T3.1-P4. Achieving lower detection limits with the SAGe Well detector for a variety of samples relevant to On Site Inspection

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Abstract

CANBERRA’s Small Anode Germanium (SAGe) Well detector is a new type of low capacitance germanium well detector manufactured using small anode technology. The detector has energy resolution performance similar to semi-planar detectors, and offers significant improvement over the existing Coaxial and Well detectors. Mathematical efficiency calibration using ISOCAS/LabSOCs framework offers great flexibility for different sample sizes and shapes. Automatic true coincidence summing correction for a wide variety of activities, including the most common fission products, can be applied to measured spectra using the standard Genie 2000 algorithm. The performance of this detector and the true coincidence correction algorithm have been evaluated for a range of sample sizes and geometries counted inside the well and on the end cap of the detector. The improved resolution performance of SAGe Well detector greatly enhances detection sensitivity and offers benefits in measuring OSI relevant radionuclides in a variety of sample holders delivering reductions in minimum detectable concentration over the existing traditional Well detector.

1. Advantages of SAGe Well detector

SAGe Well detectors have a small area signal contact with short signal lead like a BEGe [1].

Advantages:
- Low noise performance.
- Excellent low-energy resolution.
- Energy sensitivity down to 20 keV.
- Larger well diameter possible without degrading resolution performance.
- Compatibility with electric coolers.
- Supports LabSOCs and cascade summing correction.
- Lower sensitivity to ambient vibration.

2. Resolution Performance of SAGe Well

Energy resolution performance of this device was carried out with an Am-241/Eu-152 radioactive source positioned on the detector axis, normally 30mm from the end cap face of the detector. Figure 2 shows the measured energy resolution as a function of energy and Figure 3 compares the energy resolution of the SAGe Well to other detector types. SAGe Well has similar energy resolution performance to BEGe detector and offers significant improvement over BEGe (Coax) and Traditional Well detectors.

3. Characterisation of a SAGe Well

A GSW275L SAGe Well detector (28mm x 40mm well) at GBL15 has been characterised using the GEANT4 Monte Carlo software [2].

4. Measurement of OSI relevant Radionuclides

The peak efficiency achieved for a sample inside the SAGe Well is significantly greater than that achieved on the end cap of a 100% relative efficiency Coaxial detector. Recent results for a soil based sample show a factor of 2 improvement in the MDA [3], corresponding to a reduction in the count time by more than a factor 5.

5. SAGe Well vs. Coax & BEGe for large sample measurement

An On-Site Inspection may have an interest in measuring liquid samples that are best measured in a large beaker. MDAs have been estimated for a 2.4L Marinelli beaker with a liquid sample of density 1.047 g/cm³ positioned on end cap of GSW120 SAGe Well, BE380 BEGe, and GCS018 coaxial detectors (Figure 4). These three detectors are selected to have similar active volumes although they are slightly different in relative efficiency.

The peak efficiency of the SAGe Well detector is slightly lower than those of the Coax and BEGe detectors at low energies, as shown in Figure 5.

The MDA performance of the SAGe Well compares well with BEGe and Coax detectors, particularly at mid and high energies, as shown in Figure 6.

6. Conclusion

The Germanium Well detector need no longer be a dedicated detector for very small samples. The SAGe Well Detector combines excellent energy resolution over 20 keV – 3 MeV, a larger well size (up to 28 mm) without compromising resolution performance, an aspect ratio similar to coaxial detectors and compatibility with Marinelli beakers and other large sample containers. The SAGe Well’s versatility is unmatched among all types of Germanium detectors. The increased performance has been demonstrated by a reduction in MDA of OSI relevant radionuclides compared to a standard 100% relative efficiency Coaxial detector.

References

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Table 1: Comparison of improvements in MDA for 100% relative efficiency Coaxial vs. SAGe for OSI relevant radionuclides.

Table 2: Cascade correction factors for the accurate calculation of peaks in the spectrum for the calculation of the calculated activity applied to the accepted activity.

Table 3: Comparison of the actual and calculated activities for the NPL “Gamma Line” source using both methodologies. The GEANT4 & GENIE™ 2000 results represent the ratio of the calculated answer to the accepted activity.

Table 4: Comparison of improvements in MDA for 100% relative efficiency Coaxial vs. SAGe for OSI relevant radionuclides.

Table 5: Comparison of improvements in MDA for 100% relative efficiency Coaxial vs. SAGe for OSI relevant radionuclides.

Table 6: Comparison of improvements in MDA for 100% relative efficiency Coaxial vs. SAGe for OSI relevant radionuclides.

Figure 1: SAGe Well detector in Cryo-Pulse 5 Plus cryostat.

Figure 2: Measured FWHM of a SAGe Well detector.

Figure 3: Typical resolution versus energy plot for different detectors.

Figure 4: Image of 2.4L Marinelli beaker positioned on the detector end cap.

Figure 5: Absolute efficiency as a function of energy for a 2.4L Marinelli beaker with liquid sample 1g/cm³.

Figure 6: Achievable MDA estimated for 2.4L Marinelli beaker for BEGe and Coax detectors respectively for a SAGe Well detector.