simulation code status
and
benchmarking efficiency in AGATA

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4^{th} AGATA-GRETINA/GRETA
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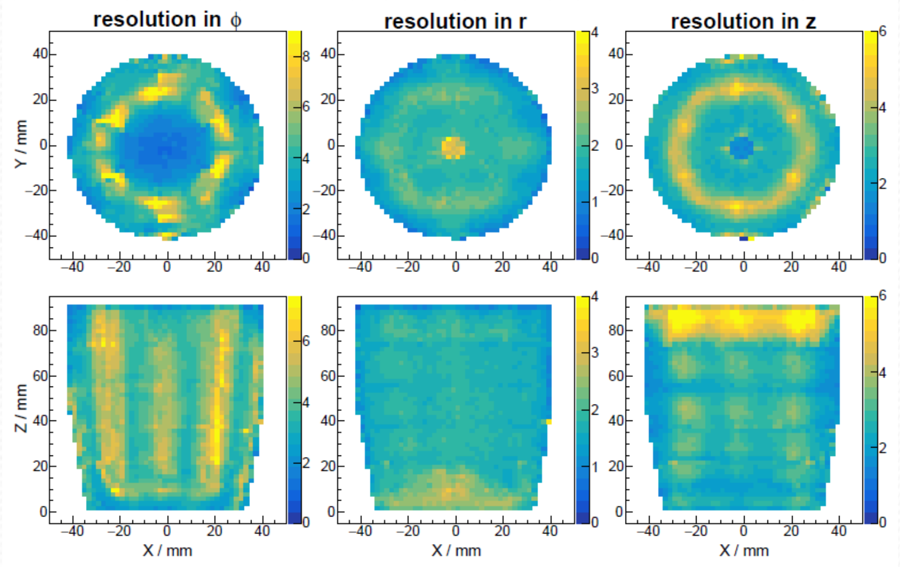
Science & Technology Facilities Council
Nuclear Physics Group

Status of the AGATA code

Original AC:

- Migrated to gitlab: https://gitlab.com/malabi-agata/agata
  - Up to Geant4.10.7
  - Not fully tested with Geant4.11 but a version also available on demand
- New functionalities added:
  - Position resolution map for each crystal type have been generated to mimic PSA position resolution *(Sidong Chen – York)*



From Eur. Phys. J. A (2023) 59:158

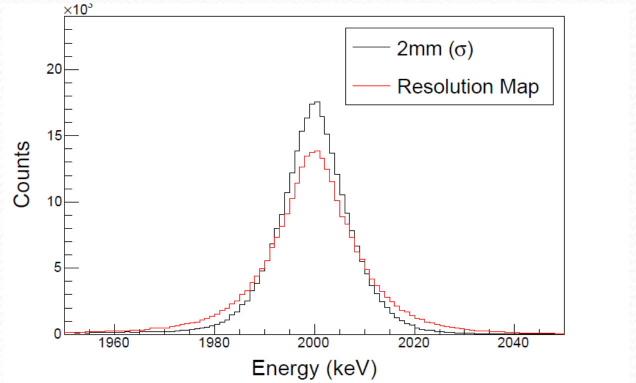


Fig. 5 Simulation of 2 MeV γ-ray spectra with Doppler correction. The γ-ray is emitted from particle moving at $0.5c$. The response of AGATA 4π array are obtained with $2\,\mathrm{mm}(\sigma)$ uniform resolution (black) and the resolution map (red).

Status of the AGATA code

Original AC:

- New functionalities added:
  - ROOT interface (I/O) has been added. *(Sidong Chen –York)*
    - Output ROOT file from MOCADI (FRS and SFRS Simulations) can be used as input.
    - Users can choose to save the output in ASCII or ROOT file.
    - OFT also modified to read the Simulation ROOT output file.
- New event generator with the possibility to have different angular distributions for different excited states *(D. Brugnara @ LNL)*
- New ancillaries as well *(D. Brugnara @ LNL and J. Bordes @ York)*
  - PRISMA, OSCAR, GALTRACE, MUGAST, S1, large LaBr crystals and the CTADIR cryogenic target.

Status of the AGATA code

Other codes versions available on:

STOGS framework *(O. Stezowski)*

- For gamma-ray spectroscopy: https://github.com/stezow/stogs

NPTOOL framework *(A. Matta)*

- For transfer reactions: https://nptool.in2p3.fr/

FAIRROOT framework *(M. Labiche)*

- For HISPEC/DESPEC collaboration at FAIR

All rely on the geometry of AGATA defined in gdml format after conversion of a CAD drawings and all are at a different level of development.

Currently limited in functionalities & ancillaries, compared with the original AC but it is up to the users to continue to develop these versions.

On-going developments with FAIRRoot

Main features:

- **No Executable:**

  Root is the executable, steering macros are called from within root

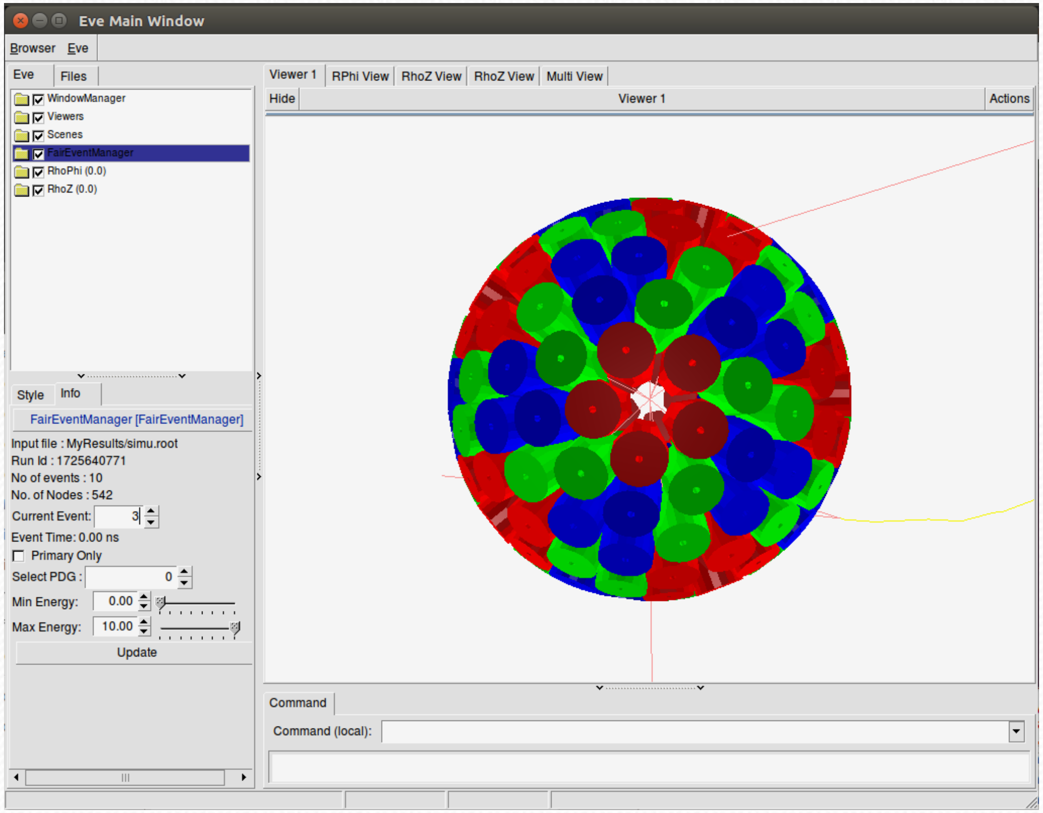
- **VMC and VGM for simulation:**
  - Running different transport MC's from the same application
  - Geometry is described once and then one can choose between different MC's and different navigations: e.g:
    - G3 Native geometry and navigation
    - G4 Native geometry and navigation
    - G4 Native geometry and Root navigation
    - G4 Root geometry and navigation

More features can be found here: https://fairroot.gsi.de/index.html

On-going developments with FAIRROOT

Similarly to CBMRoot, PANDARoot, R3BRoot, a new application called AGATARoot is being developed.

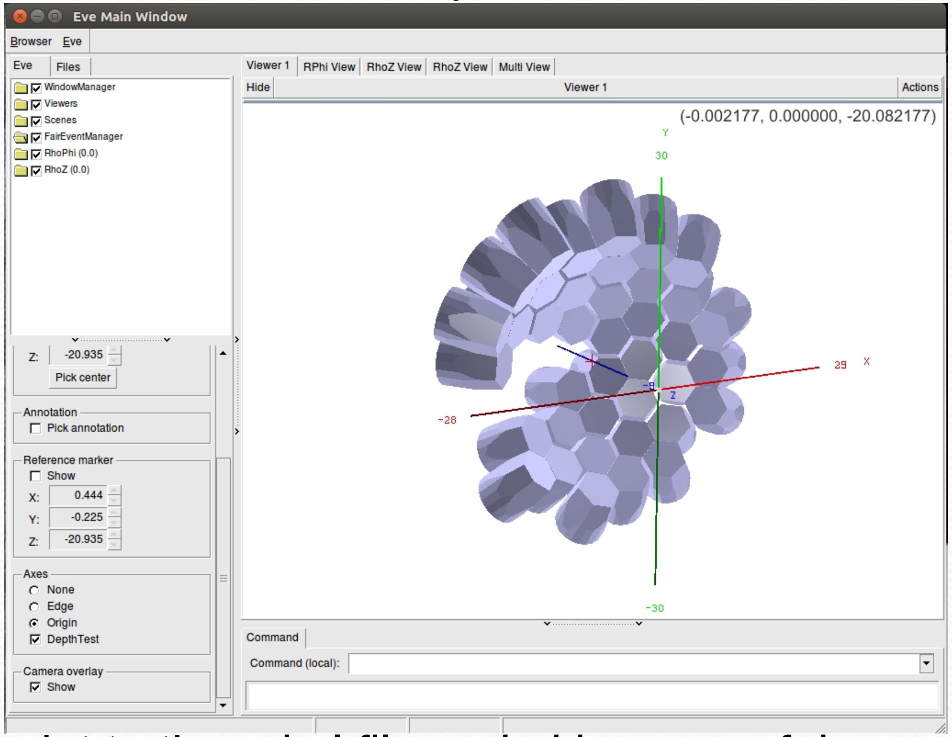
The full 4pi AGATA geometry Define in GDML format in has been imported into that new framework



Other configurations can be easily be produced:
Single crystal, single ATC, LNL configuration, etc

On-going developments with FairRoot

Once the FAIRRoot framework is installed and the AGATARoot is downloaded you can run basic simulations with a couple of command lines:



<u>To run the simulation:</u>

root – l

> .L run_sim_gdml.C

> run_sim_gdml(“simu”,“MyResults”)

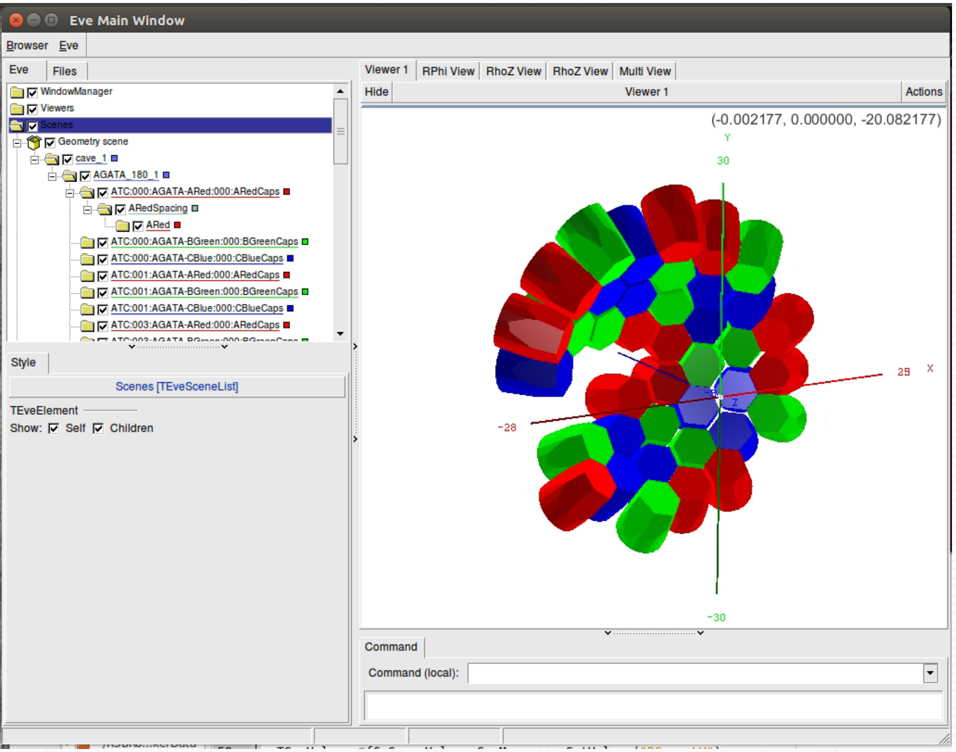
<u>To visualise the geometry and tracks:</u>

root – l AGATADisplay.C

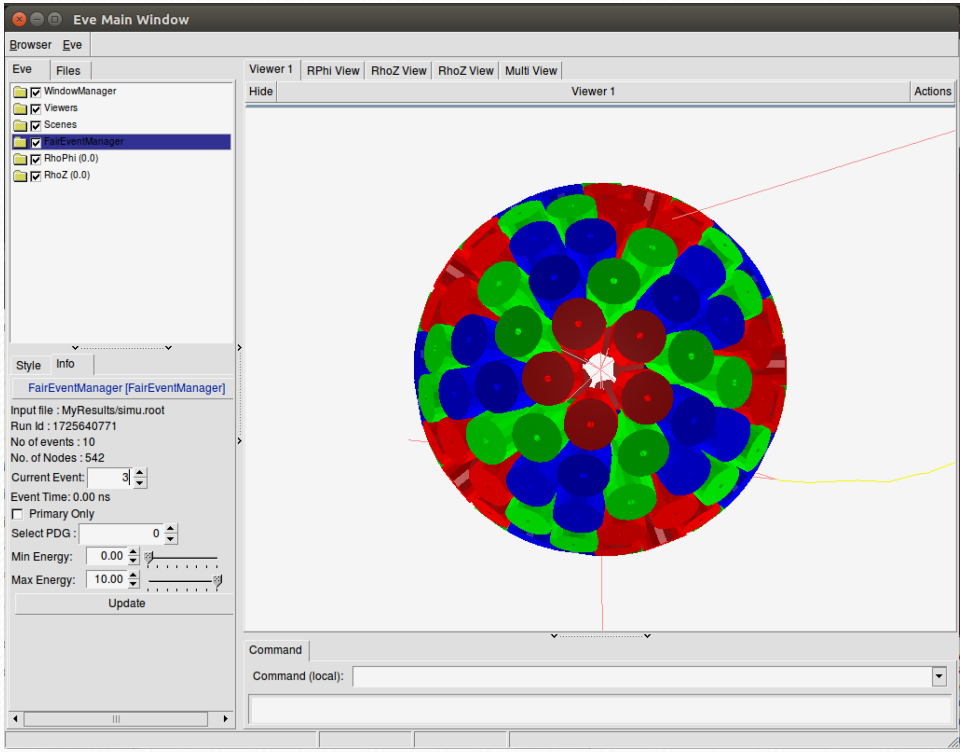
Users configure “run_sim_gdml.C” to point to the gdml file and either one of the existing predefined FairRoot event generators or a user-defined one.

On-going developments with FairRoot

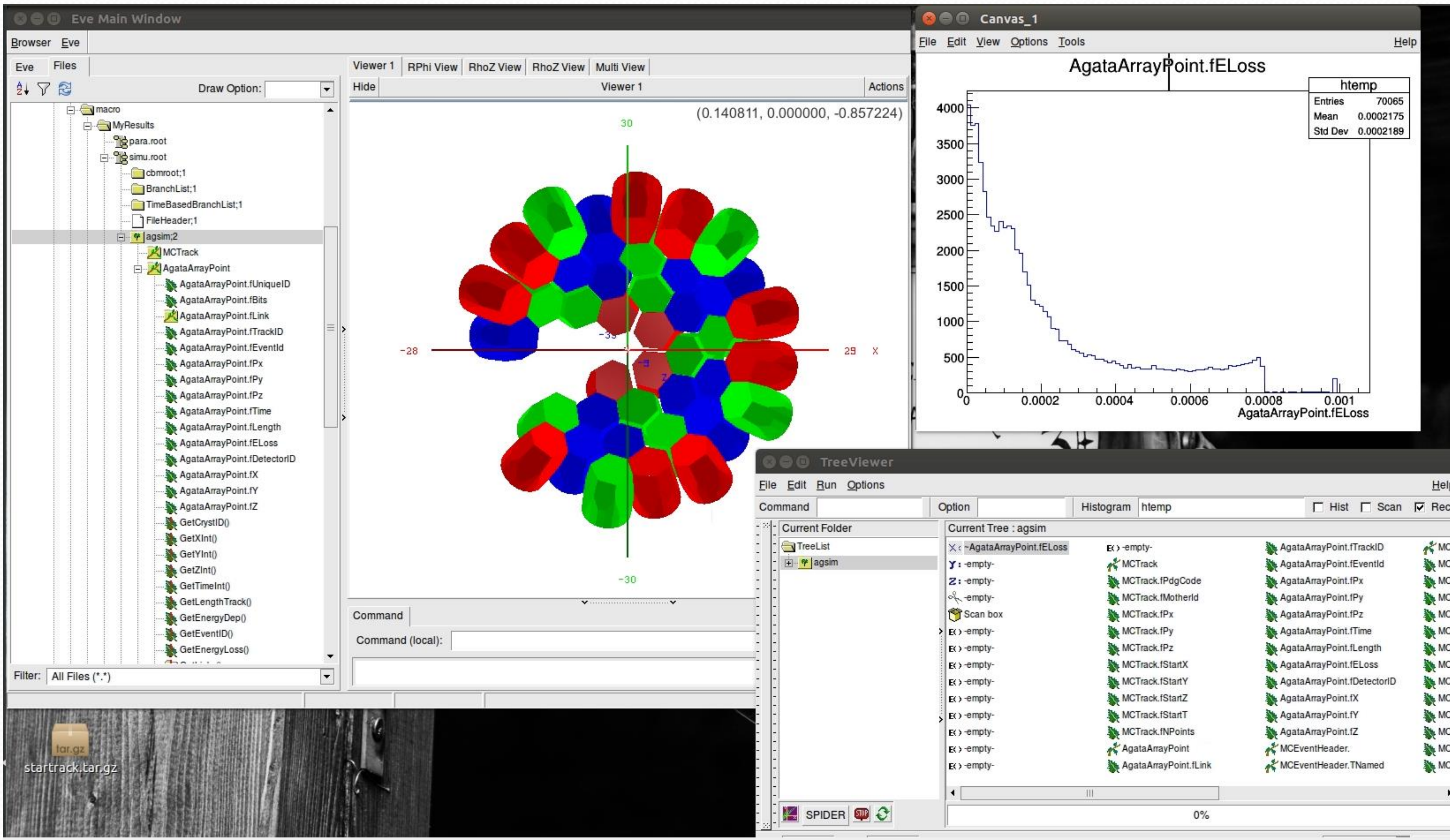
In the “Scene” folder:



In the “FairEventManager” folder:

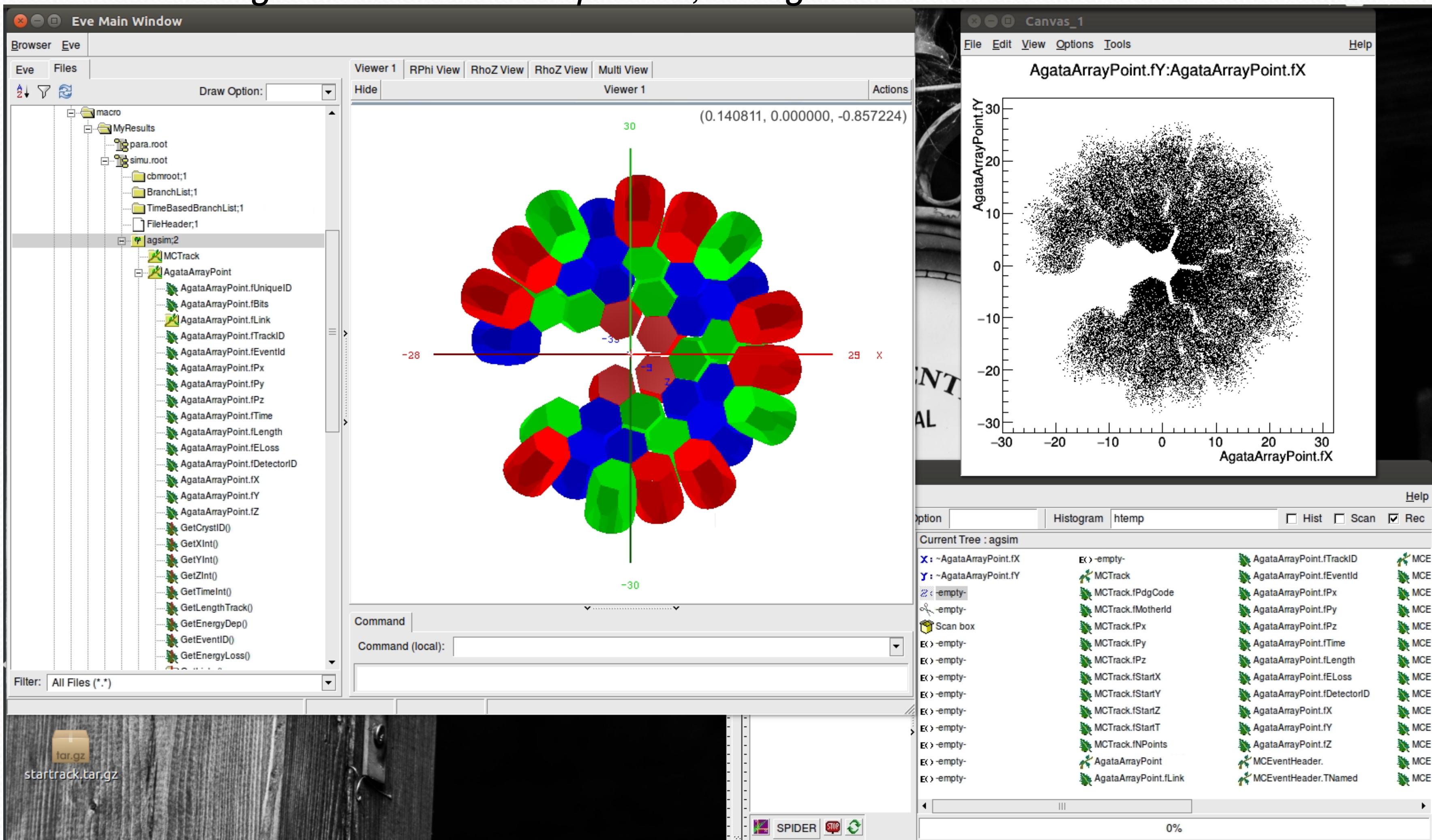


On-going developments with FairRoot



On-going developments with FairRoot

You can navigate to the root output file, using the “Files tab”



On-going developments with FairRoot

AGATARoot not yet distributed but that will come.

Currently, root output file contains all essential information the native geant4 simulation already provides before tracking:

- The crystal id.
- hit position (x,y,z) in laboratory frame,
- energy deposited at this position,
- the time information.
- and a simple segmentation.

Still to do is the interface to OFT.

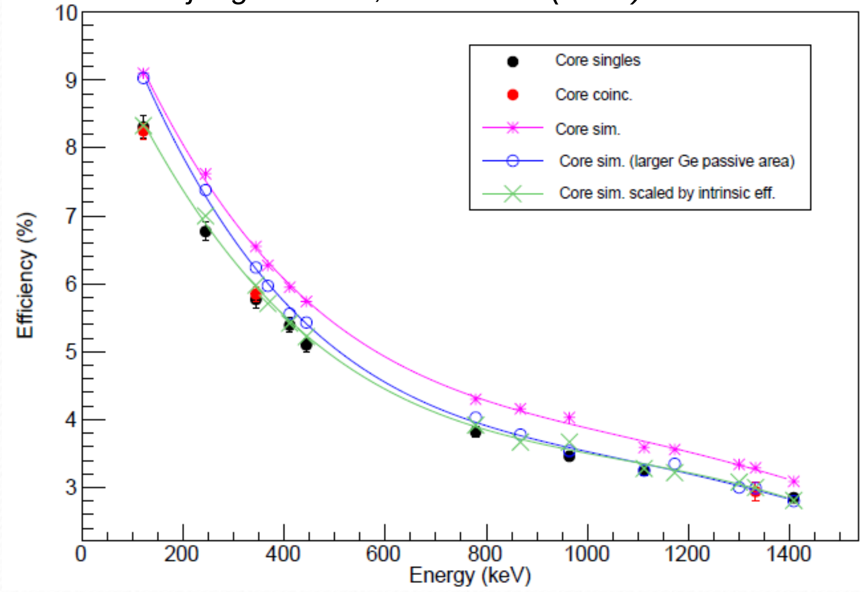
Benchmarking of efficiency

Simulated Efficiencies.

We know that simulations overestimate the measured efficiency by ~15%
(crystals have different intrinsic efficiency)

The only way to for the simulation to match the data is to weight the simulated efficiency of each crystal by there measured intrinsic efficiency.

J. Ljungvall et al., NIM A 955 (2020) 163297



Simulation and GANIL measurement with 29 crystals at Nominal

Problem:
How can we propagate this correction for the simulated tracked efficiency without reducing the size of each crystal to match their intrinsic efficiency.

Measurements

Performance up to 5MeV

1st PHASE:

^{56}Co γ-ray source measurement:

- Efficiencies up to 3.4 MeV
- Cancelled for now

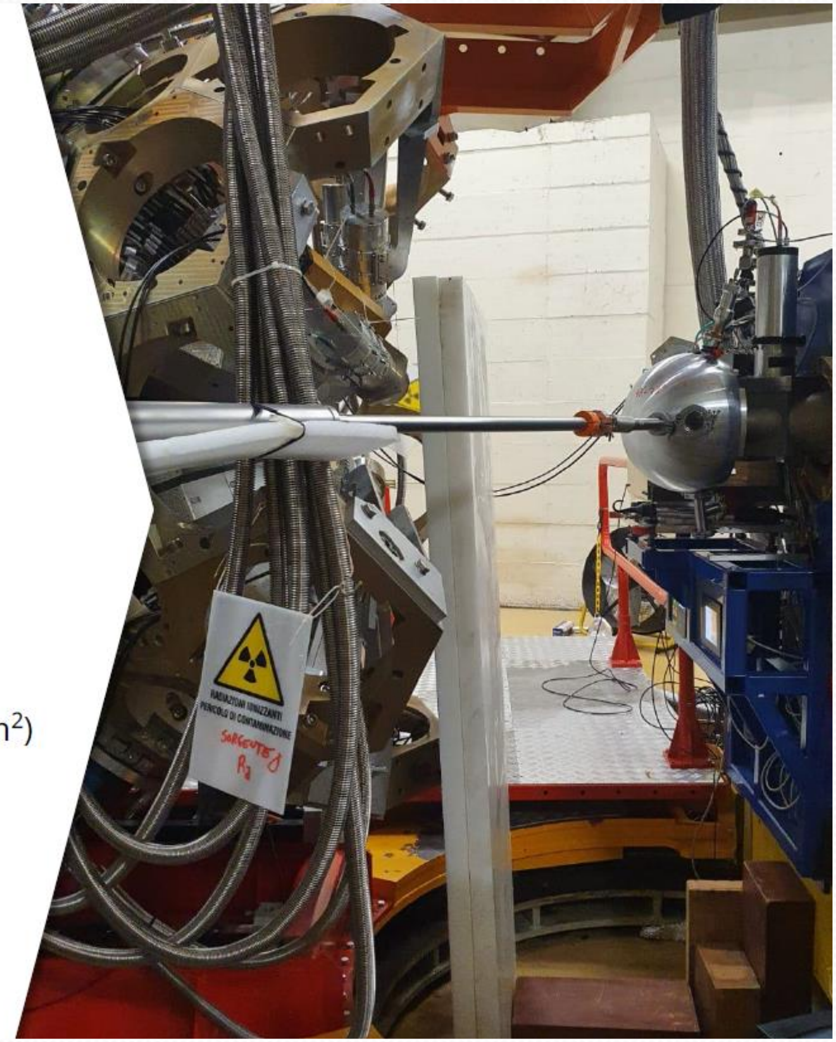
2nd PHASE:

^{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



Courtesy of R. M. Perez-Vidal

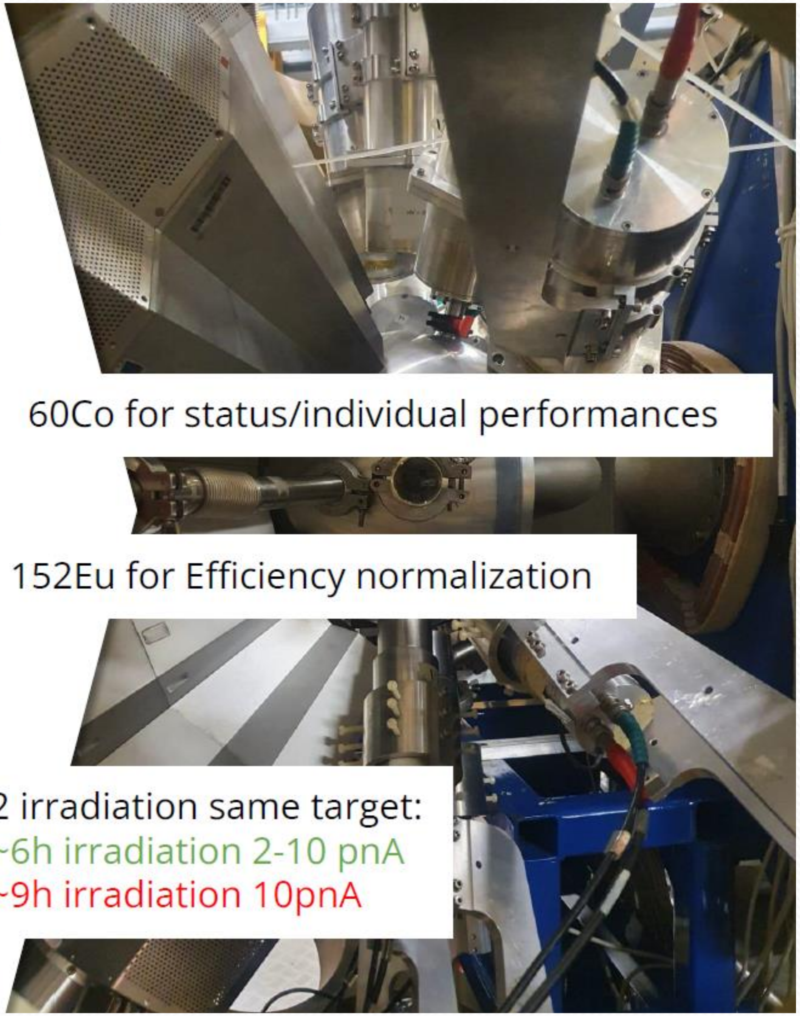
Measurements

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

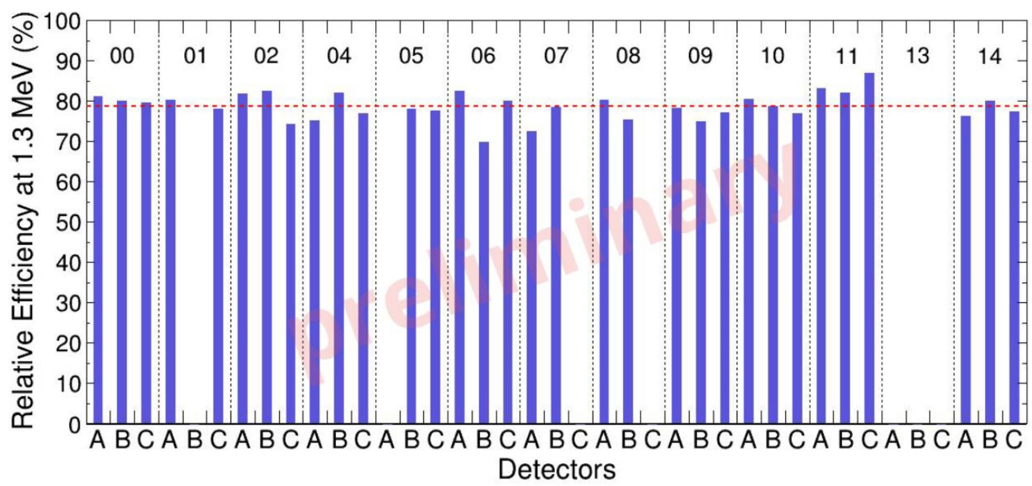
Source	Position	Duration	Rate
60Co	Nominal	2.5h	1.5kHz
	Nominal Traces	1h ; 1.5h	
	Close-up	2h	2kHz
152Eu	Nominal	4h ; 2h	2kHz
	Nominal Traces	2h ; 1.5h	
	Close-up	3h ; 2h	3kHz
133Ba	Nominal	2.3h	2kHz
	Close-up	1.6h	2.7kHz
226Ra	Nominal	4h	1.6kHz
	Close-up	2h	2KHz
Target	Nominal	5.7h	1.8kHz
	Nominal 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

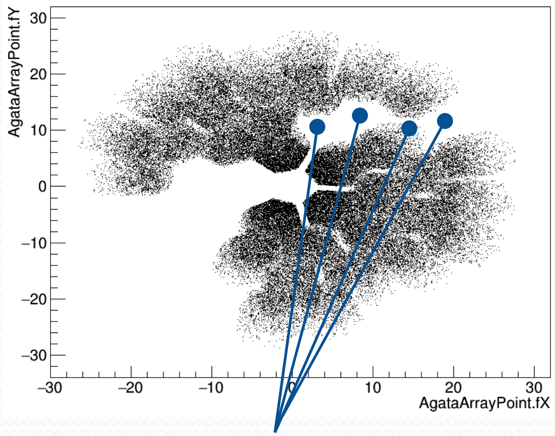


Courtesy of R. M. Perez-Vidal

32 Crystals used

AGATA crystals

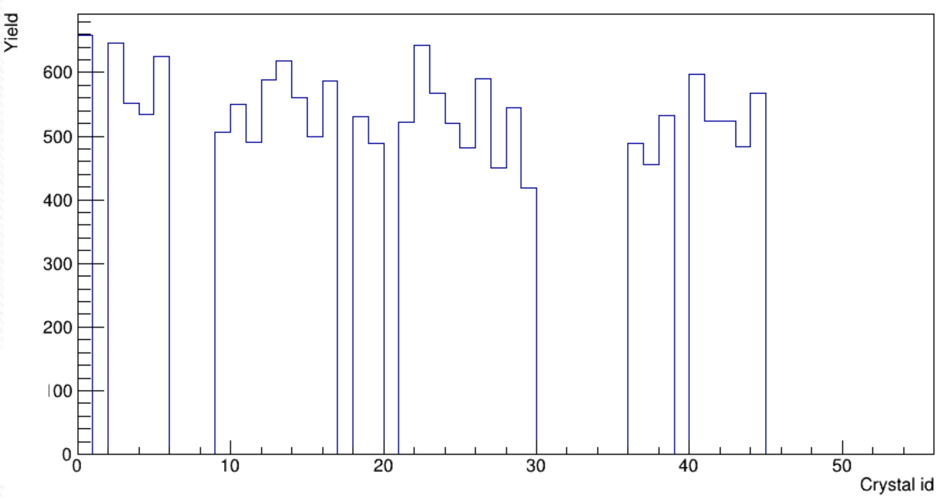




4 crystals in position but with electronics issues, so they were discarded.

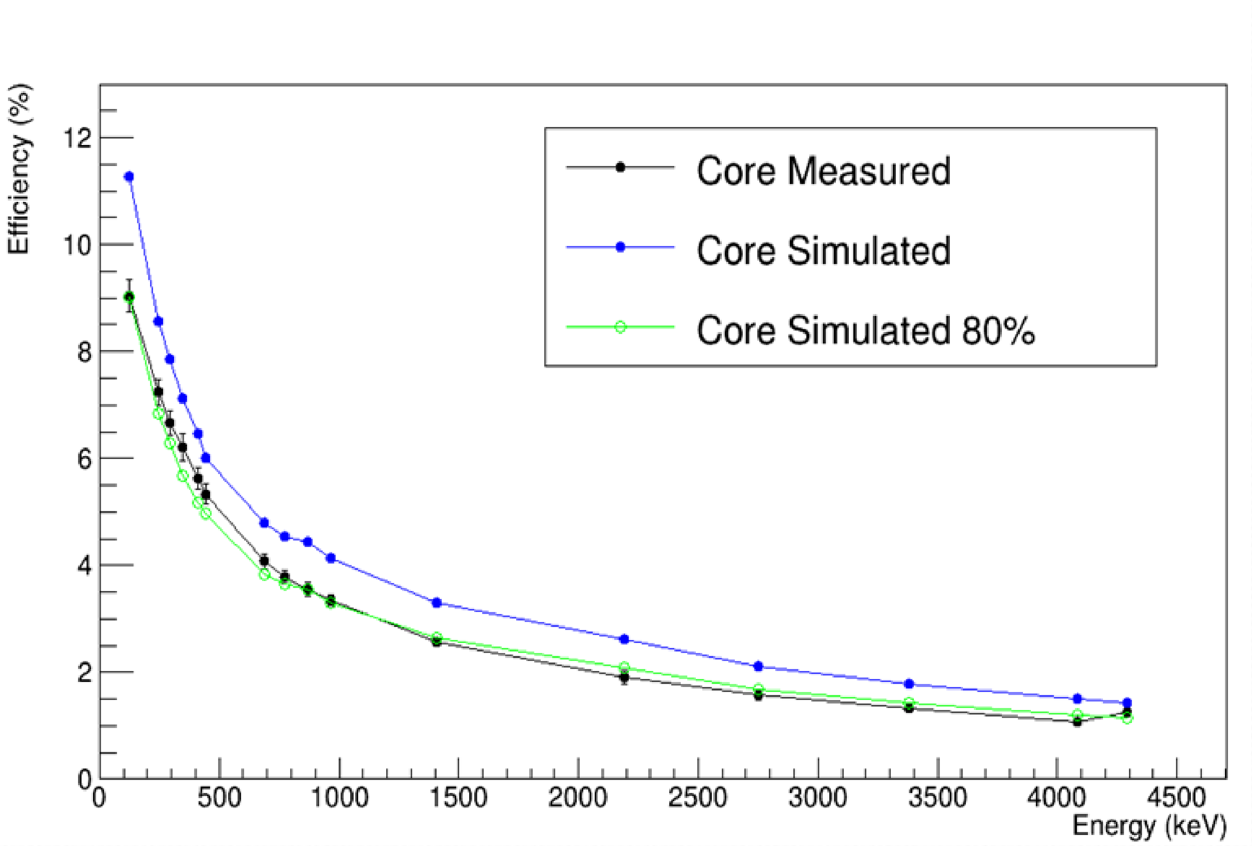
Relative efficiency to the reference value of a 3"x3" NaI at 25 cm

Crystal ID in the simulation



Measured Core efficiency vs Simulation

Preliminary Photo-peak efficiency

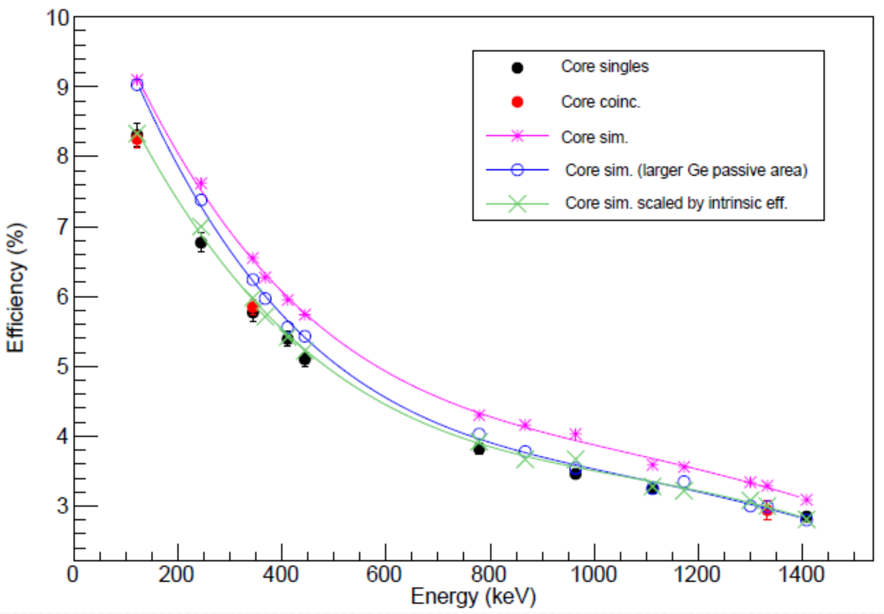


As expected there is no Match, unless we scale with by the average relative efficiency of the crystals.

Simulation with:
- chamber close
- Large Ge Passive material

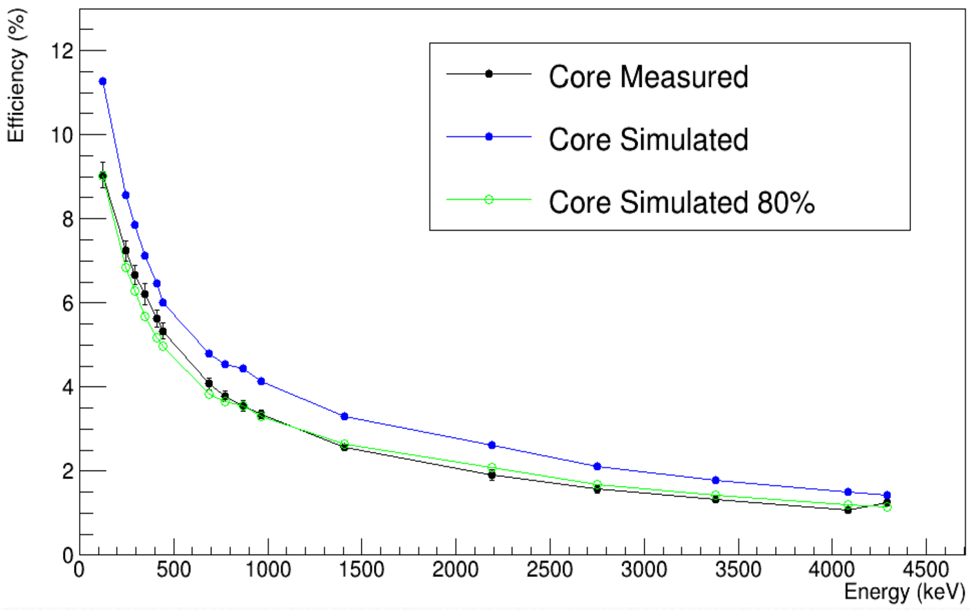
Comparison with GANIL measurement

GANIL (29 crystals)



J. Ljungvall et al., NIM A 955 (2020) 163297

LNL (32 crystals) - Peliminary



As the simulations include large passive Ge area I would expect these to match with the data above 1MeV.
→ both data and simulation need checking

What's next ?

- Finalise the data analysis of the source and in-beam efficiency measurement.

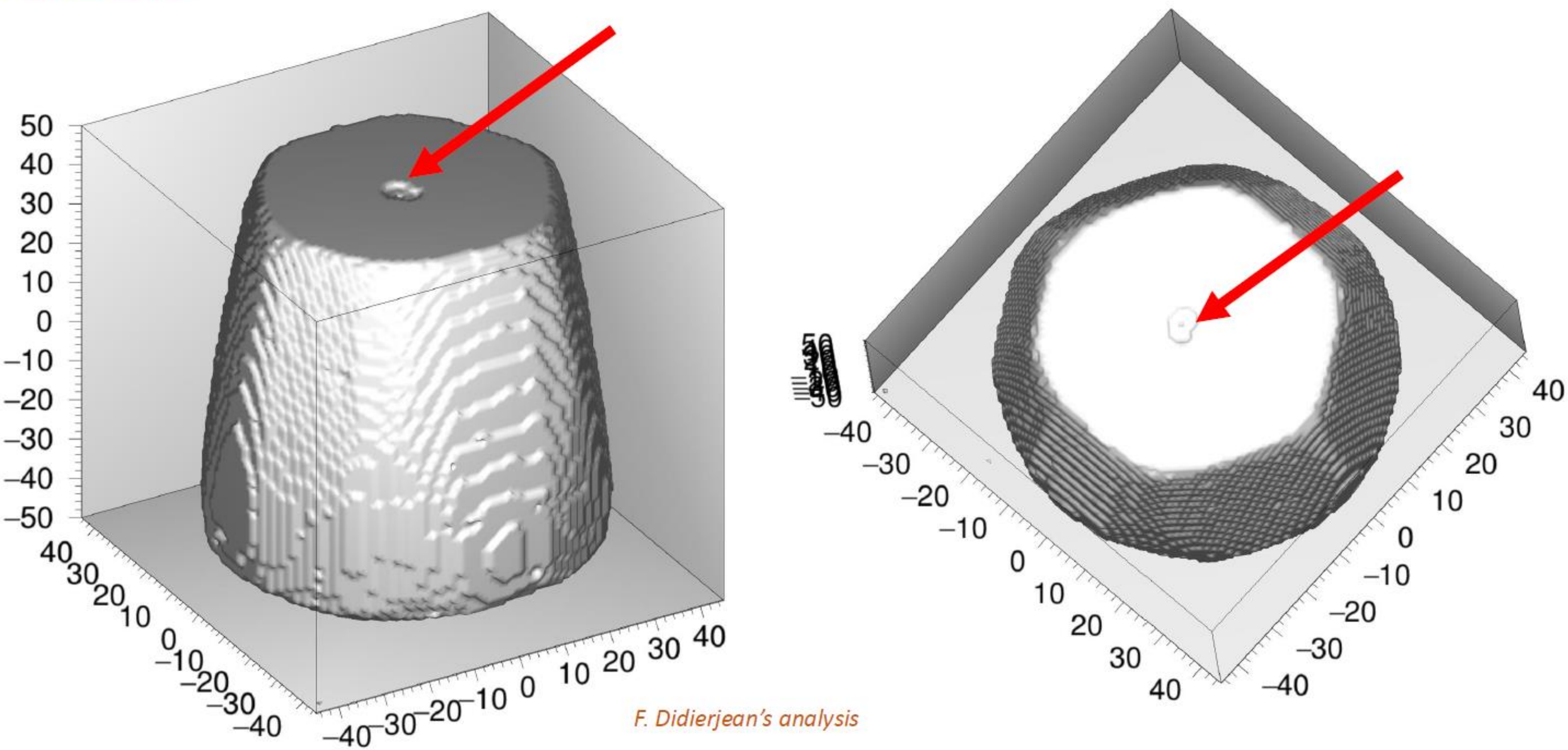
- Double check the simulations with the GANIL setup.

- Convert the Strasbourg tomography data of A005 into gdml and import into the simulation code.
  - Check simulation with measured relative efficiency
  - If successful, do the same with a crystal type B and C.

Crystal A005 tomography

A005 tomography

F. Didierjean's analysis



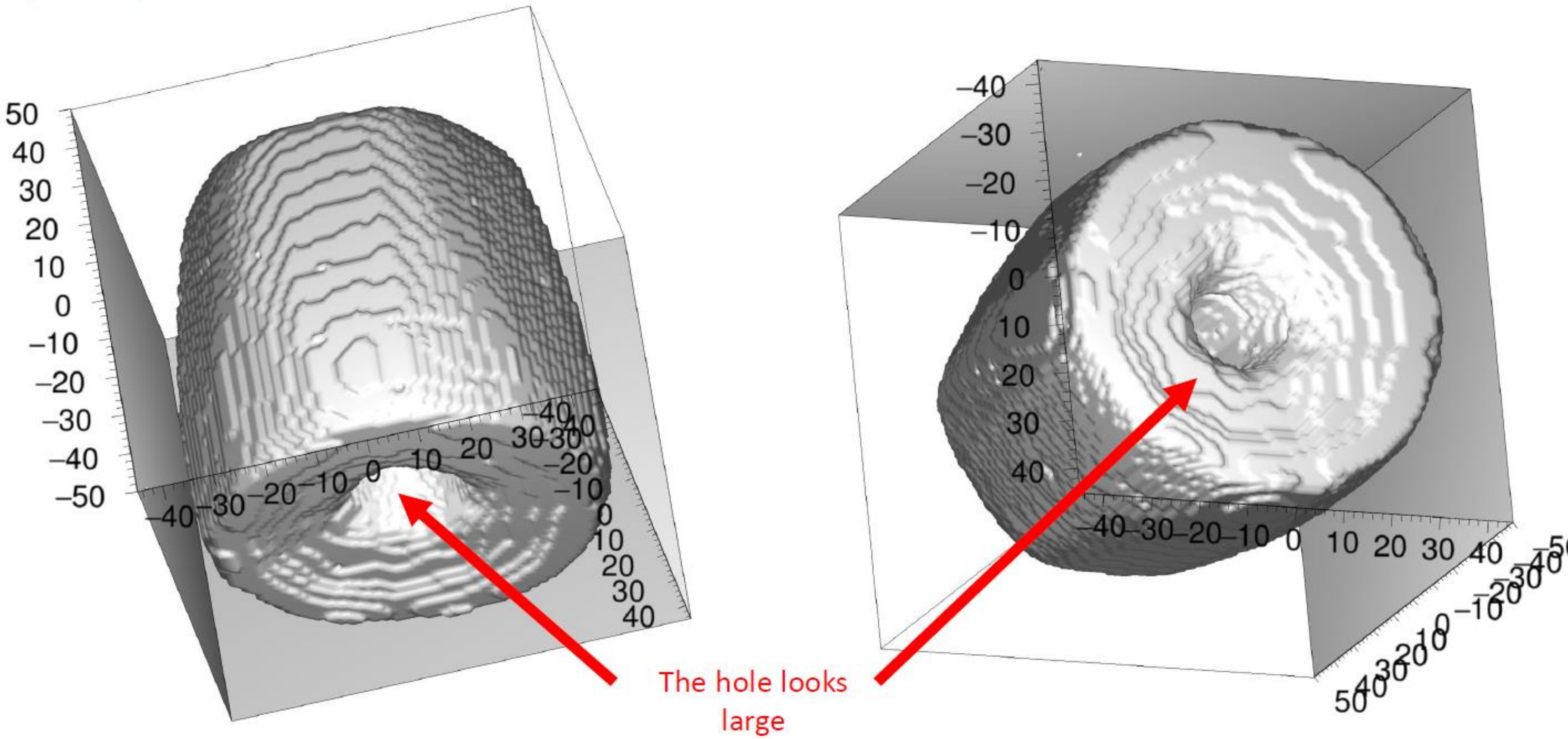
F. Didierjean's analysis

G. Duchêne

Crystal A005 tomography

A005 tomography

F. Didierjean's analysis



G. Duchêne

Conclusion

The AGATA code continue to be developed.

New implementation in more modern simulation and data analysis framework.

Still some work to do to reconcile AGATA simulated efficiency with the measured efficiency,

…. but there is a plan using crystal A005 tomography.

Thank you for your attention

…

Position resolution maps – Methodology (See also Chen's talk in PSA R&D session)

-1- AGATA Simulation code provides the primary photon interaction position and energy loss.

-2- From this information and ADL signal library, net & transient charge signals are generated in the crystal segments.

-3- From that stage, additional noise can be added.

-4- The resulting signals are then sent through the PSA process taken from AGAPRO.

-5- The deviation between the original interaction point is then determine to estimate the position resolution at that position.