System Performance of the Upgraded POST

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***Abstract*—POST (POrtable Submillimeter Telescope) is a submillimeter telescope working in the 500 GHz band. The antenna is a dual-offset Cassegrain type with a diameter of 30 cm. Here we present its performance including the receiver noise temperature, RF noise temperature and far-field antenna beam pattern measured at 462 GHz and 493 GHz respectively. Antenna pointing accuracy is also evaluated. Detailed measurement results will be presented.**

I. INTRODUCTION

POST is a 30-cm telescope for astronomical site survey and experimental observation at submillimeter wave lengths[1][2]. Recently we upgraded this telescope. A new NbN SIS junction of parallel-connected twin-junction (PCTJ) type[3] was employed. The cryogenic IF low noise amplifier (LNA) was substituted by a SiGe heterojunction bipolar transistor (HBT) type[4]. The SIS bias supply was updated to a digital one. The old backend, which is an auto-correlation spectrometer of a bandwidth of 500 MHz, was replaced by an FFT spectrometer (FFTS) of a bandwidth up to 1 GHz. In addition, the antenna driving devices of both AZ and EL directions were changed to have better accuracy of pointing and tracking. Here we mainly report on the system performance of the upgraded POST.

II. MEASUREMENT METHODS AND SETUP

The POST telescope was installed on the roof of a 20-meter high building. Receiver noise temperature was measured using the classical Y-factor method, with a piece of blackbody in room temperature and another one immersed in liquid nitrogen alternately placed before the secondary mirror of the antenna.

A CCD camera, also as a finderscope, was used to evaluate the pointing accuracy of the telescope in an indirect way. Firstly, its optical axis was aligned approximately with the radio axis of the telescope. Secondly, the snapshot of the Moon was made to determine the CCD resolution and used as a reference. Thirdly, a one-dimensional scanning of the Moon was made to find out the offsets between the optical and the radio axes in both AZ and EL directions. Finally, continuous observation of Jupiter was taken by CCD to fit the pointing accuracy. After the above process, we can get the telescope pointing accuracy and the offsets between the optical axis and the radio axis, which will be adopted in future observations.

A terahertz RF source was mounted in another building about 300 meters away from the telescope, which is sufficient to meet the far-field condition, to measure the far-field beam pattern of the telescope, as shown in Fig. 1. By scanning the antenna in various angles toward the RF source, we measured the receiving power features of the antenna from specific channels of the FFTS, and far-field beam pattern was thus obtained based on the reciprocity theorem.

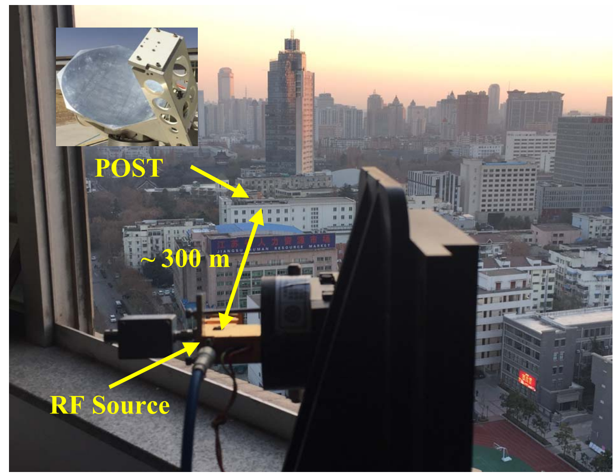

Fig. 1. Far-field antenna beam pattern measurement setup. Distance between the telescope and the RF source was about 300 meters.

III. SYSTEM PERFORMANCE

We first locked the LO at 462 GHz and got I-V curves superimposed with P-V curves as Fig. 2 depicts. The receiver noise temperature was found to be around 300 K when the SIS mixer was dc-biased between 3.9 and 5.1 mV. Similarly, we measured a receiver noise temperature of less than 400 K at 493 GHz.

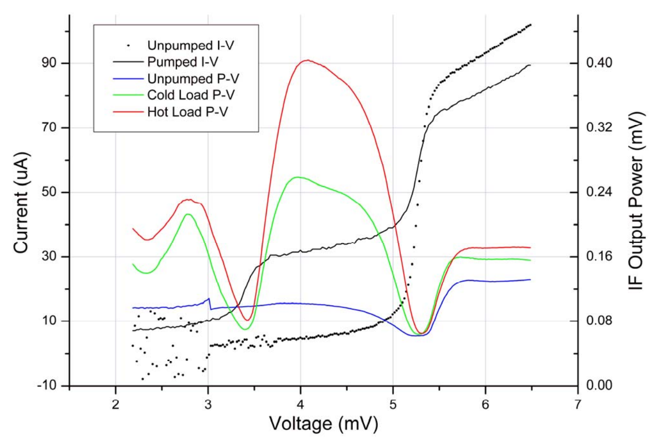

Fig. 2. Measured I-V and P-V curve of the SIS junction at positive bias voltages. Black dot and black line show the current–voltage curves without and with LO signal respectively. Red line, green line and blue line indicate the IF output power vs. voltage with hot load radiation, cold load radiation and unpumped LO signal.

RF noise temperatures were also measured at 462 GHz and 493 GHz by using the cross-line method[3]. Similar results were found. As shown in Fig. 3, the RF noise temperature measured at 462 GHz is about 140 K, which is a significant contribution to the receiver noise temperature.

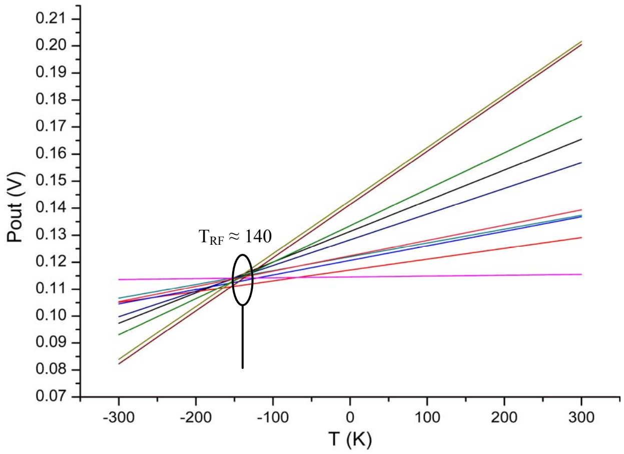

Fig. 3. RF noise temperature measured at 462 GHz. Each line is produced by linking two IF total power corresponding to the hot and the cold input load under the same LO pumping power.

To evaluate the pointing accuracy of the POST telescope, 244 consecutive photos of Jupiter were captured by the CCD camera. For all the pictures, elevation of the planet is between 40° to 68° and azimuth is from 100° and 250°. As shown in Fig. 4, residual pointing errors in AZ direction are better than in EL direction. It is understandable as EL axis is directly driven by motor while AZ axis is driven by worm gear. Total gear ratio is 1/100 of EL axis versus 1/8000 of AZ axis.

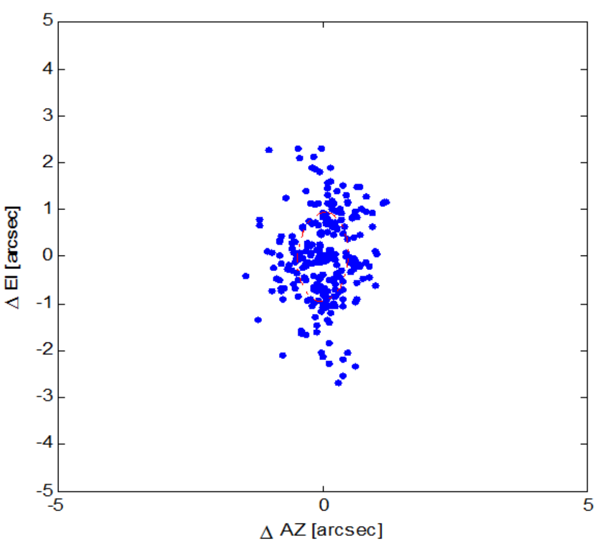

Fig. 4. Distribution of residual pointing errors. Semi-major axis of the ellipse equals to 0.95" and semi-minor axis equals to 0.48".

The Far-field beam pattern of the POST telescope was measured. We combined specific channels of the FFTS to get the total received power. Fig. 5 demonstrates one of the three normalized beam patterns measured at 493 GHz. The mapping includes data for 72×72 successive points covering 2.4° in each direction. According to the obtained 3D pattern, the half-power beam width (HPBW) in AZ and EL directions after surface fitting are 7.6' and 7.8' with an error less than 1". Similarly, the HPBWs measured at 462 GHz are 8.0' and 8.1' in AZ and EL directions, respectively.

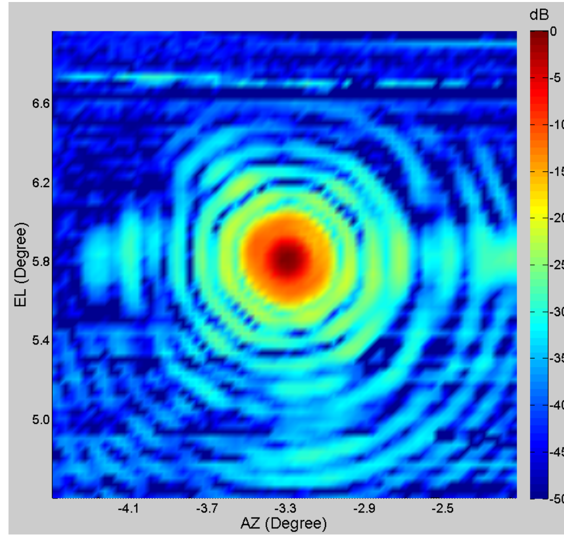

Fig. 5. Normalized far-field antenna beam pattern measured at 493 GHz. Mapping area is 2.4°×2.4° with a spatial resolution of 2' in each direction.

IV. SUMMARY

For a recently updated POST submillimeter telescope, we have evaluated its system performance including the receiver noise temperature, RF noise temperature and far-field antenna beam pattern at both 493 GHz and 462 GHz. The antenna pointing accuracy has also been evaluated by an indirect method. The POST telescope is ready for astronomical observations.

V. ACKNOWLEDGEMENT

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