A Scintillator-Based Range Telescope for Proton Therapy

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Motivation

Proton range measurements are routinely carried out as part of the quality assurance in proton therapy centres. We are developing a range telescope based on thin water-equivalent plastic scintillator sheets, conceptually similar to a Multi-Layer Ionisation Chamber (MLIC). The resulting detector aims to perform range measurements of clinical proton beams within the time of beam delivery, independent of dose rate.

Detector Principle

- The use of sheets instead of a single block of scintillator allows to remove parallax artefacts.
- The proton beam is fully absorbed in the scintillator stack.
- A snapshot of the quenched light output is taken.
- The range is reconstructed from the depth-light curve.

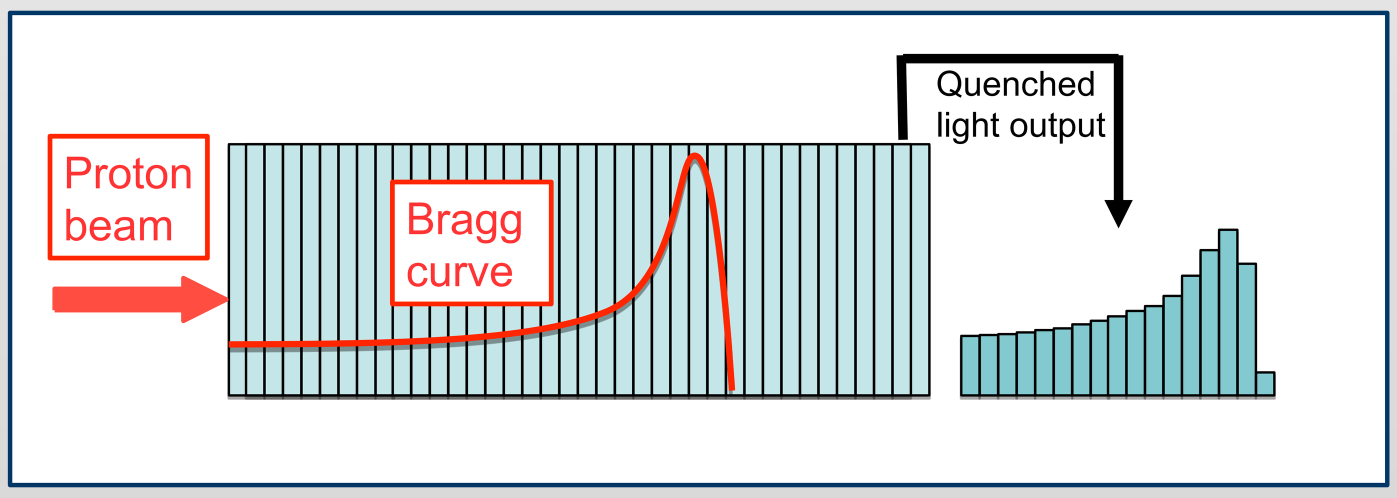

Figure 1: Principle of a scintillator-based range telescope.

Prototype Setup

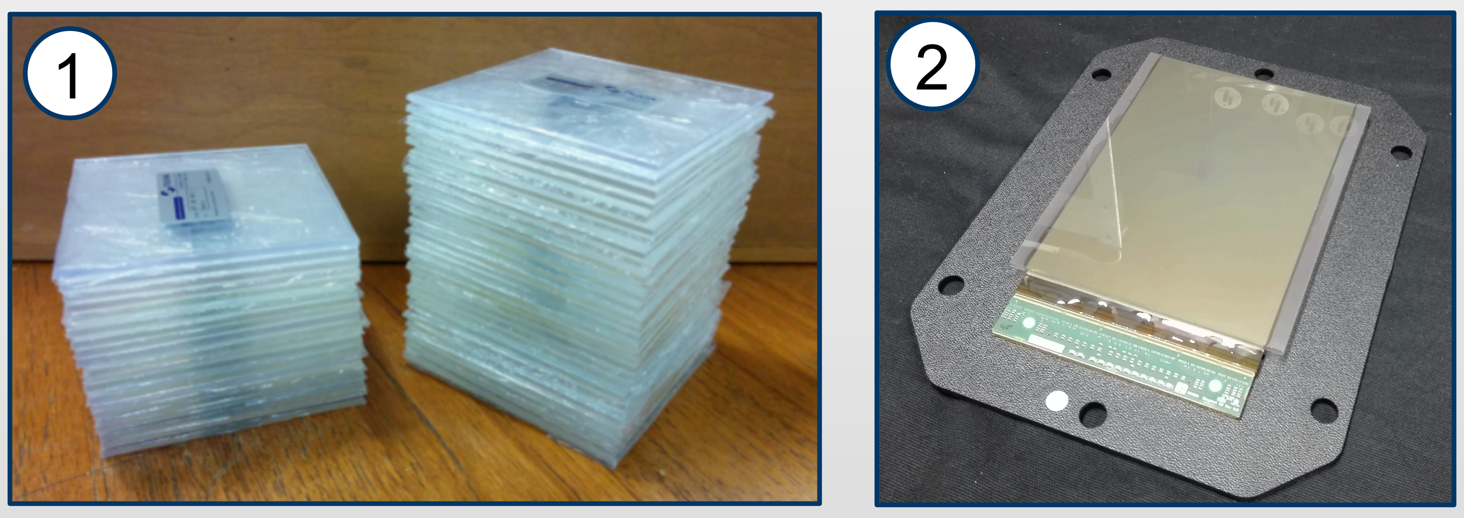

Figure 2:
1) 30x2mm and 20x3mm thick scintillator sheets (10x10cm^2).
2) 15x10cm^2 CMOS sensor for light detection.

HIT Beam Test Results

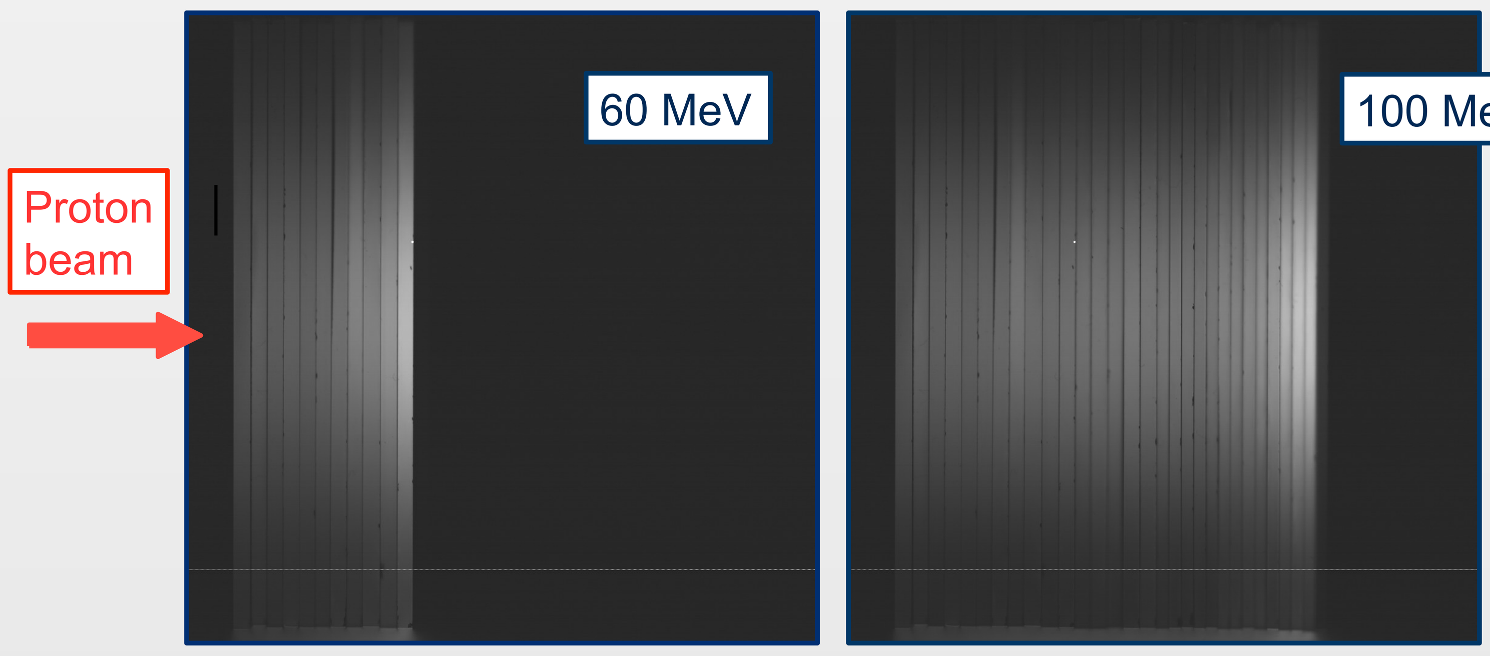

Figure 3: Snapshot of the quenched light output for two different beam energies.

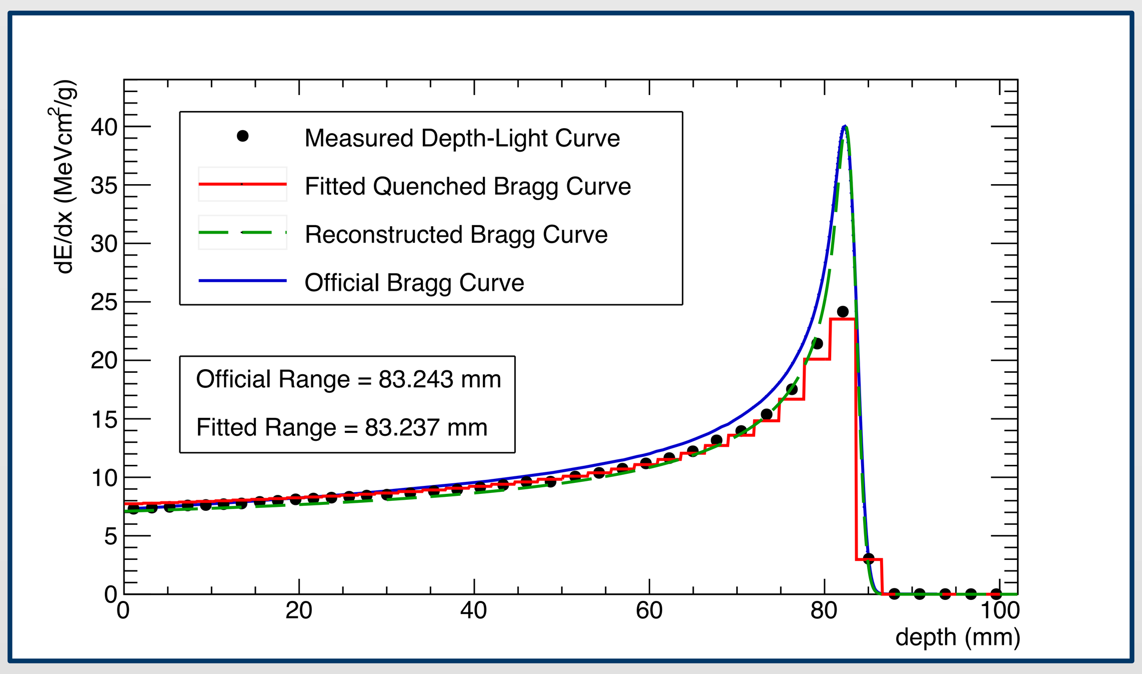

Figure 4: Novel quenched Bragg curve fit to the measured depth-light curve. The official Bragg curve is a data-validated Fluka simulation performed by Andrea Mairani and Katia Parodi in 2008.

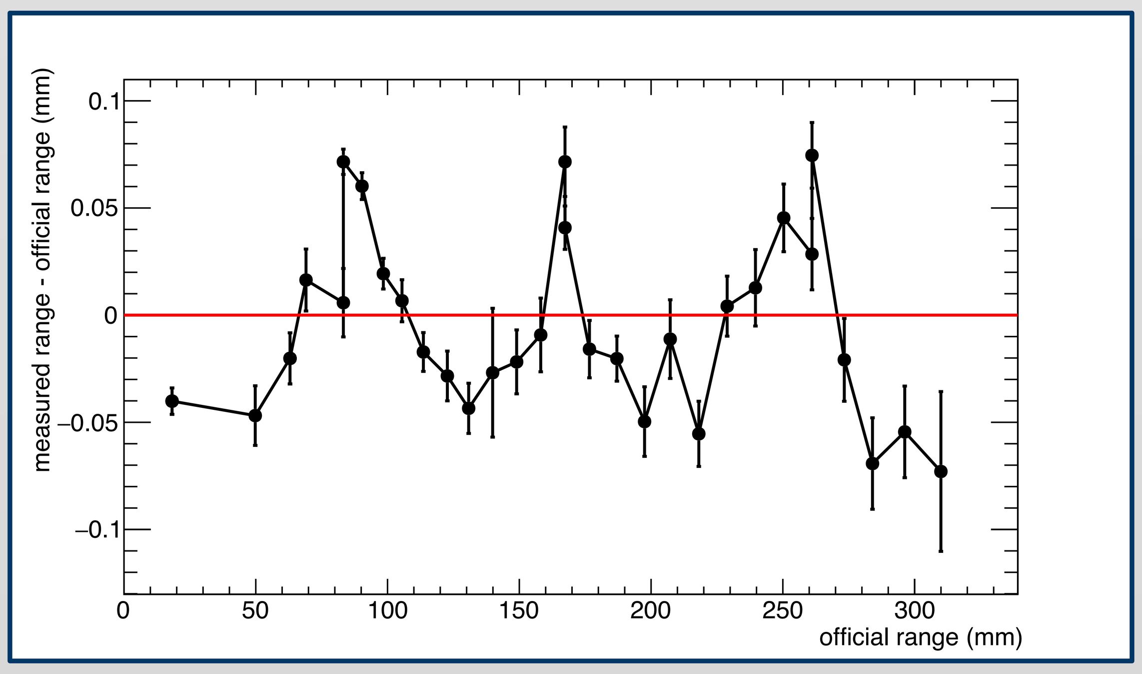

Figure 5: Difference between measured (fitted) and official range (80% fall-off). The average difference is 0.04mm.

Conclusion & Future Plans

- The detector performs fast and reliable proton range measurements with an estimated reconstruction uncertainty of ±0.04 mm which is competitive with commercial MLIC.
- The CMOS pixel sensor proves principal but is overkill. We are therefore developing a readout solution with one photo diode per sheet and a custom data acquisition system.
- The detector has also been tested with ion beams. An ion range reconstruction algorithm is under development.
- Further possible applications include the measurement of the residual helium beam range in a proposed mixed-beam therapy in which a carbon beam is used for treatment and a simultaneously accelerated helium beam is used for on-line radiography of the patient. Mixed-beam measurements with this detector will be presented by Lennart Volz on Thursday in the session on 4D Treatment and Delivery.

Marie Curie Actions

OMA

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