Energy spectrum measurements for conventional and ultra-high dose rate (FLASH) electron beams*

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Ultra-high dose rate radiotherapy (FLASH-RT) could be a highly promising approach to cancer treatment, utilising ionising radiation. This innovative technique uses ultra-high dose rate beams to deliver treatment dose in an extremely short time ($<$200 ms), resulting in a "FLASH effect" that protects healthy cells while effectively destroying tumour cells. However, this rapid dose delivery presents significant challenges for accurate dose and energy measurement, particularly in single radiation pulses [1].

In this work, we present a direct method of measuring the energy spectrum with a permanent magnet electron energy spectrometer [2], designed to evaluate the energy distribution of electron beams at a wide range of dose rates. The preliminary results obtained in the AQURE - accelerator dedicated to intraoperative radiotherapy (IORT) with the FLASH research mode indicate differences in the energy spectra of beams differing only in dose rate. This method makes it possible to obtain the energy spectra of even a single pulse and determine its most probable and average energy of the electrons in the beam. Measurements and analysis of energy spectra for FLASH beams are ongoing. Figure 1 shows the energy spectra obtained for conventional IORT electron beams with a dose rate of 10 Gy/min and nominal beam energies of 6 and 9 MeV.

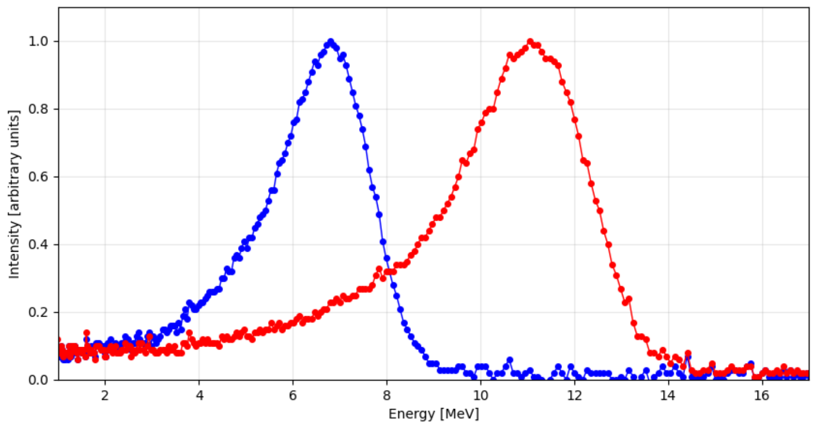

Figure 1: Energy spectra of 6 MeV (blue) and 9 MeV (red) conventional IORT electron beam (dose rate 10 Gy/min).

The ability to inspect and analyse conventional and ultra-high-dose electron beam energy spectra, and the ability to relate them to dosimetry results (e.g. percentage depth dose curve), could play a key role in understanding and implementing the clinical use of FLASH-RT.

[1] A. Lenartowicz-Gasik et al., Pol J Med Phys Eng (2025) 62-72.
[2] J.E. McLaughlin et al., Med Phys (2015) 5517-5529.

*We acknowledge support from project no. RPWP.01.01.00-30-0002/21-00 in "Wielkopolski Regionalny Program Operacyjny na lata 2014 - 2020"