



# MMS-FPI Visualization Portal

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# MMS-FPI Background

- Magnetospheric Multiscale Mission (MMS)
  - Primary focus to investigate magnetic reconnection in earth's magnetosphere
  - Launched 13 March 2015
  - Four identically instrumented observatories travelling in a tetrahedral formation
- Fast Plasma Investigation (FPI)
  - Primary goal to measure electron and positive ion phase space densities within earth's magnetosphere
  - 64 spectrometers (32 pairs) evenly distributed among the four observatories. Each observatory contains:
    - 4 Dual Electron Spectrometers (DES)
    - 4 Dual Ion Spectrometers (DIS)



# FPI Science Data



- Full sky-maps (16 zenith x 32 azimuths) at 32 energies
- Fast Survey (FS) mode
  - 4.5 sec resolution for all regions of interest (ROI)
  - Two hour files
- Burst mode
  - Segments of interest selected by Scientist in the Loop (SITL)
  - Resolution
    - DES: 30 ms
    - DIS: 150 ms
  - File durations are length of selected burst interval (usually 1-5 minutes)
- Data stored in CDF format
- Variables
  - Distributions
  - Moments
  - Energy spectrograms
  - Partial moments



# FPI Science Data



- L2 Data Holdings (as of 2019-10-15)
  - Burst: 770,262 files / 33.2 TB
  - Fast survey: 204,708 files / 8.7 TB
- Data archive
  - Science Data Center (SDC): <https://lasp.colorado.edu/mms/sdc/public>
  - Space Physics Data Facility (SPDF): <https://spdf.gsfc.nasa.gov>
- Data information and product guide
  - <https://lasp.colorado.edu/mms/sdc/public/datasets/fpi>
- Portal and visualizer (currently in prototype phase)
  - <https://fpi.gsfc.nasa.gov>



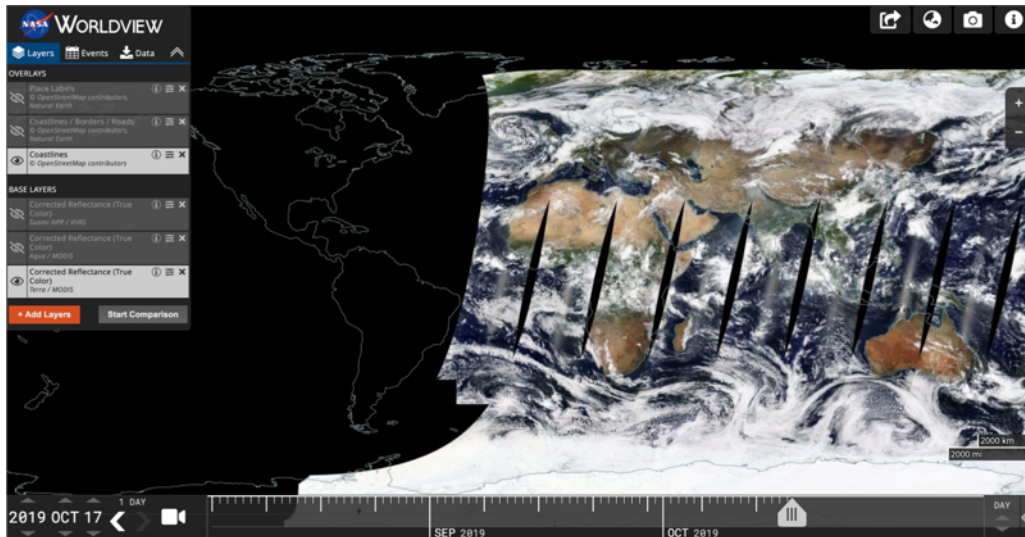
# Inspiration



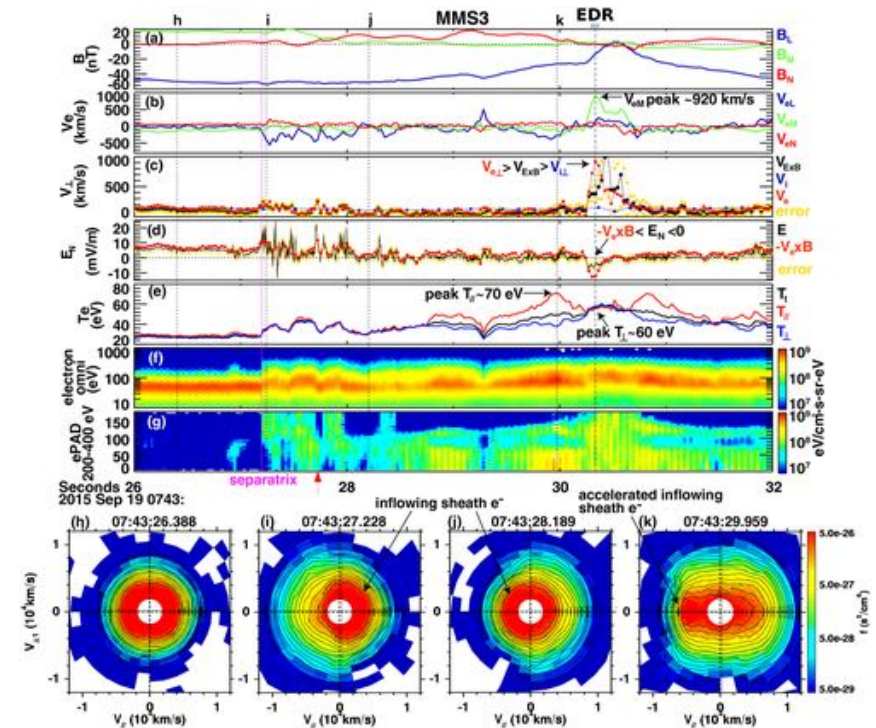
- Worldview
  - <https://worldview.earthdata.nasa.gov>
  - Interactively browse global, full-resolution satellite imagery
- Giovanni
  - <https://giovanni.gsfc.nasa.gov/giovanni>
  - Provides way to visualize, analyze, and access Earth science remote sensing data
- Aquarius L3 image browser
  - <https://podaac.jpl.nasa.gov/aquarius/gallery>
  - Animation by flipping through images
- Van Allen Probes Science Gateway
  - <http://rbspgway.jhuapl.edu>
  - Data, models, software and tools in support of the Van Allen Probes mission



# Earth Science vs Heliophysics



VS





# Earth Science vs Heliophysics

- Earth science
  - Easily relatable
  - Accessible
  - More tools / apps
  - Large community of non-scientist users: farmers, fishermen, rapid response, resource management, et al.
- Helio
  - Higher learning curve
  - Few immediate applications
  - User community mostly scientists
  - Mostly DOY tools
  - Same old IDL plots



# FPI Visualizer Initial Goals



- Fast, easy to use, and accessible (online) visualizer
- Science users
  - Interactive data browse and quicklook
  - More intensive data discovery and manipulation
  - Provide publication quality plots
  - Provide broader context for the data, e.g., where were the observatories during a time period, etc.
- Non-science users
  - Understanding of the mission's objectives
  - Outreach





# FPI Visualizer (prototype) Features

- URL: <https://fpi.gsfc.nasa.gov>
- Selection criteria
  - Observatory
  - Date
  - Featured dayside electron diffusion region (EDR) encounters identified by J. Webster (<https://doi.org/10.1029/2018JA025245>, 2018)
- Plots
  - 2, 4, and 6 hour plots of FPI and magnetic field (FGM) data on demand
  - Plots of burst data; fast survey if burst not available
- Interactivity
  - Hover over variable to show time and measurement
  - Zoom in for finer temporal view
- Download and permalink



# FPI Visualizer Home Page

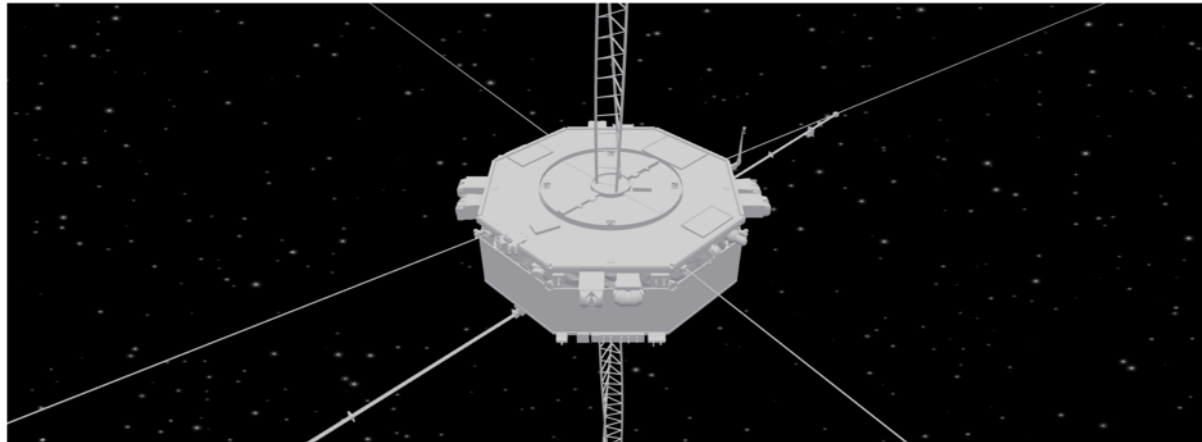


 **MMS Fast Plasma Investigation** **PROTOTYPE**

[FEEDBACK](#)

## About

The Fast Plasma Investigation (FPI) was developed for flight on the [Magnetospheric Multiscale \(MMS\) mission](#) to measure the differential directional flux of magnetospheric electrons and ions with unprecedented time resolution to resolve kinetic-scale plasma dynamics. This increased resolution has been accomplished by placing four dual 180-degree top hat spectrometers for electrons and four dual 180-degree top hat spectrometers for ions around the periphery of each of four MMS spacecraft.



*Interactive 3D Model of an MMS Satellite*

Using electrostatic field-of-view deflection, the eight spectrometers for each species together provide 4pi-sr field-of-view with, at worst, 11.25-degree sample spacing. Energy/charge sampling is provided by swept electrostatic energy/charge selection over the range from 10 eV/q to 30 keV/q. The eight dual spectrometers on each spacecraft are controlled and interrogated by a single block redundant Instrument Data Processing Unit, which in turn interfaces to the observatory's Instrument Suite Central Instrument Data Processor.

[GO TO MMS PAPER](#)

[GO TO FPI PAPER](#)

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## Visualize

### Spacecraft

MMS1 MMS2 MMS3 MMS4

October 16th, 2015 12:00

Available data spans Sep 1, 2015 to the present.

2 hrs

Featured Events

### Variables

- ☒ FGM Magnetic Field Vector
- ☒ FPI Ion Energy Spectrogram
- ☒ FPI Electron Energy Spectrogram
- ☒ FPI Electron and Ion Densities
- ☒ FPI Ion Velocity Vector
- ☒ FPI Electron Velocity Vector
- ☒ FPI Ion & Electron Temperatures
- ☐ FPI Current Density Vector

**GENERATE PLOTS**

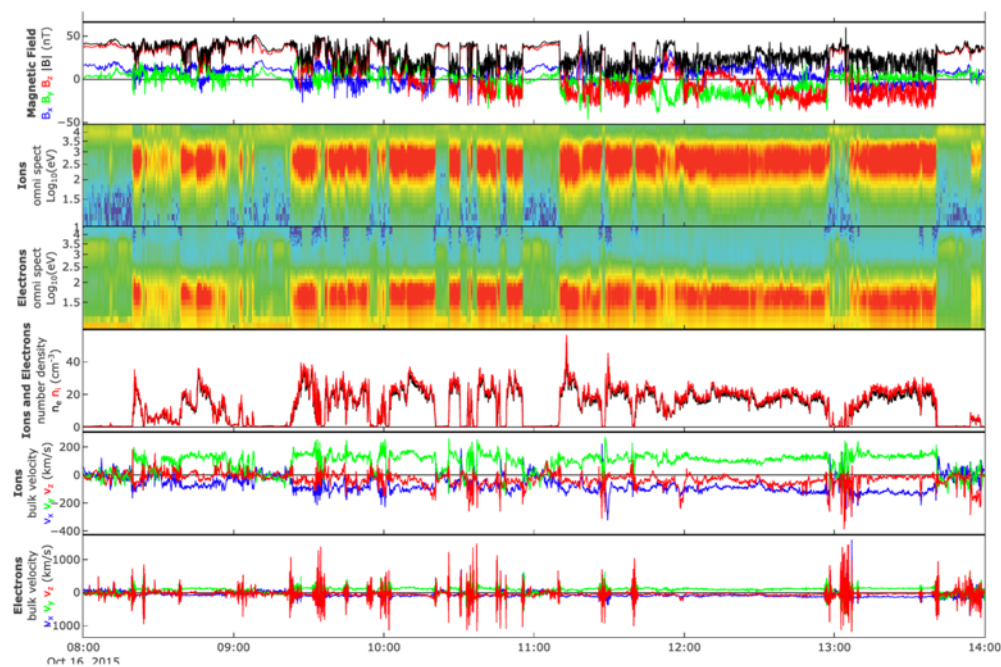
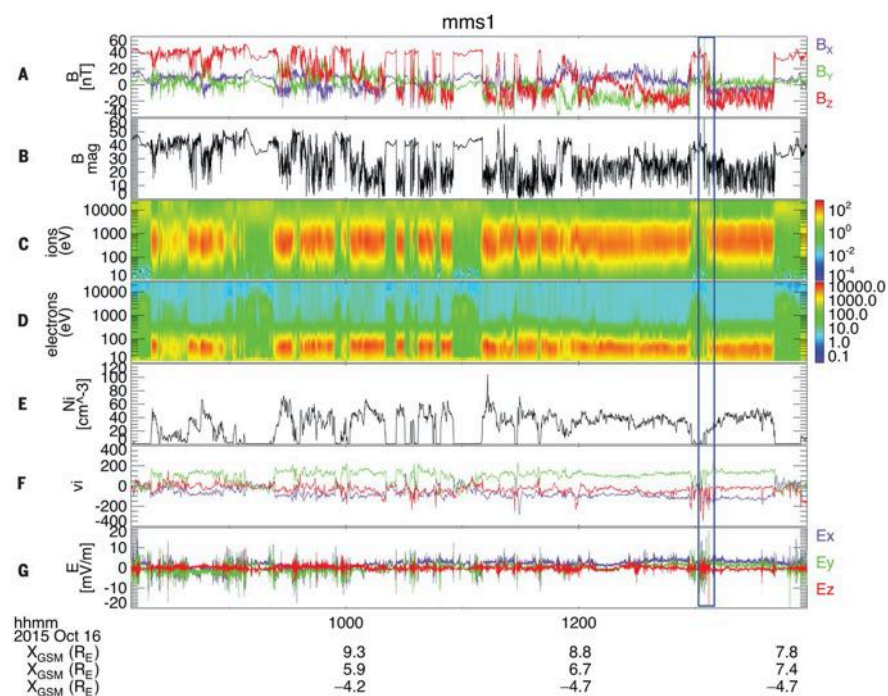


# J. Burch plot vs FPI Visualizer



<https://science.sciencemag.org/content/352/6290/aaf2939>

FPI Visualizer (dev version)





# FPI Visualizer (prototype) Development



- Frontend
  - React: JavaScript library for building user interfaces
  - Plotly: plotting library
- Backend
  - Django: Python web framework
  - CDAS RESTful Web services: access data from the SPDF
- Initial release: December 2018 for AGU fall meeting
- New release: Late fall 2019
- More frequent releases to follow



# Search SITL Comments

MMS Fast Plasma Investigation

https://fpi-staging.gsfc.nasa.gov/search\_comments?q=reconnection

Fast Plasma Investigation  
Mission · Status · Data · Publications · Education

Search SITL Comments

Every high time resolution "burst" interval available from FPI is marked by a scientist-in-the-loop (SITL) with a text comment denoting why they believe it is notable enough to warrant downlink at high time resolution. This interface allows you to search a database of those comments.

Example queries: *reconnection, wave, "cold ions"*

reconnection Search

Description	Time	Figure of Merit (FOM)	Plot
potential reconnection diffusion region	2019-08-12T14:27:33+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:25:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:22:43+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:20:13+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:17:53+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:15:23+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:13:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:10:33+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-12T14:08:13+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:25:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:22:33+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:20:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:17:43+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:15:13+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
potential reconnection diffusion region	2019-08-08T17:12:43+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
A potential reconnection diffusion region	2019-08-08T13:59:13+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
A potential reconnection diffusion region	2019-08-08T13:57:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
A potential reconnection diffusion region	2019-08-08T13:55:03+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
A potential reconnection diffusion region	2019-08-08T13:52:53+00:00	120	<a href="#">MMS1 MMS2 MMS3 MMS4</a>
	2019-06-25T14:13:43+00:00	100	<a href="#">MMS1 MMS2 MMS3 MMS4</a>

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## Path Forward



- Emulate “IDL-like” plots seen in publications
- Allow plot downloads in format that can be manipulated; e.g., PDF, etc.
- Data download links
- Arrange order of plots
- More variables, including distributions
- Multi-spacecraft plots
- Subset energies
- Search on SITL burst comments
- Plots by observatory position
- Tagging of intervals
- Animation
- Incorporation in upcoming FPI Portal



# Feedback



[fpi-feedback@lists.nasa.gov](mailto:fpi-feedback@lists.nasa.gov)