Waveguide Probes

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Introduction

- **Waveguide chosen for probe modeling**
  - WM-710, a=710 µm, f_c = 211 GHz, Band = 260 - 400 GHz
- **Develop a waveguide to CPW (GSG) probe model**
  - Parameters are free but should represent typical values
- **Different antenna configurations for waveguide excitation**
  - Vivaldi antenna
  - Patch antenna transverse plane
  - Patch antenna E plane
- **Different probe Tip and CPW geometries**
  - Probe tip pitch = 30 µm
- **Explore radiation and coupling effects during probing**
- Parasitic modes
- Effect of absorber, geometrical variations

Partitioning of the analysis

A three step approach was used to simplify the analysis
and
Decouple the effects arising from different parts of the structure

Analyse the Waveguide to CPW transition

- Vivaldi
- Patch Trans-plane
- Patch E-plane

→

Analyse the CPW to Pad transition

- Tip height
- Tip bend angle
- Tip dielectric and dimensions

→

Analyse the Combined system

- Probe(B2B) + PCB
- Parasitic modes
- Effect of Absorber
- Effect of Geometry

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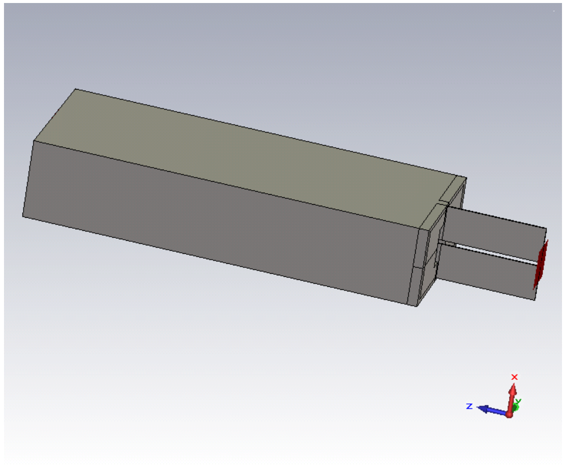
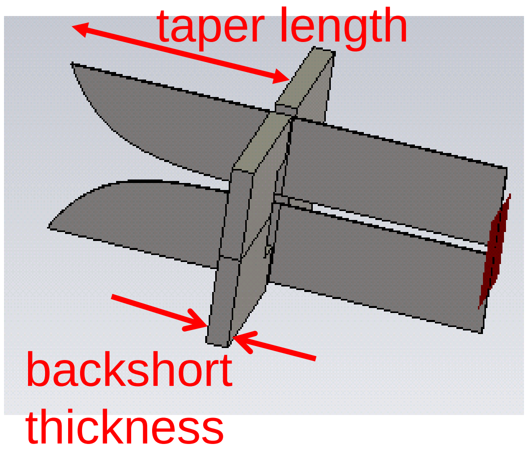
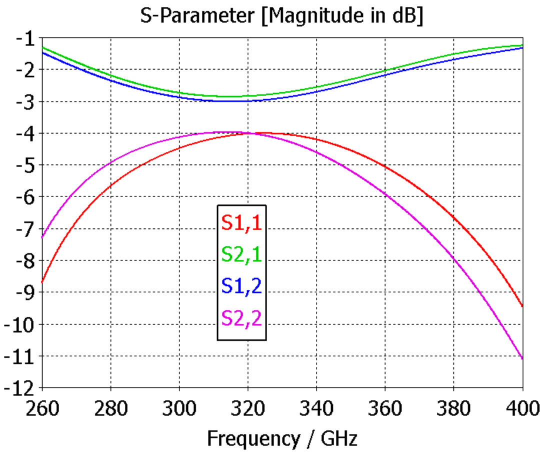
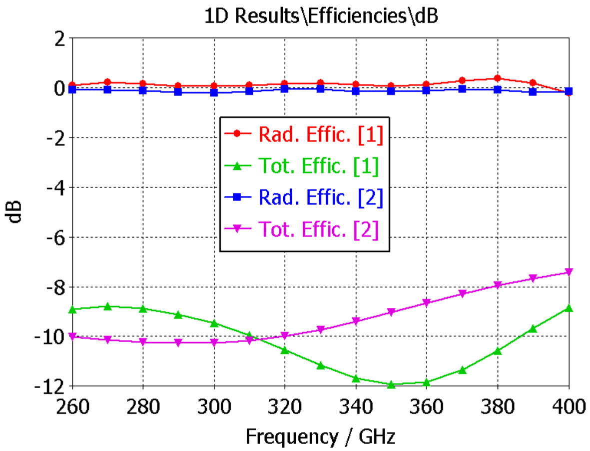
Vivaldi Antenna





- Logarithmic Slotline Antenna
  - Wide bandwidth
  - Usual in lower frequency
  - Here applied for sub-THz.
- Slotline to Rect-Wg transition
  - Taper length
  - Taper rate
  - Backshort thickness
  - Backshort cut





- E-field in the slot is tapered out to the TE10 mode pattern
- Reflection and Transmission not acceptable
- Radiation too high

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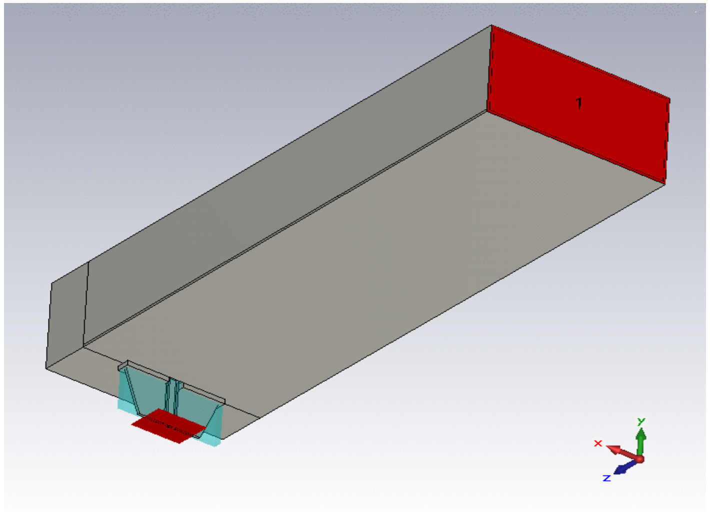
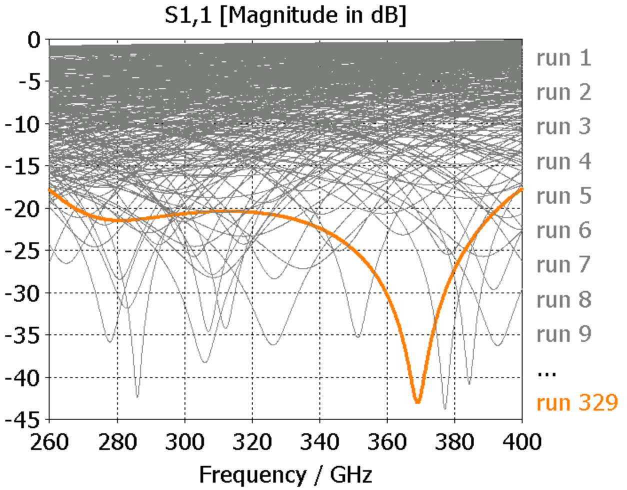
Patch Antenna Trans-Plane

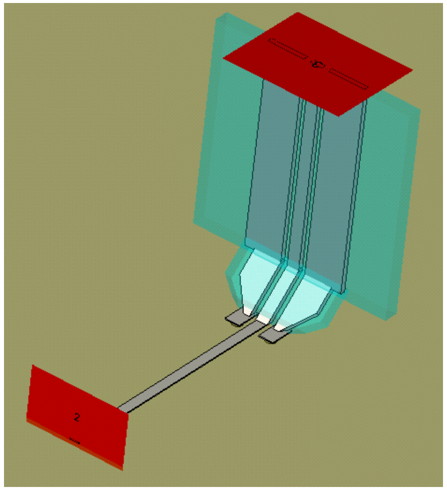


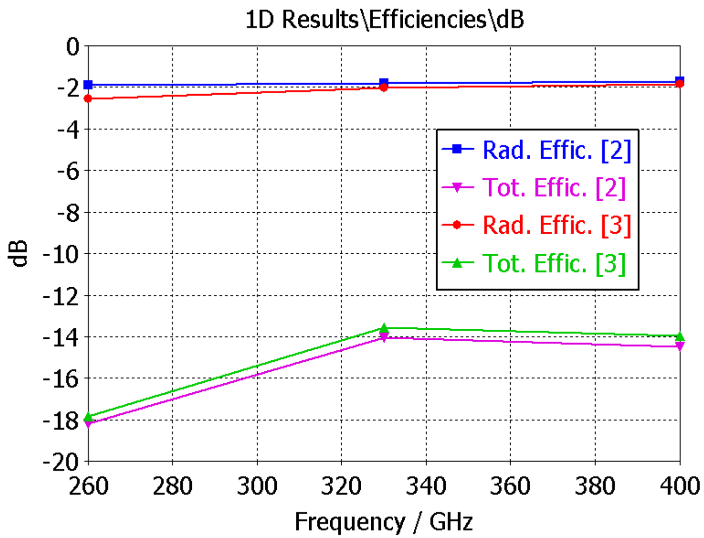


- CPW to Rect-Wg transition
  - Patch height
  - Patch width
  - Post height, width
  - Dielectric thickness , width
  - Backshort length

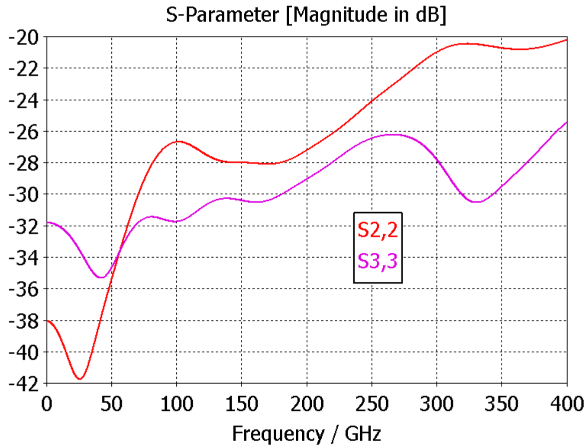
- **Broadband matching is not a trivial problem**

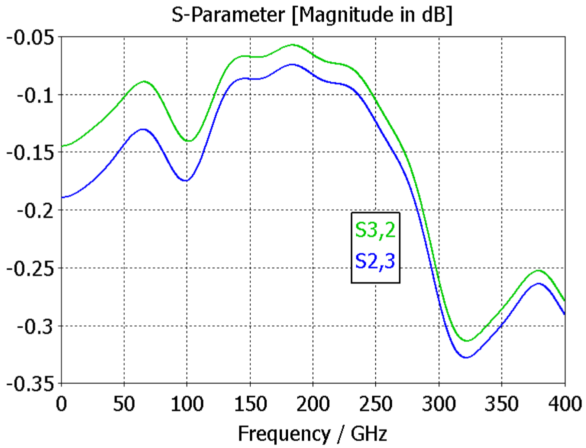
CPW to Pad Transition





- CPW to Pad transition
  - CPW width and gap
  - Tip approach angle
  - Tip height
  - Dielectric thickness
  - Dielectric constant
  - Dielectric cut
- Transmission around -0.3 dB in 260-400 GHz





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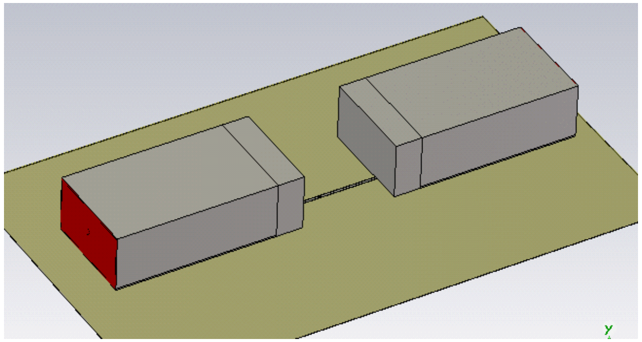
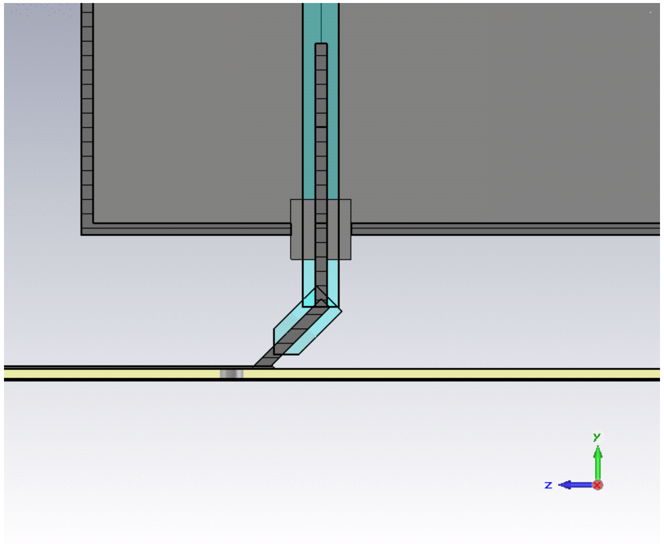
Combined System - Structure





Side View

- BCB substrate
  - Dielectric constant = 2.7
  - Dielectric height = 8 µm (typical)
- Microstrip line
  - Metal thickness = 2 µm
  - Width = 20 µm (for 50 Ω line impedance)
  - Length = 1000 µm

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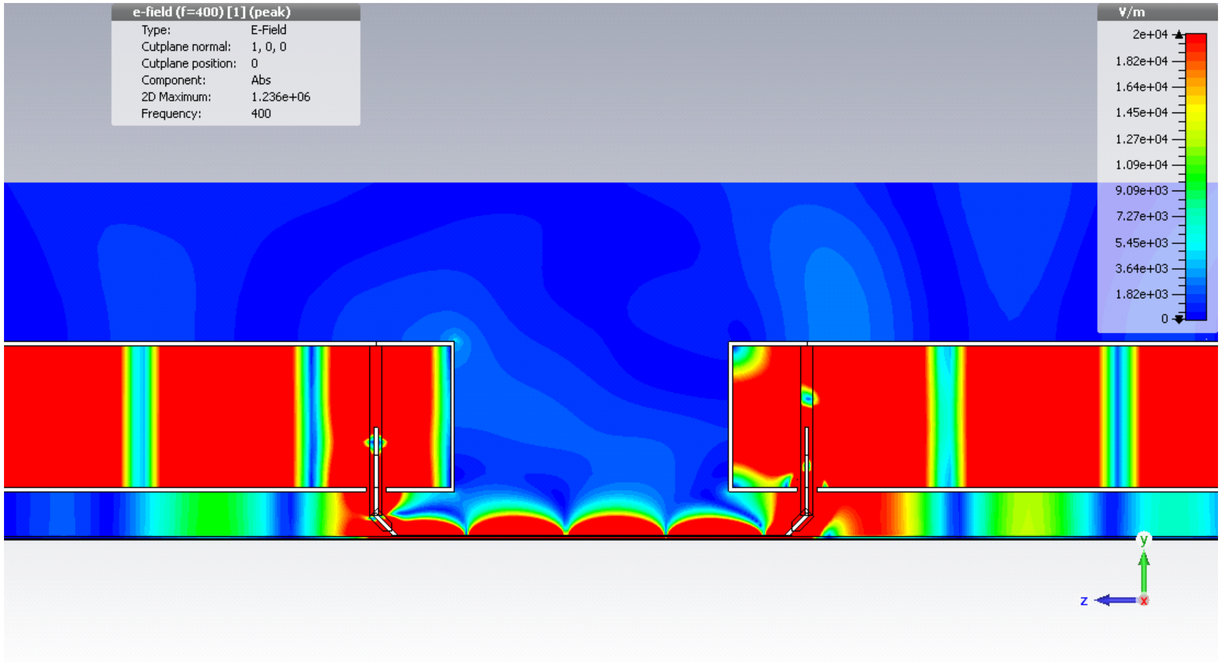
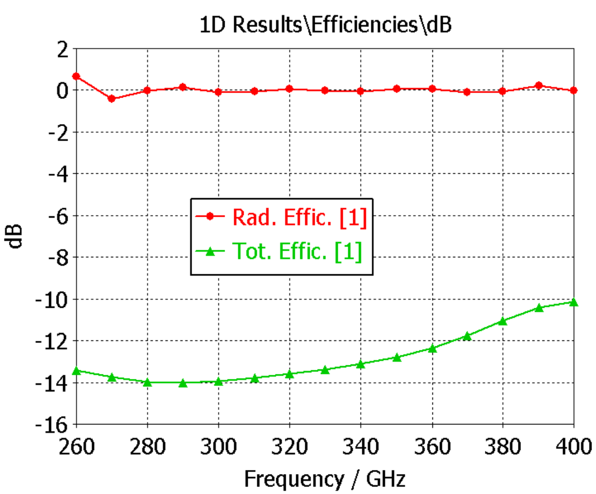
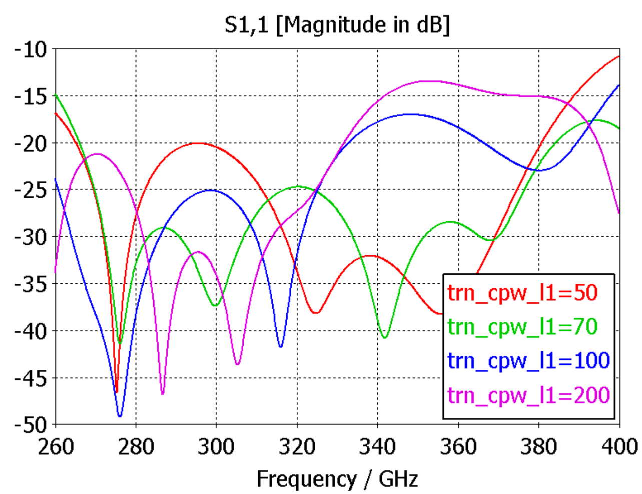
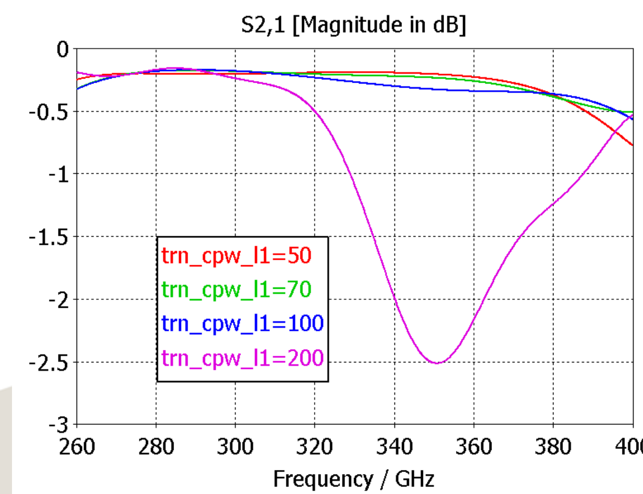
Combined System - Radiation



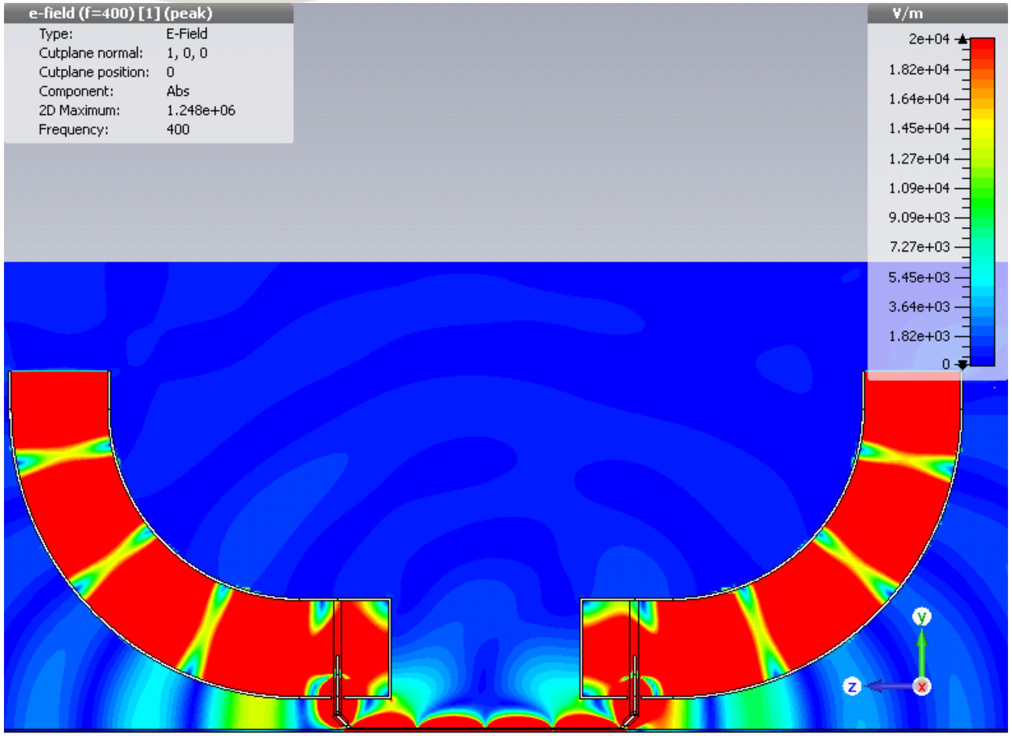
- PPL mode between PCB back metal and waveguide lower wall
- Smaller height implies smaller electrical length -> better shorting -> reduced PPL mode excitation

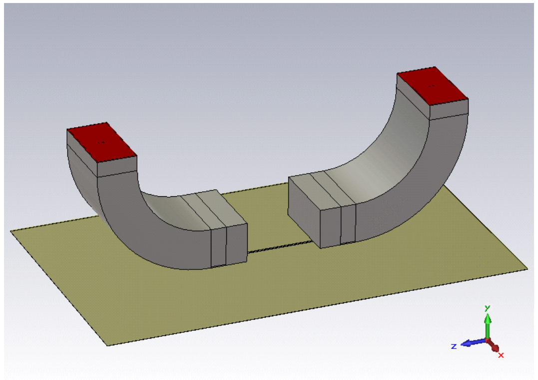




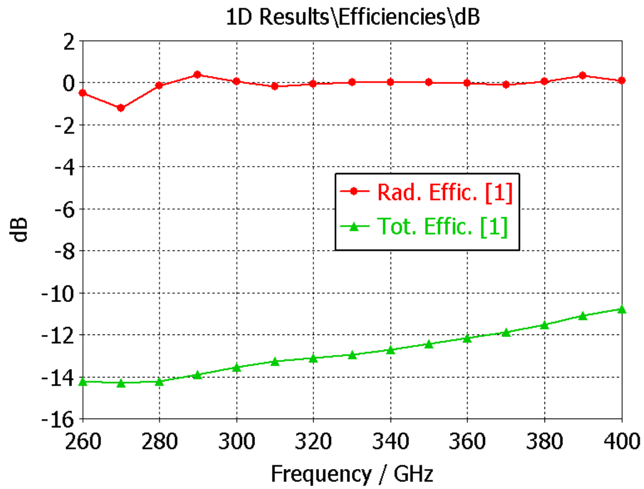


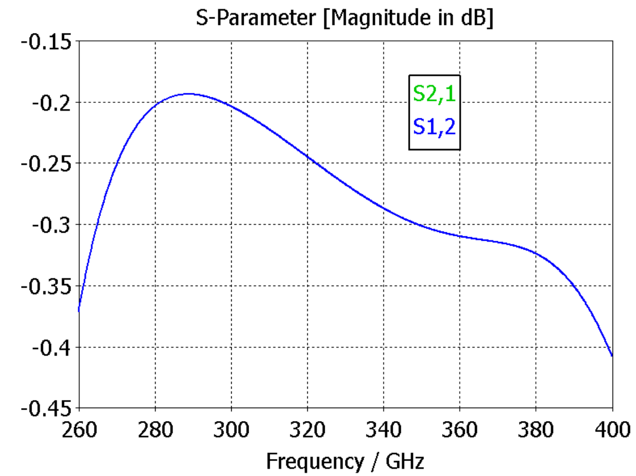
Combined System with Bends





- Bend of radius 300 µm
- 1 dB improvement in total efficiency at 400 GHz





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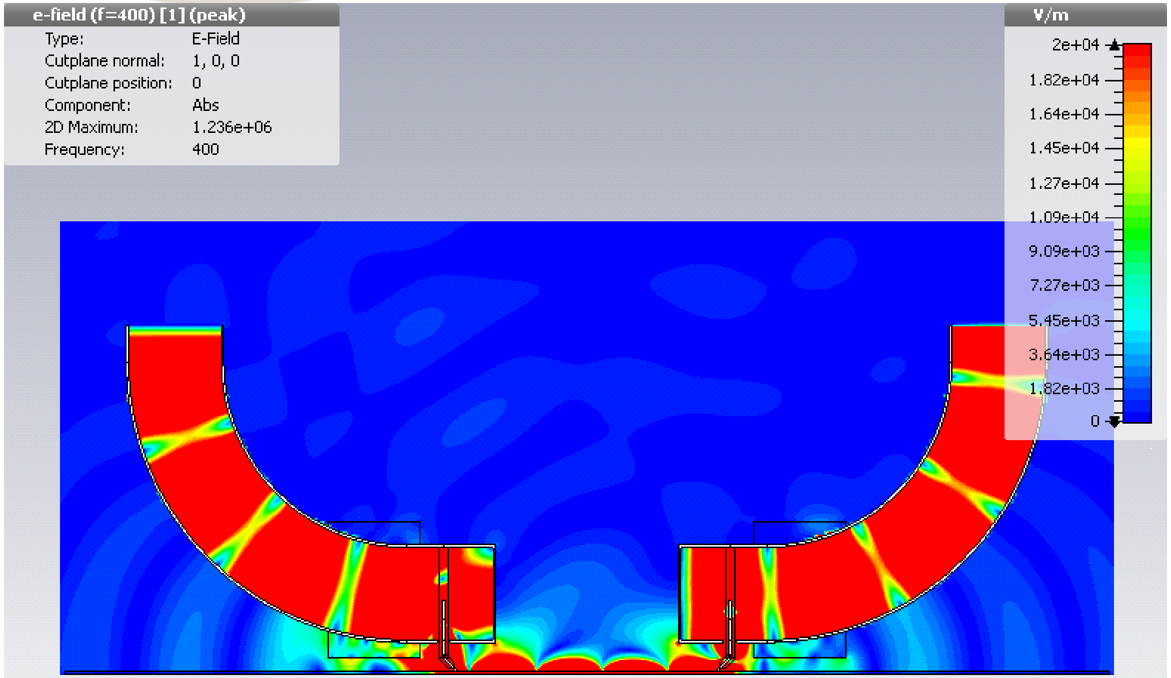
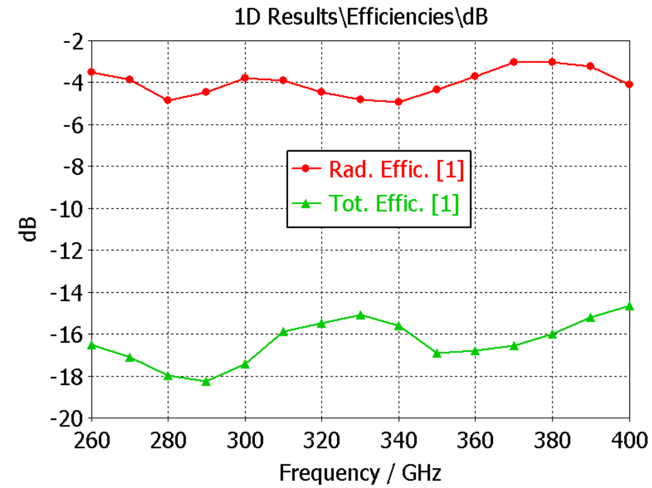
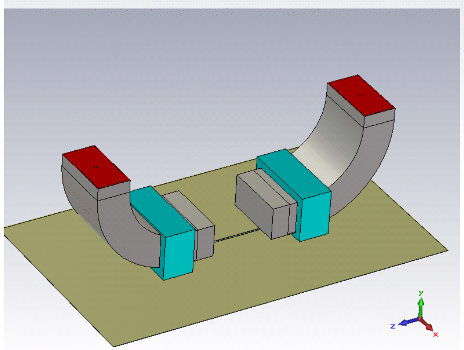
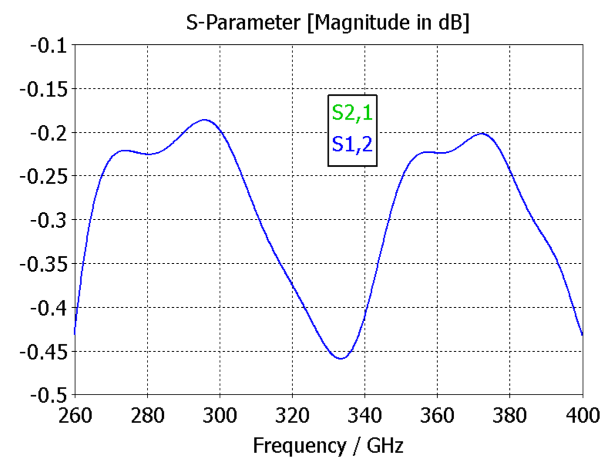
Combined System with Bend and Absorber







- Bend of radius 300 µm
- Absorber (ECCOSORB MF-117) of length 250 µm
- 4 dB improvement in total efficiency at 400 GHz
- Drop in S21 at some frequencies



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Conclusions

- **Probe example presented**
  - Basic structure to study em effects
- **Probe performance at sub-terahertz frequencies**
  - Strongly dependent on tip geometry
    - Tip height
    - Bend angle
  - Strongly dependent on environment
    - Waveguide outer wall
    - Absorber
    - PCB back metallization
    - Adjacent structures on PCB
- **Deembedding algorithm must consider**
  - Radiation
  - non-QTEM modes

Conclusions

- **Detailed 3D EM modeling of actual probes can give insight**
  - Product manufacturing includes a step-by-step development considering the em design rules.
  - Initial design rules from em field observation must be kept in the real manufactured probe.

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