Reflection Measurements of ALMA Calibration Targets with Shroud

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1 Introduction

The previous test report [1] gives the results of active and passive reflection measurements of different ALMA calibration target prototypes without shroud. The thermal simulations reported in [2] show that it will be difficult to maintain the required temperature accuracy with these initial designs. One of the suggetsed solutions is to isolate the target better from the changing enviromental conditions by reducing its aperture with a conical reflecting shroud. The thermal simulations in this report show a significant reduction of the temperature gradients and heat loss by such shrouds, while Physical Optics simulations indicated that this does not impair the RF performance.

In order to verify this design two prototype targets with shroud have been manufactured: a hot one based on the pyramidal absorber design and an ambient one with TK-RAM tiles as absorbing material. A more detailed description of these absorbers is given in [1], the geometries of the two slightly different shrouds is shown in Fig. 1.

To verify that the coherent backscatter of the targets is not degraded by shroud the S11 measurements described in [1] have been repeated with the shroud targets. In addition the test series of the TK-RAM tile absorber has been extended to the lower frequency bands that were not covered in the previous reports.

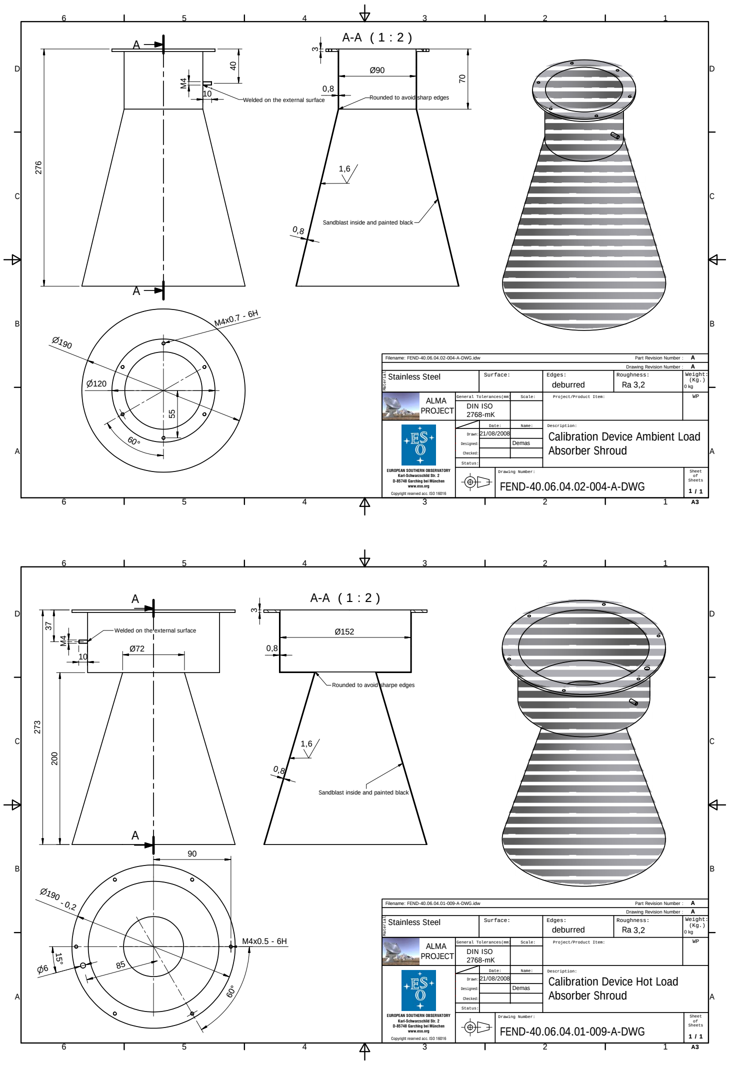

Figure 1: Shroud geometry of the hot and the ambient target.

2 Results

The measuremenmt setup and test procedure were identical the one described in the previous report. Since the effect of the shroud will depend highly on the beam parameters of the optics the measurements were concentrated on Bands 1-6 where either the original ALMA lens+horn feeds were available (Band 1 and 2) or where the IAP optics is closest the ALMA feeds. Measurements at the higher frequencies where the IAP optics produces an almost collimated beam were omitted in this test series.

Figure 2 shows the results of frequency sweeps at normal incidence using the ALMA optics and directional waveguide couplers. A similar measurement with a W-band corrugated horn antenna with a significantly lower gain than the ALMA feeds shows in Fig. 3 different results.

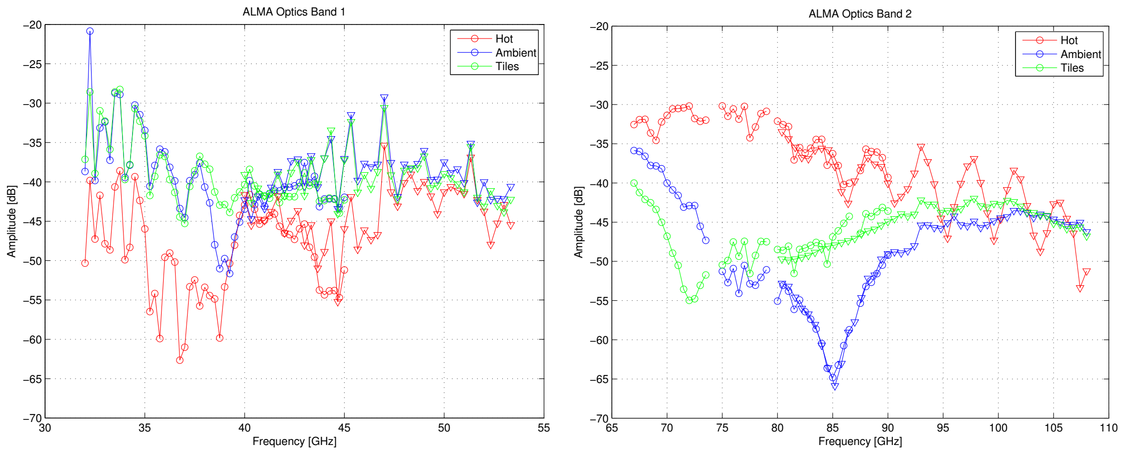

Figure 2: Normal incidence results with the Band 1 and Band 2 feeds.

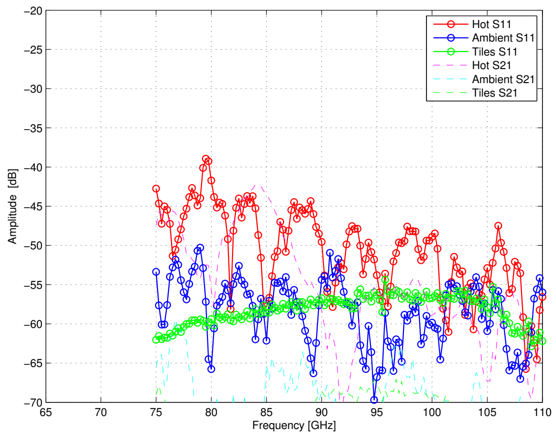

Figure 3: Normal incidence results with a corrugated W-band horn antenna with a lower directivity than the ALMA feeds. The dashed lines represent bistatic reflection results that were received with a second similar horn antenna pointing to the target from a different direction.

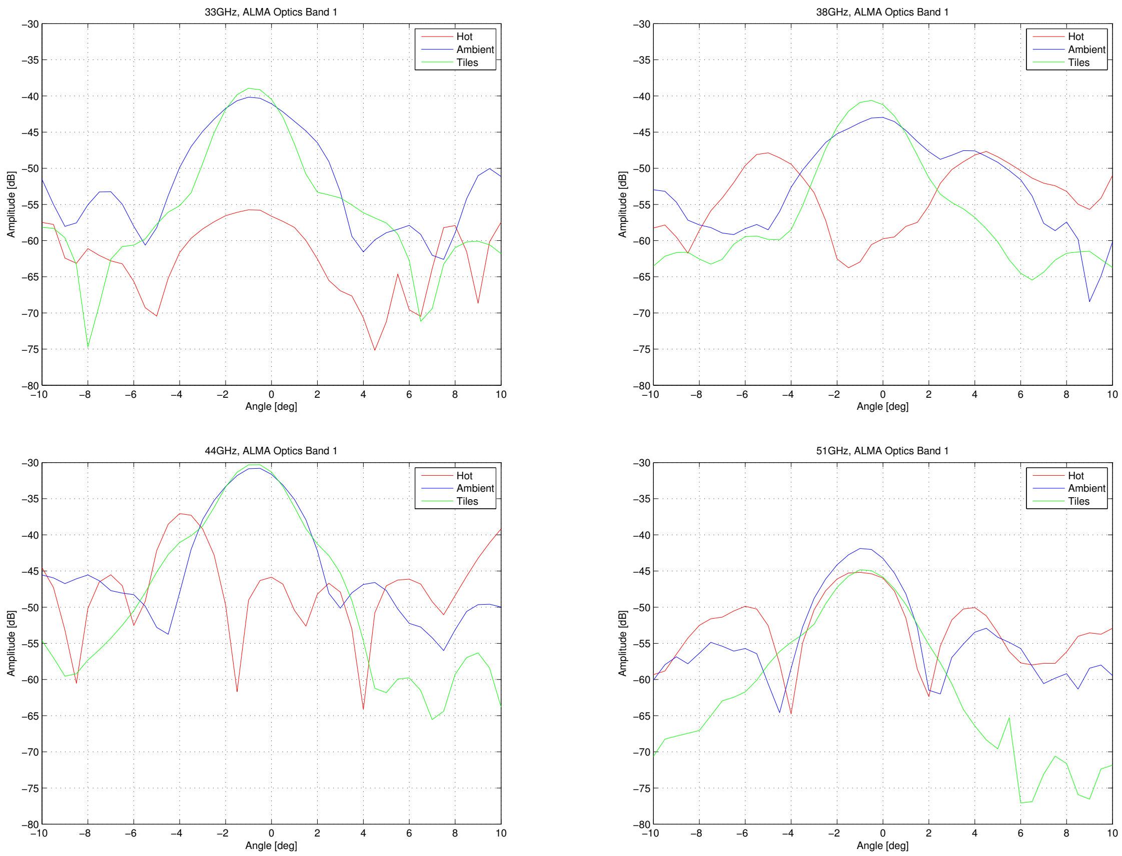

Figure 4: Variable incidence results at spot frequencies with Band 1 feed.

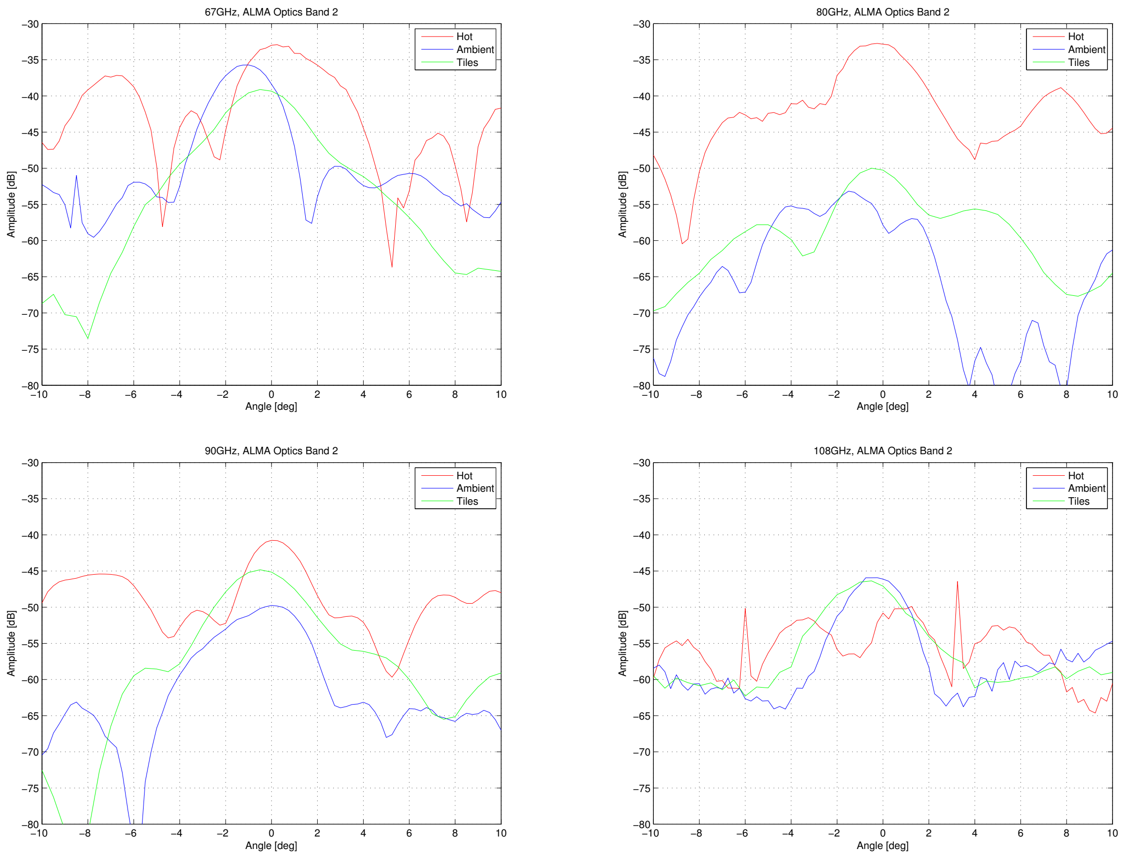

Figure 5: Variable incidence results at spot frequencies with Band 2 feed.

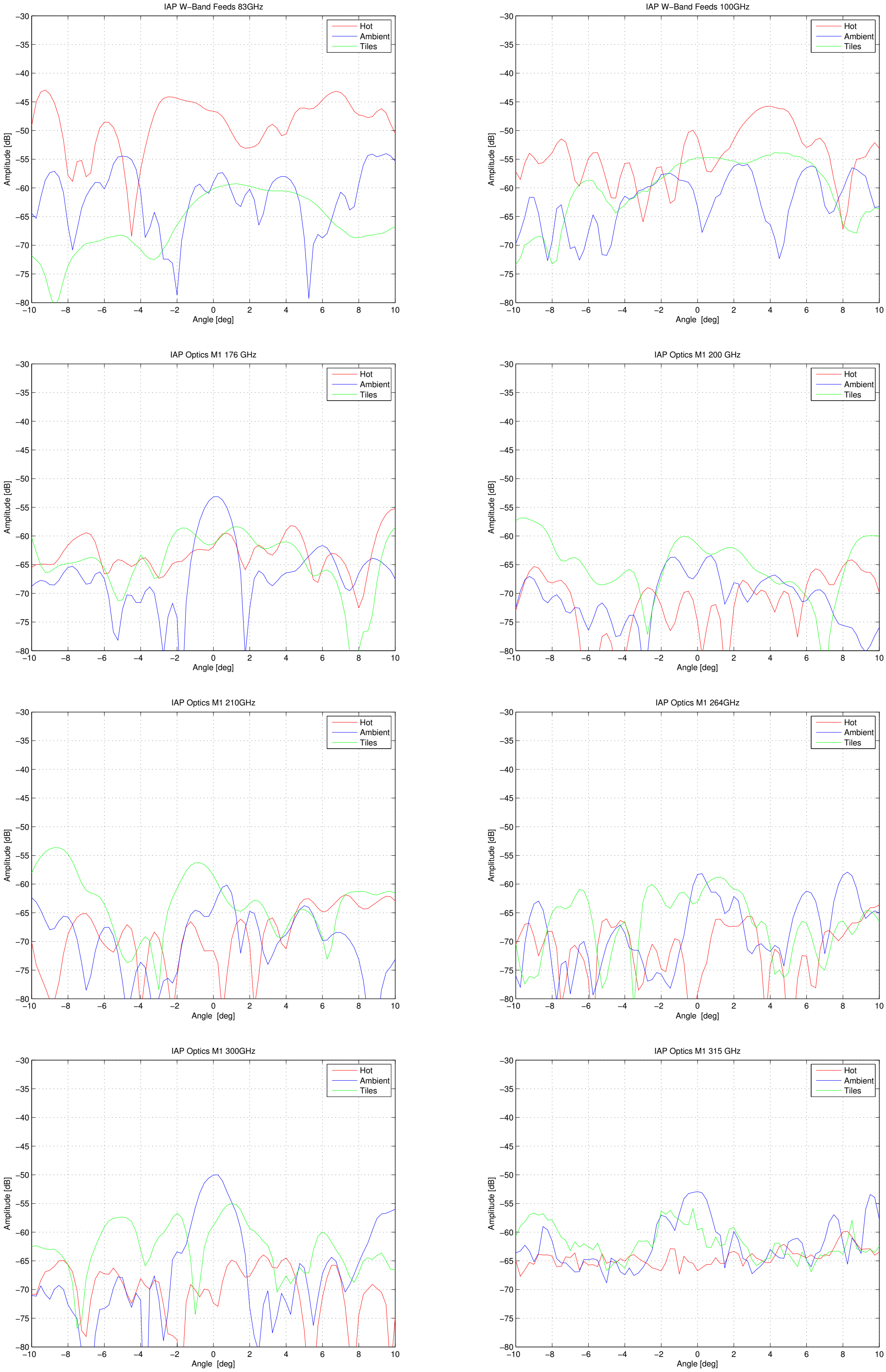

Figure 6: Variable incidence results at spot frequencies with IAP optics.

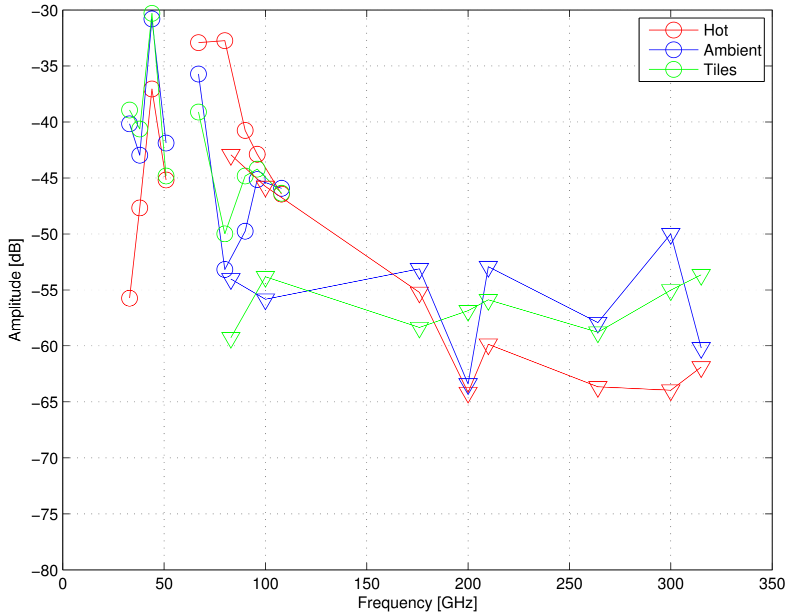

Figure 7: Summary of the maximum backscatter values of the previous figures 4 to 6.

3 Conclusions

When the hot target results of Fig. 7 are compared with those of the same pyramidal absorber without shroud in [1] we can conclude that the shroud does not lead to a significant degradadtion of the coherent backscatter performance. The same is true if the TK-RAM tiles with and without shroud in Fig 7 are compared. On the other hand all targets of this test series, including the tiles without shroud, showed a significant increase of the backscatter in Band 1 and 2. The same has been noticed before for the pyramidal target without shroud.

Currently only the coherent backscatter has been measured, radiometric tests have not been done yet. The positive effect of the shroud in the thermal stability has been demonstrated at ESO by comparing the heating power that is required to hold the target with or without shroud at a certain elevated temperature. Further measurements of the thermal gradients with an IR camera are planned at IAP together with radiometric tests at 90GHz.

References

[1] ALMA Calibration Device: Prototype Calibration Load Test Report, FEND-40.06.04.00-005-A-REP, July 2007.

[2] Thermal and Physical Optics Simulation of Calibration Targets, FEND-40.06.00.00-098-B-REP, Sept. 2008.