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## Quasi-optical Measurement for Low Loss Material Characterization in Submillimeter Wave Range

Ha Khiem Tran

*Portland State University, tranha@pdx.edu*

Thanh Ngoc Dan Le

*Portland State University*

Branimir Pejcinovic

*Portland State University, pejcib@pdx.edu*

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# Quasi-optical measurement for low loss material characterization in submillimeter wave range

By Ha Tran, Thanh Le, Prof. Branimir Pejcinovic

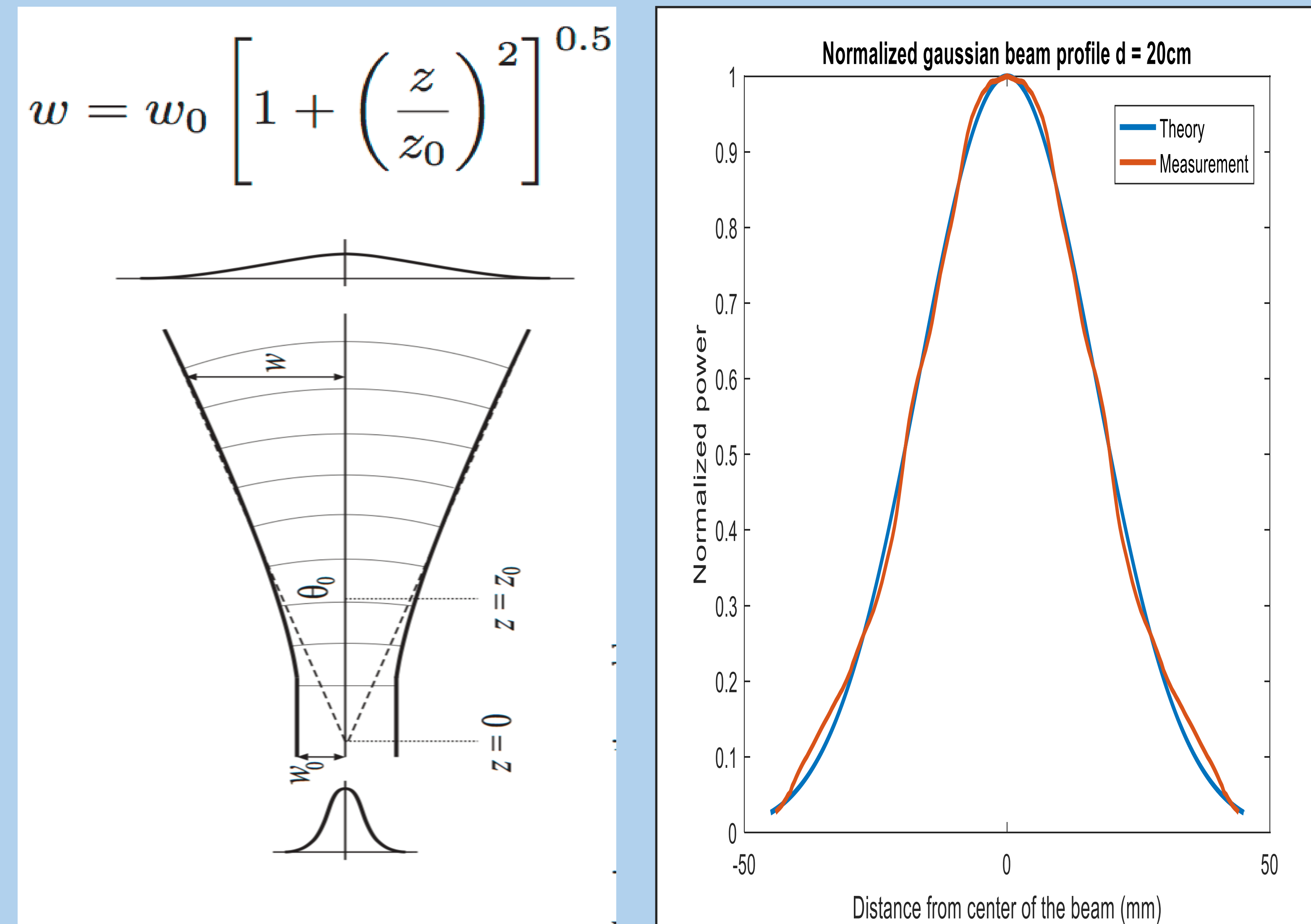
## Introduction

Quasi-optical measurement setup consists of a pair of horn antennas operated as feed for two off-axis parabolic mirrors. Once a collimated beam is generated, we measure its characteristics using Gaussian beam mode analysis. The sample under test is inserted between the two mirrors where the beam is collimated.

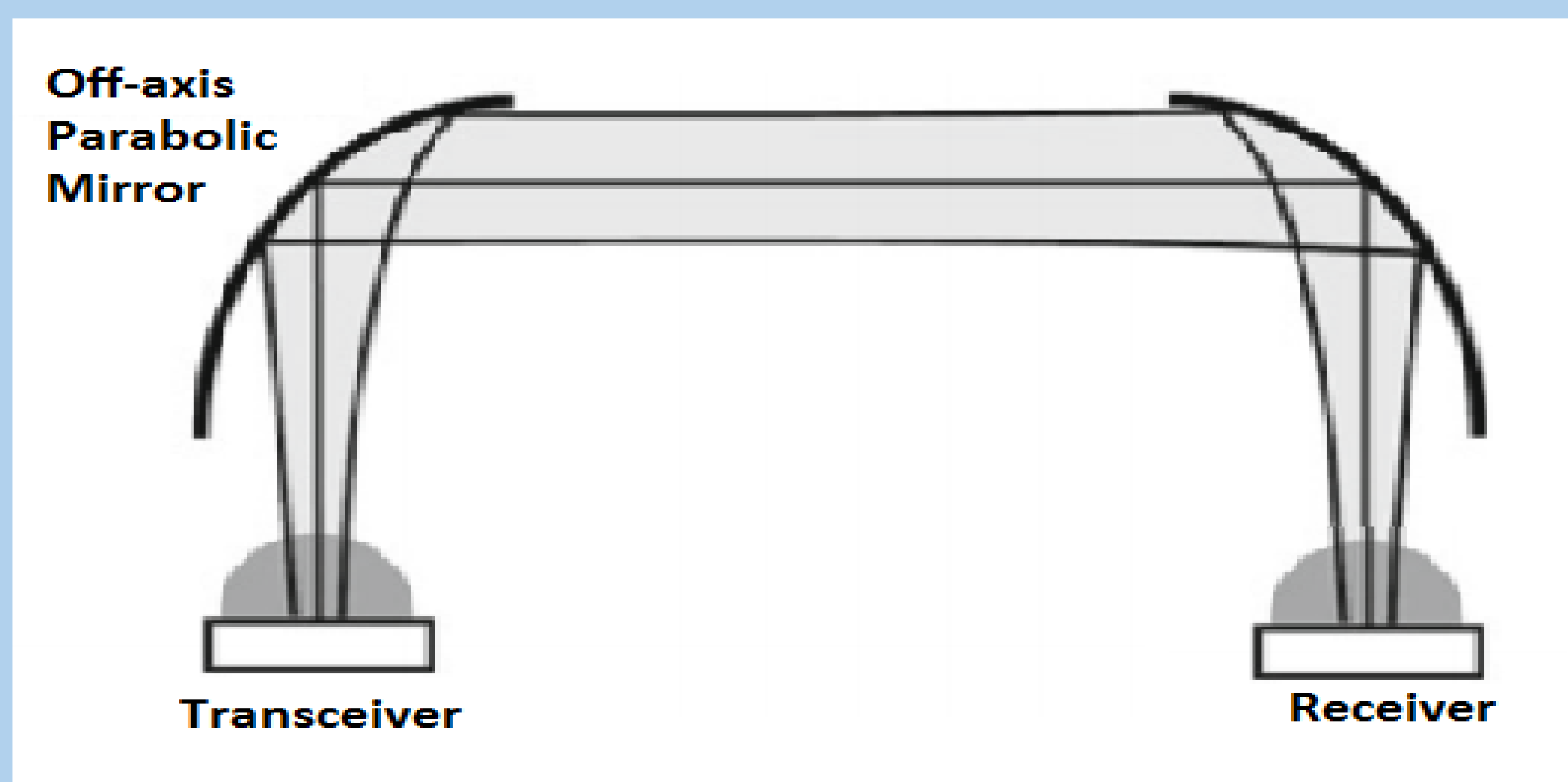
## Gaussian Beam in mm-wave domain

**Analytical Study (Left figure):** Beam radius ( $w$ ) is calculated with the Rayleigh distance ( $z_0$ ) and minimum beam waist ( $w_0$ ) [1]

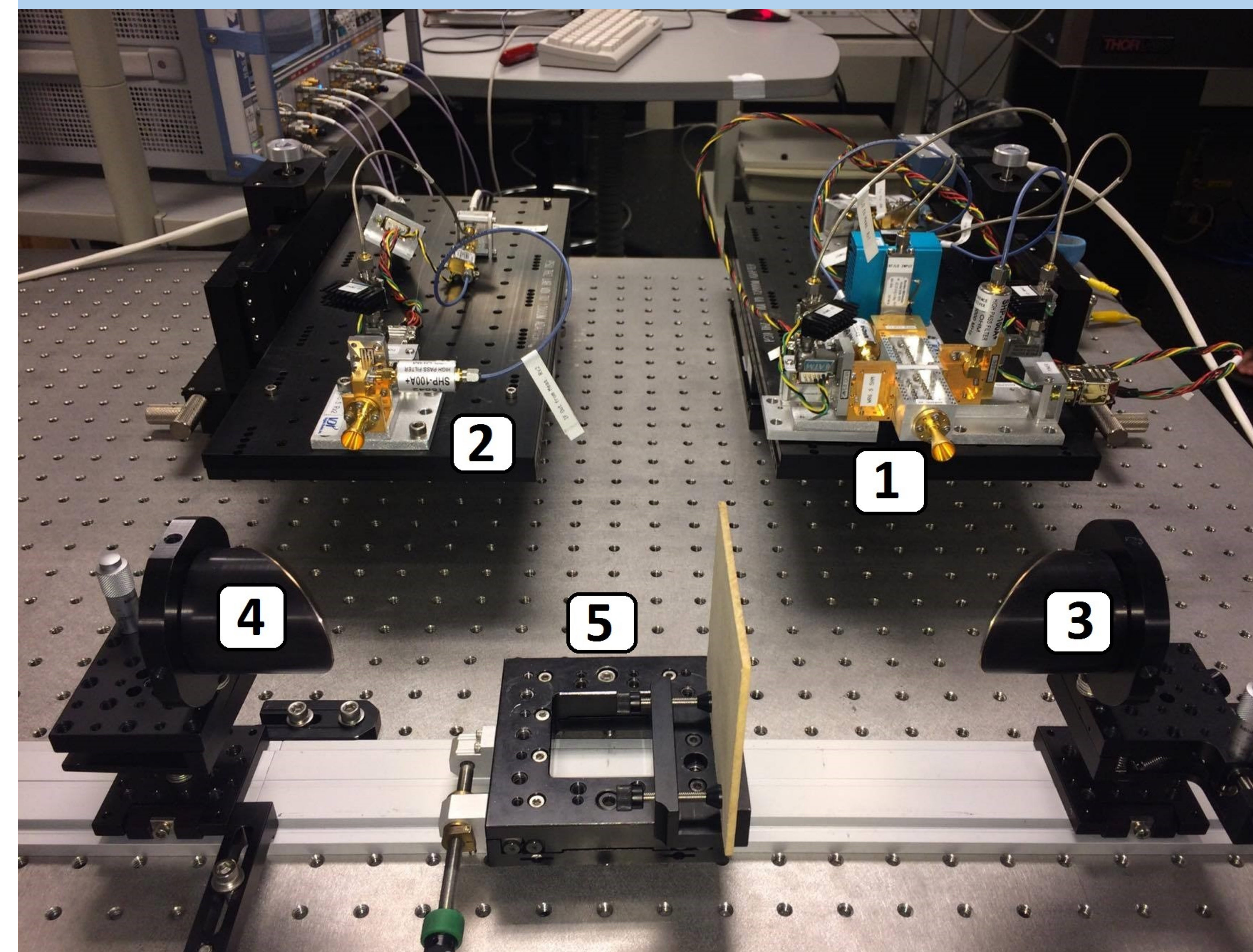
**Measured amplitude distribution (Right figure):** Far-field measurement of Gaussian beam profile was done using the receiver mounted on top of a translation stage as probe.



**THz optical path:** Two 90° off-axis parabolic mirrors are used to collimate and refocus the Gaussian beam.



## Measurement Setup

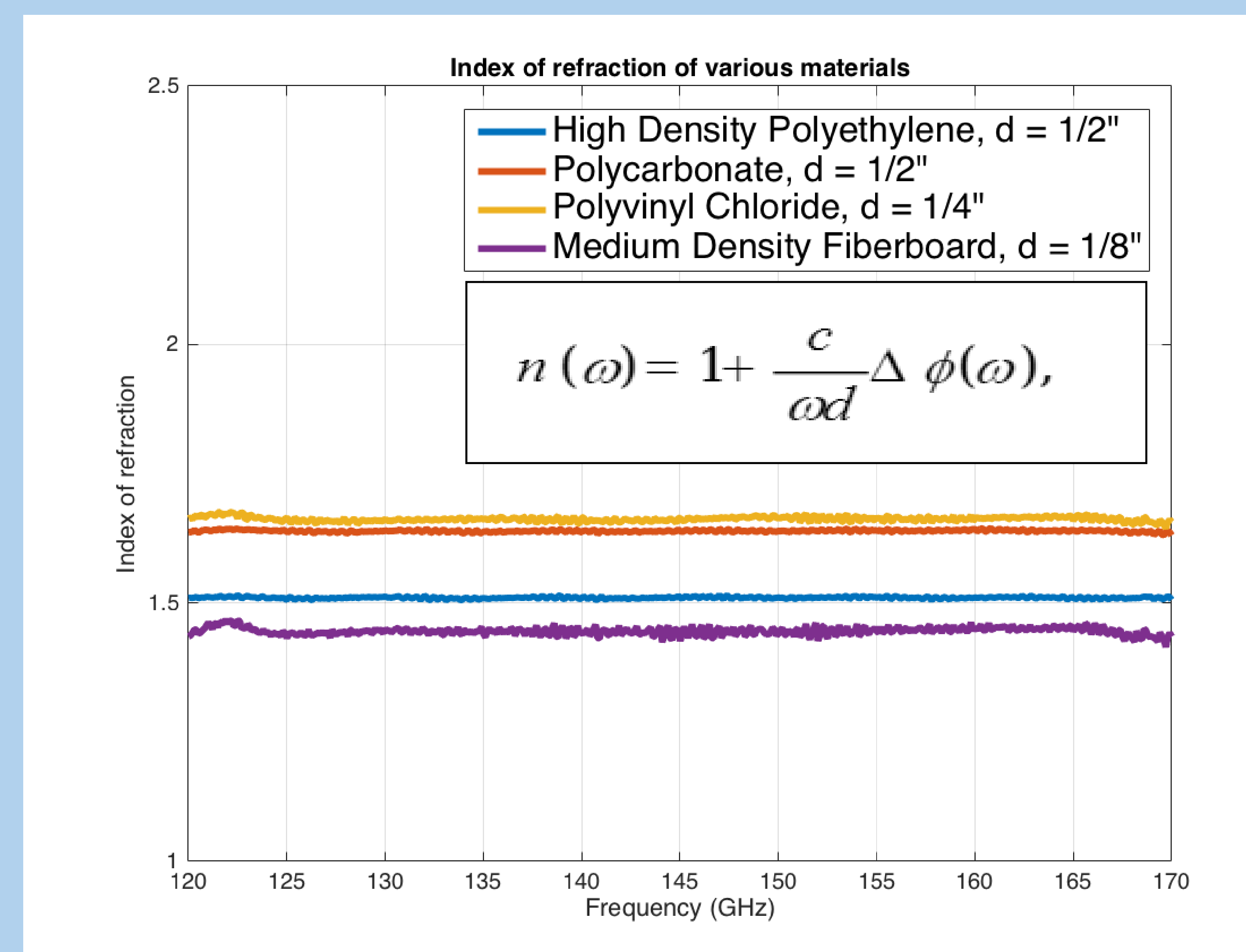


**Quasi-optical measurement setup for WR-6.5 band:**

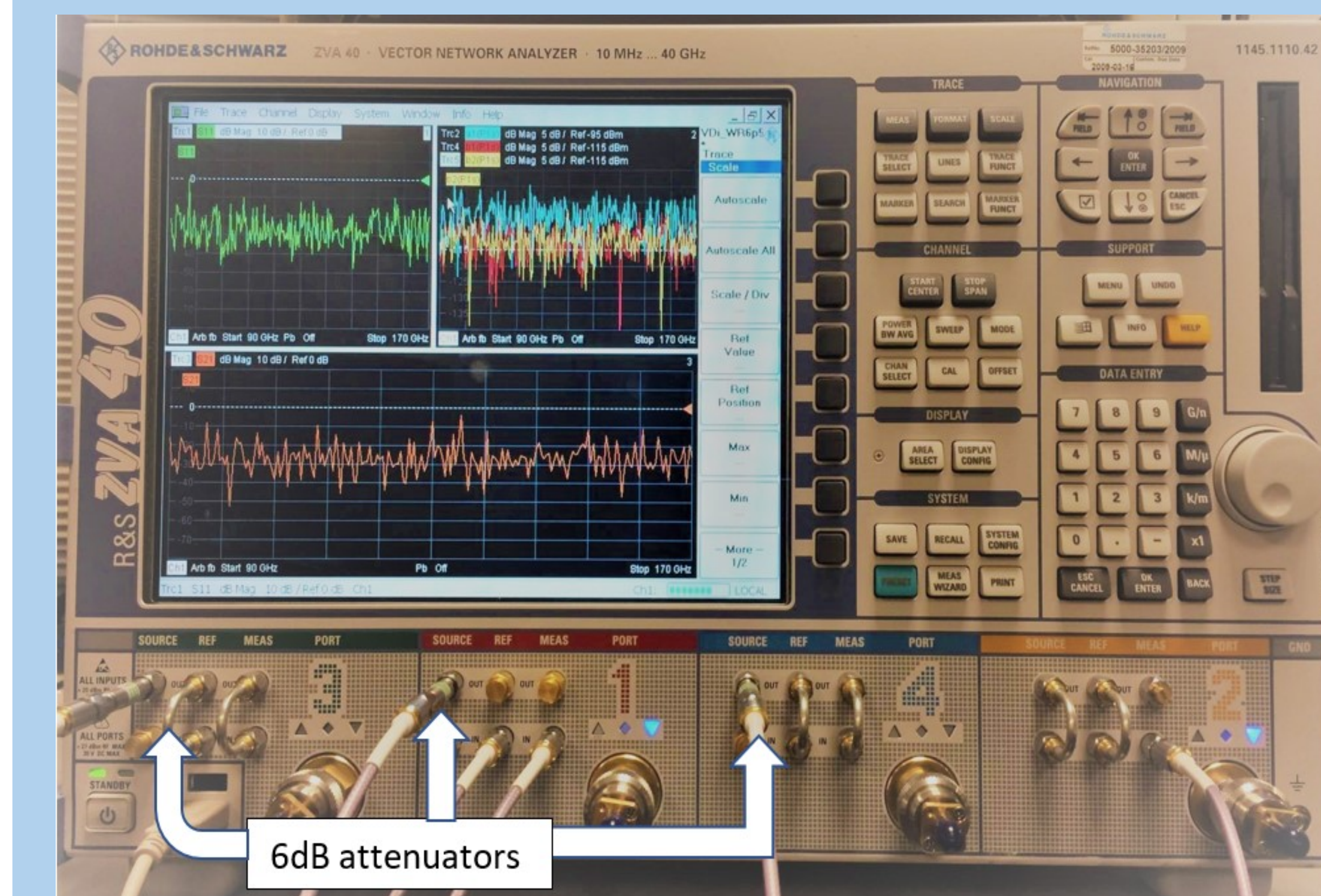
- (1): Transceiver Module      (3),(4): Off-axis parabolic mirrors  
(2): Receiver Module      (5): Sample holder

## Index of Refraction

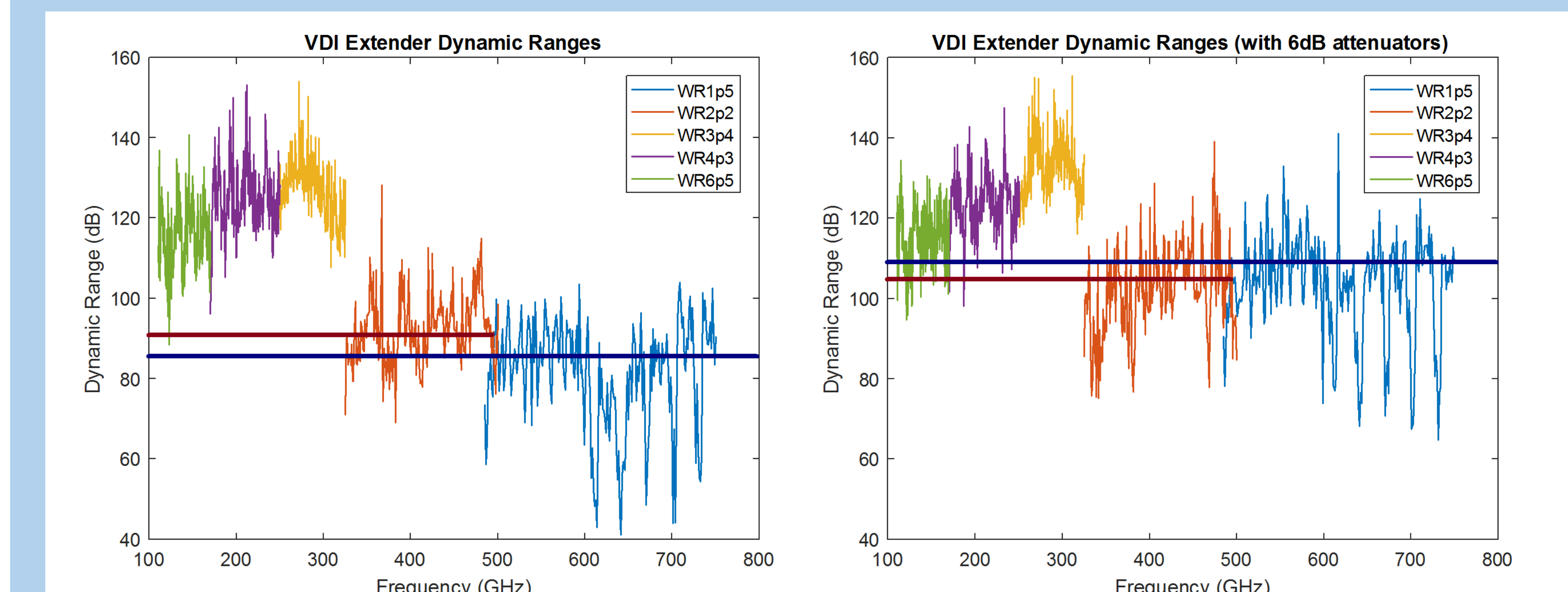
Index of refraction is calculated based on the intrinsic phase shift  $\Delta\phi(\omega)$  and sample thickness  $d$  [2].



## VDI Extender Module Dynamic Range



- ◆ Dynamic range (DR) is measured by taking the ratio between signal and noise.
- ◆ We also use 6dB attenuators to improve the overall performance of the system.



- DR Improvement:**
- ◆ 15 dB improvement in WR-2.2 range
  - ◆ 25 dB improvement in WR-1.5 range

## Future Work

For further investigation, we would like to:

- ◆ Take measurement for higher frequency bands.
- ◆ Extract imaginary part of electric permittivity from  $S_{11}$ .
- ◆ Take account of multiple reflections inside the material slabs (Farby-Perot effect) into the extraction algorithm.

## Reference

- [1] A. Kazemipour, et al. "The Horn Antenna as Gaussian Source in the mm-Wave Domain," *J. Infrared Millim. Terahertz Waves*, vol. 35, no. 9, pp. 720–731, Sep. 2014.
- [2] J. O. Tocho and F. Sanjuan, "Optical properties of silicon, sapphire, silica and glass in the Terahertz range," in *Latin America Optics and Photonics Conference (2012)*, paper LT4C.1, 2012, p. LT4C.1.