Dust Detection for a Lunar Dust Accelerator

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Introduction

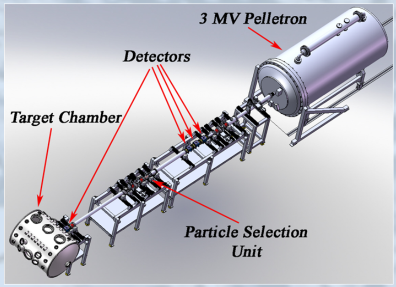
The lunar atmosphere is a surface bound exosphere (SBE) and is maintained by a dynamic equilibrium between solar wind electrons and ions, photoelectrons emitted from the surface, and ejecta from micrometeroid impacts (impacts typically ~20km/s). Due to the diffuse nature of the exosphere, the ejecta travel in ballistic trajectories and either escape the lunar environment or fall back to the surface (potentially creating secondary ejecta). A 3MV lunar dust accelerator is being built at the University of Colorado to simulate those impacts at <100km/s, which will increase understanding of the exosphere as well as provide calibration services for future in situ measurement instruments. To be useful as a scientific instrument, the accelerator must be able to detect the particles in-flight so as to select particles valuable to the particular experiment as well as provide knowledge of particle properties (i.e. charge and velocity).

Accelerator

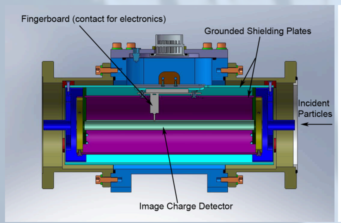
The components of the accelerator (Figure 1) are:

- 20kV pre-acceleration stage
- Einsel focusing lens
- 3MV main acceleration stage (Pelletron)
- X-Y steering module
- 3 detectors in series
  - 1st and 3rd give velocity from falling edge of signals
  - 2nd used for charge measurement
- Particle selection unit (PSU) with deflecting plates
- Final detector
- Impact chamber

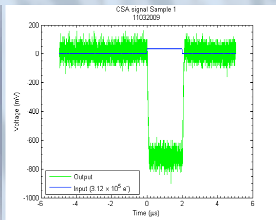
Accelerator and Detectors



a)



b)



c)

Figure 1: a) Schematic of accelerator b) Schematic of detectors c) Detector signal

The detectors consist of:

- Three concentric cylinders for EM shielding
  - Charged particle enters innermost cylinder (Figure 1 b)
  - Produces image charge on cylinder
- Three electronic components
  - "Fingerboard" probe press fitted to inner most cylinder (Figure 1 b)
  - Main electronics board, charge sensitive amplifier
    - Probe provides input image charge
    - Ideal signal shown in Figure 1 c
      - Amplitude directly proportional to charge and width gives resonant time in detector (i.e. velocity)
  - Power supply board
  - All components EM isolated by cylinders

Detector signals are analyzed by the PSU, which then determines whether or not to allow particle into target chamber.

Particle Selection

Selection is currently handled by two separate systems:

- Analog circuit which uses detector edge triggers, but requires a minimum signal amplitude. Used for large, slow moving, highly charged particles.
- Field programmable gate array (FPGA) algorithm used to detect small amplitude signals embedded in noise. Used for smaller, fast, low charged particles.
  - Algorithm is a cross correlation
  - Correlate detector signals with range of filters representing velocity ranges

Correlation

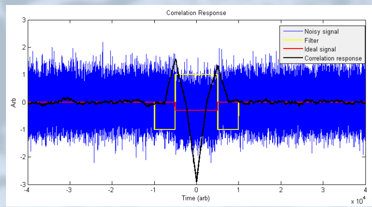


Figure 2: Simulation of a cross correlation algorithm

- 7 filters spaced at factors of 2
  - Covers velocity range from 1-128km/s
- FPGA times correlation response thresholds between 1st and 3rd detector to determine velocity
- A sample and hold of detector signals determines amplitude, charge
- Digital signal to deflecting plates opens them appropriately