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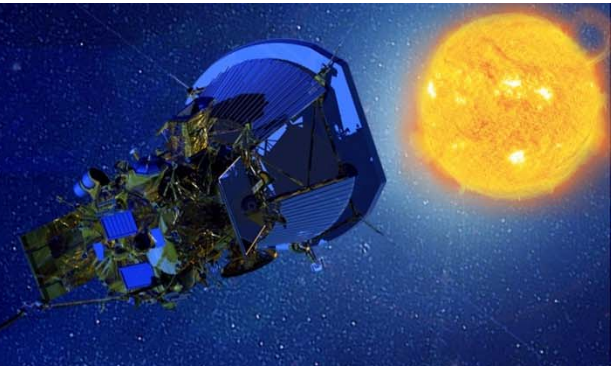

Integrated Science Investigation of the Sun Energetic Particles

Preliminary Design Review

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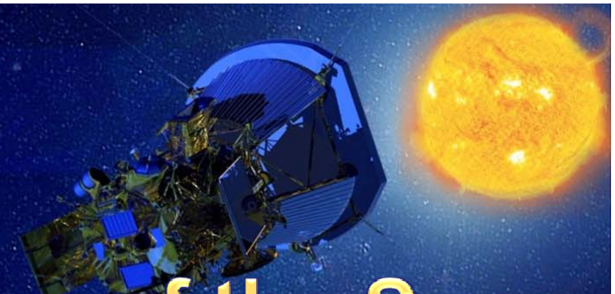
ISIS Science Operations



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ISIS Project Manager Introduction

Scott Weidner
ISIS PM (SwRI)

Introduction

- PM Introduction

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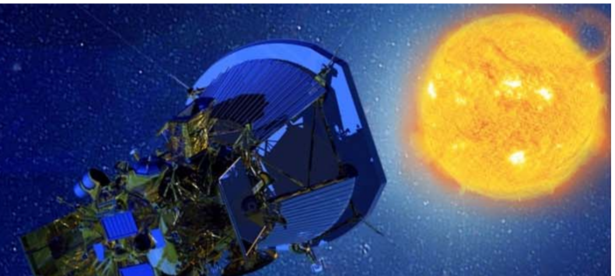

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Review Board Introduction

Larry Brown
ISIS SOC PDR Chair (JHU/APL)

Review Board Introduction

- SOC PDR Chair Opening Comments
- SOC Review Board Introductions

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ISIS Science Ops Center

N. A. Schwadron
Instrument SOC Lead (U. New Hampshire)

Science Operations Center Agenda

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Introduction (Schwadron)
- List of Governing Documents
- Heritage
- SOC Organization

Requirements Analysis (Angold)

SOC Description (Schwadron)
- SOC Description - Architecture
- SOC Description - Software Systems

Operations (Christian)
- SOC Description - Operations Planning
- SOC Description - Commanding

Testing, Processing, Data Products, Plan and Status (Schwadron)
- SOC Description - Instrument Health & Safety
- SOC Description - Telemetry
- SOC Description - Data Processing
- Data Products
- Development Plan and Schedule
- Test Plan
- Current Status

List of Governing Documents

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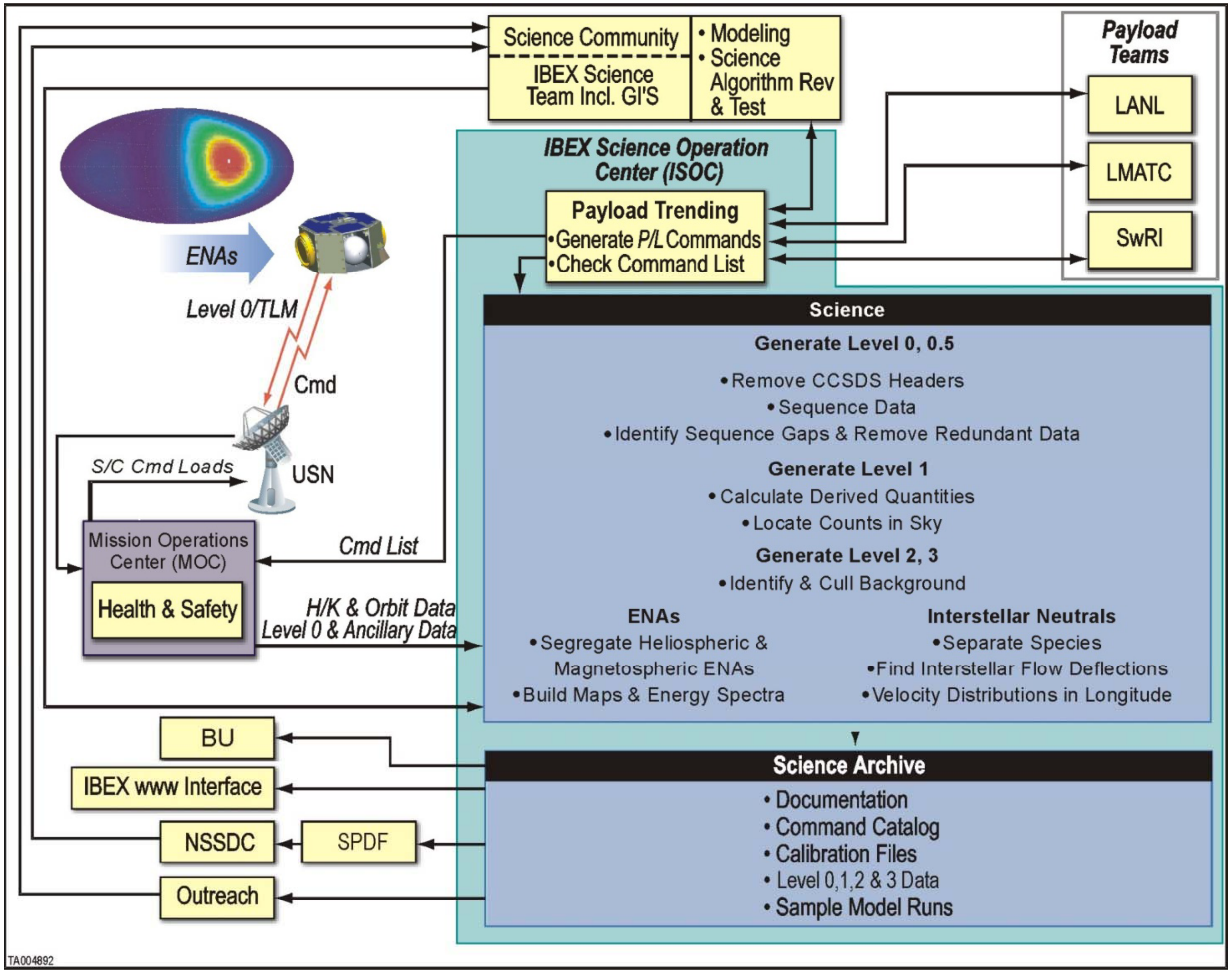
- 7434-9047 SPP Mission Requirements Document (MRD)
- 7434-9081 SPP Science Team Allocated Requirements Document (STARD)
- 7434-9101 SPP Science Data Management Plan (PDMP)
- 7434-9016 SPP Concept of Operations
- 7434-9078 SPP Mission Operations Center (MOC) to SPP Science Operations Center (SOC) and Interface Control Document (ICD)
- 7434-9139 SPP MOC Data Product Document

Heritage

- Interstellar Boundary EXplorer SOC (ISOC) at UNH
  - Two particle instruments
  - Software, Instrument Operations all managed by the ISOC
  - Interfaces with central MOC at Orbital



SOC Organization

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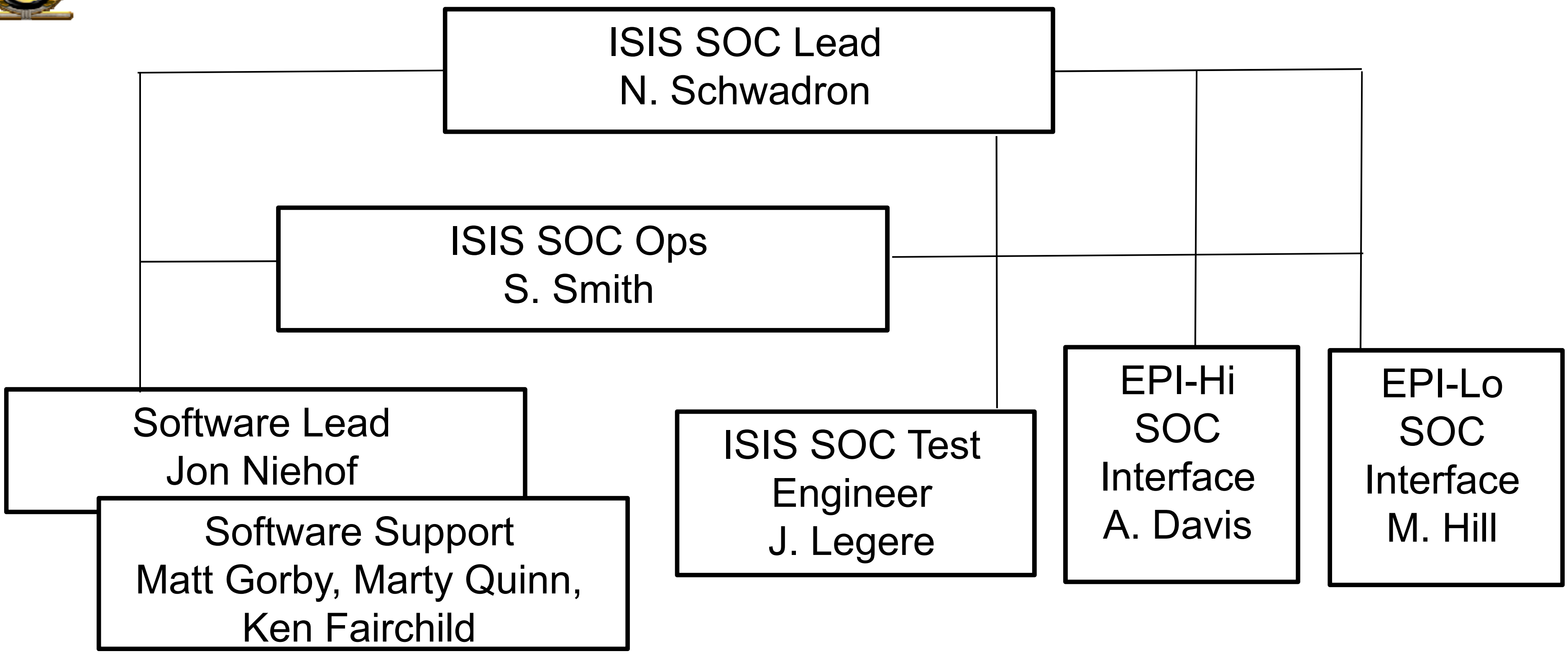

- Science and Operations Functions managed by SOC
- Software development needed for Ops, Science and Health & Safety
- ISIS SOC testing via GSEOS – "Test as you fly and fly as you test"

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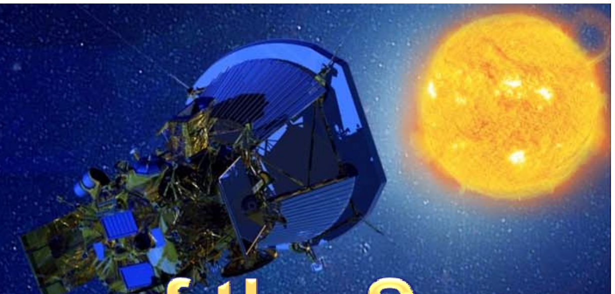

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Requirements Analysis

Nigel Angold
ISIS Systems Engineering (SwRI)

Requirements Analysis

- Public quicklook data 60 days after downlink (6 months for first 3 orbits)
- Public science data 6 months after downlink
- Share science/engineering/ancillary data among teams
- At SOC, archive all telemetry, data, software and docs for mission + 1 year
- All SOC software + data to final, deep archive by 12 months after mission end
- SOC must have APL (SPP project) approved security on computers
- SOC able to receive "remote SOC notification" of instrument fault conditions as detected by the spacecraft

Level 2 Requirements (1/3)

- [MRD-29] System: Burst Mode
  - The Mission shall be capable of sharing a limited amount of instrument messaging information sufficient for the purposes of coordinating concentrated or focused measurement (burst mode) periods.
- [MRD-66] Data Delivery: Science Data Management Plan
  - The Mission shall create, update and adhere to a NASA Headquarters-approved Science Data Management Plan that specifies file contents, metadata, formats, standards, schedule and pathways for public data access, and the destination of the data upon mission termination.
- [MRD-58] Data Delivery: Quick-Look Data
  - The Mission shall ensure that each SOC provides for public dissemination a quick-look processed version of science data (e.g. thumbnails) within 60 days (TBR) of downlink.
- [MRD-59] Data Delivery: Sharing Among Instrument Teams
  - The Mission shall be capable of sharing data between instrument teams to support data analysis
- [MRD-60] Data Delivery: Engineering Data Sharing
  - The Mission shall be capable of sharing ancillary engineering information necessary to validate and calibrate science data sets to all investigation teams prior to depositing them in a NASA-approved data repository.

Level 2 Requirements (2/3)

- [MRD-61] Data Delivery: Public Release
  - The Mission shall ensure that each SPP science investigation provides processed science data obtained as part of the SPP mission to the public no later than 6 months (TBR) from downlink of all a given encounter's data.
- [MRD-63] CDH Data Delivery: Data Retention at SOC
  - The Mission shall ensure that all instrument telemetry received by the MOC, all associated ancillary data products generated by the ground system, and any processed science data products received by the MOC at any point in the mission life cycle are retained at the MOC throughout the duration of the operational phase of the mission plus one year (TBR).
- [MRD-64] Data Delivery: Data Retention at SOCs
  - The Mission shall ensure that each SOC maintains a data archive of its instrument science, documentation, software and science data products for the life of the mission plus one year (TBR).
- [MRD-65] Data Delivery: Data Delivery to NASA
  - The Mission shall ensure that each science investigation team delivers their respective data archive from the operational phase of the mission to a NASA-designated location for a deep data archive within 12 months of completion of the operational phase of the mission.

Level 2 Requirements (3/3)

- [MRD-72] FP: Instrument Power-Down Time (*ISIS SOC Tracks this for Heath & Safety)*
  - The Mission shall provide instrument fault protection to include ground system monitoring of selected instrument health data, remote SOC notifications of critical fault conditions, and autonomous onboard instrument power-downs in response to instrument request and critical telemetry.

- [MRD-82] Safety: JHU/APL Network Security
  - The Mission shall ensure that all SPP equipment that connects to the JHU/APL internal or mission operations networks complies with JHU/APL security requirements.

Level 3 Requirements (1/7)

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- [PAY-133] CDH Data Delivery: Quick-Look Data
  - All Science Operations Centers shall provide for public dissemination a quick-look processed version of science data within 6 months (TBR) of downlink for the first three orbits after launch and 60 days (TBR) of downlink thereafter.
  - Traced back to MRD-58 : The Mission shall ensure that each SOC provides for public dissemination a quick-look processed version of science data (e.g. thumbnails) within 60 days (TBR) of downlink.
- [PAY-134] CDH Data: Data Sharing
  - All Science Operations Centers shall be capable of sharing data with other SPP instrument teams to support data analysis as specified in the Science Data Management Plan (7434-9101).
  - Traced back to MRD-59: The Mission shall be capable of sharing data between instrument teams to support data analysis

Level 3 Requirements (2/7)

- [PAY-135] CDH Data: Engineering Data Sharing
  - All Science Operations Centers shall be capable of sharing ancillary engineering information necessary to validate and calibrate science data sets with all investigation teams prior to depositing them in a NASA-approved data repository
  - Traced back to MRD-60: The Mission shall be capable of sharing ancillary engineering information necessary to validate and calibrate science data sets to all investigation teams prior to depositing them in a NASA-approved data repository.
- [PAY-136] CDH Data: Public Dissemination
  - All Science Operations Centers shall provide processed science data obtained as part of the SPP mission to the public no later than 6 months from downlink of all a given encounter's data.
  - Traced back to MRD-61: The Mission shall ensure that each SPP science investigation provides processed science data obtained as part of the SPP mission to the public no later than 6 months (TBR) from downlink of all a given encounter's data.

Level 3 Requirements (3/7)

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- [PAY-137] CDH Data Delivery: Data Retention at SOC
  - All Science Operations Centers shall maintain all instrument telemetry & all associated data products throughout the duration of the operational phase of the mission plus one year (TBR).
  - Traced back to MRD-63 :The Mission shall ensure that all instrument telemetry received by the MOC, all associated ancillary data products generated by the ground system, and any processed science data products received by the MOC at any point in the mission life cycle are retained at the MOC throughout the duration of the operational phase of the mission plus one year (TBR).
- [PAY 138] CDH Data Delivery: Data Retention at SOCs
  - All Science Operations Centers shall maintain a data archive of its instrument science, documentation, software and science data products for the life of the mission plus one year (TBR).
  - Traced back to MRD-64 : The Mission shall ensure that each SOC maintains a data archive of its instrument science, documentation, software and science data products for the life of the mission plus one year (TBR).

Level 3 Requirements (4/7)

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- [PAY 139] CDH Data Delivery: Data Delivery to NASA
  - All Science Operations Centers shall deliver its data archive from the operational phase of the mission to a NASA-designated location for a deep data archive within 12 months (TBR) of completion of the operational phase of the mission.
  - Traced back to MRD-65: The Mission shall ensure that each science investigation team delivers their respective data archive from the operational phase of the mission to a NASA-designated location for a deep data archive within 12 months (TBR) of completion of the operational phase of the mission.
- [PAY-149] FP: Instrument Fault Protection (*ISIS SOC Tracks this for Heath & Safety)*
  - All instruments shall provide data to support instrument fault protection (including ground system monitoring of selected instrument health data, remote SOC notifications of critical fault conditions, and autonomous onboard instrument power-downs in response to instrument request, detection of stale instrument heartbeat, or overcurrent).
  - Traced back to MRD-72: The Mission shall provide instrument fault protection to include ground system monitoring of selected instrument health data, remote SOC notifications of critical fault conditions, and autonomous onboard instrument power-downs in response to instrument request and critical telemetry.

Level 3 Requirements (5/7)

- [PAY 151] FP: Instrument Power-Down Time (*ISIS SOC Tracks this for Heath & Safety)*
  - All instruments shall be capable of safely powering down within TBD s upon receipt of a status message with a bit indicating power-down command.
  - Traced back to MRD-72: The Mission shall provide instrument fault protection to include ground system monitoring of selected instrument health data, remote SOC notifications of critical fault conditions, and autonomous onboard instrument power-downs in response to instrument request and critical telemetry.
- [PAY 221] FP: Instrument Reconfiguration (*ISIS SOC Tracks This For Health & Safety)*
  - All instruments shall be capable of autonomous reconfiguration to a pre-defined operational state following spacecraft-commanded power-down and subsequent power-on.

Level 3 Requirements (6/7)

- [PAY 152] FP: Instrument Power-Down Preparedness (*ISIS SOC Tracks This for Health & Safety)*
  - All instruments shall be designed to accommodate immediate loss of power (without warning) without damage to the instrument.
  - Traced back to MRD-72: The Mission shall provide instrument fault protection to include ground-system monitoring of selected instrument health data, remote SOC notifications of critical fault conditions, and autonomous onboard instrument power-downs in response to instrument request and critical telemetry.
- [PAY 283] Compliance: MOC to SOC ICD
  - All SOCs shall comply with the requirements and constraints imposed by the MOC to SOC ICD 7434-9078.

Level 3 Requirements (7/7)

- PAY 303 ISIS Calibration
  - ISIS shall shall be capable of operating to support calibration for at least 70% (TBR) of the time the spacecraft is not in a power or operationally-constrained mode outside of 0.25 AU.
  - Traced to MRD-97: Mission shall measure energetic protons and heavy ions …
- PAY-215 Payload: ISIS Burst Mode (*This is tracked by ISIS-SOC)*
  - ISIS shall be capable of sharing a limited amount of instrument messaging information sufficient for the purposes of coordinating concentrated or focused measurement (burst mode) periods, as defined in the SPP Instrument Shared Data Document 7434-XXXX (TBR).
  - This requirement meets Level 2 Requirements. ISIS will be participating in Burst Mode data sharing.

Summary

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- The ISIS team is fully aware of the high level SPP requirements and how they apply to the ISIS SOC.
- ISIS has taken ownership of the lower level requirements to ensure that the ISIS SOC will provide:
  - Timely distribution of quicklook and science data
  - Sharing of science/engineering/ancillary data among teams
  - An archive of all telemetry, data, software and documents
  - APL-approved security on its computers
  - Monitoring of ISIS instrument fault conditions
  - ISIS instrument commanding and telemetry processing

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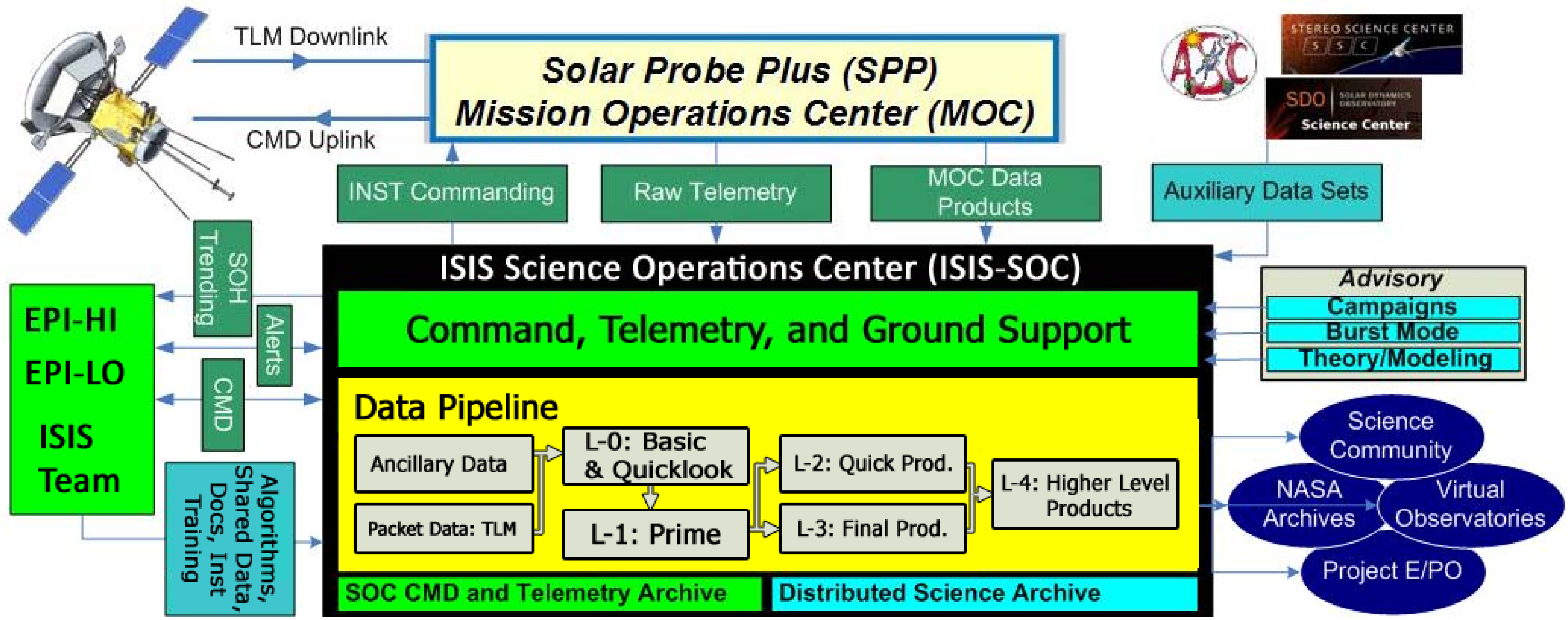
SOC Description

Nathan Schwadron
Instrument SOC Lead (U. New Hampshire)

SOC Description - Architecture (1/2)



- Both instrument teams and SOC utilize GSEOS and have the capability to perform real-time commanding in the event of contingencies and during commissioning
- Instrument-to-MOC connections will be preserved and tested periodically to insure contingency preparedness
- Need dedicated EPI-Lo & EPI-Hi “Test SOCs” in Mission Ops Center
- SOC-MOC connections will be exercised as the standard mode of instrument commanding

SOC Description - Architecture (2/2)

- The ISIS Science Operations Center (ISSOC) manages the commanding of EPI-Lo and EPI-Hi in coordination with instrument teams.
- University of New Hampshire (UNH) hosts the ISSOC, which is staffed by a small team responsible for day-to-day operations.
- Operators are brought on-board early in the project and operate the instruments during I&T.
- Command and telemetry database developed during I&T is used during flight operations.
- ISSOC utilizes a similar architecture as the IBEX Science Operations that was developed by N. Schwadron and currently runs at UNH.

SOC Description - Facilities

Facilities:

- ISIS SOC at UNH
  - Heritage: IBEX SOC
- Dedicated GSEOS machines for EPI-Hi and EPI-Lo

SOC Description - Command, Telemetry & Ground Support

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Commanding Systems – GSEOS

State-Of-Health Products: SOH Software

Command Load Testing Software

Orbit Planning Products: Orbit Planning Software

SOC Description - Science and Data Pipeline Software Systems

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Data Level Products:
Pipeline Software

Data Visualization Tools:
Pipeline Software

Ancillary Science Products:
Pipeline and Ancillary Software

Summary

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- Builds on highly successful IBEX SOC
- Thorough planning
- Facilities well prepared
- Highly experienced & dedicated personnel
- ISIS SOC team will support
  - Testing throughout Development
  - SPP Integration and Test
  - On-Orbit Operations and Science
- Implementation READY!

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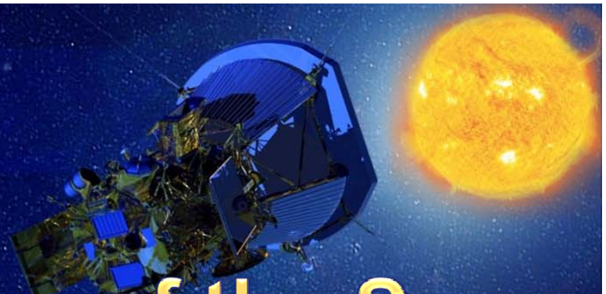

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Operations

Eric Christian
ISIS Deputy PI (GSFC)

SOC Description - Operations Planning

- Planning for instrument operations
  - Planning software
    - Automated routines and templates for initial planning
    - Interactions with ISIS SOC interfaces for finalization of planning
  - Develop rough plans three orbits ahead
    - Test command load
  - Develop definitive plans one orbit ahead
    - Final testing
    - Upload

- Commanding of EPI-Hi and EPI-Lo
  - "Flat-Sat" at UNH used to test command loads
    - Development of Flat-Sat will be Phase D work
    - Constraint Checking Modules
  - Standard Commanding performed via GSEOS at UNH SOC
  - Commissioning and Contingency response, commanding may optionally be done by EPI-Hi and EPI-Lo via GSEOS directly through MOC

SOC Description - Commanding

- GSEOS used during I&T and as much of testing as possible
  - Coordinated by ISIS SOC Test Lead
- Common GSEOS platform for instrument GSEs/SOC
- “Tested as we Fly …
  Now we will Fly as we tested”

ISIS Operations Summary

- Particle events are sporadic so the goal is to approach 100% coverage
  - Whenever possible, ISIS instruments should be taking data
  - Minimize commanding and mode changes
- Use spacecraft telemetry file system to prioritize data downlink
  - First priority: Housekeeping for health and safety
  - Second priority: Snapshot data to identify important time periods (immediately relayed to other SPP instruments)
  - Third priority: Full Science Data (rates at different cadences and event data)
- Three-step hierarchy of planned commands for near-term and longer-term changes
  - Next Solar Pass
  - Next Solar Pass + 1
  - Next Solar Pass + 2

Commanding in First 2 Months

- EPI-Hi turns on first (EPI-Lo needs two week out-gassing period)
- ISIS Statistics Gathering and Threshold Scans
  - Analysis parameters will be tuned with pre-flight calibrations, but it is likely that some fine-tuning will be required
  - After initial instrument turn on and checkout it is important that the ISIS instruments gather as much data as possible (especially raw event data)
  - Threshold scans will be required to determine optimal threshold values
  - EPI-Lo does not need to be on continuously
- ISIS EPI-Lo and EPI-Hi Table Loads and/or Software Updates
  - Table updates expected (adjustment of flux box bins) 3 weeks into statistic gathering period
  - Software updates might be needed
  - Based on STEREO experience, EPI-HI will require ~10 opportunities (on separate days) to send commands in the first two months
  - Necessary to obtain/analyze at least a few hours of new data in between command opportunities to test whether the commands worked
  - Therefore, need to collect data between commanding opportunities

Normal Science Operations

EPI-Hi and EPI-Lo operate the same whenever powered-on except for the volume/content of the data sent to the S/C inside/outside 0.25 AU

- **Spacecraft- Sun Distance R<0.25 AU (Normal Science Mode)**
  - Full nominal power
  - High data collection rate and burst data (EPI-Lo)

- **Spacecraft- Sun Distance: 0.25 AU < R (Low-rate Science Mode)**
  - Full power when not downlinking and when possible
  - Reduced data collection rate (fits within ISIS telemetry allocation)
  - Commanding window should be scheduled late in the series of telemetry passes, although it may not be used every orbit
  - Minimize power cycling the HV supplies

Nominal Operations

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- EPI-Hi and EPI-Lo are capable of switching between two routine modes autonomously (based on data received once-per-second from the spacecraft).
  - EPI-Hi has no “Burst” mode
  - EPI-Lo doesn’t change modes during “Burst” periods, it merely sends more telemetry to spacecraft (telemetry that is always generated)
- At least three special operational modes are currently envisioned:
  - Software upload mode
    - During software upload mode, data acquisition functions and some non-essential functions will be halted.
  - Calibration Science mode (more event data transmitted)
  - Safe mode

Summary

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- ISIS Instrument operation modes designed to reduce complexity
- Autonomous instrument operations simplify SPP spacecraft operations
- ISIS team will develop all of the processes necessary to verify commanding and provide safe and efficient instrument operations

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Testing, Processing, Data Products, Plan and Status

Nathan Schwadron
Instrument SOC Lead (U. New Hampshire)

SOC Description - “Test as you Fly, Fly as you Test”

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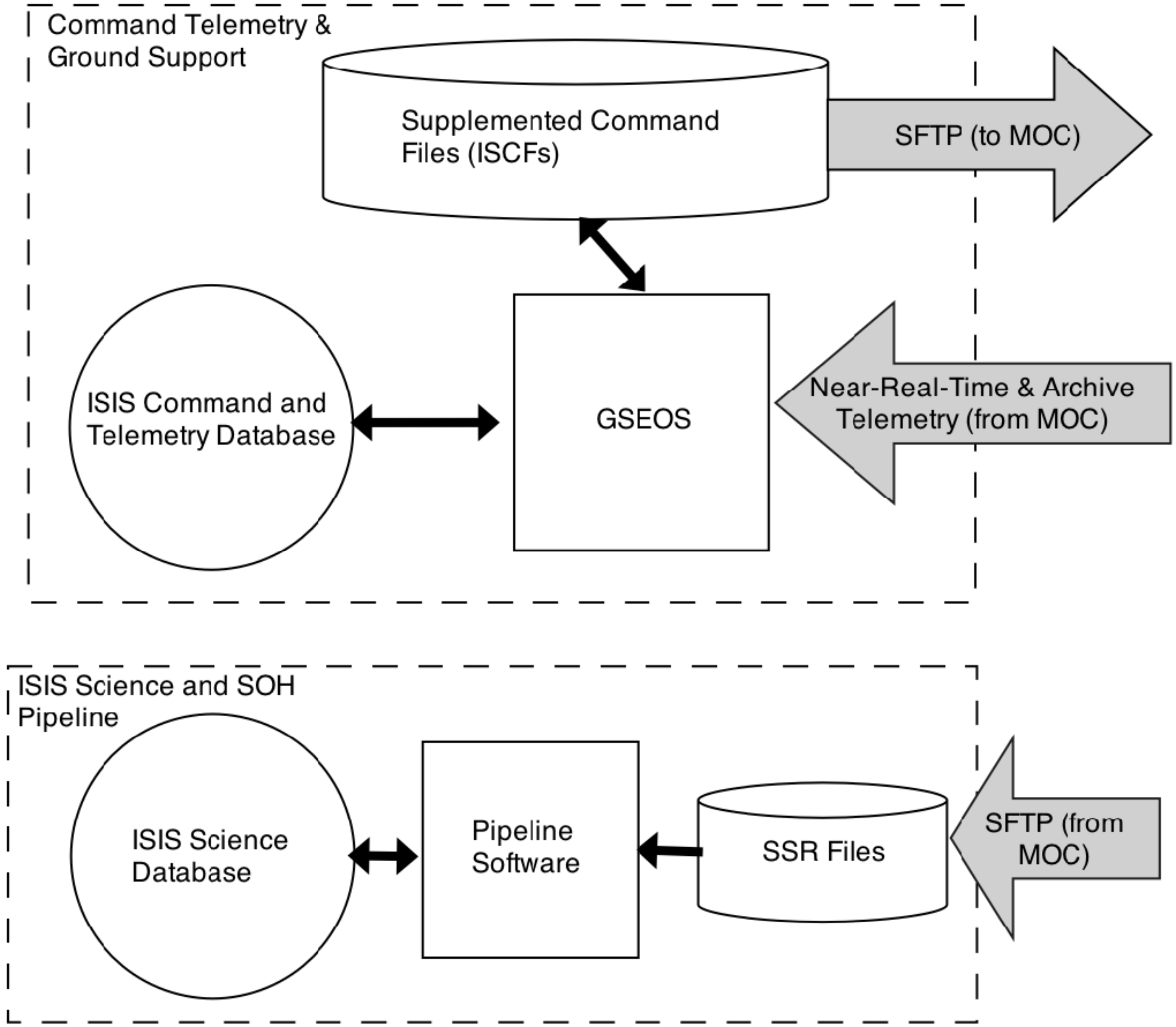
- Instrument GSEs have two types of operation:
  - Specific: direct connection to instrument
  - Flight Mode: spacecraft simulator → instrument
- GSE Flight-Mode operation incorporated into the SOC GSEOS system. Identical “look and feel” to the instrument/SOC teams during testing, I&T, commissioning and normal flight operations

SOC Description - Instrument Health & Safety

- Health and Safety limits checked throughout testing, I&T and monitored throughout commissioning and flight
- GSEOS used at ISIS SOC for health and safety monitoring during contacts
- ISIS SOC develops software, and team pages with state-of-health checks and long-term trending

SOC Description - Telemetry



SOC Description - Data Processing

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- Data processing systems
  - Pipeline code C, IDL, Perl, Java, etc ..
  - Tools (MIDL, IDL Savesets, etc.) available for visualization and analysis
  - Unix/Shell scripts launch executables in essentially any language to do their job with a clear i/o

- Data processing algorithms
  - Straightforward routines
    - Decommutation
    - Particle identification
    - Application of calibration data

- Facilities
  - All formal pipeline processing processed at ISIS SOC

- Future planning products
  - Use of SPICE ephem, SOC calendars for planning
  - Automation where possible

Data Products (1/2)

- ISIS SOC builds Level 1 and higher level data products from the Level-0 (raw) data received from MOC
- Housekeeping and status data are processed as soon as possible after receipt (all products within 3 days, select quick products < 1 hour) and posted for viewing for the ISIS team through an ISIS SOC website.
  - Housekeeping and status data downloaded first after passes, provide critical information from which to build command loads in subsequent passes.
- Level 0 data are processed as they are made available after passes and are used to construct Level 1 and higher level data products

Data Products (2/2)

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- Higher level data products include combined solar wind, magnetic field and energetic particle data, which are time-ordered with common timestamps at a cadences TBD.
- Level 1 and higher level data products are still in formulation as the instrumentation are in development.
- The ISOC archives all ISIS data and delivers data products to appropriate Heliophysics Virtual Observatories and Data Centers.

Level 0 Status and Housekeeping

Data Level	Description	Latency	Users
L0 Status Data	Snapshots of EPI-Lo and EPI-Hi data through the orbit EPI-Hi accumulates 1-hr summary files from LET & HET include a subset of hourly average science, housekeeping data (health & safety monitoring). Summary files accumulated continuously over both the ≤0.25 AU and >0.25 AU orbit phases ~2 bps for LET and ~2 bps for HET	Downloaded first following each orbit	ISIS Instrument teams
L0 Housekeeping	EPI-Hi and EPI-Lo voltages, currents, temperatures, rate monitors **EPI-Hi:** These are engineering data needed to monitor the health and safety of the instrument. Included are (a) 1-min average count rates of the individual detectors and their segments; (b) 1-minute totals of instrument live time and number of analyzed events of various kinds; (c) temperature data; (d) 1-minute leakage currents from all detector segments; (e) settings of the onboard calibration DACs; and (f) threshold settings for the pulse-height analyzers. During the >0.25 AU portion of the orbit these will be 1-hr averages rather than 1-minute averages. **EPI-Lo:** HK in 2 groups (12 channels per group). Each group collected at 1 s cadence < 0.25 AU and 30 min cadence > 0.25 AU.	Downloaded first following each orbit	ISIS Instrument teams

Level 0 Command Response/Mem Dumps

Data Level	Description	Latency	Users
L0 Command Response Data	Data products that detail results of specific commands.	Data delivered asap after tests	ISOC and ISIS Instrument Teams
L0 Memory Dumps	EPI-Hi and EPI-Lo will perform slow (bit/s) memory dumps periodically. The frequency of these dumps is being discussed. One concept is to perform memory dumps once or multiple per orbit and have checksums sent down more often (e.g., once per contact).	Frequency under discussion	ISOC and ISIS Instrument Teams

Level 0 EPI-Hi Events (1/2)

Data Level	Description	Latency	Users
L0 EPI-Hi events (z & E)	The EPI-Hi instrument includes two Low Energy Telescopes (LETs) and a High Energy Telescope (HET) that measure energetic particles. Each telescope has a stack of silicon solid-state detectors that make multiple measurements of the energy loss and arrival direction of individual ions and electrons. Most of these detectors have multiple segments. These energy loss measurements are processed in real-time to determine the nuclear charge (Z) and kinetic energy E of individual particles at processing rates of >1000 particles/sec. A sample of these "events" is downloaded (selected by a priority scheme to include all species, energies, and directions). Included are the pulse-heights from all triggered detectors and the results of the onboard processing.	Data delivered after each pass	ISOC and ISIS Instrument Teams
L0 EPI-Hi Z vs E matrices	Each of the processed "events" is sorted into several Z vs E matrices that summarize the measured composition and energy spectra for 17 (TBR) different species ranging from H to Ni ($1 \leq Z \leq 28$), four element groups, and electrons (for a total of 22 (TBR) separate "species"). For each species there are ~20 energy intervals in each of LET and HET. The Z vs E matrices are accumulated on time scales that range from 1 s to 1 hour (the shortest time-scales include only abundant species like H, He, and electrons).	"	"

Level 0 EPI-Hi Events (2/2)

Data Level	Description	Latency	Users
L0 EPI-Hi Z vs. E vs. Dir Matrices	Some of the Z vs E matrices are accumulated over multiple look directions. There are a total of 75 look directions for the three ends of the LET telescopes and 50 look directions for HET. We will call these Z vs E vs Dir. Matrices to distinguish them from the Z vs E matrices that sum over all directions.	Data delivered after each pass	ISOC and ISIS Instrument Teams

EPI-Lo Level 0 Rates

Data Level	Description	Latency	Users
L0 EPI-Lo Electron Rates	These are composed of three types: • **Regular Electron Rates** (8 angle bins & 32 energy bins from 25-500 keV). 30 s integration rate <0.25 AU, 30 minute integration rate >0.25 AU • **Hi Angle Electron Rates** (80 Angular bins & 16 energy bins 25-500 keV). Same integration times as Regular Electron Rates • **Fast Electron Rates** (8 Angle Bins, 6 Energy Bins). 0.25 s integration time < 0.25 AU, 15 s integration time > 0.25 AU.	Data delivered after each pass	ISOC and ISIS Instrument Teams
L0 EPI-Lo Ion Rates	These are composed of five types: • **Total Ions (Fast)** (8 angle bins & 8 energy bins from 30 keV -7 MeV). 0.25 s integration rate <0.25 AU, 15 s integration rate >0.25 AU • **Proton Rates** (80 Angular bins & 29 energy bins 30 keV-7 MeV). Same integration times as Regular Electron Rates • **Helium Rates** (2 Species, 80 Angle Bins, 12 Energy Bins 20 – 1500 keV/nuc). Same integration times as Regular Electron Rates • **Heavy Ion (group 1) Rates** (80 Angle Bins, 14 Energy Bins 10 – 1500 keV/nuc). Same integration times as Regular Electron Rates • **Heavy Ion (group 2) Rates** (80 Angle Bins, 14 Energy Bins 10 – 1500 keV/nuc). Same integration times as Regular Electron Rates	“	“

Level 0 EPI-Lo Events

Data Level	Description	Latency	Users
L0 EPI-Lo PHA Events	Complete information on select events. Cadence of 0.1 s < 0.25 AU and 5 s > 0.25 AU	Data delivered after each pass	ISOC and ISIS Instrument Teams
L0 EPI-Lo TOF-Only Events	80 Angle Bins and 6 Energy Bins 4-30 keV/nuc. Time-Of-Flight information allowing detailed species separation. Same integration times as Regular Electron Rates	"	"

Level 1 Data (1/2)

Data Level	Description	Latency	Users
L1 EPI-Lo Events, Rates	Products similar to EPI-Lo L0 data products, however validated and time-sorted with redundancies removed. All rates are at least 16-bit since memory requirements are not a major issue at level 1	Data accumulated after each pass (N) and made available to public in pass (N+1)	SPP Science Community
L1 EPI-Lo Particle Intensities	Absolute intensities (in units of particles/(cm^2sr-s-MeV/nuc) for ion species and in electrons/(cm^2sr-s-MeV) for electrons). These are produced from the L0 data. The time bases will range from 1-s to 1-day.	"	"

Level 1 Data (2/2)

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Data Level	Description	Latency	Users
L1 EPI-Hi Events, Rates, Matrices	Products similar to EPI-Hi L0 data products, however validated and time-sorted with redundancies removed. All rates are at least 16-bit since memory requirements are not a major issue at level 1	Data accumulated after each pass (N) and made available to public in pass (N+1)	SPP Science Community
L1 EPI-Hi LET and HET Particle Intensities	Absolute intensities (in units of particles/(cm^2sr-s-MeV/nuc) for ion species and in electrons/(cm^2sr-s-MeV) for electrons). These are produced from the L0 data for (a) the Z vs. E matrices and (b) the Z vs. E vs. direction matrices. The time bases will range from 1-s to 1-day. The shortest time bases will be computed for only abundant species such as H, He, and electrons.	"	"
L1 EPI-Hi Expanded Event Data	These data are produced for a sample of the individual ions/electrons that trigger the instrument. A priority system will ensure that all species, energies, and directions are sampled. The events include a summary of everything measured for that particle, including the designations of detectors that were triggered and all of the measured pulse heights (proportional to energy loss). Also indicated is how the particles were sorted onboard (by Z, E, and direction). A typical event requires 50-100 bits.	"	"

Level 2 and Higher

L2 data sets	Higher level products that combine various data products. These are still being defined and refined. Examples include data products time-ordered with solar wind and magnetic field data, element abundance ratios, fits to particle anisotropy data, and particle intensities associated with particular solar events.	Data accumulated after each pass (N) and made available to public in pass (N+1)	SPP Science community

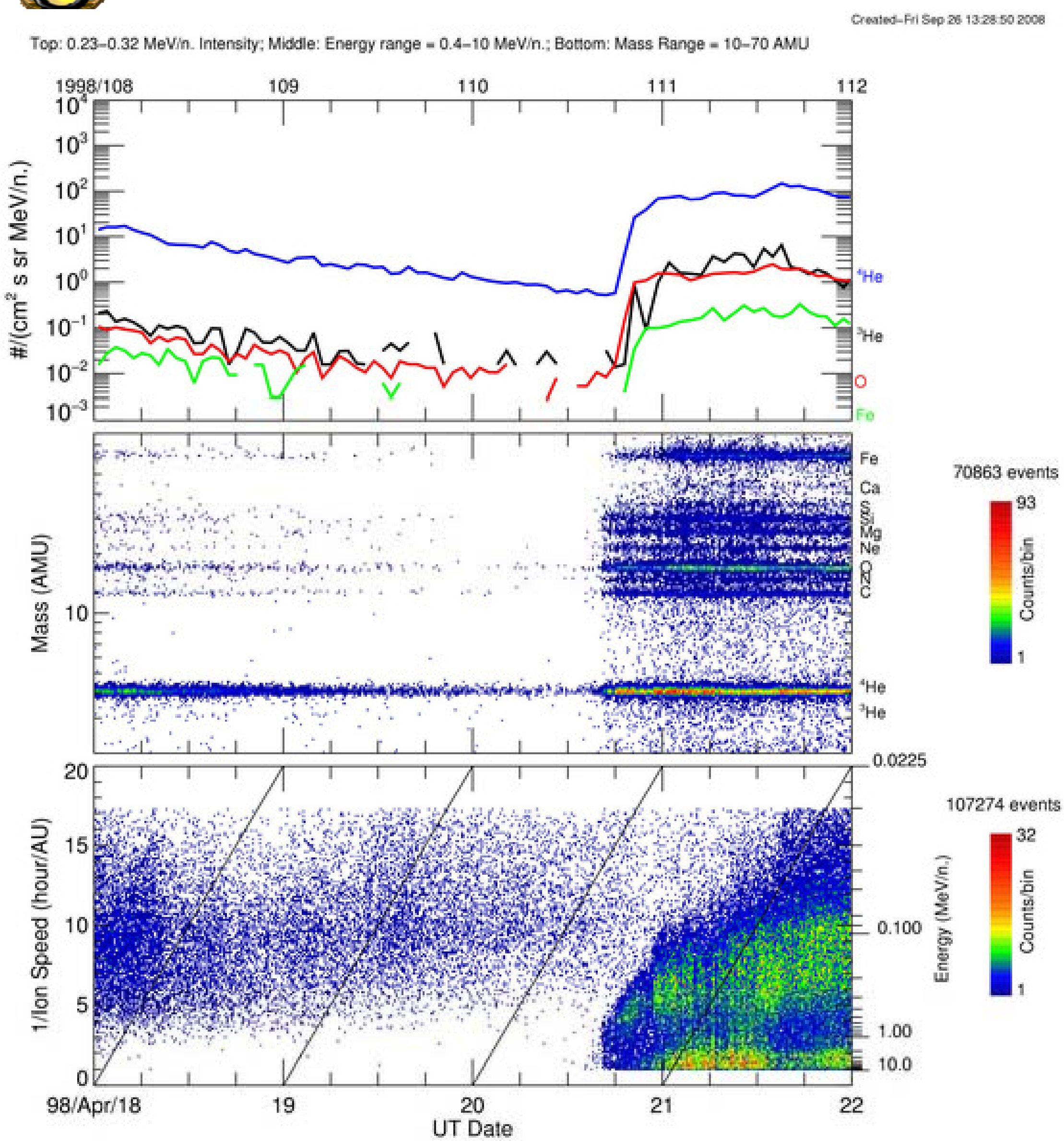
Data Products (Quicklook)

- All Science Operations Centers shall provide for public dissemination a quick-look processed version of science data within 6 months (TBR) of downlink for the first three orbits after launch and 60 days (TBR) of downlink thereafter.

- EPI-Lo:
  - Spectrograms of:
    - <1 MeV electron counts/data-interval (TBR) as a function of time, at a <= 1 hour (TBR) cadence, with 4 or more energy bins.
    - <1 MeV/nucleon total ion or single species (TBR) counts/data-interval (TBR) as a function of time, at a <= 1 hour (TBR) cadence, with 4 or more energy bins.

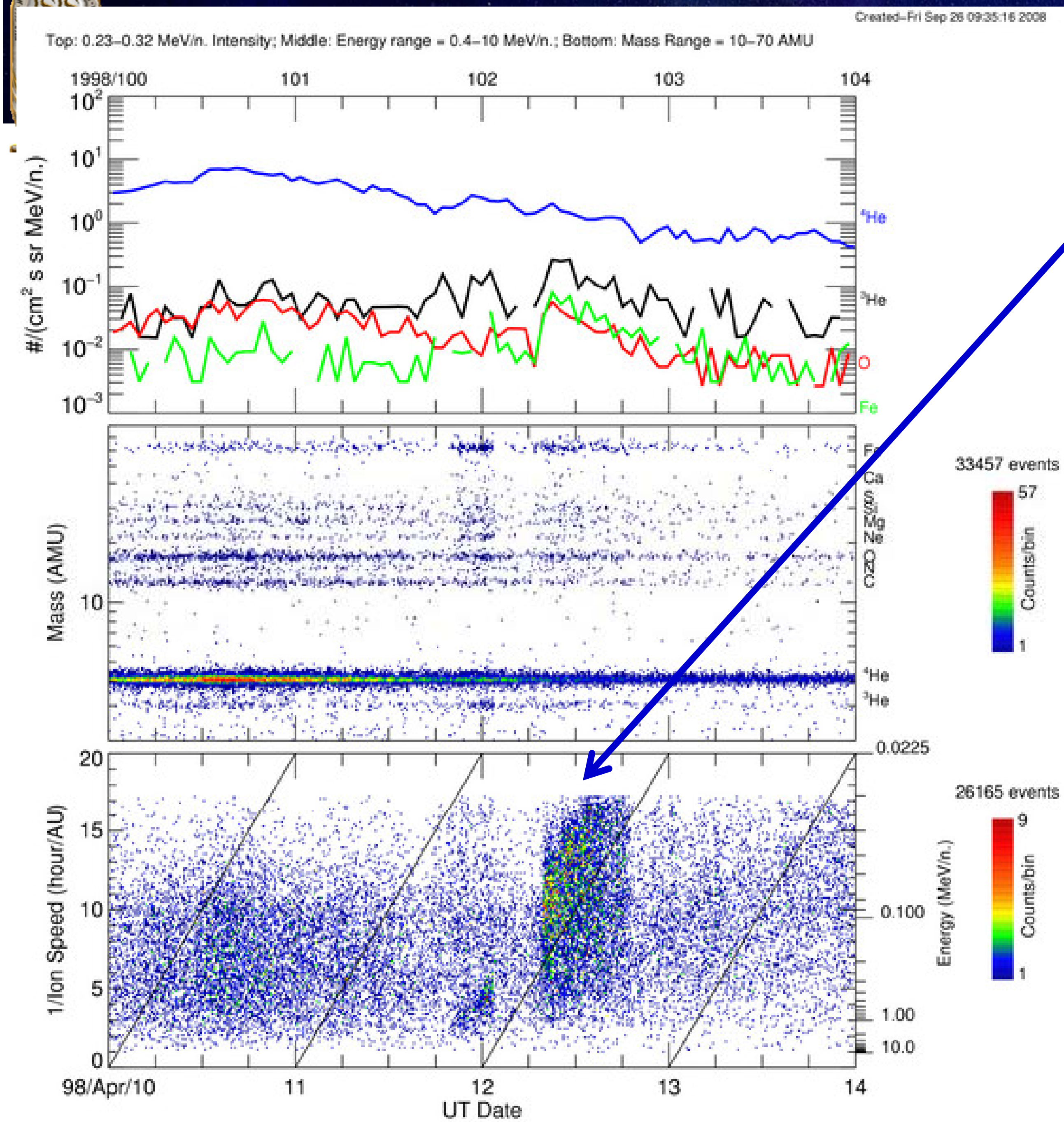
- EPI-Hi:
  - Plots of 1-hour averages of four rates:
    - 1-5 MeV electrons
    - 2-10 MeV protons
    - 10-50 MeV protons
    - 4-40 MeV/nuc HiZ ($6 \leq Z \leq 28$)

Possible Data Product (1/5)

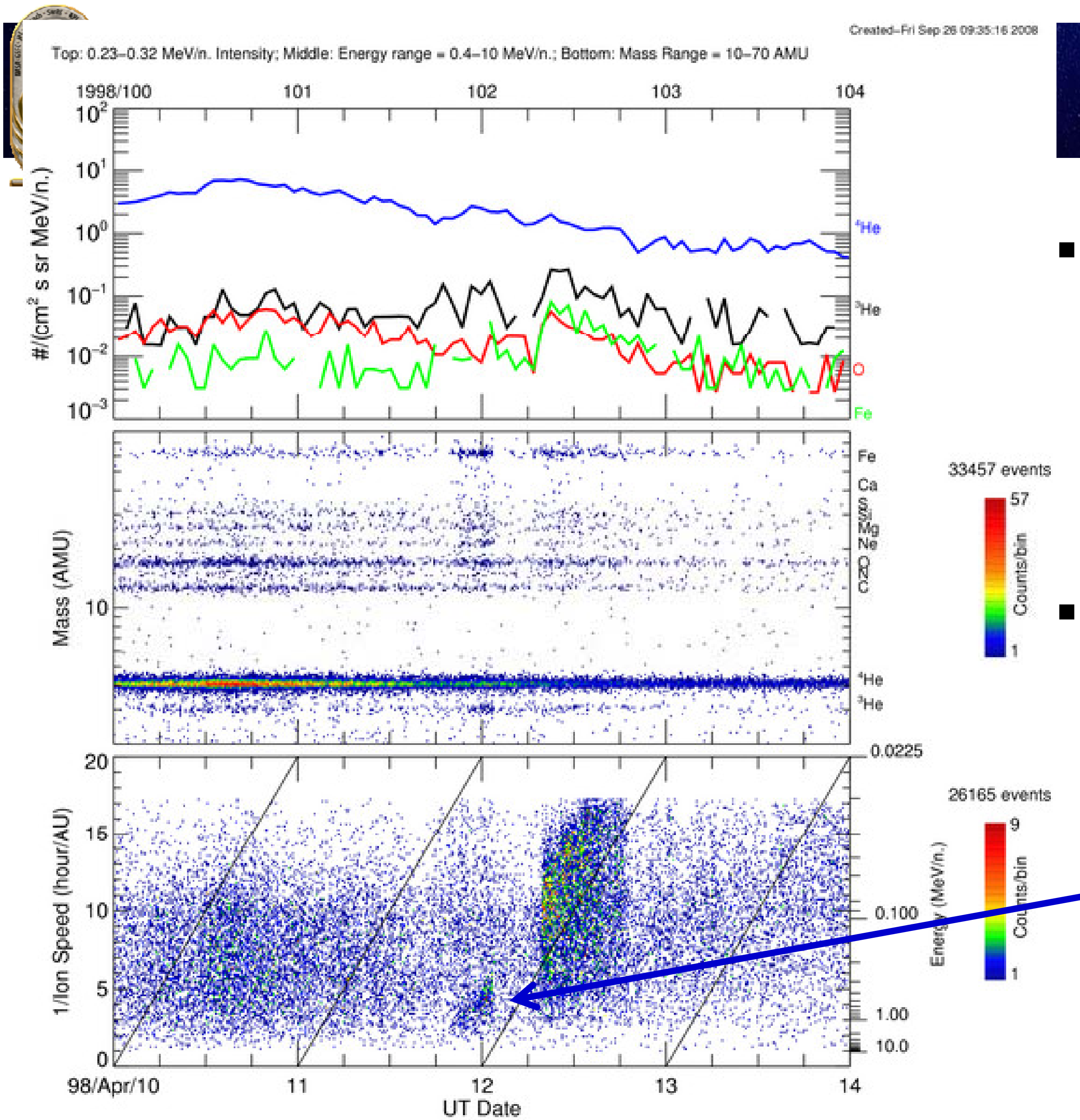


- One way of plotting SEP data
- Top plot is the usual time-intensity profile
- Each dot in the lower two panels is a particle detection
  - Middle plot shows particle mass
  - Bottom plot shows energy
- Advantages:
  - Easy identification of velocity dispersion in some events
  - Individual events are separated more clearly
  - Composition easily identified

This is image taken from the ACE website: ULEIS 4-day browse plots

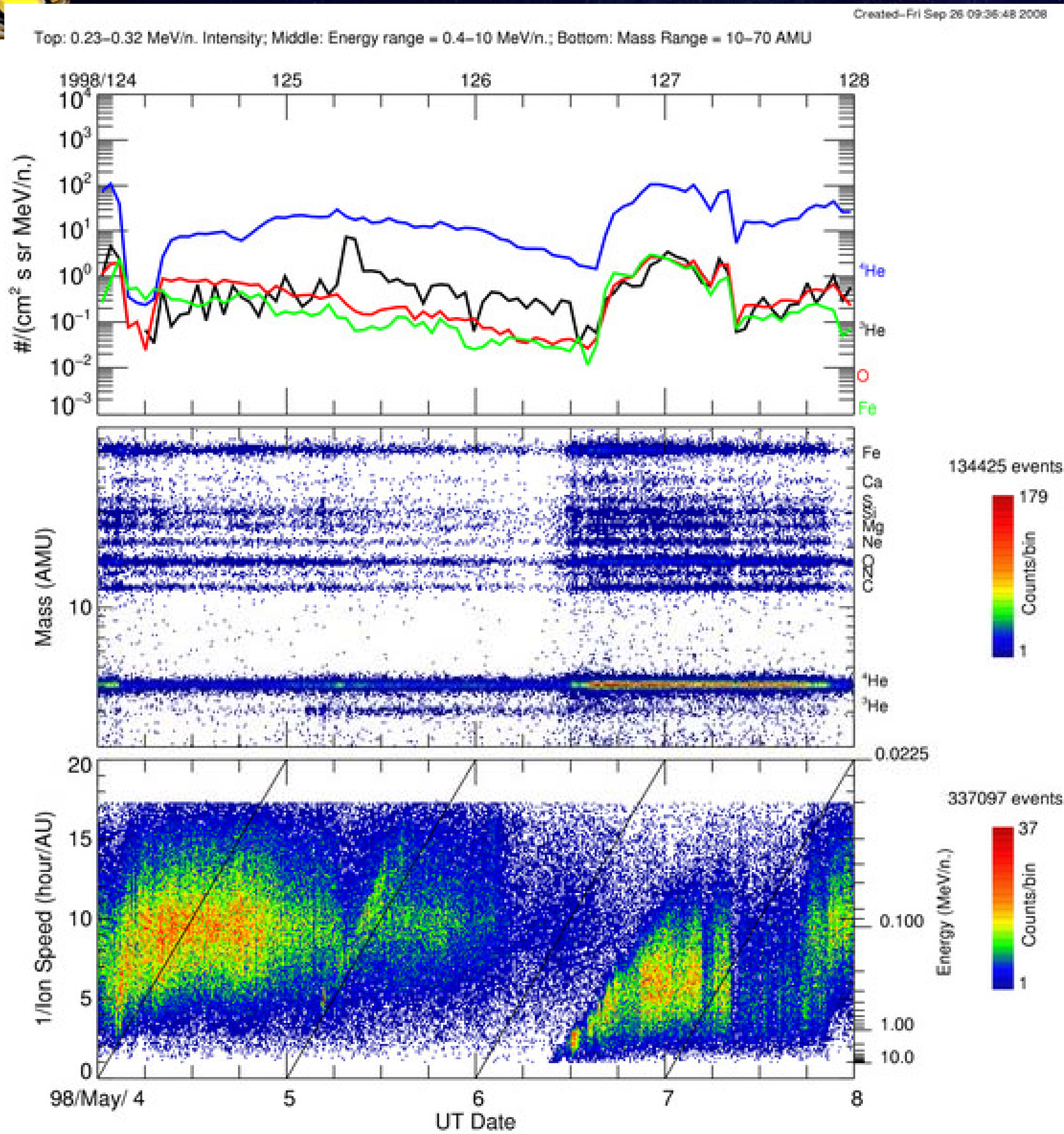


- This is an example of an event probably associated with an impulsive solar flare (rich is heavy ions and ^{3}He)



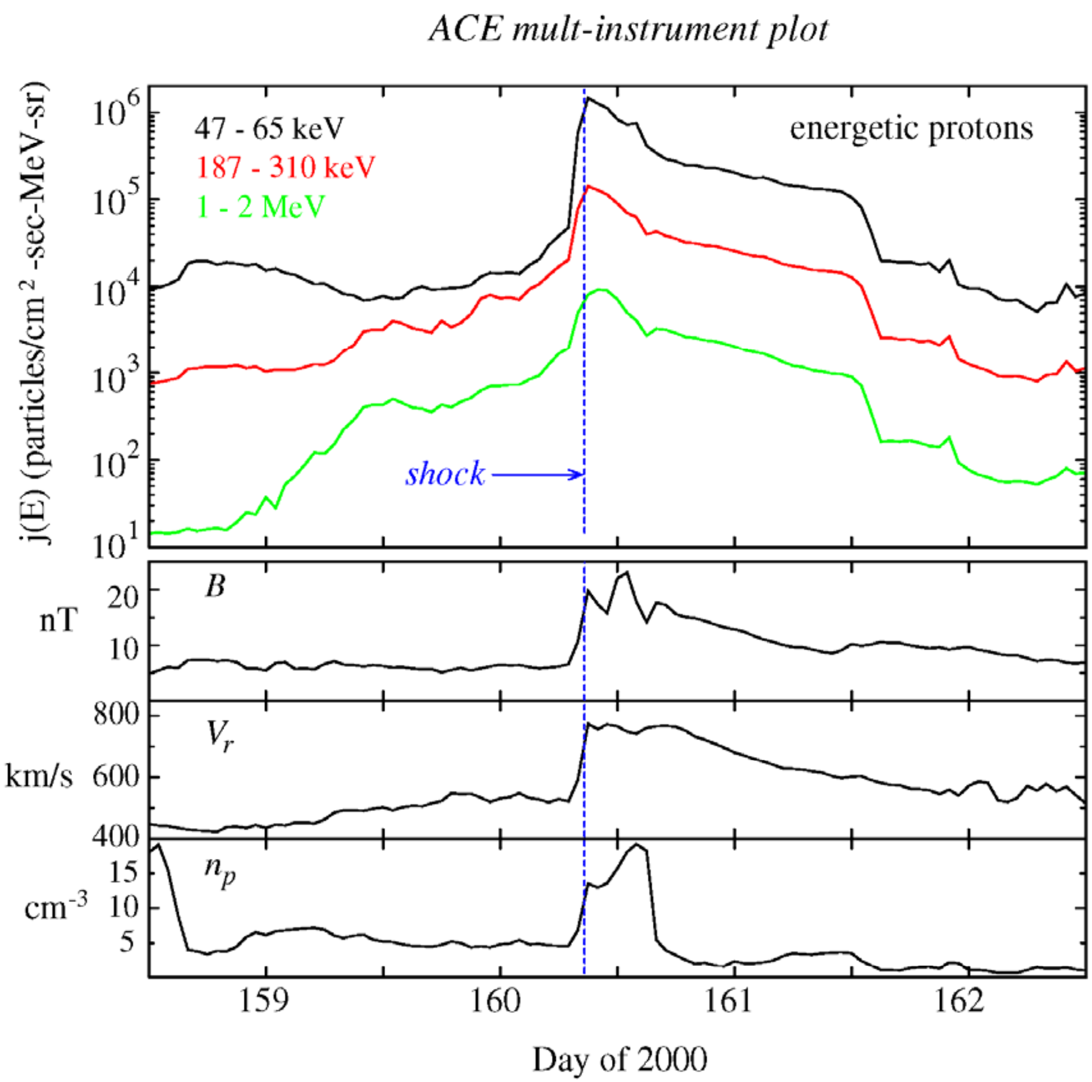
- This is an example of an event probably associated with an impulsive solar flare (rich in heavy ions and ^{3}He)
- The entire event shows a clear velocity dispersion, but there is also a dispersionless intensity “dropout” during the event

Possible Data Product (4/5)



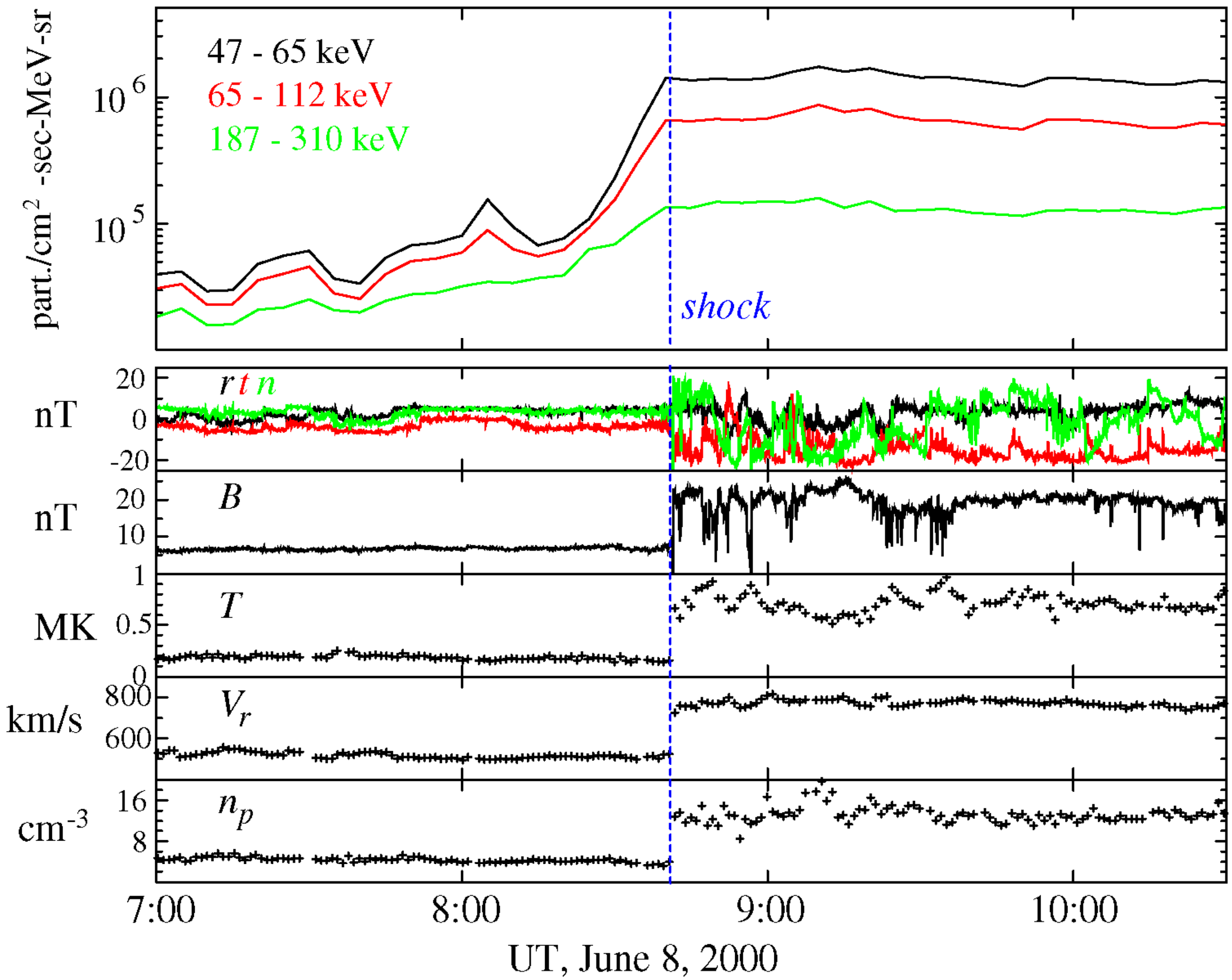
- Another good example (event starting before noon on May 6)

Possible Data Product (5/5)



- Multi-panel plots showing energetic particle intensities along with field and plasma parameters

High Time Resolution Combined Plots



Development Plan and Schedule (1/3)

- 06 November 2013 – I-PDR for ISIS/SOC - This review
- **(05/2014)** S/C emulator available, MOC-SOC ICD finalized - start of development of test SOC
  - [CSCI-1] Implementation of GSEOS at UNH.
  - [CSCI-1] Begin writing/implementation of SOC/MOC communications layer [*note]
  - [CSCI-1] Start implementation of SOC – instrument teams communication layer
- **(01/2015)** Pre-CDR ISIS SOC Peer Review (Paper-only review)
  - [CSCI-1] As instrument GSEs become operational/established, begin integration of instrument GSEOS scripts, displays and codes into the SOC GSEOS system – contingent on instrument GSE schedule
  - Purchase SOC HW components - Computers, servers, raids, UPSs, shipping crates, etc.
- **(09/2015)** Test MOC available
  - [CSCI-1] Begin testing of SOC/MOC interface and communications.
  - [CSCI-1] As instrument GSEOS codes are established at ISIS-SOC, test their functionality.
  - [CSCI-1] As instrument commanding protocols/codes are established, test SOC – instrument teams communication layer
  - [CSCI-1] As L0 test files become available test or implement HK, quicklook displays for SOC-CTG.
  - [CSCI-2] Start work with instrument teams to define L0 -> L1 processing codes

Development Plan and Schedule (2/3)

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- (**02/2017**) Pre-Instrument Delivery ISIS SOC Peer Review (Full SOC/MOC interoperability)
  - [CSCI-2] Have full L0 -> L1 codes operational based on test / calibration data
- (**03/2017**) MOC comes on-line
  - [CSCI-1] Full end-end testing of test SOC to support I&T
  - [CSCI-1] Transitioning of test SOC to APL for I&T
  - [CSCI-2] Start on work with instrument teams to implement L1->L2 processing codes
  - [CSCI-3] Extend PAPCO PRBEM cdf module to fully support ISIS data
  - [CSCI-4] Implement initial ISIS web sever with DAS-2 using ancillary data (UNH GEO, etc)
- (**12/2017**) Pre-Launch ISIS SOC Peer Review (lessons learned from I&T)
  - [CSCI-1] Transition from test SOC to full flight SOC
  - [CSCI-2] Start work on L3 processing codes (needs sample data from other SOCs)
- (**02/2018**) Mission Simulation #3 fill “in the life” test
  - [CSCI-1] Final SOC adjustments, modification
  - [CSCI-2] Complete on work with instrument teams to implement L1->L2 processing codes using best currently available calibration information
  - [CSCI-2] Complete and implement L3 processing codes

Development Plan and Schedule (3/3)

- [CSCI-2,4] Implement and test SOC-SDC Quality control loop
- [CSCI-3] Test full PAPCO operability with existing L1, L2 test data
- [CSCI-4] Have working version of ECT web site with L1 to L3 data and ancillary data

- (**08/2018**) Launch [L]
  - L to L+60days – Instrument Commissioning. Real Time SOC operations via Portable SOC at APL
  - >L+60days - Nominal Phase E Operations. SOC ops transitioned to fixed SOC at UNH.
  - L+90days – Return Portable SOC to UNH as redundant backup unit
- (Phase E) – normal ISIS-SOC operations at UNH
  - [CSCI-2] refinement of calibration procedures in L1-L2 codes based on on-orbit performance
  - [CSCI-2] Implementation of L3 -> L4 processing codes
  - [CSCI-3] Addition of Level 4 data products
  - [CSCI-4] Addition of Level 4 data products
  - [CSCI-3] (PAPCO) implementation of addition feature request from instrument teams
  - [CSCI-4] (DAS-2) implementation of addition feature request from instrument teams
- (TBD) Archive Activities

Test Plan

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- GSEOS & Commanding
  - Create commanding scenarios
  - Test connectivity to MOC
  - Interfaces to EPI-Hi and EPI-Lo
  - Test command load on Flat-Sat at UNH
- Data flow between facilities
  - Creation of faux telemetry stream
    - State-of-Health packets
    - Science Data
  - Test flow from MOC to SOC
  - Test creation of science data through level 1 from telemetry stream through pipeline

Current Status

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- Builds on highly successful IBEX SOC
- Thorough planning
- Facilities well prepared
- Highly experienced & dedicated personnel
- ISIS SOC team will support
  - Testing throughout Development
  - SPP Integration and Test
  - On-Orbit Operations and Science
- Implementation READY!