

4.0 Known Features in the FPI Data --> the checklist

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Overview

The FPI L2 data products reflect the full range of ~few eV to ~32 keV plasma populations in proximity to the spectrometers. This includes the ambient plasma environment within that energy range and – on occasion – spurious plasma populations induced in the vicinity of the spacecraft. For example, when the MMS EDI instrument is emitting 500 eV electrons, one or more FPI spectrometers often registers the signal in DES energy bin 16.

It is up to the data user to review the data and carefully consider what the measured signals indicate about the natural plasma environment versus what is indicated about any spacecraft induced plasma environment. M

The FPI team works diligently to remove as many induced effects as is possible from the FPI moment values (des-moms and dis-moms files) within our data processing pipeline. In some cases, there remains work to be done, which is best carried out on an event-by-event basis. We provide the FPI full plasma distributions (des-dist and dis-dist files) without correction so that analysis work can be performed appropriate to the specific hypothesis under study.

Following is a checklist of known data features and recommendations for mitigation:

Quality Flags <-- heed the warnings!

FPI tags its data with a variety of quality flags to indicate intervals that need warrant consideration -- and perhaps correction -- when using the data for event analysis. It is important to check these and address any noted features. The FPI quality flag definitions are identical for quicklook and L2 data products.

Many of the features discussed below are automatically flagged during the L2 data processing procedures.

See child page on [quality flags for detailed information](#). There is also a tutorial on [plotting the quality flags using the SPEDAS suite of software](#).

Instrumentation Thresholds vs the ambient plasma distribution

Significant (>25%) cold plasma (<10eV) component
Significant (>25%) hot plasma (>30keV) component

Counting Statistics and establishing the 1-count level

Know and use the statistical error information provided in the CDF files. The error associated with the inherent spectrometer counting statistics is provided in the CDF files for both the moments and for the distributions. The actual counts can be recovered from the distErr variable from $C = (f/\text{distErr})^{**2}$ with distErr from the dist CDFs.

FPI moment error calculations

Use of the Partial Moments Calculations

Quasi-neutrality Check

Comparison of the FPI ion and electron density moments can give some indication as to how much of the underlying plasma distribution is represented in the separate FPI, HPCA, EIS, FEEPS data files.

In v2.0 and greater L2 files, FPI Ne and Ni are generally reliable. Exceptions include:

1. periods for which the internally generated DES photoelectrons could not be completely removed;
2. periods when the spacecraft potential is very high and the spacecraft potential correction needs individual work; and
3. at very low DES densities, when the spurious photoelectron signal is removed, the resulting density value can be nonphysical; use caution using the FPI density moments when the corresponding quality flag is 1. (Quality Flag bit 7). <-- this is a known limitation that will be addressed in the next software release.

For L2 data, FPI densities were initially scaled by an overall factor to match those of plasma waves ([fpi_waves_cmp.pdf](#)). The overall sensitivity of DES and DIS can change with each FPI macro load in which the voltages applied to the MCP detector stack for each sensor are adjusted. In Phase 1a, the relative sensitivity of DIS across spacecraft has not been observed to change. The sensitivity of DES with respect to DIS has changed by ~10-20% over the course of commissioning and Phase 1a. A correction factor for DES densities is derived from observations of DES and DIS in the magnetosheath. The minimum time-scale for which a correction factor can be applied is an *entire orbit*, though in practice the same correction factor is typically used for *all orbits for which the MCP voltage is unchanged*. Periods where changes in DES and DIS densities are correlated and have the same ratio as in adjacent quiet magnetosheath (where there are unlikely to be 'hidden' cold ions <10eV and the entire distribution is likely within FPI's energy range) intervals suggest that the entire relevant ion and electron distribution functions are being sampled.

Photoelectron Contributions

Internally generated photoelectrons, unaffected by the spacecraft potential in the sun direction produce an effective cold electron component with density ~0.5-1 cm⁻³ and bulk velocity ~750 km/sec in the anti-sunward direction. This component varies with spacecraft spin phase. A model for this signal has been developed and the signal removed for the moment calculations as of software release v2.0. [Please see the separate page for more detailed information](#). NOTE: These photoelectrons (internal and spacecraft) are not removed from the skymap data product as users need to be aware of this signal for their specific data interval and how its removal might affect analysis and interpretations.

Background Radiation

Error Flag Bit 13: significant (>=20%) penetrating radiation (DIS only)

Spin-periodicities – Velocity Offsets

- Compression artifacts, which can be different for Survey and Burst data products
- Imperfect spectrometer response correction tables (e.g., for signals dominating the very lowest or very highest energy channels; for data intervals very near a [FPI macro change](#); and for data intervals for which sufficient burst calibration data was not readily available). Some of these can be addressed with time.
- Imperfect spacecraft potential or photoelectron signal correction. For some data intervals, data users will necessarily need to apply custom corrections.
- In some cases, even when the in-flight calibration tables have reduced the spin-period electron bulk velocity signal amplitude to below 50 km/s, there may appear more significant 20 s oscillations in the current density $n \cdot e \cdot (V_i - V_e)$ (comparable to real current densities at the magnetopause). This is a known issue and is currently beyond the scope of our current L2 processing. If such current density oscillations are noticed, please contact the FPI team, and we will address these on a case by case basis until we are able to incorporate a correction into our routine L2 processing.

Compression Artifacts

Special Topic --> FPI in the solar wind

DIS fast survey measurements in the solar wind

Onboard summing of burst counts to form fast survey data products leads to increased numbers of counts/bin in fast survey skymaps. In the solar wind, the maximum number of allowable counts in each bin is exceeded leading to clipping and resulting in a distortion of the plasma moments.

FPI burst data in the solar wind

FPI's field-of-view is binned with 11.25x11.25 deg resolution. In the polar angle direction (+Z to -Z for each sensor), angular space is continually sampled. However, the angular response in the azimuthal direction (X-Y plane) is <10deg. Therefore, as deflection states sweep out the azimuthal plane, there are gaps in the angular sampling of ambient plasma. Sharp angular structure in both DIS and DES can lead to apparent 'spikes' in the plasma moments that are spin-phase dependent. Such a phenomenon occurs often in high Mach number plasmas such as the solar wind.

Some burst segments may appear to look incomplete

Please check the burst status if you are not finding complete information. FPI has processed all available burst segments -- including those with status "DERELICT+FINISHED" (rather than "COMPLETE+FINISHED") -- meaning that some data from one or more spacecraft were not transmitted to the ground. FPI believes that "some data" is more valuable than "no data" and so is making these incomplete segments available. See an [example burst inventory list](#) here; instructions to query for your own list can be found at the [SDC's Web Services instruction page](#).

Some burst segments with status "COMPLETE+FINISHED" do not contain FPI data

While FPI data is available for most segments in which FPI is operating, there are a small number of burst segments with status "COMPLETE+FINISHED" that do not contain FPI data. Please see the [missing FPI burst segment table](#) for segments in which no FPI data is available.

Further Details:

- [Data Quality Flag Definitions](#)
- [DES Photoelectrons - further details](#)
- [Penetrating Radiation in DIS Data](#)