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An ultra-low background millikelvin optical test facility for TES bolometers

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The next generation of infrared space observatories will use cooled (< 6 K) telescopes in combination with ultra-sensitive cryogenic detectors to achieve background-limited sensitivity. Characterizing these detectors on the ground requires an ultra-low background cryogenic test facility with high rejection of stray light, magnetic fields and vibrations. To meet the challenge of testing such sensitive detectors we have constructed an ultra-low background test facility based on a cryogen-free high-capacity dilution refrigerator, paying careful attention to stray-light exclusion, shielding, and vibration isolation.
We are using this facility to characterize prototype detectors for SAFARI, the far-infrared imaging spectrometer for the SPICA satellite. SAFARI's three bolometer arrays, coupled with a Fourier transform spectrometer, will provide images of the sky with a 2x2' field of view with spectral information over the wavelength range 34-210 microns. Each horn-coupled bolometer consists of a transition edge sensor (TES), with a transition temperature close to 100 mK, and a tantalum absorber on a thermally-isolated silicon nitride membrane. SAFARI's detectors are extremely sensitive(NEP˜0.2 aW/rtHz), with correspondingly low saturation powers (˜5 fW).
For optical measurements the system contains internal cold (3-35 K) and hot (up to ˜300 K) black-body calibration sources, as well as a light pipe for external illumination. Following a long programme of optimization and characterization the test bed is in routine use, measuring the broad-band and spectral response of SAFARI prototype detectors. We describe the steps we took to create an ultra-low background millikelvin test environment. We illustrate the test facility's performance with detector measurements and describe the planned modifications that will allow us to carry out electrical and optical characterization of the full SAFARI focal plane arrays.

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