Fused Filament Fabrication using Tungsten-filled Polyethylene Terephthalate Glycol for Radiation Applications

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Introduction and Motivation

- Machining Pb and W is difficult and expensive, with complex geometries being even more challenging.
- Additive manufacturing excels with complex geometry and minimizes material waste.
- Fused Filament Fabrication (FFF) is an affordable, accessible approach to simplifying the design-build-test cycle.
- A wide range of thermoplastics are available for FFF, including those 'filled' with other materials.
- Tungsten-filled polyethylene terephthalate glycol (PETG-W) holds promise for radiation applications.

Technical Approach

- Prusament PETG-W filament
- Bambu Labs X1 Carbon 3D printer
- Computer-aided designing (CAD) with Fusion 360
- Standard test prints to determine tolerances and optimize printing parameters
- Absorber sheets for attenuation experiments
- Modular collimator designs

MTV Impact

- Presentation experience
- Undergraduate research and support
- Internships and job opportunities
- Potential publications and exposure to academia

Mission Relevance

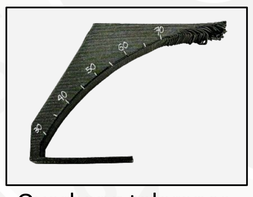
- Prototyping and manufacturing of radiation shielding, collimation, and test objects
- Broad applicability to radiation measurements

Results

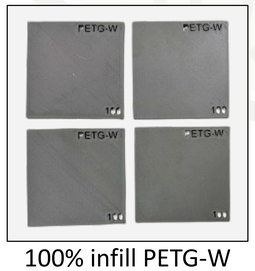
- Consistent printing parameters determined for the Bambu with the PETG-W
- Testing attenuation of PETG and PETG-W on rig using 3D printed sheets.
- Prototypes of collimators were printed on the Bambu
- Calculated half-value layer (HVL) of 1.3±0.4 mm

Bambu Labs X1 Carbon 3D printer

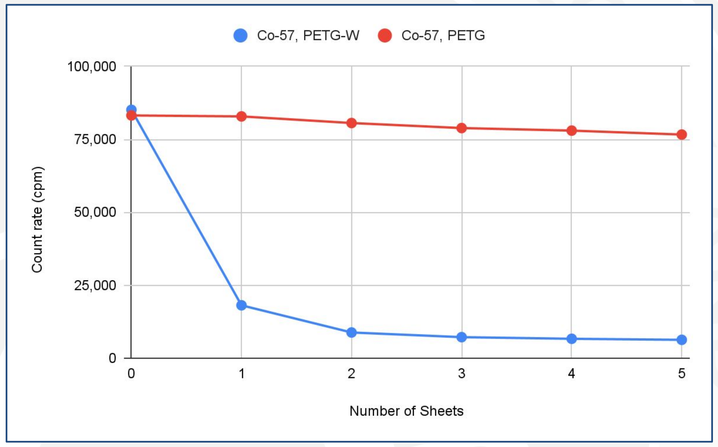
Benchy the Boat tolerance test print



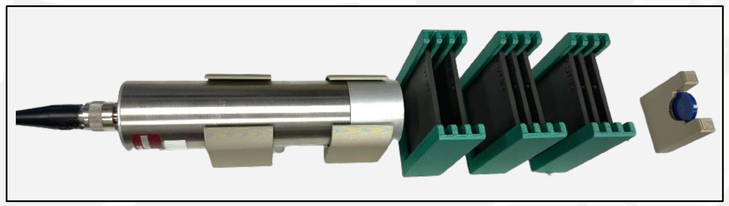
Overhang tolerance test print



100% infill PETG-W absorber sheets



Measured count rates shown as a function of number of 3.2 mm thick sheets of 100% infill PETG and PETG-W



Radiation attenuation experimental rig (created with FFF) with a detector, PETG-W sheets, and a Co-57 source.

Expected Impact

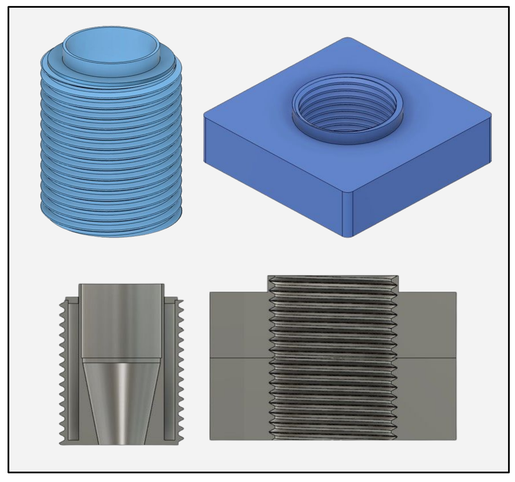
- Using 3D printing to manufacture custom radiation shielding and experiments
- Utilizing PETG-W for radiation shielding
- Novel, adjustable minification and magnification collimators
- Printing of complex coded apertures

Conclusion

- Measured PETG-W HVL agree with manufacturer's specifications.
- 3D printing with PETG-W relatively easy.
- Few print failures with PETG-W if equipment properly maintained.
- PETG-W holds promise as quick way of producing radiation shields and collimators with complex geometries.

Next Steps

- Measure HVL with Cs-137 and Co-60
- Manufacture additional absorbers for outreach and other experiments (different fills, thicknesses)
- Test and compare collimator designs
- Characterize spatial resolution limits of printing with PETG-W
- Create radiography test object



Isometric and sliced view of modular magnification collimator design

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