



## MmWave and THz Antenna Research

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### INTRODUCTION

The role of the antennas and especially antenna arrays has substantially increased due to the higher operation frequencies the currently deploying 5G and upcoming 6G wireless communication schemes.

When the fundamental limitations for the antenna in terms of directivity and aperture are combined with the Friis' Equation [1] and other propagation mechanisms, it is clear that practical communication antennas will be electrically large. This leads to narrow antenna beams, beamsteering, and LoS communication.

### RESEARCH GOALS

We have focused on research and development of practical antenna solutions to the current 5G and upcoming 6G wireless communication systems.

Our goals include efficient antenna solutions in terms of antenna volume, aperture, gain, and bandwidth.

We have concentrated on high-efficient materials, lens solutions, and manufacturing methods for highly directive antennas, especially in THz frequencies.

### MmWAVE ANTENNA RESEARCH

Linearly polarized antenna array solution for mobile backhaul link application has been recently published [2]. It contains 16 sub-arrays of 4 elements resulting a 64 element array with measured gain of 20 dB, shown in Fig. 1. This antenna was used to demonstrate 5G mmWave mobile backhaul link in the Pyeongchang Winter Olympic Games in Korea in 2018.

Our most recent research investigations include dual-band mmWave antenna array solutions which are implemented using standard PCB manufacturing processes. Results are not public yet.

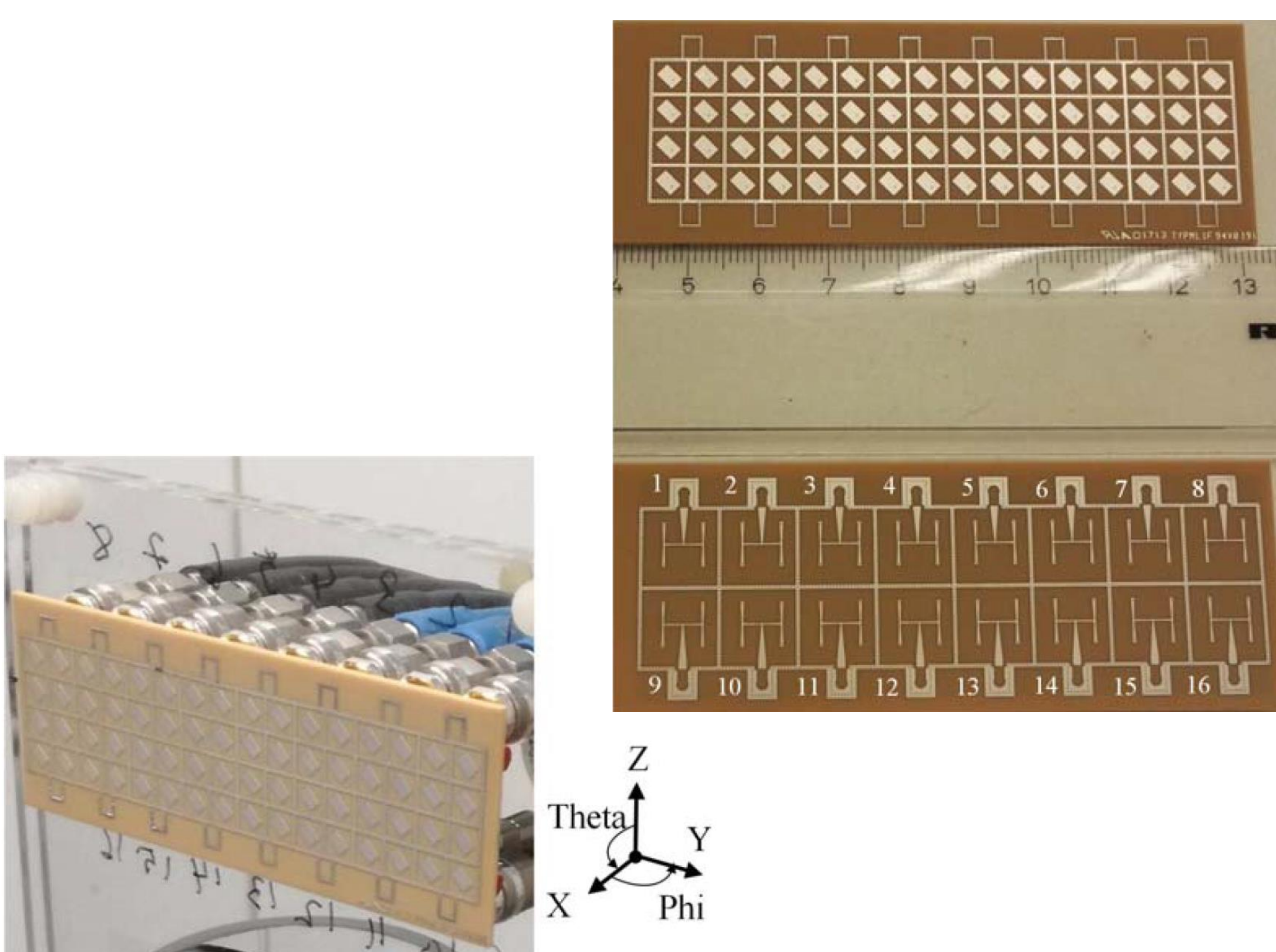


Fig. 1. Linearly Polarized 64-element Antenna Array and its feeding network for mm-Wave Mobile Backhaul Application. [1]

### THz ANTENNA RESEARCH CHALLENGES

Since the wavelength is small ( $\lambda \approx 1 \text{ mm}$  @ 300 GHz) and substrate material is lossy, antennas must be integrated to the same module with TX and RX to minimize dielectric losses.

Due to large free space attenuation, as followed by Friis' Eq.

$$\frac{P_r}{P_t} = \frac{A_r A_t}{d^2 \lambda^2},$$

where  $A_r, A_t$  are apertures for receive and transmit antennas, and  $d$  is link distance, the larger aperture to increase the directivity is essential, as shown in Fig. 2. This lead fundamentally narrow antenna beams (Fig. 3) and cause a beamsteering challenge.

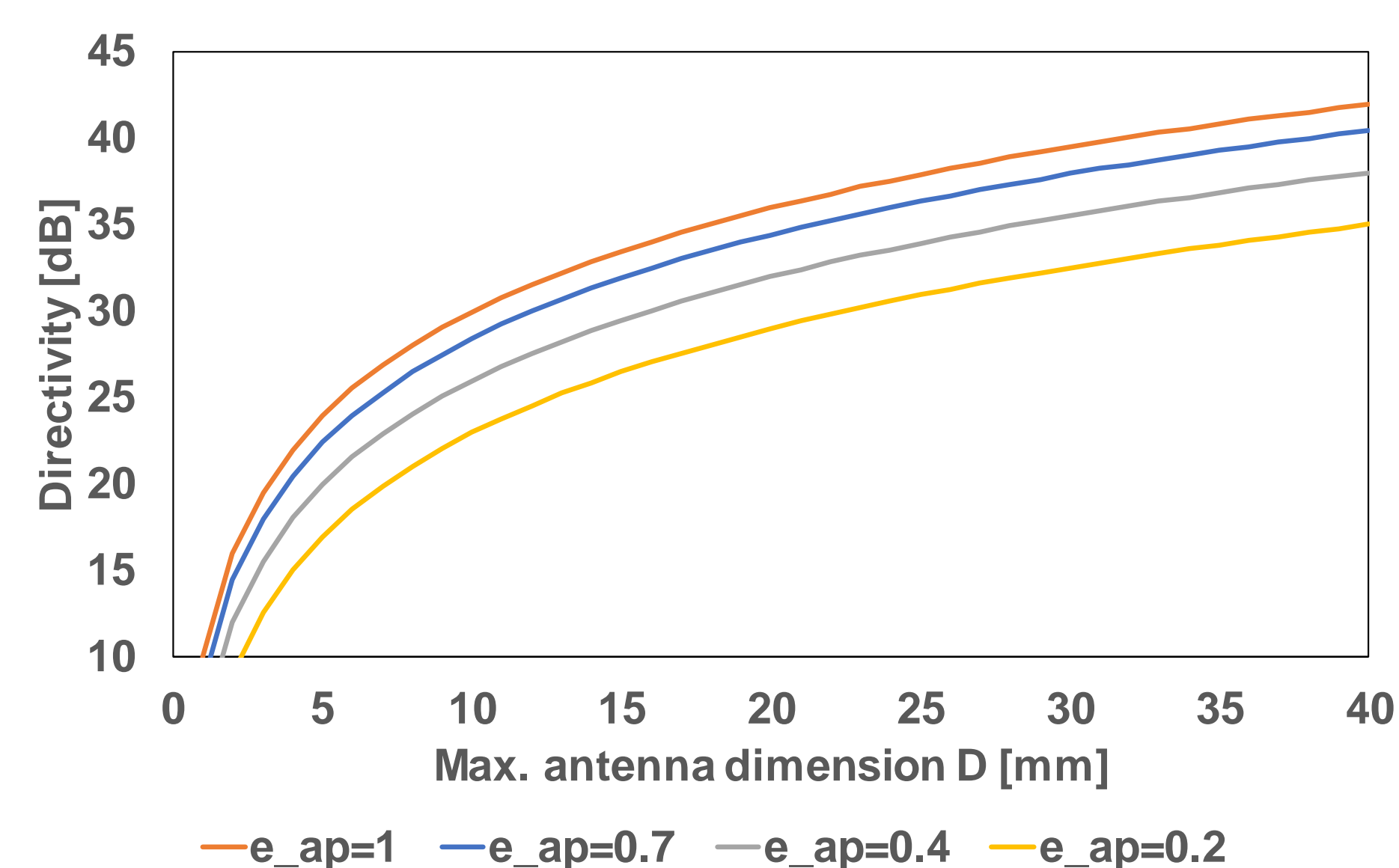


Fig. 2. Maximum theoretical directivity as a function of maximum antenna dimension ( $D$ ) for different aperture efficiencies ( $e_{\text{apt}} = 1 \dots 0.2$ ) at 300 GHz. Circular aperture assumed.

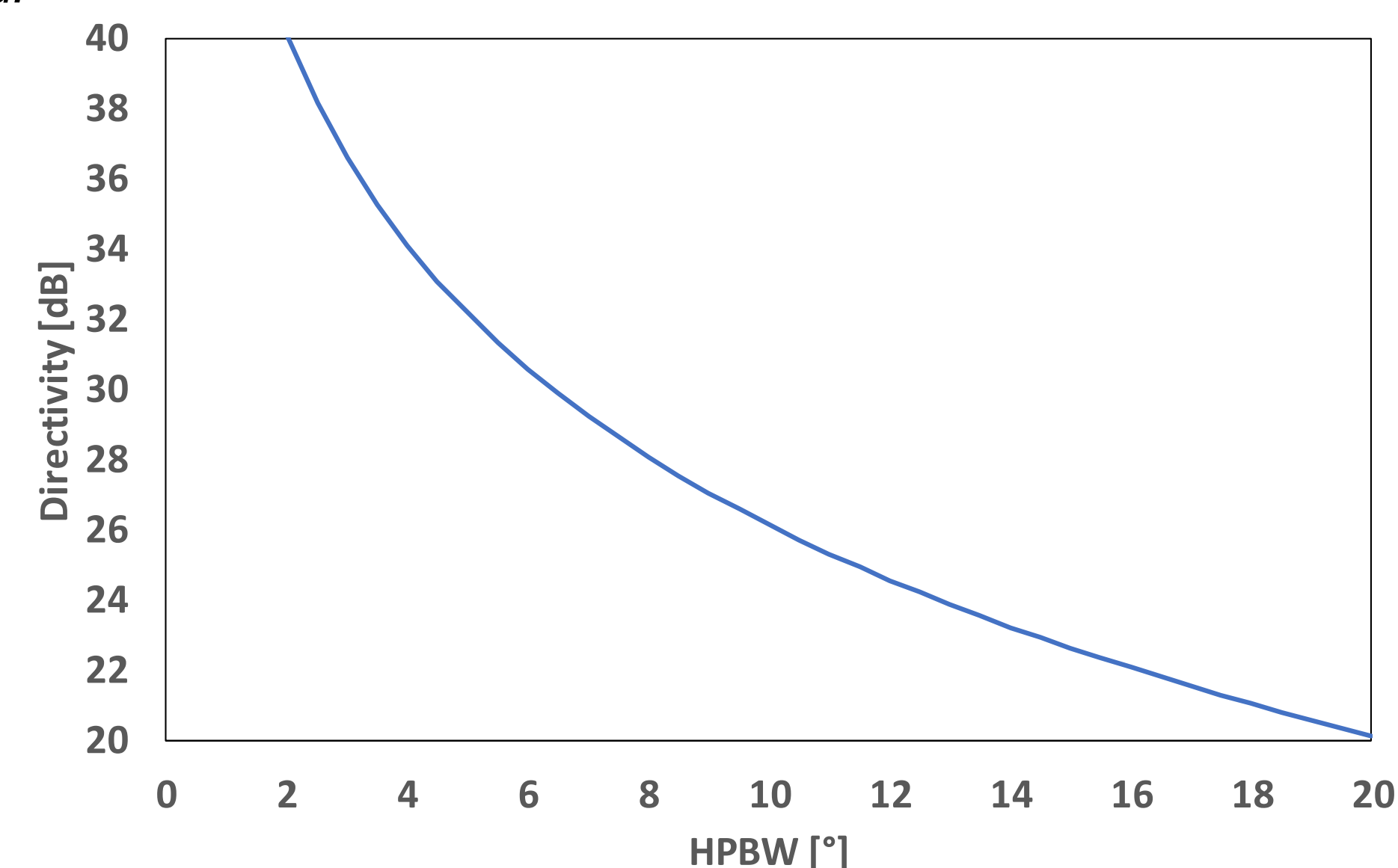


Fig. 3. Directivity as a function of the half-power beamwidth.

### THz ANTENNA RESEARCH STATUS

- System level link budget created for wideband THz communication system
- Theoretical limitations of the antenna aperture size, directivity, and far-field reviewed
- Antenna architecture definition for a planar beam steerable THz antenna arrays ongoing
- Element design using 22 nm SiGe technology has been started
- Lens design and integration studies for beam-steerable array ongoing

### References

- [1] H. T. Friis, "A Note on a Simple Transmission Formula," in *Proceedings of the IRE*, vol. 34, no. 5, pp. 254-256, May 1946.
- [2] M. Sonkki et al., "Linearly polarized 64-element antenna array for mm-wave mobile backhaul application," *12th European Conference on Antennas and Propagation (EuCAP 2018)*, London, 2018, pp. 1-5.