

Verification of a method for spectroscopy of polyenergetic proton beams using radiochromic films

Sean McCallum (1, 2), Giuliana Milluzzo (3), Marco Borghesi (1), Anna Subiel (2), Linda Mortimer (4), Francesco Romano (3)

(1) Centre for Plasma Physics, Queen's University Belfast, BT7 1NN, (2) Medical Radiation Science, National Physical Laboratory, Teddington, TW11 0LW, (3) Istituto Nazionale di Fisica Nucleare, Sezione di Catania, Via S Sofia 64, 95123 Catania, Italy, (4) Clatterbridge Cancer Centre Wirral, Clatterbridge Road, Bebington, Wirral, CH63 4JY

The large energy distributions characterizing protons accelerated through laser-driven mechanisms presents a problem for potential clinical applications requiring precise energy selection. A method of radiochromic film (RCF) spectroscopy of polyenergetic proton beams based on a deconvolution procedure is presented. This has been tested through irradiation of several RCF configurations with a clinical proton beamline at Clatterbridge Cancer Centre (CCC) and assessed through extensive Monte Carlo simulation.

Radiochromic Film Dosimetry of Laser-Driven Protons

Laser-driven protons display [1]:

- Ultra-high dose rates of values up to 10^9 Gy/s
- Large energy spreads, potentially reaching 100%

Characterization is possible through RCF imaging spectroscopy [2].

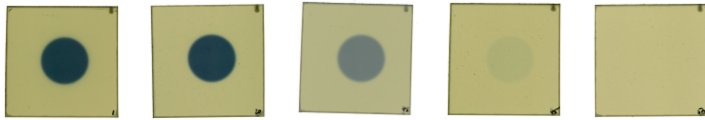


Fig 1. EBT3 RCF irradiated with the proton beamline at CCC.

Development of an algorithm for RCF Spectroscopy

Characteristic dE/dx energy loss

Require:

- RCF response function
- Deconvolution procedure

Fractional energy contributions must be eliminated to obtain the energy spectrum.

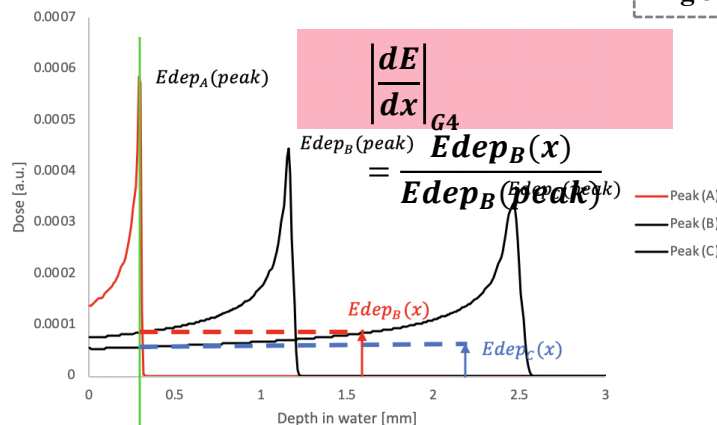


Fig 2. Monte Carlo evaluated energy sensitivity values for an EBT3 stack.

Experimental campaign at CCC & Assessment

Initial validation of the deconvolution algorithm using Geant4:

Simulated energy spectrum compared with that retrieved from deconvolution of the deposited energy
S., McCallum et al, (2022), JINST [3]

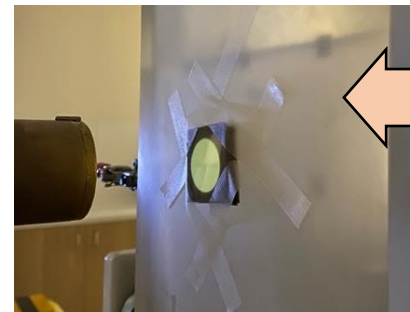


Fig 3. Stack setup at CCC.

Stack setup downstream of collimator exit

Dose profile retrieved from RCF, ionization chamber at CCC and compared with MC model (validation)

Energy spectrum found through deconvolution

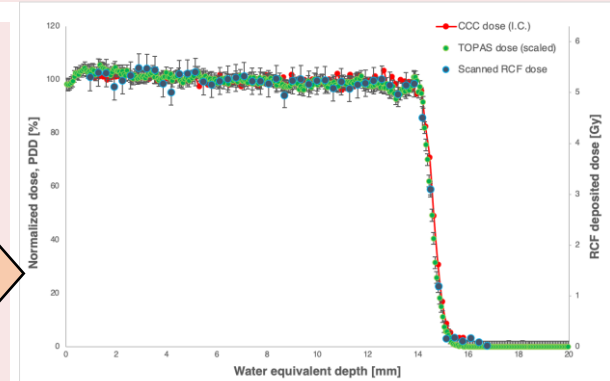


Fig 4. Dose profile comparison.

Polyenergetic proton spectrum compared with validated MC model showing comparability – reliability of algorithm assessed

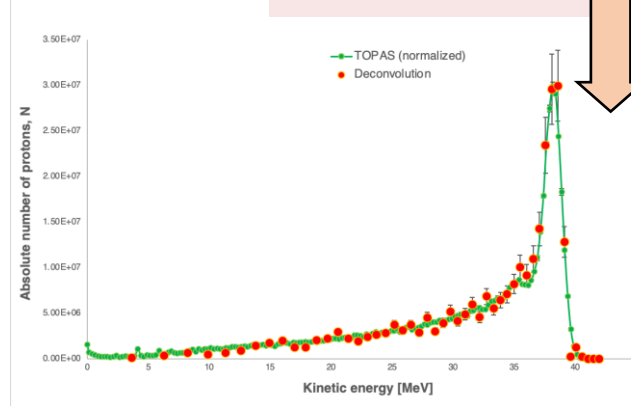


Fig 5. Spectrum found from energy deconvolution compared with MC spectrum

- [1] A. Macchi, et al. Reviews of Modern Physics, Vol 85, (2013). [2] D. Kirby, et al. Laser and Particle Beams, 29(2), (2011) 231-239. [3] S. McCallum, et al. JINST, (2022)

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