IMT511: Internal Calibration Sources Performances during cold FM ILT/IST

H. Dannerbauer[1], U. Klaas[1], J. Bouwman[1], M. Nielbock[1], J. Schreiber[1]

[1] **Max-Planck-Institut für Astronomie, Königstuhl 17, D-69117 Heidelberg, Germany**

Req. IMT511 Internal Calibration Sources Performances

IMT511 - A. History

Version	Date	Author(s)	Change description
1.1	October 26, 2007	H. Dannerbauer (MPIA), U. Klaas (MPIA), J. Bouwman (MPIA), M. Nielbock (MPIA), J. Schreiber (MPIA)	comments by UK
1.0	October 19, 2007	H. Dannerbauer (MPIA), U. Klaas (MPIA), J. Bouwman (MPIA), M. Nielbock (MPIA), J. Schreiber (MPIA)	comments by UK

IMT511 - B. Summary

We report the results of the Internal Calibration Source Test during the FM ILT/IST at MPE, Garching. The test was performed as expected in nominal mode. We conclude that the CSs worked as expected and observed during the proper FM ILT performance tests.

IMT511 - C. Data Reference Sheet

Ref	**Date**	**Archive filename**
IST Test Procedure	**10-Feb-2007**	**PACS-ME-TP-021 (RD1)**

Telemetry files	**Date**
FILT_IST_20070410_SPEC_CS_imt511_IST_OBS_47.tm IST	**2007-04-10**

IMT511 - D. Test Description

On 10th April 2007 the "Internal Calibration Sources Performance Test" was performed in nominal mode during cold FM ILT/IST as a reference test for future IST tests. The intention of this Performance Test was to monitor both the temperature stability on the selected temperature plateaux of the two calibration sources and the cool-down of the CSs, see Fig. 1. Furthermore, it was verified whether the temperature fluctuations on the selected plateaux stay within the specification. The test was performed in nominal spectroscopic housekeeping mode. At the start of the test CS1 was at 48 Ω (55 K) and CS2 at 58 Ω (60 K). Therefore, the heat-up from off-state was not recorded. Five minutes later, CS1 was heated up to 53 Ω (57.6 K) and CS2 to 63 Ω (62.5 K). For these temperatures the plateau stability was monitored. To initiate the cool-down both CSs were commanded to 39 Ω (50.5 K) which was not reached during a monitoring time of 30 minutes. For a general overview on the subject and test design, see RD1.

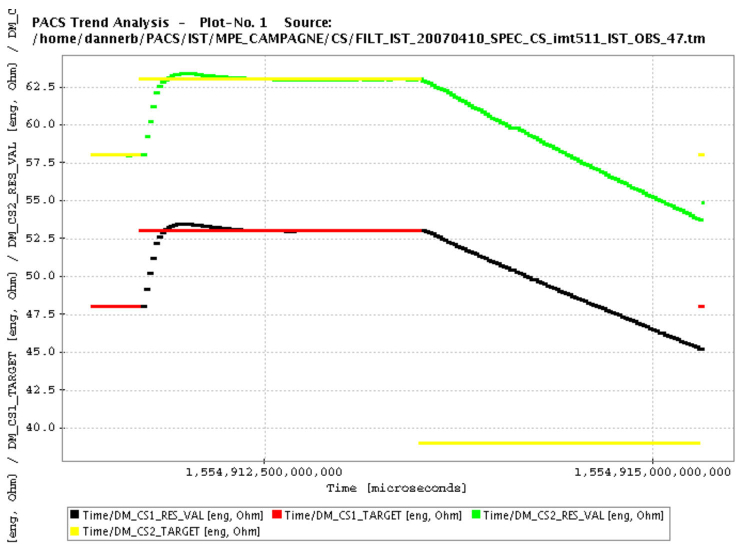

Figure 1: Overview of the performance test with the nominal HK parameters DM_CS1_RES_VAL (actual heater resistance CS1 $\propto$ temperature), DM_CS1_TARGET (set point), DM_CS2_RES_VAL (actual heater resistance CS2 $\propto$ temperature), and DM_CS2_TARGET (set point).

IMT511 - E. Results

IMT511 - E.1. Monitoring of Selected Temperature Plateaux

Fig. 2 shows the heat-up behaviour of both sources for a small step, for CS1 from 48 Ω (55 K) to 53 Ω (57.5 K), and for CS2 from 58 Ω (60.0 K) to 63 Ω (62.5 K). No anomalies are observed. The heat-up for CS1 was 2:40 min and for CS2 3 min. The stabilization time (overshoot time) for CS1 was 11:40 min and for CS2 11 min, being consistent with the stabilization times observed during FM ILT for a heat-up from off-state.

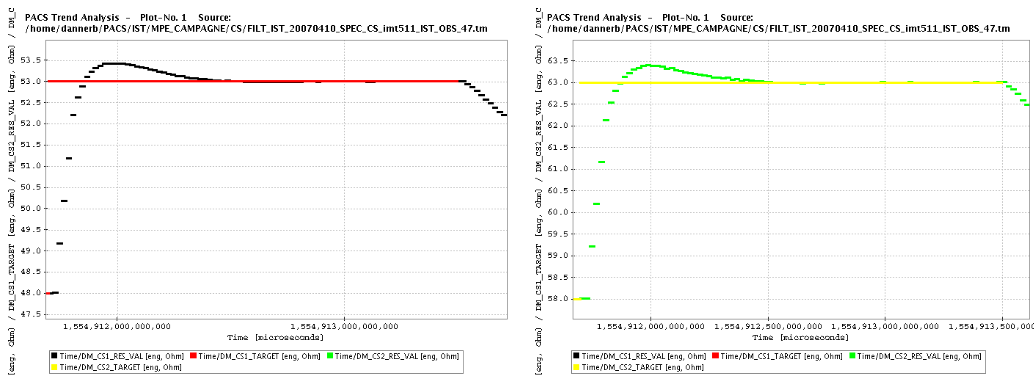

Figure 2: Trend analysis of CS heat-up behaviour for a small step. The HK parameters DM_CS1_RES_VAL (black) and DM_CS2_RES_VAL (green) are plotted against time. The setpoints are indicated by the horizontal red and yellow lines, respectively.

The peak of the maximum overshoot for CS1 is 0.4279 Ω, corresponding to ΔT = 0.3 K (0.5% of the plateau level) and for CS2 0.3994 Ω, corresponding to ΔT = 0.2 K (0.3% of the plateau level), see Figs. 3 and 4, respectively. The plateau behaviour for both CSs is stable, see Figs. 3 and 4. The fluctuations are inside a range of +0.0090 to −0.0045 Ω around the nominal resistance for CS1 and inside a range of +0.0080 to −0.0100 Ω around the nominal resistance for CS2. Hence, for both CSs the fluctuations are well within the specifications of ≈ ±0.0150 Ω corresponding to the specified temperature stability requirement of ∼ ±7mK.

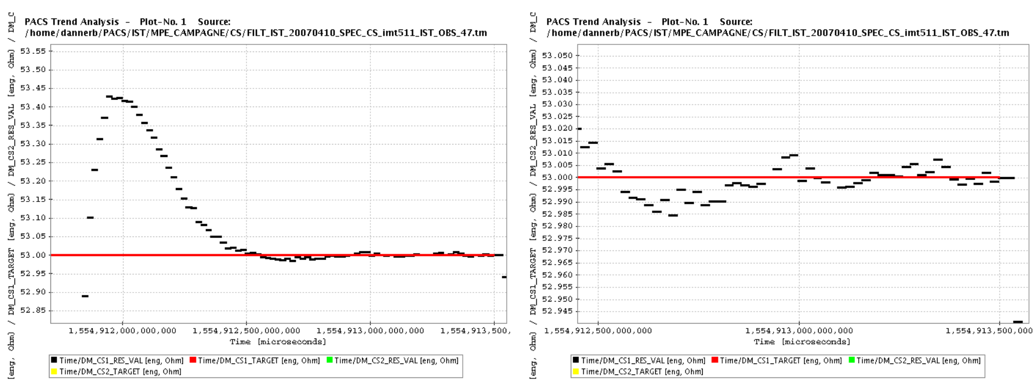

Figure 3: Trend analysis of CS1 temperature (ohmic resistance of heater) behaviour on the selected temperature plateau. In the left panel, we show the fluctuations beginning from the overshoot to the end of the test and on the right panel we show a zoom of the stabilized temperature plateau. The temperature fluctuations are well within the specified range of ≈ ±0.0150 Ω (specified requirement of ∼ ±7mK).

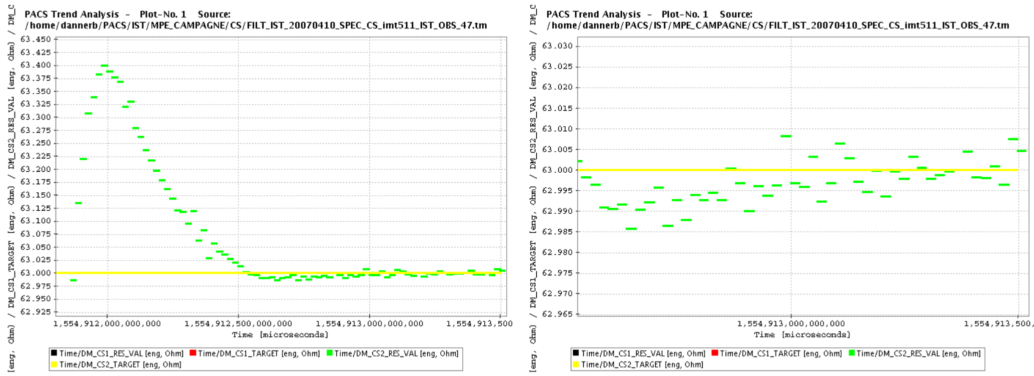

Figure 4: Trend analysis of CS2 temperature (ohmic resistance of heater) behaviour on the selected temperature plateau. In the left panel, we show the fluctuations beginning from the overshoot to the end of the test and on the right panel we show a zoom on the stabilized temperature plateau. The temperature fluctuations are well within the specified range of $\approx 0.0150\ \Omega$ commanding units (specified requirement of $\sim$7mK).

IMT511 - E.2. Cool-down of Calibration Sources

Fig. 5 shows the monitored part of the cool-down behaviour of both sources.

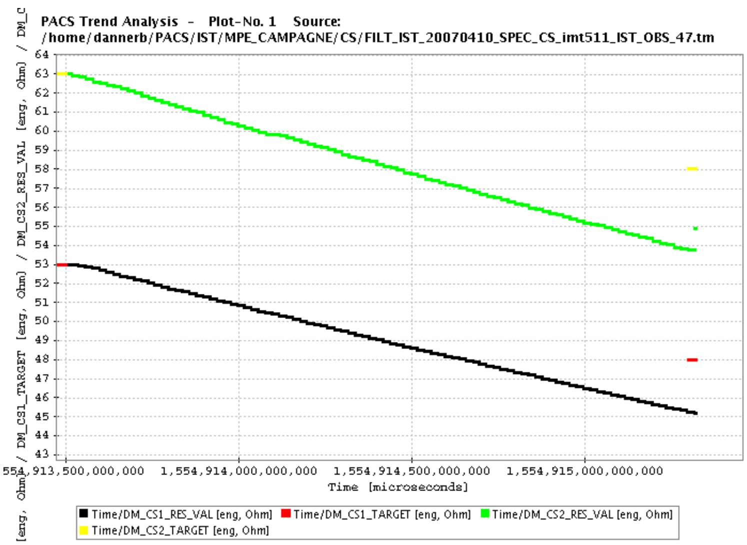

Figure 5: Trend analysis of CSs cool-down behaviour. The HK parameters DM_CS1_RES_VAL and DM_CS2_RES_VAL are plotted against time.

We describe the temporal cool-down by an exponential decay function

$$T = T_0 \times e^{-\tau\, t}$$

Determination of T at two times T_1 and T_2 yields

$$\frac{T_1}{T_2} = \frac{e^{-\tau\, t_1}}{e^{-\tau\, t_2}} = e^{\tau\,(t_2 - t_1)}$$

hence

$$\tau = \frac{ln(\frac{T_1}{T_2})}{t_2 - t_1}$$

We derive the following cool-down time constants

Table 1: CSs cool-down time constants τ

	t_1	T_1	$t_{2,1}$	$T_{2,1}$	$\tau_{30\,\mathrm{min}}(\mathrm{min}^{-1})$
CS1	16:25:00	52.9999	16:54:57	45.2316	0.005292
CS2	16:25:00	63.0046	16:54:57	53.8118	0.005266

Furthermore, we make a prediction of the cool-down time close to zero, see Table 2. We assume 0.7 Ω (∼4.8 K) as target value corresponding to the environmental temperature of the CSs.

Table 2: CSs cool-down times to off-state

	T_1	T_2	t_2 (min)	$t(T_0\times e^{-1})$ (min)
CS1	52.9999	0.7	818 = 13.6 h	189 = 3.2 h
CS2	63.0046	0.7	850 = 14.2 h	190 = 3.2 h

IMT511 - E.3. General Behaviour of CSs during Test

In the housekeeping parameters of the controller status for the CSs (DM_CS1/2_CTRL_STA) no anomalies are observed. In Fig. 6 we show the temporal shape of the heat-current of the two CSs which behaves as expected. The strong peak represents the ballistic heating with a maximum current of 10 mA followed by the controlled entry into the temperature plateau. Finally, we investigated the behaviour of the temperature sensor close to the CSs DM_CAL_SRC_TEMP, see Fig. 7. The increase of the temperature of 2.5 K (5 Ω) for both CSs leads to an increase of the environment temperature of the CSs from 4.77 K to 4.91 K at the maximum (90 seconds after start of heat-up) during the ballistic heating. Shortly after, the environment temperature drops down to 4.78 K and stays there until the moment when the cooling-down of the CSs begins, see Fig. 7, being then at 4.77 K (the same value as before the heat-up of the CSs) and continuing to slightly decrease.

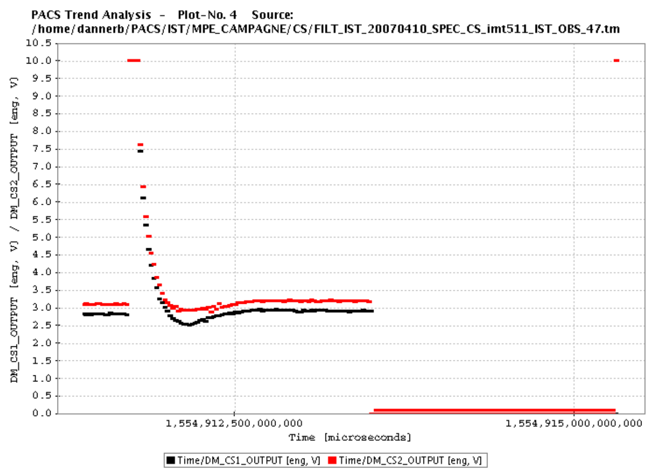

Figure 6: Trend analysis of CSs output-current behaviour. The HK parameters DM_CS1_OUTPUT and DM_CS2_OUPUT are plotted against time. The strong peak is the ballistic heating with maximum heating current, followed by the entry into the temperature plateau. During the cool-down the heater is switched off.

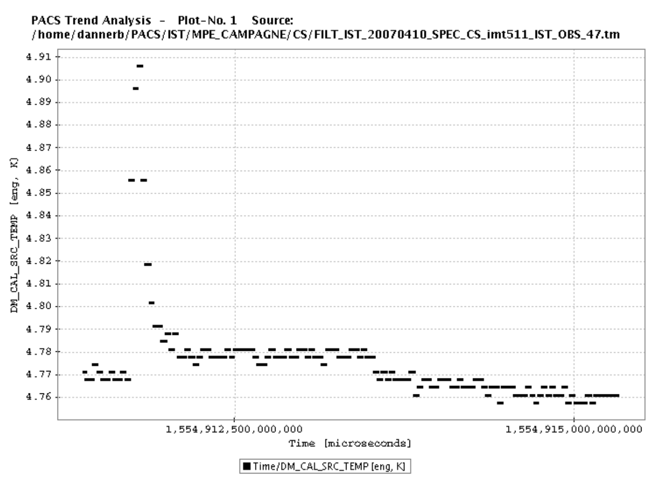

Figure 7: Trend analysis of temperature data of the sensor close to the CSs. The HK parameter DM_CAL_SRC_TEMP is plotted against time.

IMT511 - F. Conclusions

To summarize, the CSs behaved as expected. No significant difference to the performance during dedicated and longer FM ILT is noticed.

IMT511 - G. Lessons learned for IMT/IST/PV

If possible in nominal mode the selected temperature plateau for CS1 should be higher than for CS2, due to the slightly slower heat-up of CS2.