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Non-invasive particle beam tracker for high-resolution radiation quality and dose delivery monitoring in proton radiotherapy

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In current particle radiotherapy practice it is necessary to evaluate the radiation dosimetry and monitor the beam delivery procedures ideally using a simplified compact instrument with detailed time, spatial and directional response. For this purpose, we developed a non-invasive technique for wide field-of-view tracking and high-resolution dose monitoring of delivered particle accelerator beams of clinical intensity. We use a single-chip miniaturized radiation camera MiniPIX-Timepix3 [1] placed away from the beam axis (> 1 m) well beyond the isocenter (> 5 m) –see Fig. 1. We detect the scattered and secondary radiation reaching the detector. In particular, we analyze in detail the energetic scattered proton component produced in the phantom/patient and also along the beam path in air (Fig. 1c). In this approach we avoid the use of an scatter foil [2], the need for multi-detector arrays [3] or to place the detector directly on the beam axis [4]. The latter option is feasible only for non-clinical beams and beams of low-intensity (« nA). The spectral-tracking response of the pixel detector enables to resolve particle-type components, selectively measure their energy loss and map their direction of trajectory in full (2π) field-of-view. The derived information on the mixed-field decomposition together with spectral-sensitive particle tracking (Fig. 1c) serve to evaluate and monitor the primary beam and examine and characterize in detail the dose delivery and quality assurance procedures (Fig. 2). The resolving power of the technique and results are shown on measurements with (Fig. 2) and without (Fig. 1c) phantoms. An extension of the technique includes customized Monte-Carlo simulations which serve to provide absolute conversion factor of primary beam intensity.

References
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