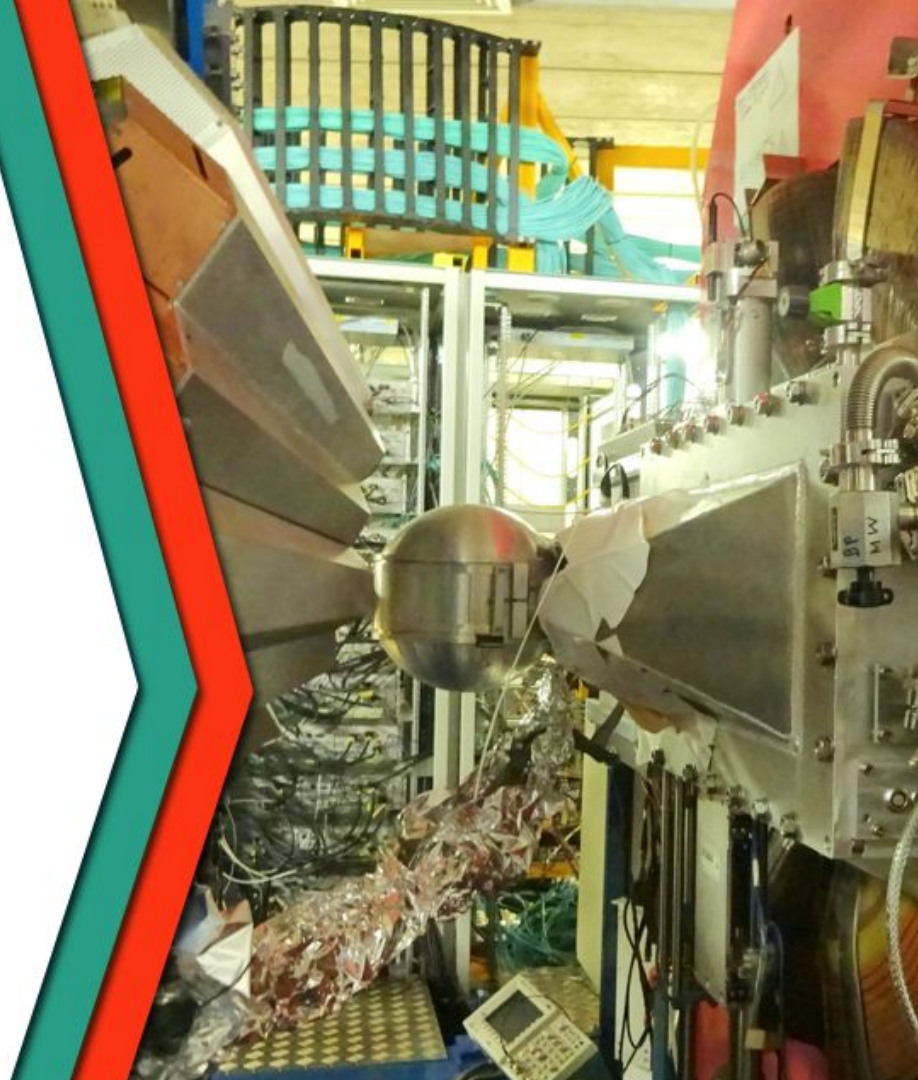
In-beam efficiency and angular correlations with AGATA

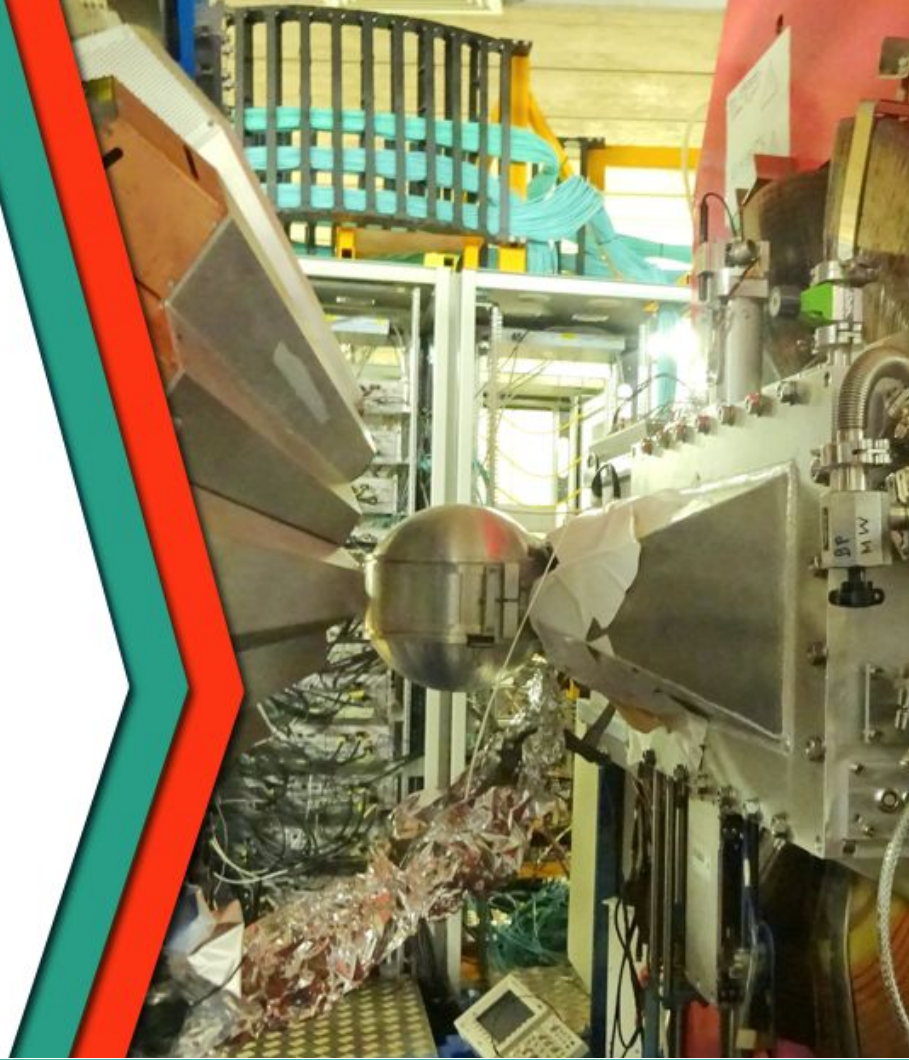
R.M. Pérez-Vidal
for the AGATA collaboration

AGATA Week | Strasbourg, 2018



Outline

- Introduction
- Experimental Setup
- AGATA performance
    - Spectra comparison
    - Efficiency
    - Angular correlations
    - Losses
    - Comparison with sources
- Summary



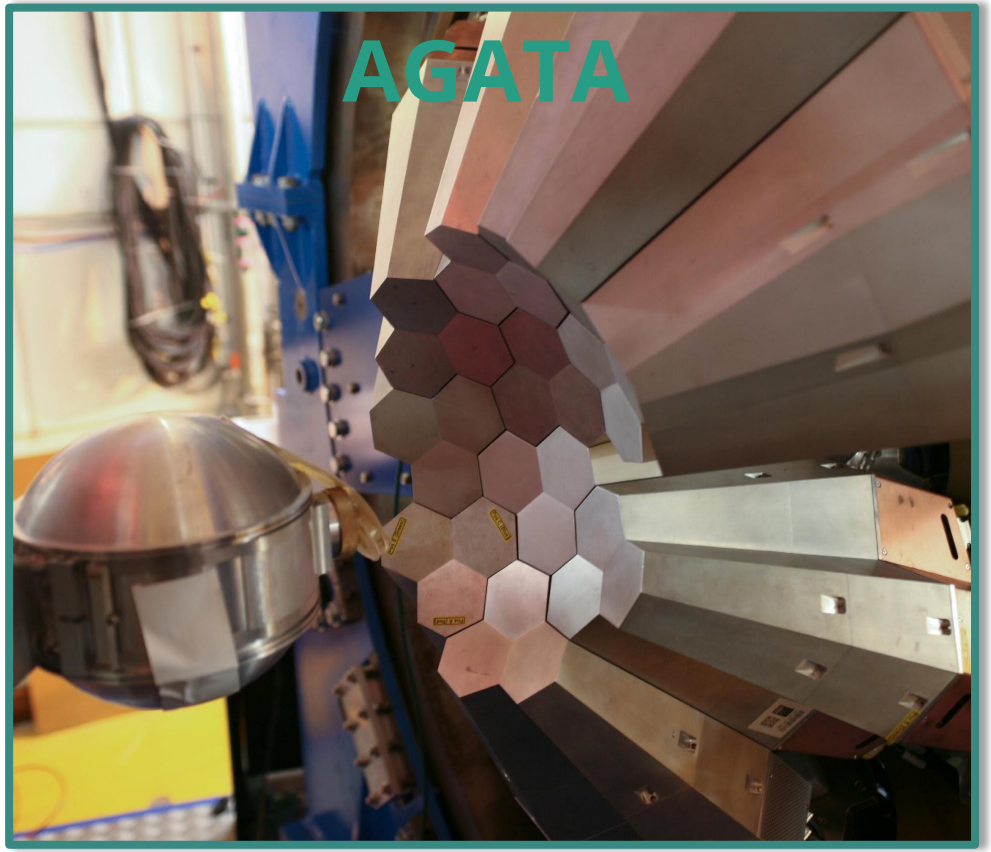
Introduction

High resolution γ-ray spectroscopy in-beam

In-beam measurements taken during AGATA-VAMOS campaign 2015

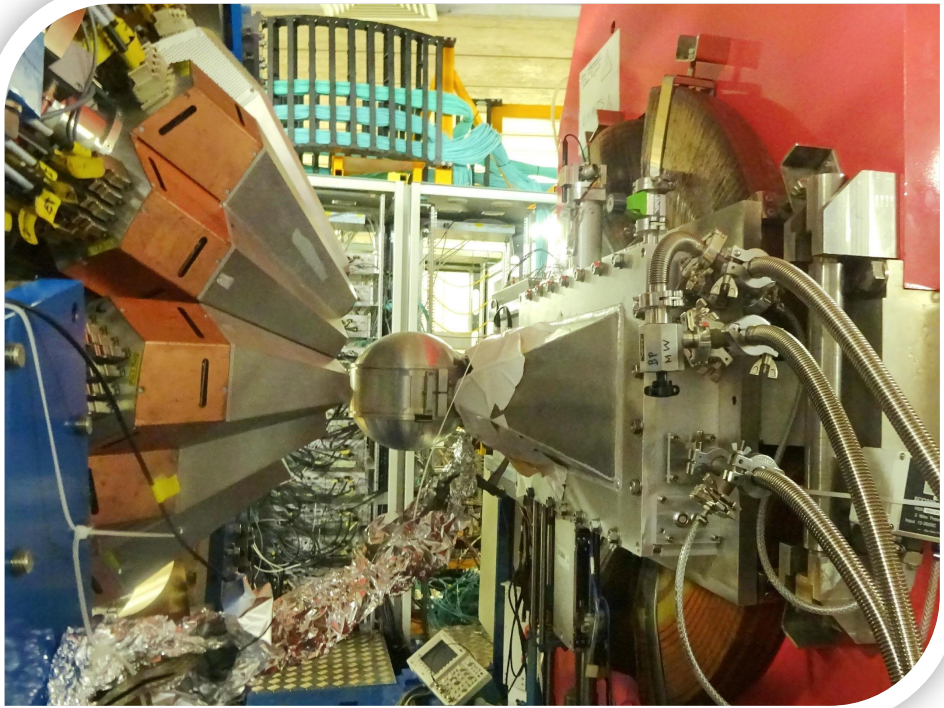
Performance characterized by:

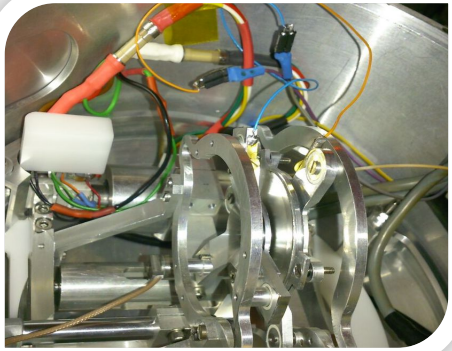
- 23 crystals (8ATC)
- Only DIGITIZER + ATCA pre-processing channels
- Chamber + cologne plunger
- Nominal position (235mm -7mm)
- Counting rate per crystal 50kHz



Experimental Setup

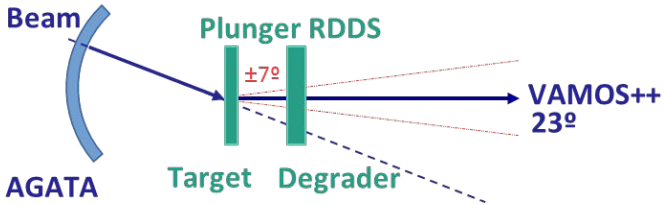
GANIL





Cologne differential plunger setup for RDDS measurements in grazing reactions. A.Dewald, Th. Pissulla, J. Jolie IKP-Uni. Köln.

LIFETIME MEASUREMENT



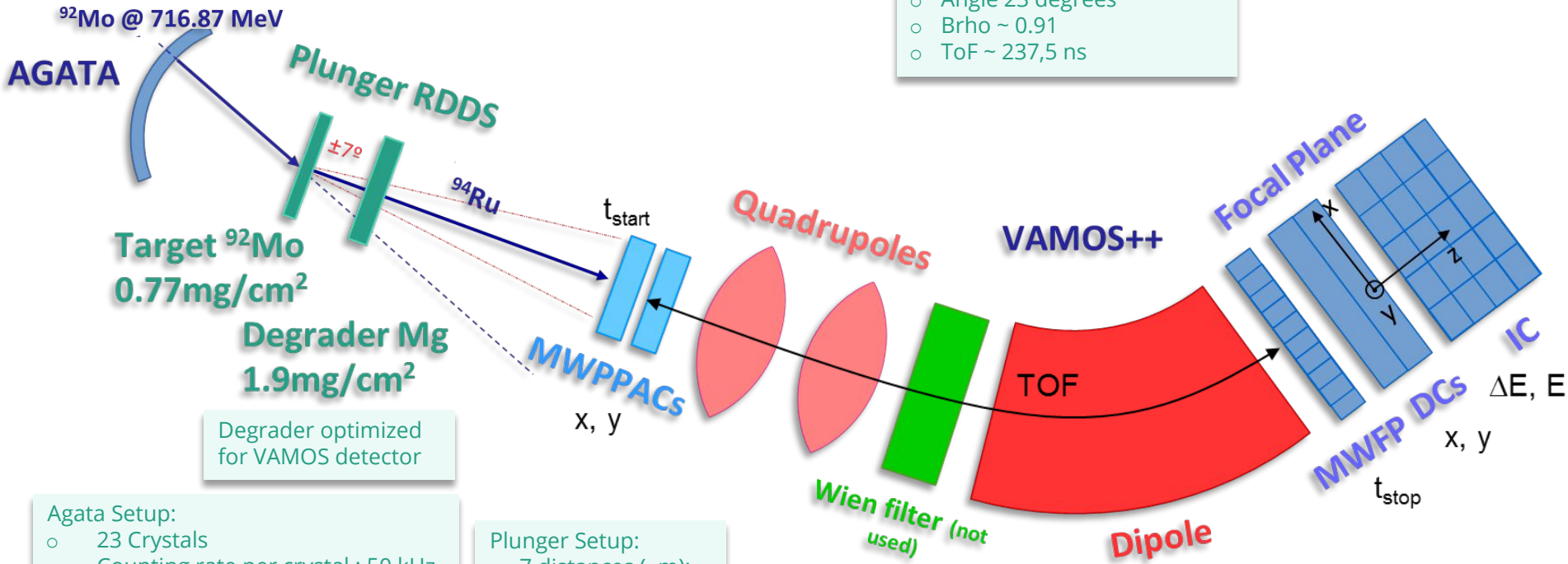
Multinucleon transfer reaction

Example: E682 ^{92}Mo +^{92}Mo 716 MeV

for proton rich nuclei

Experimental Setup

Example: E682



VAMOS++ Setup:
- Horizontal Acceptance: ±7º
- Vertical Acceptance: ±10º
- DM/M~1/220
- DZ/Z~1/66
- Angle 23 degrees
- Brho ~ 0.91
- ToF ~ 237,5 ns

Degrader optimized for VAMOS detector

Agata Setup:
- 23 Crystals
- Counting rate per crystal : 50 kHz
- Shapping 2.5 us
- Position: Nominal (23.5cm)

Plunger Setup:
- 7 distances (μm): 20, 25, 100, 500, 1000, 2000, 4000

Trigger MWPPAC & MWFP & OrGAMMA

AGATA Performance

Data preparation

Local level:

- Energy calibrations
- Segment Time alignment
- Crosstalk correction
- Correction for non working segments
- Adaptive-Grid-Search used for PSA
- Neutron damage correction

Global level:

- Energy recalibration
- Time alignment
- Tracking

Modes of analysis

Core Common: Energy of the individual central contacts histogramed together

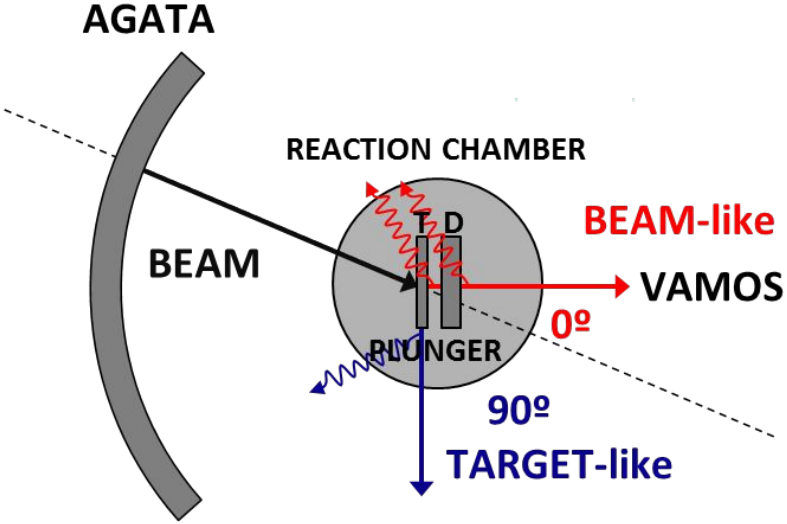
Tracked : Reconstructed energy by the tracking algorithm which uses the information given by the PSA.

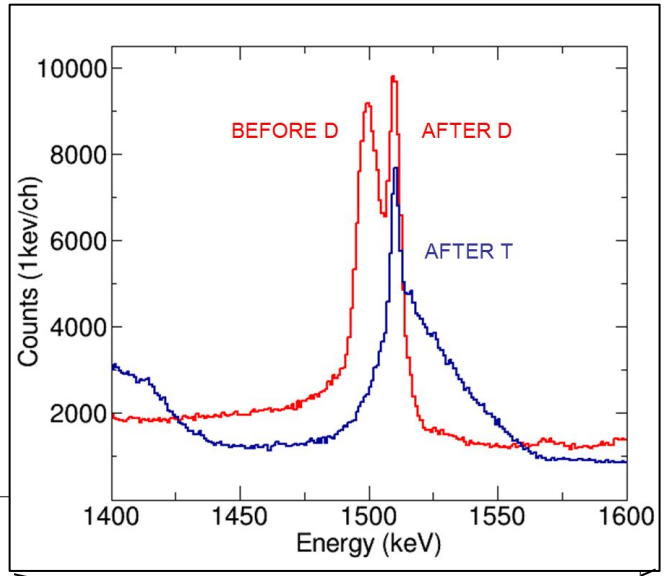
- **Tracked CC:** energy built making the energy of the segments equal to the energy of the central contact
- **Tracked SG:** Energy reconstructed by using the sum of the energy of the segments

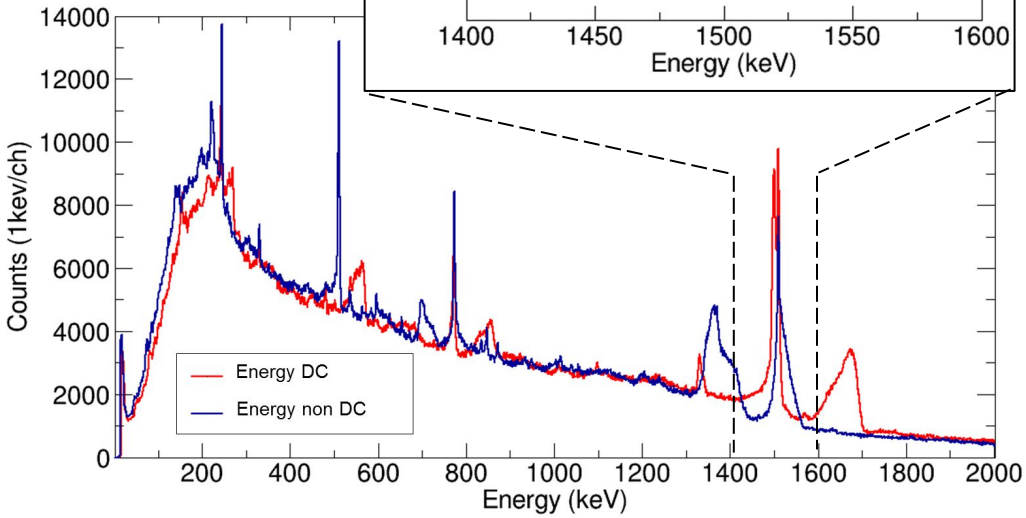
AGATA Performance

Inelastic channel: 2 cases

$^{92}Mo + ^{92}Mo \rightarrow ^{92}Mo + ^{92}Mo$

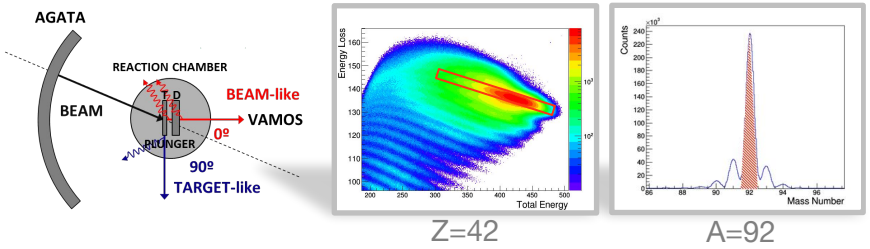


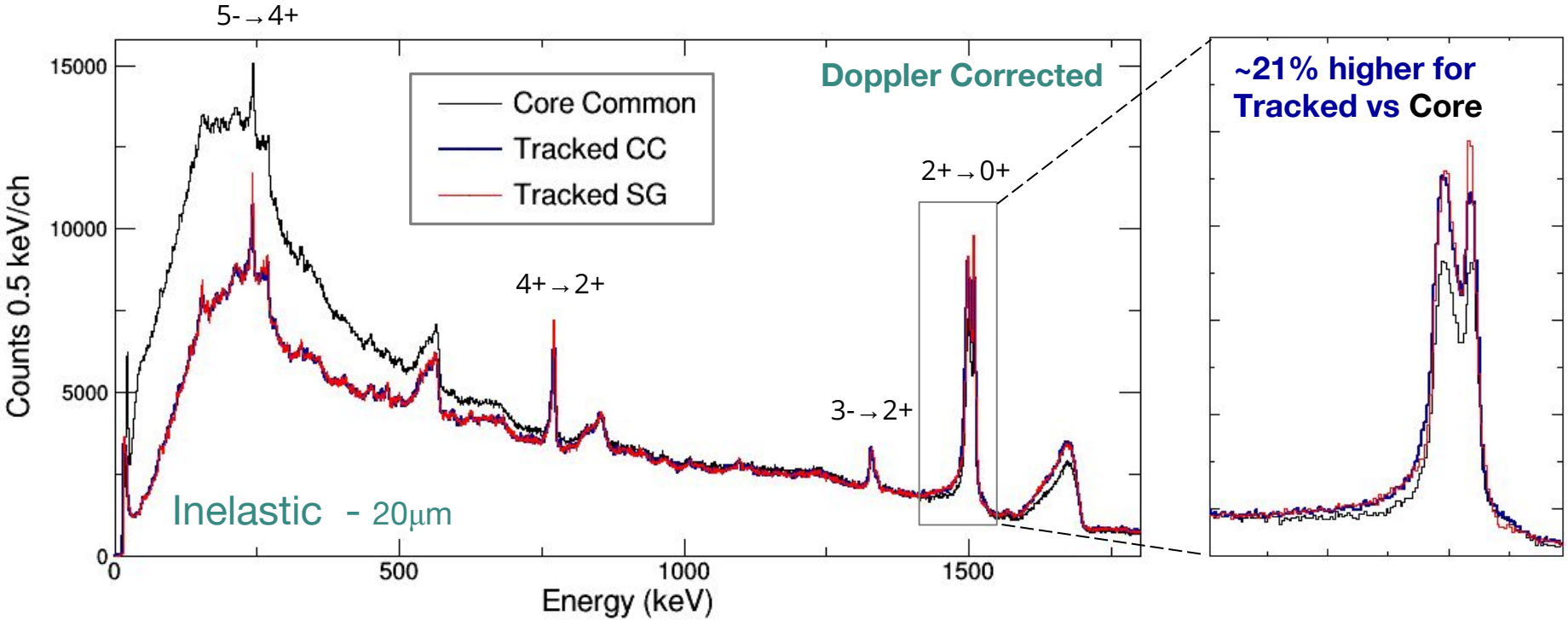




AGATA Performance

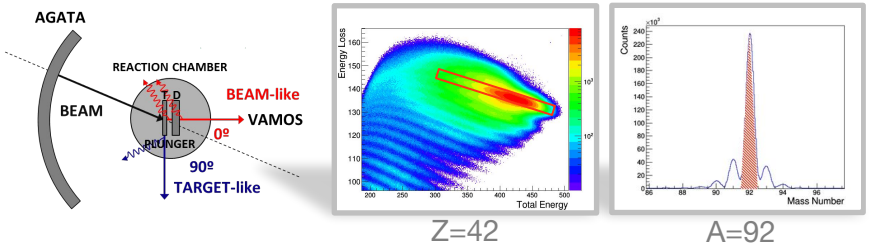
Spectra comparison: ^{92}Mo at 0º

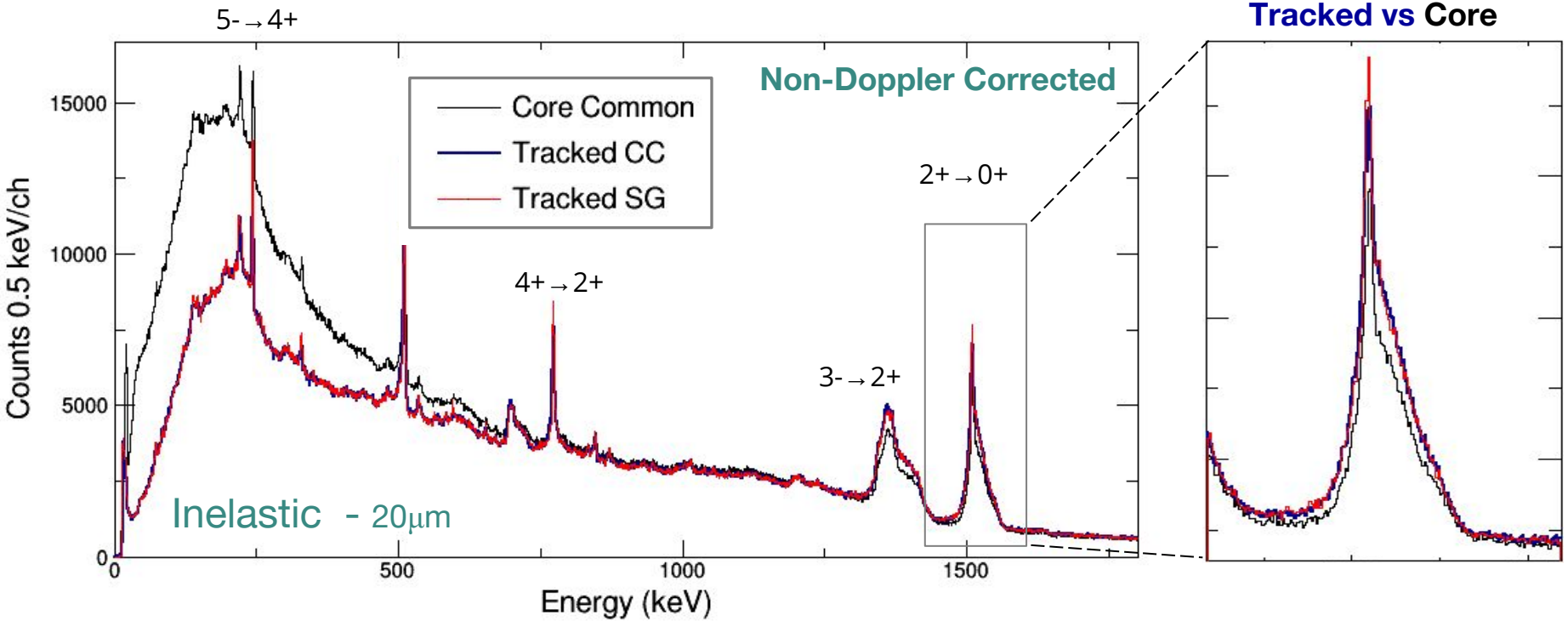




AGATA Performance

Spectra comparison: ^{92}Mo at 90º



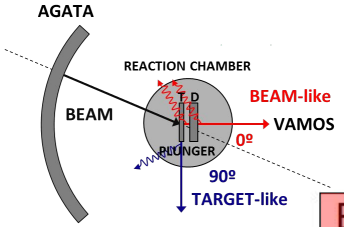


AGATA Performance

Efficiency measurement

In-beam efficiency from $\gamma - \gamma$ **coincidences:**

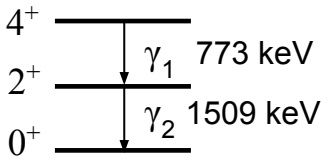
- Inelastic channel ^{92}Mo
- Two methods: efficiency from gammas at 0º (1) and gammas at 90º (2)
- Gate on 773keV (4+->2+)
- **Efficiency at 1509 keV (2+->0+)**

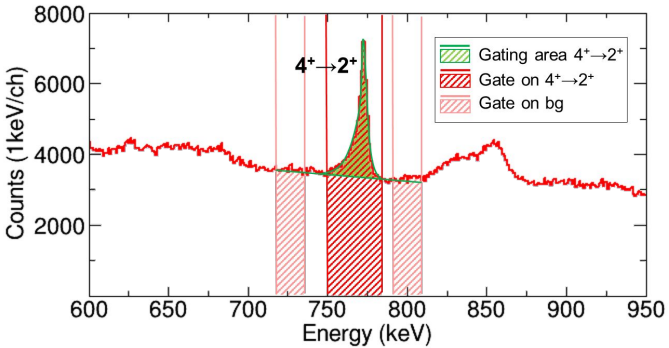


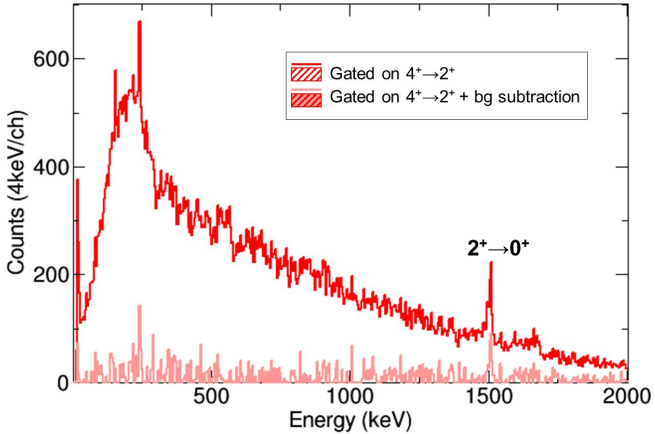
$$\epsilon_{peak}(E_2) = \frac{N_{\gamma,coinc}(E_2)}{N_{\gamma,sing}(E_1) \cdot W(\theta) \cdot 1/(1+\alpha_T(E_2))}$$

	Efficiency raw (0º)	Efficiency raw (90º)
Core Common	1.39 (15)	1.45 (13)
TrackCC	1.45 (12)	1.52 (11)
TrackSG	1.50 (12)	1.50 (11)

Efficiency raw: taking into account only the areas not correction factors applied for angular correlations or losses due to the high counting rates



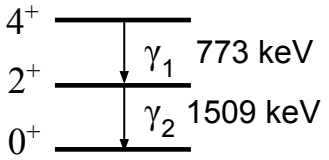




Areas subtraction example : ^{92}Mo at 0º

AGATA Performance

Efficiency measurement



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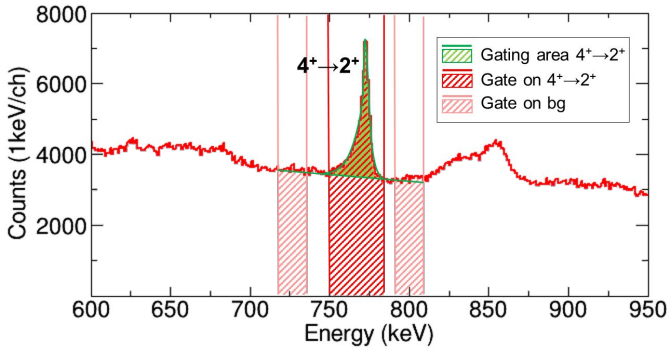

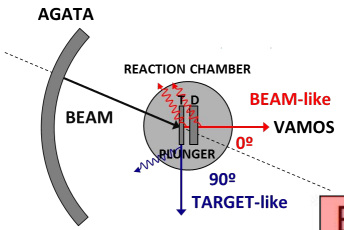

Angular correlation in-beam??

$$\epsilon_{peak}(E_2) = \frac{N_{\gamma,coinc}(E_2)}{N_{\gamma,sing}(E_1)\ W(\theta)\ 1/(1+\alpha_T(E_2))}$$

	Efficiency raw (0º)	Efficiency raw (90º)
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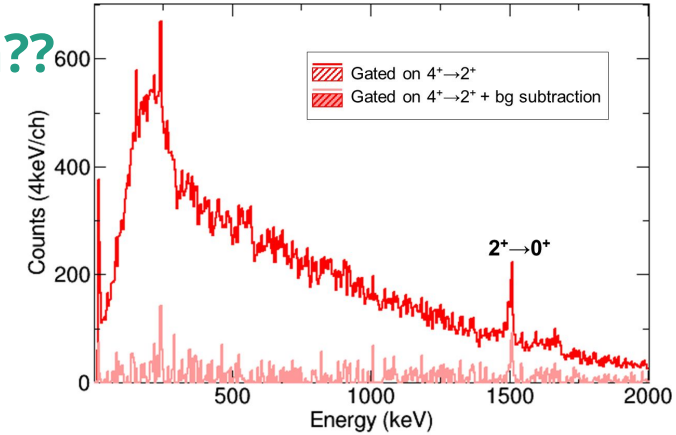
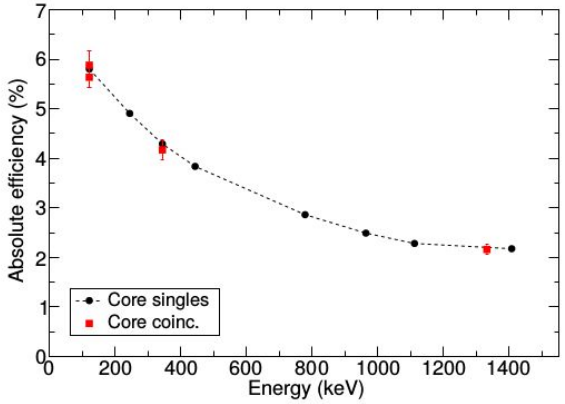


Areas subtraction example : ^{92}Mo at 0º

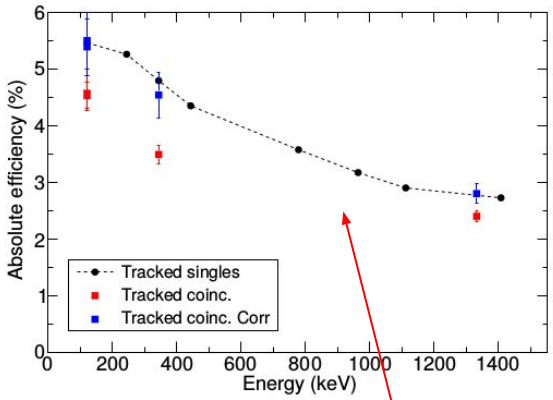
AGATA Performance

Angular correlation with sources

E682 setup, 23 detectors

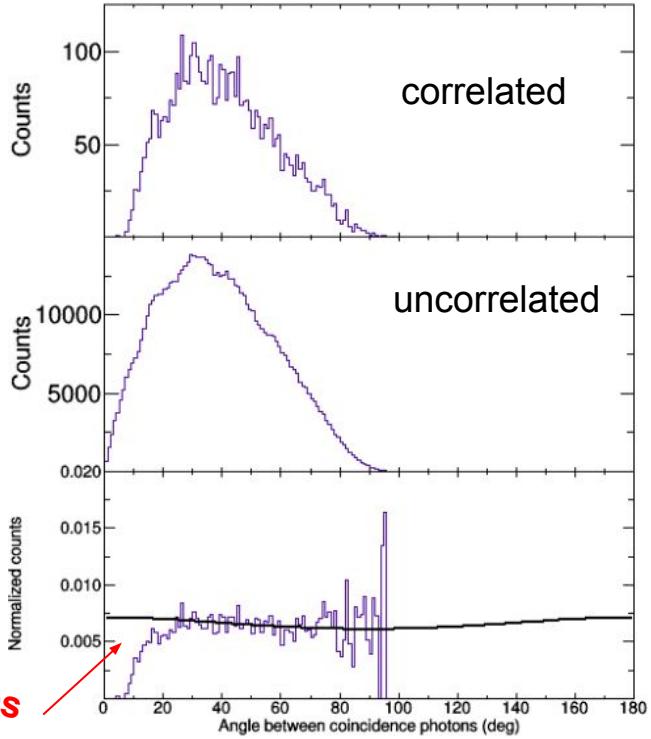


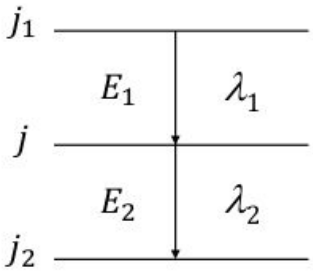
E682 setup, 23 detectors
OFT (σ_θ=0.8, prob$_{sing}$=0.02, prob$_{track}$=0.05)



~10% losses

Angular correlation of tracked gammas





$$\epsilon_{peak}(E_2) = \frac{N_{\gamma,coinc}(E_2)}{N_{\gamma,sing}(E_1) \cdot W(\theta) \cdot 1/(1+\alpha_T(E_2))}$$

$$W(\theta) = \sum_{k=0,2,..} A_k \left(j_1 \lambda_1 j \lambda_2 j_2\right) P_k \left(\cos\theta\right)$$

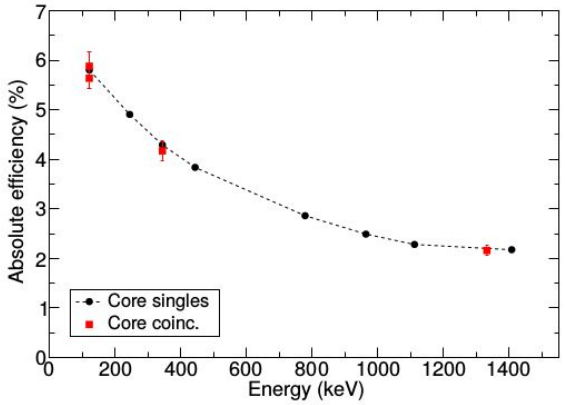
^{60}Co source example, E682 setup

$j_1 \to j \to j_2$	λ_1	λ_2	A_2	A_4
$4 \to 2 \to 0$	E2	E2	0.1020	0.0091

AGATA Performance

Angular correlation with sources

E682 setup, 23 detectors



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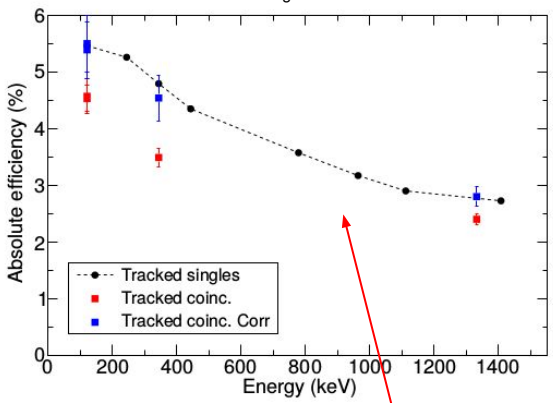
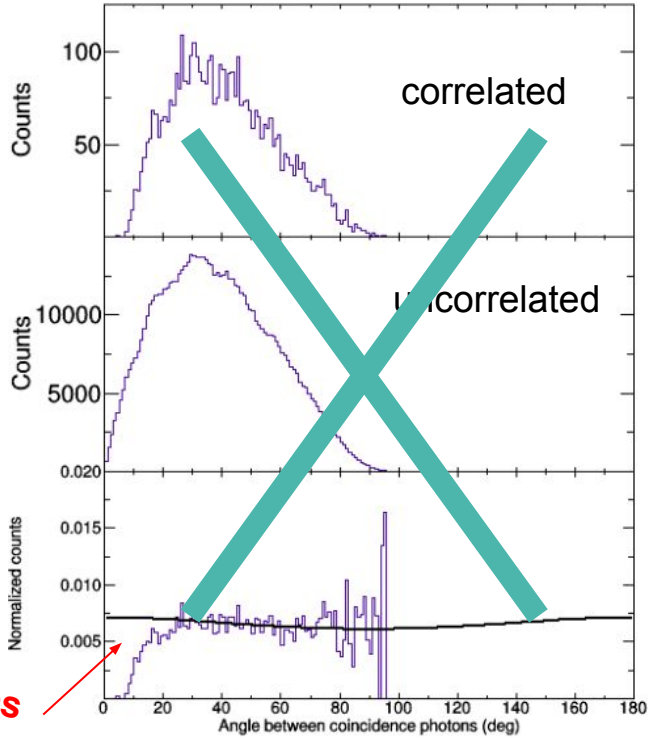
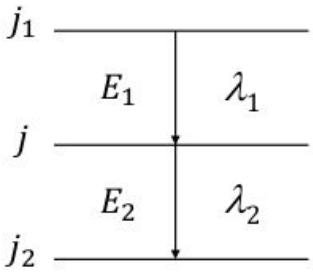


Angular correlation of tracked gammas



~10% losses



$$\epsilon_{peak}(E_2) = \frac{N_{\gamma,coinc}(E_2)}{N_{\gamma,sing}(E_1) \cdot W(\theta) \cdot 1/(1+\alpha_T(E_2))}$$

$$W(\theta) = \sum_{k=0,2,..} A_k\,(j_1 \lambda_1 j \lambda_2 j_2)\,P_k(\cos\theta)$$

This method can't be applied in-beam

^{60}Co source example, E682 setup

$j_1 \to j \to j_2$	λ_1	λ_2	A_2	A_4
$4 \to 2 \to 0$	E2	E2	0.1020	0.0091

AGATA Performance

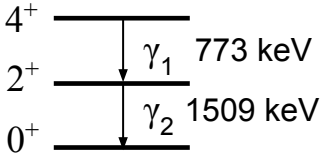
In-beam angular correlation

- In the in-beam case the source is oriented
- The gamma-gamma correlations have a triple correlation between the beam direction and the two gamma rays
- A series of tests are in progress in order to estimate the angular correlation corrections

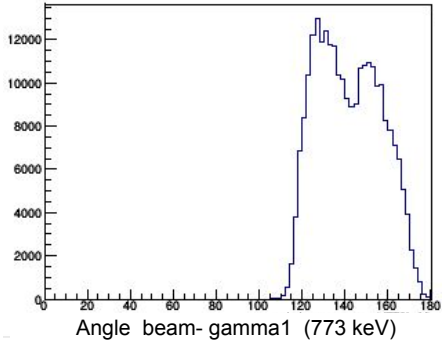
AGATA Performance

In-beam angular correlation tests

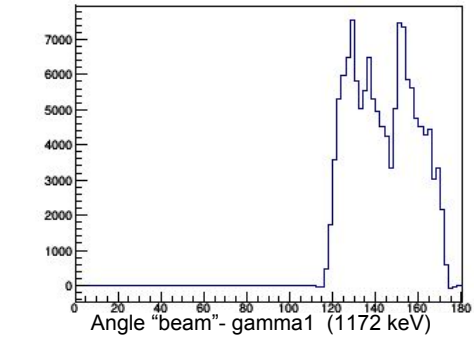
Tracked case of ^{92}Mo at 0º



Angular distribution 4+->2+ ^{92}Mo



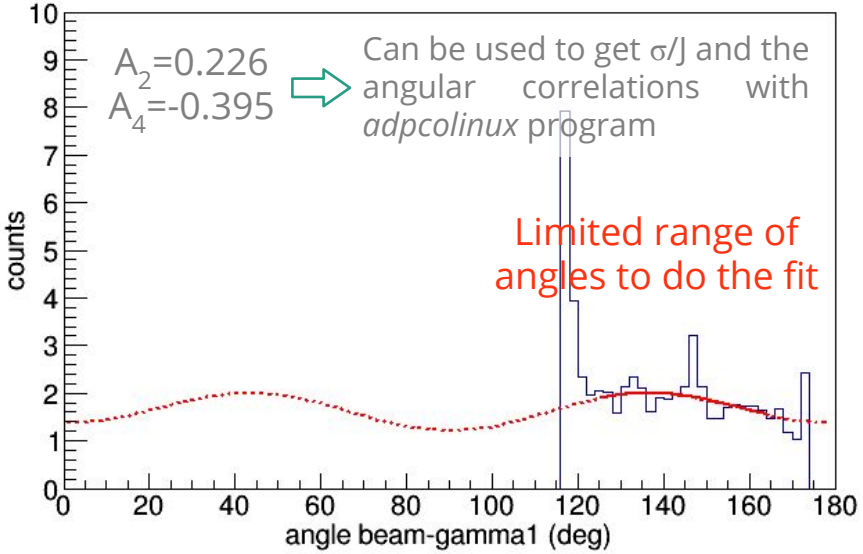
Angular distribution 4+->2+ ^{60}Co



Normalization with a non oriented source to correct by the geometrical effects

(!) Different energies

Angular distribution normalized 4+->2+ ^{92}Mo + fit

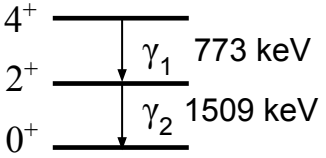


Work in progress

AGATA Performance

In-beam angular correlation tests

Tracked case of ^{92}Mo at 0º



~10% of losses at low angles (~10º) due to the tracking have been observed with the sources

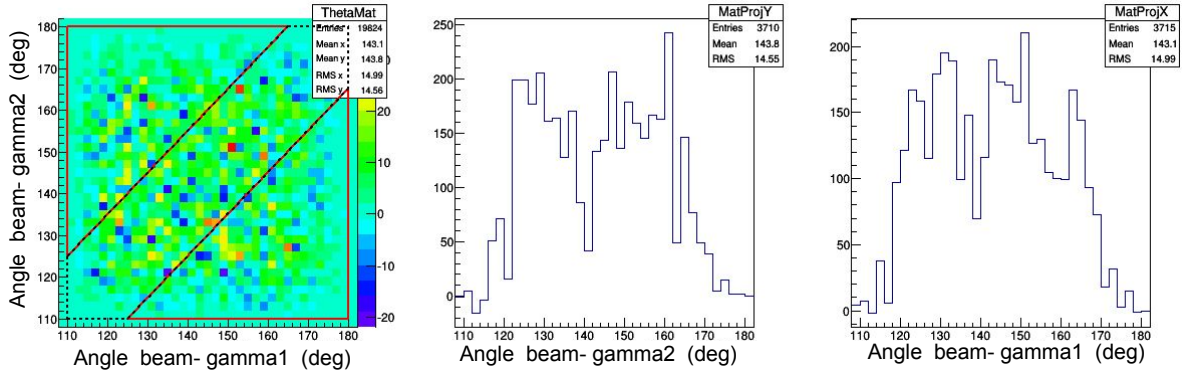
1) **Matrix of correlations from the same event**: coincident angles (diagonal <10º) should have losses

2) **Matrix of correlations from different events:** coincident angles (diagonal <10º) don't interfere (different events)

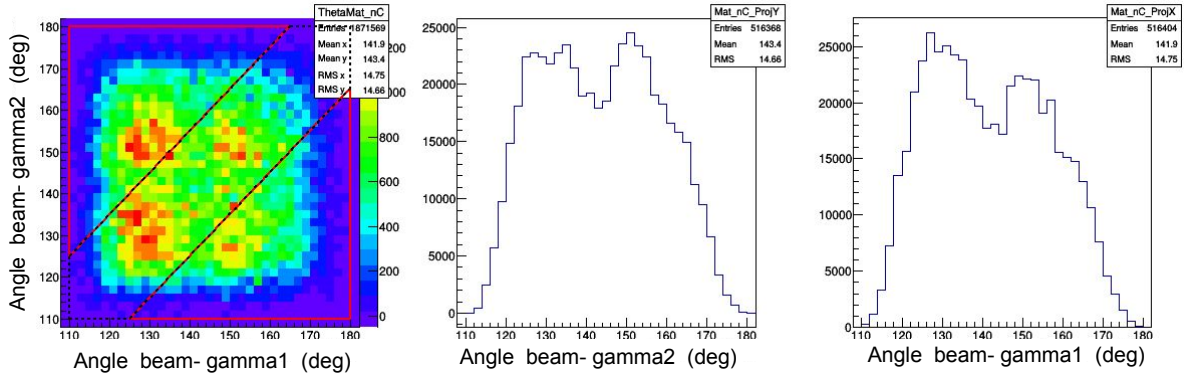
Method: comparison of the integrals of matrices 1) and 2) normalizing with the integral in non interfering angles (outside the diagonal)

Work in progress but very low statistics in E682

1)

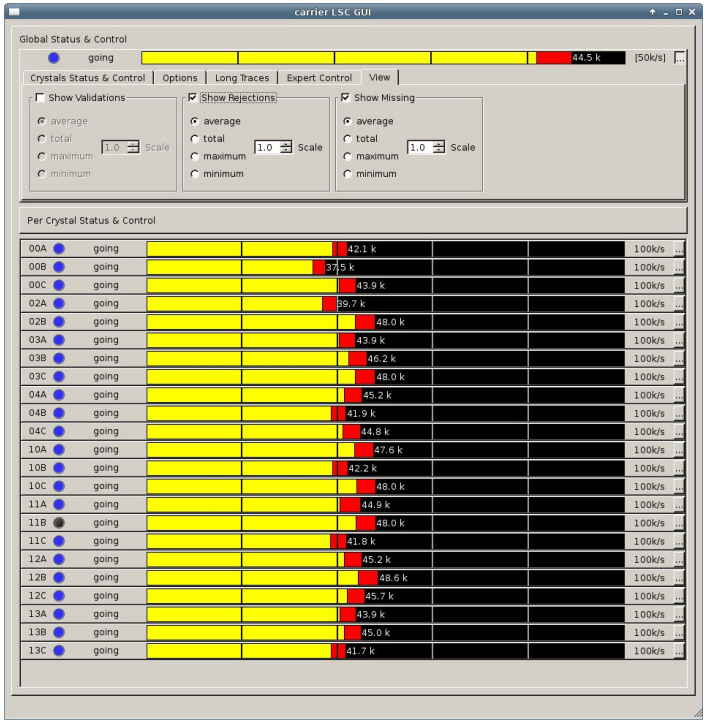


2)



AGATA Performance

In-beam losses due to high counting rates

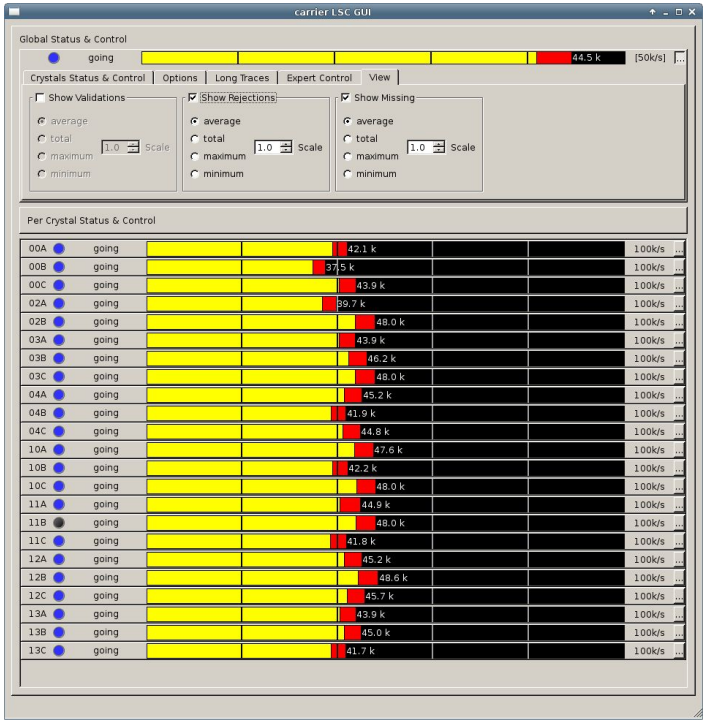


E682 rates-23 crystals

- Pile up
- GTS limitation
- High multiplicity
- Other effects?

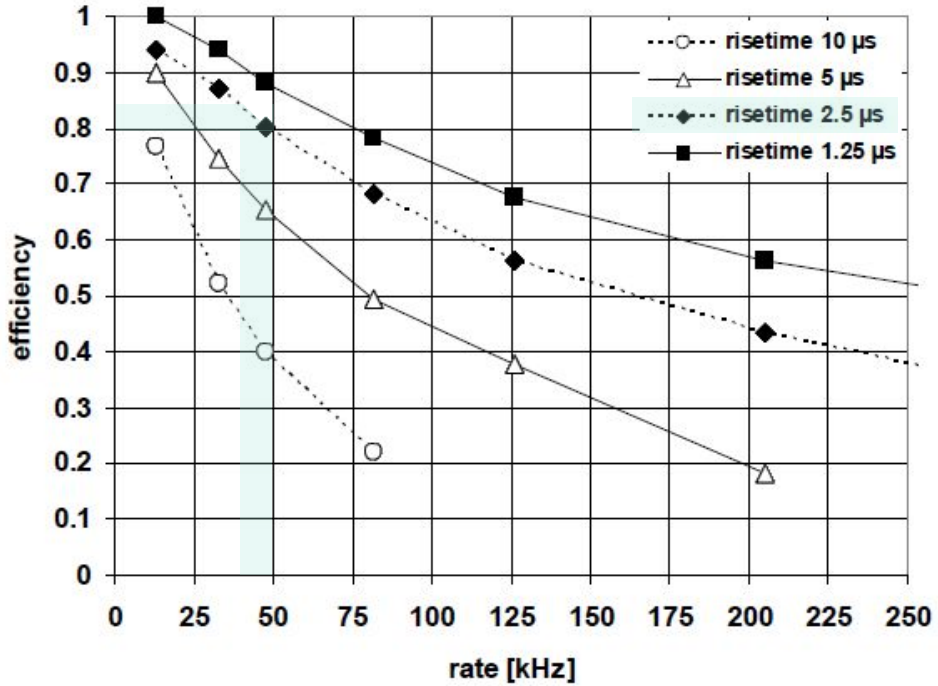
In-beam losses

Pile-up



E682 rates-23 crystals

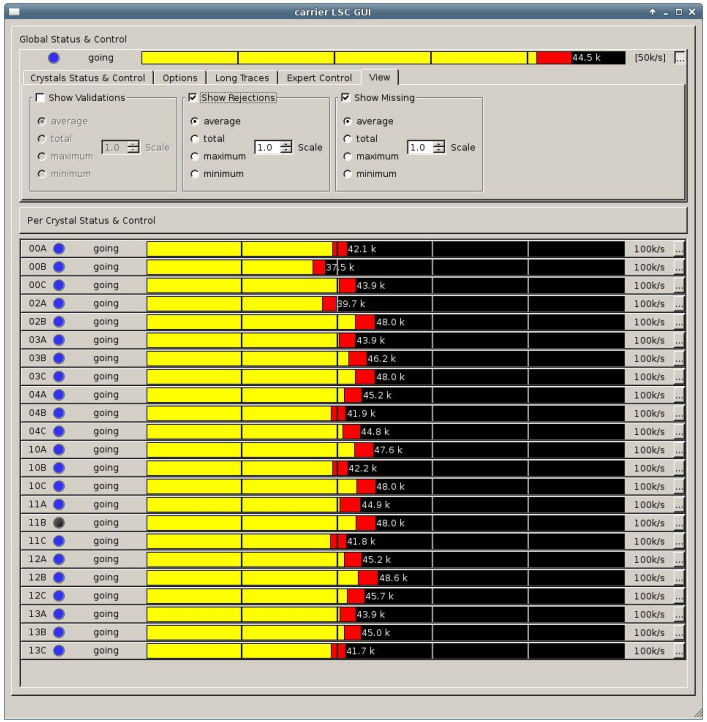
~15-20% of loss at ~40-50kHz



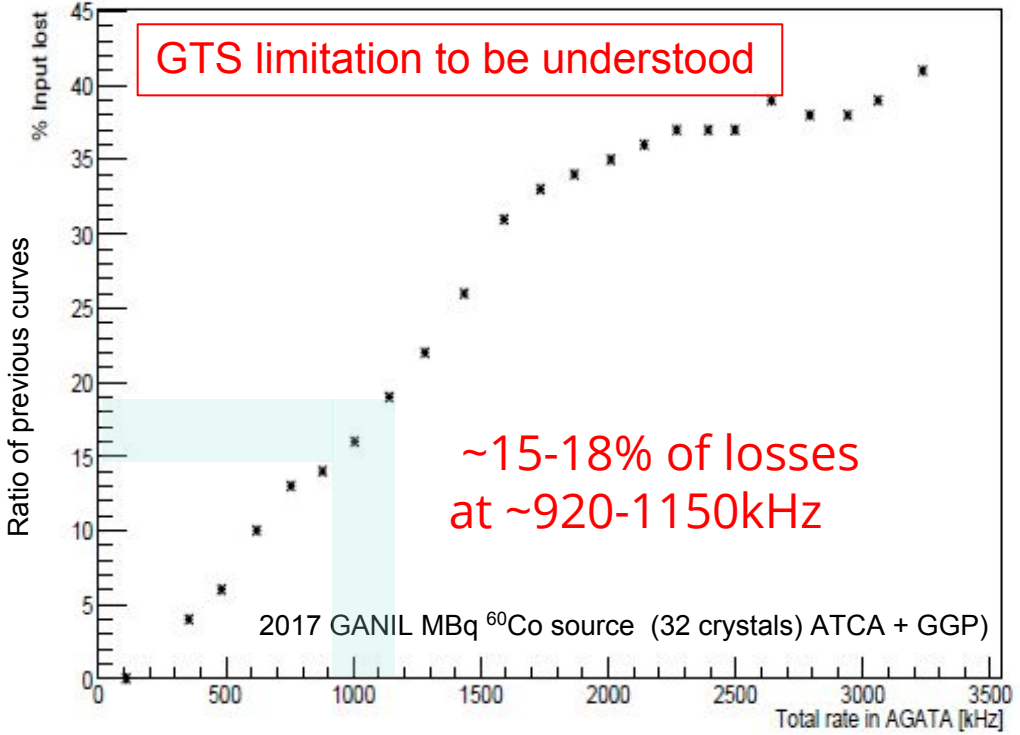
F. Recchia et al. LNL report

In-beam losses

Trigger Processor



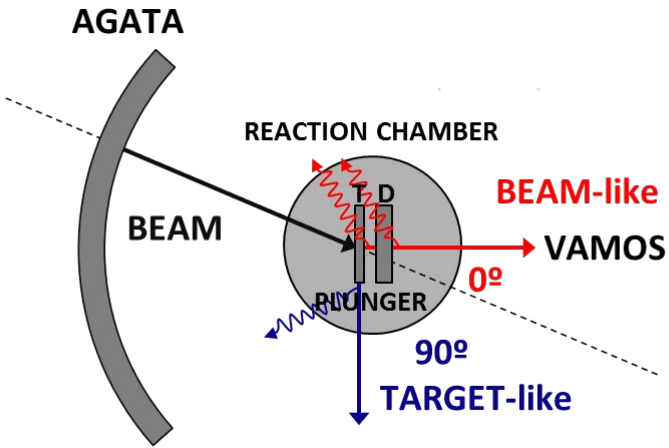
E682 rates-23 crystals



E. Clement AGATA week 2017

In-beam losses

Corrected efficiency



In-Beam efficiency at **1509keV** with gamma-gamma coincidences

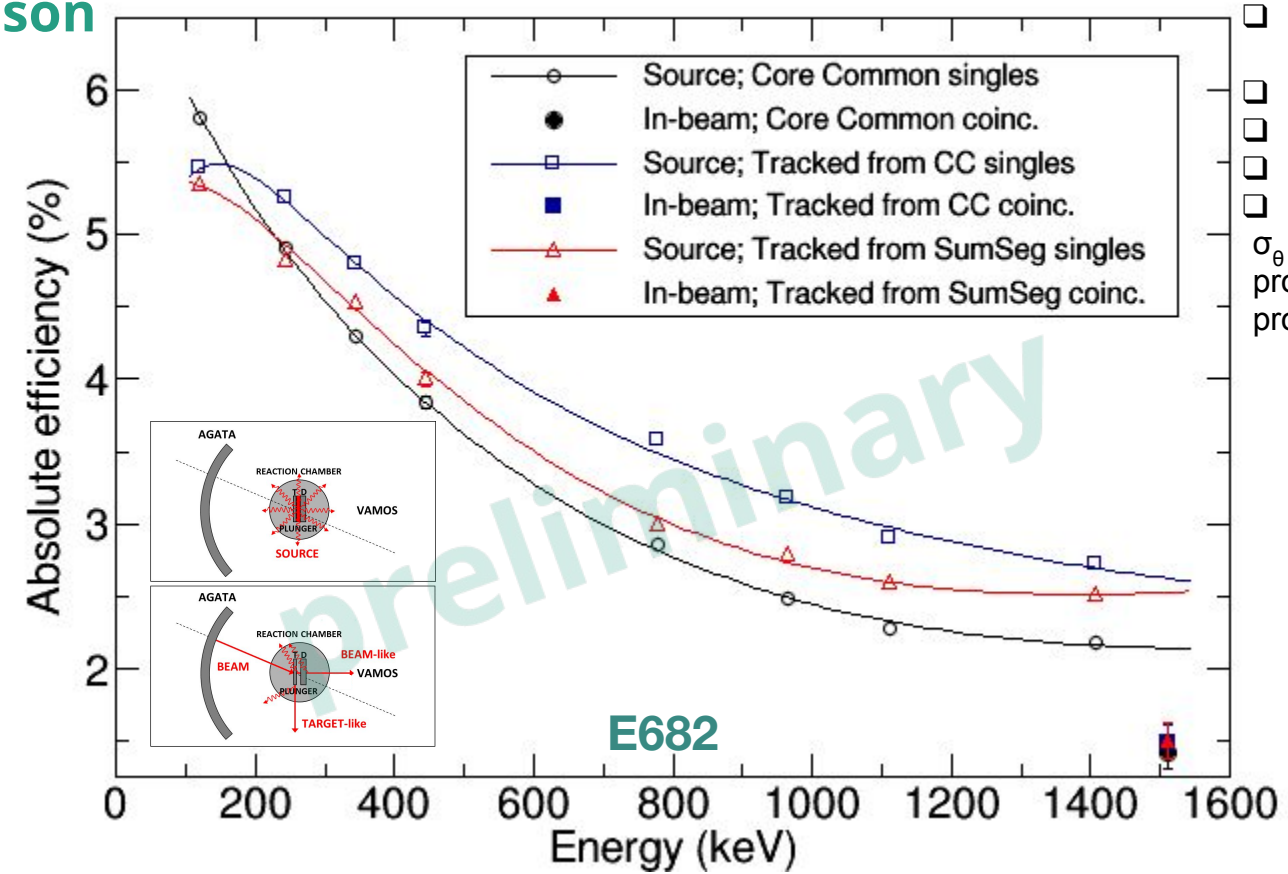
	Average Efficiency raw	Efficiency corrected by losses
Core Common	1.42 (14)	2.09 (21)
TrackCC	1.49 (12)	2.43 (20)
TrackSG	1.50 (12)	2.45 (20)

(!) Angular correlation correction not applied yet (only the ~ 10% losses seen with the sources in the tracking).
For doing the average efficiency the angular correlation correction needs to be done. The small differences found in the raw efficiency for the 2 methods indicate a small influence of the angular correlation.

Efficiency

Comparison

Source: ^{152}Eu ~550 Hz per crystal
In-beam: ^{92}Mo (1509keV) ~40-50 Hz per crystal

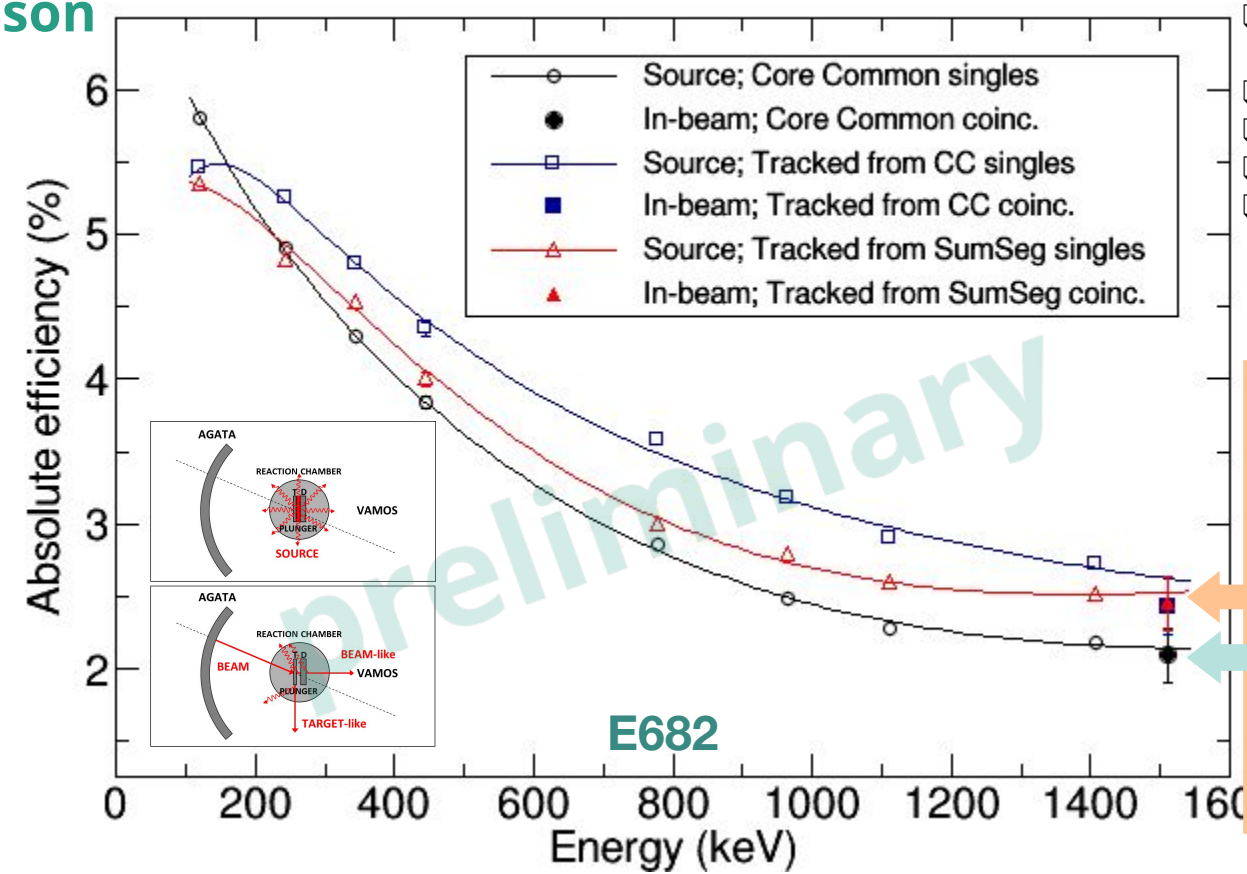


- Same setup:
  AGATA
  VAMOS++
  Plunger
- AGATA position: 22.8 cm
- 23 crystals
- Risetime: 2.5 μs
- Trigger: ancillary.sh
- OFT:
  σ_θ = 0.8
  $prob_{sing}$ = 0.02
  $prob_{track}$ = 0.05

Efficiency

Comparison

Source: ^{152}Eu ~550 Hz per crystal
In-beam: ^{92}Mo (1509keV) ~40-50 Hz per crystal



- Same setup:
  AGATA
  VAMOS++
  Plunger
- AGATA position: 22.8 cm
- 23 crystals
- Risetime: 2.5 μs
- Trigger: ancillary.sh
- OFT:
  $\sigma_\theta = 0.8$
  $prob_{sing} = 0.02$
  $prob_{track} = 0.05$

~ 10% tracking angular correlation losses

~ 18% pile-up losses

~ 17% trigger processor losses

~ small correction angular correlation to be taken into account

Summary

- The performance have been evaluated for the AGATA+PLUNGER+VAMOS++ setup used during the experimental campaign in 2015 for the experiment E682.
- The E682 data is not the best to perform efficiency measurements due to the presence of the double peak structure because of the plunger device usage.
- The AGATA efficiency for different methods of data treatment have been experimentally determined by means of calibrated gamma-ray sources and compared with in-beam gamma-ray efficiency (for the 2+ → 0+ 1509 keV transition in 92Mo).
- Corrections for pile up losses and trigger processor losses need to be applied to reach the efficiency evaluated with the sources. The experimental results are understood in terms of losses.
- The angular correlations corrections are still under investigation for the in-beam measurements. Even if they are small in our case, next investigations will be done with the Core Common mode.

In-beam efficiency and angular correlations with AGATA

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for the AGATA collaboration

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