

Data Analysis and Generalizations

A Look from a Different Perspective

STUDENT ACTIVITY

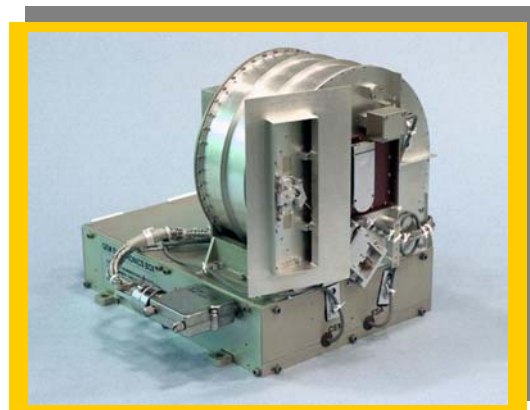
In “A Closer Look,” you observed the changes and trends in **proton** speed, temperature, and density, and the ratio of helium ions/ hydrogen ions (alpha particles/protons) in solar wind plasma streams. As mentioned in the Student Text, “Solar Wind Catcher,” these data are all processed on board the Genesis spacecraft.

Solar Wind Electrons

The solar wind also contains enough negatively charged **electrons** to counteract these positively charged alpha particles and protons. The Genesis Electron Monitor (GEM) analyzes the direction from which these solar wind electrons are coming and their flow rate (flux). In this assessment activity, you will be studying and interpreting some of the electron characteristics shown in the Electron Spin-Angle Distribution Plots that result from the GEM analysis.

Part 1. Uni-Directional Electron Streaming

- a) Start your study of solar wind electron streaming by accessing the Electron Spin-Angle Distribution Plots at http://genesis.lanl.gov/plots/test/gem_phi/1day/.
- b) Like the Genesis Summary Data Plots, you are able to select a particular date. Click on February 7, 2003.
- c) Locate the different features of the panels as you read the following description of these Electron Spin Angle Distribution Plots.



Los Alamos National Laboratory

Genesis Electron Monitor (GEM)

What you are looking at

The electron **flux**, or flow rate, data collected by the Genesis Spacecraft is plotted in these panels as a function of the **spacecraft spin angle**, 0° to 360°, on the vertical axis, and **time** on the horizontal axis. In each panel, the **relative electron flux** at a given energy is represented using a color scale. Note that the electron energy (in electron volts [eV]) for each panel is shown in the left-hand vertical scale. The *relative* flux color code is shown to the right of the panels, with the highest flux colored red.

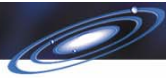
The Genesis spacecraft is oriented so that the spin axis vector lies in the **ecliptic** (the hypothetical two-dimensional surface in which the Earth's orbit around the Sun occurs), and is generally pointed Sunward. A spin angle value of 0° (and also 360°) corresponds to the position where the Genesis Electron Monitor's (GEM) “look direction” is northward.

The GEM analyzes Supra-thermal Electrons

Measured in the vicinity of Earth, solar wind electrons at energies above 100 eV can generally be considered to be **supra-thermal electrons**. Note that the lowest electron energy shown in the panels is 162 eV. Supra-thermal electrons typically do not have the same flux in all directions. Rather, these electrons usually have a flux peaked along a direction parallel (or, at times, anti-parallel) to the local interplanetary magnetic field direction.

Stationary solar wind uni-directional electron streaming

As the Genesis spacecraft rotates, the GEM's field of view sweeps across the interplanetary magnetic field direction. The GEM then detects a peak flux centered at the spin angle into which the magnetic field direction projects. For ordinary stationary solar wind flows, that is, fast coronal hole and interstream solar wind, the supra-thermal electrons stream away from the Sun **along magnetic field lines**. During these times, the GEM detects a peak flux only once per spin, indicating **uni-directional electron** streaming (UDES).



The data shown for February 7, 2003, is an example of a well-defined uni-directional electron flux. The time interval shown is one day. The single red "stripe" is the uni-directional supra-thermal electron flux. Note that the peak angle is not steady, but has some jitter. This is because the interplanetary magnetic field, which is guiding the electrons, is not steady, but fluctuates

Part 2. Bi-Directional Electron Streaming

- Go to the top of the screen and click on Electron Spin Angle Distribution Plots.
- Select January 27, 2003.
- Locate the different features of the panels as you read the following description of these Electron Spin Angle Distribution Plots.

Coronal mass ejection solar wind

In this screen, you see an example plot of coronal mass ejection-related **bi-directional electron streaming** (BDES) between the hours of 02:00:00 and 17:00:00.

There are periods of time when the supra-thermal electrons exhibit peak flux **both parallel and anti-parallel to the interplanetary magnetic field**. This phenomenon is often referred to as "counter-streaming electrons" or "bi-directional electron streaming" (BDES). The interplanetary magnetic field within many coronal mass ejection (CME) transient flows is believed to form loops that return to the solar corona along both directions. Observation of BDES is interpreted to be a probable indicator of those closed magnetic loops anchored in the Sun. When the electron flux is bi-directional, the GEM will detect a peak flux twice per spin, and the two peaks will be 180° apart as illustrated in the January 27 Electron Spin Angle Distribution Plots. You can see two distinct beams emerge at 02:00:00. Note that the plot "wraps" in angle; the peak flux at 0° and at 360° are from the same beam. Although counter-streaming is highly diagnostic of CMEs, BDES does not occur exclusively within CMEs, but can occur for other reasons as well.

Part 3. Solar Energetic Particle Events

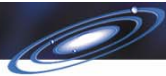
- Go to the top of the screen and click on Electron Spin Angle Distribution Plots.
- Select January 3, 2003.
- Locate the different features of the panels as you read the following description of these Electron Spin Angle Distribution Plots.

On a few occasions, the GEM has been hampered by the effects of **solar energetic particle** (SEP) events. The penetrating particle radiation results in a high background count rate for GEM, which overwhelms the solar wind electron count rate. This is an infrequent occurrence, but when SEP events happen, the plots go "all red," like you can see between 01:00:00 and 08:00:00 in the January 3 plot. SEP events do not necessarily indicate the presence of BDES.

Part 4. Analyzing Electron Spin Angle Distribution Plots

You have seen plot samples that clearly show uni-directional and bi-directional electron stream and SEP events. You have also observed that the same regime seldom flows for a whole 24-hour period. On most days, the GEM sees a variety of electron streaming, so it uses a programmed algorithm to analyze these various signals for the presence or absence of bi-directional electron signatures.

- Access the Electron Spin-Angle Distribution Plots at http://genesis.lanl.gov/plots/test/gem_phi/1day/
- Go to the top of the screen and click on Electron Spin Angle Distribution Plots.
- Select February 11, 2003.
- Keeping in mind the "typical" samples that you have observed above, you will start with February 11, 2003, and analyze three consecutive days of Electron Spin Angle Distribution Plots. Record the time spans and the type of electron streaming being detected by the GEM as being uni-directional electron streaming (UDES), bi-direction electron streaming BDES), Solar Energetic Particle Events (SEPs), or indeterminate, having none of other characteristics. Record your analysis in the data tables below.
- Repeat the procedure for February 12 and February 13.



Date: February 11, 2003	
Time Span	Type of Electron Streaming

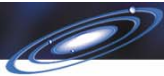
Date: February 12, 2003	
Time Span	Type of Electron Streaming

Date: February 13, 2003	
Time Span	Type of Electron Streaming

Part 5. Recording BDE values

- Access the Solar Wind Summary Data at <http://genesis.lanl.gov/plots/test/mec/1day/>
- Go to the top of the screen and click on Plots.
- Click on Solar Wind Data Summary.
- Select February 11, 2003.
- Scroll down to the bottom panel on the screen, labeled BDE, the Bi-Direction Electron indicator panel. Note that the left-hand vertical scale reads from 0.0 to 1.0. Every 2.5 minutes, the GEM assigns the BDE parameter a value of one or zero, depending on whether or not the measured electron spectrum shown in the Electron Spin Angle Distribution Plots indicates characteristics of bi-direction electron streaming.

The white solid line is the running average value of BDE. Since the BDE value at each data cycle is either a zero or a one, the running average is a value between one and zero. The red hash marks indicate a positive indication of BDE; that is, these are time when BDE average = 1. Note the width of a single hash mark. The wider marks indicate multiple cycles of BDE = 1.



- f) Record the following in the data tables below:
- 1) Time spans during which the BDE = 1 (when red hash marks are shown).
 - 2) The average BDE reading for this time period (which, in some cases when the average is changing, may be a range of averages).
 - 3) The number of cycles of BDE = 1 shown during the period. You may have to estimate the number of cycles when the hash marks are wider than a single mark.
 - 4) Go to the top of the Solar Wind Data Summary screen and record the type of solar wind regime flowing during this period.
- g) Repeat this procedure for February 12 and February 13.

February 11, 2003			
Time Span	Average BDE reading	Number of cycles of BDE = 1 (number of red hash marks)	

February 12, 2003			
Time Span	Average BDE reading	Number of cycles of BDE = 1 (number of red hash marks)	

February 13, 2003			
Time Span	Average BDE reading	Number of cycles of BDE = 1 (number of red hash marks)	

