Commissioning of new prototype ProteusOne© PBS proton therapy system

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Résumé

Purpose: We report the commissioning and monitor unit calibration process of new prototype S2C2TM proton therapy system with pulsed PBS high dose rate proton beam.
Material and methods: The S2C2TM has a frequency of 1kHz and delivers a pulsed proton beam of dose rate between 2.65 μGy/pulse and 230 μGy/pulse for the lowest (96 MeV) and highest (226 MeV) energies respectively. The facility is equipped with a compact gantry which rotates from -35◦ to 188◦ and delivers PBS proton beams of field sizes up to 20x24 cm^2. The nozzle monitor ionization chambers (IC) were designed to be able to measure high dose rate per pulse delivered charges. A prototype 14 cm plane parallel IC and a multi-layer IC were used to measure integrated depth dose curves. Spot profiles and field size and penumbra were acquired with a 2D-scintillator detector while 2D-fields uniformity and symmetry were measured with a prototype 2D-array IC. Absolute dose/monitor unit calibration was based on dose measurements in single-layer fields of size 10x10 cm^2. Plane parallel ionization chamber was used with -500V voltage to limit the effect of recombination. Following the TRS398 protocol [1], temperature and pressure (kT,P), polarity effect (kpol), beam quality factor (kQ,Q0) and recombination effect (ks) correction factors were computed and applied to the considered ionization chamber. The TRS398 pulsed beams model [2] and 3 additional Boag's models [3] were investigated to compute the fraction of free electron for the recombination effect correction, while the kQ,Q0 factor evaluation was based on Monte-Carlo Goma's results [4] for PBS proton beams.

Results: S2C2TM high dose rate per pulse beam causes mainly recombination effects in IC based detectors, and prototype detectors and nozzle IC were developed in order to take into account these beam characteristics. Measurements performed with these detectors show lateral and longitudinal dose uniformity better than 2.5 % for clinically significant field sizes,

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ranges, modulations and air-gaps. For Absolute dose the measurements were achieved in single-layer fields with plane parallel IC. The standard deviations between the ks values obtained with the 4 methods are not larger than 0.02% and 0.3% for the lowest and the highest energies respectively. ks value of 1.009 was selected for all the energies. In order to verify our measurement method absolute dose was also made with water calorimeter: measured dosimetry data agreed within 2% for the lowest and the highest energies.

Conclusion: The new prototype S2C2TM PBS proton therapy system was successfully commissioned and released for clinical use.

Bibliography:

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