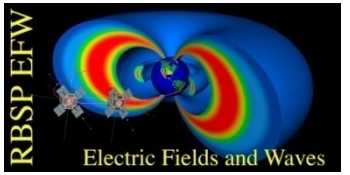


Van Allen Probes

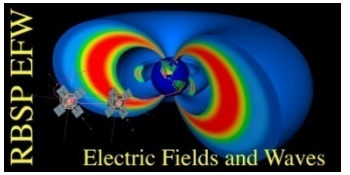
NASA Van Allen Probes
Electric Fields and Waves Instrument (EFW)
and
TDAS
(THEMIS Data Analysis Software)

John Wygant, John Bonnell
UMN, UCB SSL
wygan001@umn.edu
jbonnell@ssl.berkeley.edu

Outline: (Where to Go; What to Do When You Get There; Who To Contact When It Goes Well/Poorly)
- **EFW QuickLook Summary Plot Access**
- **EFW Data Products and Access via TDAS**

Acknowledgements:
- **EFW SOC Development Team:**
  - UCB: Peter Schroeder, Will Rachelson, , Jianbao Tao, Forrest Mozer, Jack Vernett i
  - UMN: Aaron Breneman, Kris Kersten
  - LASP: David Malaspina
- **TDAS development Team:**
  - **UCB: D King (ret), J Lewis, J McTiernan, B Sadeghi.**
  - **UCLA: P. Cruce, C. Russell, A. Flores, L. Philpott, V Angelopoulos.**

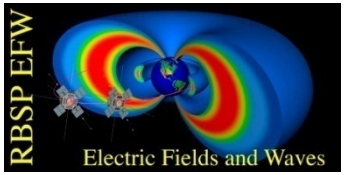
Why Use EFW (or EFI)?



- **Plasmasphere boundaries and thermal plasma distribution in space**
  - sensor potentials (V products).
  - wave dispersion characteristics (fpe/fce)
- **Large-scale convection patterns and structures**
  - E- and B-field waveforms and spin fits
- **ULF pulsation studies**
  - E- and B-field waveforms and spin fits
  - E/B and polarization, global structure (l-,m-number)
- **ELF/VLF wave (EMIC, whistler-mode) observations and distributions**
  - E- and B-field waveforms
  - Filter banks, FFT power and cross-spectra.
  - E/B and polarization, global distributions (MLT and radius).

➢ **Transport, Acceleration and Loss mechanisms.**

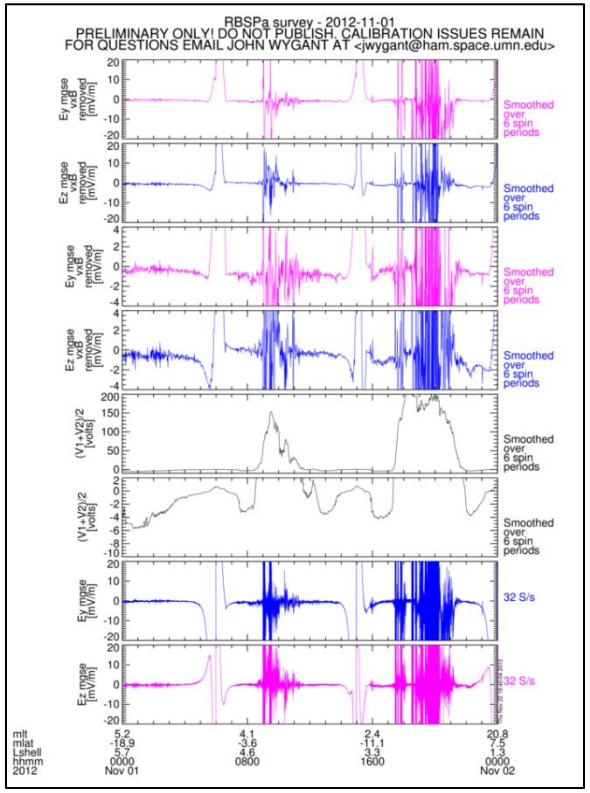
EFW QuickLook Summary Plots Access

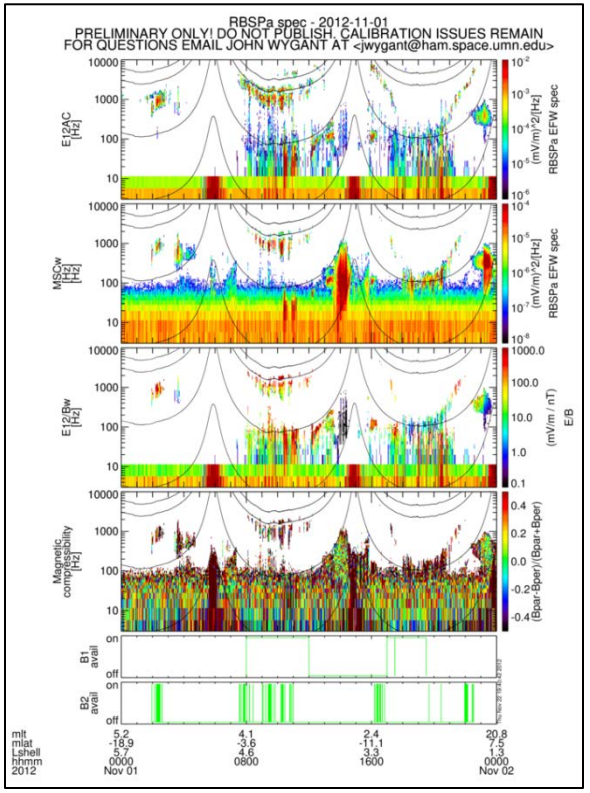


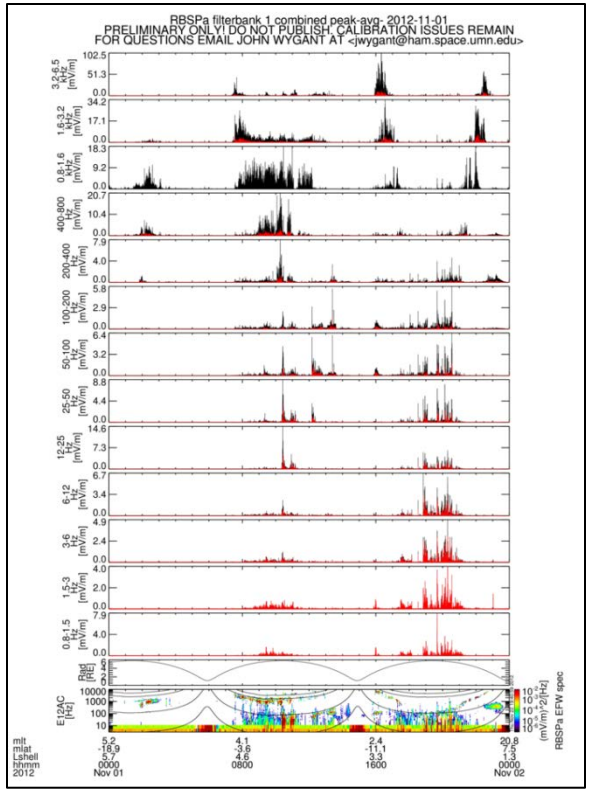
- **EFW QuickLook (QL) Summary Plots available via the following URL:**
  - http://www.space.umn.edu/missions/rbspefw-home-university-of-minnesota/
  - Click on the “Use > Daily Survey Plots” link.
- **Caveats:**
  - The QL Summary plots represent PRELIMINARY L2 data products.
  - The data depicted in the plots may contain known and unknown systematic errors which include: saturation during charging events or eclipse; inappropriate sensor bias; spin phase errors during or around eclipse; offsets and scale factor errors due to variations in plasma conditions from nominal; etc.

- **Suggested Rules of the Road for use of EFW QL Summary Plots:**
  - They should not be used in publications.
  - They should not be used in talks or other presentations until vetted by the EFW PI (John Wygant, jwygant@fields.space.umn.edu) or his designate.
  - It is suggested that users contact the EFW PI prior to starting any significant analysis utilizing the QL Summary Plots so that the data can be vetted, and one can collaborate with any members of the EFW team that are working along the same or similar lines of investigation.
  - It is also suggested that one acknowledge of the EFW PI (Wygant) in any talk or presentation that utilizes the QL Summary plots.

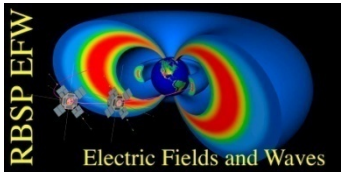
EFW QuickLook Summary Plots Examples







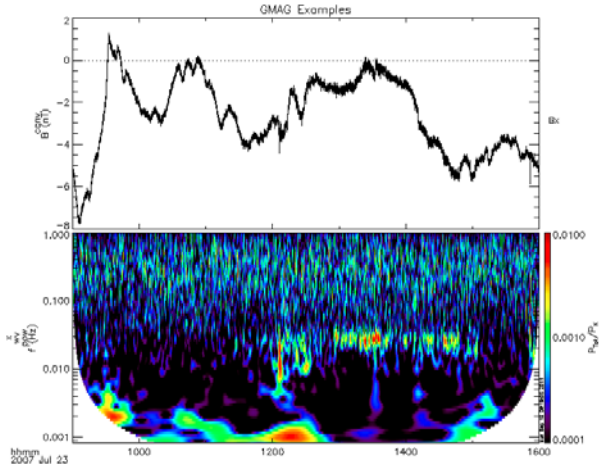
EFW Data Access
ISTP-Compliant CDFs

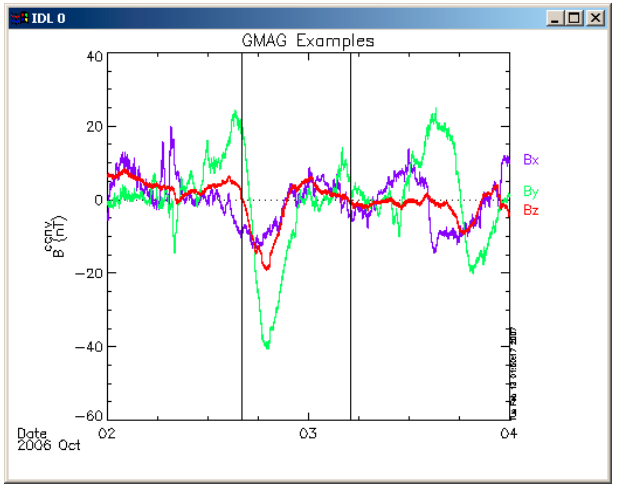


- **ISTP-Compliant L2 CDFs of EFW data available via this URL: http://www.space.umn.edu/missions/rbspefw-home-university-of-minnesota/**
- **Click on the "Use > Data" link.**
- **Data is processed from L0->L1 within 1-2 days of acquisition for survey waveform and spectral data.**
- **QL Summary Plots (quasi-L2) processed using predicted attitude and ephemerides.**
- **Full access to L1->L2 processing for general use is dependent upon public attitude and ephemerides data, which comes available about 1 week after data acquisition.**

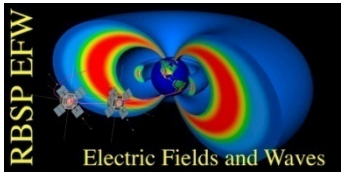
Why Use TDAS?

- **THEMIS-EFI and Van Allen Probes EFW instrument capabilities and requirements overlap.**
- **THEMIS and Van Allen Probes science overlap; TDAS includes support for "generic" ISTP-Compliant CDF data files.**
- **THEMIS-EFI data products and analysis were already incorporated into TDAS; Fluency with TDAS across EFW SOC and Science team.**
- **TDAS's power and flexibility for enabling science analysis and producing publication-quality plots, etc.**
- **Development currently scoped for command line usage (ie., we are not planning on including EFW in the TDAS GUI).**





EFW via TDAS
Acquiring and Setting Up TDAS



- **The EFW package - which includes growing TDAS support for EMFISIS, MagEIS, and other instrument data products - is available via the latest "bleeding edge" TDAS software release via this URL: http://themis.ssl.berkeley.edu/socware/bleeding_edge/thmsw_latest.zip.**
- **Eventually, the EFW routines will be part of the normal TDAS distribution available via this URL: http://themis.ssl.berkeley.edu/software.shtml; EFW routines ARE included in the numbered TDAS releases, but they are not kept up to date (i.e. the EFW routines in TDAS 8.0 are from March 2013)**
- **CAVEAT: Bleeding edge is a nightly build, and has not been fully QA tested. There will be bugs and feature changes over time.**
- **TDAS is a package built to run in IDL; it is tested against IDL 6.4-7.1, and makes extensive use of the TPLOT libraries in IDL developed and refined over many past missions (WIND, FAST, STEREO, Cluster, THEMIS/ARTEMIS, etc.). While not QA'd against IDL 8.x, a significant and successful user base of TDAS under IDL 8.2+ exists, and so earlier limits on IDL versions can be relaxed.**
- **To support the TDAS and EFW packages, patches a/o supporting libraries (dlm/dll or .so) for CDF, SPICE and GEOPACK are required:**
  - http://cdf.gsfc.nasa.gov/
  - http://naif.jpl.nasa.gov/naif/toolkit_IDL.html
  - http://themis.ssl.berkeley.edu/beta/software.shtml.
- **The process required to add the SPICE and GEOPACK support is described in README.txt files in the "external/IDL_GEOPACK" and "external/IDL_ICY" directories of the TDAS distribution, copies of which are included in the Backup Slides to this presentation.**
- **Experience with doing this setup multiple times suggests that it is much easier on Windows and Mac machines to find the existing folder or directory where IDL is storing dlm/dll and/or .so files than it is to adjust the values of environment variables in the way described in the README.txt files. On 64-bit Windows7 machines, for example, one can find these files in the following locations:**
  - **C:\Program Files\ITT\IDL64\bin\bin.x86_64**
  - **C:\Program Files\ITT\IDL64\bin\bin.x86**
- **Initial contact points for issues/questions:**
  - TDAS: Lewis (jwl@ssl.berkeley.edu).
  - EFW TDAS: Bonnell (jbonnell@ssl.berkeley.edu), Schroeder (peters@ssl.berkeley.edu).
- **BONNELL will be at GEM through noon Thursday, available to answer questions and aid in TDAS setup.**

EFW via TDAS
Running TDAS

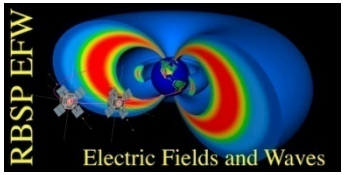
- **Live Demo Here using the batch file:**
  ssl_general/missions/rbsp/efw/examples/mini_gem_crib.pro
- **The relevant ISTP-Compliant CDFs are fetched from remote sites or from local directories (this demo uses pre-loaded data).**
- **The contents are converted to TPLOT variables, which can then be plotted on a common time axis, various plotting options manipulated, the time series waveforms or spectra extracted, manipulated, combined, and new TPLOT variables generated (this is how the preliminary L1->L2 processing is done for the QL Summary Plots, for example).**

EFW Data Products

Data Product	Notes	Coverage	Analogous THEMIS Data Product (and coverage)
E_SVY	32 samp/s; EDC12, EDC34, EDC56 (U,V, W)	Continuous	EFF (<50%)
V_SVY	16 samp/s; V1..V6.	Continuous	VAF (<50%)
MAG_SVY	64 samp/s; MAG U, V, W (disabled).	Contingency for EMFISIS-MAG	FGM
FBK	Filter Bank; 1 channel, 13 bins, pk and avg, 1/8-s cadence; E12DC (U).	Continuous	FBK
SPEC	FFT Power Spec; 7 channels, 8-s cadence; 10% df/f (64 bins); E12AC (U), E56AC (U), SCM U,V,W	Continuous.	FFT
XSPEC	FFT Cross Spec; 2 channels, 8-s cadence.	Continuous.	None.
E, B Spin Fit	10.9-s (spin period) cadence; E12DC (U), MAGU.	Continuous.	EFS, BFS
Burst1	512 samp/s: EDC, V1..V6, SCM.	7.5% (~1.8 hr/day, or 40 min/orbit)	PBurst - EFP, VAP, SCP.
Burst2	16384 samp/s: V1AC..V6AC.	0.1% (~80 s/day, or ~30 s/orbit).	Wburst – EFW, VAW, SCW.
Housekeeping	Various rates; Instrument SOH, Burst Memory Parameters, etc.	Continuous	HSK

EFW TDAS Data Access

Access Routine	Quantities Accessed	Analogous THEMIS Access Routine
RBSP_EFW_LOAD_WAVEFORM	E_SVY, V_SVY, MAG_SVY; EB1, VB1, MSCB1; EB2, VB2, MSCB2.	THM_LOAD_EFI
RBSP_EFW_LOAD_FBK	FBK.	THM_LOAD_FBK
RBSP_EFW_LOAD_SPEC	SPEC.	THM_LOAD_FFT
RBSP_EFW_LOAD_XSPEC	XSPEC.	n/a.
RBSP_EFW_LOAD_FIT	E, B Spin Fit.	THM_LOAD_FIT.
RBSP_EFW_LOAD_HSK	Housekeeping.	THM_LOAD_HSK (EFI only).
RBSP_LOAD_EMFISIS	EMFISIS L2 MAG, WFR, and HFR data products.	THM_LOAD_FGM
RBSP_LOAD_{other instruments}	Public L2 data from other instruments (RBSPICE, HOPE, MagEIS, REPT, RPS) (not yet implemented)	



Backup Slides

Mission Overview – Instruments Data Products

ISTP-Compliant CDFs Accessed via IDL/TDAS

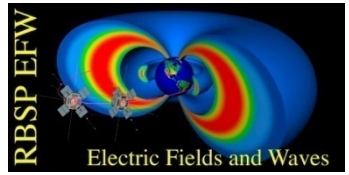
Data Level	ECT	EFW	EMFISIS	RBSPICE	RPS
L0	Raw Telemetry (Raw de-commutated telemetry received from MOC)	Raw Telemetry (Raw de-commutated telemetry received from MOC)	Raw Telemetry (Raw de-commutated telemetry received from MOC)	Raw Telemetry (Raw de-commutated telemetry received from MOC)	Raw Telemetry (Raw de-commutated telemetry received from MOC)
L1	Count Rates (Sorted time tagged instrument separated counts per second)	Time Tagged Raw waveform and spectral data (Expressed in spinning spacecraft coordinate system)	Time series and spectra (relative amplitudes); burst data Calibrated Magnetic Field values (Calibrated and corrected physical units)	Count Rates (Sorted time tagged instrument separated counts per second)	Energy/Photon deposits, singles and coincidence rates (Time tagged in UTC, magnetic field vector, minimal magnetic coordinates)
L2	Calibrated Flux (Calibrated and corrected physical units)	Calibrated Waveform and Spectral Data (In despun spacecraft coordinate system and other relevant geophysical Systems)	Spectral Quantities (Calibrated and corrected physical units); Includes low frequency spectra from MAG	Calibrated Flux (Calibrated and corrected physical units)	Flux versus Energy Spectrum
L3	Pitch Angle and Moments (Pitch angle distributions and moments of the plasma distribution)	Calibrated Waveform and Spectral Data (with VxB subtraction for DC E-field estimate)	Magnetic wave parameters	Pitch Angle and Moments (Pitch angle distributions and moments of the plasma distribution)	Energy-pitch angle spectrum and magnetic coordinates
L4	Phase Space Density (PSD units in adiabatic coordinate space)	Global Electric Field Pattern	Wave propagation parameters (Spectral matrices, WNA, polarization, Poynting flux, etc) Electron densities	Phase Space Density (PSD units in adiabatic coordinate space) (PSD will be calculated for specific ring current relevant observations)	Global Maps (flux vs E/K/Phi and PSD versus M/K/Phi)

Table 4.2. Mission Level Data Products

QuickLook Summary Plots ISTP-Compliant CDFs

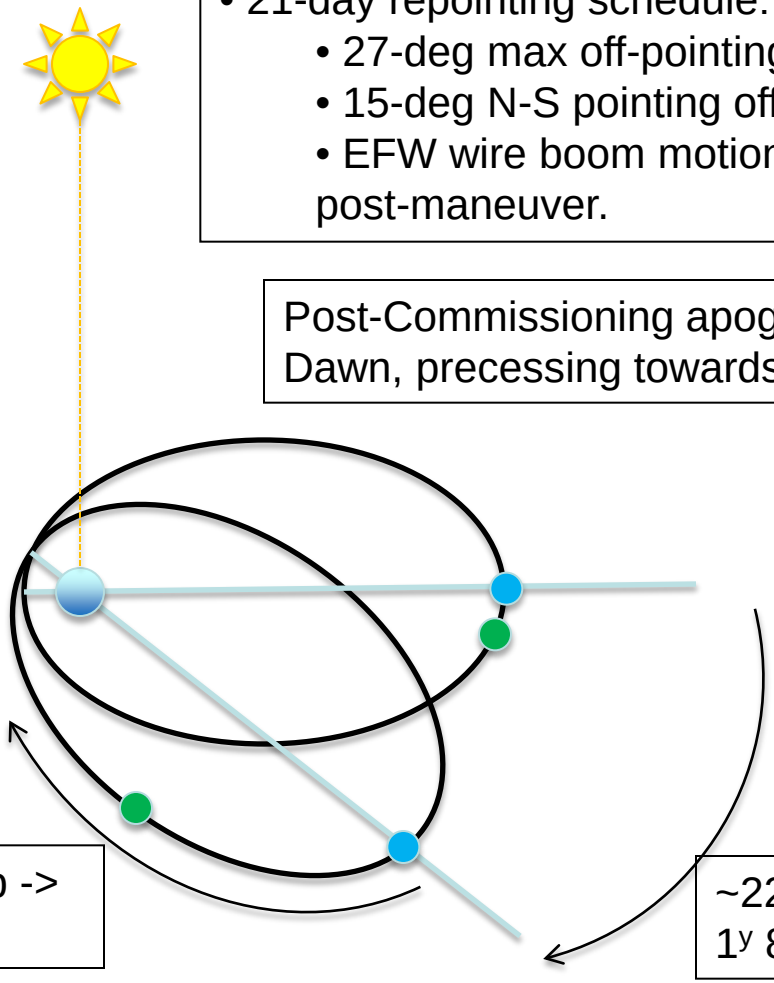
From RBSP SDMP, p.38.

Mission Overview – Orbits and Attitude



•SC spin axis points near the Sun.
• 21-day repointing schedule:
  • 27-deg max off-pointing.
  • 15-deg N-S pointing offset.
  • EFW wire boom motion < 0.5-deg, post-maneuver.

Post-Commissioning apogee is near Dawn, precessing towards Midnight …

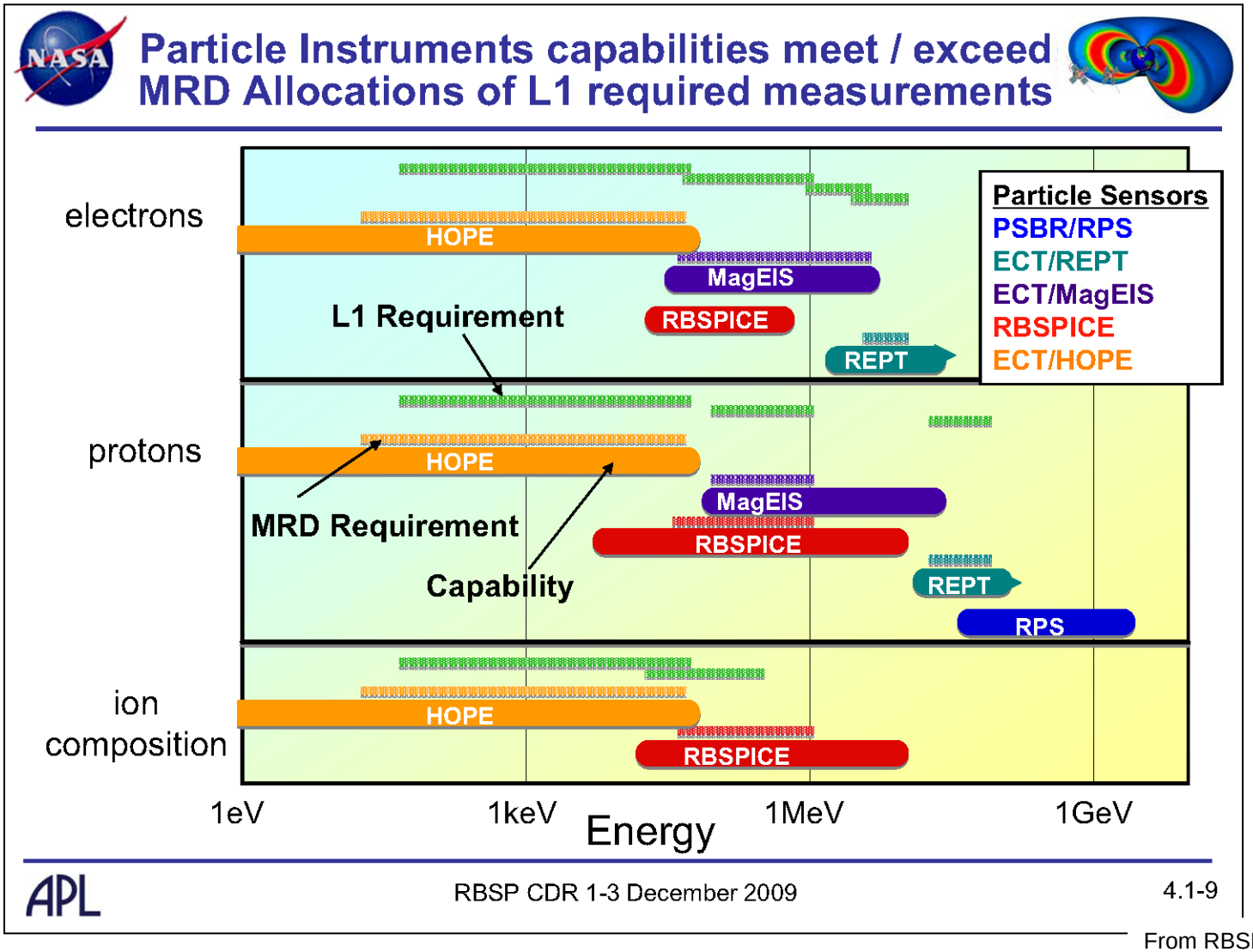


- ~ 600 km alt. perigee
- ~ 5.8 Re radius apogee
- ~ 9-hr period.
- 10-deg inclination (to equator)

~70 days/lap ->
5 laps/yr

~220 deg/yr ->
1^{y} 8^{m} precession

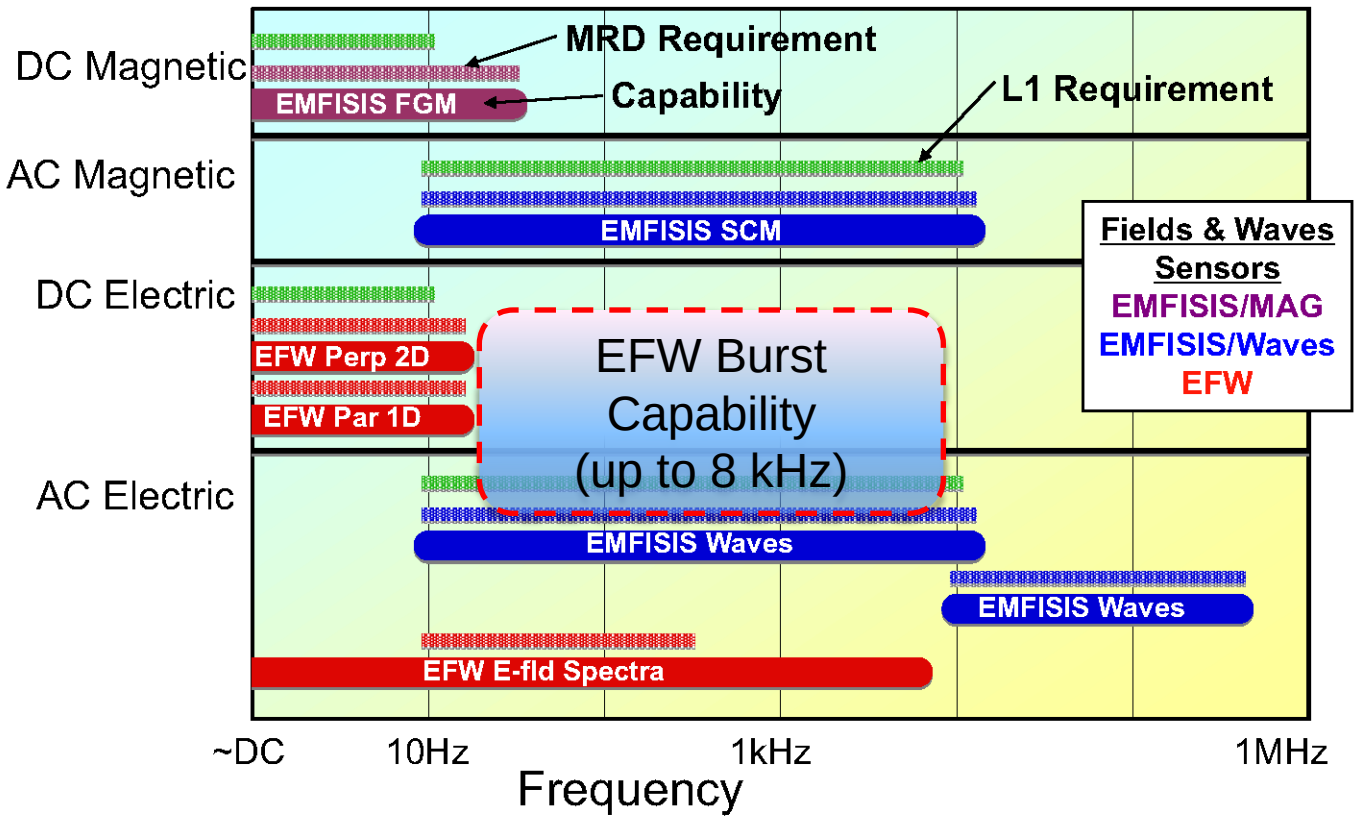
Mission Overview – Instruments Particles



From RBSP M-CDR, p.4.1-9.

Mission Overview – Instruments Fields

Fields Instruments capabilities meet / exceed MRD Allocations of L1 required measurements



APL RBSP CDR 1-3 December 2009 4.1-10

From RBSP M-CDR, p.4.1-10.

RBSP and TDAS Conventions

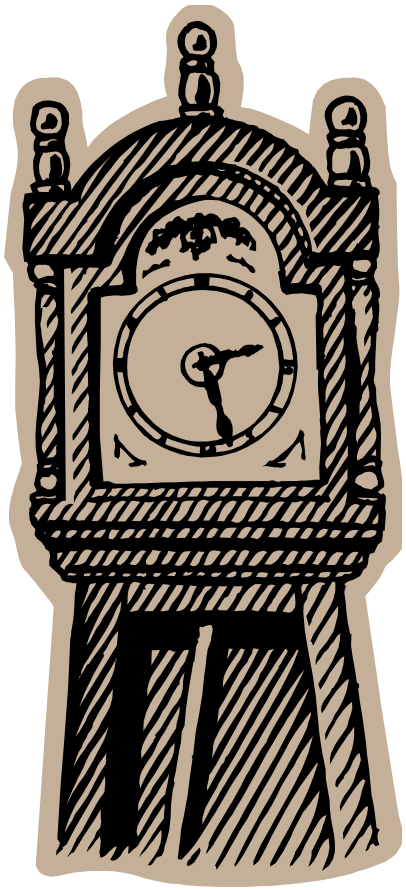
- **TDAS has a well developed software team at UCB which performs library maintenance, ensures quality, etc.**
- **TDAS has developed standards for both software in its library (including those in mission "branches" like the RBSP branch) and data products.**
- **Some of these standards need to be re-framed for RBSP purposes. A "dictionary" for RBSP which ensures we follow TDAS standards while also not creating confusion in namespaces, system variable names, and so forth is essential.**
- **All RBSP teams that intend to use TDAS need to be working together to formulate this dictionary.**
- **TDAS also has a robust quality assurance component. Software from RBSP must be accompanied with test scripts that can be run as part of QA major release testing.**

TDAS Leveraging IDL's Strengths

- **TDAS is IDL-based. It builds on IDL's strengths which has ramifications for code included in its library.**
- **IDL is platform independent. The inclusion of compiled code (C, Fortran, etc.), except where absolutely necessary as in the support for CDF and SPICE, is generally not allowed.**
- **IDL is optimized for vectorized operations. Many of the lower-level TDAS routines expect, or can handle, vectorized operations. It is good practice to take advantage of this when possible, both because it makes code more efficient and faster and because some lower-level routines will expect vectors of quantities (such as arrays of times, arrays of vectors, etc.).**

TDAS and Time

- **TDAS is designed to load data from CDF (CDF2TPLOT).**
- **Update from last Fall: TDAS now supports the new CDF time variables used by the Van Allen Probe instruments:**
  - CDF_EPOCH16: EFW.
  - CDF_TIME_TT2000: EMFISIS, RBSPICE, etc.



EFW Access via SDT

The EFW waveform data products and supporting data can also be accessed and analysed via the legacy analysis package Science Data Tool (SDT).

SDT can be installed from the website:

http://sprg.ssl.berkeley.edu/~sdt/SdtReleases.html

Five platforms are currently supported:

Solaris/SPARC
Linux, 32-bit
Linux, 64-bit)
MacOSX, 32-bit (Leopard or above)
MacOSX, 64-bit (Lion or above)

Corresponding to each platform is an "INSTRUCTIONS" guide on the webpage, which indicate how to install SDT and set up for various supported projects: FAST, POLAR-EFI, CLUSTER-EFW, THEMIS-EFI, RBSP-EFW. Once installed, instructions on how to get started using SDT are in the text document:

sdt_installation_directory/docs/SdtUse

Jack Vernetti (jackv@ssl.berkeley.edu) and Forrest Mozer (fmozer@ssl.berkeley.edu) are the primary points of contact for questions of SDT support and applications.