Near-field measurement and far-field characterization of a high-gain Cassegrain antenna at 300 GHz band based on a photonics technology

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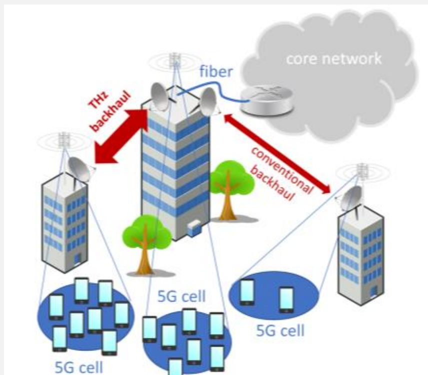
I am Yusuke Tanaka of Gifu University.
I would like to start my presentation of "Near-field measurement and far-field characterization of a high-gain Cassegrain antenna at 300 GHz band based on a photonics technology".

Thz wireless communication 2



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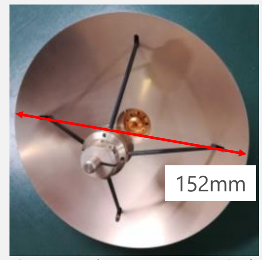


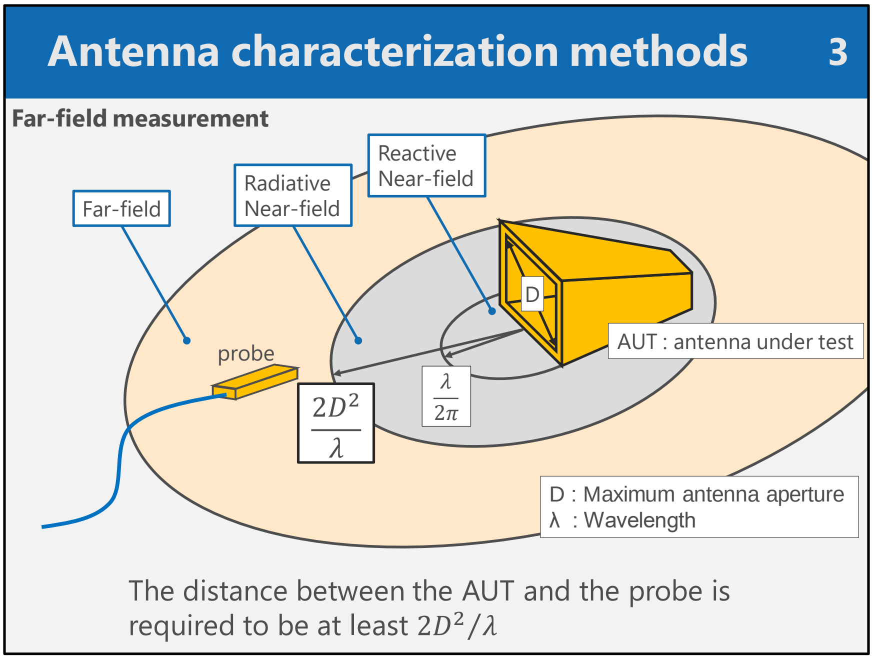
Cassegrain antenna : 48 dBi

ThoR project

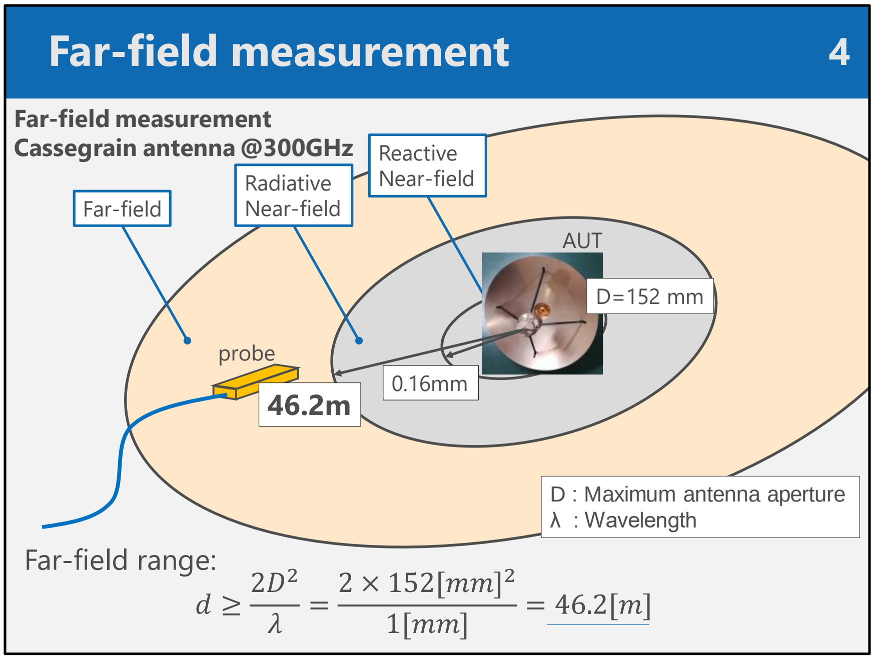
- Wireless communication over 100 Gbps at 300GHz
- Operating over several kilometers

Antenna characterization is important

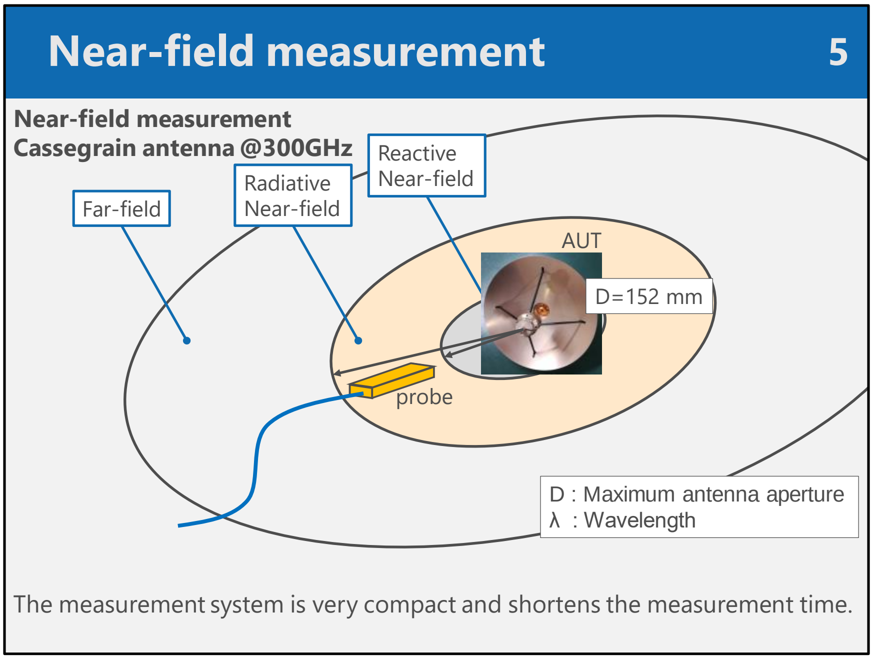
With the spread and expansion of broadband networks, the use of terahertz (THz: 0.1 to 10 THz) wave band, which is easier to expand the transmission band, is being studied. Many antennas for use in the THz wave band have also been studied.
High gain antennas are key to the realization of terahertz communications with propagation distances from a few hundred meters to several kilometers, such as ThoR.
We are aiming for wireless communication that operates over 100Gbps over several kilometers at 300GHz.
At that time, a high gain antenna of 48 dBi is used.
It is important to evaluate the characteristics of such a high gain antenna.



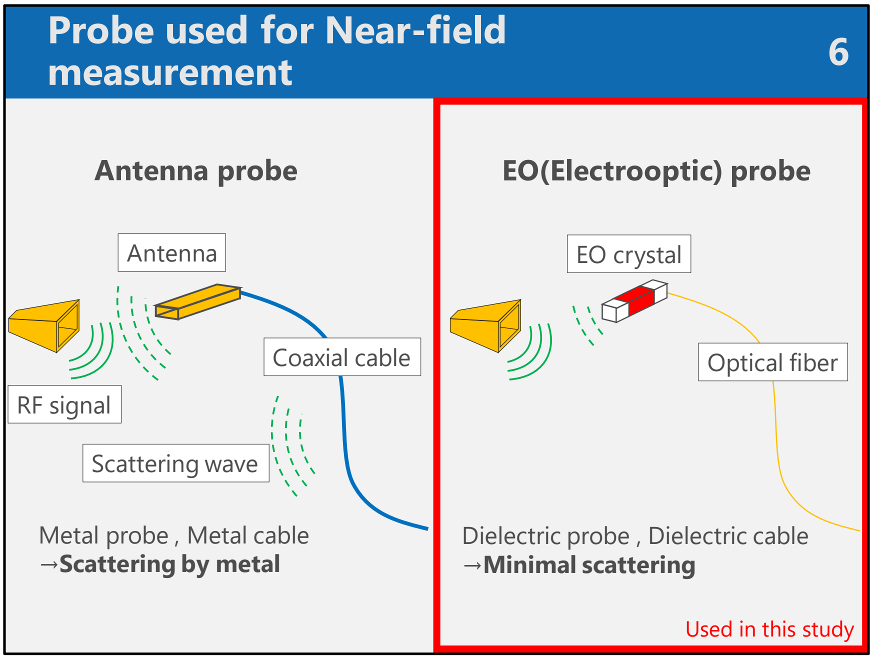
Far-field measurement is a popular method for radiation pattern characterization.
For far-field measurements, the probe needs to be placed in the far-field region.
The definition of the Far-field of the antenna is farther than 2D squared over λ.
D is the maximum antenna aperture and λ is the wavelength.
Far-field measurements require a measurement location that covers this wide range.



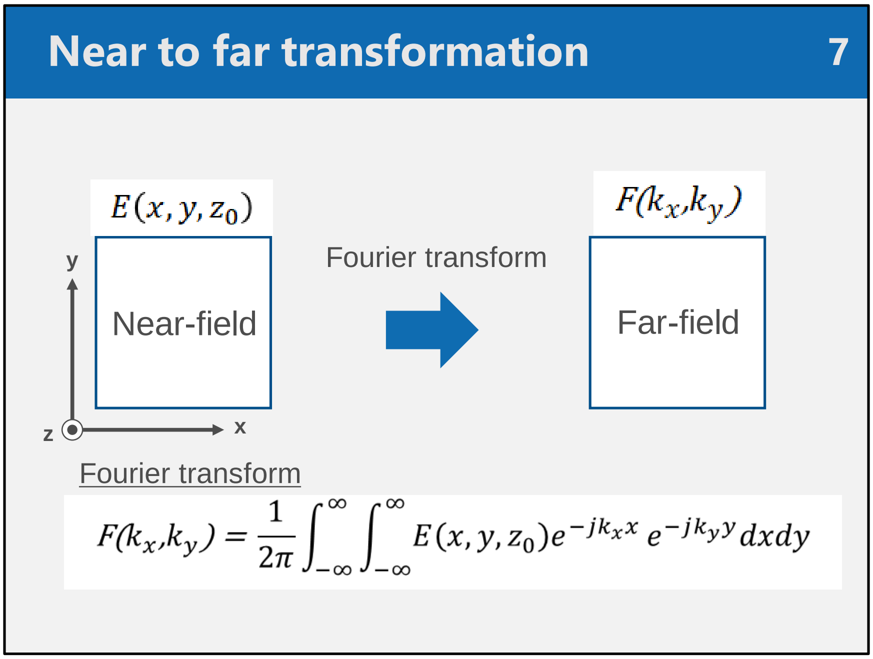
For example, to measure the radiation pattern of such a Cassegrain antenna of 152 mm in diameter at 300 GHz, the distance would need to be more than 46.2 m. Due to the high propagation loss and low signal-to-noise ratio in the THz band compared to the microwave band, it is very difficult to measure the antenna pattern under long-distance field conditions.



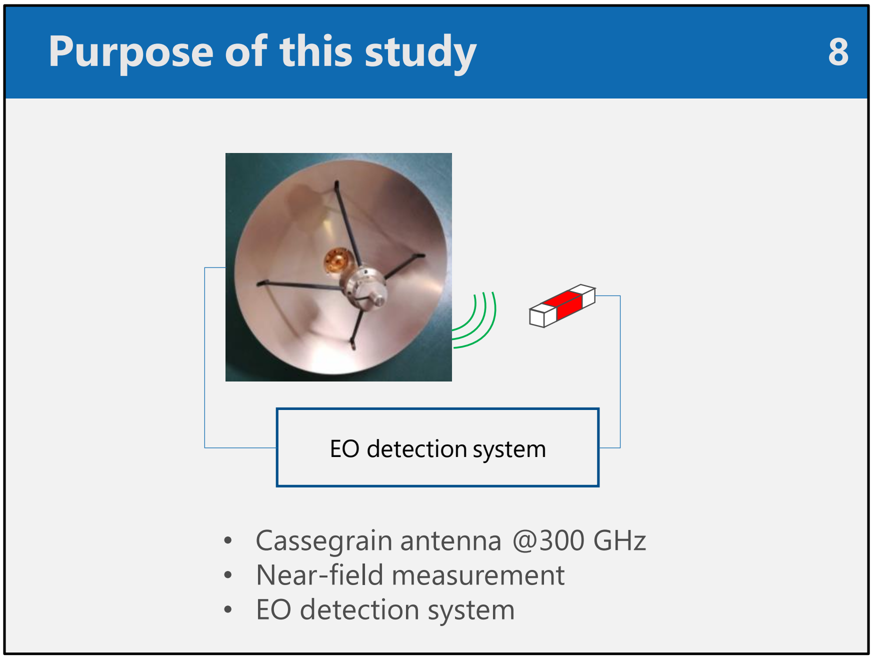
One solution is near-field measurement.
The distance between the probe and the AUT can be shortened, which makes the measurement system very compact.
The measurement range is also more compact, which reduces the measurement time.
Especially in near-field measurements, the effect of interference by probes must be minimized.



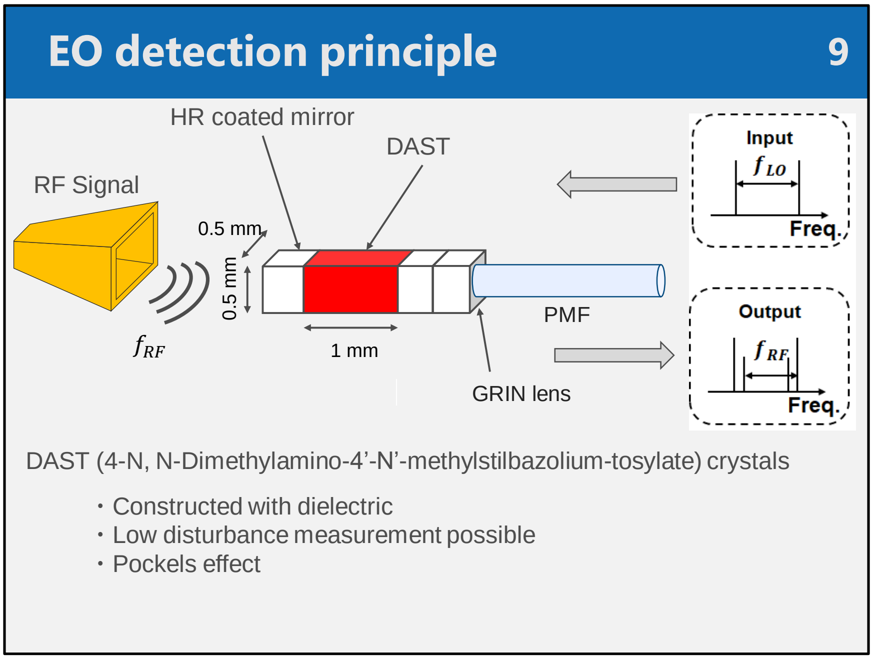
There are two types of probes used in near-field measurement.
A metal antenna is used for the waveguide probe. The measured electric field is disturbed by the scattered wave generated by the probe.
EO probes have been used recently to measure accurate Near-field because of reduced scattering.



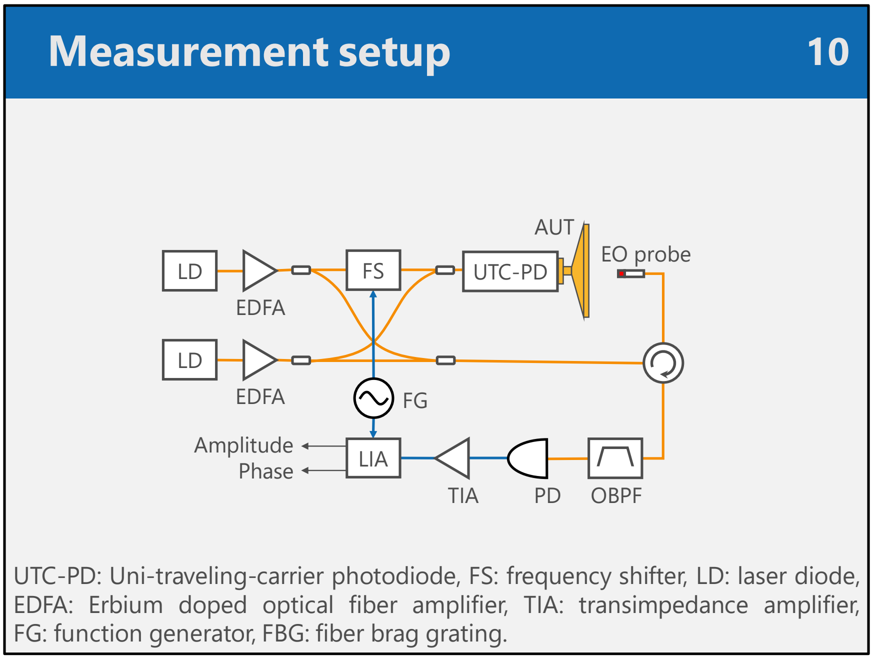
Near-field to Far-field transformation is one of the important techniques in near field measurement.
It is known that the radiated electromagnetic field is given by the Fourier transform of the wave source.
Therefore, the antenna radiation pattern can be obtained by Fourier transforming the measured near-field distribution.



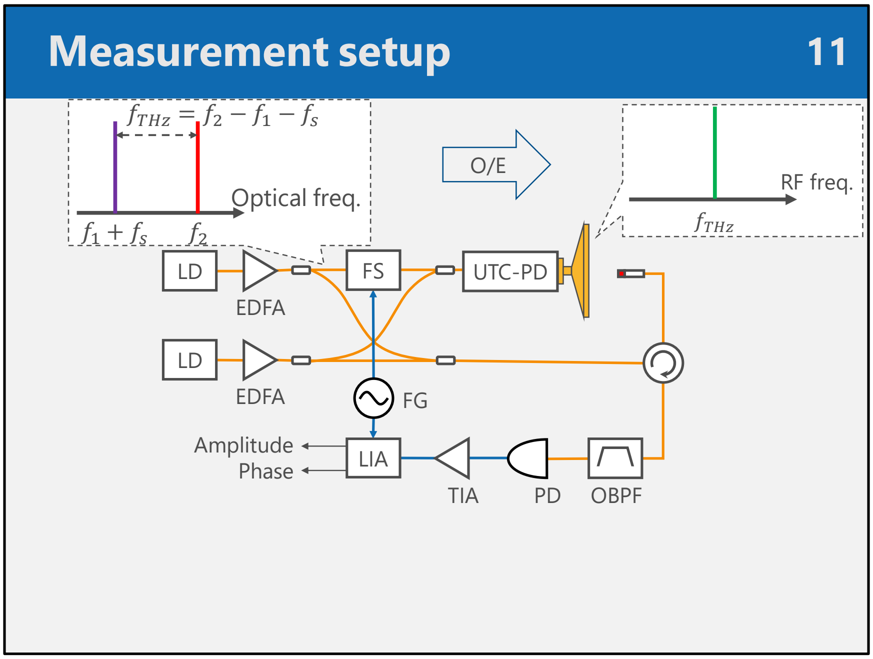
Evaluate of the radiation pattern of the Cassegrain antenna at 300 GHz. A measurement system based on optical technology is used to measure the near-field using EO probe. The radiation pattern was calculated by the Fourier transform of the measured near field.



First of all, it's about the principle of EO measurement.
DAST crystals are used for the EO sensor, and they are all made of dielectrics,
For this reason, low disturbance measurement is possible.
And this DAST has a Pockels effect in which the refractive index varies in proportion to the applied electric field
In the DAST crystal, the optical LO signal is phase-modulated by the applied electric field to generate side bands.

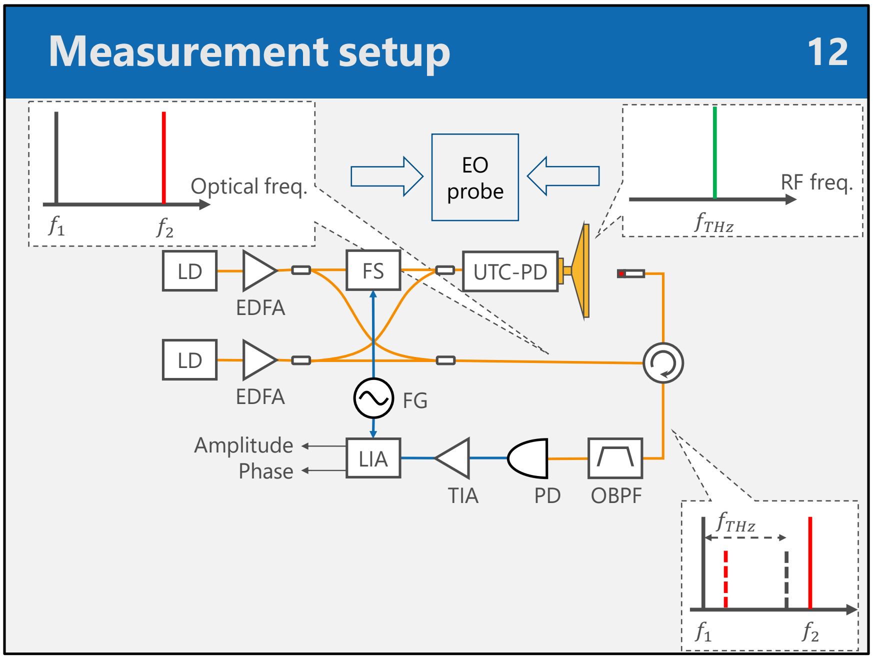


Then, I will explain the electro-optical measurement system used this time.
Electric field measurement is measured by EO sensor and unique detection system.
I will describe the detection system.
For the detection system, we used a self-heterodyne system.

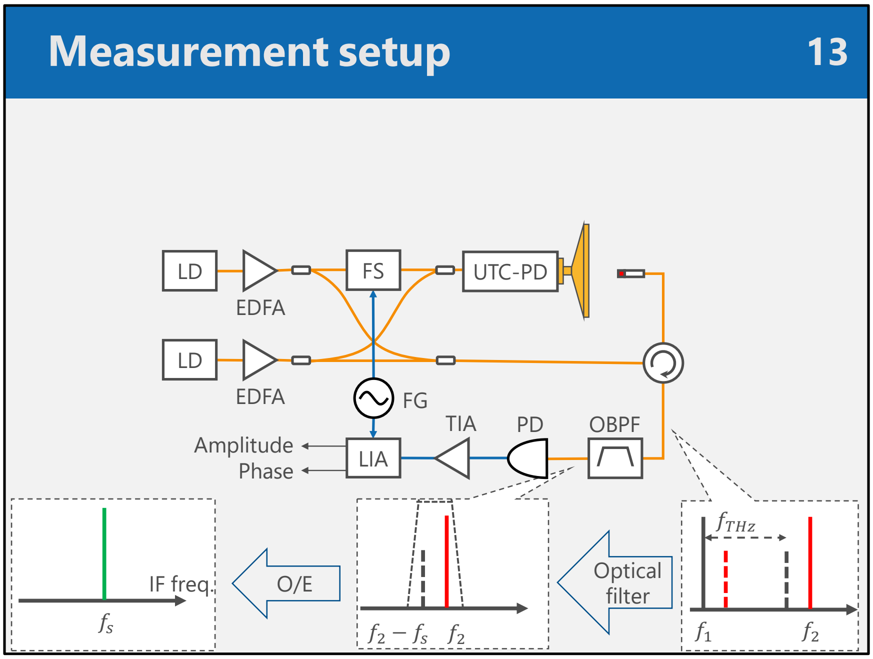


Next I explain the detection principle using frequency spectrum.

Two free-running LDs are used as optical sources.
The frequencies of the Laser diodes are set to be f1 and f2 (f2 > f1).
Here, an EO frequency shifter is used to shift the frequency of the LD1 by fs for self-heterodyne detection.
And combined using PMF couplers to produce a beat note at a frequency of f2−f1−fs for THz wave generation (RF).



In the EO probe, an optical signal composed of two frequency components interacts with an RF signal, and a sideband having the amplitude and phase information of the RF signal is generated.
Two pairs of heterodyne candidates are generated.



A single pair is extracted by an optical filter and converted to an IF signal by a photodiode.
The amplitude and phase of this IF signal are detected on the lock-in amplifier.
In this way, the electric field distribution can be detected and visualized.

Near-field measurement

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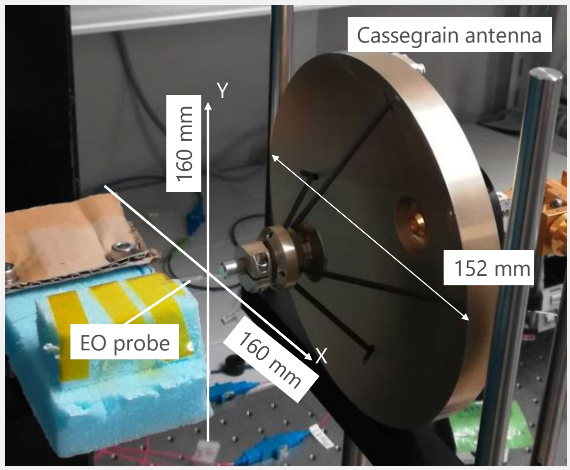
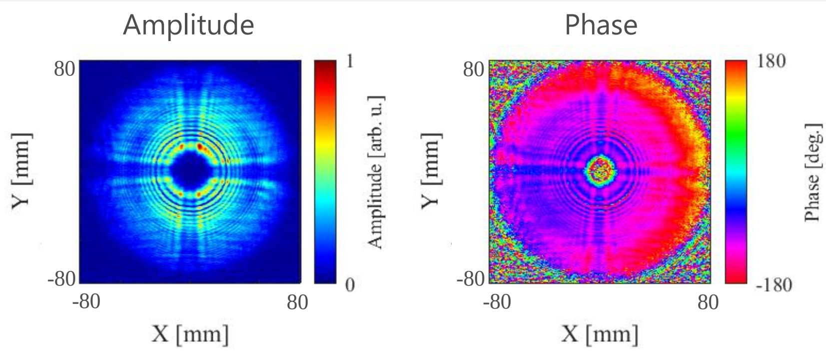


- Measured at a position 5 mm from the antenna surface and 160 mm square plane
- The EO probe was moved by 0.25 mm pitch

Next, I will explain the measurement conditions.
A 300 GHz signal was radiated from the cassegrain antenna.
I measured at a position 5 mm from the antenna surface and 160 mm square plane.
The EO probe was moved by 0.25 mm pitch.

Near-field measurement results 15



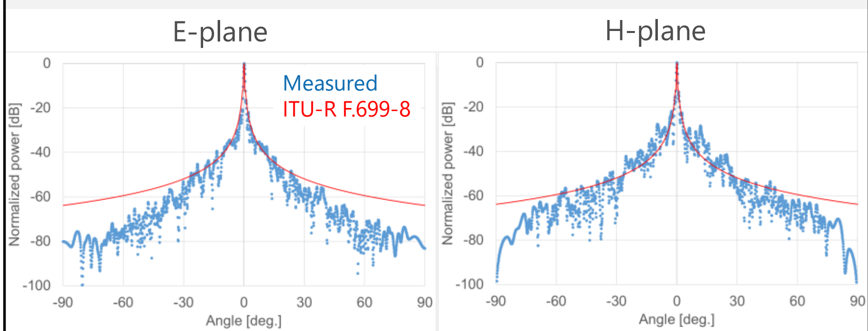
- The maximum signal-noise-ratio (SNR) was about 25 dB
- Measurement time is 12 hours

This is a near-field measurement result.

The maximum signal-noise-ratio (SNR) was about 25 dB.

Measurement time is about 12 hours.
Use this results to calculate the Far-field.

Far-field measurement results 16



FWHM[deg.]	E-plane	H-plane
Measured	0.46	0.40
ITU-R F.699-8	0.456	0.456

The results were compared with a mathematical model for interference assessment. The mathematical model is F.699-8 of ITU-R.
The E-plane resulted in higher gains than the model in the range of -26deg to +23deg and the H-plane in the range of -58deg to +47deg.The FWHM was equal to or better than the model at 0.46deg for the E-plane and 0.40deg for the H-plane.

Summary and Future works

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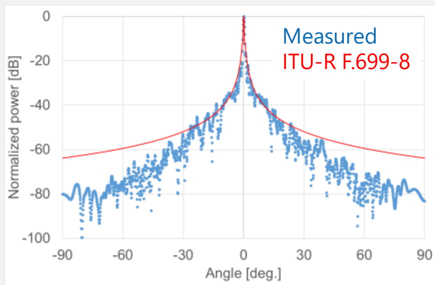
Summary



Evaluation of antenna radiation patterns by near-field measurement

Narrow FWHM compared to the radiation pattern of ITU-R F.699-8

Future works

- Measurement of Antenna gain
- Further improvements in near-field measurements
  Measures a wider range of near-fields.

The antenna radiation pattern was evaluated using near-field measurements.
A narrower FWHM was obtained compared to the radiation pattern of ITU-R F.699-8.
In the future, the evaluation method will be established by measuring the antenna gain and a wider range of near-field measurements.

Acknowledgment

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Finally,

This research was conducted with support of ThoR project.

This is all for my presentation.

Thanks.