Development and Assessment of a Spectroscopic Algorithm for Polyenergetic Proton Beams

S. McCallum [1], G. Milluzzo [1, 3], M. Borghesi [1], A. Subiel [2], F. Romano [3].

1) *Centre for Plasma Physics, Queen's University Belfast, BT7 1NN*

E-mail : smccallum05@qub.ac.uk

2) National Physical Laboratory, CMES - Medical Radiation Science, Teddington TW11 0LW, Middlesex, UK

3) Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Via S Sofia 64, 95123 Catania, Italy

The unique beam features defining the multi-MeV proton beams generated through intense laser-target interaction, including their wide energy distributions (up to 100% spread), have been widely reported [1]. Potential applications requiring a precise energy selection (e.g., in the biomedical field), demand characterization of these polyenergetic beams through accurate measurements of their energy spectra. Numerical analysis of radiochromic films (RCF) arranged in a stack configuration is an established approach for the reconstruction of the energy spectrum [2]. An algorithm has been developed that allows the proton density at each sensitive layer to be retrieved, solely through Monte Carlo calculations working in the Geant4 code [3]. This is based on the calculation of the energy loss of energetic protons in the RCF material of which the stack is composed. Evaluation of the response function of the film detector allows a discrete energy interval to be attributed to each active layer, characterized by that required to generate a Bragg peak at the given coordinates, effectively identifying the impinging proton energies that are fully stopped within each film. Traversing protons will also provide some (albeit, smaller) contribution to the signal received in each layer. As the superposition of the trajectories of two or more protons having different energies is irrelevant, a deconvolution of the total deposited energy is performed through a backwards weighted subtraction for each layer, so that only the protons in the peak region are counted in the final spectral measurement. Such an algorithm offers the potential to retrieve the energy spectrum of an impinging proton beam produced in a laser-plasma experiment. Testing has been conducted alongside simulations comparing the response of the energy spectrum retrieved through deconvolution, to that of the original spectrum sent at the source. Initial results show discrepancies between the cases, indicating that for spectra containing comparable proton densities at each sampling energy, this method of spectroscopy could require further optimization. Continued work is ongoing to examine the major sources of uncertainty surrounding this technique, including stopping power calculation, and outlining the possible intrinsic limits of the deconvolution process.

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