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## Noise measurement of SQUID and LNA in the FDM readout system for SAFARI

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The SAFARI instrument is a far infrared (34-230  $\mu\text{m}$ ) spectrometer on SPICA (SPace Infrared telescope for Cosmology and Astrophysics), which aims to study subjects such as galaxy evolution and star formation. The transition edge sensors (TES) in the SAFARI instrument are extremely sensitive and are required to have an NEP of  $2 \times 10^{-19} \text{ W}/\sqrt{\text{Hz}}$  to ensure background limited observation. It is therefore essential to have a readout system with an output noise that is dominated by the detector noise.

The laboratory amplifier chain currently used to develop the frequency domain multiplexing (FDM) readout system for SAFARI comprises a SQUID (superconducting quantum interference device) and a room-temperature LNA (low noise amplifier). A MHz-frequency calibration tone that causes a known flux excursion in the SQUID is used to measure the total readout noise at different SQUID settings. In order to identify the contributions of the SQUID and the LNA to the total noise we need to know the equivalent current and voltage noise sources of the LNA.

Extracting these noise sources from the measured output noise is rather complicated. This is due to the fact that the output noise depends not only on these noise sources but also on the SQUID noise and the loading impedance at the input of the amplifier, both of which are determined by the SQUID settings. So we need to measure the noise of the LNA separately.

Here we present the output noise of our LNA measured with different resistors ranging from 10 to 400 ohm at different temperatures (50 mK, 1.3 K and 293 K) at the input. The measured data can be well explained with a simple noise model with equivalent noise sources as fitting parameters. We found that the equivalent current and voltage noise of the LNA are  $5.4 \text{ pA}/\sqrt{\text{Hz}}$  and  $350 \text{ pV}/\sqrt{\text{Hz}}$  respectively, both of which are low enough to read out a sensitive TES array.

### **Less than 5 years of experience since completion of Ph.D**

Y

### **Student (Ph.D., M.Sc. or B.Sc.)**

Y

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