Development of a Detector for Fast Treatment Plan Verification

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Motivation

Treatment plan verification (TPV), or patient-specific quality assurance (patient QA), requires detailed information about the volumetric dose deposition within an instrumented volume, to ensure the accurate delivery of dose for a given treatment plan. Current methods of patient QA are time-consuming, necessitating the repeated scanning of water phantoms. A collaboration between the High Energy Physics group at University College London and the Physics Dept. at the University of Birmingham is developing a prototype system for **fast patient QA**.

Detector Principle

- Single-module plastic scintillator-based calorimeters developed at UCL for the SuperNEMO high energy physics experiment to **measure single proton energy**.
- Silicon trackers developed at Birmingham for the PRaVDA proton CT project to reconstruct **2D proton position**.
- Potential for reconstructing the 3D dose deposition for individual protons and therefore build up the **complete volumetric dose distribution** for a given treatment plan.
- Simple prototype to provide proof-of-concept by correlating position and energy measurements across detectors.

Simple Prototype Setup

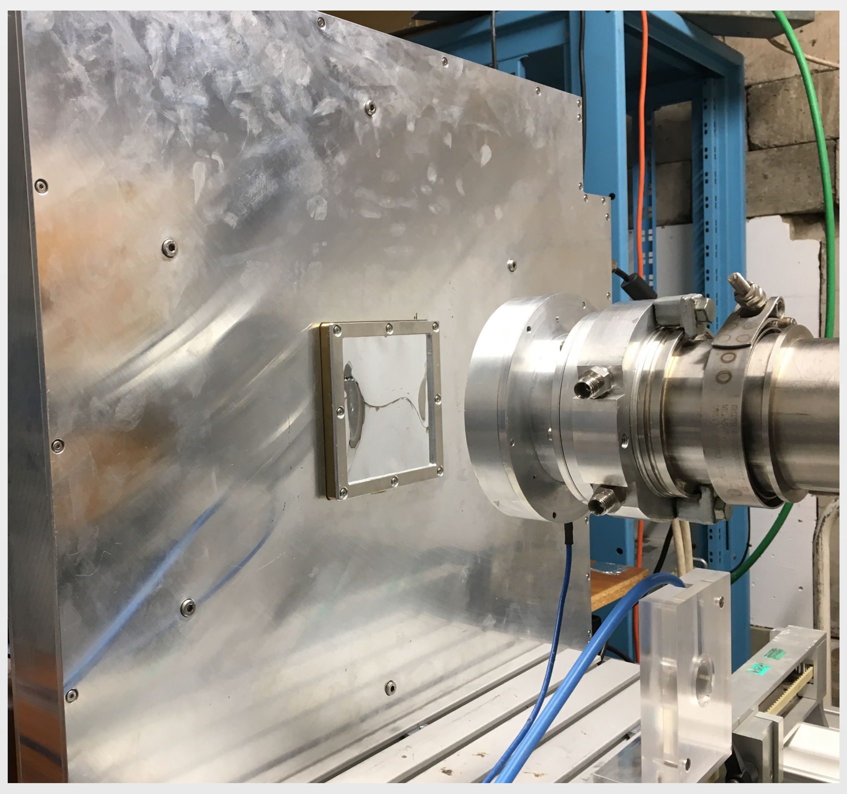

Fig 1. Single PRaVDA tracker module, located upstream of the single-module calorimeter.

Fig 2. Calorimeter: 3 × 3 × 5 cm scintillator block wrapped in mylar foil and Hamamatsu R13089 PMT.

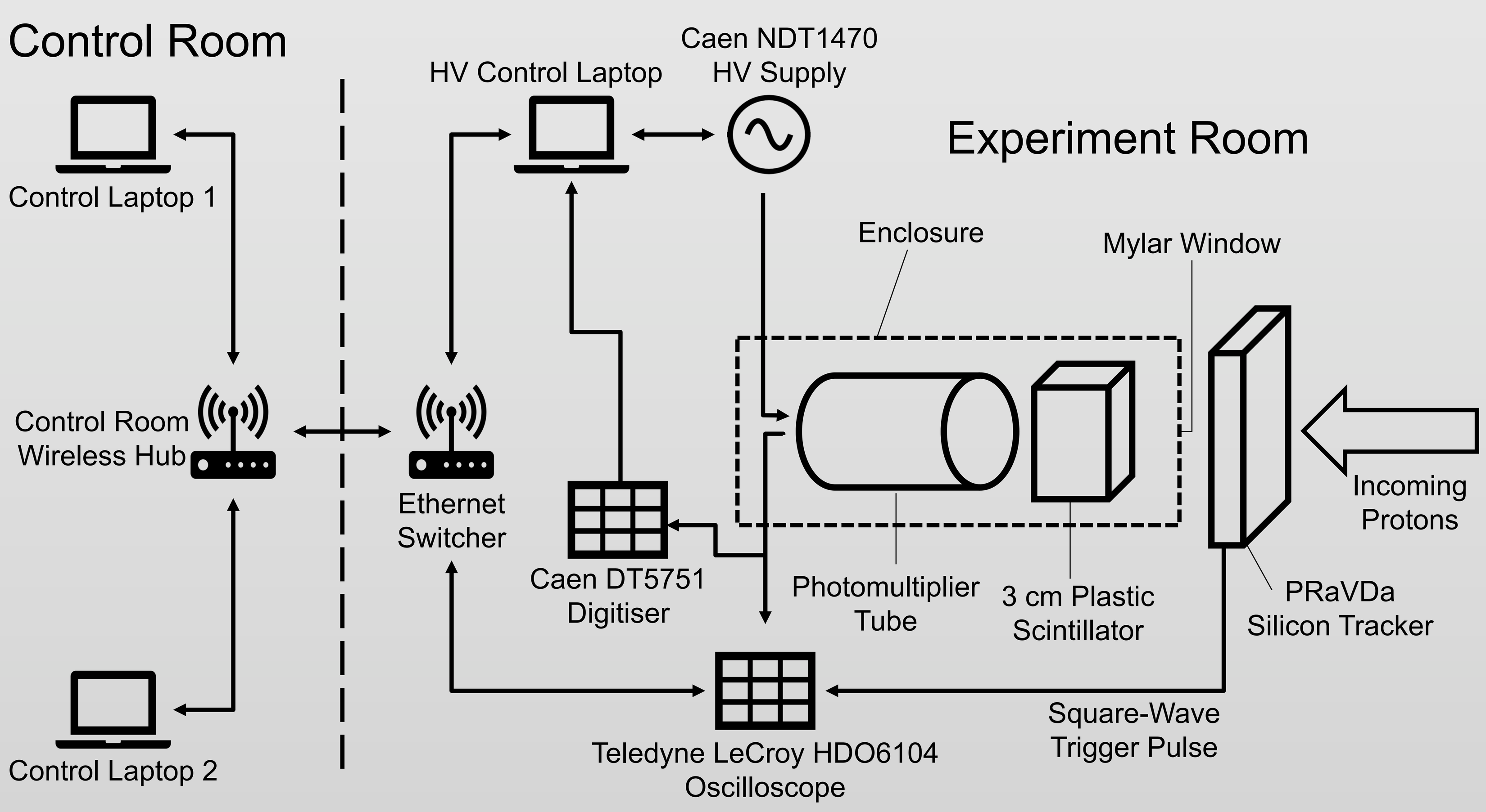

Fig 3. Schematic diagram of experimental set up. The LeCroy oscilloscope acquisition is triggered by a trigger pulse from the tracker module whenever a hit is recorded in 2 of the 3 (X,U,V) layers. The output of the PMT is also independently measured by the Caen digitiser.

Birmingham 36 MeV Beam Test Results

Fig 3. Different 2 mm collimator configurations tested with 0–6 mm thick sheets of PMMA absorber. Collimator pair (right) tested with one hole covered with 4 mm PMMA.

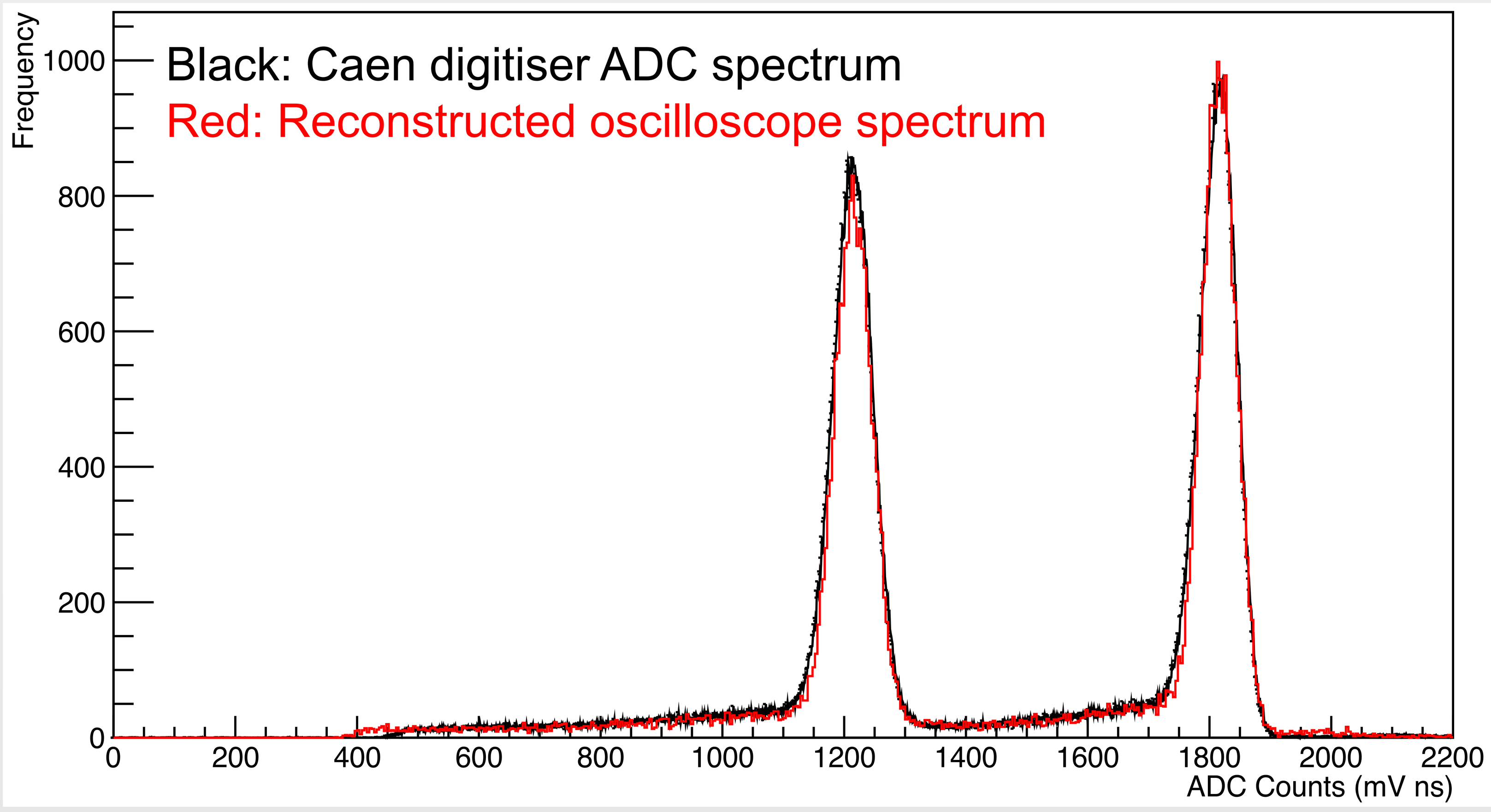

Fig 4. Reconstructed proton energy spectrum for half-covered collimator pair configuration. Black line shows spectrum as recorded by the Caen digitiser and the blue line shows spectrum from the LeCroy oscilloscope.

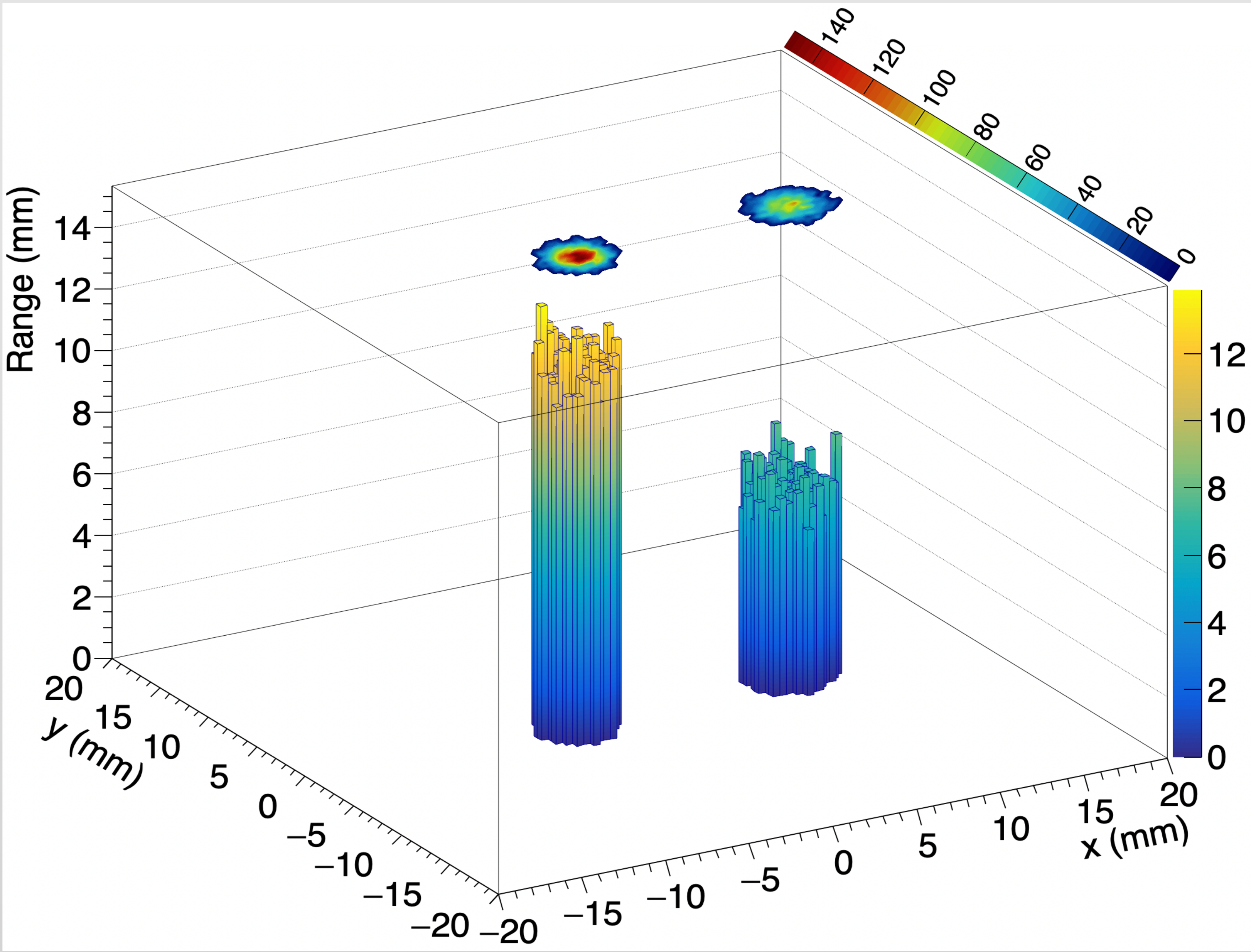

Fig 5. Reconstructed deposition in 3D for the half-covered collimator pair configuration. The range is calculated from the average proton energy, by applying a power law. The superimposed 2D plot shows the XY intensity profile for each spot. Only bins with more than 20 protons are shown. Total number of matched protons was ~17000.

Conclusion & Future Plans

- Single-proton measurements made by the tracker were successfully correlated with energy measurements made by the calorimeter, and position and energy distributions for a variety of collimator configurations were reconstructed.
- Further measurements with higher beam rates and improved detector triggering are planned.

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