HIFI SVM panel thermal stability report

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1 Document Change Record

Issue	Date	Authorisation	Total pages	Sections affected	Description of change
1	September 01 2009	P. Dieleman		All	New document

2 Table of Contents

3 Applicable documents

#	Title	Name	
AD1	HIFI satellite temperature sensors and heaters	SRON-G/HIFI/TN/2008-023	V 5

To access hyperlinks: username: hifi password: helix10$

4 Summary

After HIFI switch-on in flight, the following thermal issues became apparent:

- On the V panel: The SPIRE DCU temperature inversely influences the temperature of the WBO-V. Hence after a full SPIRE OD, it takes 20 hours after SPIRE has been set to standby before the HIFI WBO V laser temperature stability is within the specified range. The inverse relation is caused by an overreaction of the SVM WBO-V thermal control loop.
- On the H panel: Since the dissipation of the LSU is 4W in standby and 24W when operational, the resulting LSU temperature increase influences the backend temperatures significantly. The WBS H laser needs 14 hours before the drift is within specification of 0.03 k/hour. When going from the "3b dissipative mode" to an actual operational mode the WBO H laser temperature stability stays within the specified range.

4.1 Laser temperature stability specification

When considering the HIFI stability specifications, these are determined by LO power stability, not by the backend stabilities. If the thermal environment of the backends are within specification, the backend stability is far better than the HIFI system stability. Therefore one can argue that the thermal stability of the backends is overspecified. The actual specification on the laser temperature should be calculated from the relation thermal stability – IF power stability and from that curve and the HIFI stability the actual laser temperature stability requirement can be determined.

5 WBOV, HIFI vertical panel

5.1 Observations

The plots below show the WBOV laser temperature profile before, during and after a SPIRE OD.

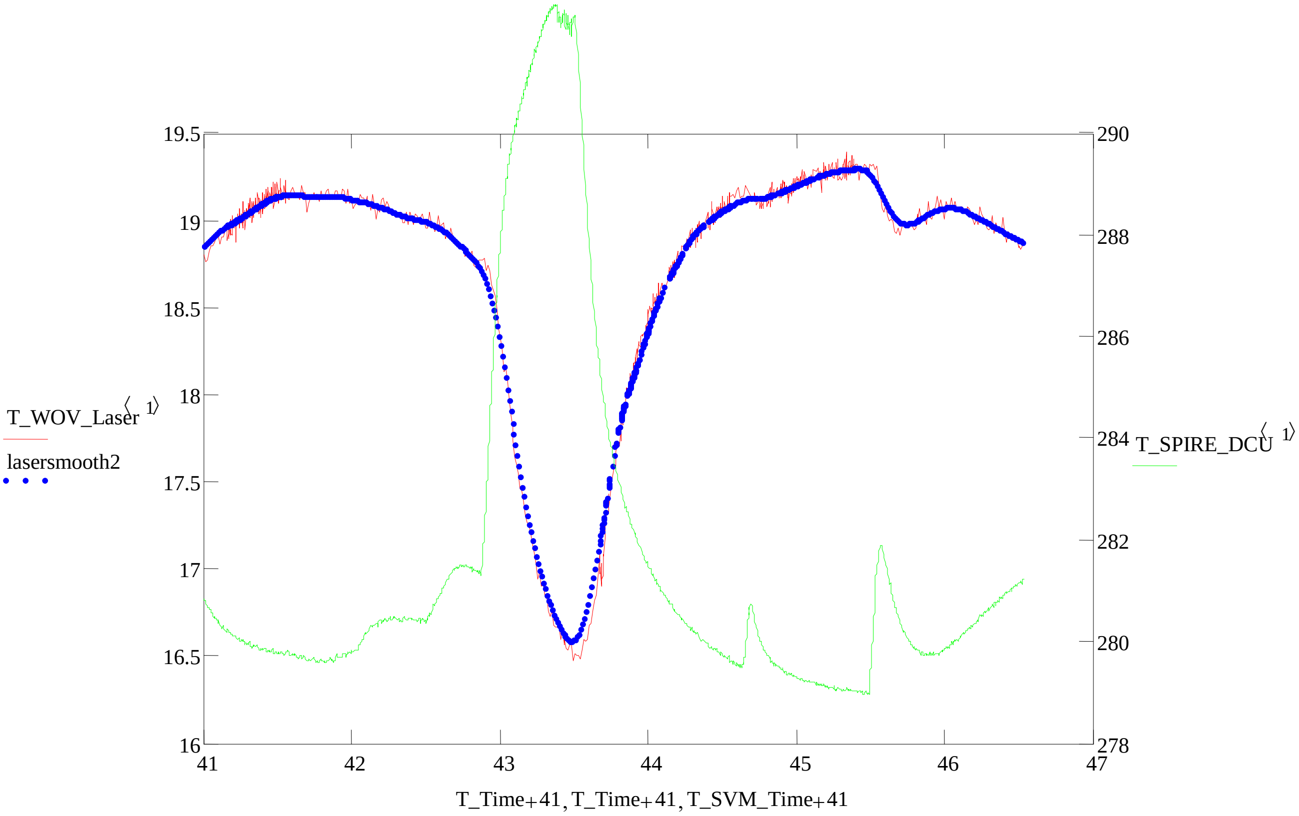


Figure 1. Spire DCU and HIFI WBO-V laser temperature as function of time in days

The WBS laser temperature excursion is 2.5ºC

The temperature scales nicely with the inverted SPIRE DCU temperature, this plot also shows the time delay between the spire unit and the laser :

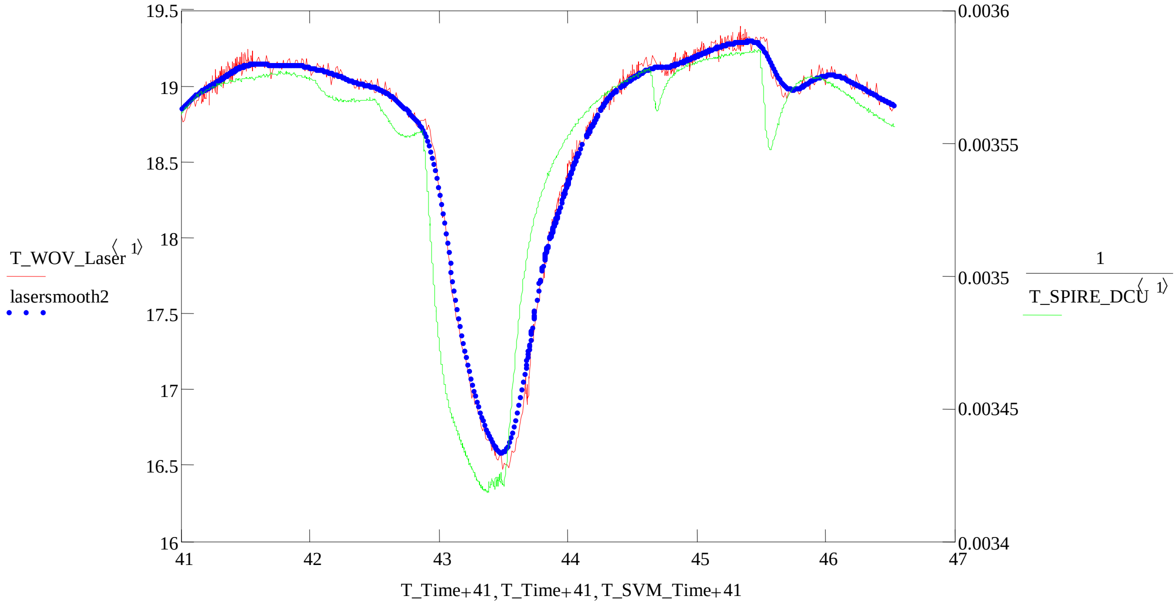


Figure 2. Again the WBO-V laser temperature, now plotted together with the inverse of the SPIRE DCU temperature.

To judge the effect on the drift, the following plot shows the T/time for the V laser, including the 0.03 K/hour specification bars:

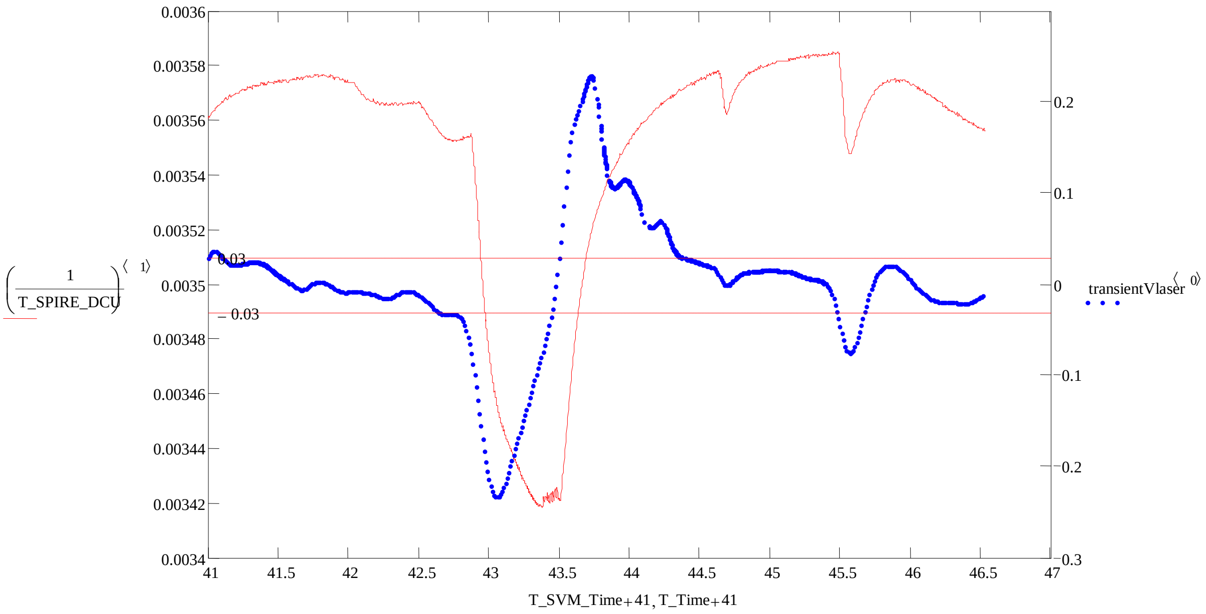


Figure 3. The derivative of the laser temperature is plotted in K/hour. The drift exceeds the specification with about a factor 10.

To judge the time it takes before the HIFI WBOV laser drift is back in specification the following plot is made.Here the SPIRE DCU LCL current is plotted, this indicates the mode change times. The resulting laser temperature is plotted as well. The time scale is in hours:

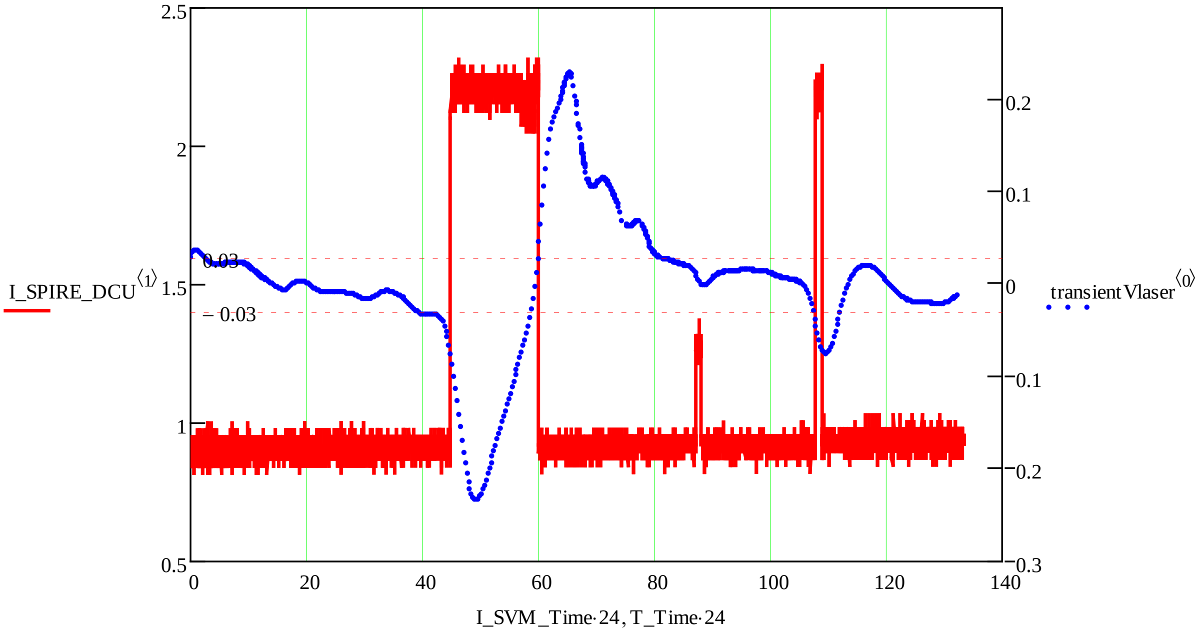


Figure 4. Laser temperature drift as finction of time in days, plotted together with the SPIRE DCU LCL current.

5.2 SPIRE – HIFI thermal interactions with SPIRE in standby.

SPIRE is in standby when the SpireHsfN_L51_I is 0.95 A. HIFI is active OD 69 and 73+74. From the last plot of the series below it can be seen that the laser temperature stability is not within specification during the HIFI OD. This is not related to SPIRE having been on. Still there is a resonse to the SPIRE panel temperature excursions, since also in the SPIRE standby case the relation between the SPIRE and HIFI unit is inverted, from which we conclude that this influence is not caused by direct or radiative box-SVM panel-box heating (the WBO-V temperature would then follow the SPIRE temperature) but instead SVM WBOV control loop is causing this thermal reaction.

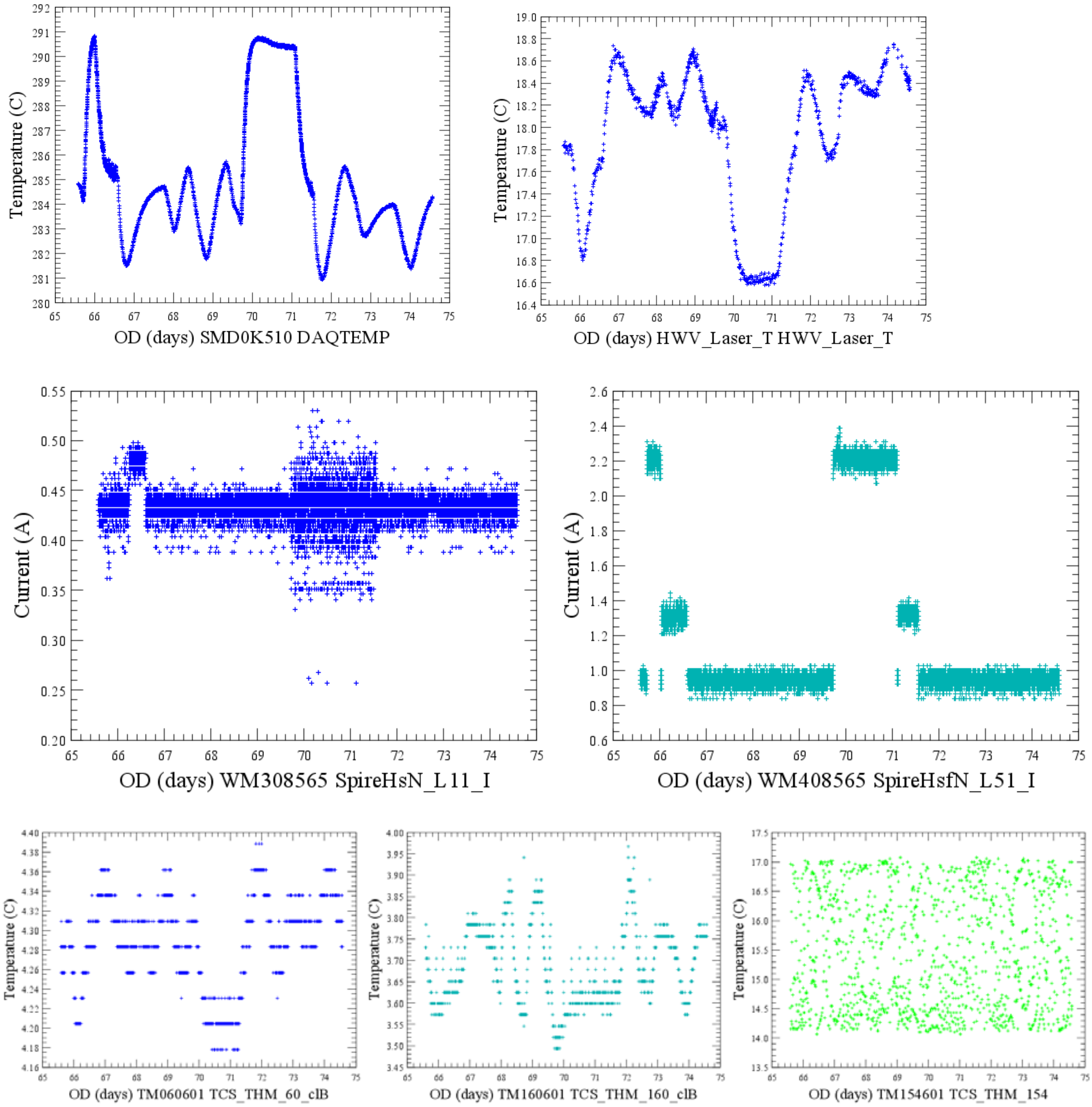


Figure 5. These plots show the SPIRE internal DCU temperature (DAQTEMP), HIFI WBO-V laser temperature, SPIRE LCL currents (to show SPIRE indeed in standby in OD 67-70) and the WBO-V panel temperature (TM060601), as reference WBO-H temperature (TM160601) and the SPIRE SVM panel temperature close to the CCU (TM154601). The DAQTEMP excursions are as high as 4 °C in standby. There is no relation between the SPIRE SVM CCU and DCU temperature.

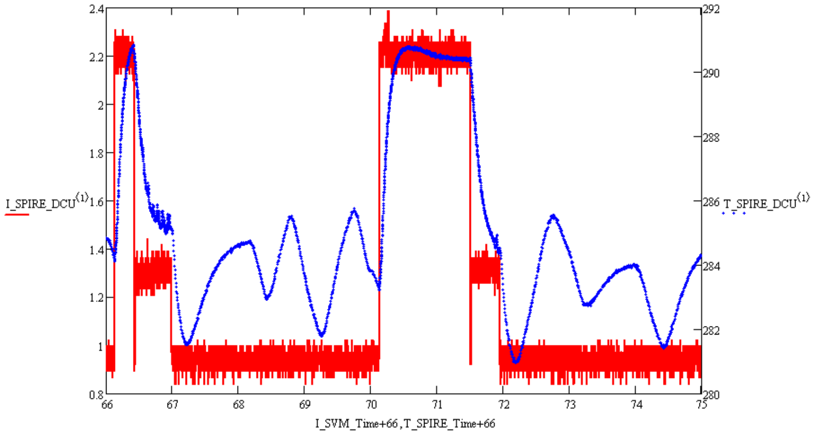


Figure 6. Temperature and current consumption of the SPIRE DCU box. Clearly the temperature swings are not caused by SPIRE dissipation changes. External causes as solar aspect angle changes are more likely.

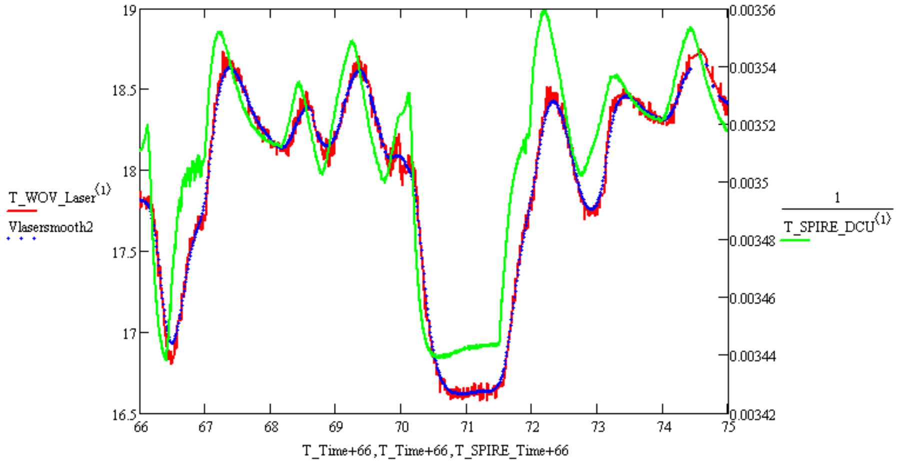


Figure 7. The resulting WBO-V laser temperature swing, plotted together with the inverse of the SPIRE DCU temperature. Clearly the laser follows the inverse temperature, even though the SPIRE box is passive. From Figure 6 the DCU internal temperature is seen to vary 4 degrees, the laser temperature swing is 0.7 degrees.

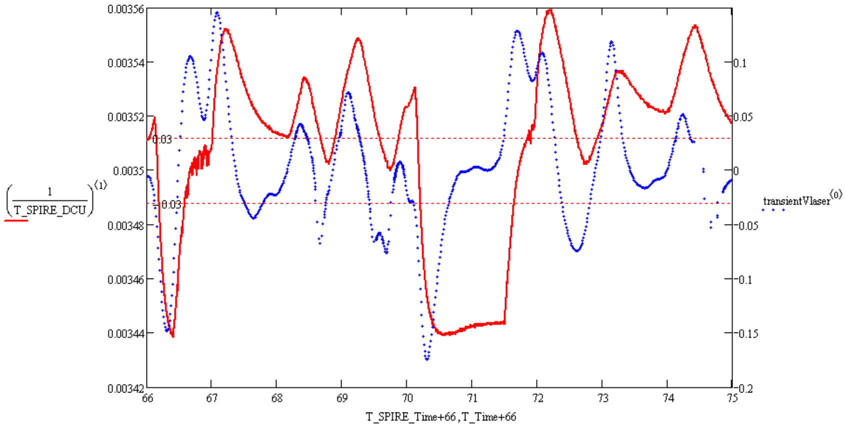


Figure 8. The laser drift in K/hour plotted together with the specification bars. Clearly even with SPIRE in standby the laser stability is out of specification.

5.3 Conclusions

After a full SPIRE OD, it takes 20 hours after SPIRE has been set to standby before the HIFI WBO V laser temperature stability is within the specified range. The time to stabilize depends on the duration of the SPIRE operational state; when SPIRE was operational for only 1 hour (at time = 105 hrs) the recovery time is 3 hours for the V laser.
Secondly, even in standby the WBO-V reacts inversely to temperature excursions of the SPIRE panel to such an extent that the WBO-V laser stability is out of specification. Clearly this points to an overreaction of the thermal control loop.

5.4 Remedies

1) Increase SPIRE CCU heater power, when DCU is in operational mode the additional dissipation can be compensated.
    a. No effect, since the SPIRE SVM panel heater is much farther away from the WBOV than the SPIRE DCU box.
    b. To be tested (as of September 1, 2009) whether synchronizing the heater switch with the switch to standby helps.

2) Keep SPIRE in dissipative standby mode.
   There is no SPIRE dissipative standby mode (see graph below, this shows the LCL currents of the SPIRE DCU)

normal standby =	0.9 A =	25 W
REDY =	1.25 A =	35 W
operational =	2.2 A =	62 W

Figure 9. SPIRE DCU LCL current in standby and operational. Clearly there is no standby mode with a dissipation close to that of the operational mode (2.2A).

3) Change WBOV heater control.
   The observation that the WBS –V laser temperatures responds inversely to the SPIRE perturbation hints to an overreaction of the thermal control loop. Therefore 2 remedies are currently considered:
   - Optimize the loop parameters
   - Remove 1 temperature sensor (TM108) from the loop. In Figure 10 it is shown that this sensor reacts much more wildly to temperature changes.

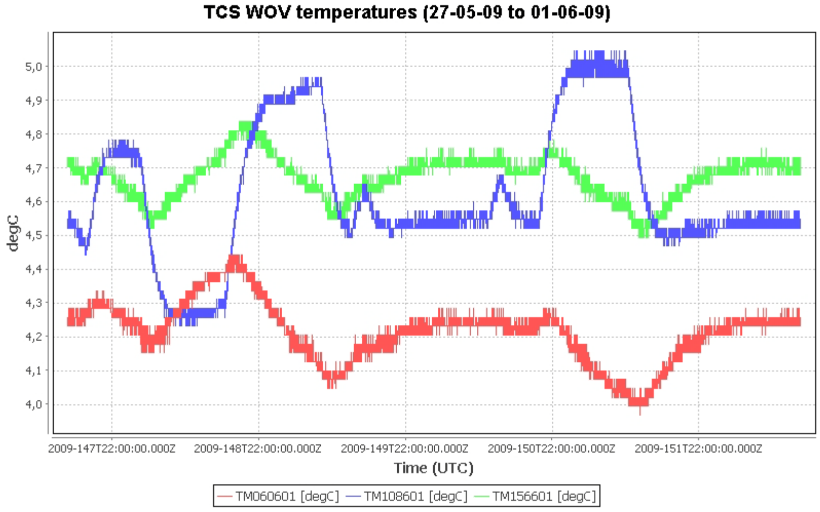
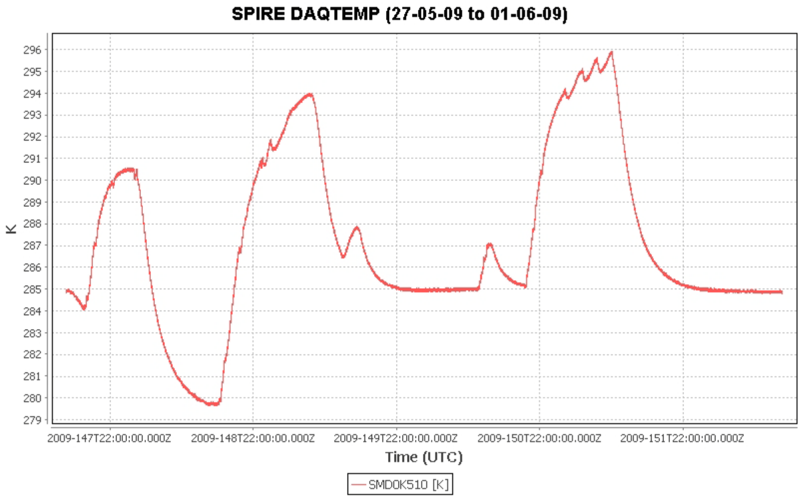


Figure 10. All three temperature sensors at the WBO-V foot on the SVM panel. The blue line (TM108) responds quite differently (almost inversely)from the other sensors and directly follows the SPIRE DCU temperature (See Figure 11), whereas the other 2 sensors are directly related to the laser temperature. Hence the suggestion to remove this sensor from the control loop.



6 WBOV, HIFI horizontal panel

6.1 *Observations of the LSU – WBO-H interaction*

In the graph below the WBO-H laser temperature is plotted as function of time. Also is the T/t in ºC/hour for the WBS H laser.

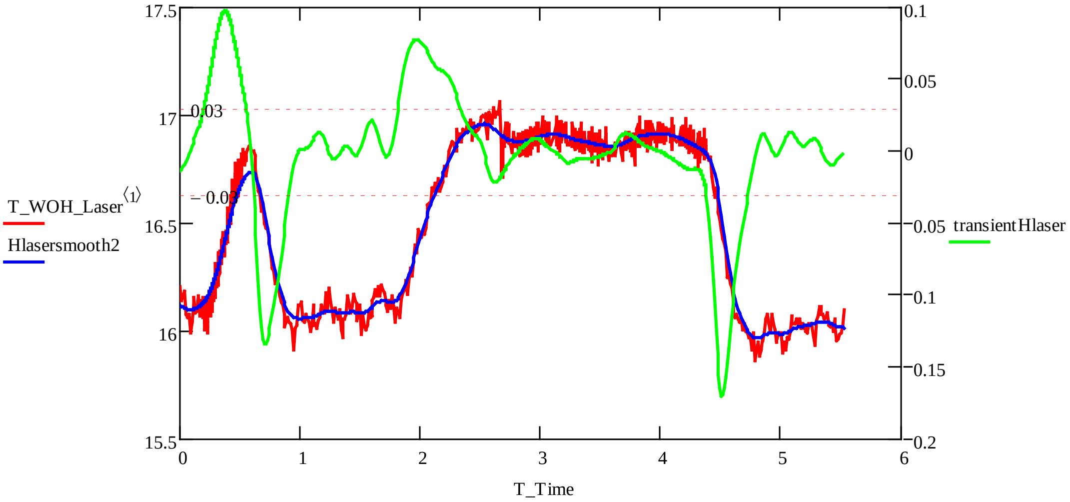


Figure 11. WBO-H laser temperature and –drift as function of time in days.

Again the timebase is set to hours, and the LCU current as well as the laser H transient curve is plotted:

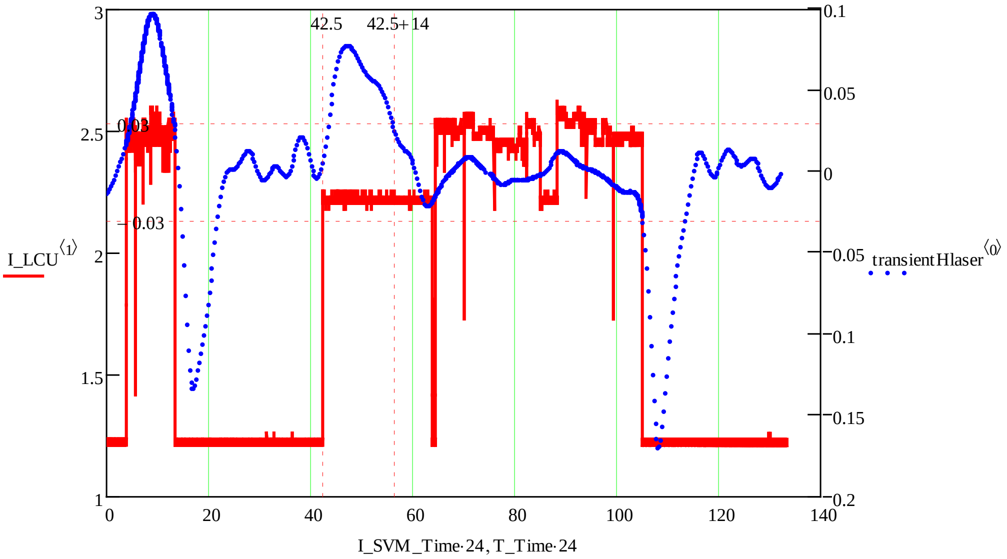


Figure 12. LCU current and laser temperature drift as function of time in hours.

6.2 Conclusions

The WBS laser needs 14 hours before the drift is within specification of 0.03 k/hour. This is for a dissipation of the LCU of 2.2A, which was the “3b dissipative mode” and hence the LSU dissipation is not at the operational 2.5 A. This means that the 14 hours is an underestimate.
It can be seen that when going from the “3b dissipative mode” to an actual operational mode the laser temperature stability stays within the specified range, which is good news.

6.3 Remedies

Implement LSU dissipative standby mode. The LSU dissipation is close enough to the operational dissipation that the backend stability stays within specification.