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Evaluation and commissioning of the SDX spirometer based system for use in proton pencil beam scanning treatment under deep inspiration breath-hold

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PURPOSE

To commission and validate the dosimetric accuracy of the Dyn'R SDX spirometer gating system to use in the deep inspiration breath-hold for proton pencil beam treatments on an IBA Proteus Plus system.

METHOD

Static Phantom Tests

- Two static phantoms were used to evaluate absolute dosimetry accuracy:
 - One consisted of a calibrated parallel plate ion chamber (PPC05) at 10 cm WET in solid water
 - The other consisted of a cross-calibrated 2D ion chamber array at 10 cm WET in solid water.
- The static tests used SOBP and select patient fields that were long enough to be interrupted up to three times.
- Measurements taken with the PPC05 were compared to uninterrupted measurements.
- 2D gamma analysis compared uninterrupted measurements against interrupted ones from 2D array using a 1%/1 mm criterion.
- These measurements were performed on all three gantries at MCI.

Motion Phantom Tests

- To evaluate motion artifacts, the end-to-end test employed an in-house motion phantom based on the Quasar Modus phantom and the Accuray Ball-Cube-2 phantom, which accepts a pair of custom-cut EBT3 films in the axial and sagittal planes (Fig. 1).
- The motion phantom plans were created based on a CT scan of the phantom to fit a spherical target with a 3 mm margin using two and three field arrangements. (Fig. 2)
- The motion phantom was aligned using the fiducial marks embedded in the phantom using kV images.
- Two sets of measurements were made, one without motion and another in DIBH with one interruption per field.
- Films were normalized to the plan values and compared against planned 3D dose with a 3%/3mm criteria.

RESULTS

Static Phantom Tests

- Ion chamber measurements were within 0.2% in all scenarios, which is <1% difference in the expected dose as suggested by AAPM TG147.

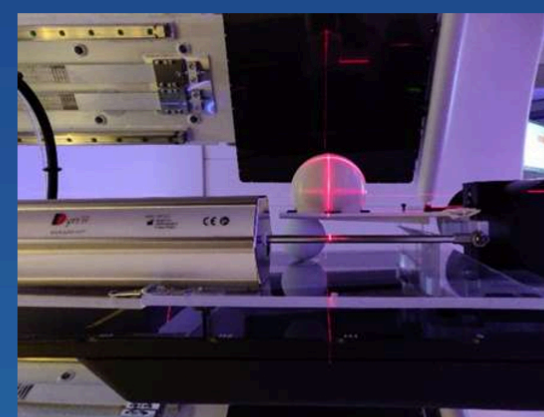


Fig. 1 - Motion Phantom Setup.

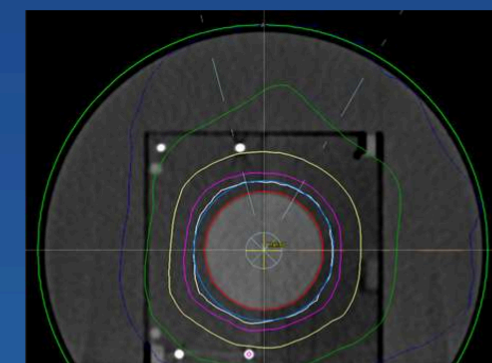


Fig. 2 - Axial view of the 3 field plan optimized to cover the target sphere to a 3 mm CTV expansion.

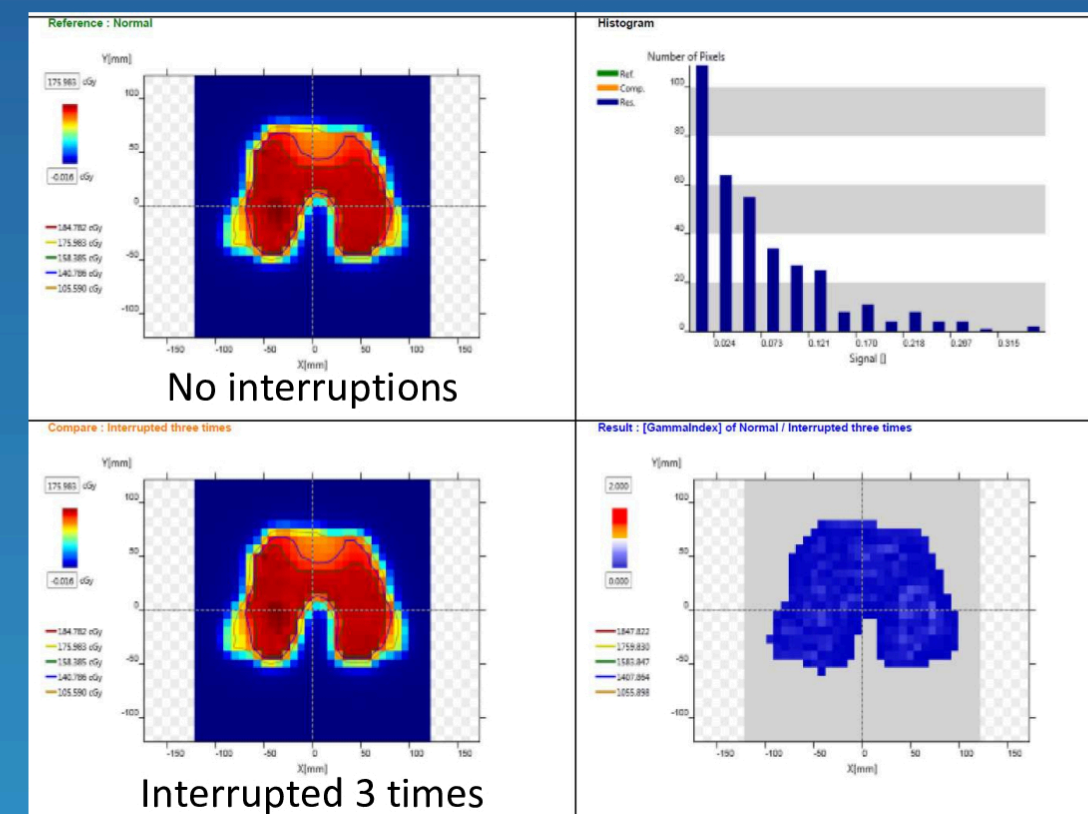


Fig. 3 — Breath hold measurements compared against uninterrupted measurements done with the 2D IC array IBA MatriXX PT.

- On all three gantries, Matrixx measurements for patient fields tested with three interruptions compared against an uninterrupted measurement had a 100% gamma pass rate. Example is shown in Fig. 3 using a 1%, 1 mm criterion.

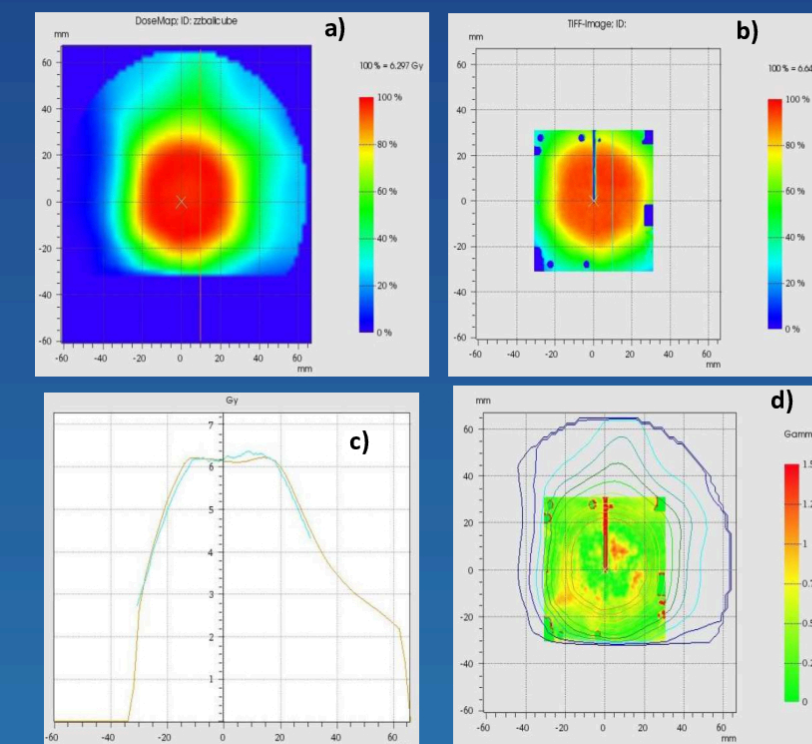


Fig. 4 - Gamma analysis for the 3 field motion phantom plan. a) 3D dose distribution, b) axial film with one interruption/field, c) a cross-profile indicated by the line in panels a) and b), and d) the gamma map at 3%/3mm.

- TG147 suggests to have < 1 mm change in localization when incorporating motion management versus standard delivery, which we are satisfying in our 2D array measurements.

Motion Phantom Tests

- No significant distortions from the planned dose were observed. Film comparison against planned dose yielded gamma pass rates above 95% in all scenarios for both two and three fields, see Fig. 4.

CONCLUSIONS

The presented commissioning process ensured accurate and reproducible results of the SDX spirometer system.