Development of the HIFI band 3 and 4 mixer units

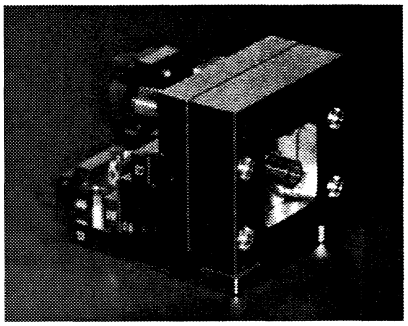
G. de Lange(1), B.D. Jackson(1), M. Eggens(1), H. Golstein(1), W.M. Laauwen(1), L. de Jong(1), S. Kikken(1), C. Pieters(1), H. Smit(1), D. Van Nguyen(1), M. Kroug(2), T. Zijlstra(2), T.M. Klapwijk(2)
(1) SRON National Institute for Space Research Postbus 800, 9700 AV Groningen, the Netherlands
(2) Department of Nanoscience, Faculty of Applied Science, Delft University of Technology. Lorentzweg 1, 2628 CJ Delft, The Netherlands

Abstract
We describe the current status of the HIFI mixer units for Band 3 and Band 4. The mixer units cover the 800-960 GHz and 960-1120 GHz frequency range and have a 4-8 GHz IF frequency band. The major requirements and the performance status are presented.

1. INTRODUCTION
The Herschel Space Observatory (launch date 2007) will fly two cameras/medium resolution spectrometers (PACS and SPIRE) and the heterodyne instrument HIFI [1,2,3]. An international consortium led by the PI institute, SRON, is building HIFI. SRON is also responsible for the development of the mixer units for band 3 (800-960 GHz) and 4 (960-1120 GHz)[4]. Each of these bands contains two tunerless waveguide mixers (to measure both orthogonal polarizations) with a 4-8 GHz IF band. The mixer unit development program is currently in the Qualification Model phase, in which extensive environmental testing will prove the flight worthiness of the units. In this paper we present the current status of the mixer unit design and the performance.

2. REQUIREMENTS
A summary of the design drivers for the mixer units is given in Table 1. The two main requirements for the instrument are reliability and sensitivity. Note that the challenging goal sensitivities of the mixer units given in Table 1 are the sensitivities of the mixer unit only, without noise contributions from the optics and IF.

3 PERFORMANCE STATUS.
The current design of the mixer unit is shown in Fig. 1.



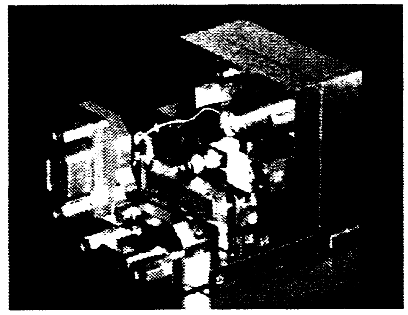


Figure 1 Front and backside view of an assembled mixer unit

The heterodyne elements in the mixer units are $Nb/Al_2O_3/Nb$ SIS twin junctions with Al and NbTiN top and bottom wiring layers, respectively. The devices are fabricated at DIMES [5,6]. For band 4 we currently use NbTiN films grown at the Jet Propulsion Laboratory by J. Stern. Some typical receiver DSB Noise Temperatures versus RF frequency of band 3 and 4 mixer units are shown in Fig. 2. The figure shows noise measurements performed at 2 K with both a thin (14 μm) and thick (55μm) mylar beam splitter, and the expected performance within the HIFI instrument . The noise temperature is measured with the full 4-8 GHz IF-band. The measured receiver noise temperature for the thin beam splitter measurement ranges from 240 to 750 K DSB, but the receiver noise temperature in HIFI will be considerable lower (by approximately 100 K) than inour laboratory receiver, since HIFI will operate with a cold diplexer and LO and without heat filters in the signal path.

T_{mix} DSB	**Band 3**		**Band 4**	
Frequency	*800 GHz*	*960 GHz*	*960GHz*	*1120 GHz*
Baseline	119 K	158 K	158 K	190 K
Goal	99 K	129 K	129 K	151 K

Sensitivities, excluding contributions from IF chain and optics losses

- Withstand shelf life, bake-out, launch and in-orbit operation (9 years)
- Mass < 75 grams
- Envelope 32x32x45 mm
- IF range 4-8 GHz, ripple < 2dB/1 GHz
- De-flux heater operating at current < 20 mA
- Magnet current < 10 mA for second minimum in the Fraunhofer pattern
- Beam quality
- Optical alignment tolerances (goal): x,y: 42 μm, tilt 0.2°
- ESD protection, EMC shielding
- Bias circuit isolation > 30 dB in IF range

Table 1 Summary of the main requirements of the HIFI band 3 and 4 mixer units

5. ACKNOWLEDGEMENT.
We would like to thank Jeff Stern from JPL for providing the NbTiN film in the band 4 mixer unit and Wim Kooi from Caltech for the detailed simulation of the IF and RF design.

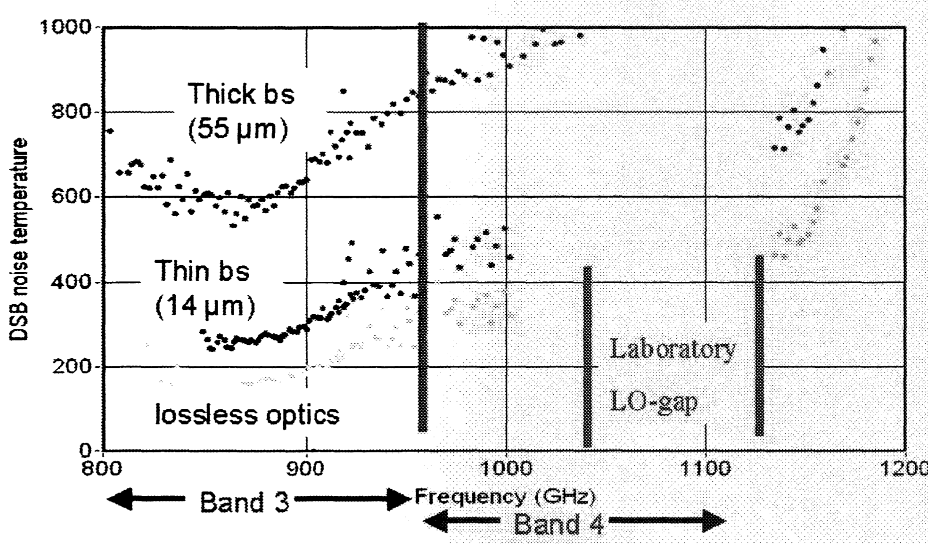


Figure 2 DSB receiver noise temperatures at 2 K measured with a thick (55 μm, upper curve) and thin (14 μm) beamsplitter of band 3 and band 4 mixer units. Data above 922 GHz is measured with the band 4 mixer unit (two different devices). The lower curves indicate the predicted performance for the case of zero optical loss.

6. REFERENCES

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