THE SSERVI-IMPACT DUST ACCELERATOR FACILITY AT THE UNIVERSITY OF COLORADO
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Introduction A hypervelocity dust accelerator for studying micrometeorite impacts has been constructed at the University of Colorado, initially (2009-2013) funded as part of the NASA Lunar Science Institute's (NLSI) Colorado Center for Lunar Dust and Atmospheric Studies (CCLDAS). Since 2014, the facility continues to receive funding from the NASA Solar System Exploration Research Virtual Institute's (SSERVI) Institute form Modeling Plasmas, Atmospheres, and Cosmic DusT (IMPACT). The accelerator was completed in 2011, and consists of a 3 MV Pelletron generator (**Figure 1.)** with a dust source, image charge pickup detectors, and interchangeable target chambers. It has been used for a large number of science experiments [2-4], as well as for the development, testing, and calibration of flight hardware [5].

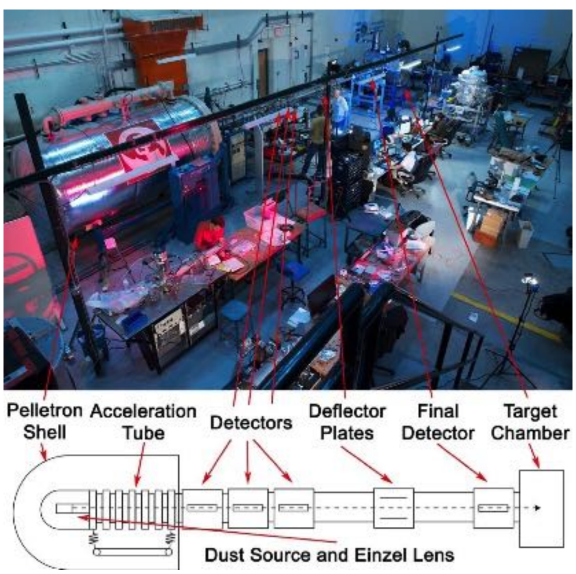

Figure 1. The SSERVI/IMPACT dust accelerator. The Pelletron on the left side creates the 3 MV potential difference through a chain induction system that works similarly to a Van de Graaf machine. The dust particles start off in a source inside the Pelletron, where they are charged and sent into the main acceleration tube. The accelerated particles are sent through detectors that determine their velocity and mass in real time. A logic circuit uses this information to decide whether or not the particle is accepted and sends a signal to the deflector plates, which divert unwanted particles out of the beam path.

Accelerator Performance The accelerator is a source of hypervelocity dust particles with radii in the range of 10 nm < a < 5 μm (Fe), and speed range in excess of 100 km/s (**Figure 2**). We have successfully accelerated particles with a variety of composition, including *Fe,Ag*, olivine, and latex.

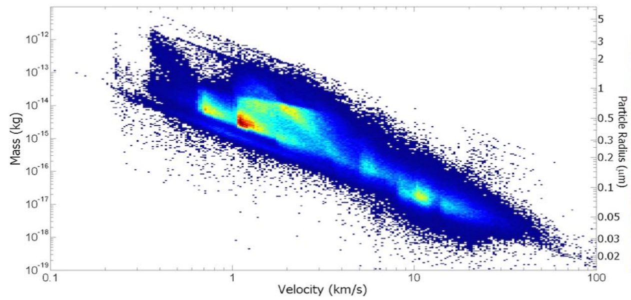

Figure 2. The performance of the IMPACT dust accelerator, showing the mass and speed distribution of the accelerated *Fe* particles.

Initial Experiments included cratering studies of thin plastic films [2], the generation of electric antenna signals [3], and the production of plasma and neutral gas [4] in dust impacts, for example.

Cratering Experiments Thin plastic films are used as spacecraft blankets as well as aperture shields of particle detectors. In addition, Permanently polarized Polyvinylidene Fluoride (PVDF) films have been used as dust detectors on a number of space missions. The scaling laws (**Figure 3**) connecting the size and the speed of a projectile to the depth and diameter of the crater they excavate remains a poorly understood but important issue for both spacecraft safety engineering, as well basic science investigations.

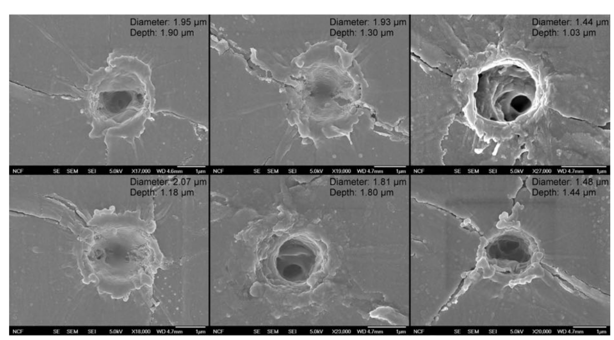

Figure 3. Sample images of craters found in PVDF [2].

The Development of Ice and Gas Targets

We have recently completed two major target upgrades: a cryogenic ice target and a high-pressure gas target. Cryogenic targets enable the studies of the effects of dust bombardment on ices throughout the solar system, including the permanently shadowed regions of the Moon, or the icy surfaces of outer solar system objects. The gas targets chamber is used to understand the ablation of meteoroids in planetary atmospheres, or in the case of the Earth, to improve our ability to analyze and interpret the data from ground-based meteor-radars.

Ice Impact Experiments The ice target consists of a LN2 cryogenic system connected to both a water-ice deposition system as well as a movable freezer/holder for a premixed liquid cartridge. Planned experiments include the bombardment of a variety of frozen targets and simulated ice/regolith mixtures, and the assessment of all impact products (solid ejecta, gas, plasma) as well as spectroscopy of both the impact-produced light flashes and the reflected spectra (UV, visible, IR). **Figure 4** shows example initial measurements of cluster size distributions generated in dust impacts of pure water ice.

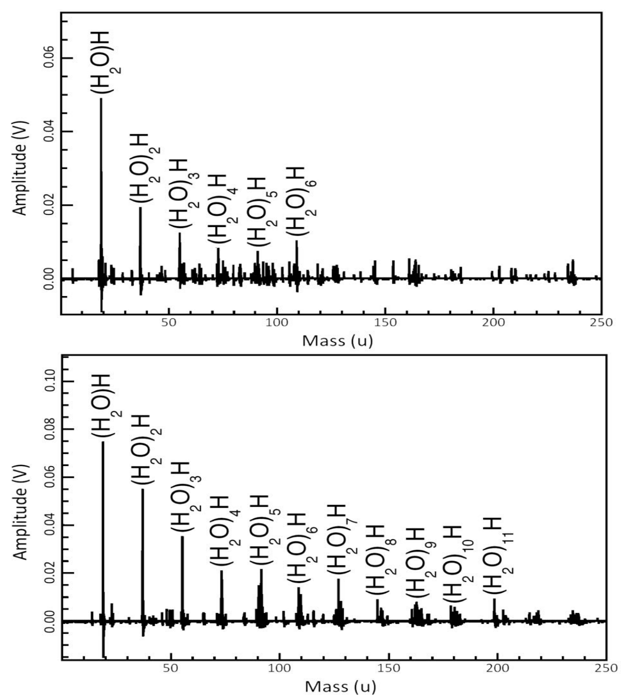

Figure 4. Initial results of the distribution of water clusters using a Time-of-Flight (TOF) mass spectrometer from *Fe* particle impacts with speed of 6 (top) and 20 (bottom) km/s into pure water ice.

Gas Target Experiments The gas target consists of a differentially pumped chamber kept at moderate background pressures, such that high-velocity (≥10 km/s) micrometeoroids are completely ablated within 10's of cm (i.e. within the measurement chamber). The chamber is configured with segmented electrodes to perform a spatially resolved measurement of charge production during ablation (**Figure 5**), and localized light-collection optics enable an assessment of the light production (luminous efficiency).

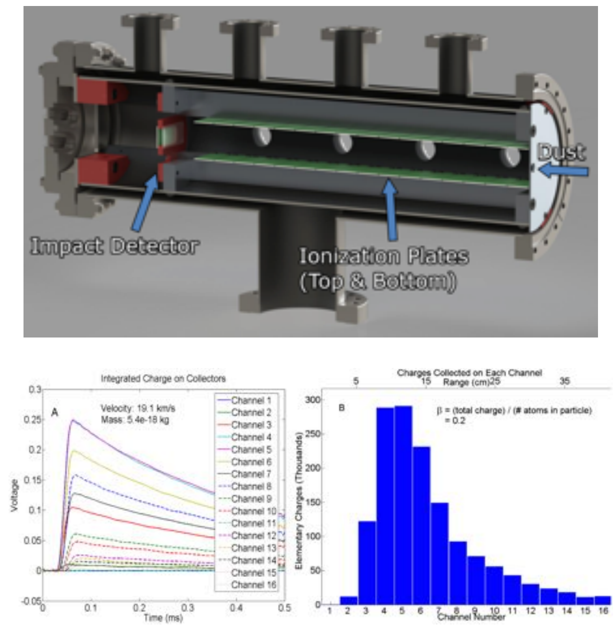

Figure 5. A cutaway diagram of the gas target chamber containing the ionization plates and the impact detector (top). The charge collected in each channel as function of time (bottom left), and the integrated total charges (bottom right)[6].

The talk will summarize our current capabilities and recent experimental results, and extend an invitation to the planetary and space science communities. New experimental groups are continually solicited to work with us on experiments addressing the effects of debris/meteoroid impacts on spacecraft and instrumentation, the atmosphere of the Earth and other planets, as well as surface effect on airless bodies in the solar system. The facility also provides a unique opportunity to cross-calibrate remote sensing and in-situ instruments for future space missions.

References:

[1] Shu et al., (2012) Rev. Sci. Instr., 83, 075108; [2] Shu et al., (2013) PSS 89, 29-35; [3] Collette et al., (2014) Icarus 227, 89-93; [4] Colette et al., (2015), JGR 120, 5298-5305; [5] Horanyi et al., (2014) Space. Sci. Rev. 185, 93-113; [6] Thomas et al., (2016) GRL, submitted.