

## Superconducting on-chip spectrometers at sub-millimeter wavelength

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We propose an on-chip spectrometer camera for sub-millimeter astronomy. The camera will be installed to the focal plane of a telescope and be operated at 0.1 K. The camera is composed of three kinds superconducting circuits, such as wideband antennas, band pass filters (BPFs), and Microwave Kinetic Inductance Detectors (MKID) [1]. All components are fabricated on the same chip by the standard photolithographic techniques. Sub-mm photons are introduced to the chip by the antenna, are divided into three colors by three BPFs. The signal are finally measured with MKID by breaking cooper pairs in the superconducting film.

The slot log-periodic antennas and the microstrip filters are made from NbTiN films to reduce signal transmission losses from the antenna to the detectors. MKID is a half-wave resonator at microwave range (3-8 GHz) and consists of a co-planar waveguide line. With the intension to improve the optical efficiency of the camera, only the middle area of the center line of the CPW is constructed with an Al film and the other parts are manufactured by NbTiN [2].

We designed two types of BPFs. One is an open ring Chebyshev's filter which has 15 % bandwidth in 150, 220, and 440 GHz. The filters were modulated from the filter optimized for microwave signals [3]. The other is lumped element filter [4] for 0.8, 1, and 1.3 THz. The former has good tolerance for production error up to 500 GHz. The latter has 10% bandwidth suitable for the atmospheric windows.

### References

1. P. Day, H. LeDuc, B. Mazin, A. Vayonakis, and J. Zmuidzinas, "A broadband superconducting detector suitable for use in large arrays," *Nature*, 425, 2003, pp. 817-821.
2. S. Yates, J. Baselmans, A. Endo, R. Janssen, L. Ferrari, P. Diener, and A. Baryshev, "Photon noise limited radiation detection with lens-antenna coupled microwave kinetic inductance detectors," *Appl. Phys. Lett.*, 99, 2011, p 073505.
3. S. Kumar, A. Vayonakis, H. LeDuc, P. Day, Peter S. Golwala, and J. Zmuidzinas, "Millimeter-wave lumped element superconducting bandpass filters for multi-color imaging," *IEEE Trans. of appl. Supercond.*, 19, 2009, pp. 924-929.
4. JS. Hong, and M. Lancaster, "Design of highly selective microstrip bandpass filters with a single pair of attenuation poles at finite frequencies," *Appl. Phys. Lett.*, 99, 2011, p 073505.