FARADAY and *PHAROS* COOLED ARRAYS:

Cryogenic Solutions for Large Dewars

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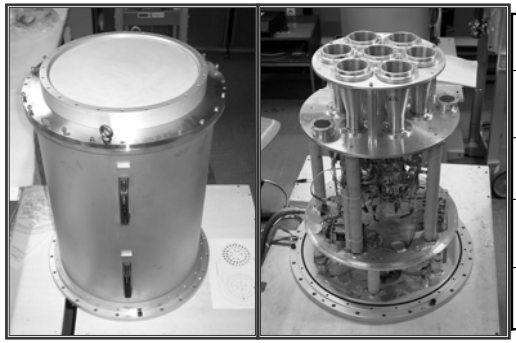
Large Dewar: What does it means?



7 horns , K Band	
Volume	**110 Liters**
External Suface	**1,30 m^2**
Shield Surface	**0,98 m^2**
Window Surface	**500 cm^2**

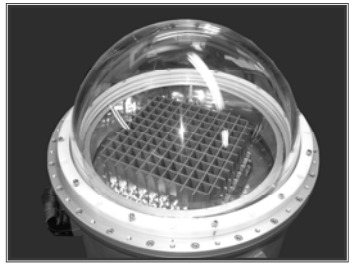
The pictures shows the Faraday 18-26.5 GHz, Dewar array, on the left the whole vacuum chamber, on the right the core of the array. The seven horns are cooled down to the 2° stage (i.e. 20 K).

Large Dewar: What does it means?

Pharos	
Volume	**110 Liters**
External Suface	**1,30 m^2**
Shield Surface	**0,90 m^2**
Window Surface	**1100 cm^2**

The picture shows the Pharos vacuum chamber with his typical dome.
The DC connectors and RF output are located on the back of the cylinder.

Large Windows



Faraday Multibeam: 500 cm^2
Mylar 100 μm thick
18 – 26.5 GHz

Pharos: 1100 cm^2
Plexiglass 16 mm thick
4.9 – 7.1 GHz

The two pictures give the idea of how much the windows are large.
Large windows represent a challenge for the designers team.

The air pressure ask for thick and strong materials while in order to minimize the Radiofrequency loss, a thin, lightweight and expanded material is preferable.

Also, the window must be hermetic to the common gases present in the air.

Finally, the window must stop the incident thermal radiation, in order to preserve the “cold” inside the Dewar.

The solution adopted in the 18-26.5GHz array is a 37.5 cm wide window surrounded by a thick Aluminum plate holed along the feed horn axis.

In this way the total weight of the air is 1100 Kg, but the shearing stress is 500 Kg only and distributed along 7 zones.

Windows Holds and Shields

An extensive study and experimental job has been done in order to find the most appropriate thermal shields.
The transparent RF window has been shielded by sandwich IR filters, while the metals has been surrounded by a Superinsulation blanket.

Required Cooling Capability

Does a large Dewar require a more powerful Cryo Generator?
What's the problem adopting the CTI 1050 instead CTI 350 ?

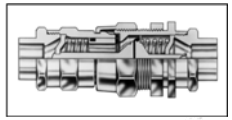
The CTI 350 gives 3 W , 17 W and require 12 SCFM He

The CTI 1050 gives 6 W , 55 W and require 28 SCFM He

The most powerful CTI He compressor may drive 40 SCFM He

SRT: Only a pipeline pair between compressor room and Prime Focus

The most important pipeline friction loss is due to Aeroquip junctions rather than pipeline cross sections



An extensive study has been commissioned to a 3rd part has shown that, for a 100 mt long pipeline, the most important contribution to the He flow friction loss, is due to the Aeroquip junctions rather than the ling pipelines.

On the SRT Antenna, we choose to drastically reduce the Aeroquip and/or switch to the mod. 5400-Sx-16 (the larger one) along the pipeline.

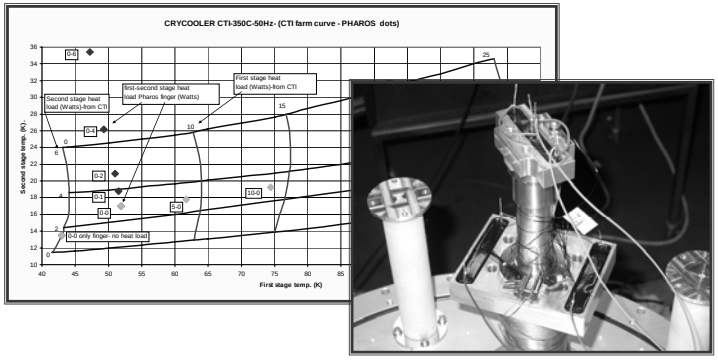
Balancing , but no compromise

The CTI 350 is the most appropriate and comfortable cryocooler from the Antenna plant and design point of view.

The CTI 350 has enough cooling capability once the largest heat losses of the Dewar has been reduced.

- Extensive use of **SUPERINSULATION** over metal structures
- Excellent **IR filters** over the RF path
- Excellent reduction of conduction thermal **paths of the cables**

Thermal Load: the method



Many are the possible methods to measure the thermal load.
The adopted method take advantage by experimental activity.
The measured data has been superimposed over the graphics coming from the factory.
A necessary initial calibration has been done in order to remove the offset.

The photo shows the heating resistors connected to the cold head and used to calibrate the graphic.

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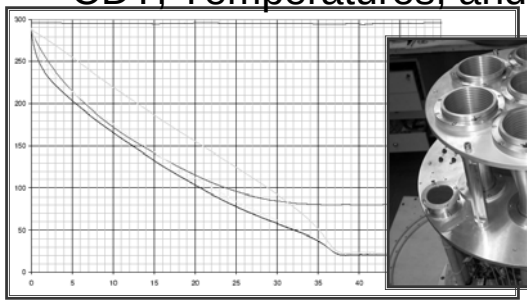
K Band Faraday Multifeed: CDT, Temperatures, and mass



Cool down time: 37 h @ 50Hz
Temperature differences: 3 K
1° stage mass: 10 Kg , 2° stage mass: 20 Kg

Bonn, Nov. 16th, 17th 2009

Faraday Multifeed: the whole receiver.

The cool down time give an idea of the enthalpy (mass and specific heat).

The temperature differences, gives an idea of the flowing heat mainly due to heat inputs.

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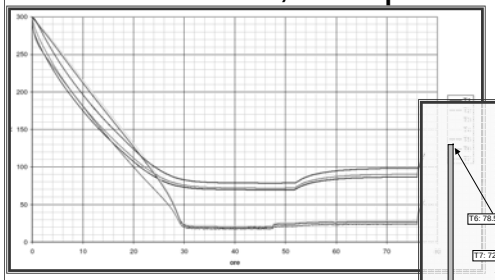
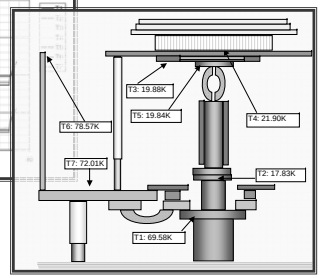
Pharos Array: CDT, Temperatures





Bonn, Nov. 16th, 17th 2009

Pharos: the whole receiver less LNAs and their cables.

Once the cryocooler has been choose , the cool down time give an idea of the enthalpy (mass and specific heat).

The temperature differences, gives an idea of the flowing heat mainly due to heat inputs.

SUPERINSULATION

"…Melius abundare quam deficere…"

without S.I. : 20 W
with S.I. : 9 W

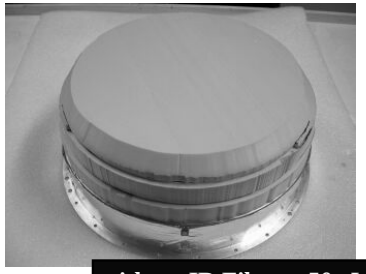
All the cooled metal parts are covered by a blanket acting as Superinsulation.

The blanket is made by ten sheets of extremely-low-emission aluminized foil each of one spaced by low thermal conductivity fabric.

The conductive sheets are spaced by a quarter of wavelength in the IR region, so the blanket acts as a resonant , stop band filter, in the far IR region.

RADIATION TROUGH THE WINDOW

No.	Materiali 80 K	Materiali 20 K	ΔT (K)	P (mW)	$\eta = P/P_0$ (%)
		Bolometro A			
1°	-	-	10.4	237.6	100.
2°	-	-	5.80	129.7	54.6
3	PP2	-	4.30	94.58	39.8
4	BP	-	5.00	110.9	46.7
5	BP + PP2	-	4.00	87.54	36.8
6	PP2 + BP	-	4.00	87.54	36.8
7	STY	-	3.20	68.79	28.9
8	HF71	-	4.20	92.23	38.8
9	"	PP4	2.70	57.06	24.0
10	STY	"	1.28	23.76	10.0
11	HF71+51+31	"	1.17	21.19	8.9
12	4x PP2	"	1.04	18.14	7.6
		Bolometro B			
14	STY+BP1	PP4+BP1	2.00	10.56	4.4
15	COMP+BP1	"	2.54	13.67	5.7
16	STY+BCB	"	1.22	6.08	2.5
17	"	PP4	3.47	19.02	8.0
18	STY	PP4+BCB	1.34	6.77	2.8
19	2xPP2+BP1+2xPP2	PP4	2.28	12.17	5.1
20	BCB	-	12.3	69.78	29.
21	2x(PP4+BP1)	PP4+BP1	2.50	13.44	5.6
22	2x(PP2+BP1)+PP2	PP4	2.00	10.56	4.4
23	"	PP4+BP1	1.35	6.83	2.8
24	KLE 130	PP4	5.90	32.99	13.8



without IR Filter : 50 W
with IR Filter : 2.5 W

IR Window filters

- 2nd stage : PP4
- 1st stage : Sty.+PP4+Sty.+PP4+PE+PP4+Sty.

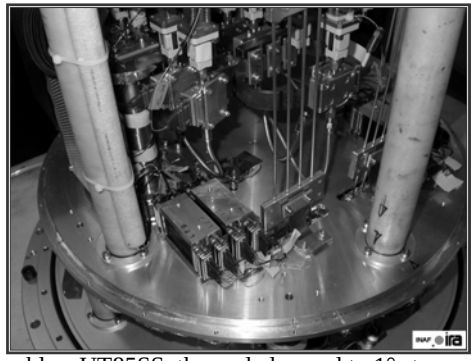
An extensive study and bibliographic research as been done in order to realize an excellent IR stop-filter but in the same time a very transparent RF window.

Candidate materials was the foam materials and the black PE sheets.
The solution adopted has been two kind of filters:

2° stage: a sheet of white colored, foamed, Eccostock PP4

1° stage: a sandwich of BASF Styrodur + PP4 + Styrodur + PP4 + Black PE + PP4 + Styrodur

CABLES & WIRES



•Coaxial cables: UT85SS, thermal clamped to 1° stage
•DC bias: AWG 34, *manganin* made, thermal clamped to 1° stage

All the 21 coaxial cables are the UT85SS. The coax cables are all thermal clamped to the 1° stage cryocooler.

The thermal load of the UT85SS is the half of the most common UT141SS.

All the 106 DC Bias cables are manganin made AWG34.

All the DC Bias cables are clamped to the 1° stage cryocooler by way of homemade connectors.

CONCLUSIONS

- Two large Dewar containing array receivers has been shown
- Both are cooled with the CTI 350, the most common cryogenerator
- Both Cryostat take advantage by extensive thermal insulation :
  - The strongest radiation source, the 1° stage radiation, is highly reduced by superinsulation.
  - The strong 2° stage radiation, due to large window has been highly reduced by thick sandwich of foam sheets.
  - The conduction thermal loss of the many cables has been reduced by long paths , thermal clamping and using Stainless Steel or Manganin.

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Internal Report

• **Optical performances of thin and composite vacuum windows**
Natale – Nesti
Internal Report

• **Sviluppo_Dewar.ppt *(in italian)***
Cresci – Panella – Nesti
Power Point presentation

• **CTI Cryogenics – private communications about He flux rate**

• **RIAL Vacuum – He pipeline pressure drop**
MS Excel sheet

THANKS