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Commissioning the Yuan-Tseh Lee Array for Epoch of Reionization Observations with Intensity Mapping

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1 Extended Abstract

The Yuan-Tseh Lee Array (YTLA) is a coplanar 13 element interferometer, which is located on Mauna Loa, Hawaii at an altitude of 3400 m on a 6 meter hexapod platform. The YTLA (formerly the Array for Microwave Background Anisotropy AMiBA) was commissioned in 2006 to study the Cosmic Microwave Background (CMB) using the thermal Sunyaev-Zeldovich (SZ) effect. The frequency of operation is in W-band (86 GHz – 102 GHz). The receiver system consists of cryogenically cooled (15 K) Low Noise Amplifiers (LNA) with a sub-harmonic mixer for the Radio Frequency (RF) to Intermediate Frequency (IF) downconversion stage. In addition, each receiver is equipped with an Ortho-Mode Transducer (OMT) to separate the two polarizations. A fixed primary Local Oscillator (LO) at 84 GHz is used to generate an IF from 2 – 18 GHz. Lag correlators using analog multipliers which provide large bandwidth and moderate frequency resolution were employed for the SZ observations. The experiment was concluded in 2014, and subsequently, plans were initiated to repurpose the telescope to study the Epoch of Reionization (EoR) using Carbon Monoxide (CO) at high redshifts ($z \sim 6$) with Intensity Mapping (IM) techniques. Using IM, one can study aggregate emission from several galaxies ($\sim$ 100 – 1000) spread over large angular scales on the sky.

The current array configuration includes the following main upgrades. Only 7 elements out of the original 13 elements are being used for the IM experiment. The analog backend has been modified for digital hybrid In-Phase Quadrature (IQ) sideband separation. This includes a tunable second LO that converts the above broadband IF to a baseband of 0–2.24 GHz. The IF upgrades consist of IQ plates which provide I and Q outputs after downconversion to baseband. The correlator has been upgraded to a digital Reconfigurable Open Architecture Computing Hardware (ROACH-2) based system. The YTLA observes two linear polarizations (X and Y) simultaneously. A total of 16 ROACHes per polarization are employed divided into 8 F(frequency) engines and 8 X (correlation) engines in an FX configuration. Thus there are two inputs per antenna into each of the F engines. The sampling rate is 4.48 Gsps and the spectral resolution is 2.1875 MHz (1024 channels across 2.24 GHz). A new coherent noise/tone injection system at IF has been also added to do Sideband Rejection Ratio (SRR) calibration and delay compensation. In addition, a new Control and Monitor system was set up using various hardware interfaces and a custom software suite.

I will be presenting results from the commissioning efforts and discuss problems and issues encountered. These include measurements of antenna System Equivalent Flux Density (SEFD), sideband separation in terms of the SRR, maps of beam size and other related parameters.