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DPU PLASTIC Processor Tasks

Overview of PLASTIC Instrument operation

PLASTIC covers the full azimuthal range (ie. in the ecliptic plane) at all times, but needs to step through energies and polar angles. The polar angle steps from +20 to – 20 degrees in 1.5 degree steps (~30 steps). In normal mode, the ESA voltage is stepped in logarithmic increments of 4%, from 10 kV to 20V in up to 144 steps. For a full cycle, the ESA will sit at one voltage, while the deflector voltages sweeps through their full set of values. Then the ESA voltage will continue to the next step. Each ESA step with a full set of deflection angles will take 420 ms, and a full cycle will take 1 minute.

There are two entrance systems for the solar wind ions. One entrance has a large geometric factor, for the low abundance heavy ions, and one entrance has a small geometric factor for the H^+ and He^{++} ions. The heavy ions are observed at the higher energies, while the H^+ and He^{++} are observed at the lower energies in the solar wind. Therefore, when the ESA step has moved into the H^+/He^{++} energy range, the configuration of the deflectors needs to change. The energy at which to switch between the two entrance systems is determined by the DPU.

There may be other modes of operation than the normal mode described above.

DPU Control tasks

The DPU is responsible for the following tasks:

- Receiving, decoding and routing commands to the instrument
- Controlling sweep and deflector HV, including determining energy step to switch between entrance systems.
- Emergency response.
- Triggering the "Tracking Mode", and controlling the stepping sequence for the tracking mode.

Receiving, decoding and routing commands to the instrument

The DPU will be able to send two types of commands to the instrument – commands initiated on the ground, and pre-defined command sequences. Examples of pre-defined command sequences are requests for housekeeping and/or monitor rate data on a routine basis, We will also define a number of standard configurations for the instrument (e.g.

Standby, Maneuver-safe, Calibration). The DPU will store the parameters for these states, and execute them on command.

Controlling deflector voltages

The DPU is responsible for loading the stepping tables for the ESA and deflectors. There may be more than one table (stepping mode), selectable by command. The exact method for determining the ESA step where the entrance system should be switched has not been determined definitively. One possibility is to start with a default energy for switching the geometric factor. From the SW proton distribution, find the peak energy. From the peak, determine the energy to switch as either a constant factor above the peak energy, or a factor based on the temperature, from the moments calculation. Use that energy step as the switching point for the whole next energy/angle cycle. This will be repeated every cycle (~ 1 min). Another possibility is to monitor the maximum in one of the arrays (TBD) for each step in a cycle. Once the rate exceeds a pre-defined value, the entrance system is switched. The merits of these schemes are still being discussed.

Emergency Response

The DPU will read critical housekeeping values and execute emergency procedures if the HK values fall out of range. Some examples are:

> If Current limits are exceeded, turn voltages down and instrument off.
> If HV discharges, step the HV back up to nominal value (like CLUSTER)

The DPU may also need to respond to spacecraft flags of critical events. For example it may need to automatically safe the instrument during thruster operations, and then automatically reconfigure the instrument at the end.

Triggering the Tracking Mode

There will be a special mode triggered by other IMPACT instruments, where we need to get high time-resolution proton data, at the expense of the heavy ion data. To do this, the DPU will need to find the peak in the SW proton/alpha distribution, and then send a stepping sequence that only includes ~ 10 energy steps around the proton peak. Our baseline is that we will still step through all 30 polar-angle deflection steps. In this scenario, the DPU still reads the data arrays every 420 ms, and we will get a proton distribution every 4.2 s. We could also reduce the number of angles that we cycle through, but then the DPU would have to read our board more frequently than every 420 ms. The tradeoffs of different implementations need to be discussed with the IMPACT team.

DPU Data Tasks:

There are five types of data that the DPU will process:

- HK data
- Monitor rate data
- Matrix Rate Data (from Classification Board)
- Raw Event data (PHA data)
- Beacon Mode data

In all cases the DPU must format the data for telemetry, including adding header information for identifying product type and data collection time.

HK Data

Instrument housekeeping data must be read at regular (TBD) intervals and formatted for telemetry. Certain key values must also be monitored by the DPU, and the DPU must execute emergency action, as necessary.

Monitor Rate data

The monitor rates data consists of the raw rates from individual counters and from checks for logical coincidences in the instrument. There will be about 24 rates (exact number TBD)

They must be read and cleared every "major" energy step. The deflection step at which they are read out must be cycled through, so that we get a sample of the rates at all positions after a number of cycles. The interface for this is still TBD – either the DPU requests the rates, or the instrument just sends them out on a scheduled interval. These rates must be summed in energy step and in time, and formatted for telemetry.

Matrix Rate Data

The 16-bit accumulators must be read and cleared after every deflection cycle (420 ms). The contents of the accumulators are listed in table 1. The accumulated data must then be further summed and processed as listed below.

Table 1. Accumulated products on Classification board.

Name	Classif. bins	Azimuthal bins	polar bins	Energy steps	Sections	Total bins	bits/item	Total Bytes
SW H/Alpha	2	30	30	1	1	1800	16	3600
SW_no TOF or E required	1	30	30	1	1	900	16	1800
SW Z>2	15	9	8	1	1	1080	16	2160
Suprathermal - Wide	10	2	1	1	1	20	16	40
Suprthermal - noE	5	6	1	1	1	30	16	60
PHA_Priority_rates	4	1	1	1	4	16	16	32
PHA Data						512	32	2048
Total						3846		9740

SW Proton and Alpha data

From the instrument, there are two arrays which contain the solar wind proton and alpha data. The first contains fully classified data: there is a 30-azimuthal bin x 30-polar bin array for each of the two species, to be read for 50 energy steps (the low energy range). The second array contains the proton/alpha data together, with only angular binning. The array used for calculating moments, and for determining the peak position will be chosen by command. A reduced distribution function from both arrays will be telemetered to the ground. If the second array is used for moments, only one set of moments (assumed protons) will be calculated.

The following processing must be done
1) calculate moments for either both species, or for protons only
2) determine the energy of the peak. This info is used both to set up the energy step to change entrance systems, and is used to generate a reduced distribution function.
3) Form reduced distribution functions, for protons and alphas, centered on the peak with 10 Energies, 8 polar, and 8 azimuthal angles. From the second array, the distribution function will have 20 energy steps, but no species division. A snapshot set of distribution functions will be telemetered every 5 complete cycles (e.g. every 5 minutes)

Heavy Ion Data

The other "matrix rate" products (SW Z>2, Suprathermals, Suprathermal-NoE, PHA Priority Rates) must be accumulated in time, and energy to create "data products" that can be telemetered at our available telemetry rate.

Raw Event data

We need to collect a sample of raw events, which are used for high resolution science analysis, as well as instrument diagnostics. We want to maximize the number of minor ions collected, and also collect a selection of ions from the different sections of the instrument. Thus we need to have a prioritizing scheme for selecting the ions. The ions need to be tagged with their priority classification. This comes from the classification board. Then, a selection of these events needs to be put into the telemetry.

Possible implementation: On the Accumulator board/PLASTIC side, we fill a buffer that contains the events, including a priority tag. We fill it with at most 512 events per ESA step.

The DPU then reads this buffer, and begins filling a PHA packet, based on the priorities. It first fills the buffer with the first 512 events that come in. Then, as more events come in, lower priority events are replaced with higher priority events.

Beacon Mode Data

The Beacon Mode data will be a subset of the normal data stream, with some small additional processing. Table 2 lists the data products for beacon mode, and the source of the data. There will also be a data quality flag associated with each parameter.

Table 2. Beacon Mode Data

Parameter	Resolution (min)	Bits	Source	Additional Processing
SW H density	1	8	Moments	None
SW He++ density	1	8	Moments	None
SW bulk velocity (vx,vy,vz)	1	8*3	Moments	None
SW thermal temperature	1	8	Moments	Average Components of temperatures tensor
Representative SW Charge states	5	8*5	SW Z>2	Summing selected bins from SWZ>2 matrix rates
Suprathermal rates	5	30*8	Supratherm al-Wide	Summing selected bins from Suprathermal matrix rates

Summary of Data Products

Tables 3-6 give telemetry tables for the Matrix Rates, moments, PHA, and Monitor Rates that show the size and time resolution of each data product. Note that these are preliminary, and the exact set of products will be determined later, but it gives an idea of the amount of memory needed to hold the products.

Table 3. Sample Matrix Rate telemetry

	M vs M/Q bins	N_Energy	N_azi	N_Polar	total bins	bits/bin	total bits	Compressed bits	Time (sec)	bits/s
H+ Peak	1	10	8	8	640	16	10240	5120	300	17.07
He++ Peak	1	10	8	8	640	16	10240	5120	300	17.07
H_alpha	1	20	8	8	1280	16	20480	10240	300	34.13
SW_Z>2 - H	2	36	8	8	4608	16	73728	36864	300	122.88
SW_Z>2 - L	13	36	8	1	3744	16	59904	29952	300	99.84
Super-thermal	10	36	2	1	720	16	11520	5760	300	19.20
Superth. - noE	5	36	6	1	1080	16	17280	8640	300	28.80
PHA_ priority	4	36	3	1	432	16	6912	3456	300	11.52
Total							210304	105152		350.5

Table 4. Sample Moments telemetry

N Species	N moments	total items	bits/item	total bits	Total bits Compressed	Time res	bits/s
2	13	26	16	416	312	60	5.2

Table 5. Sample Monitor rates telemetry

N Rates	N Energies	N Polar	total items	bits/item	total bits	Total bits Compressed	Time res	bits/s
24	18	8	3456	16	55296	27648	300	92.16

Table 6. Sample PHA telemetry

priorities	Energies	sections	Events/prior	N events	bits/event	total bits	time res	bits/s
4	36	3	5	2160	32	69120	300	230.4

Table 7. Total telemetry

	size (bits)	Time res	bits/s
Matrix Rates	94912	300	316.37
Moments	312	60	5.20
Monitor Rates	27648	300	92.16
PHA	103680	300	345.60
Housekeeping	TBD	TBD	
Total			678.27
Total including Housekeeping and Headers			**800**