

Monte Carlo Simulation of the Nonlinear Full Peak Energy Responses for Gamma-Ray Scintillation Detectors

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Introduction

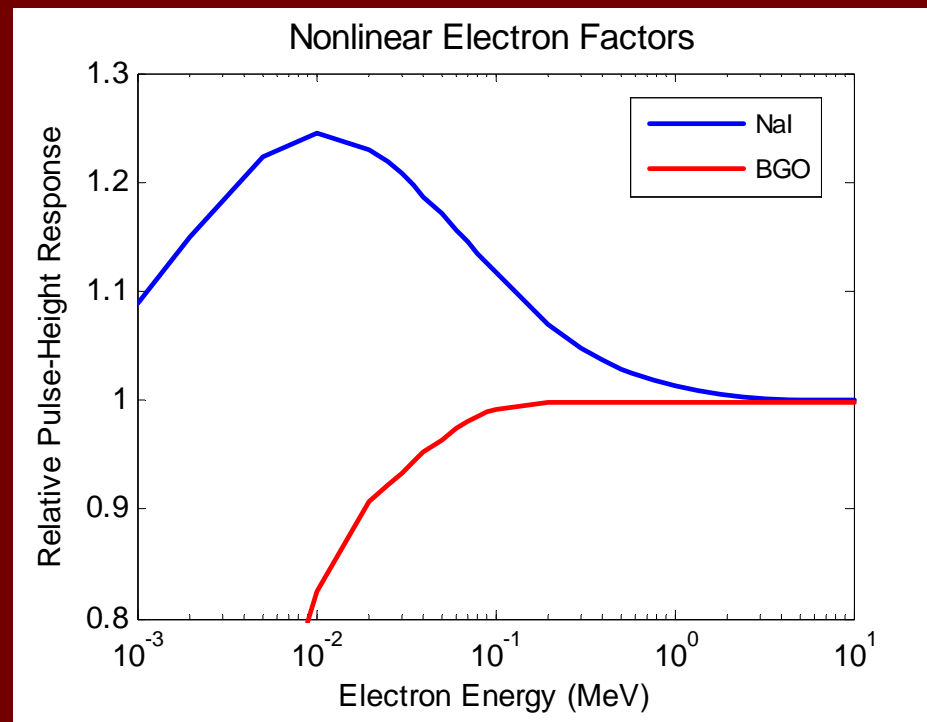
- Nonlinearity of NaI detectors well documented
- Experimental measurements
 - Heath
- Semi-empirical modeling
 - Gardner and Sood
- Direct relationship by Monte Carlo

Monte Carlo Code

- Specific purpose code - NONLIN
- Analog Monte Carlo
- Full peak energy pulse height
- Effectively infinite detector
 - Neglect spatial tracking of photon direction and position
 - Continue tracking events until a final photoelectric absorption occurs

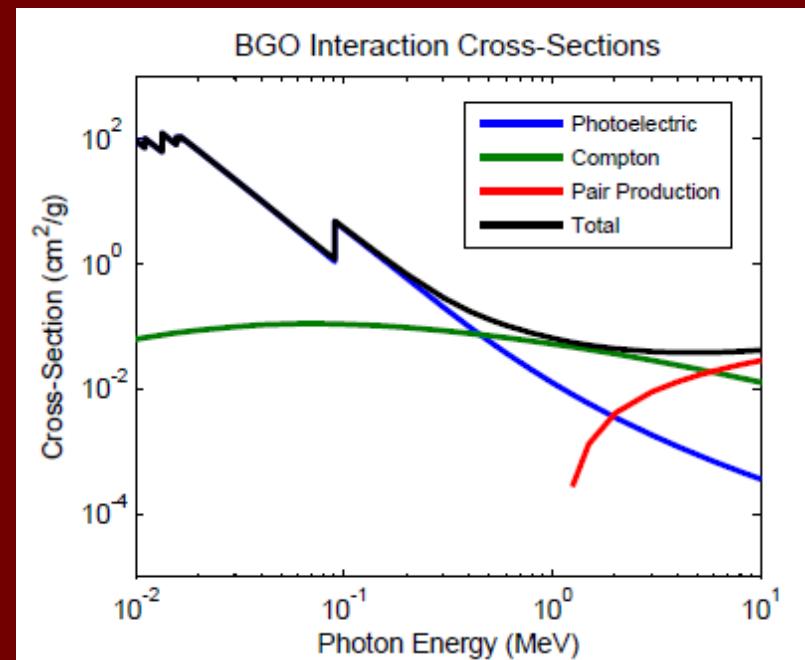
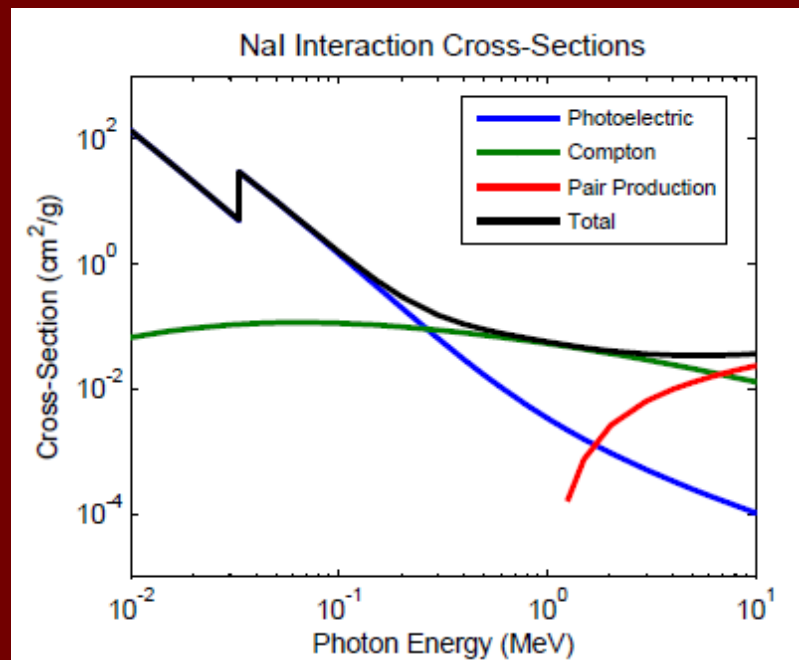
Detector Response to Electrons

- Detector response of NaI and BGO to secondary electrons (Valentine, Taulbee)



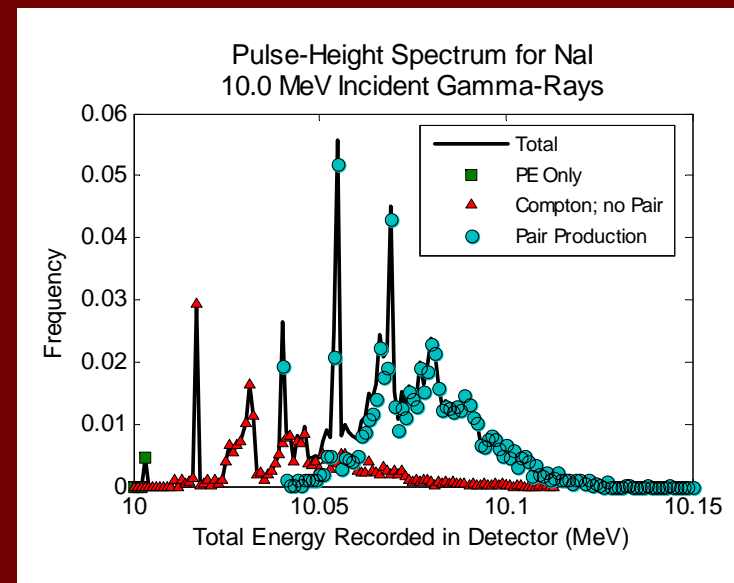
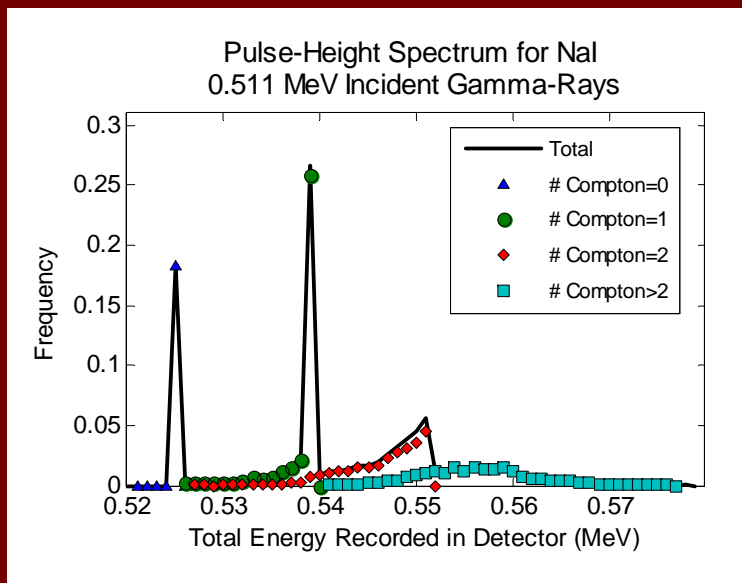
Cross-Section Data

- Photoelectric effect, Compton scatter, and pair production cross-sections (NIST)



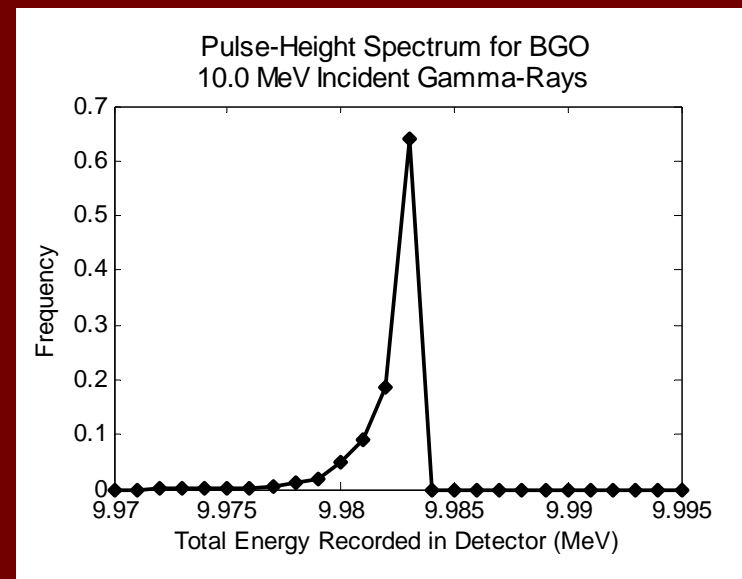
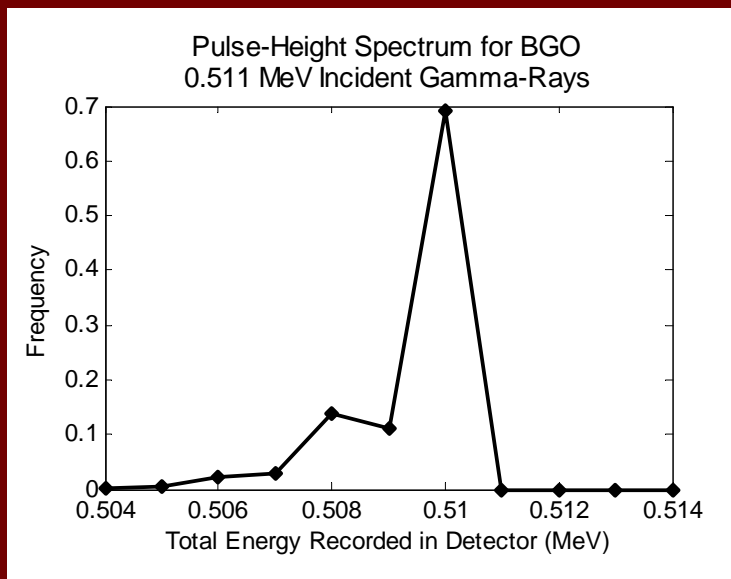
Simulation Results

- Features associated with specific interaction chain-of-events



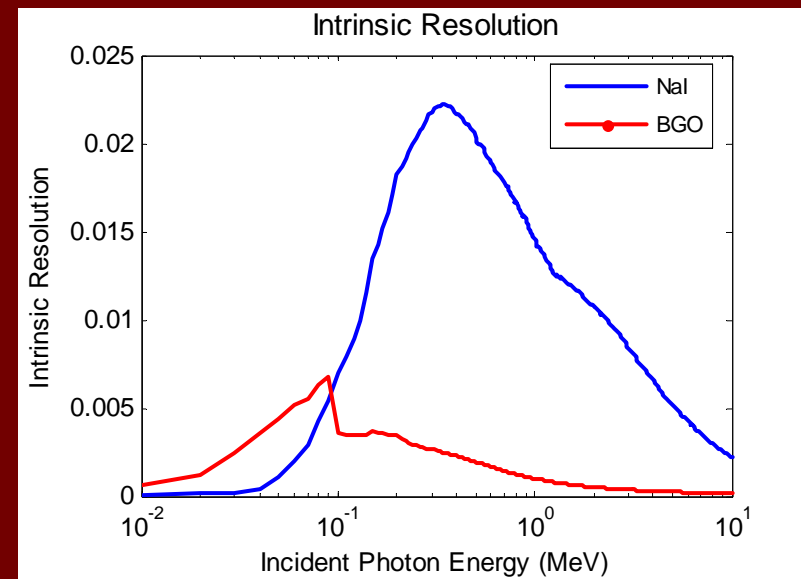
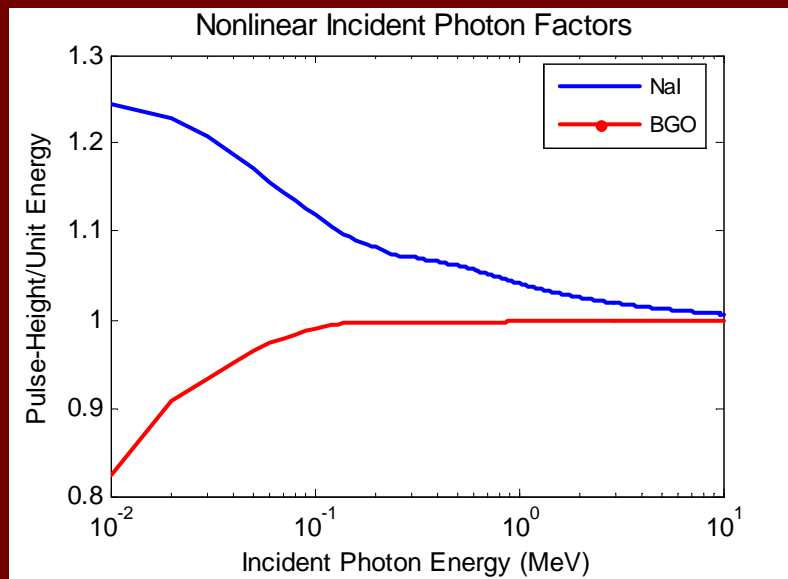
Simulation Results

- BGO pulse-height response leads to tailing at lower energies



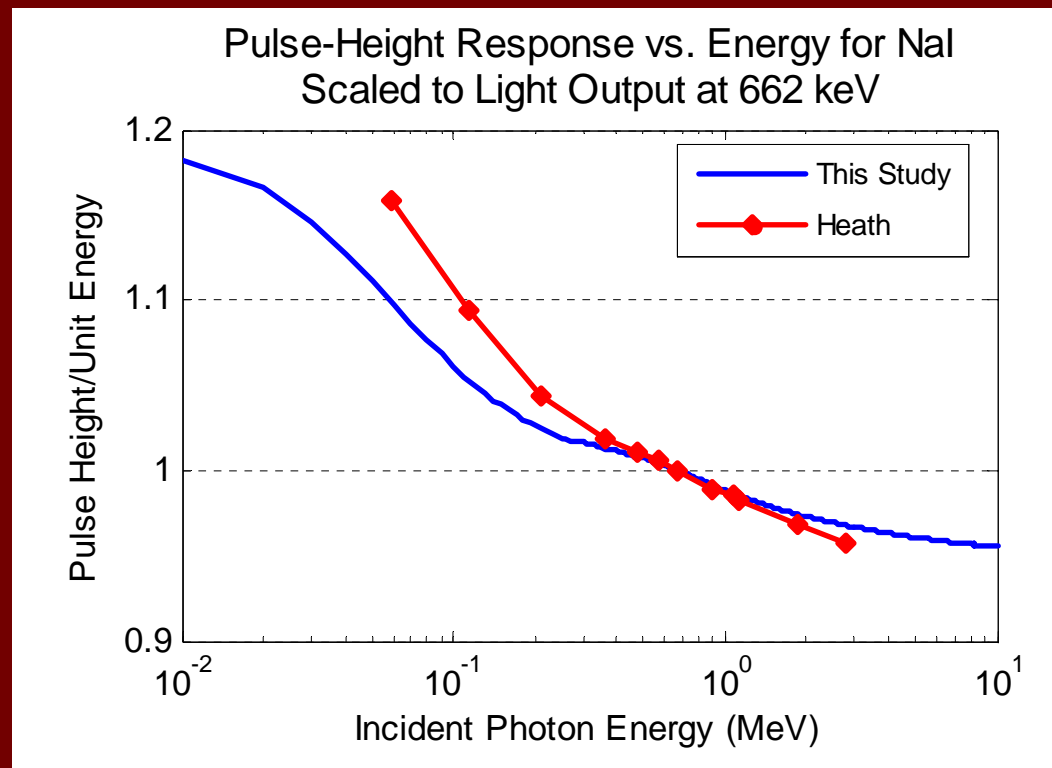
Nonlinear Factors and Resolution

- Discontinuity in BGO intrinsic resolution at K absorption edge for bismuth



Comparison to Heath Data

- NONLIN result 6% less at 0.06 MeV
- Within 1% between 0.36 and 2.7 MeV



Low Energy Response

- Measurements of Engelkemeir indicate variation in response **up to 20%** below 100 keV
- Most likely due to physical characteristics of detector
 - i.e. detector size and reflector material
- NONLIN neglects these characteristics
 - treats detector as an effectively-infinite bare crystal
- Heath suggests measurement of specific detector

References

- R.L. **Heath**, Scintillation Spectrometry Gamma-Ray Spectrum Catalog, IDO-16880-1, AEC Research and Development Report, Physics, TID-4500, 1964.
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- J.D. **Valentine**, B.D. Rooney, P. Dorenbos, More on the Scintillation Response of NaI(Tl), IEEE Trans. Nucl. Sci. 45(3) (1998) 1750-1756.
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- D. **Engelkemeir**, Nonlinear Response of NaI(Tl) to Photons, Rev. Sci. Instr. 27(8) (1956) 589-591.