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Background reduction in pulsed gamma beam experiments using segmented Germanium detectors

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Outline

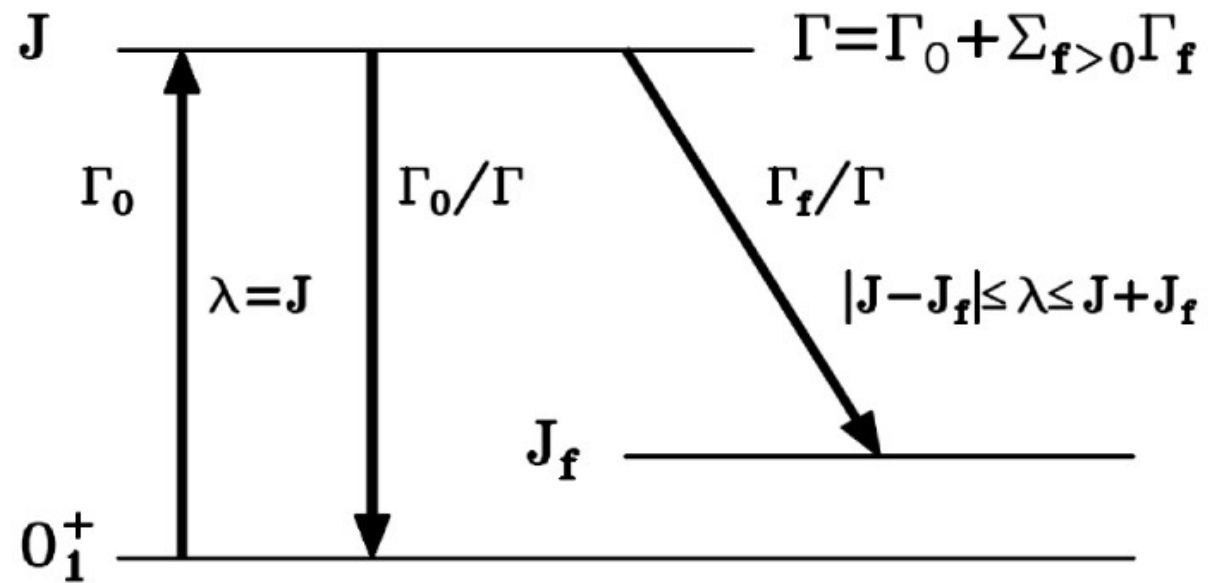
- Nuclear Resonance Fluorescence
- HPGe CLOVER detector
- The ELI-NP array of HPGe CLOVER detectors (ELIADE)
- Geant4 simulations
- Analysis



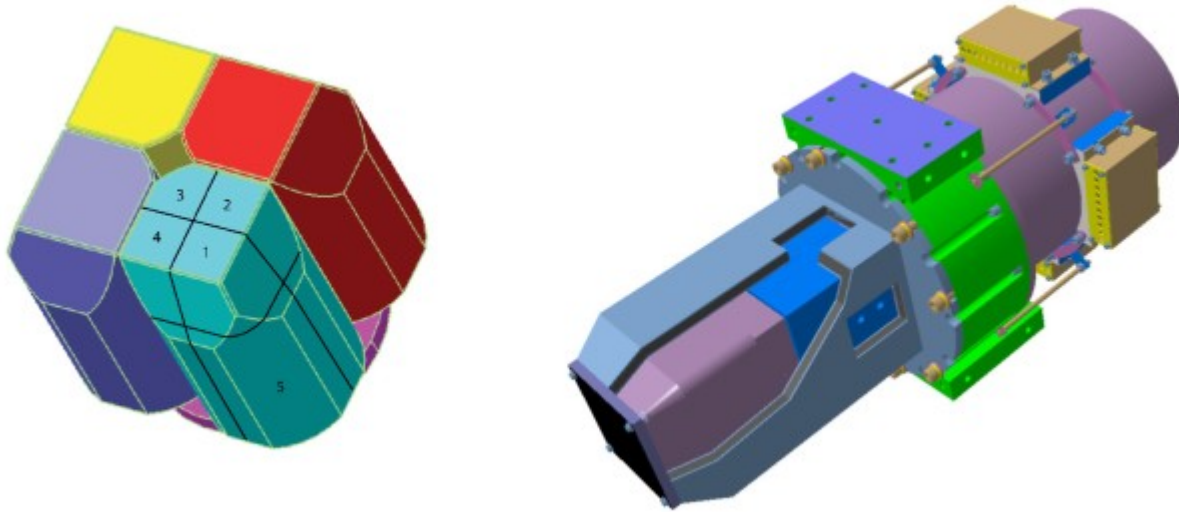
Nuclear Resonance Fluorescence

Observables

- Excitation Energy E_x
- Spin and parity J, p
- Decay Energies E_g
- Partial Widths Γ_i/Γ_0
- Multipole Mixing d
- Decay Strengths $B(p1)$
- Level Width Γ (eV)
- Lifetime t (ps – as)



HPGe CLOVER detector

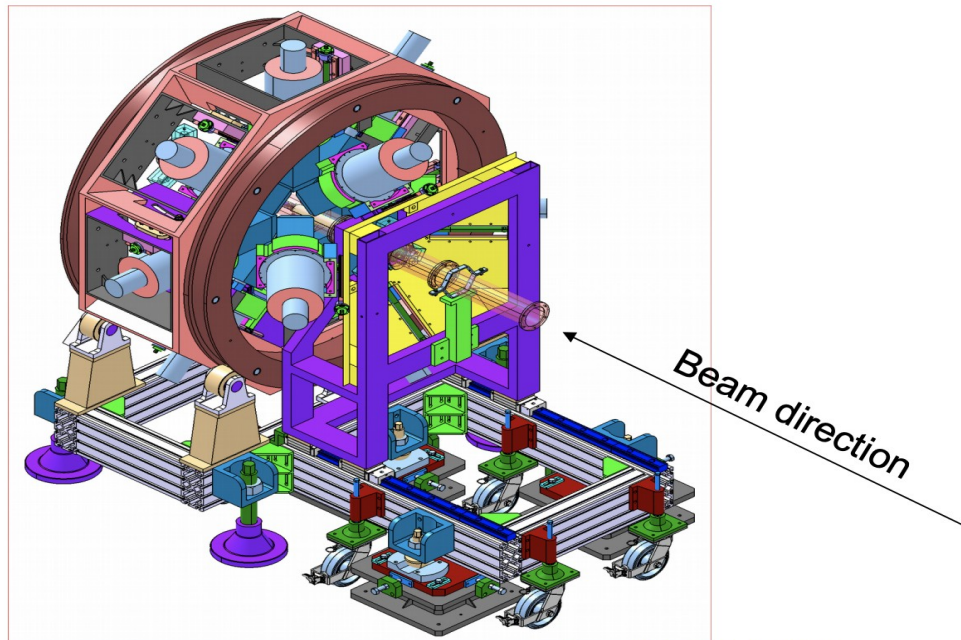


The CLOVER detector crystals geometry

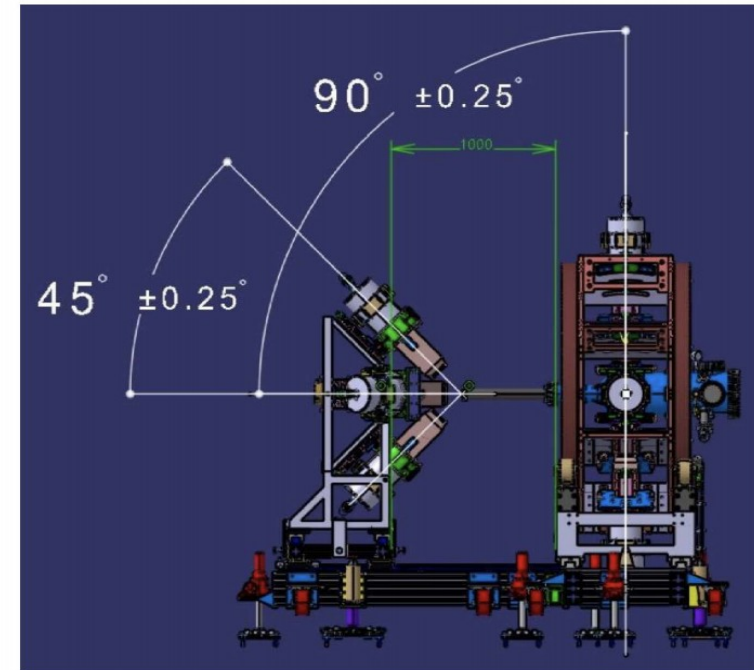
The efficiency of the CLOVER detectors is much improved by the add-back procedure of summing together the individual gamma-ray releases of energy in all four crystals.

The ELI-NP array of detectors (ELIADE)

- proposed for Nuclear Resonance Fluorescence experiments
- 8 segmented high-purity Ge clover detectors and additional 4 large LaBr₃ scintillator detectors



courtesy of C. Petku ELI-NP



The ELI-NP array of detectors (FI IADF)

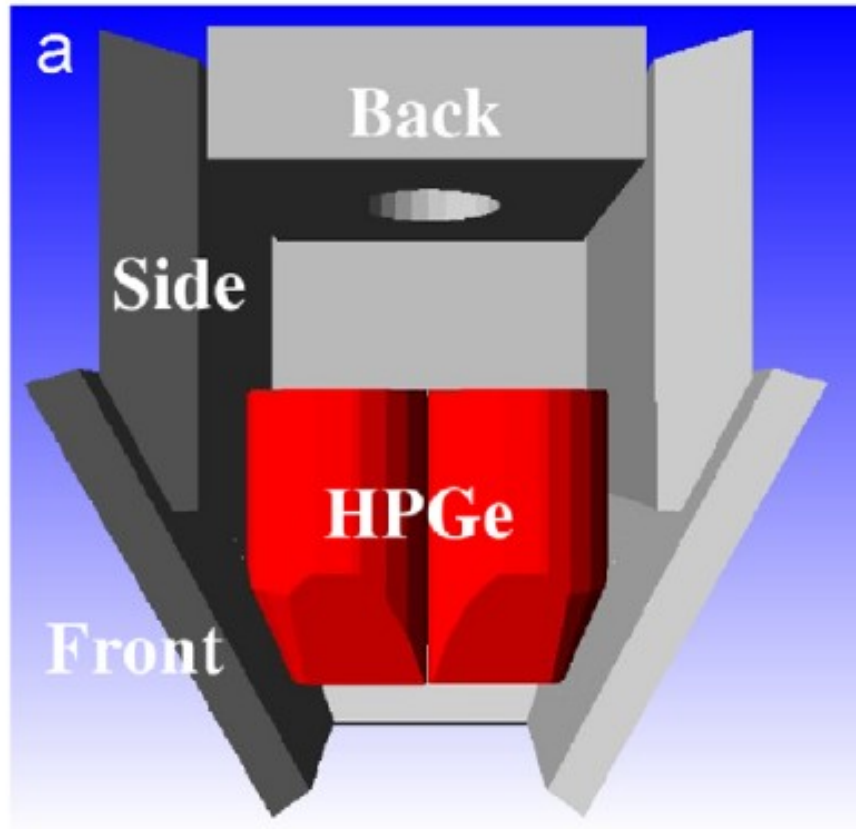
Challenge

- The high intensity of the beam that will produce a very large γ -ray background
- This background will be strongly correlated with the time structure of the beam

Solutions

- Shield the detectors with thick lead and/or copper attenuators (low energy γ rays)
- Use segmented Clovers (reduce the counting rate to 1 γ per macro-pulse per segment)

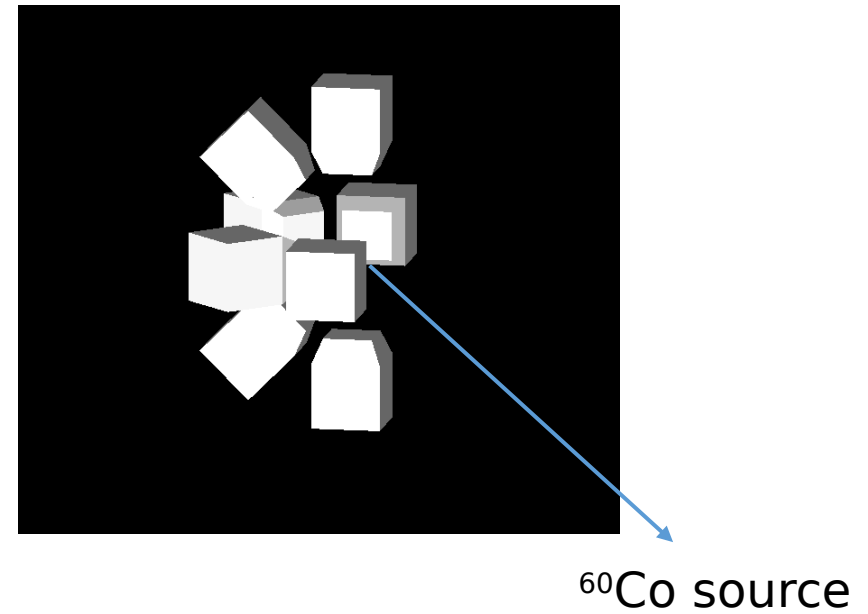
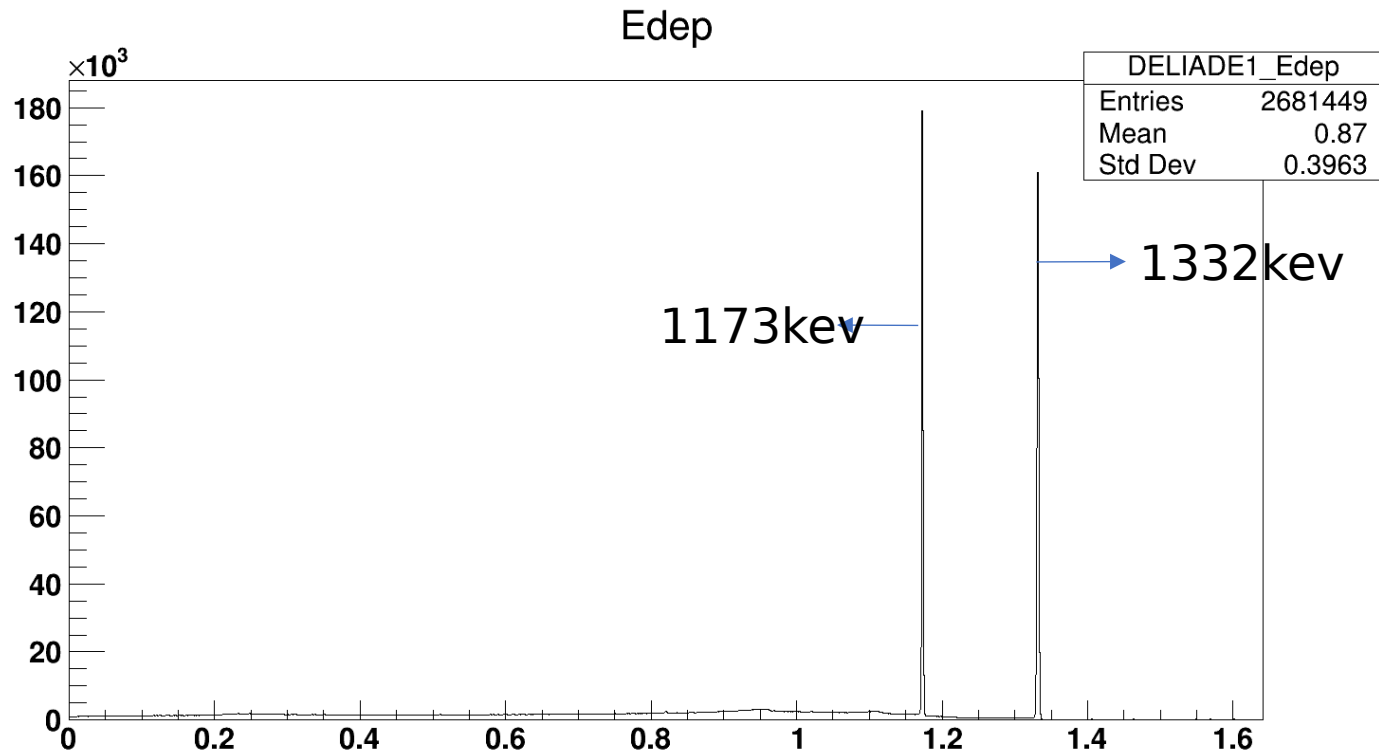
The ELI-NP array of detectors (FI IADF)



Anti-Compton Shields

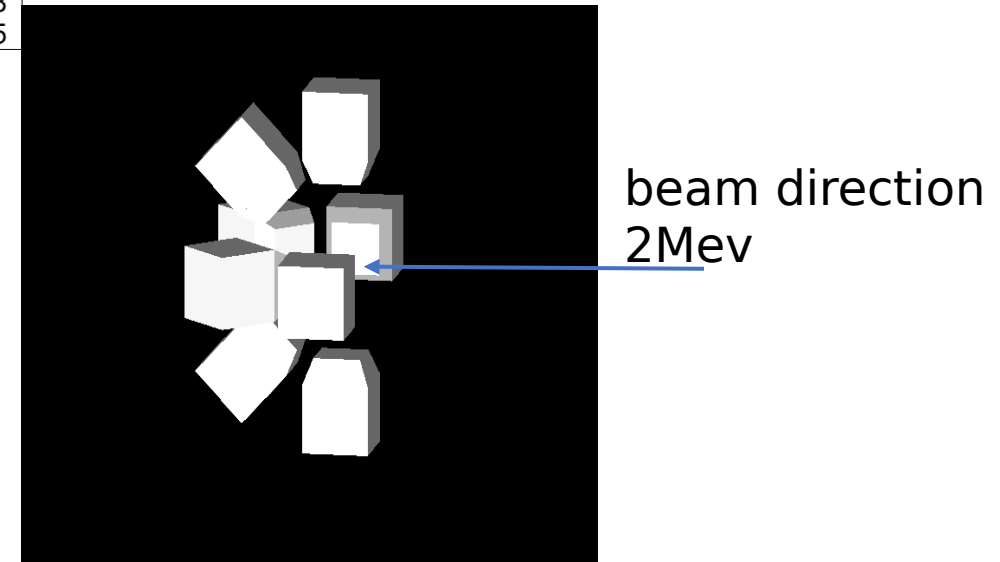
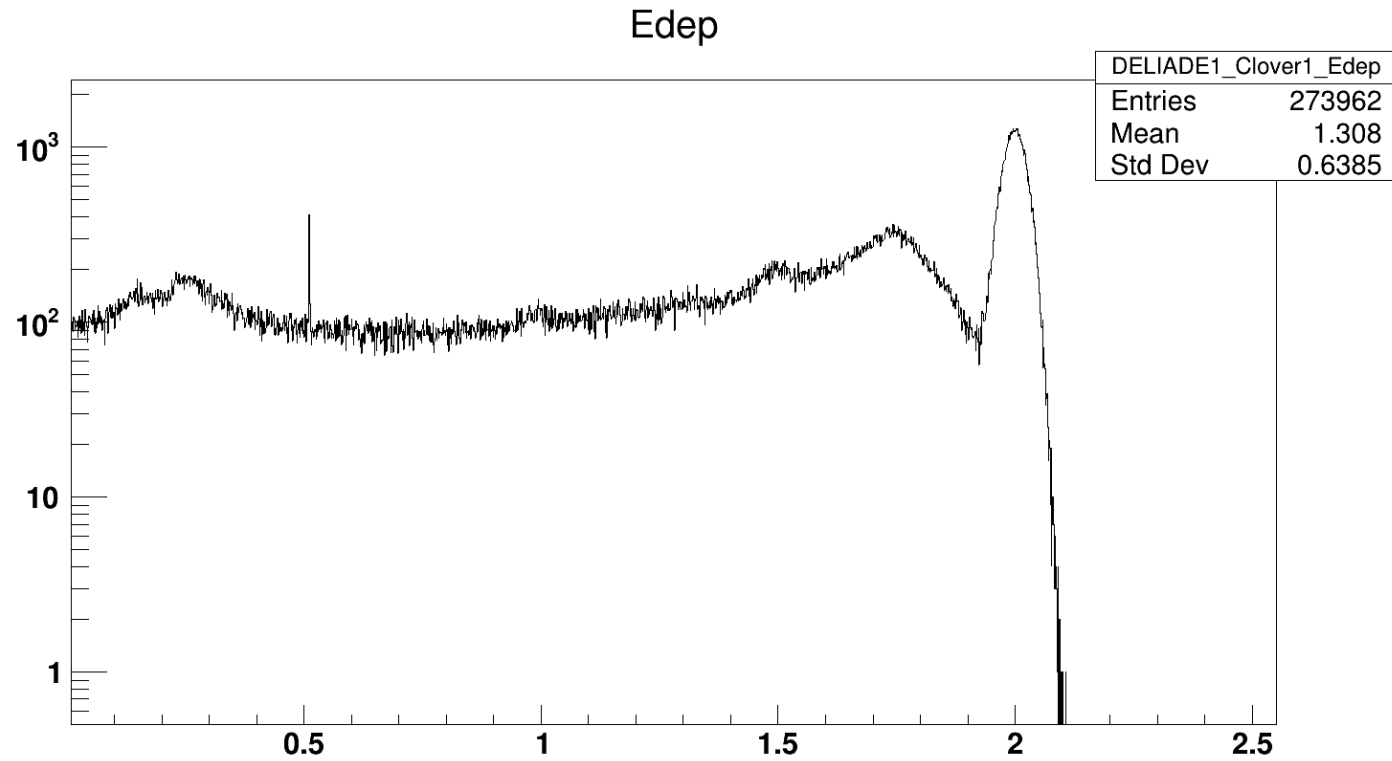
- Front shield (BGO)
- Side shield (BGO)
- Back atcher (CsI)

Geant4 simulation



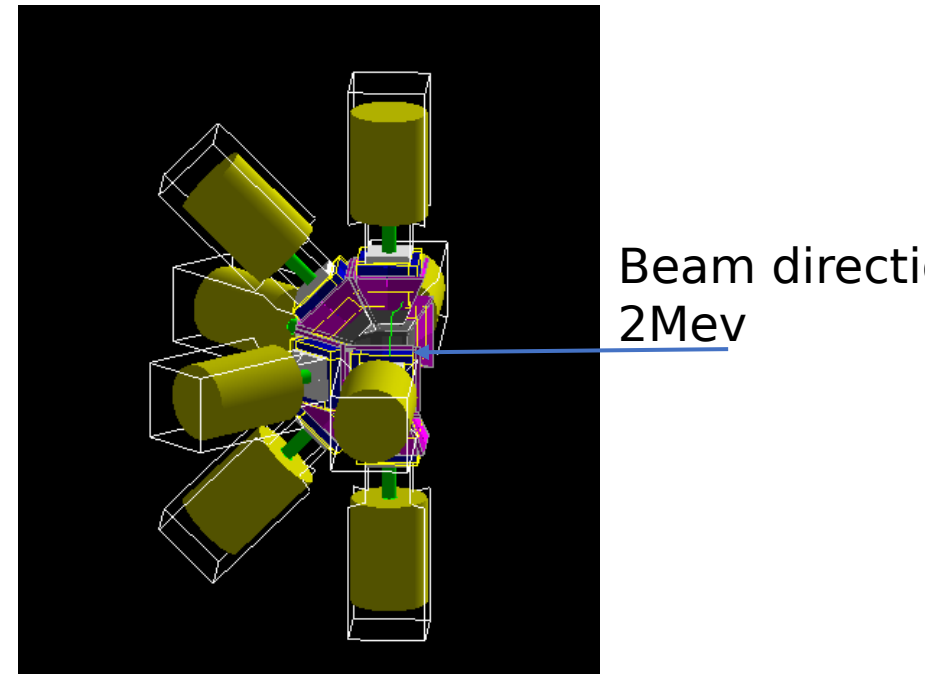
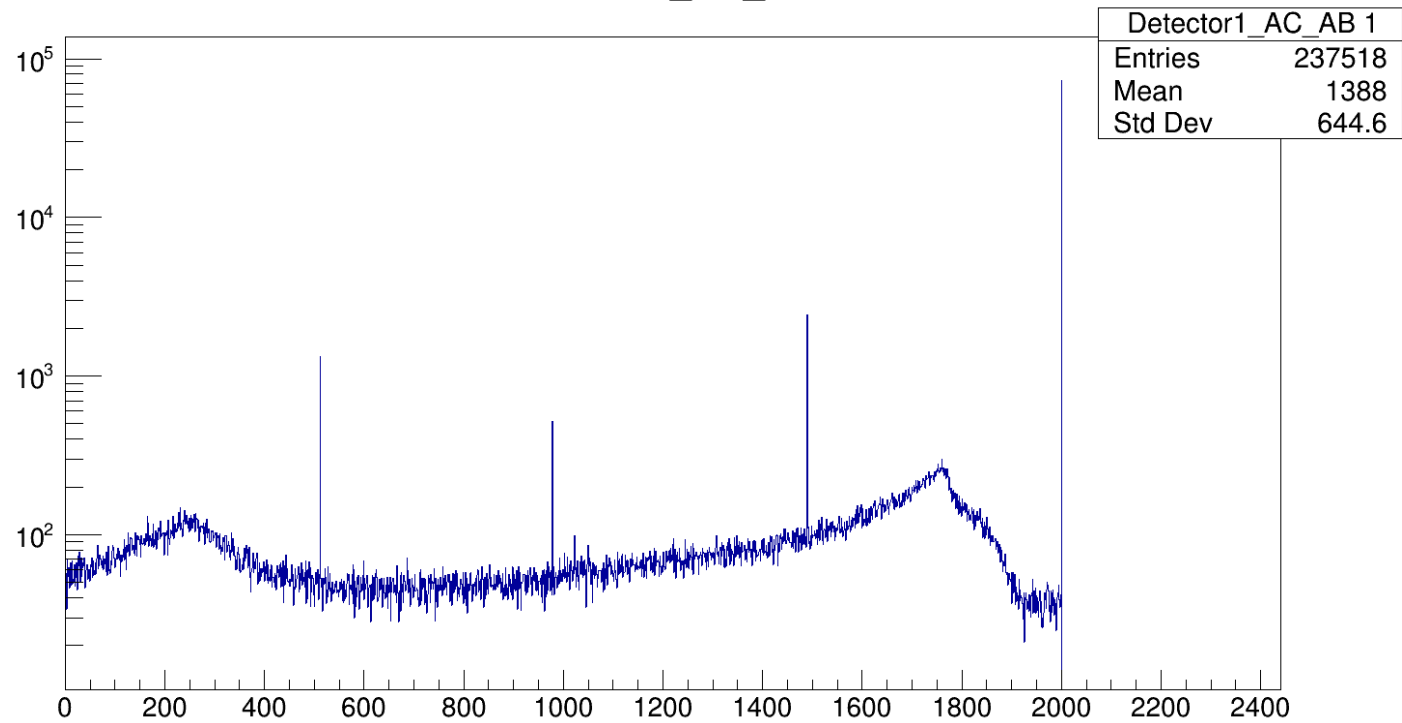
A typical energy spectrum
obtained by HPGe detectors
calculated by GEANT4

Geant4 simulation



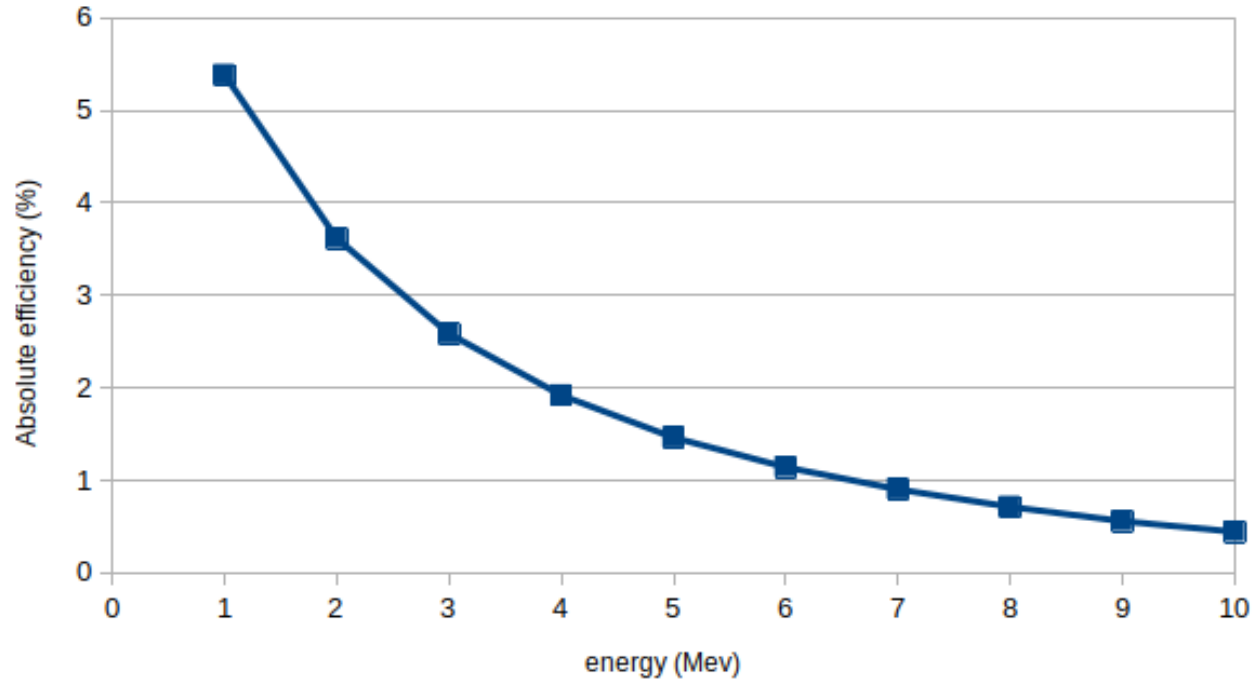
Geant4 simulation

Detector1_AC_AB 1

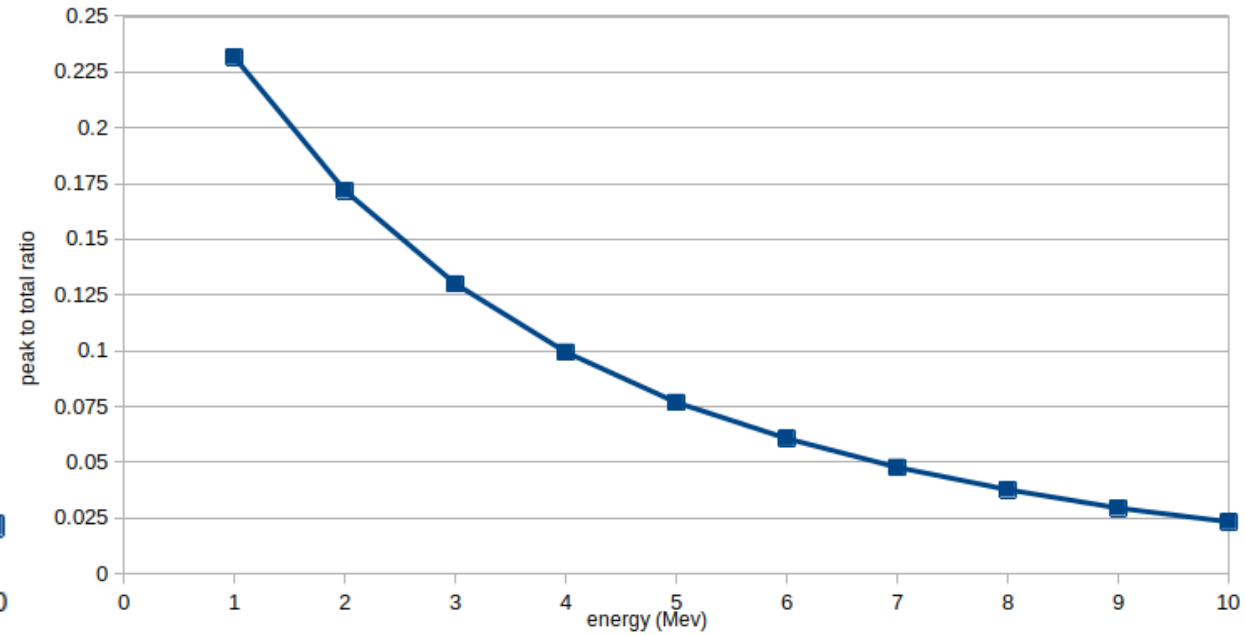


Analysis

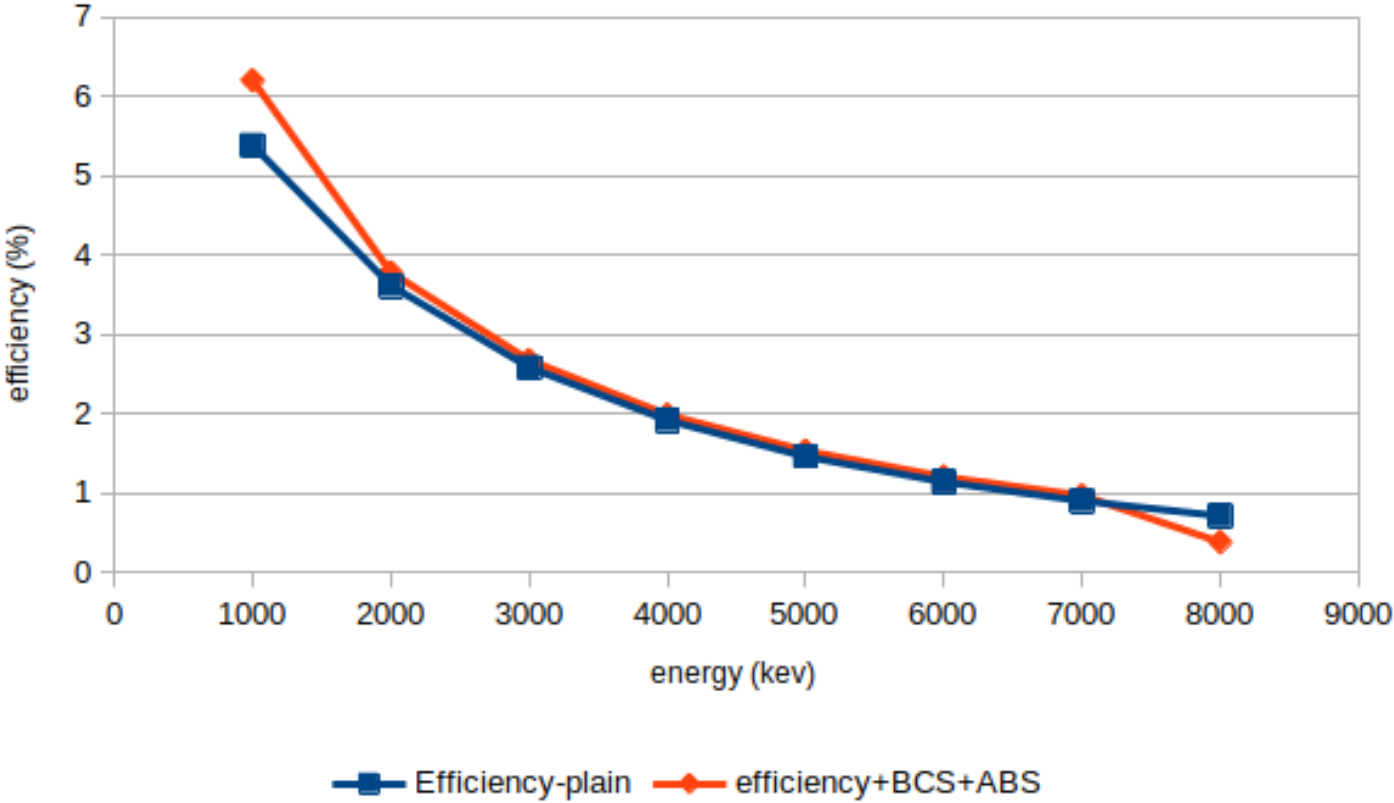
Efficiency vs Energy



peak to total ratio



Analysis

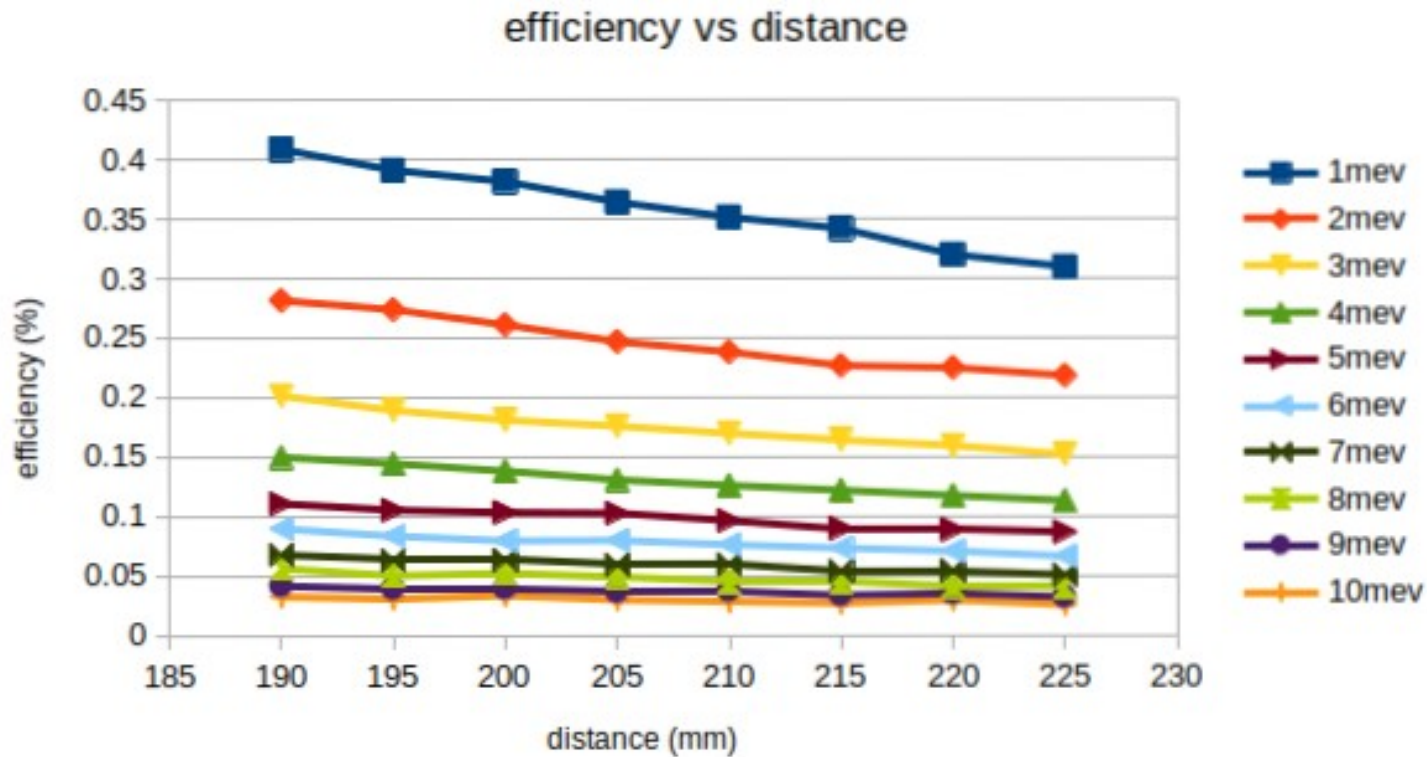


Energy: 1-8Mev GBS

Distance: 15cm

Events: 10000000

Analysis



Energy: 1-10MeV GBS

Distance: 190-225mm

Events: 10000000

What's next?

- Optimizing the Anti-Compton Shielding codes
- Different source, position, shielding
- Validating experiments

References

- Calin A. Ur etc. *Nuclear physics with advanced brilliant gamma beams at ELI-NP*
- Gabriel Suliman *The segmented clover detector array (ELIADE) for NRF experiments at ELI-NP*
- P.-A. Söderström *HIGH-RESOLUTION GAMMA-RAY SPECTROSCOPY WITH ELIADE AT THE EXTREME LIGHT INFRASTRUCTURE*

Thank you

ELI-NP Group

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