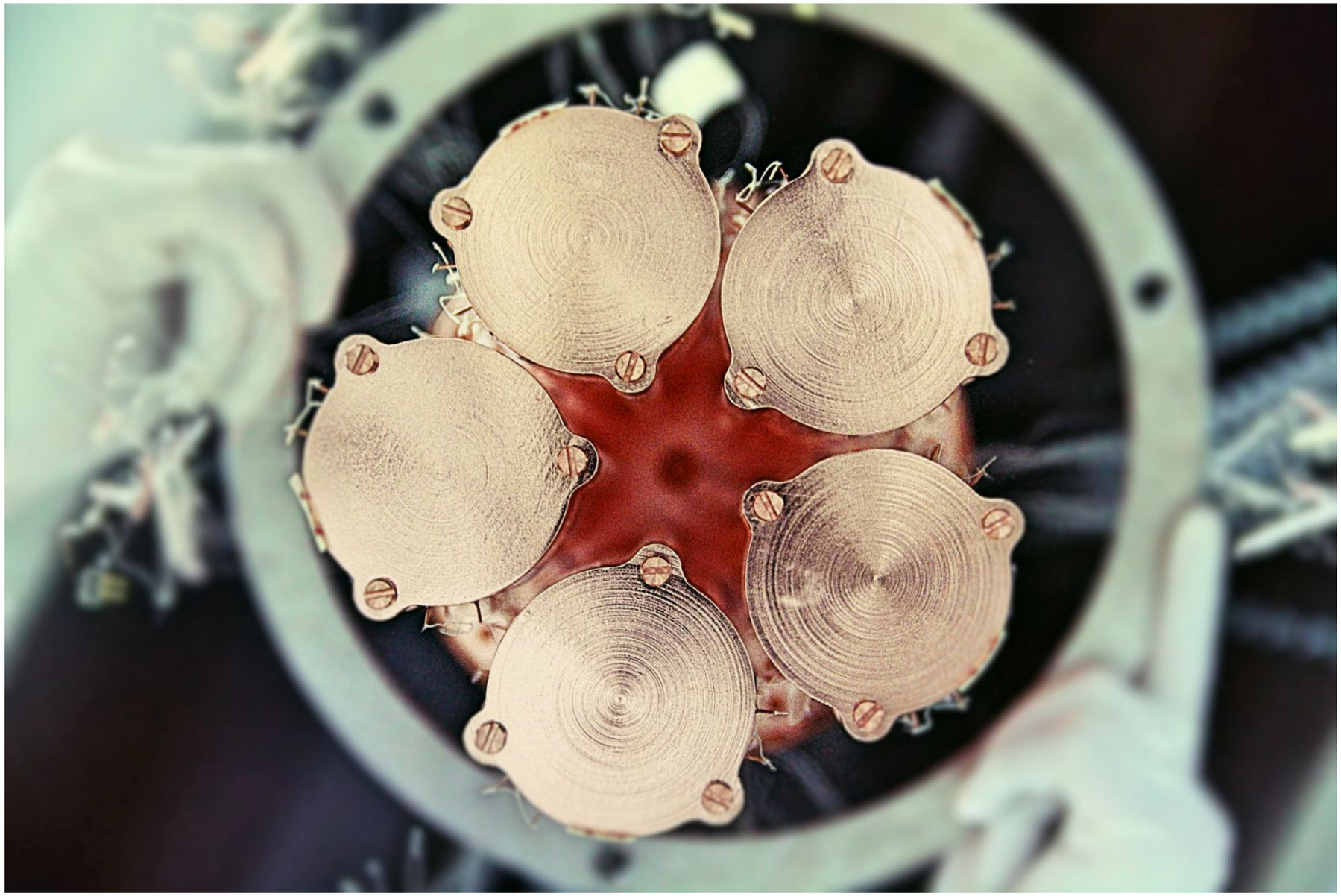
CUPID-0

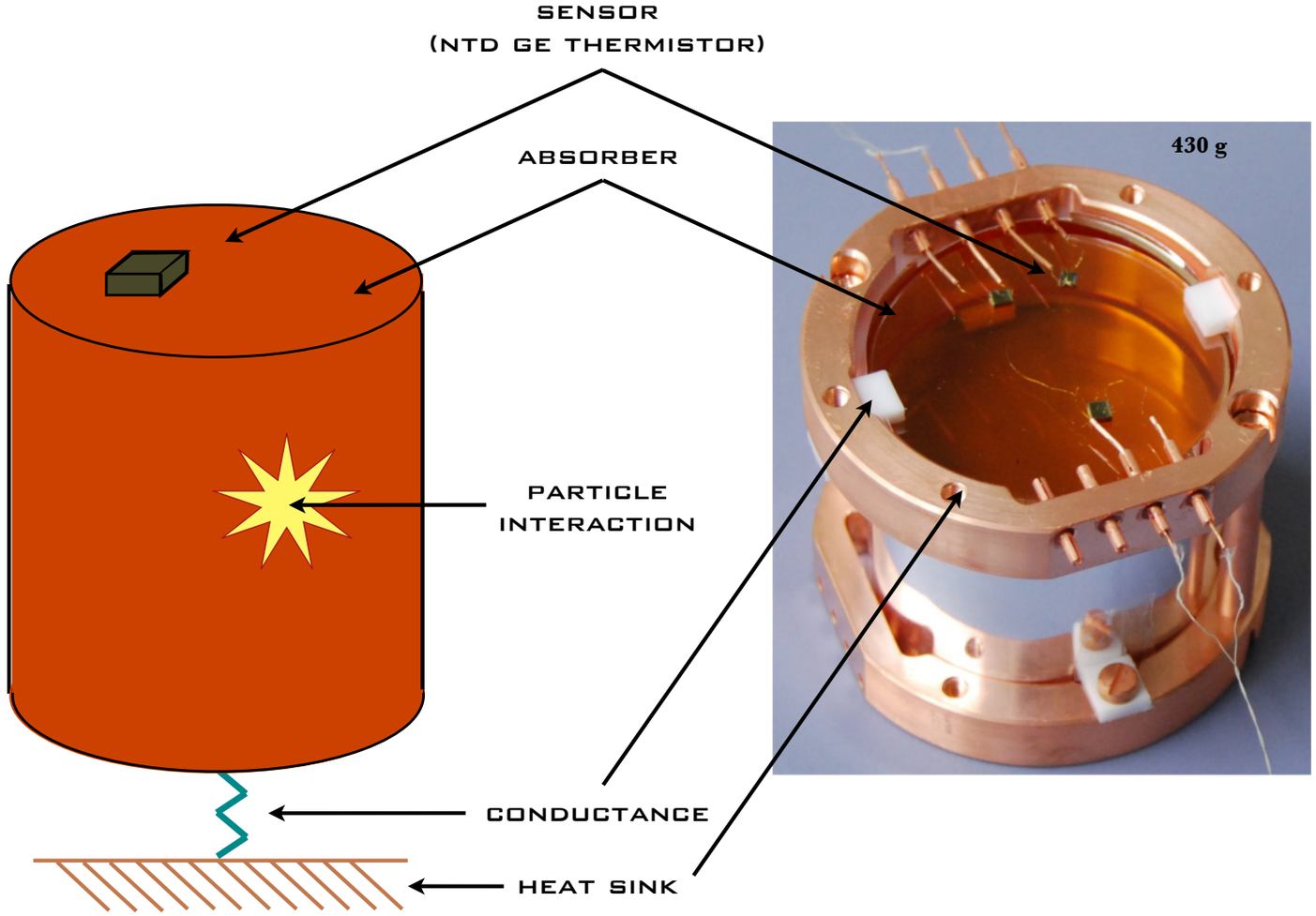


Laura Cardani on behalf of the CUPID-0 collaboration

3 April 2017

Cryogenic Calorimeters with Particle ID

- Study **^{82}Se** 0nDBD: high Q-value ~2998 keV
- Natural Se enriched in ^{82}Se from 8.7% to 96.3% (arXiv:1702.05877)
- ^{82}Se embedded in **Zn^{82}Se crystals** to be operated as **cryogenic calorimeters**

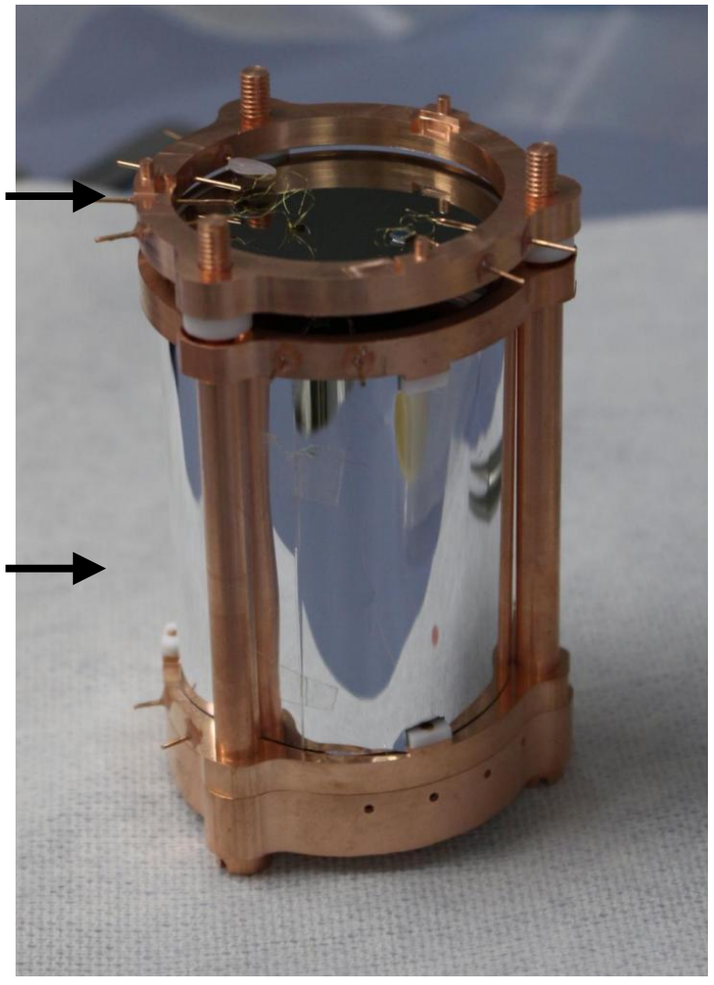


- Good energy resolution
- Containment efficiency >80%
- Scalability

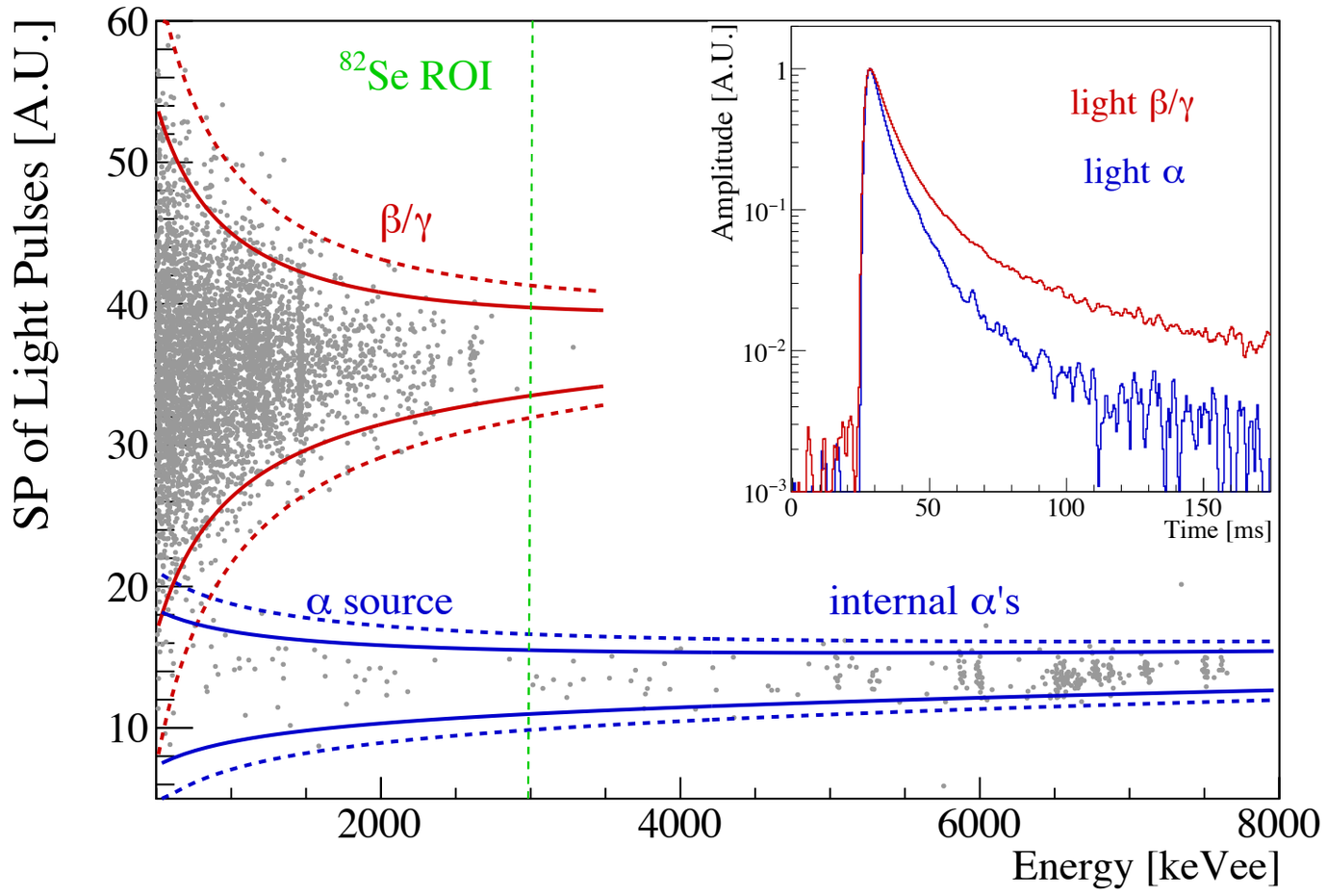
Cryogenic Calorimeters with Particle ID

LD
h=150 μm
Ge coated Si

ZnSe
wrapped with
3M Vikuti™

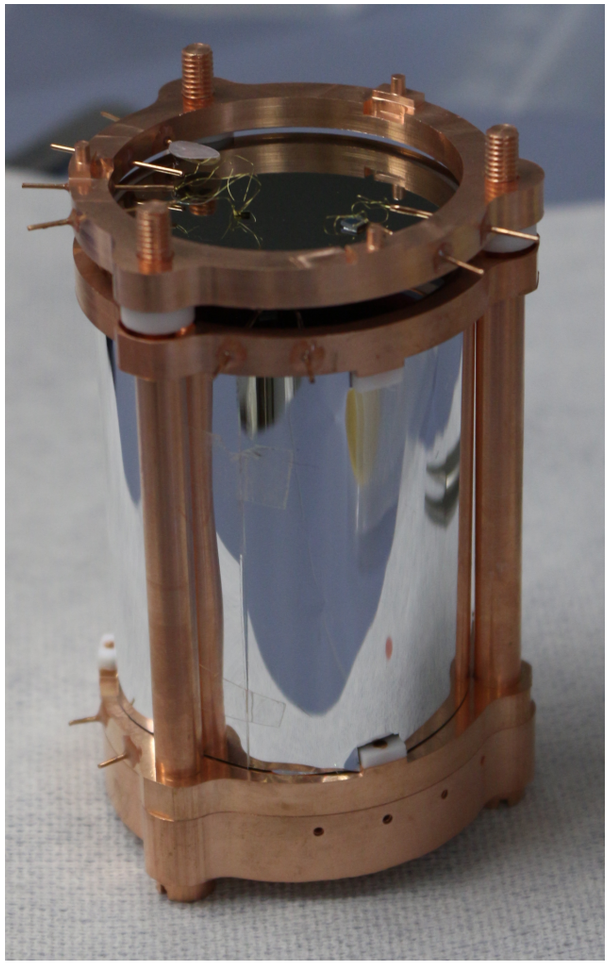


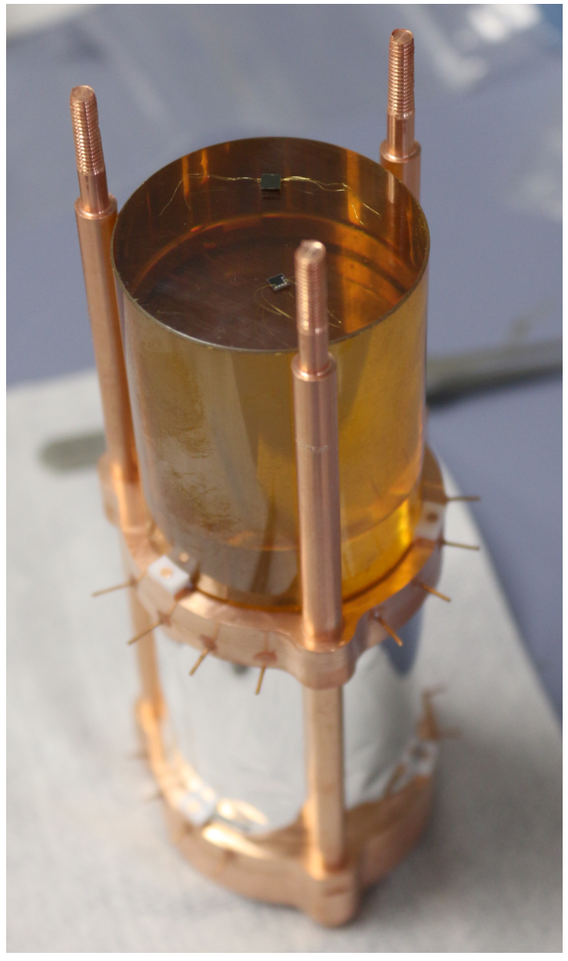
Eur.Phys.J. C76 (2016) no.7, 364



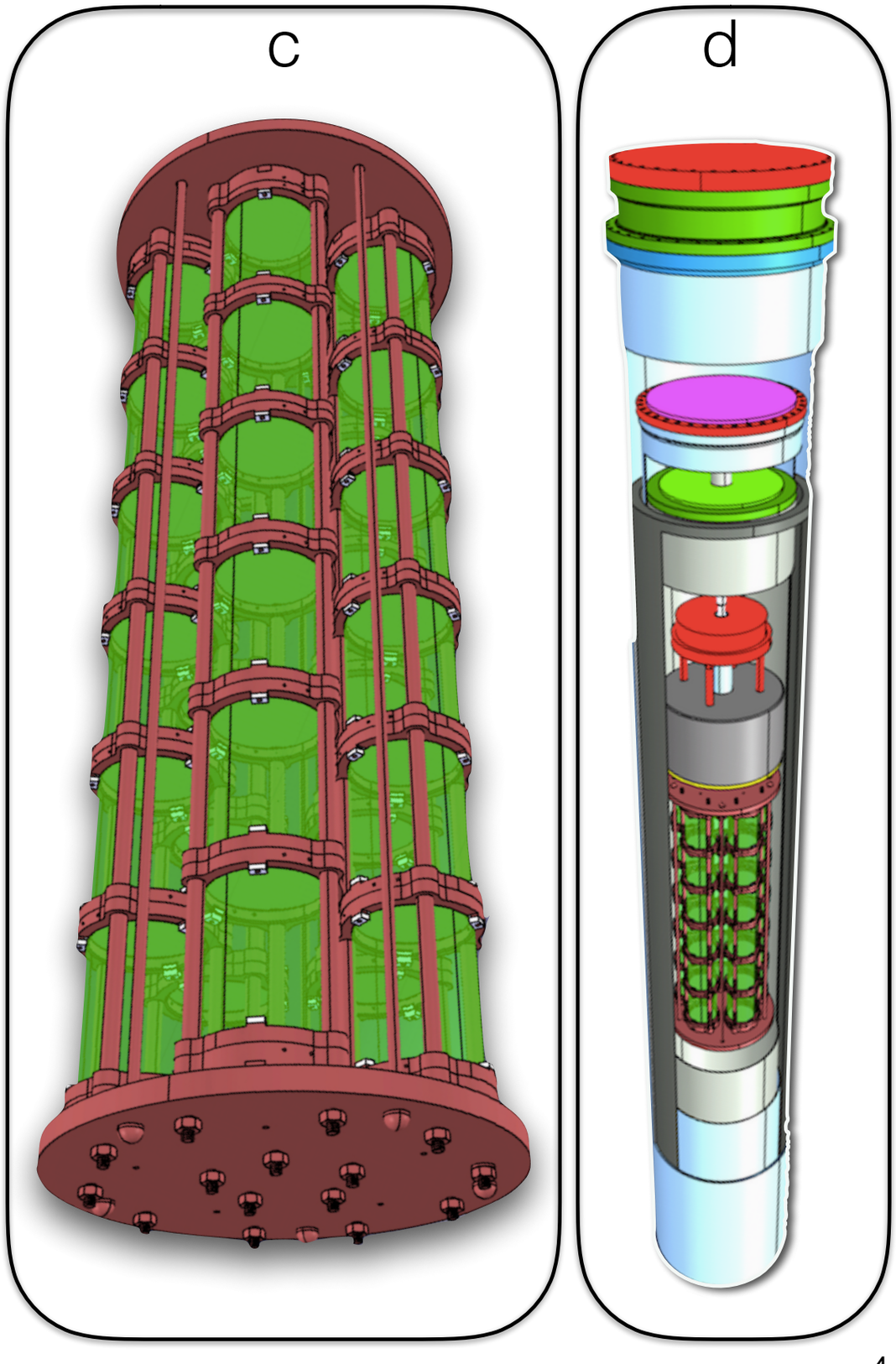
- **α's** produced by the detector material are the dominant background —> Particle ID
- Exploit **scintillation light** produced by ZnSe to **reject α's**
- Light detectors: Ge crystals operated as calorimeters

CUPID-0 Detector



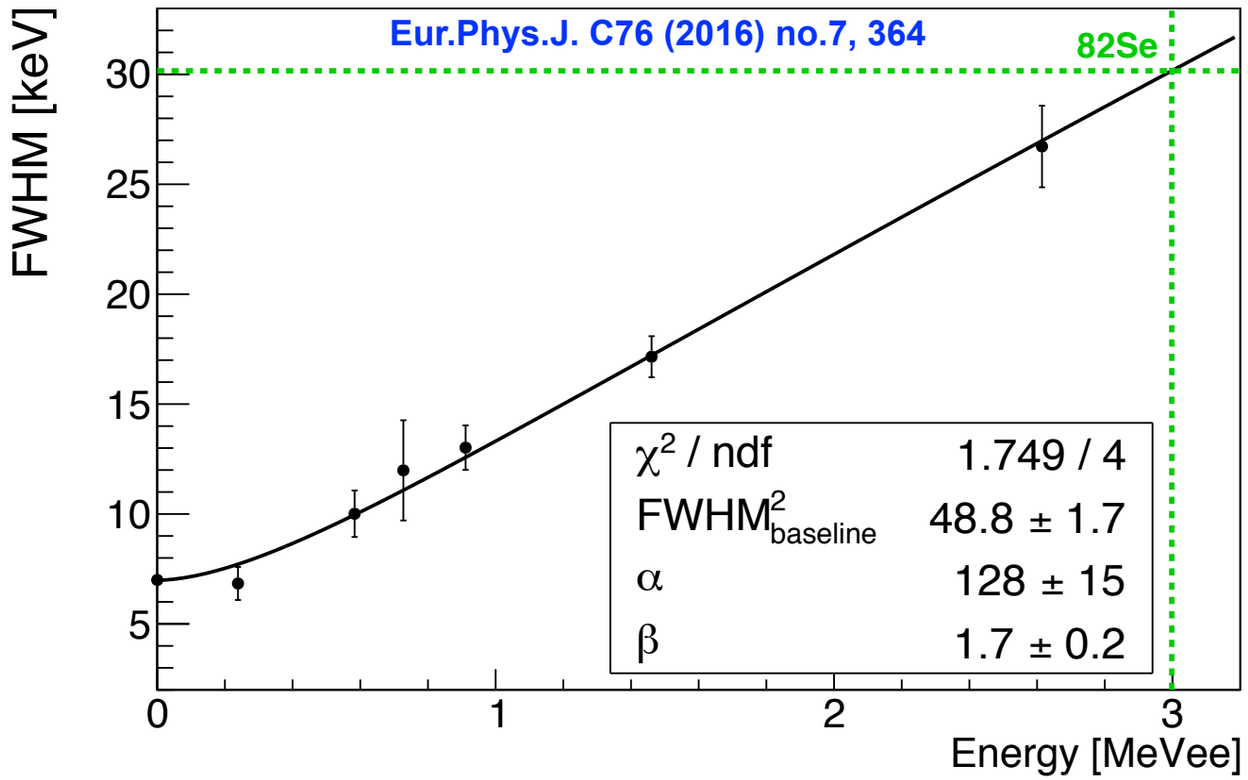


- CUPID-0 scales up this technology
- Modular ~10kg scale detector in Hall-A cryostat
- Data-taking has just started!



Where we were…

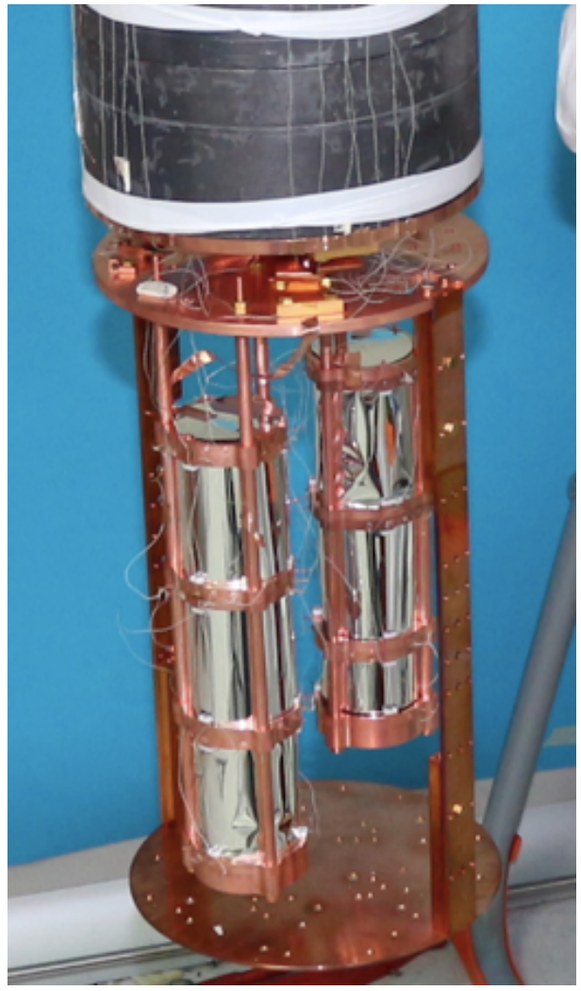
Maura Pavan's talk, scientific committee April 2016

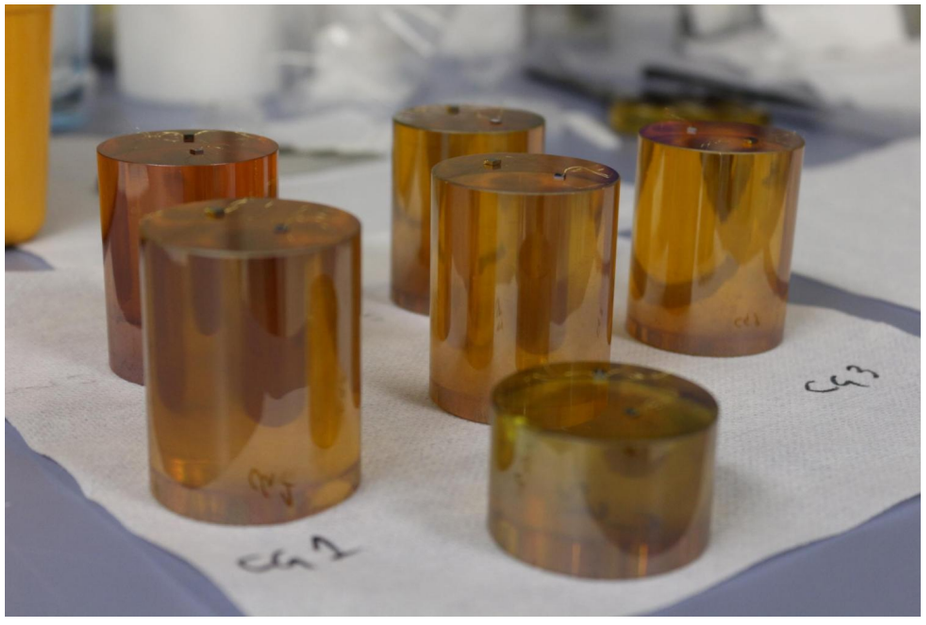


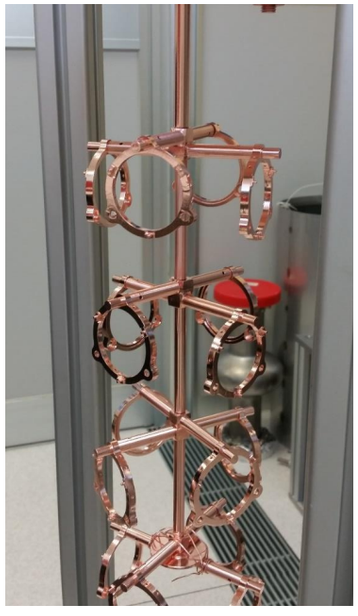
- 3 $Zn^{82}Se$ tested in Hall C R&D cryostat (20 mK instead of 5 mK)
- Reproducible FWHM at ^{82}Se Q-value of ~30 keV (not opt.)
- Complete rejection of α background
- Study of internal contaminations: ok for our target

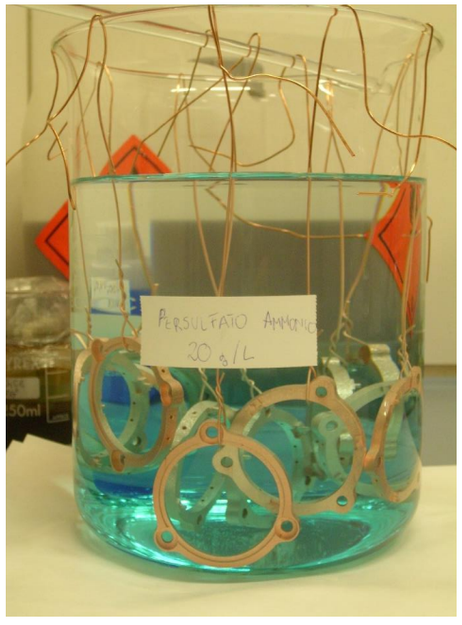
What we worked on

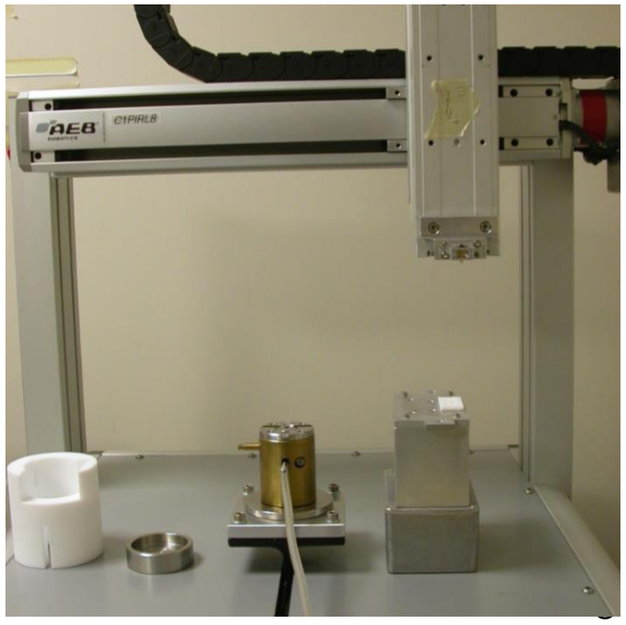
- Refurbishment and commissioning of Hall-A cryostat
- Growth, cut, polishing of all the $Zn^{82}Se$ crystals and LD
- Construction and cleaning of all detectors parts
- Development of dedicated tools for detector assembly (gluing, construction, storage…)
- Detector cooling and operation





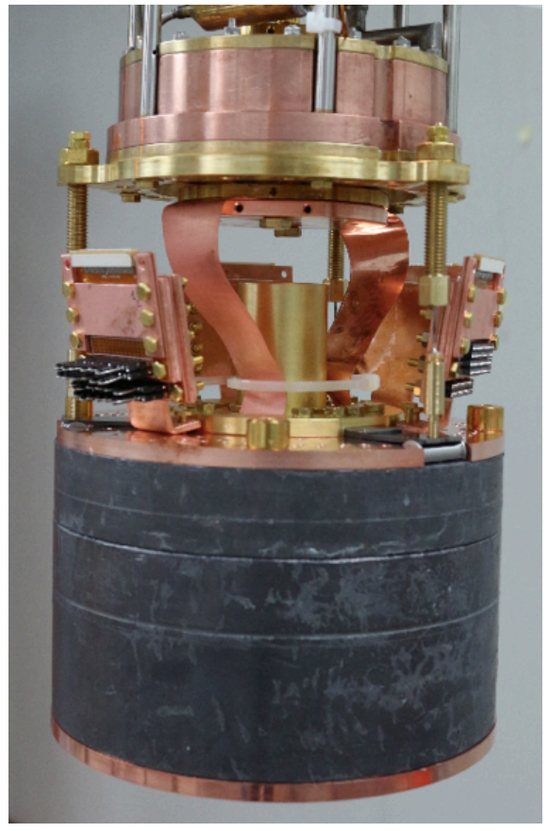


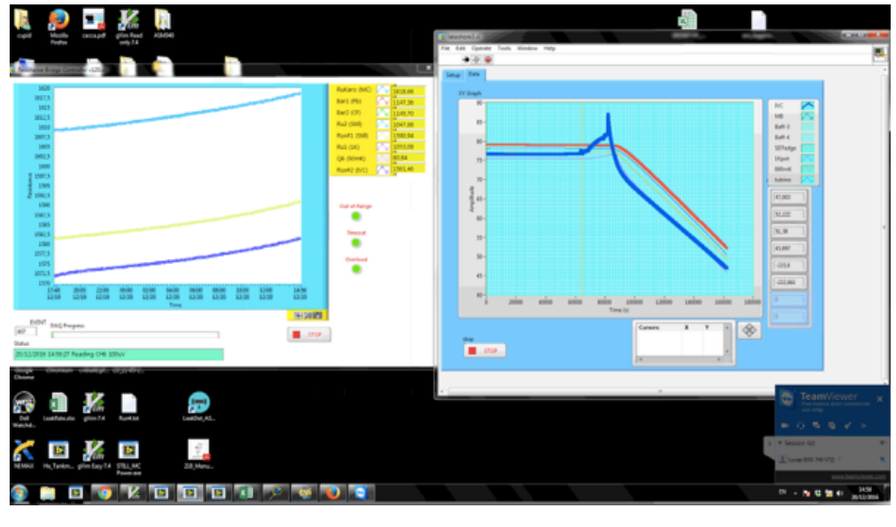




Cryostat commissioning

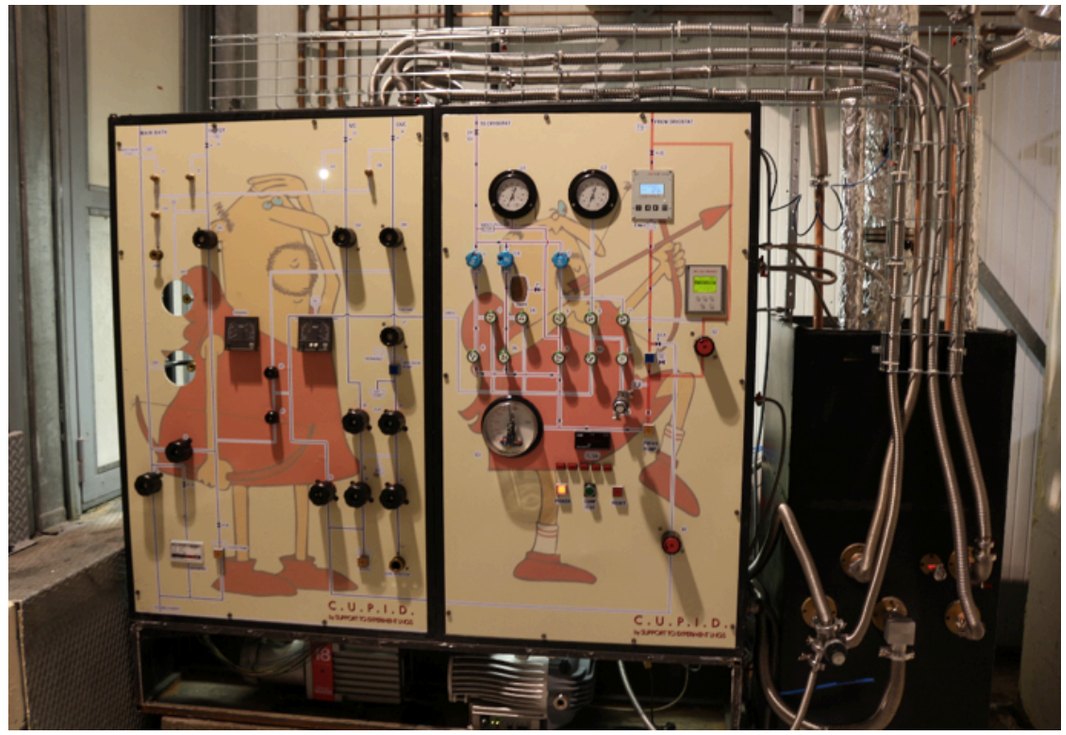
- Read-out: 136 channels available [67 used]
- New suspension for noise suppression
- Fixed old leak in the line for mixture condensing
- Electropolishing and passivation of Cu shields
- Thermometry system
- Calibration sources system: versatile (different sources), Rn-leak tight
- Monitor of the cryostat parameters
- Fixed cryostat verticalization system





Cryostat refurbishing

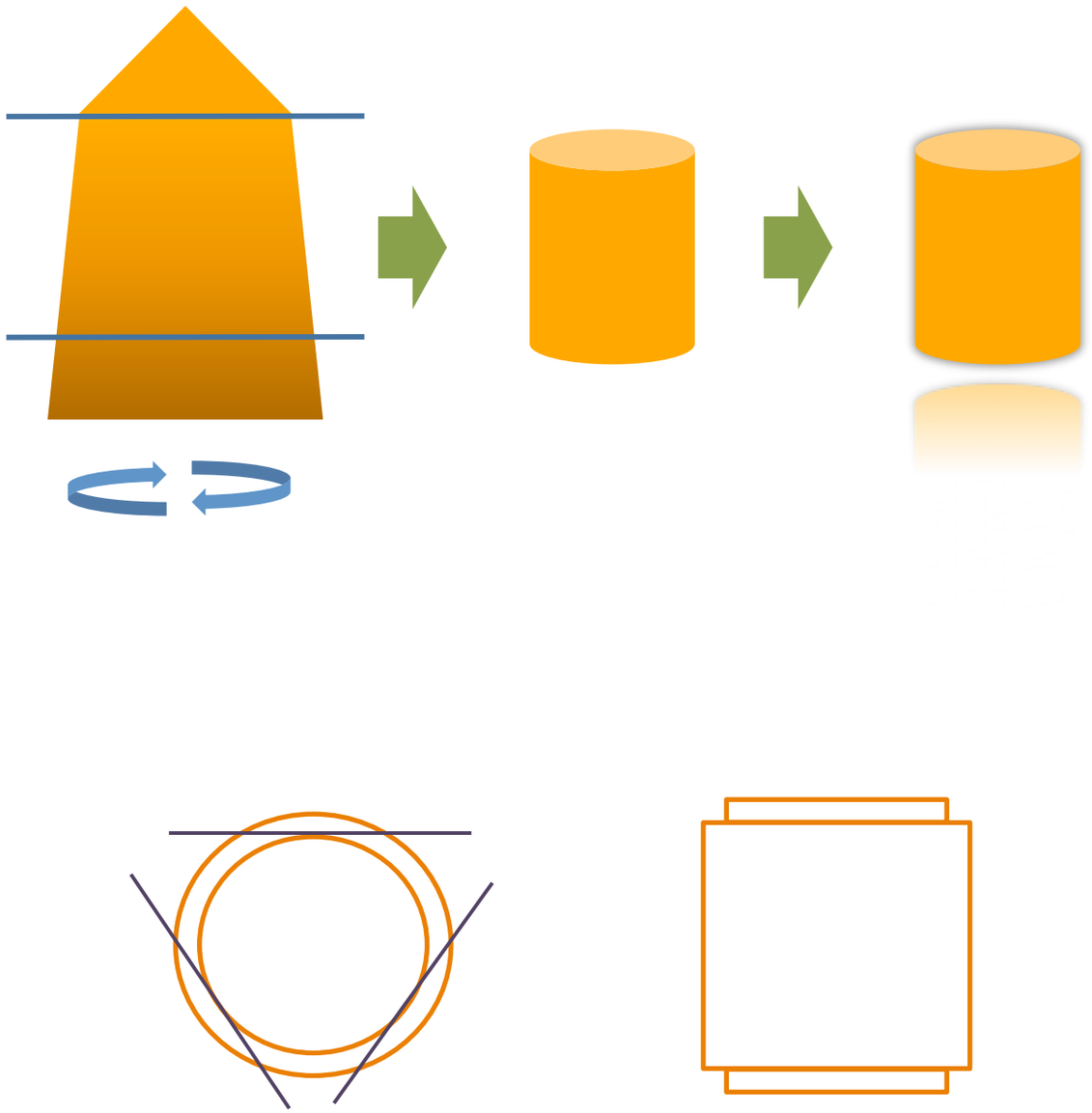
The Hall-A cryostat is very old and experienced many thermal cycles



- **May 2016: leak**
- **June 2016: thermal short-cut at 600 mK**
- **July 2016: not base temperature (~9 mK)**
- **August 2016: test of new wiring (ok) but new leak**
- **October 2016: other tests to find leaks**
- **November 2016: other tests to find and fix all leaks**
- **December 2016: all problems solved, start cooling**

Crystal Cut and Polishing

The entire process of crystal cut and polishing were made at LNGS



- Irregular shape to spare as much ^{82}Se as possible
- Several operations to simplify assembly:
  - Cut of 2 parallel faces and machining of the lateral surface (conic shape)
  - Creation of two 44 mm diameters ring
  - Cut 3 slices on lateral side

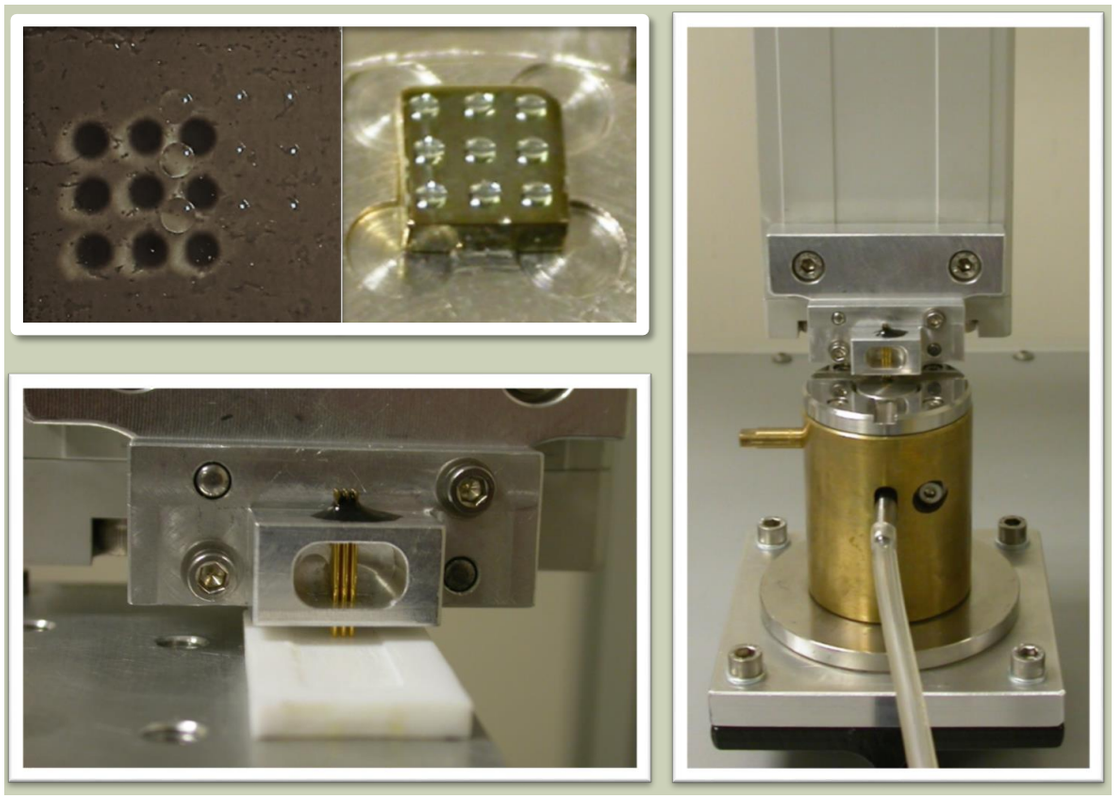
Polishing in DarkSide underground clean-room.

Thanks!

Sensors Gluing

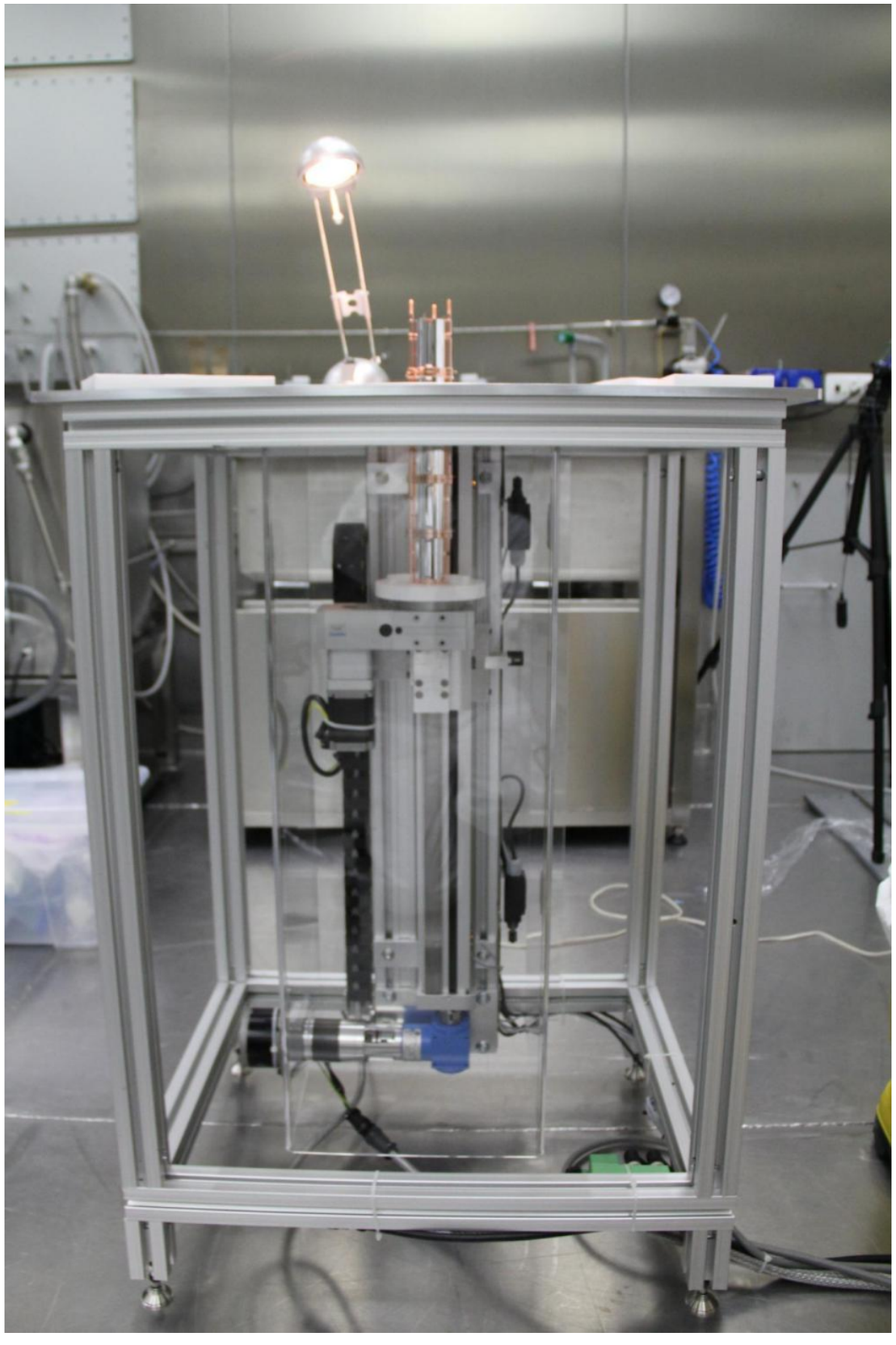
Glue of thermal sensor on each detector (ZnSe or Ge light detector)

Sensor: NTD Ge thermistor attached via glue spots

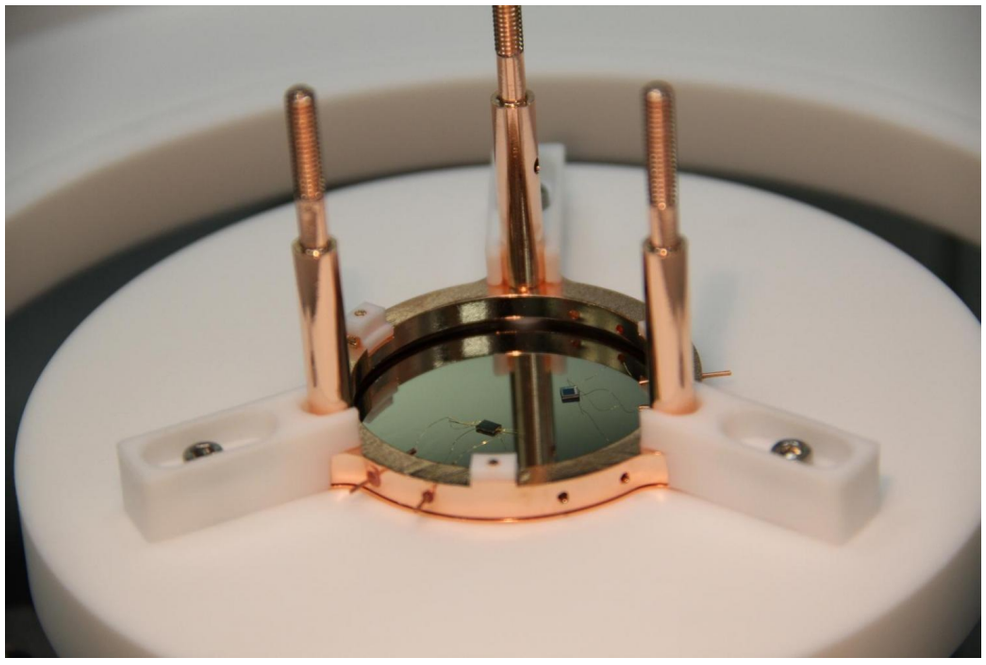


- ZnSe crystals different sizes
- LD and ZnSe thermistors different sizes
- Radio-purity

Detector Assembly



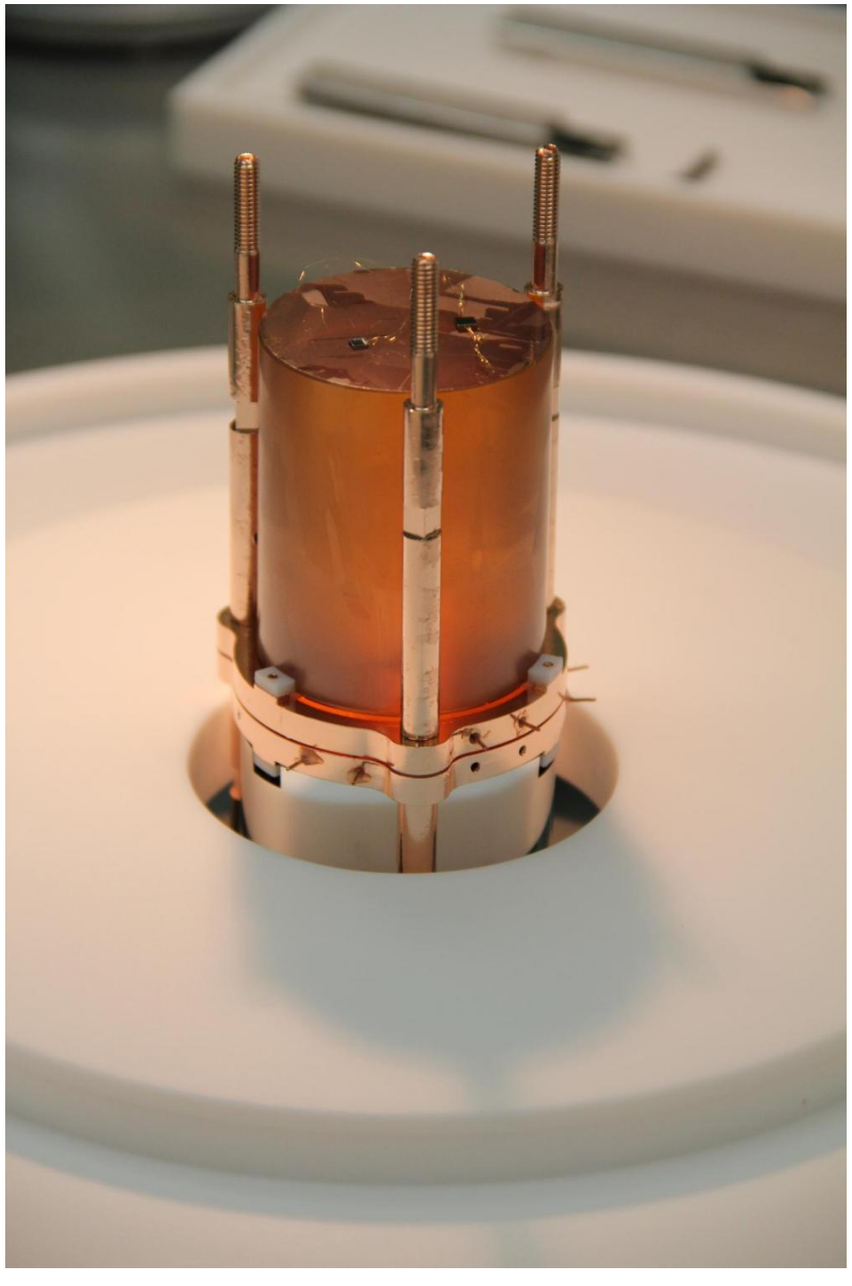
We developed many custom tools for a radio-pure detector assembly in underground clean-room

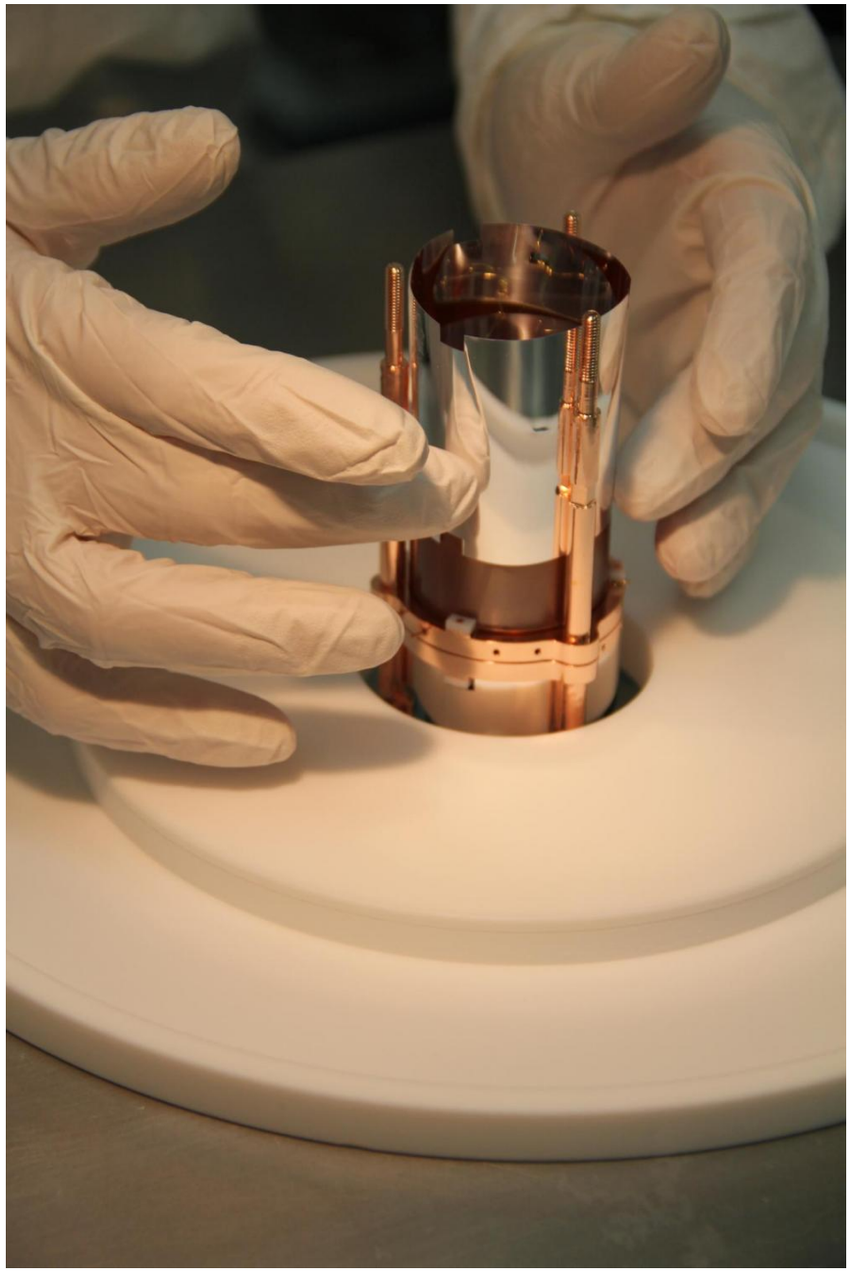


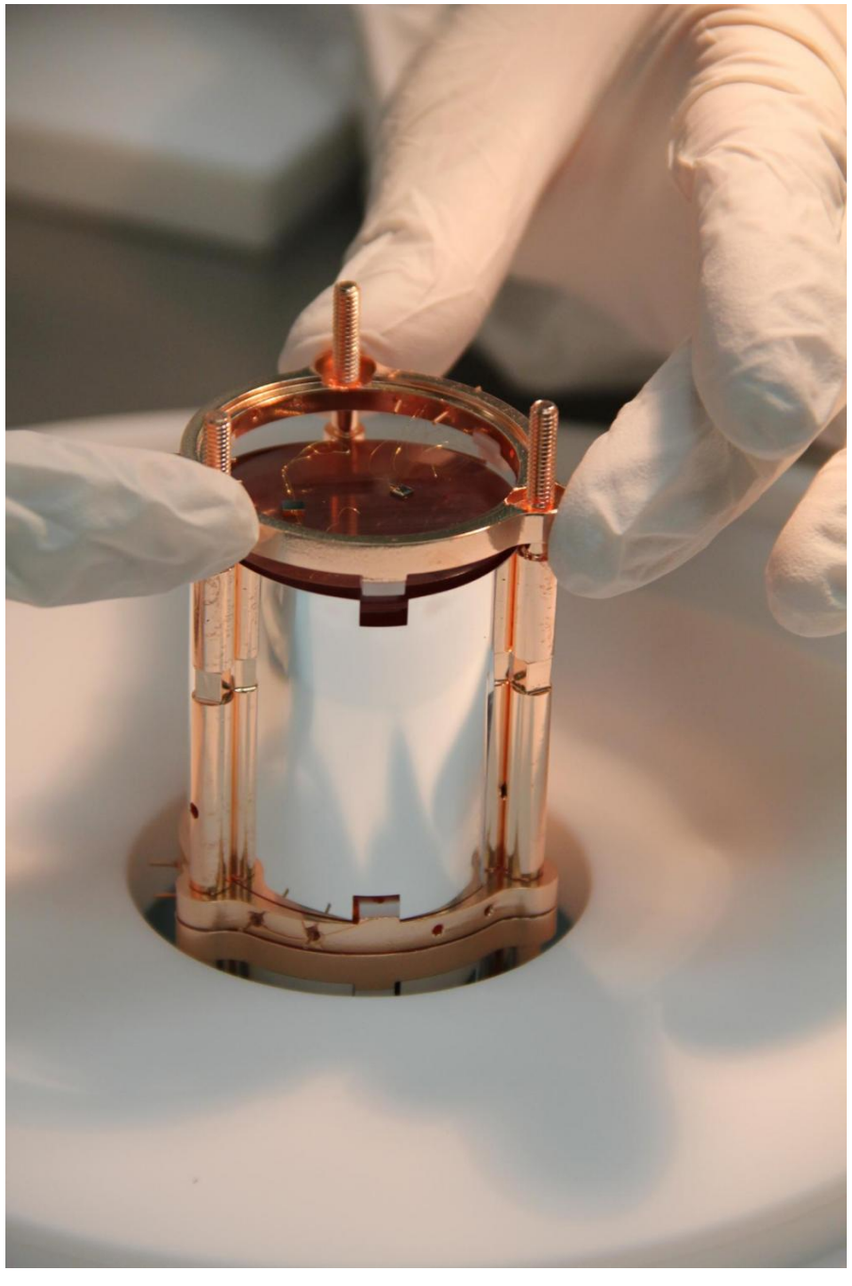
Each tower begins with a Ge light detector (previously assembled)

Mount copper columns

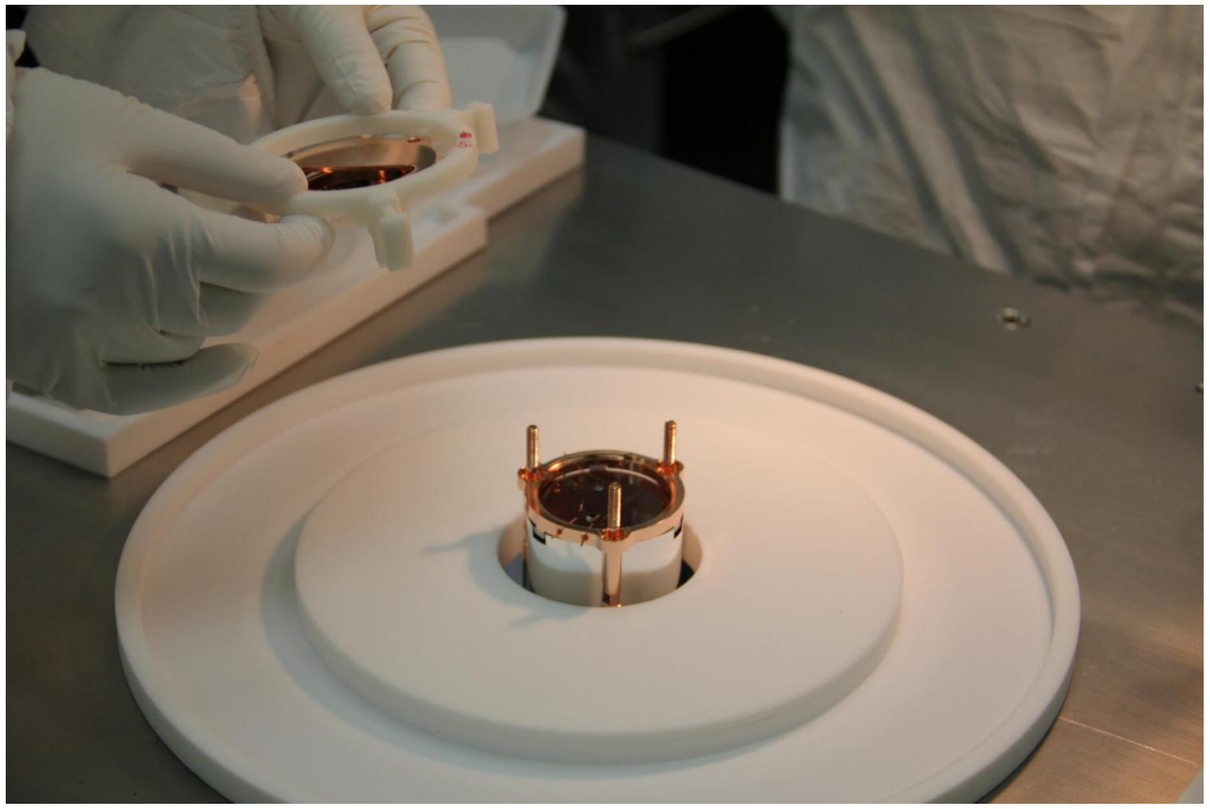
Detector Assembly

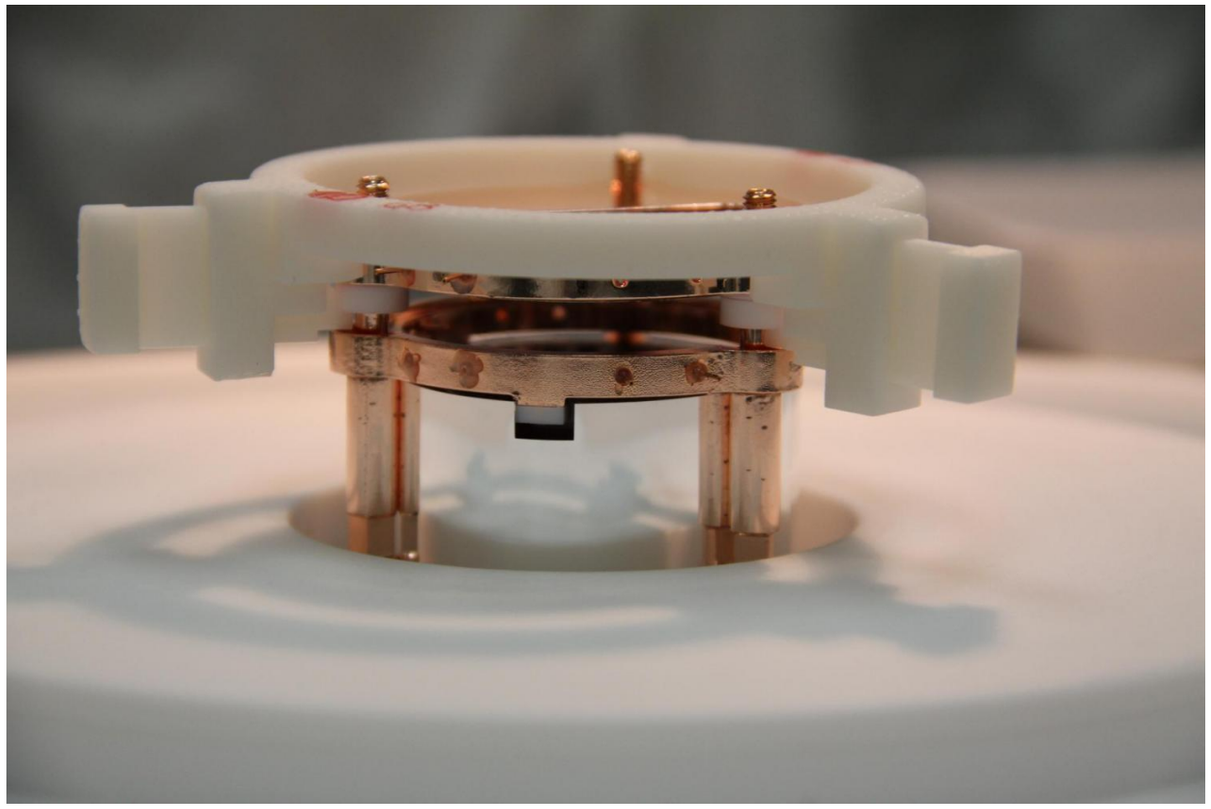


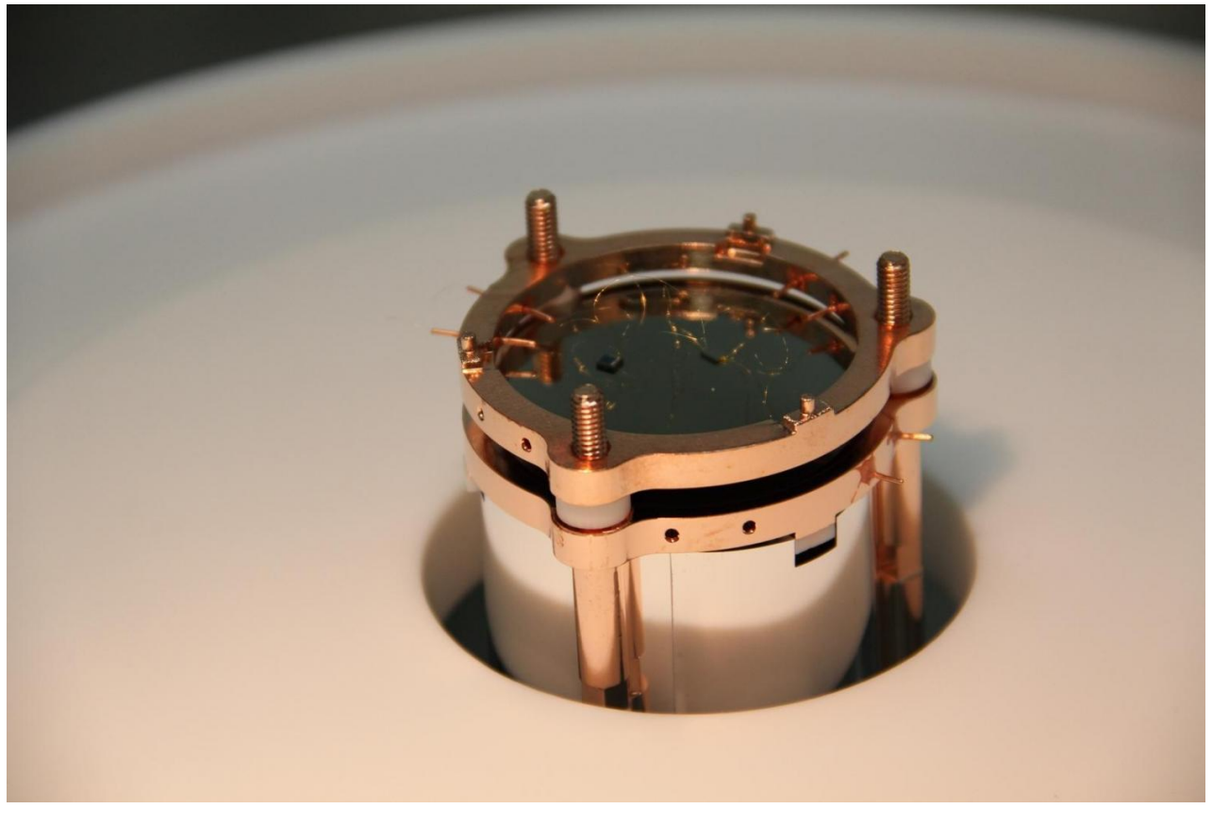




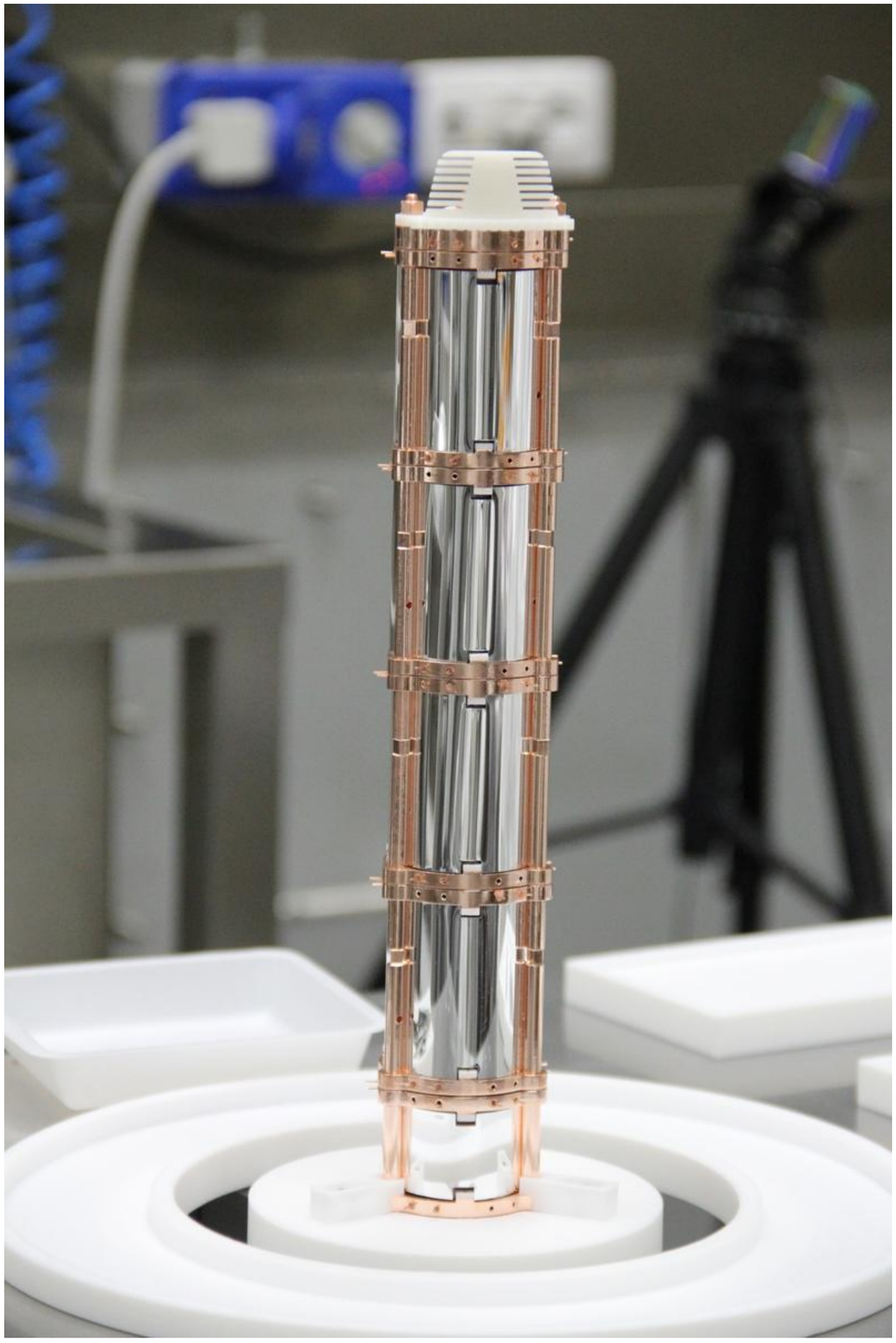
Detector Assembly

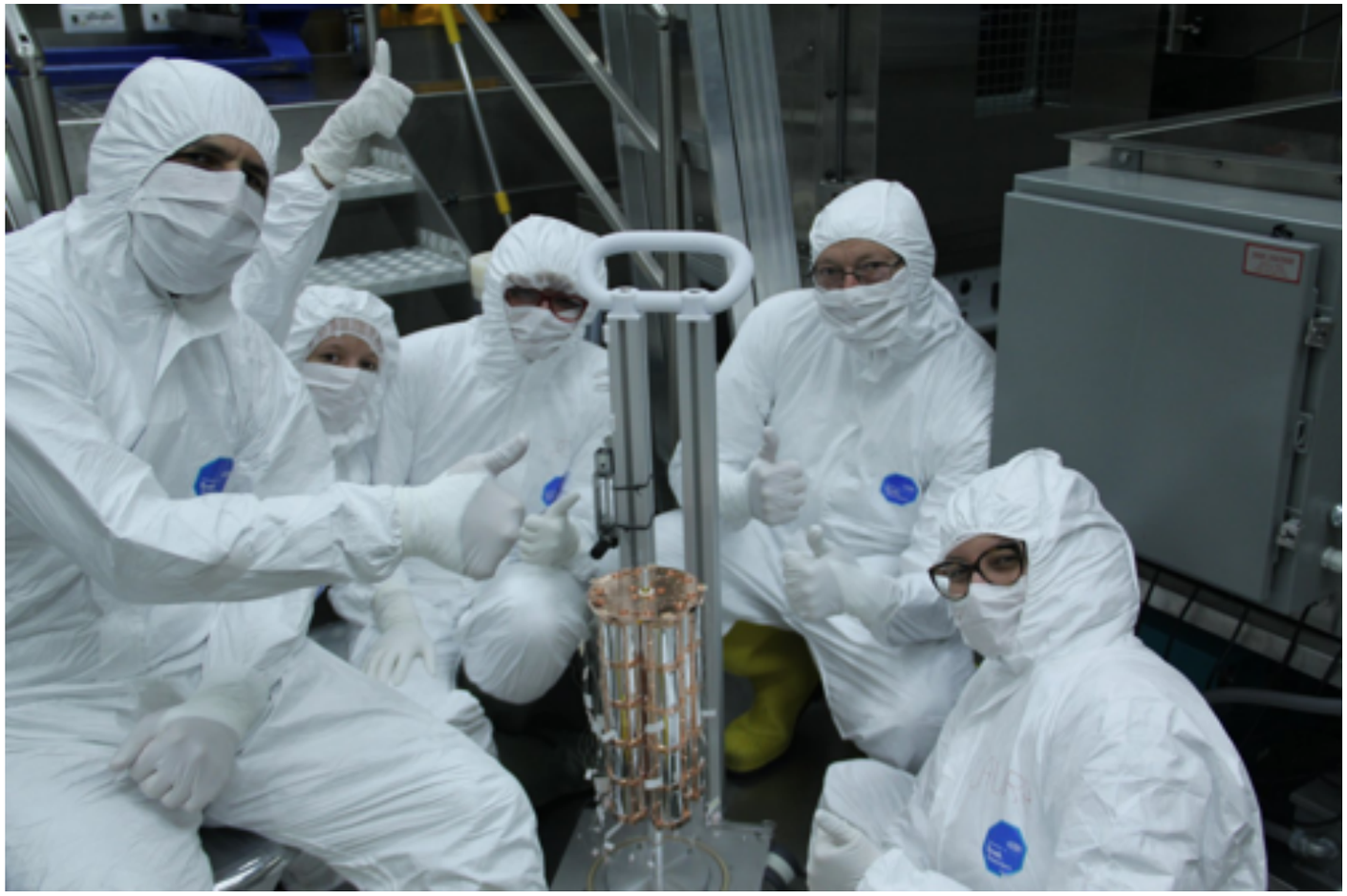






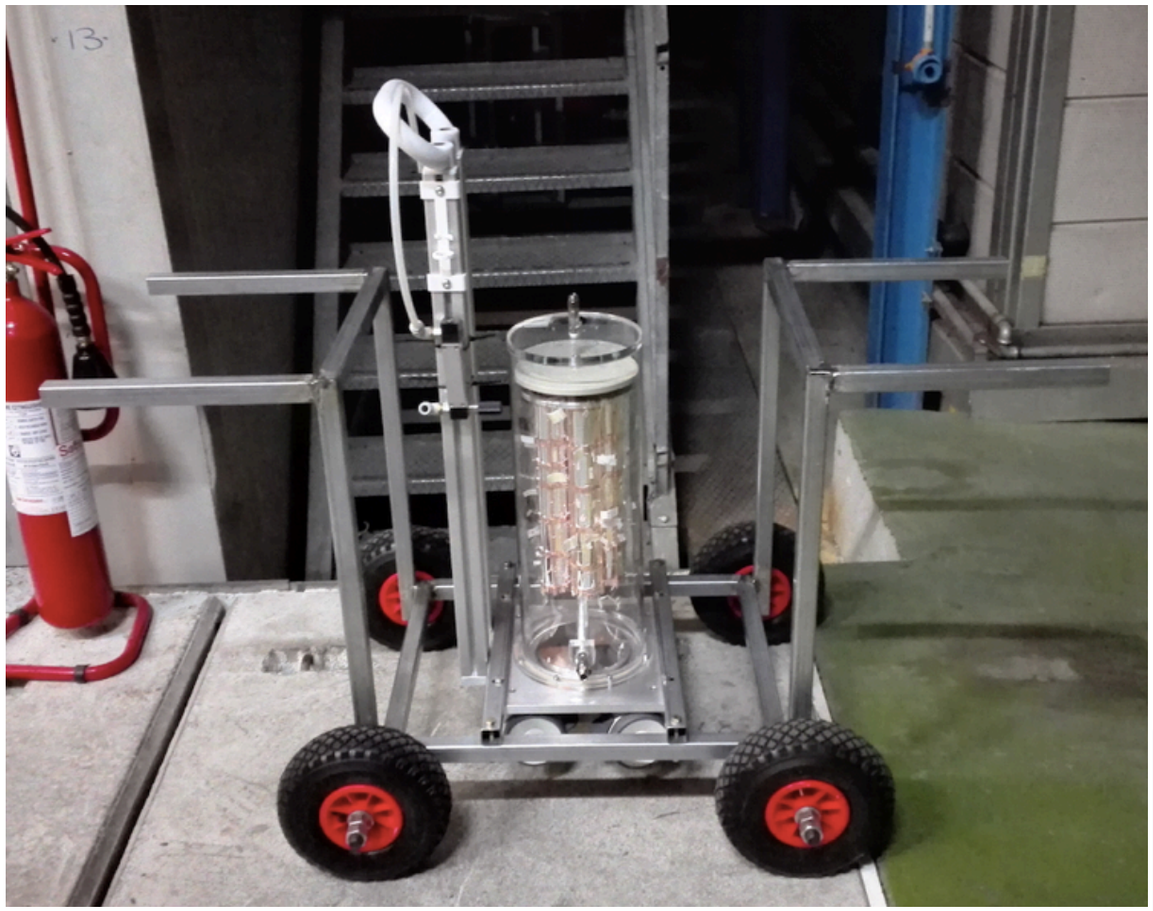
Detector Assembly





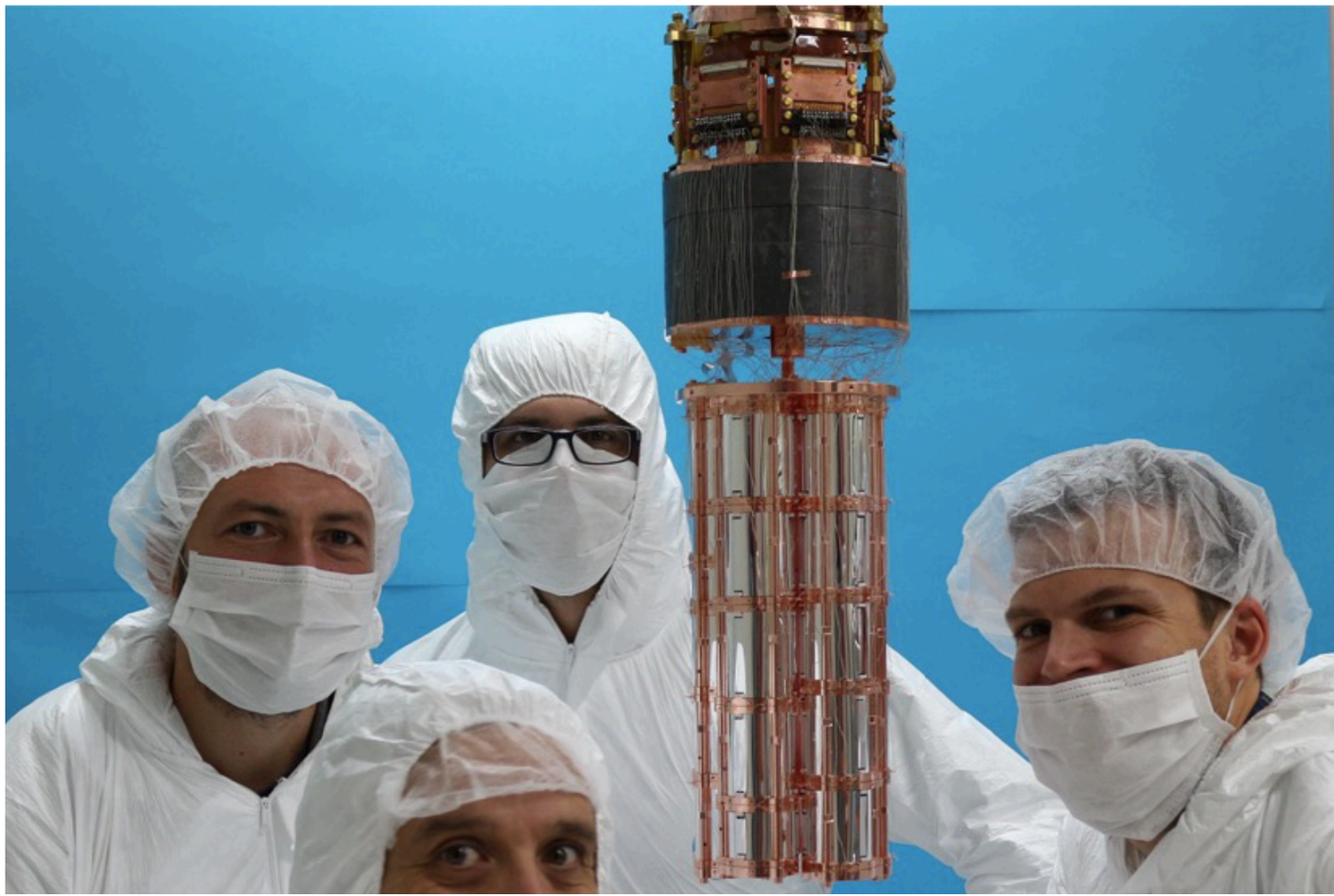
- 24 Enriched ZnSe crystals + 2 natural ZnSe
- 10.5 kg ZnSe (5.17 kg of ^{82}Se)
- CUPID-0 is a demonstrator, still it features **3.8×10^{25} 0nDBD emitters**

Detector Cool Down



- October 2016: end of the assembly
- November/December 2016: cool-down [cryogenic problems described before]
- January 2017: solved all cryogenic problems

- January 2017: other technical problems (snow + earthquake)
- February 2017: start commissioning

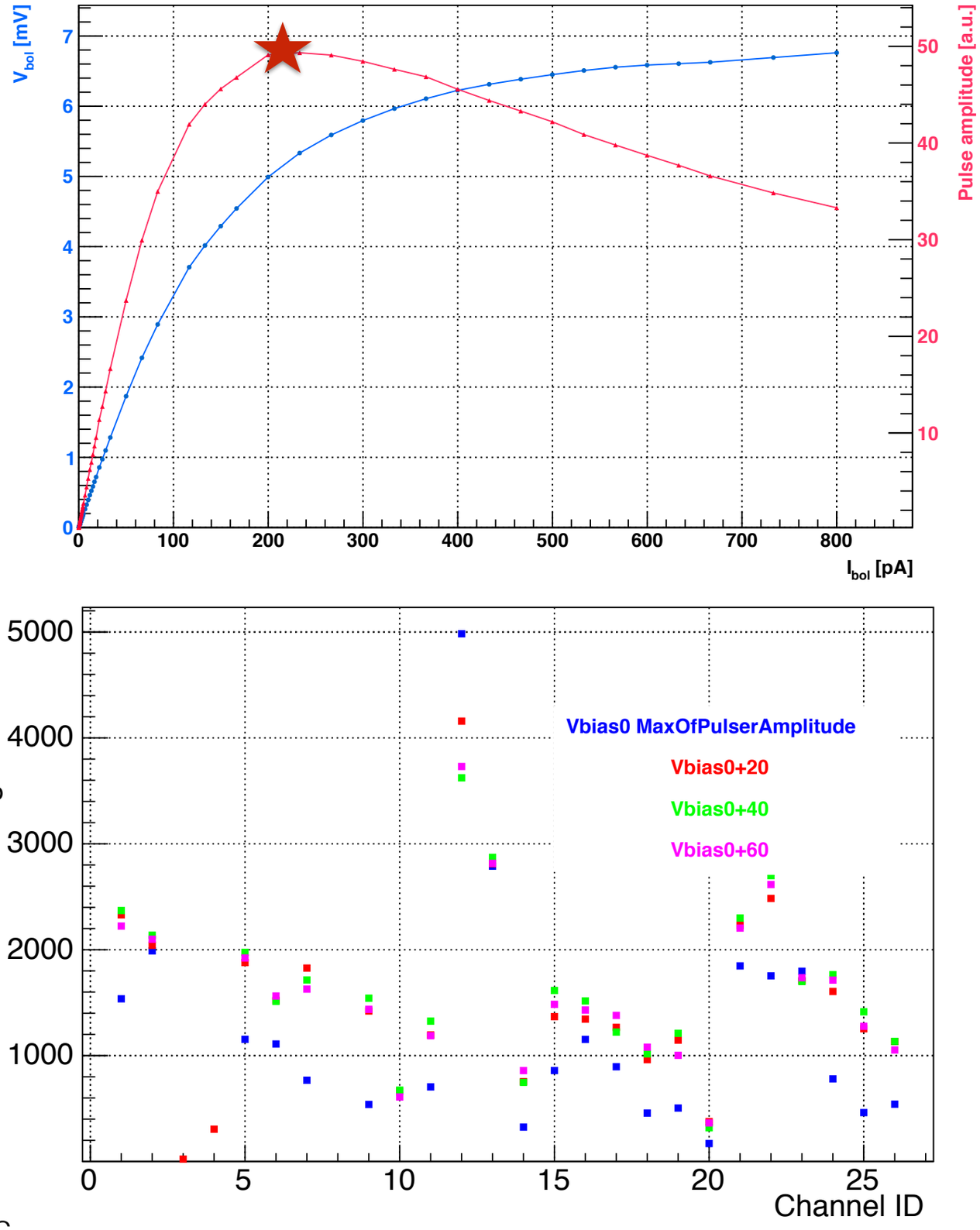


Detector Commissioning

- Search detectors best working conditions
- Commissioning of the DAQ
- Commissioning of the electronics
- Fix Light Detectors: *too cold* to work properly: use their own pulser as local heater —> it works!

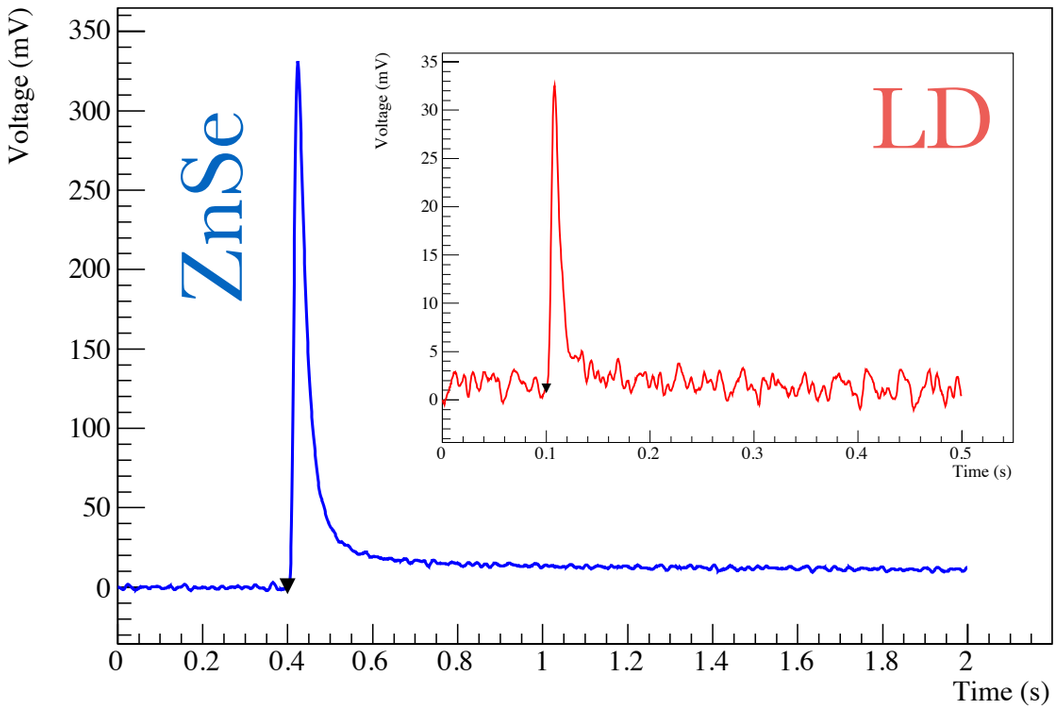
In March 2017 we completed the commissioning and started the data-taking:

all the ZnSe and light detectors work!

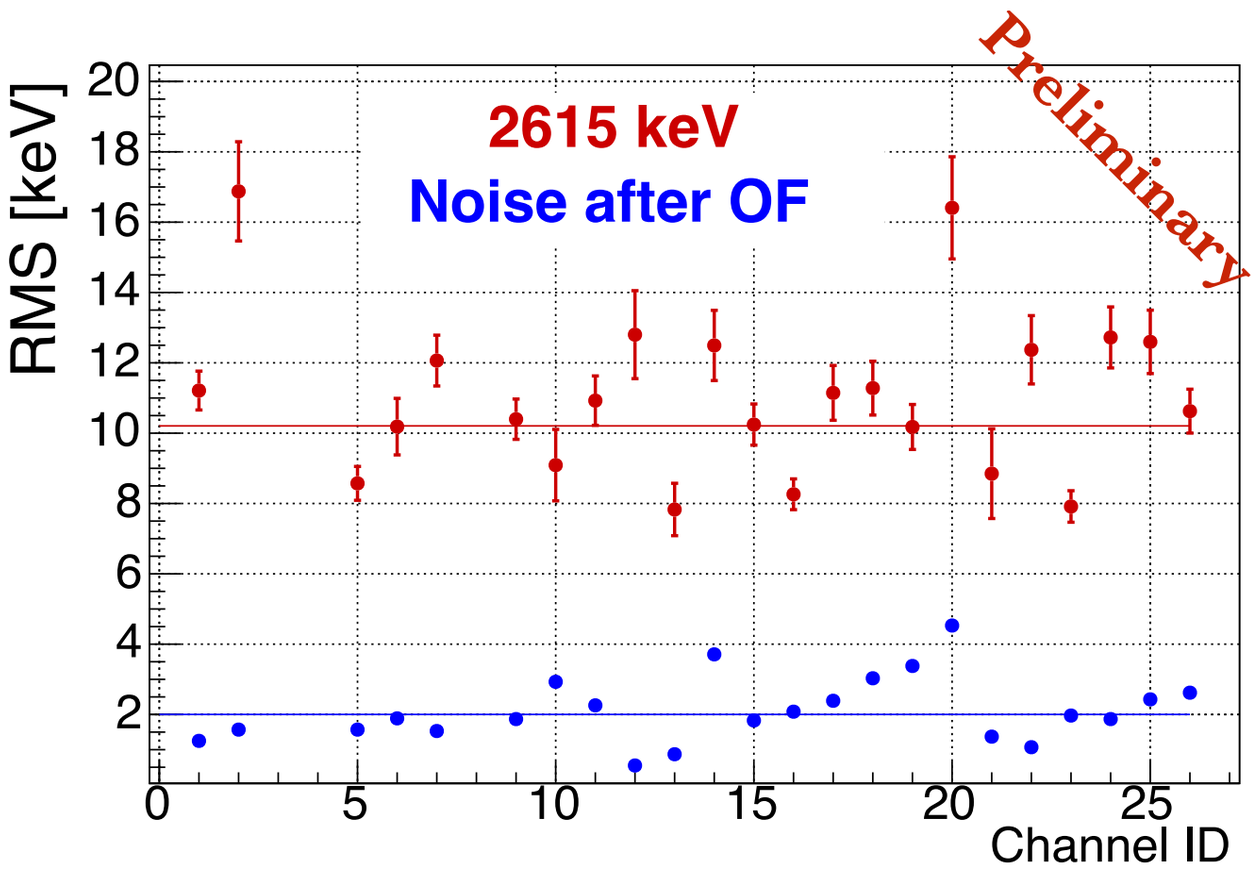


First Data

preliminary

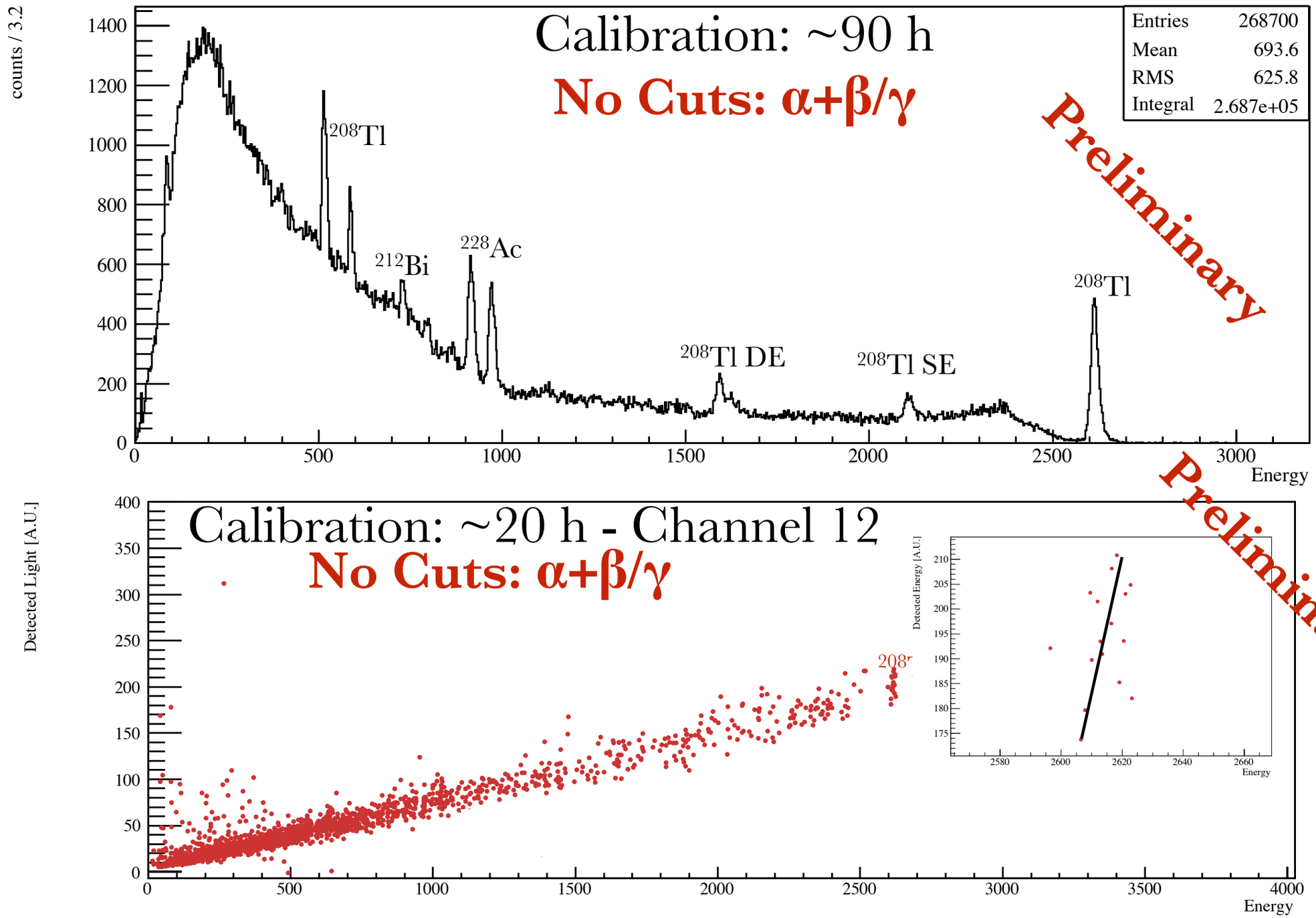


- We are seeing the first pulses from all the detectors
- We performed a run with ^{232}Th source to calibrate the detectors and evaluate the energy resolution.



- Two channels are not performing as good as the others, so they have temporarily been excluded
- Average FWHM @2615 keV = 25.5 keV
- Still some room for improvement

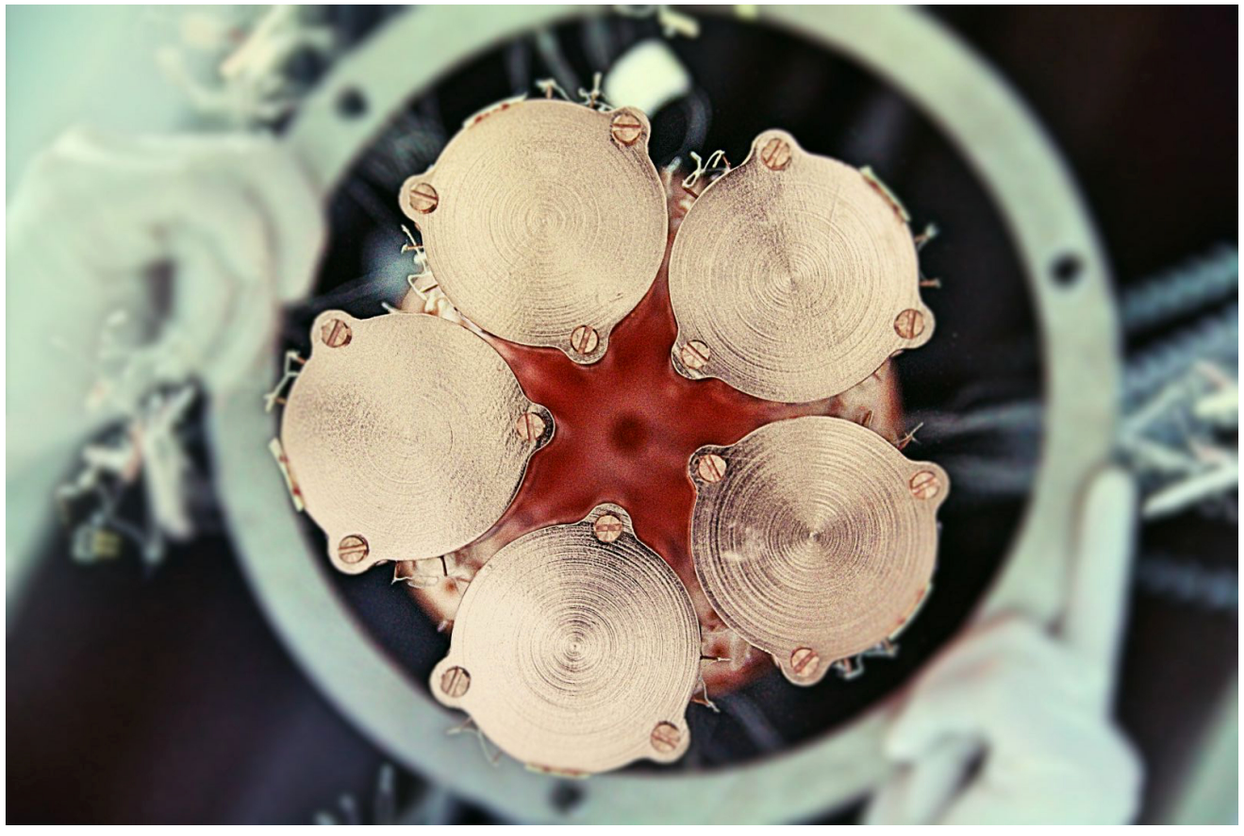
First Data



17 March: start background run!

What's next

- We just started the physics runs, we are finalizing our analysis tools
- Compute energy resolution (now preliminary)
- Background evaluation (10^{-3} counts/keV/kg/y expected)



Thanks for the attention!

BackUp

Se recovery:

a) 12.3 kg of ZnSe (6.5 kg ^{82}Se) sent to Russia to recover as much ^{82}Se as possible (we believe at least 5 kg).

b) after crystal cut and polishing we obtained a mixture of about 25-50 kg consisting (mainly) of ZnSe, SiO2 and water. This mixture contains about 1.5 kg of ^{82}Se. Understand how to recover this material.