Lunar Habitat Frame and Radiation Shielding Quantification, Mitigation, and Simulation

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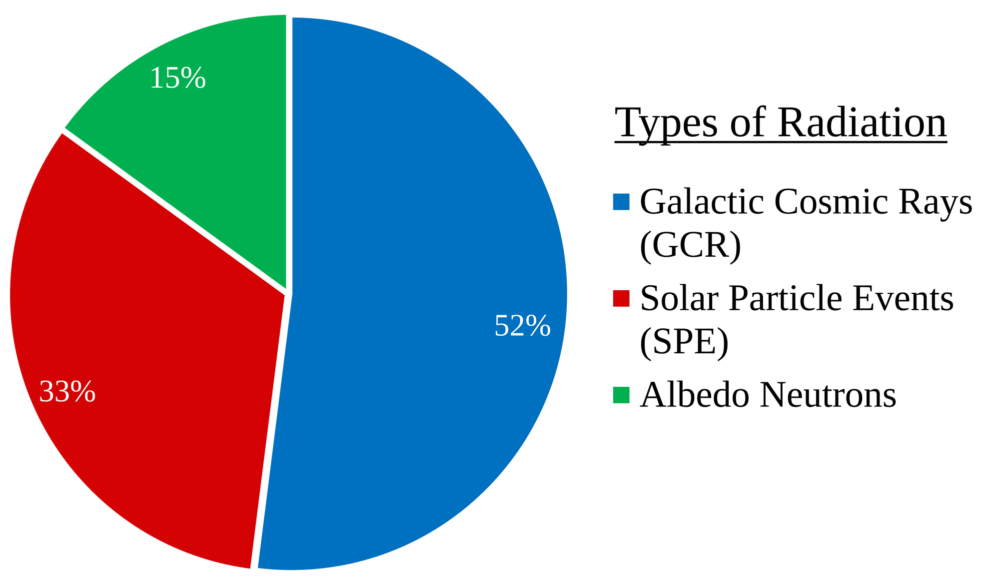
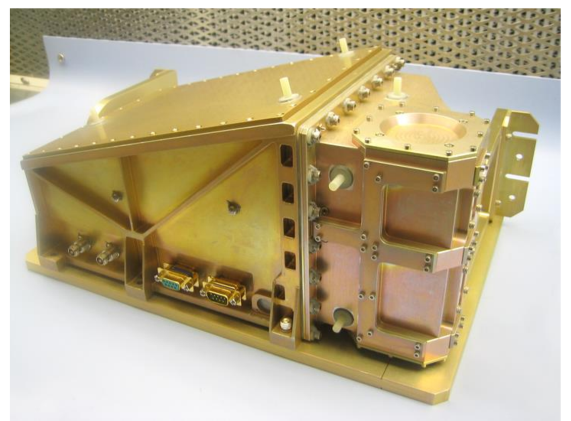
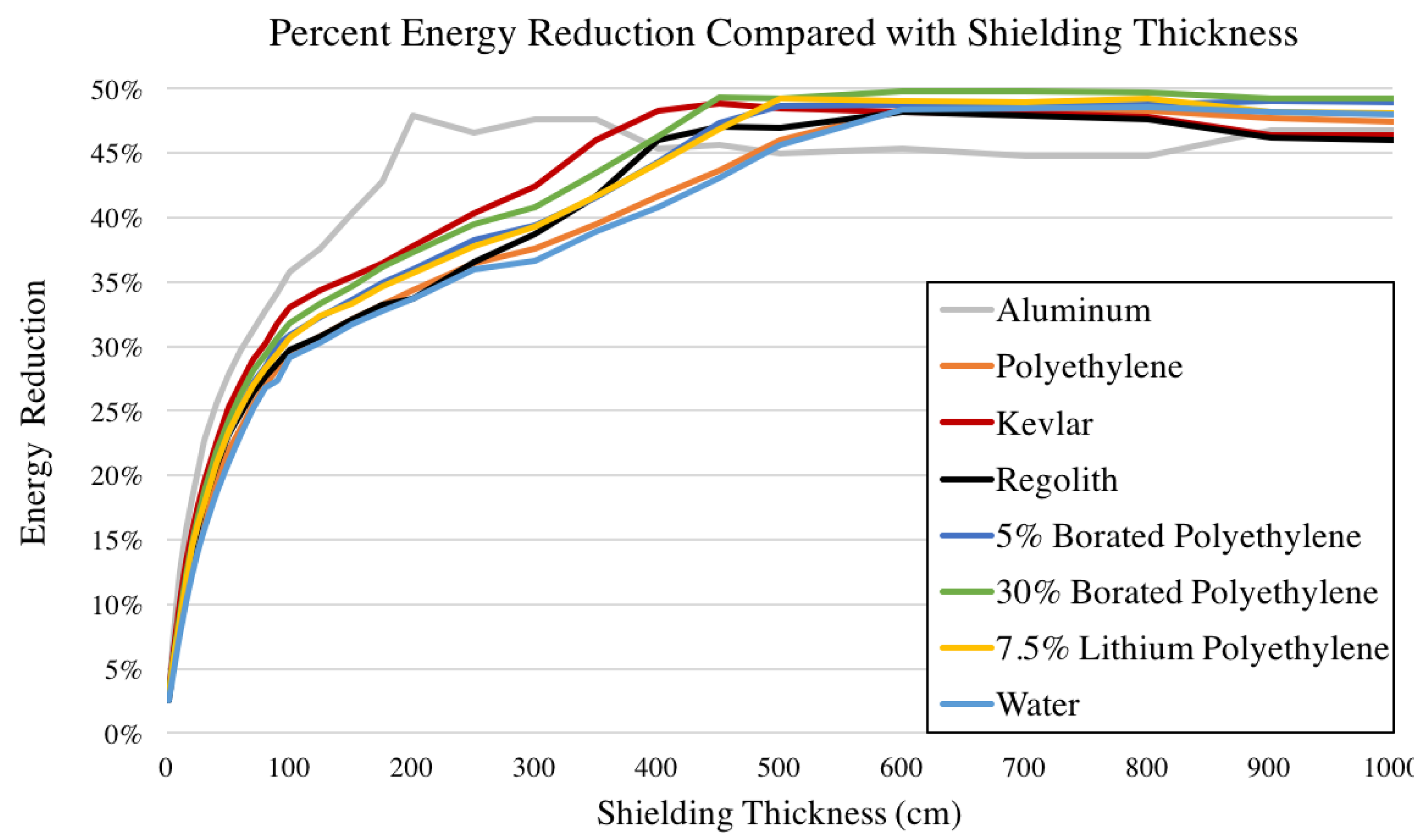
Quantification

Understanding the radiation environment on the lunar surface is vital to lunar habitation. At least three types of ionizing radiation bombard the Moon and provide a significant threat to astronauts. The Cosmic Ray Telescope for the Effects of Radiation (CRaTER)[1] has gathered radiation data since 2009.





Cosmic Ray Telescope for the Effects of Radiation (CRaTER). Currently part of the Lunar Reconnaissance Orbiter.

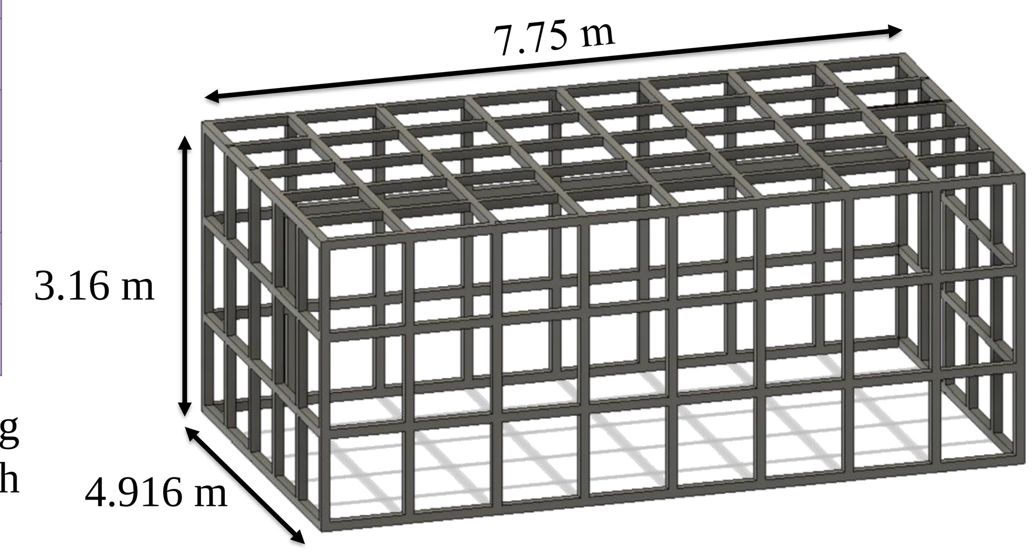


A comparison of initial materials showed that each reached a peak effectiveness at 50% reduction. As such, more simulations were needed to find effective material combinations.

Component	Thickness
Regolith	2.5
Aluminum	0.01
30% BPE	0.5
Kevlar	0.15
30% BPE	0.5
Kevlar	0.15
30% BPE	0.5
Glass	0.01
Water	0.25
Glass	0.01

Components used as shielding materials in simulations with their thicknesses in meters.

The figure below is a 3D model of the habitat frame put inside the larger shielding structure. It will provide support for the shielding material as well as an anchor for an interior inflatable habitat or some such structure. This model is modified from Brown's thesis[5].

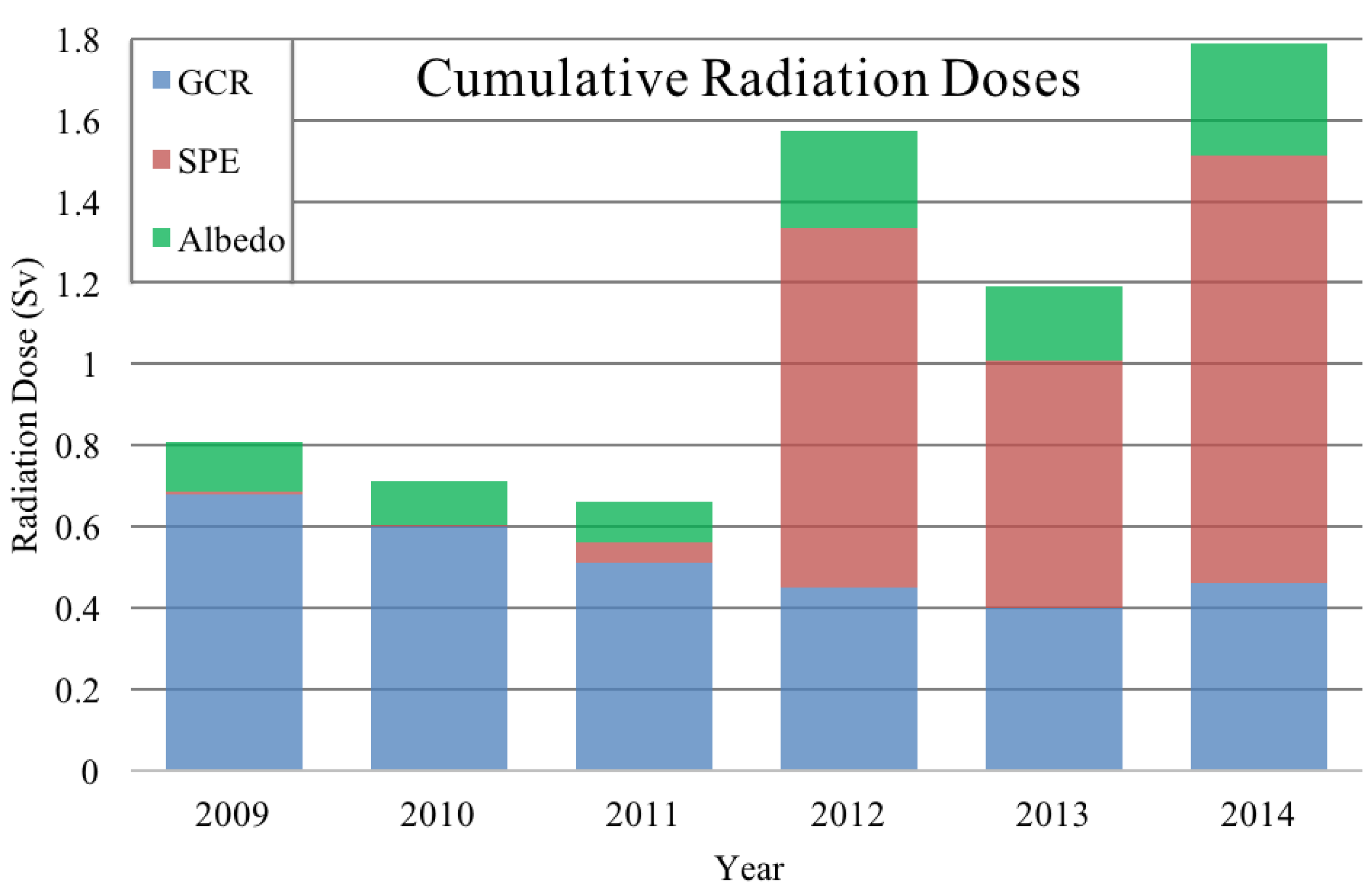


Mitigation

In order to mitigate the hazard, a shielding material must be selected. Using Geant4 Beamline, simulations have shown that certain materials and combinations of materials are effective at reducing the absorbed radiation. SPE are highly variable in their intensity and frequency[2], and shielding may not be an effective strategy. The energy and flux of protons in GCR is well understood[2] and considered in this project. Dose limits[3] are shown below for reference with cumulative doses.

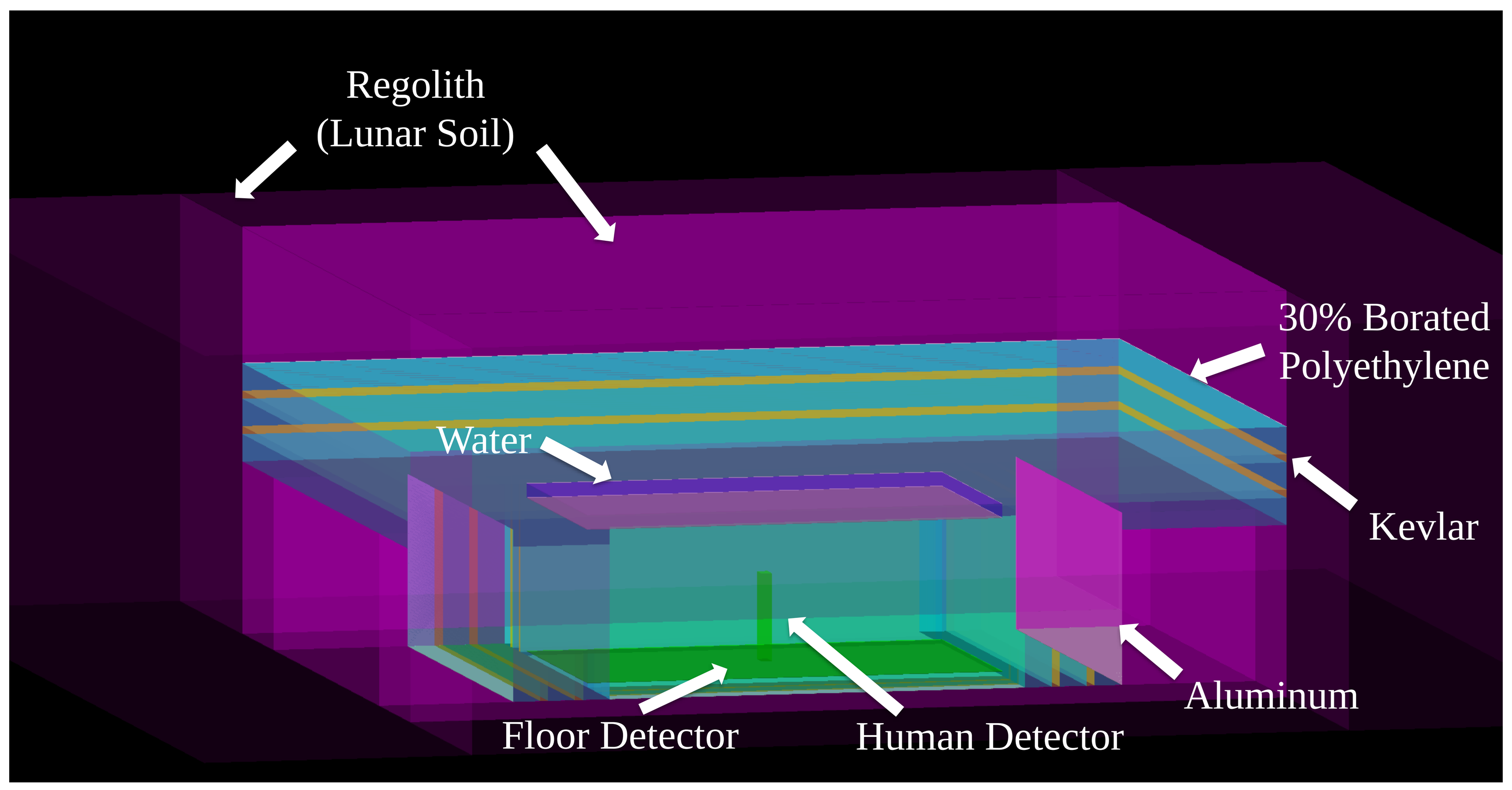
Age	Male (Sv)	Female (Sv)
25	0.7	0.4
35	1.0	0.6
45	1.5	0.9
55	3.0	1.7

Career Dose Limits (in Sieverts) Corresponding to a 3% Excess Cancer Mortality for 10-year Careers as a Function of Age and Sex, as Recommended by the NCRP (NCRP, 1989; 2000)

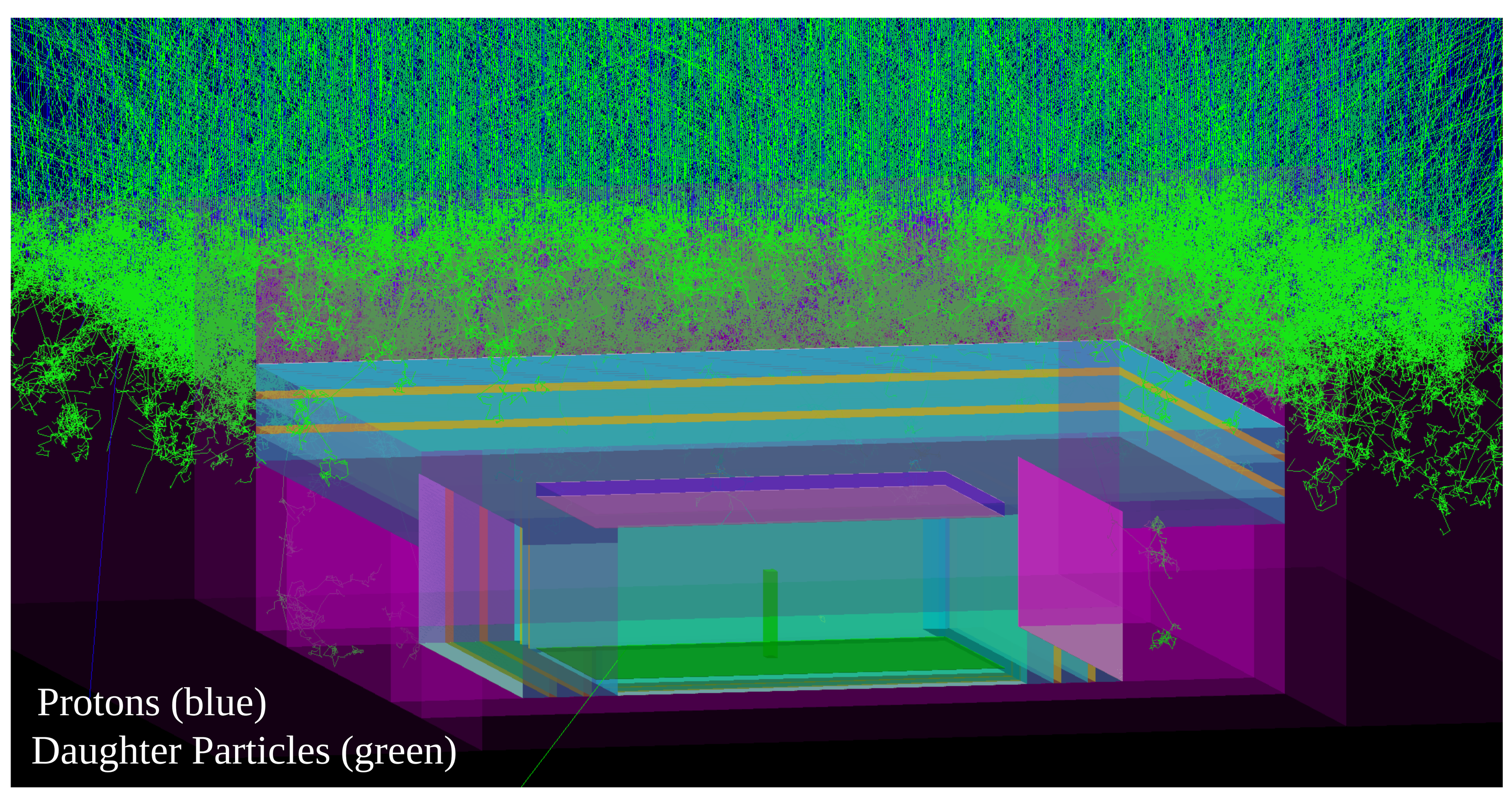


CRaTER data for GCR and SPE with estimated albedo neutron contribution[4].
A typical terrestrial dose is 0.05 Sv every three years!

Simulations



Simulated habitat consisting of various materials and a human detector.

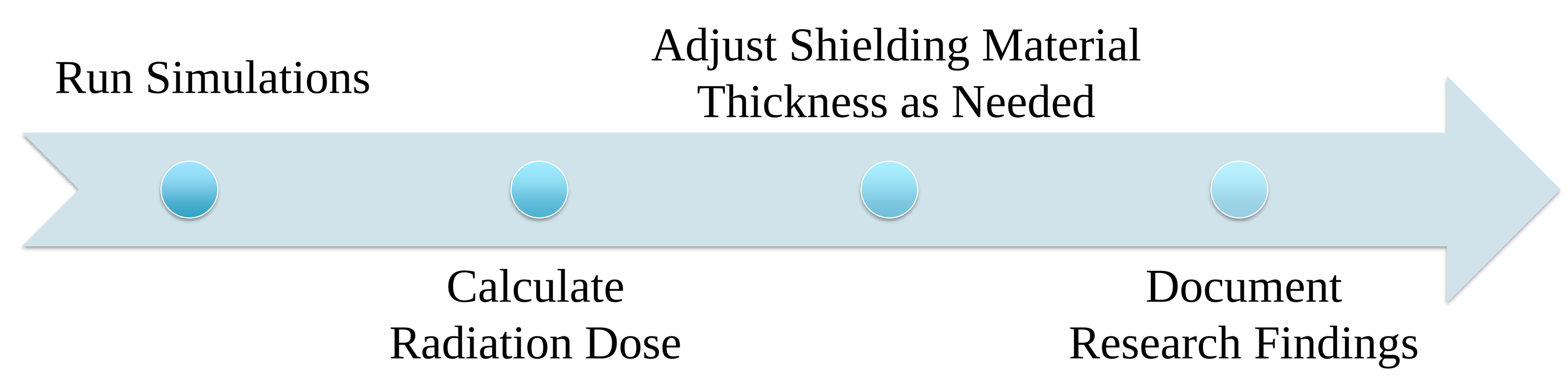


Visual representation of particle interaction with habitat, reduced by a factor of 50.

Results

The simulations have been constructed, but take a significant amount of power to run. As such, the simulations with the human detector and the floor will be run over the next several weeks. Once the simulations have been run, it will be evident how many particles will traverse the human body per second compared with how many particles hit the floor, and a conversion factor will be used to determine how long a human being can survive within the structure before reaching the radiation limits given by the NCRP[3].

Future Work



Citations

[1]Schwadron, N. A. (2015) University of New Hampshire. CRaTER Cosmic Ray Telescope. Retrieved from http://crater.unh.edu/.

[2]Heiken, G., Vaniman, D., and French, B. (1991). Lunar Sourcebook: A User's Guide to the Moon. Cambridge University Press, Houston, TX.

[3]NASA (2009). Human health and performance risks of space exploration missions. Houston.

[4]Adams, J., Bhattacharya, M., Pendleton, G., and Lin, Z. (2007). "The ionizing radiation environment on the moon." 40.

[5]Brown, K. M. (2015). "Analysis and Design of a Frame-Membrane Habitat Subjected to Extreme Temperatures on the Lunar Surface Extreme Temperatures on the Lunar Surface.

Acknowledgments

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