A Rapid Filter Bank Design and Measurement Scheme for SuperSpec

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SuperSpec is a novel spectrometer technology designed to provide the requisite resolution (R ~ 100-500), bandwidth (~1.65:1), and sensitivity (<10^-17 W/sqrt(Hz)) to investigate star formation and galaxy evolution in the early universe. SuperSpec integrates a broadband transmission line filter bank and hundreds of kinetic inductance detectors (KIDs) on a single chip only a few square cm in size, enabling construction of multi-pixel, focal-plane spectrometer arrays. Covering an instantaneous bandwidth 50% or more in the 100-500 GHz range, each filter bank is comprised of a series of spectral channels realized in superconducting half-wave resonant filters coupled to a main transmission line. Each channel is terminated by a KID and the channel's spectral resolution R is equal to the quality factor Q of the loaded resonator.

Both the main transmission line and filters are implemented as Nb microstrip lines. The KIDs are patterned in TiN. Currently, all prototype chips have integrated the filter bank with detectors, requiring characterization at sub-Kelvin temperatures due to the low Tc of TiN. Given our available cryogenic facilities, progress toward developing a science-grade device can be accelerated significantly if we can characterize the filter structure independently of the KIDs, which requires only liquid helium temperature. In addition, optical coupling to current filter bank designs is realized using a dual slot antenna and hemispherical lens. The instantaneous bandwidth can be increased by switching to feedhorn coupling. We present the design, fabrication, and characterization of several chips comprised of filter banks without KIDs and the design of a circular waveguide to microstrip transition necessary to implement feedhorn coupling.