Laboratori Nazionali di Legnaro

INFN

Istituto Nazionale di Fisica Nucleare

AGATA data analysis

E664 at GANIL

Marco Siciliano

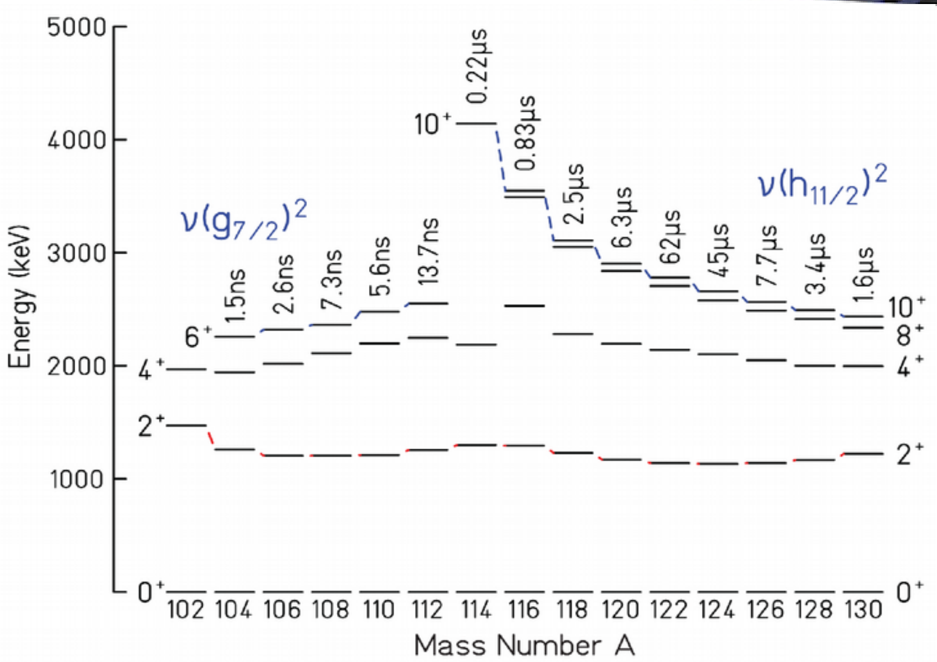
INFN – Laboratori Nazionali di Legnaro, Italy

3rd PseGe technology and application workshop
19th AGATA week

Strasbourg, 10th - 14th September 2018

AGATA ADVANCED GAMMA TRACKING ARRAY

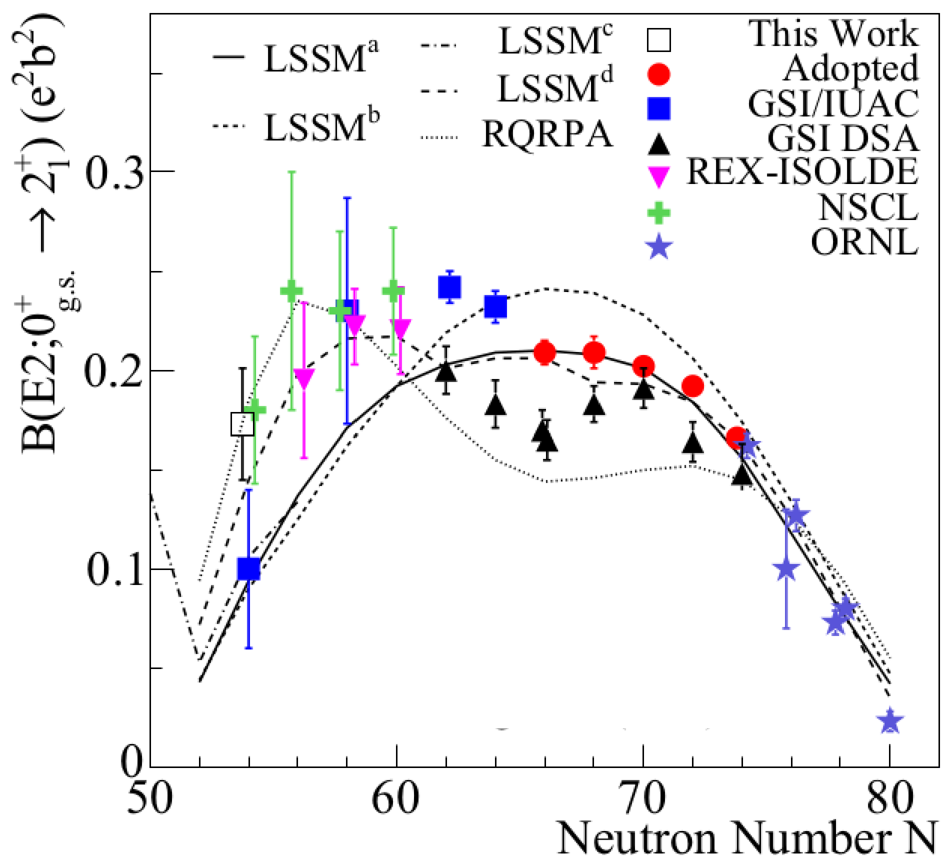
Z=50 PHYSICS CASE



R. Kumar et al., Phys. Rev. C 81 (2010) 024306.

Low-lying isomer

Rather constant excitation energy



P. Doornenbal et al., Phys. Rev. C 90 (2014) 061302R

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Z=50 PHYSICS CASE

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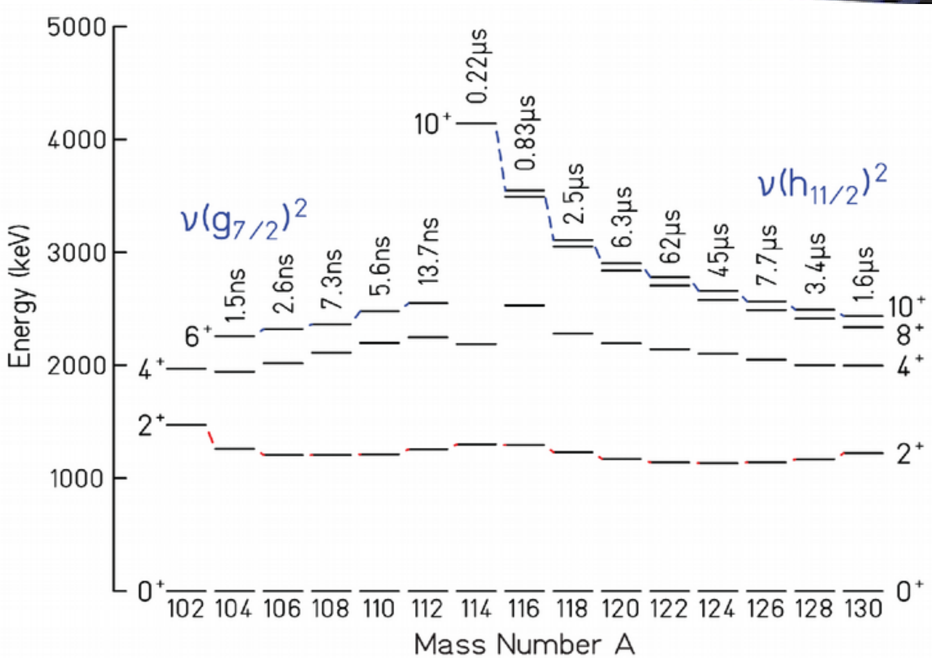
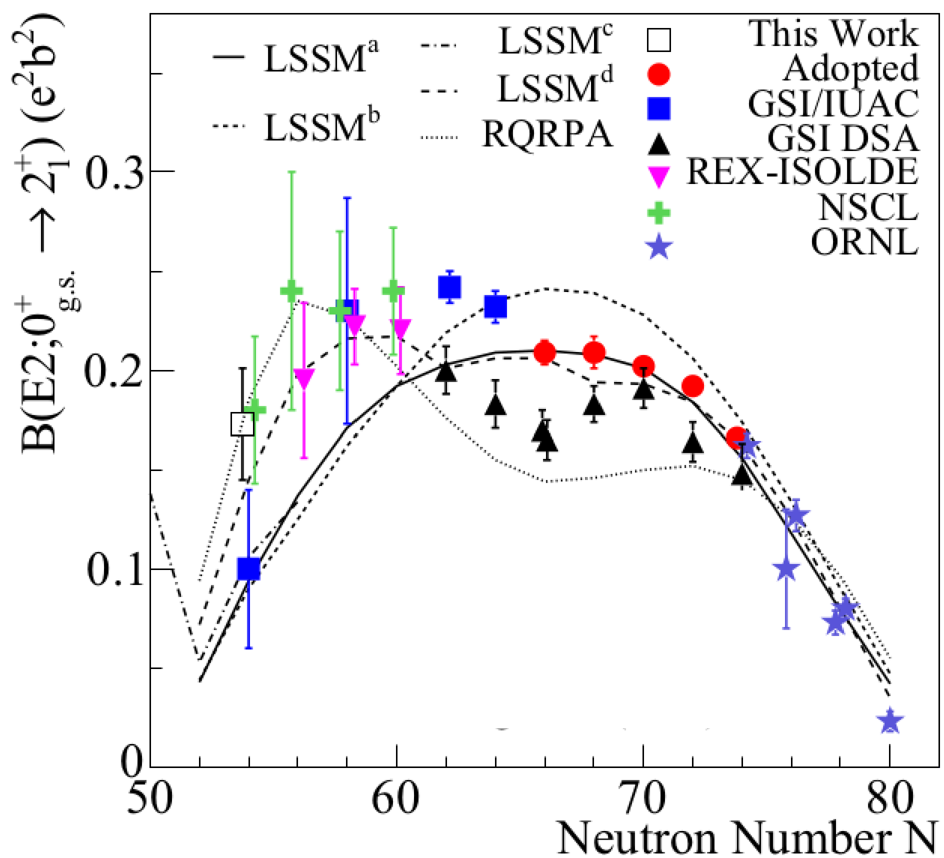


R. Kumar et al., Phys. Rev. C 81 (2010) 024306.

Complementary information via lifetime measurements and multi-nucleon transfer reactions



P. Doornenbal et al., Phys. Rev. C 90 (2014) 061302R

Low-lying isomer

Rather constant excitation energy

EXPERIMENT MOTIVATIONS

- Investigate the robustness of the proton shell closure when ^{100}Sn is approached

  → Expanding the study of the electromagnetic properties to the 2_1^+ and 4_1^+ excited states, whose wave functions should be similar.

- Reduced transition probability $B(E2;2^+ \rightarrow 0^+)$ and $B(E2;4^+ \rightarrow 2^+)$ of $^{106-108}Sn$, via lifetime measurement.

  → **First lifetime** measurement with plunger device in this region

  → **First measurement** of the $B(E2;4^+ \rightarrow 2^+)$ value for neutron-deficient Sn isotopes

  → **Complementary information** to previous Coulomb excitation experiments

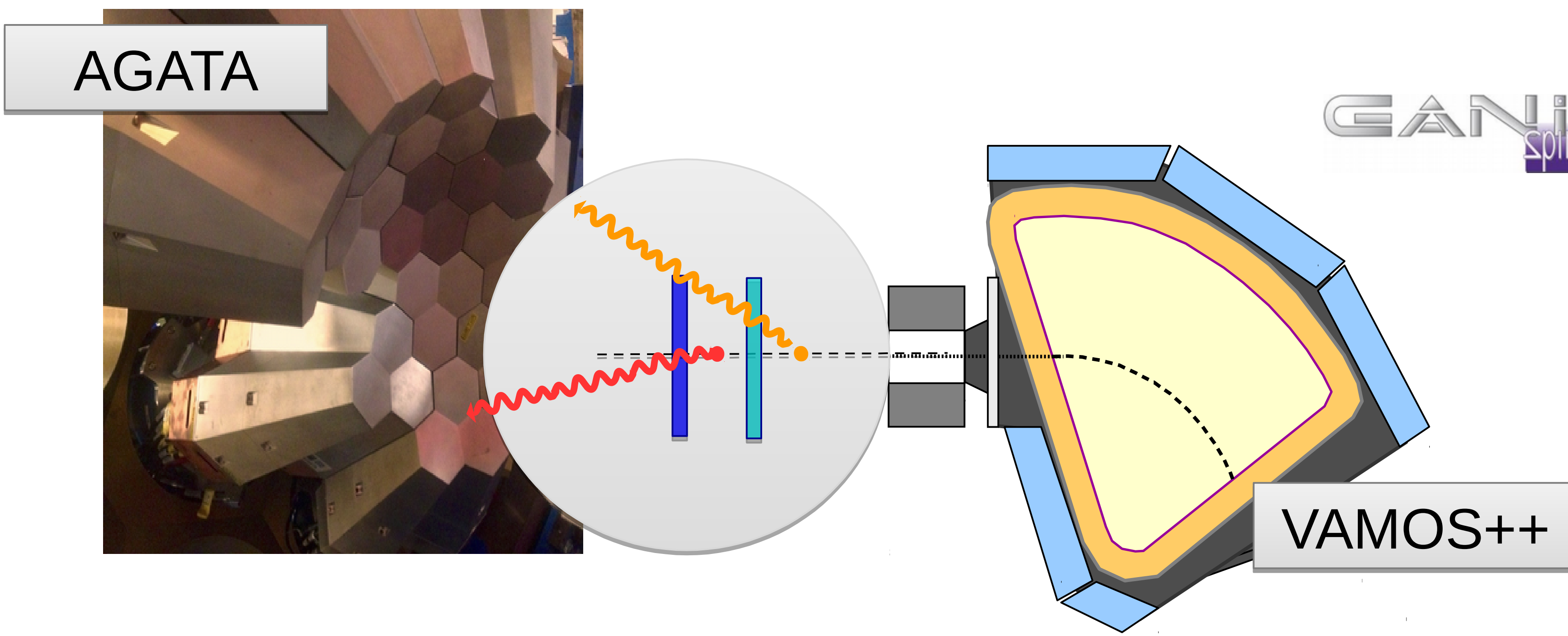
EXPERIMENT

MNT reaction to investigate the neutron-deficient Sn isotopes:

- Stable beam with **higher intensity** than previous experiment with radioactive beams
- **Direct population** of the excited states allows to study also the 4_1^+ states in ^{106,108}Sn

Beam: ^{106}Cd @ 770 MeV

Target: ^{92}Mo 0.715 mg/cm^2
Degrader: ^{24}Mg 1.6 mg/cm^2



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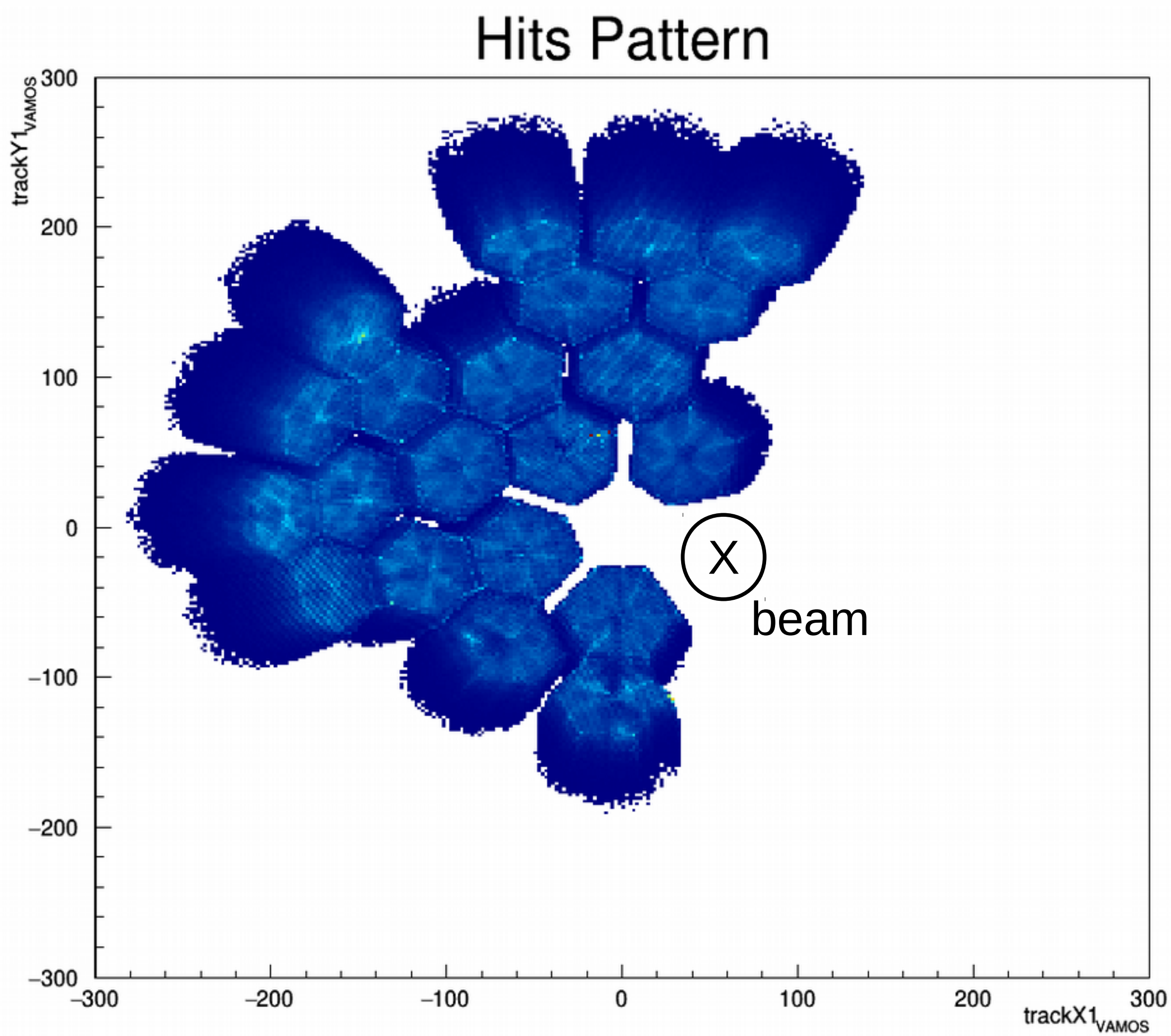

AGATA spectrometer was placed in compact configuration (18.5 cm from the target) to increase the overall efficiency.

8 ATC mounted:

- ✗ 2 crystals not in the acquisition
- ✗ 1 crystal bad condition (energy resolution 10 keV at 1332 keV)
- ✗ 3 crystals "died" during the experiment

→ almost 21 working crystals

From the comparison between the segments and the central contact signal, various correction can be applied to **improve** or **restore the performances**:

- ✔ problematic-segments correction
- ✔ neutron-damage correction
- ✔ tracking parameters

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AGATA
Problematic segments

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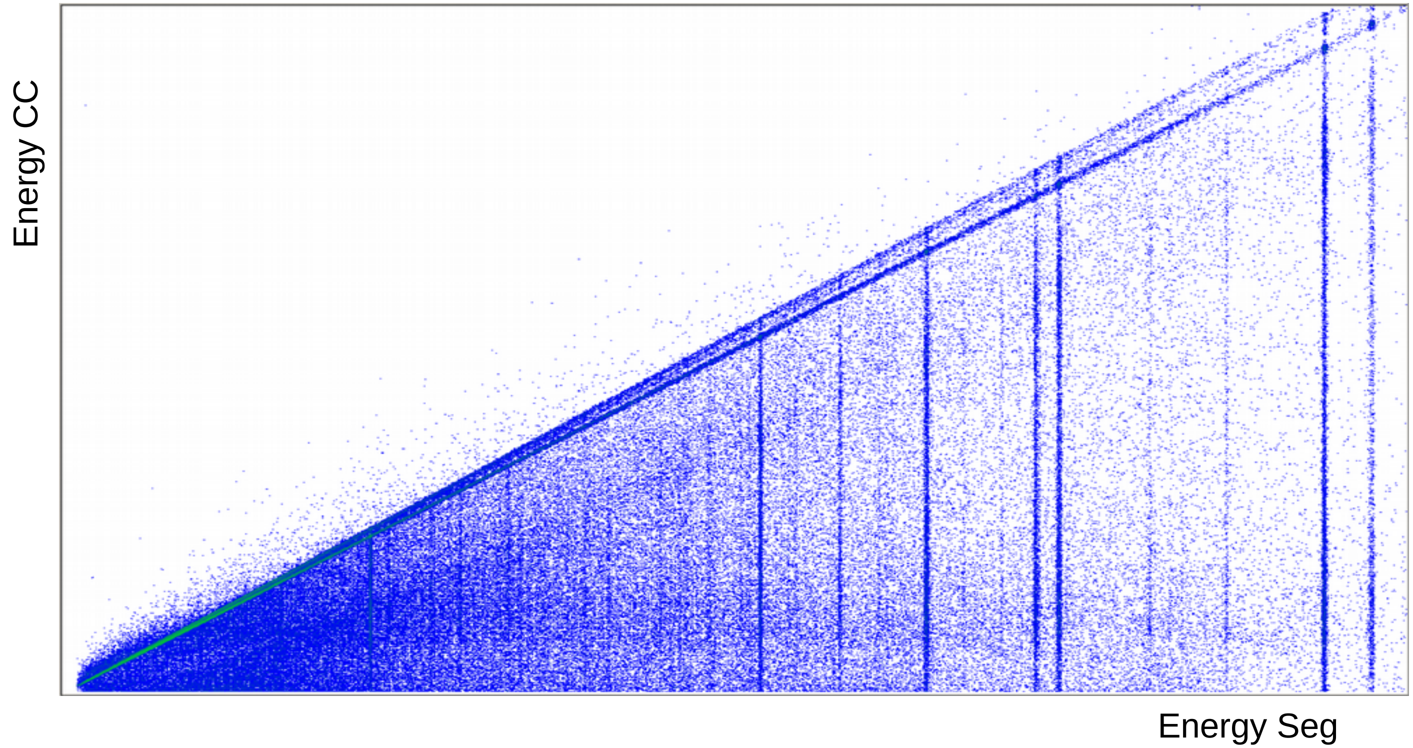
Correction of problematic detectors to restore the apparatus performances:

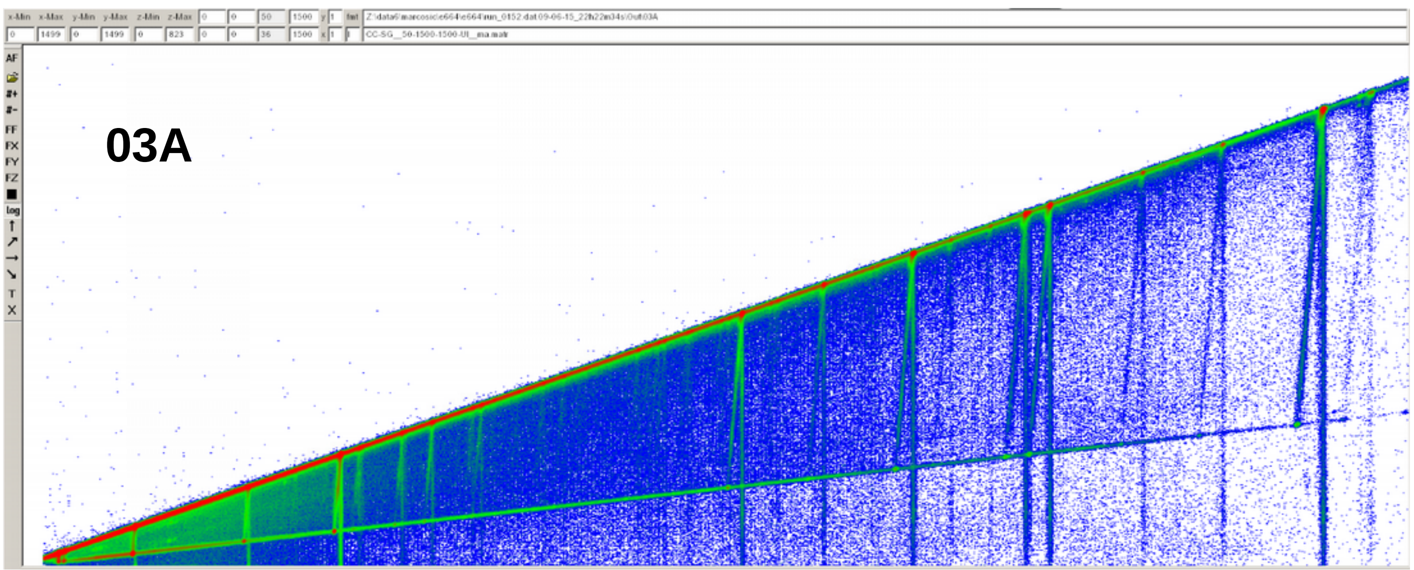
- *Broken* segment: the net charge is not collected, so it flows to neighboring segments
- *Lost* segment: the net charge is collected, but there is no information inside the data flow
- *Unstable* segment: the energy signal is present inside the data flow, but it shift with time

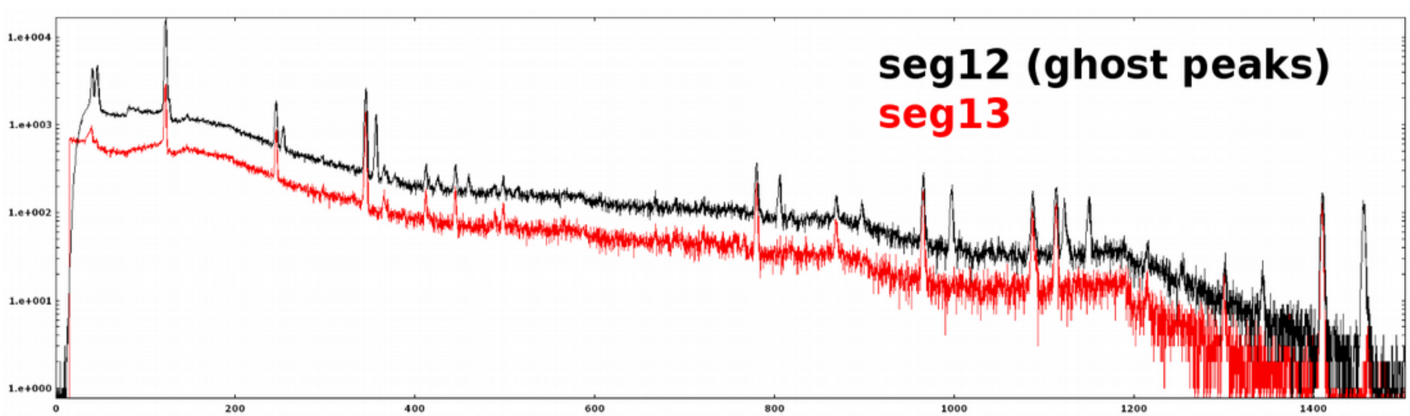
From the comparison between the signal of the segments (Seg) and the central contact (CC), the entity of the problem can be defined and it can be corrected.



AGATA
Problematic segments

For detectors that have many missing segments, only one of them can be restored but consequently there will be **ghost peaks** due to the other dead segments.



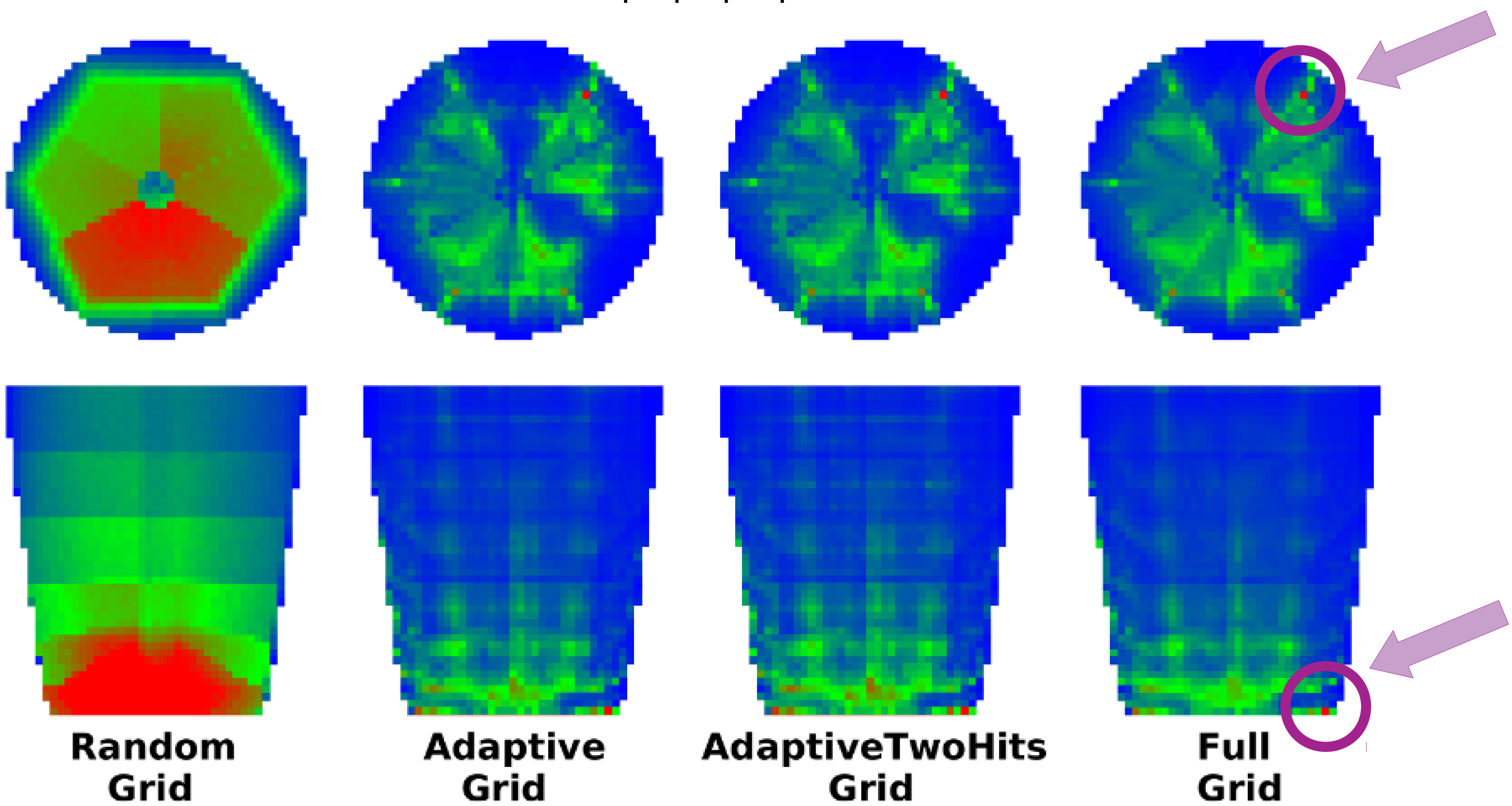


AGATA
Pulse Shape Analysis

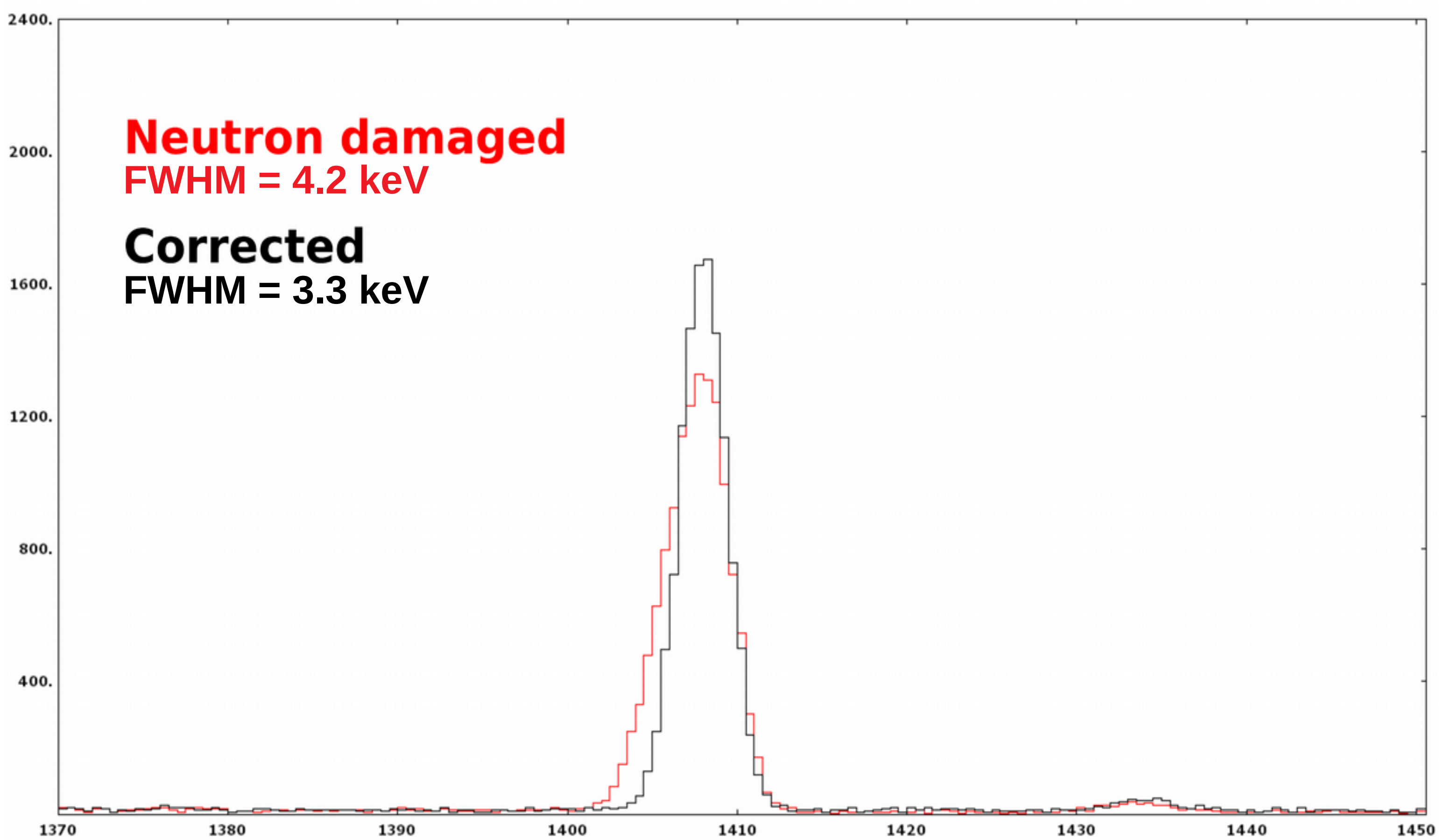
Digital electronics allow to register the traces of the acquired signals per each segment.

By comparing the signals between neighboring segments the γ-ray interaction point can be defined inside the segment itself.

(x_i, y_i, z_i, E_i)



AGATA
Neutron damage

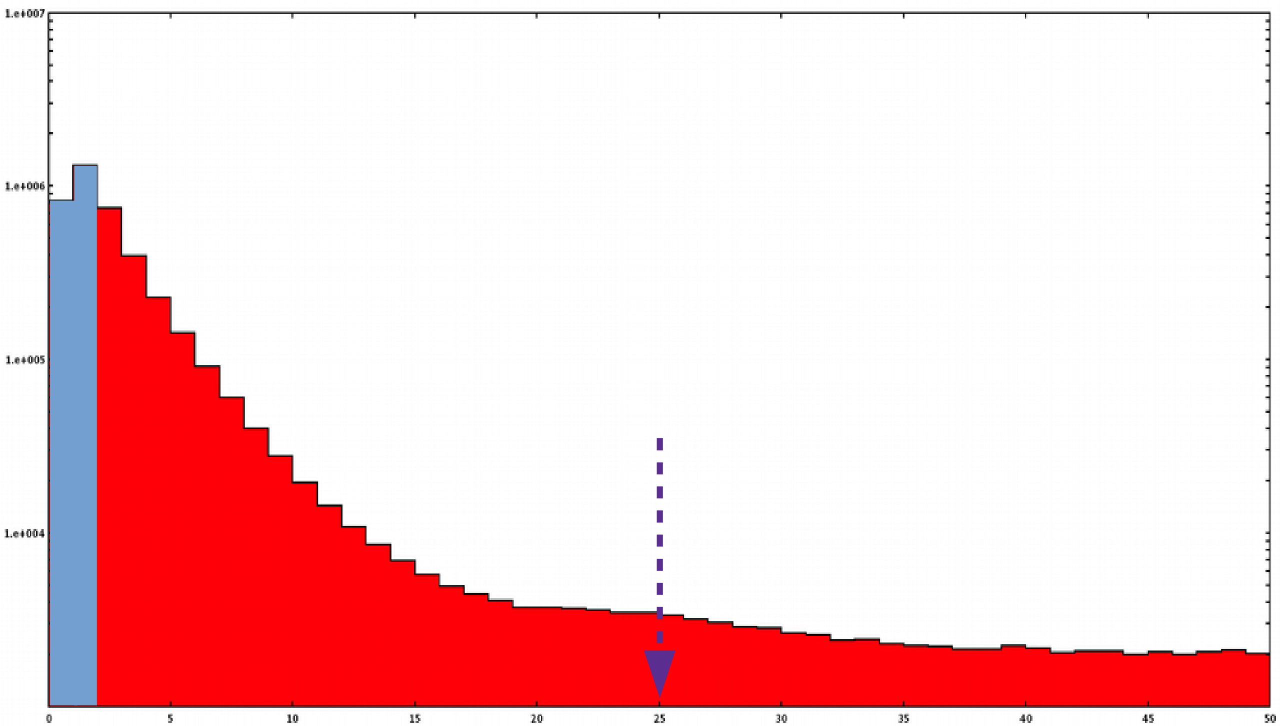


During the reaction the neutron flux damages the crystal lattice, creating traps for the charge carriers (affecting in particular holes).

- Only part of the charge is collected, causing for each peck a tail at low energy

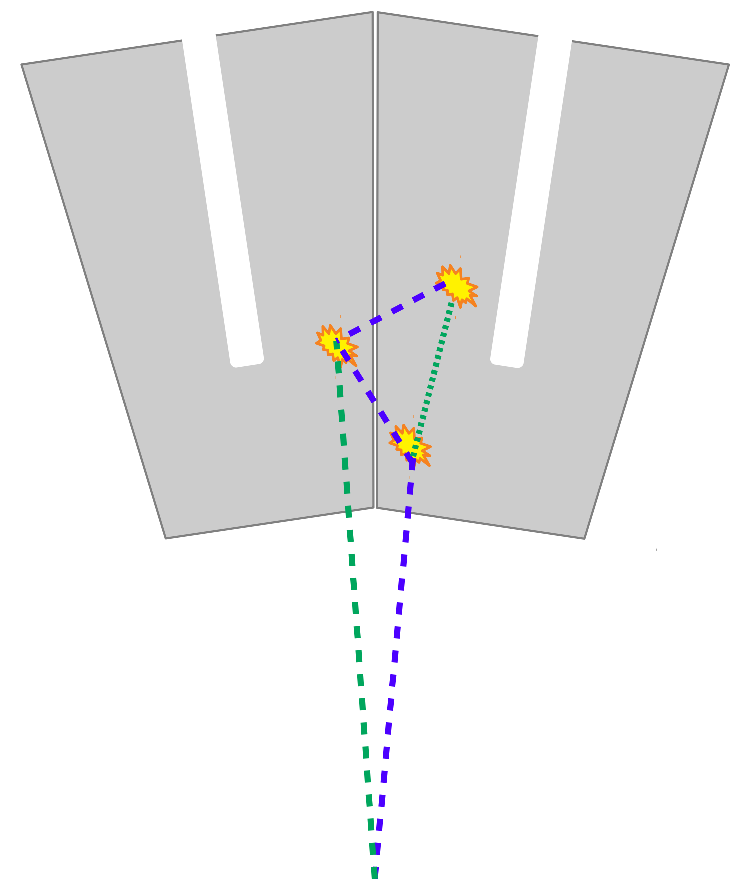
From PSA the mean free path of both electrons and holes is estimated.
The signal amplitude is scaled to overcome the underestimation of the measured energy.

AGATA Event Builder



Hits belonging to the same crystal have the same TS, estimated from the CC.

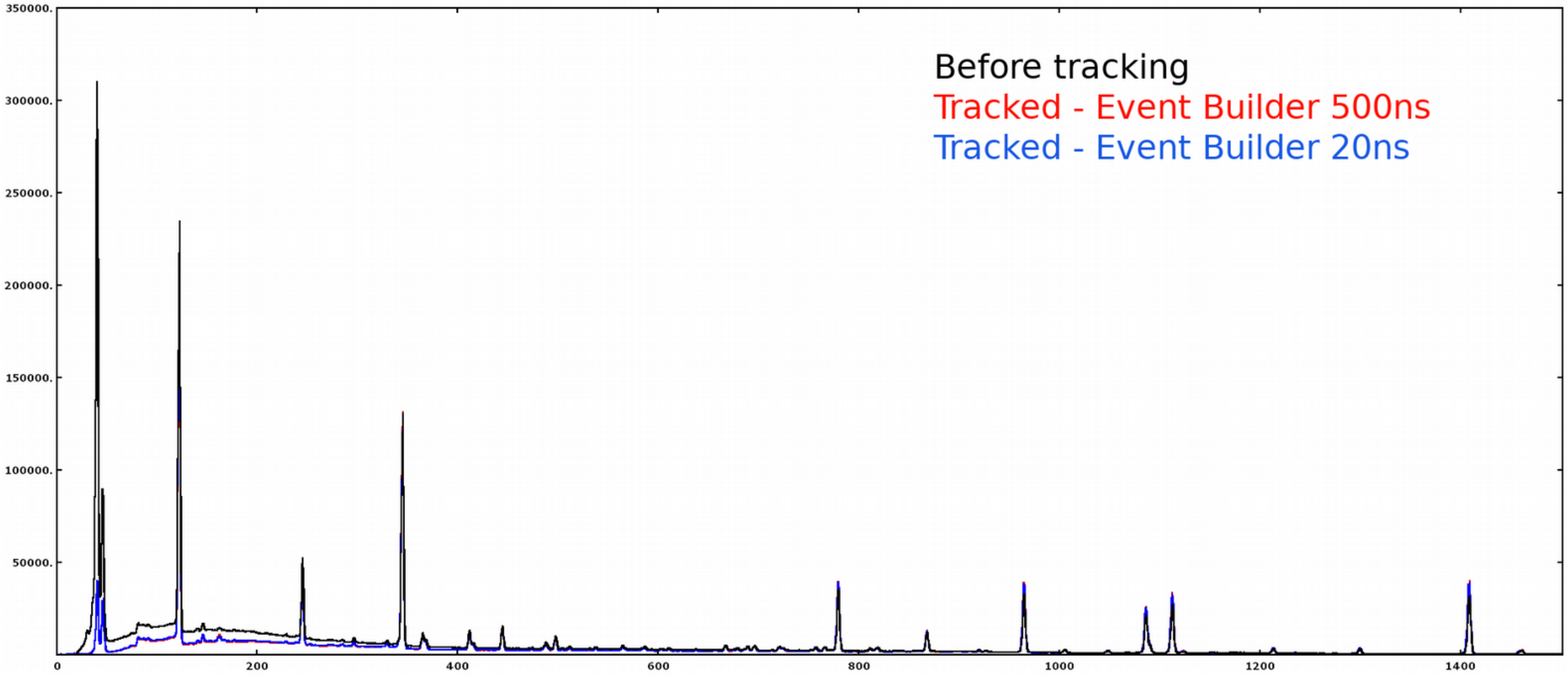
Thus, no time information is considered by the tracking algorithm to distinguish between hits belonging to different events.



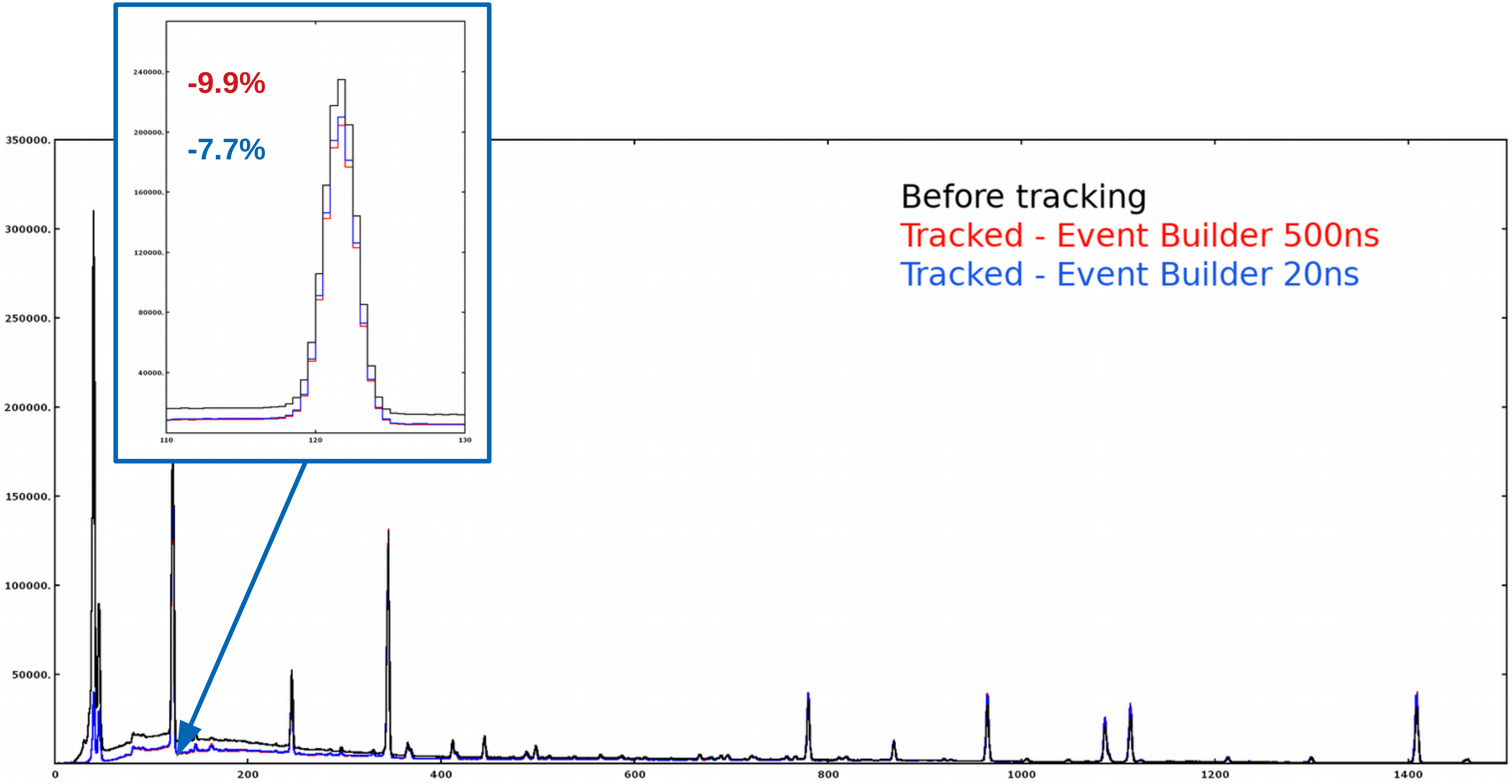
The EventBuilder merges together the information coming from all the AGATA detectors:
If the TS difference between two detectors is within a defined time window, all the hits belong to the same event.

To avoid hits belonging to different gammas to be tracked together, the time-window width should be optimised.

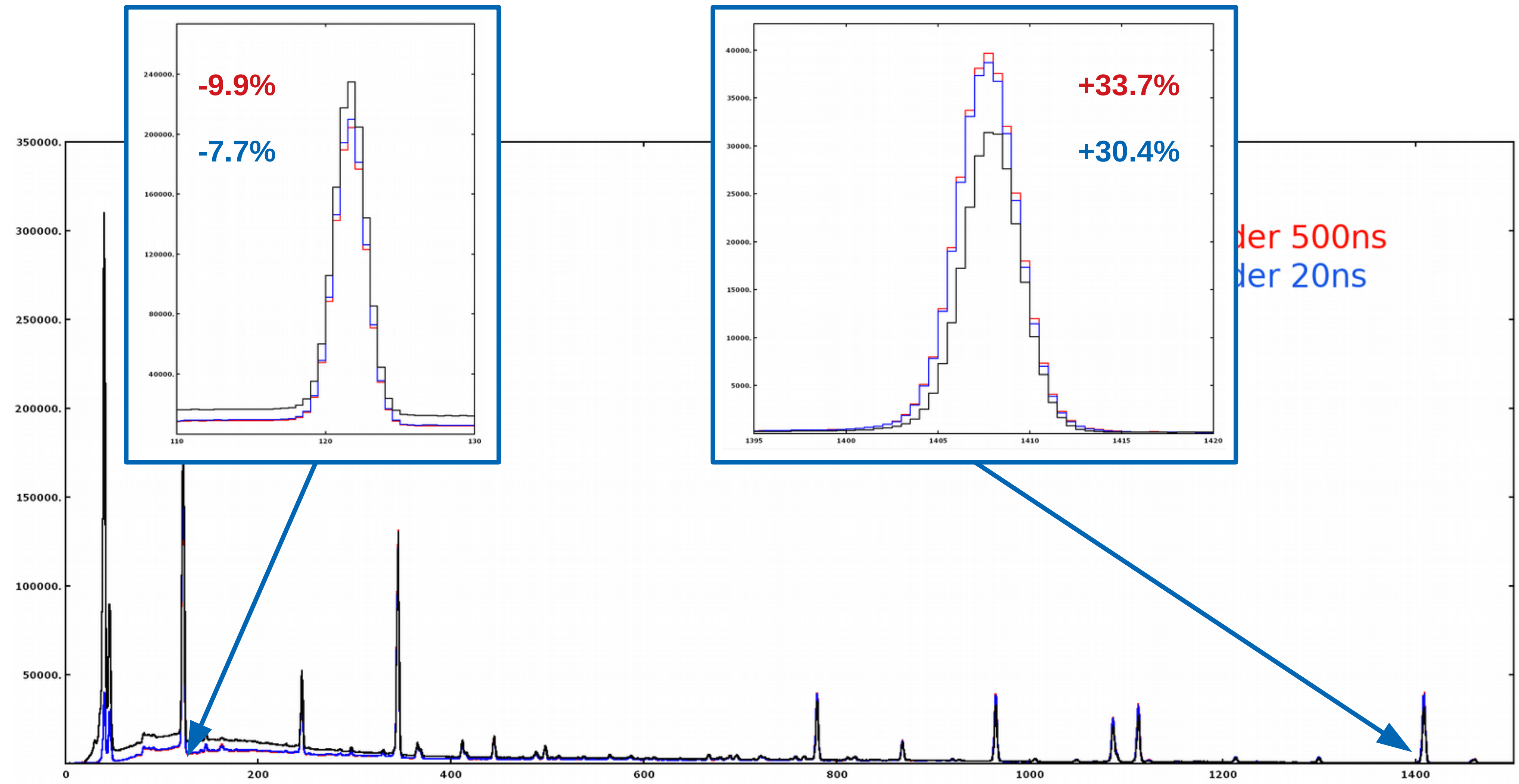
AGATA Event Builder



AGATA
Event Builder



AGATA Event Builder



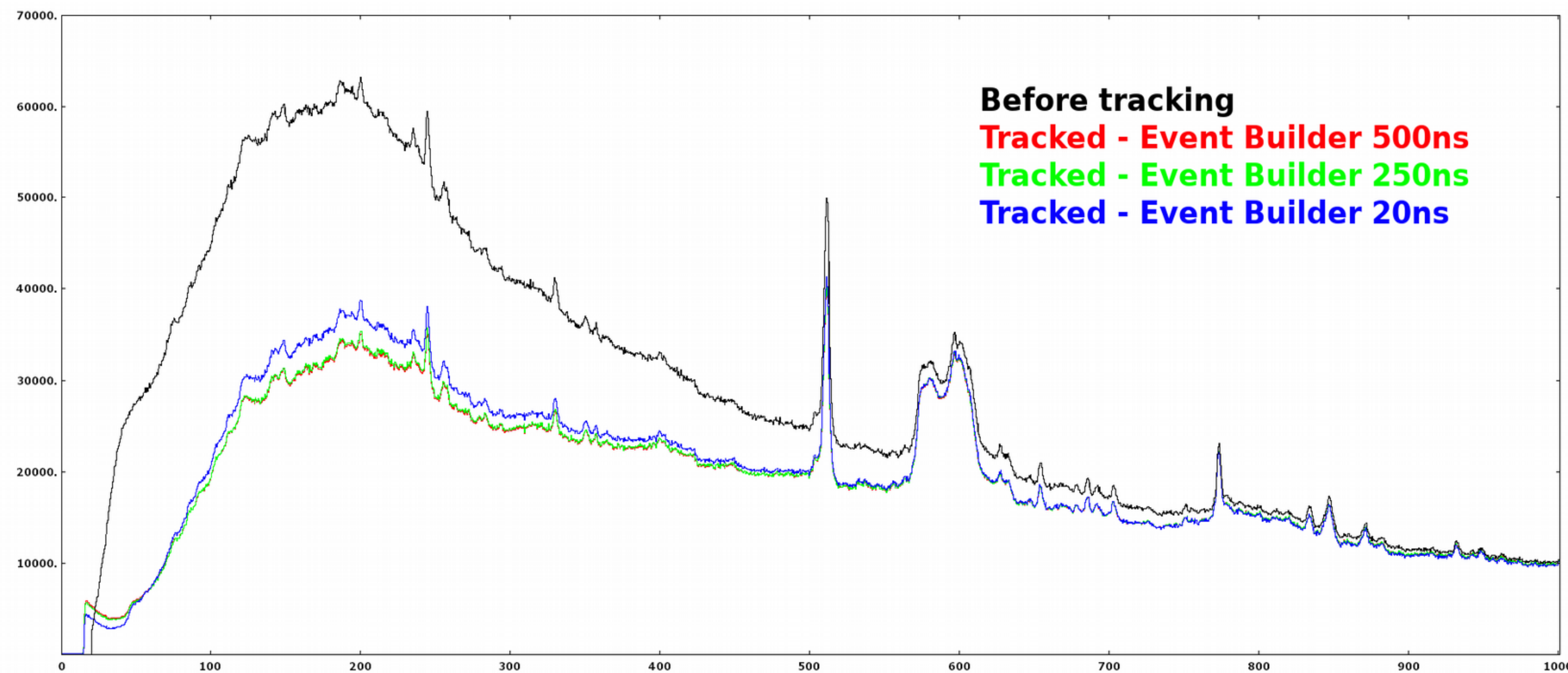
AGATA
Event Builder

The EventBuilder time window effects only the γ rays which scatters into different detectors.

- Being the number of such evens exiguous, the gain if efficiency is limited.

Except for observing isomers, there are no reason to include several beam bunches.

- More restrictive condition can be performed during the offline analysis



AGATA Tracking

Knowing the interaction points and the deposited energy, the path of the γ rays is reconstructed inside the array.

- Reduce the background, improving the Peak-to-Total (P/T) ratio
- Improve the efficiency
- Improve the Doppler correction, using the first interaction point

The tracking-algorithm parameters have been optimized for the energy range of the γ-ray transitions of interest.

- **SigmaTheta**: effective position resolution of the interaction points, used while comparing of the angles obtained from the positions and the angles from deposited energies.
- **MinProbSing**: in addition to the position requirement mentioned before, the minimum probability for accepting single interaction clusters defines a threshold for the calculated figure of merit. This probability has the effect of an energy threshold above which, in fact, events are rejected as background.
- **MinProbTrack**: the acceptance level of multiple-interaction clusters is defined by the minimum probability threshold for the figure of merit.

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AGATA
Tracking optimization

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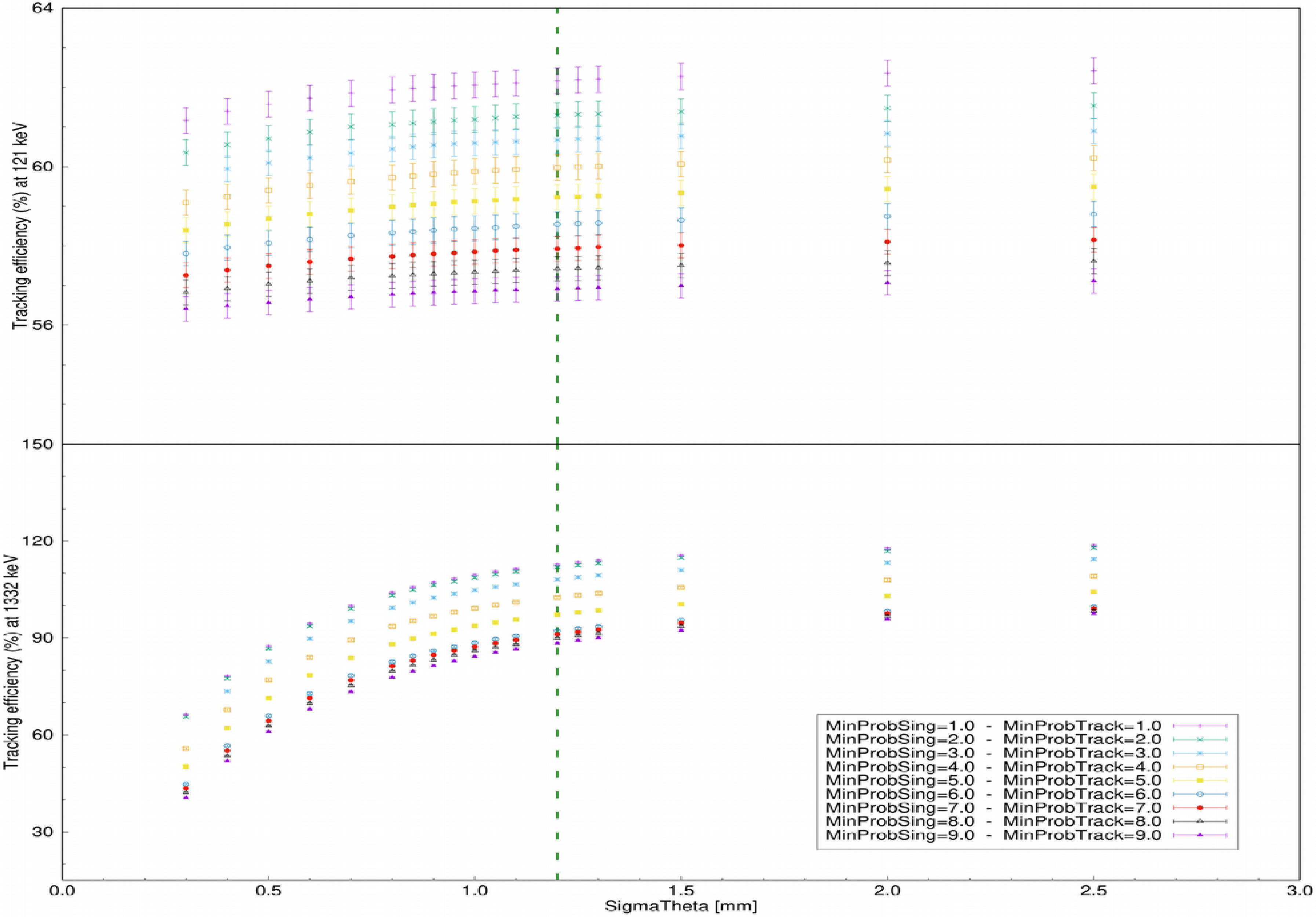

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AGATA
Tracking optimization

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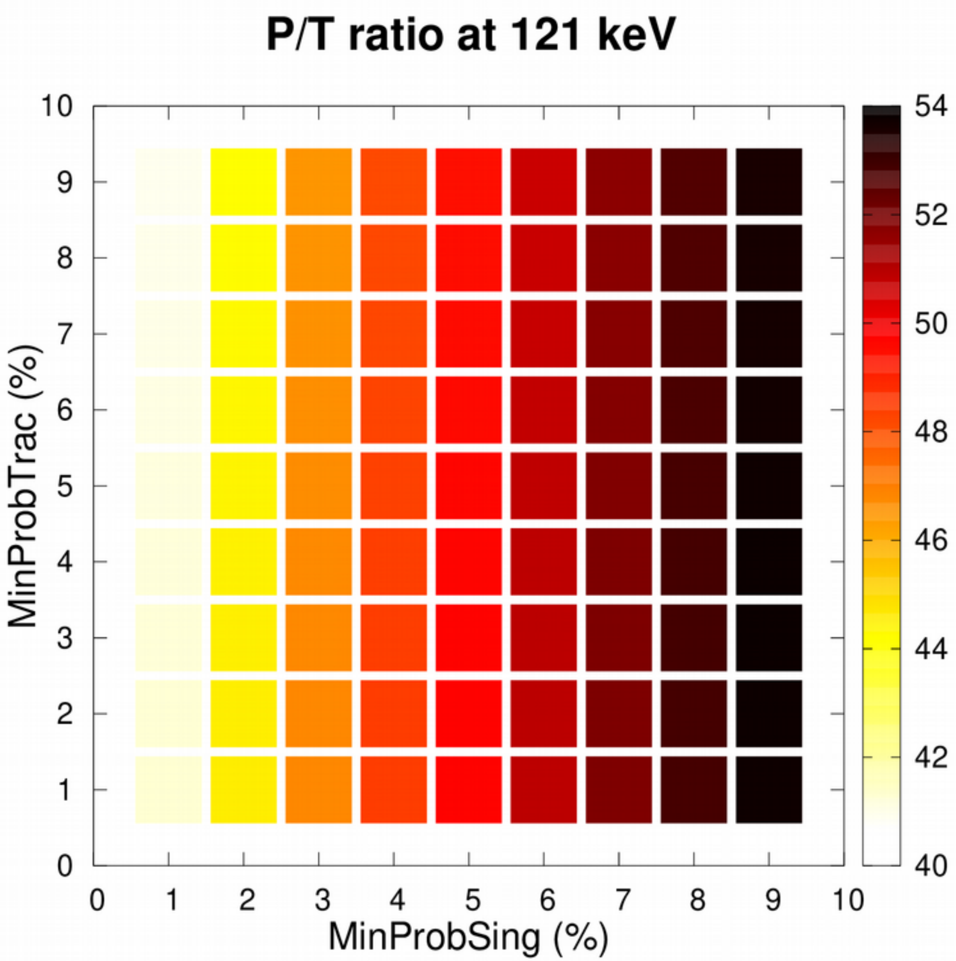
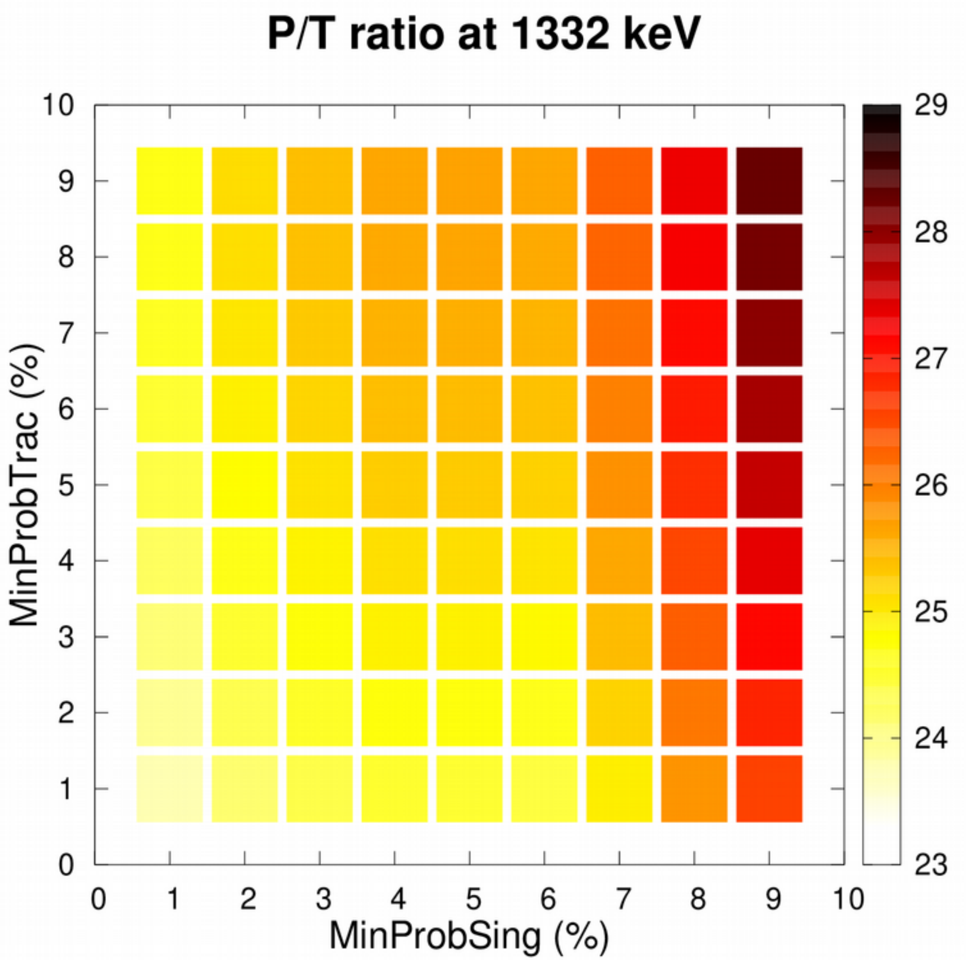
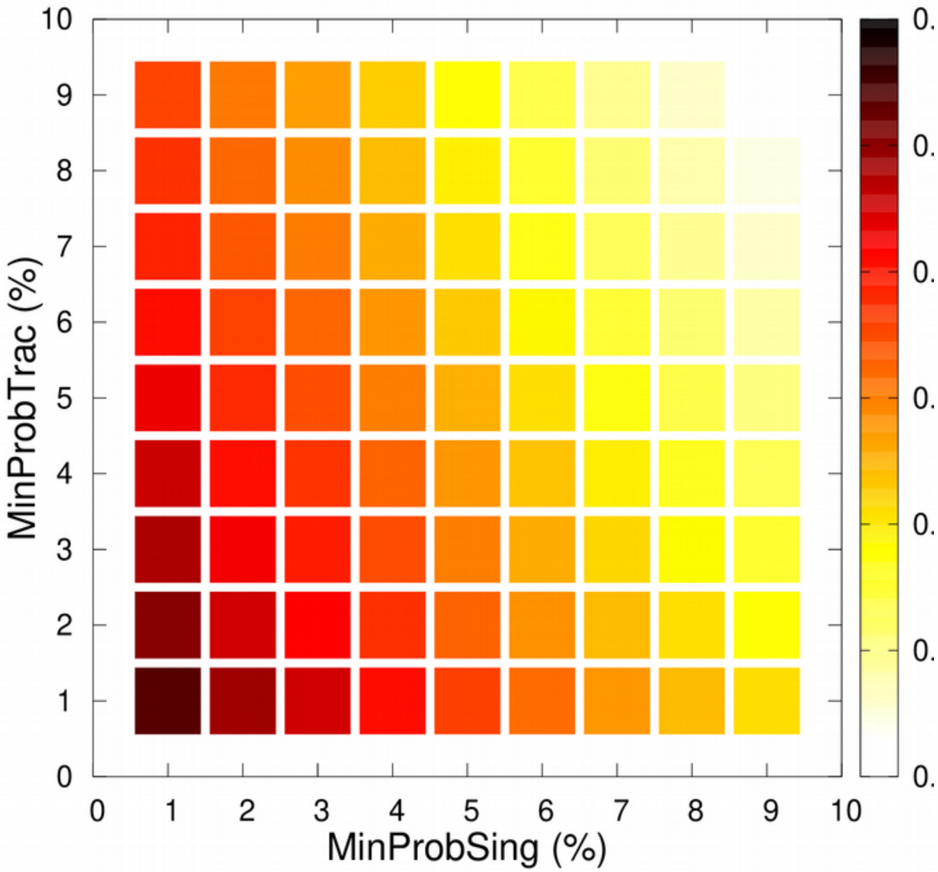


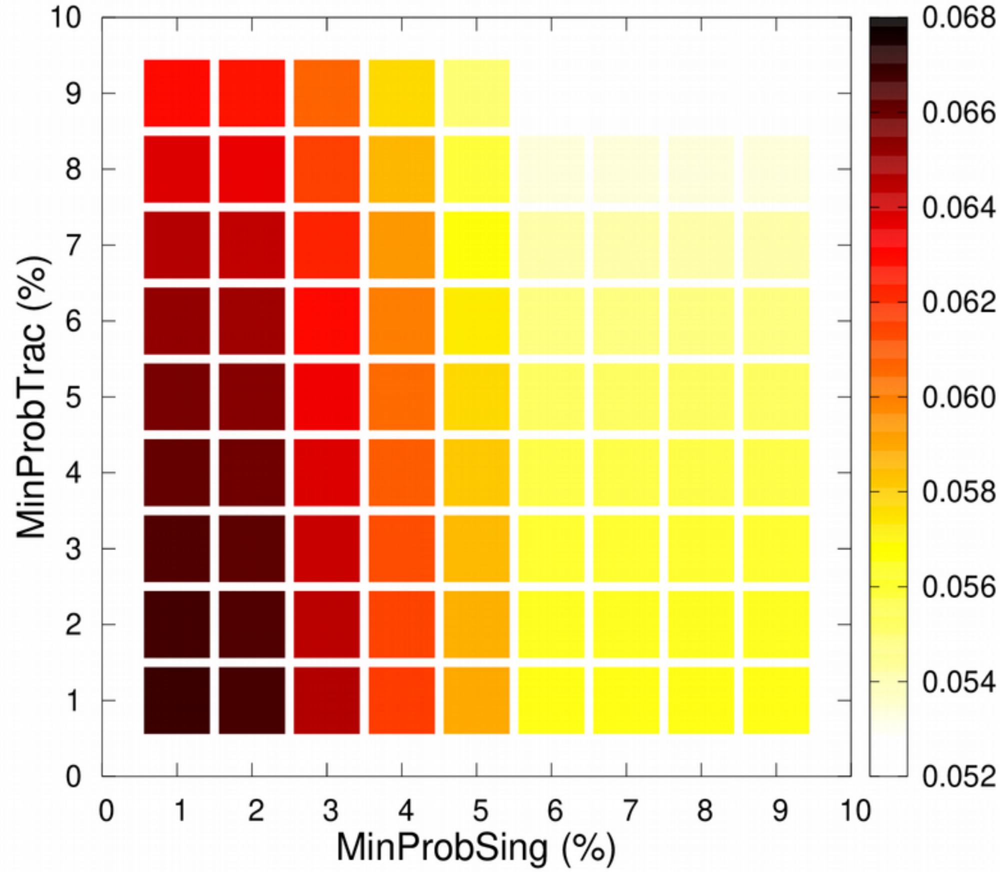


AGATA Tracking optimization

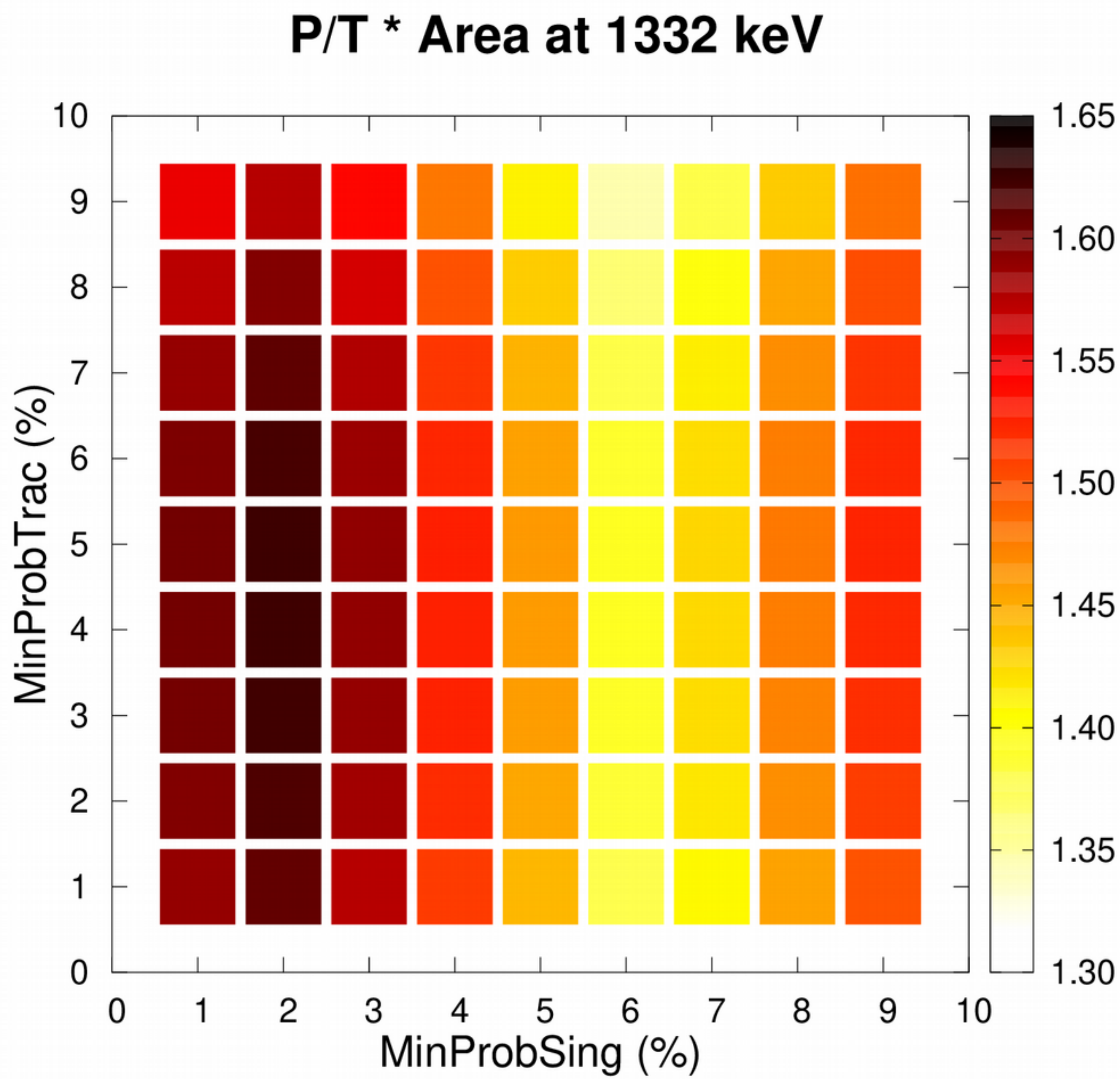
Area at 121 keV



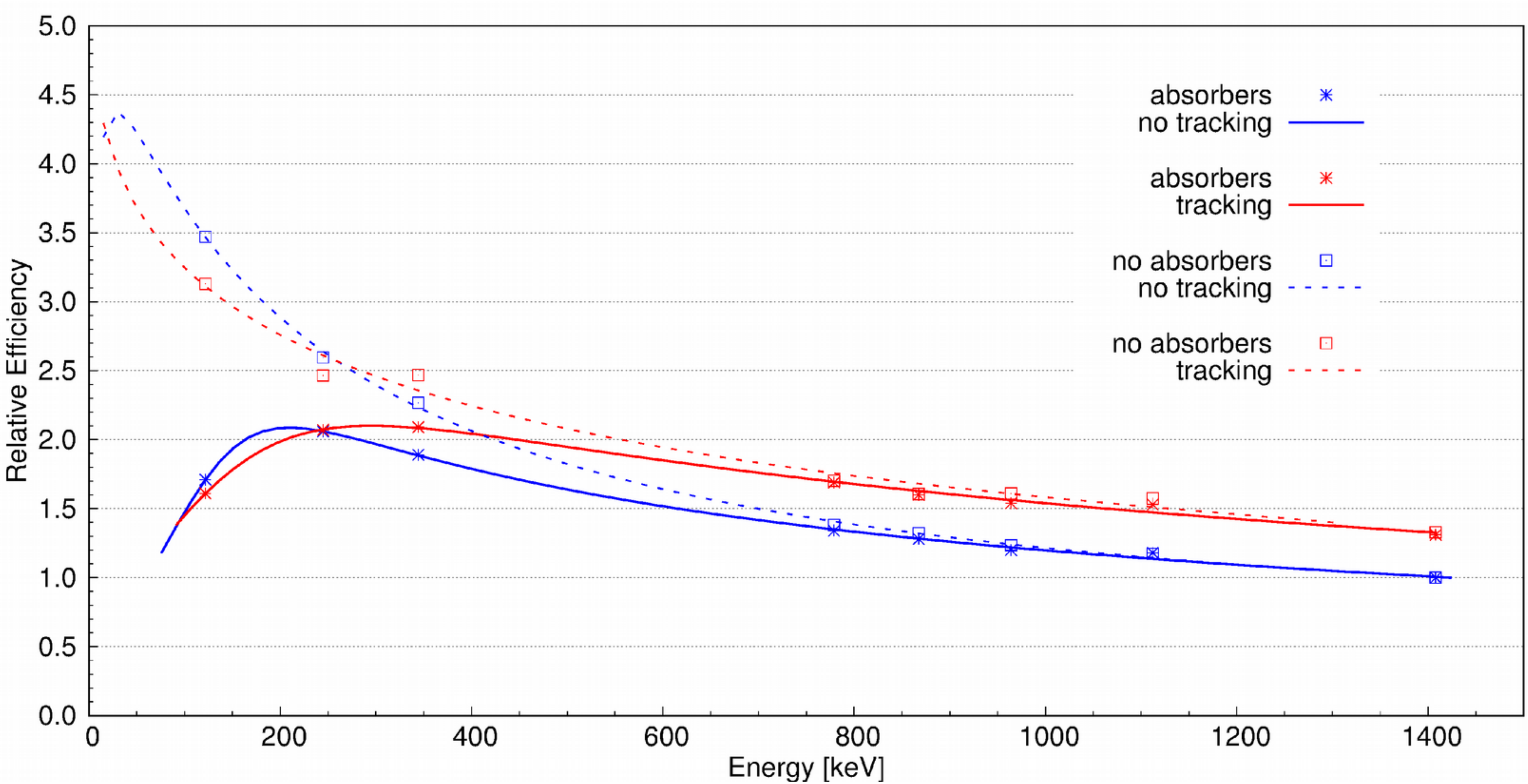
Area at 1332 keV



AGATA
Tracking optimization



AGATA
Tracking optimization



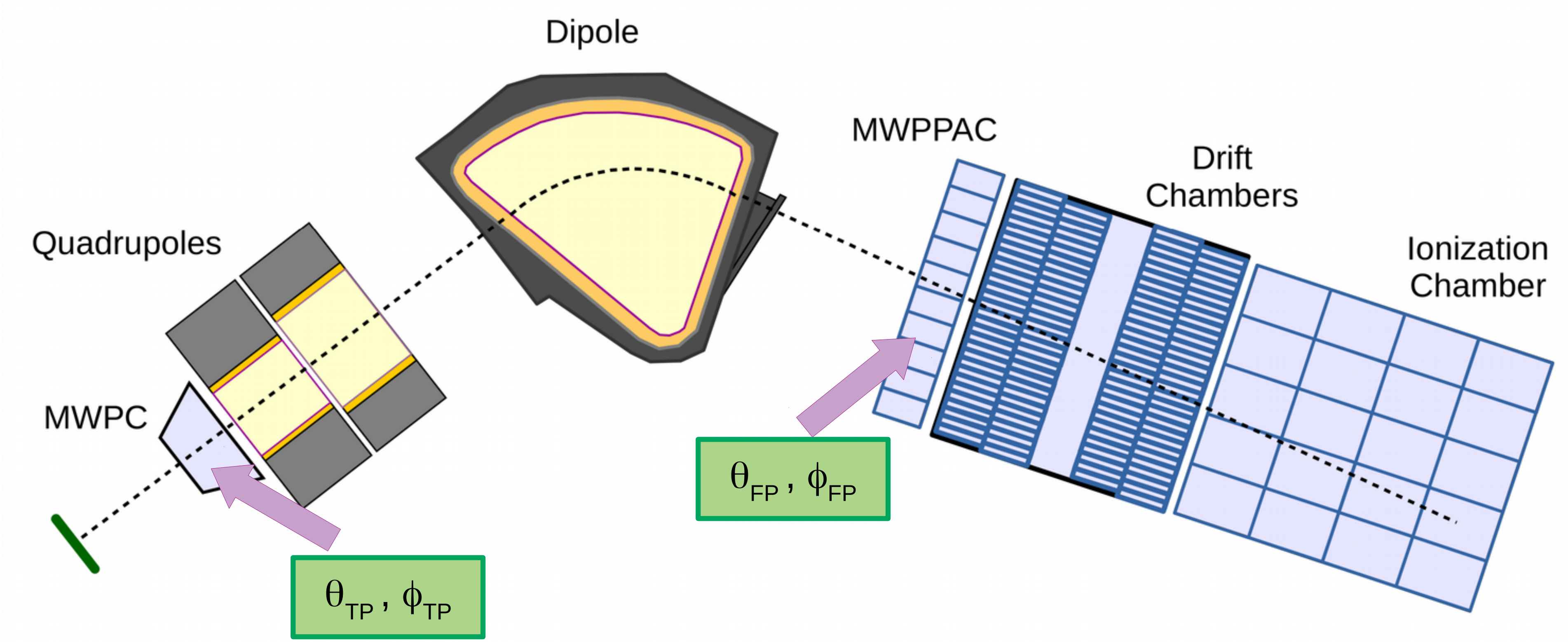
AGATA
Doppler correction

Employing AGATA and VAMOS++ spectrometers allows an event-by-event Doppler correction:

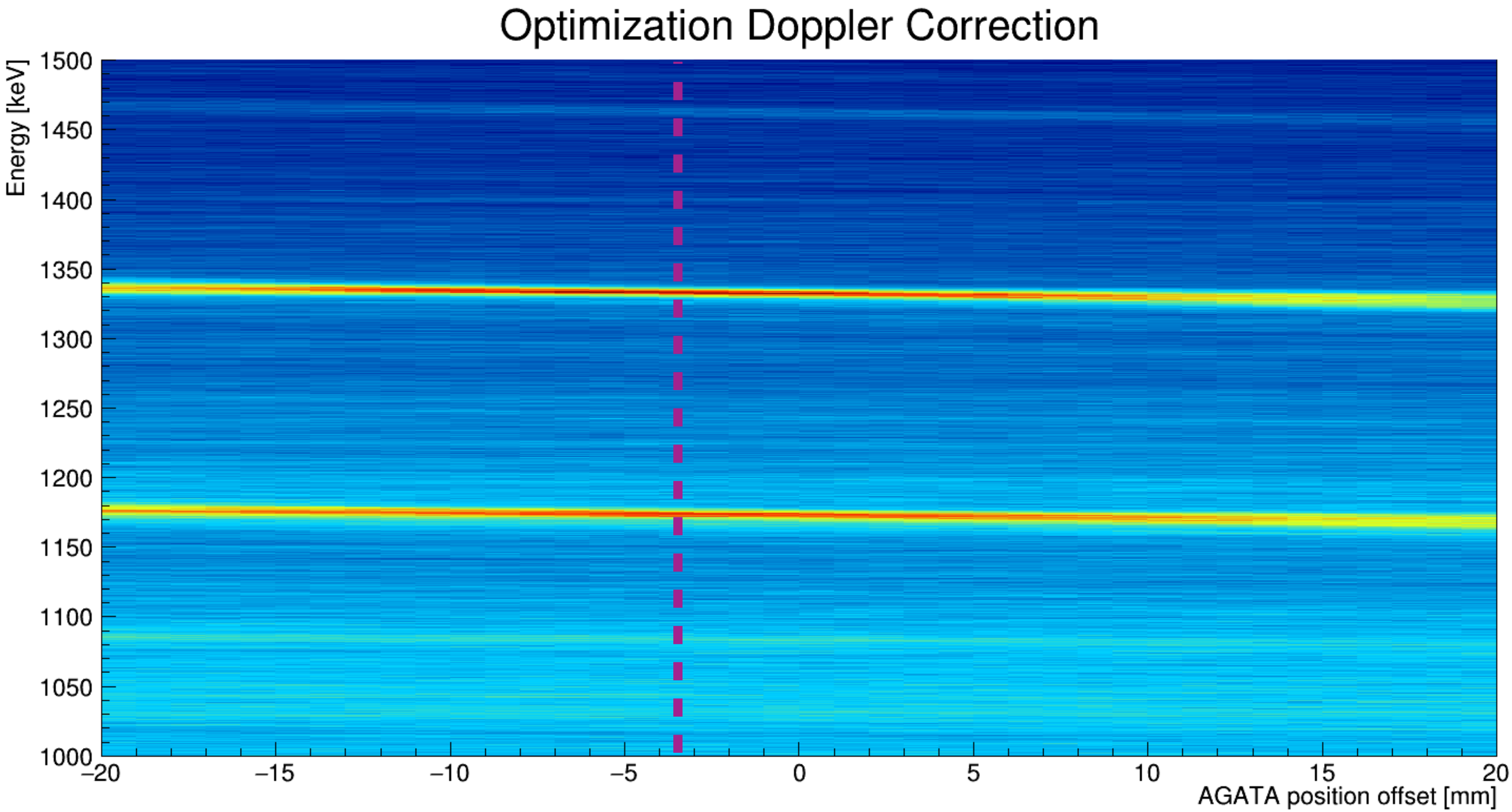
- Ion velocity vector, provided by VAMOS++ entrance detector
- First γ-ray interaction point, provided by AGATA tracking algorithm

Optimisation of the Doppler correction:

- Ions energy loss in the entrance detector
- Detectors effective position



AGATA Doppler correction

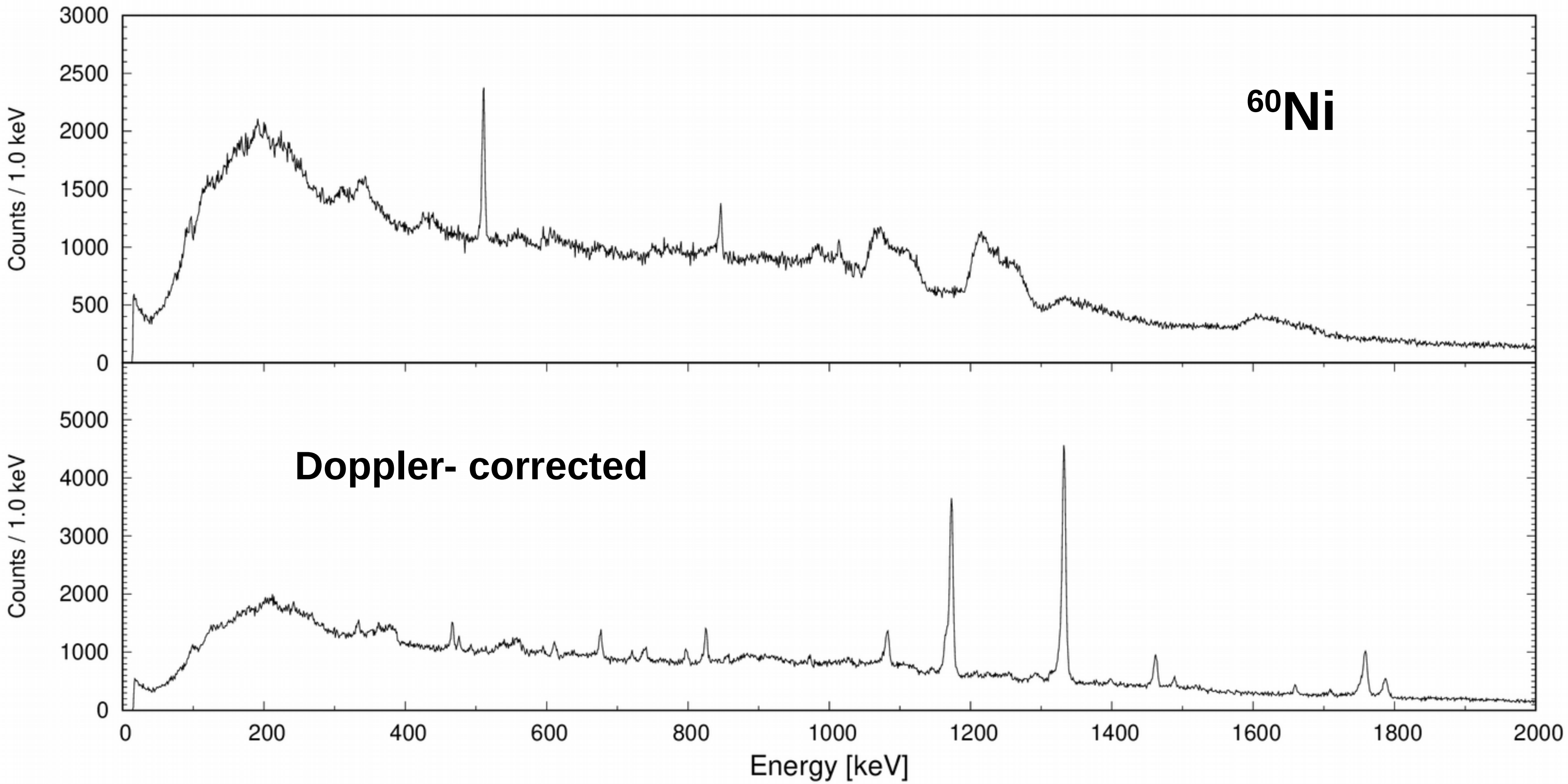


AGATA Doppler correction

^{60}Co source:
3.9 keV at 1332 keV

In-Flight ^{60}Ni:
5.3 keV at 1332 keV

For ion velocity β~11%, the in-flight energy resolution is **only 30%** larger than what was obtained with calibration sources



CONCLUSIONS

From the comparison between the segments and the central contact signal, various correction can be applied to improve or restore the performances**:**

- Problematic (*broken, lost, unstable*) segments correction reconstructs the signal
  At the moment, only 1 segment per detector can be restored

- Pulse-Shape Analysis provide information on the γ-ray interaction point inside the segment

- After estimating the mean-free path of the charge carriers, signal amplitude can be normalised to correct the neutron damage of the crystal lattice

The time information of hits belonging to the same detector is given by the TS of the central contact.
Thus, time information cannot be used to distinguish between hits belonging to different events.

EventBuilder time window affects the γ-ray reconstruction of events scattered into different detectors: in principle, small window would worsening the P/T, while large window would make the tracking overestimating the energy of the tracked γ rays.

The OFT algorithm parameters have been optimised to improve P/T and efficiency in the energy range of the γ-ray transition of interest.

M. Siciliano[1,2], J.J. Valiente-Dobón[2], A. Goasduff[1,2,3], F. Nowacki[4], A. Zuker[4], D. Bazzacco[1,3], N. Alahari[5], G. Benzoni[6], T. Braunroth[7], N. Cieplicka[6,8], F.C.L. Crespi[6,9], E. Clement[5], G. de France[5], M. Doncel[10], S. Ertürk[11], C. Fransen[7], A. Gadea[12], G. Georgiev[13], A. Goldkuhle[7], U. Jakobsson[14], G. Jaworski[2], P.R. John[1,3], I. Kuti[15], A. Lemasson[5], A. Lopez-Martens[13], H. Li[14], S. Lunardi[1,3], T. Marchi[2], D. Mengoni[1, 3], C. Michelagnoli[5], T. Mijatovic[16], C. Müller-Gatermann[7], D.R. Napoli[2], J. Nyberg[17], M. Palacz[18], R.M. Pérez-Vidal[12], M. Rejmund[5], B. Saygi[2,19], D. Sohler[15], S. Szilner[16], D. Testov[1,3] and AGATA collaboration

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THANKS FOR YOUR ATTENTION