Report on recent AGATA Simulation activities

On behalf of the

Simulation Working Group

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

18th AGATA week,
Milano - 11th Oct 2017

Science & Technology Facilities Council
Nuclear Physics Group

Outline

- **Generalities regarding the AGATA code**
- **Recent activities:**
  - **Simulations for 4π-AGATA physics white paper**
    - **Generic simulations**
    - **Specific simulations for experiment at:**
      - **Jyvaskyla (See next talk from A. Lopez-Martens)**
      - **FAIR**
      - **CERN**
  - **Possible AGATA + MINIBALL setup**
  - **2x 1pi AGATA setup**
  - **Update on simulated efficiencies and validation with sources. (See my talk this afternoon)**

Generalities

- **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 still compatible with Geant4.10.3 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
  - Still working on producing the GDML file for DIAMANT chamber.

Generic simulations

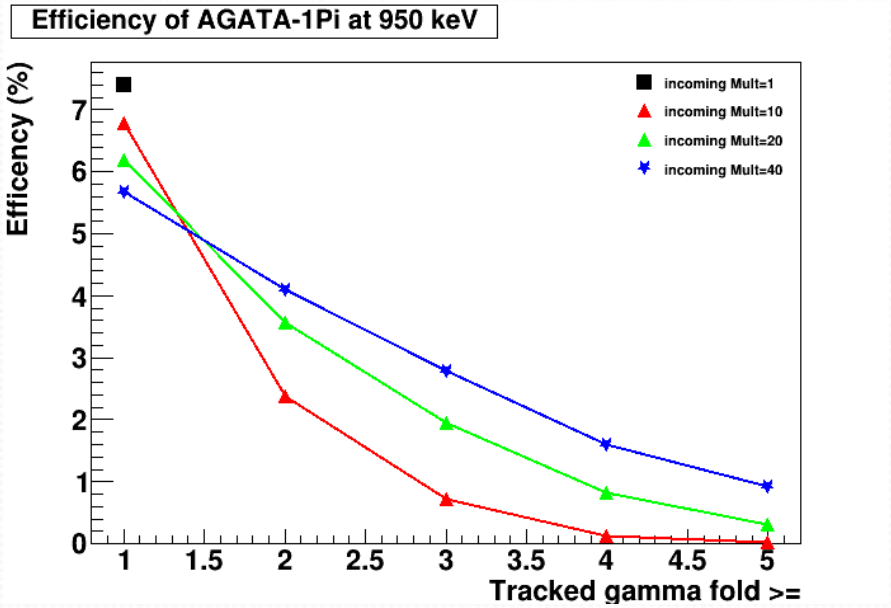
Requests from W. Korten:

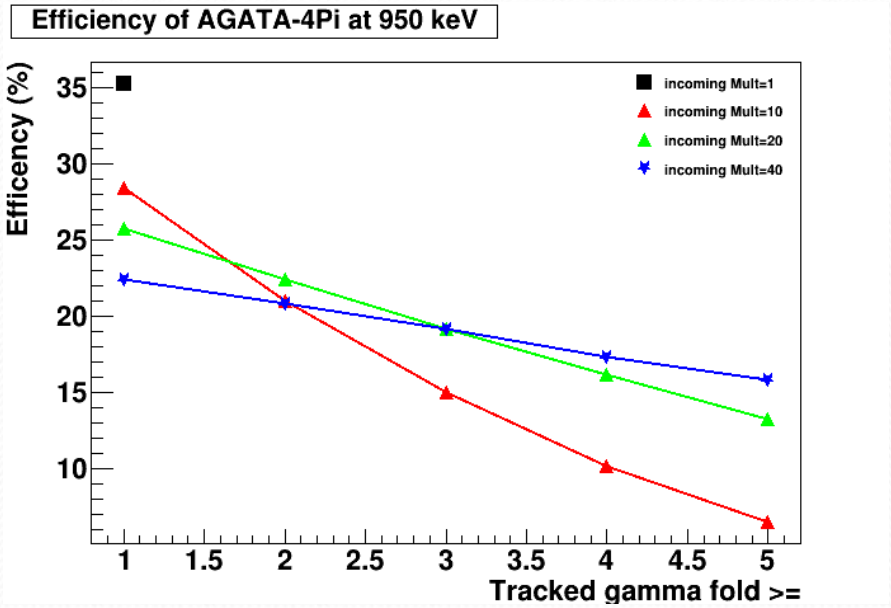
- **AGATA efficiency for a 1π and 4π array, at 1MeV and high multiplicities.**
- **Summing effects in 4π AGATA.**
  - **High multipolarity transitions competing with low multipolarity transitions.**

Generic simulations

- **AGATA 1π *vs* 4π, at 1MeV and high multiplicities**

*Cascade of γ-rays: E_i= 150keV+ 100keV * i*





Generic simulations

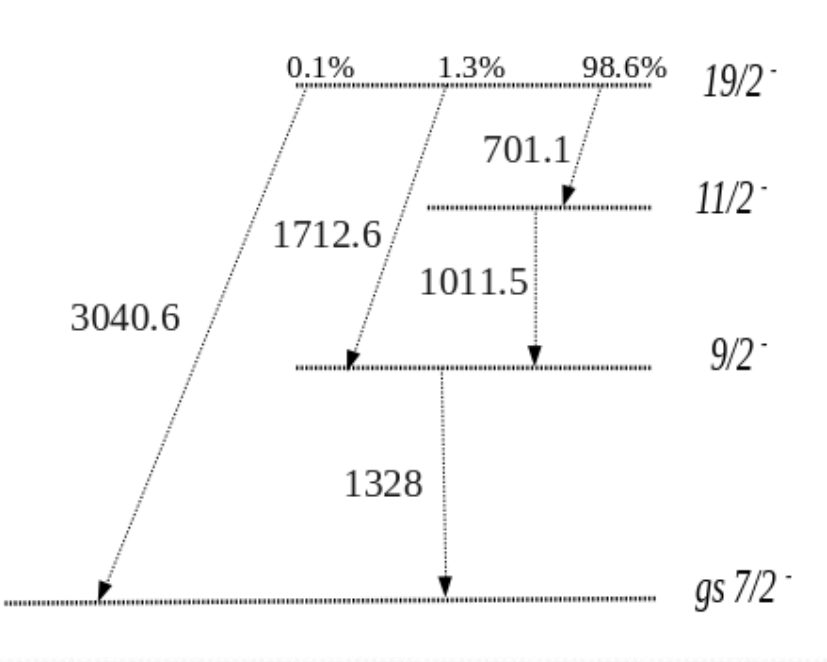
- **AGATA 1π *vs* 4π, at 1MeV and high multiplicities**

Fold:	Incoming gamma mult=1 4pi/1pi Gain	Incoming gamma mult=10 4pi/1pi Gain	Incoming gamma mult=20 4pi/1pi Gain	Incoming gamma mult=40 4pi/1pi Gain
>=1	4.8	4.2	4.2	4.0
>=2	-	8.9	6.3	5.1
>=3	-	20.9	9.9	6.9
>=4	-	85.8	19.4	10.8
>=5	-	217.7	44.3	17.0

Table 3: Gain factors when migrating from AGATA 1π to AGATA 4π

Generic simulations

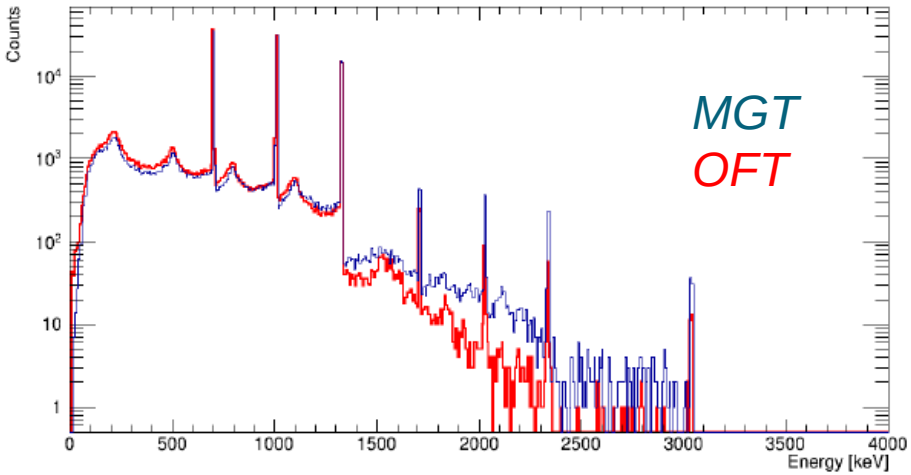
- **Summing effect in 4π AGATA**
  - Ex: ^{53}Fe
  - **Sim. Inputs:**
    - 4π AGATA
    - Source ^{53}Fe at rest
    - Chamber with 5mm and 110mm radius
    - Enhanced Ge dead area
    - External event generator
    - 10^5 events w/r to branching ratios
    - Default tracking parameters for both MGT and OFT.



^{53}Fe

Generic simulations

- **High multipolarity transition competing with low multipolarity transition**
  - Results:
    - Still large summation effects after tracking.
    - Slightly less with OFT than MGT

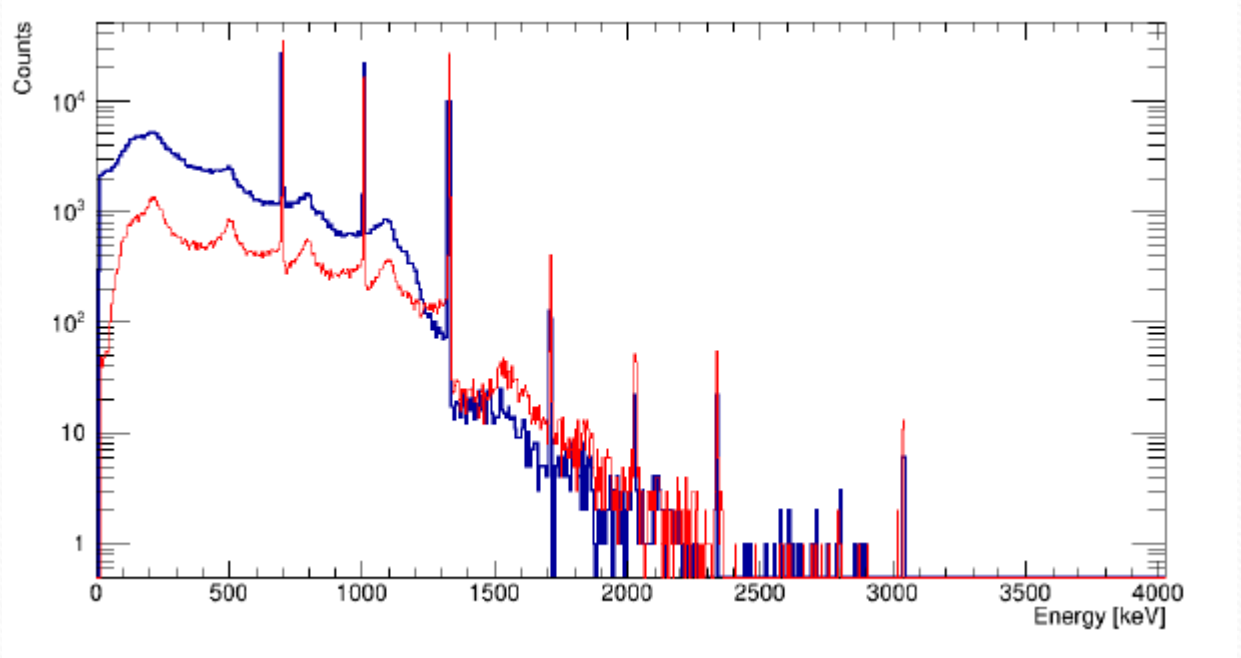


Tracked energy spectrum

Energy [keV]	701.1	1011.5	1328	1712.6	2029.1	2339.5	3040.6
Real detection	yes	yes	yes	yes	no	no	yes
Sum detection	no	no	no	yes	yes	yes	yes
Peak counts - MGT	34545	30187	28398	775	351	239	63
Efficiency (%)	35.0	30.6	28.8	-	-	-	-
Peak counts - OFT	35929	31663	28759	427	85	58	23
Efficiency (%)	36.4	32.1	29.2	-	-	-	-
Expected number of counts if no summation Given branching ratio and efficiency.				**36**	**0**	**0**	**19**

Generic simulations

- **Summing effect in 4π AGATA**

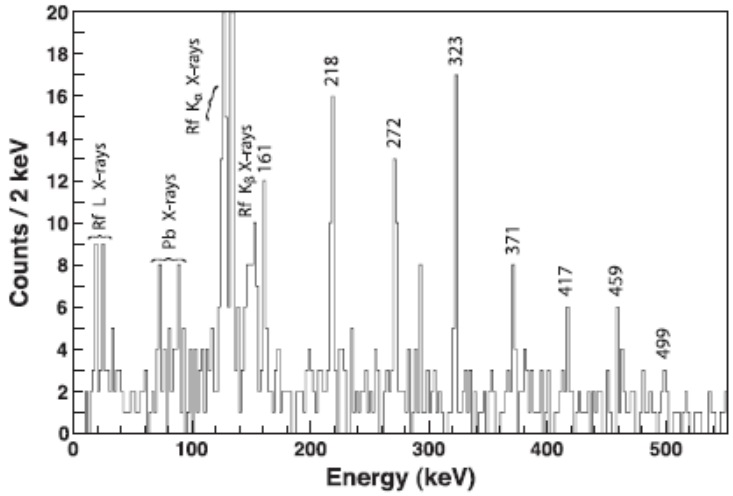


Energy spectrum before (core sum in blue) and after tracking (OFT in red)

Specific simulations

- **For Jyvaskyla:**

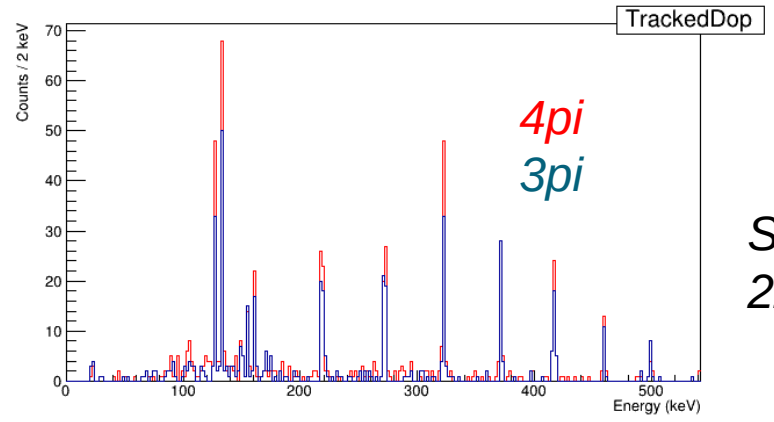
Request from P. Greenlees, J. Pakarinen, D Jenkins



Prompt Decays of ^{256}Rf in Jurogam

from P. Greenlees PRL 109, 012501 (2012)

See also A. Lopez-Martens' talk on Nobelium 254

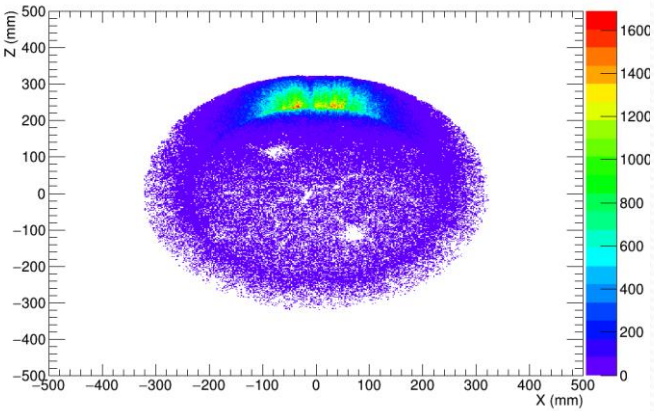


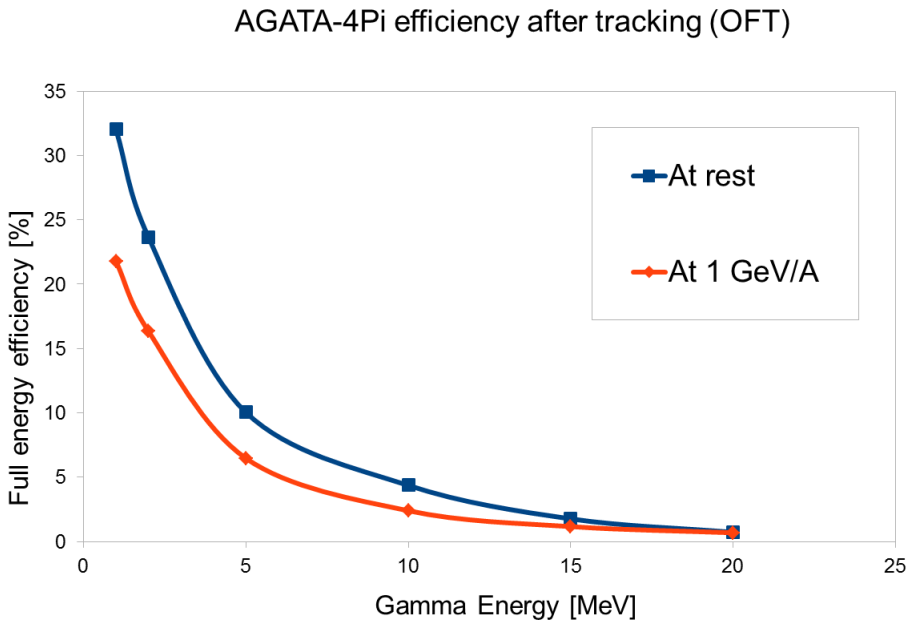
Spectrum obtained assuming 2200

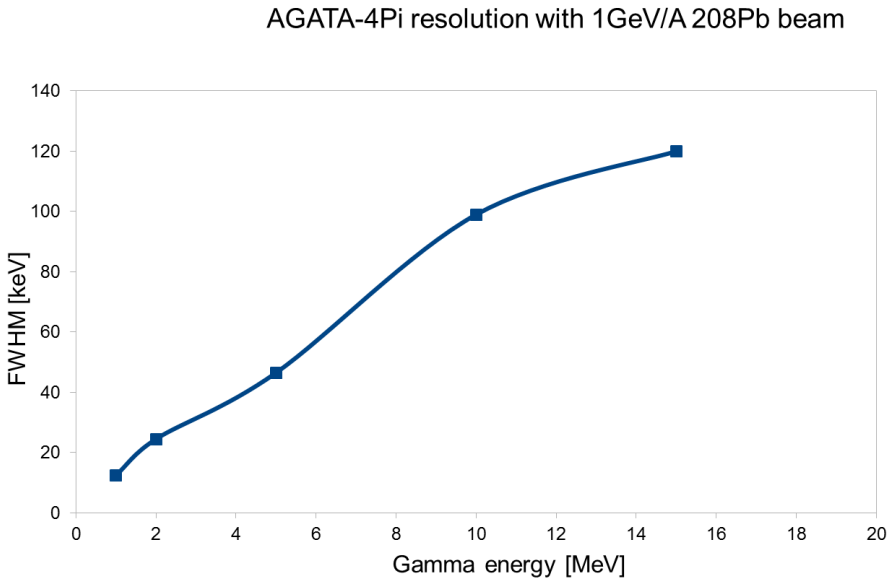
Specific simulations

- **For FAIR:**

Request from O. Wieland
208Pn on 208Pb at 1GeV/A







Specific simulations

- **For CERN:**

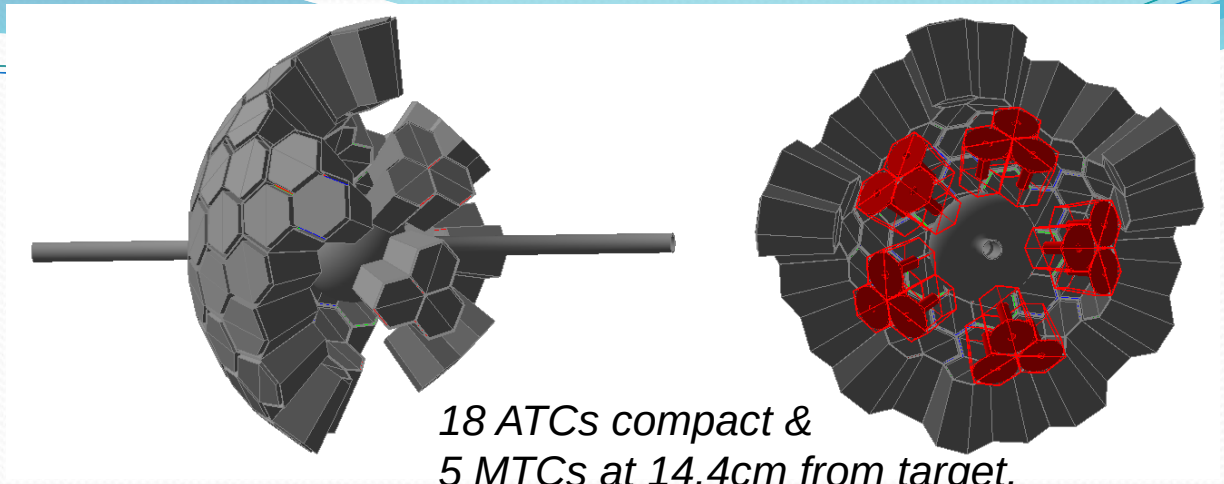
  Request from M. Zielinska and L. Gaffney.

  Safe Coulomb excitation of a mixed 144Ba/144Nd beam on a 208Pb

  Joa is on the case …

  Some preliminary results AGATA vs MINIBALL simulation but work is still on-going.

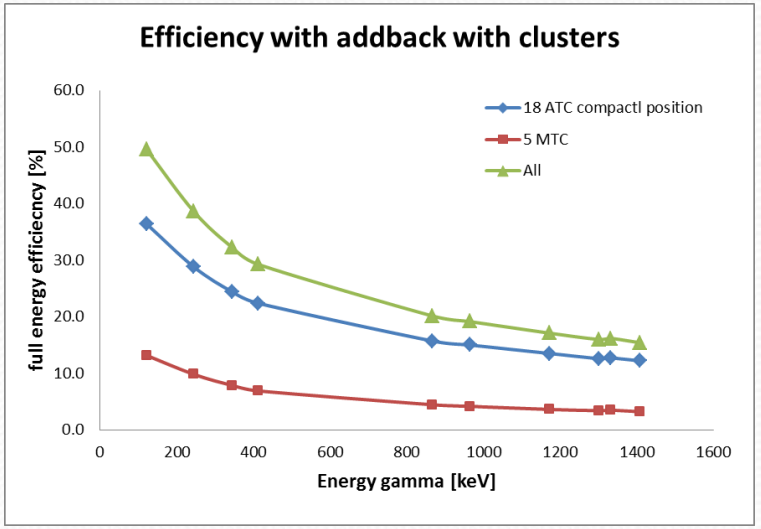
AGATA +MINIBALL



18 ATCs compact &
5 MTCs at 14.4cm from target,
2mm Al Chamber (83mm radius)

Efficiency:

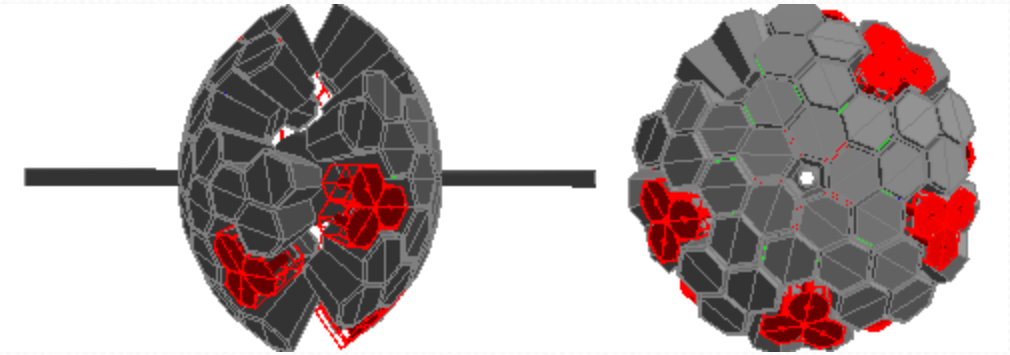
Energy [keV] (Isotropic source)	18 ATC (%) addback within cluster	5 MTC (%) addback within cluster	SUM (%) No addback	SUM (%) addback within cluster	MINIBALLcontribution (%) No addback	MINIBALLcontribution (%) addback within cluster
121	36.4	13.2	49.3	49.6	26.5	26.9
244	28.8	9.8	36.5	38.6	25.3	26.4
344	24.4	7.9	29.2	32.3	24.1	26.1
411	22.4	6.9	26.0	29.3	23.5	25.7
867	15.7	4.4	16.6	20.1	21.8	25.4
964	15.0	4.2	15.7	19.2	21.8	25.2
1172	13.5	3.6	13.8	17.1	20.8	24.7
1300	12.6	3.4	12.9	16.0	21.2	24.8
1332	12.7	3.5	12.9	16.2	21.6	25.6
1408	12.2	3.2	12.3	15.4	20.2	24.0



At 1.33MeV, efficiency with addback is ~16%, while core common is ~13%.

AGATA +MINIBALL

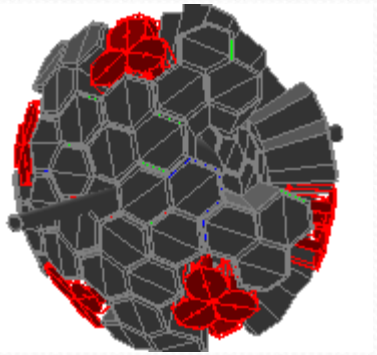
20 ATCs compact & 8 MTCs:



Other configuration: 20 ATC + 8 MTC:

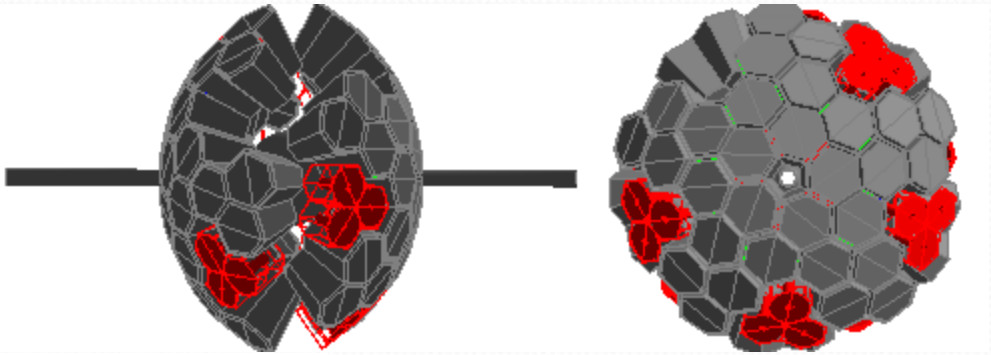
2 incomplete hemispheres with 10 ATC and 4 MTC each and shifted by 120 mm towards target.

Space for 5 MTCs on each side.



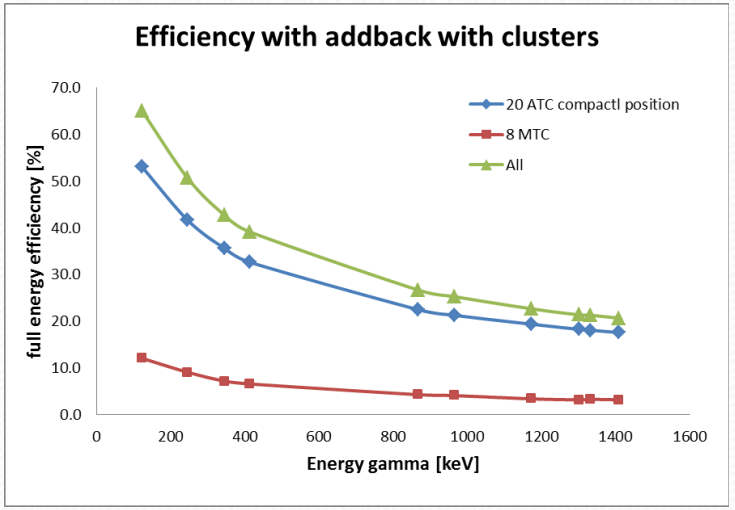
AGATA +MINIBALL

20 ATCs compact & 8 MTCs:



Efficiency:

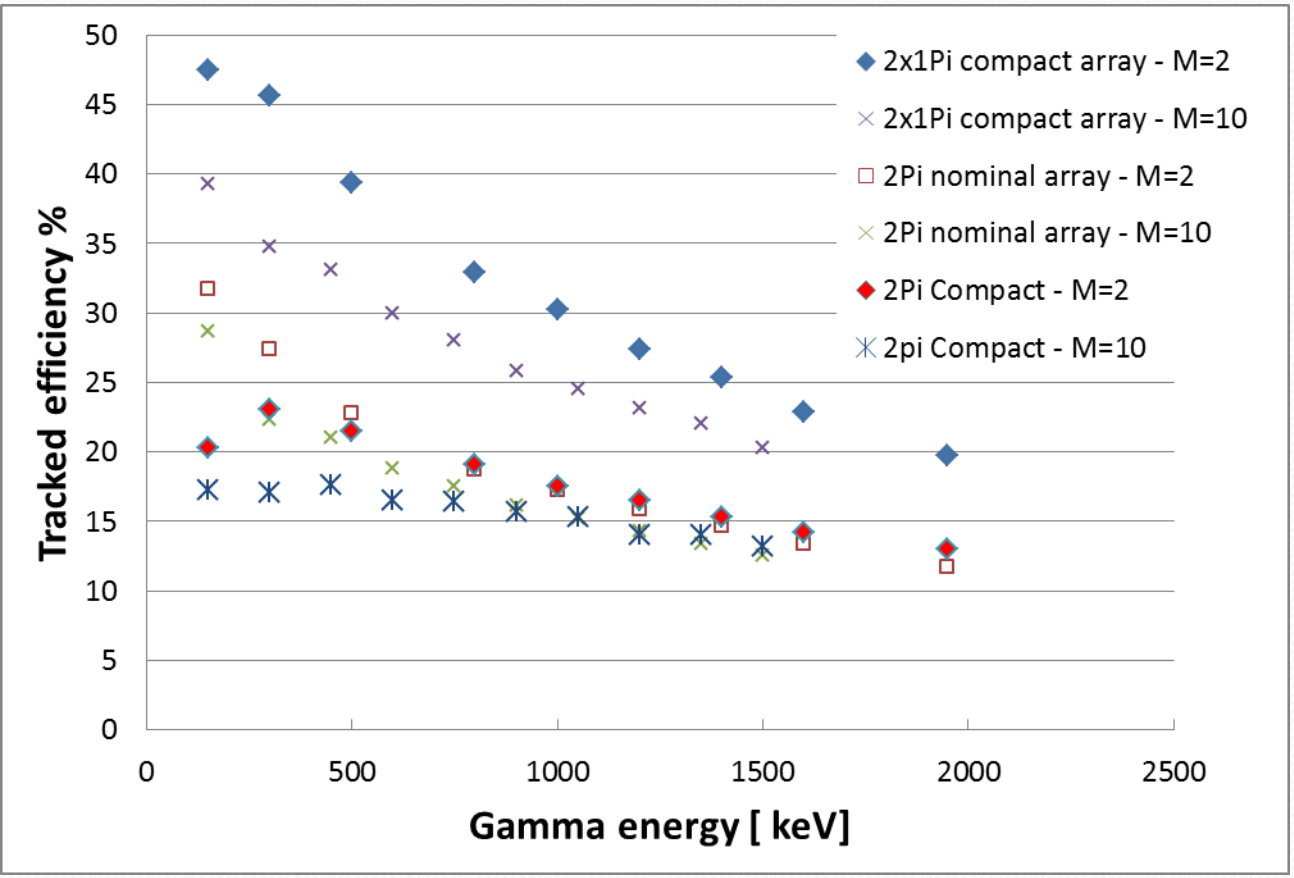
Energy [keV] (Isotropic source)	20 ATC (%) addback within cluster	8 MTC (%) addback within cluster	SUM No addback	SUM addback within cluster	MINIBALL contribution (%) No addback	MINIBALL contribution (%) addback within cluster
121	53.0	12.0	64.7	65.0	18.4	18.5
244	41.6	9.0	48.0	50.6	17.7	17.8
344	35.5	7.1	38.6	42.6	16.6	16.7
411	32.6	6.5	34.5	39.1	16.5	16.6
867	22.4	4.2	21.8	26.6	15.6	15.8
964	21.2	4.0	20.6	25.2	15.5	15.9
1172	19.3	3.3	18.1	22.6	14.4	14.6
1300	18.2	3.1	17.1	21.3	14.6	14.6
1332	18.0	3.2	17.0	21.2	14.7	15.1
1408	17.5	3.1	16.3	20.6	14.7	15.0

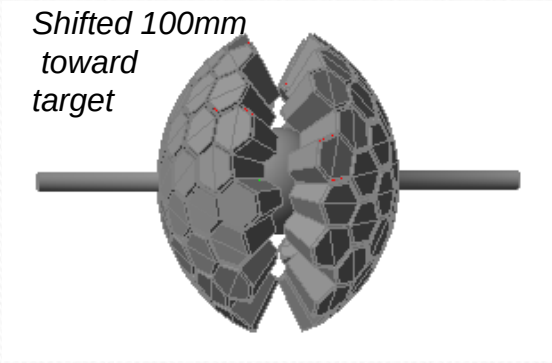


At 1.33MeV, efficiency with addback is to 21%, while core common is 17%.

2 x 1π compact configuration

Request from AMB





Input Multiplicity 2:
A γ-ray ($E\gamma$) emitted with another at 150keV

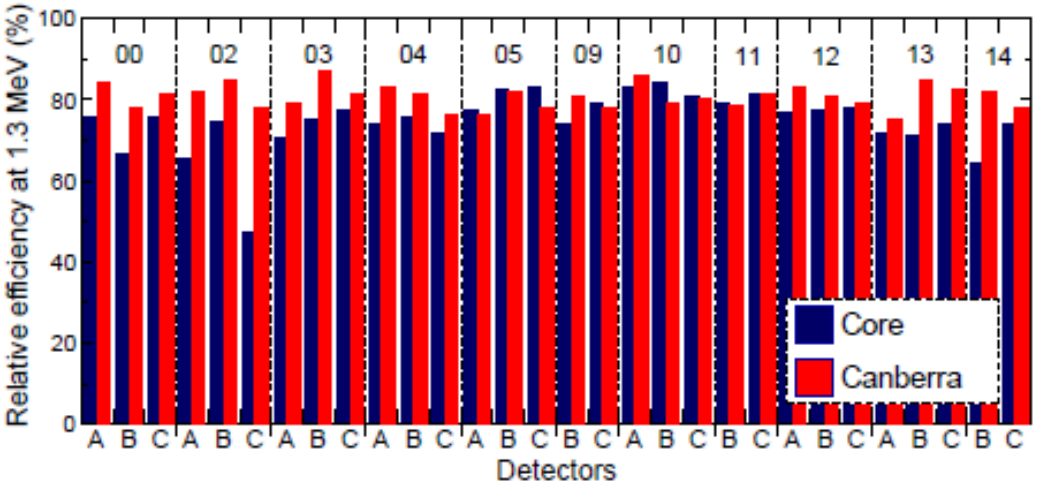
Input Multiplicity 10:
*$E_{\gamma i}$= 150keV + i*dE with dE=150keV*

Resolution at 1MeV
σ=1.3 keV at 5% v/c
σ=1.4 keV at 10% v/c

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 R.M. Perez

Courtesy of E. Clement

G4 $Single_{scaled}$ obtained with canberra crystal efficiencies (red)

Now better agreement is obtained when scaling with re-measured crystals relative efficiencies (blue)

…. See talk this afternoon

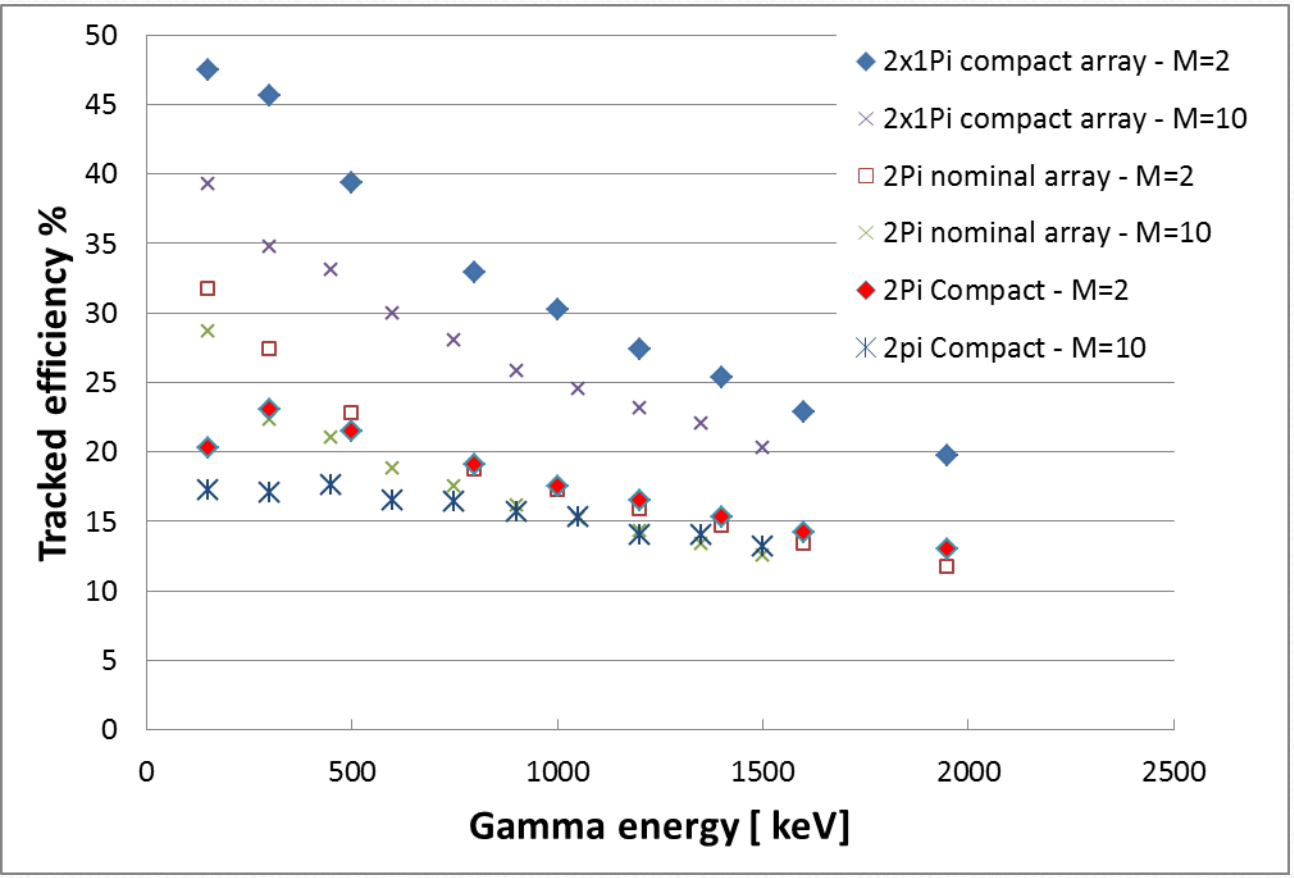
Summary

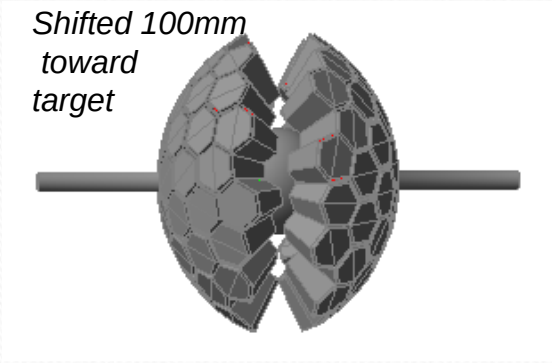
- Lots of simulations have been performed for the 4pi AGATA White Paper
  - Future Exp. at Jyvaskyla, CERN, FAIR
- A Setup AGATA-MINBALL and 2x1π have been investigated
- Progress made in the validation of the Simulation w/r to the measurements with sources.
- Still room for the code development/improvement/documentation
  - Volunteers welcome.

Thank you

2 x 1π compact configuration

Request from AMB





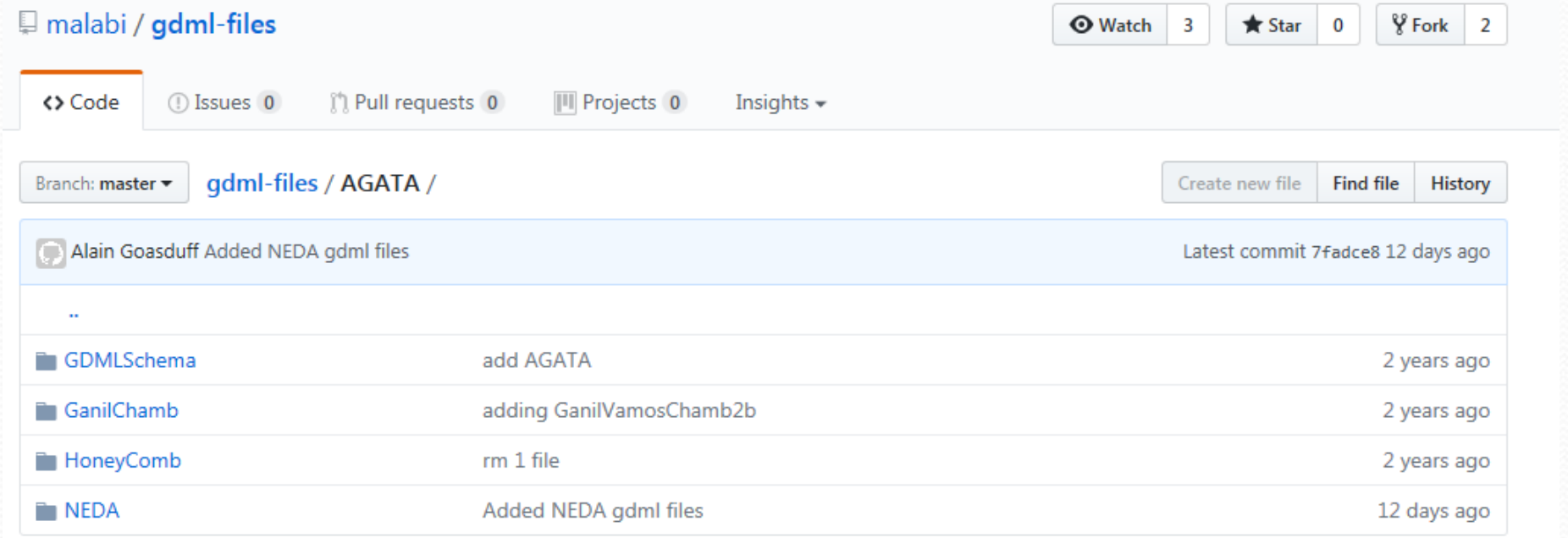
Input Multiplicity 2:
A γ-ray ($E\gamma$) emitted with another at 150keV

Input Multiplicity 10:
*$E_{\gamma i}$= 150keV + i*dE with dE=150keV*

Resolution at 1MeV
σ=1.3 keV at 5% v/c
σ=1.4 keV at 10% v/c

Generalities

- GDML files available for AGATA:



Users need to edit the trunk/CMakeLists.txt file and set the variable gdmlPATH correct path to the downloaded gdml-files/AGATA/ directory:

set(gdmlPATH "/mnt/hgfs/Echanges/MyGitHubRep/gdml-files/AGATA/")

Generalities

- GDML files available:

gdml files for GEANT4 simulations of NP detection suystems

17 commits | 2 branches | 0 releases | 2 contributors

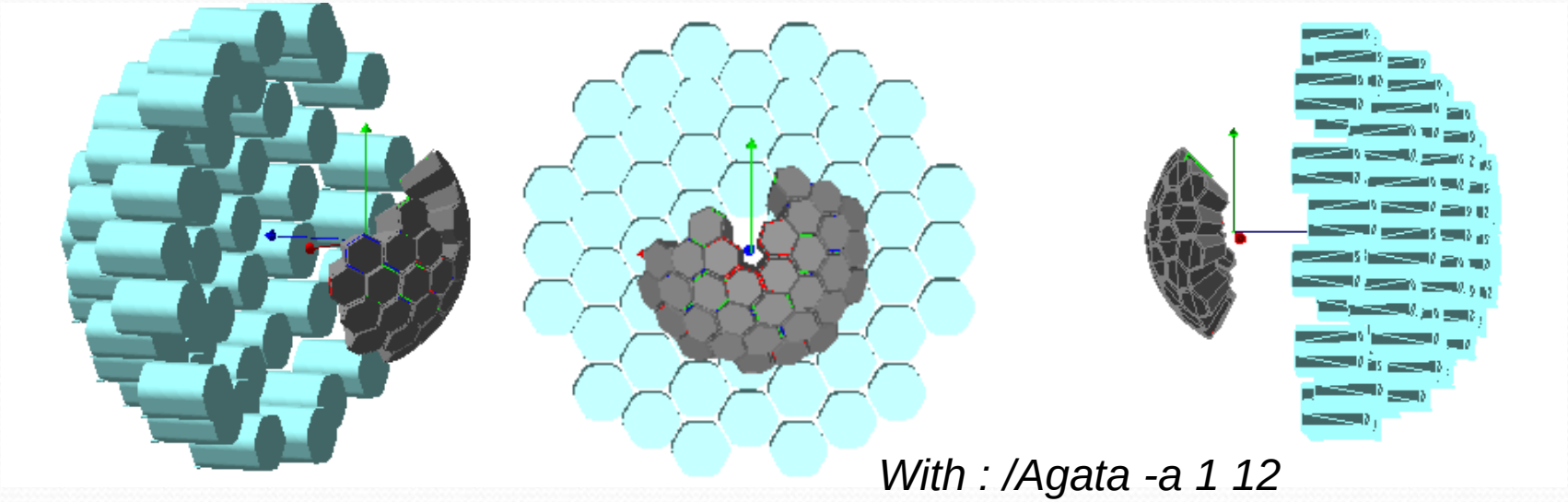
Branch: master ▾ | New pull request | Find file | Clone or download ▾

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	4 months ago
SToGS/ATC-Demo	Adding SToGs ATC demo	8 months ago
README.md	Update README.md	10 months ago

Recent Additions/Modifications

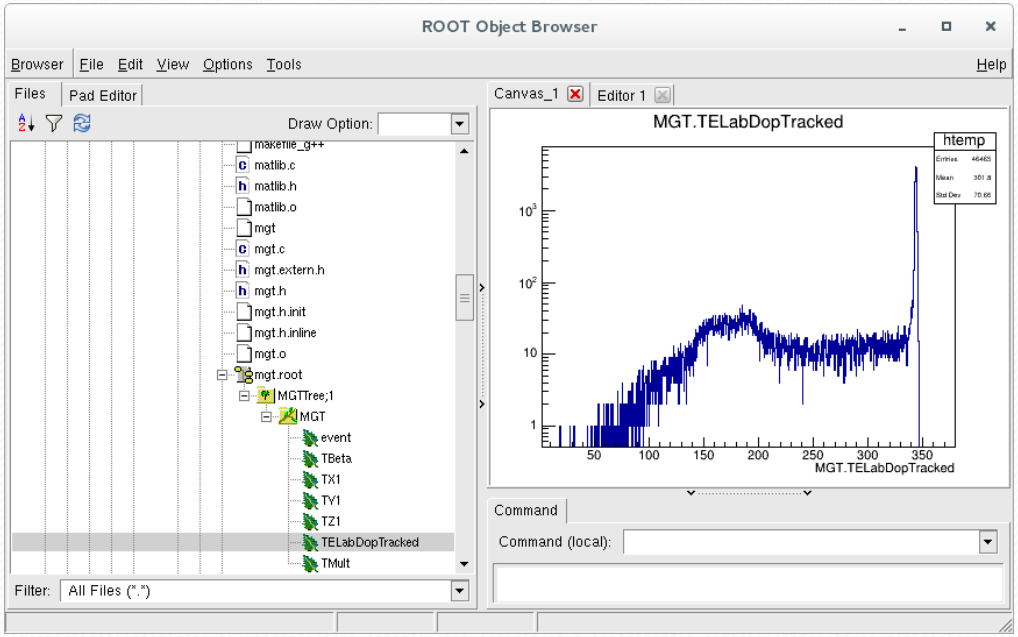
- **New Ancillarys:**
  - NEDA added to the AC package (courtesy of A. Goasduff)
  - NEDA geometry defined with GDML
    - Some issues observed when comparing results with G4.9 & G4.10 under investigations

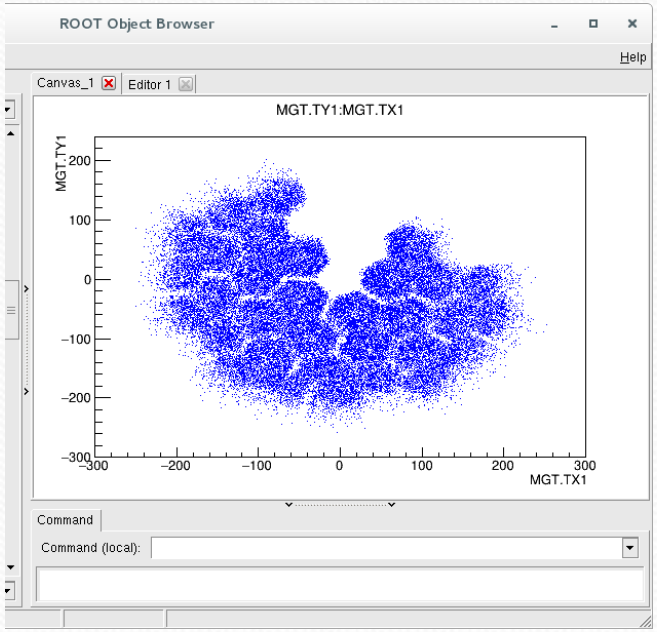


With : /Agata -a 1 12

Recent Additions/Modifications

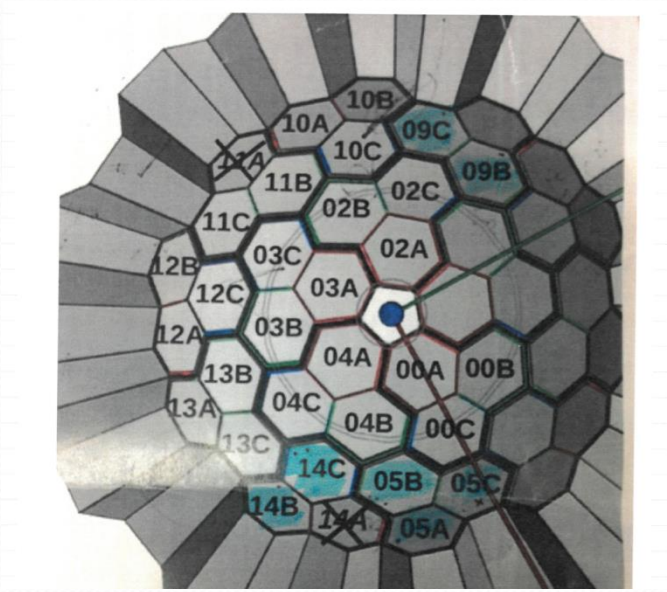
- **New analysis tools:**
  - trunk/analysis/mgt++
    - Same as mgt/ but producing a root output file “ mgt.root” with a root tree called MGTTree
    - Still need to add all the other histograms mgt can provide.





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 : $histo \rightarrow fill(Energy[cryst], Ratio[cryst])$

For calorimeter mode: $histo \rightarrow fill(\sum Energy[cryst] , \prod Ratio[cryst])$

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.

Recent Additions/Modifications

- **New analysis tools:**
  - Next step is to produce the event file after this ratio correction for the tracking algorithms.
  - Alternatively, one can increase coaxial and back passive areas in Ge crystals.
    - Pros:
      - Effect propagated all the way through tracking algorithm
      - Same for any incoming energy.
  - Increasing the Ge passive area is done in A180Solid.list

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

Generic simulations

- **High multipolarity transition competing with low multipolarity transition**
  - Results:

Energy [keV]	701.1	1011.5	1328	1712.6	2029.1	2339.5	3040.6
Real detection	yes	yes	yes	yes	no	no	yes
Sum detection	no	no	no	yes	yes	yes	yes
Peak counts - MGT	34545	30187	28398	775	351	239	63
Efficiency (%)	35.0	30.6	28.8	-	-	-	-
Peak counts - OFT	35929	31663	28759	427	85	58	23
Efficiency (%)	36.4	32.1	29.2	-	-	-	-
Expected number of counts if no summation given branching ratio and efficiency				**36**	**0**	**0**	**19**

Result for monoenergetic source (Mult=1):

Energy [keV]	701.1	1011.5	1328	1712.6	2029.1	2339.5	3040.6
Efficiency (%)	38.9	34.5	30.47	27.1	24.5	22.3	18.75