Operating of the superconducting integrated receiver channel of the TELIS atmospheric sounder.

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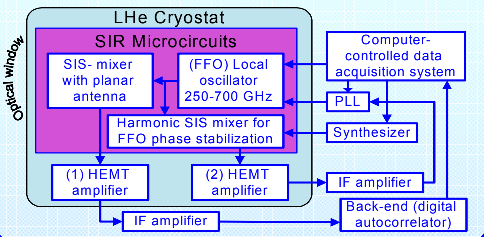
Abstract

A Superconducting Integrated Receiver (SIR) was proposed more than 15 years ago and has since then been developed up to the point of practical applications. We have demonstrated for the first time the capabilities of the SIR technology for heterodyne spectroscopy both in the laboratory and at remote operation under harsh environmental conditions for atmospheric research. Within a SIR the main components needed for a superconducting heterodyne receiver such as an SIS-mixer with quasi-optical antenna, a Flux-Flow oscillator (FFO) as the local oscillator, and a harmonic mixer to phase-lock the FFO are integrated on a single chip. Light weight and low power consumption combined with broadband operation and nearly quantum limited sensitivity make the SIR a perfect candidate for future airborne and space-borne missions. The noise temperature of the SIR was measured to be as low as 120 K, with an intermediate frequency band of 4 – 8 GHz in double sideband operation; the spectral resolution is well below 1 MHz. The SIR was implemented in the three-channel balloon-borne instrument TELIS (TErahertz and submillimeter LImb Sounder) that detects spectral emission lines of stratospheric trace gases (like ClO and BrO). These gases even in small quantities can have a significant impact on the atmosphere because they speed up certain chemical processes, such as ozone depletion.

The SIR is very sensitive to external electromagnetic interference and temperature variations, but specially developed shielding, novel design of the SIR itself and sophisticated operating algorithms provide stable operation of the device. During the flight the SIR should perform extremely stable and reliable – some measurements last about an hour. The changing of the LO frequency for next measurement should be as fast as possible (about 1 min).

Block Diagram of the Superconducting Integrated Receiver



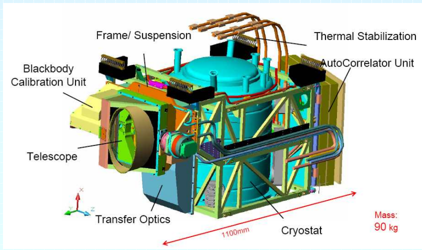
TELIS

TErahertz and submm **LI**mb **S**ounder

- **Balloon instrument on board MIPAS B2 gondola, IMK Karlsruhe**
- **Three independent frequency channels, cryogenic heterodyne receivers:**
  - **500 GHz by RAL (UK)**
  - **450-650 GHz by SRON-IREE**
  - **1.8 THz by DLR (PI-institute)**

TELIS Objectives:

- **Measure many species for atmospheric science: ClO, BrO, O_3, HCl, HOCl, etc;**
- **Chemistry, Transport, Climate**
- **Serve as a test platform for new sensors**
- **Serve as validation tool for future satellite missions**



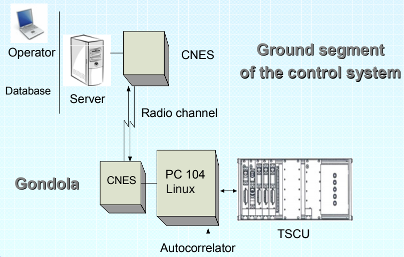
TELIS instrument model

Remote SIR operation

The SIR channel is controlled with a battery-operated ultra low noise biasing system. The SIR bias unit is digitally controlled by the on-board DLR PC-104 computer, that also interfaces with the other channels, the digital autocorrelator, and with the host instrument MIPAS. A radio link provides real-time two-way contact with the ground segment consisting of a server computer with three dedicated client computers, coupled through TCP/IP socket connections. The complete system is designed to have sufficient battery power for a 24 hour flight.

Special procedures for pre-flight tests and remote operation during the flight had been developed and tested

Communication scheme of the TELIS-SIR flight electronics

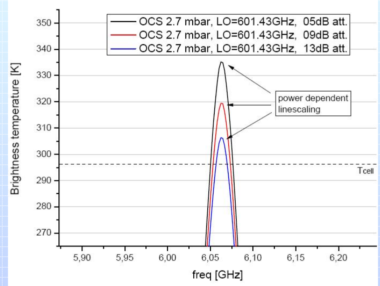


TELIS-SIR Main Parameters

#	Description	Value
1	Input frequency range	450 – 650 GHz
2	Minimum noise temperature (DSB)	120 K
3	Output IF range	4 – 8 GHz
4	Spectral resolution	< 1 MHz
5	LO frequency net	< 300 MHz
6	Dissipated power at 4.2 K stage (including IF amplifiers chain	< 30 mW
7	Operation temperature	< 4.5 K

Gas cell OCS measurements

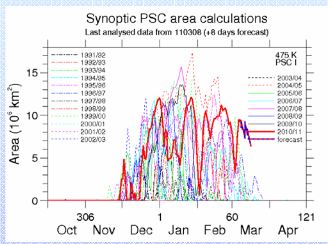
- Large discrepancy between modeled and measured spectra after first flights
- After thorough analysis strong nonlinearity in IF part of backend was found
- Possible saturation in IF chain resulted in power dependent line scaling of well-known OCS line.
- OCS gas cell measurements were performed to characterize nonlinearity effect for old data and to minimize it for 2011 flight measurements.



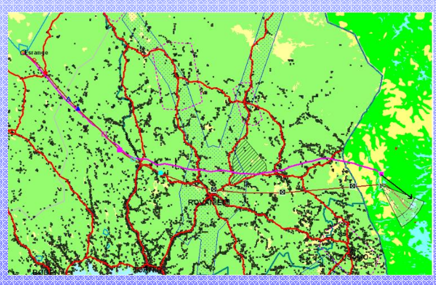
Calibrated OCS spectra, p=2.7mBar, F_{LO}= 601.43 GHz.

Kiruna'2011 flight

Synoptic PSC areas over the last 20 years as compared to the present winter:



- First launch with CNES team in Esrange
- Exceptional geophysical conditions in the Arctic
- First time recovery in Russia



Summary

- Three successful flights of TELIS instrument in Kiruna (2009-2011)
- Remote operation of the SIR during all three flights
- Scientific observation program successfully completed
- Nonlinearity in IF part of the ACS was discovered
- Gas cell measurements were performed to characterize the instrument and correct the old data
- Data analysis of all three flights is now on-going
- Future aircraft, balloon and on-ground missions are under consideration

ISSTT 2011