# Measuring prompt gamma-ray emissions from elements found in tissue during passive-beam proton therapy

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## Abstract

Prompt gamma detection during proton radiotherapy for range verification purposes will need to operate in both active and passive treatment beam environments. This paper describes prompt gamma measurements using a high resolution 2'' × 2'' $LaBr_3$ detector for a 200 MeV clinical passive-scatter proton beam. These measurements examine the most likely discrete prompt gamma rays emitted from tissue by detecting gammas produced in water, Perspex, carbon and liquid-nitrogen targets. Measurements were carried out at several positions around the depth corresponding to the location of the Bragg peak for water and Perspex targets in order to investigate prompt gamma emission as a function of depth along the beam path. This work also focused on validating the Geant4 Monte Carlo model of the passive-scatter proton beam line and $LaBr_3$ detector by making a direct comparison between the simulated and experimental results. The initial prompt gamma measurements were overwhelmed by the high amount of scattered radiation when measuring at isocenter, shifting the target further downstream from the final collimator significantly reduced the background radiation. Prompt gamma peaks were then clearly identified for the water, Perspex and graphite targets. The developed Geant4 Monte Carlo model was able to replicate the measured prompt gamma ray energy spectra, including production for important photopeaks to within 10%, except for the 4.44 MeV peak from the water target, which had more than a 50% overestimation of the number of produced prompt gamma rays. The prompt gamma measurements at various depths correlated well with the proton dose deposition; the 4.44 and 6.13 MeV photopeak profiles peaked within 1 cm of the Bragg peak and the $R_{50\%}$ value for the 3–7 MeV energy range predicted the proton range within 8 mm.