Collecting and Analyzing Surface Material from Permanently Shadowed Regions on the Moon Using an Orbiting Dust Telescope. W. R. Goode[1,2] and S. Kempf[1,2],
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We present ways in which dust particles, ejected by micrometer bombardment of the Lunar surface, can be detected and mapped to particular regions thought to possess exposed water ice on the surface. A Lunar-orbiting spacecraft carrying a dust telescope may provide valuable capabilities to ascertain the abundance and distribution of water ice within craters having permanently shadowed regions. The technique of compositional mapping by dust telescopes is possible due to the impacts of fast interplanetary meteoroids with the surfaces of airless bodies producing large amounts of ejecta particles forming a tenuous, approximately symmetric cloud of ejecta particles traveling on Keplerian trajectories (with a small fraction on escape trajectories) around the planetary body.

Dust telescopes perform in situ analysis of individual solid material samples from the surface, revealing their composition and mapping their site of origin with connections to geological features from orbit. Dust telescopes have two major components: (1) a mass spectrometer revealing chemical composition and (2) a trajectory sensor providing the dynamical properties of the dust grain so that its origin can be determined. Since the Moon possesses an ejecta cloud around it composed of surface material from which we can sample, we can gather information carried by individual grains (typically micron and sub-micron sized) similar to the way remote sensing instruments gather information carried by photons. This is particularly advantageous for permanently shadowed regions where remote sensing is typically limited by low SNR. Dust telescopes also have a proven track record of identifying water ice along with other volatiles and trace elements within ejecta grains at the ppm level.

Given the stochastic nature of Lunar ejecta detections, we apply Monte Carlo simulations to address important questions regarding the application of dust telescopes to mapping surface composition in this study: (1) What is the maximum flyby altitude over a crater at which the dust telescope can reliably associate detections of water ice and other volatiles within the crater? (2) What capabilities does the dust telescope need in terms of trajectory determination in order to map detections to geological features on the Lunar surface?