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Report of the

PC10
LAP-MAG Interference Test

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1 Introduction

The subject of this report is the investigation of a possible interference of the RPCMAG instrument by the RPCLAP instrument.

During the complete ROSETTA mission disturbance frequency lines occurred in the dynamic magnetic field spectra of RPCMAG when MAG was operated in BURST mode (SID3, 20 Hz sampling frequency). Normally RPCMAG and RPCLAP operate in parallel and therefore it could not be decided whether LAP disturbs MAG or the disturbance is generated elsewhere on the S/C. Therefore, the test sequence RP06 (refer to chapter 2 for details) has been created where LAP is switched on and off and to different modes while MAG is just 'listening' what happens. The measured values, represented by dynamic magnetic field spectra, can be seen in chapter 3. It is a known fact that ROSETTA's reaction wheels disturb RPCMAG as well. As the reaction wheel, however, change their frequency permanently, the resulting disturbance is displayed in the dynamic spectra as tilted lines and can be easily distinguished from the constant disturbance frequencies, which are subject of the present investigation. To get an impression of the reaction wheel disturbances, the resulting wheel frequencies are added in chapter 4. The analysis of the complete test is presented in chapter 5.

2 The Command Timeline of the Test

This test follows ESB3 RP01.

Configuration before this step:	MAG ON in normal mode; all other instruments OFF.
Testname:	PC10RP06 - MAG-LAP possible interference [R_RP025]
Obs slot start:	320_15:00:00
Obs slot stop:	321_17:00:00
Obs slot duration:	001_03:00:00

STEP	Date/TIME UTC	Rel. Time [hh:mm]	Makro	Command	Parameter	Comment
020	16.11/15:00	00:00	ARPS811A	MAG Mode Change VSK01264 = SID3		ModeMAG Burst mode SID3
025	16.11/15:10	00:10	ARPF510A			MAG Select OB Sensor Primary
030	16.11/19:00	04:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
040	16.11/20:00	05:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
050	16.11/21:00	06:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
060	16.11/22:00	07:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
070	16.11/23:00	08:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
080	16.11/24:00	09:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
090	17.11/01:00	10:00	ARPS811A	MAG Mode Change VSK01264 = SID3		ModeMAG Burst Mode SID3
110	17.11/01:10	10:10	ARPF511A			MAG Select IB Sensor Primary
120	17.11/02:00	11:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
130	17.11/03:00	12:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
150	17.11/04:00	13:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
160	17.11/05:00	14:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
170	17.11/06:00	15:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
180	17.11/07:00	16:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
185	17.11/08:00	17:00	ARPF510A			MAG Select OB Sensor Primary
187	17.11/08:10	17:10	ARPS811A	MAG Mode Change VSK01264 = SID4		ModeMAG Medium Mode SID4
190	17.11/09:00	18:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
200	17.11/10:00	19:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
220	17.11/11:00	20:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
230	17.11/12:00	21:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x43	LAP macro 0x503 (Vsc, waves)
240	17.11/13:00	22:00	ARPS809A	LAP Mode Change VSK01262 = SID2	ModeLAP VSK01267 = 0x50	LAP macro 0x600 (sweeps)
244	17.11/14:00	23:00	ARPS809A	LAP Mode Change VSK01262 = OFF	ModeLAP VSK01267 = 0xff	LAP off
250	17.11/17:00	26:00				RPC off at via SWOFF ITL

Table 1: Command Timeline

3 Dynamic Magnetic Field Spectra measured by RPCMAG Instrument

This section shows the dynamic spectra in LEVEL_C = ECLIPJ2000 coordinates. For the times were the instrument was operated in NORMAL mode the maximum resolvable frequency for the primary sensor is 0.5 Hz, for MEDIUM mode it is 2.5 Hz, for BURST mode it is 10 Hz.

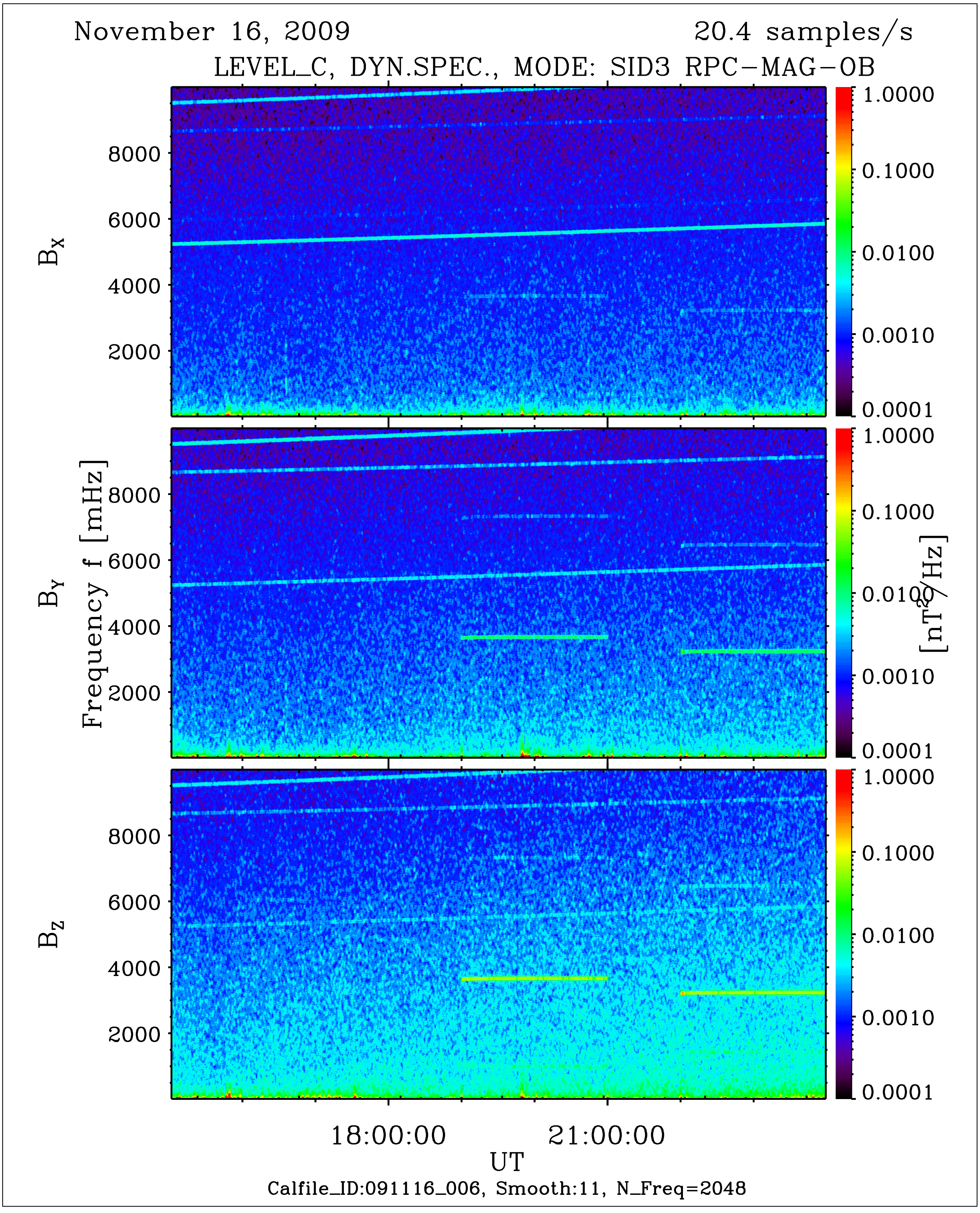

Figure 1: File: RPCMAG091116T1501_CLC_OB_M3_DS0_10000_006

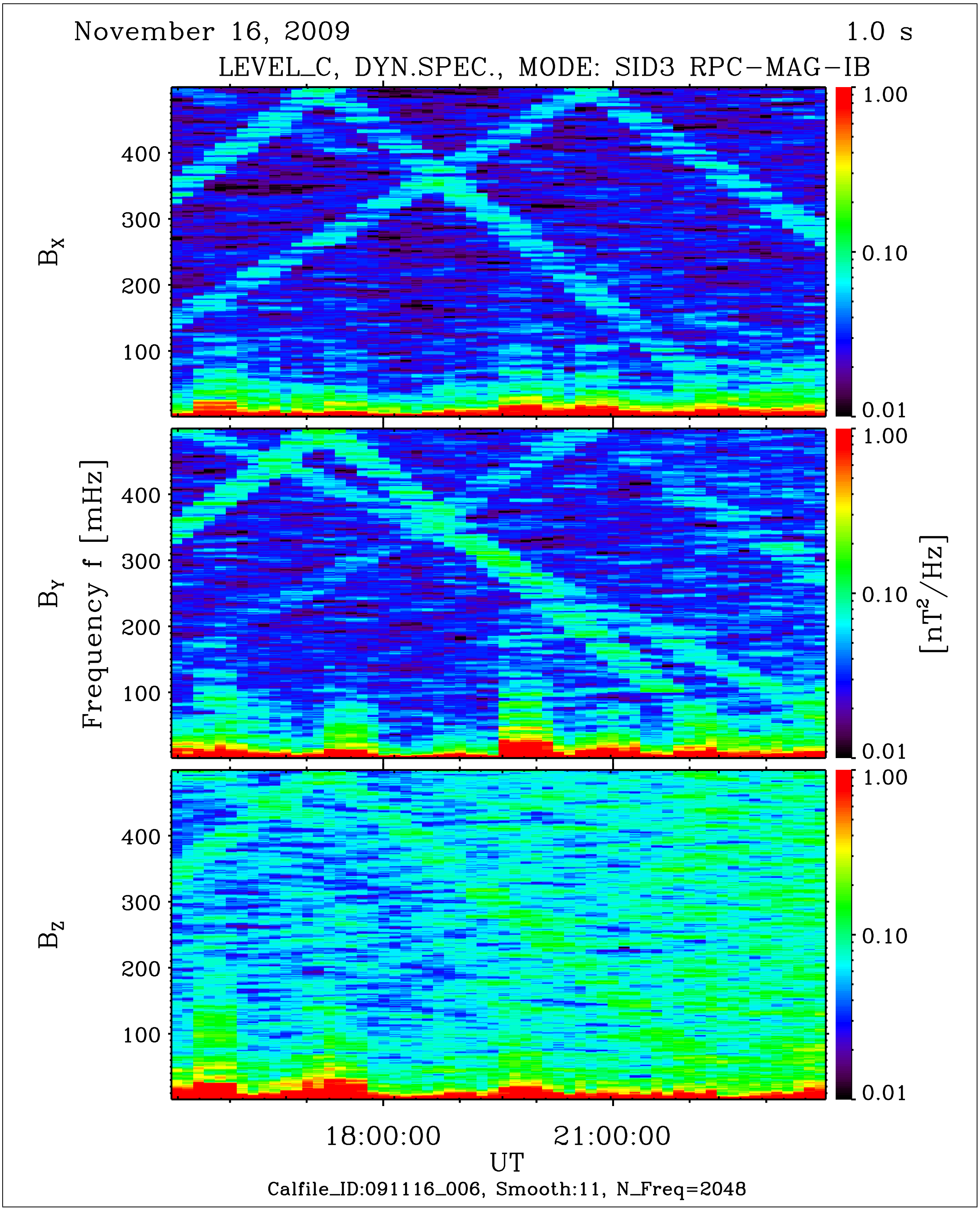

Figure 2: File: RPCMAG091116T1501_CLC_IB_M3_DS0_10000_006

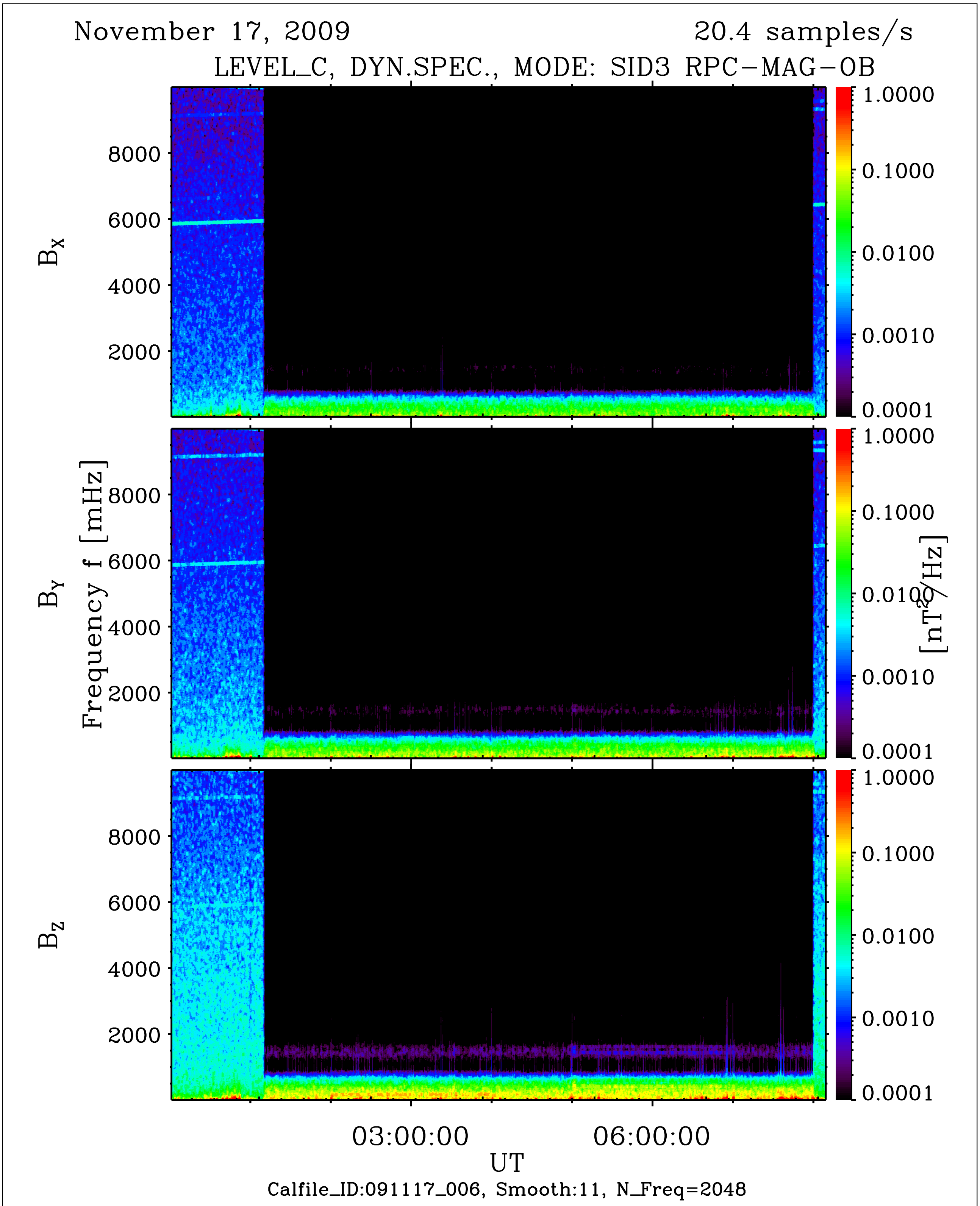

Figure 3: File: RPCMAG091117T0000_CLC_OB_M3_DS0_10000_006

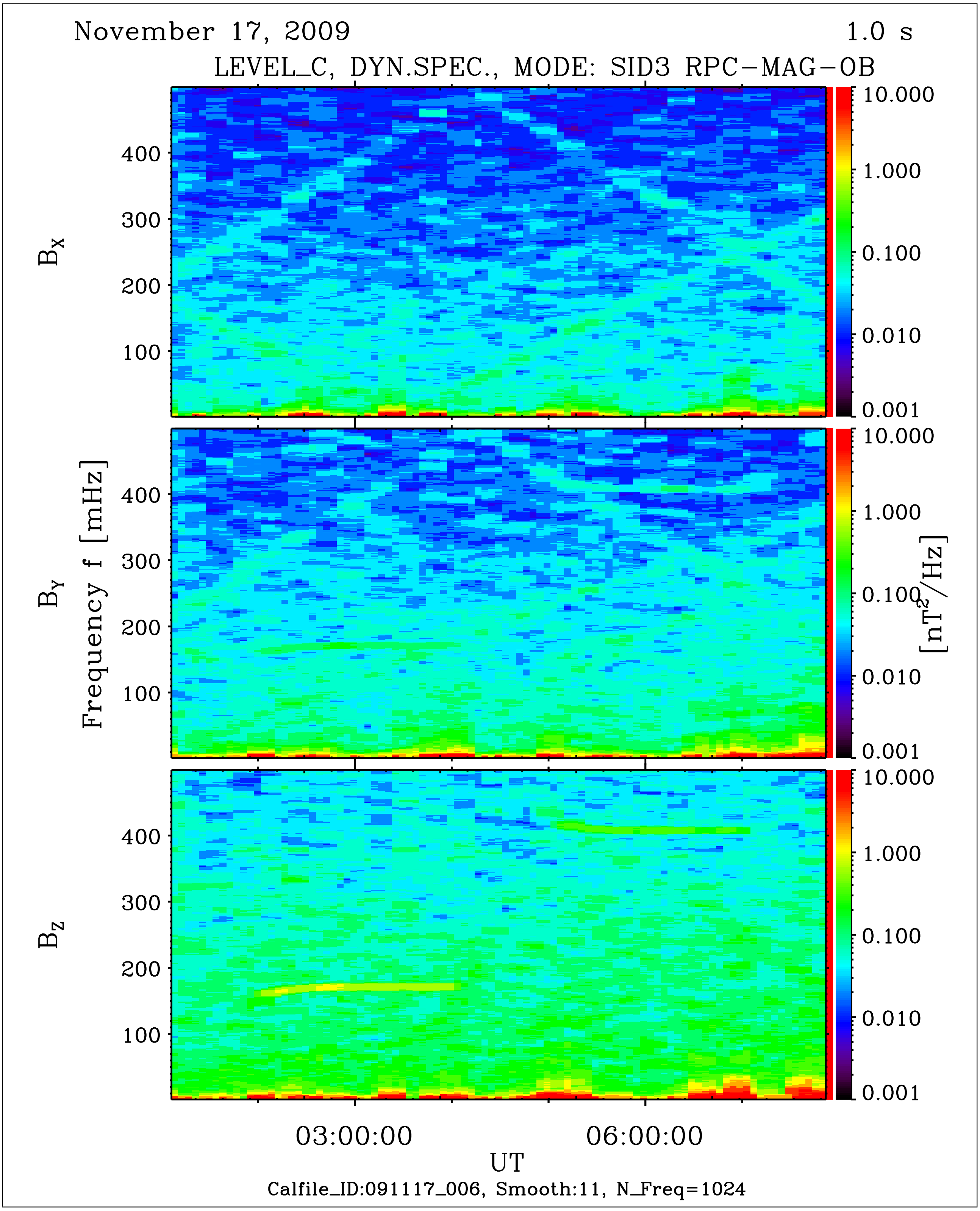

Figure 4: File: RPCMAG091117T0000_CLC_OB_M3_DS0_500_006

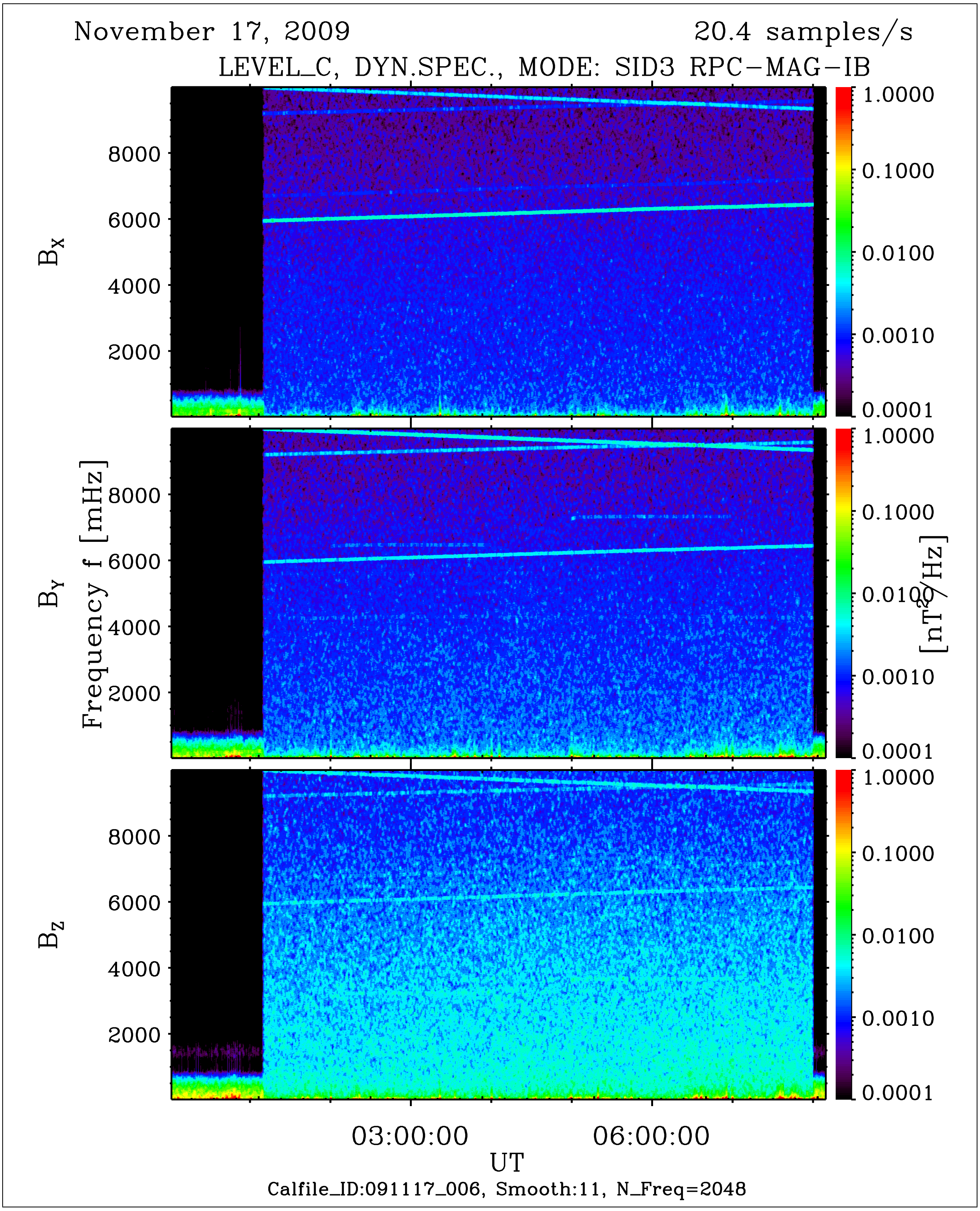

Figure 5: File: RPCMAG091117T0000_CLC_IB_M3_DS0_10000_006

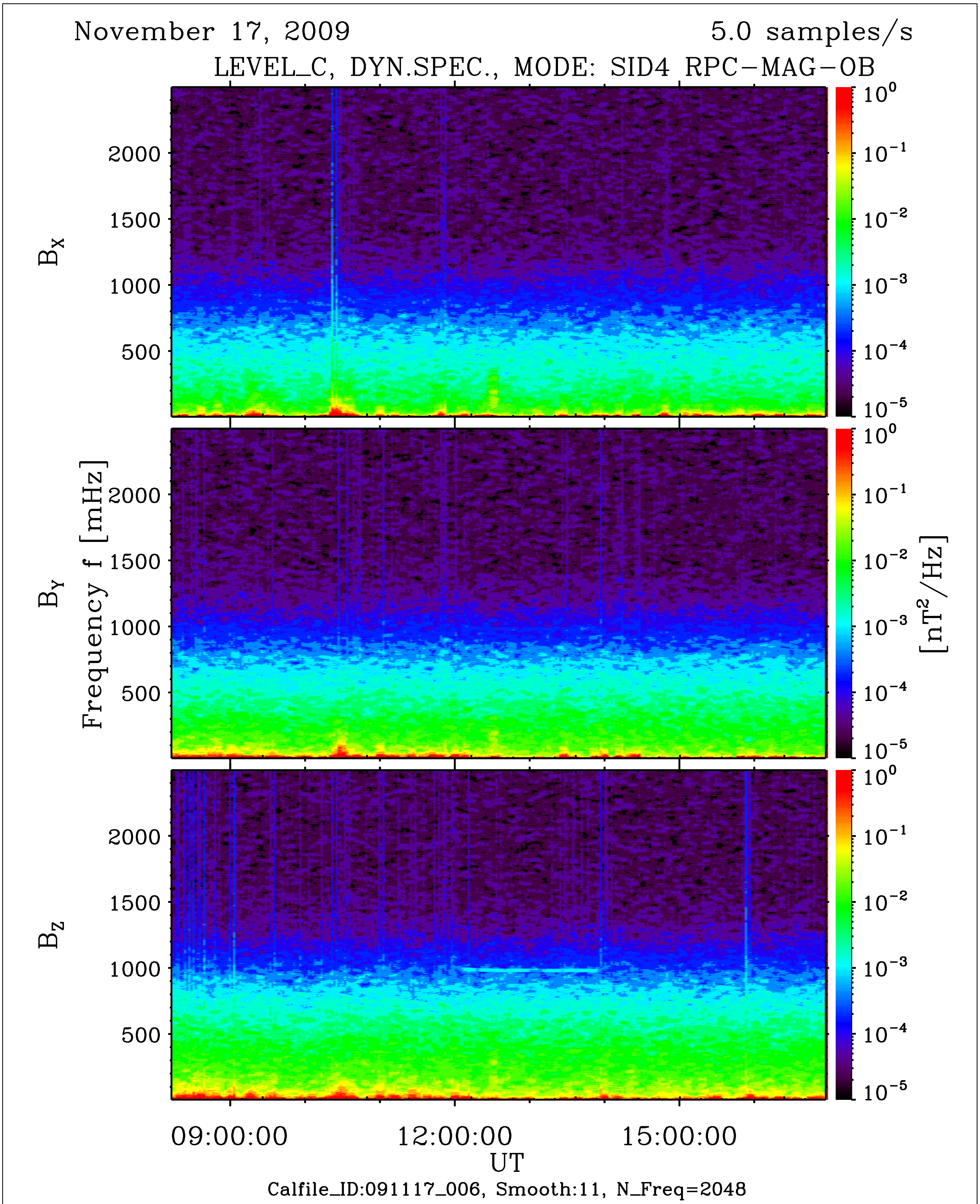

Figure 6: File: RPCMAG091117T0810_CLC_OB_M4_DS0_2500_006

4 Dynamic Spectra of ROSETTAs REACTION WHEELS

This section shows the spectra of ROSETTAs Reaction Wheels (RW). There are 4 different wheels rotating with different frequencies. The plots do not show the original rotation frequencies but the signatures that would be expected using an data acquisition system operating at 1 Hz, 5 Hz and 20 Hz sampling frequency without any aliasing filter.
These signatures are expected to be seen on the actual primary sensor.

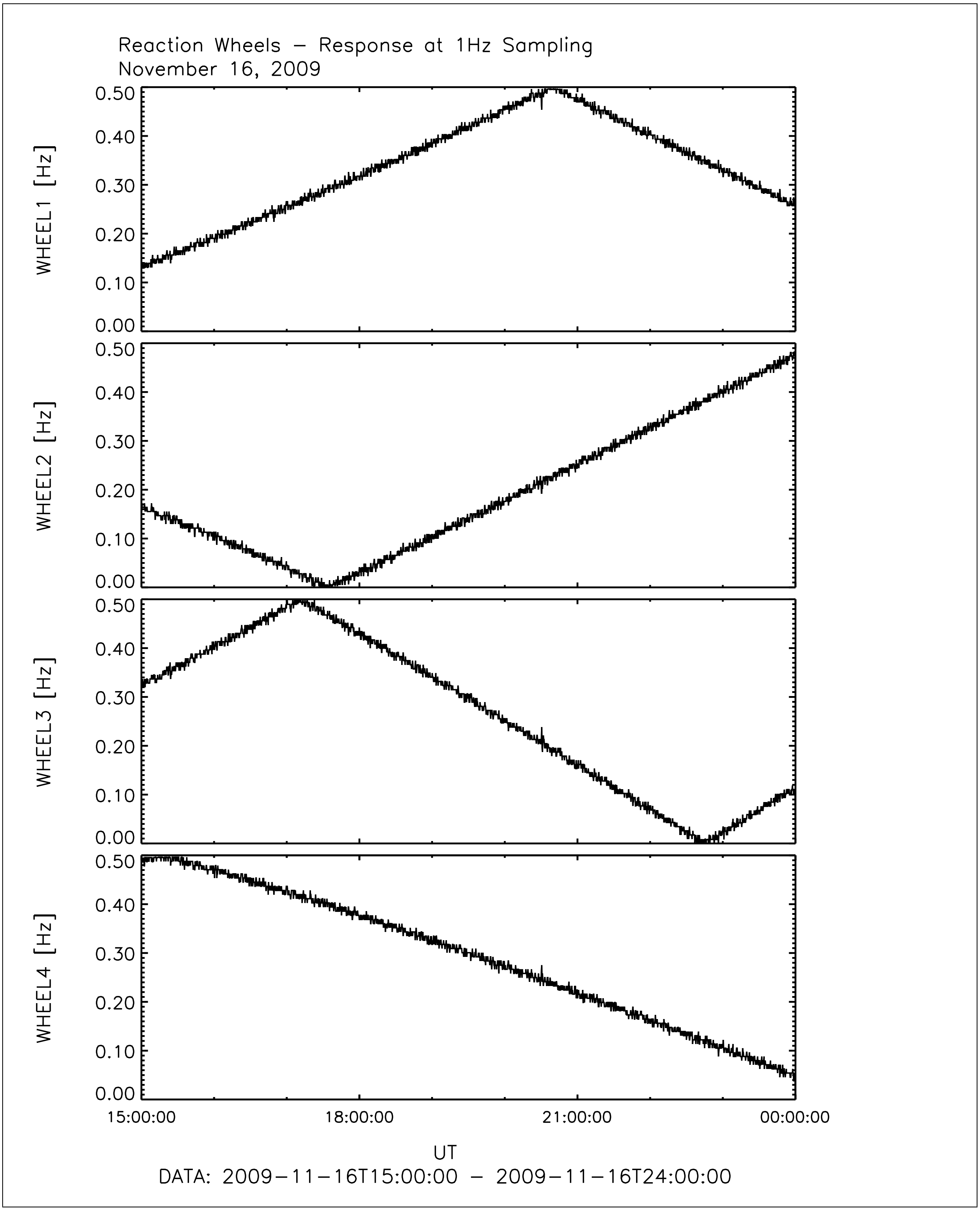

Figure 7: File: wheels_1Hz_Sampling2009-11-16T15-00

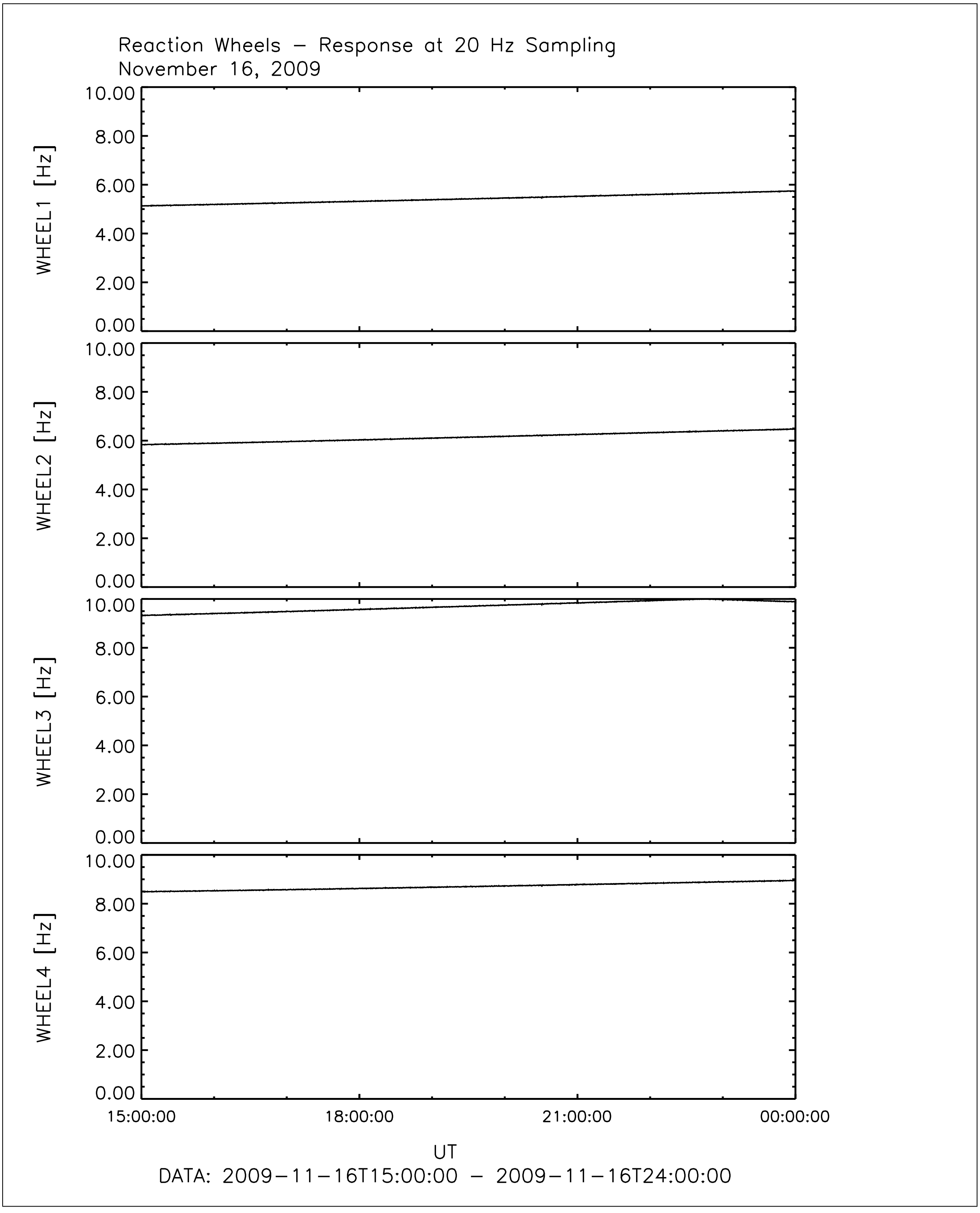

Figure 8: File: wheels_20Hz_Sampling2009-11-16T15-00

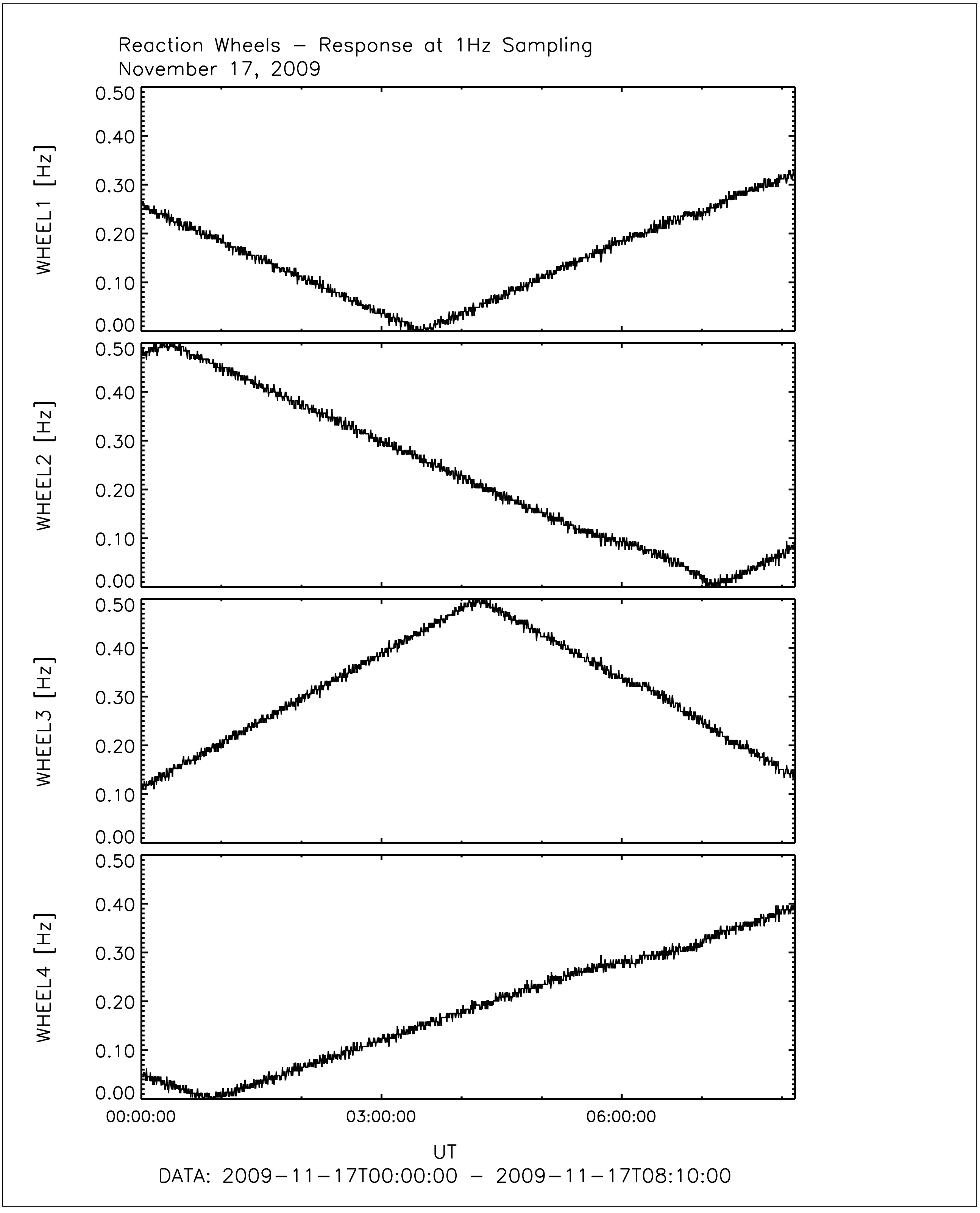

Figure 9: File: wheels_1Hz_Sampling2009-11-17T00-00

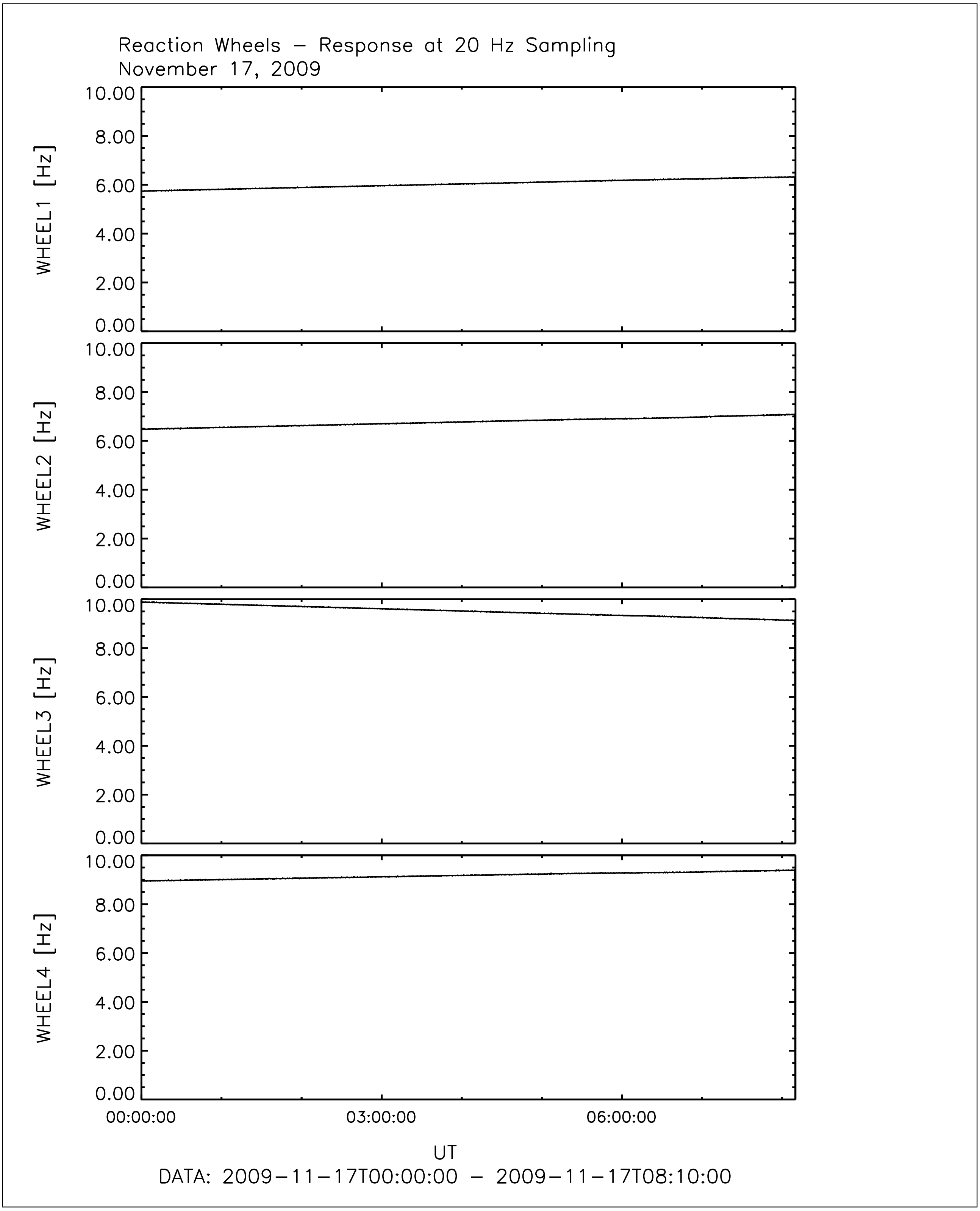

Figure 10: File: wheels_20Hz_Sampling2009-11-17T00-00

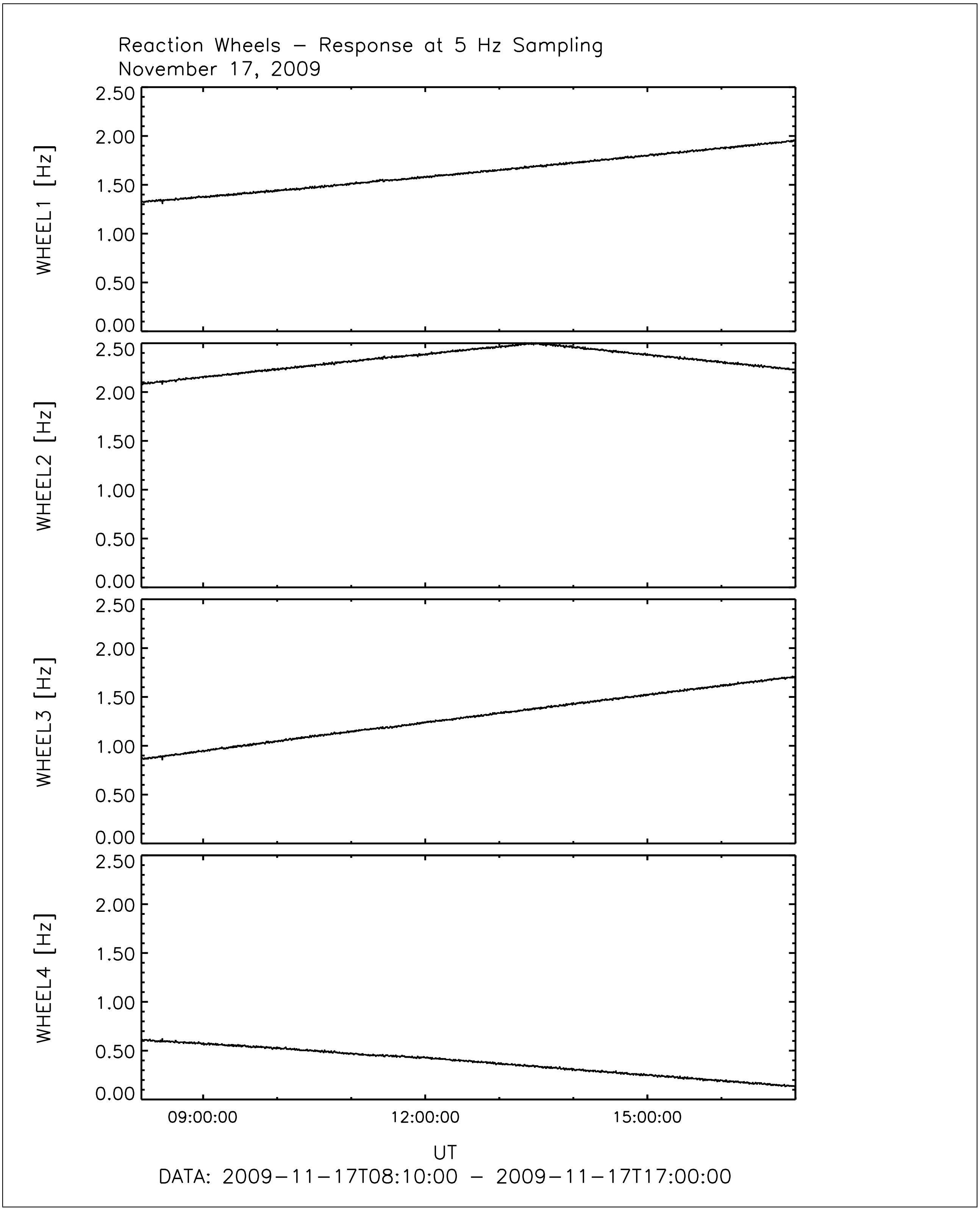

Figure 11: File: wheels_5Hz_Sampling2009-11-17T08-10

5 Analysis of the Test

The test is evaluated on base of the dynamic magnetic field spectra. The plotted spectra give a meaningful overview of the occurred disturbance frequencies.
On the first view a lot of tilted lines in the spectra are conspicious. A comparison with ROSETTA's reaction wheel frequencies show up, that all these lines are generated by the reaction wheels. They are not subject of this investigation.
However, from time to time constant disturbance frequencies (horizontal lines) appear in the spectra. These events are investigated now. The comparison of the timeline commands and the Dynamic Magnetic field spectra reveal the following facts.

- 16. November 19:00
  LAP: switch on and set to 'sweep' mode.
  MAG: (SID3,OB) sees disturbance on 3.65 Hz and first harmonic on 7.3 Hz
- 16. November 20:00
  LAP: mode change to 'wave' mode.
  MAG: Disturbance unchanged
- 16. November 21:00
  LAP: switch off.
  MAG: Disturbance vanishes
- 16. November 22:00
  LAP: switch on and set to 'wave' mode.
  MAG: (SID3,OB) sees disturbance on 3.25 Hz and first harmonic on 6.5 Hz
- 16. November 23:00
  LAP: mode change to 'sweep' mode.
  MAG: Disturbance unchanged
- 16. November 24:00
  LAP: switch off.
  MAG: Disturbance vanishes
- 17. November 01:10
  LAP: stays off
  MAG: IB sensor Primary, SID3
- 17. November 02:00
  LAP: switch on and set to 'sweep' mode.
  MAG: (SID3,IB pri 20Hz sampling) sees disturbance on 3.25 Hz & 1. harmonic on 6.5 Hz
  MAG: (SID3,OB sec 1Hz sampling) sees disturbance on 172 mHz

- 17. November 03:00
  LAP: mode change to 'wave' mode.
  MAG: Disturbance unchanged
- 17. November 04:00
  LAP: switch off.
  MAG: Disturbance vanishes
- 17. November 05:00
  LAP: switch on and set to 'wave' mode.
  MAG: (SID3,IB prim 20 Hz sampling) sees disturbance on 3.65 Hz & 1. harmonic on 7.3 Hz
  MAG: (SID3,OB sec 1 Hz sampling) sees disturbance on 410 mHz
- 17. November 06:00
  LAP: mode change to 'sweep' mode.
  MAG: Disturbance unchanged
- 17. November 07:00
  LAP: switch off.
  MAG: Disturbance vanishes
- 17. November 08:10
  LAP: stays off
  MAG: OB sensor Primary, SID4, 5 Hz Sampling
- 17. November 09:00
  LAP: switch on and set to 'sweep' mode.
  MAG: No Disturbance (max. usable frequency is 2.5 Hz)
- 17. November 10:00
  LAP: mode change to 'wave' mode.
  MAG: No Disturbance (max. usable frequency is 2.5 Hz)
- 17. November 11:00
  LAP: switch off.
  MAG: No Disturbance (max. usable frequency is 2.5 Hz)
- 17. November 12:00
  LAP: switch on and set to 'wave' mode.
  MAG: (SID4,OB, 5 Hz sampling) sees disturbance on 990 mHz
- 17. November 13:00
  LAP: mode change to 'sweep' mode.
  MAG: Disturbance unchanged
- 17. November 14:00
  LAP: switch off.
  MAG: Disturbance vanishes

The analysis of the occurring effects reveals the following:

1. The observed disturbing frequencies occur only when LAP is switched on.
2. The disturbance can be seen on
3.65 Hz / 7.3 Hz (MAG in BURST mode , 20Hz sampling) and on 410 mHz in the 1 Hz sampling mode or.
3.25 Hz / 6.5 Hz (MAG in BURST mode , 20Hz sampling) and on 172 mHz in the 1 Hz sampling mode. 990 mHz (MAG in MEDIUM mode, 5Hz sampling)
3. A unique relation between the LAP mode and the value of the occurring disturbance frequency seems not to exist.
4. A LAP mode change - if already powered on – does NOT change the disturbing frequency.
5. Although the MAG IB sensor is located closer to the S/C than the OB Sensor, the OB sensor observes a stronger disturbance. This might be an indication that the disturbance is caused by electric interference in the RPC-0 box rather than magnetically via the sensors.

As already seen at the disturbance of the reaction wheels, the disturbance mechanism is associated with aliasing effects occurring during the data sampling on the RPCMAG side. All disturbances at frequencies higher than the Nyquist frequency f_N of the actual mode ($f_N = 0.5$ Hz for SID2 (NORMAL mode), $f_N = 5$ Hz for SID3 (BURST mode), $f_N = 2.5$ Hz for SID4 (MEDIUM mode)) are folded down to the frequency range between 0 Hz and f_N.
When RPCMAG samples with the frequency f_s , i.e. the actual Nyquist frequency is $f_N = \frac{f_s}{2}$, and the observed LAP disturbance occurs at f_{obs} a possible ORIGINAL frequency f_{orig} has to meet the following condition:

$$f_{orig} = n \cdot f_s \pm f_{obs} \ , \qquad n = 0, 1, 2, \ldots$$

As both RPCMAG sensors are operated with different sampling rates in parallel (i.e BURST mode: primary Sensor 20 Hz sampling, secondary sensor 1Hz sampling) two of such conditions have to be met if the disturbance occurs on both sensors:

$$\begin{aligned} f_{orig} &= n \cdot f_{s_1} \pm f_{obs_1} \ , \qquad n = 0, 1, 2, \ldots \\ f_{orig} &= m \cdot f_{s_2} \pm f_{obs_2} \ , \qquad m = 0, 1, 2, \ldots \end{aligned}$$

Equalizing both equations could maybe reveal a suitable pair of (m, n) which fulfils the system and leads to the original disturbance frequency. However, due to the measurement uncertainty of the frequencies and the probably high values of (m, n) the solution might not be unique.

The sampling frequencies of RPCMAG are:

Mode	SID	$f_{s_{prim}}$ [Hz]	$f_{s_{sec}}$ [Hz]
NORMAL	SID2	1	0.03125
MEDIUM	SID4	5	0.03125
BURST	SID3	20	1.0

5.1 Further steps

As seen is the disturbance source clearly identified as the LAP instrument. Although the mechanism of disturbance generation is not yet understood, it is quite obvious, that only a few constant frequencies are generated.

To improve the data quality these frequency lines can be purged from data in the quasi the same way as it is done for the disturbance of the reaction wheels. Thus, the algorithm that produces the cleaned LEVEL_H data has been modified in that way that also the LAP disturbance is taking into account. For details of the algorithm refer to RO-IGEP-TR0012.

A a consequence all data sets with a version number higher or equal V3.0 will contain Reaction wheel AND LAP corrected data.