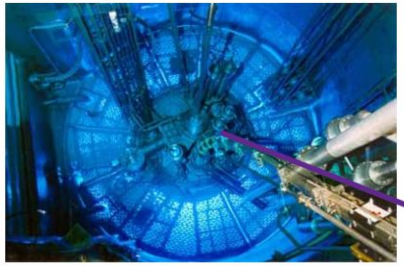
Current status of the RICOCHET experiment

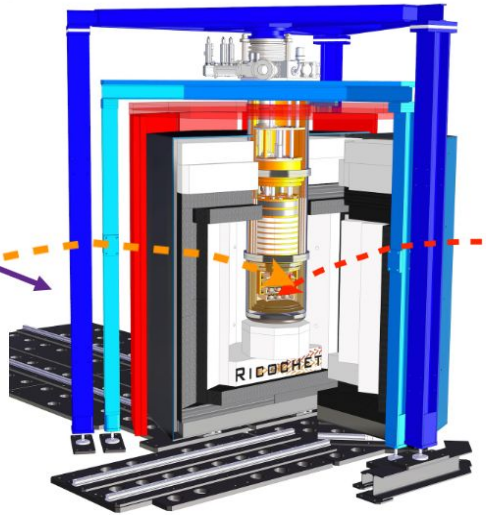
Nicolas MARTINI on behalf of the Ricochet Collaboration

RICOCHET: a reactor neutrino observatory

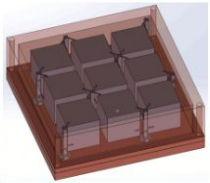
RICOCHET is a **France, USA, Canada and Russia** wide collaboration accounting for about 60 people, aiming at building a **low-energy neutrino observatory (<10 MeV)** to **measure with high precision the CEvNS process**



Neutrino



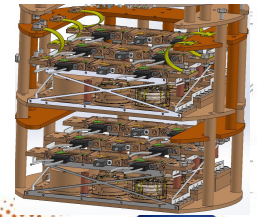
Q-ARRAY



See W. Van De Pontseele's talk

CryoCube

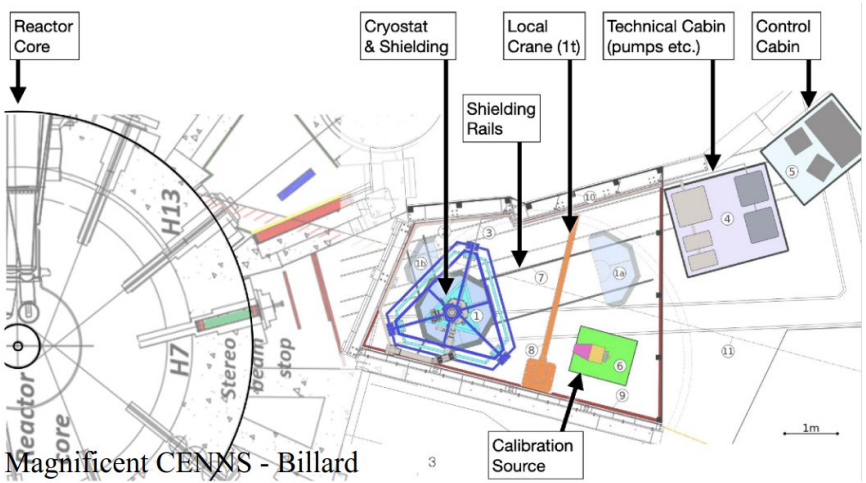
ANR AGENCE NATIONALE DE LA RECHERCHE



erc cnrs IN2P3 Les deux infinis

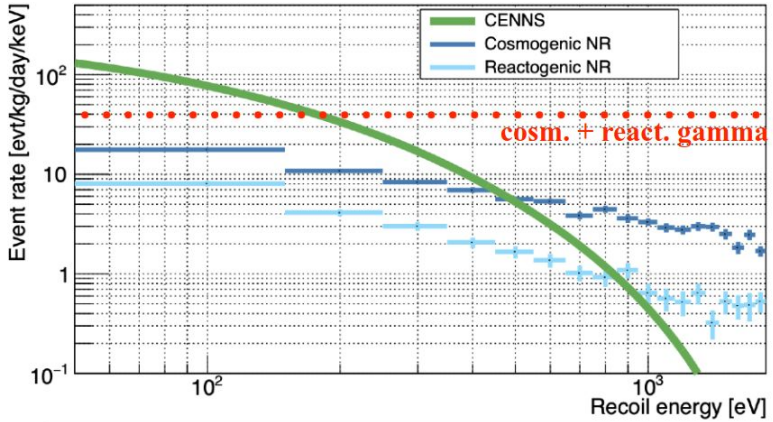
MIT · UMASS AMHERST · UNIVERSITY OF TORONTO · C2N · Northwestern University · ILL · IJCLab Irène Joliot-Curie · NÉEL · iP2i · LPSC Grenoble

ILL-H7 reactor site



- **58 MW** nominal thermal power
- **~11 evts/day/kg** (goal : 50 eV_{nr} threshold)
- **~15 m.w.e** of overburden
- 3 to 4 cycles per year : **ON/OFF modulation** to subtract uncorrelated backgrounds

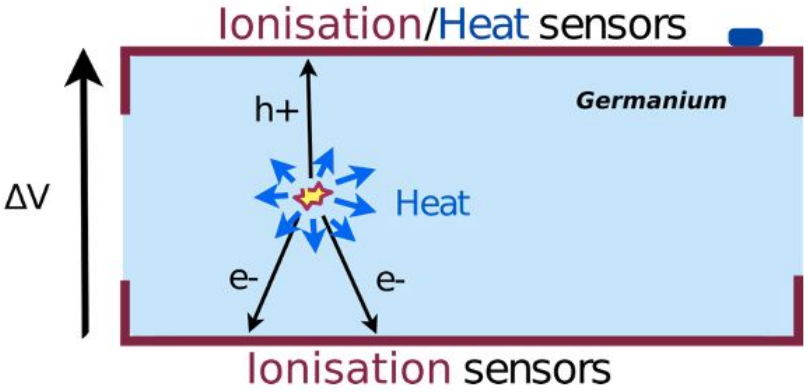
Fast and thermal neutron flux characterized :
RICOCHET Coll. EPJC **83** (2023), 20



Recoil type rate	Cosmogenic	Reactogenic	Total
R_{ER} (evts/d/kg)	9.5 ± 0.5	23.0 ± 1.6	32.5 ± 1.7
R_{NR} (evts/d/kg)	8.4 ± 0.4	1.0 ± 0.2	9.4 ± 0.5

Reactogenic neutrons negligible (~10%)
Targeted neutron background levels achievable to reach **S/B=1**

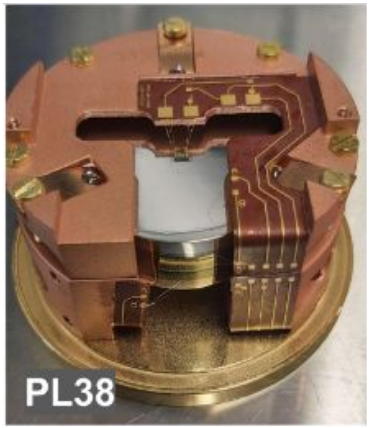
CryoCube detectors



Particle ID based on **Ionization/Heat** ratio

$Q = E_{ion}/E_{recoil}$

- Electronic recoils : Q = 1
- Nuclear recoils : Q ~ 0.3 (Lindhard)



Planar :
Fiducial volume = 98.6%

No surface events rejection

FID :
Fiducial volume = 62%

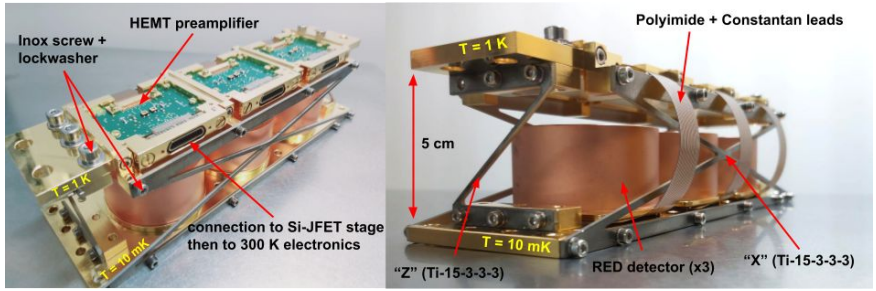
Surface events rejection

Final detector design will be based on on-site data-driven CEvNS sensitivity

CryoCube specifications

MiniCryoCube:

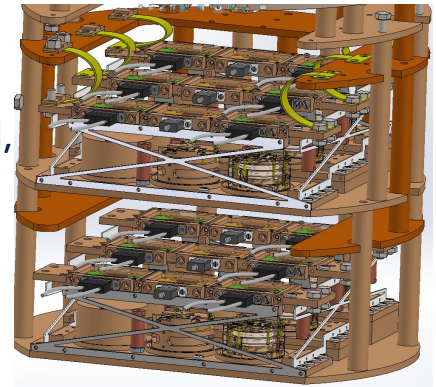
3 Ge bolometers with their cold electronics (1 K)



CryoCube (Spring 2025):

3 MiniCryoCubes per level, 2 levels

→ Array of 18 x 38 g @ ~10 mK



- Heat resolution: **20 eV (RMS)**
- Ionization resolution: **20 eVee (RMS)**
- Timing resolution: **~100 us @ 100 eV**
- Detector payload: **680 g**
- Two detector technologies: **planar and FID electrodes**

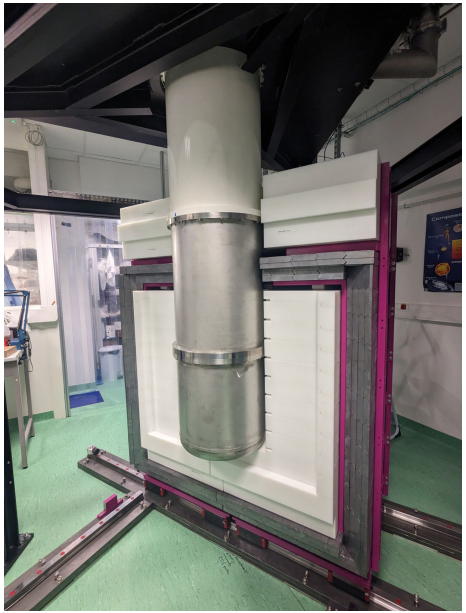
→ Achieve Particle ID down to O(10) eV with a rejection > 10^3

Paper on Ionization performances of the MiniCryoCube:

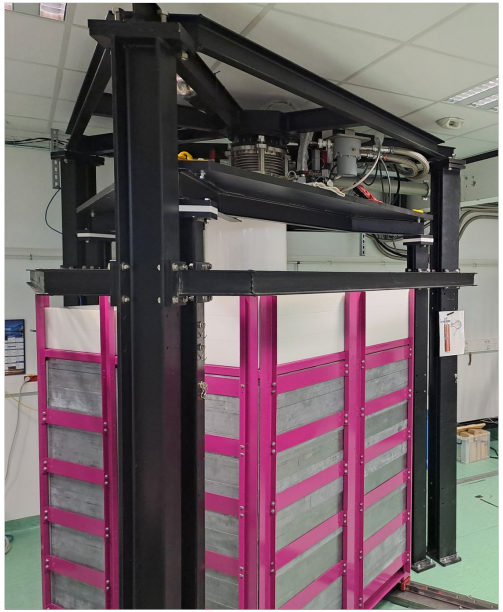
RICOCHET Coll. EPJC **84** (2024), 186

Commissioning @ IP2I

1 full MiniCryoCube with RICOCHET **dedicated electronics**



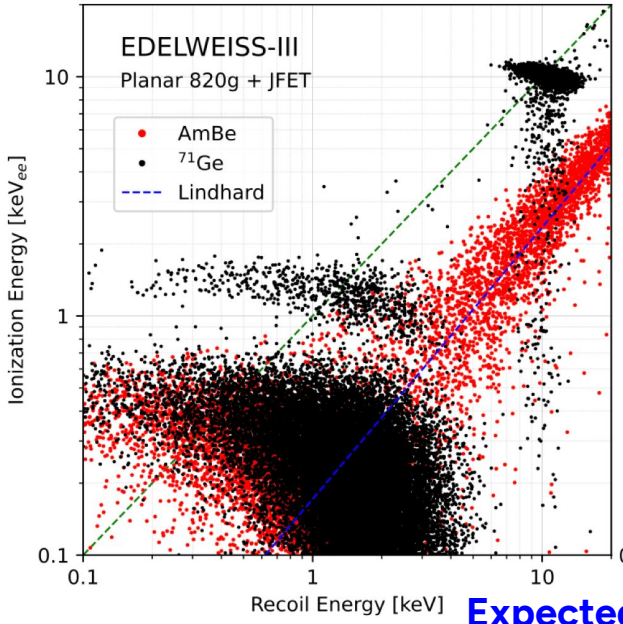
Shielding @ IP2I
Lead: **10 tons**
Polyethylene: **1.5 tons**



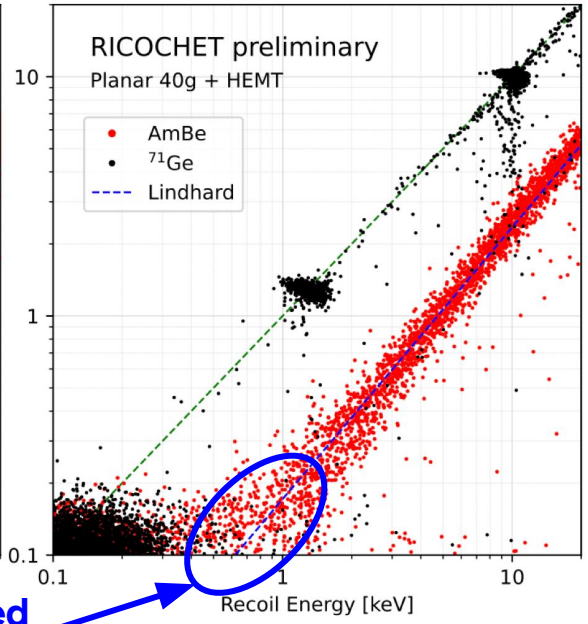
July 2023 - RUN010
September 2023 - RUN011
First detector runs in RICOCHET cryostat @ IP2I

Commissioning @ IP2I

Energy threshold: **4.5 keV$_{nr}$**
Ion threshold: **700 eV$_{ee}$**



Energy threshold: **300 eV$_{nr}$**
Ion threshold: **160 eV$_{ee}$**



Expected CEvNS signal

ER/NR discrimination threshold: **Improved by about one order of magnitude** w.r.t EDW

Heat and ionization resolutions: **~ factor 2 from RICOCHET final goals**

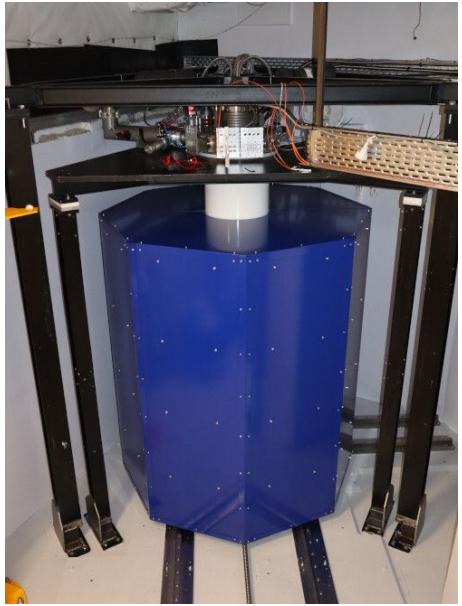
RICOCHET can now probe reactor neutrinos (CEvNS) with highly efficient LEE and ER rejection

Green light to go at ILL

Commissioning @ ILL

Outer shielding (Mar 2023):
Lead for gammas: **20 cm**
Polyethylene for neutrons: **35 cm**
Soft iron for magnetic field: **~1 ton**

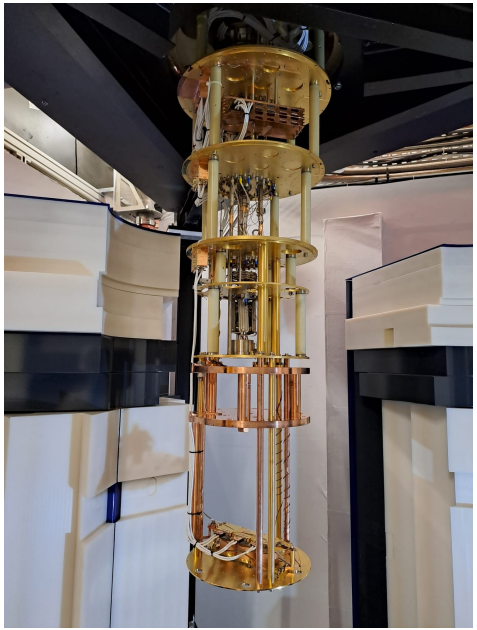
Cryostat installation:
Nov 2023 - Feb 2024

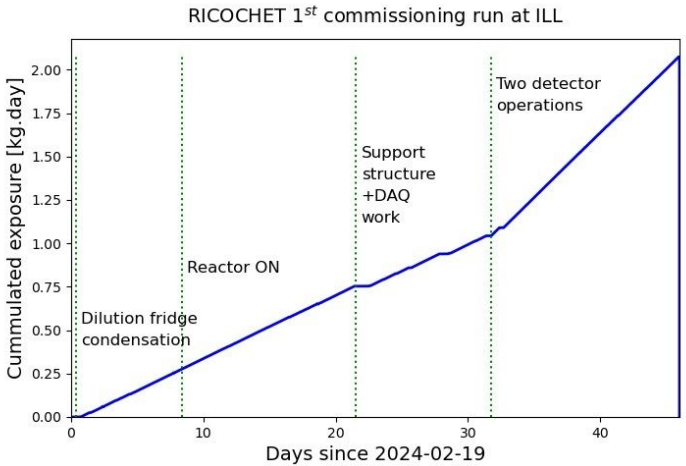


RUN012 (Feb 2024):
Cryogenic validation run
→ Minimum temperature without payload: **8.6 mK**

Commissioning @ ILL

RUN013 (Feb-Apr 2024):
First detector data taking





More than 1000 hours of data:
- On two different detectors
- Simultaneous data taking
- Reactor ON/OFF comparison
- No internal shielding

Vibration mitigation:
- Double frames (UQT)
- Damping pads
- 3rd frame for rotary valve and ballasts (RUN014)

Commissioning @ ILL

First in-situ detector performance assessment

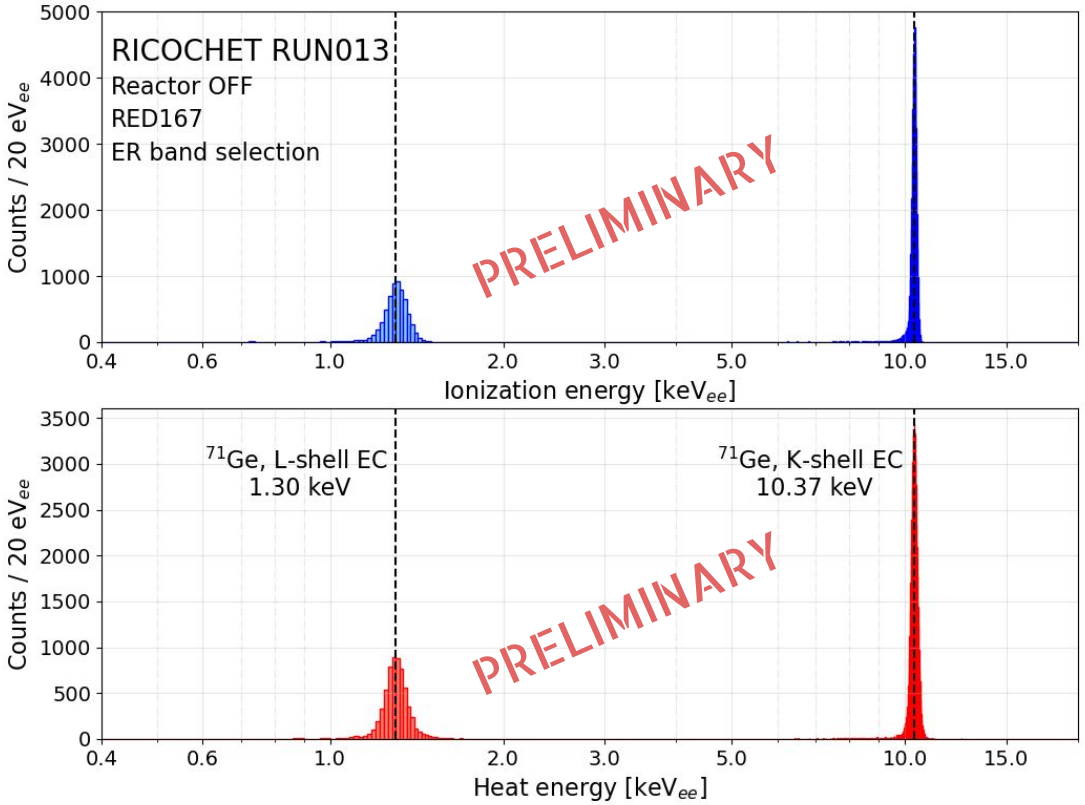
Reactor OFF data

Selection of ER events:

- Ionization energy:
  E_{ion} > 400 eV_{ee}
- Ionization yield:
  Q > 0.4

Baseline resolutions (preliminary):

- Ionization: 40-45 eV_{ee}
- Heat: 35-40 eV_{ee}



Commissioning @ ILL

Similar ON/OFF performances

First in-situ detector performance assessment

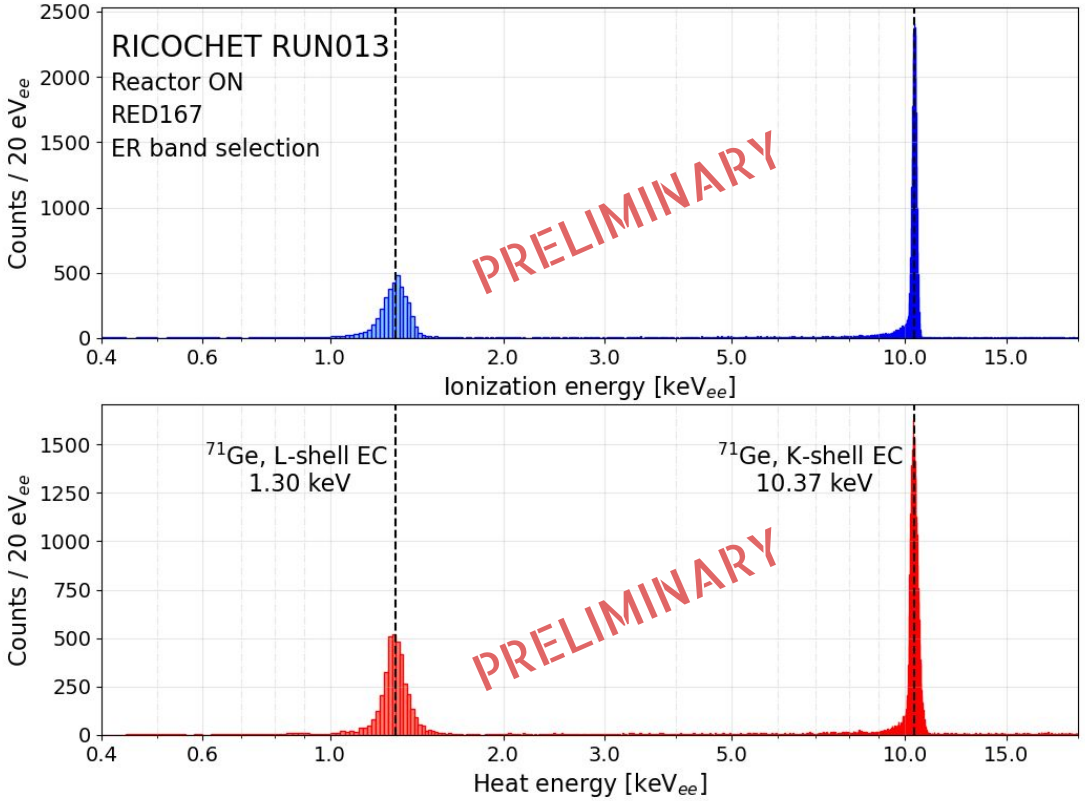
Reactor ON data

Selection of ER events:

- Ionization energy:
  $E_{ion} > 400\ eV_{ee}$
- Ionization yield:
  $Q > 0.4$

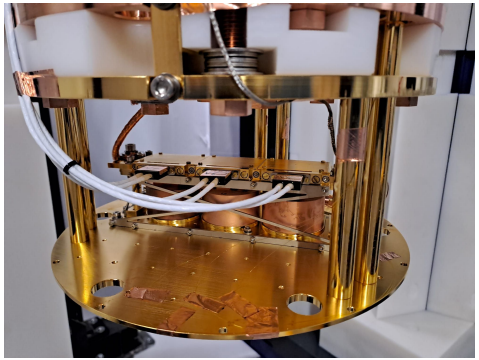
Baseline resolutions (preliminary):

- Ionization: 45-47 eV_{ee}
- Heat: 25-27 eV_{ee}

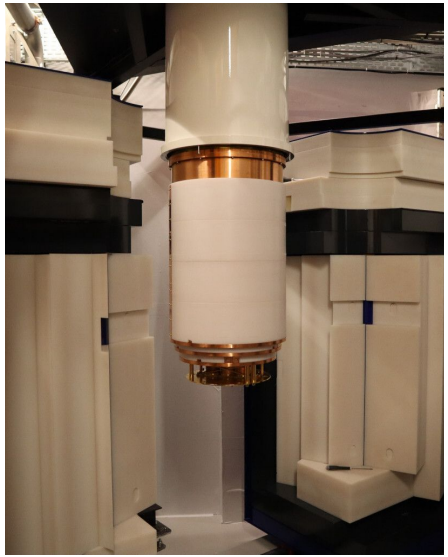


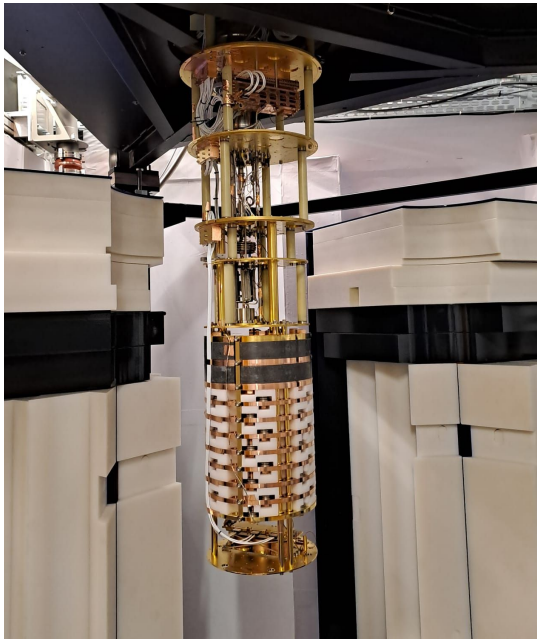
Commissioning @ ILL

RUN014, Cold and taking data since May 2024:
Goal : Characterize backgrounds with
full shielding and **improved vibration levels,**
towards **first data-driven CEvNS sensitivity**



Detector calibration and charge trap neutralization:
Optical fibers + LASER





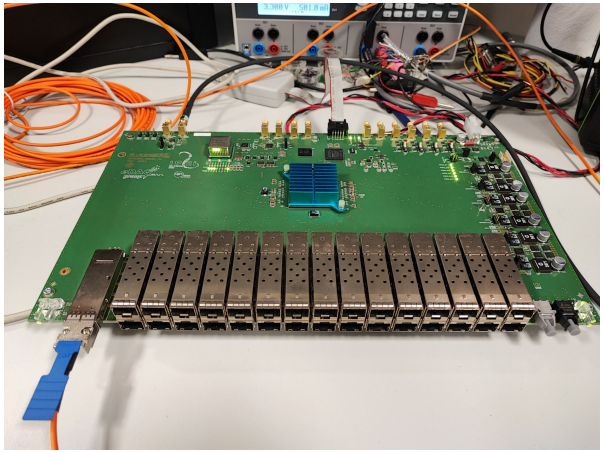
Inner shielding:

- PE/Screen: **3x8 mm, 50 cm**
- Lead + Copper stack: **15 cm**
- PE + Copper stack: **30 cm**

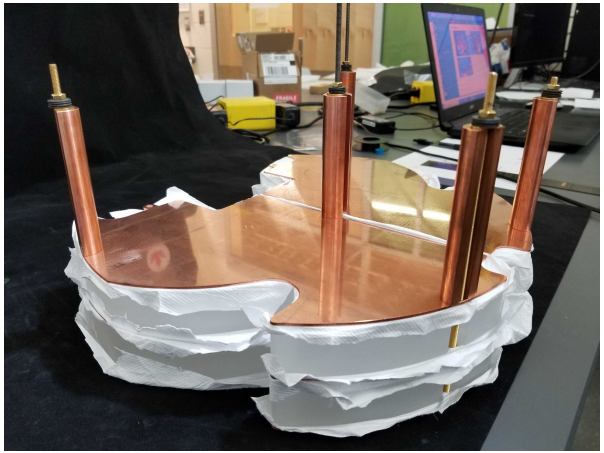
10.5 days to cool down @ 1K

Commissioning @ ILL

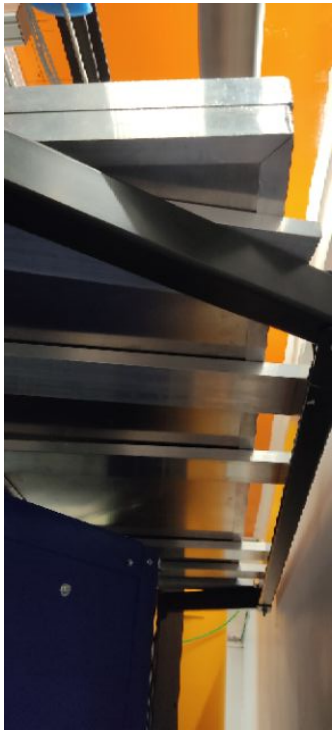
Next steps to complete the RICOCHET background mitigation strategy:
Muon veto and synchronization



Synchronization board:
Common clock for all acquisition cards and muon veto systems

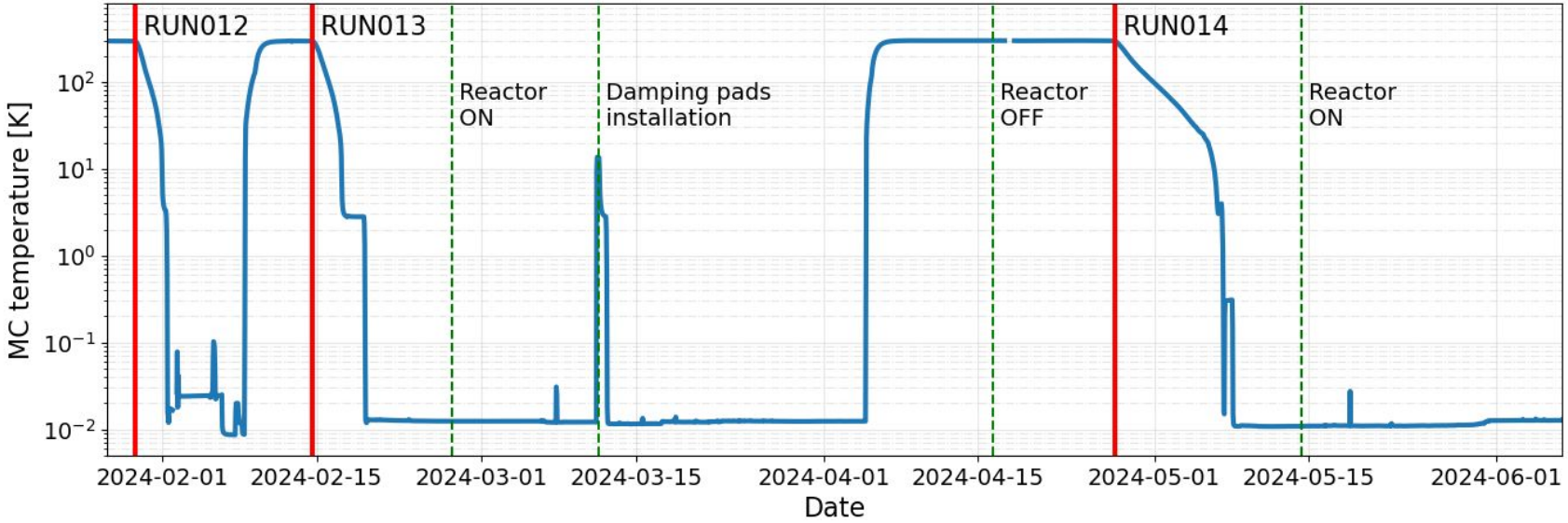


Cryogenic muon veto:
EJ-206 scintillator (6cm) @ 4K cryogenic stage
Read with SiPM



Outer muon veto:
Two-layered scintillators
Top panels installed
Side panels to come

Summary of ongoing commissioning



RUN012:
Validation of cryogenics (8.6 mK)

RUN013:
Detector performance assessment (ON/OFF) and vibration mitigation

RUN014:
Background characterization with full shielding

Prospects

2024:

- Finalization of outer and cryogenic muon veto installation
- Commissioning of readout electronics and synchronization
- First data-driven CEvNS sensitivity estimation from commissioning phase

Spring 2025:

- Completion of the full CryoCube payload and dedicated electronics
- Beginning of the RICOCHET CryoCube neutrino science phase

2025-2026:

- Cumulate 7 ON/OFF reactor cycles to achieve nominal exposure

Thanks!

is taking data, stay tuned!