SPI FM EMC test results concerning the PSD subassembly

Edition 1, Revision 0 (12/3/2001)

Author: J. Knödlseder

1. INTRODUCTION

This document provides the results of the SPI FM EMC tests that concern the PSD subassembly. The EMC tests have been performed by CNES during the period 13/2/2001 - 21/2/2001 at INTESPACE. During these tests, a number of anomalies have been discovered that concern the PSD subassembly :

- NCR 963 : PSD susceptibility when CDE is switched-on
- NCR 964 : PSD susceptibility at 30 MHz RS 4V/m

The aim of this document is to summarise the results of a deeper investigation of these anomalies which is based on the TM data that has been accumulated during the EMC tests. In addition, the impact on the scientific PSD performance is also studied.

The following quantities that were extracted from the TM are of importance for PSD performance verification in different electromagnetic environments :

1. Number of PSD time-tags : allows the detection of additional noise triggers which could arise from noise on some of the PSD channels
2. PSD channel rates : allows to identify noisy channels
3. Number of pure PSD events (PP) : allows to identify PSD noise triggers that are not associated with a AFEE time-tag
4. PSD baseline noise : allows an estimation of the PSD performance drop (see RD1 for the definition of the baseline noise)
5. PSD pulse shape visualisation : helps to identify the reason for enhanced PSD triggers

While the first two points were monitored and verified by CNES during the EMC tests, all points were investigated by CESR using a post-processing of the EMC TM data.

2. REFERENCE DOCUMENTS

RD1 PSD Software description, SPI-NT-4232-4194-CESR, Ed. 2, Rev. 0, 06/04/00

RD2 PSD User Manual, SPI-MU-423-4215-CESR, Ed. 2, Rev. 0, 19/02/01

RD3 EMC FM test procedure, SPI-PR-0-16505-CNES, Issue 1, Rev. 1, 12/02/01

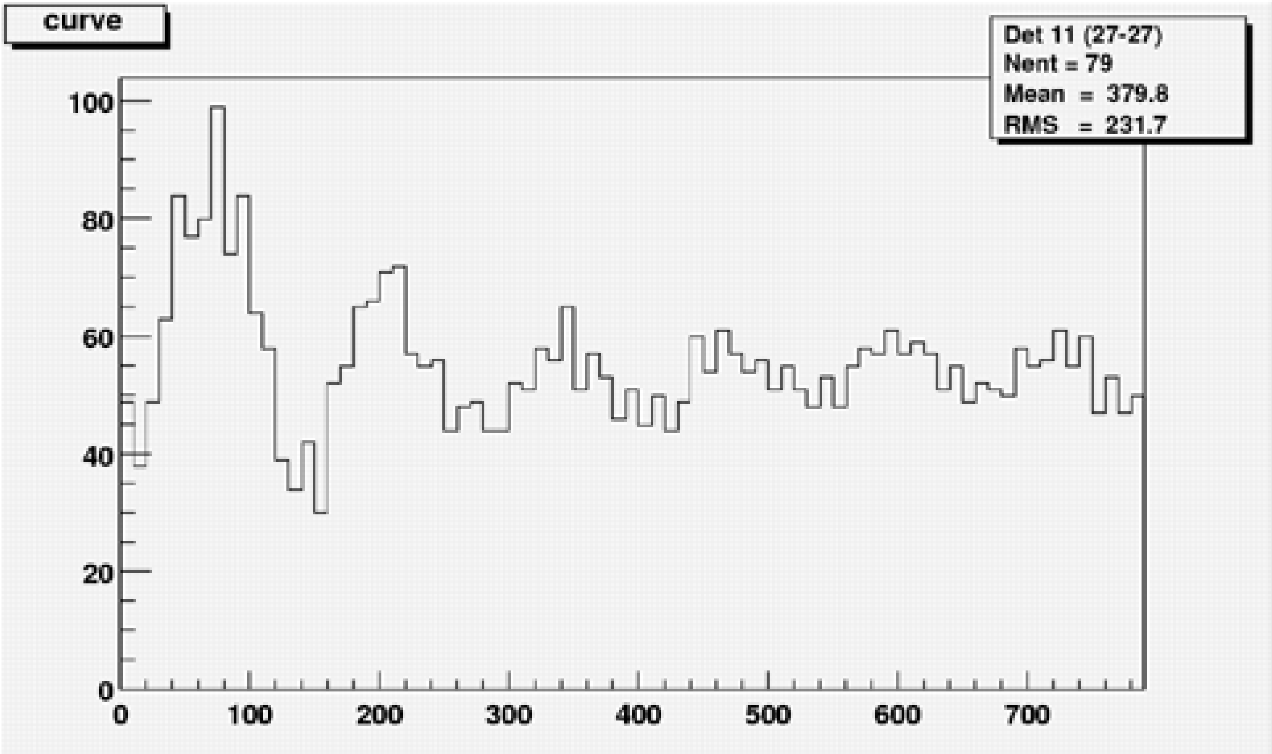

Fig. 1: Typical noise trigger on channel 11. The oscillation is due to the front-end reset of the PSD which eventually may lead to a self-triggering of the PSD sub-assembly.

3. TEST RESULTS

3.1 Channel 11 noise triggers and FET setting

During previous SPI performance verification tests, it turned out that the trigger threshold on PSD channel 11 is relatively low compared to the other thresholds (recall that only one parameter allows the setting of the FET trigger threshold, although all 19 PSD channels have a separate implementation of the front-end trigger logic; see RD2). However, since a too high FET threshold might compromise the scientific performance of PSD, it has been decided to configure PSD during EMC tests with a relatively low threshold (FET = 5), although some noise triggers may be expected in this case on channel 11.

Figure 1, which shows a PSD pulse shape for channel 11, illustrate such a typical noise trigger. Indeed, the pulse shape that is seen in case of a noise trigger always resembles the shape shown in Fig. 1, and it turned out that this noise is produced by PSD itself. In fact, after a PSD front-end trigger, the entire front-end is reset, leading to an electrical perturbation on the PSD input lines. This perturbation is a decaying oscillation which reflects the front-end reset signal. Eventually, if the front-end trigger threshold is too low, PSD may trigger on this reset signal. Since channel 11 has effectively the lowest front-end threshold, it is the first channel that becomes sensitive to self-triggering. This behaviour needs to be kept in mind to understand the following test results.

Typically, during the EMC tests, about 50% of the channel 11 triggers were noise triggers (i.e. the channel 11 trigger rate was enhanced by a factor 2 with respect to the other 18 PSD channels).

3.2. PSD susceptibility when CDE is switched-on (NCR 963)

CNES reported that the channel rate of channel 11 increased after the switch-on of the CDE. Following RD3, the CDE was switched-on the 14/2/2001 at 10:30. However, **the investigation of the EMC TM did not reveal any change in the channel 11 rate at this moment.** This is illustrated in Fig. 2 which shows the channel 11 rate (in units of counts / 64 seconds) as function of time (indicated by RowNumber). The drop of channel rate to 0 corresponds to the period where SPI was switched into CONF mode and the HT were switched off. Apparently, the channel 11 rate with CDE on is similar to the rate with CDE off.

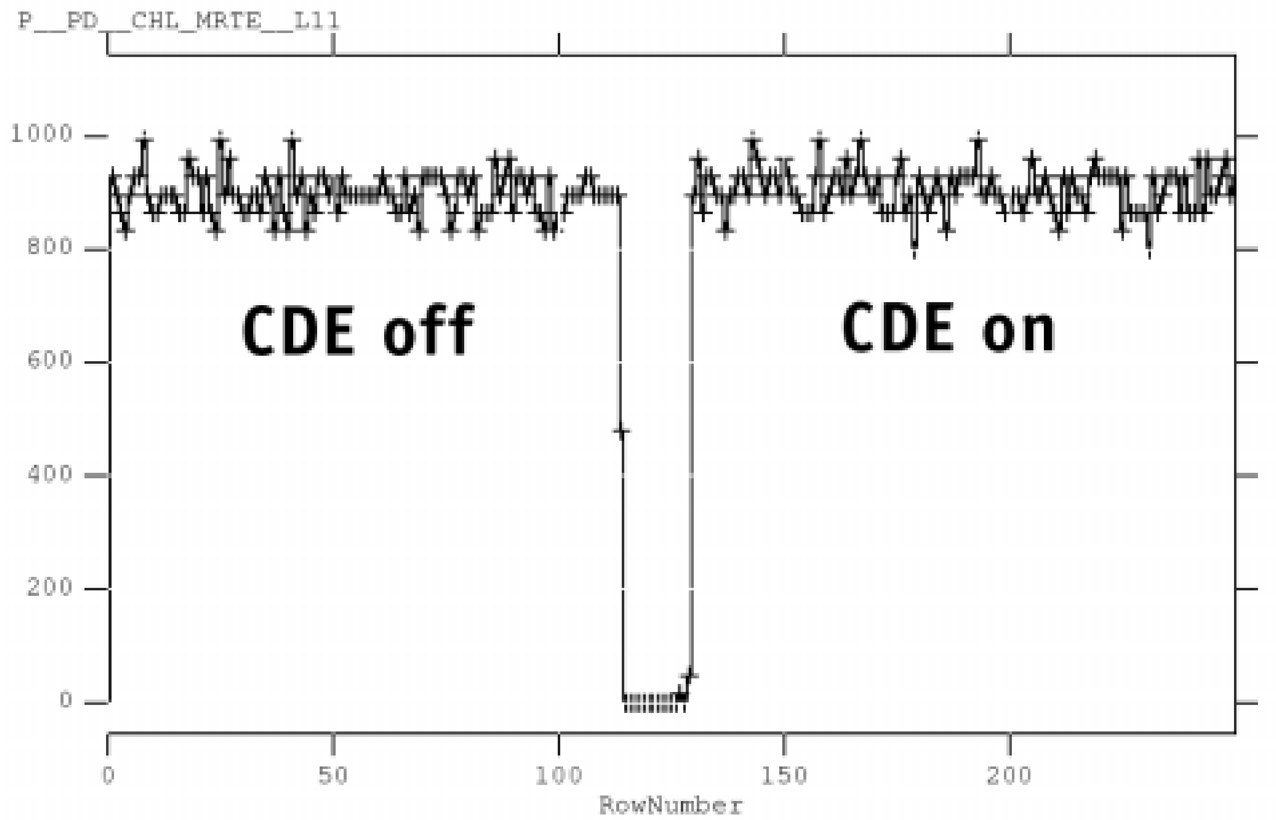

Fig. 2: Variation of PSD channel 11 rate as function of time during the transition CDE off / CDE on (in units of counts / 64 seconds).

3.3. PSD susceptibility from 80 MHz - 120 MHz (NCR 963)

CNES reported that the channel rates 5, 11, 14, 15, and 17 decreased especially at 80 MHz (NCR 963). This behaviour has been observed during the nominal RS +y/-z tests, conducted the 17/2/2001 from 11:04 - 11:37.

Figure 3. shows the channel rates for all 19 PSD channels (top) and the LLD rate (bottom) for this test period (the injection frequencies are indicated in the lower panel). Three phenomena can be observed:

1. At 30 MHz, the LLD rate rises from 1500 to 6500 triggers per second. At the same time, the channel 11 rate rises from 12 to 16 counts/sec. Also for channel 4, a slight increase is seen from 6 to 7 counts/sec.
2. At 80 MHz, the channel rates for channels 5, 9, 14, 15, and 17 are considerably reduced. The LLD rate is also reduced. Attenuating the 80 MHz signal by -6 db brings the rates back to their nominal values.
3. At 80 - 100 MHz, the channel 11 rate and the LLD rate are reduced. Attenuating the 80 MHz signal by -6 db brings the rate back to almost the nominal values.

From the analysis of the TM recorded on the CESR workstation the following explanations were obtained :

1. At 30 MHz, the noise in the PSD pulse shapes is slightly enhanced on channel 4 and 11, showing a 30 MHz oscillation in the recorded pulse shapes (see also section 3.4). The additional noise adds to the front-end reset noise that is present on all channels (see section 3.1), which then brings also channel 4 in the regime where it sees the PSD front-end perturbations (and channel 11 sees even more such perturbations). **However, it is not yet clear why channel 4 shows this susceptibility since it has not a particularily low threshold level.** Probably, the source of the 30 MHz susceptibility is not located in the PSD, and maybe the PA2 of channel 4 is particularily susceptible to 30 MHz perturbations.

   Note: During the redundant RS +y/-z tests (on 19/2/2001 from 17:21 - 17:48) only a slight increase in the LLD rate from 1600 to 2100 triggers per second has been observed at 30 MHz. Additionally, the channel rates did not increase.

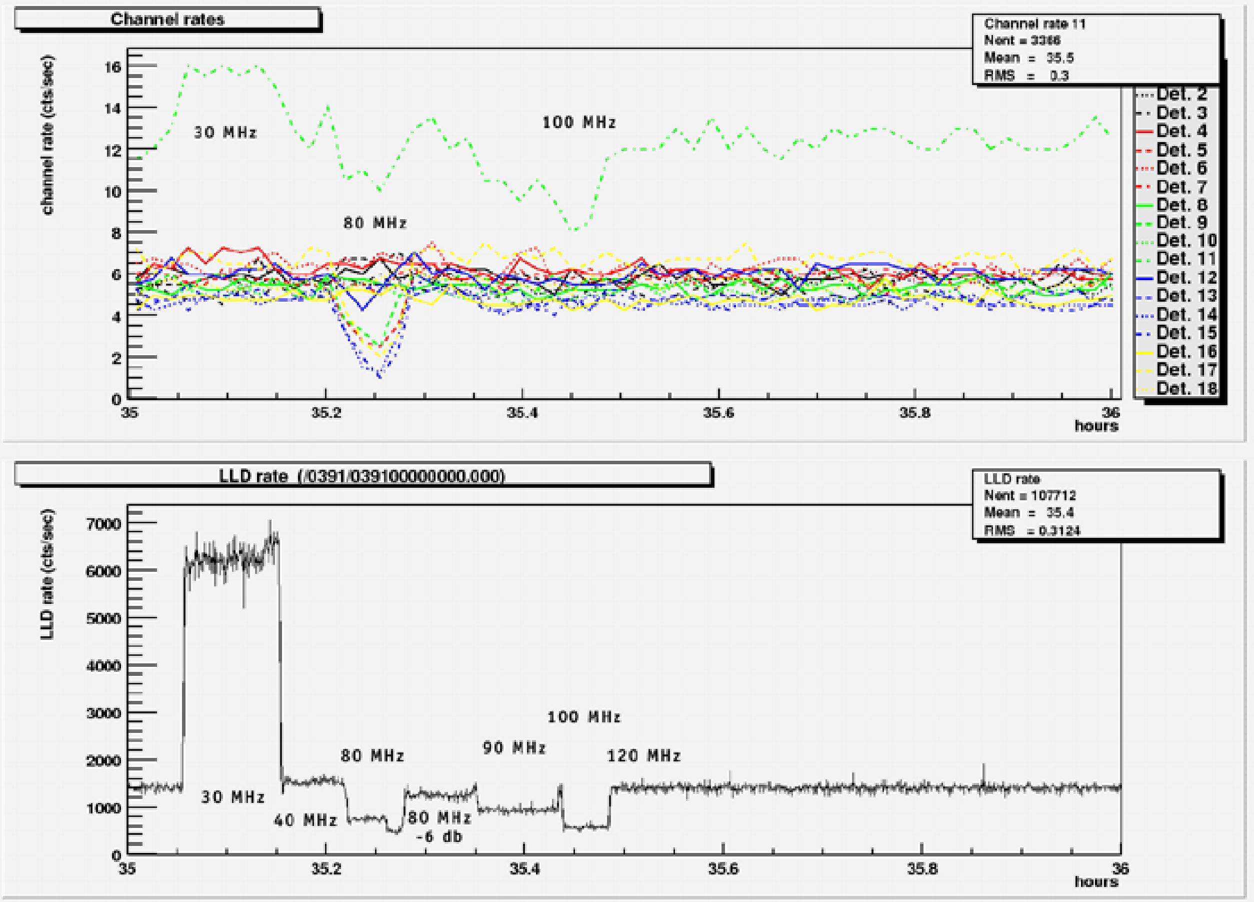

Fig. 3: Channel rates (top) and LLD rate (bottom) during the RS +y/-z injection from 30 MHz to 120 MHz. For the 80 MHz injection, the channel rates drop for channels 5, 9, 14, 15, and 17.

2. For some channels, the **80 MHz injection leads to an effective increase of the FET trigger threshold**. This is illustrated in Fig. 4 which shows the lower threshold of PSD events (PE) for all 19 detection channels and different RS +y/-z injection frequencies. Apparently, channels 5, 14, and 15 show a considerably enhanced threshold which effectively reduces the channel rates (since a higher threshold means less PSD triggers). Channel 9 and 17 suffer the same problem, although this trend is not clearly visible in Fig. 4 (the counting statistics for the threshold determination was very poor, hence the threshold determination is not very accurate).

   The prove that it is indeed the front-end trigger (FET) threshold that is effectively increased by a 80 MHz injection comes from the analysis of the average PSD pulse shapes (see Fig. 6). Apparently, at 80 MHz and also slightly at 90 MHz, the pulse shape is seriously truncated at the start of the pulse, indicating that the pulse triggers came too late. The pulse trigger, however, is determined by the FET threshold setting, and truncated pulses are a clear sign of a too high FET level.

   It is interesting to note that except for channel 9 the concerned detectors are all in the same region of the detection plane (direction -y/-z). Yet channel 16, which is in the same area, does not show a similar behaviour. Additionally, during the RS -y/-z tests where the radiation emitter was closer to the susceptible detectors, no 80 MHz susceptibility has been detected.

   Note: During the redundant RS +y/-z tests (on 19/2/2001 from 17:21 - 17:48) a similar reduction of the channel rates 5, 9, 14, 15, and 17 was observed, and the PE threshold showed a comparable increase.

3. Channel 11 generally shows a substantial amount of noise triggers due to the relatively low front-end threshold for this channel (see section 3.1). A slight increase of the FET, as observed for channels 5, 14, and 15, would bring channel 11 out of the noise and would effectively reduce the trigger rate. Indeed, at 100 MHz, the number of noise triggers on channel 11 is reduced from about 50 % to 30%, which can perfectly explain the reduction of the channel 11 rate from 12 counts / sec to about 8 counts / sec. However, with the poor statistics of the accumulated data

(only about 3 minutes for each injection) it is difficult to detect a small variation in the PSD event threshold. Thus, the hypothesis of an increased FET threshold as origin of the channel 11 rate drop could not be verified.

Note: During the redundant RS +y/-z tests (on 19/2/2001 from 17:21 - 17:48), channel 11 did not show any decrease in the channel rate at 80 MHz. However, reductions of the channel rates were seen at 50 MHz, 70 MHz, and 90 MHz.

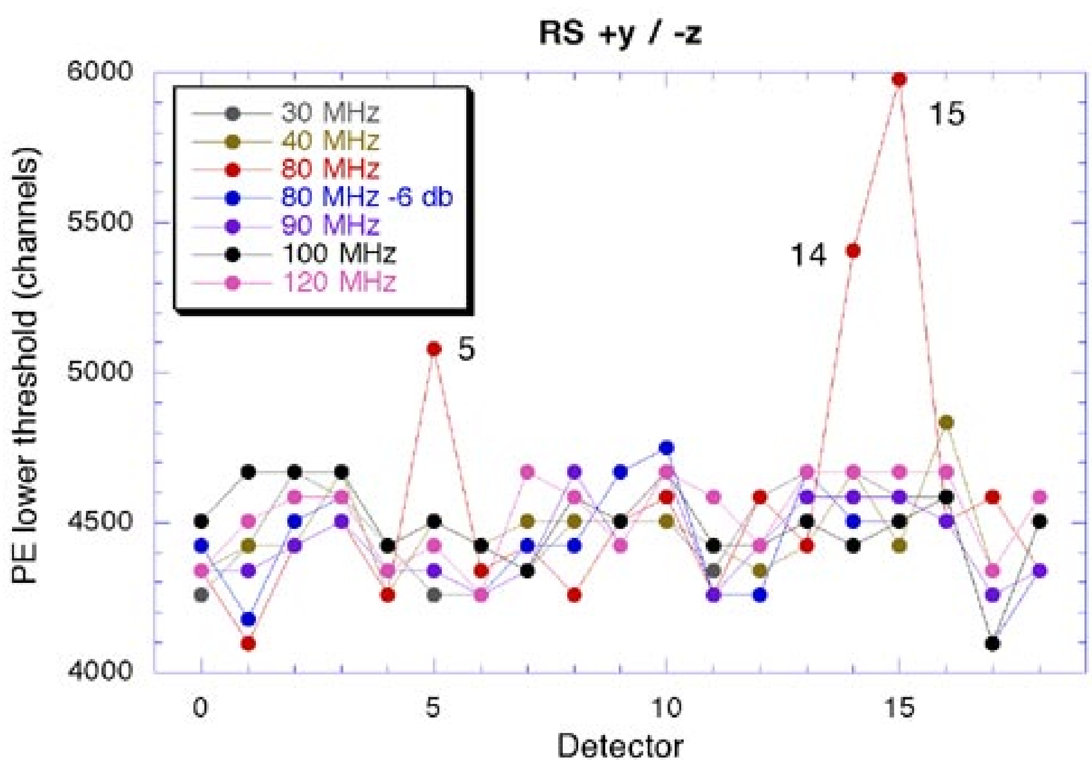

Fig. 5: PSD event lower threshold (in PHA channels). At 80 MHz, the threshold of channels 5, 14, and 15 is considerably enhanced.

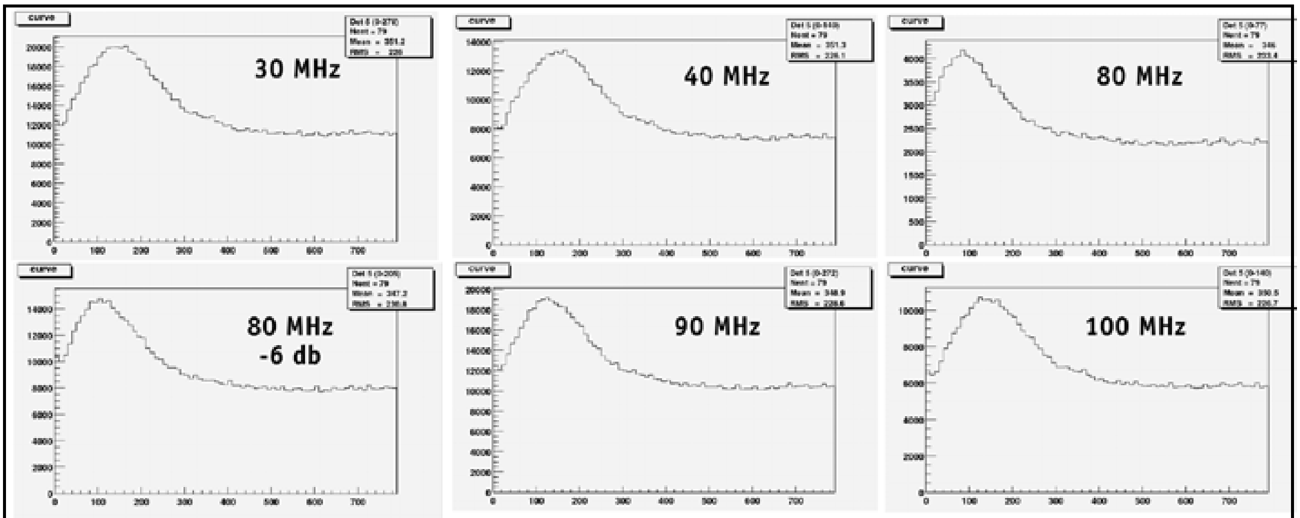

Fig. 6: Average pulse shape for channel 5 for various RS +y/-z injection frequencies. Between 80 - 90 MHz the start of the pulse shapes is truncated.

3.4. PSD susceptibility at 30 MHz during RS -y/-z injection (NCR 964)

CNES reported a susceptibility at 30 MHz (NCR 964) which has been observed during the RS -y/-z injection, conducted the 16/2/2001 at 16:55.

Indeed, the analysis of PSD pulse shapes recorded during this period reveals a strong 30 MHz oscillation superimposed on the detector pulses for some of the PSD channels. Figure 7 shows such an oscillation, recorded on channel 4. This oscillation leads to an important increase of the channel rate for the susceptible channels due to noise triggers. From the analysis of the PSD pulse shape noise (see Fig. 8) it has been determined that channels 4 and 11 are the most susceptible ones. Also channels 0, 6, 13, and 18 show some noise increase at 30 MHz, while the other channels seem to be almost unaffected by the 30 MHz injection. Reducing the injection amplitude by 6 db considerably reduces the noise on the PSD pulse shapes, bringing the trigger rate for channel 4 and 11 into a reasonable range.

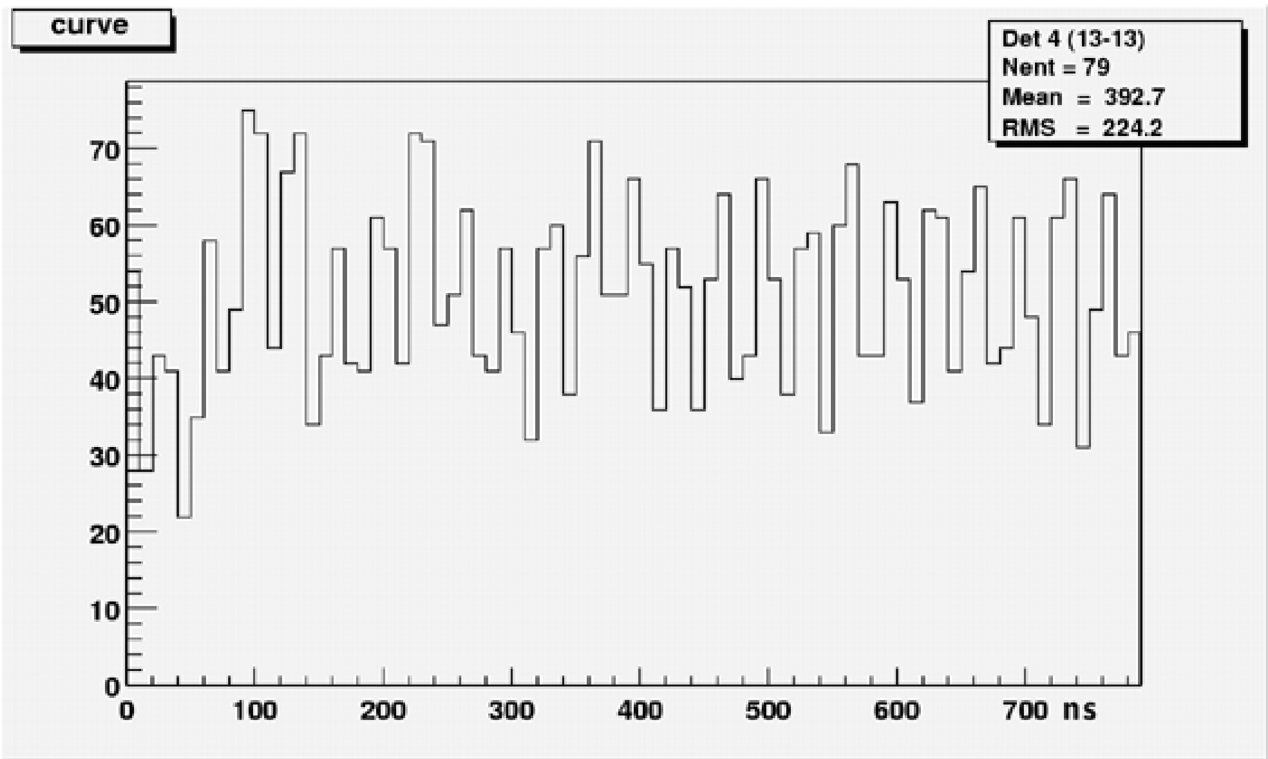

Fig. 7: PSD trigger on 30 MHz oscillation for channel 4.

Since most of the PSD electronic is common for all 19 detection channels (see RD2), the susceptibility difference among the 19 PSD channels makes it questionable if the PSD subassembly itself is susceptible to the noise injection. It could also be that some of the pre-amplifiers are particularly susceptible to a 30 MHz signal, and PSD simply sees the noise of those pre-amplifiers.

Note: The 30 MHz susceptibility detected during the RS +y/-z injections is much weaker than the RS -y/-z susceptibility. On the other hand, the RS -y/-z injection on the redundant SPI has shown a similar susceptibility on channel 4 and 11 than on the main SPI.

3.5. PSD susceptibility at 50 MHz during redundant RS +y/-z injection

During the RS +y/-z injection on the redundant SPI (19/2/2001 from 17:21 - 17:48), enhanced noise has been found at 50 MHz on PSD channels 1, 3, and 5. A inspection of the PSD pulse shapes recorded during this period has revealed that the 50 MHz signal propagated into the PSD input channels. The mean noise observed on channels 1, 3, and 5 was 4.0 - 4.3 digitalisation units, roughly 30% higher than the normal noise (see also Fig. 8).

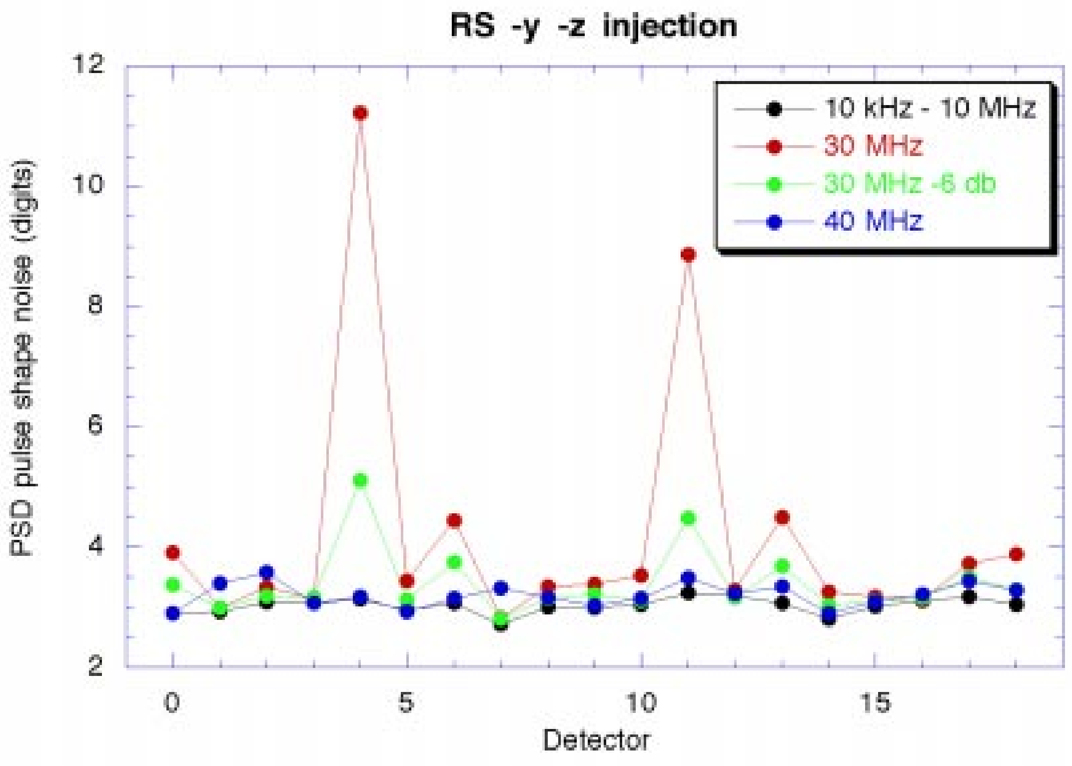

Fig. 8: PSD pulse shape noise (in PSD digitisation units) as function of the RS -y/-z injection frequency. Some channels show enhanced noise at a frequency of 30 MHz (in particular channels 4, 11, 6, and 13.

4. CONCLUSIONS

The analysis of the TM recorded during the EMC test leads to the following conclusions concerning the susceptibility of the PSD sub-assembly:

1. The CDE status (off or on) has no impact on the PSD sub-assembly. NCR 963, raised during the EMC tests, was probably based on an erroneous comparison of channel 11 trigger rates. **No CDE susceptibility has been found.**
2. The PSD sub-assembly shows some susceptibility at 80 MHz which effectively raises the front-end threshold (FET) on some of the PSD channels (in particular channel 5, 9, 14, 15, and 17). From an electronics standpoint, this susceptibility is not yet understood.
3. Between 80 - 100 MHz the noise trigger rate of channel 11 is reduced, probably also due to a slight increase of the front-end threshold.
4. The system PA2 - PSD shows some susceptibility at 30 MHz due to a propagation of the 30 MHz signal into the PSD trigger electronics for some of the PSD channels (in particular channel 4, 11; also less for channels 0, 6, 13, and 18). **This susceptibility is much stronger for an injection on the -y/-z side than for the +y/-z side.** It is not yet clear if this susceptibility appears in the PSD sub-assembly, or if it appears on some pre-amplifiers or the cable that connects the pre-amplifiers to the PSD sub-assembly.
5. At 50 MHz, a small susceptibility similar to the 30 MHz susceptibility has been observed on channels 1, 3, and 5. However, it is weaker than the 30 MHz -y/-z susceptibility.

The 80 MHz susceptibility will potentially make if difficult to have a stable lower energy threshold for all 19 PSD channels. Additionally, an increase of the threshold will truncate PSD pulses at the start (see Fig. 4), leading to a modification of the PSD pulse characteristics. In this case, the background rejection efficiency of the PSD will be reduced since the measured pulses shapes will deviate significantly from the uplinked template library. It is therefore essential to monitor the PSD pulse characteristics continuously throughout the mission. Also, a variation of the PSD lower energy threshold on some channel may be used as indication of a potential decrease of PSD efficiency on this channel.

The 30 MHz susceptibility implies additional noise on the detector pulses for some channels. Since it is more difficult to distinguish a single-site from a multiple-site interaction with such additional noise, it is expected that the background rejection efficiency will be degraded for these channels in case of 30 MHz noise.

For 50 MHz, the situation is similar, but the amplitude of the perturbation is smaller than at 30 MHz.