A SERENDIPITOUS NEW VIEW OF THE MOON.

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Introduction: We have discovered a new lunar radiation mapping method using data from the Cosmic Ray Telescope for the Effects of Radiation [1] (CRaTER) on the Lunar Reconnaissance Orbiter (LRO) that is simpler to implement while generating a much cleaner signal than previous methods. The new map is an extension of a formula that automatically and precisely identifies solar energetic particle (SEP) events in CRaTER data; we refer to the method hereafter as the SEP Index. We find that SEP events cover ~20% of the LRO mission timeline from launch through the end of 2017, and we use the remaining ~80% of the data (solar quiet periods) to map the Moon.

Solar Energetic Particle (SEP) Index: Unlike Wilson et al. [2,3] and Schwadron et al. [4,5], who made use of the energy deposited by each particle that registered in two or more detectors, the SEP Index uses only the total particle counting rates from four detectors and ignores (for now) any energy spectral information. The SEP Index takes advantage of unequal shielding within the CRaTER instrument, using the least-shielded detectors (D1 and D6) as proxies for the SEP flux, and the most-shielded detectors (D3 and D4) as proxies for the highly-penetrating background galactic cosmic ray flux. We derived the formula for the SEP Index empirically by minimizing the variations in the index during solar quiet periods and were surprised to find a form that varies by only ~1% during quiet periods over a span of more than 8 years.

New Lunar Map: When we sort quiet-time SEP Index values by location over the Moon instead of by mission time, we generate a type of radiation map of the Moon. The new map has a vastly improved signal-to-noise ratio over more complex mapping methods that targeted albedo protons [2,3,4,5] and it closely resembles lunar gamma ray maps for certain elements made by Lunar Prospector, particularly maps of KREEP terrain constituents such as titanium and thorium [6,7]. Figure 1 shows the new map with higher index values represented by darker shades. Given that detector D6 faces the Moon with minimal shielding, and that the D6 detection rate appears in the numerator of one term of the SEP Index, any "bright" or "dim" features that appear in a SEP Index map of the Moon are probably due to an enhancement or dearth, respectively, of lunar albedo particles or photons that can reach D6 more easily than the other three detectors in the SEP Index (D4, D3, and D1)

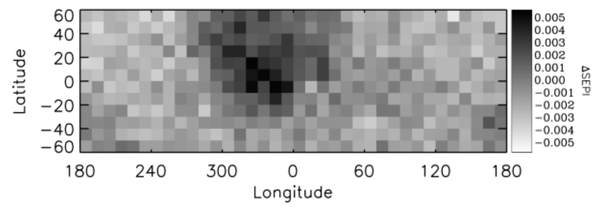

Figure 1. Lunar radiation map using SEP Index derived from CRaTER data. Darker shades represent higher index values.

Next Steps: Using the features in the lunar map as a guide, we are in the process of generating LET spectra separately for different regions to search for variations in gamma rays, neutrons, or protons that identify large-scale elemental concentrations in the regolith. If the features are indeed due to gamma rays, then the energy resolution of CRaTER's detectors gives us the potential to produce gamma ray spectra with up to 4 times the spectral resolution of Lunar Prospector. If the map features prove to be albedo protons, then these are lower-energy protons (10-50 MeV) compared to the previous proton maps (~100 MeV), meaning our two mapping methods together could provide depth resolution for elemental abundances in the lunar regolith.

References: [1] Spence et al. (2010), *Space Sci. Rev, 150*, 243-284. [2] Wilson et al. (2012) *JGR, 117*, (E12). [3] Wilson et al. (2014) *AGU Fall Meeting*. [4] Schwadron et al. (2016) *Icarus, 273,* 25-25. [5] Schwadron et al. (2018) *Planet. Space Sci., 162*, 113-132. [6] Feldman et al. (1999), *Nuclear Instruments and Methods in Physics Research A, 422*, 562-566. [7] Prettyman et al. (2002), *33rd LPSC*, Abstract #2012.