Probing Planetary Bodies for the Structure of Subsurface Volatiles: Geant4 Models of Fast, Epithermal, and Thermal Neutron Emission of Varying Stratigraphy of Water Bearing Regoliths.

Gordon Chin (NASA Goddard Space Flight Center, Code 693 gordon.chin@nasa.gov), Roald Sagdeev (University of Maryland), Jao Jang Su (University of Maryland, Joseph Murray (University of Maryland).

Introduction: A common theme driving Solar System exploration is to "Follow the Water." Passive and active neutron methods can detect near-surface (< 2m depth) water or hydrogen-bearing species on planetary bodies. Passive neutron sensing measures the flux of neutrons generated by Galactic Cosmic Rays (GCR) within the surface of asteroids, the Moon, and on Mars to infer the abundance of subsurface hydrogen or hydrogen-bearing compounds. The neutron flux can be detected remotely by orbiting instruments and the H/H_2O abundance can be derived (Fig. 1).

has signatures in the neutron energy spectrum that are diagnostic of layering structure (Fig. 2), whether it is near the surface, buried beneath a dry layer, etc.

These types of calculations are vital in understanding the vertical stratigraphy of water as revealed by the remote sensing LEND on LRO as compared to in situ sampling by the LCROSS impact in the permanently shadowed lunar region region of Cabeus.

Geant4 is a set of particle physics transport simulation codes that exploits object-oriented software methods to

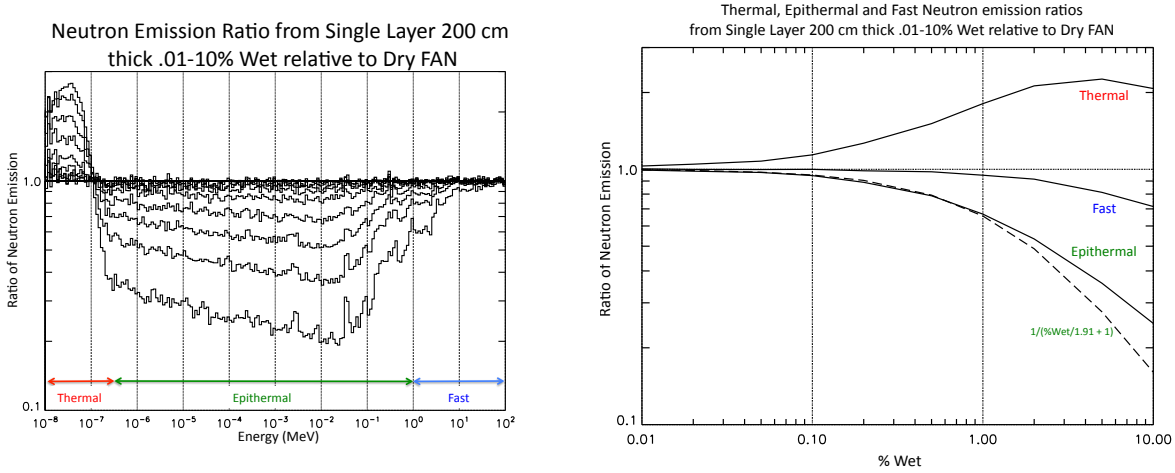

Fig. 1: Water in soil modifies **the emergent neutron spectrum generated by GCR** (*left*). Neutron energy can be binned into Thermal, Epithermal and Fast neutron ranges. Abundance of water can be inferred most sensitively by the suppression of Epithermal neutrons (*right*). Thermal neutron emission is enhanced by the presence of water, but for abundances >2% the curve flattens out. From preliminary GEANT4 calculations.

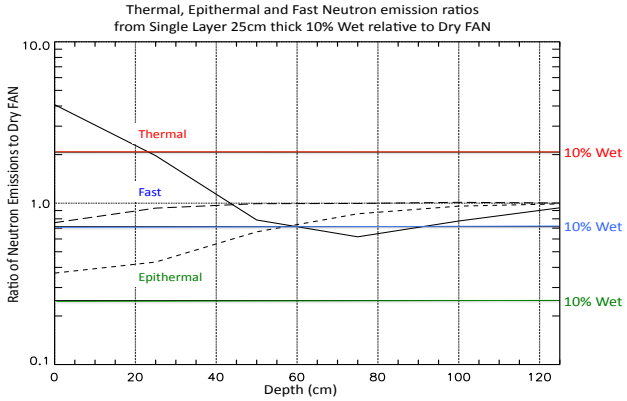

Fig. 2: Burial depth of wet soil layer modifies the emergent neutron spectrum. Emergent flux compared to flux from dry soil in Thermal, Epithermal, and Fast energy bins show different behavior as a function of depth of a single layer of 10% water fraction, 25 cm thick. Thermal neutron flux decreases monotonically with burial depth to about 60 cm, whereas epithermal neutron flux increases monotonically as burial depth increases. Solid lines show the ratio of Thermal, Epithermal, and Fast neutron to dry soil flux, for a uniform distribution of 10% water weight.

We have performed preliminary Geant4 calculations that show emplacement depth of water on the Moon

deliver a comprehensive and flexible toolkit based on a free open-source development model.