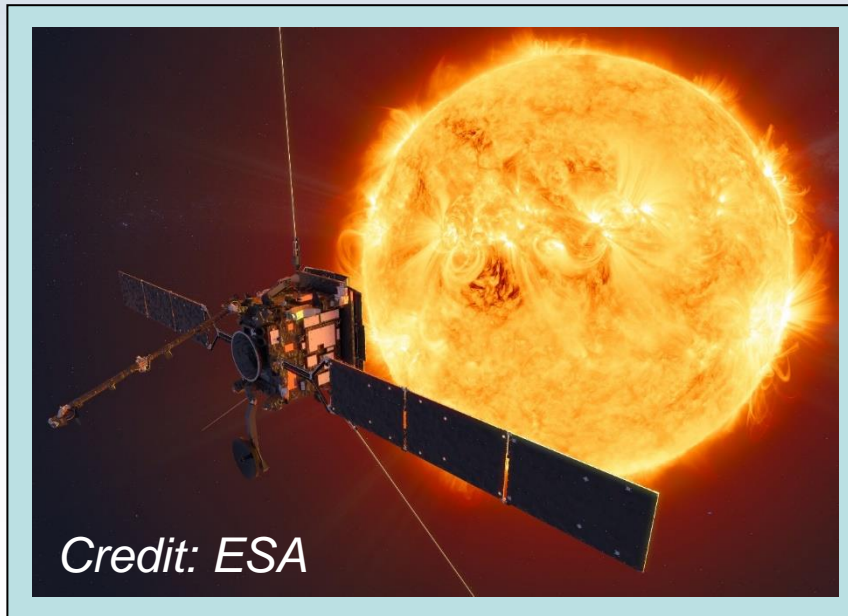RPW Team Meeting, 2nd - 4th October 2023
Solar Wind Analyser (SWA) Suite Status and News

Chris Owen on behalf of the SWA Team

Credit: ESA

11th February 2020 0403 GMT

Credit: ESA

SWA Operations Status/News

- **Overall Suite Operations:**
  - SWA PAS & EAS sensors currently operating well, producing good science data with healthy, nominal HK;
  - SWA-HIS remains powered off due to an ongoing FDIR issue (see HIS slide below);
  - All DPU HK remains nominal, no current issues with DPU HW - from computational point of view, the DPU is performing as expected;
  - All IOR commanding has been delivered to SOC in a timely fashion with very few issues;
- We held the 30th SWA team meeting at ASI HQ in Rome, Tues-Thurs, last week:
 - Good mix of instrument and science presentations.
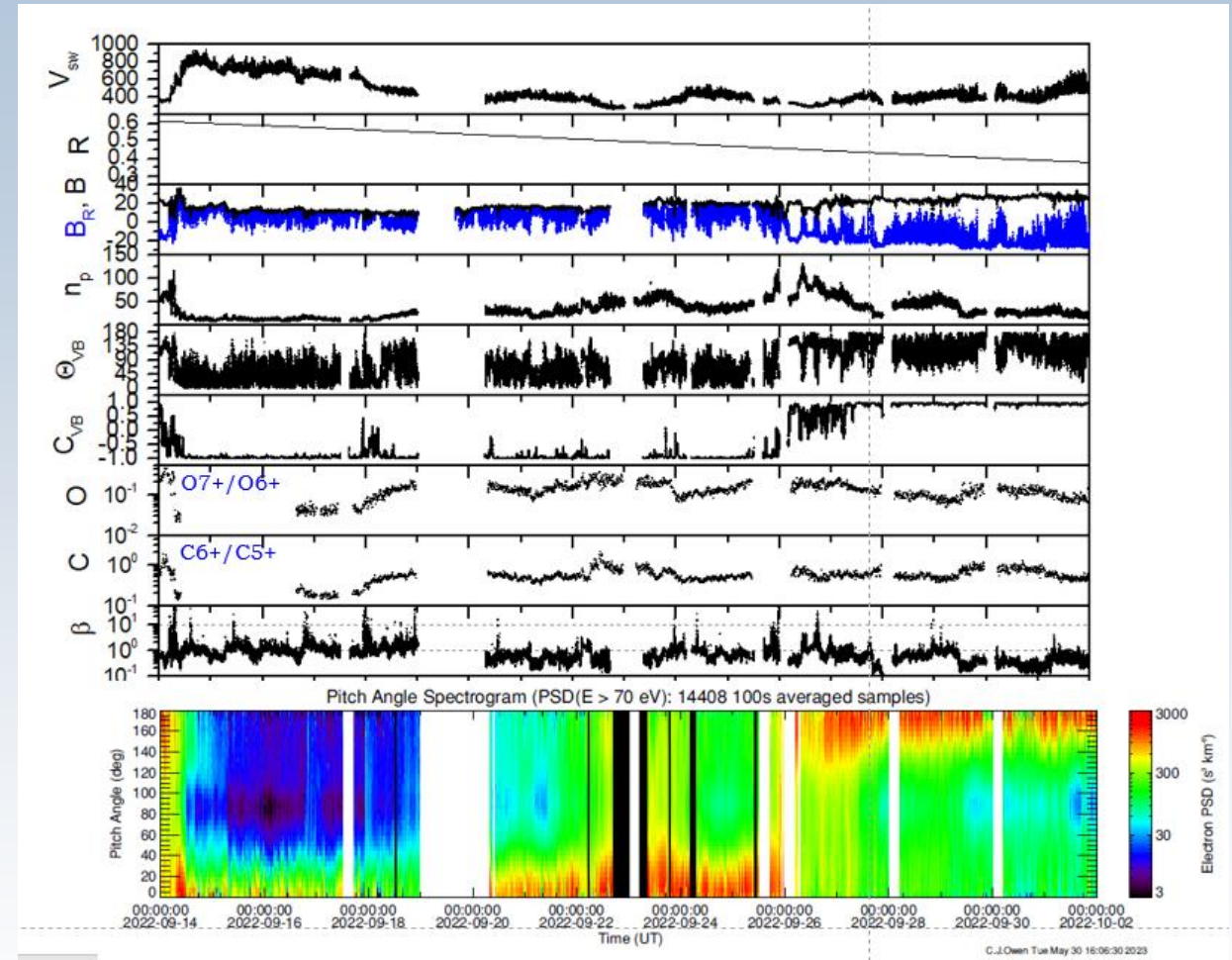
SWA Science: Characterization of solar wind fluctuations and investigation into their origin using data from all 3 SWA sensors (and others, D'Amicis et al, in preparation)

SWA activity, status, highlights

- 2023 has had its ups and downs:
  - EAS and PAS have collected data over most of this year;
  - There was a major s/c SSMM anomaly in May which shut down the entire payload;
  - We have experienced several more DPU reboots;
  - Unfortunately, we also had a major anomaly with HIS at the end of April on which the team is still working on diagnoses and (hopefully) recovery;

Example of recent SWA data taking record – EAS summary plot
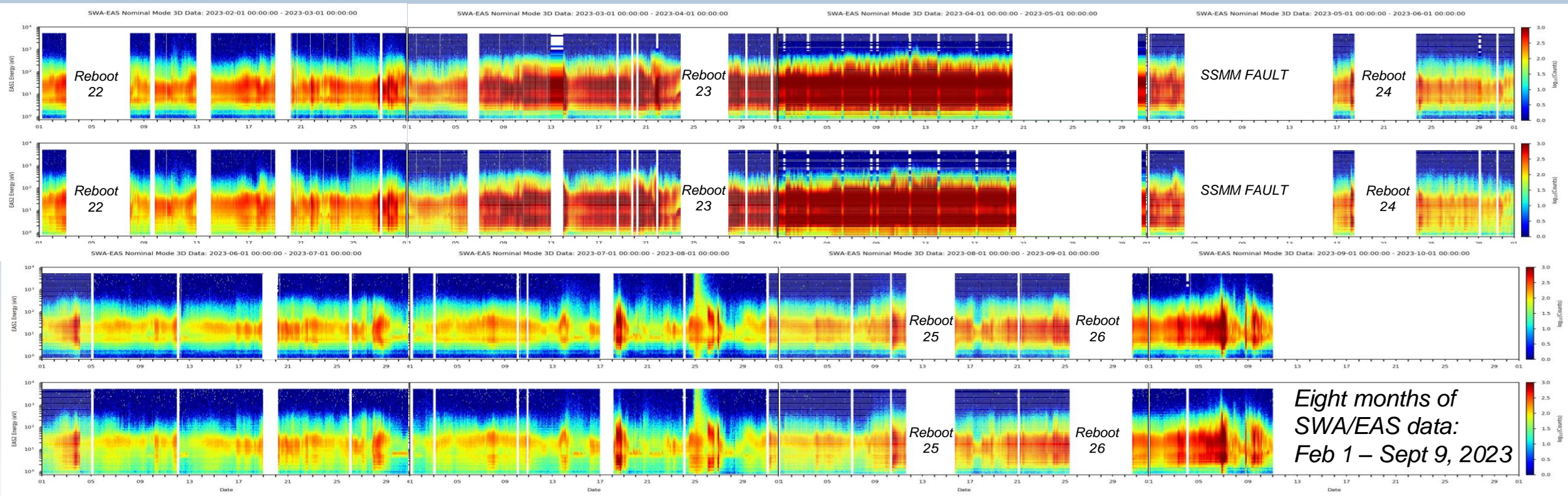

- *SWA Data acquisition/availability catalogues (by year) are being maintained by Gethyn Lewis:*
  - https://www.mssl.ucl.ac.uk/~grl/transfer/SWA_Data_Catalogue/SWA_Data_Catalog_202*.htm
- MSSL now hosts a comprehensive Quick look plots website for SWA LL data:
  - https://www.mssl.ucl.ac.uk/missions/solo_swa_quicklooks/
- This is open to the public, no password is required

Data Catalogue

- At:
https://www.mssl.ucl.ac.uk/~grl/transfer/SWA_Data_Catalogue/SWA_Data_Catalog_2023.htm

Solar Orbiter SWA Data CATALOGUE 2023

Date	DOY	STP	DPU On	EAS1 On	EAS1 Data	EAS2 On	EAS2 Data	HIS On	HIS Data	PAS On	PAS Data	Data Downlinked	Notes
01-Aug-23	213	CA	On	On	NBS	On	NBS	Off	---	On	Static	Full	
02-Aug-23	214		On	On	NBS	On	NBS	Off	---	On	Static	Full	
03-Aug-23	215		On	On	NBS	On	NBS	Off	---	On	Static	Full	
04-Aug-23	216		On	On	NBS	On	NBS	Off	---	On	Static	Full	
05-Aug-23	217		On	On	NBS	On	NBS	Off	---	On	Static	Full	
06-Aug-23	218		On	On	NBS	On	NBS	Off	---	On	Static	Full	
07-Aug-23	219	270	On	On	NBS	On	NBS	Off	---	On	Static	Full	
08-Aug-23	220	GL	On	On	NBS	On	NBS	Off	---	On	Static	Full	
09-Aug-23	221		On	On	NBS	On	NBS	Off	---	On	Static	Full	
10-Aug-23	222		On	On	NBS	On	NBS	Off	---	On	Static	Full	
11-Aug-23	223		On	On	NBS	On	NBS	Off	---	On	Static	Full	DPU rebooted. All sensors OFF at 15:09
12-Aug-23	224		SAFE	Off	---	Off	---	Off	---	Off	---	HK	
13-Aug-23	225		SAFE	Off	---	Off	---	Off	---	Off	---	HK	
14-Aug-23	226	271	SAFE	Off	---	Off	---	Off	---	Off	---	HK	
15-Aug-23	227	GW	On	On	NBS	On	NBS	Off	---	Off	---	Full	PAS recovery failed
16-Aug-23	228		On	On	NBS	On	NBS	Off	---	Off	---	Full	
17-Aug-23	229		On	On	NBS	On	NBS	Off	---	Off	---	Full	
18-Aug-23	230		On	On	NBS	On	NBS	Off	---	Off	---	Full	PAS second recovery
19-Aug-23	231		On	On	NBS	On	NBS	Off	---	On	Static	Full	
20-Aug-23	232		On	On	NBS	On	NBS	Off	---	On	Static	Full	
21-Aug-23	233	272	On	On	NBS	On	NBS	Off	---	On	Static	Full	
22-Aug-23	234	CA	On	On	NBS	On	NBS	Off	---	On	Static	Full	
23-Aug-23	235		On	On	NBS	On	NBS	Off	---	On	Static	Full	
24-Aug-23	236		On	On	NBS	On	NBS	Off	---	On	Static	Full	
25-Aug-23	237		SAFE	Off	---	Off	---	Off	---	Off	---	HK	DPU rebooted. All sensors OFF at 08:47
26-Aug-23	238		SAFE	Off	---	Off	---	Off	---	Off	---	HK	
27-Aug-23	239		SAFE	Off	---	Off	---	Off	---	Off	---	HK	
28-Aug-23	240	273	SAFE	Off	---	Off	---	Off	---	Off	---	HK	
29-Aug-23	241	GL	SAFE	Off	---	Off	---	Off	---	Off	---	HK	
30-Aug-23	242		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
31-Aug-23	243		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
Date	DOY	STP	DPU On	EAS1 On	EAS1 Data	EAS2 On	EAS2 Data	HIS On	HIS Data	PAS On	PAS Data	Data Downlinked	Notes
01-Sep-23	244		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
02-Sep-23	245		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
03-Sep-23	246		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
04-Sep-23	247	274	On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
05-Sep-23	248	CA	On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
06-Sep-23	249		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
07-Sep-23	250		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
08-Sep-23	251		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
09-Sep-23	252		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
10-Sep-23	253		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
11-Sep-23	254	275	On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
12-Sep-23	255	GW	On	On	NBSM	On	NBSM	Off	---	On	Static	Full	
13-Sep-23	256		On	On	NBSM	On	NBSM	Off	---	On	Static	Full	HK, LL & Sci in realtime
14-Sep-23	257		On	On	NBSM	On	NBSM	Off	---	On	Static		Conjunction starts
15-Sep-23	258		On	On	NBSM	On	NBSM	Off	---	On	Static		
16-Sep-23	259		On	On	NBSM	On	NBSM	Off	---	On	Static		
17-Sep-23	260		On	On	NBSM	On	NBSM	Off	---	On	Static		
18-Sep-23	261	276	On	On	NBSM	On	NBSM	Off	---	On	Static		
19-Sep-23	262	GW	On	On	NBSM	On	NBSM	Off	---	On	Static		
20-Sep-23	263		IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent		
21-Sep-23	264		IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent		
22-Sep-23	265		IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent		
23-Sep-23	266		IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent		
24-Sep-23	267		IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent	IOR sent		
25-Sep-23	268	277											

Keys

EAS Key
N = Normal Mode
B = Burst Mode
T = Trigger Mode
M = Moments
S = Single Strahl
NG = Data No Good

PAS Key
N = Normal Mode
B = Burst Mode
M = Moments
S = Snap
NG = Data No Good

HIS Key
N = Normal Mode
B = Burst Mode
P = PHA
M = Moments
R = Rates
R = VDF
NG = Data No Good
RPA = Reduced PA

SWA Status - Data

- We continue to accumulate data to support SO science, and submit these regularly to the archive (http://soar.esac.esa.int/soar/#home)

SWA	Data to ground	Data to Archive	
PAS	Science - To end of 13th September (conjunction start); LL – near real time (plot on right shows EAS & PAS LL data from today 2nd Oct 2023);	L1 and L2 data until 30th April 2023	May 2023 will be delivered in October
EAS		L1 and L2 data until 30th April 2023	May 2023 will be delivered in October
HIS		L3 solar wind composition data for ~180 days Jan-Dec 2022; Some L2 data also in archive?	Jan – Apr 2023 will be delivered in Q4 2023;

- Co-I's and their associates can also access data via the team websites.
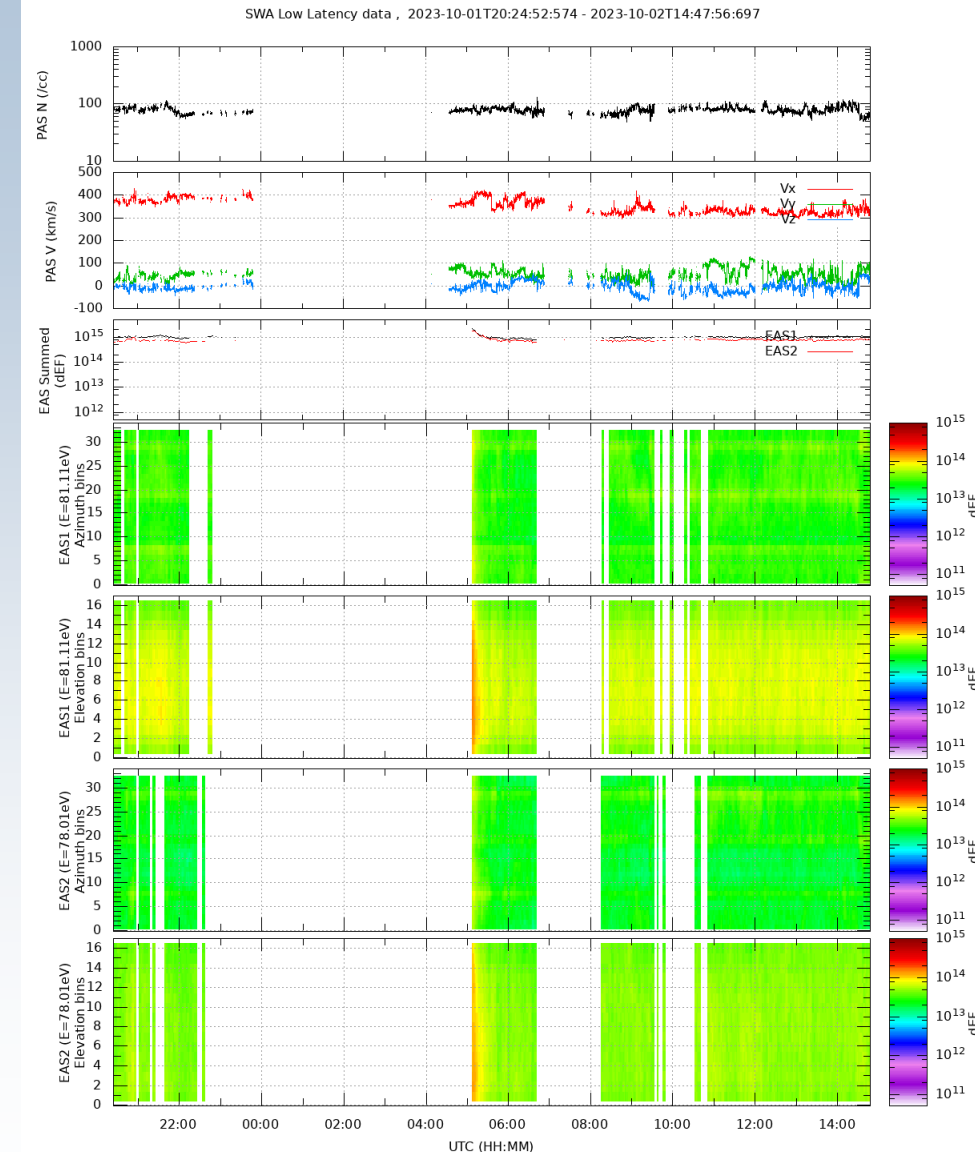
SWA EAS & PAS LL data from today.

SWA Data Issues

- PAS: Lack of high time resolution (sub-second) data due to DPU reboot issue;
  - New FSW will allow us to routinely return continuous PAS 1 sec 3D vdf data (and sporadic, ~5 minutes per hour max, EAS 1 sec 3D vdf data) as small mitigation;

- PAS: Efficiency of low-energy channels, accuracy of moments at low solar-wind speeds;
  - Confusion with (admittedly poorly documented) PAS quality parameter;
  - PAS team plans to replace this with a more intuitive 'flag' shortly;

- EAS: Weekly in-flight calibration tests monitor MCP voltages and anode thresholds;

- EAS: 'sawtooth effects' at low energies.
  - EAS sequencer modified in-flight to increase the HV settle time. In-flight engineering test results feeding into ground system processing to correct for this;

- EAS: complex spacecraft potential/photo-/secondary electron environment (see talk by Stepan);

- EAS: Ideally, we need to complete these analyses before producing L3 data products (e.g. PADs, ground electron moments) for the archive;

- HIS: .....

HIS Status

- HIS experienced a serious anomaly on 27 Apr 2023:
  - On-board C&DH computer spontaneously rebooted;
  - AC link immediately tripped red high current limit;
- AC link is a transformer that sends power to the vacuum-isolated HV bubble, housing the TOF telescope and all detectors (Detector Section);
- Six tests have been conducted without re-establishing normal AC link operation or receiving any TM from the Detector Section. One test was interrupted by an apparent commanding anomaly.

Test	Date	Outcome
1	28 April 2023	Unsuccessfully attempted normal restart of HIS
2	20 June 2023	Unsuccessfully attempted to restart AC link after delaying limit violation response to account for possible noise in the system
3, 4, 5, 5a	August 2023	Successfully established normal operation of main electronics and ground-referenced HV subsystems. Unsuccessfully attempted to restart AC link after warming HIS to ~20ºC. High-rate MAG data showed no clear signals of high-frequency HV noise.
6	12 Sept 2023	Attempted restart AC link at 20ºC with extended start time (30 sec), which was shown to be sometimes necessary during pre-launch test. Test interrupted by apparent commanding anomaly. Investigating.

- Next step: Re-run Test 6, possibly after timing modification;
- Timescale and probability of recovering HIS - ???

SWA DPU (Redundant side) Status Summary

- **The DPU generally operating nominally** (e.g. >160 days, > 5 M science packets generated since Feb 2023);
- **Reboot Issue:**
  - There have now been 26 uncontrolled re-boots of the SWA DPU since launch:
    - Half were related to PAS in high cadence operations, half to data compression of EAS & PAS data;
  - PDOR commanding to recover has generally been compiled, delivered and executed with no issues but results in a couple of days of lost operations at each occurrence;
    - thanks again to MOC and the SWA teams for work and flexibility on this;
  - The DPU team identified a bug in the compression software which was fixed with a FSW patch in August;
    - Unfortunately, 2 further reboots have occurred since;
  - The DPU and MSSL teams are now testing a FSW patch which will isolate the compression management system from the Watchdog management system:
    - Will upload to s/c once full testing has completed;
  - PAS & DPU teams have also re-designed the PAS high-cadence modes:
    - PAS can be deployed at 1-sec cadence in NM;
    - This will be used once current set of conjunction + RSW's have been completed.
  - EAS Trigger Mode (5 mins of full 3D vdfs at 1-s cadence) also now be 'schedule-able' as tool to recover TM.

L1 New High Res Mode Data

On the 10th August we modified an existing, unused engineering mode

This is the same as the Trigger Mode but we command it in weekly IOR

The command will produce 5 minutes of full, 1sec, 3d data

The Normal Mode continues

Depending on available TM we plan to use this regularly in future weekly commanding

We can double the high cadence EAS TM if we run this every hour
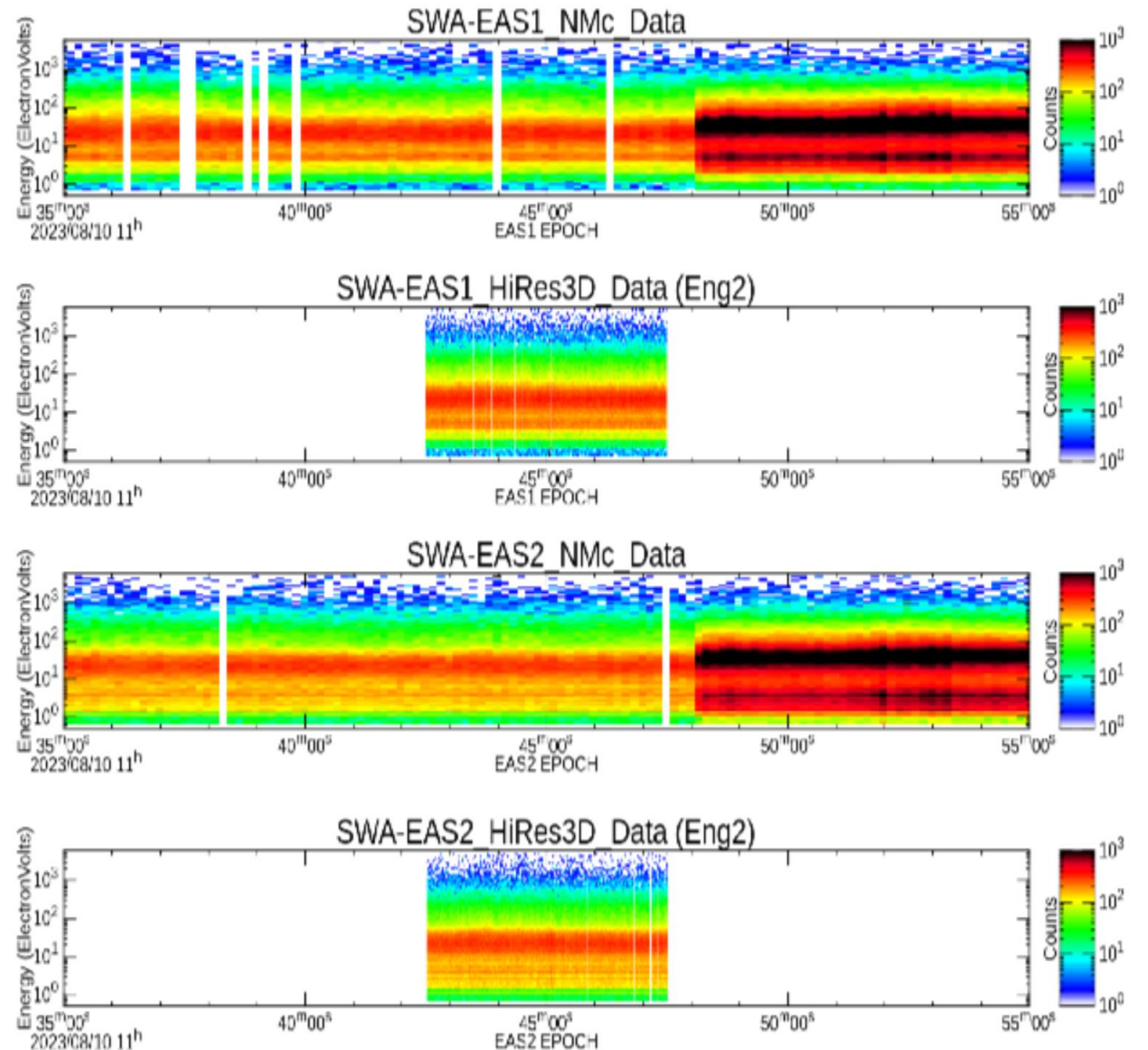
SWA L3 Data Progress and Plans

- HIS have some 2022 L3 data products in the archive and plan to expand both the number of ions covered and the time range (into 2023) as calibrations improve;

- PAS L2 data is largely a sound science product, possible deployment of L3 moments derived from different techniques (e.g. machine learning) to separate protons and alphas;

- EAS: We have been working towards combined head 3D vdf, plus 2D PAS, plus ground-derived moments (various methods) as L3 data products that will divorce the user from needing to know detailed information on the sensors;
  - Although pipelines are nearing completion, we still need to mitigate for the issues discussed above, i.e.:
    - Absolute and cross-head calibration (LPP, Paris have done a lot of work, in testing);
    - Removal of sawtooth effect (French masters project student, Tristan Desplanches, made significant advances on understanding this over last 6 months);
    - Correction for s/c potential and spacecraft-origin electrons (c.f. Stepan's work);
  - Not sure we will be completely on top of all these in the near future at least, so aspire to release some L3 data with appropriate caveat files, user beware documentation;

The Sawtooth effect

Caused by a "too short" settle time on the energy selection voltage

Each energy step has a 50us settle time before counting of electrons begins

Settle time needs to be more like ~400 us

Actual profile is rounded, so on average we sample too low energies on the upward sweep and too high energies on the downward sweep. Effect on the measured distribution then also depends on the shape of the underlying ambient distribution.
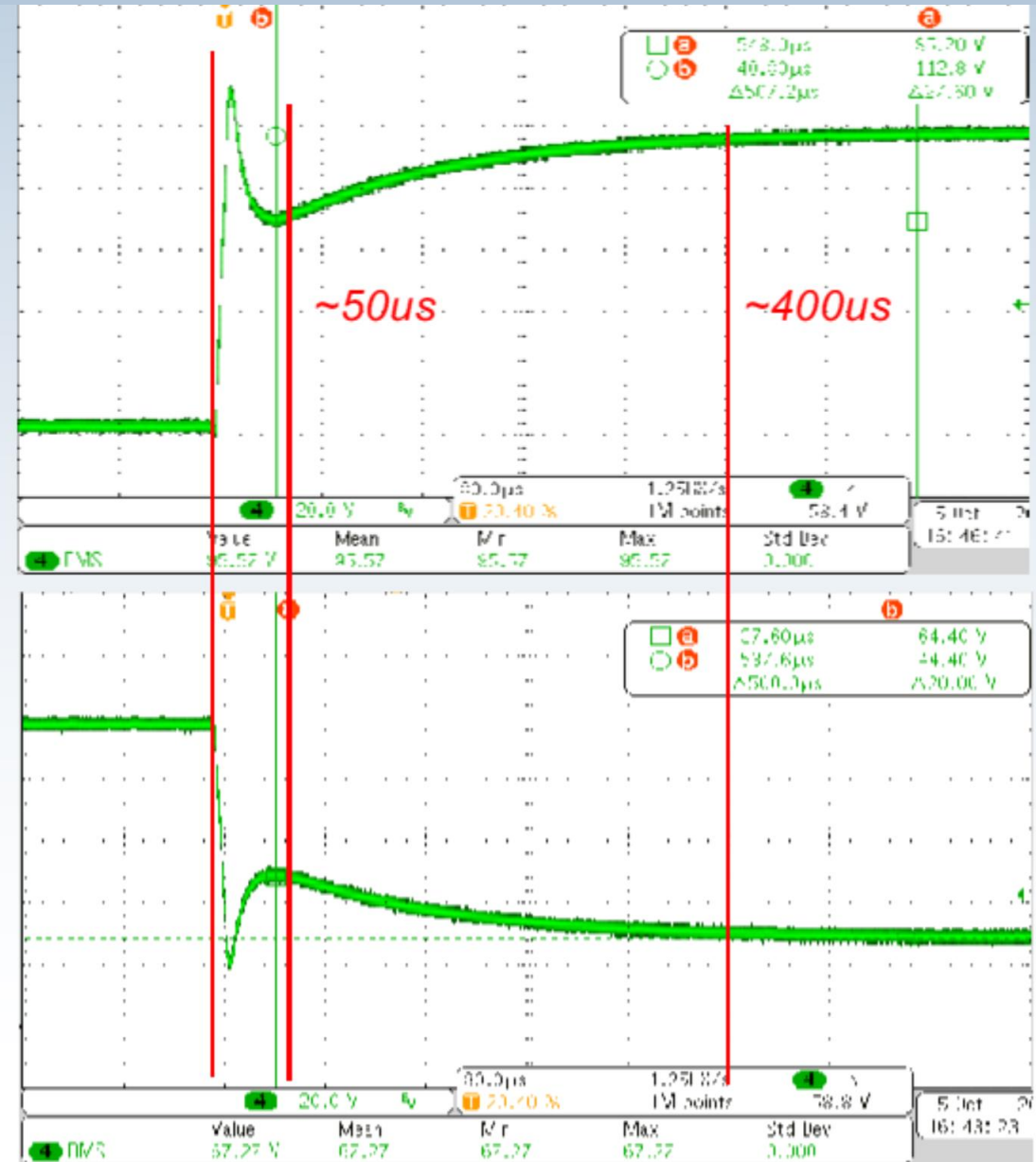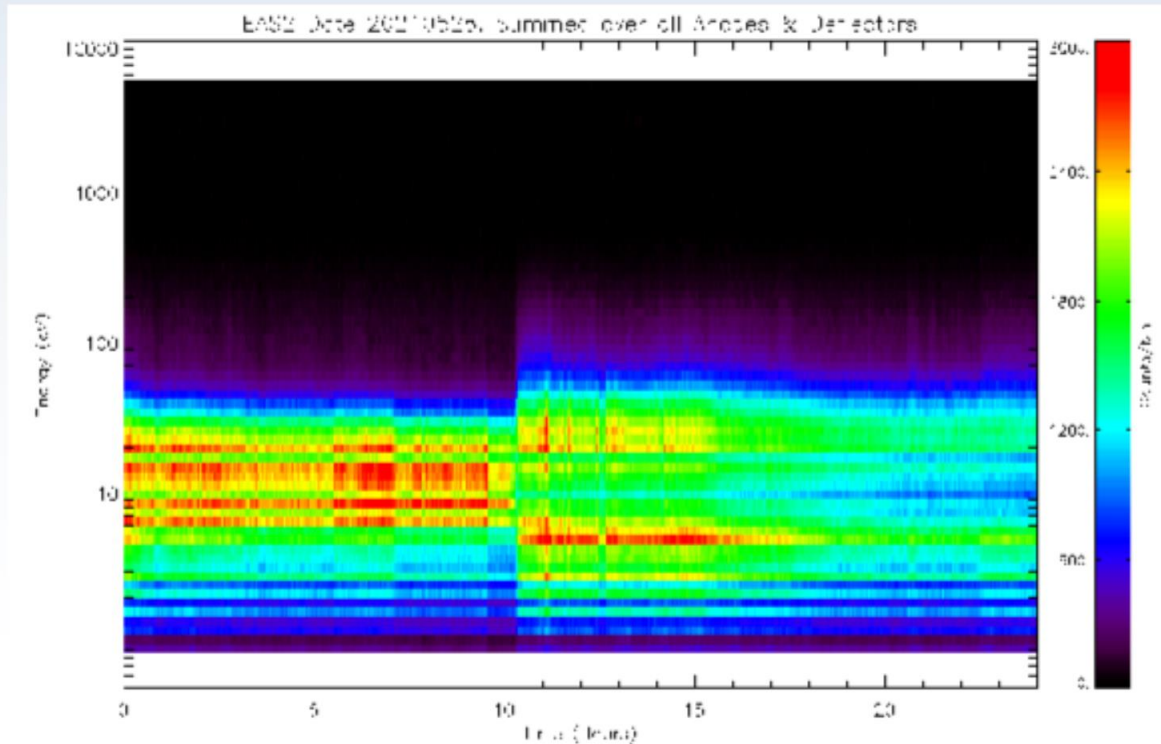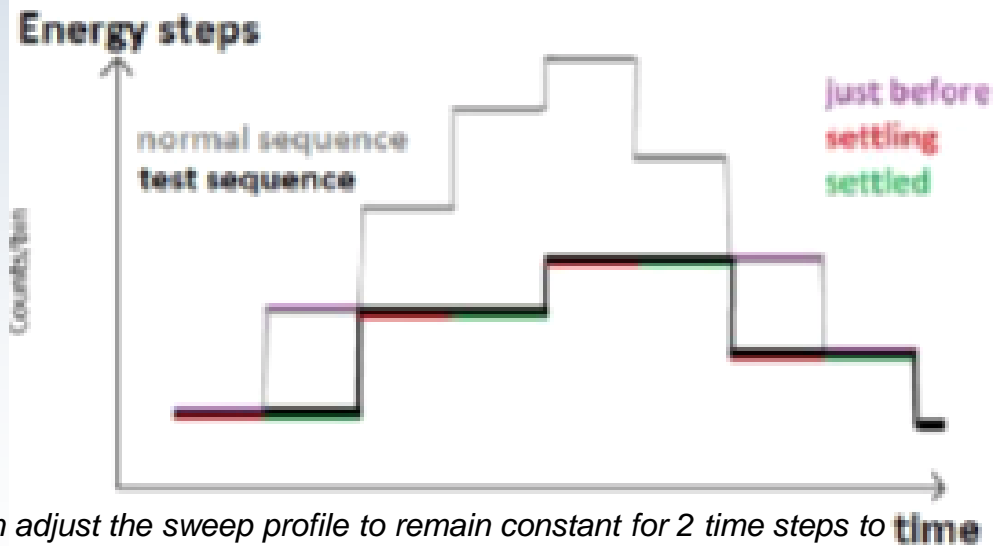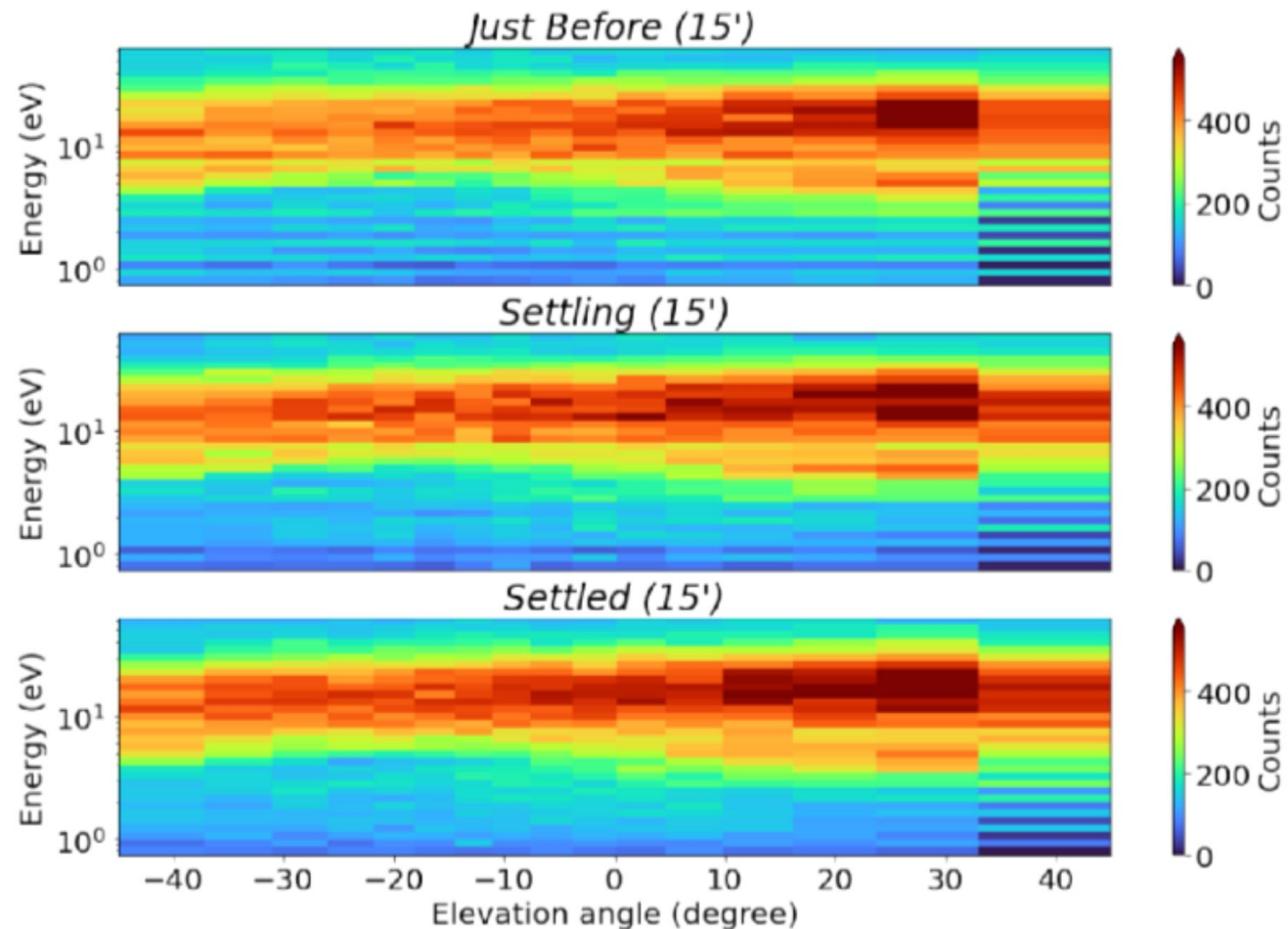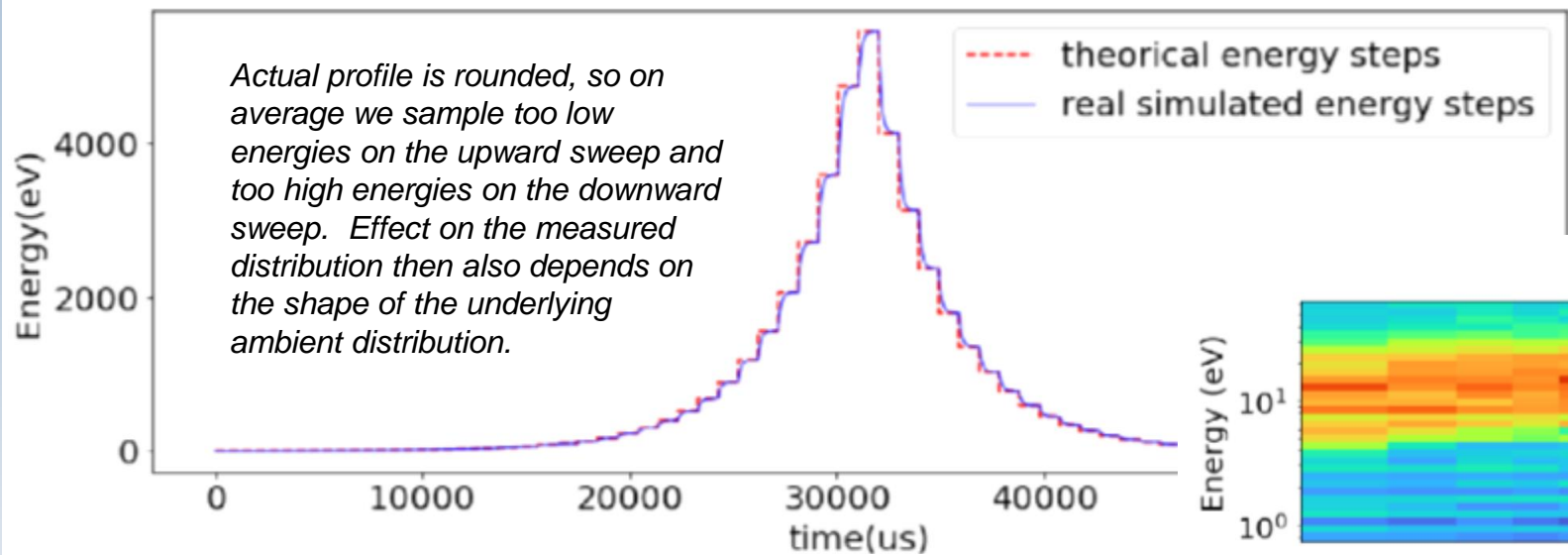
We can adjust the sweep profile to remain constant for 2 time steps to see the effect of HV settling (profiles above). The 'usual' sweep is shown top right, the first part of the test sweep pattern in middle right and the second, settled part in bottom right. The latter shows less obvious sawtooth cf the other two parts.
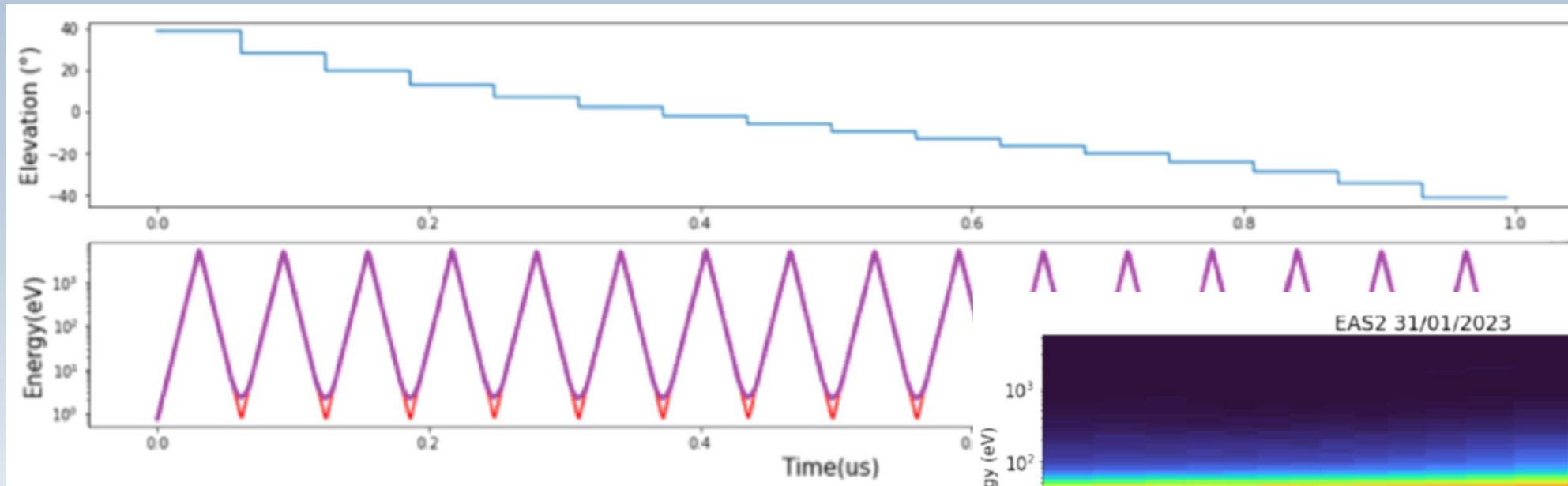
- It appears the HV sweep subsystem also struggles to reach the lowest energies – except for the first elevation scan (see profile above);

- Correction for this cleans up the measurement (compare top – uncorrected - and bottom – corrected – panels on the right.
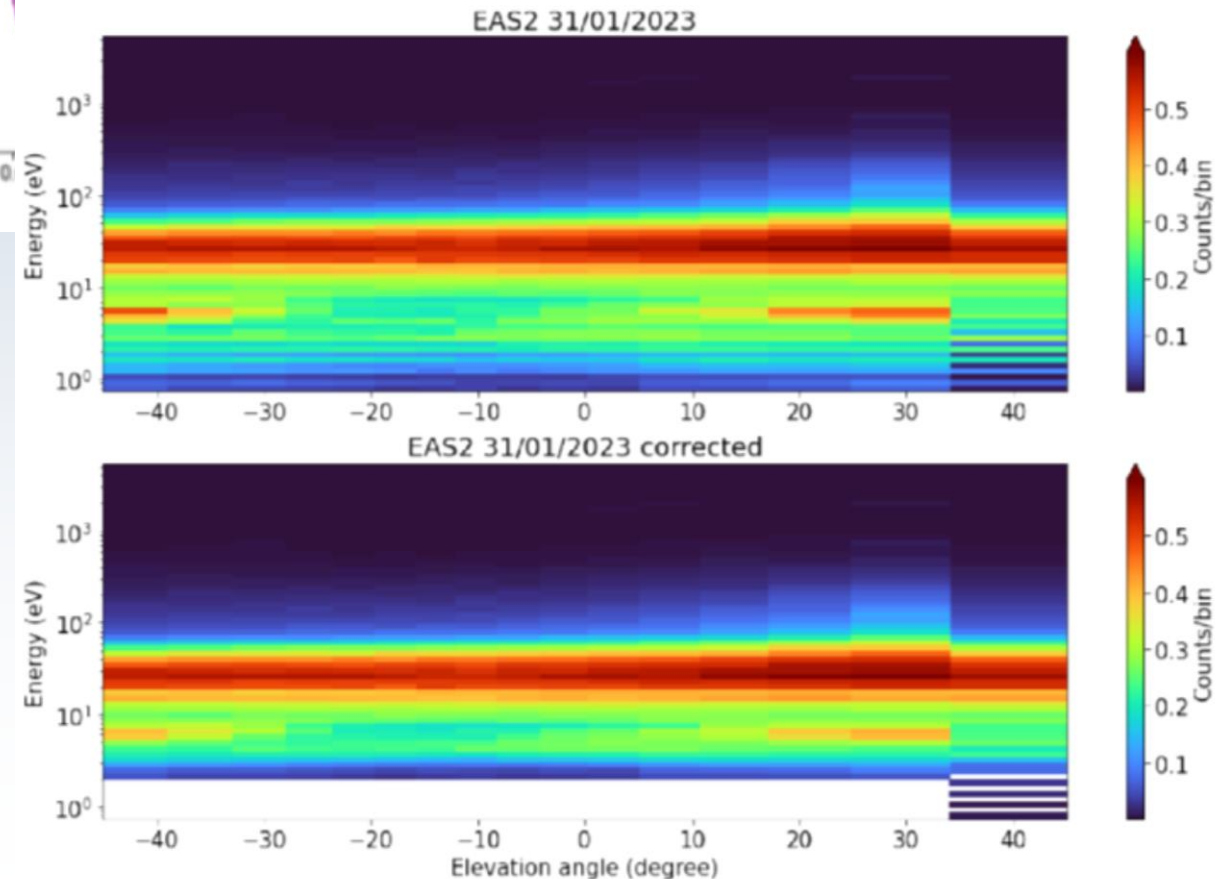
MAG-RPW-SWA Trigger Mode Coordination

- This appears to be working in terms of timing now;

- May be worth working to increase the %age of shock captures;

- At the July ISWG I showed the 2023-01-17 event – MAG data not available still;

- We also established we have a trigger in our list for 4 more events that MAG (Tim) also reported looked like they may be shocks:
  - 2023-03-14T01:08:32.966 – see next slides;
  - 2023-04-22T08:02:15.853 – see next slides;
  - 2023-05-18T05:13:59.621 – MAG data not yet available;
  - 2023-05-23T22:21:51.271 – MAG data not yet available;

- I have yet to check for events that may be available after our period of long data download latency over the summer.

Examples

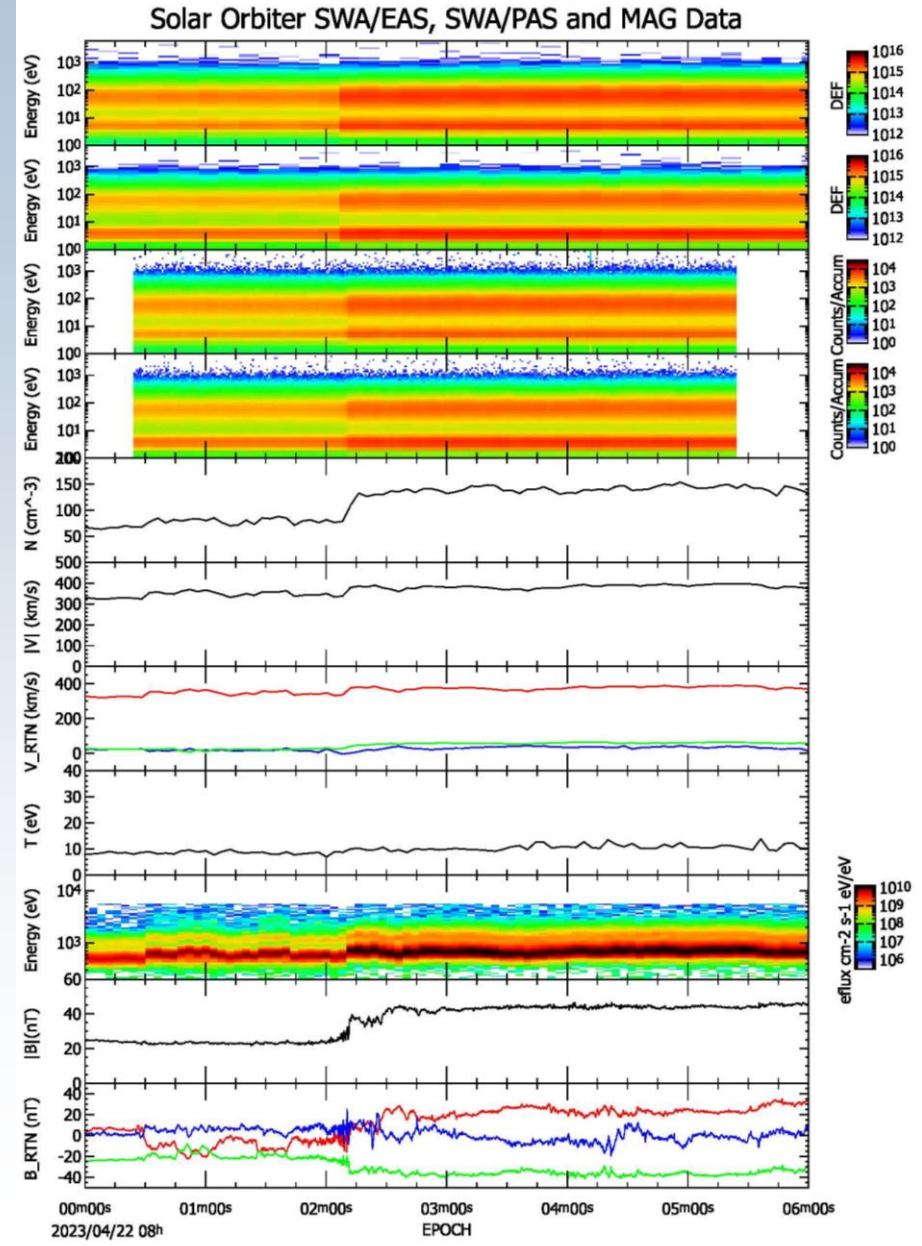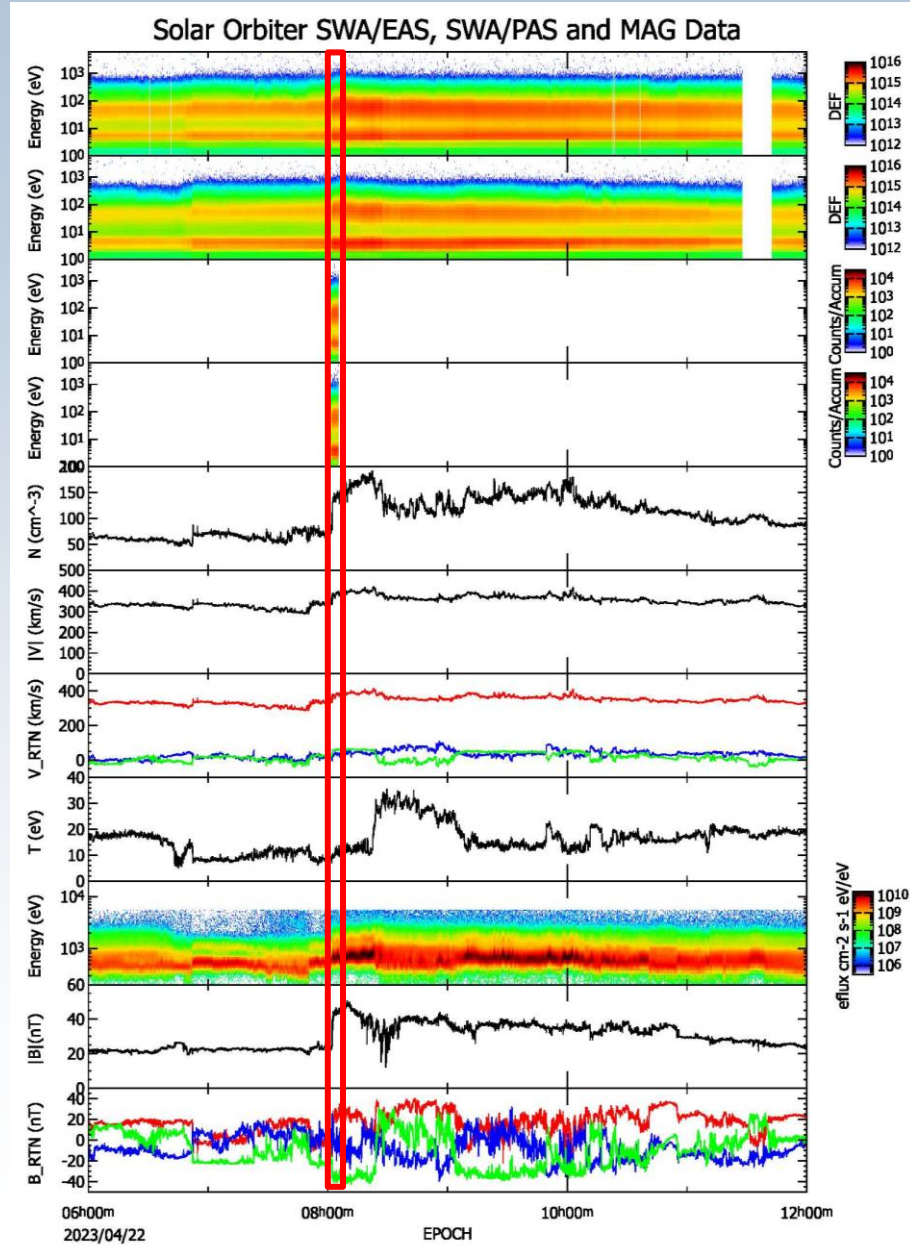*17 January 2023 – SWA responded to 1 trigger event;*
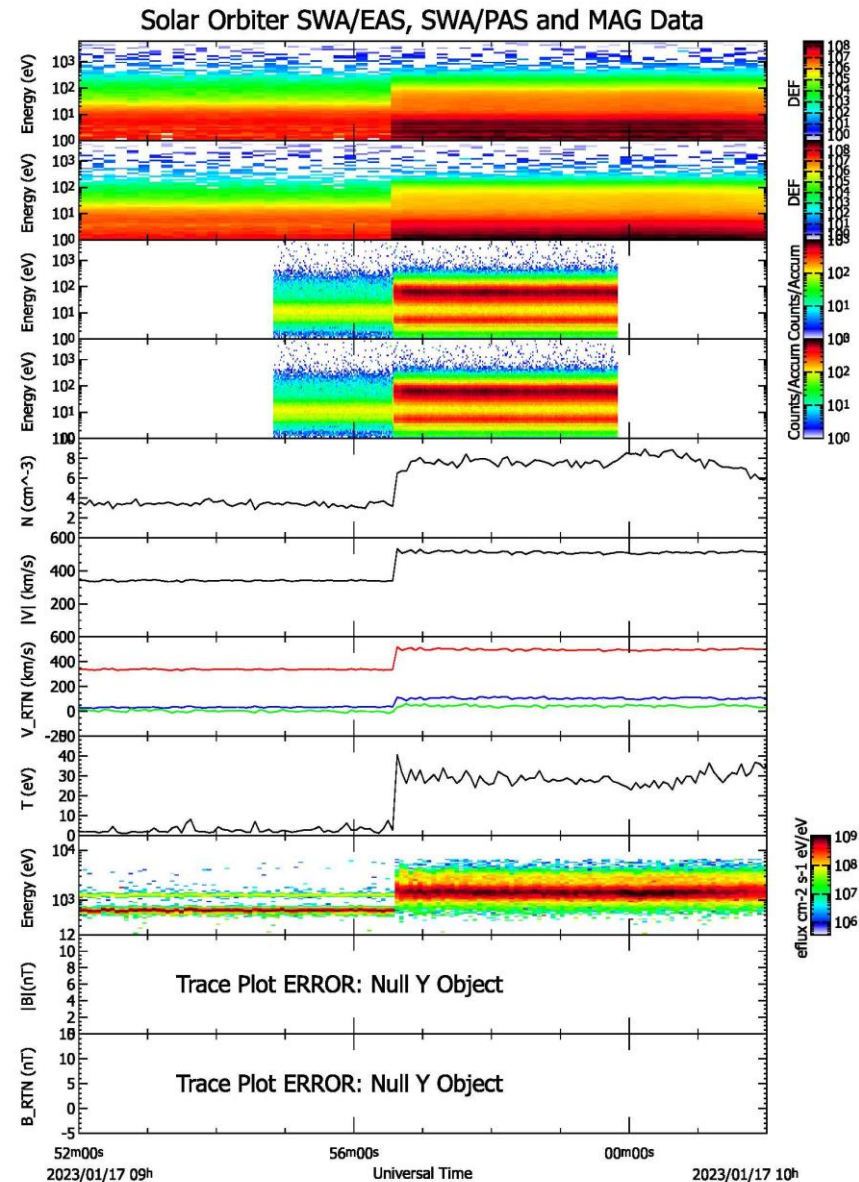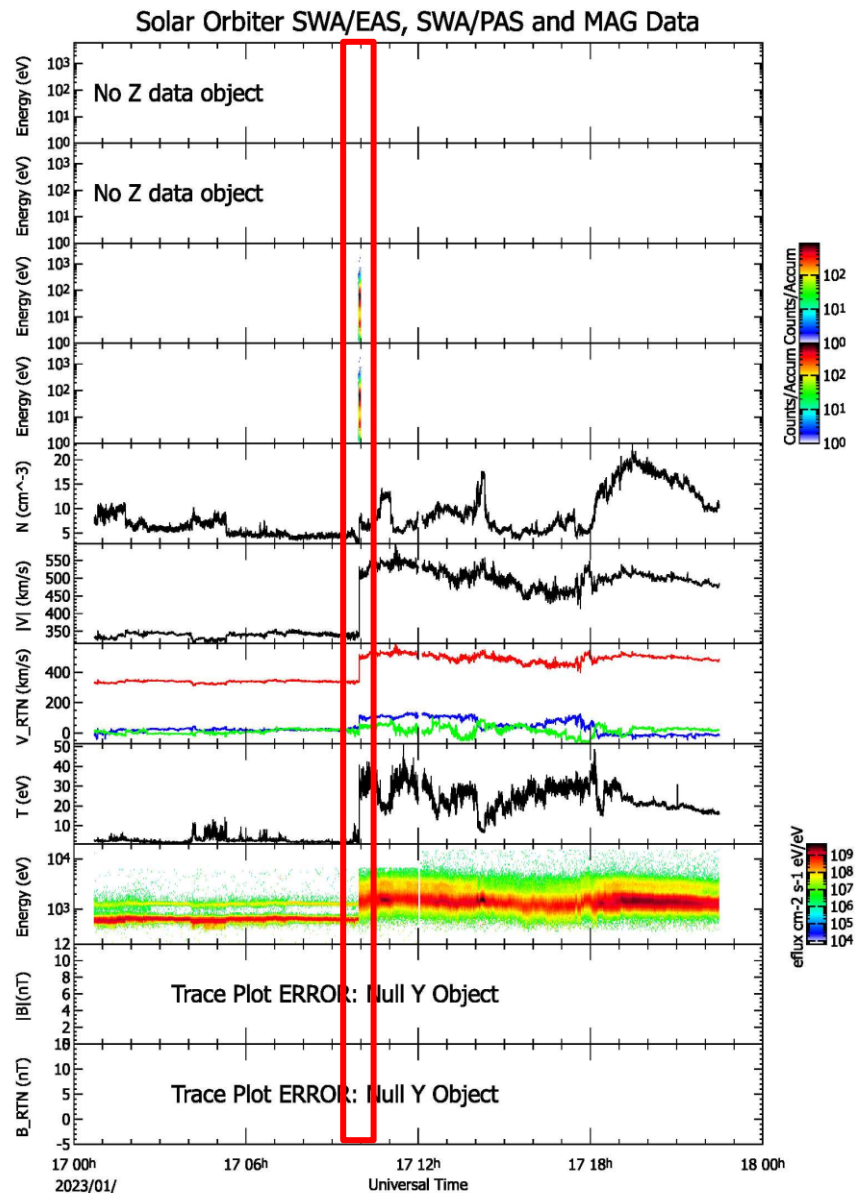
Example #2
2023/03/14 1408 UT.
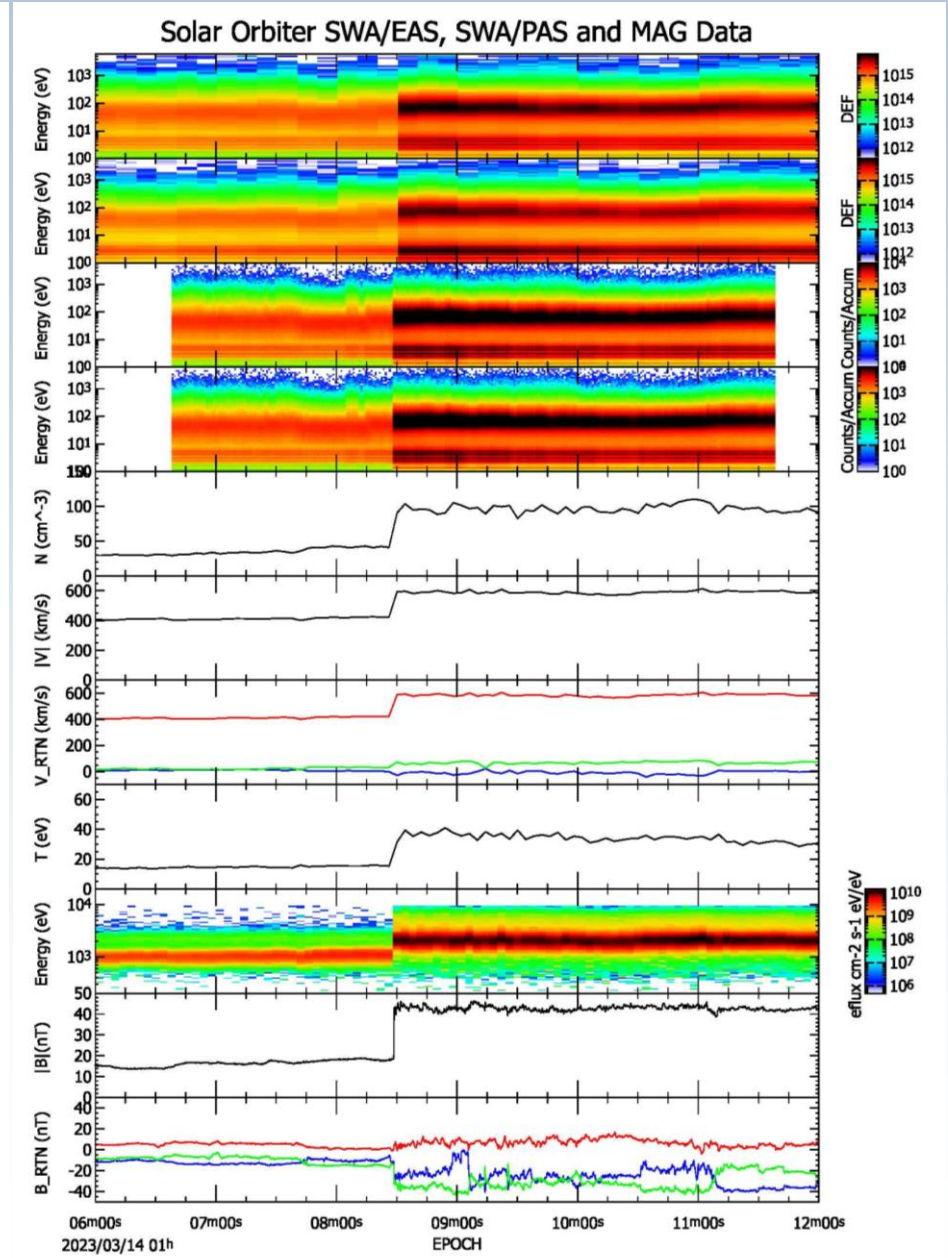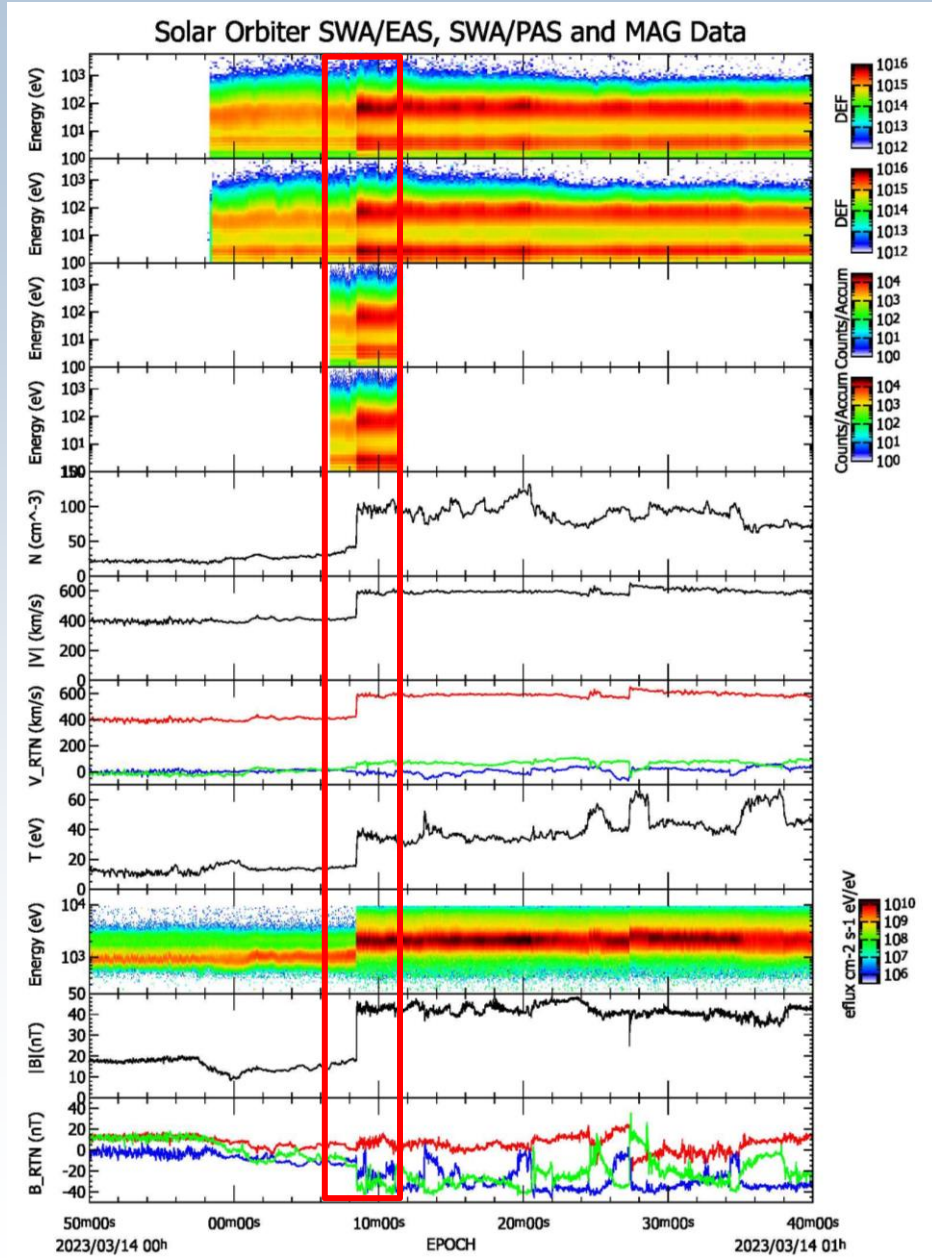
Example #3
2023/04/22 0802 UT.

Trigger Mode – Quick Publication?

- I think it would be good to put out a letter in the near future to advertise the capability of the trigger capture scheme for study of shocks (and other discontinuities?);

- Scientifically this can cover the HR EAS measurements plus anything that RPW (and MAG) may have captured from selective events;

- Methodologically could cover the shock detection algorithm and its action (although I think this may be covered in an earlier publication?);

- Does this conflict with any plans from RPW?

- If not, who from RPW might like to act as PoC on this, who should be included as co-authors who have contributed to the success of this?

Spacecraft Potential Analysis and Correction

- This is a major area for SWA-RPW coordination;

- Data analysis and SPIS work being undertaken on the SWA side
  - Stepan has some detailed analysis……