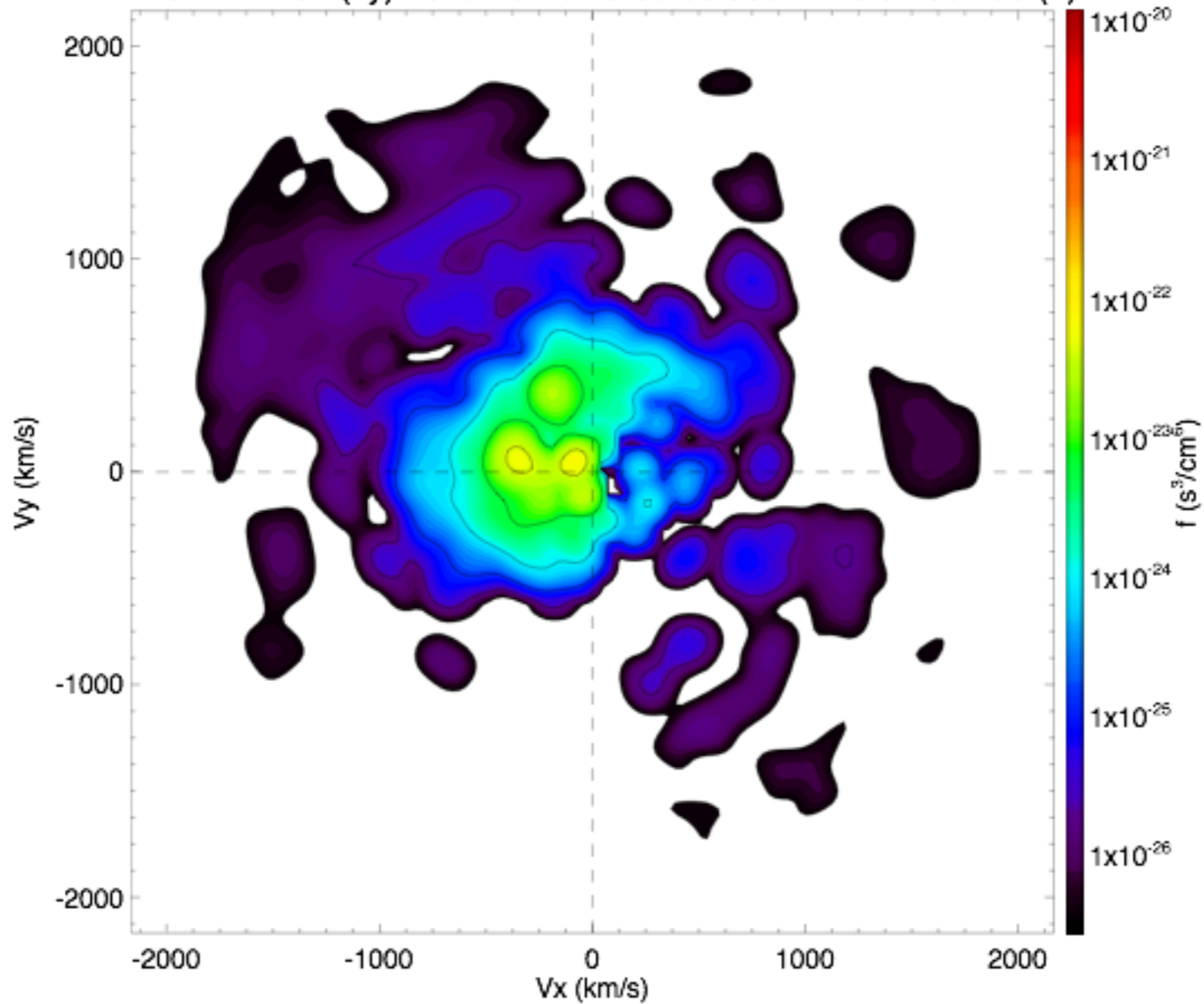


MMS 1 FPI Ion (xy) 2015-10-16/13:06:59.985 -> 13:07:00.135 (1)



MMS Data with SPEDAS

Eric Grimes (egrimes@igpp.ucla.edu)

December 10, 2017

Overview

- Getting Started
- Loading and Plotting Data
- Analysis Tools
- Examples
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Getting Started

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Getting Started Requirements

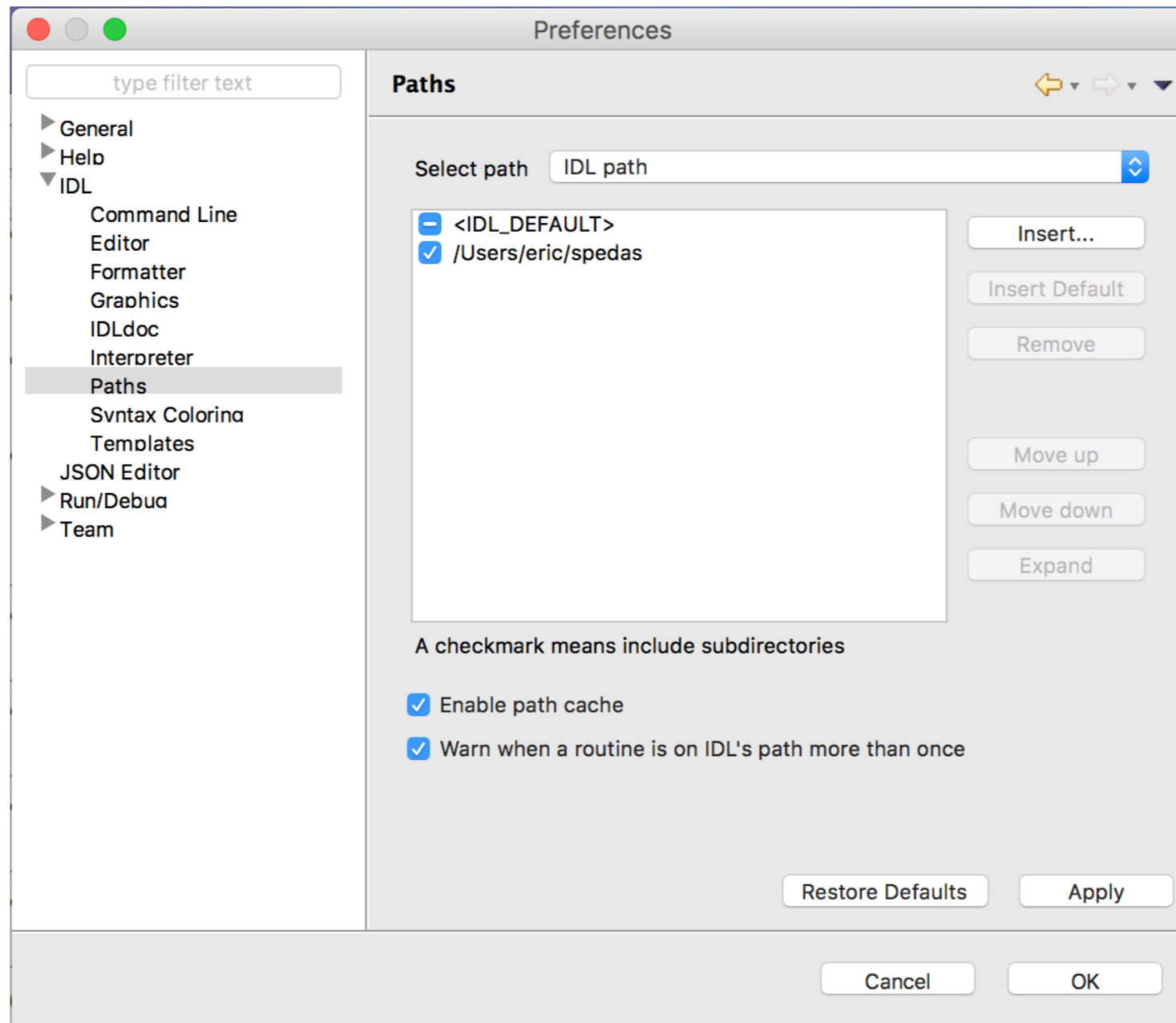
- Windows, Linux, OS X, or Solaris
- IDL 8.4+
- IDL CDF Library 3.6+

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Getting Started Installing SPEDAS

http://spedas.org/wiki/index.php?title=Downloads_and_Installation



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Getting Started Organization

spedas_gui: Components of the SPEDAS Graphical User Interface (GUI)

external: Code developed externally, but distributed with SPEDAS (CDAWeb, Geopack, etc.)

projects: Mission specific code

general: General science analysis tools

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MMS Load Routines

mms_load_fgm	Fluxgate Magnetometer
mms_load_scm	Search-coil Magnetometer
mms_load_mec	Ephemeris and Coordinates
mms_load_fpi	Fast Plasma Investigation
mms_load_hpca	Hot Plasma Composition Analyzer
mms_load_eis	Energetic Ion Spectrometer
mms_load_feeps	Fly's Eye Energetic Particle Sensor
mms_load_edp	Electric-field Double Probe
mms_load_edi	Electron Drift Instrument
mms_load_dsp	Digital Signal Processor
mms_load_aspoc	Active Spacecraft Potential Control
mms_load_tetrahedron_qf	Tetrahedron Quality Factor
mms_load_brst_segments	Burst intervals

See folder: /projects/mms/

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Getting Started Standard Keywords

- `trange` `trange=['2015-10-16', '2015-10-17']`
- `probes` `probes=[1, 2, 3, 4]`
- `level` `level='12'`
- `data_rate` `data_rate='srvy'`
- `datatype` `datatype=['des-moms', 'dis-moms']`

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Standard Keywords

- suffix `suffix='_burst_mode'`
- time_clip `/time_clip`
- no_update `/no_update`
- spdf `/spdf`
- tplotnames `tplotnames=tvarnames`

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Standard Keywords

- `local_data_dir` `local_data_dir='/Users/eric/mydata/'`
- `cdf_filenames` `cdf_filenames=data_file_list`
- `cdf_version` `cdf_version='3.0.0'`
- `min_version` `min_version='3.0.0'`
- `latest_version` `/latest_version`

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Getting Started Standard Keywords

For a complete list of keywords and their descriptions, see the header for the load routine you're interested in, e.g.,

```
; PROCEDURE:
;     mms_load_fpi
;
; PURPOSE:
;     Load data from the Fast Plasma Investigation (FPI) onboard MMS
;
; KEYWORDS:
;     trange:      time range of interest [starttime, endtime] with the format
;                 ['YYYY-MM-DD', 'YYYY-MM-DD'] or to specify more or less than a day
;                 ['YYYY-MM-DD/hh:mm:ss', 'YYYY-MM-DD/hh:mm:ss']
;     probes:     list of probes, valid values for MMS probes are ['1', '2', '3', '4'].
;                 If no probe is specified the default is probe '3'
;     level:      indicates level of data processing. FPI levels currently include 'l2',
;                 'l1b', 'sitl', 'ql'.
;     datatype:   valid datatypes are:
;                 Quicklook: ['des', 'dis']
;                 SITL: '' (none; loads both electron and ion data from single CDF)
;                 L1b/L2: ['des-dist', 'dis-dist', 'dis-moms', 'des-moms']
;     data_rate:  instrument data rates for MMS FPI include 'fast', 'brst'.
;     local_data_dir: local directory to store the CDF files; should be set if
;                 you're on *nix or OSX, the default currently assumes Windows (c:\data\mms\)
;     source:     specifies a different system variable. By default the MMS mission system
;                 variable is !mms
;     get_support_data: load support data (defined by support_data attribute in the CDF)
;     tplotnames: returns a list of the names of the tplot variables loaded by the load routine
;     no_color_setup: don't setup graphics configuration; use this keyword when you're
;                 using this load routine from a terminal without an X server running
;     time_clip:  clip the data to the requested time range; note that if you do not use
;                 this keyword you may load a longer time range than requested
```

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Getting Started

SDC Data Availability

Browse the status of the data:

<https://lasp.colorado.edu/mms/sdc/public/about/processing/>

Browse the data files:

<https://lasp.colorado.edu/mms/sdc/public/data/>

Search for data files:

<https://lasp.colorado.edu/mms/sdc/public/search/>

Browse the quicklook plots at the SDC:

<https://lasp.colorado.edu/mms/sdc/public/quicklook/>

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Getting Started Simple Example

```
; load the MMS4 FGM data
mms_load_fgm, probe=4, data_rate='srvy', trange=['2016-12-15', '2016-12-16']

; list the tplot variables loaded
tplot_names

; get the data out of a tplot variable
get_data, 'mms4_fgm_b_gsm_srvy_l2_bvec', data=bgsml_vec, dlimits=bgsml_metadata

; get basic info on the IDL vars that hold the B-field data
help, bgsml_vec ; structure, x: times, y: data (x, y, z)
help, bgsml_metadata ; plotting and file metadata

; store the data into a different tplot variable
store_data, 'new_var_with_b_gsm', data=bgsml_vec, dlimits=bgsml_metadata

; plot the newly created variable
tplot, 'new_var_with_b_gsm'
```


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Loading and Plotting Data

FGM

```
; load 20 minutes of burst-mode FGM data for probe 4 on December 15, 2016
mms_load_fgm, probe=4, data_rate='brst', trange=['2016-12-15/10:10', '2016-12-15/10:30'], /time_clip

; remove gaps
tdegap, ['mms4_fgm_b_gsm_brst_l2_bvec', 'mms4_fgm_b_gsm_brst_l2_btot'], /overwrite

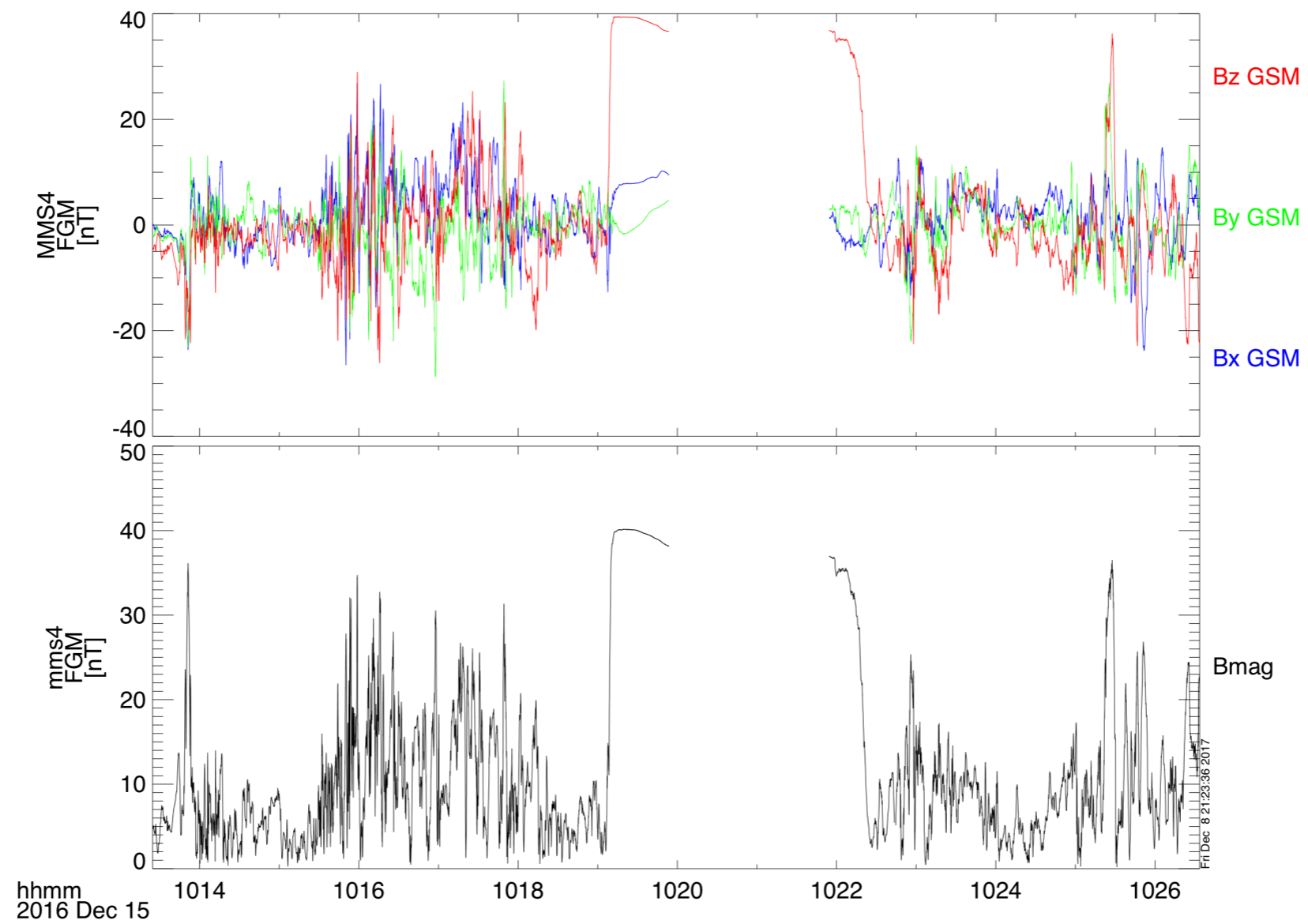
; plot the vector and magnitude
tplot, ['mms4_fgm_b_gsm_brst_l2_bvec', 'mms4_fgm_b_gsm_brst_l2_btot']

; save the plot to a postscript file
tprint, 'mms4_fgm_b_gsm_brst_l2', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/fields/>

Loading and Plotting Data

FGM



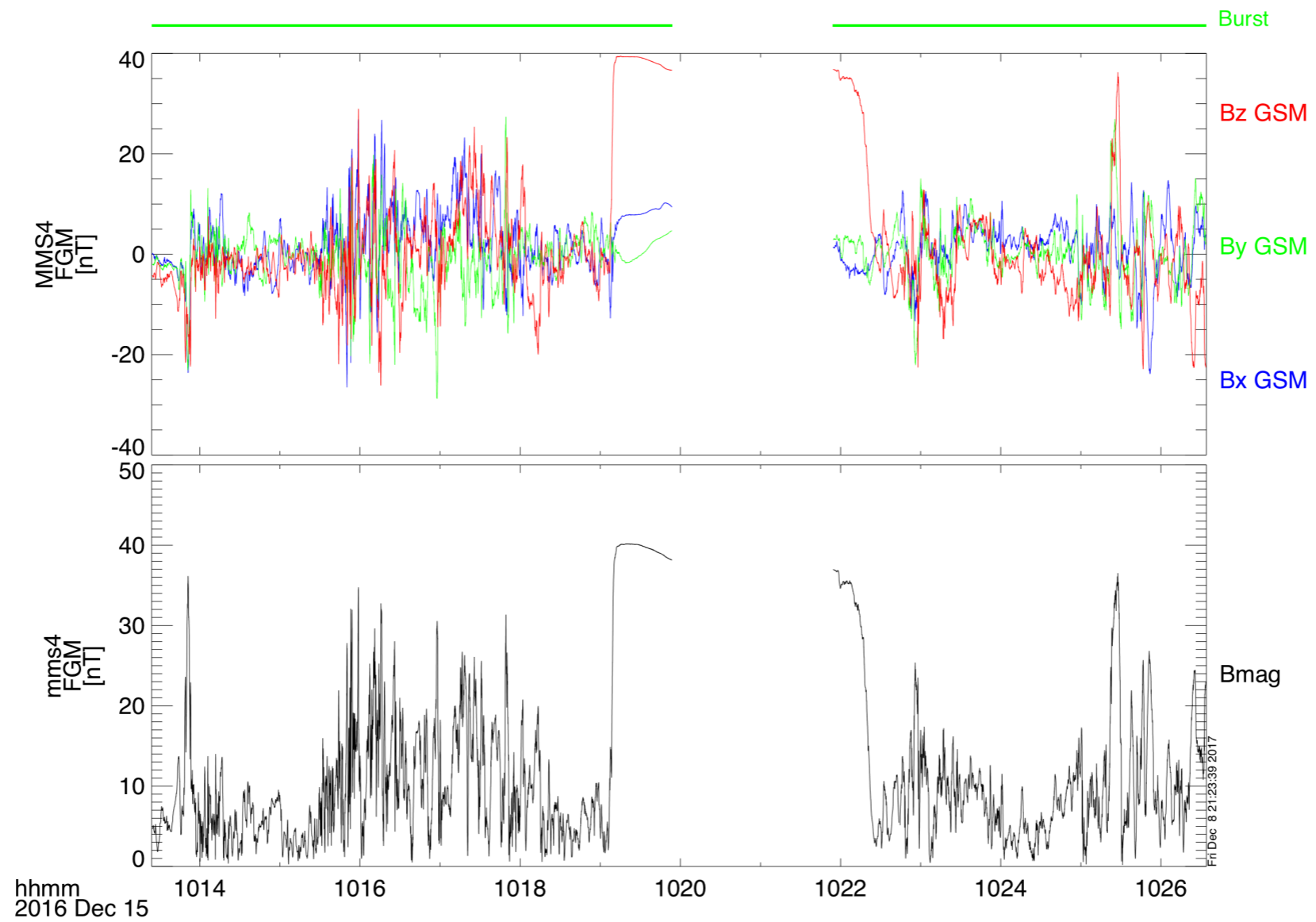
Loading and Plotting Data

FGM

```
; add burst segments bar to the top of the figure  
mms_load_brst_segments, trange=['2016-12-15/10:10', '2016-12-15/10:30']  
  
tplot, 'mms_bss_burst', /add  
  
; save the plot as a postscript file  
tprint, 'mms4_fgm_b_gsm_brst_l2_with_burstbar', /landscape
```

Loading and Plotting Data

FGM



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Loading and Plotting Data SCM

```
; load 20 minutes of burst-mode SCM data for probe 2 on December 15, 2016
mms_load_scm, probe='2', data_rate='brst', trange=['2016-12-15/10:10', '2016-12-15/10:30'], /time_clip

; plot the data
tplot, 'mms2_scm_acb_gse_scb_brst_l2'

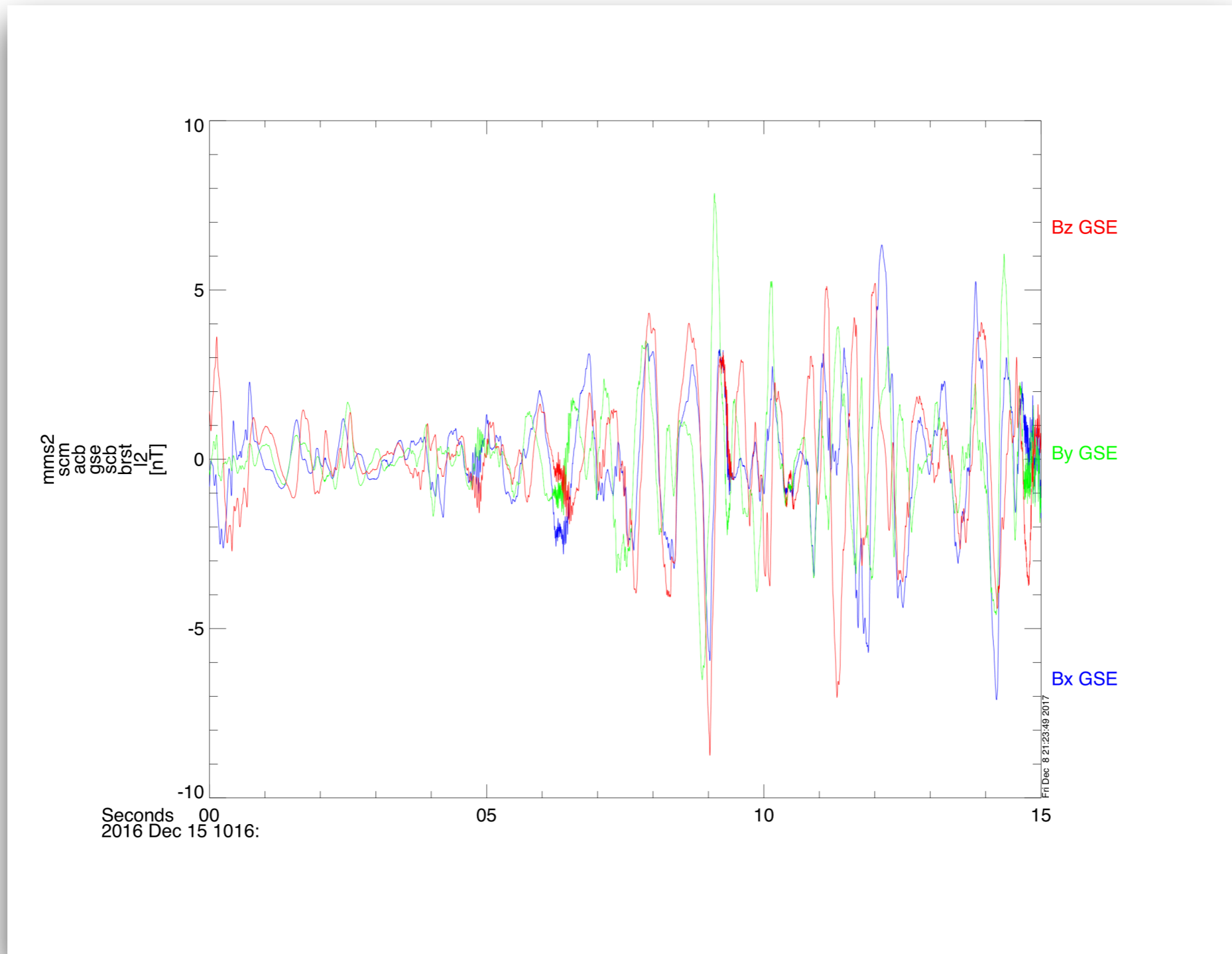
; zoom into a few seconds after 10:16
tlimit, ['2016-12-15/10:16:00', '2016-12-15/10:16:15']

; save the plot to a postscript file
tprint, 'mms2_scm_acb_gse_scb_brst_l2', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/fields/>

Loading and Plotting Data

SCM



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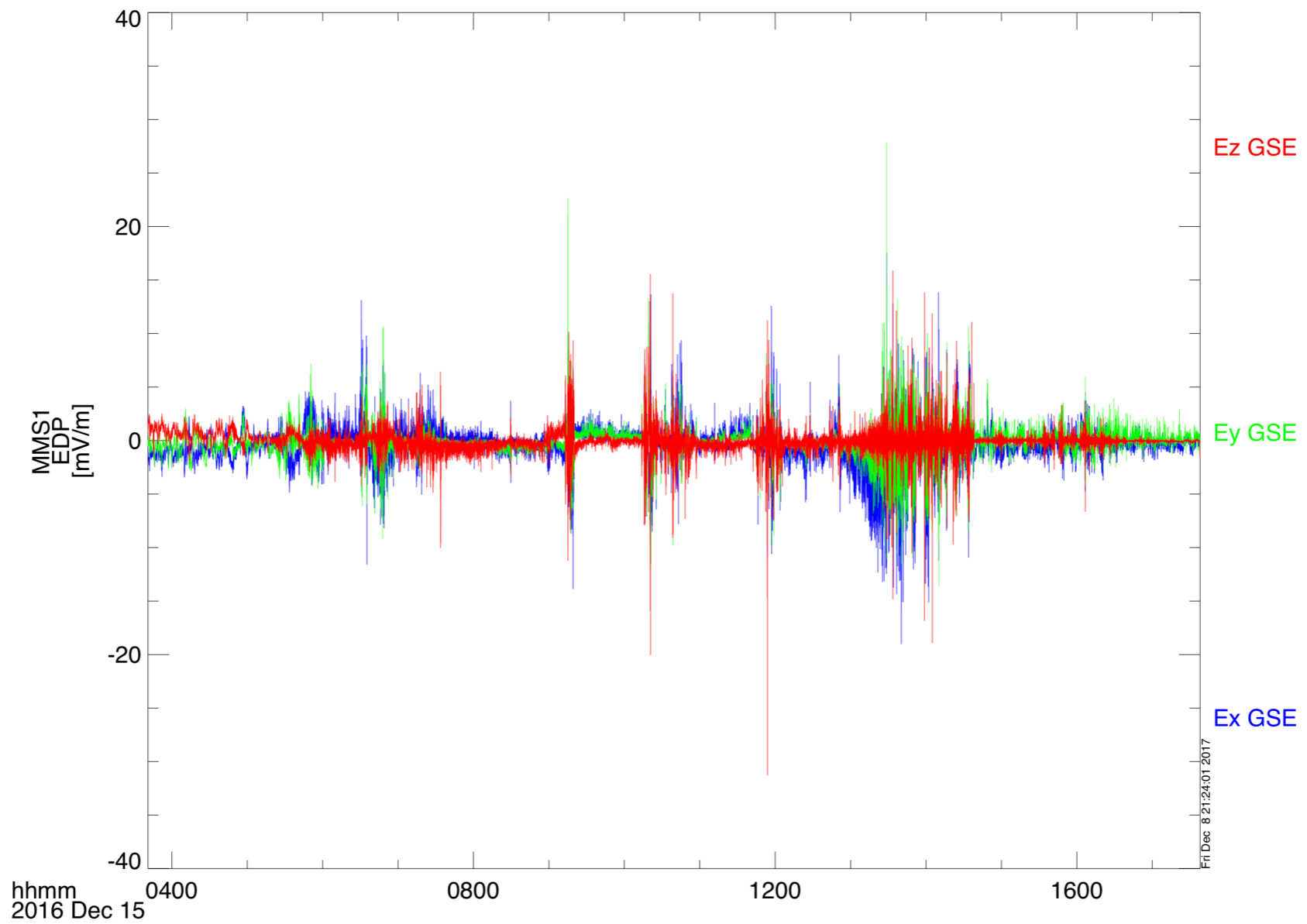
EDP

```
mms_load_edp, probe=1, level='l2', datatype='dce', trange=['2016-12-15', '2016-12-16'], /latest_version  
  
; plot the E-field data  
tplot, 'mms1_edp_dce_gse_fast_l2'  
  
; save the plot to a postscript file  
tprint, 'mms1_edp_dce_gse_fast_l2', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/fields/>

Loading and Plotting Data

EDP



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Loading and Plotting Data

FPI

```
; load the FPI electron moments data for December 15, 2016
mms_load_fpi, probe=3, data_rate='fast', trange=['2016-12-15', '2016-12-16'], datatype='des-moms'

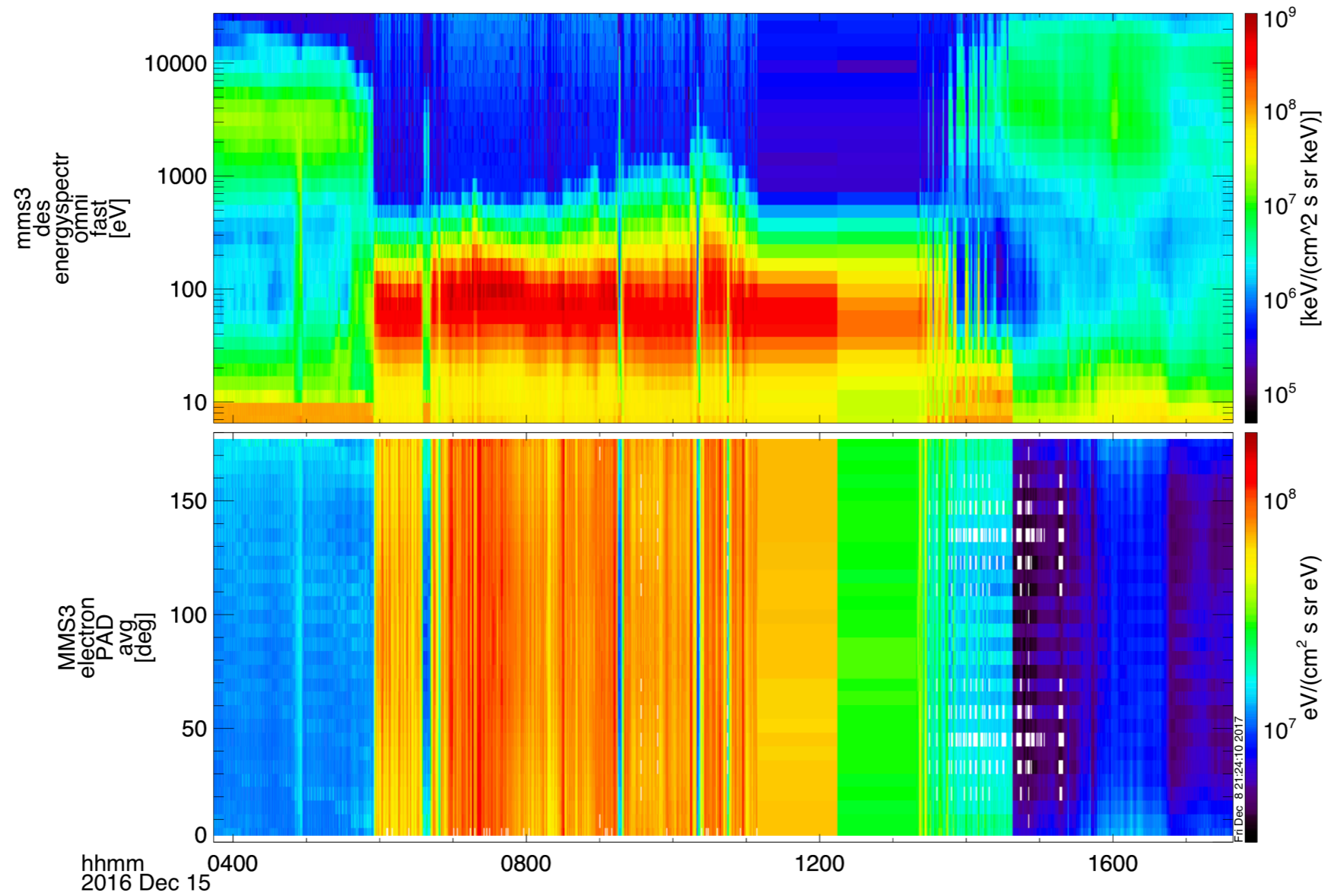
; plot the omni-directional electron energy spectra and pitch angle distribution
tplot, ['mms3_des_energyspectr_omni_fast', 'mms3_des_pitchangdist_avg']

; save the plot to a postscript file
tprint, 'mms3_des_spec_and_pad', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/fpi/>

Loading and Plotting Data

FPI



Loading and Plotting Data

HPCA

```
; load the HPCA moments data for December 15, 2016
mms_load_hpca, probe=4, data_rate='srvy', trange=['2016-12-15', '2016-12-16'], datatype='moments'

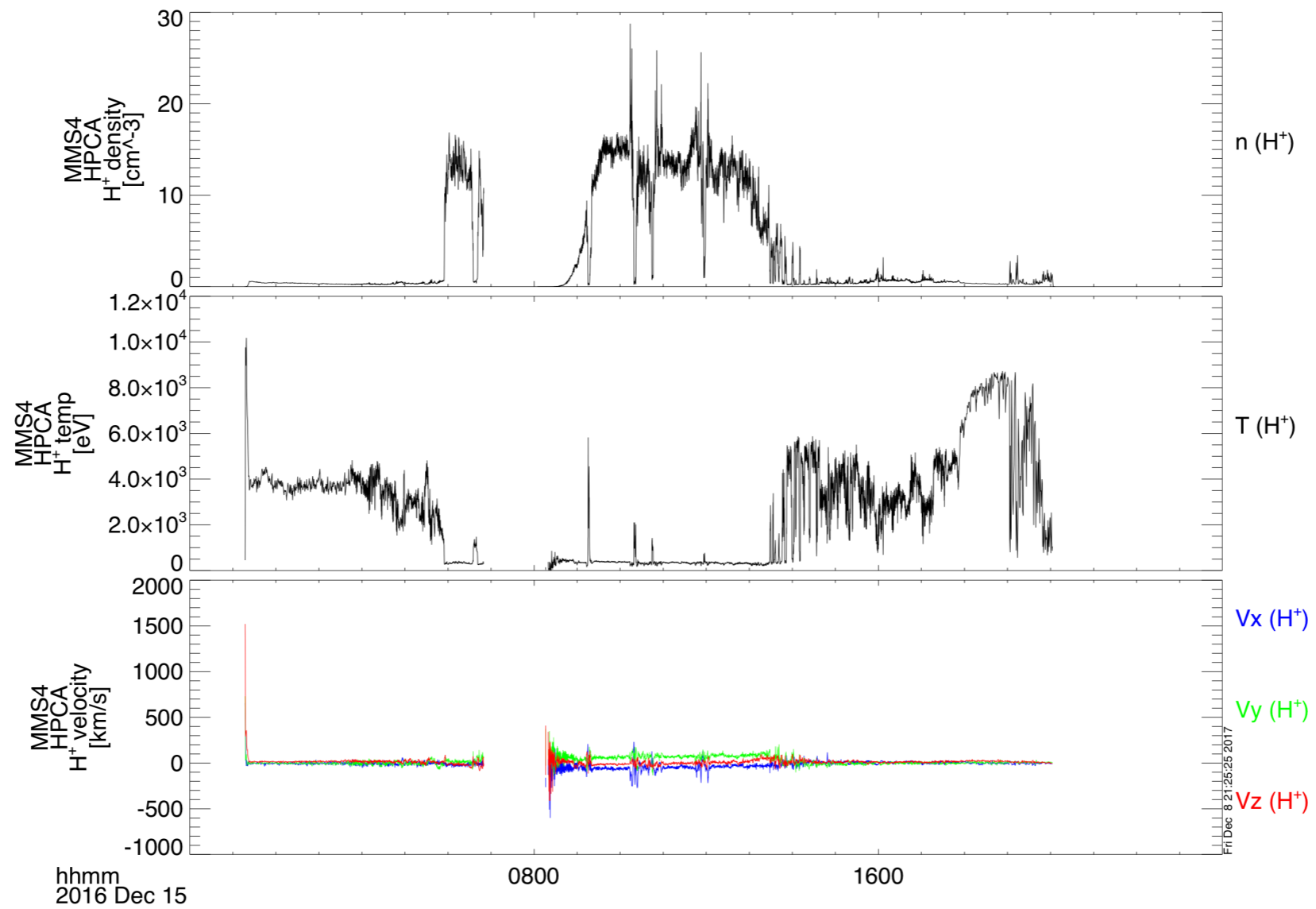
; plot the H+ density, temperature and bulk velocity
tplot, ['mms4_hpca_hplus_number_density', 'mms4_hpca_hplus_scalar_temperature',
'mms4_hpca_hplus_ion_bulk_velocity']

; save the plot to a postscript file
tprint, 'mms4_hpca_hplus_moments', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/hpca/>

Loading and Plotting Data

HPCA



Loading and Plotting Data

HPCA

```
; load the HPCA ion data for December 15, 2016
mms_load_hpca, probe=4, data_rate='srvy', trange=['2016-12-15', '2016-12-16'], datatype='ion'

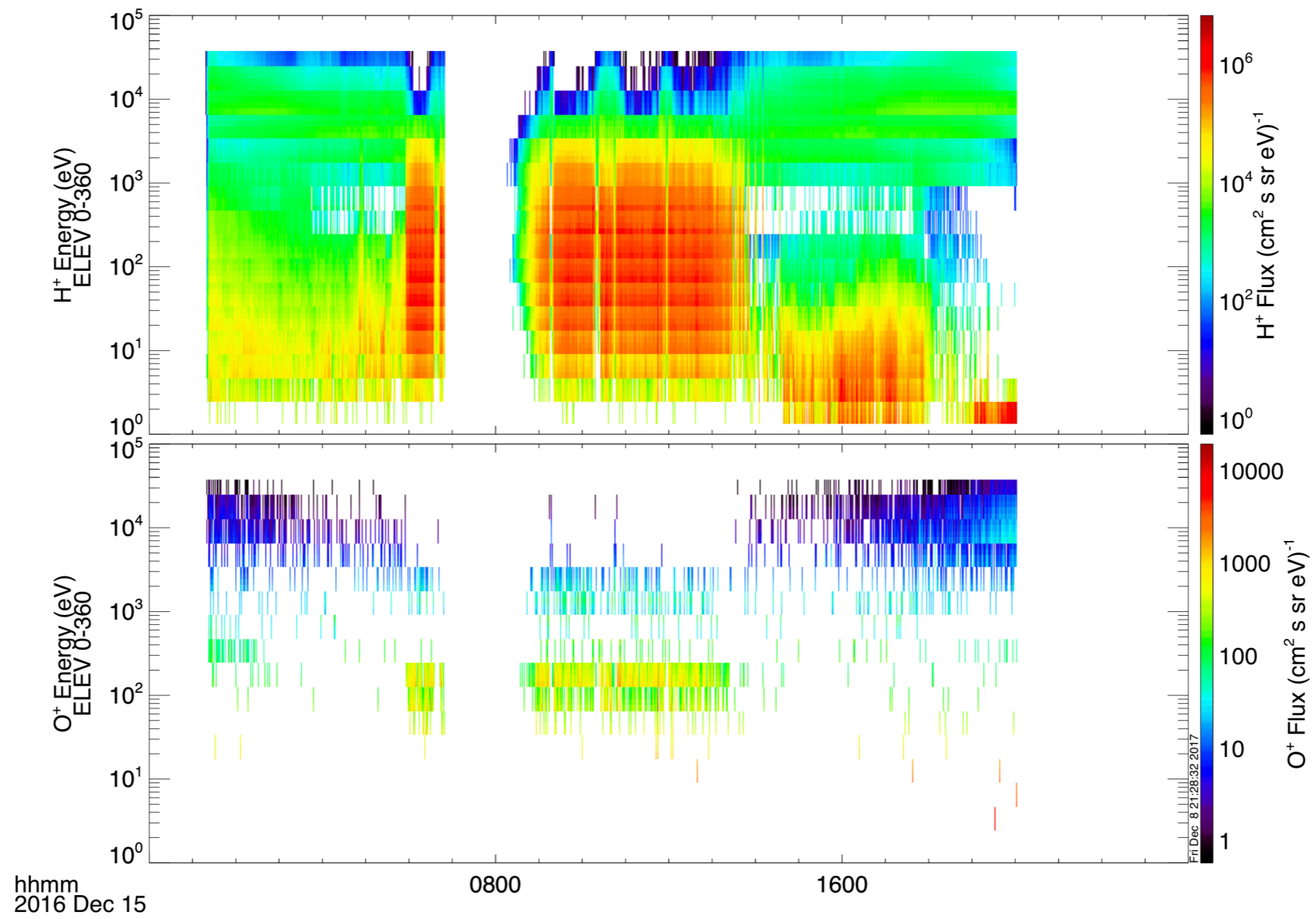
; calculate the omni-directional flux by averaging over the anodes for the full field of view
mms_hpca_calc_anodes, fov=[0, 360]
mms_hpca_spin_sum, probe=4

; plot the H+ and O+ spectra
tplot, ['mms4_hpca_hplus_flux_elev_0-360_spin', $
       'mms4_hpca_oplus_flux_elev_0-360_spin']

; save the plot to a postscript file
tprint, 'mms4_hpca_hplus_flux_fullFoV', /landscape
```

Loading and Plotting Data

HPCA



Loading and Plotting Data

EPD EIS

```
; load the EIS energy x time of flight (ExTOF) ion data for MMS4
mms_load_eis, probe=4, data_rate='srvy', datatype='extof', trange=['2016-12-15', '2016-12-16']

; calculate the EIS pitch angle distribution
mms_eis_pad, probe=4, data_rate='srvy', datatype='extof'

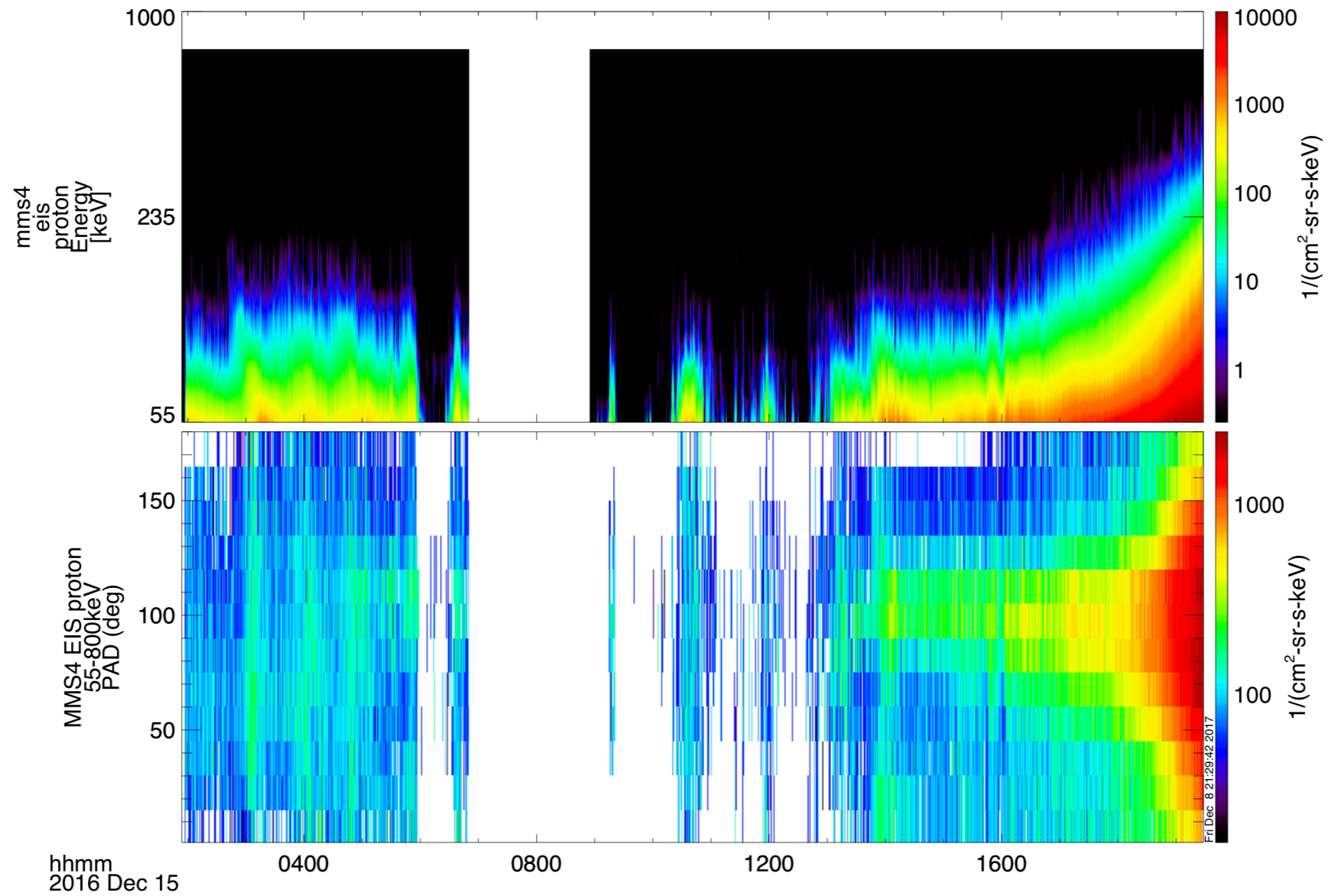
; plot the spin-averaged energy spectra and pitch angle distribution
tplot, ['mms4_epd_eis_extof_proton_flux_omni_spin',
'mms4_epd_eis_extof_55-800keV_proton_flux_omni_pad_spin']

; save the plot to a postscript file
tprint, 'mms4_epd_eis_extof_protons', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/epd/>

Loading and Plotting Data

EPD EIS



Loading and Plotting Data

EPD FEEPS

```
; load the FEEPS electron data for MMS2
mms_load_feeps, probe=2, data_rate='srvy', datatype='electron', trange=['2016-12-15', '2016-12-16']

; calculate the FEEPS pitch angle distribution
mms_feeps_pad, probe=2, data_rate='srvy', datatype='electron'

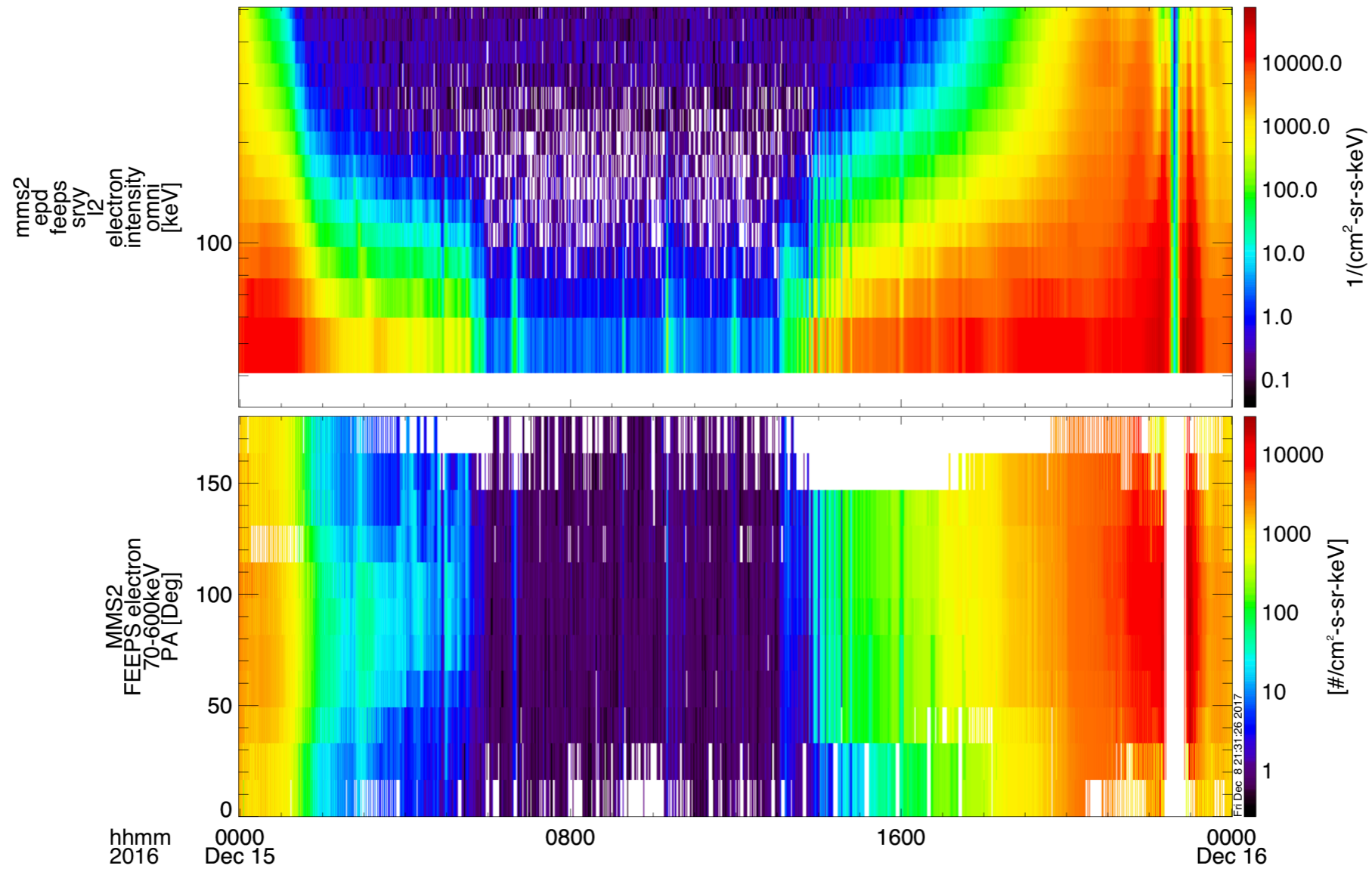
; plot the spin averaged electron spectra and pitch angle distribution
tplot, ['mms2_epd_feeps_srvy_l2_electron_intensity_omni',
'mms2_epd_feeps_srvy_l2_electron_intensity_70-600keV_pad']

; save the plot to a postscript file
tprint, 'mms2_epd_feeps_electrons', /landscape
```

<https://lasp.colorado.edu/mms/sdc/public/datasets/epd/>

Loading and Plotting Data

EPD FEEPS

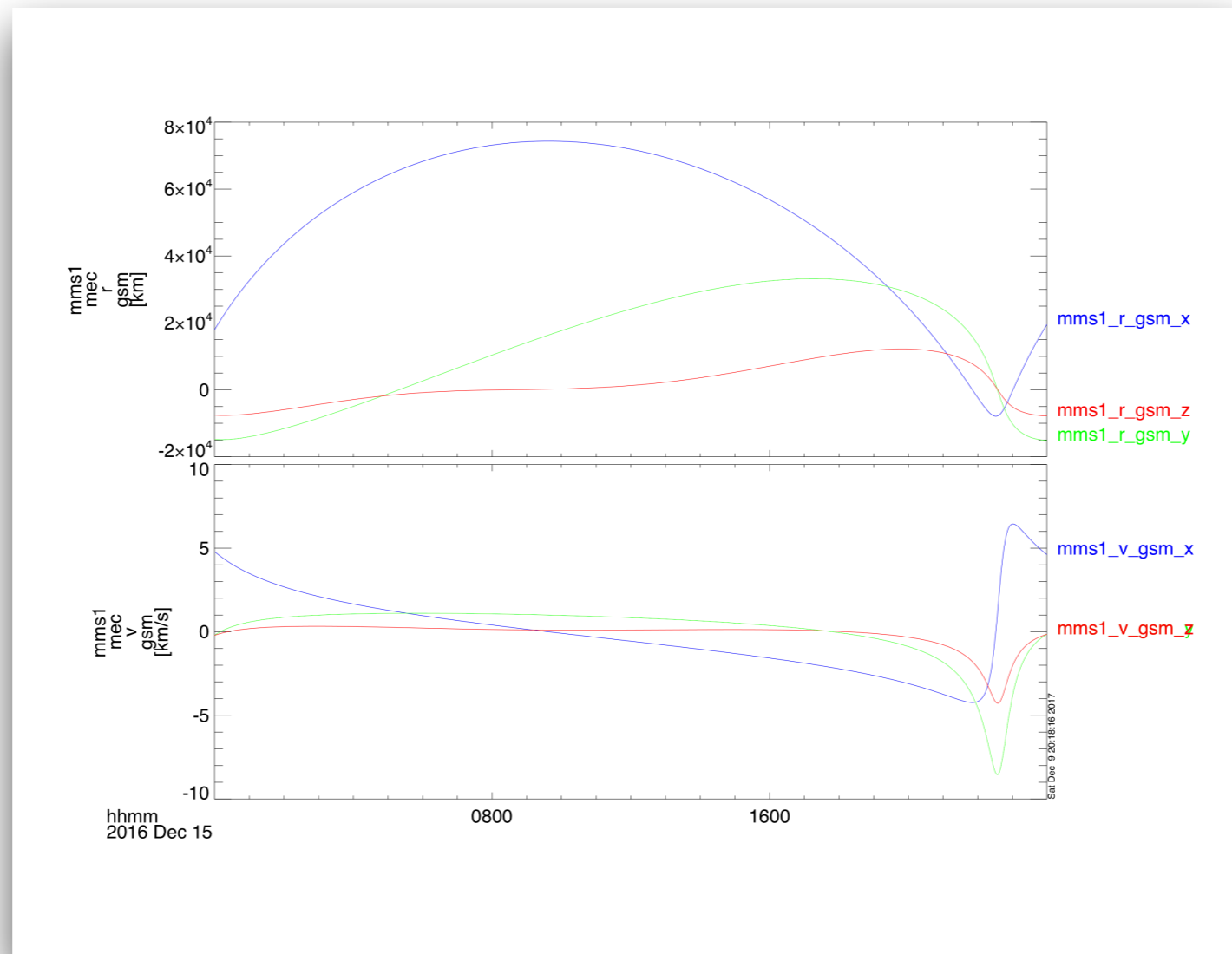


Loading and Plotting Data

MEC

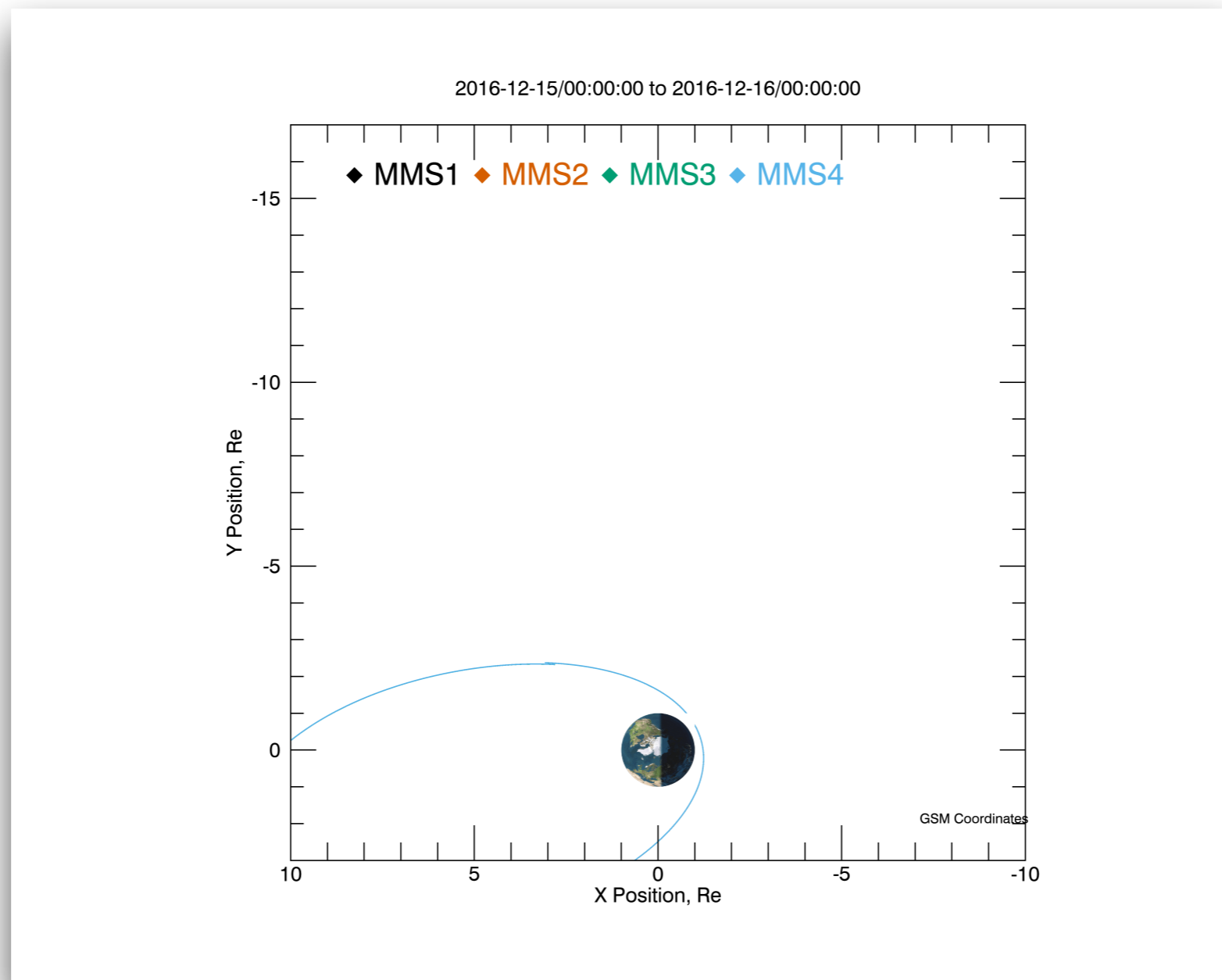
```
; load the ephemeris and attitude data for December 15, 2016  
mms_load_mec, probe=1, trange=['2016-12-15', '2016-12-16']
```

```
; plot the spacecraft position and velocity in GSM coordinates  
tplot, ['mms1_mec_r_gsm', 'mms1_mec_v_gsm']
```



Loading and Plotting Data Orbits

```
; create a plot of the spacecraft orbits  
mms_orbit_plot, trange=['2016-12-15', '2016-12-16'], coord='gsm'
```



Analysis Tools

- Coordinate Transformations
- Minimum Variance Analysis
- Dynamic Power Spectra
- Spectra from Particle Distributions
- 2D Particle Slices
- EIS angle-angle Plots
- FPI angle-angle Plots

Analysis Tools

Coordinate Transformations

```
; load the quaternions from the MEC file
mms_load_mec, probe=3, trange=['2016-12-15/10:10', '2016-12-15/10:30'], /time_clip

; we're going to transform some FGM data
mms_load_fgm, probe=3, trange=['2016-12-15/10:10', '2016-12-15/10:30'], /time_clip

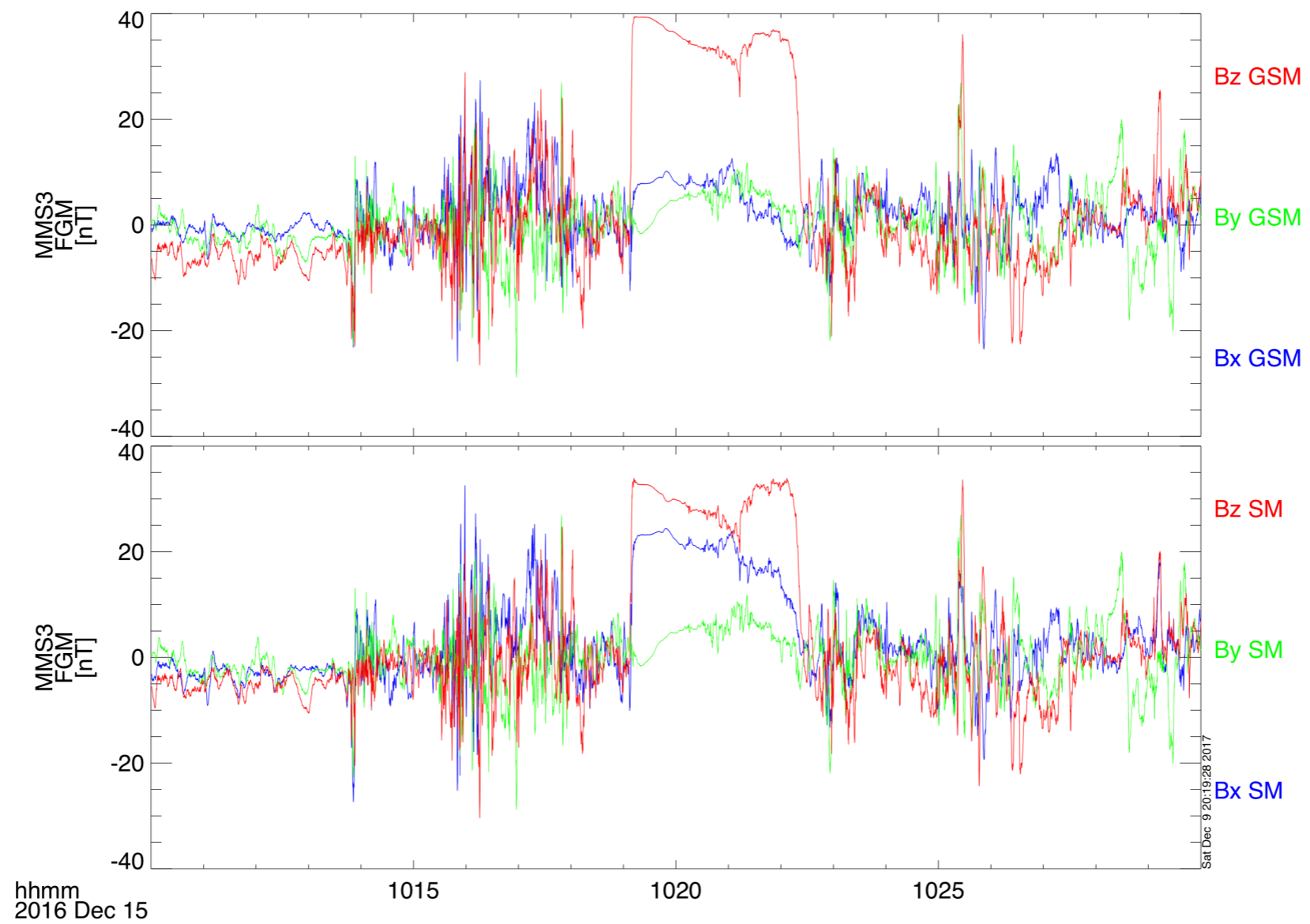
; Cotrans the FGM data from GSM to SM coordinates
mms_qcotrans, 'mms3_fgm_b_gsm_srvy_l2_bvec', 'mms3_fgm_b_sm_srvy_l2_bvec', out_coord='sm'

; plot the data in both GSM and SM coordinates
tplot, ['mms3_fgm_b_gsm_srvy_l2_bvec', 'mms3_fgm_b_sm_srvy_l2_bvec']

; save the plot to a postscript file
tprint, 'mms3_fgm_gsm_sm_coords', /landscape
```

Analysis Tools

Coordinate Transformations



Analysis Tools

Minimum Variance Analysis

```
; load some FGM data
mms_load_fgm, probe=1, trange=['2016-12-15/10:10', '2016-12-15/10:30'], /time_clip

; create the minimum variance transformation matrix
minvar_matrix_make, 'mms1_fgm_b_gse_srvy_l2_bvec', newname='mva_matrix', $
  tstart='2016-12-15/10:10', tstop='2016-12-15/10:30'

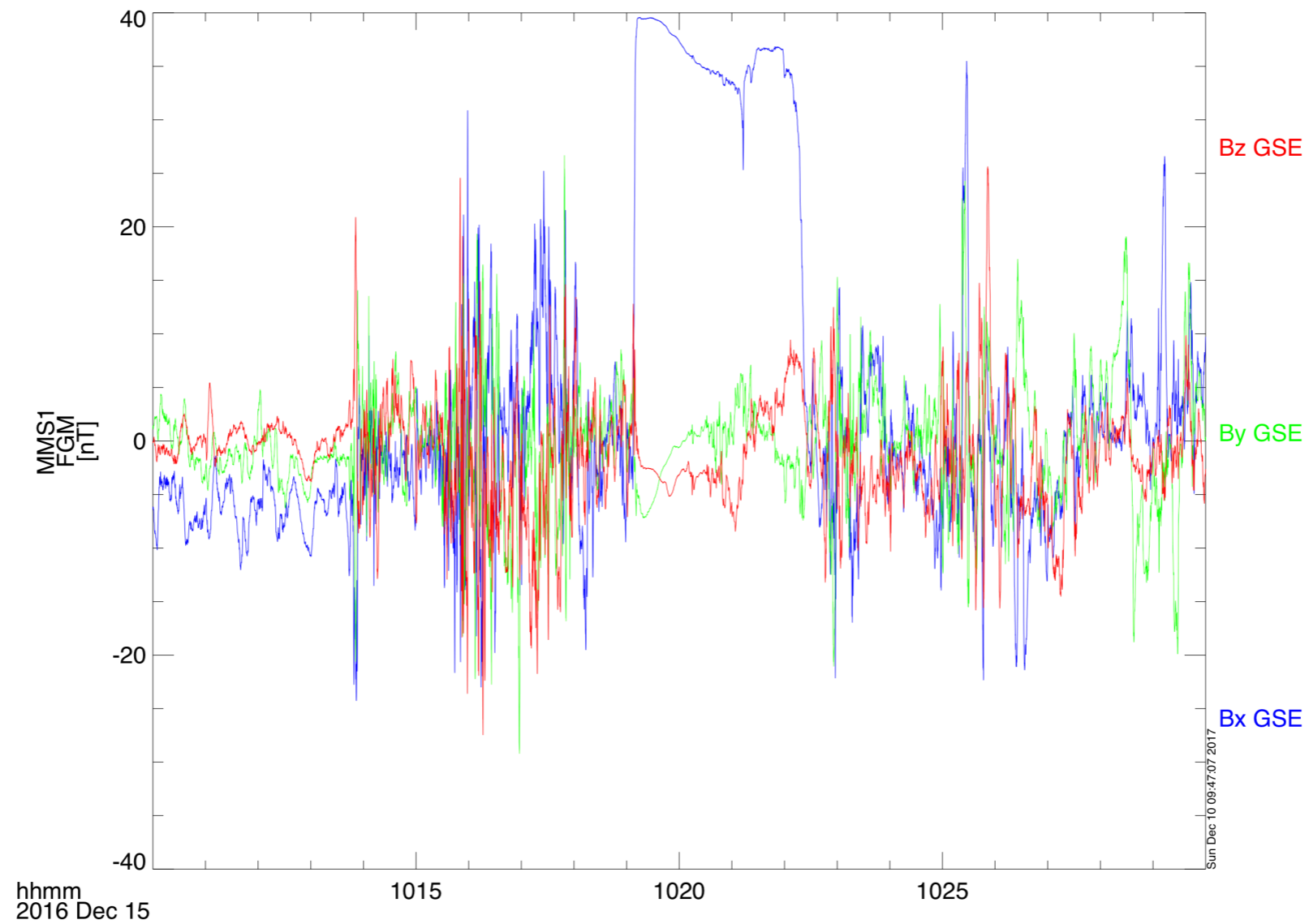
; rotate the B-field
tvector_rotate, 'mva_matrix', 'mms1_fgm_b_gse_srvy_l2_bvec', newname='mms1_fgm_b_gse_srvy_l2_bvec_mva'

; plot the vector in MVA coordinates
tplot, 'mms1_fgm_b_gse_srvy_l2_bvec_mva'

; save the plot to a postscript file
tprint, 'mms1_fgm_b_gse_srvy_l2_bvec_mva', /landscape
```

Analysis Tools

Minimum Variance Analysis



Analysis Tools

Dynamic Power Spectra

```
; load some SCM data
mms_load_scm, probe=1, trange=['2016-12-15/10', '2016-12-15/12']

; calculate the dynamic power spectra
tdpwrspc, 'mms1_scm_acb_gse_scsrvy_srvy_l2', nboxpoints=512,nshiftpoints=512,bin=1

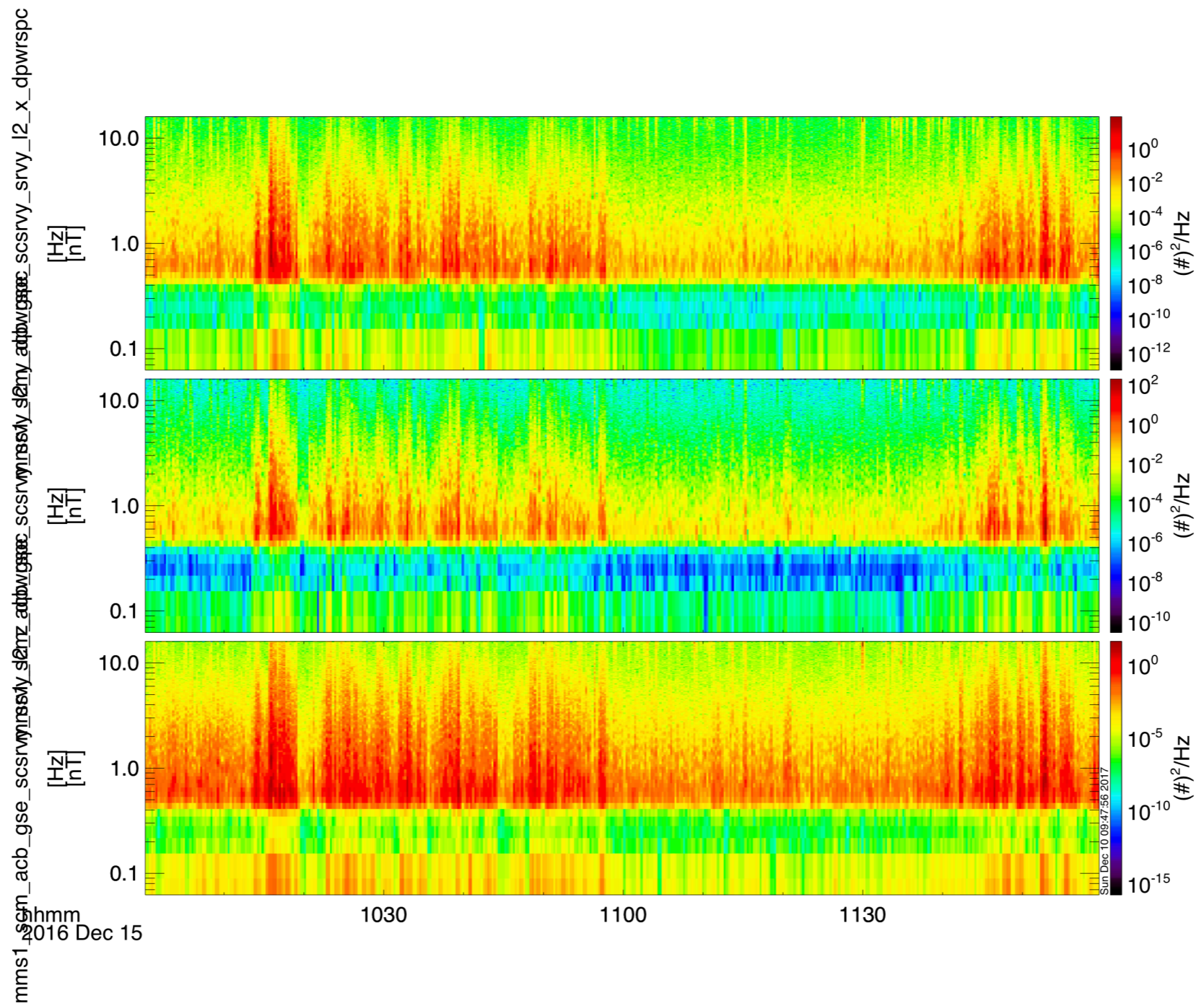
; plot the dynamic power spectra
tplot, ['mms1_scm_acb_gse_scsrvy_srvy_l2_x_dpwrspc', $
'mms1_scm_acb_gse_scsrvy_srvy_l2_y_dpwrspc', $
'mms1_scm_acb_gse_scsrvy_srvy_l2_z_dpwrspc']

; save the plot to a postscript file
tprint, 'mms1_scm_acb_gse_scsrvy_l2_dpwrspc', /landscape
```

Analysis Tools

Analysis Tools

Dynamic Power Spectra



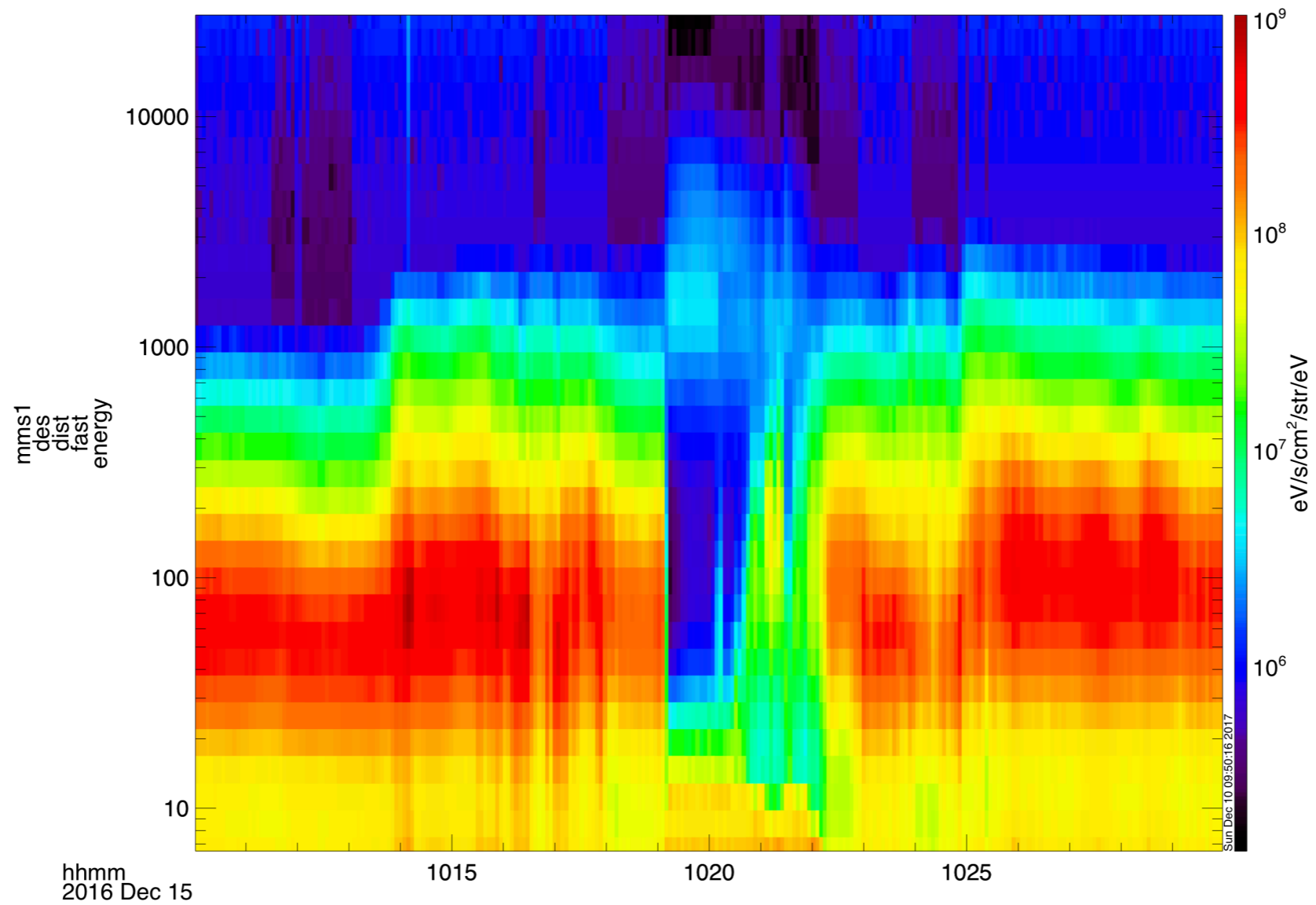
Analysis Tools

Spectra from FPI Distributions

```
; use mms_part_getspec to calculate the electron energy spectra  
mms_part_getspec, probe=1, trange=['2016-12-15/10:10', '2016-12-15/10:30'], outputs=['energy']  
  
; plot the spectra  
tplot, 'mms1_des_dist_fast_energy'  
  
; save the plot to a postscript file  
tprint, 'mms1_des_dist_fast_energy', /landscape
```

Analysis Tools

Spectra from FPI Distributions



Analysis Tools

Spectra from HPCA Distributions

```
mms_part_getspec, /center, instrument='hpca', probe=1, trange=['2016-12-15/10:10', '2016-12-15/10:10'],  
outputs=['energy']
```

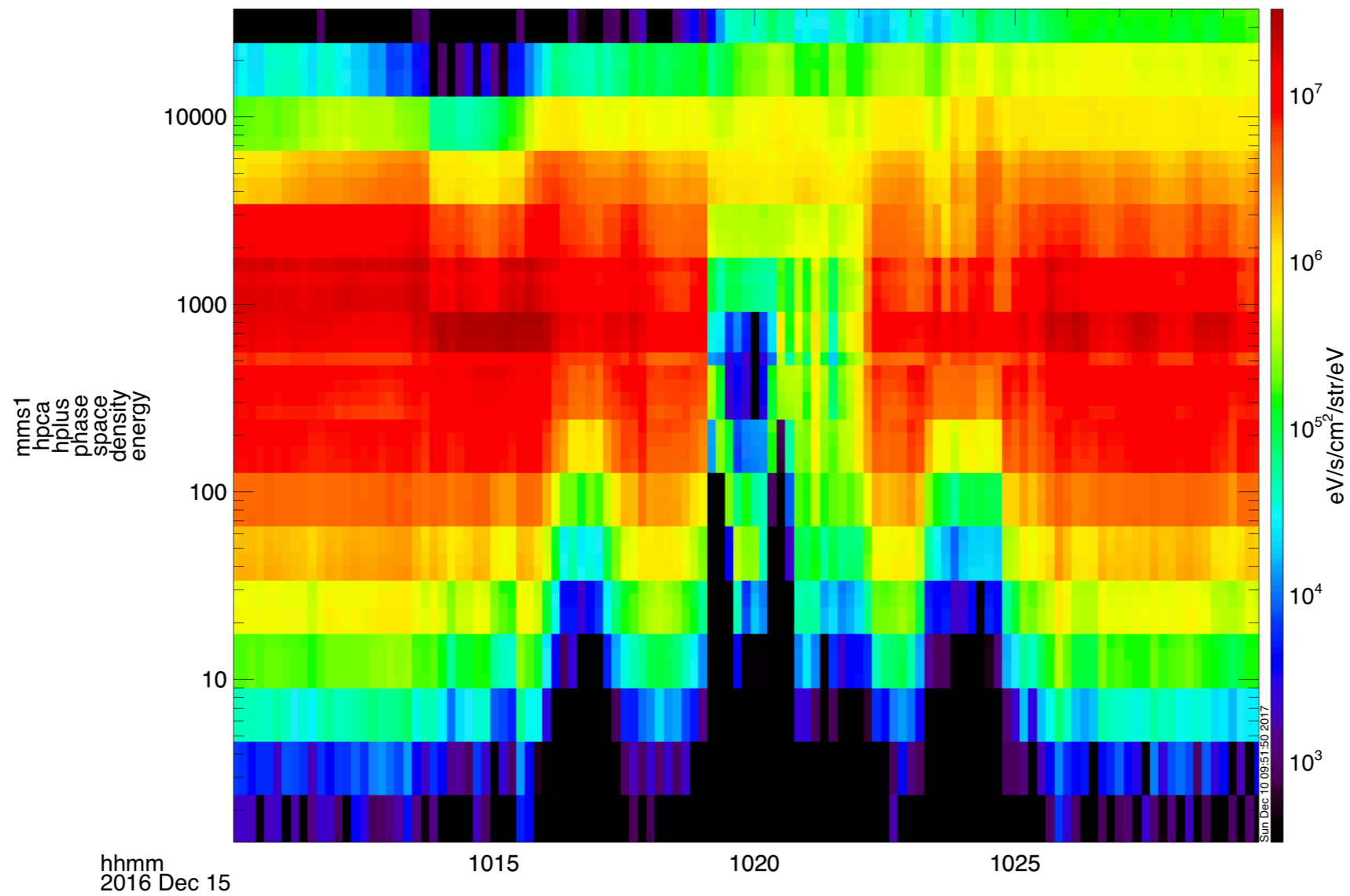
```
tplot, 'mms1_hpca_hplus_phase_space_density_energy'
```

```
; save the plot to a postscript file
```

```
tprint, 'mms1_hpca_hplus_phase_space_density_energy', /landscape
```

Analysis Tools

Spectra from HPCA Distributions



Analysis Tools

2D Particle Slices

```
; load some burst mode FPI data
mms_load_fpi, data_rate='brst', datatype='dis-dist', probe=1, trange=['2016-12-15/10:15',
'2016-12-15/10:16']

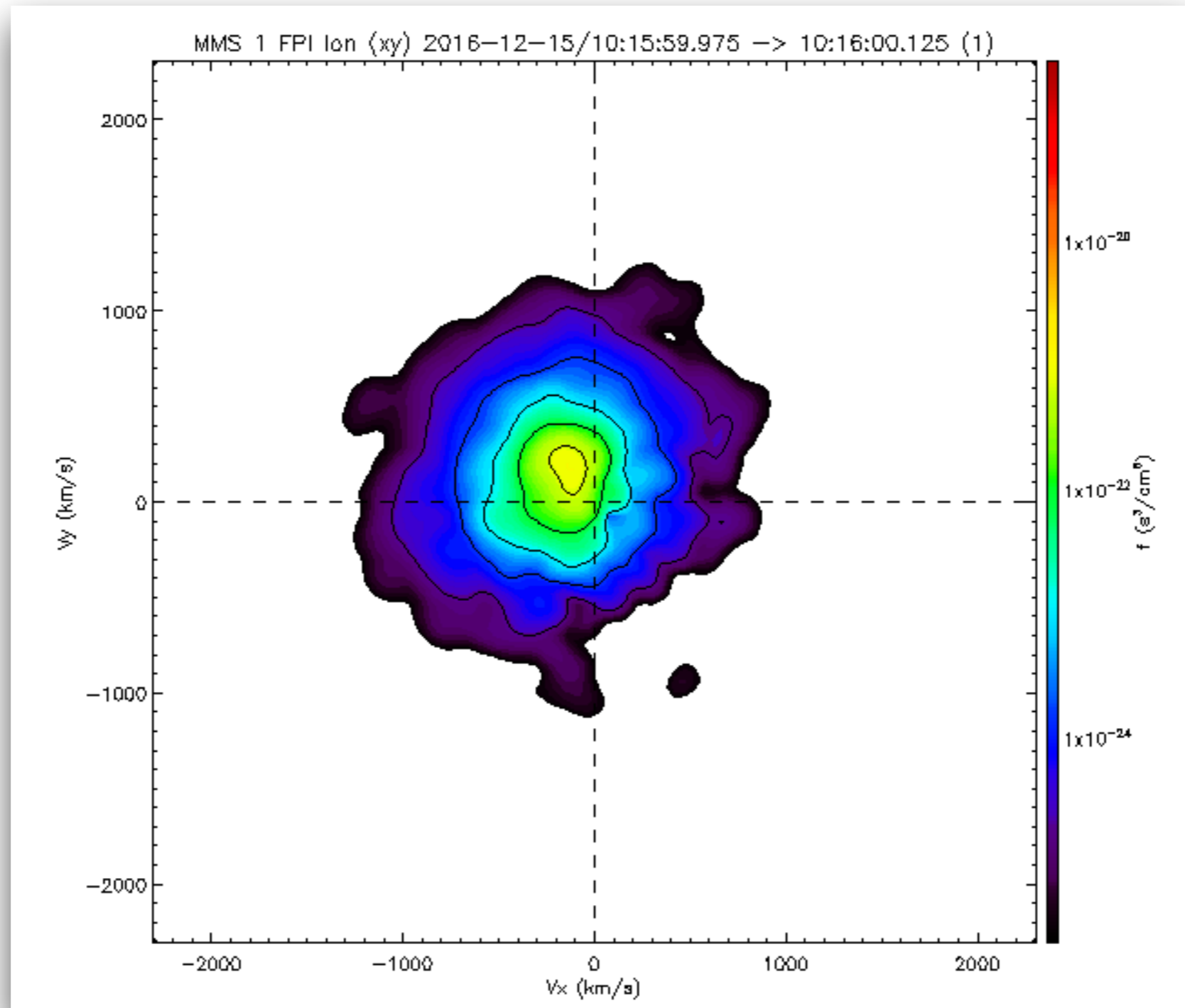
; reformat data from tplot variable into compatible 3D structures
dist = mms_get_dist('mms1_dis_dist_brst', trange=['2016-12-15/10:15', '2016-12-15/10:16'])

; get the single distribution
slice = spd_slice2d(dist, time='2016-12-15/10:16')

; plot the slice
spd_slice2d_plot, slice
```

Analysis Tools

2D Particle Slices



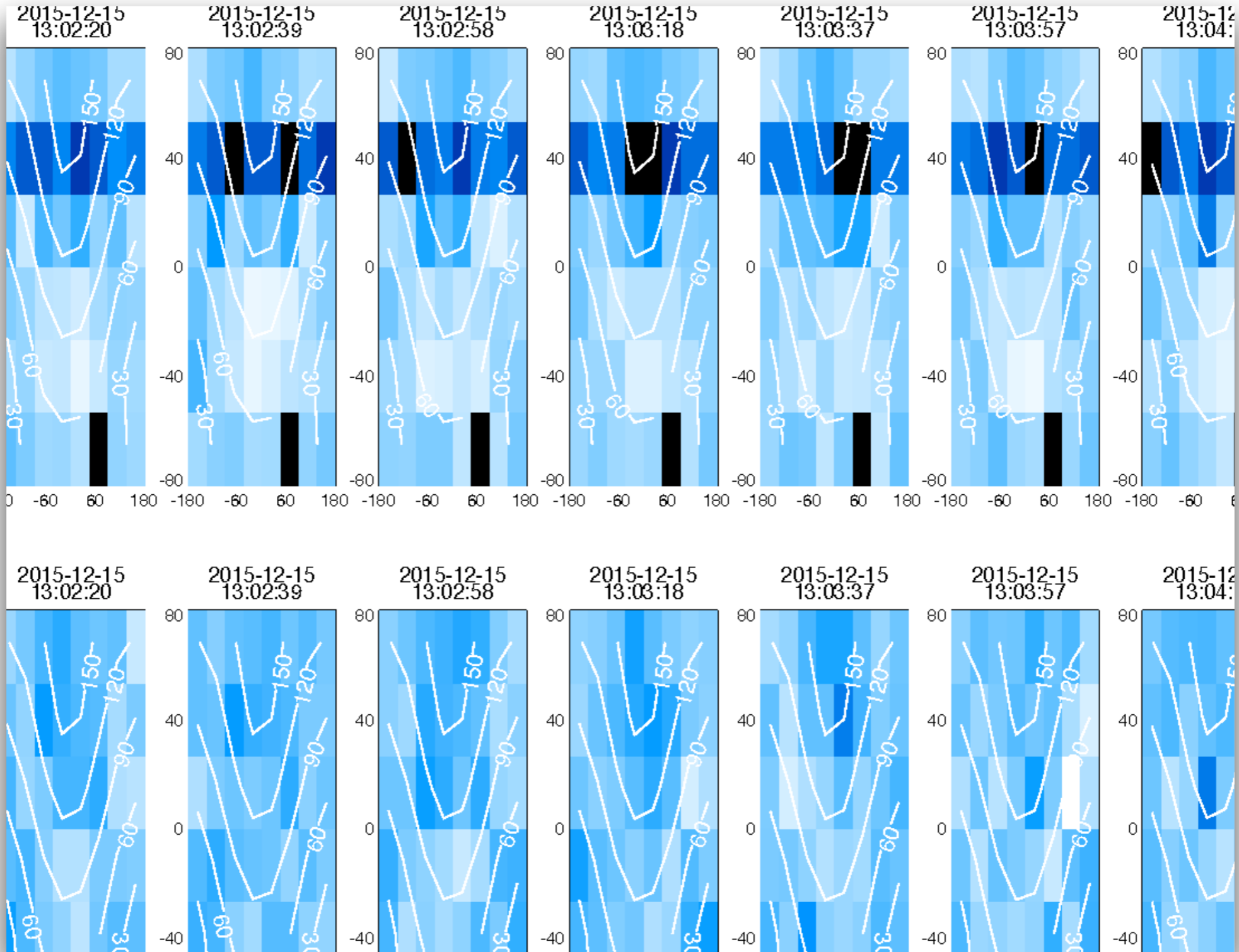
Analysis Tools

EIS angle-angle plots

```
; to plot the angle-angle plots for EIS, use the following tool  
; developed by Ian Cohen and Joe Westlake at JHU/APL  
eis_ang_ang, probe='1', trange=['2015-12-15/13:00', '2015-12-15/13:10'], energy_chan=[1, 2, 3, 4]
```

Analysis Tools

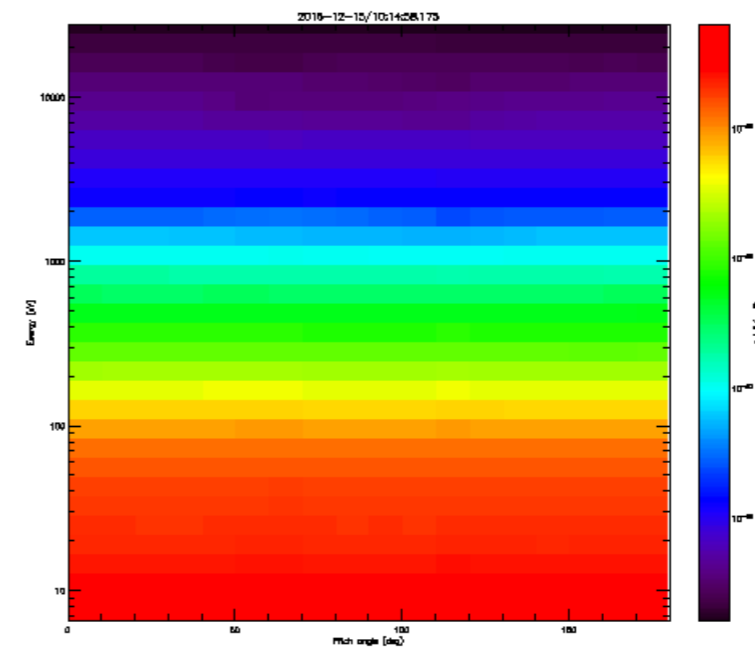
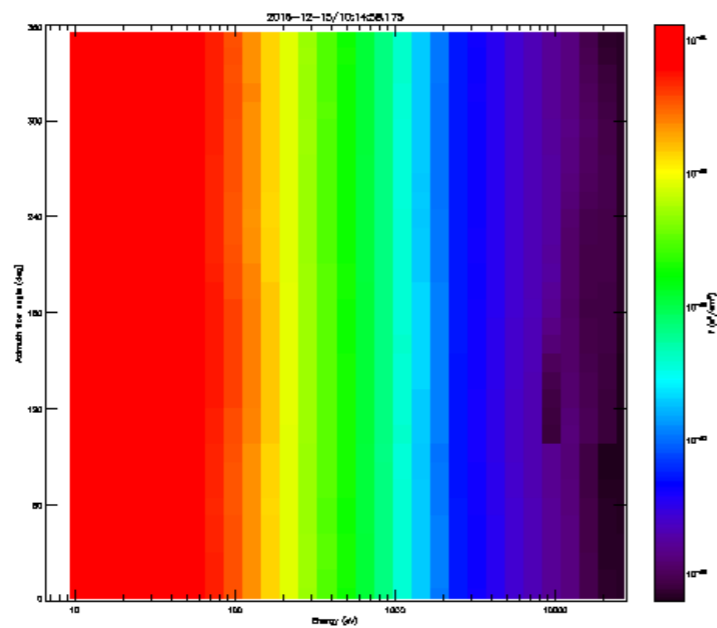
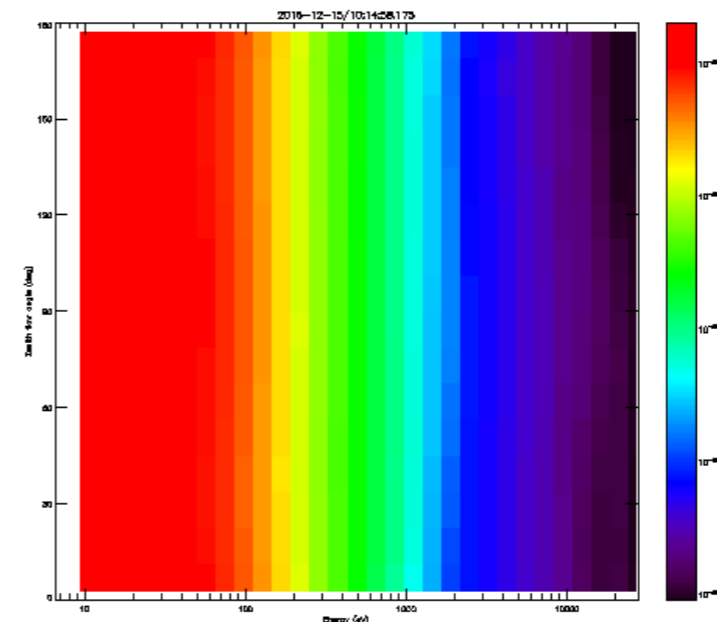
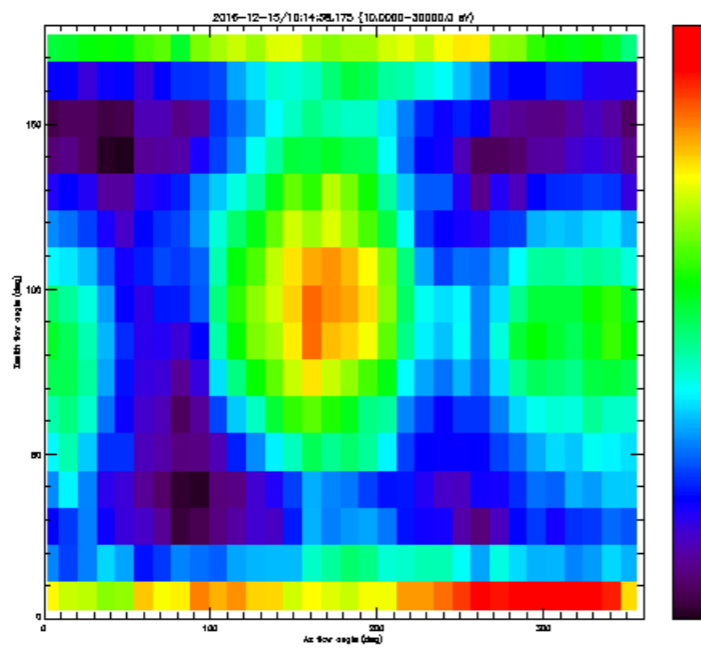
EIS angle-angle plots



Analysis Tools

FPI angle-angle plots

; we can create angle-angle plots for FPI as well
`mms_fpi_ang_ang, '2016-12-15/10:15', /png`



Examples

Where to find more examples?

[/projects/mms/examples/basic/](#)

Basic examples for each load routine; this is a good place for new users to start

[/projects/mms/examples/advanced/](#)

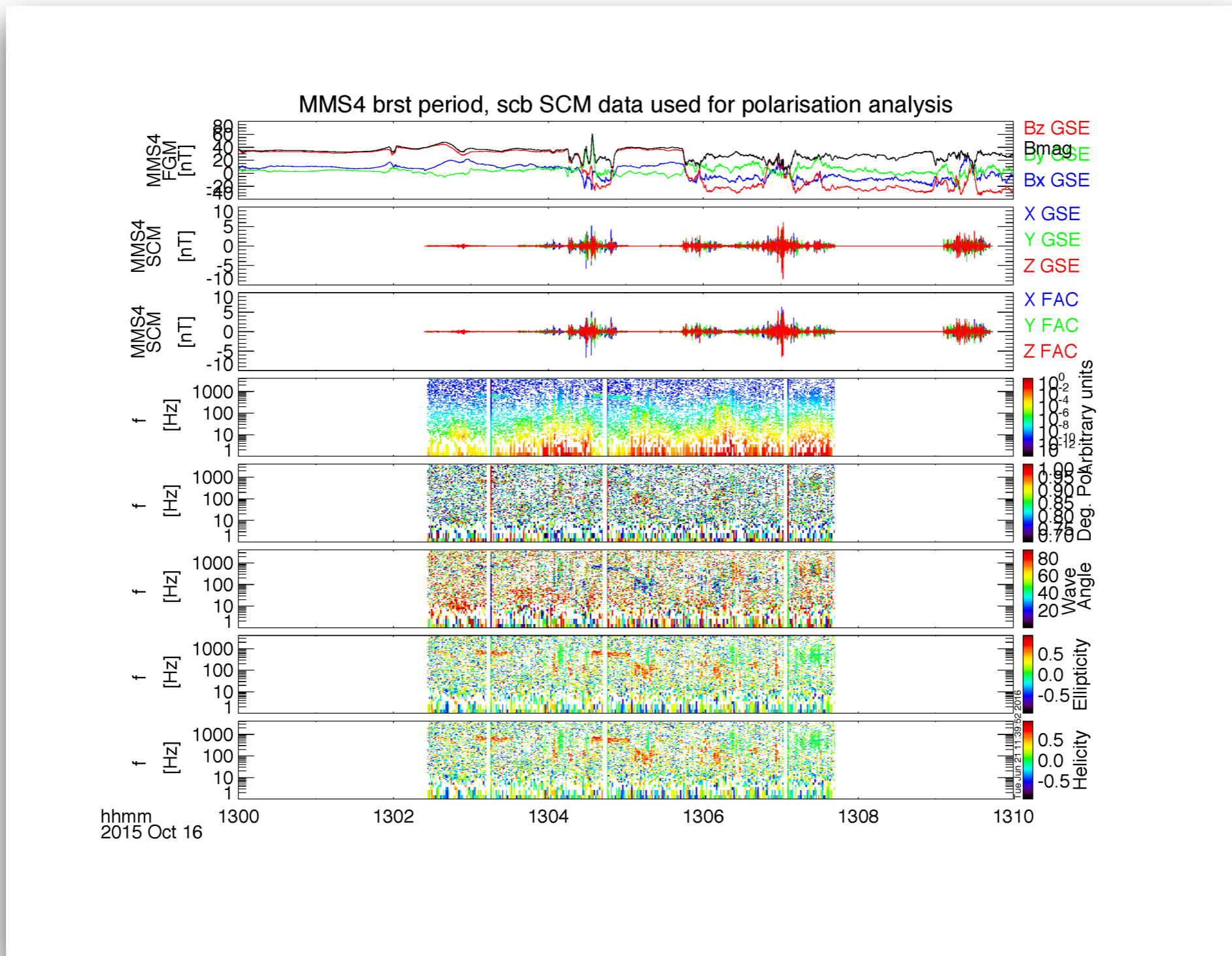
Examples showing more advanced functionality of the plugin

[/projects/mms/examples/quicklook/](#)

Scripts that create the QL plots at the SDC; note: these require MMS team member access to the SDC to run

MMS Wave Polarization Analysis

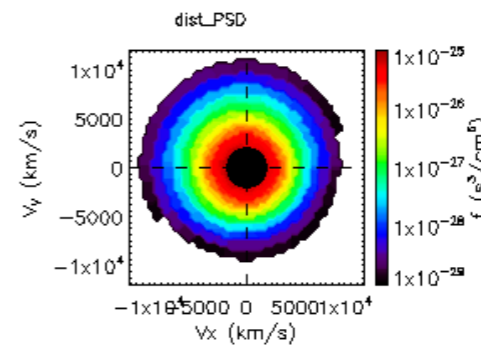
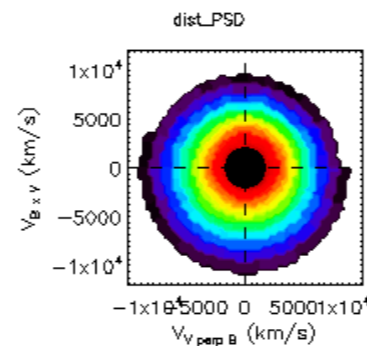
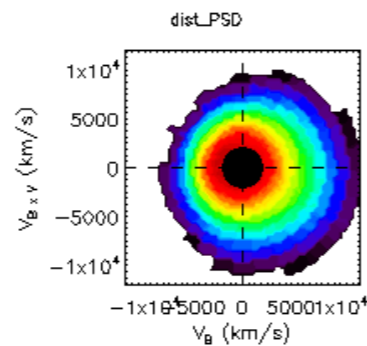
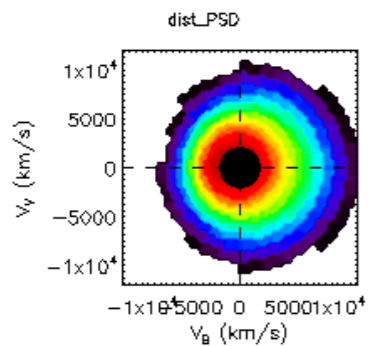
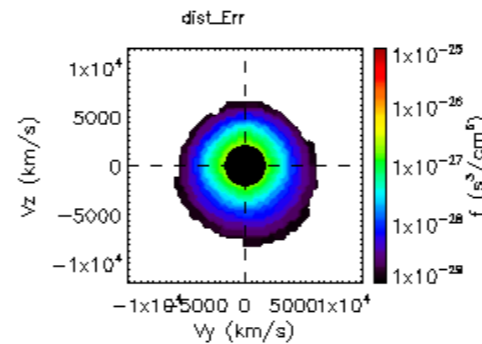
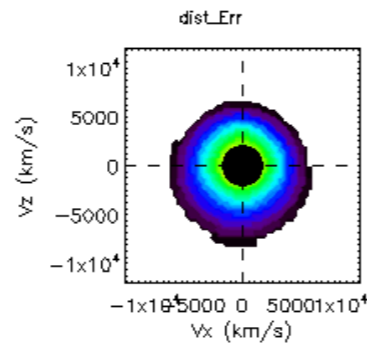
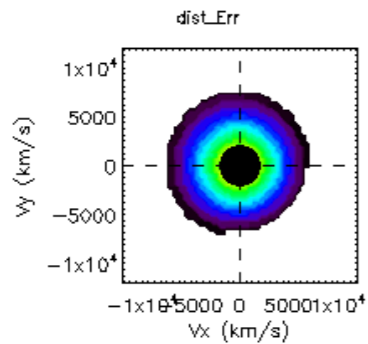
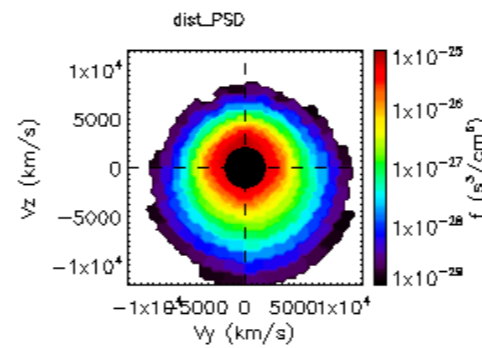
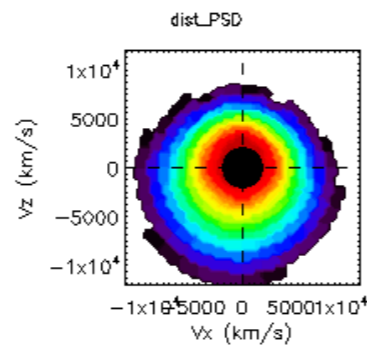
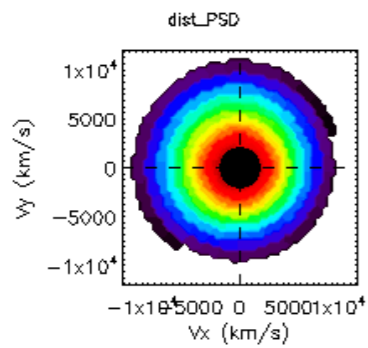
/projects/mms/examples/advanced/mms_wavpol_crib.pro



MMS FPI Distribution Slices

/projects/mms/examples/advanced/mms_fpi_dist_slice_comparison_crib_l2.pro

MMS1 FPI Electron 20151016 13:06:01.784 -> 13:06:01.814



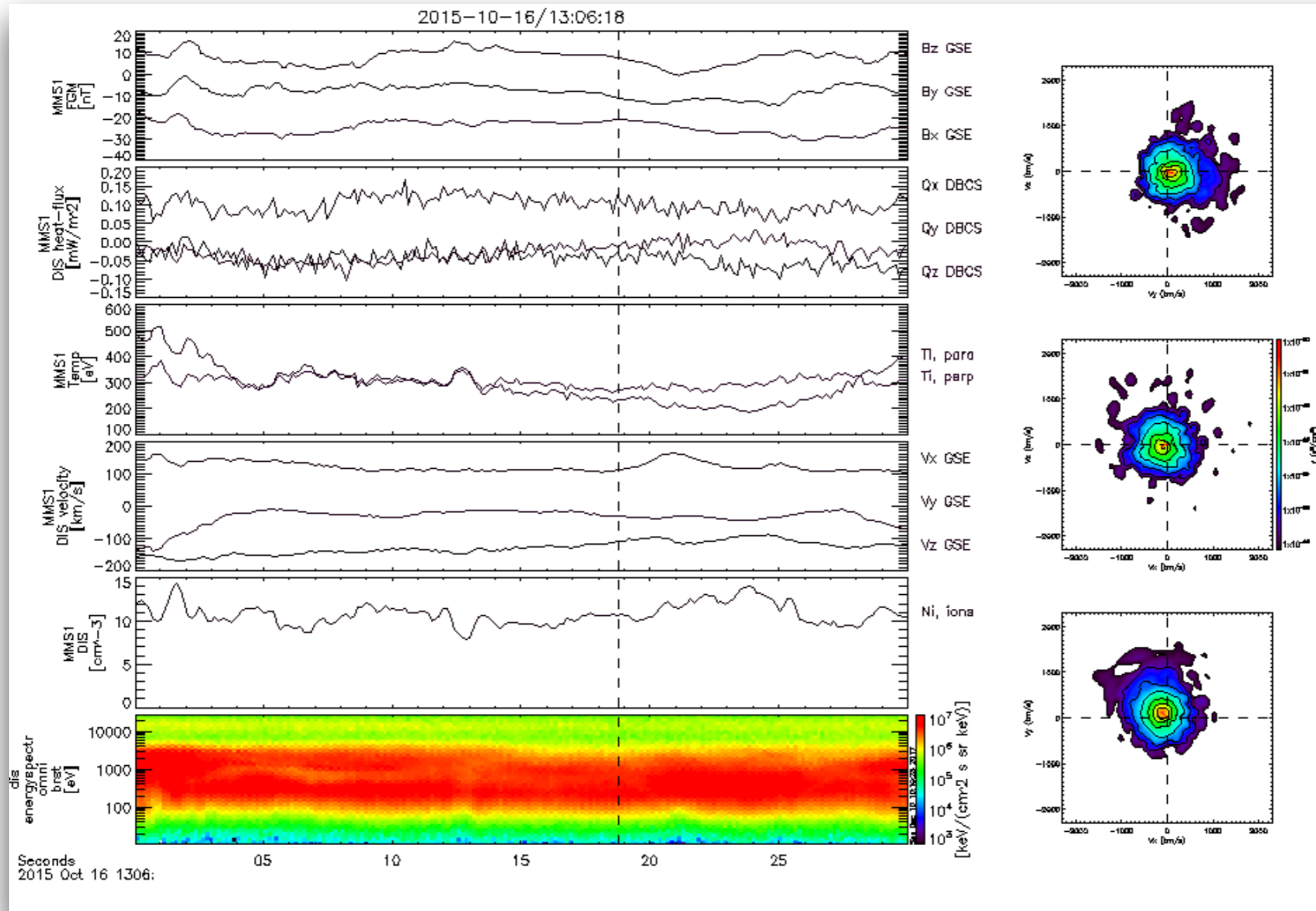
Density: 9.51224 [cm^{-3}]
 Txx: 25.3367 Tyy: 25.6826
 Txy: 0.00340046 Tyz: -0.742198
 Txz: 0.191172 Tzz: 26.5544
 Pxx: 0.0386136 Pyy: 0.0391407
 Pxy: 5.18236e-06 Pyz: -0.00113112
 Pxz: 0.000291349 Pzz: 0.0404693

FPI Electron bulk velocity

V_x : -148.121 [km/s]
 V_y : 135.013 [km/s]
 V_z : -24.4917 [km/s]

MMS Flipbook Figures

/projects/mms/examples/advanced/mms_flipbook_crib.pro



Getting Help

- SPEDAS Forum

<https://groups.google.com/forum/#!forum/spedas>

- SPEDAS Wiki

<http://spedas.org/wiki/>

- Ask Eric

egrimes@igpp.ucla.edu

SPEDAS

Other Useful Crib Sheets

`general/examples/crib_tplot.pro`

`general/examples/crib_tplot_annotation.pro`

`general/examples/crib_tplot_layout.pro`

`general/examples/crib_tplot_range.pro`

`general/examples/crib_tplot_ticks.pro`

`general/examples/crib_dproc.pro`