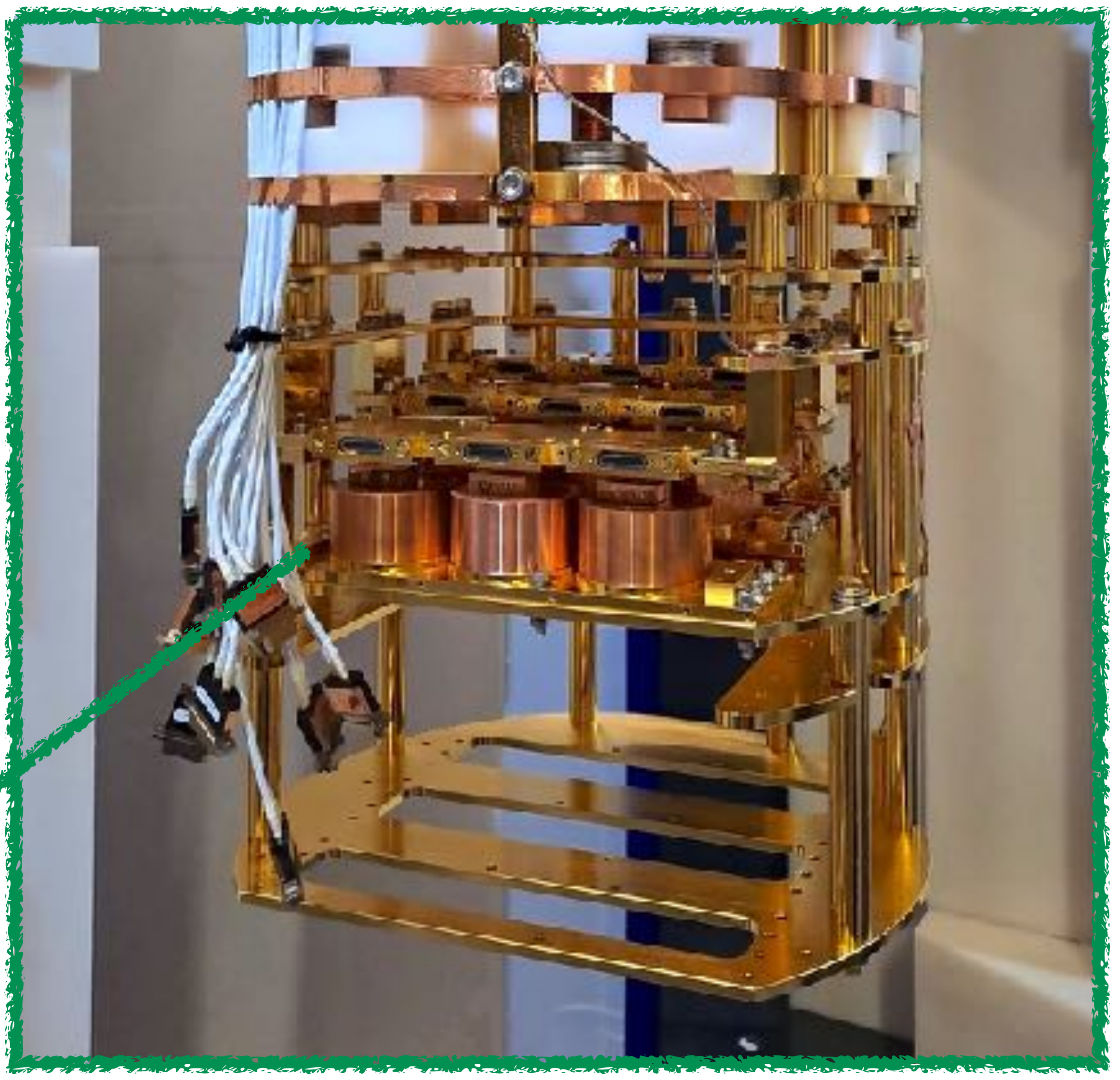
RUN014



Scaling to 9 detectors

RUN015

5 planar detectors
4 FID detectors



Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

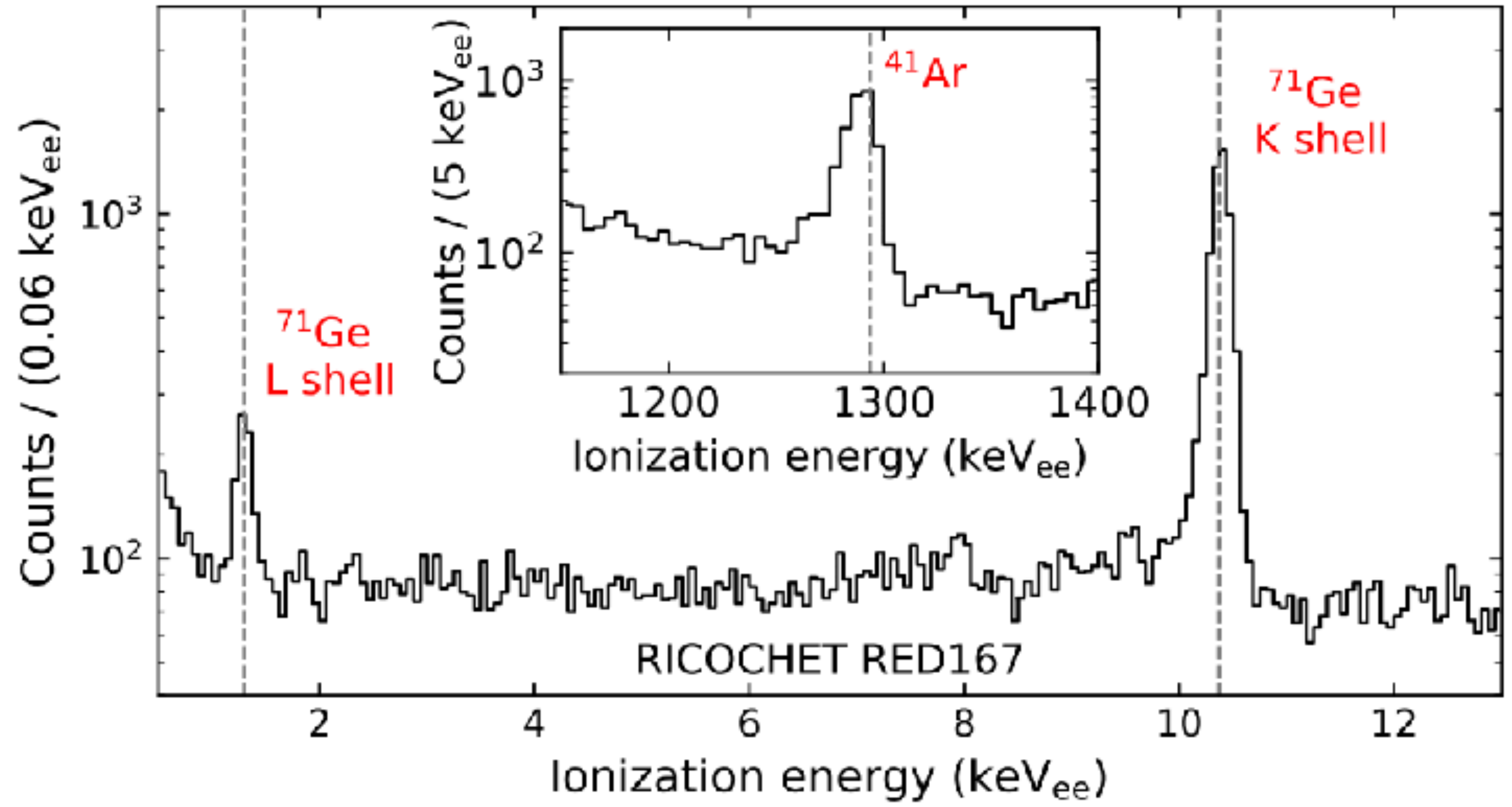
A. Armatol *et al.* (Ricochet Collaboration), arXiv:2507.22751 (2025)

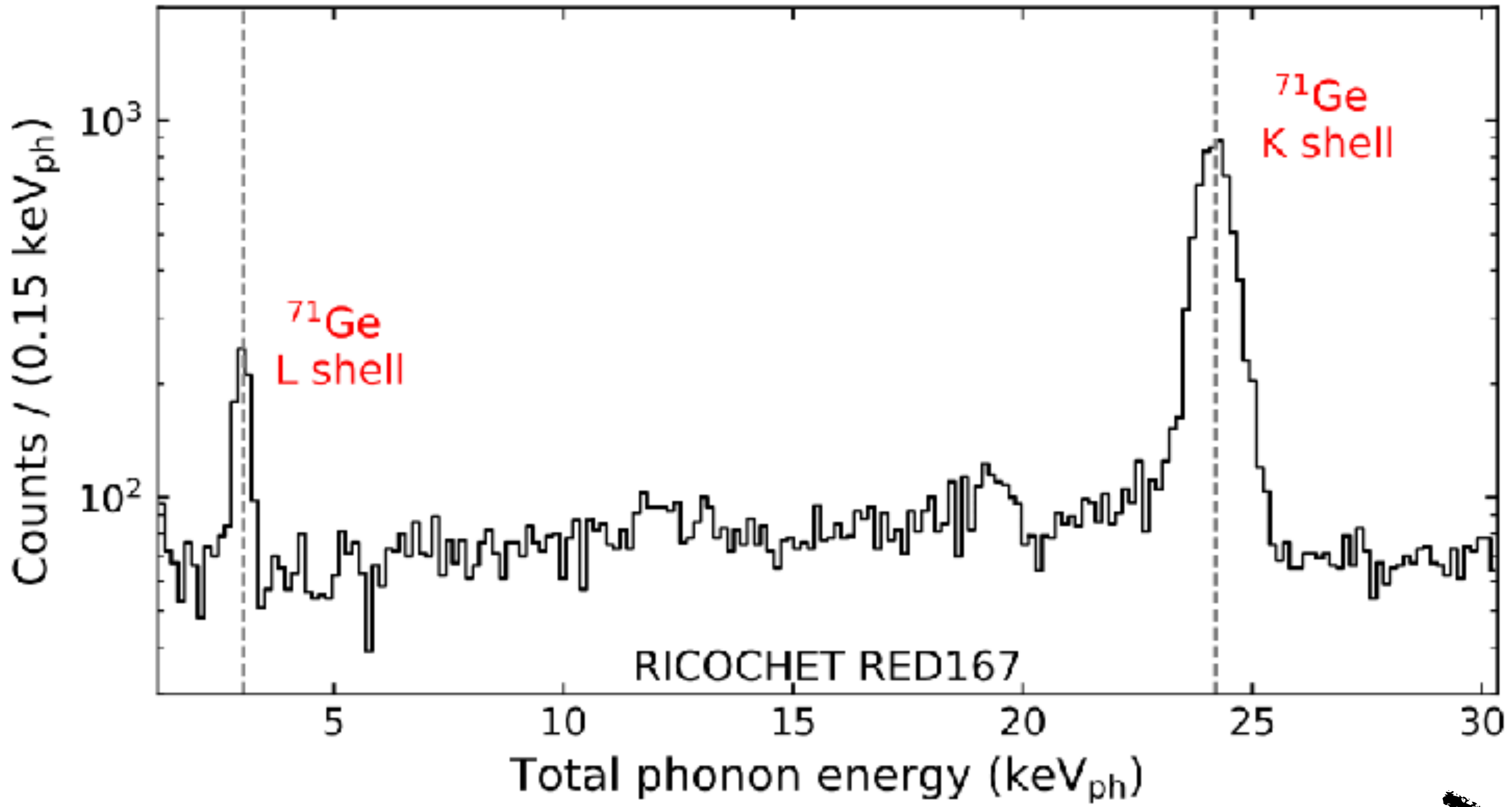
Resolution performance

Detector performance improvement during the commissioning phase through vibration mitigation.

At the end of commissioning:

- ionization baseline resolution $\sigma = 40\ eV_{ee}$
- phonon baseline resolution $\sigma = 50\ eV_{ph}$ - $80\ eV_{ph}$





RUN014 →

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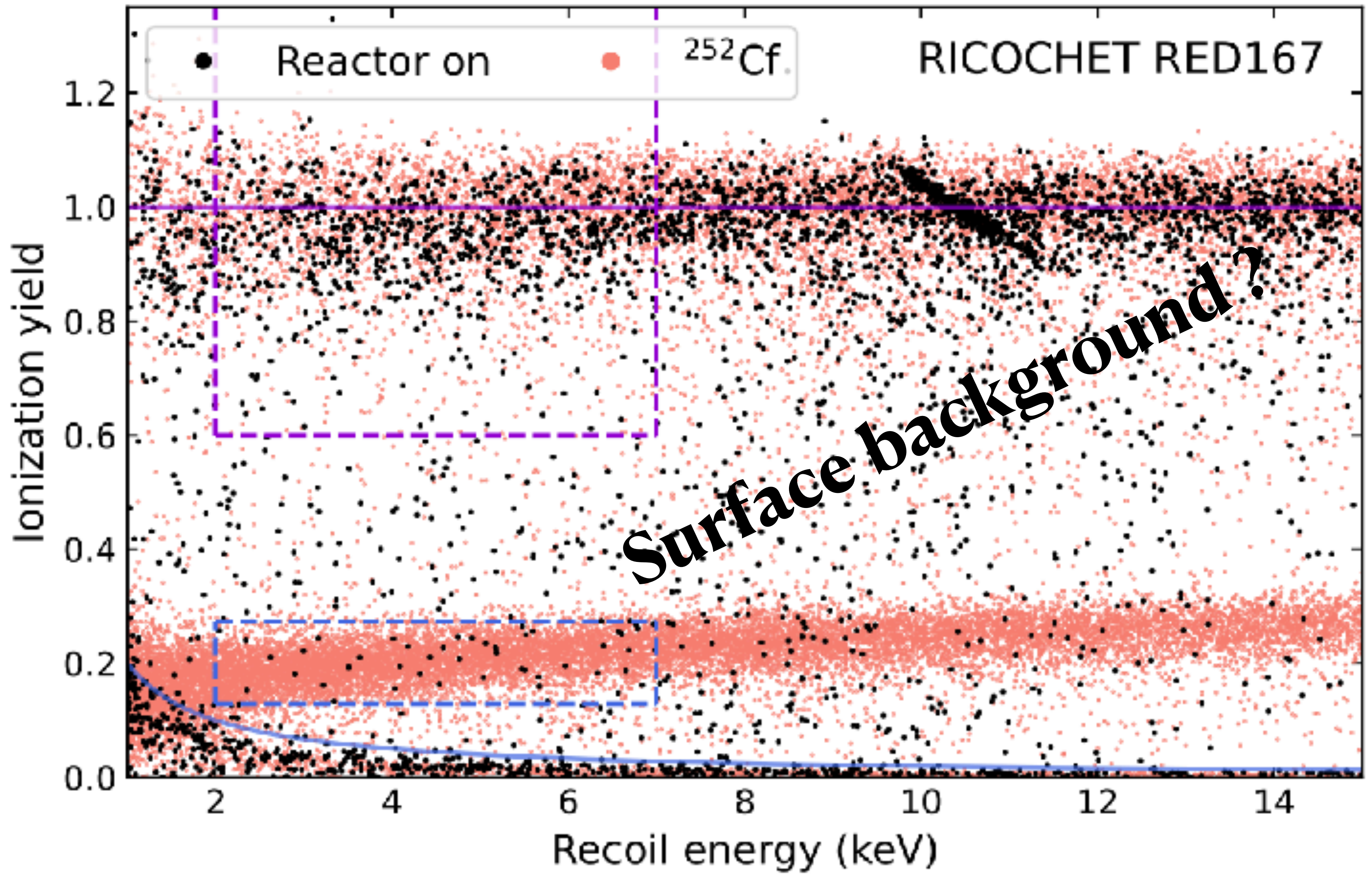
Background levels

155 h of reactor ON

253 h of reactor OFF and ^{252}Cf source

Muon veto coincidences removed



Electron recoil band

Nuclear recoil (NR) band

Heat-only events

RUN014

Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

A. Armatol *et al.* (Ricochet Collaboration), arXiv:2507.22751 (2025)

Background levels

155 h of reactor ON

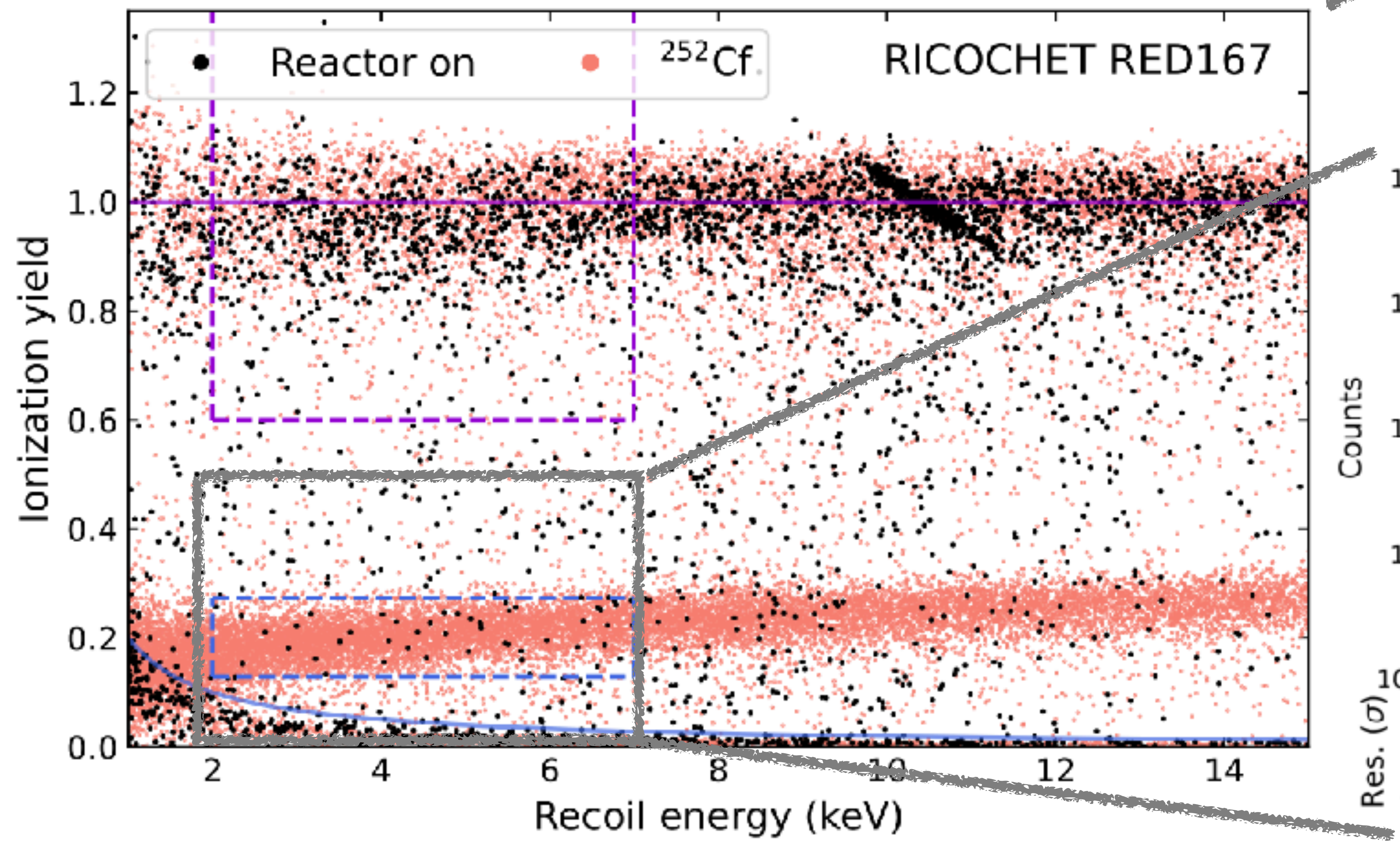
253 h of reactor OFF and ^{252}Cf source

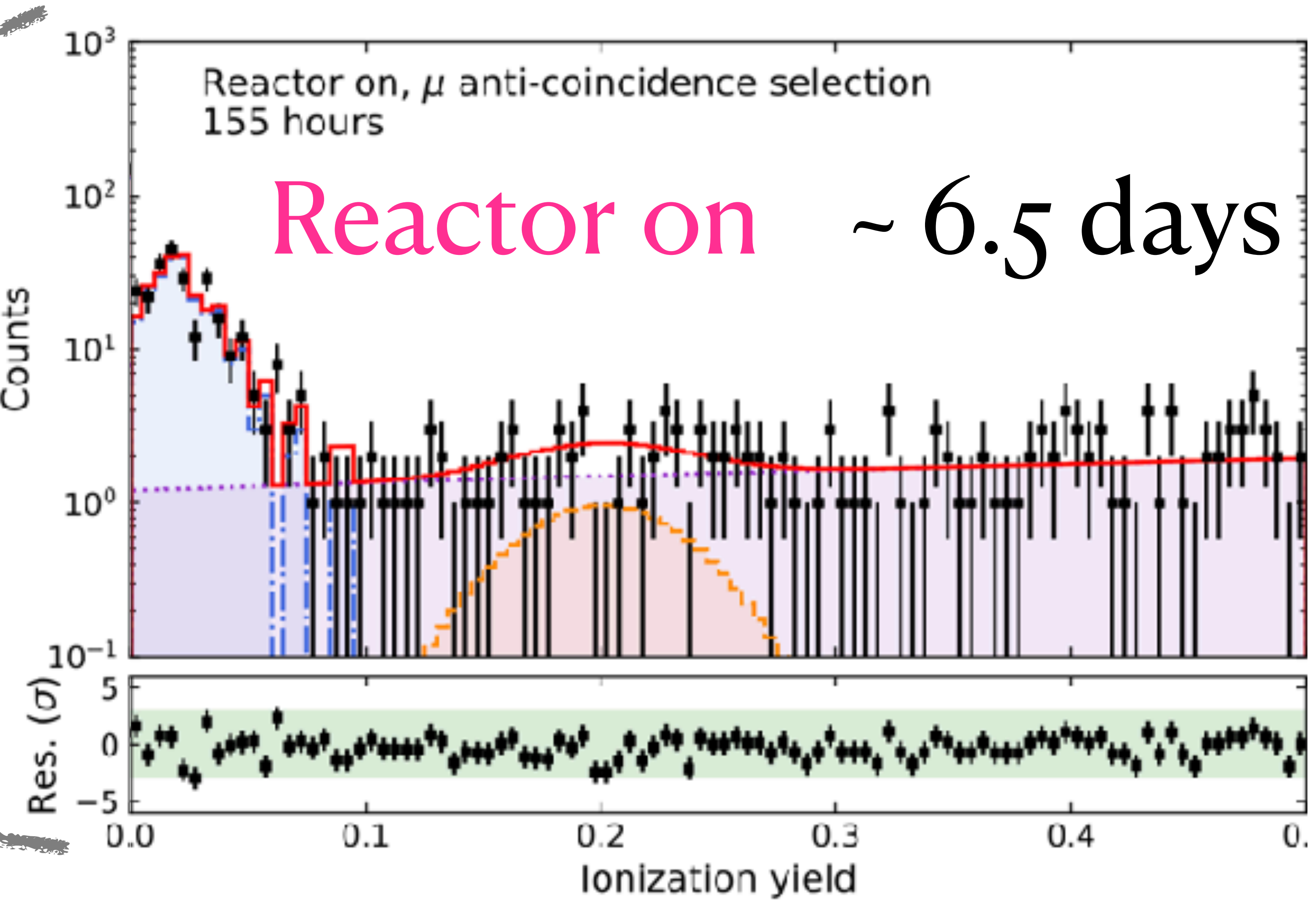
Muon veto coincidences removed

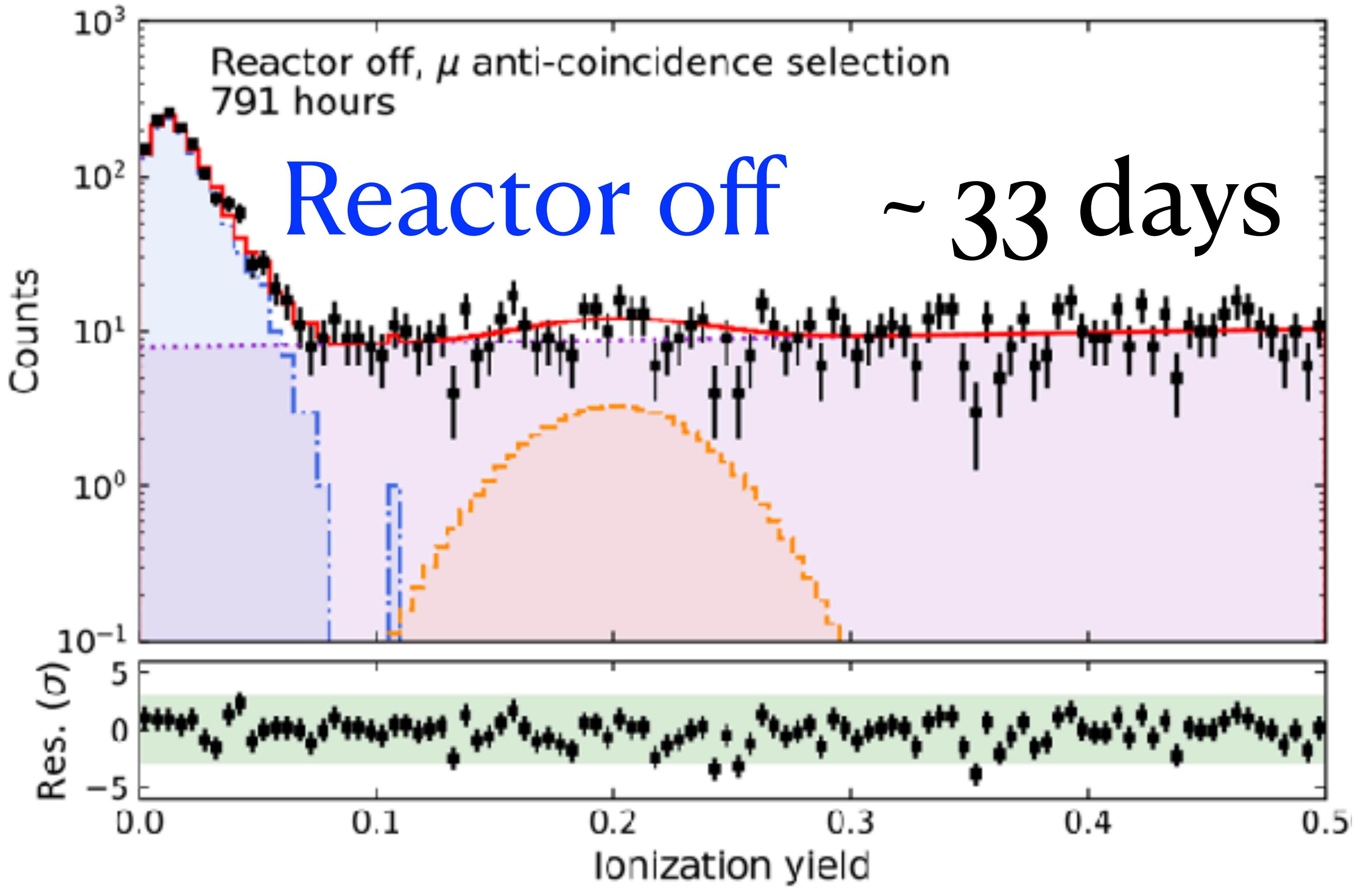
NR reactor on < 9 counts / (kg d keV)

NR reactor off < 15 counts / (kg d keV)

in 2 to 7 keV range





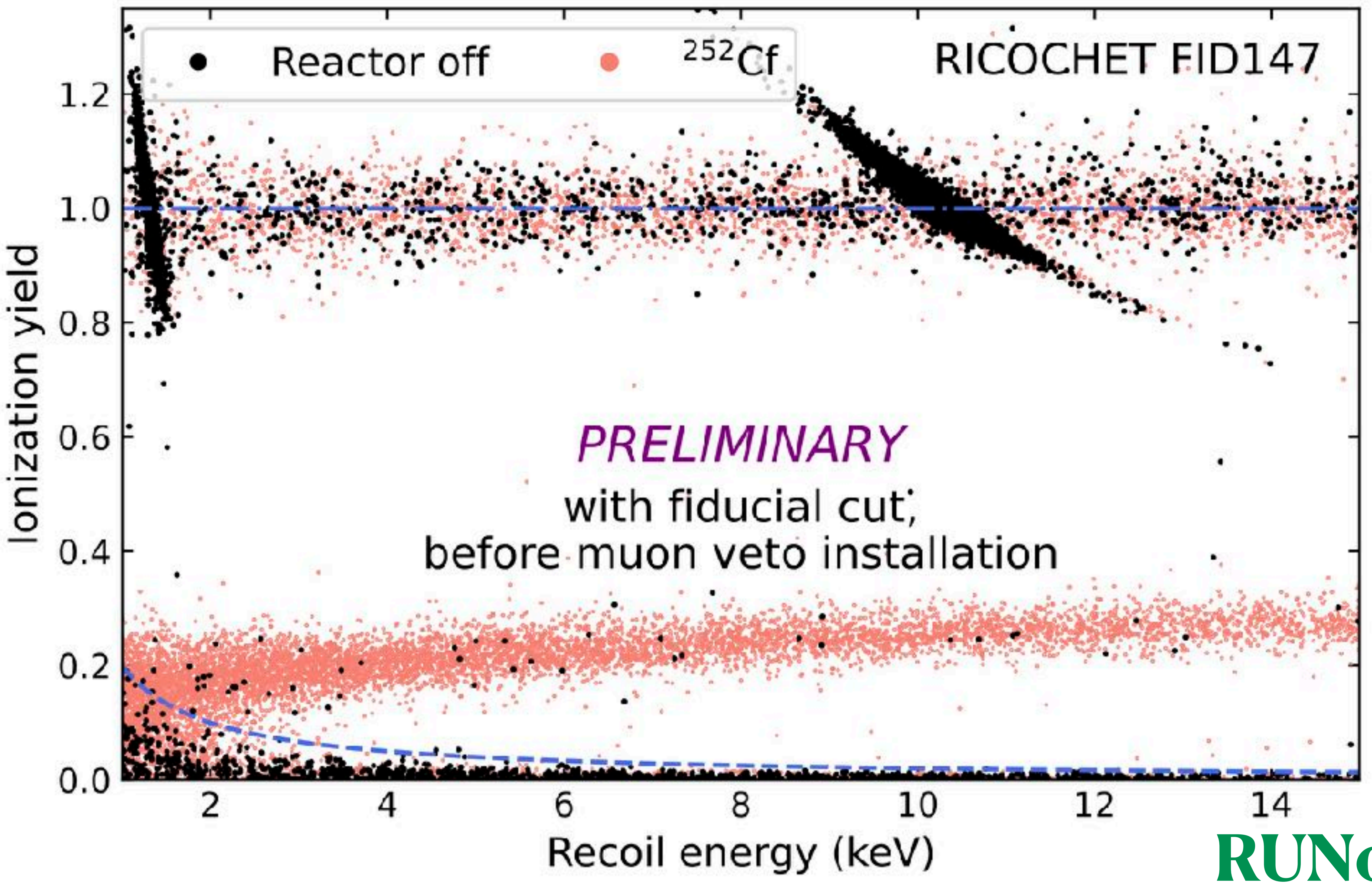


RUN014

Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

Surface background mitigation

- 277 h of reactor OFF
  102 h of reactor OFF and ^{252}Cf source
- Without muon veto



- FID detectors with surface rejection capabilities
- Investigation of etching for planar detector holder (in RUN016)

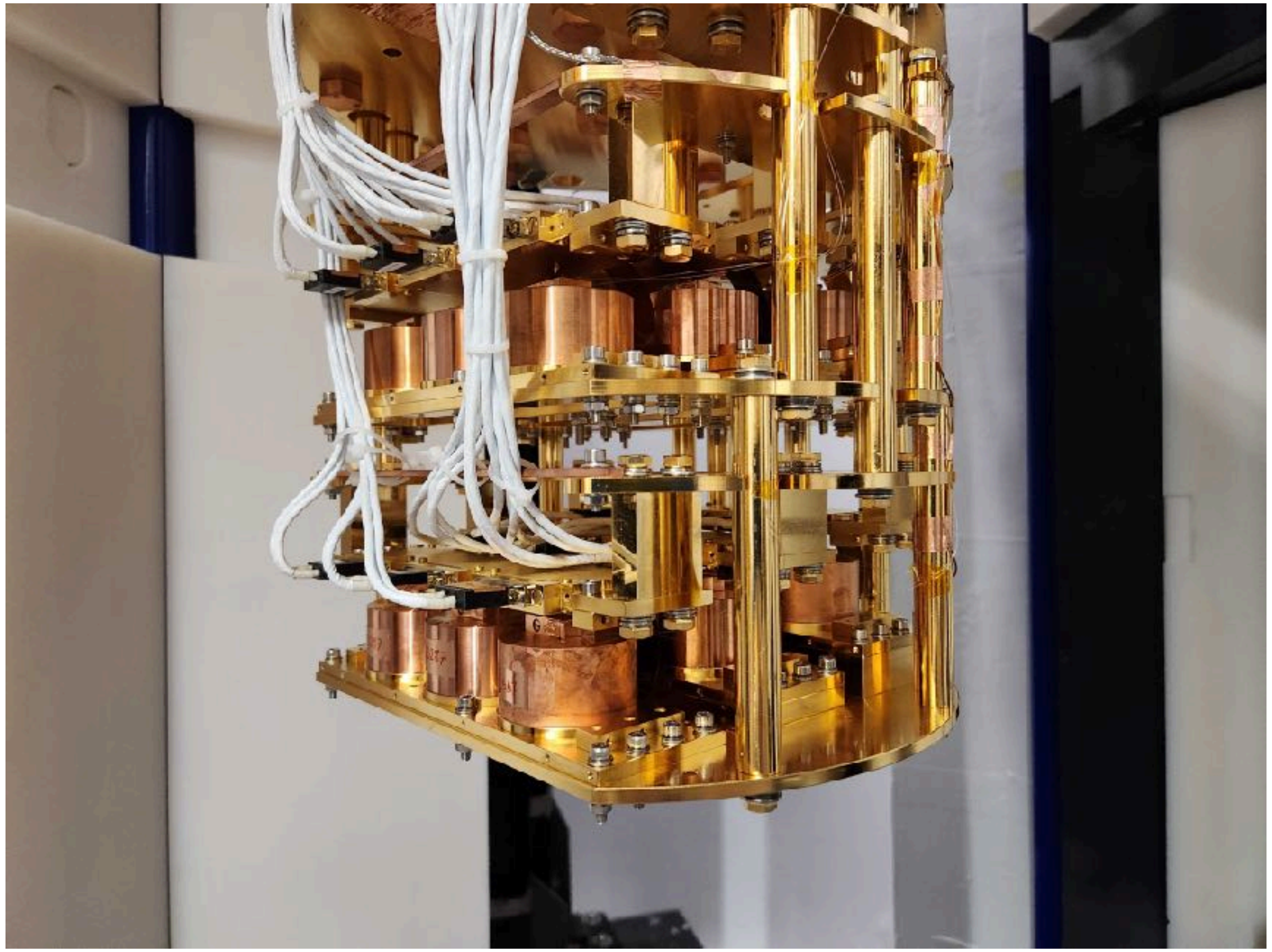
RUN015

Analysis ongoing...

Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

Science phase

7 planar detectors
11 FID detectors



The first science run with the full Ricochet payload (18 detectors for a total germanium mass of 0.76 kg) started in July 2025

New results coming soon !

RUN016

Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

Conclusions and outlook

- The installation and phased commissioning are completed.
  - an ionization baseline resolution of $\sigma = 40$ eV_{ee} and a phonon baseline resolution of $\sigma = 50$ eV_{ph} - 80 eV_{ph} were achieved at the end of RUN014;
  - Backgrounds were measured in RUN014 and an unexpected surface background was identified: mitigation through the use of FID detectors and improved cleaning procedure of the surfaces close to planar detectors.
- Data analysis of 9 detectors from RUN015 is ongoing…
- **Science phase with the full payload of 0.76 kg of germanium started this July!**

Stay tuned !

RICOCHET
A Coherent Neutrino Scattering Program

Bonus

CEνNS experiments