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Proton Radiography for adaptive radiotherapy using ATLAS FE-I4 detectors

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Due to the physical principles of the energy deposition of charged particles in matter, proton therapy allows a very precise dose deposition in the tumour, which leads to better protection of healthy tissue compared to photon radiotherapy. At the same time, the maximum dose deposition at the end of the proton trajectory is more sensitive to uncertainties in the range of the protons. A significant source of these uncertainties are inter-fractional anatomical changes in the patient during treatment. Adaptive radiotherapy, where the treatment plan is adapted to the anatomy of the day, is an important tool to optimise dose deposition.
Pixelated semiconductor detectors with energy resolution allow the kinetic energy of the protons to be measured in two dimensions. If the detector is placed downstream of the patient, the energy loss in the patient, expressed in terms of their water-equivalent thickness (WET), can be quantised (proton radiography). In this way, the patient's anatomy in the target area can be monitored over the course of treatment with a very small additional imaging dose, allowing the treatment plan to be optimised if the anatomy changes significantly.
In this paper we present a proton radiography system using ATLAS IBL FE-I4 detector modules. The particle flux and the deposited energy are well beyond the intended application of the readout chip.
We show first results for the measurement of the proton energy and the WET resolution and demonstrate the applicability of the detector for the acquisition of proton radiography images.

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