Recent developments of the AGATA Simulation Code

On behalf of the

Simulation Working Group

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19th AGATA week,
Legnaro - 19th Sep 2019

Science & Technology Facilities Council
Nuclear Physics Group

Outline

- **Generalities**

- **Update on simulates core efficiency and validation with source at rest**
  - **29 crystals (2016)**
  - **41 crystals (2019)**

- **Simulations for the Physics White-Paper with 4pi array**
  - **Review of the predicted basic performance**
  - **High-Spin Physics case**

- **Update of Simulation section in the Project Definition Document**

Generalities - update

- **AGATA Code (AC) still maintained and available here:**
  - **http://npg.dl.ac.uk/svn/agata**
  - Check it out with command: svn co http://npg.dl.ac.uk/svn/agata
- **AC is compatible with Geant4.10.3 5 and prior versions.**
  - To use GDML geometry files, Geant4 must be installed with the GDML option.

    (Please, see the INSTALL file in the Agata code svn repository)
- **GDML files available here:**
  - **https://github.com/malabi/gdml-files**
  - Get it with command: git clone https://github.com/malabi/gdml-files/AGATA

Generalities

- GDML files available:

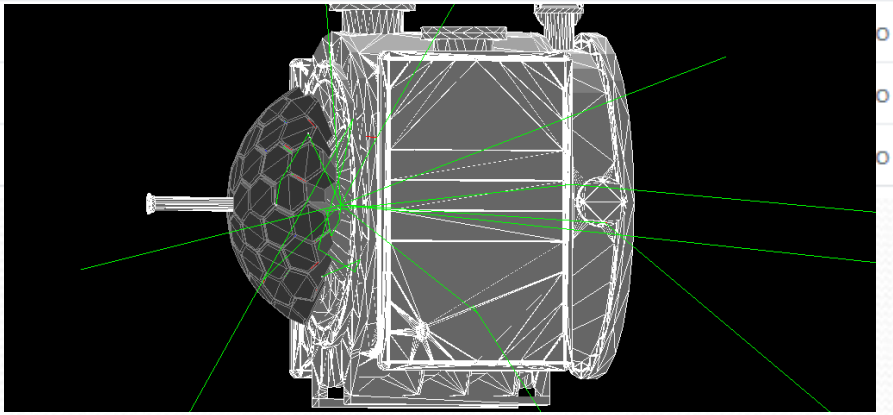
gdml files for GEANT4 simulations of NP detection suystems

17 commits | 2 branches | 0 releases | 2 contributors

Branch: master ▾ | New pull request | Find file | Clone or download ▾

Alain Goasduff Added NEDA gdml files — Latest commit 7fadce8 12 days ago

AGATA	Added NEDA gdml files	12 days ago
GALILEO	Add gdml files for GALILEO TC / GALILEO Plunger device / GALILEO SPIDER	9 months ago
MARA	Adding MARA folder	9 months ago
MuGasT	adding MuGasT chamber	
STOGS/ATC-Demo	Adding STOGs ATC demo	
README.md	Update README.md	

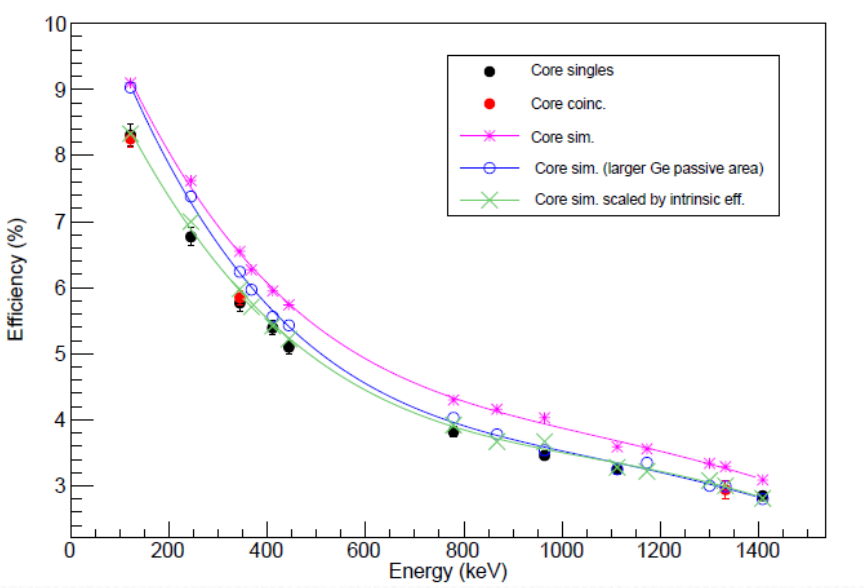


Generalities

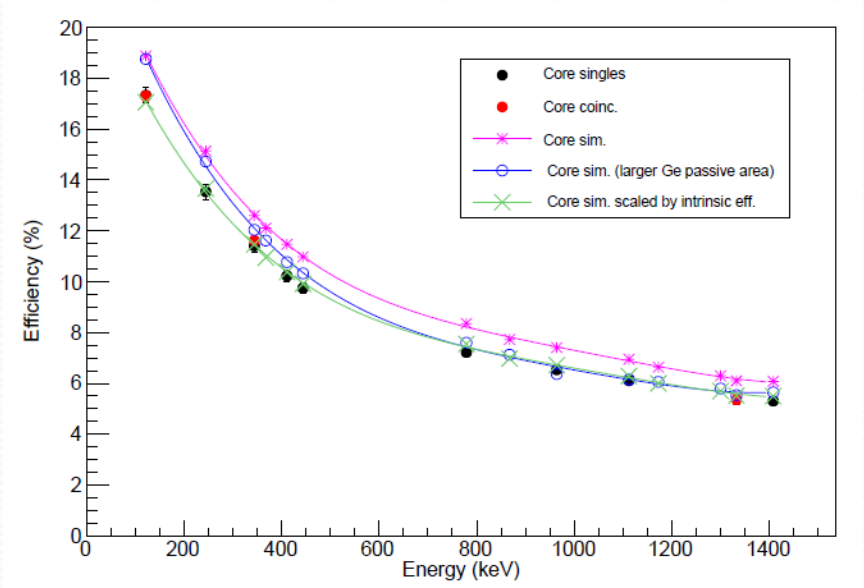
- Issue with neutron physics was reported (thanks J. Nyberg)
  - Elastic & inelastic Models and cross sections for low-energy neutrons were missing
  - Affected AGATA Codes possibly after migration to Geant4.10 and up to svn version number to 428 included
  - Problem has now been fixed (last month)
    - Modified AgataPhysicsList.cc file in the svn repository
- = A reminder that our WG should defined a list of automatic runs to test the code after a new GEASNT4 release

Core efficiency sim-vs-data

30 to 29 crystals (preparation of Agata performance at GANIL paper)



Nominal

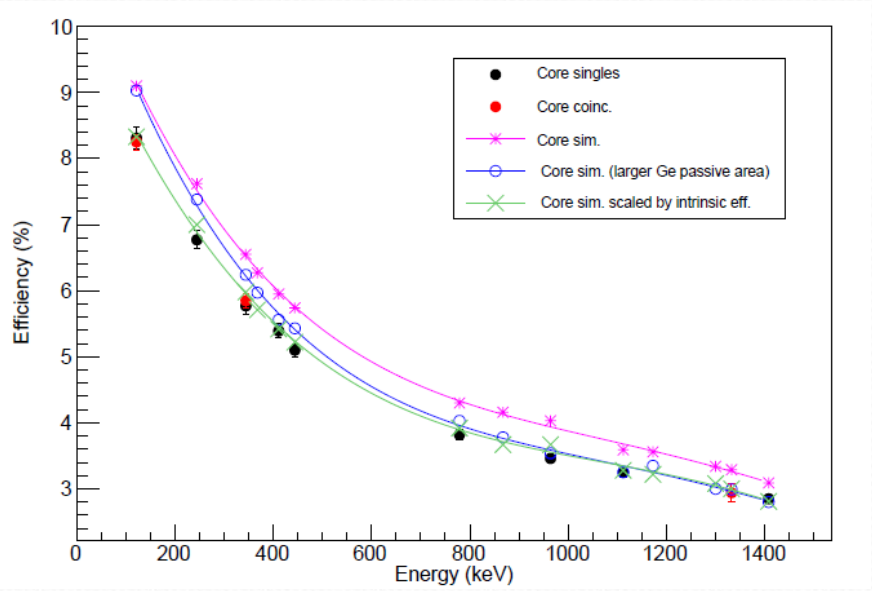


Compact

Core efficiency sim-vs-data

29 crystals - Nominal

By Adding Steel block for VAMOS ???



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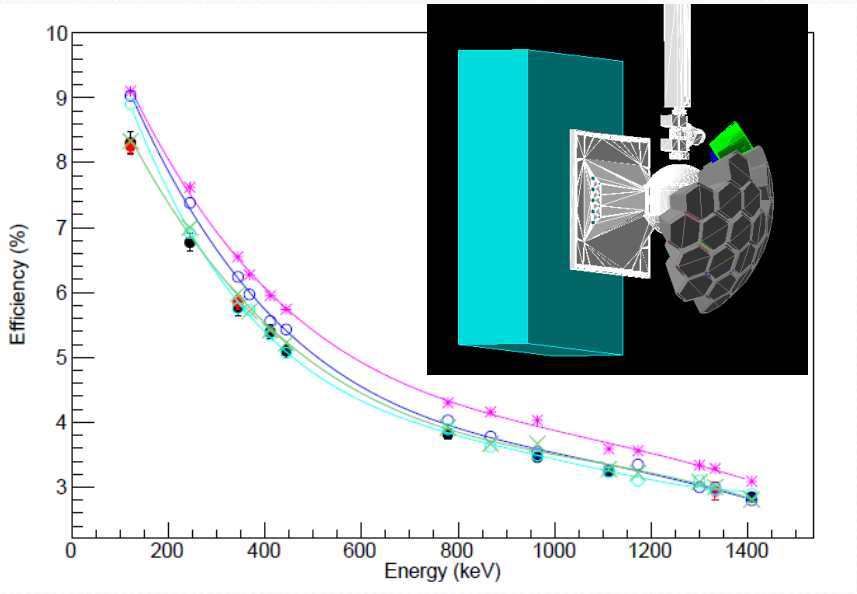
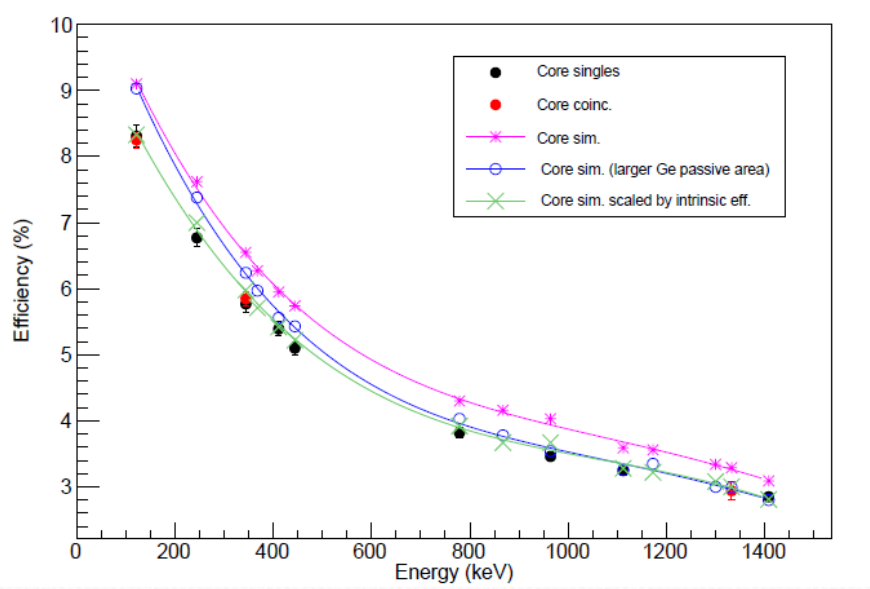


Nominal

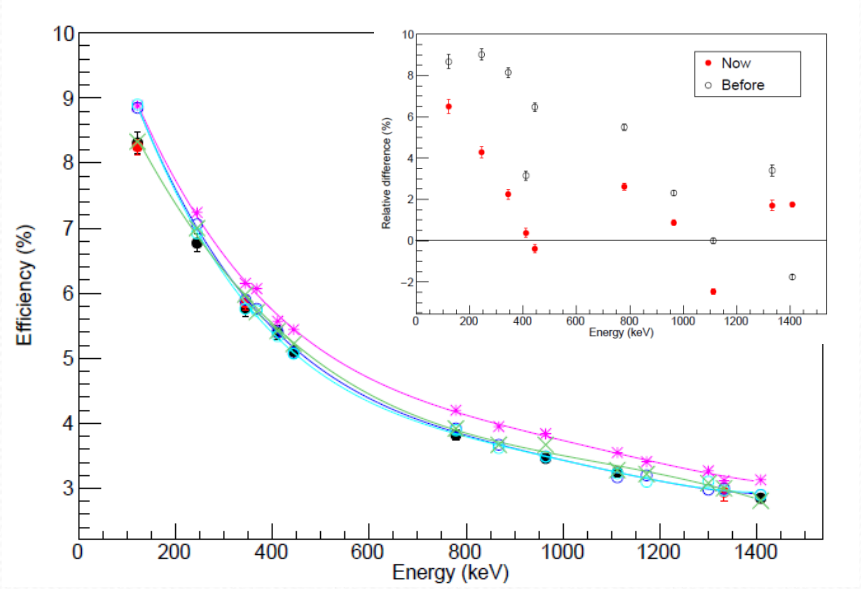
Core efficiency sim-vs-data

29 crystals - Nominal

New one is better
but still unsure why (?)



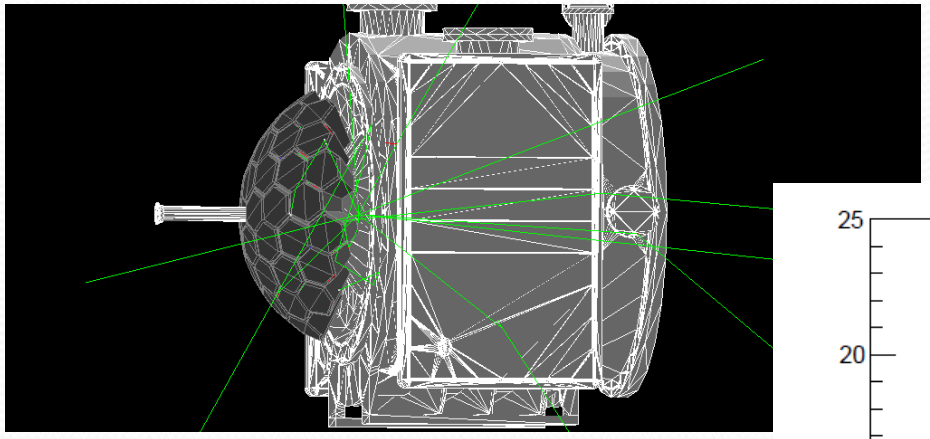
Nominal



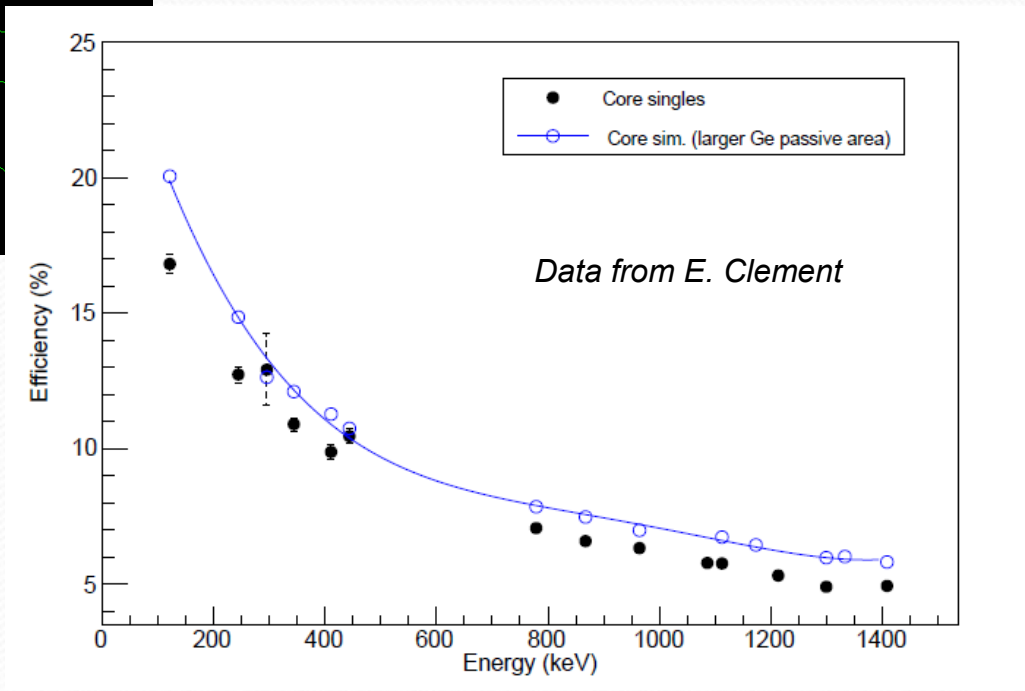
Nominal

New results needs to be cross-checked (ideally someone else in WG) ?

Core efficiency sim-vs-data



41 crystals
Core efficiency – without addback



Same Ge passive area used as for the 29-crystals simulations

~ 15-20% discrepancy

MUST2 contribution (not included in the simulation)to be checked .

Preliminary

Simulation for AGATA 4π Physics white-paper

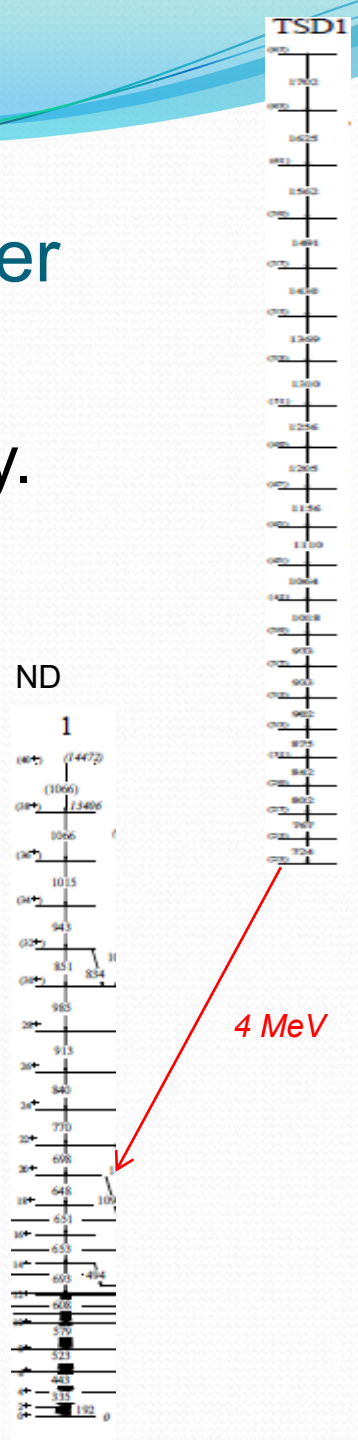
- Basic performance with 4π array have been reviewed

Detector properties specified for		Ideal Ge-shell	AGATA (OFT 2018)	AGATA & extended passive Ge (OFT 2018)
Efficiency (P_{fe})	E_γ= 0.1 MeV, M_γ= 1, $0 < \beta < 0.5$	99.5%	67-70 %	67-70%
	E_γ= 1.0 MeV, M_γ= 1, $0 < \beta < 0.5$	65-76%	35-40 %	34-38%
	E_γ= 10. MeV, M_γ= 1, $0 < \beta < 0.5$	10-14%	6-8%	3.5- 5 %
	E_γ= 1.0 MeV, M_γ= 30, $0 < \beta < 0.5$ *	36%	23-27%	21-25%
Peak-to-total ratio (P/T)	E_γ= 1.0 MeV, M_γ= 1, $0 < \beta < 0.5$	82%	51-57%	49-54%
	E_γ= 1.0 MeV, M_γ= 30 , $0 < \beta < 0.5$ *	55%	38-43%	37-41%

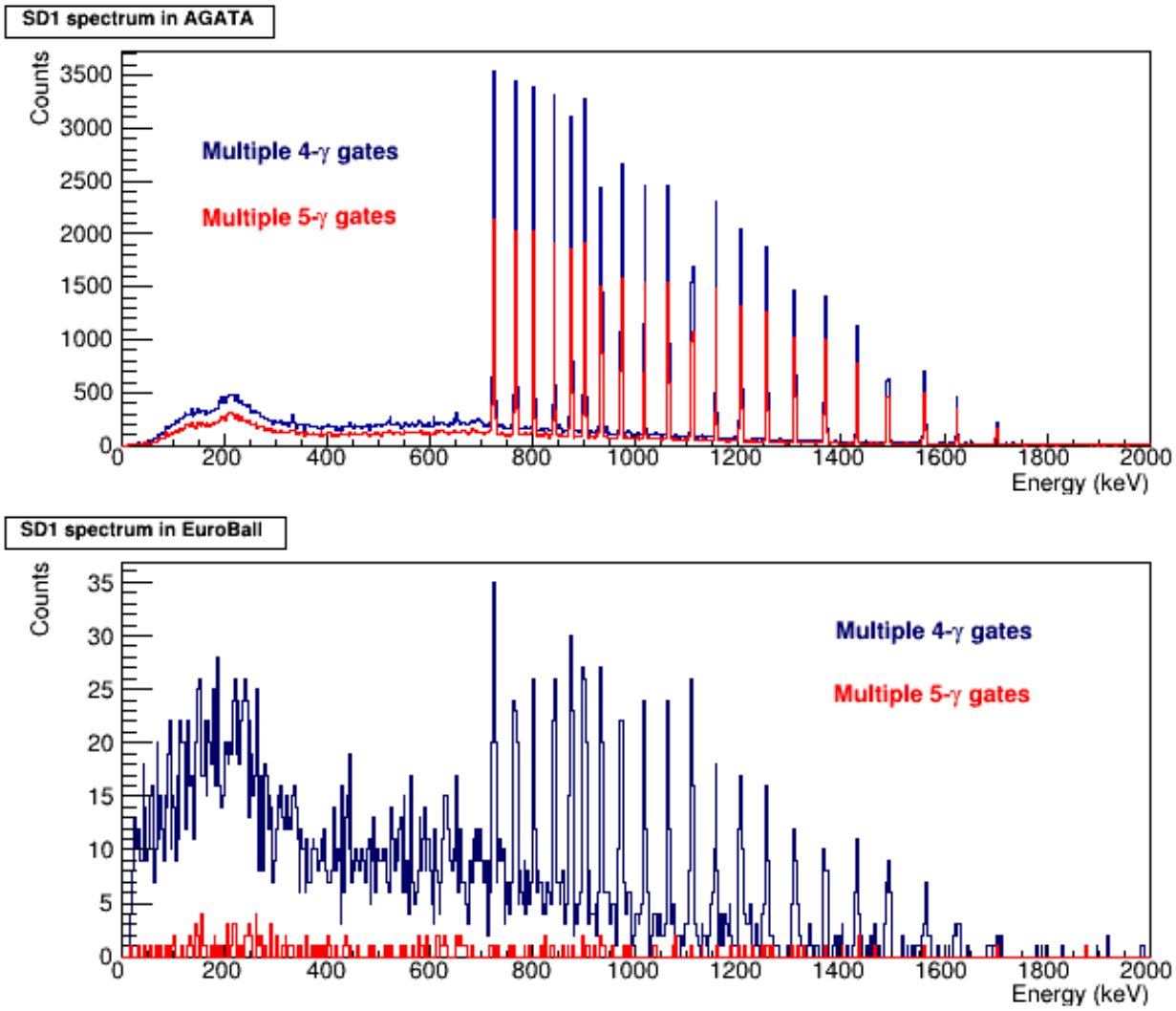
Note: No material between source and array (no chamber and no ancillary!

Simulation for AGATA 4π Physics white-paper

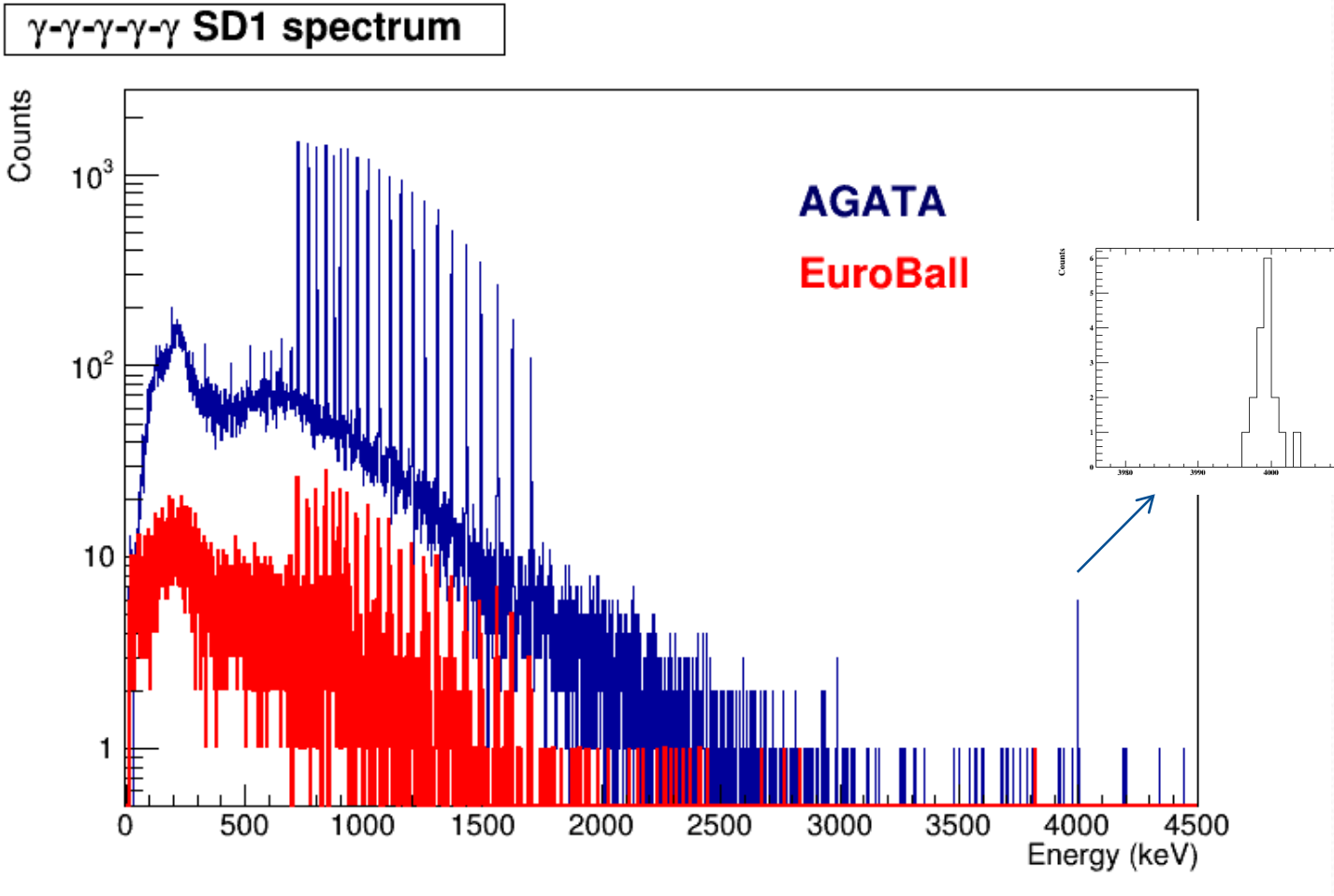
- Simulation request for typical High-spin study.
  - To compare AGATA 4π and EuroBall performances
  - We produced:
    - External Event file generated (limited to 10^8 evts)
    - Recoil velocity: ~ 200 MeV
    - ^{158}Er: ND (I=1) & SD1 (I <10^{-4})
    - Hypothetical link transition from SD1 to ND of 4 MeV (1/100 SD1 decay)
    - → 6.10^7 evts with fold≥4 in AGATA
    - ~200 times lower than observed at Gammasphere
    - Automatic multi-gate process
      - Applied to both simulation outputs
      - Using 4-γ gates and 5-γ gates



Simulation for AGATA 4π Physics white-paper

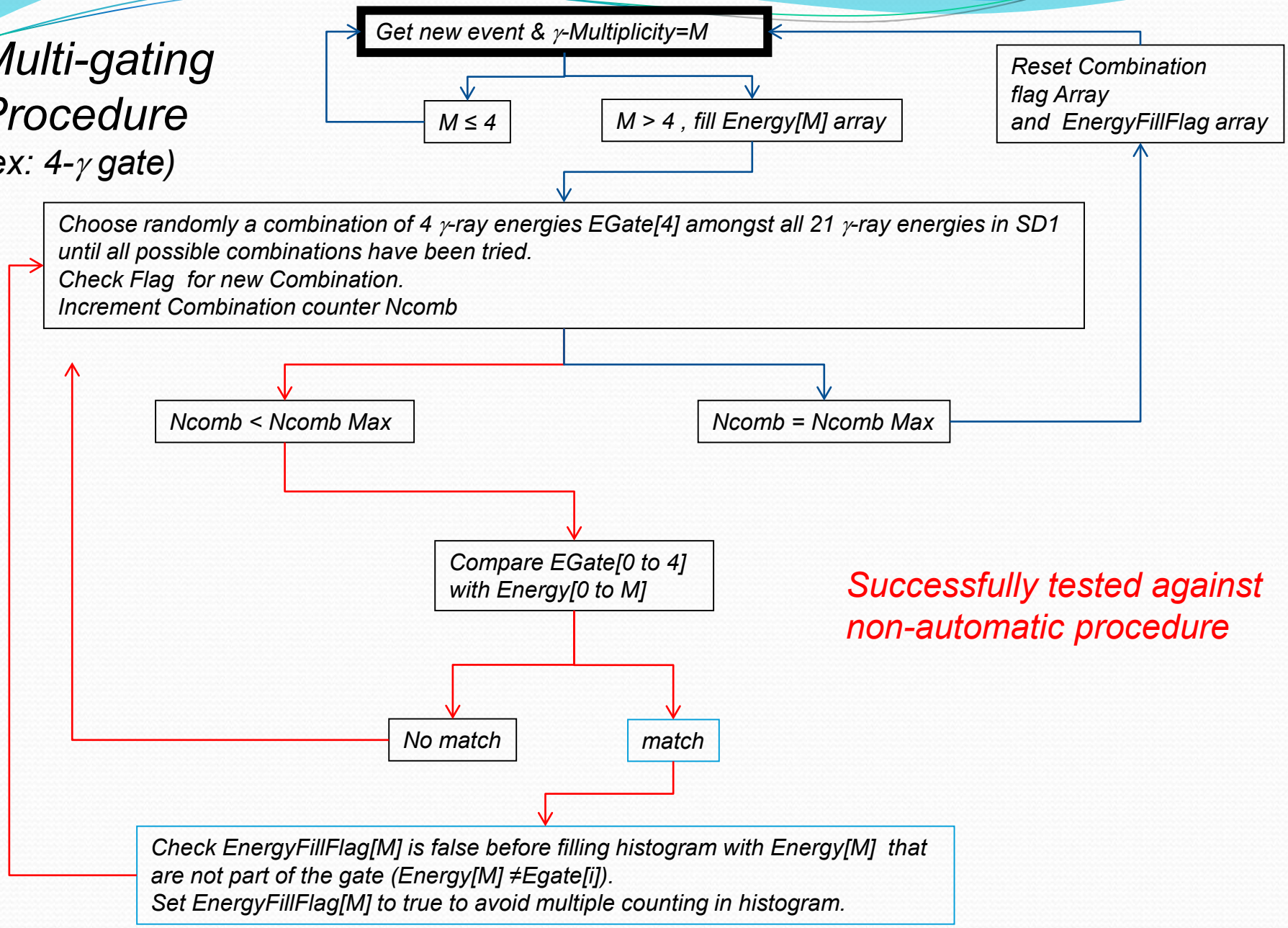


Simulation for AGATA 4π Physics white-paper



Multi-gating Procedure

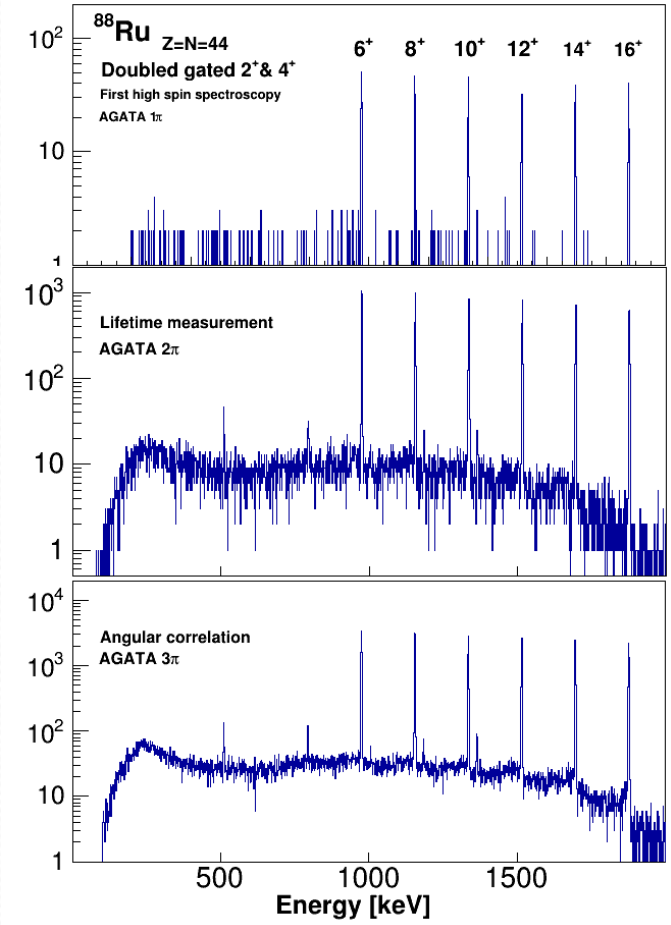
(ex: 4-γ gate)

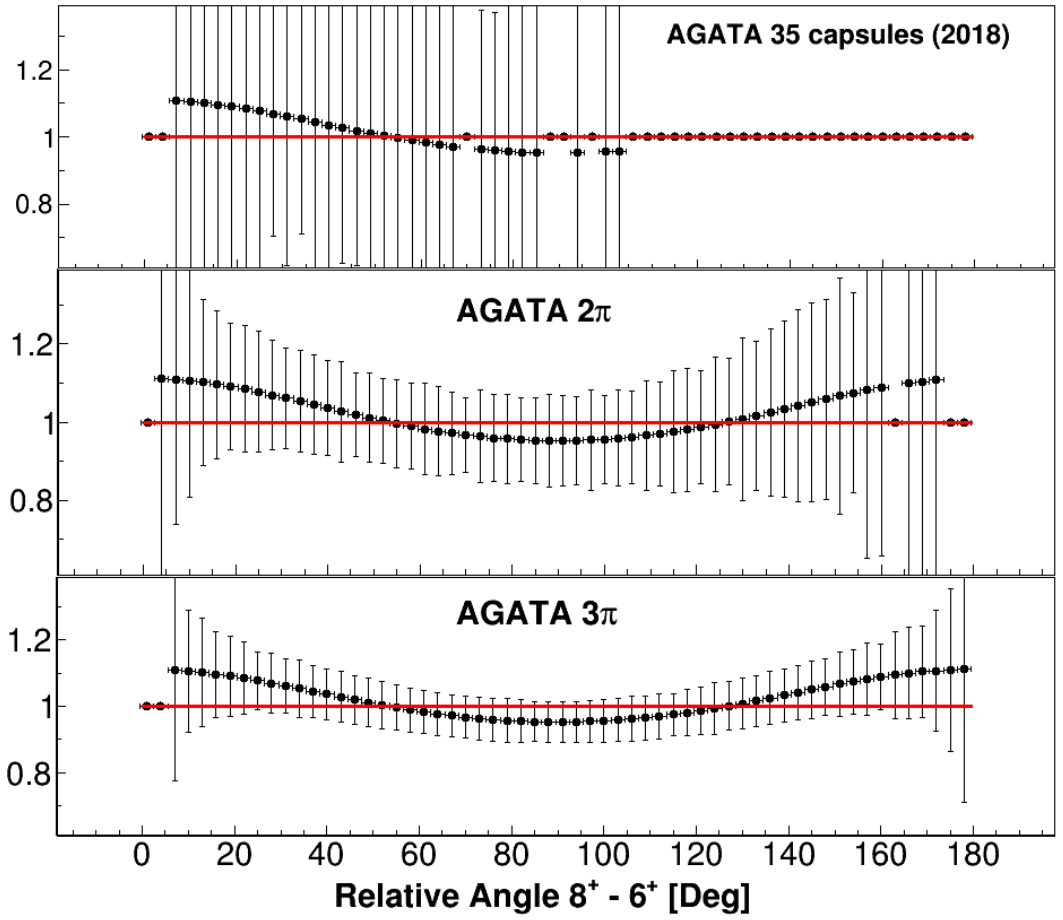


Successfully tested against non-automatic procedure

Other simulated performance toward 4π

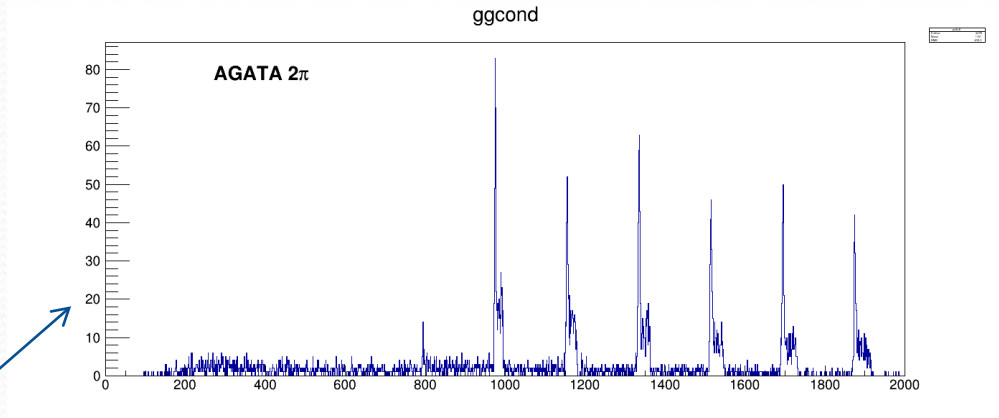
- Work from E. Clement: high spin in N=Z region

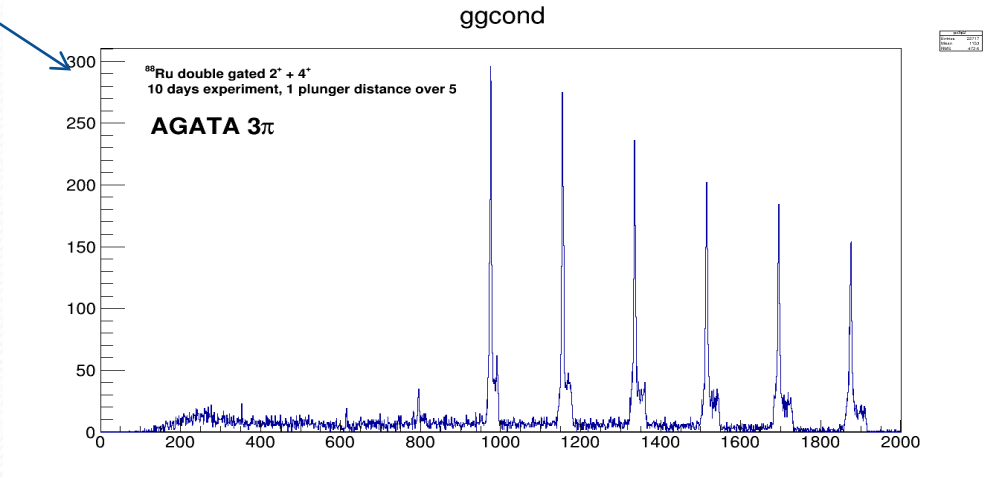




Other simulated performance toward 4π

- Work from E. Clement
  - Plunger type of experiment.
  - Target + Au degrader
  - 10 days & 5 distances
  - Spectra are double gated 2+ and 4+ for 1 target to degrader distance.





Project definition update – Simulation work

= Plan for the next decade:

- Code maintenance and dissemination
- Update generic performance predictions w/r of the number of detector, at the different facilities, low and high multiplicity
- Implement new CAD Mec. Struc. as required
- Use crystal characterisation information (Ge passive area measurement) as input to the simulation geometry.
- Develop/complete event generators.
- Simulate array performance as polarimeter
- Migrate to a more “user-friendly” framework (STOGS, NPTool, FAIRROOT)

Summary

- Still some question marks regarding the Simulated and Measured Core Efficiencies with source at rest.
  - Absorption of low-energy γ-ray may be underestimated !
  - Better agreement between data and simulation (to be cross checked)
  - To be confirmed with measurment with 41 crystal (MuGasT setup)
- Generic 4π AGATA performance has been updated
- New analysis tools have been produced to apply multigates to simulated data.
- Sensitivity of the array to extract more detailed spectroscopic information has been demonstrated as function of the AGATA angular coverage.

Thank you

Recent Additions/Modifications

```
# The 3 independent crystals of the clusters *** for AGATA-MC ***
#   Cylinder centered on z-axis and front face on z=0
#    cr  #s  p#        x y z of the Inner face              x y z of the Outer face
#

     0   6   0    33.906177   -0.000000    0.000000    48.844467   -0.070710   90.000000
     0   6   1    15.358631   30.461479    0.000000    22.153453   43.765160   90.000000
     0   6   2   -20.780862   27.320467   -0.000000   -28.562085   39.357292   90.000000
     0   6   3   -33.865099   -3.186191   -0.000000   -47.398084   -4.559934   90.000000
     0   6   4   -20.861304  -27.597830   -0.000000   -28.566730  -39.911479   90.000000
     0   6   5    15.586726  -29.970097   -0.000000    22.461366  -43.232708   90.000000
     0   0   0     5.000000   40.000000   90.000000     0.000000    0.000000    0.000000
     0   0   1    13.000000    3.000000    2.500000     0.400000    0.800000    1.300000
     0   0   2     1.000000    0.000000    0.000000     0.000000    0.000000    0.000000
#
     1   6   0    34.768773    0.000000   -0.000000    49.689796    0.721528   90.000000
     1   6   1    15.189995   29.100143   -0.000000    21.480233   42.649698   90.000000
     1   6   2   -21.610036   27.946520    0.000000   -29.959278   41.037150   90.000000
     1   6   3   -34.515980    1.715443    0.000000   -48.660064    3.028171   90.000000
     1   6   4   -17.845056  -29.899266    0.000000   -24.681675  -42.444404   90.000000
     1   6   5    21.121422  -28.647387   -0.000000    29.962271  -40.688852   90.000000
     1   0   0     5.000000   40.000000   90.000000     0.000000    0.000000    0.000000
     1   0   1    13.000000    3.000000    2.500000     0.400000    0.800000    1.300000
     1   0   2     0.000000    1.000000    0.000000     0.000000    0.000000    0.000000
#
     2   6   0    34.368758    0.000000   -0.000000    49.303402   -0.337546   90.000000
     2   6   1    20.008679   28.248525    0.000000    28.536919   40.513380   90.000000
     2   6   2   -16.582470   29.653241   -0.000000   -22.688267   42.479888   90.000000
     2   6   3   -33.870627    1.539298    0.000000   -47.639755    1.903863   90.000000
     2   6   4   -17.834223  -30.216677    0.000000   -24.533605  -43.851923   90.000000
     2   6   5    15.063353  -29.838670    0.000000    21.492077  -43.323070   90.000000
     2   0   0     5.000000   40.000000   90.000000     0.000000    0.000000    0.000000
     2   0   1    13.000000    3.000000    2.500000     0.400000    0.800000    1.300000
     2   0   2     0.000000    0.000000    1.000000     0.000000    0.000000    0.000000
```

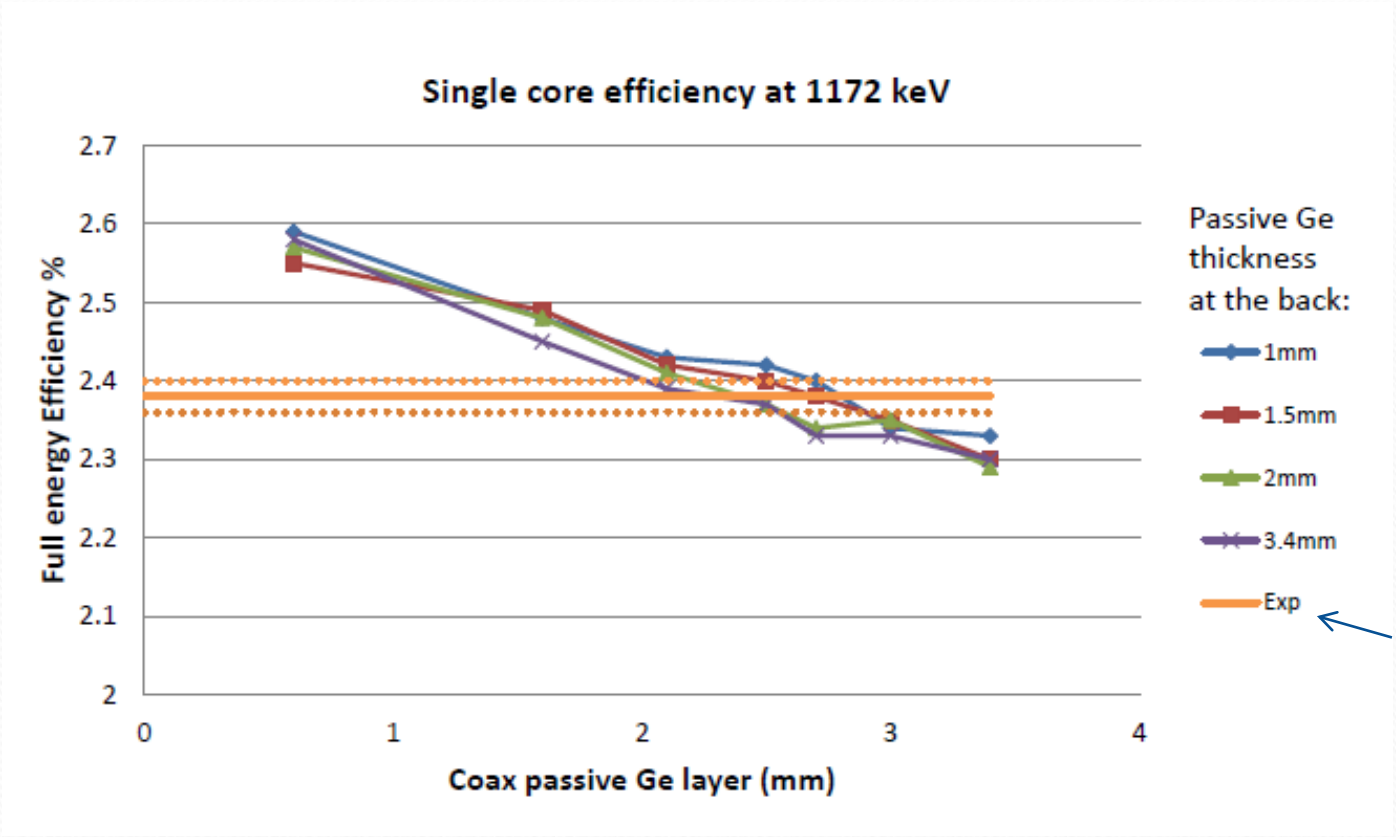
Ex: A180/A180SolidExp.list

Passivated Ge areas are:

2.5mm thick at central contact (0.6mm in A180Solid.list)

3.mm thick at the back (1mm in A180Solid.list)

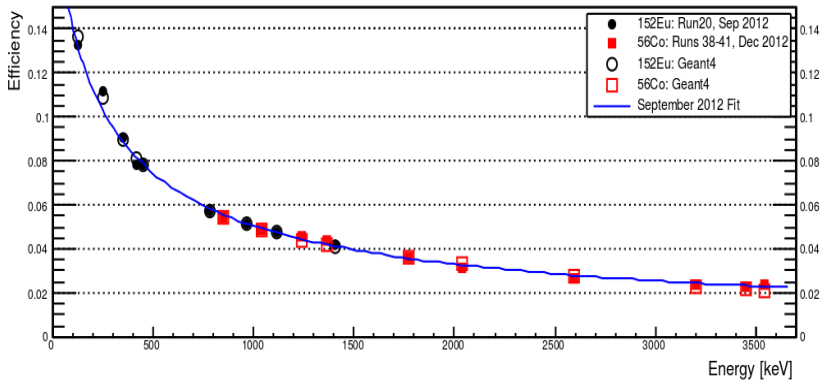
Recent Additions/Modifications

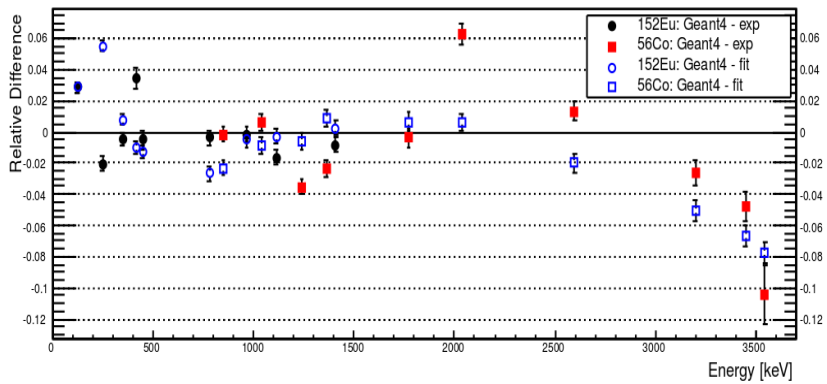


Several set of thicknesses can provide a simulated efficiency that agrees with the measured one.
So, which one ?

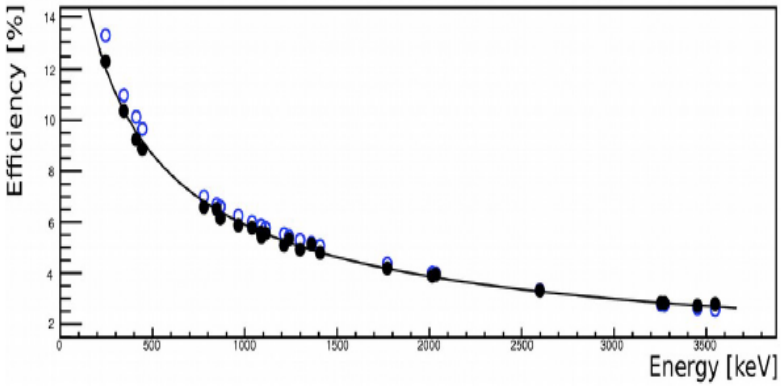
GRETINA case

3.5mm Coax and 1.5mm Back dead layer

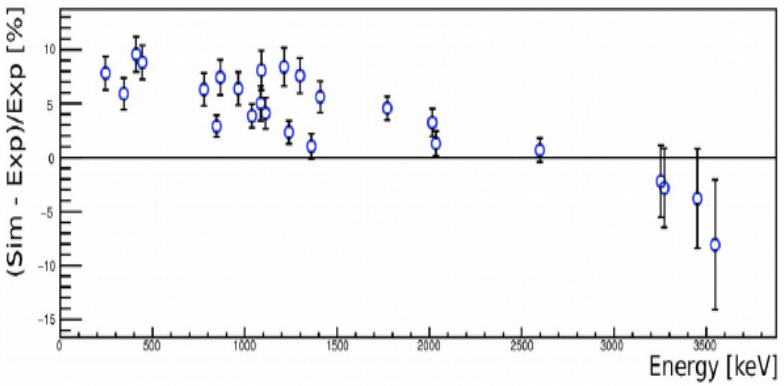




8 Quads, 2.1 mm Coax, 3.4 mm Back Dead Layers



Relative Discrepancy



Courtesy of Heather Crawford, Lew Riley et al.

Recent Additions/Modifications

- **Enhanced Ge passive area Vs "Canberra" normalised efficiencies :**

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