

Purpose: Designing a scintillation detector for proton radiotherapy requires careful considerations. Most scintillators exhibit some energy dependence due to quenching under proton irradiation. Water equivalence, one of the main advantages of plastic scintillators for photon measurement has yet to be validated for the wide range of proton energies used for proton therapy. In this work, we studied the most important factors that would affect the performance of a scintillation detector.

Method and Materials: Experimental measurements were used to study quenching effect in scintillators and the amount of the spurious light produced in the optical light guides. Monte Carlo simulations were performed with GEANT4. Proton beams between 50 and 250 MeV were simulated to study the water equivalence, the optimal size, the optimal coating of plastic and inorganic scintillators.

Results: We found that the dose deposited in a plastic scintillator was within 2% of the dose deposited in a similar volume of water on the whole depth dose curve for protons with energies higher than 50 MeV. Inorganic scintillators received a dose 5 to 10% lower than the dose in a similar volume of water. The main disadvantage of plastic scintillators is the quenching effect that reduces the amount of scintillation and result in 26% and 14% underestimation at the Bragg peak of 50 MeV and 250 MeV, respectively. To avoid the averaging effect, the radius of the scintillation detector should be 0.25 mm or less. To improve the signal of such small volume detector the scintillator can be coated with a diffuse reflector.

Conclusion: According to our experimental and Monte Carlo analysis of scintillation detection in the higher energy range for proton therapy, it is possible to construct an effective detector that would overcome the problems traditionally encountered in proton dosimetry.