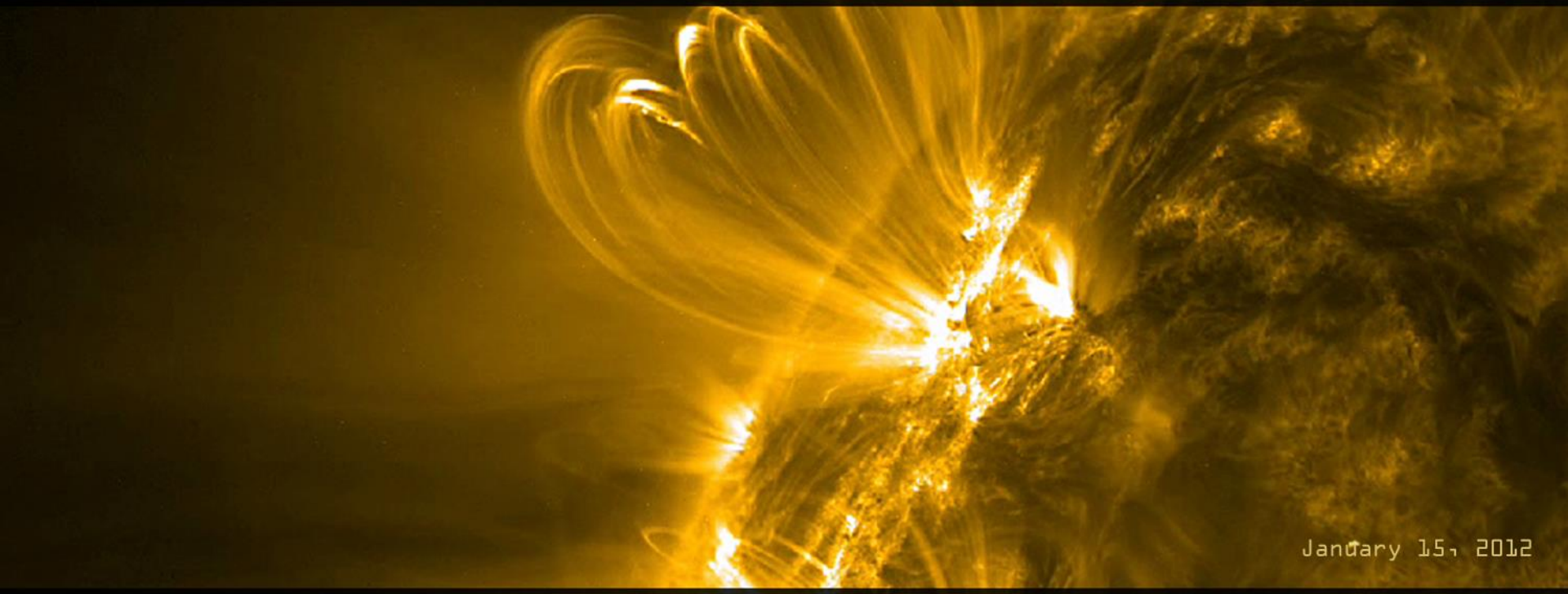
National Aeronautics and Space Administration




# Heliophysics

NAC Science Committee Presentation

Heliophysics Subcommittee Report

Maura Hagan

7 April 2015

# Heliophysics Subcommittee Membership

HPS Membership

- Vassilis Angelopoulos (University of California, Los Angeles)
- Spiro Antiochos (NASA Goddard Space Flight Center)
- Jill Dahlberg (Naval Research Lab)
- Mihir Desai (Southwest Research Institute)
- Maura Hagan (National Center for Atmospheric Research)
- W. Jeffrey Hughes (Vice Chair; Boston University)
- Michael Liemohn (University of Michigan)
- Ralph McNutt (Johns Hopkins University Applied Physics Lab)
- Neil Murphy (Jet Propulsion Lab)
- James Russell III (NASA Langley Research Center)
- W. Kent Tobiska (Space Environment Technologies)

# 30-31 March 2015 HPS Meeting

- HPD Overview and Budget Outlook ➔ Jeff Newmark's Presentation
- HPD Flight Status Report ➔
  - Two Findings
- HPD Director Update
- Geospace MOWG Report
- Two-Step Proposal Process
- Senior Review Guidelines
- MMS Update
- R&A programs update/assessment
- Other Discussion Topics
- Topics Deferred for Future Discussion

# HPS March 2015 Finding

**Finding**: The HPS applauds the imminent release of the Heliophysics Science and Technology Roadmap for 2014-2033.

**Major Reasons for the Finding**: The HPS Subcommittee approved the roadmap at its April 2014 meeting. Timely release of the roadmap following its approval maximizes the usefulness of the document.

# HPS March 2015 Finding

**Finding**: The HPS applauds the Heliophysics Division (HPD) Leadership on their plan to realize the objectives of the 2013 Decadal Survey for Solar and Space Physics (DS). HPS especially commends HPD on the plan to invest $40M additional funds into the competed research and analysis (R&A) programs in future years, to reestablish the Explorer program AO cadence to every 2-3 years, and to add more frequent Missions of Opportunity (MoO).

**Major Reasons for the Finding**: After completion of the current program, the two highest priority recommendations from the DS were implementation of the Diversify, Realize, Integrate, Venture, Educate (DRIVE) initiative and acceleration of the cadence of the Explorer program, including regular MoO opportunities. Following these recommendations provides key tools that will allow the heliophysics community to effectively address the DS science objectives.

# 30-31 March 2015 HPS Meeting

- HPD Overview and Budget Outlook
- HPD Flight Status Report
- HPD Director Update
  - Briefing by Geoff Yoder (NASA HQ)
  - Described recent search process and outcome; 4 highly qualified candidates interviewed; no selection
  - Unable to share details about next-step options under consideration
- Geospace MOWG Report
- Two-Step Proposal Process
- Senior Review Guidelines
- MMS Update
- R&A programs update/assessment
- Other Discussion Topics
- Topics Deferred for Future Discussion

# HPS March 2015 Recommendation for SC Consideration

**Recommendation for SC Consideration**: The HPS recommends that NASA SMD management take appropriate steps to establish permanent Heliophysics Division (HPD) leadership in a timely fashion. As with previous appointments, the HPD Director should be a highly experienced, well-respected heliophysics scientist. The HPS also recommends that SMD management communicate to the broader heliophysics community the importance of heliophysics science to NASA and the nation. This communication should include assurance that SMD will continue to maintain a distinct HPD, and a detailed plan for establishing permanent leadership for the HPD.

**Major Reasons for Proposing the Recommendation**: The continued lack of permanent leadership is a source of great concern to the HPS and the heliophysics community.

**Consequences of No Action on the Proposed Recommendation**: The lack of permanent leadership could stagnate the HPD program, lead to missed opportunities, and impact the morale of the entire community.

# 30-31 March 2015 HPS Meeting

- HPD Overview and Budget Outlook
- HPD Flight Status Report
- HPD Director Update
- Geospace MOWG Report
- Two-Step Proposal Process
  - Briefings by Mona Kessel and Arik Posner (NASA HQ)
  - Process analyses and outcomes (see next slide)
  - Recommended continuing two-step process going forward
- Senior Review Guidelines
- MMS Update
- R&A programs update/assessment
- Other Discussion Topics
- Topics Deferred for Future Discussion

# 30-31 March 2015 HPS Meeting

## HPD Two-Step Proposal Process 2013-2014

- Non-binding feedback to the PIs
  - Step-2 proposals were encouraged or discouraged after review of Step-1 proposals
- 2013 Guest Investigator (H-GI) Program Outcomes
  - 53% reduction in number of proposals from Step-1 to Step-2
  - 13% of discouraged Step-1 proposers submitted to Step-2
  - 1 discouraged Step-1 proposal recommended for selection
- 2014 H-GI Program Outcomes
  - 49% reduction in number of proposals from Step-1 to Step-2
  - 7% of discouraged Step-1 proposers submitted to Step-2
  - no discouraged Step-1 proposals recommended for selection
- 2014 Supporting Research (SR) Program Outcomes (in progress)
  - 31% reduction in number of proposals from Step-1 to Step-2
  - 37% of discouraged Step-1 proposers submitted to Step-2
  - To date, 5 discouraged Step-1 proposals recommended for selection

# 30-31 March 2015 HPS Meeting

## HPS Two-Step Proposal Process Discussion

- Non-binding nature of the encourage/discourage Step-1 process may lead some PIs to defer their attention to the development of a truly competitive proposal document until Step-2
- Concern that five discouraged Step-1 H-SR proposals have been recommended for funding to date
- H-SR process remains in progress
- Unanimous HPS support for continuing two-step process
- Divided HPS opinion about continuing non-binding Step-1 decisions

# HPS March 2015 Finding for SC Consideration

**Recommendation**: The Heliophysics Division (HPD) should continue to use a two-step process in evaluating proposals in the guest investigator (H-GI) and supporting research (H-SR) programs, with the outcome of Step-1 being non-binding, to “encourage” or “discourage” submission to Step-2. The decision to keep the Step-1 decision non-binding should be reevaluated when more experience with the two-step process has been obtained.

**Major Reasons for Proposing the Recommendation**: The current data indicate that the two-step process cuts total effort in producing and evaluating full proposals. However, more experience is required with this approach to ensure that excellent proposals would not be eliminated in a binding Step-1 down-selection.

**Consequences of No Action on the Proposed Recommendation**: Eliminating the two-step process will increase total effort required to prepare and review proposals. Making Step-1 binding will possibly result in eliminating excellent proposals.

# 30-31 March 2015 HPS Meeting

- HPD Overview and Budget Outlook
- HPD Flight Status Report
- HPD Director Update
- Geospace MOWG Report
- Two-Step Proposal Process
- Senior Review Guidelines
- MMS Update
- R&A programs update/assessment
- Other Discussion Topics
  - Opportunity to utilize fueled secondary payload modules
    - provide access to otherwise unachievable small satellite orbits
    - expand the limits of current scientific exploration
  - Potential interest across SMD
- Topics Deferred for Future Discussion

# HPS March 2015 Finding for SC Consideration

**Finding for SC Consideration**: Future Explorer AOs should explicitly enable the use of fueled payload adapter fittings (PAFs) as part of the delivery mechanism. Any funds saved by not using a dedicated launch vehicle should be made available for the secondary payload delivery mechanism thereby enabling new science. The reliability requirements for the fueled PAF should not be those of launch vehicles but similar to those of a spacecraft's propulsion subsystem.

**Major Reasons for Proposing the Recommendation:** It is in the spirit of the Decadal survey recommendation to implement the DRIVE initiative, calling for Diversification of observing platforms with microsatellites. Fueled PAF delivery has the potential to enable a wider range of orbits even for multi-spacecraft missions (including constellations) within the Explorer line. The reliability of a fueled PAF system can be assessed as part of the mission development, in the same way as an on-board propulsion system.

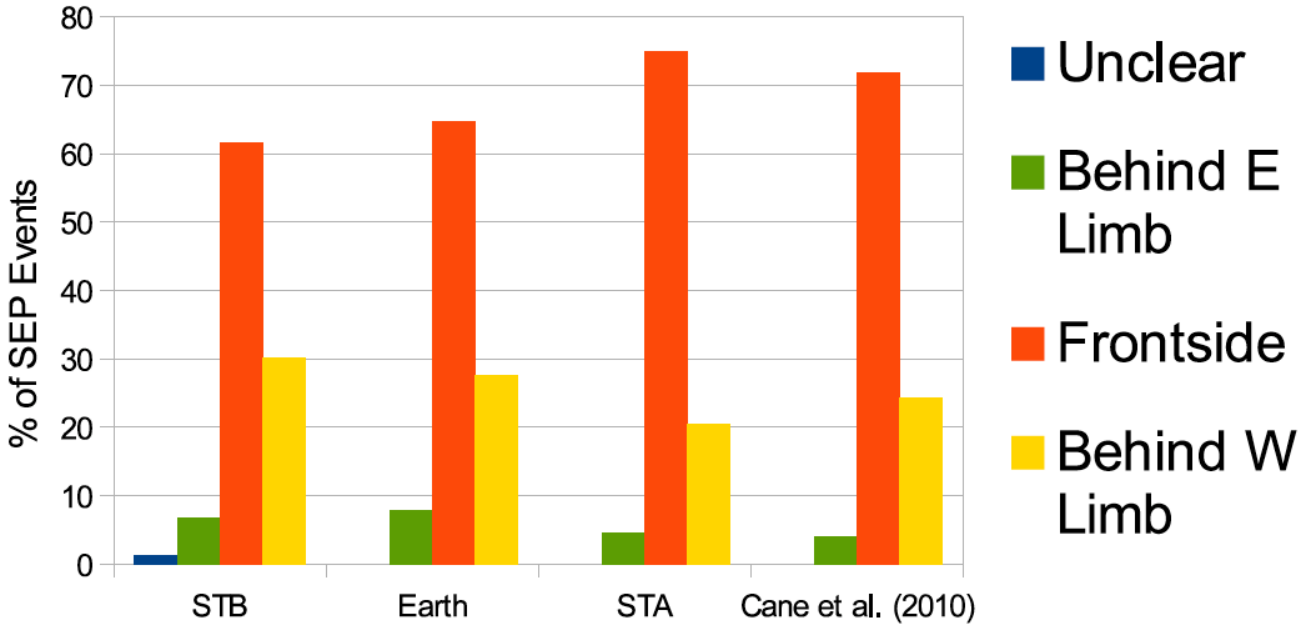
**Consequences of No Action:** A wide range of orbits would be unavailable if fueled PAFs are not utilized for new science, particularly for smaller spacecraft missions or constellations.

# 30-31 March 2015 HPS Meeting

- HPD Overview and Budget Outlook
- HPD Flight Status Report
- HPD Director Update
- Geospace MOWG Report
- Two-Step Proposal Process
- Senior Review Guidelines
- MMS Update
- R&A programs update/assessment
- Other Discussion Topics
- Topics Deferred for Future Discussion
  - Better distinguish the H-GI and H-SR program elements for ROSES 2016
  - MMS and/or synergistic HSO science H-GI proposals and awards
  - HPD staffing needs
  - Heliophysics observations using airborne platforms

# Heliophysics Science Highlights

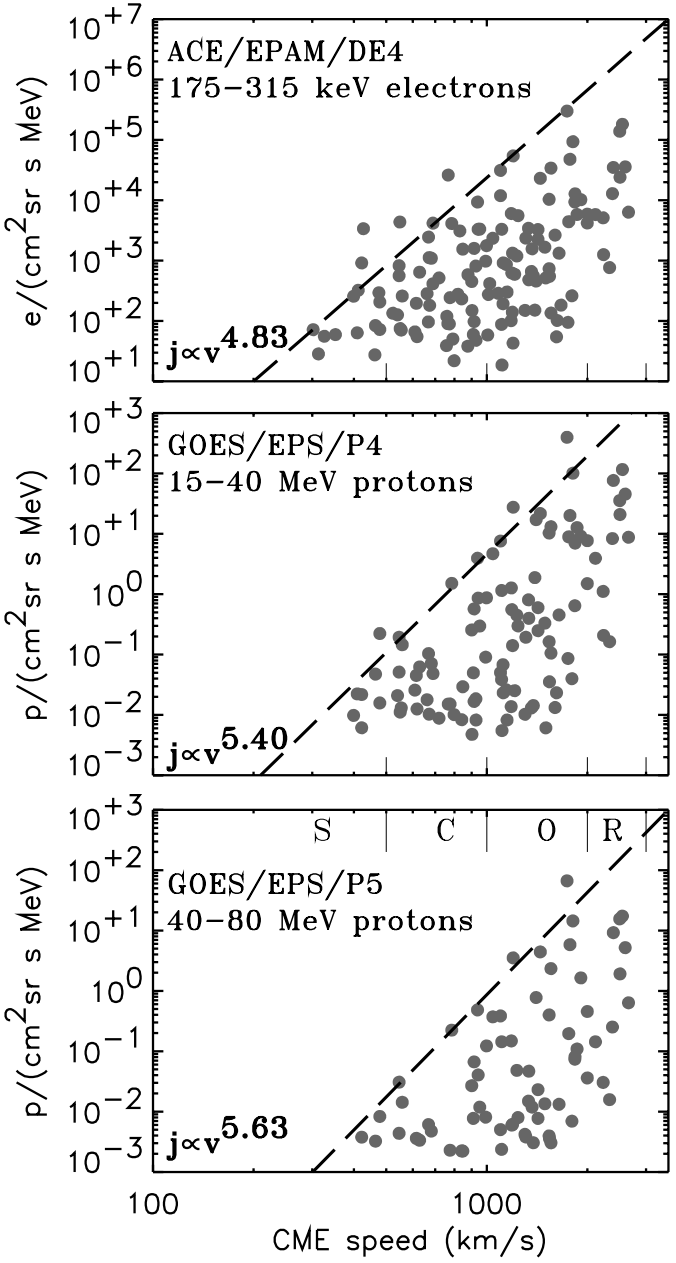
# What fraction of solar energetic particle events originate on the far-side of the Sun ?




- A study of >25 MeV proton events using STEREO-A, STEREO-B, and near-Earth spacecraft data shows that ~1/3 of the solar energetic particles observed at each of the 3 locations originate on the opposite side of Sun
- About 26% of the events originate beyond the East limb and 7% beyond the West limb
- Events that originate behind the limb (as viewed from Earth) provide no flare warning, although the coronal mass ejection (CME) may be observed
- This work illustrates the value of a 360˚ view of the Sun

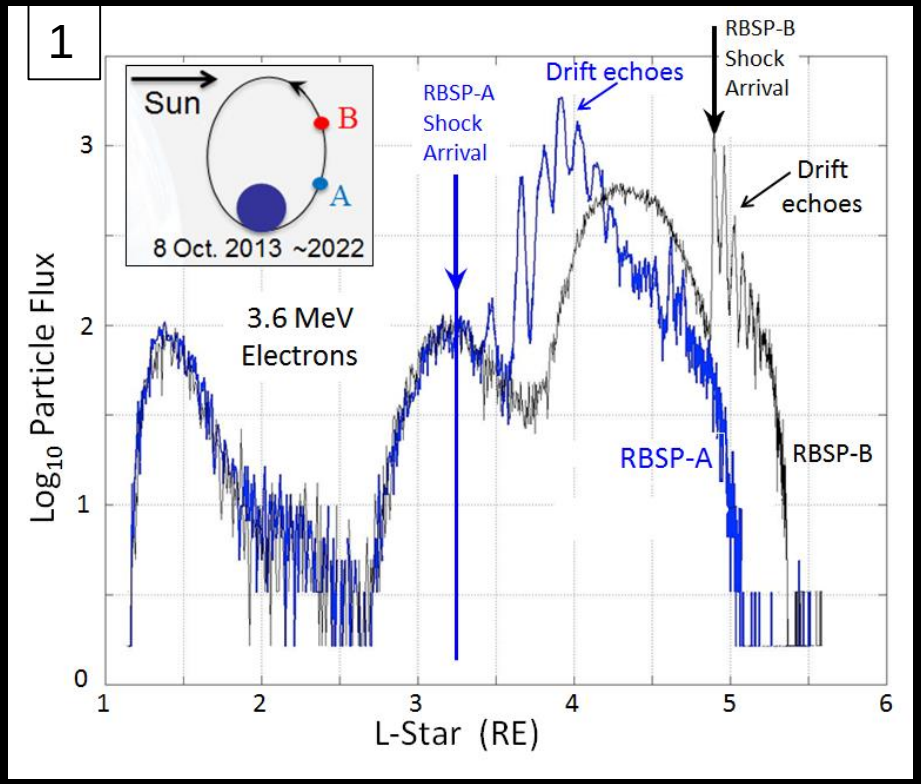
# ACE Real-Time Forecasting the Maximum Intensity of Solar Energetic Particle (SEP) Events

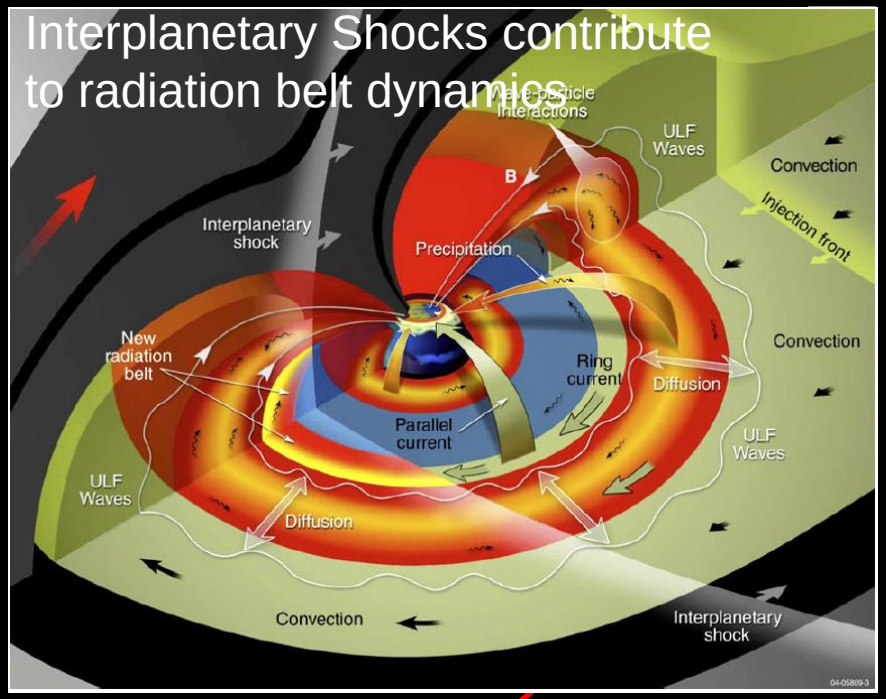
- Peak SEP proton and electron intensities (j) with solar sources between W10° to W100° show a remarkable triangular distribution when plotted vs. the observed coronal mass ejection (CME) velocity (v) such that j is proportional to $v^n$.
- From this relation, the ***maximum*** **peak proton intensity for any observed v can be quickly obtained**.
- If inner coronagraph images are available *in real time* with <10 minute cadence, a real-time *estimate of the maximum j* can be made in ≤ 20 minutes, whereas the first arriving 20 MeV protons take ~1 hour (the peak is later still).
- This provides at least **½ hour warning of the prompt peak intensity of 20 MeV protons** in the largest well-connected proton events. For **~40 MeV protons the warning time is at least ~15 minutes**.



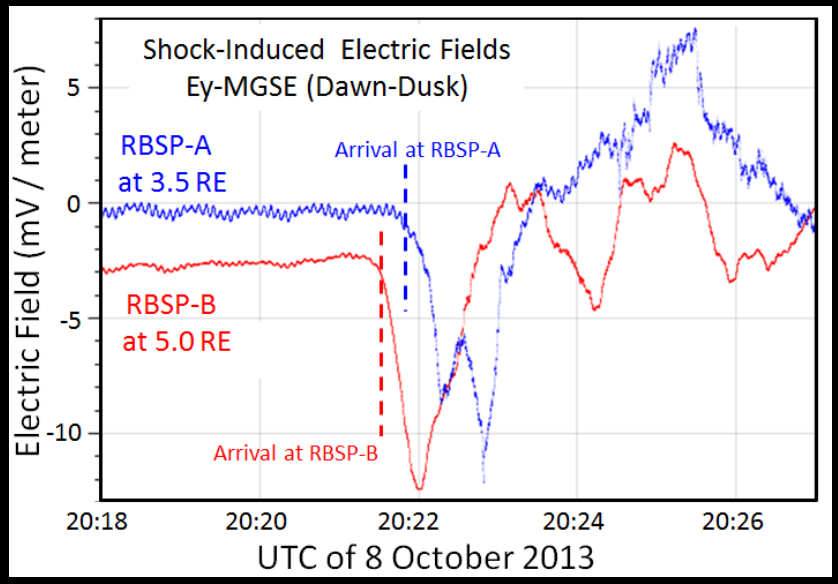
# Interplanetary Shock Wreaks Havoc on Earth's Electron Radiation Belt

- Van Allen Probes track an interplanetary shock through the inner magnetosphere (1).
- Induced electric fields (2) cause drift echoes and acceleration of MeV-class electrons throughout the outer radiation belt (1)
- Local shock effects and wave drift-resonance diffusion contribute to the acceleration (3)



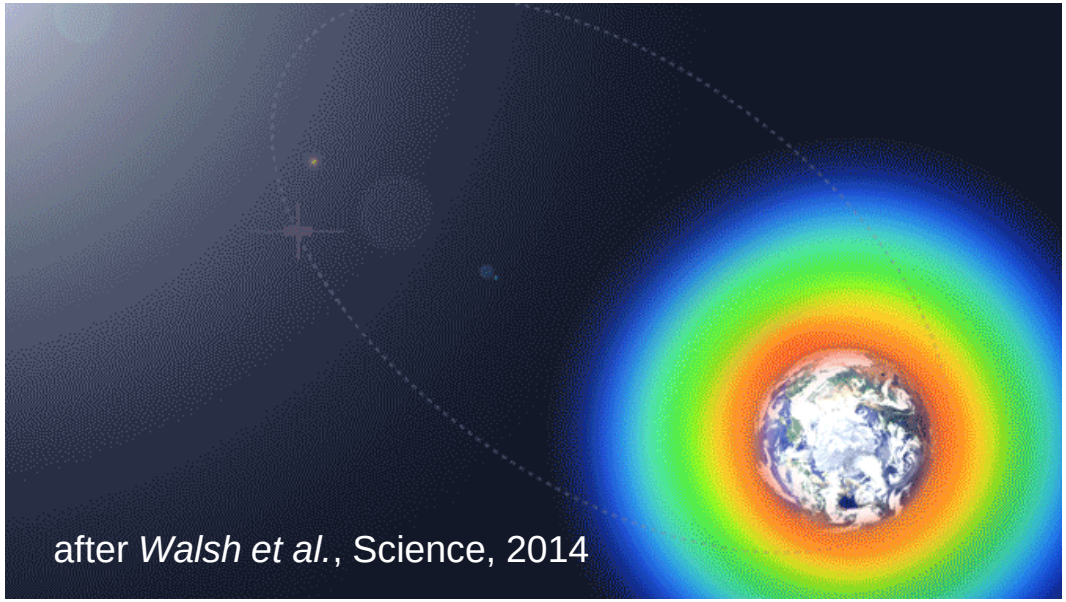




Interplanetary Shock




*Foster et al.*, 2014, in press

# THEMIS Discovers the Earth's magnetosphere fortifying its walls to shield against solar storms

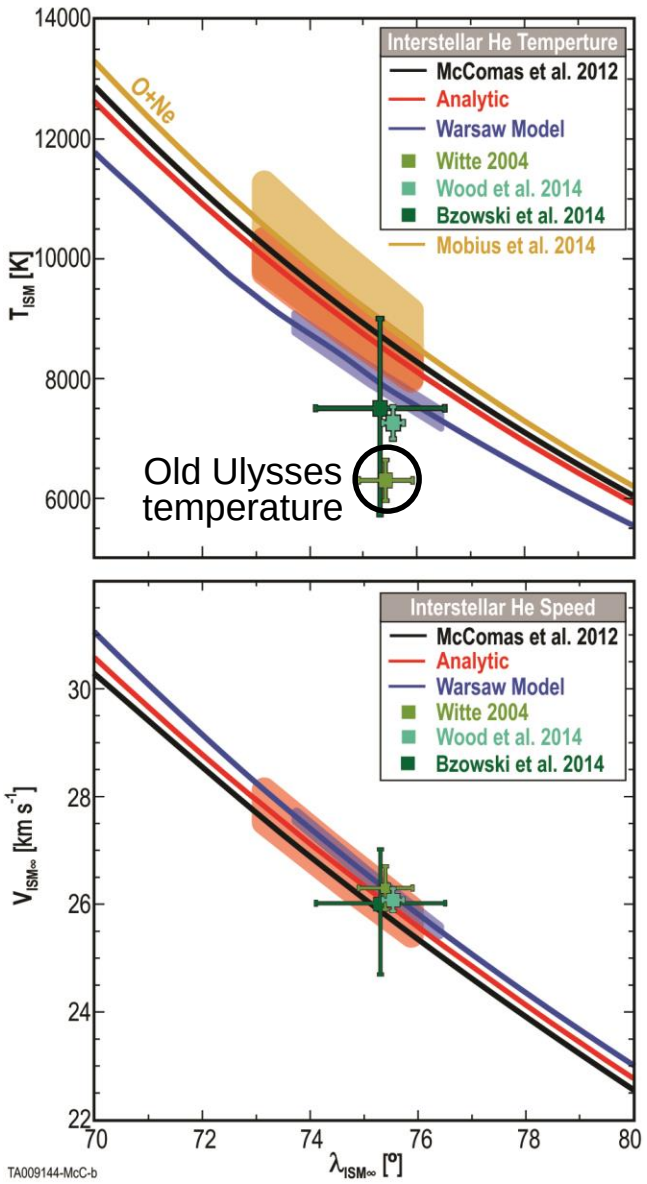



- During a geomagnetic storm NASA's THEMIS mission measured dense plasma being transported from the upper atmosphere sunward to the edge of the magnetosphere.
- The spacecraft detected the dense plasma throttling the flow of energy from the flowing solar wind into the magnetosphere.
- Simultaneous ground-based measurements from Total Electron Content (TEC) confirm the global nature of the measurements.
- This process shows a physics driven system to provide some protection from solar eruptions and disturbances.

# Possible Resolution of Ulysses-IBEX Enigma

- Interstellar He gas flows freely into heliosphere at 10's of km/s from Local Interstellar Medium (LISM)
- **Ulysses-IBEX Enigma:**
  - Ulysses data provided inflow vector and quite cold LISM temperature of **~6300 K, flow speed ~26 km/s, inflow longitude ~75°**
  - IBEX data provide tightly coupled relation between flow vector and temperature with much higher temperatures (**>7500 K**) for ~26 km/s
  - 2009-2010 IBEX data suggested somewhat slower flow (**~24 km/s**), Ulysses temperature (**~6300 K**) and a somewhat different inflow longitude **~78°**
- **Possible Resolution:**
  - Newer 2012–2014 IBEX data indicate faster (**~26 km/s**) flow and inflow longitude similar to Ulysses (**~75** °) more likely but require higher temperatures
  - Reanalysis of old Ulysses data (*Bzowski et al*. 2014; *Wood et al*, 2014) find higher temperatures (**~7500 K**)
  - Heliosphere in much warmer region of LISM (**~7000–9500 K**) - may be isothermal
  - IBEX measures ~100 deeper into distributions than Ulysses (also first H, D, O, Ne observations)

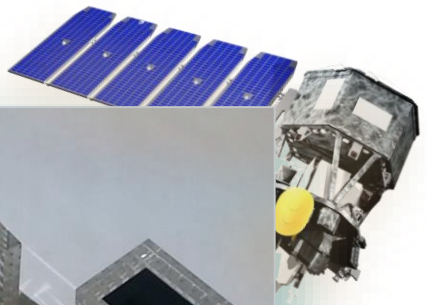
    → IBEX discovering non-thermal distribution shapes and far more complicated interstellar interaction

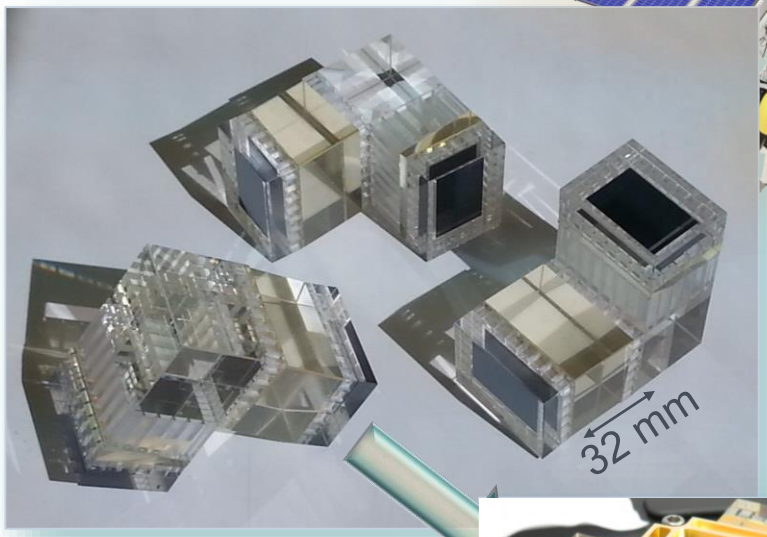


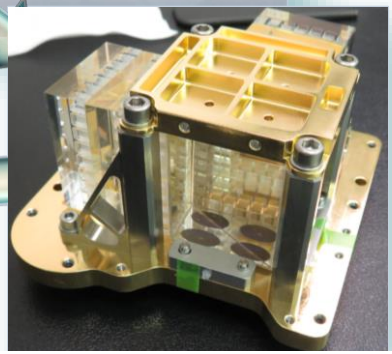

after *McComas et al*., ApJ, 2015

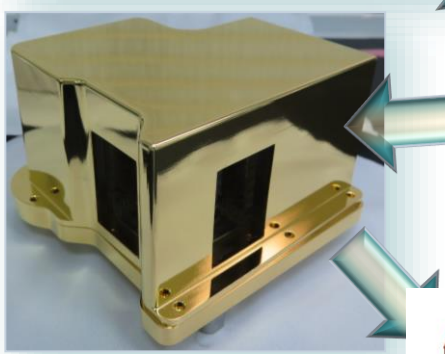
# MIGHTI Flight Interferometers Built and Delivered for Integration

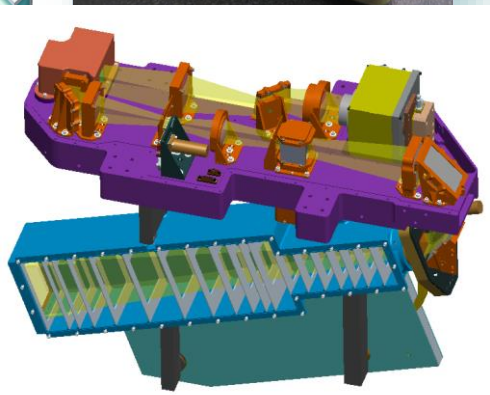
- The Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) is designed to **measure wind & temperature profiles (90-300km altitude) on board the NASA Ionospheric Connection (ICON) Explorer mission** led by the University of California, Berkeley.
- MIGHTI passed its CDR on March 31 2015, and is starting Phase D, with a planned ICON mission launch in Summer 2017.
- The key optical elements of MIGHTI are two monolithic Doppler Asymmetric Spatial Heterodyne (DASH) interferometers, each creating simultaneous fringe patterns for the atomic oxygen green and red lines to determine horizontal wind profiles.









*MIGHTI is being built under the direction of PI for NASA, Dr. Christoph Englert, Naval Research Laboratory (NRL) Space Science Division*



# End