# Detector and Calibration-source Models for the SAFARI Detector Test Facility

M. Audley[1], G. de Lange[1], C. Bracken[2]

[1]SRON Netherlands Institute for Space Research, Groningen, The Netherlands
[2]National University of Ireland, Maynooth, Ireland

## Abstract

The Japanese Space Agency's satellite observatory SPICA will use a large (3.5-m diameter) primary mirror cooled to <6 K to enable high angular-resolution, sky-background limited observations of the cold dusty Universe in the mid- and far-infrared [1]. The mission promises to revolutionize our knowledge of the origin and evolution of galaxies, stars and planetary systems. The prime instrument on SPICA is SAFARI [2], a far-infrared imaging spectrometer that will provide wide-field spectroscopic maps in the far infrared, giving us the ability to study the dynamics and chemistry of a wide range of objects. SAFARI covers the wavelength range 34-210 µm (1.4-8.8 THz) using Transition-Edge-Sensor bolometers [3]. The current prototype detectors for SAFARI sit behind a few-moded conical feedhorn and in front of a hemispherical backshort. Incoming radiation is absorbed by a 7-nm thick Ta film on a thin (<1-µm) silicon nitride membrane. We have used COMSOL Multiphysics® to calculate the optical coupling of the prototype SAFARI pixels and to investigate and optimize alternative designs. Figure 1 shows a COMSOL Multiphysics® RF model of a pyramidal integrating cavity fed by a square waveguide containing a transition boundary layer to represent the absorber of a SAFARI detector.

We have built a test facility to qualify and characterize the SAFARI focal plane units and readout before they are integrated into the instrument. To take advantage of SPICA's low-background cold mirror, SAFARI's short-wave detectors require a dark noise equivalent power (NEP) of ~0.2 aW/rtHz. Testing such sensitive detectors is challenging and requires careful attention to magnetic and RF shielding, stray-light exclusion, and vibration isolation. Simulations with COMSOL Multiphysics® have helped with the design of various components of this test bed, in particular the cryogenic black-body optical sources that we use to characterize the optical performance of the detectors. Figure 2 shows a COMSOL Multiphysics® AC/DC model of a section of a cryogenic black-body array illuminator that could be used for characterizing the SAFARI detector arrays. The central surface-mount resistor is heated by an applied current and the model shows how heat flowing through the circuit board and tracks causes thermal crosstalk.

We present examples showing how we have used COMSOL Multiphysics® to understand the optical coupling of the detectors and to support the development of the SAFARI Detector Test Facility.

## Reference

1. Bruce Swinyard et al. “The space infrared telescope for cosmology and astrophysics: SPICA A joint mission between JAXA and ESA.” Experimental Astronomy, 23, 193–219 (2008)
2. Brian Jackson et al “The SPICA-SAFARI Detector System: TES Detector Arrays With Frequency-Division Multiplexed SQUID Readout,” IEEE Transactions on Terahertz Science and Technology, 2, 1–10 (2011)
3. Kent Irwin and Gene Hilton, “Transition-edge sensors”, in Cryogenic Particle Detection, C. Enss, Ed., Springer, 81-97 (2005)

## Figures used in the abstract

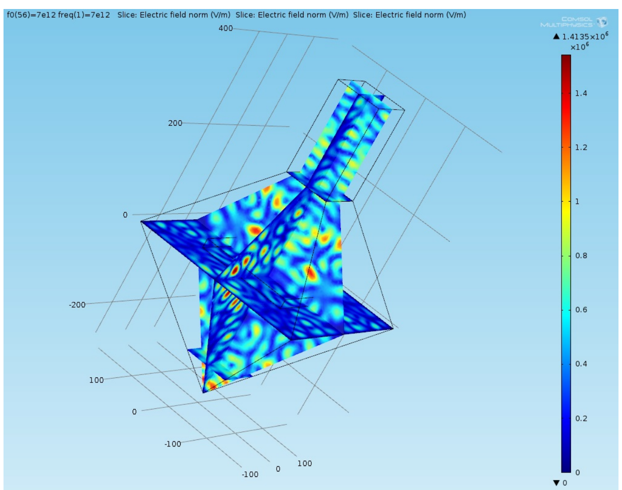


**Figure 1**: Magnitude of electric field in a pyramidal integrating cavity at 7 THz. Dimensions are in microns.

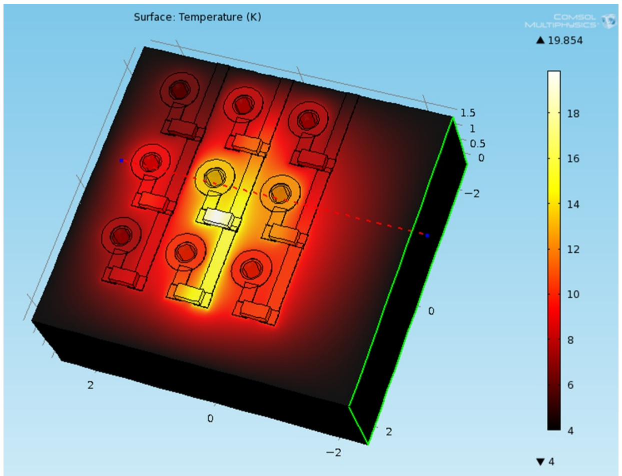


**Figure 2**: Section of a cryogenic array black-body illuminator composed of surface-mount resistors on a printed circuit board. Dimensions are in mm.