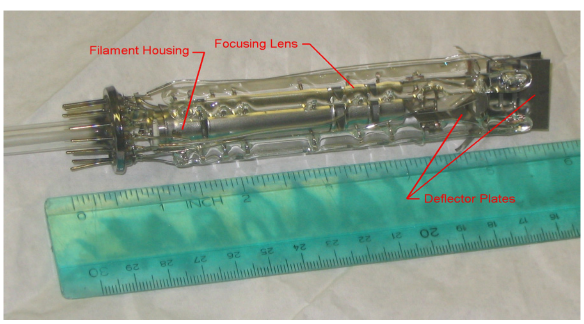
PLASMA-BASED TOOL FOR DUST REMOVAL ON THE MOON. S.A. Curtis[1], P.E. Clark[1], F.A. Minetto[1], M. Moore[1]; [1]NASA/GSFC, [2]Catholic University of America, all located at NASA/GSFC, Greenbelt, MD 20771, Pamela.E.Clark@NASA.gov.

Figure 1: SPARCLE tool being used by astronaut to clean a glove in the airlock.

Introduction We are in the process of developing SPARCLE (Space Plasma Alleviation of Regolith Concentrations in the Lunar Environment), a NASA patent protected electrostatically-based tool for dust mitigation (**Figure 1**), to the support the objective of lunar regolith interaction and simulant Investigations in order to address the issue of dust, which has become known as a health and safety hazard, as well as a potential source of equipment degradation and failure during the Apollo missions, in part due to the use of a mechanical removal strategy which led to abrasion.

The Dust Problem: The characteristic persistent adhesion and abrasion of lunar soil particles when interacting with surface introduced into the lunar environment resulted from the combined electrical and physical properties of the grains. These properties caused the particles to be easily charged, electrostatically attracted, and then almost impossible to dislodge by physical means alone. Field/charged particle/dust interactions on the Moon are complexly dependent on environmental conditions and compositional, mechanical, magnetic or electrical particle properties (e.g., Criswell, 1973; Berg et al, 1976; Sickafoose et al, 2001; Stubbs et al, 2005). Foundational simulation of dust behavior in fields has focused on individual grains (e.g., Horanyi et al, 1998;Cheng et al, 2002). Recent work (Immer et al, 2006) indicates that dust collectively responds to charge variations on an electrostatic mesh surface and can be collectively controllable with an electrostatically based approach. All of these results support the approach to dust mitigation, based on controlling of surface potential, that we present here.



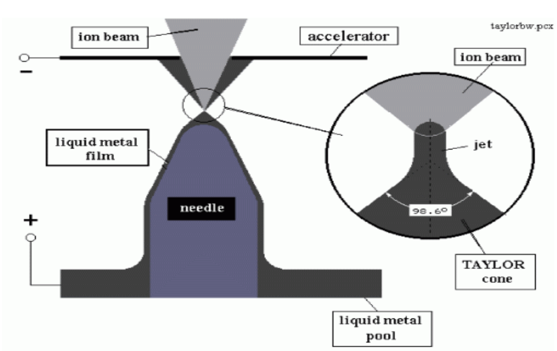


Figure 2: Electron gun above, schematic of ion gun below, built for SPARCLE effort.

Implications for surface to volume ratio for lunar fines. We are also in the process of systematically measuring surface to volume ratio (SVR) throughout the grain size distribution but particularly for the smaller fractions (<50μ) of both lunar soil and simulant to establish a basis for understanding the behavior and potential health risk associated with lunar dust. Grain size distribution will affect the protocols used to operate SPARCLE. If grains typically form clumps >3 microns in size, as our preliminary measurements with the Gemini surface area analyzer suggest, the human health risk from dust exposure (silicosis) is minimal, and the dust mitigation campaign can focus on keeping equipment clean and preventing dust from going further than the airlock environment, where SPARCLE would remove it with relatively little effort. Prevalence of micron-scale grains would necessitate more frequent and extensive cleaning of longer duration.

The Plasma-based Solution: SPARCLE leverages decades of spacecraft operations which successfully controlled spacecraft potential with charged particle beam technology (Comfort et al, 1988). The SPARCLE tool works by the same principles, attracting and removing dust from surfaces entering the airlock through the use of particle beams, and then disposing of dust in a proper receptacle through the use of oppositely charged particle beams to control the potential of the tool's surface. The SPARCLE development team is already partnered with the lunar habitat airlock design team at JSC who see tremendous potential for SPARCLE to provide lunar dust removal from any object in the airlock with minimal expenditure of resources.

Ongoing Developments: The electron and ion gun development has been completed(**Figure 2**), and we are now designing the packaging needed to complete the first SPARCLE model so that we can test its ability

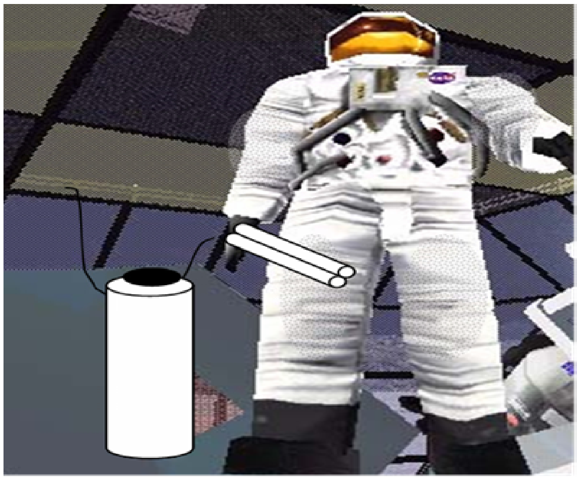


Figure 3. Components of sparkle including active double barreled gun collector and disposal container.

to attract dust with from a variety of introduced surfaces with a range of positive and negative potentials in a simulated airlock environment under a variety of temperatures and pressures, thereby establishing a proof of concept.

We are preparing to determine the most effective protocols for varying the range and timing of the particle guns outputs in order to collect dust.

Design Strategy: The final design for SPARCLE will be based on the results of the airlock simulation tests. Our present concept **(Figure 3)** involves using a cleaning wand with internal electron or ion guns to control its surface potential and generate a setting that will predictably attract dust under the ambient conditions. We are experimenting with special coatings to determine which ones facilitate removal from soft (e.g., spacesuit) and hard (e.g., walls) surfaces. The dusty wand will be cleaned by being thrust into a receptacle with an opposite charge to electrostatically remove dust from the wand. Finally, we will construct a laboratory model of the dust removal based.

References: [1] Criswell (1973) in Grard, R.J., Ed., Photon and particle interactions with surfaces in space, D. Reidel Publ Co, Dordrecht, Holland, 545-556; [2] Berg et al (1976) EPSL, 39, 377-381; [3] Sickafoose et al (2001) JGR Space Phys, 105, S5, 8343-8356; [4] Stubbs et al (2006) Adv Space Res (in press); [5] Horanyi et al (1998) JGR, 103, 8575-8580; [6] Cheng et al (2002) Journal of Adhesion, Vol. 78, pp. 929-965; [7] Immer et al (2006) Lun Plan Sci XXXVII, 2265.pdf; [8] Comfort et al (1998) Journal of Spacecraft and Rockets, Nov/Dec 1998, Vol. 35, Issue 6; 845-859.