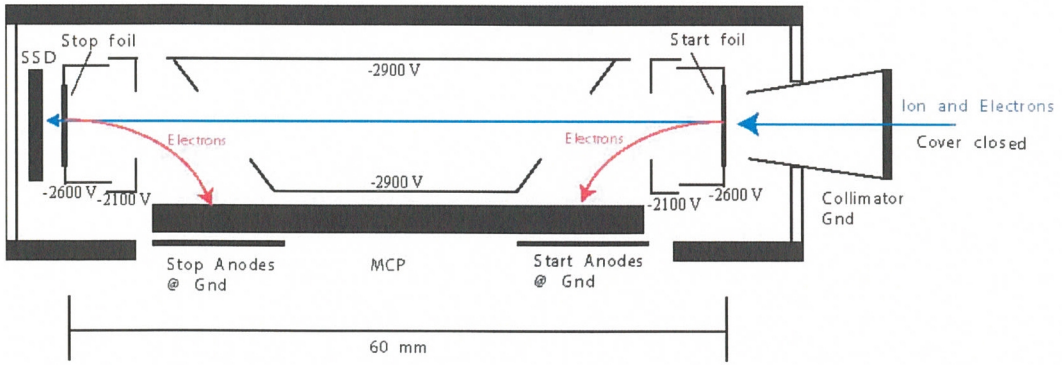
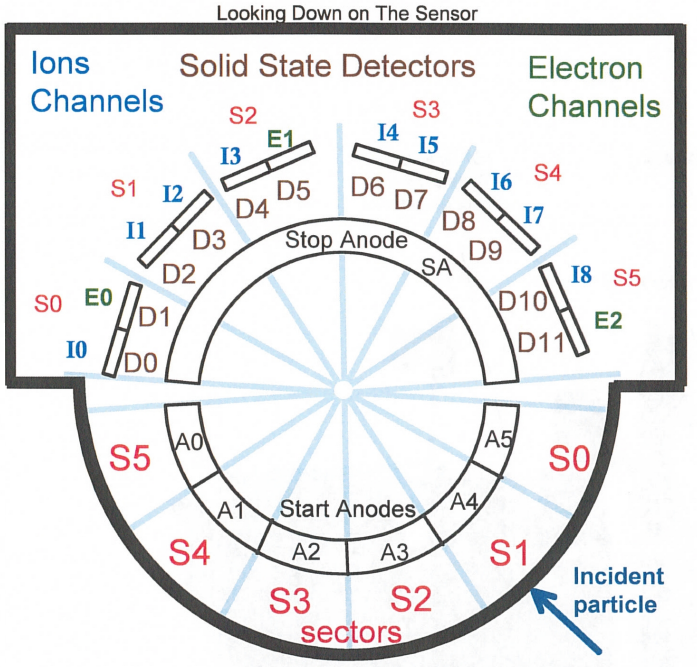
New Horizons Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI)

PRINCIPAL INVESTIGATOR: Ralph McNutt, APL
DESCRIPTION: Medium Energy Particle Spectrometer
ENERGY RANGE: 25-1000 keV (protons)
60-1000 keV (atomic ions)
25-500 keV (electrons)

FIELD OF VIEW: 160 deg x 12 deg
ANGULAR RESOLUTION: 25 deg x 12 deg
ENERGY RESOLUTION: 0.25 keV
SENSOR SIZE: 7.6 cm dia. x 2.5 cm thick
POWER: 1.4 watt
MASS: 1.5 kg





New Horizons PEPSSI Data Sets

RAW ->

nh-p-pepssi-2-pluto-v1.0

CALIBRATED ->

nh-p-pepssi-3-pluto-v1.0

New Horizons PEPSSI Data Set Evaluation Tools

Staging and Evaluation -

Machine: Dell Precision T3400

Operating System: Fedora 18 linux

Data Processing -

Machine: Sun Ultra-350

Operating System: Sun Solaris OS 5.9

Minor Diagnostics -

Machine: IBM lenovo T60p ThinkPad

Operating System: Fedora 20 linux

Documentation Evaluation

nh-p-pepssi-3-pluto-v1.0
nh-p-pepssi-3-pluto-v1.0
aareadme.txt

Case Sensitivity – File names within double quotes (“...”) are shown in upper case characters, but are listed in the archive as lower case characters. This makes a difference to some machines. Should this be discussed here?

nh-p-pepssi-3-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
ref.cat - 1

The following slide was from the New Horizons review in 2014. At that time, these documents would not be released because of ITAR concerns by JPL. The SBN was going to look into this and there was some discussion about providing a non-ITAR sensitive reference to take the place of these references. There was also some discussion about demoting these references so that the could be released to the public. These references are again in the PEPSSI data reference list.

nh-x-pepssi-2-plutocruise-v1.0/catalog
nh-x-pepssi-3-plutocruise-v1.0/catalog
ref.cat - 2

- SwRI library unable to locate the following references:

```
OBJECT               = REFERENCE
  REFERENCE_KEY_ID   = "DSN810-5"
  REFERENCE_DESC     = "
Deep Space Network / Flight Project Interface Design Book, JPL-D-810-5, Jet
Propulsion Laboratory, Pasadena, CA 2003.
  "
END_OBJECT           = REFERENCE

OBJECT               = REFERENCE
  REFERENCE_KEY_ID   = "DSN821-104"
  REFERENCE_DESC     = "
Deep Space Mission Systems, Tracking and Navigation Service, Requirements and
Design, DSMS No. 821-104, Rev. B, JPL D-17235, Jet Propulsion Laboratory,
Pasadena, CA, 2003.
  "
END_OBJECT           = REFERENCE

OBJECT               = REFERENCE
  REFERENCE_KEY_ID   = "DSN821-110"
  REFERENCE_DESC     = "
Deep Space Mission Systems, Radio Science Service, Requirements and Design,
DSMS No. 821-110, Rev. A, JPL D-17241, Jet Propulsion Laboratory, Pasadena,
CA, 2001.
  "
END_OBJECT           = REFERENCE
```

nh-p-pepssi-3-pluto-v1.0/catalog

If they are still controlled documents, they do not belong in the PEPSSI reference list which is released to the public.

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
aareadme_bu.txt

Since this file is a duplicate of the aareadme.txt file in the home directory:

Case Sensitivity – File names within double quotes (“...”) are shown in upper case characters, but are listed in the archive as lower case characters. This makes a difference to some machines. Should this be discussed here?

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
soc_inst_icd.pdf

The “rateboxdefinitionplanes.fit” file is specified either in the wrong directory or it is included within the wrong directory:

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c. For ease of use, we have added a column giving the deduced “Rate Box” of High-Ion PHA and Electron PHA events to the Level 2 PHA data. While this can, in principle, be calculated from the raw Level 2 quantities and the RATEBOXDEFINITIONPLANES.FIT file available in the CALIB/ directory of the PDS archive, the procedure is complex enough that we have found it convenient to perform this calculation in advance and include the information in the Level 2 files.

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B Rates: The TOF vs Energy plane is divided into 19 “Rate Boxes” as shown in Figure 11-6. Each high energy ion is classified into a Rate Box and further its incident sector is used to classify it, resulting in a Rate, or histogram cell designation of the form BnnSnn. The B boxes at any given point in the mission can be found in the Rate Box Definition Planes file in the CALIB/ directory.

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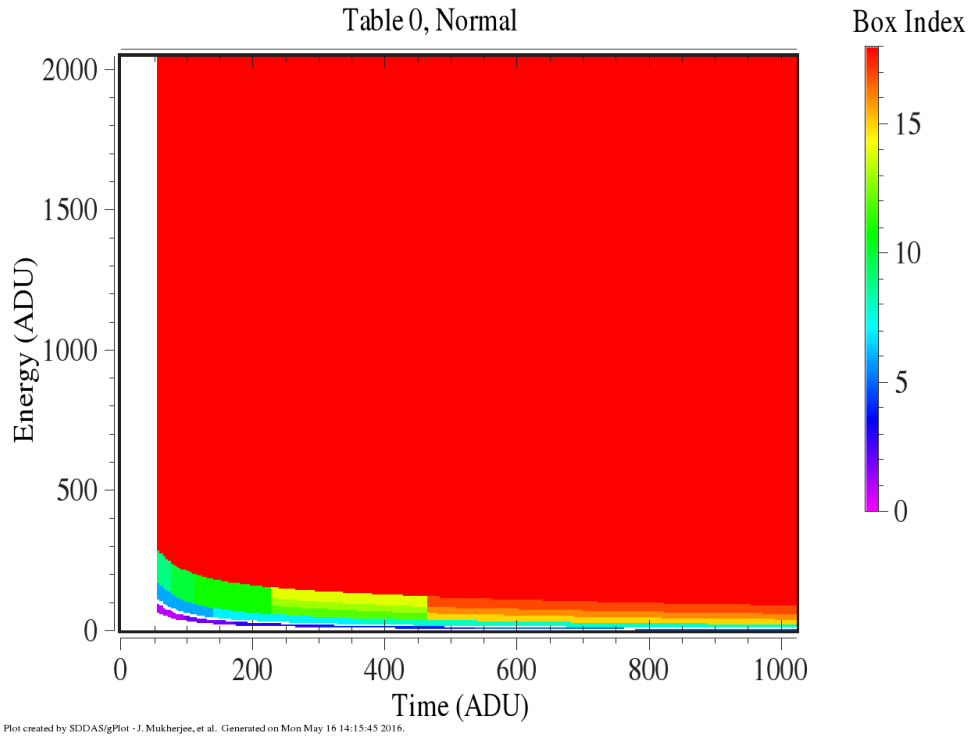
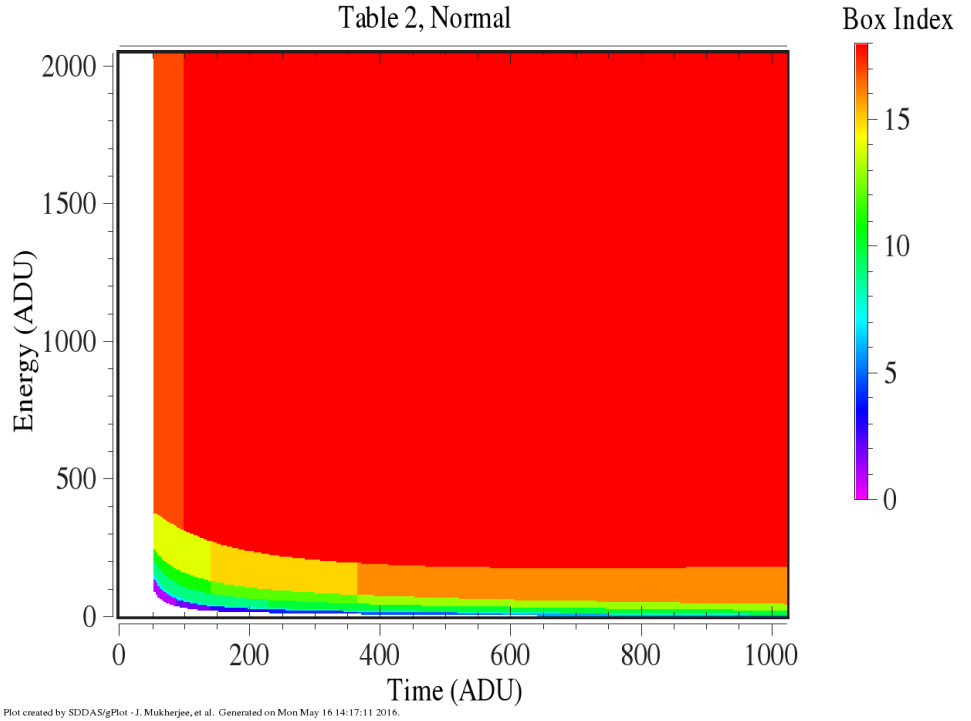
11.4.3.5.1 Rate Box Definitions

For Electrons and Low-Ions, the rate box definitions are simple ranges in Energy and TOF in ADUs which can be found in the Level 2 headers. For Hi-Ions, the Rate Boxes are regions in the TOF-Energy plane (see Figure 11-6). The precise specification of the rate boxes is complex and this is why we include rate box classifications in the Level 2 PHA data. However, we also provide the file RATEBOXDEFINITIONPLANES.FIT in the CALIB/ directory of PDS data sets.

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
rateboxdefinitionplanes.fit

I was expecting to see the rate box index 0-18 in the table; however, I can not find any number other than 0 using the fv viewer, but I was able to use a tool provided by Joey Mukherjee and I was able to read the file. Below is the results:





nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
rateboxdefinitionplanes.lbl

This file and the “rateboxdefinitionplanes.fit” file are in the wrong directory:

Level 2 PHA data. However, we also provide the file RATEBOXDEFINITIONPLANES.FIT [this file] in the CALIB/ directory of PDS data sets.

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
pdsdd_insert_newhorizons.txt

GOOD, but this file reads as through it was a left over file from creating the data files for delivery and not supposed to be included. Is is supposed to be here?

nh-p-pepssi-3-pluto-v1.0/calib/calpars
nh-p-pepssi-3-pluto-v1.0/calib/calpars
calpar.tab Data Files

I examined some random data files and they all looked good.

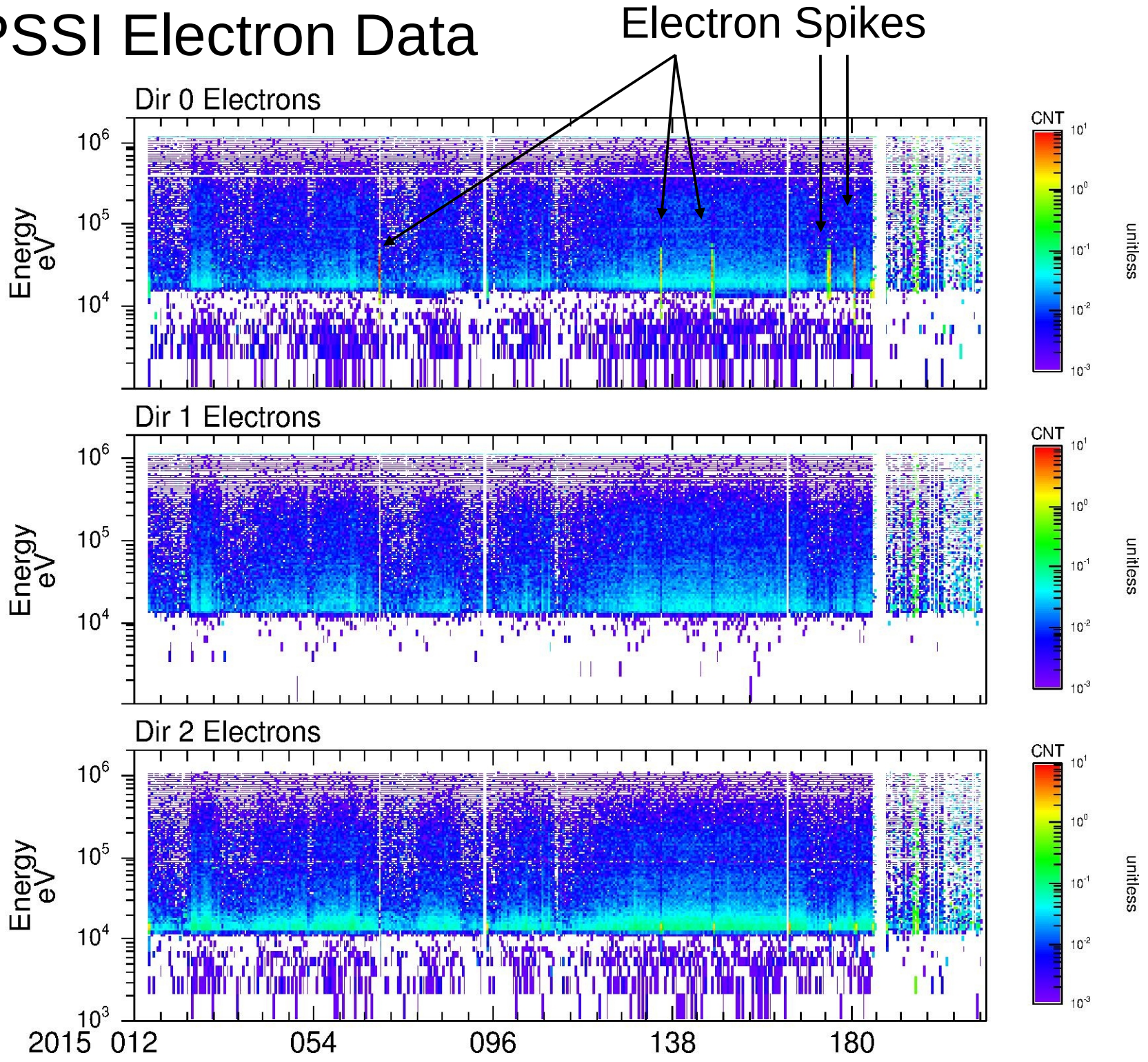
Data Evaluation

PEPSSI Electrons

The PEPSSI electrons were examined. There are electrons observed at a cutoff about 10^4 eV. This is probably the threshold level. I expect that the as the energy of the electrons decrease, the number of counts increase. Not sure why electrons are observed at energies below the 10^4 threshold. This is seen in directions 0 and 2.

I am also not sure what are the electron spikes pointed out in the next slide.

PEPSSI Electron Data



Low Energy and Heavy Ions

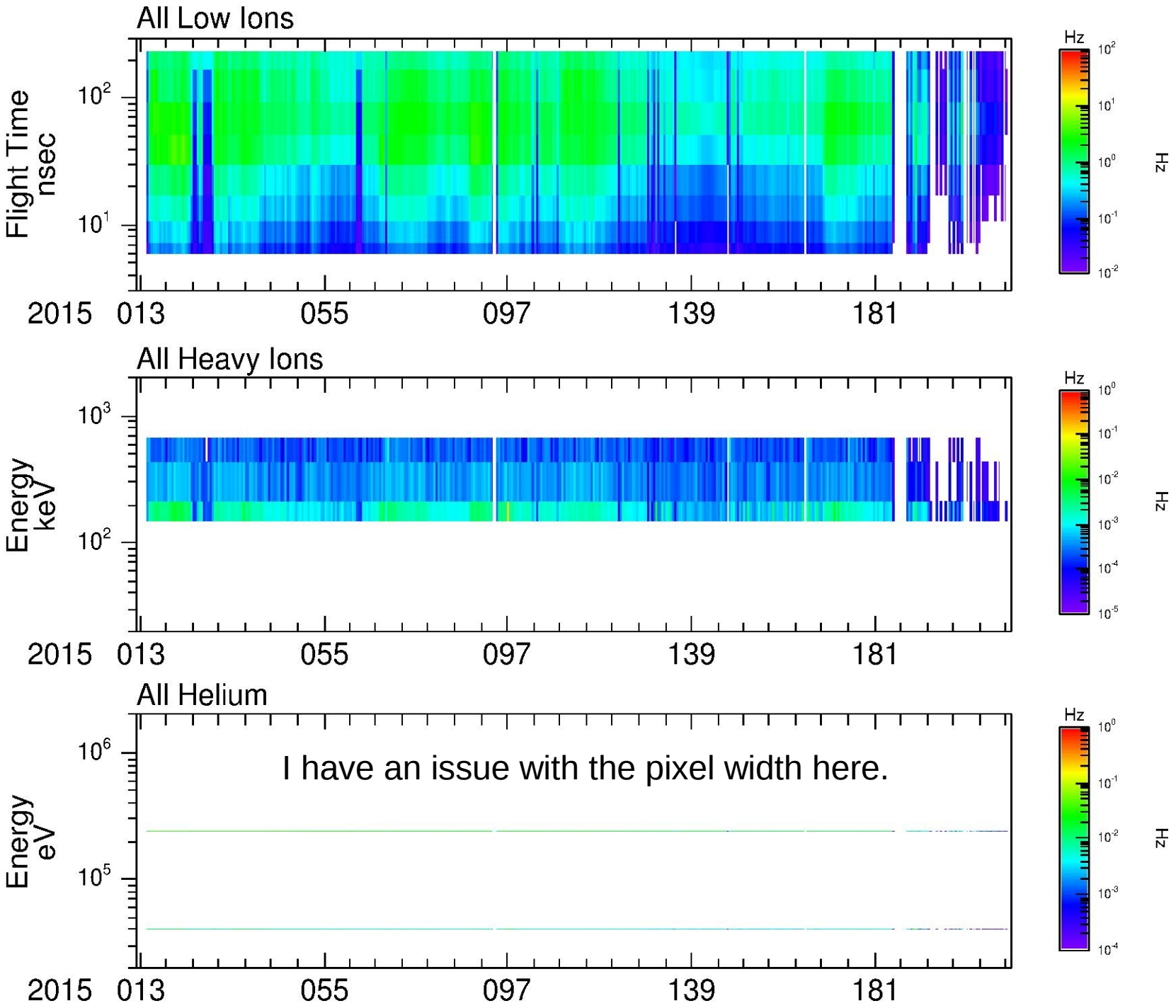
The time-of-flight spectrum for low energy ions show more ions at low energy than at higher energy. The heavy ions also show more counts at lower energy which is in the right direction.

(Note: I did not get the helium spectrogram width correct, so the spectrogram shows the improper energy width for each energy.)

Useful Table for PEPSSI

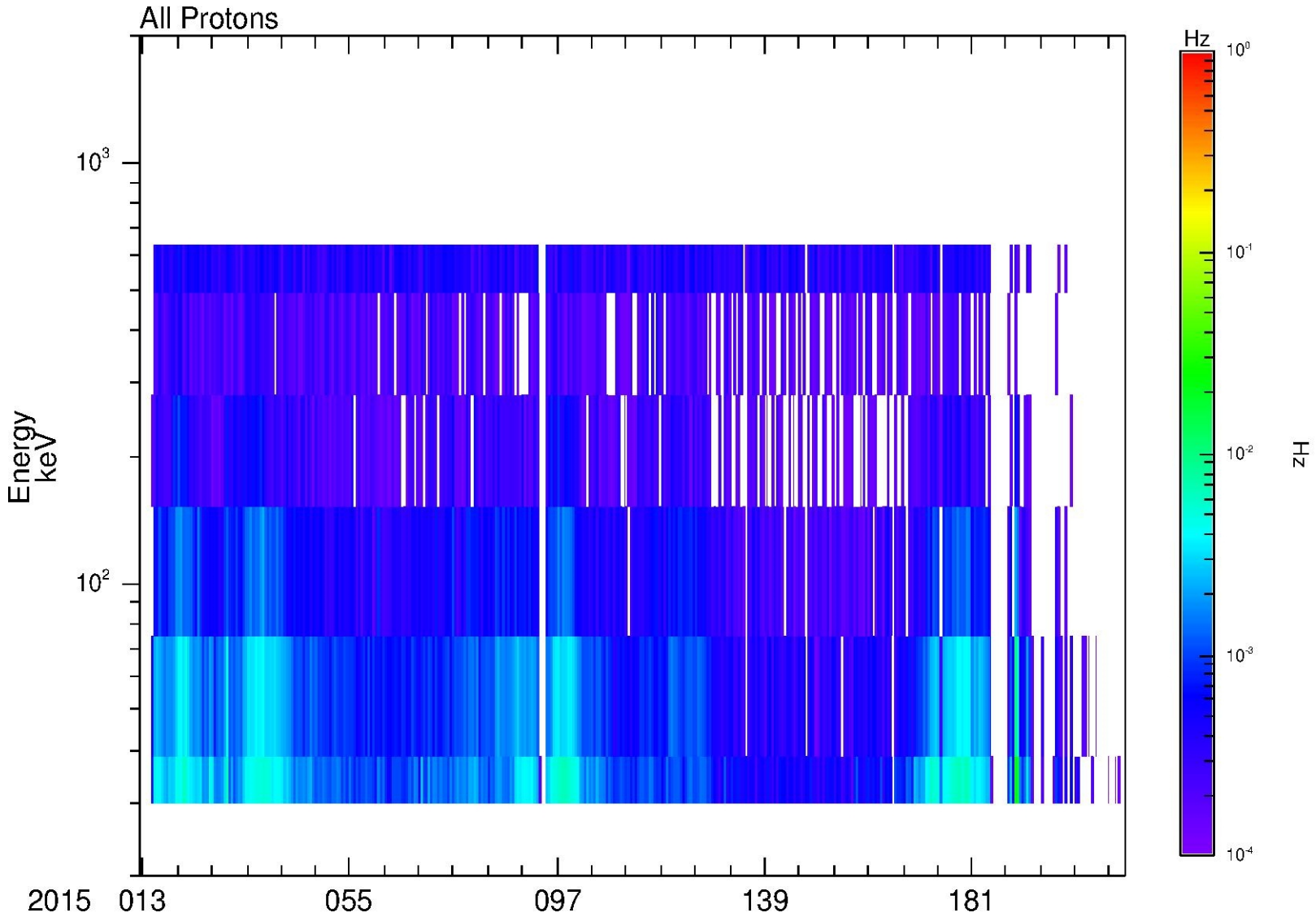
Flight Distance is 6 cm (ICD Section 11.4.5.4)

Time	Velocity	H+ Energy
1 ns	60,000 km/s	18.76 MeV
2 ns	30,000 km/s	4.69 MeV
5 ns	12,000 km/s	750.6 keV
10 ns	6,000 km/s	187.6 keV
20 ns	3,000 km/s	46.9 keV
50 ns	1,200 km/s	7.506 keV
100 ns	600 km/s	1.876 keV
200 ns	300 km/s	469 eV
500 ns	120 km/s	75 eV


All Low Ions
Flight Time
nsec
10^2
10^1
2015
013
055
097
139
181
Hz
10^2
10^1
10^0
10^{-1}
10^{-2}
Hz
All Heavy Ions
Energy
keV
10^3
10^2
2015
013
055
097
139
181
Hz
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
Hz
All Helium
Energy
eV
10^6
10^5
I have an issue with the pixel width here.
2015
013
055
097
139
181
Hz
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
Hz

PEPSSI All Protons

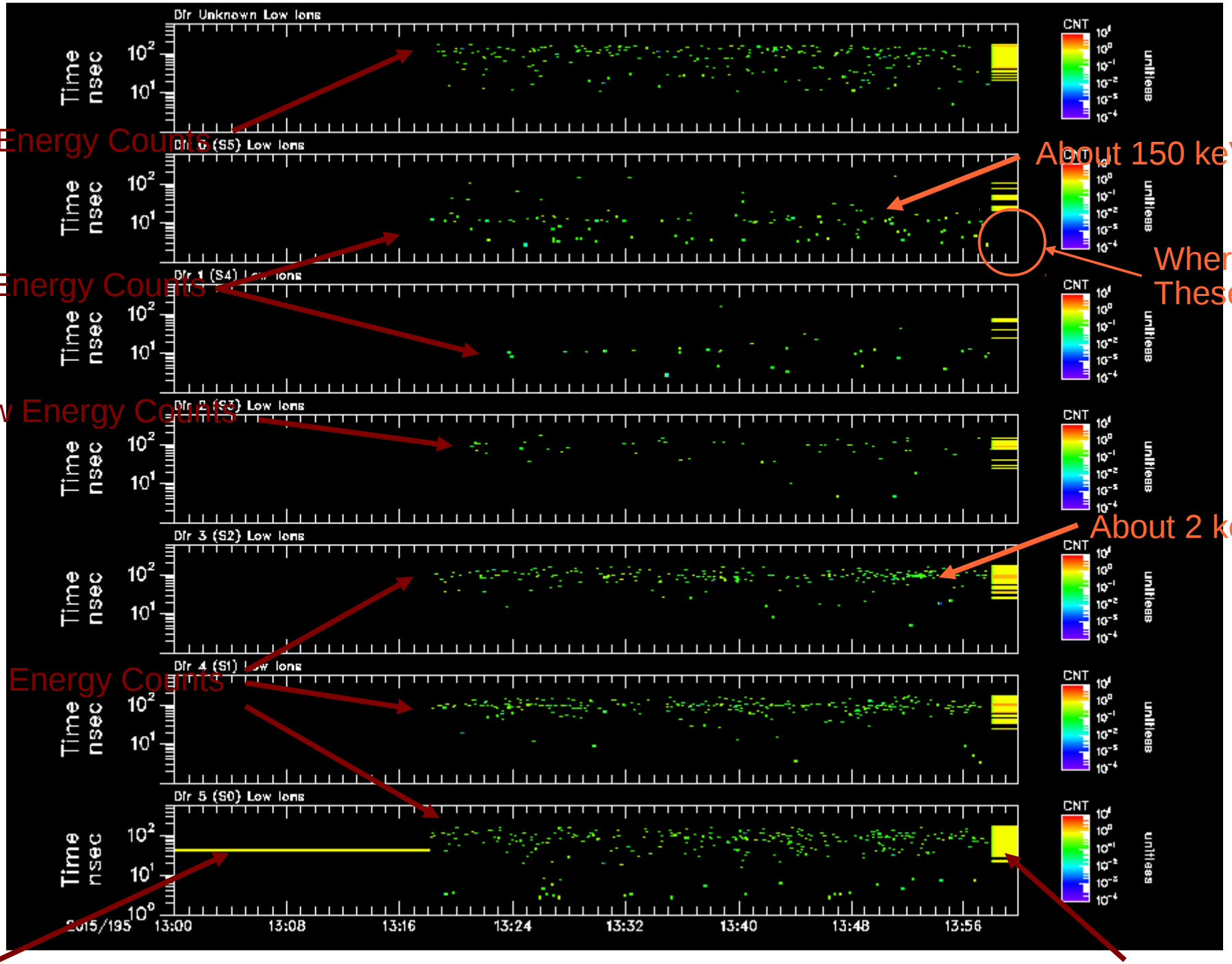
The spectrogram for All Protons show variations in intensity with energy. They have the trend that there are more protons at lower energy than at higher energy, which is a good thing.


All Protons
Energy
keV
10^3
10^2
2015
013
055
097
139
181
Hz
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
zH

PEPSSI Pluto Encounter - TOF

Examined time of Pluto Encounter. PEPSSI went to high-time resolution mode around Pluto. The TOF spectra was examined. Here, the more time that it takes to cross the PEPSSI detector, the slower the particle is traveling and the less kinetic energy it has. Looking at the Ion TOF data, around Pluto some directions see around 2 keV H+ equivalent while others see in the neighborhood of 150 keV and above. When PEPSSI transitions to lower time resolution, why does it no longer see any high energy data?

This is Pluto!



Low Energy Counts

About 150 keV H+

Where are These Ions?

High Energy Counts

Low Energy Counts

About 2 keV H+

Low Energy Counts

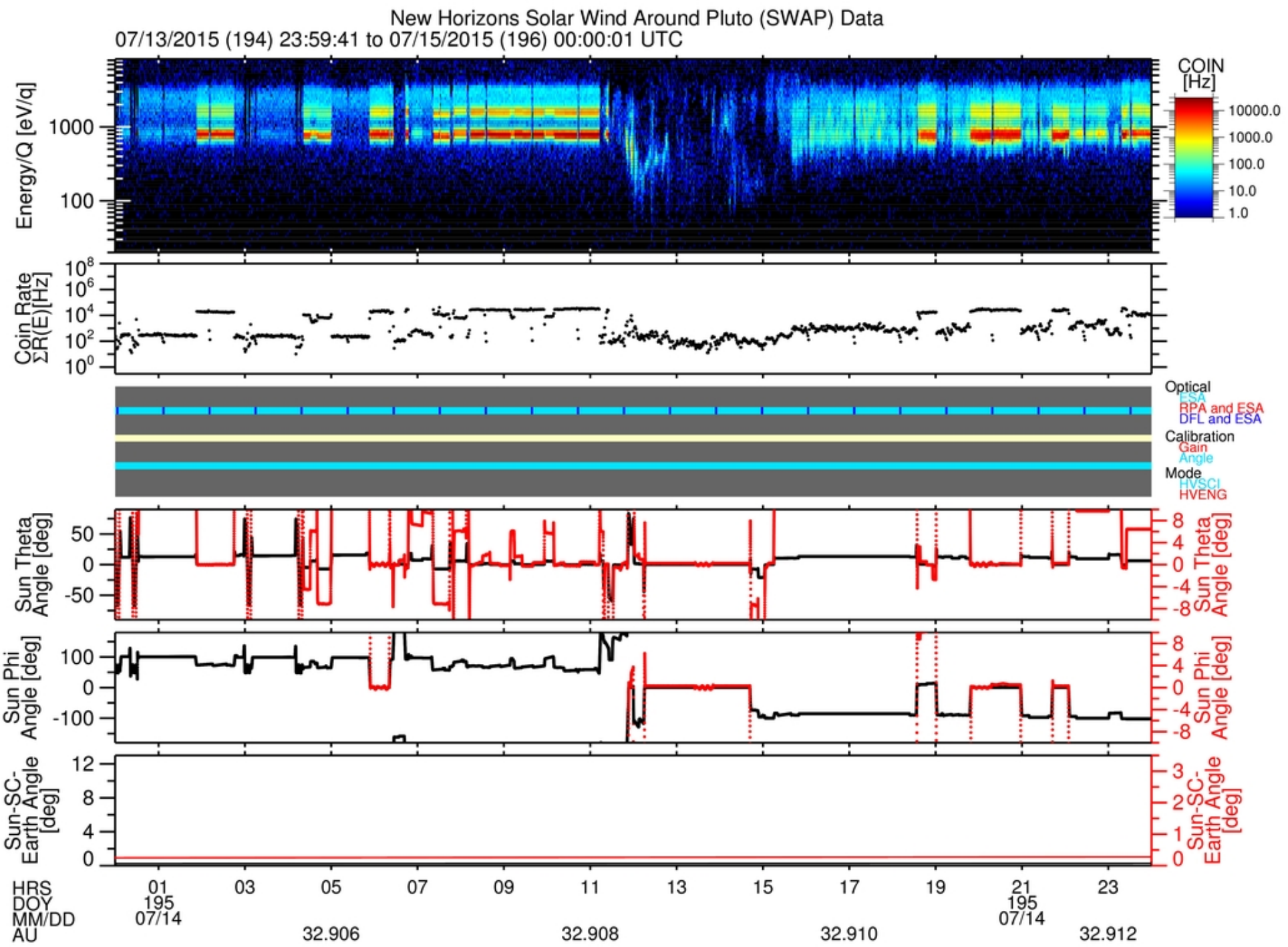
Counts in low resolution mode

Counts in low resolution mode

PEPSSI Pluto Encounter - TOF

The 150 keV particles are above the SWAP energy range, but the 2 keV line, which looks like the solar wind, should be visible in SWAP. SWAP does not see the solar wind at this time. SWAP is dominated by shocked ions.

Why does PEPSSI see the solar wind and SWAP does not?

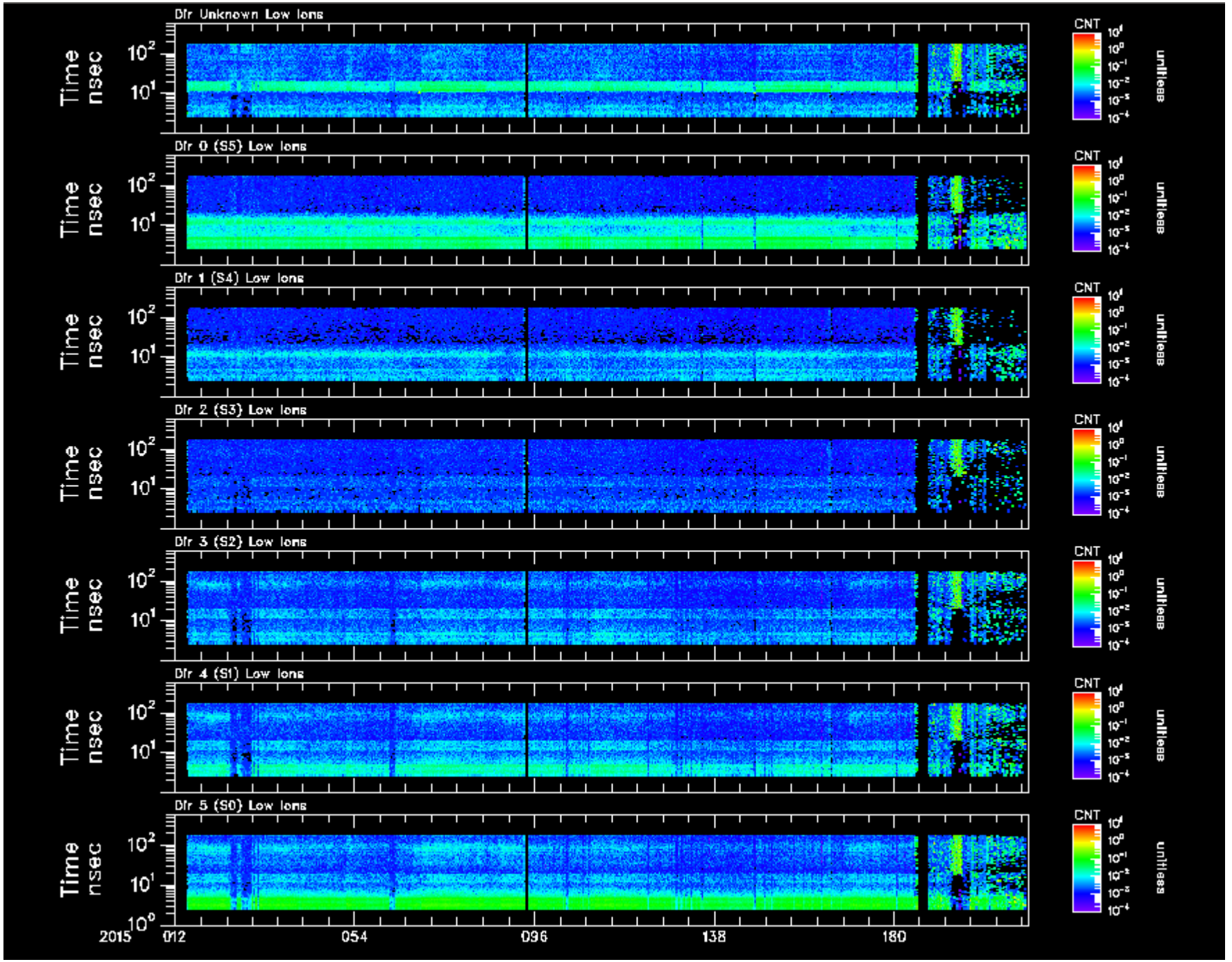


Software Version: ' 3.00000' Processed: 2016-02-12T19:21:27
Plot Created: Mon Mar 28 11:26:55 2016
Files: e/soc/data/pds-pluto/level2/swa/02 to e/soc/data/pds-pluto/level2/swa/02

Spectrogram Timing Accurate to Within: 20.00 [sec]
Plot Width:: 0.754545 [norm]
Plot Width: 8.3000 [in]

PEPSSI TOF Ions

Examining this more is the TOF spectrum over the time of the Pluto data set. The solar wind is in the region of about 1 keV, so we should see it at large TOF values if it is there. However, we do see ions in direction 0 at 10-20 ns, or about at an energy of 50-200 keV H+. We see a "ghost" line in all directions near the 1 ns time which leads me to doubt the intense line in direction 0. Directions 0 and 6 also show a very high energy intense flux. They seem more intense with higher energy which seems backward from what I would expect.

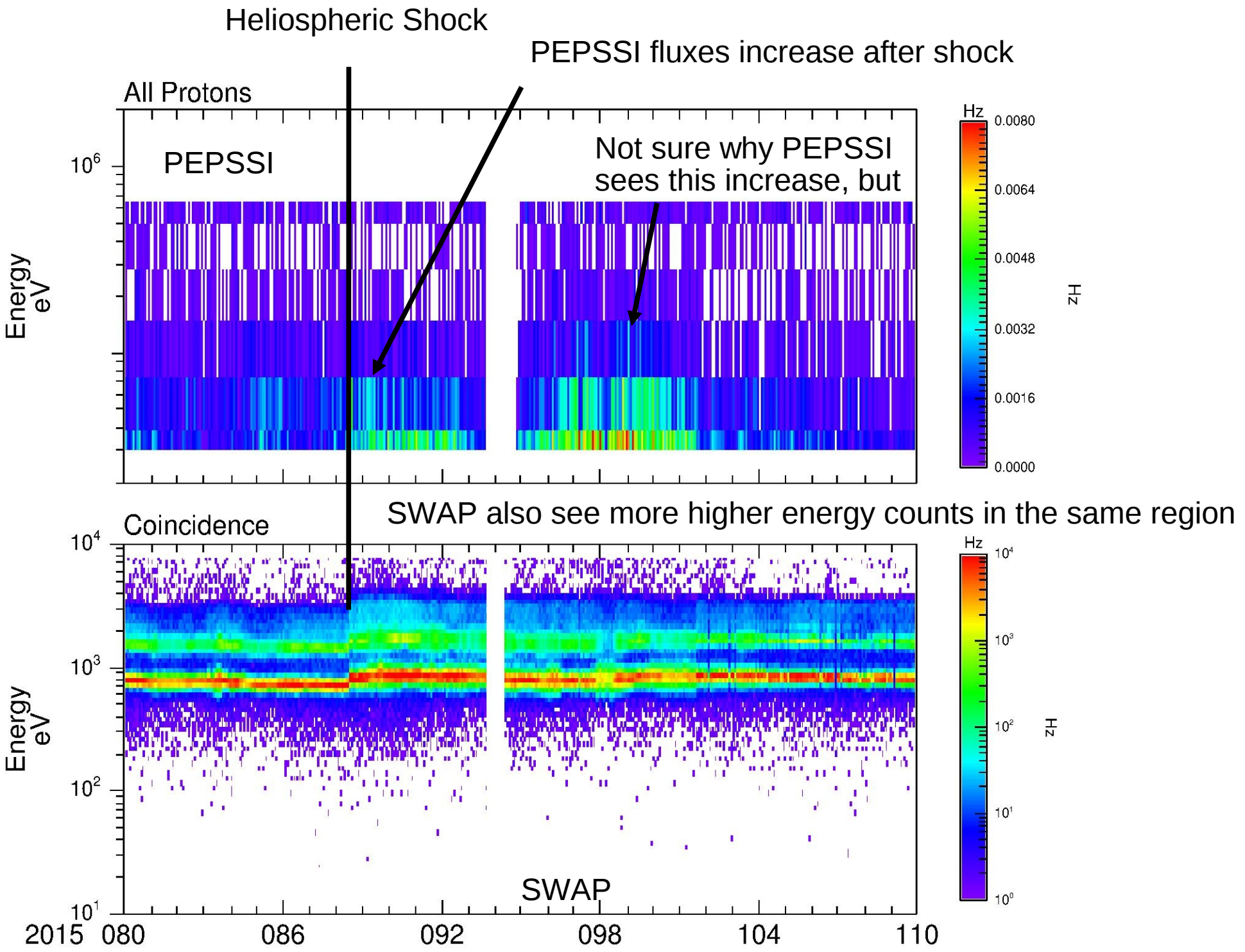

Dfr Unknown Low Ions
Dfr 0 (S5) Low Ions
Dfr 1 (S4) Low Ions
Dfr 2 (S3) Low Ions
Dfr 3 (S2) Low Ions
Dfr 4 (S1) Low Ions
Dfr 5 (S0) Low Ions
Time
nsec
CNT
unitless
2015
012
054
096
138
180

Pluto changes Background Intensities

Pluto is observed on day 195. Here we see that there is only low energy (high TOF) ions around the planet, which is correct. Since PEPSSI spends more its processing time dealing with lower energy counts, it is probably that noise levels decrease and so proportionally there is less counts transmitted in the priority scheme. If this was not the case, we would expect to see very high energy ions pass through the Pluto system like we do at Mars.

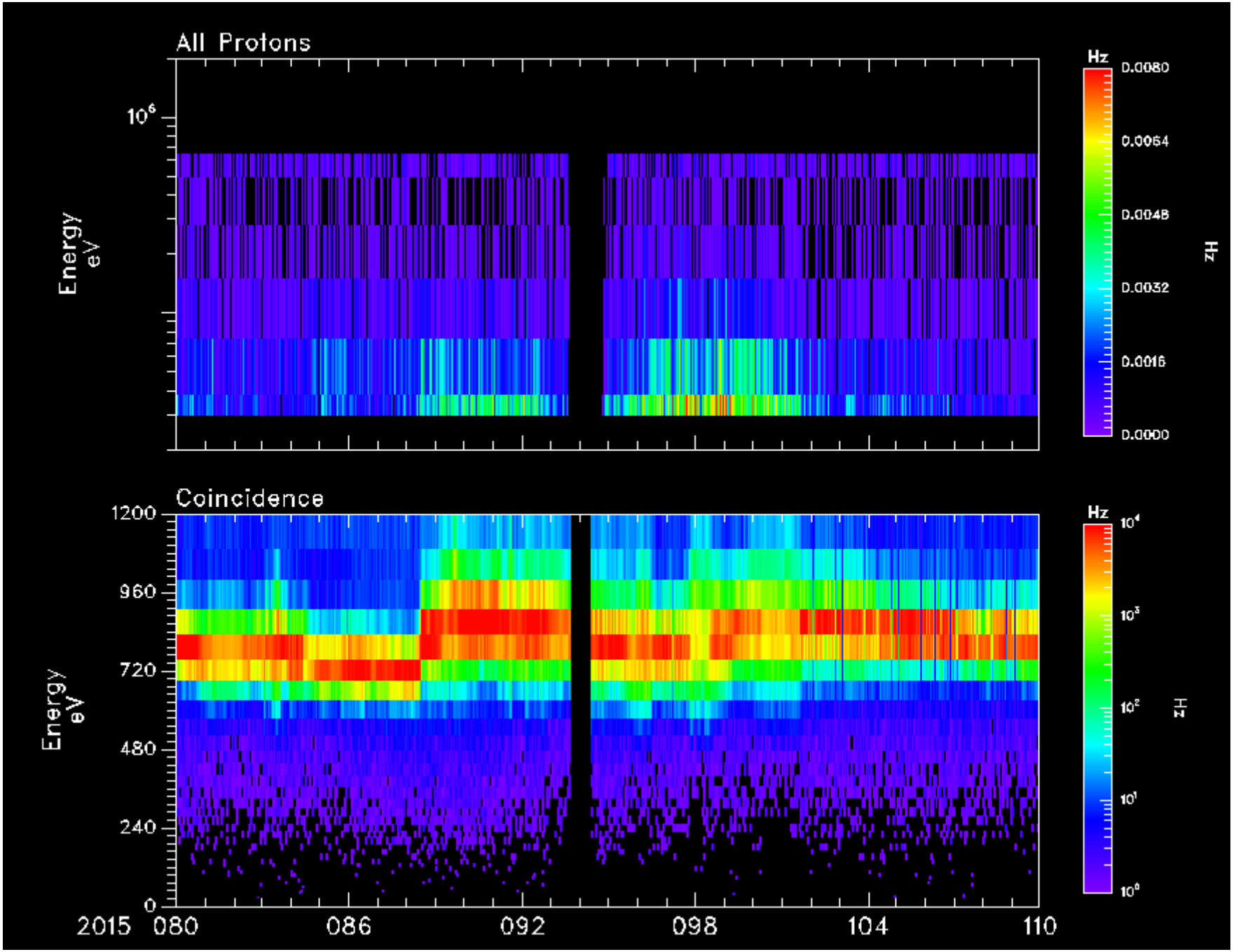
PEPSSI and SWAP at a Heliospheric Shock

Comparing SWAP and PEPSSI at a heliospheric shock is a good indication of coherence. We expect that ions at higher energy are accelerated in the shock front. So for normal conditions, when SWAP sees a heliospheric shock, we would expect to see a rise in the PEPSSI counts. The next slide shows PEPSSI and SWAP ion data.


Heliospheric Shock
PEPSSI fluxes increase after shock
All Protons
PEPSSI
Not sure why PEPSSI sees this increase, but
Energy eV
10^6
Hz
0.0080
0.0064
0.0048
0.0032
0.0016
0.0000
Hz
SWAP also see more higher energy counts in the same region
Coincidence
10^4
10^3
10^2
10^1
SWAP
10^4
10^3
10^2
10^1
10^0
2015 080
086
092
098
104
110

Heliospheric Shock or Heated Region in the Solar Wind

So is this really a heliospheric shock or just heated plasma from the Sun. Attached is a blow-up on the SWAP H+ region on a linear scale. The PEPSSI data resembles more of an extension of the SWAP H+.


All Protons
Energy
eV
10^6
Hz
0.0080
0.0064
0.0048
0.0032
0.0016
0.0000
Coincidence
1200
960
720
480
240
0
2015 080
086
092
098
104
110
10^4
10^3
10^2
10^1
10^0

Back-Up Slides

nh-p-pepssi-3-pluto-v1.0
nh-p-pepssi-3-pluto-v1.0
voldesc.cat

GOOD

nh-p-pepssi-2-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
nhsc.cat

GOOD

nh-p-pepssi-3-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
nh.cat

GOOD

nh-p-pepssi-3-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
pepssi.cat

GOOD

nh-p-pepssi-3-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
catinfo.txt

GOOD

nh-p-pepssi-3-pluto-v1.0/catalog
nh-p-pepssi-3-pluto-v1.0/catalog
dataset.cat

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
codmac_level_definitions.lbl
codmac_level_definitions.lbl

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
soc_inst_icd.lbl

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
nh_fov.lbl and nh_fov.png

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
nh_met2utc.lbl and nh_met2utc.tab

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
payload_ssr.lbl and payload_ssr.pdf

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
pepssi_ssr.lbl and pepssi_ssr.pdf

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
nh_pepssi_v110_ti.txt

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
quat_axyz_instr_to_j2k.lbl
quat_axyz_instr_to_j2k.asc

GOOD

nh-p-pepssi-3-pluto-v1.0/document
nh-p-pepssi-3-pluto-v1.0/document
seq_pepssi_pluto.lbl and seq_pepssi_pluto.tab

GOOD

nh-p-pepssi-3-pluto-v1.0/calib
nh-p-pepssi-3-pluto-v1.0/calib
calinfo.txt

GOOD

nh-p-pepssi-3-pluto-v1.0/calib
nh-p-pepssi-3-pluto-v1.0/calib
hk_n1_input_20050228.lbl
hk_n1_input_20050228.tab

GOOD

nh-p-pepssi-3-pluto-v1.0/calib
nh-p-pepssi-3-pluto-v1.0/calib
hk_stat_input_20041016.lbl
hk_stat_input_20041016.tab

GOOD

nh-p-pepssi-3-pluto-v1.0/calib/calpars
nh-p-pepssi-3-pluto-v1.0/calib/calpars
calpinfo.txt

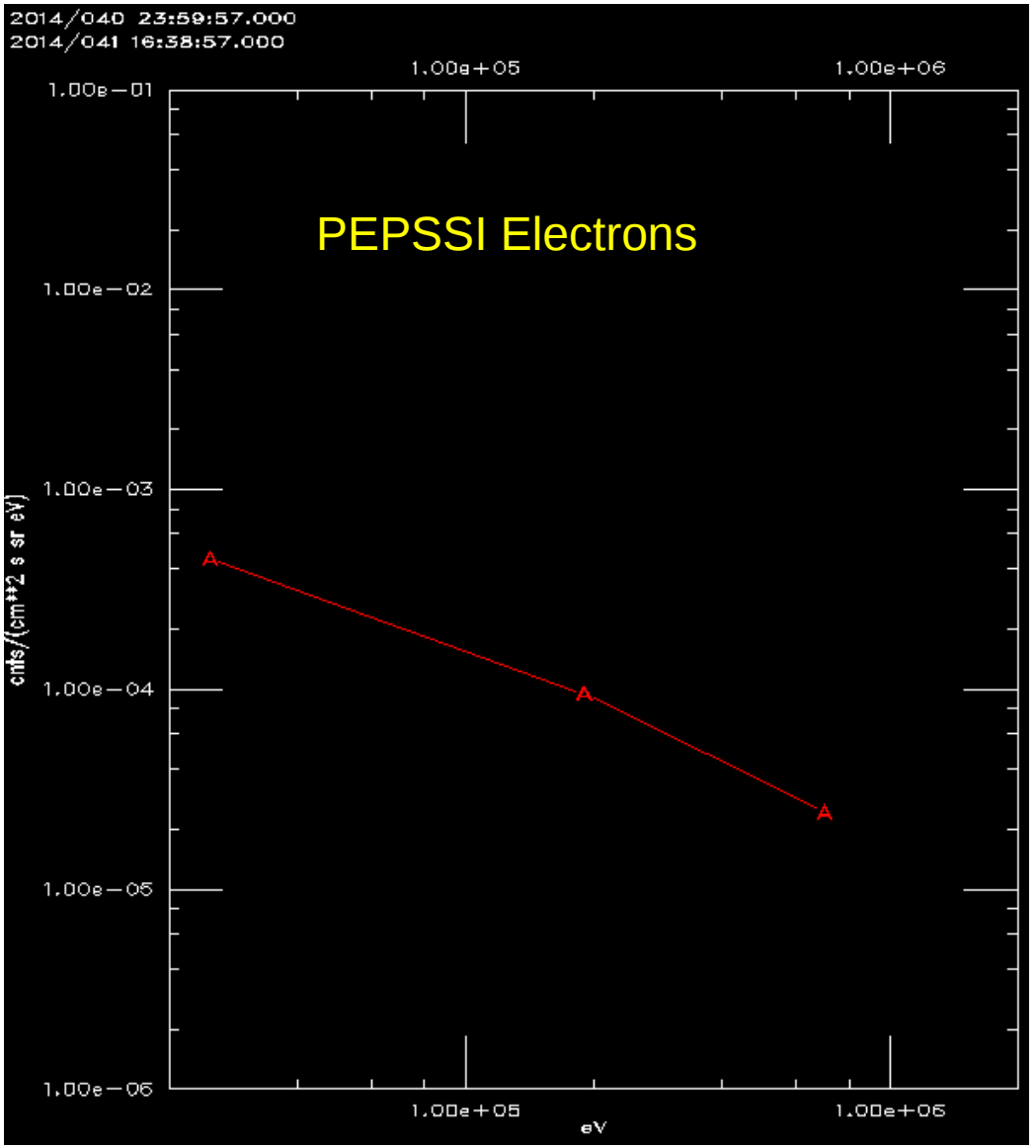
GOOD

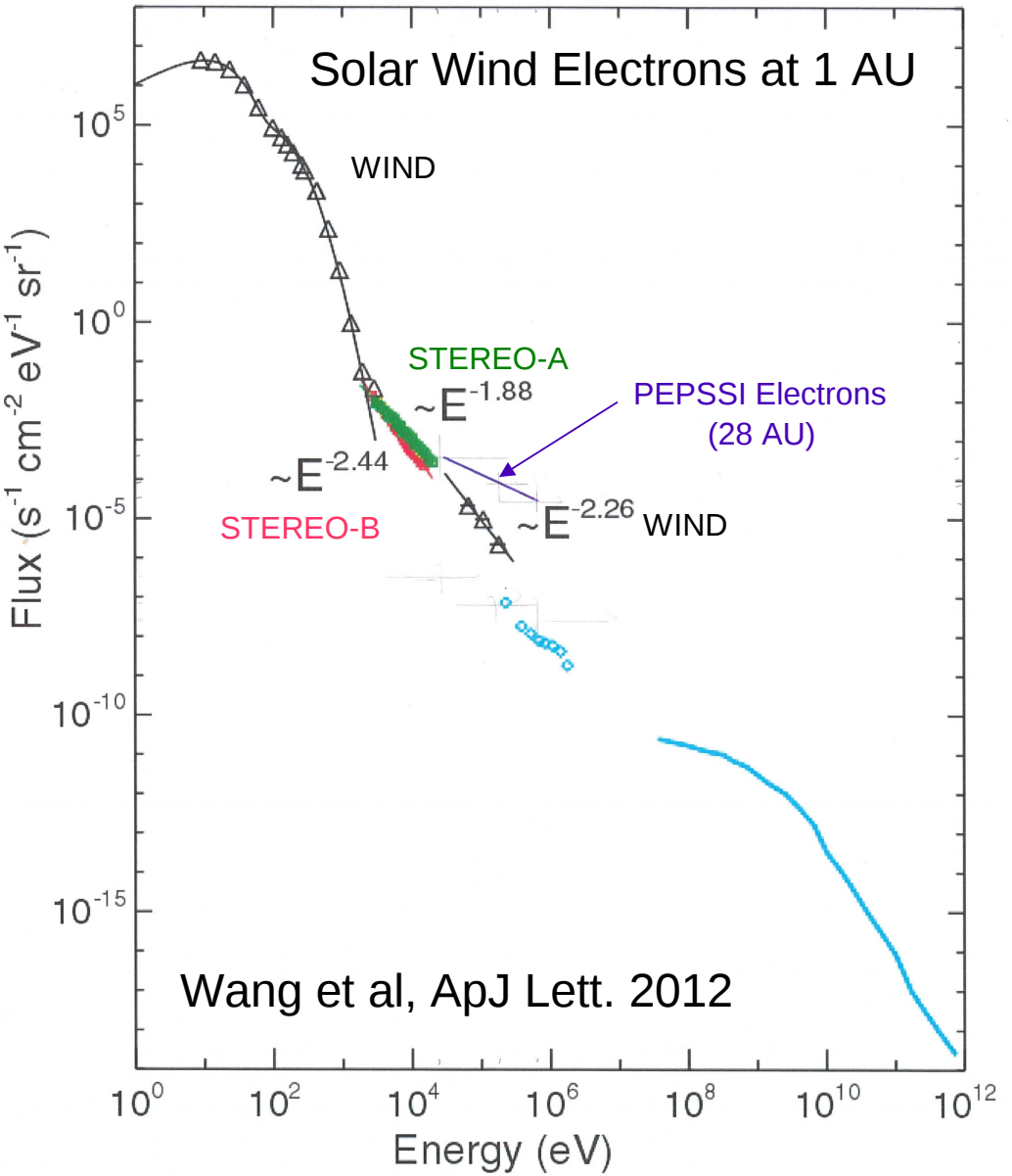
nh-p-pepssi-3-pluto-v1.0/calib/calpars
nh-p-pepssi-3-pluto-v1.0/calib/calpars
calpar_columns.fmt

GOOD

PEPSSI Electrons - 3

Why are the fluxes from PEPSSI abnormally high?





Calculation of Flux

$$\text{Flux}(i) = \text{Count Rate}(i) / [G * \Delta E(i) * 1000 \text{ eV/keV}]$$

Where Count Rate are from data file in s^{-1}

$$G = 0.14 \text{ cm}^2 \text{ sr}$$

$$\Delta E(i) = E_{high}(i) - E_{low}(i)$$

$E_{high}(i)$ and $E_{low}(i)$ are from data file in keV

and Flux(i) is in units of particles/[cm^2 s sr eV]