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Dosimetric Characterization of a Prototype Nanotechnology Microbeam Radiation Therapy Device using Gafchromic® EBT2 Film

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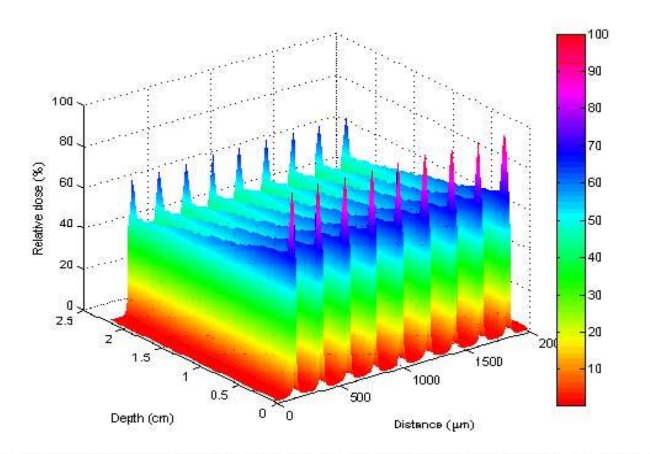
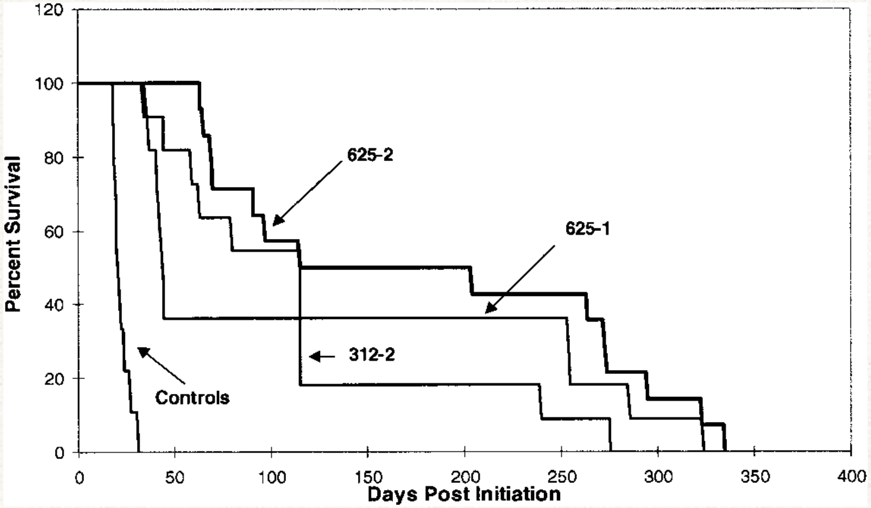
What is Microbeam Radiation Therapy (MRT)?

- Arrays of orthovoltage, parallel, microplanar X-ray beams (25 - 600μm)
- Mostly studied at synchrotron sites due to high flux and small beam divergence
- Capable of ablating highly aggressive tumors and completely sparing normal tissues at extremely high entrance doses (100-1000Gy)



Brauer-Krisch, E. (2010) *Effects of pulsed, spatially-fracitionated, microscopic synchotron X-ray beams on normal and tumoral tissue.*



Laissue, J. (1998) *Neuropathology of ablation of rat gliosarcomas and contiguous brain tissues using a microplanar beam of synchrotron-wiggler-generated X-rays*

Laissue, J. (2001). *The weanling piglet cerebellum: a surrogate for tolerance to MRT pediatric neuro-oncology.*

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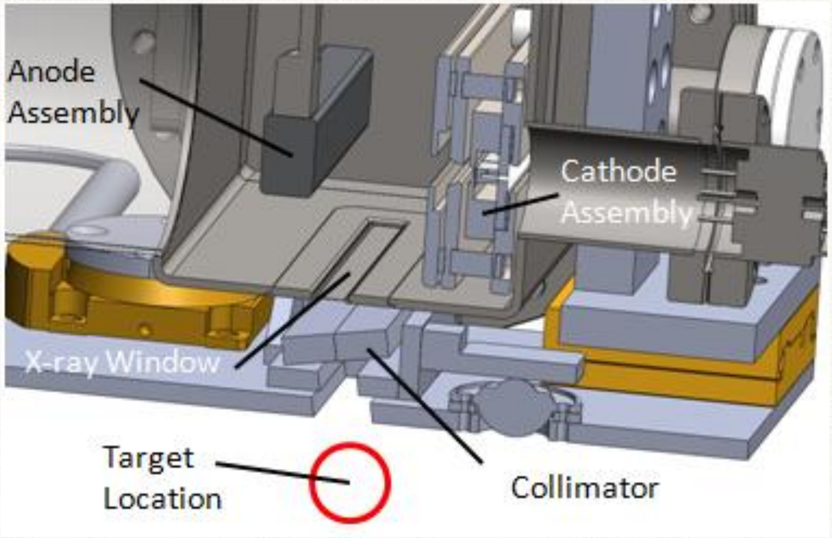
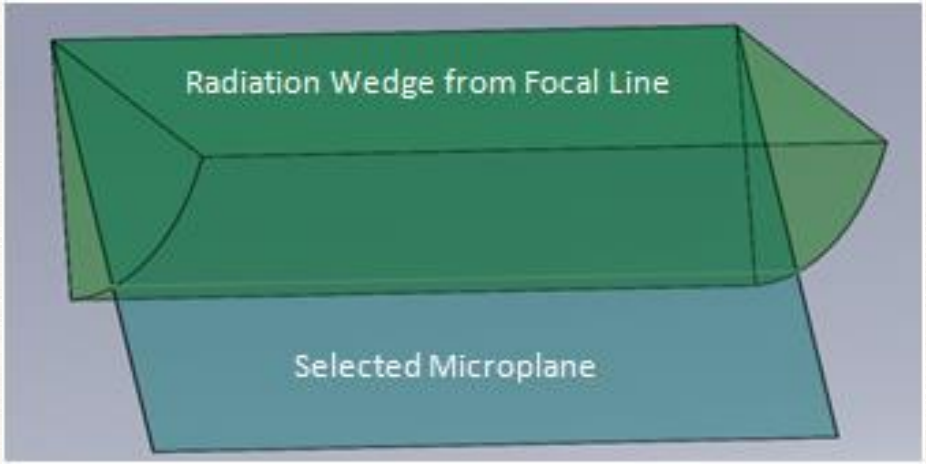
Compact MRT Device

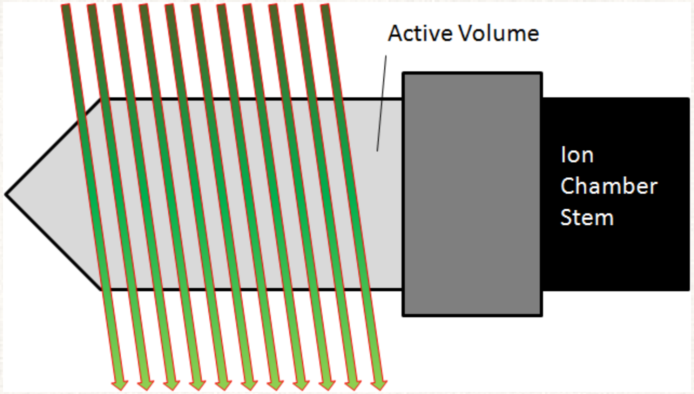
- Developed in order to further radiobiological research on MRT
- Creates wedge of X-rays from long (160mm), thin (140µm) focal line on tungsten anode held at 160kV
- 150mm x 160µm collimator selects the microplanar X-ray beam
- Semi-infinite microbeam incident upon mouse below the collimator

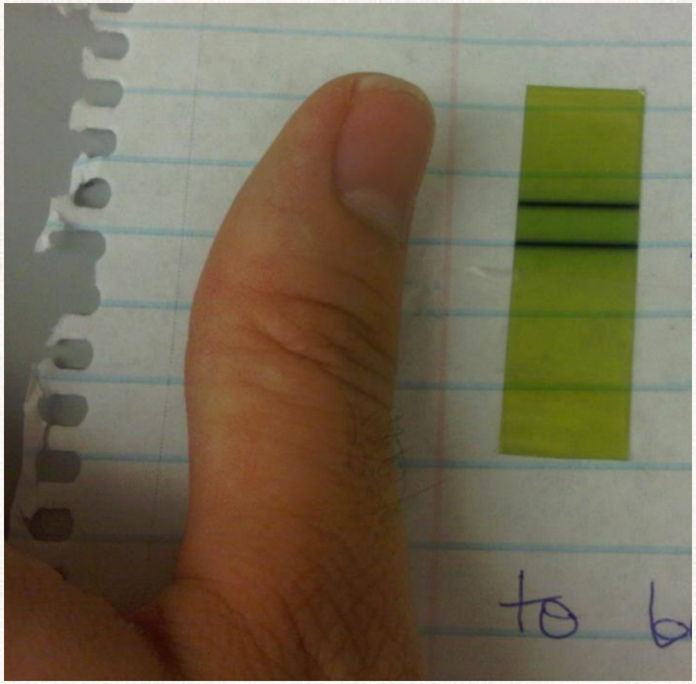




MRT Dosimetry

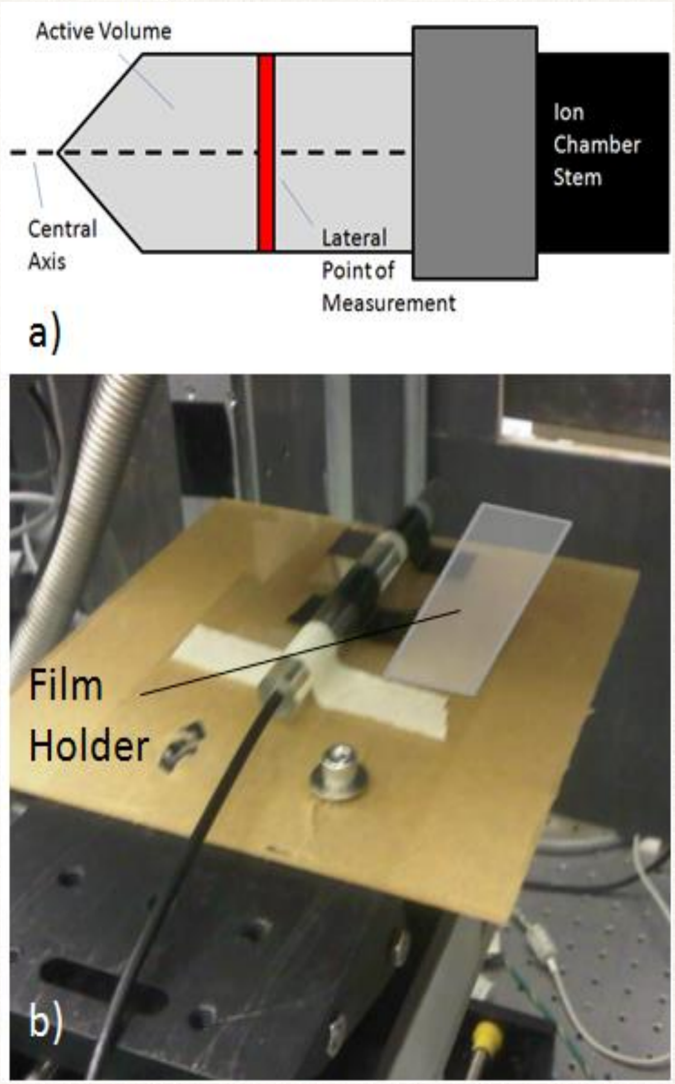
- Well-known problem of accurately measuring absolute dose in very small fields
- Only commercial option: Gafchromic® EBT2 Film
  - Had to use large scanner resolution (2400dpi)
  - Meticulously followed recommended film handling procedures
  - Carefully calibrated film in our own broad beam (w/o microbeam collimator)
  - Used most recent readout and analysis techniques from Ashland, Inc.:
    - Triple Channel Dosimetry
    - FilmQA^{TM} Pro

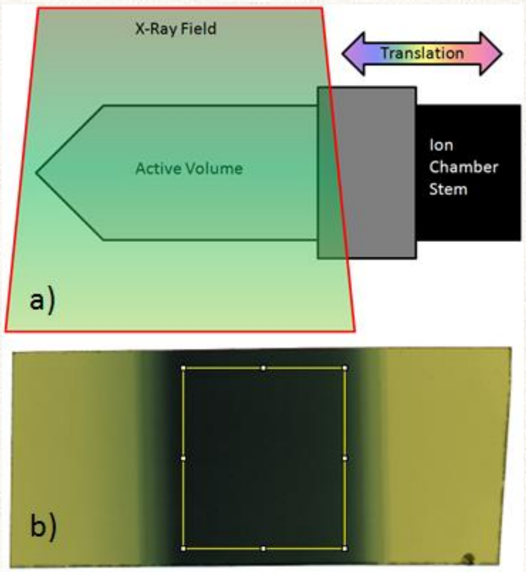


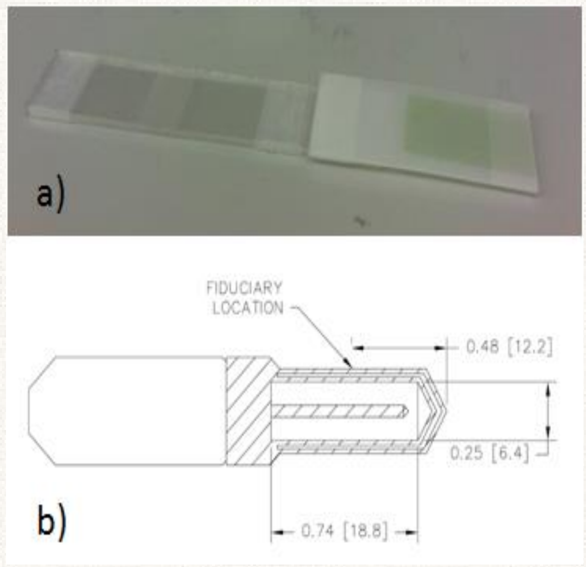


Film Calibration

- Accurate film calibration can be tricky!
- Caveats accounted for during calibration:
  - Heel effect
  - Chamber centering
  - Effective measurement point
  - Equivalent attenuation







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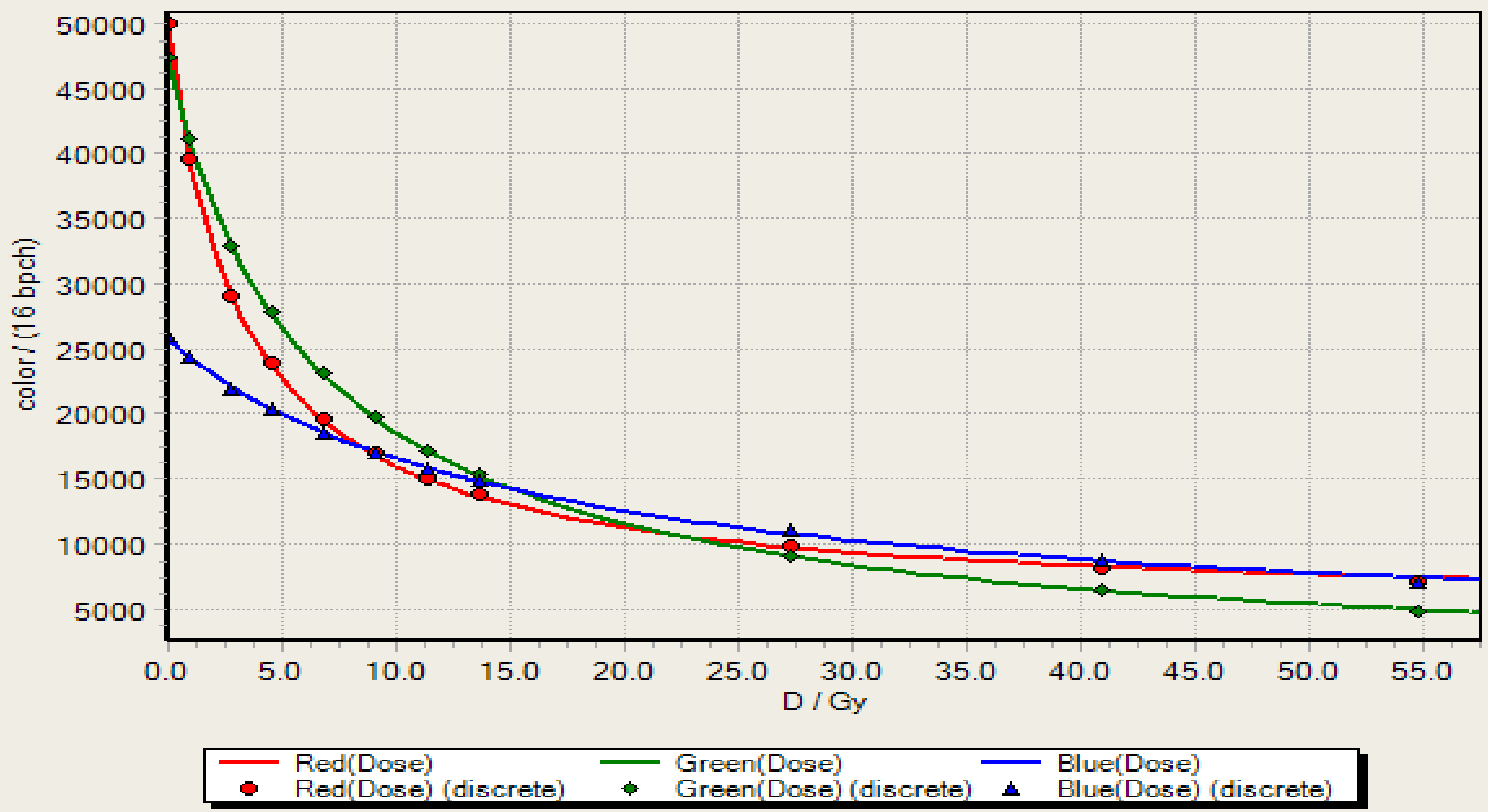
Calibration Results



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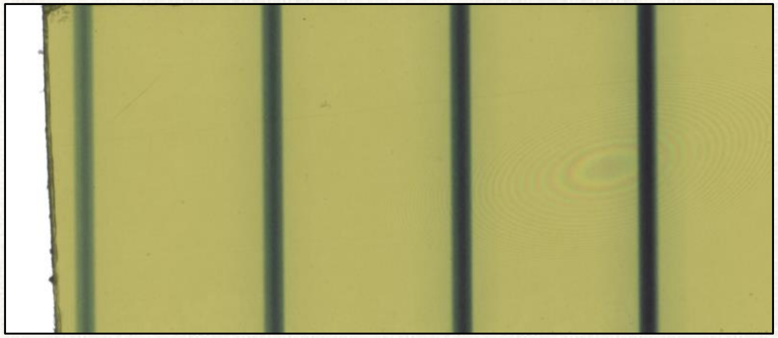
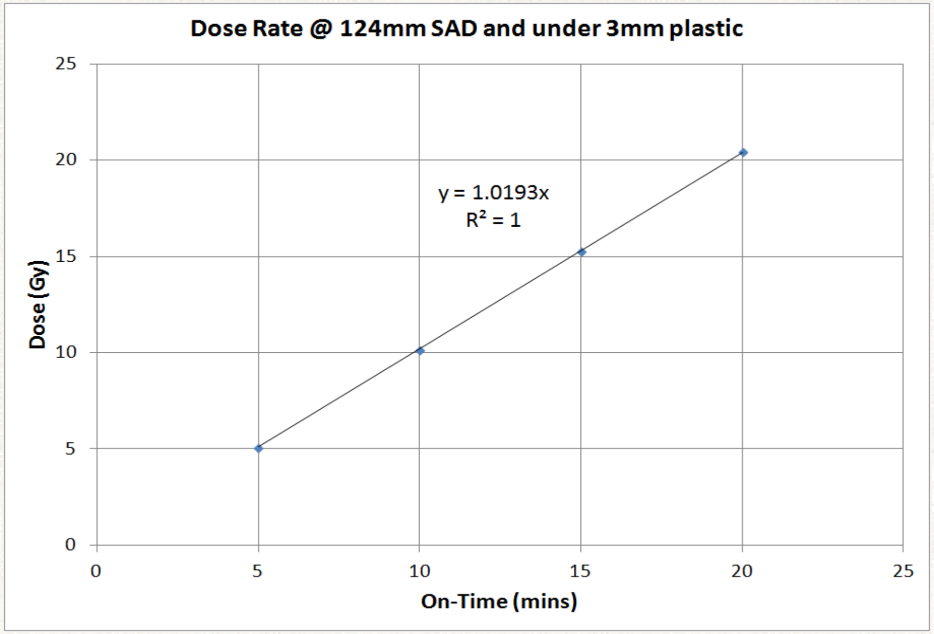
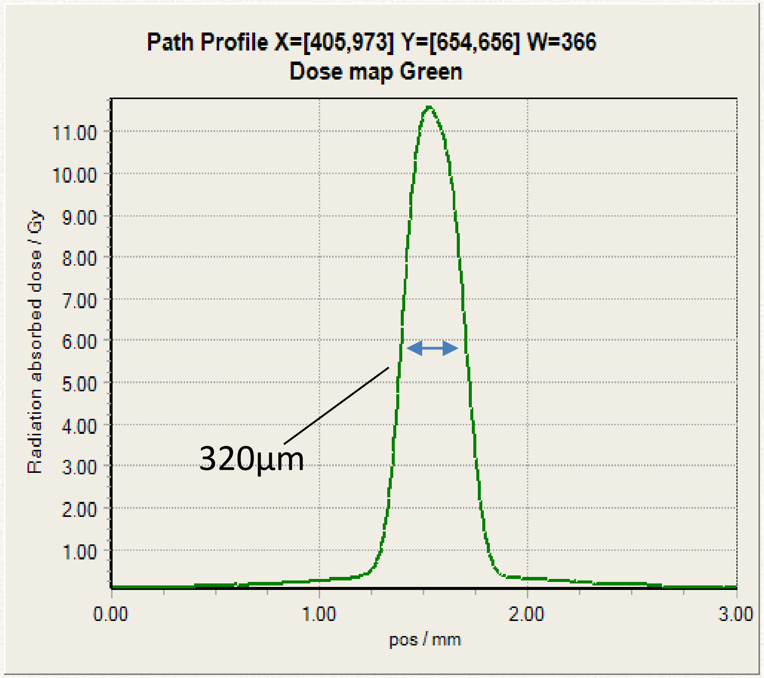
Dose Rate and Beam Width Measurement

- F-factor = 0.91 at our HVL (AAPM TG-61)
- Continuous Dose Rate = 1.02Gy/min
- Microbeam FWHM = 320µm
- Collimator flux transmission factor = 84%







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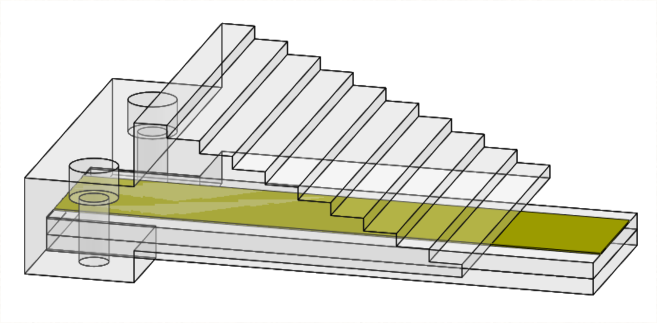
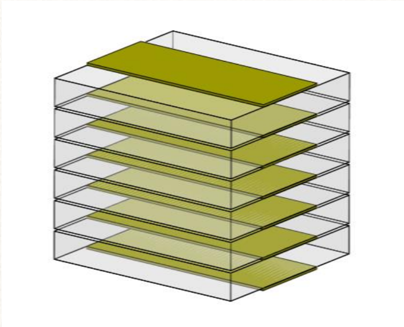
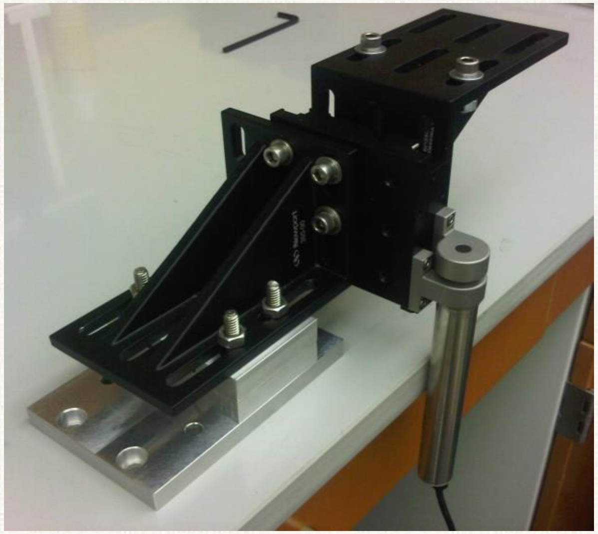
Phantom Creation

- Our beam is unique:
  - Specific phantoms had to be made
  - For TMR, PDD, HVL, etc…
- Based on use of EBT2 film
- Built for efficiency
  - Allowed for all measurements to be taken without opening the X-ray enclosure

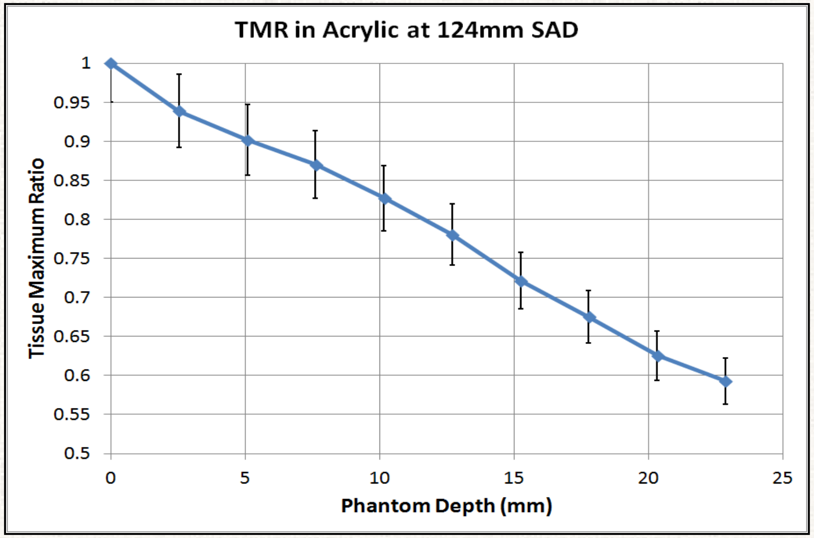


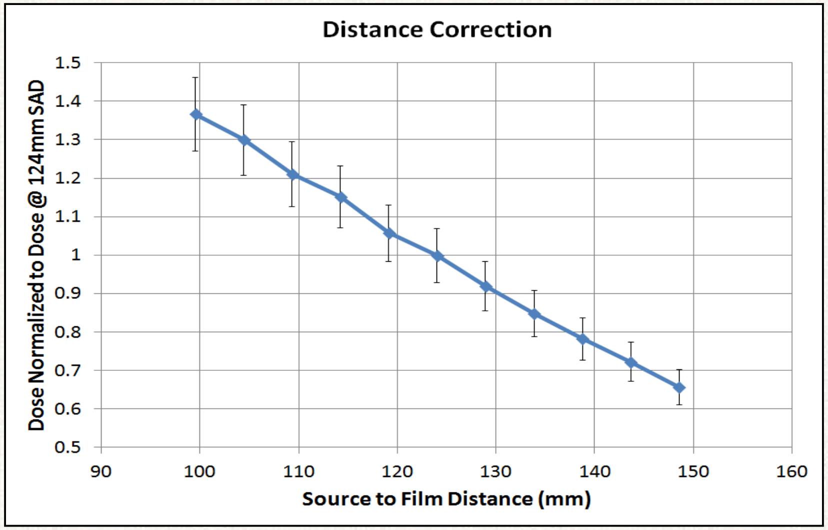


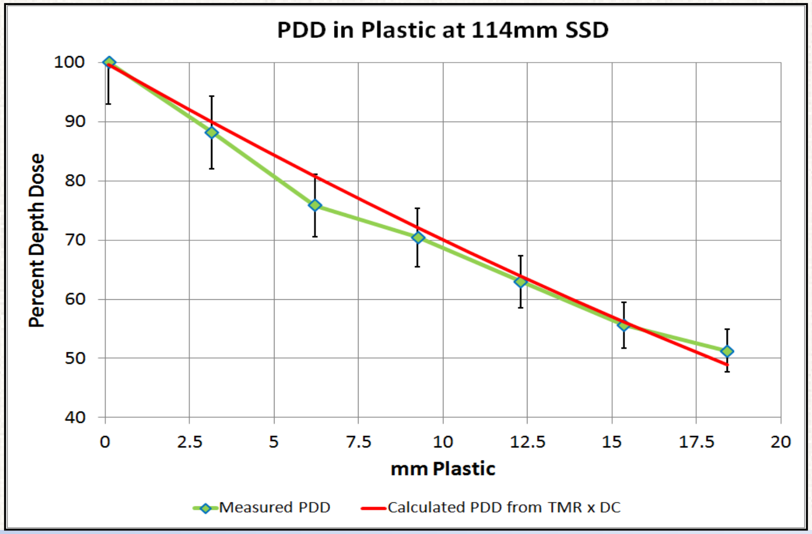


Full-Scale Dosimetric Beam Characterization

- Shown here:
  - Tissue Maximum Ratio
  - Dose vs. Distance from Source
  - Percent Depth Dose
- Also measured (not shown):
  - Half Value Layer in Al
  - PVDR vs. pitch for divergent beam
  - FWHM vs. distance from collimator
- Starting point for small animal treatment planning system

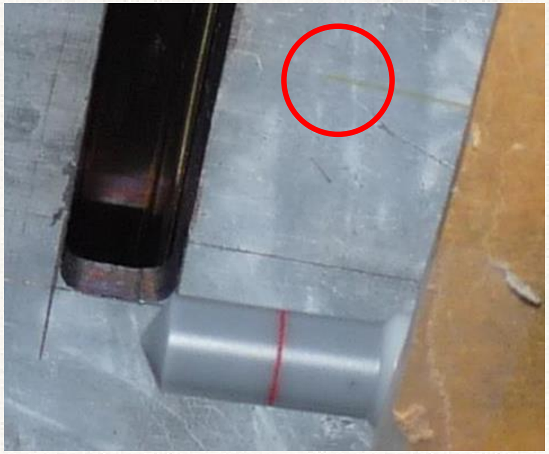


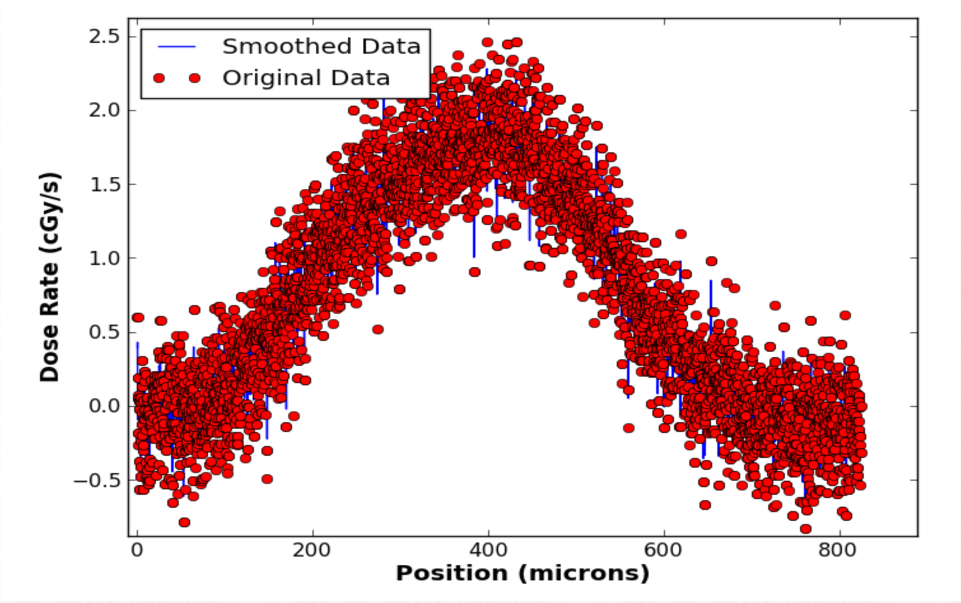


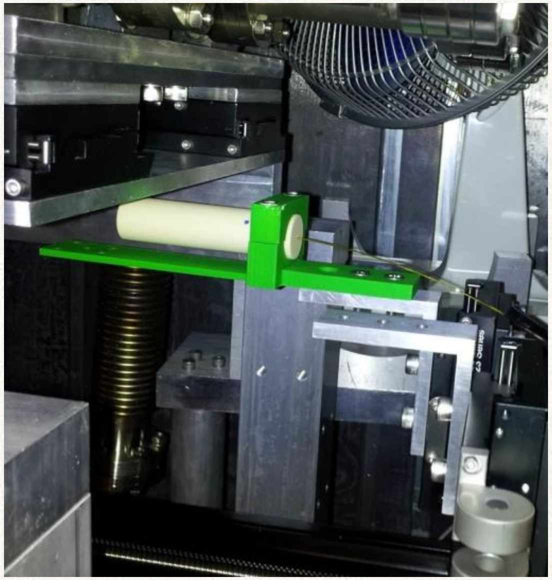


Corroboration with Outside Dosimetry Group

- Our dose rate was measured beneath 3mm of acrylic at 124mm from the source
- Microdosimeter was beneath 10mm of tissue equivalent plastic and 117mm from the source
- Expected (calculated) dose rate was 1.02Gy/min
- This agrees extremely well their measurement of 1.05Gy/min







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