Status of the high-energy performance measurement and simulation

M. Balogh, R. M. Pérez-Vidal
for the AGATA collaboration

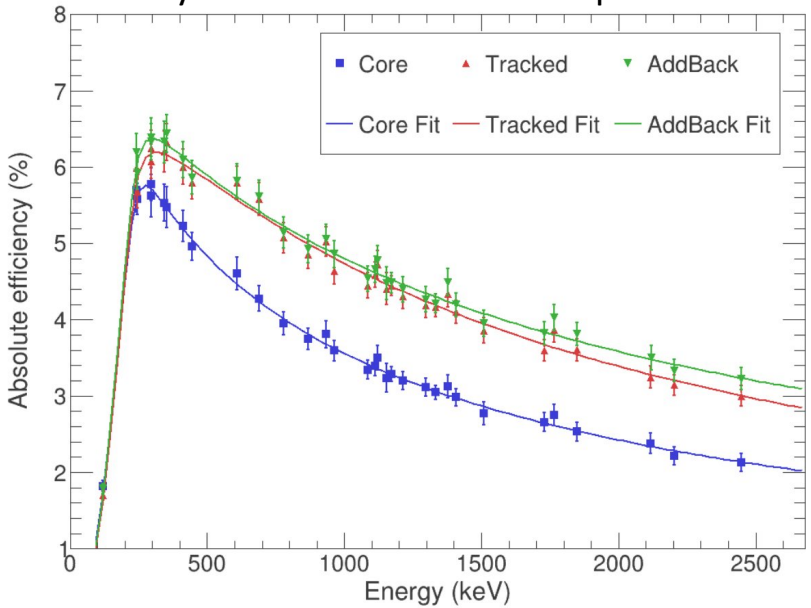
INFN-LNL, IFIC-CSIC-UV

25th AGATA Week | 19th September 2025

Measurements

How do the AGATA performances evolve at high energies?

Currently measurements: 226Ra up to 2.4 MeV



- Preparation of experimental proposals
- Analyses of γ-ray spectroscopic data
- Validation of GEANT4 simulations
- Optimization of the tracking algorithms

Analysis mode	Efficiency	P/T
Core	3.05(9) %	16.8(6) %
Tracked	4.16(12) %	32.9(9) %
Addback	4.21(13) %	28.6(8) %

@ 1.3 MeV

R. Pérez-Vidal et al., INFN-LNL Annual reports, vol. 56, 2022. (34 detectors)

Measurements

Performance up to 5MeV

1st PHASE:

^{56}Co γ-ray source measurement:

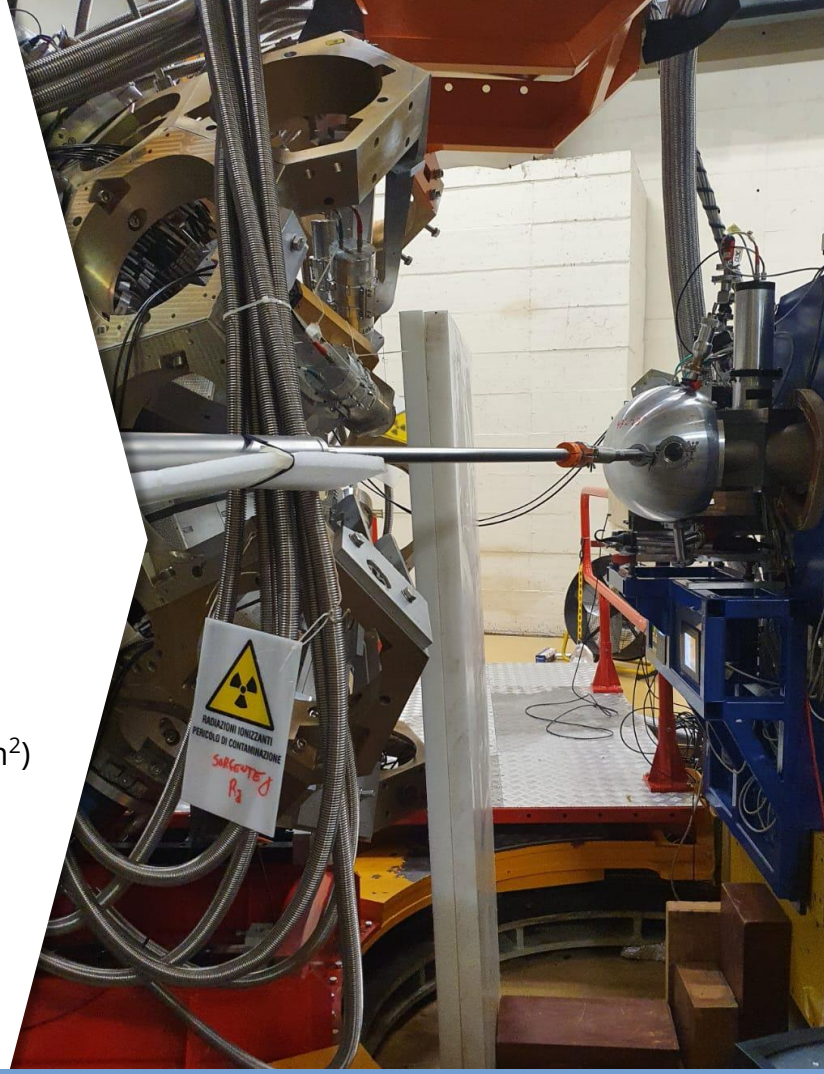
- Efficiencies up to 3.4 MeV
- Cancelled for now

2nd PHASE:

^{66}Zn(p,n) reaction:

- Efficiencies up to 5MeV
- E=13MeV (σ≈ **680 mb**)
- Target: Au (0.1mg/cm^2)+^{66}Zn (1.5mg/cm^2)+Au (1.5mg/cm^2)
- I_{beam}≈ **2-10 pnA**
- AGATA @ **back-most + paraffin wall**

26th-31st July 2024



M. Balogh, Md. S. R. Laskar, S. Bottoni, R.M. Pérez-Vidal, S. Pigliapoco
and the AGATA performance team collaboration

Measurements

Performance up to 5MeV

26th-31st July 2024

- AGATA position: Nominal (23.5 cm) and Close-up (18 cm)
- Closed chamber, Without absorbers
- 2.5μs
- ~110kBq Ga source

Source	Position	Duration	Rate
60Co	Nominal	2.5h	1.5kHz
	Nominal Traces	1h ; 1.5h	
	Close-up	2h	2kHz
152Eu	Nominal	4h ; 2h	2kHz
	Nominal Traces	2h ; 1.5h	
	Close-up	3h ; 2h	3kHz
133Ba	Nominal	2.3h	2kHz
	Close-up	1.6h	2.7kHz
226Ra	Nominal	4h	1.6kHz
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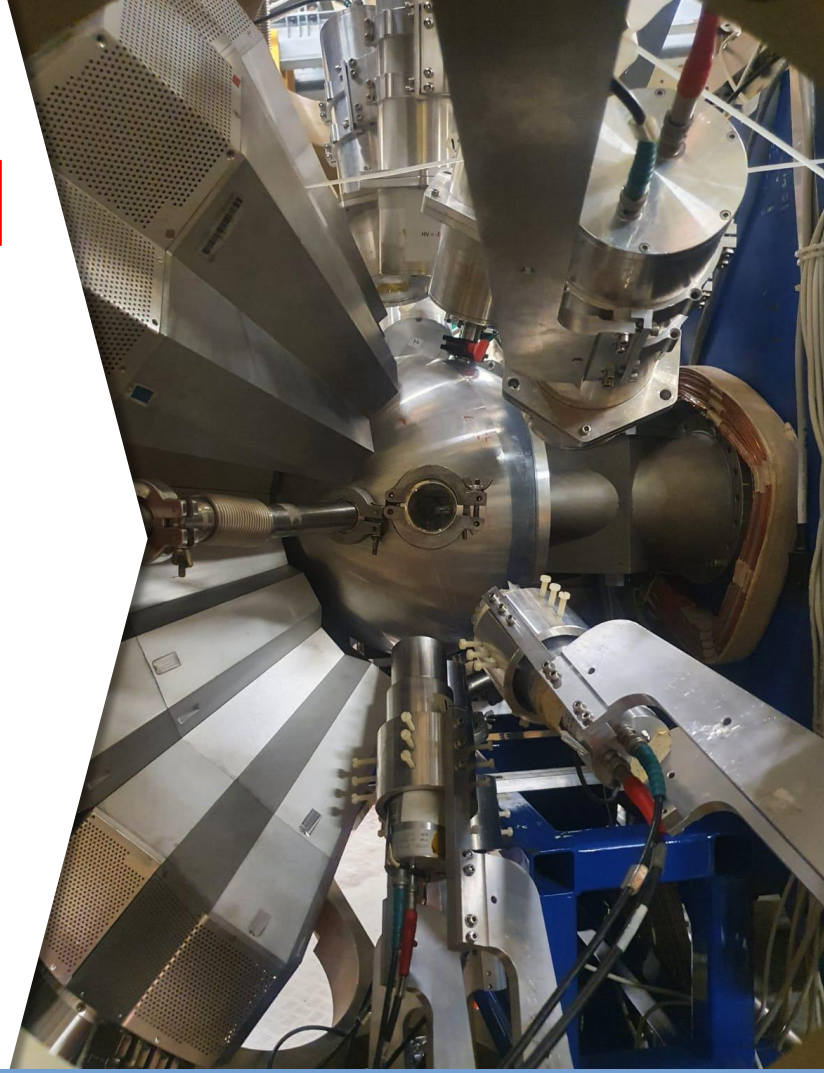
Target	Nominal	5.7h	1.8kHz
	Nominal Traces	2h	1.2kHz
	Close-up	6h	0.7kHz
	Close-up Traces	2h	0.45kHz & 1.5kHz
60Co	Far Traces	6h ; 6h	1kHz-0.8Hz



Measurements

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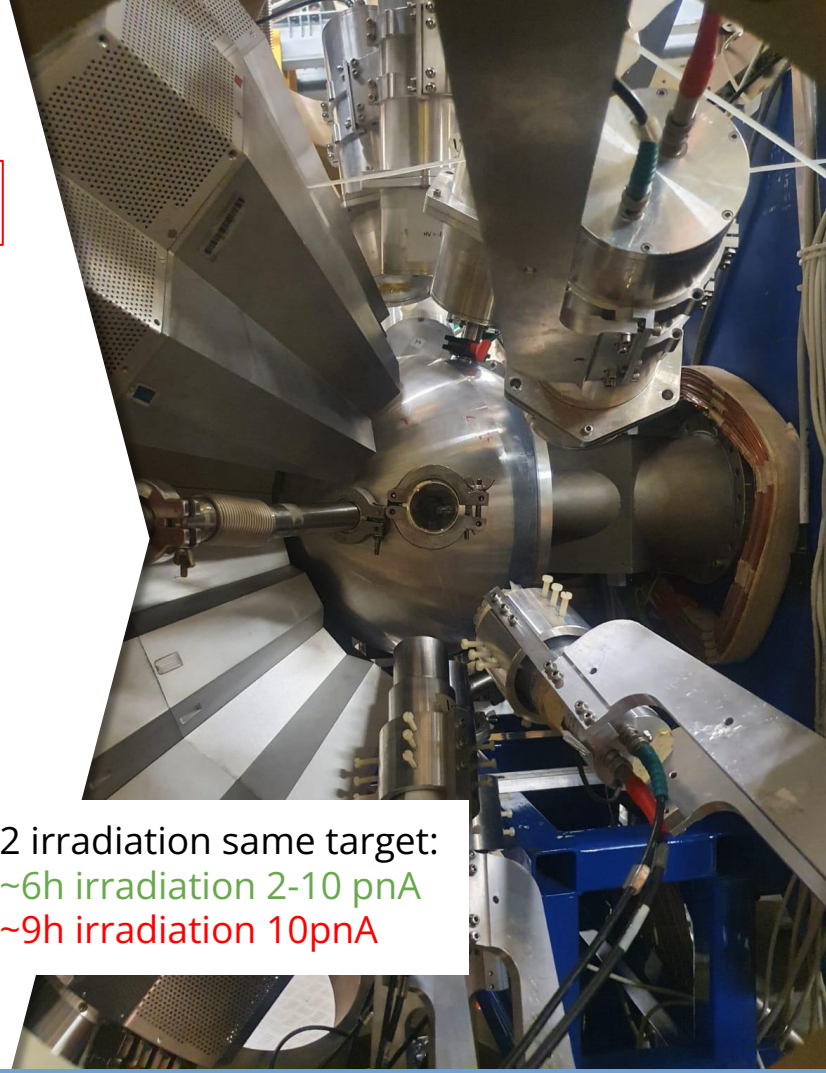

2 irradiation same target:
~6h irradiation 2-10 pnA
~9h irradiation 10pnA

Measurements

Performance up to 5MeV

26th-31st July 2024

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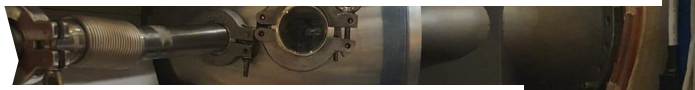
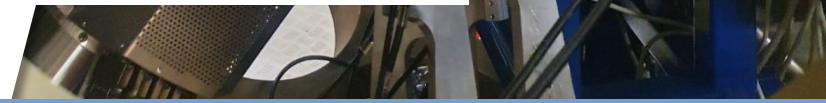
60Co for status/individual performances



152Eu for Efficiency normalization

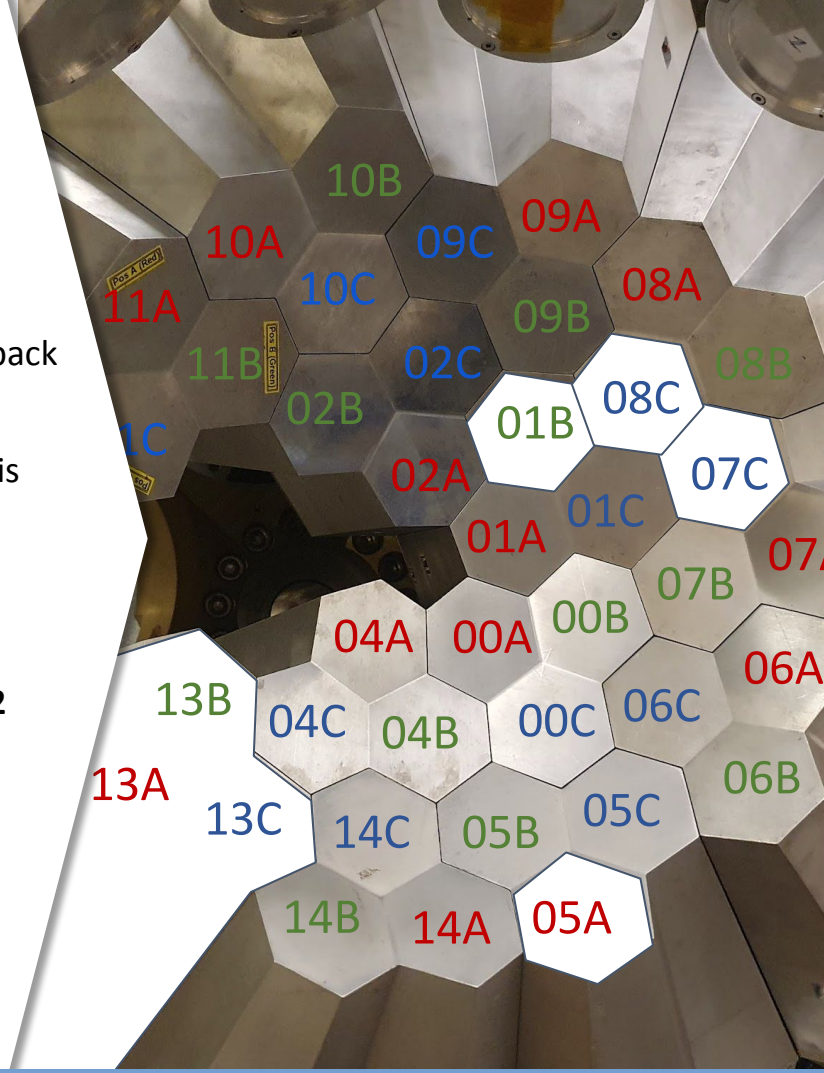
2 irradiation same target:
~6h irradiation 2-10 pnA
~9h irradiation 10pnA



Status July

12 ATC - 32 AGATA crystals

- **<u>00C and 05B:</u>** <u>losing validations very often</u>
- **04B :** segments A4, A5, A6 disappearing together and coming back over time (preamp issue) + noise (not very often)
- **05C:** gain and baseline of the core jump together over time, this change affects the gain of the core and of the segments
- **07B :** bad resolution due to the continuous oscillation of the energy in the HG core (LG ok)
- **09B, 11A**: core with strange noise in the trace (same as in **C002 and C014 - ATC 6** but with less amplitude)
- **00B:** displays a cross in the PSA hit pattern
- **02C:** seg. B4 (9) preamp issue
- **11A:** seg. F1 (30) channel digi issue



Methodology

https://baltig.infn.it/gamma/agata-efficiency

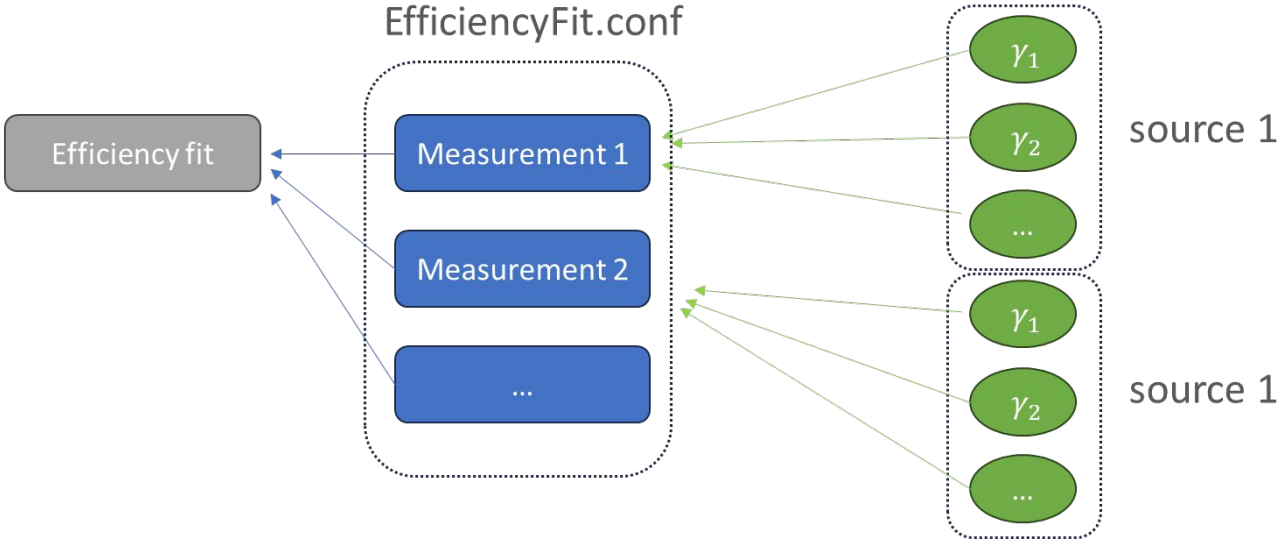
AGATA-efficiency code

- code to streamline efficiency evaluation

Methodology

AGATA-efficiency code

- Configuration-driven

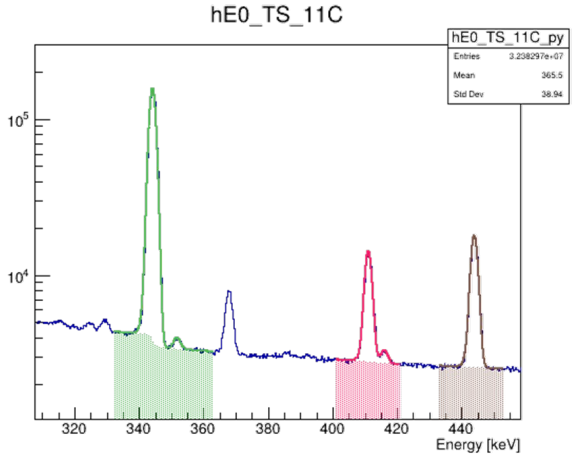


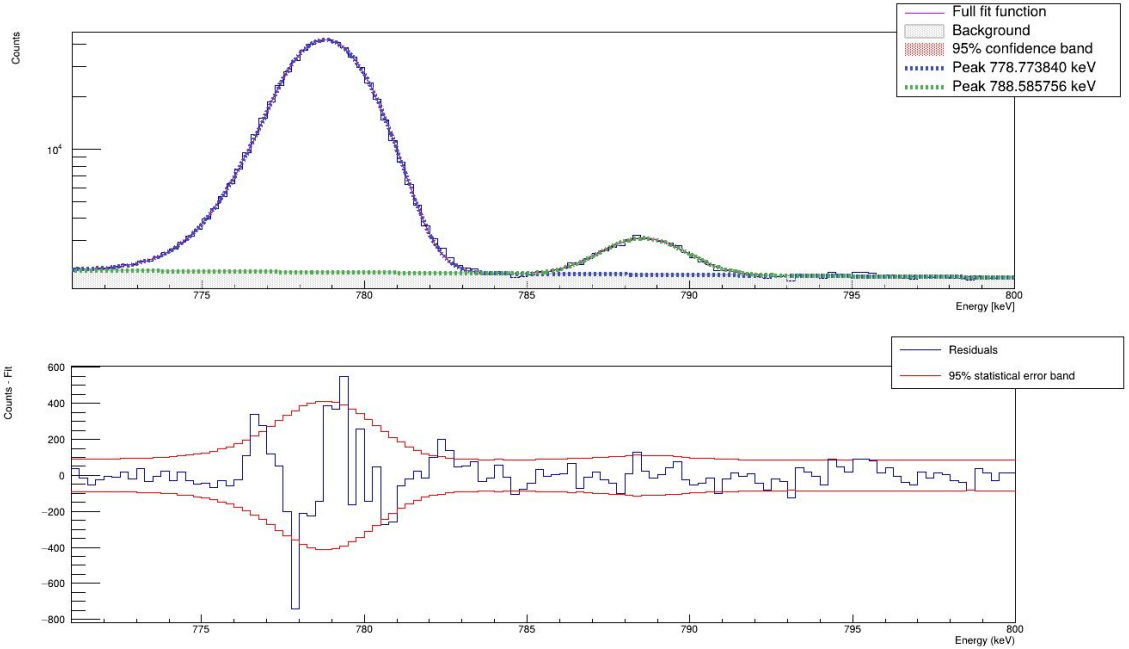
Source data taken from IAEA: `https://www-pub.iaea.org/mtcd/publications/pdf/pub1287_vol2_web.pdf`

Methodology

AGATA-efficiency code

- automated energy fitting with peak model supporting *tails* and *steps*



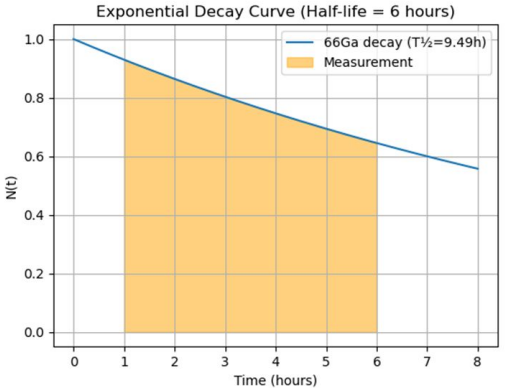


Methodology

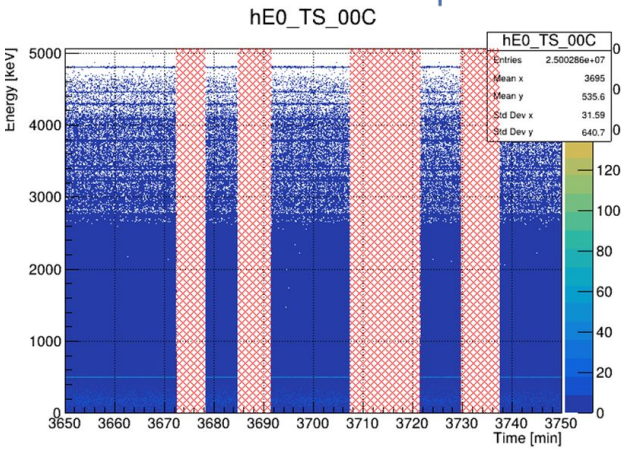
AGATA-efficiency code

- efficiency calculation
  - treatment for short-living sources
  - inactive + dead time correction

$$\varepsilon = \frac{C_{observed}}{N_{decays}\, I_\gamma}$$



$$N_{decays} = \frac{A_{source}}{\lambda}\left(e^{-\lambda(T_{start}-t_{ref})} - e^{-\lambda(T_{end}-t_{ref})}\right)D$$



Methodology

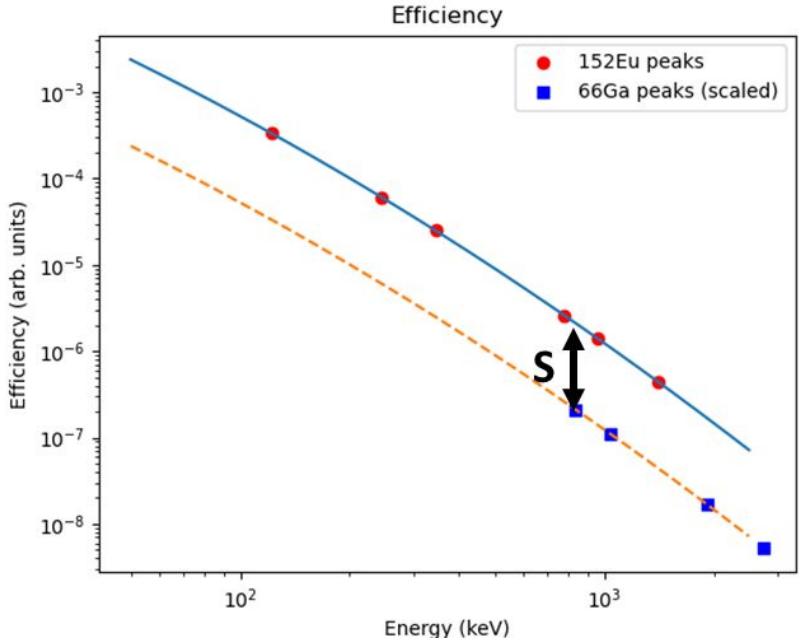
AGATA-efficiency code

- efficiency functions
  - **Exponential** $\varepsilon(E) = e^{(-\lambda E)}$
  - **Radware** $\varepsilon(E) = e^{\left[(A+Bx+Cx^2)^{-G}+(D+Ey+Fy^2)^{-G}\right]^{-1/G}}$
  - **Polynomial-logarithmic** $\ln(\varepsilon(E)) = \sum_{i=0}^{n} p_i \cdot \ln^i(E)$

Methodology

AGATA-efficiency code

- automated normalization for sources with unknown activity



Methodology

AGATA-efficiency code

- covariance-aware chi2 minimization
- sources of covariance
  - source activity
  - source half-life
  - (normalization parameter for uncalibrated sources)

Methodology

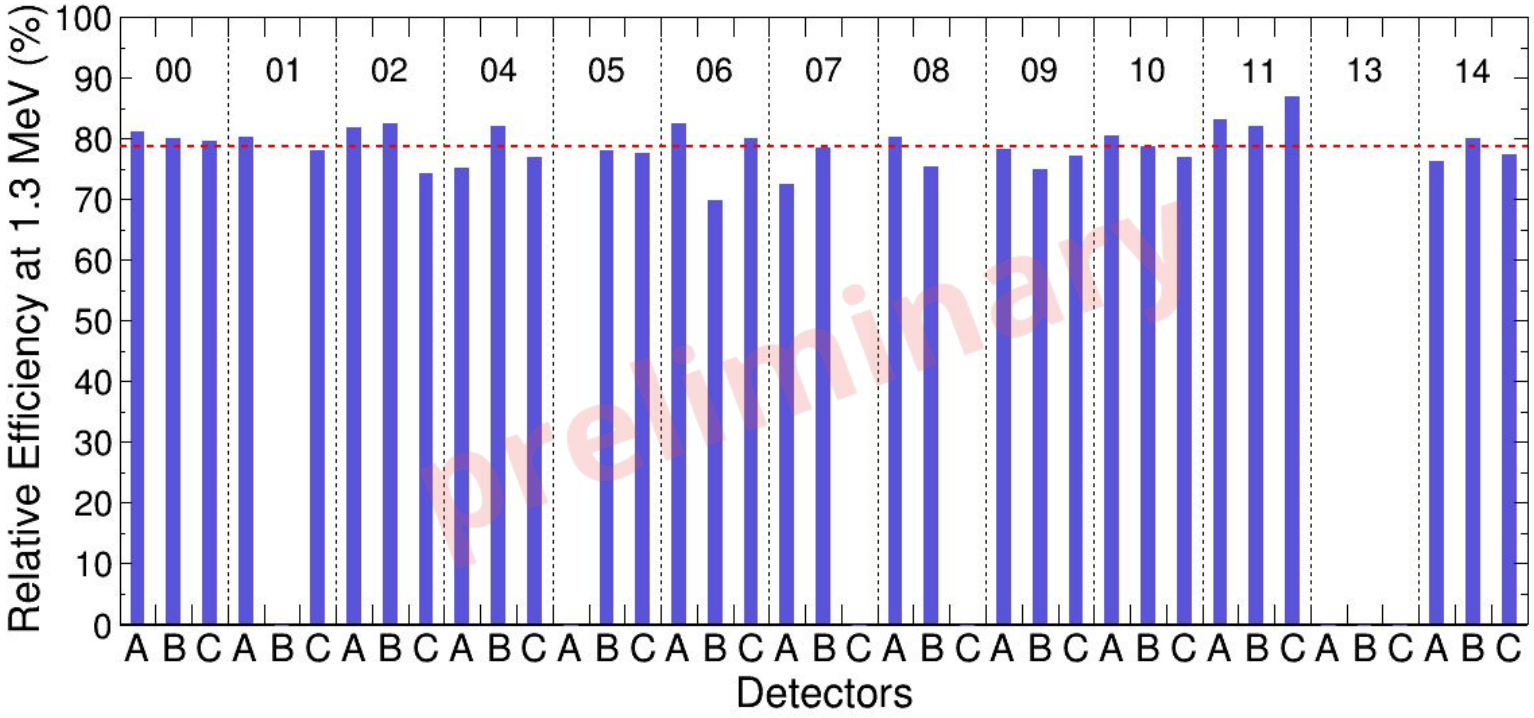
Data treatment

- energy drift corrections
- non-linear detectors

Efficiency

AGATA crystals - online efficiencies

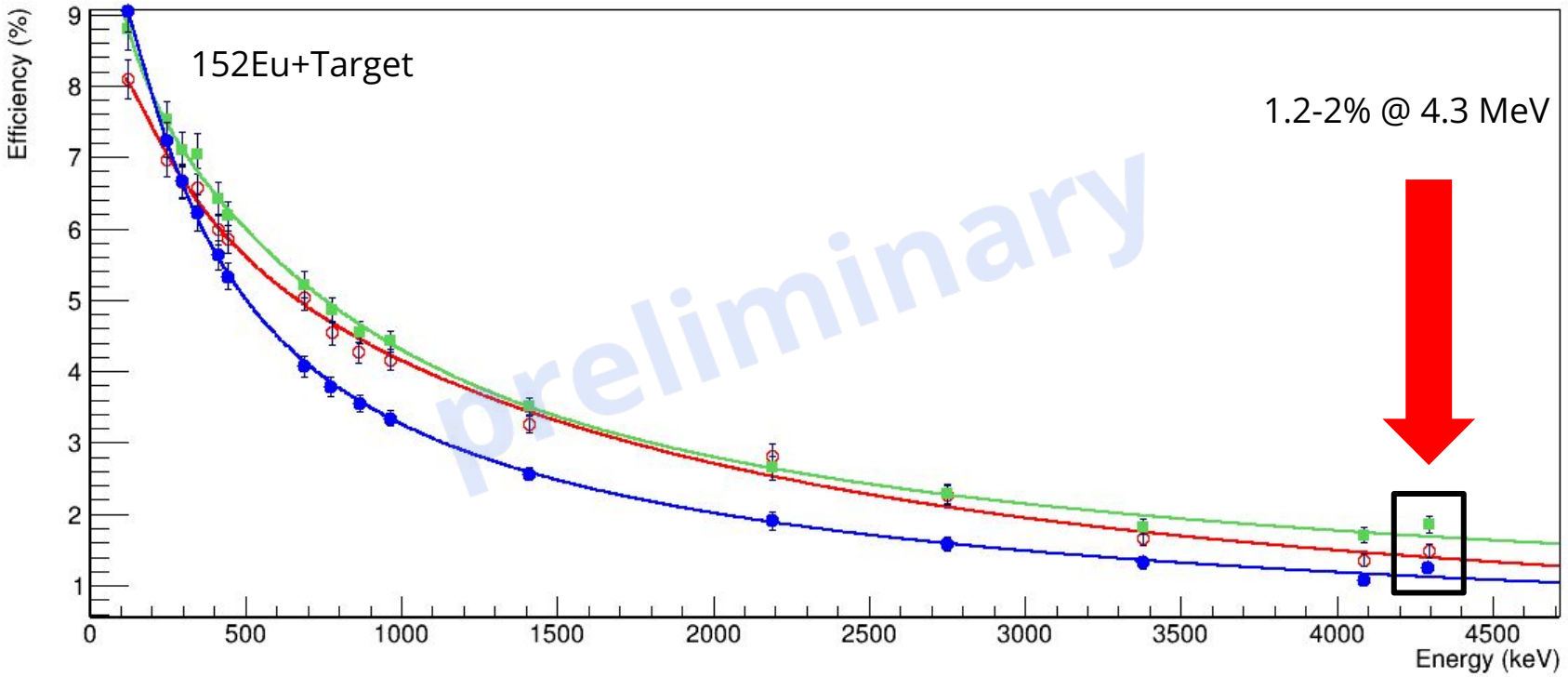
Relative efficiency to the reference value of a 3'x3' NaI at 25 cm= 0.0012



Efficiency

AGATA array @ Nominal

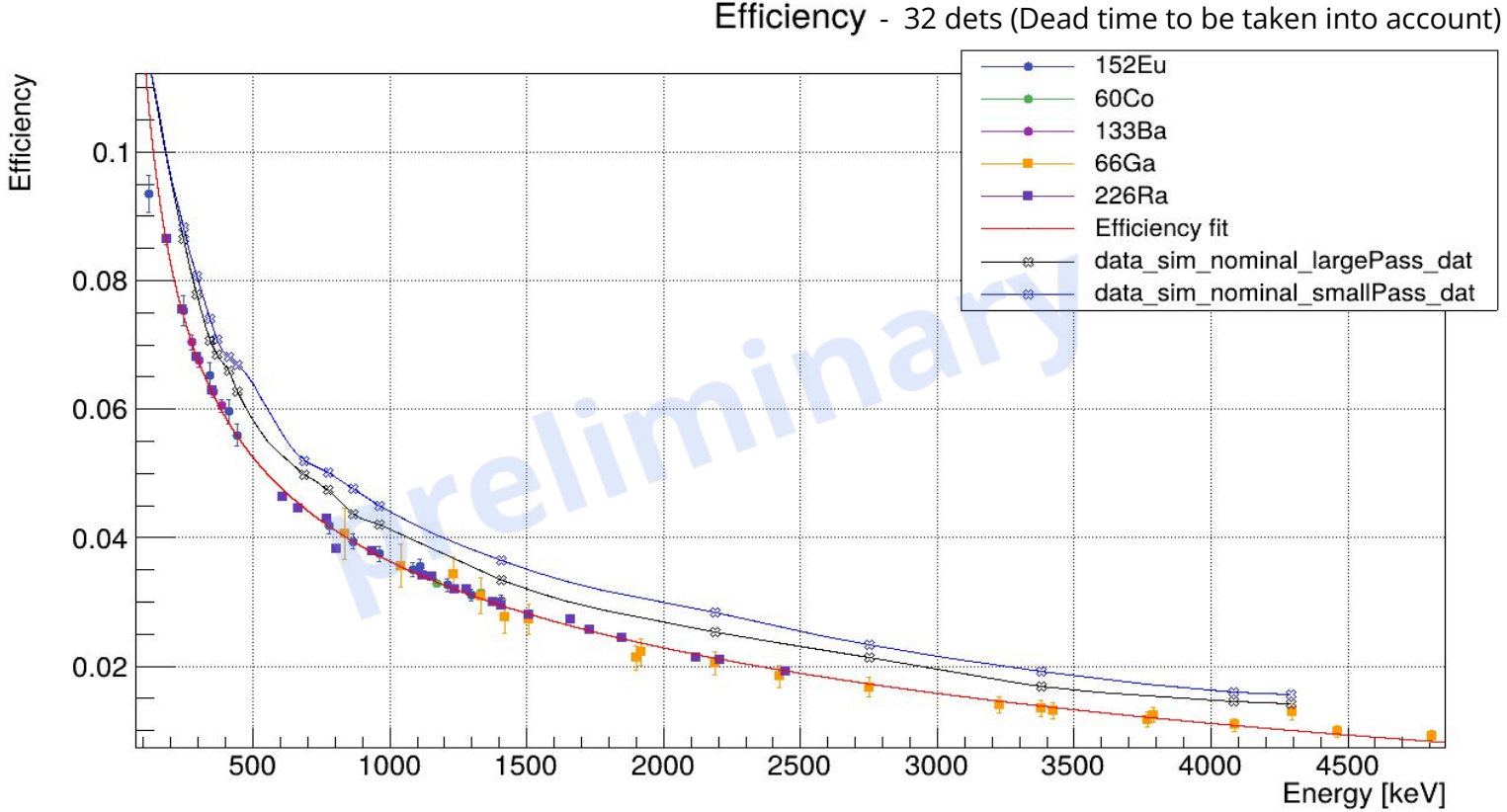
Core
Tracked
Addback



Efficiency

AGATA array @ Nominal , core

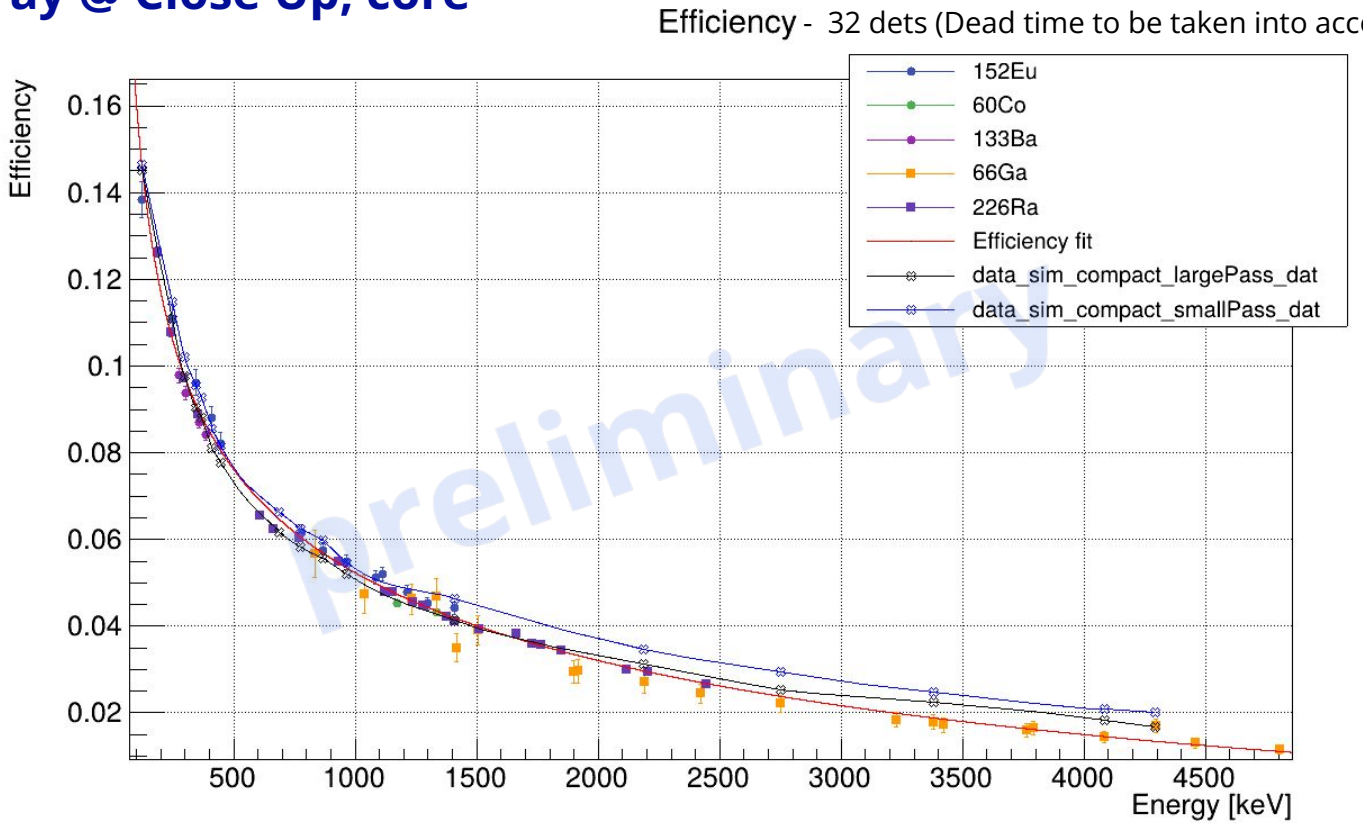
PostPSA corrections included:
- Neutron Damage correction
- Energy drift corrections
- Recalibration
- Force segments to core



Efficiency

AGATA array @ Close Up, core

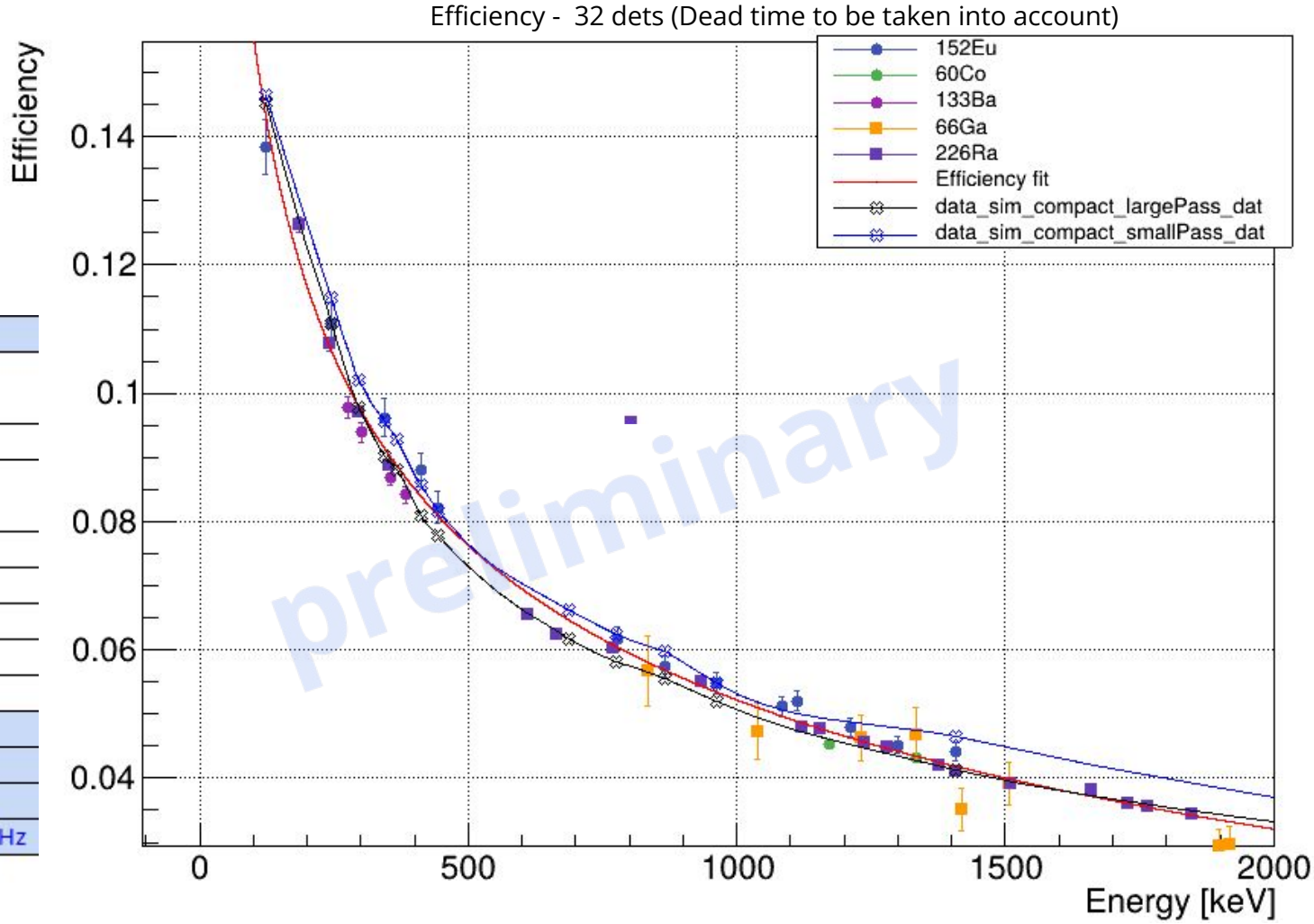
PostPSA corrections included:
- Neutron Damage correction
- Energy drift corrections
- Recalibration
- Force segments to core



Efficiency

AGATA array @ Close Up core

Source	Rate
60Co	1.5kHz
	2kHz
152Eu	2kHz
	3kHz
133Ba	2kHz
	2.7kHz
226Ra	1.6kHz
	2KHz
Target	1.8kHz
	1.2kHz
	0.7kHz
	0.45kHz & 1.5kHz
60Co	1kHz-0.8Hz



Summary

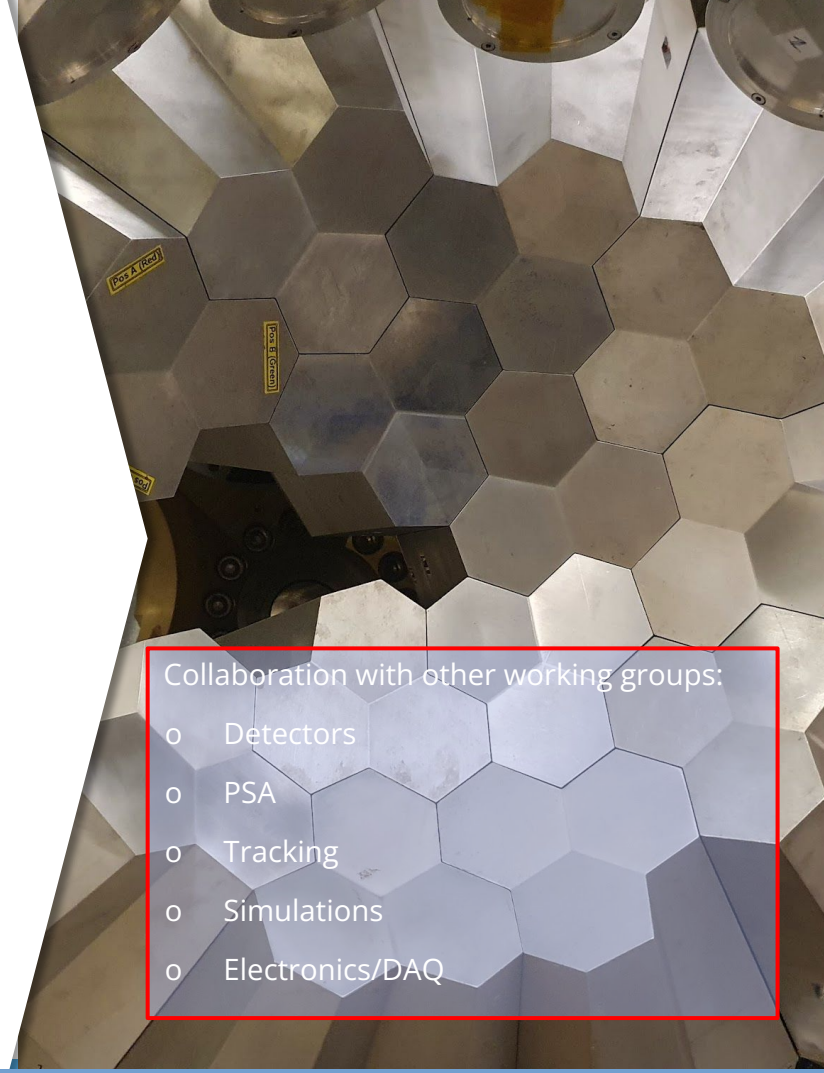
- Experiments looking for gamma rays in the region between 2-5 MeV where the performances in terms of calibration, efficiency and tracking are not well known.

- **Measurement to investigate those performances up to 5 MeV realized at the end of July 2024**

- First steps:
  - **Validation PostPSA**
  - **Core analysis**
  - **Validation of GEANT4 simulations**

- Next steps:
  - Dead time evaluation
  - Optimization of the tracking algorithms
  - Addback analysis

- Future perspectives: towards high multiplicity events



Collaboration with other working groups:

- Detectors
- PSA
- Tracking
- Simulations
- Electronics/DAQ

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AGATA Crystal lookup table

Position	ATC	Crystal			Installation date
		A	B	C	
00	**18**	017	018	018	15/01/2024
01	**13**	003	016	015	03/04/2024
02	**17**	016	017	013	01/02/2022
04	**7**	007	014	003	04/04/2024
05	**09**	001	001	006	01/05/2022
06	**19**	018	012	019	13/02/2024
07	**2**	019	019	020	18/09/2023
08	**3**	002	007	007	01/03/2022
09	**14**	014	010	016	19/10/2023
10	**15**	013	015	011	01/03/2022
11	**1**	010	011	009	01/04/2022
14	**20**	009	020	005	01/01/2023