

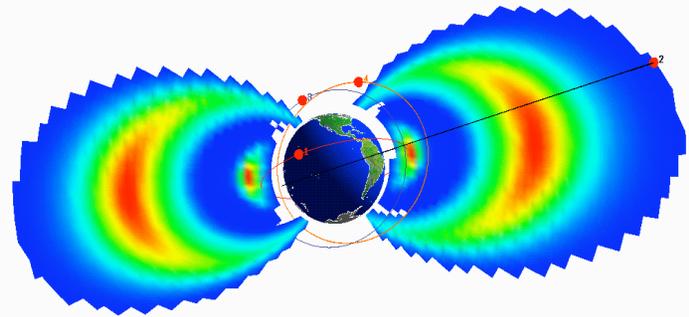


Air Force Research Laboratory

Spacecraft Space Weather Effects

Living With a Star Measurement Requirements Workshop

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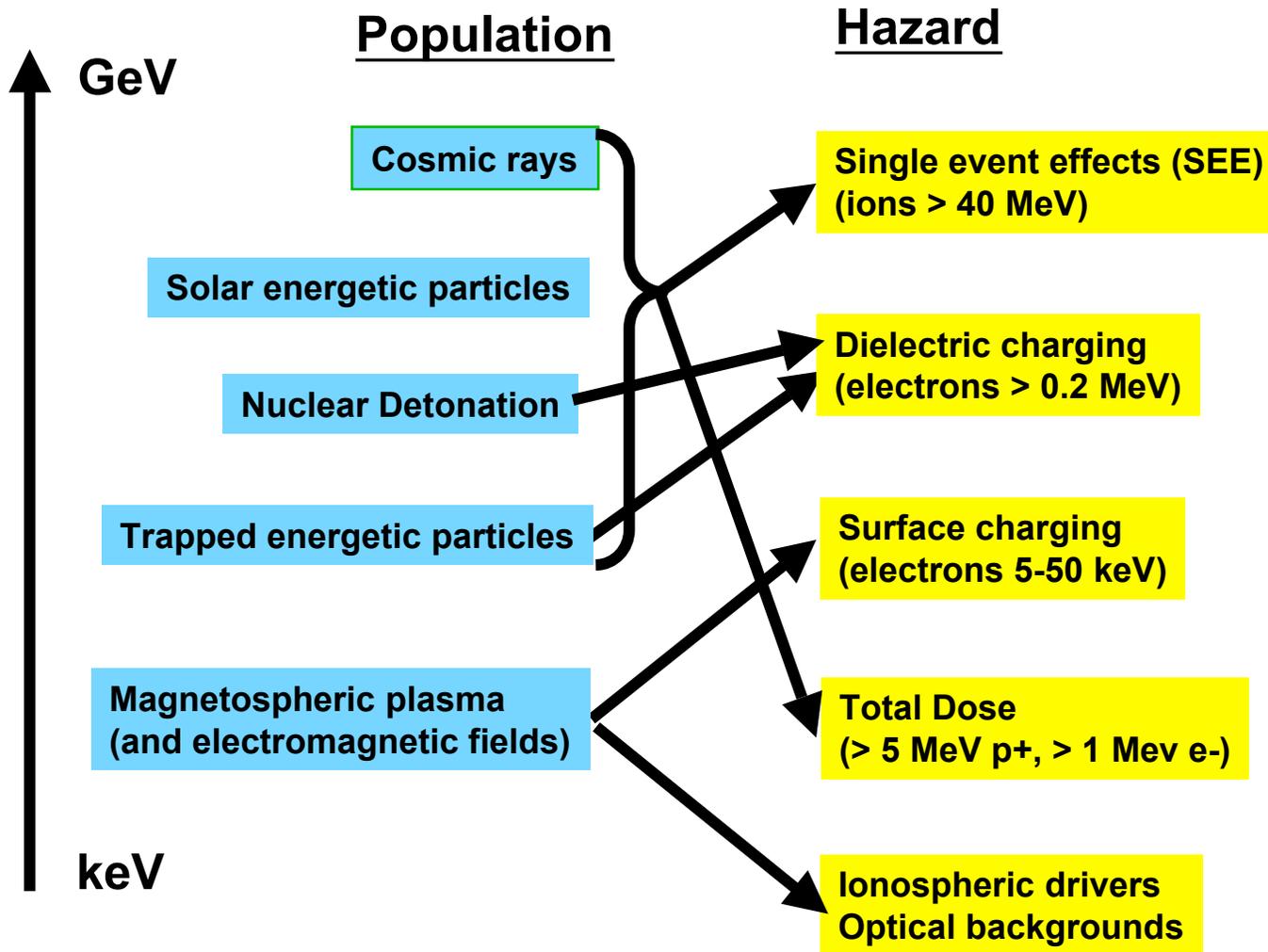
AFRL Space Weather Program Outline

- Space Weather Effects Introduction
- AFRL Radiation Belt Dynamics Program
 - Driven by military needs
 - Real-time monitors (CEASE)
 - Radiation Belt science instruments (REEPER)
 - Statistical climatology models
 - Nowcast, forecast models
 - Physics-based models
- Summary

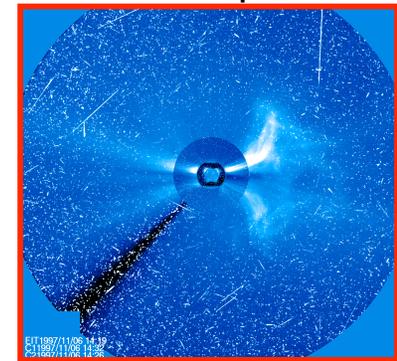


AFRL Space Weather Program - Intro

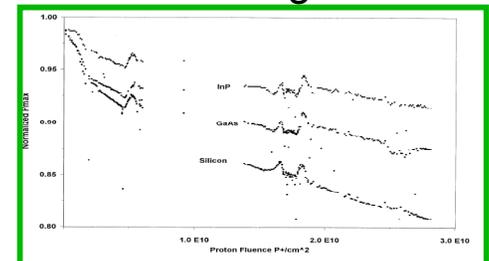
Space Particle Effects



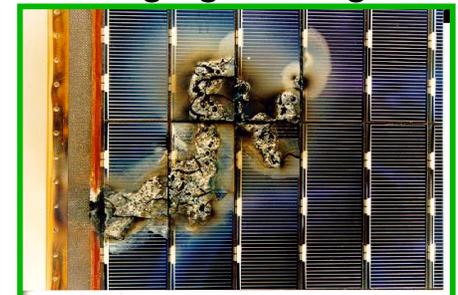
Solar Eruption



Solar Cell Degradation



Charging Damage

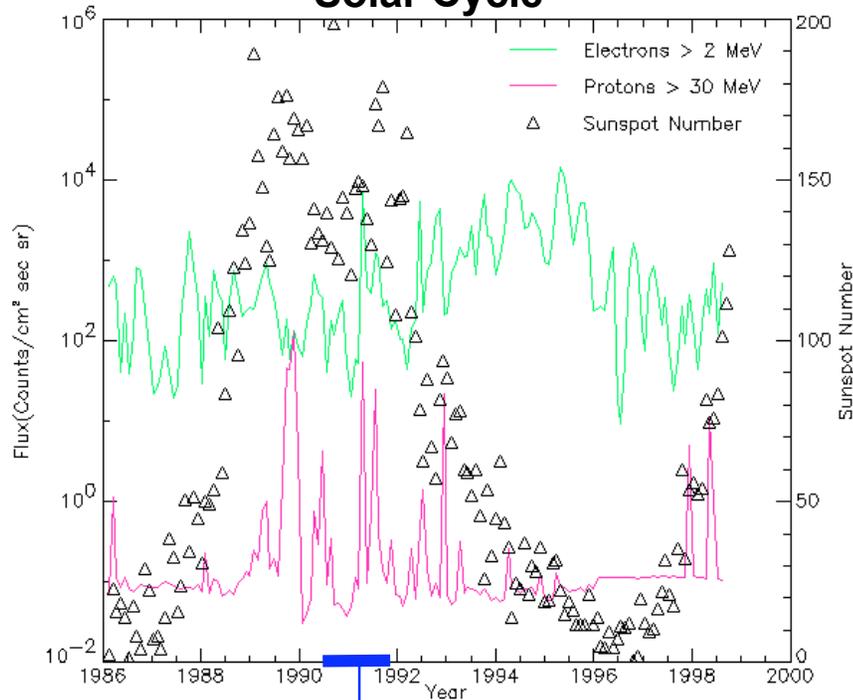




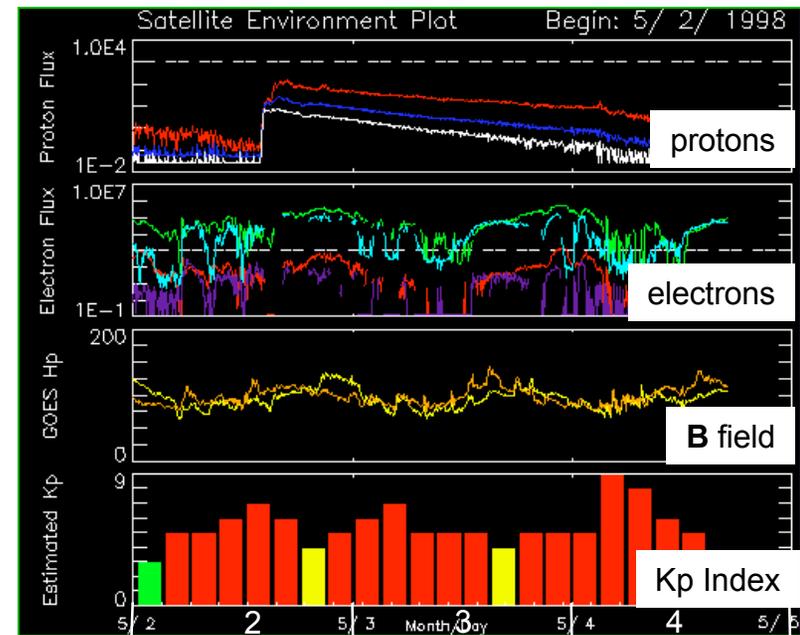
AFRL Space Weather Program - Intro

Dynamic Solar-Terrestrial Environment

Solar Cycle

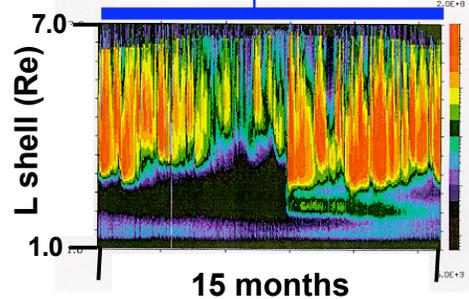


Geomagnetic Storm and Proton Event

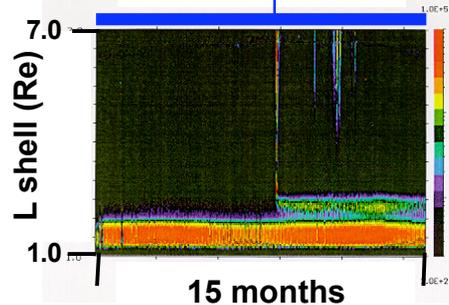


GOES data - day of May 98

Electrons



Protons



**Highly Time
Variable Radiation
Environment**



AFRL Space Weather Program Military Needs

NSSA Findings and Recommendations

From Recommendation #1: Space Weather Architecture Vector

Significant to National Security is the capability to determine rapidly whether SWx or an adversary is degrading critical satellites. In addition, it is important to design robust satellites and rapidly recover damaged satellites.

To support these needs, it is necessary to develop and employ systems and models to provide an essential capability to specify the radiation environment at satellite altitudes. The desired capability also includes forecasting of the radiation environment at satellite altitudes.



AFRL Space Weather Program

Compact Environmental Anomaly Sensor (CEASE)

- **Miniaturized instrument to monitor:**
 - Single event effects
 - Surface and deep dielectric charging
 - Radiation dose rate, Total dose
- **Can operate in two modes:**
 - Real-time hazard warning flags
 - Detailed space environment data
- **Benefits to DoD include:**
 - Reduced satellite downtime
 - Reduced user impact from malfunctions
 - Capability to rule out hostile actions

- **STP Test Flight on TSX-5, LEO**
 - Launch: Mar 00
- **STP Test Flight on STRV-1c, GTO**
 - Launch: Apr 00
- **ACTD for CEASE-II on DSP-21, GEO**
 - Launch: Jan 01

Physical Specs:

- power: 2W
- mass: 1kg
- dimension: 10 x 10 x 10 cm³

Sensors:

- 2 Radiation dosimeters
- Particle Telescope
- Single Event Effect detector



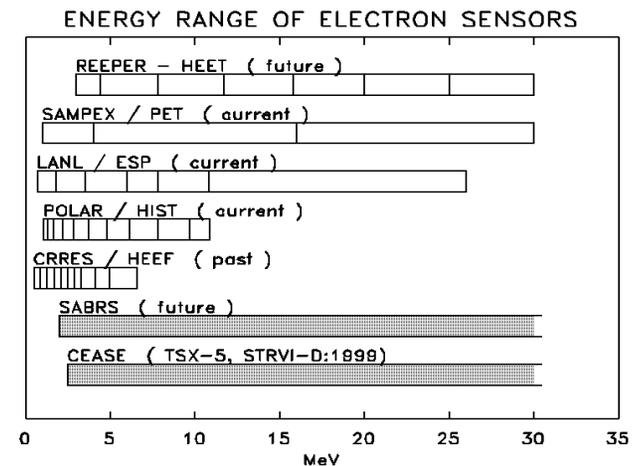
AFRL Space Weather Program

Relativistic Electron and Energetic Proton Experiment (REEPER)

DESCRIPTION

- Miniaturized instrumentation; Low power consumption
- High resolution energy measurements
- High Energy Proton (HEP)
 - 30-440 MeV protons in 22 channels
- High Energy Electron Telescope (HEET)
 - 3-30 MeV electrons in 7 channel
- Manifest on NASA IMEX satellite payload

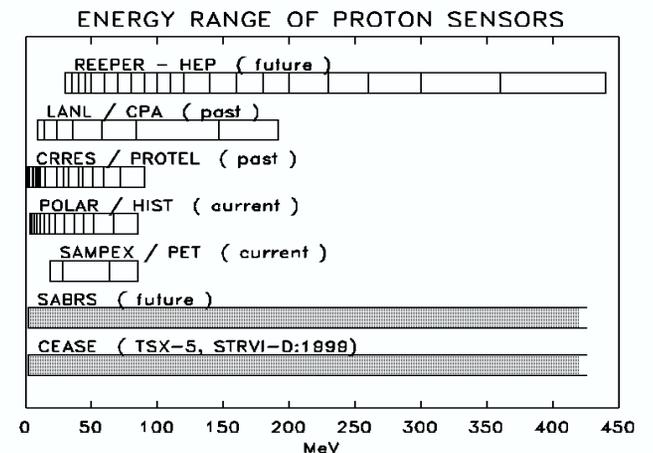
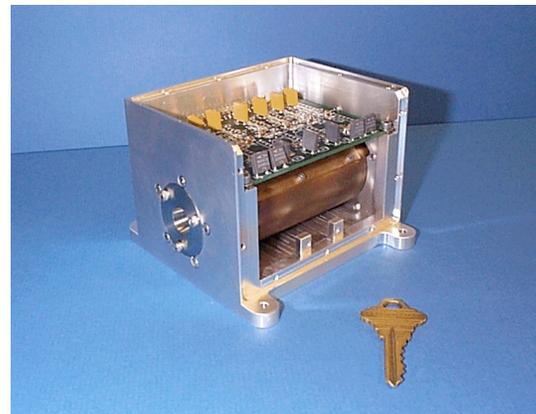
COMPARISON TO OTHER EXPERIMENTS



OBJECTIVES

- Define high energy tail of inner zone protons
- Determine the spectral hardness of inner magnetosphere electron injections

HEP Sensor Head



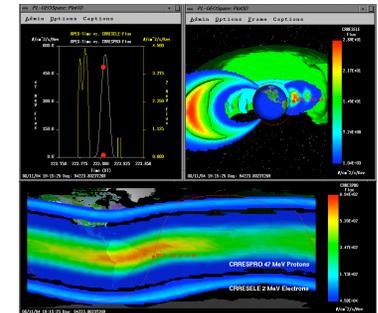


AFRL Space Weather Program

Space Particle Models

- Empirical models - primary use:
 - System design
 - Post event analysis
- Better system design models top priority
 - Give time-dependent probabilities of exceeding flux thresholds
 - Need more data !
- Forecast models valuable if warnings are timely and accurate

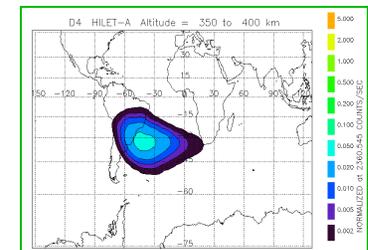
CRRES Models



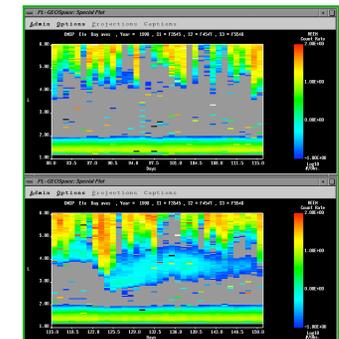
Full Spectrum of Models for Specification and Forecasting

	Distribution
Climatological	
CRRES-based cosmic ray and solar proton model	> 30
CRRES-based radiation belt models	> 300
APEX-based LEO radiation models	> 15
DMSP auroral models	> 80
Real-time specification	
DMSP-Spectra	restricted
High Energy Electron Monitor	restricted
Forecast	
Proton Prediction System	restricted
Magnetospheric Specification and Forecast Model	restricted
Above natural environment models included in AF-GEOSpace	> 70 (V1.21)

APEX LEO Model



High Energy Electron Monitor





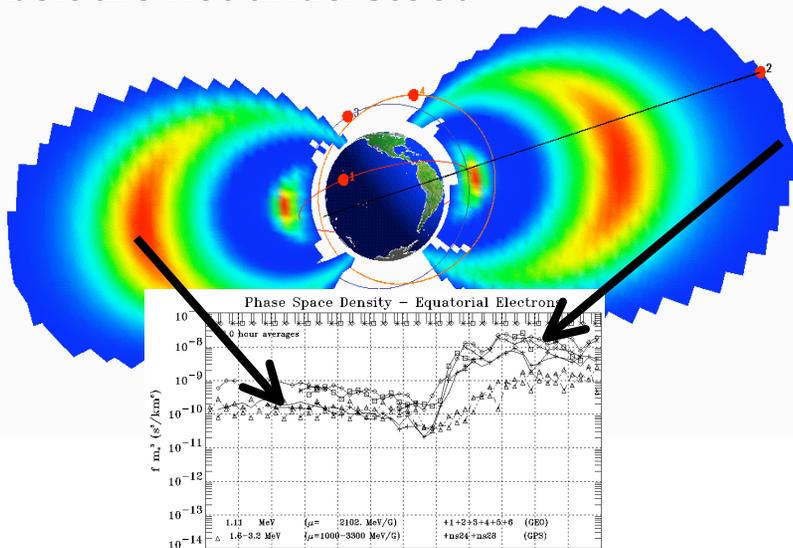
AFRL Space Weather Program

Basic Research

Electron Variability During Geomagnetic Storms

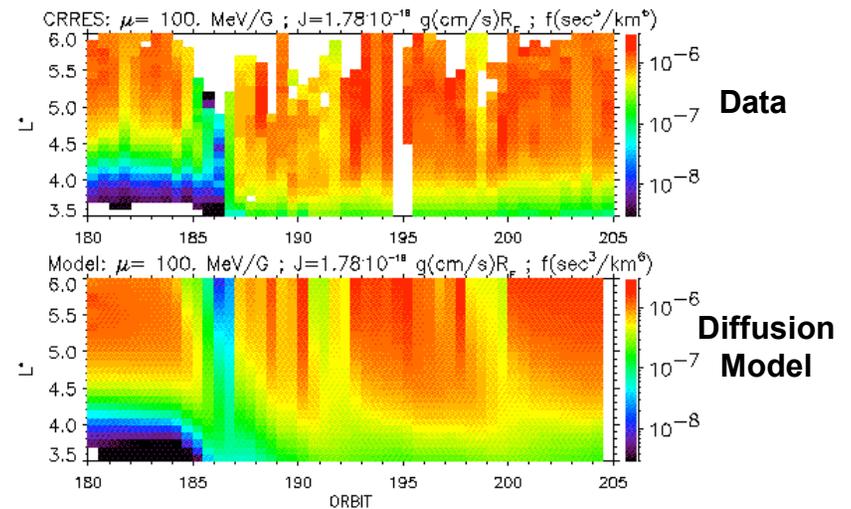
Problem

Mechanisms responsible for the dynamic variation of the 'killer' electrons in outer belt are not understood



Accomplishment

Able to reproduce observed variability of 0.5 MeV electrons with time-dependent diffusion coefficients and boundary conditions



Impact

Key step to produce accurate prediction models for natural and man-made electron radiation hazards



AFRL Space Weather Program Needs Summary

AFRL programs support NSSA Space Weather Architecture
for 2010-2025

Priorities:

1. Real-time radiation environment monitoring for anomaly resolution and situational awareness
 - Monitors on all operational satellites
2. Data coverage for climatological model development
 - Probabilities of occurrence and duration for all orbits of interest
3. Development of physics-based forecast models
 - High resolution spectral and pitch angle data
 - Better understanding of the basic physics



AFRL Space Weather Program

Possible 'Radiation Belt Mapper' Missions

- **Level 1:**
 - Simple detectors on many satellites over all orbits of interest
 - Integral or broad channel energy resolution
 - Omni or broad angular resolution
- **Level 2:**
 - Sophisticated detectors over critical orbits (e.g. GTO, Polar, GEO)
 - Detailed spectral resolution
 - Detailed pitch-angle resolution
 - Low frequency magnetometer
- **Level 3:**
 - Sophisticated detectors with broad electromagnetic field determination over critical orbits
 - Level 2 particle detectors
 - Low and high frequency magnetometer
 - DC and wave electric field instruments