Dmitry A. Testov

Calin A. Ur

Dimiter Balabanski

Anukul Dhal

Andreas Zilges et al.

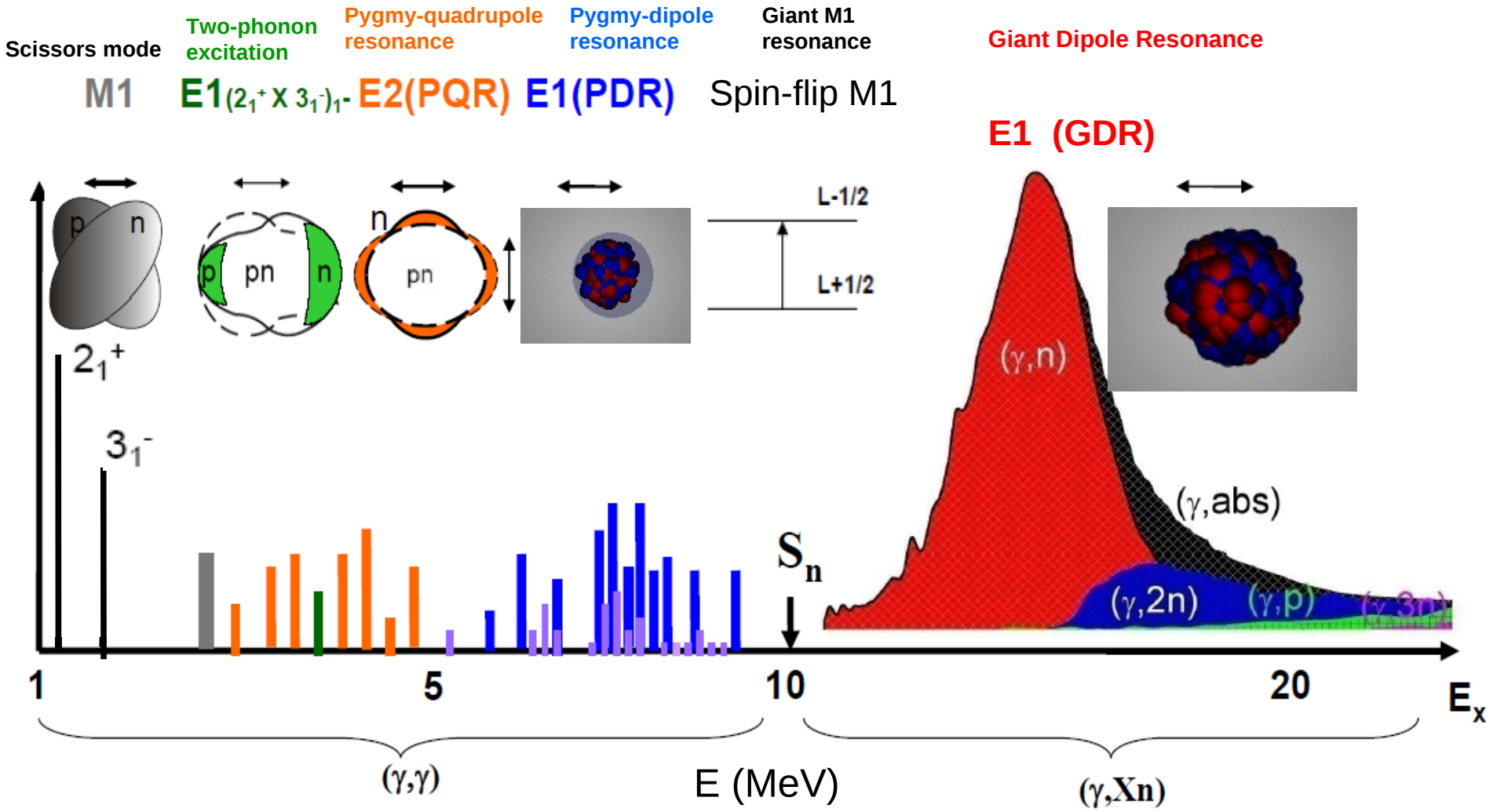
Gabriel Suliman

Norbert Pietralla et al.

Raluca Miron

ELIADE gamma ray spectrometer for NRF Experiments at ELI-NP

Characteristic Response of Atomic Nucl. to EM Radiation

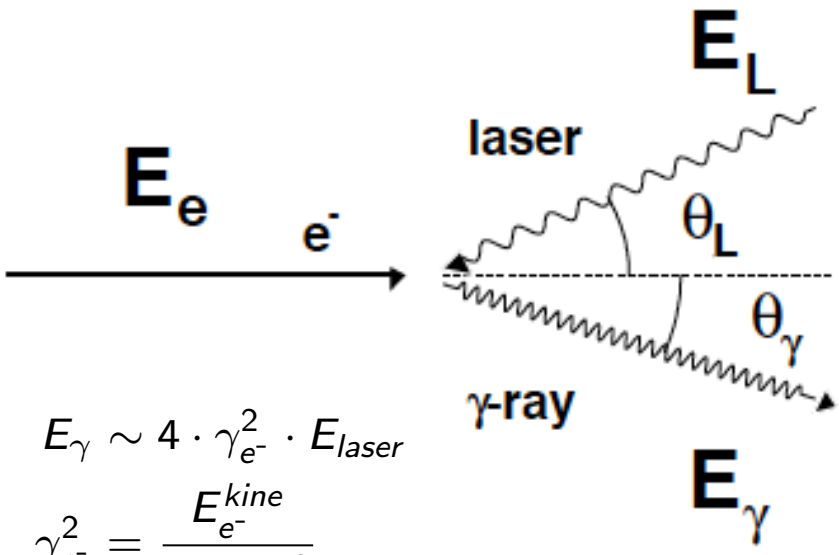


ELIADE spectrometer

ELIGANT array

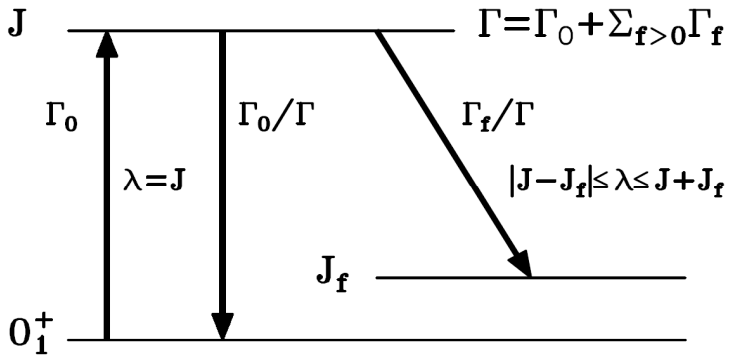
P.-A. Söderström

Photons from Laser Compton Backscattering (LCB)



$$E_\gamma \sim 4 \cdot \gamma_{e^-}^2 \cdot E_{laser}$$

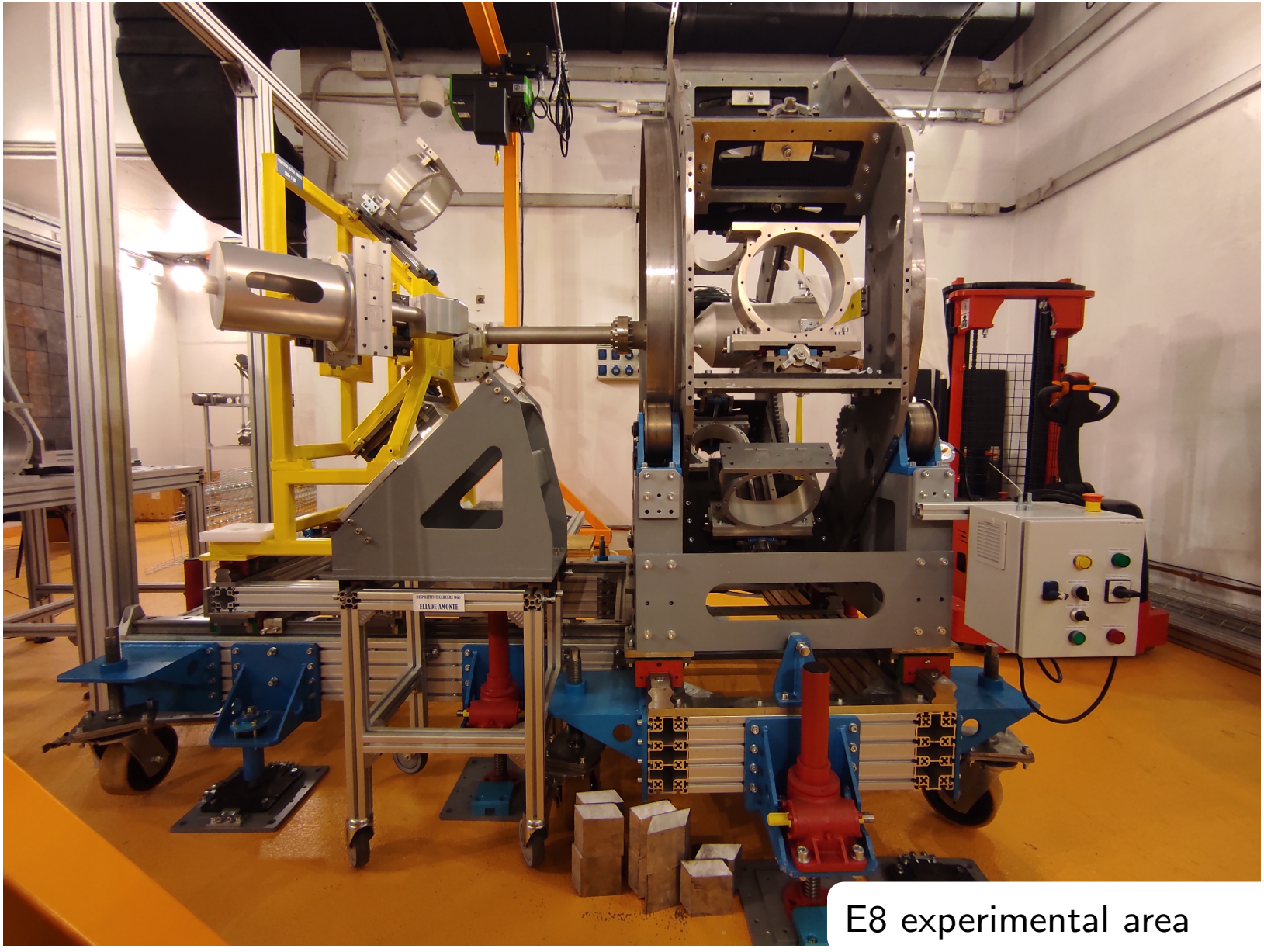
$$\gamma_{e^-}^2 = \frac{E_{e^-}^{kine}}{m_{e^-} \cdot c^2}$$



- ,,monoenergetic'' γ-beam < 20 MeV
- bandwidth $\sim$0.5%
- 10^8photons/s
- tunable energy
- Almost 100% linearly polarized beam

- Populate excited states by resonant scattering of γ rays
- Measure total (Γ) and partial (Γ_f) level widths following γ decay
- Narrow bandwidth: selective population
- Scan for new resonances
- Completely model independent measurements
- Very clean angular distributions for J^π measurements

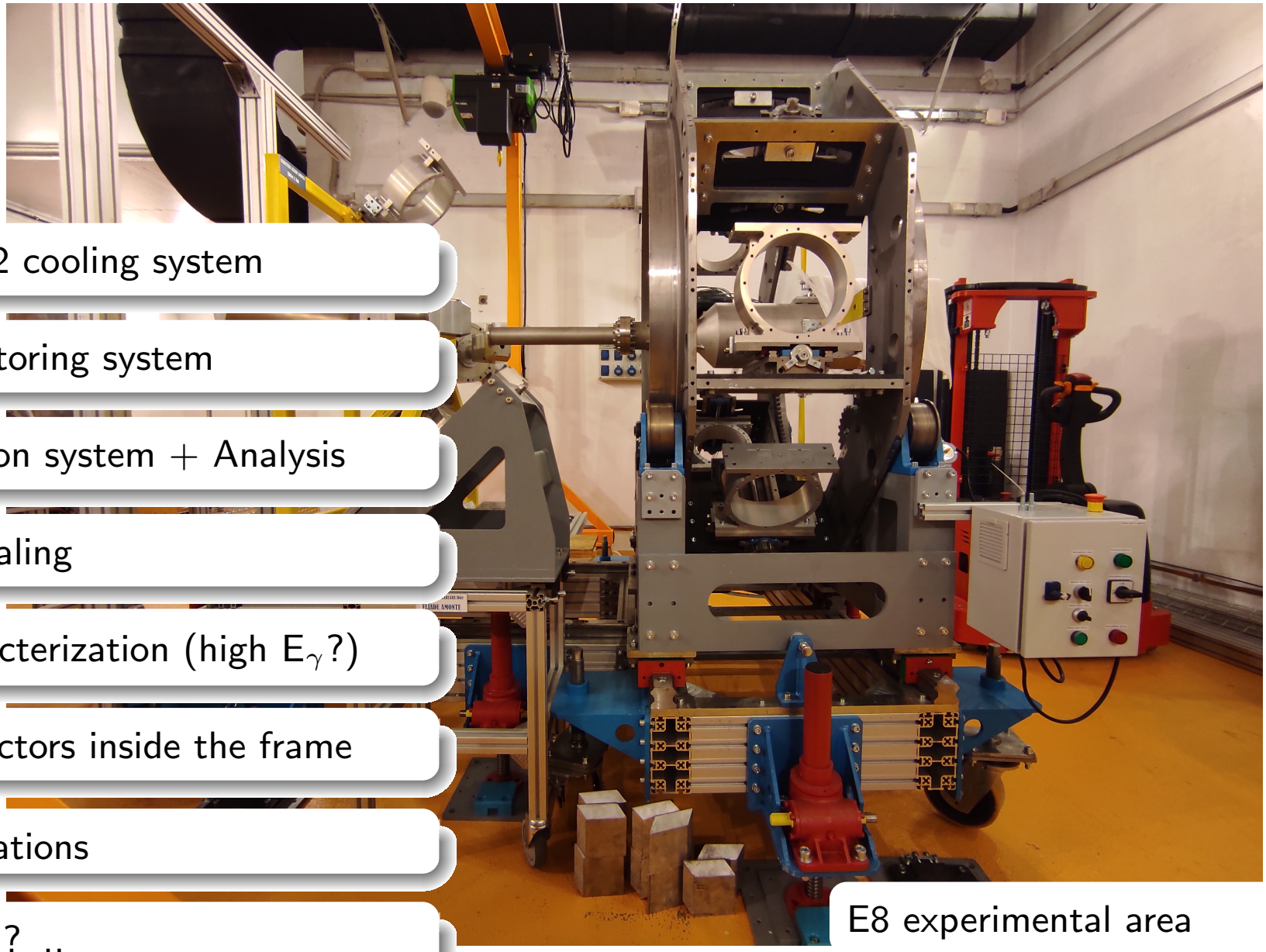
ELIADE γ-ray spectrometer in 2021, just a frame



E8 experimental area

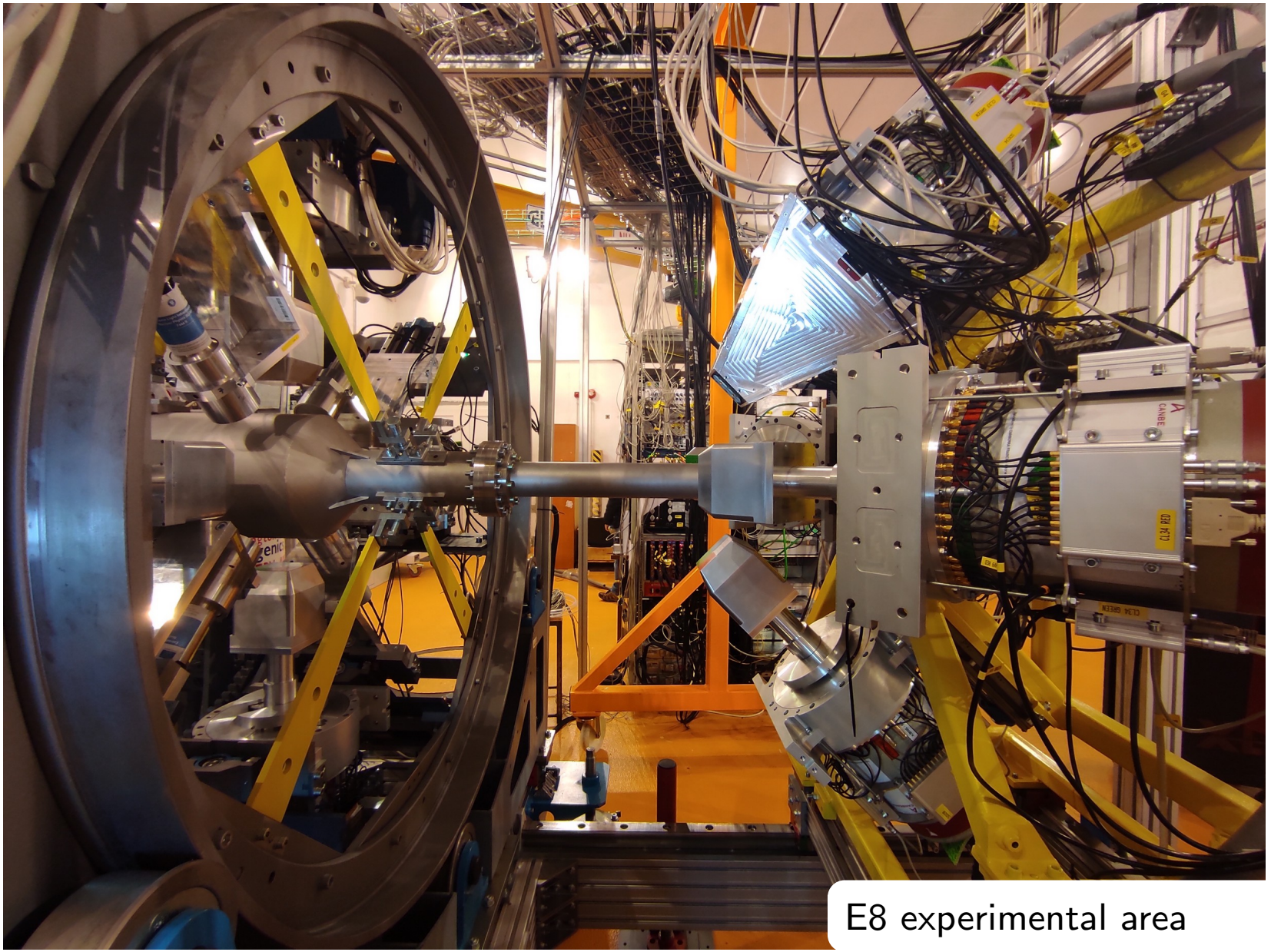
ELIADE γ-ray spectrometer in 2021, just a frame

- Automatic LN2 cooling system
- Alarm & Monitoring system
- Data Acquisition system + Analysis
- Detector Annealing
- Detector characterization (high E_γ?)
- Mounting detectors inside the frame
- Realistic simulations
- Anti-Compton ? ..



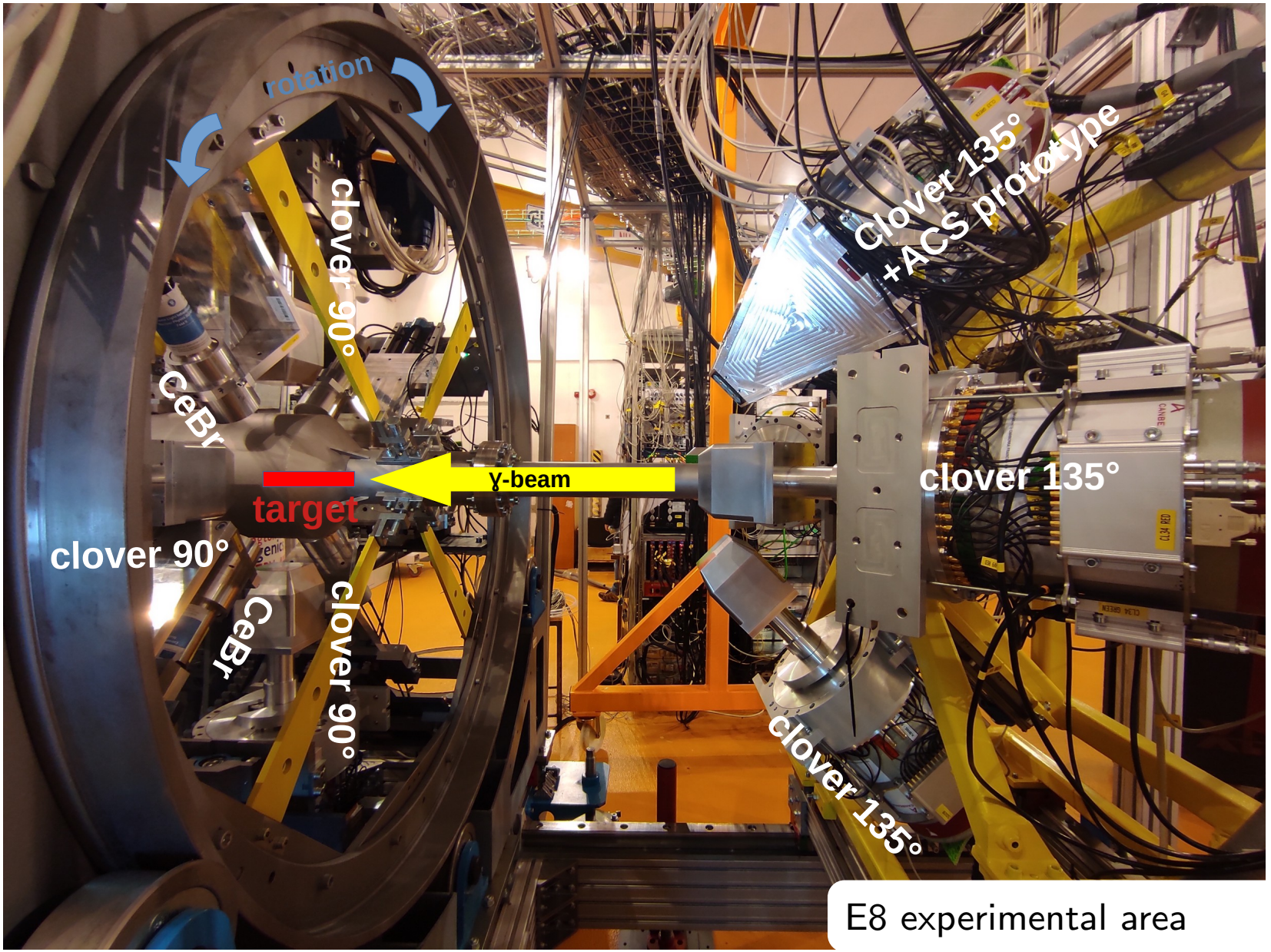
E8 experimental area

ELIADE γ-ray spectrometer in 2023, operational



E8 experimental area

ELIADE γ-ray spectrometer in 2023, operational



E8 experimental area

ELIADE γ-ray spectrometer in 2023, operational

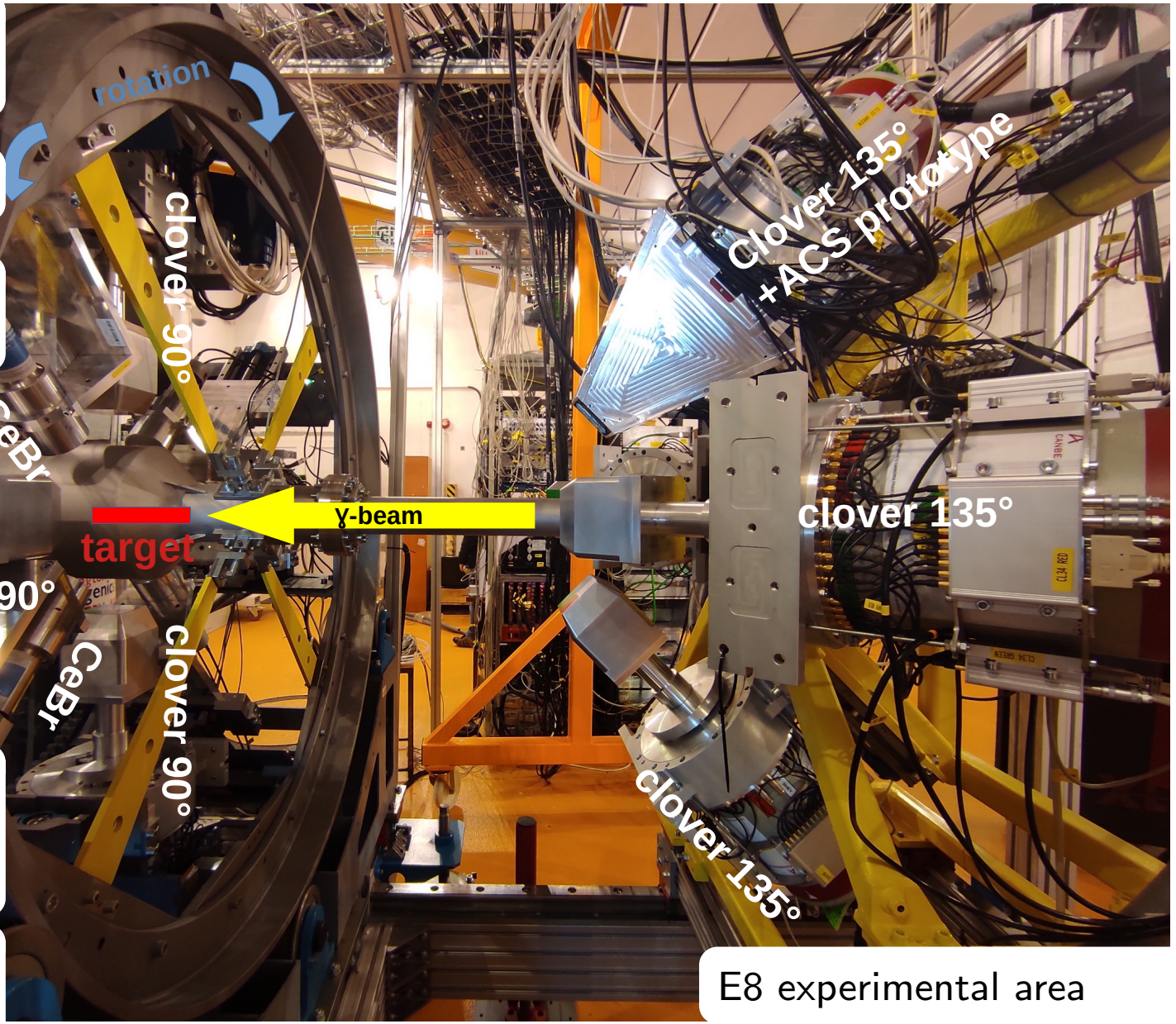
8 x HPGe Clover
(4 x 90° and 4 x 135°)

+ 4 x $LaBr_3$:Ce at 90°

target-to-detector
15 cm <d< 30 cm

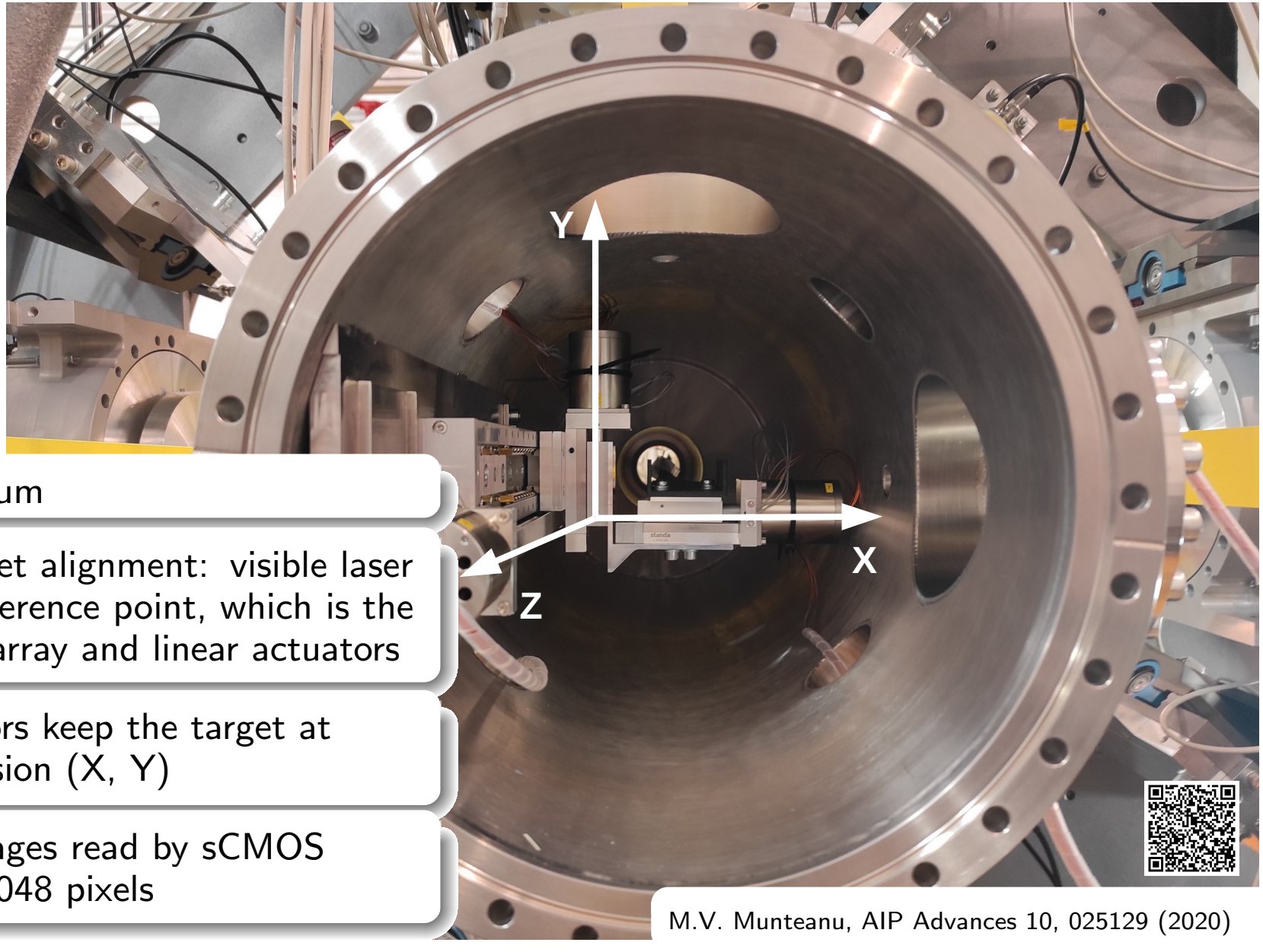
ϵ_{dmin} ≈6% for
E_γ ~1.3 MeV
(GEANT4)

Compton Supressed
update in 2023-24



E8 experimental area

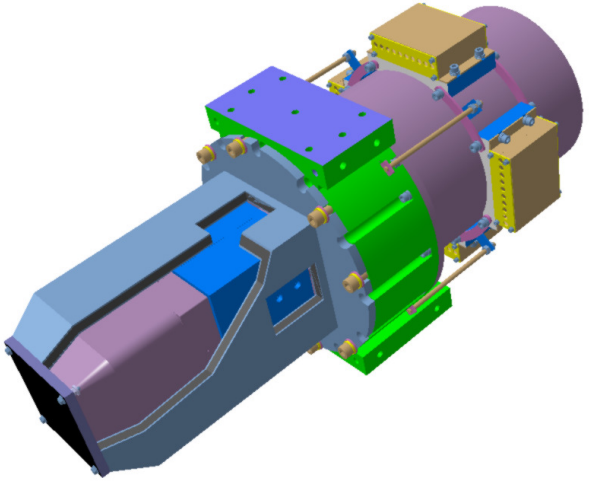
Interaction chamber

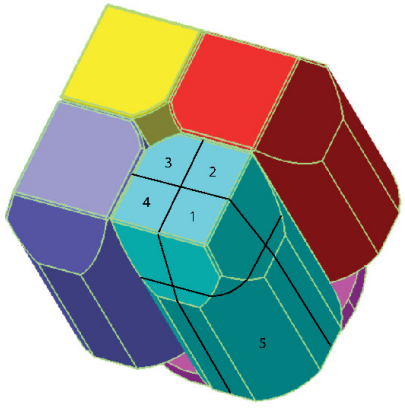


- Medium Vacuum
- Two-step target alignment: visible laser defines the reference point, which is the center of the array and linear actuators
- Linear actuators keep the target at $\pm$2-5μm precision (X, Y)
- ,,Shadow" images read by sCMOS sensor 2048x2048 pixels

M.V. Munteanu, AIP Advances 10, 025129 (2020)

Details of the ELIADE detectors

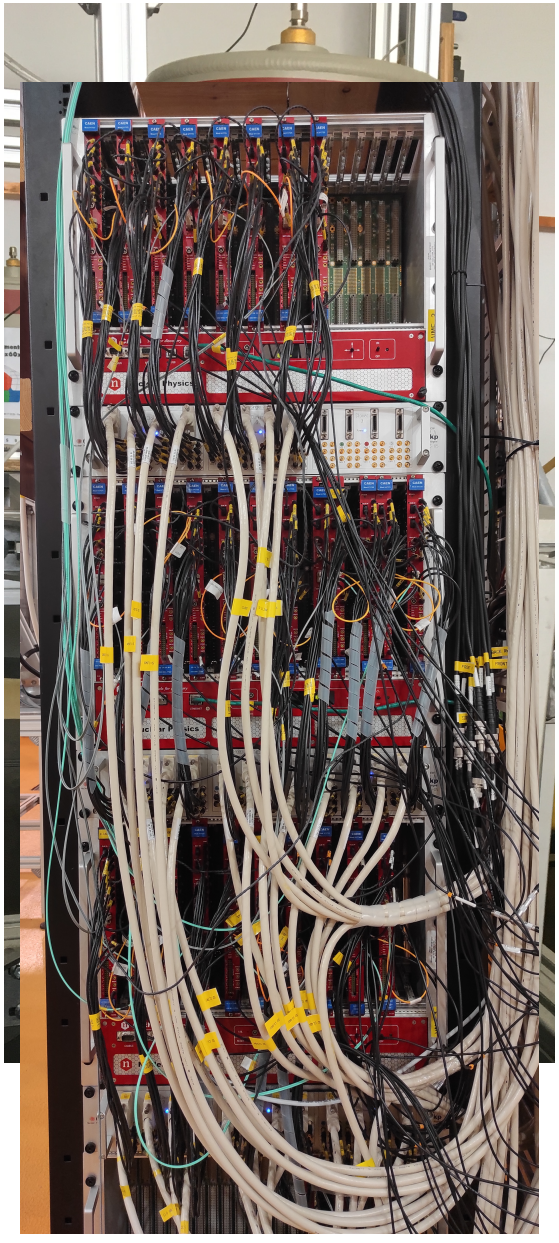


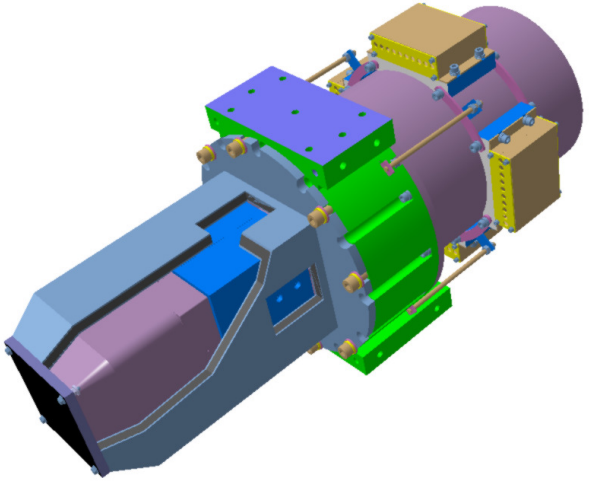


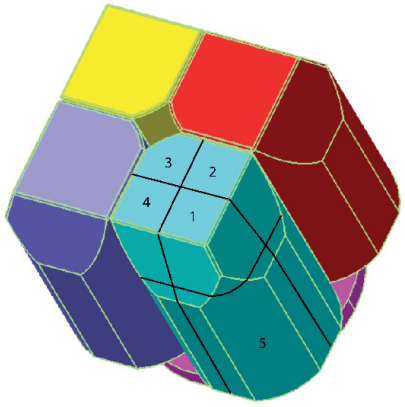
- 8 Canberra 4x60x90 Seg32 Clover detectors
- Interested in high-energy γ-rays
- Using segmented Clover detectors we can increase γ-ray count rate per detector
- Most low-energy γ-rays interact in the front segments

- 4 x $CeBr_3$, 3 inch
- High Efficiency
- good time resolution (ns)

Details of the ELIADE detectors







- 8 Canberra 4x60x90 Seg32 Clover detectors
- Interested in high-energy γ-rays
- Using segmented Clover detectors we can increase γ-ray count rate per detector
- Most low-energy γ-rays interact in the front segments

- AGATA core type preamplifiers differential output dual gain: 5 MeV and 20 MeV/fast reset/
- 32 v1725 CAEN 14 bit 250 MS/s 16 ch digitizers
- 2 v1730 CAEN 14 bit 500 MS/s 8 ch digitizers
- 8 v1730 CAEN 14 bit 500 MS/s 16 ch digitizers
- 8 front-end servers

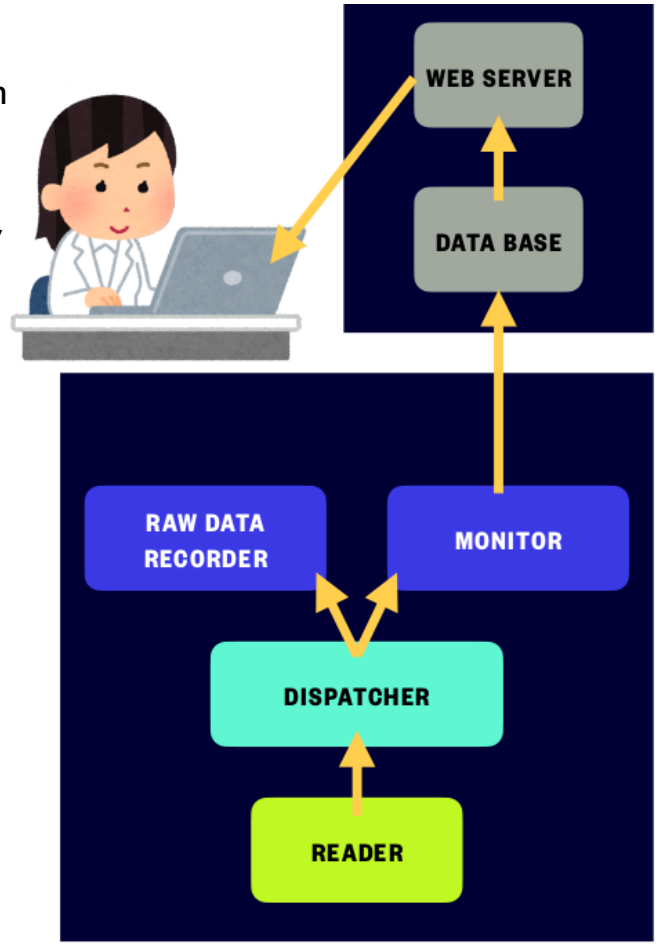
DELILA data acquisition system at ELIADE

Digital Extreme Light infrastructure Listmode Acquisition

by Soiciro Aogaki

DAQ-Middleware

- Developed by KEK (High Energy Accelerator Research Organization
- Used many experiments at KEK, J-PARC
- Based on a robotics system, good real time operation and reliability
- CAEN digitizers PHA, PSD, waveform implemeted
- QDC (soon)
- Using ROOT to plot and store data
- Browser-based GUI



DELILA at ELIADE

- One event in HPGe channel:
  Channel number: 1 Byte + digitizer number: 1 Byte;
  Energy (ADC value): 2 Bytes; Time stamp: 8 Bytes
- Waveform (250 samples): 500 Bytes
- Total: 512 Bytes
- Assuming 10^4 /s per ch 2.6 Gb/s including traces (waveformes)
- Assuming 10^4 /s per ch 61 Mb/s no traces ($\rightarrow$ 5 Tb/day)

320 ch (HPGe)

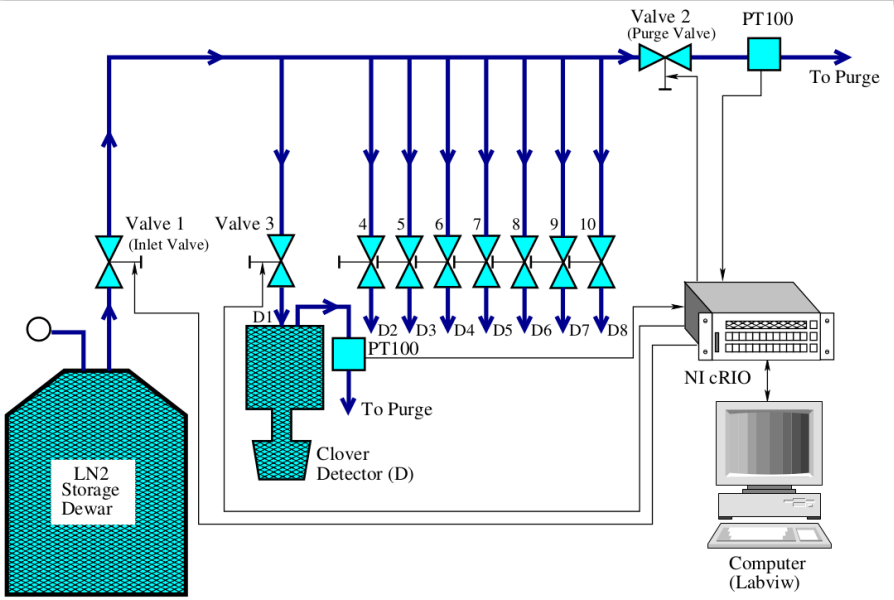
132 ch (CsI, BGO, $CeBr_3$)

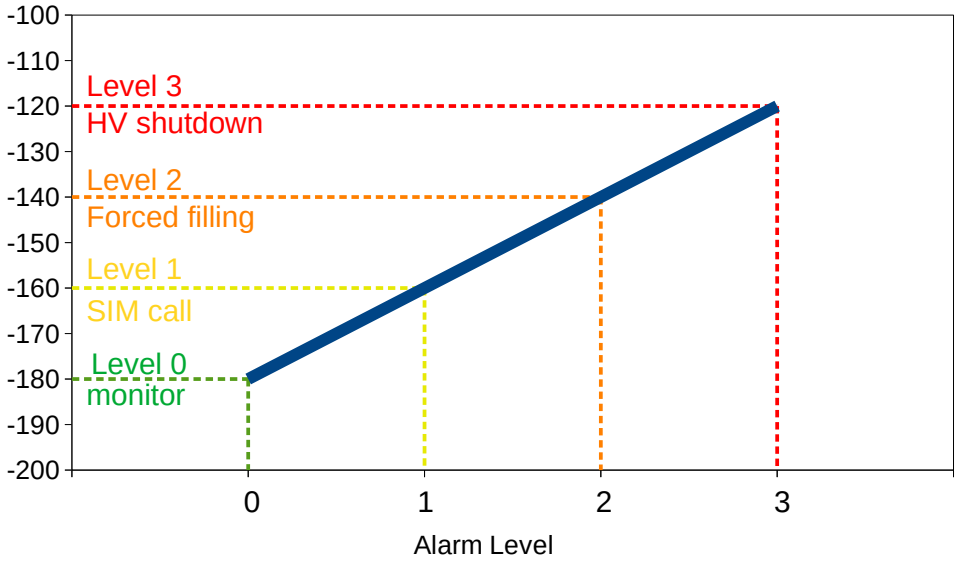
Monitoring, Alarming and Control for ELIADE (MACE)

Functionalities

- **HV**, **I_{leak}** from the CAEN SY4527 High-Voltage Source;
- Temperature of the detectors is monitored via **PT100** sensors
- **CompactRIO** (cRIO) controller activates fillings, dispatches data
- **Python** (PyEpics library) updates **InfluxDB** data base with T, HV, I_{leak}
- **GRAFANA** monitoring interface (web, Android, iOS) on-line DB visualisation
- **Passive alarm**: messages via emails and **TELEGRAM**, sim-calls
- **Active alarm**: forced filling, HV shut down
- **browser GUI** for alarms configurations/settings

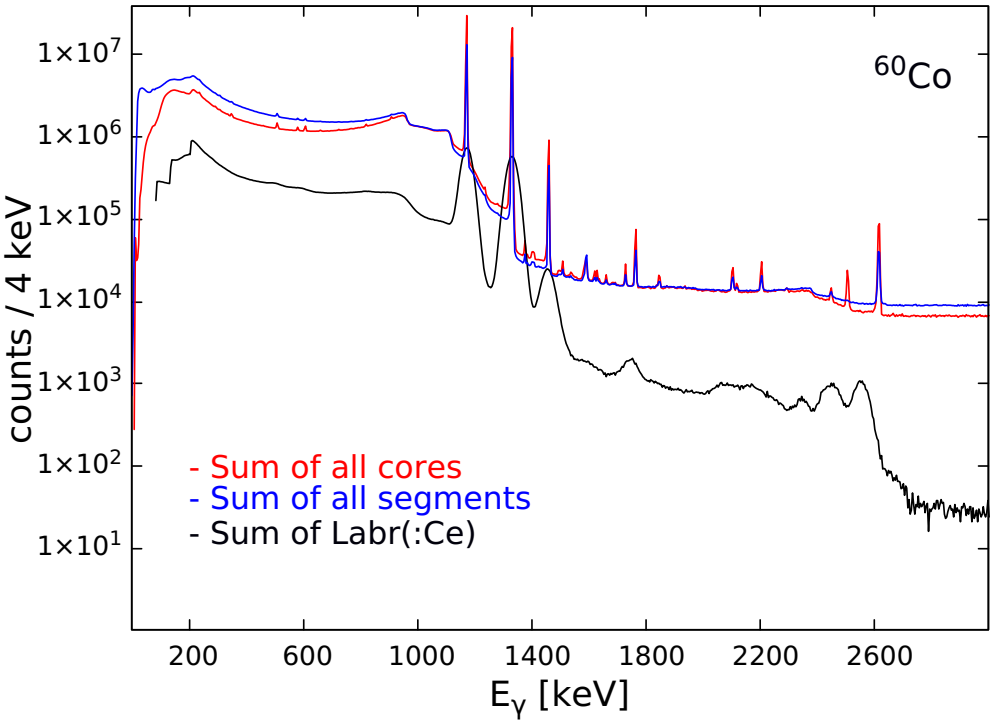
@ELIADEPING

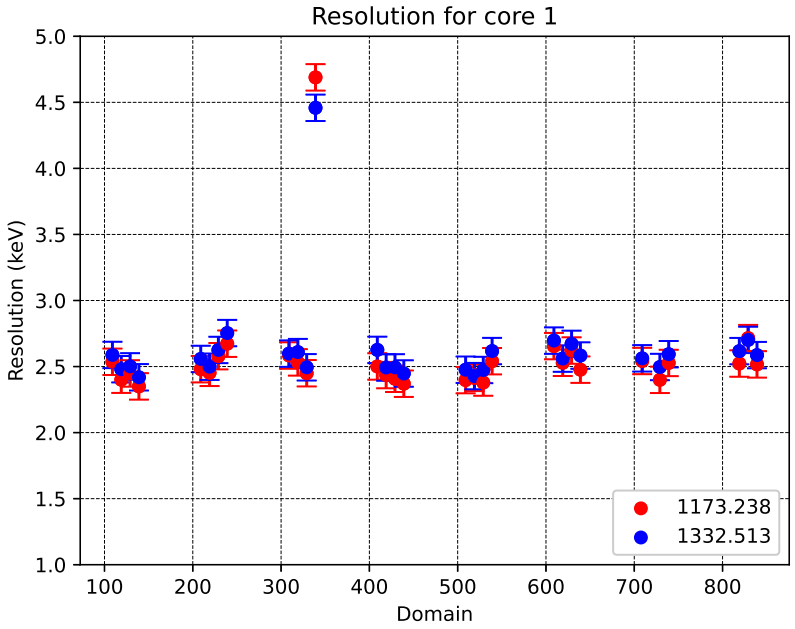


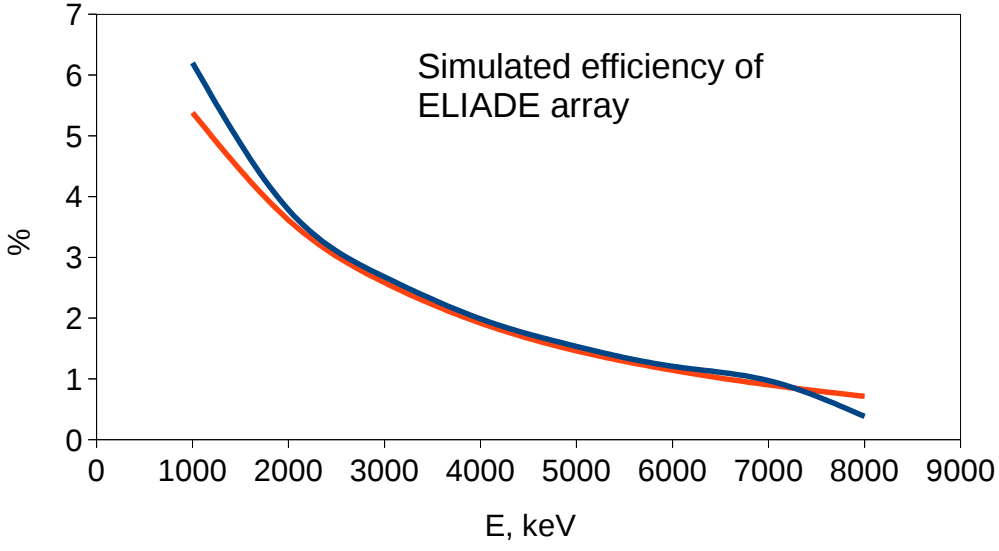


A. Dhal et al 2022 JINST 17 T07008

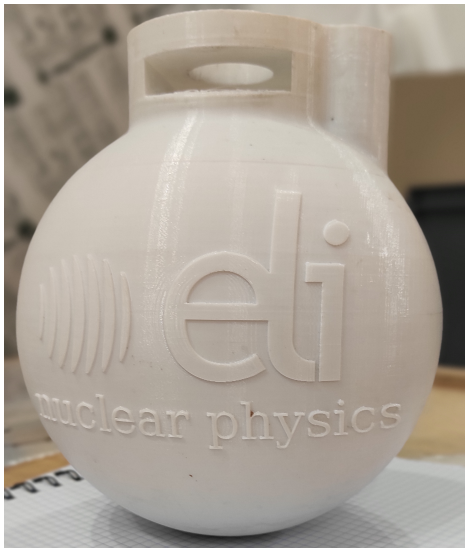
ELIADE first runs as spectrometer



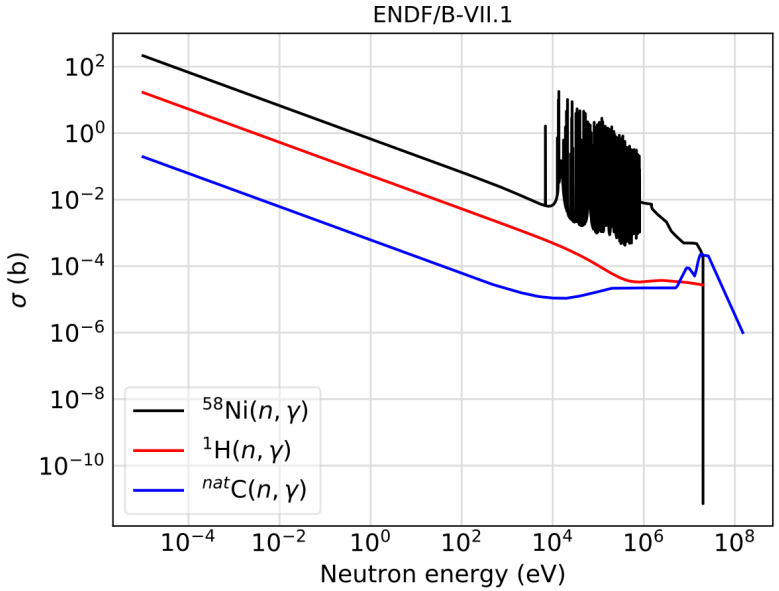


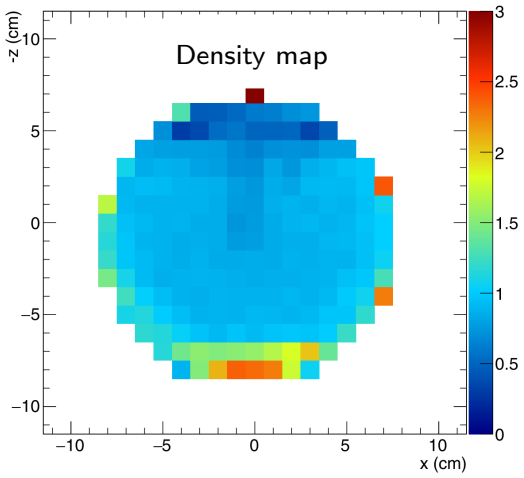


Hight energy γ-rays: composite source



- container PolyMax PC polycarbonate filament with ⌀1.75 mm
- 250 g of nickel poweder
- 1.3 kg of paraffin
- Radioactive source identification
- $\sim 2.2 \cdot 10^5$ n/s (PuBE)
- $N(E_\gamma = 9\ \text{MeV}) = \sim 450$ n/s
  $\sim 2.5 \cdot 10^{-6}$ γ/n/cm^2



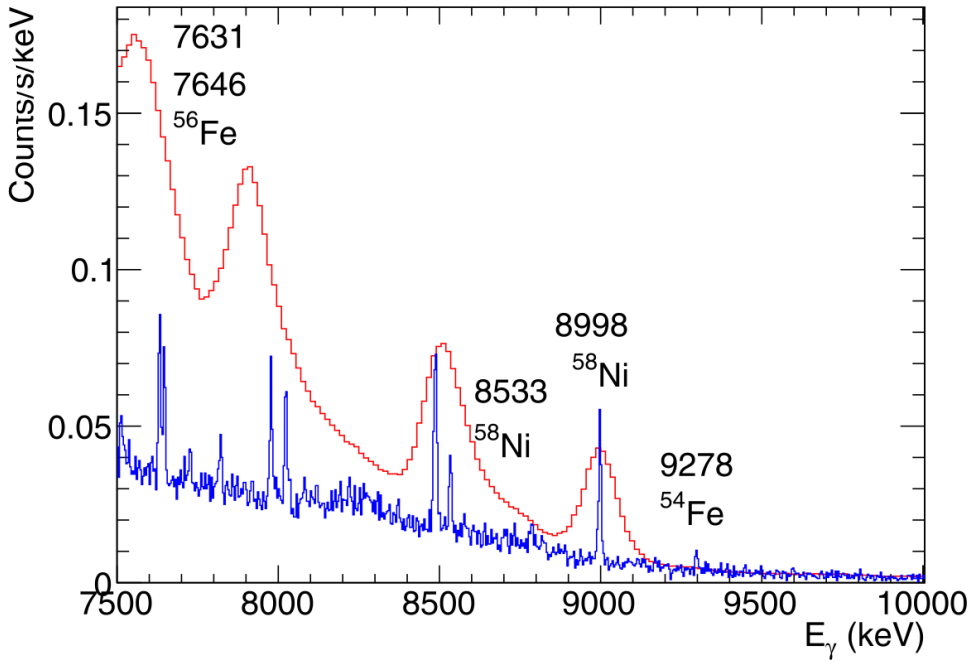


ELIGANT ($LaBr_3$)

γ-ray spectrometer

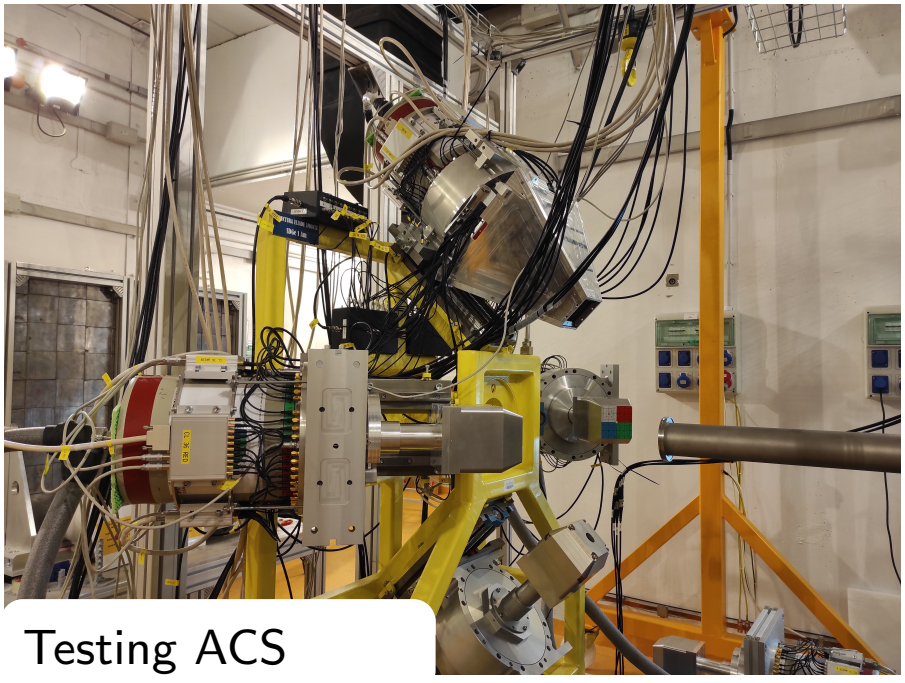
ELIADE (HPGe)

γ-ray spectrometer

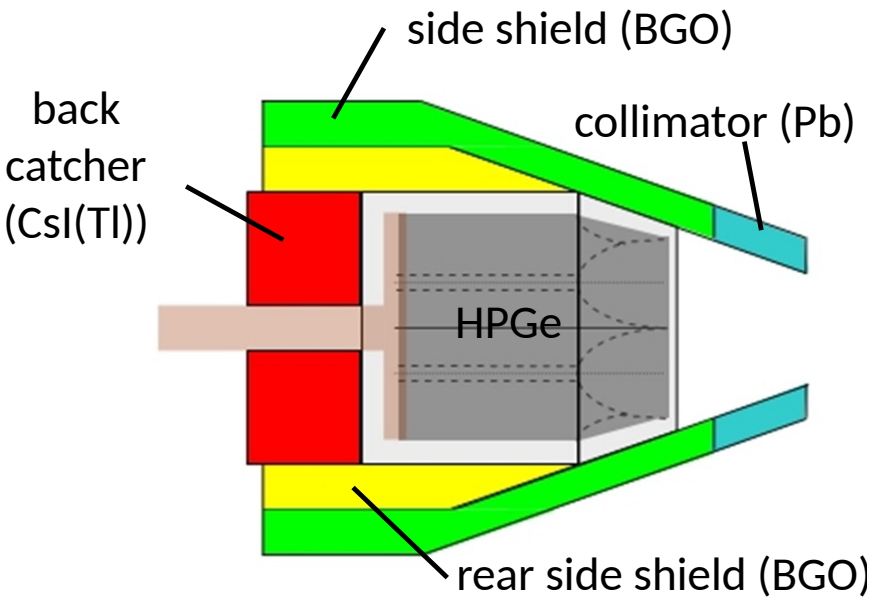


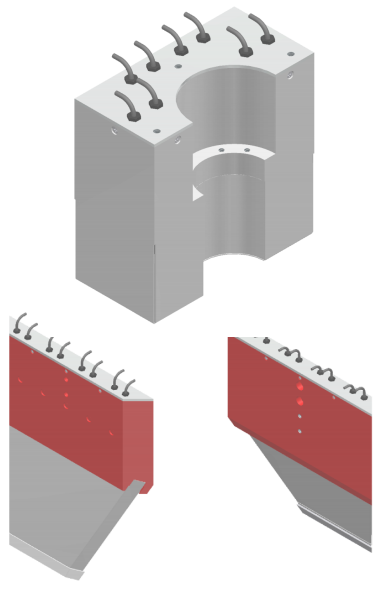
P.-A. Söderström at al., Appl. Radiat. Isot. 191 (2023) 110559

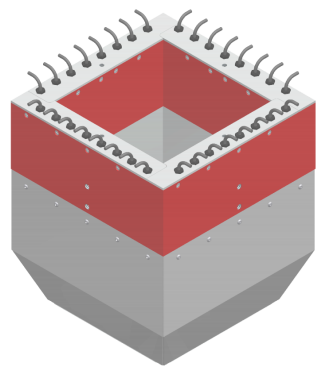
Compton Rejection test: composite PuBeNi source



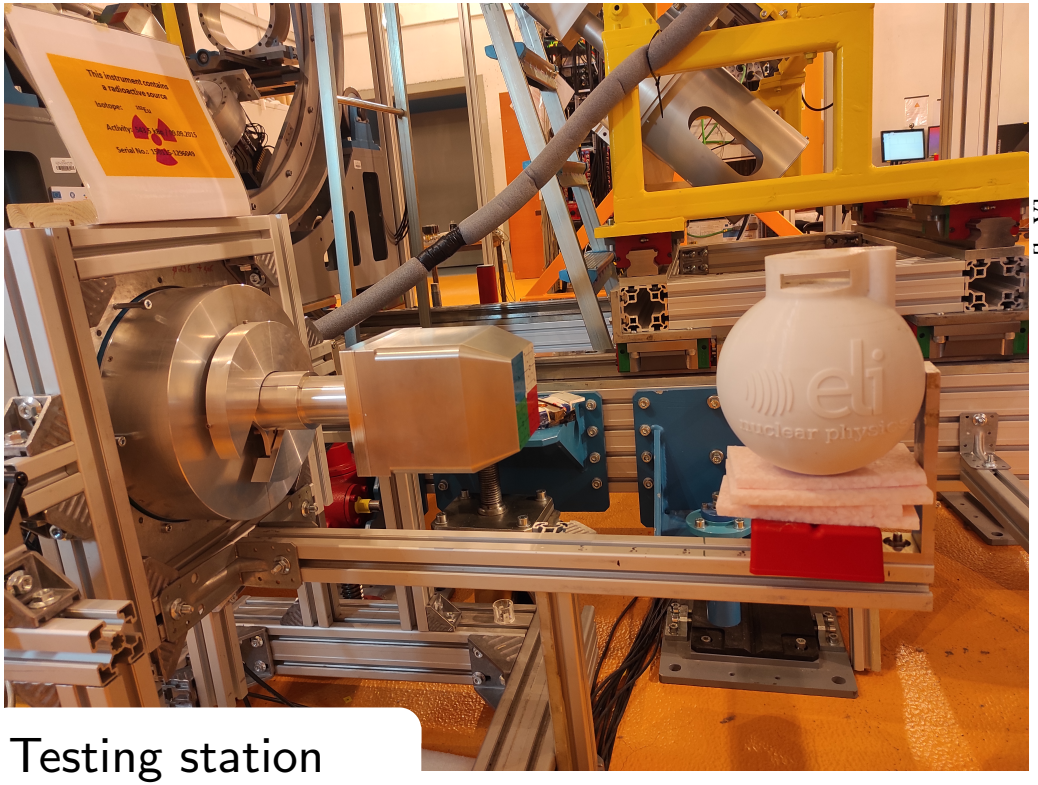
Testing ACS



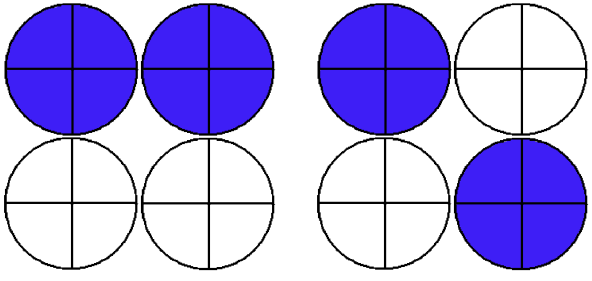




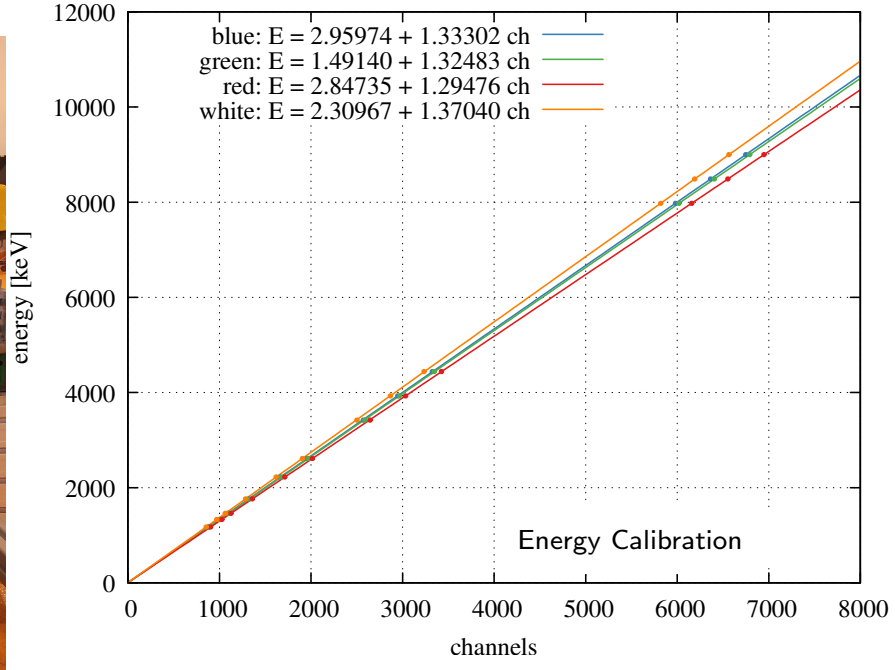
Add-back test using Co and PuBeNi sources

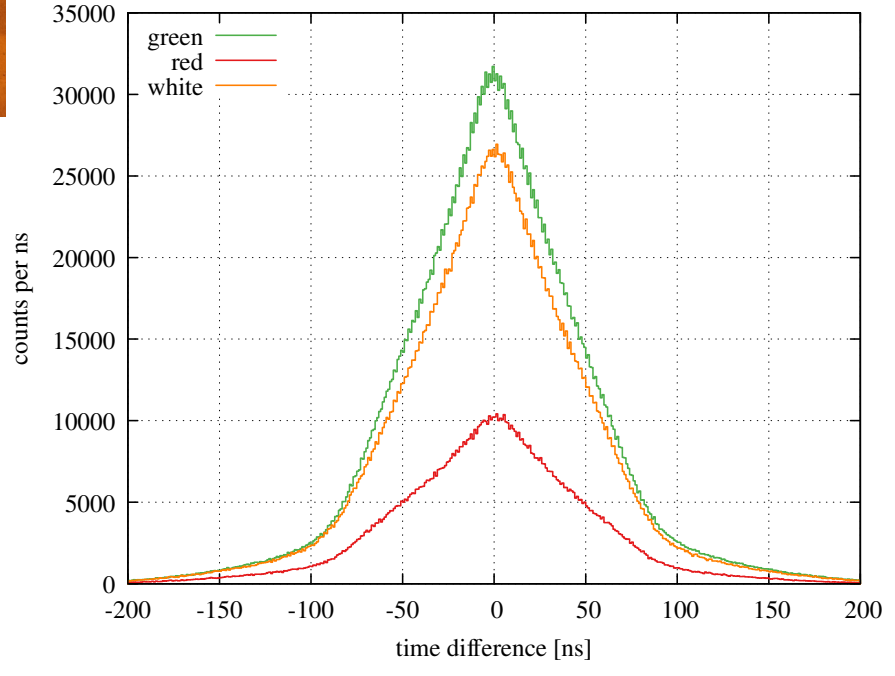


Testing station



Adjacent Diagonal





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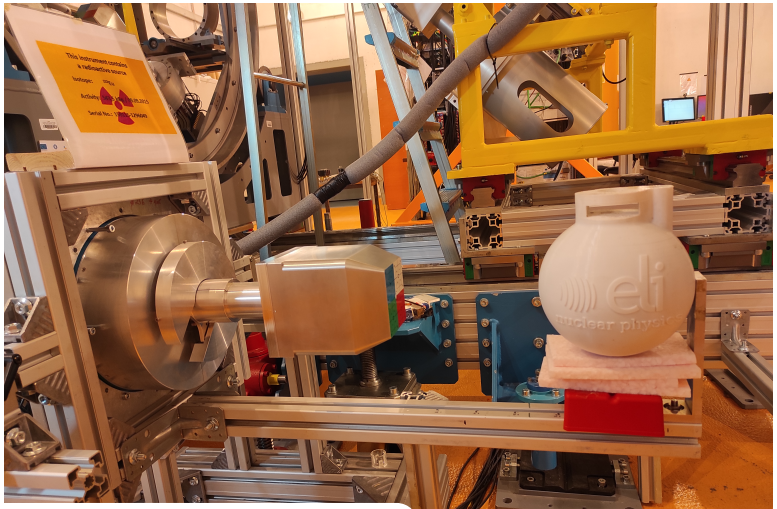
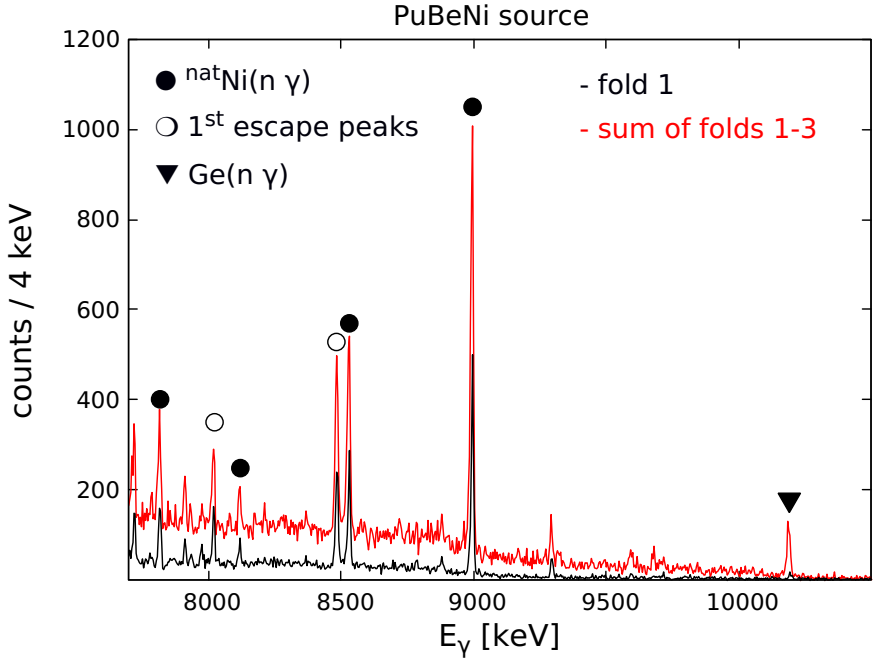
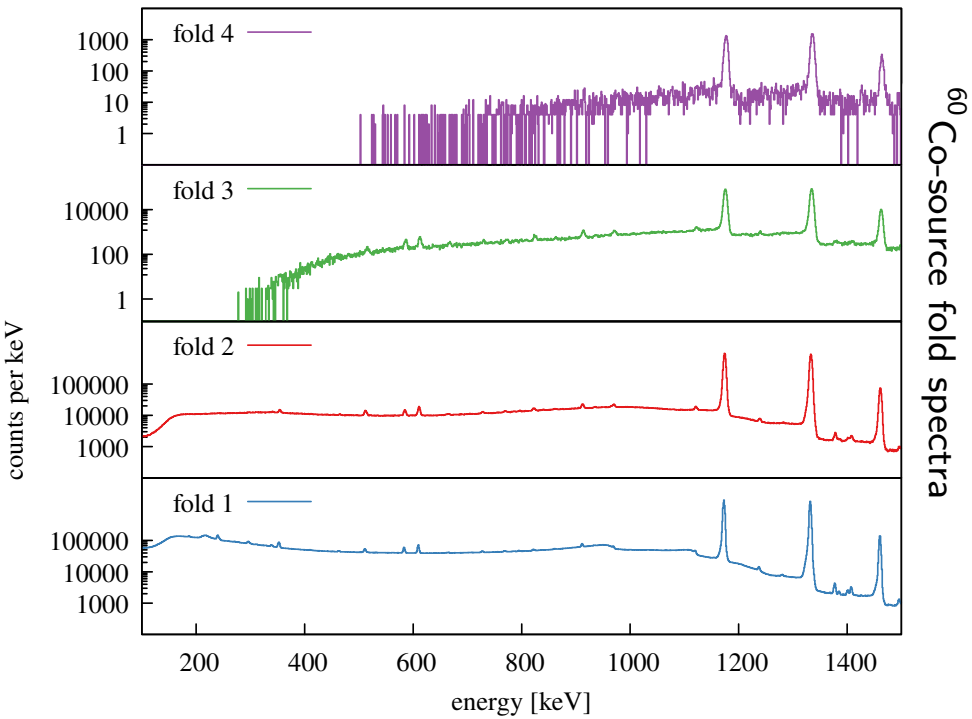


Testing station





ELIADE γ-ray spectrometer for NRF: operational

Hardware

- All the HPGe/$LaBr_3$:Cs detectors are installed in the frame
- Automatic Liquid Nitrogen filling, monitoring and alarming systems are in place
- DELILA data acquisition system is operational

Performance

- Detectors are characterized using standard calibration sources
- Response of to high energy γ-rays can be studied using composite PuBeNi source

Ongoing 2023-24

- Active anti-Compton shield is to be implemented 2023-24
- Realistic simulations simulations of ELIADE response to γ-rays are under way
- Characterization of the full array: efficiency, resolution, PT,...
- Characterization of the full array: time correlations (addback, compton-suppression, etc)

Thank you for you attention! Grazie !!!