

Development of an Experimental Setup for Flash Effect Studies at the FLUTE Electron Accelerator

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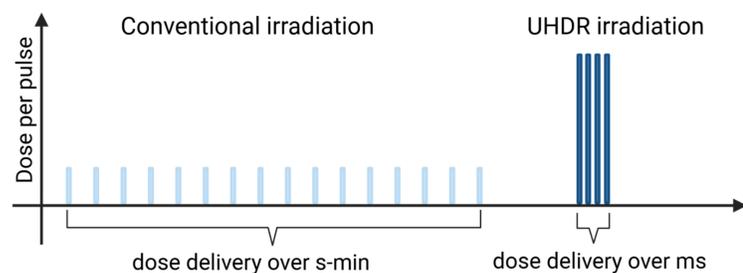
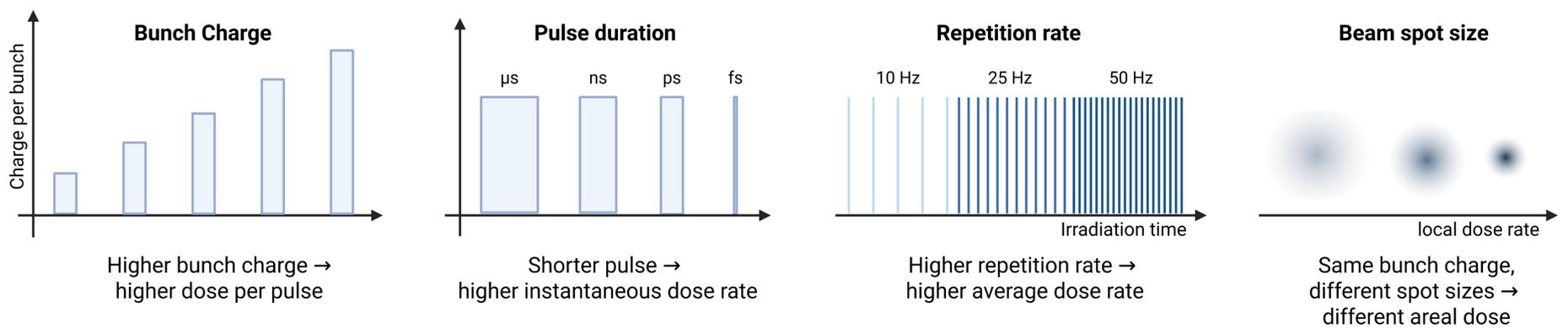
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FLASH radiotherapy is a promising new approach that employs ultra-high dose rates (UHDR) (> 40 Gy/s). Preclinical studies demonstrate tumor control comparable to conventional radiotherapy (~0.1 Gy/s), but with significantly reduced side effects in healthy tissue.

At the linear electron accelerator FLUTE (Far-Infrared Linac and Test Experiment), an experimental setup is being developed for irradiation studies with variable beam parameters, with a particular focus on UHDR.

The objective is to conduct dosimetry experiments under FLASH conditions and to carry out initial radiochemical and radiobiological studies using water, cell media, and cell cultures.



Beam parameter	Conventional	UHDR
Energy	30 MeV	30 MeV
Bunch charge	~ 10 pC	470 pC
Pulse duration (FWHM)	~ 50 ps	~10 ps
Pulse rate	10 Hz	50 Hz
Mean dose rate	0,12 Gy/s	50 Gy/s
Maximum pulse dose	0,01 Gy	~ 1 Gy

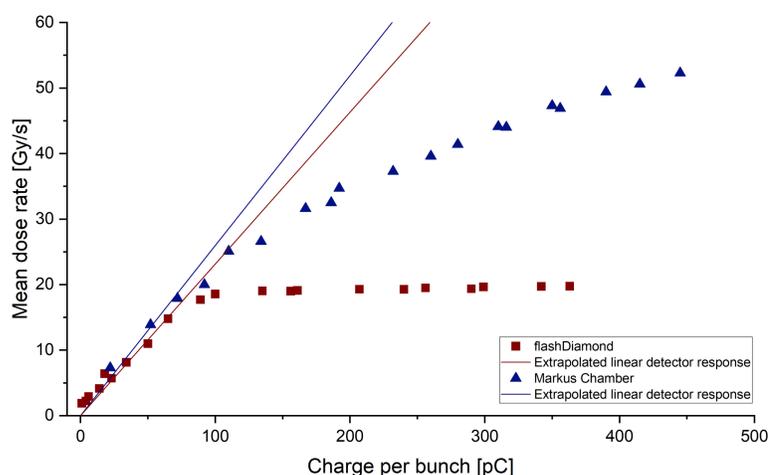
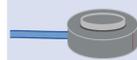


Figure 2: Mean dose rate vs. charge per bunch for flashDiamond and Markus chamber. Solid lines indicate linear extrapolation of the low-charge regime. Deviation at high charge reflects detector saturation. The non-zero intercept originates from dark current contributions affecting the charge readout.

Dosimetry at FLUTE



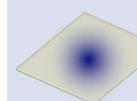
Advanced Markus Electron Chamber (PTW Freiburg GmbH)

Reference detector for absolute dose measurements at conventional dose rates. Dose-rate independent within the low to moderate dose-per-pulse regime; limited applicability under UHDR conditions.



FlashDiamond Detector (PTW Freiburg GmbH)

High temporal resolution detector designed for UHDR applications. Linear response at moderate pulse charge; saturation observed at very high instantaneous dose per pulse.



Gafchromic EBT-XD film (Ashland Inc.)

Passive 2D dosimetry with high spatial resolution. Largely dose-rate independent over a broad range; requires post-irradiation readout.



Optically Stimulated Luminescence Dosimeter (Mirion Technologies (AWST) GmbH)

Passive integrating dosimeter with high sensitivity at low total dose. Small active volume, largely dose-rate independent over a wide range; offline readout required.

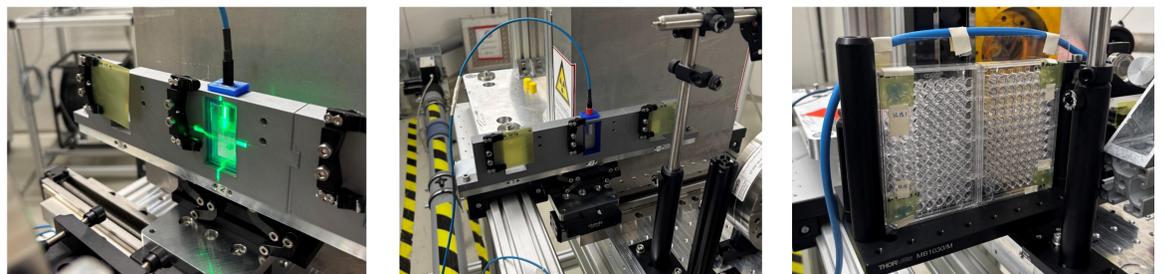


Figure 1: Experimental irradiation platform at FLUTE. Left and center: dosimetric characterization setup for conventional and UHDR regimes. Right: positioning system for irradiation of multiwell plates.

Results

- Controlled generation of conventional (0.1 Gy/s) and UHDR (>40 Gy/s) irradiation regimes at FLUTE
- Instantaneous dose rates up to ~10¹¹ Gy/s realized
- Active detector response is governed by pulse-induced instantaneous dose rate, while passive systems remain suitable alternatives in the UHDR regime
- Experimental basis established for 3D organoid-based radiobiological studies