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BACKGROUND REDUCTION OF HIGH EFFICIENCY Ge(Li) DETECTORS^(a)

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Abstract

The effect of background on the sensitivity of large Ge(Li) detector systems has been studied. Significant reductions in the number and intensity of background photopeaks and the overall background spectrum in Ge(Li) detectors have been obtained. Methods studied include material selection, cryostat design, anticoincidence shielding, massive shielding, and beta coincidence gating.

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Summary

Reduction in the number of photopeaks and in the overall counting rate in Ge(Li) detector backgrounds can be used to improve the detection sensitivity for radionuclide analysis. Computer processing of the Ge(Li) spectra by automated peak location techniques is also simplified by reducing the number of background photopeaks. Methods to reduce the background and improve the sensitivity of several large Ge(Li) detectors have been studied.

The detectors evaluated range in size from 20 cc to 140 cc nominal active volume with efficiencies of up to 22% relative to a 3" x 3" NaI(Tl) detector for a source-detector distance of 25 cm. The resolution at 1.33 MeV for the detectors studied ranged from 5.4 keV to 2.4 keV (fwhm) with a peak-to-Compton ratio of 36/1 for the largest detector.

Methods used to achieve background reduction include selection of fabrication and shielding materials, special design of the cryostat, anticoincidence shielding with NaI(Tl), massive shielding of cosmic radiation, and beta-coincidence gating. Since aluminum contains traces of thorium daughters, stainless steel has been used for fabrication of the Ge(Li) detector end caps. The molecular sieve used within the cryostat also contains natural radioactivity. Several detectors have

been fabricated with a six-inch-thick copper shield between the molecular sieve and the Ge(Li) detector. This has greatly reduced the natural radionuclide photopeaks in the background spectrum as shown in Figure 1. The major remaining peak is the 0.51 MeV annihilation peak from cosmic radiation.

Figure 1 also illustrates the effect of anticoincidence shielding with a 9-inch diameter, 8-inch long NaI(Tl) well-crystal surrounding the Ge(Li) detector. The well diameter was 3 1/4 inches and was 4 1/2 inches deep. A factor of ten reduction in background was obtained over much of the spectrum. The positron annihilation peak was also reduced by a factor of ten. Natural ^{40}K and thorium daughter peaks are visible in the anticoincidence shielded background spectrum as a result of the reduced background level. The only peak visible in the Ge(Li) detector spectrum recorded in coincidence with NaI(Tl) shield is at 0.51 MeV.

All the measurements shown in Figure 1 were made in a four-inch thick lead shield. The use of mercury shielding around the Ge(Li) detector instead of lead has been found to reduce the background by a factor of two at low energies.

Background measurements have also been made in Grand Coulee Dam to study the effect of massive cosmic-ray shielding on the background. The location of the counting facility is shown in Figure 2. Figure 3 illustrates the effect of mercury shielding and the effect of massive cosmic-ray shielding on a Ge(Li) detector background spectrum. The 0.51 MeV annihilation peak is greatly reduced by the massive shielding obtained in Grand Coulee Dam.

When thin sources are available, beta gating has been used to reduce detector backgrounds by a factor of a hundred or better. This procedure is generally limited to radiochemically separated sources but can result in substantial improvements in sensitivity for beta-emitting radionuclides.

FIGURE 1. Ge(Li) BACKGROUND SPECTRA

FIGURE 2. Location of Grand Coulee Dam Counting Facility

Figure 3. Ge(Li) Backgrounds with Mercury Shielding