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Accuracy of particulate sample analysis with a BEGe detector

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Background

- Gamma spectrometry using Germanium detectors is a widely used technique for the detection of low activities in environmental sample. Such measurements require typically close geometry arrangements with volumetric sources such as discs and cylindrical cups [1].
- This close distance arrangement increases the chance of coincidence effects for complex nuclides such as Cs-134 as shown in Fig 1. which may present in particulate samples as a result of accidental release during nuclear weapon testing.

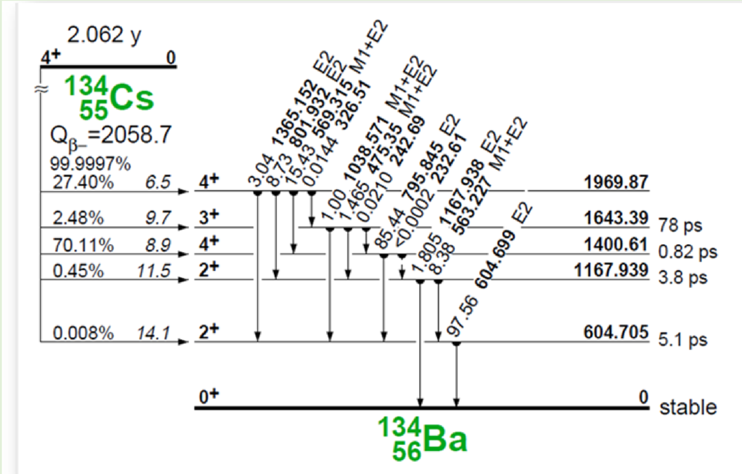

Figure 1: Decay Scheme of CS-134

- In the study several radionuclides for CTBTO International Data Centre (IDC) event screening from particulate samples [3] were analysed looking at coincidence summing effects. These samples contain fission and activation products.
- Correction factors are obtained by software based on Monte Carlo calculations A comparison of coincidence summing correction factors were made between an available commercial software package (LabSOCS) and a specifically developed software package (VGSL), developed by Radionuclide Development Unit of the IDC.
- Corrections for coincidence summing effects are essential for accuracy in gamma-ray spectrometry.

Method

- The coincidence summing corrections were computed by LabSOCS and VGSL Software for a MANUAL3M sample counted on top of a BEGe detector.
- The software tools allow the definition of all geometry-related parameters including dimensions of the sample, properties of the detector, distance or shielding between the detector and sample densities.
- The software calculates the Coincidence Correction Factors (CCF) for the gamma ray of interest which is given by $CCF = (1 - L_A)(1 - S_A)$ where:

  L_A= the probability of summing is out and

  S_A = the probability of summing in [2].

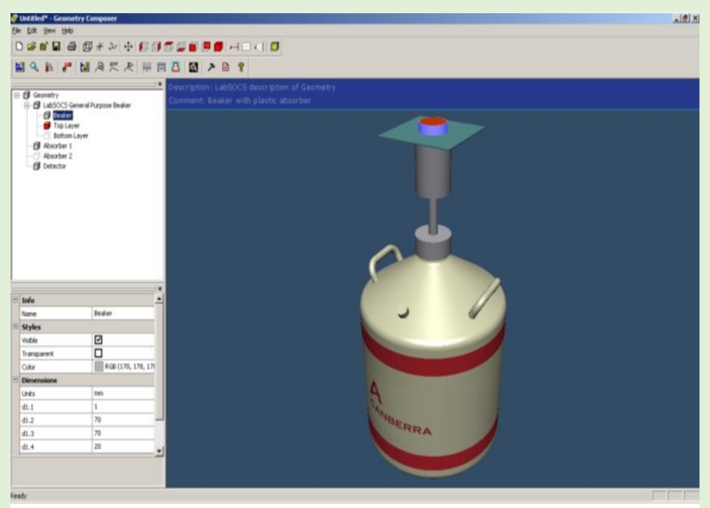

Figure 2: LabSOCS MANUAL3M

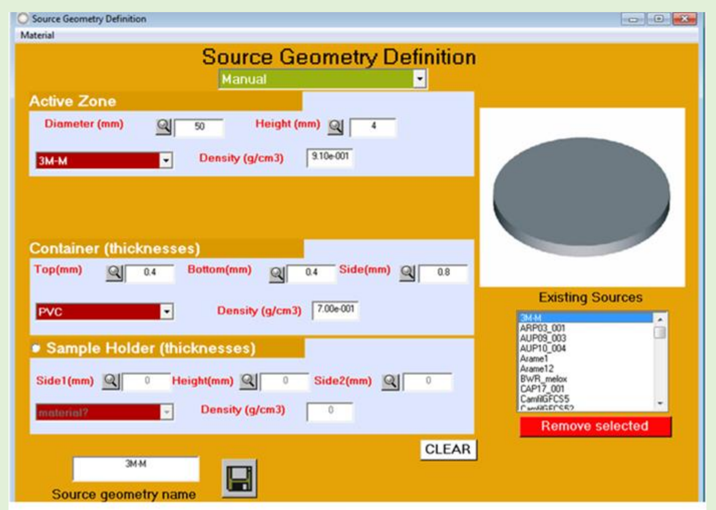

Figure 3: LabSOCS MANUAL3M

- A MANUAL3M geometry sample modeled with LabSOCS is shown in Fig.2 and Fig.3 shows a MANUAL3M geometry sample modeled with VGSL.

Findings

- Coincidence correction factors were computed from both LabSOCS and VGSL software.
- A sample of the results are summarized in Table 1.
- Most values were in good agreement with various other experimental and computational studies [4,5].
- There are a minority of cases where significant differences (e.g. Te-132) between the correction factors produced by the LabSOCS and VGSL.

Table 1: CCF for VGSL and LabSOCS

Nuclide	Energy (keV)	VGSL CCF	LabSOCS CCF
Sb-125	427.61	0.700	0.790
Sb-126	694.76	0.424	0.451
Te-132	772.38	0.614	miss
Ba-140	537.24	0.943	0.955
Eu-156	1153.63	0.706	0.740
Sc-46	888.98	0.800	0.814
Co-60	1332.42	0.803	0.817
Ba-133	355.97	0.431	0.594
Cs-134	604.60	0.733	0.754
Eu-152	1407.78	0.462	0.540
U-237	207.75	0.852	0.856

*miss = Nuclide energy was not found in the Genie 2000 coincidence library
*CCF = Coincidence Correction Factors.

Conclusion

- The study was performed to compare the correction factors for coincidence summing effects for a MANUAL3M geometry obtained by VGSL and LabSOCS.
- For the majority of nuclides, VGSL and LabSOCS software produce comparable coincidence summing correction factors that can be applied to improve the accuracy of results for IMS sample analysis.
- The results obtained are promising and further improvement may be expected with the development of the parameter settings.

Future work

- Evaluate coincidence summing corrections for all the relevant radionuclides and for all the IMS sample geometries using the outcome of proficiency test exercises.
- To develop a methodology for the selection of the appropriate coincidence correction factor between VGSL and LabSOCS in the analysis of IMS samples.

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