



Contribution ID: 172

Type: **Poster**

Medical Activities in CLEAR: Studies Towards Radiotherapy Using Very High Energy Electrons (VHEE) in the FLASH Regime

Given the present availability of high-gradient accelerator technology for compact and cost-effective electron linacs in the 100-200 MeV energy range, the interest for Very High Energy Electron (VHEE) radiotherapy (RT) for cancer treatment recently reached an all-time high. Particular significance is assumed by the Ultra-High Dose Rate (UHDR) regime where the so-called FLASH biological effect takes place, in which cancer cells are damaged while healthy tissue is largely spared. VHEE beams from linacs are especially well adapted for FLASH RT, given their penetration depth and the high beam current needed to treat large deep-seated tumours. In recent years, several multi-disciplinary user groups carried out a number of studies on VHEE and FLASH RT issues using the CERN Linear Accelerator for Research (CLEAR) user facility, in close collaboration with the local operation team. In this paper we give an overview of such activities and describe the main results of chemical and biological tests aimed at clarifying the damage mechanisms at the root of the FLASH effect and the relevant beam parameters needed to achieve it. We also describe the dedicated systems and methods developed and used in CLEAR for these activities, focusing on recent advances in the crucial aspects of uniform beam delivery and high dose rate real-time dosimetry.

Work-package

WP3 - RIs for Accelerator R&D

Facility identifier

CLEAR

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Session Classification: Cocktail - Poster session