ANALYSIS OF SEEING MEASUREMENTS FROM THE LA PALMA RoboDIMM[1]*
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1. Abstract

The RoboDIMM instrument has been measuring the seeing at the Observatorio del Roque de los Muchachos (ORM) on La Palma since August 2002. This instrument is based on the concept of the classical DIMM[2] prototype (Sarazin & Roddier 1990; Vernin & Muñoz-Tuñón 1995) and was developed by a private Dutch company for the Isaac Newton Group (ING) with several changes (in hardware and software). As a routine calibration, seeing data provided by RoboDIMM (ING) is here compared with coincident data obtained with the DIMM (IAC). RoboDIMM is installed next to the William Hershel Telescope (WHT) and the DIMM was operating at Degollada del Hoyo Verde (DHV) - see map at the end of this document-. Both data series show good agreement in 2002. In 2003, major changes in the hardware of RoboDIMM were carried out and since then the agreement is poor. It seems that RoboDIMM does not record seeing lower than 0.4". The comparison suggests that RoboDIMM might be "blind" to very good seeing values producing an "aliasing" for which the seeing values better than 0.5" are randomly re-distributed to higher values. As a result, statistics obtained with data from the new RoboDIMM version can be meaningless and not useful for site characterization.

2. Introduction

Since 1994 a differential image Motion Monitor or DIMM (Vernin and Muñoz-Tuñón. 1995) is operating and providing seeing measurements at the Observatorio del Roque de los Muchachos (ORM). It has been installed at different locations at the Observatory. The first results were analyzed and published by Muñoz-Tuñón et al., 1997 . A compendium of the statistical results at different years and different locations can be retrieved at http://www.iac.es/site-testing in Data&Statistics – Seeing Nighttime. The DIMM is operated by an observer and observations typically cover ~10-12 nights per month since the last 15 years; the sample rate is 1 data every 30-60s with a precision in every data point of 0.1" (Vernin & Muñoz-Tuñón, 1995).

Since 2002 a RoboDIMM is located next to the WHT and it is operated continuously (all nights) by the ING´s staff.

Appendix 2 shows the map of the ORM indicating the WHT and DHV where the RoboDIMM and DIMM are respectively located.

Periodic calibration campaigns are required in order to insure the quality of seeing data provided by the instruments. This report summarizes the comparison of data gathered by the two monitors on coincident periods and a subset of them simultaneous in time.

3. RoboDIMM vs DIMM

3.1 Before December 2002:

We have selected a data set gathered by the two instruments in the period August-December 2002. In Figure 1 we show the cumulative frequency (left) and the histogram functions (right) of the seeing values measured by the DIMM and RoboDIMM from August to December 2002. Statistical results are summarized in Table 1.

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[1] RoboDIMM stands for Robotic Differential Image Motion Monitor.
[2] DIMM stands for Differential Image Motion Monitor.
* All data analysed in this paper can be gathered at: http://www.iac.es/site-testing and http://www.ing.iac.es/development/seeing

From the above database we have selected a subset with data taken simultaneously in time (October 2002). The cumulative frequency (left) and the histogram functions (right) of the simultaneous seeing values in October 2002 are shown in Figure 2. Statistical results are summarized in Table 2.

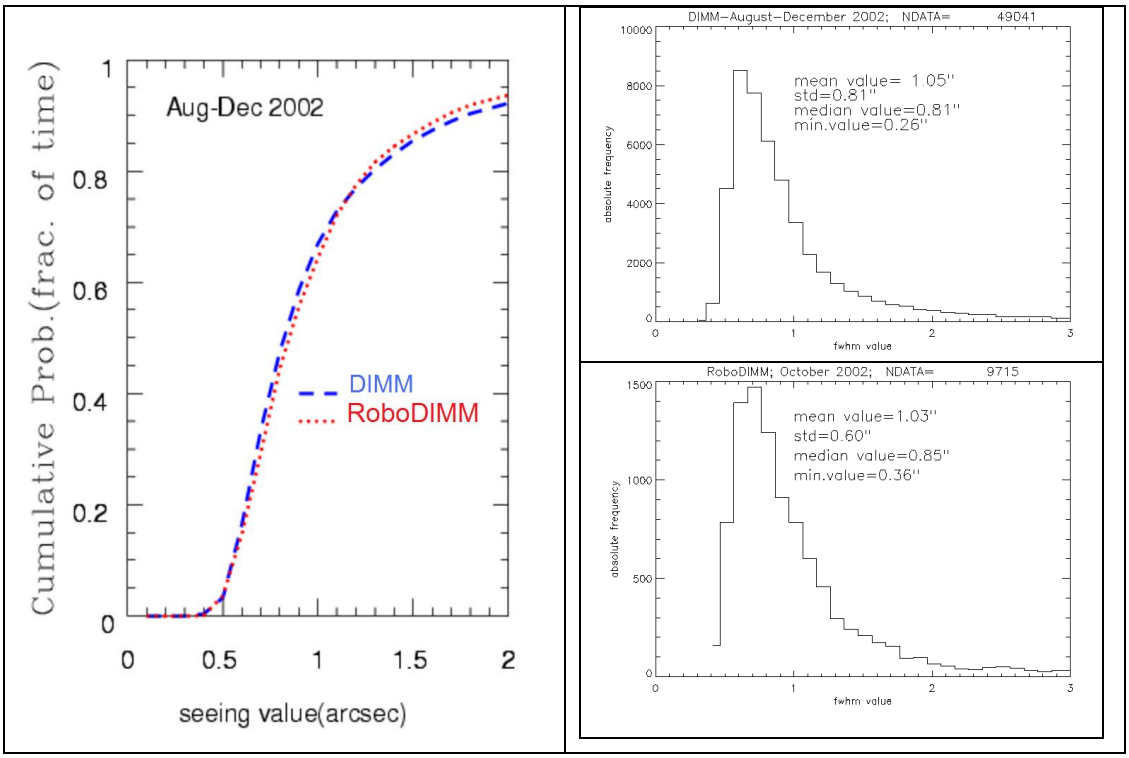

Figure 1. Cumulative frequency (left) and statistical distribution (right) of the seeing data gathered by the DIMM and RoboDIMM in the period August-December 2002.

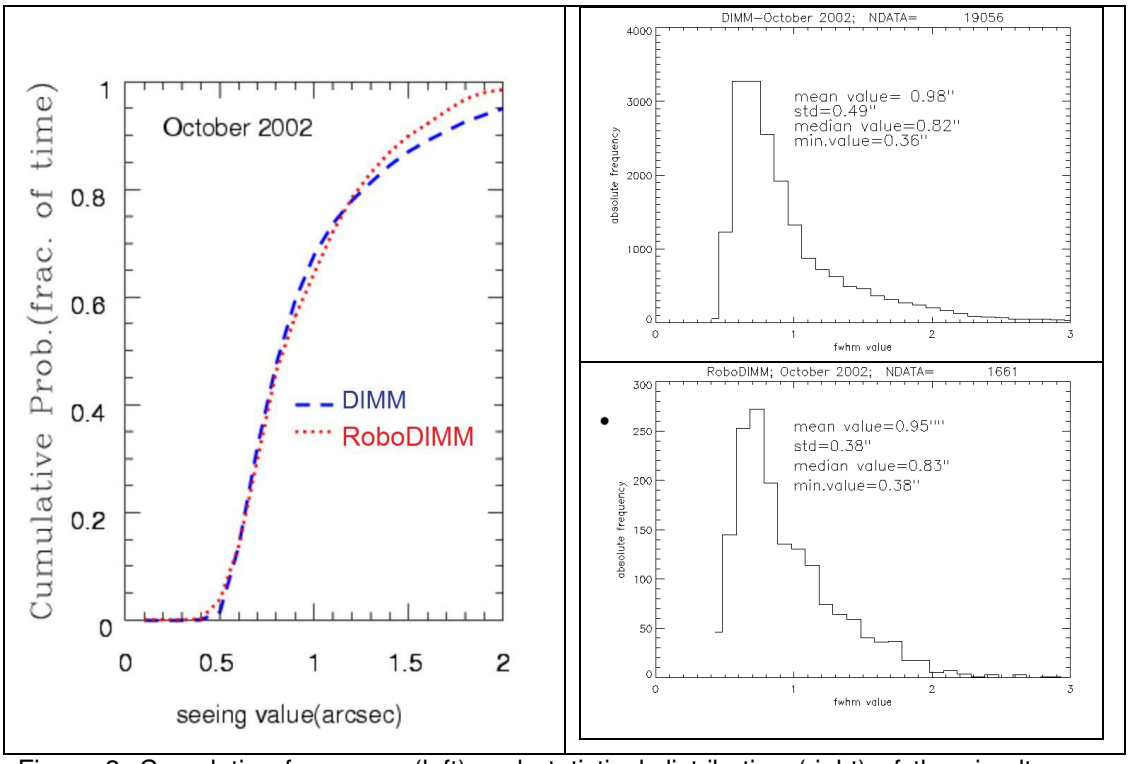

Figure 2. Cumulative frequency (left) and statistical distribution (right) of the simultaneous in time seeing data gathered by the DIMM and RoboDIMM in October 2002.

As it can be seen in Figures 1&2 and Tables 1&2, seeing values measured with the two instruments show very good agreement.

Table 1

Seeing	DIMM	RoboDIMM
Ndata	49041	9715
mean	1.05”	1.02”
std	0.81”	0.60”
median	0.81”	0.85”
< 0.4”	0.1%	0.2%
< 0.5”	1.5%	3.9%
< 1.0”	68%	64%
< 1.5”	87%	90%

Table 2

Seeing	DIMM	RoboDIMM
Ndata	19056	1661
mean	0.98”	0.95”
std	0.49”	0.38”
median	0.82”	0.83”
< 0.4”	0.1%	0.2%
< 0.5”	1.5%	3.9%
< 1.0”	68%	64%
< 1.5”	87%	90%

Tables 1 and 2. Statistical results of seeing values measured by RoboDIMM and DIMM in August-December 2002 (data coincident in period) and in October 2002 (subset simultaneous in time) respectively.

The agreement is also declared by the ING; In the web page http://www.ing.iac.es/Astronomy/development/seeing/Correl_DIMM.html it is said “Shortly after it started operating in August 2002, RoboDIMM seeing was shown to agree with the DIMM seeing monitor to within better than 10%, using samples of typically a few hour's length http://www.ing.iac.es/Astronomy/development/seeing/. First 3-4 months of data show a correlation strength of 92% between DIMM and RoboDIMM over a range of 0.63 arcsec to 1.6 arcsec. Close agreement between nightly medians when seeing is stable (periods of highly variable seeing rejected). The frequency distributions in each month largely coincide and overlap”.

In December 2002, RoboDIMM stoped operation due to technical problems; it started again in April 2003.

3.2 Data from 2003

In 2003 a warning was issued by the ING group advising of a possible wrong behaviour of RoboDIMM and asking the Instituto de Astrofísica de Canarias (IAC) for comparisons to make a diagnostic. RoboDIMM measurements from April to September 2003 provided a median value of 0.82”, unusually large when compared with the typical summer seeing value at the ORM (see Muñoz-Tuñón et al., 1997 and also more extended statistics on several years at http://www.iac.es/site-testing click on Data&Statistics and Seeing Night time)). Coincident data (April-September 2003) taken with the DIMM give a median value of 0.51”.

To undertake a new the comparison we have selected two simultaneous dataset, taken in two periods, one in November 2004 and other one in June 2005. The sample includes all possible common nights (13). Statistical seeing results of the DIMM and RoboDIMM during common observing nights in November and June are presented in Figure 3(a, b).

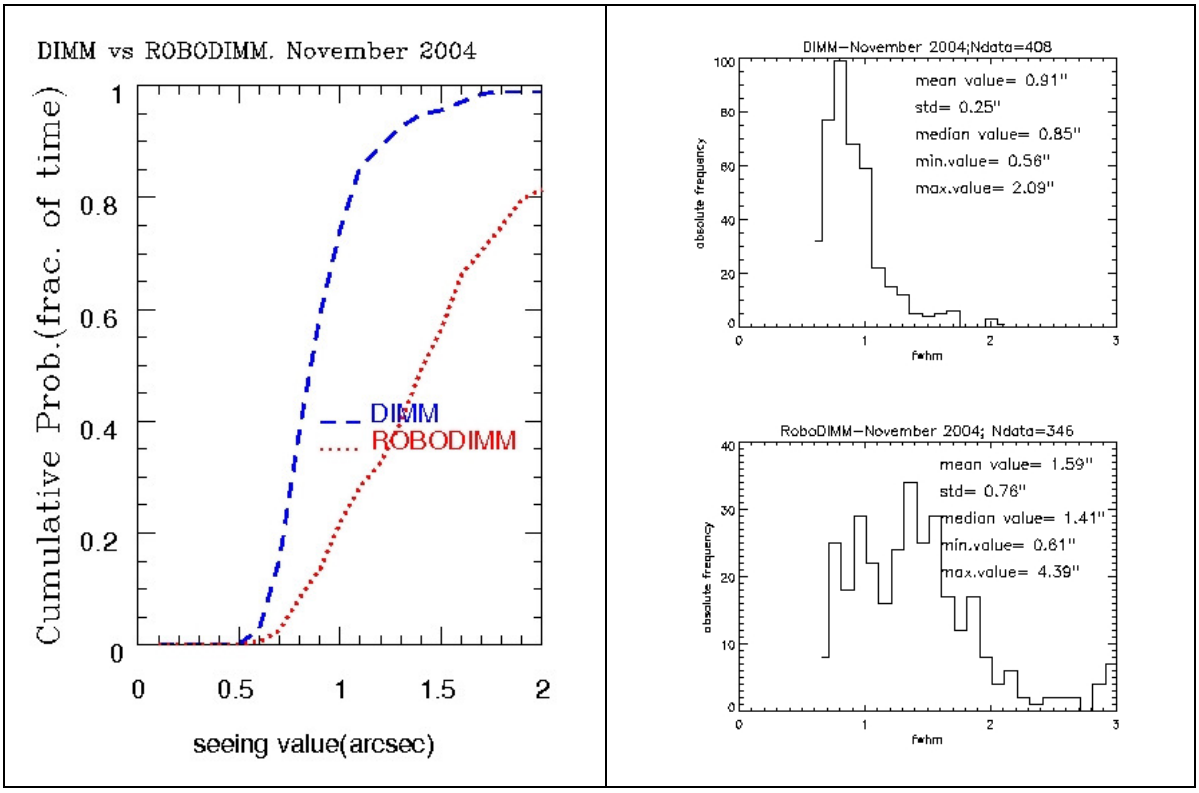

Figure 3a. Cumulative frequency (left) and statistical distribution (right) of the seeing data gathered by the DIMM and RoboDIMM for all possible common nights in November 2004.

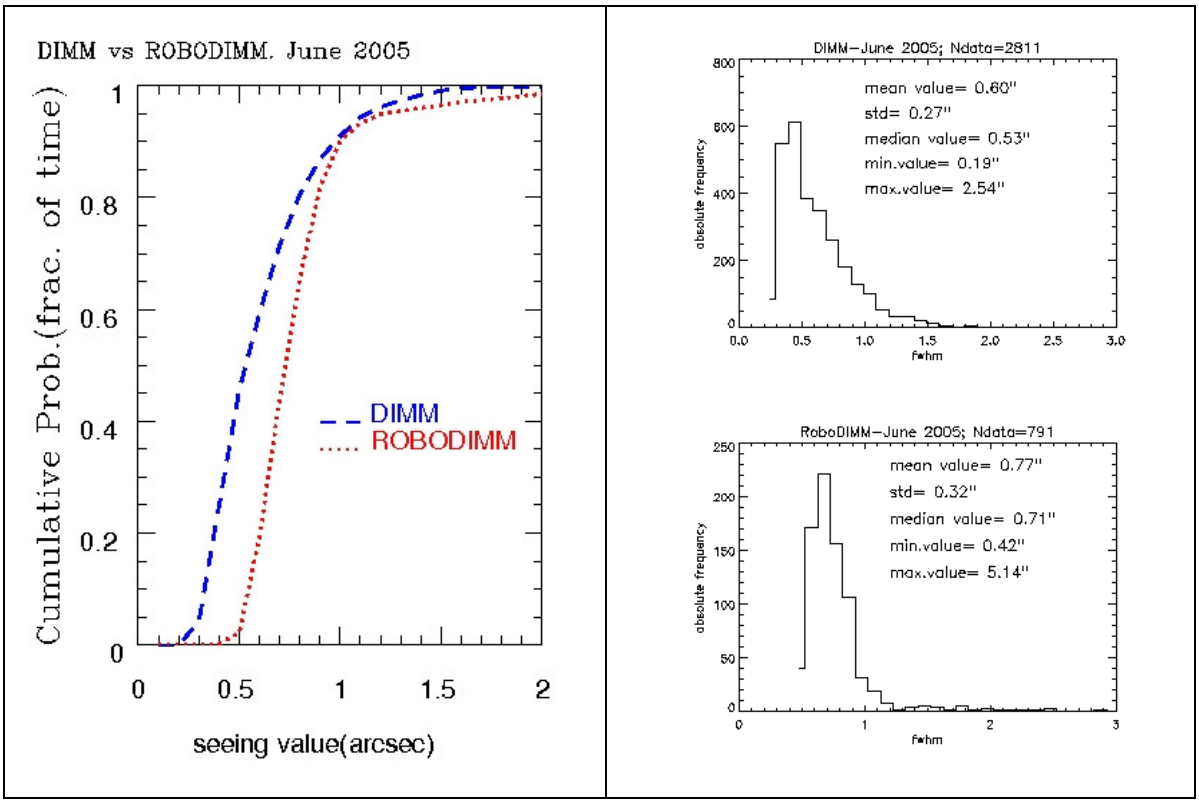

Figure 3b. Cumulative frequency (left) and statistical distribution (right) of the seeing data gathered by the DIMM and RoboDIMM for all common nights in June 2005.

Statistical results for the two periods, November 2004 and June 2005, are summarized in Tables 3a and 3b respectively.

Table 3a

Seeing	DIMM	RoboDIMM
Ndata	408	346
mean	0.91”	1.59”
std	0.25”	0.76”
median	0.85”	1.41”
< 0.4”	0%	0%
< 0.5”	0%	0%
< 1.0”	74%	22%
< 1.5”	96%	56%

Nights: 18, 19 and 20 November 2004

Table 3b

Seeing	DIMM	RoboDIMM
Ndata	2811	791
mean	0.60”	0.77”
std	0.27”	0.32”
median	0.53”	0.71”
< 0.4”	25%	0%
< 0.5”	46%	2%
< 1.0”	91%	90%
< 1.5”	99%	97%

Nights: 13, 14, 15, 16, 17, 28, 29 and 30 June 2005

Table 3(a, b). Statistical results of seeing values measured by DIMM and RoboDIMM respectively in the two periods, November 2004 (a) and June 2005 (b).

From figures 3 it is seen that the cumulative distribution function of RoboDIMM data does not follow the log normal statistical behaviour expected for such a distribution (see Fig.2 in Muñoz-Tuñón et al., 1997, and discussion therein). However the poor statistics (Ndata= 346) could be an explanation for such an irregular function. Other technical and operational possibilities can be also responsible.

In the data corresponding to June one can notice the absence of values lower than 0.5” in the measurements taken with the RoboDIMM. As it is clear in the figure 3b, RoboDIMM seeing values are larger that DIMM measurements, RoboDIMM detects much less values smaller than 0.5” and values smaller than 0.4” are never detected.

Figure 4 shows a subset of simultaneous and synchronized (less than 1 minute) seeing values measured by the DIMM and RoboDIMM during several nights (10, 15 and 16 May 2005). Vertical dashed line clearly shows the RoboDIMM seeing 0,5” threshold. Stars correspond to DIMM measurements better than 0.5” and as it can be seen in the figure are not detected by RoboDIMM.

Also it is very important to follow the behaviour of the star points. If RoboDIMM would just truncate seeing values better than 0.5” all the points would be grouped near this limit value. This is not what is seen in the plot and, values lower than 0.5” are “seen” by RoboDIMM at a large range of values (up to 1.2”) which indicates the presence of a likely aliasing in the instrument measurements.

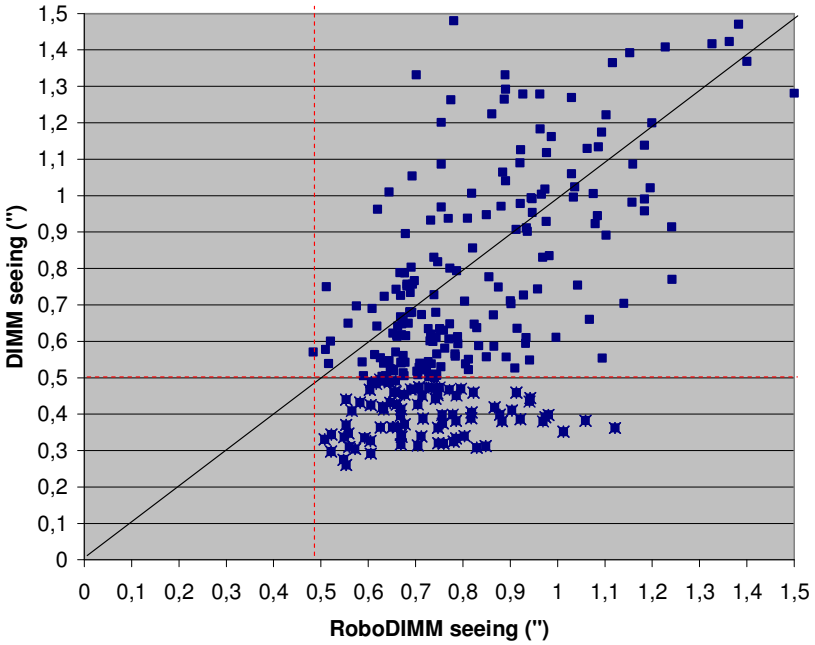

Figure 4. Simultaneous and synchronized seeing values measured by the DIMM and RoboDIMM for several nights (10, 15 and 16 May 2005). Dashed lines mark the RoboDIMM seeing truncation at 0.5". Star points correspond to DIMM points better than 0.5".

4. Conclusion

RoboDIMM and DIMM have been cross-compared from 2002 to 2005. During 2002 period both instruments lead to the same seeing statistics, but RoboDIMM operation was stopped due to technical problem. After restarting its operation in 2003, RoboDIMM seeing statistics seems to have changed.

We have compared data from DIMM and RoboDIMM in several conditions during different periods. Discrepancies between DIMM and RoboDIMM data, even using simultaneous measurements, lead us to believe that RoboDIMM reduces the precision in conditions of very good seeing (typically better than 0.6 arcsec). This behaviour would produce not only a truncation of good seeing values but also a redistribution of data in the statistical function misrepresenting, therefore, the real mean and median.

The explanation of these disagreements by local effects is quite unlikely. Actually we advise to carry out specific campaigns using both instruments in the same time and location, in order to discard any variable which might alter the measurement. The knowledge of the details of the algorithm that produces the RoboDIMM data would help definitively to understand and to solve the problem.

The hypothesis that the differences might be explained by the different locations (near WHT and DHV) of the two monitors can be discarded. RoboDIMM was always located next to the WHT, including database prior to 2003. Measurements taken with the DIMM installed at different locations at the ORM (see map in http://www.iac.es/site-testing click on Data&Statistics and on locations) show that the seeing statistics (mean and median) remain almost identical within the statistical errors.

5. References:

Muñoz-Tuñón, C., Vernin, J. and Varela, A.M., . A&A Supplement Series, Vol. 125, October 1997, 183-193.
Sarazin, M. and Roddier, F, 1990, A&A, 227,294.
Vernin, J. and Muñoz-Tuñón, C., 1995, PASP 107, 265

WEB references:
http://www.iac.es/site-testing
http://www.iac.es/site-testing click on Data&Statistics and on Seeing Nighttime
http://www.iac.es/site-testing click on Data&Statistics and on locations
http://www.ing.iac.es
http://www.ing.iac.es/Astronomy/development/seeing/
http://www.ing.iac.es/Astronomy/development/seeing/Correl_DIMM.html

Acknowledgements

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Appendix 1.

DIMM= Differential Image Motion Monitor
GTC=Gran Telescopio de Canarias
IAC= Instituto de Astrofísica de Canarias
ING= Isaac Newton Group
INT= Isaac Newton Telescope
JKT= Jacobus Kapteyn telescope
NOT=Nordic Optical telescopes; INT
ORM: Observatorio del Roque de los Muchachos
RoboDIMM= ING Robotic DIMM
TNG= Telescopio Nazionale Telescope
WHT= William Herschel Telescope

Appendix 2.

Map of the ORM indicating the WHT and DHV where the RoboDIMM and DIMM are respectively located. See acronyms in Appendix 1 (GTC2 indicates the Gran Telescopio de Canarias location and GTC1 is a preselected site).