Contribution ID: **74** Type: **not specified**

Sub-Millimetre Positron-Emission Particle Tracking using a CdZnTe Semiconductor Array

The Positron Emission Particle Tracking (PEPT) technique has been in development in Cape Town since 2009, and allows one to track a 1mm positron-emitting point source travelling at 1m/s to within 1mm, 1000 times a second. Traditionally, this utilises large scintillation Bismuth Germanium Oxide (BGO) arrays, which offer high intrinsic efficiency at 511keV (60-65\%) but low spatial resolution (4-5mm). An alternative approach is to use high energy resolution (2.87\%) CdZnTe semiconductor detectors with a higher spatial resolution (1.82mm) to track tracer particles to sub-millimetre precision. Measurements have located a low-activity ($\approx$37kBq) ^{22}Na button source in three-dimensional space with an uncertainty of 0.11mm and a signal-to-noise ratio of 85\%. Using a 4-crystal CZT array, with each crystal measuring 20mm x 20mm x 10mm, a maximum coincidence rate of 60Hz was measured using a 2.22MBq ^{68}Ga source. The CZT array is therefore more appropriate to track very small tracer particles ($\approx 10\mu$m) which necessarily have lower activities than is optimal for conventional PEPT with the HR++ currently used at PEPT Cape Town. Additionally, using a larger 16 CZT crystal array a 1.2MBq ^{22}Na tracer particle was tracked at speeds of up to 20mm/s moving in circles of down to 1mm in diameter.

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Session Classification: Posters