LA-UR-17-22498



Title: Energy-Dependent Peak Shifts in LaBr3 Detectors

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Intended for: Report

Issued: 2017-03-28

# Energy-Dependent Peak Shifts in LaBr3 Detectors

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## I. Overview

Significant peak shifts were noted in a laboratory LaBr3 detector. To investigate these issues, three LaBr3 detectors were used to collect spectra of Cs-137 with either Co-57, Co-60, or no secondary source included. The cobalt source locations were varied to control the deadtime, while the Cs-137 source remained in a fixed position relative to the detectors. Each setup was measured with a 0.8 µs and a 3.2 µs shaping time. All spectra were measured for a 100 second live time.

All three LaBr3 detectors were experienced peak-shifting as a function of deadtime and gamma-ray energies. However, the first detector (Detector A, described below) had significantly more severe peak-shifting which was also affected by the shaping time.

## II. Equipment Used

Three LaBr3 detectors were used in these measurements.

- Detector A:
    - St Gobain Brilance 380 LaBr3
    - Model: 51 SEA 13 12 /TH
    - PM: R 6231-100-01
- Detector B:
    - St Gobain Brilance 380 LaBr3
    - Model 51 SEA 13 12 /TH
    - PM R 6231-100-01
- Detector C:
    - St Gobain Scintibloc
    - Model: 25 S 38
    - PM XP 2060 B

For these detectors, the same amplifier, MCA, and power supply were used (a Canberra InSpector 2000, Model IN2K). The pole-zero was manually set for each detector.

## III. Peak Shifting vs Deadtime

The primary symptom of the bad detector is that it experiences significant peak shift, and the magnitude of the effect seems to have some energy dependence (i.e. the magnitude of the peak shift was significantly greater for the spectra with Co-60 than with Co-57) and significant shaping time dependence.

Here, the channel of the 662 keV peak of Cs-137 was measured in several source configurations, varying the input rate from the cobalt sources while keeping the cesium source stationary.

The peak-shifting behavior of Detector A is shown in Figure 1 and detailed further in Table 1. First, at low deadtimes, the 662 keV peak centroid shifts approximately 90 channels simply by increasing the shaping from 0.8 µs to 3.2 µs (while keeping the deadtime constant). This effect may suggest an issue with the preamplifier, although the output of the preamplifier does not appear different than that of the other detectors when manually observed with an oscilloscope.

Table 1: Peak shifting of Detector A

| Source | Shaping time (µs) | Peak Shift per % deadtime | Channel at 0% deadtime |
|---|---|---|---|
| Co-57 | 0.8 | 1.67 | 956.8 |
| Co-57 | 3.2 | 1.32 | 1033.4 |
| Co-60 | 0.8 | 2.44 | 954.6 |
| Co-60 | 3.2 | 8.30 | 1063 |

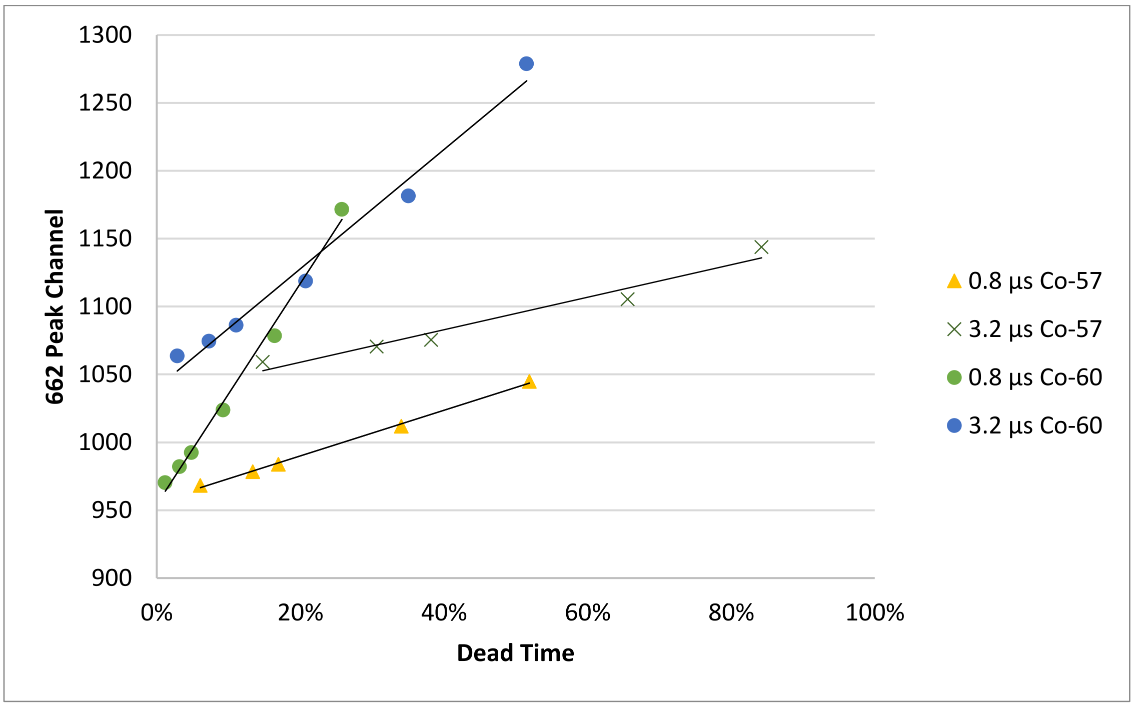


Figure 1: 662 keV Centroid vs Deadtime, LaBr3 Detector A

The other two detectors did experience a small amount of peak shifting, as shown in Figures 2-3 and quantified in Tables 2-3. However, the magnitude of these shifts were much smaller (2.5 – 10x smaller). Further, these detectors did not experience a large peak shift at low deadtimes when the shaping time was changed.

Table 2: Peak shifting of Detector B

| Source | Shaping time | Peak Shift per % deadtime | Channel at 0% deadtime |
|---|---|---|---|
| Co-57 | 0.8 | 0.437 | 904.92 |
| Co-57 | 3.2 | 0.313 | 906.06 |
| Co-60 | 0.8 | 2.678 | 901.06 |
| Co-60 | 3.2 | 1.120 | 905.97 |

Table 3: Peak shifting of Detector C

| Source | Shaping time | Peak Shift per % deadtime | Channel at 0% deadtime |
|---|---|---|---|
| Co-57 | 0.8 | 0.642 | 983.8 |
| Co-57 | 3.2 | 0.354 | 985.7 |
| Co-60 | 0.8 | 2.152 | 991.77 |
| Co-60 | 3.2 | 0.816 | 995.73 |

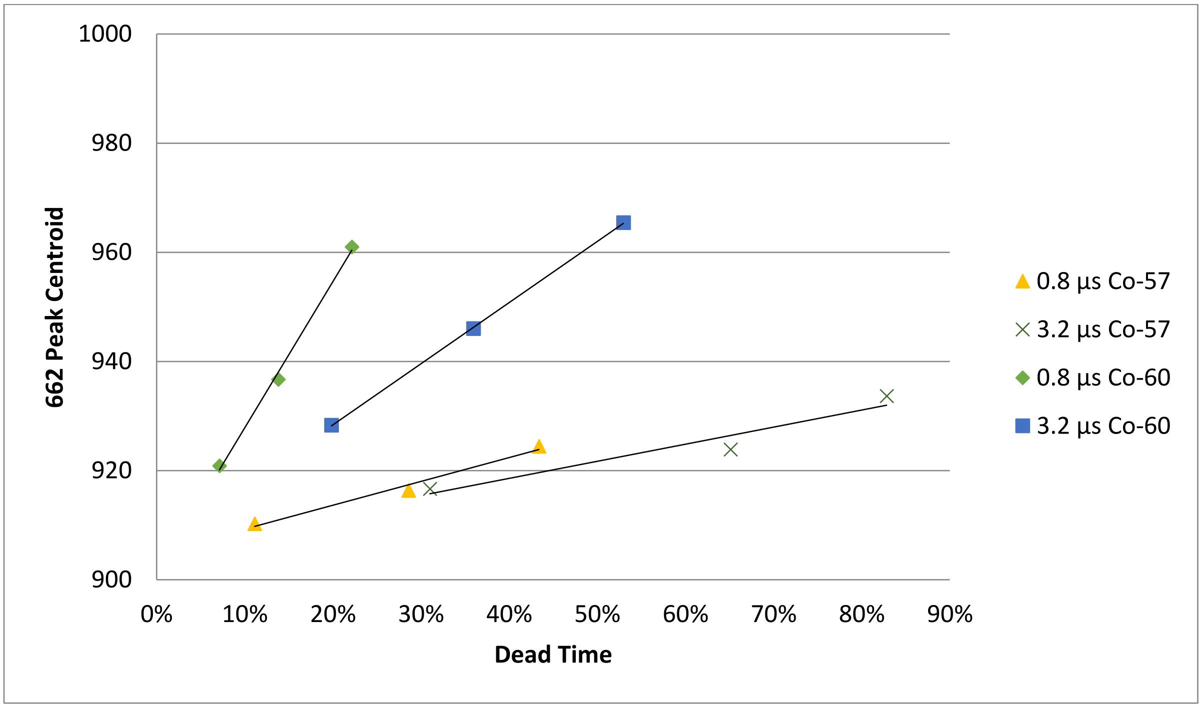


Figure 2: 662 keV Centroid vs deadtime, LaBr3 Detector B

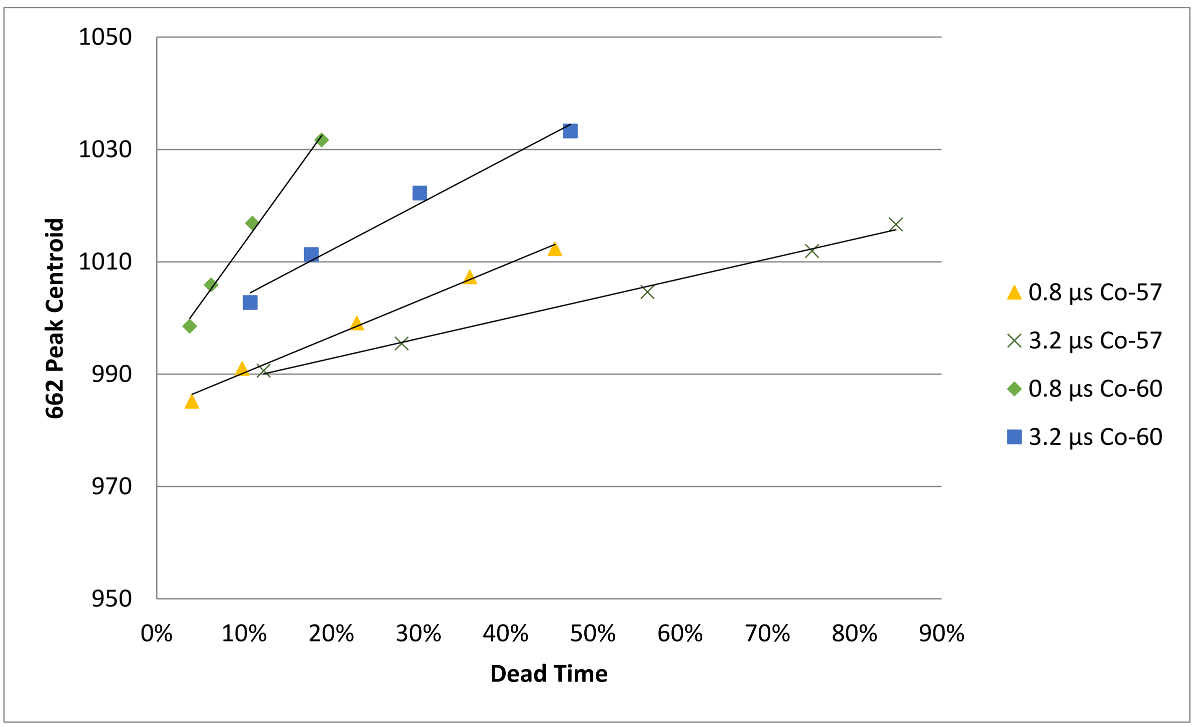


Figure 3: 662 keV Centroid vs Deadtime, LaBr3 Detector C

## IV. Peak Shifting vs Energy Rate

Another way to demonstrate the peak shifting of Detector A is to consider the energy throughput rate (the energy recorded by the detector system per unit live time). As shown below, the peak shifting of Detector A strongly depend on both shaping time and the isotope. Note that because Co-60 emits higher energy gamma-rays than Co-57, for a given energy rate, the deadtime of the Co-57 spectrum will be larger than that of the Co-60 spectrum because a higher count rate is needed to achieve the same energy rate.

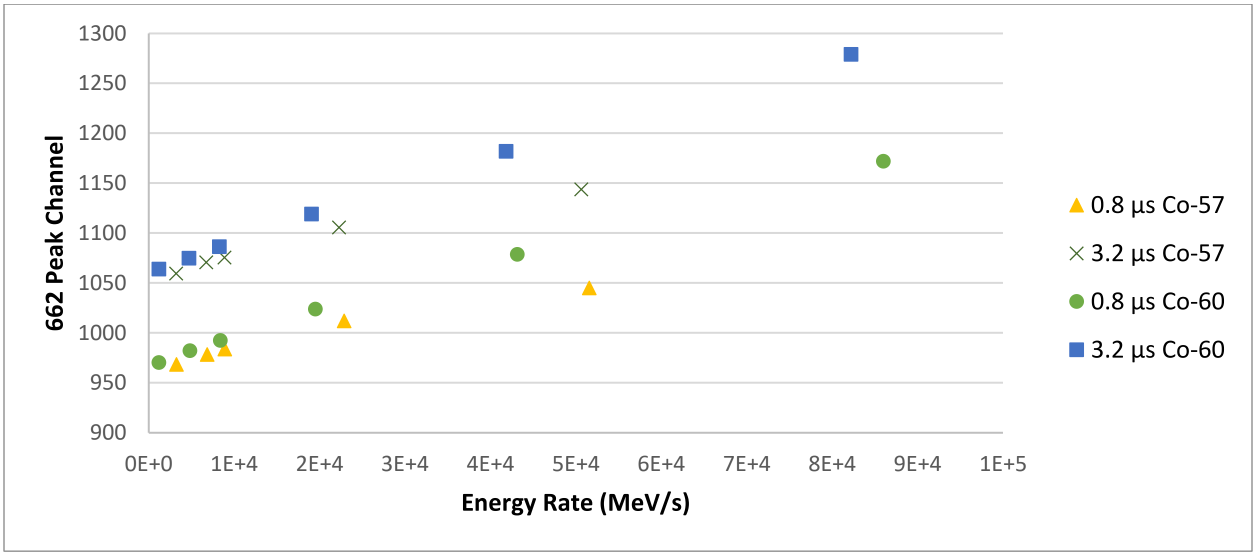


Figure 4: 662 keV Centroid vs Energy Rate, LaBr3 Detector A

The overall behavior here is similar to the other two detectors, although the magnitude of the peak-shift is still significantly larger.

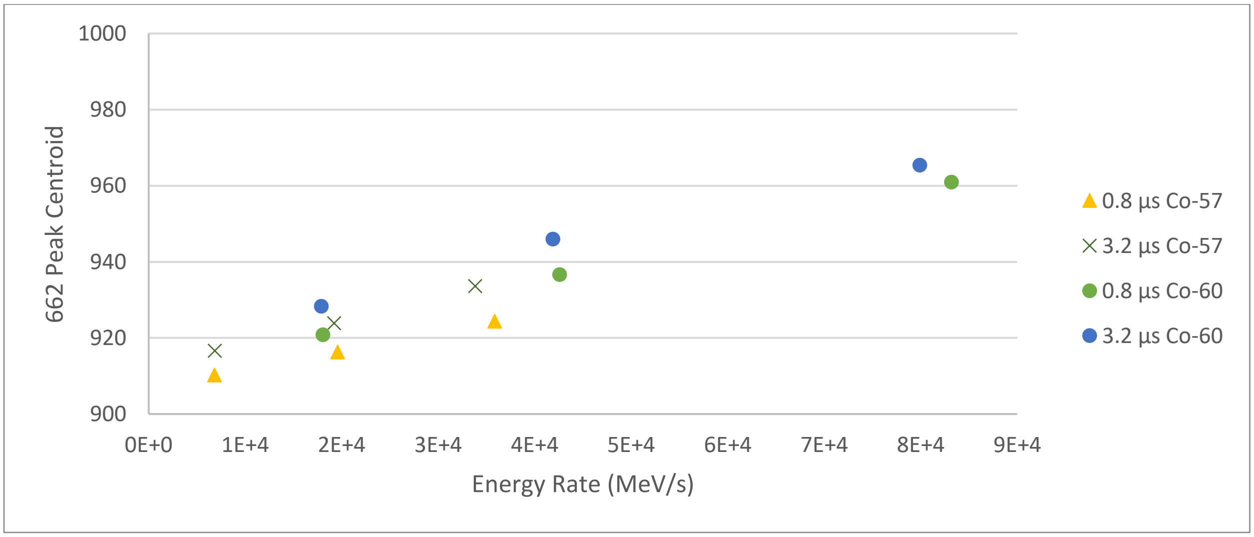


Figure 5: 662 keV Centroid vs Energy Rate, LaBr3 Detector B

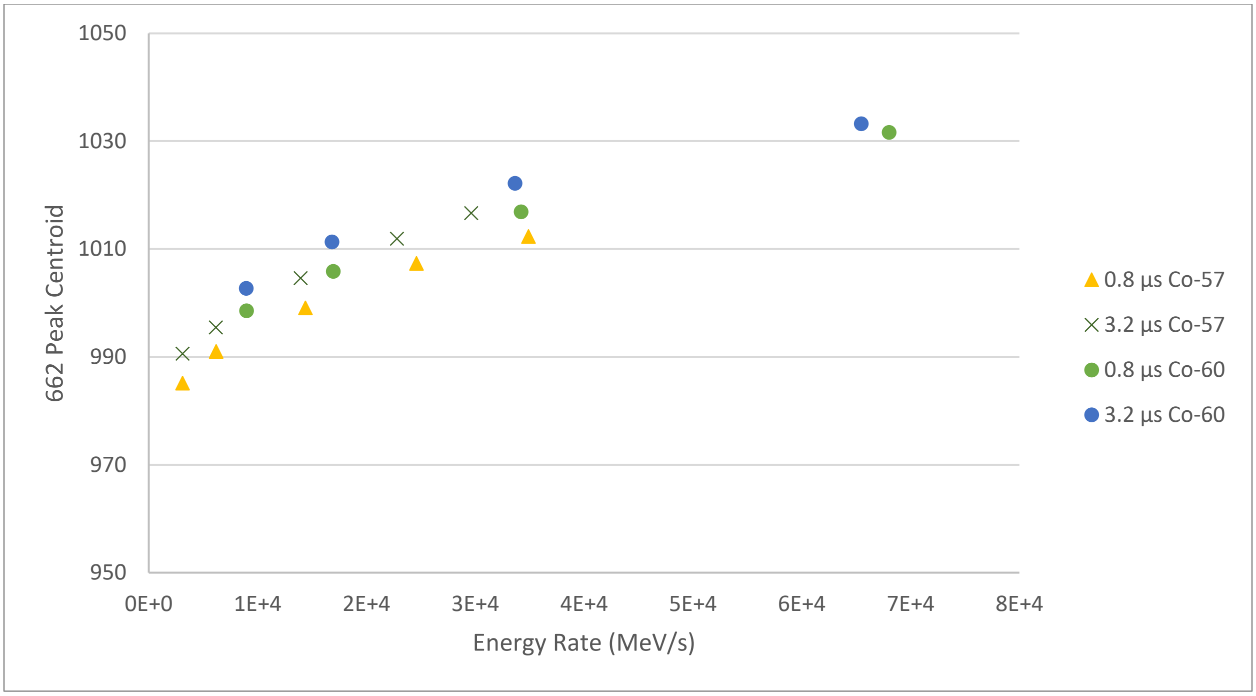


Figure 6: 662 keV Centroid vs Energy Rate, LaBr3 Detector C

## V. Throughput vs Deadtime of Detector A

The area of the Cs-137 662 keV peak vs deadtime also behaved as expected (Figure 7). Because the increased deadtime was due to a cobalt source, the area of the 662 keV is not expected to change except at a very high deadtime, where any measured gamma-ray is more likely to have originated from the cobalt source.

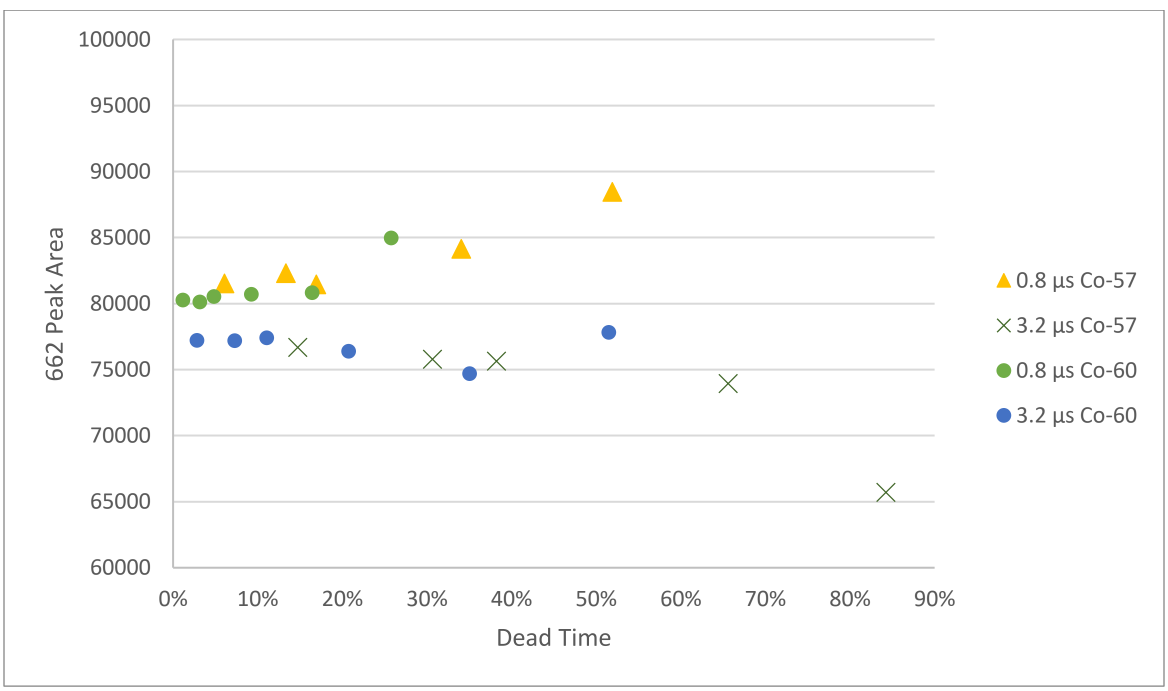


Figure 7: 662 keV Peak Area vs Deadtime, LaBr3 Detector A

## V. Conclusion

Because the same Inspector 2000 was used for all detectors, it is likely that the issue with Detector A is internal, but manual inspection of the preamplifier output with an oscilloscope was inconclusive. Further characterization of this anomalous detector is warranted. In particular, spectra with higher energy rates and higher deadtimes should be collected. In addition, peak shifts should be measured for several peak energies to explore the energy dependence of the shifting.