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Longitudinal Evaluation of the Integral Quality Monitory For Routine Clinical Quality Assurance of Photon Beams

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INTRODUCTION

Quality assurance (QA) is the backbone of safety in radiation oncology. Routine beam monitoring requires repeatable, reproducible, and reliable measurements. iRT Systems Integral Quality Monitor (IQM)[1] is a versatile device with potential to efficiently replace current QA devices, while minimizing setup error for daily and monthly QA. The purpose of this project is to compare the QA capabilities of the IQM to clinically established QA devices.

AIM

1) Compare output measurements collected by the IQM to those taken during daily and monthly output checks, which includes measurements with three other commissioned instruments.
2) Evaluate a novel symmetry calculation using the IQM and compare with symmetry measurements during daily and monthly output checks.
3) Compare longitudinal data focusing on recorded service events (i.e. beam steering, dose calibration, etc.)

METHOD

Output

- Output was measured on four energies (6X, 15X, 6FFF, 10FFF) on an Elekta VERSA
- Data was taken using the four devices with the following setup parameters over the course of one year -
  - iRT Systems Integral Quality Monitor [IQM] (accessory tray, 10x10 cm2 field, bimonthly)
  - Sun Nuclear DailyQA3[2] [DQA3](100 cm SSD, 100 MU, 20x20cm2 field, daily)
  - Sun Nuclear IC Profiler[3] (100 cm SAD setup under 5 cm of solid water, 100 MU, 20x20 cm^2 field, monthly)
  - 0.3cc PTW ion chamber (100 cm SAD setup under 10 cm of solid water, 100 MU, 10x10 cm^2 field, monthly)
- All output measurements were normalized to on or around the first day of IQM data collection and results reported in percent change from that arbitrary baseline.

Symmetry

- Data from the DQA3 and Profiler were taken under the same conditions as above, and symmetry calculated as outlined in the user manuals (cite).
- Symmetry values from the IQM were calculated using the equation below using output data (ionization counts) from 50 MU to a 4x4cm^2 field at three locations: 0 cm and ± 7cm along the central axis of the profiler being measured.

$$Symmetry\ (\%) = \frac{|\ Output\ (n)_{+7\ cm,4x4cm^2} - Output\ (n)_{-7\ cm,4x4cm^2}\ |}{Output\ (n)_{0\ cm,4x4cm^2}}\ x\ 100\%$$

RESULTS - LONGITUDINAL COMPARISONS

*Figure 1. A year of output data from four beam energies on a VERSA Elekta. Output data was collected from biweekly measurements on the IQM (black), daily QA measurements on the DQA3, and monthly measurements done with an ion chamber in solid water (yellow) and a IC array profiler (red). Data from each device was normalized to the data as close to the first day of IQM data collection as possible and reported as a percent change from that baseline. The trendline for the DQA3 data is representative of a five-day moving average. Data shows that the **IQM output** tracks with established QA devices during major changes in output (1-2%) and general similarities in trending over time. However, the IQM also seems to be more suspectable to signal noise. It is important to note not all data was taken on the same day, which may reflect curve differences in times of high signal variation.*

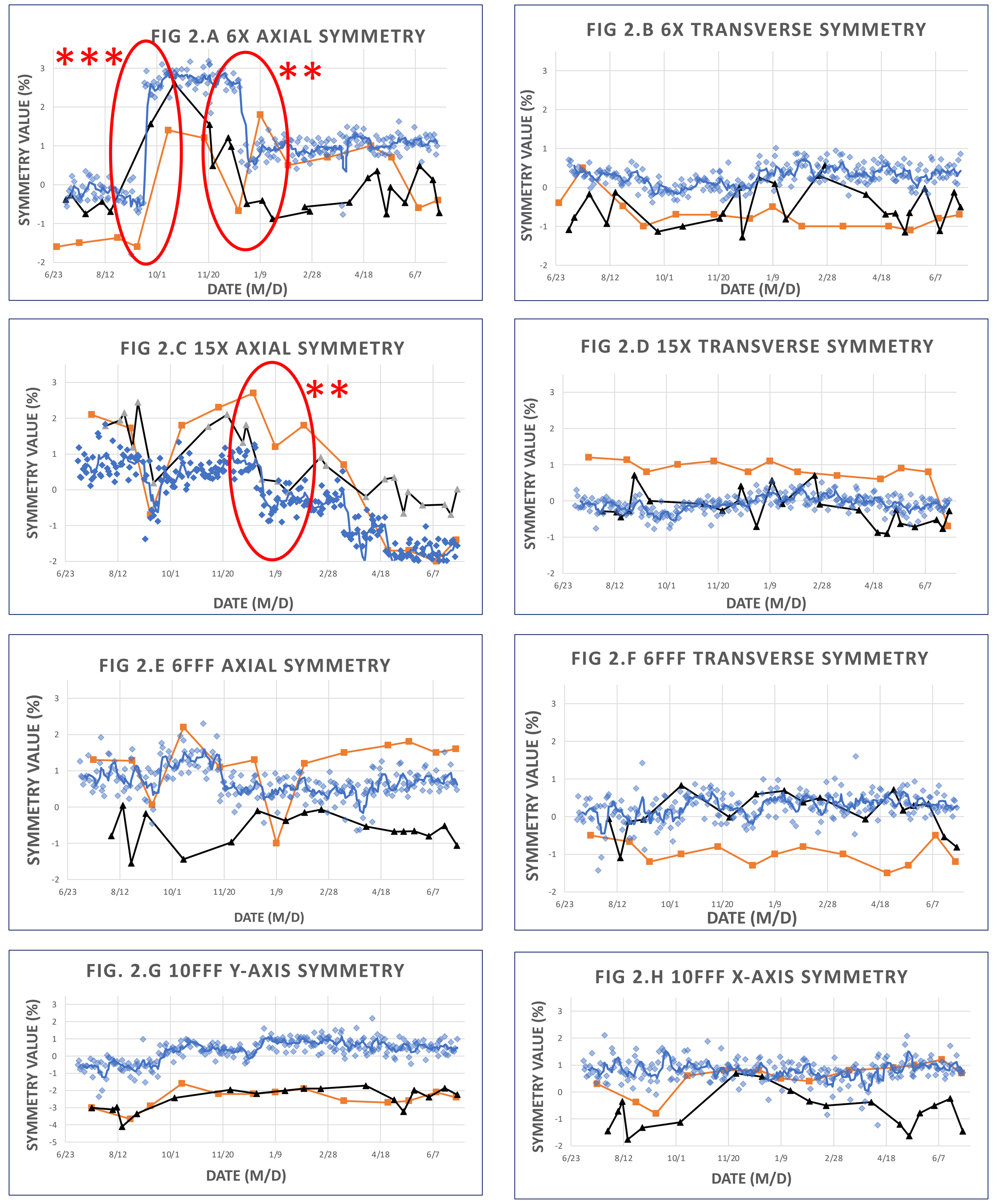

*Figure 2. One year of symmetry data from three devices: biweekly measurements from the IQM (black), daily measurements from the DQA3 (blue), and monthly measurements from the IC Profiler (orange). The trendline for the DQA3 data represents a moving average over 5 days. **Trends show** general agreement, along with the sensitivity of the IQM to large changes in symmetry also seen by the IC Profiler. There is some inconsistency between device agreement as seen between figures 2.F and 2.G wherein the IQM tracks along side either the profiler or the DQA3, respectively. Three examples where the IQM does not react with the same intensity/sensitivity to symmetry changes as the ICP are in figure 2.A (~12/01), figure 2.C (~4/20), and figure 2.E (~1.9). Note: IC profiler and IQM data was not all taken on the same days.*

Event Key

* 9/23/23 6X cooled down 1.6% during TG-51

** Symmetry adjusted using IC Profiler

*** Symmetry adjusted using IC Profiler

CONCLUSIONS

Output trends agree relatively well between the IQM and established QA devices, suggesting the IQM is sensitive to linac output changes in the same manner as established QA devices. Additional work needs to be done to establish baseline expectations of noise for the device. One event was recorded from the past year where the beam was adjusted during a TG-51 protocol[4]. All instruments show appropriate change after the adjustment.

Symmetry comparisons vary in their agreement but show general similarities in trends. Three examples of recorded service events are displayed wherein the IQM seems to display appropriate adjustment to symmetry steering. Additional work is underway to optimize signal used to calculate symmetry values using the IQM.

REFERENCES

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[2] Sun Nuclear. Daily QA 3 Reference Guide, Sun Nuclear Corporation 2020.
[3] Sun Nuclear. IC Profiler User Guide, Sun Nuclear Corporation 2021.
[4] Almond PR, et al. AAPM's TG-51 protocol for clinical reference dosimetry of high-energy photon and electron beams. Medical Physics. 1999 Sep;26(9):1847–70.

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