



# Micro-Cube Thermoluminescent Dosimeters for Small Field Dosimetry Quality Assurance



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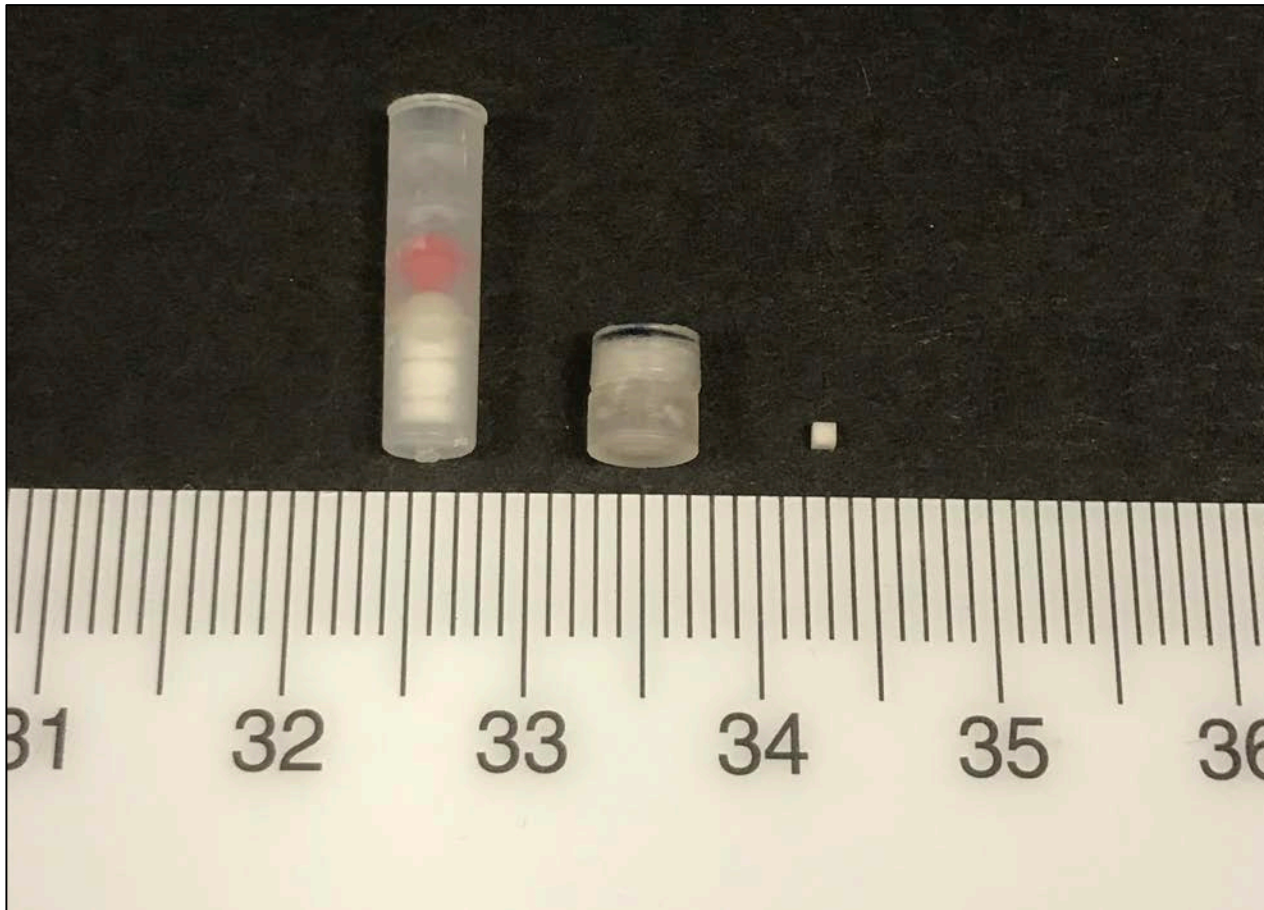
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# Project Background

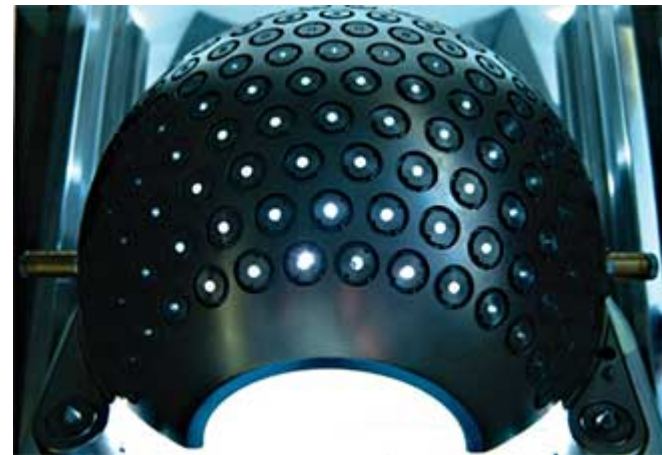
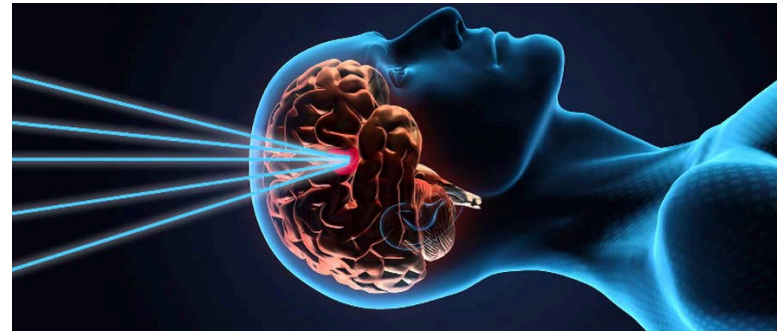
- Goal: Commission micro-cube TLD and determine accuracy and reproducibility for remote audit radiotherapy QA
  - $\pm 5\%$  accuracy
  - $\pm 3\%$  reproducibility

# Project Background



# Introduction: Small Fields

- Small fields of interest? SRS fields
  - Small field linac beams
    - 5x5 mm<sup>2</sup> field
  - CyberKnife
    - 5 mm field diameter
  - Gamma Knife
    - 4 mm field diameter



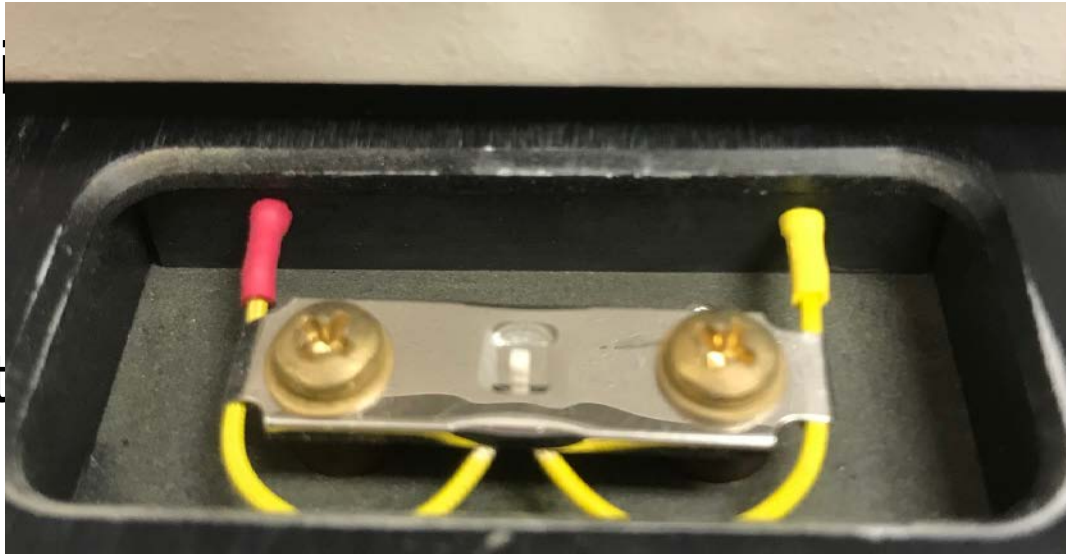
# Methods: Specific Aims

To verify the hypothesis, the following aims were established:

1. Characterize and commission TLD micro-cubes and develop guidelines for the handling process of TLD micro-cubes.
2. Commission the TLD micro-cubes for standard single beam small field output dosimetry.
3. Adapt the IROC SRS head phantom to use the TLD micro-cubes for QA, test the phantom using standard linac, CyberKnife, and Gamma Knife machines, and compare the measured and calculated doses to determine agreement and precision.

# Methods: Handling

- Selection
  - Inspect micro-cubes for non-uniformities
- Annealing
  - 1:20
- Reading
  - The t
- Reading
  - Placement in annealing planchet should be consistent



# Methods: Characterizations

## Correction Factors

$$D = TSK_L K_F K_E \text{ECF}$$

- Linearity
  - Corrects TLD response for different dose levels
- Fading
  - Corrects TLD response for time after irradiation
- Energy
  - Corrects TLD response for different energies
- Elemental Correction Factor (ECF)
  - Corrects TLD response to the average response of the batch

# Methods: Irradiation Experiments

- We tested TLD micro-cube in:
  - SRS head phantom end-to-end treatment evaluations
    - Linac, Gamma Knife, CyberKnife
  - Single field output in a linac
    - 10 x 10 cm<sup>2</sup>, 3 x 3 cm<sup>2</sup>, 2 x 2 cm<sup>2</sup>
  - Single *small* field output in CyberKnife
    - 6 cm, 2 cm, 1.5 cm, 1.0 cm, 0.75 cm, 0.5 cm



# Methods: Irradiation Experiments

- The purpose of these experiments was to:
  - 1) Determine the equivalence in dose measurements between TLD micro-cubes and TLD powder in existing IROC Houston audit tests

# Methods: Irradiation Experiments

- The purpose of these experiments was to:
  - 2) Determine agreement of TLD micro-cube measured dose and beam output/treatment planning system dose

# Methods: Irradiation Experiments

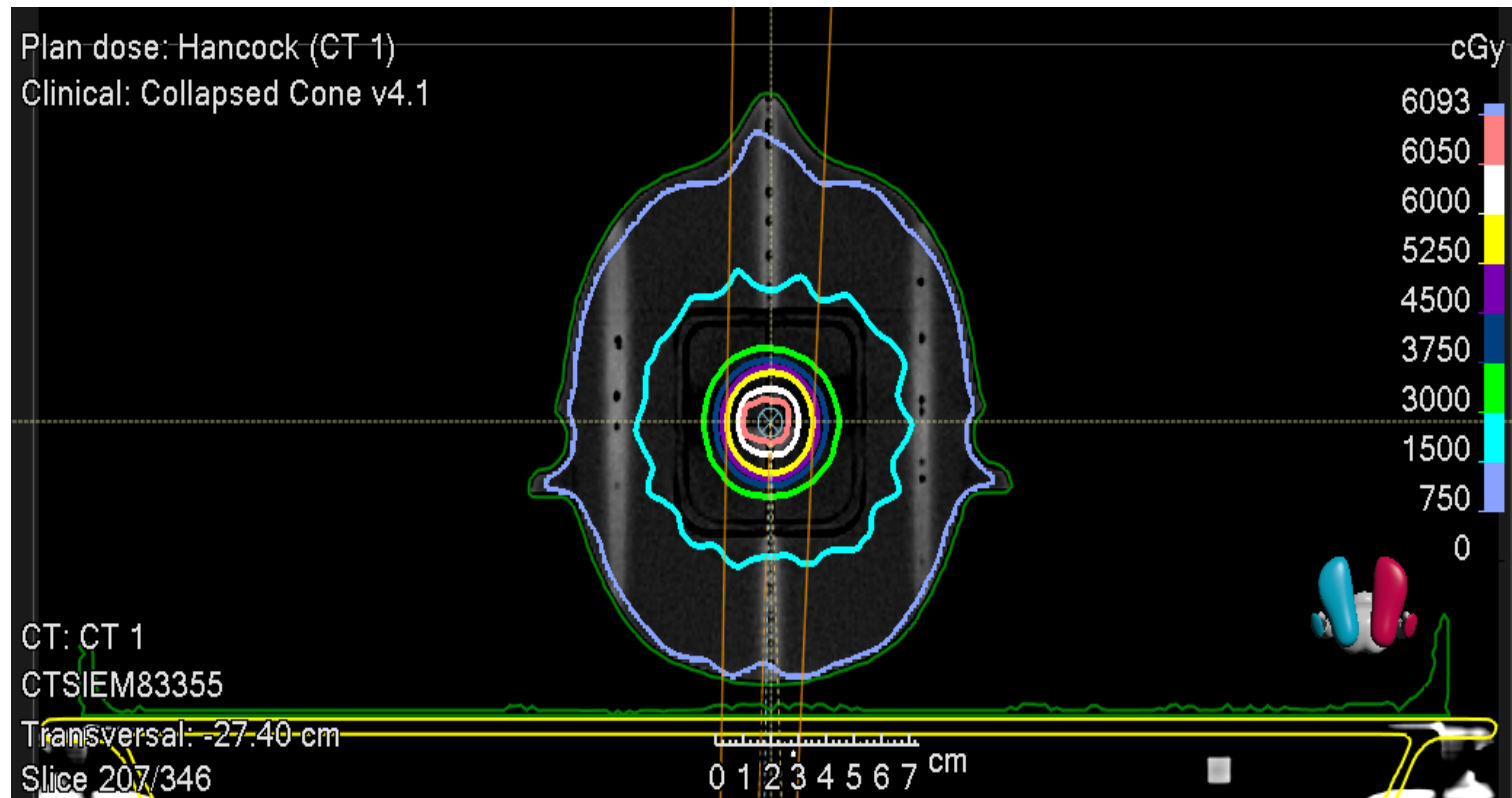
- The purpose of these experiments was to:
  - 3) Determine the accuracy and limitations of TLD micro-cubes in small field photon beams

# Methods: Irradiation Experiments

- The purpose of these experiments was to:
  - 4) Determine reproducibility in the measurements of each experiment

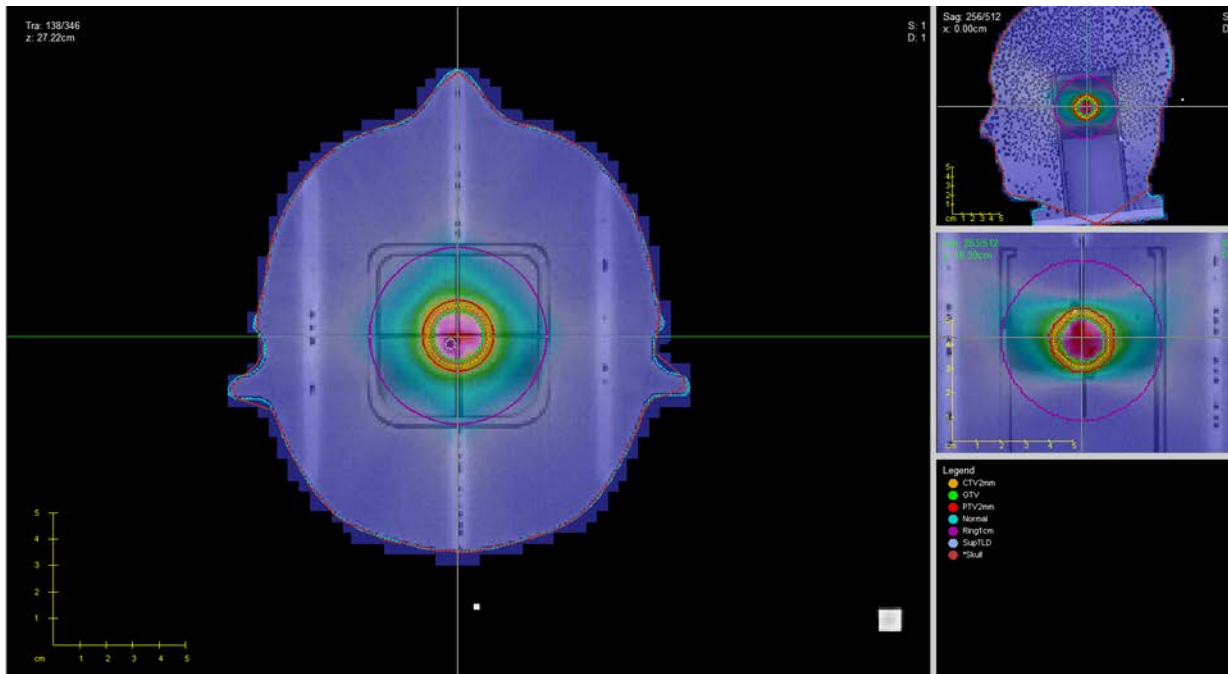
# Methods: SRS Anthropomorphic Head Experiments

- Linac
  - Delivered 600 cGy to 99% of the volume



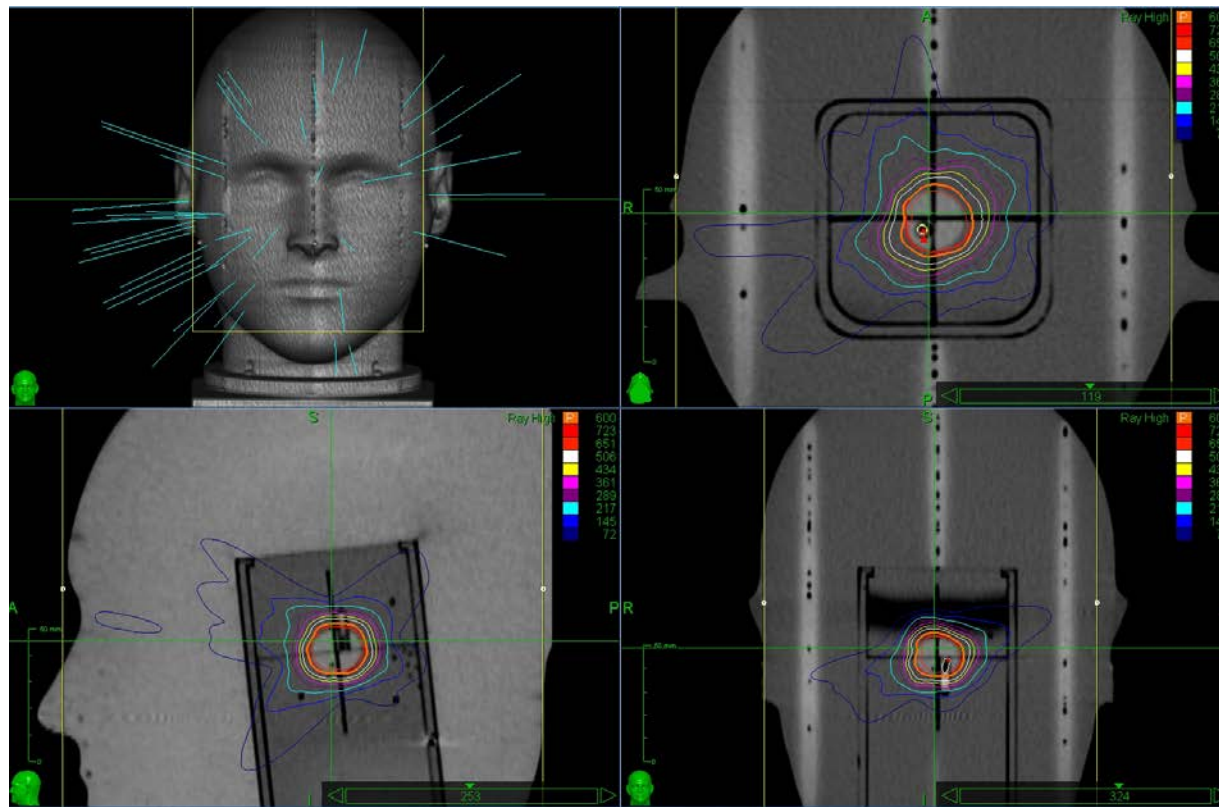
# Methods: SRS Anthropomorphic Head Experiments

- Gamma Knife
  - Delivered 400 cGy to 60% isodose line
    - 21 composite shots



# Methods: SRS Anthropomorphic Head Experiments

- CyberKnife
  - Delivered 600 cGy to 83% isodose line
    - 46 photon beams

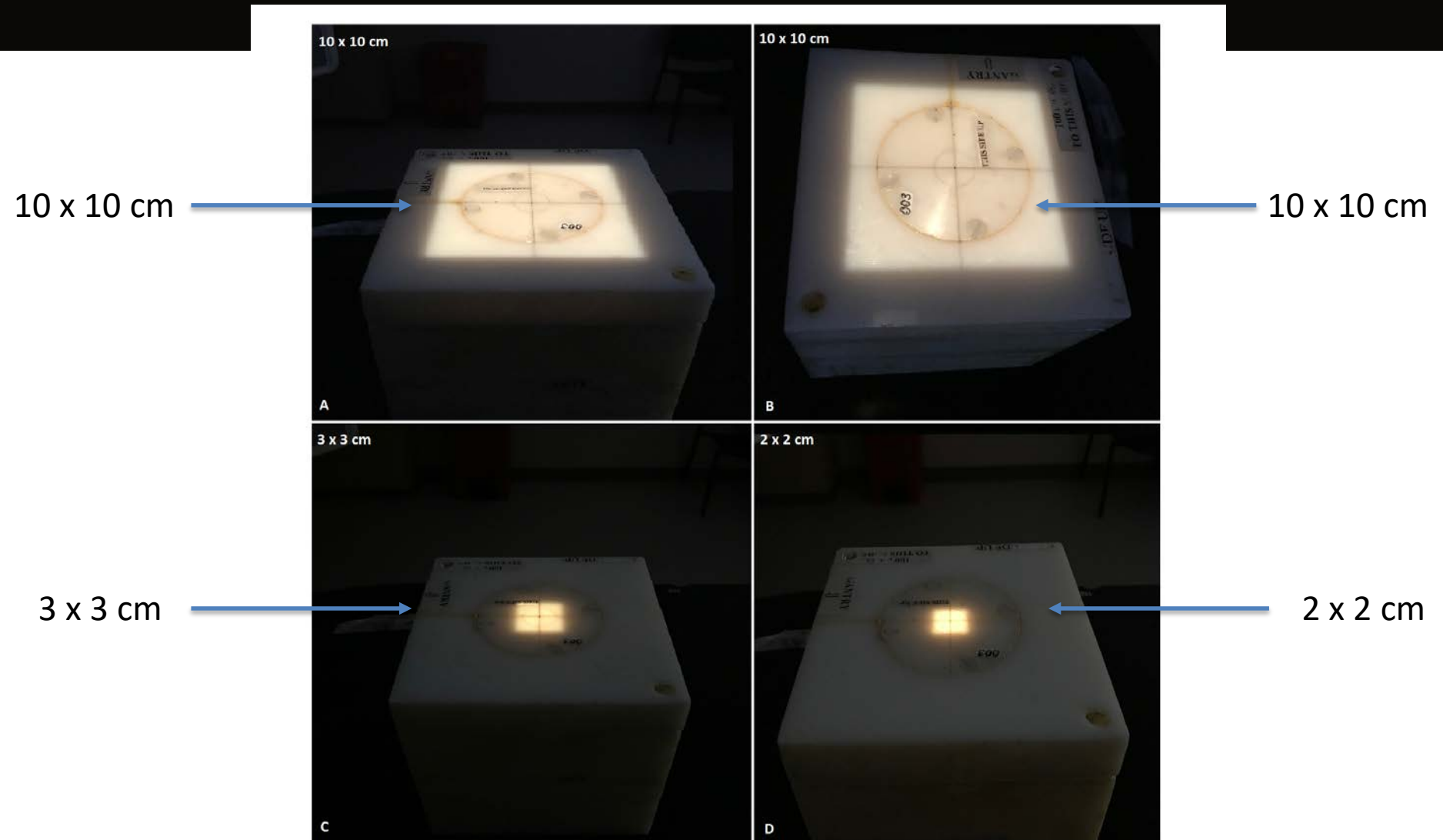


# Results: SRS Experiments

Experiment	Linac	Gamma Knife	CyberKnife
Ratio: Micro-Cube/TPS	1.01	1.00	1.00
Coefficient of Variation	0.68%	1.74%	0.78%
Ratio: Micro-Cube/Powder	1.03	0.99	1.04



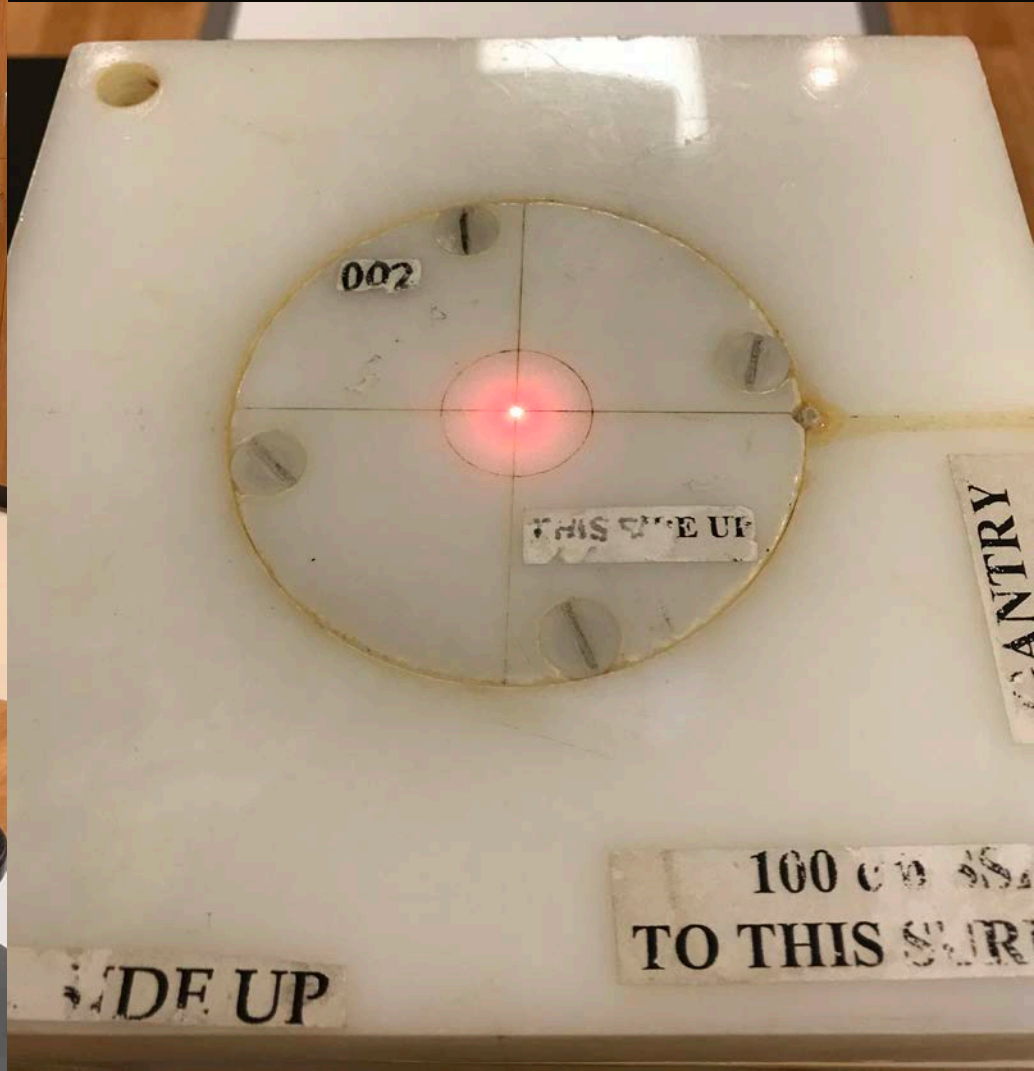
# Methods: Single Field Experiments



# Results: Single Field Measured vs. Expected Output

	10 x 10 cm <sup>2</sup>	3 x 3 cm <sup>2</sup>	2 x 2 cm <sup>2</sup>
Ratio: Micro-Cubes/Expected	1.03	1.03	1.03
Coefficient of Variation	0.53%	0.92%	0.98%
Ratio: Micro-Cubes/Powder	1.00	1.00	1.02

# Methods: Single Small Field Experiments



# Results: Small Field Experiments

Field Size	60 mm	20 mm	15 mm	10 mm	7.5 mm	5 mm
<b>Ratio: Micro-Cubes/Expected</b>	0.99	0.98	0.98	0.98	0.97	0.96
<b>Coefficient of Variation (%)</b>	0.67%	0.61%	0.32%	0.37%	0.56%	0.21%

# Results: Overview

Experiment	Average Difference from TPS Dose (%)	Max Difference from TPS Dose (%)	Average Coefficient of Variation
Single Field	3.3%	4.1%	0.8%
SRS Head	1.0%	3.4%	0.9%
Small Field	2.3%	3.7%	0.5%

# Conclusion

- Conclusion:
  - Micro-cube TLD can be commissioned to evaluate small field dosimetry, and provide reproducibility within  $\pm 3\%$ , as well as assure agreement between measured dose and calculated dose to within  $\pm 5\%$ .

- Thank you!