

## 1. Introduction

**Context:** Stereotactic Radiosurgery (SRS) delivered with sub-millimeter geometric accuracy coupled with steep dose gradients is challenging to measure accurately. This is especially true with devices dedicated to SRS like Leksell's Gamma Knife (GK) that cannot produce large field sizes. Plastic scintillation dosimeters (PSD) have a long history of being used with SRS because they offer advantages over 2D detectors like films and point detectors like ion chambers or diodes.

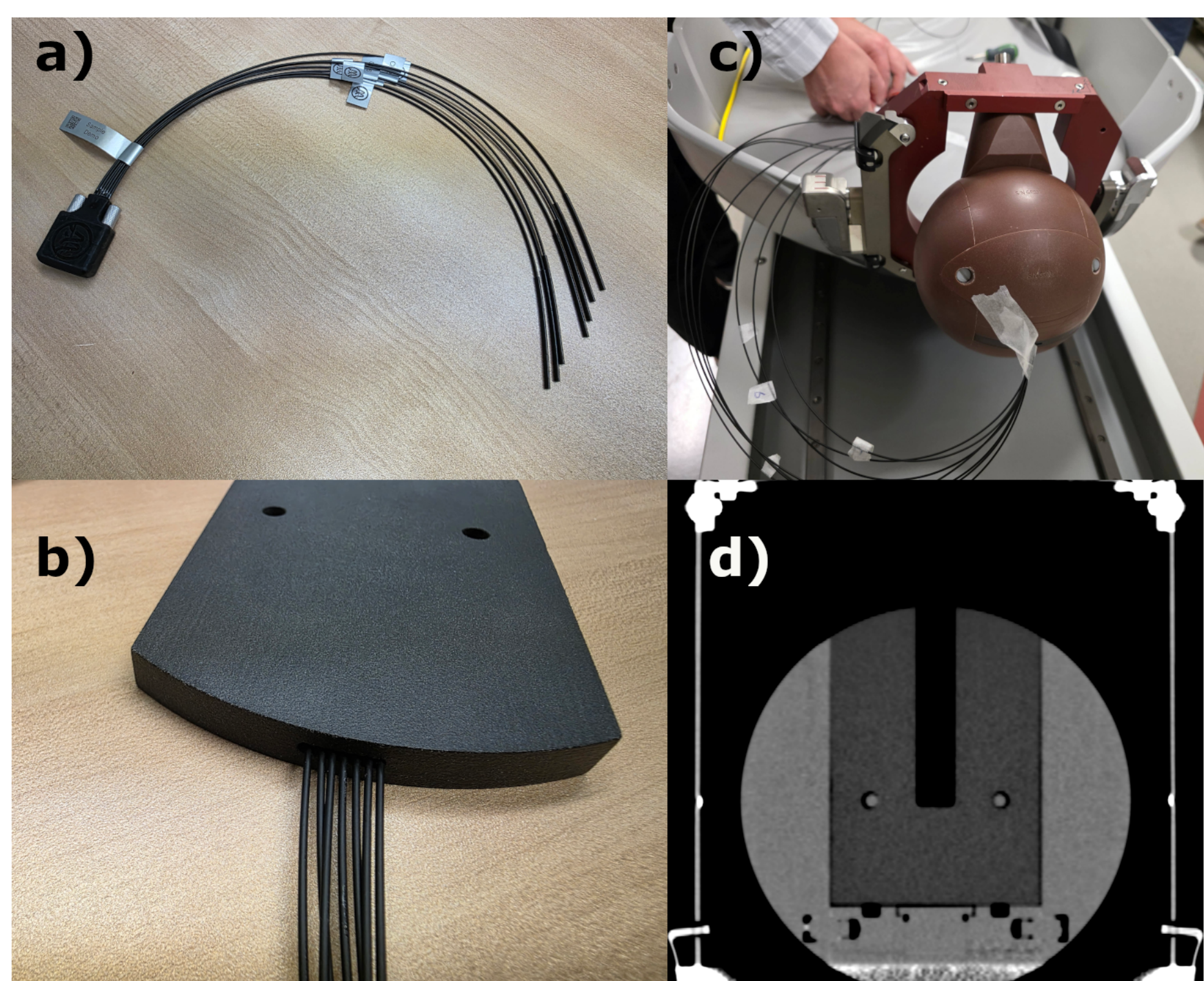
### Advantages of PSD for GK dosimetry

- High spatial resolution
- Water equivalence
- Online readout

**Purpose:** To strike a balance between the convenience of a detector array and the practicality of such system, we are proposing a new 7-points commercial prototype PSD array for dose measurements of dedicated SRS devices like GK.

## 2. Method

A seven-point PSD array was developed by Medscint to be read using the Hyperscint scintillation dosimetry platform. Each point has a sensitive volume of 1 mm diameter by 1 mm length. Irradiations were carried with the Leksell Gamma Knife Perfexion.



**Fig. 1:** The detector array and GK phantom

Each detector point is fully independent from the others (Fig. 1-a). They were inserted in a 3D printed Nylon-12 slab (Fig. 1-b) to form a linear array spaced 2 mm center-to-center, spanning a length of 12 mm. The slab was made to be compatible with the GK spherical dosimetry phantom (Fig. 1-c). Nylon-12 was chosen for its density close to that of water (nominal density of 1.01 g/cm<sup>3</sup>). However, a CT scan of the phantom (Fig. 1-d) revealed a density slightly lower than expected (0.95 g/cm<sup>3</sup>) which is likely due to the selective laser sintering (SLS) printing process.

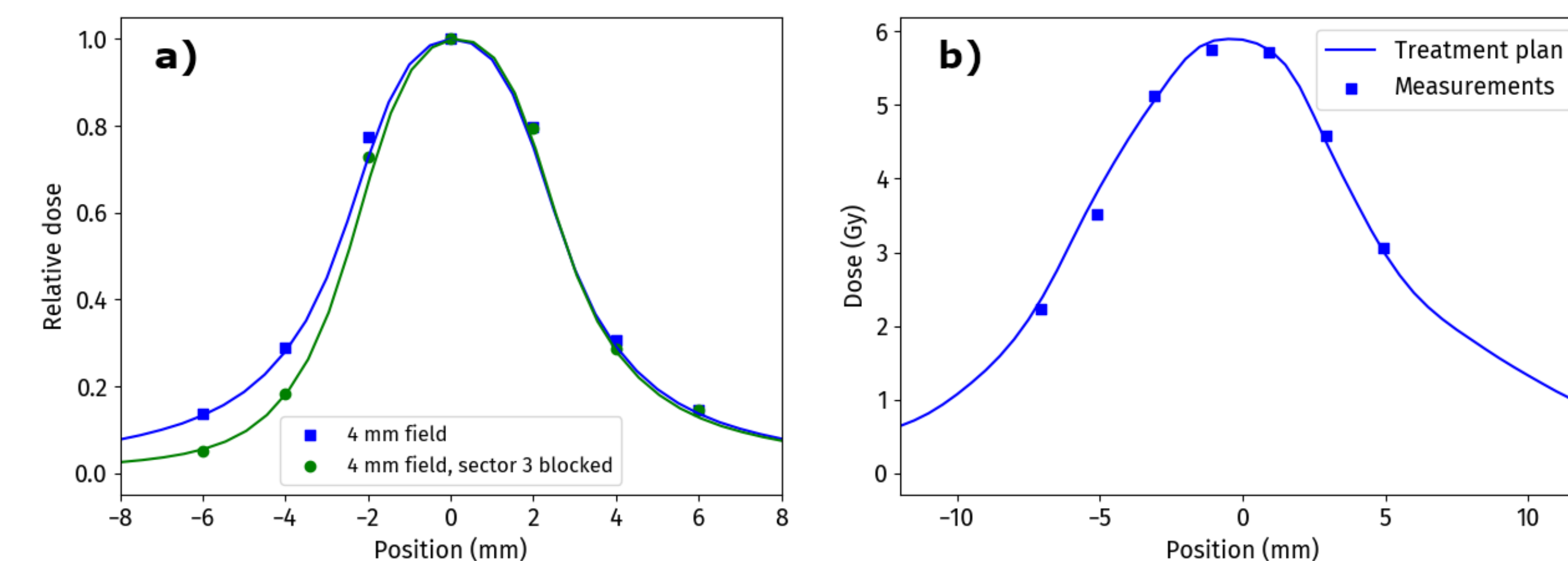
## Acknowledgements



## 3. Results

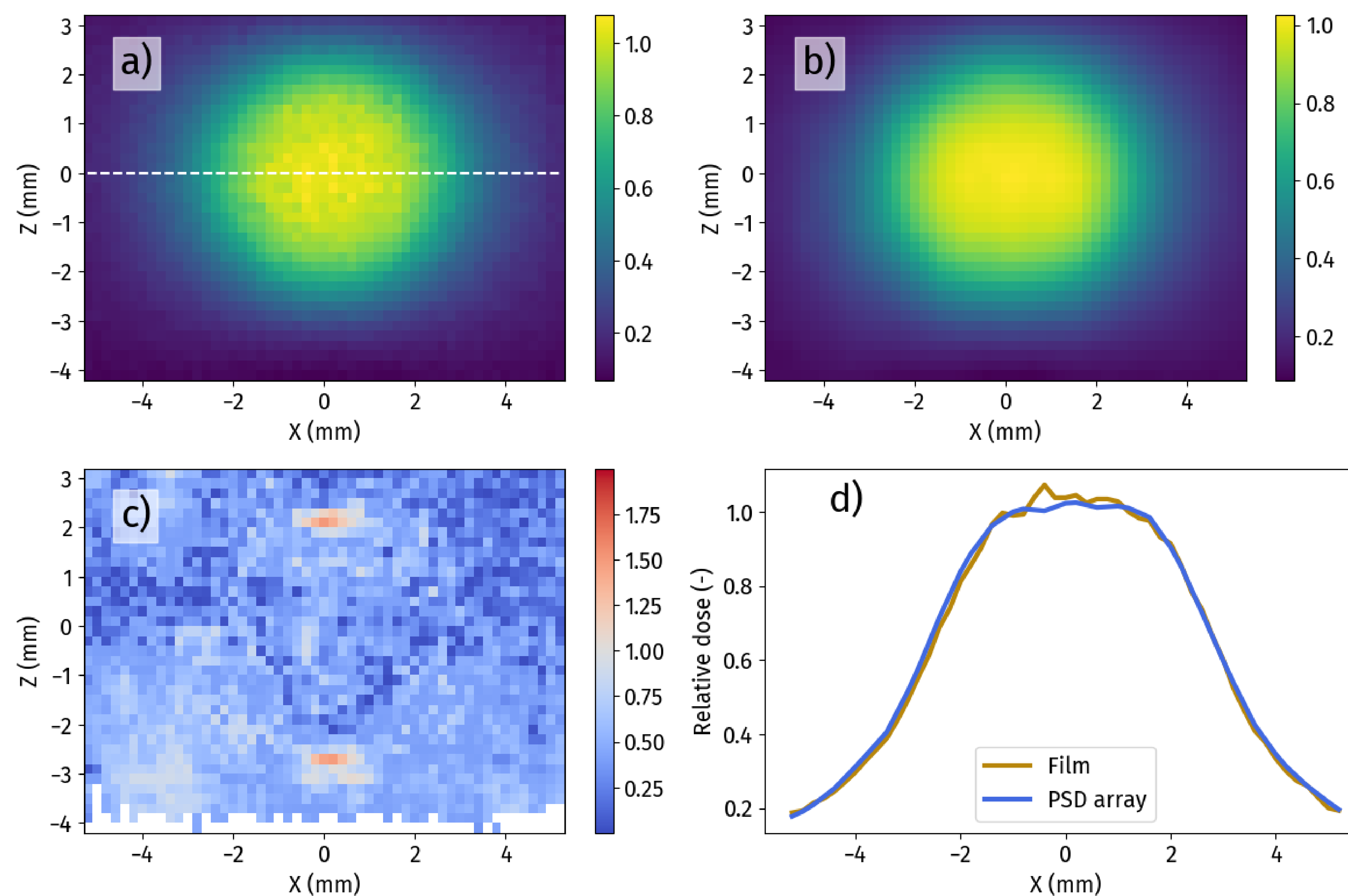
### 1D measurements

Measurements performed with the 7-points PSD for various GK fields and compared to the treatment planning system. In Fig. 2-a: a 4 mm symmetrical field and a 4 mm field with one sector (sector 3) blocked. In Fig. 2-b, measurement made for a clinical plan of a vestibular schwannoma consisting of 15 shots of 4 mm and 8 mm with blocked sectors. Average agreement with the TPS is within 1.7%. Error bars on measurements are smaller than the symbols.



**Fig. 2:** 4 mm fields measurements

### 2D scanned measurements



**Fig. 3:** Scanned 2D measurement

Two dimensional scanning in the coronal plane was performed by step-and-shoot. Five translations of the detector array were done along the direction of the array, which resulted in 35 measurements along this axis. Twenty-five positions were used in the direction perpendicular. Thus, a total of 875 measurements mapped the 2D spot profile. A treatment plan was created to cover these positions and delivery was automated (delivery time < 40 minutes). Fig. 3-a and Fig. 3-b show radiochromic film and PSD scans respectively. No smoothing was applied on either. A  $\gamma$  analysis using a 3%/0.5 mm criterion and a dose threshold of 10% of the maximum was also performed (Fig. 3-c). The  $\gamma$  pass rate was 99.0%. The only regions with  $\gamma > 1$  are situated on the periphery of the field in the direction of the inserted Nylon-12 slab which has a lower density than the rest of the phantom. A profile extracted from this 2D scan is shown in Fig. 3-d

## 4. Conclusions

- A 7-pt PSD array can monitor output factors and estimate profiles of GK fields
  - Can detect the impact of a blocked sector
- A PSD array can facilitate high resolution mapping of GK dose distributions with high accuracy
  - 2D or 3D mapping can be automated using treatment plans
- Excellent agreement with film:  $\gamma$  3%/0.5 mm >99%, but PSD are less noisy

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