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The challenge of dosimetry in Flash Radiotherapy

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Flash radiotherapy (FLASH-RT) is a new delivery mode for radiation therapy using very high instantaneous dose rate with pulsed radiation beams. Even from around 1960 there were indications that the delivery of the ionizing radiation dose in ultra-short pulses could improve the therapeutic window respect to standard radiotherapy. During last years there is a growing interest in the clinical community about FLASH-RT due to the evidence of lower toxicity in healthy tissue keeping a similar tumour control probability (TCP) than conventional radiotherapy. In this way the so called FLASH effect would provide a new radiotherapy delivery mode with lower side effects allowing more aggressive strategies for tumour treatment. FLASH effect has been observed with photon and proton beams but usually most of the studies have been performed with electron beams. Although in most clinical facilities the achievable electron energies are below 20 MeV, the use of higher beam energies, even over 100 MeV, can extend the use of these modalities to deep seated tumours and boost its clinical use.
With instantaneous dose rates exceeding 10^6 Gy/s, FLASH-RT represents a challenge for current dosimetry standards. The European Joint Research Project UHDpulse – "Metrology for advanced radiotherapy using particle beams with ultra-high pulse dose rates" is an international collaboration with the objective of studying this challenge providing metrological methods for dosimetry in FLASH-RT and trying to develop Code of Practice for this radiotherapy modality.
Different primary standards are considered for this new delivery modality, such as Fricke dosimetry or graphite calorimetry. For the secondary standards the project considers solutions based on ionization chambers, silicon and diamond devices or other custom solutions for the dosimetry. Air ionization chambers are the most used secondary standards for dosimetry worldwide. Unfortunately for these detectors the saturation correction factor can differ substantially from unity reaching values even above 10 for some high dose per pulse deliveries. The problem of ion volume recombination that arises both from the high charge carrier densities produced by the ionizing beam and the electric field perturbation of the chambers lead to an unreliable operation of these standards, One of the options to overcome this problem is the use of ultra-thin air ionization chambers, with the corresponding assembly challenge and added effects such as electron multiplication in high electric field.
We will present some results on the simulation and measurement with some commercial and custom built chambers. The effort conducted under the collaboration will contribute to a better dosimetry understanding also at intermediate dose rate modalities such as Intra Operative Radiotherapy.

Primary author(s) : Prof. GOMEZ RODRIGUEZ, Faustino (Univresidad de Santiago); PAZ MARTIN, Jose (Universidad de Santiago); Dr. GONZALEZ-CASTAÑO, Diego M (Universidad de santiago); GÓMEZ FERNÁNDEZ, Nicolás (Universidad de Santiago); Dr. PARDO-MONTERO, Juan (Instituto de Investigación Sanitaria); Dr. GAGO-ARIAS, Araceli (Instituto de Investigación Sanitaria); Dr. FLETA, Celeste (CSIC); Dr. SCHÜELLER, Andreas (PTB); Dr. BOURGOUIN, Alexandra (PTB)

Presenter(s) : Prof. GOMEZ RODRIGUEZ, Faustino (Univresidad de Santiago)

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