

IDL/SPEDAS tutorial for BC/MMO data in the Mercury workshop @ISEE on Jan. 14, 2026

Last updated: Jan. 8, 2026, by T. Hori (CHS, ISEE)

This notebook showcases some basic commands of the Mio-SC plug-in for IDL/SPEDAS to demonstrate how users can download, read, and plot Mio satellite data. For details of Mio data, please refer to the Mio-SC website at <https://miosc.isee.nagoya-u.ac.jp/data/mio.php>.

Contents of this notebook:

1. Load & plot the orbit data with the locations of some planets
 2. Load & plot SPM, MIA, and OFA data
-

1. General information on the Mio-SC plug-in for IDL/SPEDAS

- The Mio-SC plug-in has been developed by the Mio Science Center (Mio-SC) and works as a plug-in allowing the Space Physics Environment Data Analysis System (SPEDAS) [Angelopoulos et al., SSR, 2019] to handle BepiColombo/MMO satellite data. With Mio-SC plug-in, MMO data users can make the most use of a countless number of useful tools and scripts in SPEDAS to analyze the MMO data.
- Mio Science Center (Mio-SC), part of the Center for Heliospheric Science (CHS) in the Center for Integrated Data Science (CIDAS) of ISEE, has been working on development of scientific data products and data analysis tools for BepiColombo/MMO satellite data.
- SPEDAS was originally developed in Interactive Data Language (IDL) and recently has been ported to its Python implementation, PySPEDAS.
- This tutorial is to briefly demonstrate how the users can use the IDL version of SPEDAS (IDL/SPEDAS) to handle MMO data.

Some useful information on installation of the necessary set of software

- IDL (commercial software)
 - The website of the NV5 Geospatial: <https://nv5geospatialsoftware.co.jp>
 - Dynamically loadable module for SPICE toolkit
 - The website of the NAIF in NASA/JPL: <https://naif.jpl.nasa.gov/naif/index.html>
 - SPEDAS
 - SPEDAS wiki at https://spedas.org/wiki/index.php?title=Main_Page
 - Mio-SC plug-in for IDL/SPEDAS
 - The Github repository: <https://github.com/ergsc-devel/miospedas>
-

2. Some basic commands of Mio-SC plug-in to handle MMO data

2.1 Load SPICE kernels and plot trajectories of the MMO satellite

```
; Download and load BEPI SPICE kernels

del_data, '*' ;Remove all tplot variables
timespan, '2021-09-15', 30, /day ;Set a time span for 30 days from Sept 15, 2021
knls = bepi_spice_kernels( /last, /no_ck, /load ) ;Download/update SPICE kernels, skipping CK files to
speed up
; knls = bepi_spice_kernels( /last, /load ) ;Download/load all latest available kernels
```

```
; Initialize some environment variables for downloading/loading MMO data
mmo_init

; Create tplot variables containing MPO and MMO positions for the designated time span.
mmo_load_pos, /no_kernel_load
tplot_names
```

[1]

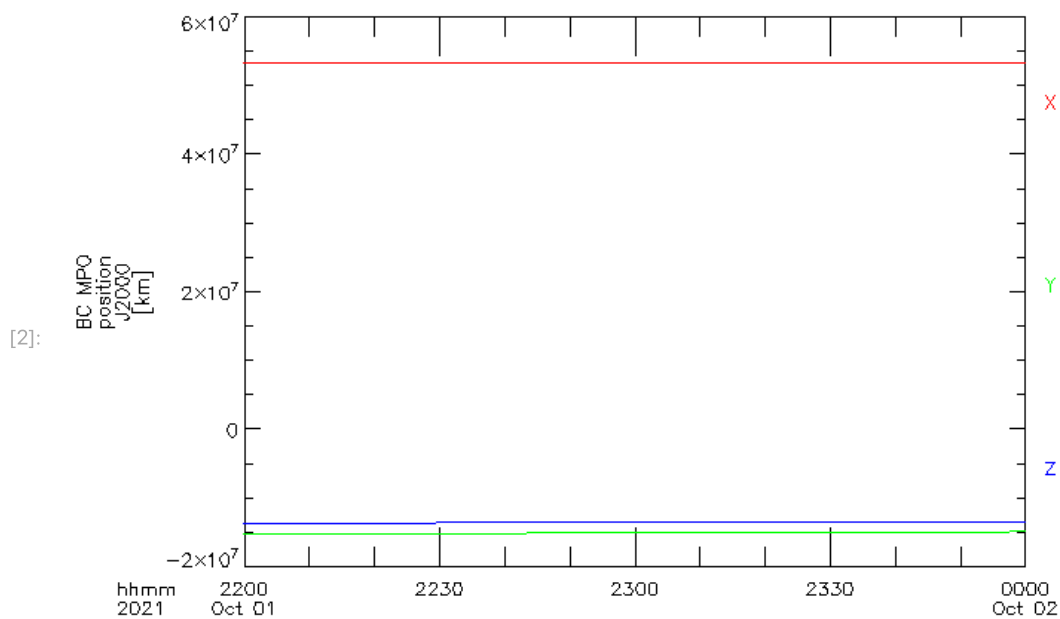
:

```
STORE_DATA(185): Deleted          31 variables
STORE_DATA(325): Creating tplot variable: 1 bc_mpo_fcp_orb_j2000
SPICE_VALID_TIMES(34): BC_MSO Not found. (Ignoring)
SPICE_BODY_POS(29):              122 Valid times from: MMO MERCURY BC_MSO
```

```
STORE_DATA(325): Creating tplot variable: 2 bc_mmo_pos_mso
1 bc_mpo_fcp_orb_j2000
2 bc_mmo_pos_mso      % Program caused arithmetic error: Floating illegal operand
```

```
loadct_sd, 48 ; Set the color table to "turbo"
!p.charsize = 1.3 & !p.font = -1
tplot, 'bc_mpo_fcp_orb_j2000'
```

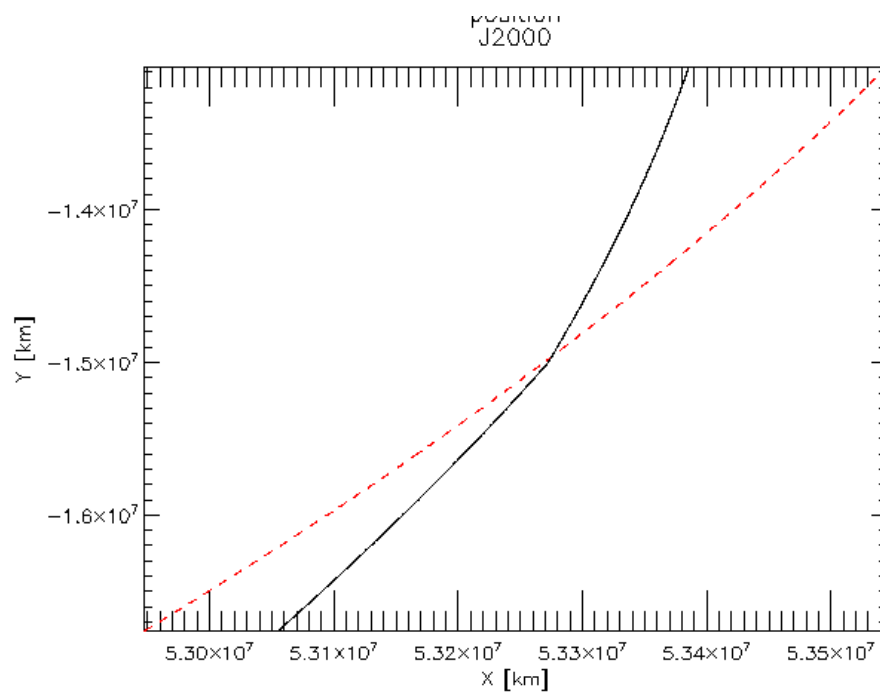
```
[1]
:
% Loading the Turbo color table
TPLOT(357): 1 bc_mpo_fcp_orb_j2000
```



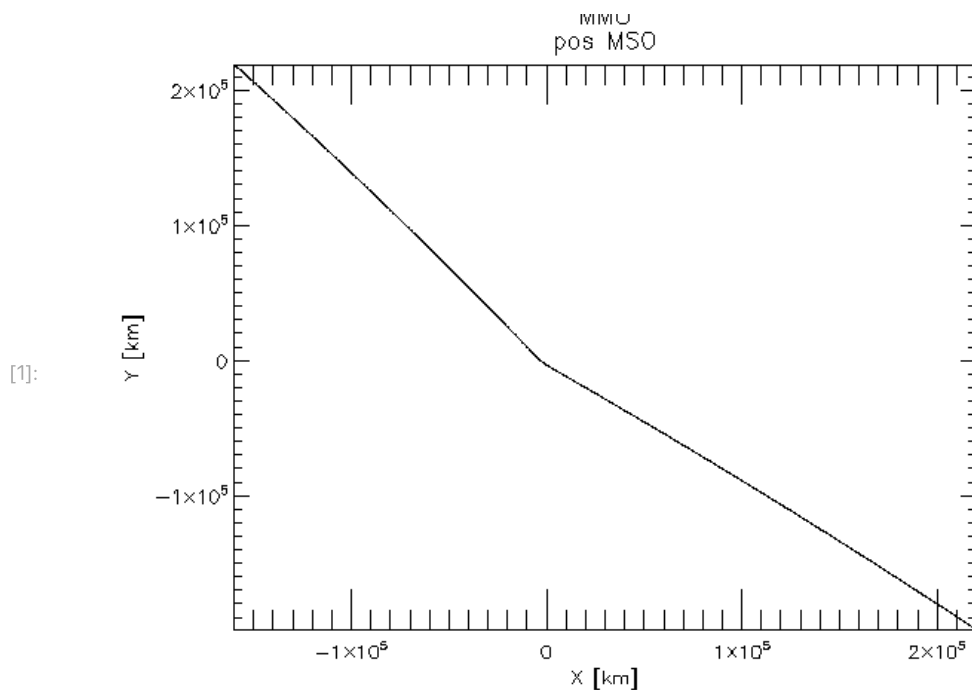
```
; Load the position data of MPO and Mercury for a more limited time range around the 1st Mercury flyby
timespan, '2021-10-01/12:00', 1, /day
mmo_load_pos, /no_kernel_load, /mercury
; Then plot them
tplotxy, 'bc_mpo_mercury_orb_j2000', /noiso, colors=6, linestyle=2
tplotxy, 'bc_mpo_fcp_orb_j2000', /over
```

```
[1]
:
TIMESPAN(53): Time range set from 2021-10-01/12:00:00 to 2021-10-02/12:00:00
STORE_DATA(325): Altering tplot variable: 1 bc_mpo_fcp_orb_j2000
SPICE_VALID_TIMES(34): BC_MSO Not found. (Ignoring)
SPICE_BODY_POS(29): 1442 Valid times from: MMO MERCURY BC_MSO
STORE_DATA(325): Altering tplot variable: 2 bc_mmo_pos_mso
STORE_DATA(325): Creating tplot variable: 3 bc_mpo_mercury_orb_j2000
% Program caused arithmetic error: Floating illegal operand
```

[2]:



```
; Plot the MM0 trajectory in MSO coordinates
tplotxy, 'bc_mmo_pos_mso', /noiso
```



2.2 Load and plot Solar Particle Monitor (SPM) data

```
timespan, '2021-10-01/22:00', 2, /hour
mmo_load_spm
tplot_names

tplot, 'mmo_spm_l2p_spm1_lv?_cnt'
```

[1]:

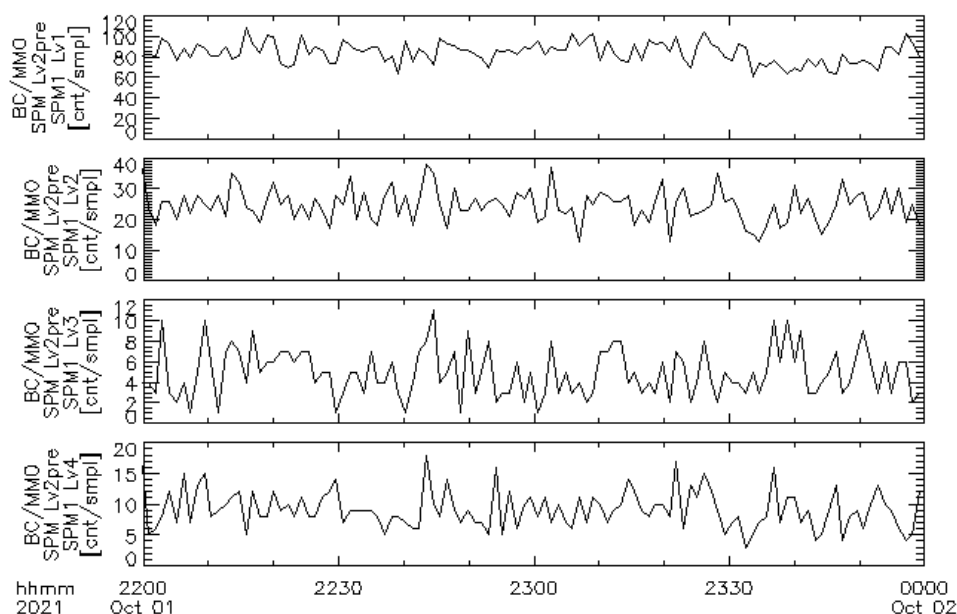
```
TIMESPAN(53): Time range set from 2021-10-01/22:00:00 to 2021-10-02/00:00:00
SPD_DOWNLOAD_FILE(289): Downloading: https://chs.isee.nagoya-u.ac.jp/data/chs/satellite/mmo/cdf/spm/l2pre/cnt/2021/10/
```

```

SPD_DOWNLOAD_FILE(312): Download failed. Trying a second time.
SPD_DOWNLOAD_FILE(391): Unauthorized to access: https://chs.isee.nagoya-u.ac.jp/data/chs/satellite/mmo/cdf/spm/l2pre/cnt/2021/10/
SPD_DOWNLOAD(238): No matching remote files found. Searching for local files.
SPD_MMS_CDF_LOAD_VARS(233): Loading file:
"/Users/horit/work/data/chs/satellite/mmo/cdf/spm/l2pre/cnt/2021/10/bc_mmo_spm_l2p_cnt_20211001_r01-v00-00.cdf"
STORE_DATA(325): Altering tplot variable: 4 mmo_spm_l2p_spm1_lv1_cnt
STORE_DATA(325): Altering tplot variable: 5 mmo_spm_l2p_spm1_lv2_cnt
STORE_DATA(325): Altering tplot variable: 6 mmo_spm_l2p_spm1_lv3_cnt
STORE_DATA(325): Altering tplot variable: 7 mmo_spm_l2p_spm1_lv4_cnt
STORE_DATA(325): Altering tplot variable: 8 mmo_spm_l2p_spm2_lv1_cnt
STORE_DATA(325): Altering tplot variable: 9 mmo_spm_l2p_spm2_lv2_cnt
STORE_DATA(325): Altering tplot variable: 10 mmo_spm_l2p_spm2_lv3_cnt
STORE_DATA(325): Altering tplot variable: 11 mmo_spm_l2p_spm2_lv4_cnt
1 bc_mpo_fcp_orb_j2000
2 bc_mmo_pos_mso
3 bc_mpo_mercury_orb_j2000
4 mmo_spm_l2p_spm1_lv1_cnt
5 mmo_spm_l2p_spm1_lv2_cnt
6 mmo_spm_l2p_spm1_lv3_cnt
7 mmo_spm_l2p_spm1_lv4_cnt
8 mmo_spm_l2p_spm2_lv1_cnt
9 mmo_spm_l2p_spm2_lv2_cnt
10 mmo_spm_l2p_spm2_lv3_cnt
11 mmo_spm_l2p_spm2_lv4_cnt
TPlot(357): 4 mmo_spm_l2p_spm1_lv1_cnt
TPlot(357): 5 mmo_spm_l2p_spm1_lv2_cnt
TPlot(357): 6 mmo_spm_l2p_spm1_lv3_cnt
TPlot(357): 7 mmo_spm_l2p_spm1_lv4_cnt

```

[2]:



2.3 Load and plot Lv.2pre data of the Mercury ion analyzer (MIA) of Mercury plasma particle experiment (MPPE) instrument

```

mmo_load_mia, level='l2pre', data_mode='l', datatype='et-all'
tplot_names, 'mmo_mia*et-all*'
tplot, ['mmo_spm_l2p_spm1_lv1_cnt', 'mmo_mia_l2p_l-et-all_count_d1']

```

[1]

```

SPD_DOWNLOAD_FILE(289): Downloading: https://chs.isee.nagoya-u.ac.jp/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/

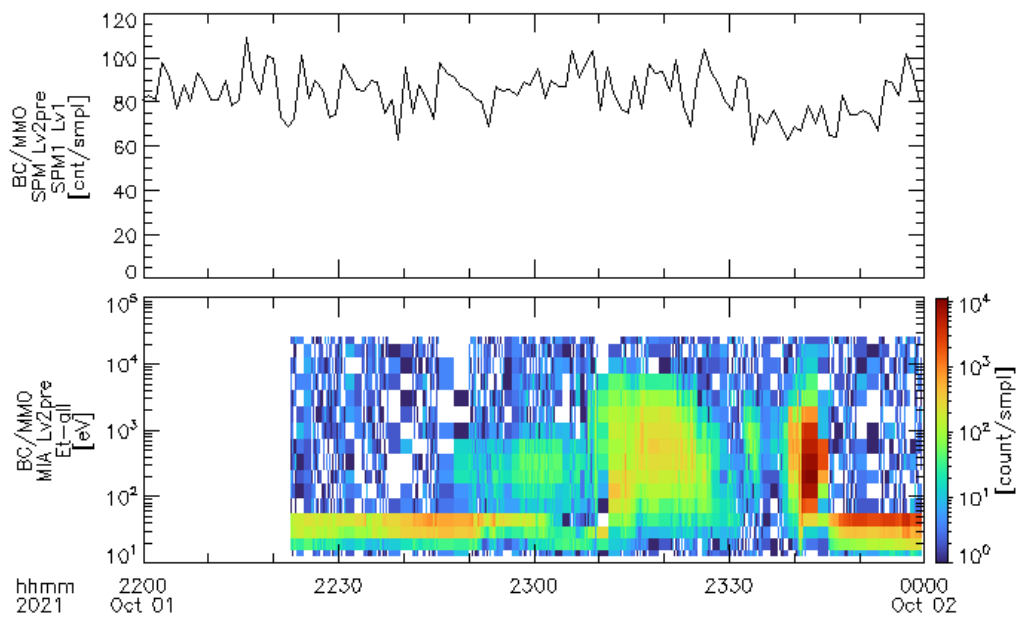
```

```

SPD_DOWNLOAD_FILE(312): Download failed. Trying a second time.
SPD_DOWNLOAD_FILE(391): Unauthorized to access: https://chs.isee.nagoya-
u.ac.jp/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/
SPD_DOWNLOAD(238): No matching remote files found. Searching for local files.
SPD_MMS_CDF_LOAD_VARS(233): Loading file:
"/Users/horit/work/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/bc_mmo_mppe-
mia_l2p_l-et-all_20211001_r00-v00-00.cdf"
SPD_MMS_CDF_LOAD_VARS(233): Loading file:
"/Users/horit/work/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/bc_mmo_mppe-
mia_l2p_l-et-all_20211001_r01-v00-00.cdf"
STORE_DATA(325): Altering tplot variable: 12 mmo_mia_l2p_l-et-all_count_d1
STORE_DATA(325): Altering tplot variable: 13 mmo_mia_l2p_l-et-all_count_d2
STORE_DATA(325): Altering tplot variable: 14 mmo_mia_l2p_l-et-all_count_d3
STORE_DATA(325): Altering tplot variable: 15 mmo_mia_l2p_l-et-all_count_d4
STORE_DATA(325): Altering tplot variable: 16 mmo_mia_l2p_l-et-all_deflux_d1
STORE_DATA(325): Altering tplot variable: 17 mmo_mia_l2p_l-et-all_deflux_d2
STORE_DATA(325): Altering tplot variable: 18 mmo_mia_l2p_l-et-all_deflux_d3
STORE_DATA(325): Altering tplot variable: 19 mmo_mia_l2p_l-et-all_deflux_d4
SPD_DOWNLOAD_FILE(289): Downloading: https://chs.isee.nagoya-
u.ac.jp/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/
SPD_DOWNLOAD_FILE(312): Download failed. Trying a second time.
SPD_DOWNLOAD_FILE(391): Unauthorized to access: https://chs.isee.nagoya-
u.ac.jp/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/
SPD_DOWNLOAD(238): No matching remote files found. Searching for local files.
SPD_MMS_CDF_LOAD_VARS(233): Loading file:
"/Users/horit/work/data/chs/satellite/mmo/cdf/mppe/mia/l2pre/et-all/2021/10/bc_mmo_mppe-
mia_l2p_l-et-swll_20211001_r01-v00-00.cdf"
STORE_DATA(325): Altering tplot variable: 20 mmo_mia_l2p_l-et-swll_count_d1
STORE_DATA(325): Altering tplot variable: 21 mmo_mia_l2p_l-et-swll_count_d2
STORE_DATA(325): Altering tplot variable: 22 mmo_mia_l2p_l-et-swll_count_d3
STORE_DATA(325): Altering tplot variable: 23 mmo_mia_l2p_l-et-swll_count_d4
STORE_DATA(325): Altering tplot variable: 24 mmo_mia_l2p_l-et-swll_count_sw
STORE_DATA(325): Altering tplot variable: 25 mmo_mia_l2p_l-et-swll_deflux_d1
STORE_DATA(325): Altering tplot variable: 26 mmo_mia_l2p_l-et-swll_deflux_d2
STORE_DATA(325): Altering tplot variable: 27 mmo_mia_l2p_l-et-swll_deflux_d3
STORE_DATA(325): Altering tplot variable: 28 mmo_mia_l2p_l-et-swll_deflux_d4
12 mmo_mia_l2p_l-et-all_count_d1
13 mmo_mia_l2p_l-et-all_count_d2
14 mmo_mia_l2p_l-et-all_count_d3
15 mmo_mia_l2p_l-et-all_count_d4
16 mmo_mia_l2p_l-et-all_deflux_d1
17 mmo_mia_l2p_l-et-all_deflux_d2
18 mmo_mia_l2p_l-et-all_deflux_d3
19 mmo_mia_l2p_l-et-all_deflux_d4
TPlot(357): 4 mmo_spm_l2p_spm1_lv1_cnt
TPlot(357): 12 mmo_mia_l2p_l-et-all_count_d1
% Program caused arithmetic error: Floating divide by 0
% Program caused arithmetic error: Floating illegal operand

```

[2]:



2.4 Load and plot Lv.2pre data of Onboard Frequency Analyzer (OFA) of Plasma wave investigation (PWI) instrument.

```
mmo_load_pwi_ofa, level='l2pre', data_mode='l', datatype='spec'
tplot_names, 'mmo_pwi_ofa_*'
tplot, ['mmo_spm_l2p_spm1_lv1_cnt', 'mmo_mia_l2p_l-et-all_count_d1',
'mmo_pwi_ofa_l2p_l_ms_B_spectra_merged']
```

```
[1]
:
SPD_DOWNLOAD_FILE(289): Downloading: https://chs.isee.nagoya-
u.ac.jp/data/chs/satellite/mmo/cdf/pwi/ofa/l2pre/spec/l/2021/10/
SPD_DOWNLOAD_FILE(351): 0 bytes complete (0.0 KB/s)
SPD_DOWNLOAD_FILE(351): 0 bytes complete (0.0 KB/s)
SPD_DOWNLOAD_FILE(351): 0 bytes complete (0.0 KB/s)
SPD_DOWNLOAD_FILE(391): Access forbidden: https://chs.isee.nagoya-
u.ac.jp/data/chs/satellite/mmo/cdf/pwi/ofa/l2pre/spec/l/2021/10/
SPD_DOWNLOAD(238): No matching remote files found. Searching for local files.
SPD_MMS_CDF_LOAD_VARS(233): Loading file:
"/Users/horit/work/data/chs/satellite/mmo/cdf/pwi/ofa/l2pre/spec/l/2021/10/bc_mmo_pwi-ofa_l2p_l-
spec-ms_20211001-r01-v01-00.cdf"
STORE_DATA(325): Altering tplot variable: 29 mmo_pwi_ofa_l2p_l_ms_spec_B_18
STORE_DATA(325): Altering tplot variable: 30 mmo_pwi_ofa_l2p_l_ms_E_spectra_merged
STORE_DATA(408): Multi- tplot variable: 30 mmo_pwi_ofa_l2p_l_ms_E_spectra_merged :
STORE_DATA(325): Altering tplot variable: 31 mmo_pwi_ofa_l2p_l_ms_B_spectra_merged
STORE_DATA(408): Multi- tplot variable: 31 mmo_pwi_ofa_l2p_l_ms_B_spectra_merged :
mmo_pwi_ofa_l2p_l_ms_spec_B_18
```

BepiColombo Mercury Magnetospheric Orbiter Plasma Wave Investigation Low- and Magnetosphere mode spectrum data for electric and magnetic field spectra data

Information about MIO PWI OFA

PI: Y. Kasaba Affiliation: Tohoku University

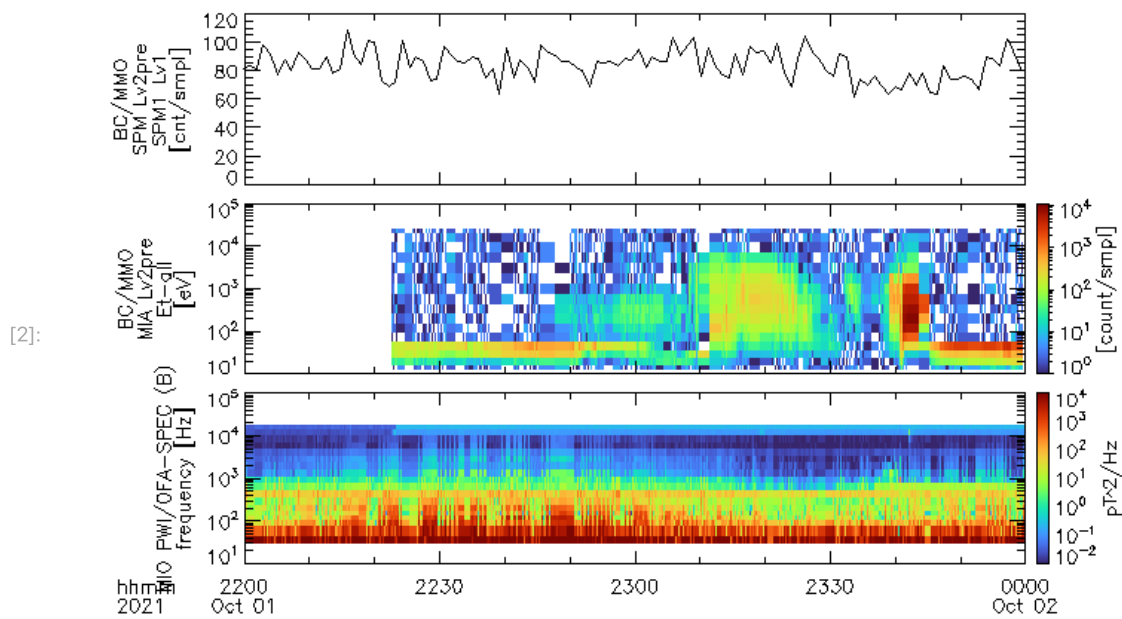
29 mmo_pwi_ofa_l2p_l_ms_spec_B_18

30 mmo_pwi_ofa_l2p_l_ms_E_spectra_merged

31 mmo_pwi_ofa_l2p_l_ms_B_spectra_merged mmo_pwi_ofa_l2p_l_ms_spec_B_18 TPLLOT(357): 4 mmo_spm_l2p_spm1_lv1_cnt TPLLOT(357): 12

mmo_mia_l2p_l-et-all_count_d1 TPLLOT(357): 31 mmo_pwi_ofa_l2p_l_ms_B_spectra_merged TPLLOT(407): 29

mmo_pwi_ofa_l2p_l_ms_spec_B_18 % Program caused arithmetic error: Floating divide by 0 % Program caused arithmetic error: Floating illegal operand



Add the satellite position at the bottom of a plot (var_label attribute)

```
split_vec, 'bc_mmo_pos_mso'
options, 'bc_mmo_pos_mso_x', ytitle='X_MS0'
options, 'bc_mmo_pos_mso_y', ytitle='Y_MS0'
options, 'bc_mmo_pos_mso_z', ytitle='Z_MS0!c[km]'
tplot_options, var_label='bc_mmo_pos_mso_'+['z','y','x']
tplot ;; replot the previously displayed variables
```

[1]:

```
STORE_DATA(325): Creating tplot variable: 32 bc_mmo_pos_mso_x
STORE_DATA(325): Creating tplot variable: 33 bc_mmo_pos_mso_y
STORE_DATA(325): Creating tplot variable: 34 bc_mmo_pos_mso_z
TPlot(357): 4 mmo_spm_l2p_spm1_lv1_cnt
TPlot(357): 12 mmo_mia_l2p_l-et-all_count_d1
TPlot(357): 31 mmo_pwi_ofa_l2p_l_ms_B_spectra_merged
TPlot(407): 29 mmo_pwi_ofa_l2p_l_ms_spec_B_18
% Program caused arithmetic error: Floating divide by 0
% Program caused arithmetic error: Floating illegal operand
```

[2]:

