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HERSCHEL/SPIRE

DCU COLD TESTS WITH JPL BACCUS CRYOSTAT

	Function	Name	Date	Visa
Prepared by With measurements from	SPIRE AIV SPIRE ELECTONICS	H. TRIOU F. PINSARD	17/11/2003	
Verified by	SPIRE SYSTEM	C. CARA	16/01/2004	
Approved by	P.A. Electronics	J. FONTIGNIE	16/01/2004	
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1 Table of contents

2 Introduction

Following the electronic tests performed at Boulder with the Baccus cryostat, this document reports the cold tests achieved at SAp with the cryostat and the DCU QM1.

With respect to the DCU AIV plan, these tests are referenced as QM1-DCU-T3.

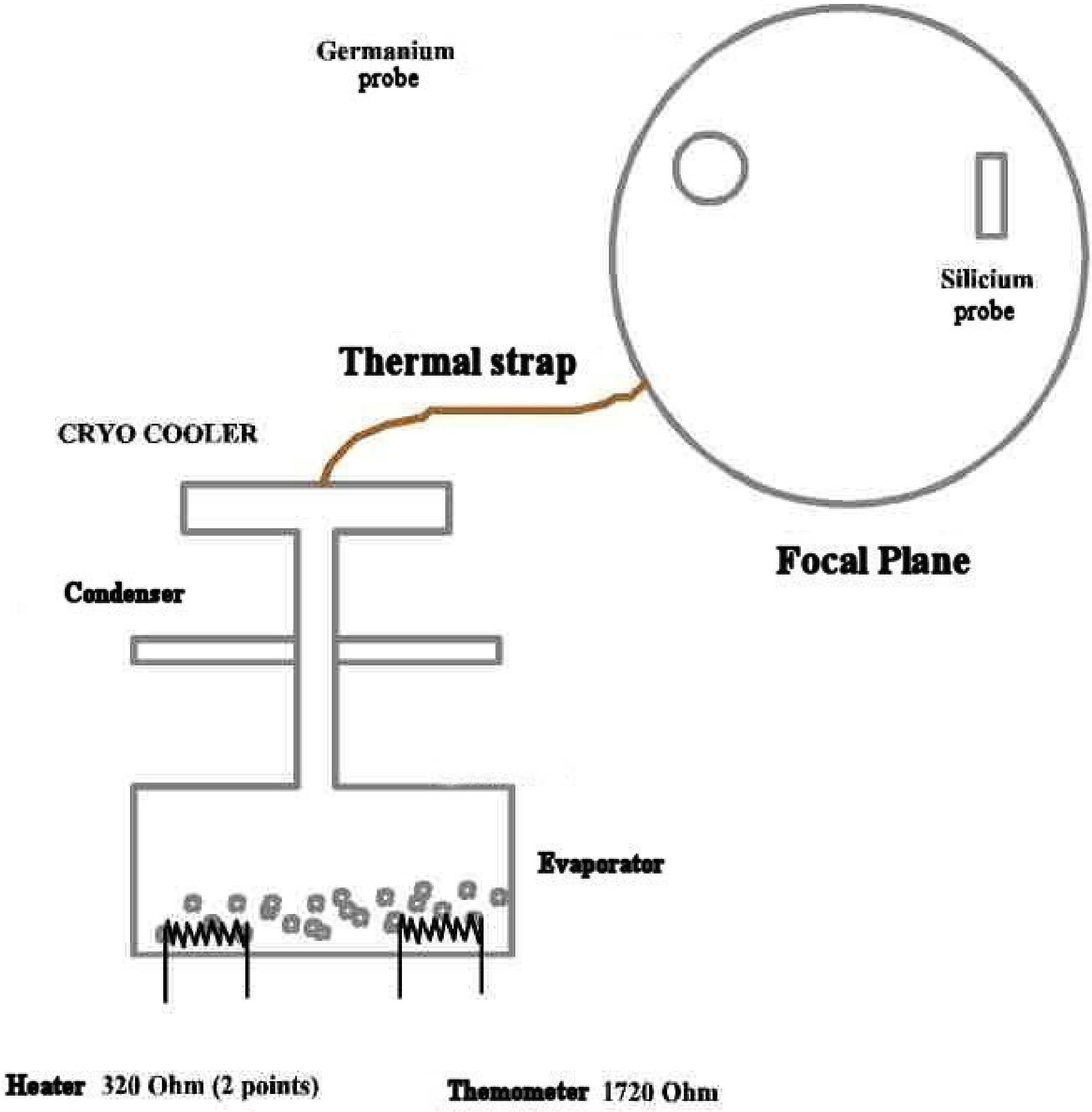
In this document, following the description of the test equipment, the principle of the measurements and the associated results are given.

3 Présentation of the cryogenic equipment

Once opened, the Baccus cryostat reveals its inner components used for the tests :

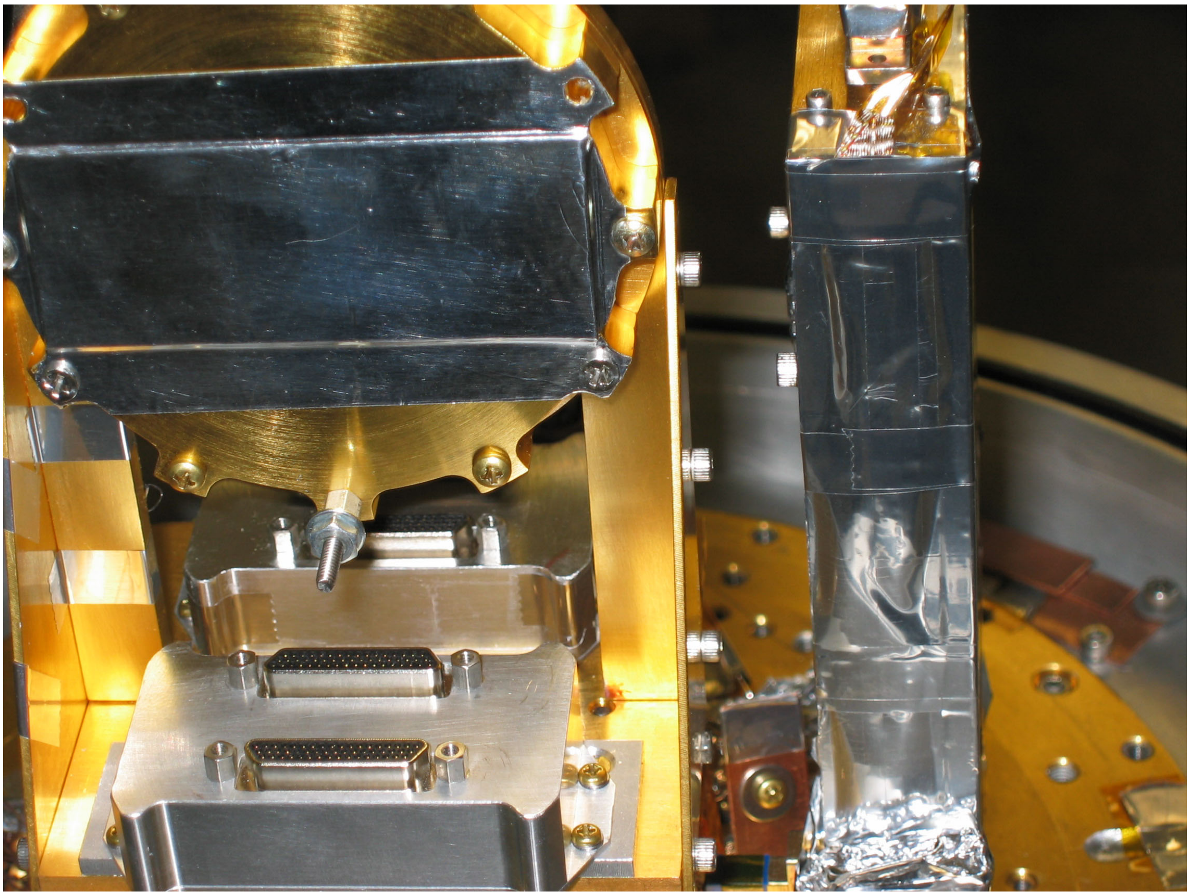
- The focal plane containing the bolometers,
- The cryo-cooler,
- The JFET box,
- The temperature / heater probes :
  - Focal Plane : Germanium + Silicium + heater (700 Ω),
  - Cryo refrigerator : Silicium (condensator) + Heater (320 Ω) + thermometry résistance (1700 Ω).
- The connections (detectors and probes).

Schematically, this gives the following configuration :



Schematic representation of the montage

The picture of the montage, with the main elements is proposed thereafter :



Picture of the montage

On this picture, we can see :

- at the upper left, the focal plane (cooled at 300 mK) containing the three (non illuminated) bolometers,
- at the bottom left, below the focal plane, the “box” containing the two resistors and the short circuit (we see the connectors on it),
- at the right part, the JFET box

Note that the electrical details of this montage are given on the electrical assembly diagram given in chapter 4 .

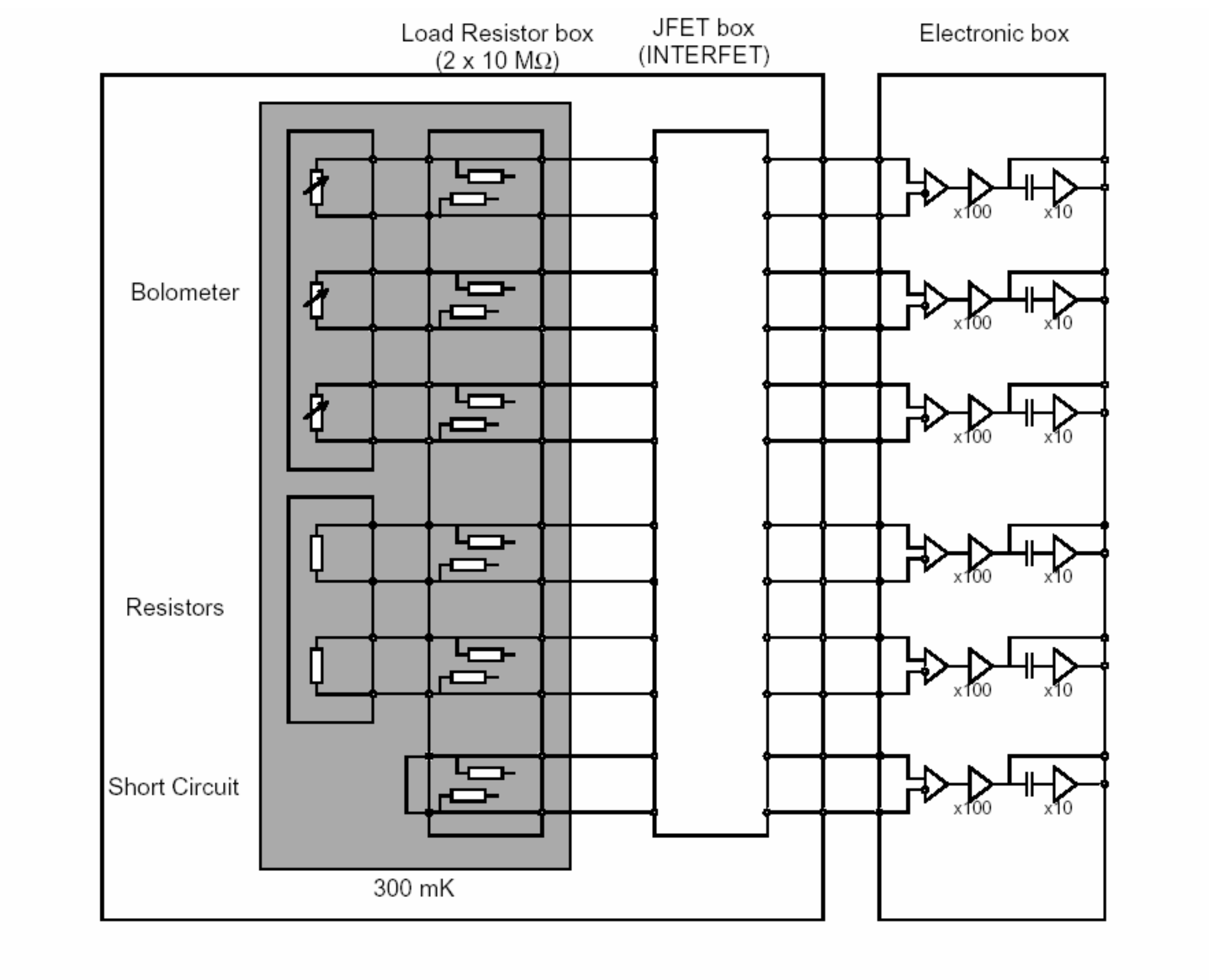
Electrical continuity measurements, performed with a dedicated electronic box, allow us to check the connections of all these equipments and to measure the bolometers resistances and resistors values. This will be detailed further.

4 Presentation of the electrical assembly

As already said, we have three bolometers and two resistances inside the cryostat. These will allow us to perform some performance measurements (especially noise). To perform data acquisition and measurements, we dispose of :

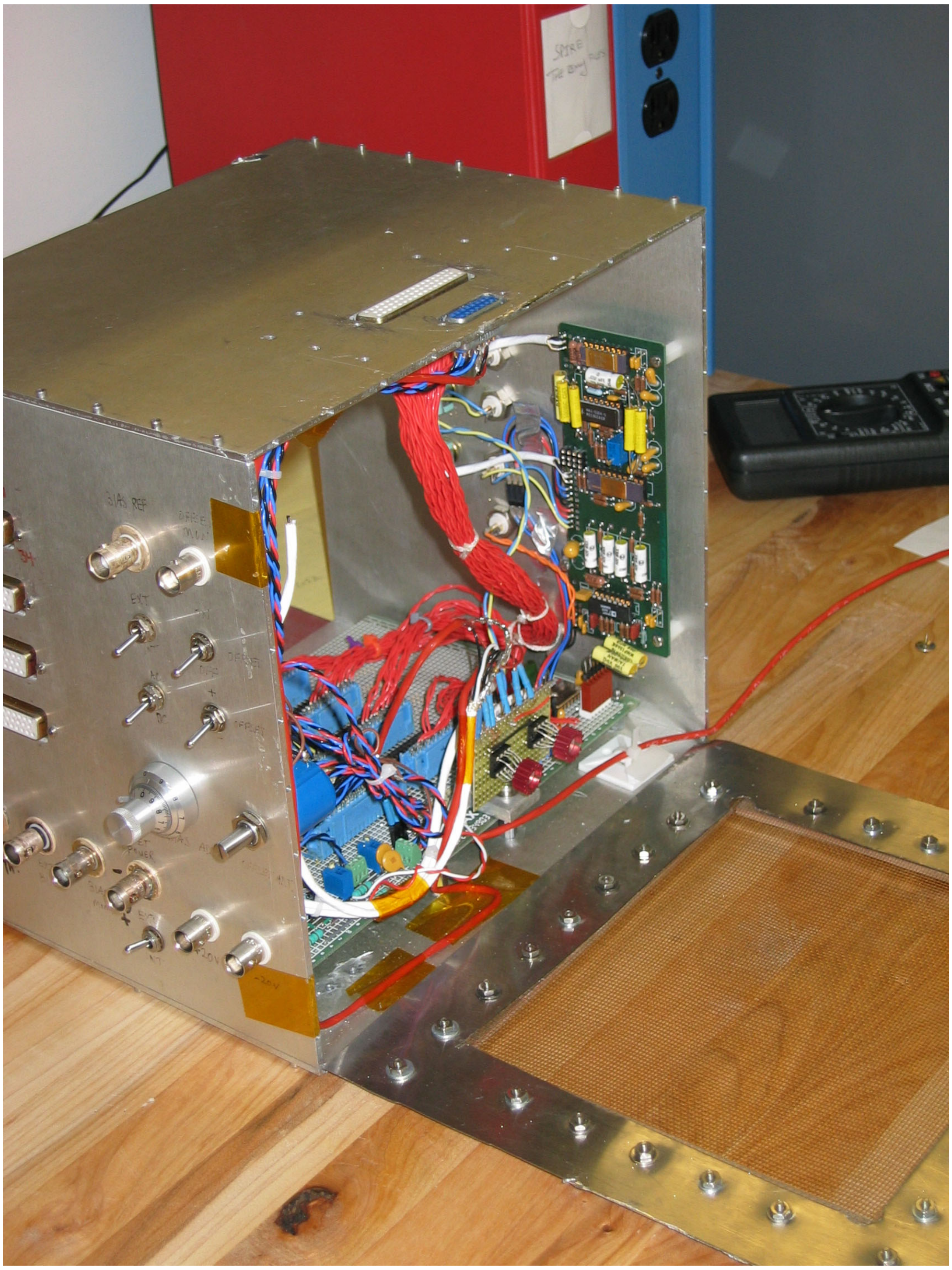
- the electronic box, provided by JPL (that allows to BIAS the bolometers and the resistors and to amplify and read the output signal),
- the DCU QM1.

The thereafter drawing shows the electrical assembly which is used (bolometers and resistors)



Electrical assembly diagram

A picture of the electronic box is given thereafter :



Picture of the JPL electronic box

5 Presentation of the electrical assembly

5.1 Measurements

We shall perform the following measurements :

- Continuity measurements : to test the continuity of the signals inside the cryostat and to measure bolometers resistances and resistor values. For this, we shall use the electronic box,
- Phase tuning measurements : When using the DCU we shall determine the optimal demodulation phase, that maximizes the output (demodulated) signal.
- Noise measurements on all the available channels (the two resistors, the three bolometers and the short circuit channel) to have an estimation of the noise using the DCU and to compare it with the same measurements performed with the electronic box at SAp. For this, we shall therefore use either the DCU or the electronic box with a spectrum analyser.

5.2 Continuity measurements

5.2.1 Principle

This measurement allows to check the electric continuity from the BIAS generation to the analog electronics input. This measurement has been performed regularly as the cryostat temperature decreases, the aim being to check the inner connections within the cryostat.

In addition, as detailed thereafter, these measurements allow to measure the bolometers resistances (depending on the temperature), and the resistors values.

5.2.2 Operating mode

Using the JPL electronic box, one needs to work in « DC BIAS » mode and to measure the continuous level at pre ampli DC output.
The continuous voltage at BIAS output is measured with a multimeter. The output voltage has been measured with BIAS levels of 0 mV and 10 mV.
We then obtain an output voltage variation which will depend on the resistor value on the corresponding channel (refer to the electrical assembly drawing); such measurements being performed on the 6 available channels : 3 bolometers, 2 resistors and one short circuit.

The resistance value of a bolometer or of any resistor can be determined using the following equation :

$$R = \frac{2 \cdot R_L \cdot \Delta V_S / G}{\Delta V_B - \Delta V_S / G}$$ (assuming the leak current in the amplification channel is negligible)

With R_L – Load resistor of the bolometers « bridge » = 10 MΩ

ΔV_B - bias variation = $|V_{B2} - V_{B1}|$ = 10 mV

ΔV_S – Corresponding output voltage variation = $|V_{S2} - V_{S1}|$

G : gain of the electronic box

For more details, refer to the diagram on page 7.

5.2.3 Continuity measurements results

The thereafter table shows the results of the measurements performed at Sap. The Focal Plane temperature reached was 2,4 ° K.

DC BIAS CHANNEL	0mV	10mV	R (Ohm)	Identified channel type
1	0,163	0,1699	138958,816	Bolometer 1
2	-0,216	-0,566	10769230,8	Resistor 1
3	0,207	0,215	161290,323	Bolometer 2
4	12,65	12,65	0	Bolometer (dead)
5	0,282	0,645	11397174,3	Resistor 2
6	-0,042	-0,042	0	Short Circuit

When the temperature decreases to 439 mK, we get the following results :

DC BIAS CHANNEL	0mV	10mV	R (Ohm)	Identified channel type
1	0,251	0,541	**8169014,08**	Bolometer 1
2	-0,192	-0,515	9542097,49	Resistor 1
3	0,297	0,022	**7586206,9**	Bolometer 2
4	12,65	12,65	0	Bolometer (dead)
5	0,43411	0,76	9668748,42	Resistor 2
6	-0,029	-0,029	0	Short Circuit

The results obtained at Boulder were :

DC BIAS CHANNEL	0mV	10mV	R (Ohm)	Identified channel type
1	0,41903	0,1966	**5721156,94**	Bolometer 1
2	-0,1476	-0,4665	9364263,69	Resistor 1
3	0,3783	0,6101	**6034886,75**	Bolometer 2
4	1,049	1,209	3809523,81	Bolometer 3
5	0,6538	0,9743	9433406,92	Resistor 2
6	0,01508	0,01508	0	Short Circuit

Note that, in Boulder, we reached the temperature of 300 mK.

The measurements show that, one of the bolometer channel (4) behaves like a short circuit. We called it “dead bolometer”. In addition, we find a resistance value for the bolometer channels around 8 MOhm whereas, in Boulder, we found approximately 6 MOhm.

5.3 Phase measurements

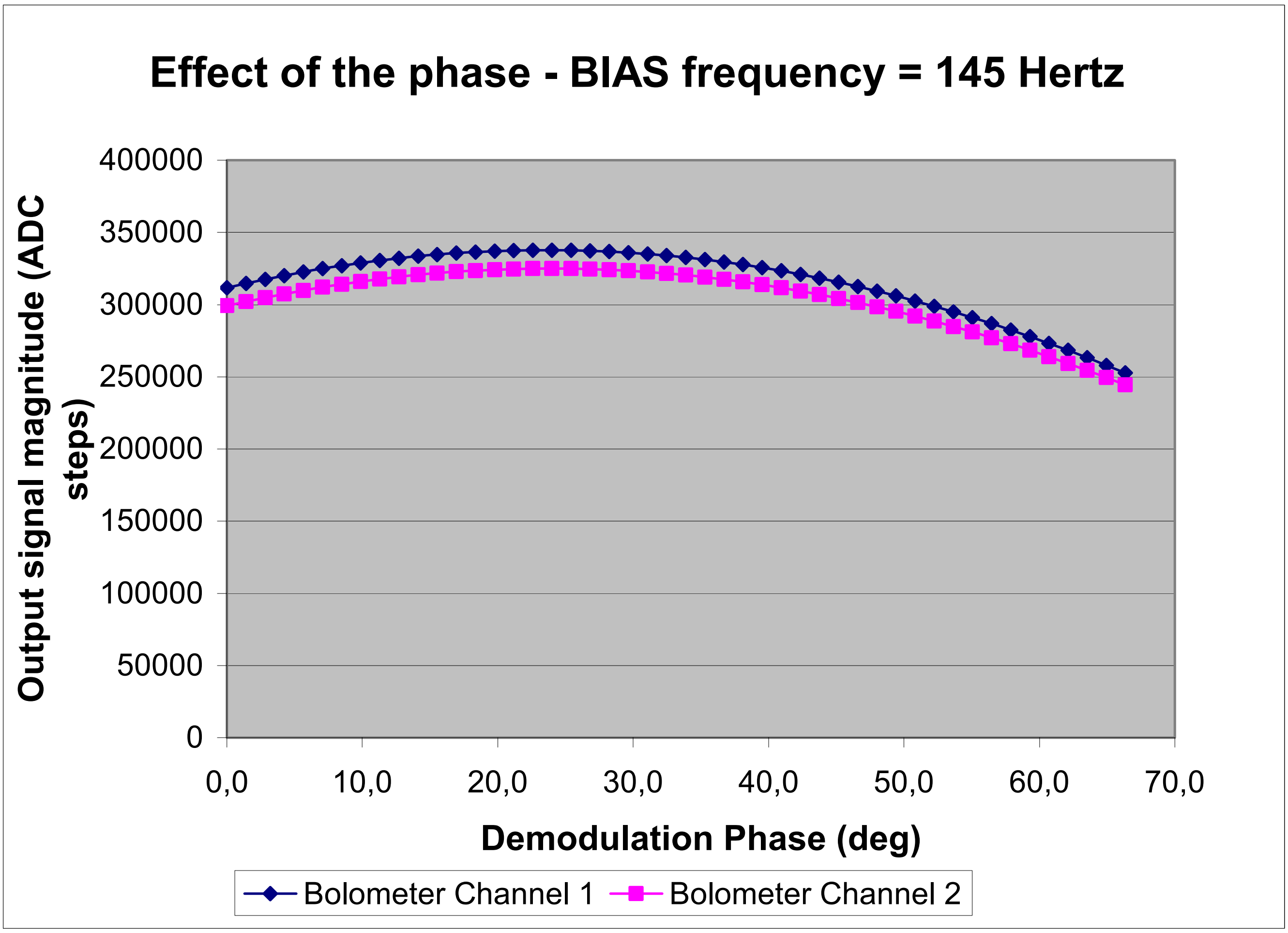
During phase measurements, we used the cryostat, with the focal plane cooled at about 400 mK, and the DCU.

The purpose of the phase measurements tests is to get the optimal phase parameter associated with a given BIAS frequency; this tuning will be used further for noise measurements.

For a given BIAS frequency, we vary the phase of the demodulation signal and check the output signal magnitude.

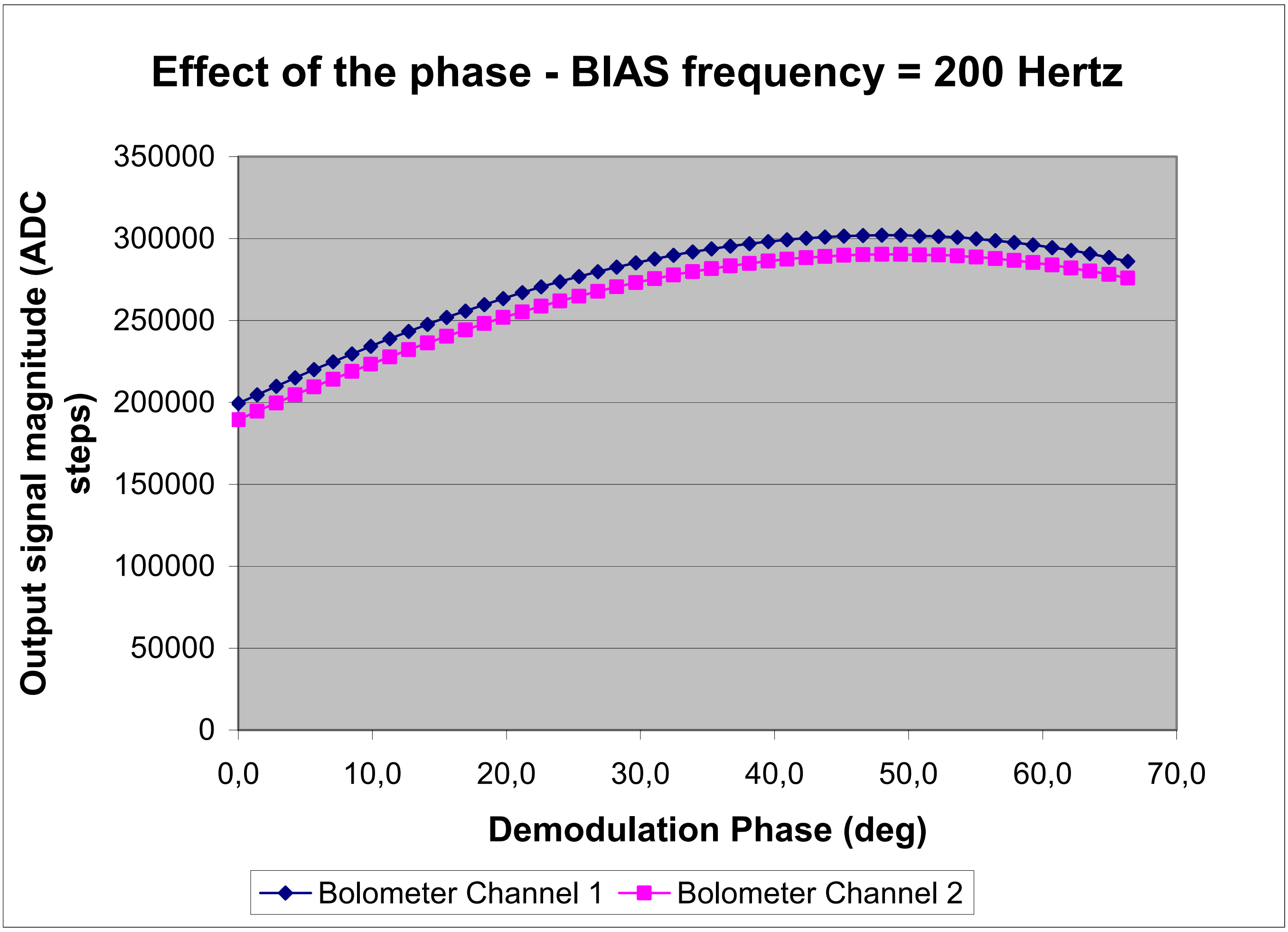
The results are the following :

Using a BIAS frequency equal to 145 Hz, we obtain :



We see that, for BIAS frequency = 145 Hz, the optimal demodulation phase is around 25.4 deg. It is the value that will be set during noise measurements.

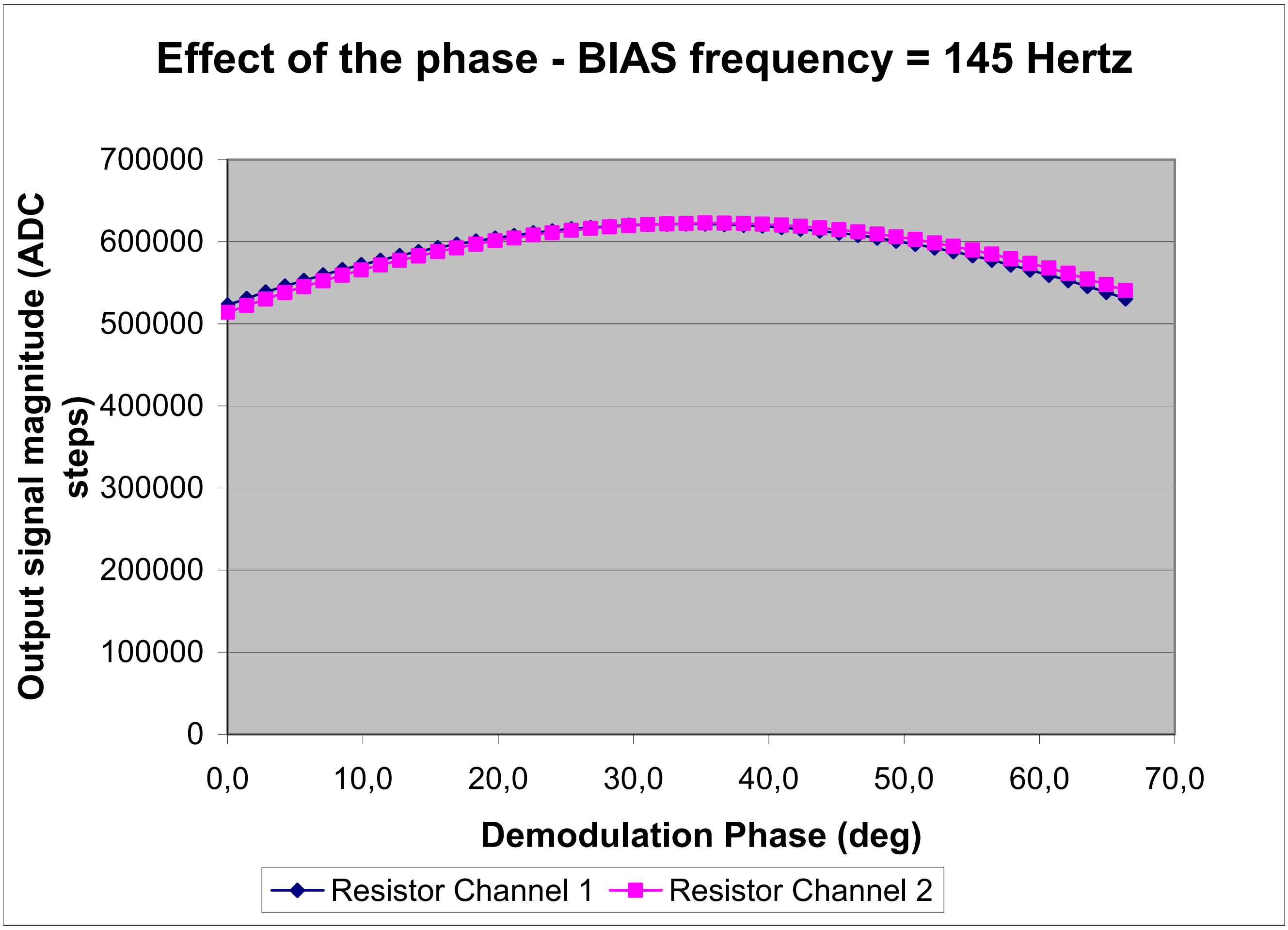
Using a BIAS frequency equal to 200 Hz, we obtain :



We see that, for BIAS frequency = 200 Hz, the optimal demodulation phase is around 49.4 deg. It is the value that will be set during noise measurements.

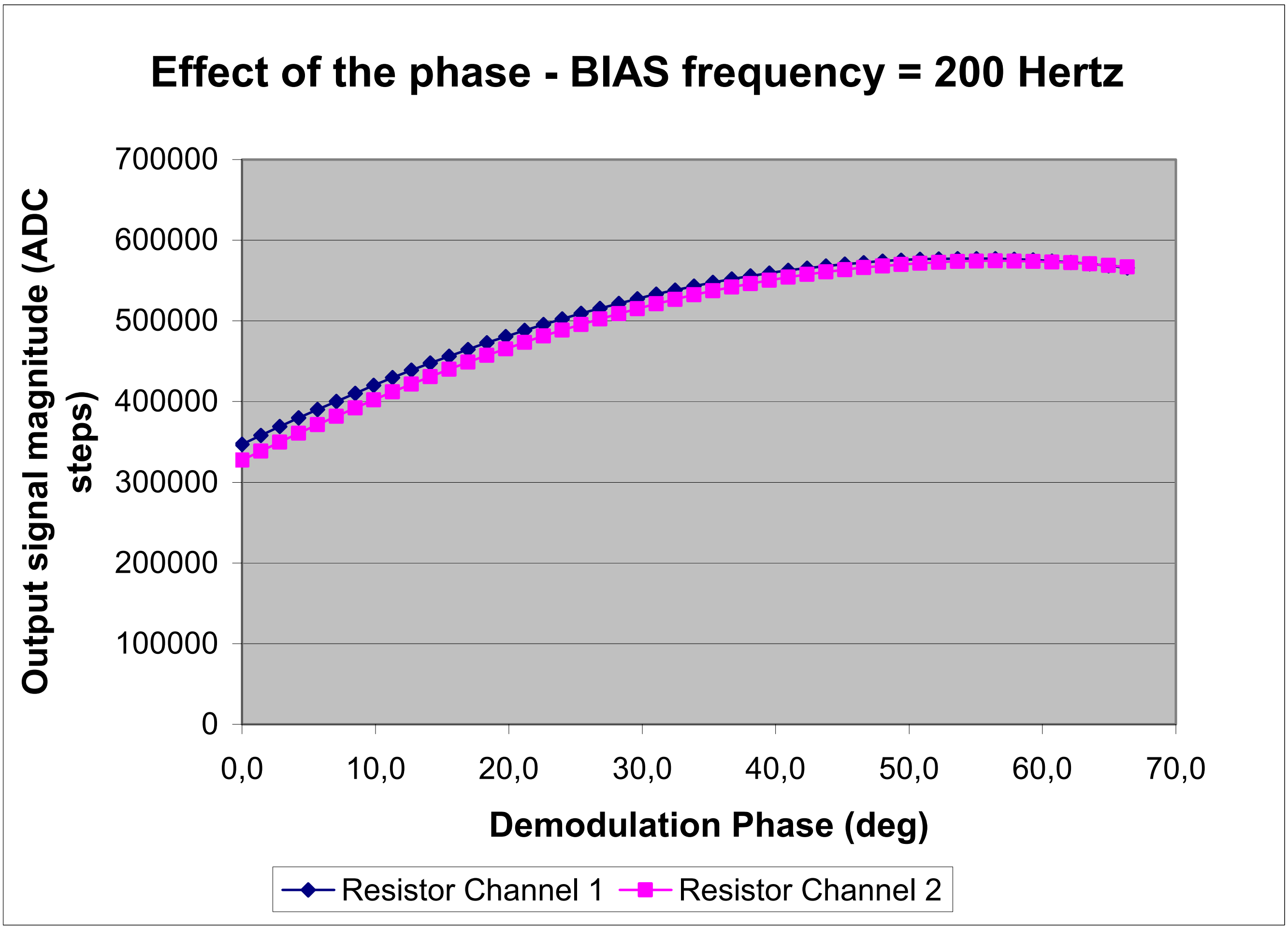
The same measurements have been performed on the resistor channels, which gives the following results :

Using a BIAS frequency equal to 145 Hz, we obtain :



We status that the optimal phase is not the same as for the bolometers. However, during noise measurements, we will perform the measurements with the optimal phase determined for the bolometters.

Using a BIAS frequency equal to 200 Hz, we obtain :



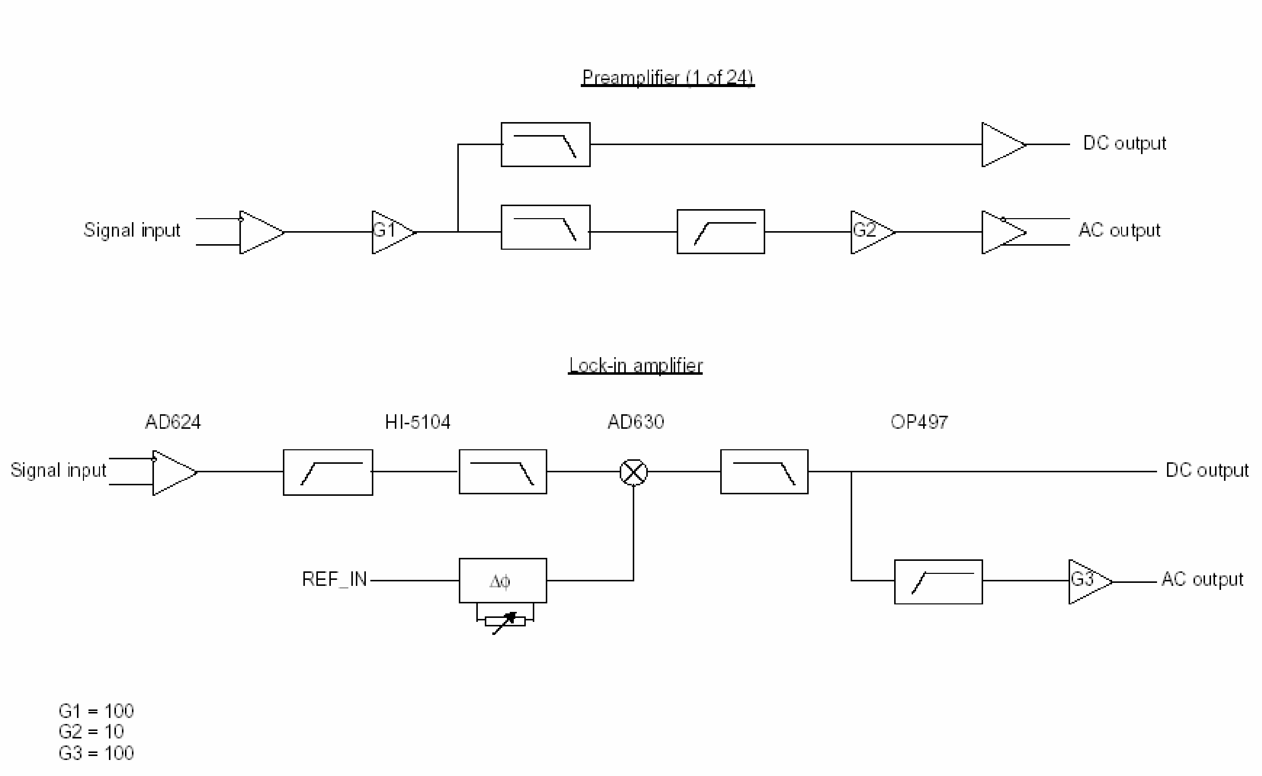
We status that the optimal phase is not the same as for the bolometers. However, during noise measurements, we will perform the measurements with the optimal phase determined for the bolometters.

5.4 Noise measurements

The focal plane being still cooled around 400 mK, we determine the overall noise using either the DCU or the electronic box.

For this, when using the DCU, we set the demodulation phase at the value, determined during the previous tests, which depends on the BIAS frequency.

The electrical scheme of the overall signal processing is the following :



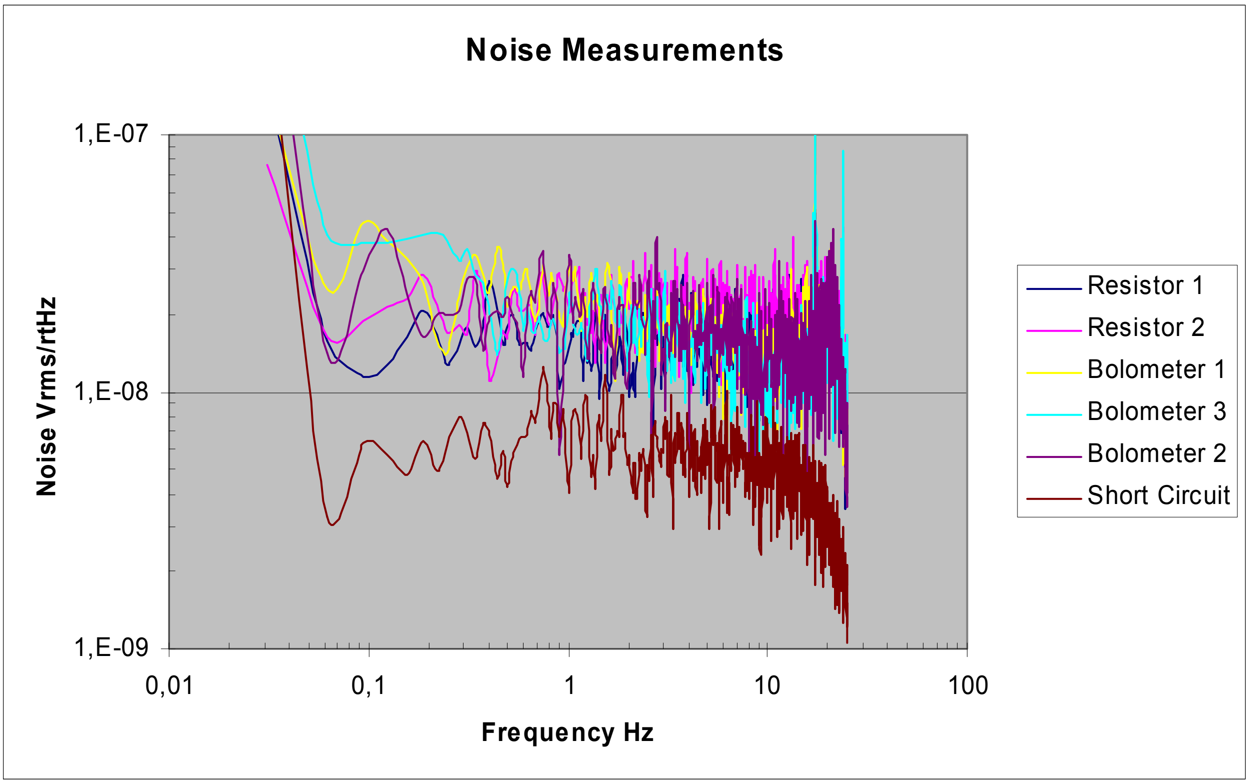
The following paragraphs detail the noise measurements obtained with the electronic box (at Boulder and at SAp) and with the DCU.

5.4.1 Measurements with the electronic box at Boulder

The noise measurements performed at Boulder on 27/02/2003 with the electronic box give the following results :

These noise measurements can be considered as reference ones.

The results come from a spectrum analyser.



The BIAS frequency equals 148 Hz

The temperature at which these measurements were performed was 286 mK.

We observe that :

- we have a white noise structure from 0.1 Hz to the maximum operating frequency range,
- the magnitude of the noise is about 30 nV/sqrt(Hz),
- the short circuit channel shows a significantly lower level which corresponds to the BIAS plus analog electronics noise (< 10 nV/sqrt(Hz)).

5.4.2 Measurements with the electronic box at Sap

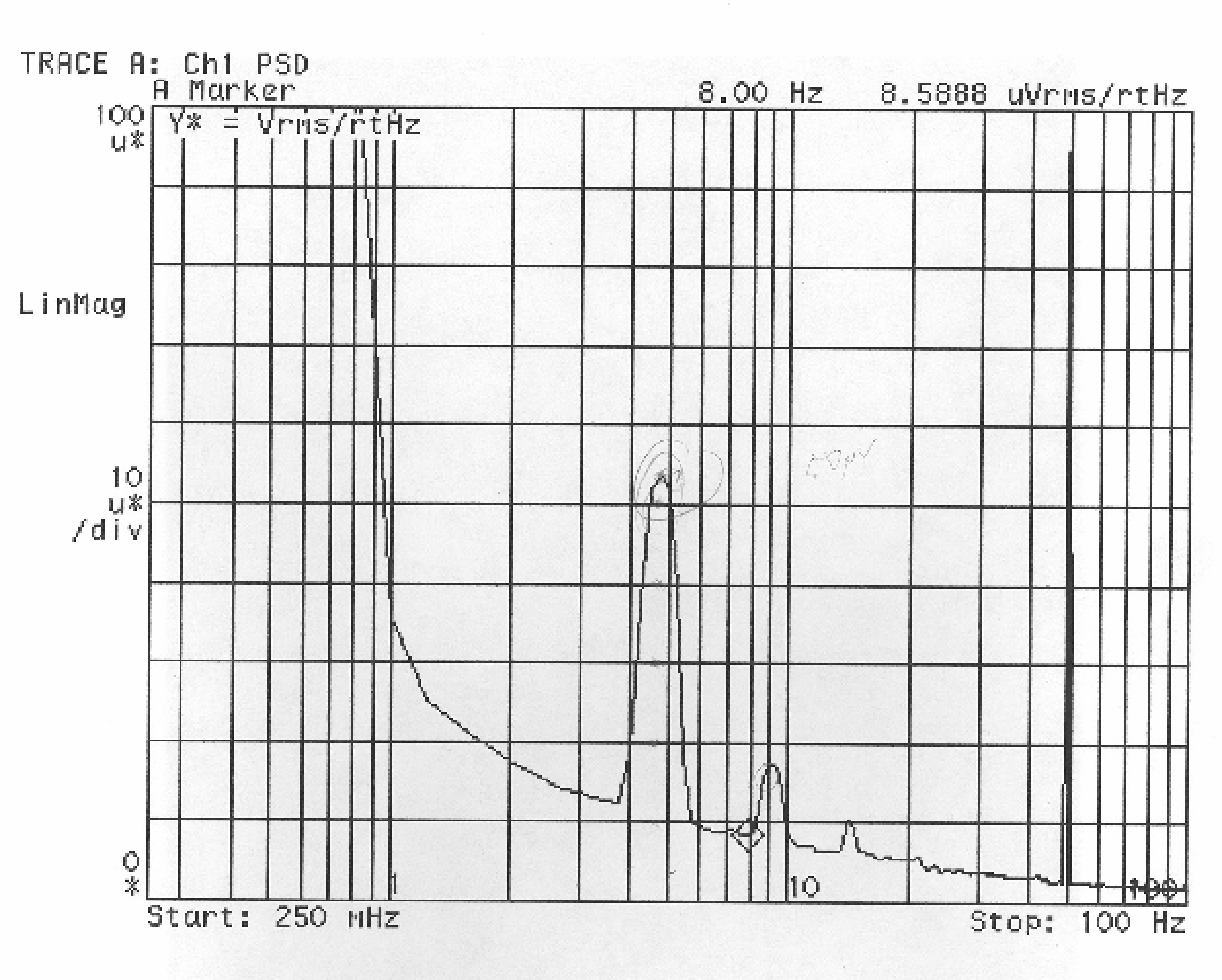
The same measurements have been performed with the JPL electronic box at SAp, using a spectrum analyser to plot the noise graphics.

The BIAS frequency equals 145 Hz.

The BIAS magnitude depends on the channel to avoid saturation problems.

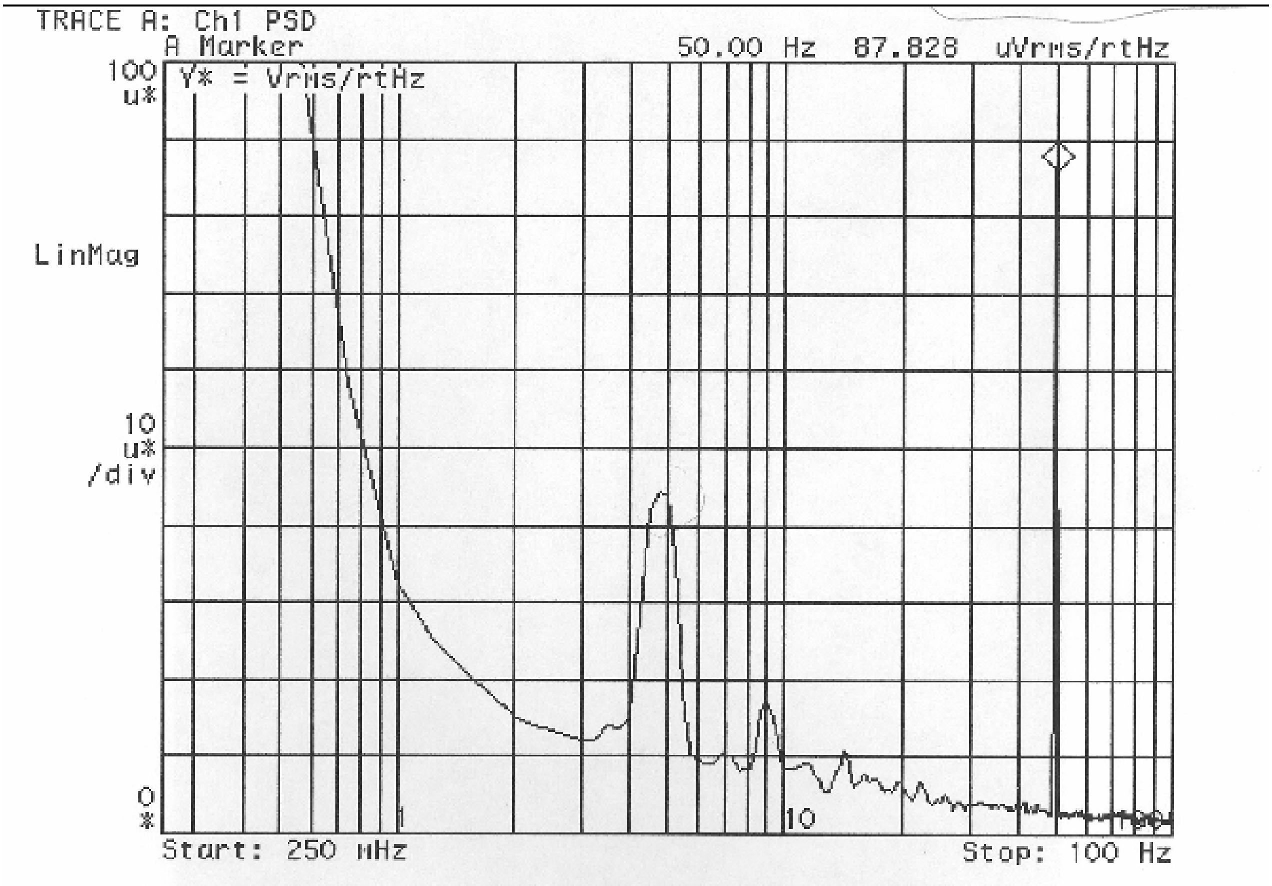
In the following plots, the measurements are relative to an absolute level at electronic box output. These measurements have therefore to be divided by the gain (1000) to get the noise at bolometers, resistors or short circuit level.

Bolometer Channel 1



Bolometer Channel 1, BIAS : 4,5 mV (0,25 to 100 Hz)

Bolometer Channel 2

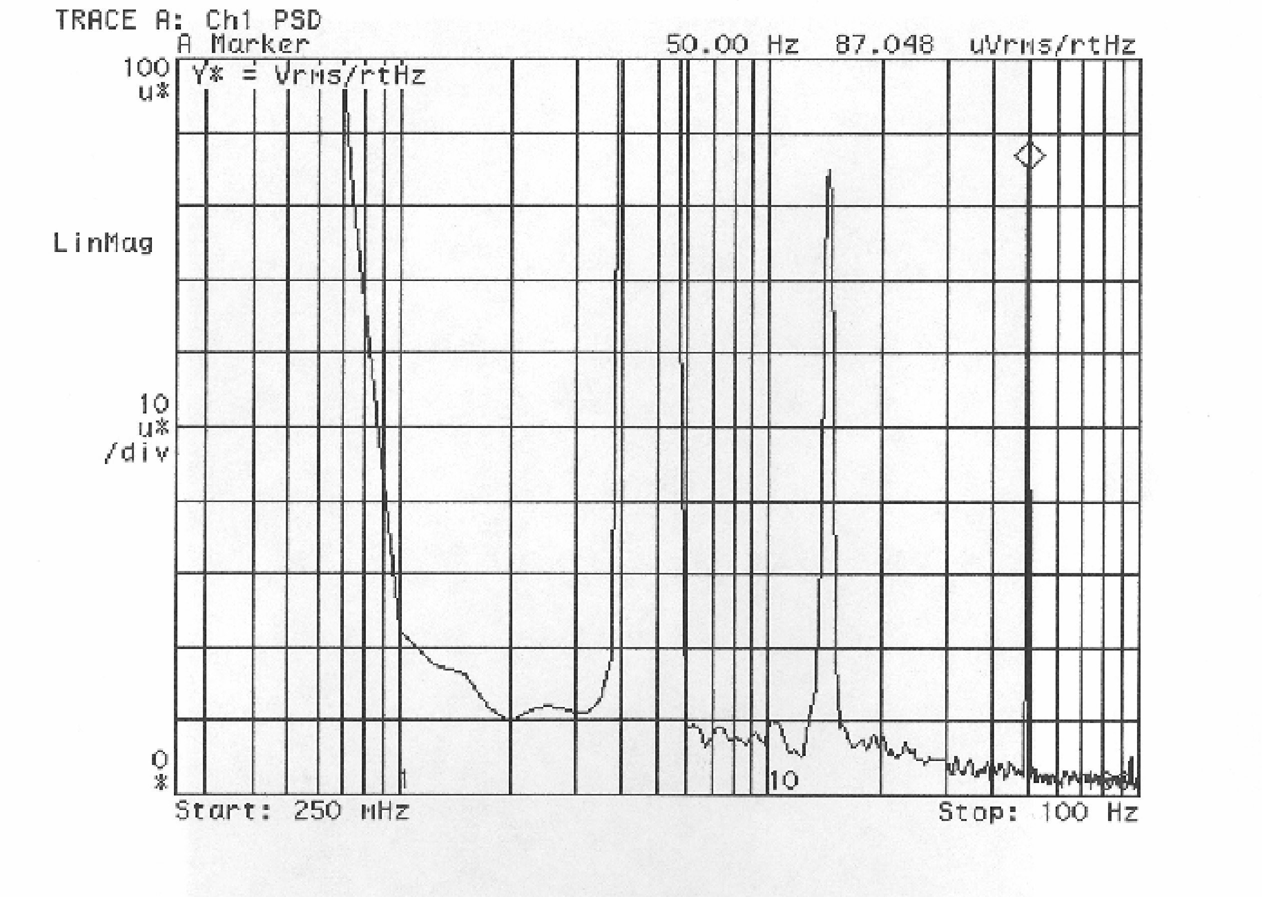


Bolometer Channel 2, BIAS : 10 mV

On bolometers channels, we observe pics (4,5 Hz, 9 Hz, 15 Hz …) the coupling between the BIAS frequency and the main supply frequency (50 Hz). We also observe the 50 Hz pic.

The noise level is about 10 nV/sqrt(Hz) in the frequency range. However, we also observe wide 1/f noise component below 1 Hz. This may have to be confirmed by further measurements.

Resistor Channel 2

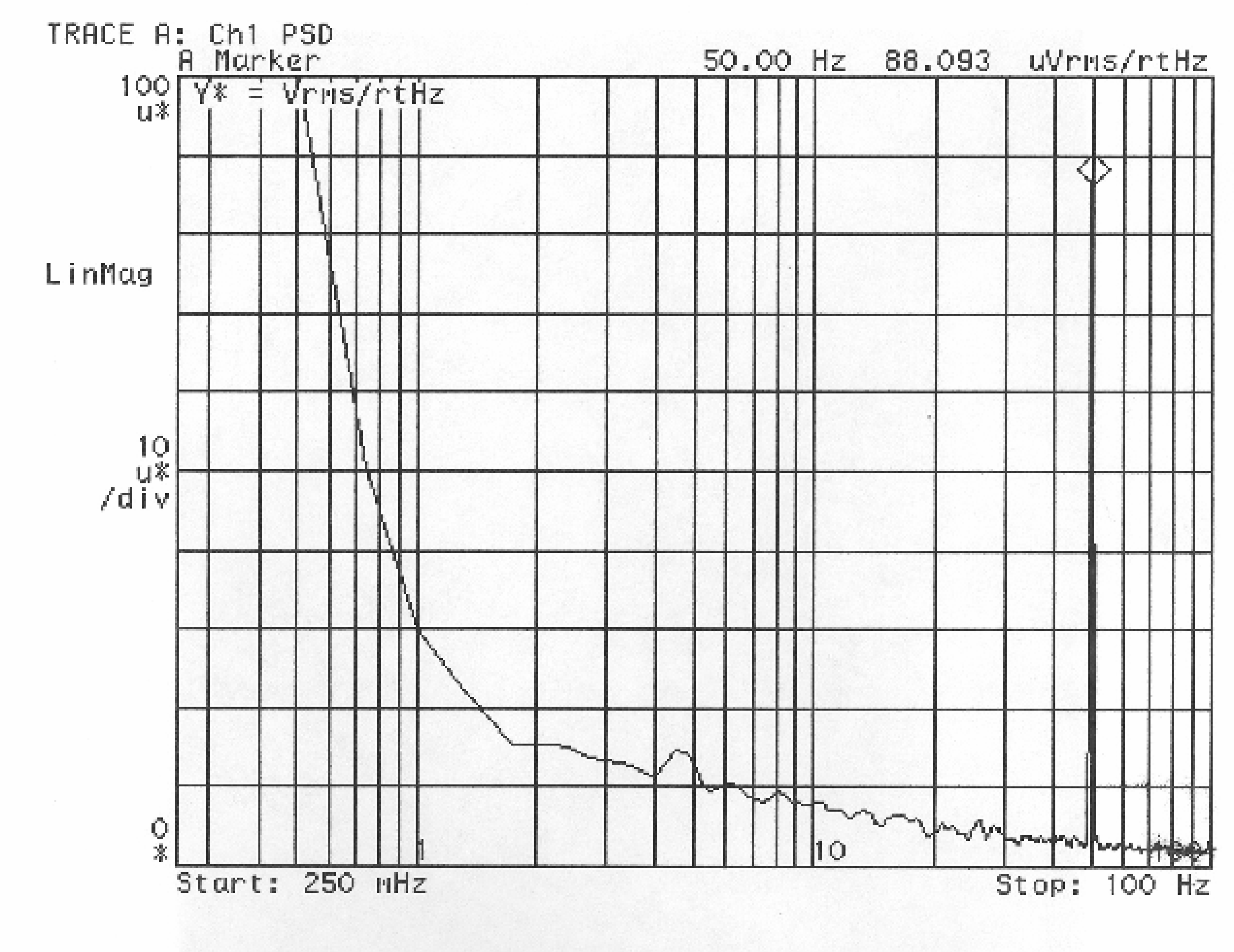


Resistor Channel 2, BIAS : 10 mV

On resistors channels, we observe pics (4,5 Hz, 9 Hz, 15 Hz …) the coupling between the BIAS frequency and the main supply frequency (50 Hz). We also observe the 50 Hz pic.

The noise level is about 10 nV/sqrt(Hz) in the frequency range. However, we also observe wide 1/f noise component below 1 Hz. This may have to be confirmed by further measurements.

Short Circuit



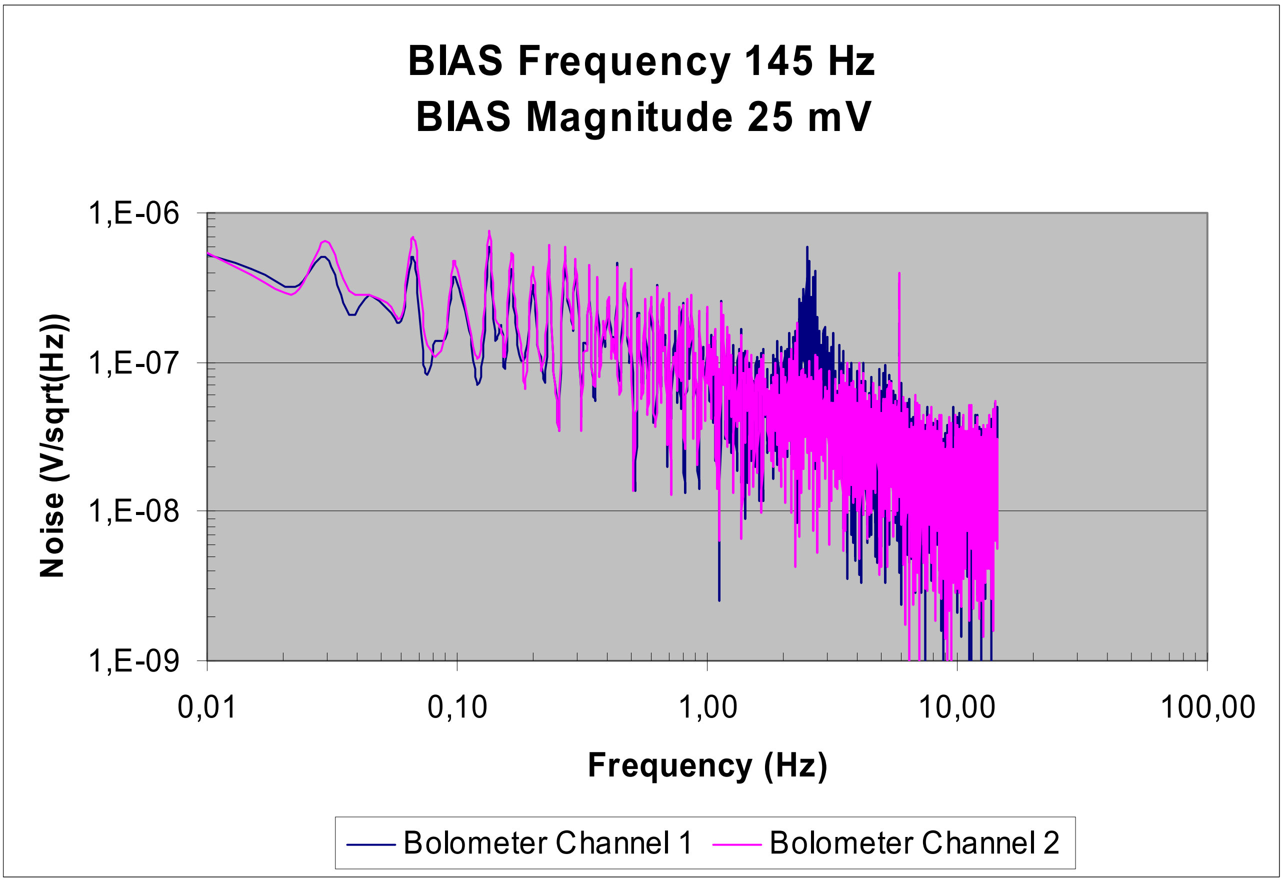
Short Circuit Channel, BIAS : 10 mV

The noise spectrum has the same shape as for bolometers except pics due to the coupling between the main supply and the Bias frequencies that do not appear.

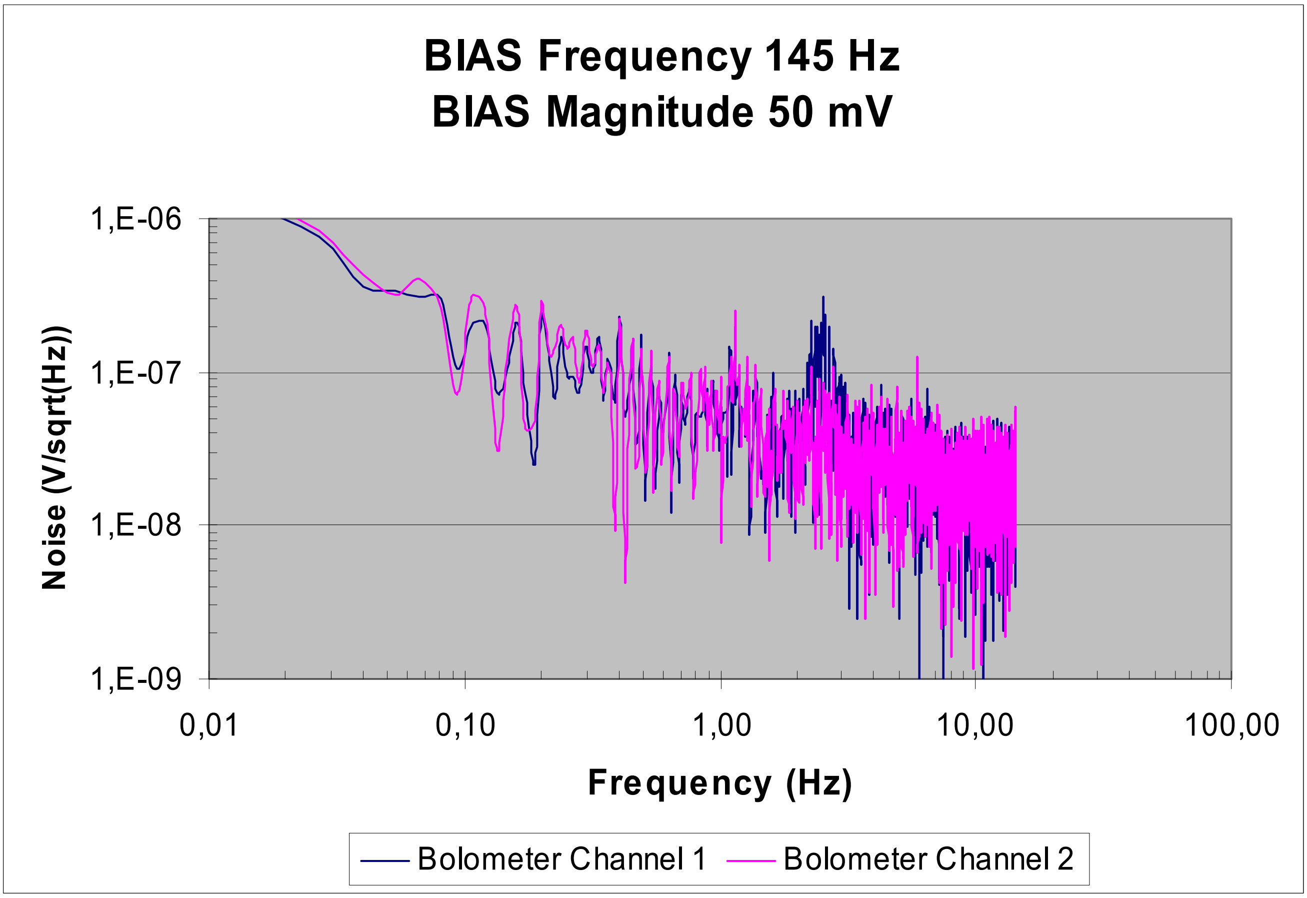
5.4.3 Measurements with the DCU

We plot the digital data coming from the DCU to represent the noise on the resistor channels, the bolometers channels (the two which are functional) and the short circuit. We perform these measurements setting two different values of BIAS magnitude (DCU amplification parameters 32 and 64).

Using the DCU with a BIAS frequency equal to 145 Hz, the results on the bolometers channels are the following :



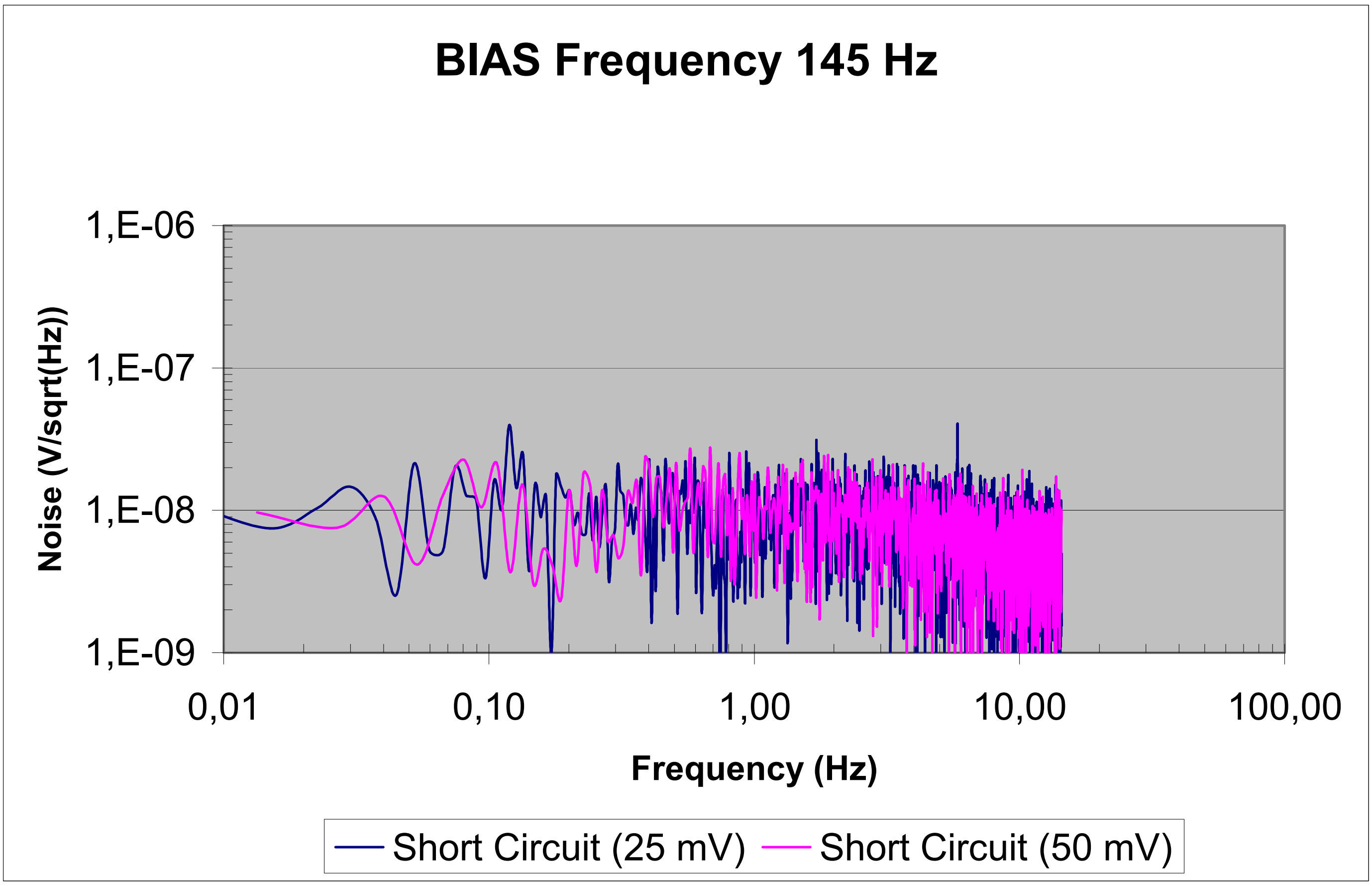
We observed that the magnitude of the signal DC level drifts (as time varies), which may explain the high value of the low frequency noise we see on that graphic.



We observed that the magnitude of the signal DC level drifts (as time varies), which may explain the high value of the low frequency noise we see on that graphic.

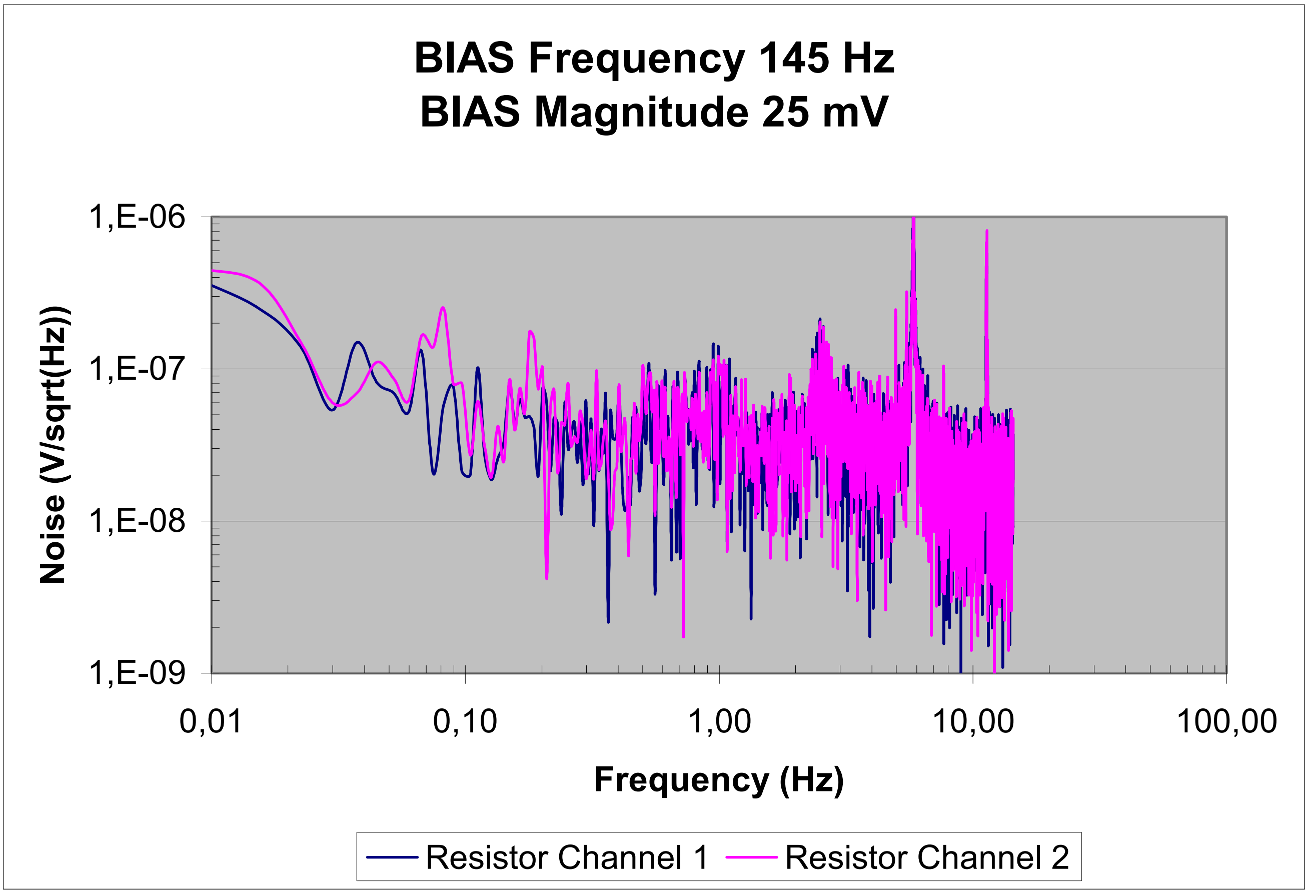
We obtain the same results as those obtained with another BIAS magnitude. This means that the noise is not dependent on the Bias magnitude and that the observed low frequency noise (drift phenomenon) is not linked with the BIAS signal itself.

Noise measurements on the short circuit channel give the following results (two BIAS input BIAS levels have been tested) :



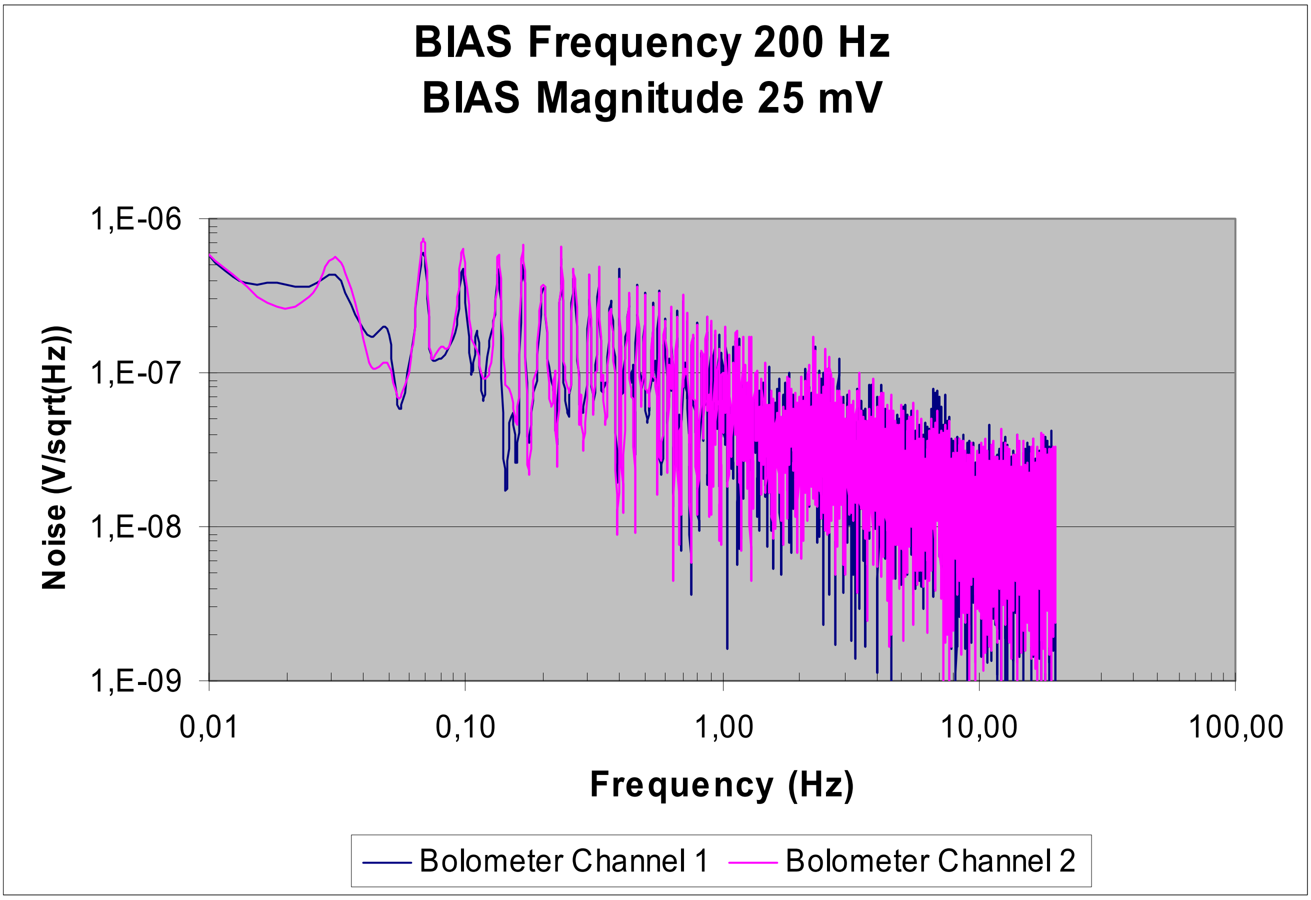
We here notice that the noise is consistent with the measurements obtained with the JPL electronic box.

Noise measurements on the resistor channels give the following results :

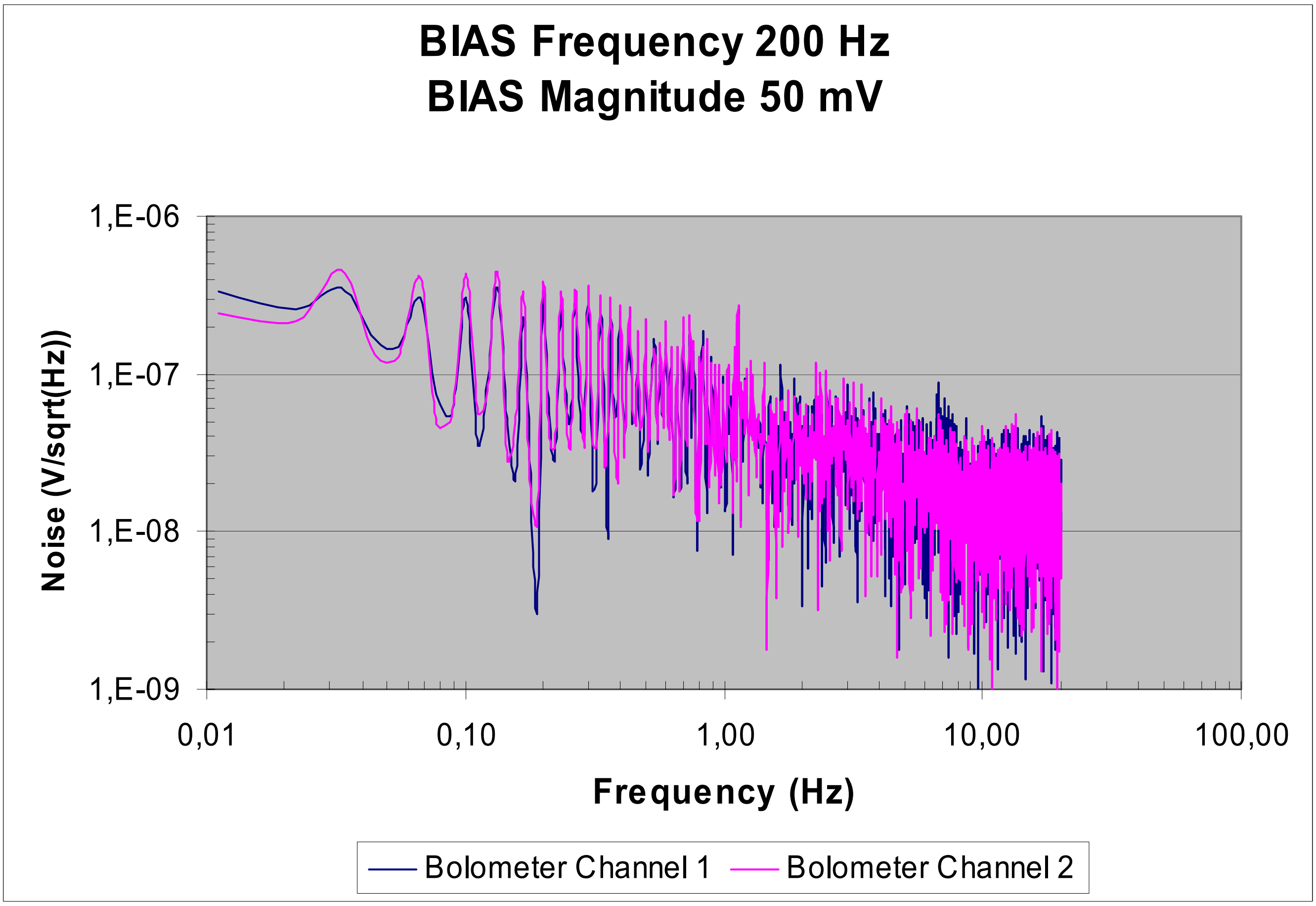


- We observe no 1/f noise,
- The mean noise level is about 100nV/sqrt(Hz)

Using the DCU with a BIAS frequency equal to 200 Hz, the results on the bolometers channels are the following :



The results we here obtain are almost the same as those observed with a BIAS frequency of 145 Hz, which indicates that the BIAS frequency has no influence on the results.



The results we here obtain are almost the same as those observed with a BIAS magnitude of 25 mV, which indicates that the BIAS magnitude has no influence on the results.

6 conclusion

The main difference with respect to JPL measurements is the low frequency noise which is higher when using the DCU.

The low frequency noise seems to be due to DC level drifts (as time varies). One explanation may be that the temperature level of focal plane was not well stabilized (we only reached 400 mK instead of the expected 300 mK)

Following the tests, we noticed that the filtering of the reference voltage used to generate the offset is not properly achieved, which raises an additional noise.