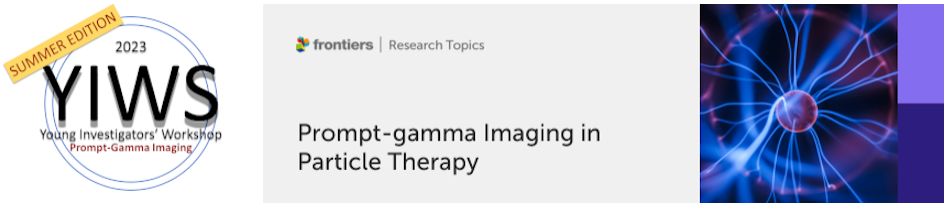

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Prompt gamma spectroscopy retrieval algorithm for element and density measurements

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Prompt gamma ray in proton therapy is the product of nuclear reaction between proton and target. The characteristic energies and intensities of prompt gamma lines can be used to determine the types of elements and their amounts in the target. In several previous experiments, it was demonstrated that no matter how complex the reaction cross-section is, once the energy of the incident proton and the irradiated element are determined, there is a definite linear relationship between the element concentration and the number of gamma-ray photons. However, this linear relationship is difficult to apply to medical imaging and the nonlinear behavior of hydrogen has not been investigated so far. In this paper, this linear relationship is extended to mixed elemental materials including nonlinear case such as hydrogen, and a universal mathematical form, which is referred to as the prompt gamma spectroscopy retrieval algorithm (PGSRA), is developed. The basic assumption of the PGSRA is that the PGS of the sample material has a relationship with the molar gamma lines of the elements. For carbon and oxygen, this relationship is linear, while for hydrogen, this relationship is nonlinear. As the 2.23 MeV gamma line originates from neutron absorption radiation, the behavior of hydrogen is carefully investigated. The linear and nonlinear relationships are verified using Monte Carlo simulations with different combinations of carbon, oxygen, and hydrogen, such as PMMA, pentanediol and ethanediol. The PGSRA developed in this work could be the first bridge between PGS and medical imaging.

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