Neutrons in AGATA

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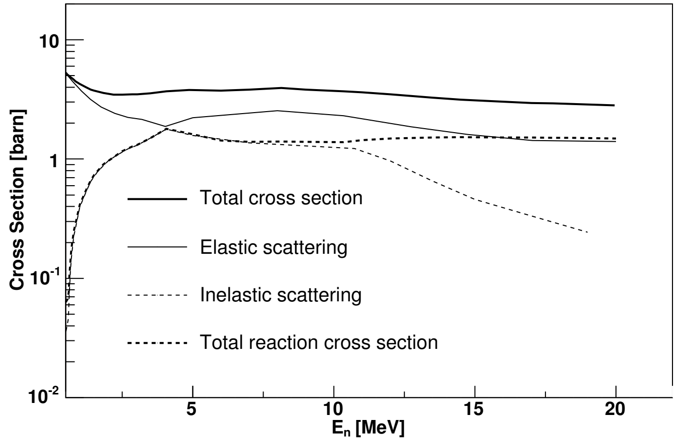
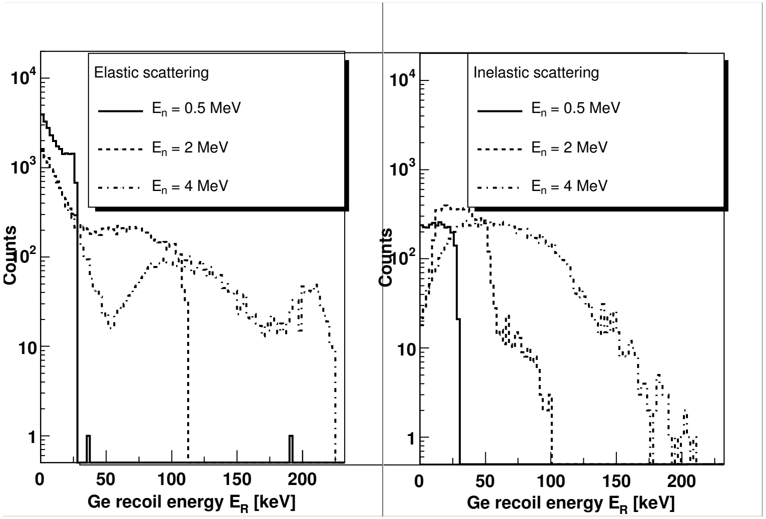
Neutrons in High-Purity Germanium detectors

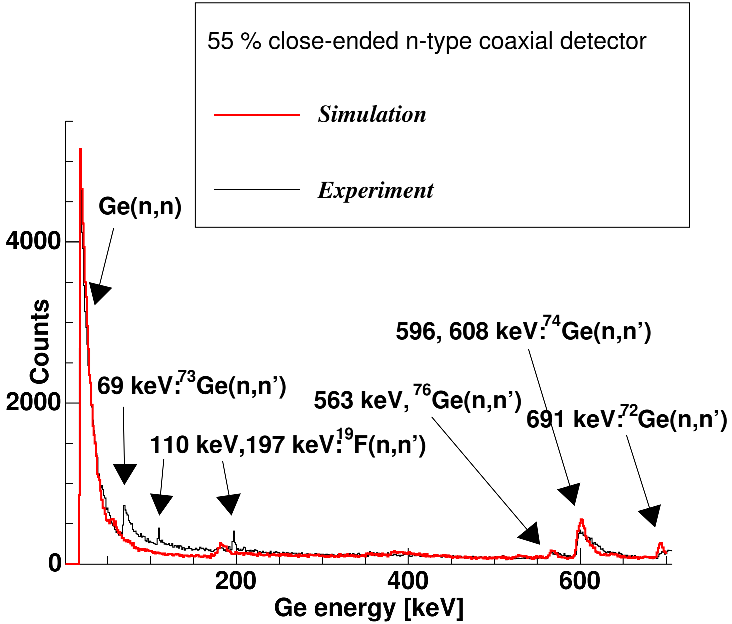
- Elastic scattering is largest.
- Mean free path in ${}^{nat}Ge$ typically a few cm.
- The number of Ge recoils per energy interval increases for low recoil energies.
- Ionization energy $E_I \approx 0.21 * E_R^{1.099}$





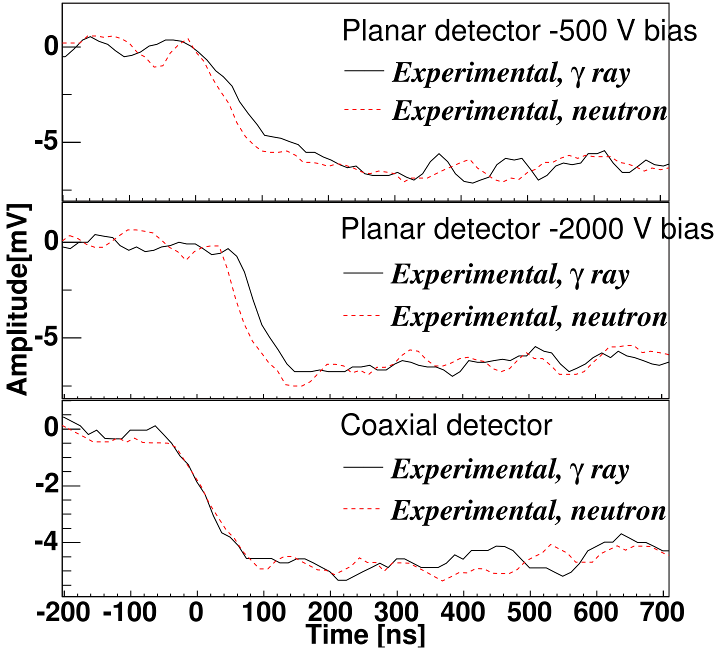
TOF neutron gated Ge energy spectrum measured with a ^{252}Cf source

- The number of elastic scattering events increases rapidly with a lower energy threshold.
- Good agreement between experiment and simulation.



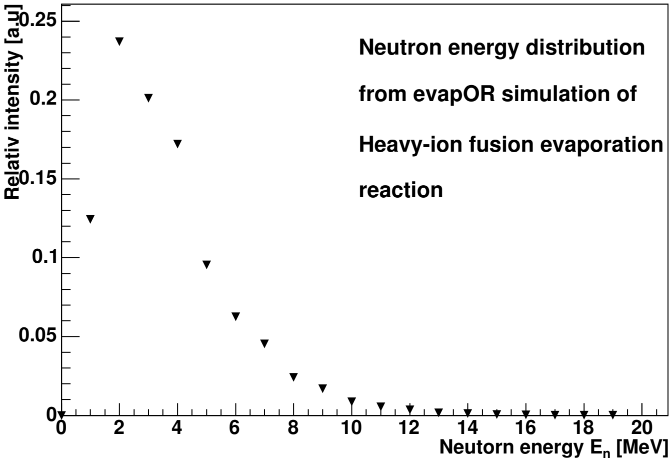
Pulse shapes measured with TNT-1

- Two different n-type detectors used for experiments, one planar and one close-ended coaxial.
- No pulse-shape differences for neutrons and γ rays!



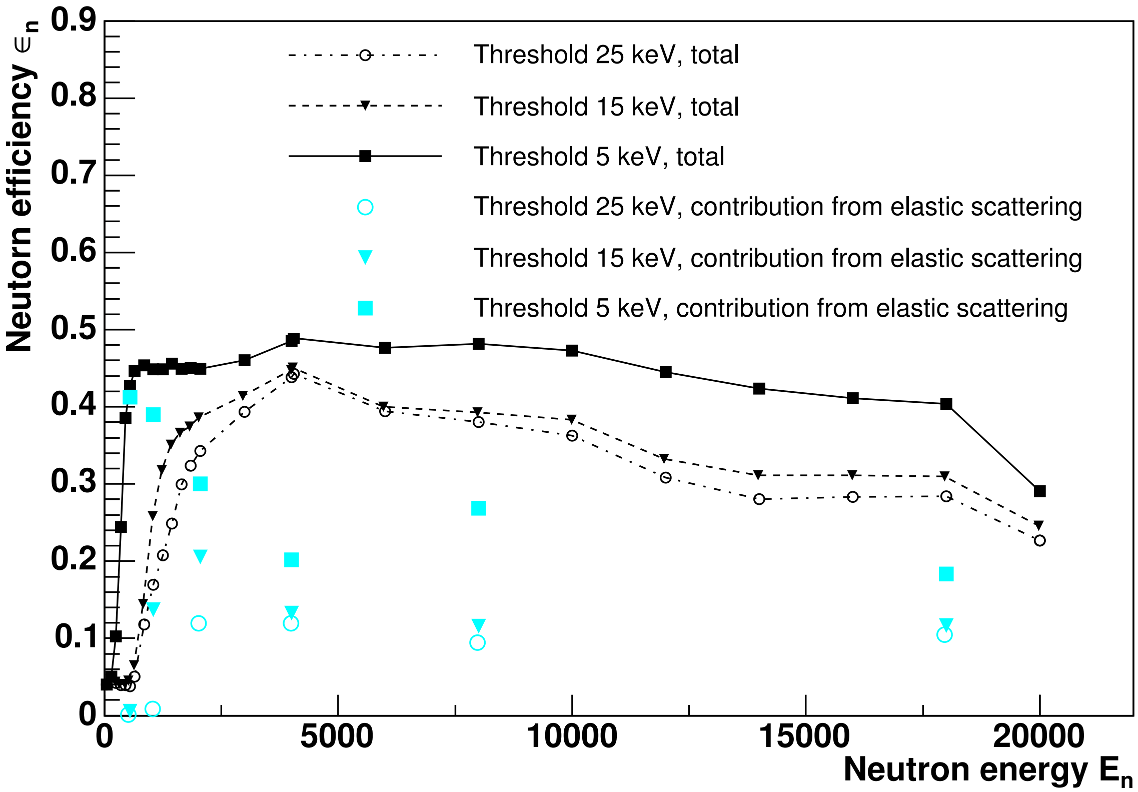
The rest of the presentation is based on:

- E. Farnea's GEANT4 AGATA simulation code. Small modification to keep track of energy depositions by germanium recoils.
- A. Lopez-Martens' tracking code. This means packing and smearing as described in `A. Lopez-Martens et al., Nucl. Instr. Methods A533 (2004) 454-466`. Energy uncertainty added.
- All results concerning individual interactions are post packing and smearing.

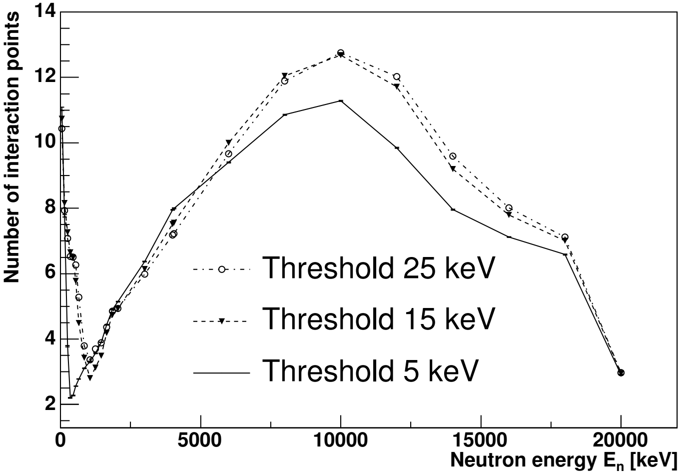


- Neutron energies were sampled from the above distribution.
- γ rays from the cascades $80 : 180 : 280 : \cdots : 2980$ keV and $100 : 400 : \cdots : 1300$ keV with 30 and 5 γ-rays each, respectively.

Neutrons will be seen in AGATA!!!



- 3-8 interactions above energy threshold per detected neutron for $E_n = 1 - 5$ MeV.
- Threshold independent.



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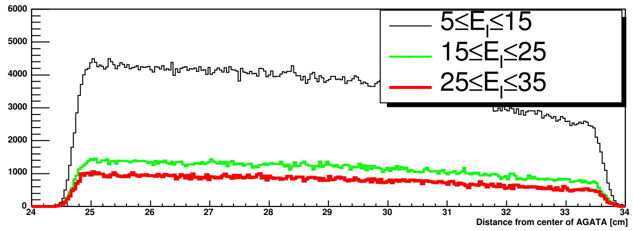
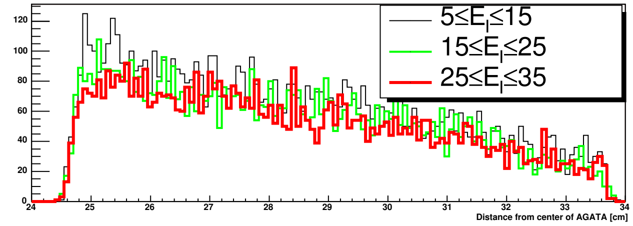
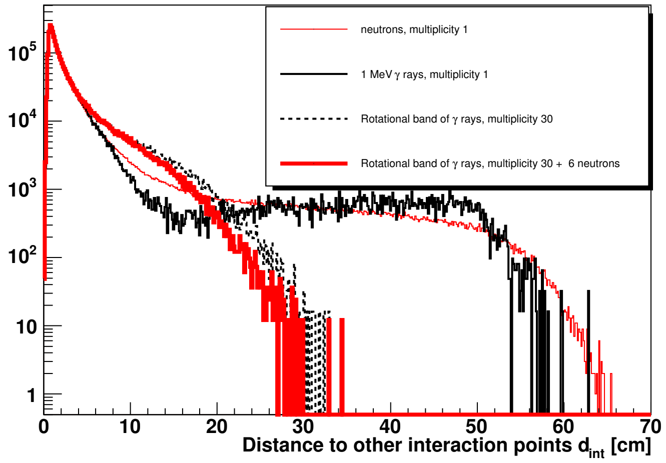
Neutrons look like γ rays!

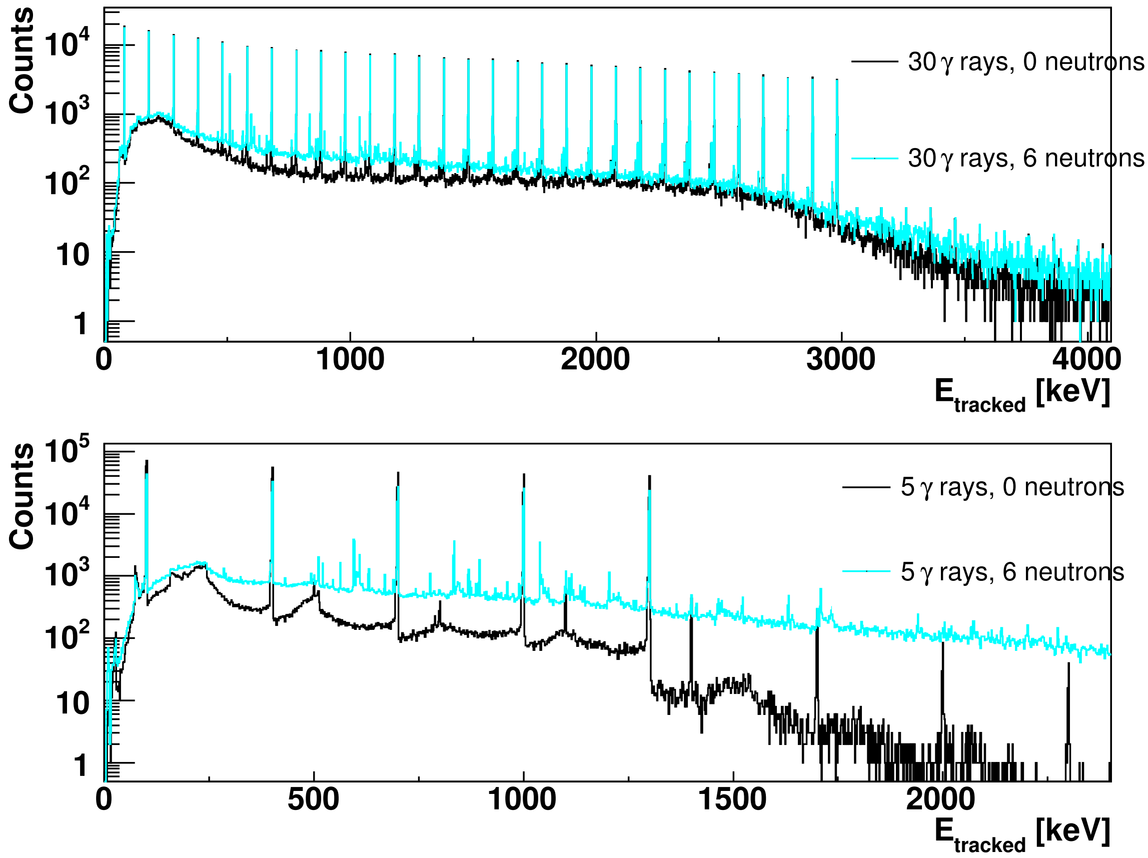
- The longitudinal interaction profile for fusion evaporation neutrons and 1 MeV γ rays is very similar.
- The distance between interaction points is similar for neutrons and γ rays.



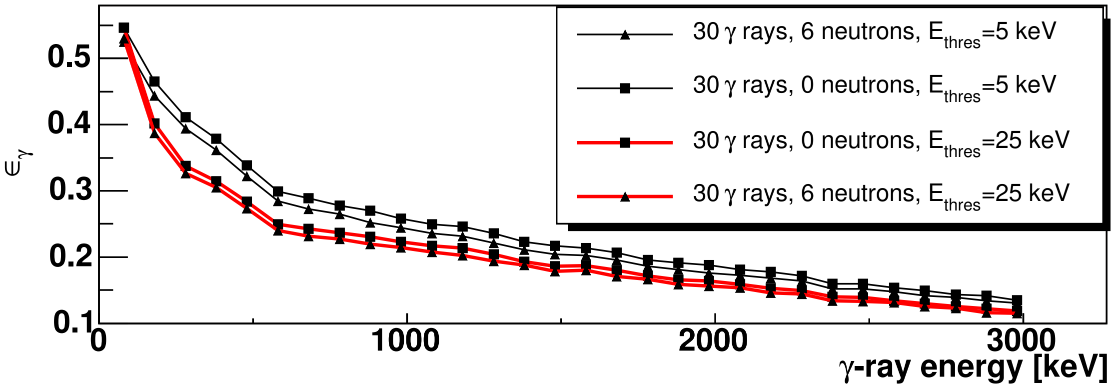


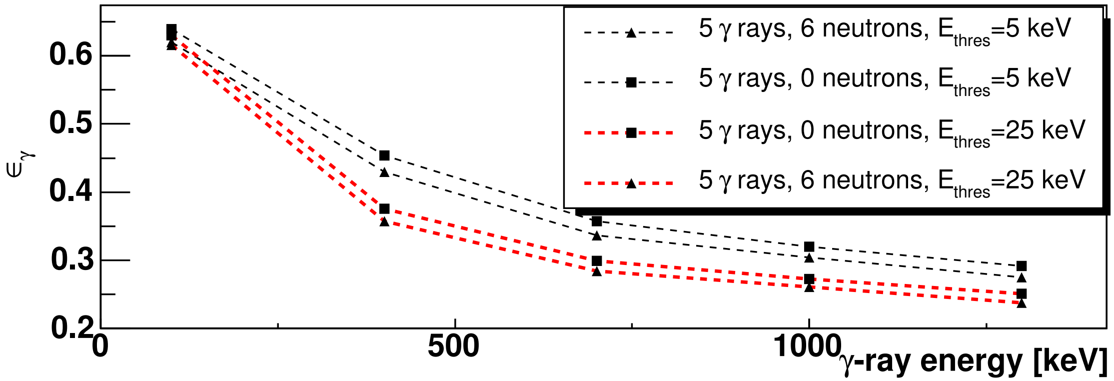


γ-ray tracking with and without neutrons.



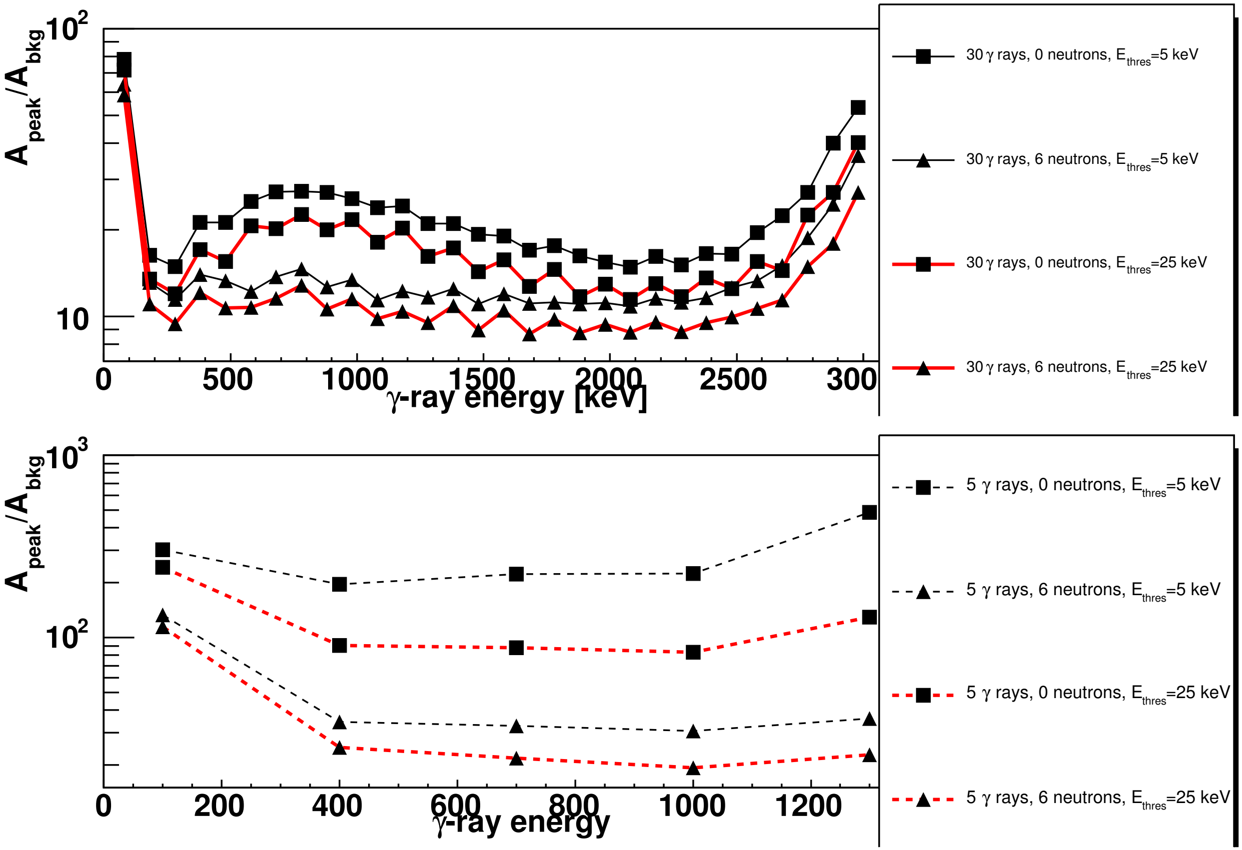
Total γ-ray peak efficiency ϵ_γ





ϵ_γ is reduced by about 1% for each emitted neutron.

Peak to background ratio



$E_\gamma \approx 1000$ keV, $E_{thres} = 5$ keV$\longrightarrow$

5 γ rays: 6 neutrons reduces peak to background with a factor of 7

30 γ rays: 6 neutrons reduces peak to background with a factor of 2

Conclusions:

- No pulse-shape difference between neutrons and γ rays in large volume germanium detectors.
- Neutrons have large interaction probability in AGATA.
- Total γ-ray peak efficiency after tracking is reduced by about 1% per emitted neutron.
- The peak to background ratio is reduced considerably for each emitted neutron due to the extra γ-rays from neutron-induced reactions.
- Attempts to find methods to discriminate neutrons and γ rays in AGATA unsuccessful so far.