Impact of Half-Value Layer Geometry on TG-61 Output for a Small Animal Irradiator

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Background

- Results from radiation biology experiments are used to design clinical trials
  - Accuracy and reproducibility of results are essential
- Market has shifted from radiation source to orthovoltage irradiators
- Small scale preliminary studies indicate that approximately 65-80% of institutions operating orthovoltage irradiators have large dosimetric inaccuracies (Seed 2015, Pedersen 2016)
  - Average dose differences around 15-20%
  - Dose differences as large as 42%

Need for Dosimetric Standardization

- Large dosimetric inaccuracies may stem from the lack of standardization in small animal research
- No regulations requiring calibration to be performed by physicists
  - often performed by manufacturer
- No widely available service for independent peer review

X-RAD 225Cx

- Common orthovoltage cabinet irradiator
- X-ray production
  - 225 kVp
  - 13 mAs
- Rotational gantry
- Adjustable animal stage
- Image guidance

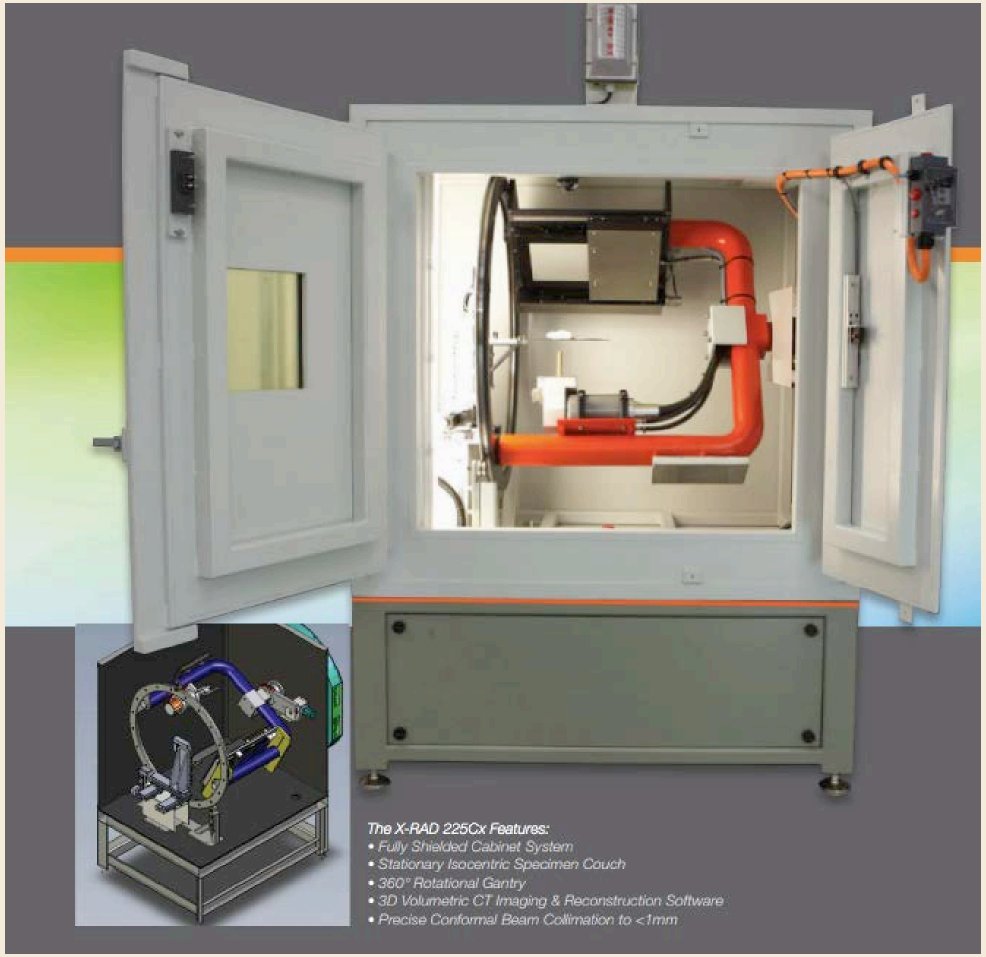


Figure 1. X-RAD 225Cx configuration
Retrieved from: http://pxinc.com/assets/brochure/xrad225cxhr.pdf

TG-61 Calibration

- TG-61: AAPM protocol for 40-300 kV x-ray beam dosimetry in radiotherapy and radiobiology (Ma, 2001)
- Challenges in applying protocol to geometry of small animal irradiators
  - In-Phantom method
  - Air-kerma calibration conditions do not match irradiation conditions
  - HVL under narrow-beam geometry

TG-61 HVL Measurements

- **TG-61 requires accurate measurement of HVL under narrow-beam geometry**

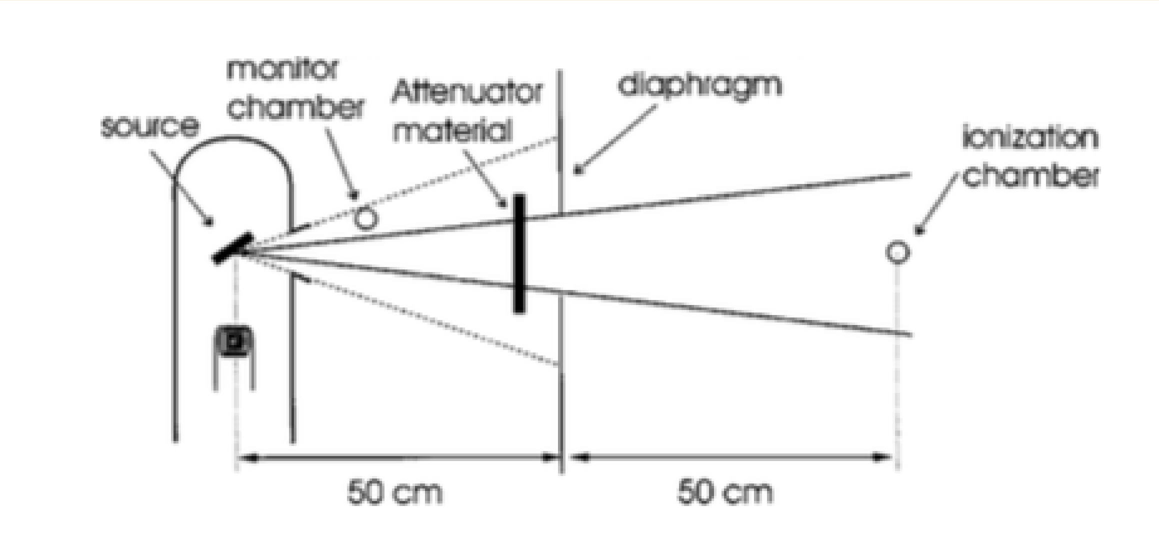
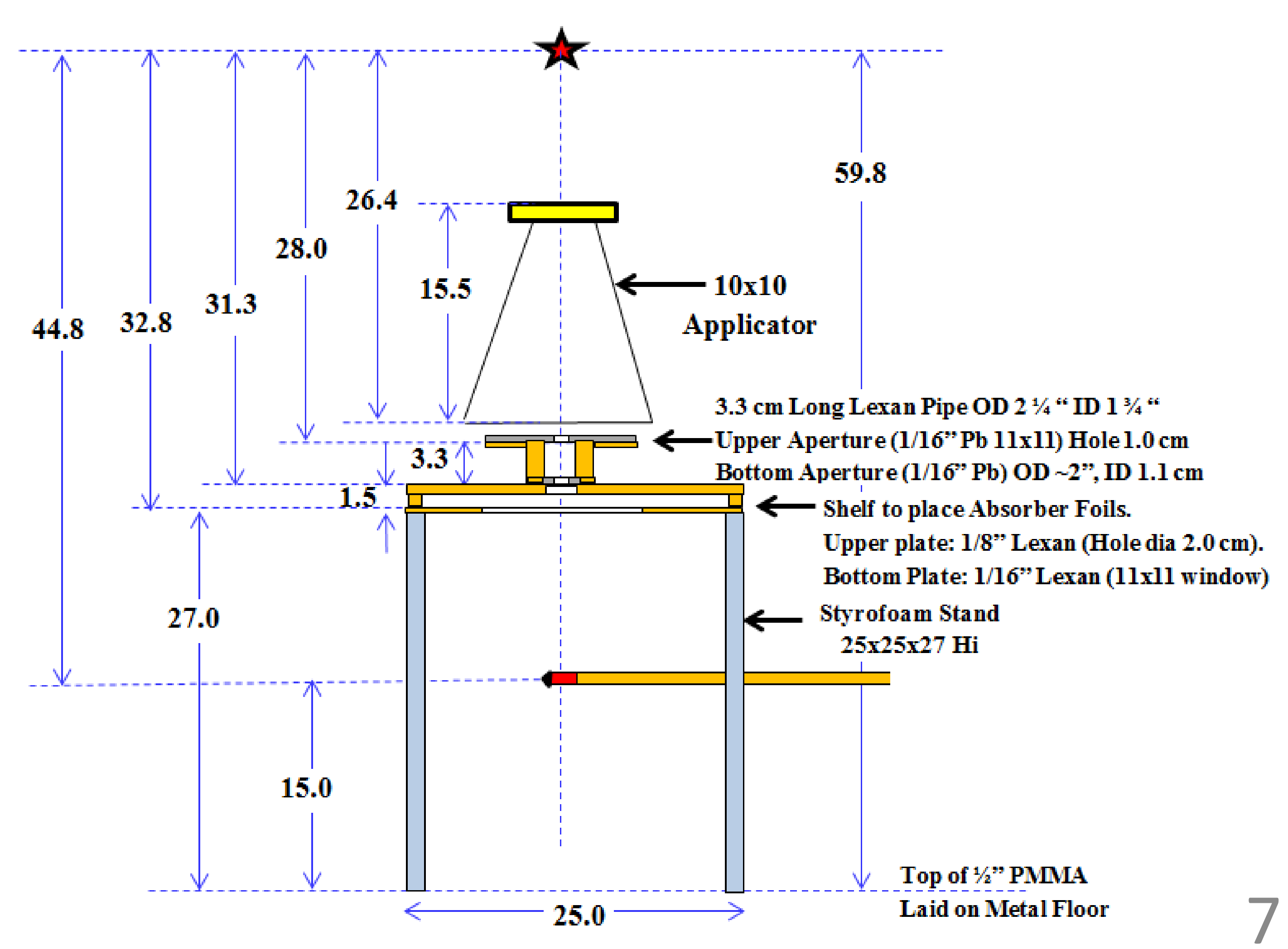


Figure 2. Experimental setup for HVL measurement
Retrieved from: Fig. 1 in TG-61

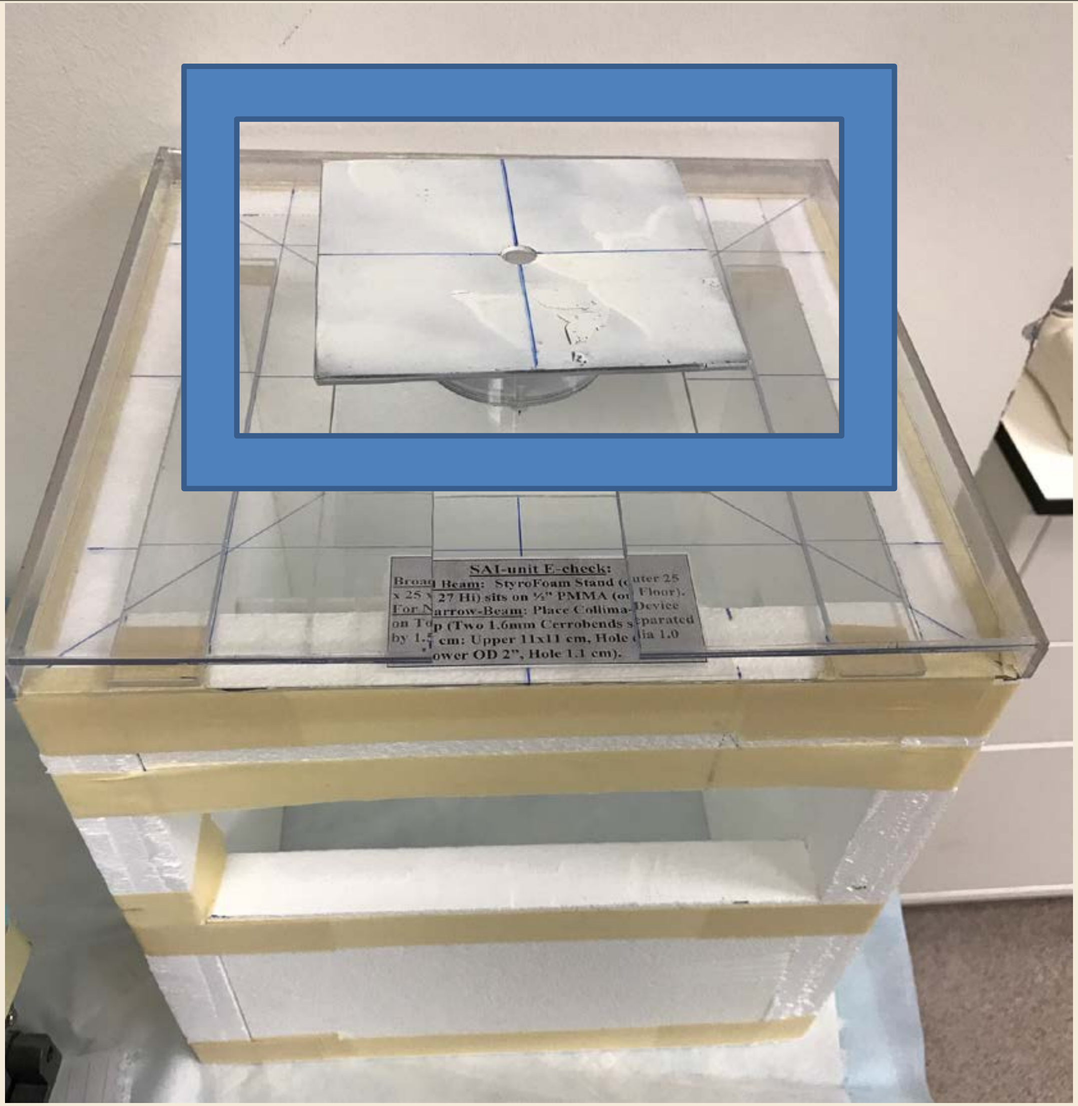
Study Purpose: To determine effect of HVL measurement geometry on TG-61 output in small animal irradiator

Narrow-Beam Collimation Device

- Designed a narrow beam collimation device for HVL measurements
  - Houses attenuating material and ion chamber according to good geometry
  - Removable narrow-beam collimator.



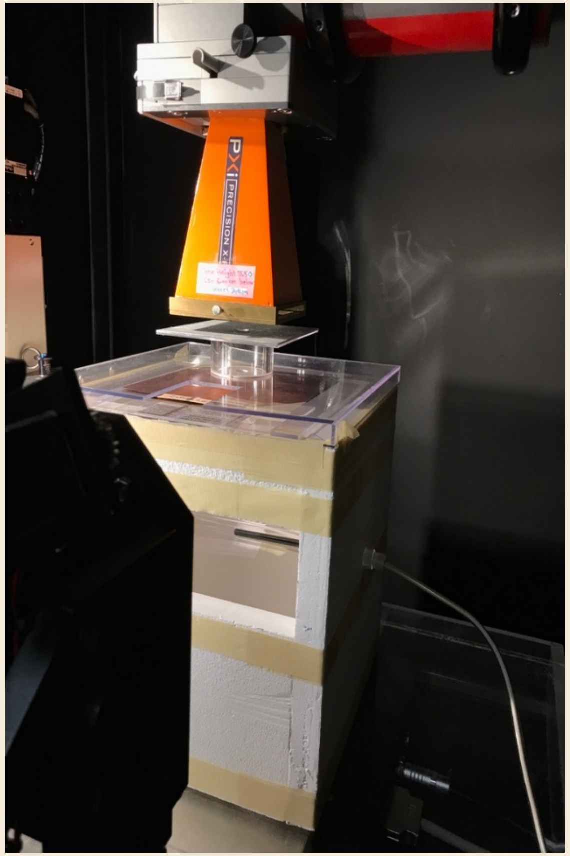
Do you need to go the extra step?



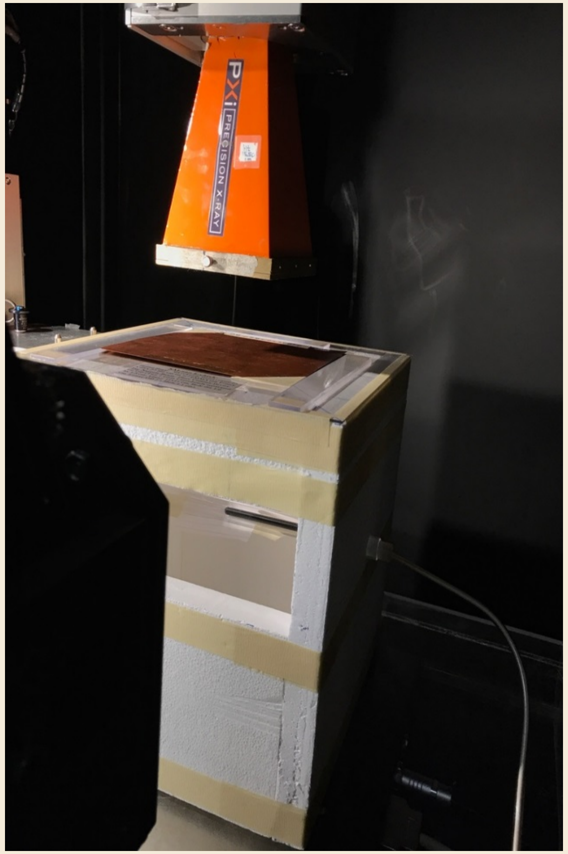
Good vs Narrow-beam Geometry

	Narrow	Good
HVL (mm Cu)	0.86	0.91
TG-61 “in-air” method output (Gy/min)	4.354	4.360

Narrow



Good



Study Conclusions

- Implementing TG-61 in small animal irradiators is not straightforward
- Investigated HVL geometry
  - Measuring HVL with Narrow-Beam Collimator yields the most accurate dose rate
  - However, good geometry without narrow-beam collimation has minimal impact on output
  - Don’t need to go to heroic measures!!
- Additional suggestions for implementing TG-61 are needed

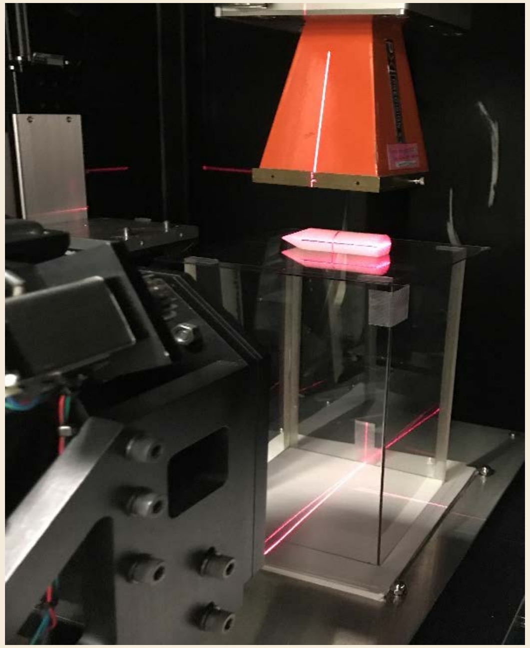
Future Work
Development of Independent Peer Review

1. RDS mails user phantom loaded with TLD and irradiation platform

2. User aligns the phantom with beam isocenter

3. User delivers 3 Gy to the phantom and returns to RDS

4. TLD analyzed using well-established protocol with uncertainty <1.5% (Kirby, 1992)



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Thank you