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Design of an Extremely Sensitive Large Volume Gamma-Ray Spectrometer for Environmental Sample Screening

High sensitivity is critical when analyzing soil, water, and foodstuffs for relatively low concentrations of environmental radioactivity. Spectroscopic radiation detection systems using NaI(Tl) have a superior detection efficiency and lower cost, but limited energy resolution when compared to semiconductor detectors. Radionuclides of interest in environmental samples following releases are restricted in number due to prior knowledge of suspected sources and the relative dose significance of different radionuclides. This diminishes the importance of fine energy resolution. NaI(Tl) becomes particularly attractive for meaningful quantification when there are low activity concentrations in physically large or copious samples. A spectroscopic radiation detection system was designed using eight 11 cm x 42.5 cm x 5.5 cm NaI(Tl) detectors. To reduce background, an 86 cm x 86 cm square, 64-cm tall shield was constructed with 18-cm thick lead walls lined by 0.3 cm-thick copper. A 5-cm thick aluminum top was machined to stably suspend the detectors along their long axes. The detectors were close-packed in an octagon resulting in a ~23 cm diameter, ~42 cm deep sensitive volume. A small company (Rexon) custom-designed a compact and affordable package incorporating a voltage divider, preamplifier, and high-voltage power supply for each detector's photomultiplier tube. Another company (RadPro) created an affordable customized single master board managing up to eight independent spectroscopy amplifiers and multichannel analyzer boards. The net result was electronics at a fraction of the cost of larger suppliers' standardized products. The design of the detectors, shield and electronics was derived mainly to provide an extremely sensitive detection system with low background radiation at minimal cost.