Calibration Hot Load for SMILES

Axel Murk

Institute of Applied Physics, University of Bern, Switzerland

murk@mw.iap.unibe.ch

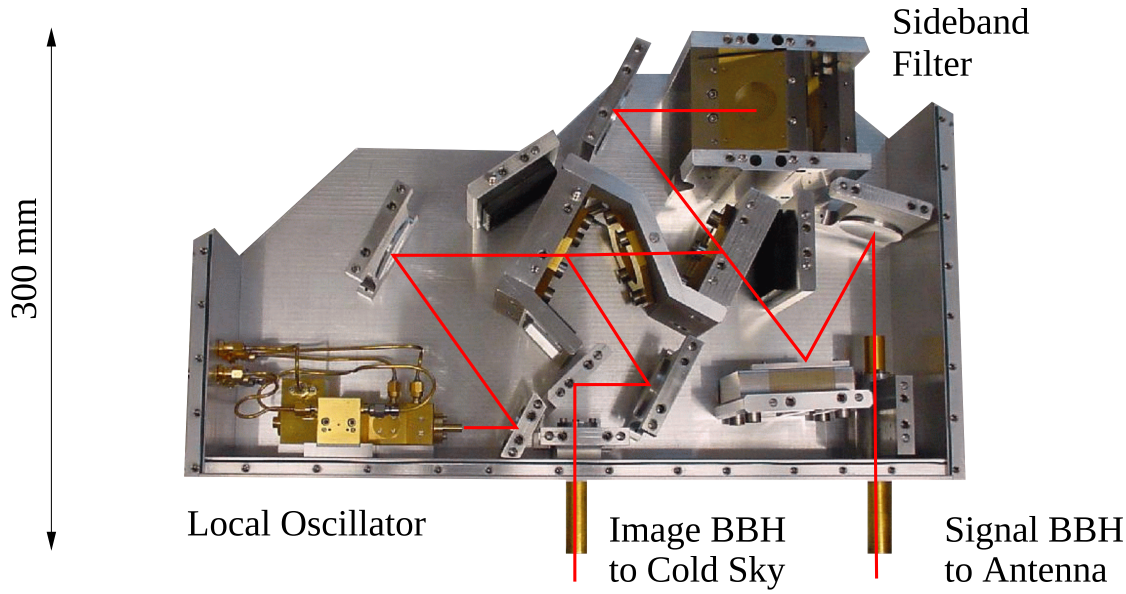
NDSC Calibration Workshop

Bern, 3-4 April 2003

The Submillimeter Limb-Emission Sounder SMILES

- Japanese instrument for the International Space Station
- Simultaneous observation of BrO, ClO, HCl, O_3 and other stratospheric trace gases in two 2 GHz wide frequency bands centered at 625 and 650 GHz
- Two superconducting SIS mixers cooled with a mechanical 4 K refrigerator
- Very high sensitivity requires low optical losses and low internal reflections
- Ambient Temperature Optics (AOPT) subsystem provides injection of the local oscillator, single sideband filtering and EMC isolation

The Ambient Temperature Optics Module of SMILES

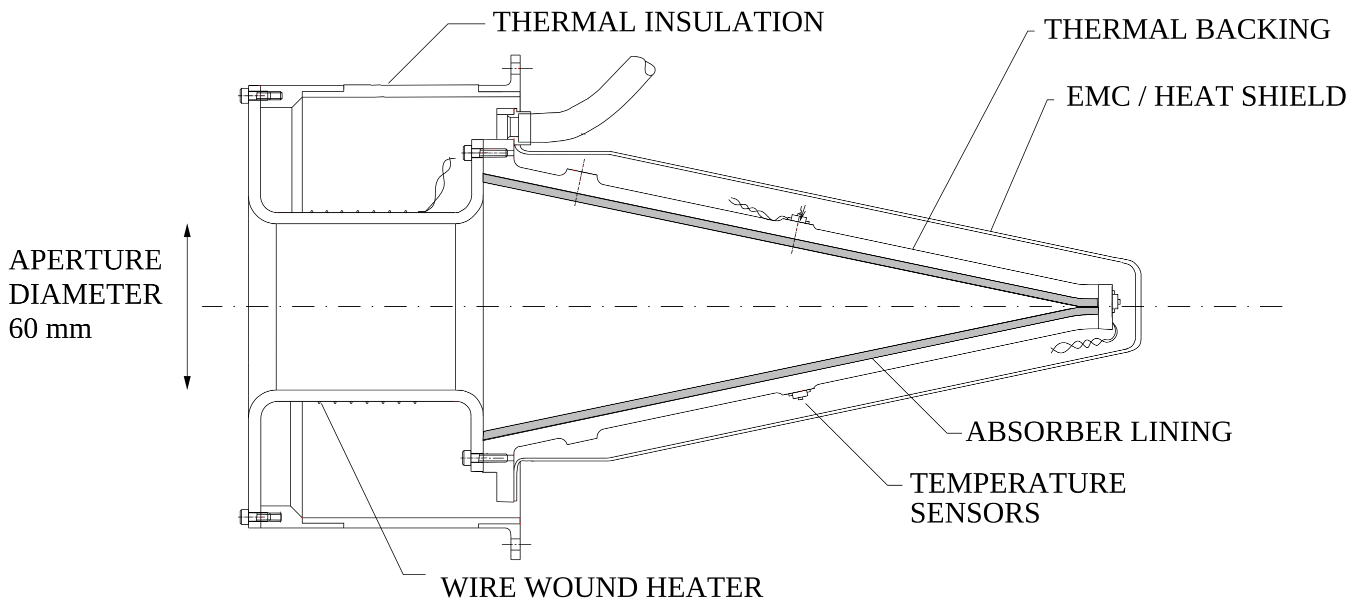


ESA Calibrated Hot Load (CHL)

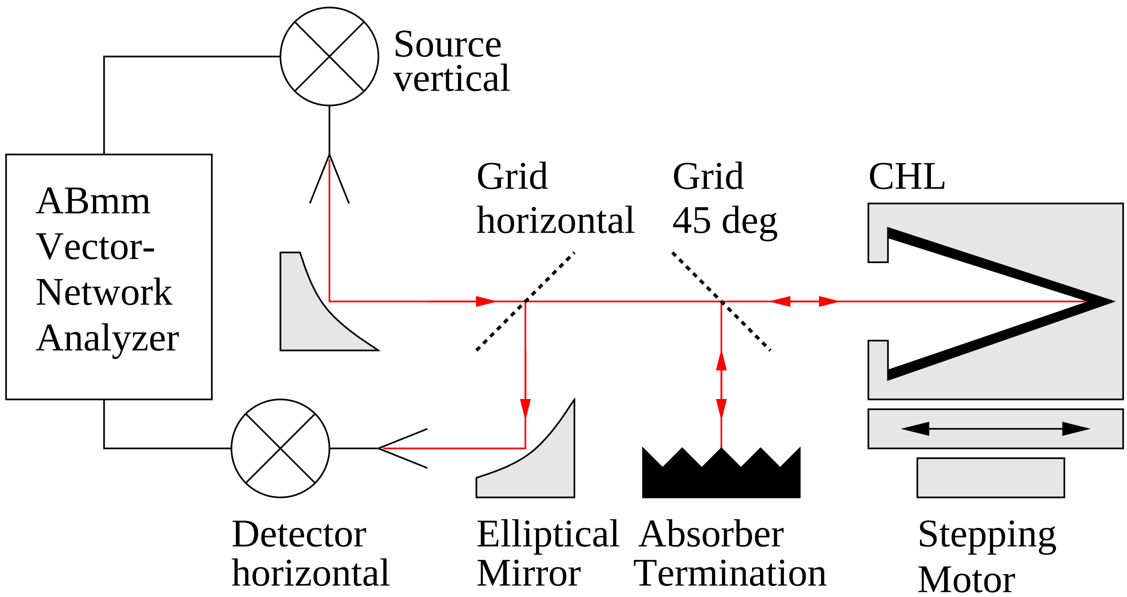
- Brightness temperature 300 K
- Thermal gradients less than 50 mK, drift less than 1 mK/s
- Bandwidth 400 - 1100 GHz
- Polarization independent
- Half-power beam-waist 10 mm at the input

- Brightness temperature variation less than 100 mK across view
- Emissivity better than 0.999
- Brightness temperature error less than 500 mK

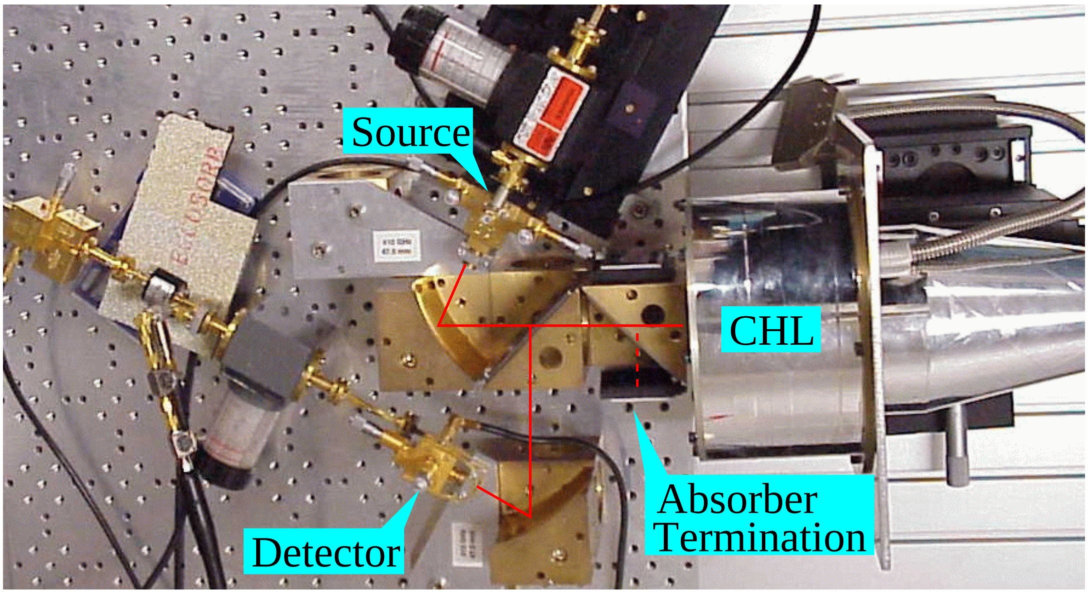
CHL Design from Thomas Keating Ltd. and AEA Technology



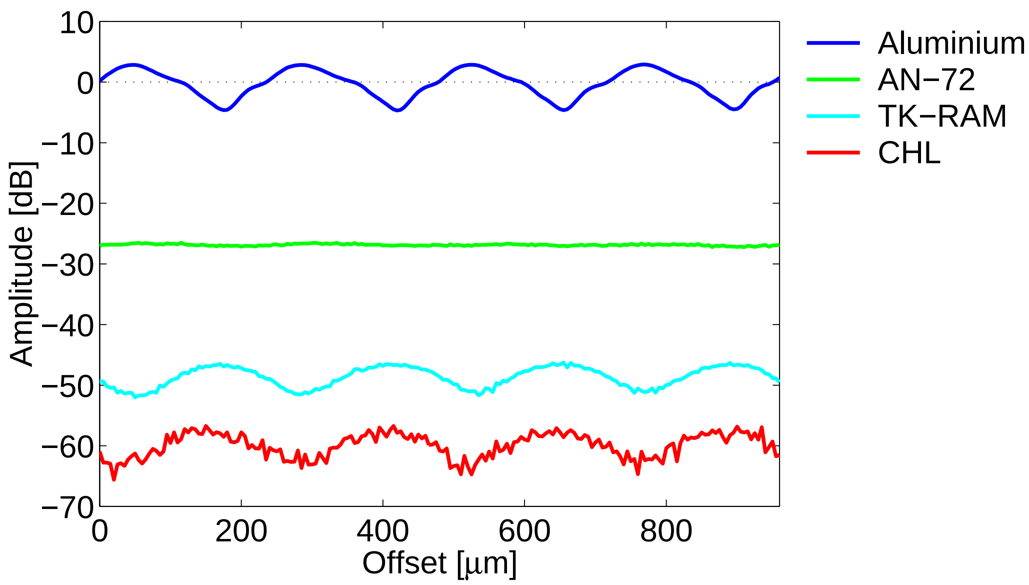
Setup of the active Reflection Measurements



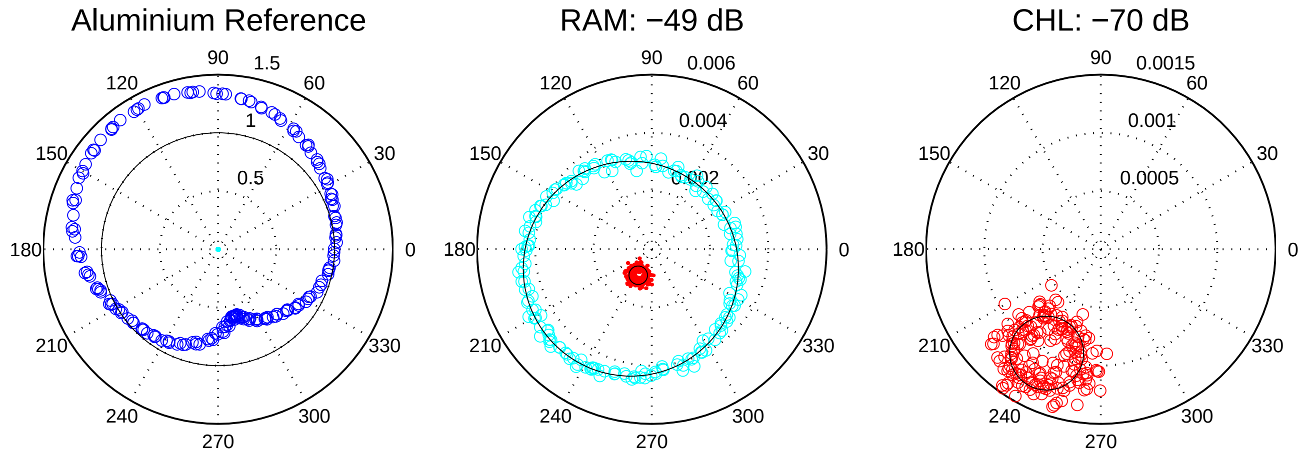
CHL and the quasi-optical Reflectometer



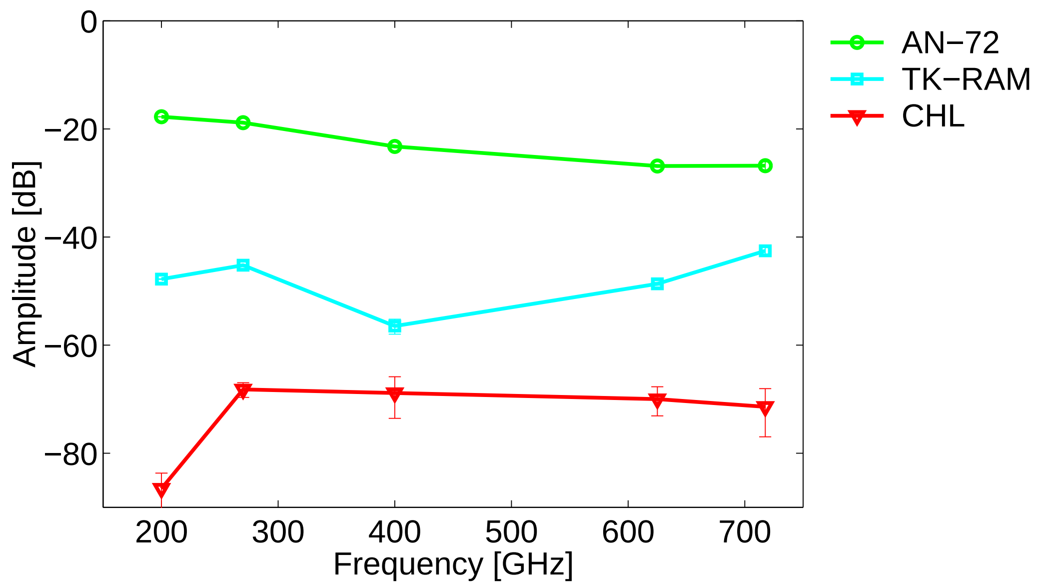
Active Reflection Measurements at 625 GHz



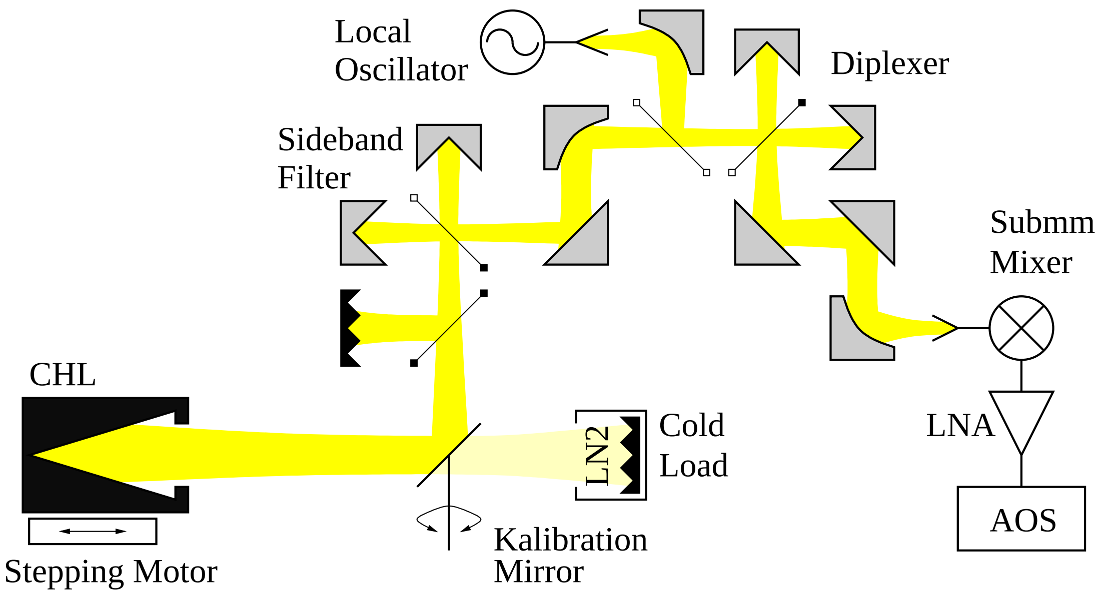
Active Reflection Measurements in Polar Coordinates



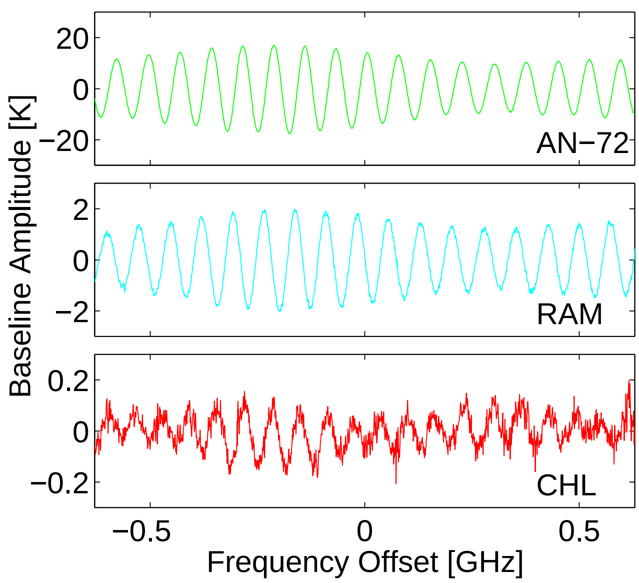
Monostatic Reflectivity at different Frequencies

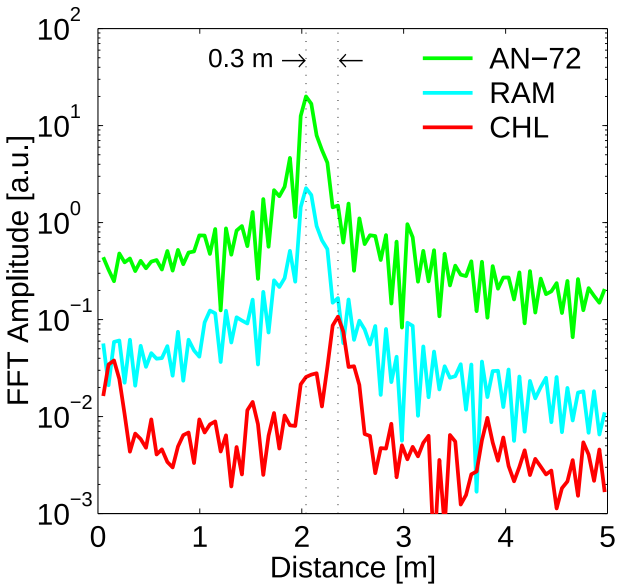


Setup of the passive Reflection Measurements



Radiometric Measurements at 273 GHz with MIRA, Forschungszentrum Karlsruhe

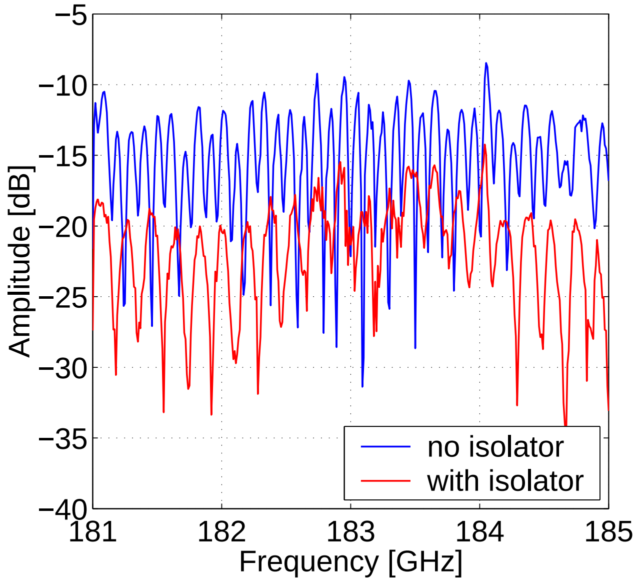


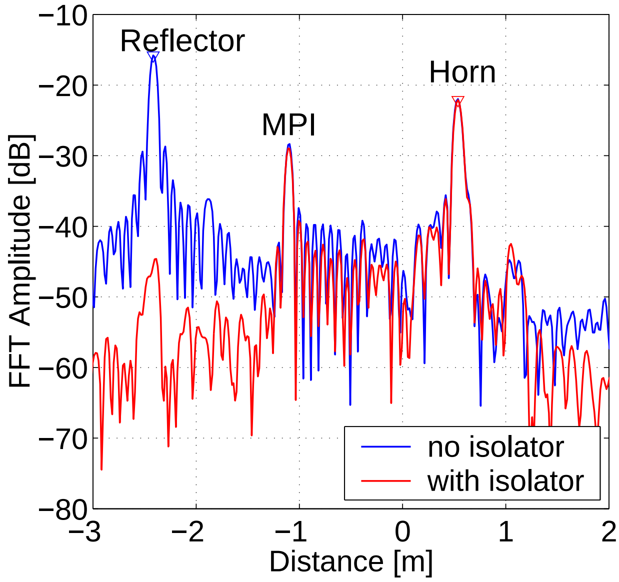


CHL Conclusions

- Active reflection measurements between 200 and 715 GHz resulted in a reflectivity better than -70 dB for the CHL. At 625 GHz TK-RAM is about 20 dB worse.
- Radiometric measurements at 273 GHz showed that the CHL produces a 10 times smaller baseline ripple than TK-RAM. This corresponds very well to the 20 dB difference in reflectivity.
- Both the active and the passive measurements are only sensitive to the monostatic reflectivity. They can not be used to prove the 0.999 emissivity required by ESA.
- CHL prototype will be used in the airborne limb-sounder MARSCHALS, and similar loads in B-SMILES and SMILES.

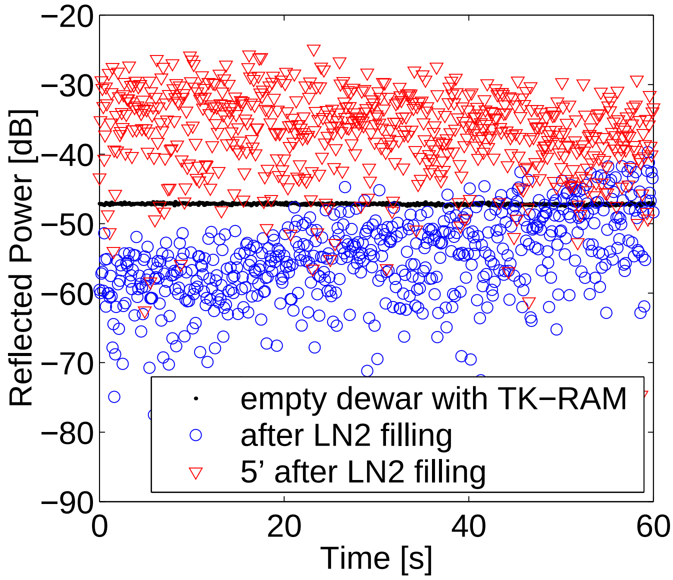
Reflection Measurements of AMSOS with complex FFT Analysis

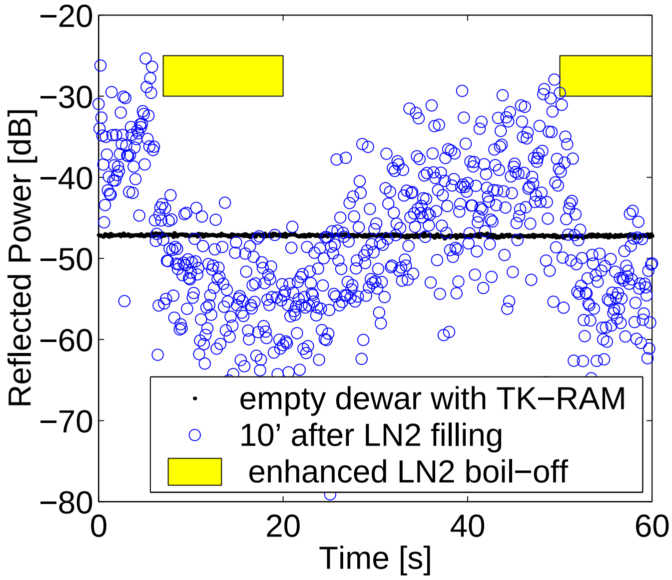




Reflections from Liquid Nitrogen @ 400 GHz

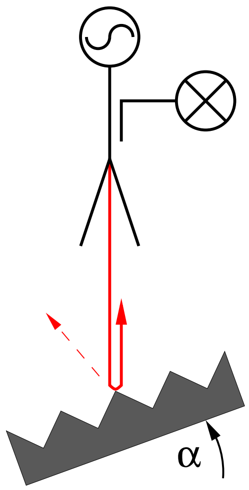
LN2: $n = 1.2 \quad \Longrightarrow \quad R_{\perp} = \left(\frac{n-1}{n+1}\right)^2 = -21\ dB$

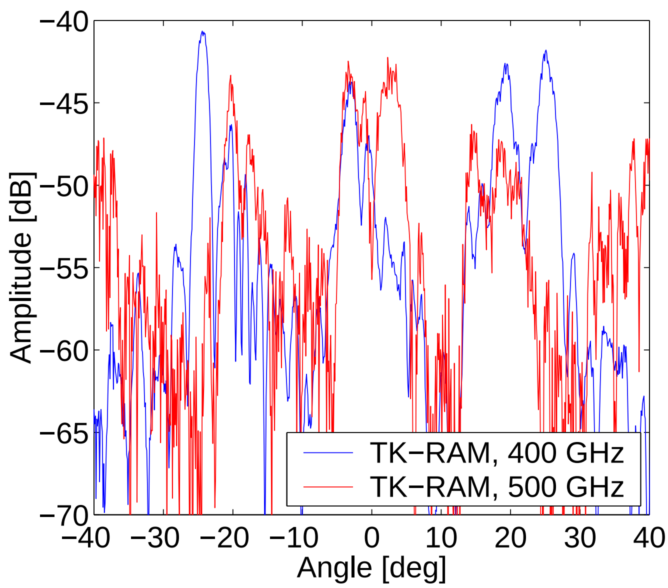




Bragg Reflections of TK-RAM

Polypropylene based absorber with periodic pyramidal corrugations





More Conclusions

- Conventional Martin-Puplett Interferometers (MPI) of single sideband filters or diplexers can lead to significant internal reflections because of the non-ideal characteristics of the wire grids and rooftop mirrors.

- Cold loads with liquid Nitrogen suffer from the reflections at the LN2 surface. The boiling of the LN2 roughens the surface and can act as an efficient phase scrambler, but the absolute calibration error has to be taken into account.

- Absorbers with a periodic surface structure show typical Bragg reflections. The angle of incidence can be optimized to minimize these reflections.