Activity assay of a $^{90}$Y microsphere sample using a coincidence detection system

**Innovation/Impact:** $^{90}$Y microsphere treatments of liver cancers have shown promising results, including increased survival rates and the potential to downstage the disease state to resectable (i.e., curable). However, there is presently no national standard for $^{90}$Y microsphere activity. Users are reliant on manufacturers to provide activity data and these given values have large uncertainties (~10%) and may not be accurate. This leads to the inability to correlate clinical outcomes with the dose received by the patient, meaning this treatment remains largely unoptimized. This work describes the use of a coincidence detection system to assay the activity of a $^{90}$Y microsphere sample. This device could be used as a standard to calibrate well-type chambers (or dose calibrators) for more accurate clinical determinations of sample activity, which would contribute toward lowering the dosimetric uncertainty associated with this treatment.

**Physical Properties of $^{90}$Y:** $^{90}$Y is a beta emitter that decays predominantly to the ground state of $^{90}$Zr. However, it can decay to an excited state of $^{90}$Zr, which can subsequently decay via internal pair production (IPP) (See Fig. 1). Recent work\(^1\) has determined the branching ratio of the IPP associated with $^{90}$Y decay to be $(31.86 +/- 0.47)\times 10^{-6}$. This branching ratio has a lower uncertainty than previous values, which enables an accurate spectroscopic assay of $^{90}$Y activity.

**Coincidence Detection System (CDS):** A CDS was developed that pairs a HPGe detector with a large NaI detector (see photograph in Fig. 2). The CDS is able to reduce the large bremsstrahlung continuum present in the photon spectrum from a $^{90}$Y source by gating the energy signal from the HPGe by the coincidence signal (see electronics block diagram in Fig. 3). This reduces the uncertainty associated with the peak analysis of the 511 keV peak (see Fig. 4 for a comparison of the gated and ungated spectra). A series of pulsers was used to correct for counting losses (again see Fig. 3). A geometric characterization of the system was completed to find the optimal source position for measurements (see Fig. 5 and 6). An efficiency calibration was completed with a $^{22}$Na standard source. The accuracy of the activity determined with the CDS was validated using a $^{90}$Y standard activity solution from the NIST Standard Reference Material (SRM) program. Measurements were then completed for a SIR-Spheres® (Sirtex Medical) sample. Results were compared to the manufacturer-stated activity of 3 GBq +/- 10%.

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Fig. 1: $^{90}$Y decay scheme diagram.  
Fig. 2: Photograph of the coincidence detection system.
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Results and Discussion: The activity determined with the CDS was within 2.6% of the NIST-stated activity of the SRM source, which is within the expanded (k=2) uncertainty associated with the CDS measurement of 4.8%. The activity of the $^{90}$Y microsphere sample was determined to be 3.72 GBq +/- 1.9% (k=1). This is 19% higher than the manufacturer-stated activity of 3 GBq and is outside of their stated uncertainty of +/-10%. Work by Selwyn et al. also determined the activity of a $^{90}$Y SIR-Sphere sample and found their assay 26% higher than the Sirtex Medical given value of 3 GBq. This suggests that the determination of the activity used by the manufacturer could be improved.

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