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Wideband Millimeter-Wave Receiver Development for the LMT-FINER Project

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Introduction:

Spectroscopic observations of the far-infrared [OIII] and [CII] lines present a pathway to explore the physical mechanisms of the emergence of massive galaxies in the epoch of reionization and beyond, which is one of the most fundamental questions in modern astronomy. To address this challenge, the Far-Infrared Nebular Emission Receiver (FINER) project is developing two wideband dual-polarization sideband-separating heterodyne receivers at 120-210 GHz and 210-360 GHz for the Large Millimeter Telescope (LMT) in Mexico. These receivers plan to provide an instantaneous intermediate frequency (IF) of 3−21 GHz per sideband per polarization, providing 40% of ALMA's light-collecting area and a similar atmospheric condition, but around five times wider IF bandwidth than current ALMA, offering a cutting-edge spectral scanning capability in the next several years.

The 210–360 GHz receiver has been assembled and integrated, and initial single-polarization 2SB measurements show a receiver noise temperature of ~100 K and an analog image-rejection ratio of ~10 dB across most of the 210–330 GHz range. Work toward full dual-polarization integration is ongoing. For the 120–210 GHz receiver, the key component designs have been completed, and the wideband SIS mixer is currently under fabrication at NAOJ.

1. Scientific Background and Project Overview

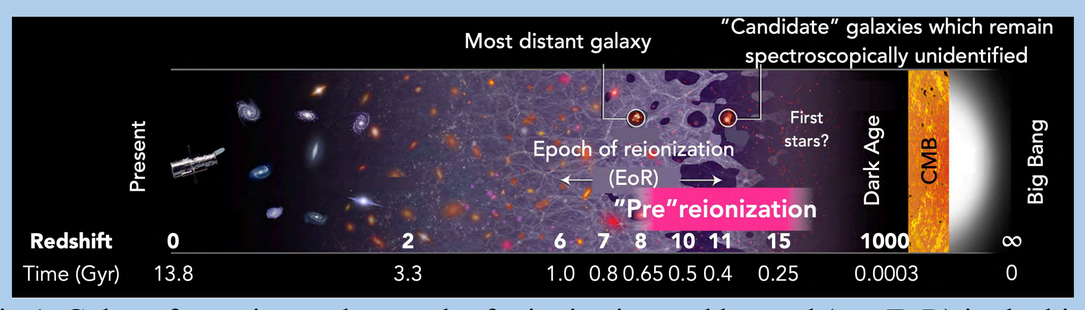


Fig 1. Galaxy formation at the epoch of reionization and beyond (pre-EoR) in the history of the Universe. credit: NASA, ESA, P. Oesch and B. Robertson (University of California, Santa Cruz), and A. Feild (STScI)

Important questions to be addressed:

1. How massive galaxies are common at the epoch of reionization and beyond (Pre-EoR)?
2. What drives an extremely high efficiency of galaxy growth?

Solution:

Spectroscopic observations of z ~10 galaxy candidate with far-IR [O III] 88.3-μm & [C II] 157.7-μm lines to identify spectroscopic redshifts and physical status of interstellar medium.

Project goal:

Two wideband heterodyne receivers at 120-210 GHz and 210-360 GHz with an IF bandwidth of 3-21 GHz.

2. Receiver Optics

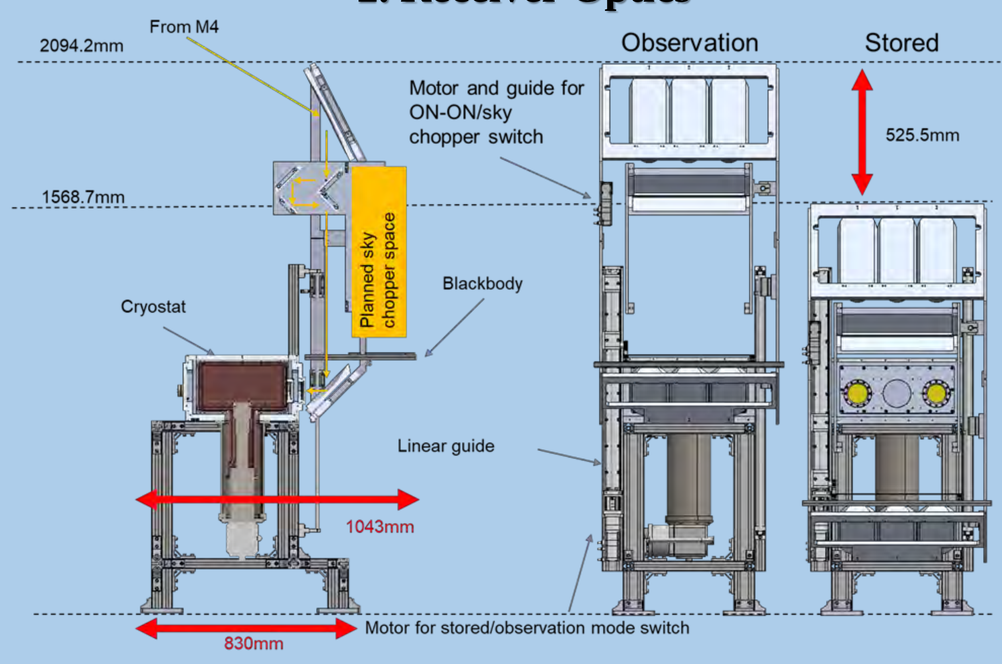


Fig 2. Optics and supporting mechanics for the FINER receivers

- Phase I Optics: Two beams on the sky with different pointing directions. Position-switching observation by changing the telescope pointing.
- Phase II Optics: Use fast sky-chopper to switch the position of the beams within ~ 1 sec (1 Hz) or even faster.

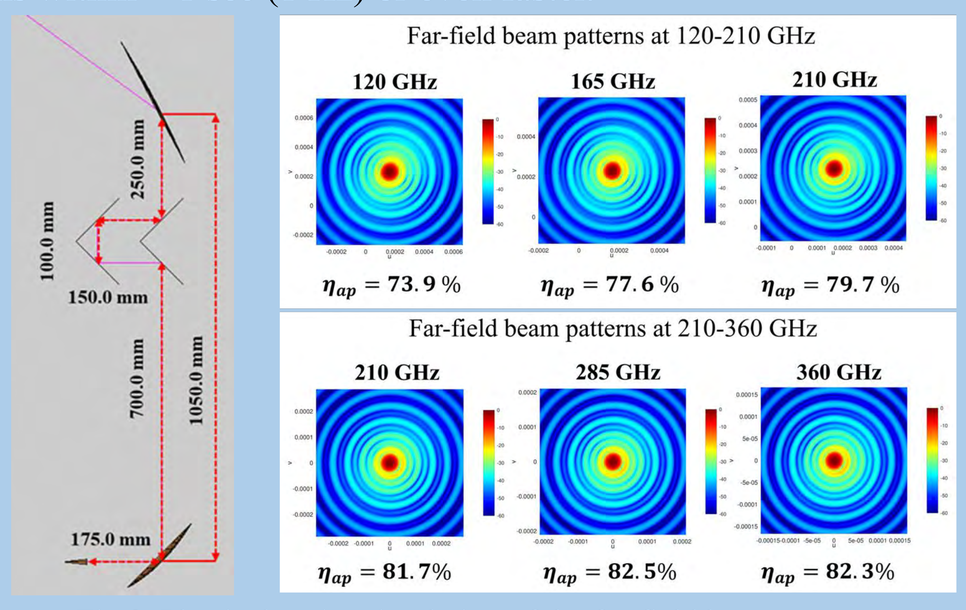


Fig 3. Physical optics simulation of the far-field beam patterns

3. Development Status of the Receiver

3.1 210-360 GHz Receiver

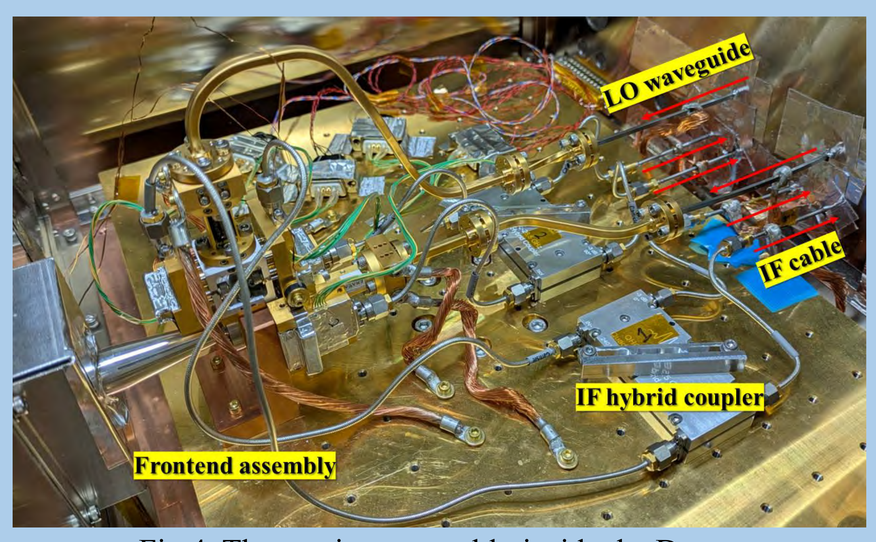


Fig 4. The receiver assembly inside the Dewar

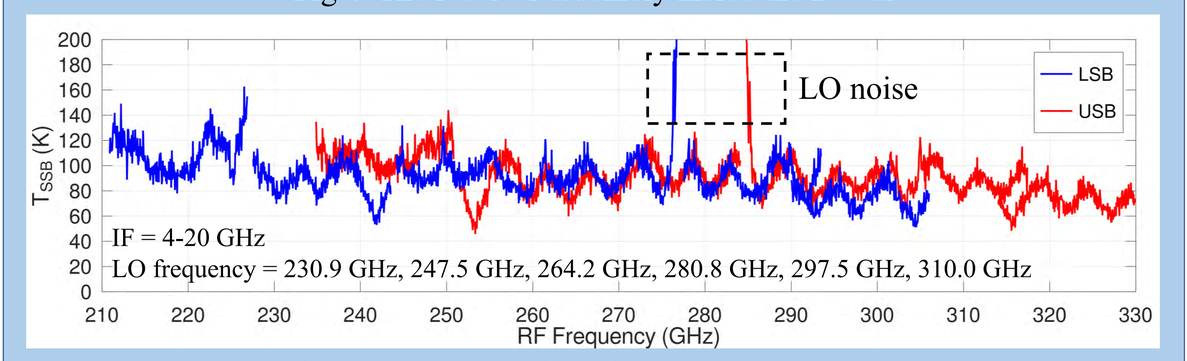


Fig 5. The measured receiver noise temperature

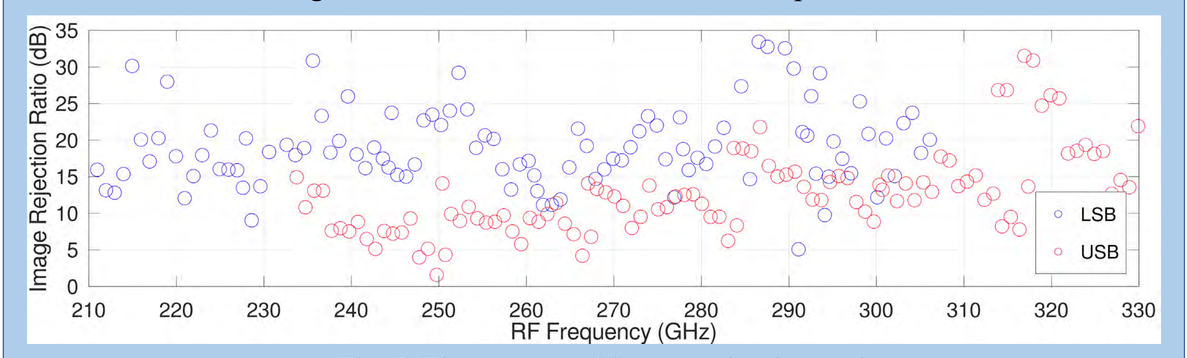


Fig 6. The measured image-rejection ratio

3.2 120-210 GHz Receiver

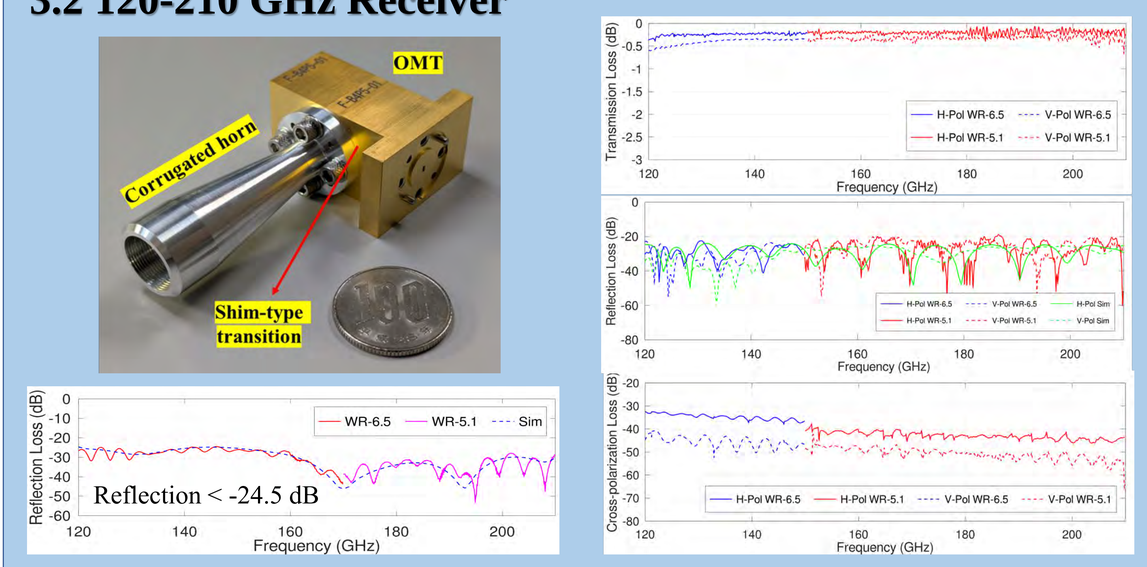
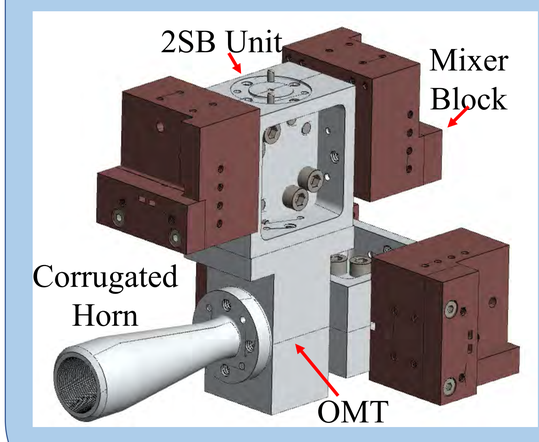


Fig 7. The measurement results for (left) the corrugated horn (right) the OMT



1. All the waveguide components has been designed and the corrugated horn, OMT and mixer blocks have been delivered.
2. Now the design of the wideband SIS mixer has been completed, and it is under fabrication at NAOJ.
3. The LO chain has been delivered.