Harmonic phase and amplitude beam characterization of a wideband on-chip spectrometer

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***Abstract*—We present a phase and amplitude beam pattern measurement technique using harmonic mixers. This allows a simultaneous multi-frequency phase sensitive characterization of a low resolution and wideband (220-420GHz) on-chip spectrometer using microwave kinetic inductance detectors. We investigate the beam quality, in particular the beam pointing and inferred telescope coupling and hence aperture efficiency. The measurements match the goal requirements for the DESHIMA-2 instrument for the ASTE telescope. The technique would be of interest for any (direct detector) spectrometer with a wide instantaneous bandwidth, particularly ones with dispersive components.**

Keywords—direct detectors, Microwave kinetic inductance detector, complex field mapping, optical characterization.

I. Introduction

Low resolution wideband direct detector on-chip spectrometers have a number of advantages in terms of compactness, bandwidth, sensitivity (for single dish applications) and scalability. As such they are a current topic of active research [1 and refs. there-in], with the recent first light instrument DESHIMA-1 [1] demonstrating the proof of principle on sky. DESHIMA-2 plans [2] to go beyond this to a full science grade instrument for the ASTE telescope. One area of improvement required is in the beam characterization, coupling and in particular pointing, which needs to be verified over the entire band prior to deployment.

Phase sensitive beam characterization has long been an important tool for sub-mm heterodyne instruments [3]. The complex beam pattern allows near to far field transformation, beam propagation and hence coupling and pointing in a single measurement prior to (on-sky) deployment. Recently the authors showed how this could be extended to direct detector (phase insensitive) arrays to allow such systems to be similarly characterized [4]. These techniques rely on two phase locked signal sources, and as such to do multi-spectral measurements require multiple measurements. We here extend this technique by using wide bandwidth harmonic mixers which produce sub-mm signals at multiple frequencies, harmonics of a base ~10 GHz signal. This allows a sparse frequency sampling over the whole band of interest in a single measurement. For dispersive spectrometers, like filter bank spectrometer used for DESHIMA 2, these signal frequencies are measured by individual filter bank detectors. Since there is only a single signal per detector, the signal to noise is then be optimized over the entire band: lower frequency harmonics with higher power do not mask the higher frequencies. Studying different harmonics enables study of the crosstalk, while wideband detectors on-chip enable the system response to be (quasi-) normalized.

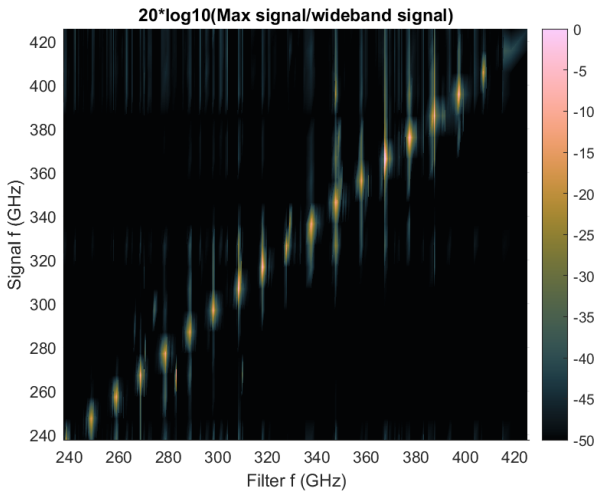

Fig. 1. Signal response matrix, the response in dB at each detector. Vertical aixs is the applied signal frequency, horizontal axis the detector frequency (from [2]).

II. Results

Some results are shown in fig.1, showing the peak normalized beam pattern response for the array from [2], measured in the far-field of the DESHIMA 2 cold optics. The stray light control and aperture efficiency, including pointing towards the telescope is matching simulations and requirements and will be discussed further.

References

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