

**R O S E T T A**  
**FLIGHT REPORTS**  
**of RPC-MAG**

**RO-IGEP-TR-0022**

**Issue: 3    Revision: 0**

**January 25, 2010**

**Report of the**  
**MARS Swing by (MSB)**  
**Time period: February 23 - 27, 2007**

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## 1 Introduction

ROSETTA's Mars Swing by (MSB) happened in the time period February 23 – 27, 2007. RPC-MAG was switched on in the time between 2007-02-23T00:00:54 and 2007-02-27T02:37:50. Around the closest Approach, however, all the orbiter payload was switched off due to power safety reasons. Therefore, there is a data gap for the time interval 2007-02-25T00:38:14 and 2007-02-25T02:35:42. The overall instrument performance was excellent. There were no problems.

This document gives a brief description of the executed activities and show the obtained data. Housekeeping data ( Temperature of the OB & IB sensor, Filter Stages A & B, Filter configuration register, Reference voltage, negative and positive 5V supply voltage, and the coarse HK sampled magnetic field data of the OB sensor ) are presented as well as magnetic field science data of the OB and IB sensor in the activated modes. Magnetic field data are plotted in s/c coordinates, ECLIPJ2000 coordinates and in Mars Solar Orbital (MSO) coordinates for the complete overview. The data are calibrated according to the results of the ground calibration and the results of the inflight temperature model 006 using the Mars flight data from February 2007. Sensitivity, Misalignment, and Temperature effects are taken into account. The s/c residual field is not subtracted. For details refer to section 5

The spectra of the magnetic field data measured by the OB sensor are plotted as well in section 7. The few measurements in BURST mode (SID3) in the hours around CA are disturbed by ROSETTAs reaction wheels (refer to section 6). This disturbance can be eliminated d by our processing S/W.

At the end overview plots for the complete swing-by period are shown in ECLIPJ2000 and MSO coordinates.

## 2 The Swing-by Geometry

This section gives an overview about the trajectory during the MARS Swing-by. ROSETTA approached from the day side, had its closest approach on February 25 at 01:58, and left through tail region. The minimum distance to earth was 261 km.

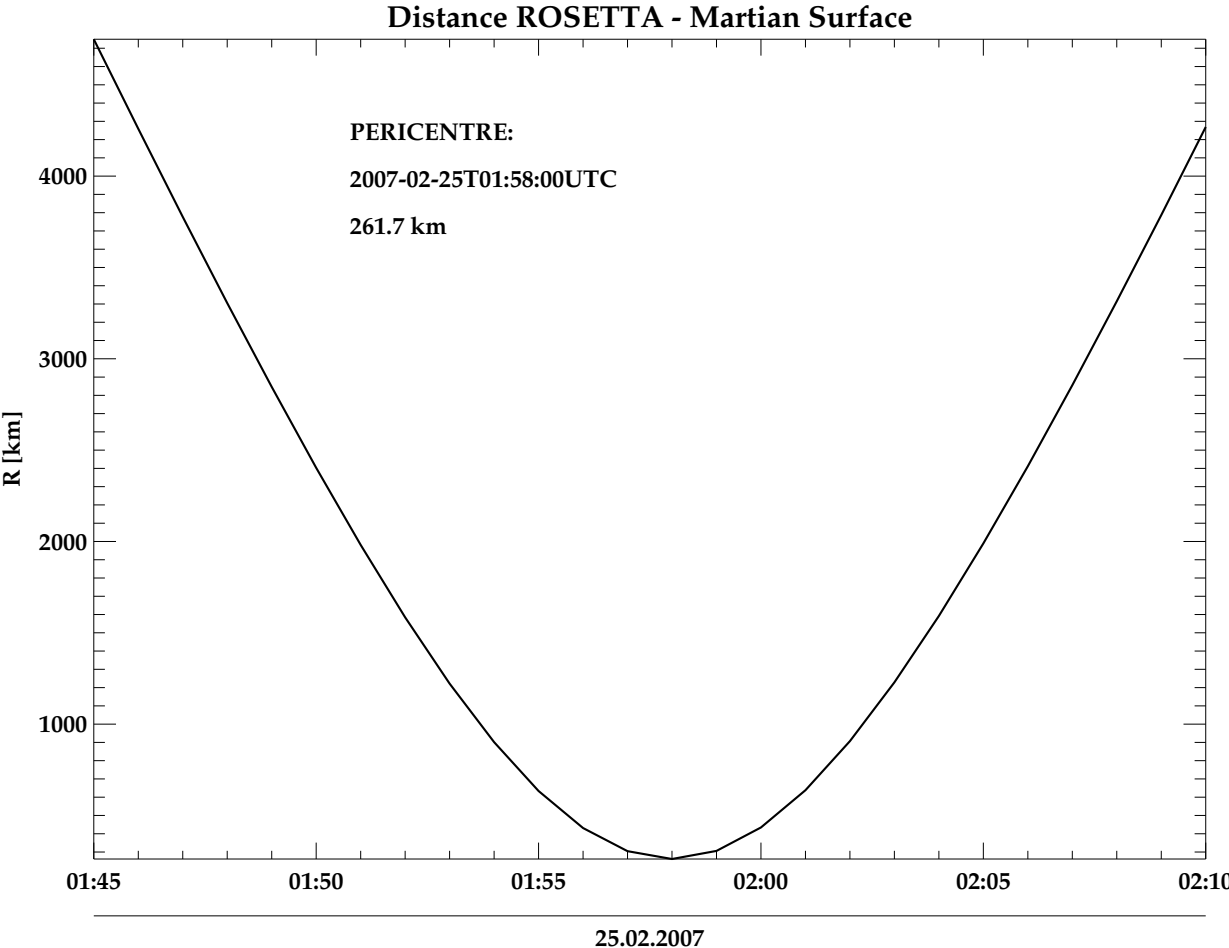


Figure 1: ROSETTA'S Distance to the Martian Surface



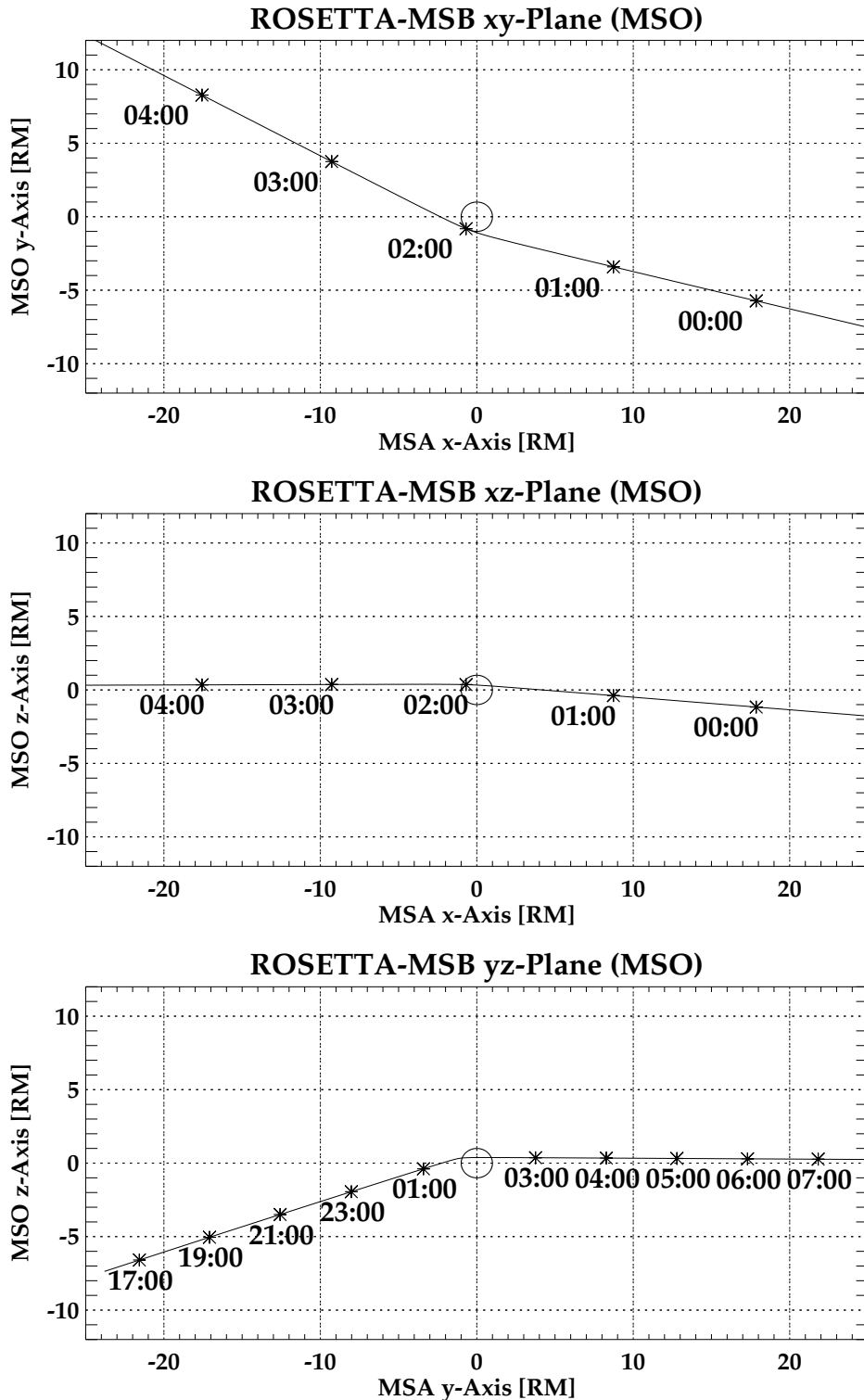


Figure 2: ROSETTA'S Swing-by Trajectory in MSO coordinates

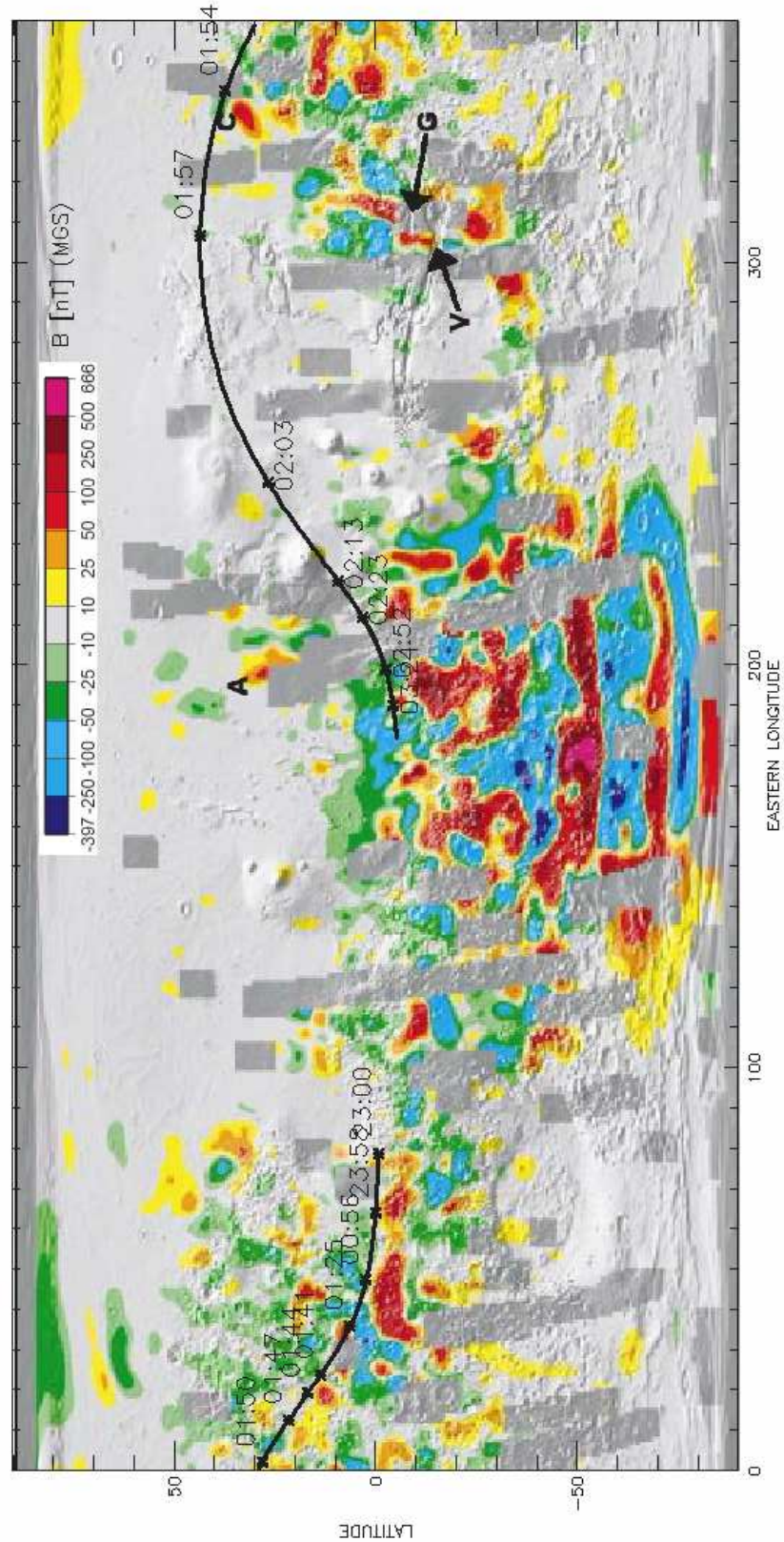


Figure 3: ROSETTA'S Swing-by ground track superimposed on MGS Magnetic Field Data

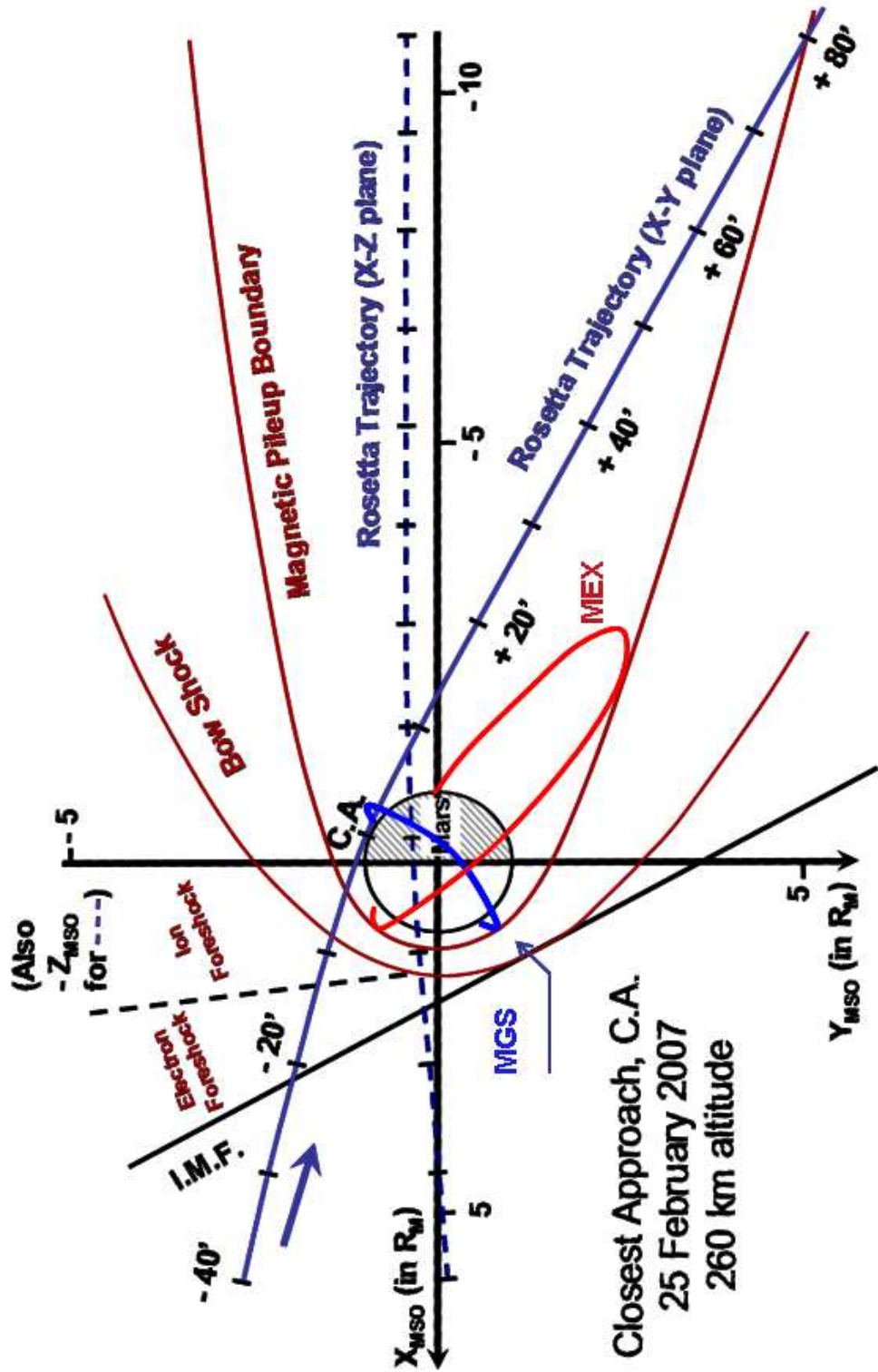


Figure 4: ROSETTA'S MARS Swingby Geometry (MSO)

### 3 ROSETTA'S Attitude during the Swing-by

The following plots show the attitude of the ROSETTA s/c during the swing-by campaign. The panels show the angles between the Base-axes of the s/c-coordinate system and the sun direction in degrees. On a second plot the angles between the s/c-coordinate axes and the MARS direction are displayed.

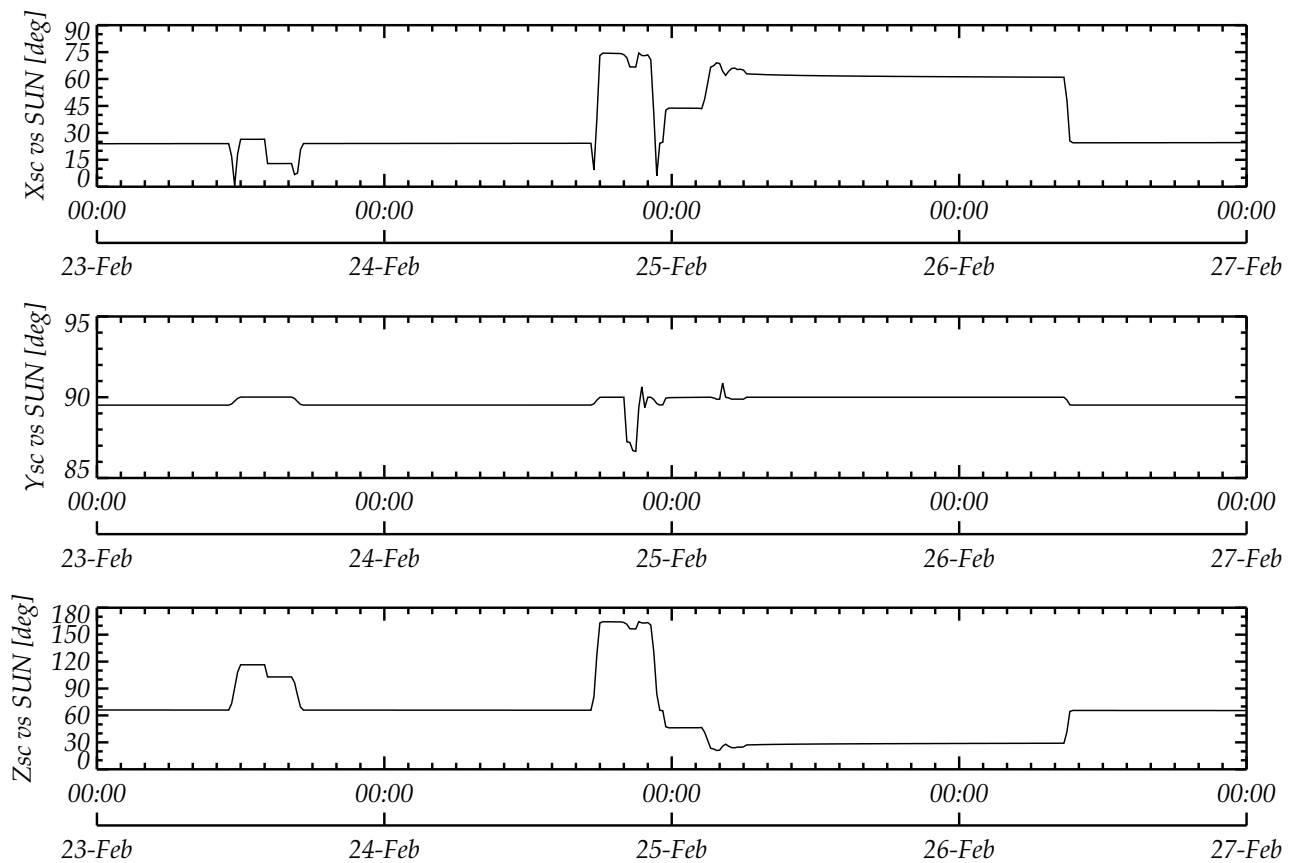


Figure 5: ROSETTA'S Attitude angles with respect to the SUN direction

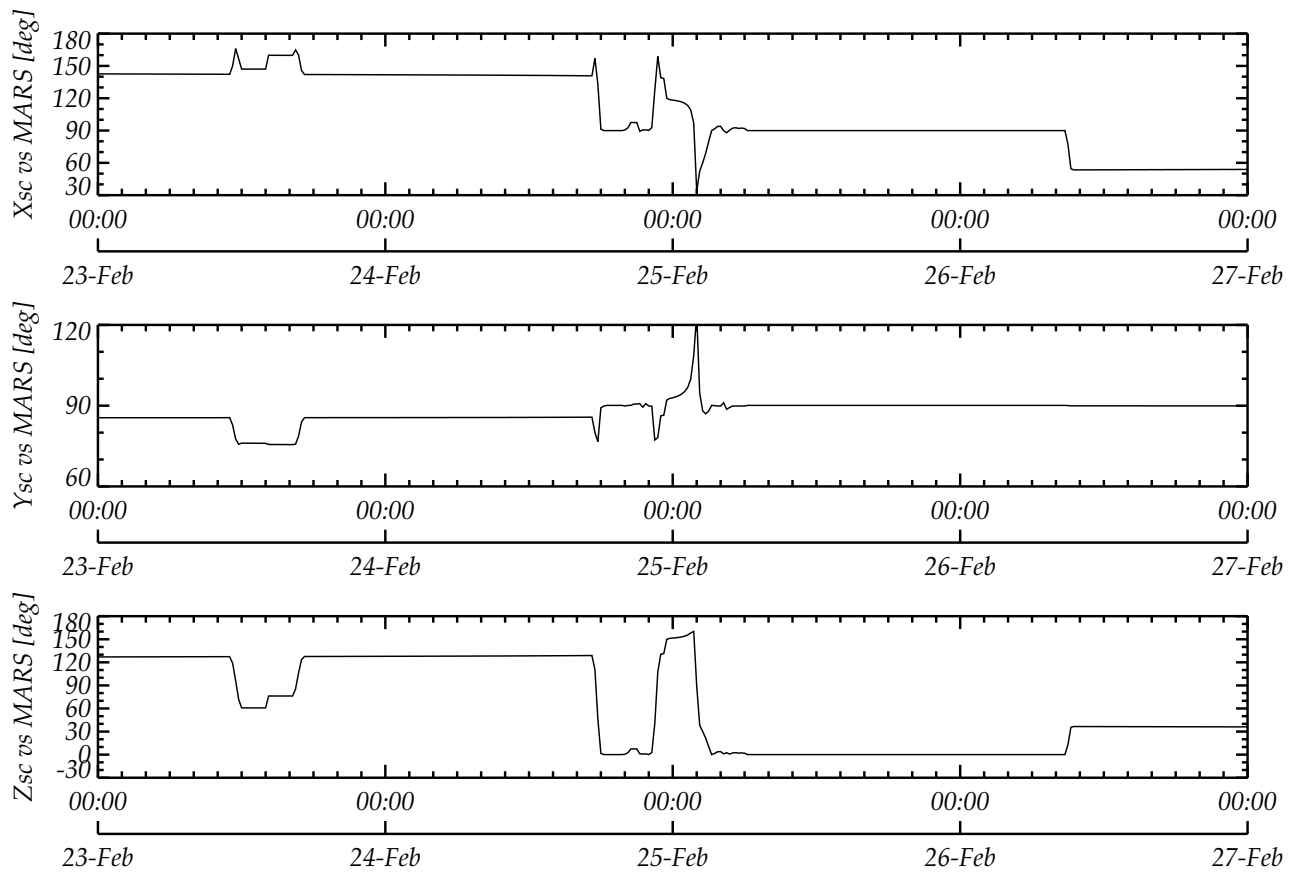


Figure 6: ROSETTA'S Attitude angles with respect to the MARS direction

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## 4 Activities and data plots of the MARS Swing-by

This chapter presents all relevant data measured by RPCMAG day by day:

- Housekeeping data (HK).
- Magnetic field of the OB sensor, sampled with 16 bit in the HK stream.
- Calibrated LEVEL\_B data (s/c coordinates) of the IB and OB sensor with the original sampling frequency.
- Calibrated LEVEL\_C data (ECLIPJ2000 coordinates) of the IB and OB sensor with the original sampling frequency.

### 4.1 February 23, 2007:

#### 4.1.1 Actions

MAG was switched on immediately after PIU and set to HK mode at 00:00:22. The normal mode SID 2 was set at 00:12. All commands passed smoothly and the instrument followed in the expected way.

### 4.2 Plots of Calibrated Data

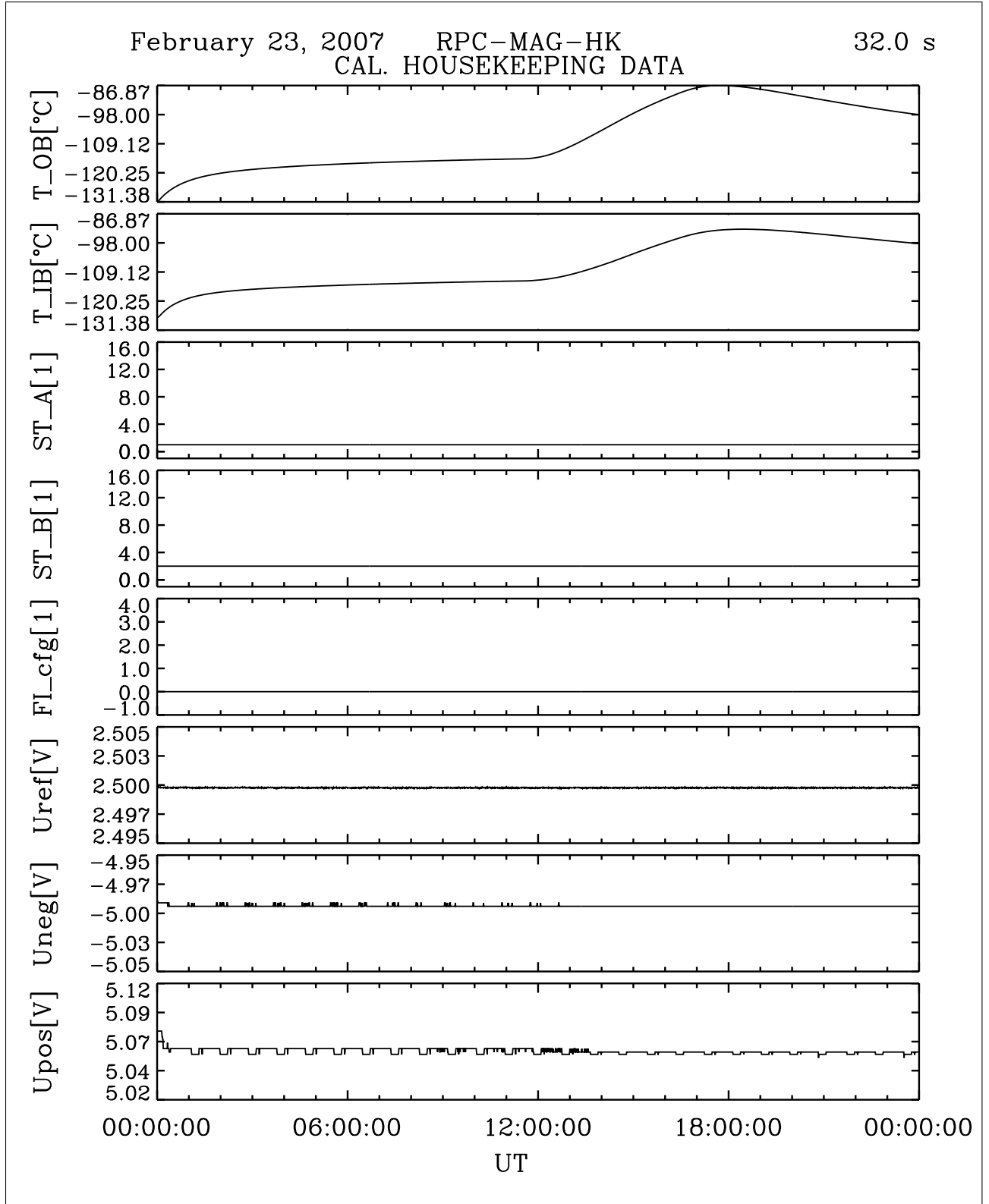


Figure 7: File: RPCMAG070223T0000\_CLA\_HK\_P0000\_2400

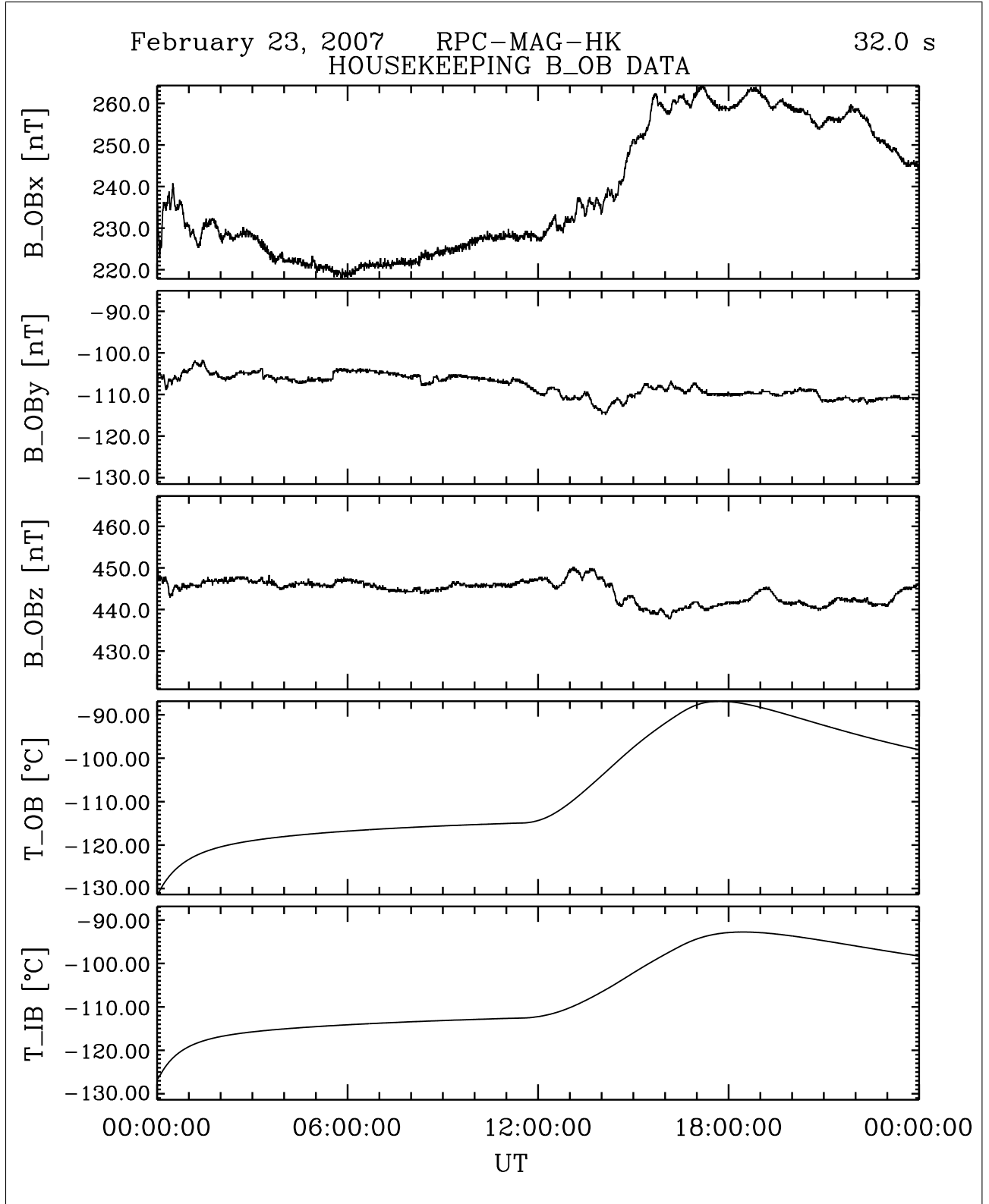


Figure 8: File: RPCMAG070223T0000\_CLA\_HK\_B\_P0000\_2400



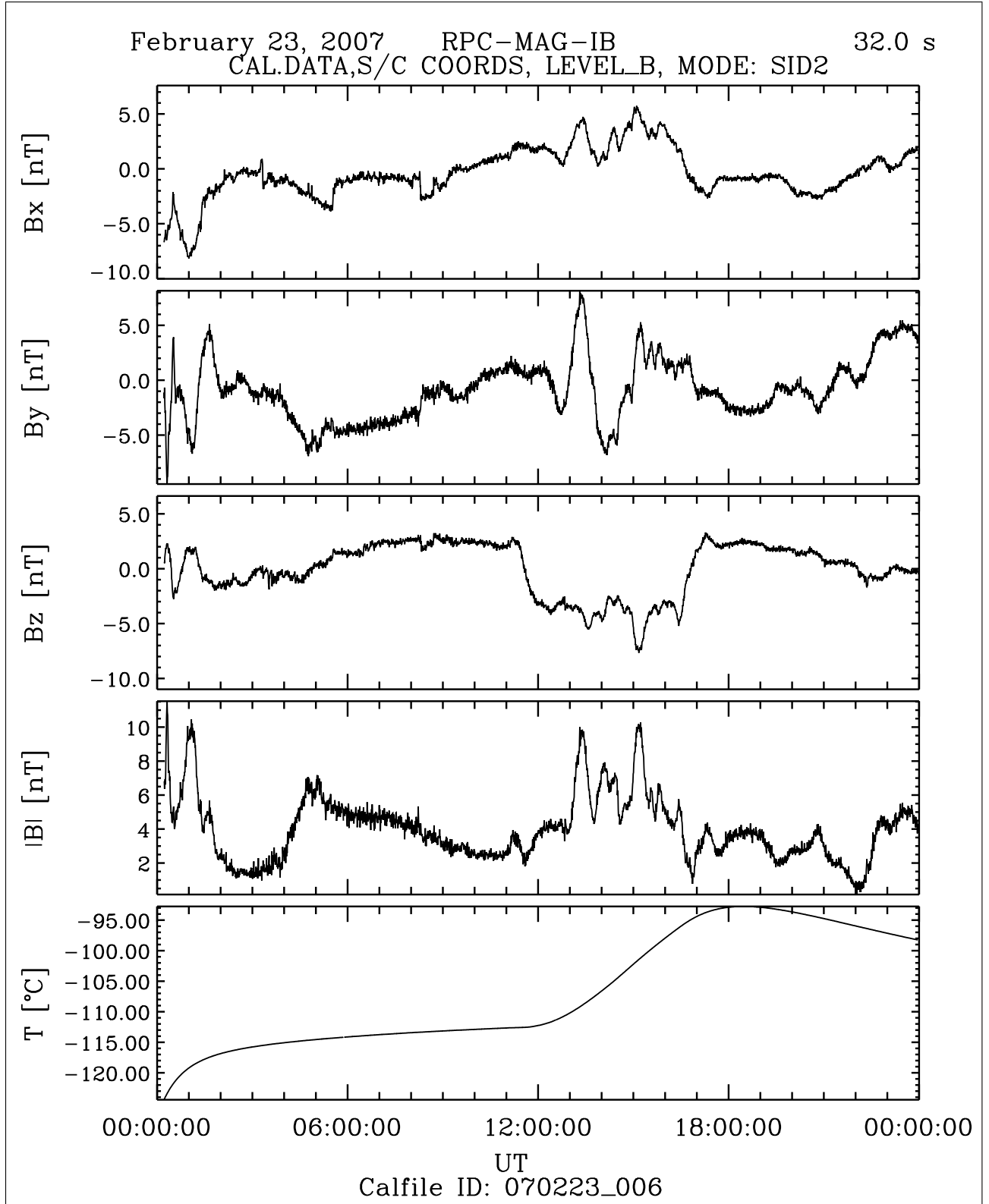


Figure 9: File: RPCMAG070223T0012\_CLB\_IB\_M2\_T0000\_2400\_006

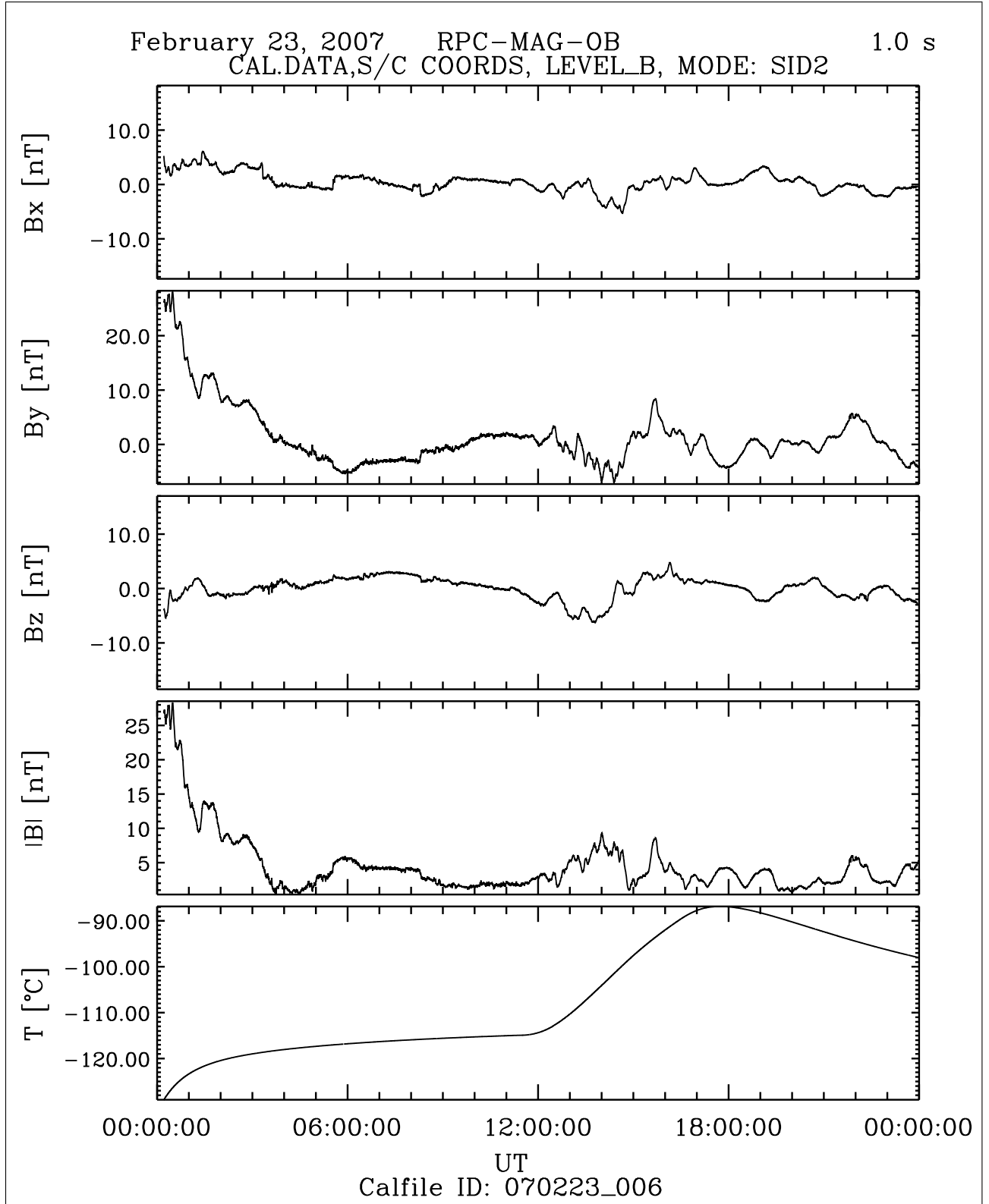


Figure 10: File: RPCMAG070223T0012\_CLB.OB\_M2\_T0000\_2400\_006

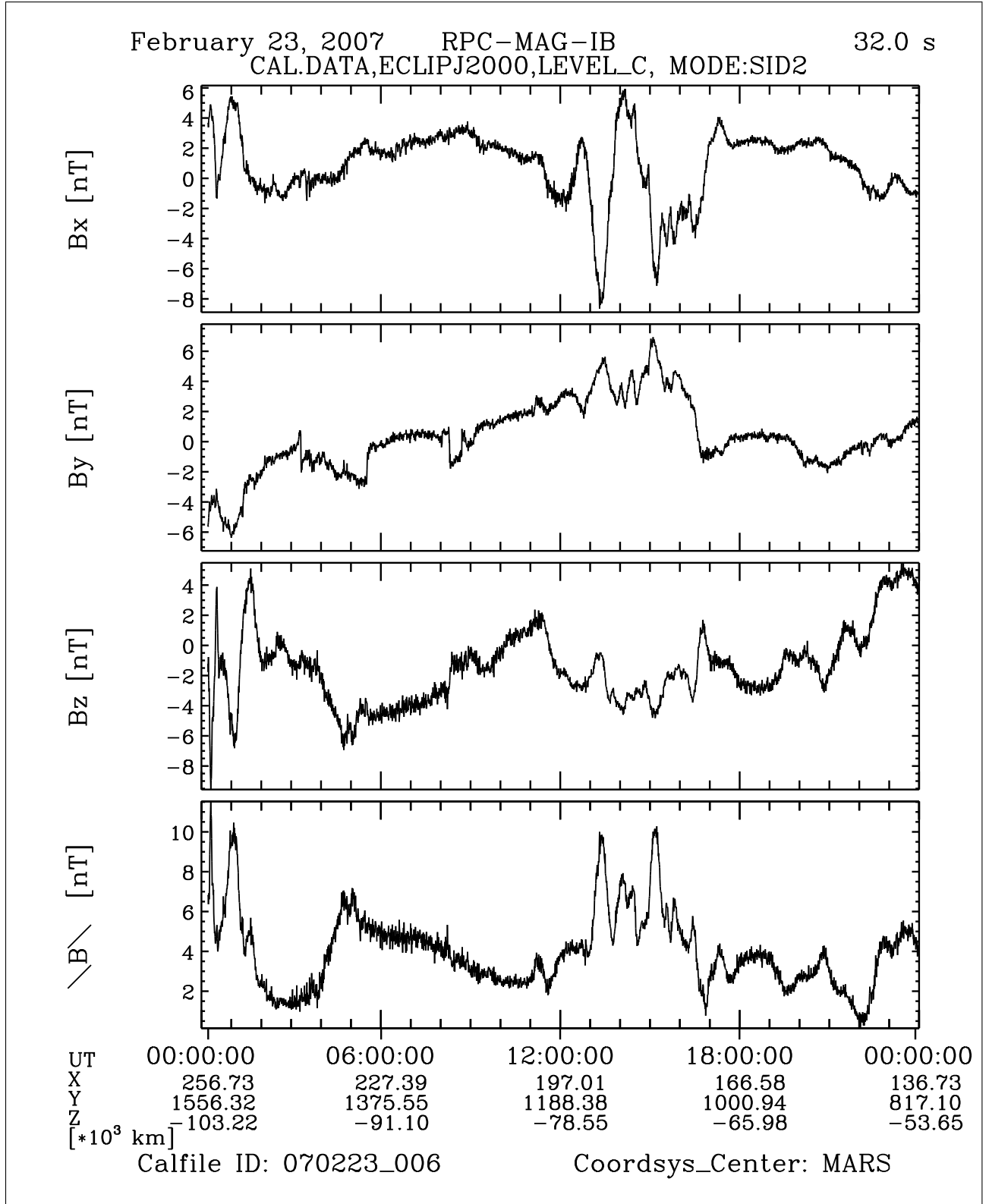


Figure 11: File: RPCMAG070223T0012.CLC\_IB\_M2\_T0000\_2400\_006

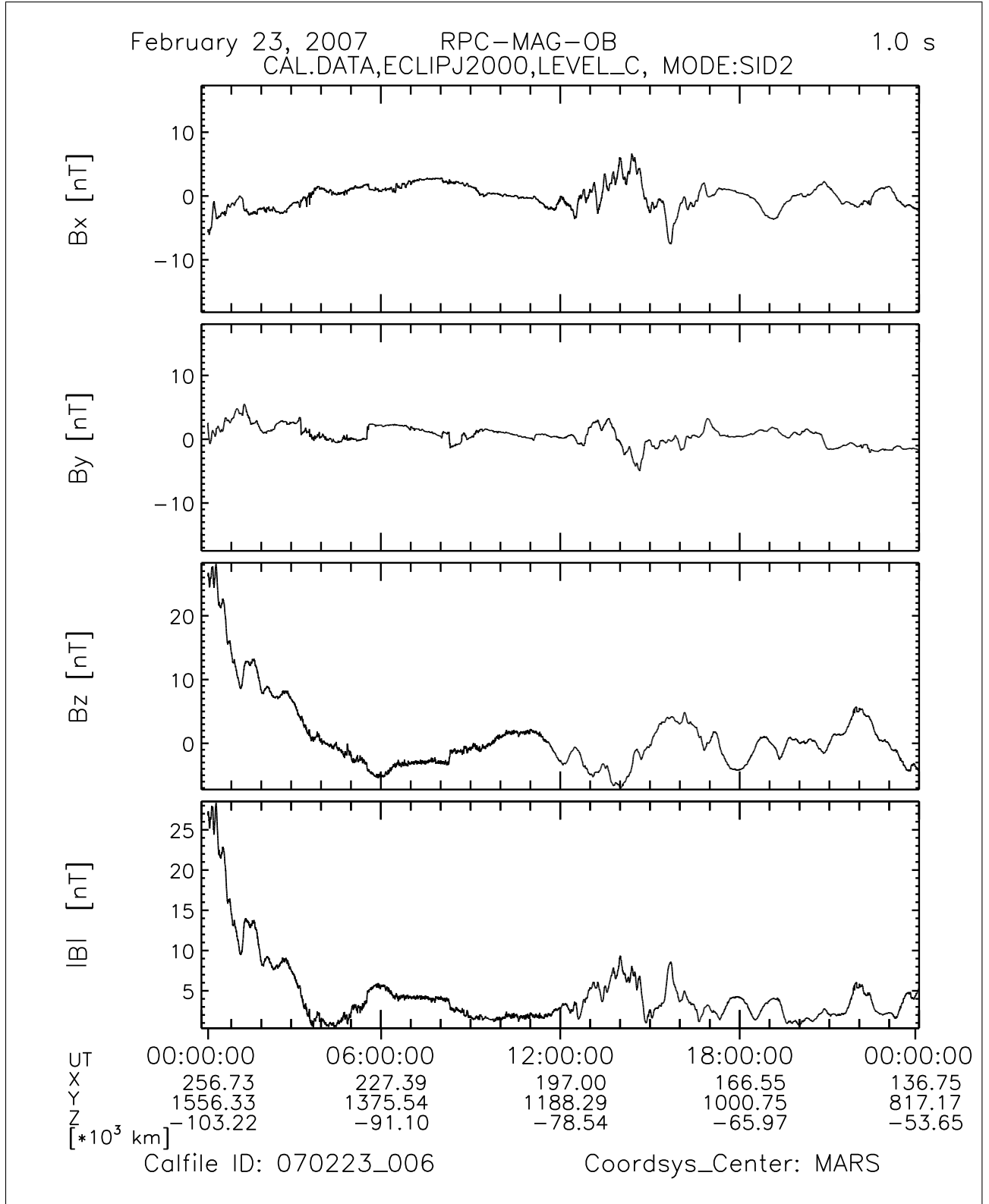


Figure 12: File: RPCMAG070223T0012\_CLC\_OB\_M2\_T0000\_2400\_006

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### 4.3 February 24, 2007:

#### 4.3.1 Actions

MAG stayed in SID2 until 20:41. Then the Burst mode SID3 was activated. All commands passed smoothly and the instrument followed in the expected way.

### 4.4 Plots of Calibrated Data

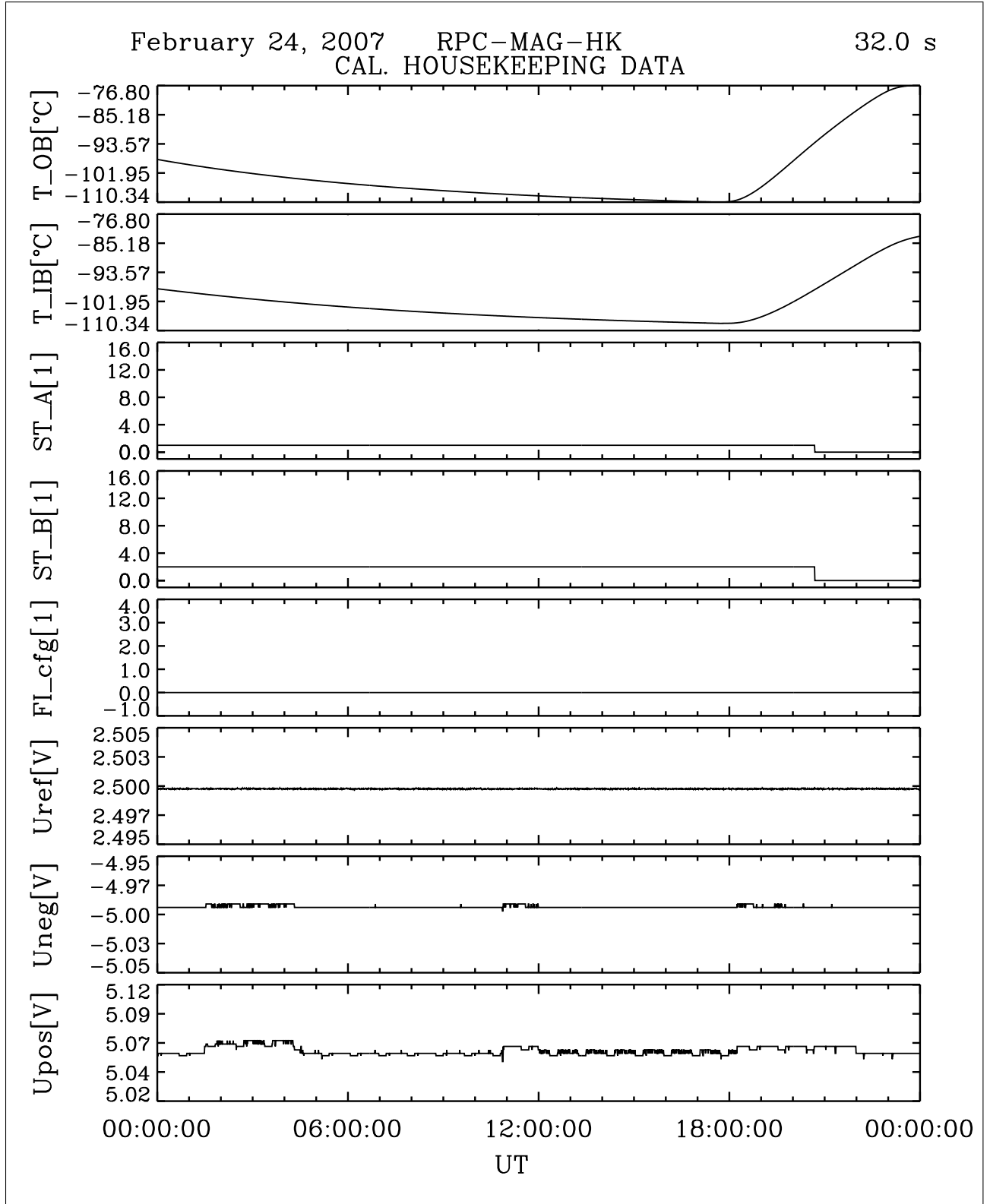


Figure 13: File: RPCMAG070224T0000\_CLA\_HK\_P0000\_2400

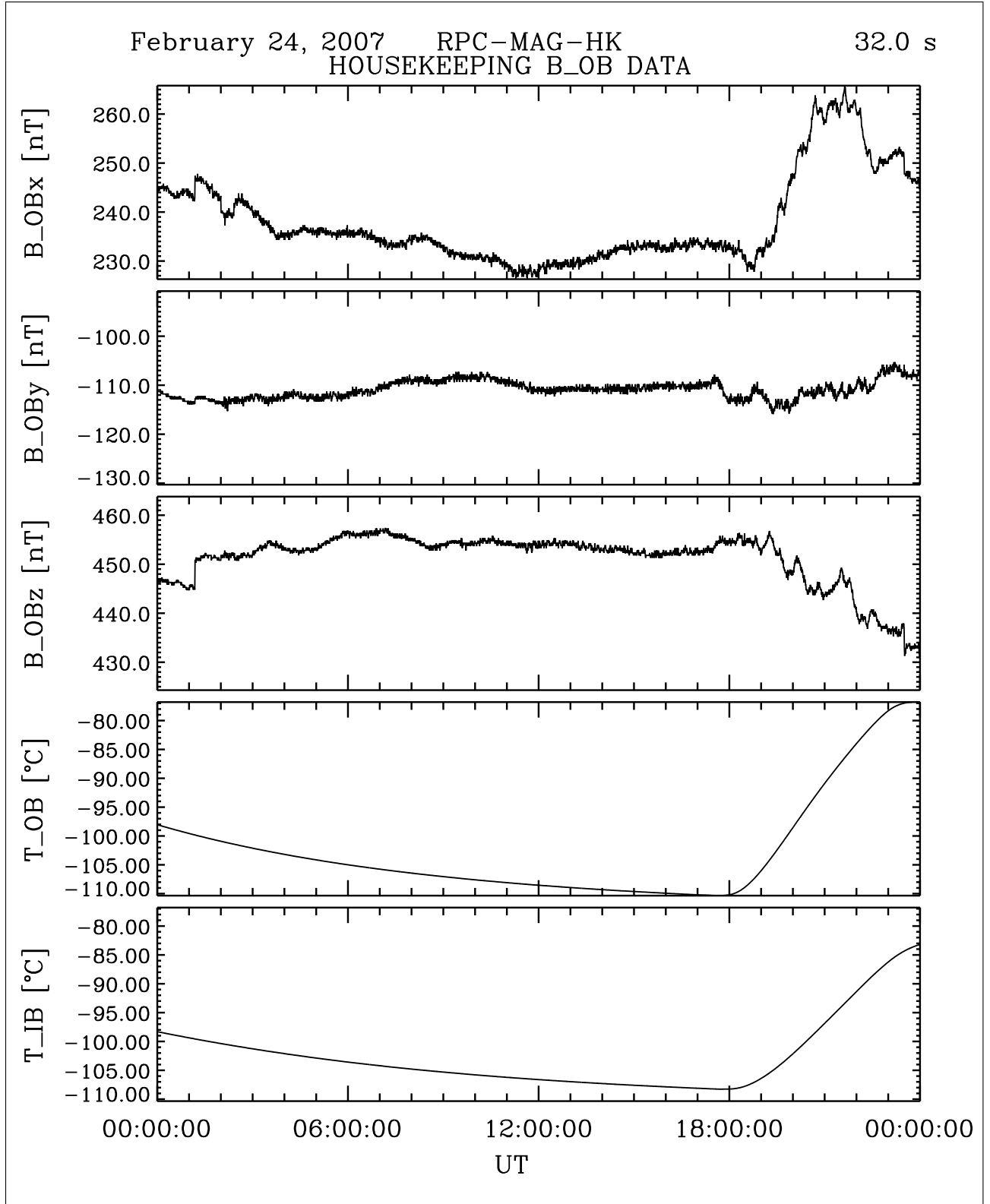


Figure 14: File: RPCMAG070224T0000\_CLA\_HK\_B\_P0000\_2400

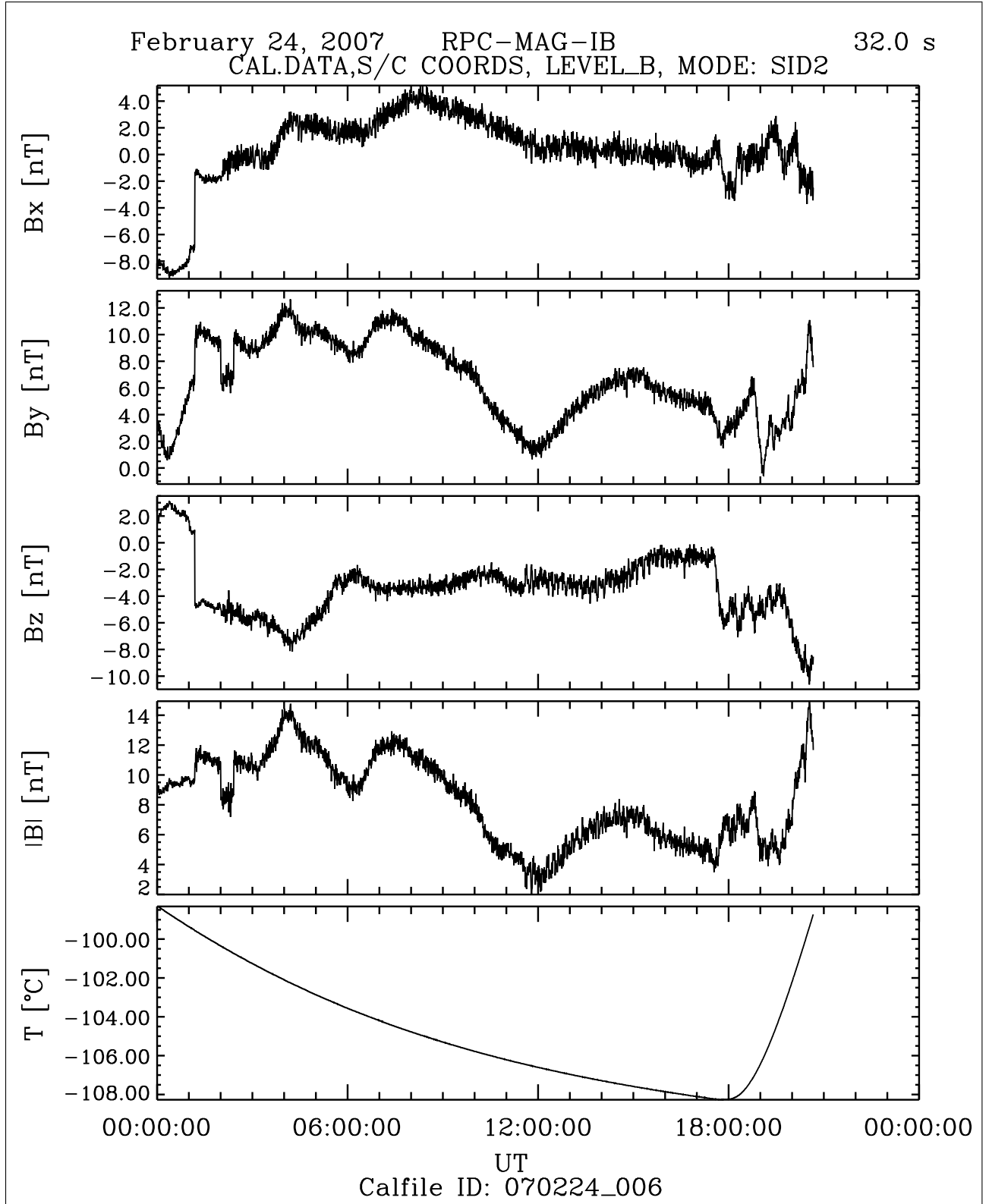


Figure 15: File: RPCMAG070224T0000\_CLB\_IB\_M2\_T0000\_2400\_006



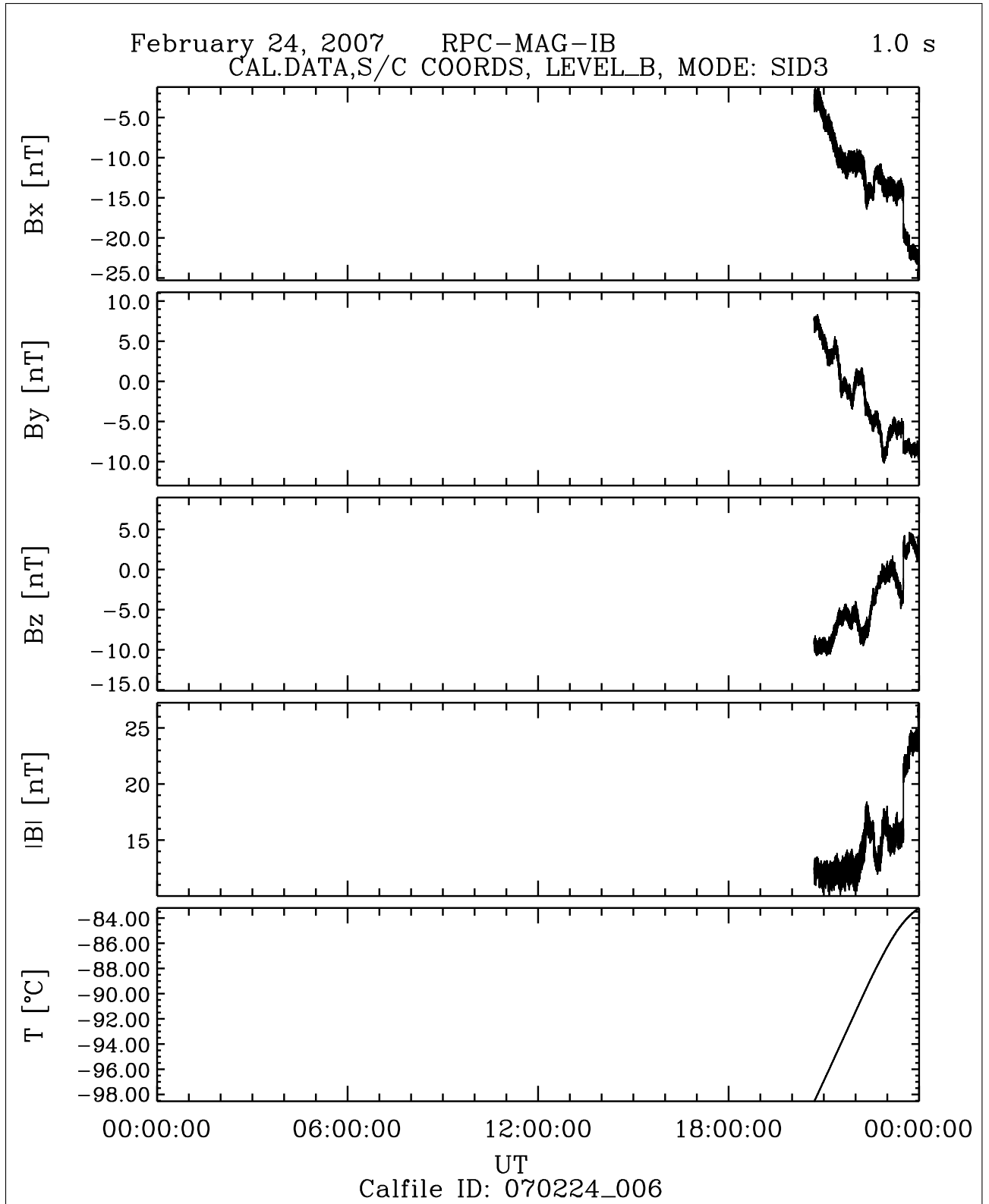


Figure 16: File: RPCMAG070224T2041\_CLB\_IB\_M3\_T0000\_2400\_006

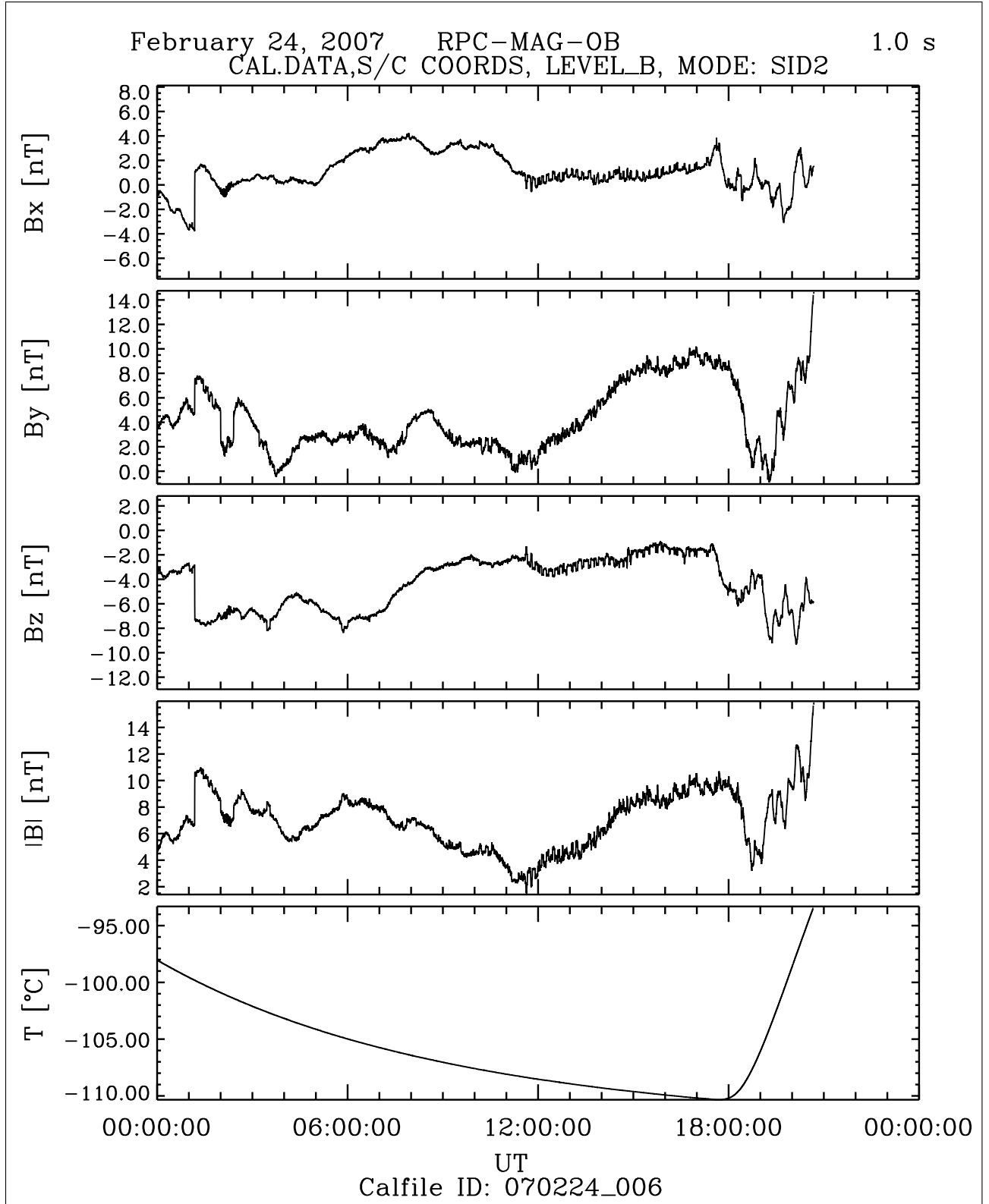


Figure 17: File: RPCMAG070224T0000\_CLB.OB\_M2\_T0000\_2400\_006

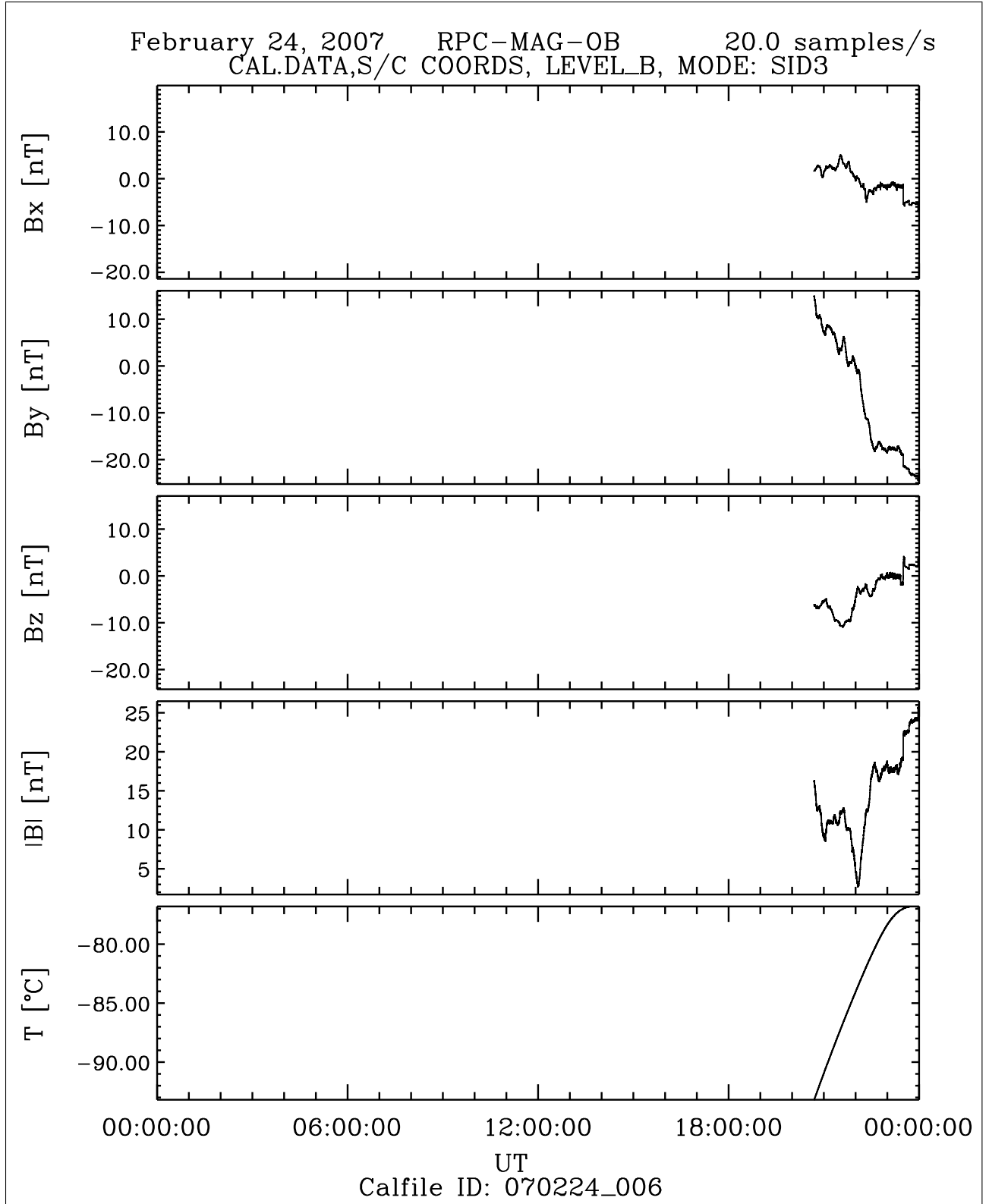


Figure 18: File: RPCMAG070224T2041\_CLB.OB\_M3\_T0000\_2400\_006

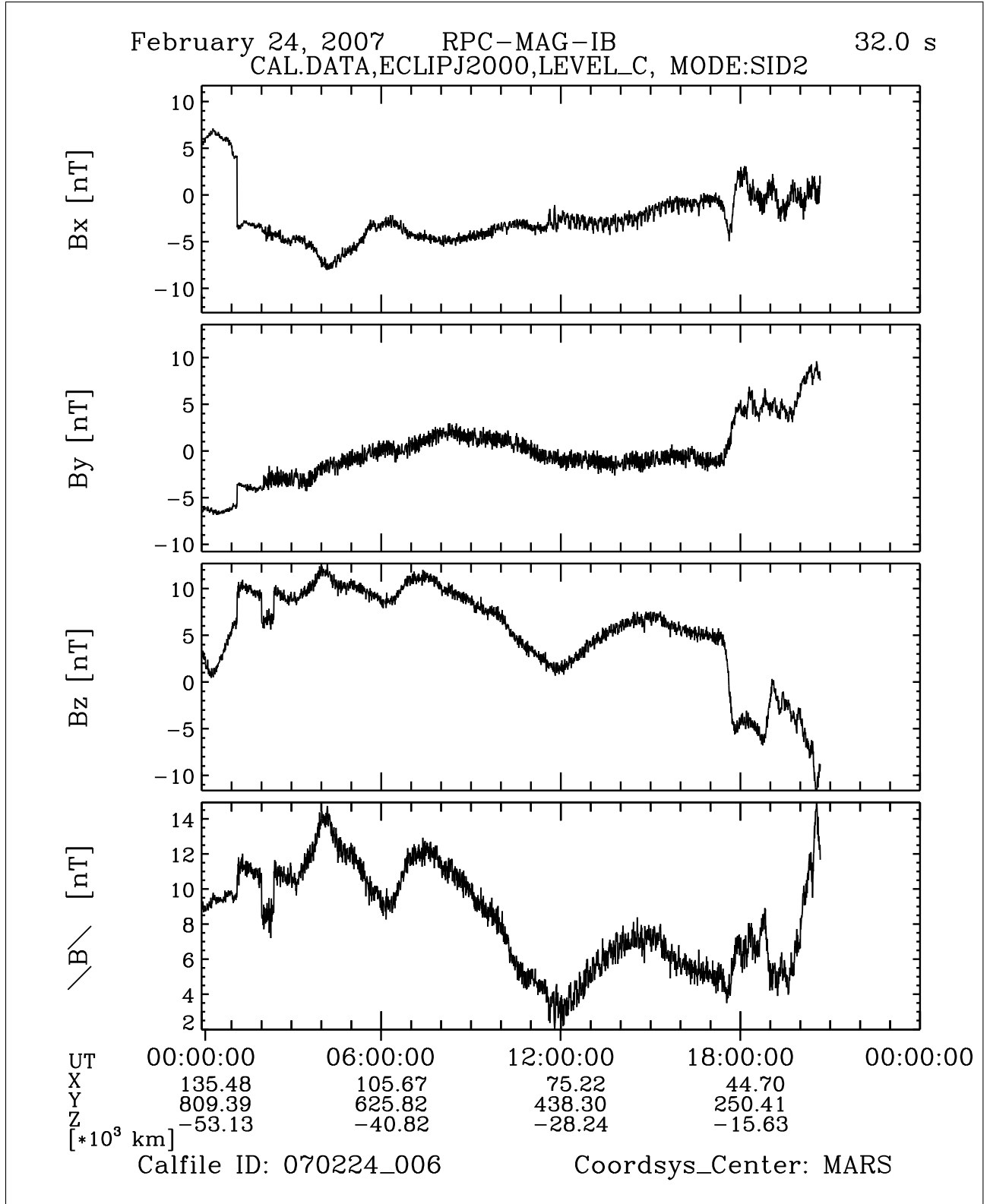


Figure 19: File: RPCMAG070224T0000\_CLC\_IB\_M2\_T0000.2400.006

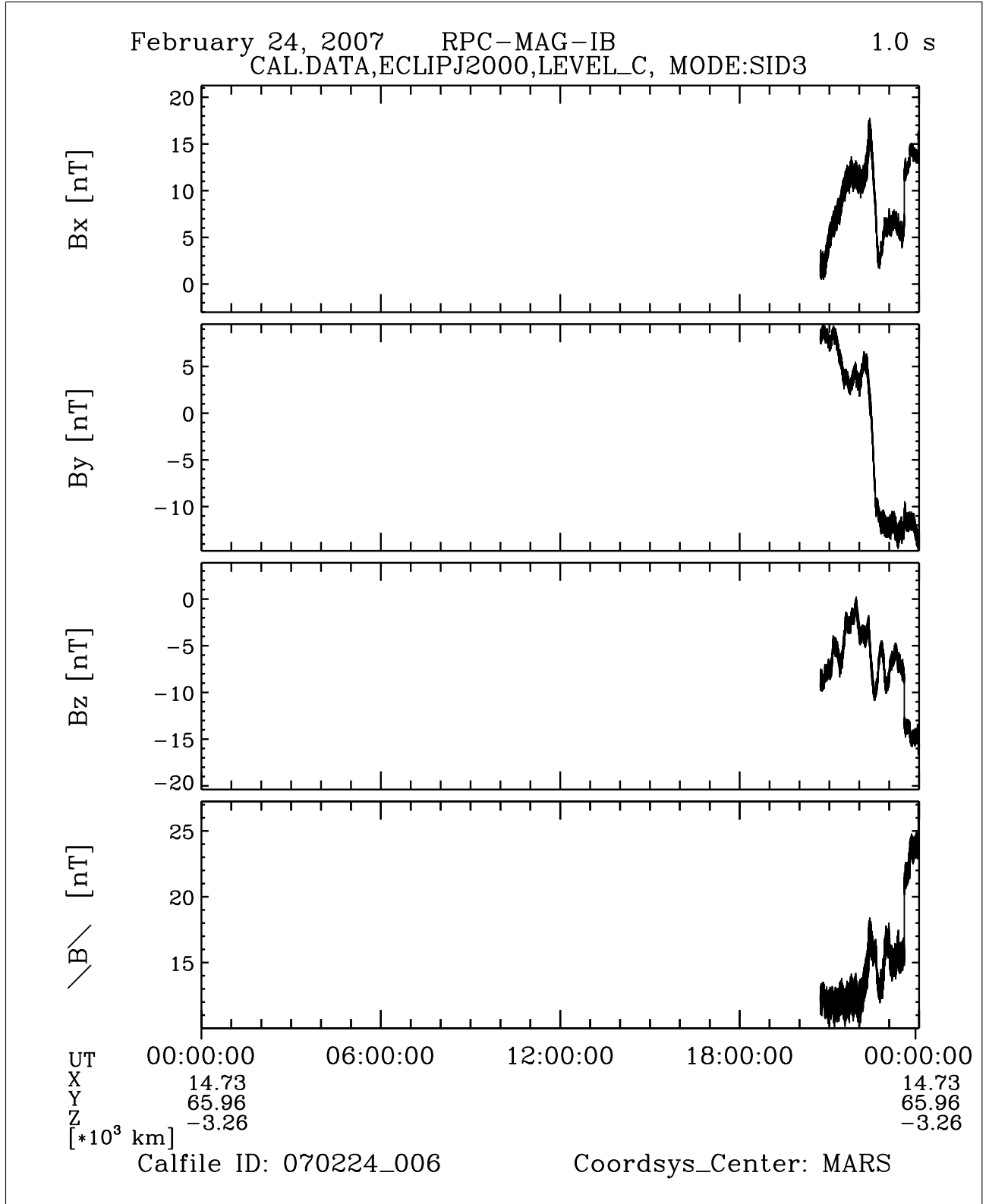


Figure 20: File: RPCMAG070224T2041\_CLC\_IB\_M3\_T0000\_2400\_006

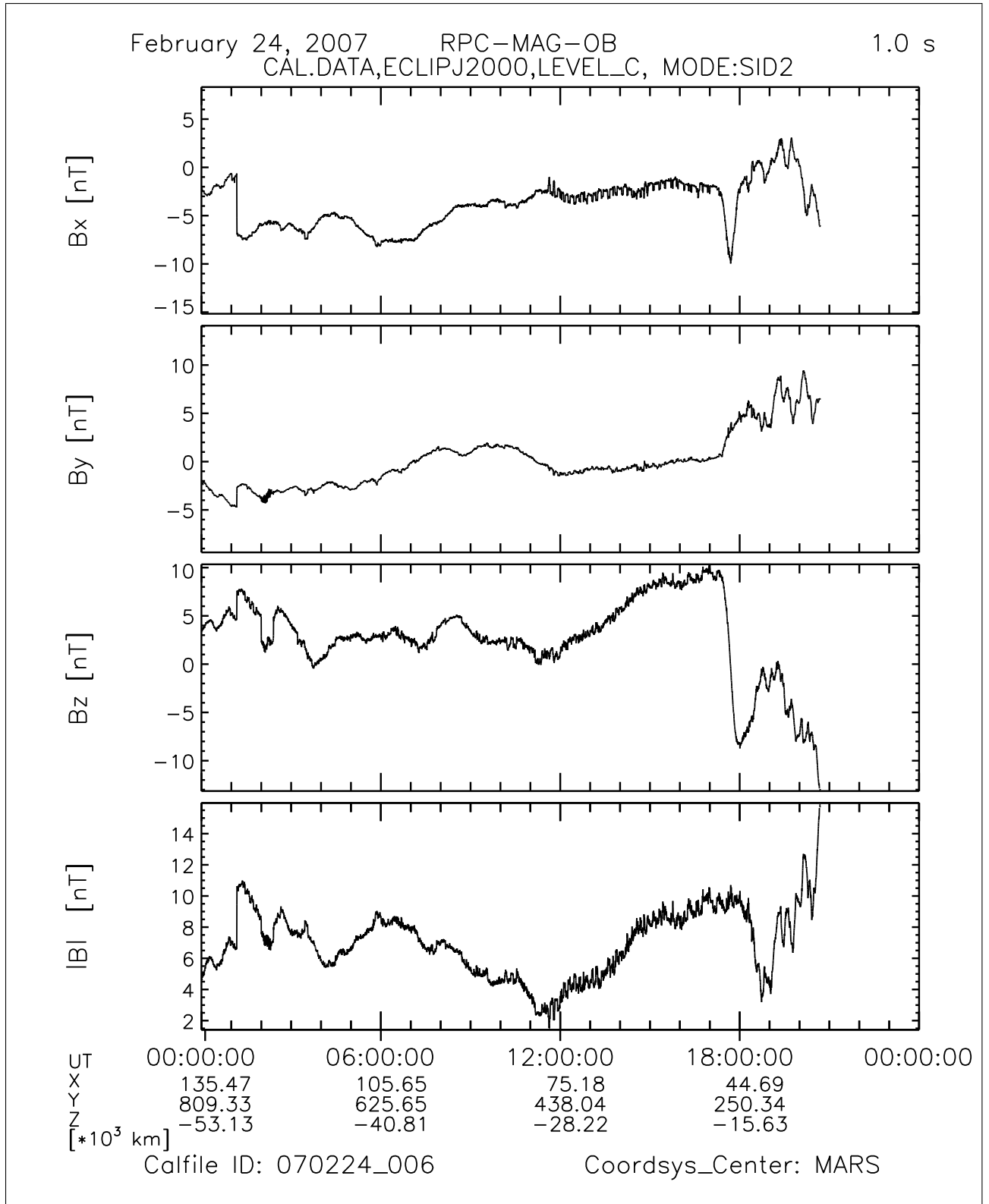


Figure 21: File: RPCMAG070224T0000\_CLC\_OB\_M2\_T0000\_2400\_006

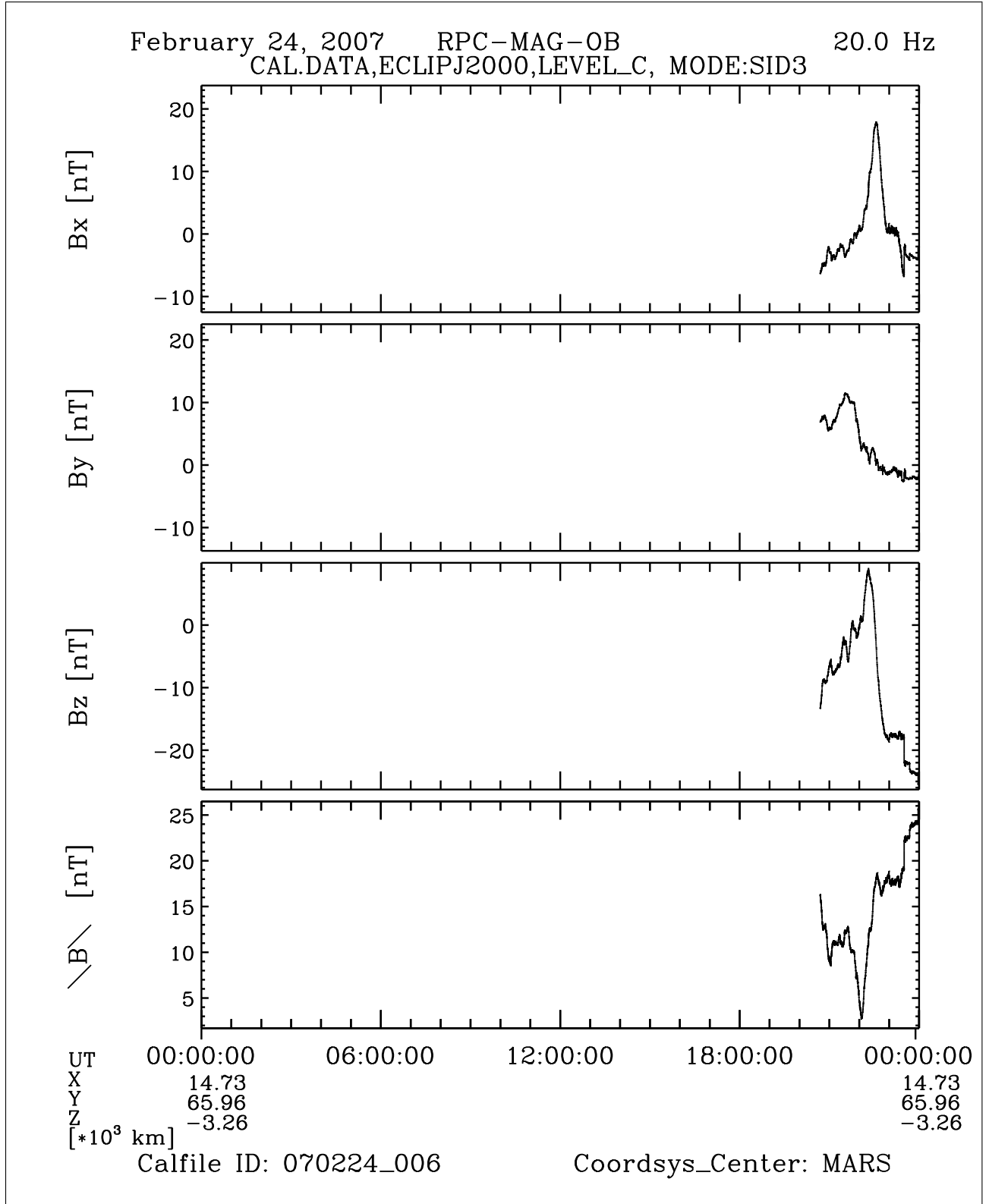


Figure 22: File: RPCMAG070224T2041\_CLC\_OB\_M3\_T0000\_2400\_006

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## 4.5 February 25, 2007:

### 4.5.1 Actions

MAG stayed in Burst mode until 00:24. Then RPC was switched off due to power saving issues during CA. RPC was switched on again at 02:35. MAG was set to Burst mode at 02:47 and stayed in SID 3 until 04:45. Then it was set back to SID2 (Normal mode). The CA was at 01:57 All commands passed smoothly and the instrument followed in the expected way.

## 4.6 Plots of Calibrated Data



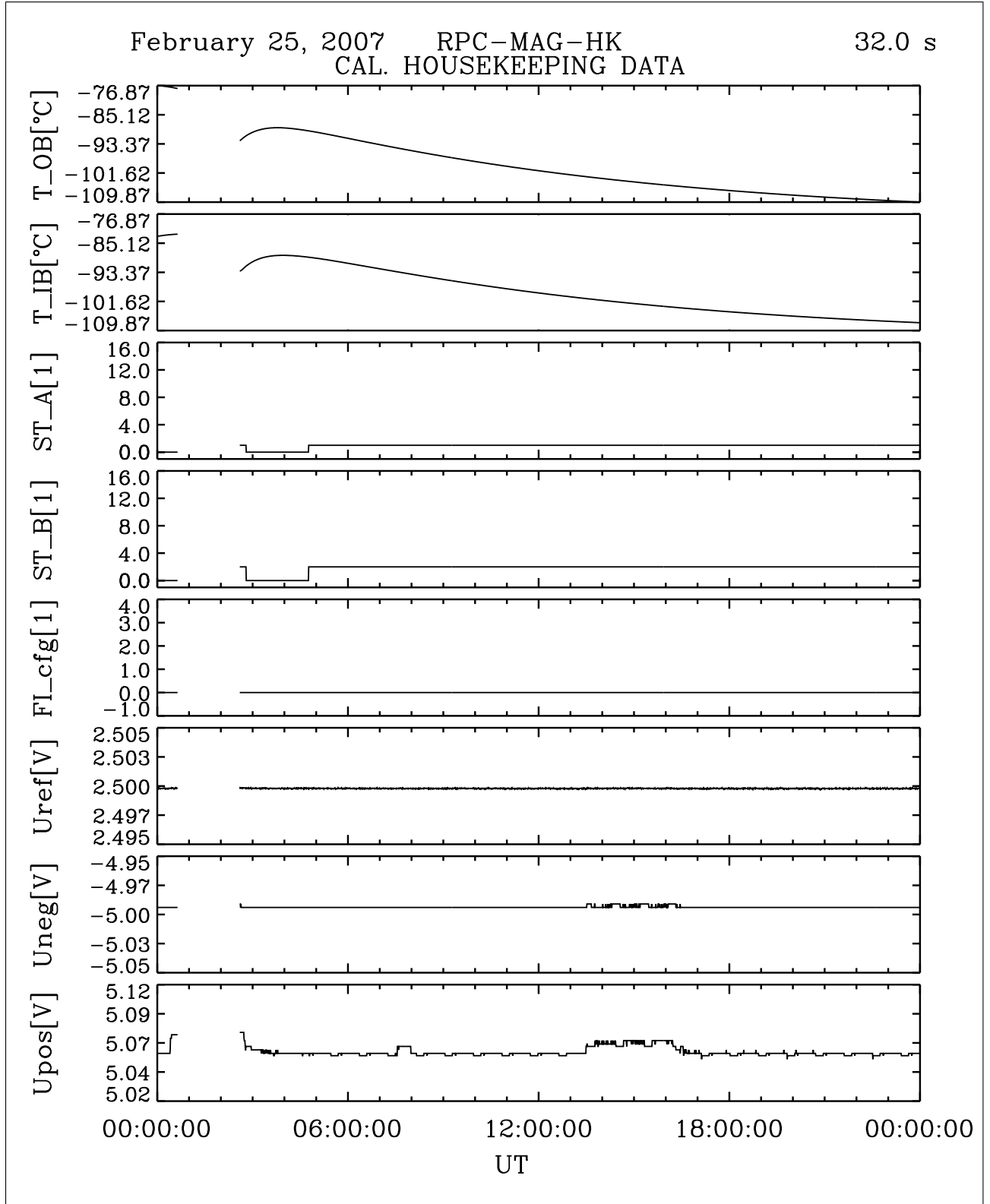


Figure 23: File: RPCMAG070225T0000\_CLA\_HK\_P0000\_2400

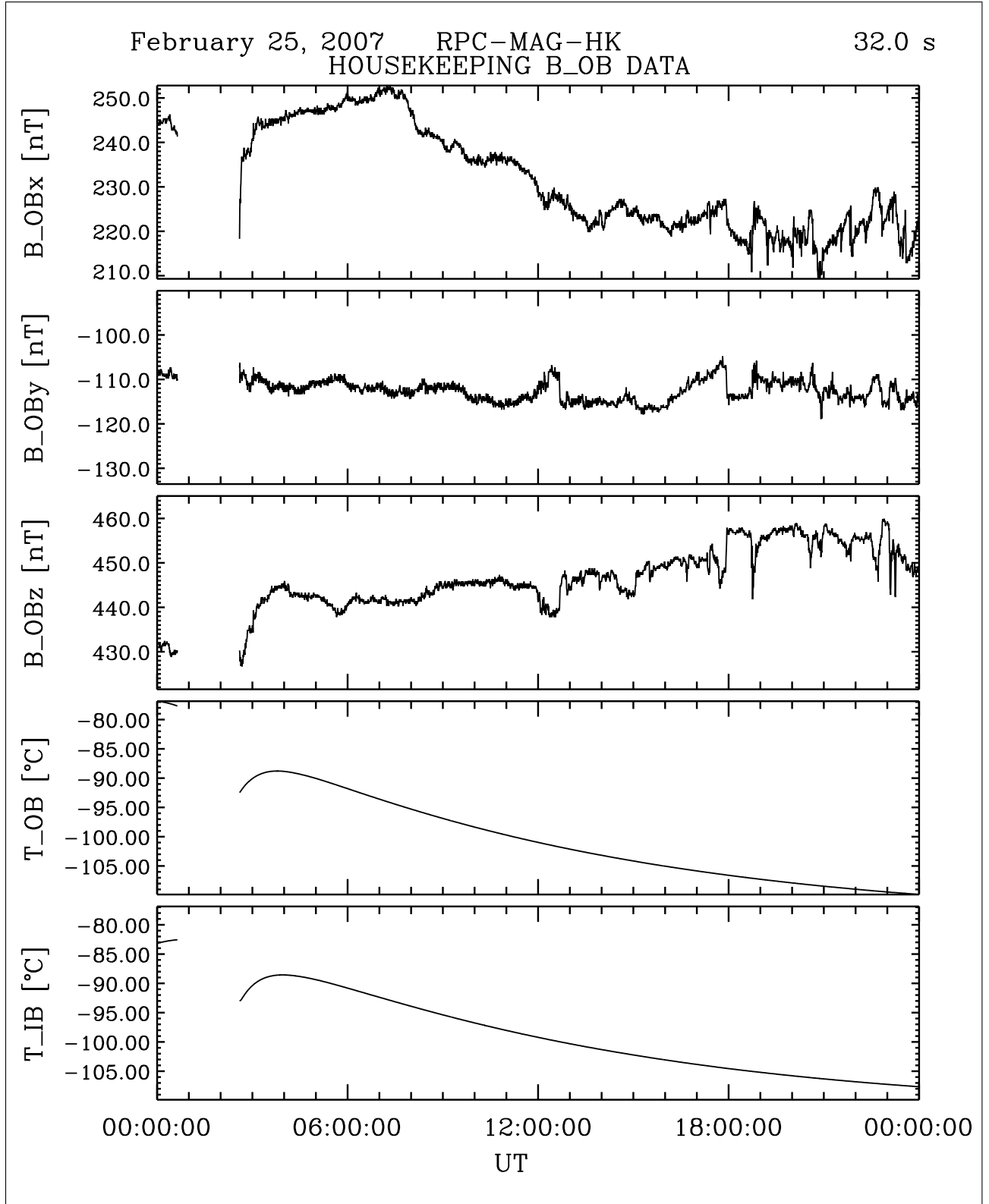


Figure 24: File: RPCMAG070225T0000\_CLA\_HK\_B\_P0000\_2400

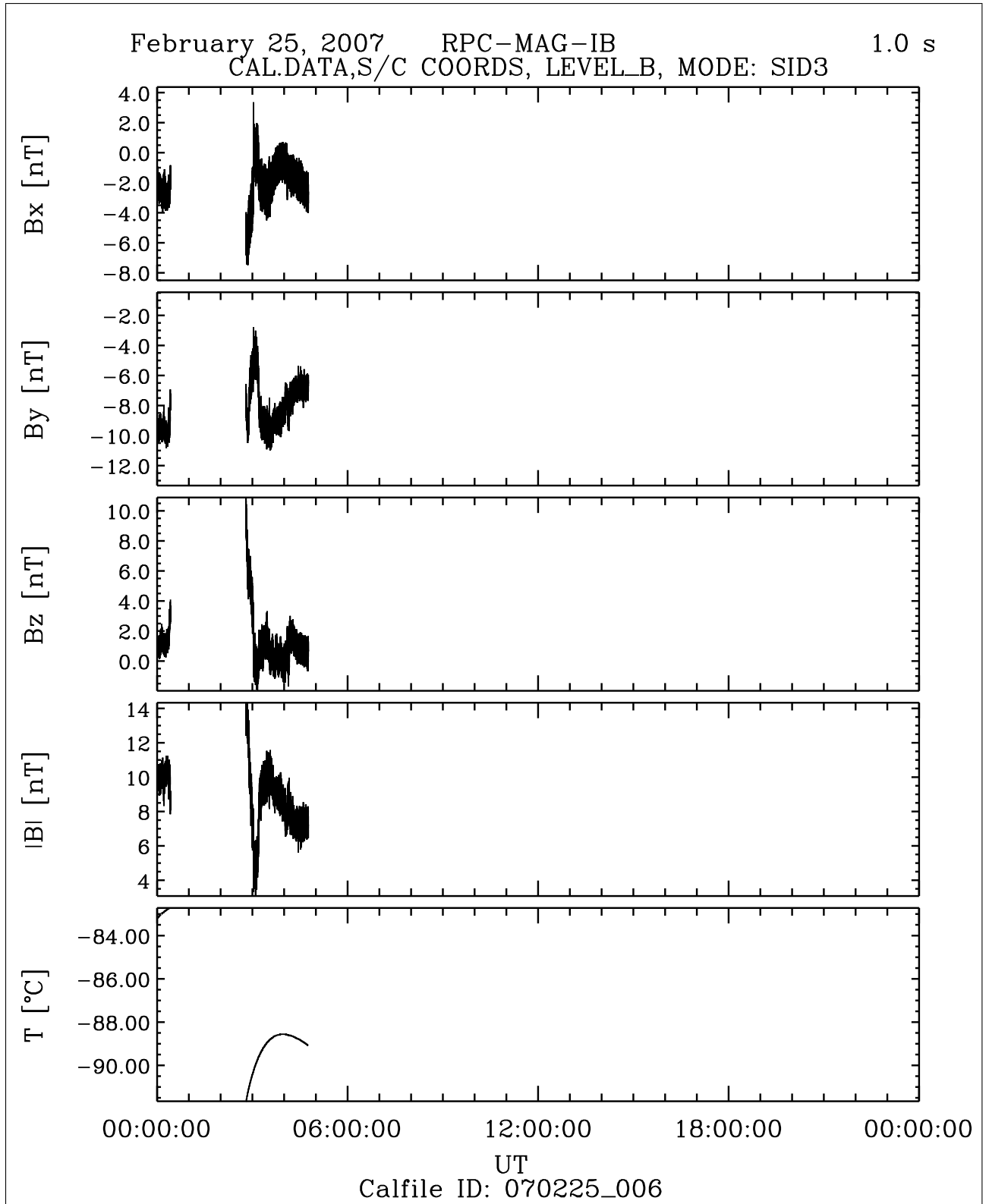


Figure 25: File: RPCMAG070225T0000\_CLB\_IB\_M3\_T0000\_2400\_006

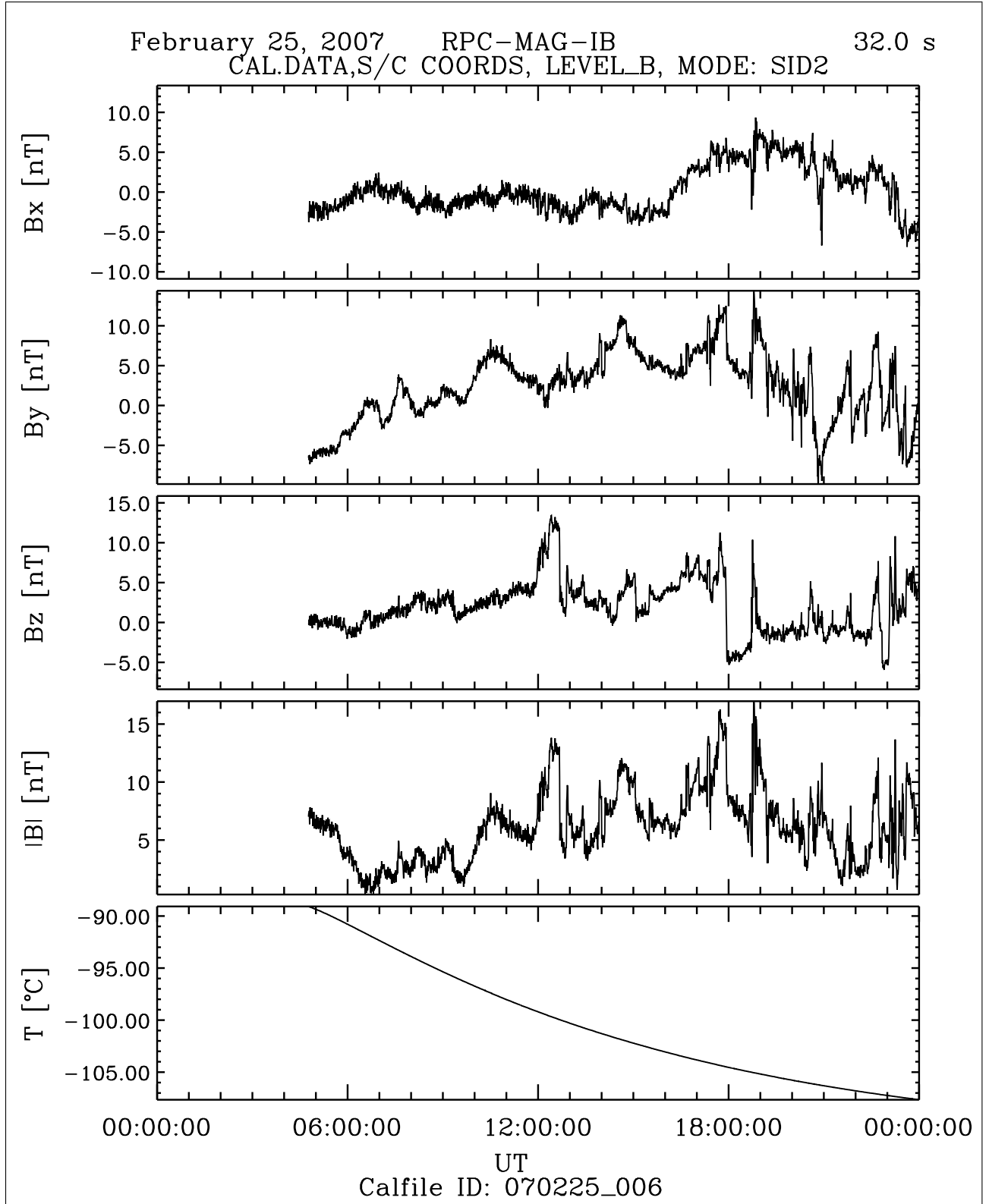


Figure 26: File: RPCMAG070225T0445\_CLB\_IB\_M2\_T0000\_2400\_006

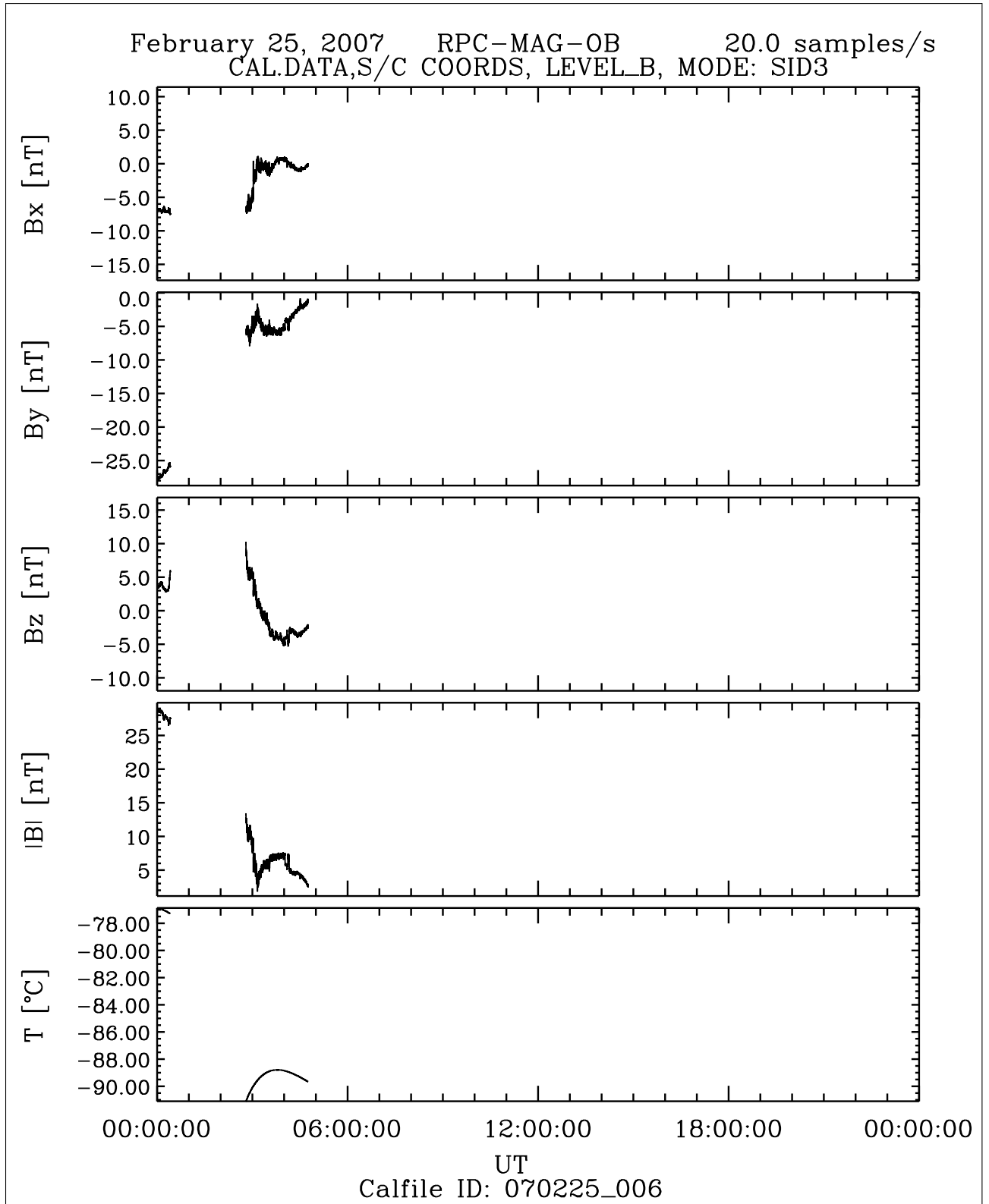


Figure 27: File: RPCMAG070225T0000\_CLB.OB\_M3\_T0000\_2400\_006

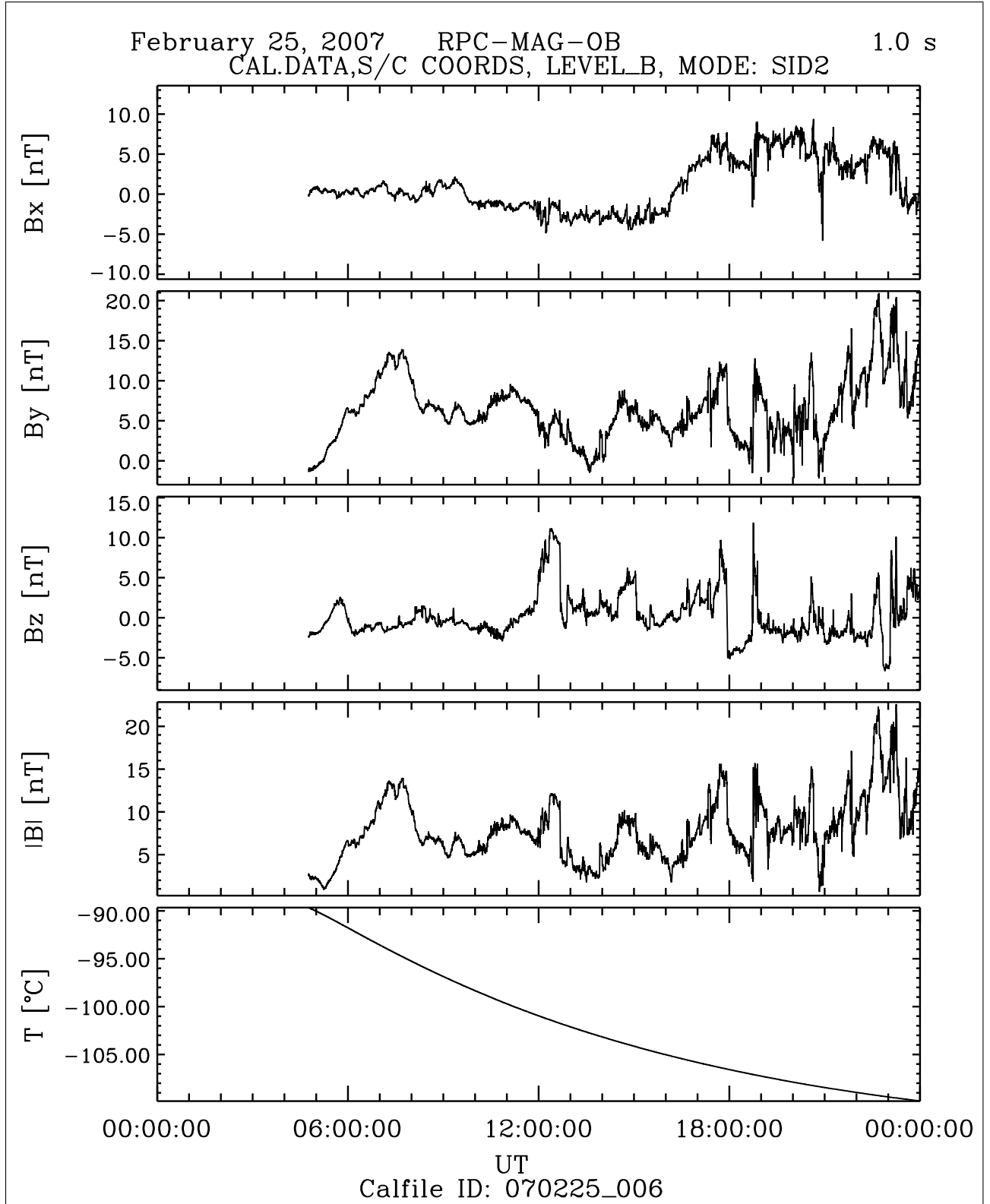


Figure 28: File: RPCMAG070225T0445\_CLB.OB\_M2\_T0000\_2400\_006

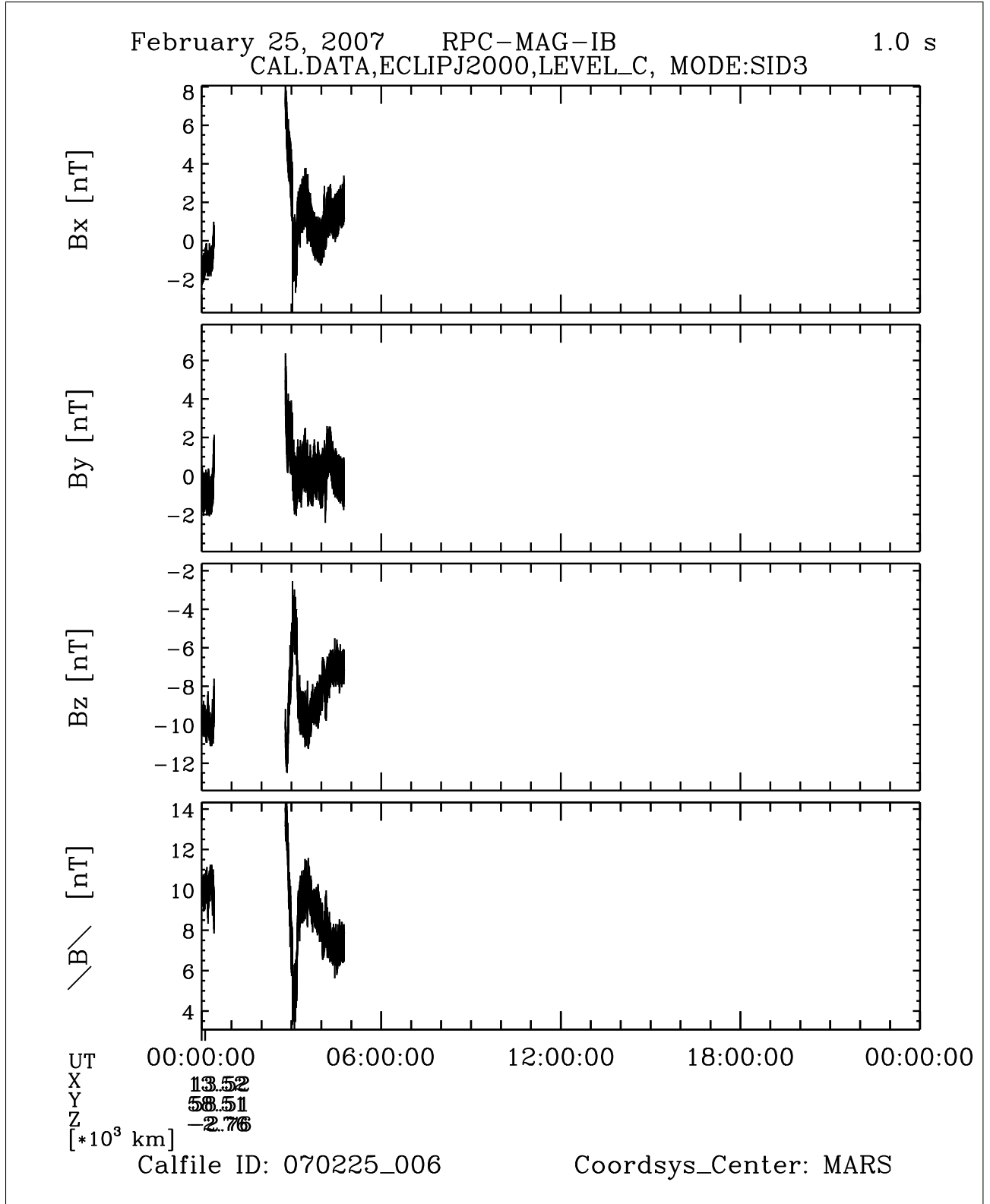


Figure 29: File: RPCMAG070225T0000\_CLC\_IB\_M3\_T0000\_2400\_006

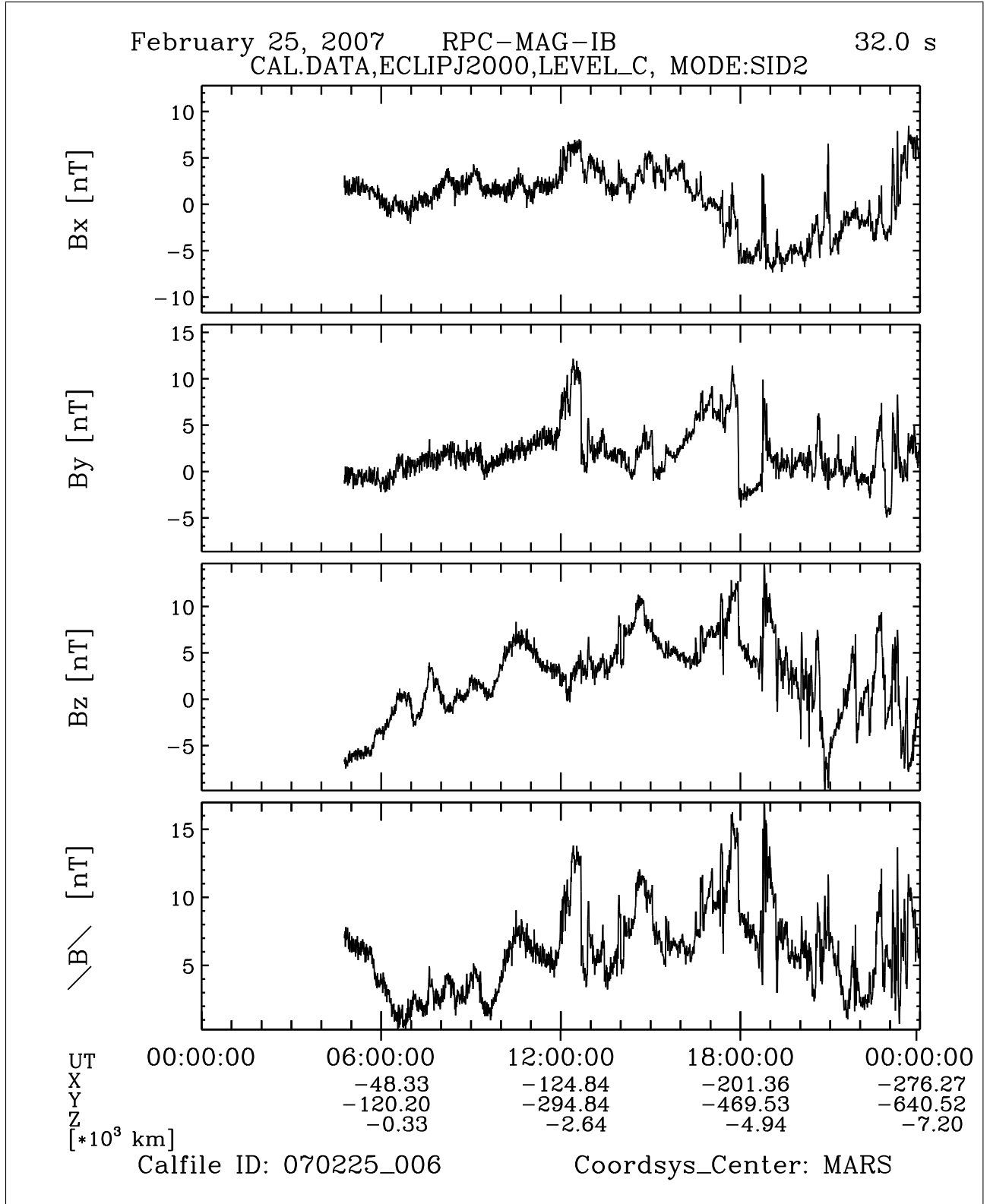


Figure 30: File: RPCMAG070225T0445\_CLC\_IB\_M2\_T0000\_2400\_006



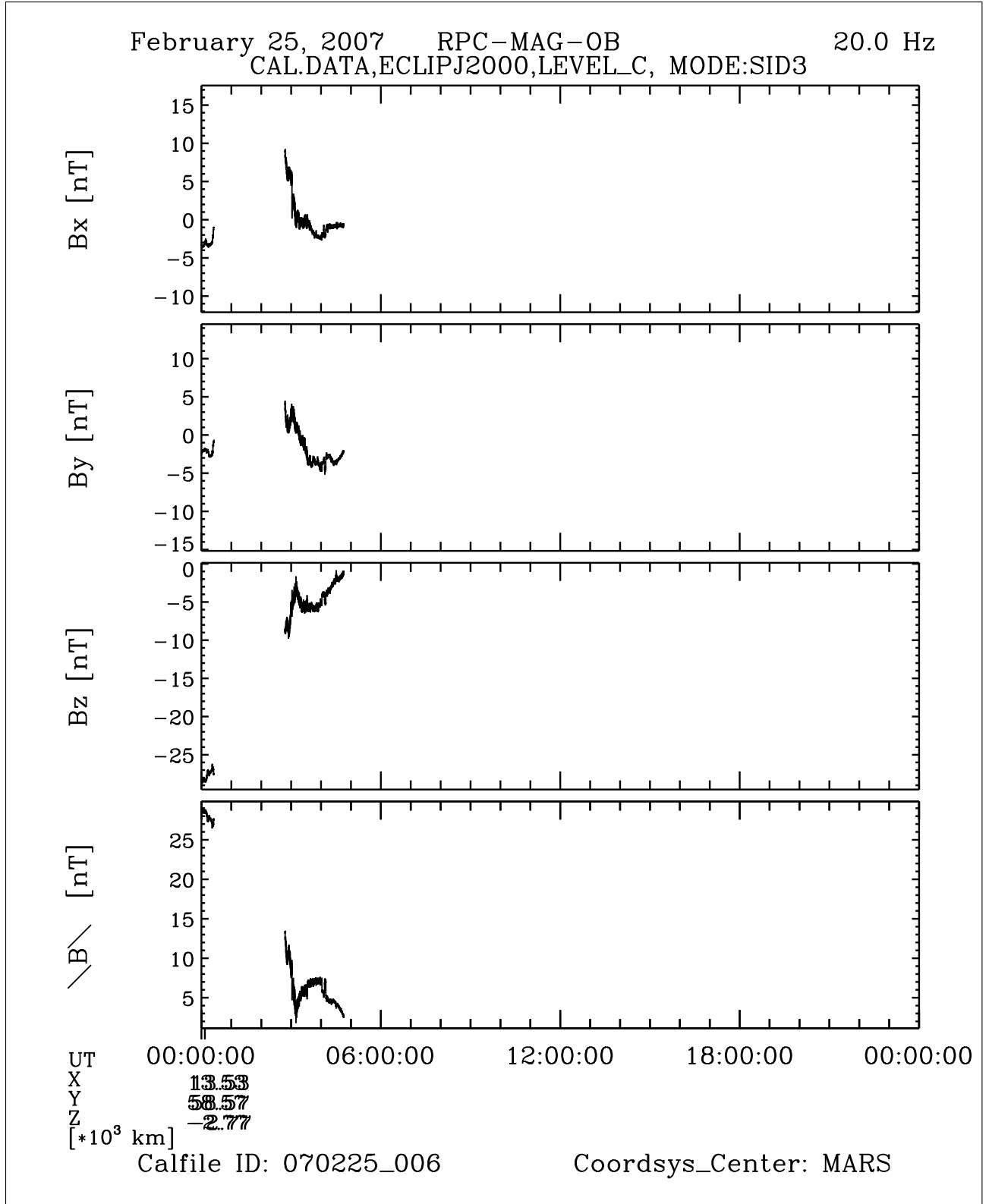


Figure 31: File: RPCMAG070225T0000\_CLC\_OB\_M3\_T0000\_2400\_006

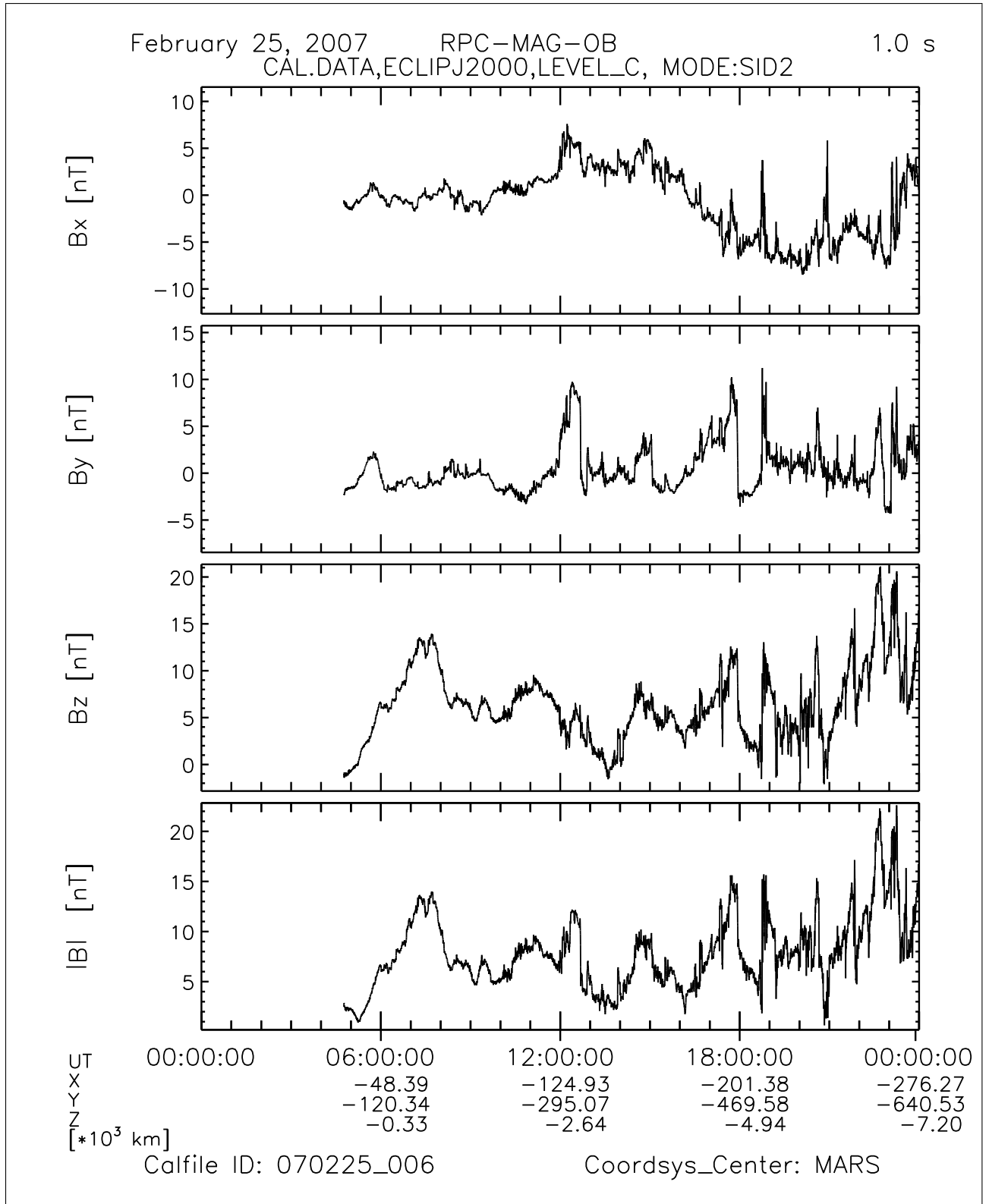


Figure 32: File: RPCMAG070225T0445\_CLC\_OB\_M2\_T0000\_2400\_006

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## 4.7 February 26, 2007:

### 4.7.1 Actions

MAG stayed in SID2 all the day.

## 4.8 Plots of Calibrated Data

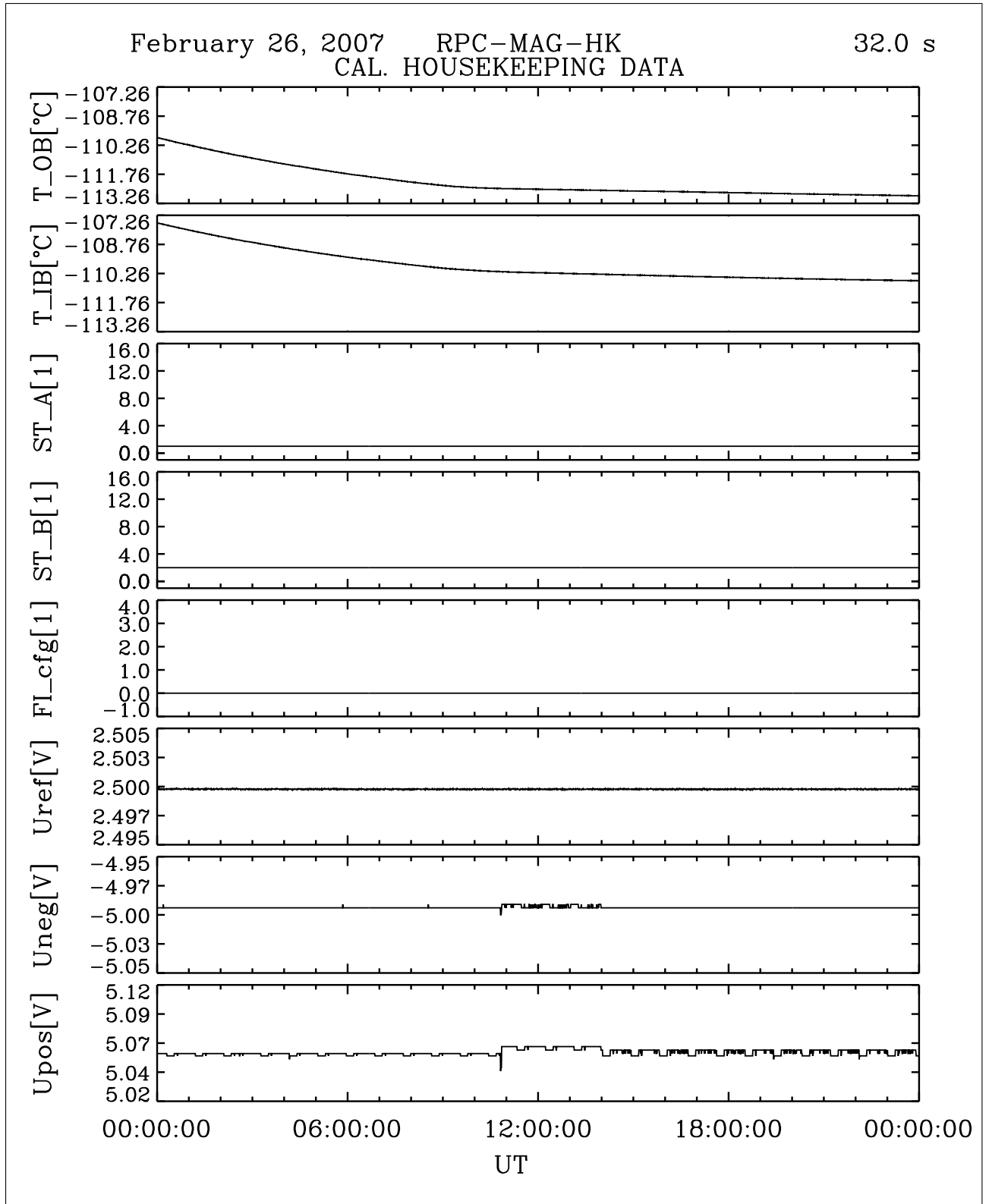


Figure 33: File: RPCMAG070226T0000\_CLA\_HK\_P0000\_2400

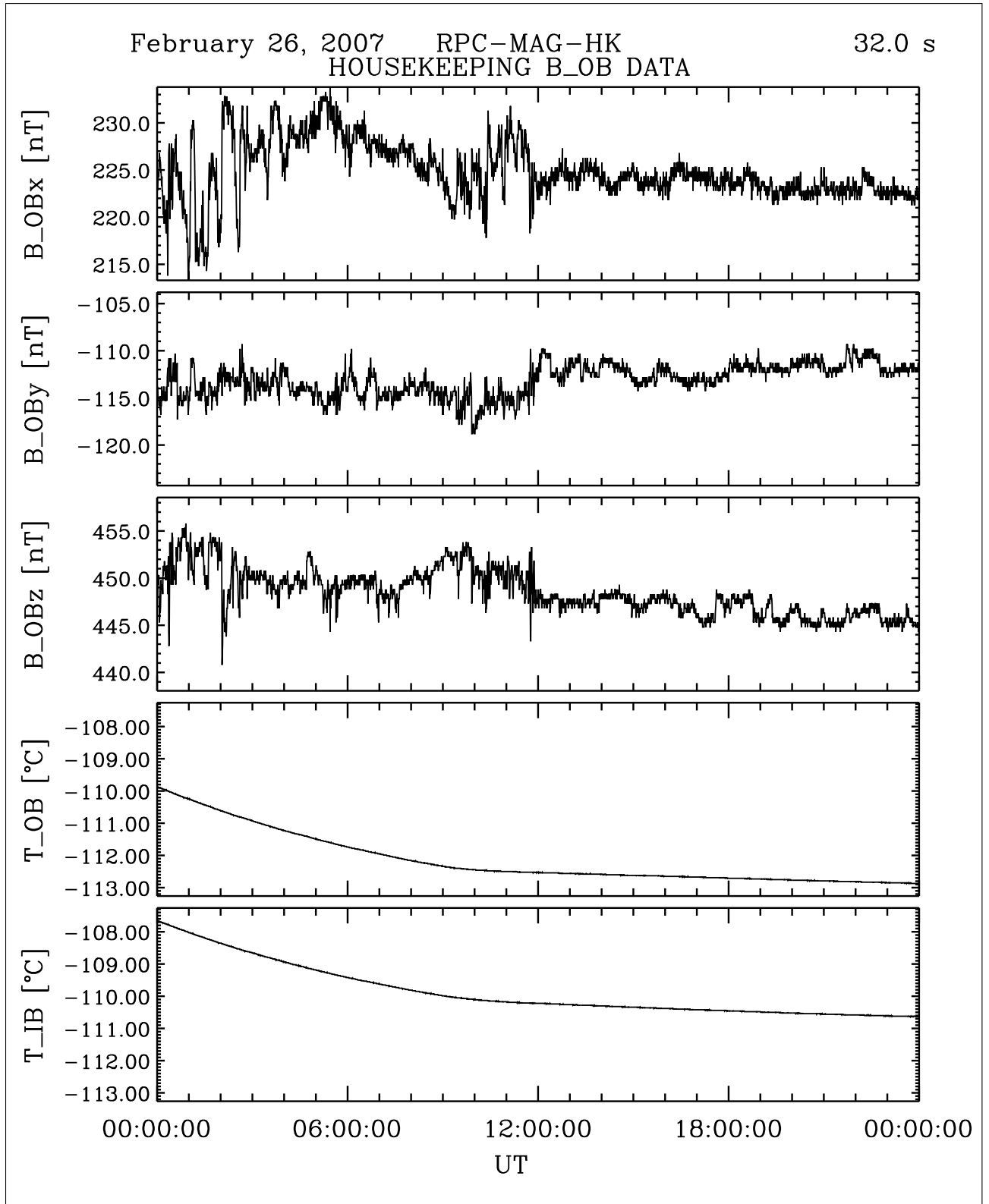


Figure 34: File: RPCMAG070226T0000\_CLA\_HK\_B\_P0000\_2400

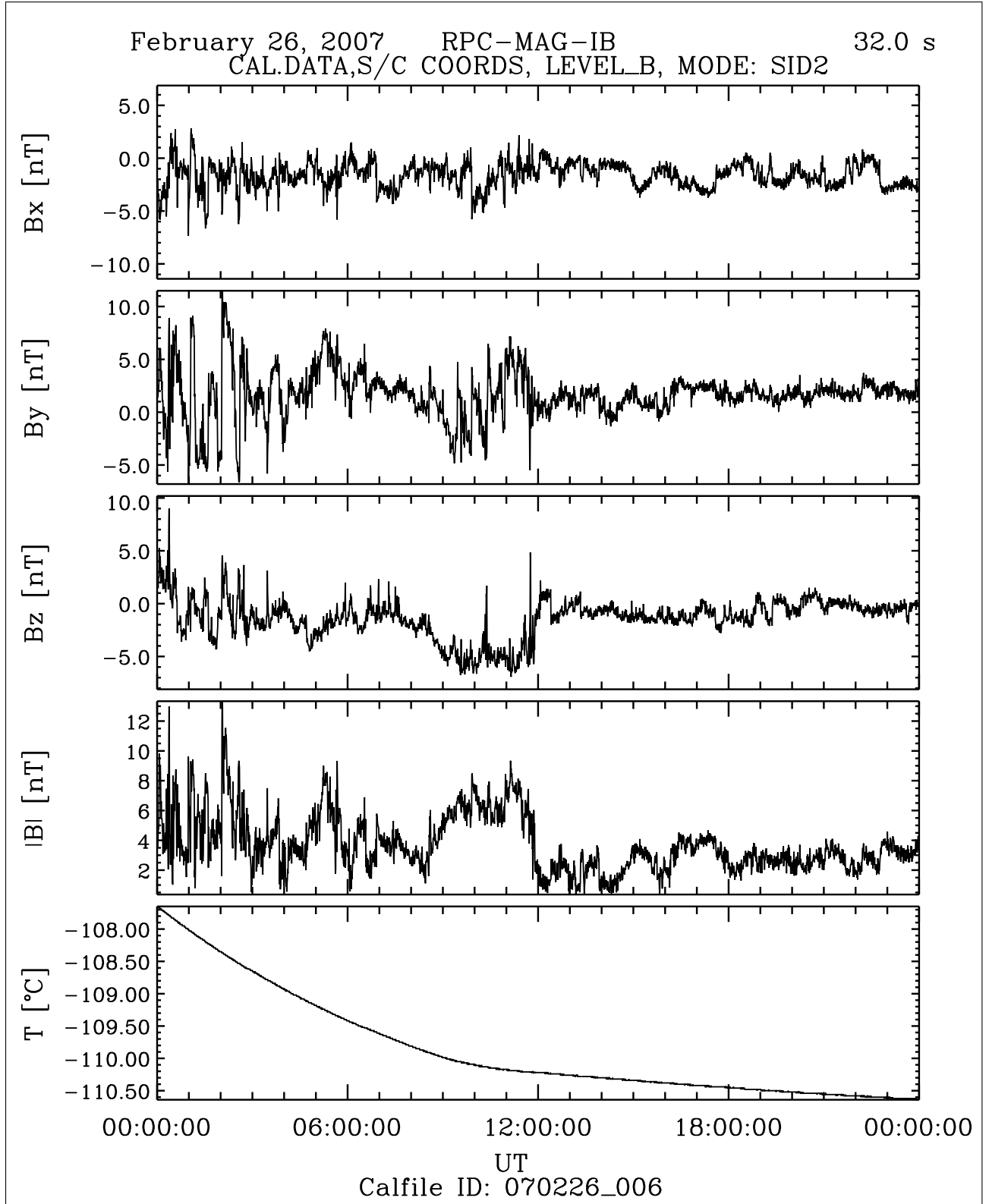


Figure 35: File: RPCMAG070226T0000\_CLB\_IB\_M2\_T0000\_2400\_006

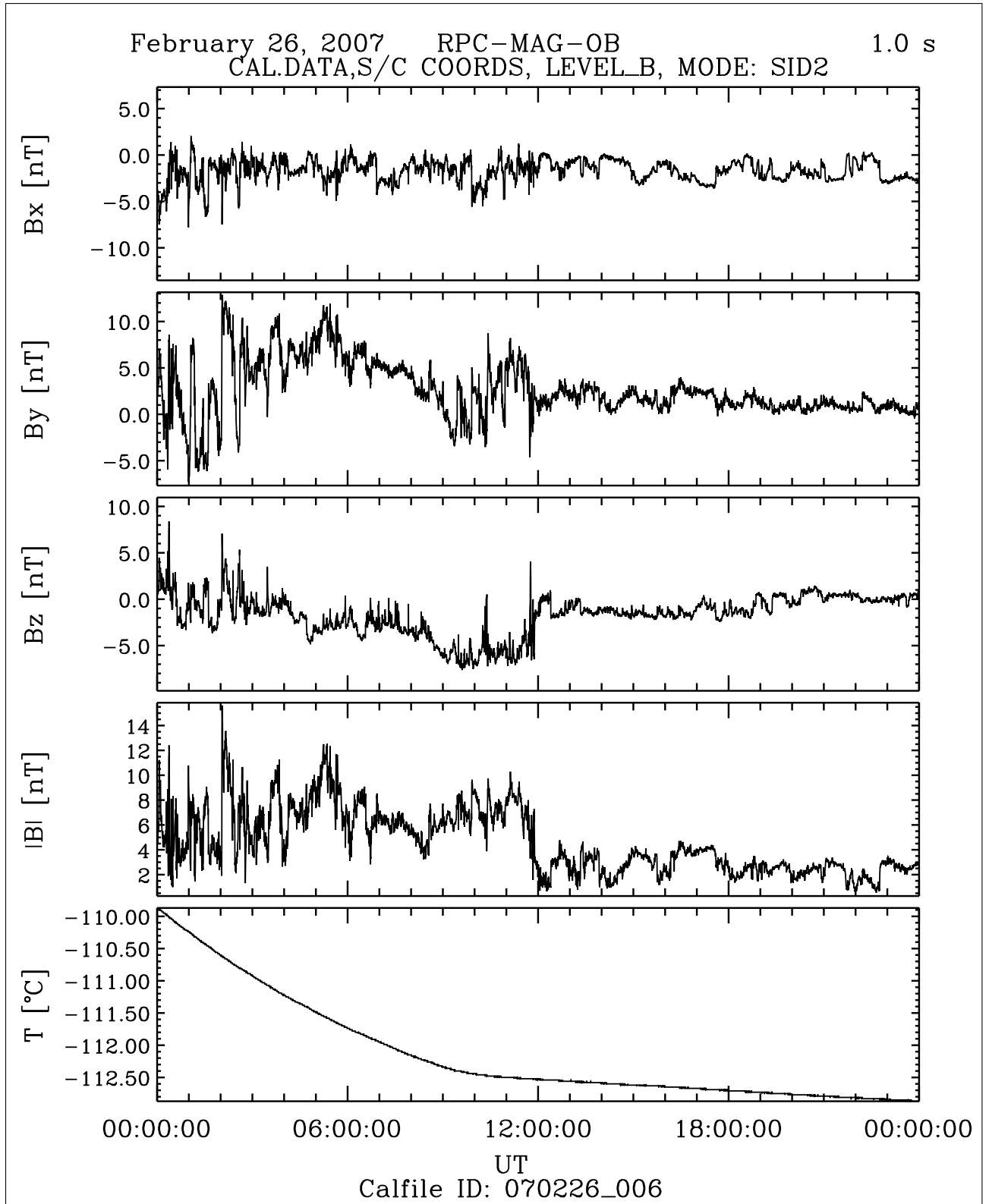
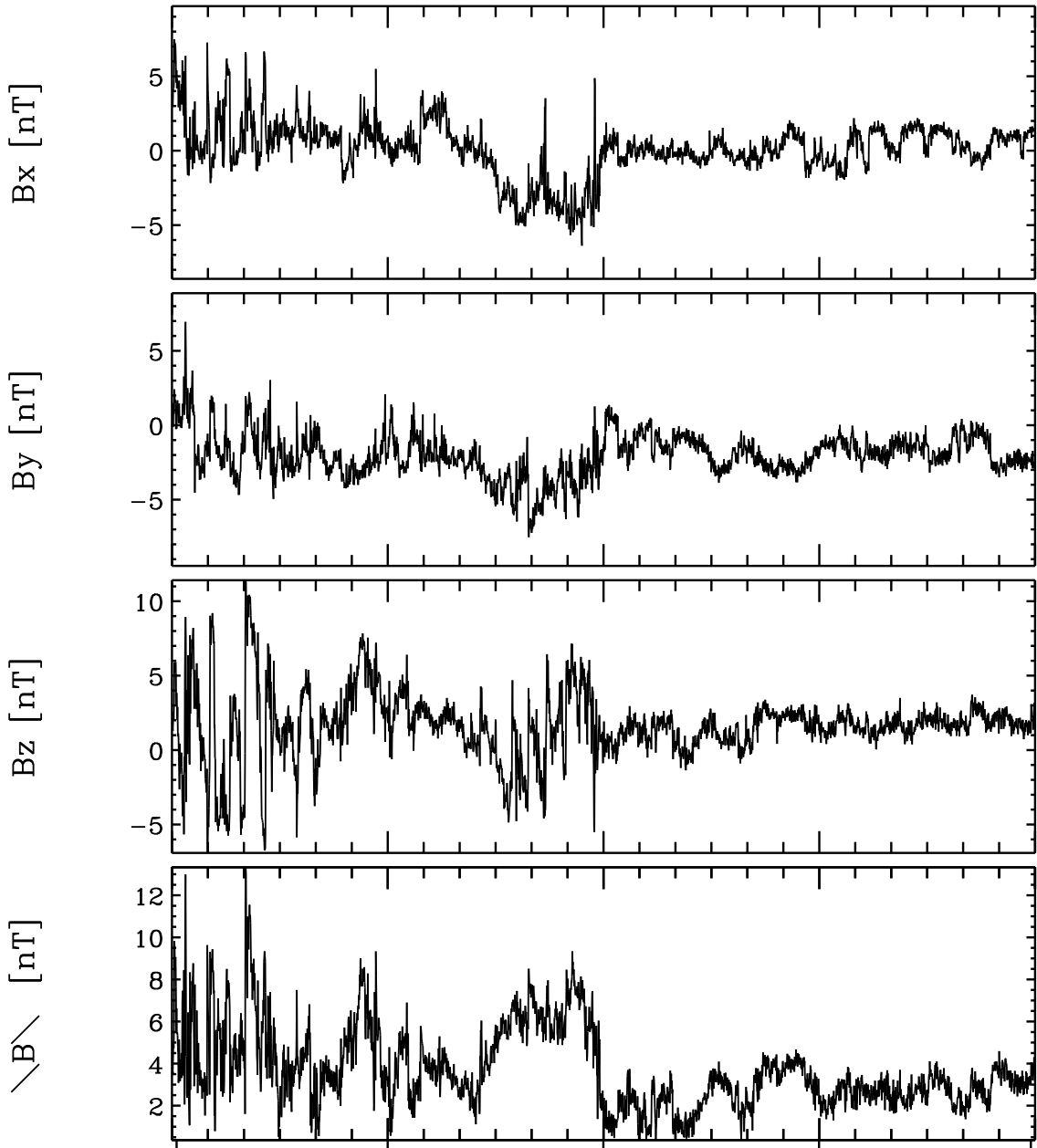


Figure 36: File: RPCMAG070226T0000\_CLB.OB\_M2\_T0000\_2400\_006

February 26, 2007 RPC-MAG-IB 32.0 s  
CAL.DATA,ECLIPJ2000,LEVEL\_C, MODE:SID2



UT	00:00:00	06:00:00	12:00:00	18:00:00	00:00:00
X	-279.44	-354.17	-430.52	-506.85	-581.82
Y	-647.76	-818.38	-992.69	-1166.99	-1338.20
Z	-7.30	-9.55	-11.85	-14.16	-16.42
[*10 <sup>3</sup> km]					

Calfile ID: 070226\_006

Coordsys\_Center: MARS

Figure 37: File: RPCMAG070226T0000\_CLC\_IB\_M2\_T0000\_2400\_006



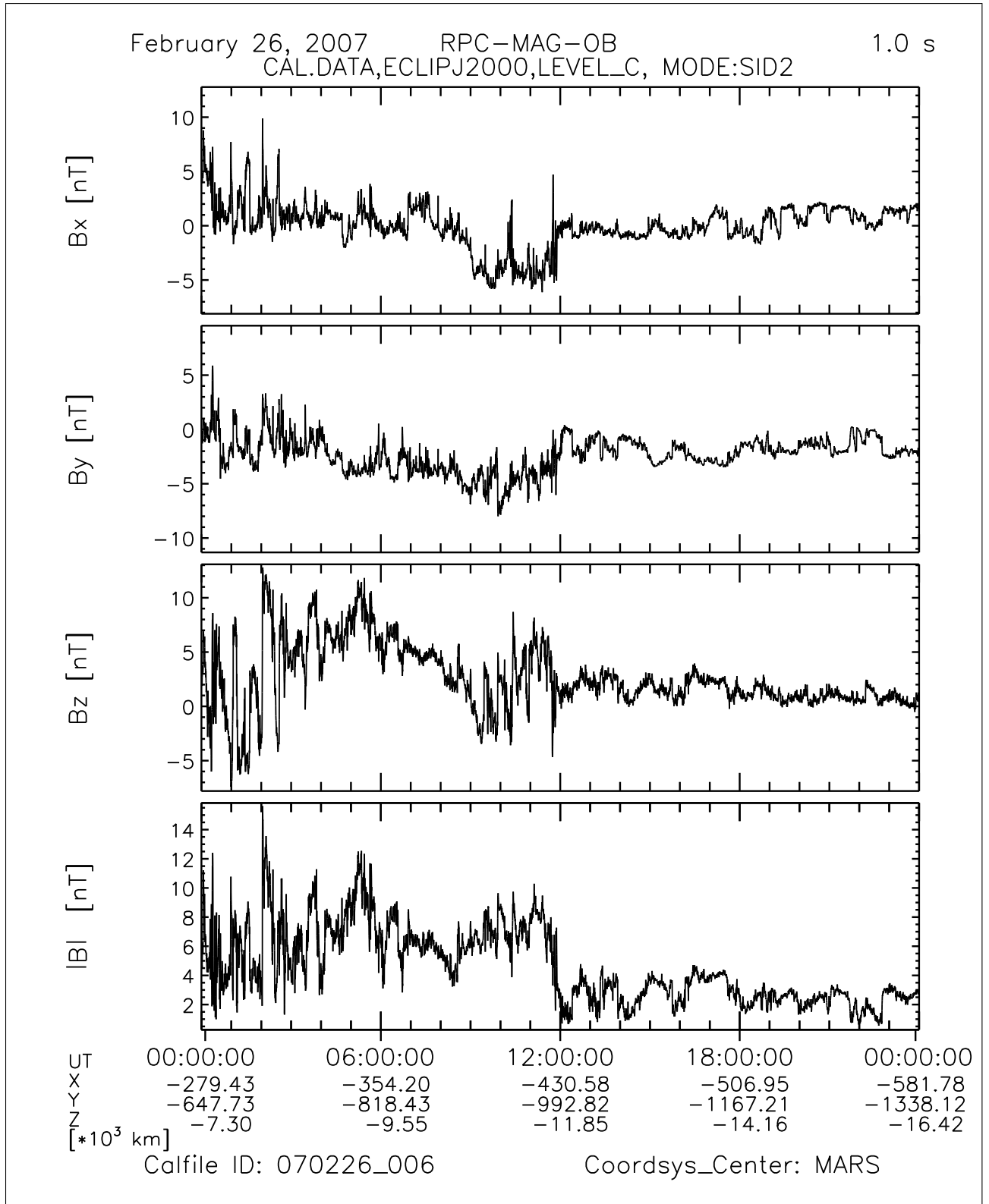


Figure 38: File: RPCMAG070226T0000\_CLC\_OB\_M2\_T0000\_2400\_006

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## 4.9 February 27, 2007:

### 4.9.1 Actions

MAG stayed in SID2 until the RPC switch off at 02:24. All commands passed smoothly and the instrument followed in the expected way.

### 4.10 Plots of Calibrated Data

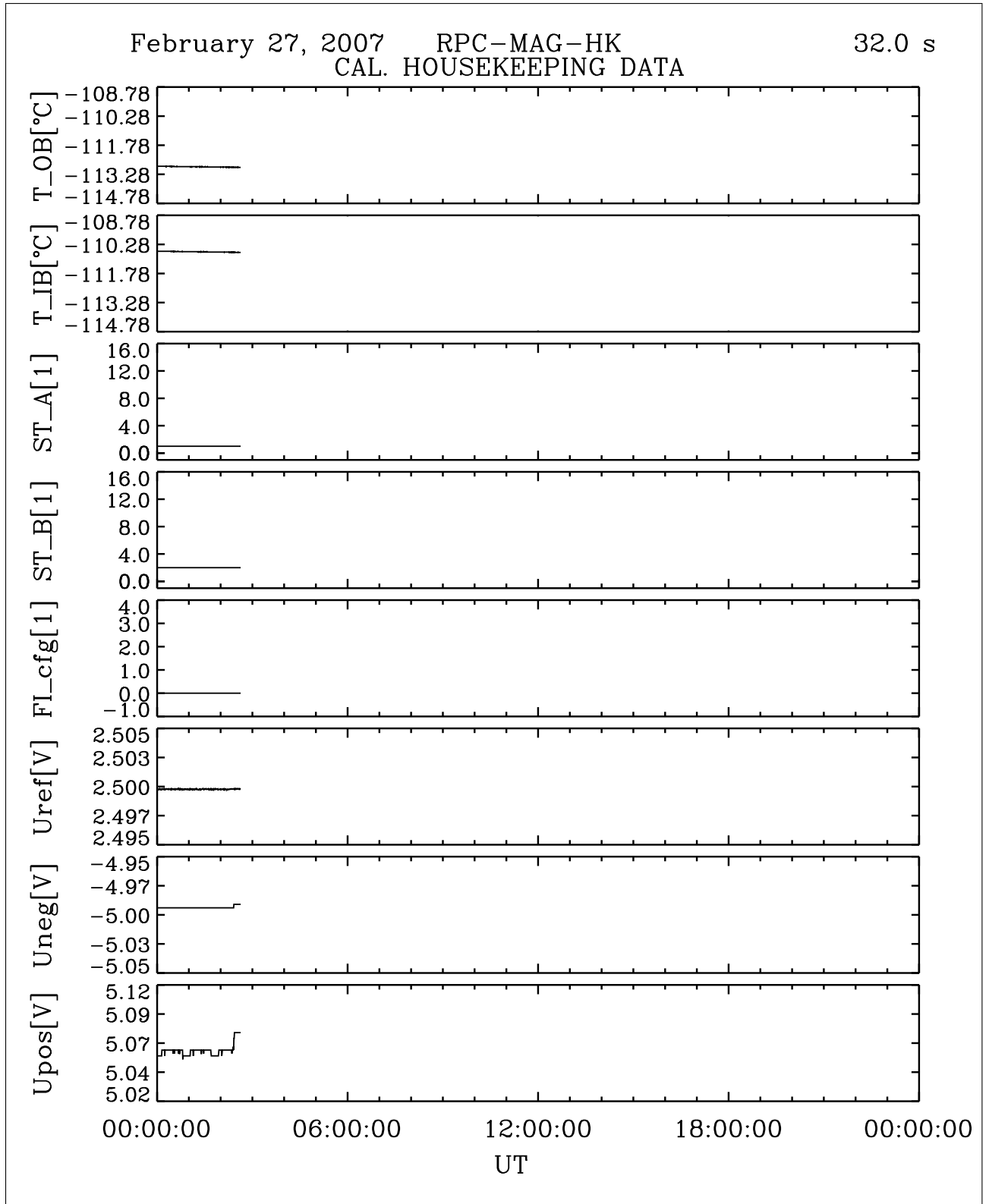


Figure 39: File: RPCMAG070227T0000\_CLA\_HK\_P0000\_2400

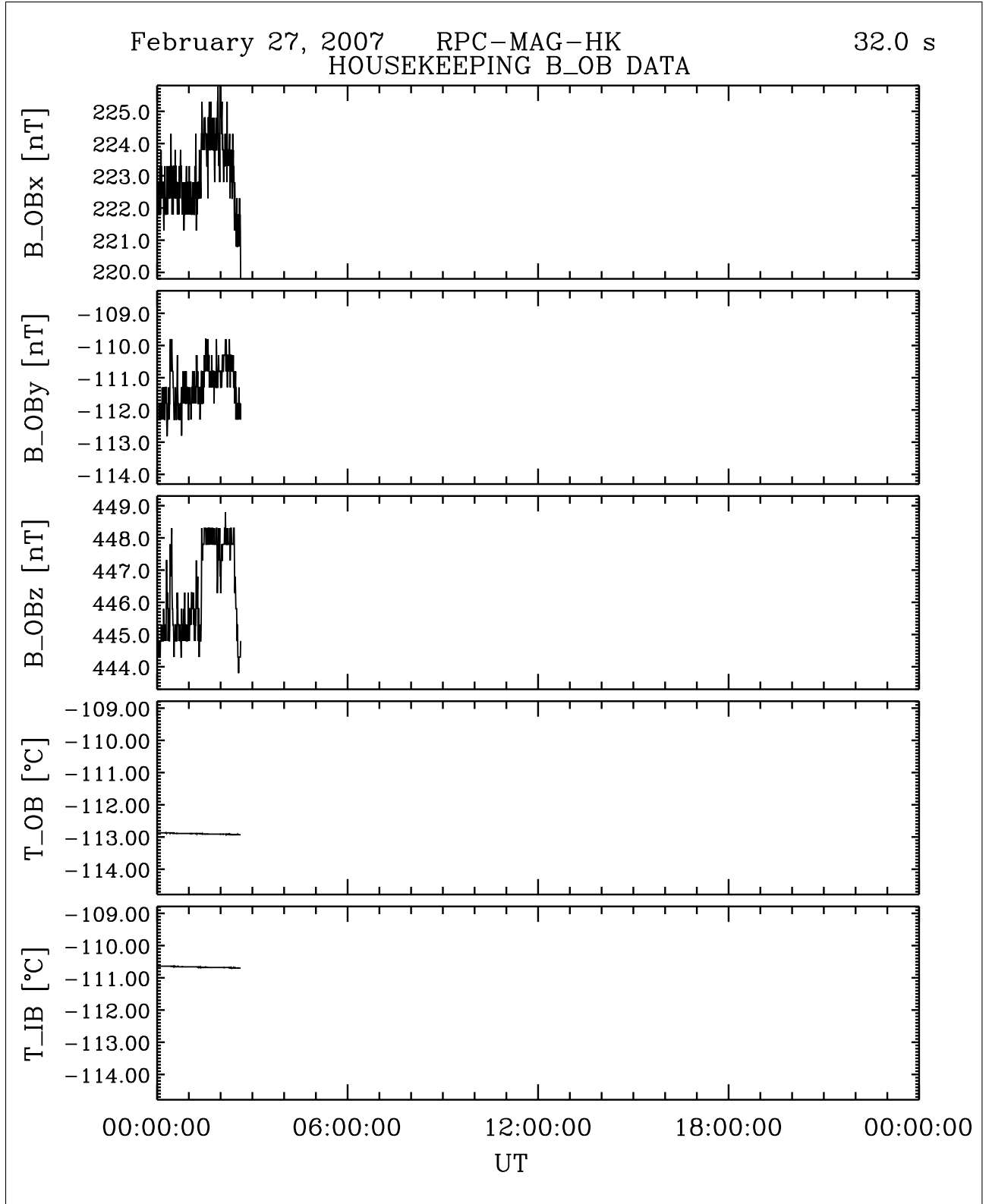


Figure 40: File: RPCMAG070227T0000\_CLA\_HK\_B\_P0000\_2400

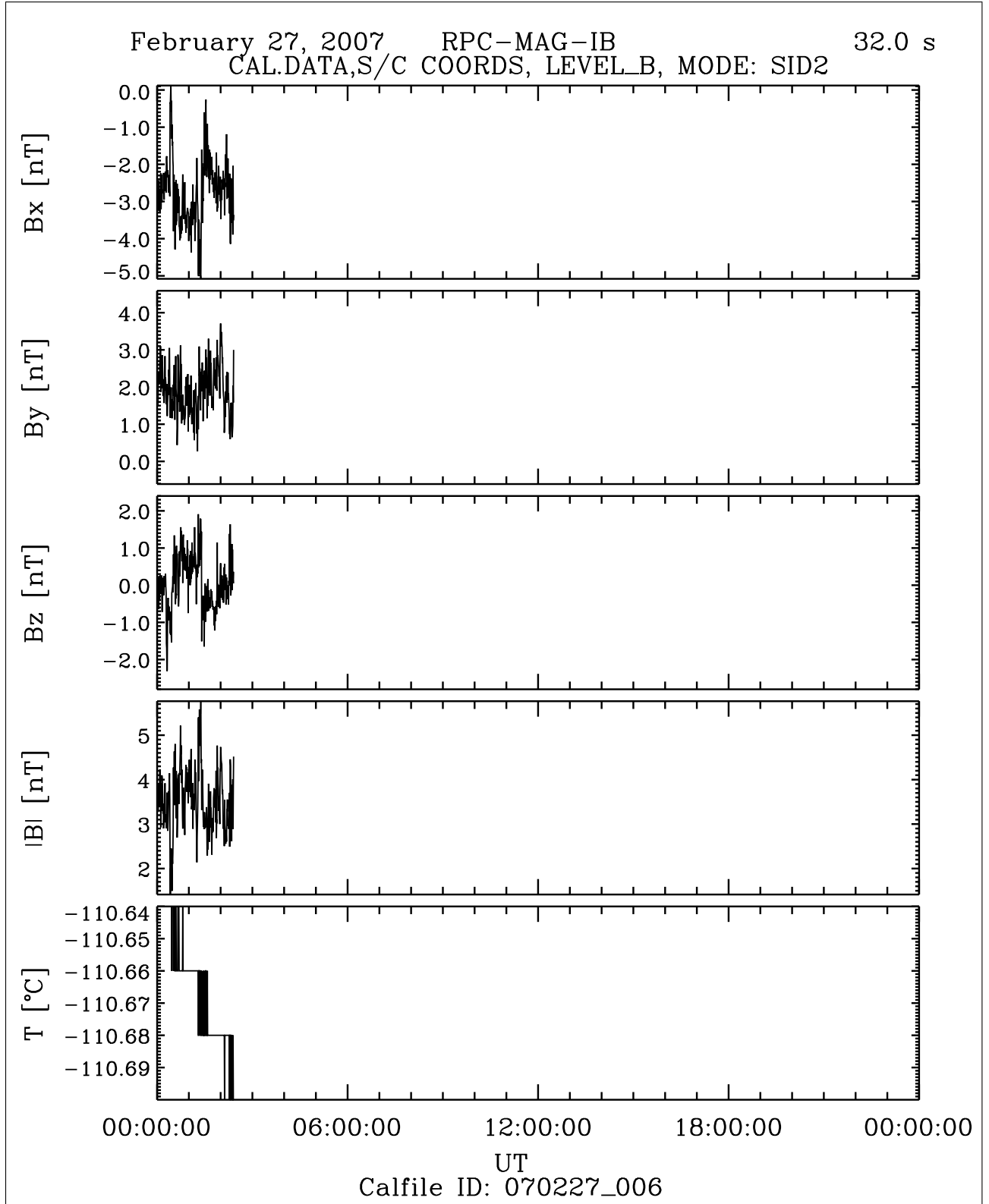


Figure 41: File: RPCMAG070227T0000\_CLB\_IB\_M2\_T0000\_2400\_006

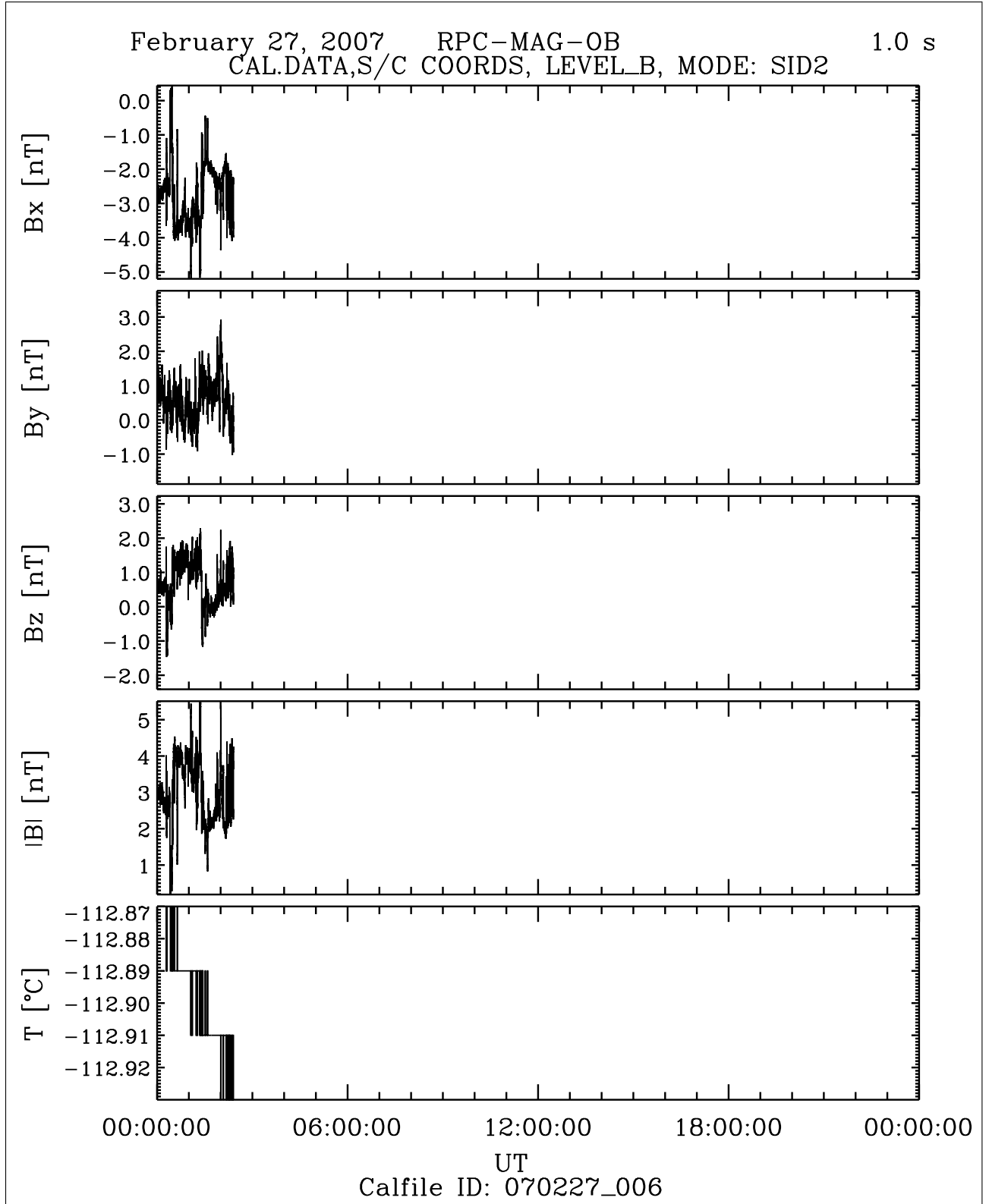


Figure 42: File: RPCMAG070227T0000\_CLB.OB\_M2\_T0000\_2400\_006

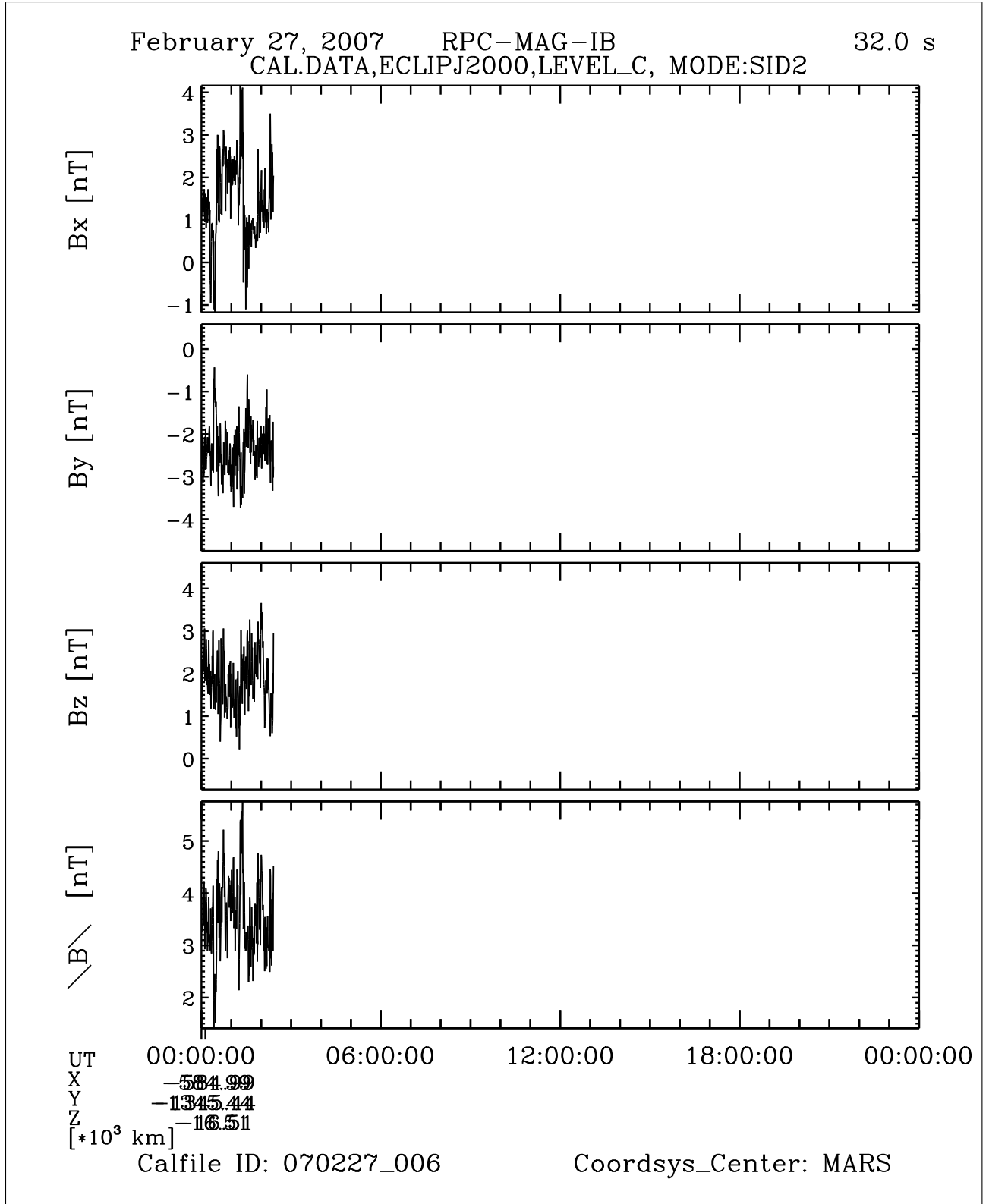


Figure 43: File: RPCMAG070227T0000\_CLC\_IB\_M2\_T0000\_2400\_006

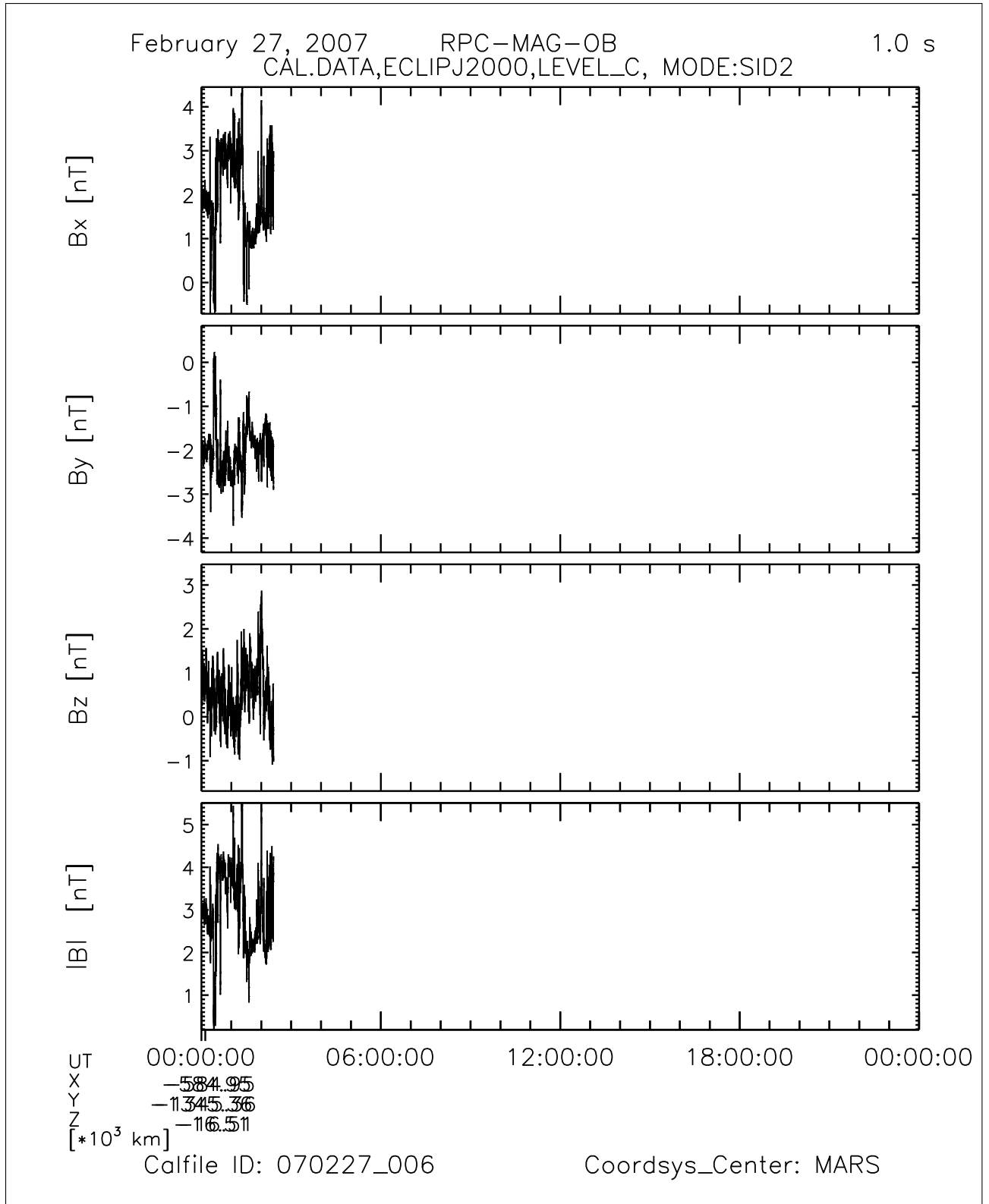


Figure 44: File: RPCMAG070227T0000\_CLC\_OB\_M2\_T0000\_2400\_006



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## 5 The new Temperature model

It turned out that the old temperature model 002, which was based on CVP and EAR1 data, was not properly applicable anymore. Due to hysteretic effects (in terms of temperature influence) of the magnetic field sensor it showed up that a more sophisticated temperature model was needed. Thus a new model (006) has been developed which is based on the following assumptions:

- The correlation of the OB magnetic field readings and the OB temperature has to be minimal.
- The correlation of the IB magnetic field readings and the IB temperature has to be minimal.
- The correlation of the IB magnetic field readings and the OB magnetic field readings has to be maximal.
- The influence of the temperature can be eliminated (minimized) by subtracting suitable polynomials  $P(T)$  from the magnetic field readings.
- The coefficients of these 6 polynomials are calculated from the optimization of the 9 above mentioned correlation coefficients. Mathematically this is done by a POWELL minimization routine.

It showed up that the best result is achieved if this calculation is done day by day in order to really take the right temperature behavior into account. The former temperature model showed significantly worse results especially at lower temperatures and faster temperature changes. The calculated polynomials can be of 5th order, but the analysis yielded that linear ones with only very little quadratic and cubic contribution are the best ones. All the MARS data and future data will be calibrated using this new model.

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## 6 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 sampling frequency without any aliasing filter.

These signatures are expected to be seen on the OB sensor operated in NORMAL and BURST modes due to our experiences from the commissioning phase. The analysis of Reaction Wheels influence is performed in the next section.

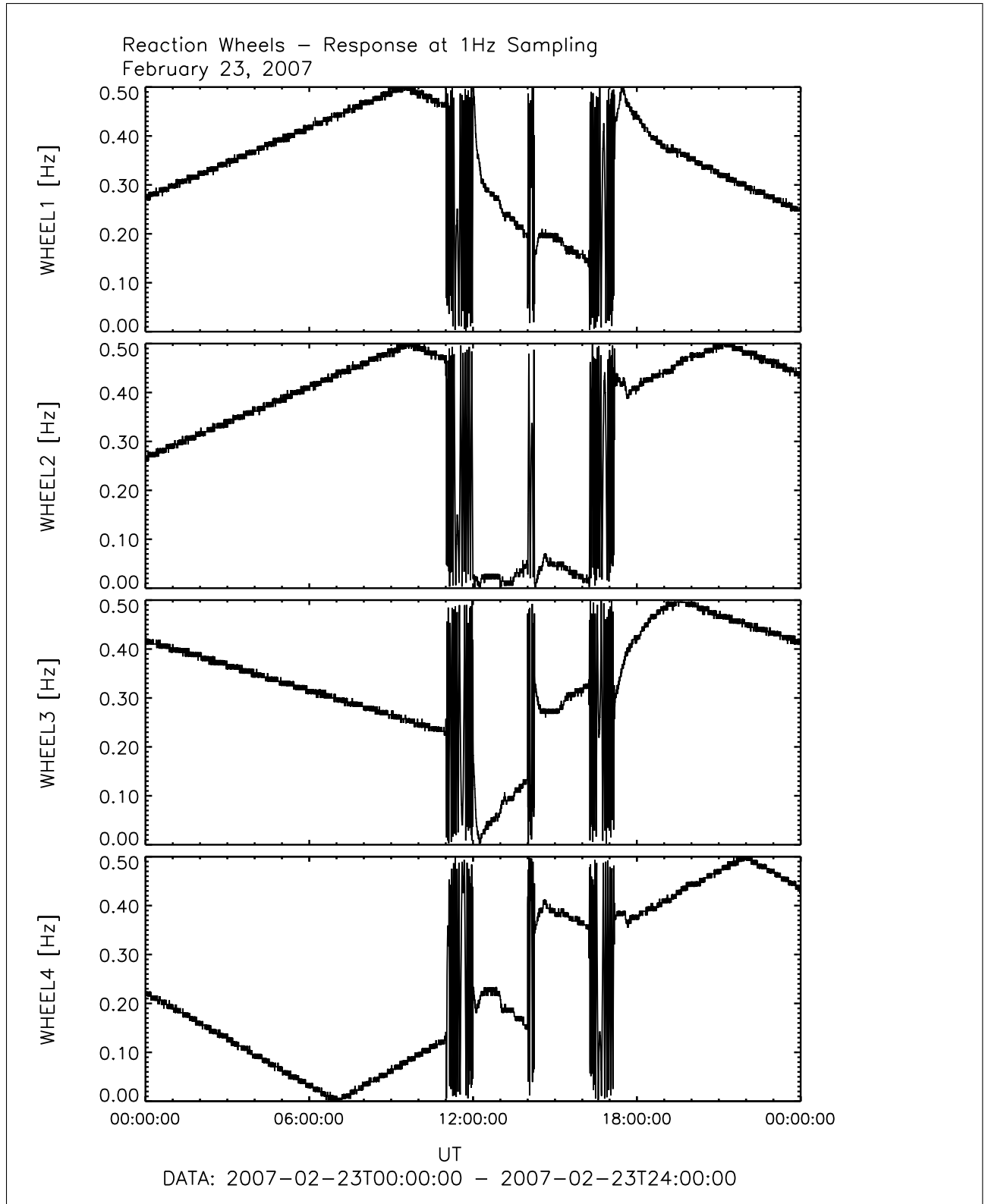


Figure 45: File: wheels\_1Hz\_Sampling2007-02-23T00-00

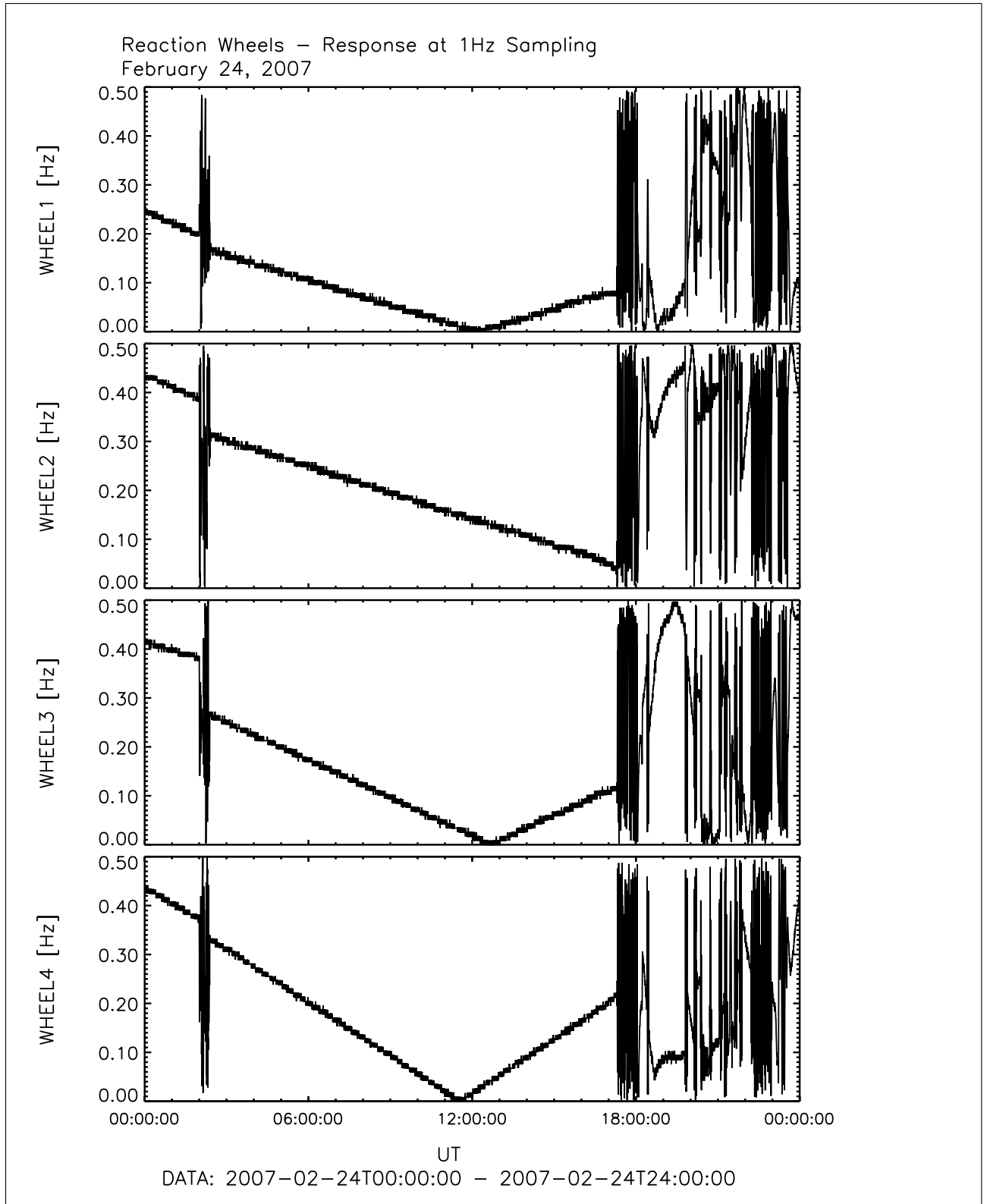


Figure 46: File: wheels\_1Hz\_Sampling2007-02-24T00-00

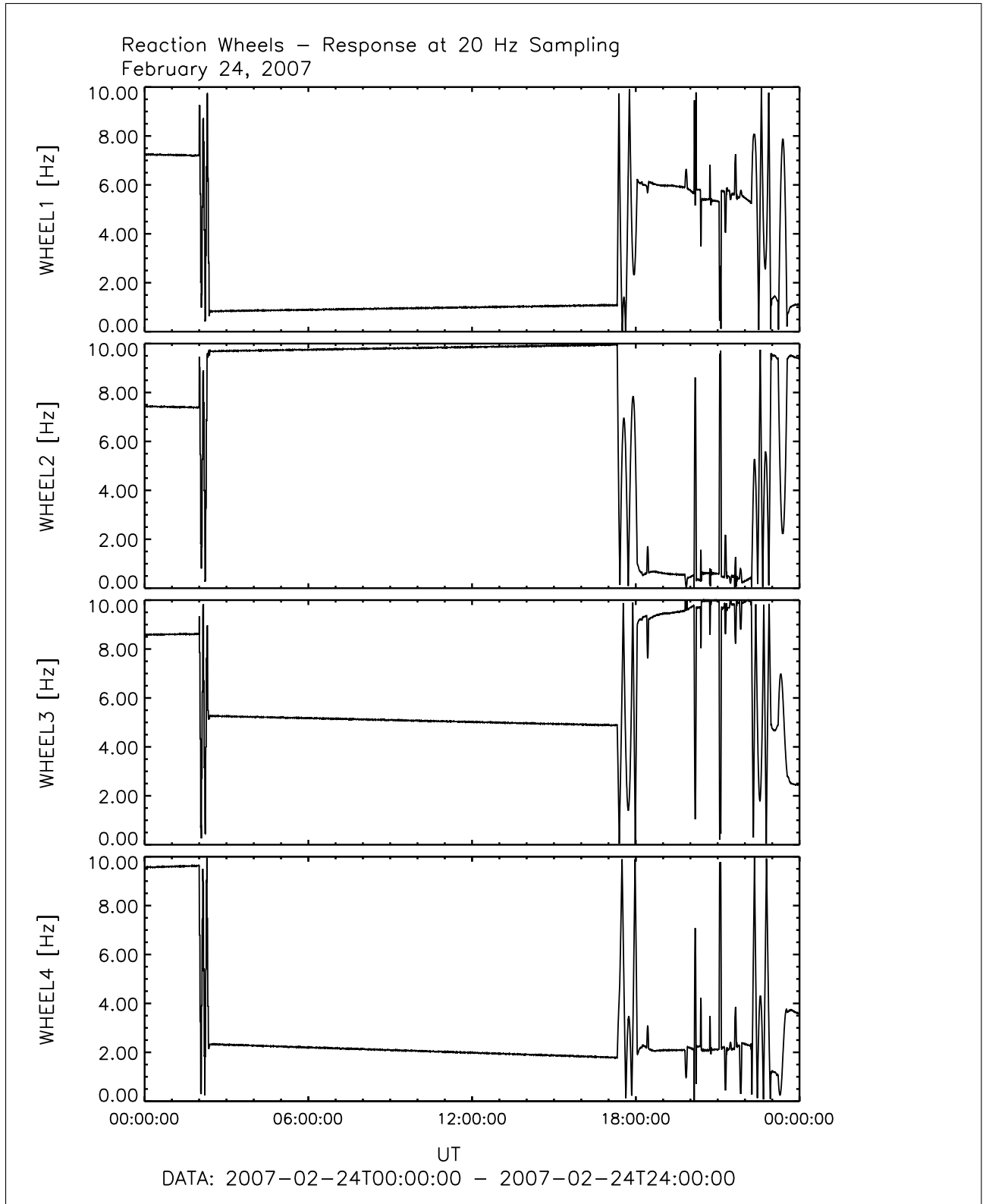


Figure 47: File: wheels\_20Hz\_Sampling2007-02-24T00-00

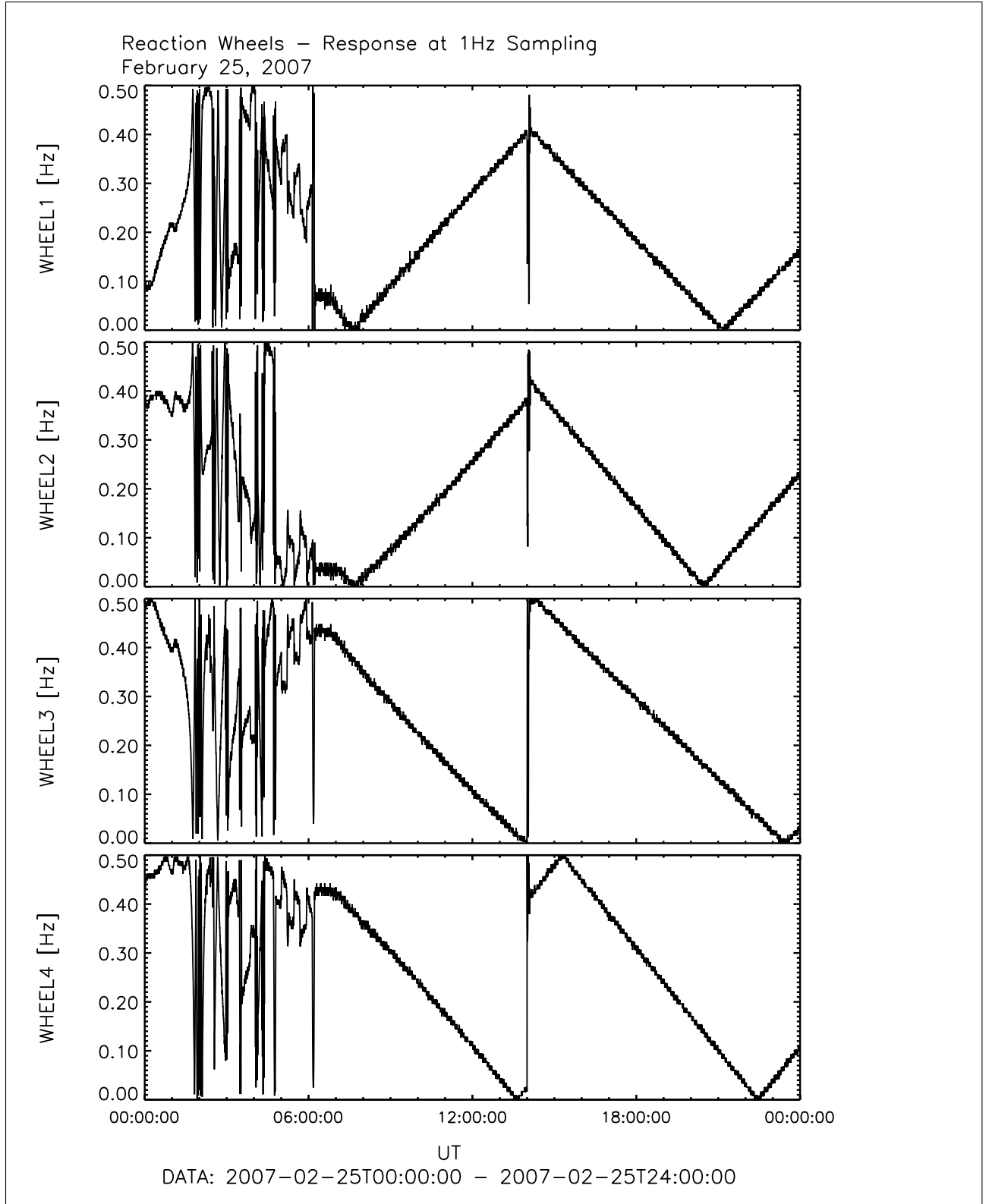


Figure 48: File: wheels\_1Hz\_Sampling2007-02-25T00-00

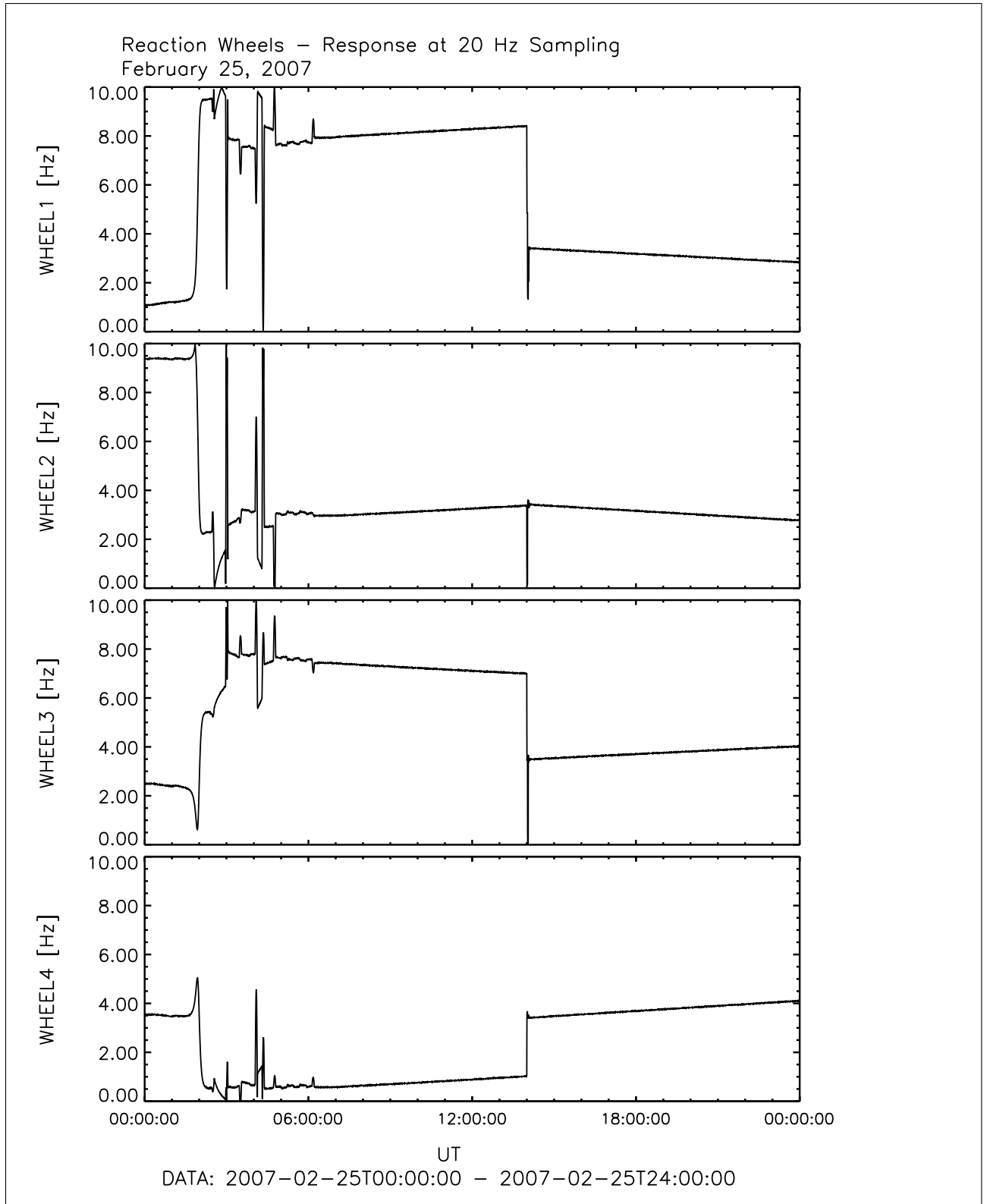


Figure 49: File: wheels\_20Hz\_Sampling2007-02-25T00-00

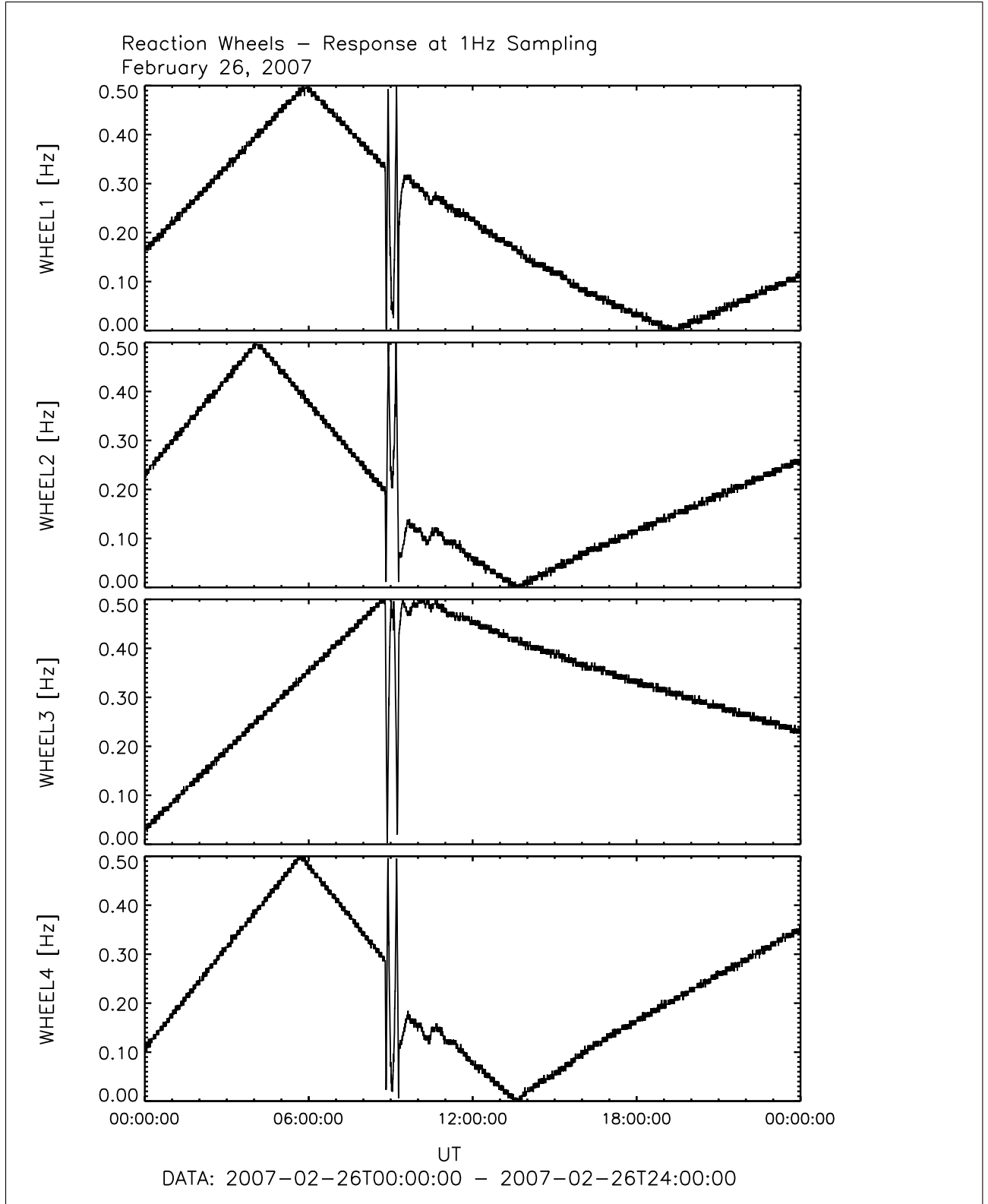


Figure 50: File: wheels\_1Hz\_Sampling2007-02-26T00-00



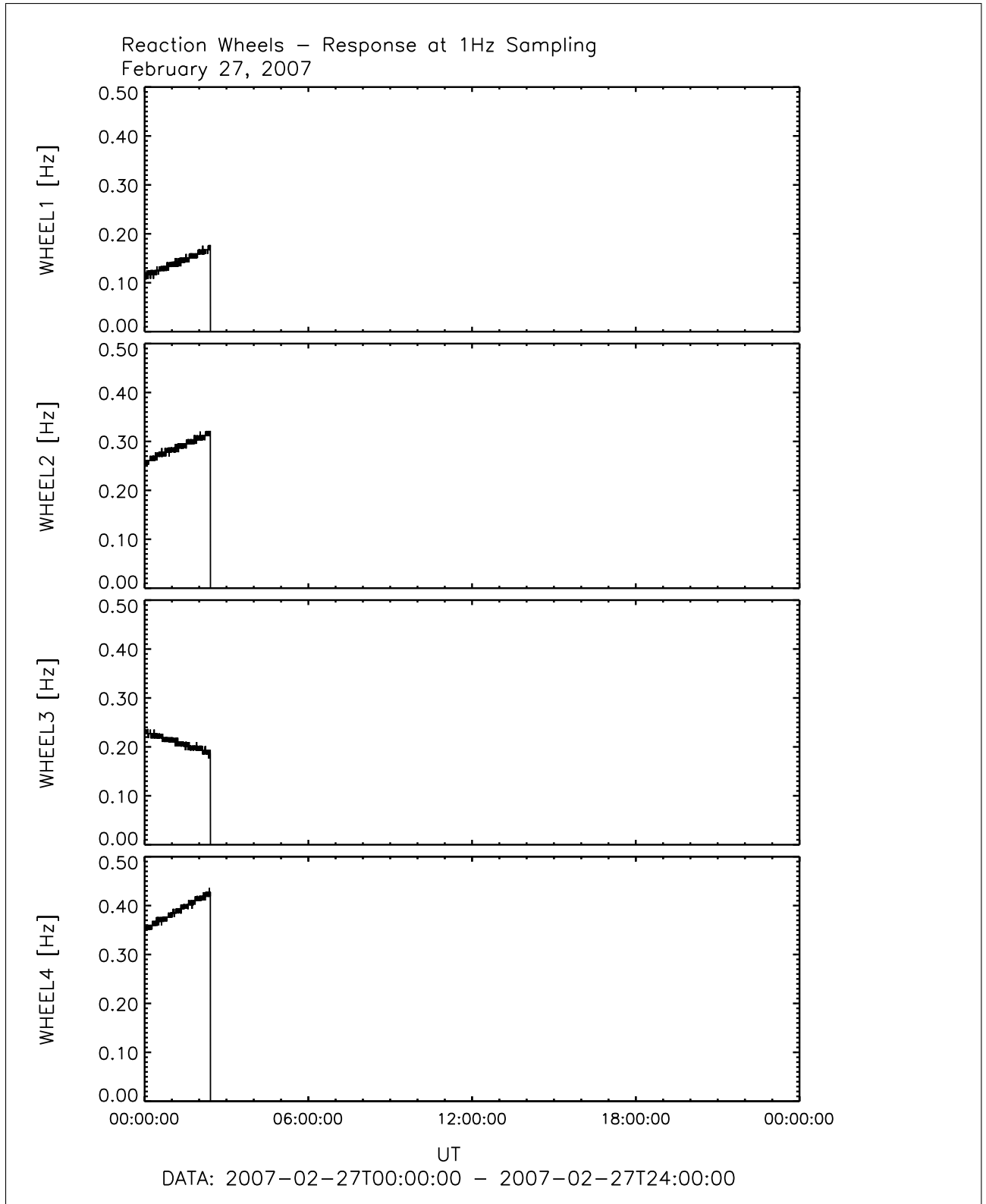


Figure 51: File: wheels\_1Hz\_Sampling2007-02-27T00-00

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## 7 Dynamic Spectra of the Swing-by

This section shows the dynamic spectra of the OB sensor in `LEVEL_C = ECLIPJ2000` coordinates. As the OB sensor was operated as primary sensor in `NORMAL` mode, `SID2`, the maximum resolvable frequency is 0.5 Hz. For the few hours around `CA` also `SID3` spectra are available. Here the maximum resolvable frequency is 10Hz.

As usual the Influence of the Reaction wheels can be seen in `BURST` mode.

A view to the spectra of the measured magnetic field shows, that there is no influence of the RWs for `SID2` operations. The Burst mode data (`SID3`), however, are clearly disturbed by the Reaction Wheels.

From time to time there are also horizontal lines in the dynamic spectrum to be seen. These lines represent constant frequencies and are caused by the LAP instrument. This behavior was investigated and proofed during the PC10 campaign in November 2010. See RO-IGEP-TR0030 for further details.

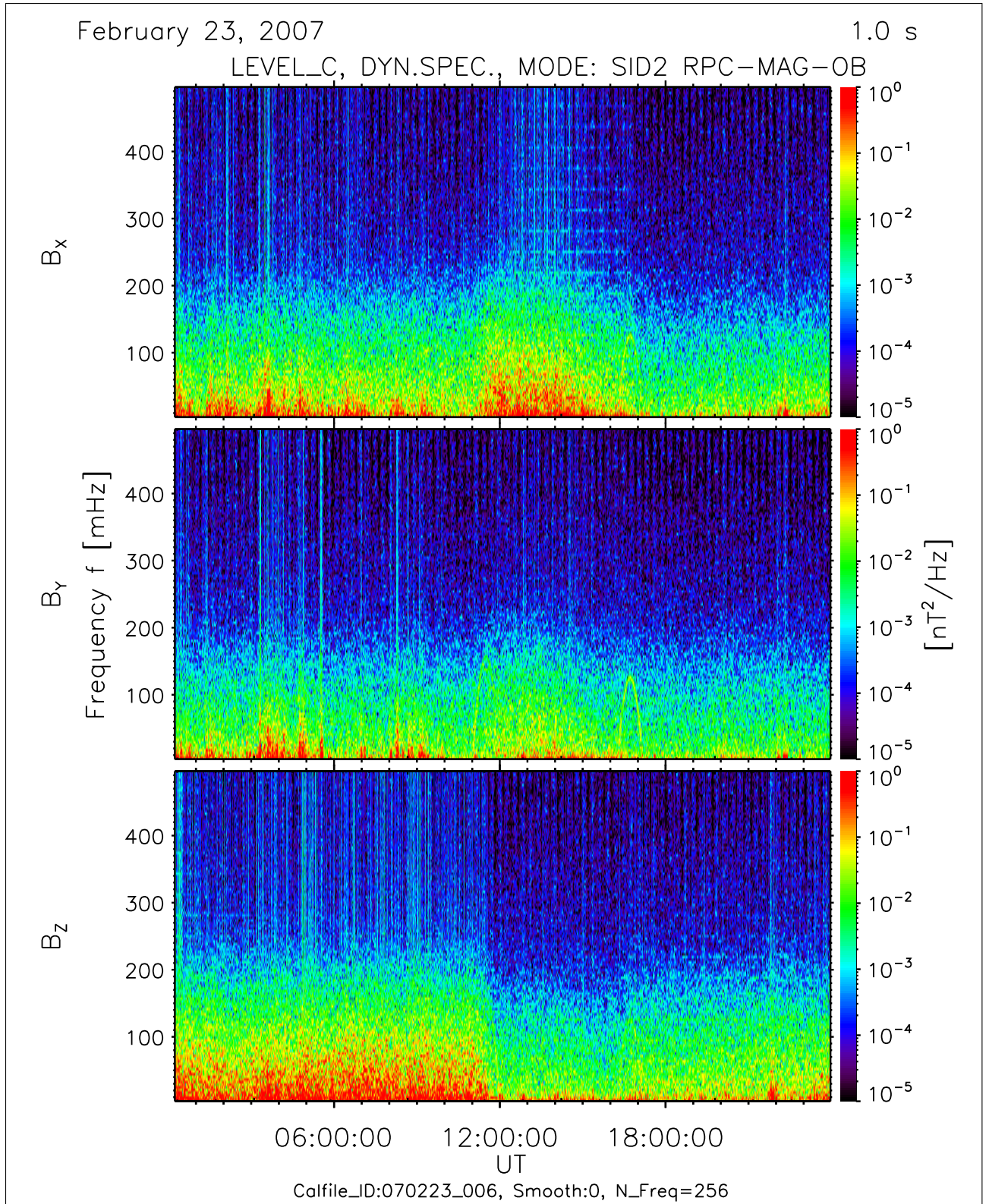


Figure 52: File: RPCMAG070223T0012\_CLC\_OB.M2\_DS0.500.006



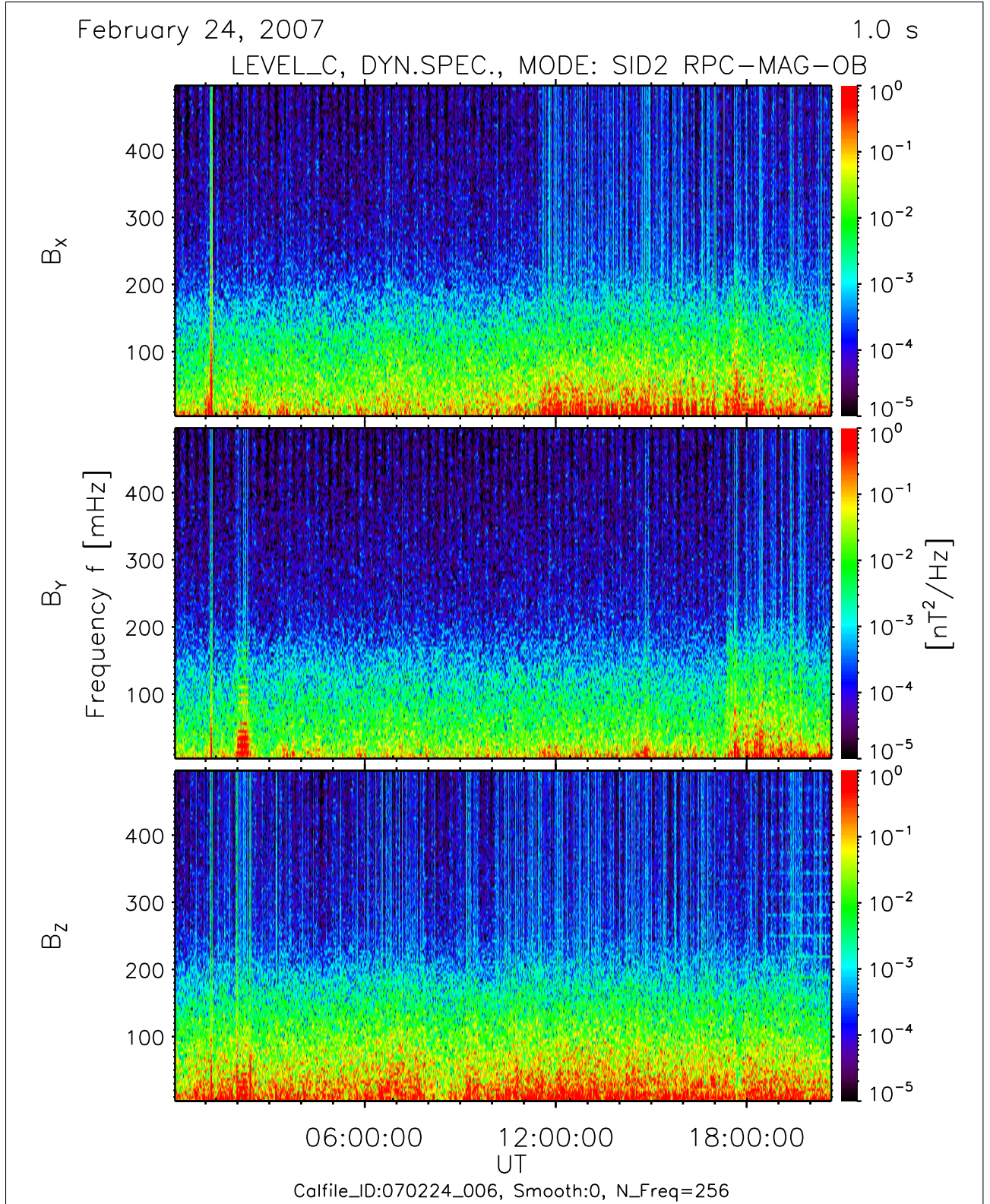


Figure 53: File: RPCMAG070224T0000\_CLC\_OB.M2\_DS0.500.006



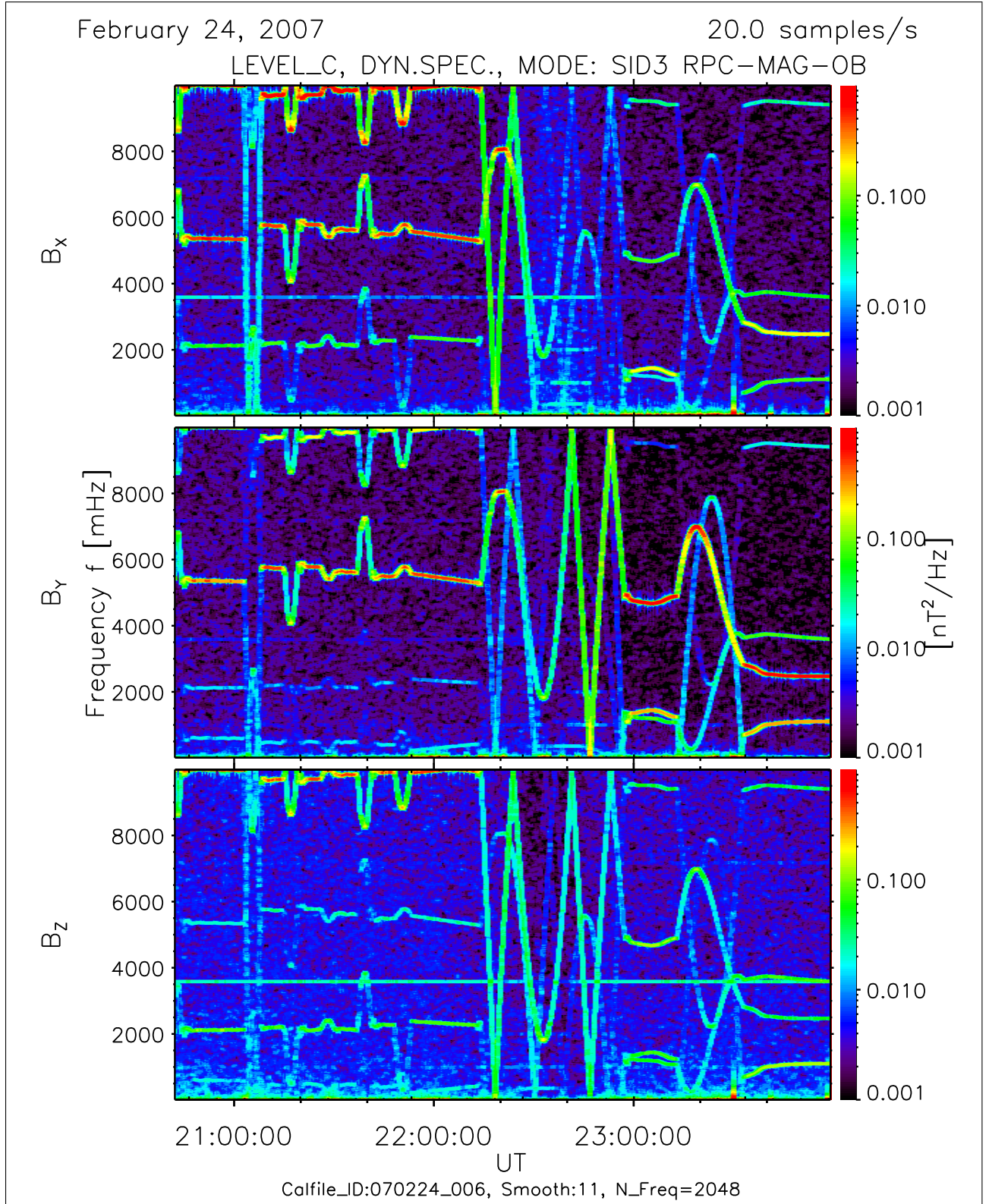


Figure 54: File: RPCMAG070224T2041\_CLC\_OB\_M3\_DS0\_10000\_006



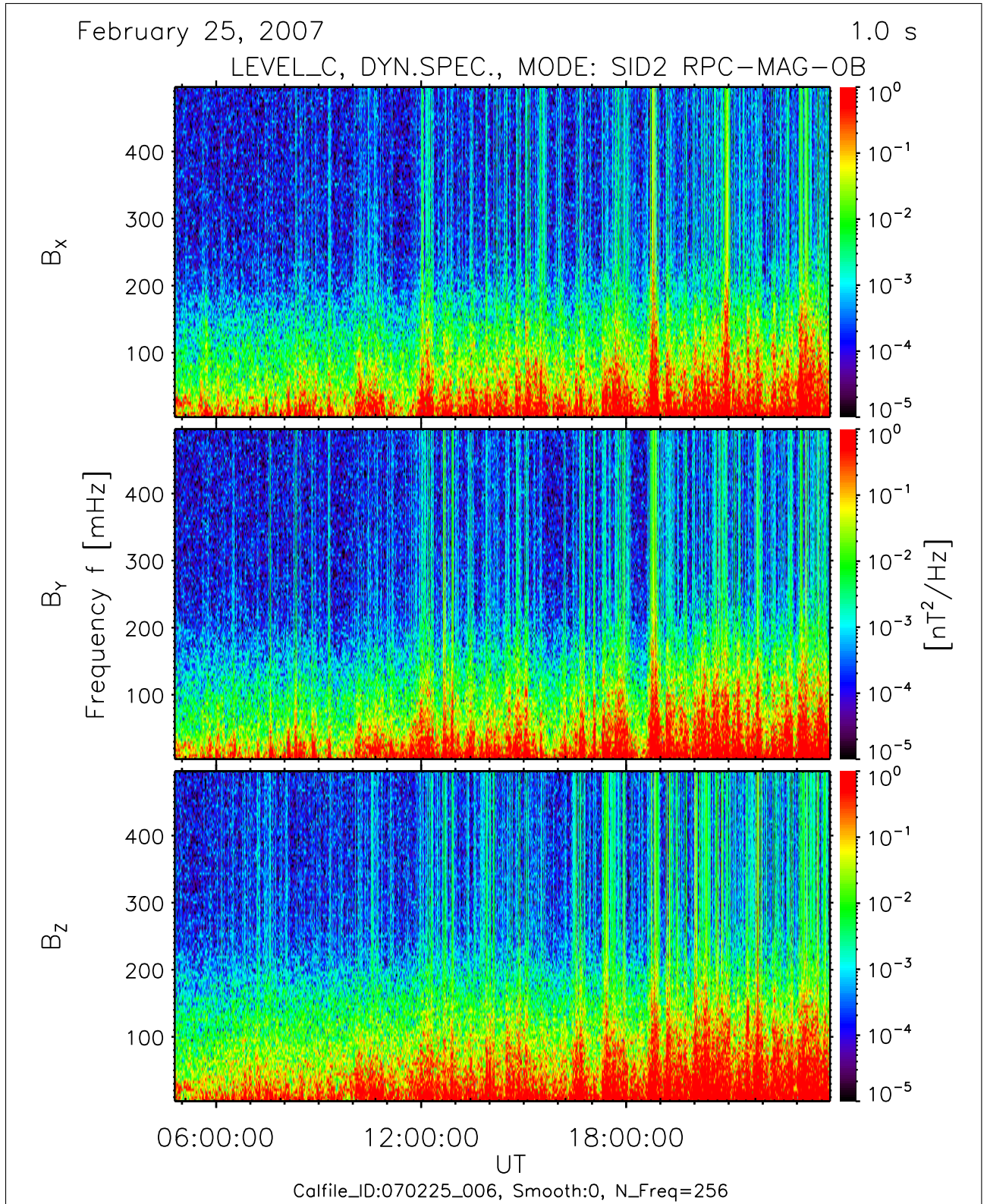


Figure 55: File: RPCMAG070225T0445\_CLC\_OB.M2\_DS0.500.006

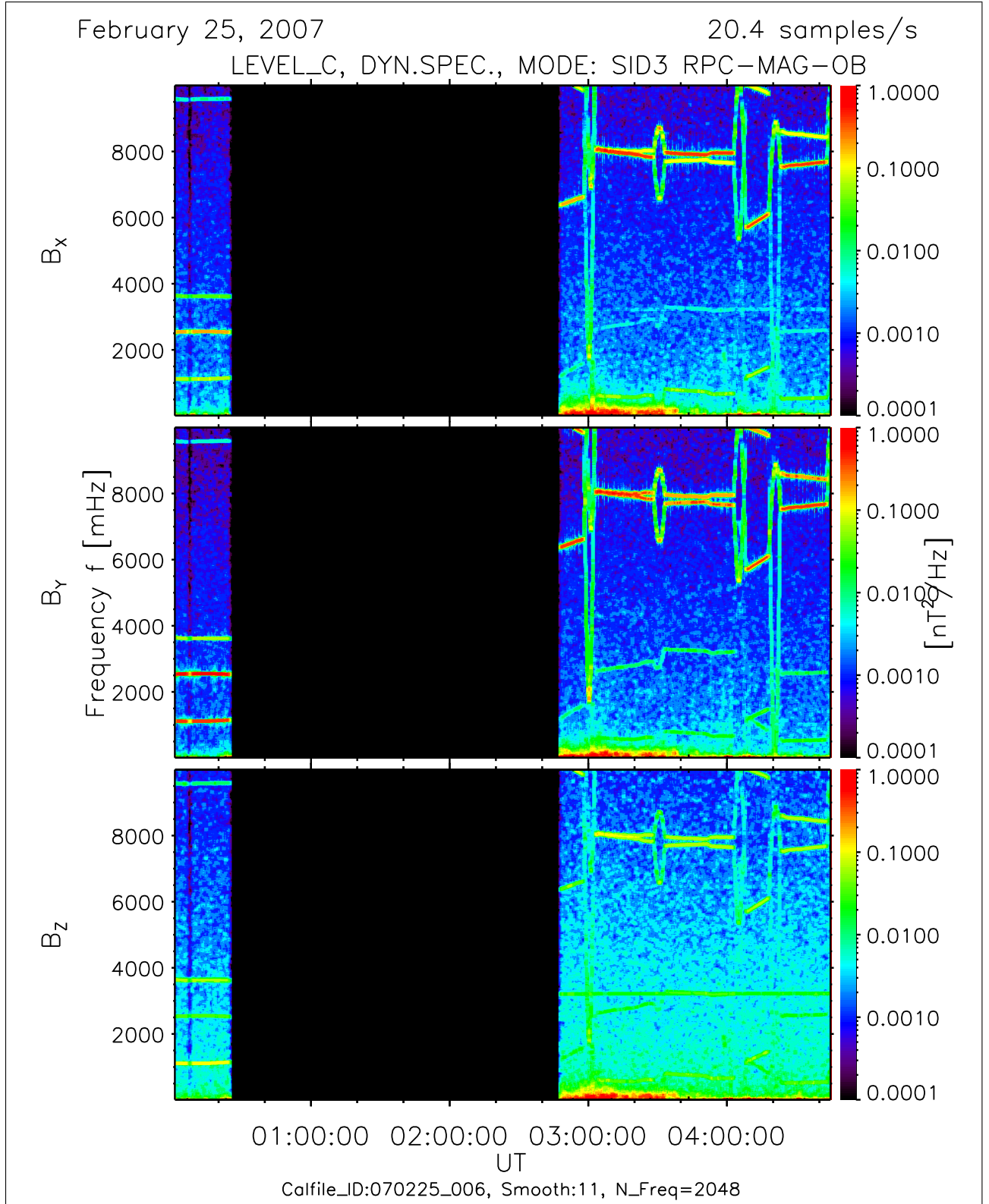


Figure 56: File: RPCMAG070225T0000\_CLC\_OB\_M3\_DS0\_10000\_006



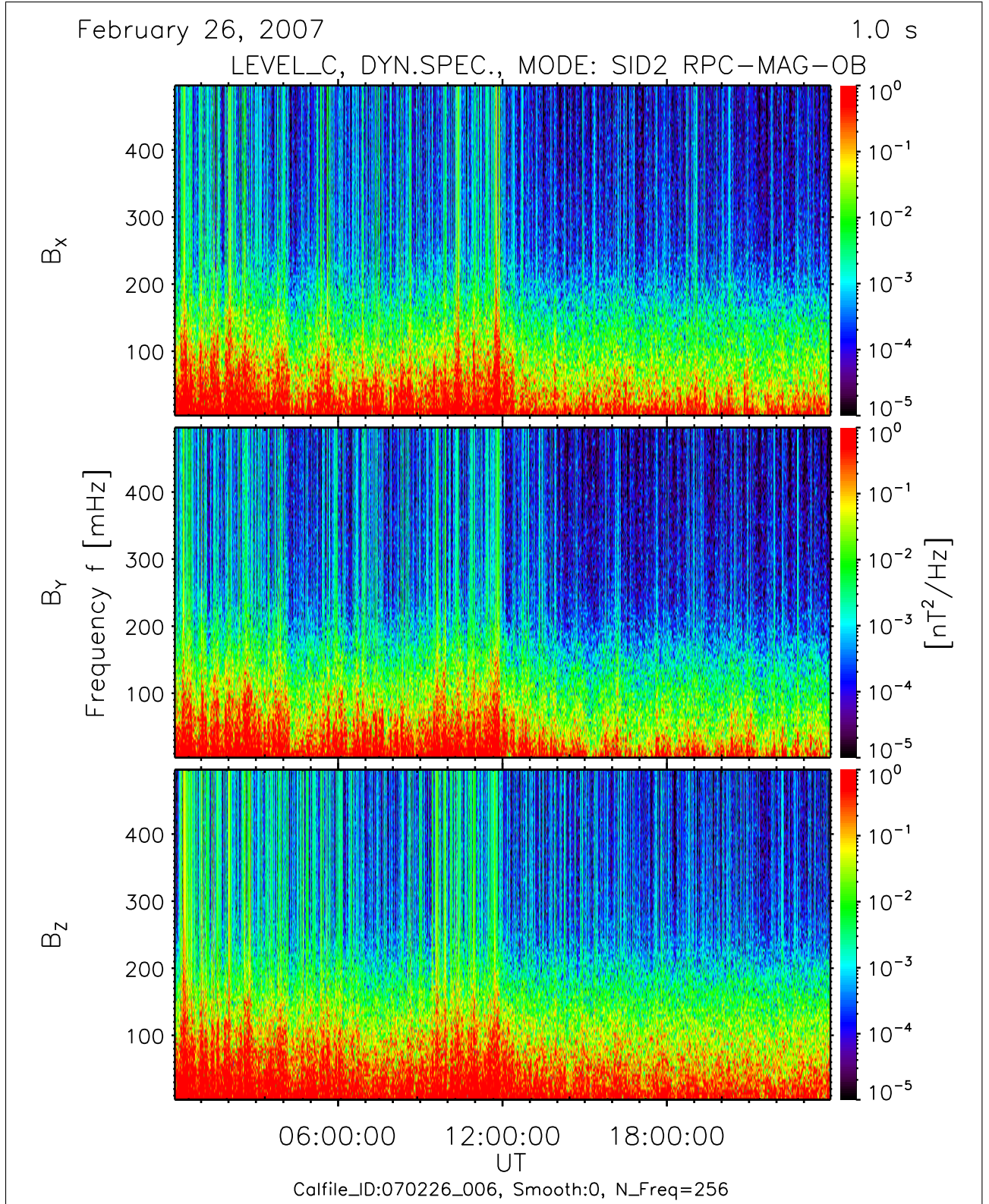


Figure 57: File: RPCMAG070226T0000\_CLC\_OB\_M2\_DS0\_500\_006



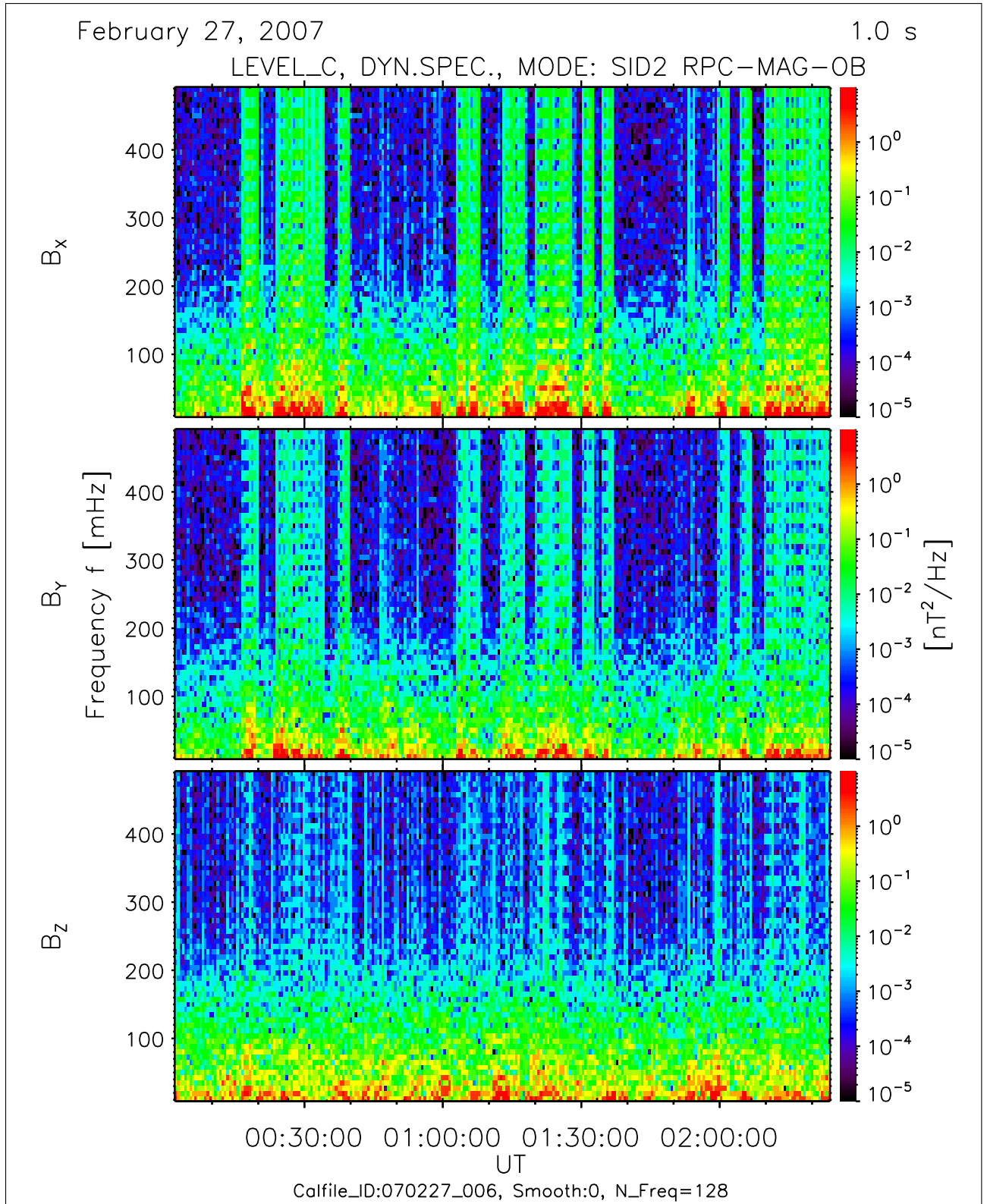


Figure 58: File: RPCMAG070227T0000\_CLC\_OB\_M2\_DS0\_500\_006

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## 7.1 Plots of Reaction Wheel and LAP Disturbance corrected Data

The following plots show the dynamic spectra of the LEVEL\_H data. These data have been purged from ROSETTAs reaction wheel disturbance and also from the disturbance of the LAP instrument. Plots are only shown for the primary sensor.

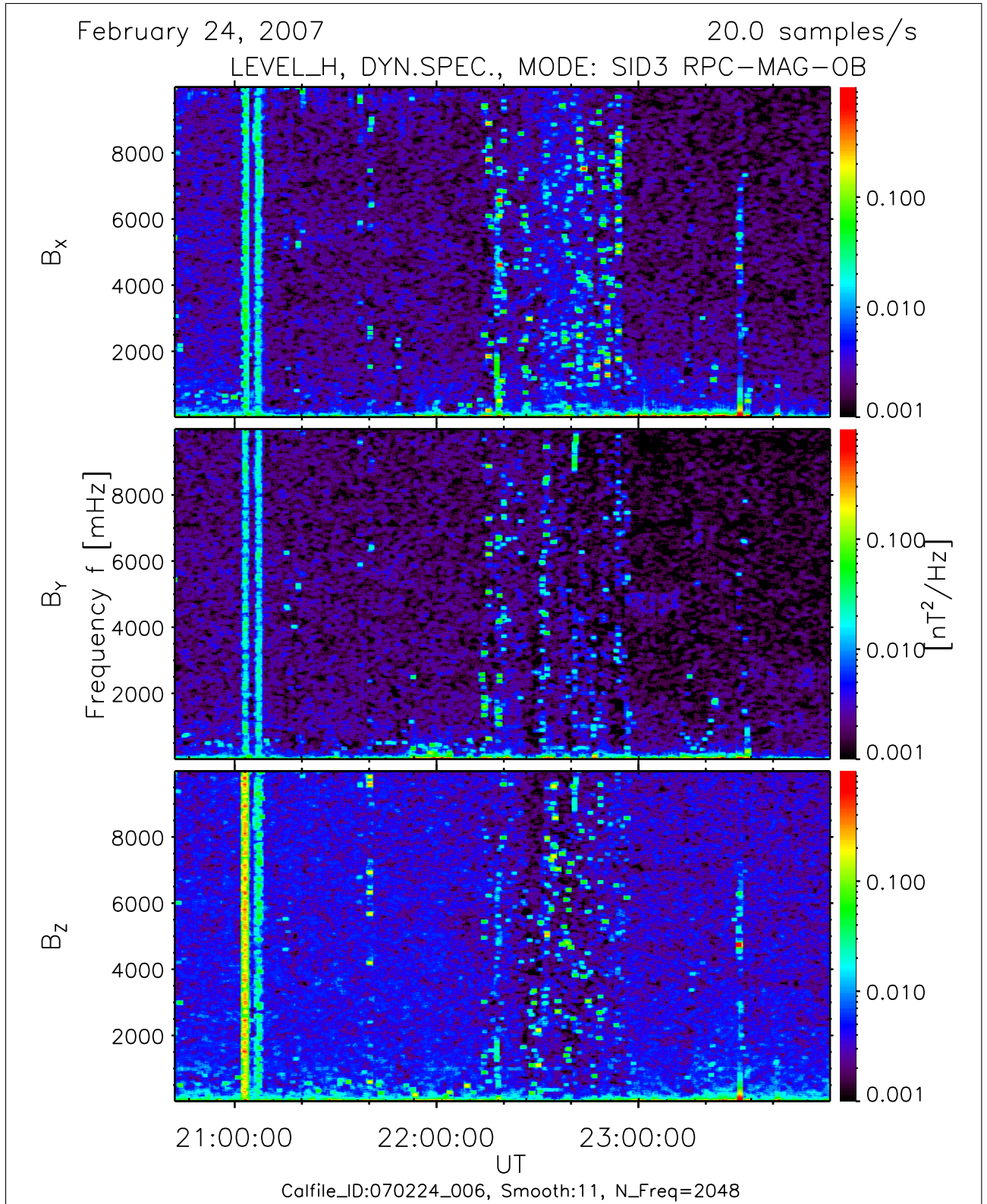


Figure 59: File: RPCMAG070224T2041\_CLH\_OB\_M3\_DS0\_10000\_006

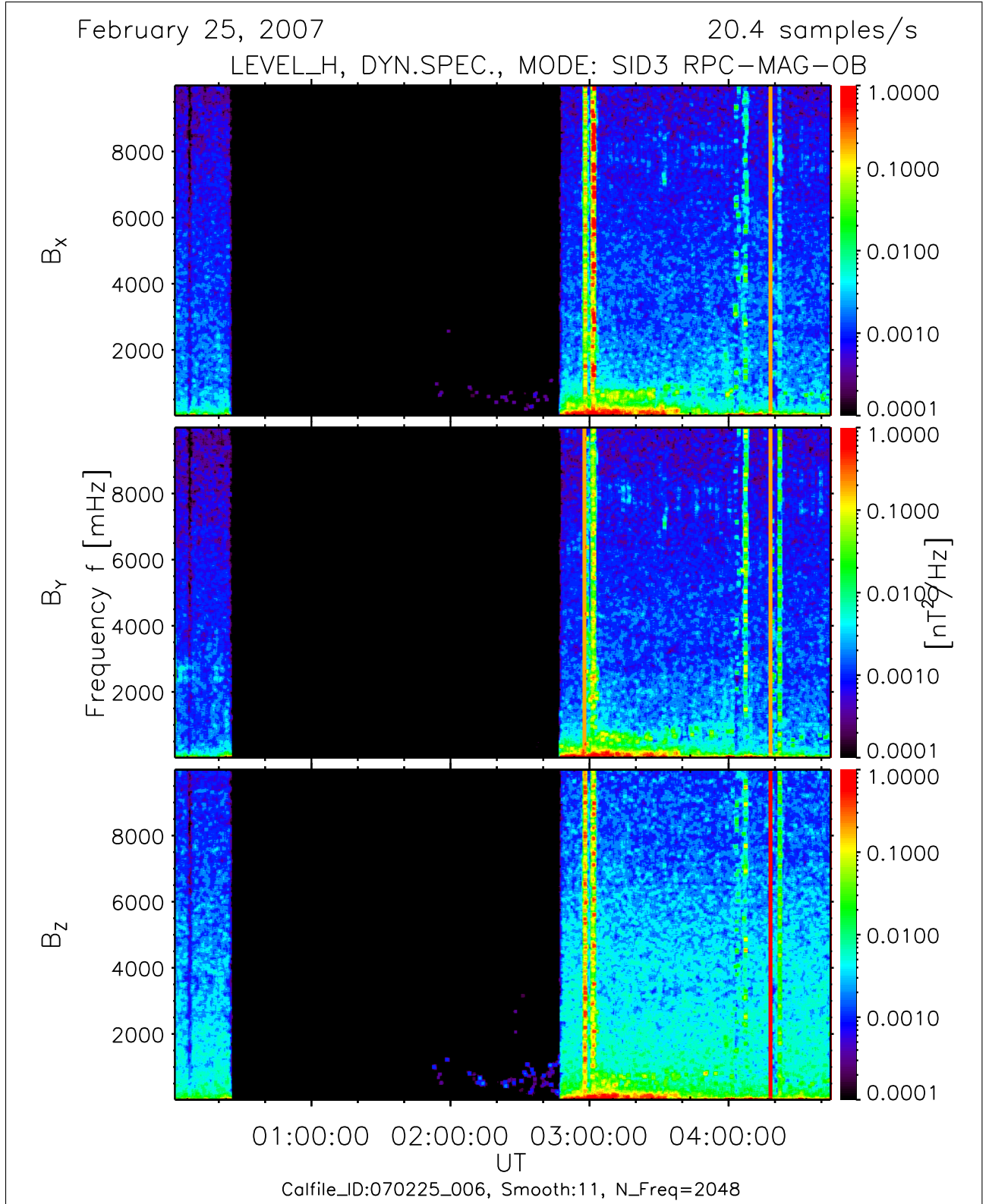


Figure 60: File: RPCMAG070225T0000\_CLH\_OB\_M3\_DS0\_10000\_006

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## 8 Complete Magnetic Field data Plots in ECLIPJ2000 & MSO Frames

The following plots show the the averaged data of the OB and IB Sensors for the complete Swing-by campaign. The first two plots show the data in the usual ECLIPJ2000 frame. The latter two are dynamically rotated to the MSO frame - the Mars centered Solar Orbital coordinates. The MSO coordinates are defined as follows:

- $X_{\text{MSO}}$ : Pointing from MARS to SUN
- $Y_{\text{MSO}}$ : Pointing from MARS in the opposite direction of the planetary motion
- $Z_{\text{MSO}}$ : Completes the system to be right handed

*RPCMAG-OB, Feb.23-27, 2007, MARS SWING BY, ECLIPJ2000*

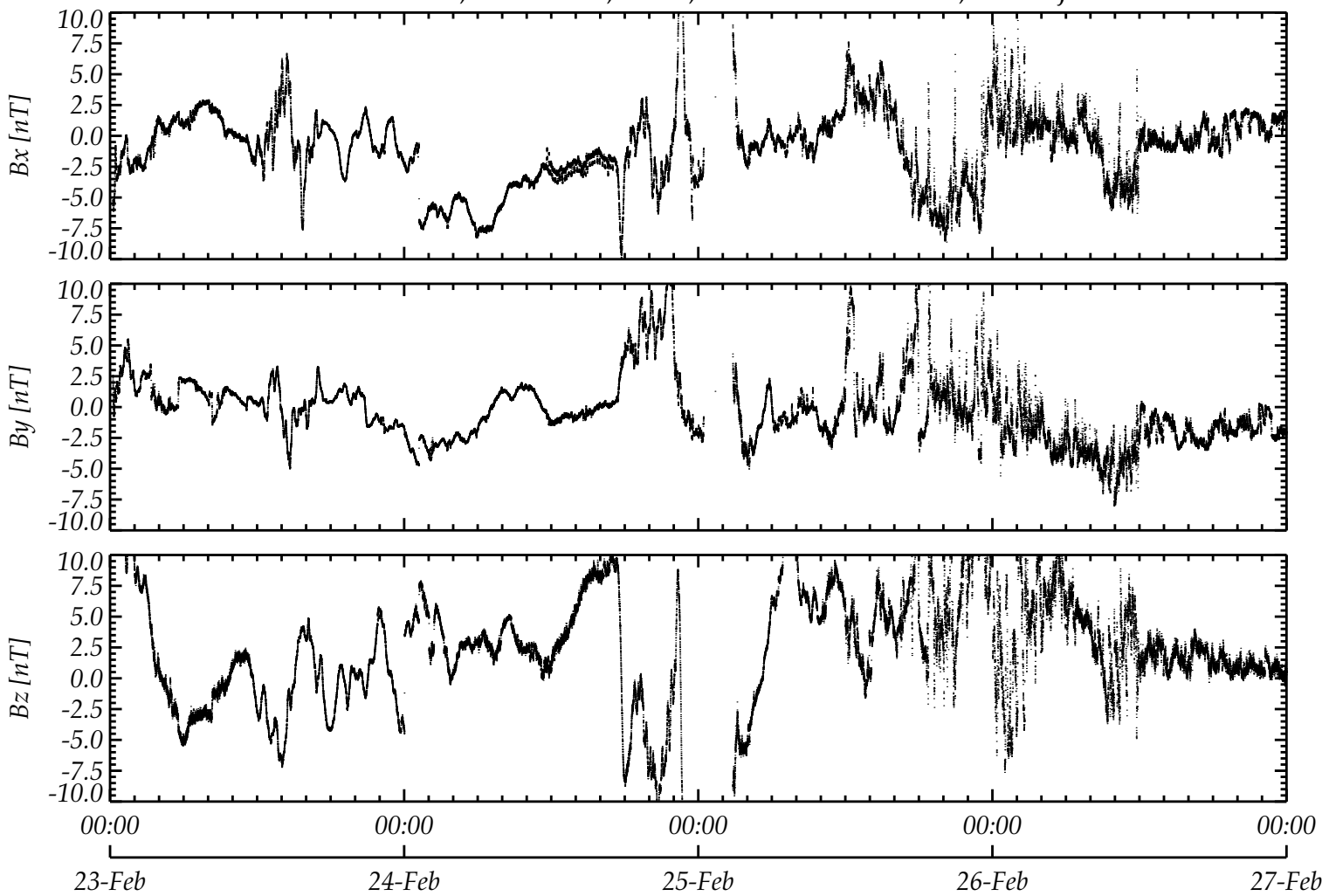


Figure 61: OB Data for the complete Swing by Period, ECLIPJ2000 Frame

*RPCMAG-IB, Feb.23-27, 2007, MARS SWING BY, ECLIPJ2000*

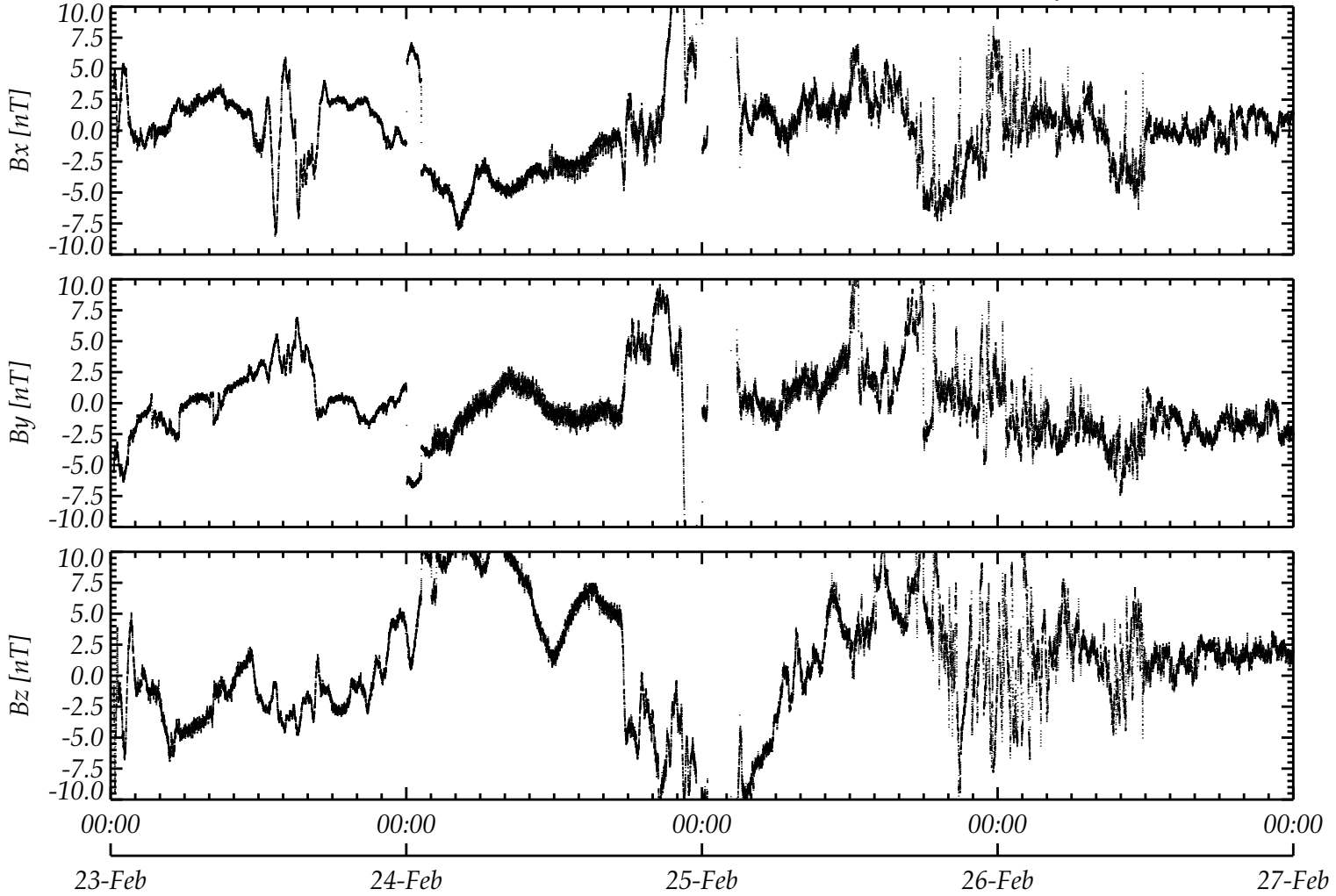


Figure 62: IB Data for the complete Swing by Period, ECLIPJ2000 Frame

*RPCMAG-OB, Feb.23-27, 2007, MARS SWING BY, MSO*

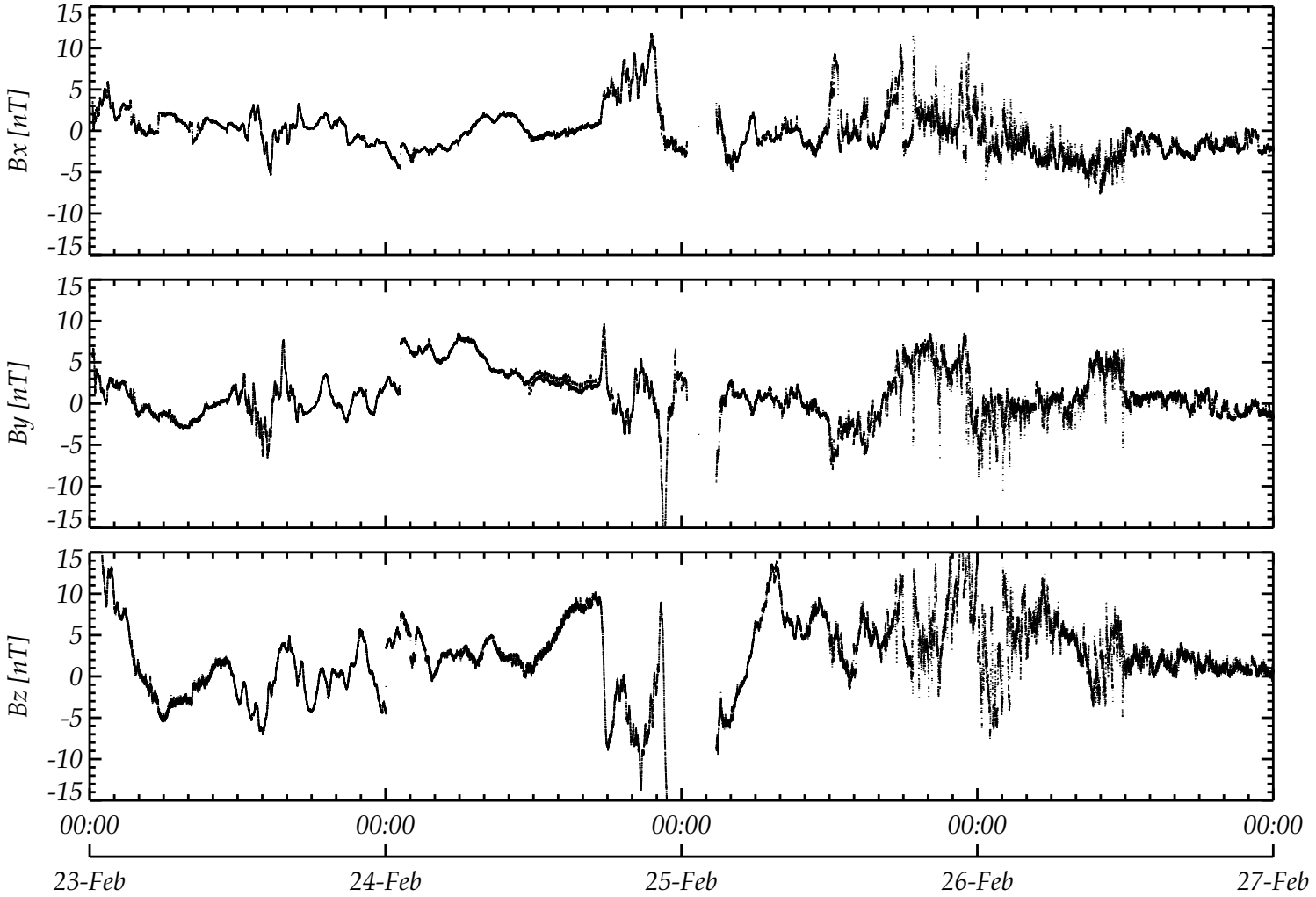


Figure 63: OB Data for the complete Swing by Period, MSO Frame



## RPCMAG-IB, Feb.23-27, 2007, MARS SWING BY, MSO

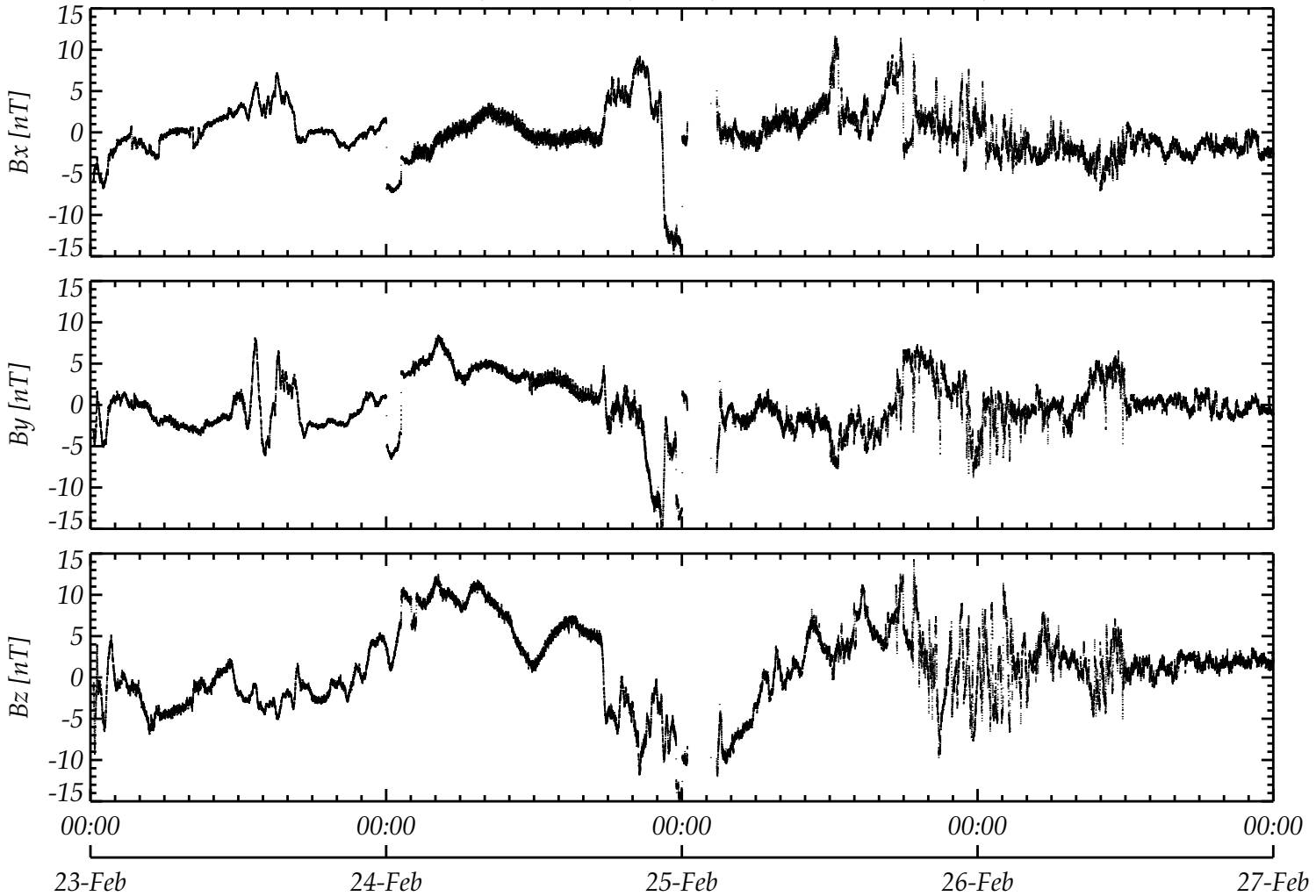


Figure 64: IB Data for the complete Swing by Period, MSO Frame

## 9 Temperature Variations at the OB Sensor during the Swing-By

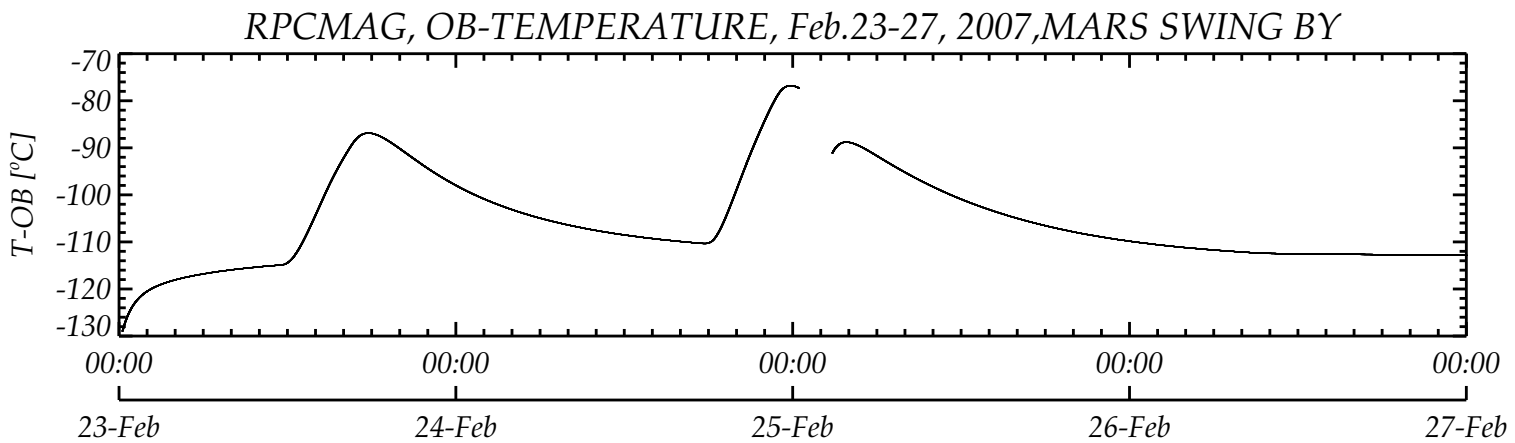


Figure 65: Temperature profile for the complete Swing by Period

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## 10 Conclusions

- RPCMAG has performed amazing measurements during the MARS Swing-by (MSB).
- Every operation has been performed successfully.
- The scientific analysis of the data is ongoing. The lack of data during CA is painful. All the other data can be used for interesting scientific research, especially in combination with the other RPC data and also comparison with MEX data.
- The spectra do not show any impact of ROSETTAs reaction wheels whilst RPCMAG operates in NORMAL mode SID2.
- The spectra show a significant disturbance of ROSETTAs reaction wheels whilst RPCMAG operates in BURST mode SID3. This is a known fact since the CVP Phase.
- The comparison between IB and OB data showed that the measurements are very sensitive to specific temperature changes at the single sensors. The behavior can be used to build a data quality indicator. A new inflight calibration model concerning the sensor temperature influence has been developed and can be successfully applied.
- A constant Swing-by attitude would have been better in terms of sensor temperature variations, but of course we are aware of the circumstances which made the attitude changes necessary.