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Large-scale Phased Array Receiver System for Giant Cylindrical Array Radio Telescope in China

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The Meridian Project Phase II Interplanetary Scintillation (IPS) telescope, designed to remotely detect solar wind and coronal mass ejections (CME) by capturing extremely weak transient radio signals from space, is a key component of the Meridian Project Phase II. The IPS telescope comprises three stations: one primary station and two auxiliary stations, all located in Xilingol League, Inner Mongolia in China. Two auxiliary stations each consist of a 30-meter antenna, located in Abaga Banner and Sunit Right Banner, respectively. The primary station is situated at the Ming'antu Observation Base of the Chinese Academy of Sciences and composed of three parabolic cylindrical reflector antennas.

The giant cylindrical array IPS radio telescope in the primary station boasts high sensitivity of approximately 8 mJy and a wide field of view (FOV) achieved through ±45 degrees mechanical and ±60 degrees electronic scanning, utilizing multi-beam phased array feed (PAF) hybrid-beamforming technology. Each parabolic cylinder reflector measures 140 meters in length in the north-south direction and 40 meters in width in the east-west direction. With its large aperture, the cylindrical array radio telescope achieves a half-power beamwidth of about 0.46 degrees at 327 MHz and 0.23 degrees at 654 MHz, delivering exceptional angular resolution.Each of the parabolic cylinderial reflector antennas is equipped with 592 dual-polarized bent dipole feeds with 0.235 meters space apart. These dipole feeds are integrated with frequency selective surfaces (FSS) to enhance scanning angles and FOV of the IPS telescope. The receiver system operates within two frequency bands: 307-347 MHz and 634-674 MHz, with an adjustable bandwidth ranging from 1 to 40 MHz and a spectral resolution of 1 MHz. Given the large number of PAF elements (~1800), implementing an all-digital beamforming architecture will significantly increase construction costs and data processing demands. Therefore, we implement a hybrid beamforming architecture for the PAF multi-beam system, which effectively reduces both computational complexity and data volume associated with the beamforming algorithm.

Development and system performance of the large-scale phased array receiver system for the Meridian Project Phase II IPS telescope will be presented in detail.

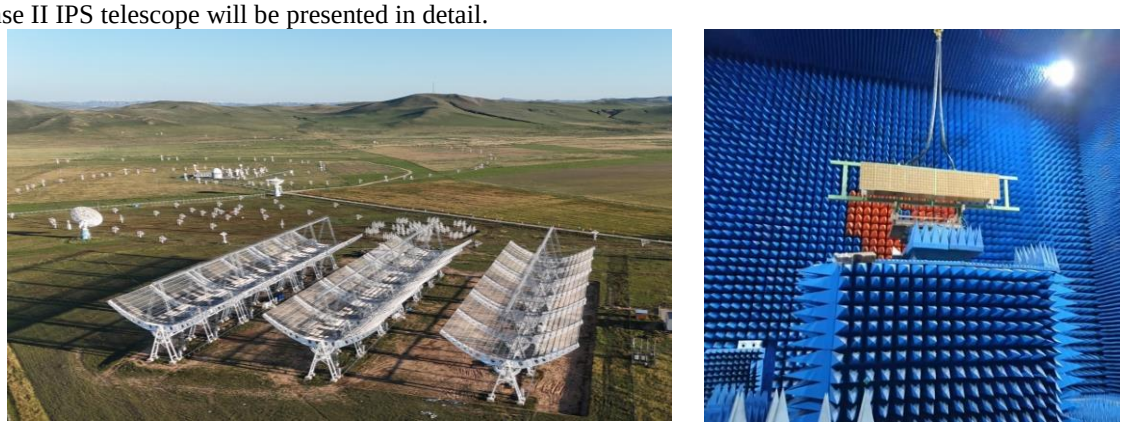

Figure 1. Meridian Project Phase II IPS cylinderical array radio telescope and Measurement of Phased Array Reciever in Microwave Anechoic Chamber

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