C.2.2 Solar Wind Electron Analyzer (SWEA)

SWEA measures the distribution function of the solar wind core and halo electrons from <1 to ~3000 eV with high spectral and angular resolution. SWEA is specifically designed to provide accurate measurements even for the extremely cold (Tec < 1 eV) core electrons which provide a tracer of ejected cold prominence material in ICMEs. It also provides nearly full sky coverage of the directionality of halo electrons, for determining the magnetic topology of ICMEs even when the IMF rotates far out of the ecliptic. SWEA will be provided by UCB and CESR.

C.2.2.1 System Description.

SWEA consists of a top-hat electrostatic analyzer (ESA) that provides a 360º field of view in a plane combined with electrostatic deflectors to provide +/-65º coverage in elevation out of the plane. The inner plate radius is 3.75 cm with plate separation of 0.28 cm giving a dE/E of 18%, an elevation angle resolution of ~7º and a geometric factor of 0.01 cm^2 ster E(eV). Electrons exiting the ESA pass through a transmission grid and are accelerated by a ~300 V potential and detected by a stacked microchannel plate (MCP). Electrons travelling along parallel trajectories are focused to a point on the MCP. The MCP output is collected by 16 sector anodes to provide ~22˚ resolution in azimuth. Figure C.2.2-1 shows a preliminary design of the analyzer and associated electronics. SWEA is designed to compensate for the effects of a positive spacecraft potential by allowing the outer hemisphere to have a variable potential that is programmable between 0 and –50 Volts. This allows better energy resolution and the capability of lowering the geometric factor to prevent saturation of the MCPs during high flux events.

C.2.2.1.1 Sensor Electronics. The electronics is divided into two parts; the front-end electronics and the common SWEA/STE Interface electronics. The former includes the high voltage supplies and preamps, and is provided with the analyzer by CESR. The latter includes the logic to run the analyzer sweeps, event counters, the serial interface to the IDPU, and the Low Voltage power converter. This part is provided by UCB to simplify the interface to the CESR section, and save resources by sharing with STE.

The MCP, Analyzer, and Deflector programmable High Voltage Power Supplies shall be provided by CESR. The Analyzer and Deflector voltages are provided by a common high voltage stack with separate optocoupled outputs, as was used in the UCB FAST supplies. This design provides fast sweeping response without a pull-down resistor. The MCP HV has a stand-alone supply. The Outer Hemisphere bias supply is also provided by CESR. All are programmed by voltage levels provided from DACs on the SWEA/STE interface electronics board. These supplies must have a wide dynamic range to cover the energy range accurately, and must track together well (especially the outer hemisphere and analyzer supplies) to avoid small differentials that may change with time or temperature.

The anodes and preamps are closely coupled to prevent electronic noise problems. The preamps will be Amptek A111F amplifier/discriminator hybrids.

The Interface logic is contained in an Actel FPGA. This will contain the event counters, and the logic required to generate the sweep waveforms (perhaps using a RAM to hold waveform patterns). It contains the serial interface to the IDPU, and also the STE digital electronics. The FPGA interfaces with Digital-to-Analog Converters (DACs) to generate the programming voltages for the CESR supplies.

The low voltage power converter is based on the same design used throughout IMPACT and PLASTIC to save development costs.

C.2.2.2 Field of View.

SWEA is mounted at the end of the fixed boom which is at the end of the astromast extendable boom, placing SWEA ~4.5 m from the spacecraft after deployment. This allows the SWEA sensor to provide an open field of view over >91% of the sky.

C.2.2.3 Data Rates and Format.

The MCP output is collected by 16 sector anodes to provide 22º resolution. This data is accumulated in periodic time intervals and transferred to the IDPU. As the analyzer sweeps in energy and elevation angle, the IDPU accumulates a 3-dimensional matrix of counts every 2 seconds. This is reduced in various ways by the software to make telemetry products. A full three-dimensional distribution is produced with 80 angles by 15 energies once a minute. Two-dimensional Pitch Angle cuts through the distribution are extracted every 16 seconds. Moments of the distribution are computed every 2 seconds. In addition, full distributions are sent to the Burst memory every 2 seconds.

C.2.2.4 Ground Support Equipment

Bench electronics, lab equipment, and electron sources are used to test and calibrate the SWEA system prior to integration with the UCB-provided SWEA/STE interface electronics. After integration with interface electronics, the IDPU Simulator GSE is used to control SWEA and display its data (see IDPU GSE section C.4.2.6)

C.2.2.5 Instrument Requirements.

The SWEA interface requirements information is included in Appendix A. The electrical interface shall be via the common SWEA/STE serial interface to the IDPU. The mechanical interface is at the end of the IMPACT boom. This location provides a clear FOV that is well isolated thermally from the spacecraft and in the shade to prevent the production of photoelectrons and UV background in the analyzer.

C.2.2.6 Calibration

Preliminary calibration of the analyzer will be performed at CESR without the interface electronics. Bench equipment shall be used to program the analyzer voltages and accumulate events.

Final calibration of the SWEA instrument will be done at UCB, together with the interface electronics, using existing calibration equipment that was developed for a similar instrument on the Wind spacecraft. This calibration will concentrate on the dynamic characteristics of the sweep waveforms and any interface problems.

C.2.2.7 Development Plan

During Phase A and early Phase B, the design will be developed and interfaces finalized. The development items are the electrostatic optics of the deflectors and the high voltage supplies. Then a prototype instrument will be fabricated and tested to prove the design. This will include an interface test between the CESR-provided analyzer and front end, and the UCB-provided interface electronics, and finally with the engineering model IDPU. In phase CD the flight instruments shall be fabricated, tested, and calibrated. Again, CESR will build the Analyzer and front-end electronics, and UCB will build the interface electronics, with integration at UCB. Flight fabrication will follow the Performance Assurance requirements called out in the IMPACT PAIP, included in an appendix to this document.

Figure C.2.2-1. SWEA