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- TECHNOLOGY DEVELOPMENT -

ESO/NAOJ Cryofacility Dry Run Report

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1 Change Record

Version	Date	Affected sections	Reason
A	10/01/2016	All	Draft version

2 Applicable and reference Documents

2.1 Applicable documents

AD-1.	B2+3 Warm Test Baseplate ICD	iALMA-TEC-ICD-IAB-001-G	28/10/2015
AD-2.	iALMA Cryofacility dry-run specifications	iALMA-TEC-SPE-IAB-001-A	21/11/2014
AD-3.	Cryostat Design Report	FEND-40.03.00.00-007-A-REP	2005
AD-4.			
AD-5.			

2.2 Reference documents

REF1.	ALMA Band 2(+3) Cryogenic Design Report	Report	2013
REF2.			
REF3.			
REF4.			

3 Table of content

4 Introduction and Scope

A cryostat, developed by NAOJ, reproducing the ALMA crystat interfaces has been provided to the CryoWaves Lab in order to perform preliminary integration and functionality cryogenic test of the Band 2+3 prototype cartridge.

Scope of this document is

(i) To describe the configuration of the NAOJ Cryostat at CryoWaves Lab at INAF-IASFBO

(ii) To report about the results of such cryostat dry run and preliminary run with the cartridge prototype installed in.

5 Dry Run Setup

The cryostat built-in equipment provided consists of:

- a 3-stage 4K cooler cold head by Sumitomo Heavy Industries;
- a set of four temperature sensors (LakeShore DT670) monitoring temperatures of the different stages of the cryostat, one sensor each for the 100 K and 20 K stage and two sensors for the 4K stage;
- a LakeShore 218 temperature monitor for reading temperature sensors and a connecting cable;
- a Granville-Philips micro-ion vacuum gauge to monitor cryostat pressure

Additional equipment available at CryoWaves Lab has been used:

- a Sumitomo Heavy Indudstries compressor model F50-H to feed RDK cold head;
- a scroll pump by Edwards, model XDS5;
- a turbo-molecular pump by Edwards Vacuum, model EXT75DX;
- a Turbo Instrument Controller and pressure sensor reading by Edwards Vacuum;
- A pirani gauge APG by Edwards Vacuum;
- A LakeShore 340 temperature controller

The list of sensors and locations are described in the table below.

Id	Sensor	Location
A	DT670	100K flange
B	DT670	20K flange
C	DT670	4K flange
D	DT670	4K cold head

Table 1 The table reports the readout channel Id, the type of the sensors and the position inside the chamber.

A set of three heaters are also located on the different temperature stage flanges to be used for warm up speeding up.

6 First Dry Run data

After setting up the chamber with all the dedicated equipment a first dry run was performed with the dummy cartridge contained in the cryostat at its delivery to INAF-IASF Bologna.

It was closed and sealed in the afternoon of November, 3rd 2016, and pumped down all night long by the scroll pump until it reached a pressure of $2.3 \cdot 10^{-2}$ mBar in the morning of November, 4th 2016, when the turbo pump was activated. After the pressure dropped down below 10^{-4} mBar, on November, 4th 2016, 14:30 CET, the cooler was activated and cooldown started.

On November, 5th 2016, 17:30 CET, after sensor reading reached the minimum values reported in the table below, the cooler was switched off and the warm up started.

Id	Min T reached [K]
TA	65.173
TB	9.482
TC	1.619
TD	1.891

Unfortunately the acquisition failed during the run so that the whole temperature curves were lost, so an additional cooldown-warmup cycle was performed. This second cycle was started when the temperature of the different sensors were as displayed in the table below:

Id	2nd cycle Starting T [K]
TA	281.0
TB	260.25
TC	267.9
TD	259.6

The second cycle curves are reported in the figures below. From the temperature curves it is evident that the coldest stages reached quickly their operating temperatures in less than 9 hours, while the warm up times are very long due to passive heating with no active heaters used to speed up the things. The details of the timescales are reported in the table below where the steady state low temperatures are reported together with the time spent to reach them. Also the time it took for each sensor to reach 280 K in the warm up is reported:

Id	Steady low T [K]	Cooldown Time (hours)	Warmup Time (hours)
TA	65.173	21.25	64.9
TB	9.482	18.4	80.5
TC	1.619	7.8	86.1
TD	1.891	7.8	87.5

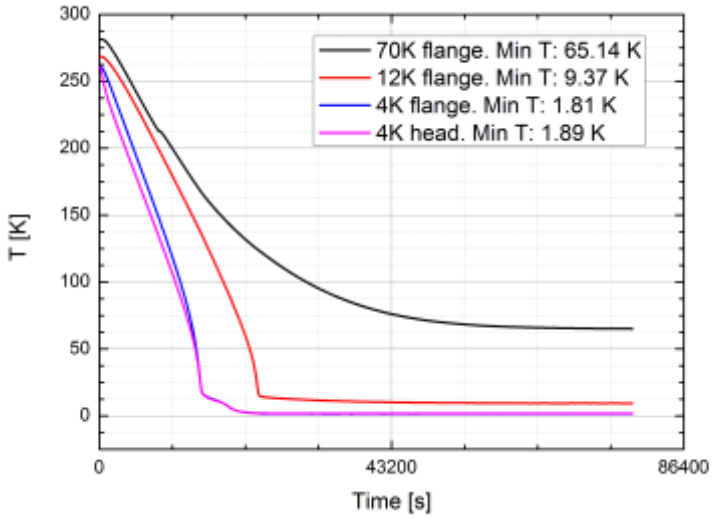

Figure 1 The overall behaviour of the different temperature stages during the second cycle cooldown of the NAOJ cryostat dry run. The coldest stages reached the operating temperatures in about nine hours while the 100 K stage reached a steady final temperature of about 65 K in about 20 hours.

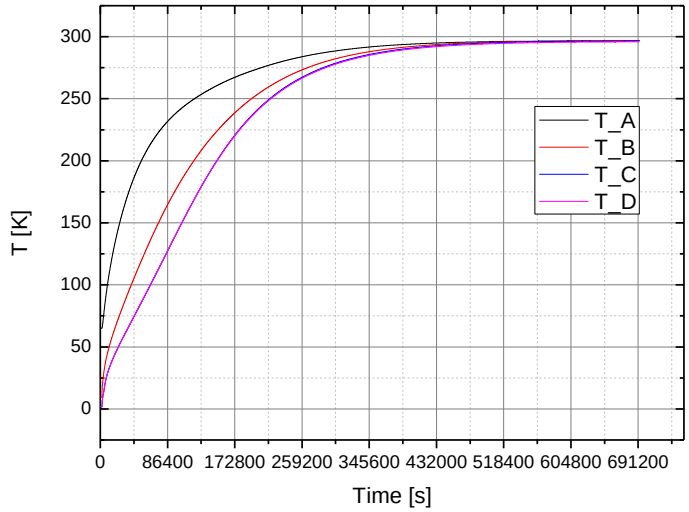

Figure 2 The overall behaviour of the different temperature stages during the second cycle warm up. With no active procedure applied to speed up the process, the passive warm up allowed all the stages temperature to reach 280 K in about four days.

7 Second Dry Run data

A second dry run was performed with the Band 5 cartridge interfaces mounted in the chamber.

It was closed and sealed in the afternoon of November, 24th 2016, and pumped down by the scroll pump until it reached a pressure of $1.4 \cdot 10^{-1}$ mBar on November, 24th 2016, 19:30 CET, when the turbo pump was activated. After the pressure dropped down to $5.4 \cdot 10^{-4}$ mBar, on November, 24th 2016, 19:38 CET, the cooler was activated and cooldown started.

The cooldown temperature curves are reported in the figure below. Unfortunately the acquisition failed during the night so the only cooldown time that could be monitored was the 4 K stage that reached a steady state temperature of about 2 K in 7.9 hours, a value in line with the previous data. In the first part of the warm up the heaters in the 4 K and 20 K stage were activated so that the warm up was shorter than the first dry run case; this time all the stages reached a temperature of 280 K in about three days.

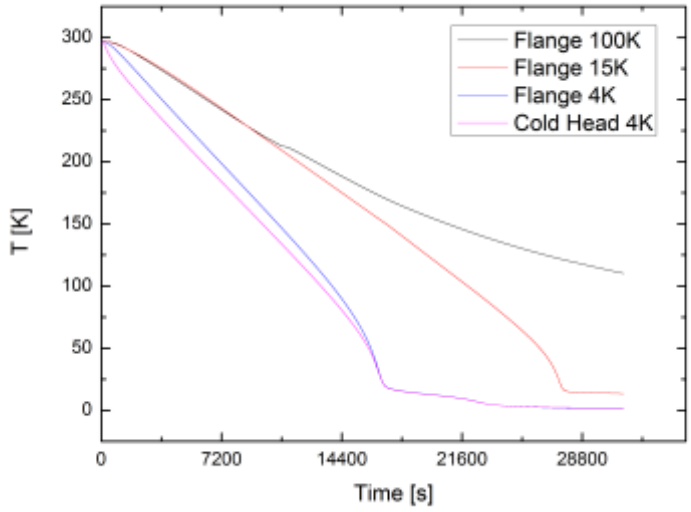

Figure 3 The overall behaviour of the different temperature stages during the second dry run cooldown of the NAOJ cryostat. The final part of the cooldown was not monitored due to a failure in the acquisition.

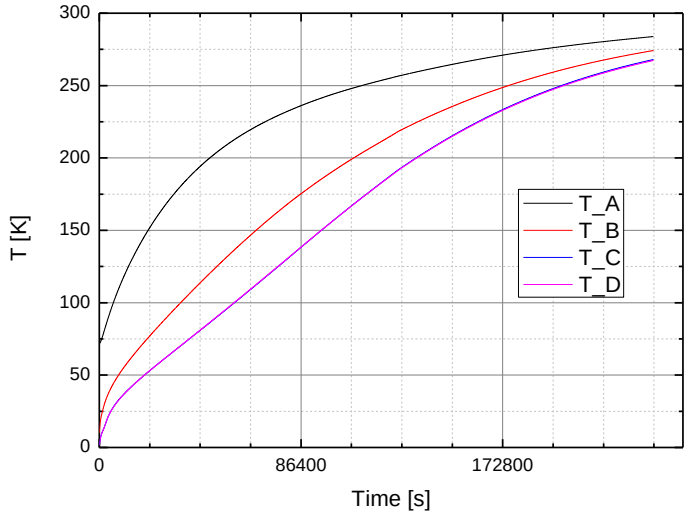

Figure 4 The overall behaviour of the different temperature stages during the second dry run warm up. During the first part of this warm up the heaters were activated in the coldest stages so that the time spent warming was shorter.

A second cycle was performed for this second dry run also.

The cryostat was closed and sealed on November, 29th 2016, 12:30 CET, and pumped down by the scroll pump until it reached a pressure of $2.7 \cdot 10^{-2}$ mBar on November, 30th 2016, 9:50 CET, when the turbo pump was activated. After the pressure dropped down below $1.0 \cdot 10^{-4}$ mBar, on November, 30th 2016, 12:10 CET, the cooler was activated and cooldown started.

From the temperature curves it is evident that the coldest stages reached quickly their operating temperatures in less than 12 hours. The warm up times are longer as usual; this time heaters were activated during the first six hours to speed up the warm up. The details of the timescales are reported in the table below where the steady state low temperatures are reported together with the time spent to reach them. Also the time it took for each sensor to reach 280 K in the warm up is reported:

Id	Steady low T [K]	Cooldown Time (hours)	Warmup Time (hours)
TA	70.733	22.4	59.9
TB	10.244	21.75	73.3
TC	1.730	8.5	78.6
TD	1.999	8.3	79.5

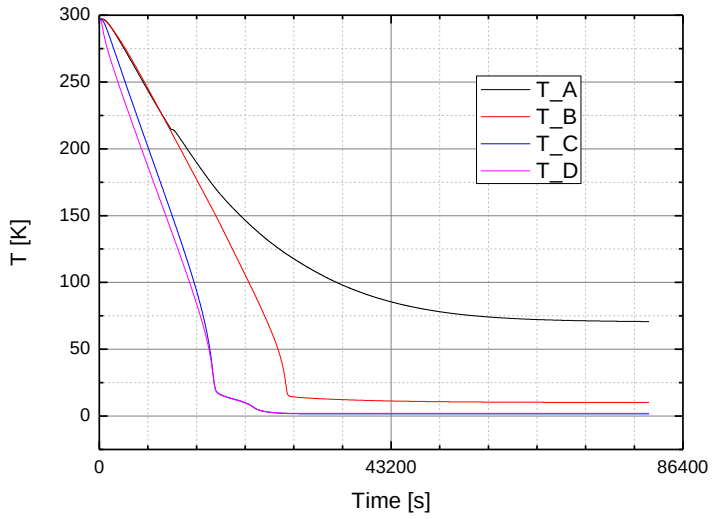

Figure 5 The overall behaviour of the different temperature stages during the second cycle of the second dry run cooldown of the NAOJ cryostat..

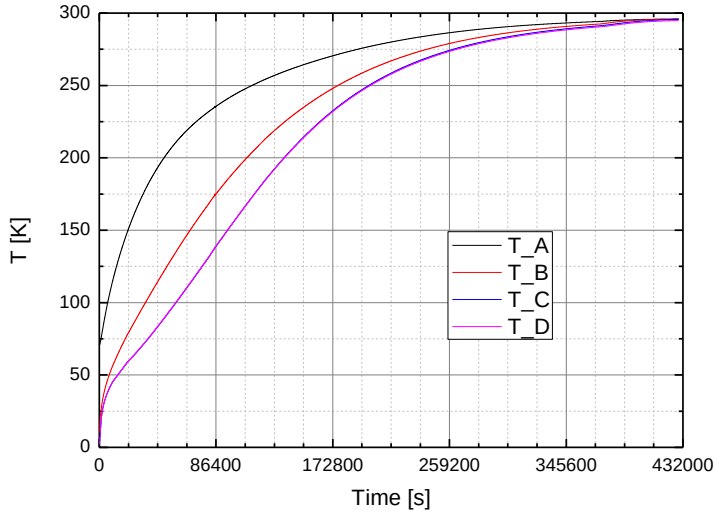

Figure 6 The overall behaviour of the different temperature stages during the second cycle of the second dry run warm up. During the first part of this warm up the heaters were activated in the coldest stages so that the time spent warming was shorter.

8 JPL LNAs Run Data

A first run with the full cartridge, equipped with JPL LNAs, integrated in the cryostat was performed in order to functional test this preliminary setup.

After an unsuccessful pumping due to an o-ring missing in the lens mounting structure, the cryostat was finally closed and sealed on December, 15th 2016, 9:05 CET, and pumped down by the scroll pump until it reached a pressure of $8.2 \cdot 10^{-2}$ mBar on December, 15th 2016, 10:35 CET, when the turbo pump was activated. After the pressure dropped down below $1.0 \cdot 10^{-4}$ mBar, on December, 15th 2016, 12:00 CET, the cooler was activated and cooldown started.

From the temperature curves it is evident that the coldest stages reached quickly their operating temperatures in less than 12 hours. The warm up times are much shorter than previous runs, the related different procedure applied was:

- the heaters in the two coldest stages were kept continuously active up to the moment they reached a temperature of 230 K;

- at the beginning of the warm up the turbo pump was switched off and the valve, connecting it to the scroll pump, was closed.

The details of the timescales are reported in the table below where the steady state low temperatures are reported together with the time spent to reach them. Also the time it took for each sensor to reach 280 K in the warm up is reported:

Id	Steady low T [K]	Cooldown Time (hours)	Warmup Time (hours)
TA	71.190	21.5	29.5
TB	9.919	19.8	32.7
TC	1.494	9.7	35.7
TD	1.813	9.2	36.1

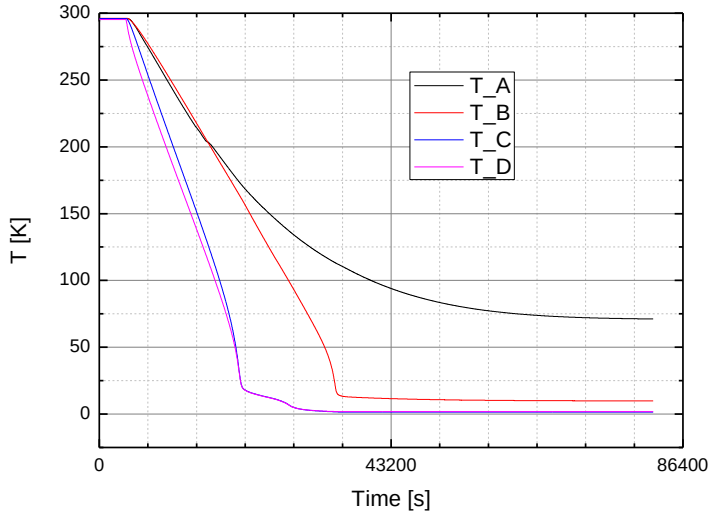

Figure 7 The overall behaviour of the different temperature stages during the cooldown of the NAOJ cryostat for the first run with the whole cartridge preliminary setup.

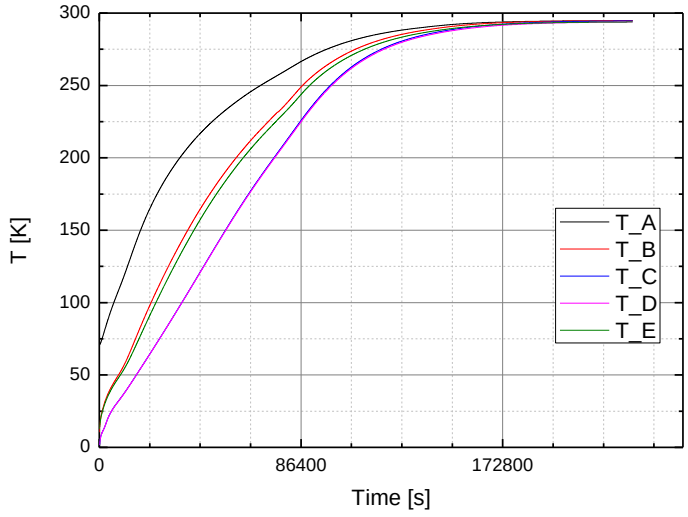

Figure 8 The overall behaviour of the different temperature stages during the warm up phase of the first run with the whole cartridge preliminary setup. This phase was shorter than previous runs because the heaters were active for most of the time. An additional sensor, T_E, was used to monitor the amplifier assembly temperature.

9 Summary and Conclusion