Test beam results of a fluorescence-based monitor for ultra-high dose rates

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Over the past decades, research in radio and particle therapy (RT, PT) has been focused on the goal of maximising the tumour control while minimising the damage to the healthy tissue. Recent advances in RT with ultra-high dose rate (>100 Gy/s) delivered in a short treatment time (<500 ms) through narrow (order of μs), high dose (~1 Gy) pulses, have been found to have a protective effect on healthy tissues whilst keeping an anti-tumor efficacy comparable with conventional RT [1]. This effect has been named "FLASH effect". The great interest around this experimental evidence has led to an intense research activity on the development of monitoring techniques for charged beams at ultra-high dose rates. FLASH poses an unprecedented challenge since the performances of conventional detectors are usually compromised by non-linear effects due to the very high flux of particles [2].
The FlashDC (Flash Detector beam Counter) exploits the air fluorescence to monitor in real time the beam fluence and spatial distribution with high accuracy and minimal impact on treatment delivery. A detector based on this mechanism, innovatively introduced for this kind of application, could provide a linear response for any charged beam and in a wide range of dose rates and energies, and will result in the manufacture of a simple and economical device. Several prototypes have been developed for proof-of-principle studies, using a FLUKA Monte Carlo simulation for geometry optimization. The background evaluation plays an important role on the detector design, and thus various strategies to select the relevant optical photon signal have been investigated.
The analysis performed on data collected from the latest test beam campaigns with electrons delivered at FLASH intensities by the ElectronFlash LINAC at the CPFR in Pisa, for the first time including background subtraction, showed a linear correlation between the signal collected by the detector and the delivered dose-per-pulse over the whole range of intensities explored, proving that fluorescence can be used to perform beam monitoring for studies on FLASH-RT. In this contribution the FlashDC monitor will be presented together with the expected performances and the results of preliminary test beam measurements obtained with electron beams delivered in FLASH modality.

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[1] B. Lin et al, Front. Oncol. 11 (2021), DOI: 10.3389/fonc.2021.644400
[2] F. Di Martino et al, Front. Phys. 8 (2020), DOI: 10.3389/fphy.2020.570697