EXPLORATION OF RESOURCES IN LUNAR POLAR REGIONS M. Horanyi[1,2](horanyi@colorado.edu), E. Bernardoni[1], S. Kempf[1], Z. Sternovsky[1,2], J. Szalay[3], [1]Institute for Modeling Plasmas, Atmospheres, and Cosmic Dust (IMPACT), U. of Colorado, Boulder, CO, USA, [2] Laboratory for Atmospheric and Space Physics (LASP), U. of Colorado, Boulder, CO, USA, [3] Princeton University, Princeton, NJ, USA

Introduction: The Moon is continually bombarded by on the order of 10^6 kg/y of interplanetary dust particles (IDP) that are micrometeoroids of cometary and asteroidal origin. Most of these projectiles range from 10 μm to about 1 mm in size and impact the Moon with speeds in the characteristic range of 10 to 72 km/s. At Earth, the passage through the atmosphere ablates most of these particles turning them into "shooting stars". However, they directly reach the surface of the Moon, generate secondary ejecta particles and leave a crater record on the surface from which the micrometeoroid size distribution has been deciphered [1]. Most of the ejecta particles have initial speeds below the escape speed from the Moon (2.4 km/s) and following ballistic orbits return to the surface, blanketing the lunar crust with a highly pulverized and impact gardened regolith with ≫ 1 m thickness. Micron and sub-micron sized secondary particles that are ejected at speeds up to the escape speed form a highly variable, but permanently present, dust cloud around the Moon. Such tenuous clouds have been observed by the Galileo spacecraft around all lunar-sized Galilean satellites at Jupiter [2]. Our understanding of the lunar dust exosphere is based on NASA's Lunar Atmosphere and Dust Environment Explorer mission (Fig.1) [3]. The findings provide a unique opportunity to map the composition of the lunar surface from orbit and identify regions that are rich in volatiles, providing opportunities [4] for future in situ resource utilization (ISRU).

In Situ Resource Utilization is a key element in establishing human habitats on the Moon. The expected availability of water ice, and other volatiles, in Permanently Shadowed Regions (PSR) makes the lunar poles of prime interest. However, the relative strength of the various sources, sinks, and transport mechanisms of water into and out of PSRs remain largely unknown. The quantitative characterization of the temporal and spatial variability of the influx of IDPs to the polar regions of the Moon is critical to the understanding the evolution of volatiles in PSRs. A dust instrument onboard a polar orbiting lunar spacecraft could make fundamental measurements to assess the availability and accessibility of water ice in PSRs. Water is thought to be continually delivered to the Moon through geological timescales by water-bearing comets and asteroids and produced continuously in situ by the impacts of solar wind protons of oxygen-rich minerals on the surface. IDPs are an unlikely source of water due to their long UV exposure in the inner solar system, but their high-speed impacts can mobilize secondary ejecta dust particles, atoms and molecules, some with high-enough speed to escape the Moon. Other surface processes that can lead to mobilization, transport and loss of water molecules and other volatiles include solar heating, photochemical processes, and solar wind sputtering. Since the efficiency of these are reduced in PSRs, dust impacts remain the dominant process to dictate the evolution of volatiles in PSRs.

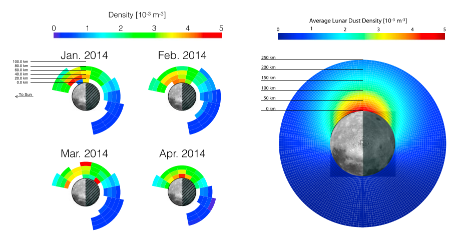

Fig.1 *The dust ejecta cloud observed by LDEX for each calendar month LADEE was operational in 2014 (left), and the modelled average lunar dust density distribution for particles with radii* $\geq 0.3\ \mu m$ *(right panel) shown in a reference frame where the Sun is on the left [5].*

In the absence of an atmosphere, each incoming IDP directly hits the lunar surface and generates a copious number of secondary particles, with sufficient speeds, reaching over 200 km altitude before most of them returns to the surface. The continually present dust ejecta cloud was observed by LADEE/LDEX. A more capable dust instrument, in addition to the size and speed of an impacting particle, can also measure the composition of secondary ejecta particles, resulting in a surface composition map with a spatial resolution comparable to the height of the spacecraft. This talk will describe the available instrumentation, its testing and calibration using the SSERVI /IMPACT dust accelerator facility at the University of Colorado, Boulder.

Summary: A polar-orbiting spacecraft will directly sample the lunar ejecta, providing the critical link between IDP bombardment and water in PSRs.

References: [1] E. Grün, et al., *Icarus*, 62:244, 1985. [2] H. Krüger, et al., *Icarus*, 164:170, 2003. [3] R. C. Elphic, et al., Space Sci. Rev., 185:3, 2014. [4] F. Postberg, et al., Planet. Space Sci., 2011. [5] J. R. Szalay and M. Horányi. *Geophys. Res. Lett.*, 42:10,580, 2015.