MMSEDPana

User Manual

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Document Change Log

Issue/ Rev.	Issue Date	Sections	Reason for Change
1	7 Oct 2020	All	Initial release, based on edptest usermanual Iss 2
2	20 Sep 2023	All	Incorporates changes of software since issue 1
3	30 Sep 2023	5, 6	Final revisions

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1 Overview

The program MMSEDPana displays and analyzes data from the NASA Magnetospheric Multiscale (MMS) Mission related to spacecraft charging. Special emphasis is laid on the operation of the ASPOC instruments which control the spacecraft potential by emitting energetic ion beams.

1.1 Instrument data

Inputs to the program include data from the instruments

Acronym	Name	Ref.	Format	Parameter
ASPOC	Active Spacecraft Potential Control	[1]	CDF	Ion beam current
			ASCII	on/off times
EDI	Electron Drift Instrument	[2]	SAV	Gun beam current
			ASCII	on/off times
EDP	Electric Field Double Probes, consisting of:	[3]		
SDP	Spin Plane Double Probes	[4]	CDF	Spacecraft potential, Electric field
ADP	Axial Double Probes	[5]	CDF	Spacecraft potential, Electric field
FGM	Flux Gate Magnetometer	[6]	CDF	Magnetic field
FPI	Fast Plasma Instrument, consisting of:	[7]		
DES	Dual Electron Sensors		CDF	Electron moments, energy distributions
DIS	Dual Ion Sensors		CDF	Ion moments, energy distributions

In addition to instrumental data the spacecraft attitude data (DEFATT files) may be applied to determine the spin phase.

1.2 Processing options

Processing options include the following

- Plots or tables of data over time. Data include ASPOC current, spacecraft potential, electric field probe potentials, electric field total, components, and elevation angle, plasma density, plasma temperature, calculated plasma current, plasma bulk velocity, Mach number, Debye length, magnetic field, vxB components, ExB conponents
- Maps of electric field vectors and ExB vectors
- Plots of data over spin phase in rectangular or polar co-ordinates
- Multiple plots of the same parameter from many time slots
- Phase space density and differential flux of plasma data
- Recalibration and offset calculation of EDP data
- Averaging over spin periods
- Filtering according to operational status of ASPOC and EDI
- Time series filtering (running mean, high pass)

- Spin tone calculation and correction (harmonics, Hampel filters)
- Calculation of plasma current to the spacecraft from plasma moments (density and temperature) or from the distribution function
- Calculation of plasma velocity from electric and magnetic fields
- Calculation of electric field from plasma velocity and magnetic field
- Correlation between spacecraft potential and electric field, see [8]
- Correlation between spacecraft potential and plasma density
- Correlation between spacecraft potential and currents from plasma and ASPOC
- Correlation between spacecraft potential and plasma bulk velocity
- Correlation between spacecraft potential and vxB
- Correlation between individual probe potentials
- Correction of spacecraft potential by trend with bulk ion velocity, ion Mach number, or plasma temperature
- Calculation of photocurve from dual spacecraft potential data in multiple function options, see [9]
- Calculation of photocurve from spacecraft potential and plasma electron data in multiple function options, see [10]
- Reconstruction of uncontrolled spacecraft potential based on the above fitting methods
- Reconstruction of plasma density based on the above fitting methods
- Reconstruction of plasma current based on the above fitting methods
- Generation of spin period data files for further analysis by the program CorrVandFlux
- Fast Fourier Transformation and dynamic FFT spectra of spacecraft potential, probe potential, and electric field
- Analysis of ASPOC current sweeps

1.3 Output

- Plots in PNG or Postscript format
- ASCII tables of data (full resolution or spin period averages)
- ASCII tables of fitted parameters
- Output of spin average data set for post processing with the program corrVandFlux

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3 System Requirements

Source codes are compatible with IDL 8.7 or higher.
The SPEDAS software library is required.

4 Installation

4.1 Contents of distribution

The distribution comes as a zip file mmsedpana.zip containing three directories.

doc	documentation including this document and the EDP data products guide
opstables	ASPOC and EDI on-off time data files
source	IDL source code

4.2 Directories and environment variables

The program stores its settings from a previous run in a section within a file named ini_file.txt located in the directory specified in the IDL environment variable 'USERPROFILE", normally pointing to C:\Users\<userID>.

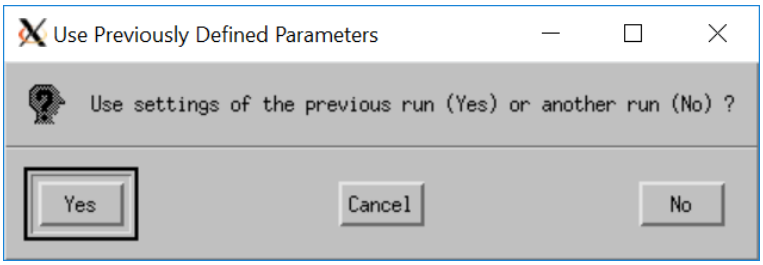
The program remembers the location of the output data from the last run in an environment variable.

The program requires the input data to be located in the MMS SPEDAS directory structure.

Tables with operational data should be put into a dedicated directory.

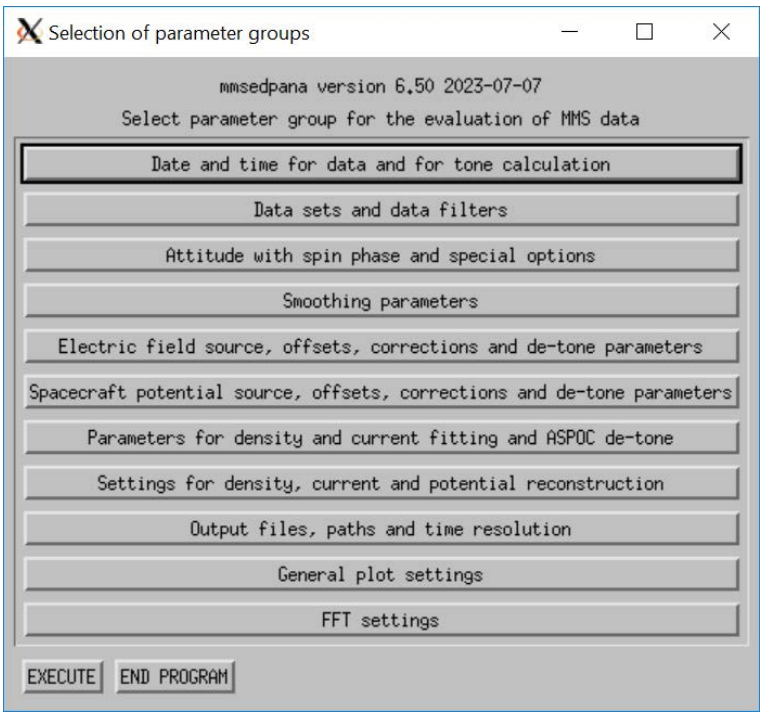
4.3 Step-by-step installation procedure

- Unpack the zip file
- Move the files in the directory "source" to the appropriate path of the IDL distribution for subsequent compilation and execution.
- Move the files in the directory "opstables" to the final location.
- Load the sources into the IDL development environment and execute them. Note that the generation and subsequent execution of a .sav file may lead to errors, probably due to the large size of the source code.
- If program settings from a previous run have already been stored for some reason, the following window will appear:

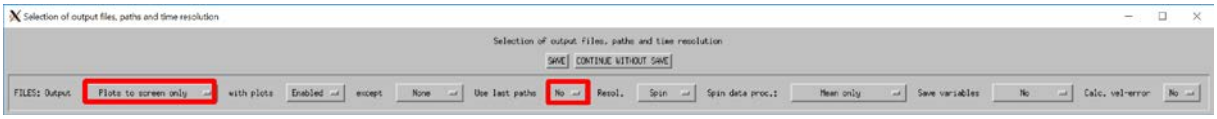


Note that this selection does not apply to the paths of input and output files. These will be selected in other windows. Pressing "Yes" ("Ja") if a previous run is available and its settings shall be used. Otherwise, particularly in the first run immediately after installation, enter "No" ("Nein") and continue.

- Thereafter the main control panel shown below should appear. Eleven subpanels with input parameters can be called from the main panel. After completion of all settings, the program will start execution after the button "EXECUTE" has been pressed. The button "END PROGRAM" exits the program.

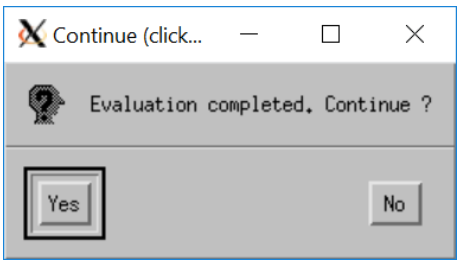


- The main purpose of the first execution of the program is to set up the environment variables for the directories. Therefore, the next selections are for the plot or table output directory.
- Select the button "Output files, paths and time resolution". The the following window



select (as highlighted) Output to plots to screen only and "No" to use last paths if mmsedpana is executed on a system for the first time in order to set the environment variable storing the paths to the default values. Failing to do so will crash the program. The default value for the output path is the path of the executed program.

- After the calculations have finished, the following dialogue will appear unless the option "Ask" has been set to "Never":



By clicking "Yes" ("Ja") the user will be guided to the main control panel, and the program is ready for a new calculation.

The program remembers all previous settings.

Note that the plots on the screen can be moved or copied to the clipboard only after "Yes" ("Ja") has been pressed.

By clicking "No" ("Nein") the program exits.

5 Input Data

5.1 General remarks

MMS instrument data are available to the public from the MMS Science Data Center (https://lasp.colorado.edu/mms/sdc/public/) on the page
https://lasp.colorado.edu/mms/sdc/public/about/browse-wrapper/

A copy of some data is located at IWF Graz at leo1/nas/mms/spedas (instrument data) and leo1/nas/mms/sdc/data/ancillary (ancillary data for spin phase determination)

Instrument data (see section 4.2) in CDF are located under the directories mms1, mms2, mms3, mms4.

Definitive attitude files (see section 4.3) are located in the directories ancillary/mms1/defatt, ancillary/mms2/defatt, ancillary/mms3/defatt, and ancillary/mms4/defatt.

Instrument data have to be in CDF format according to the MMS specifications.

All data have to come from the same spacecraft with the following exceptions:
a) A second EDP file from a different spacecraft is permitted in order to compare controlled and uncontrolled potentials.
b) FPI data can be taken from a different spacecraft (a warning message will be displayed).

5.2 Instrument data

5.2.1 Instrument EDP, spacecraft potential and probe voltages

See [3] for a description of EDP data types.

Parameter(s): spacecraft potential and probe voltages. The electric field is derived from the data by the program if no EDP electric field data file is selected.

Telemetry modes allowed: slow, fast, brst

File types allowed: l1b_dcv128, l1b_dce, l2_scpot

Multiple files are permitted (SPEDAS automatically reads all files within the specified time interval).

Comment: This is the standard EDP data type, useful for many purposes, except if electric field data in the calibration by the EDP team are required. In this case, use l2pre_dce files, which have, however, the drawback that they do not contain the spacecraft potential. The program offers the capability to process both an l2_scpot file and an l2pre_dce file in parallel.

5.2.2 Instrument EDP, electric field

See [3] for a description of EDP data types.

Parameter(s): electric field, calibrated by the EDP team

Telemetry modes allowed: slow, fast, brst

File types allowed: l2pre_dce, l2_dce

Multiple files are permitted (SPEDAS automatically reads all files within the specified time interval).

Comment: This file type can be used stand-alone, but in this case, no spacecraft potential will be available. It can also be used in parallel to a spacecraft potential file.

5.2.3 Instrument ASPOC

Parameter(s): ion beam currents

Telemetry modes allowed: srvy

File types allowed: l2

SPEDAS automatically reads all files within the specified time interval.

Comment: This file is required to obtain the exact value of the ion current. If only the operational status of ASPOC is of interest, this file is not required because this information is taken automatically from the operational status files.

5.2.4 Instrument FPI

Parameter(s): moments or distribution functions from plasma electrons or ions

Telemetry modes allowed: fast, brst

File types allowed: l1b_moms, l2_moms, l1b_dist, l2_dist

SPEDAS automatically reads all files within the specified time interval.

Comment: Either electron data from the DES sensors or ion data from the DIS sensors can be selected. Moments data should be used for calibrated values of plasma densities and currents. Distribution function data may be used to display energy-time spectrograms. Densities, temperatures, and currents from distribution function data are derived by the program using simple algorithms, in particular without corrections for spacecraft potential and photo-electrons.

5.2.5 Instrument FGM

Parameter(s): magnetic field

Telemetry modes allowed: srvy

File types allowed: l2

SPEDAS automatically reads all files within the specified time interval.

Comment: This file is required if ExB or vxB shall be calculated.

5.2.6 Instrument EDI

Parameter(s): Electron beam current

Telemetry modes allowed: Not applicable

File types allowed: Not applicable

The EDI beam current data are not taken from the SPEDAS directories but from files in the subdirectory EDI_Current of the opstables directory. See section 4.3.4.

Comment: These data may be included in the current balance of the spacecraft for exact analyses.

5.3 Support data

5.3.1 Definitive attitude files

Definitive attitude files are required if the user selects the default option for the spin phase determination in the top left drop list of the main control panel.
An example for a file name is: MMS1_DEFATT_2015206_2015207.V00 for data of MMS1 starting on day of year 206 of 2015 and ending on the following day. Because of the asynchrony between attitude files and instrument data files which often are organized according to calendar days, it is normally necessary to input both the attitude file starting on the day before the instrument data and the one on the same day.

5.3.2 ASPOC ON-OFF times

Time intervals when the ASPOC instruments are emitting ion beams (active periods) are listed in eight files, one for each instrument. At present, the period covered by the files is from 2015-03-28 to 2023-07-03. The files are:

mms1_asp1_20150328_20230703.txt
mms1_asp2_20150328_20230703.txt
mms2_asp1_20150328_20230703.txt
mms2_asp2_20150328_20230703.txt
mms3_asp1_20150328_20230703.txt
mms3_asp2_20150328_20230703.txt
mms4_asp1_20150328_20230703.txt
mms4_asp2_20150328_20230703.txt

Each file contains two columns with the start and end times of individual active intervals.

5.3.3 EDI ON-OFF times

Time intervals when the EDI instruments are emitting electron beams (active periods) are listed in four files, one per spacecraft. Active is defined to be the EDI current greater than 0.01 µA. At present, the period covered by the files is from 2015-09-01 to 2023-06-27. The files are:

edi1.txt
edi2.txt
edi3.txt
edi4.txt

Each file contains two columns with the start and end times of individual active intervals.

5.3.4 EDI current

Data of the EDI electron current are interesting because they counteract the ASPOC ion current. EDI electron current data are not taken directly from the SPEDAS directories but are taken from files located in the subdirectory EDI_Current/hk. There are 16 files in total in IDL .sav format. At present, the period covered by the files is from 2015-09-01 to 2023-06-27.

6 Output Data

6.1 Plots

By default the program outputs plots to the display. Depending on the selected options up to 32 plot windows may appear. By selecting "Plots to screen and files" or "Plots to XXX files" in the drop list for output files the user may generate plot files containing the same graphics as on the display (see also section 3.3). By default, the program proposes a file name string in the nomenclature mms<N>_<date>_<starttime>_<stoptime>_<unit><processing code>.png.

The unit code is always "edp".
Possible processing codes are combinations of:

""	Standard processing
"p"	The mean spacecraft potential has been subtracted from individual probe potentials
"3d"	The electric field has been calculated using all 6 probes, including the axial ones
"eaut"	An automatically determined correlation term with the electric field has been subtracted from the spacecraft potential
"efix"	A manually set correlation term with the electric field has been subtracted from the spacecraft potential

The format of the plot files is PNG or Postscript. The user may change the file name. The output will consist of multiple files with names starting with the chosen name to which strings according to the contents are appended, for example mms1_20150726_0415_0425_edpp_vsc.png for a spacecraft potential plot of mms1 in the selected time period.

6.1.1 Plot file types and file names

Code	Content
asp	full resolution ASPOC current over time
aspa	spin average ASPOC current over time
avfld	average electric field offset from spin period fits
avsch	full resolution ASPOC current over spacecraft potential
cmd	full resolution potential of probe common mode differences over time
cmdphi	full resolution potential of probe common mode differences over spin phase
cmdvsc	full resolution potential of probe common mode differences over spacecraft potential
curr	spin average calculated and reconstructed plasma current over time
currh	full resolution calculated plasma current over time
davsch	full resolution d(ASPOC current)/d(change of potential) over mean potential
debye	full resolution Debye length over time
def	differential flux of plasma data over time
defe	differential flux of plasma data over energy in several time slots

Code	Content
dens	spin average measured and reconstructed plasma density over time
densh	full resolution plasma density over time
denshrec	full resolution reconstructed plasma density over time
densphi	full resolution plasma density over spin phase
densrec	spin average reconstructed plasma density over time
df1	dynamic Fourier spectrum of electric field component 1
df2	dynamic Fourier spectrum of electric field component 2
dfs	dynamic Fourier spectrum of spacecraft potential
dsfld	full resolution despun electric field components from SCPOT file over time
dslephi	full resolution electric field components from DCE file over spin phase
dslephiasp*	full resolution electric field components from DCE file over spin phase with colour scale from ASPOC current
dslfld	full resolution despun electric field components from DCE file over time
dslfldres	full resolution despun electric field components from SCPOT file over time
dsmod	average electric field amplitude from spin period fits of despun E-field data
dvp	spin average probe potentials relative to probe 1 over time
edslphi	full resolution despun electric field components from DCE file over spin phase
eelev	full resolution elevation angle of electric field
ephi	full resolution electric field components from SCPOT file over spin phase
ephiasp*	full resolution electric field components from SCPOT file over spin phase with colour scale from ASPOC current
erawrec	full resolution raw over reconstructed electric field
etvpi	full resolution probe potentials over electric field strength
etvsc	full resolution spacecraft potential over electric field strength
etvsca	spin average spacecraft potential over electric field strength
etvscmap*	Map of minimum Vsc (or residual Vsc) over E12 and E34 for several phase angle bins
evsia	average electric field over ASPOC current
exbh	full resolution ExB components over time
exbxy	full resolution ExB vector x and y components labeled with spin phase
exbxz	full resolution ExB vector x and z components labeled with spin phase
exbyz	full resolution ExB vector y and z components labeled with spin phase
exy	full resolution electric field vector x and y components labeled with spin phase
exz	full resolution electric field vector x and z components labeled with spin phase
eyz	full resolution electric field vector y and z components labeled with spin phase
fld12	full resolution electric field components over time
fldres	full resolution residual electric field over time (to check spin tone removal)
ft	Fourier spectrum of electric field
ftn	Fourier spectrum of plasma density
ftp	Fourier spectrum of spacecraft potential
ivcurve	fitted line of plasma current over spacecraft potential (I-V-curve)
ivsc	spin average calculated and reconstructed plasma current over spacecraft potential
ivsch	full resolution calculated and reconstructed plasma current over spacecraft potential
mach	spin average Mach number over time
machh	full resolution Mach number over time
machvsc	full resolution spacecraft potential over Mach number
mag	spin average magnetic field components over time
magh	full resolution magnetic field components over time
mod	average electric field amplitude from spin period fits of probe data
nvsc	spin average measured and reconstructed plasma density over spacecraft potential

Code	Content
nvsch	full resolution measured and reconstructed plasma density over spacecraft potential
psd	phase space density of plasma data over time
psde	phase space density of plasma data over energy in several time slots
recfld12	full resolution reconstructed spinning electric field over time
regr	regression coefficient of partial PSD or DEF over energy
scat	scatterplot between controlled and uncontrolled potentials in spin average
scath	scatterplot between controlled and uncontrolled potentials in full resolution
temp	spin average measured plasma temperature over time
temph	full resolution plasma temperature over time
tempvsc	full resolution spacecraft potential over plasma temperature
vel	spin average plasma bulk velocity over time
velh	full resolution plasma velocity components over time
velvsc*	full resolution spacecraft potential over plasma velocity or its components
vp	spin average probe potentials over time
vp34vp12	full resolution potentials of probes 3+4 over potentials of probe 1+2
vphi	full resolution plasma velocity over spin phase
vpi	full resolution probe potentials over time
vpi2	full resolution potential of probe pairs over time
vpivp1	full resolution probe potentials over potential of probe 1
vpphi	full resolution probe potentials over spin phase
vpphi2	full resolution potential of probe pairs over spin phase
vsc	full resolution spacecraft potential over time
vsca	spin average spacecraft potential over time
vscmintest	test of running minimum of full resolution spacecraft potential data
vscphi	full resolution raw or spin tone corrected spacecraft potential over spin phase
vscrec	spin average measured and reconstructed spacecraft potential over time
vscrech	full resolution residual and reconstructed spacecraft potential over time
vscres	full resolution residual spacecraft potential (after spin tone removal) over time
vscres3	full resolution spacecraft potential after special detone procedure over time
vscresphi	full resolution raw and residual spacecraft potential over spin phase
vxb	spin average vxB components over time
vxbh	full resolution vxB components over time
vxbvsc*	full resolution spacecraft potential over vxB or its components
wkd	depth of wake features in probe data
wke	error in calculation of wake features in probe data
wkp	phase of wake features in probe data

6.2 Tables

By selecting "Table" in the drop list for output files the user may generate an ASCII file containing spacecraft potential, probe voltages, and electric field components. If available, also electron or ion density, temperature and current aswell as plasma bulk velocity are written. By default, the program proposes a file name string in the nomenclature mms<N>_<date>_<starttime>_<stoptime>.txt.

6.3 Fitting parameters

6.3.1 Fitting controlled and uncontrolled potentials

If the setting is "Iph" in the panel "Settings for density, current and potential recontruction" in the section "RECONSTRUCTION" the program calculates a best fit for the photo-electron

spectrum based on controlled and uncontrolled potentials, and generates a text file in the output directory with a file name starting with "rmsv_mms<N1>_mms<N2>", followed by acronyms according to the fitting method, date and time.
An example for a file name is rmsv_mms1_mms2_t2_none2d_20150726_0130_0400.txt.
In this example, mms1 is the spacecraft with ASPOC ON, mms2 is the one with ASPOC OFF, "t2" refers to a Maxwellian fit with two terms, "none" means that no correction of the potential for electric field effects has been performed (alternative options would have been "auto" for an automatic correction or "fixd" for a user-specified one).
The file contains a header line and a data line, for example:

```
scon sunc nt E-corr yyyymmdd tsrt tend Vcmin Vcmax Vumin Vumax    ndat nit vcs*E3 terms
mms1 mms2  2 none2d 20150726 0130 0400  4.13  5.09 11.09 47.35     464  13  5.519     0.00  -
1.64  11.24  -3.82
```

scon controlled spacecraft (ASPOC ON)
sunc uncontrolled spacecraft (ASPOC OFF)
nt number of terms in Maxwellian fit
E-corr method of electric field effect correction
2d spin plane components of the electric field would have been used for a correction
tstrt start time
tend end time
Vcmin minimum controlled potential
Vcmax maximum controlled potential
Vumin minimum uncontrolled potential
Vumax maximum uncontrolled potential
ndat number of data points
nit number of iterations in the fit
vcs*E3 standard deviation in the fit, multiplied by factor 1000
terms parameters of the fit (j0, V0, j1, V1, ...)

If the user checks the button "Naka" and/or "Naka-fit" in the panel "Genral plot settings" under the section "I-V FIT RESULTS", the program applies the photo-electron spectrum derived by Nakagawa [11] for a best fit based on controlled and uncontrolled potentials, and generates a text file in the output directory with a file name starting with "naka_mms<N1>_mms<N2>", followed by acronyms according to the electric field correction method, date and time.
An example for a file name is naka_mms1_mms2_enone2d_20150726_0130_0400.txt.
In this example, mms1 is the spacecraft with ASPOC ON, mms2 is the one with ASPOC OFF, "enone" means that no correction of the potential for electric field effects has been performed (alternative options would have been "eauto" for an automatic correction or "efixd" for a user-specified one). A user-specified correction can be set up in the main control panel in the line VSC under "Correct for Et" "Manual" and with values specified in the same line.
The file contains a header line and a data line, for example:

```
scon sunc E-corr yyyymmdd tsrt tend Vcmin Vcmax Vumin Vumax    ndat stddev Nakarea
mms1 mms2 none2d 20150726 0130 0400  3.60  4.47 11.09 47.35     464  0.096   1.604
```

scon controlled spacecraft (ASPOC ON)
sunc uncontrolled spacecraft (ASPOC OFF)
E-corr method of electric field effect correction
2d spin plane components of the electric field would have been used for a correction
yyyymmdd date
tstrt start time
tend end time
Vcmin minimum controlled potential
Vcmax maximum controlled potential
Vumin minimum uncontrolled potential
Vumax maximum uncontrolled potential
ndat number of data points
stddev standard deviation in the fit

Nakarea sunlit spacecraft area for which the Nakagawa photo-electron spectrum fits best to the data (this parameter only appears if "Naka-fit" has been checked.

6.3.2 Fitting spacecraft potential and plasma data

If the setting is "Ie" in the panel "Settings for density, current and potential recontruction" in the section "RECONSTRUCTION" the program calculates a best fit for the photo-electron spectrum based on spacecraft potential and plasma data, and generates a text file in the output directory with a file name starting with "rmse_mms<N1>", followed by acronyms according to the fitting method, date and time.
An example for a file name is rmse_mms1_s1tp_none2d_20150716_0130_0530.txt.
In this example, mms1 is the spacecraft with ASPOC and FPI data, "s1" means that a single spacecraft has been used for the potential data, "tp" refers to a power law fit, "none" means that no correction of the potential for electric field effects has been performed. Alternative options would have been "auto" for an automatic correction or "fixd" for a user-specified one.
The file contains a header line and a data line, for example:

```
scon sunc sdes nt E-corr yyyymmdd tsrt tend Vcmin Vcmax Vumin Vumax Iemin  Iemax    ndat nit
chisqu terms
---- mms1 mms1  p none2d 20150716 0130 0530 ----- -----  3.66  4.37  0.03   2.70     708   1
0.090     5.92  -0.35
```

scon controlled spacecraft (ASPOC ON)
sunc uncontrolled spacecraft (ASPOC OFF)
sdes spacecraft with plasma data from the DES sensor
nt number of terms in Maxwellian fit
E-corr method of electric field effect correction
2d spin plane components of the electric field would have been used for a correction
tstrt start time
tend end time
Vcmin minimum controlled potential
Vcmax maximum controlled potential
Vumin minimum uncontrolled potential
Vumax maximum uncontrolled potential
Iemin minimum electron current to the spacecraft
Iemax maximum electron current to the spacecraft
ndat number of data points
nit number of iterations in the fit
chisq Chi^2 in the fit
terms parameters of the fit (j0, V0)

6.4 ASPOC current and spacecraft potential

If the EDP input data contain periods with multiple ASPOC currents, the program calculates a Maxwellian fit with one term between the spacecraft potential and the (log) ASPOC current, and generates a text file in the output directory with a file with the nomenclature "asp_<date>_<starttime>_<endtime>_mms<N1>_mms<N2>.txt".
An example for a file name is asp_20150715_223000_230000_mms3_xxxx.txt.
In this example, mms3 is the spacecraft with ASPOC and EDP data, and "xxxx" means that no second spacecraft without ASPOC ON has been selected.
The file contains a header line and a data line, for example:

```
yyyymmdd tstart   tend scon sunc   Vunc  Vc10  Vc20  Vc30  Vc40  Vc50  Vc60  Vc70  Vc80   I60
I70   I80   a0mx19 -bmx19 r2mx19   a0mx29 -bmx29 r2mx29   a0powl -bpowl r2powl
20150715 223000 230000 mms3 xxxx  -----  7.79  4.53  3.76  3.16  3.22  2.41  2.46  2.68 59.58
68.43 78.02   200.99  1.963  0.964   216.16  1.875  0.901   231.83  0.643  0.971
```

yyyymmdd data

tstart start time
tend end time
scon controlled spacecraft (ASPOC ON)
sunc uncontrolled spacecraft (ASPOC OFF)
Vunc uncontrolled potential
Vc10 controlled potential with 10 µA ASPOC current
Vc20 controlled potential with 20 µA ASPOC current
Vc30 controlled potential with 30 µA ASPOC current
Vc40 controlled potential with 40 µA ASPOC current
Vc50 controlled potential with 50 µA ASPOC current
Vc60 controlled potential with 60 µA ASPOC current
Vc70 controlled potential with 70 µA ASPOC current
Vc80 controlled potential with 80 µA ASPOC current
I60 actual ASPOC ion beam current with 60 µA nominal total current
I70 actual ASPOC ion beam current with 70 µA nominal total current
I80 actual ASPOC ion beam current with 80 µA nominal total current
a0mx19 Parameter a0 for the Maxwellian fit between data with ASPOC current >19 µA
bmx19 Parameter b for the Maxwellian fit between data with ASPOC current >19 µA
r2mx19 squared correlation coefficient of the fit for ASPOC current >19 µA
a0mx29 Parameter a0 for the Maxwellian fit between data with ASPOC current >29 µA
bmx29 Parameter b for the Maxwellian fit between data with ASPOC current >29 µA
r2mx29 squared correlation coefficient of the fit for ASPOC current >29 µA
a0powl Parameter a0 for the power law fit between data with ASPOC current >9 µA
bpowl Parameter b for the power law fit between data with ASPOC current >9 µA
r2powl squared correlation coefficient of the fit for ASPOC current >9 µA

6.5 Spin tone

The user may specify to perform a spin tone correction of the spacecraft potential in some data interval and use the parameters to correct the tone in a different time interval. The spin tone parameters can be saved on disk by selecting in the "Spin-av Vsc from" section of the control panel "Selection of spacecraft potential source, ...", in the drop list entitled "Vsc-tone" the entry "Remove abs" or "Remove rel" and in the last drop list in this line the entry "Save". In this case the program generates a text file in the output directory containing the spin tone coefficients. The file name follows the nomenclature "asp_mms<N>_<date>_<starttime>_<endtime>_vtone.txt".
In order to use this file, the drop list entry "Recall" has to be selected.

7 Program Capabilities Overview

Spin averages of all data can be calculated and plotted. Most of the processing can be applied not only to full resolution data but also to the spin averages.

The total electric field can be determined from all probes or from a subset. Electric field data suffer from offsets and asymmetries between probe pairs. In order to obtain better total field data, the software can either rely on calibration done by the EDP team or process the data by removing offsets (calculated, or according to manual input), adjusting the amplitudes and shifting the phase of the orthogonal components.

Running means can be subtracted from s/c potential, individual probe voltages, electric field components, total electric field, and total electric field after spin tone removal. For the potential, either a running mean or a lower envelope of the data can be selected for subtraction.

A correlation between potential and electric field data has been identified. In order to evaluate the details, fits between these data sets can be calculated (separated into two electric field regimes). The analysis can be restricted to a certain range of spin phase angles. Optionally, the identified dependence of the potential from the electric field can be subtracted from the potential, or manually defined correlation coefficients can be used for this correction.

Spin tone (coefficients of harmonics of the spin frequency) is calculated of spacecraft potential and electric field components, either by applying a constant tone to all data, or by smoothing of spin tone components determined at every spin period. The spin tone can be subtracted from the respective data. The resulting potential is free of variations due to spacecraft geometry. The advantage for electric field data lies in the better determination of the main field direction, if only the spin frequent component is left in the data and higher frequency artefacts are removed. For the electric field, spin tone can be removed either from components or the total field. Spin tones of the potential can be stored for later application to different dates or time intervals, with the option to apply them as is or in proportion to the mean potential.

The program supports the analysis of the optionally pre-processed spacecraft potential for its dependence on plasma density, using methods described in section 4 and others. When data of a controlled and an uncontrolled s/c are available, then both data sets are used to derive a photo-electron spectrum fitting the observations. Plasma data can be included in this analysis if available. The fitting function(s) for the photo-electron spectrum can be selected among a power law, and up to 3 Maxwellian terms. Multiple weight and filter functions are available to improve the convergence of the non-linear fits. The range of potentials and currents used in the fit can be restricted.

Based on the above fits, or on parameters defined manually, plasma density and plasma electron current can be reconstructed from spacecraft potential, or the uncontrolled potential can be reconstructed from the controlled potential. In the case of density reconstruction, the electron temperature can be taken from FPI data or chosen manually.

Spectral analysis (Fast Fourier Transform) can be applied to electric field components, spacecraft potential, and probe voltages. Both global coefficients and dynamic spectra (varying with time) can be calculated.

Bulk velocity components can be calculated from magnetic and electric field data

Induced electric field can be calculated from bulk velocity and magnetic field data

Plasma electron currents are taken from moments data or particle distributions.

Spacecraft orientation (spin phase) can be derived from definitive attitude files, from pattern recognition of spikes in the EDP data which occur due to shadowing when a probe pair is Sun-aligned, or from manual input.

ASPOC currents can be read from data files or from ON/OFF time tables.

Processing can be restricted to times when ASPOC is ON or OFF on either of the EDP data sets, and data around ASPOC current changes can be ignored. Processing can be restricted to times when EDI is passive or active.

Spacecraft potential can be filtered to an upper limit in some plots.

The time interval from which spin tones are calculated can be filtered.

Regarding plots, many scaling and formatting options are available:

- All input and derived variables can be plotted over time, in full time resolution or spin averages if applicable.
- Many variables can be plotted not only over time but also over spin phase.
- Probe voltages can be plotted in absolute values or as differences to the average or a reference probe
- Spin phase plots can be made in rectangular or polar co-ordinates, the latter either in rotating body coordinates or inertial coordinates
- Electric field components can be plotted against each other (X-Y, X-Z, Y-Z)
- Maps of the electric field in body or inertial coordinates, color coded with residual spacecraft potential can be drawn
- Uncontrolled vs. controlled potential, optionally color coded with ASPOC current or total electric field can be produced
- Potential vs. total electric field, optionally color coded with spin phase
- Global and dynamic FFT results
- Reconstructed density, current or potential
- Current vs. potential data and fitting results for all processing options, and with results from literature for comparison (Nakagawa, Cully, Andriopoulou), always optionally color coded with ASPOC current or total electric field.
- For selected plot types, up to 100 plots from subsequent time slots in the same scale can be produced, in order to produce "movies" of temporal evolutions.

Tabulated output is available for input and processed potential and electric field data, as well as for fitting parameters.

8 Interaction Between Programs

8.1 Role of mmsedpana

The program mmsedpana fulfils a dual purpose:

- It can analyse data in all telemetry rates including the reconstruction of densities at the time resolution of the input data. This operating mode is suited for time intervals between seconds and single days. Features of the data at time scales shorter than the spin period can be analysed.
- It can produce output files of spin average data, but without reconstruced densities, to be further processed by other programs. This processing chain is described in this section.

8.2 Producing spin average data

Step 1:
mmsedpana has been used to produce spin average data in Fast Survey mode covering 2 months each, separately for electrons (FPI DES sensor) and ion (FPI DIS sensor) in the unix environment at IWF (leo1). The nomenclature of these files is:
mms*_<date>_0000_0000_edppeev und *edppeiv.txt
The files have a 5-line header as in this example:

```
Input data file =
mms1_edp_scpot_fast_l2
Columns = 11
Time[UT]                Phase12 E12ampl E34ampl Etotamp   ExDSL   EyDSL     Vsc Density
Temp Current ASP-EDI velGSEx velGSEy velGSEz
Time[UT]                  [deg]  [mV/m]  [mV/m]  [mV/m]  [mV/m]  [mV/m]     [V] [cm^-3]
[eV]    [uA]    [uA]  [km/s]  [km/s]  [km/s]
2017-03-01T02:06:10.541  62.774  -1.832   2.272   2.918  -1.832   2.272   2.104    -NaN    -
NaN    -NaN   0.000    -NaN    -NaN    -NaN
```

Step 2:
The files for electrons and ions habe been concatenated to two single files covering the entire time period, using the program mmsedpoutput_concatenate_leo. The nomenclature of these two files is:
mms*_out_fastedppeev.txt and mms*_out_fastedppeiv.txt
The files have a 5-line header as in this example:

```
Dummy Line
Dummy Line
Dummy Line
Time[UT]                Phase12 E12ampl E34ampl Etotamp   ExDSL   EyDSL     Vsc Density
Temp Current ASP-EDI velGSEx velGSEy velGSEz
Time[UT]                  [deg]  [mV/m]  [mV/m]  [mV/m]  [mV/m]  [mV/m]     [V] [cm^-3]
[eV]    [uA]    [uA]  [km/s]  [km/s]  [km/s]
2015-09-01T09:52:06.527  59.617  -0.018  -0.261   0.262  -0.018  -0.261   3.003   0.650
259.67   2.845  19.712   -7.05  -21.41   31.68
```

Step 3:
In the next step, the electron and ion files are combined in pairs to single files using the program mmsedpoutput_merge_vel_ei_leo. The nomenclature of these files is:
mms*_out_fastedppeandiv.txt.
The files have a **2-line** header as in this example:

```
Time[UT]                Phase12 E12ampl E34ampl Etotamp   ExDSL   EyDSL     Vsc El.Dens
El.Temp El.Curr ASP-EDI  veGSEx  veGSEy  veGSEz IonDens IonTemp IonCurr  viGSEx  viGSEy
viGSEz
Time[UT]                  [deg]  [mV/m]  [mV/m]  [mV/m]  [mV/m]  [mV/m]     [V] [cm^-3]
[eV]    [uA]    [uA]  [km/s]  [km/s]  [km/s] [cm^-3]    [eV]    [uA]  [km/s]  [km/s]  [km/s]
2015-09-01T09:52:06.527  59.617  -0.018  -0.261   0.262  -0.018  -0.261   3.003   0.650
259.67   2.845  19.712   -7.05  -21.41   31.68   0.763 5855.32   1.241   -0.67    2.58    8.45
```

The files shall get the extension .dat, copied to a Windows environent, and converted into MS-DOS for further processing.

Data in Slow Survey mode get a similar, but shortened treatment, as they do not contain FPI data.

Step 4:
mmsedpana has been used to produce spin average data in Slow Survey mode covering 4 months each, in the unix environment at IWF (leo1). The nomenclature of these files is: mms*_<date>_0000_0000_edppess. In this configuration, mmsedpana automatically adds NaN values for the missing electron and ion data and directly outputs file in the format of step 3 above.

Step 5:
Concatenation of the 4-month data files into single ones for the entire time period by the program mmsedpoutput_concatenate_leo, similar to step 2 above. The files shall get the extension .dat, copied to a Windows environent, and converted into MS-DOS for further processing. Also the first three dummy header lines must be deleted.

Step 6:
Finally, the Fast Survey and Slow Survey outputs (mms*_out_fastedppeandiv.dat and mms*_out_slowedppeandiv.dat) have been merged in the Windows environment into a single file for each spacecraft, using the program mmsedpoutput_merge_vel_fastslow. The nomenclature of these files is: mms*_out_edppeandivfands.dat.

8.3 Anyalysing spin average data and reconstruction of spin average densities

Three programs working in the Windows environment analyse spin average data, define parameters for the reconstruction of plasma densities, and produce tables of the reconstructed values.

8.3.1 corrVandFlux

- Reads spin average data from a single spacecraft (mms*_out_edppeandiv.dat), orbit data, solar aspect angle data, and solar indices
- Calculates reconstruction parameters for a single magnetospheric region or for all regions together, and outputs files of these parameters. Available regions are: magnetosphere, magnetosheath, solar wind. Parameters are different for ASPOC OFF and ASPOC ON (nominal current). Therefore there are 6 parameter files in total.
- Produces plots with data from a single region or all regions together.
- Plots solar correlations.
- Calculates reconstructed densities.
- Uses a special temperature law for the combination of ASPOC ON, inside magnetosphere.
- Uses correction terms for the spacecraft potential in dependence of electric field, ion velocity, F10.7 cm flux, ion Mach number.
- Outputs parameter files to be used by corrVandFluxPredef.
- Outputs reconstructed density files for a single region and a single ASPOC state in a format compatible with outputs of multiple regions produced by corrVandFluxPredef.

8.3.2 corrVandFluxPredef

- This program serves to use the six parameter files produced by corrVandFlux to produce a single file with reconstructed densities covering all regions.
- Reads spin average data from a single spacecraft (mms*_out_edppeandiv.dat), orbit data, and solar indices
- No filtering of input data except for time
- Results near the region boundaries are interpolated in order to get smooth transitions
- Outputs reconstructed density files for all regions and ASPOC states together in a format compatible with outputs of single regions produced by corrVandFlux.

8.3.3 corrVandFluxRec

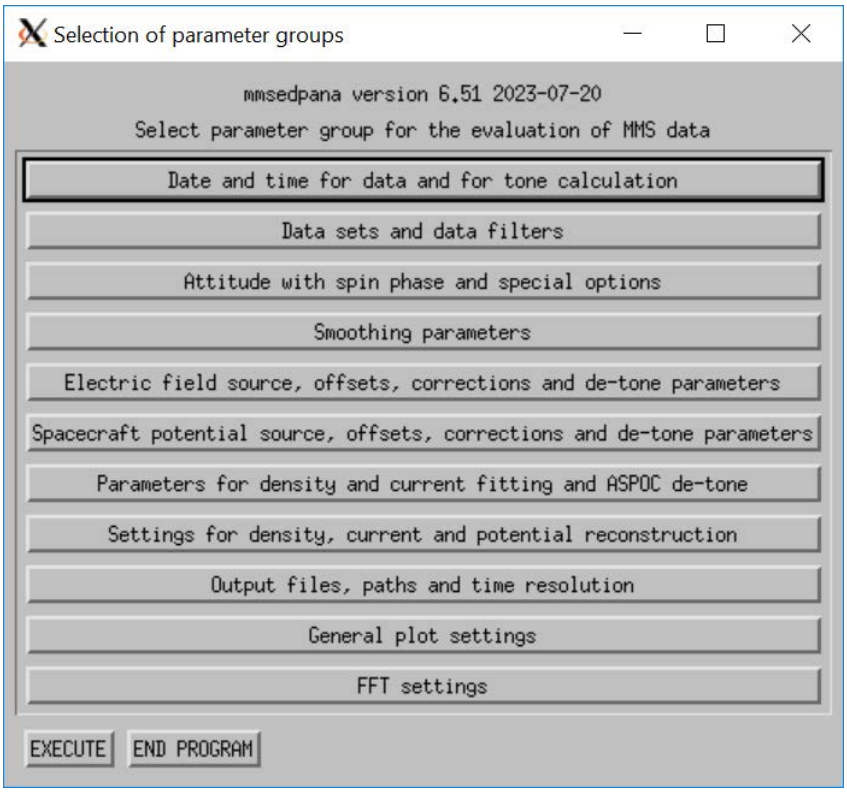
- Reads a reconstructed density file, orbit data, and solar data.
- Plots solar correlations.
- Plots correlations between measured and reconstructed data.

9 Control Panel Items

The program checks for most possible inconsistencies between entries in the control panel windows, for example if the program is asked to use ASPOC data but no ASPOC data file has been specified. However, bad entries into the control panel are not always checked and the program might crash in these cases, for example if letters are entered into a field that requires a number. There is a main control panel which allows the user to select themes, or groups of parameters, to be set in a subpanel.

9.1 Main control panel

There is a main control panel which allows the user to select themes, or groups of parameters, to be set.



9.2 Subpanels

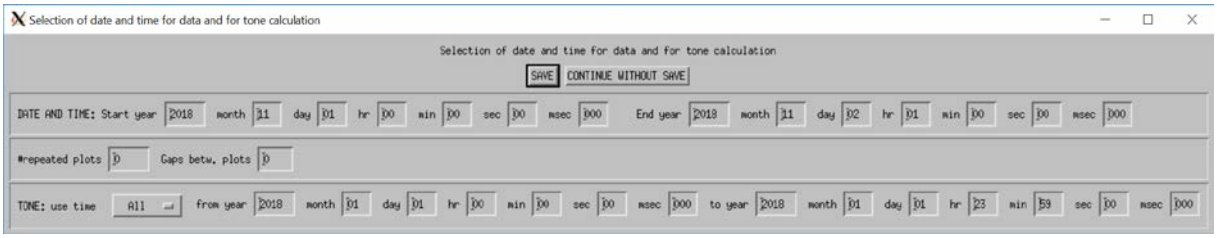
The subpanels are organized according to themes. Possible inputs are numerical values, selections in drop lists, and buttons.

Two buttons are present at the top of each subpanel:

Label: **SAVE**
Description: Saves the entries into the subpanel and returns to the main control panel.

Label: **CONTINUE WITHOUT SAVE**
Description: Returns to the main control panel without saving the changes made in the subpanel.

9.3 Panel "Date and time for data and for tone calculation"



9.3.1 Group "DATE AND TIME"

Type: Number
Label: **Start year**
Variable: startyy
Description: Year of the start of the time interval.

Type: Number
Label: **month**
Variable: startmo
Description: Month of the start of the time interval (1 ... 12).

Type: Number
Label: **day**
Variable: startda
Description: Day of the start of the time interval (1 ... 31).

Type: Number
Label: **hr**
Variable: starth
Description: Hour of the start of the time interval (0 ... 23).

Type: Number
Label: **min**
Variable: startm
Description: Minute of the start of the time interval (0 ... 59).

Type: Number
Label: **sec**
Variable: starts
Description: Second of the start of the time interval (0 ... 59).

Type: Number
Label: **msec**
Variable: startms
Description: Milliseconds of the start of the time interval (0 ... 999).

Type: Number
Label: **End year**
Variable: endyy
Description: Year of the end of the time interval.

Type: Number
Label: **month**
Variable: endmo
Description: Month of the end of the time interval (1 ... 12).

Type: Number
Label: **day**
Variable: endda
Description: Day of the end of the time interval(1 ... 31).

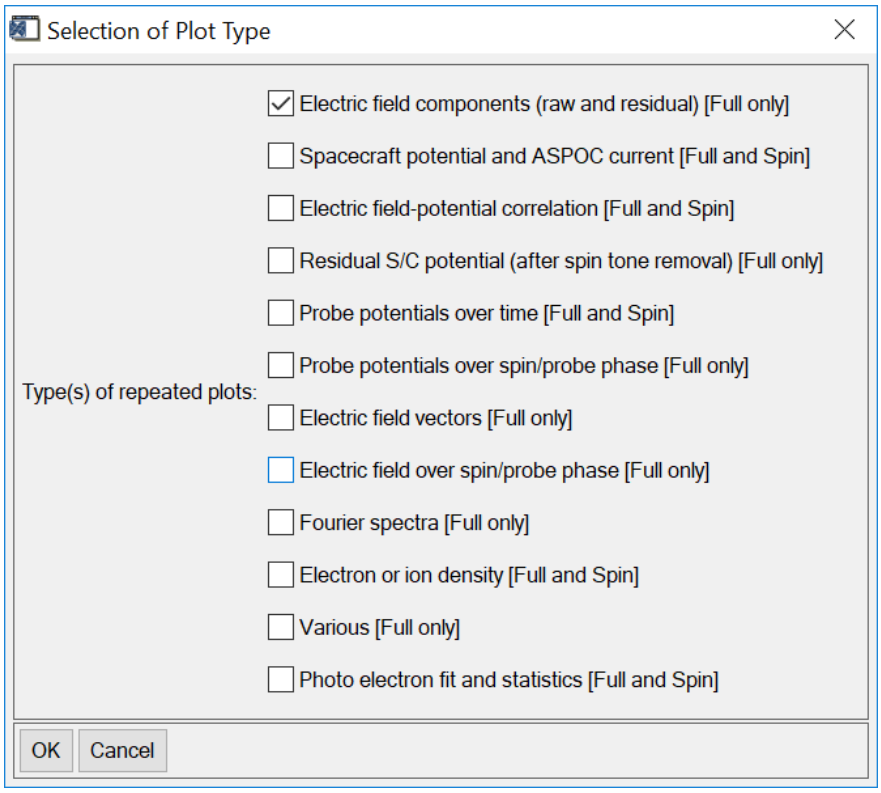
Type: Number
Label: **End hr**
Variable: endh
Description: Hour of the end of the time interval (0 ... 23).

Type: Number
Label: **min**
Variable: endm
Description: Minute of the end of the time interval (0 ... 59).

Type: Number
Label: **sec**
Variable: ends
Description: Second of the end of the time interval (0 ... 59).

Type: Number
Label: **msec**
Variable: endms
Description: Milliseconds of the end of the time interval (0 ... 999).

Type: Number
Label: **#repeated plots**
Variable: nrepeat
Description: If set >0, a series of plots of the same parameters but for different time intervals will be created. The time interval of the first plot is given by the start and end times set at the left. The following selection window will be displayed after also all other settings have been done and the "Execute" button has been pressed:



Type: Number
Label: **Gaps betw. plots**
Variable: gapsize
Description: If set >0, there will be gaps in time between the individual plots of the series. For example, a gap of 1 will introduce a time gap of the size of one plot.

9.3.2 Group "TONE"

Type: Drop list
Label: **use time**
Variable: tonewindow
Description: Spin tones may be calculated by averaging over the entire time interval selected at the very left of this line, or from a limited time interval. The application of the spin tone is always throughout the full time interval.
Selection:

All	The entire time interval is used to calculate the spin tone.
Inside	The time inside the limits defined at the right is used to calculate the spin tone.
Outside	The time outside the limits defined at the right (i.e., before and after) is used to calculate the spin tone.

Type: Number
Label: **from year**
Variable: tonestartyy
Description: Year of the start of the time interval (2015 ... 202X).

Type: Number
Label: **month**
Variable: tonestartmo
Description: Month of the start of the time interval (1 ... 12).

Type: Number
Label: **day**
Variable: tonestartda
Description: Day of the start of the time interval (1 ... 31).

Type: Number
Label: **hr**
Variable: tonestarth
Description: Hour of the start of the time interval (0 ... 23).

Type: Number
Label: **min**
Variable: tonestartm
Description: Minute of the start of the time interval (0 ... 59).

Type: Number
Label: **sec**
Variable: tonestarts
Description: Second of the start of the time interval (0 ... 59).

Type: Number
Label: **msec**
Variable: tonestartms
Description: Milliseconds of the start of the time interval (0 ... 999).

Type: Number
Label: **to year**
Variable: toneendyy
Description: Year of the end of the time interval (2015 ... 202X).

Type: Number
Label: **month**
Variable: toneendmo
Description: Month of the end of the time interval (1 ... 12).

Type: Number
Label: **day**
Variable: toneendda
Description: Day of the end of the time interval (1 ... 31).

Type: Number
Label: **hr**
Variable: toneendh
Description: Hour of the end of the time interval (0 ... 23).

Type: Number
Label: **min**
Variable: toneendm
Description: Minute of the end of the time interval (0 ... 59).

Type: Number
Label: **sec**
Variable: toneends
Description: Second of the end of the time interval (0 ... 59).

Type: Number
Label: **msec**
Variable: toneendms
Description: Milliseconds of the end of the time interval (0 ... 999).

Recommended maximum time interval for Fast Survey data is 2 months, taking between one half up to a few hours of processing time. Slow Survey data are processed faster, and a maximum time interval of 4 hours is recommended. Time intervals of up to a few days are processed within a few minutes.

9.4 Panel "Data sets and data filters"

Type: Text
Label: **Science data directory root**
Variable: local_data_dir
Description: Root directory of the SPEDAS directory structure. All science data are read from this location. On the system leo1 of IWF, the entry shall read "/nas/mms/spedas/mms/"

Type: Text
Label: **Aux data directory root**
Variable: local_sdc_dir
Description: Root directory of the MMS SDC directory structure. The definitive attitude files are read from this location. On the system leo1 of IWF, the entry shall read "/nas/mms/sdc/". An example for an attitude file of mms1 is: "/nas/mms/sdc/data/ancillary/mms1/defatt/MMS2_DEFATT_2016001_2016002.V00".

9.4.1 Group "DATASETS"

Type: Drop list
Label: **EDP#1**
Variable: withedsl
Description: The program can process two types of EDP data files: 1) spacecraft potential data files and derive the electric field from the individual probe data in these files, 2) electric field data files which contain the despun electric field only. This selection defines whether just one of these file types is used, or both file types in parallel. The latter possibility allows to combine spacecraft potential data with electric field data in the version calibrated by the EDP team. This selection (EDP#1) is valid for the primary spacecraft. The secondary spacecraft (#2) is the one used for comparisons between controlled (#1) and uncontrolled (#2) potentials from different spacecraft.
Selection:
- Single file: Use spacecraft potential data (l2_scpot) OR despun electric field data (l2pre_dce or l2_dce)
- Vsc and E files: Use spacecraft potential data (l2_scpot) AND despun electric field data (l2pre_dce or l2_dce)

Type: Drop list
Label: **EDP#1 data type**
Variable: typeno
Description: Selects the type of spacecraft potential data. Default should be the use of calibrated level 2 data (l2_scpot) for spacecraft potential and probe voltages or calibrated level 2 electric field data (l2_dce) which contain the despun electric field only. For more information see the EDP data products guide [3].
Selection:
- l1b_dcv128: Use uncalibrated data from the commissioning phase (l1b_dcv128)
- l1b_dce: Use uncalibrated electric field data (l1b_dce)
- l2_scpot: Use calibrated spacecraft potential data (l2_scpot)
- l2pre_dce: Use calibrated electric field data (l2pre_dce) in which the Z component is measured by the ADP probe
- l2_dce: Use calibrated electric field data (l2_dce) in which the Z component is partially replaced by inferred data

---

Type: Drop list
Label: **E-DSL data type**
Variable: typenoe
Description: Selects the type of electric field data used in addition to the spacecraft potential file. For more information see the EDP data products guide [3].
Selection:
- l2pre_dce — Use calibrated electric field data (l2pre_dce) in which the Z component is measured by the ADP probe
- l2_dce — Use calibrated electric field data (l2_dce) in which the Z component is partially replaced by inferred data

---

Type: Drop list
Label: **Rate**
Variable: rateno
Description: Selects the data rate of the EDP data (spacecraft potential and electric field).
Selection:
- slow — Slow Survey Mode
- fast — Fast Survey Mode
- brst — Burst Mode
- comm — Modes used during commissioning

Type: Drop list
Label: **Bird**
Variable: birdno
Description: Selects the MMS spacecraft of the EDP data (spacecraft potential and electric field).
Selection:
- MMS1 — MMS1
- MMS2 — MMS2
- MMS3 — MMS3
- MMS4 — MMS4

Type: Drop list
Label: **EDP#2**
Variable: withedp2
Description: Determines whether EDP spacecraft potential data are also taken from a second spacecraft in order to derive plasma parameters from the differences between the potentials. Typically EDP#2 should contain uncontrolled spacecraft potential data within the chosen time interval.
Selection:
- No — Use EDP#1 data only
- Yes — Use both EDP#1 (controlled) and EDP#2 (uncontrolled) data

---

Type: Drop list
Label: EDP#2 data type
Variable: typeno1
Description: Selects the type of spacecraft potential data of the second spacecraft.
Selection:

l1b_dcv128	Use uncalibrated data from the commissioning phase (l1b_dcv128)
l1b_dce	Use uncalibrated electric field data (l1b_dce)
l2_scpot	Use calibrated spacecraft potential data (l2_scpot)
l2pre_dce	Use calibrated electric field data (l2pre_dce) in which the Z component is measured by the ADP probe
l2_dce	Use calibrated electric field data (l2_dce) in which the Z component is partially replaced by inferred data

---

Type: Drop list
Label: Rate
Variable: rateno1
Description: Selects the data rate of the EDP#2 data.
Selection:

slow	Slow Survey Mode
fast	Fast Survey Mode
brst	Burst Mode
comm	Modes used during commissioning

Type: Drop list
Label: Bird
Variable: birdno1
Description: Selects the MMS spacecraft of the EDP#2 data.
Selection:

MMS1	MMS1
MMS2	MMS2
MMS3	MMS3
MMS4	MMS4

Type: Drop list
Label: Add FPI
Variable: withfpi
Description: Defines whether FPI data input is used, and which FPI data type.
Selection:

No	No FPI data file(s) used
Moments	Moments data files are used (*fpi*des-moms* or *fpi*dis-moms*)
Distributions	Distribution data files are used (*fpi*des-dist* or *fpi*dis-dist*)

Type: Drop list
Label: **above eV**
Variable: fpimomsfrom
Description: Determines the energy level in FPI data for partial moments calculations. The selected energy is the lower boundary for the integration of flux over energy. This entry is only valid if partial moments data are selected. Note that the energy levels are default ones. The actual levels in the selected data may differ. This selection is only valid if "Moms" have been set to "Partial".
Selection:
all all energy levels are used
energy value
Selected energy

Type: Drop list
Label: **Sensor**
Variable: unitnop
Description: Selects either electron data from the DES sensor or ion data from the DIS sensor. This selection is only valid if "Moments" or "Distributions" have been selected under "Add FPI".
Selection:
DES DES
DIS DIS

Type: Drop list
Label: **Moms**
Variable: fpimomsispart
Description: Selects FPI data with either full or partial moments. electron data from the DES sensor or ion data from the DIS sensor. For example, mms1_fpi_fast_l2_dis-moms_20200616000000_v3.3.0.cdf or mms1_fpi_fast_l2_des-partmoms_20170701060000_v3.3.0.cdf.
This selection is only valid if "Moments" or "Distributions" have been selected under "Add FPI".
Selection:
Full Full moments
Part Partial moments

Type: Drop list
Label: **Rate**
Variable: ratenop
Description: Selects the data rate of the FPI data.
Selection:
fast Fast Survey Mode
brst Burst Mode

Type: Drop list
Label: **Bird**
Variable: birdnop
Description: Selects the MMS spacecraft of the FPI data. Whereas EDP and ASPOC data must come from the same spacecraft, the spacecraft of FPI data may be different from the one with EDP data. In this case a warning message will be displayed.
Selection:
- MMS1 MMS1
- MMS2 MMS2
- MMS3 MMS3
- MMS4 MMS4

Type: Drop list
Label: **Interpolate**
Variable: interpolatefpi
Description: Defines the method to match the time series of EDP and FPI data
Selection:
- No Do not interpolate FPI data, but maintain the time resolution of FPI data. FPI data points are given the nearest time stamp of EDP data.
- Yes FPI data are interpolated to the time steps of EDP, which often have a better time resolution

---

Type: Drop list
Label: **Te**
Variable: domanualfullte
Description: The user may choose to override the measured particle temperature by a fixed value entered to the right, which will be used for the calculation of the plasma current.
Selection:
- Measured Use measurements from the FPI input data
- Fixed Value: use a fixed value specified at the right

Type: Number
Label: **<none>**
Variable: manualfullte
Description: Value of a fixed temperature used for the calculation of the plasma current.

Type: Drop list
Label: **Flags**
Variable: usefpiflags
Description: Defines the use of FPI flags, which are 14-bit variable as listed below. One can choose to ignore them, to show them in selected plots, or to show them and filter FPI data accordingly.
Caveat: Flags cannot be processed together with FPI dstributions
The selection of flags can be made in the panel "General plot settings".

FPI flags are:

0	Manually
1	Saturation is present
2	Reported Vsc>20V
3	Invalid Vsc
4	>10% cold plasma
5	>25% hot plasma
6	High sonic Mach number
7	Low calculated density (DES:0.05/cc, DIS: 0.0/cc)
8	Onboard bentpipe magnetometer data used instead of srvy l2pre
9	L2pre Mag
10	No internal photoelectron correction applied
11	Compression error
12	Spintone calculation error (DBCS only)
13	Significant penetrating radiation (>20%)

Selection:
Ignore
Show
Show&Filter

Type: Number
Label: **#Dist**
Variable: ndist
Description: Defines the number of distributions that are plotted over a time interval in plots of particle spectra. If set to zero, only the total distribution is plotted.

Type: Drop list
Label: **FGM**
Variable: withfgm
Description: Defines whether magnetic field data files from FGM are used. The data rate is always Slow Survey
Selection:
No
Yes

Type: Drop list
Label: **Bird**
Variable: birdnof
Description: Selects the MMS spacecraft of the FGM data. Whereas EDP and ASPOC data must come from the same spacecraft, the spacecraft of FGM data may be different from the one with EDP data. In this case a warning message will be displayed.
Selection:
- MMS1 MMS1
- MMS2 MMS2
- MMS3 MMS3
- MMS4 MMS4

9.4.2 Group "ASP"

Type: Drop list
Label: **ASP**
Variable: withasp
Description: Defines whether an ASPOC ion beam current data file is used. If no file is available, the program offers the options to use a constant beam current throughout, or a constant value of the beam current only during the ASPOC operating times. These other options can be selected under the label "Iaspoc in Ie-fit" in the panel "Selection of parameters for density and current fitting and ASPOC de-tone".
Selection:
- No
- Yes

Type: Drop list
Label: **Bird**
Variable: birdnoa
Description: Selects the MMS spacecraft of the ASPOC data. Normally, ASPOC data should come from the same spacecraft as the EDP data. However, a different spacecraft can be selected here. In this case a warning message will be displayed.
Selection:
- MMS1 MMS1
- MMS2 MMS2
- MMS3 MMS3
- MMS4 MMS4

Type: Drop list
Label: **ASP filter on SC1**
Variable: aspocafilter
Description: Defines whether data processing shall be performed for all data or be restricted to times when ASPOC on the first spacecraft is OFF or ON. These times are given in the ASPOC operational data files.
Selection:
- Any no filtering
- OFF
- ON

Type: Drop list
Label: **SC2**
Variable: aspocbfilter
Description: Defines whether data processing shall be performed for all data or be restricted to times when ASPOC on the second spacecraft (EDP#2) is OFF or ON. These times are given in the ASPOC operational data files.
Selection:
- Any — no filtering
- OFF
- ON

Type: Drop list
Label: **EDI**
Variable: withedi
Description: Defines EDI beam current data are added to the current balance. The EDI beam current data are not taken from the SPEDAS directories but from files in the subdirectory EDI_Current of the opstables directory.
Selection:
- No
- Yes

Type: Drop list
Label: **EDI filter**
Variable: edifilter
Description: Defines whether data processing shall be performed for all data or be restricted to times when EDI on the first spacecraft is OFF or ON. These times are given in the EDI operational data files.
Selection:
- Any — no filtering
- OFF
- ON

Type: Drop list
Label: **Ask**
Variable: dontask
Description: Defines the handling of progress or error messages of the program in the form of a dialogue window which require input by the user.
Selection:
- Always — All progress and error messages are displayed
- Only at end — Only the dialogue window at the end of the processing is displayed.
- Never — No user inputs required. This option is the preferred one for batch processing.

9.4.3 Group "CONTENT FILTERS"

Type: Number
Label: **Filter ASP steps>(uA)**
Variable: aspfiltercurr
Description: The ASPOC current is occasionally stepped up in 10 µA intervals for short periods in order to investigate the current-voltage characteristic. These operations last for less than three minutes. The program attempts an automated evaluation. It averages the potentials and currents, respectively, during each step. If a value other than zero is entered here, it defines the tolerance window for the current around the current steps. Zero tolerance means that all data are used. If the value is not zero, then data used in the calculation must obey |actual_current - nominal_current| < tolerance. Nominal current steps are 10, 20, 30, 40, 50, 59.5, 68.5, and 78.0 µA.

Type: Number
Label: **before(s)**
Variable: aspfiltertbef
Description: Data may be filtered out for the time (in seconds) before ASPOC current steps, for example to obtain a clean correlation with density data.

Type: Number
Label: **after(s)**
Variable: aspfiltertaft
Description: Data may be filtered out for the time (in seconds) after ASPOC current steps, for example to obtain a clean correlation with density data.

Type: Number
Label: **Step level factor**
Variable: asplevelsfact
Description: This variable is useful for the analysis of ASPOC current sweeps. In these sweeps, the typical currents have been set to [0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 59.5, 68.5, 78.0]. The variable can be used to multiply these values if necessary, for example when only a single emitter is operational. The default value is 1.0.

Type: Number
Label: **and tolerance factor**
Variable: aspleveltolfact
Description: This variable is useful for the analysis of ASPOC current sweeps. In these sweeps, tolerances around the typical currents have been set to [1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 2.0, 2.5]. The variable can be used to multiply these values if necessary, for example when emitters produce less than the nominal ion current. The default value is 1.0.

Type: Number
Label: **Density>**
Variable: densfiltermin
Description: Minimum particle density in FPI data used for filtering input data.

Type: Number
Label: **<**
Variable: densfiltermax
Description: Maximum particle density in FPI data used for filtering input data.

Type: Number
Label: **Vsc>**
Variable: vscfilterhmin
Description: Minimum spacecraft potential used for filtering input data.

Type: Number
Label: **>**
Variable: vscfilterhmax
Description: Maximum spacecraft potential used for filtering input data.

Type: Drop list
Label: **Ez**
Variable: eelevfilterswitch
Description: Allows to filter data for the elevation angle of the electric field. If enabled, the threshold can be set in the following field. The nominal value is 89.9.
Selection:
- All — Filtering for the elevation angle of the electric field is disabled
- Below — Electric field data below the given magnitude of the elevation angle are selected
- Above — Electric field data above the given magnitude of the elevation angle are selected

---

Type: Number
Label: **deg(+/-)**
Variable: eelevfilterthresh
Description: Threshold magnitude of the electric field angle. The nominal value is 89.9.

9.4.4 Group "SPINAV FILTERS"

Type: Number
Label: **Iaspoc>**
Variable: aspfilterimin
Description: Minimum ASPOC current used for filtering input data for spin average data processing.

Type: Number
Label: **<**
Variable: aspfilterimax
Description: Maximum ASPOC current used for filtering input data for spin average data processing.

Type: Number
Label: **Vsc>**
Variable: vscfiltermin

Description: Minimum spacecraft potential used for filtering input data for spin average data processing.

Type: Number
Label: **<**
Variable: vscfiltermax
Description: Maximum spacecraft potential used for filtering input data for spin average data processing.

Type: Number
Label: **Et>**
Variable: etfiltermin
Description: Minimum total electric field when processing spin-averaged data.

Type: Number
Label: **<**
Variable: etfiltermax
Description: Maximum total electric field when processing spin-averaged data.

Type: Number
Label: **Density>**
Variable: densfilteramin
Description: Minimum FPI particle density when processing spin-averaged data.

Type: Number
Label: **Density>**
Variable: densfilteramax
Description: Maximum FPI particle density when processing spin-averaged data.

9.4.5 Group "iV FILTERS"

Type: Drop list
Label: **Te(spin)**
Variable: domanualspinte
Description: Sets whether a constant temprature given at the right is used for determining the spin average plasma current from density.
Selection:
Measured Data measured by FPI are used
Fixed value:
The temperature given at the right is used

Type: Number
Label:
Variable: manualspinte
Description: Constant temprature for determining the spin average plasma current from density.

Type: Number
Label: **nHampel(iV)**
Variable: nivscHampel
Description: Threshold in standard deviations sigma for the Hampel filtering used in fitting the current-voltage relation.

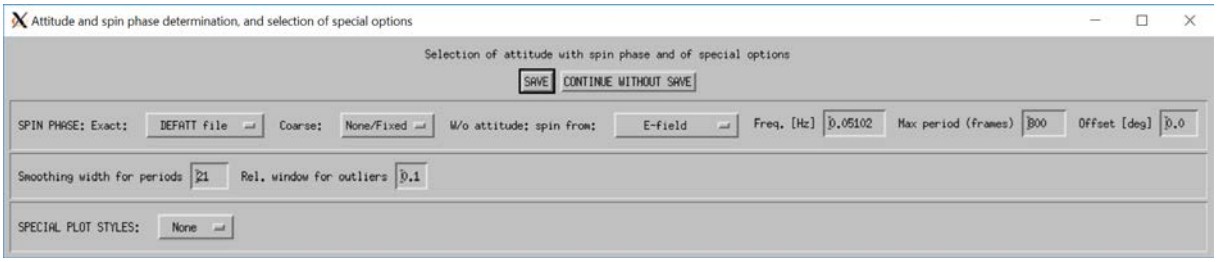
Type: Number
Label: **Upper % used**
Variable: upperfract
Description: Only this given upper percentage of data in the current-voltage relation is used for the fitting. Background for this variable is the observation of many outliers towards low density, probably due to an incorrect setting of the photoelectron cutoff at low energy.

Type: Drop list
Label: **Show**
Variable: upperfracshow
Description: Defines whether the selected upper fraction of data is highlighted in the current-voltage plot.
Selection:
Yes The part of data selected as upper fraction is highlighted in the plot.
No The part of data selected as upper fraction is not highlighted in the plot.

Type: Drop list
Label: **Clean gaps**
Variable: cleangap
Description: Defines whether spin average data with trailing data gaps longer than 60 seconds shall be processed.
Selection:
Yes Filter is turned on
No Filter is turned off

Type: Drop list
Label: **Time**
Variable: dotimefilter
Description: This setting is only valid if pre-processed spin average data are used as input. In this case the selection defines whether a time interval different fro mthe interval of the pre-processed data shall be used. The new time interval can be set in a subsequent window.
Selection:
Yes A different time interval is requested
No The time interval of the input file is used

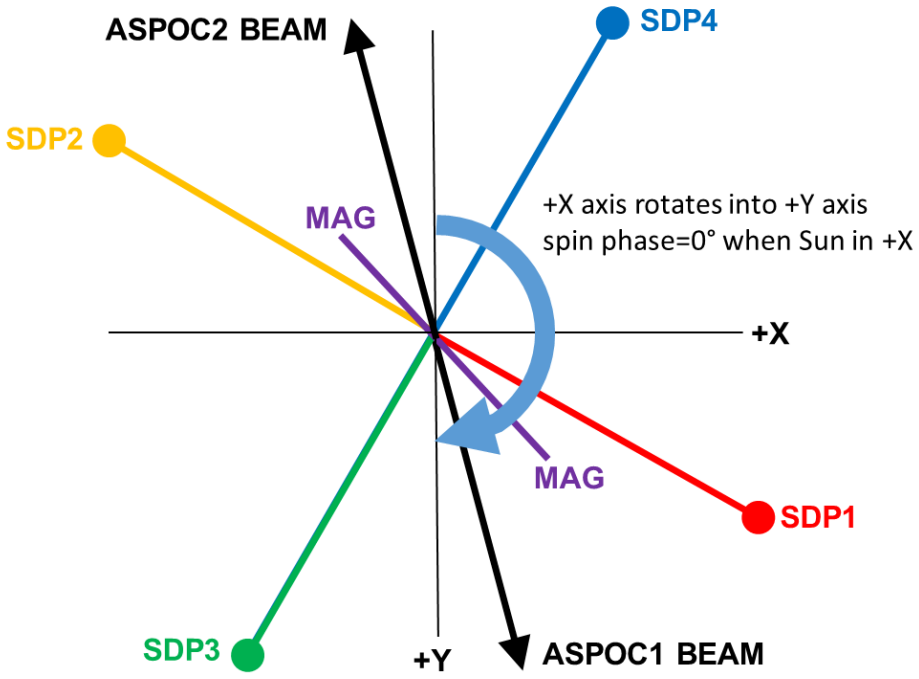
9.5 Panel "Attitude with spin phase and special options"



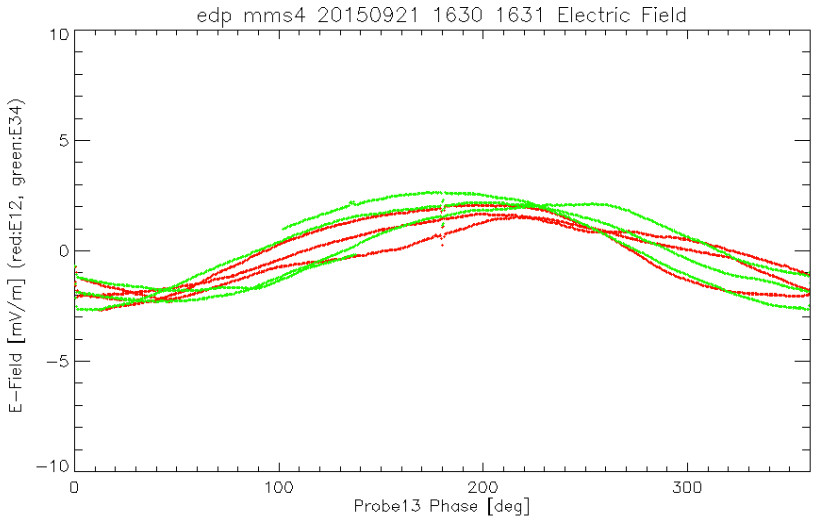
This panel is only relevant for special purposes related to the spin phase determination. Normally, the definitive attitude (DEFATT) files shall be used

9.5.1 Group "SPIN PHASE"

Type: Drop list
Label: **Exact**
Variable: spiketry
Description: This entry defines the method to obtain the spin phase of the data. The definition is illustrated below. The position shown in the plot corresponds to spin phase zero, if the Sun is assumed be in +X. The spacecraft rotates in clockwise direction. For example, the probe SDP4 will point towards the Sun at spin phase 60°.



If a probe pair is sun-aligned, the shading of the booms can lead to a short spike in the measured voltages and the electric field derived from the voltages as shown in the plot below at 180°. (The plot is in "Probe13 Phase" which is the spin phase rotated individually for each field component such that the respective probe pairs are sun-aligned at phase zero.)



These spikes can be used to identify the spin phase if no attitude file is available.

Selection:

No — No attempt is made to obtain the exact spin phase

E-field spikes — The program tries to identify the spin phase based on the spikes mentioned above. As these spikes will not always be present, this method may fail.

DEFATT file — This is the reliable method to obtain the exact spin phase. It requires definitive attitude files (DEFATT or DEFATS).

Type: Drop list
Label: Coarse:
Variable: periodsearch
Description: This selection is only relevant if "Exact" has been set to No.
Selection:

None/Fixed — Spin periods are set according to the fixed spin frequency entered at the right.

E-data — Spin phase is determined from the first electric field component (X or probes 12). Spin phase zero is defined where these data increase and cross the average value.

Type: Drop list
Label: W/o attitude: spin from:
Variable: autospin
Description: This selection is only relevant if "Exact" has been set to No AND "Coarse:" has been set to No.; THEN correct the spin period based on the frequency of zero crossings of the lag data
Selection:

Values at right — Spin periods are set according to the fixed spin frequency entered at the right.

E-field — Correct the spin period based on the frequency of zero crossings of the lag between spin start times identified from electric field data and times calculated from the fixed spin period.

Type: Number
Label: **Freq. [Hz]**
Variable: spinfreq
Description: This is the spin frequency used to determine the spin phase in the fixed frequency option.

Type: Number
Label: **Max period (frames)**
Variable: maxlag
Description: If the spin period or spin phase are derived from the EDP data the program tries to determine the parameters within a number of data points. This number at the same time defines the maximum possible spin period and spin phase (measured in data points). The number entered here defines this maximum.

Type: Number
Label: **Offset [deg]**
Variable: spinphaseoffset
Description: This entry adds a constant value (in degrees) to the calculated spin phase.

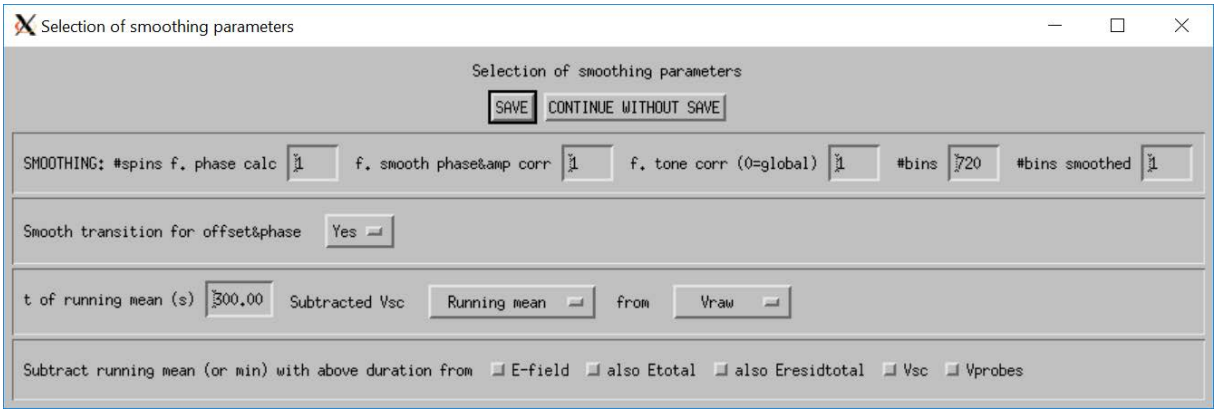
Type: Number
Label: **Smoothing width for periods**
Variable: spinsmooth
Description: If the spin period is derived from the EDP data, this value defines a smoothing interval for the identified individual periods.

Type: Number
Label: **Rel. window for outliers**
Variable: relspinwindow
Description: If the spin period is derived from the EDP data, there are often outliers which the program tries to eliminate by interpolation. This value provides a criterion for outliers (measured in fractions of a spin period).

9.5.2 Group "SPECIAL PLOT STYLES"

Type: Drop list
Label: **Special Plot Styles**
Variable: dospecial
Description: If activated, the style (mainly labels) of one plot is changed according to some publishing requests. Leave this setting at "None".
Selection:
- None — All plots come in normal style.
- Fabrice — The labes of a probe phase plot are modified.

9.6 Panel "Smoothing parameters"



9.6.1 Group "SMOOTHING"

Type: Number
Label: **#spins f. phase calc.**
Variable: fitsize
Description: Enter here the number of spin periods over which individual spin period related parameters are calculated.

Type: Number
Label: **f. smooth phase&amp corr**
Variable: phasesmooth
Description: Defines the width of a smoothing window (in spin periods) for spin period related parameters, for example for some of the correction functions with electric field.

Type: Number
Label: **f. tone corr (0=global)**
Variable: tonesmooth
Description: Defines the width of a smoothing window (in spin periods) for spin tone parameters of spacecraft potential or electric field. If a non-zero value is provided then a smooth transition between subsequent periods (see "Smooth transition for tone" is performed in addition. If the value is zero then a single set of parameters will be calculated covering the complete time interval. A value other than zero cannot be used together with the save and recall option of spin tone parameters.

Type: Number
Label: **#bins**
Variable: histone_bins
Description: This variable is used in the calculation of spin tones of spacecraft potential and probe potentials by bins of mean values over the spin period. It defines the number of bins per spin period.

Type: Number
Label: **#bins smoothed**
Variable: naver
Description: This variable is used in the calculation of spin tones of spacecraft potential and probe potentials by bins of mean values over the spin period. It defines the size of the smoothing window for the binned data.

Type: Drop list
Label: **Smooth transition for offset&phase**
Variable: offstrans
Description: If the program has been set to calculate offsets of electric field data and/or spin phase based on the data, these calculations are performed for each spin period, which may lead to discontinuities of the corrected data. This entry allows for a smooth transition of the corrected data between the middle of the first period until the middle of the second one.
Selection:
No — No smoothing of offsets and phase values between spin periods
Yes — Calculate a smooth transition of the corrected data between the middle of the first spin period until the middle of the second one

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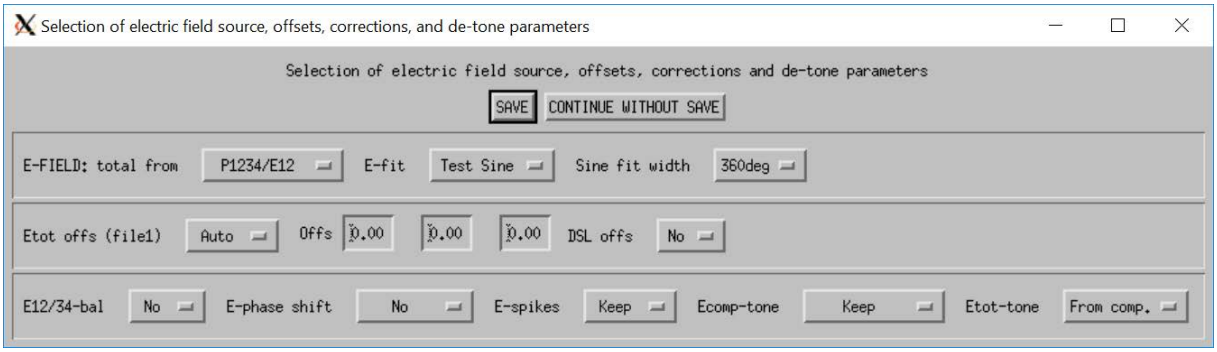
Type: Number
Label: **t of running mean (s)**
Variable: highpassseconds
Description: This number defines the width of the smoothing interval in seconds for the high pass filter of selected parameters. The parameter selection can be done in the buttons in the line below ("Subtract running mean (or min) with above duration from"). The resulting smooth values will be subtracted from the data.

Type: Drop list
Label: **Subtracted Vsc**
Variable: highpassmin
Description: Defines the type of the smoothed data (the reference) used in the high pass filter of the spacecraft potential.
Selection:
Running mean
A running mean of the data over the duration specified elsewhere is used.
Lower envelope
The lower envelope of the data during the period specified elsewhere is used. It is calculated in the following way. 1) a running mean to smooth out very short term fluctuations is calculated (typically a small fraction of the spin period, e.g. 1 second; 2) First (y') and second (y'') derivatives are calculated, and minima of the running mean are identified as zeroes in y' when y'' is positive; 3) The minima are interpolated by a function which is constant (y'=0) at the minima, e.g. a cosine function; 4) This function is subtracted from the data.
Lower env.+test
Same as above, but the subtracted function is stored for later display (for checking)

Type: Drop list
Label: **from**
Variable: highpassofres
Description: Defines on which stage of the spacecraft potential data the high pass is applied.
Selection:
Vraw Original data
Vresidual "Residual" data, i.e. data already processed by the program (electric field correction, offset calculation, etc.)

Type: Button
Label: **Subtract running mean (or min) with above duration from**
Variable: highpassselect
Description: These buttons define the parameters from which a running mean is subtracted, i.e. to which a high pass filter is applied.
Selection:
E-field Electric field components
also Etotal
Total electric field in addition to electric field components
also Eresidtotal
Total electric field after various corrections in addition to electric field components
Vsc Spacecraft potential
Vprobes Individual probe voltages

9.7 Panel "Electric field source, offsets, corrections and de-tone parameters"



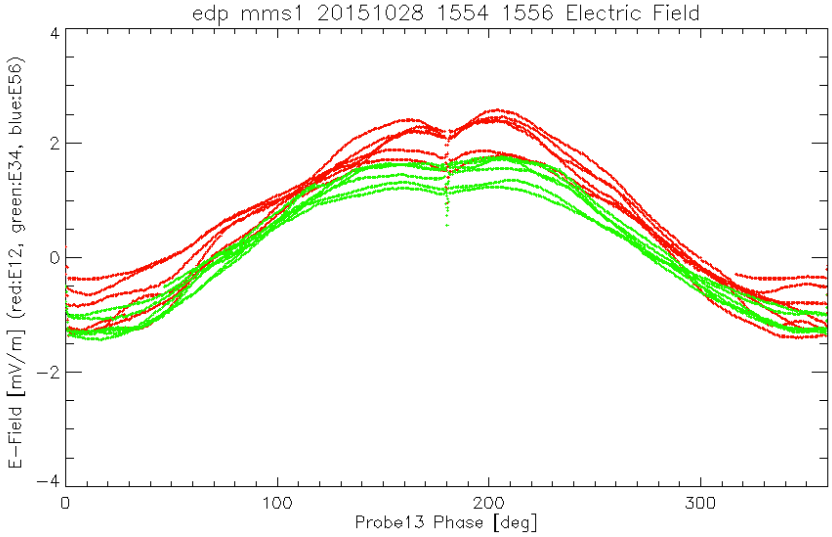
9.7.1 Group "E-FIELD"

Type: Drop list
Label: total from
Variable: etotsource
Description: Defines the electric field components used to calculate the total electric field. The offsets of the components (as specified elsewhere) are subtracted before the total field is calculated.
Selection:

P1234	Probes 1 through 4 (all probes in the spin plane), i.e. $\sqrt{E_{12}^2 + E_{34}^2}$
P123456	Probes 1 through 6 (all probes, spin plane and axial probes), i.e. $\sqrt{E_{12}^2 + E_{34}^2 + E_{56}^2}$
P12	Only probe pair 1-2, i.e. $\lvert E_{12} \rvert$
P34	Only probe pair 3-4, i.e. $\lvert E_{34} \rvert$
P56	Only probe pair 5-6 (these are the axial probes), i.e. $\lvert E_{56} \rvert$
E12+E34	Magnitude of the sum of the spin plane components, i.e. $\lvert E_{12} + E_{34} \rvert$

Type: Drop list
Label: E-fit
Variable: doharmonics
Description: Defines the shape of the function fitted to the electric field data to obtain the spin phase harmonic coefficient
Selection:

Test Sine	Sine wave (zero order harmonics), for test purposes
Harmonics	Harmonics of order 0 to 11 are calculated
Sine+Gauss	Starting from a sine function from data outside ±90° of antisunward direction, i.e. within 60° and 240° spin phase, a Gaussian function is added to the sine function. This tries to cope with a characteristic shape of the electric field data which sometimes show a secondary minimum centered around the maximum of the nominal sine function, see example below.



Type: Drop list
Label: Sine fit width
Variable: do180
Description: This entry is only valid if "Sine+Gauss" has been selected for the shape of the function fitted to the electric field data to obtain the spin phase harmonic coefficient. The value defines the range of data used to determine the sine function before the Gaussian is added.
Selection:
360deg Use all data
180deg Only use data of half of the spin period, outside the range 60° to 240°.

Type: Drop list
Label: Etot offs (file1)
Variable: dooffsetetotal
Description: Defines the method to calculate electric field offsets of the EDP data on the first spacecraft. These offsets are subtracted from the data before the total field is calculated.
Selection:
No No offset correction
Auto Offset is calculated from sine fits to the data
Fix Fixed offsets are applied:
[E12,E34,E56]
[0.63, -0.49, 0.00] for mms1
[0.30, -0.07, 0.60] for mms2
[-1.40, 1.58, -1.85] for mms3
[-0.80, 0.54, -1.30] for mms4
Manual Offsets entered in the control panel under the label "Offs" are used.

Type: Number
Label: Offs
Variable: efieldmanoffset0
Description: Manually defined offset of the electric field component E12

Type: Number
Label:
Variable: efieldmanoffset1
Description: Manually defined offset of the electric field component E34

Type: Number
Label:
Variable: efieldmanoffset2
Description: Manually defined offset of the electric field component E56 (axial)

Type: Drop list
Label: DSL offs
Variable: dodespunoffset
Description: Defines whether DSL-X and DSL-Y offsets tabulated by the EDP team shall be applied to the despun electric field data. These tables can be found in the operations file directory as mms<N>_edp_sdp_dsl_<date>_<version>.txt. This is a poorly tested function: do not use!
Selection:
- No — No offset is subtracted from despun electric field data
- Yes — Use DSL-X and DSL-Y offsets tabulated by the EDP team

---

Type: Drop list
Label: E12/34-bal
Variable: dobalanceetotal
Description: This is the first of five parameters in this line of the control panel to remove anomalies in the electric field data. If activated, this entry adjusts the amplitudes of the two spin plane components of the electric field (E12 and E34) to become identical.
Selection:
- No — Electric field components E12 and E34 remain unchanged
- Auto — Electric field components E12 and E34 are adjusted.

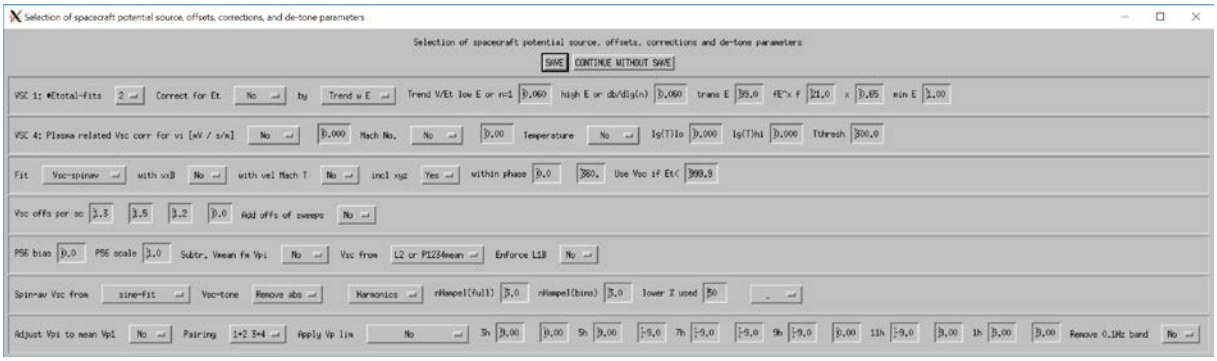
Type: Drop list
Label: E-phase shift
Variable: resphaseadjust
Description: This adjusts the phase shift between the two spin plane components of the electric field (E12 and E34) to become 90 degrees. Three methods are offered.
Selection:
- No — Electric field components E12 and E34 remain unchanged
- Bits — A bitwise cross correlation between the components is performed. Then the component E34 is moved in time such that the best correlation is established for a 90° shift between the two components.
- Sine(old) — A sine fit of each spin plane component is performed, then the components are modified according to the procedure:
  d2 = (90-phase(E12))
  ωtoff = ωt + 180 - phase(E12) + phase(E34)
  E12=(E12+Amplitude(E12)*(sin(ωtoff-d2)-sin(ωtoff)))/(2*cos(d2)-1
  E34=(E34+Amplitude(E34)*(cos(ωtoff+d2)-cos(ωtoff)))/(2*cos(d2)-1)
  Thereby both the amplitude and phase of components is modified
- Sine — A sine fit of the both spin plane components E12 and E34 is performed, then E34 is modified according to the procedure:
  oldfit = Sinamp(E34)*sin(ωt) + Cosamp(E34)*cos(ωt)
  newfit = (Sinamp(E12)*cos(ωt) - Cosamp(E12)*sin(ωt))*Amp(E34)/Amp(E12)
  E34 = E34 - oldfit + newfit
  Thereby only the phase of the component E34 is modified.

Type: Drop list
Label: **E-spikes**
Variable: removespikes
Description: If a probe pair is sun-aligned, the shading of the booms can lead to a short spike in the measured voltages and the electric field derived from the voltages. If set, this parameter removes the electric field data in the time interval from 2° before and 2° after the nominal time of the spike and replaces the measurement by an interpolation between the adjacent data.
Selection:
Keep Electric field data are unchanged.
Remove Remove spikes by interpolation between neighboring data.

Type: Drop list
Label: **Ecomp-tone**
Variable: removeetone
Description: The program calculates the spin tone of the electric field components with orders 0 to 11 (from the spin frequency up to 12 times the spin frequency). This entry defines whether the spin tone is removed from the data.
Selection:
Keep No correction of the spin tone in the electric field data.
Rem. order>1
Keep the spin frequency, but remove all higher components of the spin tone from the data.
Remove all
Remove all components of the spin tone from the data.

Type: Drop list
Label: **Etot-tone**
Variable: removeettone
Description: Defines whether spin tone of the total electric field is calculated through the components or directly from the total field.
Selection:
From comp.
Calculate and correct the spin tone of the total electric field based on the spin tones of the components
Separate Calculate and correct the spin tone of the total electric field based on the spin tone of the total electric field

9.8 Panel "Spacecraft potential source, offsets, corrections and de-tone parameters"



9.8.1 Group "VSC 1"

Type: Drop list
Label: **#Etotal-fits**
Variable: find2evfactors
Description: Defines whether the trend of spacecraft potential with total electric field (or with vxB) is calculated as a single value or in the form of two different values for low and high electric field, whereby both trend lines are constrained to form a continuous function.
Selection:
1 Single trend line
2 Two trend lines

Type: Drop list
Label: **Correct for Et**
Variable: doevfactor
Description: Defines the method to correct the spacecraft potential for the dependence on the total electric field.
Selection:
No No correction is performed
Auto The correction parameters are calculated by the program.
Manual The correction parameters are entered manually.

Type: Drop list
Label: **by**
Variable: evcorrmode
Description: If the spacecraft spacecraft potential is corrected for the dependence on the total electric field, this selection defines whether trend lines defined by the following three entries are used, or an exponential function defined by the next three entries.
Selection:
Trend Correction is performed by trend lines
E^x Correction is performed by an exponential function

Type: Number
Label: **Trend V/Et low E or n=1**
Variable: evfactor1
Description: This value defines the trend correction factor for low electric fields (lower than "trans E").

Type: Number
Label: **high E or db/dlg(n)**
Variable: evfactor2
Description: This value defines the trend correction factor for high electric fields (higher than "trans E").

Type: Number
Label: **trans E**
Variable: evthreshset
Description: This value defines the electric field value separating the two trend lines in case that the correction factors are entered manually.

Type: Number
Label: **fE^x f**
Variable: evfactorx
Description: This value is used in the manual correction of spacecraft and probe potentials as function of total electric field, but only if the exponential function method has been selected and for electric fields larger than "min E". This value is the factor in the exponential function.

Type: Number
Label: **x**
Variable: evfactorexponent
Description: This value is used in the manual correction of spacecraft and probe potentials as function of total electric field, but only if the exponential function method has been selected and for electric fields larger than "min E". This value is the exponent in the exponential function.

Type: Number
Label: **min E**
Variable: evmine
Description: This value is used in the manual correction of spacecraft and probe potentials as function of total electric field, but only if the exponential function method has been selected and for electric fields larger than "min E". This value is the minimum electric field for which the exponential function is applied.

9.8.2 Group "VSC 4"

Type: Drop list
Label: **Plasma related Vsc corr for vi [mV / s/m]**
Variable: dovifactor
Description: Defines whether the spacecraft potential shall be corrected by a trend with total bulk ion velocity.
Selection:
No Correction shall not be applied.
Yes Correction shall be applied using the factor at the right.

Type: Number
Label:
Variable: vifac
Description: Correction factor for the spacecraft potential with bulk total ion velocity in [mV / s/m].

Type: Drop list
Label: **Mach No.**
Variable: dovmachfactor
Description: Defines whether the spacecraft potential shall be corrected by a trend with ion Mach number.
Selection:
No Correction shall not be applied.
Yes Correction shall be applied using the factor at the right.

Type: Number
Label:
Variable: vmachfac
Description: Correction factor for the spacecraft potential with ion Mach number.

Type: Drop list
Label: **Temperature**
Variable: dotempfactor
Description: Defines whether the spacecraft potential shall be corrected by one or two trends with the logarithm of plasma temperature.
Selection:
No Correction shall not be applied.
Yes Correction shall be applied using the factors at the right.

Type: Number
Label: **lg(T)lo**
Variable: tempfaclo
Description: Correction factor for the spacecraft potential with log(temperature) for temperatures below the threshold temperature given at the right.

Type: Number
Label: **lg(T)hi**
Variable: tempfachi
Description: Correction factor for the spacecraft potential with log(temperature) for temperatures above the threshold temperature given at the right.

Type: Number
Label: **Tthresh**
Variable: tempfacthresh
Description: Threshold temperature for the correction of spacecraft potential by two different trends with temperature.

Type: Drop list
Label: **Fit**
Variable: doarrv2res
Description: Defines whether the spin tone fitting of the spacecraft potential is performed on the original value of the potential or the potential minus the spin average value. In time intervals of strongly varying spin average values it is prefereble to subtract this value.
Selection:
Vsc Spin tone calculation is performed on the original potential
Vsc-spinav Spin tone calculation is performed on the potential from which the spin average value has been subtracted-

---

Type: Drop list
Label: **with vxB**
Variable: dovxbcorr
Description: Defines whether a correlation between spacecraft potential and electric field derived from plasma velocity v and magnetic field B (total of vxB vector) is performed in addition to the correlation with the measured electric field.
Selection:
No No correlation with total vxB is performed.
Yes A correlation with total vxB is performed.

Type: Drop list
Label: **with vel Mach T**
Variable: doevelcorr
Description: Defines whether correlations between spacecraft potential and plasma velocity, ion Mach number, and plasma temperature are performed, and plotted together with the data.
Selection:
No No correlations are performed.
Yes Correlations are performed.

Type: Drop list
Label: **incl xyz**
Variable: dovxbcorrcomp
Description: Defines whether a correlation between spacecraft potential and electric field derived from plasma velocity v and magnetic field B (vxB vector) is performed also with the XYZ components of the vxB vector.
Selection:
No No correlation with vxB components is performed.
Yes A correlation with vxB components is performed.

Type: Number
Label: **within phase**
Variable: evphase1
Description: This lower limit of the spin phase in degrees is applied to all correlation calculations with the spacecraft potential.

Type: Number
Label:
Variable: evphase2
Description: This luppr limit of the spin phase in degrees is applied to all correlation calculations with the spacecraft potential.

Type: Number
Label: **Use Vsc if Et<**
Variable: maxetotal
Description: Spacecraft potential data are used only if the total electric field stays below some maximum. The entry here sets this limit of the electric field.

Type: Number
Label: **Vsc offs per sc**
Variable: vpp1
Description: Defines the offset of the spacecraft potential measurement on mms1, which is used for the program-internal calibration of the raw data: Vsc(calibrated) = Vsc(raw)*1.2 + offset

---

Type: Number
Label:
Variable: vpp2
Description: Defines the offset of the spacecraft potential measurement on mms2, which is used for the program-internal calibration of the raw data: Vsc(calibrated) = Vsc(raw)*1.2 + offset

---

Type: Number
Label:
Variable: vpp3
Description: Defines the offset of the spacecraft potential measurement on mms3, which is used for the program-internal calibration of the raw data: Vsc(calibrated) = Vsc(raw)*1.2 + offset

---

Type: Number
Label:
Variable: vpp4
Description: Defines the offset of the spacecraft potential measurement on mms4, which is used for the program-internal calibration of the raw data: Vsc(calibrated) = Vsc(raw)*1.2 + offset

---

Type: Drop list
Label: Add offs of sweeps
Variable: addsweepoffset
Description: The occasional increases of ASPOC beam currents for test purposes (current sweeps) have been used to derive correction term to the official offset of the spacecraft potential. By setting this selection to Yes, the following values are added to the measured and calibrated potentials (for mms1-4, respectively): 0.22, 0.05, -0.14, 1.59.
Selection:
No Spacecraft potential remains unchanged
Yes Correction terms are added to the potential

Type: Number
Label: P56 bias
Variable: axialcalibbias
Description: This parameter may be added as a constant term to the axial probe voltages Vaxial(corrected) = axialcalibbias + Vaxial(raw)*axialcalibfactor

---

Type: Number
Label: P56 scale
Variable: axialcalibfactor
Description: This parameter may be applied as a factor to the axial probe voltages Vaxial(corrected) = axialcalibbias + Vaxial(raw)*axialcalibfactor

---

Type: Drop list
Label: Subtr. Vmean fm Vpi
Variable: subtractvsc
Description: By subtracting the average probe voltage from the individual probe voltages, the common variation of the spacecraft potential is eliminated and differences between the probes become better visible.
Selection:
No Probe voltages remain unchanged
V1234 The average voltage of all spin plane probes is subtracted.
V56 The mean voltage of the axial probes is subtracted.

Type: Drop list
Label: Vsc from
Variable: vscfromwhat
Description: This selection defines the source of the "spacecraft potential" used in the calculations and plots.
Selection:

L2 or P1234mean
: If the calibrated potential is available in the input data, it will be used. Otherwise the average of the four spin plane probes is the basis of the spacecraft potential calculation.

P1234max
: The maximum of the four spin plane probes is the basis of the spacecraft potential calculation.

P12mean
: The average of the spin plane probes 1 and 2 is the basis of the spacecraft potential calculation.

P34mean
: The average of the spin plane probes 3 and 4 is the basis of the spacecraft potential calculation.

P56mean
: The average of the axial probes 5 and 6 is the basis of the spacecraft potential calculation.

P123456mean
: The average of all six probes is the basis of the spacecraft potential calculation.

P123456max
: The maximum of all six probes is the basis of the spacecraft potential calculation.

P123456maxSpecial
: The spacecraft potential is defined by the following procedure:
get mean and stddev of each probe voltage,
multiply each voltage by the mean of all 4 stddevs divided by its own stddev,
get new mean of each probe voltage,
then shift each voltage to the original mean of all four voltages,
then define Vsc as average of the four probe voltages in the spin plane

---

Type: Drop list
Label: Enforce L1B
Variable: enforcel1b
Description: If activated, it enforces the use of individual probe data to get spacecraft potential (used for spin phase filtering of probe pairs) when reading files containing both uncalibrated (L1B-type) data and calibrated L2 data (l2_scpot).
Selection:

No
: L2 EDP data of spacecraft potential inside data files are used, if available

Yes
: Spacecraft potential is derived from probe voltages and program internal calibration parameters.

Type: Drop list
Label: Spin-av Vsc from
Variable: spinavvscfromwhat
Description: This entry provides two options to calculate spin averages of spacecraft potential
Selection:
sine-fit Spin average potential is derived from the constant term of a sine fit to the data (this is the standard method).
min-probe-diff
Spin average potential is taken as snapshot at the time when the difference between individual probes is a minimum.

Type: Drop list
Label: Vsc-tone
Variable: removevtone
Description: Defines some options the removal of a spin tone from the spacecraft potential
Selection:
Keep No removal of the spin tone
Remove abs
A spin tone is calculated from the defined time interval or based on saved parameters, and removed from the data without further change.
Remove rel
A spin tone is calculated from the defined time interval or based on saved parameters, and its amplitude is varied in proportion to the average spacecraft potential during a spin period before the tone is removed from the data.
Iasp stat
This option does not remove the spin tone, but it calculates different spin tones for different current levels identified by using the option "Filter ASPOC steps>(µA)" in line 3 entitled "DATASETS". The constant term resulting from these fits is output in the ASPOC current and spacecraft potential file (see section 5.4). Optionally the quality of the fits can be checked by plotting in the section "PLOT" "Fit-examples".

Type: Drop list
Label:
Variable: do_histone
Description: Defines the method for spin tone removal from the spacecraft potential
Selection:

Harmonics Spin tone is fitted by a harmonic function

Bins_mean
Parameters are sorted into bins of spin phase angle. Then the mean value in each bin is calculated

Bins_median
Parameters are sorted into bins of spin phase angle. Then the median value in each bin is calculated

A spin tone is calculated from the defined time interval or based on saved parameters, and removed from the data without further change.

Remove rel
A spin tone is calculated from the defined time interval or based on saved parameters, and its amplitude is varied in proportion to the average spacecraft potential during a spin period before the tone is removed from the data.

Iasp stat
This option does not remove the spin tone, but it calculates different spin tones for different current levels identified by using the option "Filter ASPOC steps>(µA)" in line 3 entitled "DATASETS". The constant term resulting from these fits is output in the ASPOC current and spacecraft potential file (see section 5.4). Optionally the quality of the fits can be checked by plotting in the section "PLOT" "Fit-examples".

Type: Number
Label: nHampel(full)
Variable: nhampel
Description: Threshold in standard deviations sigma for the Hampel filtering used in fitting spacecraft potential data over spin phase angle.

Type: Number
Label: nHampel(bins)
Variable: nhampel2
Description: After binning the spacecraft potential by applying the Hampel filter with the previously defined limit, the resulting curve may still have outliers. In order to remove outliers from this result, a second Hampel filtering is applied with the limit in standard deviations sigma given here.

Type: Number
Label: lower % used
Variable: lowerfract
Description: Contrary to the current-voltage characteristic, outliers of the spacecraft potential are predominantly on the positive side, due to the known dependence of the electric field. Therefore the user my choose to only use a lower fraction of spacecraft potential data within each soin phase angle bin.

Type: Drop list
Label:
Variable: saverecallvtone
Description: Spin tone parameters derived in a previous run may be recalled, or parameters derived in the current session may be saved for future use. The data are stored in a file in the current output directory. The output file names have the syntax <bird>_<date>_<timerange>_vtone.txt'.
Selection:
_ Spin tone parameters are neither saved nor recalled
Save Spin tone parameters derived in this session will be saved
Recall Spin tone parameters derived in a previous session will be recalled. The user will be prompted for the file to use.

Type: Drop list
Label: Adjust Vpi to mean Vp1
Variable: adjusttomeanvp1
Description: Defines a possible adjustment of individual probe voltages to the voltage of probe 1.
Selection:
No No change of individual probe voltages
Auto For each individual probe voltage except probe 1, the individual mean value is replaced by the mean voltage of probe 1:
Vi = Vi - mean(Vi) + mean(V1)

Type: Drop list
Label: Pairing
Variable: otherprobepairs
Description: The program can plot the mean voltages of pairs of probes. Normally it plots the mean of opposite probes (1 and 2, or 3 and 4). This entry may change the combination.
Selection:
1+2 3+4 Pair 1 is defined as P1+P2, pair 2 is defined as P3+P4
1+3 2+4 Pair 1 is defined as P1+P3, pair 2 is defined as P2+P4

Type: Drop list
Label: Apply Vp lim
Variable: dovplim
Description: If enabled, data are marked as valid only within user defined limits of probe potentials within each spin period. We define P1 as the potential derived from the mean value P1=MEAN((Vp1+Vp2)/2) and P3=MEAN((Vp3+Vp4)/2), where Vpi have been properly shifted in time to the time of probe 1. Imagine P1 and P3 to be plotted in polar coordinates. The polar angle is indicated as hours on a clock. The points at the right define a minimum and a maximum of the permitted deviation of P3 from P1 as a function of spin phase angle.
Selection:
No No limits
V34 over V12
Limits apply
CMD over Vsc(TBI)
To be implemented (Common mode difference over spacecraft potential)

Type: Number
Label: 3h
Variable: vplim(0,0)
Description: Lower limit of P3-P1 at 3h spin phase angle

Type: Number
Label:
Variable: vplim(1,0)
Description: Upper limit of P3-P1 at 3h spin phase angle

Type: Number
Label: 5h
Variable: vplim(0,1)
Description: Lower limit of P3-P1 at 5h spin phase angle

Type: Number
Label:
Variable: vplim(1,1)
Description: Upper limit of P3-P1 at 5h spin phase angle

Type: Number
Label: 7h
Variable: vplim(0,2)
Description: Lower limit of P3-P1 at 7h spin phase angle

Type: Number
Label:
Variable: vplim(1,2)
Description: Upper limit of P3-P1 at 7h spin phase angle

Type: Number
Label: 9h
Variable: vplim(0,3)
Description: Lower limit of P3-P1 at 9h spin phase angle

Type: Number
Label:
Variable: vplim(1,3)
Description: Upper limit of P3-P1 at 9h spin phase angle

Type: Number
Label: 11h
Variable: vplim(0,4)
Description: Lower limit of P3-P1 at 11h spin phase angle

Type: Number
Label:
Variable: vplim(1,4)
Description: Upper limit of P3-P1 at 11h spin phase angle

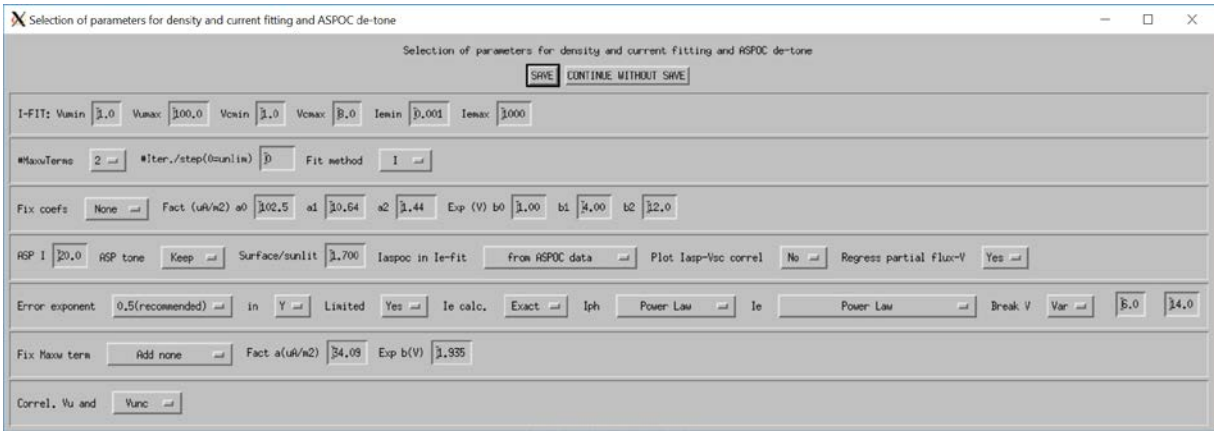
Type: Number
Label: 1h
Variable: vplim(0,5)
Description: Lower limit of P3-P1 at 1h spin phase angle

Type: Number
Label:
Variable: vplim(1,5)
Description: Upper limit of P3-P1 at 1h spin phase angle

Type: Drop list
Label: Remove 0.1 Hz band
Variable: remove01Hzband
Description: Frequencies in the range 0.1 Hz +/- 10% may be removed from the corrected spacecraft potential.
Selection:

No	No removal
Yes	Frequency band is removed

9.9 Panel "Parameters for density and current fitting and ASPOC de-tone"



9.9.1 Group "I-FIT"

Type: Number
Label: Vumin
Variable: vulimitmin
Description: Defines the minimum uncontrolled spacecraft potential used in the fit between controlled and uncontrolled potential to obtain the photo-emission characteristic.

Type: Number
Label: Vumax
Variable: vulimitmax
Description: Defines the maximum uncontrolled spacecraft potential used in the fit between controlled and uncontrolled potential to obtain the photo-emission characteristic.

Type: Number
Label: Vcmin
Variable: vclimitmin
Description: Defines the minimum controlled spacecraft potential used in the fit between controlled and uncontrolled potential to obtain the photo-emission characteristic.

Type: Number
Label: Vcmax
Variable: vclimitmax
Description: Defines the maximum controlled spacecraft potential used in the fit between controlled and uncontrolled potential to obtain the photo-emission characteristic. This value also serves as threshold between controlled and uncontrolled potentials if the option "criterion is Vcmax" is set under "Iaspoc in Ie-fit if no data file".

Type: Number
Label: Iemin
Variable: ielimitmin
Description: Defines the minimum plasma electron current used in the fit between spacecraft potential and plasma electron current to obtain the photo-emission characteristic.

Type: Number
Label: Iemax
Variable: ielimitmax
Description: Defines the maximum plasma electron current used in the fit between spacecraft potential and plasma electron current to obtain the photo-emission characteristic.

Type: Drop list
Label: **#MaxwTerms**
Variable: ntermsrms
Description: Defines the number of terms in the fits based on Maxwellians
Selection:

1	1 term (converges almost always)
2	2 terms (converges often)
3	3 terms (converges rarely)

Type: Number
Label: **#Iter./step(0=unlim)**
Variable: iterrms
Description: If greater than zero, this defines the number of iteration steps in the non-linear fitting calculations.

Type: Drop list
Label: **Fit method**
Variable: methodrmsv
Description: Defines the numerical method used to derive the photo-emission curve from the controlled and uncontrolled potential. Note that both methods only apply to the determination of the photo-emission based on datasets of a controlled and uncontrolled potential. Normally the selection "I" converges more easily.
Selection:

I	Uses the function getiaspoc2d. Independent variables are the controlled and the uncontrolled potential. The fitting is performed according to the following example for two terms: j(unc) = a*exp(-vscunc/b) + c*exp(-vscunc/d) = j(cont) = a*exp(-vsccont/b) + c*exp(-vsccont/d) - Iaspoc/sunlit_area
V(u)	Uses the function getvsc2d. Independent variables are the uncontrolled potential and the ASPOC current.

Type: Drop list
Label: **Fix coefs**
Variable: fixexrms
Description: In order to improve the convergence of the nonlinear fit for the photo-electron curve, either the exponents or the factors of the Maxwellian terms may be kept fixed at the values entered to the right.
Selection:

None	No constraints
Exp	The exponents are fixed
Factor	The factors are fixed

Type: Number
Label: **Fact (µA/m2) a0**
Variable: coefsrmsvx0
Description: Fixed factor of the first Maxwellian term in $\mu A/m^2$.

Type: Number
Label: **a1**
Variable: coefsrmsvx2
Description: Fixed factor of the second Maxwellian term in µA/m^2.

Type: Number
Label: **a2**
Variable: coefsrmsvx4
Description: Fixed factor of the third Maxwellian term in µA/m^2.

Type: Number
Label: **Exp (V) b0**
Variable: coefsrmsvx1
Description: Fixed exponent in V (=characteristic voltage) of the first Maxwellian term.

Type: Number
Label: **b1**
Variable: coefsrmsvx3
Description: Fixed exponent in V (=characteristic voltage) of the second Maxwellian term.

Type: Number
Label: **b2**
Variable: coefsrmsvx5
Description: Fixed exponent in V (=characteristic voltage) of the third Maxwellian term.

9.9.2 Group "ASP"

Type: Number
Label: **ASP I**
Variable: maxcurrent0
Description: For the derivation of the photo-emission curve it is necessary to assume or measure the ASPOC ion current. This entry gives the ASPOC ion current if the selection drop list further below is set to "const. (I-FIT setting)".

Type: Drop list
Label: **ASP tone**
Variable: removeatone
Description: Defines whether the spin tone in the ASPOC current data shall be removed. The spin tone exists due to the fact that the photo electrons near the emitter produce a spin dependent current which subtracts from the ion current. Note that the tone removal works best in periods of constant ion current setting.
Selection:
Keep No correction is applied
Remove Spin tone is corrected

Type: Number
Label: Surface/sunlit
Variable: areafudge
Description: The effective spacecraft surface area for the generation of photo-electrons is generally assumed to be the projected area of the spacecraft to the Sun. In the case of MMS, an area of 5.9 m^2 is assumed, which includes the surfaces of the various booms. On the other hand, the assumed effective surface area for plasma electron interaction with the spacecraft surface, which is an important parameter for the calculation of the plasma electron current from plasma density and temperature, is less well defined. Options include
a) the projected area, i.e. the same area as for photo-electrons (5.9 m^2),
b) twice the projected area, based on the argument that most of the electrons travel along magnetic field lines and hit the surface across a projected surface, but from opposite sides. This would result in a value of about 11.8 m^2 (with an uncertainty due to the variable direction of the field and the non-spherical shape of the spacecraft).
c) the total surface area of the spacecraft, which for MMS is 34 m^2.
The parameter to be entered here is a multiplier to the projected area:
plasma electron interaction surface = factor * projected area.
Depending on the assumptions a), b), or c), the respective factors are 1.0, 2.0, or 5.76.
The standard value based on best fit to FPI data is 1.7.

Type: Drop list
Label: Iaspoc in Ie-fit
Variable: iefitwithall
Description: Defines the values the ASPOC ion current used in various plots and calculations.
Selection:

const. (I-FIT setting)
: The constant value entered in the field "ASPOC current" in the group "I-Fit" is used.

criterion is Vcmax
: The controlled potential serves as criterion whether ASPOC is ON or OFF. Potentials higher than Vcmax defined in the group "I-Fit" are assumed to coincide with ASPOC OFF, and potentials below this value are assumed to have ASPOC ON at the current value entered in the field "ASP I" in the group "I-Fit".

from operations data
: The status of ASPOC is taken from the operations data files (ON-OFF times) and the current is the one entered in the field "ASP I" in the group "I-Fit".

from ASPOC data
: ASPOC currents are taken from the cdf input file.

Type: Drop list
Label: Plot Iasp-Vsc correl
Variable: doiaspstat
Description: Defines whether correlations between the ASPOC current and spacecraft potential shall be calculated and plotted.
Selection:

No
: No correlations and plots.

Yes
: Correlations and plots are performed.

Type: Drop list
Label: **Regress partial flux-V**
Variable: dopartcorr
Description: Defines whether correlations between partial particle flux and spacecraft potential shall be calculated and plotted.
Selection:
- No — No correlations and plots.
- Yes — Correlations and plots are performed.

Type: Drop list
Label: **Error exponent**
Variable: weightsrms
Description: The convergence of the nonlinear fit to obtain the photo-emission spectrum is critical. This selection allows to define relative weights to the data points to improve the convergence.
Selection:
- -2 — Weight is uncontrolled potential (of the second spacecraft) to the power -2.
- -1 — Weight is uncontrolled potential (of the second spacecraft) to the power -1.
- 0 — Weight is unity.
- 0.5(recommended) — Weight is uncontrolled potential (of the second spacecraft) to the power -0.5.
- 1 — Weight is uncontrolled potential (of the second spacecraft) to the power +1.
- 2 — Weight is uncontrolled potential (of the second spacecraft) to the power +2.
- hist — The total weight of all data points of the uncontrolled potential (of the second spacecraft) in each interval is equal. There are 30 intervals, logarithmically spaced in the range between 1 V and 60 V.
- dVdI — Weights are set according to (dV/dI) [errors ~ (dI/dV)] derived from the Nakagawa function.

Type: Drop list
Label: **in**
Variable: weightsiny
Description: Selects whether any errors are calculated in X (spacecraft potential) or Y (density or current).
Selection:
- X — Mimimum error is calculated in X
- Y — Mimimum error is calculated in Y

Type: Drop list
Label: **Limited**
Variable: limitedrms
Description: Certain limits to the calculated parameters in the fit of the photo-emission curve using Maxwellians may be applied.
Selection:
- No — Unlimited
- Yes — Limited

Type: Drop list
Label: Ie calc.
Variable: methodrmse
Description: Defines the formula used to calculate plasma electron current. The "exact" option includes the correction terms for an attracting sphere
Selection:
Simple Current ~ density * root(temperature)
Exact Current ~ density * root(temperature) * (1 + potential/temperature_in_eV)

Type: Drop list
Label: Iph
Variable: powerrmsv
Description: Defines the function used for the fit between controlled and uncontrolled potentials to obtain the photo-emission spectrum.
Selection:
Maxwellians
Fit with one or more Maxwellian terms
Power Law
Fit with a power law
Max w power init
Fit with one or more Maxwellian terms, using a power law fit for the start values.
Maxw from power
Fit with one or more Maxwellian terms, which are obtained by approximating a power law to the data.

Type: Drop list
Label: Ie
Variable: powerrmse
Description: Defines the function used for the fit between potential and plasma current to obtain the photo-emission spectrum.
Selection:
Maxwellians
Fit with one or more Maxwellian terms
Power Law
Fit with a power law
Max w power init
Fit with one or more Maxwellian terms, using a power law fit for the start values.
Maxw from power
Fit with one or more Maxwellian terms, which are obtained by approximating a power law to the data.
3-range Maxw (set error exp=0)
Fit with 3 Maxwellian terms separated in potential range. In this case the separating potentials can be entered manually in the two fields at the right, or calculated automatically based on minimum total error.

Type: Drop list
Label: **Break V**
Variable: Vbreakvariab
Description: Defined whether the potentials separating the validity of three Maxwellian fittings are set manually by the values entered at the right, or are calculated automatically based on minimum total error.
Selection:
Fix
Fixed limits given at the right are used
Var
Variable limits are calculated

Type: Number
Label:
Variable: Vbreak1
Description: Potential separating the fits at low and medium potential

---

Type: Number
Label:
Variable: Vbreak2
Description: Potential separating the fits at medium and high potential

---

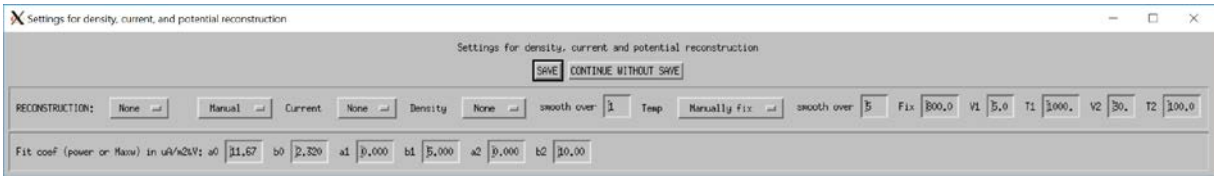
Type: Drop list
Label: **Fix Maxw term**
Variable: fixmaxwflag
Description: A fixed Maxwellian term may be added to the terms which are fitted to the data to obtain a photo-emission spectrum, that is, the fit itself is a delta to the fixed term.
Selection:
Add none No fixed term is added.
Add preset term
A term derived from fits obtained at the current sweeps for currents ≥ 30 µA as of 2016-11-13 is added. The values are:
[189.94/5.9, 1.831] for mms1
[215.90/5.9, 1.782] for mms2
[206.03/5.9, 1.977] for mms3
[90.51/5.9, 1.791] for mms4
Add user term
A fixed term defined by the parameters at the right is added.
Use user-b in 1st
Use fixed term for the exponent b only.

Type: Number
Label: **Fact a(µA/m2)**
Variable: fixmaxwusera
Description: Fixed factor of the first Maxwellian term in $\mu A/m^2$.

Type: Number
Label: Exp b(V)
Variable: fixmaxwuserb
Description: Fixed exponent in V (=characteristic voltage) of the first Maxwellian term.

Type: Drop list
Label: Correl. Vu and
Variable: dovsc13fit
Description: Defines the pair of spacecraft potential values correlated with each other
Selection:
- Vunc — Correlates the controlled potential with the uncontrolled one.
- Vunc-Vc — Correlates the controlled potential with the difference between uncontrolled and controlled potentials.

9.10 Panel "Settings for density, current and potential reconstruction"



9.10.1 Group "RECONSTRUCTION"

Type: Drop list
Label:
Variable: reconselect
Description: Defines whether the photocurve shall be used to use measured spacecraft potential to calculate time series of density, plasma current, and - if the input potential is controlled by ASPOC - the uncontrolled potential.
Selection:
- None — No reconstruction of density, current, and uncontrolled potential
- by Ie — Reconstruction of density, current, and uncontrolled potential from the photocurve derived from a fit between spacecraft potential and FPI data of density or current
- by Iph — Reconstruction of density and current from the photocurve derived from a fit between controlled and uncontrolled spacecraft potential

---

Type: Drop list
Label:
Variable: reconvmanual
Description: Defines whether the photocurve shall be derived from the input data or the be defined by the parameters entered in the line below.
Selection:
- From Data — Use calculated photocurve
- Manual — Use photocurve defined by the parameters given below

---

Type: Drop list
Label: **Current**
Variable: reconi
Description: Defines whether the plasma current time series shall be reconstructed.
Selection:
None No reconstruction of the plasma current time series
Ie fit Reconstruction of the plasma current time series from the fit between plasma current and spacecraft potential

---

Type: Drop list
Label: **Density**
Variable: reconn
Description: Defines whether the plasma density time series shall be reconstructed.
Selection:
None No reconstruction of the plasma density time series
Ie fit Reconstruction of the plasma density time series from the fit between plasma current and spacecraft potential
by Iph Reconstruction of the plasma density time series from the photocurve derived from a fit between controlled and uncontrolled spacecraft potential

---

Type: Number
Label: **smooth over**
Variable: reconsmooth
Description: Length of the smoothing interval for the time series of reconstructed data (density, current, uncontrolled potential).

Type: Drop list
Label: **Temp**
Variable: reconntempfrom
Description: Defines whether the plasma temperature measured by FPI shall be used to reconstruct density from the spacecraft potential, or a fixed value of temperature given at the right, or by temperatures given by two points of a straight line, alo given at the right.
Selection:
Use FPI Use calculated photocurve
Manually fix
Use the temperature given by the parameter "Fix" given at the right.
2-point fit w/V
Use temperatures given by linear interpolation with spacecraft potential using the pairs of values (V1,T1) and (V2,T2) given at the right.

Type: Number
Label: **smooth over**
Variable: reconntempsmooth
Description: Length of the smoothing interval for the time series of measured temperature used to reconstruct plasma density.

Type: Number
Label:
Variable: reconntemp
Description: Fixed temperature used to reconstruct plasma density.

Type: Number
Label: **V1**
Variable: reconntempV1
Description: First spacecraft potential of the linear variation of temperature used for reconstruction given by the two points (V1,T1) and (V2,T2).

Type: Number
Label: **T1**
Variable: reconntempT1
Description: First temperature of the linear variation of temperature used for reconstruction given by the two points (V1,T1) and (V2,T2).

Type: Number
Label: **V2**
Variable: reconntempV2
Description: Second spacecraft potential of the linear variation of temperature used for reconstruction given by the two points (V1,T1) and (V2,T2).

Type: Number
Label: **T2**
Variable: reconntempT2
Description: Second temperature of the linear variation of temperature used for reconstruction given by the two points (V1,T1) and (V2,T2).

Type: Number
Label: **Fit coefs (power or Maxw) in A/m2 and V. a0**
Variable: reconnseta0
Description: Factor of the power law or of the first Maxwellian term, in $\mu A/m^{-2}$

Type: Number
Label: **b0**
Variable: reconnsetb0
Description: Negative exponent of the power law or characteristic potential of the first Maxwellian term in V

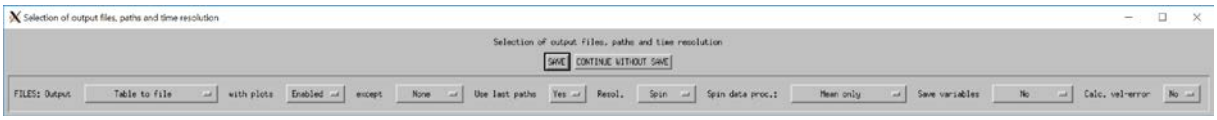
Type: Number
Label: **a1**
Variable: reconnseta1
Description: Factor of the second Maxwellian term, in $\mu A/m^{-2}$

Type: Number
Label: **b1**
Variable: reconnsetb1
Description: Characteristic potential of the second Maxwellian term in V

Type: Number
Label: **a2**
Variable: reconnseta2
Description: Factor of the third Maxwellian term, in $\mu A/m^{-2}$

Type: Number
Label: **b2**
Variable: reconnsetb2
Description: Characteristic potential of the third Maxwellian term in V

9.11 Panel "Output files, paths and time resolution"



9.11.1 Group "FILES"

Type: Drop list
Label: **Output**
Variable: makeoutput
Description: Defines output options for tables and plots
Selection:

Plots to screen only
: Plots to screen only, no output in files

Table to file
: Output of tabulated data

Plots to screen and files
: Plots to screen, and output of plot files in PNG format

Plots to PNG files
: No plots to screen, output of plot files in PNG format

Plots to PS files
: No plots to screen, output of plot files in Postscript format. This option has been added because the generation of PNG files on leo1 is very slow.

Type: Drop list
Label: **with plots**
Variable: disableplots
Description: If set, this selection disables all plots with the exception of a single plot type given in the next button
Selection:
- Enabled — All plots are enabled
- Disabled — All plots except one type given at the right are disabled

---

Type: Drop list
Label: **except**
Variable: disableexcept
Description: If plots are disabled, the plot type defined here will still be plotted.
Selection:
- None — All plots are disabled.
- ivsc — Plots of current over spacecraft potential are NOT disabled.
- nvsc — Plots of density over spacecraft potential are NOT disabled.
- etvsca — Plots of spin average spacecraft potential over electric field are NOT disabled.
- scat — Plots of correlations between potentials from two spacecraft are NOT disabled.
- temp — Plots of temperature over time are NOT disabled.
- dens — Plots of density over time are NOT disabled.
- vsca — Plots of spin average spacecraft potential over time are NOT disabled.
- ivcurve — Plots of the I-V curve are NOT disabled.
- allbutf(t) — Only plots over time remain disabled.

Type: Drop list
Label: **Use last paths**
Variable: usesavedpath
Description: Defines whether the paths for input data in cdf, input operational data, input attitude data, and outputs used in the previous run of the program shall be used.
Selection:
- No — Use the default path, which is the path of the executed program.
- Yes — Use the previous paths.

Type: Drop list
Label: Resol.
Variable: plotmore
Description: Defines the resolution of plotted data
Selection:
- Spin: Plots of spin resolution data.
- Full: Plots of data in the full available resolution
- All: Plots additional data which are rarely used:
  Lag (in data frames) between the spin plane components of the electric field
  Quality of the fit for each spin period
  First spin plane component of the electric field (E12)
  Second spin plane component of the electric field (E34)
  Probe potentials as a function of spacecraft potential
  Probe voltages as a function of total electric field
  Spacecraft potential as a function of spin phase
  Average potential of pairs of probes over time
  Average potential of pairs of probes over spin phase

Type: Drop list
Label: Spin data processing
Variable: spinmodein
Description: Sets options for the output of spin averaged data.
Selection:
- Mean only: Calculate spin averages only. Do not calculate any photocurve parameters or spin tone corrections or electric field dependencies
- Mean+coefs: Calculate spin averages and photocure parameters. Do not calculate any spin tone corrections or electric field dependencies
- Mean+coefs+fine correction: Calculate everything: spin averages, photocurve parameters, spin tone corrections, and electric field dependencies

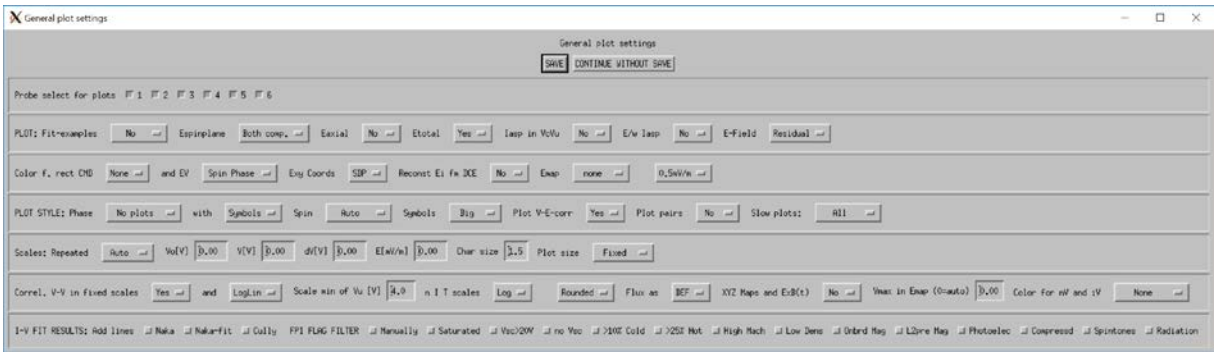
---

Type: Drop list
Label: Save variables
Variable: varsave
Description: Defines whether the calculated spin averages and parameter settings shall be output to a file in IDL .sav format, which can be read and analysed by the program in a future run.
Selection:
- No: No data file is generated, the program executes normally.
- Save and stop: Generate the data file without further calculations and plotting
- Save and contrinue: Generate the data file and continue the execution of the program with all calculations and plots

---

Type: Drop list
Label: **Calc. vel-error**
Variable: doverror
Description: Defines whether the error of plasma velocities is plotted and output in the output table.
Selection:
No No calculation.
Yes Calculation and output of velocity errors.

9.12 Panel "General plot settings"



9.12.1 Group "Probe select for plots"

Type: Button
Label: **Probe select for plots**
Variable: probeselect
Description: These buttons define which probe voltages are plotted.
Selection:
1
2
3
4
5
6

9.12.2 Group "PLOT"

Type: Drop list
Label: **Fit-examples**
Variable: dotestplots
Description: If set, examples of the fits to the electric field components, spacecraft potential, or probe voltages, over single spin periods are plotted.
Selection:
No No test plots are created.
E-field Test plots for the electric field are created.
Vprobe Test plots for the probe voltages are created.
S/C Pot Test plots for the spacecraft potential are created.
Isweep Test plots for spin tone fitting of the spacecraft potential at different ASPOC current steps (as commanded during current sweeps) are created.
CMD Test plots for Common Mode Data

Type: Drop list
Label: **Espinplane**
Variable: plotplane
Description: Defines which of the spin plane components of the electric field are plotted.
Selection:
- Both comp. Both comp.
- E12 or EX E12 or Ex only
- E34 or EY E34 or Ey only

Type: Drop list
Label: **Eaxial**
Variable: plotaxial
Description: Defines whether the axial components of the electric field are plotted.
Selection:
- No Axial components are not plotted.
- Yes Axial components are plotted.

Type: Drop list
Label: **Etotal**
Variable: plotetotal
Description: Defines whether the total electric field is plotted.
Selection:
- No Total electric field is not plotted.
- Yes Total electric field is plotted.

Type: Drop list
Label: **Iasp in VcVu**
Variable: plotiaspoc
Description: Defines whether the points in the plot of uncontrolled versus controlled potential shall be color-coded with the ASPOC ion current.
Selection:
- No Points are plotted in black.
- Yes Points are plotted in color according to the ASPOC ion current.

Type: Drop list
Label: **E/w Iasp**
Variable: plotewithaspoc
Description: Defines settings for plots of electric field components over spin phase with a color code according to the ASPOC ion current.
Selection:
- No No such plots
- All All components are plotted.
- E12 The component E12 is plotted.
- E34 The component E34 is plotted.
- E56 The component E56 (axial) is plotted.

Type: Drop list
Label: **E-Field**
Variable: plottone
Description: Defines for plots of the electric field and of vxB, and under the condition that the spin tone has been calculated, whether the residual data (with the tone subtracted) or the spin tone is plotted.
Selection:
Residual The residual data are plotted.
Tone The spin tone is plotted.

Type: Drop list
Label: **Color f. rect CMD**
Variable: pairstrend
Description: Defines the parameter for the color scale in rectangular (not in polar) Common Mode Difference plots.
Selection:
None No color scale
Vsc The color scale is spacecraft potential
Etot The color scale is total electric field
n The color scale is partcle density
T The color scale is particle temperature
Time The color scale is time

Type: Drop list
Label: **and EV**
Variable: ecorrlabel
Description: Defines the parameter for the color scale in the electric field over spacecraft potential plots.
Selection:
None No color scale
Spin Phase
The color scale is spin phase angle
Rel. Time The color scale is relative time

Type: Drop list
Label: **Exy Coords**
Variable: plotdespunexb
Description: Defines whether the spin plane components of the electric field are plotted in the original co-ordinate system which is rotating with the spacecraft, or after despinning.
Selection:
SDP The original, rotating co-ordinates are applied.
DSL The data are plotted after a despin procedure has been applied.

Type: Drop list
Label: **Reconst Ei fm DCE**
Variable: vscfromeidcecorr
Description: Defines whether the spaceccraft potential shall be modified according to the following procedure:
Derive spinning electric field data from the dce file (arreX) over spin phase for various phase shifts (in 10 degree steps around the nominal value 150 deg) and search for best correlation with electric field data from the scpot file (arrcX). The phase shift is applied individually to the E12 and E34 components. Then define Vsc as (the negative of) the maximum probe voltage (after standard calibration has been applied) and subtract half of the reconstructed E-field component using the spinning data with best correlation angle.

Selection:
- No — The spacecraft data remain unchanged
- Yes — The spacecraft data are modified

Type: Drop list
Label: **Emap**
Variable: evphasebini
Description: Defines the number of plots generated in the format of maps of the spin plane, where the spin plane components of the electric field define the position in the map, and the symbols are color coded according to the spacecraft potential. Based on the selection, the full range of spin phase (0° to 360°) is divided by 1, 2, 4, 8, or 16, and the according number of individual plots is created.
Selection:
- none — No spin plane maps of the electric field are generated.
- 22.5deg — 16 plots each covering 22.5° of spin phase are generated.
- 45deg — 8 plots each covering 45° of spin phase are generated.
- 90deg — 4 plots each covering 90° of spin phase are generated.
- 180deg — 2 plots each covering 180° of spin phase are generated.
- 360deg — 1 plots covering 360° of spin phase is generated.

Type: Drop list
Label:
Variable: evexybini
Description: Defines the width of individual bins (the resolution) of the electric field in the spin plane maps.
Selection:
- 0.1mV/m
- 0.2mV/m
- 0.5mV/m
- 1mV/m
- 2mV/m
- 5mV/m

9.12.3 Group "PLOT STYLE"

Type: Drop list
Label: **Phase**
Variable: dophaseplots
Description: Defines the co-ordinate system of plots over "spin phase" and similar.
Selection:

- Spin_rect The plots are rectangular (i.e., the spin phase or "probe phase" is the abscissa, the data are the ordinate), and the abscissa is the spin phase (for a definition see section 7.1).
- Probe_rect The plots are rectangular and the abscissa is the "probe phase" which is defined as follows: For plots of individual probe voltages, the phase is zero when the probe points sunward. For plots of electric field components, the phase is zero when the probe P1 (component E12) or P3 (component E34), respectively, points sunward.
- Spin_polar The plots are polar, the plot angle is the spin phase (zero pointing to the right, in anticlockwise orientation), and the data are the radius.
- Probe_polar
  The plots are polar, the plot angle is the probe phase (zero pointing to the right, in anticlockwise orientation), and the data are the radius.
- No plots
  No spin phase plots are generated (to save processing time and to reduce the number of plots)

Type: Drop list
Label: **with**
Variable: phaseplotlines
Description: Defines the style of plots in full resolution over spin phase.
Selection:

- Symbols Symbols are drawn at each data point, no connecting lines.
- Lines Data points are connected by lines, no symbols are plotted.

Type: Drop list
Label: **Spin**
Variable: autodolines
Description: Defines the style of plots in spin period resolution over spin phase.
Selection:

- Connected Points are connected by lines
- Auto Plot style depends on the number of data points in a plot. For less than 150 points, data values are shown as horizontal dashes (histogram-like). For 150 or more points, values are shown as "+" or "x" symbols.

Type: Drop list
Label: **Symbols**
Variable: bigsymbols
Description: Defines the size of symbols in plots
Selection:

- Normal Normal size (0.3)
- Big Big symbols (0.8)

Type: Drop list
Label: **Plot V-E-corr**
Variable: dovecorrplots
Description: Defines whether the correlation between spacecraft potential and total electric field shall be plotted. These plots may be turned off as their calculation takes extra time.
Selection:
- No — No such plots.
- Yes — Plots of spacecraft potential over total electric field are generated.

Type: Drop list
Label: **Plot pairs**
Variable: dopairsplots
Description: Defines whether the correlation between spacecraft potential and total electric field shall be plotted. These plots may be turned off as their calculation takes extra time.
Selection:
- No — No such plots.
- Both — Plots of probe pair data and of common mode differences are generated.
- CMD — Plots of common mode differences are generated.

Type: Drop list
Label: **Slow plots**
Variable: checktimeconsuming
Description: Some calculations are time consuming, which may lead to extremely long processing times, in particular for processing in full resolution and with input files in Fast Survey mode, are even more extremely, in Burst Mode. Such calculations in particular are the non-linear fits for the photo-electron spectrum. The threshold
Selection:
None|vs spin|n&I-fits|Iasp-fits|All
- None — All available plot formals are generated only if the amount of data corresponds to less than one hour in Fast Survey Mode. If the time interval is longer, certain time consuming calculations and plots are skipped.
- vs spin — Among time consuming plots, only the ones for spacecraft potential, probe potentials, and electric field as a function of spin phase or probe phase are generated irrespectively of the time interval.
- n&I-fits — Among time consuming plots and calculations, only the fits between spacecraft potential(s) and plasma density or current and results thereof are generated irrespectively of the time interval.
- asp-fits — Among time consuming plots and calculations, only the fits between ASPOC current and spacecraft potential are generated irrespectively of the time interval.
- All — All available plot formals are generated irrespectively of the time interval.

9.12.4 Group "Scales"

Type: Drop list
Label: Repeated
Variable: freezerepeat
Description: Defines the scale of the dependent variable (Y)
Selection:
Auto The scale is adjusted to the current plot data
Freeze The scale of the first plot window is used for all plots

---

Type: Number
Label: Vo[V]
Variable: vscalemin
Description: Defines the minimum scale value for plots of potentials and voltages. The minimum value is typically zero.

Type: Number
Label: V[V]
Variable: vscalemax
Description: Defines the maximum scale value for plots of potentials and voltages.An entry of zero defaults to 30 V.

Type: Number
Label: dV[V]
Variable: dvscalemax
Description: Defines the maximum scale value for plots of potentials and voltages in the mode where the spacecraft potential is subtracted from the data and only the deviations are plotted. The minimum scale value is set to -maximum.

Type: Number
Label: E[mV/m]
Variable: escalemax
Description: Defines the maximum scale value for plots of the electric field. The minimum scale value is set to -maximum.

Type: Number
Label: Char size
Variable: cs
Description: Defines the size of characters in plot labels (default is 1.5 in IDL units)

Type: Drop list
Label: **Plot size**
Variable: dovariableplotsize
Description: Defines size of plot windows in dependence of the chosen character size for the axis labels (selection "Char size" at the left). Note that the size of the plot panel (the axes) is always constant. This selection defines the size of the plot window around it.
Selection:
- Fixed: The size of the plot window is kept constant, irrespective of the character size of the axis labels. As a result, large character sizes (> 1.5) result in huge axis labels with a tendency to exceed the plot window size.
- Variable: The size of the plot window is adapted to the character size of the axis labels. As a result, the size of the plot windows varies with the chosen character size. Large character sizes may result in huge plot windows with a tendency to exceed size of the display.

Type: Drop list
Label: **Correl. V-V in fixed scales**
Variable: fixedscales
Description: Defines the scales of the plots correlating the controlled potential with the uncontrolled one.
Selection:
- No: Scales are defined by the range of the data.
- Yes: Scales are fixed to 2 V ... 6 V for the controlled potential and between the "scale min of Vu" and 30 V or 40 V for the uncontrolled potential.

Type: Drop list
Label: **and**
Variable: dologlogivplot
Description: Defines the scale for the potential in the plot of current as a function of spacecraft potential.
Selection:
- LogLin: Plots log(current) over potential
- LogLog: Plots log(current) over log(potential)

Type: Number
Label: **Scale min of Vu [V]**
Variable: yuncmin
Description: Defines the minimum uncontrolled potential in the plot scale.

Type: Drop list
Label: **n I T scales**
Variable: dolognitplots
Description: Defines the scale for the density, current, and temperature in the plots of these quantities over time.
Selection:
- Lin: Quantities are plotted in a linear scale.
- Log: Quantities are plotted in a logarithmic scale.

Type: Drop list
Label:
Variable: doexactnitplots
Description: Defines the rounding of the scale for the density, current, and temperature in the plots of these quantities over time.
Selection:
Rounded Scale range is rounded
Data Scale range is exactly the range of the data

Type: Drop list
Label: **Flux as**
Variable: dofpipsdplots
Description: Selects the plotted parameter of the particle distribution fnuction
Selection:
DEF Differential electron flux (or ion flux)
PSD Phase space density

Type: Drop list
Label: **XYZ Maps and ExB(t)**
Variable: doxyzmaps
Description: XYZ maps are plots of two components of the electric field drawn against each other. If the axial electric field is enabled, three plots will be generated: X-Y, X-Z, and Y-Z. Without axial electric field only the X-Y map is generated. The data points are color coded with the spin phase.
Selection:
No No maps and ExB vector components over time are plotted.
Yes Maps and ExB vector components over time are plotted.

Type: Number
Label: **Vmax in Emap (0=auto)**
Variable: vmaxinemap
Description: For the maps of the electric field components in the spin plane with color coding according to the spacecraft potential (other definitions for these plots are given in the line above), this entry defines the maximum spacecraft potential applied for the color code. A value of zero does an auto scale.

Type: Drop list
Label: Color for nV and iV
Variable: ivcorrlabel
Description: Defines the color coding in plots of density and current over spacecraft potential.
Selection:
- None — No color coding.
- E-field — Data points are color coded by the electric field.
- Temperature — Data points are color coded by plasma temperature.
- Rel. Time — Data points are color coded by relative time of mission.

9.12.5 Group "I-V FIT RESULTS"

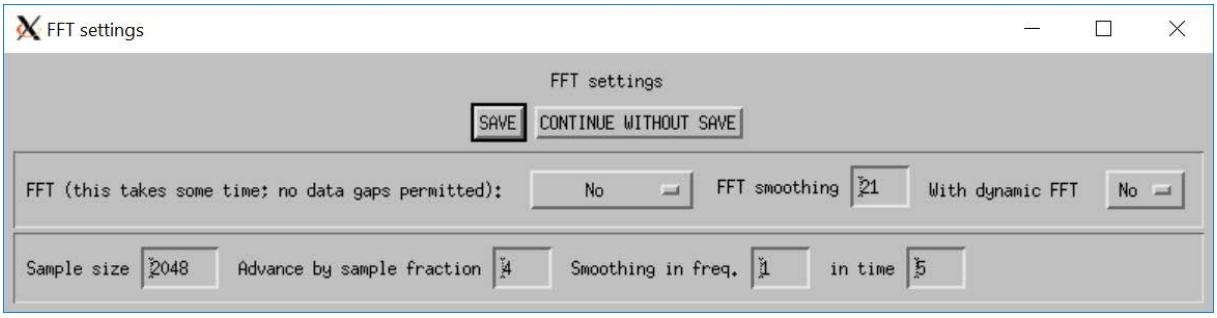
Type: Button
Label: Add lines
Variable: allvsc13lines
Description: This selection serves two purposes: a) It defines whether certain fits to obtain the photo-emission spectrum are performed, and b) it turns on various curves calculated on the basis of literature values of the photo-emission spectrum.
Selection:
- linear — Performs a linear regression between controlled potential (x) and the logarithm of the uncontrolled potential (y), log10(y) = const + factor0*x
- quad — Performs a quadratic regression (parabola) between controlled potential (x) and the logarithm of the uncontrolled potential (y), $\log10(y) = const + factor0*x + factor1*x^2$
- Naka — Spectrum by Nakagawa [11]
- Naka-fit — Spectrum by Nakagawa [11] but with a global scaling factor to match the observed data.
- Cully — Spectrum by Cully et al. (2007), derived from Cluster, after Pedersen et al. 2001: j=53.2*exp(-V/3) + 2.8*exp(-V/10)
- And45 — Spectrum after Andriopoulou, based on MMS data of April-May 2015
- And67 — Spectrum after Andriopoulou, based on MMS data of June-July 2015
- And17 — Spectrum after Andriopoulou, based on MMS data as presented at the MMS Science Working Team meeting in Key West in 2017
- calculate Iph — The non-linear fit between the controlled and uncontrolled potential is performed and the resulting curve is plotted.
- calculate Ie — The non-linear fit between the potential and plasma current is performed and the resulting curve is plotted.

9.12.6 Group "FPI FLAG FILTER"

Type: Button
Label:
Variable: fpiflags
Description: This selection activates FPI flags for display and filtering.
Selection:

Manually	Manually
Saturated	Saturation is present
Vsc>20V	Reported Vsc>20V
no Vsc	Invalid Vsc
>10% Cold	>10% cold plasma
>25% Hot	>25% hot plasma
High Mach	High sonic Mach number
Low Dens	Low calculated density (DES:0.05/cc, DIS: 0.0/cc)
Onbrd Mag	Onboard bentpipe magnetometer data used instead of srvy l2pre
L2pre Mag	L2pre Mag
Photoelec	No internal photoelectron correction applied
Compressd	Compression error
Spintones	Spintone calculation error (DBCS only)
Radiation	Significant penetrating radiation (>20%)

9.13 Panel "FFT settings"



9.13.1 Group "FFT"

Type: Drop list
Label: FFT (this takes some time; no data gaps permitted)
Variable: dofft
Description: Defines for which parameters a Fast Fourier Transform is calculated over the entire time interval
Selection:

No	No FFT is calculated.
Efield	FFTs of the two spin plane components of the electric field are calculated.
Potential	FFTs of the spacecraft potential and individual probe voltages are calculated.

Type: Number
Label: FFT smoothing
Variable: ssmoothing
Description: Defines the smoothing term of FFT data in the frequency domain for the global FFT calculations.

Type: Drop list
Label: **With dynamic FFT**
Variable: dodynamicfft
Description: Defines whether dynamic FFTs are calculated. Note that gaps in the input data are not handled properly, i.e. the FFT is calculated as if there were no gaps.
Selection:
No No dynamic FFT
Yes Dynamic FFTs are calculated

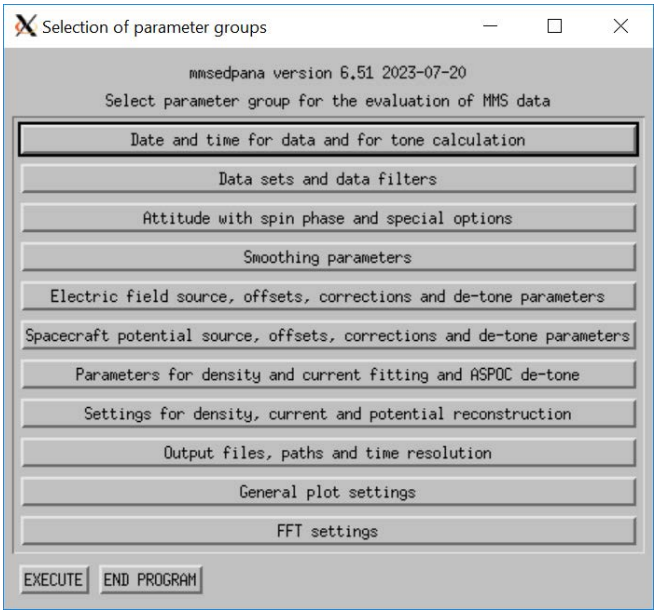
Type: Number
Label: **Sample size**
Variable: sampsize
Description: This is the number of data points in an individual sample in the dynamic FFT.

Type: Number
Label: **Advance by sample fraction**
Variable: sampsizefraction
Description: This is the fraction of the sample size by which the time interval is advanced in the dynamic FFT. For example, a value of 4 with a sample size of 2048 advances each calculation by 512 data points.

Type: Number
Label: **Smoothing in freq.**
Variable: smoothing
Description: Defines the smoothing term of FFT data in the frequency domain for the dynamic FFT calculations.

Type: Number
Label: **in time**
Variable: tsmoothing
Description: Defines the smoothing term of FFT data in the time domain for the dynamic FFT calculations.

9.14 Execution



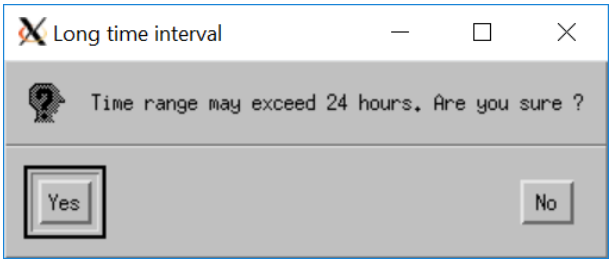
Type: Button
Description: By pressing this button the execution of the program will continue by asking for input data.

EXECUTE

Type: Button
Description: This button ends the program execution. Paths and settings will be stored in the system for later re-use.

END PROGRAM

If the chosen time range includes a day boundary, the following message appears:

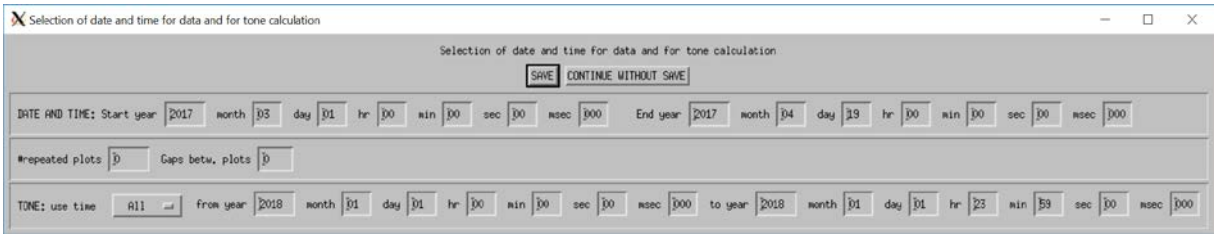


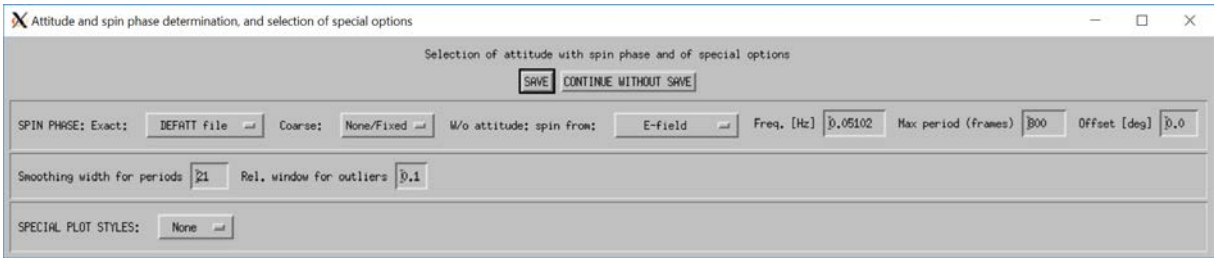
10 Generation of spin average data

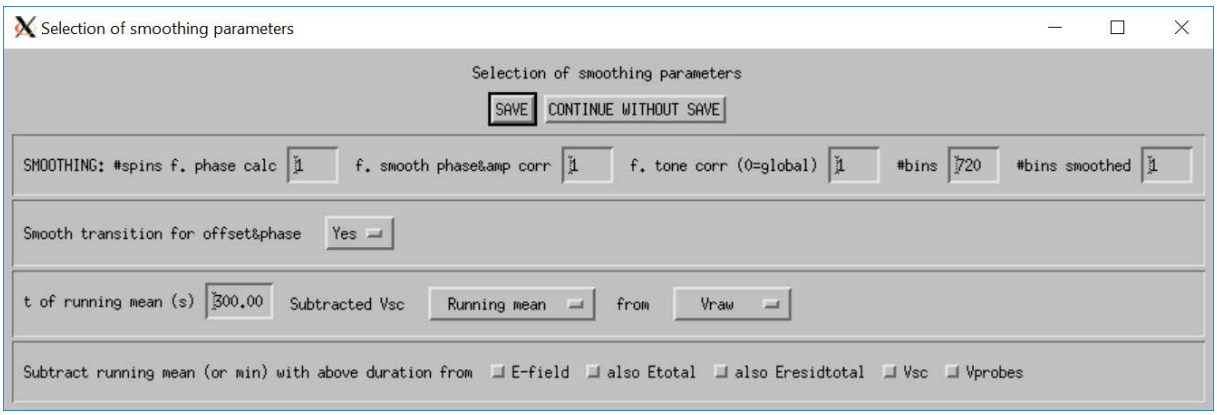
The program mmsedpana has been used to generate spin average data of spacecraft potential, electric field, ASPOC current, electron and ion density, temperature, and current. The files in the distribution cover the time range 2015-09-01 to 2023-05-31. Due to the long processing time, the data have been analysed in batches of 2 months, and for electron and ion data separately. The combination of electron and ion data has been performed by the program mmsedpoutput_merge_ei. The concatenation of the 2-month files has been performed by the program mmsedpoutput_concatenate. The first lines of one of these files are reproduced below.

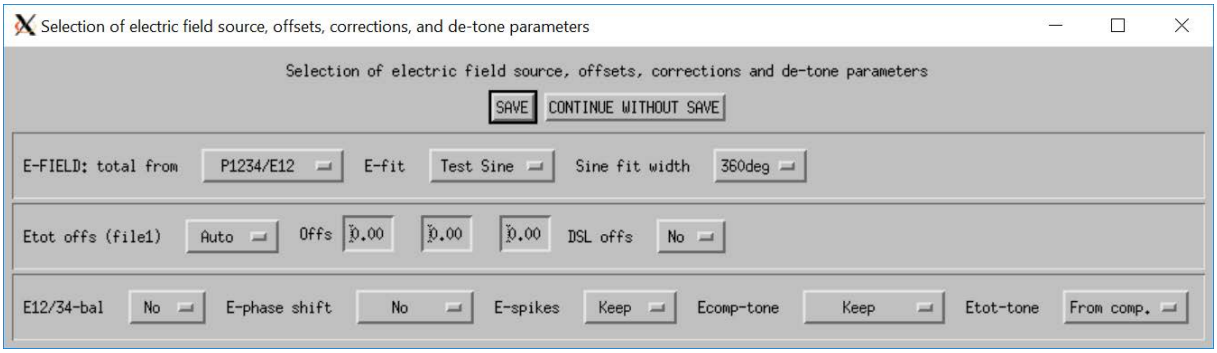
Time[UT]	Phase12	E12ampl	E34ampl	Etotamp	E12offs	E34offs	Vsc	El.Dens	El.Temp	Current	ASP-EDI	IonDens	IonTemp	IonCurr
Time[UT]	[deg]	[mV/m]	[mV/m]	[mV/m]	[mV/m]	[mV/m]	[V]	[cm^-3]	[eV]	[uA]	[uA]	[cm^-3]	[eV]	[uA]
2015-09-01T10:57:15.574	49.690	-0.113	0.845	0.852	1.035	0.209	3.248	0.003	1180.71	0.025	19.704	0.694	5971.97	14.398
2015-09-01T10:57:34.934	72.326	-0.138	1.094	1.102	1.199	0.355	3.265	0.000	0.00	-NaN	19.698	0.657	6358.34	14.074
2015-09-01T10:57:54.293	78.699	-0.129	0.721	0.733	1.196	0.404	3.253	0.004	9408.15	0.092	19.708	0.625	6519.73	13.554
2015-09-01T13:45:17.883	81.981	0.713	0.575	0.916	0.468	0.416	12.186	NaN	NaN	NaN	0.000	NaN	NaN	NaN
2015-09-01T17:55:16.063	75.360	0.469	0.207	0.513	0.982	0.571	3.882	0.880	536.54	5.512	19.704	0.933	5464.22	18.528
2015-09-16T08:07:12.741	86.343	-1.440	3.208	3.517	1.554	0.359	3.709	0.054	1842.15	0.620	19.696	1.566	2285.55	20.132
2015-09-16T08:07:32.101	90.372	-0.269	1.980	1.998	1.355	0.356	3.682	0.026********		2.417	19.702	0.615	5117.68	11.817
2015-09-16T08:08:10.820	93.797	-0.524	-2.161	2.224	1.449	0.316	3.661	0.015	3824.07	0.248	19.701	0.577	5796.00	11.793
2015-09-16T08:08:30.180	85.540	-0.039	-2.596	2.597	1.211	0.261	3.683	0.01521	122.67	0.601	19.697	0.680	5207.62	13.180
2015-09-16T08:08:49.540	88.396	-0.150	-2.481	2.485	1.320	0.138	3.695	0.025	3353.28	0.389	19.704	0.795	4789.27	14.778
2015-09-16T08:09:08.899	84.859	-0.252	-2.151	2.166	1.153	0.205	3.700	0.064	1725.93	0.715	19.704	0.723	5532.54	14.441

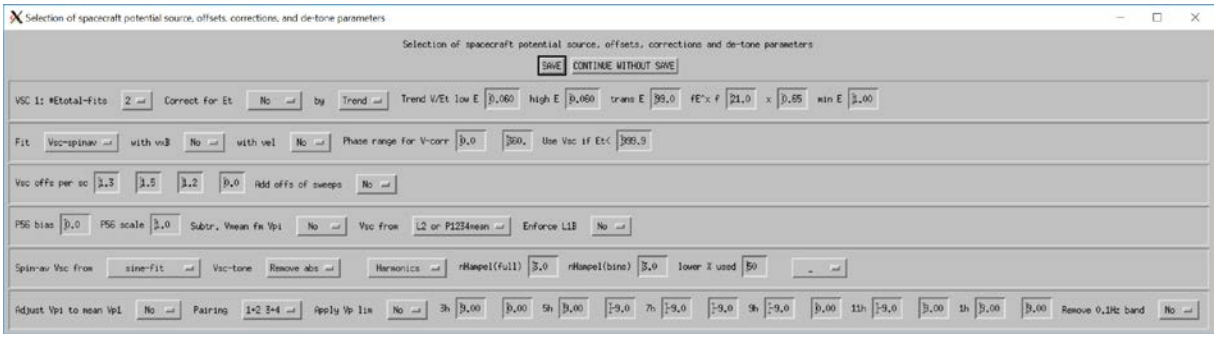
The settings of mmsedpana can be seen in the control panels listed below.

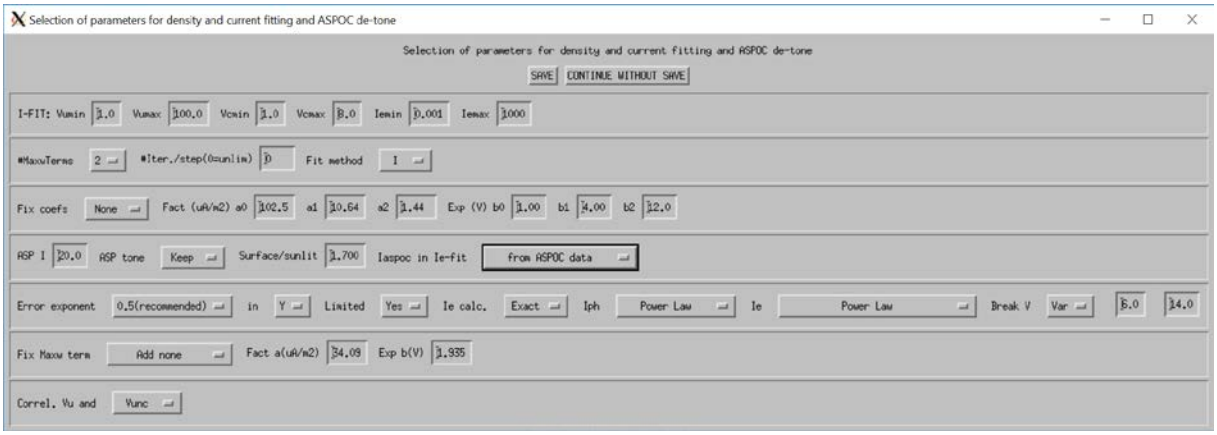


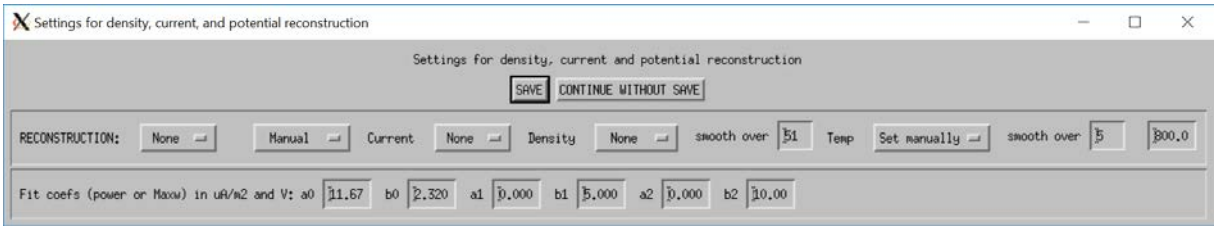


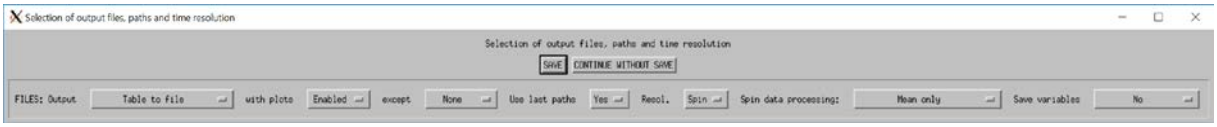

Selection of smoothing parameters
Selection of smoothing parameters
SAVE
CONTINUE WITHOUT SAVE
SMOOTHING: #spins f. phase calc
f. smooth phase&amp corr
f. tone corr (0=global)
#bins
#bins smoothed
Smooth transition for offset&phase
Yes
t of running mean (s)
Subtracted Vsc
Running mean
from
Vraw
Subtract running mean (or min) with above duration from
E-field
also Etotal
also Eresidtotal
Vsc
Vprobes

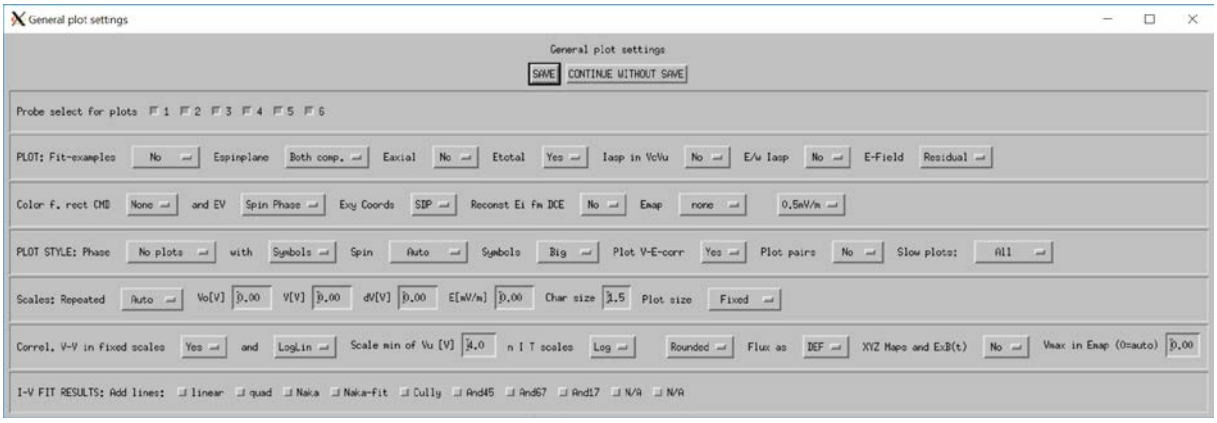

Selection of electric field source, offsets, corrections, and de-tone parameters
Selection of electric field source, offsets, corrections and de-tone parameters
SAVE
CONTINUE WITHOUT SAVE
E-FIELD: total from
P1234/E12
E-fit
Test Sine
Sine fit width
360deg
Etot offs (file1)
Auto
Offs
DSL offs
No
E12/34-bal
No
E-phase shift
No
E-spikes
Keep
Ecomp-tone
Keep
Etot-tone
From comp.


Selection of spacecraft potential source, offsets, corrections, and de-tone parameters
Selection of spacecraft potential source, offsets, corrections and de-tone parameters
SAVE
CONTINUE WITHOUT SAVE


Selection of parameters for density and current fitting and ASPOC de-tone
Selection of parameters for density and current fitting and ASPOC de-tone
SAVE
CONTINUE WITHOUT SAVE
I-FIT: Vumin
Vumax
Vcmin
Vcmax
Iemin
Iemax
#MaxwTerms
#Iter./step(0=unlim)
Fit method
Fix coefs
Fact (uA/m2) a0
a1
a2
Exp (V) b0
b1
b2
ASP I
ASP tone
Keep
Surface/sunlit
Iaspoc in Ie-fit
from ASPOC data
Error exponent
0.5(recommended)
in
Y
Limited
Yes
Ie calc.
Exact
Iph
Power Law
Ie
Power Law
Break V
Var
Fix Maxw term
Add none
Fact a(uA/m2)
Exp b(V)
Correl. Vu and
Vunc


Settings for density, current, and potential reconstruction
Settings for density, current and potential reconstruction
SAVE
CONTINUE WITHOUT SAVE
RECONSTRUCTION:
None
Manual
Current
None
Density
None
smooth over
Temp
Set manually
smooth over
Fit coefs (power or Maxw) in uA/m2 and V: a0
b0
a1
b1
a2
b2





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12 Annex: List of Routines

12.1 Main program

MMSEDPANA

12.2 Routines inside mmsedpana.pro

CURVEFIT
CW_BGROUP
CW_FORM
EP_TICKSD
GAPOPLOT
GETIASPOC1D
GETIASPOC2D
GETIPOWER2D
GETLNIASPOC3PARTS
GETMAXW
GETVSC2D
GET_ASPOC
GET_EDI
GET_EDPBIAS
GET_EDPOFFSET
INCROPLOT
INCROPLOT2
INTERPOL
MATCH
MMSEDPANA
NAKAGAWA_FUNCT
NOTICK
POLY_FIT
POLYFITW (obsolete, may be replaced by POLY_FIT with MEASURE_ERRORS keyword)
POWERTOMAXW
READ_TEXT
REGRESS
TANGENTREPLACE
TIMEAXISD
TWOSLOPES
WHERE_1ASPOC
WHERE_1EDI
WHERE_2ASPOC
WHERE_2EDI

12.3 External routines developed by IWF

ESCAPE
GAUSSSINFIT
INI_FILE

12.4 Third party routines

MPFIT
MPFIT2DFUN
MPFITFUN