Optical performance of ultrasensitive FIR TES detectors for future space missions

D. Morozov[1*], P. D. Mauskopf[1], P. A. R. Ade[1], D. Griffin[2], J.R. Gao[3,4], H. F. C. Hoevers[3], P. Khosrapanah[3], M. Ridder[3], M. Bruijn[3], D. Goldie[5], D. Glowacka[5], S. Withington[5] and N. Trappe[6]

1 Cardiff University, School of Physics and Astronomy, Cardiff, CF24 3AA, UK
2 Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Didcot OX11 0QX, UK
3 Space Research Organization of the Netherlands, Utrecht 3584, the Netherlands
4 Kavli Institute of NanoScience, Delft University of Technology, Delft, the Netherlands
5 Cambridge University, Detector and Optical Physics Group, Cavendish Laboratory, Cambridge CB3 0HE, UK
6 National University of Ireland, Maynooth, Ireland

* Contact: Dmitry.Morozov@astro.cf.ac.uk, phone +44-2920-870159
This work is supported by ESA TRP contract: ITT-1-5922/08/NL/EM TES spectrometer.

***Abstract*—**Future Far-Infrared Fourier transform spectrometer instruments such as SAFARI-SPICA require sensitive detector arrays with high optical coupling efficiency over extremely wide bandwidths ($\Delta\lambda/\lambda \sim 1$). In principle, this can be achieved with multi-moded coupling optics and detectors with thin superconducting film absorbers operating above the gap. We describe the design, modeling and optical performance of single and multi-moded horns coupled to different cavity and absorber geometries in the wavelength ranges from 34-60 μm (SAFARI S-band) and 100-210 μm (SAFARI L-band). We define the coupling efficiency of an optical configuration to be the ratio of the power absorbed by the detector from a far field source divided by the power absorbed by an ideal black absorber with an area equal to the unit cell in the focal plane (e.g. the square of the pixel spacing for a square array). The system optical coupling efficiency is determined by the forward beam efficiency of the horn, reduced by additional power reflected out of the horn by the cavity/absorber combination as well as power radiated out of gaps in the cavity. We compare single-mode simulations and measurements of S-band and L-band detectors in hemispherical cavities. The simulated and measured coupling efficiencies depend on the horn and cavity geometries, the effective impedance and area of the absorbing metal films. We measure a coupling efficiency of 70% for an S-band detector in a 500 μm diameter hemispherical cavity with an absorber area of 200 x 200 μm^2, a square impedance of 400 Ohms coupled to a conical horn with exit aperture 46 μm. We also measure a coupling efficiency of 40% for an L-band detector in a 500 μm diameter hemispherical cavity with an absorber area of 320 x 320 μm^2, a square impedance of 90 Ohms coupled to a conical horn with an exit aperture of 120 μm. Both measurements agree with simulations of the absorption efficiencies for these geometries. Finally, we describe the design and measurements of optimized L-band and S-band detector arrays coupled to square horn arrays.

Dark performance of the S-band detectors is presented by SRON group (abstract by P. Khosropanah *et al* at this conference).