

Challenges in migrating  $^{90}\text{Y}$  calibrations to new ionization chambers: geometry, height, and impurity effects.

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**Objectives:** Yttrium-90 microspheres are used for targeted radiotherapy in patients with liver cancer. Activity measurements of irradiated glass microspheres are traceable to a standard developed at the National Institute of Standards and Technology (NIST) in 1991. The very small pair-production branch in  $^{90}\text{Y}$  decay allows (potentially quantitative) imaging by positron emission tomography (PET). We have recently achieved a PET recovery coefficient of  $0.93 \pm 0.02$  with a uniform phantom filled with  $^{90}\text{YCl}$ , where the main uncertainty contributions came from the uncertainty on the pair production branching ratio and from the dose calibrator activity assay; the uncertainty on calibration of the PET scanner is not included. In 2014, it was deemed necessary to transfer the NIST standard for  $^{90}\text{Y}$  glass microspheres from one aging ionization chamber (dose calibrator) to several others, resulting in a possible bias and increased uncertainty. In this work, we show that quantitation of  $^{90}\text{Y}$  microsphere PET images will be limited in both accuracy and precision by the dose calibrator measurements. **Methods:** Two v-vials containing  $^{90}\text{Y}$  microspheres were measured on a dose calibrator for which geometry-specific (with and without hand-shield) dial settings were established as part of the 1991 standardization. The calibration curve method was then applied with four other chambers to determine new calibration factors. **Results:** The initial assays revealed an  $\approx 4\%$  difference between the activities determined with and without the hand-shield. It appears that a change in the source geometry between 1991 and 2014 introduced a systematic bias that must now be treated as a source of uncertainty. Calibration factors were determined for three of the four chambers, with total combined uncertainties  $\approx 4\%$  mostly due to the uncertainty on the initial assay. The fourth chamber suffered from a  $>8\%$  activity-dependent bias. Height and impurity effects were studied in detail, offering plausible explanations for the observed bias. **Conclusions:** NIST calibrations for  $^{90}\text{Y}$  glass microspheres have been transferred to several newer ionization chambers. The transfer identified a significant source of uncertainty in the measurements, which could be resolved by new primary measurements and new determinations of geometry-specific calibration factors. If the goal is to know the activity to better than  $10\%$ , then the present standards suffice. But if image quantitation is limited by the precision of the activity assay, then the drive towards patient-specific image-guided dosimetry may also drive a need for an improved standard with the  $\approx 1\%$  uncertainties more typical of NIST activity calibrations.