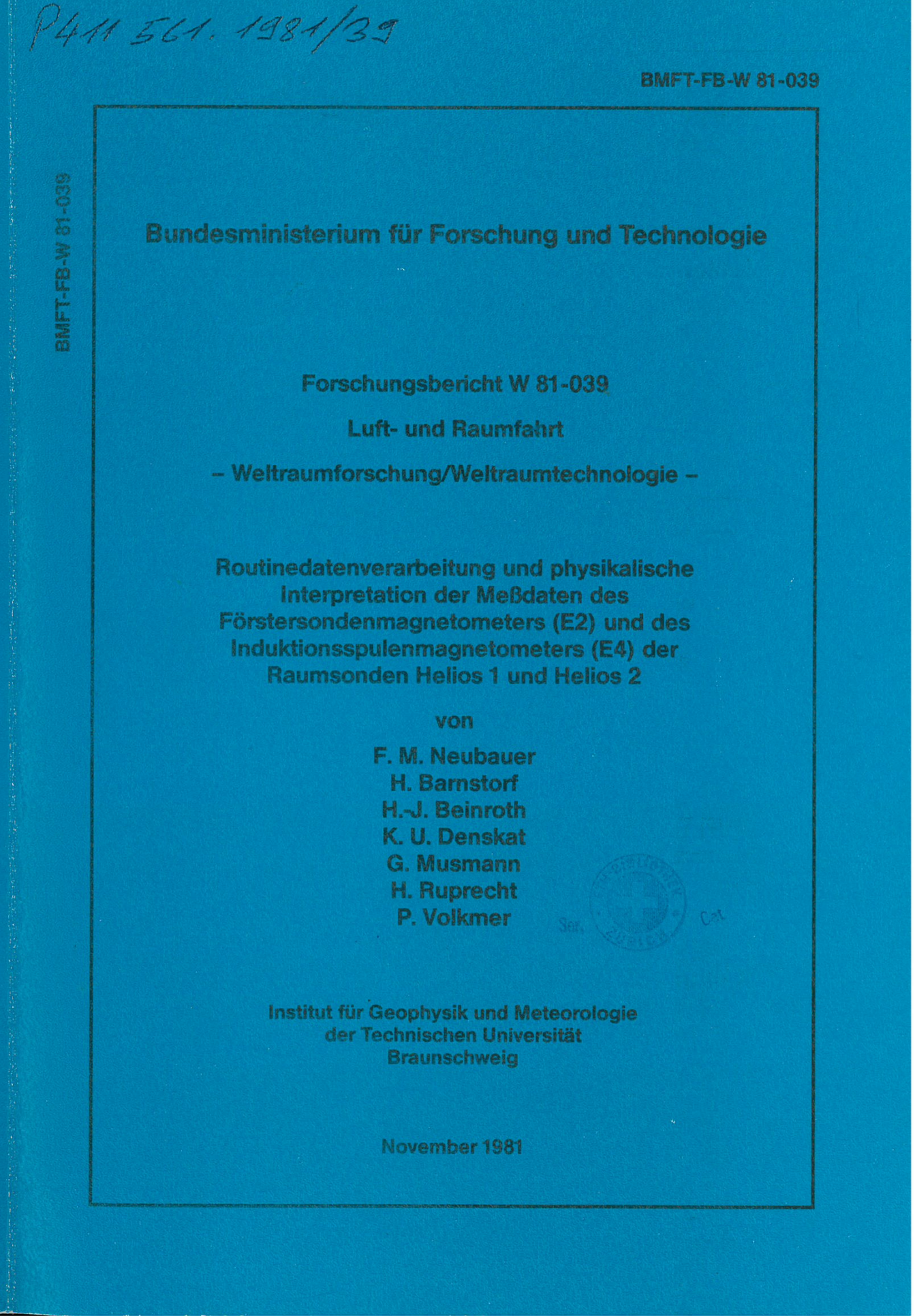

BMFT-FB-W 81-039

BMFT-FB-W 81-039

Bundesministerium für Forschung und Technologie

Forschungsbericht W 81-039

Luft- und Raumfahrt

– Weltraumforschung/Weltraumtechnologie –

Routinedatenverarbeitung und physikalische Interpretation der Meßdaten des Förstersondenmagnetometers (E2) und des Induktionsspulenmagnetometers (E4) der Raumsonden Helios 1 und Helios 2

von

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November 1981

HELIOS search coil E4: open questions

Thierry Dudok de Wit (U. Orléans)

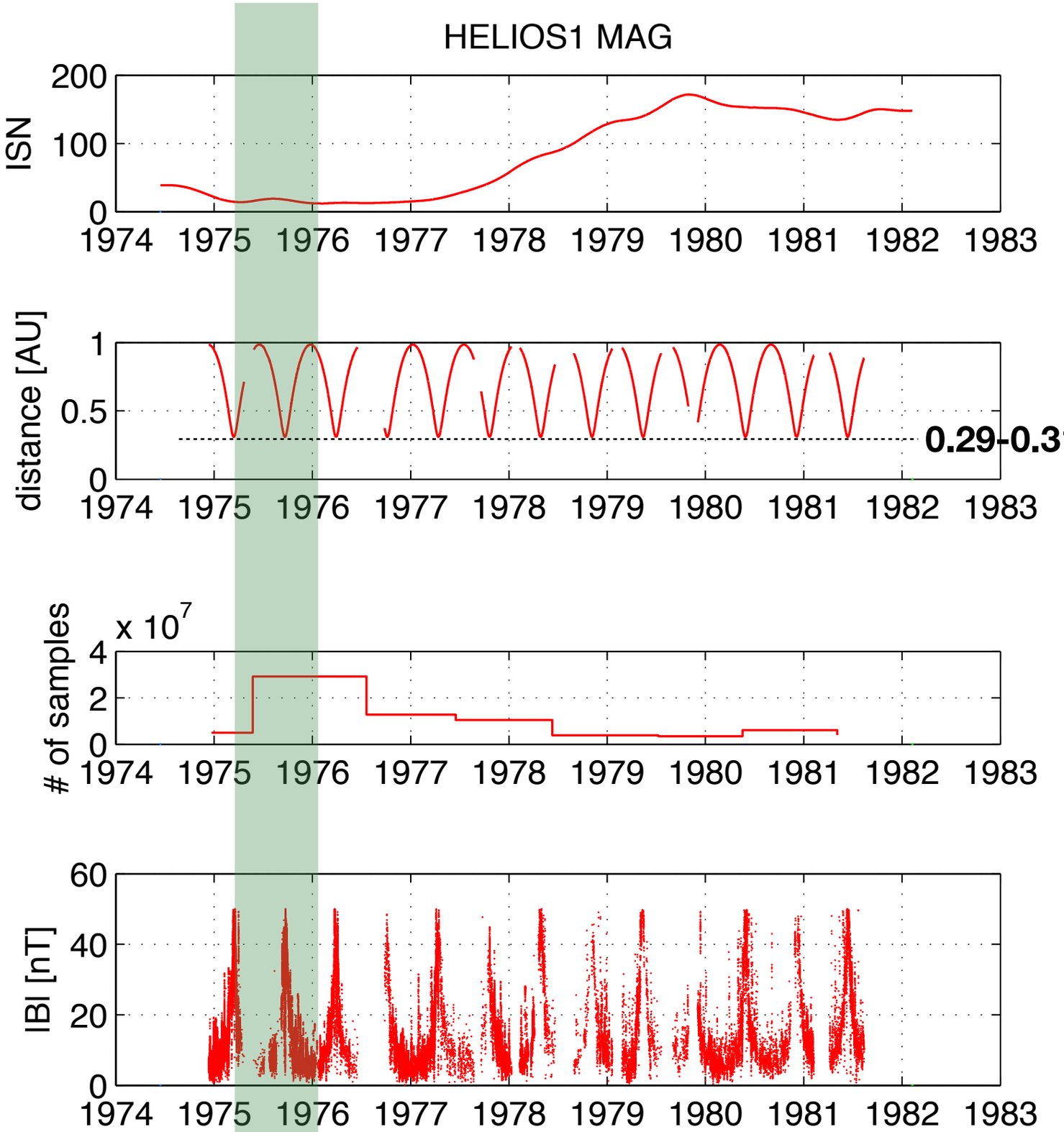
with contributions by Jean-Yves Brochot, Matthieu Kretzschmar, Chadi Salem, three lonely moose, …

E4 in a nutshell

- 8 sec sampling period
- 2 (3) components
- 8 channels
  - 4.7-10, 10-22, 22-47, 47-100, 100-220, 220-470, 470-1000, 1000-2200 Hz
- 2 data products, mostly available simultaneously:
  - maximum value within 8 sec
  - mean value within 8 sec

HELIOS 1 E2 summary plot

search-coil data available



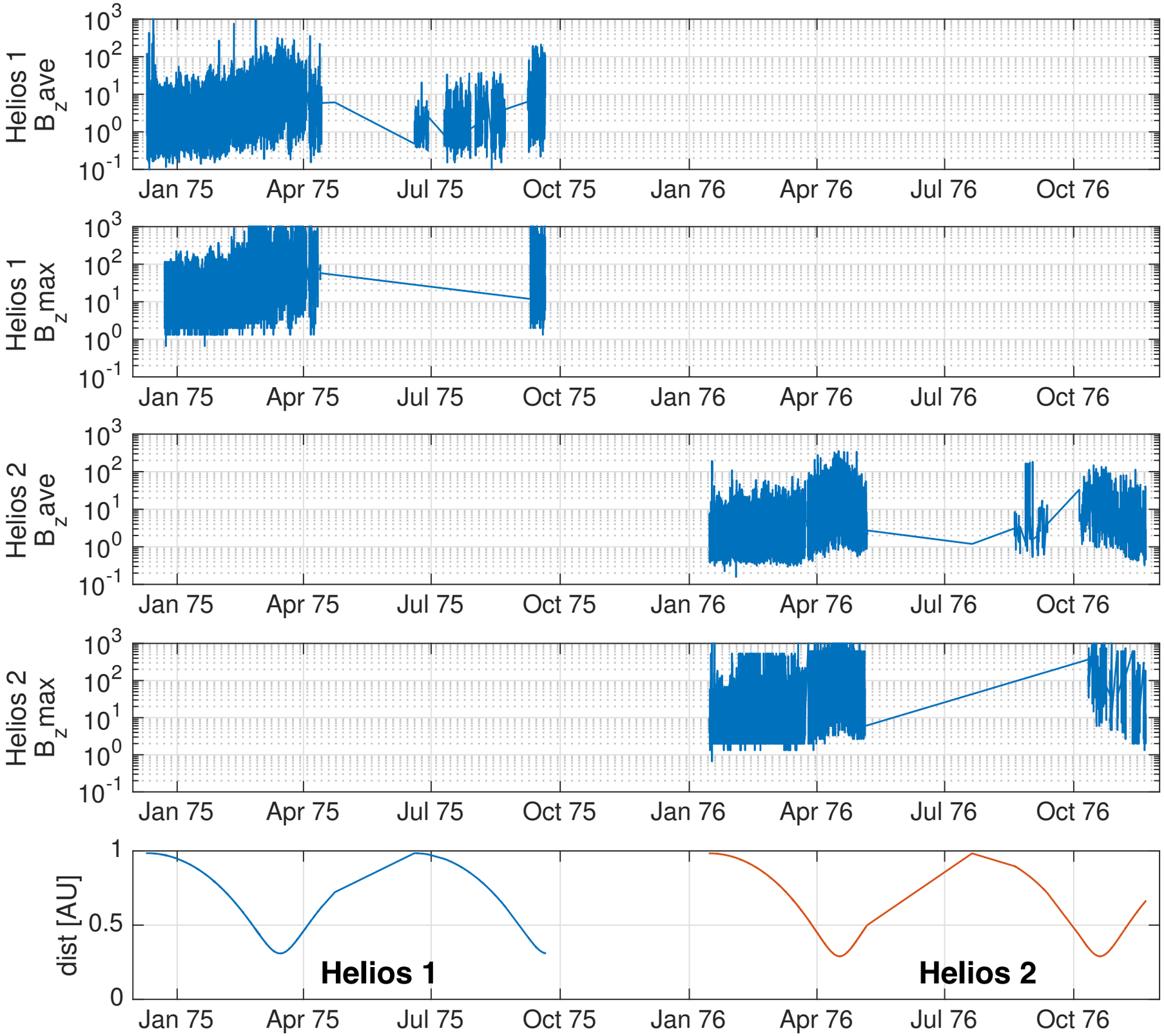
Sunspot number

Radial distance

Nr of samples/year

|B|

HELIOS 1 & 2 E4 summary plot



Helios 1
Bz average

Helios 1
Bz max

Helios 2
Bz average

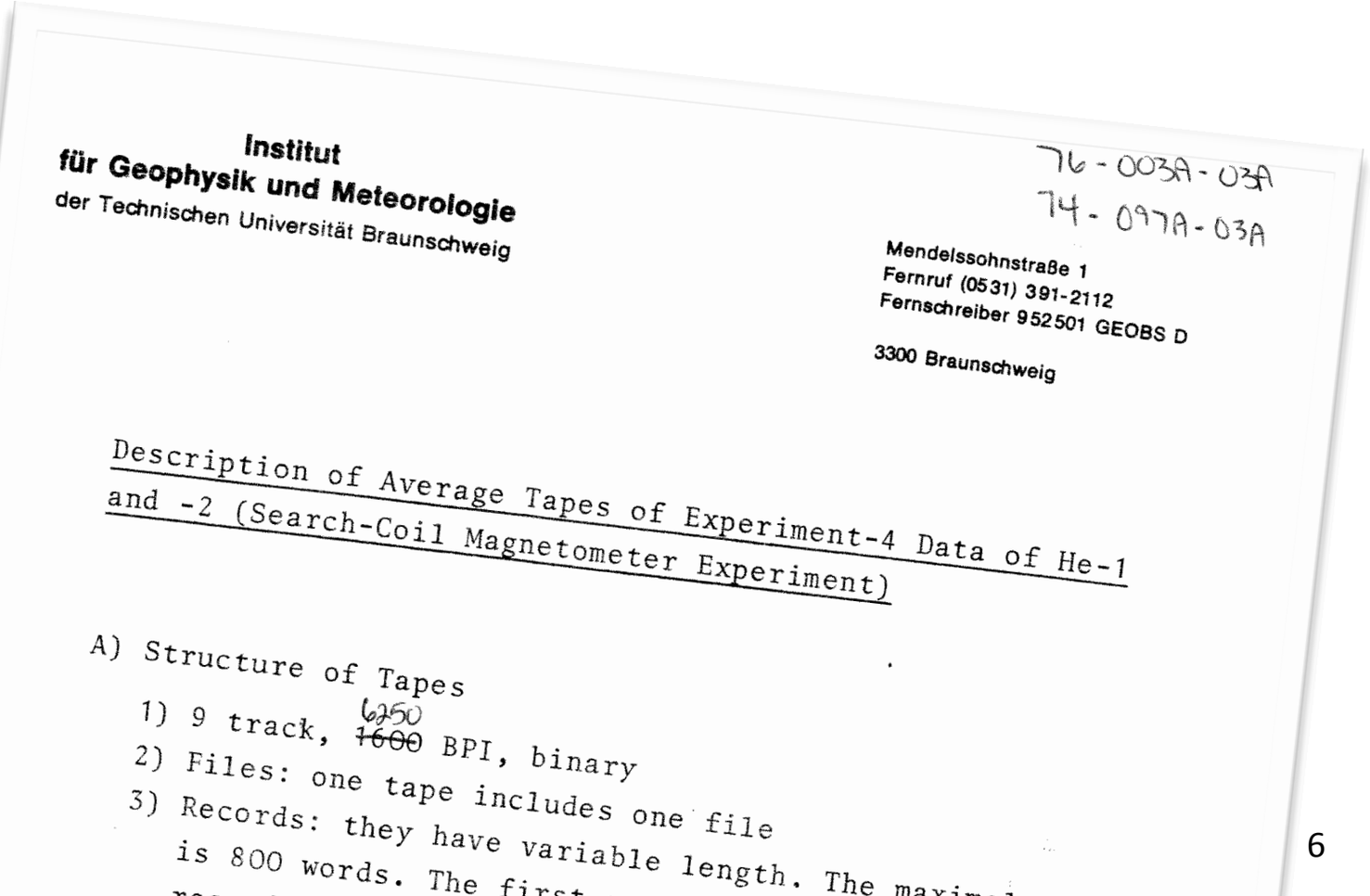
Helios 2
Bz max

Raw data

Extracting the data...

- E4 binary files available at NSSDC (128 MB)
  - 9 tape dumps for Helios 1 (1974-1975)
  - 9 tape dumps for Helios 2 (1976)

- not all files could be properly read (trial and error)
  - 18 ascii files for Helios 1
  - 18 ascii files for Helios 2



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Fernschreiber 952501 GEOBS D

3300 Braunschweig

Description of Average Tapes of Experiment-4 Data of He-1 and -2 (Search-Coil Magnetometer Experiment)

A) Structure of Tapes

1) 9 track, ~~1600~~ 6250 BPI, binary
2) Files: one tape includes one file
3) Records: they have variable length. The maxima

What the ascii data look like

```
1975-07-19T16:34:36,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0201 0.0223
1975-07-19T16:34:44,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0202 0.0220
1975-07-19T16:34:52,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0200 0.0223
1975-07-19T16:35:00,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0199 0.0223
1975-07-19T16:35:08,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0201 0.0219
1975-07-19T16:34:36,663Z 89.67 108.29 100.54 0.905917 -3.0643 164.50 950.40 0.9961 0 Y 0.0201 0.0223
```

+ 14 other columns with B

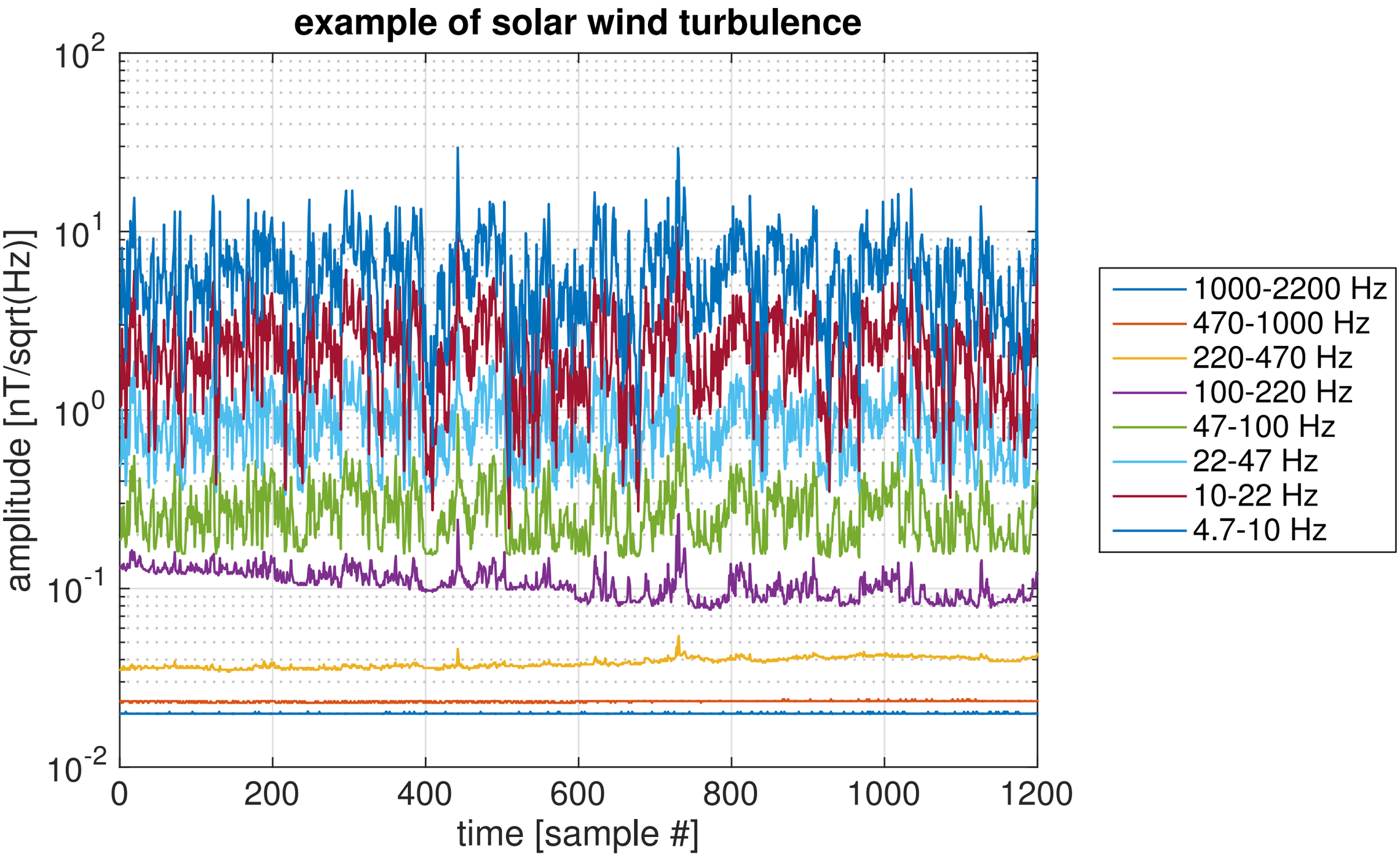
What is finally available

- **Helios 1 - average**
  - Bx 24838 samples 2.3 days
  - By 1’001’230 samples 93 days
  - Bz 1’026’068 samples 95 days
- **Helios 1 - peak**
  - Bx 27 samples < 1 min
  - By 712’160 samples 66 days
  - Bz 712’187 samples 66 days
- **Helios 2 - average**
  - Bx 1’039’622 samples 96 days
  - By 1364 samples 0.12 days
  - Bz 1’040’986 samples 96 days
- **Helios 2 - peak**
  - Bx 947’144 samples 88 days
  - By 722 samples 0.07 days
  - Bz 947’866 samples 88 days

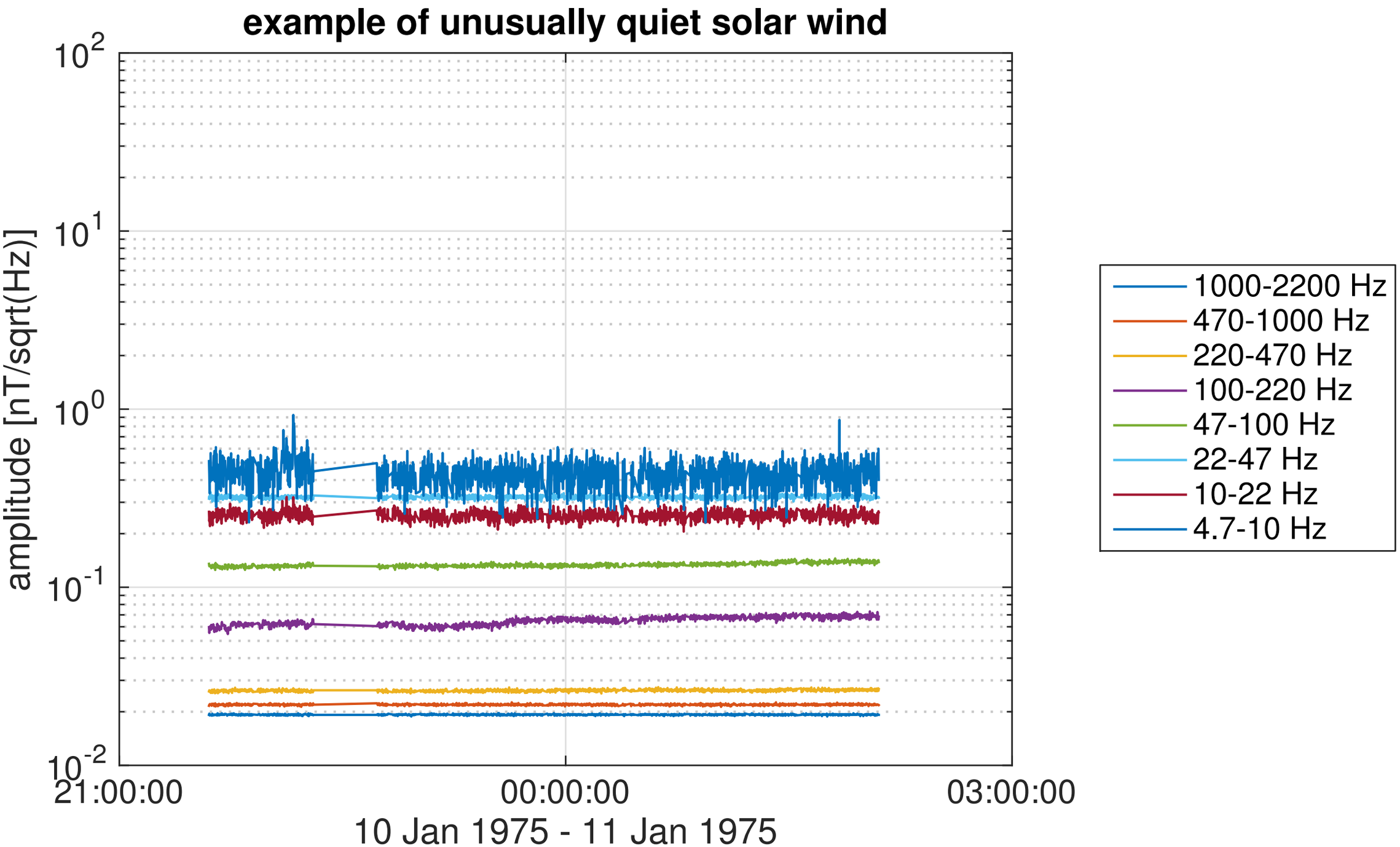
Did we miss anything ?
Why this asymmetry between Bx and By ?

What the data look like

Example

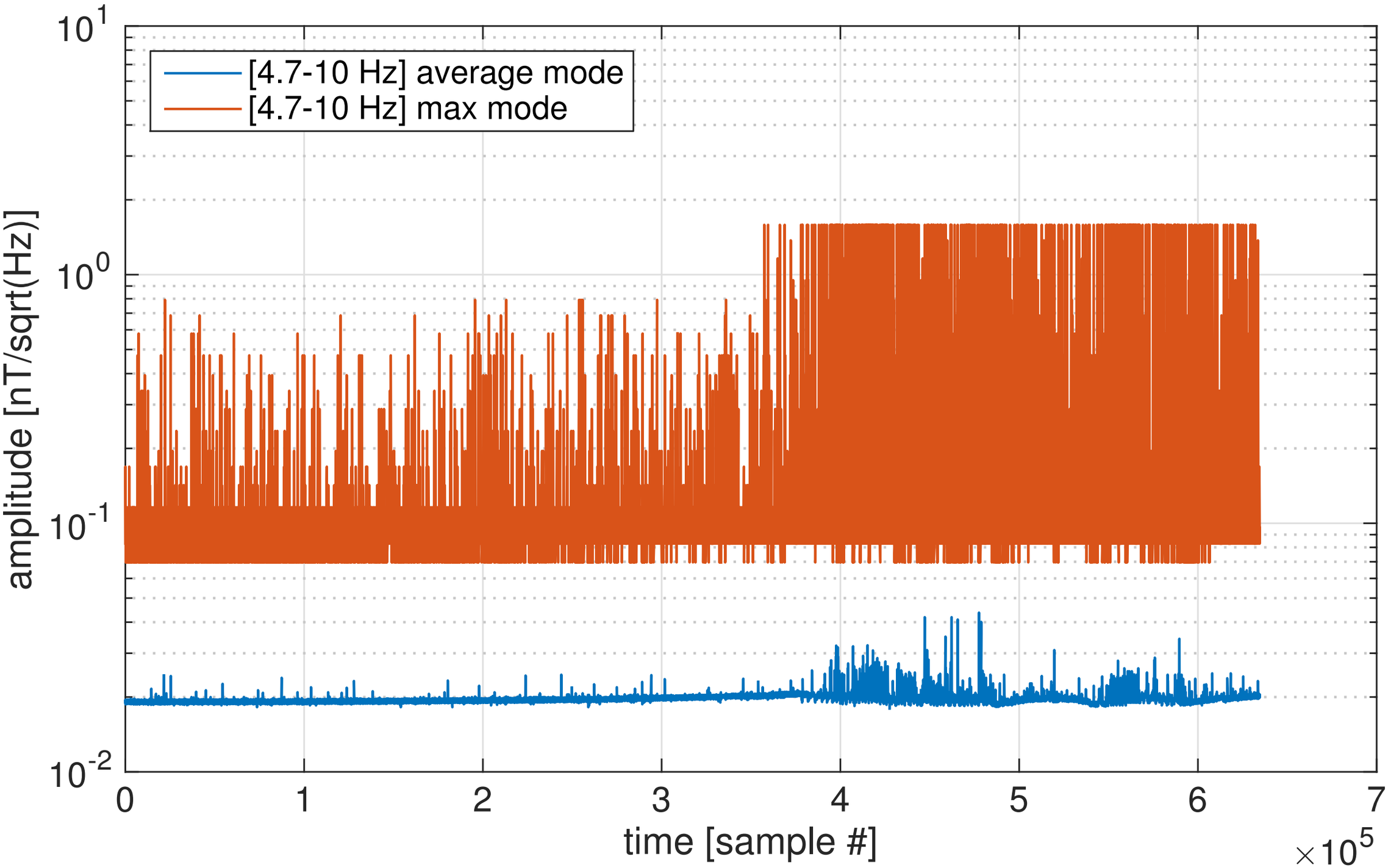

example of solar wind turbulence
amplitude [nT/sqrt(Hz)]
10^2
10^1
10^0
10^{-1}
10^{-2}
0
200
400
600
800
1000
1200
time [sample #]
1000-2200 Hz
470-1000 Hz
220-470 Hz
100-220 Hz
47-100 Hz
22-47 Hz
10-22 Hz
4.7-10 Hz

Example

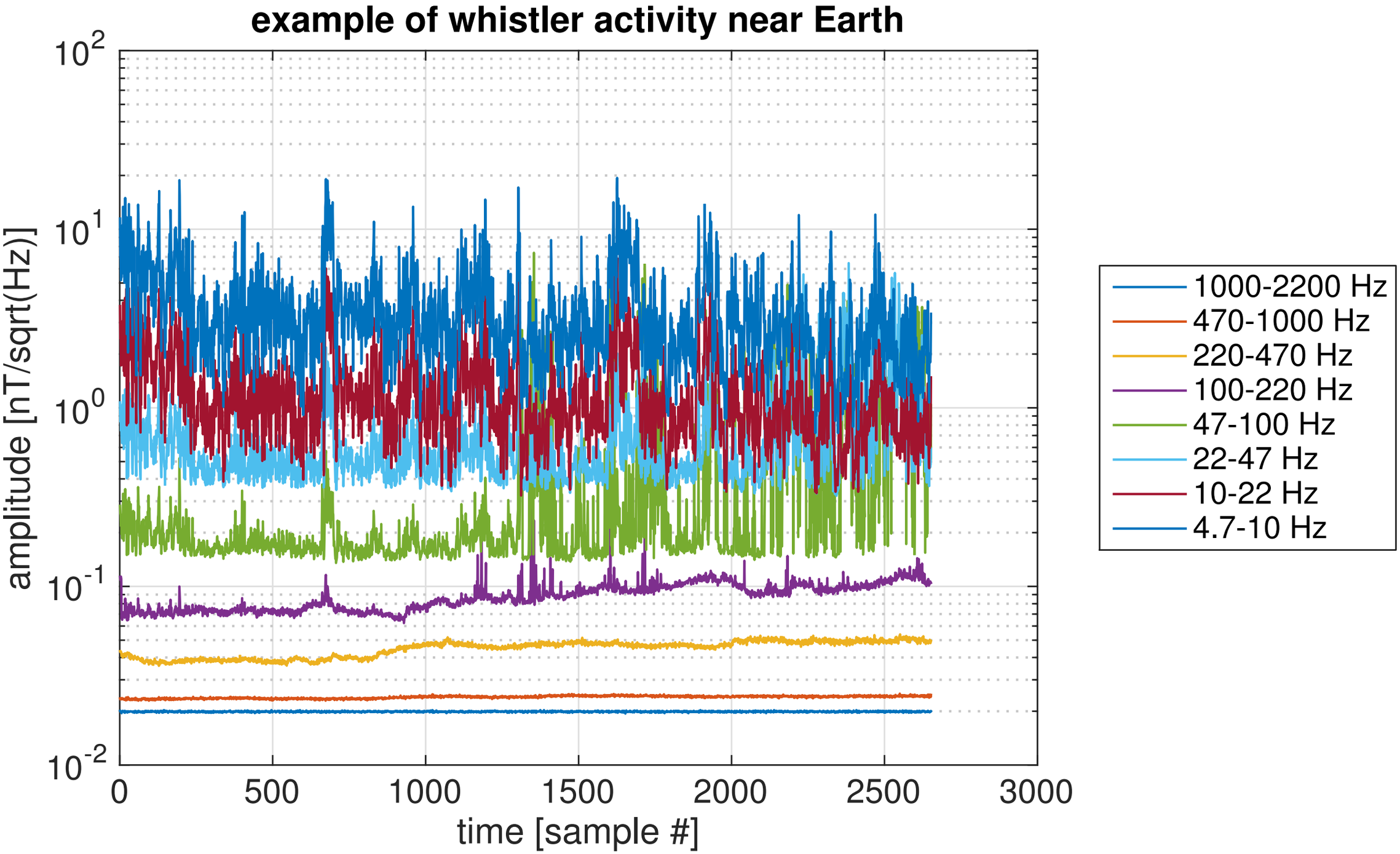

example of unusually quiet solar wind
amplitude [nT/sqrt(Hz)]
10^2
10^1
10^0
10^{-1}
10^{-2}
21:00:00
00:00:00
03:00:00
10 Jan 1975 - 11 Jan 1975
1000-2200 Hz
470-1000 Hz
220-470 Hz
100-220 Hz
47-100 Hz
22-47 Hz
10-22 Hz
4.7-10 Hz

Example

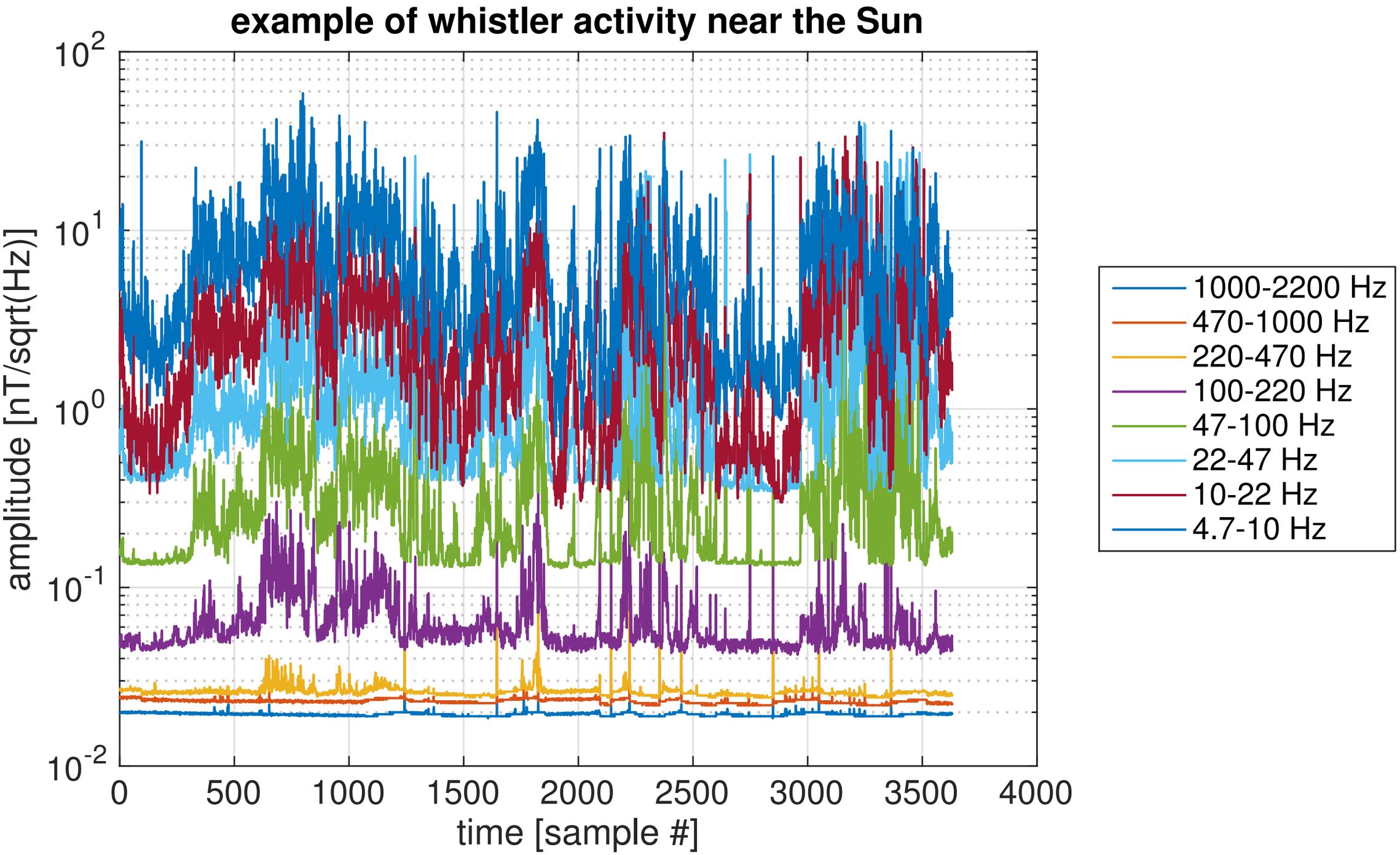
all bands occasionally exhibit saturation, especially in max mode



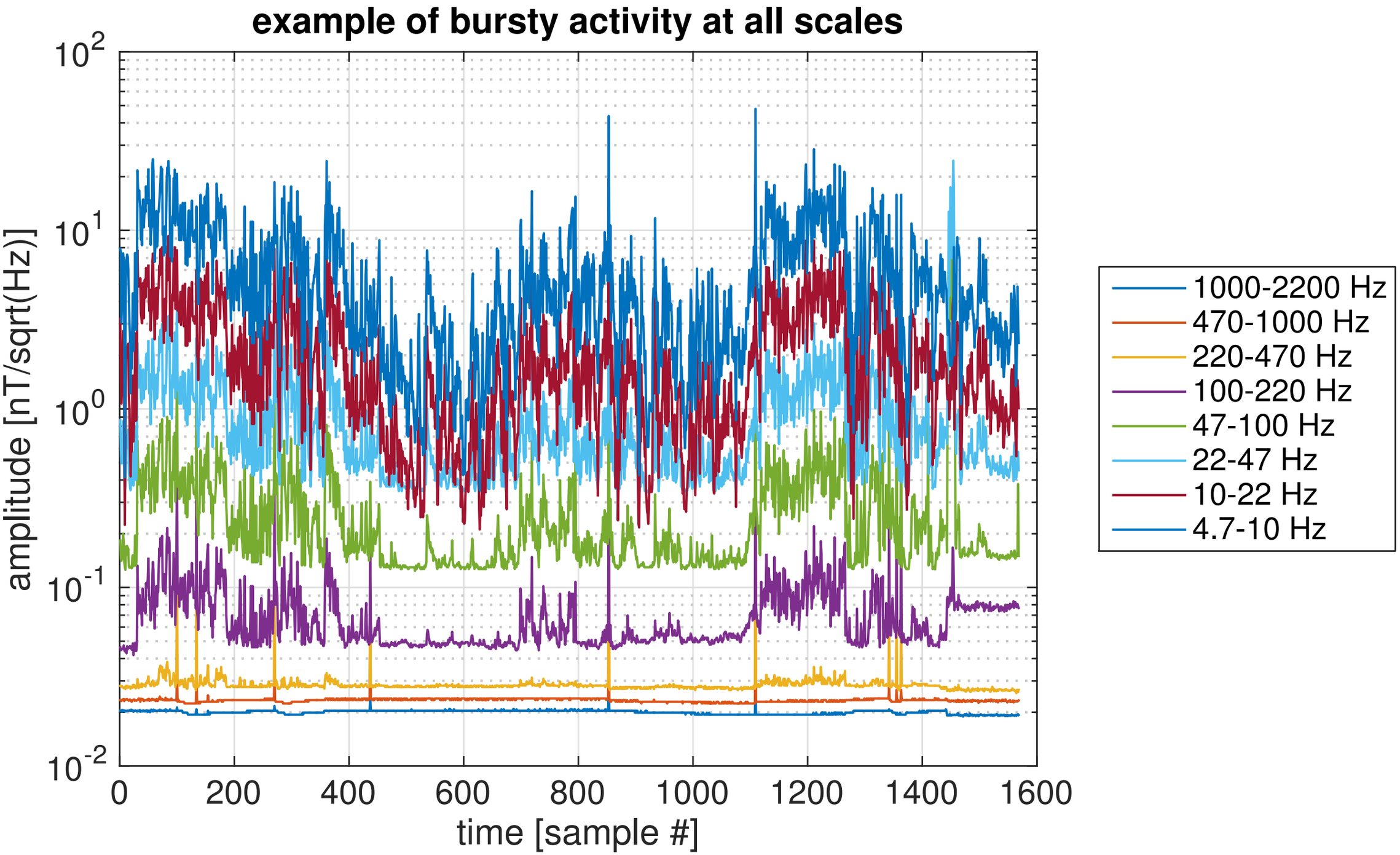
Example


example of whistler activity near Earth
amplitude [nT/sqrt(Hz)]
10^2
10^1
10^0
10^{-1}
10^{-2}
0
500
1000
1500
2000
2500
3000
time [sample #]
1000-2200 Hz
470-1000 Hz
220-470 Hz
100-220 Hz
47-100 Hz
22-47 Hz
10-22 Hz
4.7-10 Hz

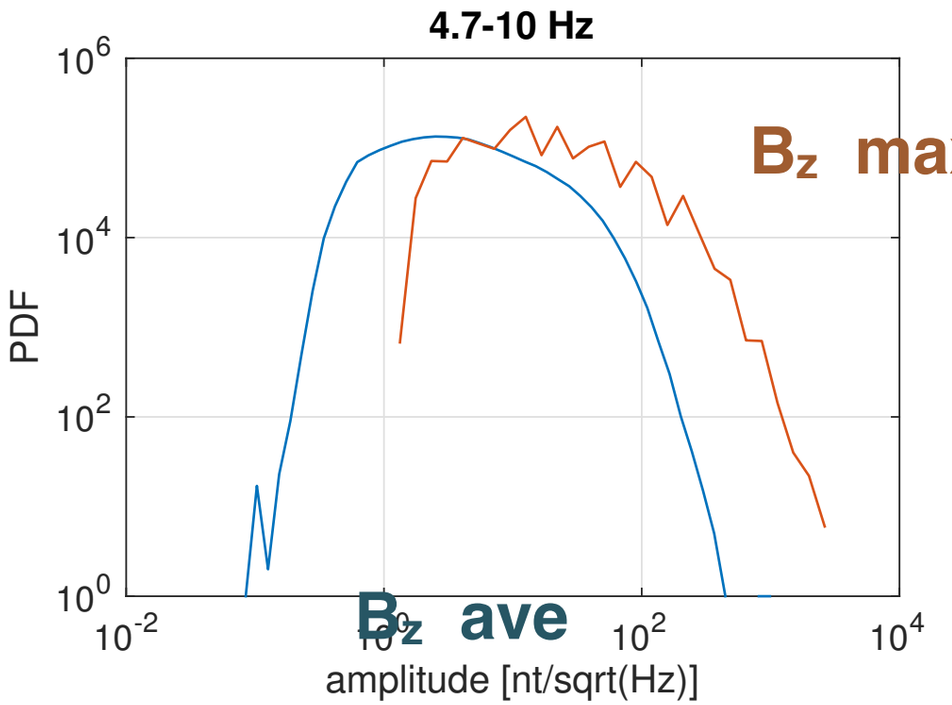
Example

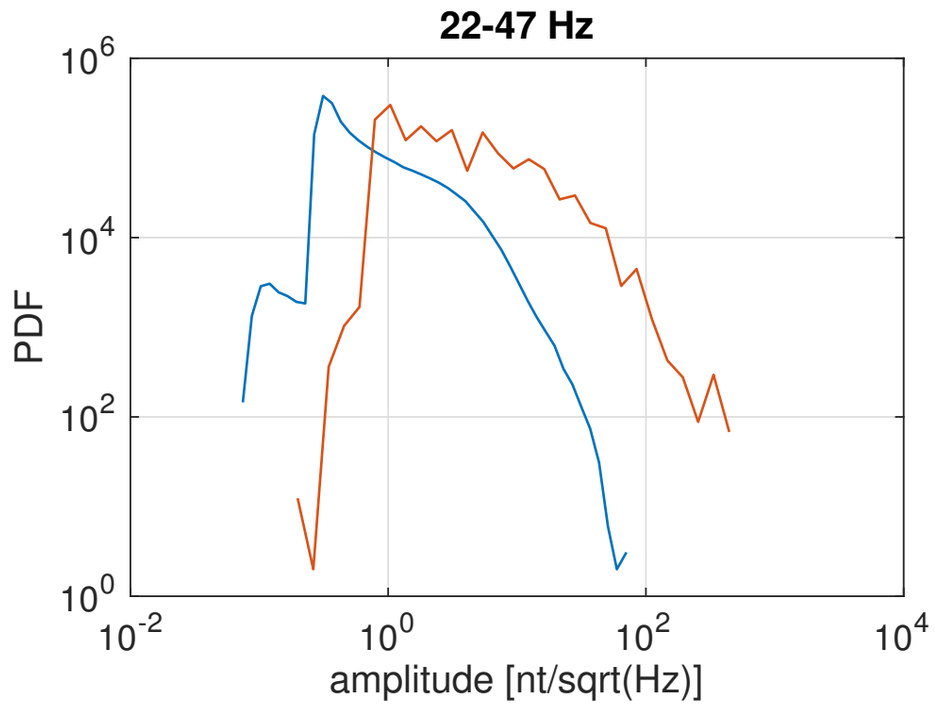

example of whistler activity near the Sun
amplitude [nT/sqrt(Hz)]
time [sample #]
1000-2200 Hz
470-1000 Hz
220-470 Hz
100-220 Hz
47-100 Hz
22-47 Hz
10-22 Hz
4.7-10 Hz

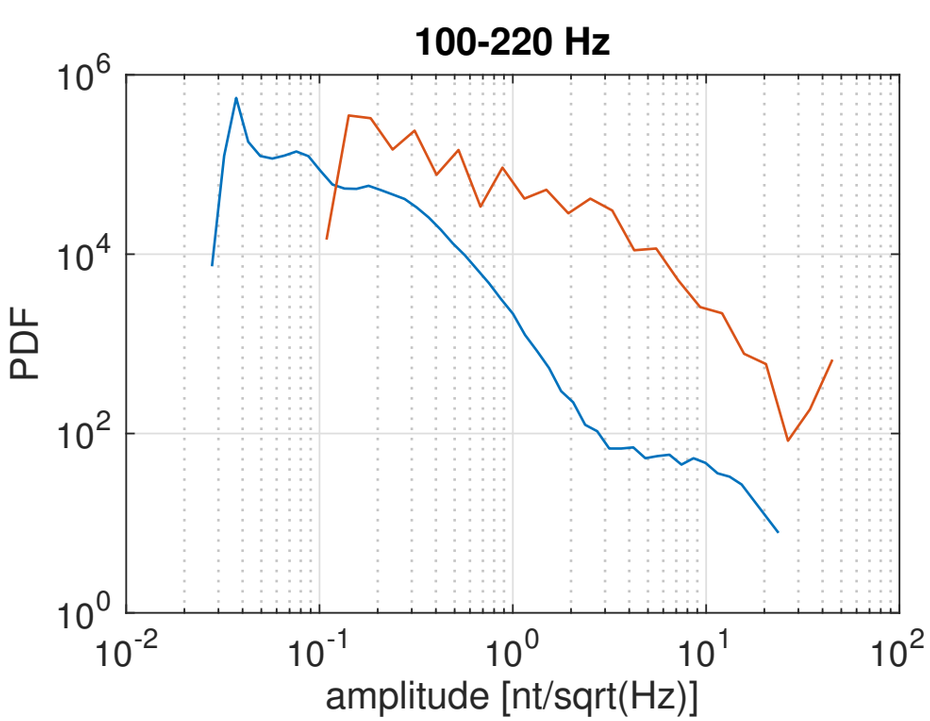
Example

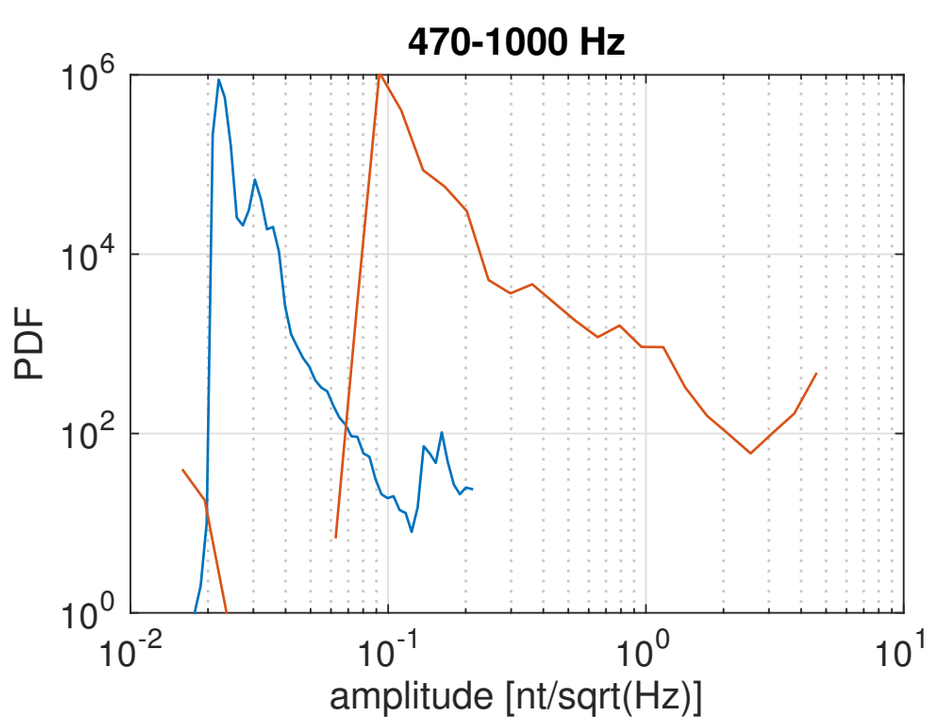

example of bursty activity at all scales
amplitude [nT/sqrt(Hz)]
time [sample #]
1000-2200 Hz
470-1000 Hz
220-470 Hz
100-220 Hz
47-100 Hz
22-47 Hz
10-22 Hz
4.7-10 Hz

PDF







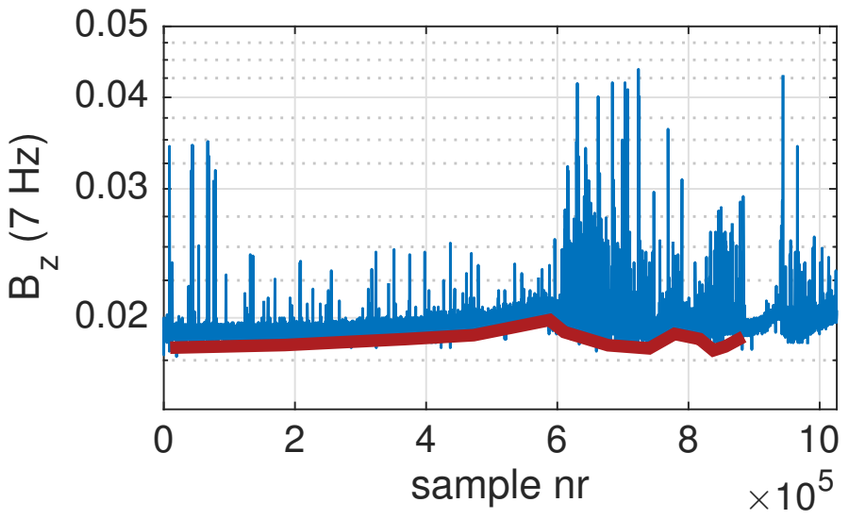


log-normal pdfs are to be expected for turbulence
lower cutoff becomes visible > 47 Hz

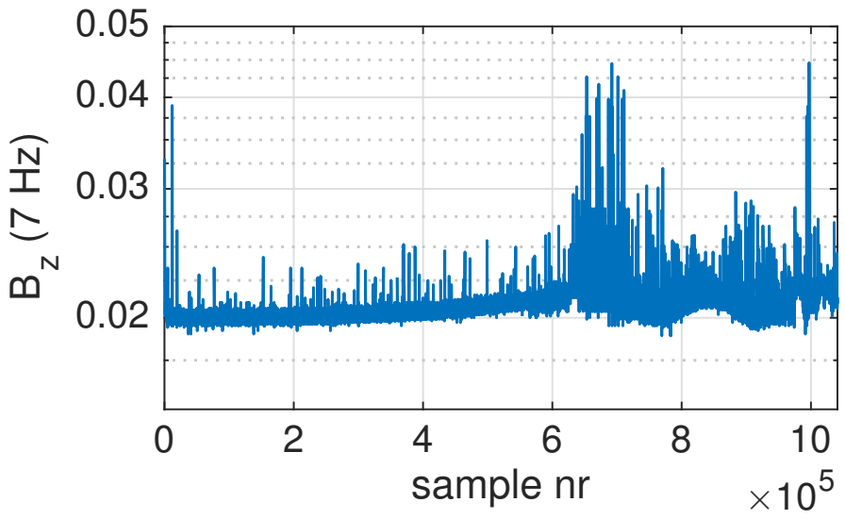
Noise floor

Noise floor : temperature dependence ?

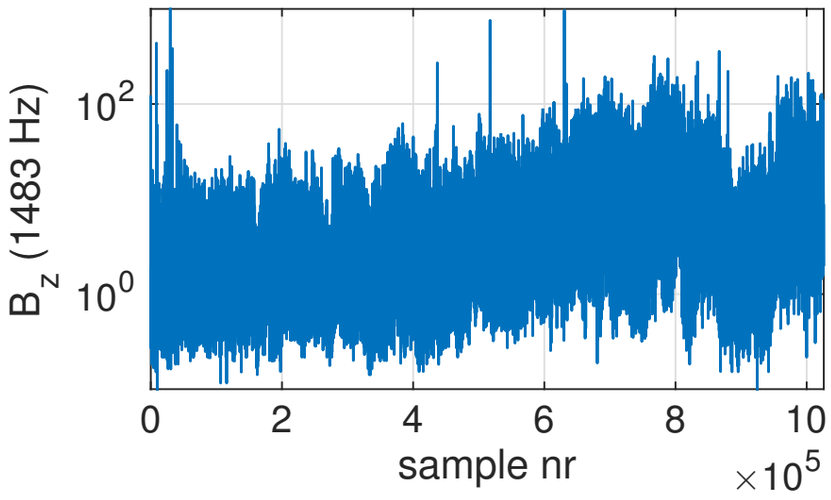
Helios 1

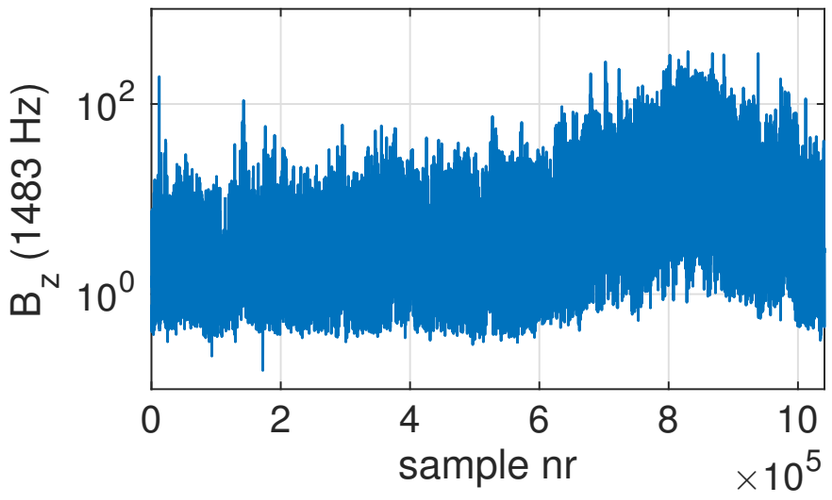


Helios 2

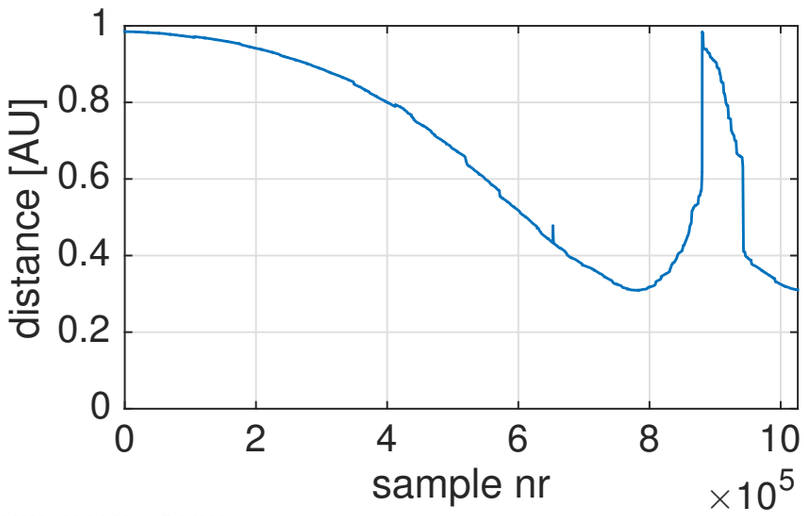


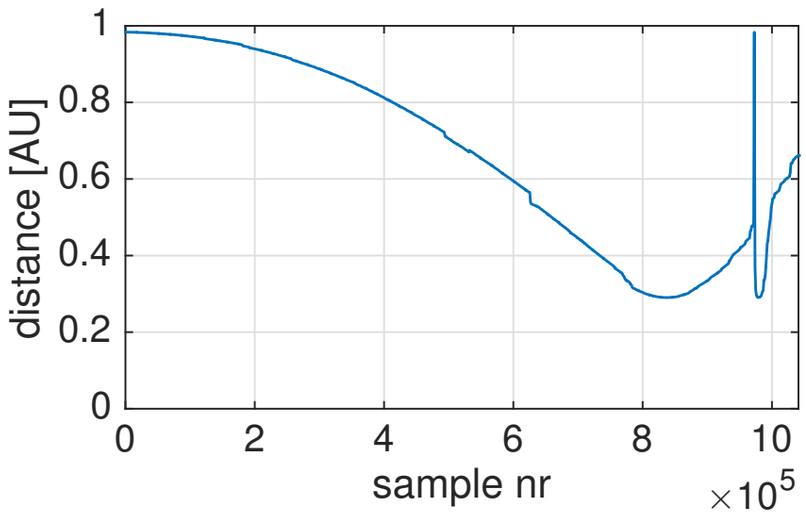
f = 1483 Hz



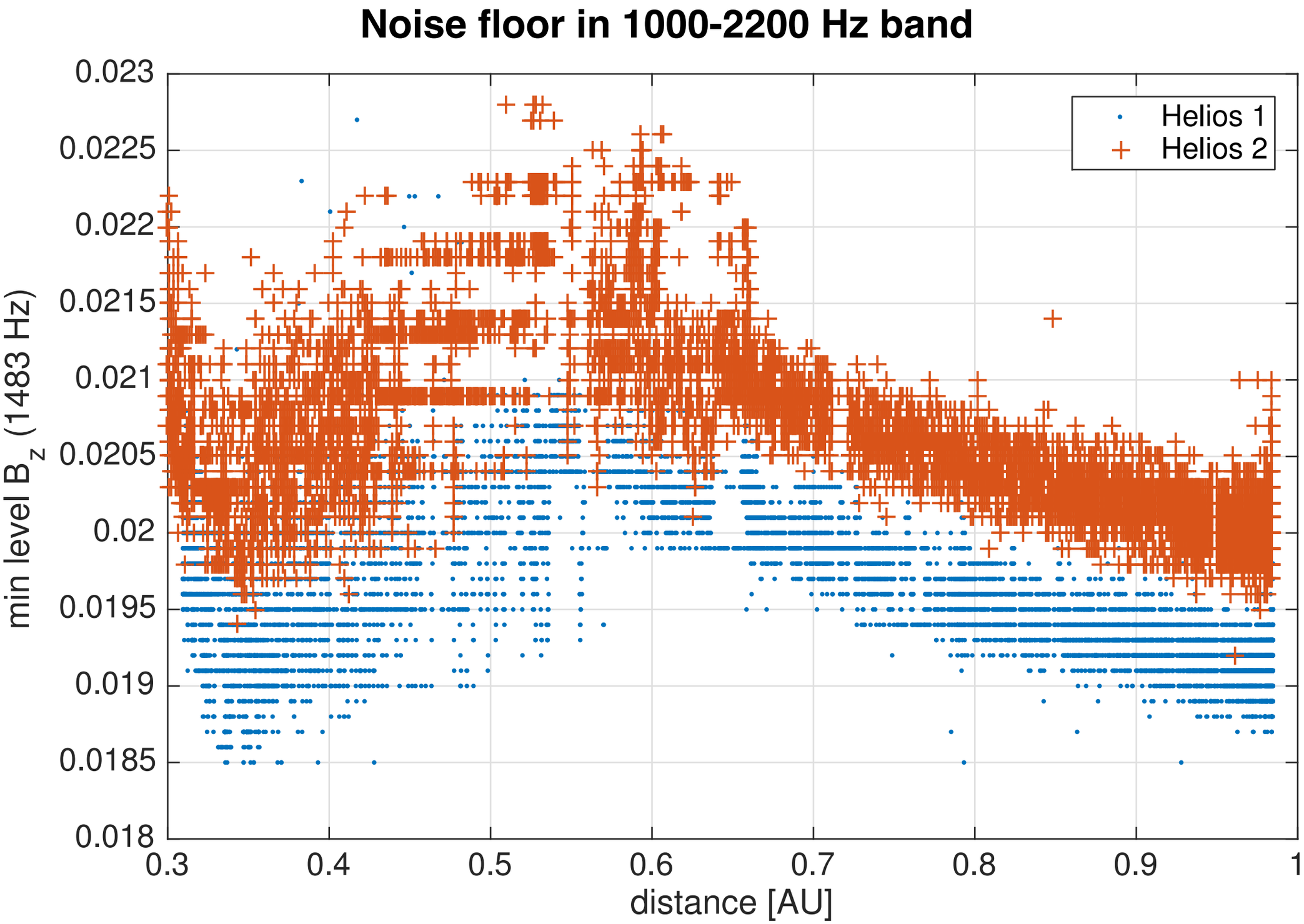


f = 7 Hz



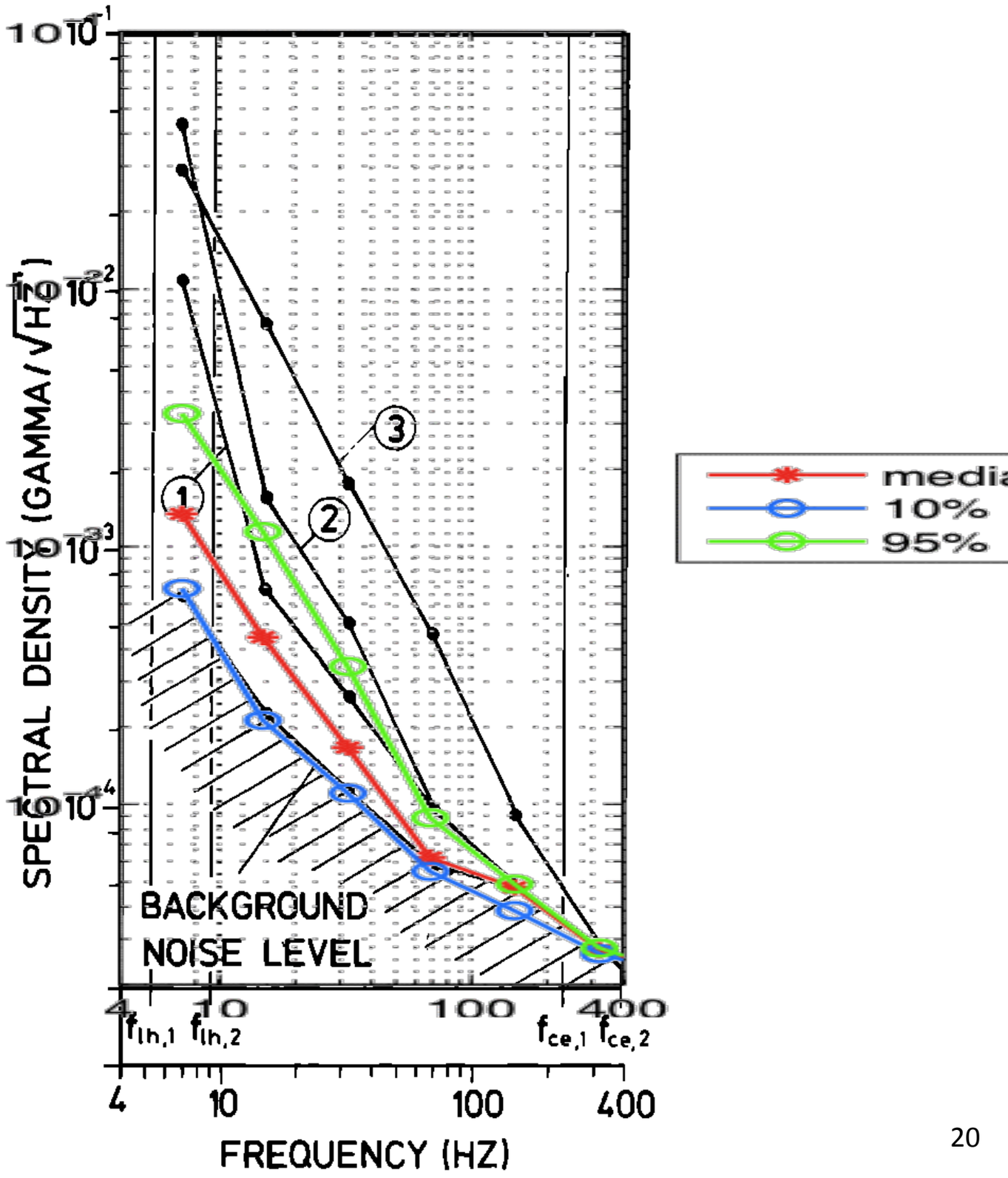


Noise floor : temperature dependence ?



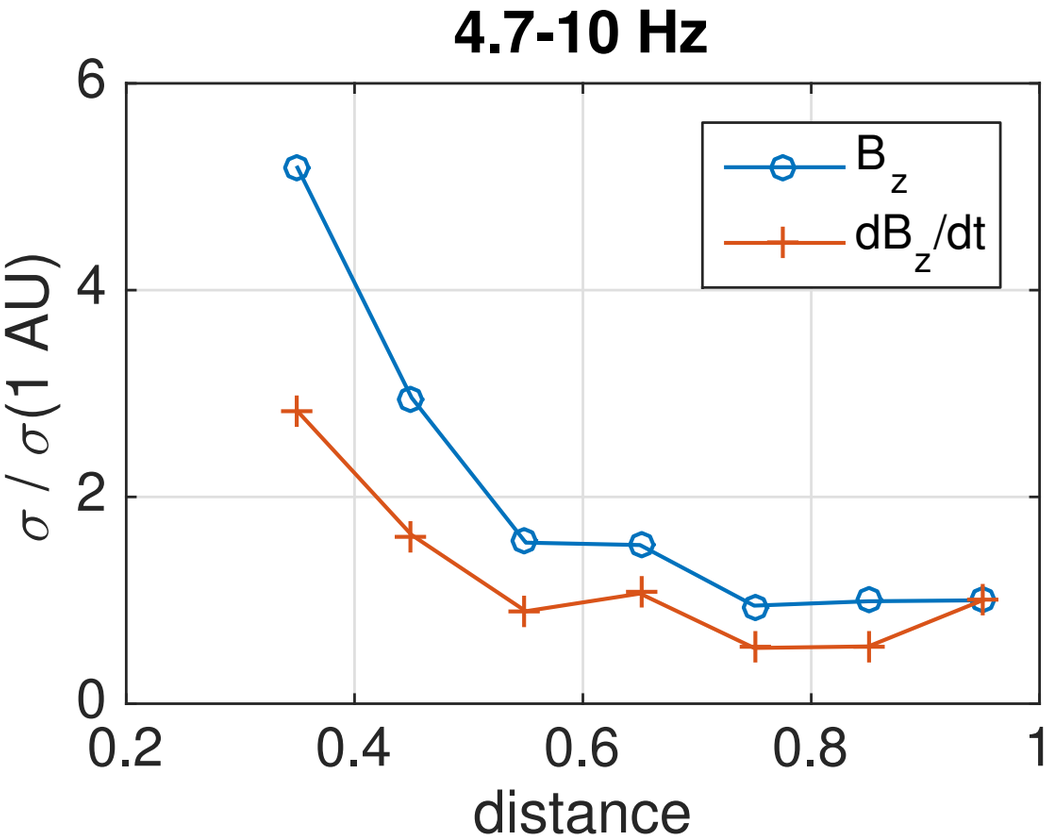
Noise level

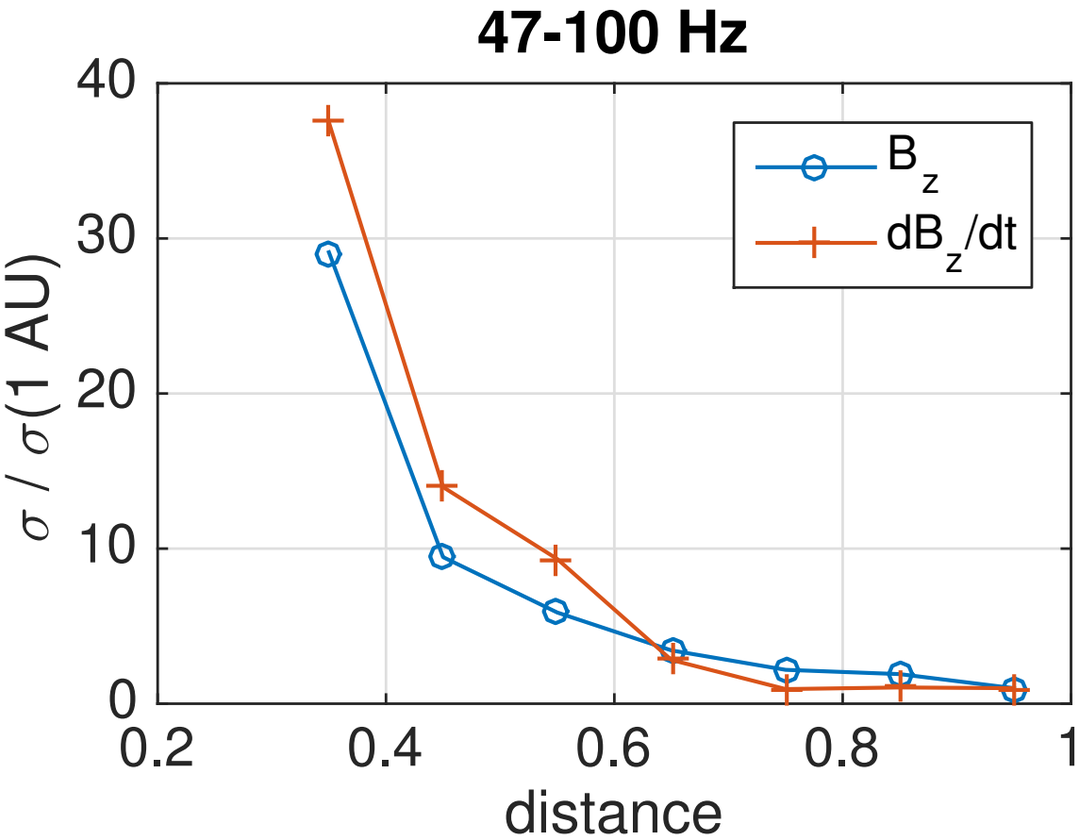
- Channels > 100 Hz seem to be dominated by noise



Signal or noise ?

- time-scales increase with solar distance, fluctuation levels of B_z and dB_z/dt should scale differently





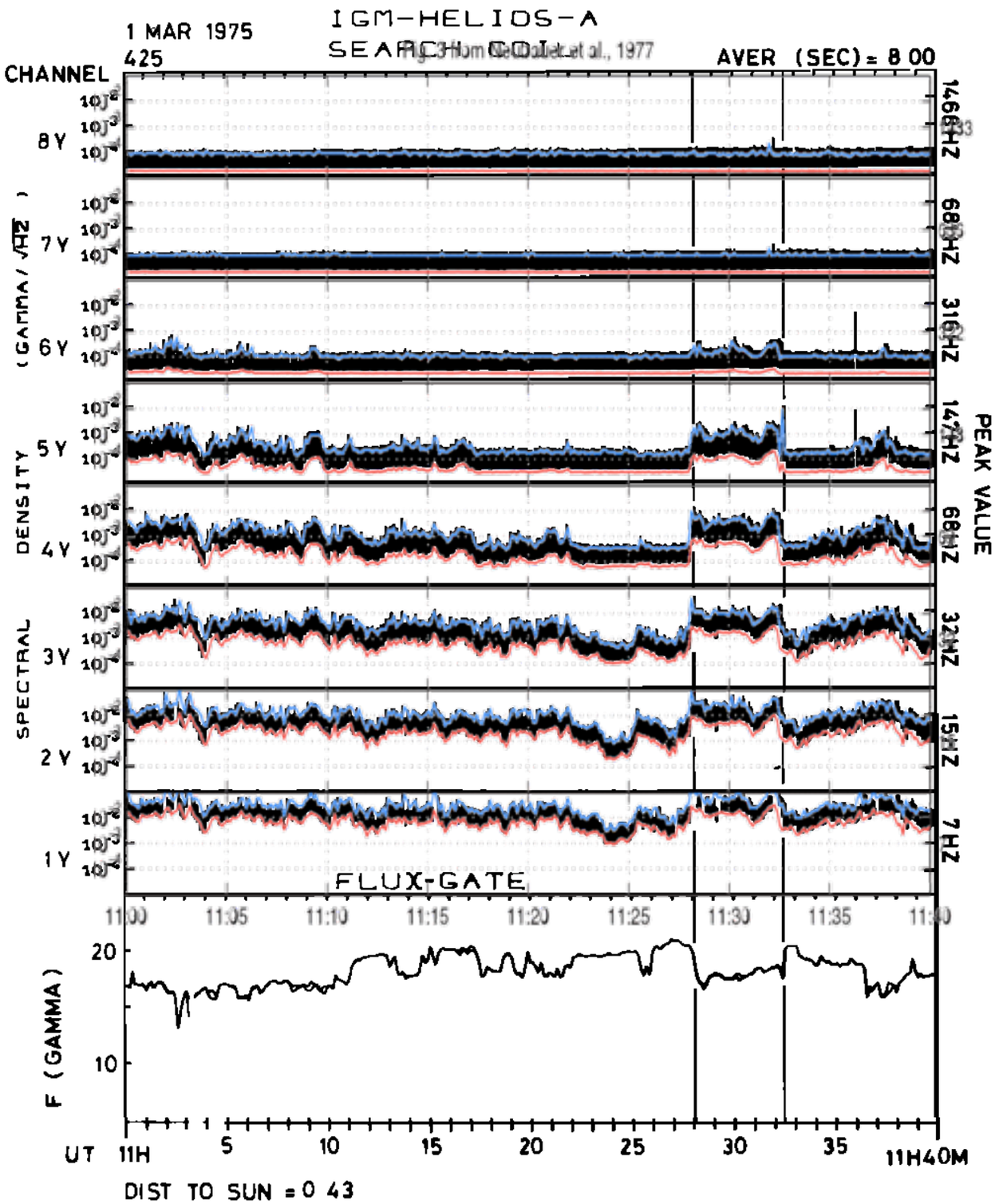
consistent with f^{-a} spectrum

consistent with uncorrelated noise

Absolute calibration

Comparison with original plots

- **factor of 1000** needed to match the original plots by F. Neubauer

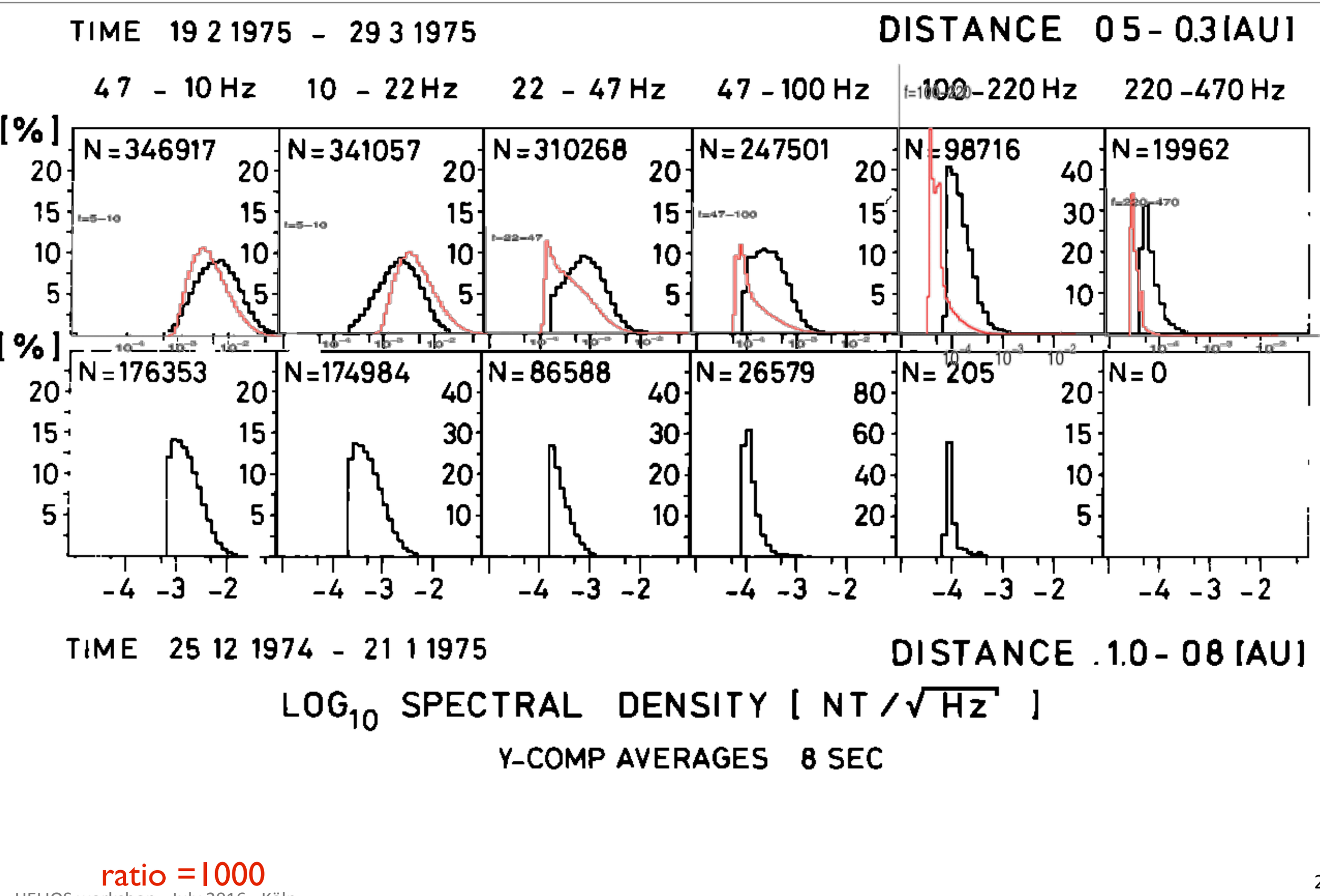


Sanity check: comparison with original plots by F. Neubauer

(color) my data, reduced 1000x

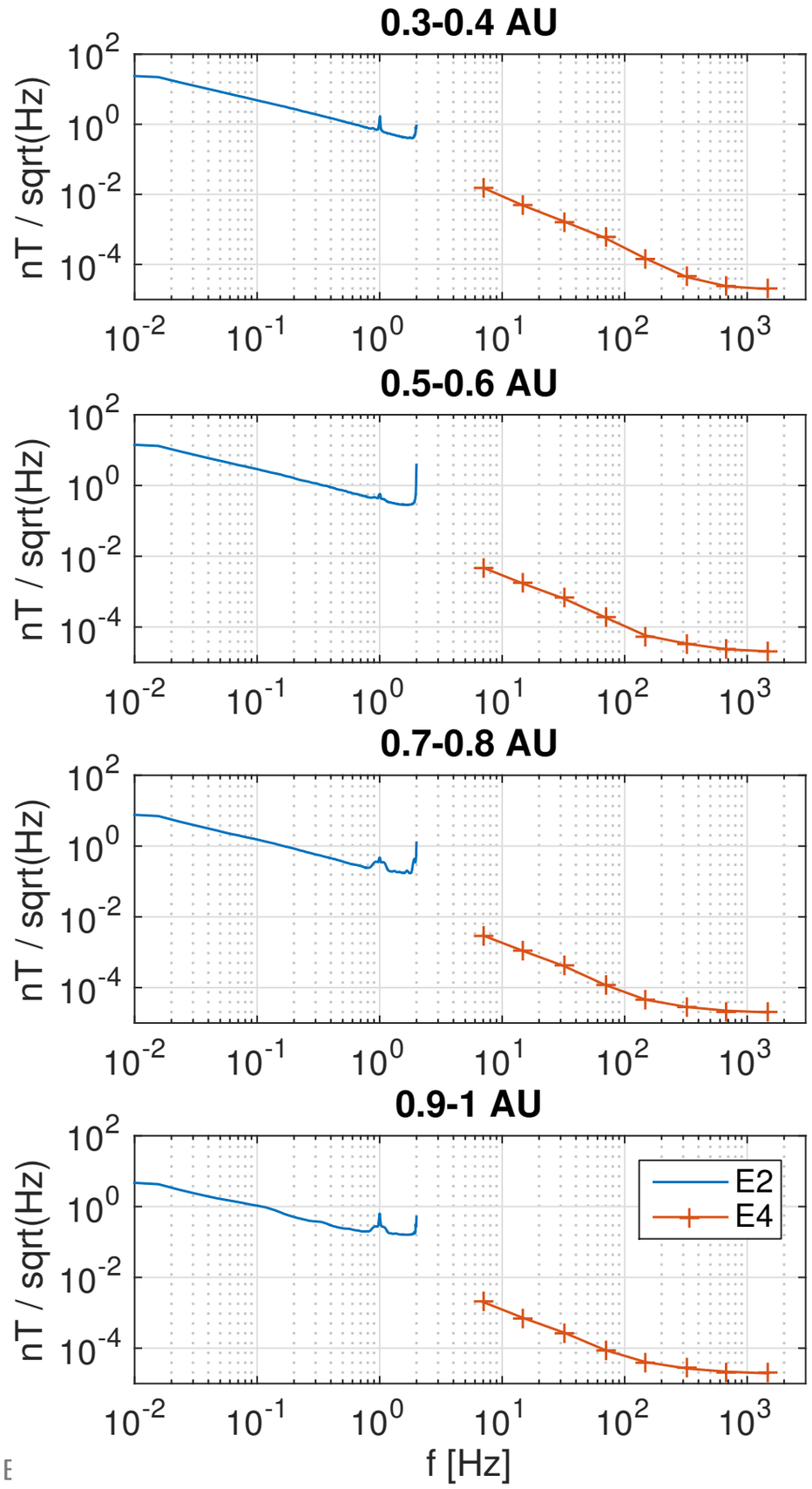
(black) Neubauer et al. (1977)

But plots do not always match



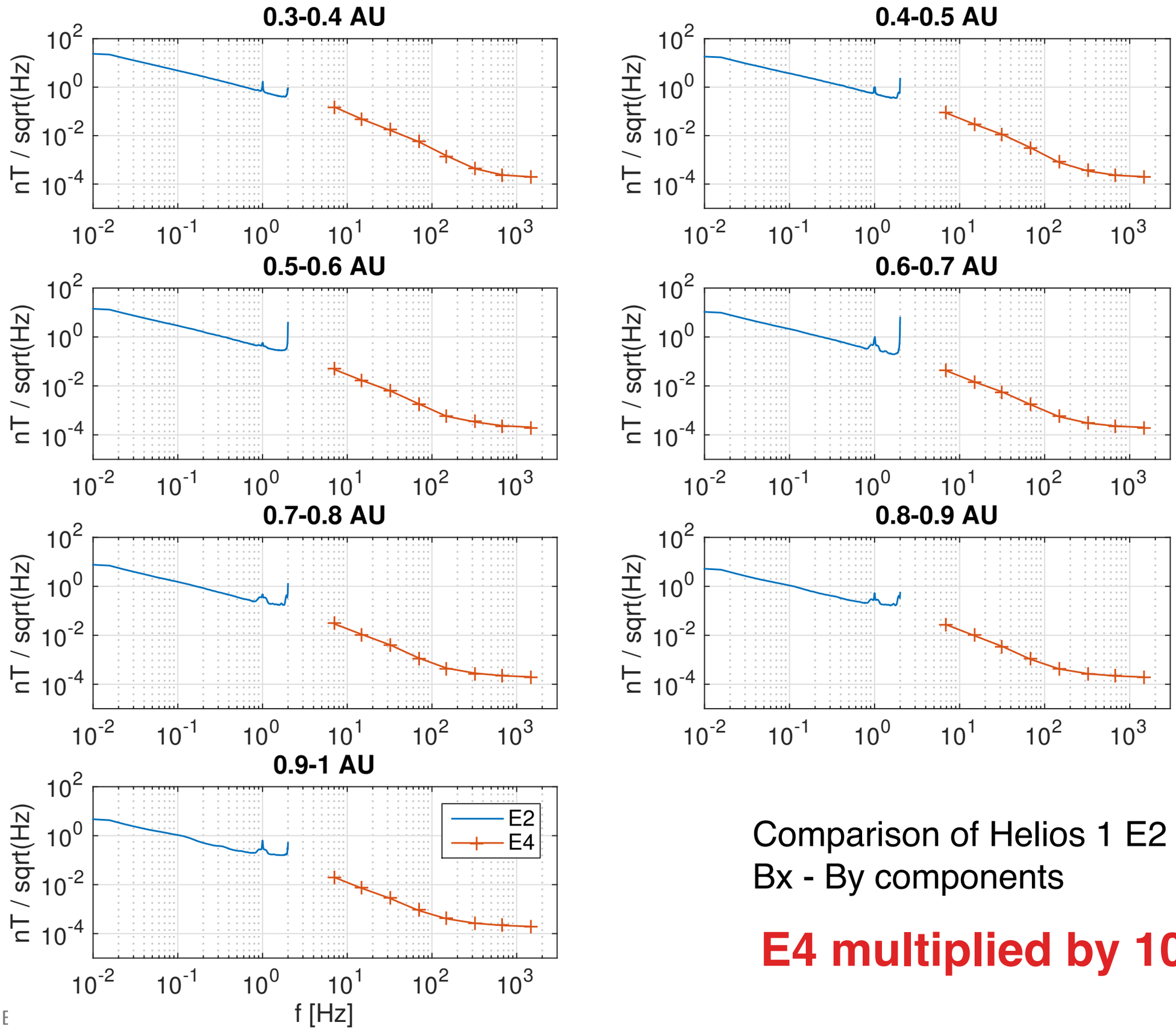
ratio = 1000

Do E2 and E4 match ?



Comparison of Helios 1 E2 and E4
Bx - By components

Do E2 and E4 match ?



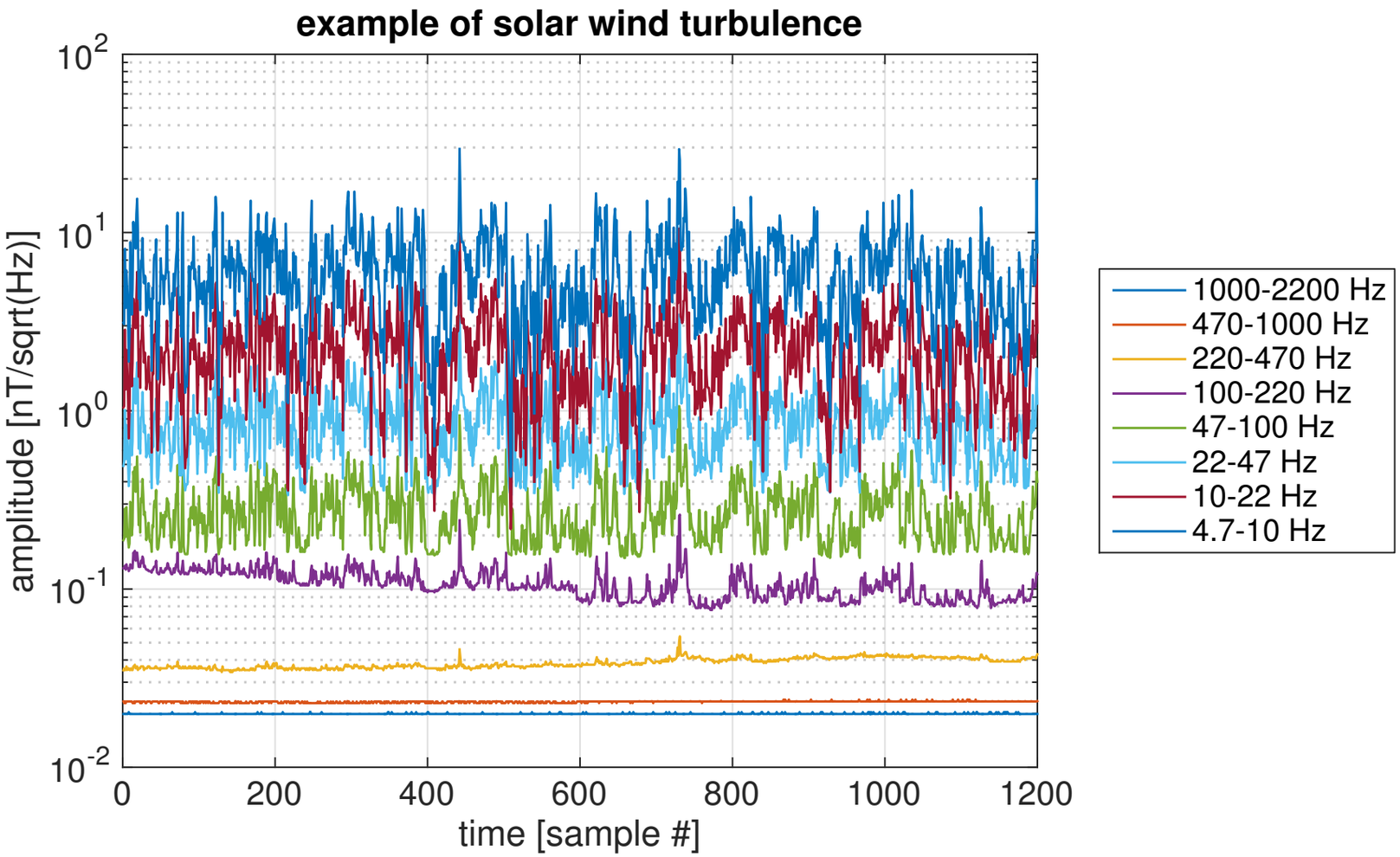
Comparison of Helios 1 E2 and E4
Bx - By components

E4 multiplied by 10

A low-dimensional model to identify wave activity

Low-dimensional mode

- Most channels evolve very **coherently** : similar fluctuations observed at all scales



- coarse approximation $B_z(t, f) \approx f(t) \cdot g(f)$

Low-dimensional model

- Look for separable model

$$B_z(t,f) = \sum_{i=1}^{N} f_i(t) \cdot g_i(f)$$

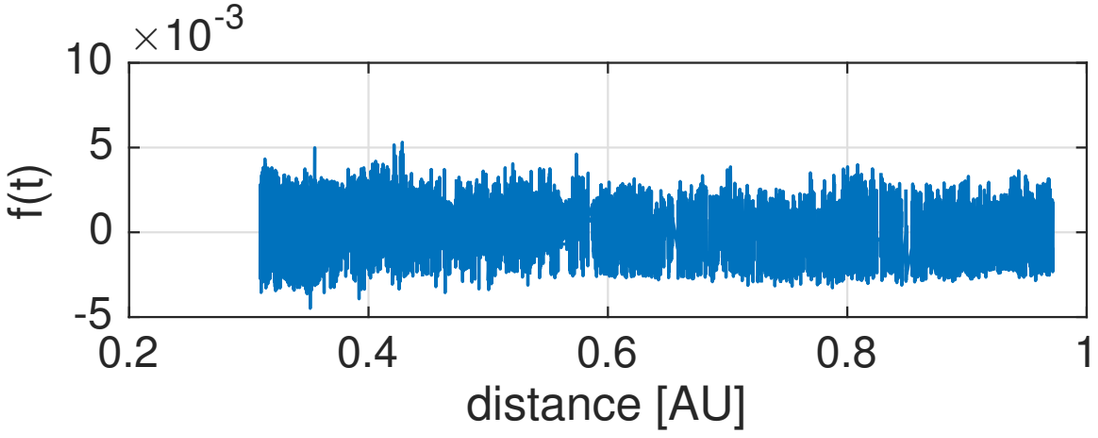
- For pure Kolmogorov turbulence, one would have

$$g(f) = f^{-\frac{5}{3}/2}$$

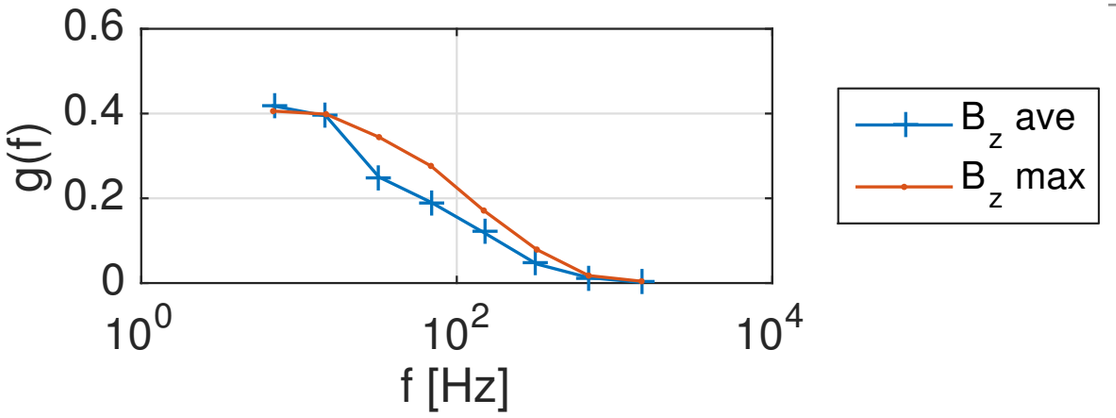
- Assume that the $f_k(t)$ are independent (evolve differently in time): use Independent Component Analysis

- With N=4 terms, **all the salient features** of the wavefield can be described

Low-dimensional model



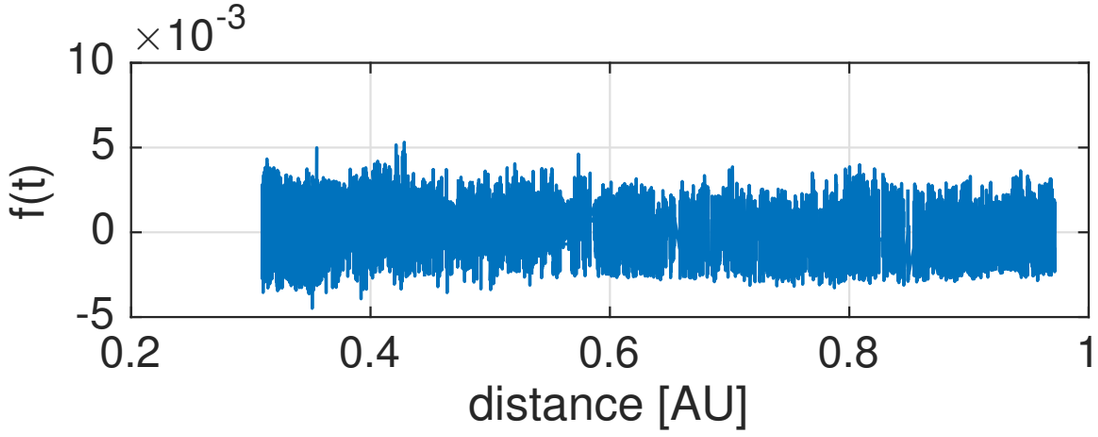
$f_1(t)$

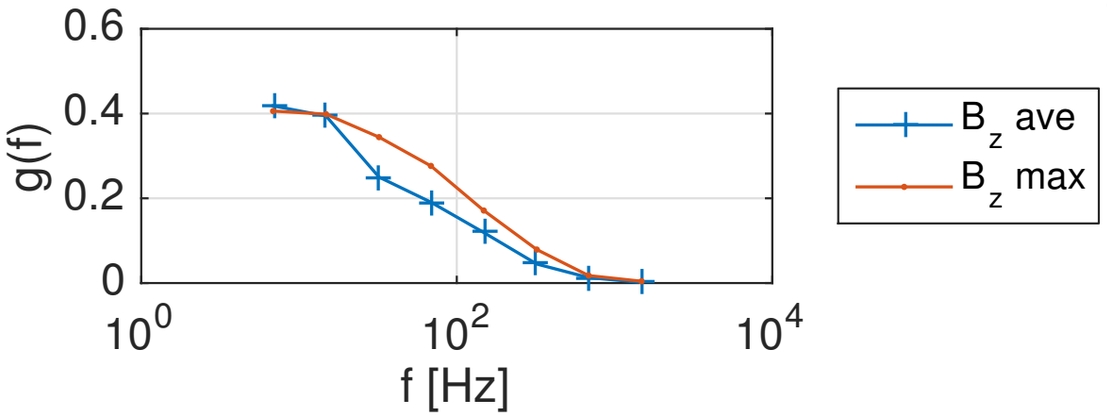


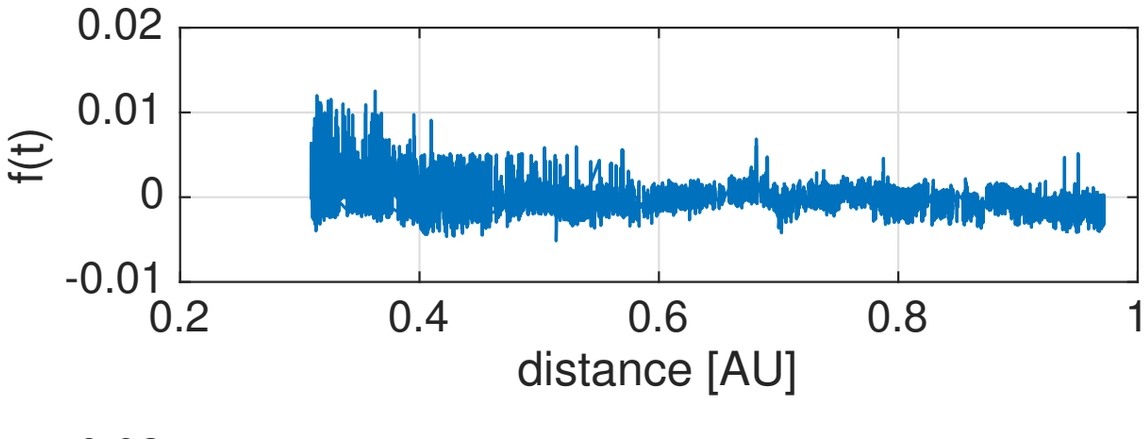
$g_1(f)$

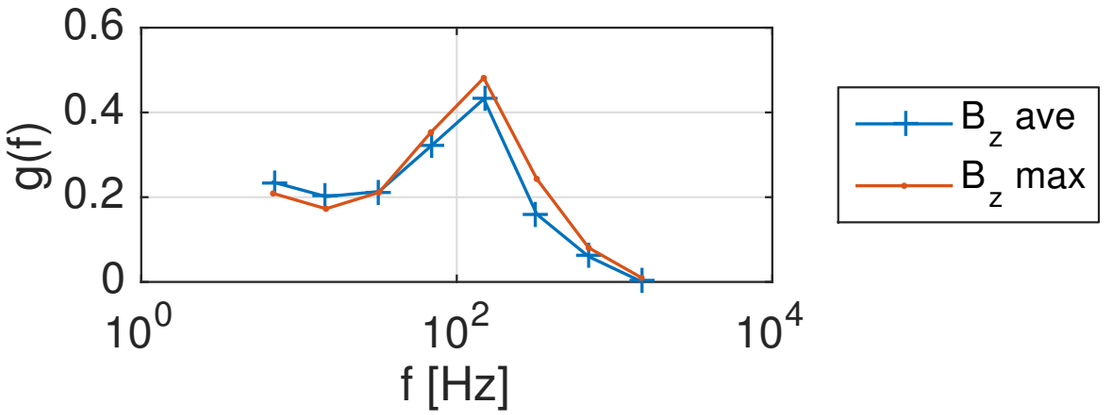
first mode describes a typical turbulent wavelfield

Low-dimensional model







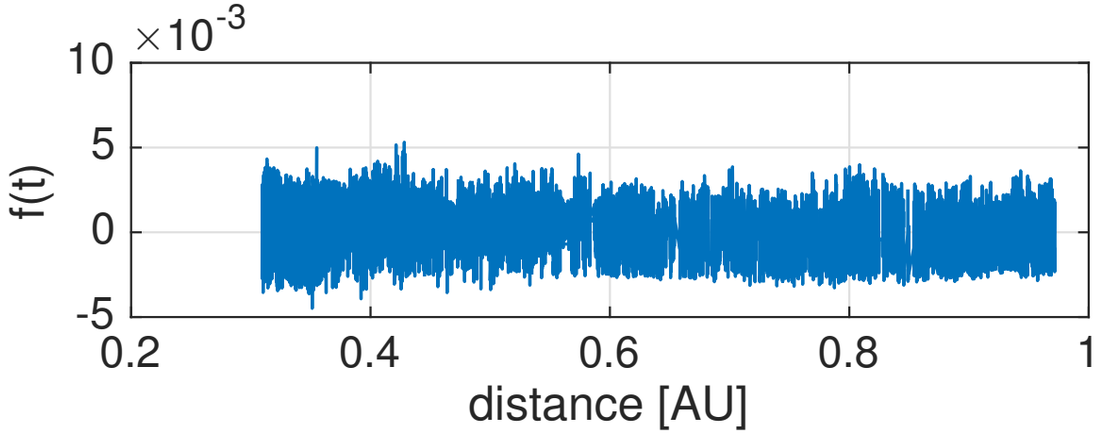


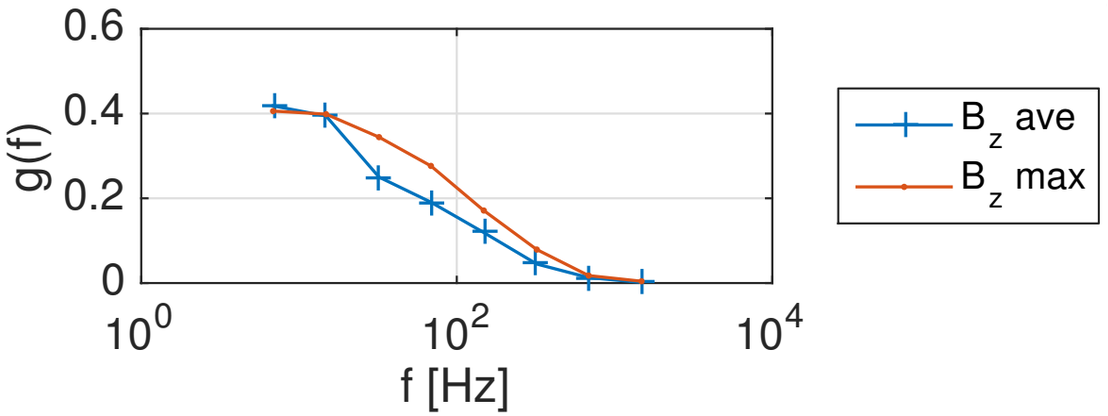
$f_2(t)$

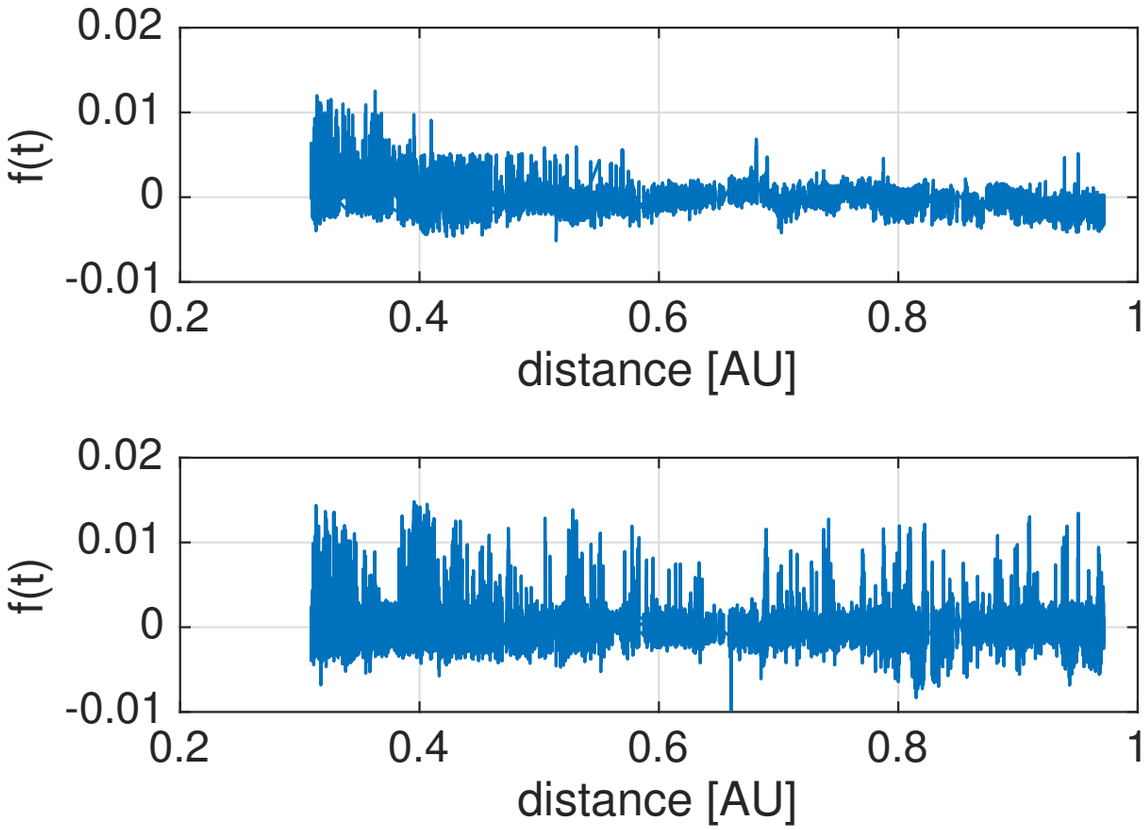
$g_2(f)$

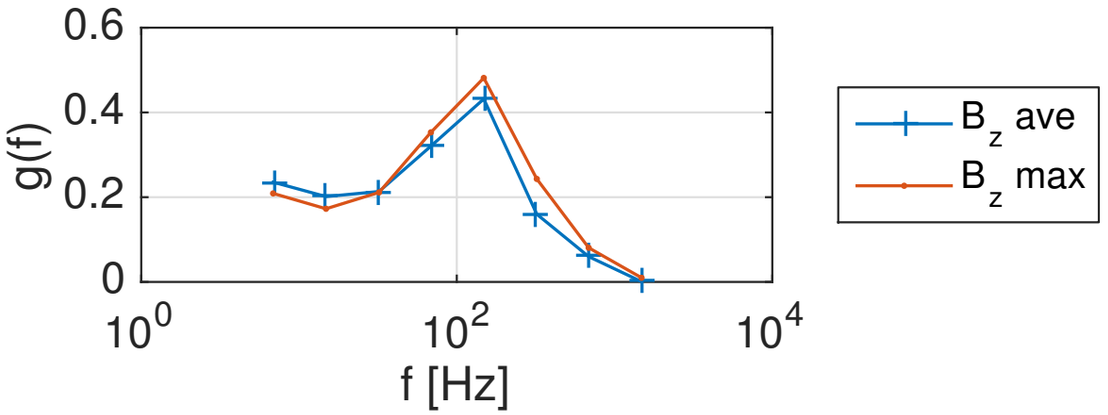
2nd mode describes whistler activity nearby the Sun

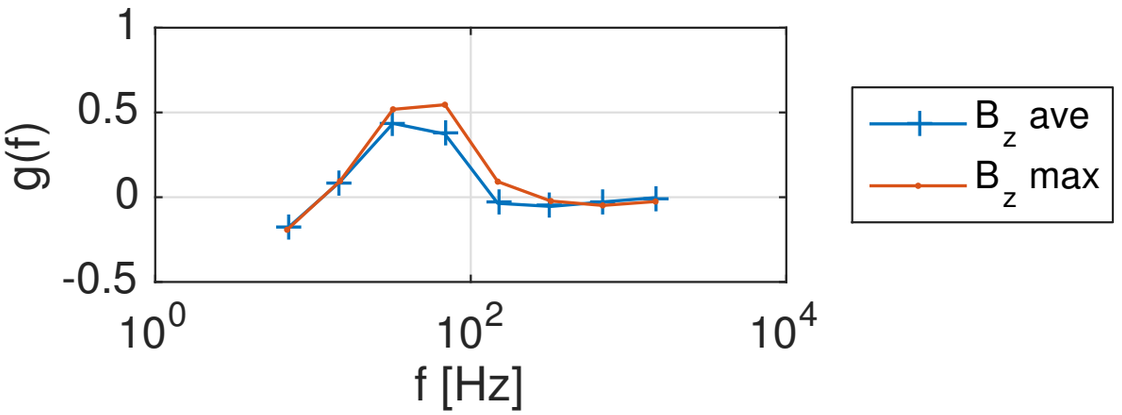
Low-dimensional model





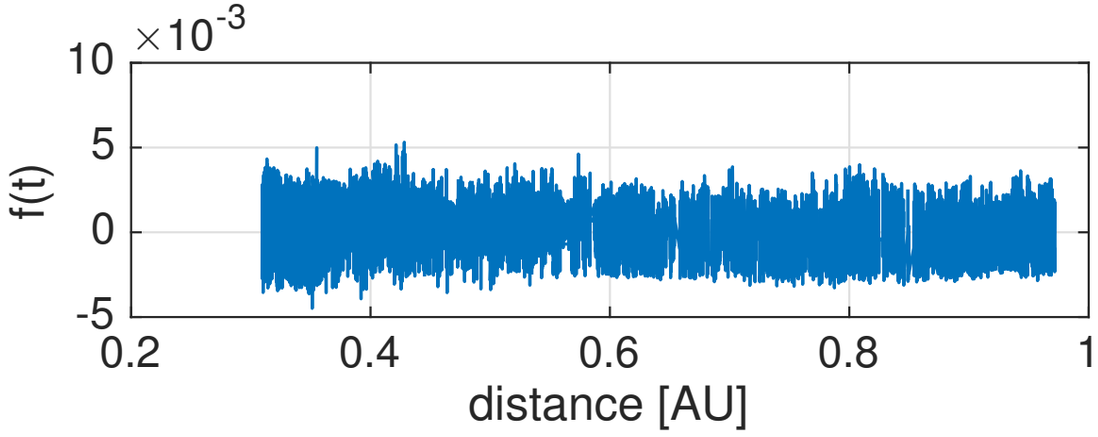


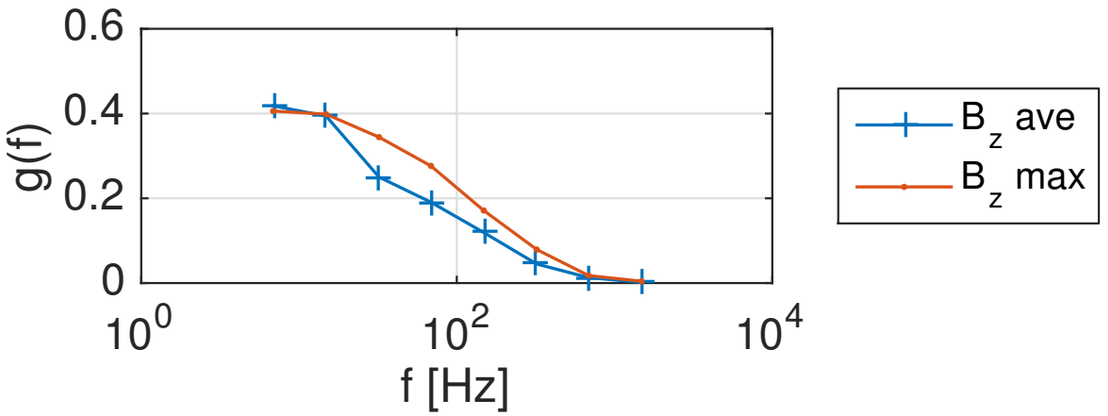


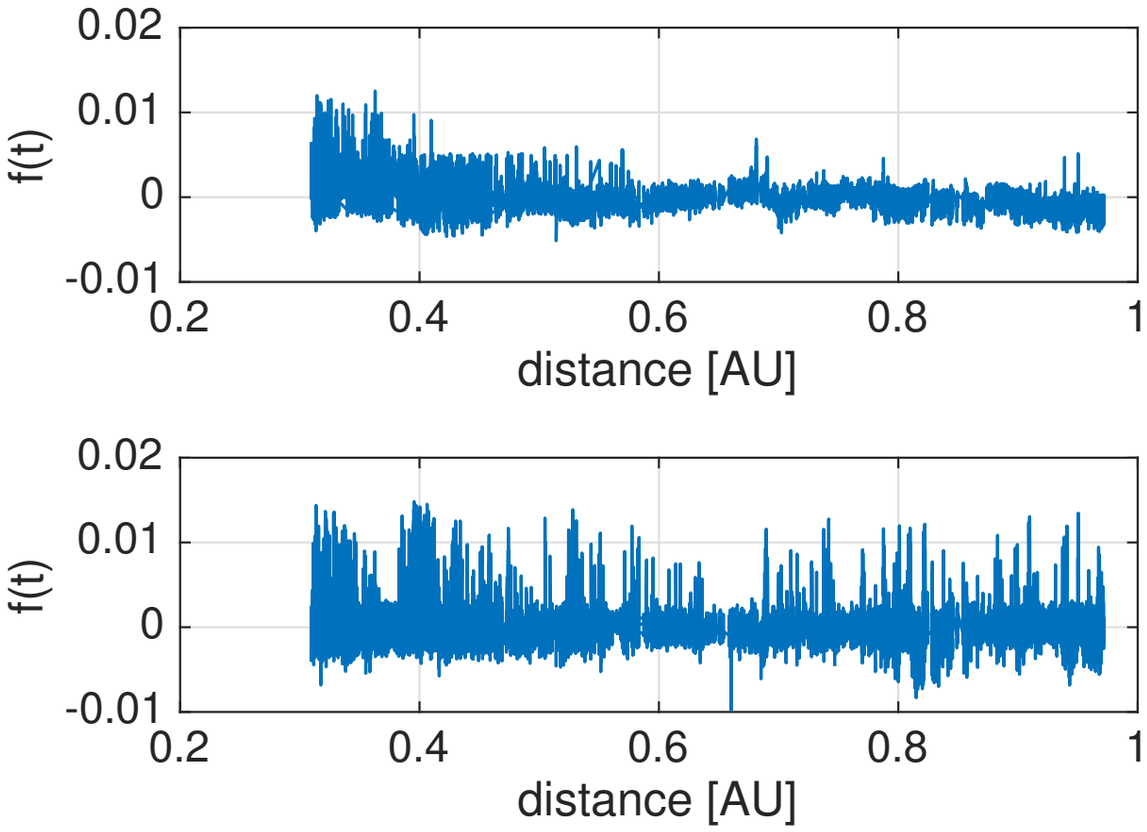


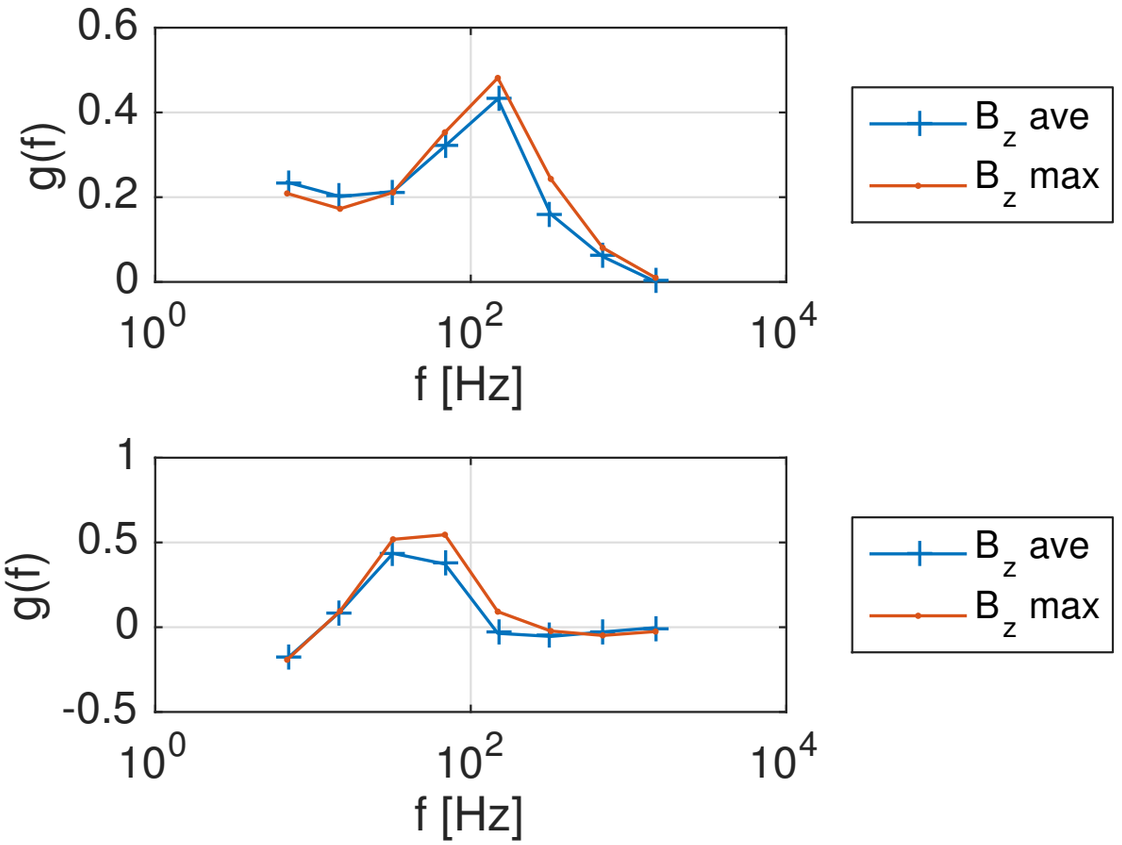
3rd mode describes whistler activity farther away from the Sun

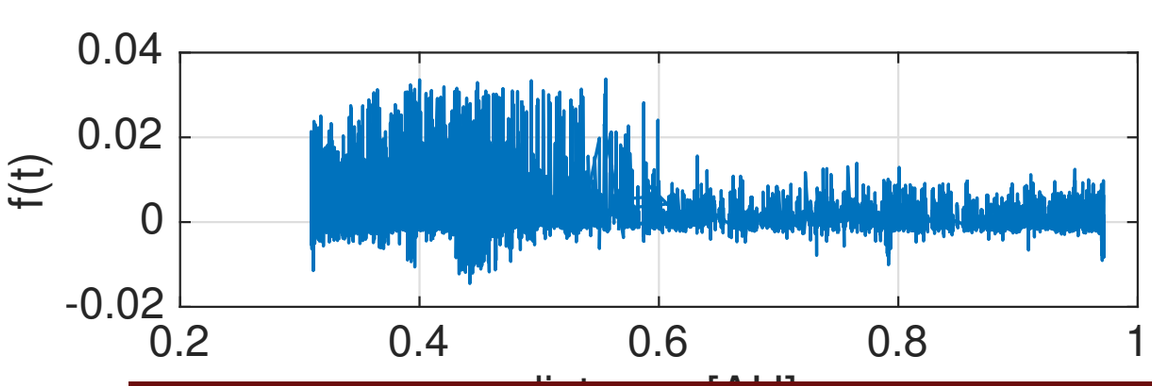
Low-dimensional model

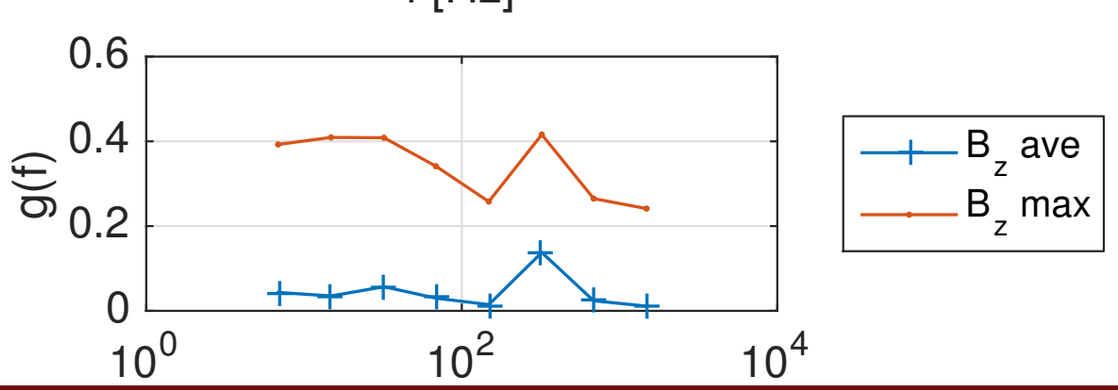












4th mode is completely different: shock-like transients near Sun

Conclusions

- Do we have access to all the existing data ? probably not
- The data look reasonably sound
  - but bands > 47 Hz are most dominated by noise
  - saturation is frequent : hard to analyse bursts
  - no attempt yet to use Bx & Bz together
- Absolute amplitude still has a 10x ambiguity
- Spectra consist of a mix of 4 features, including whistler wave bursts

Noise level in Helios 1 E2 B_x