AGATA
Simulated efficiency
vs
Measured efficiency

Marc Labiche (marc.labiche@stfc.ac.uk)

18th AGATA week,
Milano - 11th Oct 2017

Science & Technology Facilities Council
Nuclear Physics Group

Outline

- **Introduction of a long-lasting problem**
  - **over estimation of the efficiency in the simulation code**
    - **Observed with source runs at LNL, GSI and GANIL**
- **Various attempted solutions:**
  - **Increase of passive material in the Simulation**
  - **Correction with capsule relative efficiency**
    - **Using Canberra measurement**
    - **Using AGATA collaboration measurements**
- **Outlook**

^{60}Co source run at LNL

Derived from ^{60}Co; values given in % at 1332.5 keV

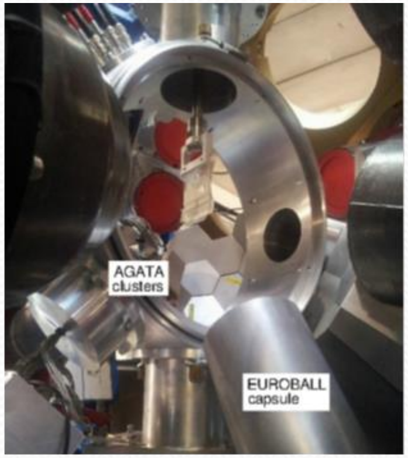
		Before tracking Efficiency	Before tracking P/T	After tracking Efficiency	After tracking P/T
Single Spectrum	Experimental	1.70	19.5	1.77	41.5
	Simulated	1.84	22.9	2.41	58.7
	Ratio	**0.92**	**0.85**	**0.73**	**0.71**
Sum Spectrum	Experimental	2.33	33.0	1.86	44.5
	Simulated	2.73	44.5	2.56	60.0
	Ratio	**0.85**	**0.75**	**0.73**	**0.71**

Measured versus simulated efficiencies and P/T ratio from a ^{60}Co measurement with the AGATA demonstrator at LNL. Presented at the 13th AGATA week (2013) by D. Bazzacco

- *Large discrepancies between simulation and measurement*

- *Some possible explanations:*
  - *Lack of passive material included in the simulation*
  - *Measurement conditions not ideal (source activity not reliable, Dead time, Background …)*
- *Investigation using an external trigger was then suggested.*
- *Focus on core efficiency, first.*

^{60}Co source run at GSI



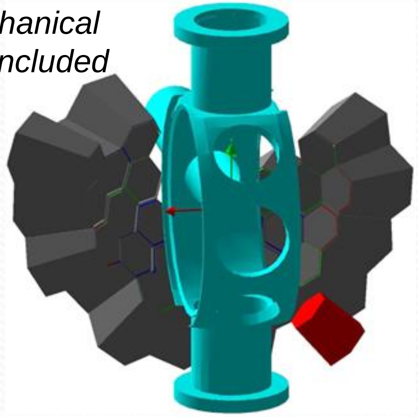
- Source runs with 21 crystals

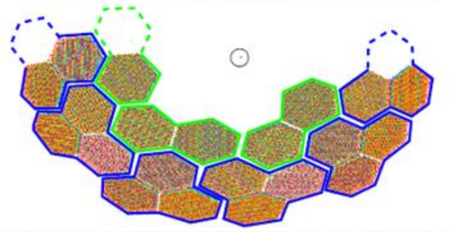
N. Lalovic et al. NIM A 806 (2016) 258-260

Full energy peak efficiency before tracking

@ 1172 keV	ε_{Exp} (%)	ε_{Sim} (%)	P/T_{exp} (%)	P/T_{sim} (%)
Core Common	2.38(2)	2.55(14)	18.3(2)	23
Calorimeter	3.30(2)	3.71(17)	32.2(3)	42

More mechanical structure included in the simulation



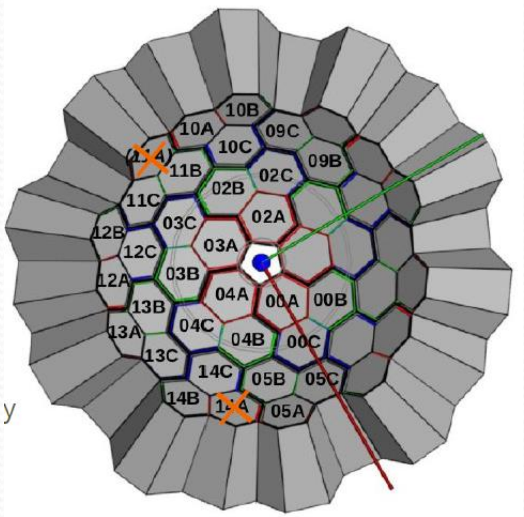


So, still large discrepancies:
~7% discrepancy on the Core Common Efficiency
~12% discrepancy on the Calorimeter Efficiency

^{60}Co source run at GANIL

- Source run with 30 crystals with nominal and compact configuration.

Data from R.M. Perez (Agata week 2016)

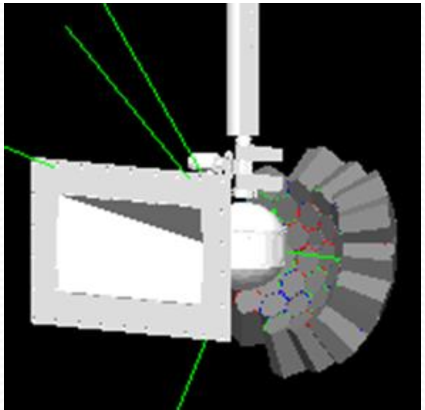


Core efficiency at 1.3 MeV

Nominal	Efficiency	P/T	Compact	Efficiency	P/T
Experiment	2,78%	19,17%	Experiment	5,04%	18,95%
Simulation	3,25%	~~ongoing~~	Simulation	5,77%	~~ongoing~~

20.5% 20.1%

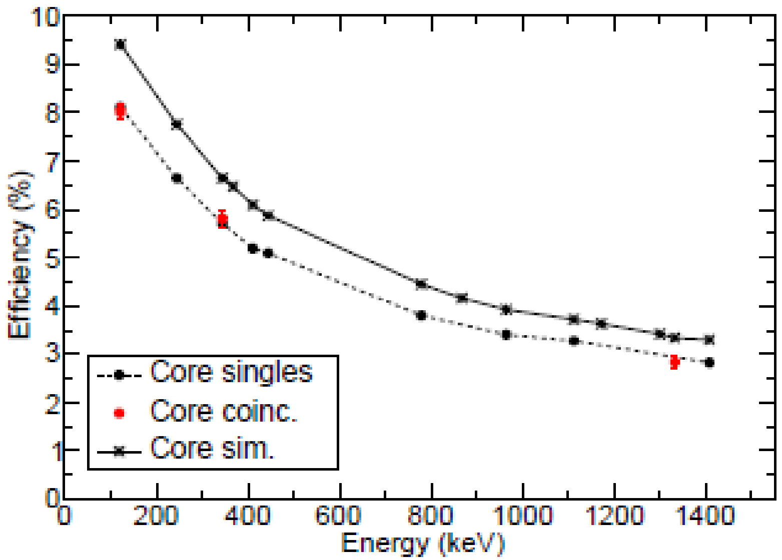
Still large discrepancies observed in efficiency.



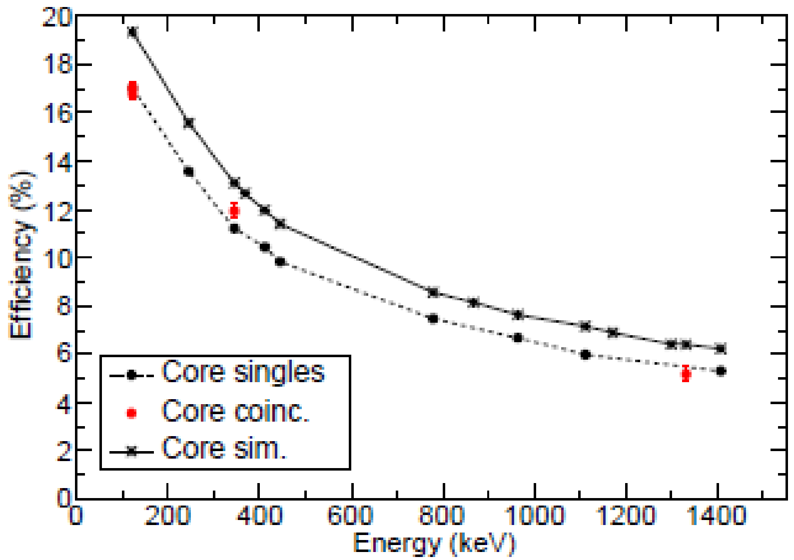
Adding ^{152}Eu data:

Data: Courtesy of M. Perez

Nominal



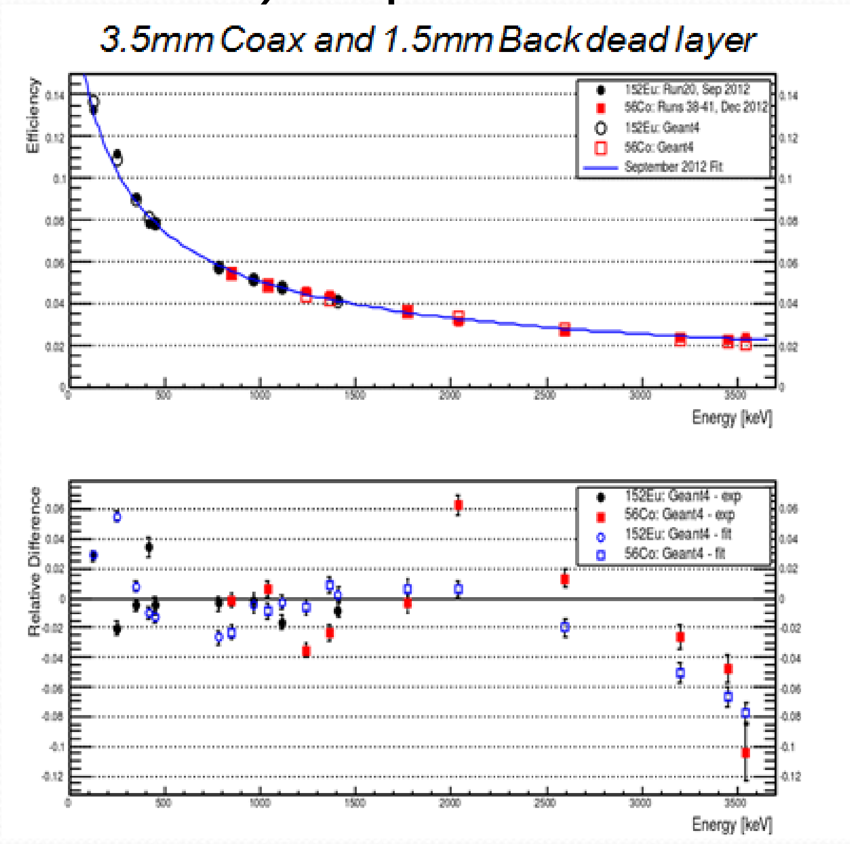
Compact



Discrepancies across this energy range for both configuration.

Various investigated solutions

- Passive materials
  - Realistic chamber (CAD-to-GDML file) helps but not enough.
  - Increase Passive Ge area in the crystals:
    - Seems to work for GRETINA:

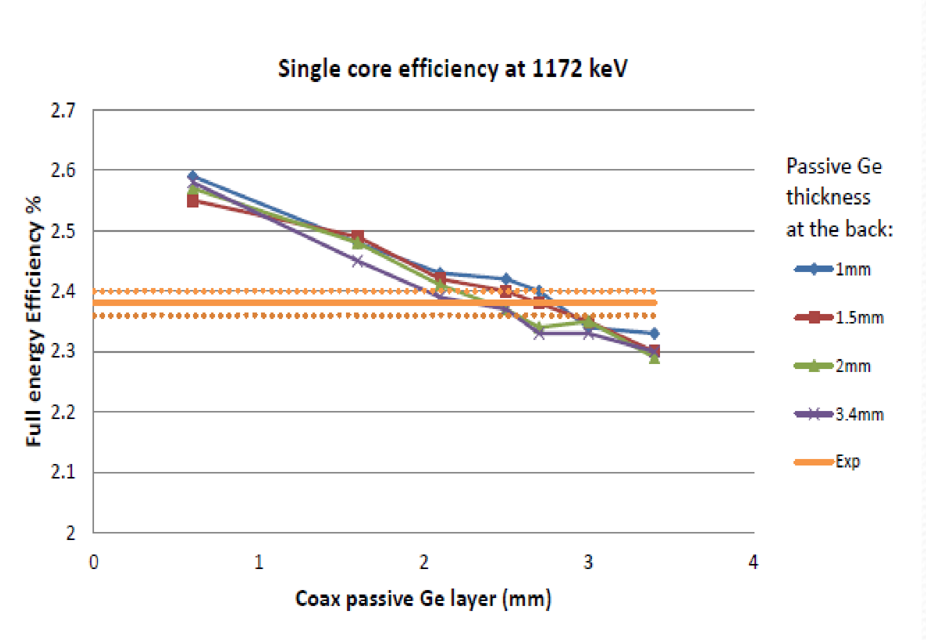


Courtesy of Heather Crawford, Lew Riley et al.

Various investigated solutions

- Passive materials
  - Realistic chamber (CAD-to-GDML file) helps but not enough.
  - Increase Passive Ge area in the crystals:
    - For AGATA crystals different set of coax/back dead area can be used to reproduce the data.

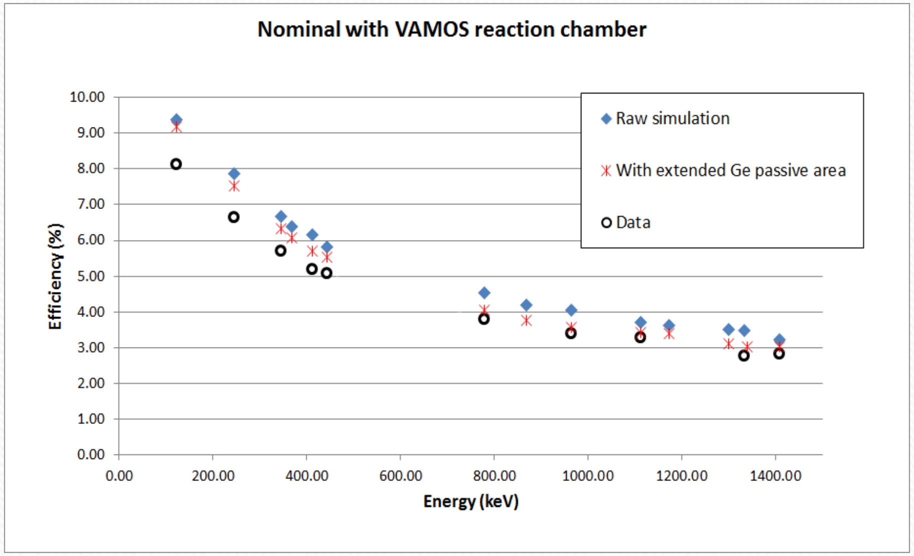
    - So which one ?
    - Probably different for each crystal

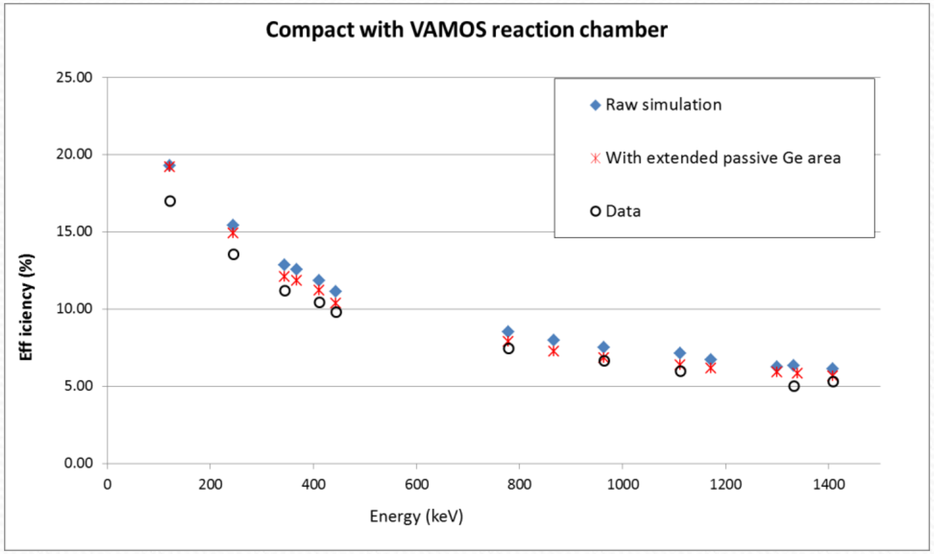


M. Labiche AGATA week 2017

Various investigated solutions

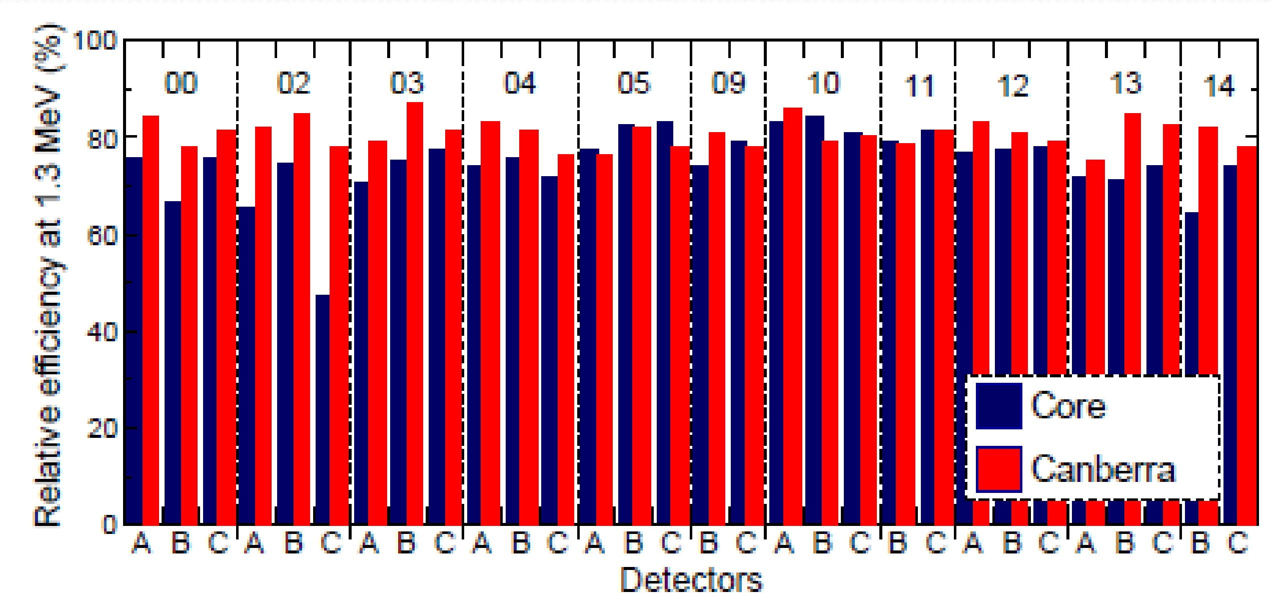
- Using thicknesses of 2.5mm at the coax and 3mm at the back reduces the discrepancies for the highest energy but not for the lowest.
  - As one could expect.





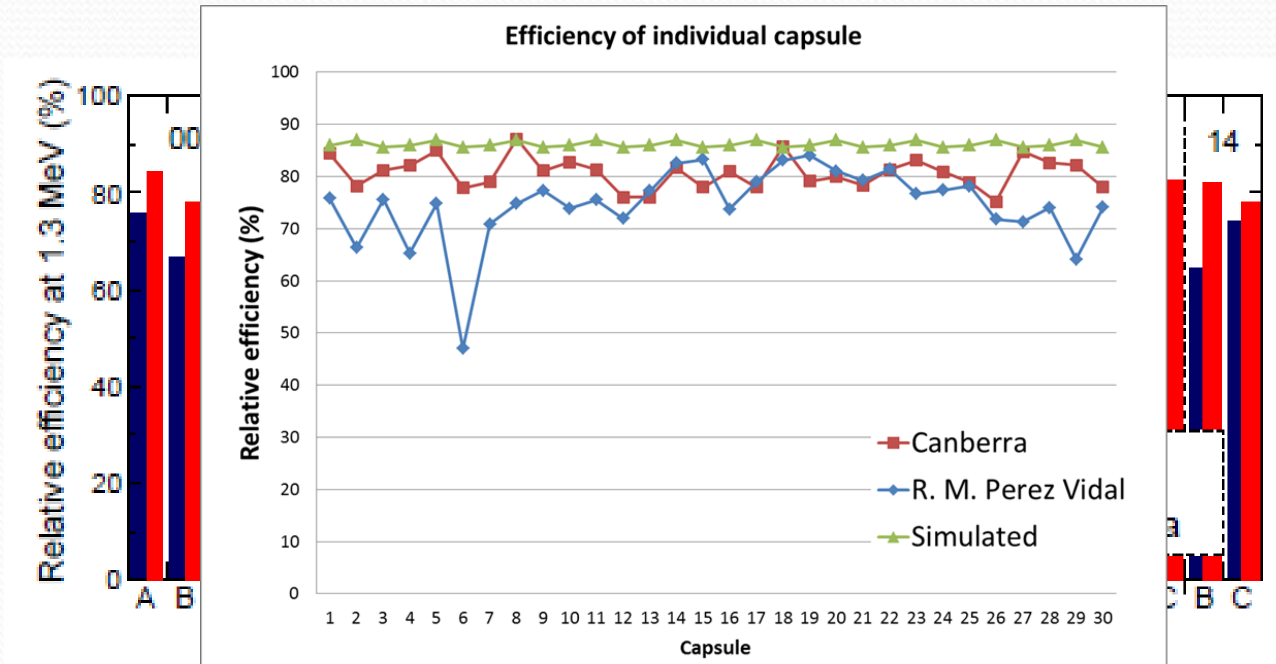
Various investigated solutions

- Correcting with the measured relative efficiency of each crystals, using:
  - (a) Canberra measurements
  - (b) our Collaboration measurements:



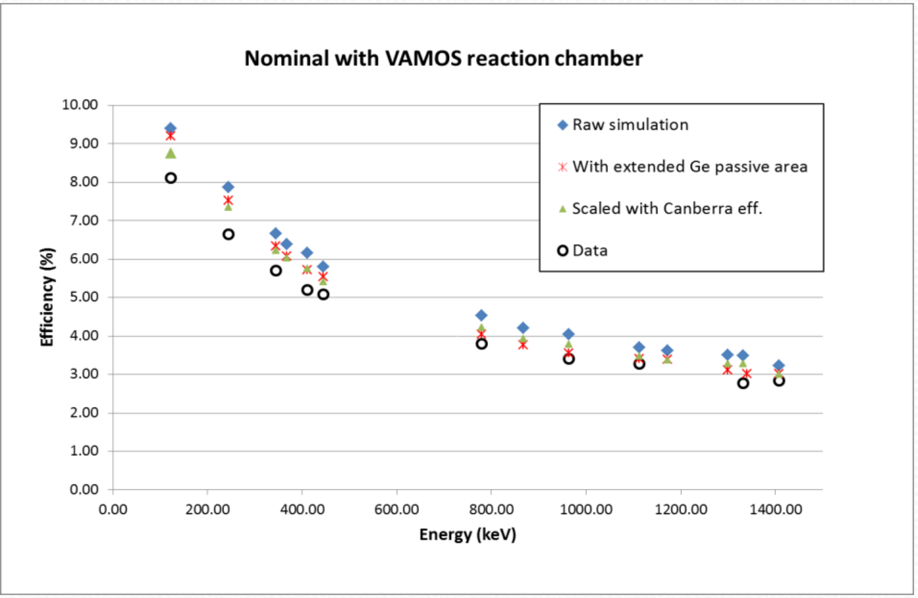
Various investigated solutions

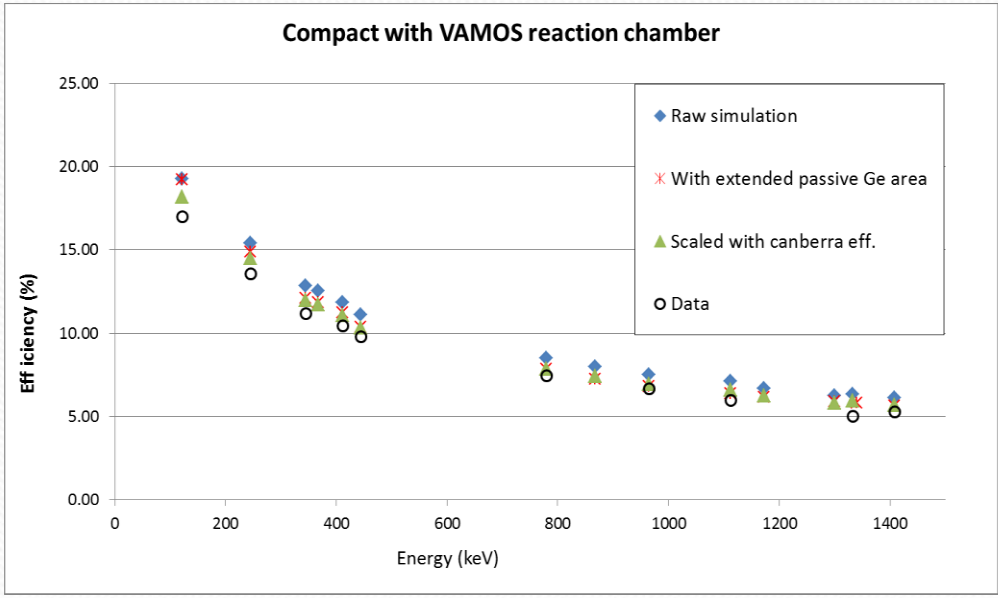
- Correcting with the measured relative efficiency of each crystals, using:
  - (a) Canberra measurements
  - (b) our Collaboration measurements:



Various investigated solutions

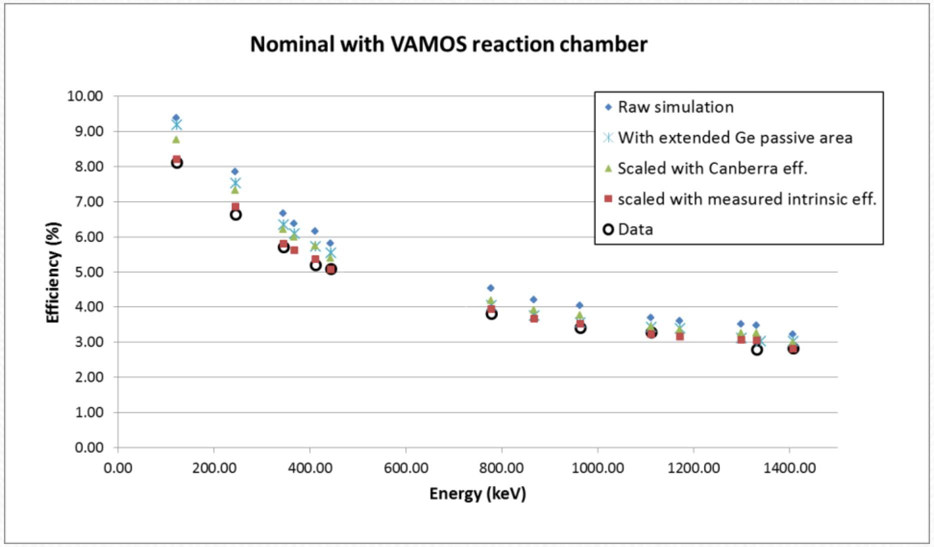
- Scaling with Canberra efficiencies

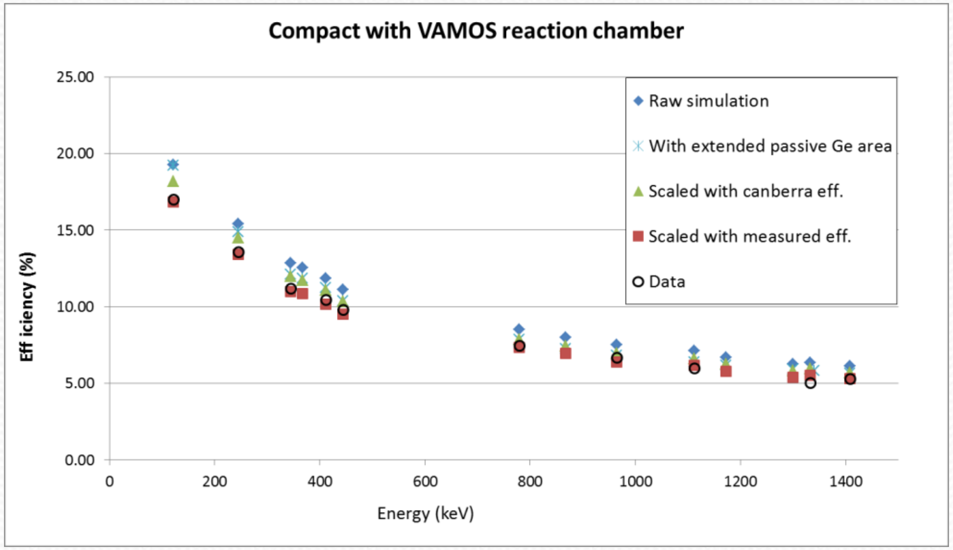




Various investigated solutions

- Scaling with our Collaboration efficiencies





A better match is obtained.
The discrepancies are now below 5%

Simulated Core efficiency and Validation

Table 5: Measured AGATA efficiencies

Energy (keV)	Ref	Measured in single/core	GEANT4 Single efficiency /core	GEANT4 $Single_{scaled}$ efficiency /core
1.1 MeV	N. Lalovíc, NIMA 806 (2016)	0.113% in nominal	0.13%	0.12%
1.4 MeV	E. Clément, NIMA 855 (2017)	0.097% in nominal	0.11%	0.10%
1.3 MeV	R. Perez, AGATA Week 2016	0.095% in nominal	0.12%	0.11%
1.3 MeV	R. Perez, AGATA Week 2016	0.173% in compact	0.22%	0.21%
1.1 MeV	E661	0.228% in compact	0.253%	0.234%

0.102 %
0.184%

Courtesy of E. Clement

Outlook

- Low crystal efficiency would still suggest:
  - larger Ge passive area or/and smaller crystals than expected.
  - loss in readout electronics

- Does is this relative efficiency evolved in time ?
  - Can we reproduce GSI/LNL source run

- Need to find a way to apply this efficiency correction on an event by event basis so it can be propagated through the tracking reconstruction procedures.

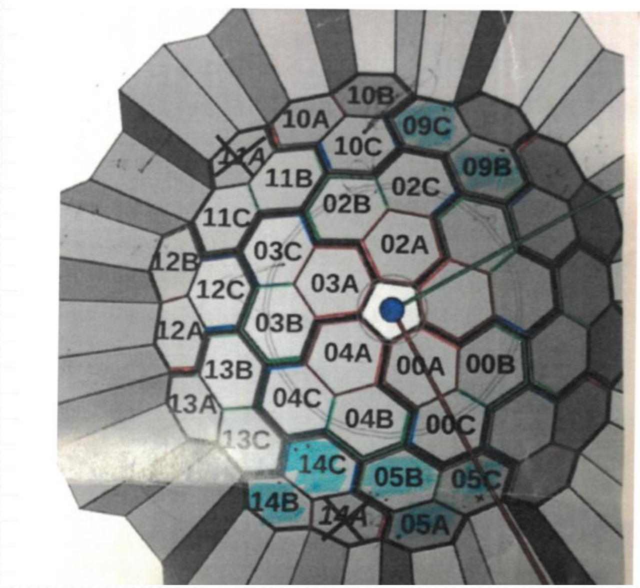
  - A possibility is to scale the crystal geometry in the simulation so it matches the measured its relative efficiency.
    - Means 180 different crystals for 4pi array to define in the simulation.
    - Easier said than done.

- Then, compare simulated tracked efficiency with the measured tracked efficiency.

Thank you

Recent Additions/Modifications

- **New analysis tools:**



Crystal Location	Crystal Name	Measured Relative Efficiency (Canberra)	Geant4 Relative Efficiency (E. Clement)	Ratio
00A	a001	0.84	0.86	0.98
00B	b004	0.782	0.87	0.90
00C	c010	0.78	0.858	0.91
01A	a010	0.76	0.86	0.88
01B	b012	0.816	0.87	0.94
01C	c014	0.78	0.858	0.91
02A	a009	0.821	0.86	0.95
02B	b005	0.8	0.87	0.92
02C	c008	0.778	0.858	0.91
03A	a005	0.79	0.86	0.92
03B	b002	0.872	0.87	1.00
03C	c009	0.811	0.858	0.95
04A	a004	0.78	0.86	0.91

.....

Ratio values are used as input in the AgataRead file and applied when filling histograms as follow:

For singles mode : *histo→fill(Energy[cryst], Ratio[cryst])*

For calorimeter mode: *histo→fill(∑ Energy[cryst] , ∏ Ratio[cryst])*

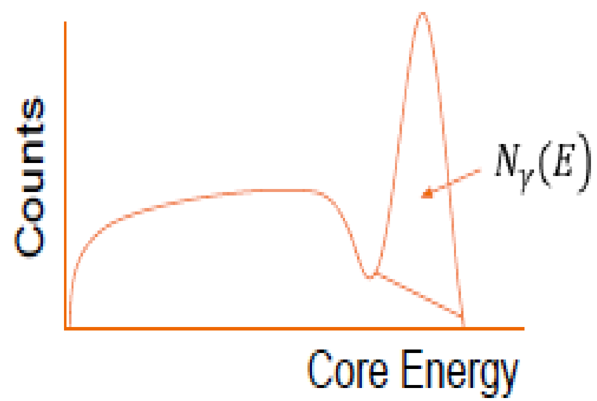
Note: Table re-ordered in the AgataRead input file so that the first crystal in the table correspond to the first crystal positioned in the simulation.

Method

Absolute efficiency

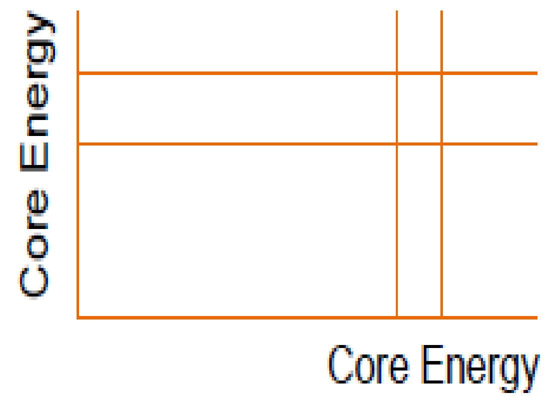
$$\epsilon_{abs} = \frac{number\ of\ \gamma\ recorded}{number\ of\ \gamma\ emitted\ by\ the\ source}$$

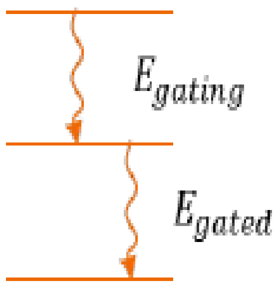
Singles



$$\epsilon(E) = \frac{N_\gamma(E)}{A \cdot I_\gamma(E) \cdot t_m \cdot (1 - t_{DT})}$$

γ – γ coincidences



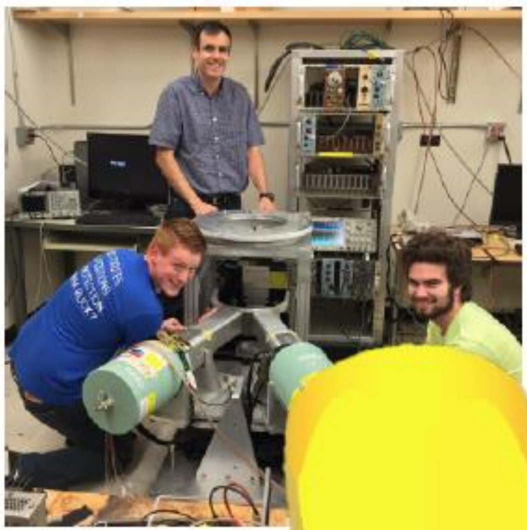


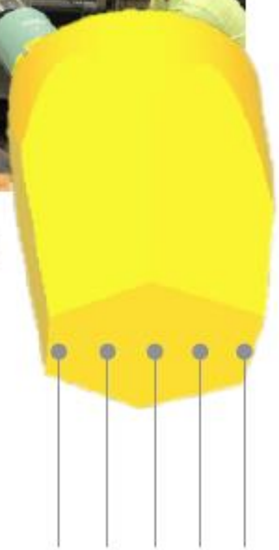
$$\epsilon(E_{gated}) = \frac{N_\gamma(E_{gated})}{N_\gamma(E_{gating})} \cdot {}^{Dets}/_{(Dets-1)}$$

Comparison of the two methods for evaluation of dead-time t_{DT}

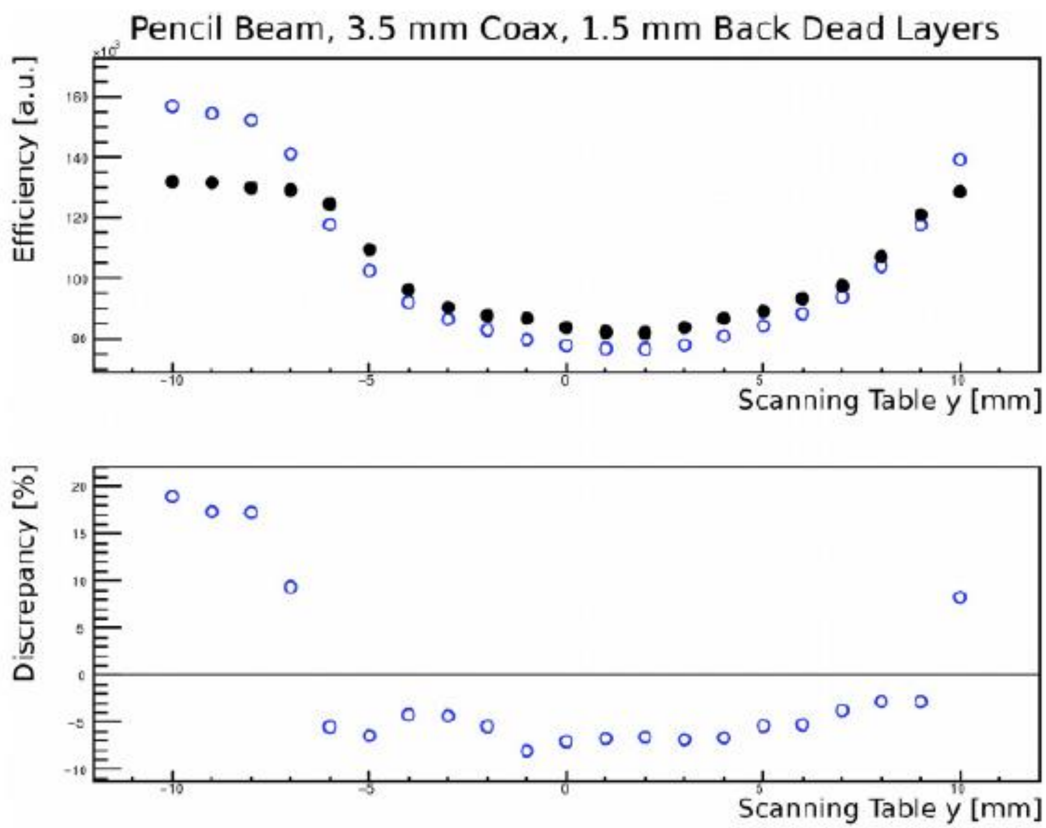
GRETINA case

Pencil Beams and Coaxial Dead Layers





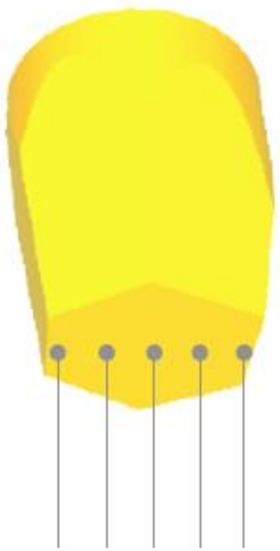
Prof. Lew Riley,
Sean Gregory and
Ethan Haldeman

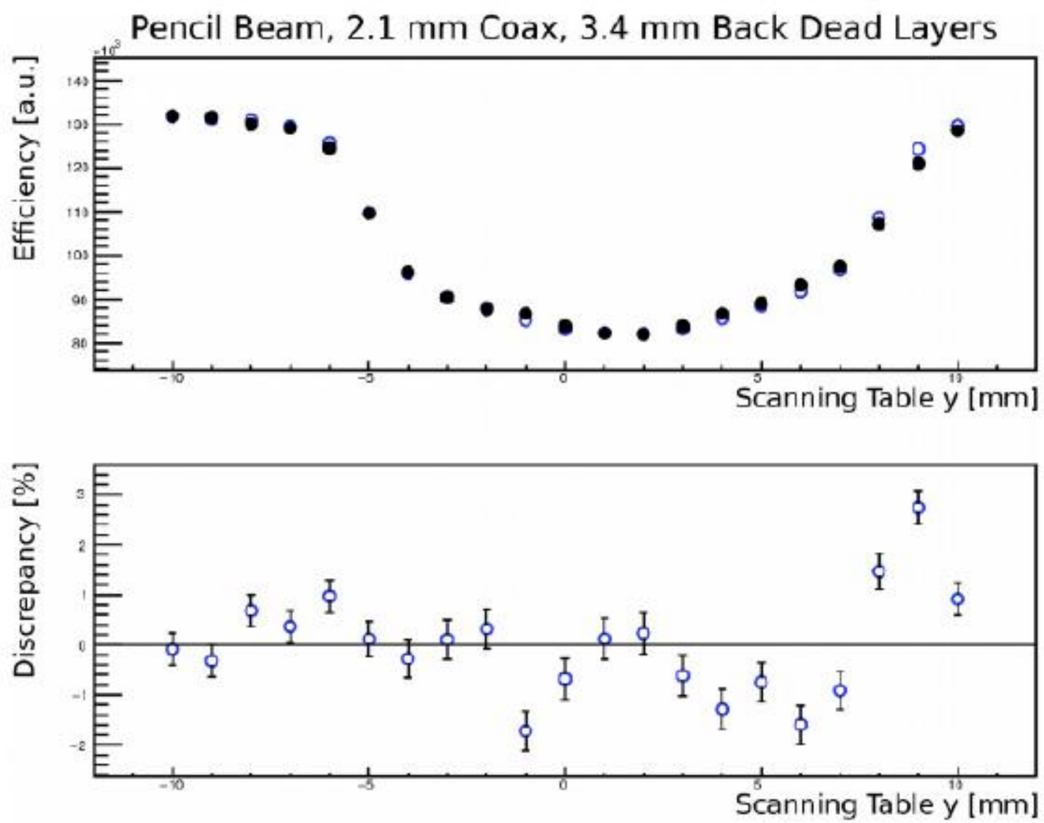


Courtesy of Heather Crawford, Lew Riley et al.

GRETINA case

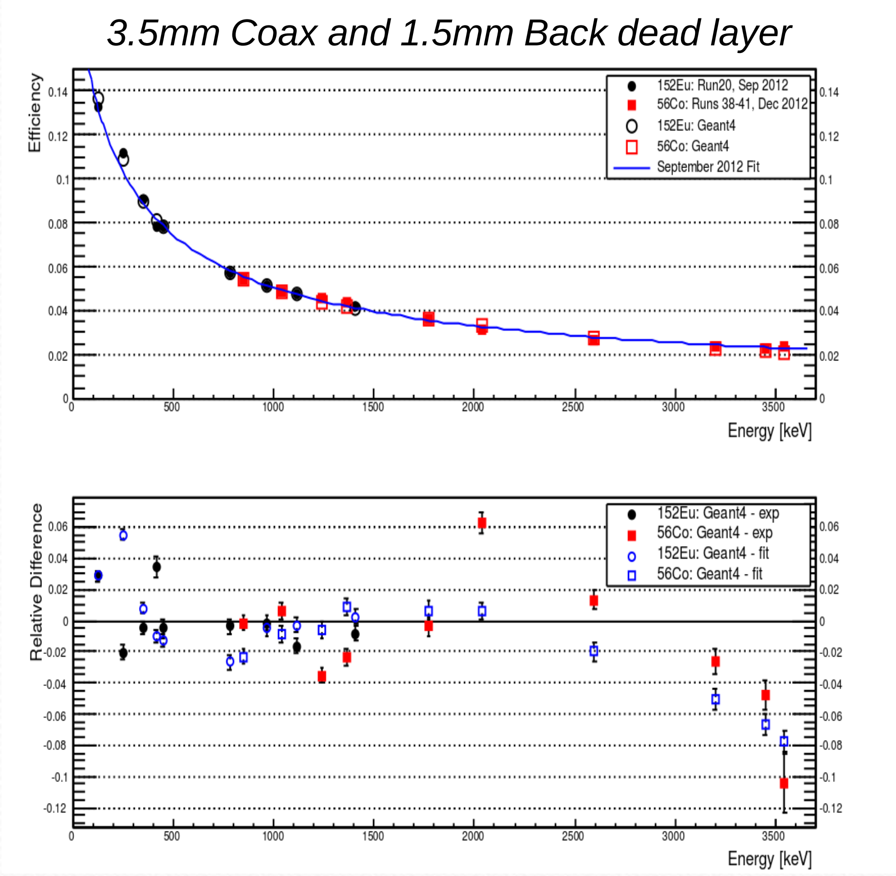
Pencil Beams and Coaxial Dead Layers

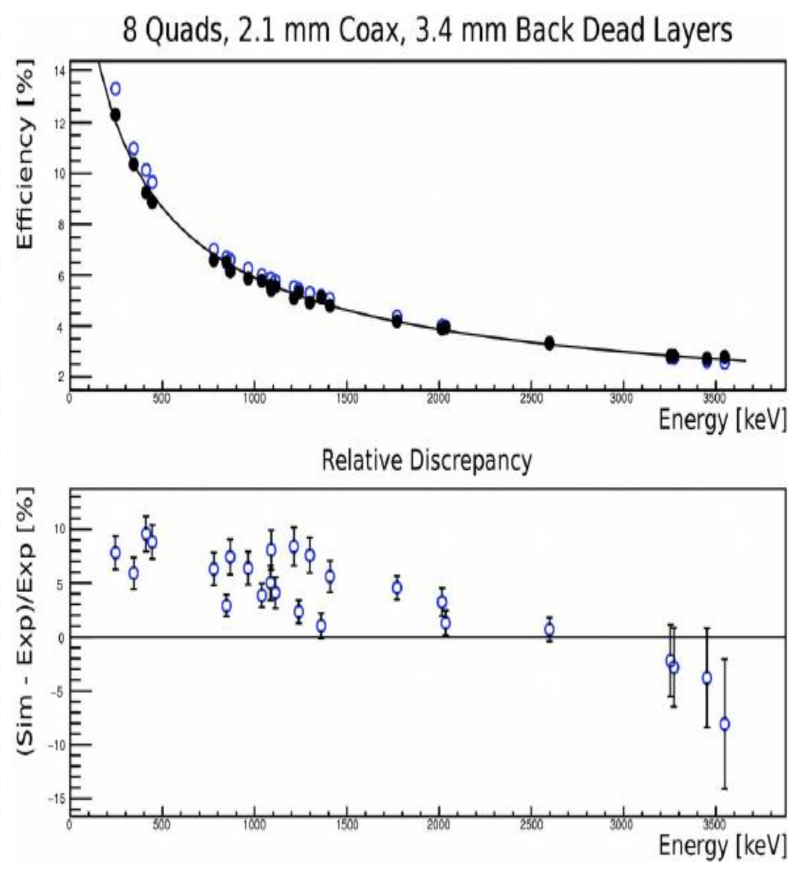




Courtesy of Heather Crawford, Lew Riley et al.

GRETINA case





Courtesy of Heather Crawford, Lew Riley et al.

Recent Additions/Modifications

- **<u>Enhanced Ge passive area Vs “Canberra” normalised efficiencies :</u>**

Core Efficiency for 32 crystals in Compact configuration, Mγ=1

Energy:	1112 keV
Original passive areas:	8.1*
Enhanced Passive areas:	7.3
Applying Canberra efficiency factor :	7.6*
Measured (E661):	7.3*

** Courtesy of E. Clement*

Simulated Core efficiency and Validation

Table 5: Measured AGATA efficiencies

Energy (keV)	Ref	Measured in single/core	GEANT4 Single efficiency /core	GEANT4 $Single_{scaled}$ efficiency /core
1.1 MeV	N. Lalovíc, NIMA 806 (2016)	0.113% in nominal	0.13%	0.12%
1.4 MeV	E. Clément, NIMA 855 (2017)	0.097% in nominal	0.11%	0.10%
1.3 MeV	R. Perez, AGATA Week 2016	0.095% in nominal	0.12%	0.11%
1.3 MeV	R. Perez, AGATA Week 2016	0.173% in compact	0.22%	0.21%
1.1 MeV	E661	0.228% in compact	0.253%	0.234%

Courtesy of E. Clement

Still room for improvements:

- check simulations with a realistic chamber geometry

- add angular correlation effects

- check with an optimised/measured set of thickness parameters for the Ge passive areas