Contribution ID: **29** Type: **Talk**

Electron and proton Flash research at the Dresden Platform for ultra-high dose-rate radiobiology

Wednesday 25 June 2025 09:30 (30 minutes)

The FLASH effect describes the observation of normal tissue protection by ultra-high dose rates (UHDR), i.e. dose delivery in a fraction of a second, at similar tumor-killing efficacy of conventional dose delivery and promises great benefits for radiotherapy patients. Dedicated studies are now necessary to define a robust and optimum set of dose application parameters for FLASH radiotherapy and to identify underlying mechanisms. These studies require particle accelerators with high beam intensity and variable temporal dose application characteristics for numerous radiation qualities, equipped for preclinical radiobiological research.
The “Dresden platform” as a research hub for ultra-high dose rate radiobiology unites clinical and research electron and proton accelerators with radiobiology infrastructure and know-how, offering an unique environment for preclinical FLASH effect studies.
Applying the zebrafish embryo model a comparative pre-clinical study was conducted across the ELBE electron research accelerator, a clinical proton cyclotron, and an advanced laser-driven proton source applied for FLASH-relevant in vivo irradiations for the first time. The flexible beam pulse structure at ELBE allows to demonstrate a protective effect of UHDR irradiation up to 10^5 Gy/s average electron dose rate, compared to conventional beam delivery over minutes. The proton experiments suggest the consistency of the protective effect even at escalated dose rates of 10^9 Gy/s for laser-driven relative to conventional proton beams.
Moreover, the first mice experiments investigating the response of brain normal tissue and subcutaneous tumors for UHDR and conventional proton beams started recently.
With the first clinical FLASH studies underway, research facilities like the Dresden platform, addressing the open questions surrounding FLASH, are essential to accelerate FLASH’s translation into clinical practice.

Summary

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Session Classification: Pre-Workshop ”Medical applications”

Track Classification: Pre-Workshop ”Medical applications”