VMC

Venus Monitoring Camera on Venus Express

Commissioning Report

VMC-MPAE-TN-MCRB-001

Issue 1
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1 Scope of the Report

This report describes the Venus Monitoring Camera (VMC) activities during the cruise, orbit insertion and the commissioning orbits phases.

2 Cruise phase

2.1 First switch on

The first switch on of VMC wat on 21.11.2005. Ten full frame images were commanded and received. VMC operated nominally. The data obtained proved useful to supplement stray light data obtained later. Figure below shows the signal strength (DN) as a function of exposure time in seconds for all four VMC channels. Linear fit confirms the expected linear response of the VMC CCD.

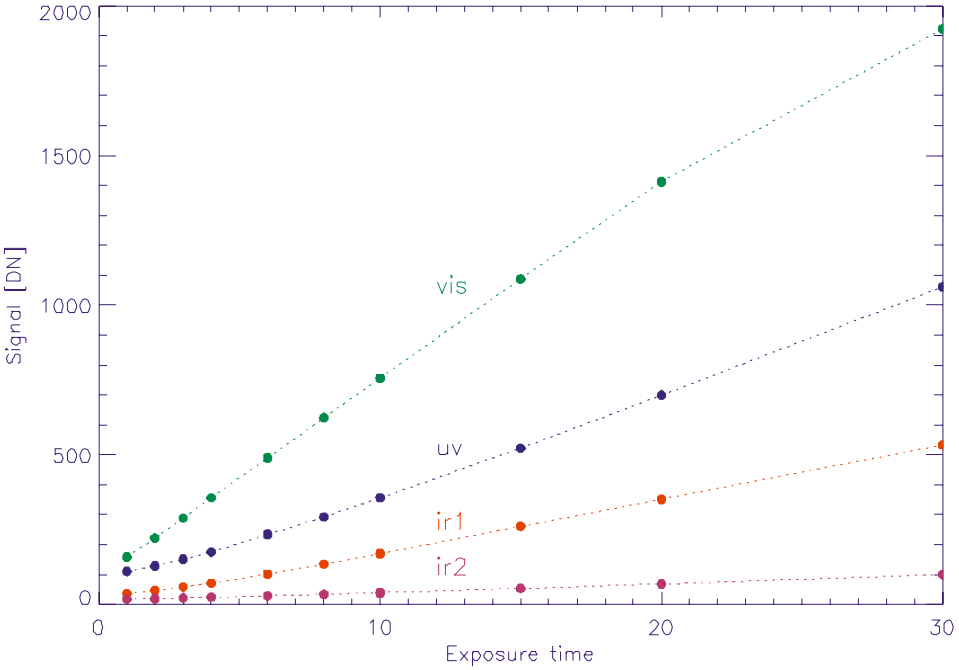

Figure 2-1 Stray light during the first switch on sequence confirms the expected linear response of the VMC CCD detector. Exposure time is in seconds.

2.2 Earth – Moon observations

Earth/Moon images were obtained on 23.11.2005. The distance at that time was already 3.5 Mkm and neither Earth nor Moon could be resolved. Twelve full frame images were commanded and received. At the same time VMC S/W update was activated and successfully tested. One example of the images received is shown in Figure below.

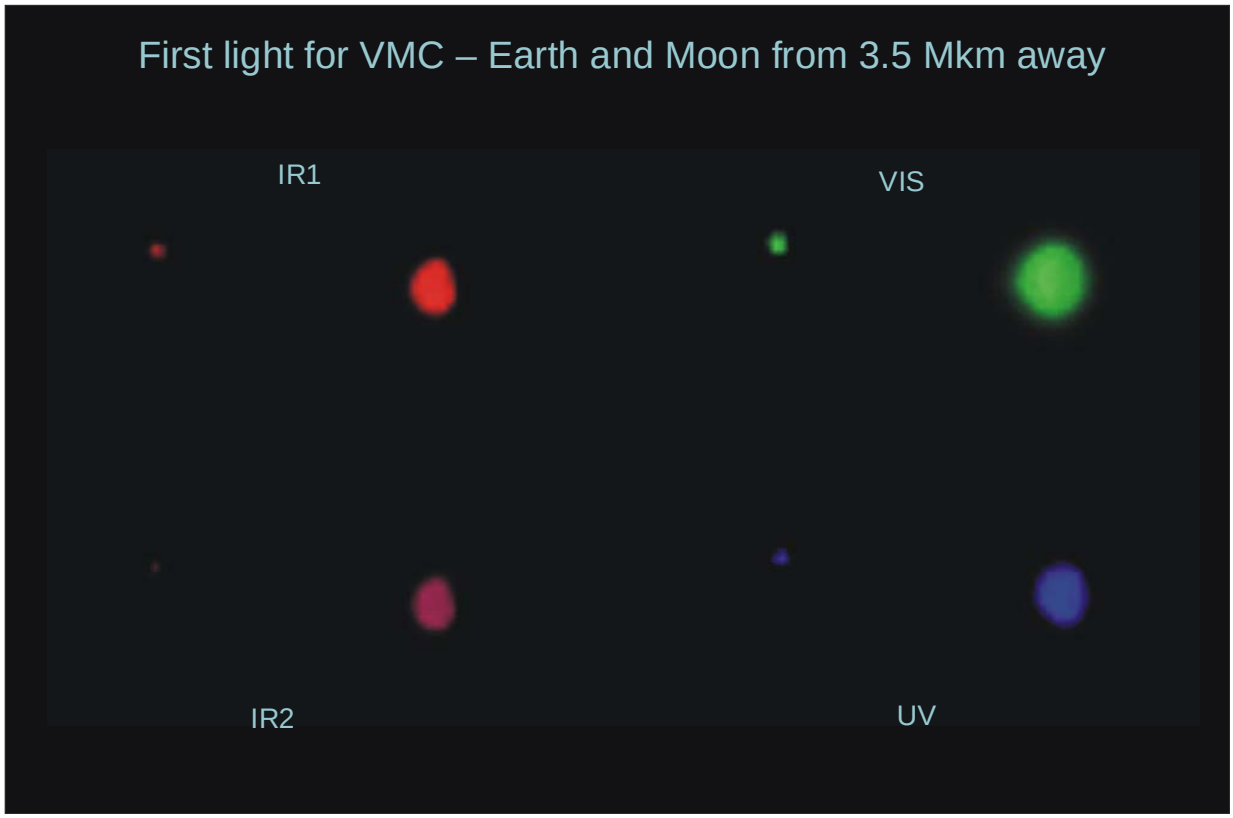

Figure 2-2 Earth – Moon images obtained in the four channels of VMC. False colour. Earth is overexposed to enable seeing moon in all channels at the same time.

2.3 Geometric calibration – alignment

The Earth-Moon images were used for checking the alignment of the optics. Figure below shows the expected position of the Earth in comparison the position in the image. Alignment error is less then 1.5 degree in all channels and this is acceptable.

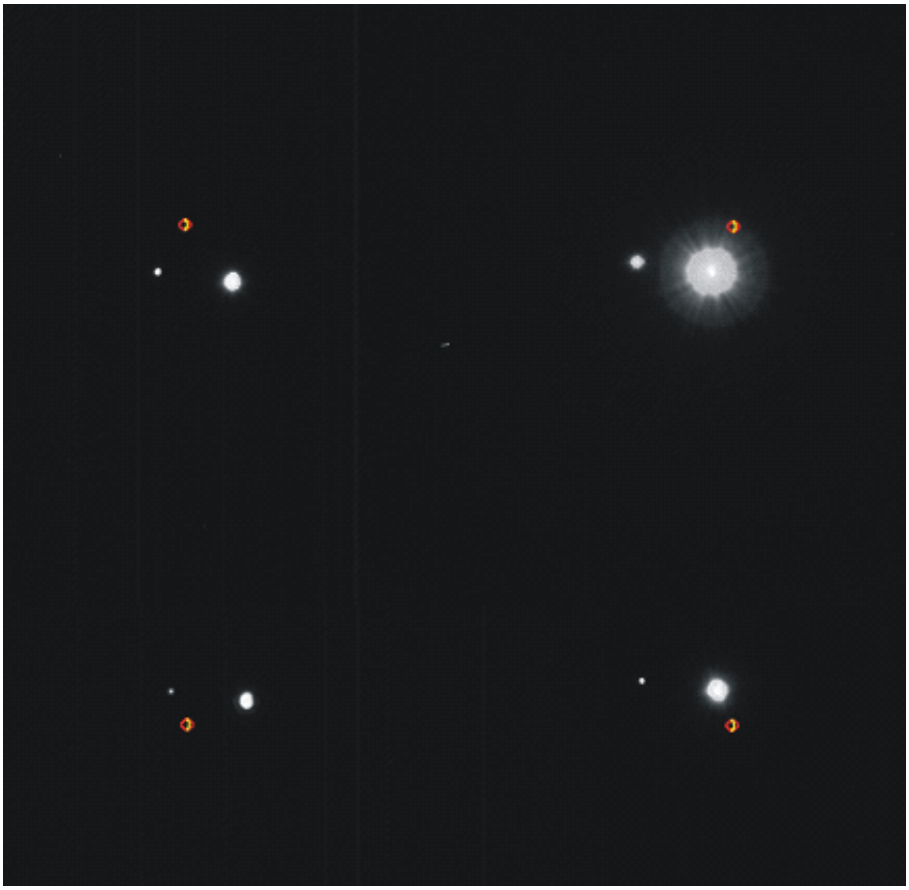

Figure 2-3 Red dots show the expected position of the Earth. The alignment error is less than 1.5 degrees in all channels and is acceptable.

The optical alignment was confirmed with images of star Sirius. The figure below shows the images of Sirius in two of the VMC channels together with the expected position of the star. The alignment error is the same as that derived from the Earth – Moon images.

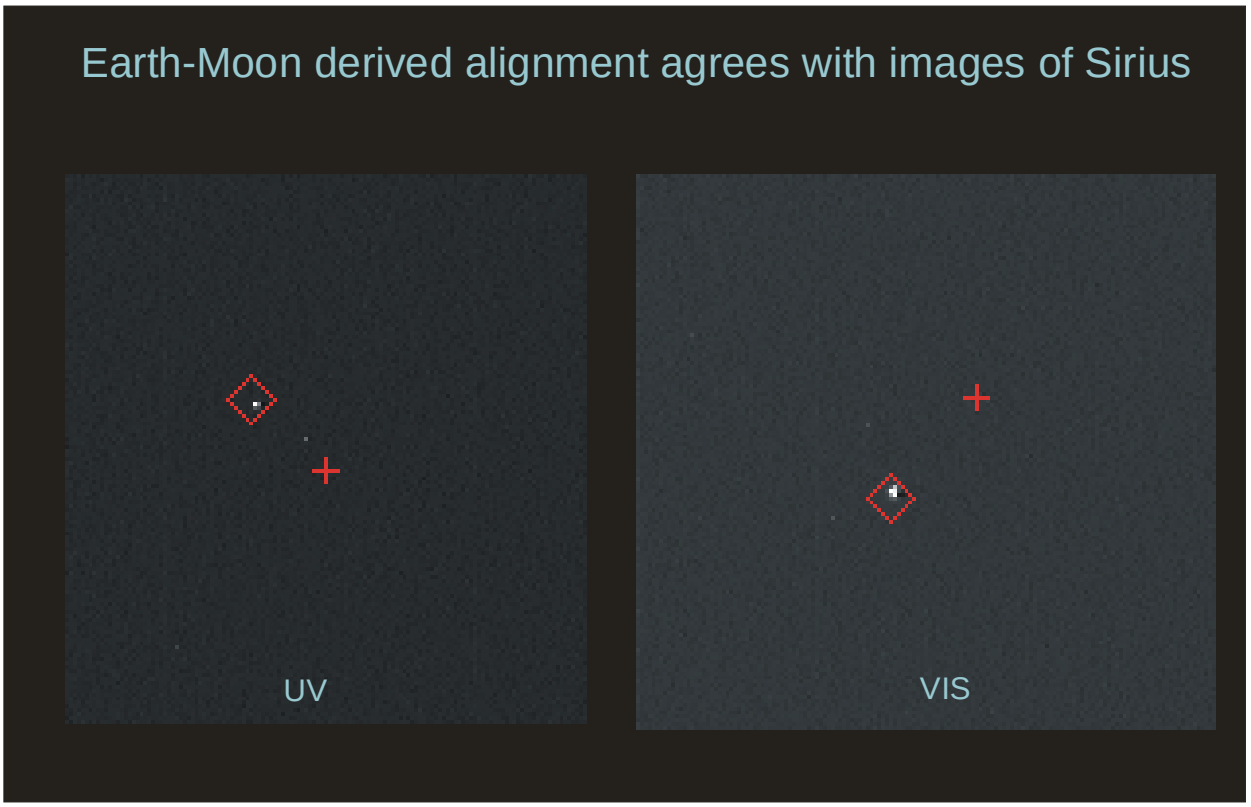

Figure 2-4 VMC images of Sirius in uv and visible together with the expected position of the star (red cross). Optical alignment error is the same as that obtained from Earth – Moon images.

2.4 First images of Venus

The first images of Venus were obtained on 23.11.2005. 12 full frame images were commanded and received. At the same time S/W update was activated and tested successfully. Venus at that time was an unresolved object a point source. The obtained data confirmed again the small alignment error and more importantly showed that VMC is in focus as measured on ground before launch.

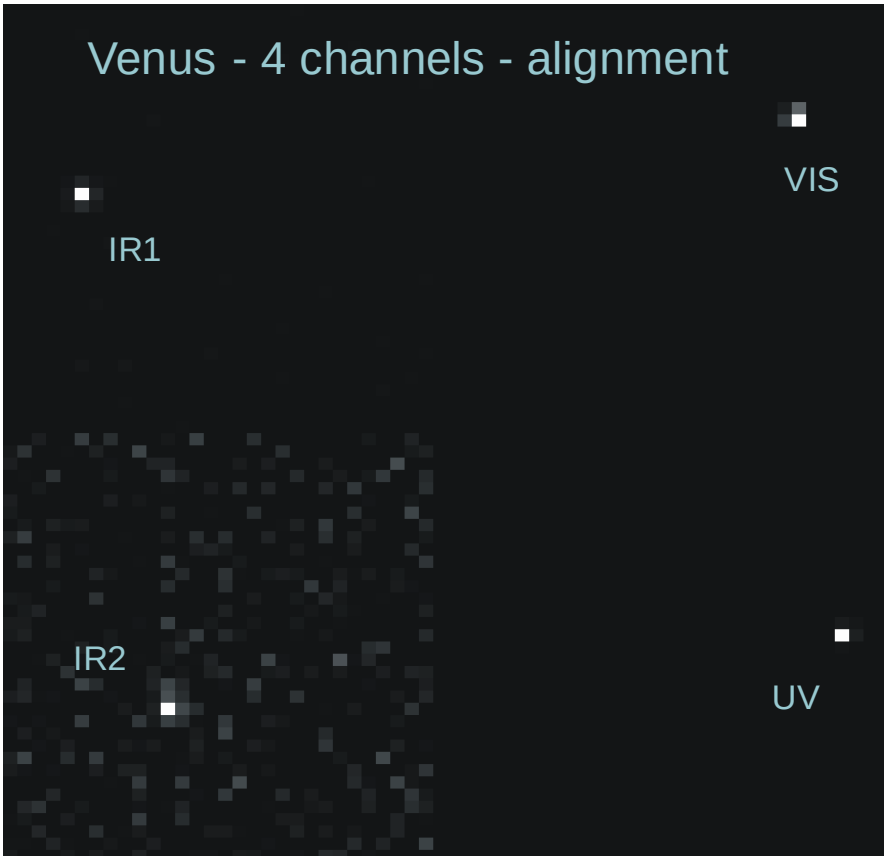

Figure 2-5 First VMC images of Venus – showing alignment and point spread function. The VMC is in expected good focus.

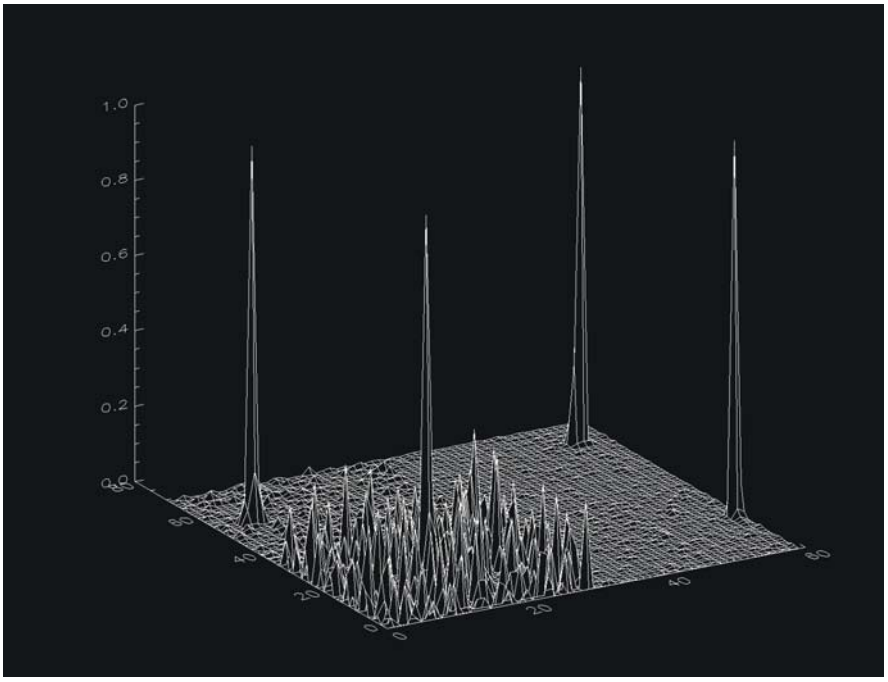

Figure 2-6 First images of Venus. Signal in all channels is normalized to unity. Venus is here a point source and covers as expected less than one pixel. This proves that focus of VMC is good and has not changed since before launch.

2.5 Stray light test

Stray light test was performed on 02.12.05. 36 full frames were commanded and received. The S/C axis was pointed between 90 and 10 degrees from the Sun with 5 degrees intervals. The obtained data is summarized in figures below. Most of the data with angle to the Sun < 20 degrees is saturated. This test was repeated in February 2006 with different exposure times, but analysis of these data has not been completed to date.

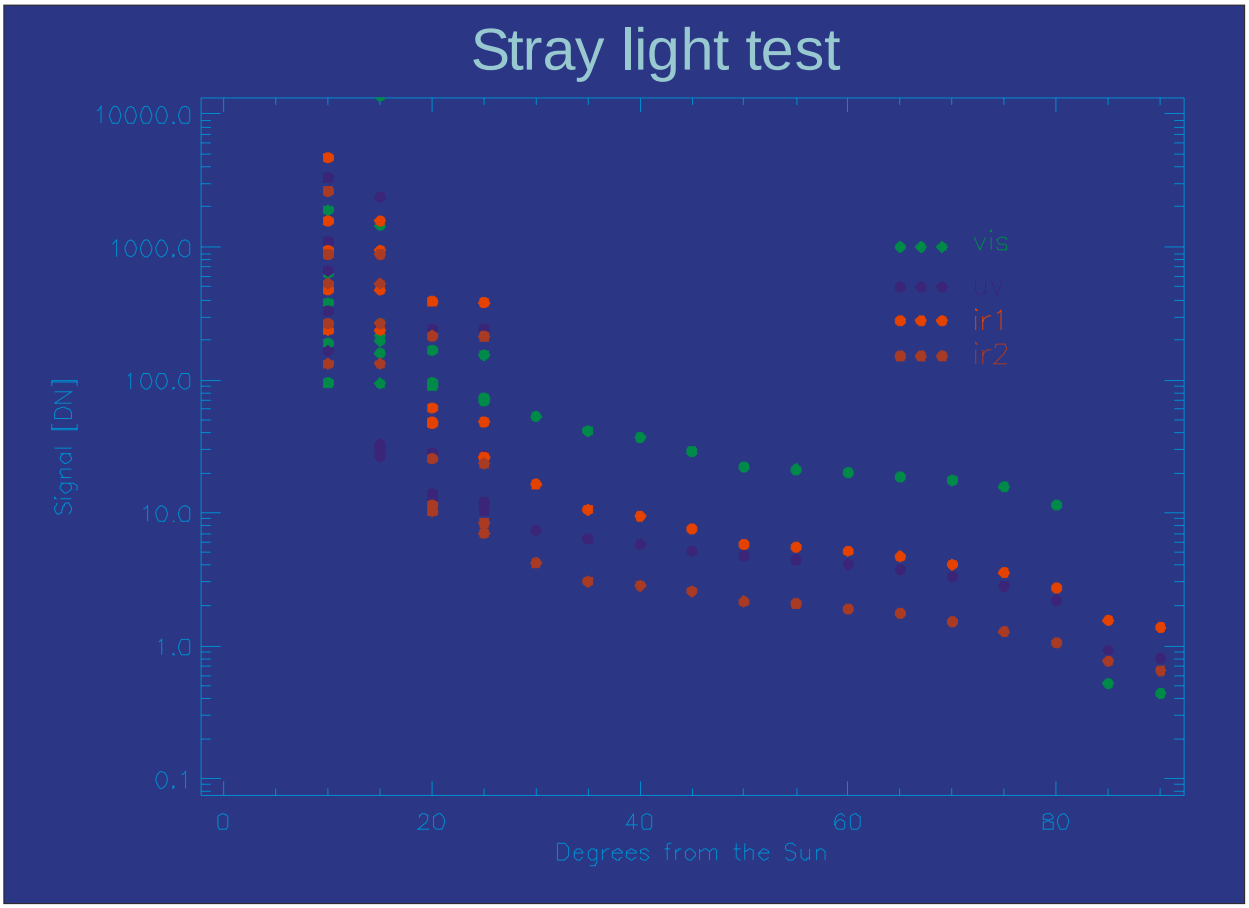

Figure 2-7 First stray light test. Stray light is minimal for data with Sun angle > 30 degrees. Data for smaller angles is mostly saturated and can not be analyzed.

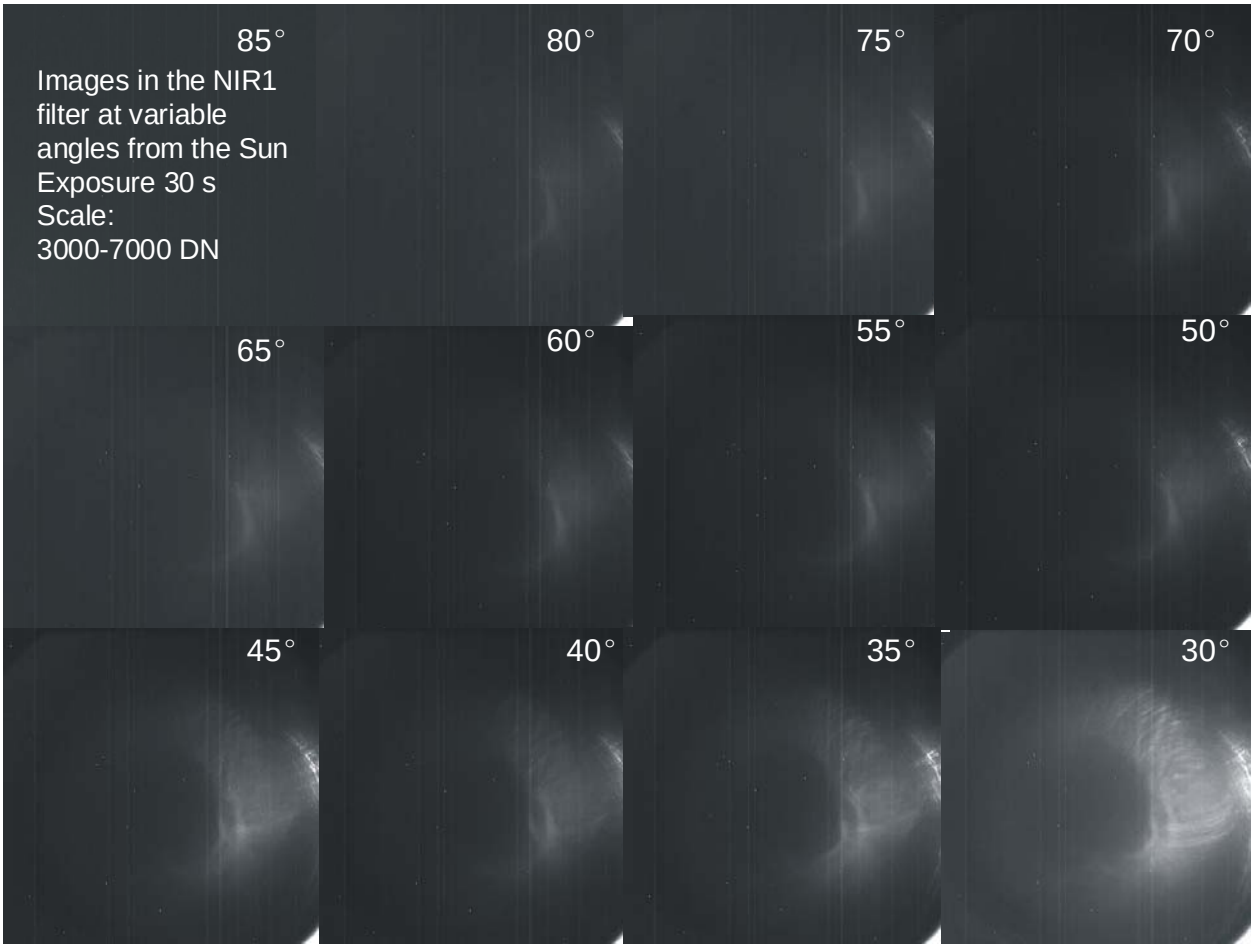

Figure 2-8 Examples of stray light patterns obtained.

3 Venus insertion orbit

3.1 Sun strip

The horizontal dark stripe was discovered in all UV images. Example is shown in figure 2-9.

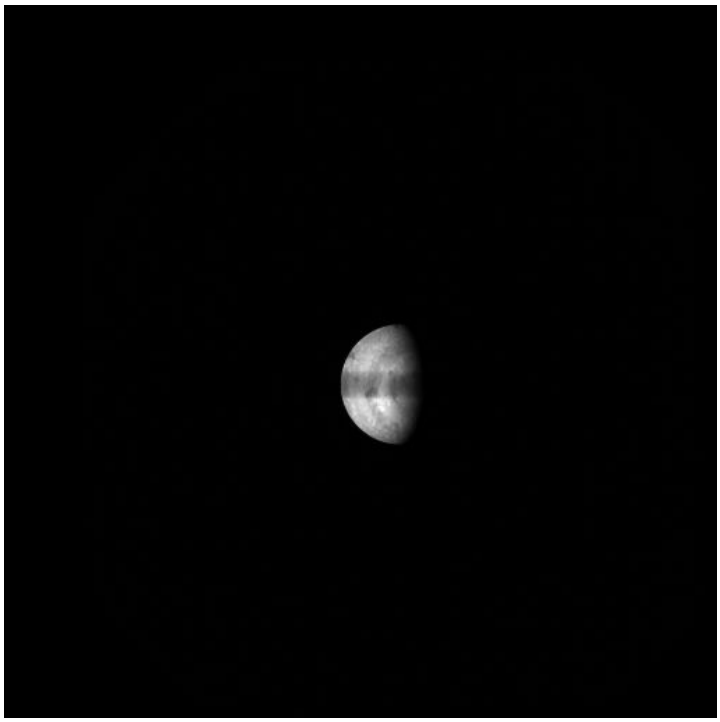

Figure 3-1 UV image of Venus v0001_0076.uv2 taken in Capture orbit.

The dark stripe crosses the image horizontally (almost perpendicular to the CCD columns) and has width of ~18 pixels at half-minimum (figure 2.2).

The detailed description and analysis of this anomaly can be found in a separate document

VMC-MPAE-TN- SS010_001_Anomalous features in VMC images_iss3_rev0.doc

Here we will only point out a few general aspects of this anomaly. First Venus images taken during insertion orbit covered only a small section of the CCD. For this reason we did not know the extent of the strip. Later during the stray light test and the first pericentre passage we discovered the full extent of the strip. See figures below. It is now known that the strip is due to a long staring at the Sun during the cruise phase. Some pixels were exposed to the Sun for as long as 50 hours. It was not known before by the VMC team but the micro-lens layer of the CCD goes somewhat opaque when exposed to uv radiation. More details can be inferred from the figures below and the above mentioned document.

After discussing the problem with the project, ASTRIUM and ESOC, sun avoidance of 10 degrees was recommended and was found to be possible.

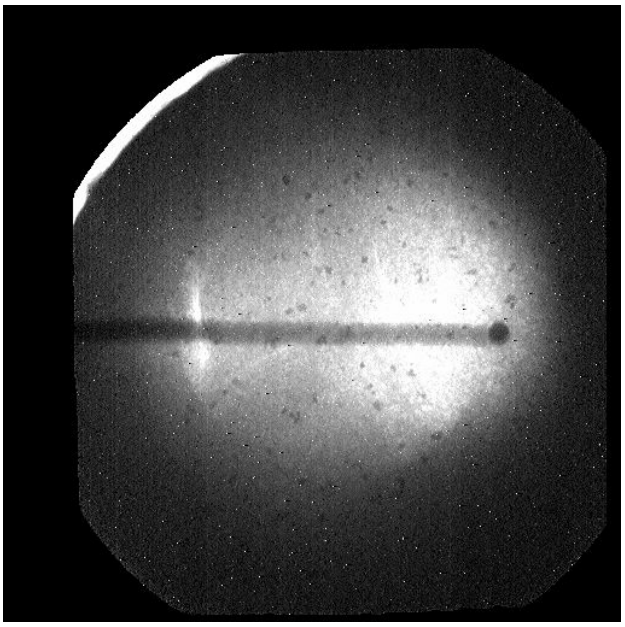

Figure 3-2 UV image v0002_0010.uv2 taken during in-orbit stray light characterization on April 24, 2006.

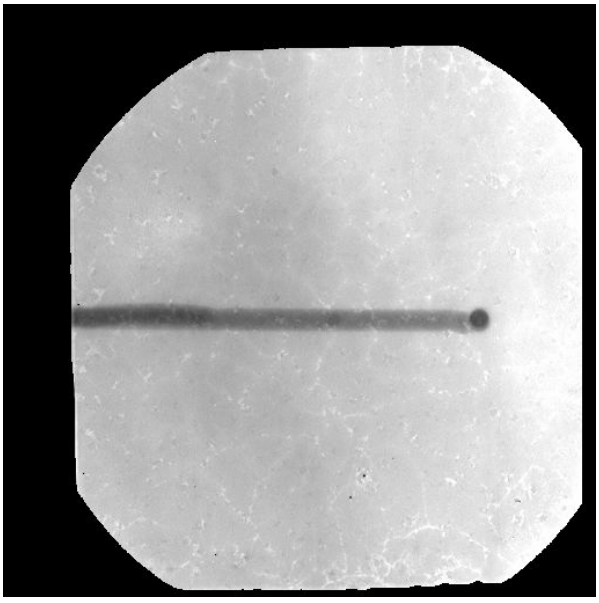

Figure 3-3 UV image v0004_0033.uv2 taken during the first pericentre pass.

3.2 Dark spots and filaments

The figures above and many others discussed in

VMC-MPAE-TN- SS010_001_Anomalous features in VMC images_iss3_rev0.doc

show an irregular pattern which is obviously not part of the Venus. It is now almost certainly known that this pattern comes from CCD and most likely from the micro-lens layer. To date it is not known how this pattern originated and whether it will evolve with time.

If we can assume that the pattern will not evolve it should be possible to correct images by constructing new flat fields by averaging many close up Venus images. This has been already attempted with a few available images and the result is promising. An example of a corrected image is shown in the figure below.

Figure 3-4 Corrected image (original Figure 3-2). Although the sun strip is still visible, most of the artifacts are removed. It is hoped that averaging many images in the future will produce a significantly better flat field and hence a better correction.

4 MTP001

VMC was routinely operated.

VMC long exposure images did not work (AR-35) initially. The problem is solved by applying the RAM patch at instrument switch ON. Verified by re-test of orbit sequence. It will be fixed permanently in an forthcoming new S/W version.

So far, only one Single Event Upset (SEU) error in each memory area, SRAM and SDRAM, were detected and corrected during scrubbing, no indication of any SEU effect in the Xilinx devices.

5 VMC commanding

Writing of the VMC commanding files is taking up most of the time resources of the small VMC team. We must say VSOC has been very helpful with our work so that we can meet the various deadlines. In spite of the heavy workload only one major error occurred resulting in loss of data from seven limb observations. This was due to a simple fact that the corresponding lines were commented out in the ptr file. Only several other individual images were lost here and there due to commanding mistakes.

6 Data handling and archiving

Retrieval of data from DDS system has caused no problems to date.

Data is routinely processed through the calibration pipeline.

Archiving preparation is on schedule.

7 Conclusions

- The VMC is operated routinely.
- The VMC performance
    - Focus is nominal meaning very good
    - Optical miss-alignment is less than 1.5 degree and acceptable
    - CCD performance has been compromised for two reasons
        - Long term exposure to the sun (uv channel is the only one effected). This problem is understood and work around solution is available. This will improve as more data will be available.
        - Background pattern in the images most likely caused by damage to the micro-lens layer of the CCD. The cause is not yet known. As long as the pattern will not evolve a good work around solution is also possible
    - Spectral calibration check
        - Data is available – however has not been analyzed yet (see next point)

- The writing of commanding files takes up almost all of the VMC's team resources. The remaining time has been eaten up by analyzing the problems with the CCD. For this reason data analysis has been almost completely neglected. Operations is becoming more of a routine however and it is hoped that in the near future things will improve with data analysis.