

Prompt gamma-ray measurement as method of monitoring changes in tissue undergoing proton irradiation

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It has been proposed that measuring prompt gamma-ray emission from patients during proton therapy may be a useful tool to determine dose delivery during proton irradiation therapy. The energies of gammas emitted from the irradiated tissue are characteristic of the elemental composition of the tissue and the intensities of the lines are a function of elemental concentration and density. Observing prompt gamma rays could also be used to monitor changes in the composition of tissue that may take place during the irradiation. Monte Carlo simulations have been performed [1] that demonstrate these effects and the possibility of developing a method of “prompt gamma-ray imaging.”

Work at TAMU:

Two experiments have been performed at the TAMU Cyclotron Institute using proton beams on the SEE line. For these measurements, a 40 MeV proton beam accelerated by the K500 cyclotron was impinged, in air, on tissue-equivalent phantom targets. The resulting prompt gamma rays were measured. In the first experiment in December 2008, bone- and tissue-equivalent targets were irradiated and the gamma spectrum was measured using a 70% efficiency HPGe detector surrounded by a passive lead shield. Gamma emission lines from the elemental components of the samples were identified and the intensities of these lines were demonstrated to be dependent on the composition and density of the sample. The Monte Carlo simulation, using the experimentally determined efficiency curve, very well reproduced the spectrum measured.

In the second measurement, performed in April 2009, a bismuth germanate oxide (BGO) shield was employed to allow for active Compton suppression. The Compton suppression was done in software, such that the BGO could be used as both a passive and active shield, and the results could be compared to determine whether active suppression would be desirable for future measurements. A narrow (4mm) slit was used and the detector was setup perpendicular to the beam path. The sample was then moved along the beam direction and a radiation depth profile was measured. As the high-energy gamma-ray lines from the inelastic excitation of ¹²C and ¹⁶O in probe were dominant, the addition of Compton suppression was beneficial to decrease the background and diminish the escape peaks (Figs. 1 and 2). Detailed analysis continues.

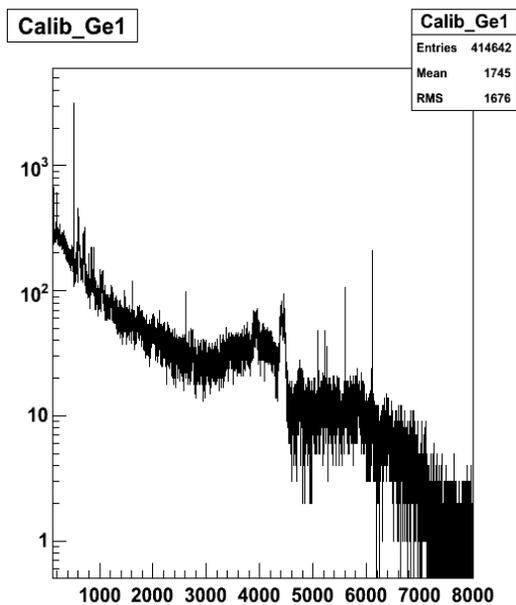


FIG. 2. Gamma spectrum from irradiated Lucite target without BGO Compton suppression. Calibration is 1 keV/channel.

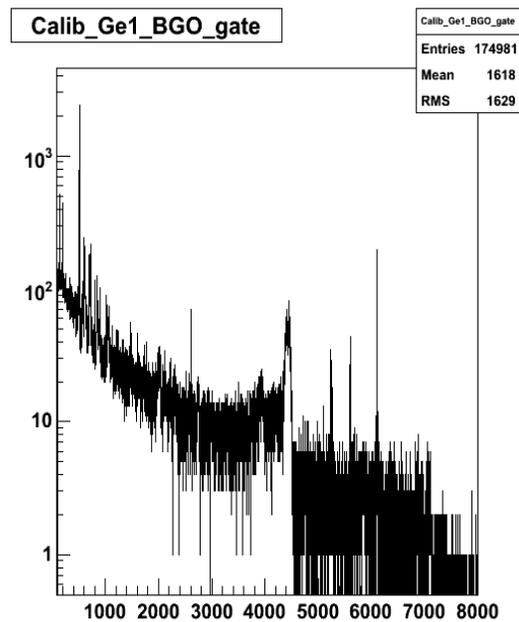


FIG. 1. Gamma spectrum from irradiated Lucite target with Compton Suppression.

[1] J. C. Polf *et al.*, Phys. Med. Biol. **54**, 731 (2009).