

# **Modal Analysis of Far-Infrared Multimode Horns and Waveguides for Ultra-Low-Noise Detectors for Astronomy**

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We have developed the theory and the numerical procedures for modelling optical systems of ultra-low-noise detectors for far-infrared and submillimeter astronomy. A variable temperature blackbody load has been engineered to test the optical efficiencies of ultra-low-noise Transition Edge Sensors using these procedures. Multimoded horns and waveguides are used in the experiment. To improve on initial simulations and have a more comprehensive understanding of the experimental results, we have run a set of simulations to examine the loss due to mis-matching of waveguide modes and the attenuation due to the waveguide itself, and hence to understand how they would affect the throughput of the waveguide.

This method enables us to assess all performance information for multimoded optical systems easily and accurately, while most commercial simulators are not able to handle multi-mode simulations. It is also fast to run over wide frequency ranges.