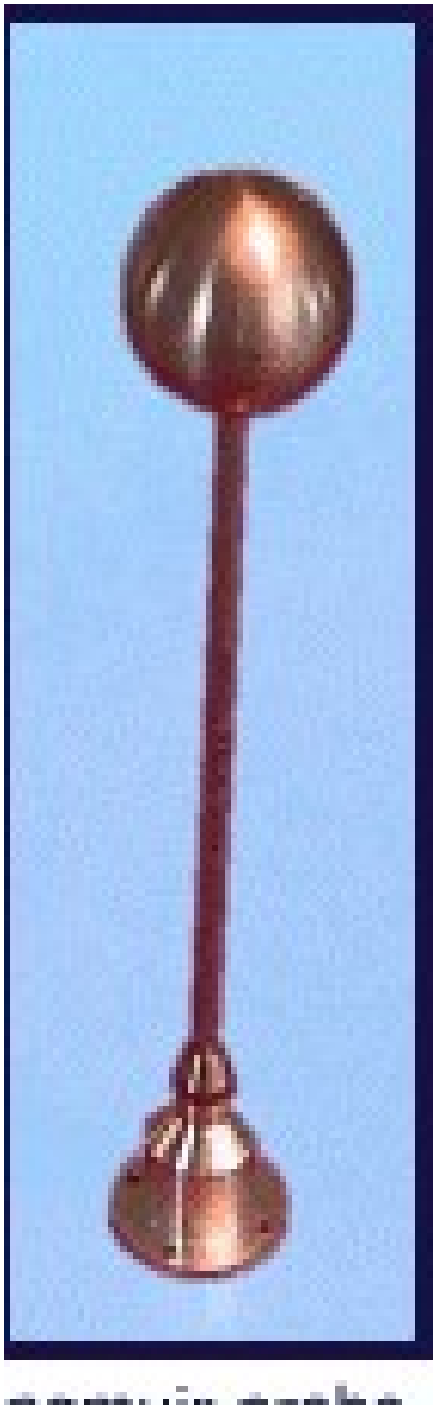
ROSETTA PLASMA CONSORTIUM
LANGMUIR PROBE

Probe Radius:	25 mm
Bias Voltage Range:	±31 V
Bias Current Range:	±44 nA
Current Measurement Range:	±0.2 mA (low gain) ±0.01 mA (high gain)
Voltage Measurement Range:	±40 V
Analog Anti-Aliasing Filters:	20 Hz, 4 kHz, 8 kHz
Digital Filters:	Flexible, in Flight Software
Number of spherical Probes:	2
Probe Surface Coating:	Titanium Nitride
ADCs for Each Probe:	16 bit at 18.75 kHz (high rate) 20 bit at 57.8 Hz (low rate)
Boom Length:	2.24 m for Probe 1 1.62 m for Probe 2

Each probe can individually operate in bias voltage or bias current mode

Internal offset determination and calibration by possibility to sweep over open probe or internal resistor

One of the probes can be used by RPC-MIP in its long Debye length mode



RPC LAP
Data Set Evaluation Tools

Evaluation -
- Machine: IBM Ienovo T60p ThinkPad
- Operating System: fedora 27 linux

Staging -
- Machine: Dell Precision T3400
- Operating System: fedora 27 linux

Data Processing -
- Machine: Sun Ultra-350
- Operating System: Sun Solaris OS 5.9

RPC LAP Data Sets

ro-c-rpclap-5-ext1-deriv2-v1.0

Document Evaluation

ro-c-rpclap-5-ext1-deriv2-v1.0/document ro-irfu-lap-ug.pdf

RID: RPCLAP-US-RF-001

Can not identify the probes in this figure

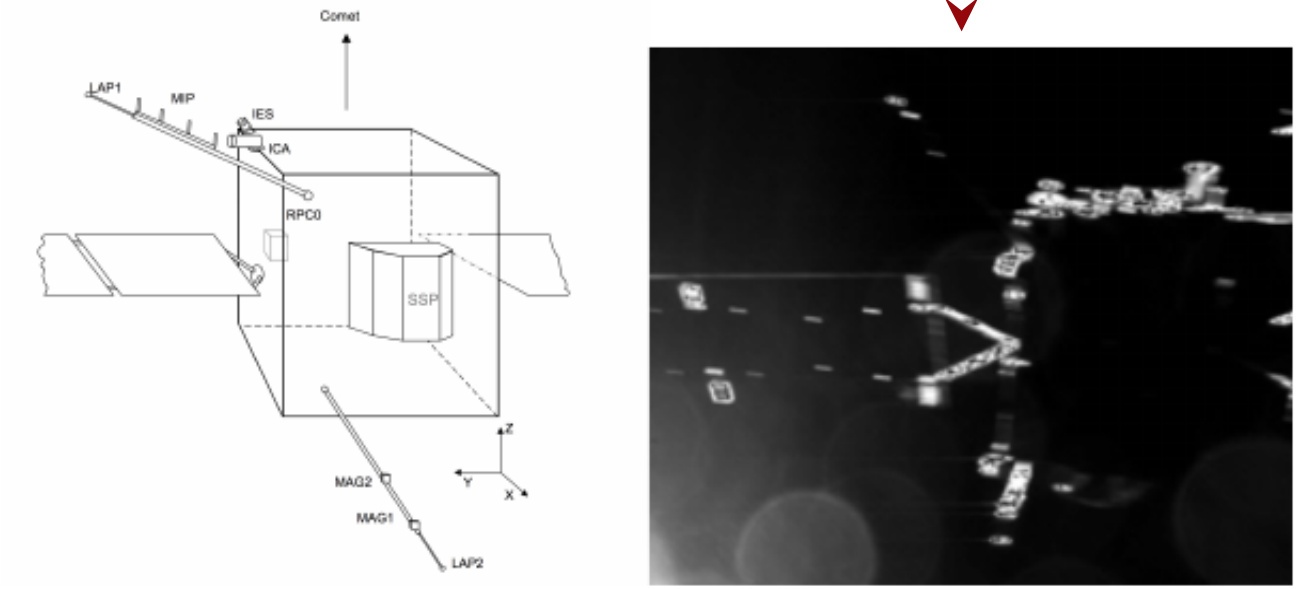


Figure 1. Left: Mounting of the LAP sensors on Rosetta at the tips of the two solid booms, as well as other RPC sensors and units. Right: Both LAP probes are visible in this image by ROLIS on Philae shortly after its separation from Rosetta, from a similar angle.

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.lbl

RID: RPCLAP-US-RF-002

None Included

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 1 of 6

RID: RPCLAP-US-RF-003

If this report is to be archived, then it must be improved. There are places in this presentation which include references to people by first names, and the meaning is lost. There are references to papers which are non-standard and can not easily be identified. There are notes which are most likely now resolved and should be removed or updated, It could benefit from improving some of the figures and some of the axes are missing labels. An unknown math symbol is included which should be defined. Included on the following slides are some examples.

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 2 of 6

RID: RPCLAP-US-RF-003

Extracted from slide 5:

Correction for cold plasma greatly improves statistics. This is not planned to implement in the archive, but should be described in the LAP User Guide (not there now).

Remove Extra Note!!

Extracted from slide 10:

show below that the two methods agree very well. We can therefore create a consistent data product U_SC by combining the two datasets, giving very high (95%? We should check) coverage of the mission.

Fix Note

Not proper citation format

Odelstad+ GRL 2015 and Odelstad+ MNRAS 2017 compared LAP Vsc estimates to ICA data, finding LAP typically picks up a fraction 0.7-1 of the true Vsc.

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 3 of 6

Extracted from slide 10:

Who is Fredrik and Sofia?

Recent LAP-ICA xcal by Fredrik and Sofia shows we can extend the LAP range of Vsc values by extrapolating the ion current in sweeps where Vz is out of the LAP bias range. This method is now used for U_SC, extending the LAP range not only of

Extracted from slide 21:

study

This and following two slides:
LAP-ICA Xcal tudy by Elias Odelstad, published in Odelstad+ MNRAS 2017

Who is Anders?

Not proper citation format

Extracted from slide 29:

The following slide is a study by Anders from autumn 2018, using V_PH_KNEE for Vsc and cross calibrating to MIP over 14 day intervals. Should be updated with

RID: RPCLAP-US-RF-003

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 4 of 6

Extracted from slide 31:

- Top left: Vsc versus lg(n_{MIP})
- Mid plot: Ratio of Vsc density fit to MIP data
  - Bi-weekly mean and standard deviation shown (both based on log10 values)
  - Also the standard deviation of lg(n_{MIP}) (magenta)

What is the function lg()?

Extracted from slide 33:

- 80% of the data falls within ~0.3 = lg(2) from 0
- 98% of the data falls within ~0.6 = lg(4) from 0

Extracted from slide 34:

- Model fits: Vs = p1 lg n + p2

Extracted from slide 37:

2. NPL.TAB from IxL still not completed

Update Note

RID: RPCLAP-US-RF-003

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 5 of 8

Extracted from slide 39:

RID: RPCLAP-US-RF-003

The ne0 parameter should depend on photoemission, and indeed peaks at perihelion (c.f. Johansson+ MNRAS 2017).

Not proper citation format

Extracted from slide 44:

Engelhardt+ A&A 2018 found that dI/dV = 70 nA/V well separates sweeps with and without cold e-.

MIP can detect cold e- by a fully independent method (Gilet+, Rad. Sci. 2017). It turns out (N. Gilet, work in preparation) MIP does so essentially always when LAP

Slide 42: What is the vertical axis?

Extracted from slide 48:

Compared to radial ion flow speed derived from neutral gas and plasma density by Odelstad+ JGR 2018. Found to be within a factor 1.5 from each other.

Not proper citation format

ro-c-rpclap-5-ext1-deriv2-v1.0/document LAP_Xcal_Report_Outline.pdf – 6 of 6

Extracted from slide 51:

Who is Kevin?

Combining COPS and MIP (& TIMED/SEE via Kevin)

Extracted from slide 53:

- Three methods for finding the photoelectron emission saturation current Iph was studied by Johansson+ MNRAS 2017 and found to give similar results:

Not proper citation format

RID: RPCLAP-US-RF-003

ro-c-rpclap-5-ext1-deriv2-v1.0/document RO-IRFU-LAP-EAICD.PDF – 1 of 5

RID: RPCLAP-US-RF-004

Section 2.6.7, page 44:

$$\frac{dI}{dV_{ps}} = A_p e^2 n_e \sqrt{\frac{1}{2\pi k_B T_e m_e}},$$

where A_p is the surface area of the probe, n_e is the electron number density, T_e is the electron temperature and other constants have their usual meaning.

Please define all terms. The value of e can mean the natural number 2.71828, the charge on an electron 1.602e-19 C. or in the case of this documrnt, elsewhere within the documen text, the probe number. The value of q has also been defined elsewhere in this document to mean charge on an ion. Rather than go through this document and make the notation consistent, just define all of the symbols in this equation.

ro-c-rpclap-5-ext1-deriv2-v1.0/document RO-IRFU-LAP-EAICD.PDF – 2 of 5

RID: RPCLAP-US-RF-005

Section 3.5, page 66:

In TSO:

- X_TSO points towards the sun.
- Z_TSO is along the normal of the target (67P, Mars, Earth) orbit around the sun (the angular momentum vector).
- Y_TSO completes the right hand triad (X,Y,Z).

In TSEQ:

- X_TSEQ points towards the sun (identical to X_TSEQ).

I believe that you mean TSO here

ro-c-rpclap-5-ext1-deriv2-v1.0/document RO-IRFU-LAP-EAICD.PDF 3 of 5

RID: RPCLAP-US-RF-006

Section 4.4.3.5 Document Directory, page 85:

The following files (not described in the table) were found in the Document Directory. No statements were included that this was not the Directory listing for the current data set:
LAP_Xcal_Report_Outline.pdf
ro-irfu-lapmac-160804_ext1.lbl
ro-irfu-lapmac-160804_ext1.pdf
ro-irfu-lap-ug.lbl
ro-irfu-lap-ug.pdf
rpc_user_guide.lbl
rpc_user_guide.pdf

ro-c-rpclap-5-ext1-deriv2-v1.0/document RO-IRFU-LAP-EAICD.PDF – 4 of 5

RID: RPCLAP-US-RF-007

Section 5.3.2.3.5. Plasma Density, page 133:

```
   OBJECT = COLUMN
       NAME         = TIME_UTC
       START_BYTE   = 1
       BYTES        = 23
       DATA_TYPE    = TIME
       UNIT         = "SECOND"
       DESCRIPTION = "UTC time YYYY-MM-DD
HH:MM:SS.FFFFFF."
    END OBJECT = COLUMN
```

This number of bytes can not contain this Time format shown In the Description. Data files reflect the number of bytes and not the Time format

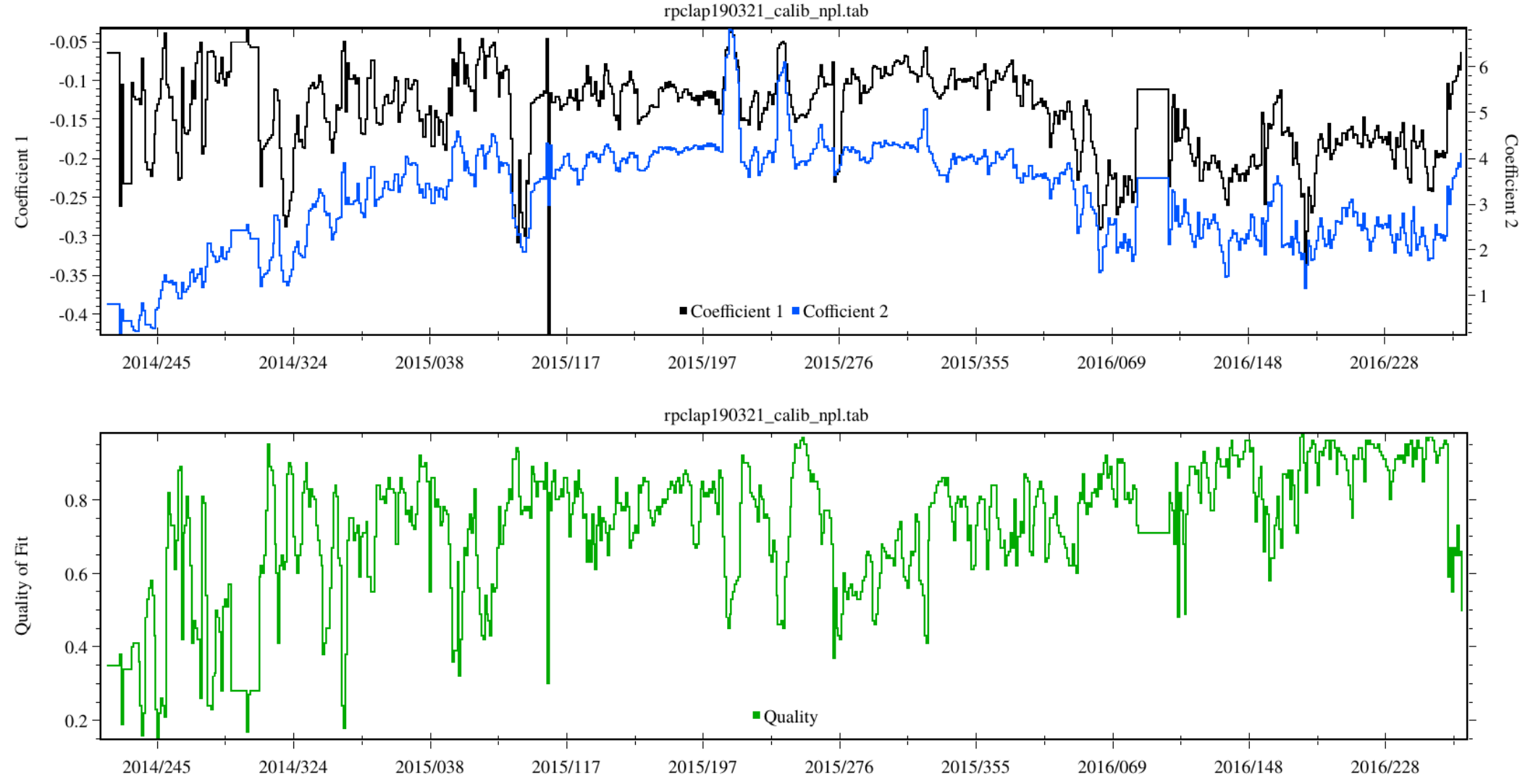
ro-c-rpclap-5-ext1-deriv2-v1.0/document RO-IRFU-LAP-EAICD.PDF – 5 of 5

Some Editorial Comments Submitted

RID: RPCLAP-US-RF-008

ro-c-rpclap-5-ext1-deriv2-v1.0/calib rpclap190321_calib_npl.tab

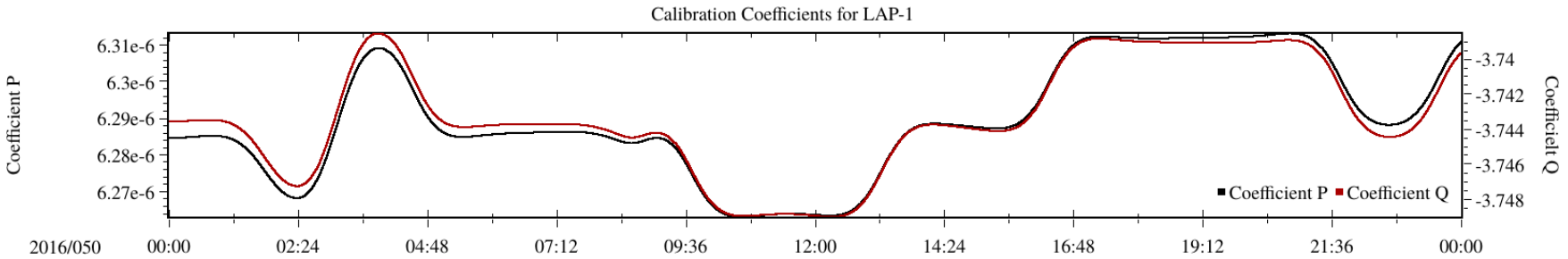
LOOKS GOOD

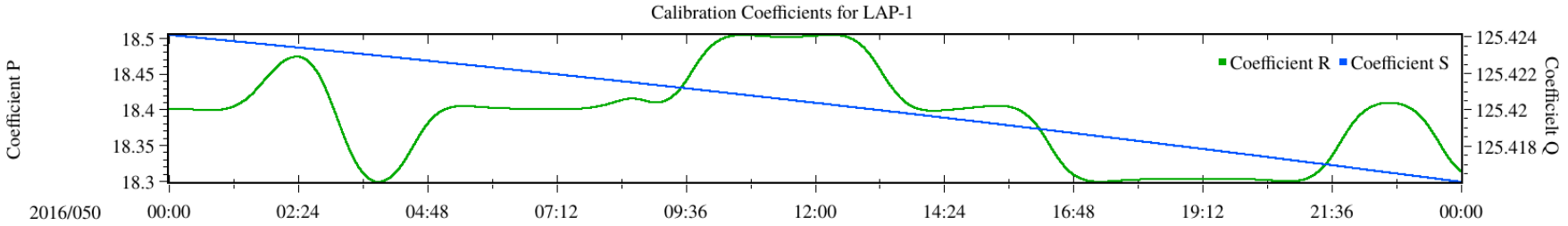


Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Tue Apr 30 11:59:56 2019.

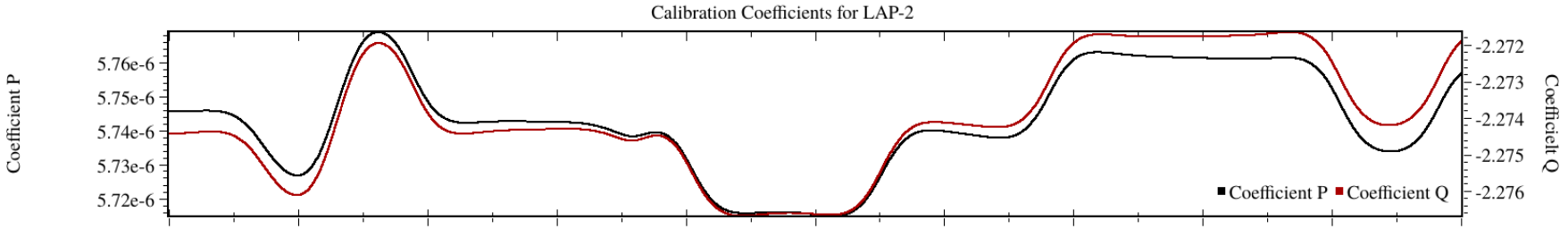
ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap160218_calib_coeff.tab

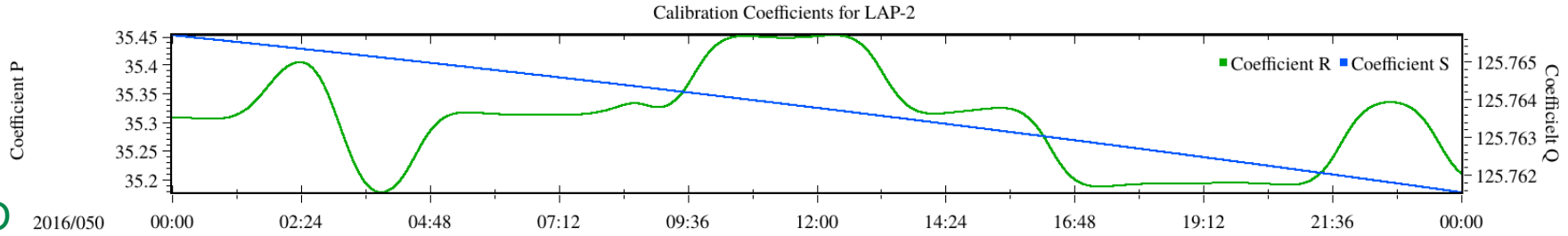
LAP-1





LAP-2



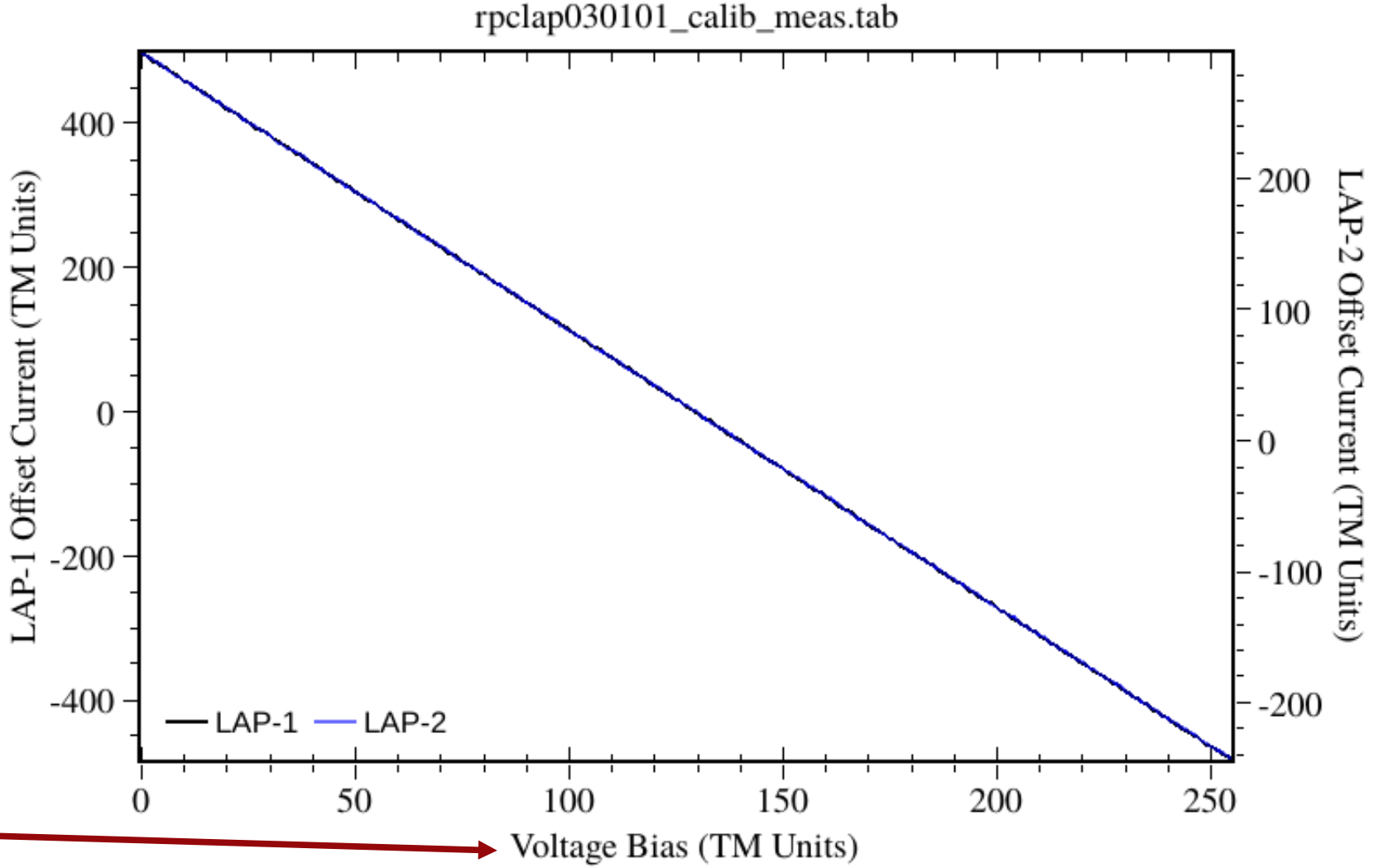


LOOKS GOOD

Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Sun Apr 28 16:19:59 2019.

ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_meas.tab

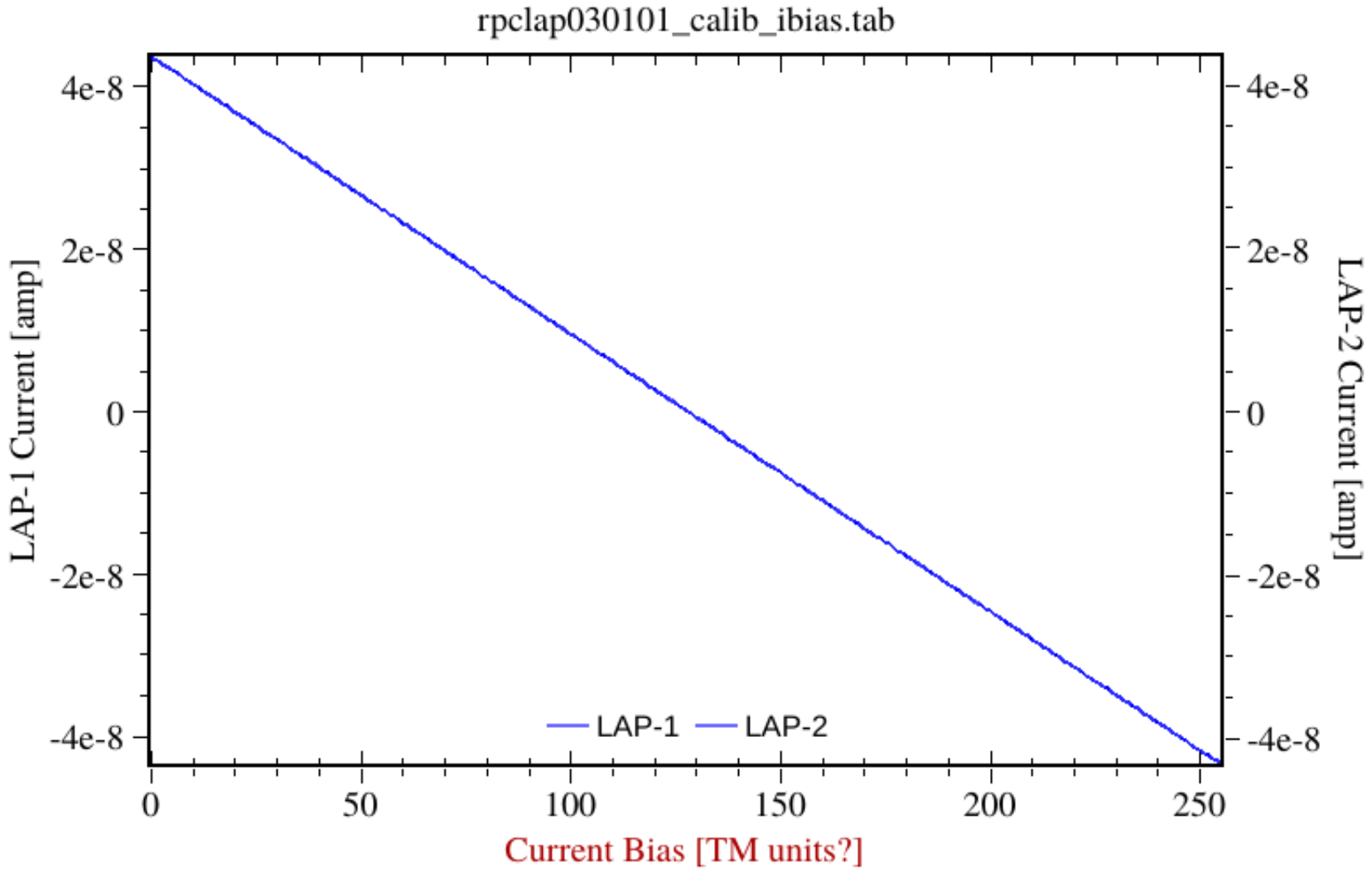
The label file says says the quantity is the voltage bias; however, shouldn't this be the current telemetry value?



This seems like it should be the telemetry value of the current.

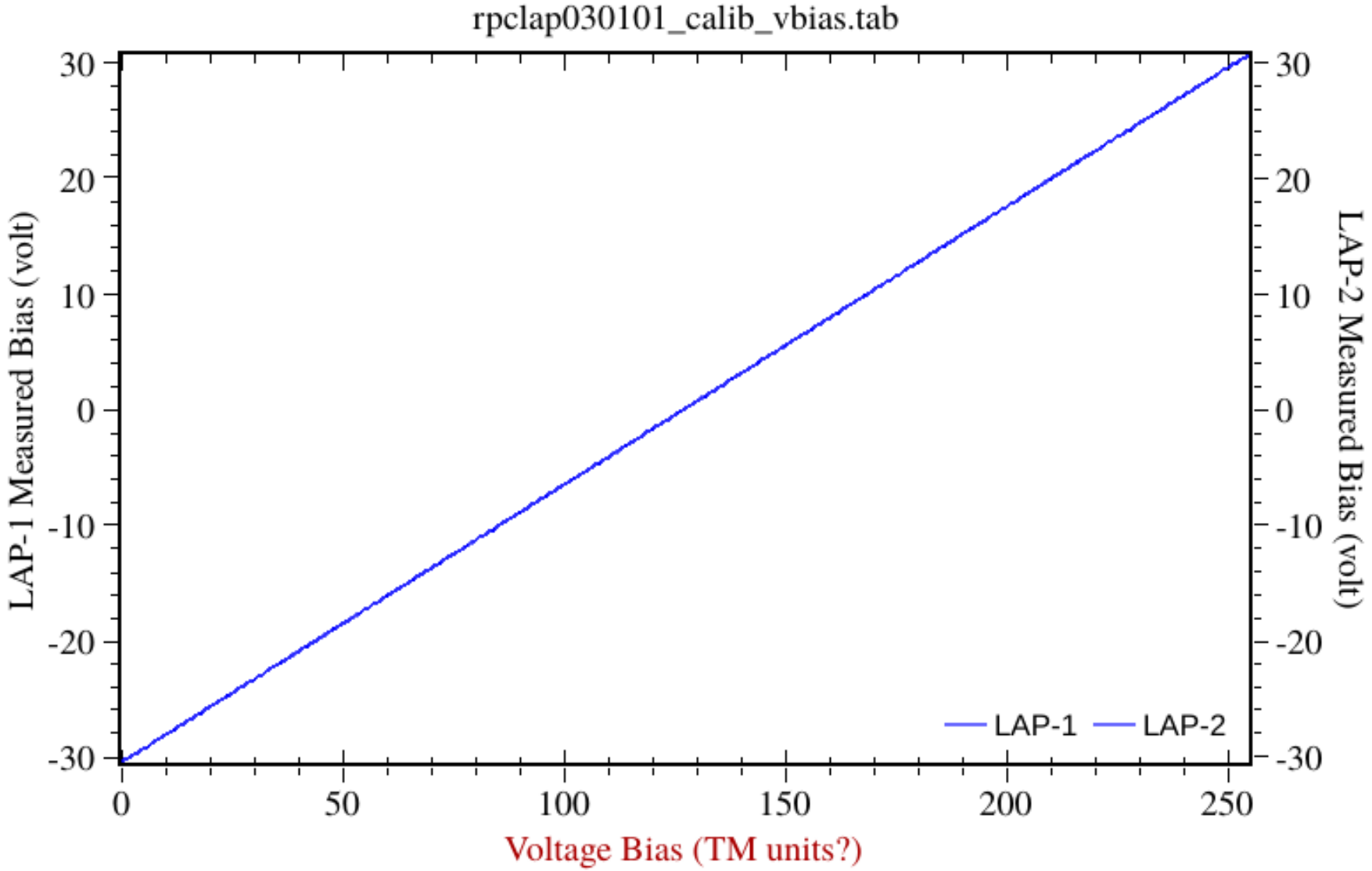
ro-c-rpclap-5-ext1-deriv2-v1.0/calib rpclap030101_calib_ibias.tab

Guessed at Current Bias Units – No comment in the label file



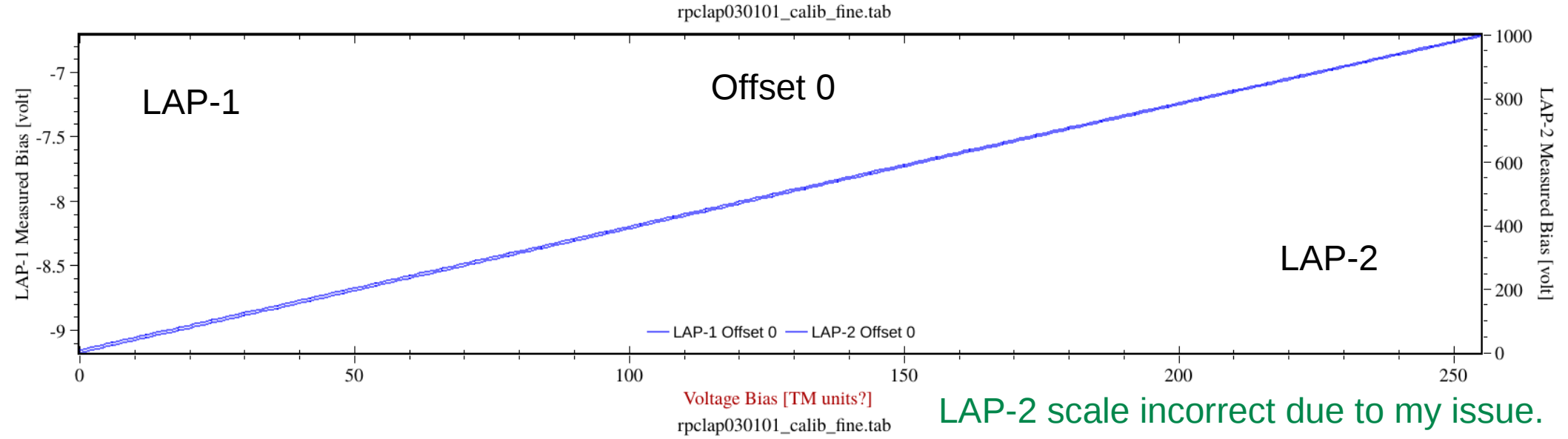
ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_vbias.tab

Guessed at Voltage Bias Units – No comment in the label file

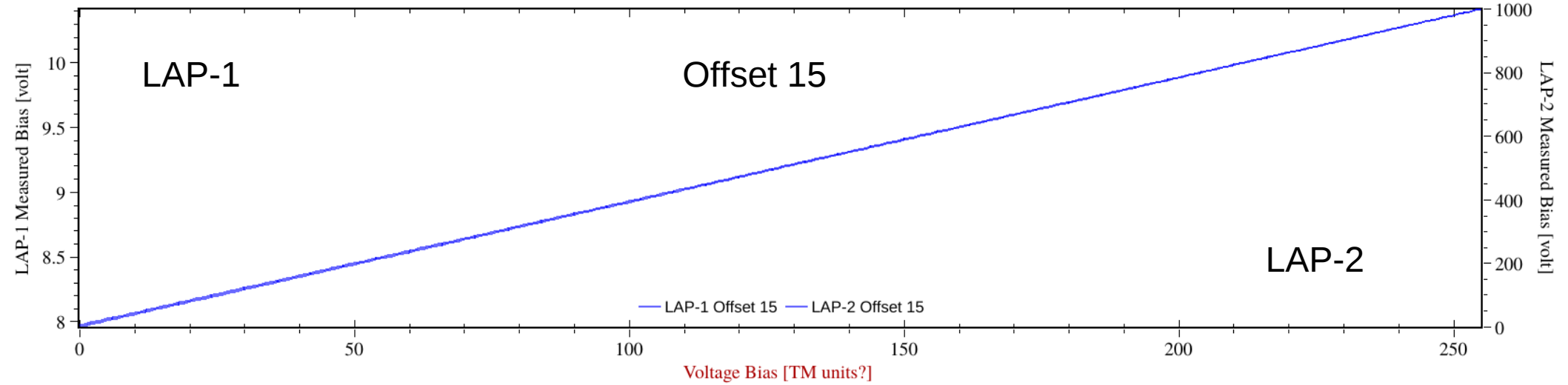


ro-c-rpclap-5-ext1-deriv2-v1.0/calib rpclap030101_calib_fine.tab

Guessed at Voltage Bias Units – No comment in the label file.



LAP-2 scale incorrect due to my issue.



Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Thu May 2 11:53:24 2019.

ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_frq_d_p1.txt
rpclap030101_calib_frq_d_p2.txt

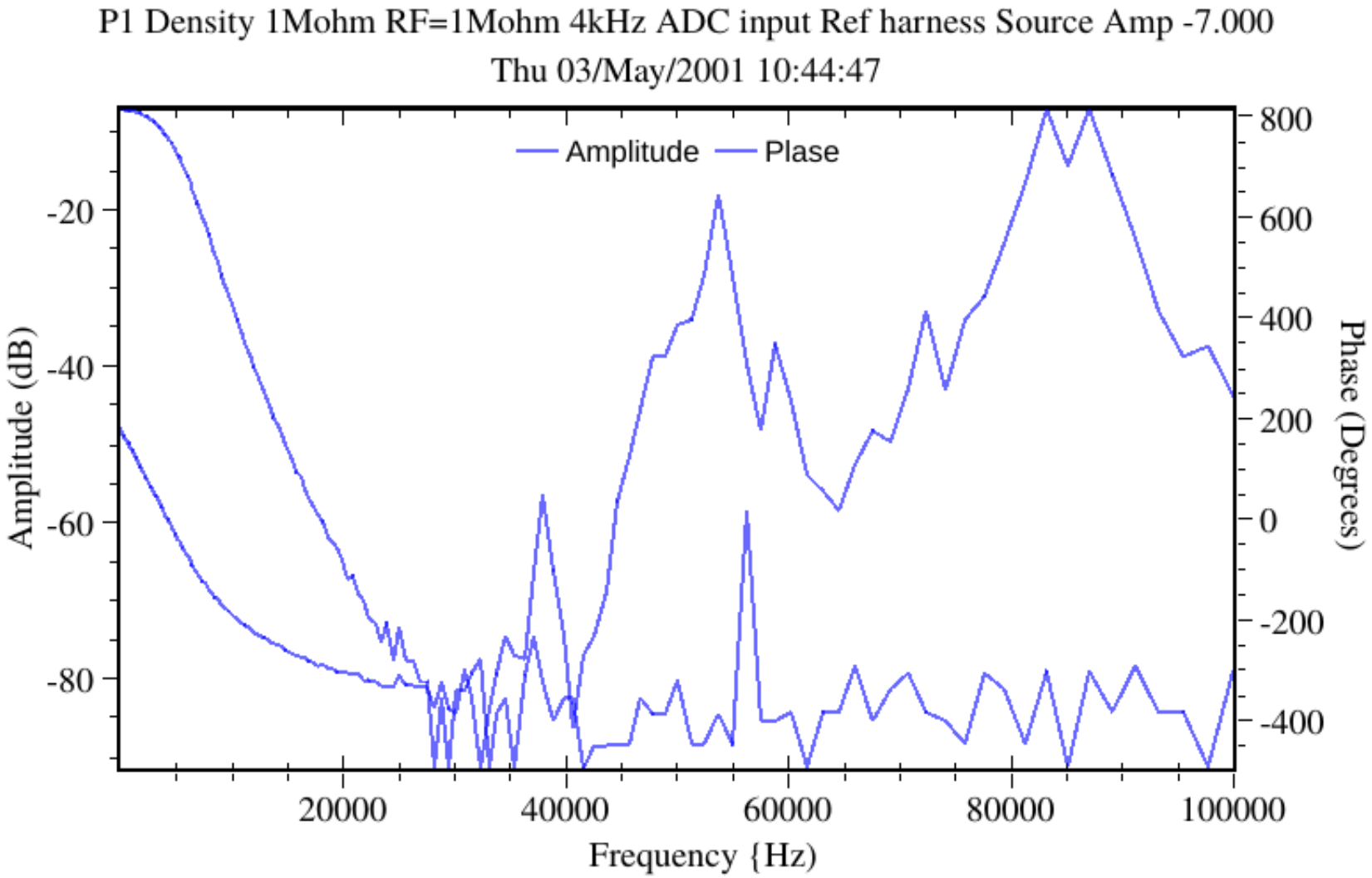
These files appear to contain some unintended content. There is a file name tag on the beginning of every line, which seems unrelated to anything in the file and not described by the label file. This file name tag seems to indicate that a number of poorly-formatted files were concatenated to make this poorly-formatted file.

These files actually a series of tables, separated by three header lines that provide some sort of context. The third line is column headings, which don't appear to align with the columns below. The columns themselves are not quite decimal-aligned or fixed-width.

If none of the calib/ info is relevant to the level 5 data, it could all be omitted and users referred to the lower level data for calibration details (in the CONFIDENCE_LEVEL_NOTE, for example, or the data set description).

ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_frq_d_p1.txt
rpclap030101_calib_frq_d_p2.txt

The phase angle scale is incorrect due to my issue.

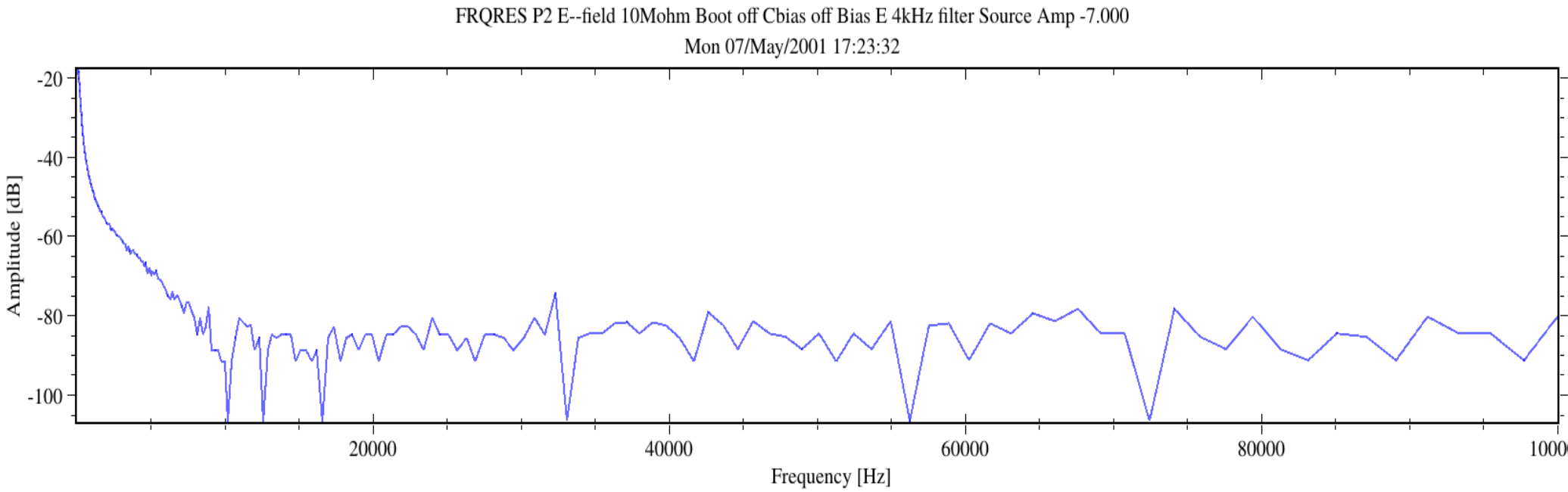


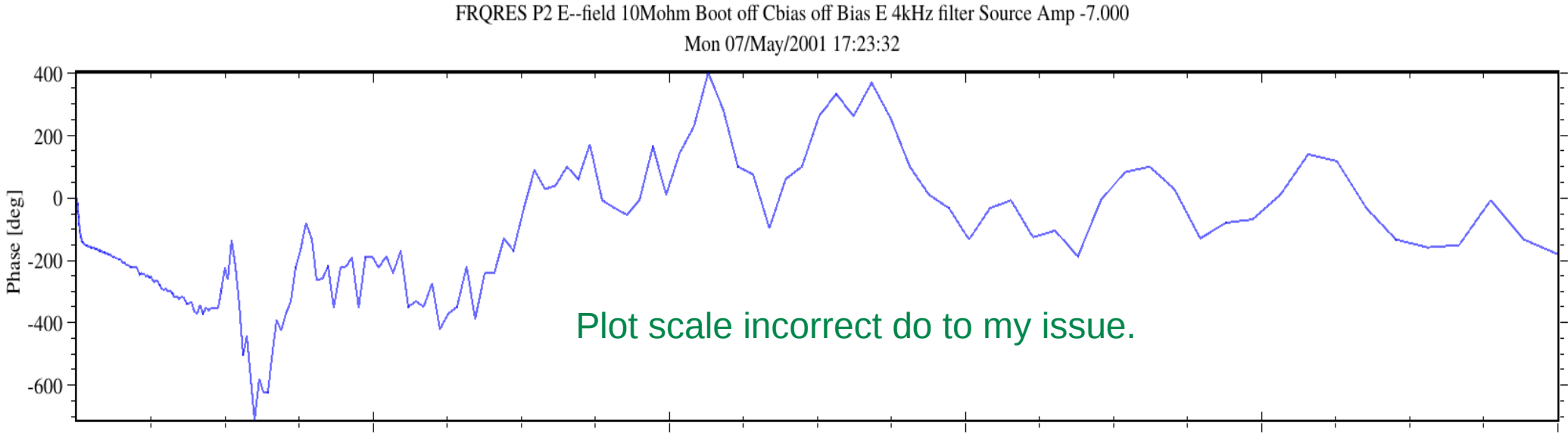
ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_frq_e_p1.txt
rpclap030101_calib_frq_e_p2.txt

These files actually a series of tables, separated by three header lines that provide some sort of context. The third line is column headings, which don't appear to align with the columns below. The columns themselves are not quite decimal-aligned or fixed-width.

If none of the calib/ info is relevant to the level 5 data, it could all be omitted and users referred to the lower level data for calibration details (in the CONFIDENCE_LEVEL_NOTE, for example, or the data set description).

ro-c-rpclap-5-ext1-deriv2-v1.0/calib
rpclap030101_calib_frq_e_p1.txt
rpclap030101_calib_frq_e_p2.txt





Data Evaluation

lap_20160215_000000_914_npl.lbl

RID: RPCLAP-US-RF-009

There is an inconsistency between the number of bytes in the UTC Time object and its description. This example describes timing to the microsec; however, the number of bytes allocated is only enough to hold millisec resolution. A check of the corresponding tab file shows only millisec resolution. This issue appears in only the NPL label files.

```
OBJECT = COLUMN
    NAME        = TIME_UTC
    START_BYTE  = 1
    BYTES       = 23
    DATA_TYPE   = TIME
    UNIT        = "SECOND"
    DESCRIPTION = "UTC time YYYY-MM-DD HH:MM:SS.FFFFFF."
END_OBJECT = COLUMN
```

NPL Data Assumptions

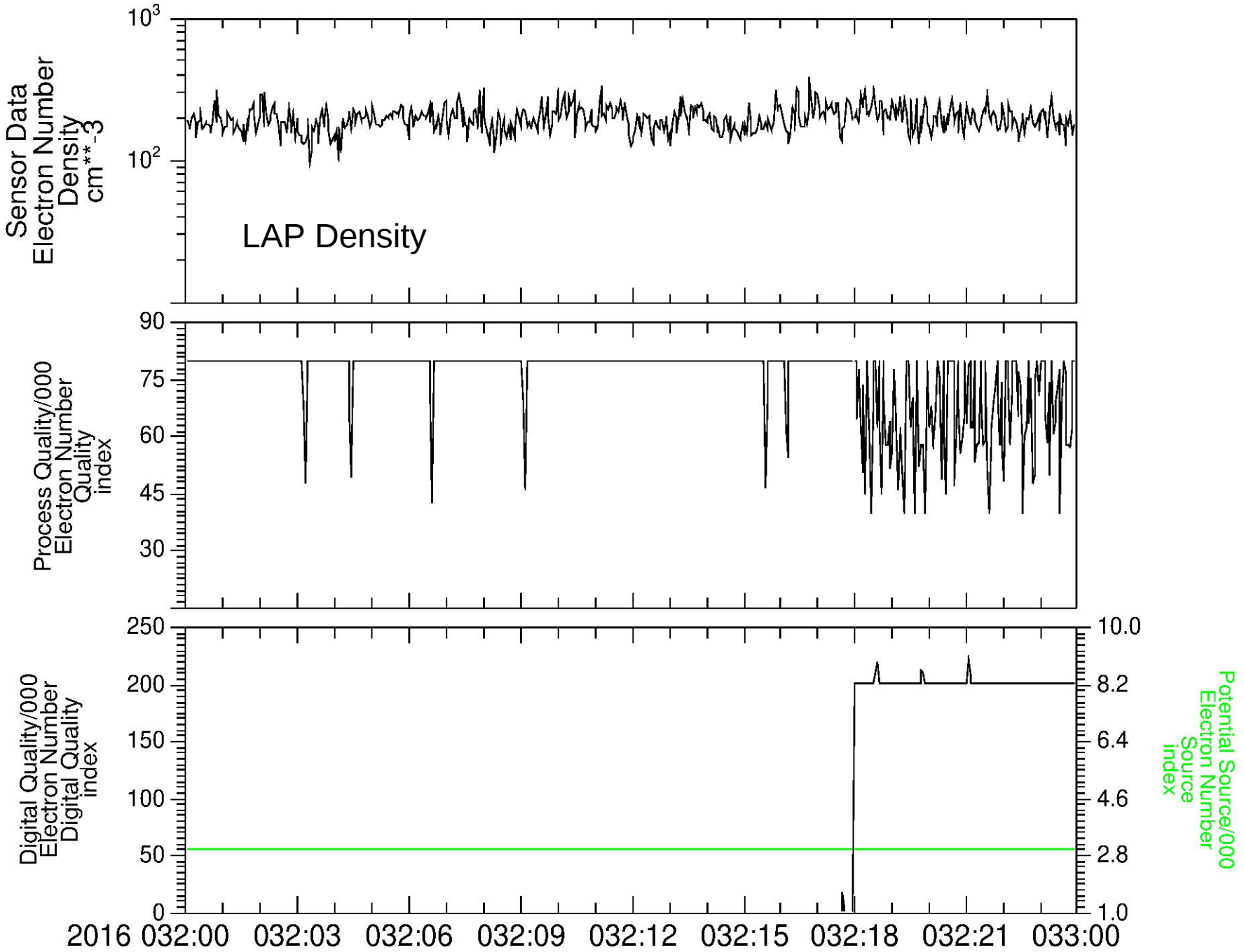
One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time.

RID: RPCLAP-US-RF-010

The accumulation time width is not given. The macro used to determine the NPL data is given in the data file name (ex. lap_20160215_000000_914_npl.tab for macro 0x914). The macro value was used along with the cadence row in the file ro-irfu-lapmac-160804_ext1.pdf file to determine an accumulation time of 160 sec in order to display the data. It is not known if this is correct since no information is given.

RID: RPCLAP-US-RF-011

NPL Data


Sensor Data
Electron Number
Density
cm**-3
10^3
10^2
LAP Density
Process Quality/000
Electron Number
Quality
index
90
75
60
45
30
Digital Quality/000
Electron Number
Digital Quality
index
250
200
150
100
50
0
Potential Source/000
Electron Number
Source
index
10.0
8.2
6.4
4.6
2.8
1.0
2016 032:00
032:03
032:06
032:09
032:12
032:15
032:18
032:21
033:00

ASW Data Assumptions

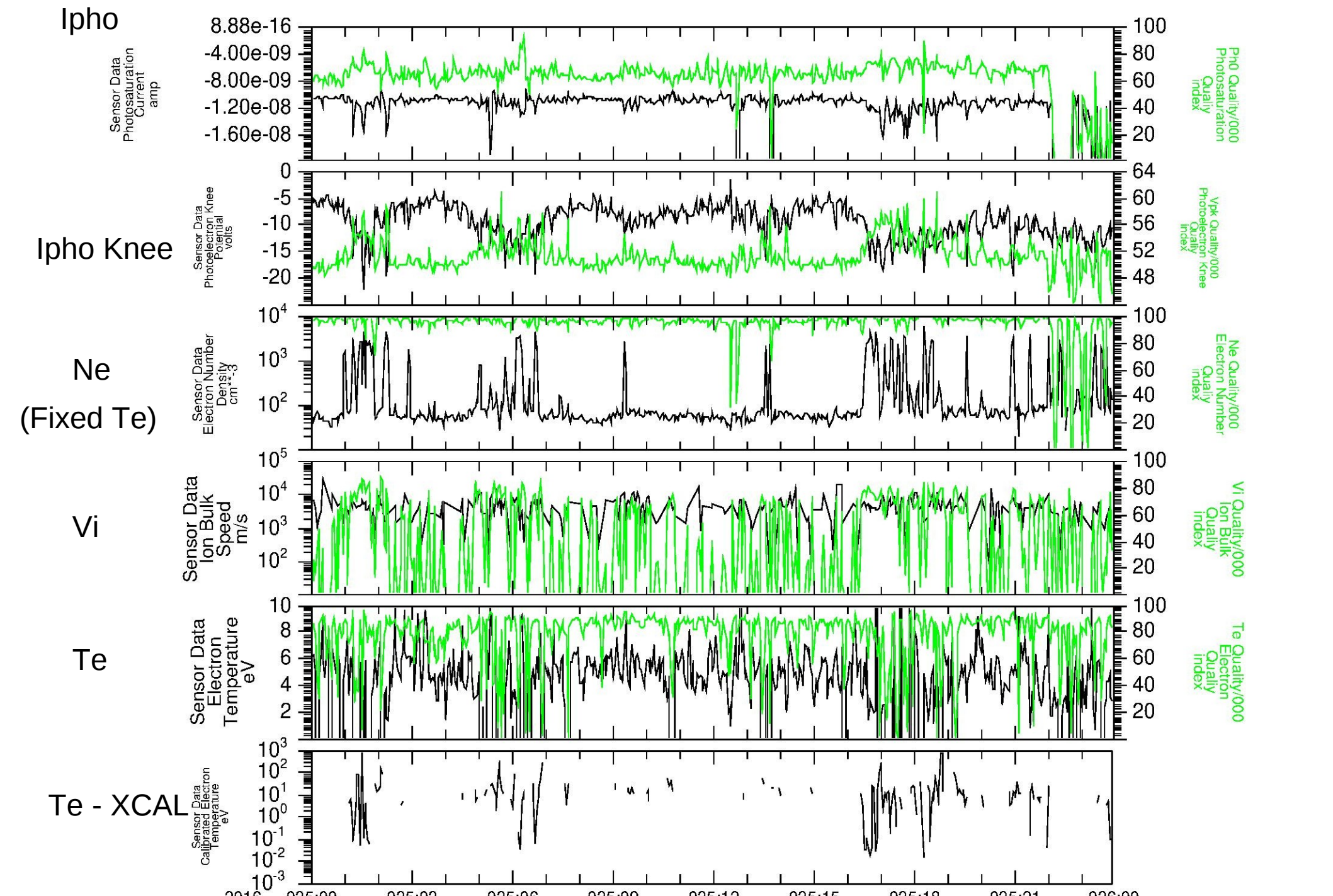
One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time.

RID: RPCLAP-US-RF-010

The accumulation time width is not given. The macro used to determine the ASW data is given in the data file name (ex. lap_20160215_000000_914_asw.tab for macro 0x914). The macro value was used along with the cadence row in the file ro-irfu-lapmac-160804_ext1.pdf file to determine an accumulation time of 160 sec in order to display the data. It is not known if this is correct since no information is given.

RID: RPCLAP-US-RF-011

ASW Data


Ipho
Sensor Data
Photosaturation
Current
amp
8.88e-16
-4.00e-09
-8.00e-09
-1.20e-08
-1.60e-08
Ph0 Quality/000
Photosaturation
Quality
Index
Ipho Knee
Sensor Data
Photoelectron Knee
Potential
volts
Vpk Quality/000
Photoelectron Knee
Quality
Index
Ne
(Fixed Te)
Sensor Data
Electron Number
Density
cm**-3
Ne Quality/000
Electron Number
Quality
Index
Vi
Sensor Data
Ion Bulk
Speed
m/s
Vi Quality/000
Ion Bulk
Quality
Index
Te
Sensor Data
Electron
Temperature
eV
Te Quality/000
Electron
Quality
Index
Te - XCAL
Sensor Data
Calibrated Electron
Temperature
eV

USC Data Assumptions

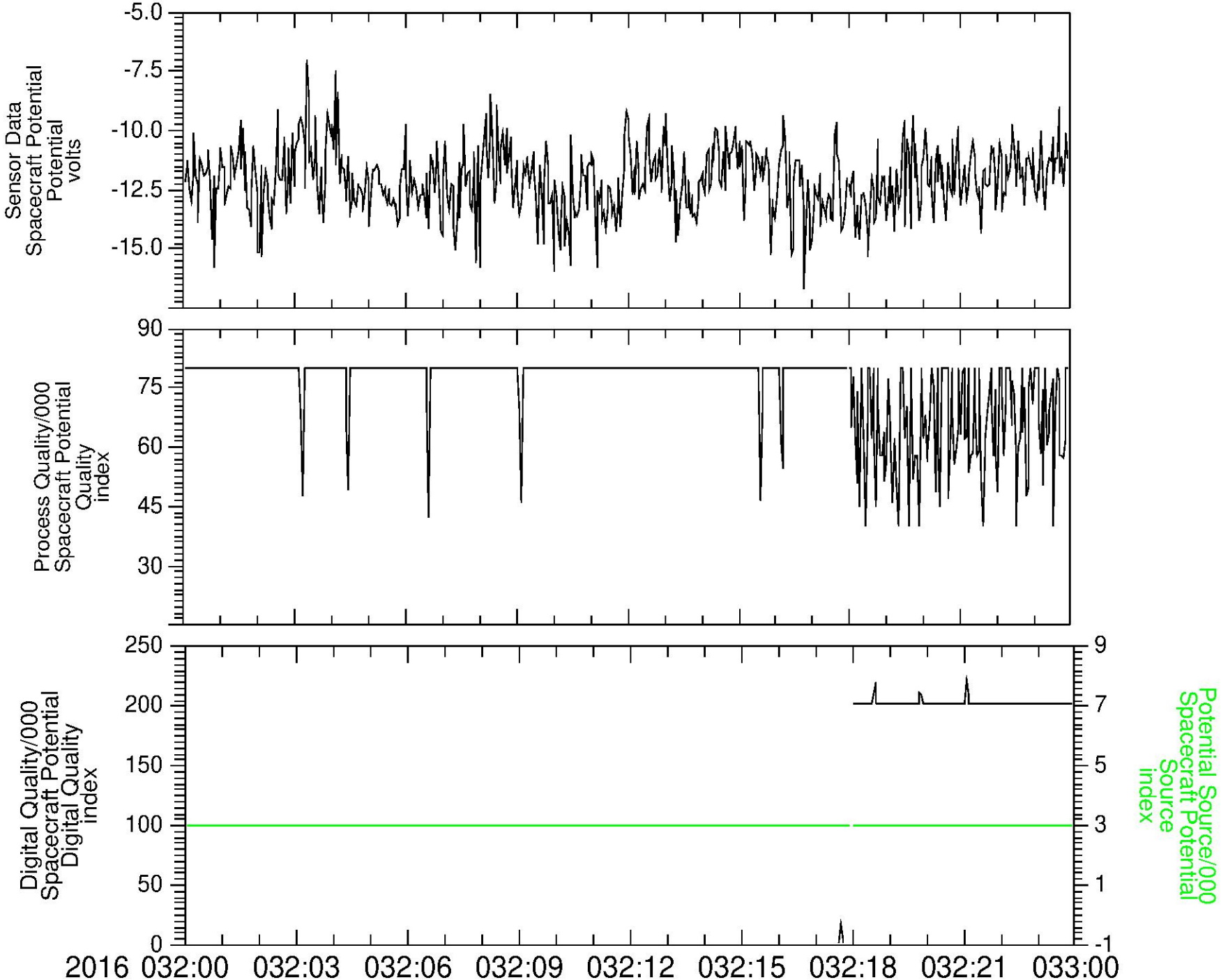
One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time.

RID: RPCLAP-US-RF-010

The accumulation time width is not given. The macro used to determine the USC data is given in the data file name (ex. lap_20160215_100414_802_usc.tab for macro 0x802). The macro value was used along with the cadence row in the file ro-irfu-lapmac-160804_ext1.pdf file to determine an accumulation time of 32 sec in order to display the data. It is not known if this is correct since no information is given.

RID: RPCLAP-US-RF-011

USC Data


Sensor Data
Spacecraft Potential
Potential
volts
-5.0
-7.5
-10.0
-12.5
-15.0
Process Quality/000
Spacecraft Potential
Quality
index
90
75
60
45
30
Digital Quality/000
Spacecraft Potential
Digital Quality
index
250
200
150
100
50
0
Potential Source/000
Spacecraft Potential
Source
index
9
7
5
3
1
-1
2016 032:00
032:03
032:06
032:09
032:12
032:15
032:18
032:21
033:00

EFL Data Assumptions – 1 of 2

One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time.

RID: RPCLAP-US-RF-010

The accumulation time width given by the base accumulation time (1/57.3 sec) multiplied by the number of samples averaged multiplied by the downsampling rate. Here the number of samples averaged and the downsampling rate are determined by the sampling configuration variable from the TAB file and Table 3 on page 25 of the ro-irfu-lap-eaicd.pdf file.

However, since the sampling configuration is “0” in the TAB files, it is possible that the measurement is an instantaneous value with an accumulation width of zero time. It is not clear what should be used for the accumulation width since both are possible.

EFL Data Assumptions – 2 of 2

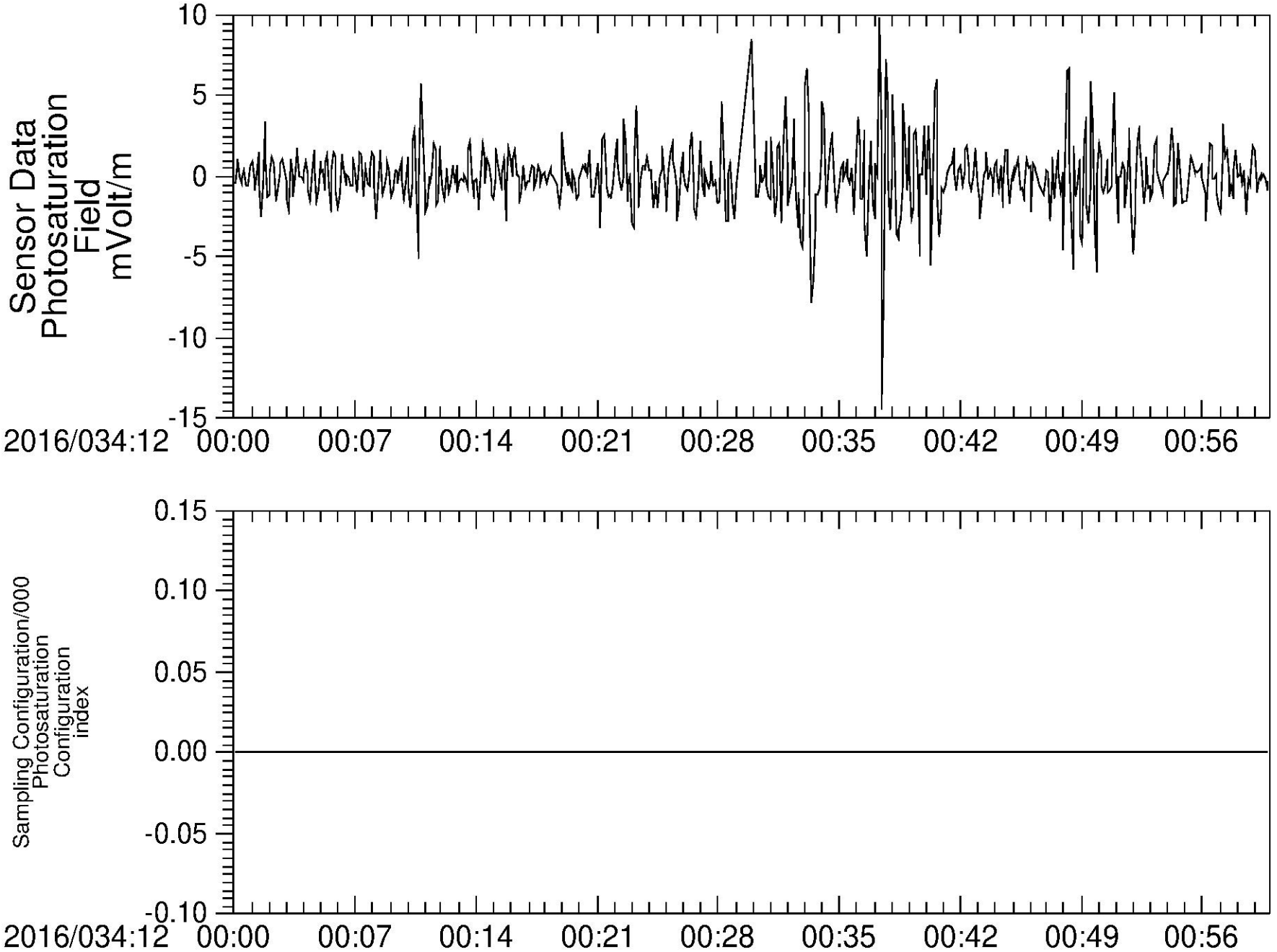
Both of these timing assumptions seem to disagree with the ro-irfu-lap-eaicd.pdf file which states

> sweeps. This gives a 32 or 64 second data gap to the electric field measurement, so instead of a moving average, the average value of the raw voltage difference over the 96 seconds of continuous data available between the gaps is subtracted

and seems to suggest a longer accumulation time. However, a longer accumulation time is not reflected by the data TAB file.

RID: RPCLAP-US-RF-011

EFL Data


Sensor Data
Photosaturation
Field
mVolt/m
10
5
0
-5
-10
-15
2016/034:12
00:00
00:07
00:14
00:21
00:28
00:35
00:42
00:49
00:56
Sampling Configuration/000
Photosaturation
Configuration
index
0.15
0.10
0.05
0.00
-0.05
-0.10
2016/034:12
00:00
00:07
00:14
00:21
00:28
00:35
00:42
00:49
00:56

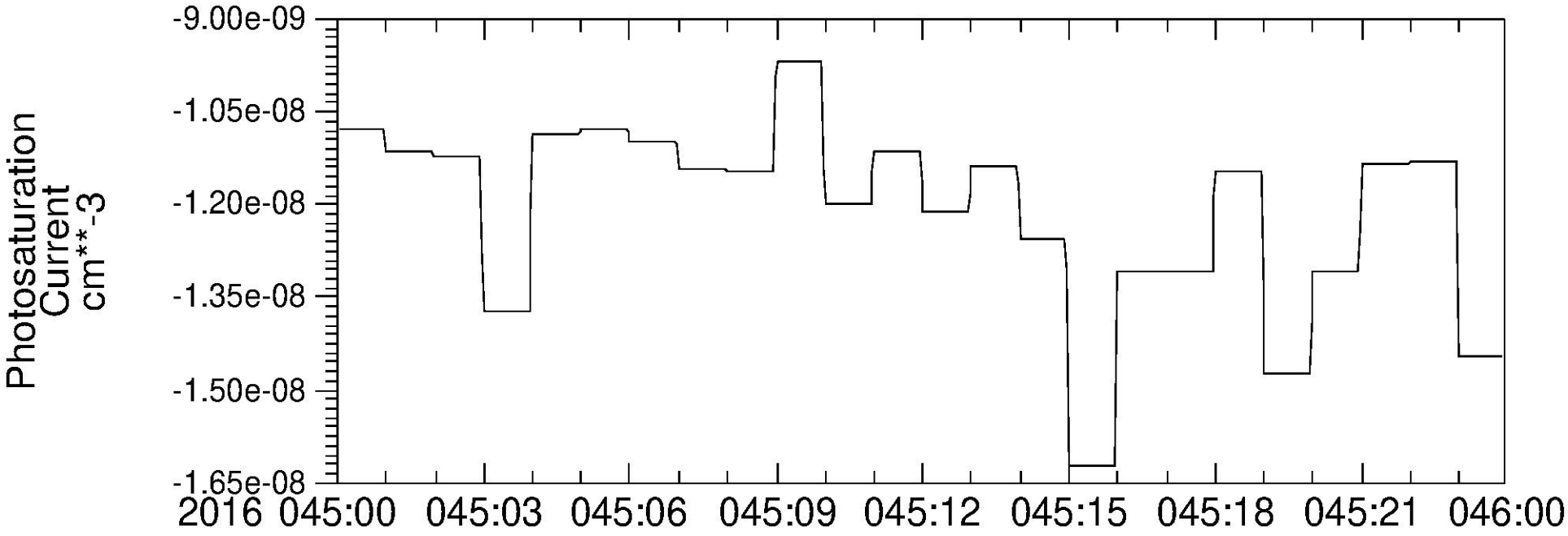
PHO Data Assumptions

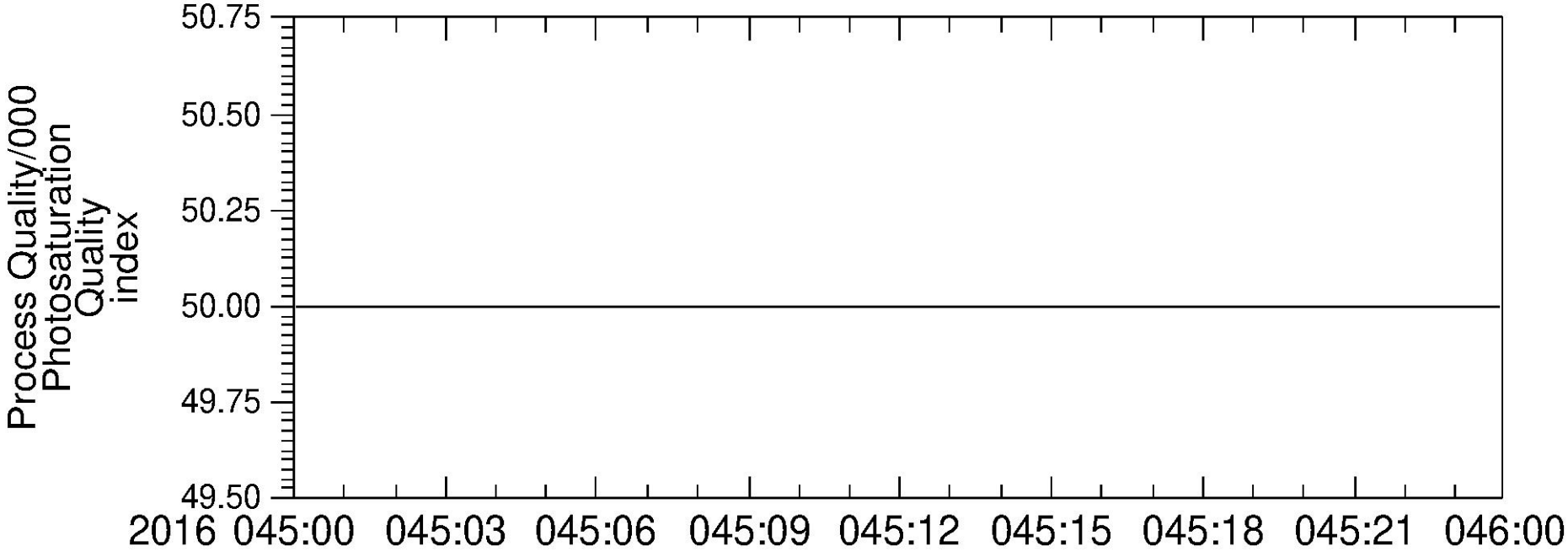
One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time with the accumulation width given in the ro-irfu-lap-ug.pdf document and the data file name (ex. lap_20160215_000000_60m_pho.tab for 60 minutes).

RID: RPCLAP-US-RF-010

RID: RPCLAP-US-RF-011

PHO Data


Photosaturation
Current
cm**-3
-9.00e-09
-1.05e-08
-1.20e-08
-1.35e-08
-1.50e-08
-1.65e-08
2016 045:00
045:03
045:06
045:09
045:12
045:15
045:18
045:21
046:00


Process Quality/000
Photosaturation
Quality
index
50.75
50.50
50.25
50.00
49.75
49.50
2016 045:00
045:03
045:06
045:09
045:12
045:15
045:18
045:21
046:00

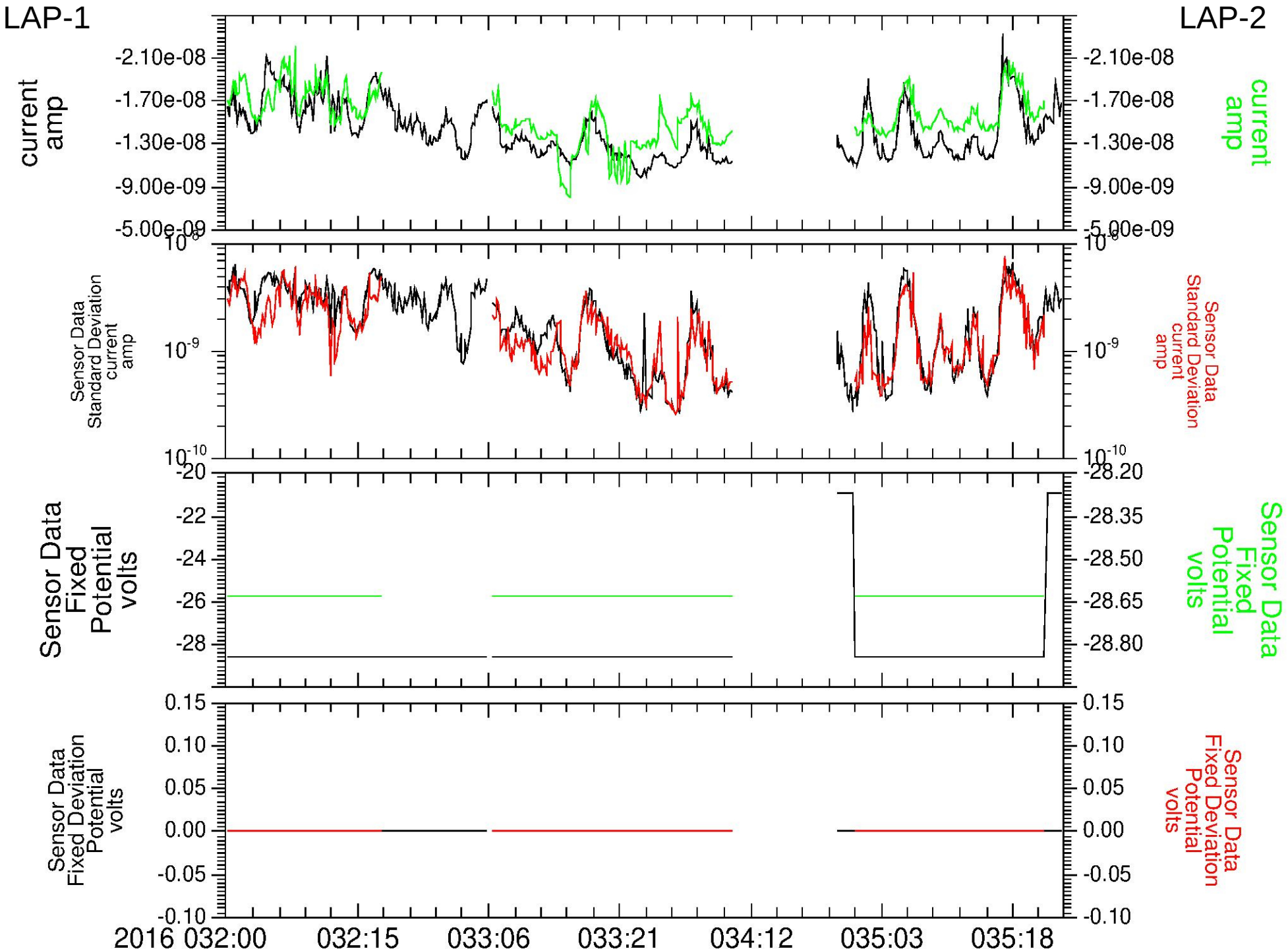
ID Data Assumptions

One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time with the accumulation width given in the ro-irfu-lap-ug.pdf document and the data file name (ex. lap_20160215_000000_32s_i1d.tab for 32 sec).

RID: RPCLAP-US-RF-010

RID: RPCLAP-US-RF-011

ID Data


LAP-1
LAP-2
current amp
-2.10e-08
-1.70e-08
-1.30e-08
-9.00e-09
-5.00e-09
Sensor Data Standard Deviation current amp
10^{-8}
10^{-9}
10^{-10}
Sensor Data Fixed Potential volts
-20
-22
-24
-26
-28
-28.20
-28.35
-28.50
-28.65
-28.80
Sensor Data Fixed Deviation Potential volts
0.15
0.10
0.05
0.00
-0.05
-0.10
2016 032:00
032:15
033:06
033:21
034:12
035:03
035:18

VD Data Assumptions

One UTC Time stamp is given in the TAB files. This time stamp is assumed to mark the center of the accumulation time with the accumulation width given in the ro-irfu-lap-ug.pdf document and the data file name (ex. lap_20160215_100414_32s_v2d.tab for 32 sec).

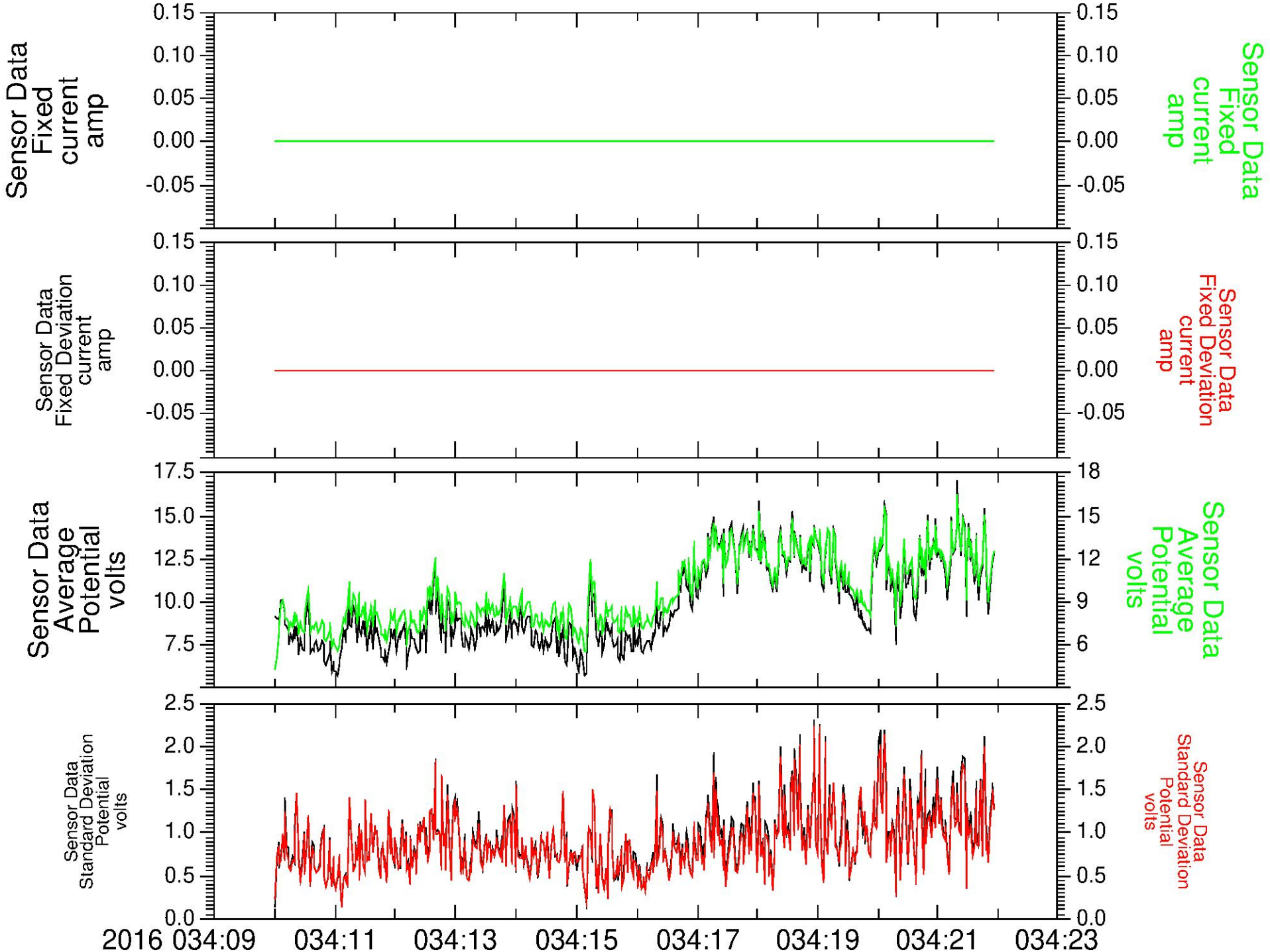
RID: RPCLAP-US-RF-010

RID: RPCLAP-US-RF-011

VD Data

LAP-1

LAP-2



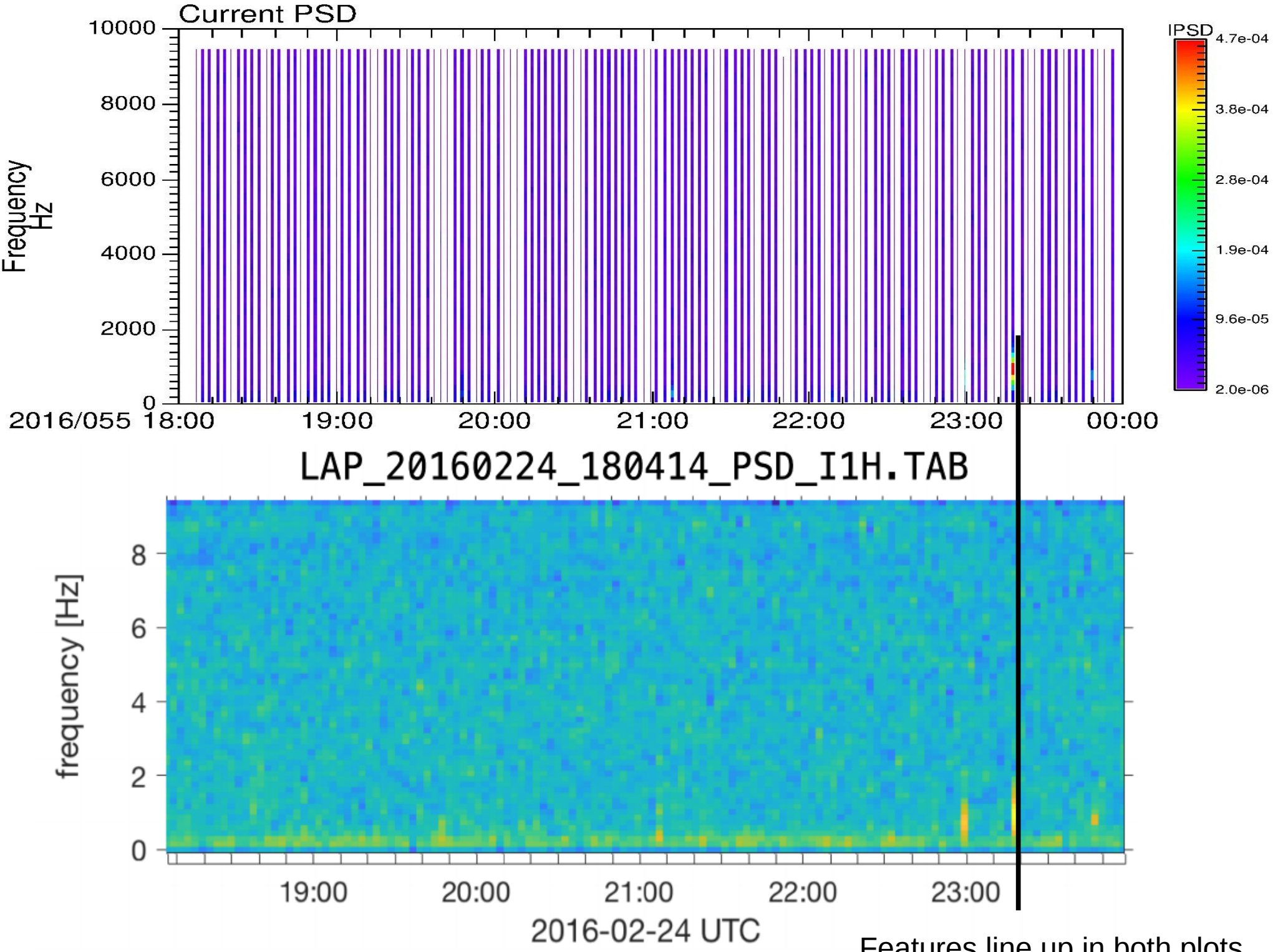
PSD FRQ & IH Data Assumptions

The UTC Time range is given in the PSD IH TAB file and a frequency table is given in the FRQ file; however, the frequency width is not given in either the FRQ or PSD IH files. Comparison with Figure 8 in the in the ro-irfu-lap-ug.pdf document shows that the first frequency bands begin at 0.0 Hz and shows continuously from one frequency value to the next. Therefore, the PSD frequencies are assumed to specify the lowest frequency value for each frequency step which has a width continuing to the next step. The frequency width of the highest step is assumed to be the same as determined from the second highest step.

RID: RPCLAP-US-RF-012

The frequency range given in the FRQ TAB file (kHz) does not agree with those shown on Figure 8 in the in the ro-irfu-lap-ug.pdf document (Hz). It is assumed that the values shown in Figure 8 are are correct, the unit label is incorrect.

RID: RPCLAP-US-RF-013



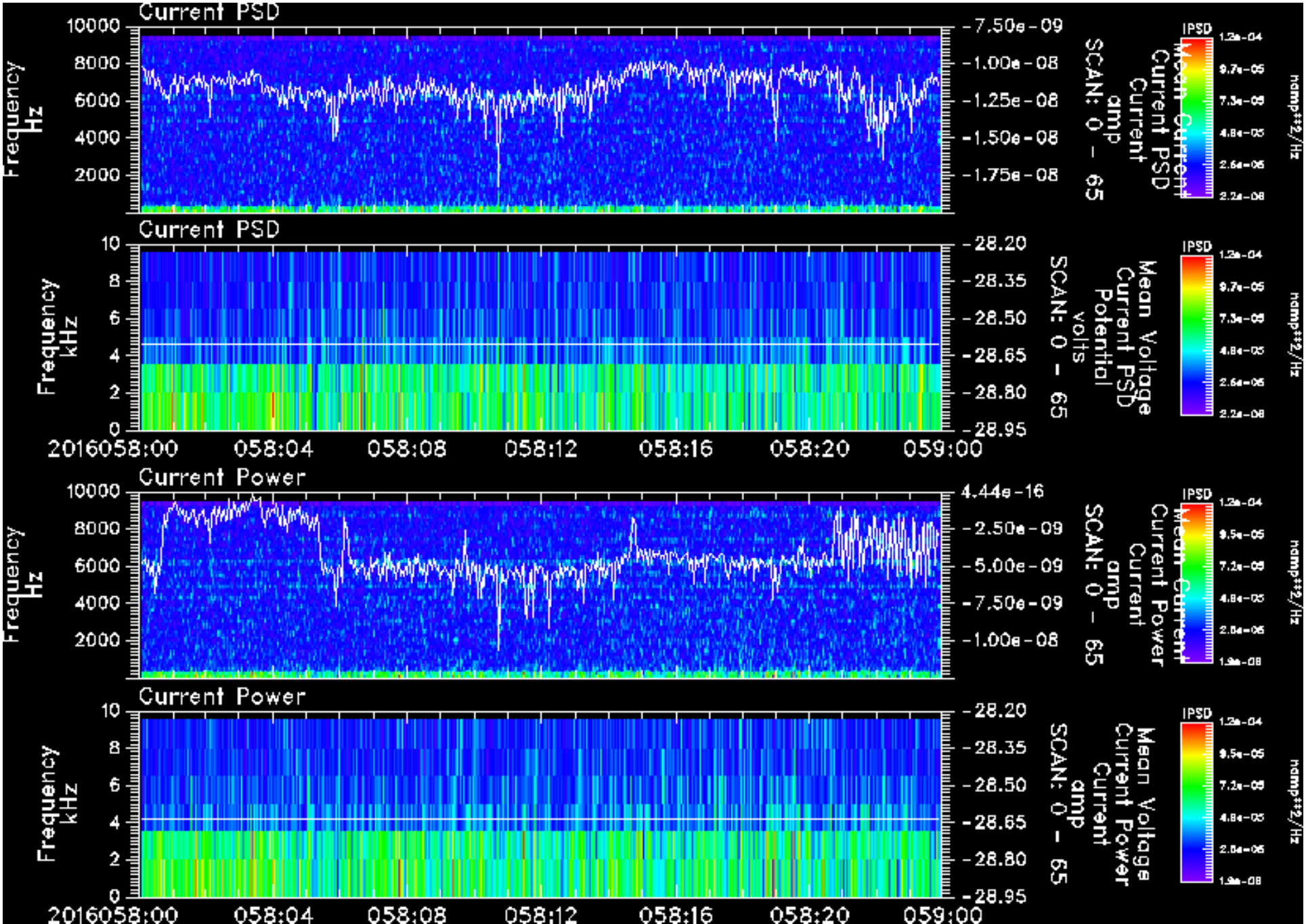
Features line up in both plots

Figure 8. Example spectrogram of LAP1 HF data.

PSD FRQ & IH Data

LAP-1

LAP-2



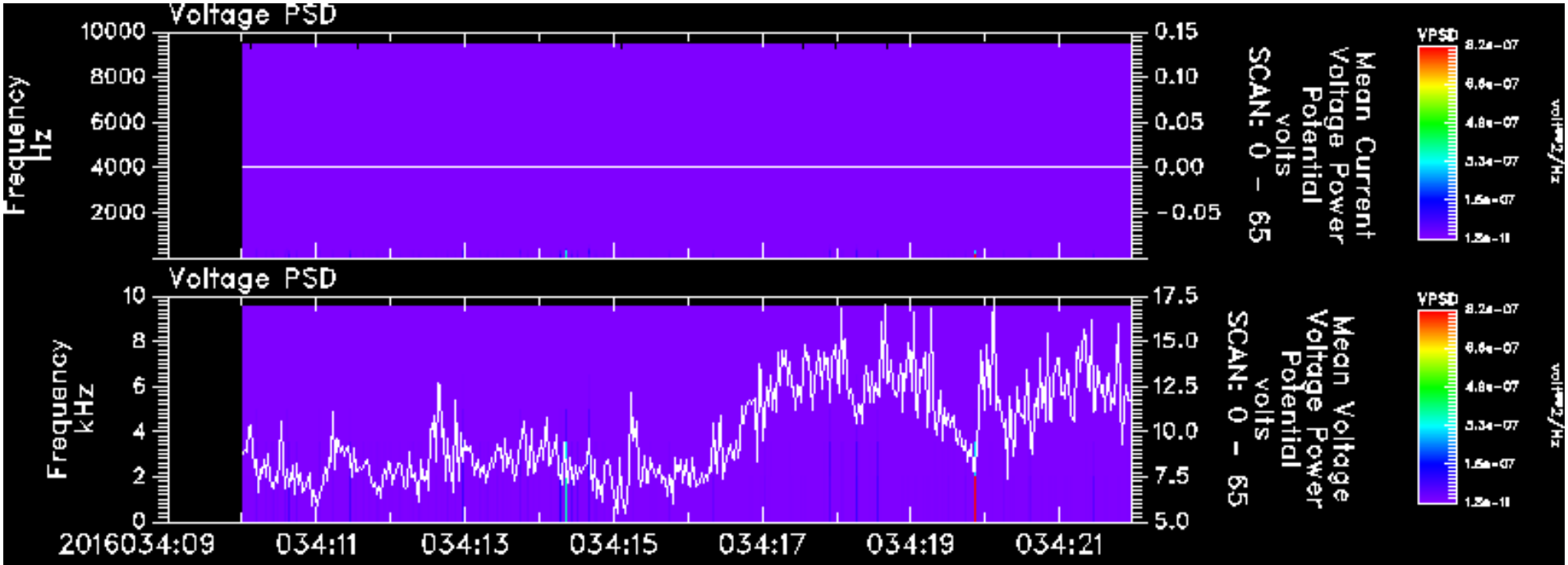
PSD FRQ & VH Data Assumptions

The UTC Time range is given in the PSD VH TAB file and a frequency table is given in the FRQ file; however, the frequency width is not given in either the FRQ or PSD IH files. Comparison with Figure 8 in the in the ro-irfu-lap-ug.pdf document shows that the first frequency bands begin at 0.0 Hz and shows continuously from one frequency value to the next. Therefore, the PSD frequencies are assumed to specify the lowest frequency value for each frequency step which has a width continuing to the next step. The frequency width of the highest step is assumed to be the same as determined from the second highest step.

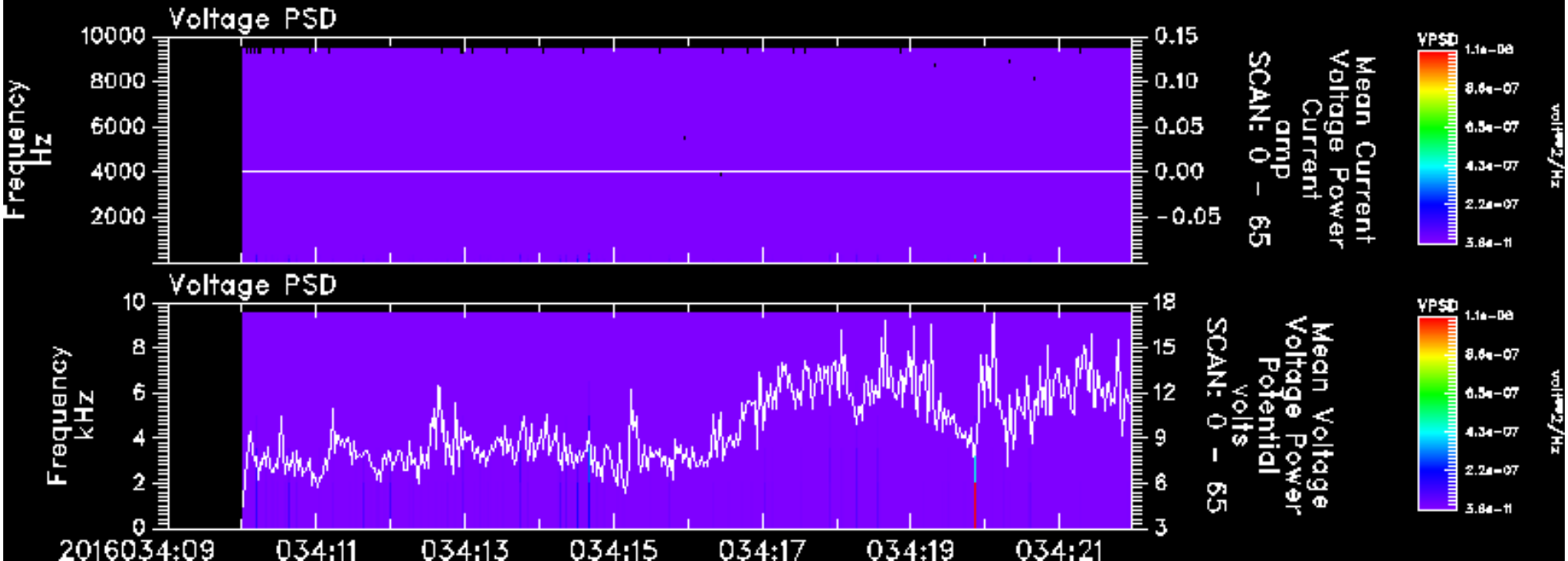
RID: RPCLAP-US-RF-012

PSD FRQ & VH Data

LAP-1



LAP-2



Backup Slides

ro-c-rpclap-5-ext1-deriv2-v1.0 aareadme.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0
voldesc.cat

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/index
indxinfo.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/index
indxinfo.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/index
index.lbl & index.tab

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/index checksum.lbl & checksum.tab

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog
catinfo.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog dataset.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog
rpclap_inst.cat

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog
rpclap_pers.cat

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog
rpclap_ref.cat

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/catalog rpclap_software.cat

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/document
docinfo.txt

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/document
eriksson2007a.lbl & eriksson2007a.pdf
eriksson2008a.lbl & eriksson2008a.pdf

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/document
flight_reports/irfu-ros-opr-ext1_v10.lbl
flight_reports/irfu-ros-opr-ext1_v10.pdf

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/document
ro-irfu-lapmac-160804_ext1.lbl
ro-irfu-lapmac-160804_ext1.pdf

GOOD

ro-c-rpclap-5-ext1-deriv2-v1.0/document
rpc_user_guide.pdf

Rudy to look at this later