The RICOCHET experiment

Valentina Novati
on behalf of the Ricochet Collaboration

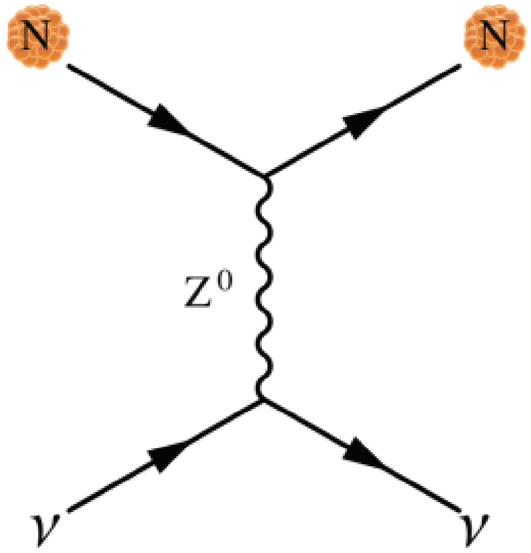
Annecy, Nov. 7th, 2025

enigmass+

CEvNS

Coherent elastic neutrino-nucleus scattering (CEvNS)

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

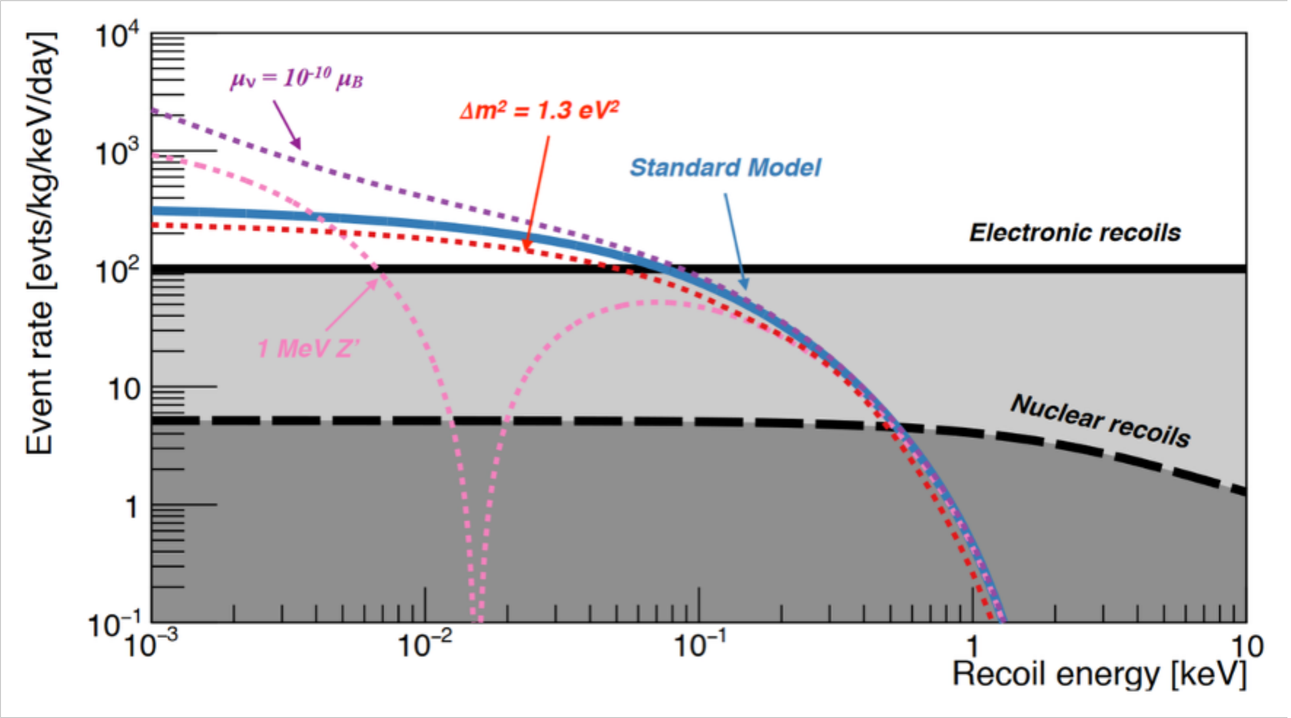


D. Z. Freedman, Phys. Rev. D 9, 1389 (1974)
D. Akimov et al. (COHERENT Collaboration), Science 357, 1123, (2017) - ArXiv:1708.01294

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

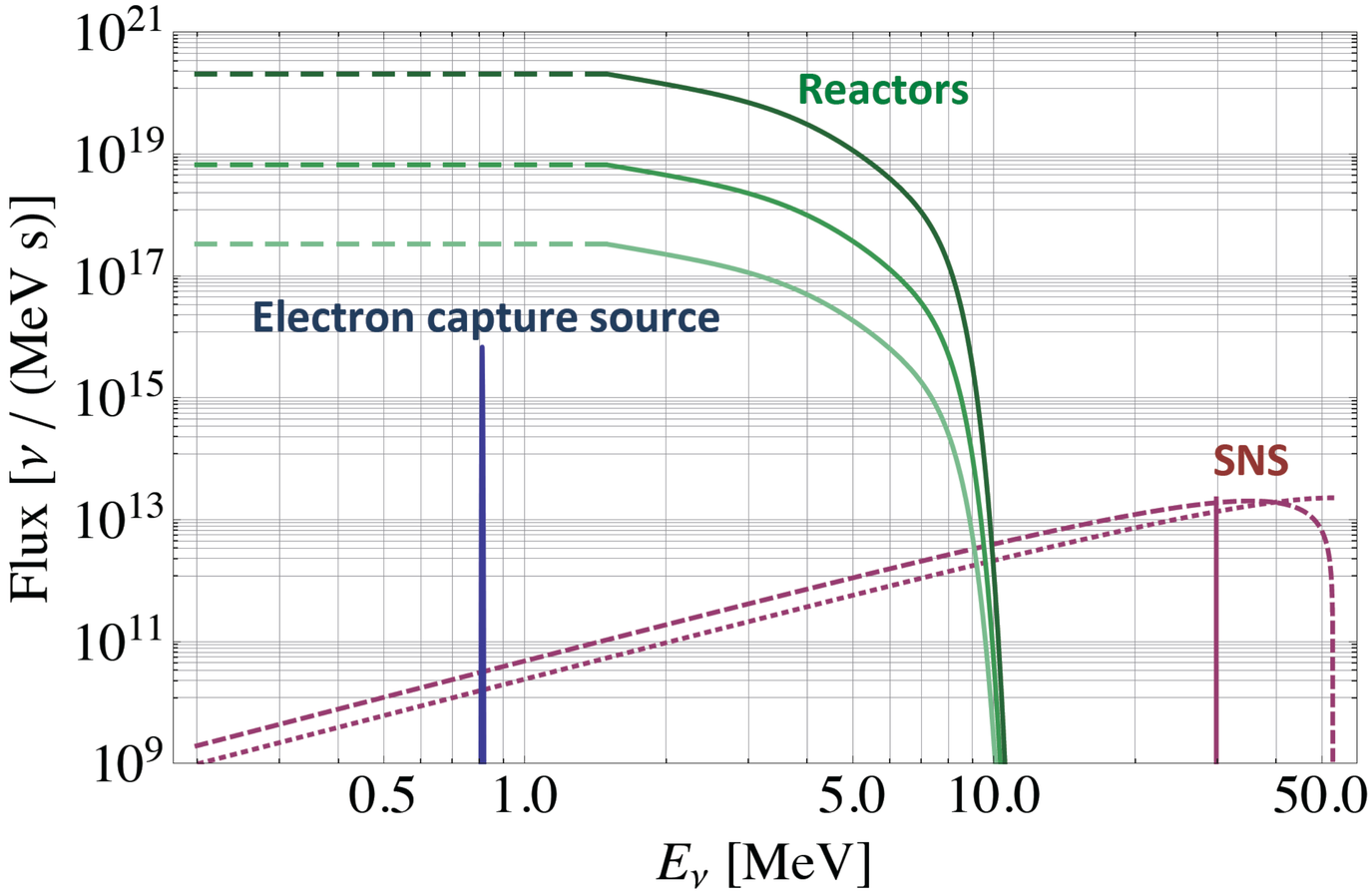


Need large exposure to be sensitive to physics beyond the Standard Model

Reactor antineutrinos

x 10⁴ times higher flux than the SNS

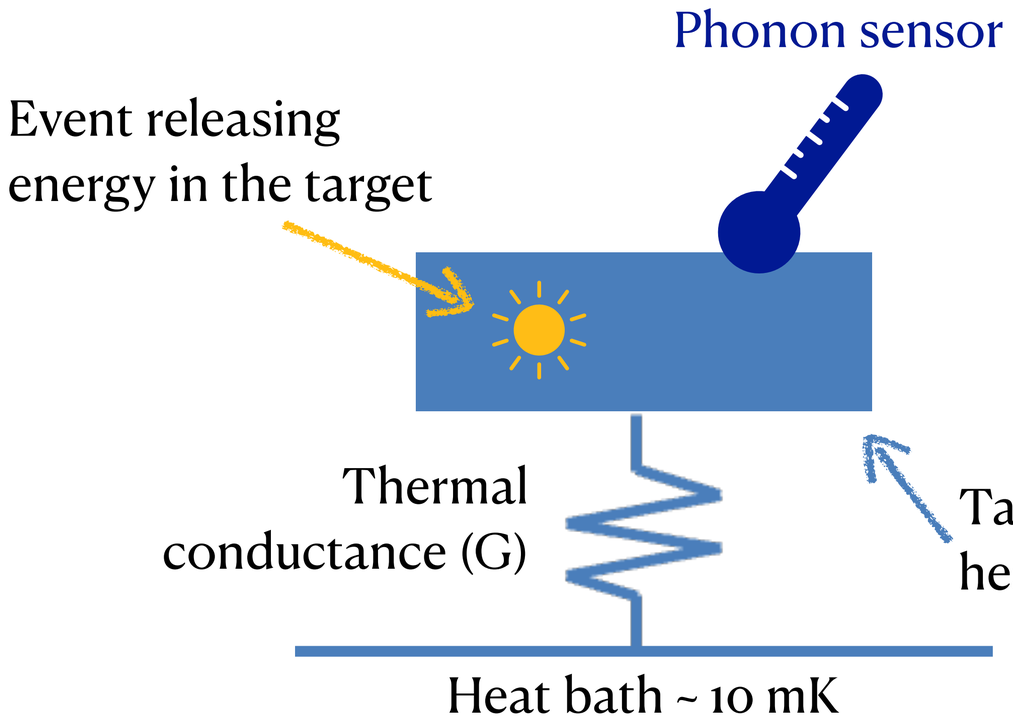
- Reactors are a source of antineutrinos with a larger flux than the SNS
- But a lower energy threshold is required

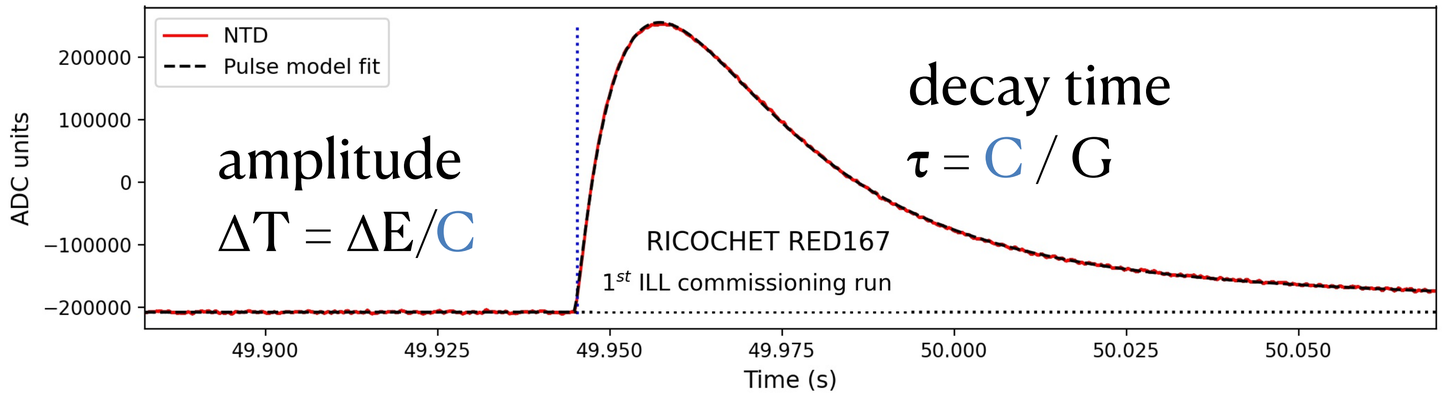


Despite the high antineutrino flux, the interaction is rare

Cryogenic calorimeters

Cryogenic calorimeters are phonon-mediated detectors

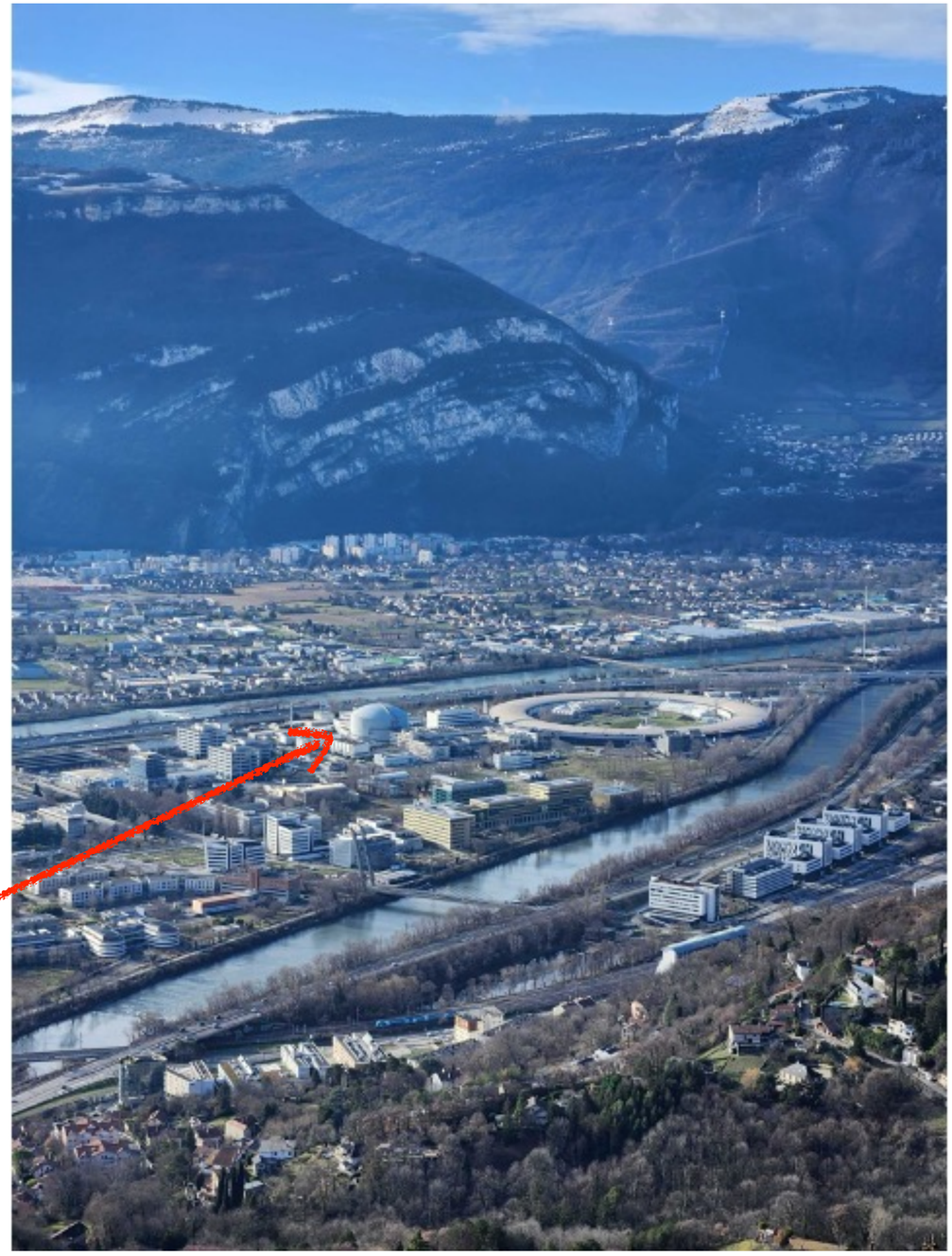




Cryogenic calorimeters have exquisite resolutions and low thresholds

Ricochet at the ILL

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

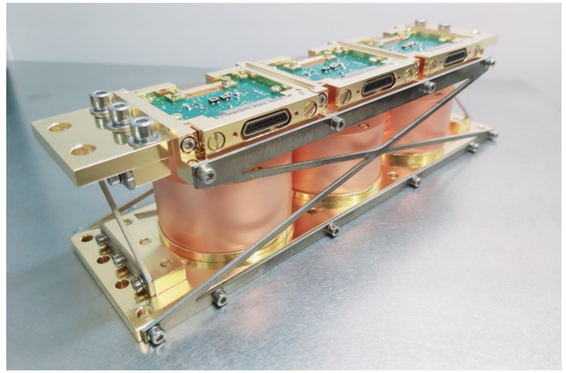


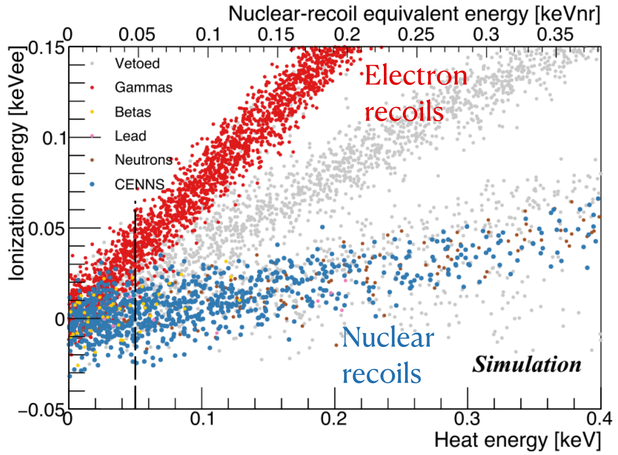
Two detector technologies

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

CryoCube

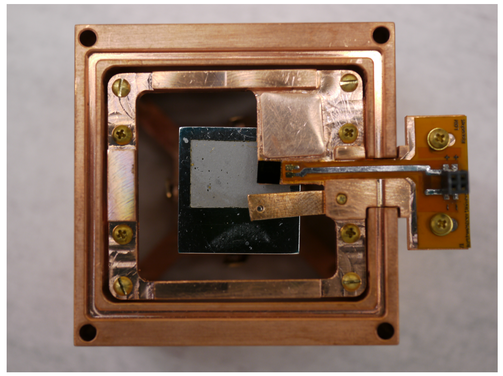
- Phonon and ionization readout for particle identification
- Neutron-transmutation-doped germanium thermistors for the phonon readout
- Germanium targets

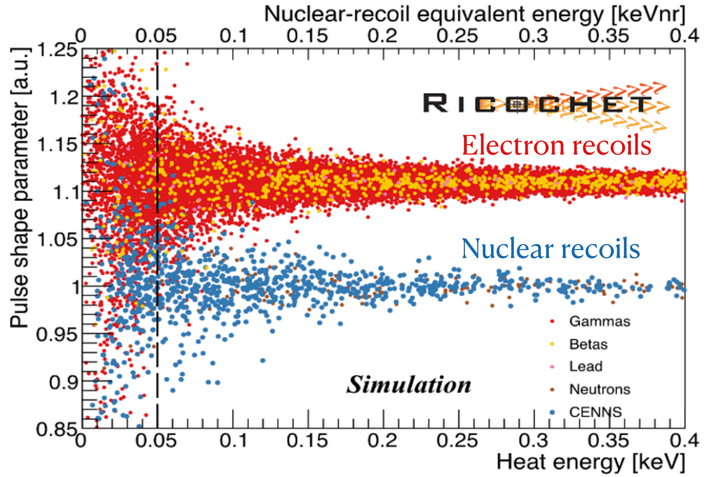




Q-Array

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





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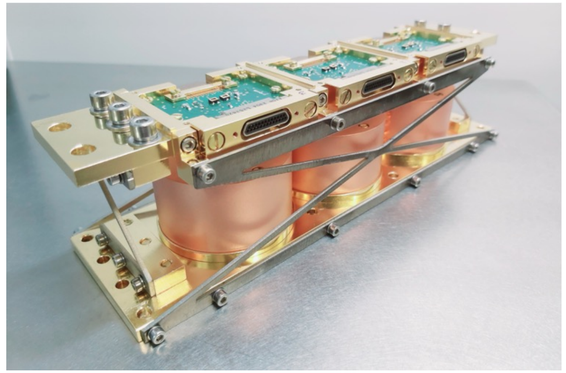

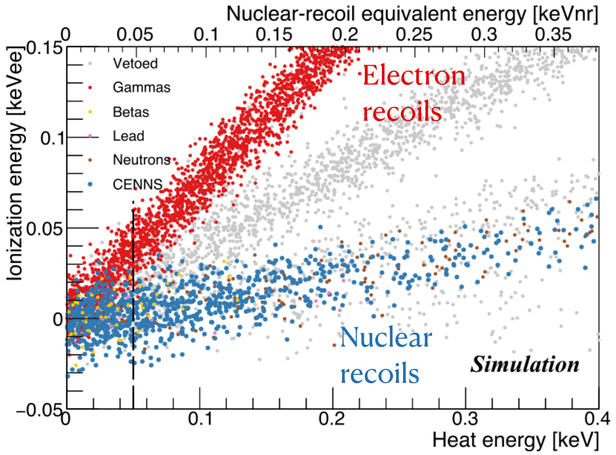

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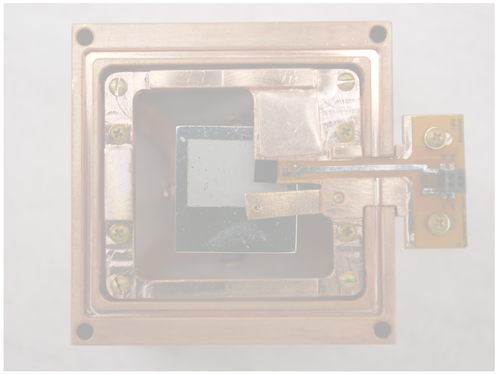
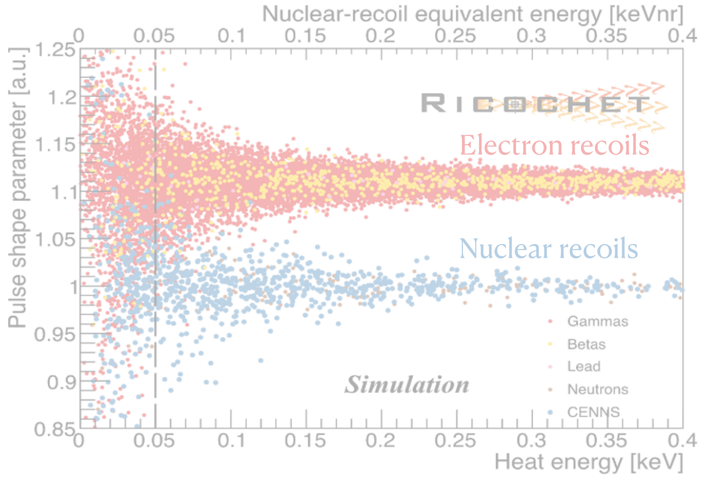
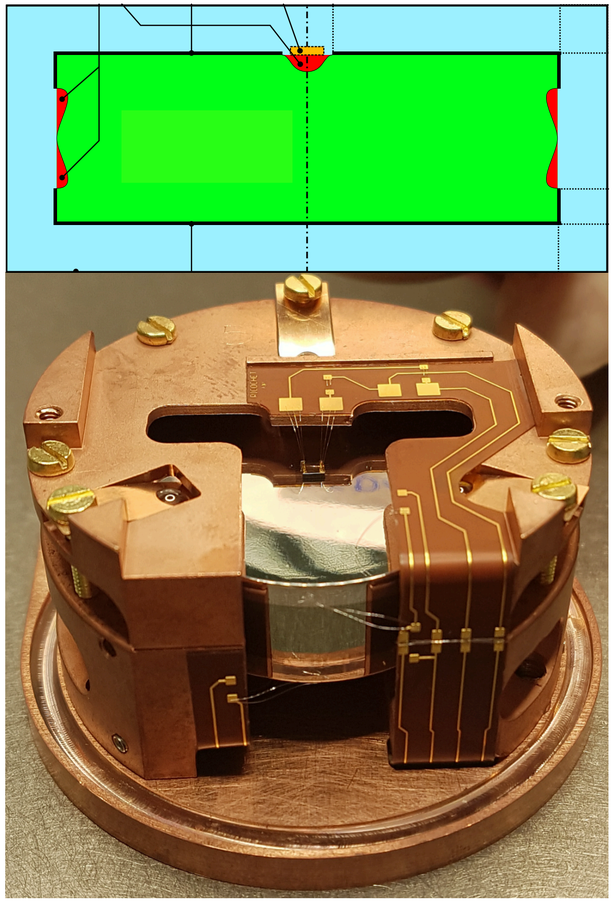


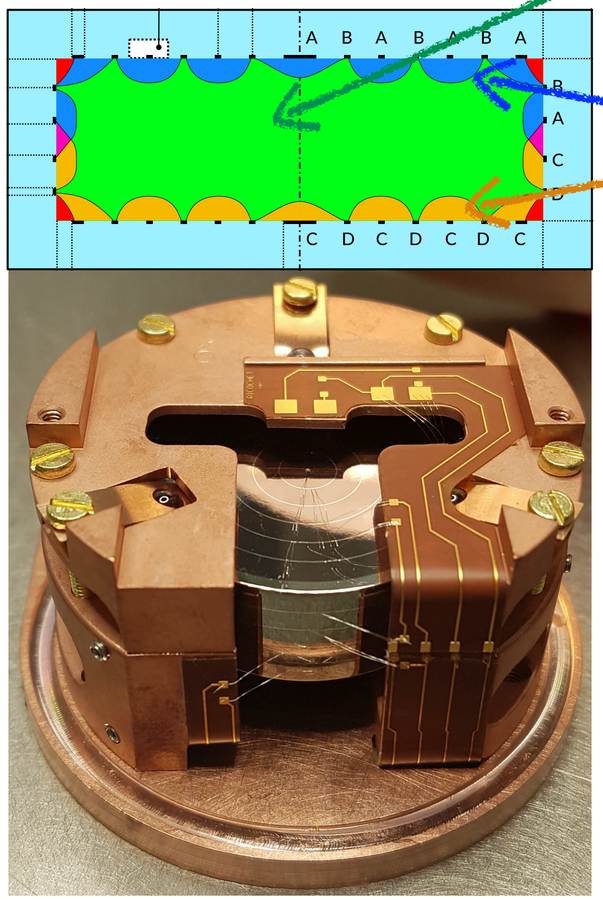


CryoCube: two electrode geometries

Planar
electrode geometry



Fully Inter-Digitized (FID)
electrode geometry



Fiducial volume

Veto volume

Planar geometry:

- No surface event discrimination
- All the volume is sensitive

FID geometry:

- Surface event discrimination
- Reduced sensitive volume

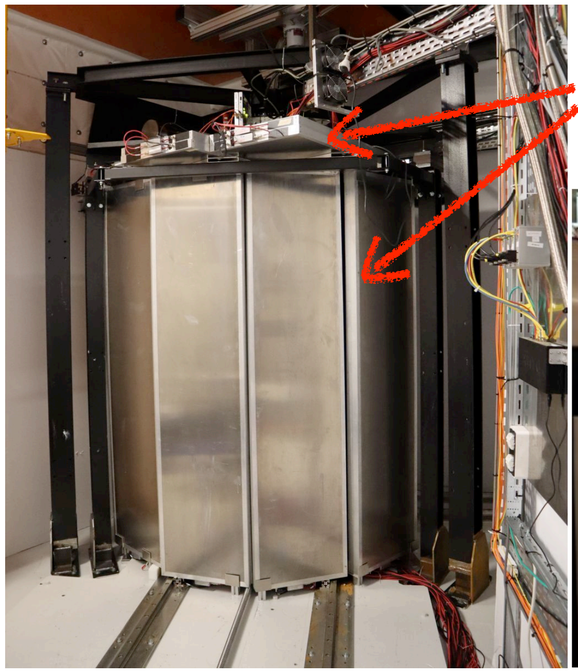
Neganov-Trofimov-Luke (NTL) effect:

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

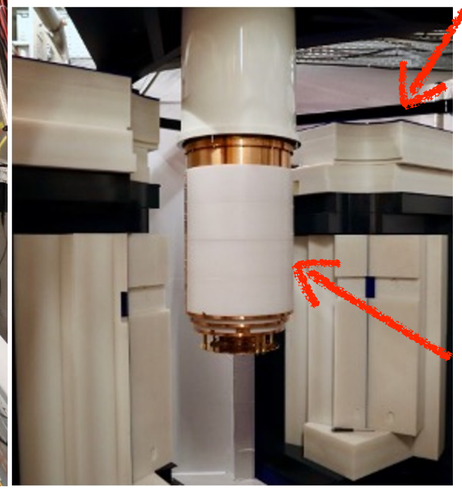
I will express phonon energy as the recoil energy plus the NTL gain

Background mitigation

Cosmogenic, reactogenic and radiogenic background rejection:
15 m water equivalent overburden from the water transfer channel



Outer muon veto

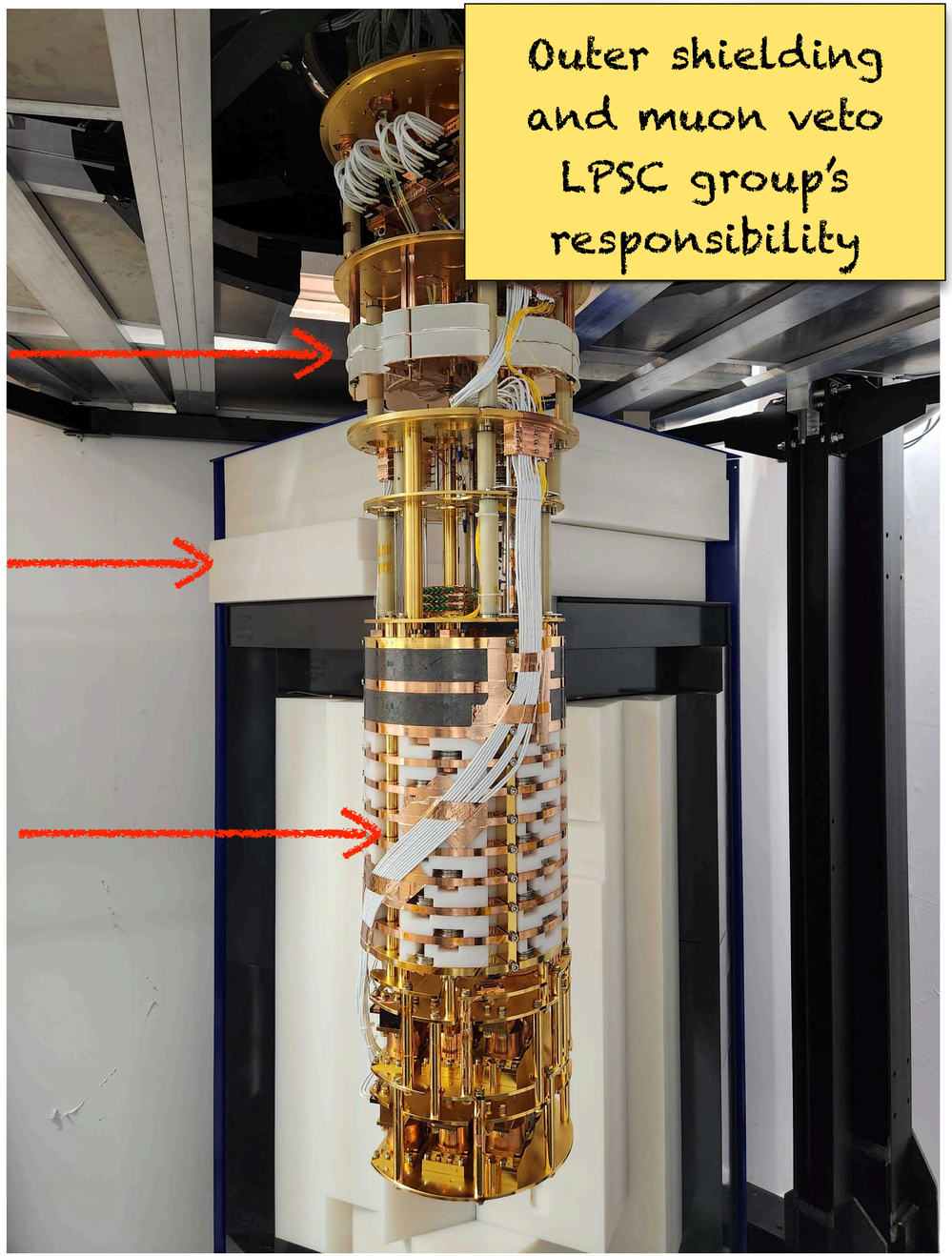


HDPE sheets at 1K, 4K and 50K

Inner shielding (Pb, Cu and HDPE)

Outer shielding (Pb, HDPE, soft iron)

Cryogenic muon veto



Outer shielding and muon veto LPSC group's responsibility

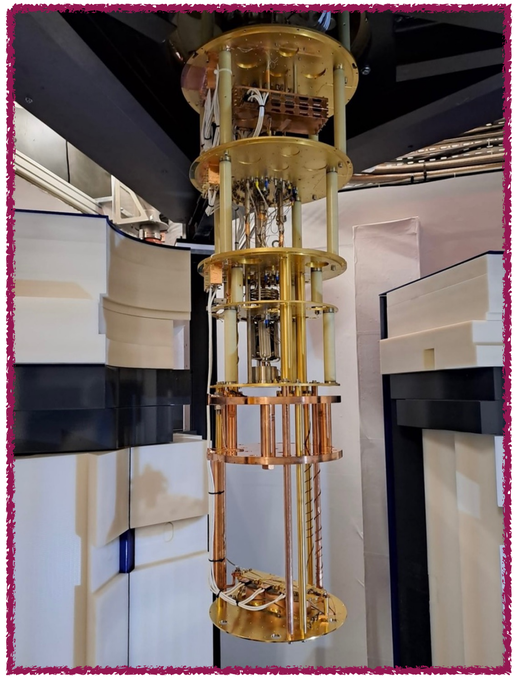
Commissioning at the ILL

LPSC strong contributions to operations

Cryogenic commissioning

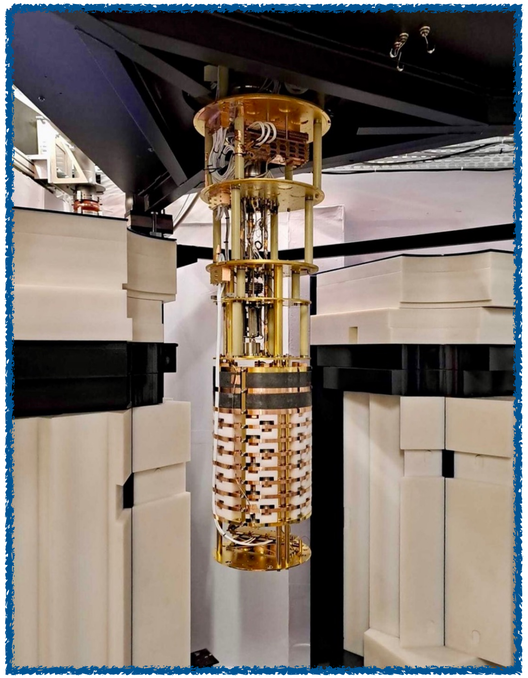
Detector commissioning

RUN013



Background commissioning

RUN014

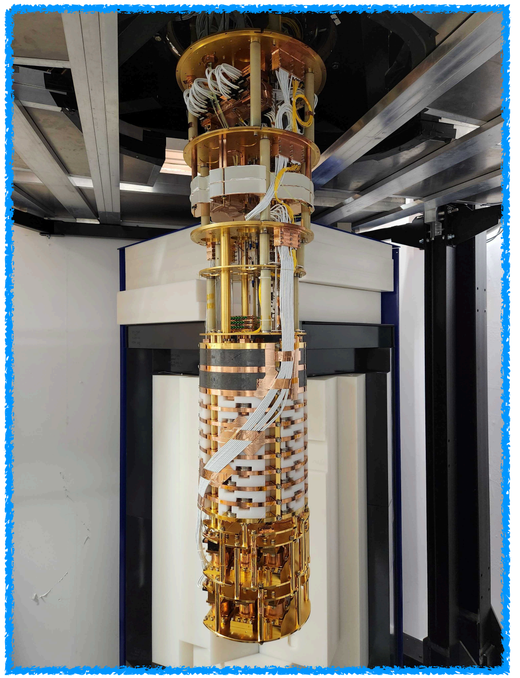


Scaling to 9 detectors

RUN015

Full payload - science run

RUN016



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

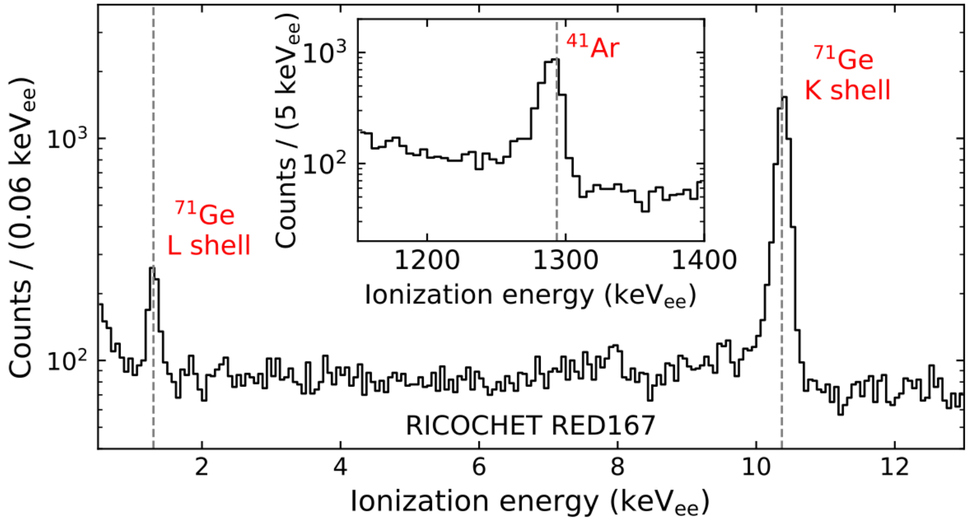
A. Armatol *et al.* (Ricochet Collaboration), arXiv:2507.22751 (2025)

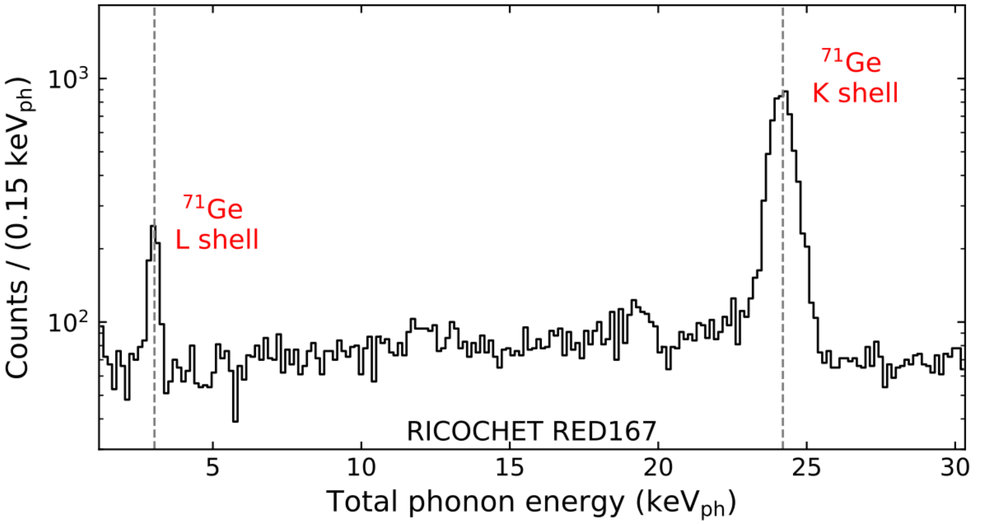
Resolution performance

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 $\sigma = 50\ eV_{ph}$ - $80\ eV_{ph}$

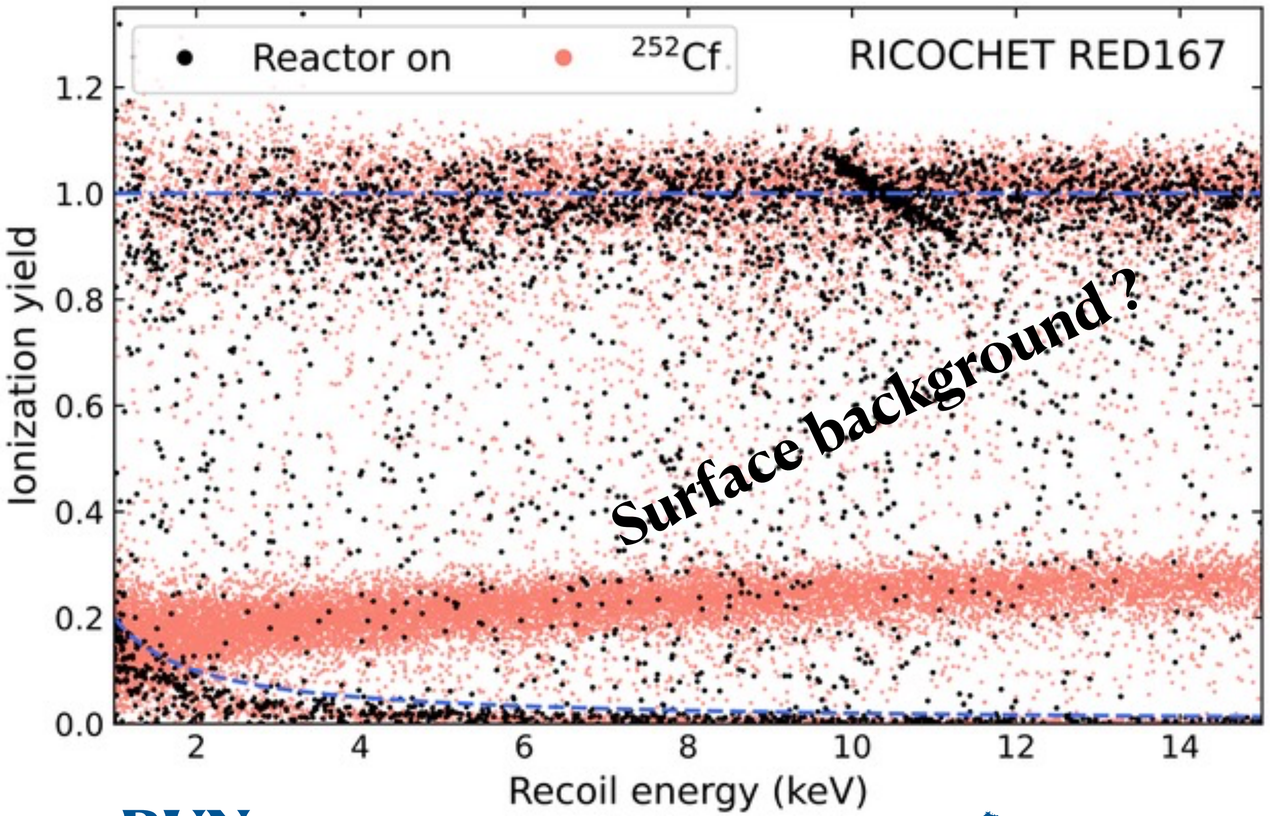




RUN014 →

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

Background levels



Electron recoil band

155 h of reactor ON

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

Muon veto coincidences removed

Nuclear recoil (NR) band

Heat-only events

RUN014

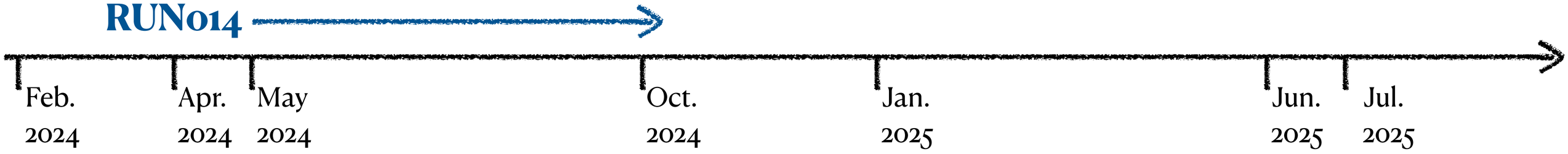
Feb. 2024 — Apr. 2024 — May 2024 — Oct. 2024 — Jan. 2025 — Jun. 2025 — Jul. 2025

Background levels

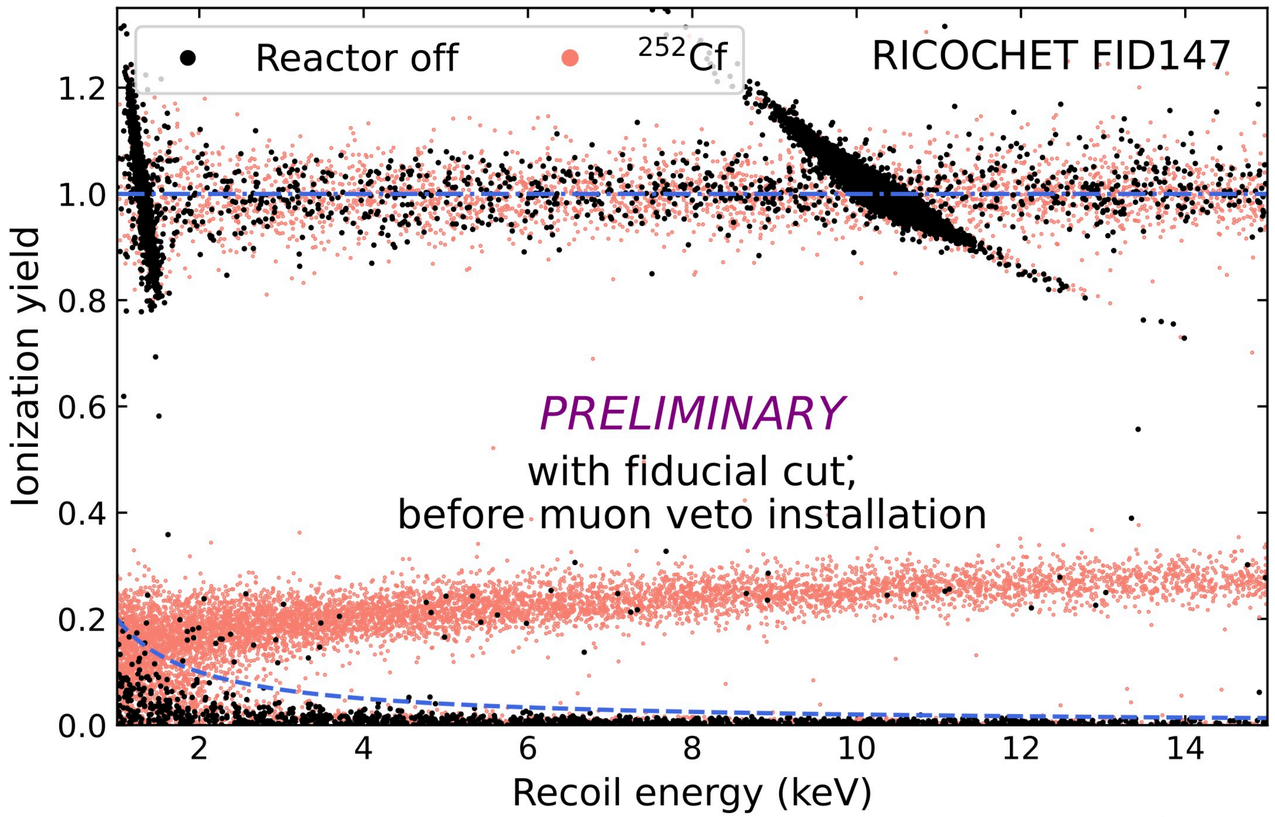
LPSC strong contributions to simulations and analysis

Nuclear recoil between 2 and 7 keV					
Reactor	Detector	μ	Data [DRU]	Simulation [DRU]	
				Cosmogenic	Reactogenic
on	det 1	anticoinc.	< 25	4.6 ± 0.8	0.4 ± 0.1
	det 2		< 9		
off	det 1	anticoinc.	< 15	4.6 ± 0.8	-
	det 2		< 21		-
off	det 1	coinc.	14 ± 3	15 ± 2	-
	det 2		13 ± 3		-

DRU = counts / (keV kg day)



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)

Analysis ongoing...

RUN015 →

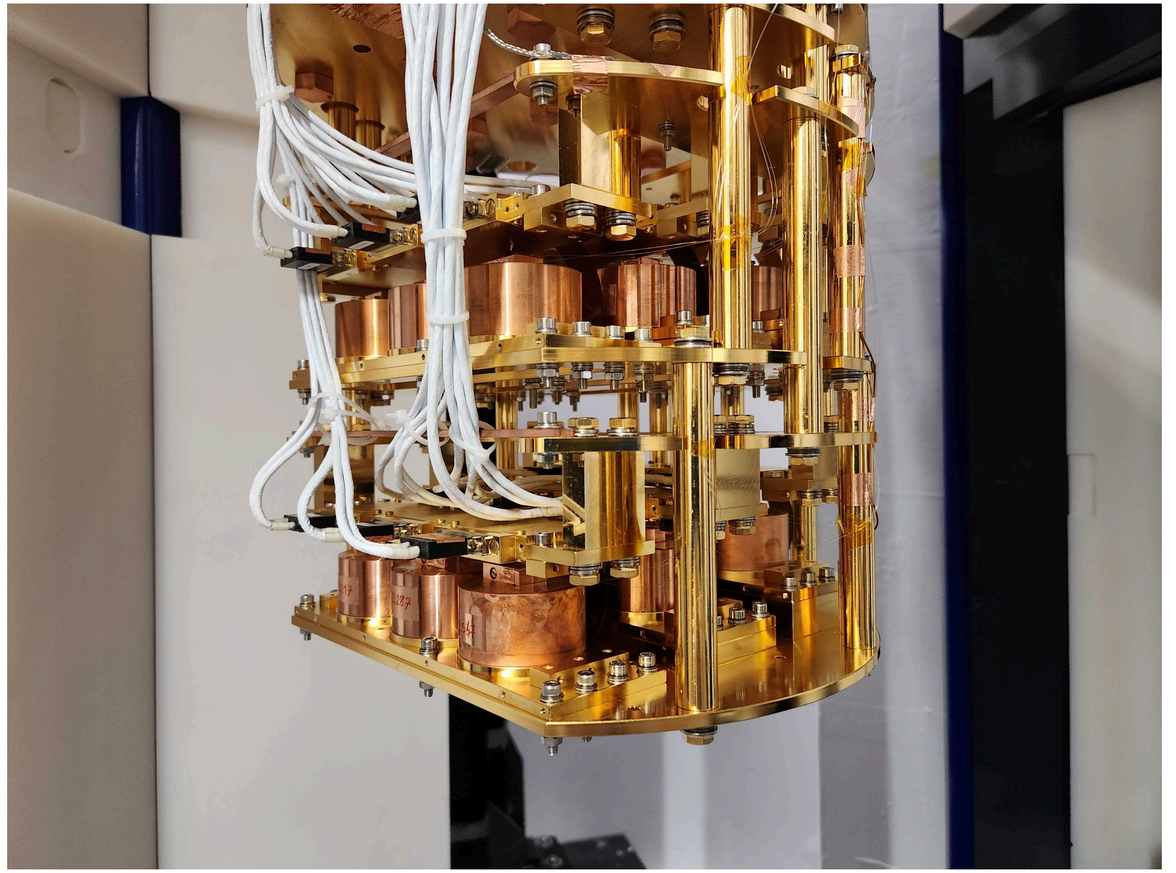
Feb. 2024 | Apr. 2024 | May 2024 | Oct. 2024 | Jan. 2025 | Jun. 2025 | Jul. 2025

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

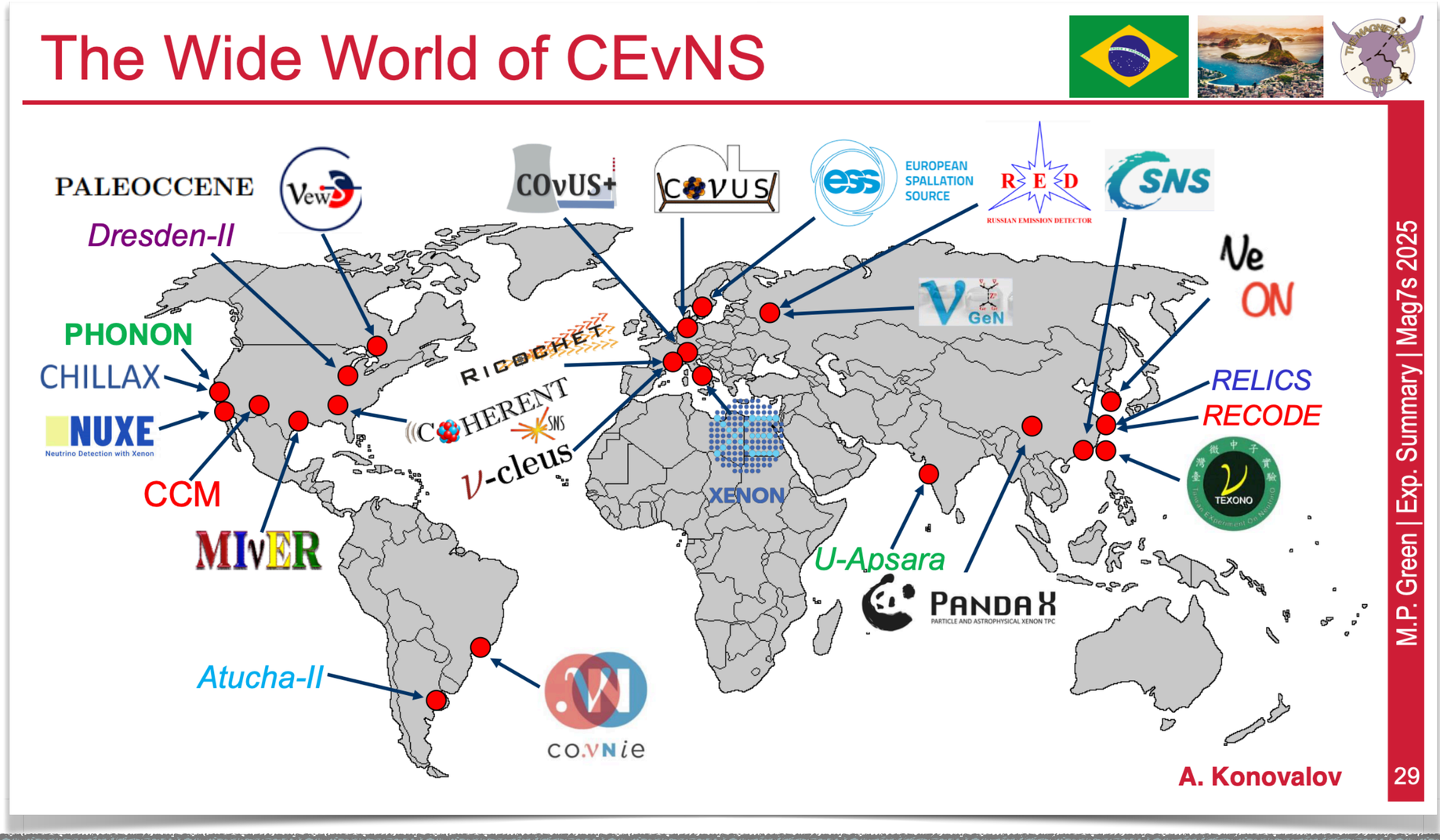
- The installation and phased commissioning are completed.
  - An ionization baseline resolution of σ = 40 eV_{ee} and a phonon baseline resolution of σ = 50 eV_{ph} - 80 eV_{ph} were achieved at the end of RUN014;
  - Backgrounds were measured in RUN014 and an unexpected surface background was identified: 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

CEvNS experiments



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

Background levels

155 h of reactor ON

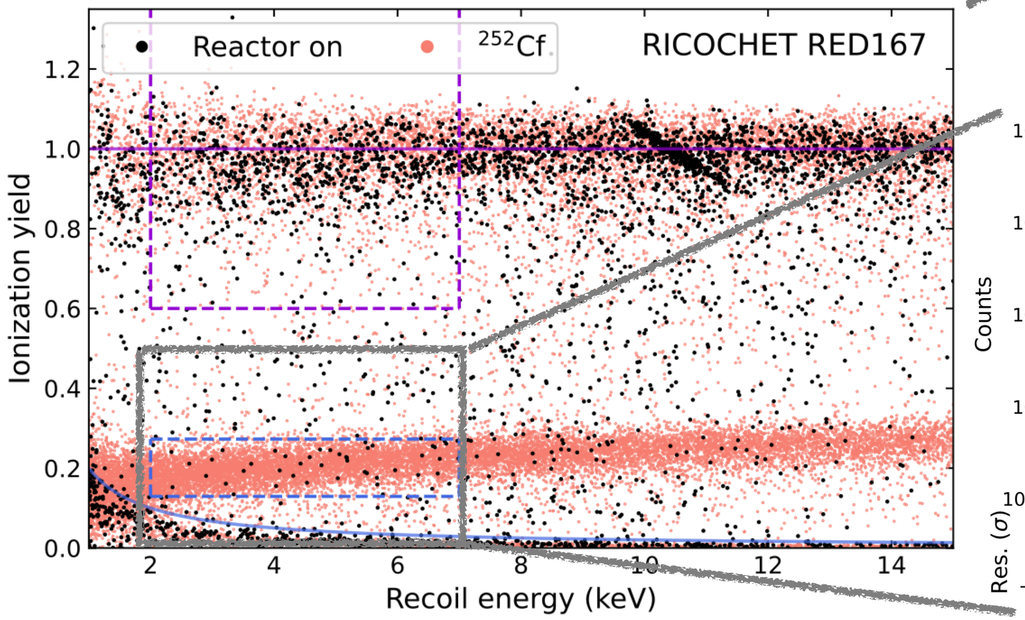
253 h of reactor OFF and ^{252}Cf source

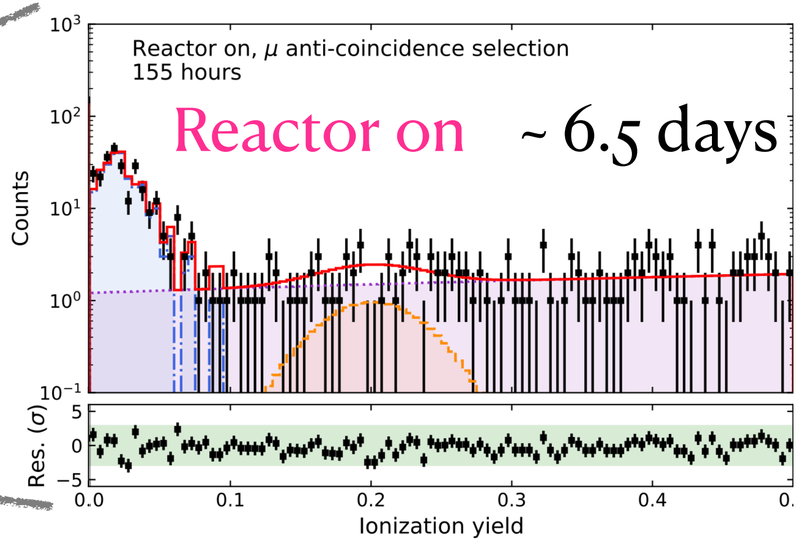
Muon veto coincidences removed

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

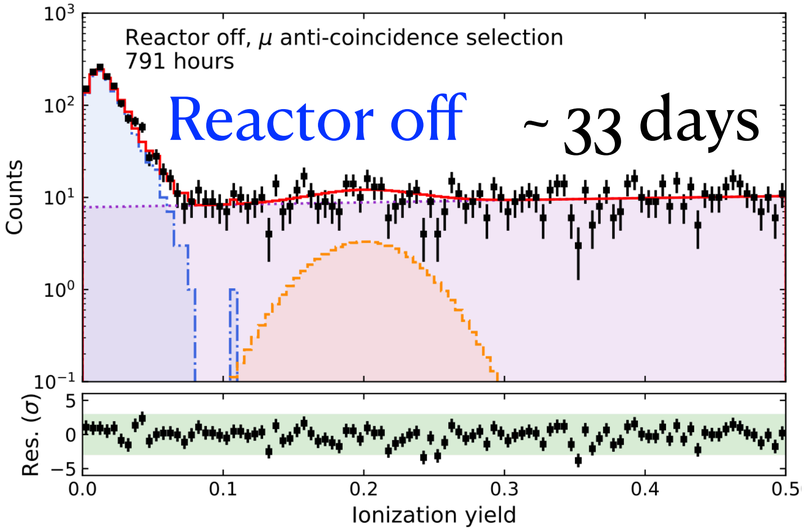
NR reactor off < 15 counts / (kg d keV)

in 2 to 7 keV range





Reactor on ~ 6.5 days



Reactor off ~ 33 days

RUN014

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