The design, construction and measurement of a quasi-optical multiplexer and antenna for space-borne atmospheric measurements from 56 to 425 GHz

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***Abstract*—we have developed a low-loss quasi-optical multiplexer (QOM) for future space-based meteorological radiometry covering nearly a decade of frequencies - from 54 GHz to 425 GHz. We have shown that very low loss can be combined with high channel co-alignment in a compact package, suitable for surviving the launch environment.**

The QOM uses shallow angle low-loss dichroic plates (DCP's) allowing polarization diversity and ultra-Gaussian horn feeds to minimize both component size and standing waves.

The losses in the multiplexer were measured using a novel double path S_{11} VNA technique, and beam co-alignment was verified by scanning with a wideband detector.

I. INTRODUCTION

Next generation space-borne radiometers for meteorological measurements at millimeter wavelengths require multiple channels in a compact instrument. Here we report on a breadboard system optimized for frequencies between 54 and 425 GHz which has been integrated within a volume of 600 x 400 x 200 mm. The QOM has been designed to use low incidence angles at both dichroics and mirrors to minimize cross-polar and higher order mode generation, and to optimize the DCP performance.

Fig. 1. The doubled layered QOM, with Cu-colored DCPs on the top layer with the VNA head in the top right of the picture.

Precision ellipsoidal and hyperbolic mirrors were machined to 10 μm RMS tolerances such that Ruze scattering is minimal. The baseplate was also machined to a tolerance of +/-1 mm such that co-axial alignment of all 5 channels could be achieved by shimming at the < 0.5 mm level.

Ultra-Gaussian horns (UG) (see [1]) have been employed in all channels to achieve low sidelobes (< −24 dB) and hence low edge truncation for a given beam diameter. This is particularly important in the QOM, where the major task is to fold a number of periscopes into the required volume. These horns have also been very effective in reducing standing waves. Measurement in the time-domain showed that almost no scattering occurs at component edges, or in apertures in the QON baseplate.

In addition, we have developed low-loss dichroics [2] which are polarization insensitive and provide rapid switches from reflection to transmission to pick off neighboring channels – see Fig. 2.

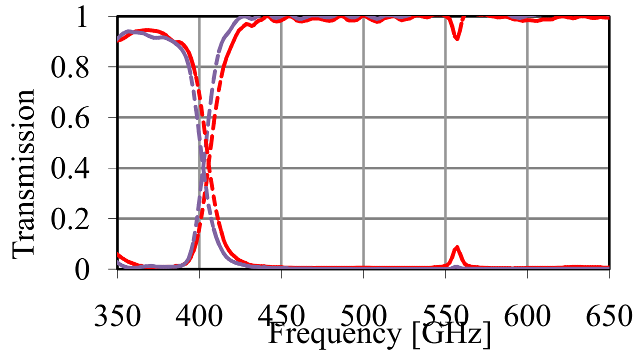

Fig. 2. Dichroic for separating 380 and 425 GHz bands at 22.5 degree beam incidence. Red and blue depict P and S-state polarization.

II. RESULTS

S_{11} losses were measured using a double pass technique for a beam reflected from a flat mirror placed at the antenna interface ~1 m from the QOM; results for one channel are shown in Fig. 3.

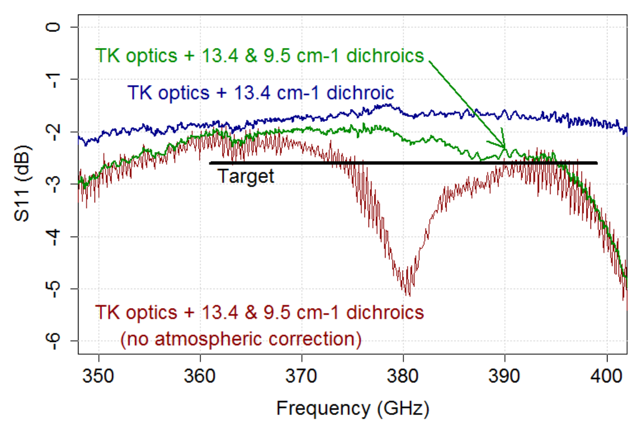

Fig 3. Double pass losses at 380 GHz. The water absorption for the ~ 8 m return path is predicted by absorption models.

[1]. P.A. Ade, R. J. Wylde, J. Zhang. "Ultra-Gaussian Horns for ClOVER - a B-Mode CMB Experiment," 20th International Symposium on Space Terahertz Technology, Charlottesville, 20-22 April 2009.

[2]. P. Ade, C. Tucker, "A Review of Metal Mesh Filters," Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, 2006.