Dynamic range definition for SCM : preliminary report

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The purpose of this study is to use the search-coil and fluxgate data from the Helios 1 & 2 missions to estimate the expected level of magnetic field fluctuations for the Search-Coil Magnetometer (SCM) search-coil onboard the Solar Probe Plus mission, for distances ranging from 9 solar radii (0.044 AU) to 1 AU.

This is a very preliminary summary, as most of the calculations and the validation of the results are still in progress.

Data sources

We use the raw binary files from the Helios 1 & 2 search-coils, provided in binary format by the instrument PI M. Neubauer. The data from the Helios 1 & 2 fluxgate sensors can be downloaded directly from http://nssdc.gsfc.nasa.gov

Here we shall focus on Helios search-coil data only.

While the fluxgate data are in ASCII format and can be easily processed, considerable efforts were needed to extract the search-coil data from the binary (and partly corrupted) tapes. This work was done by Jean-Yves Brochot. Finally, only 35% of the data could be used, representing in total about 700'000 samples per spacecraft at a cadence of 8 sec. The By and Bz components are almost complete whereas the Bx has many outages (over 90%). Each component is represented in terms of the root mean square value in 8 frequency channels centered on 1600, 735, 345, 160, 74, 35, 16 and 8 Hz.

There are two files for each; one with the mean value and one with the maximum in each sampling interval. Here we focus on the second.

Processing

Considerable preprocessing was needed to remove unwanted noise from the data. The main step involves median filtering to remove spikes associated with instrument saturation. But many spikes still have to be removed by hand, after visualisation.

From this we binned the amplitudes in different heliocentric distances ranging from 0.3-0.4, 0.4-0.5, ... 0.9-1 AU. The perihelion of the Helios 1 spacecraft was 0.29 AU. Assuming a power law scaling, these spectra were then extrapolated down to 0.044 AU. The power law scaling is a reasonable assumption [Cranmer, 2005] but can be refined.

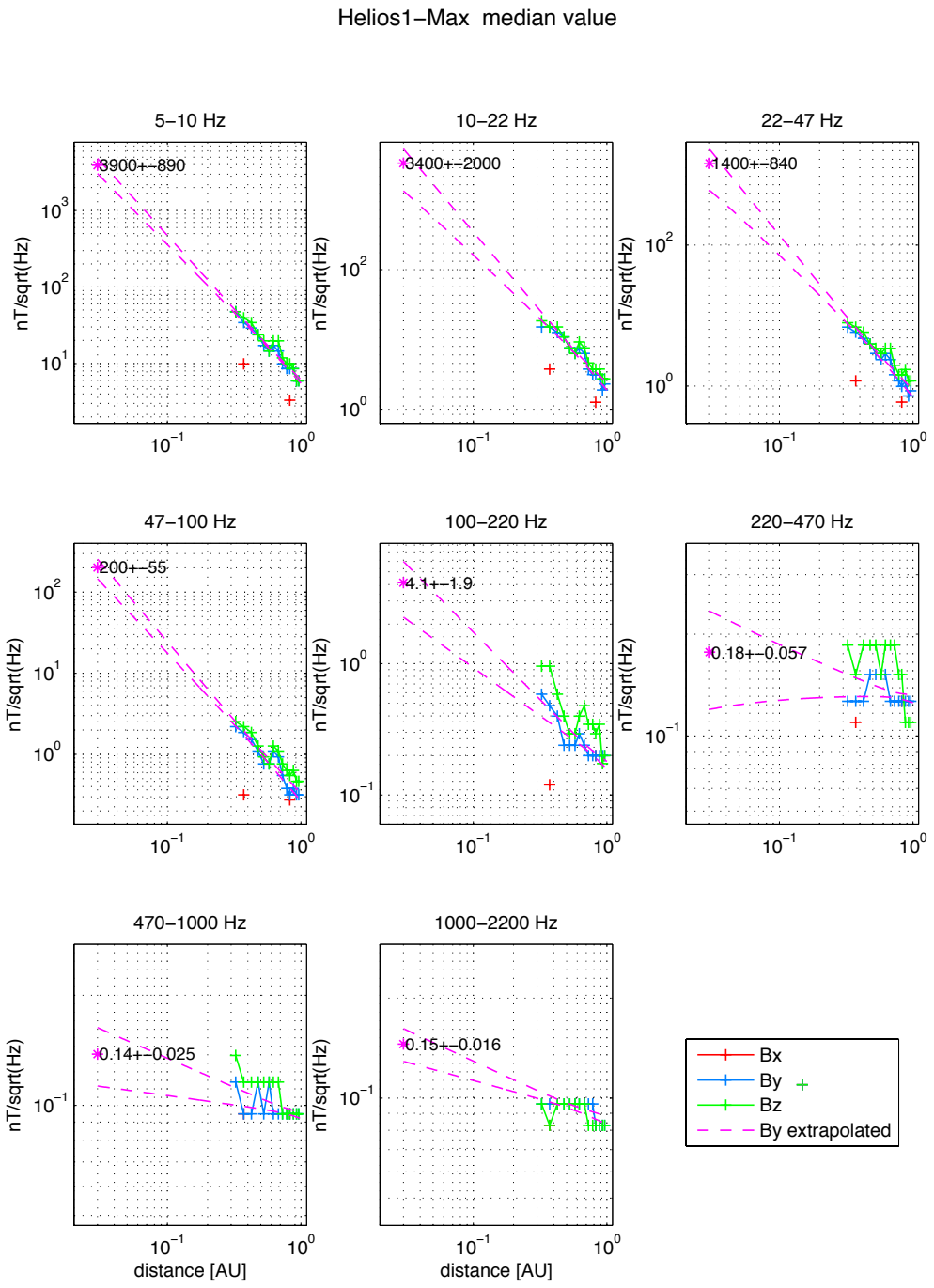

Figure 1 : Extrapolation of maximum level of magnetic field from Helios 1, showing the 3 components for the various frequency bins. Error bars reflect the uncertainty of the extrapolation only.

The most critical value is the one at 9 solar radii, which is overplotted on the dynamical range of the instrument in Figure 2.

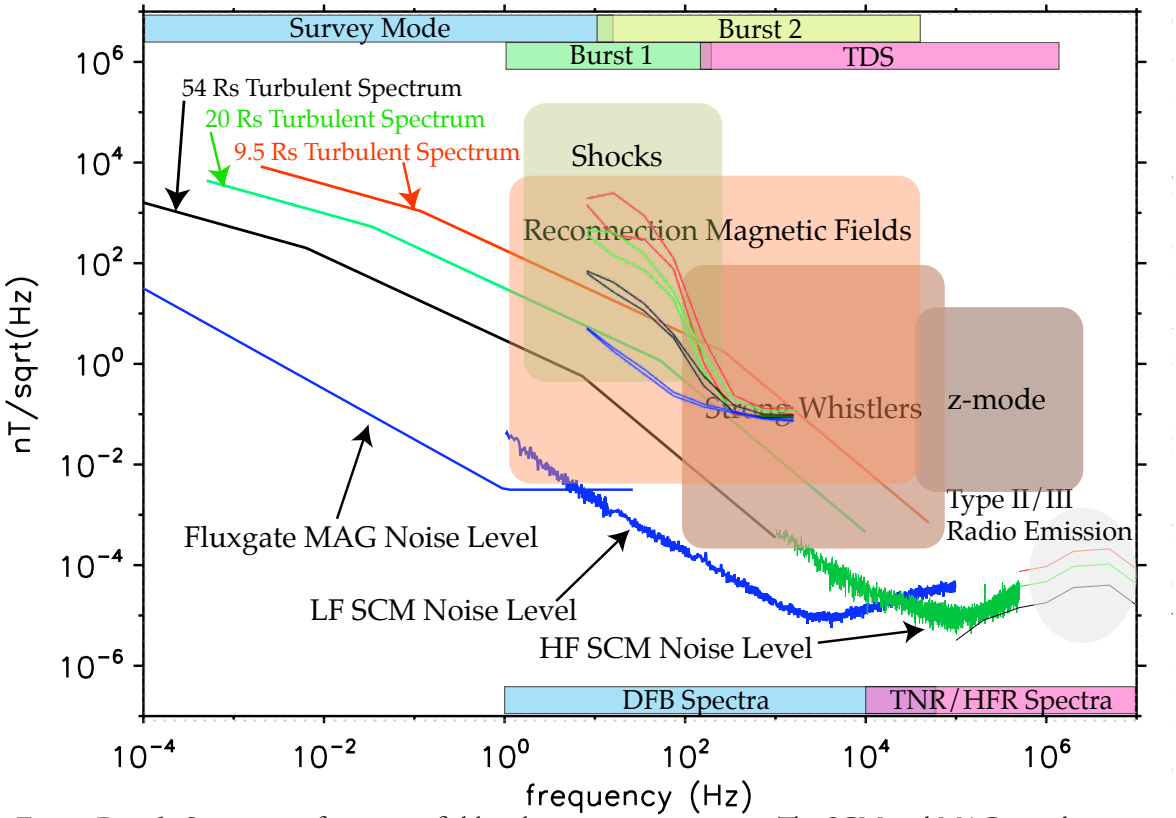

Figure D.2-6. Sensitivity of magnetic field and waves measurements. The SCM and MAG together cover the full range of required measurements. SCM becomes more sensitive than MAG at ~10 Hz. The HF SCM measures z-mode, very intense radio bursts, and very fast solitary waves.

Figure 2 expected level of magnetic field. The red, green, black and blue curves respectively stand for heliocentric distances of 9, 20, 54 solar radii, and 1 AU. The interval reflects the uncertainty of the power law extrapolation and not the variability of the magnetic field, which is most likely higher.

Next steps (in progress)

Several steps are still needed before these data can be truly exploited for instrument specification

- we're now in the process of estimating the probability density of the fluctuation amplitude versus frequency and heliocentric distance. This is the most important product.
- validation is crucial, and the first test consists in comparing these results against levels observed by other spacecraft at 1 AU
- all data will be separated in 3 bins according to solar activity level, since the level of fluctuations changes with solar activity
- these data will be merged with the spectra estimated by Lomb-Scargle spectral analysis from the fluxgate data in order to obtain one single composite and check for continuity

References

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