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Objectives

Quality assurance (QA) plays an important role in radiation therapy to prevent errors and ensure that the radiation system can deliver accurate treatments and patients receive the prescribed treatment. This work demonstrates the efficiency of dosimetry tools for the dosimetry chain in carbon ion therapy.

Methods

Machine QA consists of measuring properties of the therapy system. For PBS particle beams, the main interested quantities are:

1. Absorbed dose-to-water. Ionization chambers (IC) are commonly used for absolute dosimetry. As recommended by dosimetry protocols (e.g. TRS398), the response of IC must be corrected for different effects.
2. Beam energy. Three approaches are presented: (1) water phantom with a large IC [high accuracy, time consuming], (2) multi-layer IC, called Zebra (180 ICs, resolution ~2mm) [good accuracy, fast] and (3) 2D-detector combined with wedges, called Sphinx Compact [less accurate, fast], dedicated to daily QA check (repeatability).
3. Individual spots and scanned fields. Two high resolution 2D-detectors were used: (1) scintillator-based detector, called Lynx (resolution:0.5mm, area:30x30cm²) and (2) semiconductor-based detector, called myQA Phoenix (resolution:0.2mm, area:40x40cm²).

Measurement-based PSQA are presented using a 2D IC-based detector, called MatriXX AiR. MatriXX AiR was calibrated in terms of absorbed dose-to-water against an IC following TRS398.

Results

Figure 1 shows the response of a Lynx and a myQA Phoenix, using the same map. As we can notice, both detectors are in excellent agreement (also confirmed by the numerical values of spot positions and spot shapes).

Figure 2 shows Bragg Peak curves measured with a water phantom and a Zebra. Using a thin plate in front of the device, the resolution of the device was doubled.

Figure 3 shows Bragg peak regions measured with a Sphinx Compact. Currently, the device is composed of wedges dedicated to 3 specific carbon ion beam energies.

For PSQA, the response of MatriXX AiR was compared to TPS-calculated dose plans, using different gamma passing rates. Except for one plan, gamma passing rates exceed 95% under 2%/2mm. The performances of the device were also tested by modifying the plans to mimic delivery errors. Significant drops in passing rates were observed, confirming that MatriXX AiR is sensitive to small dose discrepancies.

Conclusions

Results demonstrate that tested devices are functional and effective for QA of PBS carbon ion beams.

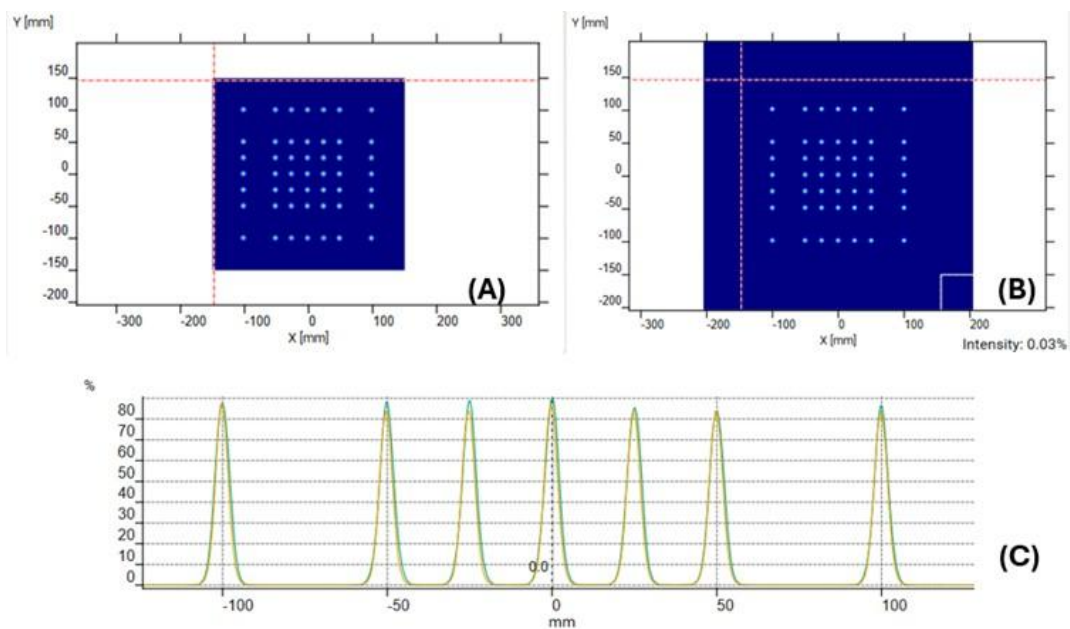


Fig 1. Same spot map measured with a Lynx (A) and a myQA Phoenix (B) in carbon ions. Fig 1-C shows spot crossline profiles measured with both detectors

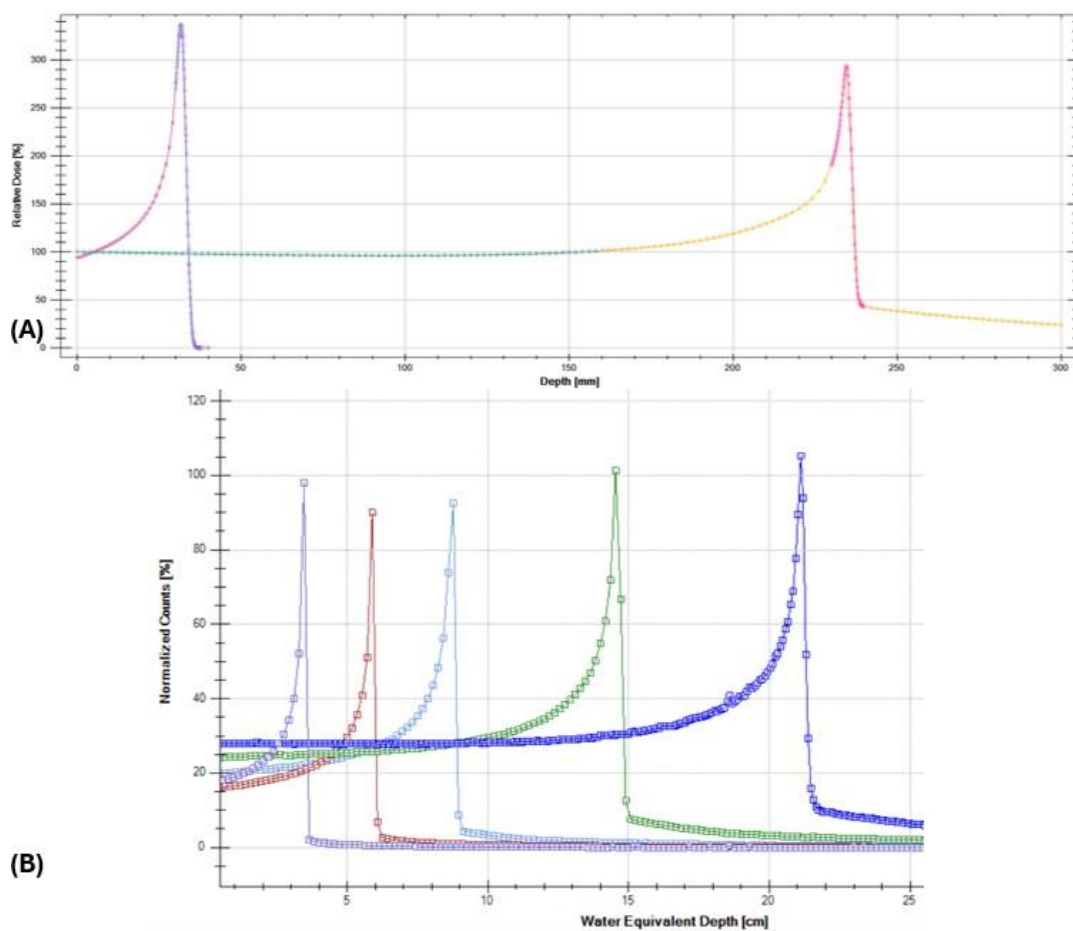


Fig 2. Bragg Peak curves measured with (A) a Stingray in a water phantom and (B) a Zebra in carbon ion beams.

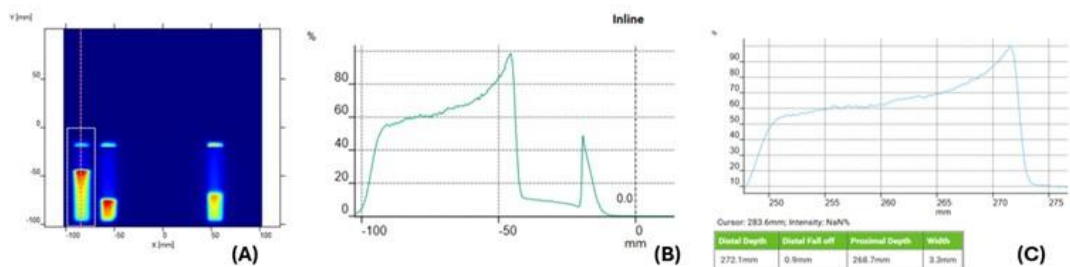


Fig 3. (A) Response of the Sphinx Compact (2D semiconductor-based detector with a wedge) showing 3 patterns for beam energy check (i.e. 386 MeV/n, 280 MeV/n and 209 MeV/n), (B) Inline profile measured by the 2D detector, (C) Analysis of the Bragg peak region