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Detectors for beam monitoring and dosimetry at ultra-high dose rates for FLASH Radiotherapy

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FLASH radiotherapy (RT) is attracting a significant interest since the first investigations carried out in 2014 [1]. Several preclinical studies worldwide have demonstrated that ultra-high dose rate (UHDR) beams produce an improvement of normal tissue sparing, compared to conventional dose-rate RT, while maintaining same tumor control probability (FLASH effect). However, to fully understand the mechanisms behind the effect and to support the future clinical translation of FLASH radiotherapy, novel beam monitoring and dosimetry technologies must be developed, and new approaches studied [2]. Currently used detectors for reference dosimetry for conventional radiotherapy, such as ionization chambers, saturate at these extreme regimes, therefore the optimization of already established technologies as well as the investigation of new instrumentation for dosimetry are required [3]. Alternative approaches, such as calorimetry or the use of solid state detectors are currently being studied and their usage at UHDRs is under assessment. The challenges characterizing dosimetry for FLASH radiotherapy vary considerably depending on the accelerator type and technique used to produce the relevant UHDR radiation environment. Different beam pulse structures can be used for the acceleration of the radiation beams, depending on the specific accelerator, and the related dose and dose-rate per pulse can affect the detector response. A reliable measurement also of the instantaneous dose rate, beyond an accurate measurement of the dose, are relevant at these extreme regimes. The main challenges coming from the peculiar beam parameters characterizing UHDR beams for FLASH RT will be discussed. A status of the current technology will be provided, including recent developments for established detectors and novel approaches currently under investigation with a view to predict future directions in terms of dosimetric approaches and practical procedures for the clinical translation of FLASH RT.

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[3] M. McManus M., SCIENTIFIC REPORTS, vol. 10, ISSN: 2045-2322 (2020).

Summary

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