Contribution ID: **180** Type: **Oral Presentation**

Uncertainty analysis for Positron Emission Particle Tracking (PEPT) measurements

Tuesday, 4 July 2017 15:20 (20 minutes)

In the technique of Positron Emission Particle Tracking (PEPT), and its equivalent subsets, a single radioactive tracer particle is frequently located as it moves through the system under study. Detection of pairs of annihilation photons emitted by the particle define a line along which the particle is thought to be positioned, and each location is then calculated via a triangulation approach assuming a fixed signal to noise ratio. A contiguous set of locations then define the particle trajectory, and are used to measure the kinematic and dynamic parameters of the particle motion. Often these parameters are further processed to infer the global system behaviour.

Uncertainties are introduced at each stage of the measurement process; of particular note are those driven by the fundamental physics, the detection systems, and the statistical processes used to extract the trajectory from the measured data. Once the uncertainty in each location measurement is defined, the uncertainty budget for the derived quantities typical to a PEPT study can be calculated. Here we present a full analysis of the measurement uncertainty budget and its propagation as applied to PEPT measurements. Typically we can locate a particle moving at 1 m/s at a rate above 1 kHz, to within 0.5 mm (stat) and 0.5 mm (sys) as measured in three dimensions.

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Primary author: Dr LEADBEATER, Thomas (University of Cape Town)

Co-authors: Prof. BUFFLER, Andy (University of Cape Town); Dr COLE, Kathryn (University of Cape Town); Mr VAN HEERDEN, Michael (University of Cape Town)

Presenter: Dr LEADBEATER, Thomas (University of Cape Town)

Session Classification: Applied Physics

Track Classification: Track F - Applied Physics