A Novel method for a PBS system spot absolute position check with stereotactic imaging system

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Abstract

Objectives:

Proteus®ONE (Ion Beam Application Inc. Belgium) the world 1st commercial compact PBS proton system uses the scanning magnet to correct the proton beam position in order to compensate the gantry sagging. We developed and implemented a novel QA system for the absolute position check with different gantry angles (-20 to 180 degree) and energies (70 to 226.7MeV) on the stereotactic imaging system .

Methods:

The XRV-100 (Logo System International) phantom is composed with a scintillator imaging cone coupled with a CCD camera. During the proton spot beam delivery, the CCD camera captures the two light spots where the proton beam intersected with the scintillator imaging cone and then converted to machine coordinates. The real time recorded 2D image sequences are used to reconstruct the beam vectors and the beam flux maps. The phantom is first scanned with a Philips CT scanner with slice thickness of 0.8 mm and exported to Raystation 4.0 treatment planning system (TPS). Two series of plans are created. (1) Gantry-Star shot with spot in the center with different gantry angles (Energies 70, 160, 226MeV; gantry angle: from -20 to 180 degree). (2) Non-isocentric spot plan (a single energy spot per plan with spot position X(in-plane): +/-2cm; Y(cross-plane):+/-2cm. The plans are delivered on the IBA AdaptDelivery System with fiducial tracking (4 of fiducials are embedded on one end of the cone and 2 of them are embedded bottom of the cone). Before the beam delivery, the stereotactic X-ray images are fused to the CT using IBA AdaptInsight software. Then the results are compared with the planned vectors from the IBA proton machine delivery file (PLD file). The differences of the coordinates, including the translational coordinates X, Y between the measured and the planned are analyzed. The average of the beam-by-beam delivery accuracy and maximum deviation are used to assess the overall delivery accuracy of the IBA compact PBS proton system.

Results:

The coordinates of the captured beam vectors in the XRV-100 data and derived IBA coordinates are aligned with the PLD file coordinates successfully. The average delivery accuracies of the gantry star shot with three different energy deliveries are 70MeV: 0.66 ± 0.12 mm; 160MeV: 0.56 ± 0.17 mm; 226.7MeV: 0.65 ± 0.21 mm Maximum deviations are 70MeV X: -0.58 mm Y: -0.56 mm, 160MeV X: -0.66 mm, Y: -0.65 mm, 226MeV X: -0.74mm Y: -0.88mm respectively. The average overall delivery accuracies of the non-isocentric spot are 0.43 ±0.22 mm. This QA procedure was tested 5 times in a month by different physicists to evaluate the reproducibility. All the spot positions measurements vary less than 0.2mm throughout the tests.

Conclusions:

The XRV-100 has been proven to be an efficient and powerful QA tool in PBS Gantry QA test with stereotactic imaging system. The experimental results agree with stated sub-millimeter delivery accuracy of IBA Proteus®ONE system, and the highly reproducibility in the measurements performed by different physicists.

XRV 100 IGRT Alignment for Gantry iso check

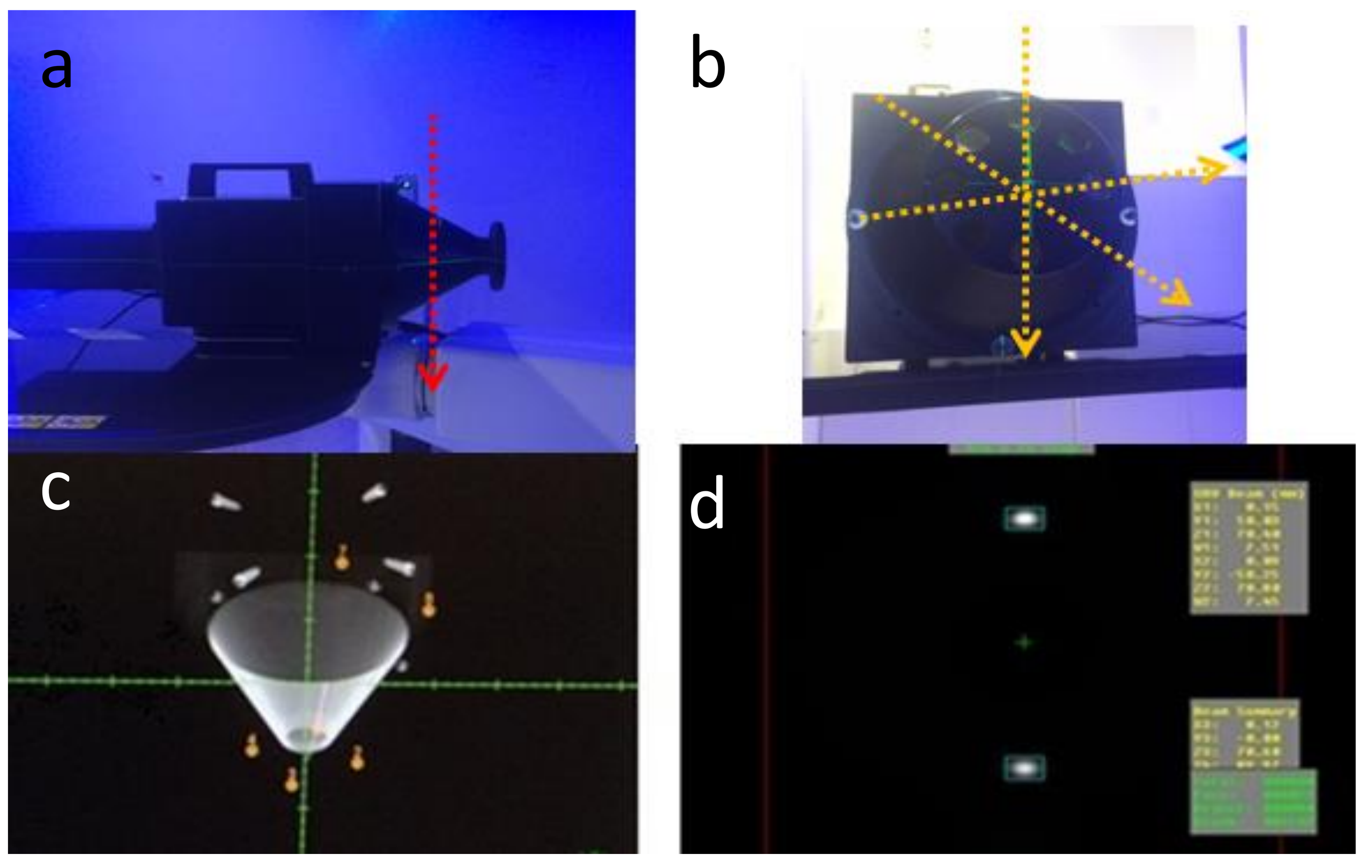

Figure 1 (a) XRV-100 setup on the robotic couch ; (b) Gantry star shot and pristine beam direction; (c) IGRT alignment with CT image. (d) Spot position captured in the XRV cone

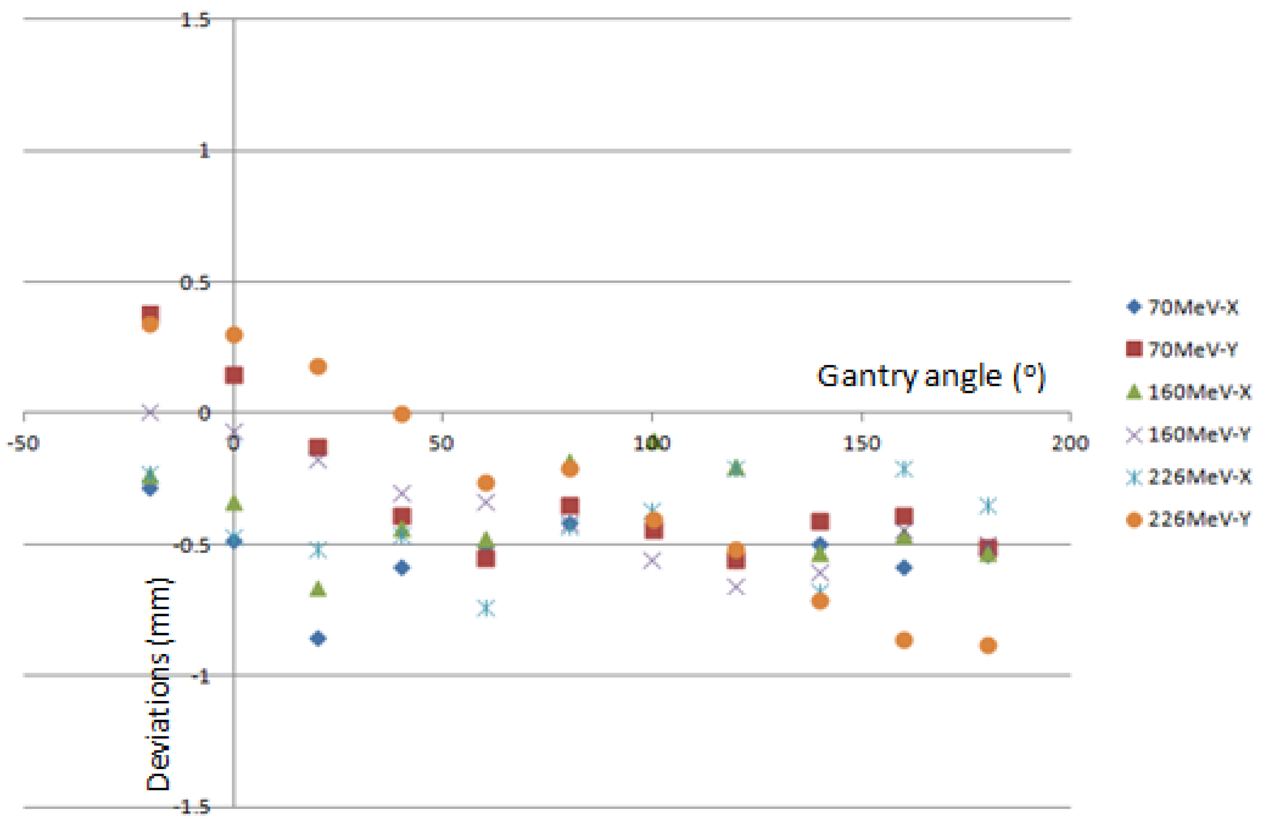

Figure 2. Central spot position deviations from the iso with different gantry angle and proton energy.

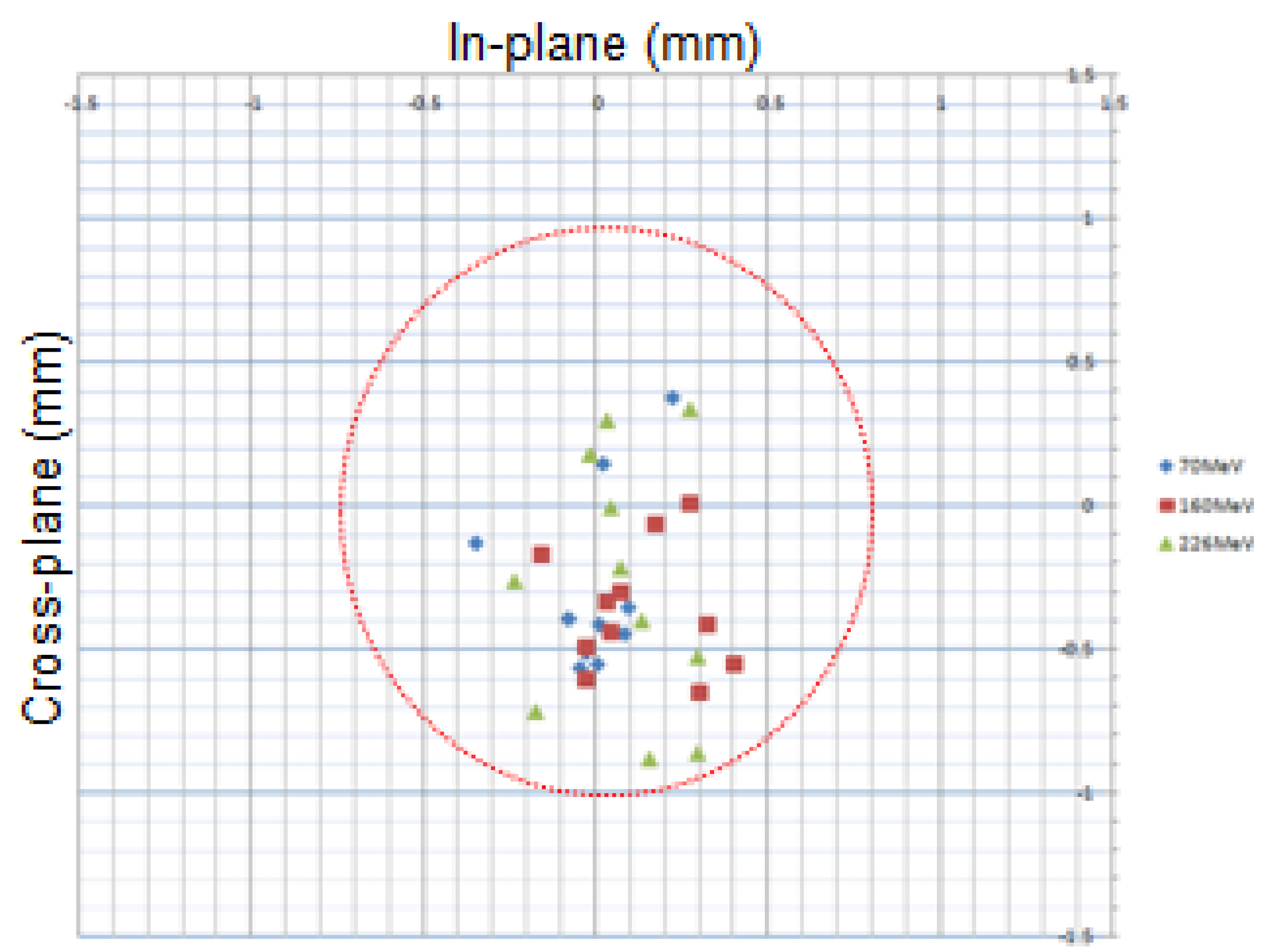

Figure 3. Central spot position plot in-plane and cross-plane throughout different gantry angles.

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