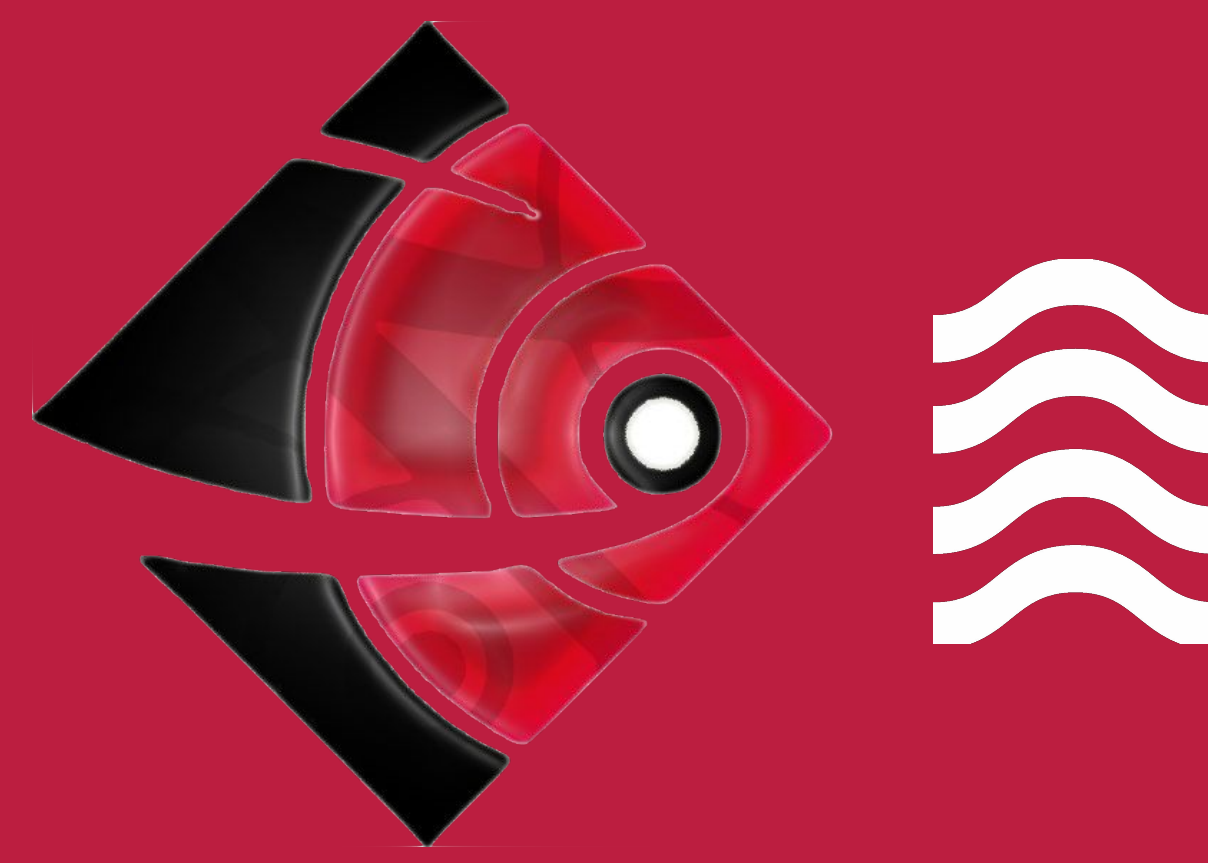




# Comparative Analysis of Beam Qualities: Small Animal Cabinet Irradiators vs. NIST Beams

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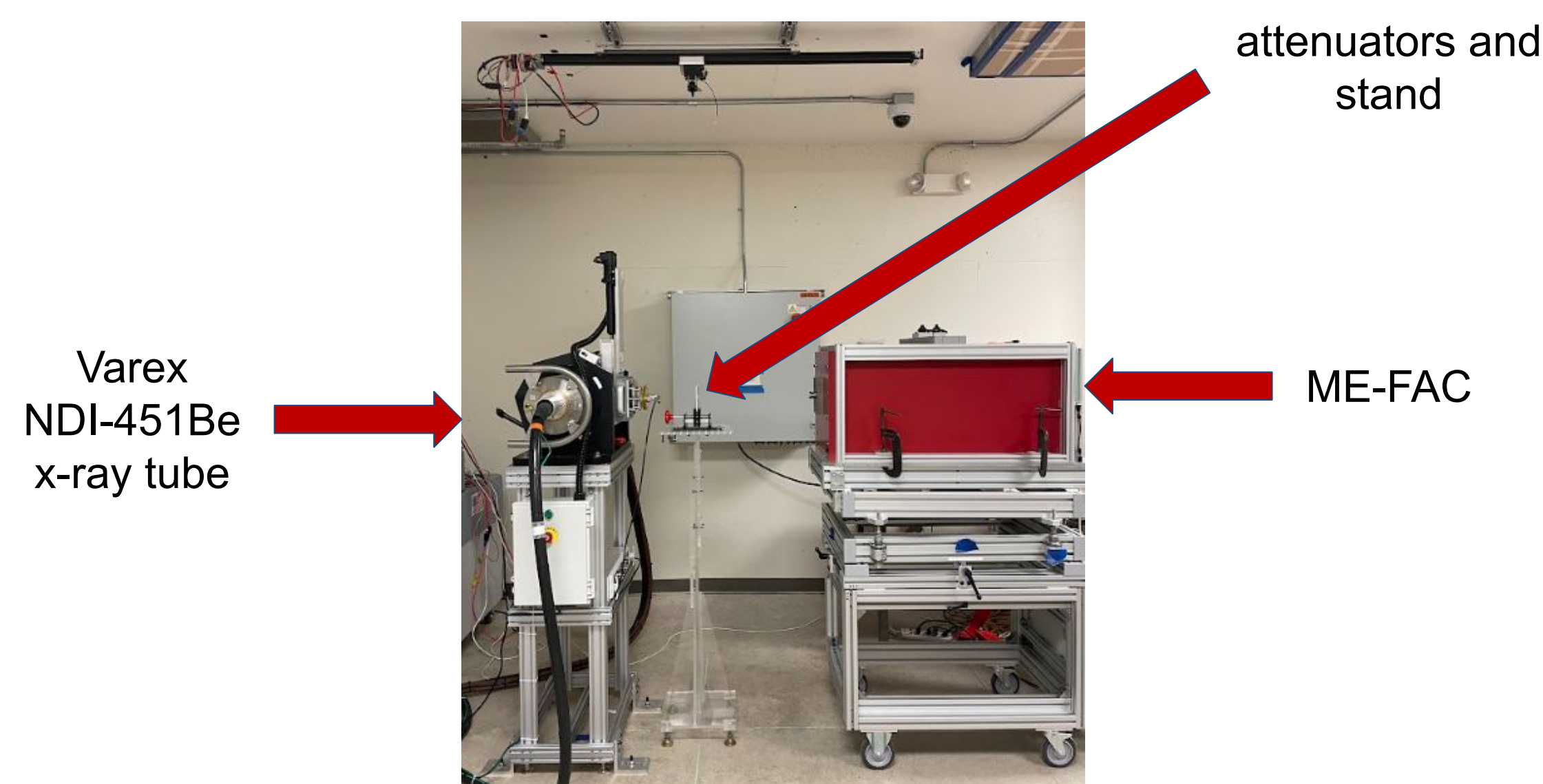


## Introduction

This study presents a comparative analysis of beam qualities between commercial small animal cabinet irradiators and the National Institute of Standards and Technology's (NIST) light (L), moderate (M), and heavy (H) filtered beam series. Small animal cabinet irradiators are equipped with x-ray beams with added filtration that is less attenuating than the NIST M-series beams, but which have recommended operating potentials greater than the NIST L-series beams. Additionally, the functional range of a beam in a small animal cabinet irradiator is typically less than 70 cm which differs from the standard measurement distance of 100 cm at NIST. Because dosimeter response depends on radiation types and energy, it is important for the calibration beam to closely resemble the research beam to reduce uncertainty in the dose determination.

## Methods

- A Varex NDI-451Be x-ray tube with adjustable kV and mA settings (Fig. 1) and custom filters were used to develop eight beams matching those in commercial small animal cabinet irradiators.
- High purity aluminum or copper attenuators were positioned midway between the x-ray tube anode and the aperture of a medium energy free air chamber (ME-FAC) (Fig. 1).
- Measurements were taken to create attenuation curves for determination of half-value layer (HVL) and quarter-value layer (QVL) for each beam.
- HVLs and QVLs were compared to published values for the NIST L, M, and H-series beams.<sup>1</sup>



**Figure 1:** X-ray tube, attenuator stand, and ME-FAC setup for attenuation curve measurements

## Results

### Small Animal Cabinet Irradiator Beam Quality Difference from NIST M-series

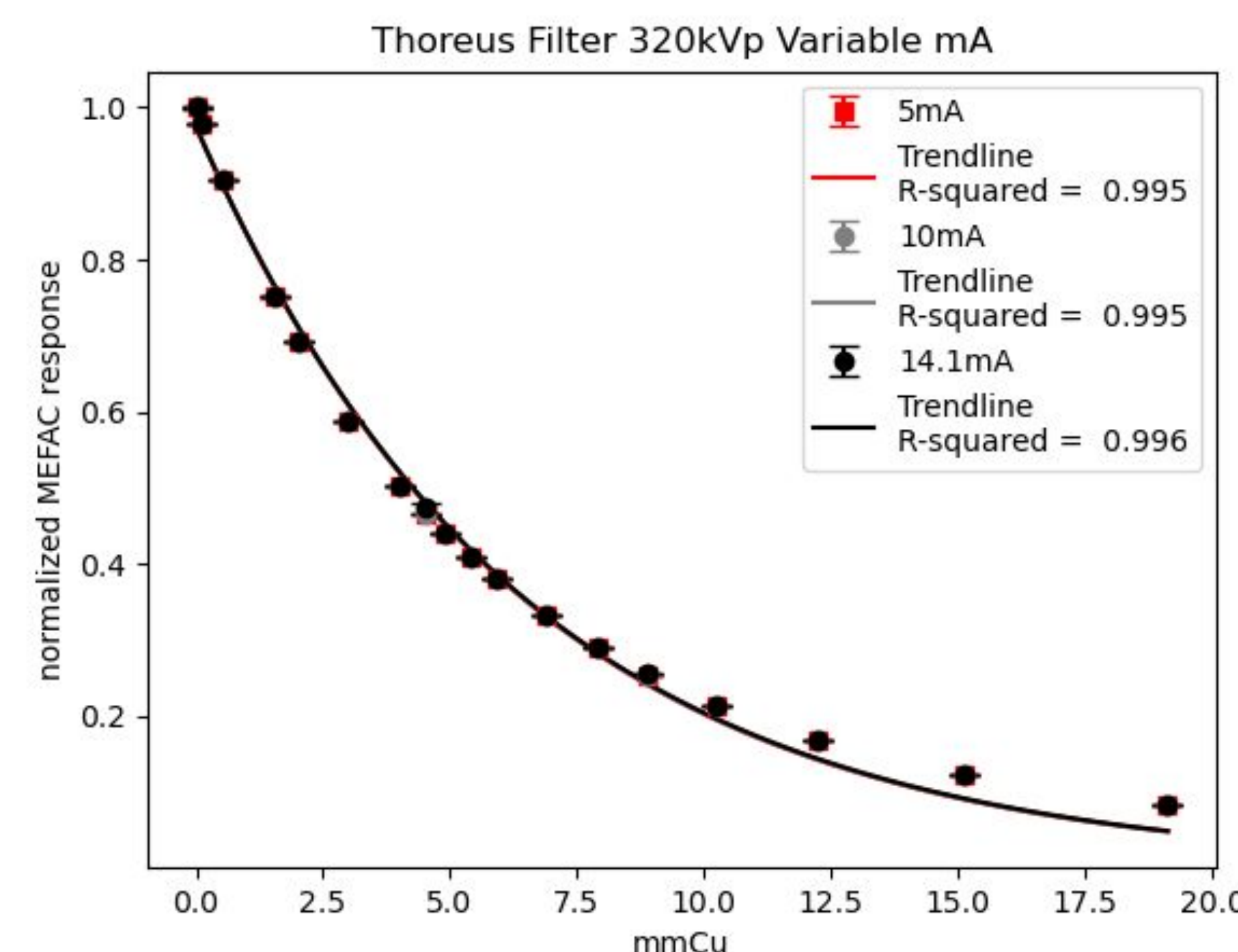
The experimental aluminum and copper HVLs had an average difference of -11% and -51% from the NIST M-series beams, respectively (Table 1 and Fig. 2).

Filter	kVp	Cabinet HVL		% diff NIST M-Series	
		Al	Cu	Al	Cu
1mmCu	300	17.4	2.51	-20%	-53%
Thoreus	225	18.8	2.97	-13%	-23%
Thoreus	320	20.9	4.07	-4%	-23%
0.15mmCu	220	10.7	0.66	-34%	-71%
0.3mmCu	160	10.0	0.64	-10%	-25%
3mmAl	195		0.37		-76%
2mmAl	225		0.35		-85%
Average % difference				-11%	-51%

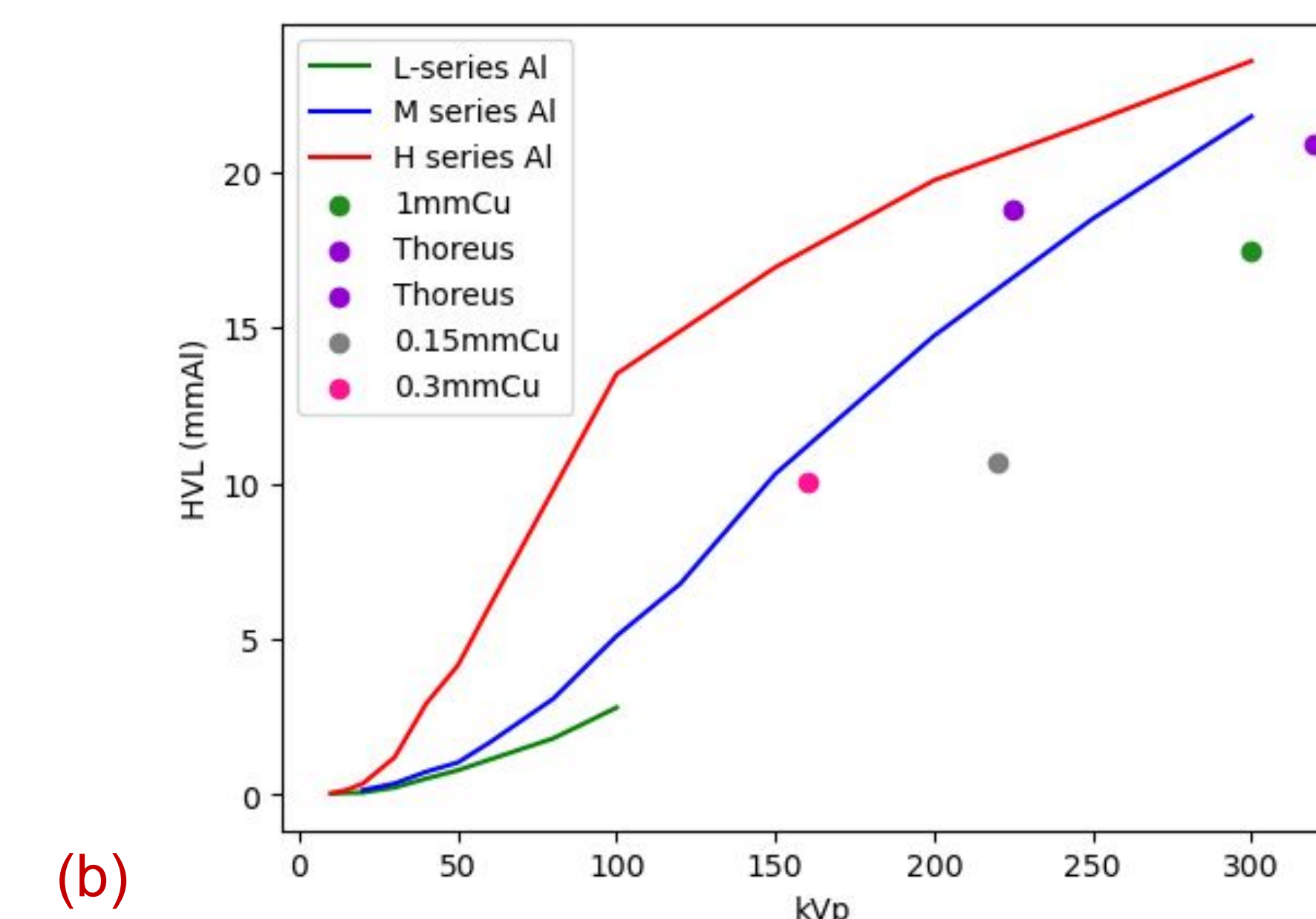
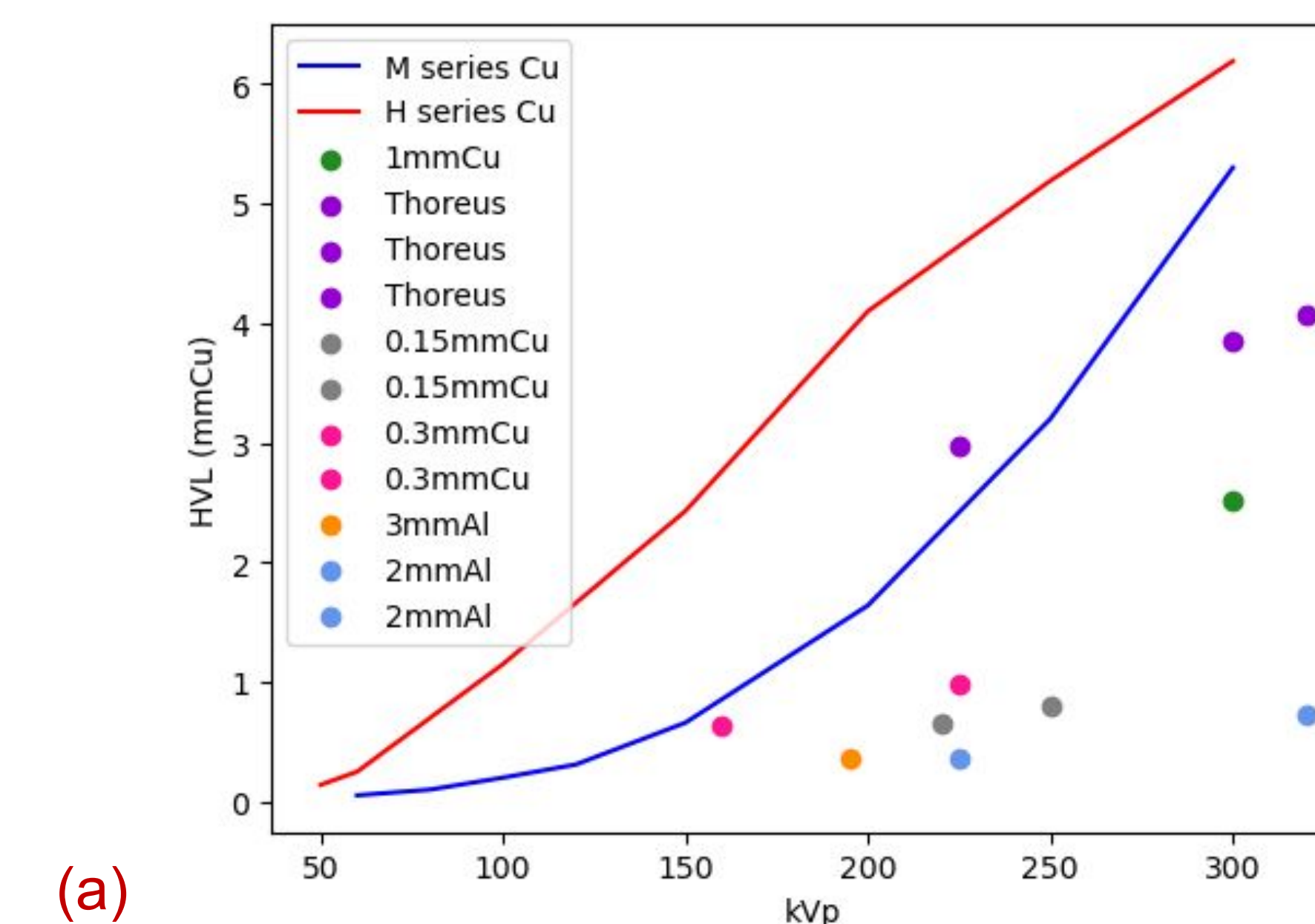
**Table 1:** Aluminum and copper HVL measurement from commercial cabinet conditions compared to NIST M-series respective HVL

### Impact of mA

Adjusting the current setting did not result in significant changes in the determinations of the HVL or QVL (Fig. 3).



**Figure 3:** Variable mA settings using a Thoreus filter at 320 kVp



**Figure 2:** (a) Copper and (b) Aluminum HVLs measured using small animal cabinet irradiator filters compared to NIST beam L-, M-, and H-series

### Impact of Distance

Altering the measurement distance from the anode to the maximum cabinet irradiator distance of 70 cm impacts the HVL by 0.91% and QVL by 1.25% compared to the standard 100 cm distance (Table 2).

Distance (cm)	HVL (mmCu)	QVL (mmCu)	% diff.	
			HVL	QVL
70	4.10	8.97	-0.91%	1.25%
100	4.07	9.08		

**Table 2:** Variable distance conditions using a Thoreus filter at 320 kVp

## Conclusions

- This study reveals the need for an additional NIST traceable beam series that more closely matches small animal cabinet irradiator beams or correction factors to account for the beam differences.
- A correction may need to be developed to account for the differences in distance measurements in calibration compared to the smaller distances used in small animal cabinet irradiators.
- It was confirmed that the mA difference between these commercial irradiators do not affect the beam quality under the same filter and constant potential conditions.
- These findings can aid researchers in refining experimental setups and understanding the need for further calibration protocols in radiobiology experiments using small animal cabinet irradiators.

## References

- <sup>1</sup>CMO. (2022). CALIBRATION OF X-RAY RADIATION DETECTORS. <https://www.nist.gov/system/files/documents/2022/06/21/procedure03v461.pdf>

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