### Prepared By:

<table>
<thead>
<tr>
<th>Name(s) and Signature(s)</th>
<th>Organization</th>
<th>Date</th>
</tr>
</thead>
</table>

### Appendix 3 Change Record

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Affected Section(s)</th>
<th>Reason/Initiation/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2006-11-22</td>
<td>3.2, 7</td>
<td>First Version</td>
</tr>
<tr>
<td>A1</td>
<td>2007-09-26</td>
<td>3.2</td>
<td>AI for optics CDR, removed section on meniscus lens from appendix Include note that report is for information only!</td>
</tr>
</tbody>
</table>
Table of Contents

1 Band 3 ........................................................................................................................... 4
2 Return Loss Measurements............................................................................................... 4
3 Radiation patterns Measurements ..................................................................................... 7

3.1 Measure of the system: Custom Microwave Transition + horn................................. 7
3.2 Measure of the system: Custom Microwave Transition + horn + PTFE plano-convex lens.................................................................................................................. 11
4 Comparison of the two lenses performances: ................................................................. 18
5 ALMA Band 3 system measurements ............................................................................. 19

5.1 Introduction...................................................................................................................... 19
5.1.1 Measurement procedure.............................................................................................. 19
5.1.2 Measurements.............................................................................................................. 19
5.1.3 Conclusion..................................................................................................................... 23
6 ALMA band 3 horn and lenses ......................................................................................... 23
7 ALMA BAND 3 RE-OPTIMISATION. OPTION B ............................................................ 23
8 ALMA BAND 3 Horn and Lens Drawings ...................................................................... 23
9 ALMA BAND 3 Warm Optics Drawings ........................................................................ 23

List of Tables:

TABLE 1: BEAM WAIST AT DIFFERENT FREQUENCIES .............................................. 10
TABLE 2: COMPARISON OF LENS PERFORMANCE ...................................................... 18
TABLE 3: BAND 3 OPTICS MEASUREMENTS .............................................................. 20

List of Figures:

FIGURE 1: MEASUREMENT OF BAND 3 HORN, RETURN LOSS ................................. 5
FIGURE 2: MEASUREMENT OF BAND 3 HORN, RETURN LOSS WITH VARIOUS LENSES.................................................................................................................. 6
FIGURE 3: MEASUREMENT OF BAND 3 HORN, RETURN LOSS VS. CUSTOM HORN AND LOAD .......................................................................................... 6
FIGURE 4: MEASUREMENT BAND 3 HORN, RADIATION PATTERN 86GHZ.............. 7
FIGURE 5: MEASUREMENT BAND 3 HORN, RADIATION PATTERN 92GHZ.............. 8
FIGURE 6: MEASUREMENT BAND 3 HORN, RADIATION PATTERN 100GHZ............ 8
FIGURE 7: MEASUREMENT BAND 3 HORN, RADIATION PATTERN 107GHZ............ 9
FIGURE 8: MEASUREMENT BAND 3 HORN, RADIATION PATTERN 115GHZ............ 9
FIGURE 9: MEASUREMENT BAND 3 HORN, CROSS-POLARIZATION PATTERN 115GHZ.......................................................... 10
FIGURE 10: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 85GHZ .............................................................. 11
FIGURE 11: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 85GHZ, CO-POLAR .................................................. 11
FIGURE 12: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 85GHZ, CROSS-POLAR .............................................. 12
FIGURE 13: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 92GHZ .............................................................. 12
FIGURE 14: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 92GHz, CO-POLAR .......................... 13
FIGURE 15: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 100GHz .............................. 14
FIGURE 16: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 100GHz, CROSS-POLAR .......... 14
FIGURE 17: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 107GHz ............................... 15
FIGURE 18: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 107GHz, CO-POLAR .............. 15
FIGURE 19: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 115GHz ............................... 16
FIGURE 20: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 115GHz, CO-POLAR .............. 16
FIGURE 21: MEASUREMENT BAND 3 HORN, RADIATION PATTERN WITH PTFE PLANO-CONVEX LENS 115GHz, CROSS-POLAR ............. 17
FIGURE 22: MEASUREMENT BAND 3 SYSTEM, WAIST DIAMETER VS. FREQUENCY ................................................................. 20
FIGURE 23: MEASUREMENT BAND 3 SYSTEM, WAIST POSITION VS. FREQUENCY ................................................................. 21
FIGURE 24: MEASUREMENT BAND 3 SYSTEM, BEAM DIRECTION VS. TELESCOPE AXIS AND FREQUENCY ................................. 21
FIGURE 25: 85GHz 2D SCAN MEASUREMENTS .......................................................................................................................... 22
FIGURE 26: 100GHz 2D SCAN MEASUREMENTS .......................................................................................................................... 22
FIGURE 27: 115GHz 2D SCAN MEASUREMENTS .......................................................................................................................... 23
ALMA band 3 horn measurements
F. Coq & A.L Fontana, July 2004

1 Band 3
Measurements were made on the horn for the band 3 optics to determine the differences of the use of a meniscus phase correcting lens and a plano-convex lens. Both of these lenses were fit into the mouth of the horn. The measurements are outlined in the report below. The conclusion of the report was the plano-convex lens gave a better mismatch performance and was slightly better in the polar diagrams especially at the higher frequencies.

Note:
Those measurements were made with the ALMA band 3 horn built at HIA, associated with the rectangular to circular Custom Microwave transition.

The IRAM workshop had machined the horn flange flat after the previous measurements.

2 Return Loss Measurements
The S11 of the horn was measured twice, to verify the validity of the measurements. The results obtained are quite similar to the measurements made at HIA. The horn return loss is below –23dB in all the ALMA band 3 frequency band (84GHz-116GHz), and is better than –25dB above 87GHz and better than –30dB above 94GHz.
For high frequencies, the S11 measured is slightly better than the HIA measurement.
The ALMA band 3 horn was also tested with different lenses: the meniscus HDPE lens initially mounted on the HIA horn, and a plano-convex PTFE lens designed at IRAM.

The results obtained for the horn associated to the meniscus HDPE lens are also quite similar to the HIA measurements (and always slightly better for high frequencies).

The use of a plano-convex lens gives better VSWR results, particularly for low frequencies.
To verify that our measurements were made with enough dynamic range, we have compared our horn measurements to the measure of a Custom Microwave rectangular horn, and to a WR10 waveguide load:

Figure 2: Measurement of band 3 horn, return loss with various lenses

Figure 3: Measurement of band 3 horn, return loss vs. custom horn and load
3 Radiation patterns Measurements

The radiation patterns of the horn were measured at 85GHz, 92GHz, 100GHz, 107GHz and 115GHz, for the transition + horn system, for the transition + horn + meniscus HDPE lens, and for the transition + horn + plano-convex PTFE lens.

Co-polarized fields were measured for all those frequencies and configurations, and cross-polarized fields were measured at 85GHz, 100GHz and 115GHz for the horn associated with the two lenses and at 115GHz for the horn without lens.

The cross-polar measurements were made on horizontal and vertical directions. A measure of cross-polar levels in the 45 degrees direction would have certainly given worse results in terms of cross polar, and should be make in the future.

Concerning the scans in 2 dimensions: the 2D cross-polar scans are not normalized to the co-polar maximum values; those plots are just presented to verify the expected shape of the pattern, so the color scales corresponding to the patterns levels are not showed.

The waist size was estimated for all these configurations, at 85GHz, 100GHz and 115GHz.

3.1 Measure of the system: Custom Microwave Transition + horn

![Figure 4: Measurement band 3 horn, radiation pattern 86GHz](image)
Figure 5: Measurement band 3 horn, radiation pattern 92GHz

Figure 6: Measurement band 3 horn, radiation pattern 100GHz
Figure 7: Measurement band 3 horn, radiation pattern 107GHz

Figure 8: Measurement band 3 horn, radiation pattern 115GHz
Figure 9: Measurement band 3 horn, cross-polarization pattern 115GHz

Table 1: Beam Waist at different Frequencies

<table>
<thead>
<tr>
<th>Waist size, f = 85GHz</th>
<th>5mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waist size, f = 100GHz</td>
<td>4.2mm</td>
</tr>
<tr>
<td>Waist size, f = 115GHz</td>
<td>3.6mm</td>
</tr>
</tbody>
</table>
3.2 Measure of the system: Custom Microwave Transition + horn + PTFE plano-convex lens

![Graph showing radiation patterns for the system](diagram1.png)

**Figure 10:** Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 85GHz

![Graph showing co-polar radiation patterns for the system](diagram2.png)

**Figure 11:** Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 85GHz, co-polar
Figure 12: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 85GHz, cross-polar

Figure 13: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 92GHz
Figure 14: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 92GHz, co-polar
Figure 15: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 100GHz

Figure 16: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 100GHz, cross-polar
Figure 17: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 107GHz

Figure 18: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 107GHz, co-polar
Figure 19: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 115GHz

Figure 20: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 115GHz, co-polar
Figure 21: Measurement band 3 horn, radiation pattern with PTFE plano-convex lens 115GHz, cross-polar
4 Comparison of the two lenses performances:

Table 2: Comparison of Lens Performance

<table>
<thead>
<tr>
<th></th>
<th>HDPE meniscus lens</th>
<th>PTFE plano-convex lens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return Loss</td>
<td>&lt; -17.5dB</td>
<td>&lt;-24dB</td>
</tr>
<tr>
<td>Side lobes level (85GHz)</td>
<td>-22.5dB</td>
<td>-26dB</td>
</tr>
<tr>
<td>Side lobes level (92GHz)</td>
<td>-24dB</td>
<td>-23.5dB</td>
</tr>
<tr>
<td>Side lobes level (100GHz)</td>
<td>-22dB</td>
<td>-25dB</td>
</tr>
<tr>
<td>Side lobes level (107GHz)</td>
<td>-21.5dB</td>
<td>-21dB</td>
</tr>
<tr>
<td>Side lobes level (115GHz)</td>
<td>-19.5dB</td>
<td>-20.5dB</td>
</tr>
<tr>
<td>On-axis cross-polar level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(85GHz)</td>
<td>-37dB</td>
<td>-34dB</td>
</tr>
<tr>
<td>On-axis cross-polar level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(100GHz)</td>
<td>-30dB</td>
<td>-28dB</td>
</tr>
<tr>
<td>On-axis cross-polar level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(115GHz)</td>
<td>-40dB</td>
<td>-37dB</td>
</tr>
<tr>
<td>Waist size (85GHz)</td>
<td>9.07mm</td>
<td>9mm</td>
</tr>
<tr>
<td>Waist size (100GHz)</td>
<td>9.39mm</td>
<td>8.9mm</td>
</tr>
<tr>
<td>Waist size (115GHz)</td>
<td>9.65mm</td>
<td>9.19mm</td>
</tr>
</tbody>
</table>
5 ALMA Band 3 system measurements
M.Carter, F.Coq

5.1 Introduction
The ALMA band 3 optics were measured on the IRAM phase and amplitude antenna range. A summary of these measurements are shown below.

5.1.1 Measurement procedure.

The measurements were made at room temperature using a Schottky diode mixer in the place of the SIS mixer. The measurements were made with the ALMA horn fixed to the ALMA cryostat top plate. The distance from the horn to the front plate was the same as that required in the cold. The horn used was the IRAM phase corrected horn. However the meniscus lens was used as the phase corrector and not the plano-convex lens that would be used in the actual system. The difference that this would make was considered to be negligible.

5.1.2 Measurements

Measurements were made on the on the Band 3 optics system. These measurements are resumed below. These measurements were made using the meniscus lens and not the planar convex lens.
### Table 3: Band 3 Optics Measurements

Band 3 system measurements October 05  
Measurements made with horn plus meniscus lens  
Z transmitter to cryostat top plate 380mm

<table>
<thead>
<tr>
<th>Freq. [GHz]</th>
<th>Polarisation</th>
<th>meas. Angle</th>
<th>measured Zw</th>
<th>error Zw</th>
<th>CX*1000 [mR]</th>
<th>Xw [mm]</th>
<th>Wo [mm]</th>
<th>error Wo [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>radial</td>
<td>100</td>
<td>195</td>
<td>15</td>
<td>32</td>
<td>6.1</td>
<td>22.6</td>
<td>0.6</td>
</tr>
<tr>
<td>85</td>
<td>radial</td>
<td>10</td>
<td>189</td>
<td>21</td>
<td>1</td>
<td>0.6</td>
<td>22.1</td>
<td>0.1</td>
</tr>
<tr>
<td>85</td>
<td>Tangential</td>
<td>100</td>
<td>181</td>
<td>29</td>
<td>32</td>
<td>4.7</td>
<td>22.1</td>
<td>0.1</td>
</tr>
<tr>
<td>85</td>
<td>Tangential</td>
<td>10</td>
<td>219</td>
<td>-9</td>
<td>1</td>
<td>1</td>
<td>22.6</td>
<td>0.6</td>
</tr>
<tr>
<td>93</td>
<td>radial</td>
<td>100</td>
<td>209</td>
<td>1</td>
<td>32</td>
<td>6.3</td>
<td>20</td>
<td>-1</td>
</tr>
<tr>
<td>93</td>
<td>radial</td>
<td>10</td>
<td>181</td>
<td>29</td>
<td>0.1</td>
<td>0.11</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>93</td>
<td>Tangential</td>
<td>100</td>
<td>181</td>
<td>29</td>
<td>32</td>
<td>4.2</td>
<td>20</td>
<td>-1</td>
</tr>
<tr>
<td>93</td>
<td>Tangential</td>
<td>10</td>
<td>222</td>
<td>-12</td>
<td>2</td>
<td>0.3</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>100</td>
<td>radial</td>
<td>100</td>
<td>203</td>
<td>7</td>
<td>32</td>
<td>6.4</td>
<td>19</td>
<td>0.3</td>
</tr>
<tr>
<td>100</td>
<td>radial</td>
<td>10</td>
<td>226</td>
<td>-16</td>
<td>1.2</td>
<td>0.1</td>
<td>19</td>
<td>0.3</td>
</tr>
<tr>
<td>100</td>
<td>Tangential</td>
<td>100</td>
<td>193</td>
<td>17</td>
<td>32</td>
<td>4.7</td>
<td>19</td>
<td>0.3</td>
</tr>
<tr>
<td>100</td>
<td>Tangential</td>
<td>10</td>
<td>262</td>
<td>-52</td>
<td>1.7</td>
<td>0.2</td>
<td>19</td>
<td>0.3</td>
</tr>
<tr>
<td>107</td>
<td>radial</td>
<td>100</td>
<td>298</td>
<td>-88</td>
<td>32</td>
<td>9</td>
<td>17.7</td>
<td>0.2</td>
</tr>
<tr>
<td>107</td>
<td>radial</td>
<td>10</td>
<td>191</td>
<td>19</td>
<td>1.7</td>
<td>0.2</td>
<td>17.2</td>
<td>-0.3</td>
</tr>
<tr>
<td>107</td>
<td>Tangential</td>
<td>100</td>
<td>172</td>
<td>38</td>
<td>32</td>
<td>3.9</td>
<td>17.3</td>
<td>-0.2</td>
</tr>
<tr>
<td>107</td>
<td>Tangential</td>
<td>10</td>
<td>284</td>
<td>-74</td>
<td>2.4</td>
<td>0.4</td>
<td>17.5</td>
<td>0</td>
</tr>
<tr>
<td>113</td>
<td>radial</td>
<td>100</td>
<td>274</td>
<td>-64</td>
<td>32</td>
<td>8.7</td>
<td>14.9</td>
<td>-1.7</td>
</tr>
<tr>
<td>113</td>
<td>radial</td>
<td>10</td>
<td>222</td>
<td>-12</td>
<td>1.6</td>
<td>0.3</td>
<td>16.3</td>
<td>-0.3</td>
</tr>
<tr>
<td>113</td>
<td>Tangential</td>
<td>100</td>
<td>222</td>
<td>-12</td>
<td>32</td>
<td>0.57</td>
<td>16.1</td>
<td>-0.5</td>
</tr>
<tr>
<td>113</td>
<td>Tangential</td>
<td>10</td>
<td>283</td>
<td>-73</td>
<td>1.7</td>
<td>0.3</td>
<td>15.1</td>
<td>-1.5</td>
</tr>
</tbody>
</table>

![Figure 22: Measurement band 3 system, Waist diameter vs. frequency](image-url)
Figure 23: Measurement band 3 system, Waist position vs. frequency

Figure 24: Measurement band 3 system, beam direction vs. telescope axis and frequency
Figure 25: 85GHz 2d scan measurements

Figure 26: 100GHz 2d scan measurements
Figure 27: 115GHz 2d scan measurements

The measurements shown and tabulated show that there is a reasonable correlation with theory. There seems to be an error in Z, which occasionally gives an error of \( \pm 75 \) mm. However, this seems to be random and probably an error in the measurements. If this is real it is related to frequency and would then be probably due to the use of the meniscus lens in the horn.

5.1.3 Conclusion

The measurements made show that the warm optics for band 3 are close to theory and should be accepted.

6 ALMA band 3 horn and lenses

7 ALMA BAND 3 RE-OPTIMISATION. OPTION B
   This report is for information only!

8 ALMA BAND 3 Horn and Lens Drawings

9 ALMA BAND 3 Warm Optics Drawings
ALMA band 3 horn and lenses

F. Tercero, J.A. López Fdez, M. Carter, A.L. Fontane

Centro Astronómico de Yebes
Apdo. 148 19080 Guadalajara
SPAIN
Phone: +34 949 29 03 11 ext.210
Fax: +34 949 29 00 63
f.tercero@oan.es

As result of reflection measurements of the horn and the lenses over all the ALMA band 3 bandwidth, new designs of meniscus lenses have been made to improve mismatch. Yebes proposed modifications in the corrugations of the old lenses and a new PTFE meniscus lens. In the other side IRAM has designed a plano-convex PTFE lens with excellent mismatch performance. All these lenses have been simulated (FDTD). The results of the simulations do not follow accurately the measurements but the plano-convex lens is still the better of the simulated lenses. The problems with this lens come from the fit to the layout of the optical system. Finally a new optimisation of the meniscus lens in HDPE is presented showing in simulated results a mismatch of -21.7 dB like the worst result, while the IRAM plano-convex lens shows a mismatch of –23.0 dB.
1 Introduction

After the Groningen All Hands Meeting a new optimisation of the band 3 optical system was done. The optical design was really improved to an ideal aperture efficiency of 81% (blocking not included) and frequency independent system over the band of the ALMA band 3 (84 GHz-116 GHz). The minimal changes in the layout was in the horn aperture (new aperture radius to 14.900 mm fitted to 14.775 mm for horn design requirements), new distance from horn aperture to elliptical mirror and new distance from the elliptical mirror to the subreflector (done moving the flat mirror towards the subreflector).

As result of the new horn aperture radius a new meniscus lens design in HDPE was done (named in the document as horn02_lens02). This horn and lens were measured showing a poor matching in the lower band. The alternatives to the lens measured were the following:

- Improvement of corrugations, with a variable deepness of the corrugations from the centre of the aperture to the edge (horn02_lens03)
- Improvement of corrugations and improvement of dielectric thickness of the lens (horn02_lens03_b, horn02_lens03_d)
- Lower epsilon material, using PTFE in a design similar to horn02_lens03 (horn02_lens04)
- Lower epsilon material, using PTFE and improvement of dielectric thickness of the lens in a design similar to horn02_lens03_b (horn02_lens04_a)
- Change the shape of the lens to a plano-convex one (horn02_lens05)

These horn and lenses are summarized with all the available information of dimensions, material, corrugations, simulations and measurements. Main advantages of the horn and lenses arrangement in the optical layout is also commented.
2 Horn

This section is a review of all the available information of the horn (named horn02) of 14.775 mm of aperture radius designed by M. Carter.

<table>
<thead>
<tr>
<th>name</th>
<th>horn02</th>
</tr>
</thead>
<tbody>
<tr>
<td>aperture radius a(mm)</td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle $\theta_{bo}$ (deg)</td>
<td>18</td>
</tr>
<tr>
<td>input waveguide diameter d (mm)</td>
<td>3</td>
</tr>
<tr>
<td>step corrugation p (mm)</td>
<td>1</td>
</tr>
</tbody>
</table>

IRAM has the design: Yes
IRAM has made it: Yes
IRAM measurement: Yes
HIA measurement: Yes$^{(1)}$

$^{(1)}$ There is a measurement of HIA but we do not know if it is the same designed horn

Tabla 1. Horn data

2.1 Horn simulations

Fig. 1. Horn simulation. Yebes
Fig. 2. Horn with square to circular transition simulation. Probably, the whole horn is not simulate, only the first 10 or 15 slots. IRAM

2.2 Horn measurements

Fig. 3. Measurement from “lenses measurements 27012004.doc” sent to Yebes 28/01/04. IRAM
Fig. 4. Measurement from “ALMA BAND 3 HORN MEASUREMENTS (1).doc” sent to Yebes 28/01/04.
IRAM

Fig. 5. Measurement from “ALMA BAND 3 HORN MEASUREMENTS (1).doc” sent to Yebes 28/01/04.
IRAM
2.3 Horn comments

- The design of the horn is really good over all the bandwidth
- The square to circular is perfectly designed as Fig. 1 and Fig. 2 shows that the performance is quite good
- IRAM measurements do not agree to the simulations. Some problems with measurements or construction of horn and transitions.
- HIA measurements shows a ripple but the envelope follows the simulations.
3 HDPE Meniscus Lenses

Two lenses have been designed in order to improve the reflection measurements.

3.1 horn02_lens03

3.1.1 Data

Changes in edge thickness to accommodate the corrugations and variable corrugations from the axis to the edge of the lens.

<table>
<thead>
<tr>
<th>Name</th>
<th>horn02_lens03</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aperture radius a (mm)</td>
<td>14.775</td>
</tr>
<tr>
<td>Semiangle θ (deg)</td>
<td>18</td>
</tr>
<tr>
<td>Dielectric εr</td>
<td>HDPE 2.32</td>
</tr>
<tr>
<td>Edge thickness e (mm)</td>
<td>1.8</td>
</tr>
<tr>
<td>Total thickness etotal (mm)</td>
<td>8.366</td>
</tr>
<tr>
<td>Dielectric thickness ediel (mm)</td>
<td>6.026</td>
</tr>
<tr>
<td>Lens focal distance f (mm)</td>
<td>53.839</td>
</tr>
<tr>
<td>Corruggations center p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.607</td>
</tr>
<tr>
<td>Corruggations edge p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.713</td>
</tr>
</tbody>
</table>

IRAM has the design Yes 24/11/03

IRAM has made it No

IRAM measurement No

HIA measurement No

---

Tabla 2. Lens data

---

(1) Total thickness is since the aperture of the horn to the vertex of elliptical surface
(2) Includes the corrugations and means the dielectric thickness in the axis before of the surface corrugation
(3) p means step, t means dielectric teeth and s means deepness of corrugation
3.1.2 Simulation

![Graph showing S-Parameter Magnitude in dB over frequency from 80 to 120 GHz.]

**Fig. 7. Simulation of horn02_lens03**

3.1.3 Comments

- Low frequency behaviour near –20 dB
### 3.2 horn02_lens03_b

Similar design to 3.1 but optimising the dielectric thickness to minimize $s_{11}$

#### 3.2.1 Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>horn02_lens03_b</td>
</tr>
<tr>
<td>aperture radius a (mm)</td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle $\theta_{boc}$ (deg)</td>
<td>18</td>
</tr>
<tr>
<td>dielectric dielectric $\varepsilon_r$</td>
<td>HDPE 2.32</td>
</tr>
<tr>
<td>edge thickness e (mm)</td>
<td>2.5</td>
</tr>
<tr>
<td>total thickness etotal (mm)</td>
<td>8.974</td>
</tr>
<tr>
<td>dielectric thickness ediel (mm)</td>
<td>6.634</td>
</tr>
<tr>
<td>lens focal distance f (mm)</td>
<td>54.447</td>
</tr>
<tr>
<td>corrugations center p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.607</td>
</tr>
<tr>
<td>corrugations edge p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.711</td>
</tr>
<tr>
<td>IRAM has the design</td>
<td>No</td>
</tr>
<tr>
<td>IRAM has made it</td>
<td>No</td>
</tr>
<tr>
<td>IRAM measurement</td>
<td>No</td>
</tr>
<tr>
<td>HIA measurement</td>
<td>No</td>
</tr>
</tbody>
</table>

*Tabla 3. Lens data*
3.2.2 Simulation

![Simulation of horn02_lens03_b](image)

Fig. 8. Simulation of horn02_lens03_b

3.2.3 Comments
- 2 dB better in worst frequency than previous design
- 0.6 mm increased dielectric thickness could affect noise
3.3 horn02_lens03_d
Similar design to 3.2 but changing the step of the corrugation.

3.3.1 Data

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>horn02_lens03_d</td>
</tr>
<tr>
<td>aperture radius</td>
<td>a (mm)</td>
</tr>
<tr>
<td></td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle</td>
<td>θ_boc (deg)</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td>dielectric</td>
<td>ε_r</td>
</tr>
<tr>
<td></td>
<td>HDPE 2.32</td>
</tr>
<tr>
<td>edge thickness</td>
<td>e (mm)</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
</tr>
<tr>
<td>total thickness</td>
<td>etotal (mm)</td>
</tr>
<tr>
<td></td>
<td>8.974</td>
</tr>
<tr>
<td>dielectric thickness</td>
<td>ediel (mm)</td>
</tr>
<tr>
<td></td>
<td>6.634</td>
</tr>
<tr>
<td>lens focal distance</td>
<td>f (mm)</td>
</tr>
<tr>
<td></td>
<td>54.447</td>
</tr>
<tr>
<td>corrugations center</td>
<td>p(mm), t(mm), s(mm)</td>
</tr>
<tr>
<td></td>
<td>0.6, 0.3, 0.607</td>
</tr>
<tr>
<td>corrugations edge</td>
<td>p(mm), t(mm), s(mm)</td>
</tr>
<tr>
<td></td>
<td>0.6, 0.3, 0.725</td>
</tr>
<tr>
<td>IRAM has the design</td>
<td>No</td>
</tr>
<tr>
<td>IRAM has made it</td>
<td>No</td>
</tr>
<tr>
<td>IRAM measurement</td>
<td>No</td>
</tr>
<tr>
<td>HIA measurement</td>
<td>No</td>
</tr>
</tbody>
</table>

Tabla 4. Lens data
3.3.2 Simulation

![S-Parameter Magnitude in dB](image)

**Fig. 9. Simulation of horn02_lens03_d**

3.3.3 Comments

- It improves the behaviour in the low frequency respect all the other lenses. That is, in low frequency bands where the results of mismatch were not very good.
- 0.3 mm of cutting tool can be a problem in mechanisation.
4 PTFE Meniscus Lenses

Two lenses have been designed in order to improve the reflection measurements. The lower dielectric constant of the PTFE should improve the reflection within the other actions.

4.1 horn02_lens04

This lens is designed like lens of section 3.1. Variable deepness corrugations in elliptical surface.

4.1.1 Data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>horn02_lens04</td>
</tr>
<tr>
<td>aperture radius a(mm)</td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle θ_boc (deg)</td>
<td>18</td>
</tr>
<tr>
<td>dielectric ε_r</td>
<td>PTFE 2.10</td>
</tr>
<tr>
<td>edge thickness e (mm)</td>
<td>1.8</td>
</tr>
<tr>
<td>total thickness etotal (mm)</td>
<td>9.076</td>
</tr>
<tr>
<td>dielectric thickness ediel (mm)</td>
<td>6.736</td>
</tr>
<tr>
<td>lens focal distance f (mm)</td>
<td>54.549</td>
</tr>
<tr>
<td>corrugations center p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.623</td>
</tr>
<tr>
<td>corrugations edge p(mm), t(mm), s(mm)</td>
<td>0.8, 0.4, 0.753</td>
</tr>
<tr>
<td>IRAM has the design</td>
<td>Yes 21/11/03</td>
</tr>
<tr>
<td>IRAM has made it</td>
<td>Yes</td>
</tr>
<tr>
<td>IRAM measurement</td>
<td>Yes</td>
</tr>
<tr>
<td>HIA measurement</td>
<td>No</td>
</tr>
</tbody>
</table>

Tabla 5. Lens data
4.1.2 Simulation

![Graph of S-Parameter Magnitude in dB](image)

Fig. 10. Simulation of horn02_lens04

4.1.3 Measurements

![Graph of Return Loss](image)

Fig. 11. Measurements of horn02_lens04 from "lenses measurements 27012004.doc" sent to Yebes 28/01/04. IRAM

4.1.4 Comments

- The choice of PTFE improves the mismatch performance
- The measurements do not follow to the simulations
### 4.2 horn02_lens04_a

Similar design to 4.1 but optimising the dielectric thickness to minimize $s_{11}$

#### 4.2.1 Data

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>aperture radius</td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle $\theta_{boc}$ (deg)</td>
<td>18</td>
</tr>
<tr>
<td>dielectric $\varepsilon_r$</td>
<td>PTFE 2.10</td>
</tr>
<tr>
<td>edge thickness $e$ (mm)</td>
<td>2.0</td>
</tr>
<tr>
<td>total thickness $e_{total}$ (mm)</td>
<td>9.247</td>
</tr>
<tr>
<td>dielectric thickness $e_{diel}$ (mm)</td>
<td>6.907</td>
</tr>
<tr>
<td>lens focal distance $f$ (mm)</td>
<td>54.720</td>
</tr>
<tr>
<td>corrugations center $p$, $t$, $s$ (mm)</td>
<td>0.8, 0.4, 0.623</td>
</tr>
<tr>
<td>corrugations edge $p$, $t$, $s$ (mm)</td>
<td>0.8, 0.4, 0.753</td>
</tr>
<tr>
<td>IRAM has the design</td>
<td>No</td>
</tr>
<tr>
<td>IRAM has made it</td>
<td>No</td>
</tr>
<tr>
<td>IRAM measurement</td>
<td>No</td>
</tr>
<tr>
<td>HIA measurement</td>
<td>No</td>
</tr>
</tbody>
</table>

*Tabla 6. Lens data*
4.2.2 Simulation

![Graph of S-Parameter Magnitude in dB]

$S_{11}$

**Fig. 12. Simulation of horn02_lens04_a**

4.2.3 Comments

- The best meniscus lens for PTFE and HDPE meniscus lenses
- Moderate dielectric thickness
4.3 **horn02_lens05**  
Design of a plano-convex lens designed by IRAM

### 4.3.1 Data

<table>
<thead>
<tr>
<th>name</th>
<th>horn02_lens05</th>
</tr>
</thead>
<tbody>
<tr>
<td>aperture radius</td>
<td>a (mm)</td>
</tr>
<tr>
<td></td>
<td>14.775</td>
</tr>
<tr>
<td>semiangle</td>
<td>$\theta_{boc}$ (deg)</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td>dielectric</td>
<td>$\varepsilon_r$</td>
</tr>
<tr>
<td></td>
<td>PTFE 2.10</td>
</tr>
<tr>
<td>edge thickness</td>
<td>e (mm)</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>total thickness</td>
<td>etotal (mm)</td>
</tr>
<tr>
<td></td>
<td>7.318</td>
</tr>
<tr>
<td>dielectric thickness</td>
<td>ediel (mm)</td>
</tr>
<tr>
<td></td>
<td>7.318</td>
</tr>
<tr>
<td>lens focal distance</td>
<td>f (mm)</td>
</tr>
<tr>
<td></td>
<td>--</td>
</tr>
<tr>
<td>corrugations center</td>
<td>p(mm), t(mm), s(mm)$^{(3)}$</td>
</tr>
<tr>
<td></td>
<td>0.8, 0.4, 0.624</td>
</tr>
<tr>
<td>corrugations edge</td>
<td>p(mm), t(mm), s(mm)$^{(3)}$</td>
</tr>
<tr>
<td></td>
<td>0.8, 0.4, 0.624</td>
</tr>
</tbody>
</table>

| IRAM has the design         | IRAM design   |
| IRAM has made it            | Yes           |
| IRAM measurement            | Yes           |
| HIA measurement             | No$^1$        |
| Yebe has the design         | Yes (28/01/04) |

*Tabla 7. Lens data*
4.3.2 Simulation

![Graph showing S-Parameter Magnitude in dB for horn02_lens05 simulations.](image1)

*Fig. 13. Simulation of horn02_lens05*

4.3.3 Measurements

![Graph showing Return loss (dB) for horn(1) and horn(1) + plano-convexe lense PTFE.](image2)

*Fig. 14. Measurement from “lenses measurements 27012004.doc” sent to Yebes 28/01/04. IRAM*

4.3.4 Comments

- The horn and lens arrangement is the best since the simulations and measurements in mistmatch
- The difference with the best PTFE meniscus lens is 0.7 dB in the simulations
- Measurements and simulations do not follow exactly
- Moderate dielectric thickness
- The fit of this lens in the optics must be done after the horn and lens measurement of the radiation patterns
5 Conclusions

The comparison of horn and lens measurements and simulations do not fit very well. Really the reflection simulations are not as accurate as other simulations and are very mesh dependent. However the measurements of the horn made in the HIA shows similar behaviour than simulations but a little ripple is added. Construction and measurement is extremely complicate at this frequencies and maybe some problems in these issues could be investigated. As first main conclusion, the design of IRAM horn is excellent but some problems could be found with construction or measurement system.

The simulations of all lenses shows that PTFE is preferred to HDPE because the lower dielectric constant makes the mismatch lower. However, in the electrical point of view, higher dielectric thickness is found in PTFE thickness than in HDPE lenses. Other points should be taken into count like, easiness for construction, tolerances in construction, control in the dielectric constant of material at ambient and cryogenic temperature, losses in dielectric…Electrical criteria for materials are not definitive, all other criteria could be more important.

Any lens used in the system will never have a mismatch better that –23 dB. This number is for the plano-convex PTFE lens designed by IRAM. The meniscus lens is always worse than the plano-convex lens, but only 1 dB. There is an optimum meniscus lens which has the lowest mismatch. It is designed with an optimum edge thickness. These improvements are very slight. It is very difficult to detect such slight improvements in the measurements, because any added mismatch of the horn, transition, measurement system… will mask the results. Simulations of meniscus and plano-convex lenses shows differences less than 1 dB and could be difficult to find in the measurement system.

The analysis of the radiation patterns of the whole system taking into account the horn, lens, elliptical and flat mirror could be simulated with PO after the horn and lens radiation pattern measurement. Previous calculations with theoretical models of horn and lenses are not as accurate as needed now. Calculations with PO are better after the radiation pattern measurements.
ALMA BAND 3 RE-OPTIMISATION. OPTION B

F. Tercero, J.A. López Fernández, C.Y. Tham, M. Carter

Centro Astronómico de Yebes,
Apdo. 148
19080 Guadalajara
SPAIN

Phone. +34 949 29 03 11 ext. 210
Fax. +34 949 29 00 63
e-mail. f.tercero@oan.es
www.oan.es

ABSTRACT

This option B modifies relative positions of horn and flat mirror respect the elliptical mirror that it is still fixed in its current position. The aperture of the horn is also reduced to 14.90 mm in order to decrease the taper to the level of -10 dB

I. INTRODUCTION

The results of the PO simulations of the band 3 for Option A shows good results in aperture efficiency but little worse noise temperature is achieved due to spillover in the reflectors. This option modifies the horn aperture in order to achieve a taper of about -10 dB.

In this option, the mirror is fixed to the current values (focal distance of mirror is 203 mm). The layout of the system is the same that Option A and the horn aperture is 14.90 mm

The whole system is simulated with PO in the actual antenna position (that is offset in the cassegrain focus and tilted to hit the secondary mirror) reviewing the truncation levels in the elliptical and flat mirror in order to determine the accurate diameters of both mirrors. Complete antenna analysis is available with the calculated values of aperture efficiency and noise temperature due to spillover in mirrors
II. RADIOTELESCOPE DATA

Data of the radiotelescope useful to synthetize the system and calculate the coupling of the radiated fields to the subreflector like an aperture efficiency measurement.

\[ D := 12 \times 10^3 \]  
Main dish diameter

\[ \text{FED} := 8 \]  
Equivalent focal ratio

\[ \text{M}_2 \_2c := 6177 \]  
Distance between primary and secondary foci

\[ \text{exc} := 1.10526 \]  
Secondary eccentricity

\[ \text{rs} := 375 \]  
Subreflector radius

\[ \text{Lr} = 5882.87 \]  
Cassegrain focus to hyperboloid vertex distance

\[ \text{prof} = 111.33 \]  
Thickness of the subreflector between edge and vertex

\[ \Phi_r = 3.58 \]  
Semiangle of secondary

\[ \text{ws}(12) = 319.044 \]  
Beam radius in the subreflector in order to achieve the -12dB of taper in the edge of the subreflector

III. HORN AND LENS DATA

\[ \text{radio\_boc} := 14.9 \]  
Aperture radius

\[ \text{aboc\_boc} := 18 \]  
Half flare angle (deg)

\[ n := \sqrt{2.32} \]  
Refraction index of HDPE at 300 K

\[ \tan \delta := 3 \times 10^{-4} \]  
Losses LAMB

\[ e := 1 \]  
Edge thickness

Horn only QO data

\[ \text{FD} = 1.837 \]  
\[ w_0(\lambda_0, \text{FD}, \beta) = 4.121 \]  
\[ \text{axial}(\text{FD}, \beta) = 45.857 \]

\[ \beta = 5.073 \]  
\[ \Delta(\lambda_0, \text{FD}, \beta) = 37.386 \]  
\[ \text{slant}(\text{FD}, \beta) = 48.217 \]

\[ ze(\lambda_0, \text{FD}, \beta) = 17.796 \]
Horn plus lens data

\[ f_1 = 53.589 \]  

focal distance of the lens

\[ \text{etotal}(FD, \beta, n, f_1, e) = 7.731 \]  

total thickness of the lens since the horn aperture to ellipsoidal vertex lens

\[ w_{0\text{out}} = 10.388 \]  

Beam waist in the vertex lens

Theoretical radiation pattern of the horn plus lens at central frequency

\[ \theta := -25, -24.8.. 25 \]
IV. CABIN OPTICS

The fundamental GBM of the system horn plus lens and ideal lens (elliptical mirror) is optimized with -12 dB goal in the edge of the subreflector. The radius of curvature is optimized to be equal to the distance between the cassegrain focus to the edge of the subreflector. That is Lr+prof.

The multimode analysis and the further PO analysis shows that the actual edge taper in the subreflector edge is higher (-9 dB / -10 dB).

\[ T := 13 \quad \text{Taper goal} \]

\[ d30 := 287.46 \quad \text{Mirror to cassegrain focus distance goal} \]

\[
\text{Fundamental GBM taper in subreflector:} \quad \text{Rout}(d2, d3 + Lr + \text{prof}, f2, w0out, \lambda_0) = 6.079 \times 10^3
\]

\[
\text{Fundamental GBM beam radius in subreflector:} \quad \text{waistout}(d2, d3 + Lr + \text{prof}, f2, w0out, \lambda_0) = 311.068
\]

\[
\text{Fundamental GBM curvature radius in subreflector:} \quad \text{Defocused in wavelengths}
\]

**Feed horn data**
- \( \text{FD} = 1.837 \)
- \( \beta = 5.073 \)
- \( \text{radio}(\text{FD,} \beta) = 14.9 \)
- \( \text{axial}(\text{FD,} \beta) = 45.857 \)

**Lens data**
- \( f1 = 53.589 \)
- \( \text{etotal}(\text{FD,} \beta, n, f1, e) = 7.731 \)
- \( e = 1 \)
- \( n = 1.523 \)

**System data**
- \( f1 = 53.589 \)
- \( d2 = 209.779 \)
- \( f2 = 203 \)
- \( d3 = 287.459 \)
Fundamental GBM propagation (5*beam radius). d2 is the position from horn to elliptical mirror and d2+d3 is the position from the horn to cassegrain focus.

![Beam propagation diagram]

**eficiencia vs taper**

Radiation pattern in cryostat window and elliptical mirror at low frequency. Multimode calculation.

\[ z_0 = \frac{50}{d_2 - 0.01} \]

window distance

elliptical mirror distance

![Near field pattern in window and mirror]

The truncation level in the cryostat window is about -35 dB and in the elliptical mirror is -30 dB.
\[ r := 0, 20...800 \]
\[ z_0 := d_2 + d_3 + L_r + \text{prof} \quad \text{distance since the vertex lens to the edge of the subreflector} \]

\[ P_{c0}(r, z_0, \lambda_{\text{low}}) = -9.926 \]
\[ P_{c0}(r, z_0, \lambda_0) = -9.926 \]
\[ P_{c0}(r, z_0, \lambda_{\text{upp}}) = -9.926 \]

Efficiency is calculated as coupling to top-hat function in the subreflector

\[ \varepsilon_{\text{taper}}(\lambda_{\text{low}}) = 0.923 \quad \varepsilon_{\text{taper}}(\lambda_0) = 0.923 \quad \varepsilon_{\text{taper}}(\lambda_{\text{upp}}) = 0.923 \]
\[ \varepsilon_{\text{spill}}(\lambda_{\text{low}}) = 0.97 \quad \varepsilon_{\text{spill}}(\lambda_0) = 0.97 \quad \varepsilon_{\text{spill}}(\lambda_{\text{upp}}) = 0.97 \]
\[ \varepsilon_{\Delta}(\lambda_{\text{low}}) = 0.994 \quad \varepsilon_{\Delta}(\lambda_0) = 0.991 \quad \varepsilon_{\Delta}(\lambda_{\text{upp}}) = 0.988 \]
\[ \varepsilon_{\text{blk}}(\lambda_{\text{low}}) = 0.988 \quad \varepsilon_{\text{blk}}(\lambda_0) = 0.989 \quad \varepsilon_{\text{blk}}(\lambda_{\text{upp}}) = 0.989 \]
\[ \varepsilon_{\text{ap}}(\lambda_{\text{low}}) = 0.879 \quad \varepsilon_{\text{ap}}(\lambda_0) = 0.877 \quad \varepsilon_{\text{ap}}(\lambda_{\text{upp}}) = 0.874 \]

band3_PO_optionB.mcd
01/07/2003
V. GRASP DATA

The script is calculated using some inputs that define the layout. We suppose that the elliptical mirror has to be fixed in the classical and alternative band 3 solution. It is one of the most problematic mirror in the warm optics design. The inputs of the system are the following:

- $\theta_i$ : Incidence angle respect the normal (highly fixed to 25 deg)
- $d_2$, $d_3$ : System distances defined along this doc
- $x_{\text{ellip}}$, $y_{\text{ellip}}$, $z_{\text{ellip}}$ : Central point of elliptical mirror
- $d_{\text{ellip}}$, $d_{\text{flat}}$ : Projected diameters of both mirrors

The outputs of the system will be:

- Detailed geometry data
- Clearance in cassegrain focus
- Pointing angle of the antenna due to offset
- GRASP file

V-a. Input/Output data

$$\theta_i := 25 \text{ deg}$$

Incidence angle

$$d_2 = 209.799$$

Horn to elliptical mirror distance

$$d_3 = 287.459$$

Elliptical mirror to cassegrain focus distance

$$\begin{pmatrix}
x_{\text{ellip}} \\
y_{\text{ellip}} \\
z_{\text{ellip}}
\end{pmatrix} :=
\begin{pmatrix}
54.0 \\
306.0 \\
-24.51
\end{pmatrix}$$

Position of the elliptical mirror (center or main ray incidence) referred to cassegrain focus.

$$\text{diam}_{\text{ellip}} := 130$$

Projected diametre of elliptical mirror

$$\text{diam}_{\text{flat}} := 115$$

Projected diametre of flat mirror

$$\begin{pmatrix}
d_{31} \\
d_{32} \\
\theta_{\text{sub}} \text{ deg}
\end{pmatrix} =
\begin{pmatrix}
160.024947 \\
127.434445 \\
1.792978
\end{pmatrix}$$

Elliptical to flat mirror distance

Flat mirror to cassegrain plane distance

Tilted angle of main ray

$$\text{cass}_{\text{clearance}} = 60.806$$

Radius of clearance in cass focus

$$\theta_{\text{pointing}} \text{ deg} = 0.10990914$$

New antenna pointing (deg)

$$\theta_{\text{flat}} \text{ deg} = 24.104$$

Flat mirror angle respect the cryostat plane
\[ r_{\text{elip}} = 71.72 \]
Rim radius of elliptical mirror (large)

\[ 0.5 \cdot \text{diam}_{\text{ellip}} = 65 \]
Rim radius of elliptical mirror (short)

\[ r_{\text{flat}} = 62.992 \]
Rim radius of flat mirror (large)

\[ 0.5 \cdot \text{diam}_{\text{flat}} = 57.5 \]
Rim radius of flat mirror (short)

**V-b. System layout**

The system has been simulated off axis, in the actual position in the receiver's cabin.

**V-c. GRASP file**

Click in area to see the detailed GRASP data

**GRASP data**
VI. DATA ACQUISITION

The analysis of several critical points of the optics is done for the frequencies 85, 100 and 115 GHz. The analysis is done for the simulated horn. These results must be compared with the results of the current band 3 optics related in the report2.pdf from Tham.

The points to be compared are the following:

- Far field comparison of simulated/measured horn with the SWE
- Radiation pattern in elliptical mirror, flat mirror and in cassegrain focus. Truncation levels
- Radiation pattern in subreflector. Taper and coupling to top-hat function
- Radiation pattern of antenna. Gain, aperture efficiency, SLL
- Noise temperature of the system

VI-a. Simulated Horn 85 GHz
The mean value of the taper in the edge of the subreflector

\[
\text{Taper} = 10.103
\]

\[
R_{\phi0} = 6021
\]

\[
R_{\phi90} = 6034
\]

The coupling to the top hat function on the subreflector

\[
\varepsilon_{\text{taper}} = 0.9089 \quad \varepsilon_{\text{spill}} = 0.9557 \quad \varepsilon_{\Delta} = 0.9925 \quad \varepsilon_{\text{blk}} = 0.9883
\]

\[
\varepsilon_{\text{ap}} = 0.8519
\]
gain = 79.672

eap = 0.813

SLL = 27.671

Tin

= 60

Equivalent noise temperature after main reflector
VI-b. Simulated Horn 100 GHz

NF in Elliptical Mirror 100 GHz

NF in Flat Mirror 100 GHz
The mean value of the taper in the edge of the subreflector

\[
\text{Taper} = 9.987
\]

\[
R_{\phi 0} = 5991
\]

\[
R_{\phi 90} = 5970
\]

The coupling to the top hat function en the subreflector

\[
\epsilon_{\text{taper}} = 0.9103 \quad \epsilon_{\text{spill}} = 0.9627 \quad \epsilon_{\Delta} = 0.9901 \quad \epsilon_{\text{blk}} = 0.9888
\]

\[
\epsilon_{\text{ap}} = 0.8579
\]

\[
\text{Equivalent noise temperature after main reflector}
\]

\[
T_{\text{in}} = 58.327
\]

\[
SLL = 20.413
\]

\[
\text{gain} = 81.117
\]

\[
\epsilon_{\text{ap}} = 0.8191
\]

\[
\text{SLL} = 20.413
\]

\[
T_{\text{in}} = 58.327
\]

\[
\text{gain} = 81.117
\]

\[
\epsilon_{\text{ap}} = 0.8191
\]

\[
\text{SLL} = 20.413
\]

\[
T_{\text{in}} = 58.327
\]
VI-c. Simulated Horn 115 GHz

NF in Elliptical Mirror 115 GHz

NF in Flat Mirror 115 GHz

band3_PO_optionB.mcd
01/07/2003
The mean value of the taper in the edge of the subreflector

\[ \text{Taper} = 10.064 \]
\[ R_{\theta 0} = 6054 \]
\[ R_{\phi 0} = 6010 \]

The coupling to the top hat function en the subreflector

\[ \varepsilon_{\text{taper}} = 0.914 \quad \varepsilon_{\text{spill}} = 0.9633 \quad \varepsilon_{\Delta} = 0.9874 \quad \varepsilon_{\text{blk}} = 0.9886 \]
\[ \varepsilon_{\text{ap}} = 0.8594 \]

Equivalent noise temperature after main reflector

\[ \text{Gain} = 82.325 \]
\[ \varepsilon_{\text{ap}} = 0.818 \]
\[ \text{SLL} = 21.842 \]
\[ \text{F}_{\text{in}} = 58.245 \]
VII. CONCLUSIONS

Option B optics has been calculated. The difference with Option A optics is the aperture radius of the horn (15.465 mm A and 14.900 mm B). Other parameters like distances between elements are unchanged. The conclusions of optionA document concerning to the changes to do in the layout are directly applicable in this optics.

The main difference in the results of the calculations are the following. The taper in the edge of the subreflector is a frequency-independent taper of -10 dB. The changes in the efficiency figures are 0.3 % in low frequency and 0.1 % in the rest of the bandwidth. No practical differences in the aperture efficiency are observed. The noise temperature due to spillover in the reflector is improved 1.2K in the center and the high range of the band. Sidelobes are also slightly improved due to the less uniform illumination in the subreflector.

As main conclusion this horn lets a more standard taper in the subreflector with an slightly improvement in the noise temperature.
NOTES:

1. PRESS PINS TO DEPTH AS SHOWN.

2. NOTE ORIENTATION OF DOWEL PINS AND FLAT FEATURE.

MATERIAL RECOMMENDED: CANADA