# CONSTRUCTING LUNAR NEUTRON FLUX MAPS WITH LRO/LEND SENSOR FIELD OF VIEW.

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Neutron detection rates within the Lunar Reconnainssance Orbiter (LRO) Lunar Exploration Neutron Detector (LEND) have been mapped globally as well as targeted on the Moon's polar regions [1–4]. Similar mapped measurements were acquired with the earlier Lunar Prospector Neutron Spectrometer (LPNS) [4,5]. Maps are constructed by identifying a measurement of neutron flux with its lunar coordinates, building up a map of detection rates over each location. Spatial smoothing can be applied to the mapped measurements due to finite spatial resolution in the detector system, which convolves emissions from a broad region into detections at a particular coordinate. Defining the convolution function to apply to a map poses challenges, as the function changes with orbit altitude and the energy of the detected neutrons. Reconstructing the field of view (FOV) for individual measurements is far too computationally expensive. We have had success with developing finely-sampled maps to which a psf corresponding to the average spacecraft altitude at each coordinate for each neutron detector can be applied to construct a global map of neutron flux from the Moon in distinct energy intervals.

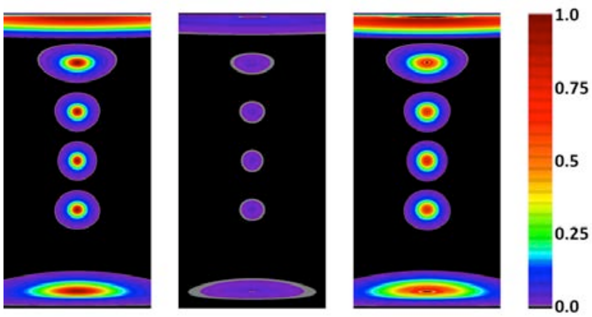


**Fig. 1**: Point-spread function (psf) on the Moon for (*left*) uncollimated detector, (*center*) LEND collimated detector CSETN, and (*right*) uncollimated component of collimated detector, at latitudes from equator to pole in cylindrical Mercator projection. Each psf peaks at unity. The displayed strips are ±90° latitude and 90° in longitude (width), sampled at 0.125°/pixel.

The natural spatial resolution of an uncollimated neutron detector is dominated by anisotropic emission from the surface into free space (Fig. 1). The detector is sensitive to emission all the way out to the horizon, which distance varies according to the altitude of the spacecraft. Emission intensity declines with increasing slant angle relative to the surface normal, approximately proportional to cosine raised to a small power of order 1-1.5. Collimation can further restrict the effective FOV, as with the CSETN detector of LEND, for which detected neutrons include the narrow collimated FOV as well as neutrons out of collimation that penetrate the finite opacity of the collimator wall [6]. Neutrons that penetrate the collimator wall to reach the detector originate from the lunar surface at greater average energy than the population in collimation [7].

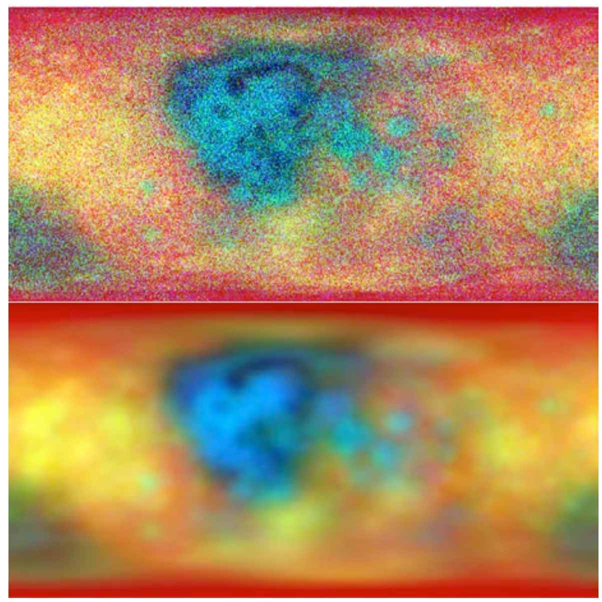

**Fig. 2:** Global map of lunar neutron emission. Red = thermal, E<0.4 eV; green = epitherml, 0.4 eV < E < 10 keV; blue = high-energy epithermal, 0.4 eV < E < 1 MeV; minus estimated background [4]. (*top*) Flux assigned directly per 0.5° pixel; (*bottom*) flux convolved with estimated psf for altitude and latitude.

The LRO data used here were acquired in 2009–2011, while the spacecraft was in circular orbit at 50 km altitude. The smoothing method should work for the elliptical orbit that LRO has occupied since 2011 by constructing maps for intervals during which the orbit is stable, combining maps from differing periods.

**References:** [1] Mitrofanov *et al.* (2010) *Science* **330**, 483–486.s [2] Sanin *et al.* (2012) *JGR-Planets* **117**, E00H26. [3] Litvak *et al.* (2012a) *JGR-Planets* **117**, E00H22. [4] Livengood *et al.* (2017) *P&SS*, in review. [5] Maurice *et al.* (2004) *JGR-Planets* **109**, E07S04. [6] Litvak *et al.* (2012b) *JGR-Planets* **117**, E00H32. [7] Livengood *et al.* (2015) *Icarus* **255**, 100–115.