Development and initial characterization of an **MRI-compatible multi-point dosimetry array**

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Scalability

A prototype optical read-out system was developed to facilitate large-scale arrays of PSDs, allowing up to 7 modules of 7 points to be read in parallel for a total of **49 points**.

Read-out side:

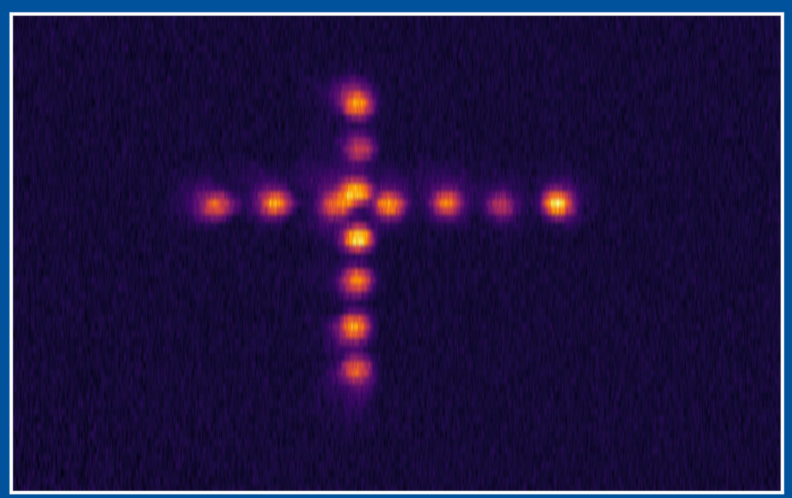

Fig. 7: The read-out system field of view has been tested to support the simultaneous read-out of 49 PSDs. For this image, the 7-point module was connected horizontal and vertical to the read-out system.

Detector side:

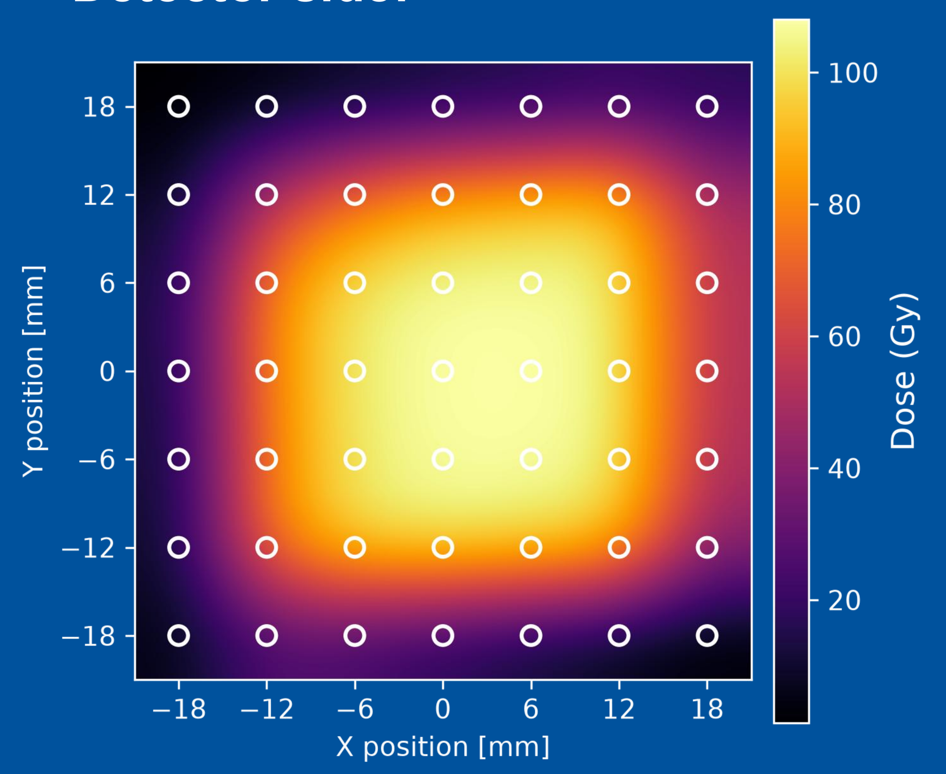

Fig. 8: A 49-point measurement of a 3x3 field obtained by translating the 7-point module at 7 locations along the left-right axis. The white circles indicate the positions of the PSDs.

Introduction

Dosimetric quality assurance (QA) is essential for treatment validation on the **MR-linac**. However, many conventional QA approaches are challenging in the presence of a magnetic field.

In this study a plastic scintillator large scale array for QA, including a novel read-out system *(Fig. 1)* making it capable of real-time measurement is characterized for the first time.

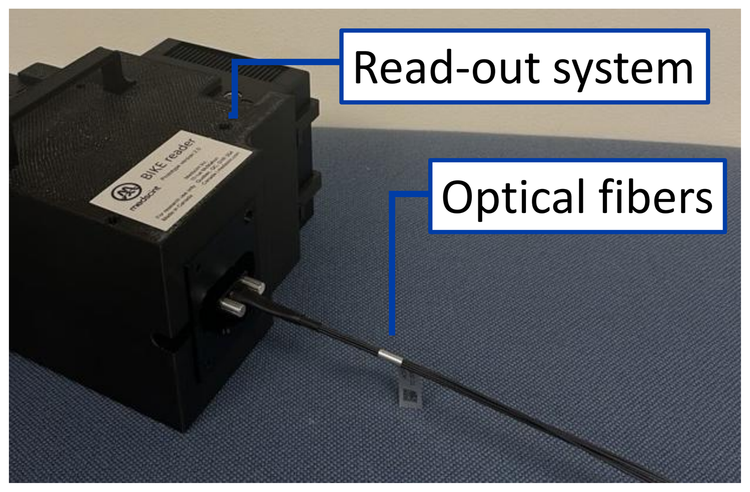

Fig. 1: The multi-point read-out system.

Conclusion

The prototype multi-point dosimetry array shows good performance in initial QA testing under static and dynamic experimental conditions, with additional work planned to demonstrate the scalability to more PSDs.

Methods and Materials

To demonstrate the dosimetric capabilities of the system, an initial set of seven plastic scintillation detectors (PSDs) (Medscint, Canada) was used.

All measurements were performed on a 1.5 T Unity MR-linac (Elekta, Sweden). Calibration was carried out to relate the measured light intensity to the absorbed dose for each scintillator element. The PSDs were **read out at 10Hz.**

For **basic system characterization**, the seven PSDs were embedded in a module which was placed between solid water slabs and a bolus slab *(Fig. 2)*.

The **reproducibility** was obtained, and **field size dependence** was measured and compared to treatment planning system (TPS).

Plan QA was performed for prostate SBRT plans *(Fig. 3)* by inserting a cassette containing the 7 PSDs in the MRI^{4D} motion phantom (IBA QUASAR, Canada) *(Fig. 4)*. An artificial caudal **target drift** of 1 mm/min was introduced to investigate motion sensitivity.

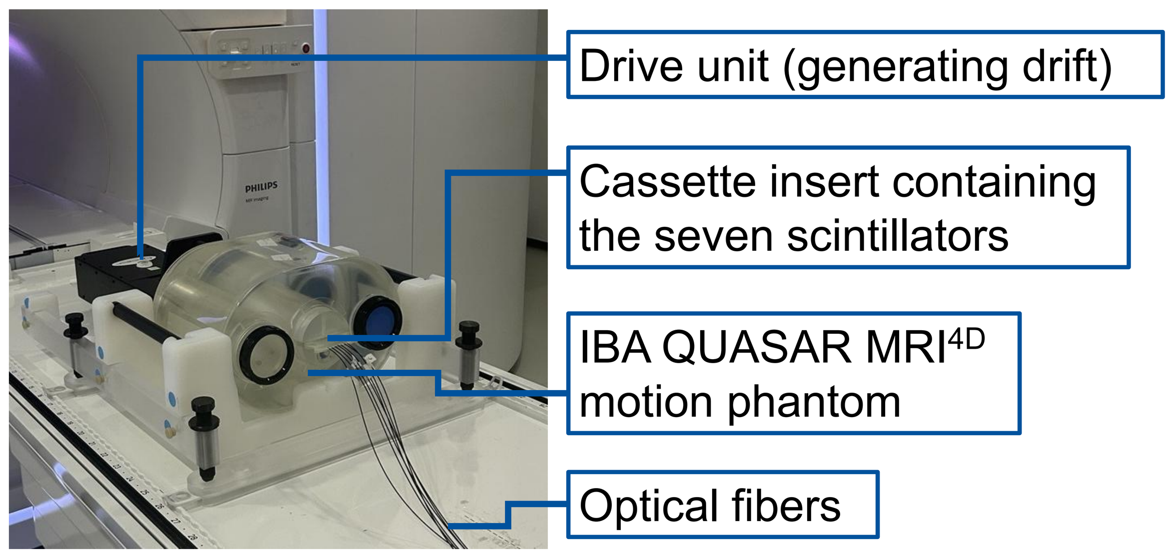

Fig. 4: The set up for the plan QA measurements.

Basic Characteristics

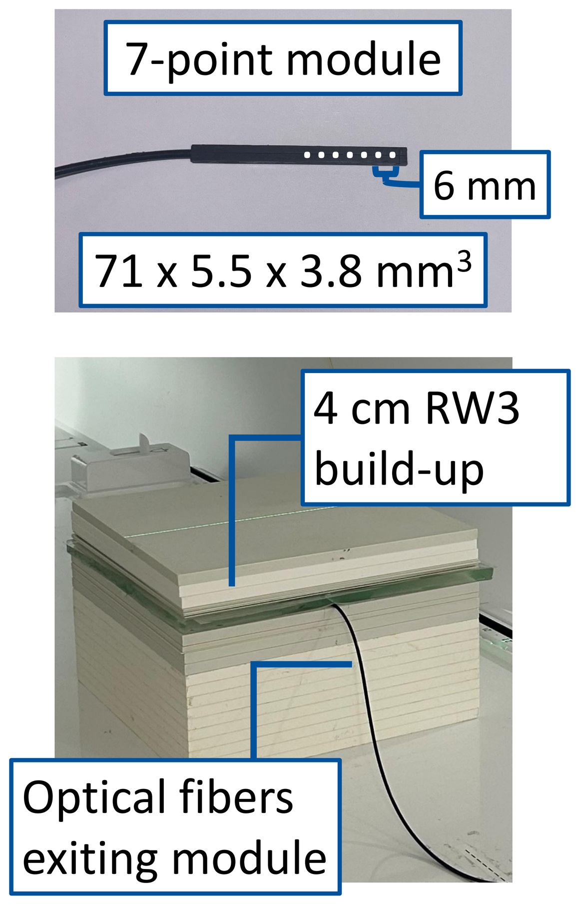

Fig. 2: The setup for the basic characteristics, with the seven scintillator points inside the module.

Results and Discussion

For reproducibility, the relative SD was **<=0.2%** for the seven PSDs. For field size dependence the maximum differences with reference doses were **2% or better** *(Fig. 5)*. The mean absolute difference was **0.6%**.

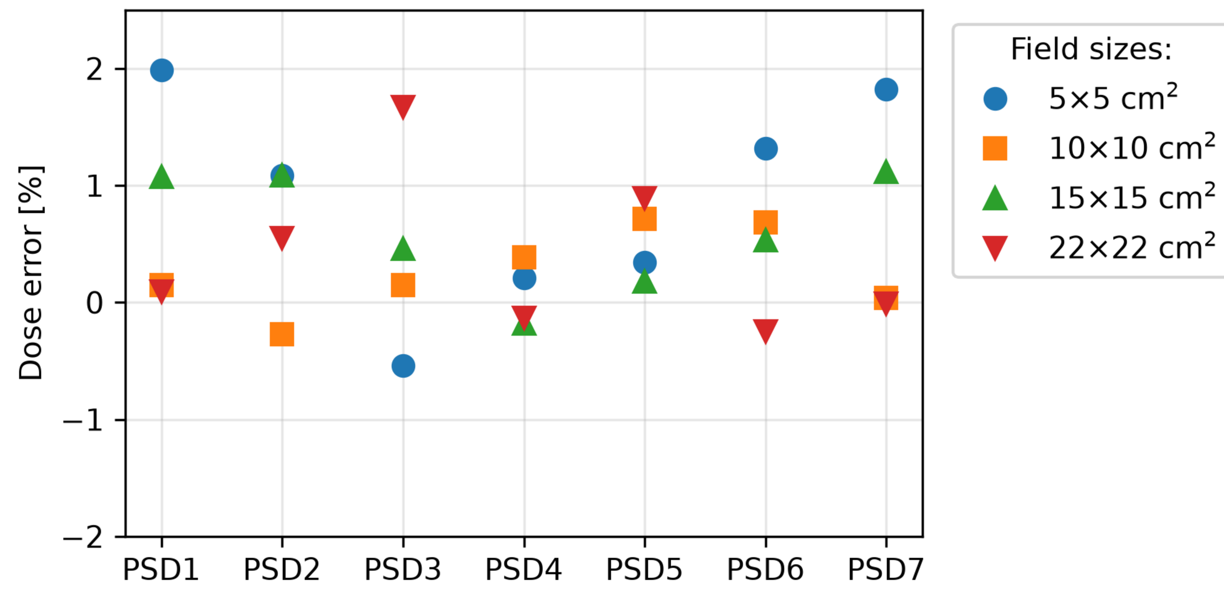

Fig. 5: The results for field size dependence, where the dose error is relative to the Monaco based treatment planning dose value.

Time-resolved plan QA

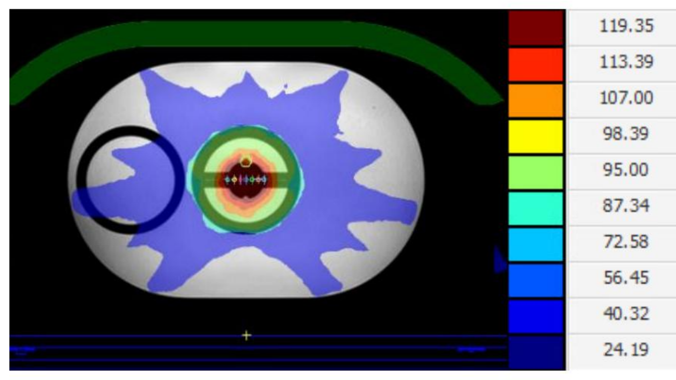

Fig. 3: The dose distribution for one of the prostate plans.

Results and Discussion

The induced subtle motion drift reduced the mean dose across measurement points by 2% as expected *(Table 1)*.

	No drift [cGy]	With drift [cGy]
PSD1	398.6	393.1
PSD2	416.8	411.0
PSD3	423.6	415.2
PSD4	424.4	416.0
PSD5	424.3	415.2
PSD6	426.7	418.4
PSD7	397.2	389.6

Table 1: The accumulated doses for the prostate plan, with and without drift.

Real-time performance with **high temporal dose information** is shown, for PSD4 in *Fig. 6*. The array maintained performance during **dynamic experiments**.

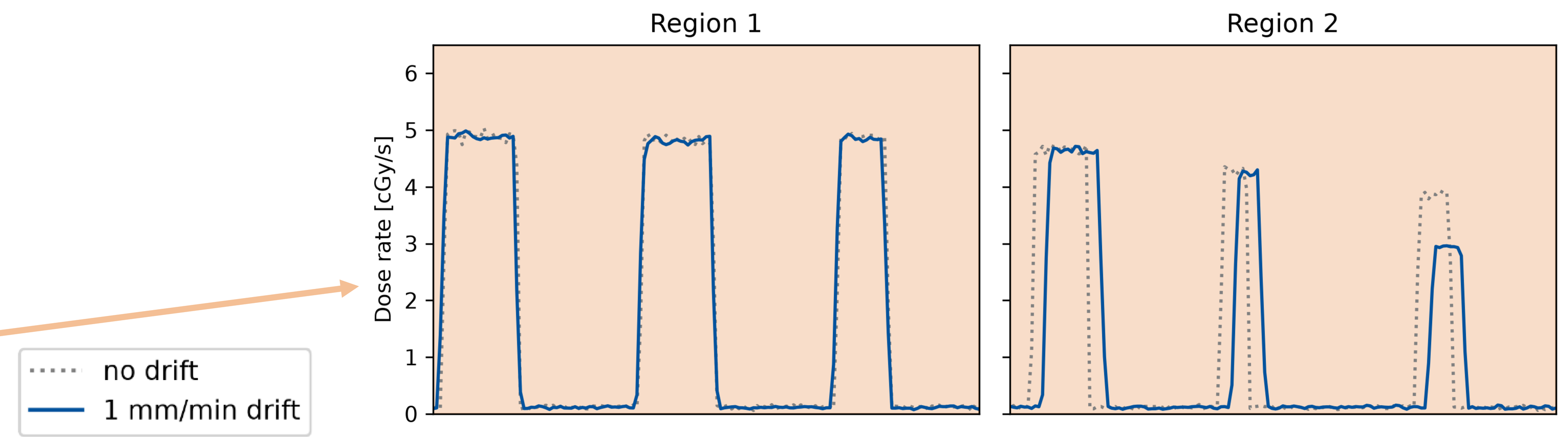
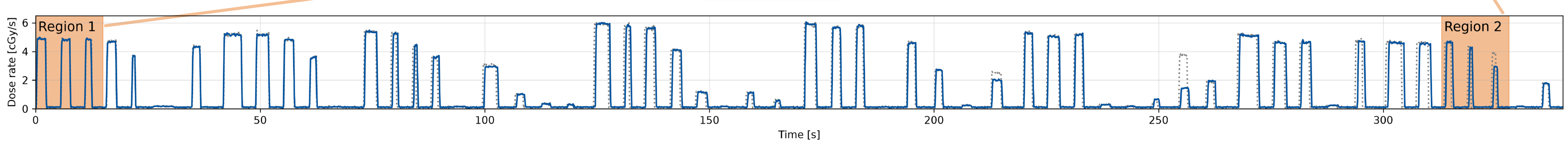

Fig. 6: The real-time dose measured with PSD4 for a prostate SBRT plan, with and without drift.

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