An ion analyzer for the lunar surface with E parallel to B

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Abstract. We present a novel instrument concept to measure the energy and mass spectra of ions incident on the lunar surface, based on the E-parallel-B or Thomson-parabola device used extensively as a diagnostic in the plasma fusion community. The Apollo-era Suprathermal Ion Detector Experiment (SIDE) was the first instrument package to perform in-situ measurements of ions incident on the lunar surface. The ions can originate from a variety of sources, including the solar wind, the Earth's magnetotail, and photoionization of the thin lunar atmosphere. The species and energy distribution of ions arriving at the lunar surface depend in a complicated and poorly-understood fashion on the phase of the lunar day, the position of the Moon with respect to the Earth, and on the local plasma environment.

The SIDE instrument used a stepped electrostatic mass analyzer in combination with a stepped crossed-field (Wien) velocity filter to analyze incoming ions. The stepped mode of operation limited both the resolution of the device (six energy steps, twenty velocity steps, in conjunction with a twenty-step dedicated energy analyzer) and the temporal resolution (2.6 minutes for a full energy-velocity scan).

A modern diagnostic tool with significant heritage in the plasma fusion community is the E-parallel-B analyzer. This instrument is capable of analyzing the charge-to-mass ratio and momentum of individual particles. Each ion passing through a region with parallel E and B fields is deflected to a unique location on a 2D target according to its energy and mass. Energy and mass spectra can then be recorded using a 2D sensing technique; for example, a microchannel plate backed by a cross-delay-line (XDL) readout. The E-parallel-B design has the additional advantage of being physically compact and requiring modest field magnitudes, with electric fields on the order of a few kV/m and magnetic fields of tens to hundreds of gauss, neither of which require exotic construction or heavy components.

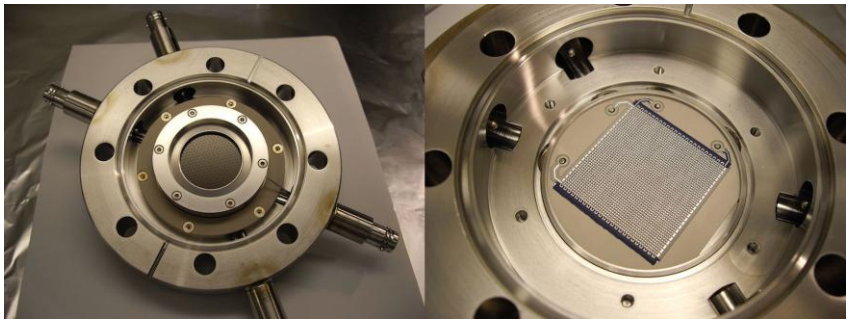

Figure 1: Microchannel plate backed by cross-delay-line sensor for detection of ions incident on the lunar surface (courtesy Sensor Sciences LLC).