GREAT: status and future opportunities

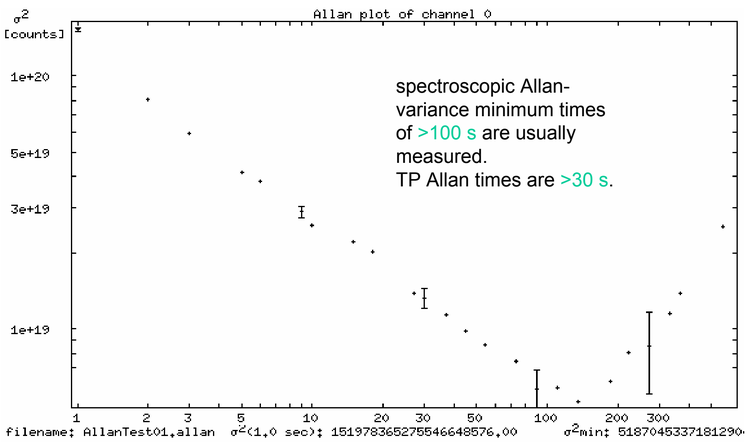
MPIfR[1]
KOSMA[2]
MPS[3]
DLR-Berlin[4]

S. Heyminck[1], R. Güsten[1], U.U. Graf[2], J. Stutzki[2], P. Hartogh[3], H.-W. Hübers[4], B. Klein[1], T. Klein[1], I. Camara[1], et al.

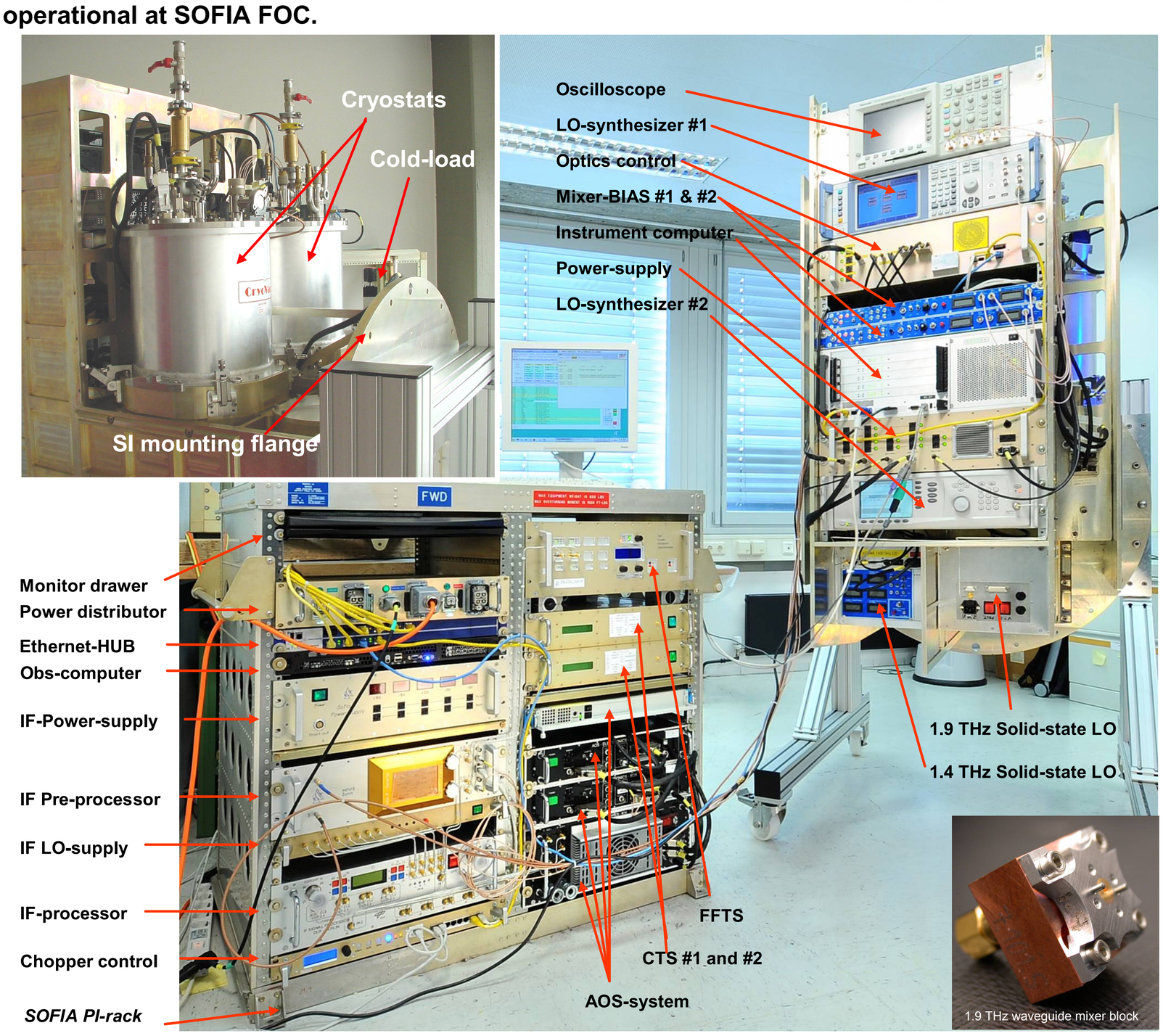
GREAT, the German REceiver for Astronomy at THz frequencies, on board of SOFIA will offer unique heterodyne observing capabilities in the frequency range above the highest Herschel/HIFI-bands. In the post-Herschel/HIFI phase it will provide the only opportunity for FIR heterodyne observations at frequencies not accessible from ground. GREAT is planed to be shipped to the NASA Palmdale facilities, the present home of SOFIA, in October this year. First science flights with GREAT are expected in the first half of 2011.

GREAT is a far-infrared heterodyne receiver based on a modular receiver concept, developed by a consortium of four German science institutes. In its first incarnation the receiver will offer four independent receiver channels out of which two can be operated simultaneously.

The both L-Band channels (operating around 1.4 and at 1.9THz , respectively) are operational and finally tested. The M-Band (2.5 – 2.7 THz) channel is in its final build-up phase and should be ready in time for the first GREAT science flights. The H-Band channel, targeting the [OI] line, is foreseen to be operational at SOFIA FOC.

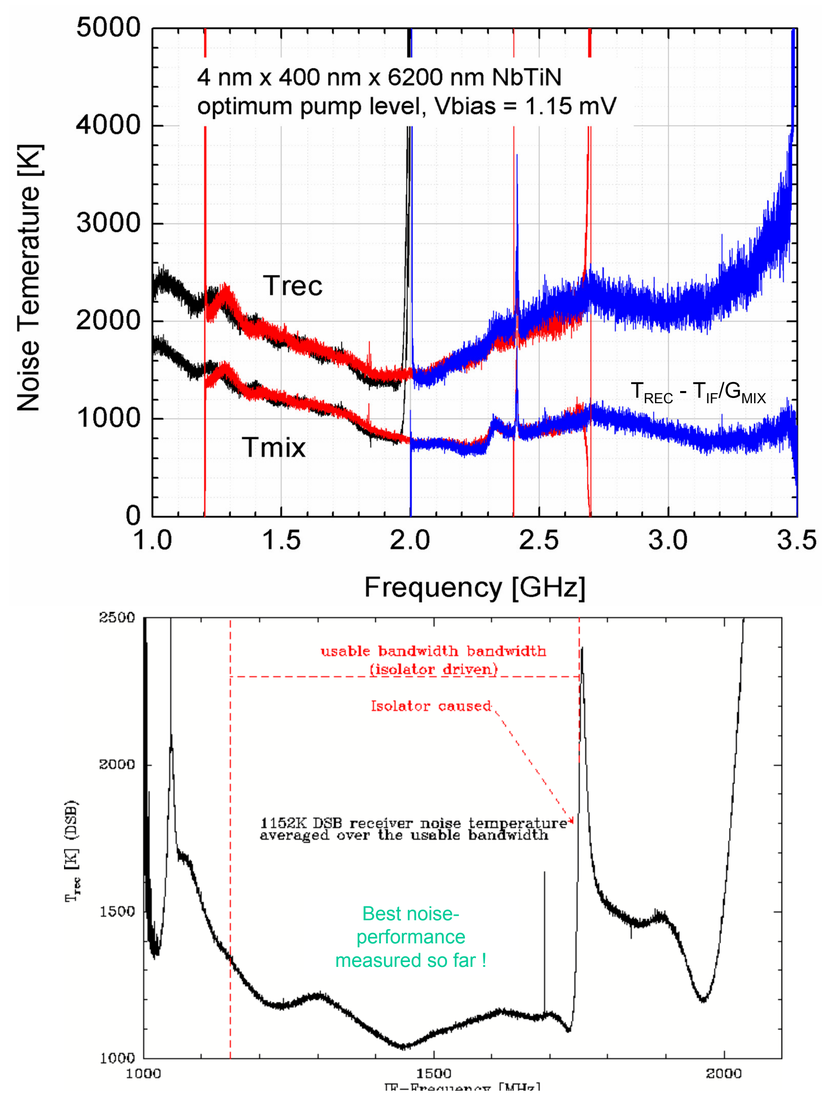


Typical measurement of the spectroscopic Allan stability time of the L#1-band channel at 1.4 THz.



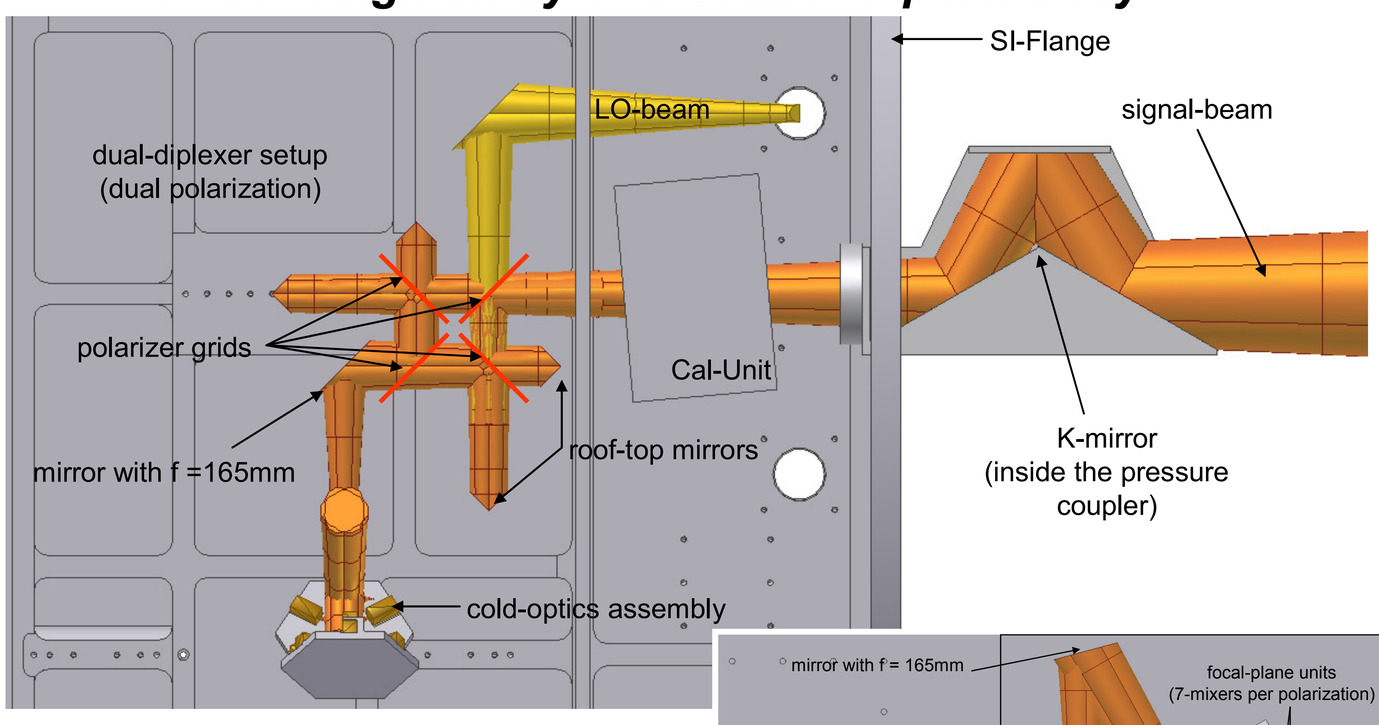
Lab-pictures of GREAT in L-L configuration during the PSR in December 2008. The system is fully tested and ready for shipment.

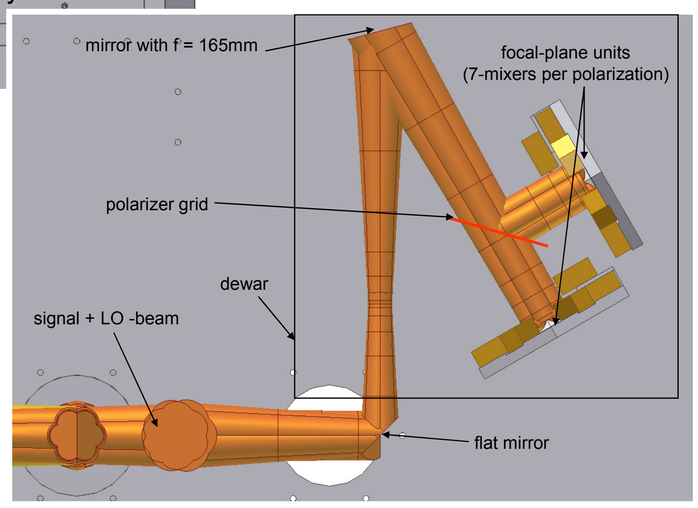
The **heterodyne mixing** elements in both L-band and the M-band channel are wave guide HEB-mixers made by KOSMA. They show excellent noise performance and stabilities. The IF roll-off is above 3 GHz (see also plot below) and hence allows for a receiver IF-bandwidth of up to 1.5 GHz.



Best measured noise performance of the L#2 channel so far (at 1.81 THz). The measurement was performed using the old HEB-isolator combination with a limited bandwidth of only 700 MHz. The new wide bandwidth HEB / MMIC combination is undergoing final test and will be used for short science.

First design study of a GREAT 7-pixel array





Draft optics layout for a dual-polarization 7-pixel GREAT receiver. In orange the beam-path of the signal beams is shown. Two Martin-Puplett interferometers act as diplexer for the LO-injection, one for each polarization. Both polarizations are superimposed behind the diplexer-arrangement. Therefore only one cryostat window is required and best possible position matching between the both sub-arrays on sky is guaranteed.

Inside the cryostat both polarizations are split-up again and fed onto separate focal-plane mixer arrangements. With a quasi-monolithic cold optics approach we here can avoid difficult adjustments of the cold optics.

GREAT with its modular concept offers the possibility to upgrade to small scale heterodyne focal plane arrays. We are currently working on a design for hexagonal 7 pixel [OI] and/or [CII] mappers. Within the GREAT instrument framework even a dual polarization 2 × 7 pixel [CII] array would be possible. These future upgrades will become possible because of ongoing basic research activities for critical technologies within the GREAT consortium.

	1.9THz	2.7THz	4.7THz
Wavelength [µm]	158	112	63
Beam-size [arcsec]	14.99	10.63	5.98
Waist size in focal-plane	2.51	1.78	1
Beam-spacing in focal-plane [mm]	7.5	5.32	2.99
Beam-spacing on sky [FWHM]	2.1	2.1	2.1
Beam-spacing in focal-plane [waist]	2.99	2.99	2.99
7-Pixel Footprint in f-plane (5 ω-contur) [mm]	27.55	19.53	10.99

Optics data of a GREAT array

GREAT Array Features:

- ✓ **arrays act as new GREAT-channel**
  - ➔ **all single pixel channels can be used as before**
    - ➢ **avoids construction & airworthiness overheads**
    - ➢ **possible use of existing LO-systems (output power dependent)**
- ✓ **K-mirror for >360° image de-rotation**
- ✓ **7-pixel hexagonal packing**
  - ➢ **for wave-guide mixers: dual polarization receiver possible**
  - ➔ **14 times the mapping speed of a single channel**
- ✓ **no modifications to the GREAT main structure required**
  - ➢ **but cryostat needs to be modified**

Possible updates:

- ✓ **new cryostat with closed cycle refrigerator**