OPTIMUM SHAPE OF LABORATORY SAMPLES FOR GAMMA SPECTROSCOPY FOR VARIOUS SIZE AND SHAPE GE DETECTORS

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Sample containers come in many different sizes and shapes. The most common are cylinders and Marinelli beakers. But, what is the optimum size? The optimum size is that which gives the maximum counting efficiency for the energy of interest for the given sample size. There is no single correct answer for all applications. The optimum size sample is a function of the sample mass available, sample density, energy, and also the size and shape of the Ge detector.

Ge detectors come in a wide variety of sizes and shapes. Even if the user has several detectors all of the "same efficiency" as implied by the "relative efficiency" value for the detector, the detectors are rarely the same physical size.

Relative efficiency values are computed by all Ge detector manufacturers, in accordance with an IEEE or IEC Standard. But, this value does not define the actual detector shape. Relative efficiency is merely the efficiency at 1332 keV for a point source on the axis of the detector at 25cm from the detector endcap face, relative to the efficiency for a hypothetical 3"x3" NaI detector for the same energy and geometry.

Detectors with the same value of "relative efficiency" are not all equal in detection efficiency for other energies than 1332 keV, nor for sample shapes other than a point source at 25cm. Ge detectors come in a wide range of diameters and thickness', depending upon the detector type, and the source of the Ge material. It is the physical size and shape of the active volume of the Ge, and it's placement in the endcap housing that determines the true counting efficiency. So, unless the counting requirement is to assay point sources of Co-60 at 25cm, this "relative efficiency" value is of little practical use in the counting laboratory.

For this document we compare several types of nominally 40% relative efficiency detectors. This size represents the median size of detectors ordered, and offers good price/performance value for most applications. Three examples of Ge diameters and thickness will be used, and are shown in the following table.

Aspect Ratio	Diameter	Thickness	Volume	Comment
High	80 mm	25 mm	126 cc	Canberra BEGe detector
Medium	62 mm	44.5 mm	134 cc	Canberra XTRa coax detector
Low	55.3 mm	73.5 mm	176 cc	Other vendor n-type coax detector

For the purposes of this experiment, the internal construction of the detectors is typical for that type of detector. The diameters and thickness was adjusted so that all detectors had 43% relative efficiency. These do not represent any particular detector, but the comparison between the detectors is believed to be valid.

For each of the 3 detectors, the sample shape with the maximum efficiency was computed. The Canberra mathematical efficiency calibration program ISOCS was used for the efficiency calibrations. The sample was water, in all cases. The sample volume was 500cc, in all cases. The sample was assumed to be within a polyethylene container 2mm thick and located directly on the endcap of the detector.

Three different energies were considered: 122, 662, and 1332 keV.

For the cylindrical container, the diameter and height of the sample were varied until the best combination was found that gave the highest efficiency at that energy. For the Marinelli beaker, the sample thickness on the side, depth of the well, and sample thickness on the end were varied until the best combination was found that gave the highest efficiency at that energy. A 1cm gap between the endcap diameter and the well inner diameter was assumed.

The results of this experiment will be presented in the following 3 tables, one for each energy. The tables will show the efficiency, and the dimensions of each sample.

122 keV

	Cylinder			**Marinelli**	**Beaker**		
Aspect Ratio	**Max Eff**	**Diameter cm**	**Thickness Cm**	**Max Eff**	**Well Depth cm**	**Side thickness**	**End thickness**
High							
Medium							
Low							

662 keV

	Cylinder			**Marinelli**	**Beaker**		
Aspect Ratio	**Max Eff**	**Diameter cm**	**Thickness Cm**	**Max Eff**	**Well Depth cm**	**Side thickness**	**End thickness**
High							
Medium							
Low							

1332 keV

	Cylinder			**Marinelli**	**Beaker**		
Aspect	**Max Eff**	**Diameter**	**Thickness**	**Max Eff**	**Well**	**Side**	**End**

Ratio		cm	cm		Depth cm	thickness	thickness
High							
Medium							
Low							