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Large-Area Radiation Sources for the In-flight Calibration of the GLORIA Interferometer

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GLORIA

The Gimballed Limb Observer for Radiance Imaging of the Atmosphere (GLORIA) is a joint project of Research Centre Juelich and Karlsruhe Institute of Technology, Germany.

The GLORIA instrument as illustrated in Fig. 1 is an airborne imaging Fourier Transform Spectrometer deployed in the belly pod of the German research aircraft HALO as well as on board the high-flying Russian research plane Geophysica. The instrument provides detailed pictures of spatial structures in the Upper Troposphere/Lower Stratosphere (UTLS) region, which plays a crucial role in the climate system.

GLORIA uses a two-dimensional detector array for detailed infrared limb observations in emission. The detector array consists of 128 x 128 single detectors providing over 16000 simultaneous limb views.

GLORIA also serves as proof of concept for the InfraRed Limb Sounder of PREMIER, ESA's candidate Earth Explorer Core missions.

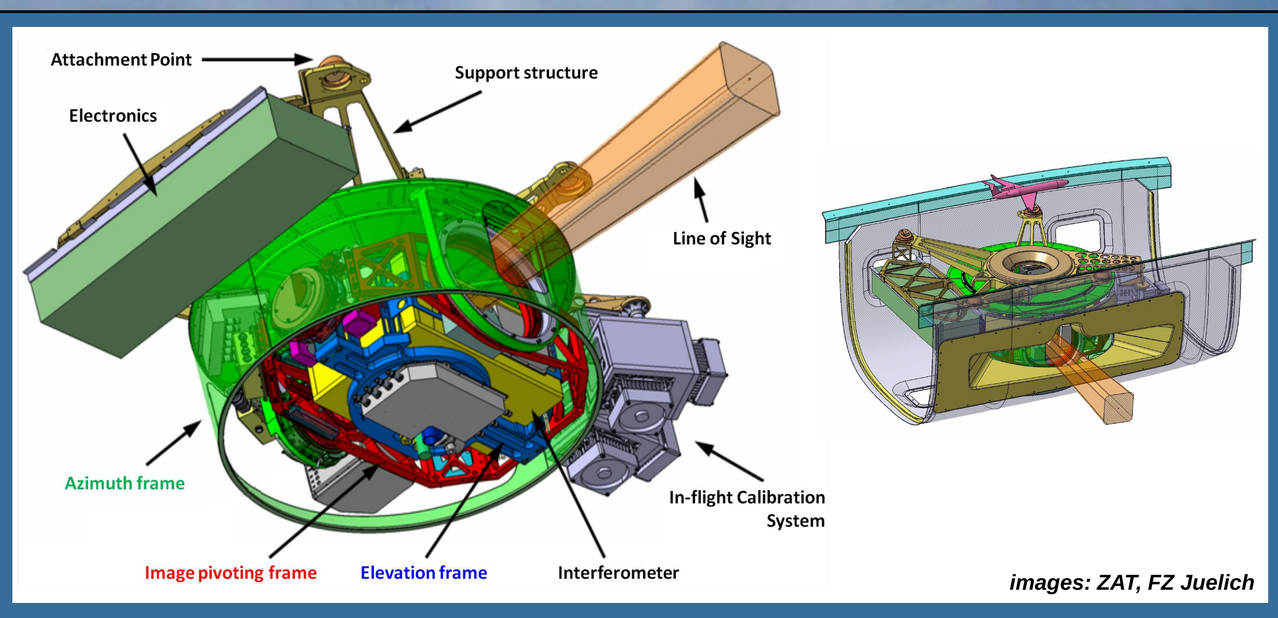


Figure 1: Gimbal mounted GLORIA instrument with in-flight calibration system

Figure 2: GLORIA In-flight Calibration System

In-flight Calibration

The GLORIA in-flight calibration system (see Fig. 2) consists of two identical high-precision blackbodies (GBB-C and GBB-H), which are independently controlled at two different temperatures in the range of the atmospheric infrared radiance emissions. In order to operate GBB-C at 10 K below ambient temperature and GBB-H at 30 K above ambient temperature respectively, Thermo-Electric Coolers (TECs) are used offering the advantage of avoiding cryogens and mechanical coolers. An additional benefit of TECs is the dual utilisation for cooling and heating by just switching the direction of the electrical current. For temperature control, platinum resistance thermometers (PRTs) type DIN B/10 are used with a nominal temperature uncertainty of 0.03 K at 0 ˚C.

GLORIA in-flight calibration system has been comprehensively characterized for its spatially (full aperture) and spectrally (7 µm to 13 µm) resolved radiation properties in terms of radiation temperature traceable to the international temperature scale (ITS-90) at the national metrology institute of Germany (PTB).

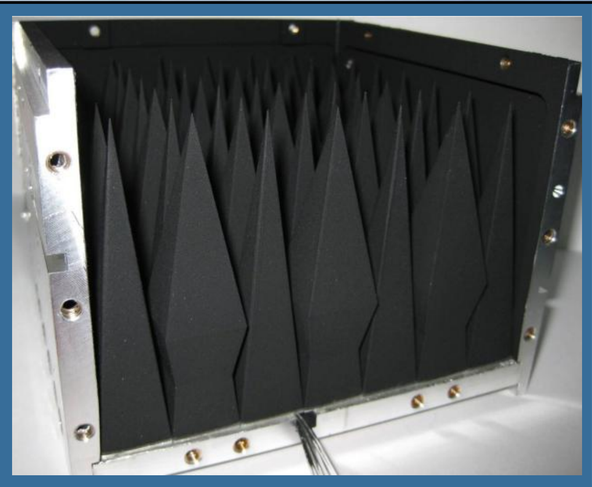
Blackbody Design

The optical surface (OS) of a GBB consists of a pyramid field with 49 single spires made of aluminium (see Fig. 3). The pyramids as well as the casing are varnished with NEXTEL-Velvet Coating 811-21 which has a measured emissivity of greater 0.967 in the spectral range between 5 µm and 12 µm. Due to the steep angles of the pyramid spires (83˚-79˚) most of the incoming radiation is reflected into the back, and thus absorption is enhanced. Shape factors for the pyramid field in a medium-size box have been calculated, leading to a total calculated emissivity of 0.9996.

The GBB-OS is temperature-controlled by a cooler consisting of four times two TECs (see Fig. 4). The aluminium casing surrounding the GBB-OS is partly thermally decoupled with the front part serving as a stray light baffle which is also temperature-controlled by TECs. The stray light baffle is operated at a slightly lower temperature in order to act as a water vapour trap, so condensation on the optical surface is inhibited.

The GBBs are suspended by GFRP (Glass-Fibre-Reinforced-Plastic) tubes. In order to reduce the adverse influence of the thermal environment, the GBBs are covered with polystyrene foam sheets. The overall weight of one GBB is 9.5 kg. An electronics box, which houses the temperature control unit as well as the power supply, is part of the GLORIA in-flight calibration system.

Figure 3: Pyramid field of 49 single spires



… varnished with NEXTEL-Velvet Coating

Calibration requirements	
FOV (optical surface)	126 mm x 126 mm
Temperature uncertainty	< 0.1 K
Emissivity	> 0.997
Temperature homogeneity	< 0.15 K
Temperature stability	< 0.025 K/min

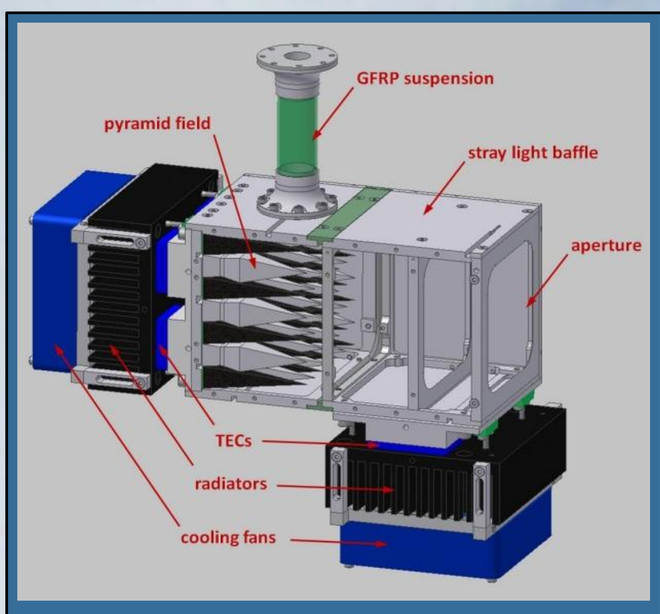


Figure 4: Concept of the GLORIA BlackBody

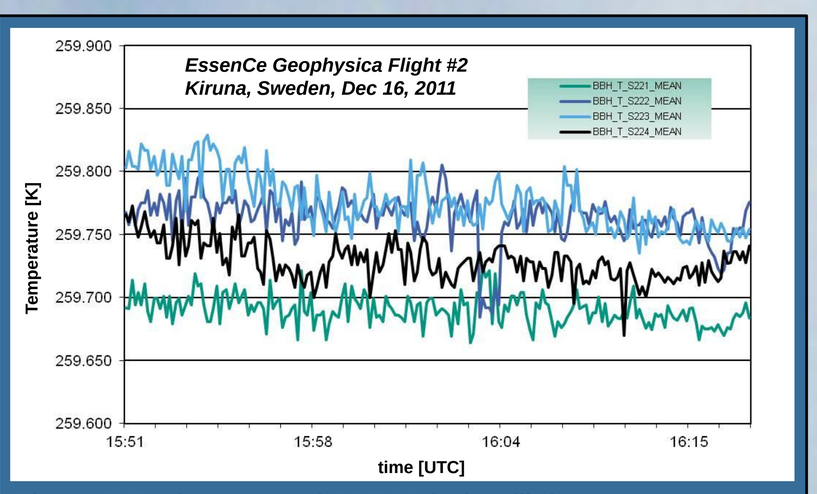
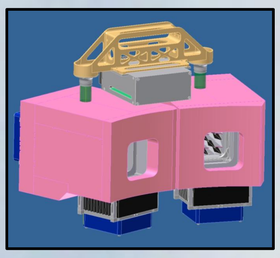


Figure 5: Performance of GBB-H during flight



Achieved performance during flight			
Homogeneity:	+/- 0.075 K	T drift:	< 0.025 K/h
Noise:	+/- 0.025 K	T setting accuracy:	- 0.25 K

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