Low Activity Studies of ^{11}C Activation Via GATE Monte Carlo

A Elmekawy[1], C. Butuceanu[2], L. Qu[2], L. Ewell[1]

1) Hampton University Department of Physics
2) Hampton University Proton Therapy Institute

4/28/15

Purpose: To investigate the behavior of a Monte Carlo simulation code with low levels of activity (~1,000Bq). Such activity levels are expected from phantoms and patients activated via a proton therapy beam.

Method and Materials: Three different ranges for a therapeutic proton radiation beam were examined in a Monte Carlo simulation code: 13.5, 17.0 and 21.0cm. For each range, the decay of an equivalent length ^{11}C source and additional sources of length plus or minus one cm was studied in a benchmark PET simulation for activities of 1000, 2000 and 3000Bq. The ranges were chosen to coincide with a previous activation study, and the activities were chosen to coincide with the approximate level of isotope creation expected in a phantom or patient irradiated by a therapeutic proton beam. The GATE 7.0 simulation was completed on a cluster node, running Scientific Linux Carbon 6 (Red Hat©). The resulting Monte Carlo data were investigated with the ROOT (CERN) analysis tool. The half-life of ^{11}C was extracted via a histogram fit to the number of simulated PET events vs. time.

Results: The average slope of the deviation of the extracted carbon half life from the expected/nominal value vs. activity showed a generally positive value. This was unexpected, as the deviation should, in principal, decrease with increased activity and lower statistical uncertainty.

Conclusion: For activity levels on the order of 1,000Bq, the behavior of a benchmark PET test was somewhat unexpected. It is important to be aware of the limitations of low activity PET images, and low activity Monte Carlo simulations.