Optical design and verification of the sub-millimeter limb sounder TELIS

P. Yagoubov[1], G. de Lange[1], A. Baryshev[2], R. Hesper[2], V. Koshelets[3], G. Wagner[4], M. Birk[4], A. Murk[5]

SRON Netherlands Institute for Space Research

[1]National Institute for Space Research, SRON, the Netherlands
[2]Kapteyn Astronomical Institute /SRON
[3]Institute of Radio Engineering and Electronics, IREE, Russia
[4]Institute for Remote Sensing Technology, DLR, Germany
[5]Institute of Applied Physics, University of Bern, Switzerland

TELIS

Abstract

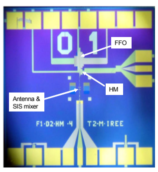
TELIS (Terahertz and submm Limb Sounder) is a cooperation between European institutes, DLR, RAL and SRON, to build a three-channel balloon-borne heterodyne spectrometer for atmospheric research. The optical front-end of the instrument consists of a dual-offset Cassegrain pointing telescope (elliptical shape 28x14 cm), calibration blackbody and the relay optics (common for the three channels). Beam separation between the channels is performed quasioptically by a dichroic filter and a polarizer. After the splitting, the three beams enter the liquid helium cooled cryostat, where each receiver has dedicated cold optics and mixer elements.

In this poster we present the optical design and verification of the quasioptical 500 - 650 GHz channel for TELIS. It is based on a phase-locked Superconducting Integrated Receiver (SIR). The SIR chip is placed on the flat back surface of the elliptical silicon lens forming an integrated lens-antenna. Further shaping and relaying of the beam is done by means of reflective optics.

Design and validation of the optics, as well as estimation of optical components tolerances, have been performed using commercial software packages ZEMAX and GRASP.

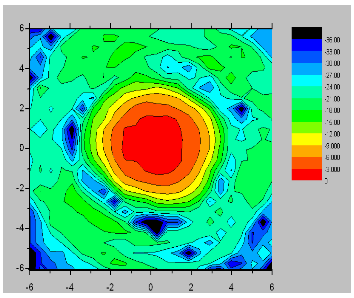
We present experimental results of the far field amplitude beam measurements of the integrated lens-antenna, amplitude-phase measurements of the SIR cold optics and first results of the vertical beam profile of the complete instrument performed at 600 GHz.

SIR chip design & Integrated lens-antenna characterization

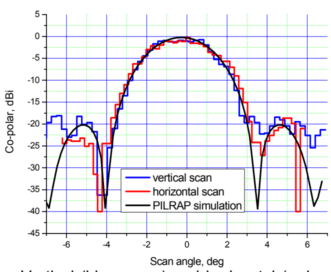


On-chip integration of the mixer and LO – Superconducting Integrated Receiver

Quasioptical coupling using integrated lens-antenna configuration

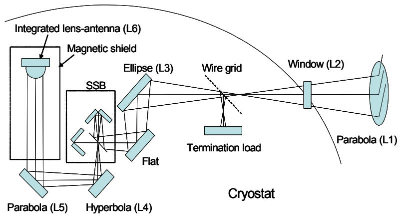


Far-field 2D scan of the integrated lens-antenna beam pattern. The isolines are at -5 dB, -10 dB, -15 dB, -20 dB etc

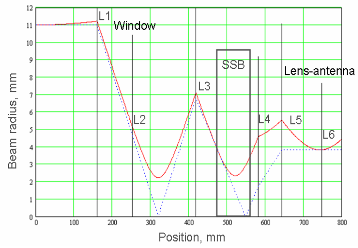


Vertical (blue curve) and horizontal (red curve) far-field scans. The fit (black curve) is calculated by PILRAP.

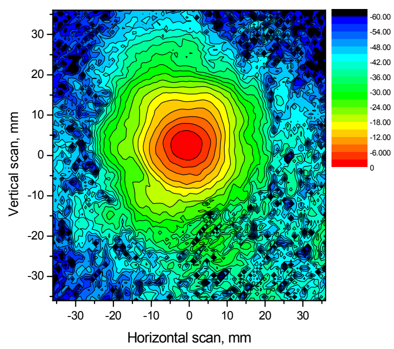
Cold optics design & amplitude-phase measurements



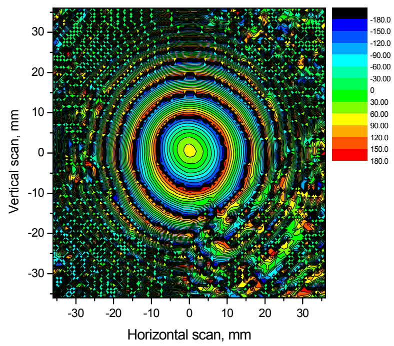
Layout of the SIR cold channel. In the test flight the SIR will operate in double sideband mode; SSB filter is replaced by a set of two plane mirrors (not shown in the picture).



Optical (dotted line) and quasioptical (solid line) trajectories (1/e field level @625GHz) in the cold channel. The curved mirrors (L1), (L3), (L4) and L5), the window (L2) and the integrated lens-antenna (L6) are given schematically as thin vertical lines, representing thin lenses.

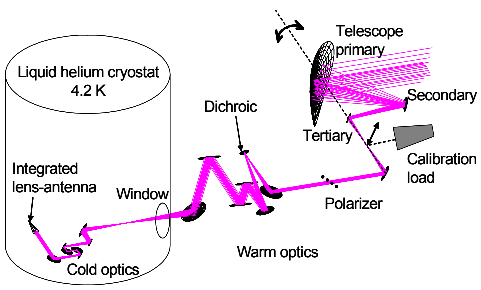


SIR cold channel amplitude distribution. Distance from the waist position – 110mm. Frequency - 600GHz.

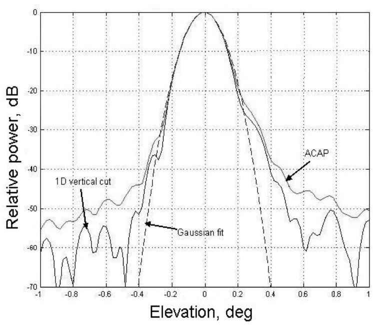


SIR cold channel phase distribution. Distance from the waist position – 110mm. Frequency - 600GHz.

SIR channel optics design



Schematics of the 500-650 GHz channel optics. The telescope is rotated around the axis coinciding with the direction of the output beam. Wire grid polarizer and dichroic plate are used to separate this receiver from the two other frequency channels (not shown). The cold optics and mixer element are located inside the cryostat at the ambient temperature 4.2 K.



Calculated by GRASP far field 1-D vertical (elevation) cut and Azimuthally Collapsed Antenna Pattern (ACAP) at 625 GHz.

Summary

- Integrated lens-antenna has been modeled using PILRAP. Far field amplitude beam measured at 600GHz is in a good agreement with simulations.
- The optics has been designed using 1-D MathCad tool and verified by GRASP. Amplitude-phase beam measurements of the cold optics are performed at 600GHz. The measured beam waist is 2.25mm (within1% of the designed value), Gaussisity of the measured beam is 92.4%.
- Compact range (copy of the TELIS telescope with horizontally oriented slit source at the focus) is setup for the vertical beam profile measurements. Preliminary tests indicate 0.4deg FWHM beam at 600GHz, in excellent agreement with the design. The corresponding beamsize at tangent point is 1.6km.

Acknowledgements

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For further information please contact: p.a.yagoubov@sron.rug.nl

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