

Interplanetary Energetic Particle Measurements from NASA's Heliophysics System Observatory

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DREAM-2 is a Goddard-led science team of the NASA Solar System Exploration Research Virtual Institute (SSERVI)
PI: William Farrell, NASA GSFC

Heliophysics System Observatory

Interplanetary Legacy

IMP-8

Helios 1, 2

Pioneer 10, 11

Ulysses



Voyager (2)



Solar Probe

July 31, 2018



Solar Orbiter-ESA

February 2019



SET-1

Planetary

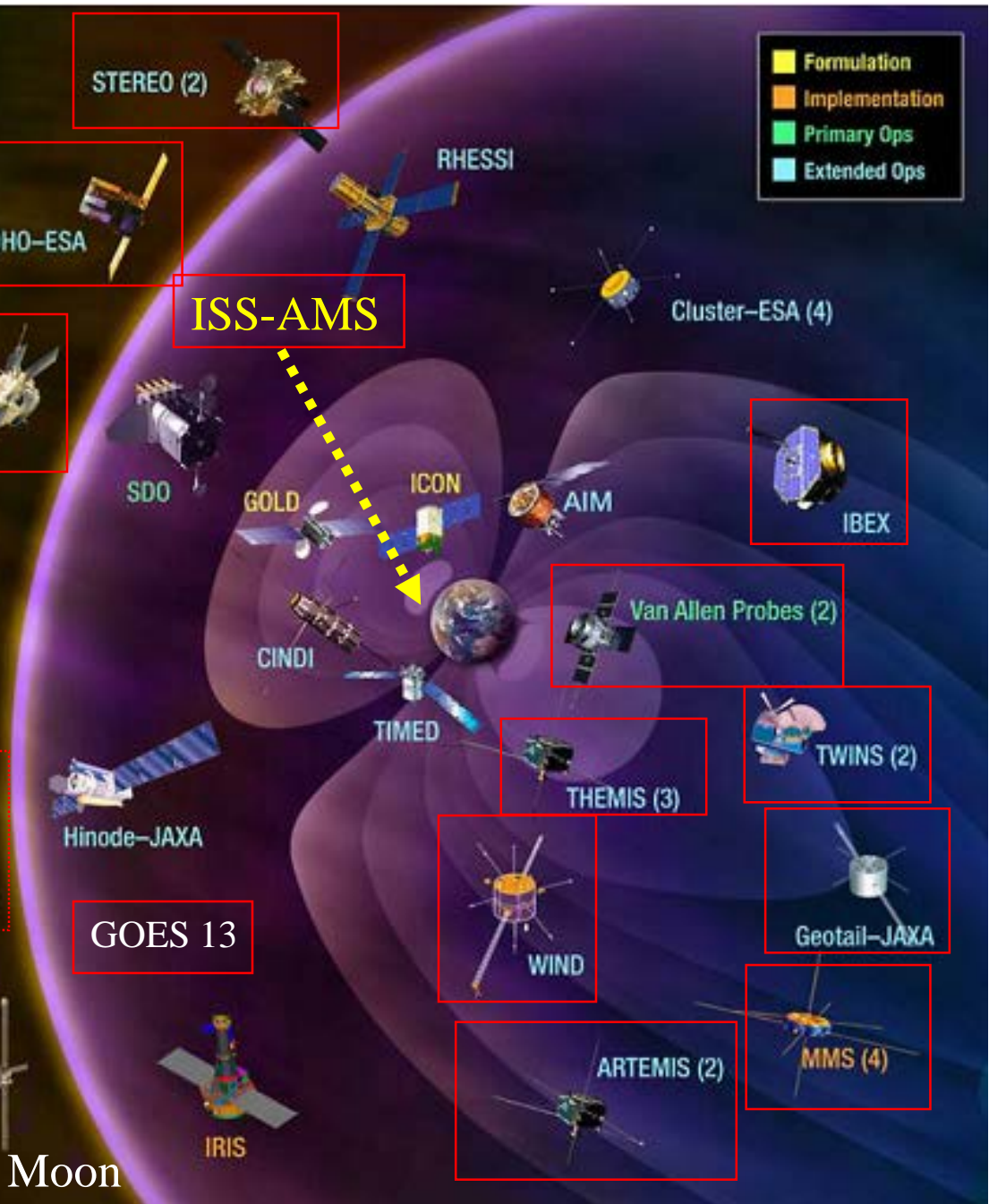
Maven, MSL - Mars

New Horizons - Pluto

Cassini - Saturn

Galileo - Jupiter

Lunar Reconnaissance Orbiter - Moon



STEREO (2)

SOHO-ESA

ACE

SDO

GOLD

ICON

AIM

IBEX

Van Allen Probes (2)

TWINS (2)

THEMIS (3)

Geotail-JAXA

WIND

ARTEMIS (2)

MMS (4)

IRIS

Hinode-JAXA

CINDI

TIMED

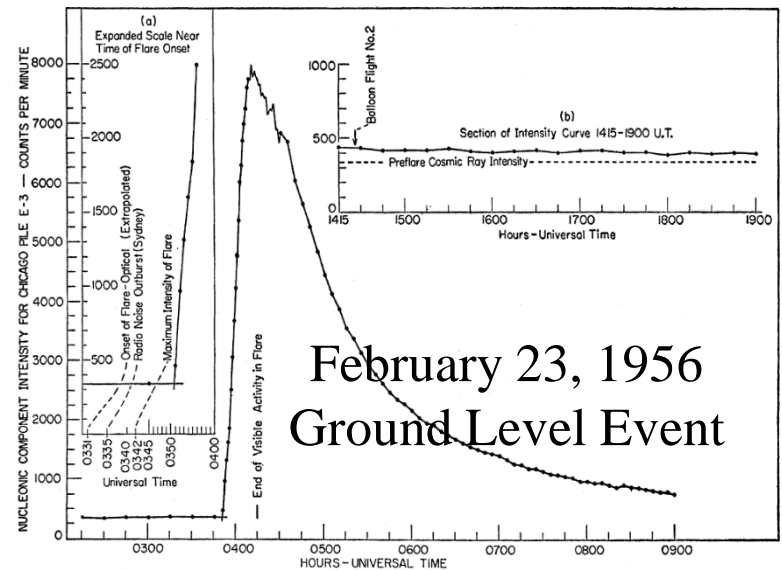
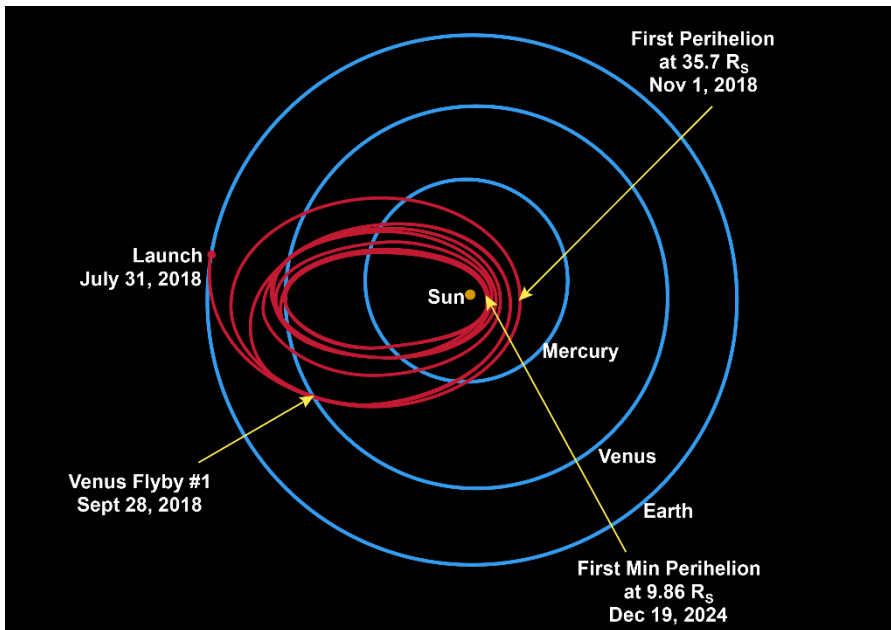
GOES 13

SET-1

| | |
|--------|----------------|
| Yellow | Formulation |
| Orange | Implementation |
| Green | Primary Ops |
| Blue | Extended Ops |



Professor Eugene N. Parker
University of Chicago

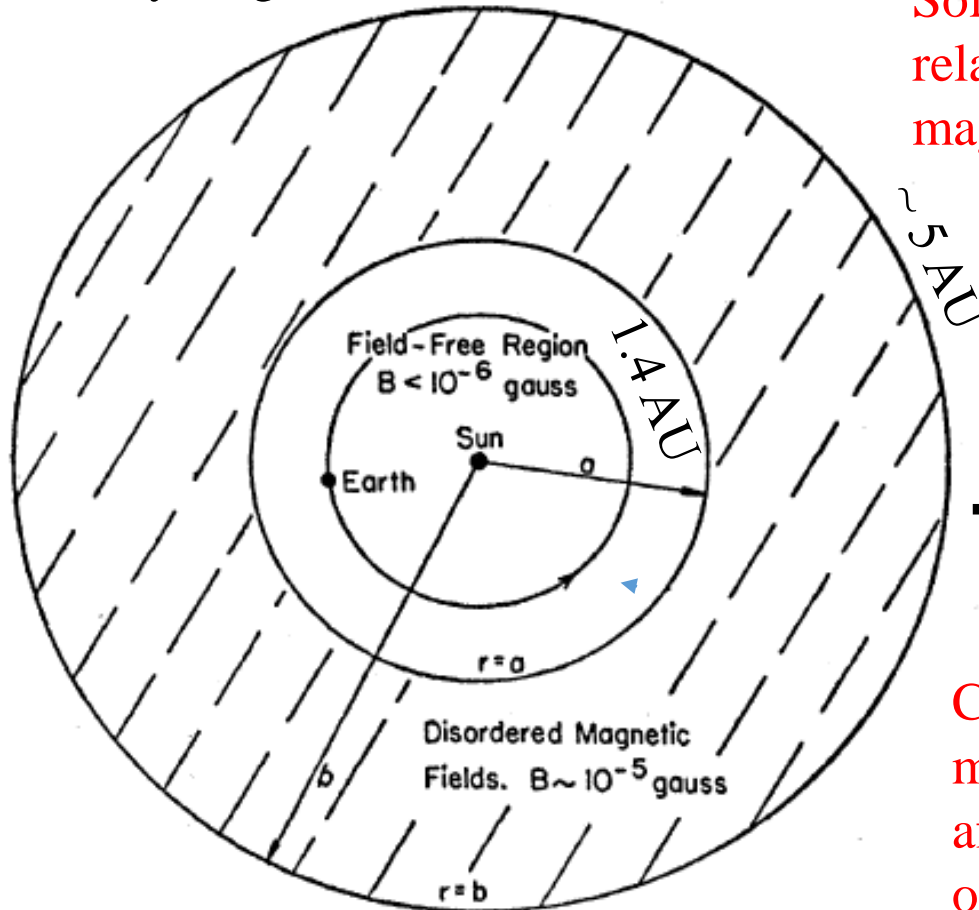


February 23, 1956
Ground Level Event

FIG. 2. Nucleonic component intensity as a function of time for the Chicago neutron monitor E-3. One-minute intervals are shown between \sim 0330 and \sim 0423 U.T. (a) Onset of intensity increase on expanded scale. (b) Period of the cosmic ray increase during which balloon flight number 2 was undertaken (see also Fig. 5).

Mars orbits at 1.38 – 1.67 AU within inner zone of the Meyer et al. shell of turbulent interplanetary magnetic fields

Solar energetic particles propagate relatively freely along solar wind magnetic field lines from Sun to Mars



Voyager 1 left the heliosphere at 122 AU on Aug. 24, 2012

Cosmic ray particles are heavily modulated at Mars and Earth after inward diffusion from the outer heliosphere and local interstellar space.

Meyer, Parker, and Simpson
(Phys. Rev., 1956)

FIG. 8. Cross section of the model for the inner solar system at the time of the solar flare of February 23, 1956. The inner volume $r=a$ represents a cavity "free" of magnetic fields (B (rms) $< 10^{-6}$ gauss). The barrier of thickness $b-a$ represents the shell-like region through which the cosmic rays diffuse.



Space Physics Data Facility

+ ABOUT

+ DATA & ORBITS

+ ModelWeb at CCMC

+ SCIENCE ENABLED

+ AND MORE

Access Data & Orbit Services

- + Heliophysics Data Portal (formerly VSPO)
- + Gateway to Services
- + CDAWeb
- + CDAWeb Inside IDL
- + OMNIWeb Plus (now including COHWeb, ATMOWeb, FTP Browser, HelioWeb and CGM)
- + Direct FTP to Data
- + Direct HTTP(S) to Data
- + SSCWeb
- + 4D Orbit Viewer
- + GIFWalk data and orbit plots

Access Models

- + Community Coordinated Modeling Ctr. (CCMC)
- + ModelWeb at CCMC

Heliophysics Virtual Observatories

- + NASA's Heliophysics Data Environment
- + Heliophysics Data Portal (formerly VSPO)
- + SPASE Data Model
- + VEPO - Virtual Energetic Particle Observatory
- + VHO - Virtual Heliospheric Observatory

NASA's Space Physics Data Facility (SPDF)

The SPDF is a project of the Heliophysics Science Division (HSD) at NASA's Goddard Space Flight Center. SPDF consists of web-based services for survey and high resolution data and trajectories. The Facility supports data from most NASA Heliophysics missions to promote correlative and collaborative research across discipline and mission boundaries. [Read More here.](#)

News & Announcements

NOTICE: The MMS Level 2 data products are available via SPDF FTP/HTTP and all data sets are available in CDAWeb . The range of publicly available MMS data will continue to be updated weekly.

NOTICE: February 13, 2017 HTTPS: The SPDF web sites (CDAWeb, OMNIWeb, SSCWeb, etc.) will be automatically redirecting HTTP requests to use the HTTPS protocol. Please begin using the HTTPS protocol directly as soon as possible and contact us with any problems. FTP data access is not affected at this time. For further information, please read the SPDF HTTPS announcement.

New CDF Version 3.6.3.1 Released

Common Data Format (CDF) Version 3.6.3.1 is now available. This release contains a minor change to the earlier release of V3.6.3.0 and includes a new leap second added for 1/1/2017. Please read the change notes that describe the changes made in this release, as well as all previous releases. Updates for Perl, IDL, Matlab, and Java interfaces and the SKTeditor CDF editor are also available.

New CDF Version 3.6.3 Released

Common Data Format (CDF) Version 3.6.3 is now available. We strongly urge all CDF users to promptly

Special Services

- + CDF/netCDF/FITS/ HDF/XML /ASCII Format Translations

SPDF Web Service APIs

- + CDAWeb
- + SSCWeb
- + Data Format Translations

Software

- + CDF (Common Data Format)
- + Space Physics use of CDF
- + Data Format Translations
- + CDF SKTEditor
- + MakeCDF
- + CDAWlib /CDFX (IDL)
- + ViSBARD (visualization)

Additional Databases

- + LunaSOX - Lunar Solar Origins Exploration
- + Magnetospheric State Database
- + Multi-satellite Bow Shock Database
- + Multi-satellite Magnetopause Crossing Database

Links

pdf.gsfc.nasa.gov

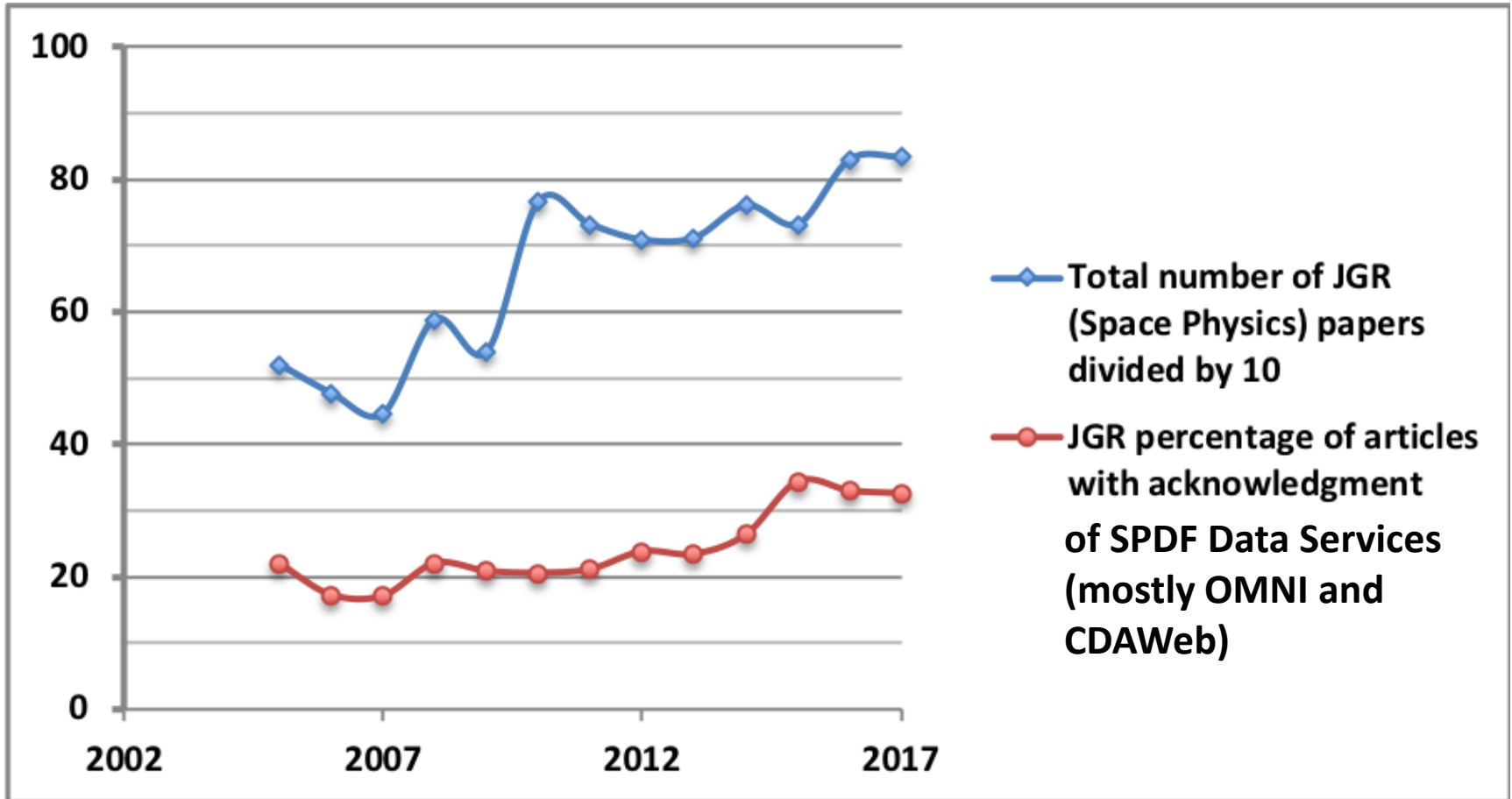
NASA Active Final Archive for non-imaging solar, geospace, and heliospheric data

Heliophysics Data Portal (VxO)

Value-Added Data Services

CDAWeb
OMNIWeb
HelioWeb
SSCWeb

Common Data Format (CDF) standards and tools





Virtual Energetic Particle Observatory

vepo.gsfc.nasa.gov

+ Home

Virtual Energetic Particle Observatory

+ Introduction

+ Data Product Information

+ Organization

+ Data Sources

+ Multi-source Spectra

LATEST VEPO NEWS Principal Investigator: John F. Cooper, NASA GSFC

+ Relativistic Electrons Uncovered with NASA's Van Allen Probes
M. Johnson-Groh, NASA/GSFC, Mar. 15, 2017

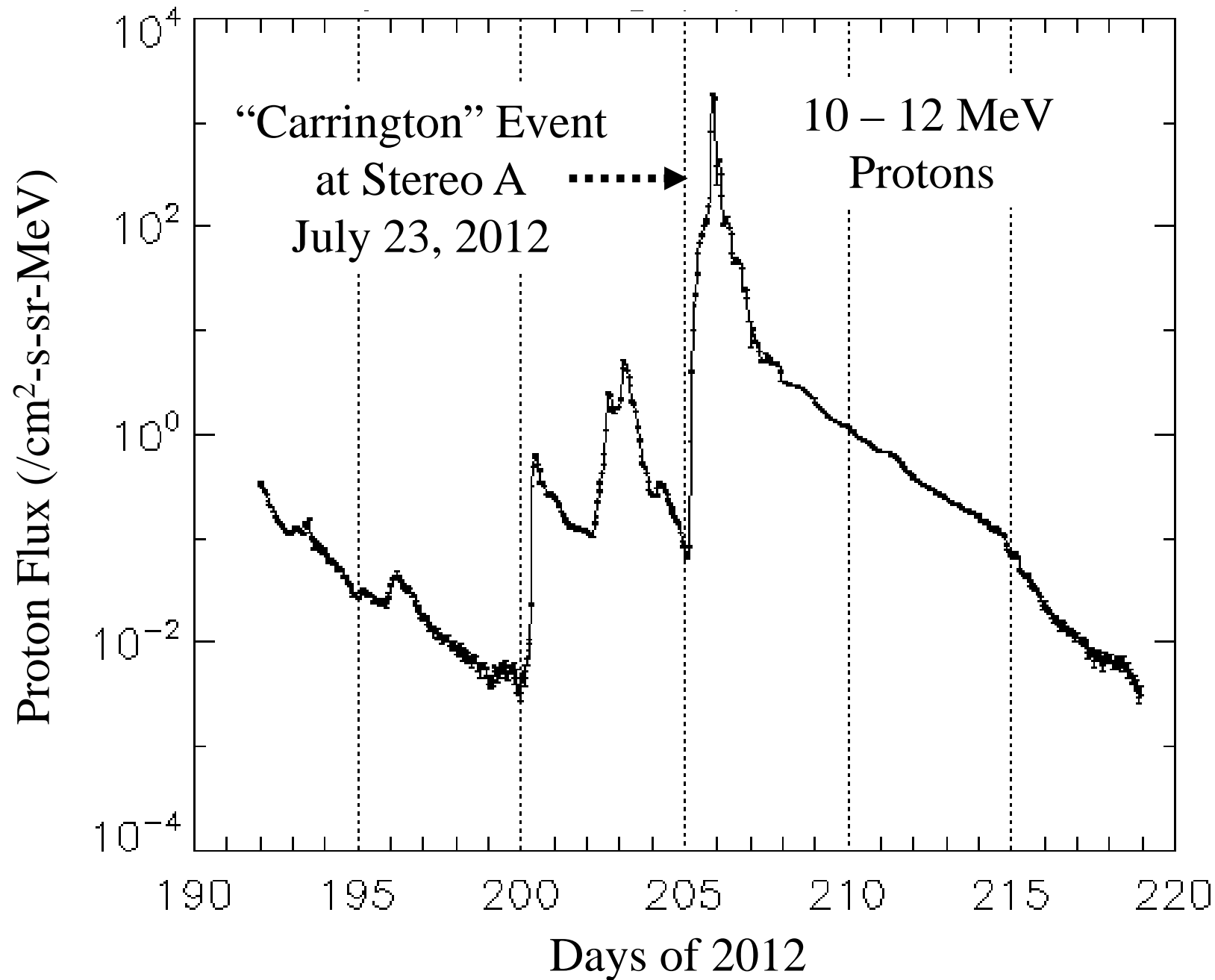
+ Alien Particles from Outer Space are Wreaking Low-grade Havoc on Personal Electronic Devices
D. Salisbury, Vanderbilt University, Feb. 17, 2017

+ Extreme Space Weather-Induced Electricity Blackouts Could Cost U.S. more than \$40 Billion Daily
American Geophysical Union, Jan. 18, 2017

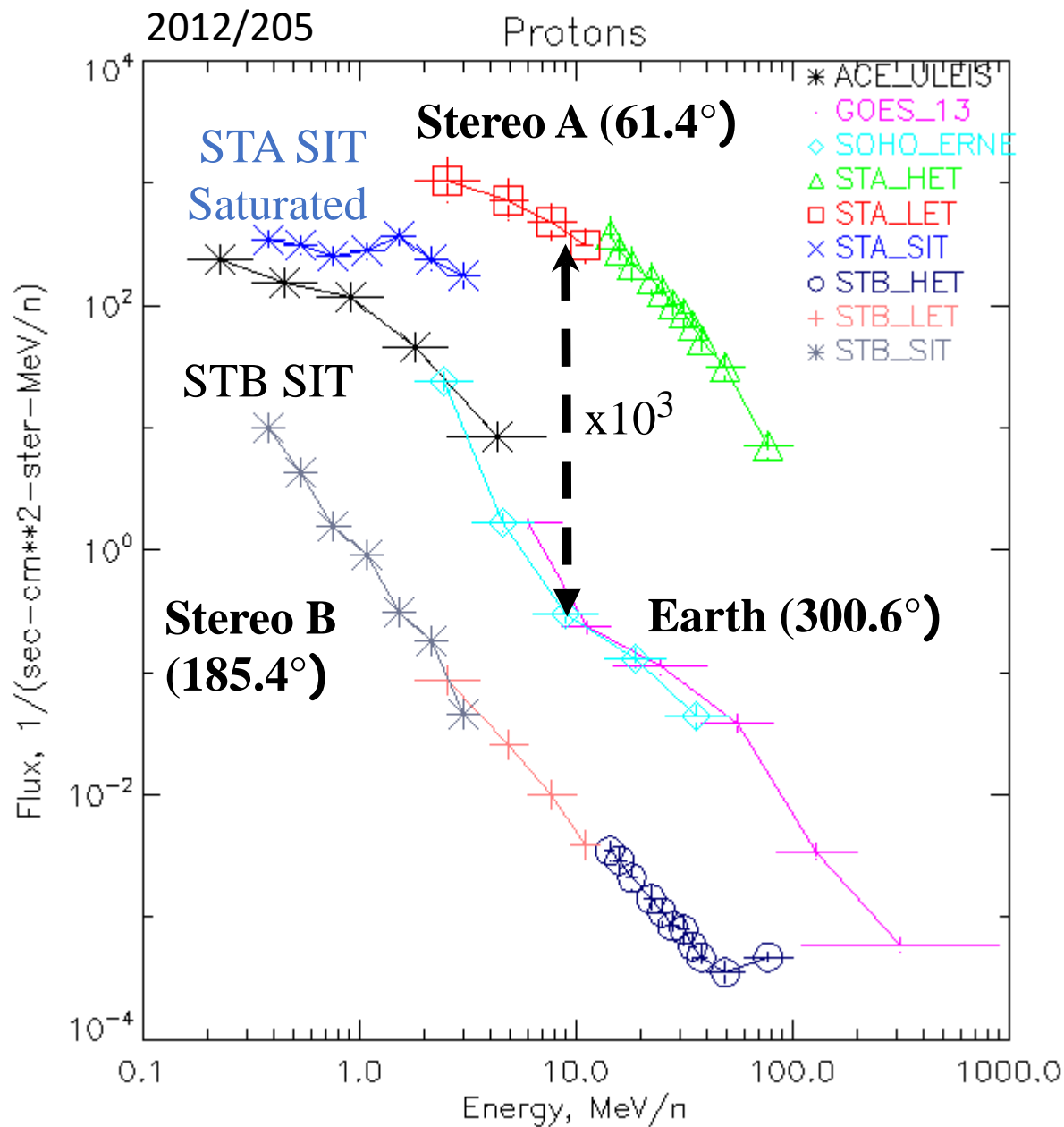
Warning: Be careful what data you look for, you may find it !

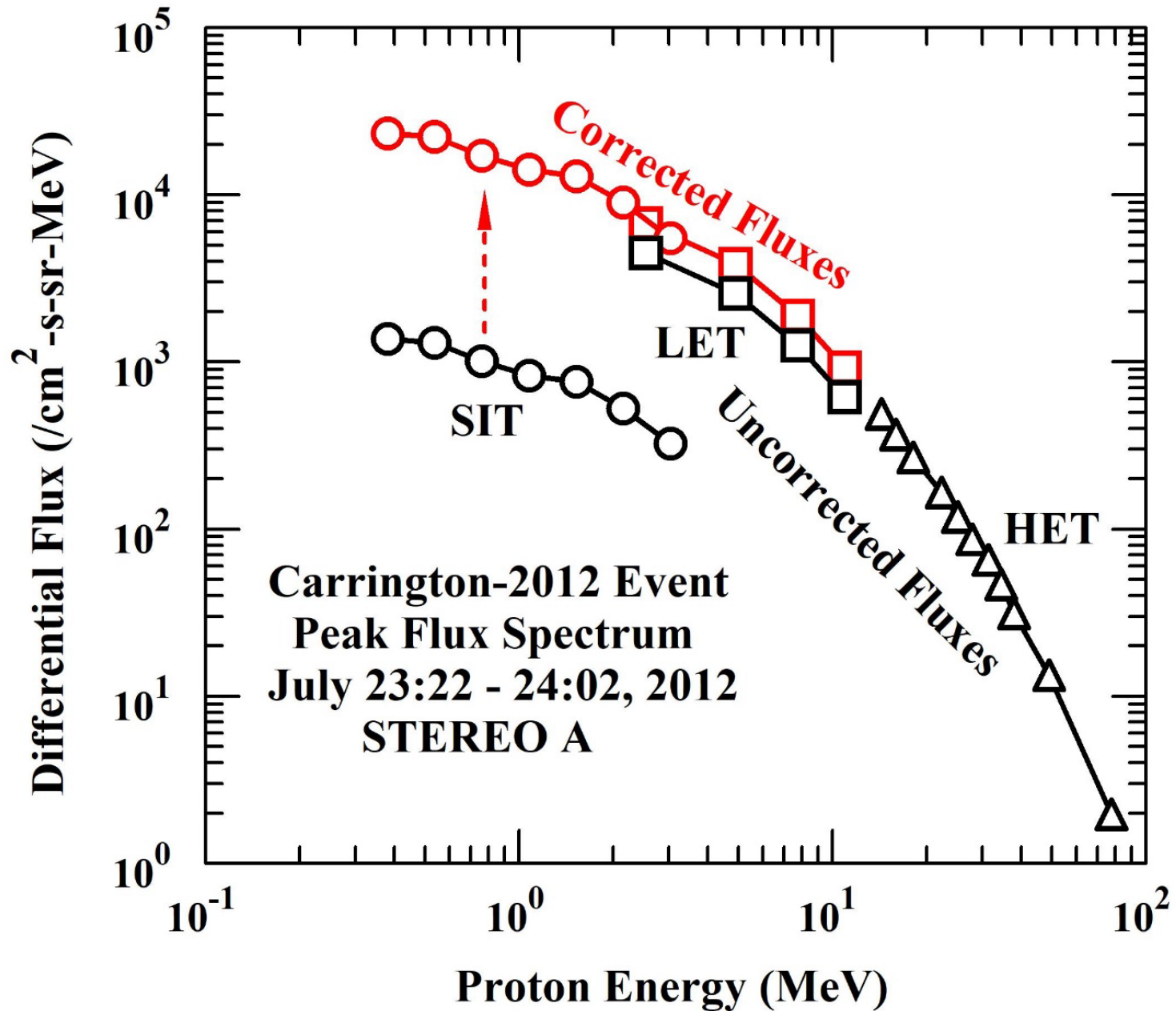
| Spacecraft or Instrument | Time Average | Ion | Time Duration | Energy Range (MeV/n) |
|--|---------------|--------------|--------------------------------|----------------------|
| Advanced Composition Explorer (ACE) | | | 1997-08-25 – Present | |
| Electron, Proton, and Alpha Monitor (EPAM) | 1 day | He | 1997-08-30 – 2015-05-30 | 0.4 – 3.9 |
| Solar Energetic Particle Ionic Charge Analyzer (SEPICA) | 1 hour | H, He | 1997-10-07 – 2005-02-05 | 0.40 – 6.0 |
| Solar Isotope Spectrometer (SIS) | 1 hour | He | 1997-08-29 – 2018-01-07 | 3.4 – 41.2 |
| Ultra-Low-Energy Isotope Spectrometer (ULEIS) | 1 hour | H, He | 1998-02-19 – 2018-01-07 | 0.06 – 8.7 |
| Helios 1 | | | 1974-12-10 – 1986-02-10 | |
| Cosmic Ray Particle Instrument (E6) | 1 hour | H, He | 1974-12-11 – 1983-12-31 | 4.0 - 51.0 |
| Cosmic Ray Instrument (E7) | 30 min | H, He | 1974-12-16 – 1982-12-31 | 3.4 - 206.5 |
| Helios 2 | | | 1976-01-15 – 1980-03-03 | |
| Cosmic Ray Particle Instrument (E6) | 1 hour | H, He | 1976-01-16 – 1980-03-08 | 4.0 - 51.0 |
| Cosmic Ray Instrument (E7) | 30 min | H, He | 1976-01-19 – 1979-12-23 | 3.4 - 204.5 |
| Interplanetary Monitoring Platform 8 (IMP-8) | | | 1973-10-26 – 2006-10-07 | |
| Charged Particle Measurements Experiment (CPME)* | | | | |
| Cosmic Ray Nuclear Composition (CRNC) Experiment | 1 hour | H,He | 1973-10-30 – 2001-10-26 | 10.9 - 95.0 |
| Goddard Medium Energy (GME) Experiment | 30 min | H,He | 1973-10-30 - 2001-10-26 | 0.9 - 237.0 |
| WIND | | | 1994-11-01 - Present | |
| Energetic Particle Acceleration, Composition and Transport (EPACT) - LEMT | 1 hour | He | 1994-11-03 - 2017-12-31 | 2.0 - 7.4 |
| EPACT - STEP | 1 hour | He | 1995-01-01 - 2017-12-17 | 0.04 - 2.5 |

| Spacecraft or Instrument | Time Average | Ion | Time Duration | Energy Range (MeV/n) |
|---|---------------|--------------|--------------------------------|----------------------|
| Pioneer 10 | | | 1972-03-03 – 2003-01-23 | |
| Charged Particle Instrument (CPI) | 15 min | H, He | 1972-03-03 – 1992-08-27 | 3 - 67 |
| Cosmic Ray Telescope (CRT) Experiment | 6 hour | H, He | 1972-03-06 – 1994-12-31 | 3.4 - 413.0 |
| Pioneer 11 | | | 1973-04-06 – 1995-09-30 | |
| Charged Particle Instrument (CPI) | 15 min | H, He | | 3 - 67 |
| Cosmic Ray Telescope (CRT) Experiment | 6 hour | H, He | 1973-04-06 – 1994-12-31 | 3.4 - 413.0 |
| Solar Heliospheric Observatory (SOHO) | | | 1995-12-02 – Present | |
| Energetic and Relativistic Nuclei and Electron (ERNE) Experiment | 1 hour | H, He | 1996-05-07 – 2017-12-25 | 1.3 - 130.0 |
| Solar Terrestrial Relations Observatory A (STEREO A) | | | 2006-10-26 – Present | |
| IMPACT/SEP High Energy Telescope (HET) | 1 hour | H | 2006-12-01 - 2018-01-14 | 13.6 - 100. |
| IMPACT/SEP Low-Energy Telescope (LET) | 1 hour | H, He | 2007-03-29 - 2017-11-30 | 1.8 - 15.0 |
| IMPACT/SEP Suprathermal Ion Telescope (SIT) | 1 hour | H, He | 2007-01-01 - 2017-09-14 | 0.1 - 10.2 |
| Solar Terrestrial Relations Observatory B (STEREO B) | | | | |
| IMPACT/SEP High Energy Telescope (HET) | 1 hour | H | 2006-12-01 - 2014-09-27 | 13.6 - 100. |
| IMPACT/SEP Low-Energy Telescope (LET) | 1 hour | H, He | 2007-03-29 - 2014-09-27 | 1.8 - 15.0 |
| IMPACT/SEP Suprathermal Ion Telescope (SIT) | 1 hour | H, He | 2007-01-27 - 2014-09-29 | 0.1 - 10.2 |
| Ulysses | | | | |
| Cosmic Ray and Solar Particle Investigation (COSPIN) | 1 day | H, He | 1990-10-23 - 2009-06-30 | 2.0 - 95.0 |
| Heliosphere Instrument for Spectra, Composition and Anisotropy at Low Energies (HISCALE) | 1 day | He | 1990-11-14 - 2009-06-09 | 0.3 - 3.9 |



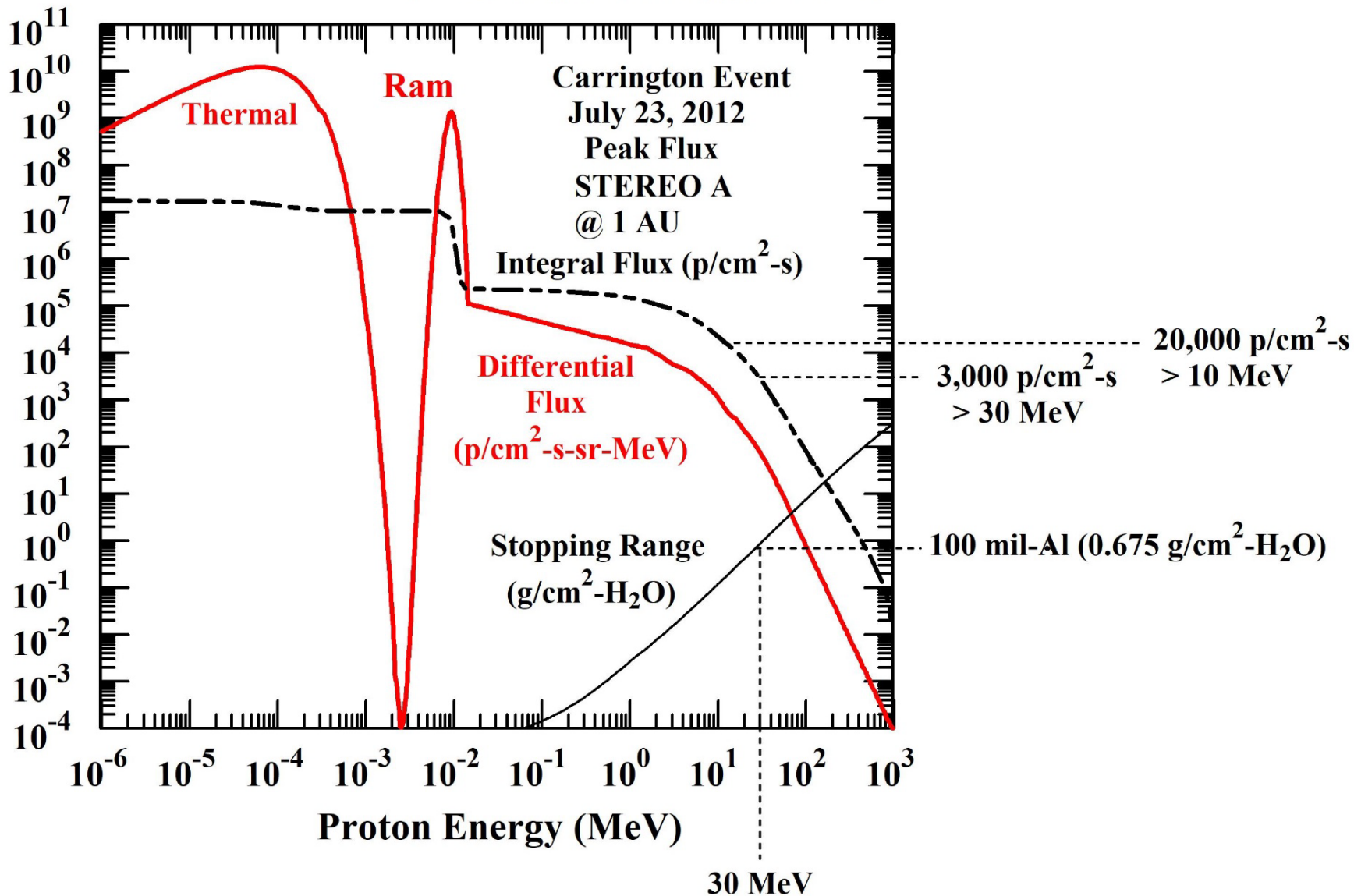
“1859 Carrington Event” at Stereo A (STA): July 23, 2012





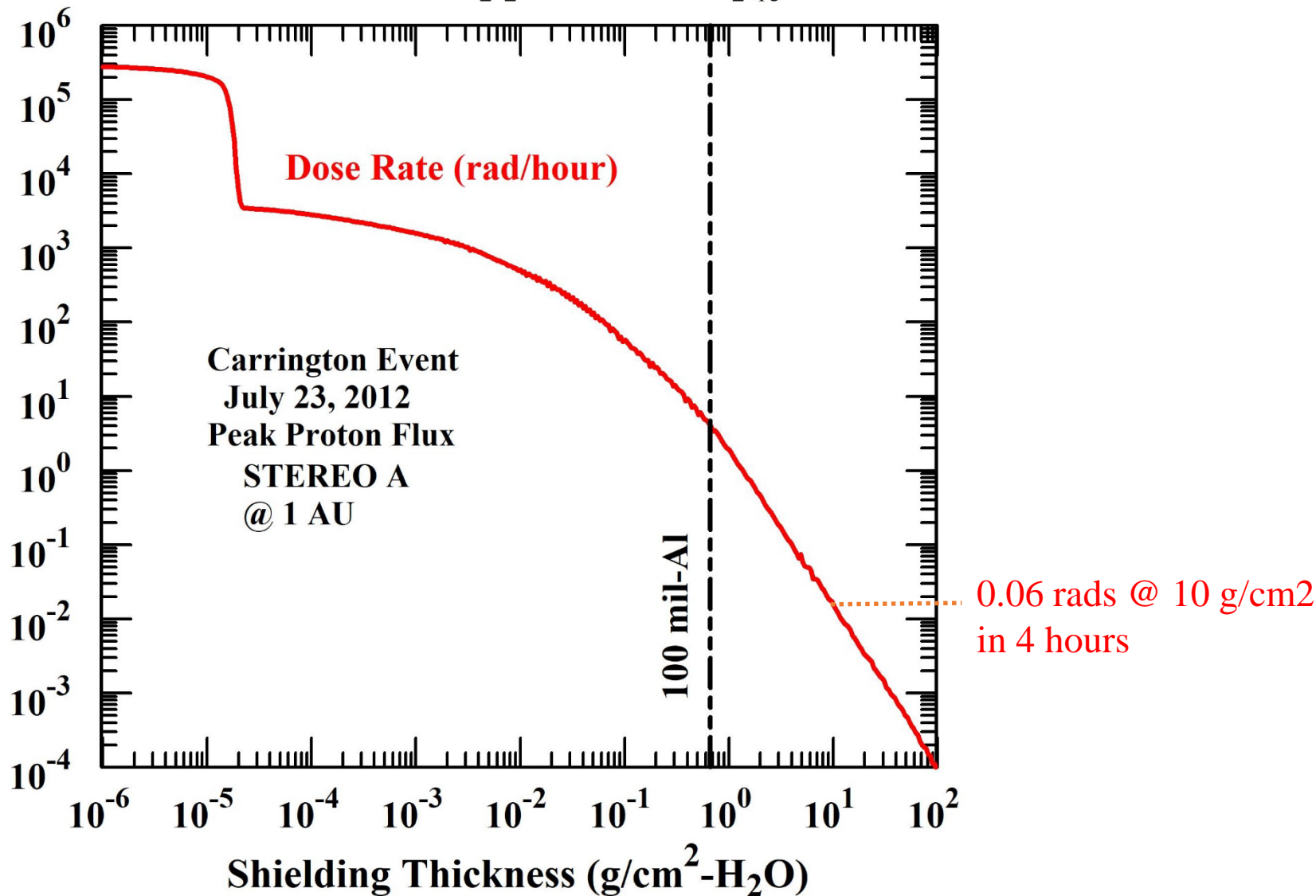
3-D Average Directional Proton Flux Spectrum Worst Case: Peak Flux, July 23, 2012 "Carrington" Event

MSSP1_H_CARRINGTON20120723_b.pgw JFC 2018-04-13



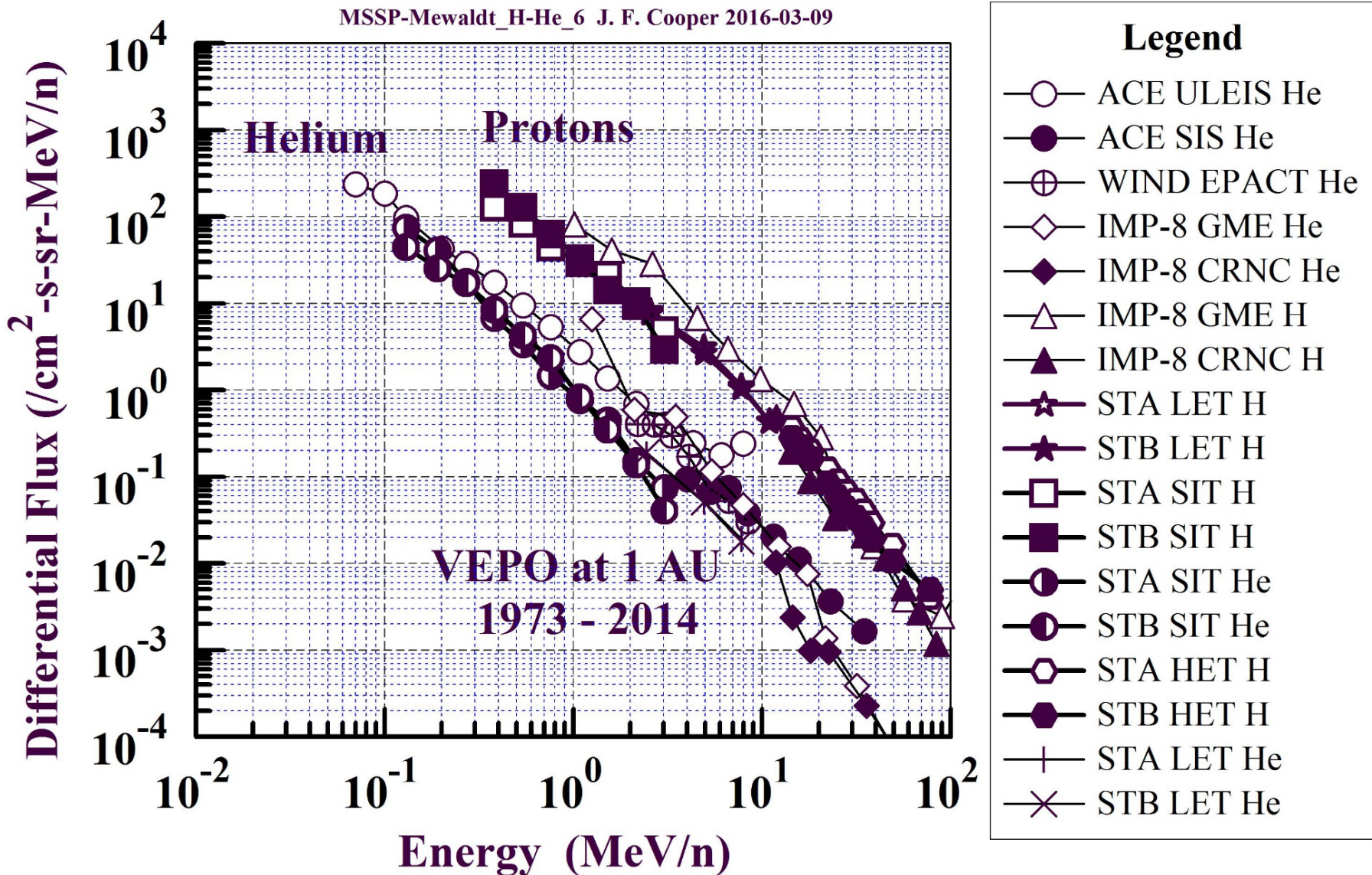
3-D Average Omnidirectional Background Worst Case: Peak Flux, July 23, 2012 "Carrington" Event

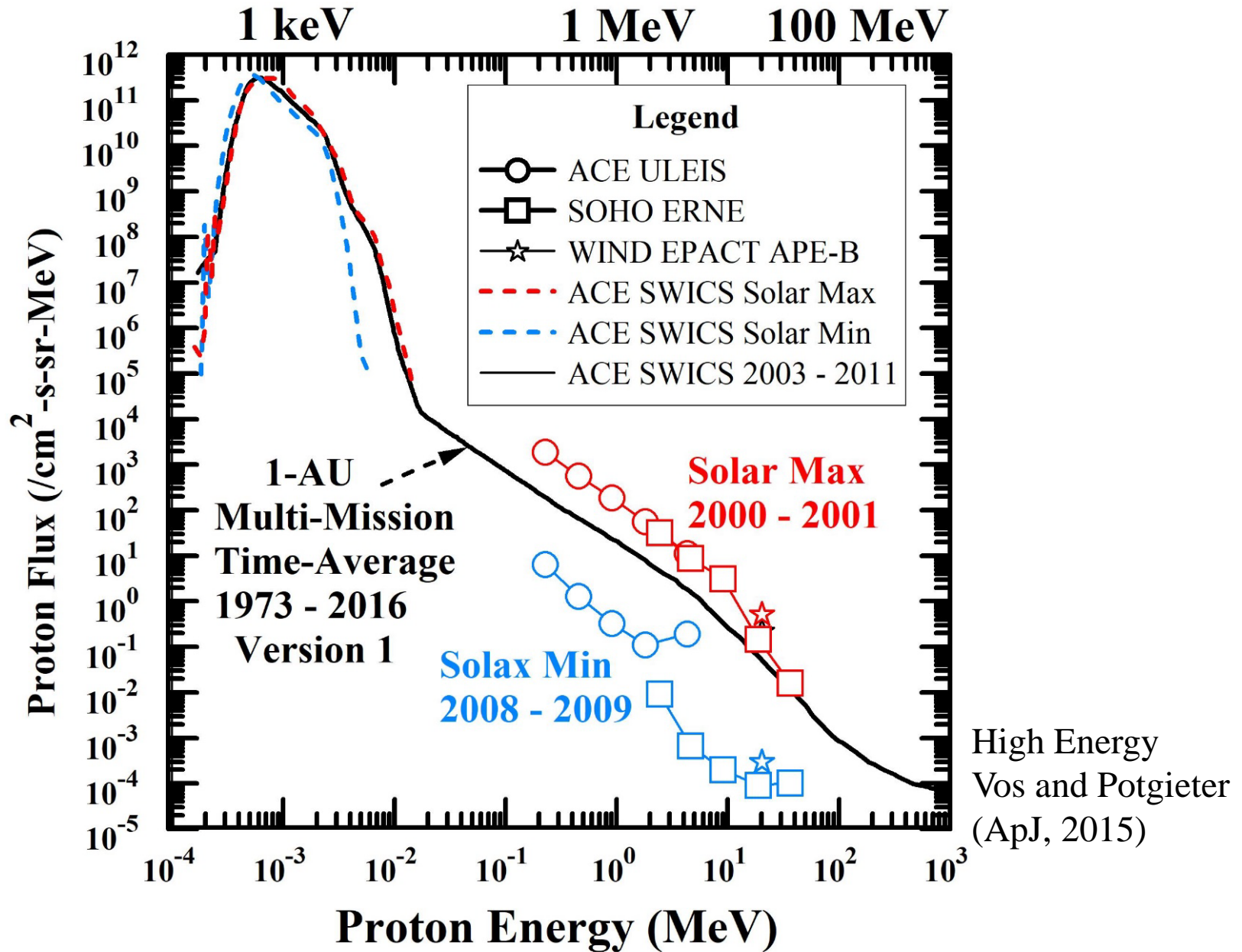
MSSP1_H_CARRINGTON20120723_d.pgw JFC 2018-04-13



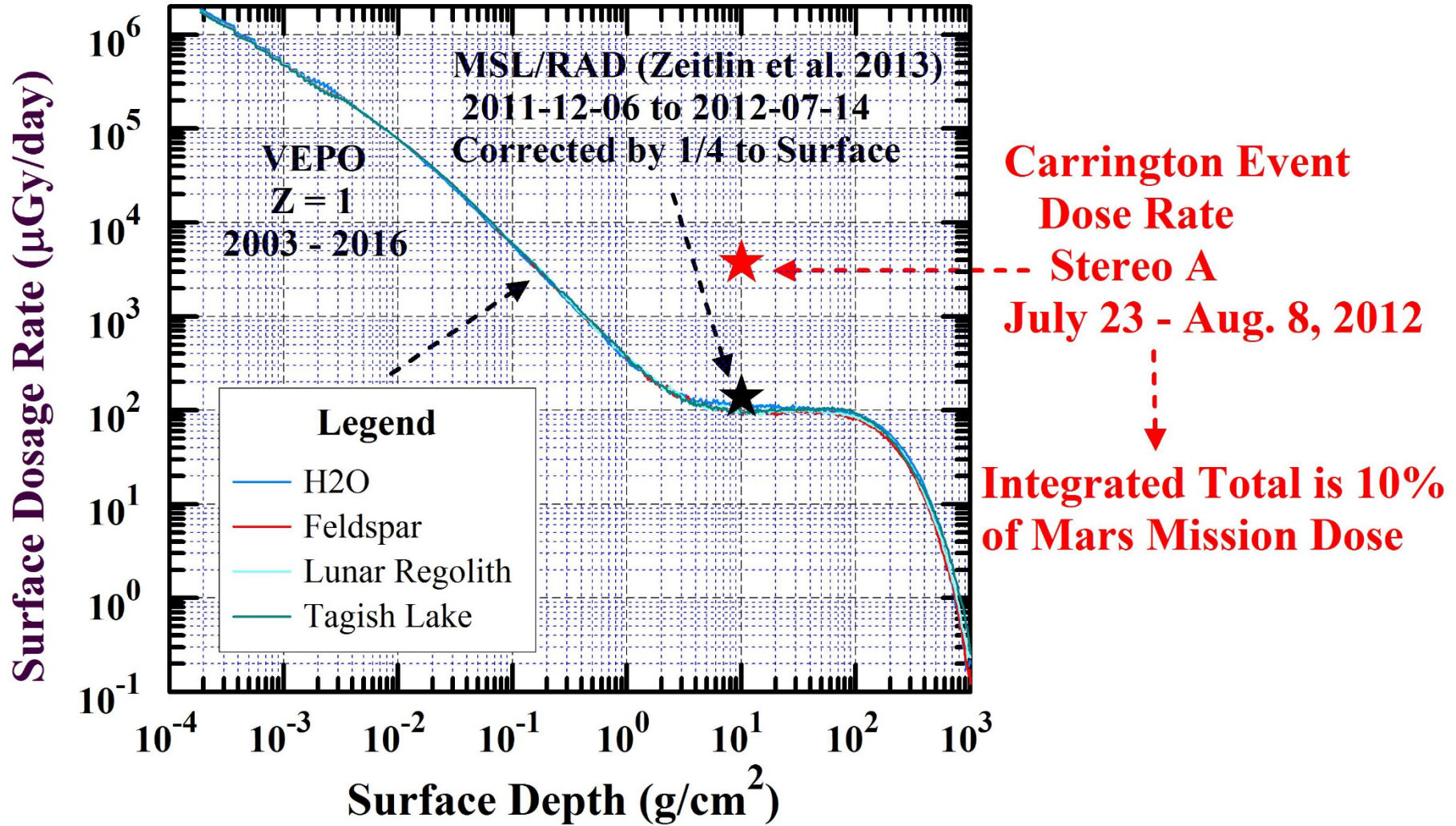
What are the time-averaged proton and helium ion flux spectra at 1 AU?

Composite Proton and Helium Spectra at 1 AU from VEPO MSSP-1 Data





Phobos Surface Radiation Model Version 1 (Protons > 10 keV)





Our future habitats on
the Moon and Mars

