



Evaluation of High-Resolution Radiochromic Film Dosimetry for Peak and Valley Characterization In Microbeam Radiation Therapy

Michael J Gajda, BSc¹, Anna Hahut, PhD², Jelena Popovic, PhD², Tatjana Paunesku, PhD², Gayle Woloschak, PhD² and Ahtesham Ullah Khan, PhD, MS³,

(1)University of Wisconsin–Madison, Madison, WI, (2)Northwestern University, Chicago, IL, (3)Department of Medical Physics, School of Medicine and Public Health, University of Wisconsin - Madison, Madison, W



Introduction

- Microbeam radiation therapy (MRT) is an emerging modality
- MRT has promise for treating bulky tumors [1]
- Micron-scale beams creates dosimetry challenges
- EBT4 Radiochromic Film (RCF) has high spatial and dose resolution for MRT dosimetry
- Using a preclinical irradiator with focused 50 kVp x-ray beams we investigated RCF's viability

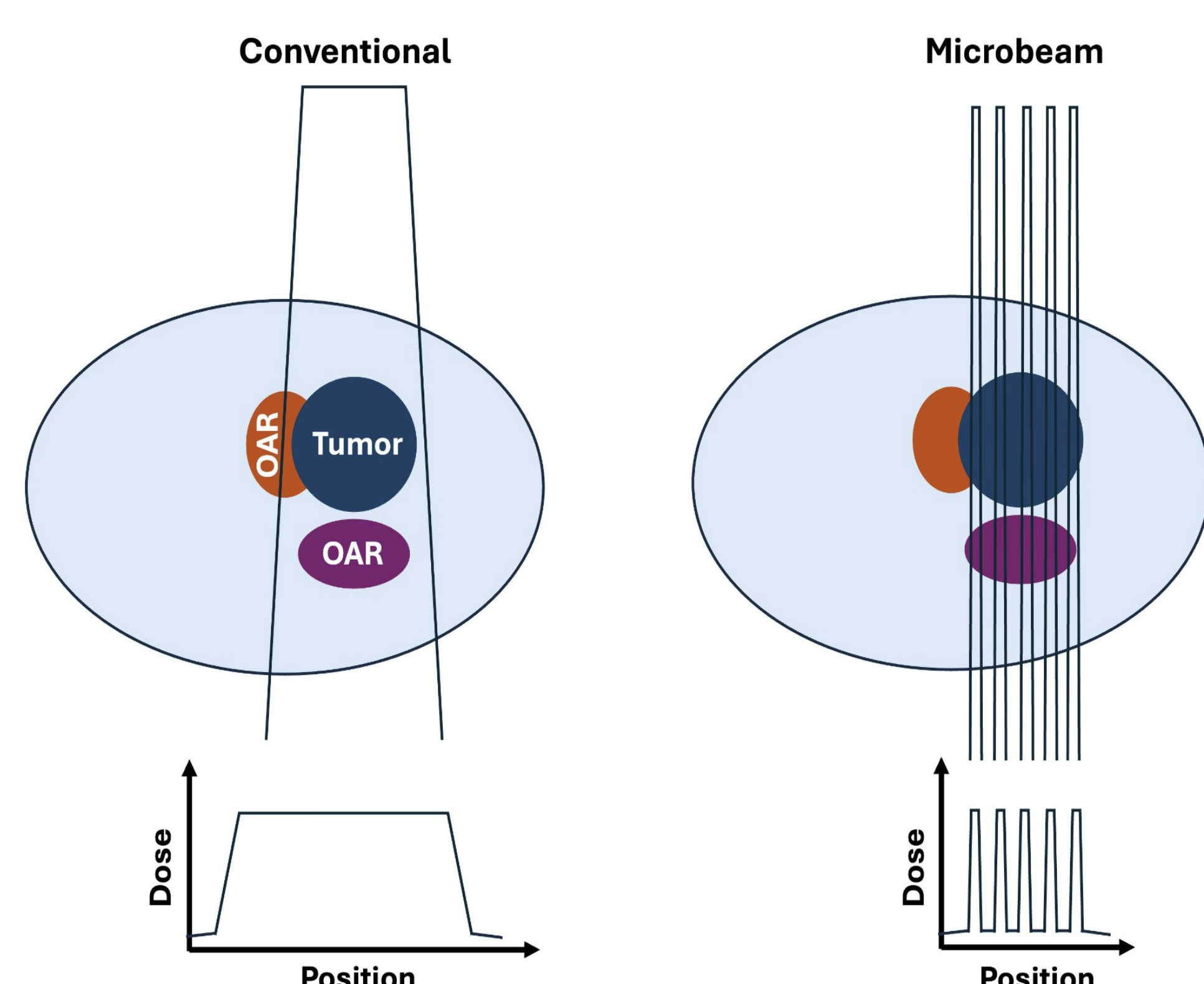
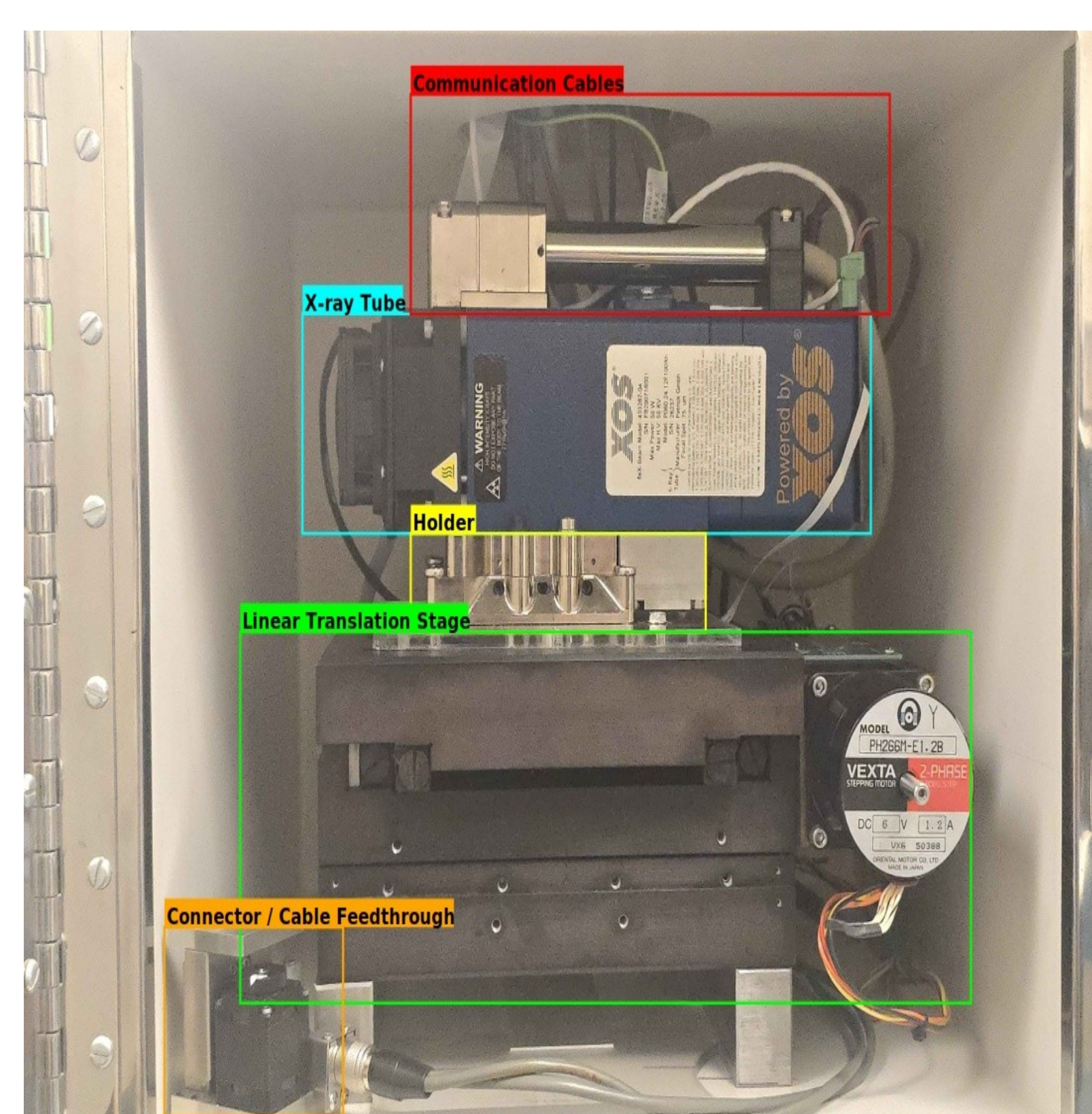


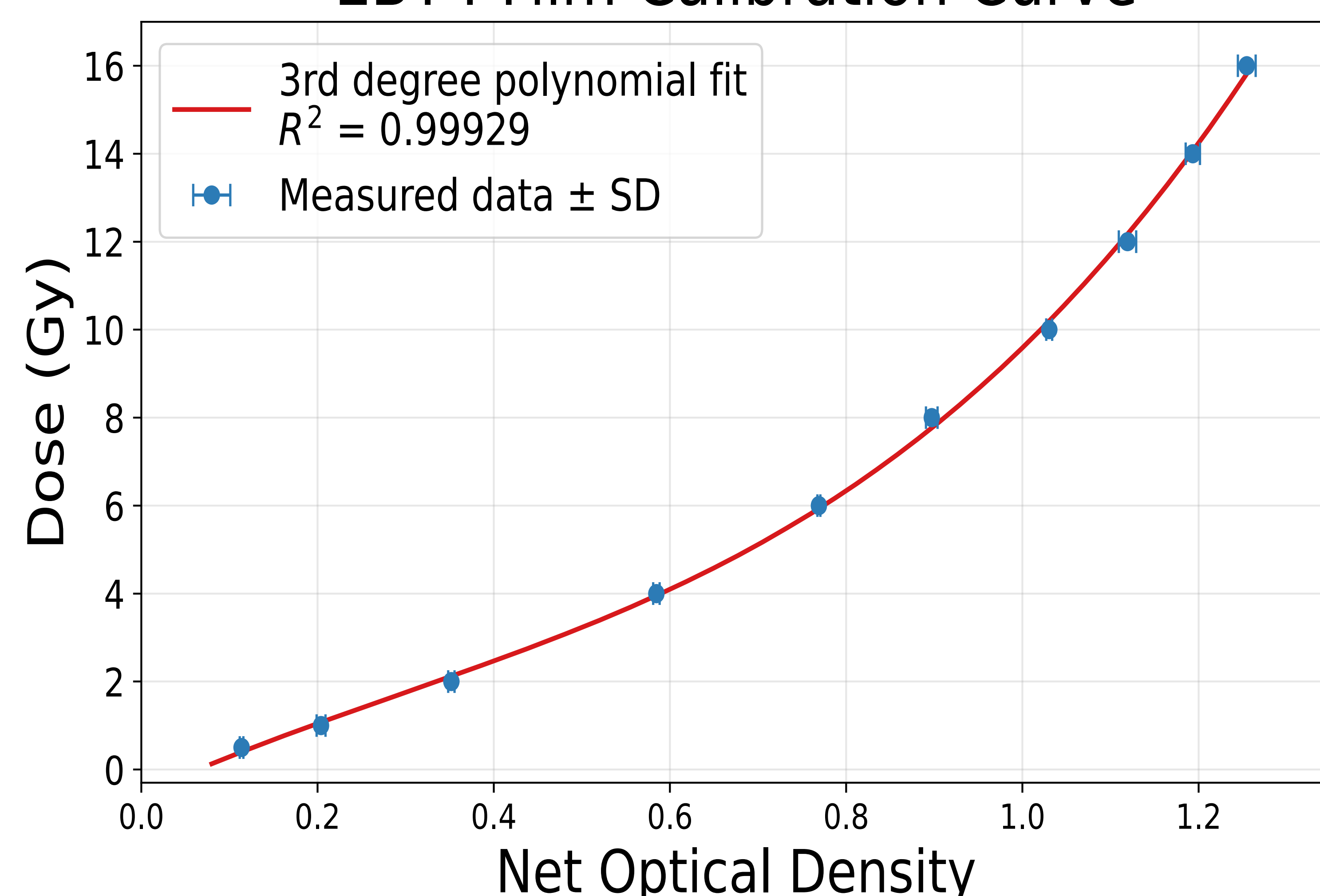
Figure: Diagram of MRT versus conventional radiotherapy

Methods



- Calibrations were performed according to AAPM TG-235.
- Radiation was delivered using a focused rhodium-anode x-ray tube (FXS) with a 50 μm focal spot.
- EBT4 has an energy-dependent response at kV energies, corrected via an energy correction factor. [2]
- RCF was given doses of 2, 4, and 6 Gy (100 μA and 800 μA).
- 5 dose stripes were delivered by moving the tube, with tube current being modulated depending on current needed

EBT4 Film Calibration Curve



Top Figure: Photograph of the X-ray tube atop a stage used to move the irradiator.
Bottom Figure: The EBT4 calibration curve used for the results.

Results

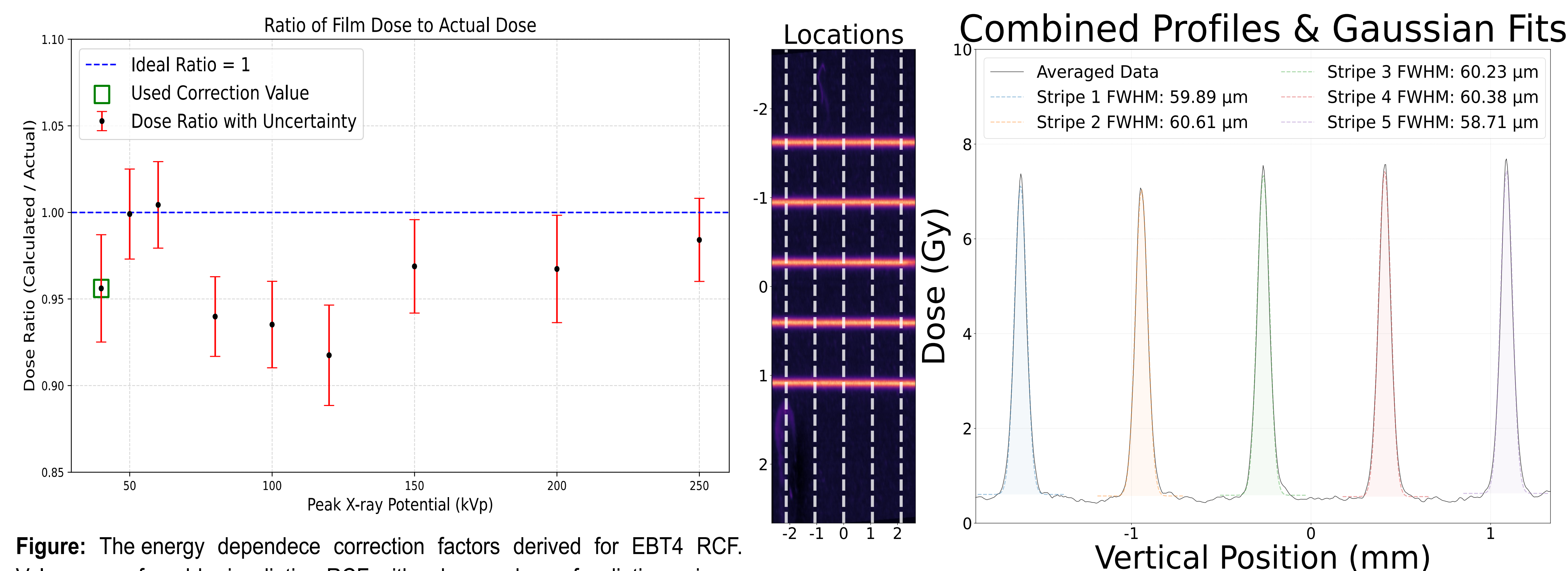


Figure: The energy dependence correction factors derived for EBT4 RCF. Values were found by irradiating RCF with a known dose of radiation using a tungsten X-ray tube with HVL filters applied to produce various kVp spectra. The 40 kVp value was used for this work. [3]

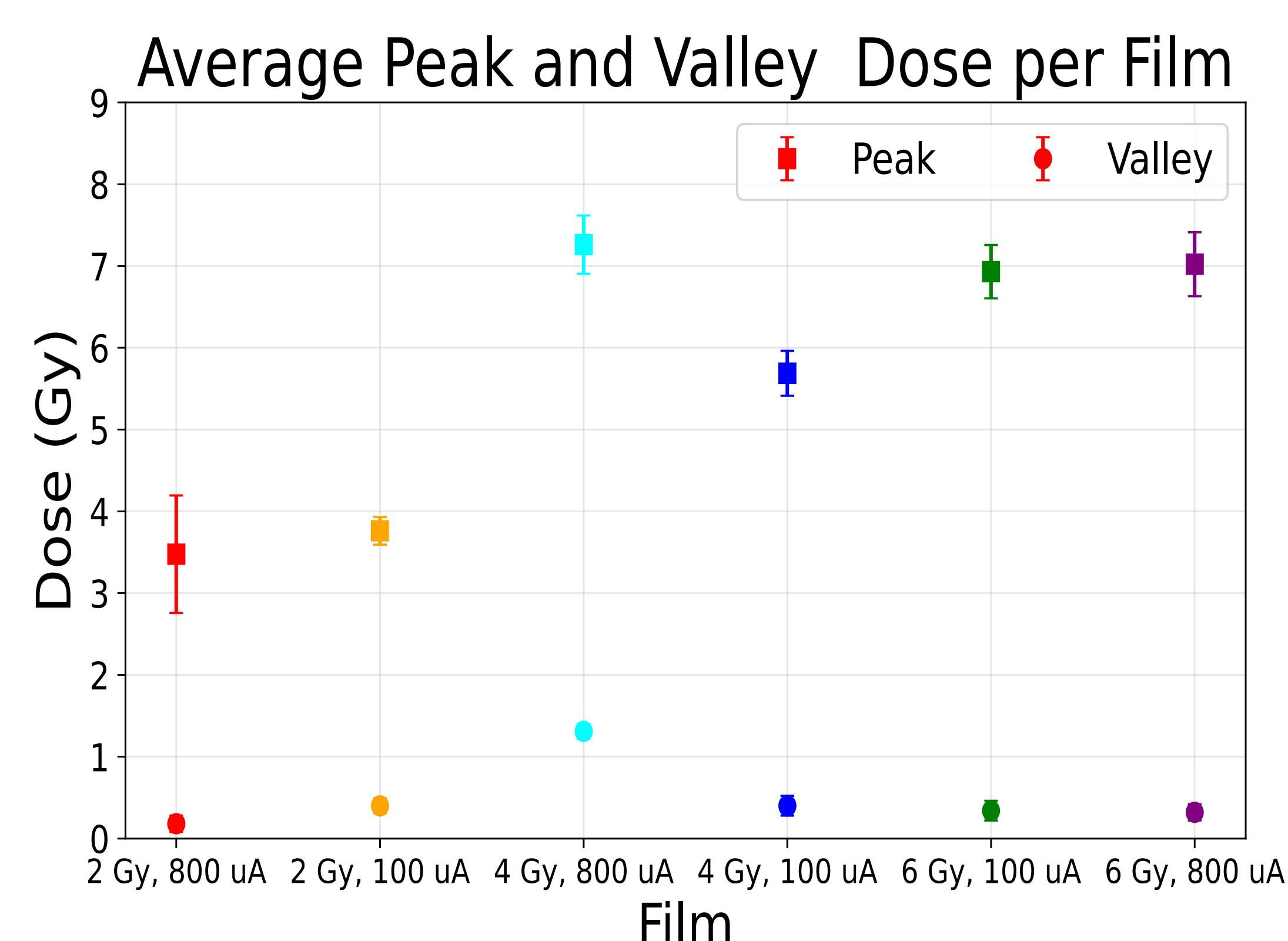
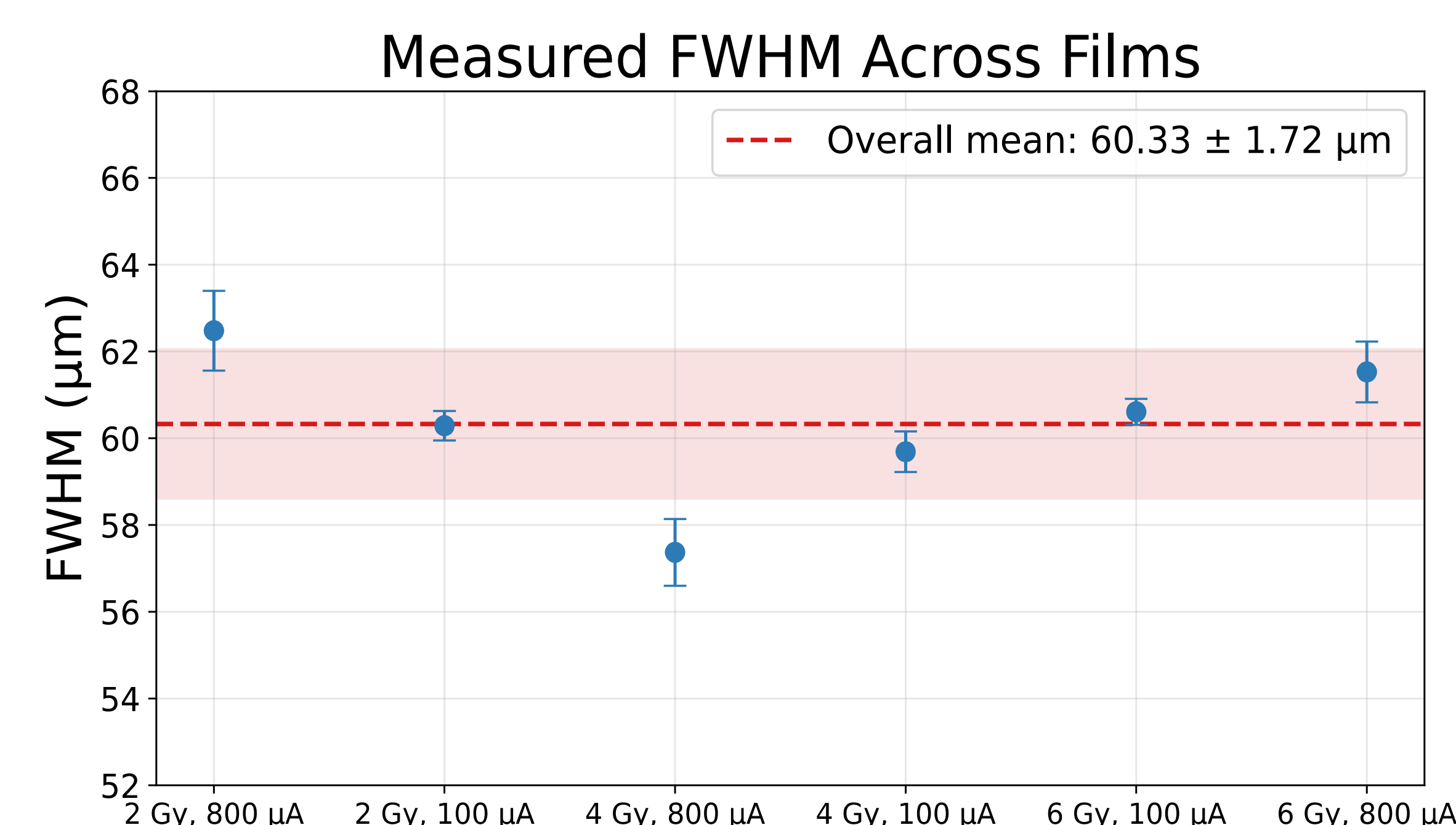


Figure: Average valley and peak dose per film across each film's 5 stripes and 4 valley areas. Varying current with the same motor speed led to equivalent doses, except for the 4 Gy 800 μA RCF, which was attributed to variation in motor speed or current.



Top Left Figure: Heatmap of dose values for the film irradiated with 6 Gy, 100 μA . The five vertical dashed lines mark the extraction locations; Top Right: Dose profiles extracted at the five vertical sampling line. Bottom Figure: Summation plot of averaged FWHM per film, showing values ranging from 57 to 63 μm across all films. The spread is likely attributable to mechanical vibration of the FXS motor during irradiation.

Conclusion and Future Work

- There is an energy dependent response in EBT4 and the response must be corrected
- EBT4 can spatially resolve MRT under ideal conditions
- Under longer MRT irradiations, EBT4 reads out higher dose
- Future work will involve the presence of a secondary dosimeter to verify dose results

References

- [1] Slatkin, D.N., Spanne, P., Dilmanian, F.A. and Sandborg, M., Microbeam radiation therapy, 1982.
[2] Chan MF, Park J, Aydin R, Lim S-B. Technical note: Energy dependence of the Gafchromic EBT4 film: Dose-response curves for 70 kV, 6 MV, 6 MV FFF, 10 MV FFF, and 15 MV x-ray beams. 2023
[3] Ashland. Gafchromic EBT4 2026