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CHANGE RECORD

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INTRODUCTION AND SCOPE

This document reports on the RCA24 Flight Model on – ground calibration scientific data analysis. Tests were performed from 16th January 2006 to 8th February 2006 (including functional tests) at Alcatel Alenia Space – Milano according to the LFI Calibration Plan.

The RCA is composed by the following units:

ITEM	No. TYPE	ACTUAL
44 GHz RCA 24 FM FH + OMT ASSEMBLY	FH PART NUMBER	700100405-01D
	FH SERIAL NUMBER	02
	OMT PART NUMBER	700100408-01D
	OMT SERIAL NUMBER	002
44 GHz RCA 24 FM FEM	PART NUMBER	PLABC - P
	SERIAL NUMBER	4F2
44 GHz RCA 24 FM WAVEGUIDES ASSEMBLY	Cu WG PART NUMBER	700100406
	Cu WG SERIAL NUMBER	002
	SST WG PART NUMBER	700100407
	SST WG SERIAL NUMBER	005
44 GHz RCA 24 FM BEM	PART NUMBER	PLABD - P
	SERIAL NUMBER	2
44 GHz RCA 24 FM 4K REFERENCE WAVEGUIDES	R WG PART NUMBER	PLTES051
	R WG SERIAL NUMBER	N/A
	L WG PART NUMBER	PLTES050
	L WG SERIAL NUMBER	N/A

The radiometer scheme is reported in *Figure 1-1*

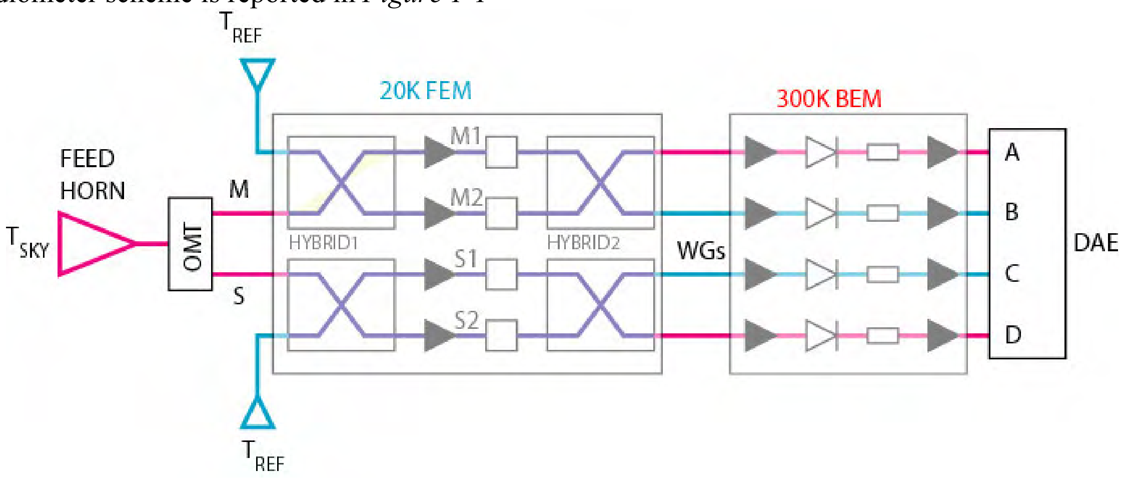


Figure 1-1: RCA24 scheme. M means Main Arm; S means Side Arm. A and B output channels are connected through the waveguides with M1 and M2 front end Low Noise Amplifiers. C and D output channels are connected with S1 and S2 front end Low Noise Amplifiers

The temperature sensors are here explained in

Table 1-1: Temperature sensors acquired during RCA tests

ID	Rachel Labels	Notes
0	FEM TEMP	FEM controller
1	SKY TEMP	Skyload back plate controller
2	REF TEMP	Reference Load temperature
3	VG1 TEMP	Cu/SS waveguide Interface controller
4	VG2 TEMP	BEM body Temperature
5	VG3_TEMP	3rd V-groove controller
6	BEM_TEMP	BEM controller
7	S40K_TMP	Shroud 40 Kelvin
8	SLN2_TMP	4K cooler head
9	SMON_TMP	Skyload eccosorb lateral side
10	RMON_TMP	Teflon support
11	S40C_TMP	Feed Horn Flange

Hereafter the test performed during the campaign:

Table 1-2: List of files acquired during the RCA24 test campaign

Filename	Notes
044LFI24 RCA FM AMB 200601171736	RCA functional test at ambient temperature
044LFI24 RCA FM CRY 200601201751	Bad file.
044LFI24 RCA FM CRY 200601201758	Bad file.
044LFI24_RCA_FM_CRY_200601201808	RCA functional test at cryogenic temperature (sky and ref still cooling down)
044LFI24_RCA_FM_XXX_200601201852	SKY and REF thermal steps for linearity check
044LFI24_RCA_FM_XXX_200601210328	"
044LFI24_RCA_FM_XXX_200601211201	"
044LFI24_RCA_FM_XXX_200601212034	"
044LFI24 RCA FM XXX 200601220508	"
044LFI24_RCA_FM_XXX_200601221341	"
044LFI24_RCA_FM_XXX_200601222214	"
044LFI24_RCA_FM_XXX_200601230647	"
044LFI24_RCA_FM_CRY_200601231449	RCA functional test at cryogenic temperature
044LFI24 RCA FM XXX 200601231514	PS/SW diodes functionality test
044LFI24 RCA FM TUN 200601231639	Tuning of DAE offset removal and PGA gain
044LFI24 RCA FM TUN 200601241106	Phase switch tuning
044LFI24_RCA_FM_TUN_200601241607	Vg1 tuning
044LFI24_RCA_FM_TUN_200601250047	"
044LFI24_RCA_FM_TUN_200601250919	"
044LFI24_RCA_FM_TUN_200601251409	Vg2 tuning
044LFI24_RCA_FM_TNG_200601251801	Noise temperature and gain test (3 steps on both sky and ref)
044LFI24_RCA_FM_TNG_200601260235	"
044LFI24_RCA_FM_OFT_200601261251	Radiometer offset test with sky at 11k and ref from 8.5 to 13K
044LFI24_RCA_FM_XXX_200601261443	DAE-RACHEL test
044LFI24_RCA_FM_XXX_200601261542	DAE-RACHEL test
044LFI24_RCA_FM_TNG_200601261554	RCA TNG test on ref load with Tsky=11.256K; Tref=13K; unsuccessfully ended due to check on DAE-RACHEL
044LFI24 RCA FM XXX 200601261631	Check of DAE - RACHEL integrity
044LFI24 RCA FM XXX 200601261650	Check of DAE - RACHEL integrity
044LFI24_RCA_FM_XXX_200601261710	Check of DAE - RACHEL integrity after reboot of DAE pc
044LFI24_RCA_FM_TNG_200601261757	RCA TNG test (with OFT test included)
044LFI24_RCA_FM_TNG_200601270237	"
044LFI24_RCA_FM_OFT_200601271126	RCA offset test

Filename	Notes
044LFI24_RCA_FM_LIS_200601271332	RCA linearity test
044LFI24_RCA_FM_LIS_200601272211	"
044LFI24_RCA_FM_LIS_200601280644	"
044LFI24_RCA_FM_LIS_200601281517	"
044LFI24_RCA_FM_LIS_200601282351	"
044LFI24_RCA_FM_ELE_200601311451	RCA ELE test on channel S1 - aborted
044LFI24_RCA_FM_ELE_200601311503	RCA ELE test on channel S1 - aborted cryo science console crash
044LFI24_RCA_FM_ELE_200601311518	RCA ELE test on channel S1 - VG1
044LFI24_RCA_FM_ELE_200601311631	RCA ELE test on channel S1 - VG2
044LFI24_RCA_FM_ELE_200601311728	RCA ELE test on channel S1 - VD
044LFI24_RCA_FM_ELE_200601311814	RCA ELE test on all channels with Vg1 voltage changing
044LFI24_RCA_FM_ELE_200601311840	RCA ELE test on all channels with Vg2 voltage changing
044LFI24_RCA_FM_ST3_200601311934	RCA chopped test with Tref from 8.5 to 20K (Tsky=8.5k); then Tsky at 20 K. Long acquisition for noise evaluation
044LFI24_RCA_FM_ST3_200602010411	"
044LFI24_RCA_FM_THF_200602011256	Output voltage sensitivity to thermal changes in the FEM
044LFI00_RCA_FM_XXX_200602011640	Test on RACHEL data acquisition
044LFI24_RCA_FM_UNC_200602011731	RCA unchopped noise test
044LFI24_RCA_FM_UNC_200602020242	
044LFI24_RCA_FM_UNC_200602021115	" -- UNC test ended
044LFI24_RCA_FM_SPR_200602021228	RCA SPR test. G=1; offset=0
044LFI24_RCA_FM_SPR_200602021413	RCA SPR test. G=1; offset=0. Interrupted
044LFI24_RCA_FM_AMB_200602021456	Errore di etichetta. E' un SPR. Check di rumore sui dati acquisiti
044LFI24_RCA_FM_SPR_200602021515	RCA SPR test. G=16; offset=vedi 'offset & gain calibration" sheet
044LFI24_RCA_FM_SPR_200602021549	"
044LFI24_RCA_FM_SPR_200602021649	"
044LFI24_RCA_FM_ST3_200602021916	ST3 test with blanking time=22.5 us
044LFI24_RCA_FM_ST3_200602020353	"
044LFI24_RCA_FM_THF_200602031158	THF test, Tfem change from 20 to 22,24,27K. Blanking time=22.5 us
044LFI24_RCA_FM_THV_200602031300	RCA THV test (VG3 temp from 60, to 62, to 64K)
044LFI24_RCA_FM_THF_200602031643	THF test, Tfem change from 20 to 22,24,27K. Blanking time=7.5 us
044LFI24_RCA_FM_SPR_200602031736	SPR test to -25 dBm and -31dBm to check for saturation effect on Beff
030LFI24_RCA_FM_LIS_200602031922	RCA LIS test with Sky load temperature steps. Week end acquisition. Errore di etichetta!!! E' 44, non 30.
030LFI24_RCA_FM_LIS_200602040408	"
030LFI24_RCA_FM_LIS_200602041241	"
030LFI24_RCA_FM_LIS_200602042115	"
030LFI24_RCA_FM_LIS_200602050548	"
030LFI24_RCA_FM_LIS_200602051422	"
030LFI24_RCA_FM_LIS_200602052255	"
030LFI24_RCA_FM_LIS_200602060729	"
044LFI24_RCA_FM_ST1_200602061151	RCA chooped test with different blanking times, for spikes investigation
044LFI24_RCA_FM_ST1_200602061838	RCA long acquisition in radiometer stable operating conditions (Tsky= 8.7980K; Tref=8.4999K; chopped; gain=16 on all channels; offset=0xA on M1, 0x9 on M2, 0xE on S1, 0xD on S2)
044LFI24_RCA_FM_ST1_200602070313	"
044LFI24_RCA_FM_ST1_200602071147	"

Filename	Notes
044LFI24_RCA_FM_ST1_200602072022	"
044LFI24_RCA_FM_ST1_200602080456	"
044LFI24_RCA_FM_SPR_200602081222	RCA swept source test - new transition - 28 dBm
044LFI24_RCA_FM_SPR_200602081308	RCA swept source test - new transition - 31 dBm
044LFI24_RCA_FM_SPR_200602081426	RCA swept source test - new transition - 25 dBm
044LFI24_RCA_FM_SPR_200602081509	RCA swept source test - new transition - 34 dBm
044LFI24_RCA_FM_THB_200602081710	Output voltage sensitivity to thermal changes in the BEM
044LFI24_RCA_FM_THB_200602080145	"
044LFI24_RCA_FM_THB_200602081018	"

APPLICABLE DOCUMENTS

[AD 1] M.Bersanelli, *Planck-LFI Calibration Plan*, PL-LFI-PST-PL-008, Issue/Rev 1.0, July 2003

[AD 2] E.Alippi, P.Guzzi, *Planck LFI 44GHz Radiometer Chain Assembly (RCA) Specification*, PL-LFI-PST-SP-007, Issue/Rev. 2.0, March 2002

REFERENCE DOCUMENTS

[RD 1] A.Mennella, et. al, *Data analysis and calibration matrix of LFI 44 GHz QM receiver (LFI24)*, PL-LFI-PST-AN-003, Issue/Rev 1.0, May 2005

[RD 2] P. Battaglia, *44GHz RCA #24 FM Test Report,* PL-LFI-LAB-RP-059, Issue 1

[RD 3] F. Cuttaia, A. D'Arcangelo, D. Lawson, L. Stringhetti, *nonlinearity investigation at 44 GHz using prototype units:BEM44_B3_DC and BEM44_B4_DC*, PL-LFI-PST-TN-073, 1.0

[RD 4] N. Roddis, D. Lawson, F. Cuttaia D. Kettle et al. *Planck LFI – 44 GHz FM FEM 4F2 Final Performance Test Report*, PL-LFI-JBO-RP-090

ANNEXES

[ANNEX 1] P. Battaglia, *LIS RaNA analysis report*

[ANNEX 2] F. Villa, *SPR RaNA analysis report*

[ANNEX 3] M. Sandri, *ST3 RaNA analysis report with blanking Time of 7.5 usec*

[ANNEX 4] M. Sandri, *ST3 RaNA analysis report with blanking Time of 22.5 usec*

[ANNEX 5] M. Sandri, *UNC RaNA analysis report*

TUNING

DAE TUNING

The fist step of tuning was the tuning of the DAE with the aim to set the PGA offset and the PGA gain of the DAE appropriately. The signal coming from each BEM detector, $V_{BEM}^{(i)}$, can be amplified and offset in the following way:

$V^{(i)}=G^{(i)}\cdot(V_{BEM}^{(i)}-Off^{(i)})i=A,B,C,D$

The gain needs to be set in order to be sure that the noise induced by the DAE is not influencing the noise of the radiometric signal from BEM detectors. The offset needs to be set in order to stay in the [–2.5, +2.5] Volts output range when the gain has been set properly fo the input temperature rangeThe activity is recorded on the data set `044LFI24_RCA_FM_TUN_200601231639`. .

According to the test procedure, the log file report the following sequence:

Table -5-1: LOG file of the DAE tuning.

1	2006-01-23T15:43:40	DAE offset tuning and PGA gain
2	2006-01-23T15:51:53	FEM on
3	2006-01-23T15:52:35	PS/SW on
4	2006-01-23T16:04:13	Offset removed; now increasing Tref from 8.5 to 25K
5	2006-01-23T16:49:49	PGA gain set to 16 on all channels
6	2006-01-23T16:59:40	Tref set back to 8.5K
7	2006-01-23T17:33:34	test ended

The DAE PGA gain and Offset are stored in the configuration file so that RaNA analysis software is able to convert the signal into the BEM output detector real signal.

Table -5-2: Best DAE PGA gain and offset values derived from the test.

	Gain	Offset [HEX]	Offset [Volt]
Detector A	16	A	0.092
Detector B	16	9	0.087
Detector C	16	E	0.126
Detector D	16	D	0.122

RADIOMETER TUNING

Radiometer performances are strongly dependent on the amplifiers and phase switches voltage and current supply values. They can be varied and the right supply conditions needs to be determined. Although the best supply condition has been determined at FEM level by JBO team, an appropriate tuning procedure has been applied also at RCA level with the aim to search for best working conditions when the FEM is connected to the entire RCA under thermal conditions as close as to the flight one. During tuning procedures the gain and offset of the DAE were set to 1 and 0 respectively.

As shown in the following paragraphs, there is no doubt about the best working points both for phase switches and amplifiers. For all the amplifiers, the noise temperature versus Vg1 and isolation versus Vg2 is well identified and in agreement (even if small differences are presents) with numbers provided by JBO as nominal values (see [RD 4]).

Phase switches tuning

The tuning of PS has been performed by varying the PS current supply (I1 and I2) in order to reach the best working condition, i.e. when the SKY-REF output difference is as close as possible to zero when one amplifier at time is switched on. According to Seiffert et al. 2002 page 1187, formula (4), the output of each detector is (differenced with r = 1) is

for the Phase switch M1

$$\begin{cases} V_{out}^{(A)} = \frac{1}{4} kB \cdot a \cdot G_{BEM}^{(A)} \cdot G^{(M1)} \left(2T_N^{(M1)} + Tsky + Tref \right) \cdot \left(A_1^{(M1)} - A_2^{(M1)} \right) \\ V_{out}^{(B)} = -\frac{1}{4} kB \cdot a \cdot G_{BEM}^{(B)} \cdot G^{(M1)} \left(2T_N^{(M1)} + Tsky + Tref \right) \cdot \left(A_1^{(M1)} - A_2^{(M1)} \right) \end{cases}$$

when M2 is off.

For the phase switch M2

$$\begin{cases} V_{out}^{(A)} = \frac{1}{4} kB \cdot a \cdot G_{BEM}^{(A)} \cdot G^{(M2)} \left(2T_N^{(M2)} + Tsky + Tref \right) \cdot \left(A_1^{(M2)} - A_2^{(M2)} \right) \\ V_{out}^{(B)} = -\frac{1}{4} kB \cdot a \cdot G_{BEM}^{(B)} \cdot G^{(M2)} \left(2T_N^{(M2)} + Tsky + Tref \right) \cdot \left(A_1^{(M2)} - A_2^{(M2)} \right) \end{cases}$$

when M1 is off.

For the phase switch S1

$$\begin{cases} V_{out}^{(C)} = \frac{1}{4} kB \cdot a \cdot G_{BEM}^{(C)} \cdot G^{(S1)} \left(2T_N^{(S1)} + Tsky + Tref \right) \cdot \left(A_1^{(S1)} - A_2^{(S1)} \right) \\ V_{out}^{(D)} = -\frac{1}{4} kB \cdot a \cdot G_{BEM}^{(D)} \cdot G^{(S1)} \left(2T_N^{(S1)} + Tsky + Tref \right) \cdot \left(A_1^{(S1)} - A_2^{(S1)} \right) \end{cases}$$

when S2 is off.

For the phase switch S2

$$\begin{cases} V_{out}^{(C)} = \frac{1}{4} kB \cdot a \cdot G_{BEM}^{(C)} \cdot G^{(S2)} \left(2T_N^{(S2)} + Tsky + Tref \right) \cdot \left(A_1^{(S2)} - A_2^{(S2)} \right) \\ V_{out}^{(D)} = -\frac{1}{4} kB \cdot a \cdot G_{BEM}^{(D)} \cdot G^{(S2)} \left(2T_N^{(S2)} + Tsky + Tref \right) \cdot \left(A_1^{(S2)} - A_2^{(S2)} \right) \end{cases}$$

when S1 is off.

Here we defined the following quantities:
Tn -> noise temperatures of the LNAs at the front end (for M1,M2,S1,S2)
Gbem -> Gain of the LNA at the back end (A,B,C,D)

It should be noted that the differenced output is null as the two state of the phase switches exhibit the same insertion loss A1 and A2 at a given I1 and I2 pair and that as one detector is balanced (for example detector A when M2 is off) automatically the other detector output (detector B in this case) is null as well.

The table Table 5-3 reports the optimal phase switch bias values versus the nominal values has been declared by JBO.

Table 5-3: Optimal Vs nominal phase switches bias values.

Phase switch bias values		PS M1		PS M2		PS S1		PS S2	
		I1	I2	I1	I2	I1	I2	I1	I2
Nominal (JBO)	[mA]	0.7967	0.7995	0.7977	0.7974	0.7992	0.7978	0.7962	0.7987
	[HEX]	CE	CD	D0	C6	CF	C9	CA	CF
Optimal	[mA]	0.5931	0.8967	0.4943	0.9856	0.4971	0.9821	0.4914	0.9714
	[HEX]	9A	E6	82	FF	82	FF	7C	FF

In the four plot below, the tuning curves are reported.

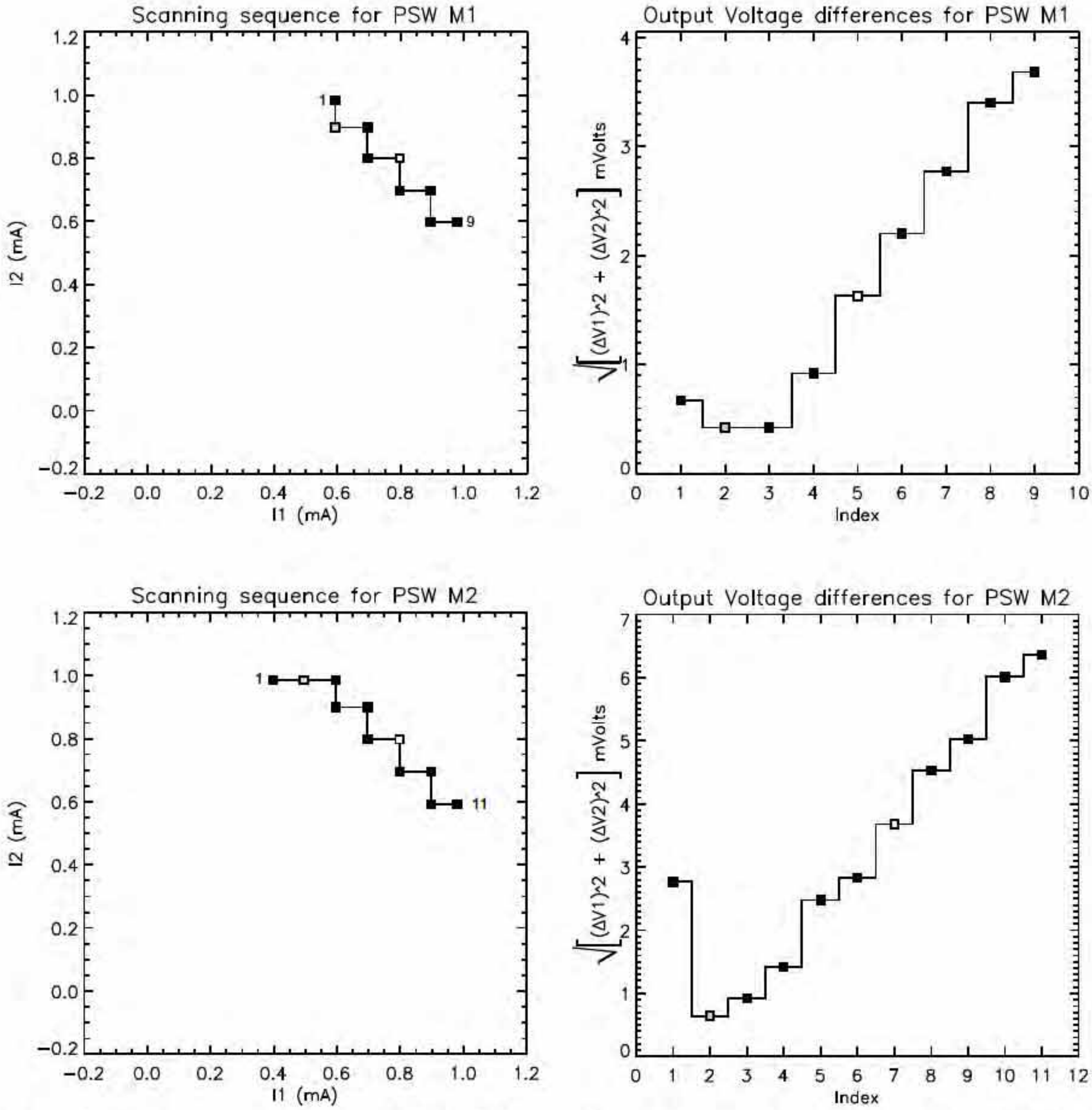


Figure 5-1: Phase switch tuning of the Main Arm (M1 and M2). In the left panel the scanning sequence on the (I1,I2) plane is shown together with the measurement index. On the right the voltage difference as a function of measurements index. The white square is the nominal value while the grey is the best value found at RCA level.

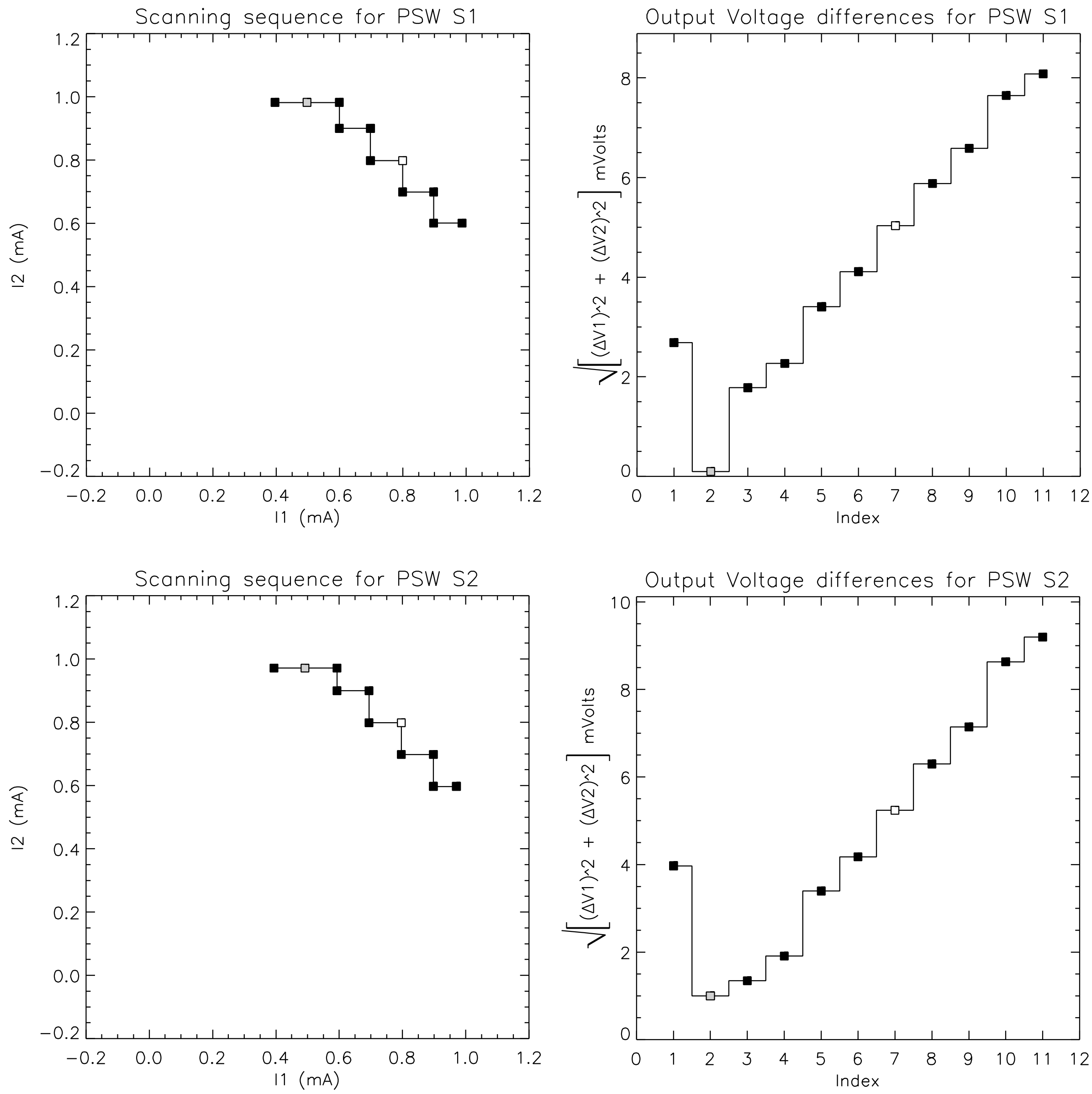


Figure 5-2: Phase switch tuning of the Side Arm (S1 and S2). In the left panel the scanning sequence on the (I1,I2) plane is shown together with the measurement index. On the right the voltage difference as a function of measurements index. The white square is the nominal value while the grey is the best value found at RCA level.

Tuning of the Amplifiers

To search for best working conditions the noise temperature and the isolation have been measured as a function of Vgate 1 and Vgate 2. Firstly the minimum noise conditions have been found by varying the Vgate1 keeping the Vgate2 and Vdrain fixed. The noise temperature was measured with the Y factor method as reported in Eq. 1 (here physical temperatures have been assumed for the calculation).

Eq. 1:

$$T_{noise} = \frac{T_{hot} + Y \cdot T_{cold}}{Y - 1}$$

$$Y = \frac{V_{hot}}{V_{cold}}$$

The sky load was fixed at 8.8163 Kelvin, and the reference load temperature was changed from 8.500 Kelvin to 25.000 Kelvin. Due to the non perfect thermal isolation between the Sky load and the reference load, the sky load rised to 11.214 Kelvin when the reference load was set to 25 Kelvin. This effect has been taken into account for radiometer isolation calculation.

Once optimal Vgate 1 has been determined, Optimal Vgate 2 has been found by optimising the isolation parameter calculated as follows:

Eq. 2:

$$Isol = \frac{(\Delta V_{SKY} - G \cdot \Delta T_{SKY})}{\Delta V_{REF} + (\Delta V_{SKY} - G \cdot \Delta T_{SKY})}$$

Voltages are at the DAE. JBO values have been corrected taking into account the effect of the cryo harness. Drain Voltages (Vd) are not tuned. Nominal (JBO) values have been assumed.

Table -5-4: Nominal (JBO) and optimal Front End amplifiers voltage supply

LNA Bias Values on Main arm		Amplifier M1			Amplifier M2		
		Vg1	Vg2	Vd	Vg1	Vg2	Vd
Nominal	[mV]	1.2994	1.3450	1.1823	1.2985	1.3446	1.1783
	HEX	D3	D6	D0	D3	D6	D0
Optimal	[mV]	1.4861	1.3450	-	1.4855	1.3446	-
	HEX	DF	D6	-	DF	D6	-
LNA Bias Values on Side arm		Amplifier S1			Amplifier S2		
		Vg1	Vg2	Vd	Vg1	Vg2	Vd
Nominal	[mV]	1.3137	1.3443	1.0343	1.2985	1.3442	1.0121
	HEX	D4	D6	B7	D3	D6	B3
Optimal	[mV]	1.2048	1.3443	-	1.3928	1.3442	-
	HEX	CD	D6	-	D9	D6	-

In the plot below the amplifier tuning curves are reported.

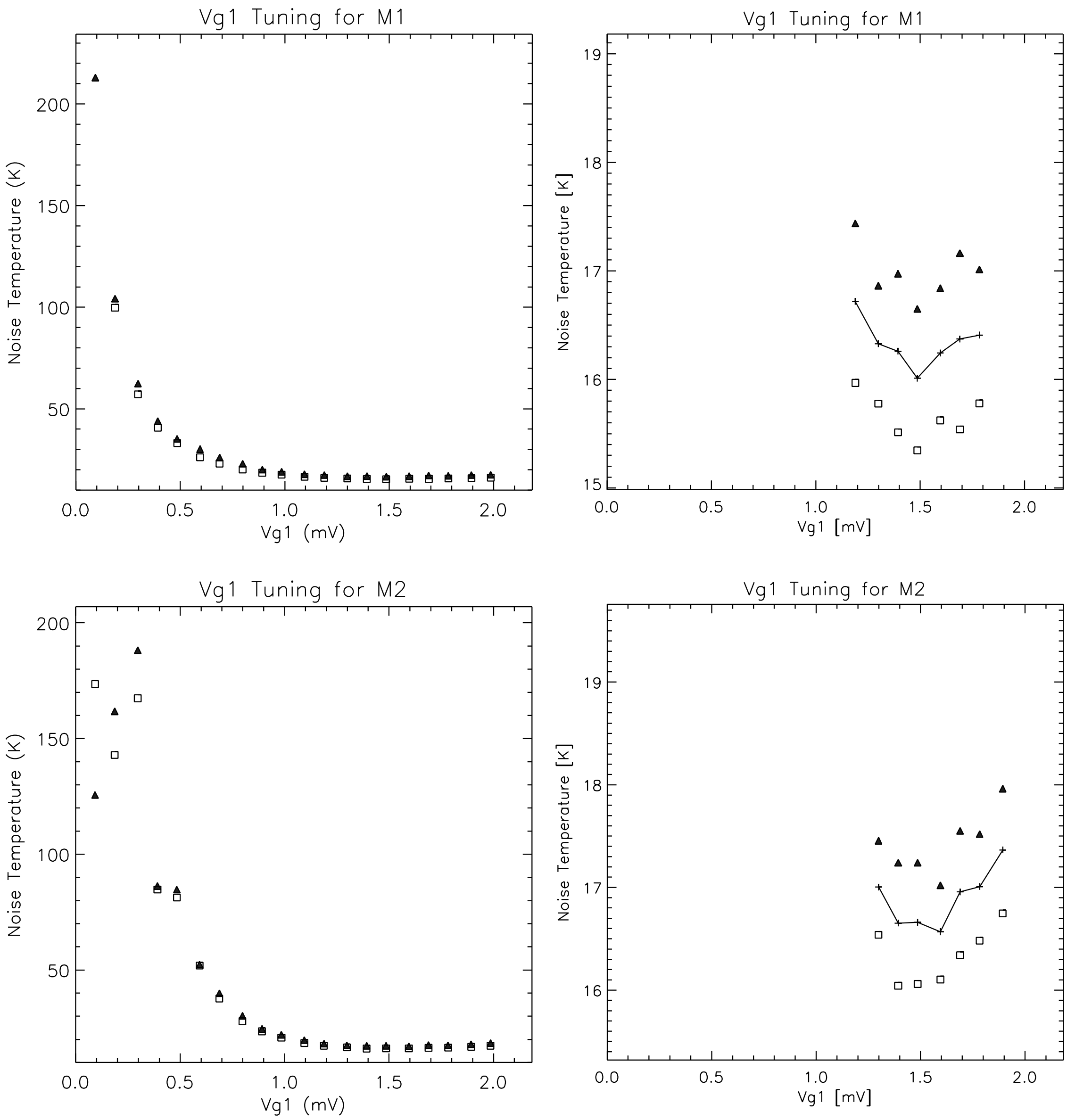


*Figure 5-3: Tuning of the low noise amplifiers on Main arm (M1 and M2). The right panel is the same plot of the left one but with a different Y – scale. Triangles are the noise temperatures calculated on detector A; Square are the noise temperatures calculated on detector B. The line on the plot on the right is the 1/sqrt(2) * sqrt(detA^2+det^B^2).*

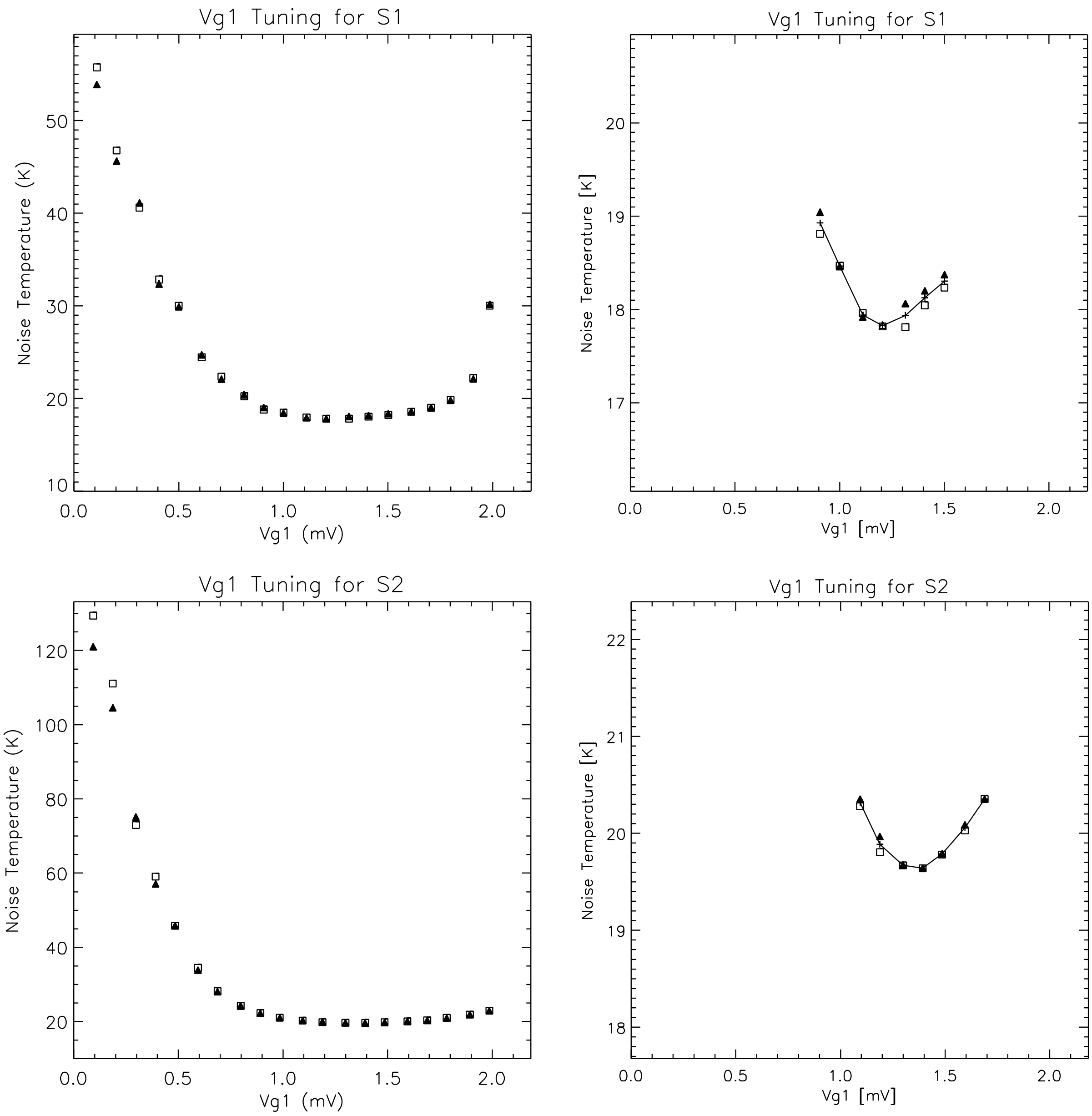


*Figure 5-4: Tuning of the low noise amplifiers on Side arm (S1 and S2). The right panel is the same plot of the left one but with a different Y – scale. Triangles are the noise temperatures calculated on detector A; Square are the noise temperatures calculated on detector B. The line on the plot on the right is the 1/sqrt(2) * sqrt(detC^2+det^D^2).*

Figure -5-5: The four Vg1 tuning curves

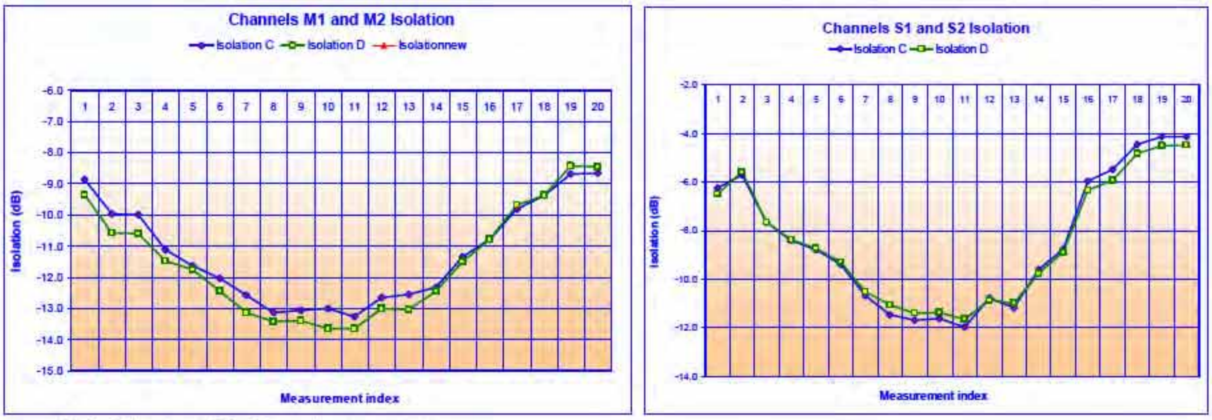


Figure -5-6: The two Vg2 tuning curves

Back End Module offset

BEM offset is determined by recording each detector output when the FEM is off. The values stored are used in data analysis when required. The values are reported in Table -7.

Table -5-5: BEM radiometric offset values.

	BEM offset (Volts)
Detector A	0.0042
Detector B	0.0047
Detector C	0.0047
Detector D	0.0033

BASIC PERFORMANCES

RCA_OFT: Radiometer offset

It is calculated by keeping the reference load temperature and the sky load temperature equal and constant. Then the voltage difference between the sky and load signal is measured.
file considered: `044LFI24_RCA_FM_TNG_200601270237`

Channel	offset (V)	Sigma (V)
Detector A	-0.0008	0.0002
Detector B	-0.0023	0.0003
Detector C	-0.0049	0.0003
Detector D	-0.0037	0.0003

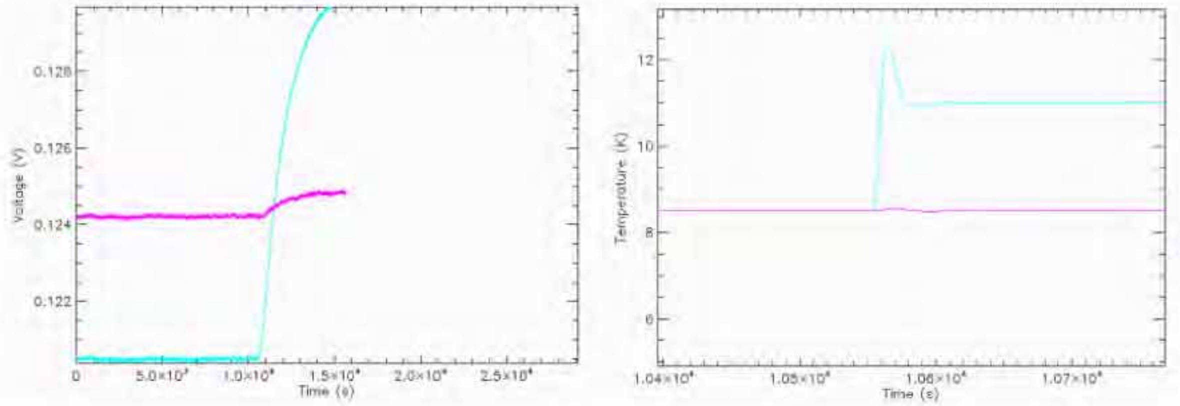


Figure -6-7: ChA data (left), sensor data (right). Changing T: Tsky (Cyan)

While it is possible to calculate the offset by changing the reference temperature in non equilibrium conditions, it is not straightforward to determine the point where the brightness sky temperature is equal to the brightness load temperature from the temperature sensor data.

However, if we consider the signal difference between the channels calculated at the crossing point, this is fairly constant and comparable with the one reported above. This is a confirmation of the robustness of the determination.

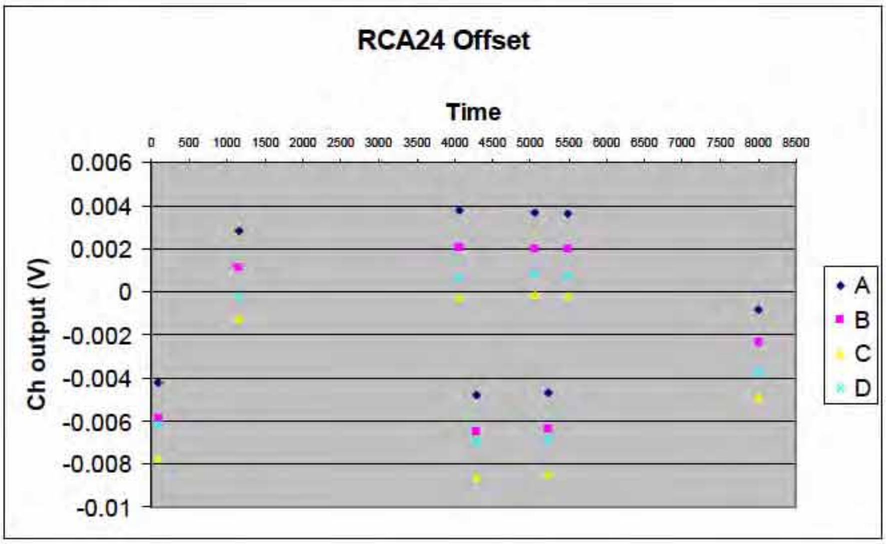


Figure -6-8: offset determination from dynamic non-equilibrium data.

RCA_TNG: Noise temperature and Gain Test Results

The receiver noise temperature has been calculated in two ways:

1. by changing the reference load (REF) temperature keeping the sky load (SKY) temperature fixed, and
2. by changing the sky load temperature keeping the reference load temperature fixed.

Reference load temperature variation

Two different calculations have been performed on the same data set

1. Linear interpolation (Y-factor standard method if only two points are considered);
2. non linear interpolation by fitting a 2[nd] order polynomial either on Vout = f(Tin) and Tin=f(Vout) and then averaging the two values.

The data set taken is the following: `044LFI24_RCA_FM_TNG_200601261757`

In the first data set the REF temperature has been varied from 8.5 Kelvin to 25 Kelvin and the SKY has been set to 8.5 Kelvin.
The REF temperature sequence has been the following: [13.0, 15.0, 22.0, 25.0, 8.5] as seen in Figure -6.

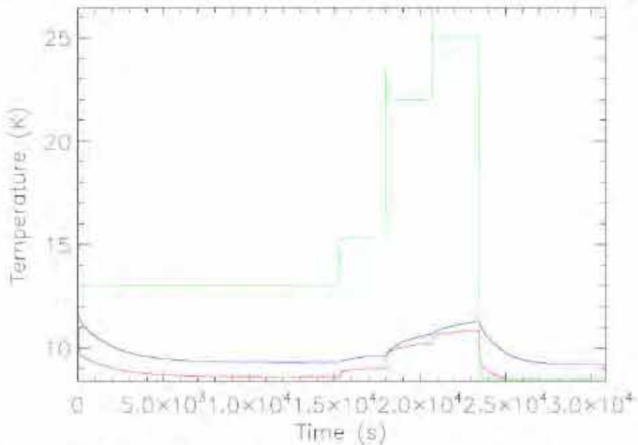


Figure -6-9 Temperature curves for: Reference load (green), Skyload back plate (red), and skyload Eccosorb (blue).

The results are reported here. The error is the fit uncertainty and does not includes any systematic error from measurements, including the error derived from the thermal coupling between the REF and SKY load. As seen from figure Figure -6 the sky load temperature is not constant during the test, resulting in a leakage of SKY temperature variation into the REF signal. This is a small effect since for each step the SKY temperature variation is about 1 K and the isolation is better than 10 dB giving a systematic effect of the order of a small fraction of Kelvin.

Table -6-6: basic performances obtained varying the Reference load temperature and keeping the SKY load temperature constant. The numbers have been obtained using the SKY_TEMP probe as a sky load temperature. For isolation the error has not been calculated. It will be reported in the next update of the document.

	Gain [V/K]	Gain [K/V]	Tnoise [K]	Tnoise [K]	Isolation [dB]

	x 1E-03		*Linear*	*Parabolic*	
DETECTOR A	2.85±0.02	351.9±2.5	23.3±0.2	15.105±0.008	-15.3
DETECTOR B	2.98±0.03	335.6±3.4	20.8±0.2	14.997±0.008	-15.4
DETECTOR C	3.45±0.03	289.9±2.5	26.3±0.2	17.970±0.009	-13.0
DETECTOR D	3.31±0.03	302.1±2.7	27.4±0.3	19.067±0.011	-13.1

The complete RaNA output is reported here (RCA24_TNG_results130206_SKY-txt)

```
INPUT DATA: 044LFI24_RCA_FM_TNG_200601261757
Centre frequency (Hz) =,    4.4000000e+10
Channel: A
Changing signal: Load
BEM offset (v) =,    0.00420000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     8.499994277954 ,     0.089797845014 ,     0.088995517641
 ,    13.000000000000 ,     8.624217987061 ,     0.103908740159 ,     0.089883180045
 ,    15.337013244629 ,     9.010433197021 ,     0.111010450148 ,     0.091106719733
 ,    22.000000000000 ,    10.204465866089 ,     0.129977071779 ,     0.094736261671
 ,    25.000000000000 ,    10.805504798889 ,     0.138059135905 ,     0.097072188678

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002855350562 ,    23.293947760584 ,   -15.263628254357 ,     0.000630106757

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000023220898 ,     0.190411564242 ,    -0.223656649100 ,     0.000361313308

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    15.105353329558 ,     0.008460724069

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -14.256462269368 ,   177.807773320661 ,   716.854305246704

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.004485587875 ,     0.080544394726 ,     0.354370685414

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.064903746566 ,     0.003462039586 ,    -0.000017057809

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
============================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: B
Changing signal: Load
BEM offset (v) =,    0.00470000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     8.499994277954 ,     0.086222577645 ,     0.083943022913
 ,    13.000000000000 ,     8.624217987061 ,     0.100722009769 ,     0.084904635963
 ,    15.337013244629 ,     9.010433197021 ,     0.108069090573 ,     0.086144843642
 ,    22.000000000000 ,    10.204465866089 ,     0.127920401931 ,     0.089825462921
 ,    25.000000000000 ,    10.805504798889 ,     0.136469325488 ,     0.092195413749

OUTPUT
           ******** Linear fit **********

Parameters
```

```
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002984466581 ,    20.831673658213 ,   -15.374882486448 ,     0.000437532387

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000027158818 ,     0.203162514361 ,    -0.281069768302 ,     0.000407218337

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    14.996870690542 ,     0.008079303615

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -14.414870319207 ,   207.508111338046 ,   539.798347765838

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.004538590029 ,     0.083645573655 ,     0.376716015812

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.060840308437 ,     0.003505282548 ,    -0.000014553462

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: C
Changing signal: Load
BEM offset (v) =,    0.00470000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     8.499994277954 ,     0.122470461670 ,     0.117701170901
 ,    13.000000000000 ,     8.624217987061 ,     0.139918609173 ,     0.119148379938
 ,    15.337013244629 ,     9.010433197021 ,     0.148704662269 ,     0.120827452460
 ,    22.000000000000 ,    10.204465866089 ,     0.172246036333 ,     0.125797277016
 ,    25.000000000000 ,    10.805504798889 ,     0.182342326763 ,     0.128976113685

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.003453105330 ,    26.311451364239 ,   -12.991528253092 ,     0.000759649664

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000028573293 ,     0.202957740671 ,    -0.066509571923 ,     0.000447447756

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    17.970475577330 ,     0.009668688084

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -16.329284863047 ,   140.363230477165 ,   441.940603895566

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.006482684144 ,     0.086722826957 ,     0.285049139440

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.092061659397 ,     0.004225913696 ,    -0.000019107275

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: D
Changing signal: Load
BEM offset (v) =,    0.00330000

There are ,           5 , time windows
   ,tmin, tmax
```

```
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     8.499994277954 ,     0.121462377268 ,     0.117835164898
 ,    13.000000000000 ,     8.624217987061 ,     0.138194477771 ,     0.119163042844
 ,    15.337013244629 ,     9.010433197021 ,     0.146644553428 ,     0.120788102728
 ,    22.000000000000 ,    10.204465866089 ,     0.169252443473 ,     0.125588350242
 ,    25.000000000000 ,    10.805504798889 ,     0.179015647399 ,     0.128721692932

OUTPUT
          ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.003315407907 ,    27.372906238421 ,   -13.089139280805 ,     0.000751462630

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000031552691 ,     0.250452140325 ,    -0.097316215754 ,     0.000495711711

          ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    19.067536442548 ,     0.011292558175

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -17.198342835702 ,   146.942403480755 ,   463.595424129938

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.007646229215 ,     0.103680019218 ,     0.345734044967

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.092658026926 ,     0.004002050041 ,    -0.000016597907

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
===============================================================
```

Table -6-7: basic performances obtained varying the Reference load temperature and keeping the SKY load temperature constant. The numbers have been obtained using the SMON_TMP probe as a sky load temperature. For isolation the error has not been calculated. It will be reported in the next update of the document.

	Gain [V/K]	Gain [K/V]	Tnoise [K]	Tnoise [K]	Isolation [dB]
	x 1E-03		*Linear*	*Parabolic*	
DETECTOR A	2.79±0.02	358.4±2.6	23.3±0.2	15.105±0.008	-13.5
DETECTOR B	2.91±0.03	343.6±3.5	20.8±0.2	14.997±0.008	-13.6
DETECTOR C	3.37±0.03	296.7±2.6	26.3±0.2	17.970±0.010	-12.0
DETECTOR D	3.24±0.03	308.6±2.9	27.4±0.3	19.068±0.011	-12.0

The complete RaNA output is attached here (RCA24_TNG_results130206_SMON.txt):

```
INPUT DATA: 044LFI24_RCA_FM_TNG_200601261757
Centre frequency (Hz) =,     4.4000000e+10
Channel: A
Changing signal: Load
BEM offset (v) =,    0.00420000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     9.206043243408 ,     0.089797845014 ,     0.088995517641
 ,    13.000000000000 ,     9.314086914062 ,     0.103908740159 ,     0.089883180045
 ,    15.337013244629 ,     9.623371124268 ,     0.111010450148 ,     0.091106719733
 ,    22.000000000000 ,    10.604500770569 ,     0.129977071779 ,     0.094736261671
 ,    25.000000000000 ,    11.203733444214 ,     0.138059135905 ,     0.097072188678

OUTPUT
          ******** Linear fit **********
```

```
Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002787107164 ,     23.293947760584 ,    -13.541564658362 ,     0.000642465758

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000023524650 ,     0.190411564242 ,    -0.098354377747 ,     0.000359371869

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    15.105353329558 ,     0.008460724069

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -14.256462269368 ,   177.807773320661 ,   716.854305246704

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.004485587875 ,     0.080544394726 ,     0.354370685414

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.064903746566 ,     0.003462039586 ,    -0.000017057809

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: B
Changing signal: Load
BEM offset (v) =,    0.00470000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.499953269958 ,     9.206043243408 ,     0.086222577645 ,     0.083943022913
 ,    13.000000000000 ,     9.314086914062 ,     0.100722009769 ,     0.084904635963
 ,    15.337013244629 ,     9.623371124268 ,     0.108069090573 ,     0.086144843642
 ,    22.000000000000 ,    10.604500770569 ,     0.127920401931 ,     0.089825462921
 ,    25.000000000000 ,    11.203733444214 ,     0.136469325488 ,     0.092195413749

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002913486189 ,     20.831673658213 ,    -13.599316500155 ,     0.000562351711

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000026021004 ,     0.203162514361 ,    -0.119620108874 ,     0.000404508072

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,    14.996870690542 ,     0.008079303615

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -14.414870319207 ,   207.508111338046 ,   539.798347765838

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.004538590029 ,     0.083645573655 ,     0.376716015812

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.060840308437 ,     0.003505282548 ,    -0.000014553462

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: C
Changing signal: Load
BEM offset (v) =,    0.00470000

There are ,           5 , time windows
```

```
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,      8.499953269958 ,     9.206043243408 ,     0.122470461670 ,     0.117701170901
 ,     13.000000000000 ,     9.314086914062 ,     0.139918609173 ,     0.119148379938
 ,     15.337013244629 ,     9.623371124268 ,     0.148704662269 ,     0.120827452460
 ,     22.000000000000 ,    10.604500770569 ,     0.172246036333 ,     0.125797277016
 ,     25.000000000000 ,    11.203733444214 ,     0.182342326763 ,     0.128976113685

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.003370799672 ,    26.311451364239 ,   -11.954777228272 ,     0.000775737207

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.000027722982 ,     0.202957740671 ,    -0.041019985965 ,     0.000445154464

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,     17.970475577330 ,     0.009668688084

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -16.329284863047 ,   140.363230477165 ,   441.940603895566

 ,sigma(a0),sigma(a1),sigma(a2)
 ,      0.006482684144 ,     0.086722826957 ,     0.285049139440

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,      0.092061659397 ,     0.004225913696 ,    -0.000019107275

 ,sigma(a0),sigma(a1),sigma(a2)
 ,      0.000013522504 ,     0.000001666725 ,     0.000000047192
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: D
Changing signal: Load
BEM offset (v) =,    0.00330000

There are ,           5 , time windows
   ,tmin, tmax
 ,   30000.00 ,   30600.00
 ,   14600.00 ,   15200.00
 ,   17400.00 ,   18000.00
 ,   20000.00 ,   20600.00
 ,   22400.00 ,   23000.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,      8.499953269958 ,     9.206043243408 ,     0.121462377268 ,     0.117835164898
 ,     13.000000000000 ,     9.314086914062 ,     0.138194477771 ,     0.119163042844
 ,     15.337013244629 ,     9.623371124268 ,     0.146644553428 ,     0.120788102728
 ,     22.000000000000 ,    10.604500770569 ,     0.169252443473 ,     0.125588350242
 ,     25.000000000000 ,    11.203733444214 ,     0.179015647399 ,     0.128721692932

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.003236361455 ,    27.372906238421 ,   -12.030832965882 ,     0.000767166527

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.000031325075 ,     0.250452140325 ,    -0.059257170899 ,     0.000492676724

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,     19.067536442548 ,     0.011292558175

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -17.198342835702 ,   146.942403480755 ,   463.595424129938

 ,sigma(a0),sigma(a1),sigma(a2)
 ,      0.007646229215 ,     0.103680019218 ,     0.345734044967
```

```
Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.092658026926 ,     0.004002050041 ,    -0.000016597907

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     0.000013522504 ,     0.000001666725 ,     0.000000047192
==========================================================
```

Sky load temperature variation

Two different calculations have been performed on the same data set

3. Linear interpolation (Y-factor standard method if only two points are considered;
4. non linear interpolation by fitting a 2nd order polynomial either on Vout = f(Tin) and Tin=f(Vout) and then averaging the two values.

The data set taken is the following: `044LFI24_RCA_FM_TNG_200601270237`

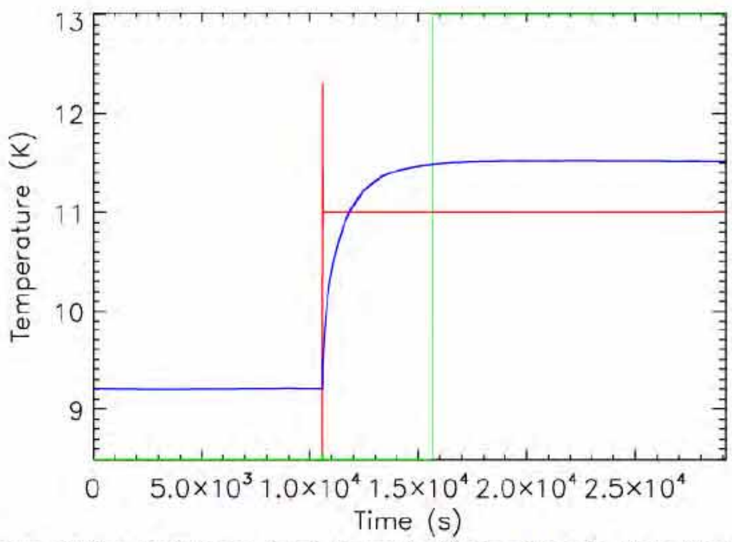


Figure -6-10 Temperature of the Reference load (green), Skyload back plate (red), and of the skyload Eccosorb (blue).

Table -6-8: basic performances obtained varying the sky load temperature (SKY) and keeping the REF load temperature constant. The numbers have been obtained using the SKY_TEMP probe as a sky load temperature. For isolation the error has not been calculated. It will be reported in the next update of the document.

	Gain [V/K]	Gain [K/V]	Tnoise [K]	Tnoise [K]	Isolation [dB]
	x 1E-03		Linear	Parabolic	
DETECTOR A	2.8±0.1	357±13	23±1	N/A	-14
DETECTOR B	2.9±0.2	345±24	21±1	N/A	-15
DETECTOR C	3.5±0.2	286±16	24±1	N/A	-13
DETECTOR D	3.5±0.2	286±16	24±1	N/A	-12

The complete RaNA output is attached here (`RCA24_TNG_results140206_SKY.txt`):

```
FILE SET: 044LFI24_RCA_FM_TNG_200601270237
INPUT
```

```
Centre frequency (Hz) =,    4.4000000e+10
Channel: A
Changing signal: Sky
BEM offset (v) =,    0.00420000

There are ,           2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.500000953674 ,     8.499986648560 ,     0.088943654469 ,     0.089781689384
 ,    11.000000000000 ,     8.499951362610 ,     0.096272602732 ,     0.090048351402

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002836119704 ,    22.745260453537 ,   -14.544450849812 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000134757170 ,     1.050539304214 ,    -2.737244590941 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,                -NaN ,                -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,    -9.542968750000 ,    61.484375000000 ,  1533.250000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  3785.097284748535 , 81872.578332838617 , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.194519042969 ,    -0.019409179688 ,     0.001439571381

 ,sigma(a0),sigma(a1),sigma(a2)
 ,    55.355750749549 ,    12.940564247249 ,     0.740909635950
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: B
Changing signal: Sky
BEM offset (v) =,    0.00470000

There are ,           2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     8.500000953674 ,     8.499986648560 ,     0.083910695171 ,     0.086226398787
 ,    11.000000000000 ,     8.499951362610 ,     0.091238900503 ,     0.086452020489

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.002852302595 ,    21.038141471361 ,   -15.245992266988 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000152768659 ,     1.112057043386 ,                NaN , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,                -NaN ,                -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,    -2.407226562500 ,   -15.437500000000 ,  2298.000000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  5344.701504214297 , ****************** , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.253753662109 ,    -0.034828186035 ,     0.002314567566
```

```
 ,sigma(a0),sigma(a1),sigma(a2)
 ,     55.355750749549 ,     12.940564247249 ,      0.740909635950
============================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: C
Changing signal: Sky
BEM offset (v) =,    0.00470000

There are ,           2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,      8.500000953674 ,      8.499986648560 ,      0.117648577972 ,      0.122467095982
 ,     11.000000000000 ,      8.499951362610 ,      0.126930292168 ,      0.122924557960

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.003543701673 ,     24.088303843365 ,    -13.280546801147 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.000165318458 ,      1.039453715317 ,     -1.004742493796 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,                -NaN ,                -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,    -23.933593750000 ,    342.406250000000 ,    -80.250000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,   5991.999763459447 , 98138.351836192523 , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,      0.222625732422 ,     -0.017471313477 ,      0.001425743103

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     55.355750749549 ,     12.940564247249 ,      0.740909635950
============================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: D
Changing signal: Sky
BEM offset (v) =,    0.00330000

There are ,           2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,      8.500000953674 ,      8.499986648560 ,      0.117800586159 ,      0.121471709547
 ,     11.000000000000 ,      8.499951362610 ,      0.127088868757 ,      0.122076438080

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.003487199177 ,     24.106753265960 ,    -12.136855038002 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.000185407184 ,      1.163647344259 ,     -0.651409921857 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,                -NaN ,                -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,    -11.496093750000 ,     27.687500000000 ,    949.750000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,   7921.942813046962 , ****************** , ******************
```

```
Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,      0.303802490234 ,     -0.036407470703 ,      0.002509593964

 ,sigma(a0),sigma(a1),sigma(a2)
 ,     55.355750749549 ,     12.940564247249 ,      0.740909635950
===========================================================
```

Table -6-9: basic performances obtained varying the sky load temperature (SKY) and keeping the REF load temperature constant. The numbers have been obtained using the SMON_TMP probe as a sky load temperature.

	Gain [V/K]	Gain [K/V]	Tnoise [K]	Tnoise [K]	Isolation [dB]
	x 1E-03		*Linear*	*Parabolic*	
DETECTOR A	3.1±0.1	323±10	19±1	N/A	-14
DETECTOR B	3.1±0.2	323±21	18±1	N/A	-15
DETECTOR C	3.9±0.2	256±13	21±1	N/A	-13
DETECTOR D	3.8±0.2	263±14	21±1	N/A	-12

The complete RaNA output is attached here (RCA24_TNG_results140206_SMON.txt):

```
FILE SET: 044LFI24_RCA_FM_TNG_200601270237
INPUT
Centre frequency (Hz) =,     4.4000000e+10
Channel: A
Changing signal: Sky
BEM offset (v) =,     0.00420000

There are ,            2 , time windows
   ,tmin, tmax
 ,     8000.00 ,   10000.00
 ,    15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,      9.203175544739 ,      8.499986648560 ,      0.088943654469 ,      0.089781689384
 ,     11.476989746094 ,      8.499951362610 ,      0.096272602732 ,      0.090048351402

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.003116813957 ,     19.324793860498 ,    -14.544296064818 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,      0.000148232906 ,      0.957934190731 ,     -2.736853443802 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,                -NaN ,                -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,     -7.663085937500 ,     64.703125000000 ,   1352.687500000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,   3785.097284748535 ,  81872.578332838617 , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,      0.006538391113 ,      0.020982742310 ,     -0.000998497009

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  31250.606600491261 ,   6806.260681446264 ,    365.119008020742
===========================================================

INPUT
Centre frequency (Hz) =,     4.4000000e+10
Channel: B
Changing signal: Sky
BEM offset (v) =,     0.00470000

There are ,            2 , time windows
   ,tmin, tmax
 ,     8000.00 ,   10000.00
 ,    15000.00 ,   15600.00
```

```
 ,Tchange, Tfixed, Vchange, Vfixed
 ,     9.203175544739 ,     8.499986648560 ,     0.083910695171 ,     0.086226398787
 ,    11.476989746094 ,     8.499951362610 ,     0.091238900503 ,     0.086452020489

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.003134598489 ,    17.771418217687 ,   -15.245807297693 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000168021622 ,     1.014360703039 ,                NaN , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,               -NaN ,               -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,    -7.742187500000 ,   155.625000000000 ,  1165.000000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  5344.701504214297 , ****************** , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.034400939941 ,     0.013507843018 ,    -0.000594615936

 ,sigma(a0),sigma(a1),sigma(a2)
 , 31250.606600491261 ,  6806.260681446264 ,   365.119008020742
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: C
Changing signal: Sky
BEM offset (v) =,    0.00470000

There are ,           2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     9.203175544739 ,     8.499986648560 ,     0.117648577972 ,     0.122467095982
 ,    11.476989746094 ,     8.499951362610 ,     0.126930292168 ,     0.122924557960

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.003894426184 ,    20.546883179173 ,   -13.280435438137 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000181855920 ,     0.946607438537 ,    -1.004676975104 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,               -NaN ,               -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -18.355468750000 ,   290.125000000000 ,    50.062500000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  5991.999763459447 , 98138.351836192523 , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.014572143555 ,     0.026607513428 ,    -0.001268625259

 ,sigma(a0),sigma(a1),sigma(a2)
 , 31250.606600491261 ,  6806.260681446264 ,   365.119008020742
===========================================================

INPUT
Centre frequency (Hz) =,    4.4000000e+10
Channel: D
Changing signal: Sky
BEM offset (v) =,    0.00330000
```

```
There are ,            2 , time windows
   ,tmin, tmax
 ,    8000.00 ,   10000.00
 ,   15000.00 ,   15600.00

 ,Tchange, Tfixed, Vchange, Vfixed
 ,     9.203175544739 ,     8.499986648560 ,     0.117800586159 ,     0.121471709547
 ,    11.476989746094 ,     8.499951362610 ,     0.127088868757 ,     0.122076438080

OUTPUT
           ******** Linear fit **********

Parameters
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.003832331566 ,    20.563672374287 ,   -12.136773363234 , -9999.000000000000

Statistical uncertainties
 ,Gain (V/K),Tn (K),Iso. (dB),Lin. coeff
 ,     0.000203921568 ,     1.061537003392 ,    -0.651381349560 , -9999.000000000000

           ******** Parabolic fit **********

Average noise temperature
 ,Tn (k),Sigma (K)
 ,               -NaN ,               -NaN

Temperature versus Voltage parabolic fit parameters
Equation: T = a0 + a1 * V + a2 * V^2
 ,a0,a1,a2
 ,   -11.312500000000 ,    56.187500000000 ,   732.750000000000

 ,sigma(a0),sigma(a1),sigma(a2)
 ,  7921.942813046962 , ****************** , ******************

Voltage versus temperature parabolic fit parameters
Equation: V = a0 + a1 * T + a2 * T^2
 ,a0,a1,a2
 ,     0.044525146484 ,     0.020122528076 ,    -0.000920534134

 ,sigma(a0),sigma(a1),sigma(a2)
 , 31250.606600491261 ,  6806.260681446264 ,   365.119008020742
===========================================================
```

Consistency of the Results

The white noise limit has been calculated and compared with the requirement. The white noise limit is defined at a given SKY temperature as follows:

Eq. 3: $$\Delta T = \sqrt{2}\,\frac{T_{SKY}+T_{SYS}}{\sqrt{B}}\,1000\,\left[mK\sqrt{sec}\right]$$

where B is the bandwidth [Hz], τ is the integration time [sec], T_{SKY} and T_{SYS} are the Skyload antenna temperature [K] and noise system temperature [K] respectively.
From measurements the white noise limit is calculated as follows:

Eq. 4: $$\Delta T = G[K/V]\,\frac{1}{\sqrt{2}}\,WN\,\sqrt{\frac{\tau}{\tau-\tau_{BT}}}$$

where *WN* is the white noise as derived from RaNA, τ is the 122 microSec (1/8KHz) integration time and τ_{BT} is the blanking time (7.5 microSec). G is the gain (K/V) which needs to be know from RCA_TNG tests.

The requirements has been calculated assuming Tsys = 16.60 Kelvin (see [AD 2]), while the white noise limit form measurements has been derived in two way:

1. From the Tsys and B derived from tests applying the Eq. 3. Tsys values were obtained from parabolic values of Table -8 and B were obtained from RCA_SPR test as the average of values reported in **Table -15**.
2. Directly From WN measurements apllying the Eq. 4 where *WN* is the white noise level derived from RaNA FFT module when the detector output is calibrated. Firstly the white noise limit has been derived form *RaNA_FFT* module selecting a stable (200 sec) calibrated acquisition data chunk. The White noise of differenced calibrated[1] detectors has been selected (A–B and C–D). Then the number has been corrected by the Blanking time.

Table -6-10: white noise as derived from measurements and compared with the requirements

	Requirement	From Measured Tsys & B	ratio Over requirement	From Data After calibration	Ratio over requirement	Consistency ratio
	mK*Sqrt(s)	mK*Sqrt(s)		mK*Sqrt(s)		
SKY = 8.5 REF = 8.5						
Detector A-B	0.36313793	0.46475550	1.27983190	0.53157180	1.46382893	1.14376657
Detector C-D		0.48183657	1.32686931	0.55026239	1.51529859	1.14201043
SKY = 20.0 REF = 20.0						
Detector A-B	0.53612862	0.70134971	1.30817435	0.74483493	1.38928402	1.06200219
Detector C-D		0.69443963	1.29528551	0.76755169	1.43165587	1.10528209

Two main considerations can be appointed:

1. from measured values (in both cases) the white noise limit is outside the specifications. See "*ratio over requirement*" column of **Table -12**

2. within 14% for 8.5 Kelvin case, and 10% for the 20.0 Kelvin case, the measured WN is in agreement with the WN calculated form the measured Tsys (TNG) and measured B (SPR). See consistency ratio column of **Table -12**.

RCA_LIS: LINEARITY AND ISOLATION (L TERENZI AND P. BATTAGLIA)

The linearity has been evaluated extensively by changing both the REF and the SKY temperature in several steps.

[1] The calibration has been obtained in the following way:

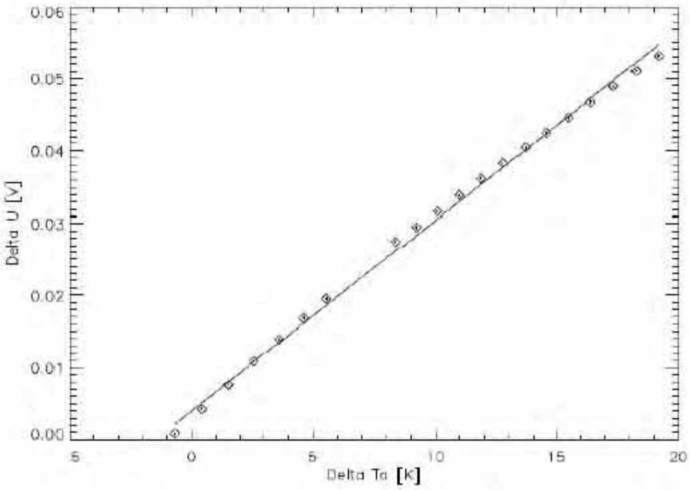


Figure -6-11: Non linearity of the RCA24. Here the detector A output voltage as function of Input temperature (differenced values) is reported. A linear fit is reported also showing that the linear extrapolation to determine the noise temperature is not appropriate.

Figure -8 reports the results of the REF variation data set. It is evident that the linear interpolation does not represent the radiometer behavior. Specifically the analysis has been performed on the following datasets:

sky load temperature steps:
030LFI24_RCA_FM_LIS_200602040408
030LFI24_RCA_FM_LIS_200602041241
030LFI24_RCA_FM_LIS_200602042115
030LFI24_RCA_FM_LIS_200602050548
030LFI24_RCA_FM_LIS_200602051422
030LFI24_RCA_FM_LIS_200602060729

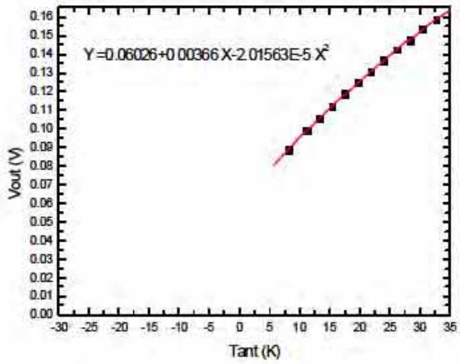
reference load temperature steps are:
044LFI24_RCA_FM_LIS_200601271332
044LFI24_RCA_FM_LIS_200601272211

From these datasets the characteristic curves V output Vs. T input were built for each detector and then a parabolic fit has been performed, as reported in next sections.

The noise temperature is then evaluated as the intersection on the T axis and results are reported in Table -13

Table -6-11: Noise temperature evaluated from parabolic fits

Detector Id	Tn from Sky backplate (K)	Tn from sky absorber (K)	Tn from Ref steps (K)
A	14.08	16.49	17.28
B	14.38	15.74	16.29
C	16.25	18.89	19.55
D	16.73	19.59	20.34



Parabolic fit for Detector A output

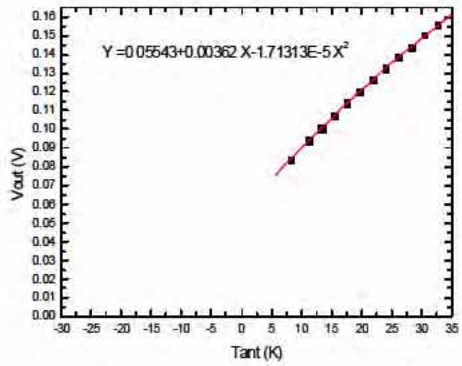
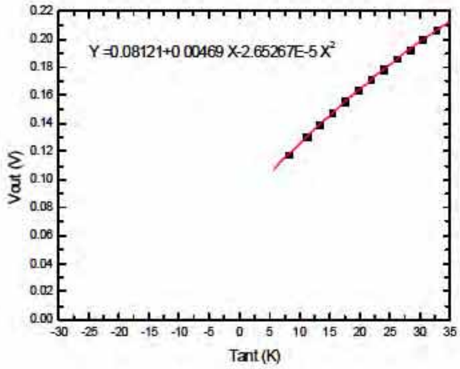
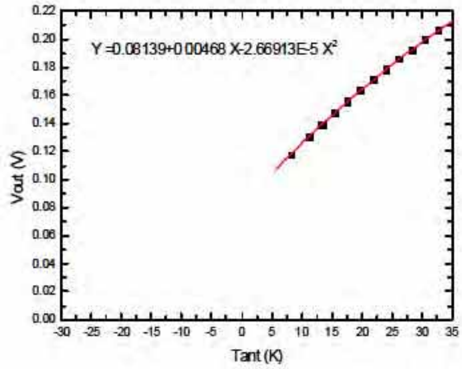


Fig. 1 Parabolic fit for Ch. B output

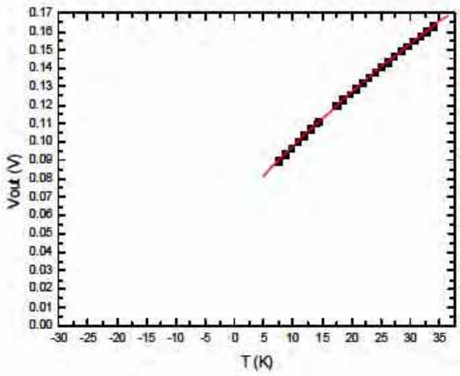


Parabolic fit for Ch. C output



Parabolic fit for Ch. D output

Figure -6-12: Curves Vout as a function of Tin for the four detectors with associated parabolic fit based on the Skyload temperature variation.



Parabolic fit for Detector A output

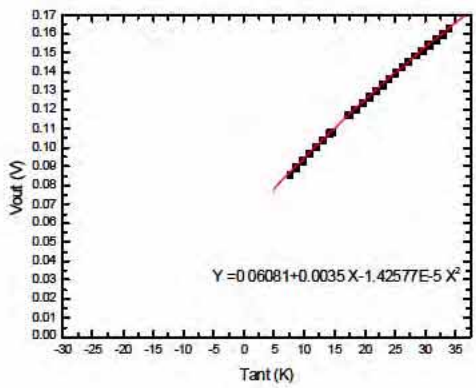
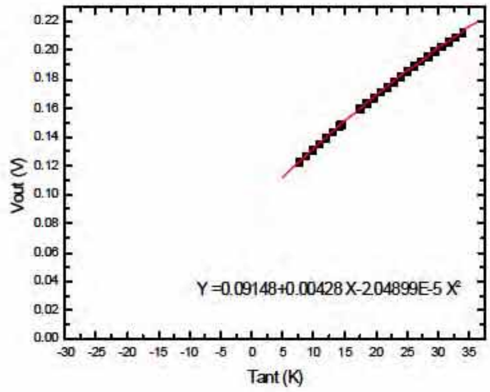
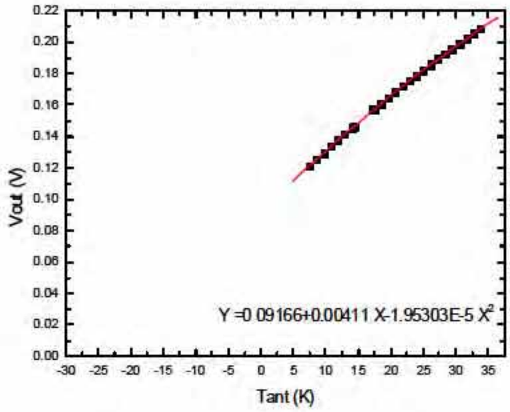


Fig. 2 Parabolic fit for Ch. B output



Parabolic fit for Ch. C output



Parabolic fit for Ch. D output

Figure -6-13: Curves Vout as a function of Tin for the four detectors with associated parabolic fit for Reference load variation.

In figure Figure -11 the comparison between the calibration curve at RCA level and the calibration curve obtained at JBO with the same FEM (4F2) and the "representative" BEM is reported.

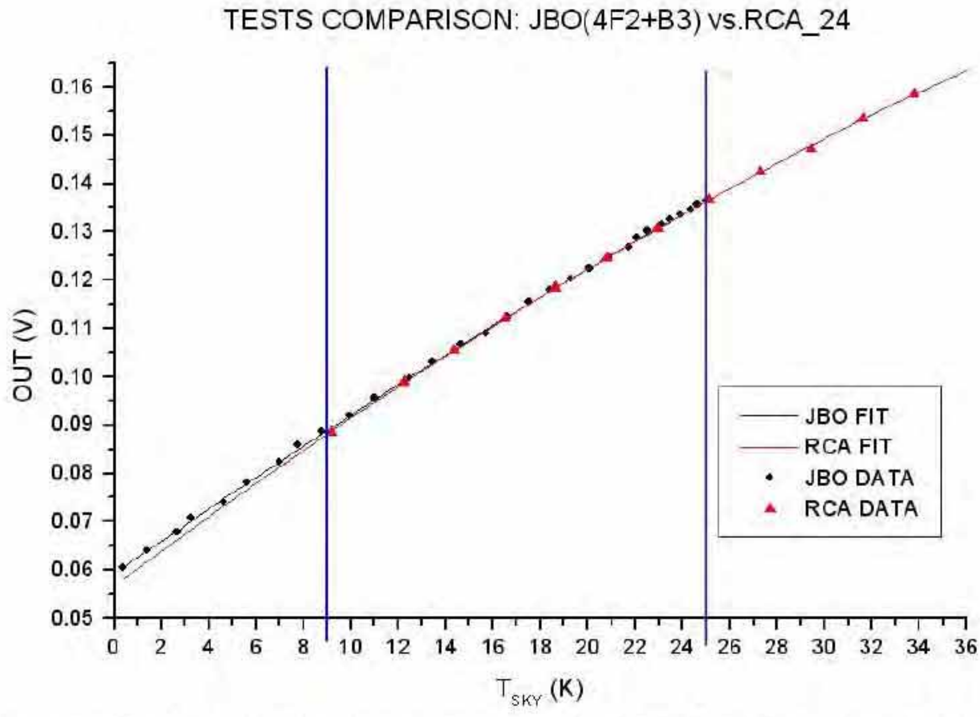


Figure -6-14: Comparison between compression curves obtained at JBO and the curve obtained on the RCA. Abscissa values (T) are physical temperatures.

Here the output of the fit performed on both data set of Figure -11:

```
Polynomial Regression for Data2_RCADATA:
Y = A + B1*X + B2*X^2

Parameter          Value     Error
------------------------------------------------------------
A         0.0566     5.34054E-4
B1        0.00369    5.30013E-5
```

```
B2      -1.99361E-5         1.2079E-6
------------------------------------------------------------
R-Square(COD)    SD        N        P
------------------------------------------------------------
0.99992 2.18497E-4        12       <0.0001
------------------------------------------------------------

JBO

13-03-2006 14:55

Polynomial Regression for Data2_JBOoutRENOR:
Y = A + B1*X + B2*X^2

Parameter         Value     Error
------------------------------------------------------------
A       0.05923   2.38928E-4
B1      0.00344   4.20327E-5
B2      -1.38481E-5         1.52627E-6
------------------------------------------------------------

R-Square(COD)    SD        N        P
------------------------------------------------------------
0.99974 4.08315E-4        30       <0.0001
------------------------------------------------------------
```

Consistency check

As in Chapter 6.2.3 a further check was performed between different methods of evaluating the RCA noise and comparing to the measured white noise.
Actually, combining two detectors, the white noise level is estimated by using Eq. 1 here reported:

Eq. 5: $$WN\,[K\sqrt{s}] = \sqrt{2}\,\frac{T_{SKY}+T_{SYS}}{\sqrt{B}}$$

Considering the measured white noise and taking into account the bandwidth evaluated from the SPR test, we can compare the noise temperature (Tsys) to the ones evaluated from the parabolic fits.
We report in the Table -14 the results of this comparison, taking into account the reference load steps results, which is better sampled.

Table -6-12 Comparison between noise temperature evaluated from white noise level and from parabolic fit.

Channel Id	Tn from WN (@ 9 K)	Tn from WN (@ 20 K)	Tn from Ref steps (K)
A	17.94	17.11	17.28
B			16.29
C	21.21	22.64	19.55
D			20.34

RCA_SPR: Bandpass measurement

The RCA_SPR was performed several times with two different measurement setup. Here we report on the tests performed on 08 February 2006 with the ESA equipment and coax – waveguide WR22 transition of INAF / IRA – Bologna.
The following equipment has been used:

- Sweeper: AGILENT Model HP83650B, Synthesized sweeper generator, 10 MHz-50 GHz, output coaxial connector: 2.4 mm, s/n 3844A00889 Option 001 [2]
- WR22 to Coax Transition: HPU281A S/N 00271 PC2.4 Female [3]
- Cable Gore PC24 M–F [4]

[2] Thanks to ESA – ESTEC
[3] Thanks to Segio Mariotti INAF/IRA - Bologna
[4] Thanks to ESA – ESTEC

Typical data steam is showed hereafter:

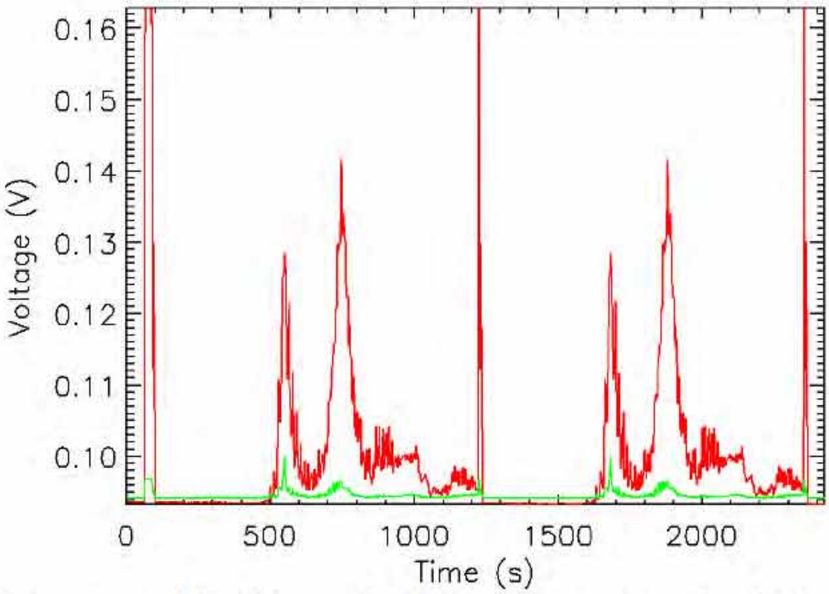


Figure -6-15: typical data steam of the SPR test. The highest peaks are due to the trigger sequence. Here two complete scanning are visible.

Test has been performed at different power level to control the dependence of the bandwidth with the input power. Data were selected with a BIN = 10, i.e with sampling frequency of 409,6 Hz.

Hereafter the data set used for the analysis.

Data set	Trigger sequence [dB] to Power level	Fmin [GHz]	Fmax [GHz]	Step [GHz]	Power level [dBm]
044LFI24 RCA FM SPR 200602081222	[+6,0,+3,0]@43GHz	33.0	50.0	0.05	-28
044LFI24 RCA FM SPR 200602081308	[+6,0,+3,0]@43GHz	33.0	50.0	0.05	-31
044LFI24 RCA FM SPR 200602081426	[+6,0,+3,0]@43GHz	33.0	50.0	0.05	-25
044LFI24 RCA FM SPR 200602081509	[+6,0,+3,0]@43GHz	33.0	50.0	0.05	-34

Table -6-13: Bandwidth and centre frequencies as calculated from RCA_SPR tests at different input power levels.

	Power level	-34 dBm	-31 dBm	-28 dBm	-25 dBm
DETECTOR A	Centre frequency [GHz]	45,8	45,75	45,75	45,70
	Bandwidth [GHz]	5,18	5,15	5,21	5,48
DETECTOR B	Centre frequency [GHz]	42,7	42,4	42,60	42,40
	Bandwidth [GHz]	4,11	4,08	4,11	4,31
DETECTOR C	Centre frequency [GHz]	44,95	45,3	44,90	44,90
	Bandwidth [GHz]	5,84	5,82	5,85	6,06
DETECTOR D	Centre frequency [GHz]	45,8	45,6	45,60	45,60
	Bandwidth [GHz]	5,31	5,26	5,24	5,46

The RaNA report is attached in [ANNEX 2]

NOISE PROPERTIES

RCA_STn: Noise Properties whit Blanking time at 7.5 uSec

Long acquisition time has been performed with the aim to derive noise spectra.
The complete data set of the RCA_STn test with 7.5 uSec Blanking time is composed by the following files:
044LFI24_RCA_FM_ST3_200601311934
044LFI24_RCA_FM_ST3_200602010411
the temperature step sequence is reported in Table -16

Table -7-1: Reference Temperature steps for Noise properties test (STn) with blanking time set at 7.5 uSec

SKY Temperature	REF Temperature	Duration
8.5 K	8.5 K	3 hours
8.5 K	15.0 K	3 hours
8.5 K	20.0 K	3 hours
20.0 K	20.0 K	> 3 hours

For RaNA analysis report see [ANNEX 3]

One–Over–F Noise

A fourier transform has been applied on data to obtain the 1/f knee frequency and noise properties. For 1/f knee calculation data were selected with a BIN = 100 which correspond to a sampling frequency of 40.96 Hz.

The following data set have been used:

8.5 / 8.5 Selected from 6000 – 9600 sec, bin 100 for FFT and 1/f from file
044LFI24_RCA_FM_ST3_200601311934
8.5 / 15.0 Selected from 18000 – 21600 sec, bin 100 for FFT and 1/f from file
044LFI24_RCA_FM_ST3_200601311934
8.5 / 20.0 Selected from 27000 – 30600 sec , bin 100 for FFT and 1/f from file
044LFI24_RCA_FM_ST3_200601311934
8.5 / 20.0 Selected from 0 – 2300 sec, bin 100 for FFT and 1/f from file
044LFI24_RCA_FM_ST3_200602010411
20.0 / 20.0 Selected from 17000– 20600 sec, bin 100 for FFT and 1/f from file
044LFI24_RCA_FM_ST3_20060201041

1/f noise characteristics are obtained with a low frequency fit performed in RaNA on the first 100 points.

T sky = 8.5 K T ref = 8.5 K	Detector A	Detector B	Detector C	Detector D
N points	100	100	100	100
1/f knee frequency	0.019151267	0.015103840	0.013183459	0.013582492
R factor	0.99093361	0.97444466	0.96211290	0.97053342
1/f Slope	-0.82010482	-0.65829013	-1.0709042	-0.64832215

T sky = 8.5 K T ref = 15.0 K	Detector A	Detector B	Detector C	Detector D
N points	100	100	100	100
1/f knee frequency	0.051340815	0.047499838	0.074341964	0.043245239
R factor	0.83562430	0.81408551	0.82611294	0.83541596

1/f Slope	-1.4042004	-1.1985528	-1.1274810	-1.6001614

T sky = 8.5 K T ref = 20.0 K	Detector A	Detector B	Detector C	Detector D
N points	100	100	100	100
1/f knee frequency	0.081967980	0.11770954	0.12823660	0.12559542
R factor	0.77027375	0.74650903	0.76796442	0.77756538
1/f Slope	-0.75416777	-1.0130608	-0.96450069	-0.85185084

T sky = 8.5 K T ref = 20.0 K	Detector A	Detector B	Detector C	Detector D
N points	100	100	100	100
1/f knee frequency	0.044086995	0.22504667	0.11904563	0.073183471
R factor	0.76939549	0.74560601	0.76714197	0.77673272
1/f Slope	-1.3220033	-0.64327066	-1.0465040	-1.0364742

T sky = 20.0 K T ref = 20.0 K	Detector A	Detector B	Detector C	Detector D
N points	100	100	100	100
1/f knee frequency	0.0309392	0.023263408	0.0299469	0.0112632
R factor	0.98784370	0.97164433	0.97432299	0.98477319
1/f Slope	-1.14133	-0.92104277	-0.494557	-0.960773

In the following table the 1/f characteristics obtained by an optimized fitting is reported. The numbers of point used for the low frequency fit is reported for each detector. As expected the 1/f slope is higher than the previous case on the same data set. In this case BIN = 10 is used so that the sampling frequency is `fsampl=409.600 Hz`.

T sky = 8.5 K T ref = 8.5 K	Detector A	Detector B	Detector C	Detector D
N points	32	40	50	48
1/f knee frequency	0.013858681	0.010152675	0.013311407	0.0097304887
R factor	0.99093361	0.97444466	0.96211290	0.97053342
1/f Slope	-1.1343570	-1.2556144	-1.1768240	-1.1469410

T sky = 8.5 K T ref = 15 K	Detector A	Detector B	Detector C	Detector D
N points	40	20	27	22
1/f knee frequency	0.032347724	0.018819524	0.024777906	0.019364033
R factor	0.83562430	0.81408551	0.82611294	0.83541596
1/f Slope	-1.1641802	-1.2654416	-1.2730909	-1.3858901

T sky = 8.5 K T ref = 20 K	Detector A	Detector B	Detector C	Detector D
N points	40	40	13	20
1/f knee frequency	0.032725138	0.031172324	0.025288716	0.029122881
R factor	0.76939549	0.74560601	0.76714197	0.77673272
1/f Slope	-1.5389077	-1.3639073	-1.5650727	-1.4914354

T sky = 20 K T ref = 20 K	Detector A	Detector B	Detector C	Detector D
N points	23	22	17	57
1/f knee frequency	0.022884615	0.015451202	0.0086230259	0.0095582080
R factor	0.98784370	0.97164434	0.97432299	0.98477319
1/f Slope	-1.3587311	-1.3821912	-1.2737109	-1.3518250

White Noise Level and Equivalent Bandwidth

The white noise level has been calculated with the *RaNA_FFT* module using the high frequency part of the amplitude spectrum. From the white noise limit the equivalent bandwidth has been derived. Same data stream as the 1/f calculation has been used. Data were not binned and 5 minutes have been taken for each reference temperature step. For each step the last 300 seconds of the data taken for 1/f noise have been taken for this analysis.

T sky = 8.5 K T ref = 8.5 K	White noise level [V/Sqrt(Hz)]			Effective bandwidth [GHz]		
	Sky	*Load*	*Diff*	*Sky*	*Load*	*Diff*
DETECTOR A	2.3911097E-6	2.3825331E-6	3.3686713E-6	6.05	6.21	6.10
DETECTOR B	2.7307620E-6	2.7863794E-6	3.8515952E-6	4.20	4.25	4.22
DETECTOR C	2.9333096E-6	3.0500096E-6	4.1389373E-6	6.95	6.95	6.98
DETECTOR D	3.2796545E-6	3.3973353E-6	4.6375054E-6	5.45	5.39	5.45

A check of the white noise level and of the bandwidth has been obtained "on the fly" from the data set: `030LFI24_RCA_FM_LIS_200602060729.` Data were selected from 9000 sec to 9120 sec. The SKY and the REF temperatures were controlled at 8.5 Kelvin.

T sky = 8.5 K T ref = 8.5 K	White noise level [V/Sqrt(Hz)]			Effective bandwidth [Ghz]		
	Sky	*Load*	*Diff*	*Sky*	*Load*	*Diff*
DETECTOR A	2.3953849E-6	2.3938020E-6	3.3596808E-6	6.03	6.15	6.13
DETECTOR B	2.7420499E-6	2.7910231E-6	3.9060745E-6	4.18	4.25	4.12
DETECTOR C	2.9517504E-6	3.0926208E-6	4.2750416E-6	6.91	6.80	6.59
DETECTOR D	3.2923426E-6	3.4269758E-6	4.7556956E-6	5.43	5.33	5.21

T sky = 8.5 K T ref = 15.0 K	White noise level [V/Sqrt(Hz)]			Effective bandwidth [GHz]		
	Sky	*Load*	*Diff*	*Sky*	*Load*	*Diff*
DETECTOR A	2.4286140E-6	2.7754576E-6	3.3573049E-6	6.17	6.77	6.46
DETECTOR B	2.7696234E-6	3.2110502E-6	3.8014634E-6	4.31	4.84	4.58
DETECTOR C	2.9610358E-6	3.4613976E-6	4.1154848E-6	7.21	7.73	7.47
DETECTOR D	3.3133110E-6	3.8931049E-6	5.1013099E-6	5.63	5.84	4.75

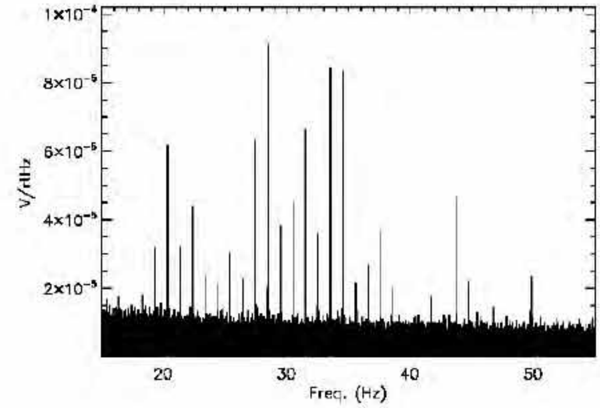
T sky = 8.5 K T ref = 20.0 K	White noise level [V/Sqrt(Hz)]			Effective bandwidth [GHz]		
	Sky	*Load*	*Diff*	*Sky*	*Load*	*Diff*
DETECTOR A	2.4549107E-6	2.9964741E-6	3.3605925E-6	6.52	7.37	6.96
DETECTOR B	2.8457061E-6	3.5172037E-6	3.8789901E-6	4.43	5.20	4.77
DETECTOR C	3.0639142E-6	3.7820030E-6	4.2176562E-6	7.29	8.11	7.69
DETECTOR D	3.4174493E-6	4.2344567E-6	4.7312778E-6	5.72	6.16	5.97

T sky = 20.0 K T ref = 20.0 K	White noise level [V/Sqrt(Hz)]			Effective bandwidth [GHz]		
	Sky	*Load*	*Diff*	*Sky*	*Load*	*Diff*
DETECTOR A	2.8802763E-6	3.0187845E-6	4.1354894E-6	7.95	7.41	7.71
DETECTOR B	3.4334850E-6	3.5380203E-6	4.8585270E-6	5.25	5.23	5.25
DETECTOR C	3.7202974E-6	3.8010036E-6	5.2385262E-6	8.14	8.21	8.21
DETECTOR D	5.2385262E-6	4.2887443E-6	5.9514633E-6	6.27	6.19	6.24

Spikes

Presence of spikes has been investigated on the same data streams selected for the 1/f performances (ST3 data files, 7.5 microsec blanking time).

Spikes are present on the spectrum in the range 15 – 50 Hz in all the detectors but only on the " load " output signal. The frequency separation between spikes is 1 Hz at all sky temperatures except at the 20K / 20K acquisition for which the separation is 2 Hz. Spectra of the Sky signal show only the 50 Hz. See detail of the analysis in [ANNEX 3]



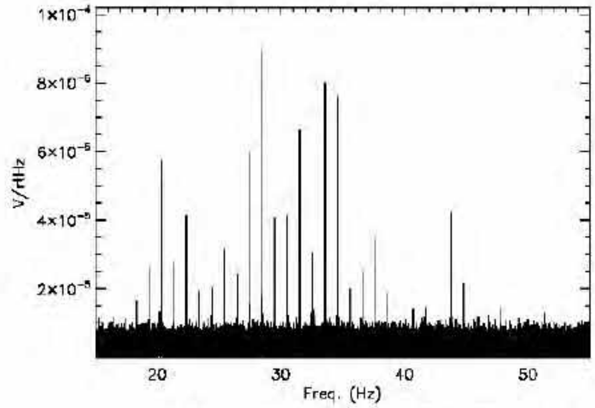


Figure -7-1: **Channel A (T_{sky} = T_{load}= 8.5). Left: Sky. Right: Sky – r Load.**

RCA_STN: NOISE PROPERTIES WHIT BLANKING TIME AT 22.5 USEC

Long acquisition time has been performed with the aim to derive noise spectra. The complete data set of the RCA_STn test with 22.5 uSec of Blanking time is composed by the following files:
`044LFI24_RCA_FM_ST3_200602021916`
`044LFI24_RCA_FM_ST3_200602020353`
The temperature step sequence is reported in Table -17

Table -7-2: Reference Temperature steps for Noise properties test (STn) with blanking time set at 22.5 uSec

SKY Temperature	REF Temperature	Duration
8.5 K	8.5 K	3 hours
8.5 K	15.0 K	3 hours
8.5 K	20.0 K	> 3 hours

For detailed RaNA analysis report see [ANNEX 4]

One–Over–F Noise

A fourier transform has been applied on data to obtain the 1/f knee frequency and noise properties. For 1/f knee calculation data were selected with a BIN = 100 which correspond to a sampling frequency of 40.96 Hz. The following data set have been used:

8.5 / 8.5 Selected from 6000 – 9600 sec, bin 10 for FFT and 1/f from file
044LFI24 RCA FM ST3 200602021916
8.5 / 15.0 Selected from 18000 – 21600 sec, bin 10 for FFT and 1/f from file
044LFI24 RCA FM ST3 200602021916
8.5 / 20.0 Selected from 27000 – 30600 sec , bin 10 for FFT and 1/f from file
044LFI24 RCA FM ST3 200602021916
8.5 / 20.0 Selected from 27000 – 30600 sec , bin 10 for FFT and 1/f from file
044LFI24 RCA FM ST3 200602020353

Sky and Ref signals are swapped in the AUX and DAT fits files.

Values reported in the following tables are derived from the 044LFI24_RCA_FM_ST3_200602021916 data set.

T sky = 8.5 K T ref = 8.5 K	Detector A	Detector B	Detector C	Detector D
N points	35	36	37	37
1/f knee frequency	0.014546620	0.013976986	0.012954546	0.012362468
R factor	0.98498239	0.98396320	0.97615648	0.96442687
1/f Slope	-1.2292430	-1.1917645	-1.1061443	-1.0505744

T sky = 8.5 K T ref = 15 K	Detector A	Detector B	Detector C	Detector D
N points	40	21	28	31
1/f knee frequency	0.017352801	0.022514440	0.027794254	0.027824288
R factor	0.84255040	0.83257348	0.84993677	0.84100600
1/f Slope	-1.3963167	-1.1624808	-1.1410641	-1.2448988

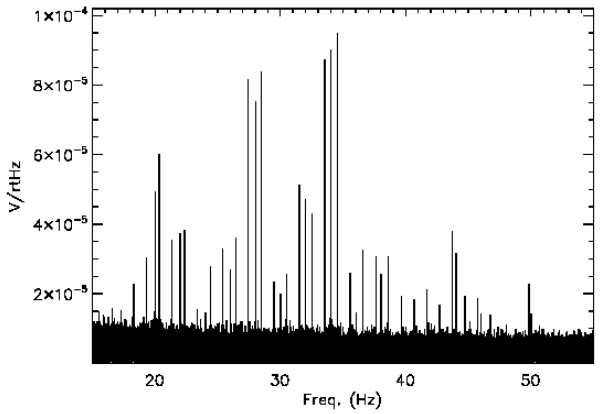
T sky = 8.5 K T ref = 20 K	Detector A	Detector B	Detector C	Detector D
N points	50	30	15	27
1/f knee frequency	0.028481395	0.035835074	0.015964216	0.040063351
R factor	0.77869597	0.76436391	0.79211657	0.78467622
1/f Slope	-1.4187067	-1.5674627	-1.6651125	-1.2935414

White Noise Level and Equivalent Bandwidth

Under analysis. To be written for next revision of the document.

Spikes

Spikes are presents also with blanking time equal to 22.5 microsec. They are thicker and slightly higher. In the third step of the 044LFI24_RCA_FM_ST3_200602021916 data set no spike appear. This is quite strange because in 044LFI24_RCA_FM_ST3_200602020353, that has been carried out in the same condition of the previous one, spikes are well evident. Different time interval have been selected on both data sets in order to investigate this issue, but the conclusion seem the same. Details of the analysis are reported in [ANNEX 4].



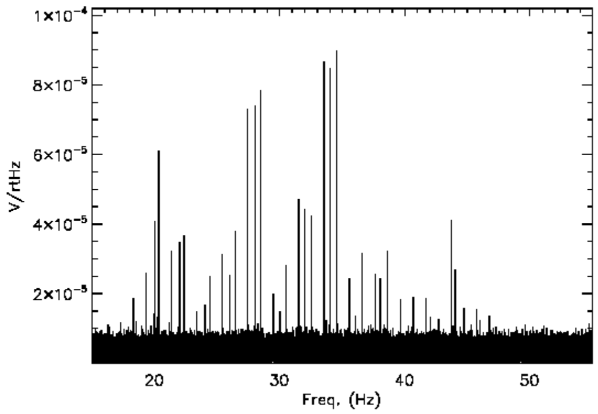


Figure -7-2: Channel A (Tsky = Tload= 8.5). Left: Sky. Right: Sky – r Load.

RCA_UNC: UNCHOPPED DATA

Noise properties have been derived also from unchopped data, i.e. with all the phase switches off.
Data stream are
044LFI24_RCA_FM_UNC_200602011731
044LFI24_RCA_FM_UNC_200602020242
TBW.

Spikes are still present also in the unchopped data (see [ANNEX 5] for details).

SUSCEPTIBILITY TESTS

Any thermal and electrical variation on the RCA subsystem units produces an variation of the output signal from each of the four detector. To quantify this the following tests have been performed: RCA_THF, RCA_THV and RCA_THB. Data analysis has been performed considering the RCA working in linear conditions.

RCA_THF: Susceptibility to FEM temperature variations

The test has been performed by varying the temperature of the FEM keeping constant the temperatures of the other thermal interfaces.
The temperature of the FEM has been set to 20K (nominal), 22K, 24K, and 27K as seen in Figure -15

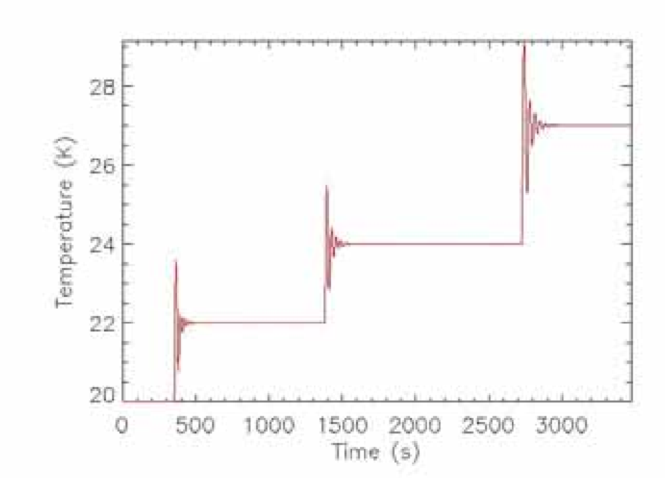


Figure -8-1: FEM temperature step during the RCA_THF test

The temperature behaviour of the other thermal interfaces are reported in the next figures (Figure -16) showing the sky and reference load temperatures, and the BEM temperature.

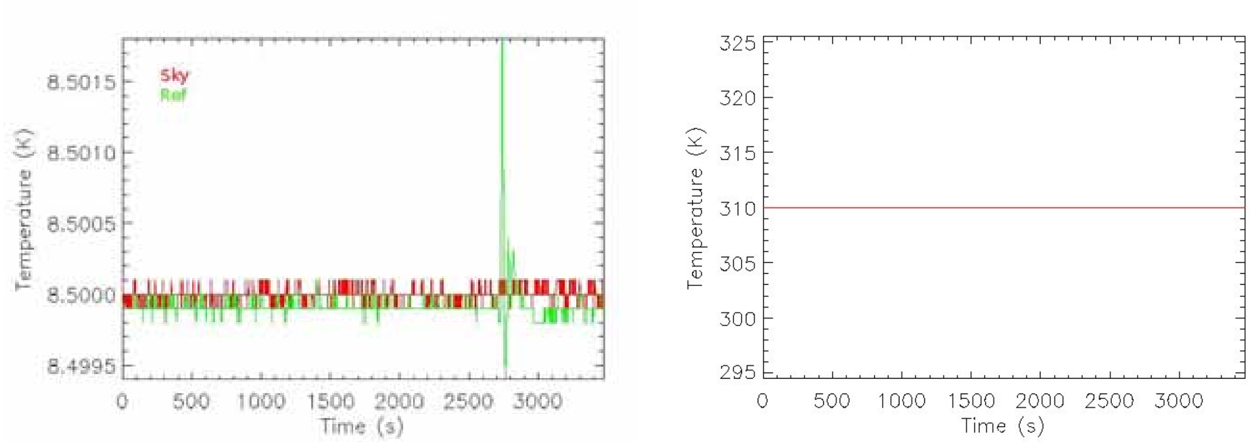


Figure -8-2: Left – Sky Load (red) and Reference Load (green) temperature behaviour during the RCA_THF test; right – BEM temperature behaviour during the RCA_THF test
To do the analysis, the radiometric output for each channel in the three steps was recorded. We can see the output of the channels in the figures below, after calibration:

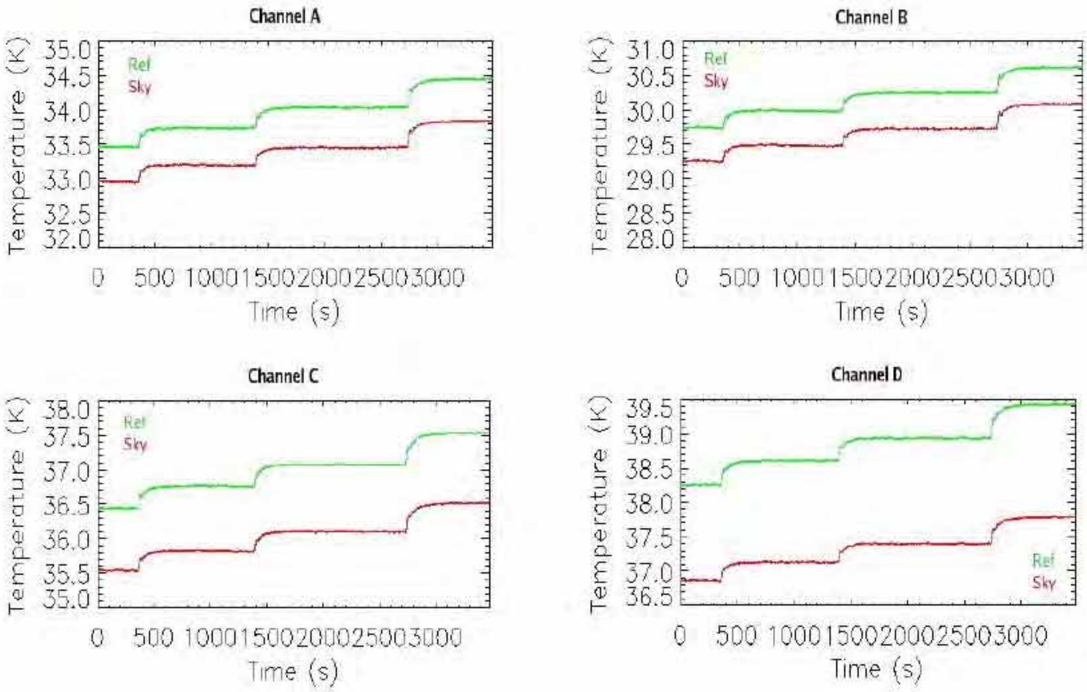


Figure -8-3: Radiometric output of the 4 detectors during the RCA_THF test

The default parameters for the four channels are:

Table -8-1: Default input parameters for RCA_THF analysis

	Ch. A	Ch. B	Ch. C	Ch. D
Freq (*GHz*)	44			
$L_{feed-OMT}$ (*dB*)	0.1			
L_{4k} (*dB*)	0.1			
r	0.98505937	0.98372304	0.97526107	0.96364971
T_{sky} (*K*)	8.5			
T_{ref} (*K*)	8.4999			
G^{dB}_{F1} (*dB*)	35			
G^{dB}_{F2} (*dB*)	35			
T_{nF1} (*K*)	18	18	20	20
T_{nF2} (*K*)	18	18	20	20
$\partial G^{dB}_{F1}/\partial T^{FE}_{phys}$ (*dB/K*)	-0.05	-0.05	-0.05	-0.05
$\partial G^{dB}_{F2}/\partial T^{FE}_{phys}$ (*dB/K*)	-0.05	-0.05	-0.05	-0.05
$\partial T_{nF1}/\partial T^{FE}_{phys}$ (*K/K*)	0.08	0.08	0.08	0.08
$\partial T_{nF2}/\partial T^{FE}_{phys}$ (*K/K*)	0.08	0.08	0.08	0.08
Gain Calibration Factor (*V/K*)	0.00281052	0.00296853	0.00339661	0.00325405

Calculating the theoretical and the measured transfer functions with RaNA, we obtain:

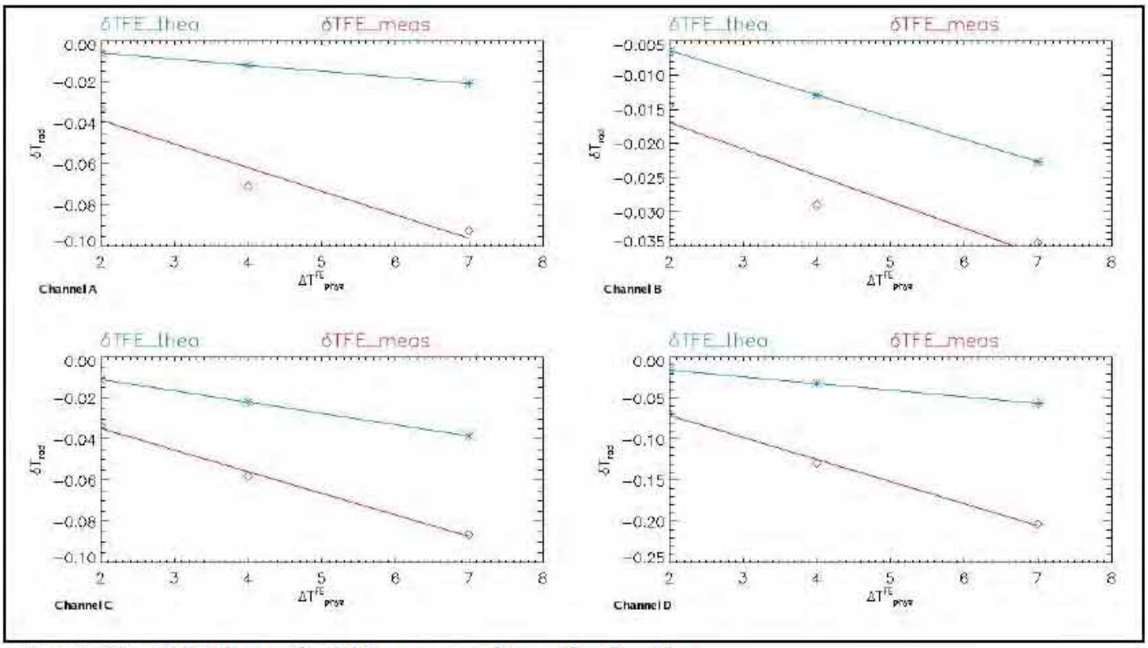


Figure -8-4: RCA_THF theoretical Vs measured transfer function

Table -8-2: RCA_THF Analysis Result based on default parameters

	Channel A	Channel B	Channel C	Channel D
$f_{therm}^{front-end}$ (K/K) theoretical	-0.002965	-0.00323	-0.005493	-0.00807
$f_{therm}^{front-end}$ (K/K) measured	-0.011477	-0.00385	-0.01052	-0.02685

To improve the results obtained with the default parameters, I am going to change any of them. In particular, I change the $\partial G_{FE}^{dB} / \partial T_{phys}^{FE}$ and $\partial T_{nFE} / \partial T_{phys}^{FE}$. The best values will be:

Table -8-3: Optimized parameters of RCA_THF test

	Ch. A	Ch. B	Ch. C	Ch. D
$\partial G_{F1}^{dB} / \partial T_{phys}^{FE}$ (dB/K)	-0.131	-0.054	-0.08	-0.12
$\partial G_{F2}^{dB} / \partial T_{phys}^{FE}$ (dB/K)	-0.131	-0.054	-0.08	-0.12
$\partial T_{nF1} / \partial T_{phys}^{FE}$ (K/K)	0.03	0.067	0.075	0.03
$\partial T_{nF2} / \partial T_{phys}^{FE}$ (K/K)	0.03	0.067	0.075	0.03

and calculating the transfer functions, the new results:

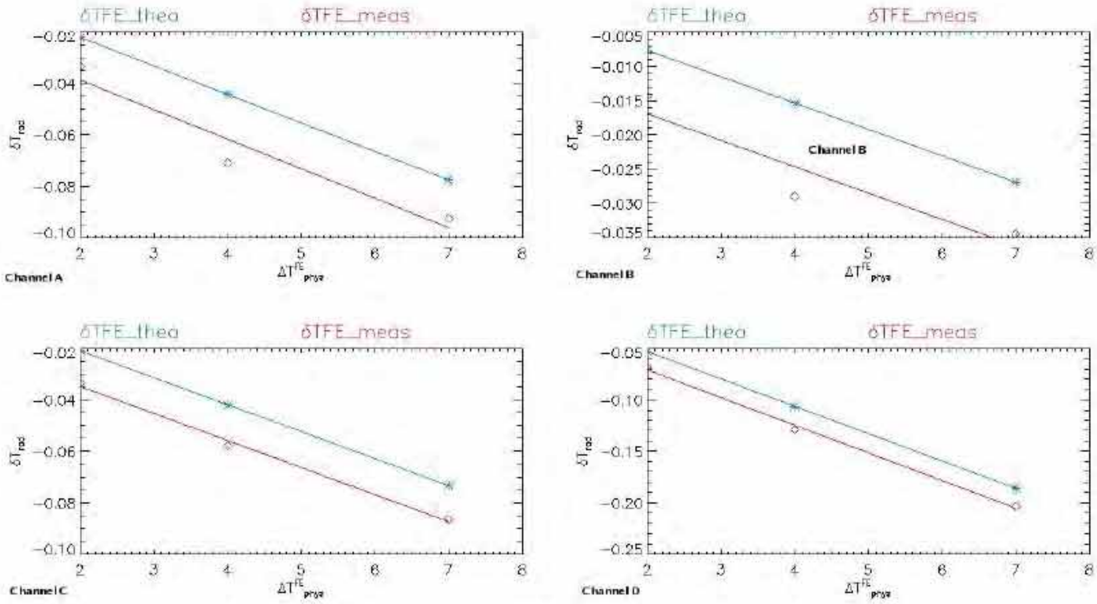


Figure -8-5: RCA_THF theoretical Vs measured transfer function after optimisation of the parameters.

Table -8-4: RCA_THF Optimal transfer function Vs. theoretical

	Channel A	Channel B	Channel C	Channel D
$f_{therm}^{front-end}$ (K/K) theoretical	-0.01108	-0.00384	-0.01048	-0.02658
$f_{therm}^{front-end}$ (K/K) measured	-0.011477	-0.00385	-0.01052	-0.02685

RCA_THV: Susceptibility to V-Groove Temperature variations

The test consists in three steps in the T_{vg3}(the coldest): 62, 64, 60.75 K respectively. The following graphics show the T_{vg3} temperature sensor measurements.

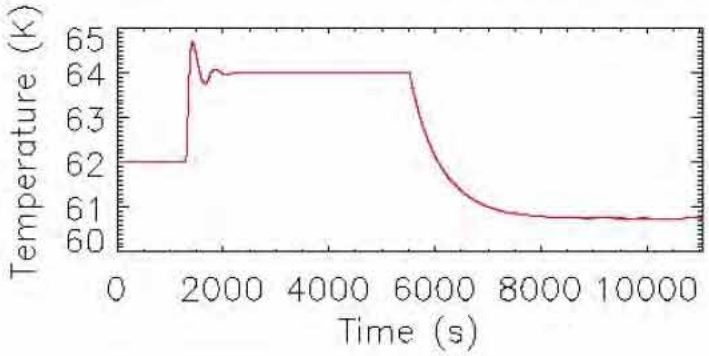


Figure -8-6: VG3 temperature variation during the RCA_THV test.

Sky load and reference load were stabilized during the test so that only VG3 temperature where varied. The T_{sky} and T_{ref} behavior during the test is reported in Figure -21

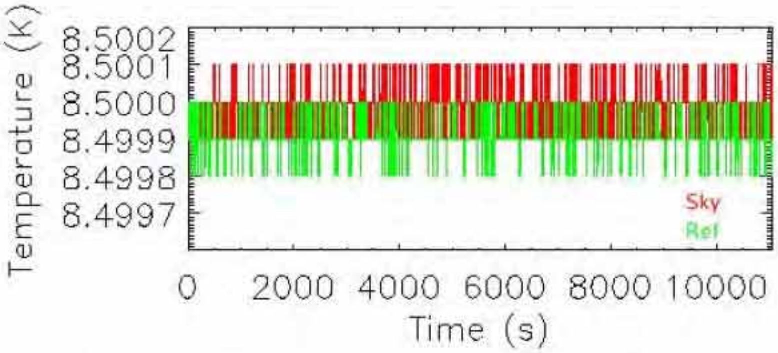


Figure -8-7: Sky Load and Reference Load temperature behaviour during the RCA_THV test.
Also the FEM and BEM temperatures were controlled during the test. They are reported in Figure -22

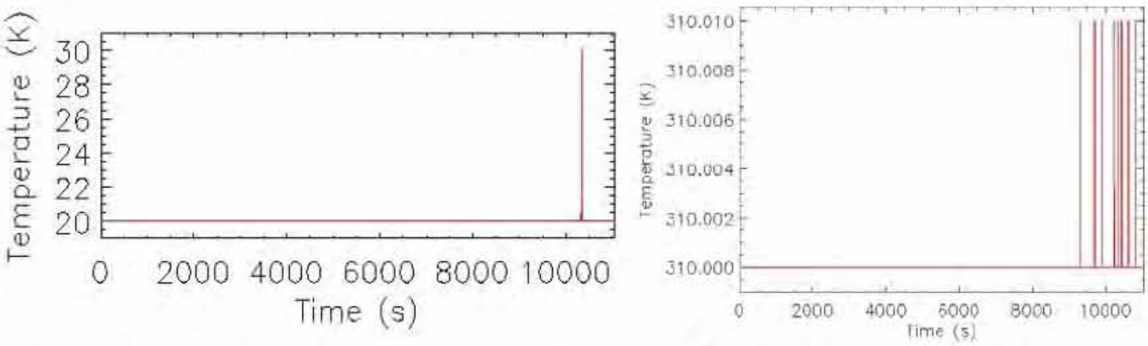


Figure -8-8: FEM (left) and BEM (right) temperature behaviour during the RCA_THV test

Detector A analysis

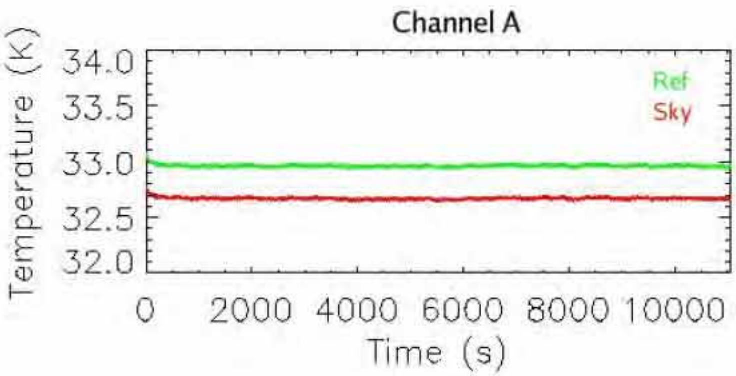


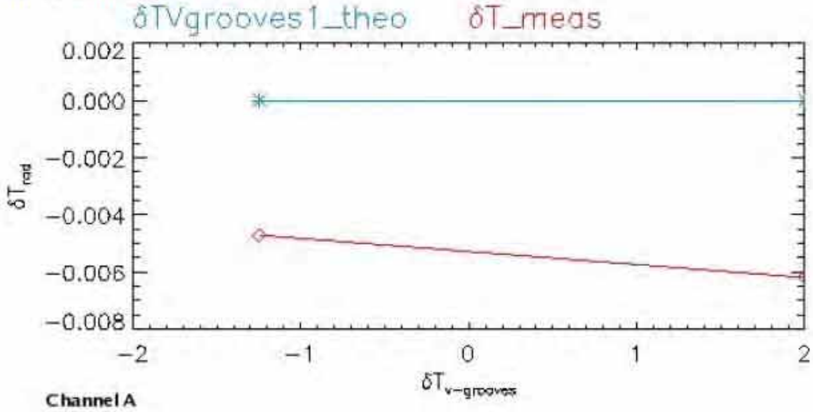
Figure -8-9: Detector A calibrated output

VG3_TEMP (K)	Ref (K)	Sky (K)
62,0023	32,9633	32,6749
63,9997	32,9583	32,6638
60,0069	32,9628	32,6697

Receiver parameters used in the computation of the theoretical transfer functions:

Frequency (GHz)	44
$L_{feed-OMT}$ (dB)	0.1
r	1.0088256
G_{F1} (dB)	35
G_{F2} (dB)	35
L_{WG1} (dB)	0.03
L_{WG2} (dB)	1.29
L_{WG3} (dB)	0.097
L_{WG4} (dB)	0.095
L_{WG5} (dB)	0.07
G (V/K)	0.0028105238

The transfer functions obtained with RaNA:



Fmeas (K/K)	-0.000457
Ftheo (K/K)	5.36e-07

Detector B Analysis

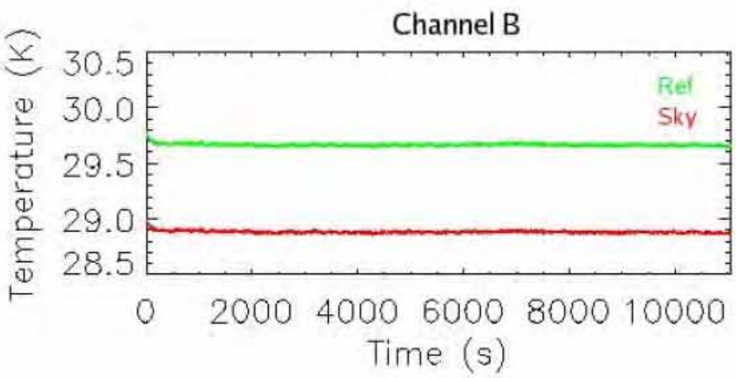


Figure -8-10: Detector B calibrated output

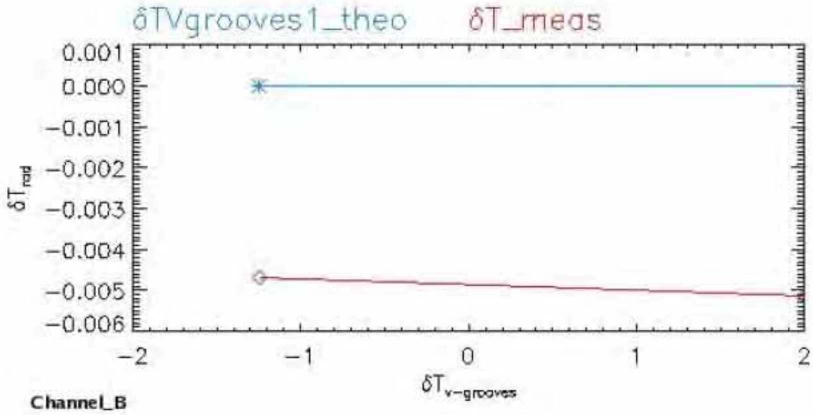
VG3_TEMP (K)	Ref (K)	Sky (K)
62,0023	29,675836	28,895266
63,9997	29,666386	28,880938

60,0069	29,664536	28,879556

Receiver parameters used in the computation of the theoretical transfer functions:

Frequency (GHz)	44
$L_{feed-OMT}$ (dB)	0.1
r	1.0270138
G_{F1} (dB)	35
G_{F2} (dB)	35
L_{WG1} (dB)	0.03
L_{WG2} (dB)	1.29
L_{WG3} (dB)	0.097
L_{WG4} (dB)	0.095
L_{WG5} (dB)	0.07
G (V/K)	0.0029685353

The transfer functions obtained with RaNA:



Fmeas (K/K)	-0.000137
Ftheo (K/K)	1.616e-06

Detector C Analysis

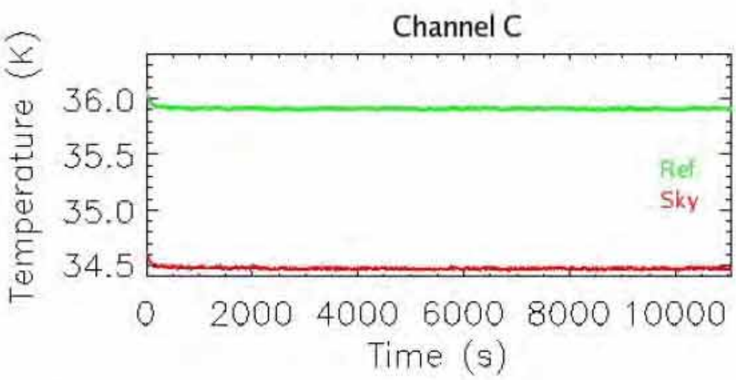


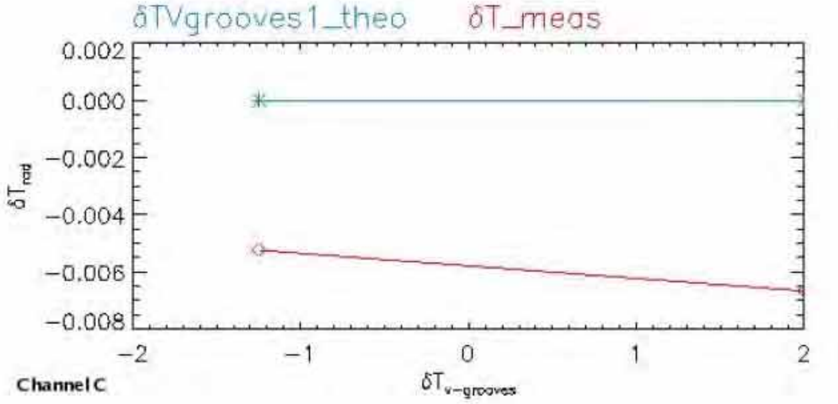
Figure -8-11: Detector C calibrated output

VG3_TEMP (K)	Ref (K)	Sky (K)
62,0023	35,916970	34,483885
63,9997	35,909278	34,469853
60,0069	35,909331	34,471301

Receiver parameters used in the computation of the theoretical transfer functions:

Frequency (GHz)	44
$L_{feed-OMT}$ (dB)	0.1
R	1.0415577
G_{F1} (dB)	35
G_{F2} (dB)	35
L_{WG1} (dB)	0.03
L_{WG2} (dB)	1.29
L_{WG3} (dB)	0.097
L_{WG4} (dB)	0.095
L_{WG5} (dB)	0.07
G (V/K)	0.0033966079

The transfer functions obtained with RaNA:



Fmeas (K/K)	-0.00044
Ftheo (K/K)	2.45e-06

Detector D Analysis

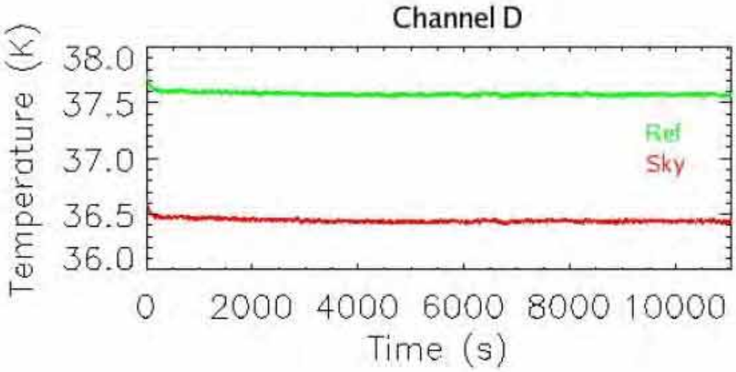


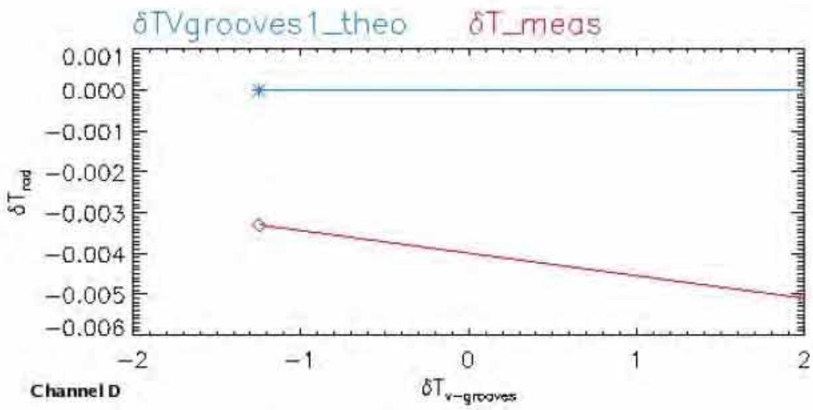
Figure -8-12: Detector D calibrated output

VG3_TEMP (K)	Ref (K)	Sky (K)
62,0023	37,602233	36,467792
63,9997	37,569760	36,431206
60,0069	37,572780	36,435905

Receiver parameters used in the computation of the theoretical transfer functions:

Frequency (GHz)	44
$L_{feed-OMT}$ (dB)	0.1
R	1.031108
G_{F1} (dB)	35
G_{F2} (dB)	35
L_{WG1} (dB)	0.03
L_{WG2} (dB)	1.29
L_{WG3} (dB)	0.097
L_{WG4} (dB)	0.095
L_{WG5} (dB)	0.07
G (V/K)	0.0032540548

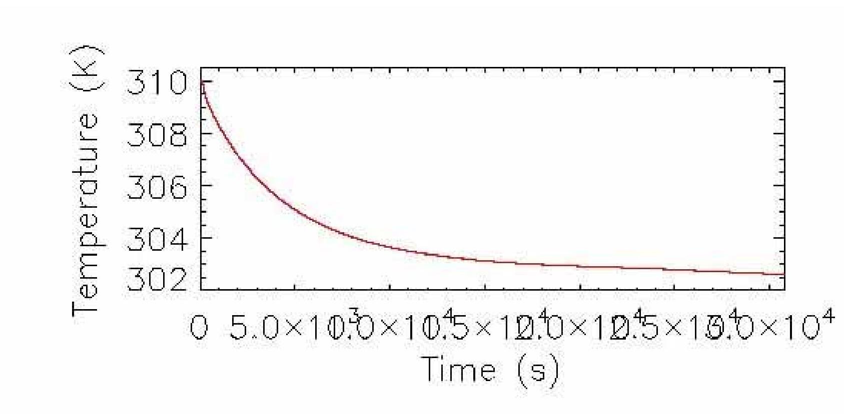
The transfer functions obtained:



Fmeas (K/K)	-0.00055
Ftheo (K/K)	1.849e-06

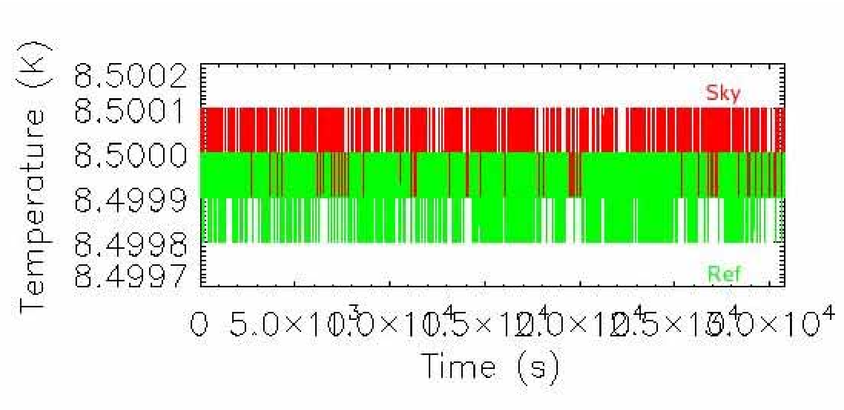
RCA_THB: Susceptibility to BEM Temperature variations

The BEM temperature was cooled continuously from a maximum (310K) to a minimum (302.6K). In the data analysis, small section of data in which the temperature did not change significantly were used assuming quasi-stationary conditions.

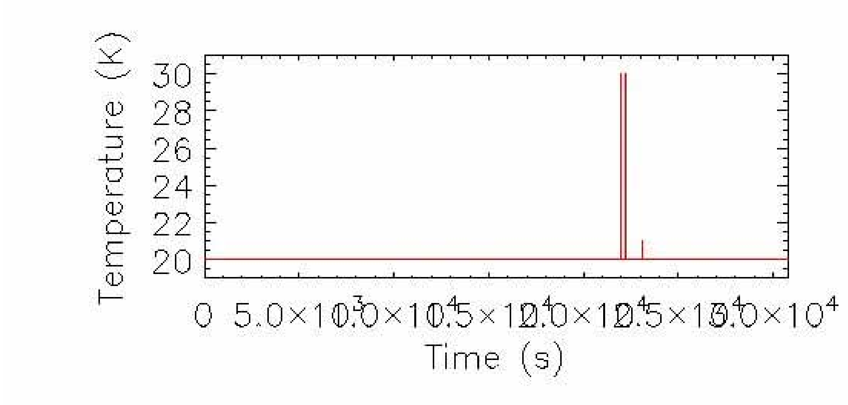


Temperature behaviour during the test:

In the next figure we show the sky and reference load temperatures.

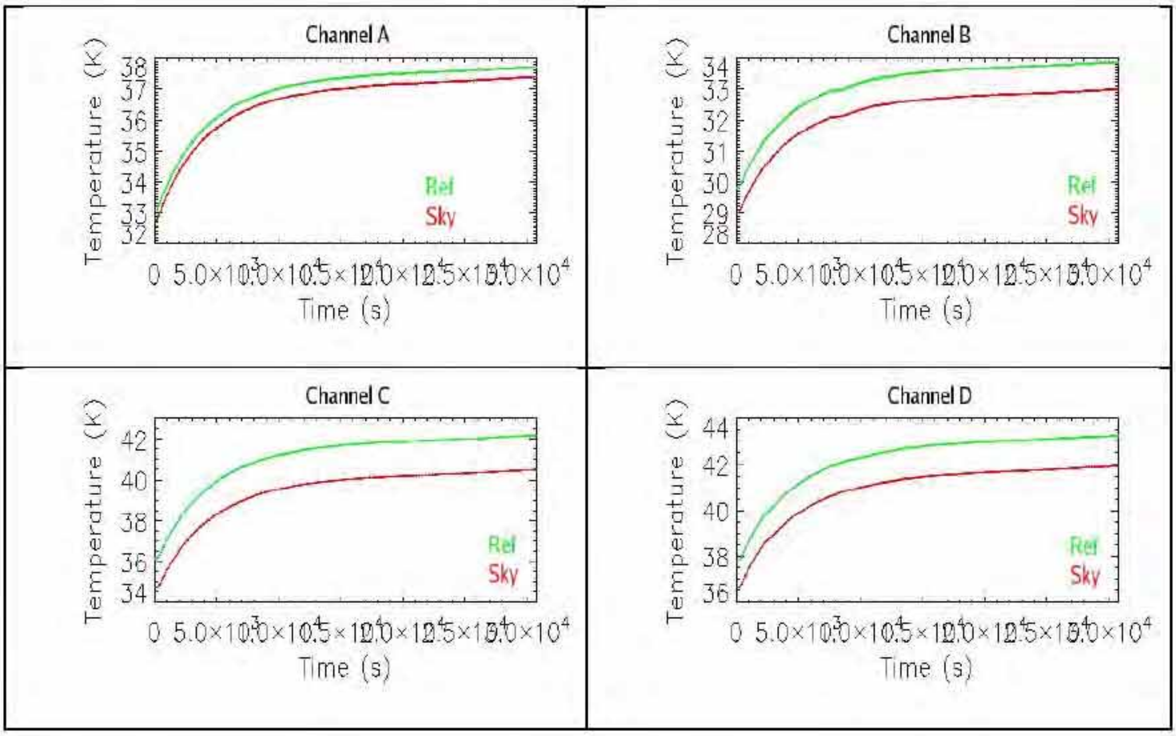


Finally, the FEM physical temperature:



Radiometric output:

To do the analysis, the radiometric output for each channel in the four steps were recorded. We can see the output of the channels in the figures below:



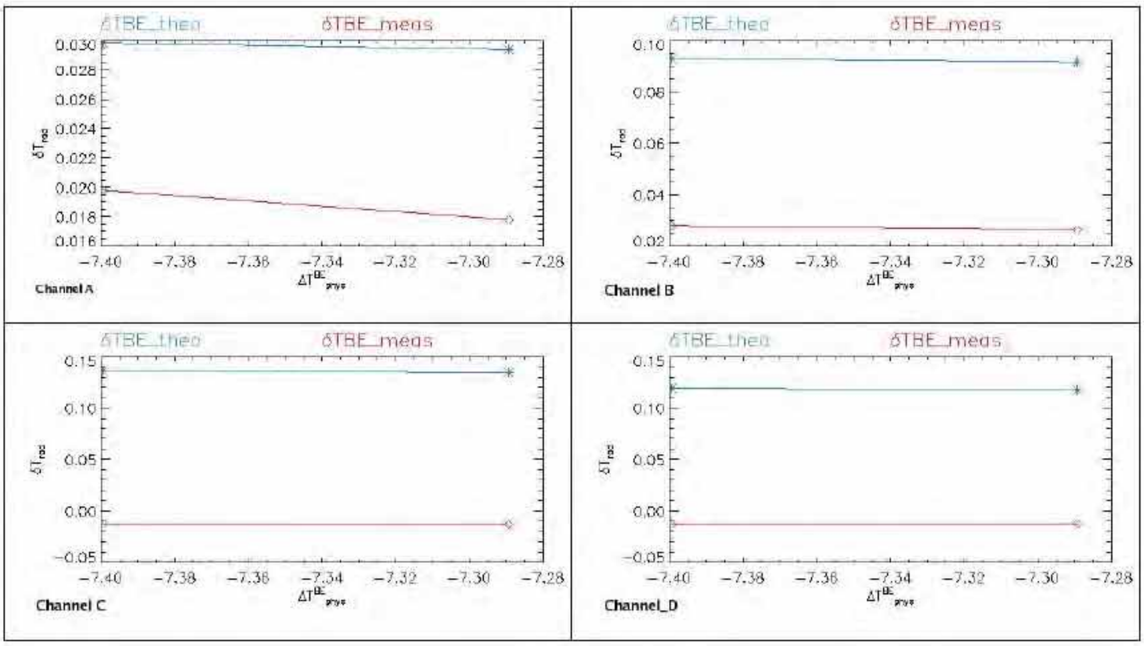
Results

The default parameters for the four channels are:

	Ch. A	Ch. B	Ch. C	Ch. D
Freq(*GHz*)	44			
$L_{feed-OMT}$ (*dB*)	0.1			
L_{4k} (*dB*)	0.1			
r	0.99069043	0.97323292	0.95989066	0.96934545
T_{sky} (*K*)	8.5			
T_{ref} (*K*)	8.4999			
T_{FEphys} (K)	20			
G_{F1}^{dB} **(*dB*)**	35			
G_{F2}^{dB} **(*dB*)**	35			

T_{nF1} (*K*)	18	18	20	20
T_{nF2} (*K*)	18	18	20	20
$\partial G_{B1}^{dB} / \partial T_{phys}^{BE}$ (*dB/K*)	-0.061	-0.067	-0.06	-0.07
$\partial G_{B2}^{dB} / \partial T_{phys}^{BE}$ (*dB/K*)	-0.061	-0.067	-0.06	-0.07
$\partial a^{dB} / \partial T_{phys}^{BE}$ (*dB/K*)	-0.01	-0.01	-0.01	-0.01
Gain Calibration Factor (*V/K*)	0.00281052	0.00296853	0.00339661	0.00325405

Calculating the theoretical and the measured transfer functions with RaNA, we obtain:



		Channel A	Channel B	Channel C	Channel D
$f_{therm}^{back-end}$	(K/K) theoretical	-0.00403	-0.012571	-0.018447	-0.016113
$f_{therm}^{front-end}$ $f_{therm}^{back-end}$ measured	(K/K)	-0.01821	-0.014478	-0.003948	-0.003567

RCA_ELE: Susceptibility to Disturbance on Bias Lines

A perturbing sinusoidal signal is superimposed to bias lines. Disturbance amplitude is 20 mV p-p. Signal frequency is changed according to the procedure and the output is recorded. As expected the output signal is perturbed. The amplitude of the peaks is measured from FFT data. Results are reported for a perturbation on Vg1, S1 (corresponding to channel A-B).

Test condition:

- Disturbance on Vg1 – S1 (Side-arm)
- Disturbance amplitude: 20mV

Data are selected (binning 1) according to the intervals reported in log file.
FFT parameters:
Sampling frequency: 4096 Hz
Windowing: No
Removed linear fit: No
Fast FFT: Yes

Peak values are evaluated from the plots within RaNA.

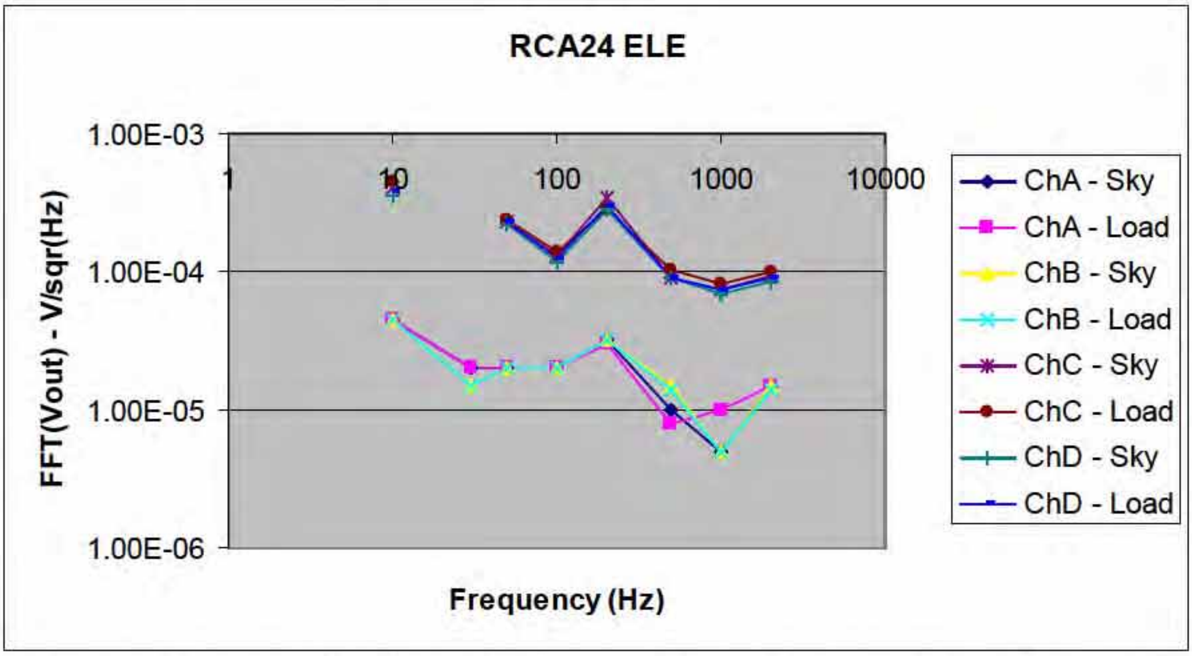


Figure -8-13: Peak amplitude of the output (undifferenced), perturbing frequency up to 2kHz on Vg1.
As it is readily seen, the perturbation on A – B is one order of magnitude higher than on the other channel. No perturbation is seen in differenced data.

Differential data (below 2kHz)

Differential data show a substantial cancellation of the disturbance in the S1 channels.
See as an example the case of 10Hz disturbance on channel D. Peak amplitude in differential data is reduced by about one order of magnitude.

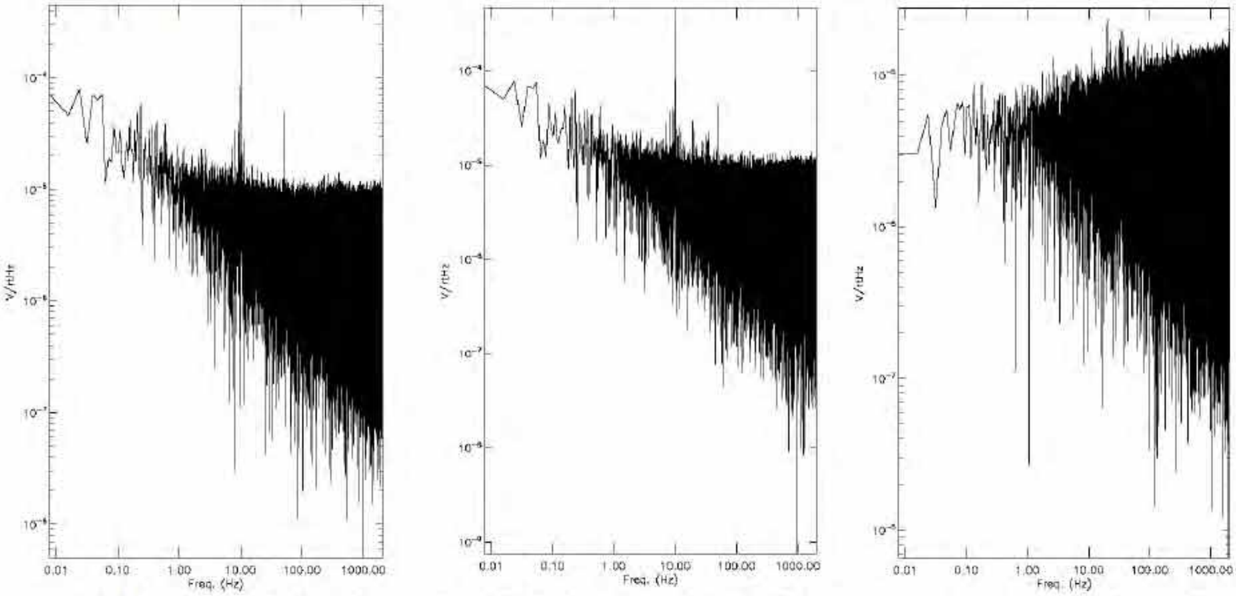


Figure -8-14: Channel D, 10Hz disturbance. Left: Sky data. Centre: Load data. Right: Differenced data (the gain modulation factor applied is r=0.96967781)

Analysis on Higher frequencies and perturbation on the other bias lines is on-going

Effect on Idrain

The perturbing signal is applied on channel C. The effect is also visible, for the file ELE_200601311631 also on Idrain. the main feature is an increase of Idrain noise. No clear correlation is found in output data.

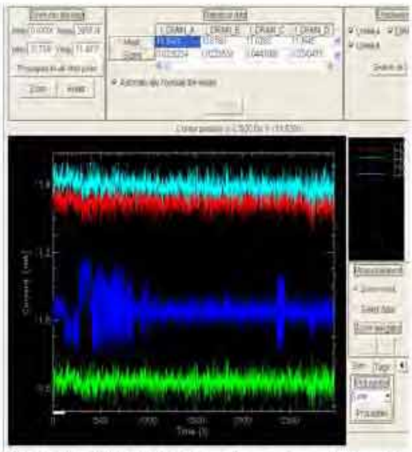


Figure -8-15**Rana output on file ELE_200601311631 showing Idrain signal. The noisy data on Channel C are visible and the sigma is double the other channel one.**

A sinusoidal voltage signals, 20mV p-p in amplitude is superimposed on bias lines on the S1 channel. The output is then recorded.

FFT of the output is analysis in for each of the perturbing frequencies.

Frequency (Hz)	ΔV (mV)	ΔV (mV)
	Vg1	Vg2
5	20	20

10	20	20
30	20	20
50	20	20
100	20	20
500	20	20
1E3	20	20
2E3	20	20
3E3	20	20
4E3	20	20
5E3	20	20
8E3	20	20
10E3	20	20
20E3	20	20
50E3	20	20
100E3	20	20
500E3	20	20
1E6	20	20

The effect reported below are present in both files, i.e. with the disturbance applied on Vg1 and Vg2. the effect is comparable.

Main features not strictly related to the disturbance

50Hz signal

The 50Hz peak is always present on all channels at all perturbing frequencies. Its amplitude is between 2E-5 and 5E-5. This signal is present on Sky, Load and Unscrambled signal. As expected,it is cancelled in differenced data (S-r*L).
The amplitude is comparable in the 4 channels

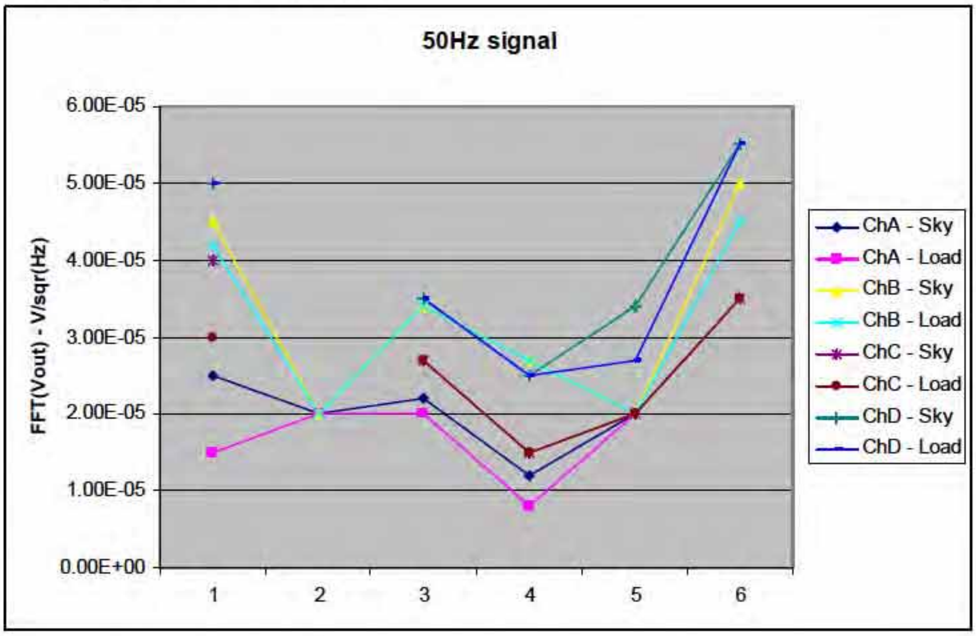


Figure -8-16:50Hz peak value evaluated from the FFT plots. Different measures refer to different part of the data stream where disturbance is applied.

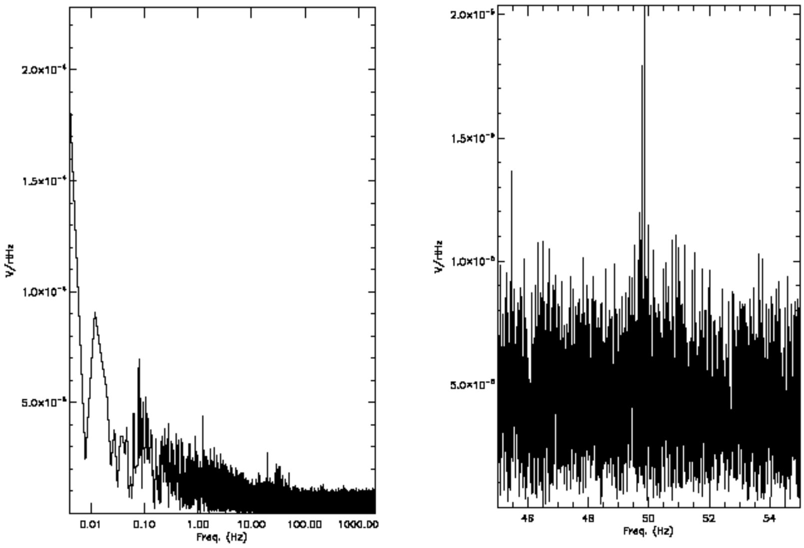


Figure -8-17 :Example of spectrum showing the 50Hz signal. Channel A – sky. No disturbance is applied.

Features on Load signal around 20Hz

A series of peaks is present in the Load around 20Hz. Their amplitude is around 5E-5 V/√Hz. they are not cancelled in differenced data.

Features at high frequency

A series of peaks, whose amplitude is around 2E-5 V/√Hz, is noticed in unscrambled data between 4060 and 4080 Hz. they are present in all channels, with or without disturbance on bias lines.

Behaviour of the output related to the disturbing signal

Two frequency ranges of the disturbance can be defined:

Frequency below the 2 kHz

In this case the perturbing signal is visible in Sky and Load output in all channels at the perturbing frequency. Its amplitude is around 1E-4 V/√Hz in C and D channels (where the disturbance is applied) and around 5E-5 V/√Hz in A and B channels. The signal is not present in differenced data, as expected.

Frequency above 2 kHz

A signal is present in all channels at the frequency difference between the perturbing frequency and the switching frequency. This signal is present in all channels on sky and Load output. Is is also present in differenced data.

High frequencies (above 50kHz)

No effect is noticed

CONCLUSIONS AND RECOMMENDATIONS

Performances

Noise temperature have been calculated using different data sets and different method. Because of saturation. linear or parabolic fit has been applied to data either on the reference load and on the sky load variation. In addition the noise temperature has been calculated from white noise level. The consistency of the results is good.

The noise temperature of the RCA24 is within the requirement for channels A and B and slightly outside the requirement for channel C and D.
The bandwidth is outside requirements. The combination of the a final effect the white noise level is about 40% higher that required.

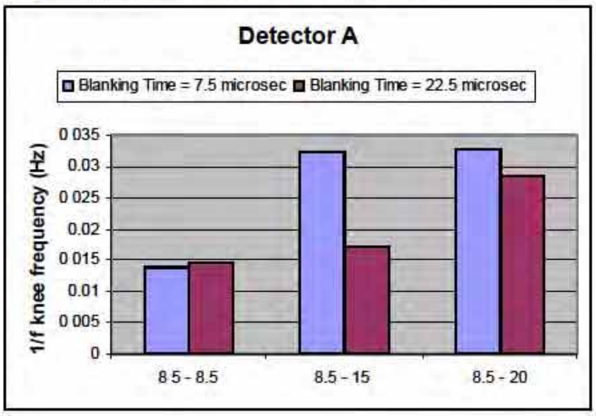
I/f is within the requirements with the loads controlled at the same temperature.

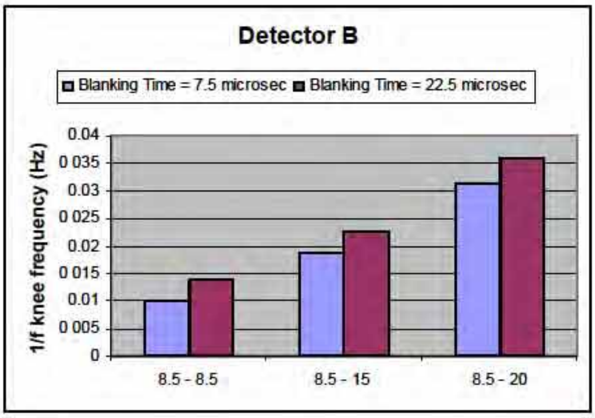
Calibration Matrix

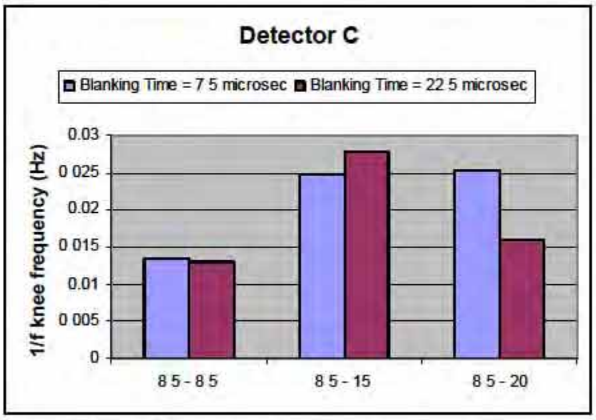
	A	B	C	D
Gain (K/V)	358	344	297	309
T noise (16.6K) PAR	15.1	15.0	18.0	19.1
T noise (16.6K) LIN	23.3	20.8	26.3	27.4
Isolation (<-13dB)	-13.5	-13.6	12.0	-12.0
Band (8.8GHz) WN	6.1	4.2	7.0	5.5
Band (8.8GHz) SPR	5.2	4.1	5.8	5.3
Central Freq.(GHz) 44GHz	45.8	42.7	45.0	45.8
1/f (<50 mHz)	14 mHz	10 mHz	13 mHz	10 mHz
R (~1)	0.99093361	0.97444466	0.96211290	0.97053342

Blanking time

Blanking time has been changed to investigate the effect on the noise spectrum. There is no evident effect on the white noise limit and 1/f while spikes increase in number. Hereafter we report the variation of the knee frequency values with blanking time.







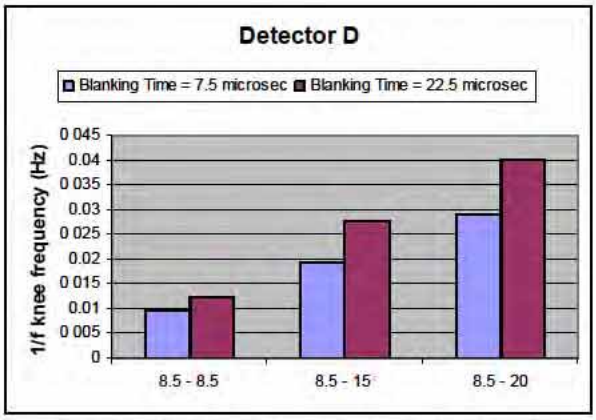


Figure -9-18: Comparison between knee frequencies calculated at the two blanking time. In the X axis the temperature of the SKY and REF are reported in Kelvin.

RECCOMENDATIONS FOR OTHER RCA TESTS

It clear that the main problem encountered in this RCA is the saturation. It make the data analysis complicated. The extensive LIS test has been performed with the goal to investigate the saturation in a more reliable way. It is recommended that such a test will be performed also on the other RCA's.
In addition it can be readily seen form TNG and LIS tests that the choice of the §SKY sensor has a big impact on the estimation of the noise temperature. SKY load has been modified to permit the mounting of an additional temperature sensor on the pyramids in order to increase the accuracy of the knowledge of the brightness temperature of the sky load itself.

Report

RaNA

Fri Feb 10 16:26:35 2006

Chapter 1

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-view

Chapter 2

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-tn

2.1 rana_tn_mini_report_001

2.1.1 RANA_TN

Noise temperature calculation

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT DATA

Channel #	A
Temperature varied	REF_TEMP
$T_{\rm hot}$	34.899876 K
$T_{\rm cold}$	8.4999084 K
$V_{\rm hot}$	0.16279903 V
$V_{\rm cold}$	0.089689379 V
$\sigma(T_{\rm hot})$	0.00044247592 K
$\sigma(T_{\rm cold})$	4.3500582e-05 K
$\sigma(V_{\rm hot})$	0.00024249070 V
$\sigma(V_{\rm cold})$	0.00016540564 V
frequency	44.000000 GHz

RESULTS

$T_{\rm noise}$	24.858655 K
$\sigma(T_{\rm noise})$	0.17075100 K

COMMENT

2.2 rana_tn_mini_report_002

2.2.1 RANA_TN 001

Noise temperature calculation

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT DATA

Channel #	B
Temperature varied	REF_TEMP
T_{hot}	34.899883 K
T_{cold}	8.4999084 K
V_{hot}	0.16307081 V
V_{cold}	0.086142954 V
$\sigma(T_{\mathrm{hot}})$	0.0028001140 K
$\sigma(T_{\mathrm{cold}})$	4.2913438e-05 K
$\sigma(V_{\mathrm{hot}})$	0.00029509097 V
$\sigma(V_{\mathrm{cold}})$	0.00018957933 V
frequency	44.000000 GHz

RESULTS

T_{noise}	22.037662 K
$\sigma(T_{\mathrm{noise}})$	0.17835208 K

COMMENT

2.3 rana_tn_mini_report_003

2.3.1 RANA_TN 002

Noise temperature calculation

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT DATA

Channel #	C
Temperature varied	REF_TEMP
$T_{\rm hot}$	34.899857 K
$T_{\rm cold}$	8.4999084 K
$V_{\rm hot}$	0.21299492 V
$V_{\rm cold}$	0.12231001 V
$\sigma(T_{\rm hot})$	0.00066893757 K
$\sigma(T_{\rm cold})$	4.3112199e-05 K
$\sigma(V_{\rm hot})$	0.00030402441 V
$\sigma(V_{\rm cold})$	0.00020687911 V
frequency	44.000000 GHz

RESULTS

$T_{\rm noise}$	28.074267 K
$\sigma(T_{\rm noise})$	0.18486340 K

COMMENT

2.4 rana_tn_mini_report_004

2.4.1 RANA_TN 003

Noise temperature calculation

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT DATA

Channel #	D
Temperature varied	REF_TEMP
$T_{\rm hot}$	34.899796 K
$T_{\rm cold}$	8.4999075 K
$V_{\rm hot}$	0.20855465 V
$V_{\rm cold}$	0.12128275 V
$\sigma(T_{\rm hot})$	0.0012851172 K
$\sigma(T_{\rm cold})$	4.1813299e-05 K
$\sigma(V_{\rm hot})$	0.00034402724 V
$\sigma(V_{\rm cold})$	0.00023088056 V
frequency	44.000000 GHz

RESULTS

T_{noise}	29.154576 K
$\sigma(T_{\text{noise}})$	0.22057640 K

COMMENT

Chapter 3

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-oft

Chapter 4

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-ling

4.1 rana_ling_mini_report_001

RANA_LING 001

Linearity, Isolation and Gain

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT
Channel: A
Sky temperature source: REF_TEMP
Ref temperature source: SMON_TMP
Changing voltage channel: Ref

44.0 GHz radiometer						
$T_{\rm change}$ [K]	$\sigma T_{\rm change}$ [K]	$T_{\rm fixed}$ [K]	$\sigma T_{\rm fixed}$ [K]	$V_{\rm change}$ [V]	$\sigma V_{\rm change}$ [V]	$V_{\rm fixed}$ [V]
8.4999084	4.3115477e-05	9.2013140	0.00096808624	0.089688993	0.00016539719	0.0888479
9.5999012	1.2354741e-05	9.1981821	0.00067229255	0.093227336	0.00017063316	0.0890014
10.700000	0.0000000	9.1977272	0.00014358206	0.096730057	0.00017566098	0.0891511
11.800000	0.0000000	9.1981182	0.00012569994	0.10016880	0.00017685156	0.0893015
12.900000	0.0000000	9.2511120	0.010027397	0.10355221	0.00018304916	0.0895449
14.000000	0.0000000	9.3785295	0.021260753	0.10691559	0.00018754190	0.0900399
15.100000	0.0000000	9.5515165	0.025105925	0.11023330	0.00019154813	0.0907181
18.400000	0.0000000	9.9876337	0.046421140	0.11989233	0.00020316148	0.0924019
19.500000	0.0000000	10.271344	0.027920684	0.12302643	0.00020623292	0.0935312
20.600000	0.0000000	10.501657	0.032145672	0.12612572	0.00020980485	0.0944656
21.700001	0.0000000	10.703438	0.035602987	0.12916629	0.00021046098	0.0952676
22.799999	0.0000000	10.907239	0.025955282	0.13217501	0.00021795696	0.0960654
23.900000	0.0000000	11.111769	0.026933545	0.13512645	0.00022053233	0.0968478
25.000000	0.0000000	11.306596	0.029071601	0.13802980	0.00022334444	0.0975807
26.100000	0.0000000	11.501092	0.025426069	0.14094873	0.00022156797	0.0983628
27.200001	0.0000000	11.687194	0.027973380	0.14379351	0.00022921287	0.0990859
28.299999	0.0000000	11.877437	0.019075615	0.14659001	0.00023377091	0.0998117
29.400000	0.0000000	12.041280	0.022389287	0.14938223	0.00023710989	0.1004380
30.500000	0.0000000	12.222549	0.021423796	0.15216782	0.00023970903	0.1011574
31.599998	0.0000000	12.395093	0.021273198	0.15492447	0.00024269471	0.1018606

RESULTS

I [dB]	σI [dB]	G [V/K]	σG [V/K]
-12.634826	-0.11428682	0.0026377664	1.1028994e-05

L	σL	$T_{\rm noise}$ [K]	$\sigma T_{\rm noise}$ [K]
0.0013234911	0.00038279233	24.378769	0.12108727

COMMENTS

4.2 rana_ling_mini_report_002

RANA_LING 002

Linearity, Isolation and Gain

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

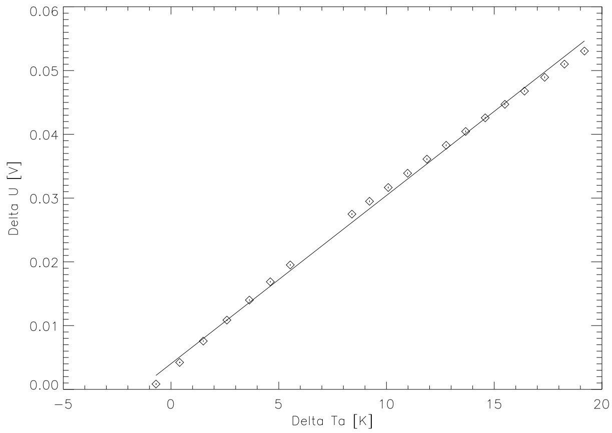


Figure 4.1: Response linearity (differenced values)

INPUT
Channel: B
Sky temperature source: REF_TEMP
Ref temperature source: SMON_TMP
Changing voltage channel: Ref

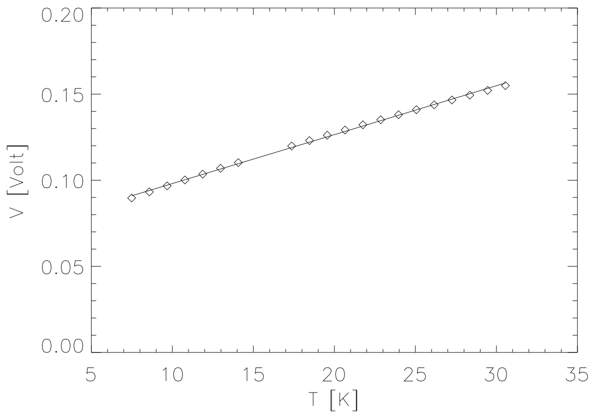


Figure 4.2: Response linearity (changing temperature vs changing voltage

44.0 GHz radiometer						
T_{change} [K]	σT_{change} [K]	T_{fixed} [K]	σT_{fixed} [K]	V_{change} [V]	σV_{change} [V]	V_{fixed} [V]
8.4999075	4.2404889e-05	9.2005177	0.00046896774	0.086153022	0.00018915450	0.08382969
9.5999012	1.2354741e-05	9.1981821	0.00067229255	0.089773931	0.00019416196	0.08399253
10.700000	0.0000000	9.1976948	0.00016375813	0.093343135	0.00019981518	0.08415059
11.800000	0.0000000	9.1981096	0.00012069573	0.096899116	0.00020480238	0.08431933
12.900000	0.0000000	9.2507401	0.0089641176	0.10038799	0.00020936362	0.08458251
14.000000	0.0000000	9.3819113	0.018861592	0.10385717	0.00021528078	0.08509445
15.100000	0.0000000	9.5470104	0.023143329	0.10728405	0.00021866259	0.08574596
18.400000	0.0000000	10.007889	0.041871753	0.11731450	0.00023270882	0.08752688
19.500000	0.0000000	10.261366	0.040651307	0.12059985	0.00023835102	0.08855825
20.600000	0.0000000	10.490770	0.033058830	0.12386470	0.00024180202	0.08950301
21.700001	0.0000000	10.713081	0.028580474	0.12707438	0.00024694731	0.09039627
22.799999	0.0000000	10.911295	0.025238082	0.13023452	0.00025161515	0.09117570
22.799999	0.0000000	10.913470	0.023721019	0.13023419	0.00025162524	0.09118374
23.899998	0.0000000	11.116502	0.021518733	0.13336598	0.00025426672	0.09198295
25.000000	0.0000000	11.314510	0.027622277	0.13647582	0.00025861098	0.09276365
26.100000	0.0000000	11.495701	0.022775516	0.13954546	0.00026309788	0.09347806
27.200001	0.0000000	11.685015	0.029523611	0.14260312	0.00026805268	0.09422217
28.299999	0.0000000	11.870015	0.022140421	0.14560025	0.00027114012	0.09494161
29.400000	0.0000000	12.046835	0.022687344	0.14859585	0.00027485195	0.09564546
30.500000	0.0000000	12.221851	0.025611771	0.15156318	0.00027945770	0.09633911

RESULTS

I [dB]	σI [dB]	G [V/K]	σG [V/K]
-12.953748	-0.15950153	0.0028077455	1.2456547e-05

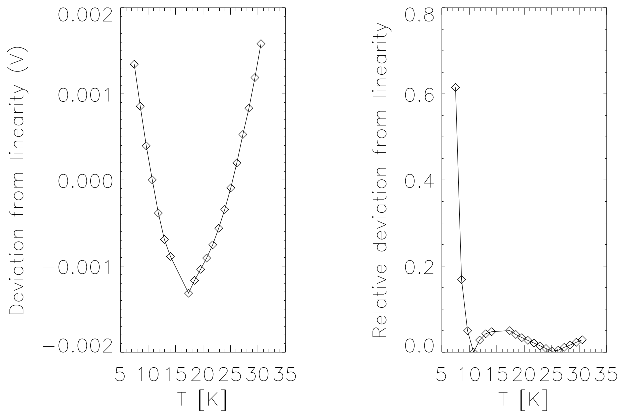


Figure 4.3: Deviation from linearity

L	σL	T_{noise} [K]	σT_{noise} [K]
0.0010429591	0.00038808541	21.568257	0.10660005

COMMENTS

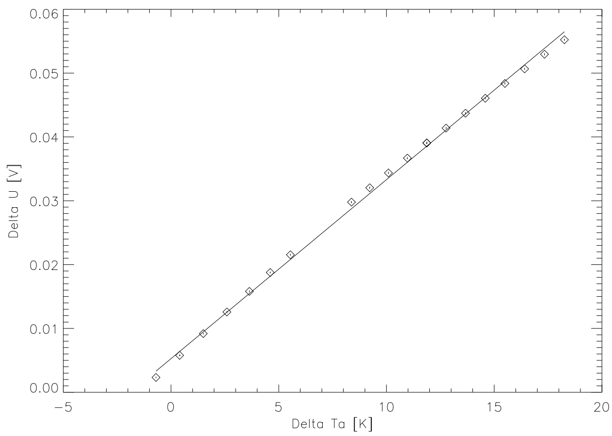


Figure 4.4: Response linearity (differenced values)

4.3 rana_ling_mini_report_003

RANA_LING 003

Linearity, Isolation and Gain

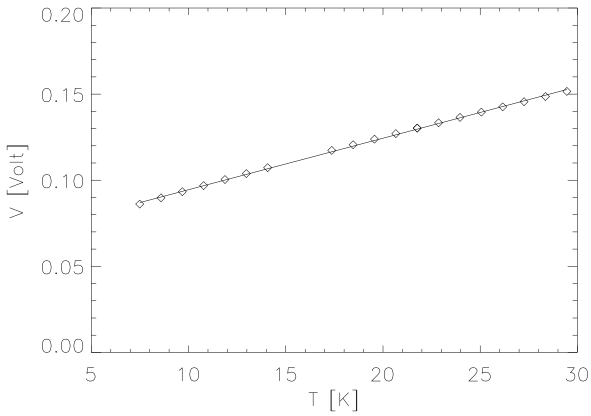


Figure 4.5: Response linearity (changing temperature vs changing voltage

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT
Channel: C
Sky temperature source: REF_TEMP
Ref temperature source: SMON_TMP
Changing voltage channel: Ref

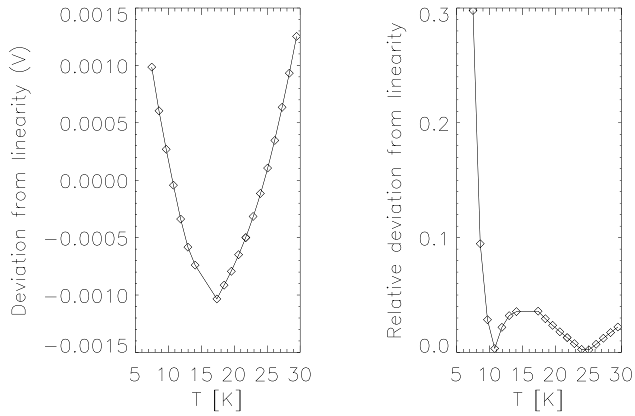


Figure 4.6: Deviation from linearity

44.0 GHz radiometer						
$T_{\rm change}$ [K]	$\sigma T_{\rm change}$ [K]	$T_{\rm fixed}$ [K]	$\sigma T_{\rm fixed}$ [K]	$V_{\rm change}$ [V]	$\sigma V_{\rm change}$ [V]	$V_{\rm fixed}$ [V]
8.4999075	4.0735864e-05	9.2004528	0.00044462236	0.12231194	0.00020654268	0.11748784
9.5999022	1.2092967e-05	9.1980505	0.00068465353	0.12665044	0.00021212678	0.11773725
10.700000	0.0000000	9.1977386	0.00013815206	0.13094973	0.00021775565	0.11798832
11.800000	0.0000000	9.1981249	0.00012267445	0.13521112	0.00021754939	0.11824746
12.900000	0.0000000	9.2541990	0.0077055078	0.13941236	0.00022761061	0.11865877
14.000000	0.0000000	9.3767977	0.022510484	0.14358173	0.00023265060	0.11933848
15.100000	0.0000000	9.5489902	0.021706201	0.14768010	0.00023667274	0.12025849
18.400000	0.0000000	9.9712610	0.054526504	0.15963559	0.00024802275	0.12250065
19.500000	0.0000000	10.262620	0.034032591	0.16355221	0.00025321379	0.12404199
20.600000	0.0000000	10.485491	0.036917619	0.16743139	0.00025750778	0.12527791
21.700001	0.0000000	10.703012	0.026744092	0.17120943	0.00025970931	0.12642086
22.799999	0.0000000	10.913084	0.026075244	0.17491712	0.00026520691	0.12752220
23.900000	0.0000000	11.117643	0.027118932	0.17861949	0.00026656335	0.12859657
25.000000	0.0000000	11.305542	0.023408219	0.18223533	0.00027301371	0.12956416
26.100000	0.0000000	11.489501	0.024773711	0.18579511	0.00027296309	0.13052252
27.200001	0.0000000	11.685828	0.024821477	0.18934635	0.00027902227	0.13154652
28.299999	0.0000000	11.855917	0.027884638	0.19283886	0.00028180430	0.13244656
29.400000	0.0000000	12.048846	0.021332091	0.19632583	0.00028583086	0.13347655
29.400000	0.0000000	12.048846	0.021332091	0.19975690	0.00029023708	0.13438720
31.600000	0.0000000	12.398529	0.018943211	0.20313778	0.00029133333	0.13532589

RESULTS

I [dB]	σI [dB]	G [V/K]	σG [V/K]
-11.387913	-0.057471819	0.0032101601	1.4177329e-05

L	σL	T_{noise} [K]	σT_{noise} [K]
0.0015088780	0.00044769329	27.197451	0.10860157

COMMENTS

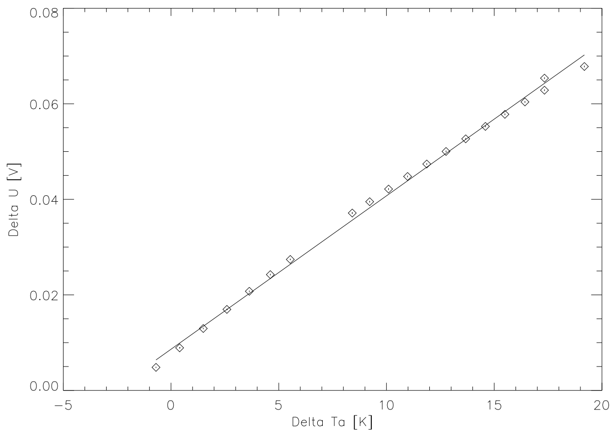


Figure 4.7: Response linearity (differenced values)

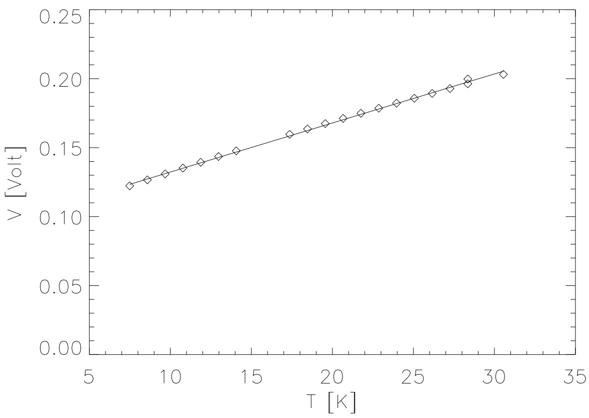


Figure 4.8: Response linearity (changing temperature vs changing voltage

4.4 rana_ling_mini_report_004

RANA_LING 004

Linearity, Isolation and Gain

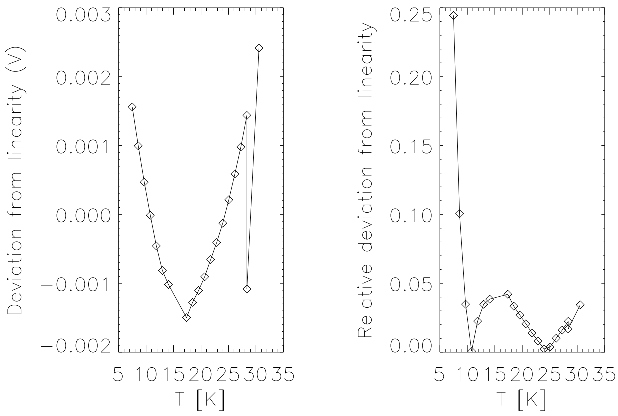


Figure 4.9: Deviation from linearity

Data from file set: 044LFI24_RCA_FM_LIS_200601272211
Contained in directory: /data

INPUT
Channel: D
Sky temperature source: REF_TEMP
Ref temperature source: SMON_TMP
Changing voltage channel: Ref

44.0 GHz radiometer						
$T_{\rm change}$ [K]	$\sigma T_{\rm change}$ [K]	$T_{\rm fixed}$ [K]	$\sigma T_{\rm fixed}$ [K]	$V_{\rm change}$ [V]	$\sigma V_{\rm change}$ [V]	$V_{\rm fixed}$ [V]
8.4999065	4.3090622e-05	9.2006979	0.00050896965	0.12128611	0.00023090963	0.11761438
9.5999022	1.5057376e-05	9.1983051	0.00076180132	0.12546547	0.00023669695	0.11784395
10.700000	0.0000000	9.1976871	0.00016058513	0.12959967	0.00024314225	0.11807556
11.800000	0.0000000	9.1981287	0.00012184452	0.13367407	0.00024863321	0.11830158
12.900000	0.0000000	9.2499180	0.0095657157	0.13770564	0.00025459841	0.11867365
14.000000	0.0000000	9.3798904	0.021853182	0.14171736	0.00026006671	0.11936713
15.100000	0.0000000	9.5470104	0.023143329	0.14566703	0.00026464846	0.12023382
18.400000	0.0000000	9.9823856	0.054103974	0.15715554	0.00027992789	0.12245930
19.500000	0.0000000	10.267952	0.033063896	0.16091204	0.00028461111	0.12394877
20.600000	0.0000000	10.495318	0.032148119	0.16465248	0.00028926638	0.12516790
21.700001	0.0000000	10.706464	0.031142870	0.16828650	0.00029383418	0.12626549
22.799999	0.0000000	10.916189	0.030065930	0.17189220	0.00029878814	0.12735538
23.900000	0.0000000	11.117234	0.029496117	0.17543149	0.00030286483	0.12837697
25.000000	0.0000000	11.313122	0.024523683	0.17893466	0.00030838881	0.12936758
26.100000	0.0000000	11.490610	0.030578265	0.18236274	0.00031217975	0.13026552
27.200001	0.0000000	11.695782	0.020071145	0.18575828	0.00031509047	0.13127435
28.299999	0.0000000	11.855917	0.027884638	0.18914800	0.00031973083	0.13211901
29.400000	0.0000000	12.046504	0.024887303	0.19250015	0.00032447239	0.13310368
30.500000	0.0000000	12.226324	0.018877598	0.19576788	0.00032760266	0.13399277
31.599998	0.0000000	12.388502	0.022297196	0.19898397	0.00033187180	0.13480931

RESULTS

I [dB]	σI [dB]	G [V/K]	σG [V/K]
-11.360938	-0.078556374	0.0030534780	1.3870575e-05

L	σL	$T_{\rm noise}$ [K]	$\sigma T_{\rm noise}$ [K]
0.0016111815	0.00051433142	28.722220	0.15617763

COMMENTS

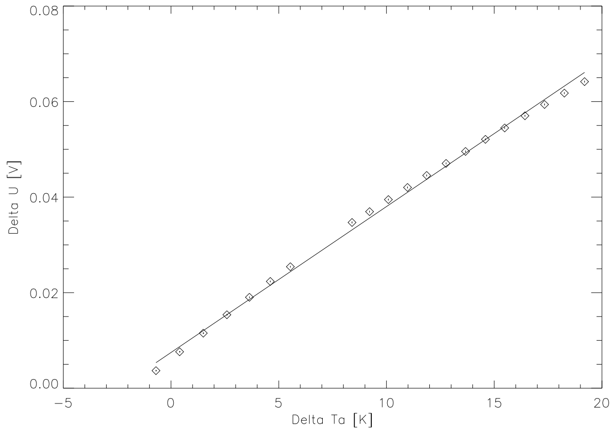


Figure 4.10: Response linearity (differenced values)

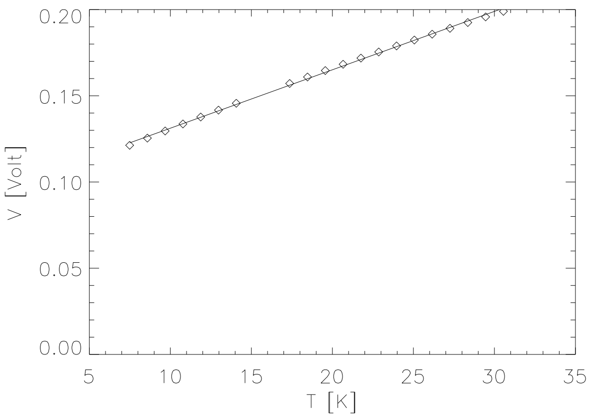


Figure 4.11: Response linearity (changing temperature vs changing voltage

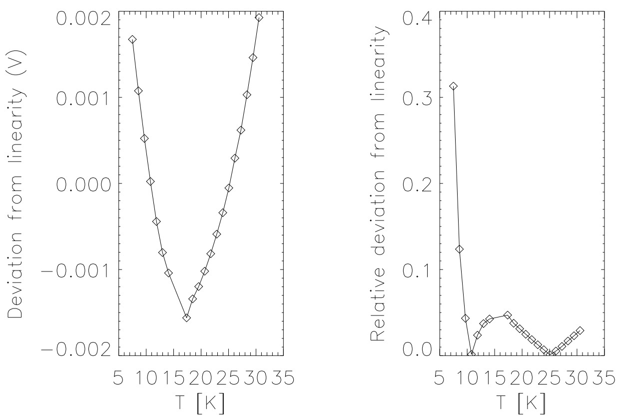


Figure 4.12: Deviation from linearity

Chapter 5

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-fft

Chapter 6

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-susc

Chapter 7

/home/battaglia/RaNA-Fri-Feb-10-15:04:11-2006/rana-spr

RaNA Report
SPR TEST 1222

F.VILLA

Mon Feb 13 12:20:26 2006

Chapter 1

RaNA-Mon-Feb-13-12:14:30-2006/rana-spr

1.1 rana_spr_mini_report_001

1.1.1 RANA_SPR_001

Data from file set: 044LFI24_RCA_FM_SPR_200602081222
Contained in directory: /home/villa/VILAS/CALIBRATION_DATA/fm/rca24

Input Data

Frequency: 44 GHz
Trigger Detector: A
F_min: 33.00 GHz
F_max: 50.00 GHz
Step: 0.05 GHz
Threshold: 0.0300 V/s
Useful Data: 50.00 %
Calibration File: /home/villa/LIFE/RaNA/RaNA_SPR/cal_FM_44_08022006.dat

Comments

Test Setup: coax-WR22 Mariotti; Ccoax cable and sweeper from ESA
Power floor = -28dBm;
trigger seq=[+6,0,+3,0]@43GHz;
scan from 33 to 50 at +3dB step 0.05 GHz, 3000msec each;
Data BIN=10

Output Data

Derivative Plots

Table 1.1: Central frequency and equivalent bandwidth.

Channel	Central Frequency (GHz)	Equivalent Bandwidth (GHz)
A	45.75	5.21
B	42.60	4.11
C	44.90	5.85
D	45.60	5.24

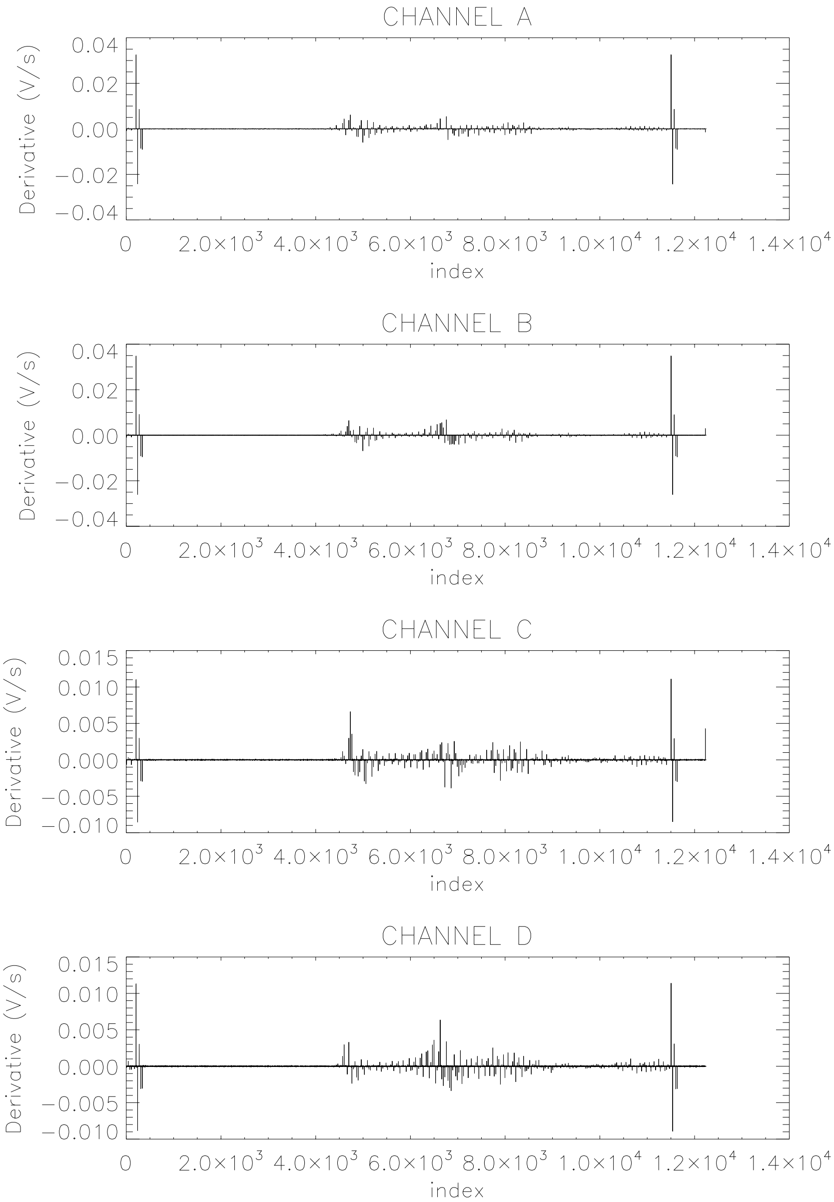


Figure 1.1: Data binned with a bin equal to 0.

Selected Plots

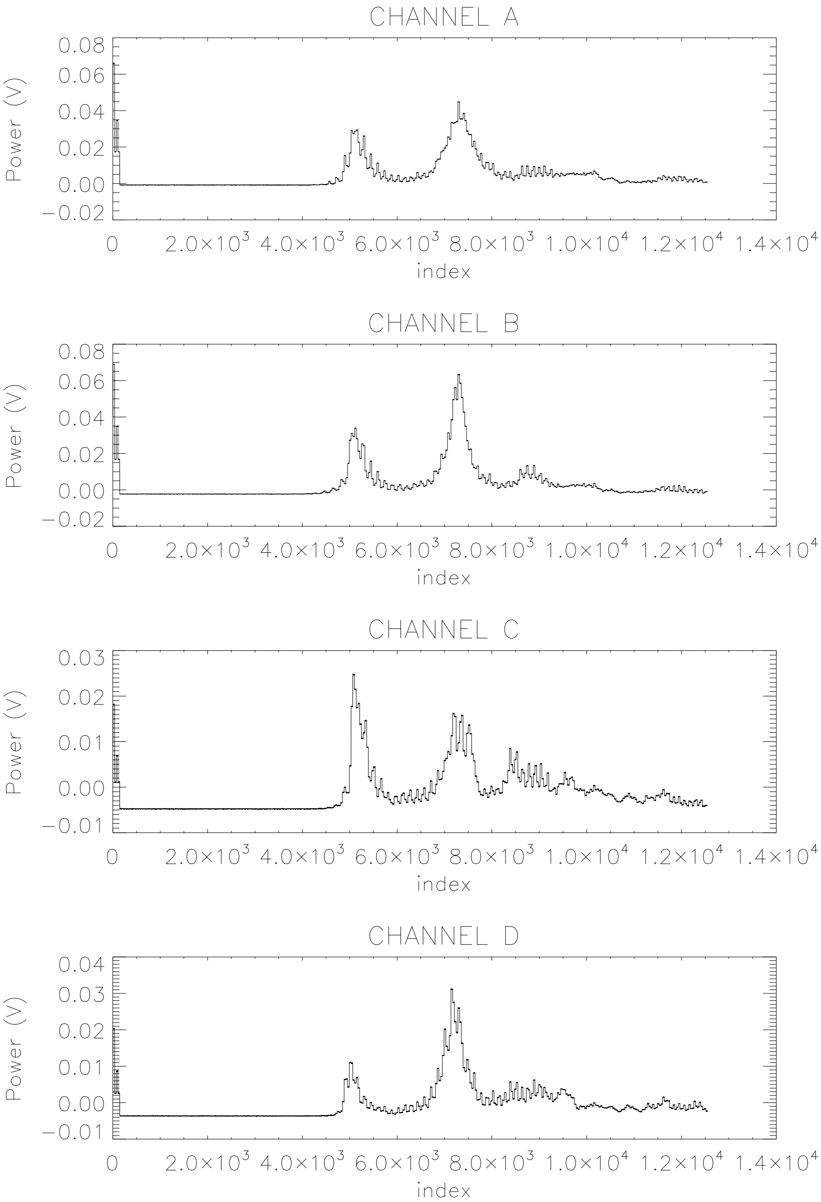


Figure 1.2: Data binned with a bin equal to 0.

Radiometer Spectral Response

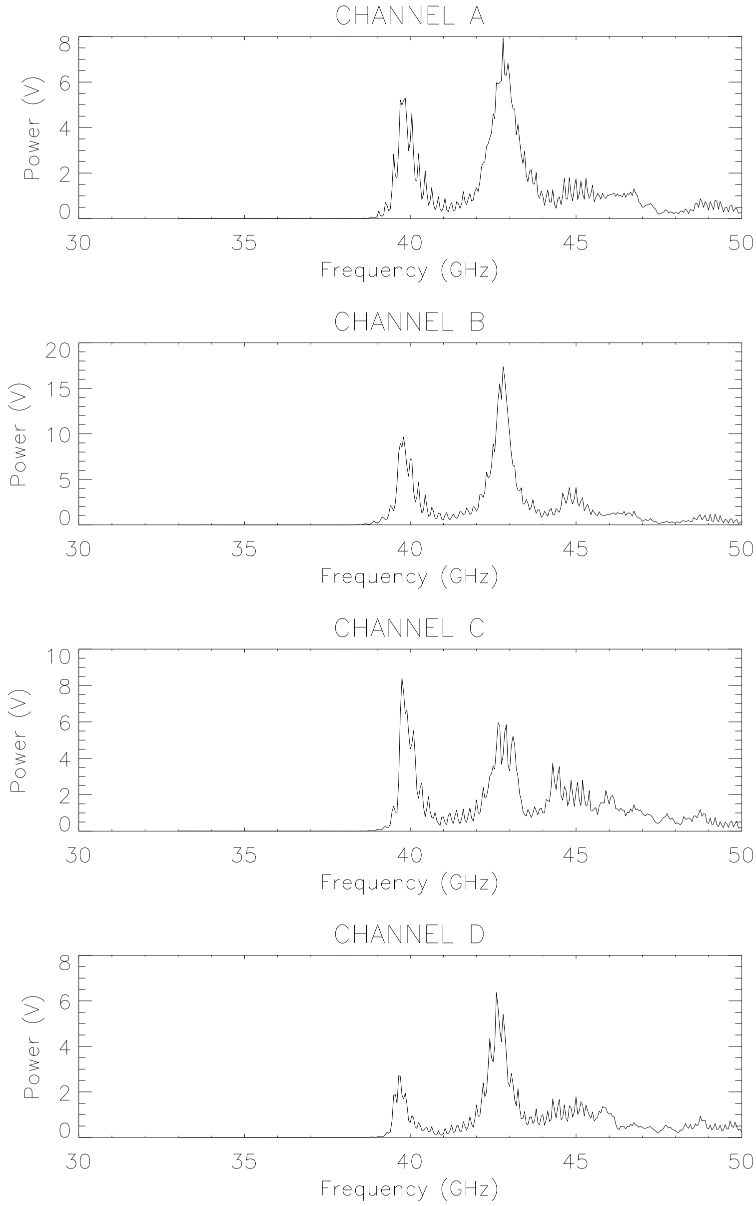


Figure 1.3: Calibrated data.

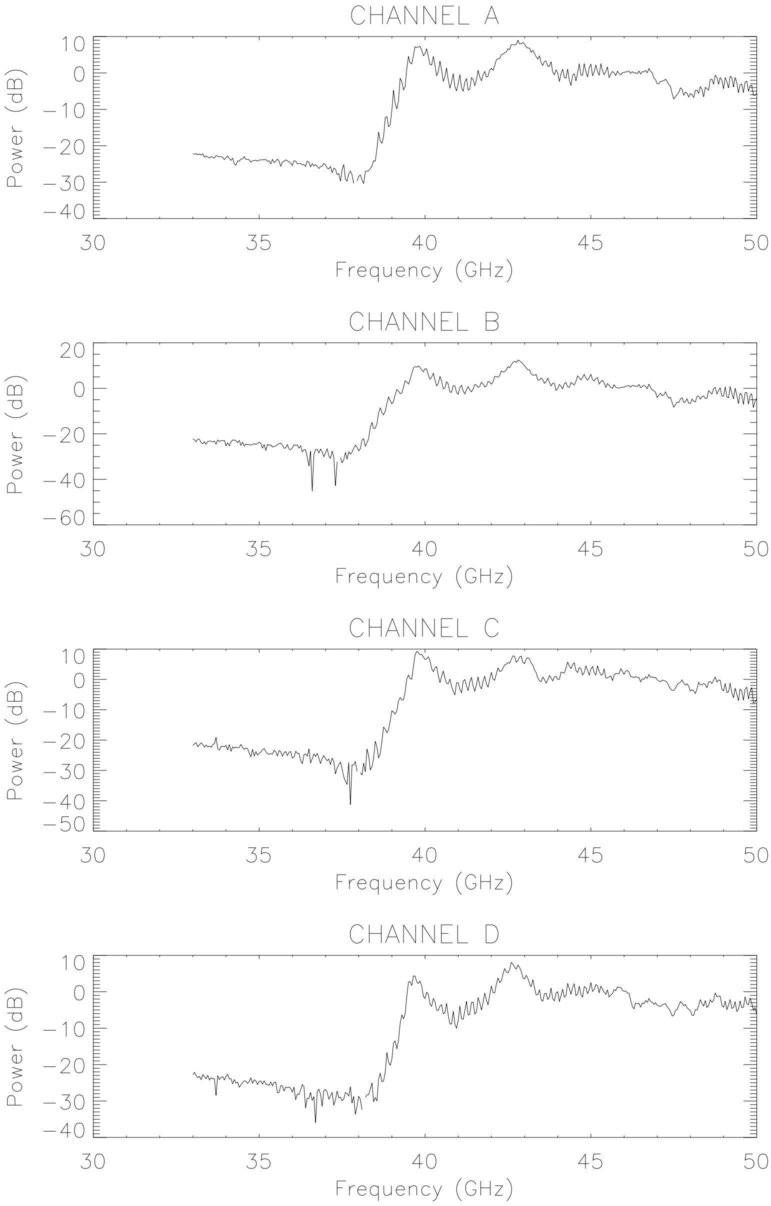


Figure 1.4: Calibrated data in dB.

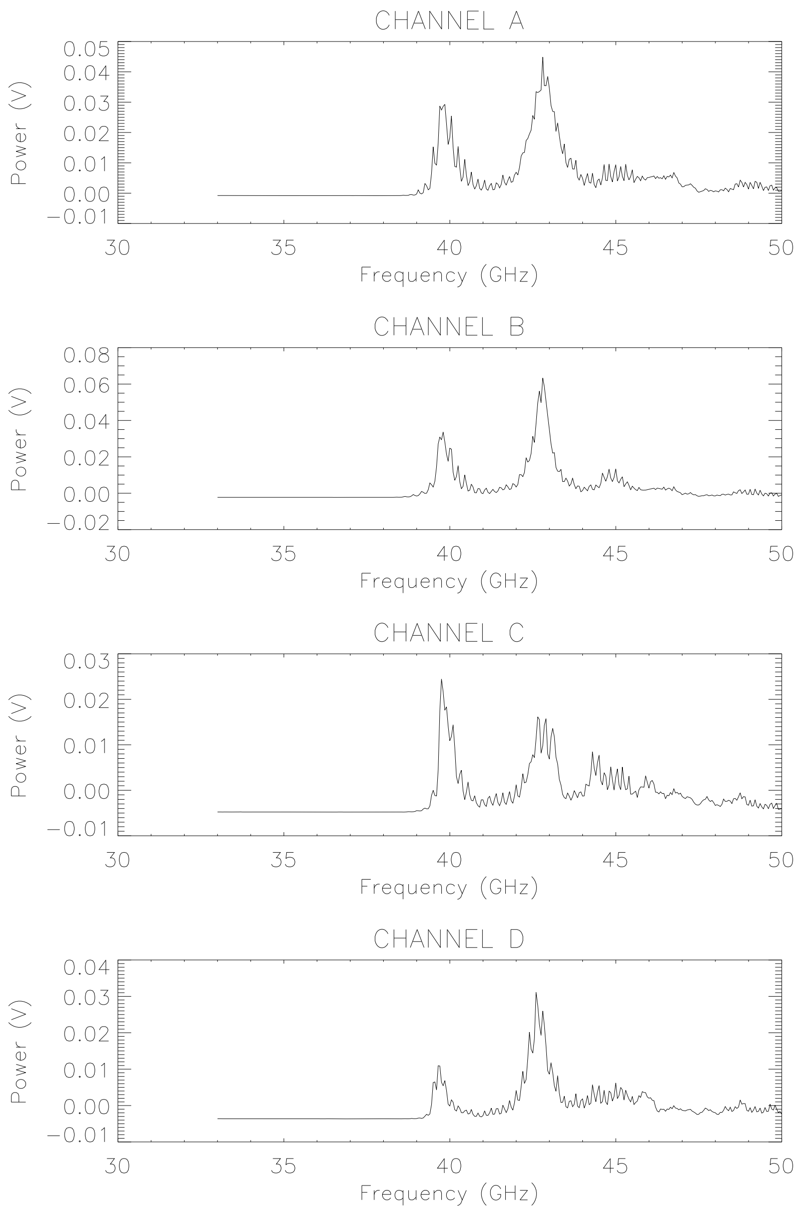


Figure 1.5: Uncalibrated data.

RaNA Report
SPR TEST 1308

F.VILLA

Mon Feb 13 12:25:54 2006

Chapter 1

/home/villa/RaNA-Mon-Feb-13-12:23:21-2006/rana-spr

1.1 rana_spr_mini_report_001

1.1.1 RANA_SPR_001

Data from file set: 044LFI24_RCA_FM_SPR_200602081308
Contained in directory: /home/villa/VILAS/CALIBRATION_DATA/fm/rca24

Input Data

Frequency: 44 GHz
Trigger Detector: A
F_min: 33.00 GHz
F_max: 50.00 GHz
Step: 0.05 GHz
Threshold: 0.0100 V/s
Useful Data: 50.00 %
Calibration File: /home/villa/LIFE/RaNA/RaNA_SPR/cal_FM_44_08022006.dat

Comments

Test Setup: coax-WR22 Mariotti; Ccoax cable and sweeper from ESA
Power floor = -31dBm;
trigger seq=[+6,0,+3,0]@43GHz;
scan from 33 to 50 at +3dB step 0.05 GHz, 3000msec each;
Data BIN=10

Output Data

Table 1.1: Central frequency and equivalent bandwidth.

Channel	Central Frequency (GHz)	Equivalent Bandwidth (GHz)
A	45.75	5.15
B	42.40	4.08
C	44.90	5.82
D	45.60	5.26

Derivative Plots

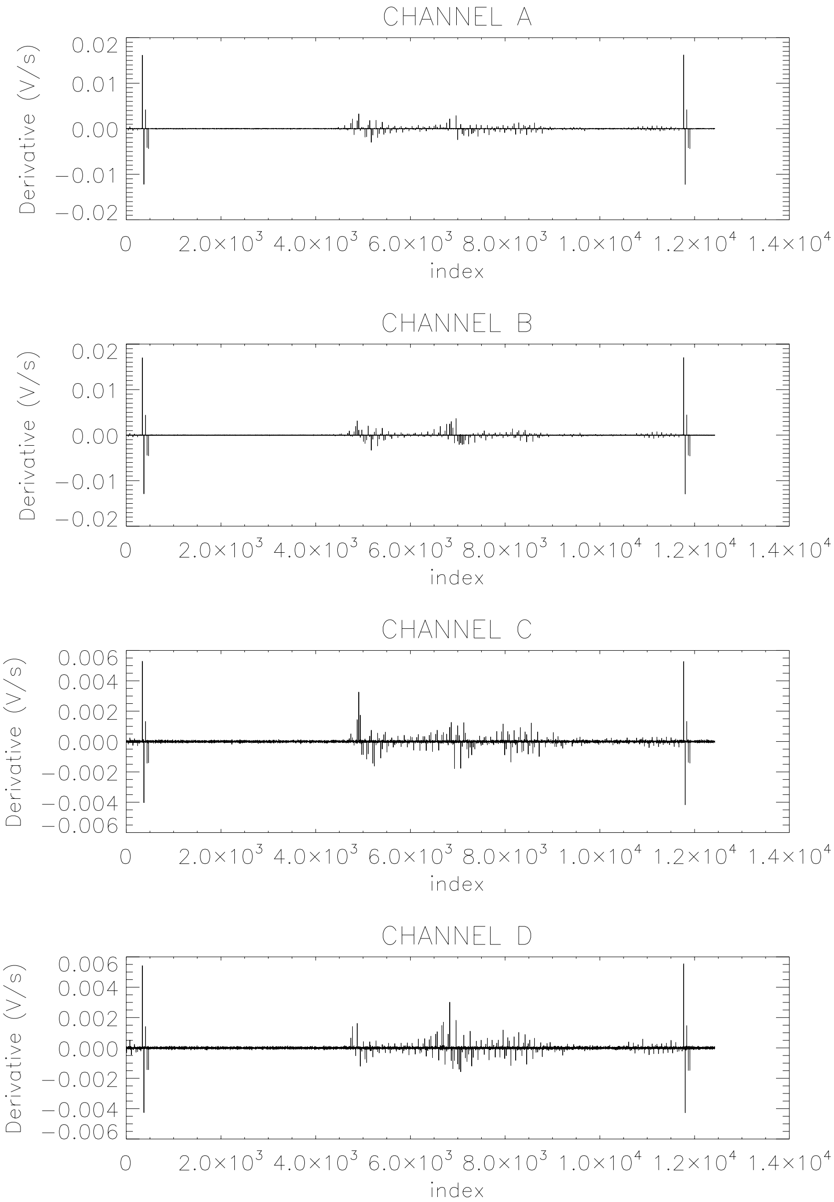


Figure 1.1: Data binned with a bin equal to 0.