

## **FLASH and VHEE studies at CLEAR facility at CERN**

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Radiation Therapy (RT) is key component of effective cancer treatment and control. It is estimated that about half of all cancer patients would benefit from radiotherapy for treatment of localised disease, local control, and pain relief.

In RT the ultimate goal is to destroy the tumour, whilst minimising the damage to surrounding healthy tissue. Previous advances in RT have relied heavily on developments in improving imaging for targeting the dose to the tumour and delivery methods such as Intensity Modulated Radiation Therapy (IMRT), Volumetric Modulated Arc Therapy (VMAT) and use of hadrons taking advantage of the Bragg peak.

Very High Energy Electrons (VHEE) are a promising new modality for tumour treatment since they can be magnetically scanned and focused to improve treatment, and are capable of reaching deep-seated tumours within the patient whilst having a much lower magnetic rigidity than equivalent protons.

In addition, recent studies involving the ultra-high dose rate (mean dose rate above 100 Gy/s) delivery of ionizing radiation and termed FLASH radiotherapy (FLASH-RT), have uncovered some surprising and unexpected therapeutic benefits and has caused tremendous excitement since FLASH selectively spares healthy tissue and this may revolutionize modern day RT.

Currently the underlying mechanism for FLASH is still not well understood, however exploring which biological effects could be key to this phenomena is a huge area of research. Currently the CERN Linear Accelerator for Research (CLEAR) facility providing upto 200 MeV electron beam for irradiation studies is a unique place where VHEE-FLASH experiments can be carried out. FLASH and related experiments being carried out in CLEAR include: a) Dosimetry for VHEE, in particular at Ultra High Dose Rates, testing detectors and exploring the use of standard electron-beam diagnostics for real time dose rate evaluation b) Chemistry studies (e.g., Oxygen Peroxide production in water), c) Biological effects (e.g., on Plasmids and Zebra-Fish Eggs) at very high dose rates, with the goal to study the FLASH effect.