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## **E3DD-Lite on RAPID: the L3DD Product (Implementation of the J-Mode)**



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## Summary

In April-May 2004, a new patch has been uploaded to RAPID that replaces the data in the IPAD and EPAD in nominal mode with data from 2 channels of burst mode E3DD. The RAPID software package `msf2sci` has been updated (version 5.5 or later) to handle this, by producing a SCI output file for the pseudo data product (or class) called *L3DD* (for E3DD-Lite). The L3DD data record in the SCI file is structured the same as for E3DD in burst mode, except that only 2 energy channels are present instead of 8. Those two channels correspond to channels 1 and 3 (counting 1–8) of the full E3DD SCI record.

The L3DD product is also available in burst mode, being simply a subset of the existing E3DD\_BM product.

The time resolution for L3DD is one record per spin.

IPAD and EPAD no longer exist in nominal mode.

## The E3DD\_NM problem

It has long been recognized that the electron distributions measured by RAPID in nominal mode (NM) leaves much to be desired. The E3DD\_NM product is not really 3D at all, more like 2D, with the distributions smeared out over the entire spin. Some relief had been achieved since July 2003 with the introduction of the NM3 mode on SC2, granting RAPID enough of the unused CIS telemetry to run in burst mode (BM) with the full E3DD\_BM distribution every spin. However, this solution involves only SC2, where CIS is not operating, and requires negotiating with PEACE, who also demand the CIS telemetry.

## Search for software solutions

The PEACE Team had demanded that we seek a software solution, or at least try to rule one out. Mark Lankton from LASP came to Lindau and Braunschweig (May 2003) to examine the DPU software in the hope of finding the magic solution. The task was made more challenging by the fact that only 200 bytes are available for additional patching. We discovered that an additional 2K was available in volatile RAM. This made the situation somewhat more realistic, but with the disadvantage that the patch would need reloading after every power-off (which should be rare, a few times a year during long eclipses).

Mark proposed 3 possible reprogramming schemes to improve the E3DD angular resolution in NM, all involving loss of time resolution, and loss of EPAD and IPAD. They would all require considerable reprogramming effort and it was not proved that any of them could fit into the 2K limit.

In September 2003, while visiting RAL, I discussed the 3 proposals with the Co-Is there, to try to reach a decision as to which we should go for. None of them were really “exciting”. Jackie Davies stressed that it would be better to keep the original E3DD\_NM, and that led to a

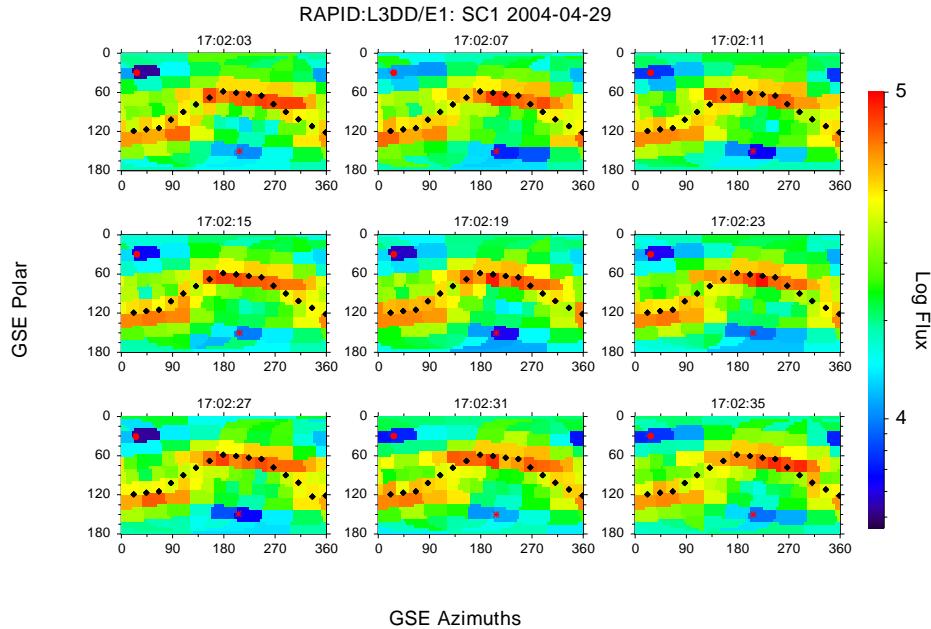


Figure 1: Demonstration of L3DD (E3DD-Lite) on SC1 after patch uploading

totally new idea. It broke our mindset on this problem. Instead of trying to obtain all or most of E3DD\_BM in NM, we just take two of the 12 energy channels at full angular resolution, and place them in the IPAD and EPAD slots of the NM data block. The magic solution was found, since IPAD and EPAD each contain exactly the same number of bytes, 96, as does one E3DD\_BM energy channel. We decided to call this the *Jackie Option*, and later the *J-Mode* for RAPID.

## Implementation

The great advantage of the J-Mode is its simplicity. It just requires writing existing data into new positions in the data block. The RAPID DPU generates the data blocks for both NM and BM all the time, but only one is output depending on telemetry mode.

IDA in Braunschweig confirmed that this programming change would most likely fit within the 200 byte limit on the non-volatile RAM. They even offered to undertake the entire writing, testing, maintaining of the patch.

Christian Dierker of IDA prepared a preliminary version, as a revision to the main “big patch” that was made up shortly after commissioning, and this was uploaded to SC1 on April 20, 2004. A number of problems were immediately obvious, and Christian had to produce a second version. This was uploaded on April 27, and proved to be successful (see Figure 1).

The times of uploading to other spacecraft are given in Table 1.

Table 1: Times of uploading of J-Mode patch

SC1	April 20	10:00	Test version
SC1	April 27	11:30	Final version
SC3	April 30	07:19	Final
SC4	May 3	11:19	Final
SC2	May 13	15:38	Final

(The times listed are when the new patch was activated.)

## The L3DD product

The J-Mode makes available a new data product in NM, which could be called E3DD-Lite since it is a reduced version of E3DD. To make the designation handier, I call it *L3DD* (think of Lite 'Electrons in 3D). The program `msf2sci` has been modified (version 5.5 or later) to produce this with the command line parameter `/k=13dd`, a new possible value for the allowed products (also called 'classes' at times).

The L3DD records (one per spin) in the SCI file are very much like those for E3DD in BM: for each energy, there are fluxes in  $9 \times 16$  directions, but for 2 instead of 8 energies. Compare the format description lines in the two SCI files:

For L3DD:

```
! Format DATA(2,9,16), counts in 2 energies, 9 directions, 16 sectors
```

For E3DD\_BM:

```
! Format BM: DATA(8,9,16), counts in 8 energies, 9 directions, 16 sectors
```

The indices are given in Fortran style, i.e. the leftmost (energy) varies fastest.

The two energy channels for L3DD correspond to channels 1 and 3 from E3DD. These are hard-wired into the patch, so any decision to change these will require the patch to be rewritten and uploaded. This is a consequence of trying to keep within the 200 byte limit for reprogramming.

The L3DD product is also produced in BM, directly from the E3DD data.

## Side effects

The J-Mode does not come without strings, of course. The following should be noted:

- EPAD no longer exists. The SCI files will still emulate it in BM from E3DD data. In principle, a version of EPAD could still be emulated from the L3DD data in NM, but it is questionable as to whether it is worth the programming effort.
- IPAD no longer exists in NM, but it will still appear in BM.
- E3DD\_

## For experts and other crazy people

This section can be skipped by most users. It gives some details that may be needed by anyone who wants to work directly with raw data blocks.

### The energy channels

The E3DD raw data block consists of  $12 \times 96$  bytes for 12 energies and 96 directions. The first 4 energy channels are for pedestal monitoring and do not count as part of the science output. The SCI files place them in a separate PED output file, removing them from the E3DD SCI file, which only contains the 8 remaining science channels.

The two L3DD channels are (in IDA terminology counting from 0 to 11) numbers 4 and 6, corresponding to channels 1 and 3 of the 8 E3DD channels in the SCI files.

Chan. 4 (Science chan. 1) → IPAD  
Chan. 6 (Science chan. 3) → EPAD

Note: during the week of the preliminary test patch on SC1 (April 20–27), the channel assignments were opposite to the above.

### Rebining of directions

The 96 directions of the E3DD data block constitute a compressed form of the  $9 \times 16$  array of detectors and sectors. There are in fact only 8 sectors for the two outer IES heads, which look closest to the spin axis. This makes the interpretation of the directions extremely complicated and prone to error. Hence the SCI files repack the 96 directions into a  $9 \times 16$  array, halving the counts from doubled sectors and placing them into two.

This repacking applies to both E3DD\_BM and L3DD, and as such is nothing new. It is just interesting to note that it is the coincidence of 96 bytes in the IPAD/EPAD blocks and in each E3DD\_BM channel that makes the J-Mode so simple to program.

### Flagging

The presence of the J-Mode (and thus L3DD) is indicated by setting the most significant bit of the content descriptor 1 byte. This is byte 4 in the data blocks (counting from 0). Thus this byte is 80h (decimal 128) or more when J-Mode is active.

This bit was previously used to indicate "IIMS Simulation Active". According to the RAPID Instrument User's Guide, this mode is intended for testing before integration with the spacecraft, and may even not be installed afterwards. In fact, during the uploading on April 20, a corrupted command actually switched the RAPID unit into this mode, but the data block remained as normal, and not at all like that described by the User's Guide. This indicates that this test mode really has not been installed in the flight units, and therefore we may use its flag bit for indicating L3DD.

In BM, this bit is not set (is 0) since the BM data block is not altered.

During the test patch on SC1, April 20–27, it was bit 6, not 7, that was used as a flag. This bit is normally set (to 1) so its unsetting (to 0) was to be the flag. It was found that this could lead to some problems, so the flag was changed in the final version. (Bit 7 was inadvertently set anyway during this time, by the corrupted command mentioned above.)