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UHDpulse http://uhdpulse-empir.eu/

Towards primary and secondary standards for dosimetry in Flash radiotherapy

Objective

The development of code of practice (CoP) for new radiotherapy modalities are usually based on existing dosimetry protocols (AAPM TG51 or IAEA TRS-398) which are modified for the specificity of the modality. The Flash radiotherapy is a new modality in which the prescribed dose is delivered with ultra-high dose rate. Although in the early stage of development, it has already shown advantage over treatments using conventional dose rate as the adverse dose effect on healthy tissue is reduced. The challenge with dosimetry for Flash modality is that the use of ionization chambers as secondary standards is not suitable due to high level of ion recombination, it can be larger than 50%. In addition, the dependence of the ion recombination is not linear with the dose per pulse. To be obtained, it requires extensive measurements and intra-type variation between ionization chambers can be in the 2-5% range. The lack of precise accurate measurements and accurate theoretical model of the ion recombination hampers the progress of the Flash modality. The UHDpulse project is an EMPIR funded collaboration to develop reliable dosimetry methods for Flash modality and guidance for CoPs.

Materials and Methods:

The response of different types of detectors has been measured in an ultra-high dose per pulse 20 MeV electron beam provided by the research accelerator at PTB Braunschweig. To monitor the beam, a non-destructive Integrating Current Transformer (ICT) is integrated in the beamline.

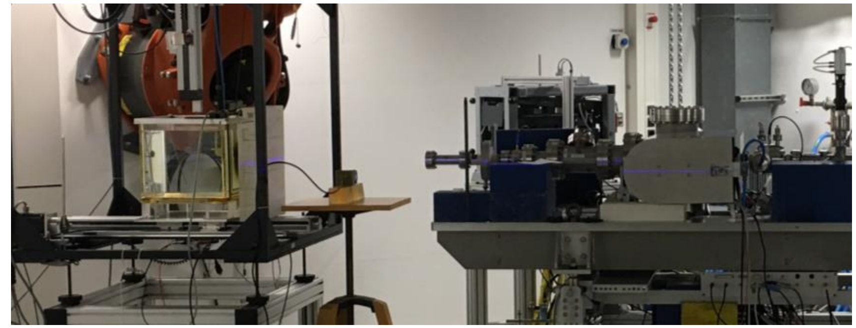

Figure 1: Set-up at the Metrological Electron Accelerator Facility (MELAF) at PTB, Germany.

The detectors used are plane-parallel chambers (Advanced Markus, PPC40, PPC05), alanine pellets and a probe-type graphite calorimeter. The ion collection efficiency of ion chambers has been obtained for a range of 0.5 to 2 Gy-per-pulse.

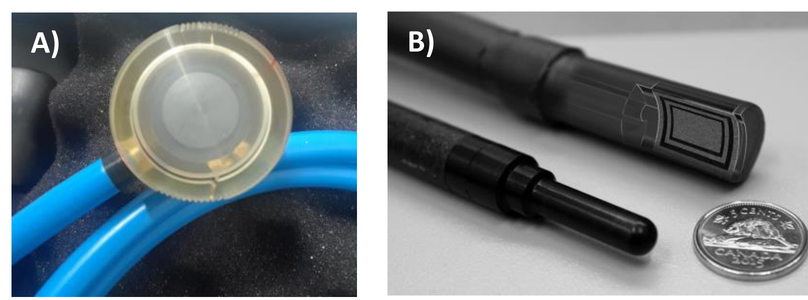

Figure 2: A) Picture of an Advanced Markus ion chamber. B) Picture of the Aerrow (top) with a cross-sectional drawing compared to an Exradin A12 (bottom left) ion chamber and a 5-cent Canadian coin (21 mm wide).

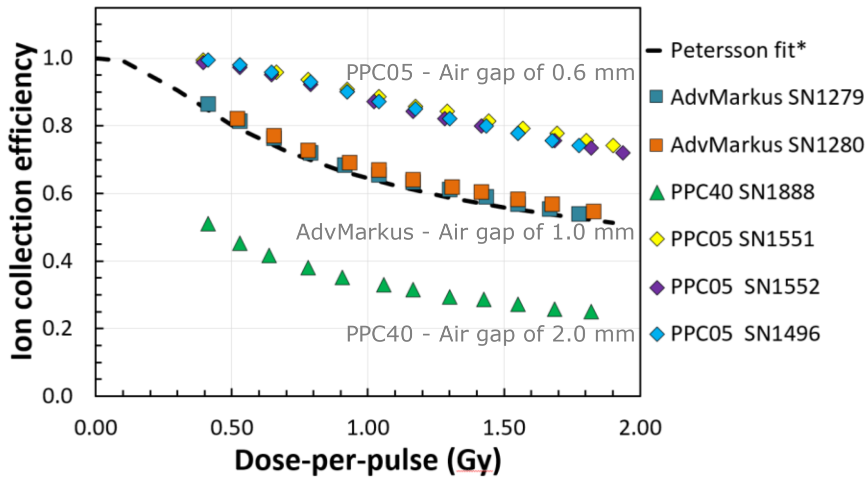

Figure 3: Ion collection efficiency in ultra-high dose per pulse electron beams

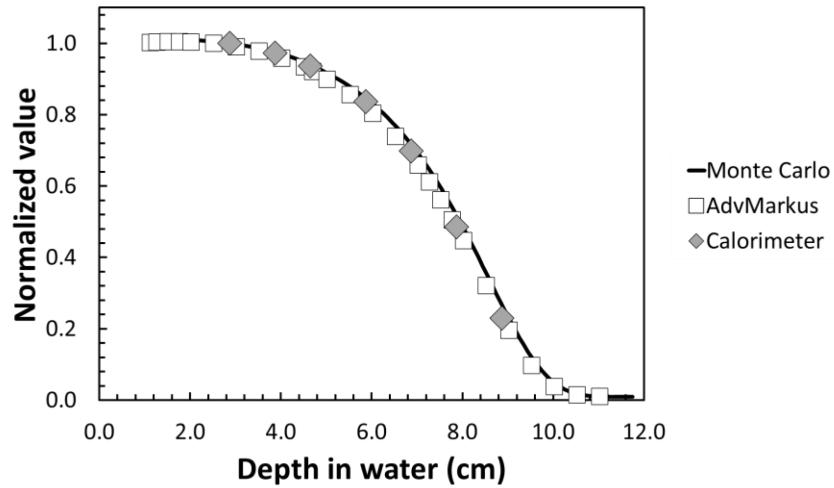

Figure 4: Depth dose measurement in water with calorimetry and ionometry compared to Monte Carlo simulation.

Results:

The dependence of the ion collection efficiency is not linear with the dose per pulse for all types of detectors and intra-type variations in the 2-5% range have been observed as illustrated in figure 3. In figure 4, the depth dose measurement with calorimeter and ion chamber compared to Monte-Carlo calculation is shown. The half-value depths in water R_{50} obtained from measurement and simulation agree within 1 mm.

Conclusions and Significance:

Although the project is still in early stage, calorimetry is showing promising results for absorbed dose measurements both at National Metrological Institutes and in Clinics. Calorimetry gets simpler at Flash dose rate as the dose delivery is in a few seconds or less. The preliminary results show that advanced thermal insulation of the calorimeter is not required, nor the use of a heat lost correction factor. For relative measurement, also other types of dosimeters such as plastic scintillators, diodes, or diamond detectors are under investigation to determine the best option. In this presentation, preliminary results of the investigation of calorimeter and ionization chambers will be shown.

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