The Accuracy of 3-D Inhomogeneity Photon Algorithms in Commercial Treatment Planning Systems using a Heterogeneous Lung Phantom

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Introduction

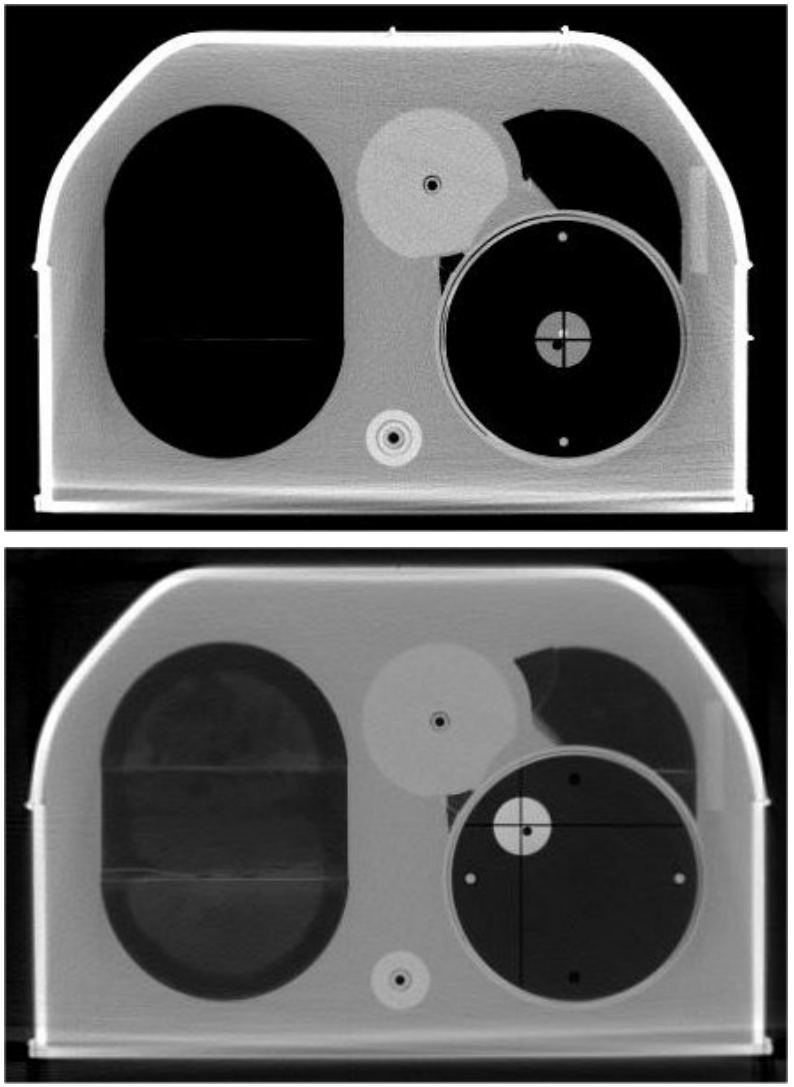
- Simple density-correction algorithms have insufficient accuracy within the lungs
- Previous studies of lung density corrections
  - based on slab phantoms
  - simple beam geometries
- Current generation convolution based algorithms should provide better dose estimates
- Limited data is available verifying the accuracy in an anthropomorphic phantom
- Differences between implementations of heterogeneity correction algorithms needs to be quantified before applying them in multi-institutional clinical trials

Objectives

- Quantify the differences between heterogeneous dose estimates from the calculation algorithms of three 3-D treatment planning systems and dosimetry measurements.
  - Philips Pinnacle^3 (Collapsed Cone Convolution)
  - Varian Eclipse (Pencil Beam with 1/D correction)
  - CMS XiO (MultiGrid Superposition)
    (Clarkson with 1/D correction)
- Develop clinically constrained conformal treatment plans for lung inserts with a centrally and medially located tumor.
- Measure dose distributions delivered by these treatments.
- Compare measured and calculated dose distributions based on the TG-53 criteria of ±5%/3mm.

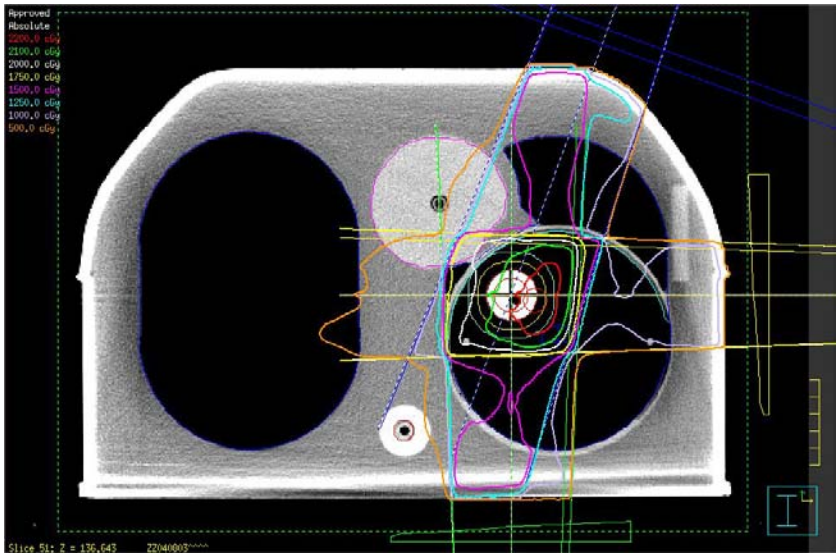
Methods and Materials

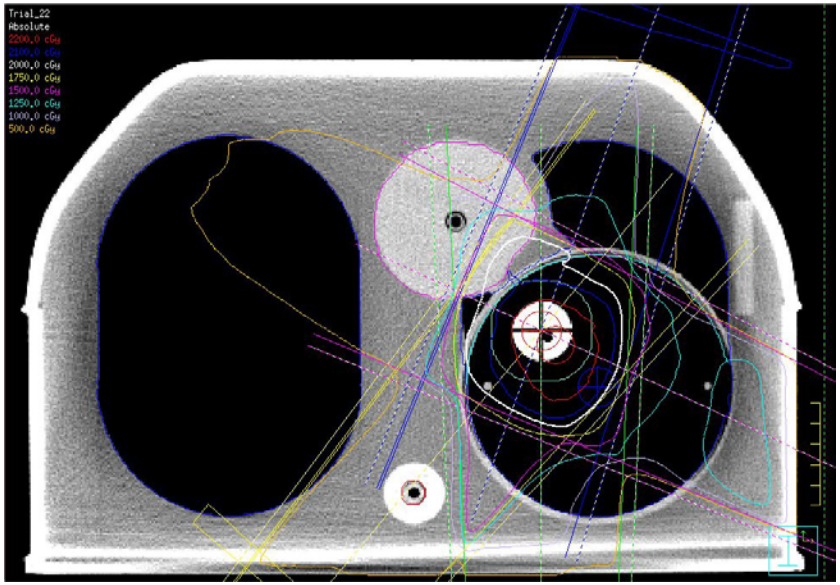
- RPC's Anthropomorphic Thorax Phantom
  - Simulated heart, spine, lungs, and lung tumor heterogeneities
  - Tumor located centrally, or toward anterior mediastinum
  - TLD (Tumor, Heart, Cord)
  - Radiochromic film (Axial, Coronal, and Sagittal)



Methods and Materials

- Conformal Treatment Plans
  - Clinically constrained prescriptions
  - Limited to four fields
  - 6 MV or 18 MV plans
  - 20Gy to prescription point
- Dosimetric evaluation criteria
  - 5% or 3mm distance to agreement (TG-53)
  - Relaxed constraint level were investigated to 7%/7mm





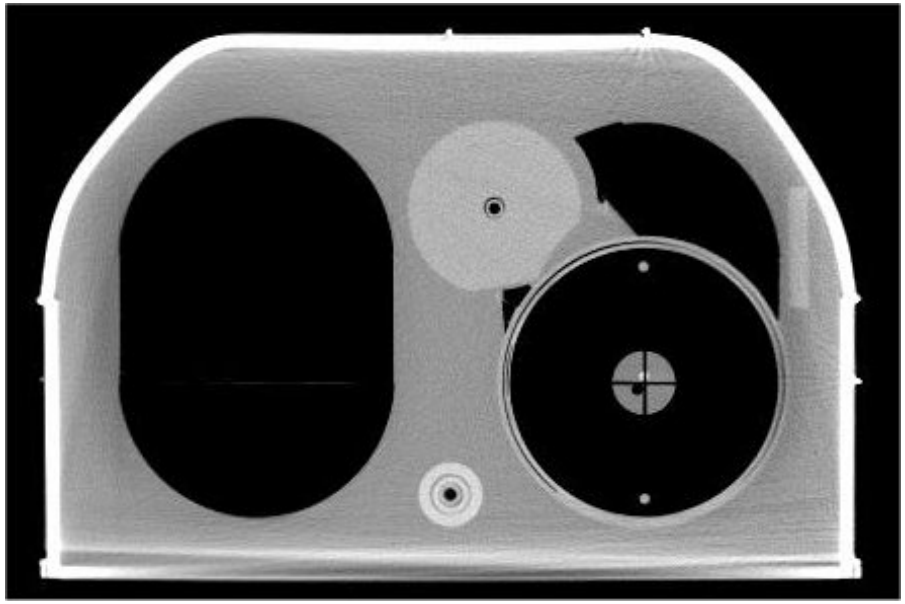
Methods and Materials

- Dosimeters
  - TLD's for absolute dose in tumor (superior and inferior), heart, and cord. Corrected for measured output and calibration differences.
  - Radiochromic Film for 2-D dose distributions (axial, sagittal, coronal) and profiles. Converted from OD to Dose. Films were normalized to the TLD dose.
  - Film localization was based on registration pinholes.
  - Dosimetry reproducibility evaluation – 3 irradiations.

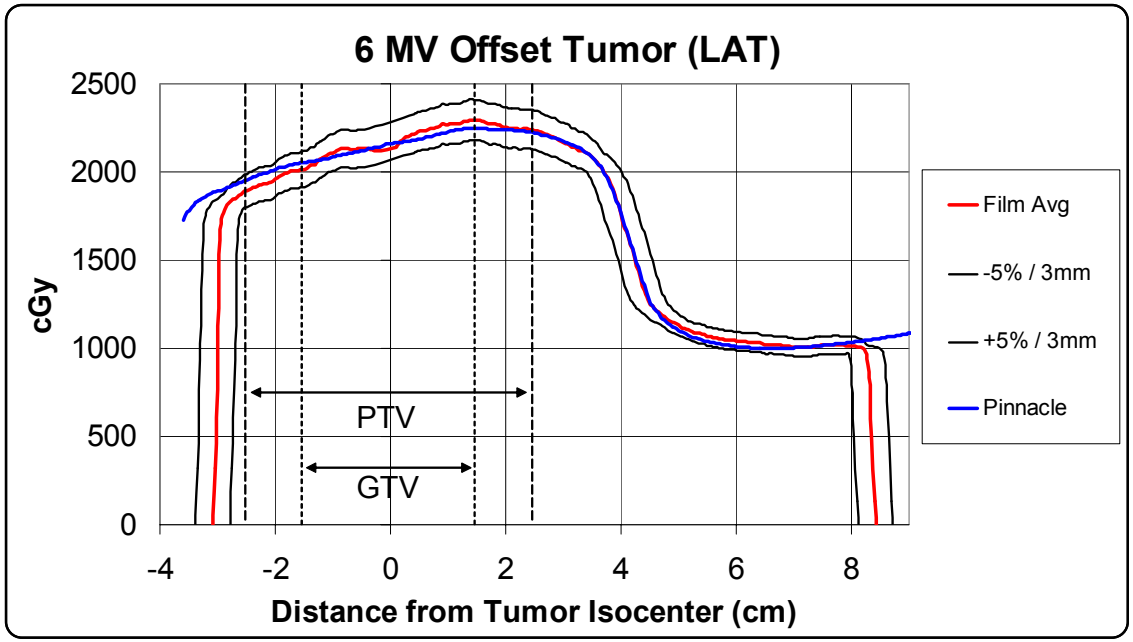
TLD Results

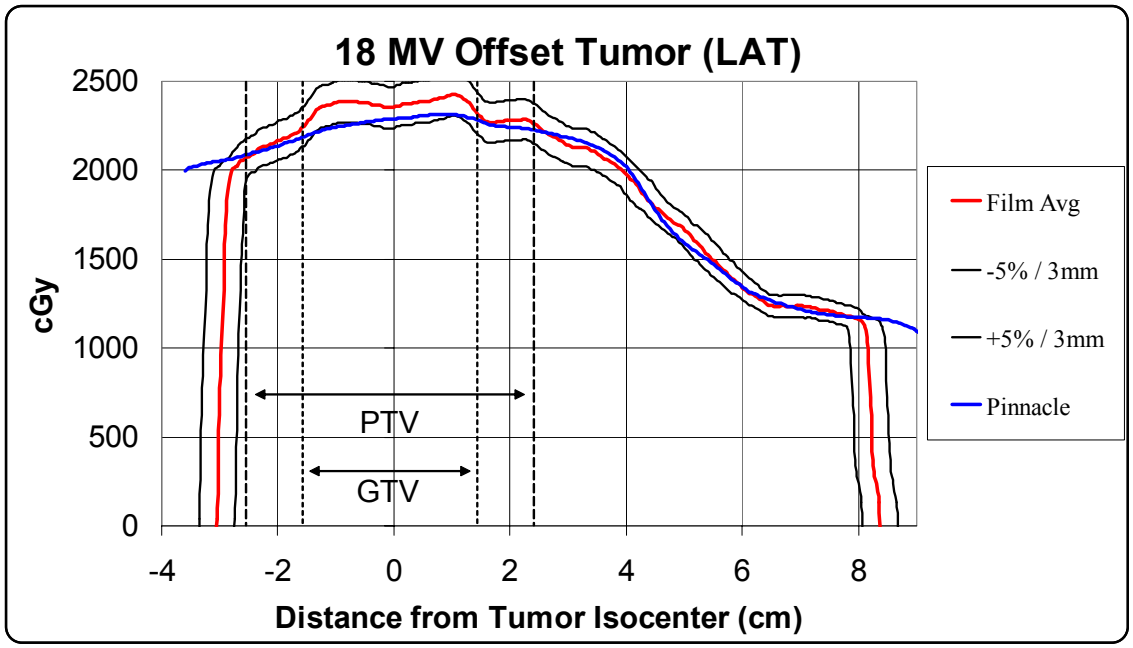
Measured / Calculated

Plan / Energy	Pinnacle	XiO MGS	Eclipse	XiO Clarkson
Center 6 MV	1.022	0.981	0.957	0.925
Offset 6 MV	1.017	0.978	0.965	0.919
Offset 18 MV	1.038	1.030	1.012	0.960



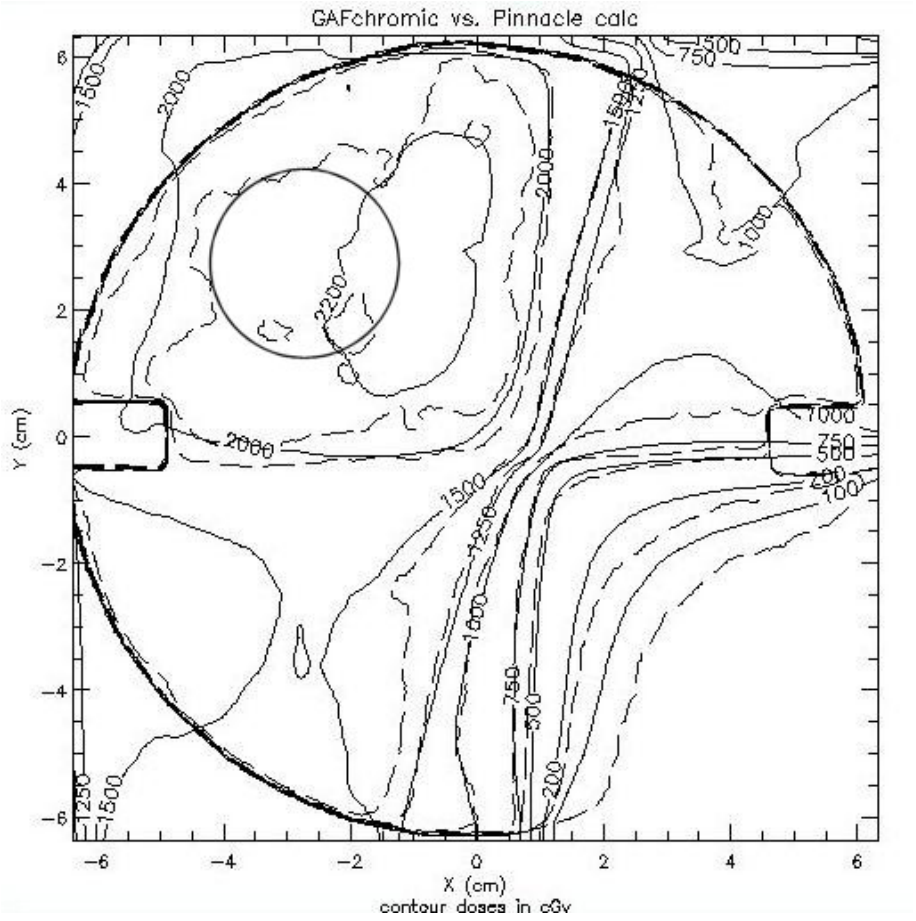
Pinnacle Profile Results



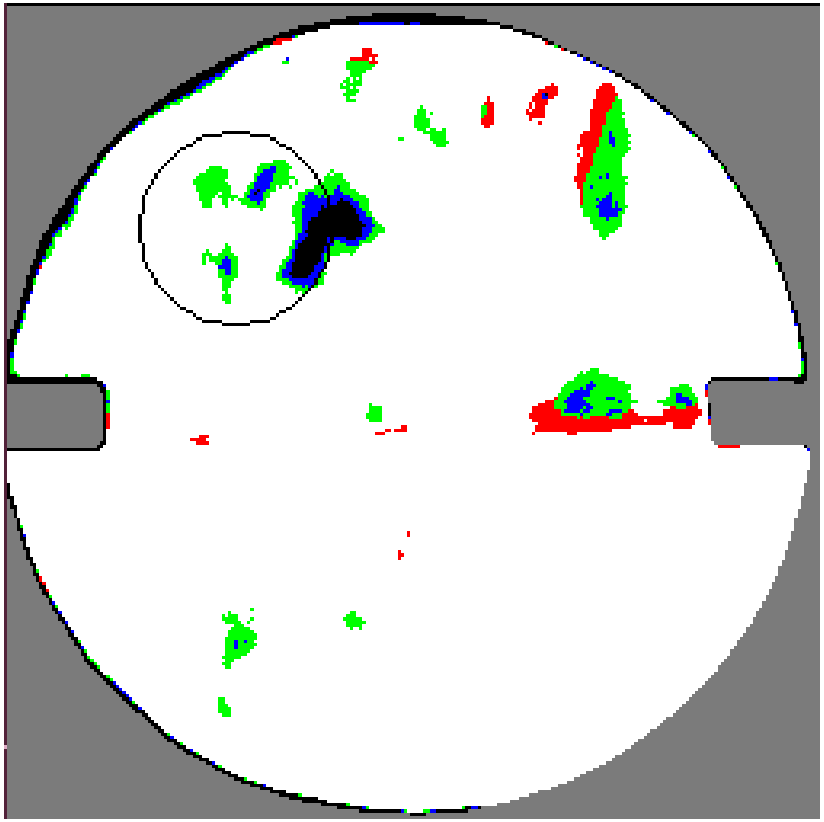


Average profile from normalized film and Pinnacle calculated profile comparison for the offset tumor plans

Pinnacle 2-D Results for 6 MV Offset

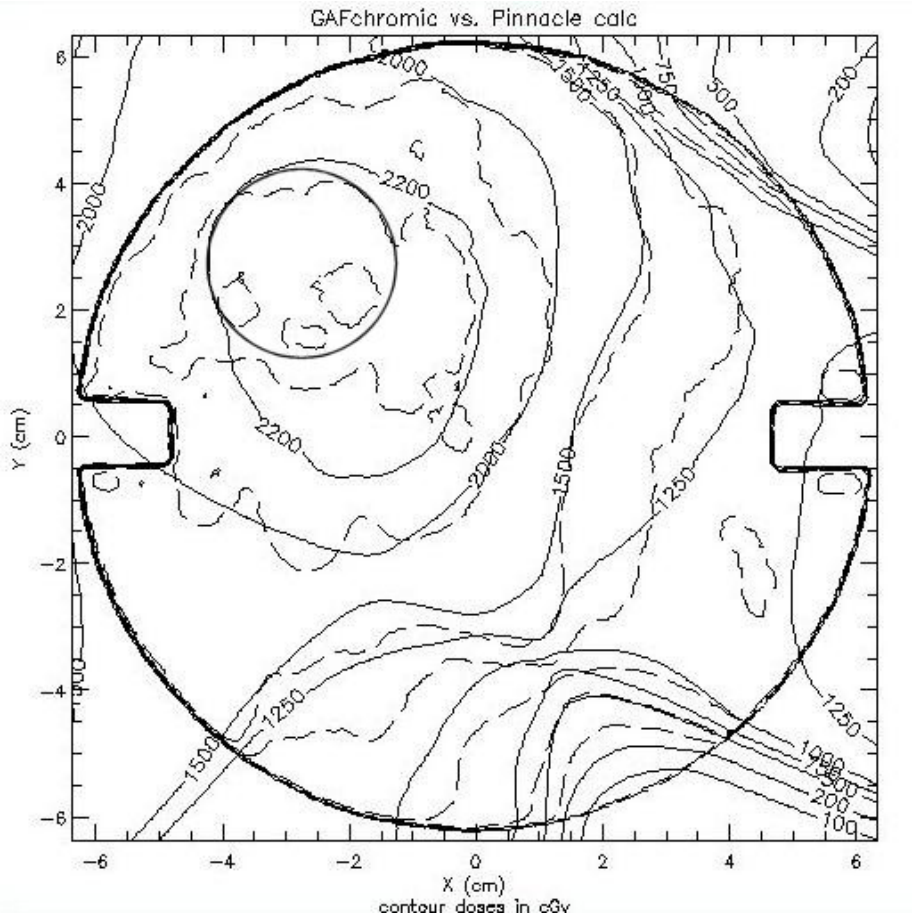


The contours on the left show a comparison of film vs calculated



The display on the right shows binary agreement map results from 5%/3mm – 7%/7mm

Pinnacle 2-D Results for 18 MV Offset



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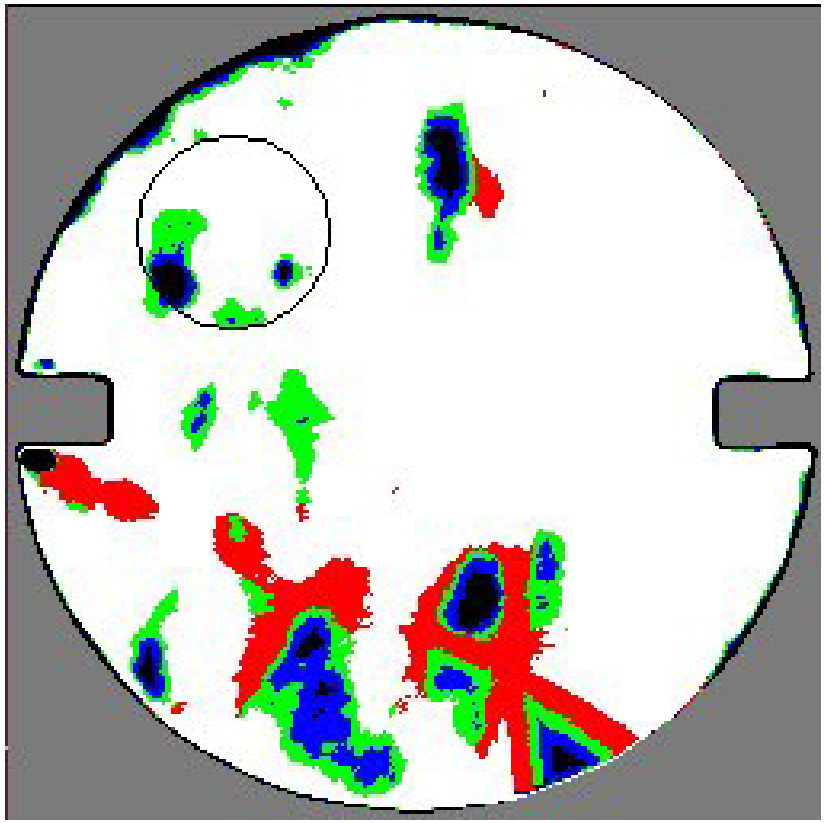

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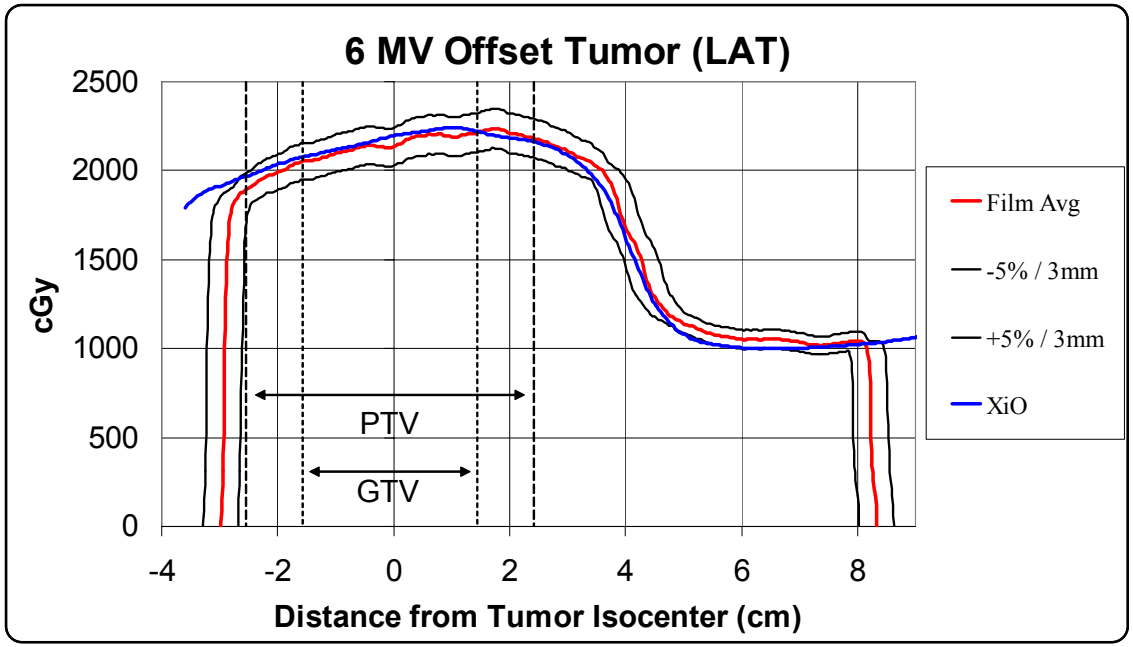

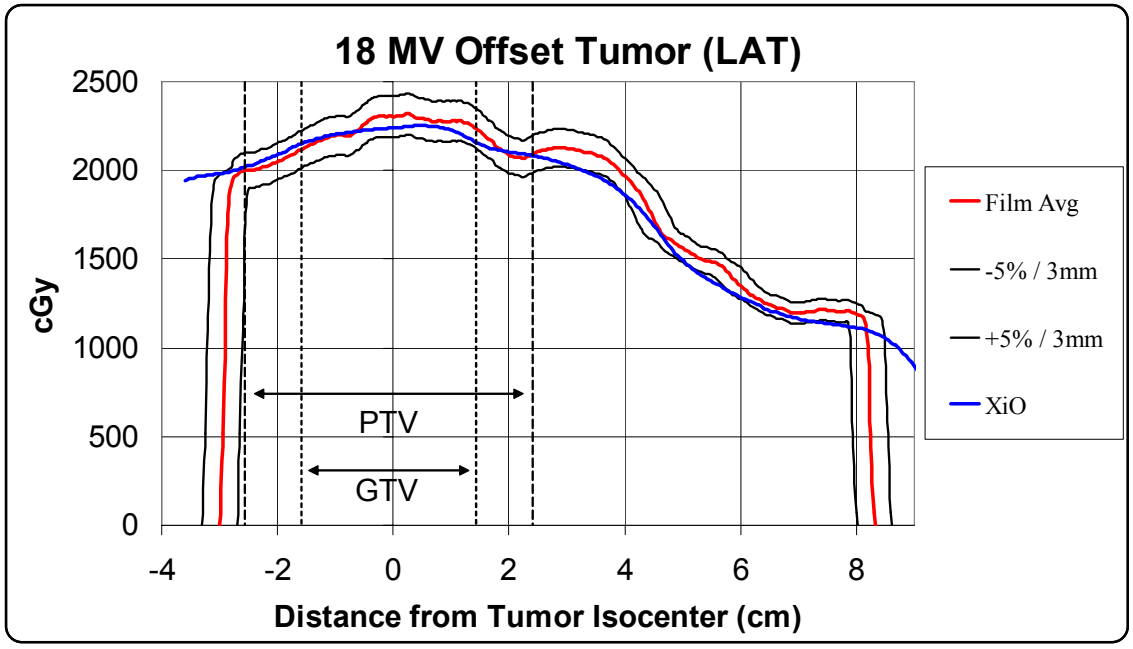

XiO MGS Profile Results

Average profile from normalized film and Eclipse calculated profile comparison for the offset tumor plans

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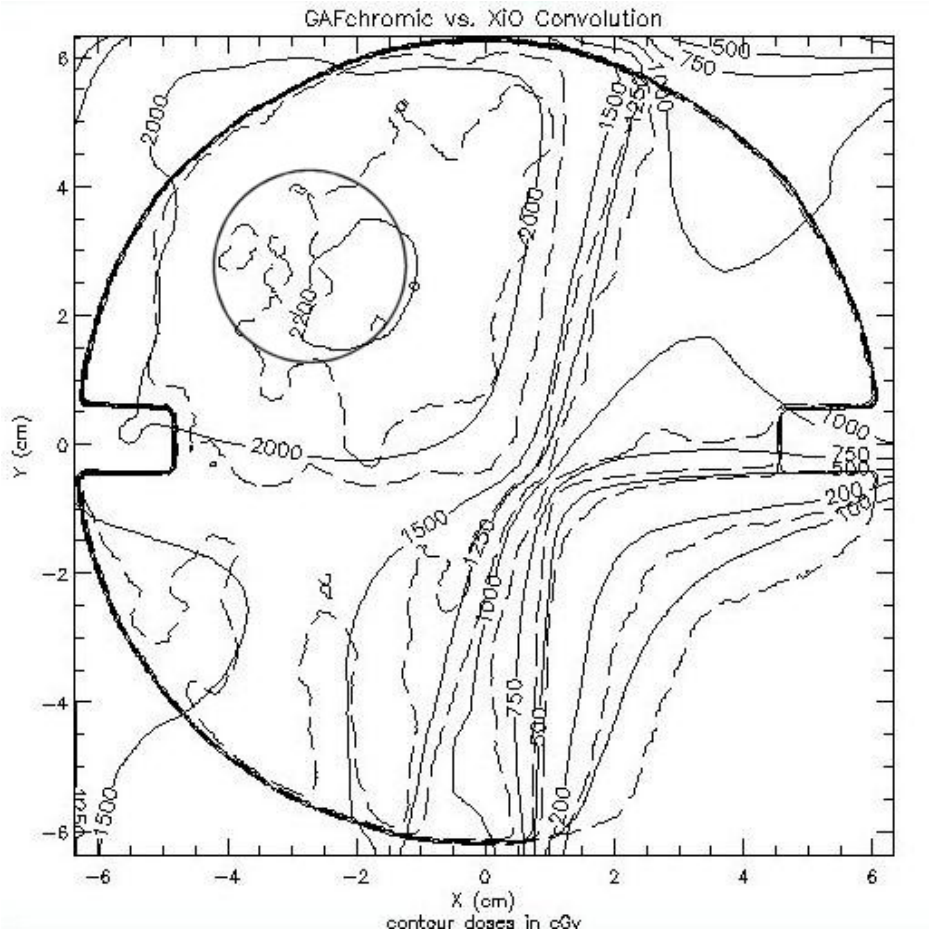

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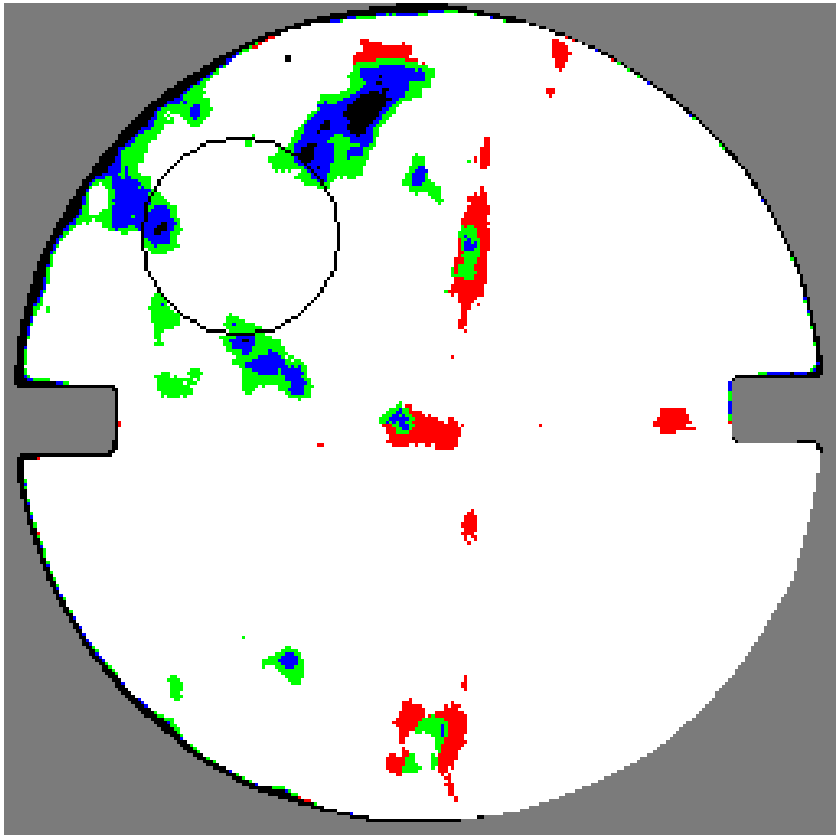

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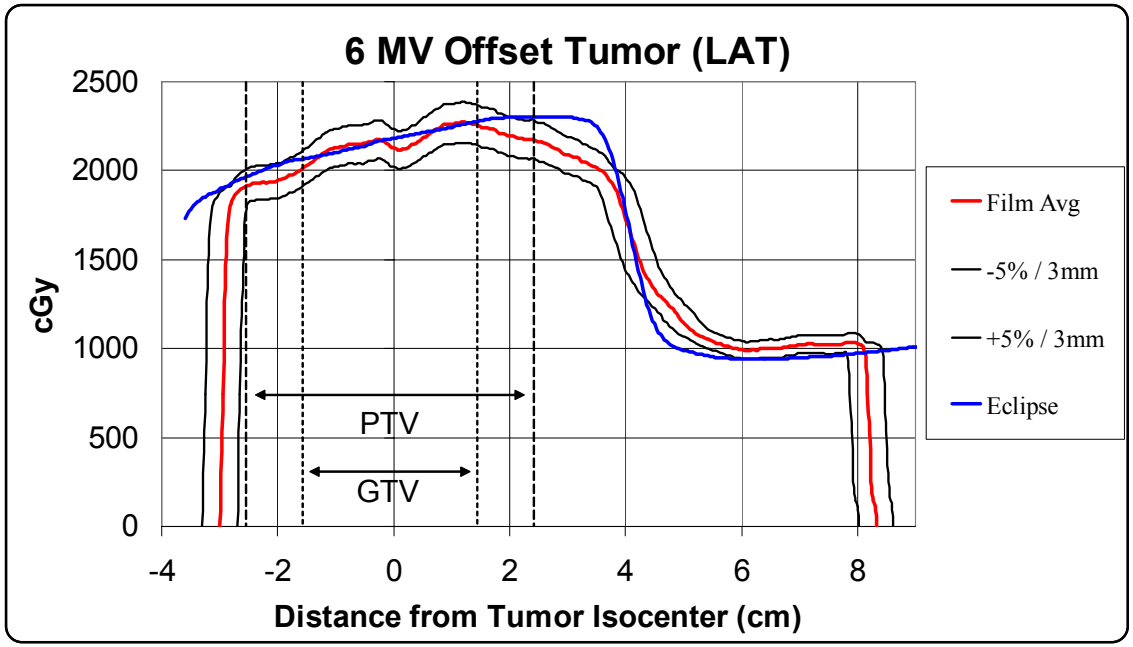
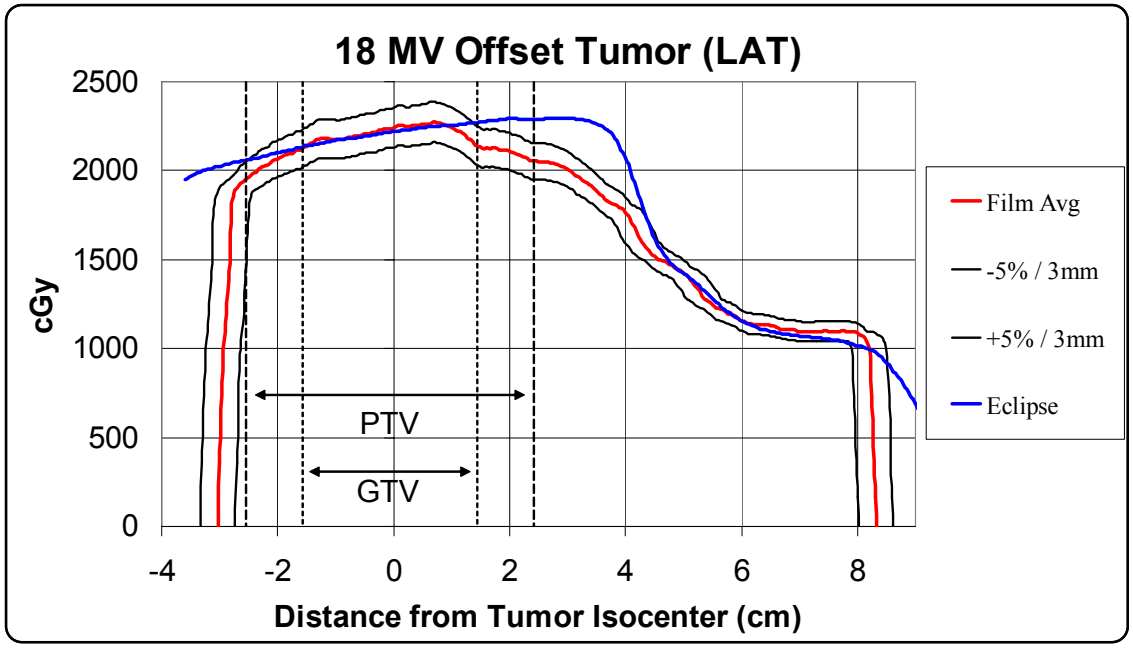
Eclipse Profile Results





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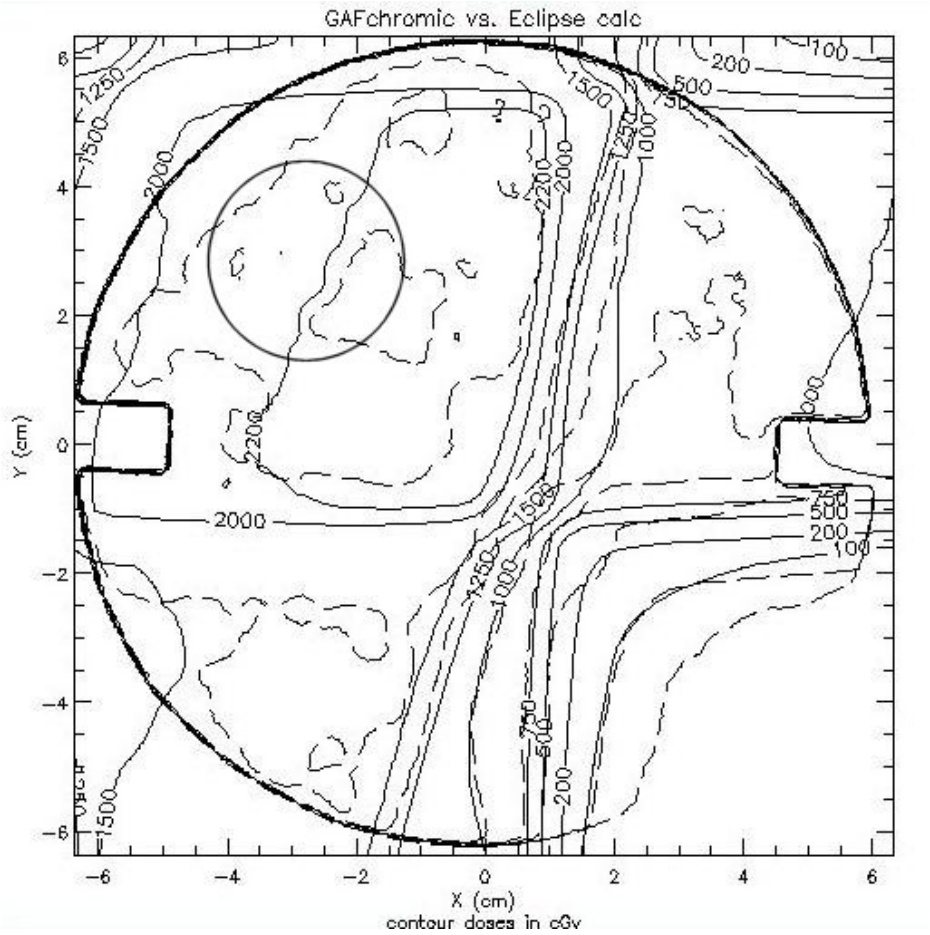

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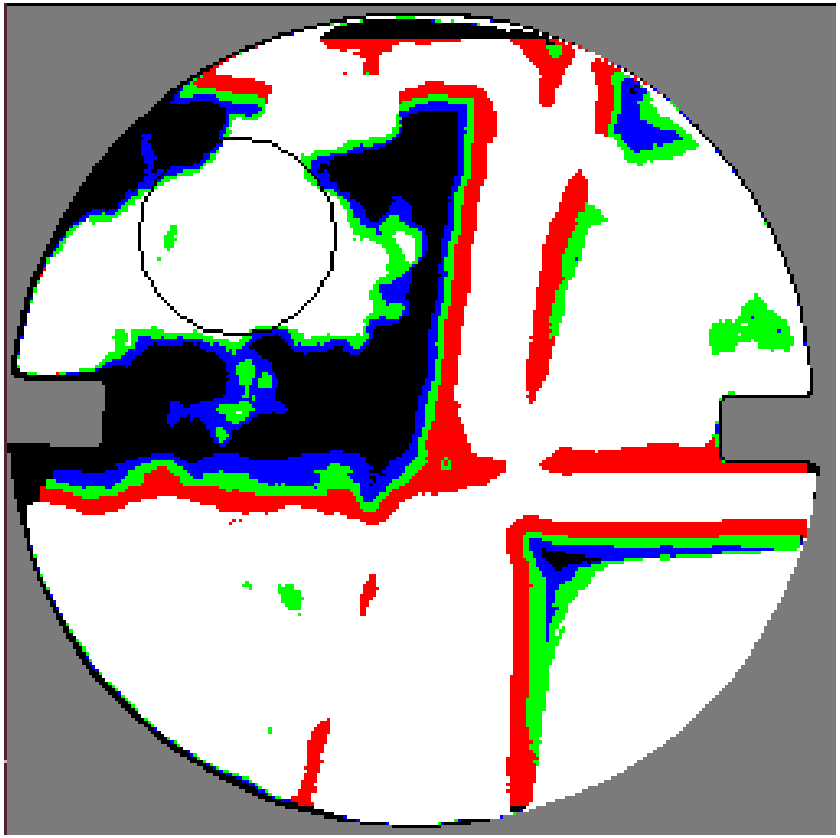

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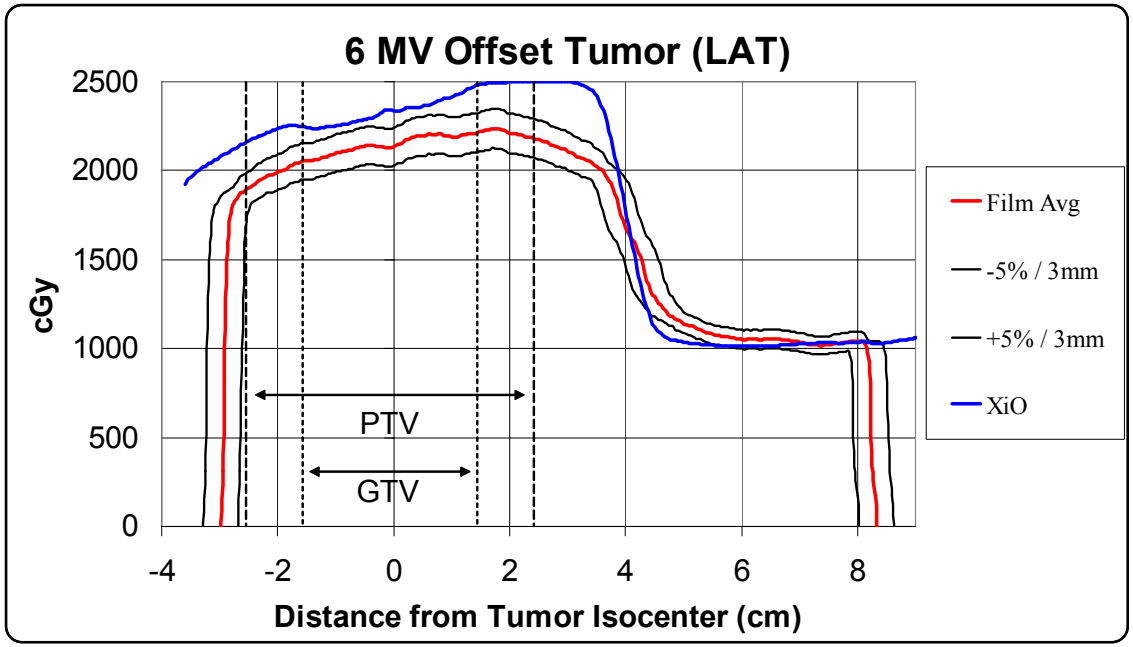
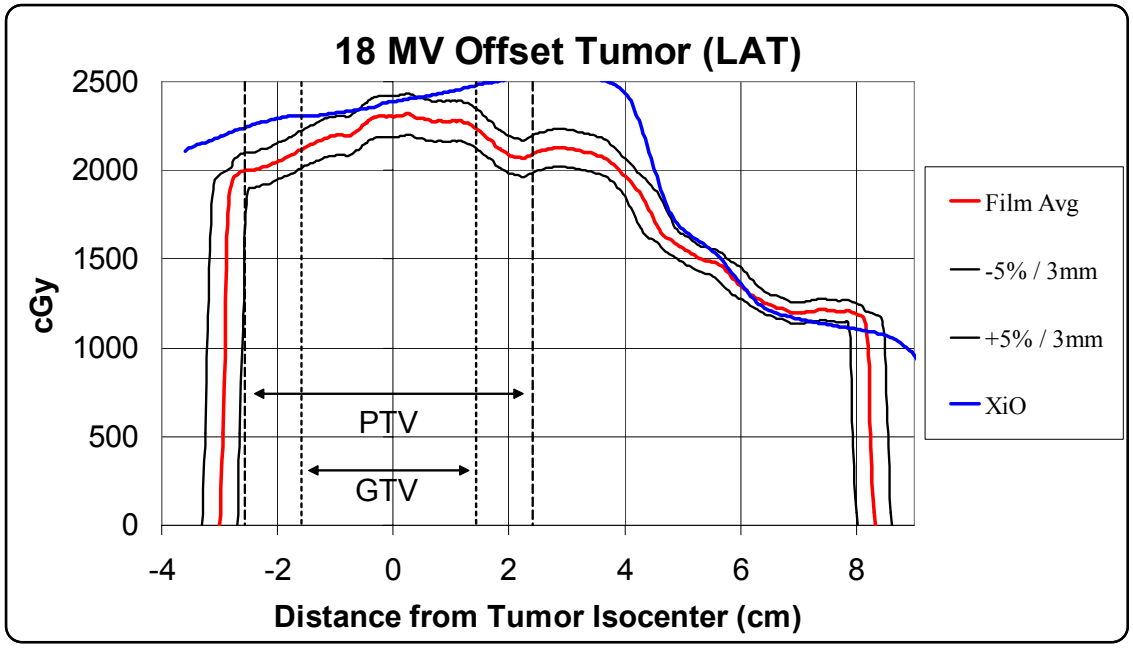
XiO Clarkson Profile Results





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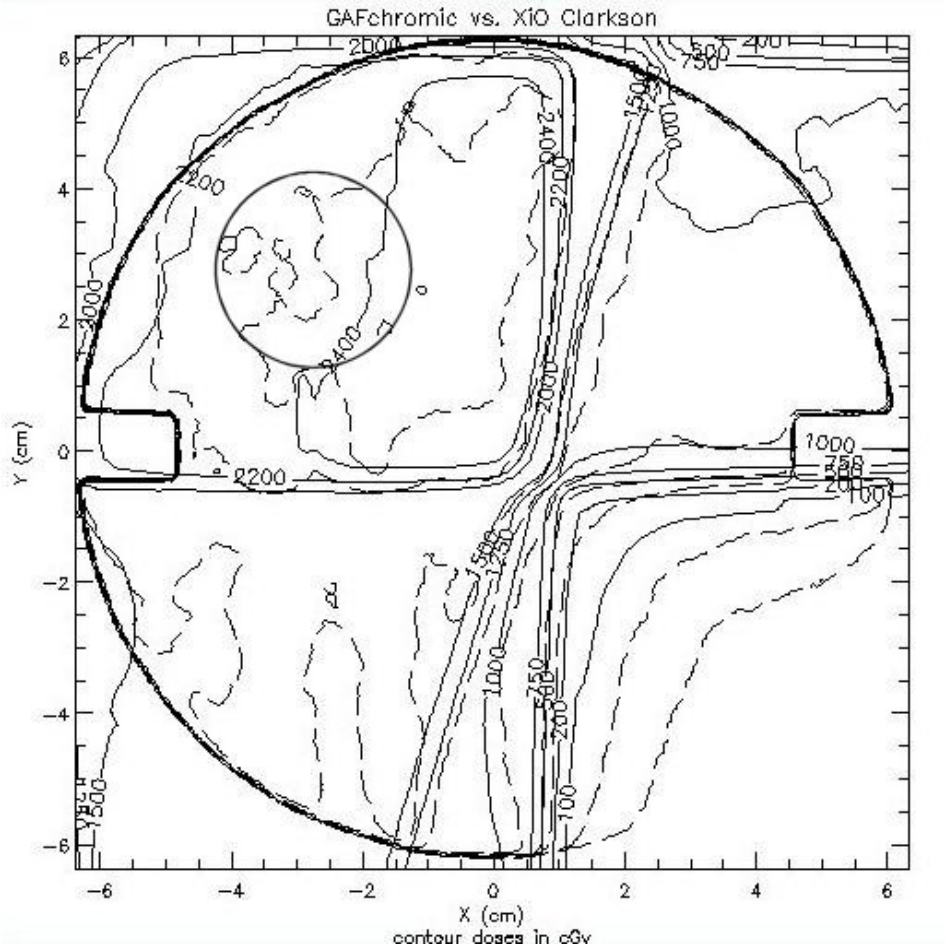
XiO Clarkson 2-D Results for 6 MV Offset



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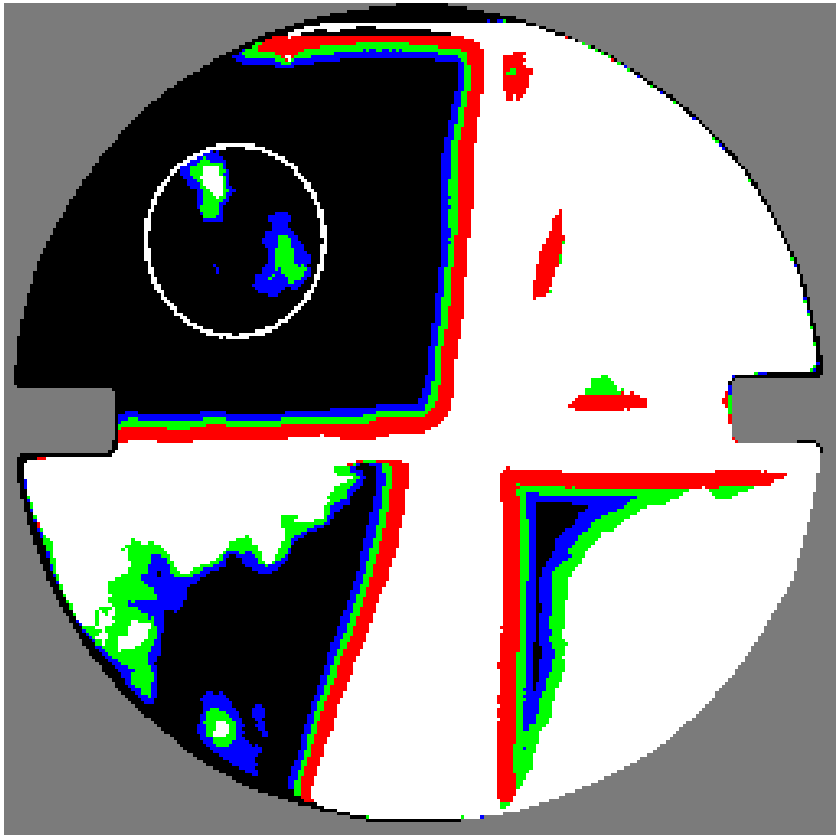

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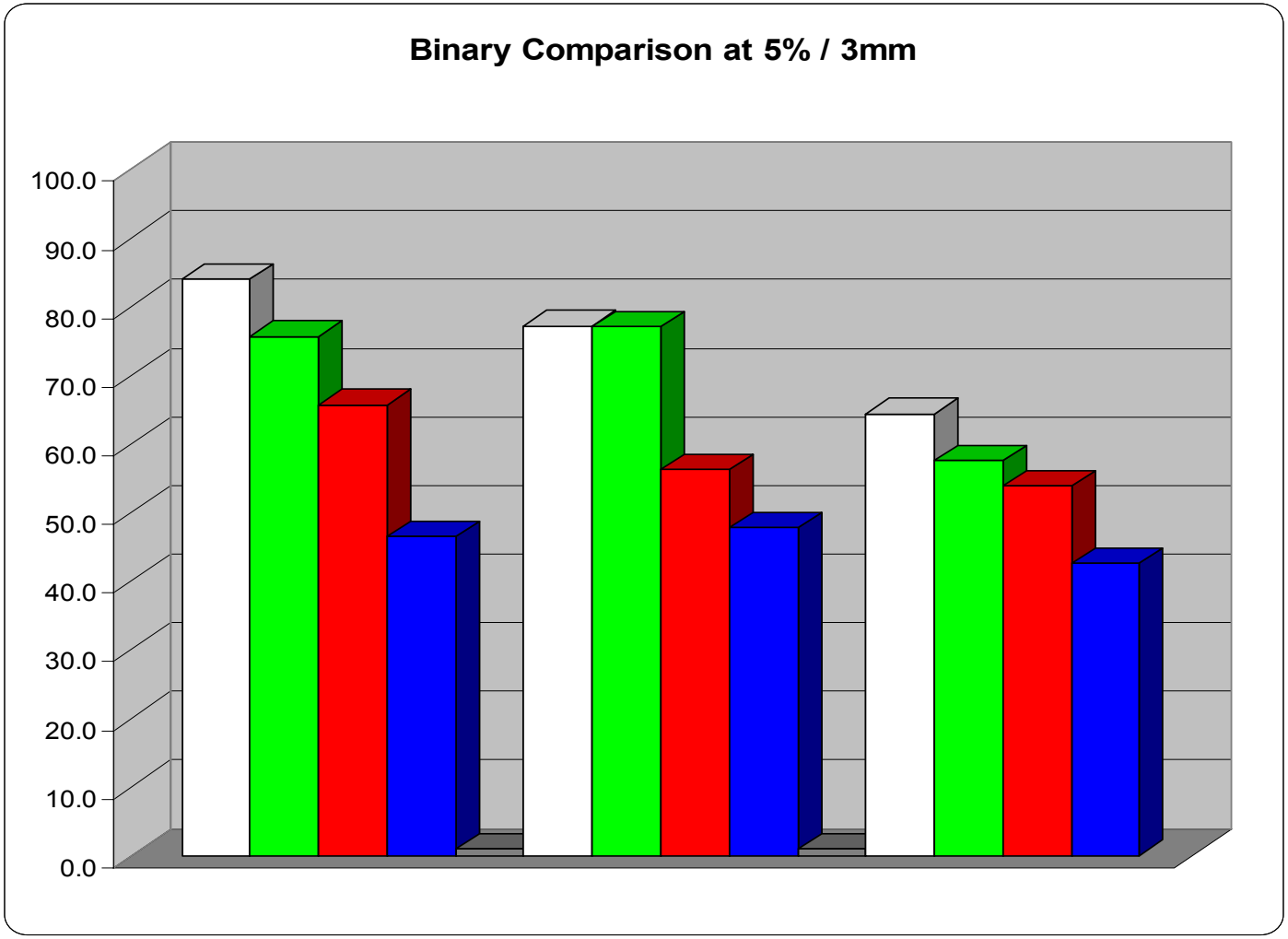
Results - Binary Comparison



Conclusions

- Pinnacle and XiO's MGS provide clinically acceptable results
- Pinnacle and XiO's MGS could be compared directly in clinical trial settings
- Eclipse does not account for the increased lateral range of secondary particles
- XiO's Clarkson overestimates the dose ~10% throughout the PTV

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