Solar Wind Around Pluto SWAP

PRINCIPAL INVESTIGATOR
Dave McComas, Princeton University

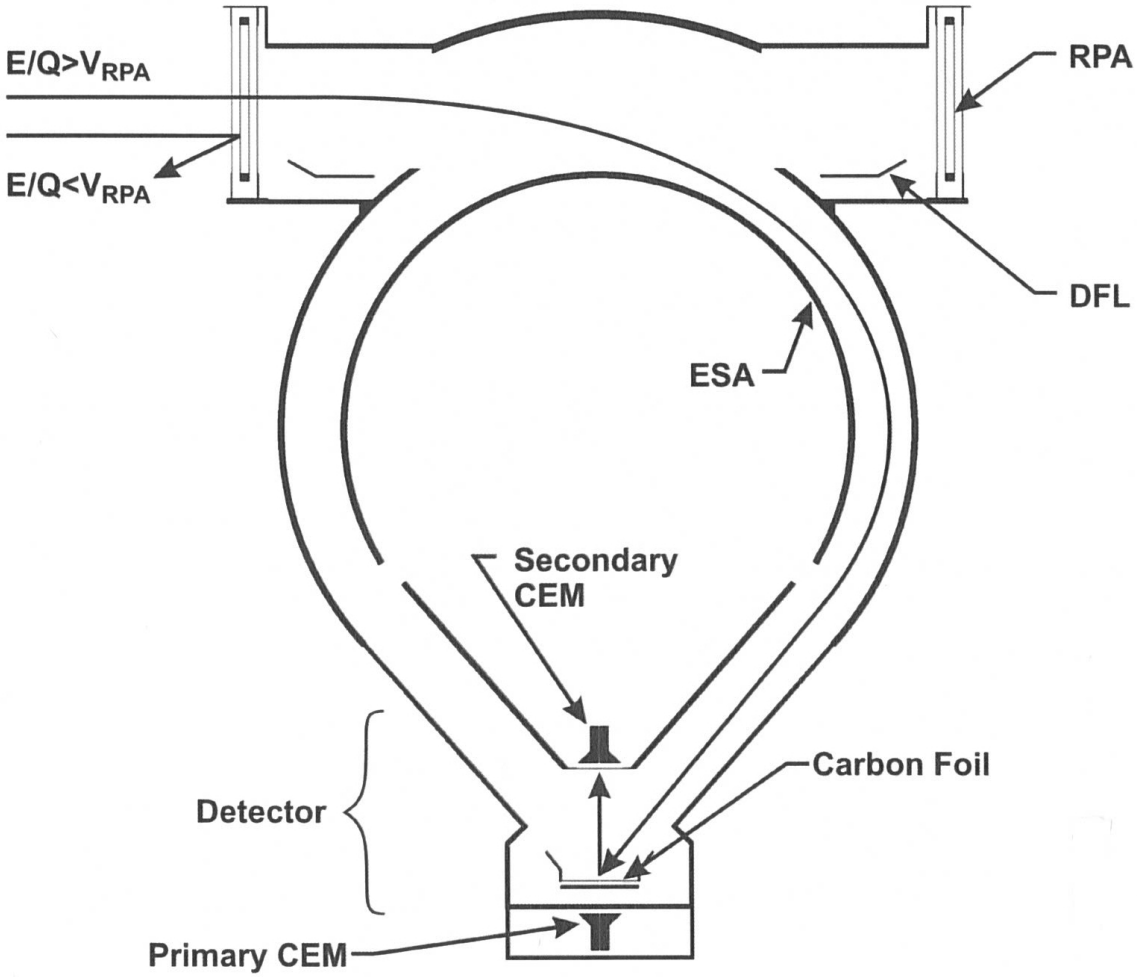
DESCRIPTION
Low Energy Plasma Instrument

ENERGY RANGE
30 eV - 7.7 keV

FIELD OF VIEW
270 deg x 10 deg
(deflection angles up to +15 deg)

ENERGY RESOLUTION
1 eV (< 2 keV); 9% (> 2 keV)

SPECIES
All Ions



New Horizons SWAP Data Sets

RAW Data Sets:
nh-a-swap-2-kem1-v2.0

CALIBRATED Data Sets:
nh-a-swap-3-kem1-v2.0

New Horizons SWAP Data Set Evaluation Tools

Staging and Evaluation -

Machine: Dell Precision T3400

Operating System: Fedora 27 linux

Data Processing -

Machine: Sun Ultra-350

Operating System: Sun Solaris OS 5.9

Minor Diagnostics -

Machine: IBM lenovo T60p ThinkPad

Operating System: Fedora 25 linux

SWAP Documentation Evaluation

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
dataset.cat – 1 or 2

```
DATA_SET_ID                          = "NH-A-SWAP-3-KEM1-V2.0"

OBJECT                               = DATA_SET_INFORMATION

  START_TIME                         = 2018-08-14T20:08:02.011
  STOP_TIME                          = 2019-01-30T18:08:02.177
  DATA_SET_DESC                      = "

  Data Set Overview
  =================

    This data set contains Calibrated data taken by
    the New Horizons Solar Wind Around Pluto instrument during the
    KEM1 ENCOUNTER mission phase.

    SWAP comprises electro-optics and detectors to obtain count rate
    measurements of the solar wind; measuring the solar wind before,
    during and after the Pluto encounter will allow characterization
    of the atmospheric escape rate of Pluto. The SWAP electro-optic
```

New Horizons has moved way beyond Pluto and this dataset is describing the first encounter with a Kuiper Belt object (KBO). The science should reflect the fact that SWAP Is measuring the solar wind in the area of the KBO. Although not technically Incorrect, the emphasis should be on KBO and not on Pluto.

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
dataset.cat – 2 or 2

```
The leapsecond adjustment (DELTA_ET = ET - UTC) was 65.184s at
NH launch, and the first three additional leapseconds occurred
in at the ends of December, 2009, June, 2012 and June, 2015.
Refer to the NH SPICE data set, NH-J/P/SS-SPICE-6-V1.0, and the
SPICE toolkit documentation, for more details about leapseconds.
```

Update text to include leapsecond at the end on December 2017.
Review all New Horizons trajectory information to determine the Influence and if reprocessing trajectory information is necessary.

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
nh_kem.cat

This Looks Odd

voldesc.cat gives an end date for this mission phase as

```
The nominal start and stop times for the
  KEM1
mission phase are
  2018-08-14T20:08:02.011
and
  2019-01-30T18:08:02.177
```

This end date was just over a year ago.

Short name	Start(1,3)	Stop(2,3)	Full MISSION_PHASE_NAME, plus optional Description
KEM1	2018-08-14	TBD	KEM1 ENCOUNTER, KBO1 ENCOUNTER, KBO1 approach, flyby, post-encounter (4)

```
4 These mission phase dates and/or designations are still under
consideration and will most likely change in future versions of this
mission catalog.
```

Yet this file and note do not yet show an end date. In addition, the SWAP data do not exceed the Date given in voldesc.cat file.

```
OBJECT                  = MISSION_INFORMATION
  MISSION_START_DATE    = 2016-10-26
  MISSION_STOP_DATE     = 2021-09-30
```

However, this end date for the mission is given in this file.

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
nhsc.cat

This document needs to be updated. There are references to measurements at Pluto in numerous places. New Horizons is no longer measuring Pluto and is essentially a new mission to the Kuiper Belt. The instrument description gives no confidence that the New Horizons instruments can measure properties of a KBO. The focus of this document is on Pluto and does not discuss the capabilities of the instruments beyond Pluto. I suspect that this is a hold-over document which was never updated for the current extended mission.

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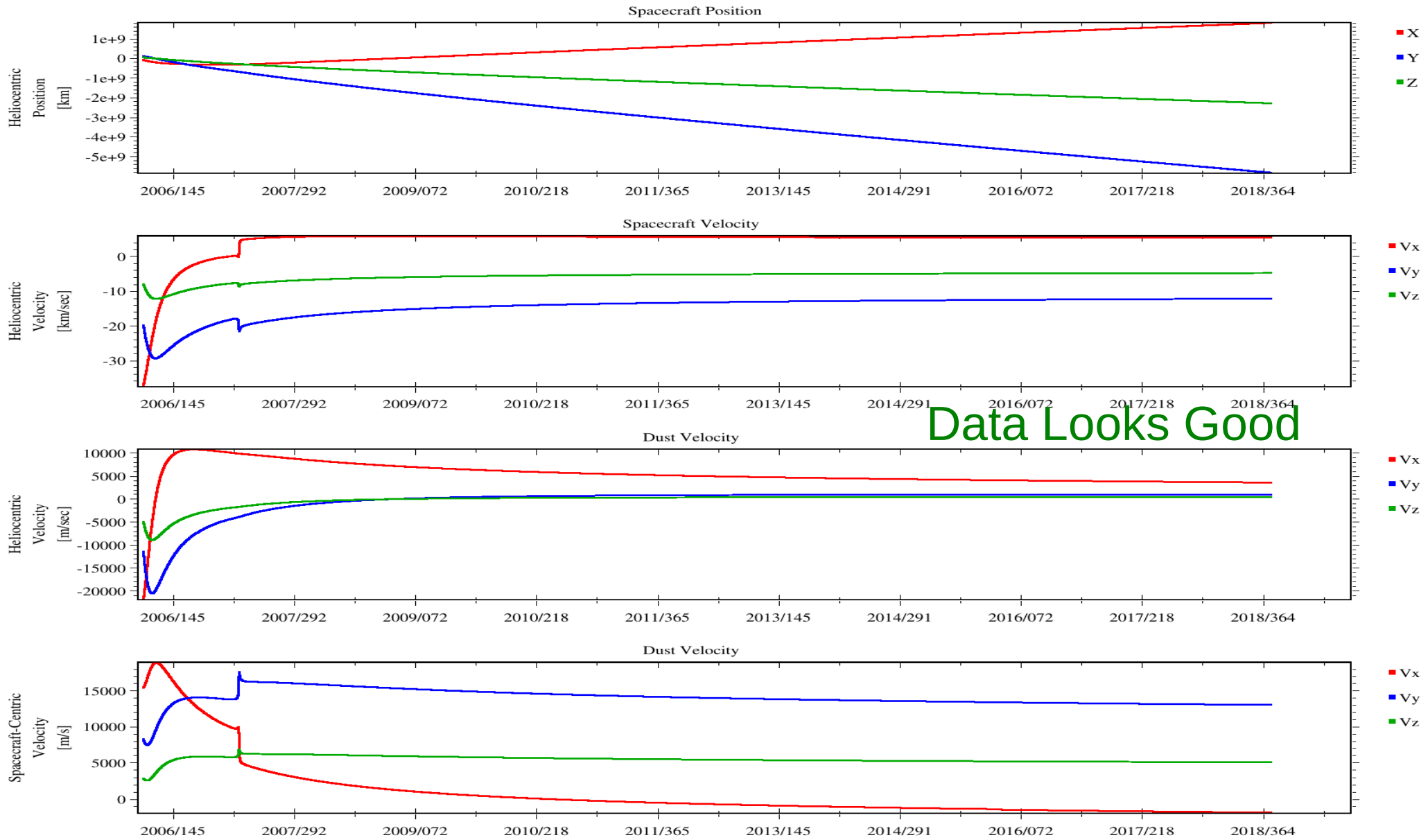
nh-a-swap-3-kem1-v2.0/document
nh_mission_trajectory.tab



Data Looks Good

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
swap_cal.pdf – 1 of 3

uncertainty in the location of the center of the ESA passband to about 10% for ions 7

Figure 5: Diagram defining the roll (φ) angle. The view is looking at the top of the instrument towards the spacecraft. entering anywhere in the 10° instrument Field-Of-View (see Figure 31 of [MCCOMASETAL2008]). We then use the RPA and ESA

This text reads oddly, so a comparison of this document with that from the kemcruise1 phase was performed. This comparison shows that the underlined text was inserted In the middle of the old sentence. It is assumed that this text was inserted by accident and should be removed.

In addition, the Roll angle is defined in Figure 11 whereas Figure 5 is the variation in the ESA response width with respect to the Azimuth.

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
swap_cal.pdf – 2 of 3

Caption of Figure 8 is not on the same page as the Figure. In addition, the axis labels of Figure 8 need to be enhanced since they are almost unreadable.

Figure 10 is not called out in the text and is a graphical representation of the azimuth angle definition. Figure 11 is not called out in the text and is a graphical representation of the roll angle definition. Both of these figures are necessary in this document and should be called out and described in the text.

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
swap_cal.pdf – 3 of 3

on calibration measurements taken during the sequence SWAP-009-6. In Figure 7 we show the SWAP-009-6 data for days 290-292, 299-301, 304-309, 316-318, 320-321, 335-339, 343- 344 used to create the background files. Here we plot the count rates in Hz times the square of the distance from the Sun in AU ($R_{Sun,AU}$) versus the energy. Most of the vertical spikes are the solar wind peaks. In the middle panel the solar wind peak and 3 points below and above the energy of the peak have been removed from each scan individually. The bottom panel of Figure 7 is an average of the top bin where the average

Figure 7 is the voltage variation of the CEMs.
This text describes Figure 9. Please update.

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
soc_inst_icd.pdf

This document should be updated with the proper pros to indicate that SOC processing continues beyond Pluto and what changes if anthing. There are odd items which seem to be missing, like the last entry in the CEM Gain Test list in Table 14-1 is in 2008. The last reference given in section 14.11, SWAP Publications To Date, looks like it has not been updated since 2010. Additional information about operation post the Jupiter encounter is lacking, including information about the current operation and processing of the SWAP by the SOC. This document needs to be examined and updated accordingly.

nh-a-swap-2-kem1-v2.0/document
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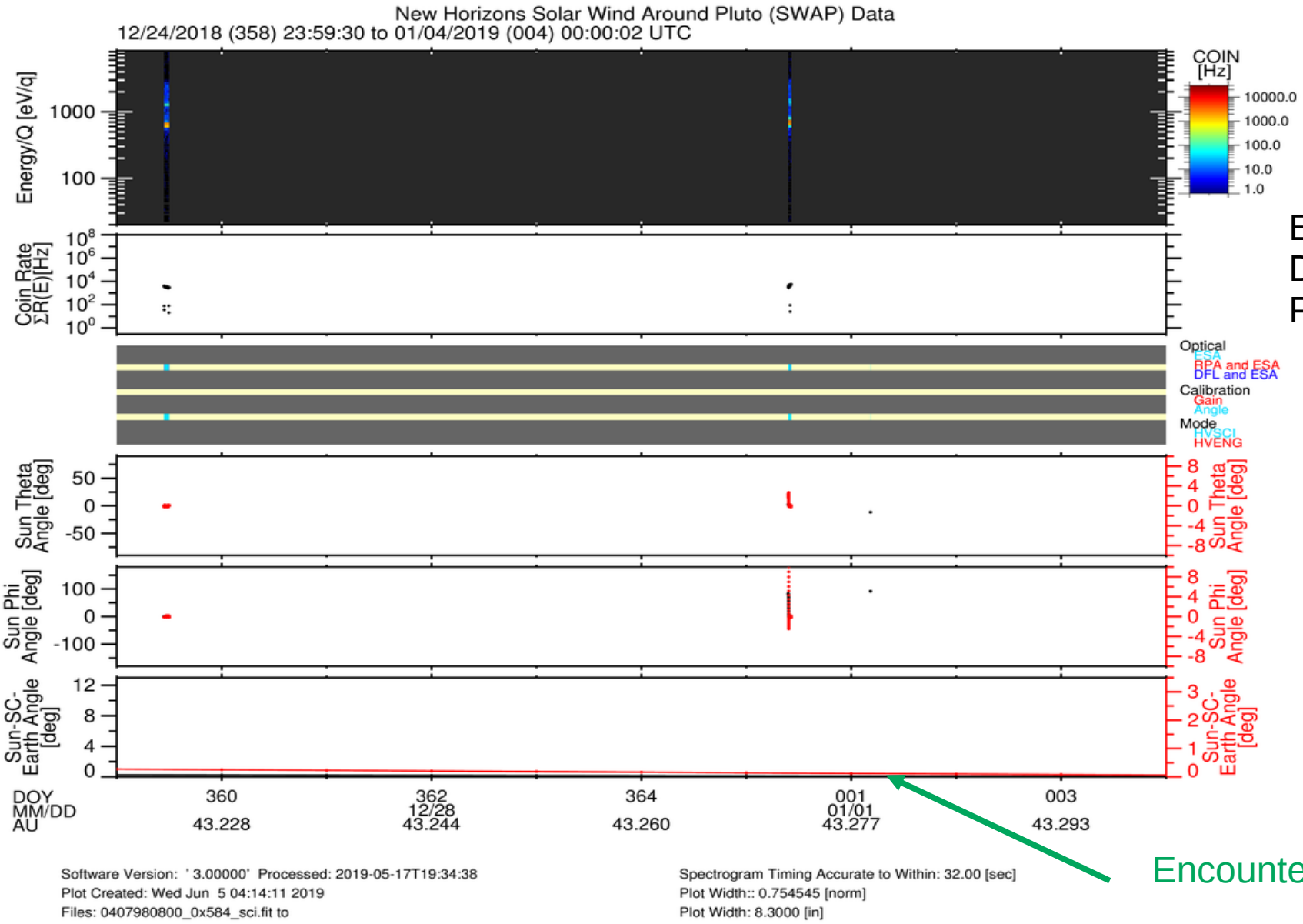
data_summary_plots/swap_010day_201812242359.png



Encounter Day Summary Plot

Encounter – No Data

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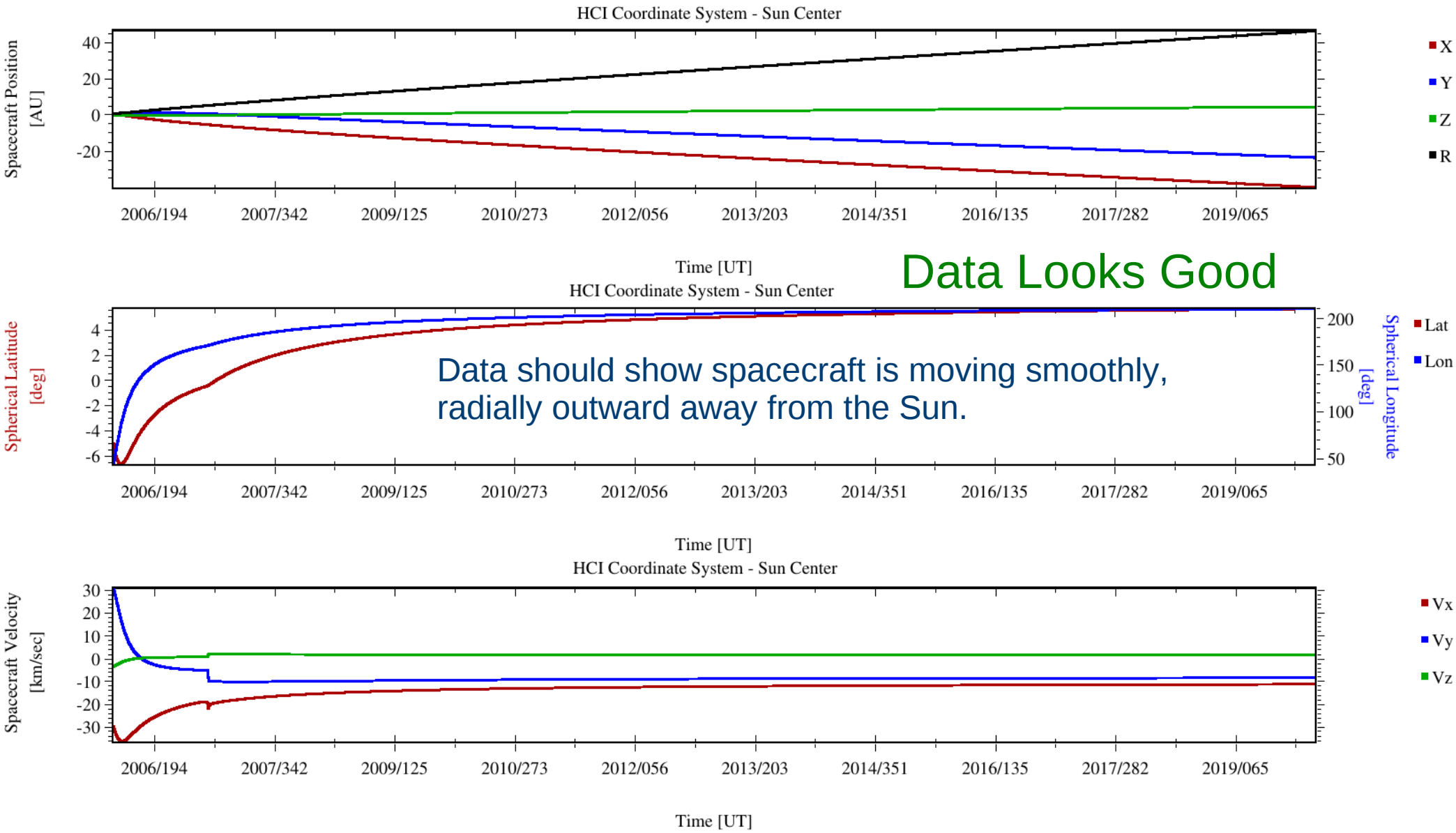
traj/traj_2006_2021_1d.tab

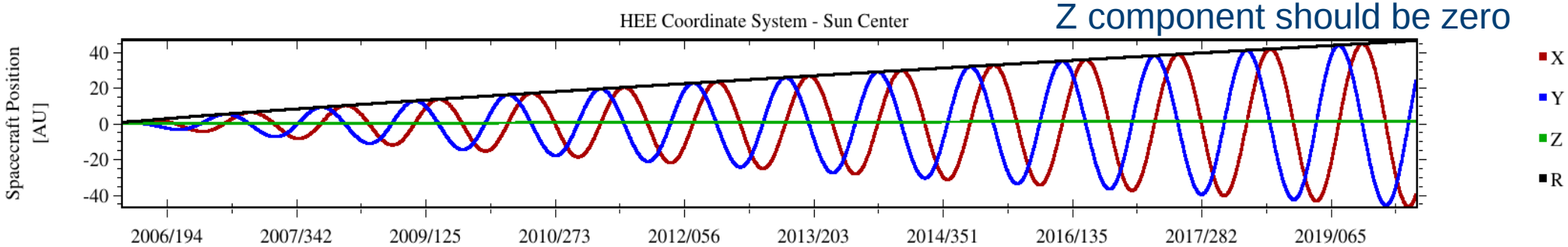


Data Looks Good

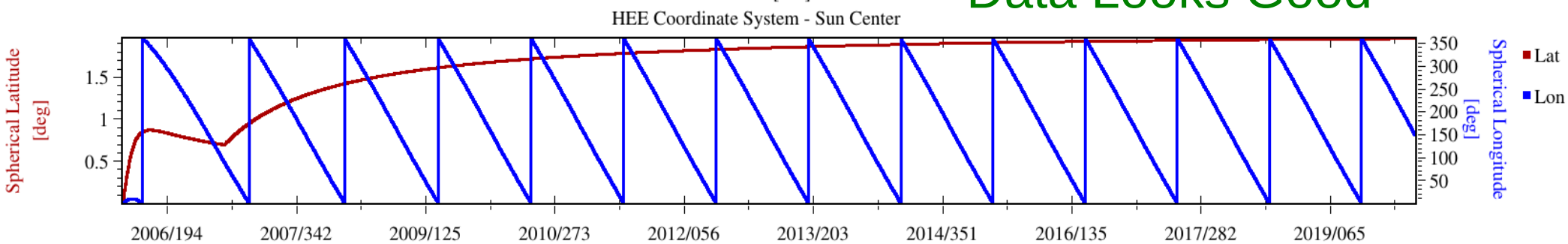
Data should show spacecraft is moving smoothly, radially outward away from the Sun.

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
traj/traj_2006_2021_1d.tab

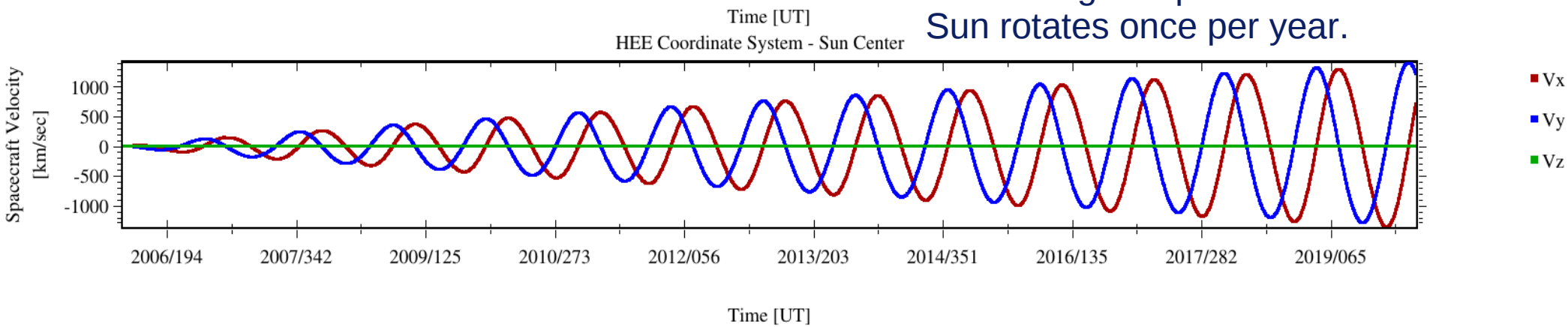
Z component should be zero



Data Looks Good



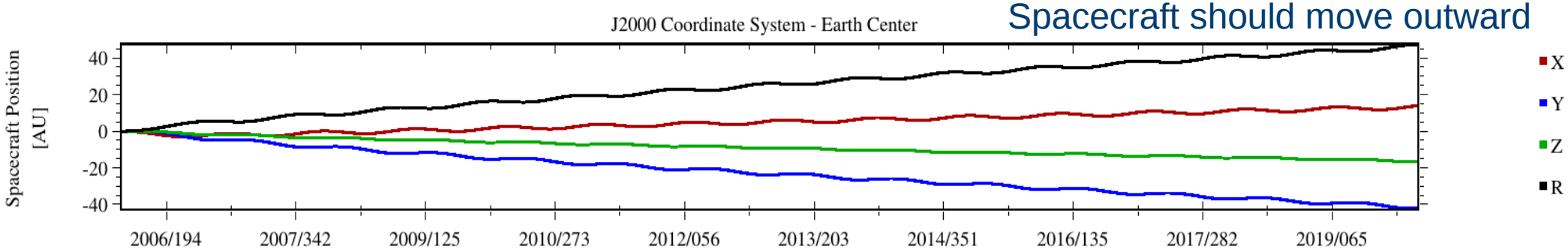
Remaining components oscillate as Sun rotates once per year.



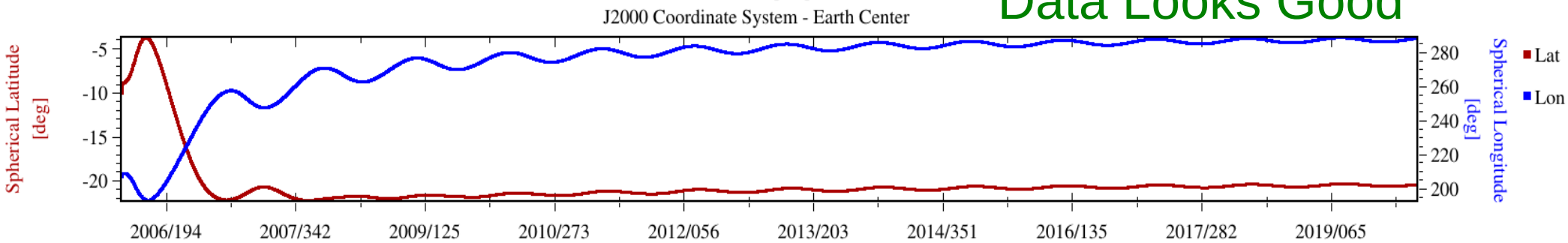
Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Wed Feb 5 20:46:28 2020.

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
traj/traj_2006_2021_1d.tab

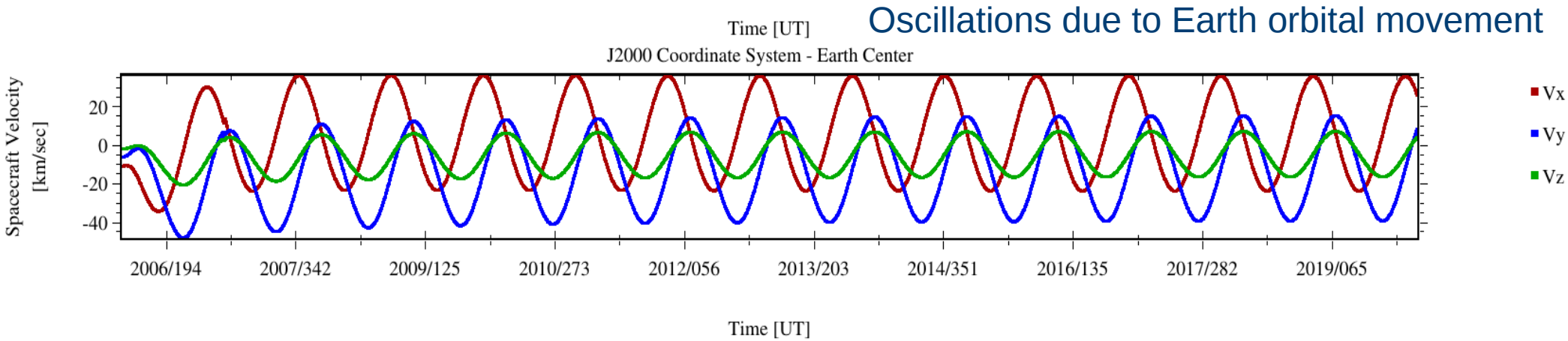
Spacecraft should move outward



Data Looks Good



Oscillations due to Earth orbital movement



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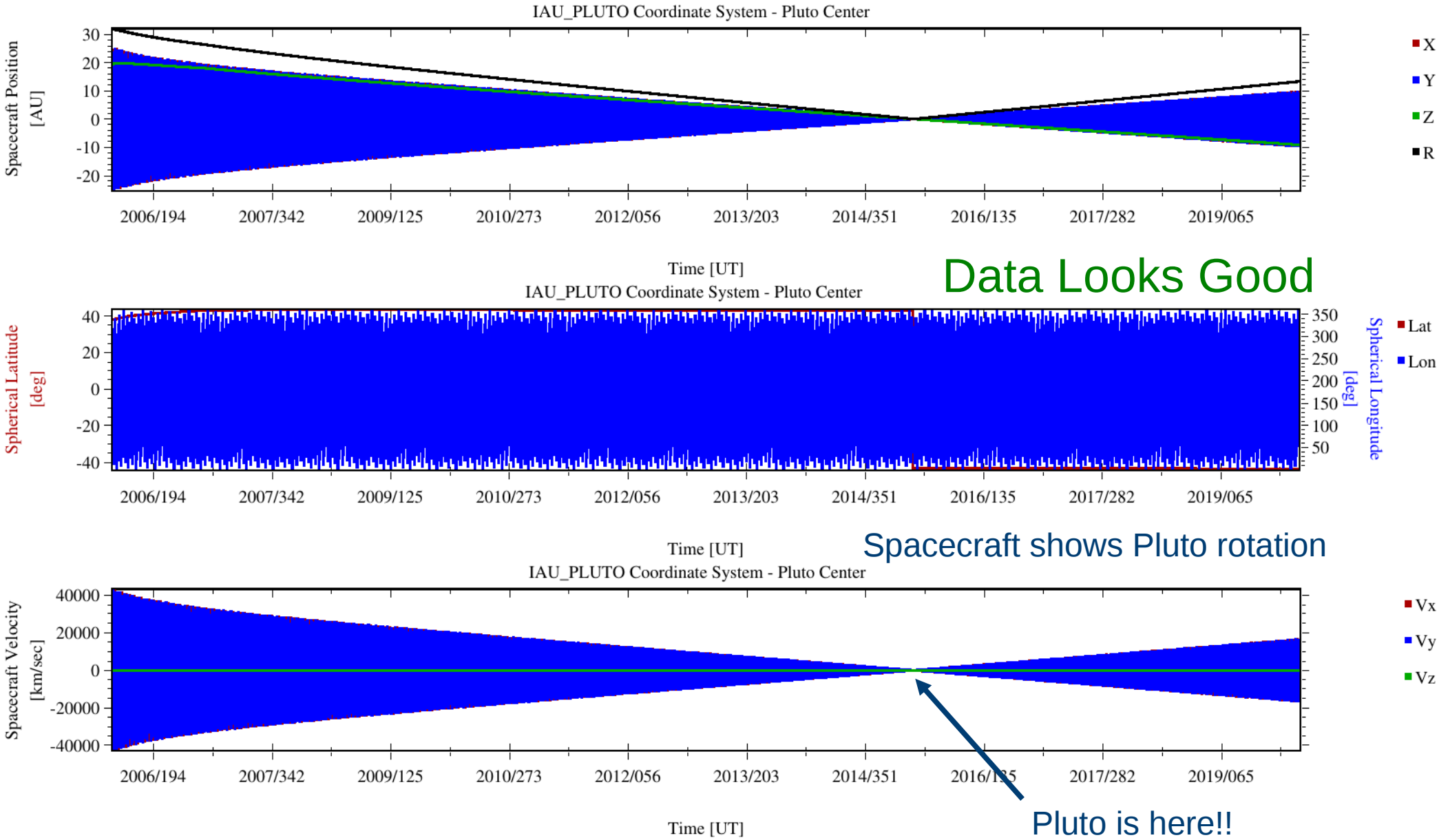
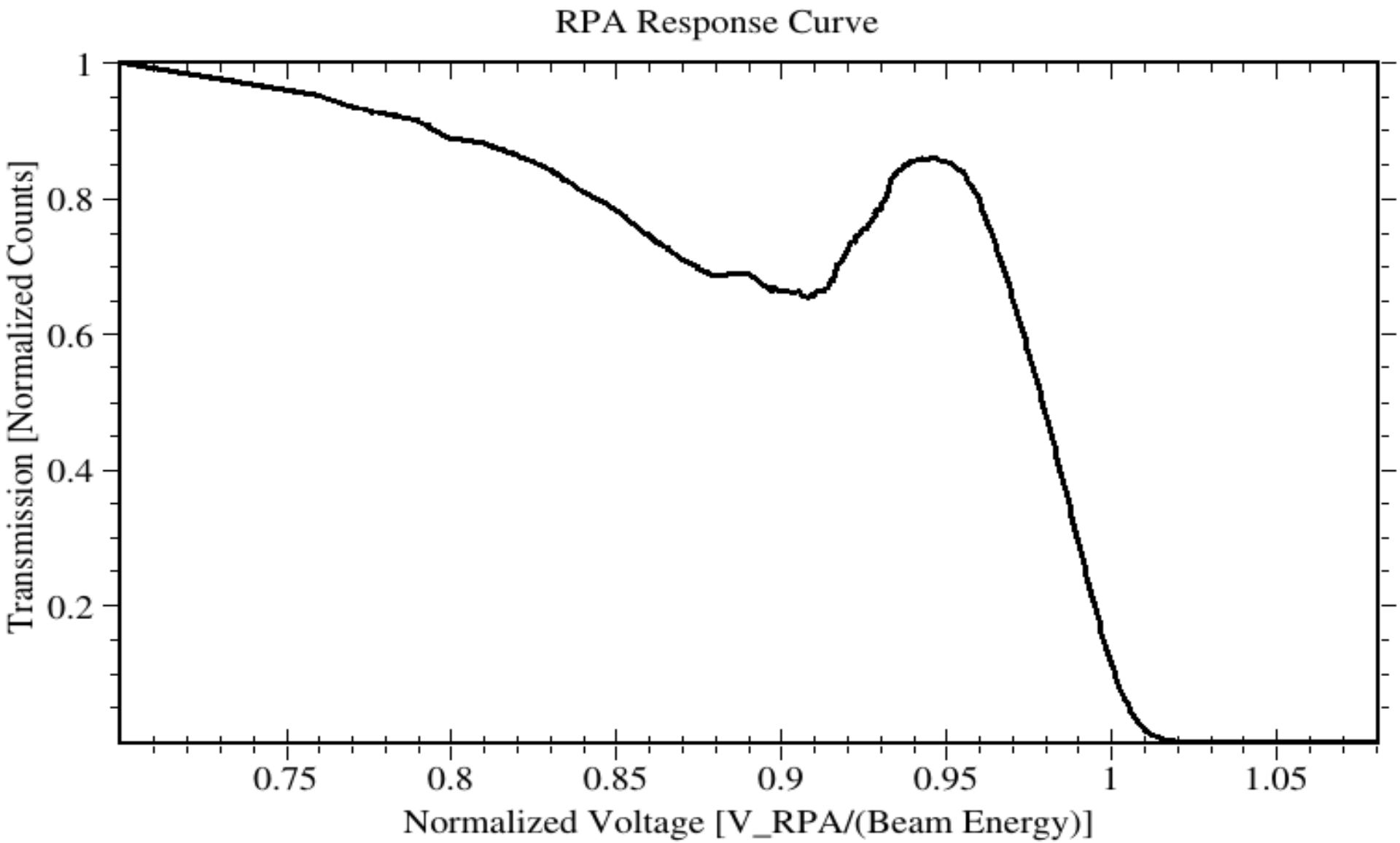


Data Looks Good

Spacecraft shows Pluto rotation

Pluto is here!!

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2./calib
rpa_shape.tab



Data Looks Good

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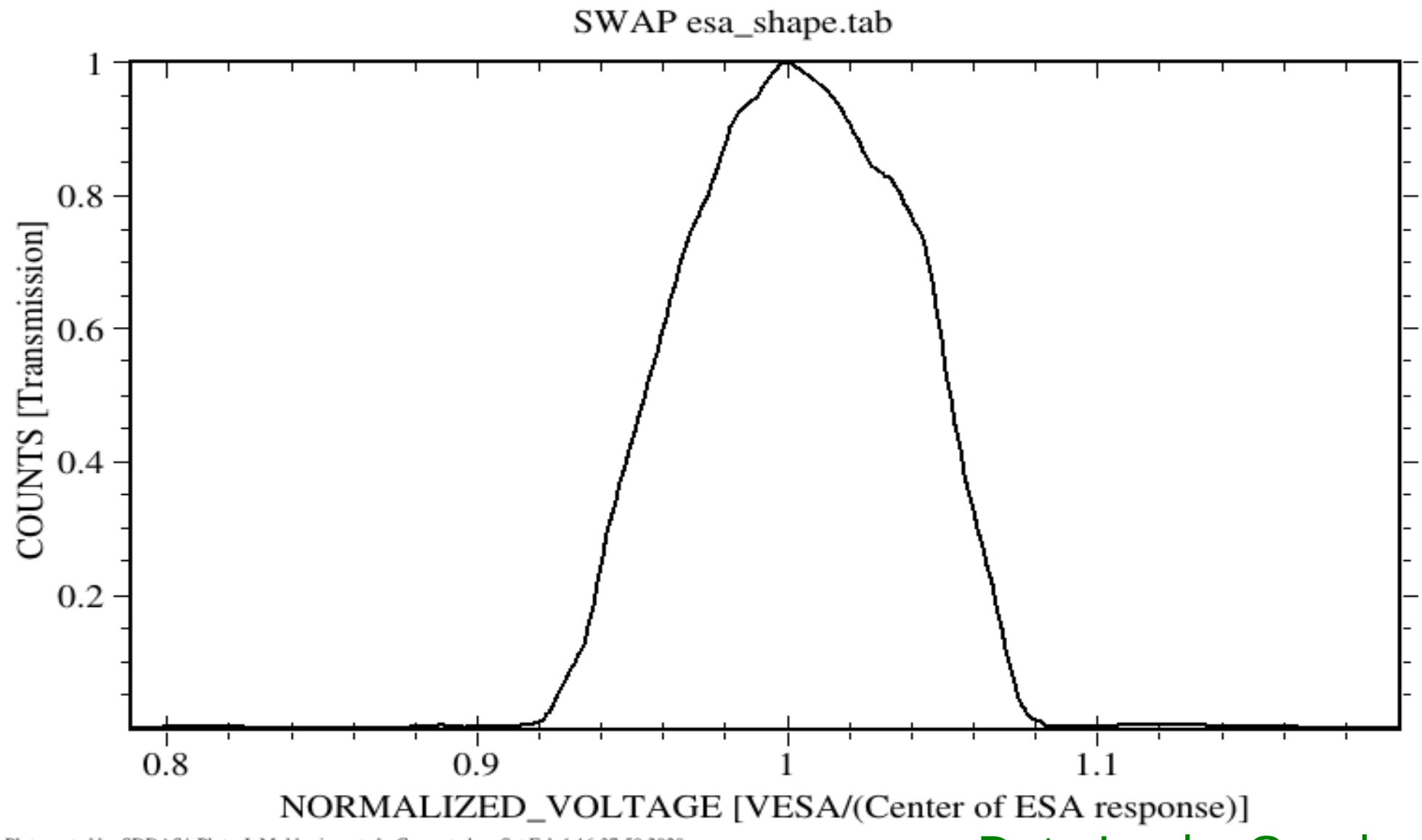
esa_shape.tab



Data Looks Good

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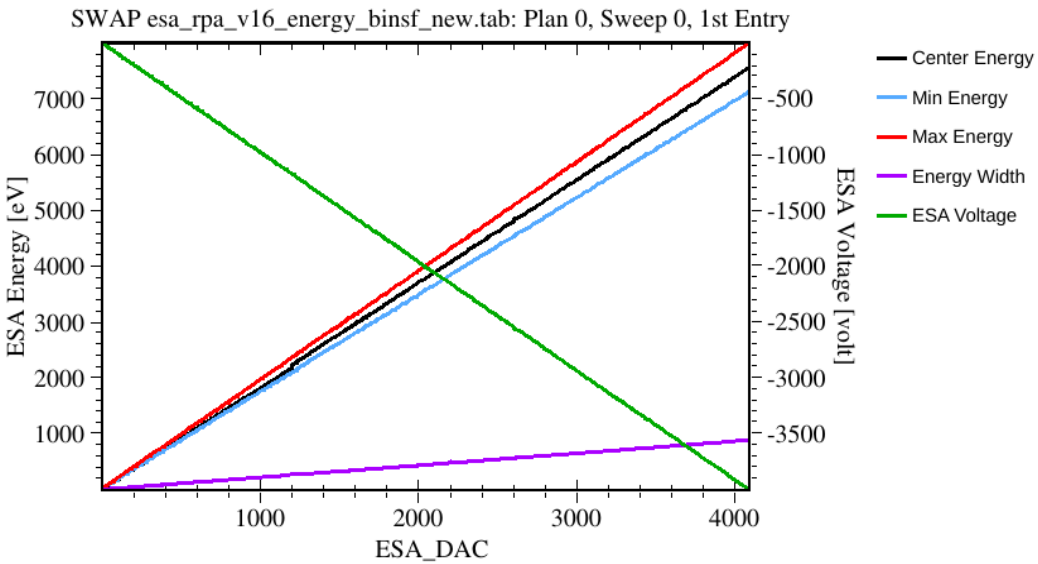

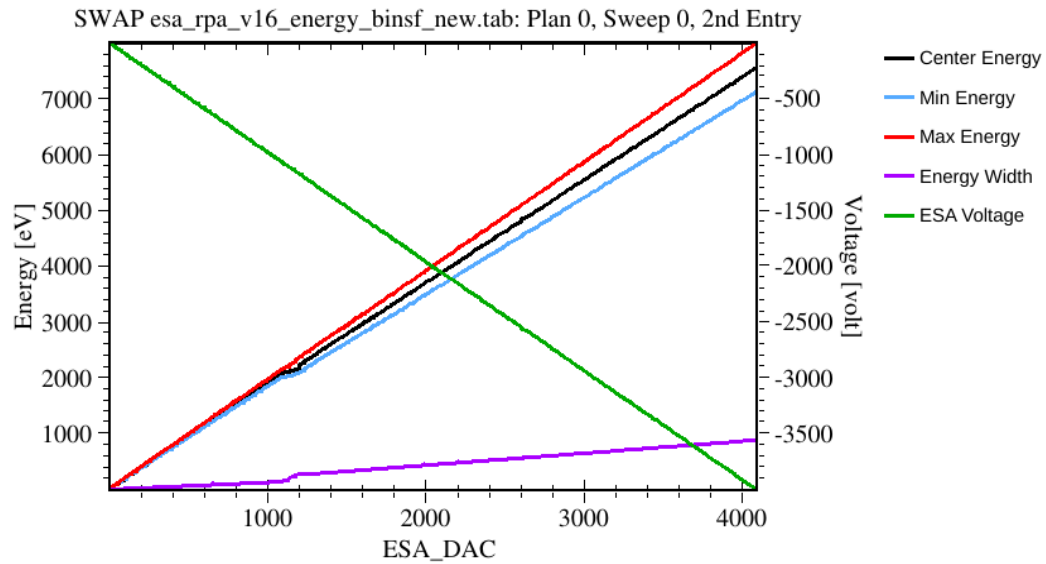

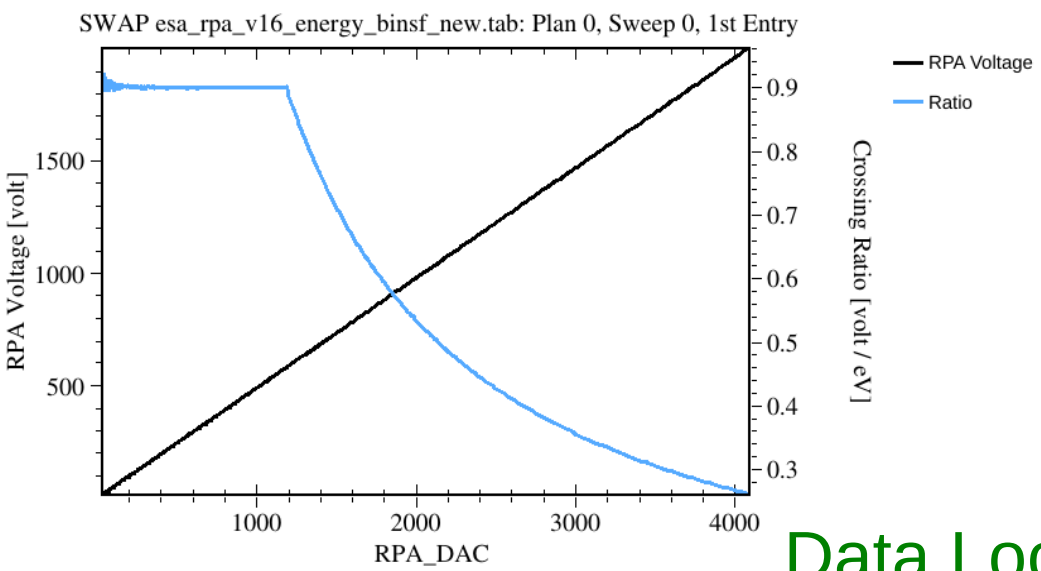

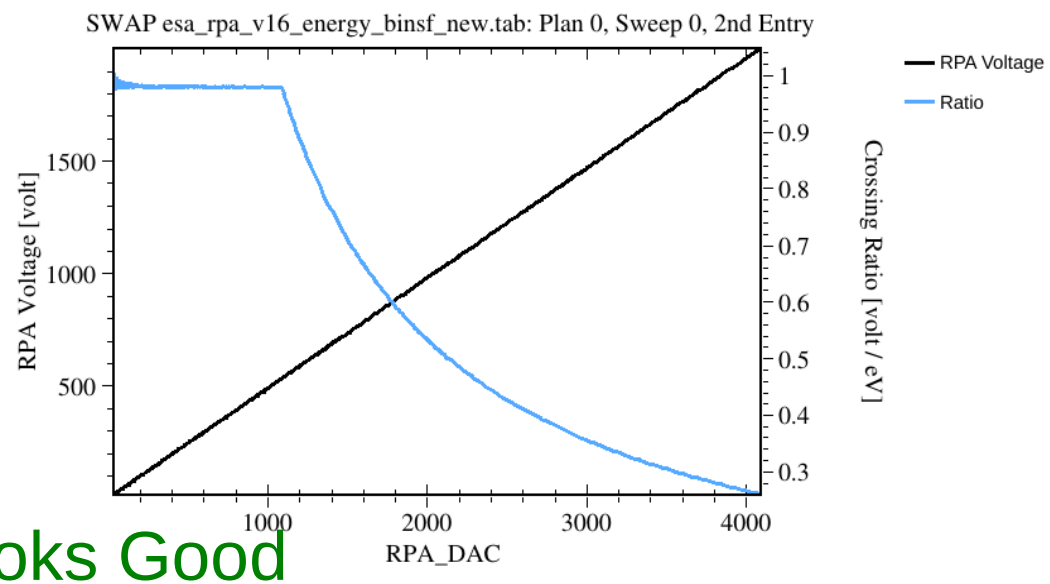

Data Looks Good

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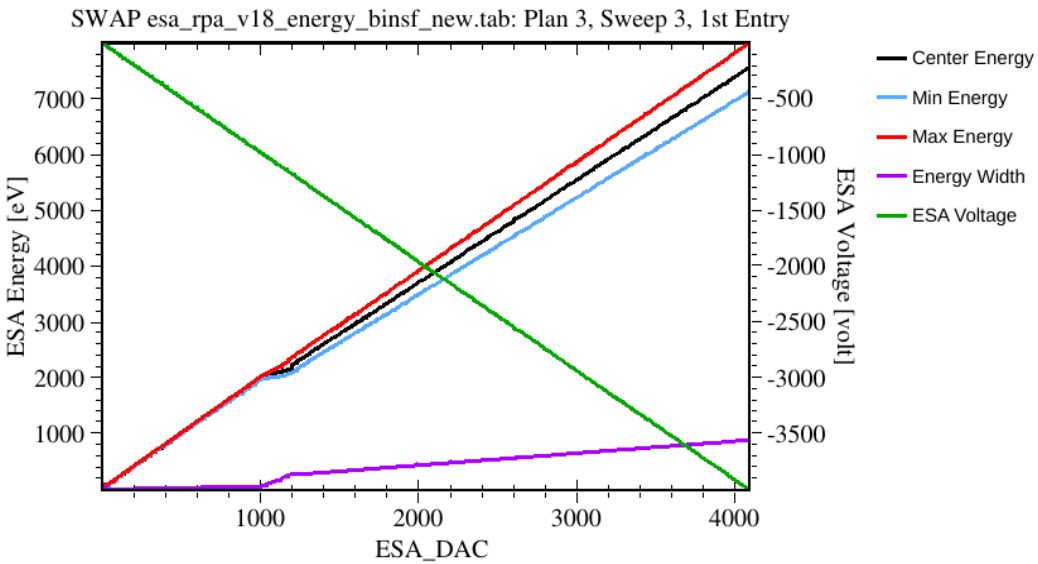

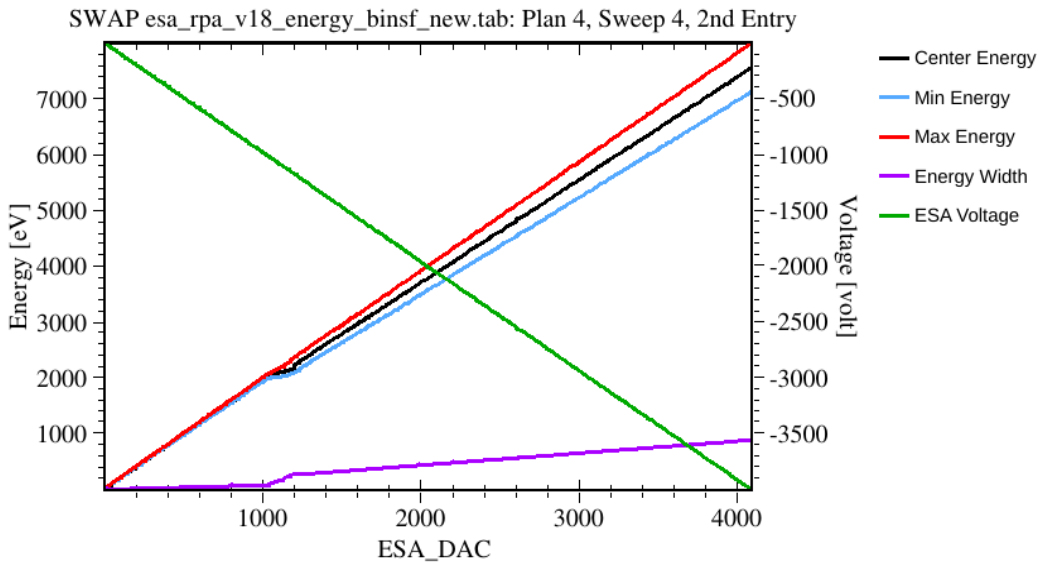

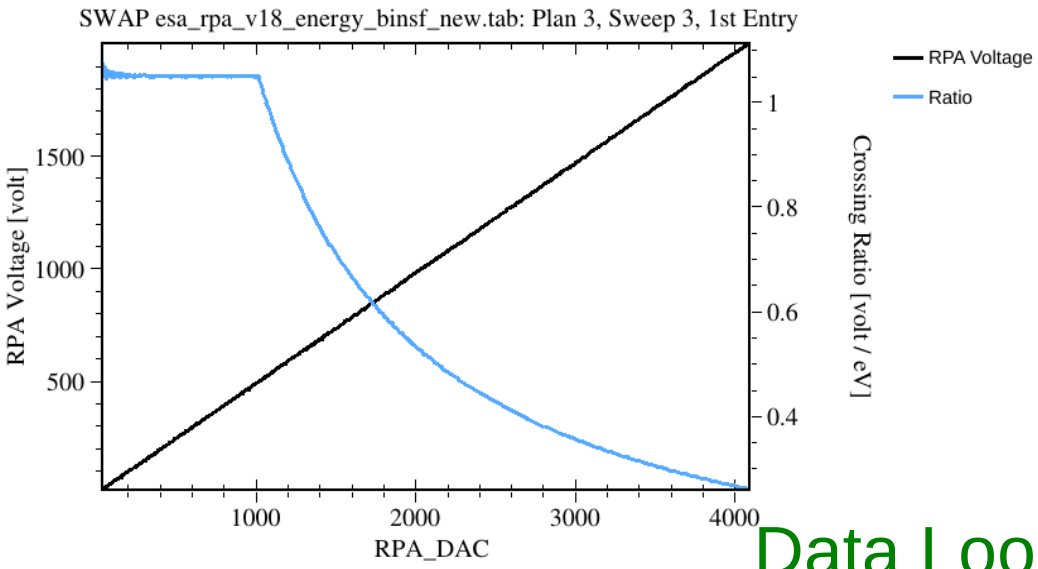

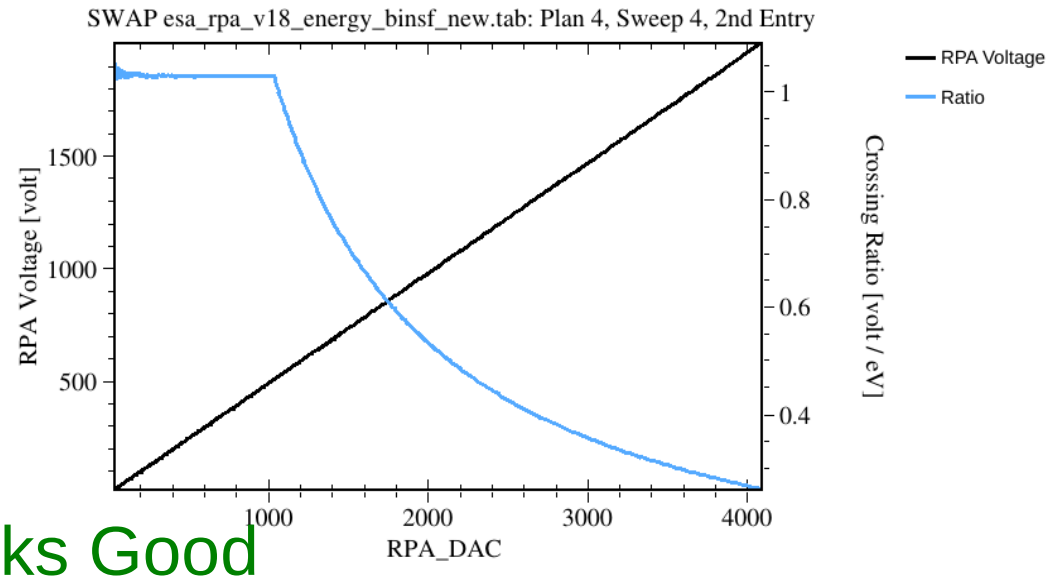

Data Looks Good

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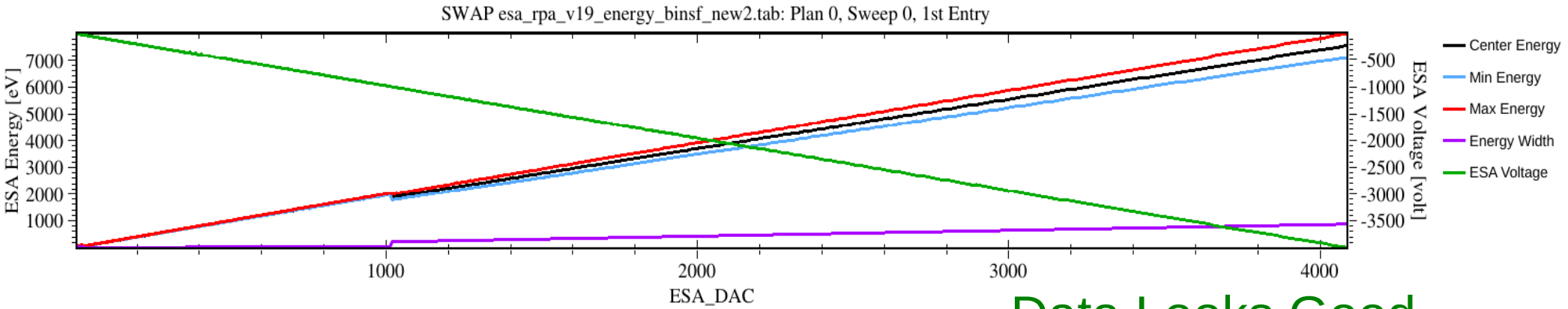

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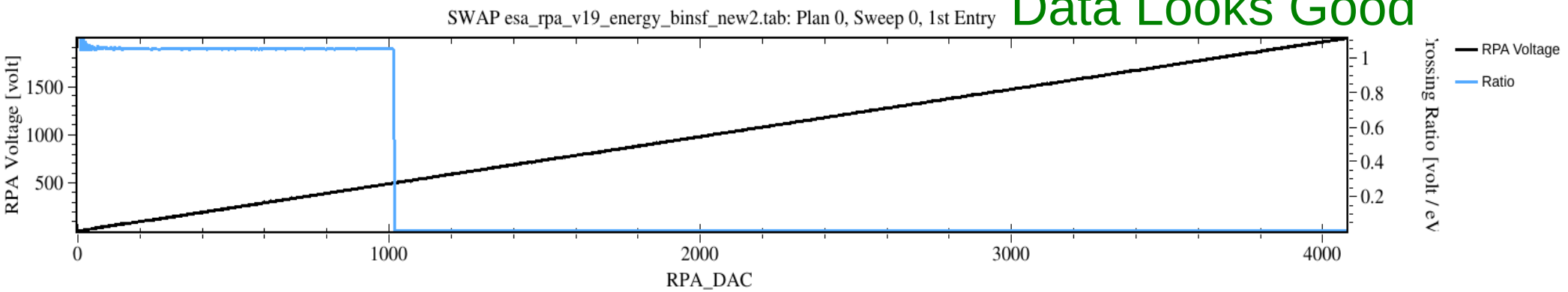

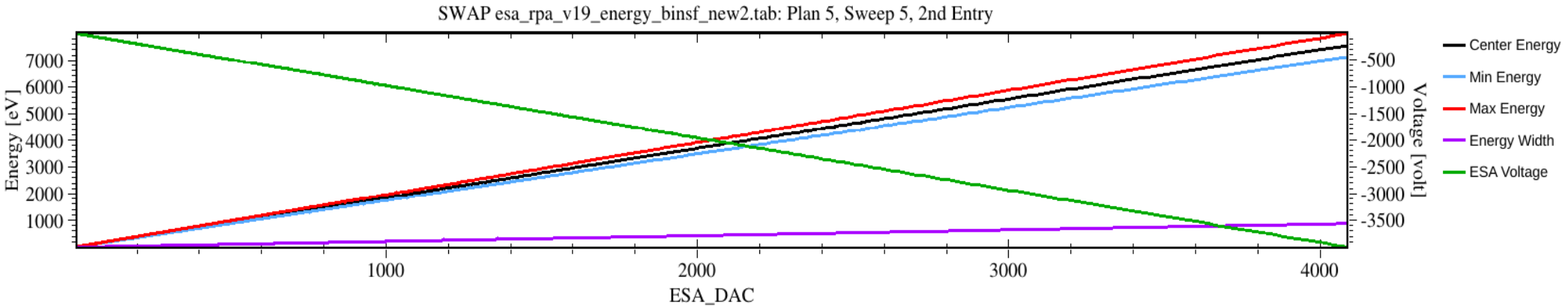

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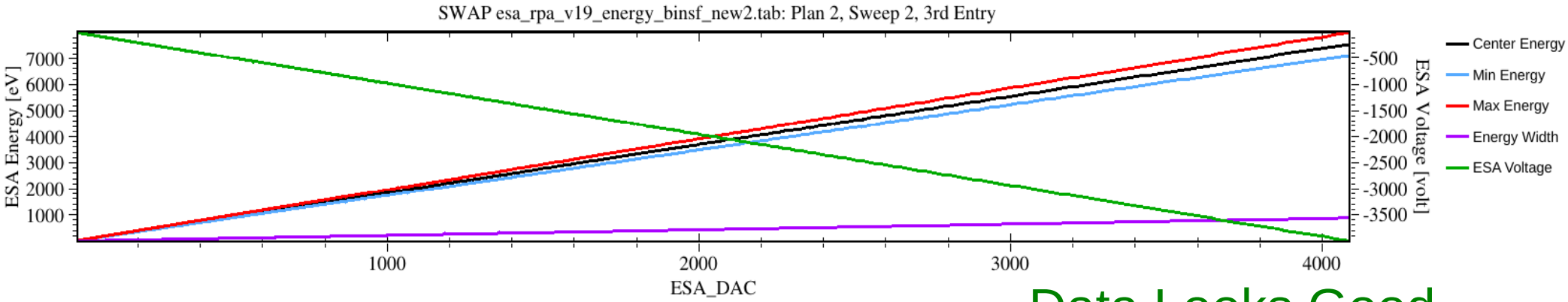
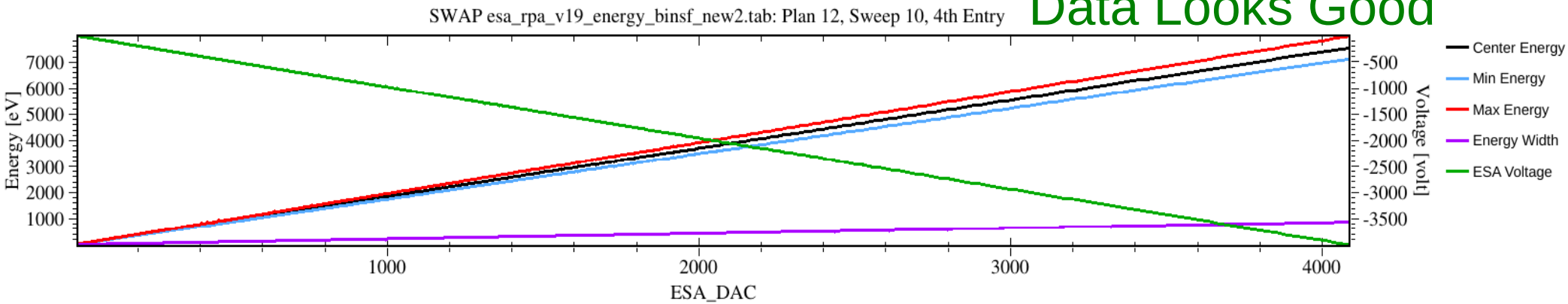
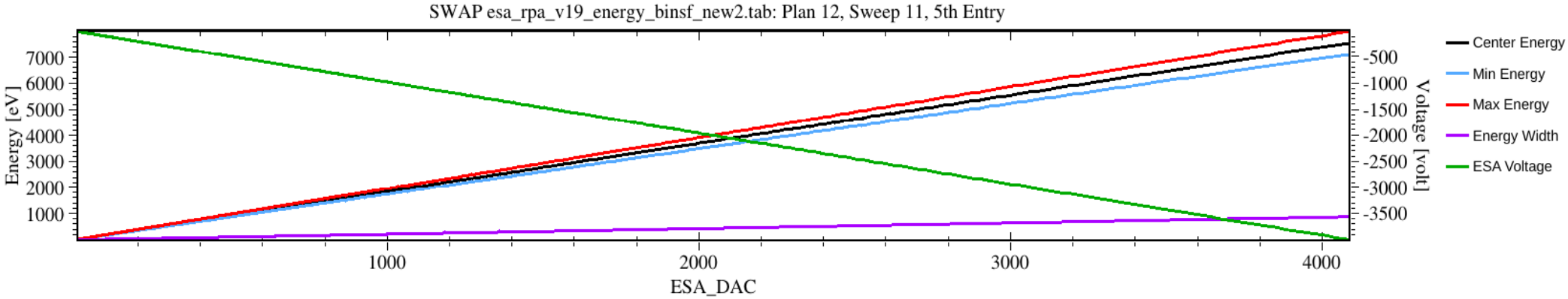


Data Looks Good





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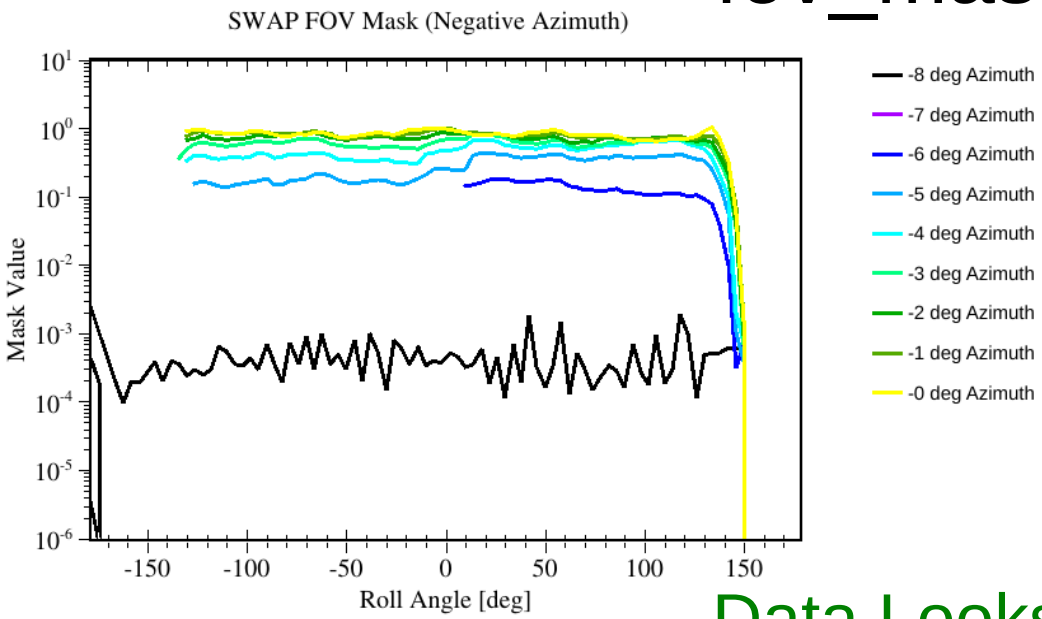

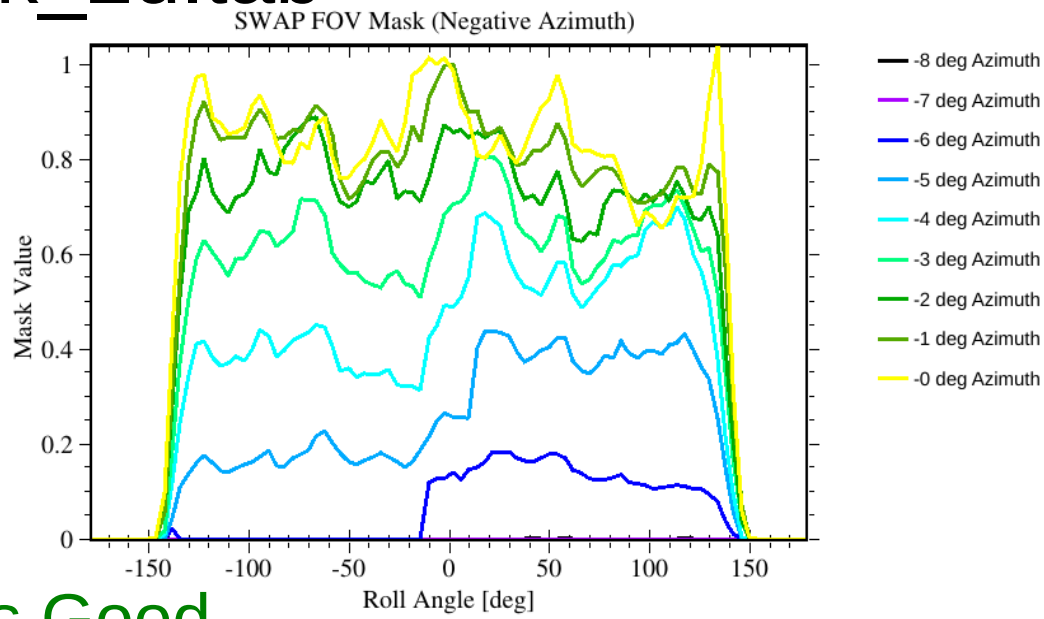

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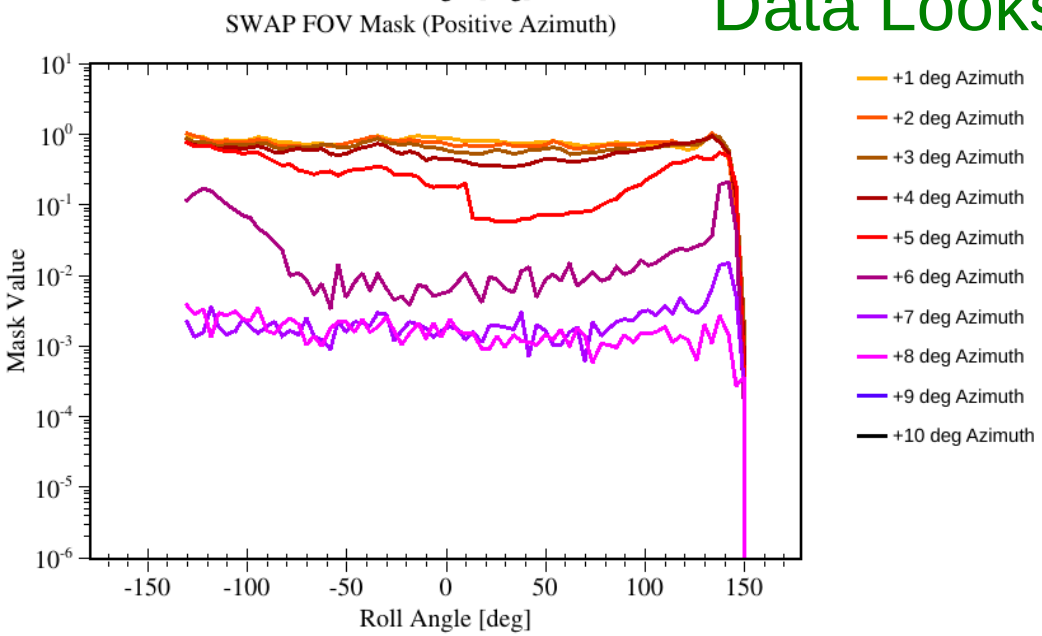

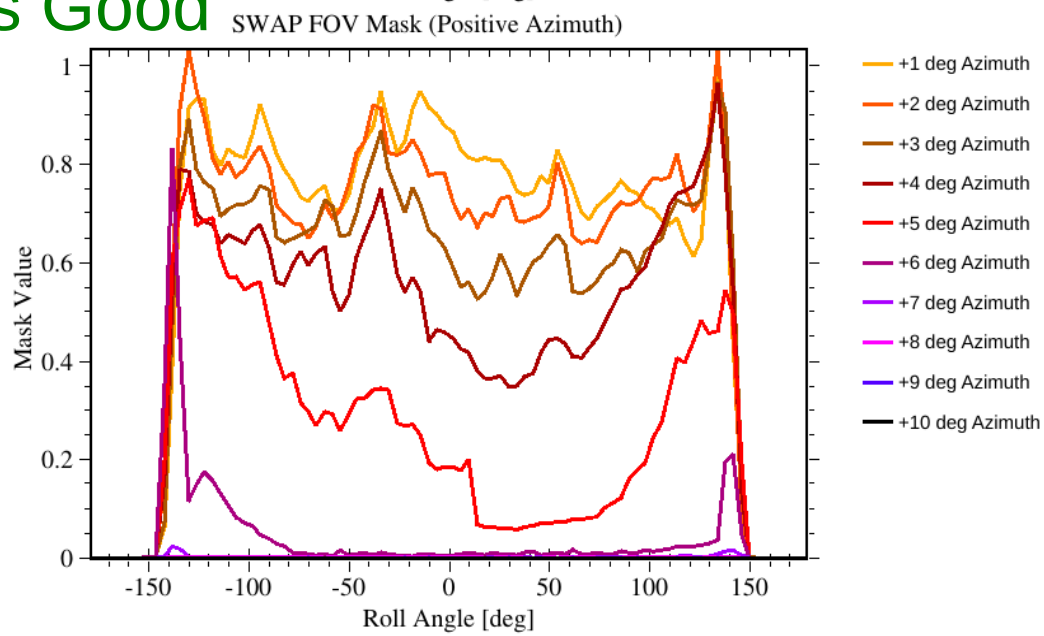

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nh-a-swap-3-kem1-v2.0/calib
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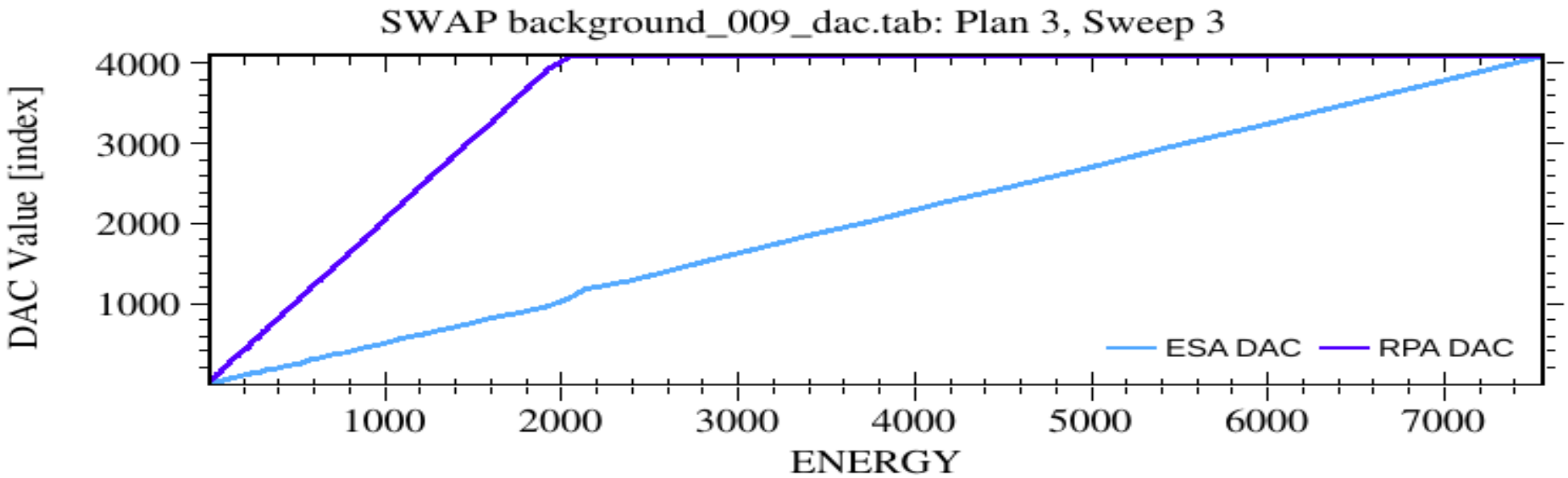

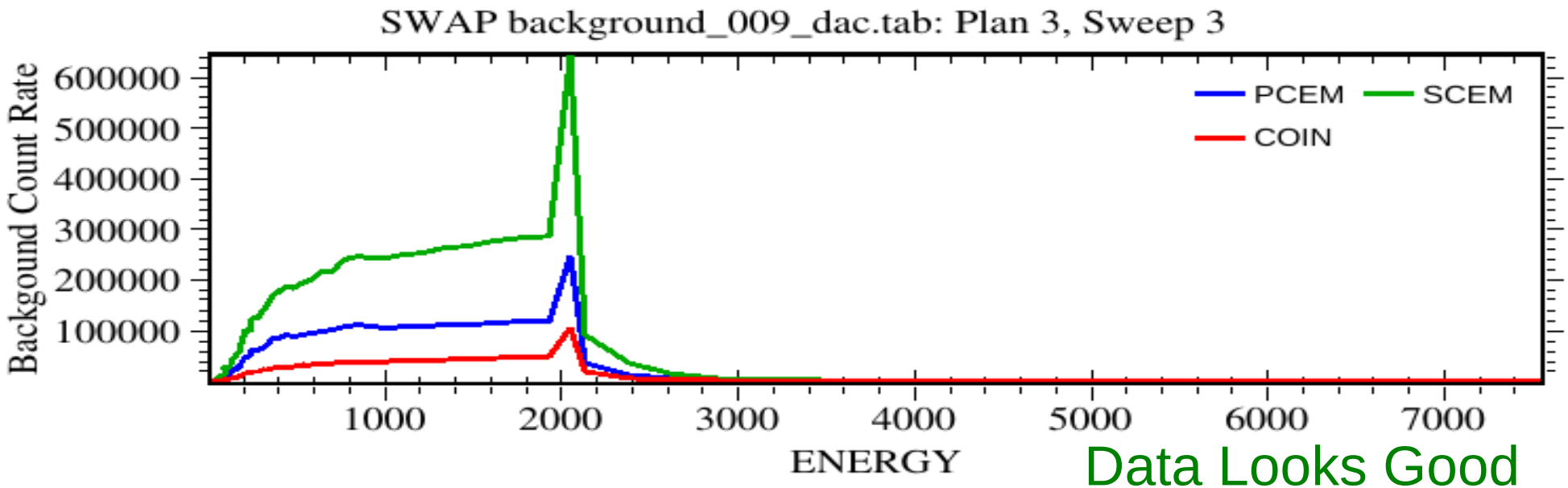

Data Looks Good

Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Sat Feb 1 19:46:09 2020.

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nh-a-swap-3-kem1-v2.0/calib
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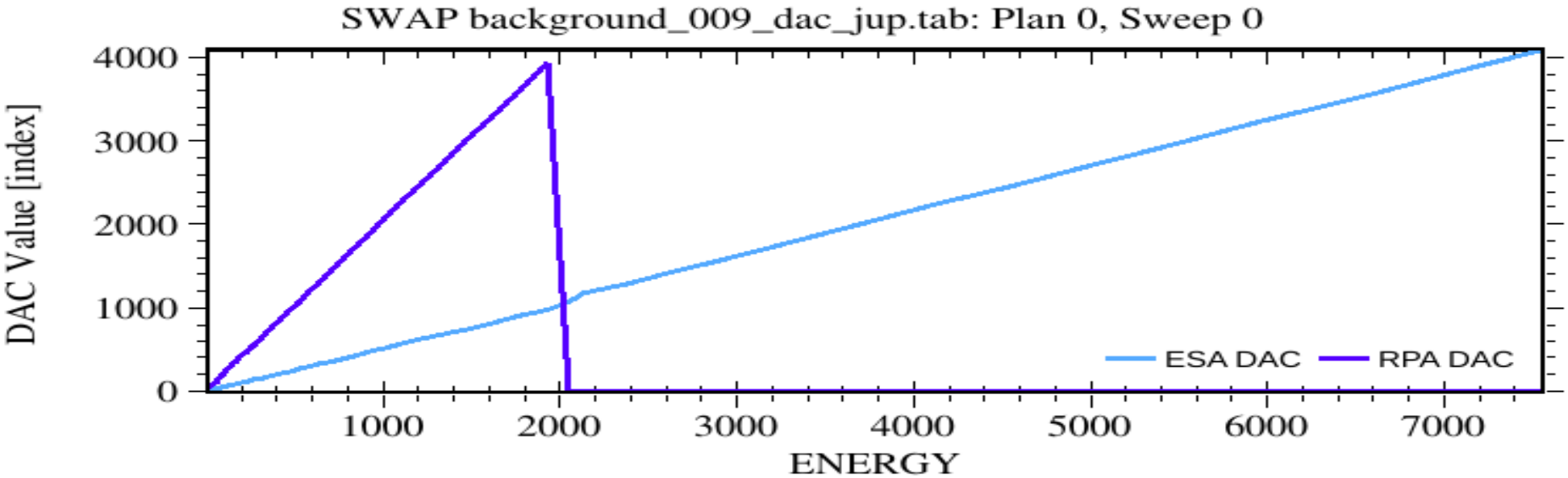
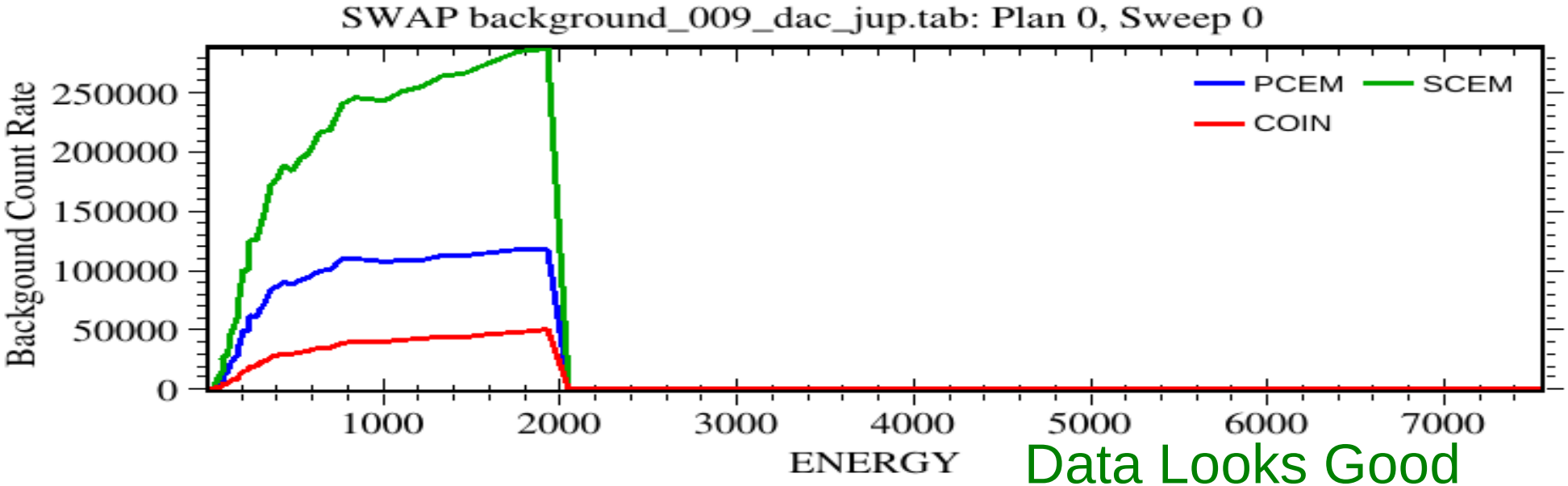


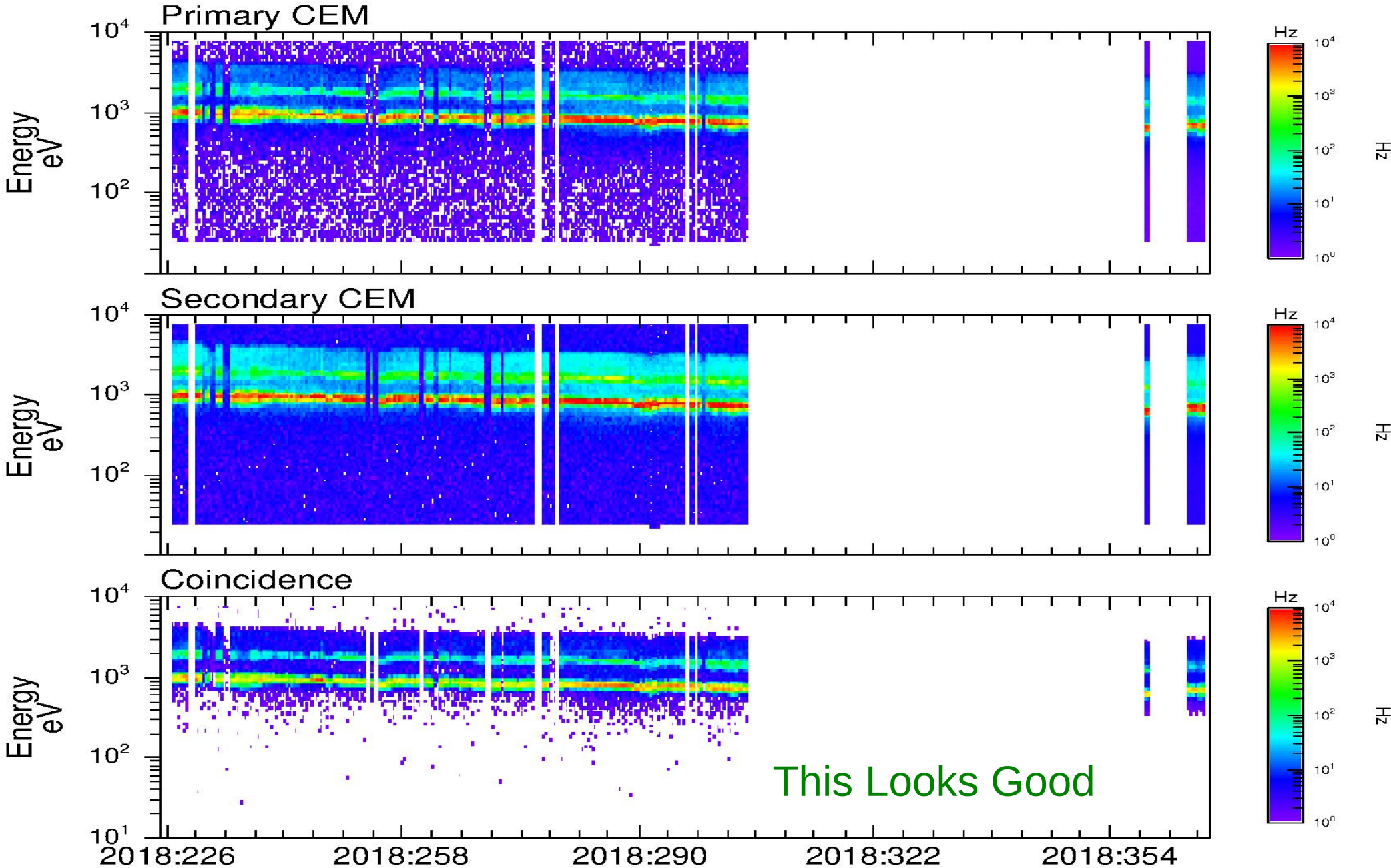


Data Looks Good

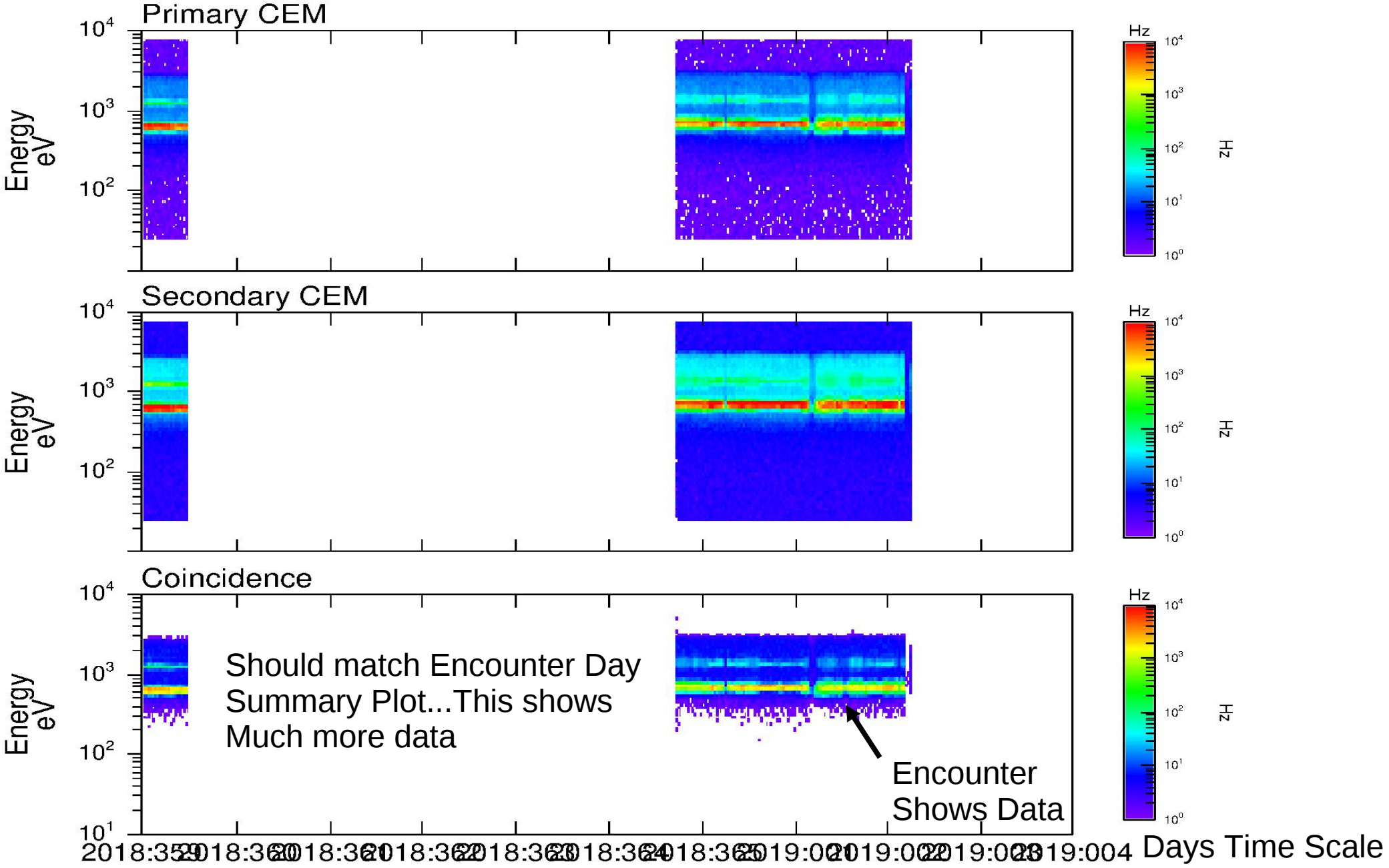
Plot created by SDDAS/gPlot - J. Mukherjee, et al. Generated on Sat Feb 1 19:46:30 2020.

SWAP Data Evaluation

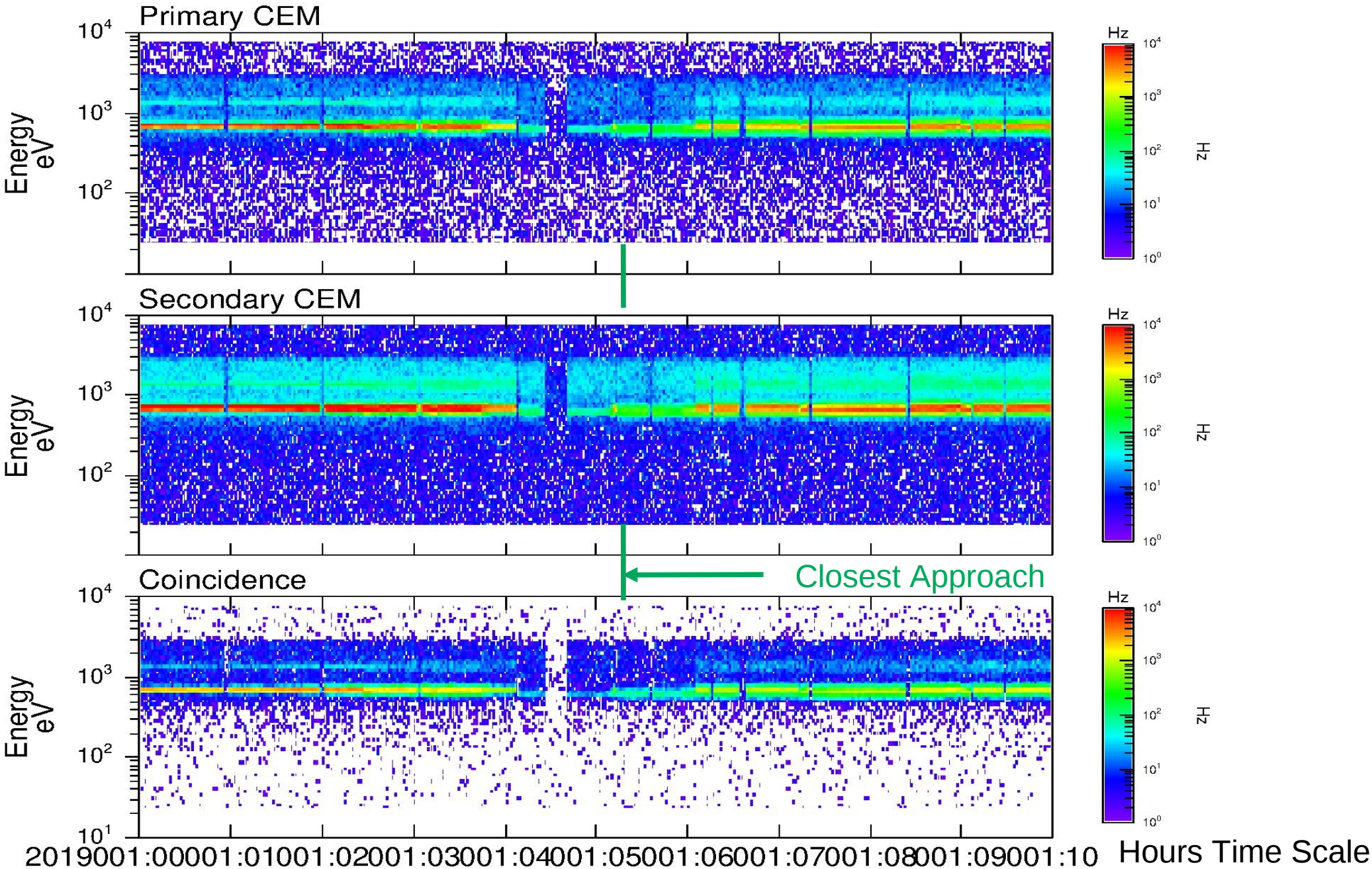
nh-a-swap-3-kem1-v2.0/data
Science Data (0x584)



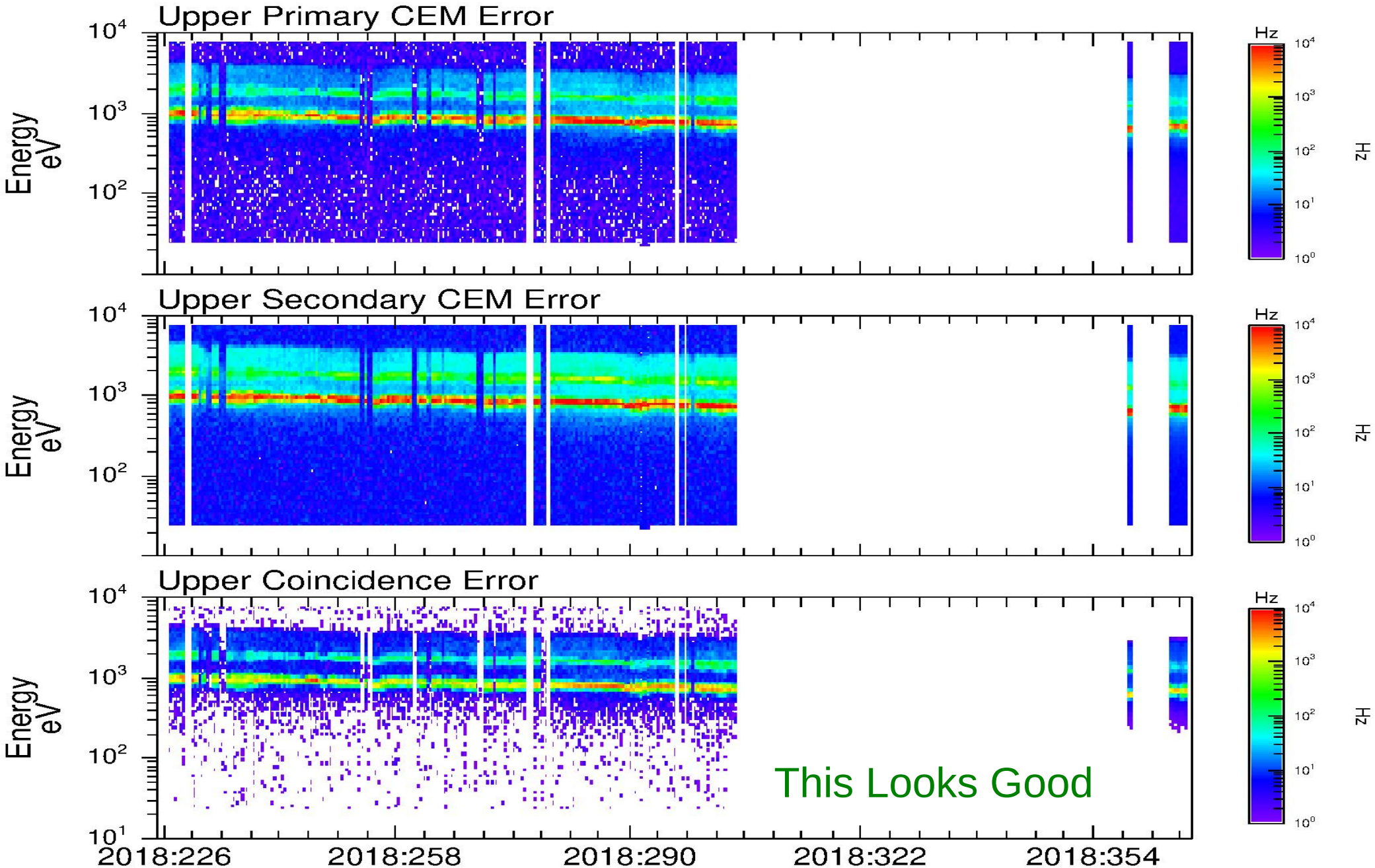
nh-a-swap-3-kem1-v2.0/data
Science Data (0x584)



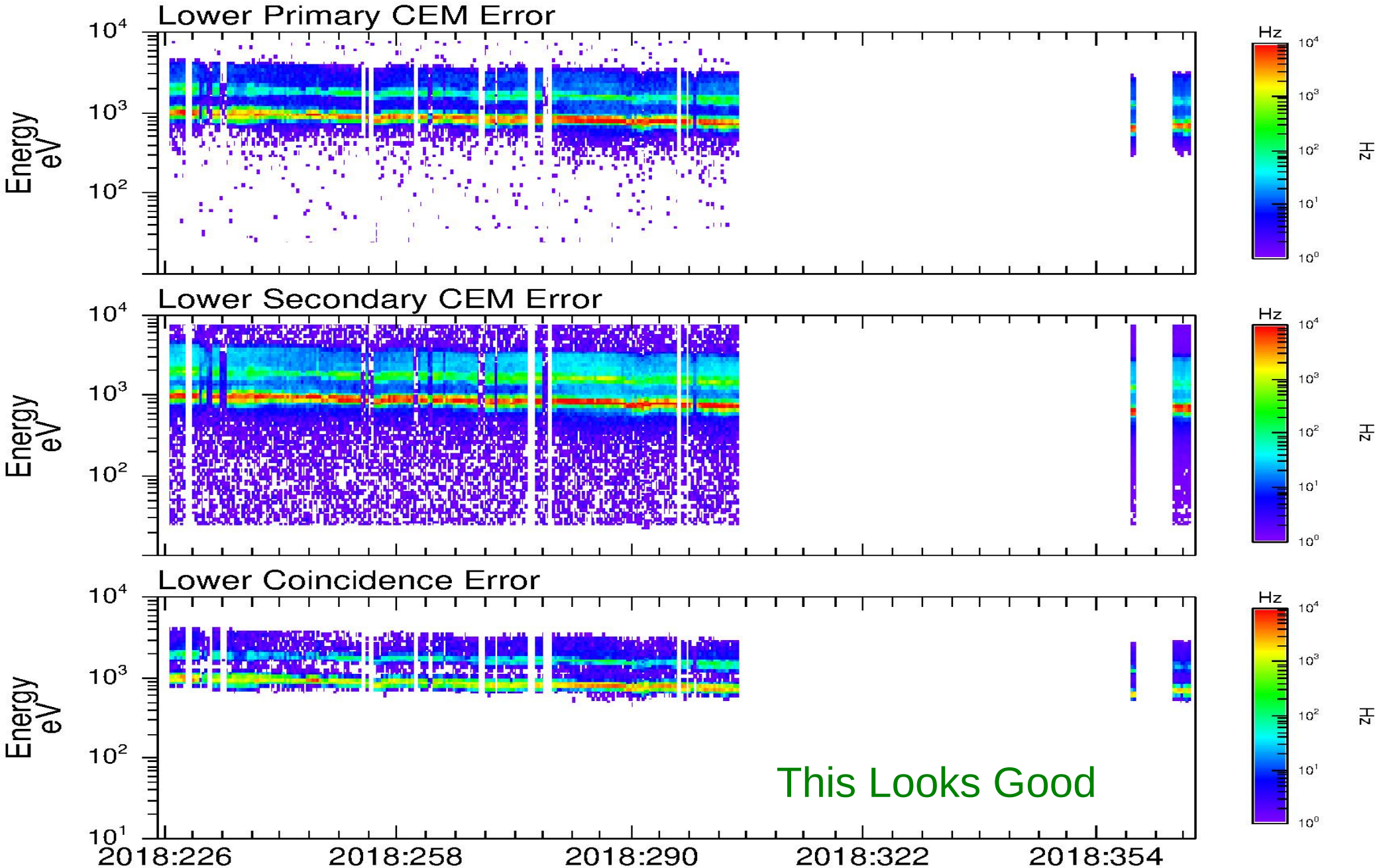
nh-a-swap-3-kem1-v2.0/data
Ultima Thule Encounter



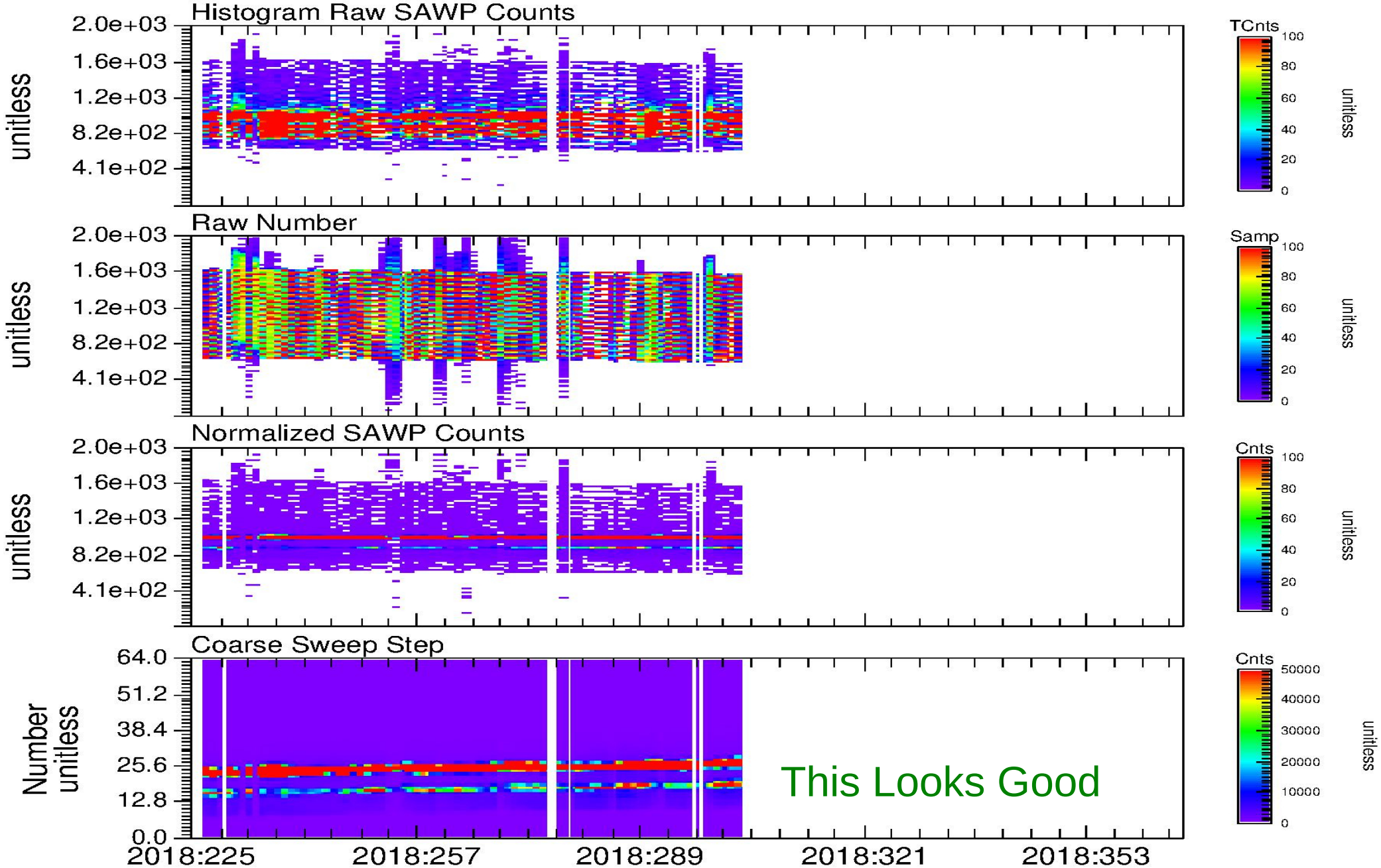
nh-a-swap-3-kem1-v2.0/data
Absolute Maximum Uncertainty



nh-a-swap-3-kem1-v2.0/data
Absolute Minimum Uncertainty



nh-a-swap-3-kem1-v2.0/data
Histogram Data (0x586)

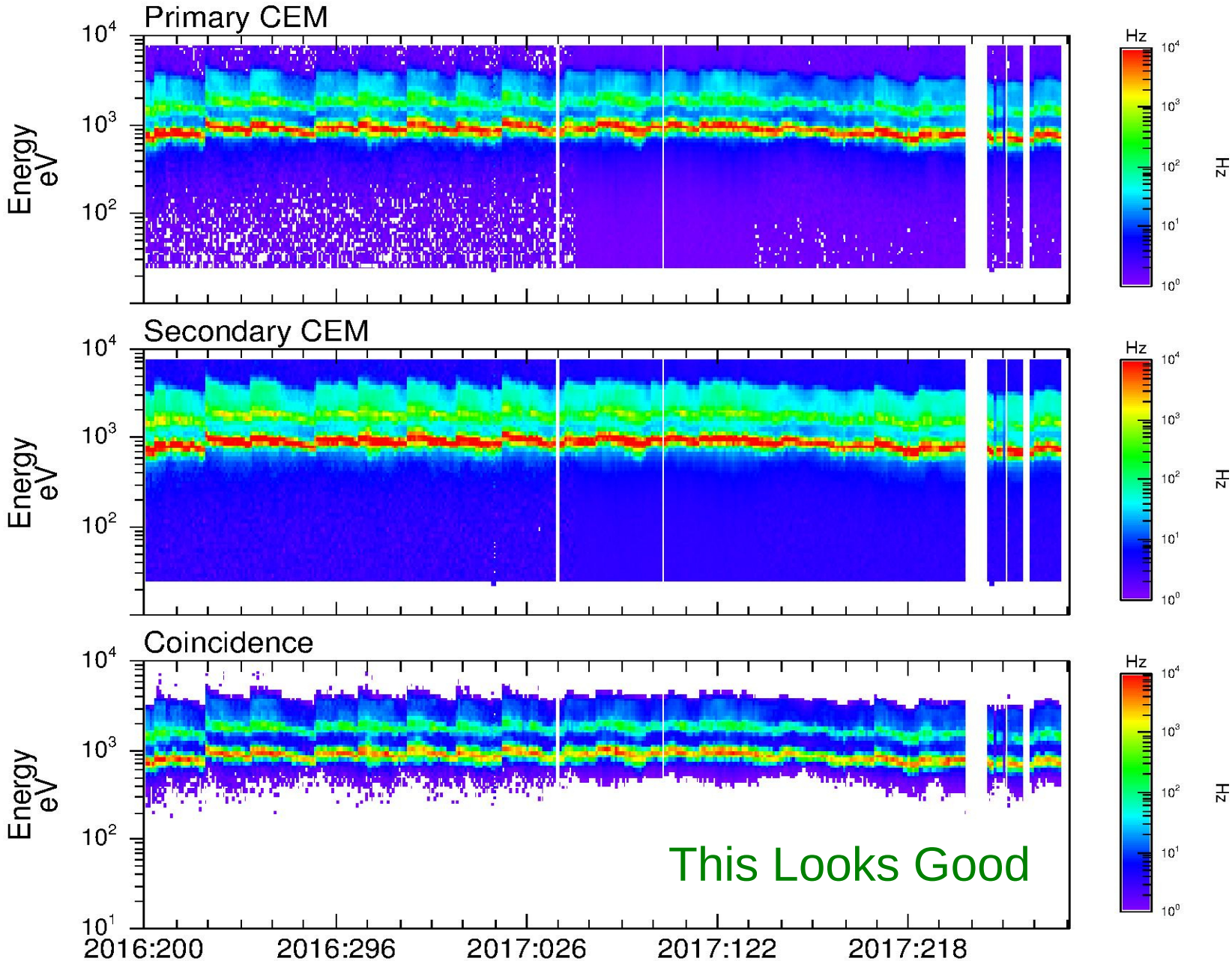


Certification

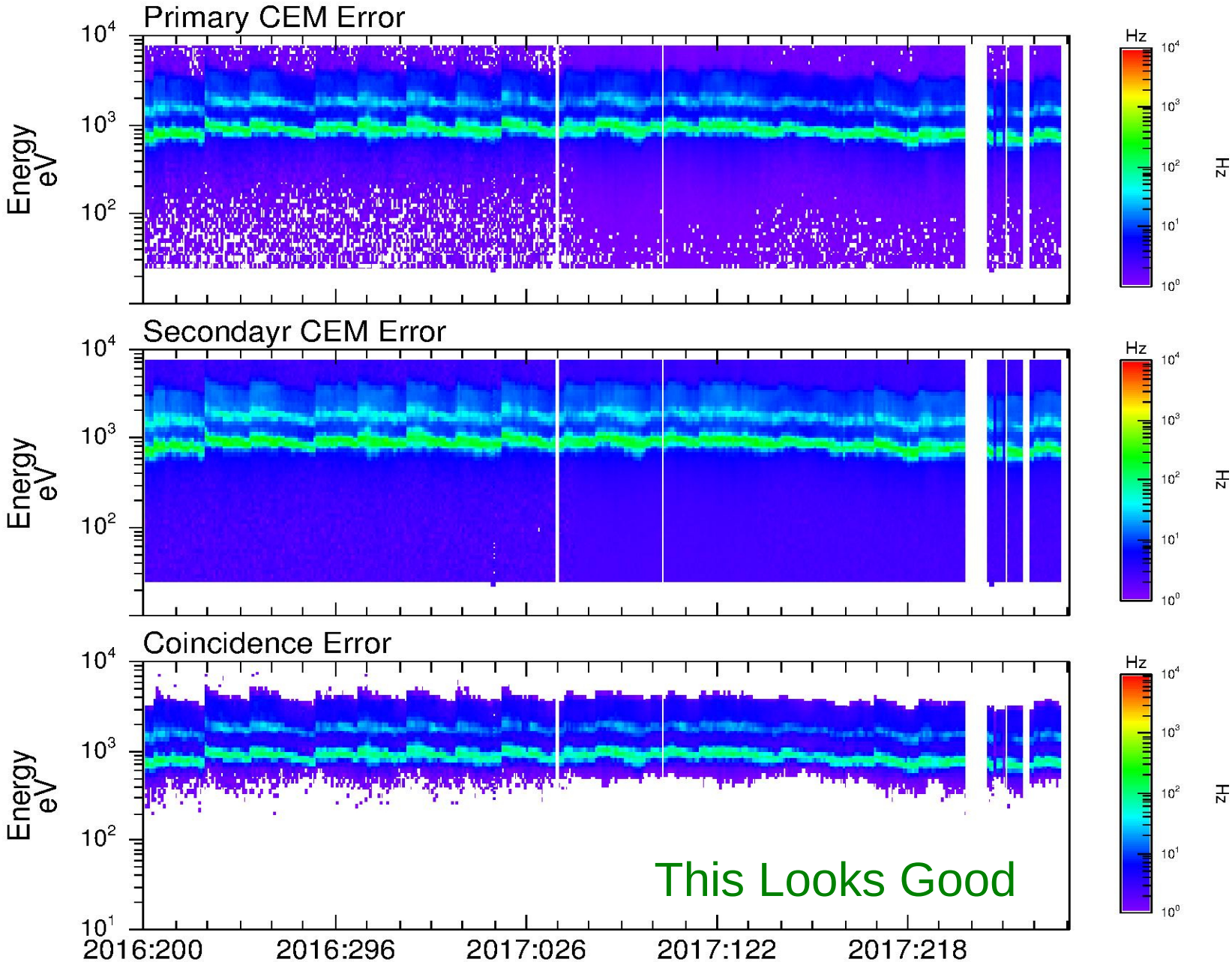
These SWAP data are certifiable and look good to be released to the public; however, there are some issues with the SWAP documentation. In particular, the SWAP calibration catalog file, the New Horizons spacecraft catalog file, and the instrument ICD. There are some other minor issues which need to be cleaned up. In addition, the project should look into whether or not the proper leap second SPICE kernel was included in the trajectory information. Although this probably would not affect SWAP, being 1 second off may effect other New Horizons spacecraft instruments.

BACK-UP SLIDES

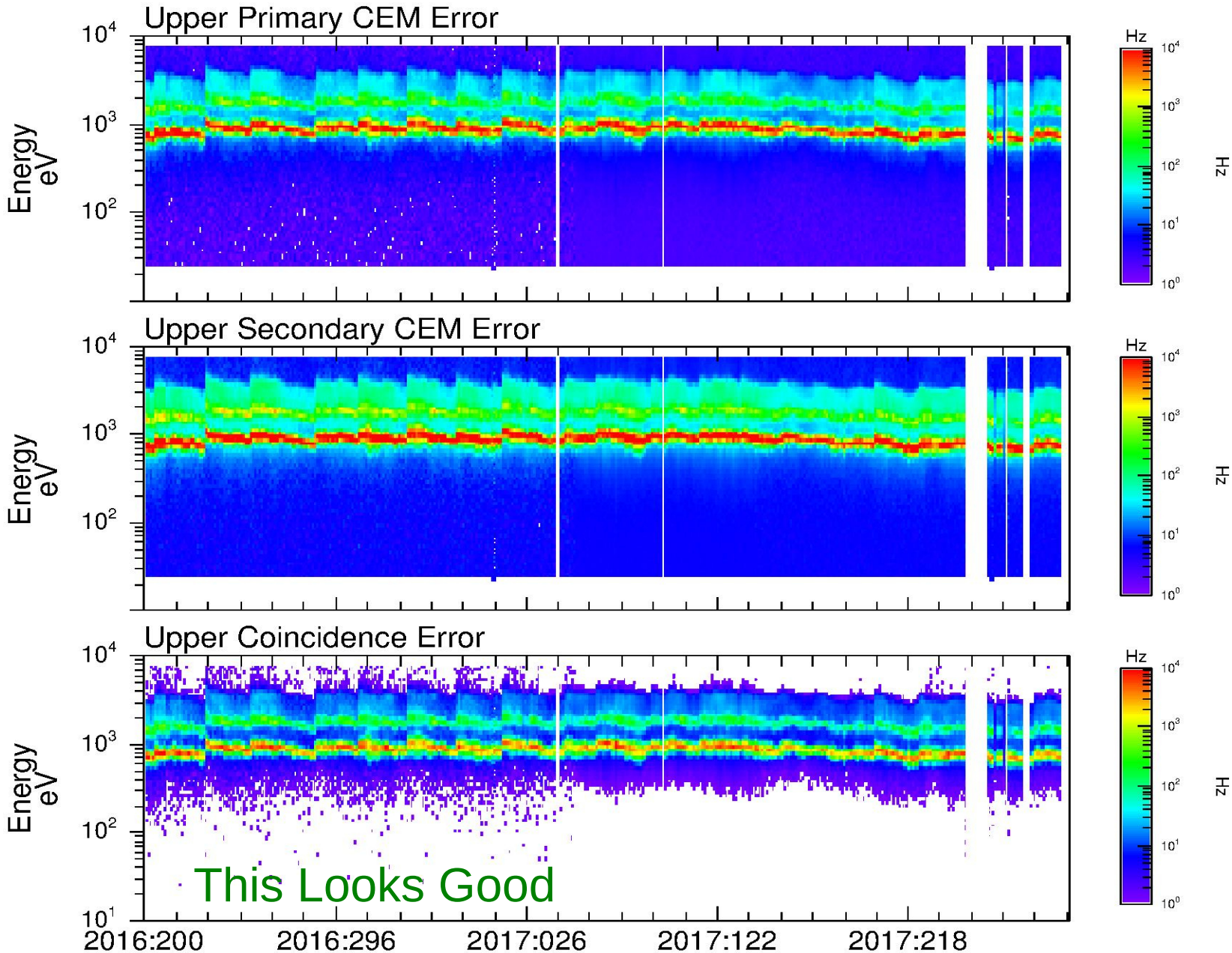
nh-p-swap-3-pluto-v3.0/data
Science Data (0x584)



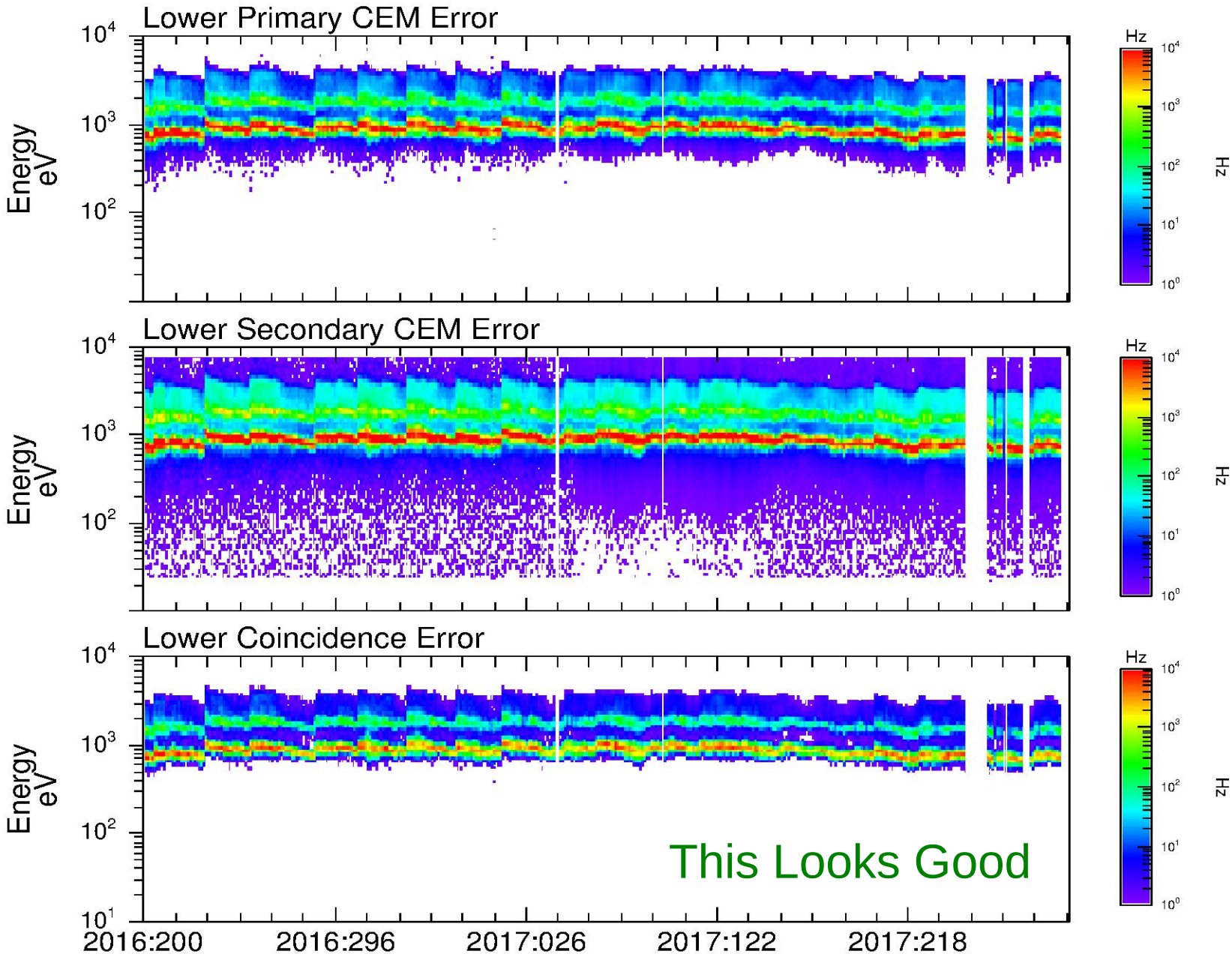
nh-p-swap-3-pluto-v3.0/data
Relative Uncertainty



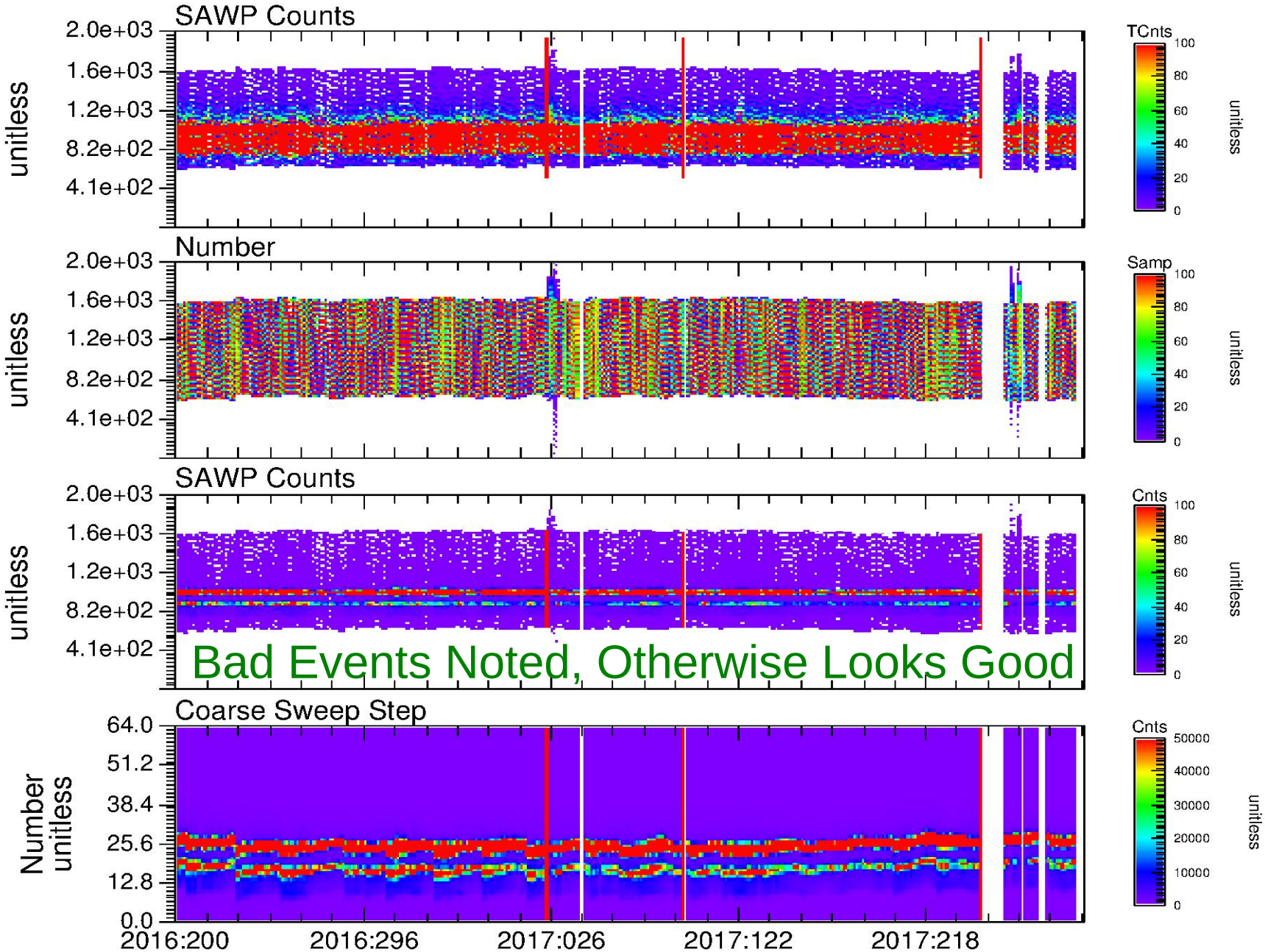
nh-p-swap-3-pluto-v3.0/data
Absolute Maximum Uncertainty



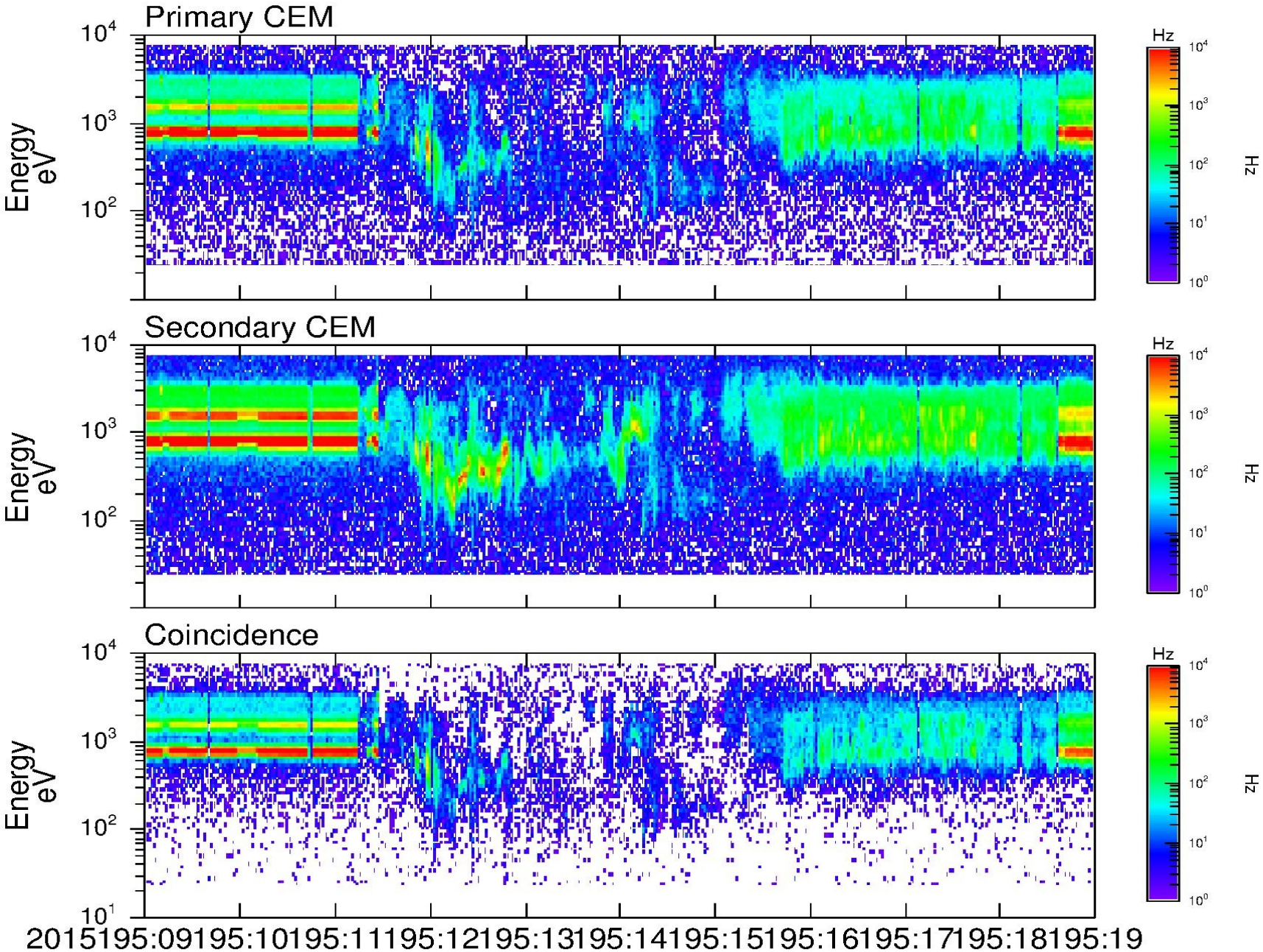
nh-p-swap-3-pluto-v3.0/data
Absolute Minimum Uncertainty



nh-p-swap-3-pluto-v3.0/data
Histogram Data (0x586)



nh-p-swap-3-pluto-v3.0/data
Pluto Encounter



nh-a-swap-2-kem1-v2.0
nh-a-swap-3-kem1-v2.0
aareadme.txt

GOOD

nh-a-swap-2-kem1-v2.0
nh-a-swap-3-kem1-v2.0
voldesc.cat

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2./calib
calinfo.txt

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
rpa_shape.lbl and rpa_shape.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
esa_shape.lbl and esa_shape.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
list_energy_files.lbl & list_energy_files.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
esa_rpa_v16_energy_binsf_new.lbl
esa_rpa_v16_energy_binsf_new.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
esa_rpa_v18_energy_binsf_new.lbl
esa_rpa_v18_energy_binsf_new.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
esa_rpa_v18_energy_binsf_new2.lbl
esa_rpa_v18_energy_binsf_new2.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
fov_mask_2d.lbl & fov_mask_2d.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
background_009_dac_jup.lbl
background_009_dac_jup.tab

GOOD

nh-a-swap-2-kem1-v2.0/calib
nh-a-swap-3-kem1-v2.0/calib
background_009_dac.lbl
background_009_dac.tab

GOOD

nh-a-swap-2-kem1-v2.0/index
nh-a-swap-3-kem1-v2.0/index
indxinfo.txt

GOOD

nh-a-swap-2-kem1-v2.0/index
nh-a-swap-3-kem1-v2.0/index
index.lbl & index.tab

GOOD

nh-a-swap-2-kem1-v2.0/index
nh-a-swap-3-kem1-v2.0/index
slimindx.lbl & slimindx.tab

GOOD

nh-a-swap-2-kem1-v2.0/index
nh-a-swap-3-kem1-v2.0/index
checksum.lbl & checksum.tab

GOOD

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
catinfo.txt

GOOD

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
ref.cat

GOOD

nh-a-swap-2-kem1-v2.0/catalog
nh-a-swap-3-kem1-v2.0/catalog
swap.cat

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
docinfo.txt

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
codmac_level_definitions.lbl
codmac_level_definitions.pdf

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
lunineetal1995.lbl & lunineetal1995.pdf

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
nh_fov.lbl & nh_fov.pdf

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
nh_met2utc.lbl & nh_met2utc.tab

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
nh_mission_trajectory.lbl
nh_mission_trajectory.tab

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
nh_swap_v200_ti.txt

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
payload_ssr.lbl & payload_ssr.pdf

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
quat_axyz_instr_to_j2k.lbl
quat_axyz_instr_to_j2k.asc

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
swap_ssr.lbl & swap_ssr.pdf

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
seq_swap_kem1.lbl & seq_swap_kem1.tab

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
swap_cal.lbl

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
soc_inst_icd.lbl

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
data_summary_plots/data_summary.lbl

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
traj/trajinfo.txt

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
traj/traj.fmt

GOOD

nh-a-swap-2-kem1-v2.0/document
nh-a-swap-3-kem1-v2.0/document
traj/traj_2006_2021_1d.lbl

GOOD