MMS dayside (and flank) current sheet database
Update

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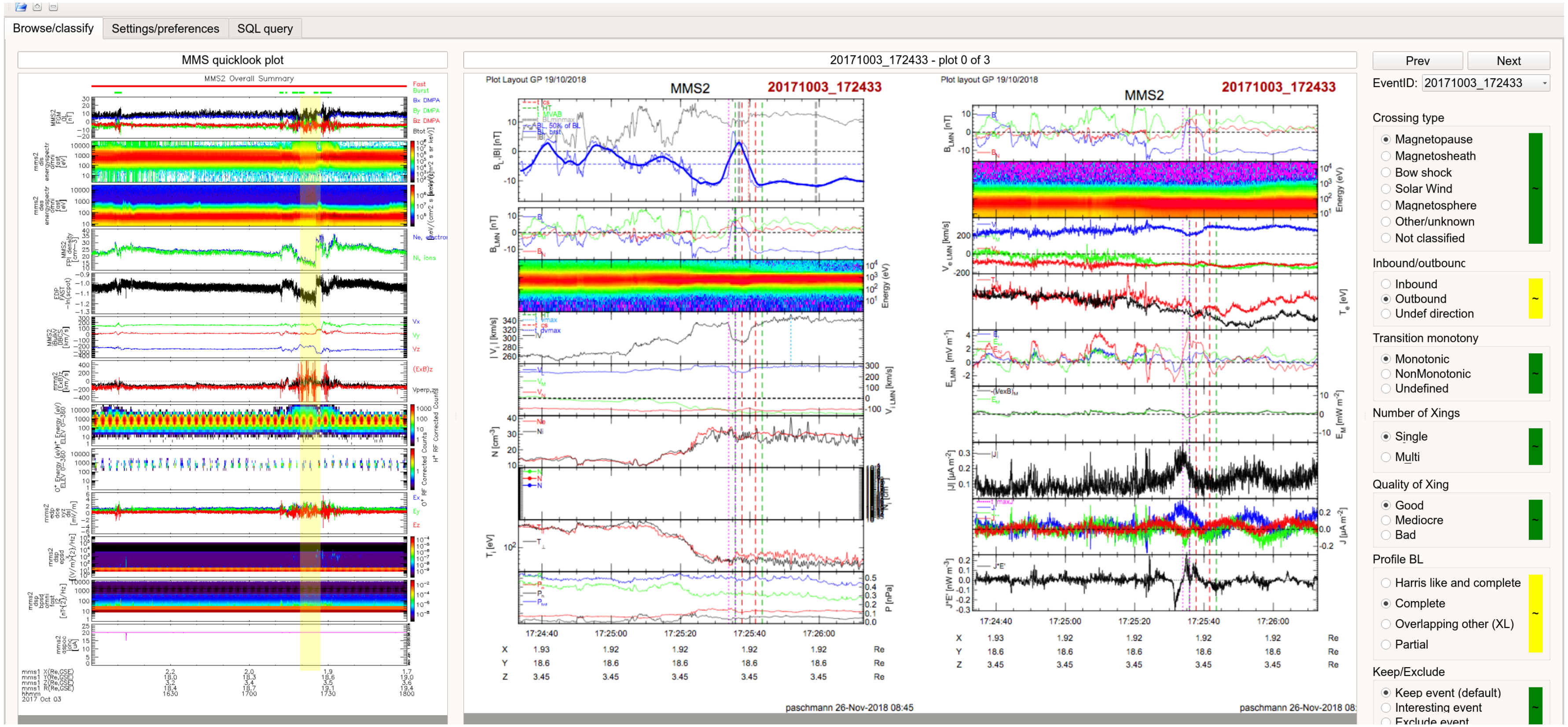
- Builds on ideas/experience from statistical analysis by Cluster flank MP (H14), THEMIS flank MP (H19 or H20?).
- All MMS phase 1 (2015-early 2017) and Phase II (later years) data downloaded, characterized and stored in a large database.
- ca 10000 intervals in Phase I, so far 6700 events for Phase II.
- (Most) intervals classified into category: solar wind, bow shock, m'sheath, m'pause, m'sphere, unknown.
- Focus on **Magnetopause crossings**, but MP, MSH, BS, SW also identified
- Macroscopic parameters (crossing duration, speed, orientation, current density, TD vs RS.....)

- Identify intersting events for further study
- Background parameters (velocity, thickness....) for events
- OMNI data for specific event
- Upstream and downstream HPCA (composition measurements).
- Statistics
- ....

Access method 1: Browse plots, content



GUI tools for UNIX like systems (Linux, MacOS-X..), but open source and written by SH, so anyone with compiler an knowledge can translate to other OS'es (successfully installed MPE, ISS, UiB, SSL Berkeley)

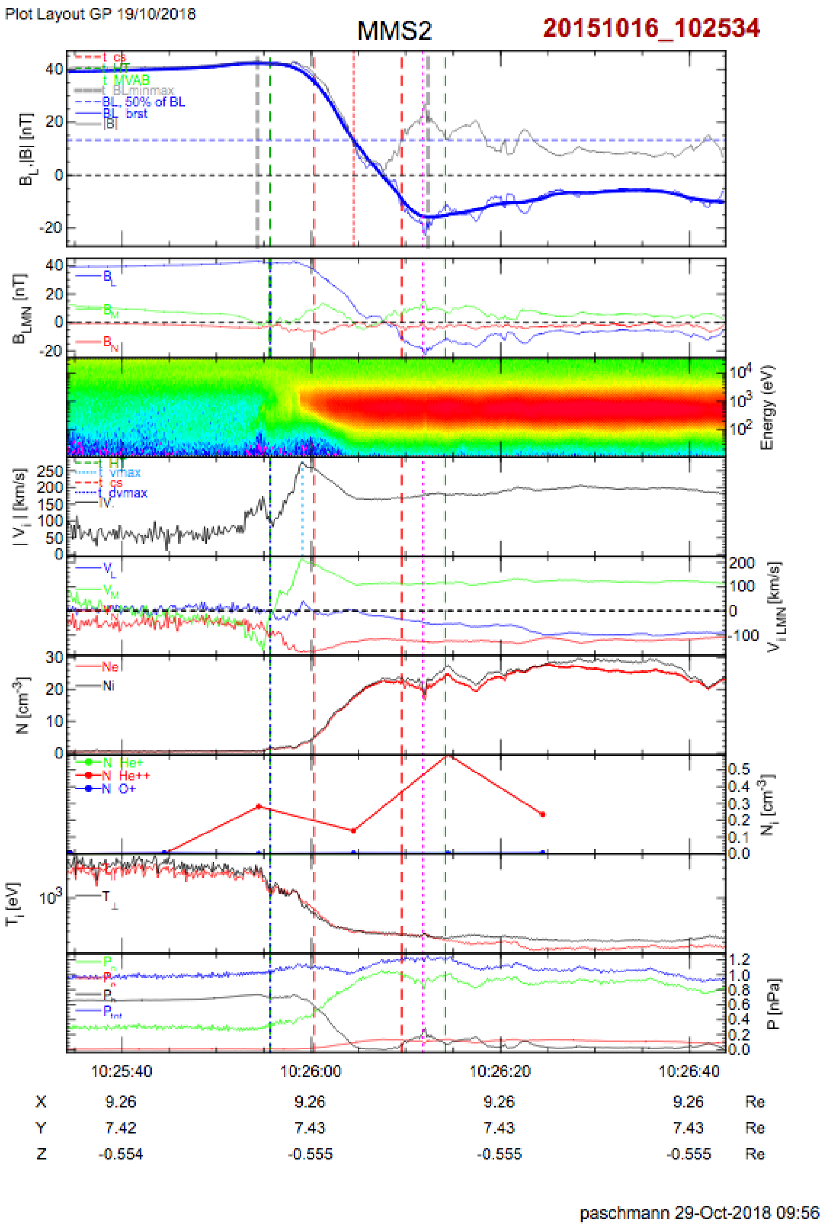
Access method 2: SSH client or SQL client

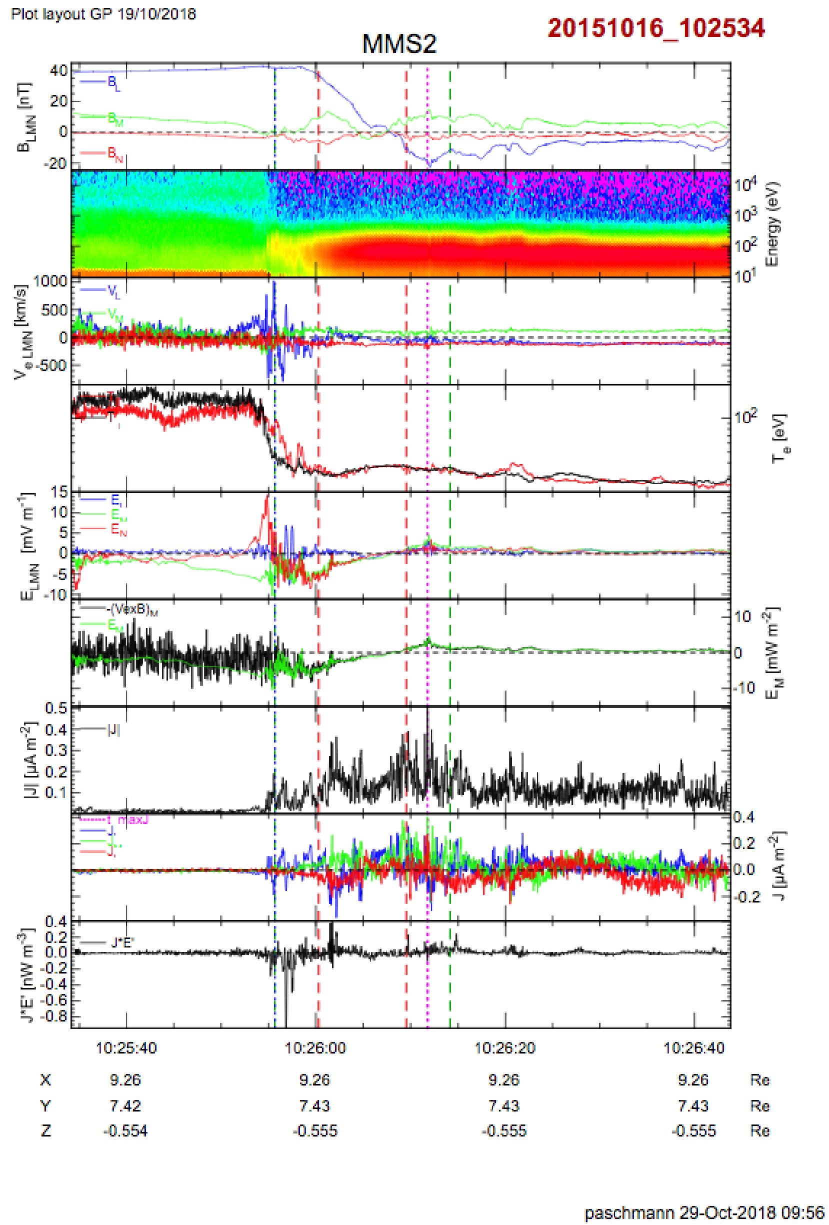
- The DB can be accessed from command line/terminal based ssh client.
- .. or any other (e.g., grahical) SSH client
- .. or any SQL client with SSH capability (e.g., SequelPro for MacOS-X)
- The database can be queried using standard SQL language.
- .. the simplest SQL would select ALL parameters and export to *.txt file
- .... but don't ask SH why your disk got full, or how to decode text files.
- In the team, I know that Paul T has extensive experience with DBs, SQL
- An IDL structure that combines all tables (static, phase 1 only, not updated) is available from Tai Phan, SSL, together with a description of the parameters.
- Database tables comprise just MMS2up updated tables (phase I and II), and evolves as new events are added.
- MMS1, 3, 4 tables exist in an earlier version (less parameters) for phase I.

- Step 1: run a script that downloads the data, one month at a time
  - brst-mode FGM, FPI moments, HPCA
  - EDP fast data
  - plus 9 minutes FGM srvy data for each event
  - plus corresponding 1-min. resolution OMNI data (IMF, SW, propagated; AE, DsT, F107) from CDAWeb
  - ca. 10000 intervals total for Phase 1, approx 6700 events for phase II
- Step 2: run a script that tells the QSAS analysis system to build so-called 'Working Lists' (WLs) for all events from a full month; the WLs contain all the needed time series, and are analyzed in Step 4. The (zipped) WLs are permanently stored on a Dropbox account, so that they are available for any reprocessing (such as became necessary after our September 2018 team meeting)
- Step 3: delete the underlying data to save storage space

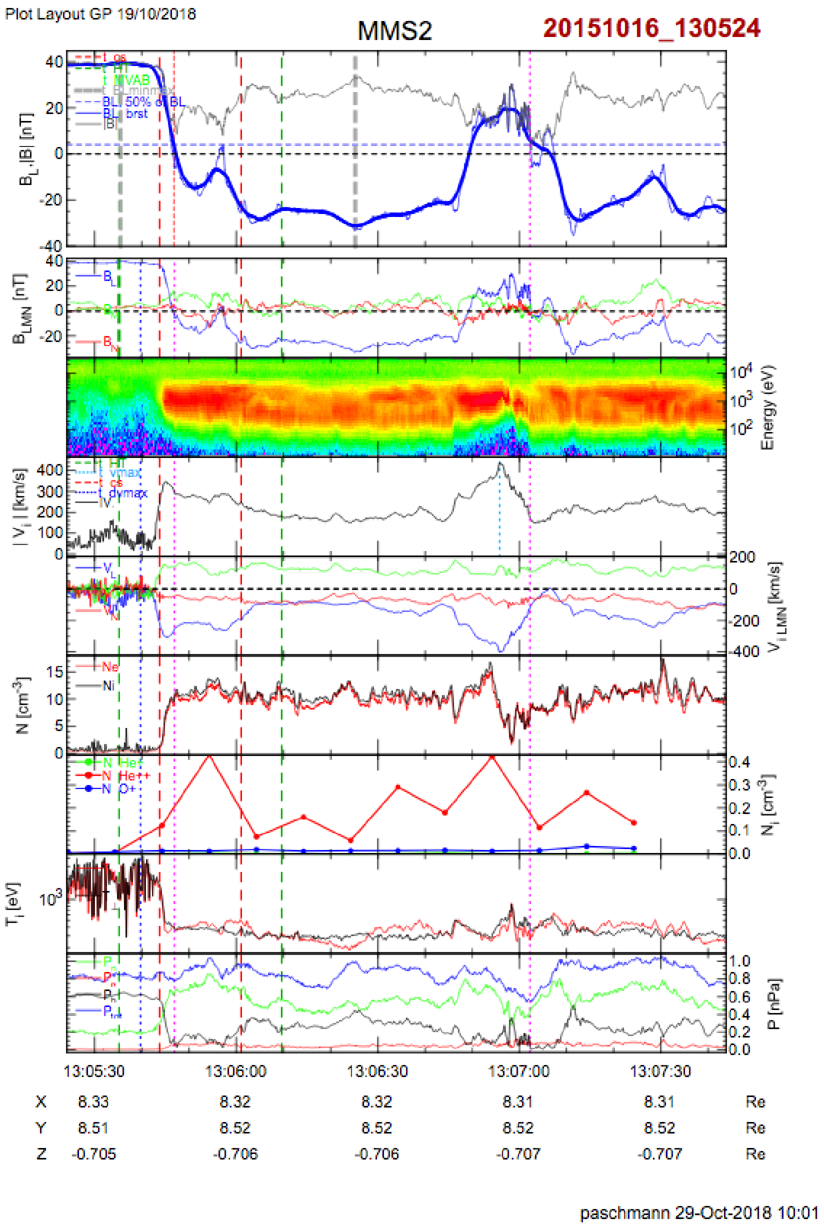
- Step 4: run a QSAS batch file that analyzes the data in the WLs, makes plots, and exports to the database. In detail:
  - calculate $\boldsymbol{J}_p$, using ion and electron bulk velocities and electron densities
  - run unconstrained MVAB over full brst interval to get LMN needed for the search routines
  - find characteristic times in the B_L, B, V_L, V, and J time series, as explained on the next pages
  - if a burst interval contains several crossings, only one is analyzed
  - determine the sense of the crossings from sign(ΔB_L)
  - run MVAB and Minimum-Faraday-Residue (MFR)
  - run the HofTel routine to determine the deHoffmann-Teller frame and test the Walén relation
  - extract $\boldsymbol{B}, \boldsymbol{V}, N, T_{\|}, T_{\perp}$ (i & e), and $\boldsymbol{J}_p$, at the characteristic times described in later pages
  - create low-resolution overview plots in a new format for all events (examples on next pages)
  - export the selected quantities to the DB

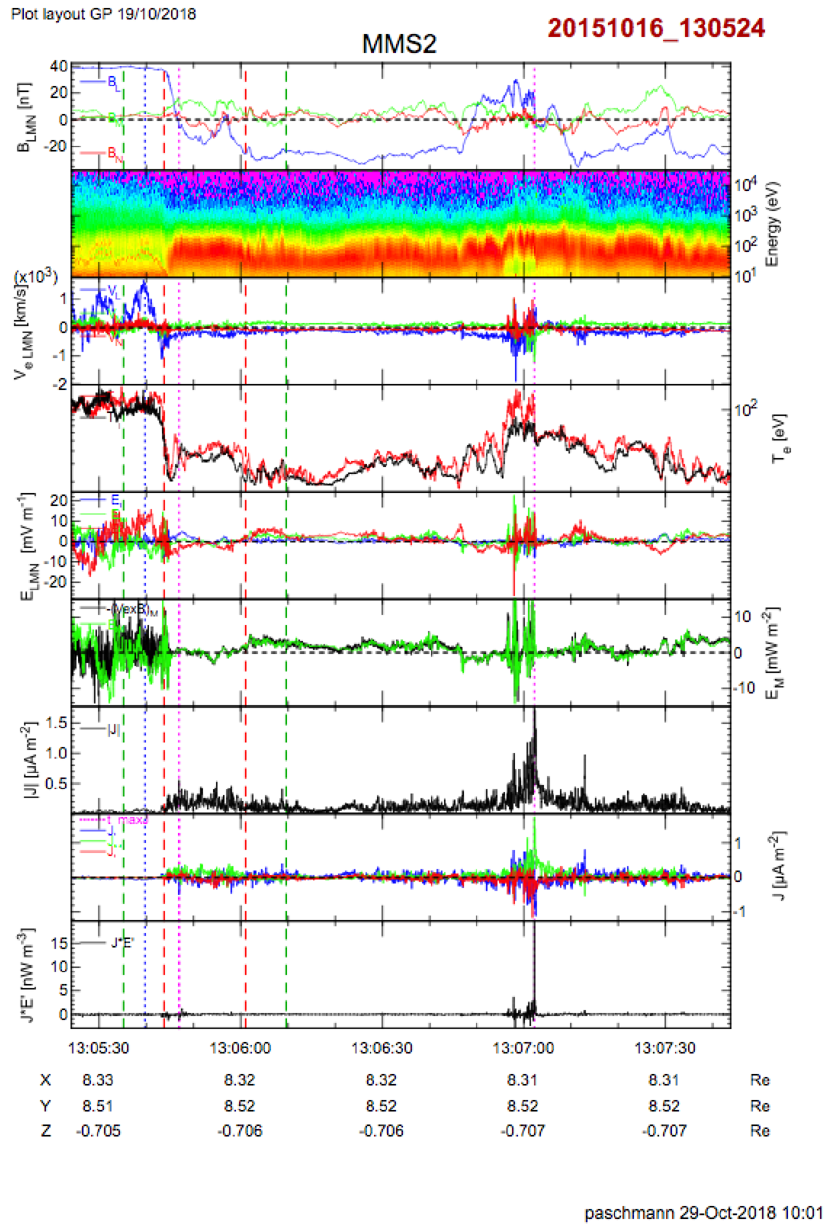
Overview Plots I





Overview Plots II





Identification of the width (duration) of the current sheets was the starting point for the creation of the MMS database. Here is how it is done:

- a search routine scans the B_L time series, finds the time, t_0, where 50% of the transition has occurred (the orange line in the left figure), and from there moves up and down the B_L curve by 38% to find the times, t_{88} and t_{12}, where 88% and 12% of the transition are reached, respectively (the red lines in the figures) [1]
- the interval $t_{cs} = t_{88} - t_{12}$ (between the red lines) is taken as the current sheet crossing duration
- extending the t_{cs} interval by 50% on both sides, we get the time interval, t_{ht}, between the green vertical lines, which covers the full transition in almost all cases.

[1] The 76% jump between the two times was chosen because in a hyperbolic tangent curve representing a Harris sheet, 76% of the total change occurs within the characteristic time interval 2 τ - see e.g., H04, H14

The search routine also identifies a number of other characteristic times:

- the time, $t_{max\,J_p}$, where the current density J_p maximizes in the t_{ht} interval
- NEW the time, $t_{max\,J_p\,brst}$, where J_p maximizes in the full t_{brst} interval
- the time, $t_{max\,\Delta V}$, where the magnitude of the difference, $|\Delta\boldsymbol{V}|$, between the local ion bulk velocity vector and the velocity at the magnetosheath reference time (i.e., at the green line on the magnetosheath side), maximizes in t_{ht} interval
- the time where the ion bulk velocity magnitude, V, maximizes in t_{brst} interval
- the time where B has a minimum in t_{ht} interval

where t_{ht} refers to the tome interval between the two green lines in the plots and t_{brst} to the full burst interval.

NEW: At the September 2018 ISSI team 442 meeting it was decided to do the searches on parameters whose time series have been linearly joined onto the electron time tags, so that they now all have the electron cadence. The characteristic times ($t_{max\,Jp}$, $t_{max\,Jp\,brst}$, $t_{max\,\Delta V}$) therefore now have electron time-resolution. Note that for some of the slower-cadence parameters, the linear joining onto the faster electron tags does not obey Nyquist.

Data extracted from the time series at the characteristic times, defined in the previous pages, as well as results from running MVAB, MFR, HofTel, are exported into four separate tables in the MMS database, at present only for MMS2. The tables with subscript 'up' are new and include the improvements decided at the September 2018 team meeting. The OMNI table is universal.

- MMS2/MMS2up
- MMS2-ions/MMS2up-ions
- MMS2-elctrns/MMS2up-elctrns
- MMS2-misc/MMS2up-misc
- MMS-OMNI

- EventID
- SC position (at start time of brst interval)
- GSE components of L, M, N, based on MVAB for full brst-interval
- $\boldsymbol{B}$ at start and end of the intervals t_{brst} and t_{ht}
- characteristic times $t_0, t_{12}, t_{88}, t_{max\,\Delta V}, t_{max\,Jp}$
- absolute B_{min} and its time t_{Bmin}; B_{minCS} within the current sheet
- MVAB and MVAB0 eigenvectors, eigenvalues, B_n, for interval $t_{mvab} = t_{ht}$

- GSE components of $\boldsymbol{B}$, $\boldsymbol{V}_i$; $N_i, T_{i\|}, T_{i\perp}$ at:
  - start and end times of the full burst interval and the interval t_{ht} (between green lines)
  - times $t_{max\Delta V}$, and t_{maxJ}
- $T_{i\|}, T_{i\perp}$, averaged over t_{cs} (between the red lines)
- dis error flags
- H^+, He^+, He^{++}, and O^+ densities from HPCA at beginning and end of burst interval

- GSE components of $\boldsymbol{E}$, $\boldsymbol{V}_e$; $N_e, T_{e\|}, T_{e\perp}$:
  - at start and end of the t_{brst} and t_{ht} intervals
  - and at times $t_{max\Delta V}$ and t_{maxJp}
- des error flags

- deHoffmann-Teller and Walén analysis results for ions and electrons, for 3 intervals ($t_{ht}, t_{ht1max}, t_{maxht2}$, see below))
  - $\boldsymbol{V}_{\mathrm{HT}}$ and HT correlation coeficient
  - Walén -slope and -correlation coefficient
- MFR results (normal, V_n, eigen-vectors and -values), for interval $t_{mvab}(= t_{ht})$
- $\boldsymbol{J}_p$ at t_{maxJ}
- $\boldsymbol{J}_p$, averaged over t_{cs}
- $t_{maxJ,brst}$
- $\boldsymbol{B}, \boldsymbol{V}i,e, Ni,e, Ti,e_{\parallel}, Ti,e_{\perp}$, $\boldsymbol{J}_p$ at $t_{maxJ,brst}$

t_{ht1max} is the interval between the start of the t_{ht} interval and $t_{max\Delta V}$, while t_{maxht2} covers the remainder of the t_{ht} interval.

Table MMS-OMNI

The OMNI table contains 1-min. resolution data from CDAWeb

- IMF and SW, propagated to the magnetopause
- AE
- Dst
- F107

- derivable quantities (e.g., $\boldsymbol{V}_{\mathrm{A}}$, P, α, β, DV^*, LMN-components of vector quantities, etc.) are NOT stored in the database
- functions have been created that calculate these quantities from the data in the database, for example:
  - shear angle
  - IMF and MMS clock angles
  - current sheet (CS) crossing duration, t_{cs}
  - current sheet speed $V_n = \boldsymbol{V}_{\mathrm{HT}} \cdot (N_{mvab}$ or $N_{mvab0})$,$V_{n,mfr}$
  - current sheet thickness $d = t_{cs} * V_n$
  - normalized current sheet thickness d/λ
  - $\alpha, \beta, \lambda, r_{gyro}$ upstream and downstream
  - new scalar parameter Q to check Walén jump relation
  - T_{inflow}
  - asymmetric $\boldsymbol{V}_{\mathrm{A}}$
  - inflowing magnetic energy
  - He^+/H^+, He^{++}/H^+, O^+/H^+ density ratios

Event Classification

The event classification involves the following steps:

- query DB for MP candidates
  - by selecting crossings with certain properties, such as $B_{L,msph} > 20\,\mathrm{nT}$
- export selected events to a file
- open file in Stein's imgcomp too, which displays overview plots and corresponding 2-hour QuickLook plot
- by visual inspection, identify:
  - event-type (mp, msph, msh, bs, sw)
  - crossing-direction (i=inbound, o=outbound)
  - bl-profile (mon=monotonic, nmon=nonmonotonic)
  - fit-quality (gf=good, mf=mediocre, bf=bad)
  - crossing-number (s=single, mult=multiple)
  - crossing-completeness (compl=complete, part=partial, over=too wide, harri = Harris-like)
- classifications are stored as 'FlagStr' in the MMS2 table (and will eventually be transferred to the MMS2up table)

Classifications were initiaded GP; TP. and MØ. are classifying dayside (Phase 1 only); SH (flanks, phase II, flanks)