SOLAR ORBITER
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Poster 137

Merging of MAG and RPW/SCM magnetic waveforms on Solar Orbiter: preliminary results

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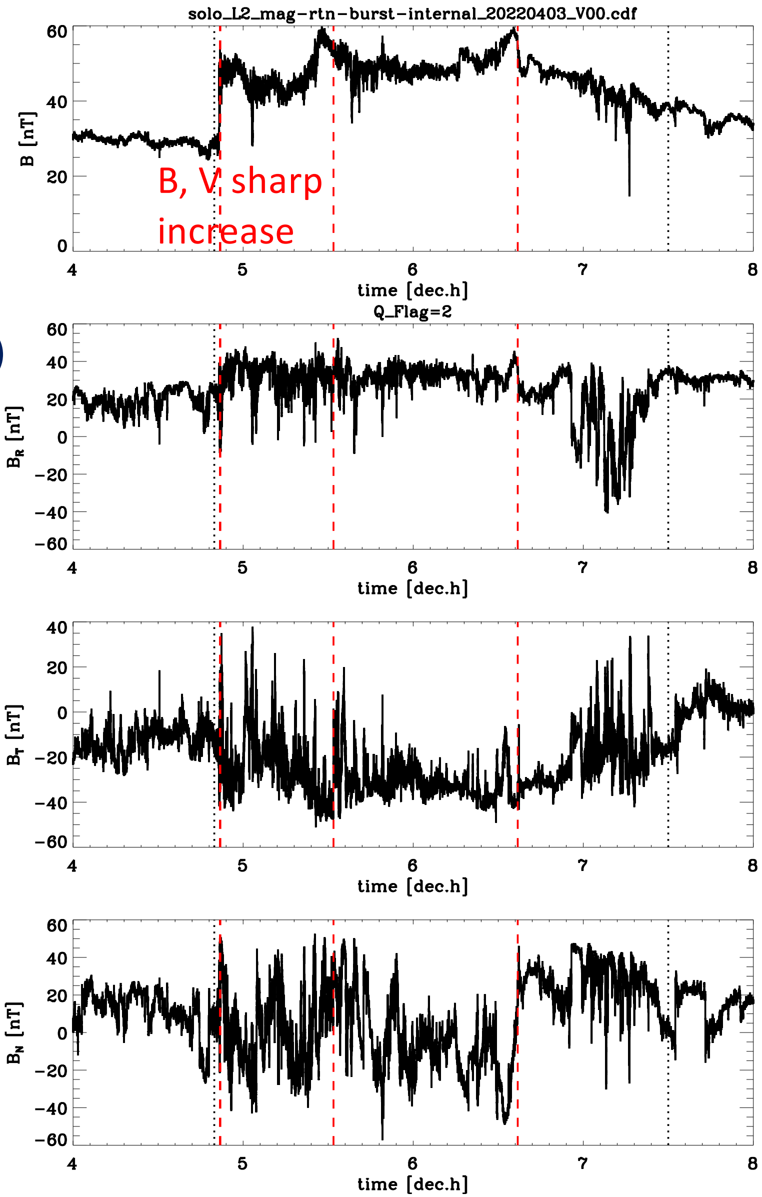
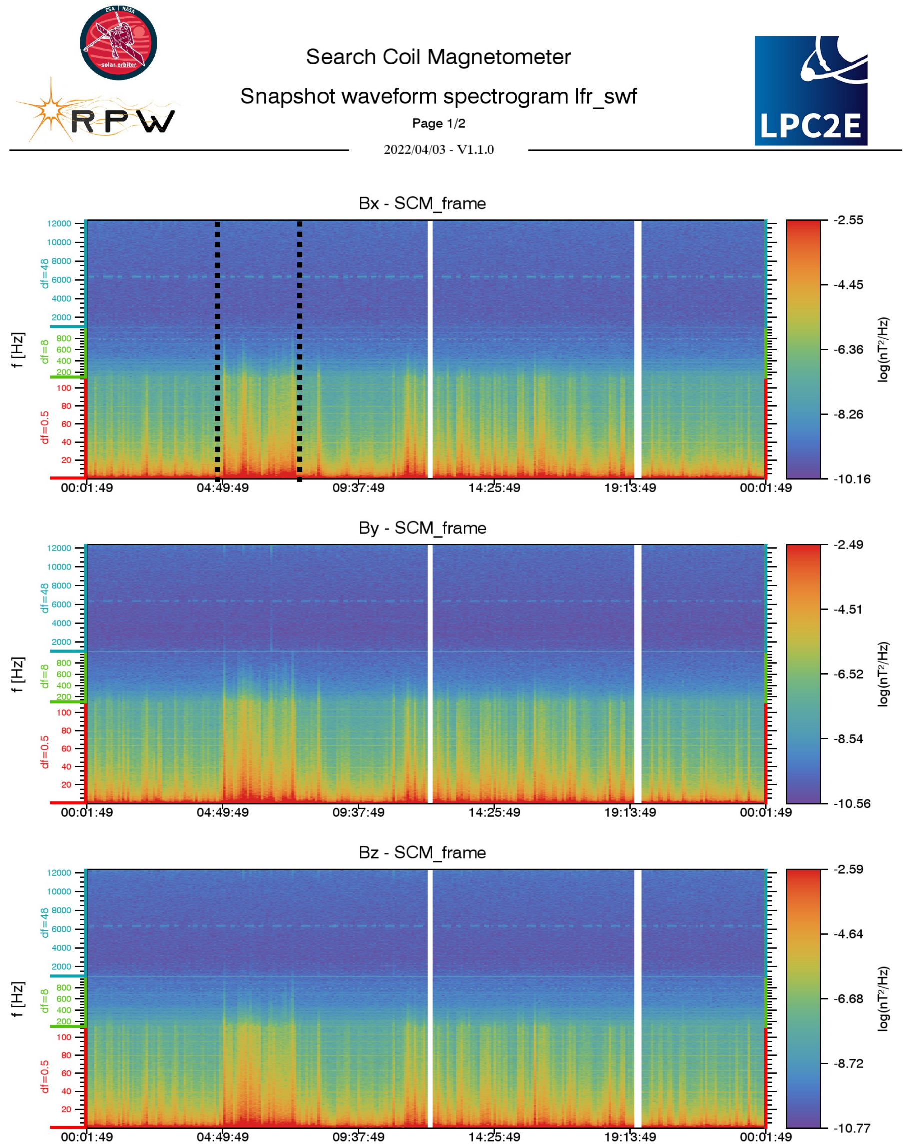
MAG & SCM 2022-04-03 discontinuity at ~4:50 UT (V~550 =>700 km/s)

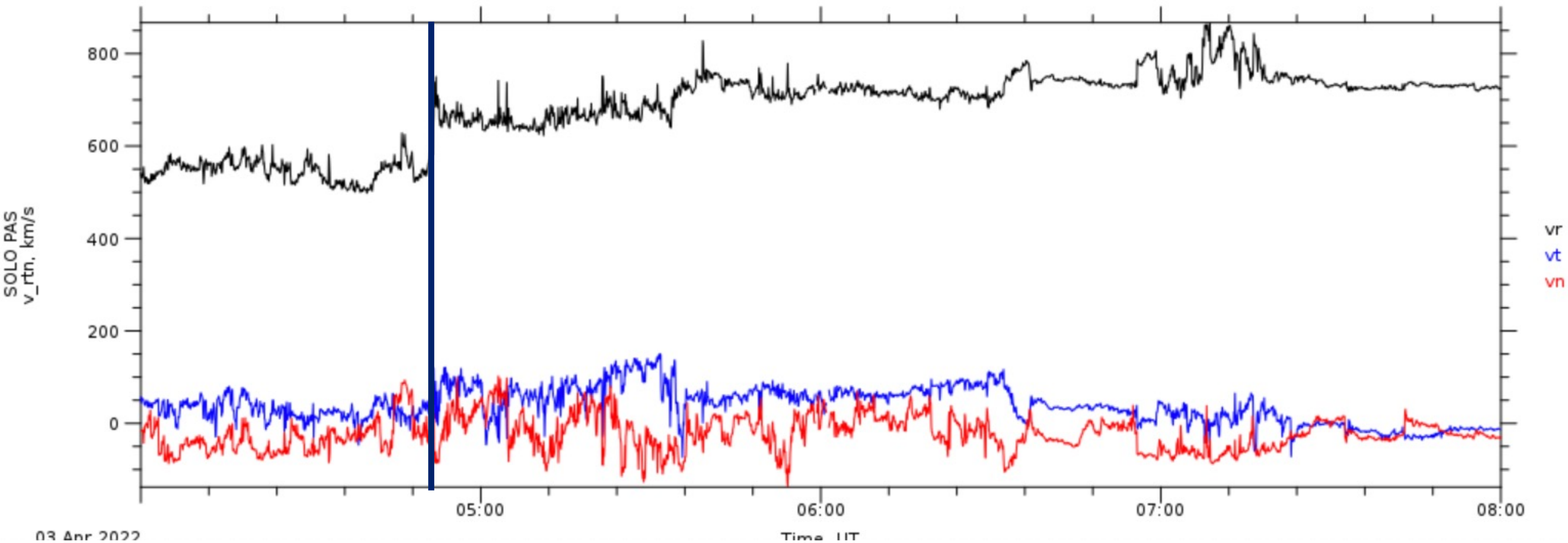
Strong signal is detected on SCM.

SCM snapshots:
8 s : 256 Hz
0.5 s : 4096 Hz
0.083 s: 24576 Hz (2048 data points)



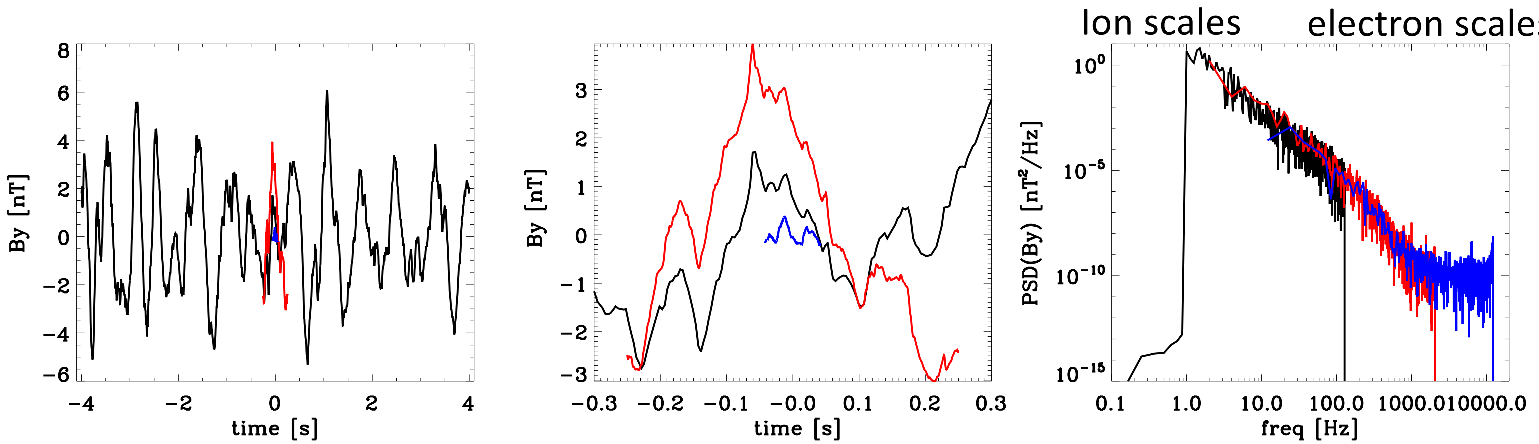


SOLO PAS on 2022-04-03
plot with AMDA/CDPP



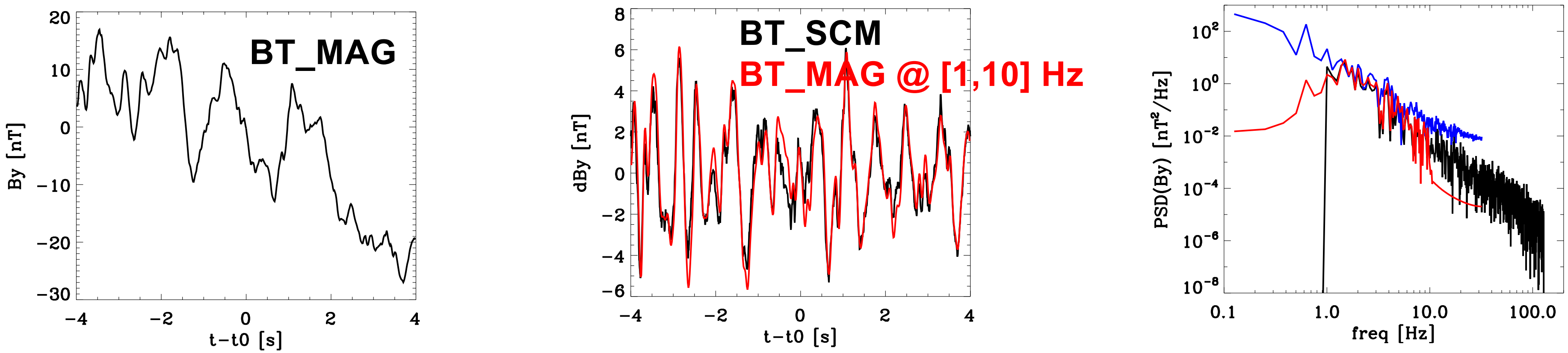
=> Discontinuity at ~04:50 UT is a boundary of different solar wind flows

The most intense snapshot at 4:51:53 UT within the strong gradient of |B| and |V|
V ~ 550 => 700km/s



8 s : 256 Hz
0.5 s : 4096 Hz
0.083 s: 24576 Hz

MAG & SCM comparison



Comparison MAG/SCM

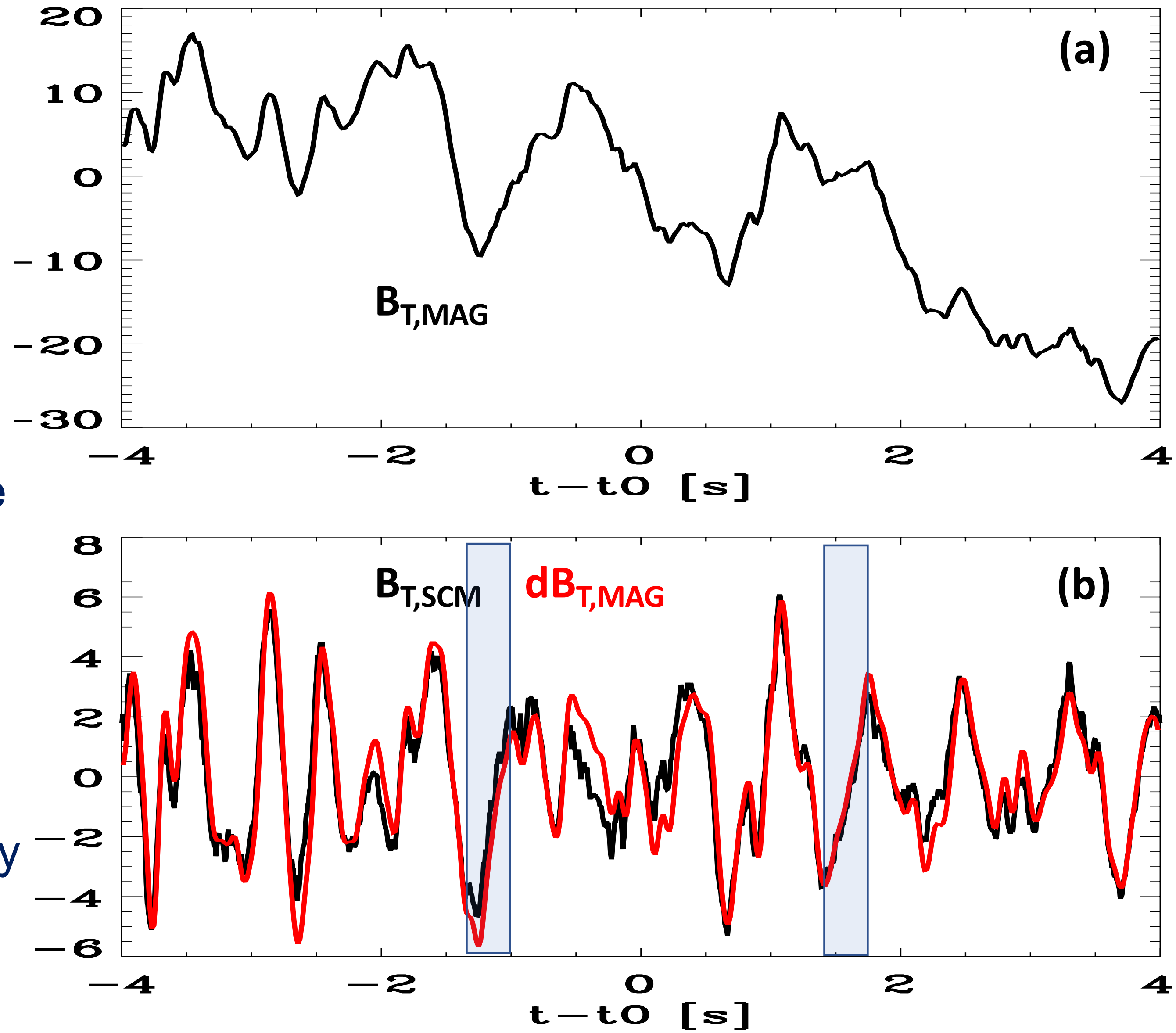
(a) ZOOM on B_T component.

(b) SCM (black lines) &
Band-pass-filtered MAG @[1,10] Hz (in red)

Nice correspondence within the frequency range of the overlap, i.e., 1-10 Hz.

Is there a time delay between MAG and SCM?

Let's take 5 Hz as the frequency of merging (see RPW meeting on 17/06/22)



Merging procedure using Haar Wavelets (Andre's method),

see appendix of [Alexandrova, Mangeney et al. 2004, JGR]

- Let's consider B_j (j=x,y,z) magnetic field component on MAG, B_{j_mag}, and its corresponding time, t_{mag}, during the SCM chosen snapshot of 8 seconds (256 vectors/sec data), B_{j_scm}, t_{scm}. (We omit 'j' below).
- We interpolate B_{mag} data on t_{scm} time grid with dt=1/256 time resolution.
- We perform Haar WT of interpolated B_{mag} and of B_{scm}=> we get two sets of wavelet coefficients W_{mag} & W_{scm}, which depend on time t and time scale τ. We combine these coefficients in the following way, where m is the scale index and m_0 corresponds to the merging time scale of 0.2 sec (5 Hz). The inverse WT gives B_{mix}.

$$W_{\text{mix}}(m,t) = a_m W_{\text{scm}}(m,t) + b_m W_{\text{mag}}(m,t)$$

$$a_m = \begin{cases} 1, & \text{for } m < m_0 \\ 2^{-2(m-m_0+1)}, & \text{for } m \geq m_0 \end{cases}$$

$$b_m = 1 - a_m$$

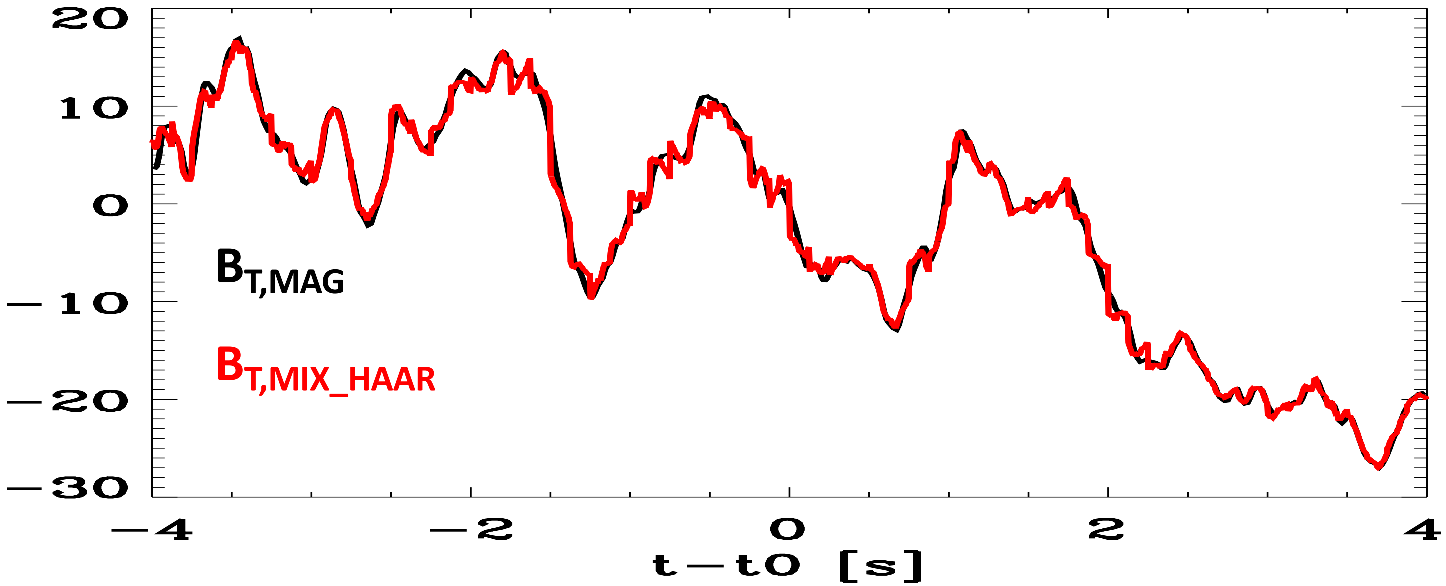
$$\tau_m = 2^m dt_{\text{scm}}$$

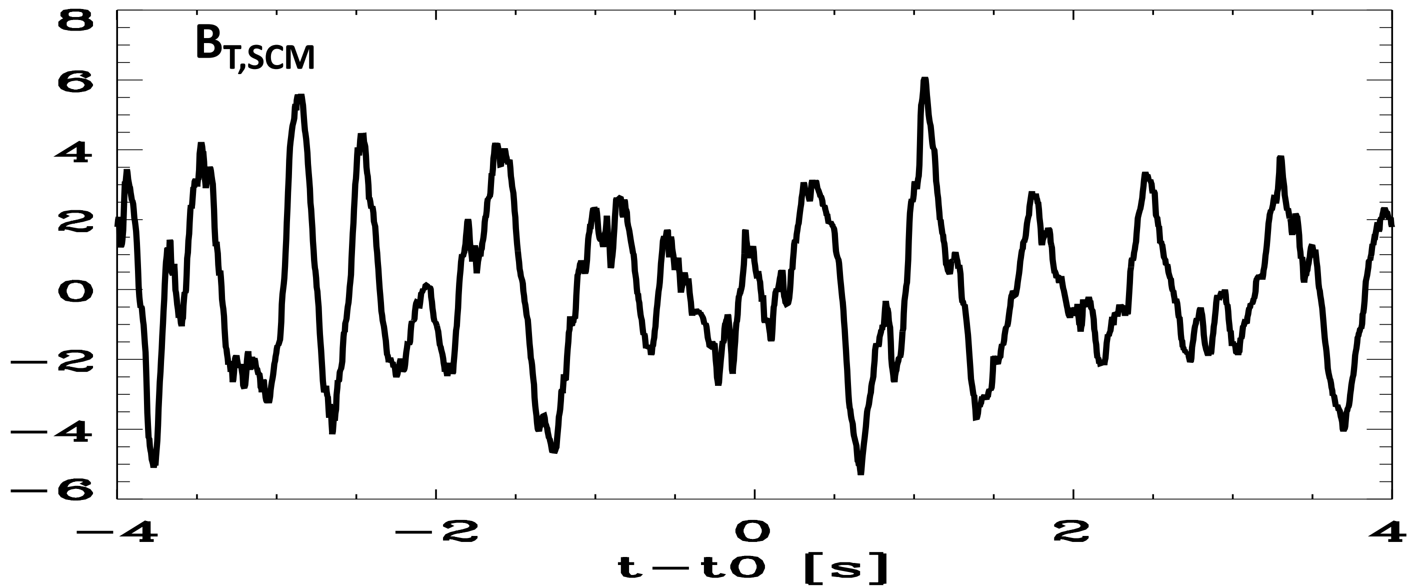
$$\tau_0 = 0.2 \text{ s}$$

Merging in wavelet's space

(Cluster heritage)
f_0=5 Hz

B_T component

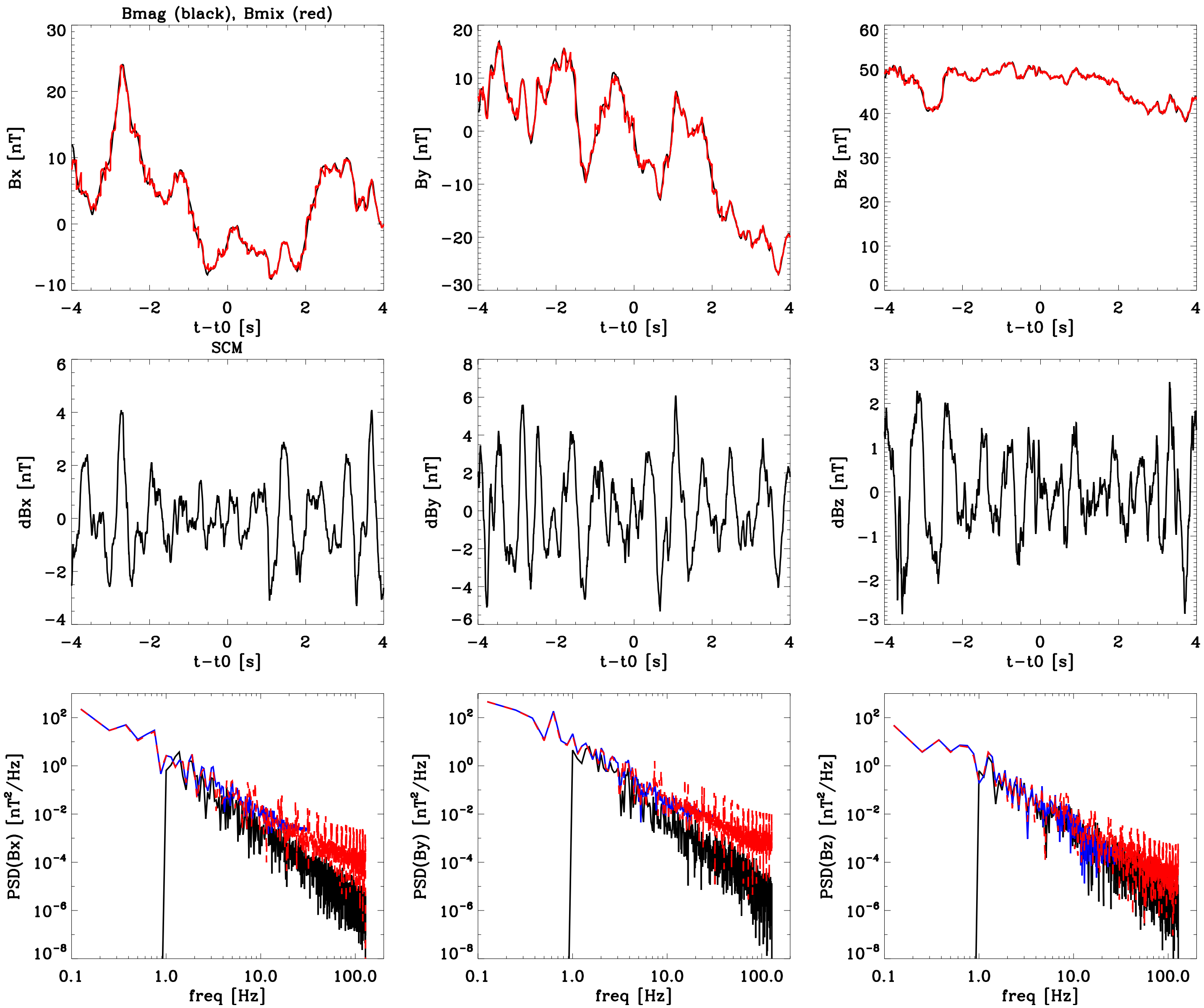




Merging in wavelet's space

(Cluster heritage)
f_0=5 Hz

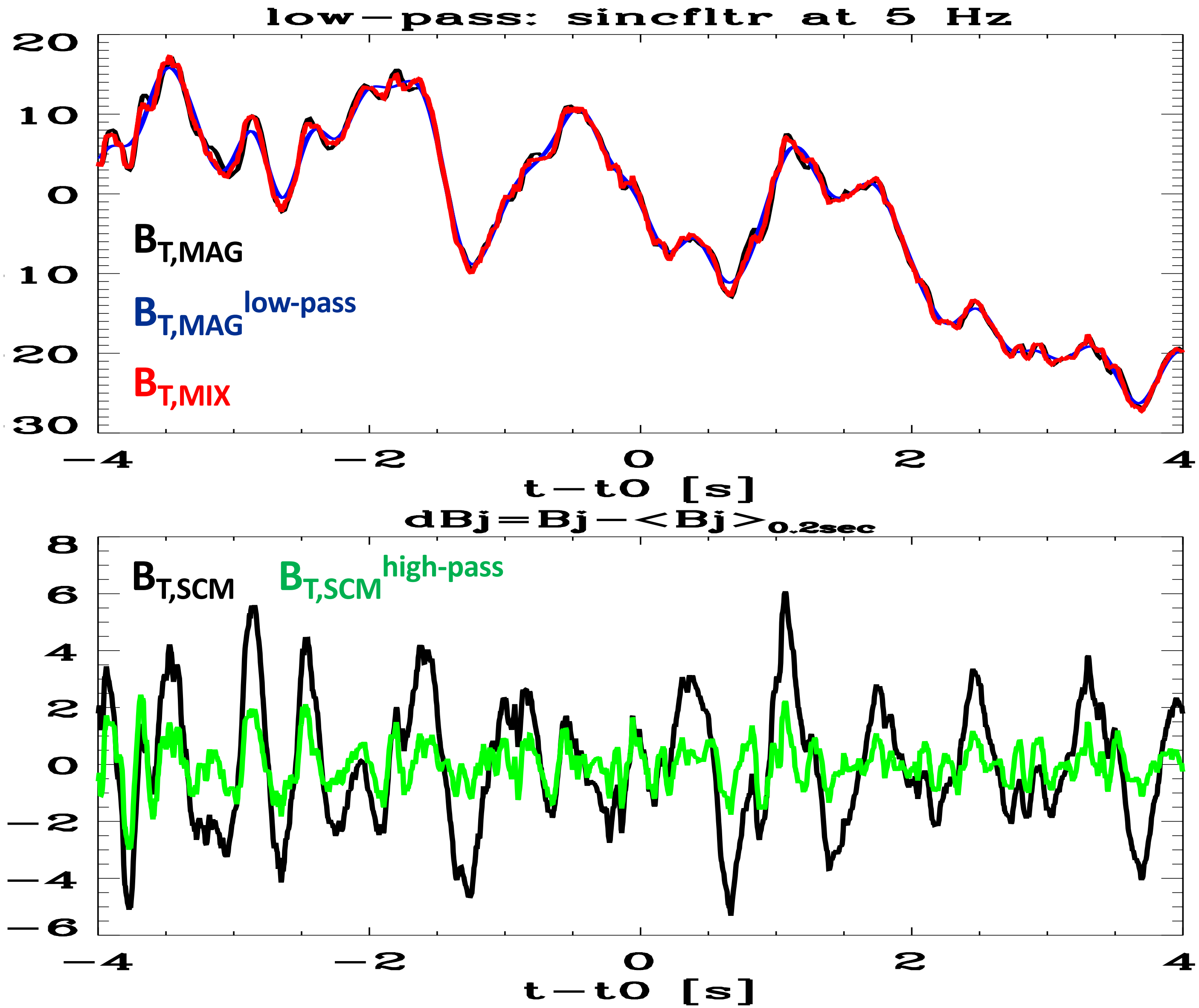
NB: PSDs of B_{mix} data contain high frequency noise due to non-periodicity of the signal (there is a strong discontinuity at the boundary).



Merging in time space

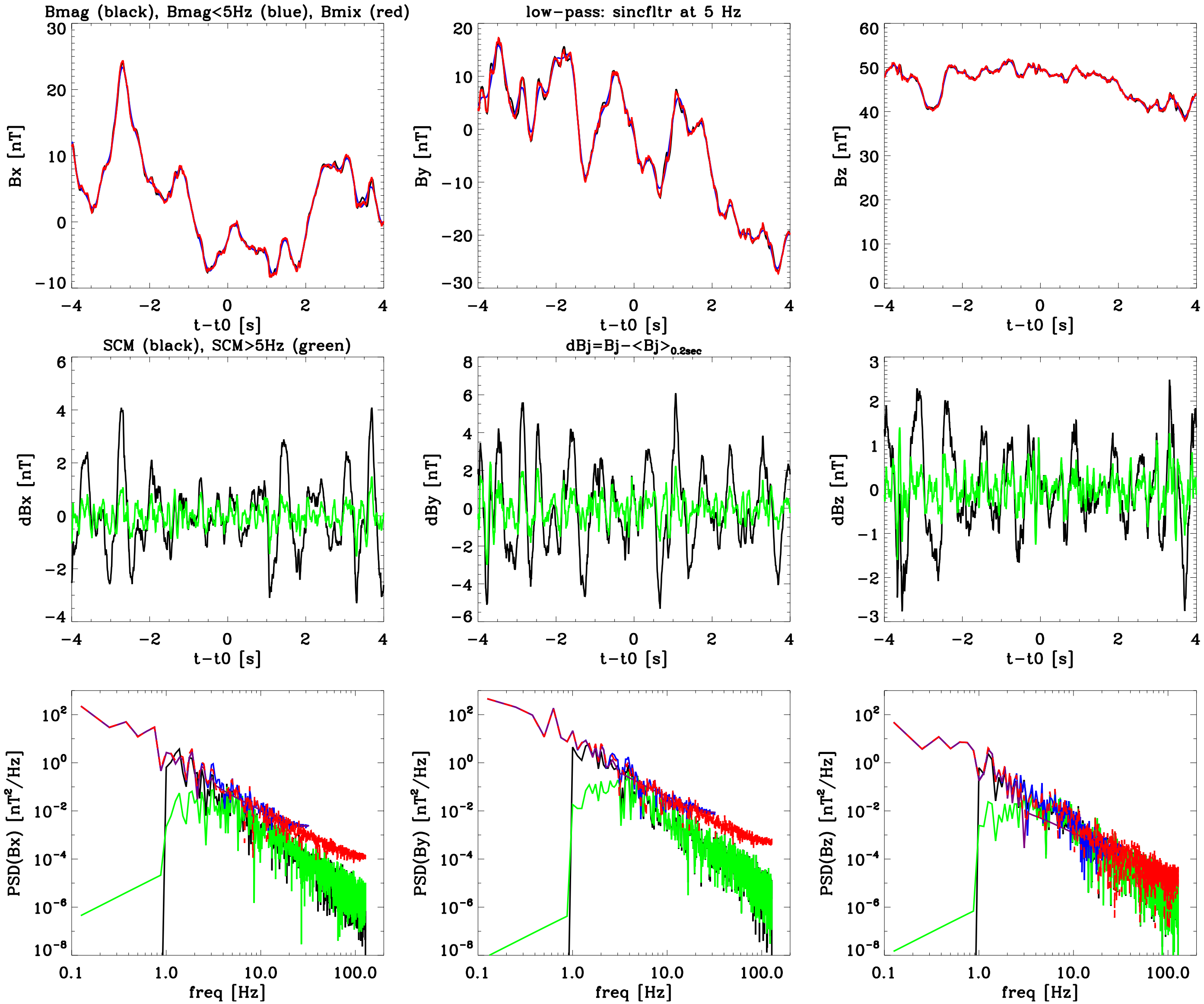
(MMS heritage)
f_0=5 Hz

ZOOM on B_T



Merging in time space

(MMS heritage)
f_0=5 Hz



Discussion

- We attempt to merge low frequency MAG data with high frequency SCM data.
- RPW/LFR/SCM snapshots are complex data: every 5/10 min we have 3 snapshots of different length T and sampling frequency f_s but with the same number of data point in each, N=2048 :

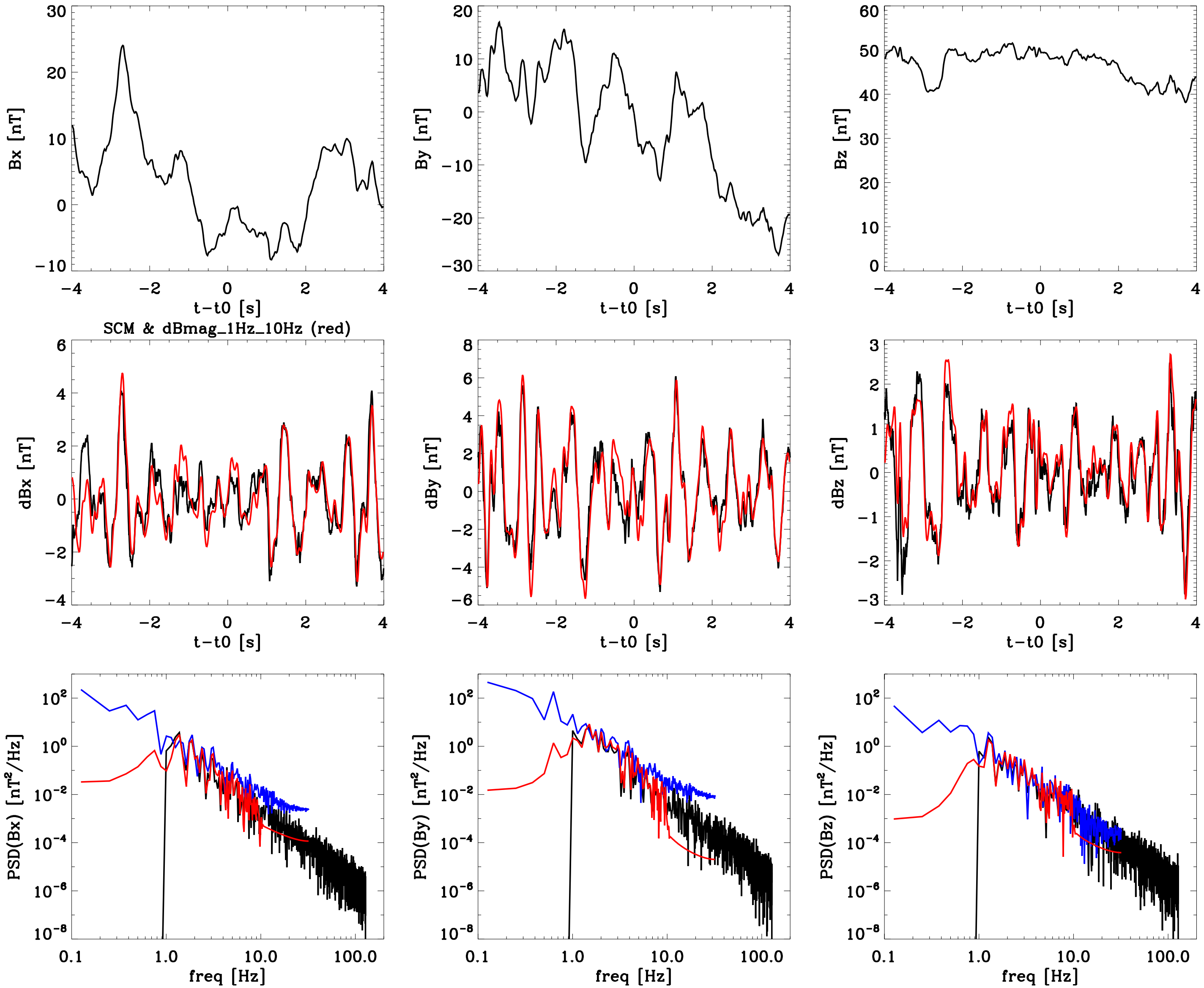
  (1) T=8 s, f_s=256 Hz
  (2) T=0.5 s, f_s=4096 Hz
  (3) T=0.083 s, f_s=24576 Hz

- Merging of B_{mag} with $B_{scm(1)}$ is done around f_0=5 Hz using Haar WT and in time space using classical sin(x)/x filter.
- Next steps:
  - time delay between MAG and SCM ?
  - sort out the edge effects (mirror-reverse the same time interval, …?)
  - continue the procedure for high-frequency data: merge B_{mix} with $B_{scm(2)}$ and then this new product merge with $B_{scm(3)}$
  - test the procedure with different energy level SCM data
  - test different f_0 for each level of merging (MAG + 3 SCM snapshots)
  - choose the best approach: WT space vs time space merging
  - apply to all data ? or produce merged data on demand ?

Comparison MAG/SCM in RTN for the snapshot at 4:51:53 UT

SCM (black lines) & Band-pass-filtered MAG @[1,10] Hz (in red)

Corresponding PSDs



Examples of snapshots in maxima of $|B_{MAG}|$

SCM snapshots within the discontinuity ramp (one of the strongest signal)

t_{start} =4.86484 dec.h = **4:51:53.424 UT**

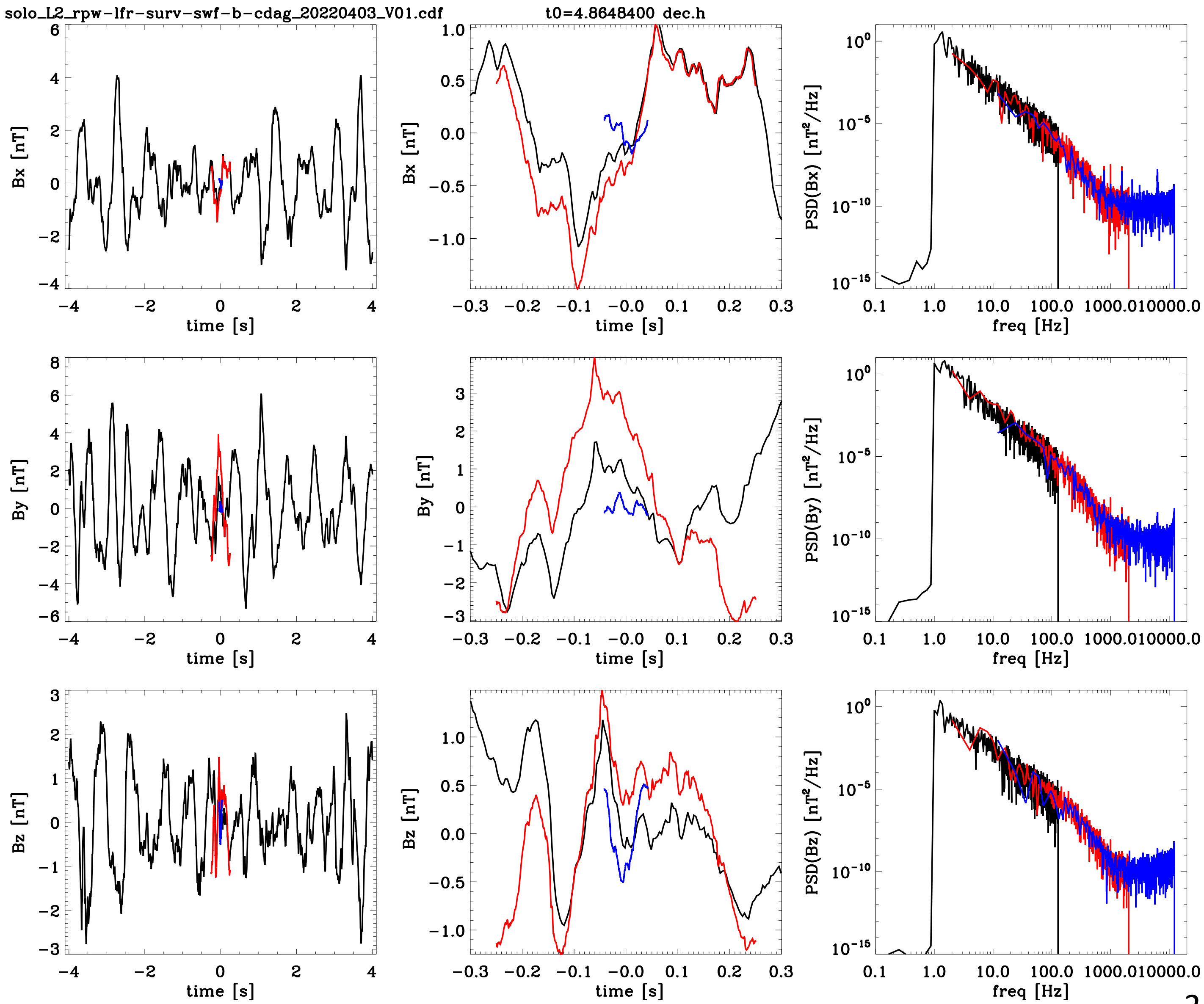
SCM snapshots:

8 s : 256 Hz

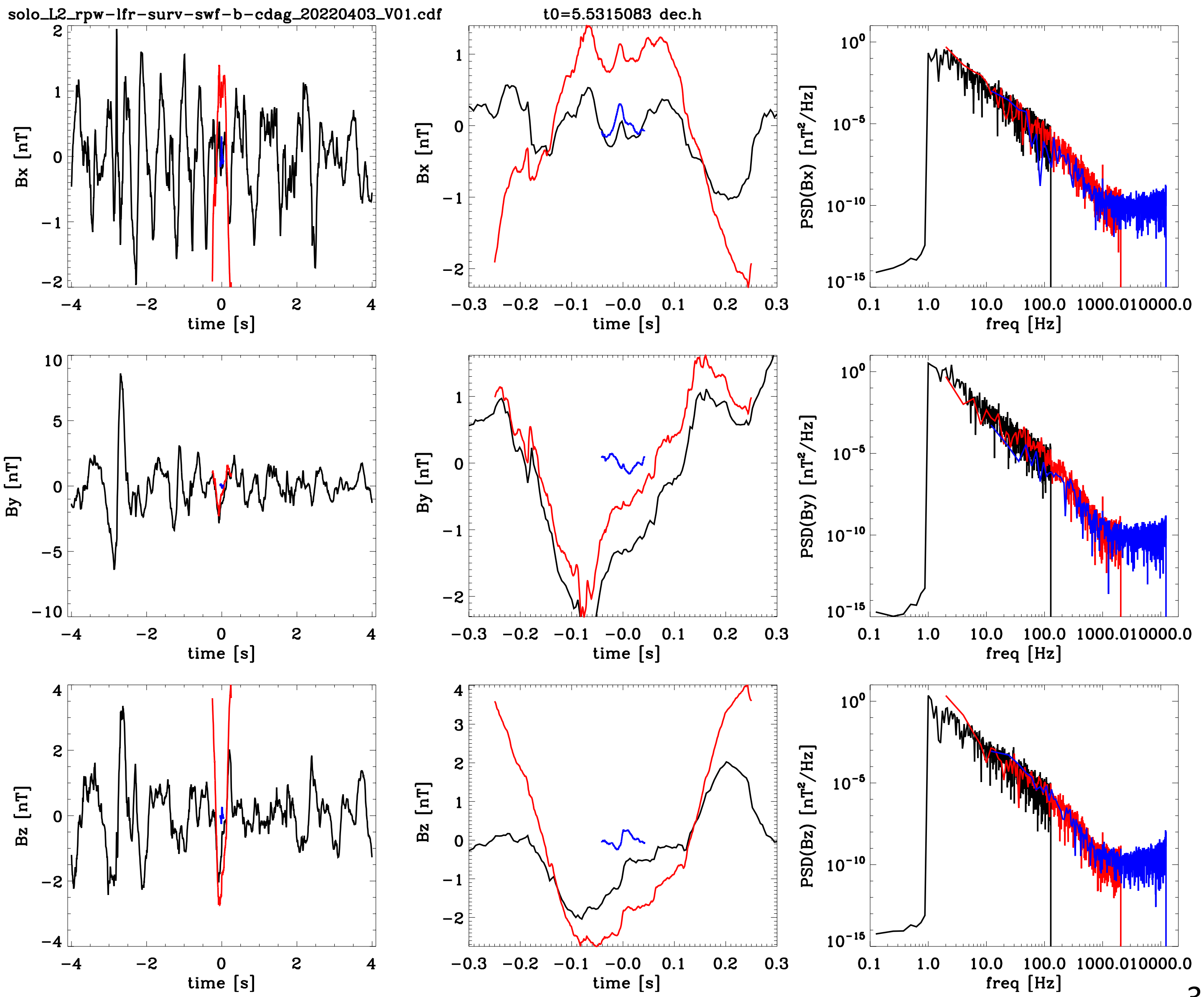
0.5 s : 4096 Hz

0.083 s: 24576 Hz

(2048 data points per snapshot)



SCM snapshots within a max of |B|
t_{start}=5.53151 dec.h
= **5:31:53.436 UT**



SCM snapshots within another max of |B|, t_{start} = 6.6148 dec.h = **6:36:53.433 UT**