The Low Energy Electrostatic Analyzer (LEESA) for DSX

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Abstract

The Low Energy Electrostatic Analyzer (LEESA) is a 90° quadraspherical ESA designed for the Demonstration and Science Experiments (DSX) satellite. LEESA measures electron and ion fluxes from 30 eV to 100 keV. LEESA has two input apertures with the same fields of view (FOV), one for ion and one for electron measurement. LEESA measures the directional of the particles by offering 5 angular zones within a 90° FOV. LEESA is designed to operate at two different data rate levels, sampling once per 0.0125 sec or once per 0.125 sec. Here we discuss the design characteristics, performance, and operation of the LEESA instrument.

Intrument Description

LEESA determines the arrival energy of charged particles by allowing incoming particles to traverse a 90° spherical electrostatic analyzer (ESA) also referred to as a quadrasphere. The ESA consists of two oppositely biased quadrangular analyzers. As a charged particle passes through the plates its path is deflected toward the inner sphere by the potential difference between the shells. A cutaway view of the instrument showing the arrangement of the hemispheres, apertures and micro-channel plate (MCP) detectors is shown in Figure 1.

Mode of Operation

LEESA is capable of storing a number of fully flight-programmable energy scan patterns. That is, LEESA is not limited to slewing through all 256/2 energy bands sequentially, it can be repeatedly reprogrammed to execute complex energy scans that fit the needs of individual experiments. For example, LEESA could dwell at a particular energy for some time and then scan a broader energy range. The goal is for LEESA to be able to support a number of experimental modes and adapt to changing mission requirements.

LEESA stores the programmed scans as a series of lines, pages, and books. A line consists of 40 energy values, a page consists of 32 lines, and a book contains 4 pages. LEESA can store 32 unique line sets, 32 pages sets, and 4 book sets (2 for each data rate). In flight, LEESA will run through books, pages, and lines sequentially allowing for a tremendous number of allowable scan patterns.

Calibration

A set of raw electron counts for one electron calibration run performed on 8 September 2010 (file identifier 998e001) is shown in Figure 3. The instrument was scanned from -57° elevation (unfocused angle) to 83° in 40 steps of 3°. At each elevation angle, the instrument was scanned from -12° to 12° of 2°. At each of the 533 angular orientations of the instrument, the electron beam was stepped over 11 discrete energies from -1000 eV to +2000 eV in 100 eV steps. LEESA was commanded to an ESA bias command of 178 for this run. The counts recorded by the instrument at each position and energy are shown as intensity plots in Figure 3. The ESA central band-pass energy was set to -2 keV for this sample run and as such the beam appears most centered for the -2 keV scan. The individual MCPs' active areas are clearly visible as horizontal strips at each energy level. Another important feature that can be seen is the acceptance of the focused angle grows larger as you move away from incidence normal to the LEESA aperture. The zones of the edges of the instrument are much broader in focused angle acceptance at a given energy than the central zone. The electron MCP associated with zone 5 is shadowed by the MUMBO calibration fixture and so does not appear at an elevation angle of -57°. An immediately obvious feature is that the angles at which the beam can be seen by the instrument clearly vary with beam energy. This behavior is expected and model results match the observed behavior.

LEESA Science Objectives

LEESA supports the primary DSX experiment which is active VLF transmissions to observe wave-particle interactions in the medium Earth orbiting (MOO) radiation belt region. Observed particle fluxes in the LEESA energy measurement range will allow diagnosis of electrostatic sheath dynamics and local plasma heating which is a potential sink of injected VLF. During high power transmissions, the LEESA survey mode will be a high cadence sampling of energies selected for this diagnosis. The secondary DSX experiment includes a suite of five particle instruments to characterize the energetic particle environment in MEO across energies from eV to 10-100 MeV. LEESA covers the lower portion of this energy range. The instrument will observe ring current and radiation belt seed populations. It is not designed to sample the low energies of the cold plasma that forms the bulk of the plasmasphere (though it may sample the energetic tail of this distribution). At energies observed by LEESA, there are significant longitudinal variations in plasma density (the drift tube). The 10th electron MCP associated with zone 5 is shadowed by the MUMBO calibration fixture and so does not appear at an elevation angle of -57°. An immediately obvious feature is that the angles at which the beam can be seen by the instrument clearly vary with beam energy. This behavior is expected and model results match the observed behavior.

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