The need of compact profiled corrugated horns at longer mm-waves (ALMA band 1) and at around 1 THz (band 10)

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Abstract—

I. Introduction

Conical corrugated horns are the preferred choice for reflector antenna feeds at mm- and sub-mm wave frequencies due to good beam symmetry, good cross-polarization, low side-lobes and lower loss than non-corrugated conical horns. High performance horns invariably require small opening angles and large apertures, which translate in long horns. In turn, long horns are inconvenient for some frequency bands. On the one hand, long conical corrugated horns at the lower end of the mm-wave range (ALMA band 1) are heavy, bulky and difficult to manufacture in one piece. On the other hand, these horns are very difficult to accurately fabricate for frequencies approaching 1 THz and above (ALMA band 10 and above). In this case, horns are long in terms of the wavelength and dimensions of corrugations are very small. This results in difficult to determine fabrication errors (irregular corrugation shapes, non-built corrugations, metal left inside the horn, etc.) which degrade performance.

Recently, the focus on heterodyne receivers at these frequencies is moving towards multi-pixel receivers to improve mapping abilities when used in high resolution telescopes such as ALMA. Such receivers need high performance horns which can be fabricated with good repeatability. In the case of the ALMA band 10 long conical horn, the final production yield was around 70%. One of the main reasons for this relatively low yield was the high number of corrugations and their size in comparison with the horn length. Shorter profiled horns are easier to fabricate and would improve the yield in a multi-pixel receiver.

Profiled corrugated horns are known to be a good alternative to conical corrugated horns when length is an issue. The length of these horns is reduced by changing the shape of the horn profile from the waveguide input to the horn aperture. The change in the profile excites higher order modes which must be controlled in order to not have narrow band performance degradations.

The choice of the profile will determine the return loss of the horn, the beam size, the position of the phase center and their frequency dependence. Traditional and more irregular profiles provide horn designers with extra possibilities and more flexibility. However, great care must be exercised in order to get the required performance in all the bandwidth of interest. Mode-Matching/Method of Moments software is of great help for this task.

In the last year, NAOJ Future Development team has been working on optics designs for different receivers, among other research lines. In particular, designs have been produced for horns for ALMA band 1 and band 10. The designed profiled horns achieved the same performance as long conical horns at much reduced length and number of corrugations. However, some intermediate design failures highlighted the difficulty of dealing with higher-order modes. At the beginning of 2015, this research will be extended and new designs will be produced at ALMA band 10 frequencies and at 1.2-1.6 THz. This paper will report on this research and designs.