# Enhanced Plasma and Charged Particle Data Support in NASA's Planetary Data System

Joseph N. Mafi[1], In Sook Moon[1], Jeremy Faden[2], Chris Piker[3], Lucas Miller[4], Steven P. Joy[1], Raymond J. Walker[1], Jerry W. Manweiler[4]

[1]Earth, Planetary, & Space Sciences, UCLA, Los Angeles, CA, U.S.A.; [2]Cottage Systems, Iowa City, IA, U.S.A.; [3]Physics & Astronomy, University of Iowa, Iowa City, IA, U.S.A.; [4]Fundamental Technologies, LLC, Lawrence, KS, U.S.A.;

Data Usability

Background
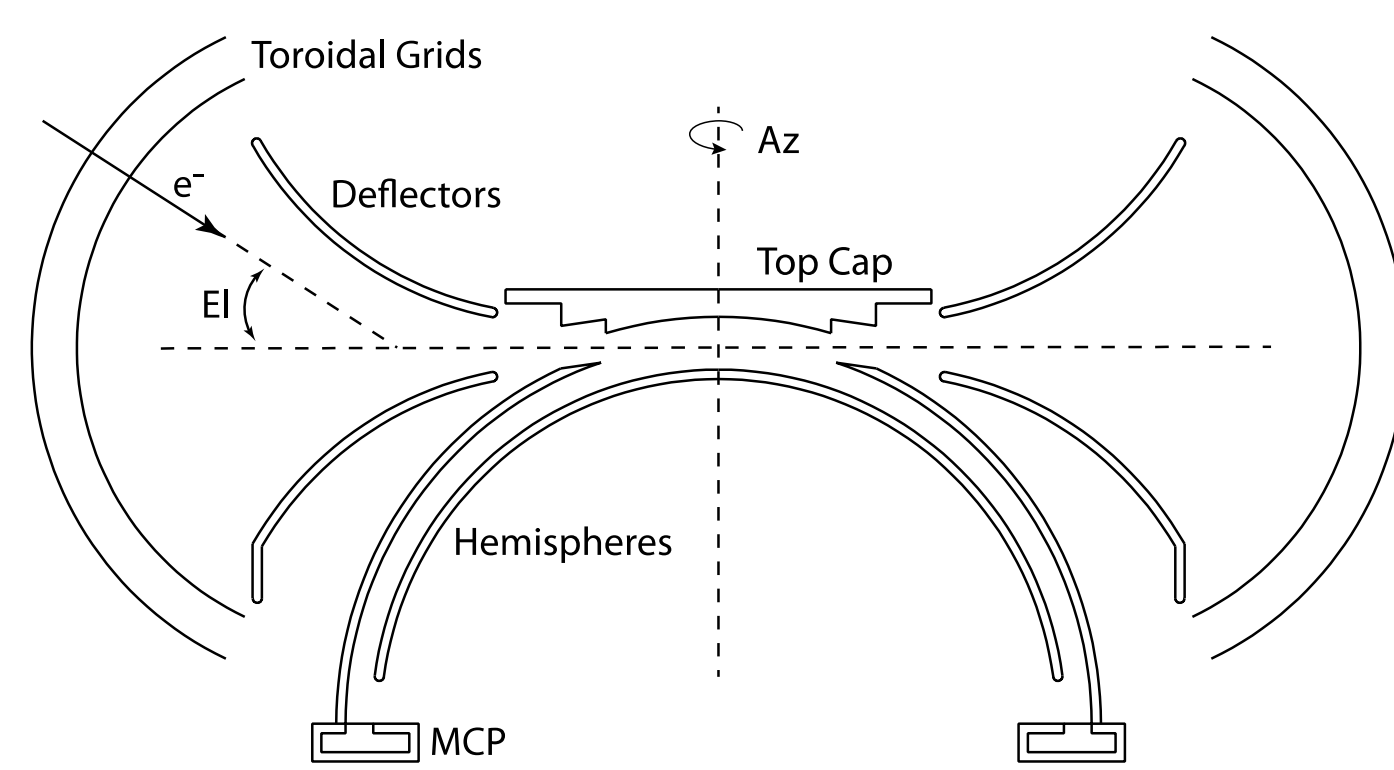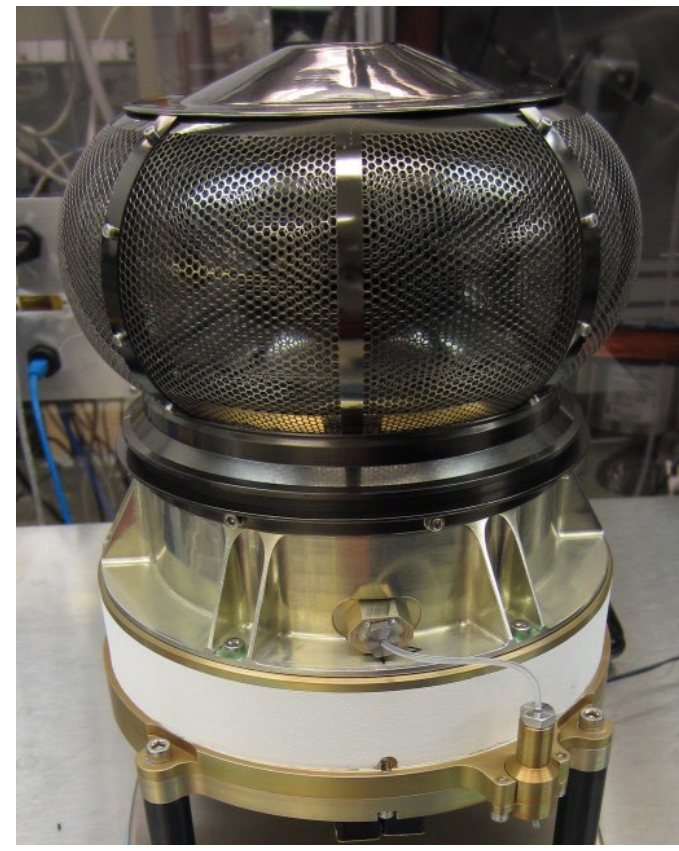
MAVEN SWEA

- Charged particle and plasma data are some of the most complex data curated by the Planetary Data System (PDS) Planetary Plasma Interactions (PPI) Node.
- A typical data array might consist of time ordered counts or flux organized by one or more look directions (e.g. azimuth and elevation), and other physical parameters such as energy or mass.

- Under Version 3 of the PDS Information Model (IM) multidimensional data had to be "flattened" into 2-dimensional tables in order to be describable by PDS metadata.
- Methods used to flatten the data and to describe the flattening in the metadata varied from data set to data set.
- Generic tools to read, visualize, and analyze these flattened data do not exist making them difficult for most data users to use.
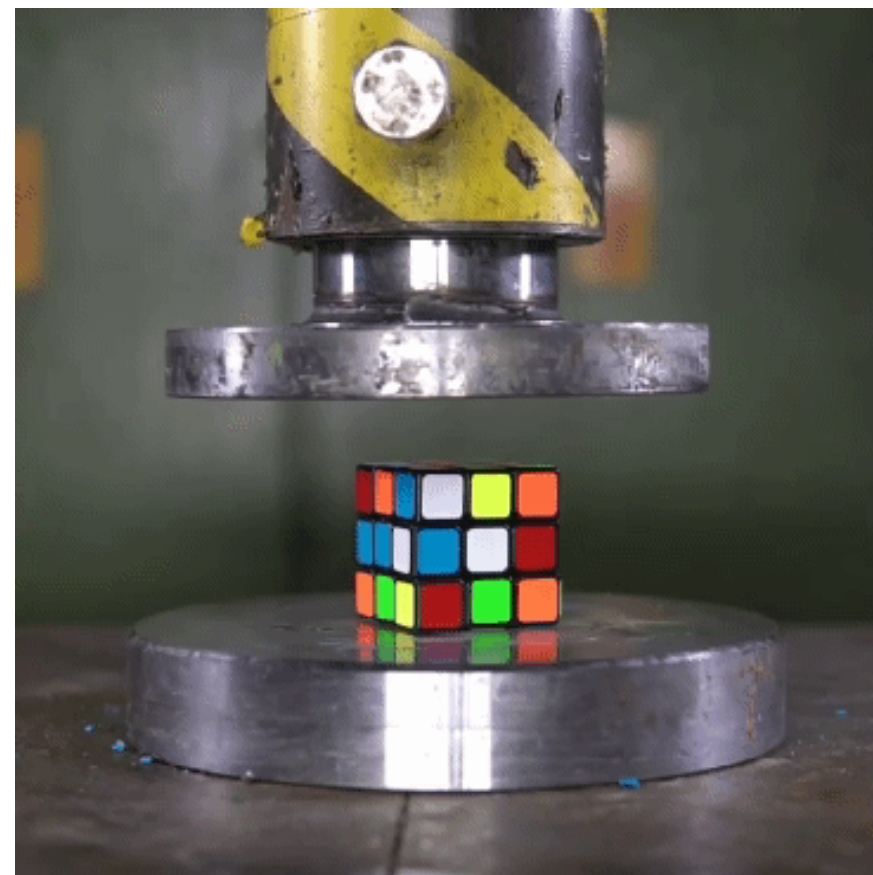
Improving Accessibility

- In order to support the MAVEN mission, in September 2014 the PDS Management Council approved the archive of data in the Common Data Format (CDF) with PDS4 metadata.
- Working with NASA's Space Physics Data Facility, PPI developed the "CDF-A" specification (https://pds-ppi.igpp.ucla.edu/doc/CDF-A-Specification-v1.0.pdf) which provides guidelines for creating PDS4-compliant CDF formatted data files.
- In response to community concerns about the usability of PPI's particle and plasma data holdings, PPI decided upon CDF-A as a possible solution.
- CDF is one of most widely used formats in the fields and particles community and has wide support (IDL, MATLAB, Python, Autoplot, etc.)

Translation to CDF

- PDS is in the middle of a multiyear project to translate its PDS3 metadata to PDS4.
- In parallel with this project PPI has embarked on a major effort to translate its multidimensional particle and plasma data holdings to CDF-A.
- This effort is actively supported by PPI Sub-Nodes, sub-contractors and data providers:
    - U. Iowa – Voyager PWS, Cassini RPWS, Galileo PWS
    - Fundamental Technologies, LLC – Galileo EPD, Voyager LECP, Cassini MIMI
    - SWRI, San Antonio, TX – Venus Express ASPERA-4
- PPI is working with a number of mission instrument teams for both active and past missions to support the delivery of CDF-A versions of their data to PDS.
- Original data providers will be invited to review the CDF-A files before they are released to the public.
- New data providers, including both mission and individual data providers, will be required to provide multidimensional particle and plasma data in CDF-A format.

## Data Accessibility

PDS Information Model (IM)

- There were no faceted metadata parameters in PDS3 that would unequivocally identify the type of scientific result contained in a data file. This information had to be documented in a description or inferred from the instrument type.
- PDS4 includes Primary_Result_Summary, a parameter that can be used to identify the type of scientific observation a data file contains.

Local Data Dictionaries (LDD)

- **Particle LDD** – Contains additional metadata that identify the specific type of particle data contained in a data file.
- **Multidimensional LDD** – Contains parameters that help define the relationship between a CDF data array, and associated support data (e.g. energy tables, etc.).

Data Visualization

- A number of options for viewing data to have been added to the PPI data webpages. These tools, which are in various stages if implementation.
- **PNGWalk** – Tool to quickly page through pre-generated a data set, then transition quickly Autoplot for further study.
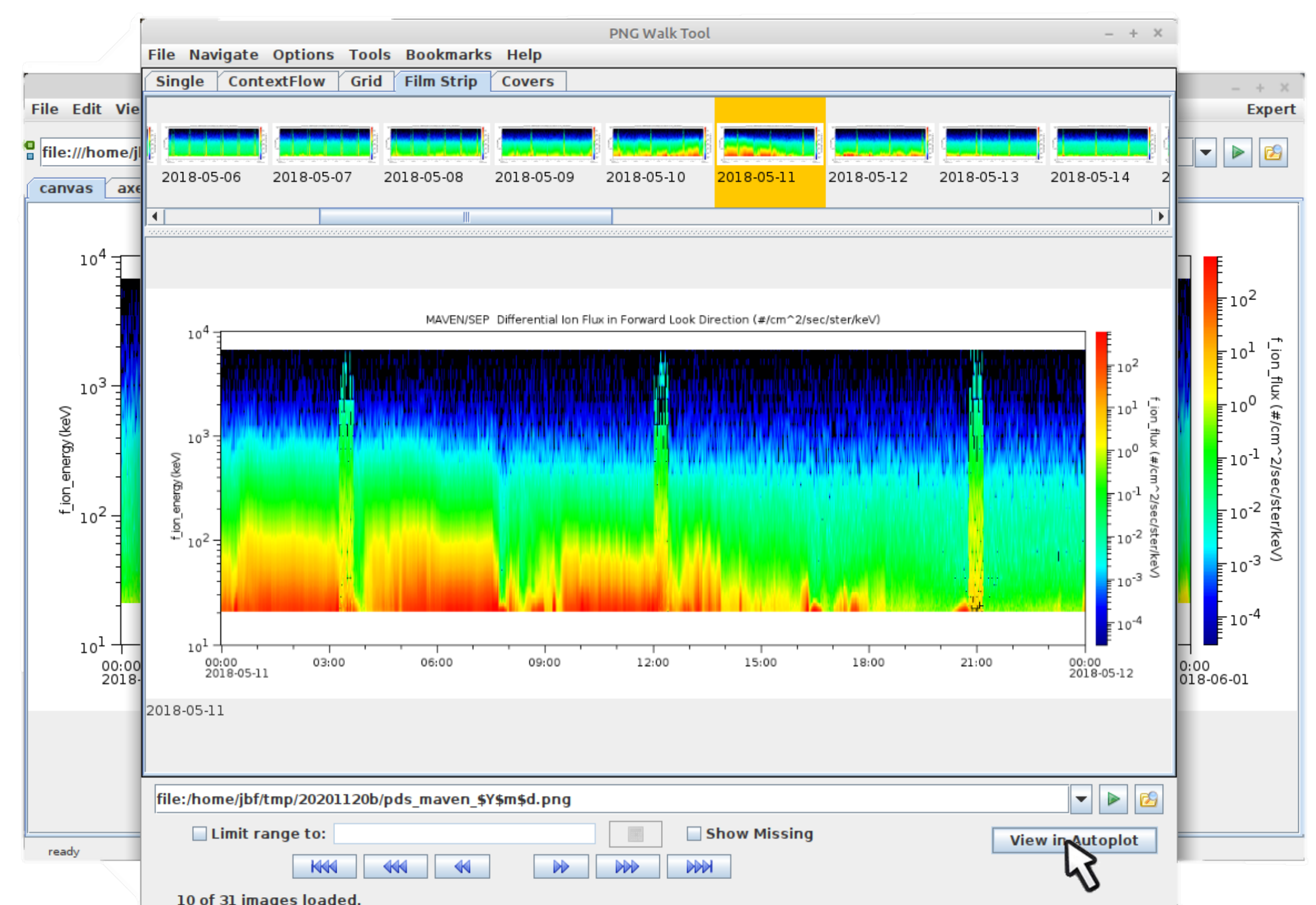
- **Autoplot** (http://autoplot.org/) – A plotting tool that supports a variety of file formats including ASCII, CDF and NetCDF. Plot settings may be saved in a ".vap" file.
- **TOPCAT** (http://www.star.bris.ac.uk/~mbt/topcat/) – A graphical viewer supporting CDF, VOTable and FITS. The PPI website sends the data to TOPCAT via a SAMP Hub (http://wiki.ivoa.net/twiki/bin/view/IVOA/SampInfo).
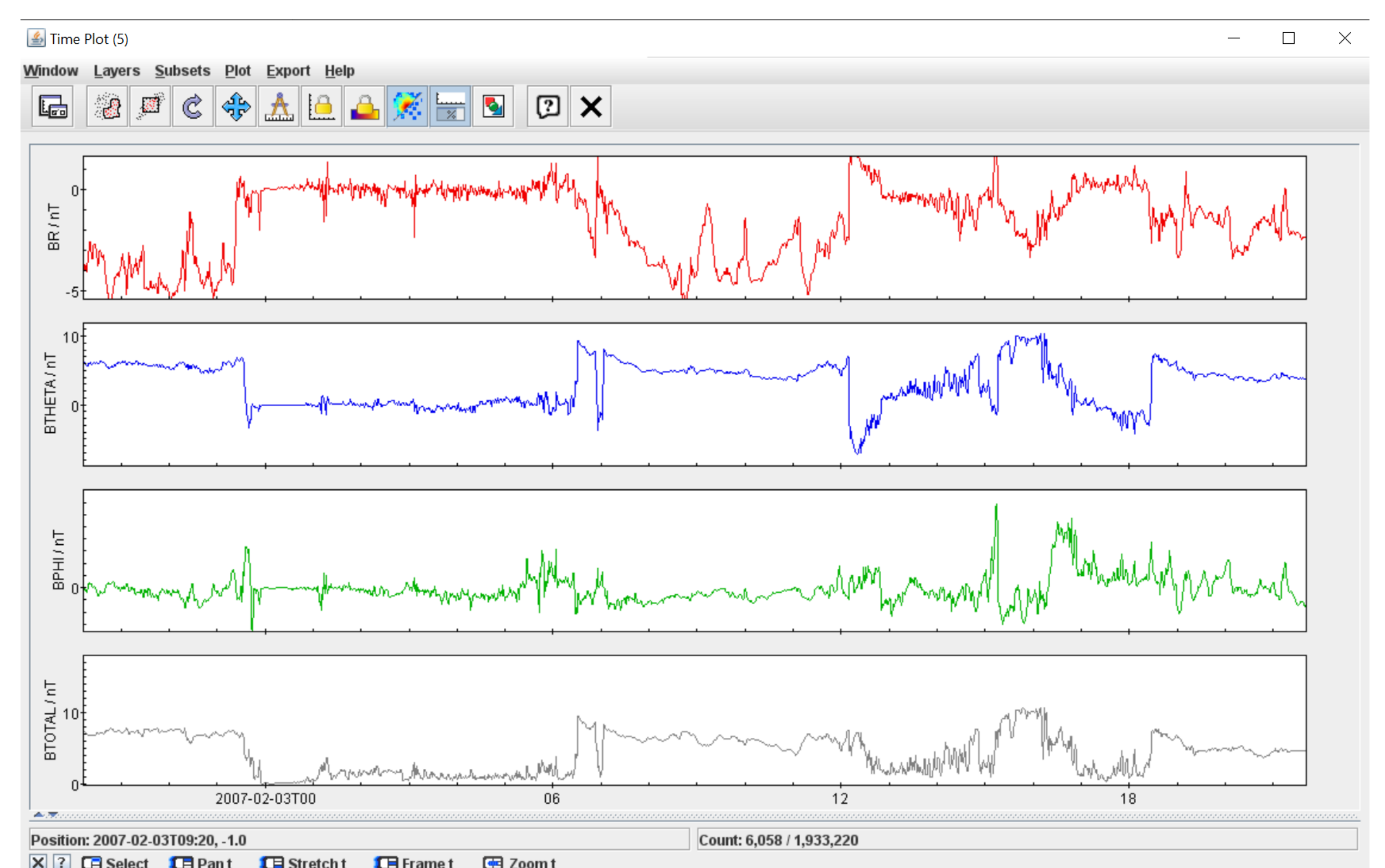
Web Services

- PPI has implemented instances of the Heliophysics Application Programming Interface (HAPI), International Virtual Observatory Alliance's (IVOA) Table Access Protocol (TAP) (which uses EuroPlaNet-TAP or EPN-TAP), and IVOA's Simple Application Messaging Protocol (SAMP) servers.
- PPI is supporting the development of the PDS API, which optimize search on PDS4 metadata.
- Please see In Sook Moon's poster, "Making the PDS Planetary Plasma Interactions (PPI) Node Data Accessible vi the EPN-TAP Protocol, API Server and PDS API".