Contribution ID: **259** Type: **Poster**

On the Design of Wideband Sub-mm Wave Superconducting Integrated Filter-bank Spectrometers

Thursday 25 July 2019 18:45 (15 minutes)

Sub-mm wave on-chip filter-bank spectrometers disperse THz radiation by means of shunted band-pass filters whose ideal frequency response is a matched-filter to the Lorentzian-shaped spectrum of broadened extra-galactic emission lines, resulting in a resolution requirement of $R = f/\delta f \sim 500$. Furthermore, the instantaneous bandwidth of operation should be as wide as possible to allow for blind spectroscopic scans. For the implementation of these filter-banks we studied in detail co-planar filters, consisting of a single patterned superconducting film, and microstrip filters. A filter with $R = 500$ needs to have a low enough loss ($1/\tan\delta = Q_i > 5000$) to limit unwanted signal attenuation. We found that co-planar filters are strongly limited by radiation losses, especially for sub-mm waves. Hence, we designed in Sonnet a filter based on a microstrip half-wave resonator, free from spurious resonances within an octave band. For the dielectric we use PECVD a-Si, with a measured Q_i 10^4. The high stress of a-Si sets however a maximum thickness of ~300 nm, which imposes sub-micron featured filters. With the aid of a circuit model developed in-house we predict the interaction between filters when arrayed in a filter-bank configuration. This code made obvious three extra requirements for large filter-banks: (1) a low reflection off-resonance per filter is needed (reflection <-20 dB), (2) the high frequency filters must lead in the filter-bank to limit their losses, and (3) the inter-filter spacing in the thru-line must be $\lambda/4$, and cannot be a higher odd multiple, in order to avoid the coherent addition of reflections from the filters to fall within an octave band. Based on these constraints we designed a filter-bank with 347 efficient channels sampling an octave bandwidth (220-440 GHz) with a resolution of $R = 400$. A set of demonstrators with narrower bandwidth are being fabricated and their measurements will follow.

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

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

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Session Classification: Poster session

Track Classification: Low Temperature Detector Applications