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Title: Modeling Gamma-ray and Neutron Spectroscopic Signatures in the Martian Subsurface

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Modeling Gamma-ray and Neutron Spectroscopic Signatures in the Martian Subsurface

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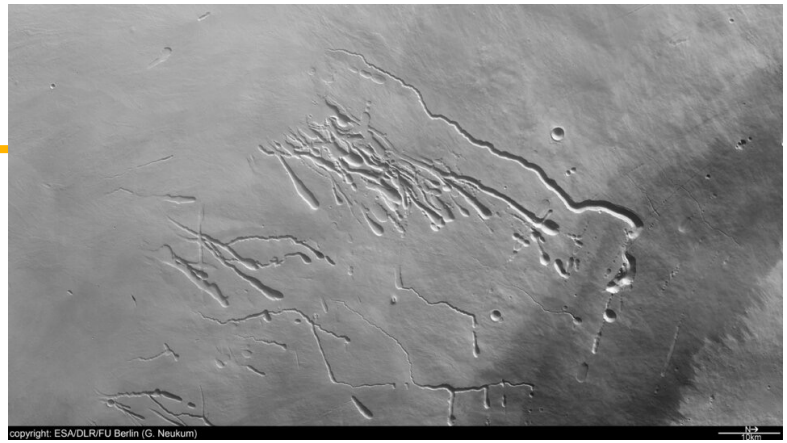
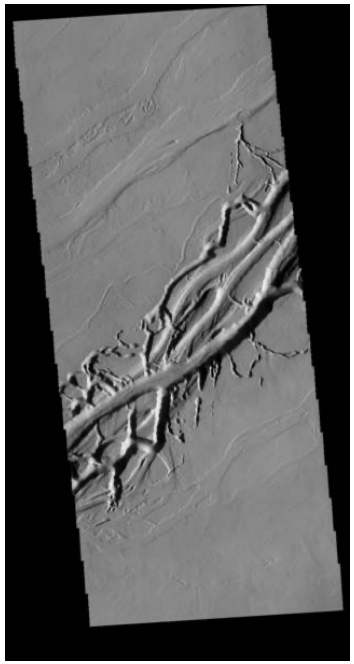
Background

- Gamma-ray and neutron spectroscopy (GRNS) is used for geochemical remote sensing of planetary surfaces
- Gamma rays and neutrons are produced as secondary particles through the interaction of galactic cosmic radiation (GCR) and high energy solar particles with planetary surfaces
- Can be directly measured to help determine elemental composition, abundance, and hydration of surface materials

Background



- Martian caves / subsurface environments such as lava tubes have been identified from orbit
- Potential for astrobiological discovery because of their shielding effect from the harsh radiation on the surface and likely presence of elements necessary for life



Top image: lava tubes at Pavonis Mons from ESA's Mars Express Spacecraft (esa.int);

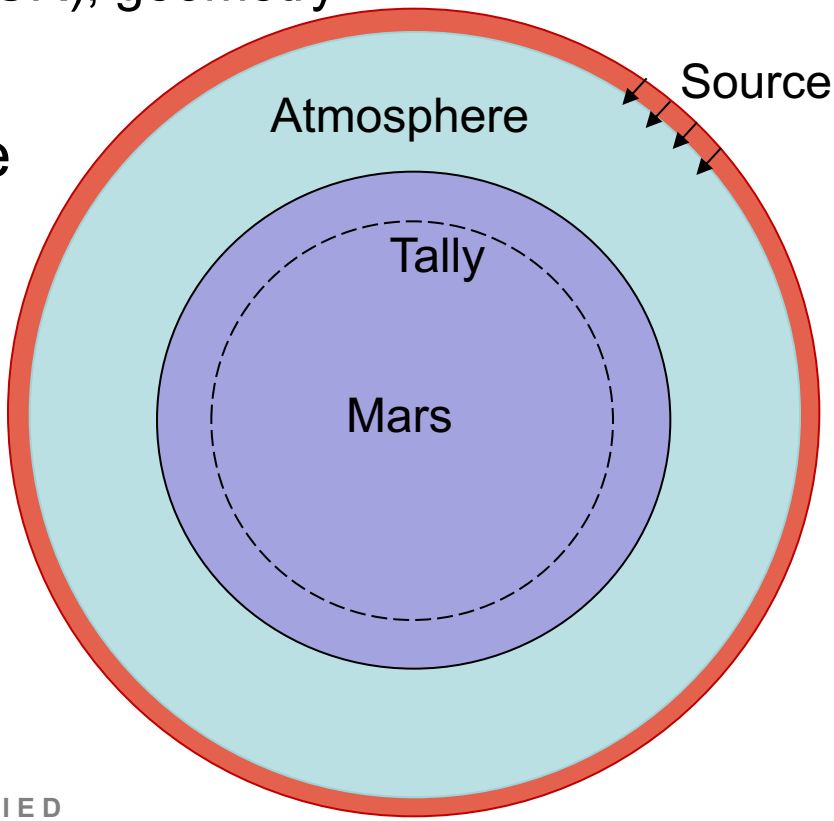
Bottom image: lava tubes between Olympus Mons and Alba Mons from NASA's Mars Odyssey Spacecraft (nasa.gov)

Objective

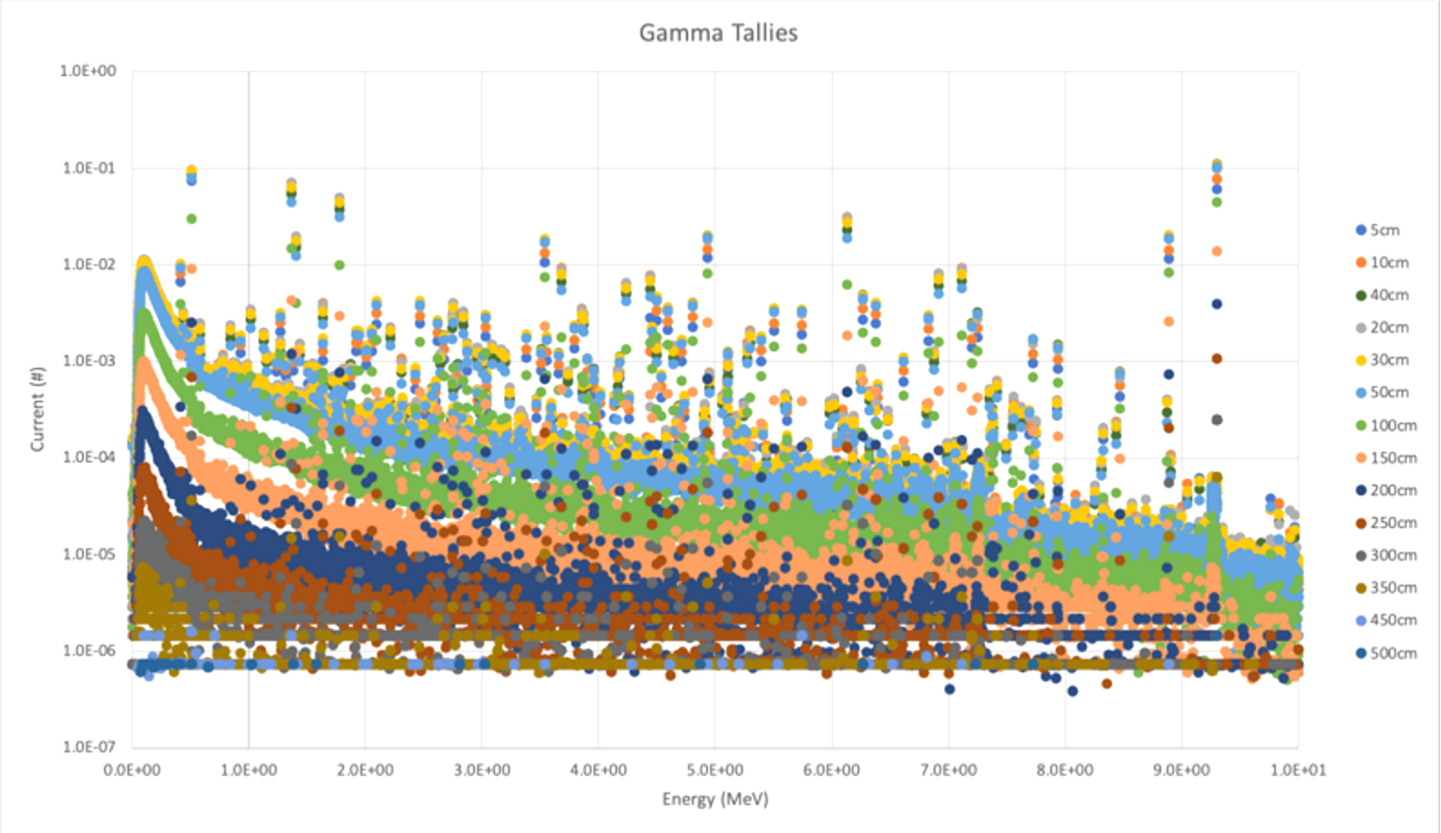
- Big picture: to determine the GRNS signatures in cave environments for future mission planning and instrument development
- This project seeks to develop Monte Carlo N-Particle (MCNP) models to constrain the GRNS at depths up to 5 meters and in cave interiors

Approach

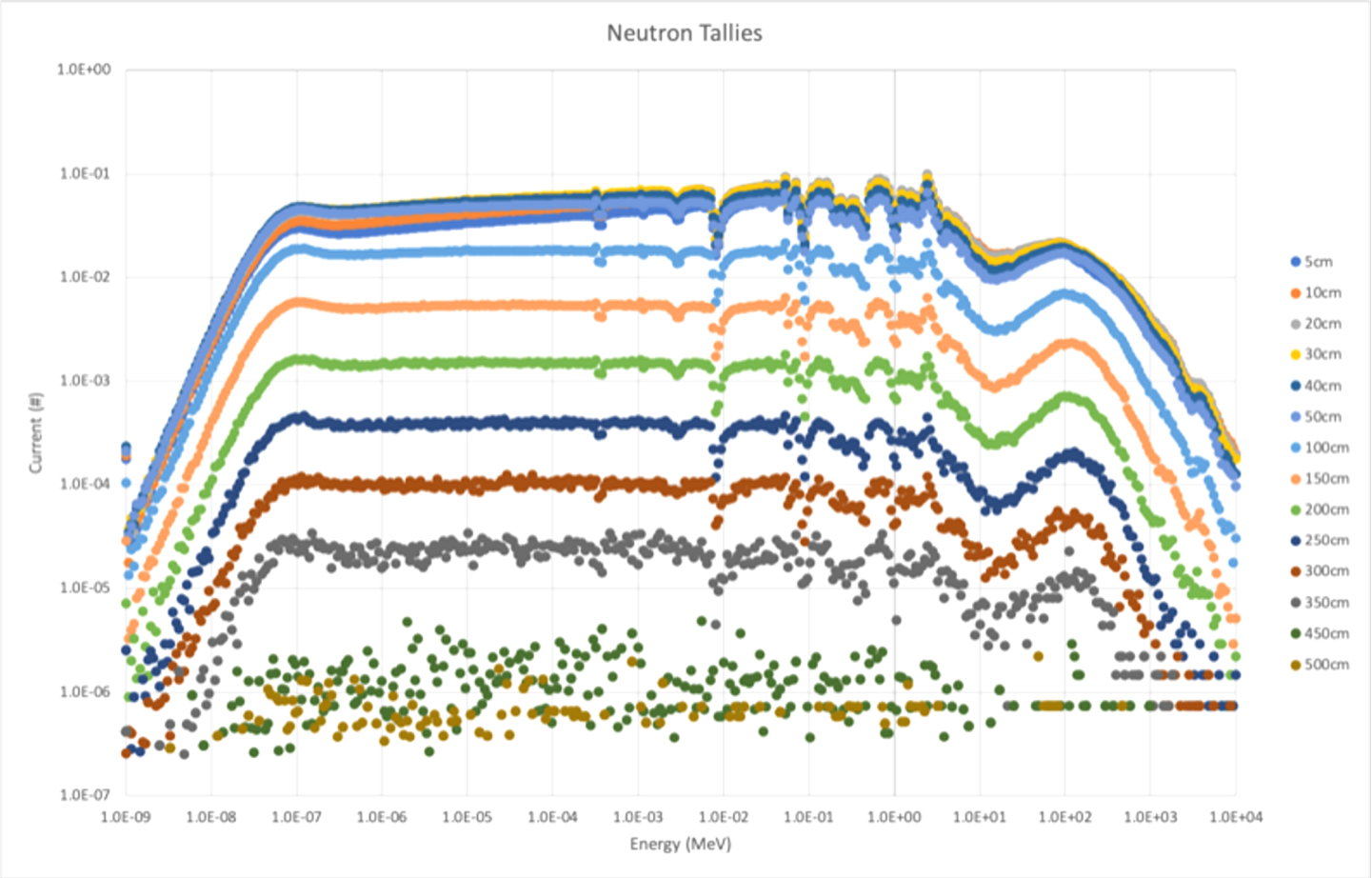
- Adapting physical parameters of system into MCNP
  - Atmospheric composition and bulk chemical composition of planet, radiation particle source (GCR), geometry
- Running simulations to generate the particle spectra of interest
  - Protons, neutrons, gammas
  - F1 tally: current over surface
  - Vary by changes in depth



Results


Gamma Tallies
Current (#)
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
0.0E+00
1.0E+00
2.0E+00
3.0E+00
4.0E+00
5.0E+00
6.0E+00
7.0E+00
8.0E+00
9.0E+00
1.0E+01
Energy (MeV)
5cm
10cm
40cm
20cm
30cm
50cm
100cm
150cm
200cm
250cm
300cm
350cm
450cm
500cm

Results


Neutron Tallies
Current (#)
1.0E+00
1.0E-01
1.0E-02
1.0E-03
1.0E-04
1.0E-05
1.0E-06
1.0E-07
1.0E-09
1.0E-08
1.0E-07
1.0E-06
1.0E-05
1.0E-04
1.0E-03
1.0E-02
1.0E-01
1.0E+00
1.0E+01
1.0E+02
1.0E+03
1.0E+04
Energy (MeV)
5cm
10cm
20cm
30cm
40cm
50cm
100cm
150cm
200cm
250cm
300cm
350cm
450cm
500cm

Analysis / Summary

- Gamma spectrum requires further analysis to obtain characteristic gamma-ray lines
- Separate and analyze neutrons in epithermal, thermal, and fast ranges
- Drop off in particle production by 2-3m depth
  - Vary composition and hydration
  - Add variance reduction to deeper layers to increase particle production

Next Steps / Future Work

- Continue refining models:
  - Adjust particle source (GCR) to account for solar modulation
  - Develop geometry of cave / lava tube interiors
- Simulate active detection methods to compare with measurements captured via the pulsing neutron generator on MSL's Dynamic Albedo of Neutrons (DAN) instrument

Acknowledgments

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Questions?

- Thank you!