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[[1]](#footnote-1)

LaBr3 Detector Gaussian Broadening

*Abstract*— Blah

*Index Terms*—Counting Statistics, Gamma-Ray Detection, Scintillation, Monte Carlo, NIM, Radiation Detection Electronics

# INTRODUCTION

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ODELING nuclear radiation interactions with detectors is an important aspect of research in nuclear sciences. Monte Carlo N-Particle Transport Code Version 5 (MCNP5) has the capability of modeling the interactions to produce an expected gamma spectrum from a source. The goal of this project is to characterize the gaussian broadening of a 1.5”x1.5” Lanthanum Bromide (LaBr3) detector full width half maximum (FWHM) as a function of energy for use in MCNP5.

Inorganic scintillators can detect gamma radiation where the energy is converted to signals for processing. An ideal spectrometer would produce a delta function for the energy at the gamma ray full energy peak (FEP) [1]. The non-ideal response of the detector produces a spread in the energy deposited. Lanthanum halide scintillation detectors have effective scintillator characteristics including excellent energy resolution (3-4% at 662 keV), high Z, high density, and a fast decay time [2].

MCNP5 does not automatically handle the energy response in a detector with gaussian broadening of the energy peaks. Instead, the energy is deposited discretely. A realistic detector response will have spread in the energy. The gaussian broadening of the energy peak can be implemented by MCNP5 with user supplied inputs [3].

# Theory

Gamma radiation spectroscopy can be used to identify radioactive sources amongst other things. Gamma radiation interacts with matter though the photoelectric effect, Compton effect, and pair production. The FEP can be used to determine the radioactive source by the emission energy. Scattered photons have a continuum of energies under the FEP [1]. Additional peaks are present in the spectroscopy; however, they do not contribute as much to source characterization. The Compton edge occurs when maximum energy is transferred to an electron in a single Compton scatter. A backscatter occurs when a gamma scatters off surrounding material and back into the detector. An annihilation peak at 511 keV is produced with pair production.

MCNP5 has a special treatment for gaussian energy broadening to better simulate energy peaks in a radiation detector [3]. The input requires a fit to a gaussian function, where E is the broadened energy, E0 is the unbroadened energy, C is a normalization constant and A is the gaussian width [3]

(1)

The gaussian width (also the standard deviation here) is related to the full peak FWHM by:

(2)

The FWHM used by MCNP takes inputs to fit the energy broadening. The constants are detector dependent, so the constants are experimentally determined. The FWHM is fit to:

(2)

The LaBr3 (Talk about where gammas in terms of energy, how data is fit(least sq), and

# Experiment

The testing includes the setup of a NIM general purpose detection system. After the system is setup, a counting experiment is performed using Cesium 137, Cobalt 60, Sodium 22, and Europium 152 as sources. These were chosen since the expected peaks that were collected are easily separated from the others and are easily separated from their respective compton edges and back scatter.

A LaBr3detector was used to register the gammas and a MCB with Gamma Vision was used to create the spectrums individually. Sources were placed as close to the detector as possible without causing the dead time to exceed two percent. Each source was ran on its own and the set up was used for the entire duration without stopping for more than a few minutes. The time ran to collect each sources spectrum was varied since each source was different in how quickly the relevant peak could be identified. Gamma Vision was set to use its max amount of channels (8192).

# Results and Discussion

The testing includes the setup of a NIM general purpose detection system. After the system is setup, a counting experiment is performed using a pulser as a source.

# References

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| [1] | "Lab Manual, NaI: Gamma-Ray Spectroscopy," NENG 605, AFIT, Winter 2018. |
| [2] | G. F. Knoll, Radiation Detection and Measurement, Ann Arbor, MI: Wiley, 2010. |
| [3] | X-5 Monte Carlo Team, "LA-UR-03-1987," Los Alamos National Laboratory, Los Alamos, NM, 2003. |
| [4] | W. R. Leo, Techniques for Nuclear and Particle Physics Experiments, New York: Springer-Verlag, 1994. |

TABLE III

Count Rate Results

|  |  |  |
| --- | --- | --- |
| Series | Count Rate  [Counts per Minute] | Count Rate Error  [Counts per Minute] |
| 5 x 1-min Counts | 3598.2 | 26.8 |
| 3 x 5/3-min Counts | 3598.4 | 26.8 |
| 2 x 2 ½-min Counts | 3598.2 | 26.8 |
| 1 x 5-min Count | 3598.4 | 26.8 |

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