Geant4 simulations of the LNL ancillaries

A. Goasduff

I. Zanon

E. Pilotto

M. Sedlak

M. Rocchini

S. Bottoni

E. Gamba

F. Crespi

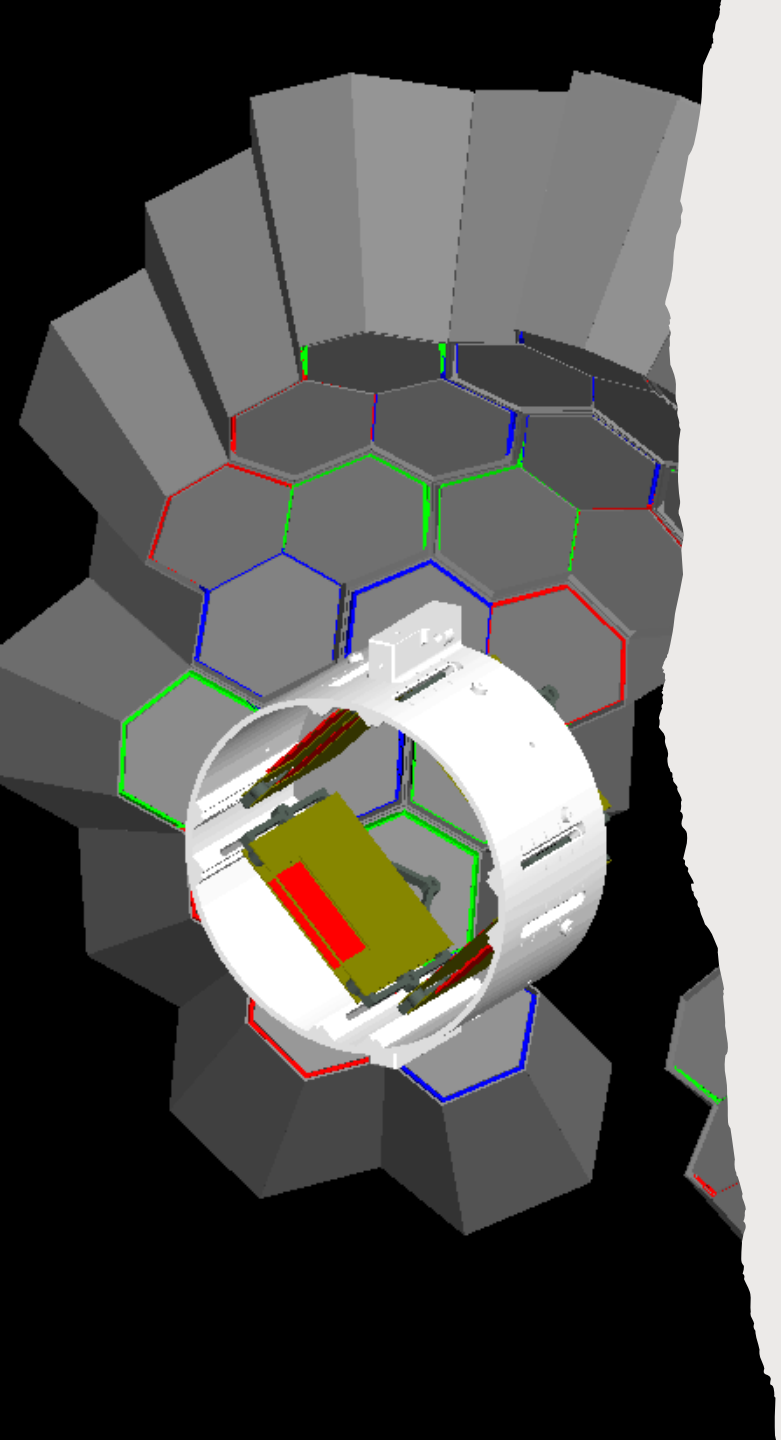
D. Brugnara

General remarks

- The LNL ancillaries have been included in the agata Geant4 simulation package
- Some of them have been added recently:
  - OSCAR
  - SAURON
  - CTADIR
  - MUGAST
  - $LaBr_3$
- Other were present and used with the GALILEO geometry:
  - SPIDER
  - LNL Scattering chamber
  - PLUNGER
  - GALTRACE
- The simulations are used frequently for proposals and data analysis such as evaluation of the DSAM effect, evaluation of setup efficiency, …
- Many of these developments are a team effort of the local team or of the PhD students that are analyzing their data

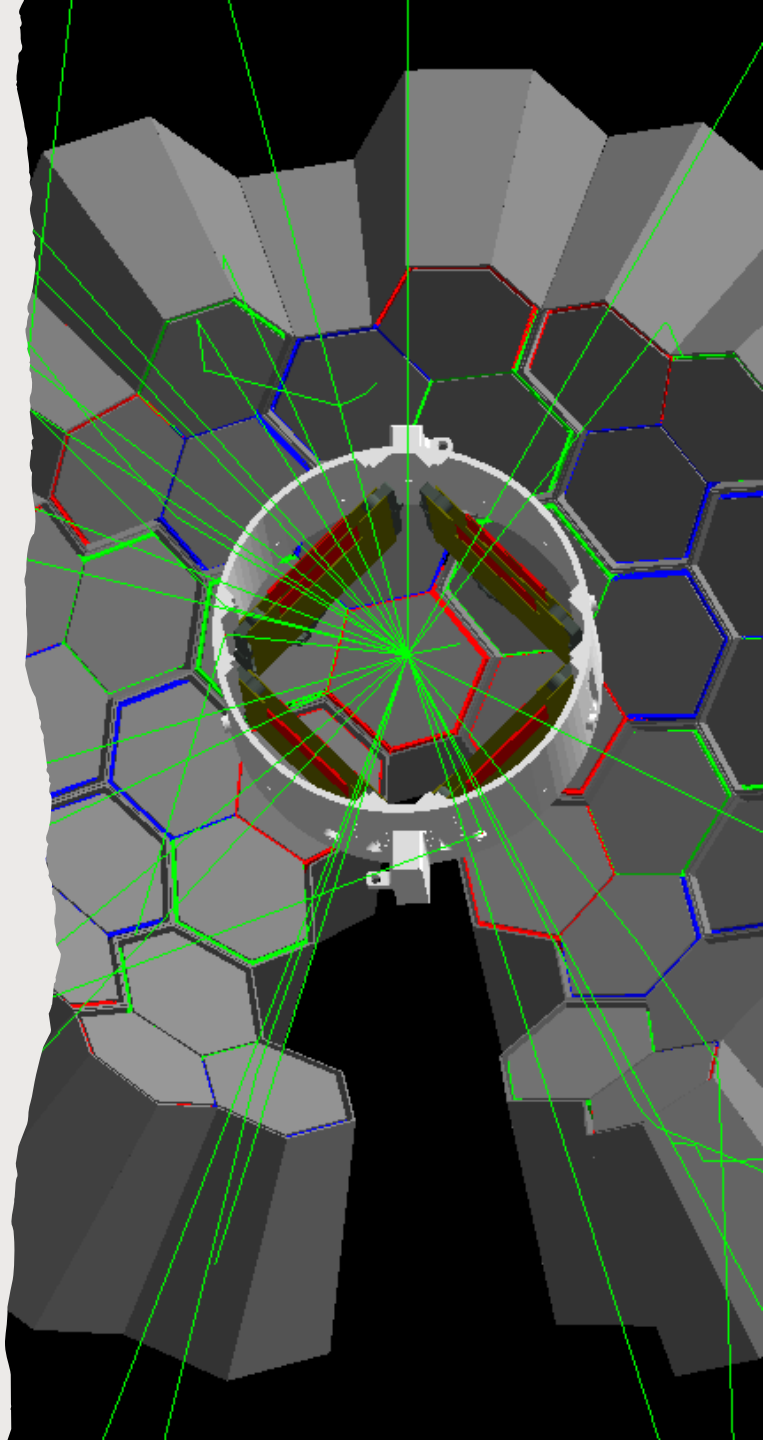
Current status

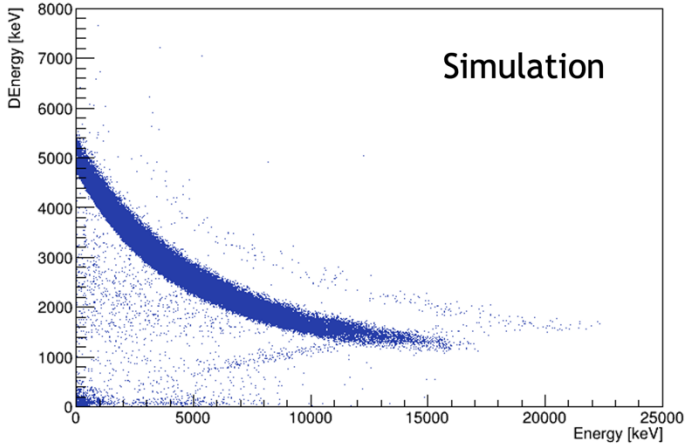
- **We have recently merged the local version with the official codebase**
- Currently available in a forked version of the Gitlab repository:
  - https://gitlab.com/danielebrugnara/agata-simulations.git
- Will be merged into the official repository once verified by Marc:
  - https://gitlab.com/malabi-agata/agata
- Tested with Geant4 v10.7

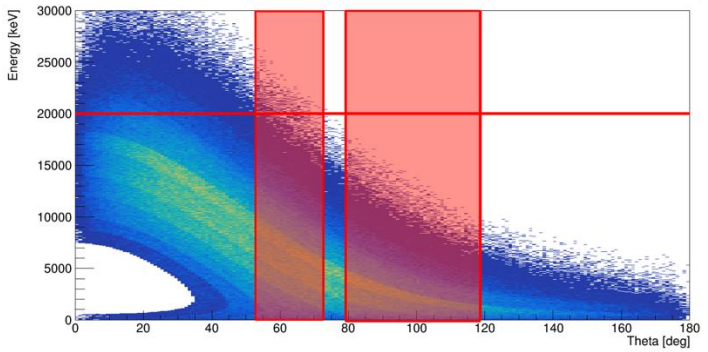


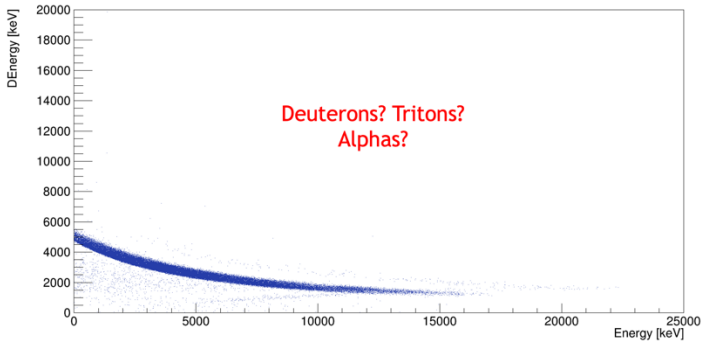
GALTRACE

- ΔE-E Si telescopes
- Highly segmented 200 um-thick ΔE layer for high position resolution (60 pads)
- 4 pads of 1-1.5 mm-thick E layer
- DOI: 10.1393/ncc/i2022-22098-3





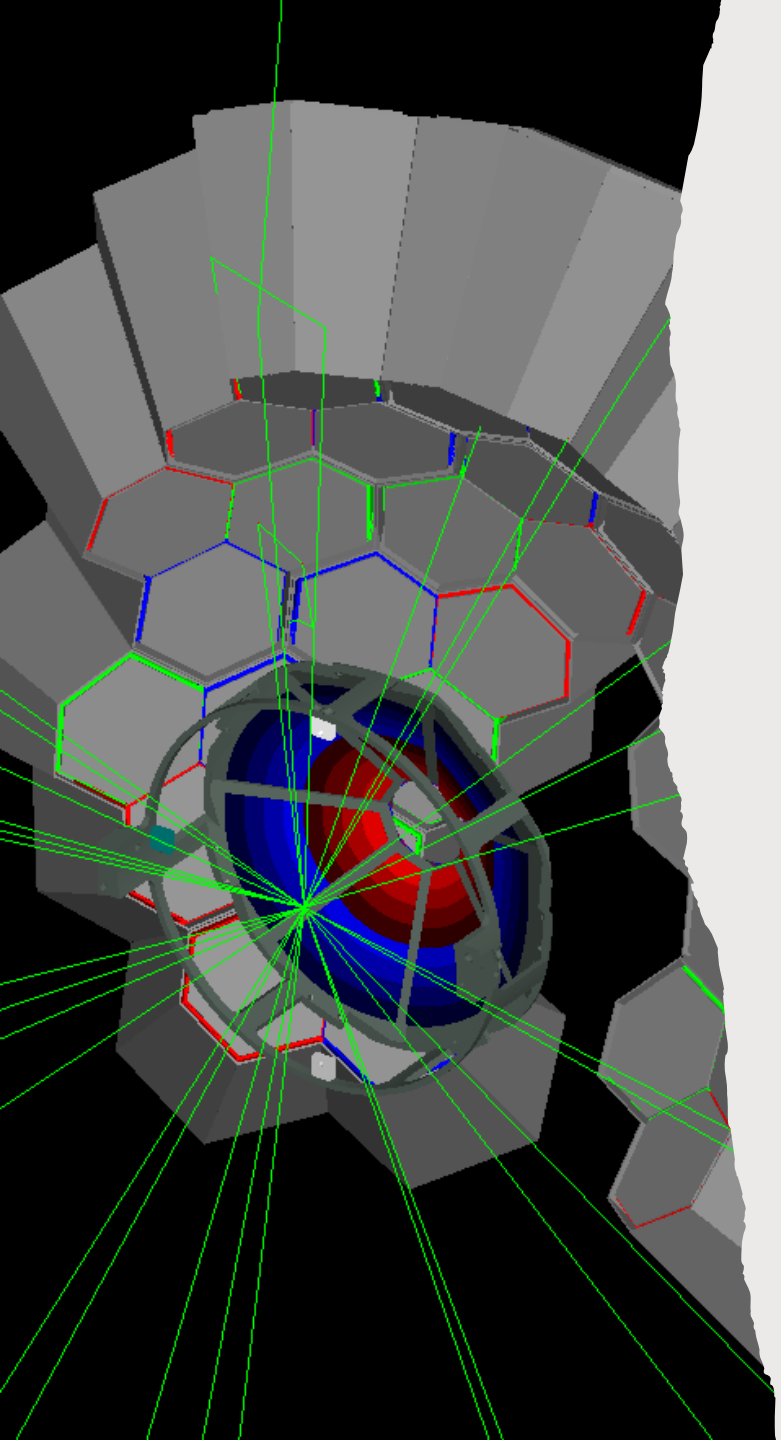




I. Zanon, A. Goasduff

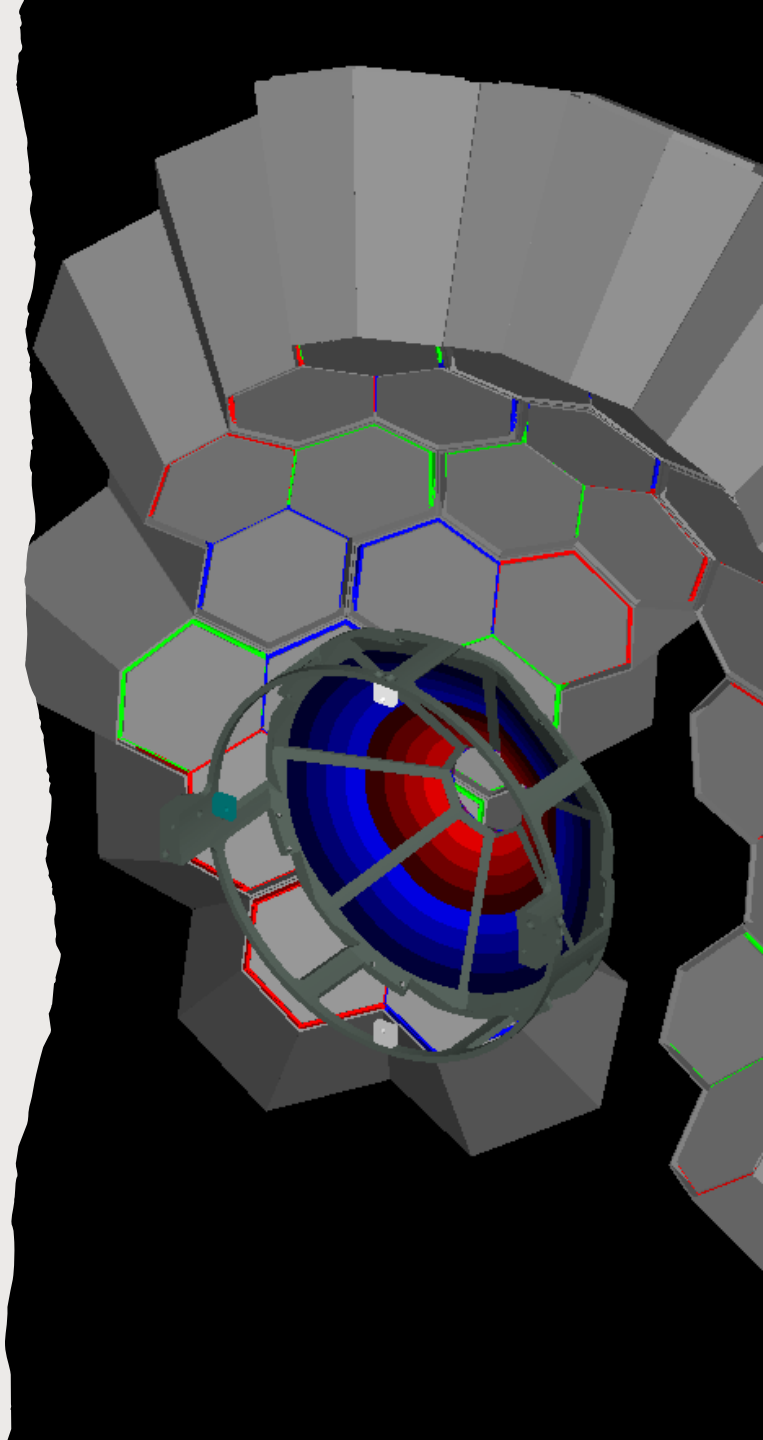
GALTRACE

- $^{7}Li(^{13}C,^{19}O)p$ @ 23 MeV
- The simulation was exploited to evaluate why no alphas were seen in the telescopes
- The overall efficiency was also evaluated



Spider

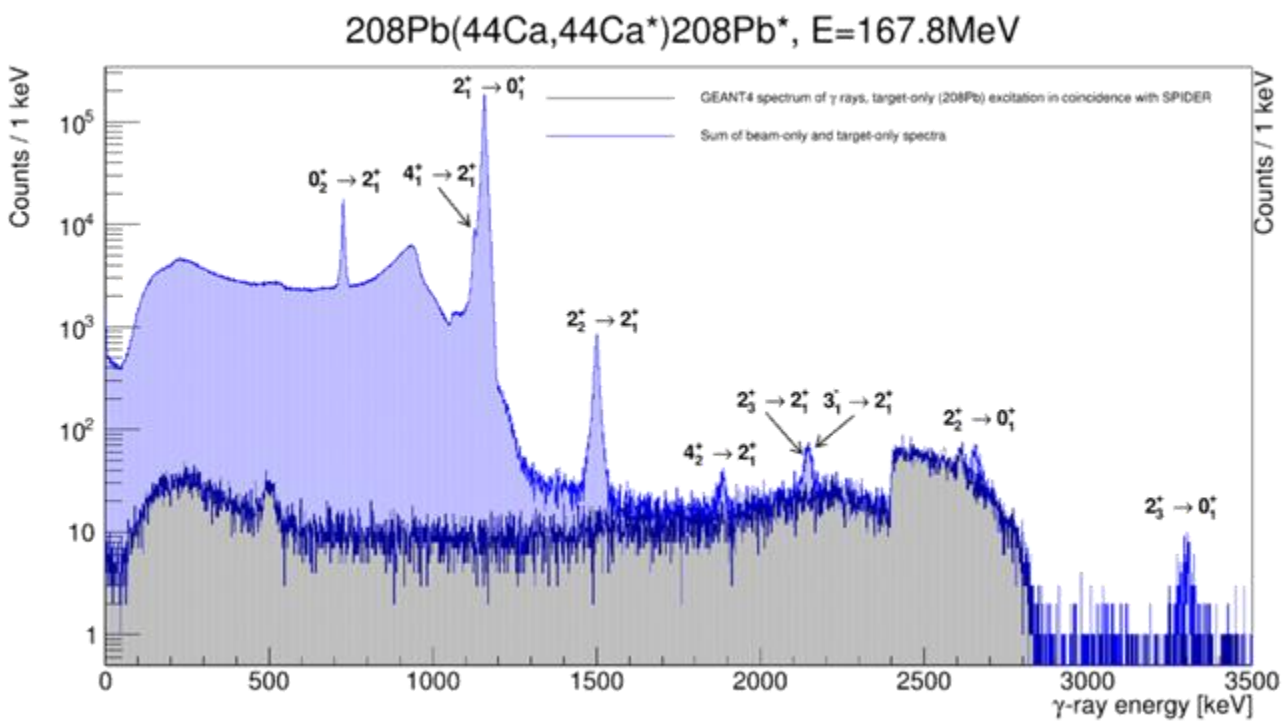
- Silicon stripped detector made up by 7 trapezoids at backward angles
- Each trapezoid is segmented in 8 parts
- It has been mainly used for Coulex reactions but recently also for direct reactions
- DOI: https://doi.org/10.1016/j.nima.2020.164030

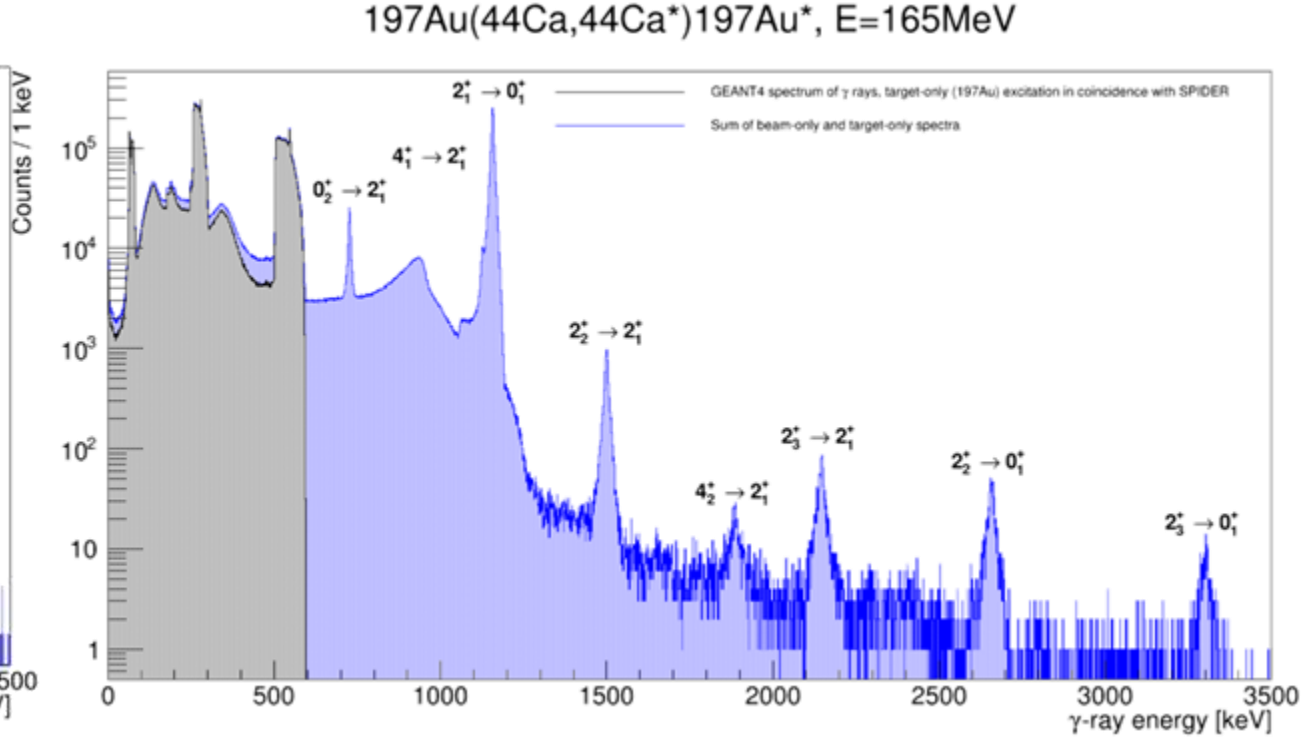


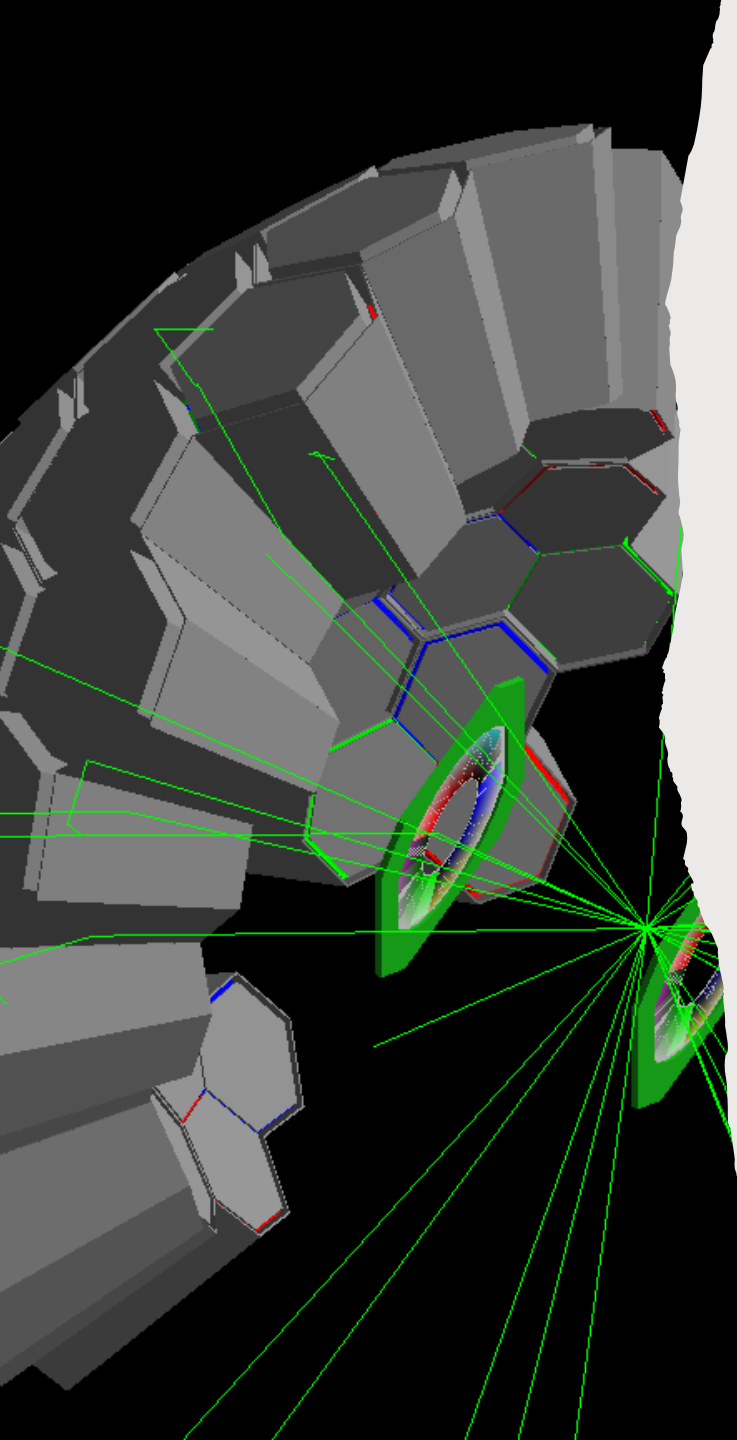
Example: Coulex of ^{44}Ca

- Important do estimate the yield of the various transitions
- FWHM of Doppler corrected peaks
- Signal to background of the spectra at a given energy with different beams/targets

M. Balogh

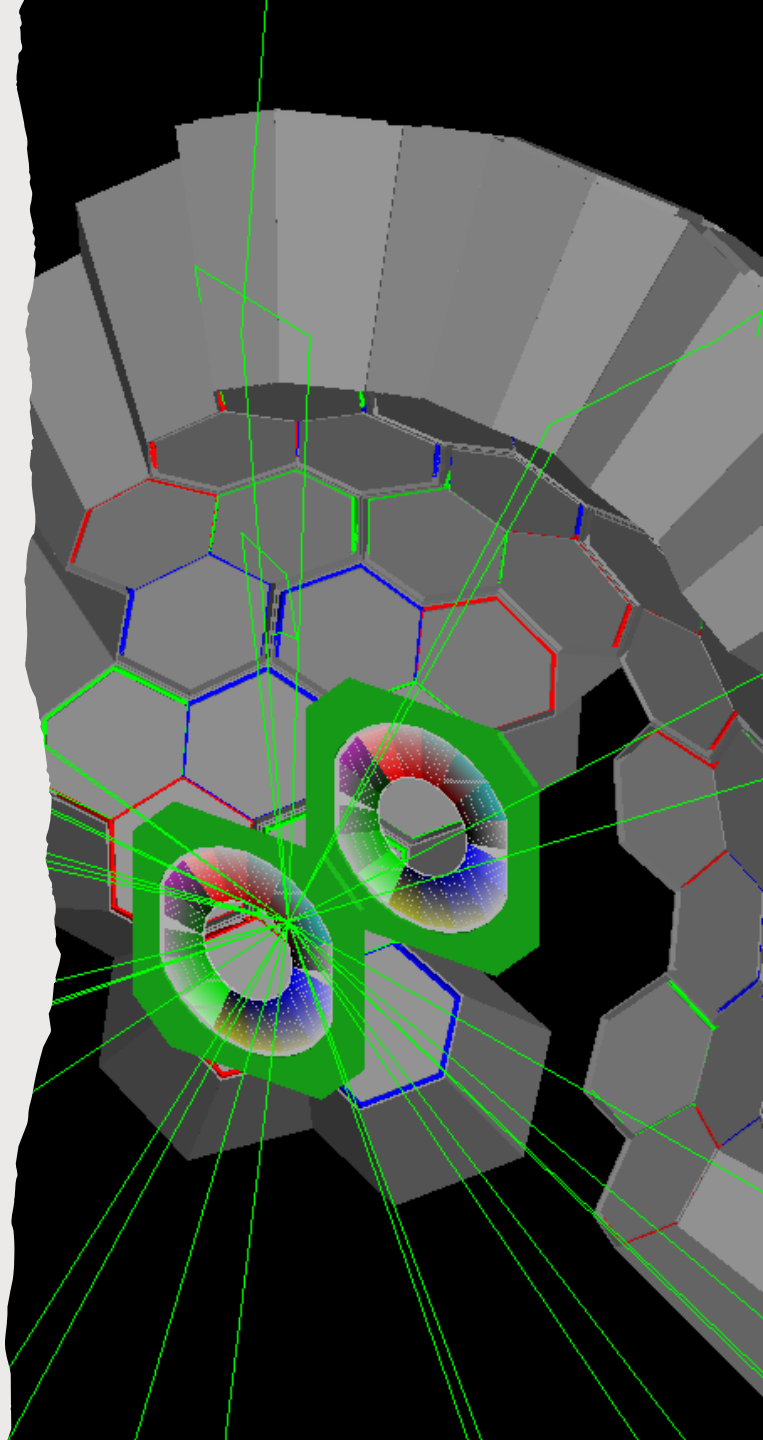






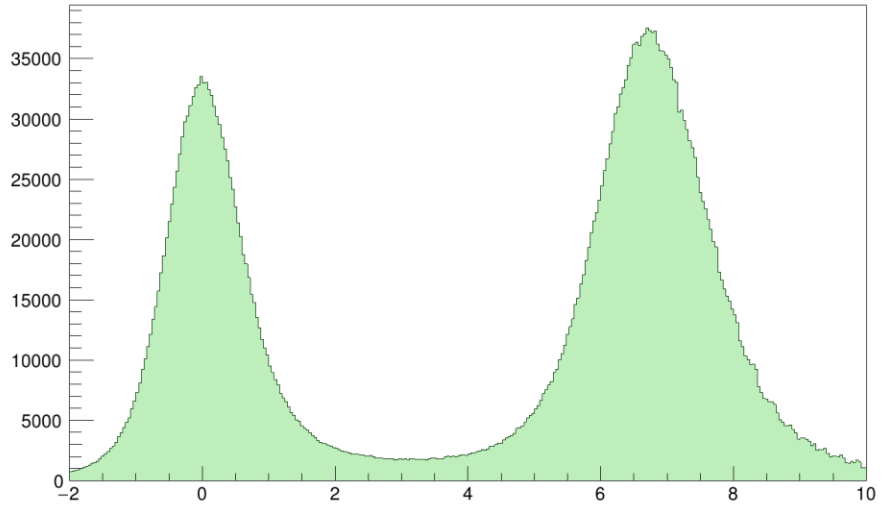
Sauron

- 64+16 channels DSSSD detector
- 0.3, 0.5, 1.5 mm
- Multiple thicknesses available
- The detector has high position sensitivity
- It is possible to place one detector downstream and another upstream with respect to the target

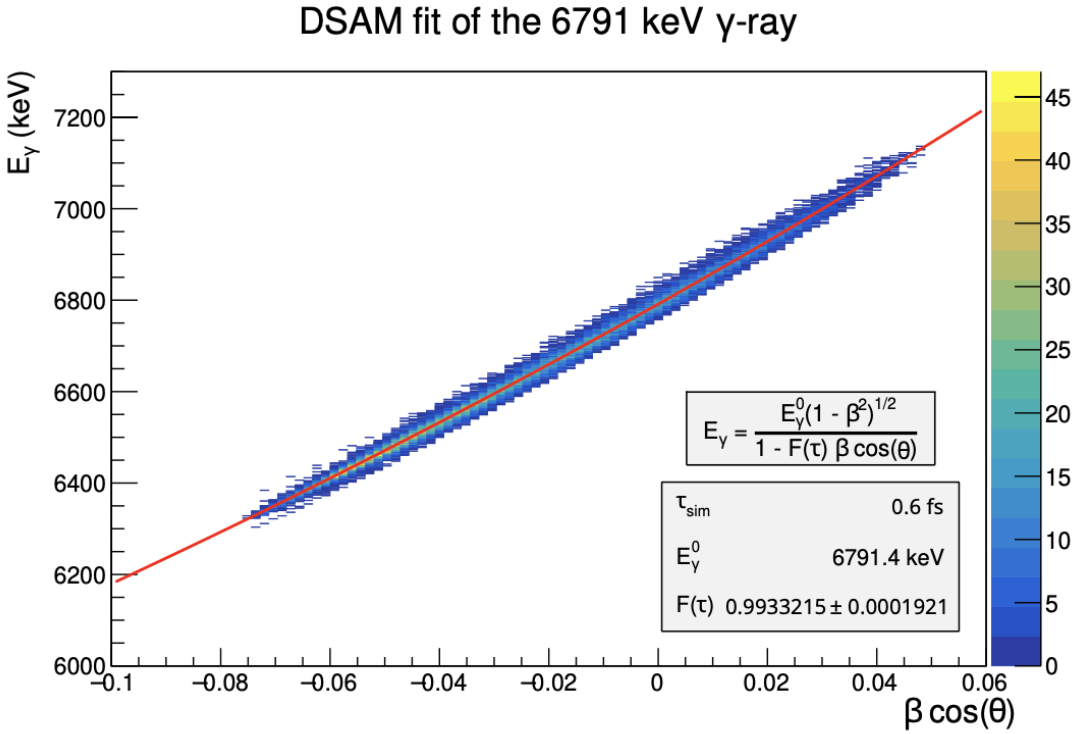


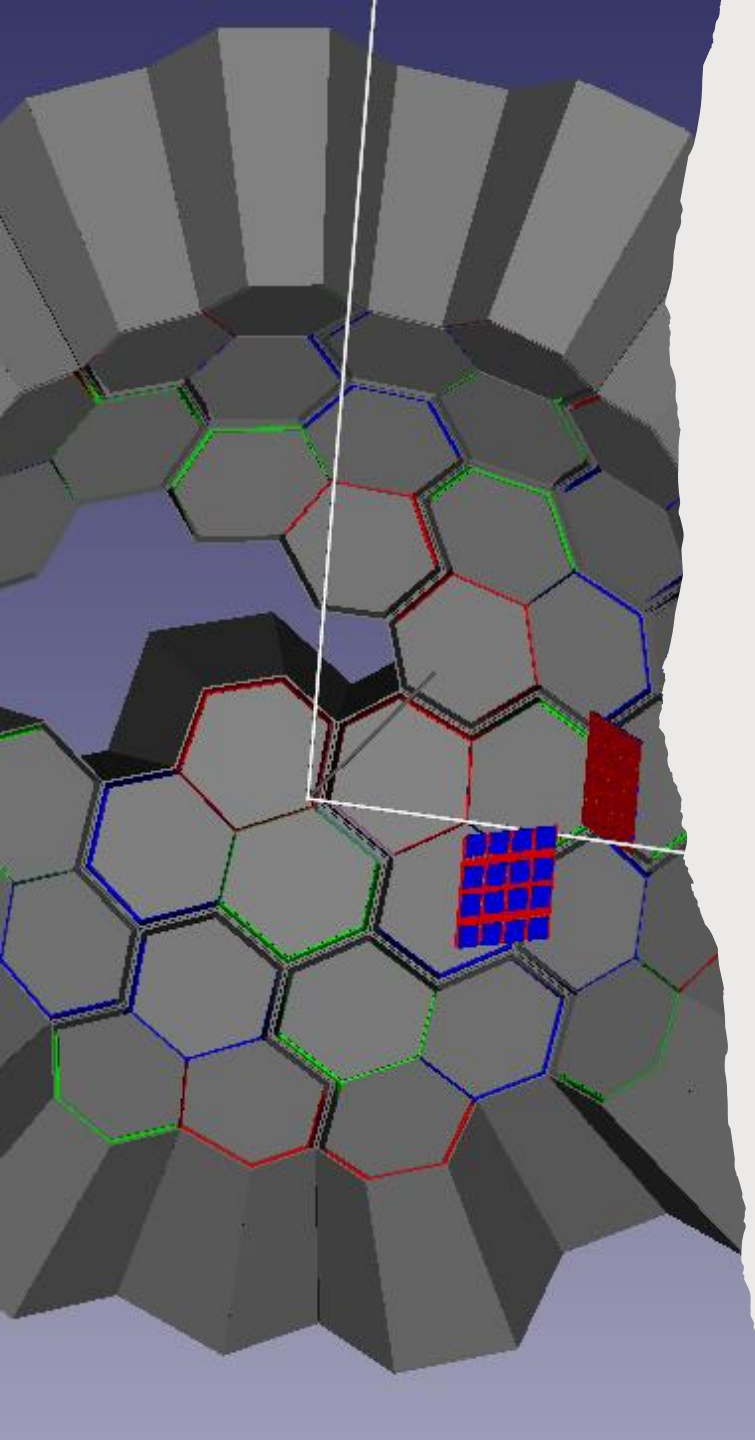
$^{16}O(^{3}He,^{4}He)^{15}O$ @ 50 MeV

J. Skowronski
E. Pilotto
[more on Friday@9:00]



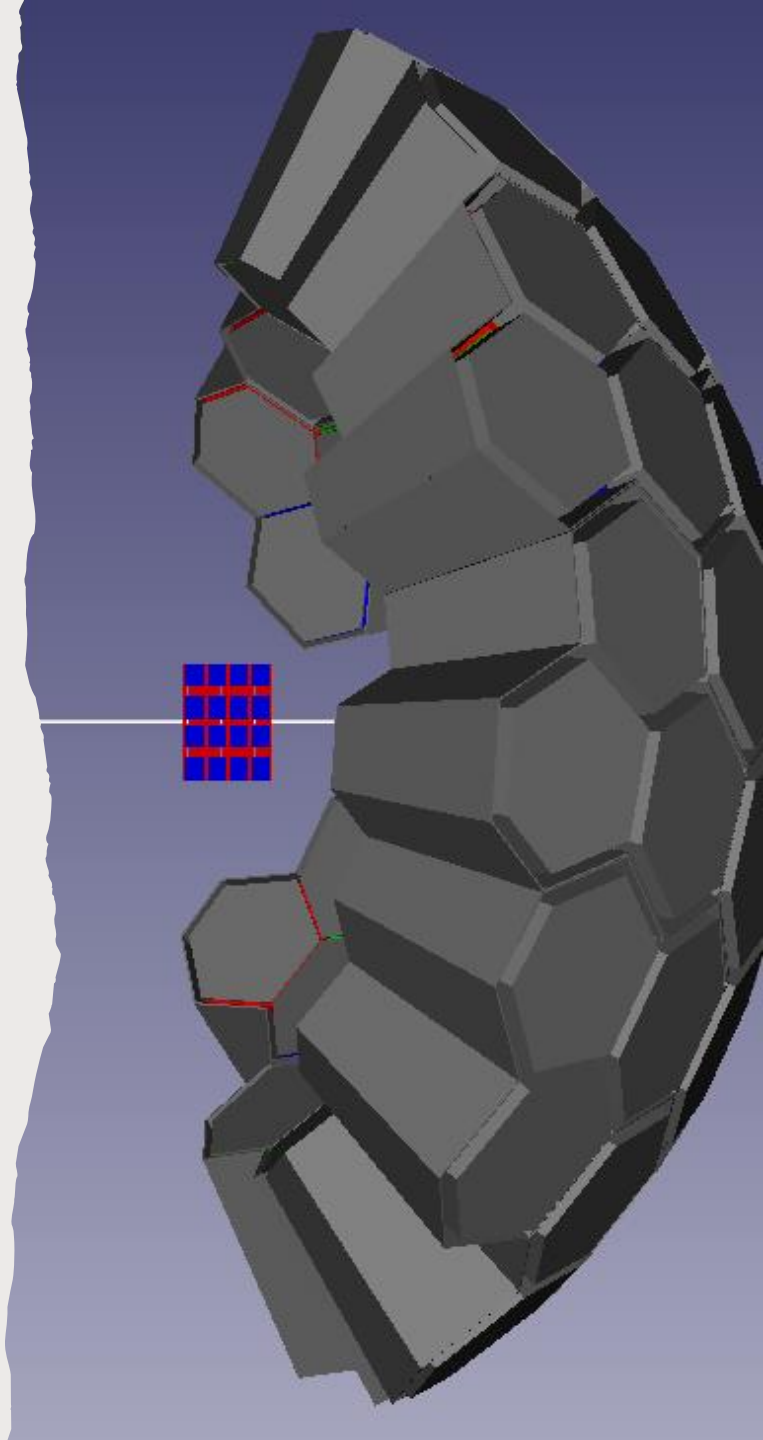
- Constraining the $^{14}N(p,\gamma)^{15}O$ reaction
- Measurement of the Lifetime of the 6.793 MeV state in ^{15}O
- The lifetime is of the order of fraction of fs (0.5 fs)
- The Geant4 simulation indicates that AGATA has the sensitivity to reach such a low value



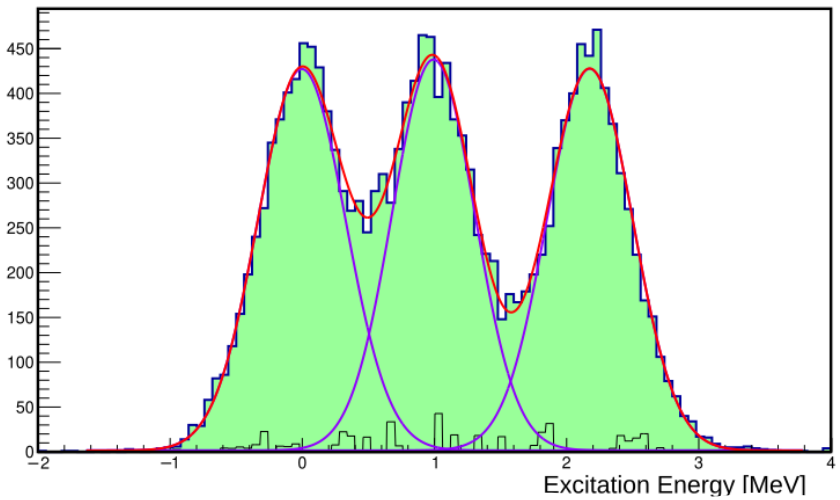


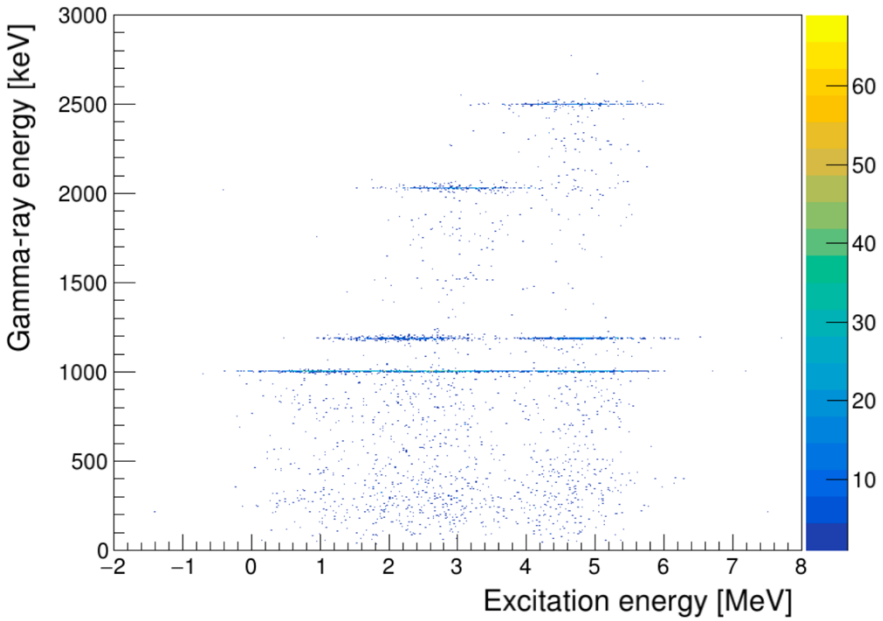
Oscar

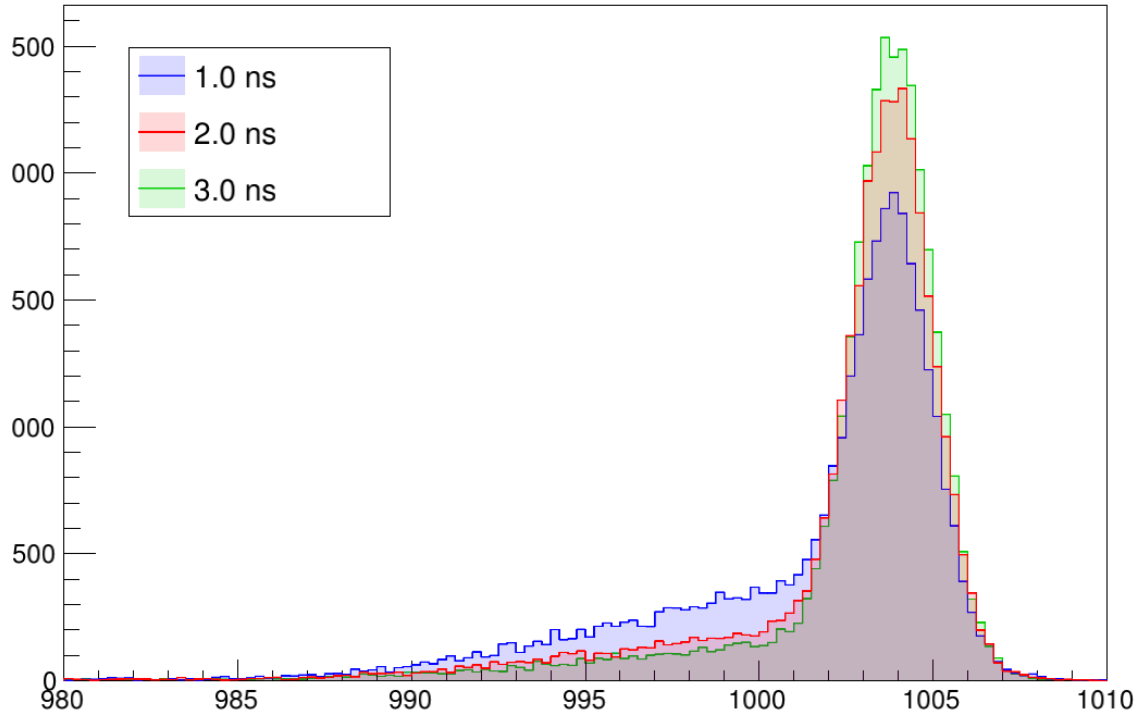
- Telescopes consisting of 1 mm-thick pixels (4x4) and a stripped 30 um-thick ΔE layer.
- This allows it to combine energy resolution, position sensitivity and particle identification
- Used up two now for two experiments with AGATA
- DOI: https://doi.org/10.1016/j.nima.2017.09.046



$^{58}Ni(^{16}O,^{14}C)^{60}Zn$

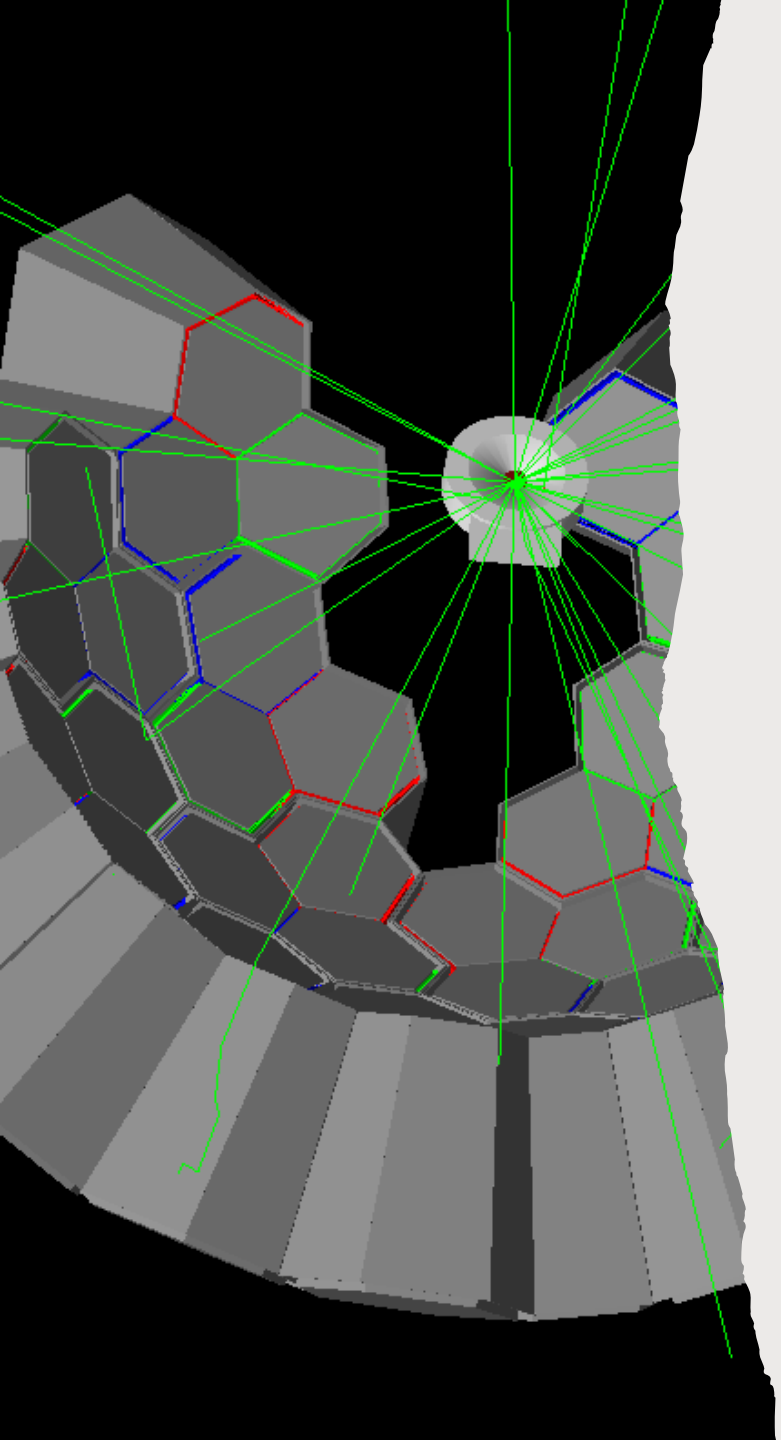






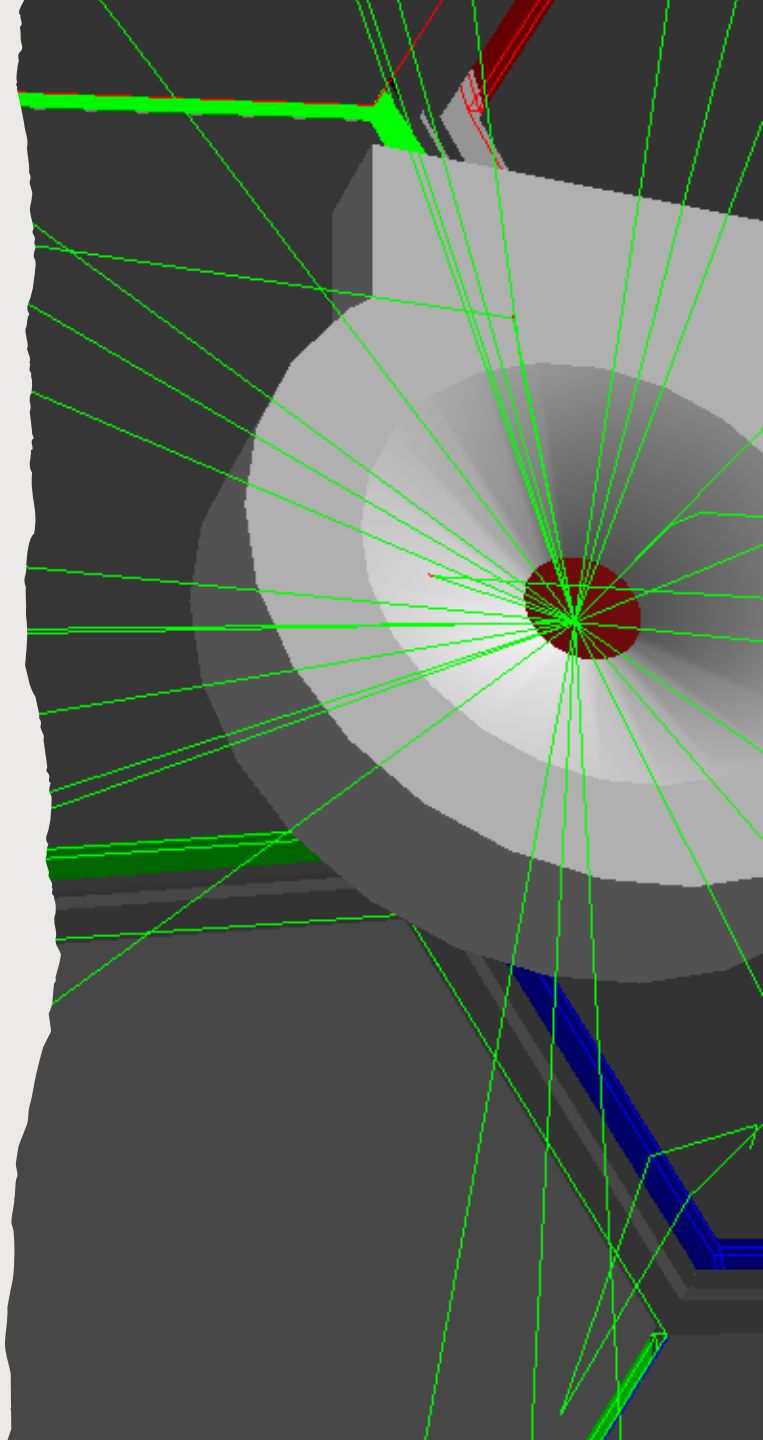
E. Pilotto

- The simulation has been used to study the excitation energy resolution, necessary to select the direc population of the short lived state of interest
- The second step is to understand the line-shape effect (DSAM) of the lifetime and thus the sensitivity of the setup



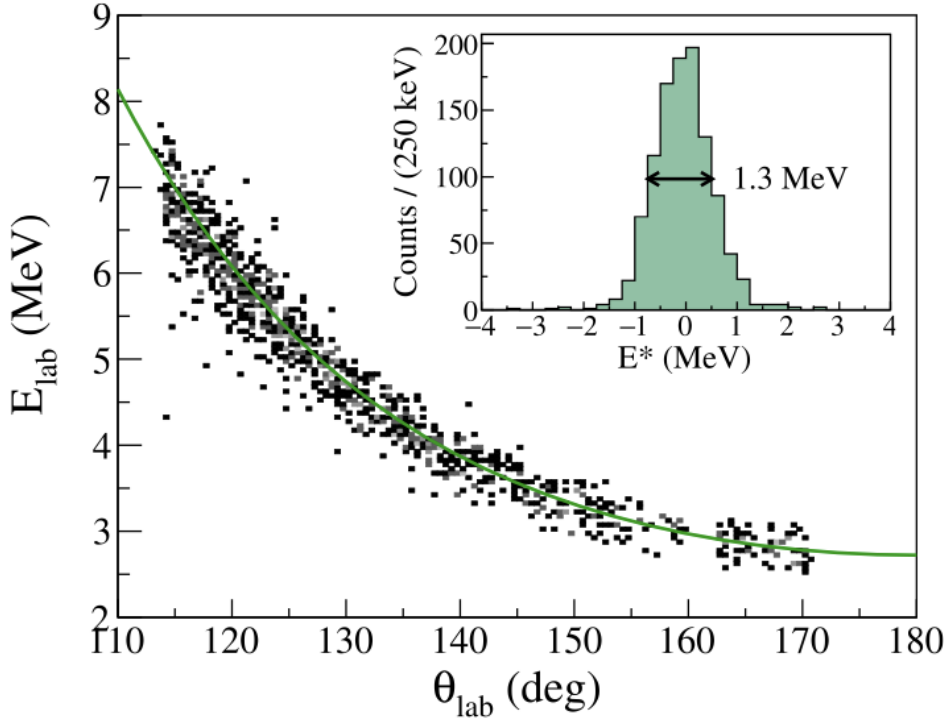
CTADIR

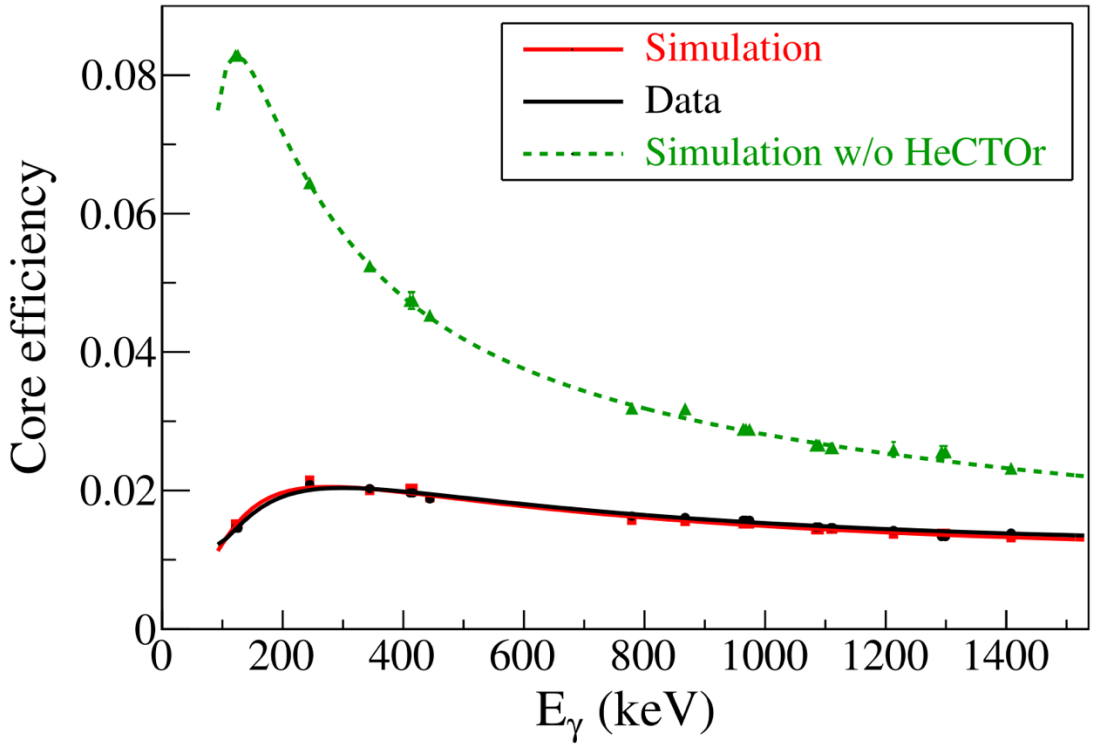
- ^{3}He cryogenic target (≅ 8K)
- Cooled gas contained withing 3-mm thick cell and HAVAR 3 um-thick containment windows
- The evaluation of the energy loss in the gas and windows is crucial
- The gamma-ray absorption probability for long-lived states (>2 ns) can play is not negligible
- DOI: 10.1393/ncc/i2022-22108-6
- DOI: https://doi.org/10.1016/j.nima.2021.165830

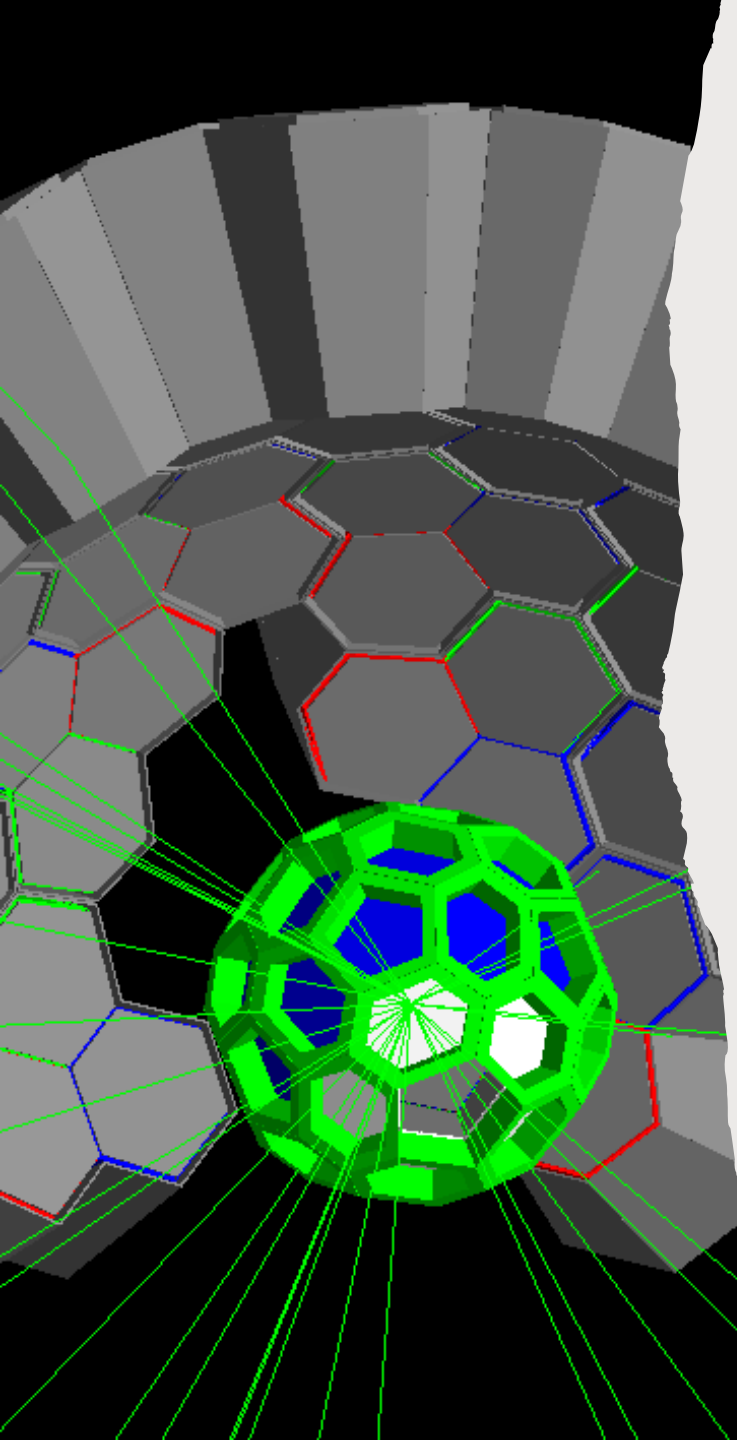


CTADIR/HECTOR

- Significant absorption for long-lived states (HECTOR, Orsay cryogenic target, used for a GANIL experiment)
- Comparison with source data yields remarkable compatibility
- ^{60}Co source placed 85 mm behind the target to simulate a 8 ns $t_{1/2}$ state

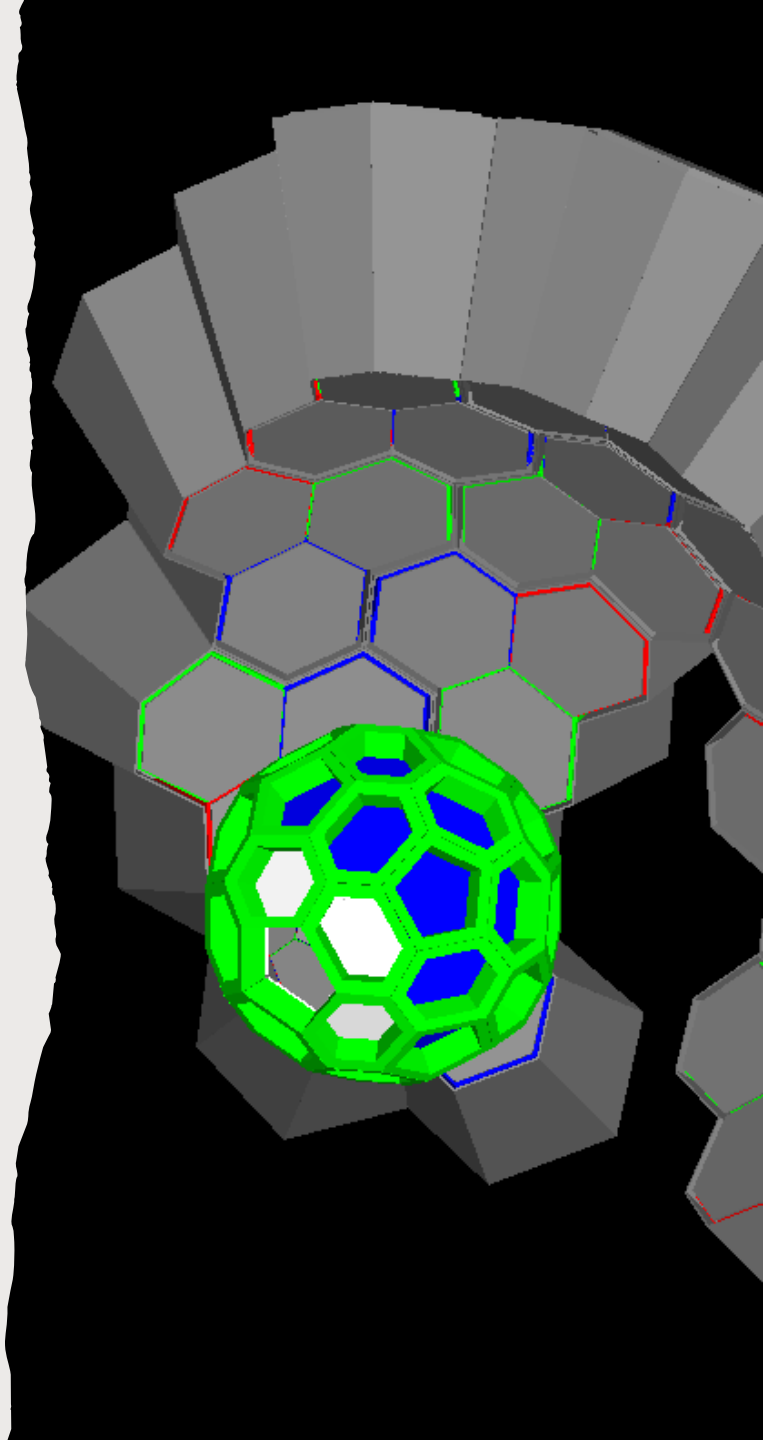


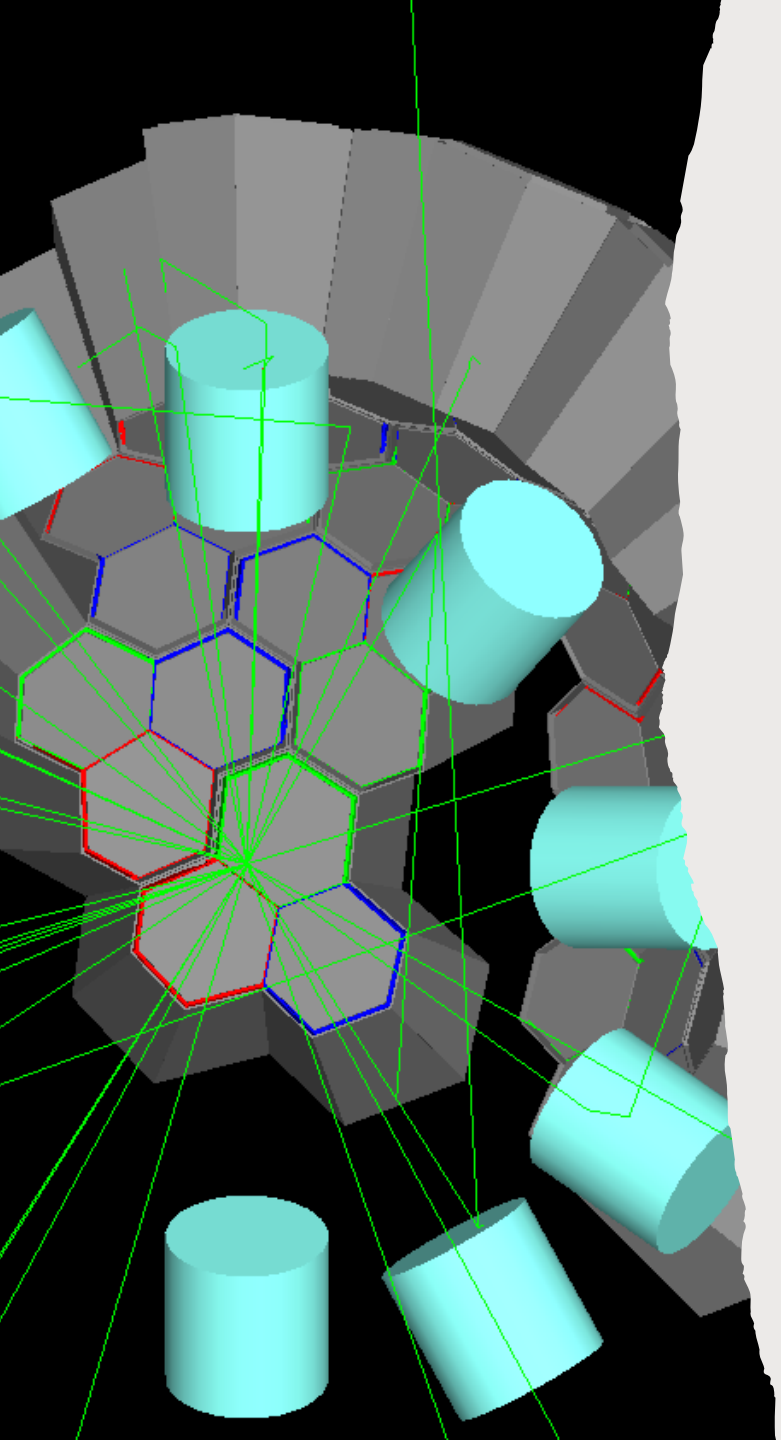




Euclides

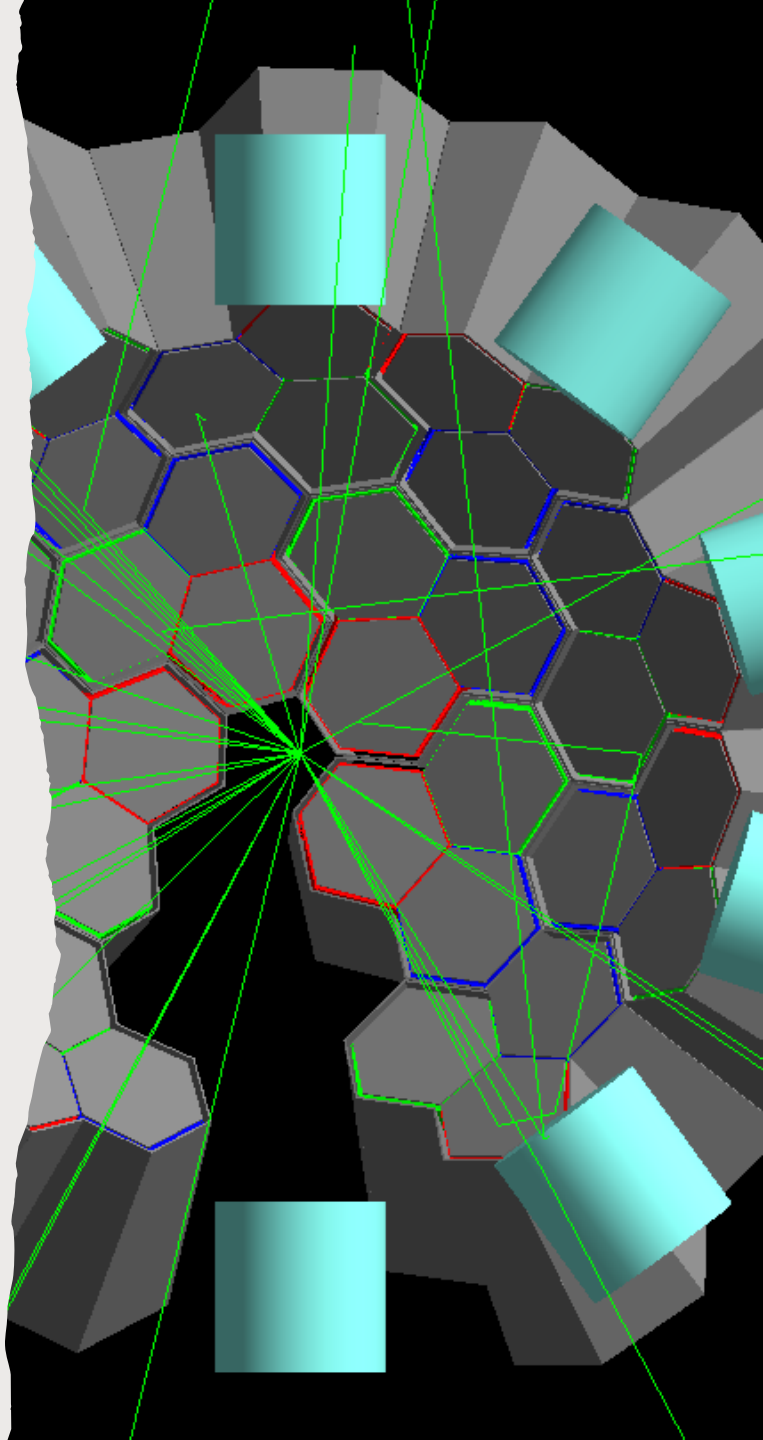
- Virtually 4 π silicon telescopes array
- Mainly used for light charged particle detection in fusion evaporation reaction
- The simulation includes the full geometry and the support structure
- Absorbers can be added
- DOI: https://doi.org/10.1140/epja/i2019-12714-6





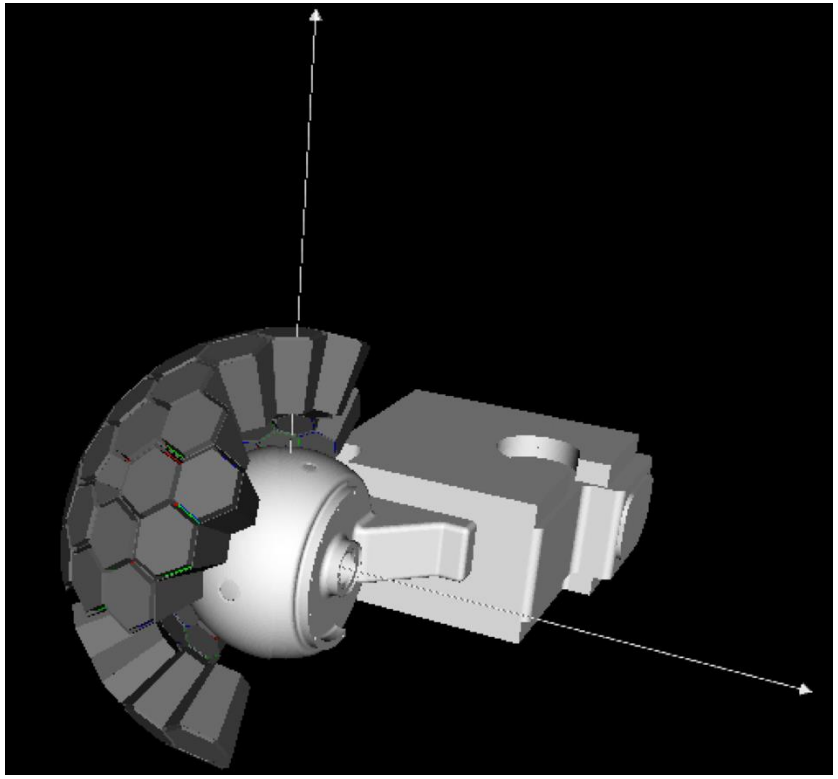
$LaBr_3$

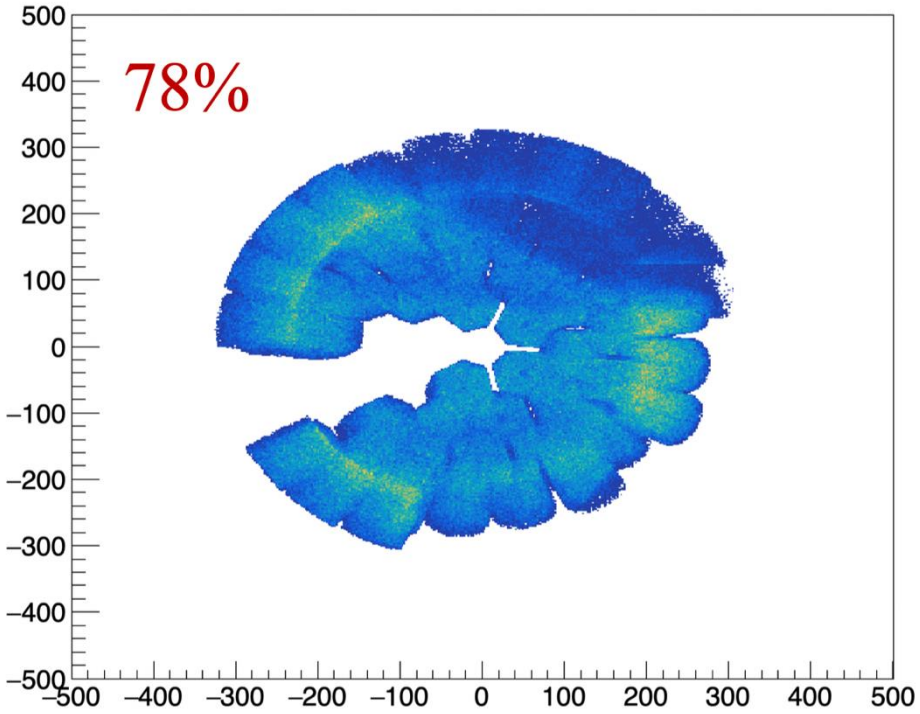
- **GDML based geometry**
- Large volume 3x3 inches detectors developed by the UniMi group
- DOI: https://dx.doi.org/10.1109/NSSMIC.2007.4437258



Scattering chamber

- GDML geometry
- Useful to understand the absorption of gamma rays from the beam dump





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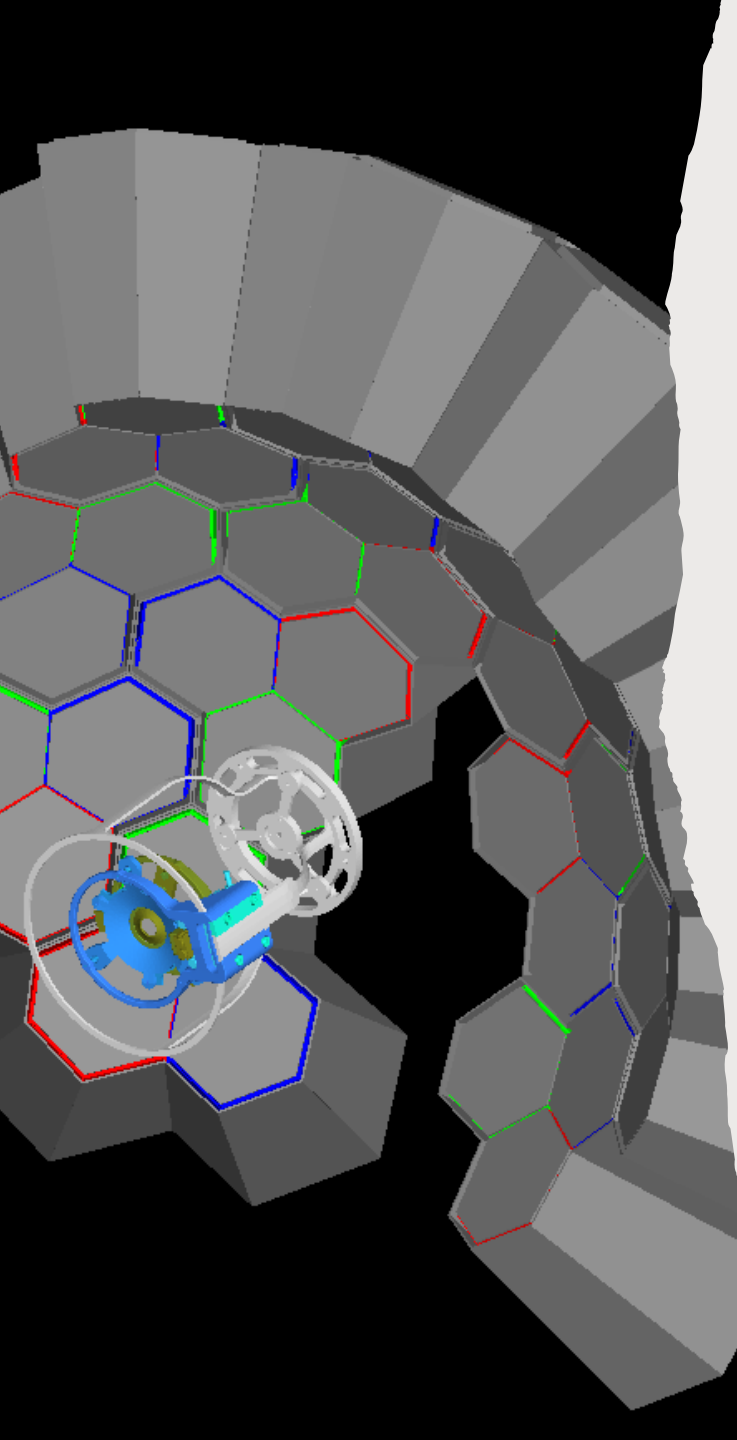
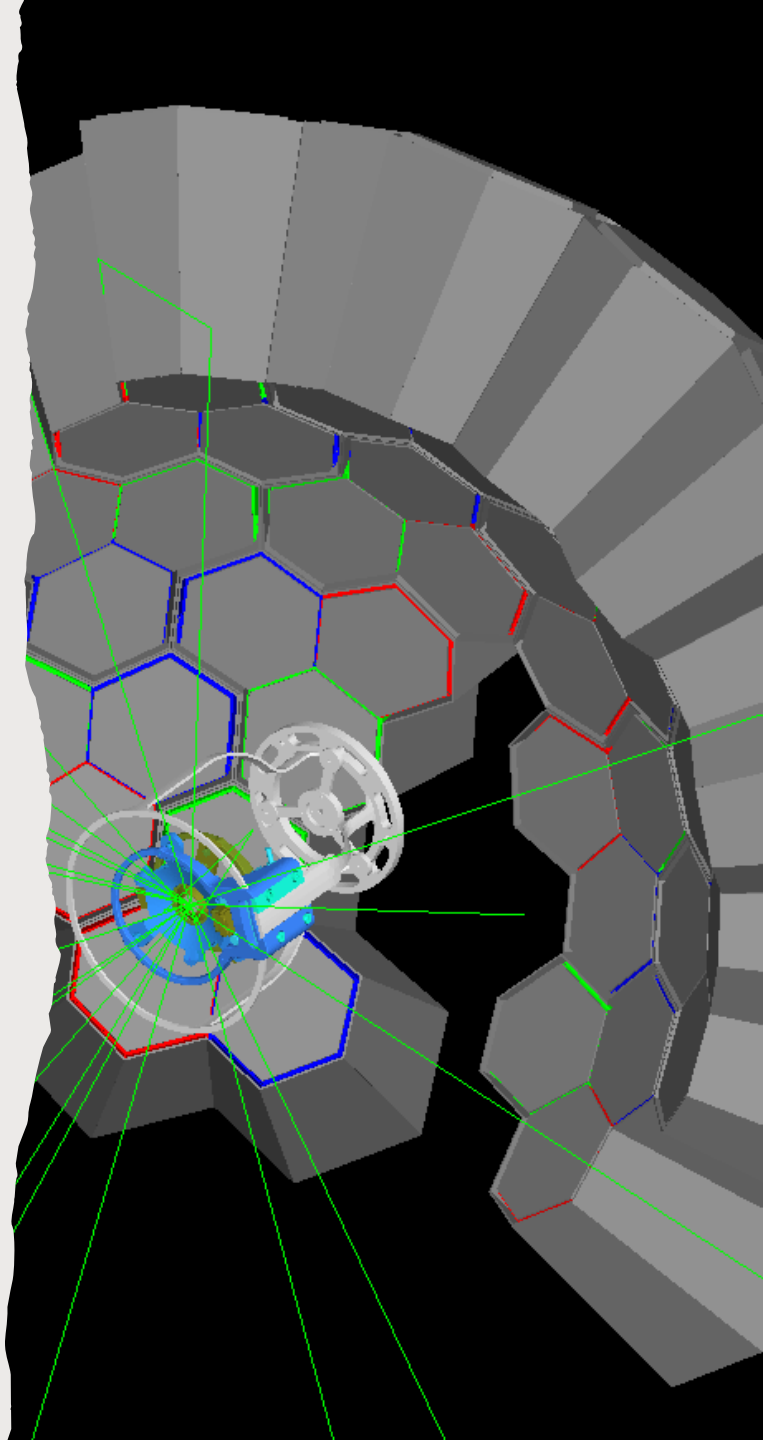


Plunger

- **GDML-based geometry**
- Mainly necessary to evaluate absorption
- The plunger simulation generally does not need the full geometry
- DOI: https://doi.org/10.1016/j.nima.2018.12.077



Conclusions

- All ancillary detectors used up to now at LNL can be simulated
- The simulation package is essential not only for proposals but also to perform precision measurements such as DSAM
- Please let the local team know if you encounter issues

- **I. Zanon**
- **A. Goasduff**
- **E. Pilotto**
- **M. Sedlak**
- **M. Rocchini**
- **D. Brugnara**

Prisma