A Scintillator-Based Range Telescope for Proton Therapy

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Motivation

The precise knowledge of the range of a proton beam is crucial for an accurate treatment because of the steep fall-off at the end of a Bragg curve. Proton beam range measurements are carried out as part of the daily **quality assurance** in proton therapy centres. We are developing a range telescope based on **water-equivalent** plastic scintillator. The resulting detector aims to be as **fast and precise** as a Multi-Layer Ionisation Chamber at only a **fraction of the cost**.

Detector Principle

- The Proton beam is fully absorbed in the scintillator stack.
- Each scintillator sheet is read out individually.
- Light output is “quenched” (Birk's law).

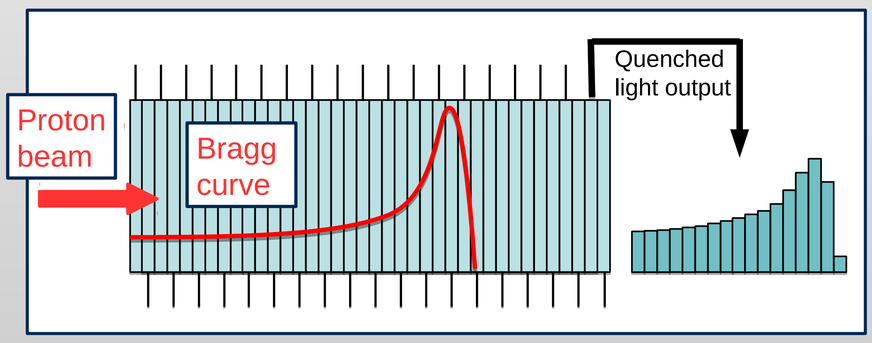

Figure 1: Principle of a range telescope.

Prototype Setup

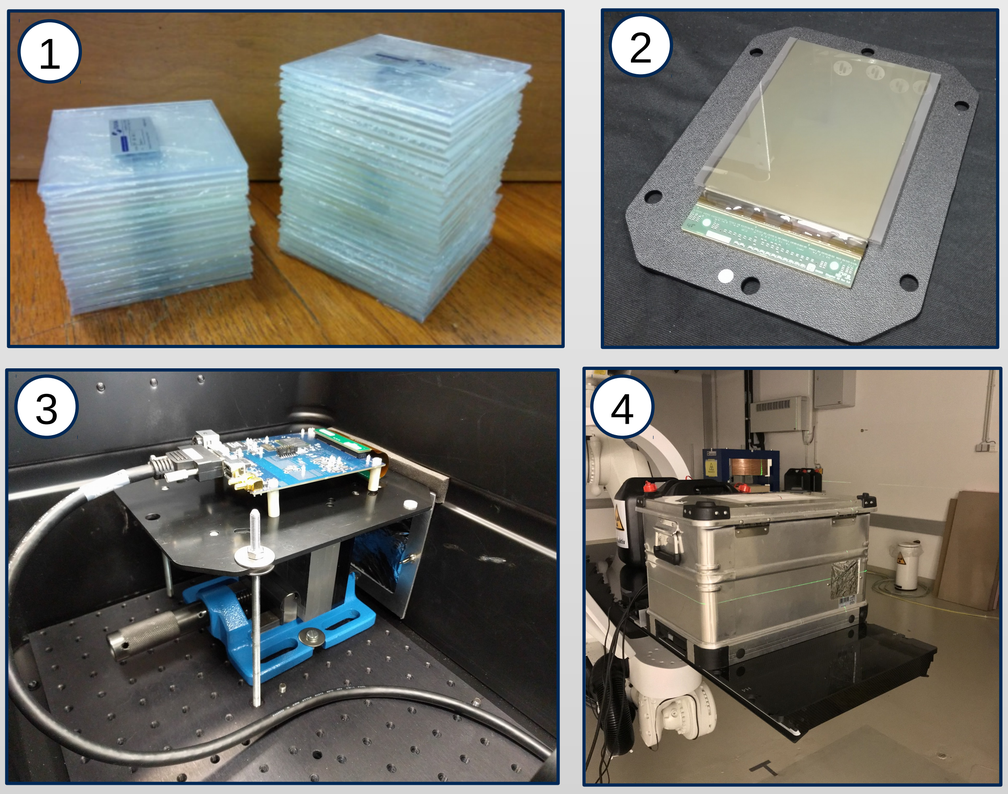

Figure 2:

1) 30x2mm and 20x3mm thick scintillator sheets (10 x 10cm^2).
2) 15 x 10cm^2 Monolithic Active Pixel Sensor (CMOS).
3) Scintillator stack fixed in vice with pixel sensor on top.
4) Prototype in light-tight enclosure on treatment couch.

MedAustron Beam Test Results

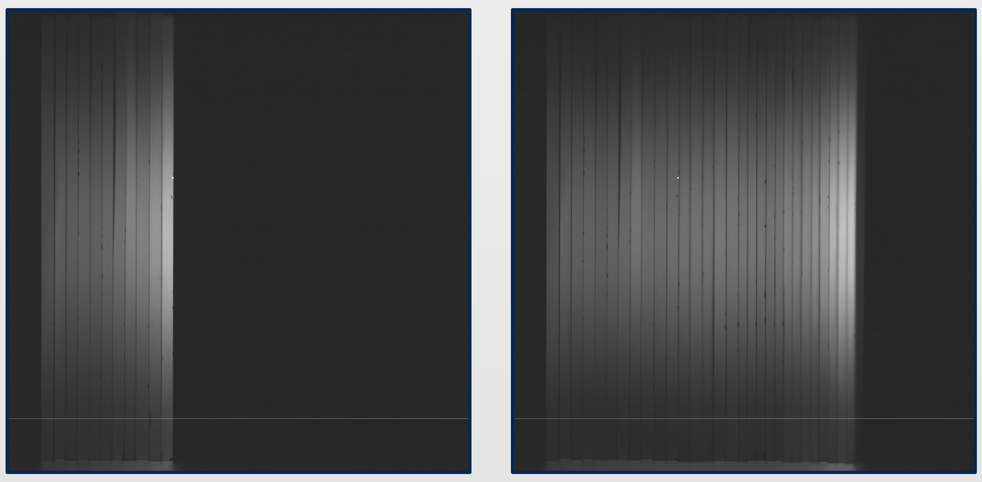

Figure 3: Quenched light output for two different beam energies.

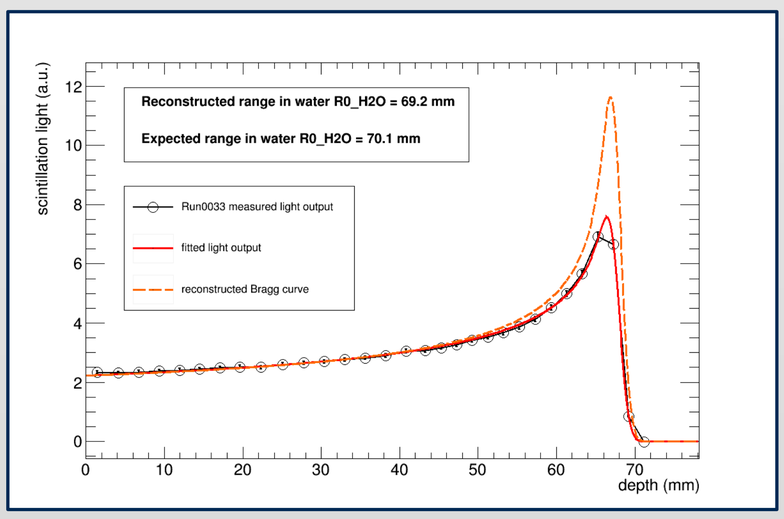

Figure 4: Fit of a quenched Bragg curve to the integrated light output and reconstruction of a pristine Bragg curve.

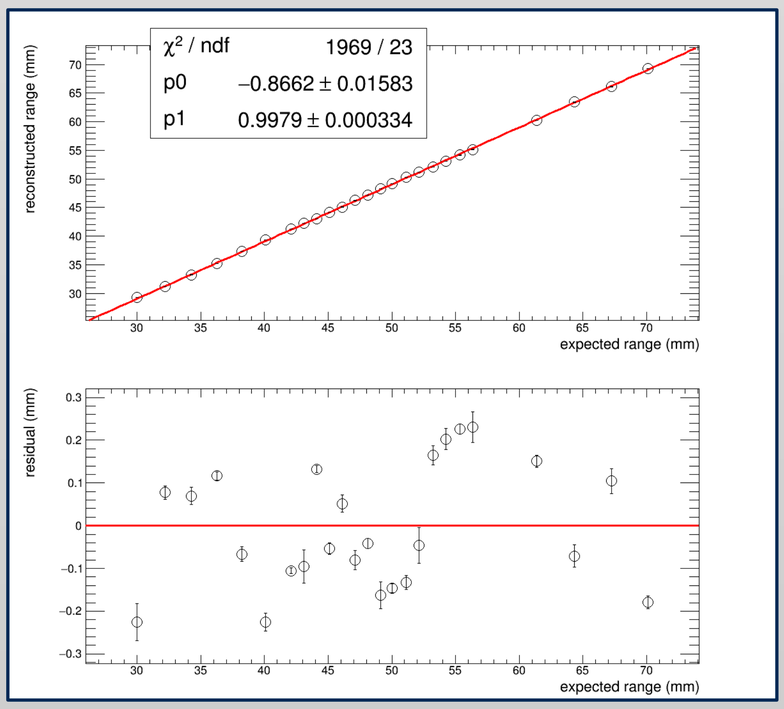

Figure 5: Reconstructed vs. expected ranges and residuals.

Conclusion & Future Plans

- Prototype range telescope developed and tested.
- Able to do range reconstruction using a new model of a quenched Bragg curve.
- Water-equivalent range reconstructed within ±0.15 mm.
- Pixel sensor proves principal but is overkill.
- Investigate readout solution with one photodiode per sheet and custom DAQ.
- Data analysis currently offline in ROOT: develop online data analysis tool.
- Build a working clinical prototype at 250 MeV.

Marie Curie Actions

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