Fast On-the-Fly Near-field Antenna Measurement at 500GHz

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***Abstract*—A near-field antenna measurement system using On-the-Fly (OTF) method is described here. Compared with the step-and-integrate technique, which samples discrete positions at certain step, the OTF scan obtains the near-field data while the scanner is still moving, thus greatly reducing the measurement time. Measurement done at 500GHz is presented here, showing the OTF method can improve the efficiency by a factor of nearly 2.5 and the accuracy of the data is comparable with that get from the step-and-integrate method. The scan effect of OTF is also discussed**

I. Introduction

NEAR-FIELD measurements widely used to characterize electromagnetic radiation properties of a variety of antenna and quasi-optical systems at terahertz frequency [1]. It is often difficult to meet the criterion of far-field distance of $2D^2/l$ at short wavelength [2]. Besides, the feed antennas, especially those integrated with superconducting receivers in the cryostat, are preferred to bemeasured in the near-field range, as it is difficult to rotate the cryostat [3]. It is also important to fully characterize the feed horns in the near-field because the beam coupling usually takes place in the near-field region [4].

The usual method used to sample near-field data is step-and-integrate technique. It samples the near-field at fixed discrete positions, which means the scanner has to stop to sample the data. Such method is more vulnerable to the changes in the system, as it usually takes hours to map the entire 2-D data [5-7].

In order to reduce the measurement time, we apply the On-the-Fly (OTF) technique [8] to the near-field measurement system. The OTF technique is a commonly method used in astronomical observing. Contrasted to the step-and-integrate mapping, the OTF records the near-field data and scanner position information in a continuous way while the scanner is moving smoothly and rapidly across the near field. There are several advantages using the OTF mapping. First of all, the sample time is significant reduced, as there is no need to start and stop the scanner. Second, the system change will be reduced as the entire measurement time is less.

OTF measurement of the spiral antenna integrated with HEB at 500GHz has beentaken based on the near-field antenna measurement developed at Purple Mountain Observatory (PMO) [9]. This paper will first describe the measurement system, then the scanning effect of OTF will be discussed. Finally, the result of OTF scan will be given and it will be compared with that from step-and-integrate technique.

II. System Setup

The measurement system is shown in Fig.1. The detector of the system is a superconducting hot electron bolometer (HEB) mixer [10] integrated with the spiral antenna, which is mounted on the back of an elliptical lens with a diameter 10mm.

The RF and LO is generated by microwave synthesizer followed by an AMC with a multiplication factor of 36 separately. The RF and LO are injected into the HEB mixer by a beam splitter made of a 25 micron-thick Mylar film. The 360 MHz IF signal is amplified by a cryogenic HEMT low-noise amplifier and then by two stages of room-temperature amplifiers. The Probe of RF signal is a diagonal horn, which is mounted on a motor controlled XY scanner, which covers a span of 300 mm in each axis and has a resolution of 10 micron.

The phase reference for the test signal recorded by mixing the output of RF and LO base frequency generated by synthesizers, which produces the 10 MHz IF signal.

Data acquisition is done by a dual-channel high-speed ADC with a sampling rate of 800 MHz and a resolution of 12 bit/sample. The 360 MHz IF signal and 10 MHz reference are recorded simultaneously. Digital FFT is applied to obtain the spectrum of both channels.

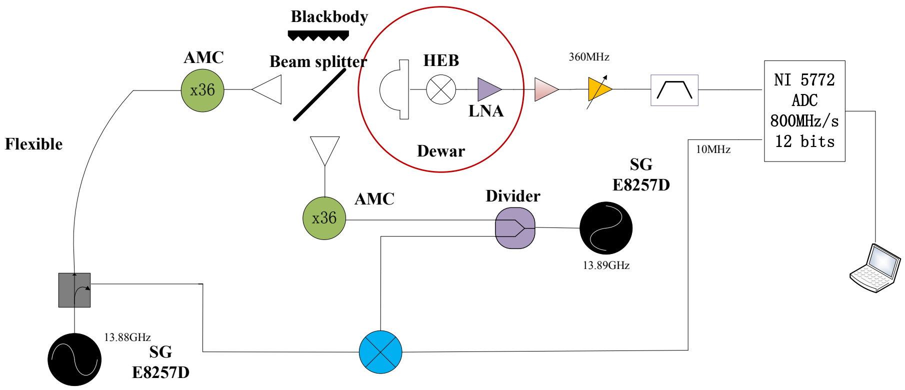

Fig. 1 Schematic of system layout

III. OTF IMPLEMENTATION

The measured co-polarized near-field data of the spiral antenna that is integrated with HEB mixer is shown in Fig. 2. The near-field of the antenna has been scanned on a regular rectangular grid of 80´ 80 mm. The used scan pattern is meandric along the vertical axis, meaning that horizontal scans (x direction) from left to right and vice-versa are taken, each time increasing the vertical position (y direction). The calibration is done by sampling a fixed point in the scanning area when a vertical scan is over [3]. The total scan time of OTF is about 900 s at the scan speed at 20 mm/s, which is about 2.5 times faster than the step-and-integrate scan.

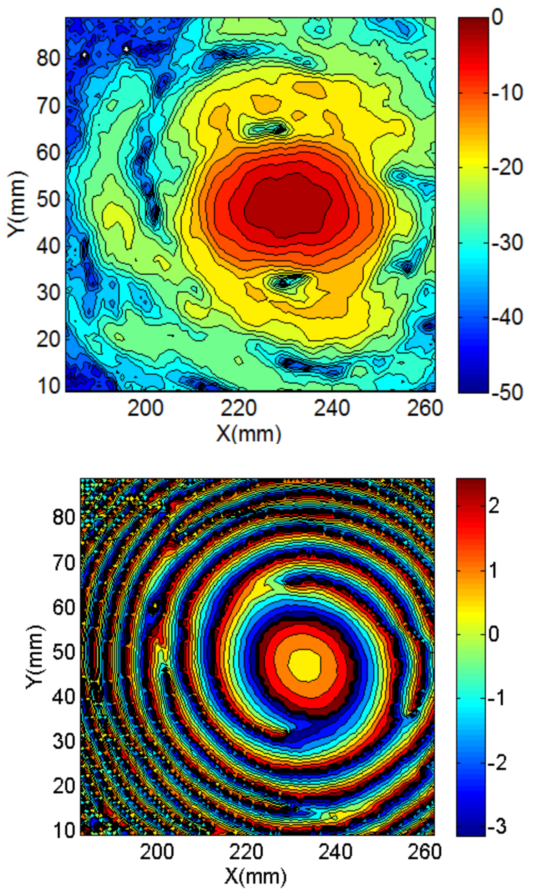

Fig. 2 Measured near-field amplitude and phase.

The near-field to far-field (NTF)transformationis done to compare the result of the OTF scan and the step-and integrate scan. The H-plane and E-plane result are shown in Fig. 3. No probe compensation is taken into consideration. The E-plane is exactly the same with that get from step-and-integrate. The H-plane shows a bit difference. This is because the scan direction is horizontal (x-direction), the receiver gain and phase instability affects the measurement data more across the y-direction [9].

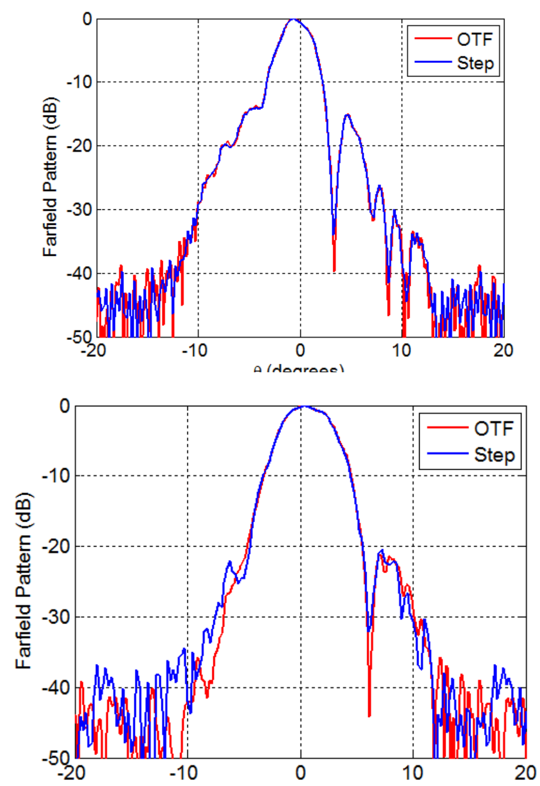

Fig.3 Far-field Comparison of OTF scan and Step-and-integrate scan. a) E-plane b) H-plane

IV. CONCLUSION

A successful OTF scan of the spiral antenna integrated with HEB is done at 500 GHz, which shows about 2.5 times faster than the step-and-integrate technique. Also, the far-fields get from the two technique are nearly the same.The OTF scan probably shows better accuracy as the scan time is much shorter and the system amplitude and phase drift are much smaller.

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