Heavy Ion Sensor

Present Status – Part 1

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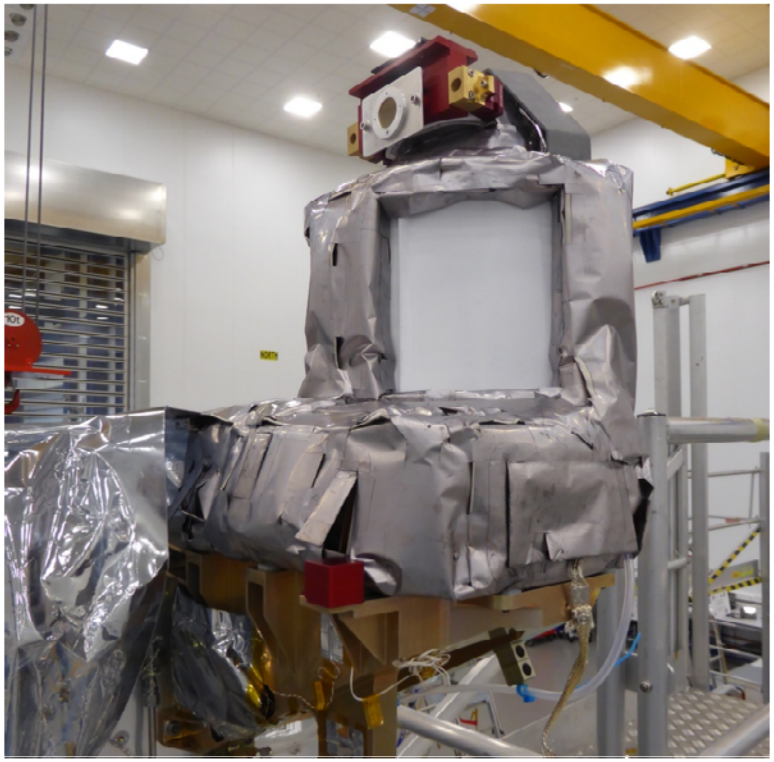
Agenda

- Brief instrument description and goals
- Instrument performance to date
- Commissioning summary:
  - Plasma measurements at 30s
  - Minor ions in E/q – T space
  - C6+ to He2+ separation
  - Pickup ions
- Problems and issues



HIS as installed on the S/C

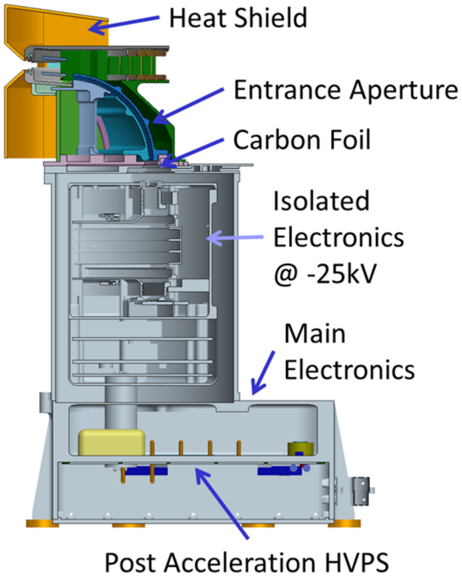
HIS Introduction

The Heavy Ion Sensor (HIS) has been developed to measure distribution functions of heavy ions (i.e. m≧4) in the solar wind

Physical properties of heavy ions carry important information about processes governing the outflow of the solar wind:

- Charge states of the heavy ions are established very low in the corona and controlled by the local electron temperature and density
- Relative abundances of ions are affected by how long those particles were subject to the gravitational potential of the Sun or other fractionation processes
- The distribution functions of the ions trace the plasma processes that are at work during the expansion

Instrument design is based on the combination of an electrostatic analyzer (to select E/q and directions of arrival), followed by a post-acceleration, and a time-of-flight – total-energy measuring system.



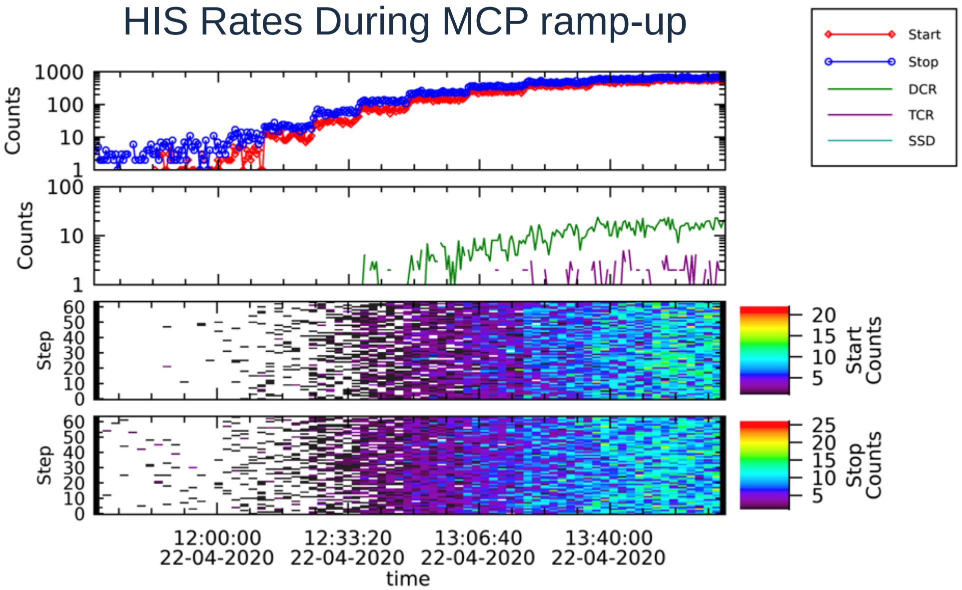
HIS Science Performance to Date

- Almost 100 hours of operation in flight at full capabilities without any spurious event
- 20 hours over 3 days of full science data
- MCP and SSD performances exactly as during calibration
- All level one requirements verified during calibration
- Ready to collect a wealth of novel and important data

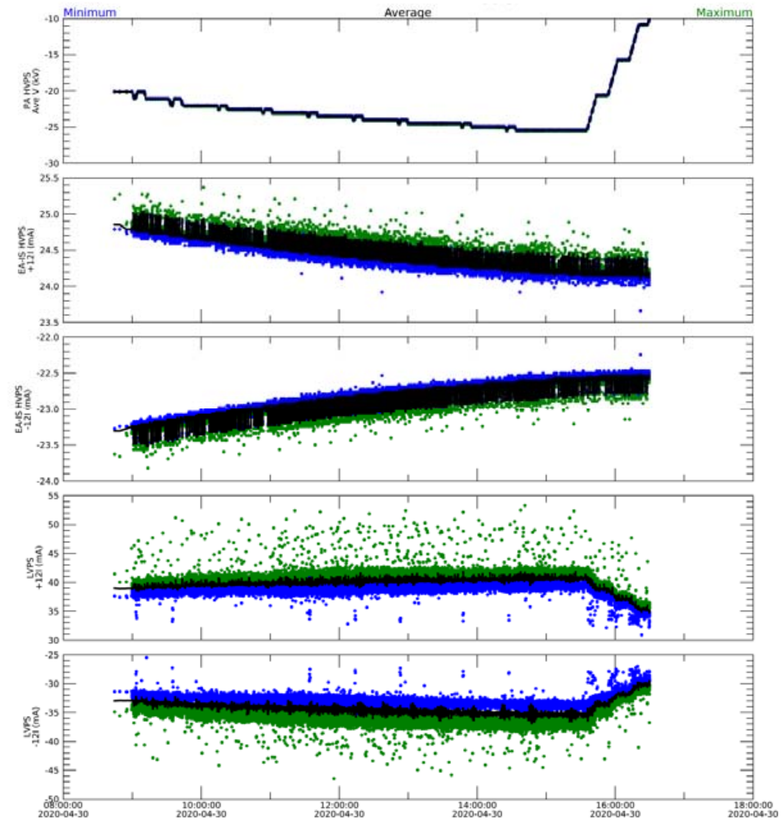
L1-Requirement	Requirement	Status	Actual range
LWS-SOC-SWA-HIS-M1	Energy range 0.5-60 keV	√	0.5 – 80 keV
LWS-SOC-SW A-HIS-M2	Elevation range +17 : -17	√	-20:+20
LWS-SOC-SW A-HIS-M2	Azimuth range -30 : +66	√	-30 : +66
LWS-SOC-SWA-HIS-11	m/dm > 4	√	m/dm > 5 for m=1-36; m/dm=4 for m=40-86
LWS-SOC-SWA-HIS-11	dt < 30 sec	√	1,000 particles collected in 30 seconds
LWS-SOC-SWA-HIS-11	6% < d(E/q)/(E/q) < 10%	√	8%
LWS-SOC-SWA-HIS-12	He+2; C+4 to C+6; 0+5 to 0+8; Fe+6 to Fe+20; Mg+6 to Mg+12; Ne+6 to Ne+9; Si+6 to Si+12; He+; C+ and O+	√	Verified for all of those, plus S+1 to S+5, Kr+1 to Kr+3

HIS Post-Launch Performance

HIS Rates During MCP ramp-up



Post-acceleration ramp to -26 kV

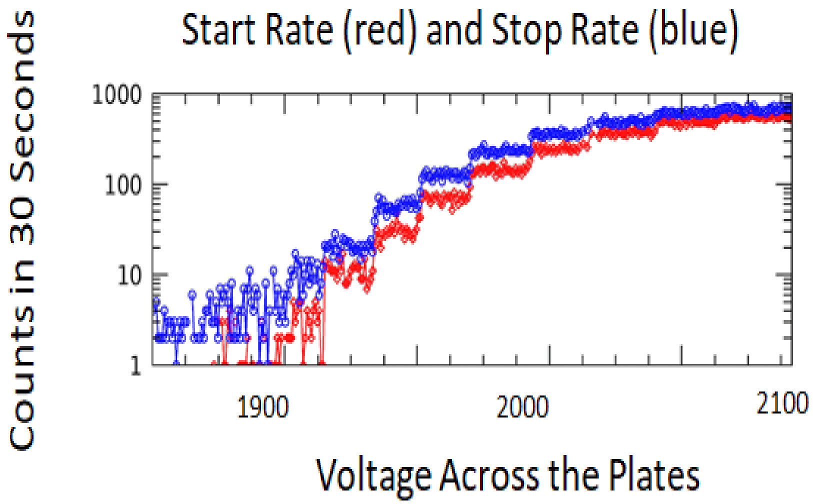


Science Assessment

- Ground calibration verified HIS as fully operational
  - Measurements included solar-wind-like high charge states for multiple ions
  - Preliminary data analysis completed
  - Further analysis and comparison with simulations underway
- All performance details satisfy Level 1 Science Requirements
- In-flight performances collected to date confirm requirements for the sensor can be met, once the sensor is properly tuned
- Mission Operations and Data Analysis infrastructure fully operational
- Team actively collaborating with and contributing to Science Operation Working Group and Science Working Team planning

MCP Performances

- MCP gain was checked using cosmic rays as stimulants
- Counts (~30 cts/s) corresponding to the expected fluence through the MCP area; coincidences also matching what expected
- Counts showed the expected trend with voltage, reaching plateau at around 2050-2100V



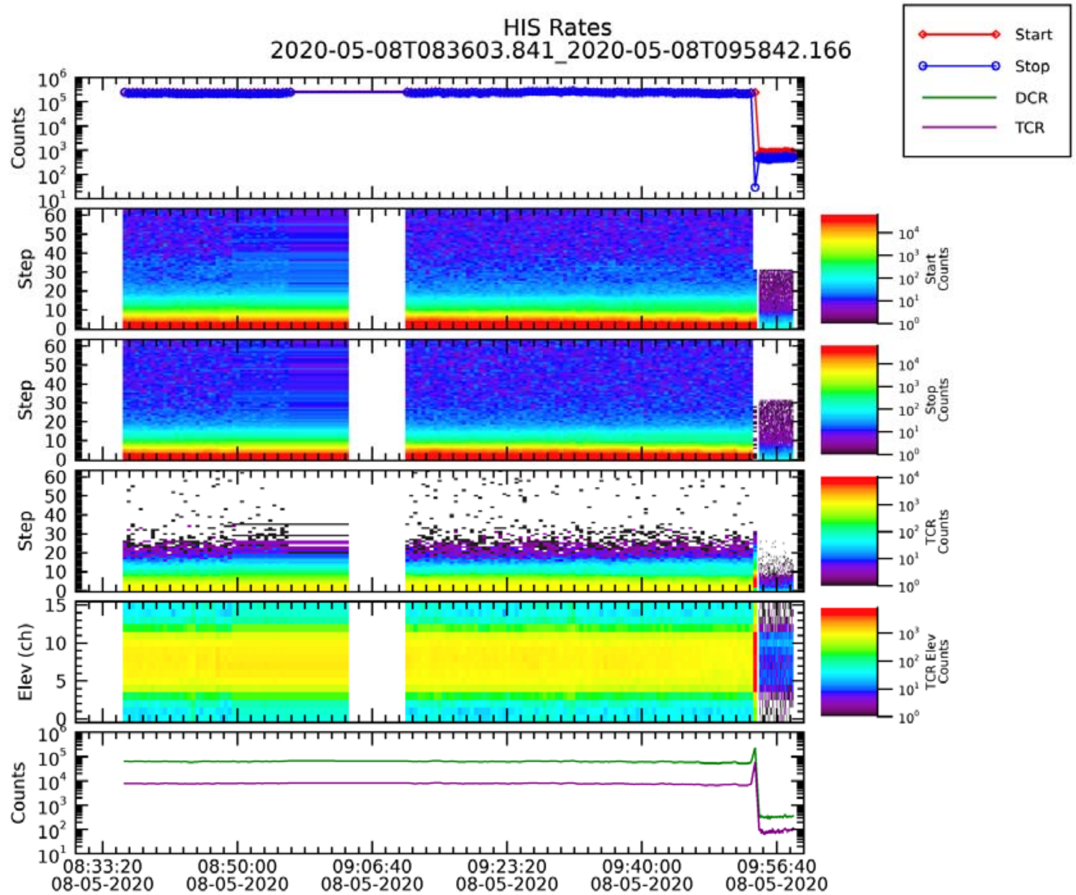
SSD Performances

- SSD noise as expected
- Thresholds have been raised slightly from calibration to optimize sensor performance:
  - Values could have stayed the same, but we decided to raise them slightly to bring dark counts from 1,000/s to 100/s
  - For long term operations we may relax back, once performances have been confirmed

Detector	Azimuth	Calibration Threshold	Flight Threshold	Counts/s
0	57.8	293.6	297.5	35.6
1	54.7	279.6	284.7	20.4
2	51.5	272.6	284.7	35.6
3	48.4	283.1	287.0	15.3
4	45.3	283.1	287.0	56
5	42.1	272.6	284.7	15.3
6	39.0	283.1	290.9	45.8
7	35.9	276.1	284.7	25.5
8	32.8	269.1	284.7	30.5
9	29.6	283.1	290.9	15.3
10	26.5	269.1	284.7	10.2
11	23.4	269.1	284.7	10.2
12	20.2	272.6	284.7	56
13	17.1	283.1	284.7	10.2
14	14.0	283.1	284.7	10.2
15	10.9	283.1	284.7	15.3
16	7.7	290.1	286.2	15.3
17	4.6	290.1	290.1	5.1
18	1.5	276.1	284.7	35.6
19	-1.6	286.6	286.6	5.1
20	-4.7	276.1	284.7	10.2
21	-7.8	272.6	284.7	15.3
22	-10.9	272.6	284.7	20.4
23	-14.1	279.6	284.7	15.3
24	-17.2	321.6	337.2	188.4
25	-20.3	321.6	321.6	208.8
26	-23.5	307.6	307.6	239.3
27	-26.6	300.6	308.4	234.2
28	-29.7	321.6	333.3	916.5
29	-32.8	OFF	OFF	OFF

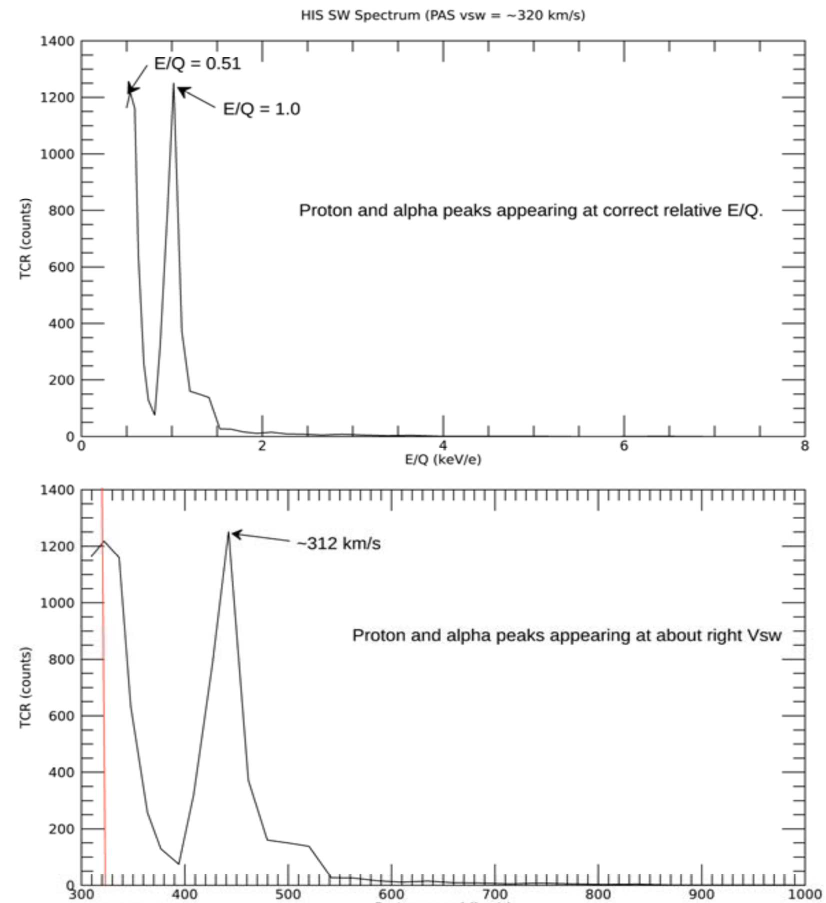
Data Overview

- Normal and burst mode
- Alignment of E/q and elevation channels in burst still to be completed
- Start and stop have some background from cosmic rays and accidentals (more later)
- TCR very clean (as expected)
- Good directionality



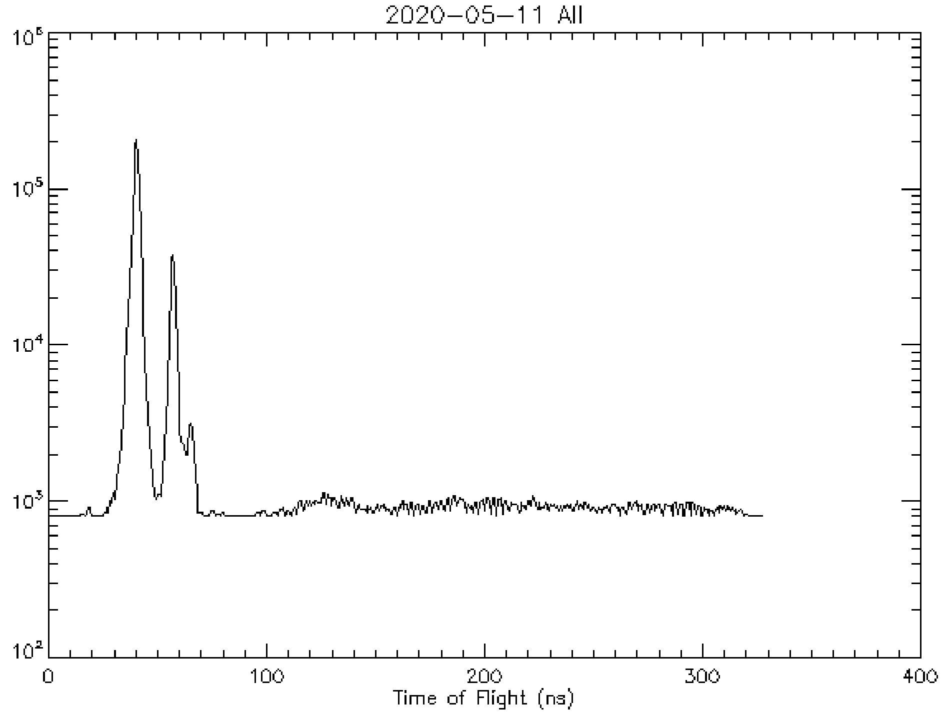
Plasma Properties 2020-5-11

- Values collected at 30s integration time
- Well corresponding to the PAS measurements
- Calculation of moments work in progress



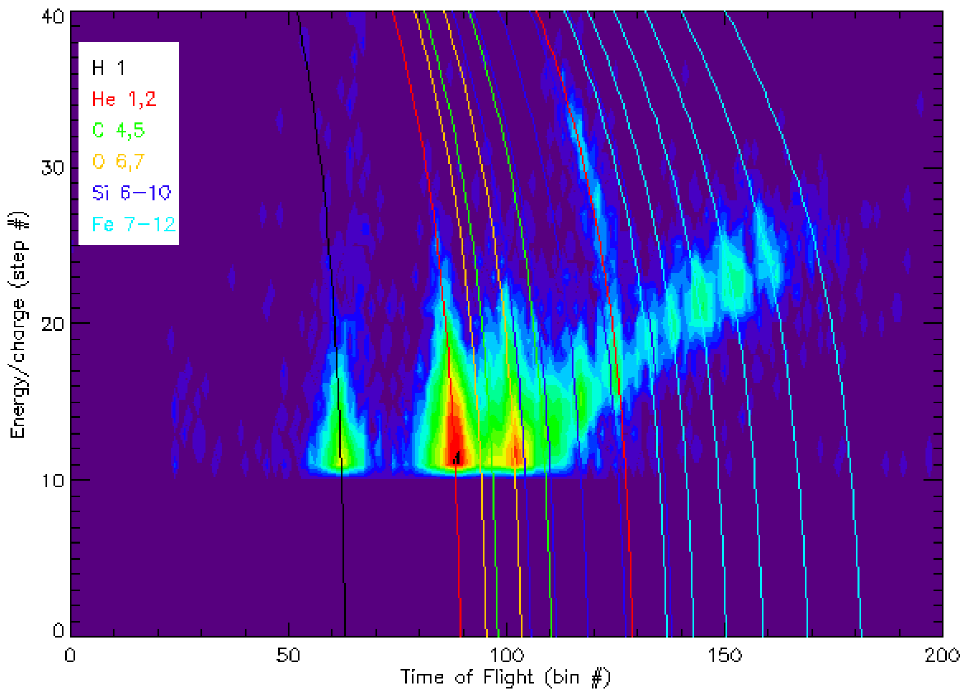
Time of Flight Spectra

- Protons, alphas, and O6+ clearly identified in ToF only
- High level of background caused by proton accidentals: start and stop proton efficiencies are at ~70%, and a start can be coupled to a stop from a different particle
- This (and total load on the plates) is the reason for the Proton Avoidance tool, which is implemented in the flight software, but not yet activated

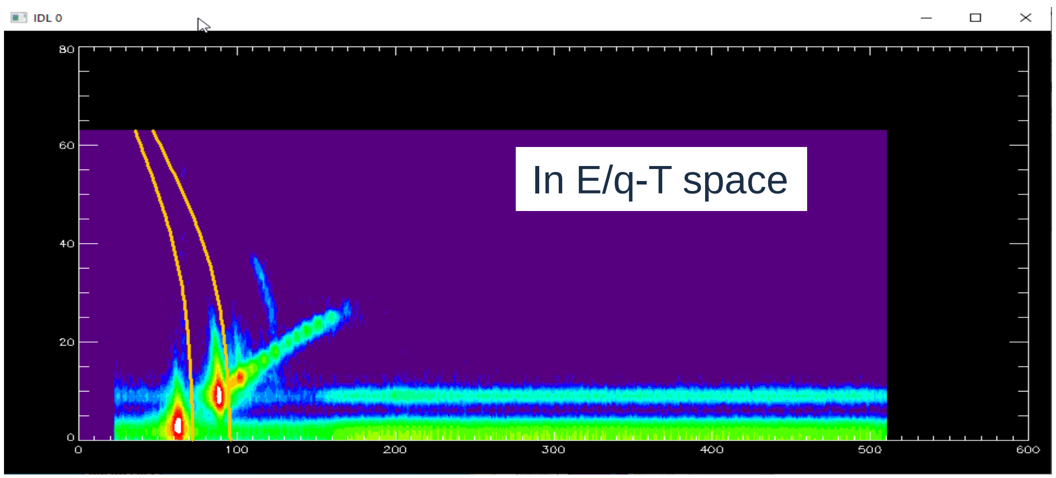


In E/q – ToF Space

- Particles align well along measured calibration tracks
- Intensities are greatly affected by the accidentals and by the choice of priority table (more later)
- It is estimated that presently the efficiency is between 1% and 5%
- Tools are already available in the flight software to counteract both effects; need to be activated and tested



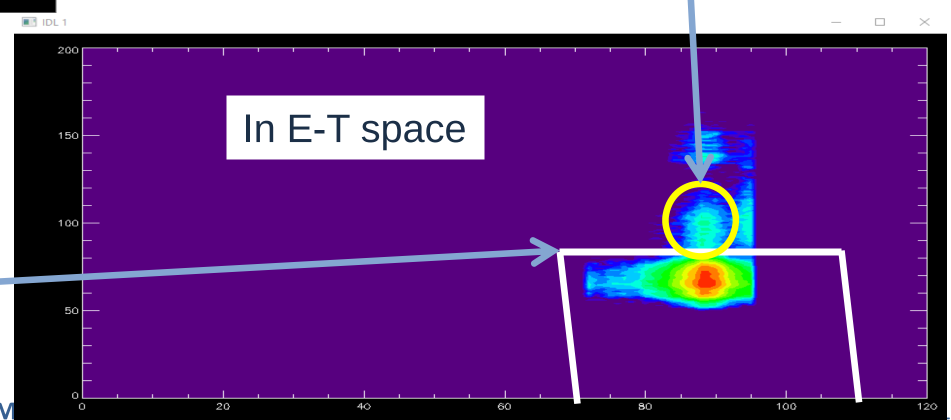
Using Solid State Detector Information



m/q between 1.3 and 2.2

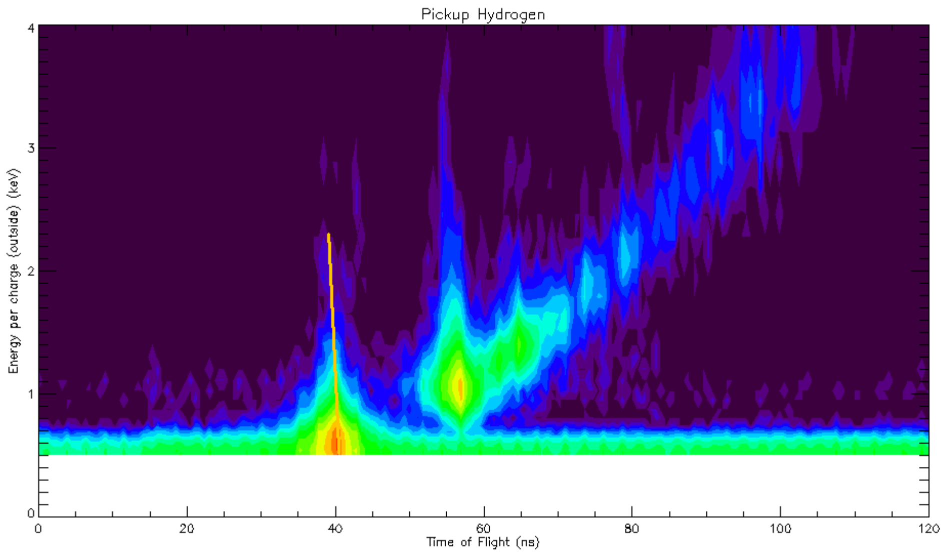
This level in Energy defines the boundary between He^{2+} and C^{6+} and O^{8+}; it is slightly function of E/q

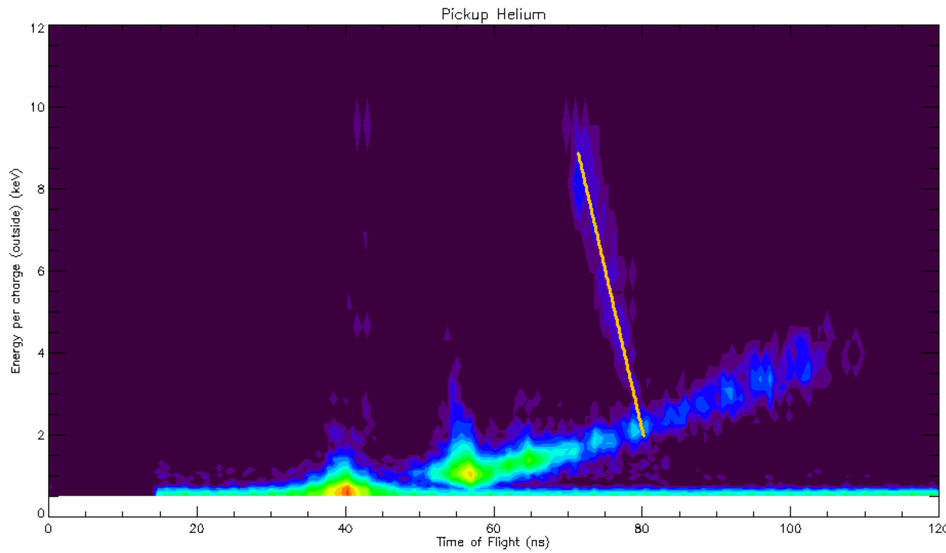
C6+



Pickup Ions

- Both pickup protons and He observed
- Distributions cut off at 2 V_{SW}





FDIR: Fault Detection, Isolation, and Recovery (1 of 2)

- Self protects the instrument if conditions appear critical or dangerous
- Tripped two limits during commissioning:
  - Low temperature on the sensor (-40°C)
    - Not a dangerous situation *per-se*, Instrument would survive
    - It was observed during TV that as temperature gets below -40°C, the AC link for the detector section has a hard time to start and requires more power
    - This is undesired, and the plan was never to attempt turning the instrument on at those low temperatures
    - Unfortunately, this was not recognized as a requirement by Astrium, and the survival heater was set just at -39°C (+/-1°C)
    - As it happens, once during power up we hit the point at the lowest temperature and the instrument (correctly and as planned) turned itself off

FDIR: Fault Detection, Isolation, and Recovery (2 of 2)

- High current on +12V, driven by EAIS
  - Issue already noted during TVac, and reported as NCR:
    - Power cycle of EAIS power supply does not completely reset the configuration
    - As a result, feedback loop may start drifting, causing current to raise
    - Eventually current reaches 100mA in the drive circuit, at which point the FDIR detects a dangerous situation and turns HIS off
  - Suggested and implemented cure in the flight software: enable EAIS, set all bits to 0; HIS chose to disable EAIS after all bits were set to maintain double safety commanding
  - Unfortunately, this patch made the situation worse, and FDIR turned HIS off twice (4/24 & 4/28)
  - In close collaboration with IRAP we identified an updated scheme
    - Enable EAIS, set all bits at zero, and set voltage on EAIS at a low level of –100V
    - Patch was effective
  - We will implement this in the flight software at a future point in time
  - Note that the drifting situation may arise only during test campaign: for normal flight operation EIAS is always on and commanded to appropriate voltages

Spacecraft Commanding (aka NCR-1419)

- Before starting commissioning, we were afraid of "double miss" command (aka NCR 1419), where missing two consecutive commands would cause spacecraft to turn off power to the instrument
  - This happened to SWA during ground operation on the ETB
  - This might have caused severe effects during commissioning
- ESA/Airbus performed a patch on the flight software, whereby a missing Service 20 message would not count as a missed command
  - This reduced drastically (3-4 orders of magnitude) the probability of a "double miss", as Service 20 messages come every 125ms
- SWA did not experience any "single miss" command during in-flight commissioning
- Note that SpaceWire still exhibits problems at spacecraft level:
  - On two instances, clogging of SpaceWire bus by instrument A did produce "multiple errors" and hence reboots on instrument B and C
  - On one instance, heavy commanding of instrument D produce a collapse of th spacecraft messaging system, and spacecraft went into safe mode
  - Problem is actively been investigated by ESOC / ESA / Airbus