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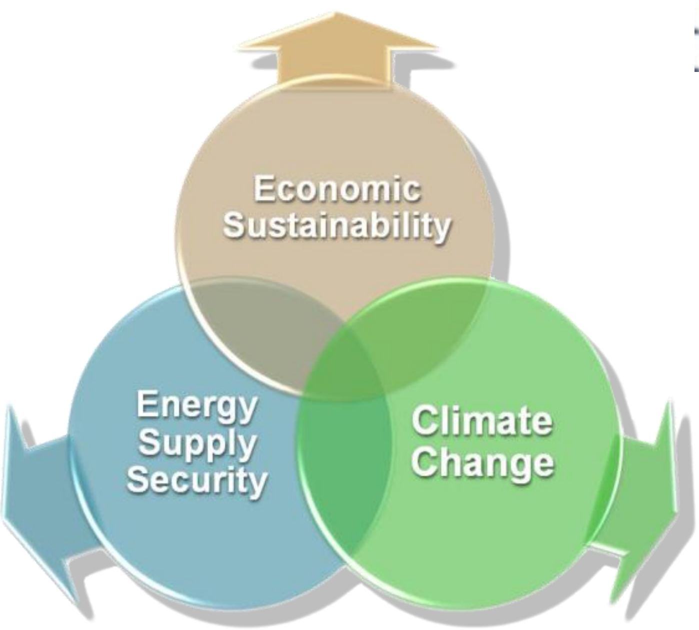

MICROWAVE LAUNCHER DESIGN FOR DOPPLER SENSING IN CHEMICAL LOOPING COMBUSTION

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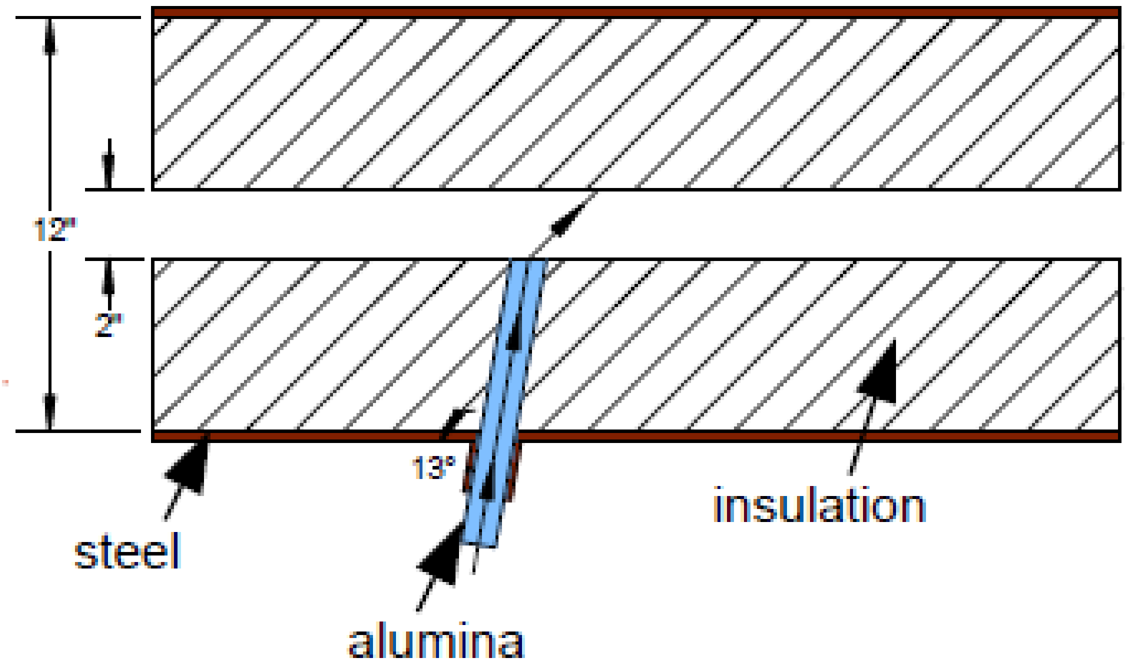
INTRODUCTION

Chemical looping combustion system

- measure mass flow rate of particles
- high temperature, high pressure



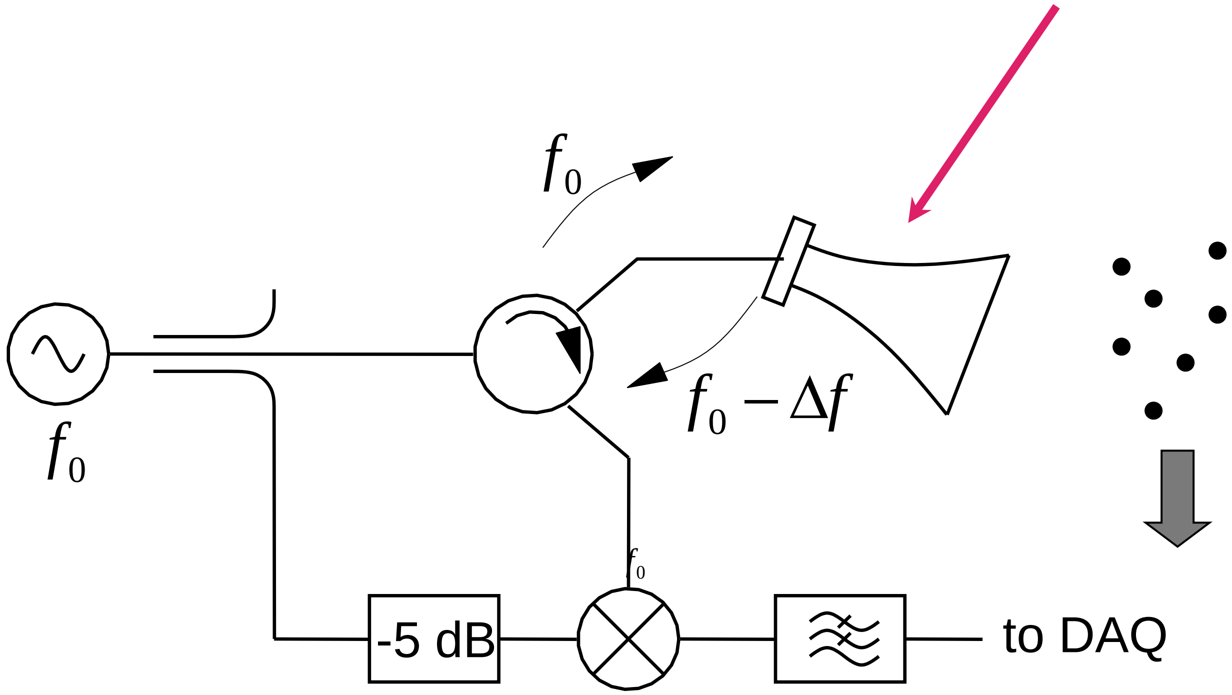
INTRODUCTION

Microwave Doppler sensor

- frequency shift

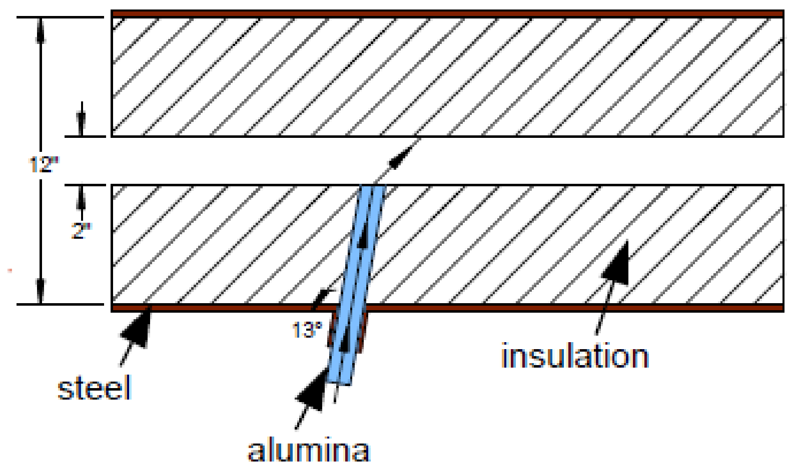
$$f_d = 2f\frac{v}{c}cos\theta$$

- amplitude of signal



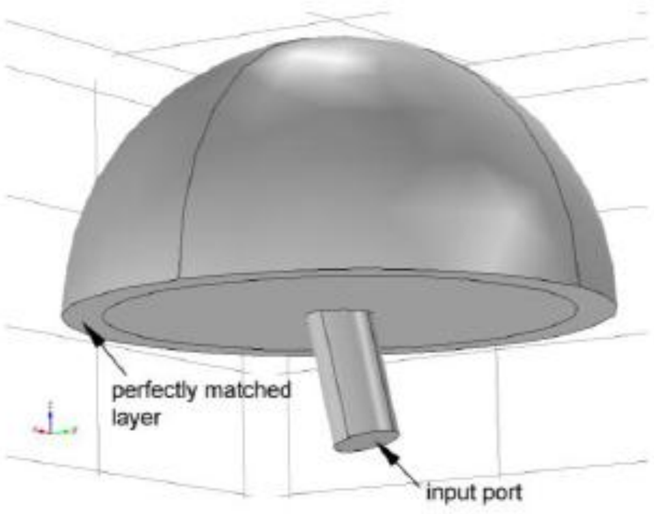
USE OF COMSOL

- **Design in two-step strategy:**
  - cylindrical waveguide to flow region: determine the best mode, overmoded waveguide
  - coaxial transmission line to cylindrical waveguide: launch the best mode
- **COMSOL 4.3, emw (electromagnetic waves) module**

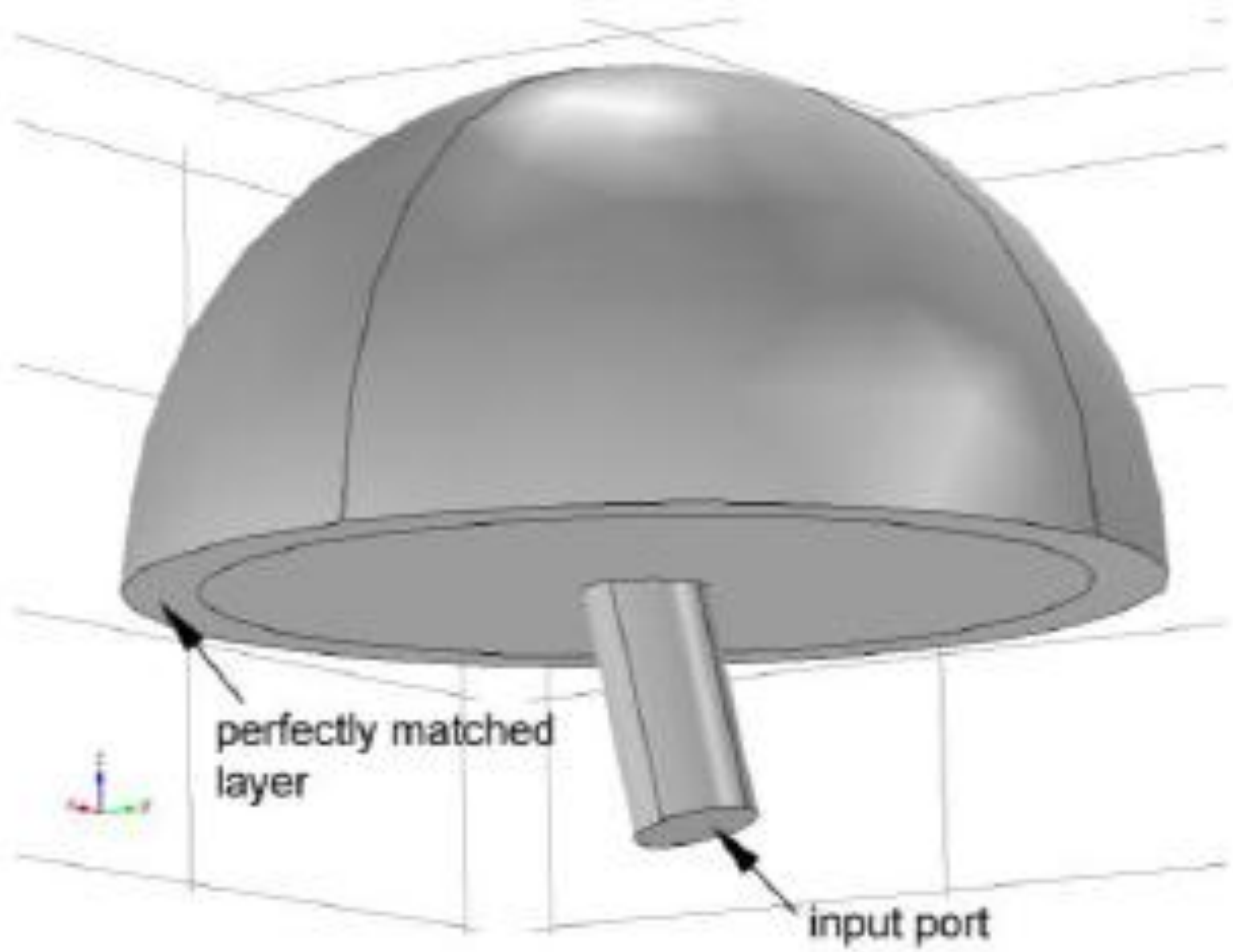


Step 1: cylindrical waveguide to flow region

- **Operating frequency f=10 GHz**
- **Cylindrical waveguide: alumina, d = 1 inch,** $\varepsilon_r = 9$
- **Flow region: air,** $\varepsilon_r = 1$
- **Spherical perfectly matched layer (PML)**
- **Wavelength in alumina: 1 cm**



STEP 1:
CYLINDRICAL WAVEGUIDE TO FLOW REGION



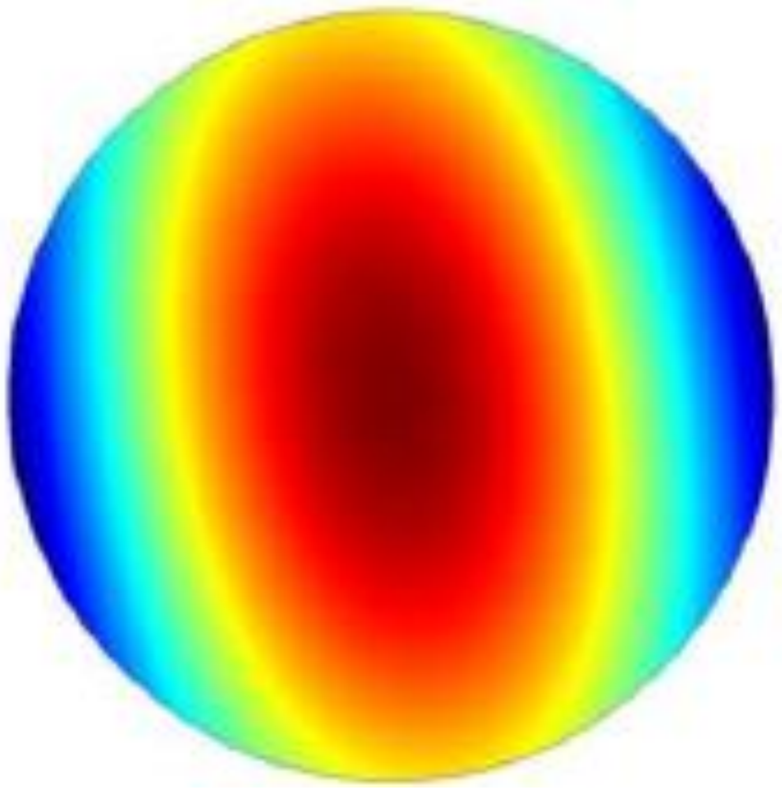
geometry for simulation

- **boundary mode analysis at input port**
- **overmoded waveguide**

STEP 1: CYLINDRICAL WAVEGUIDE TO FLOW REGION

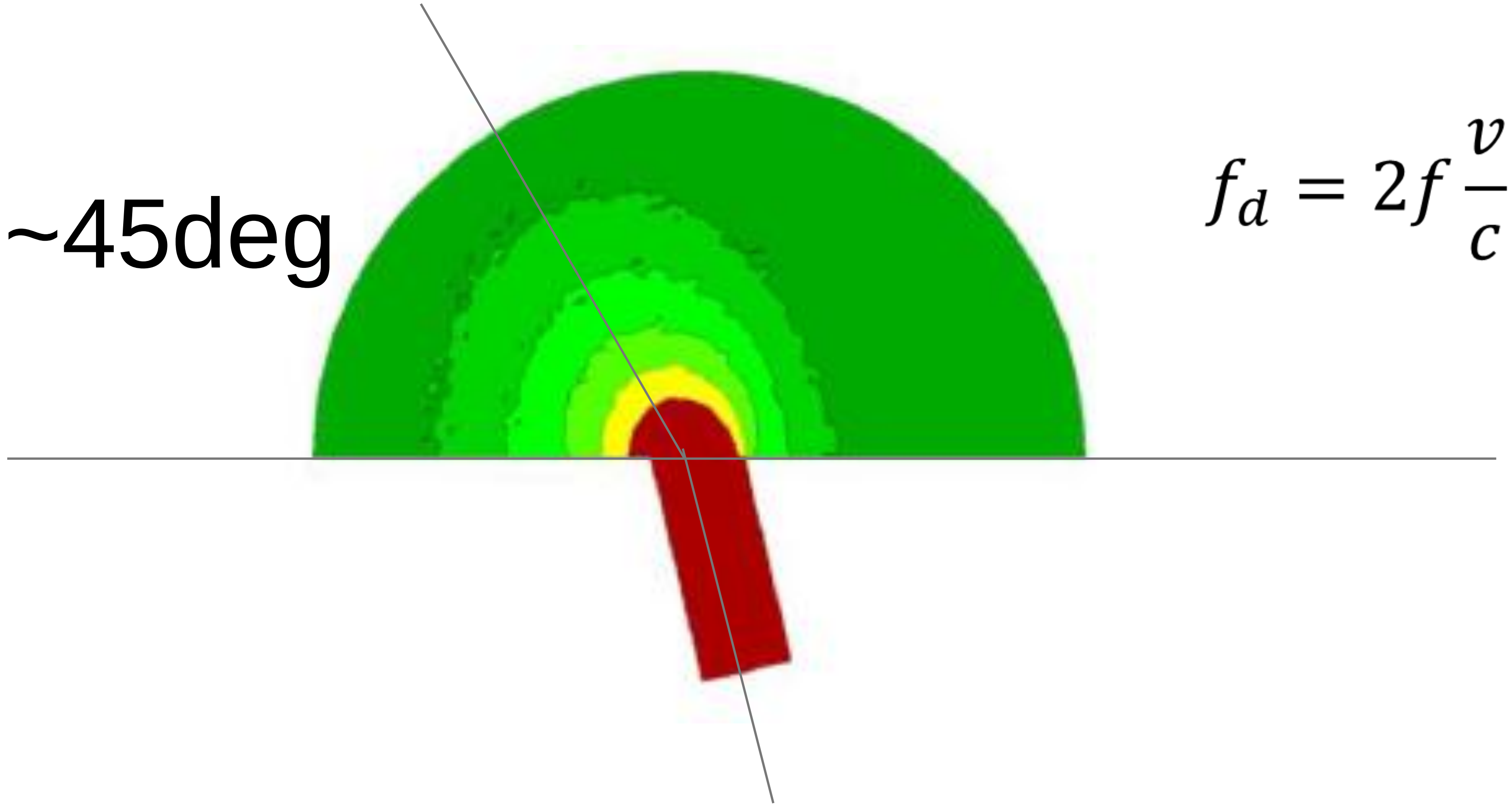
mode (out-of-plane wavenumber, m^{-1})	S_{11}(dB)
281	-2.30
327	-0.38
366	-0.40
461	-0.36
463	-0.41
475	-2.53
531	-1.18
548	-2.38
579	-7.61
598	-2.02
611	-5.59

Simulated S11 for several modes



Ey at the input port for the 611 m^{-1} TE11 mode

STEP 1: CYLINDRICAL WAVEGUIDE TO FLOW REGION

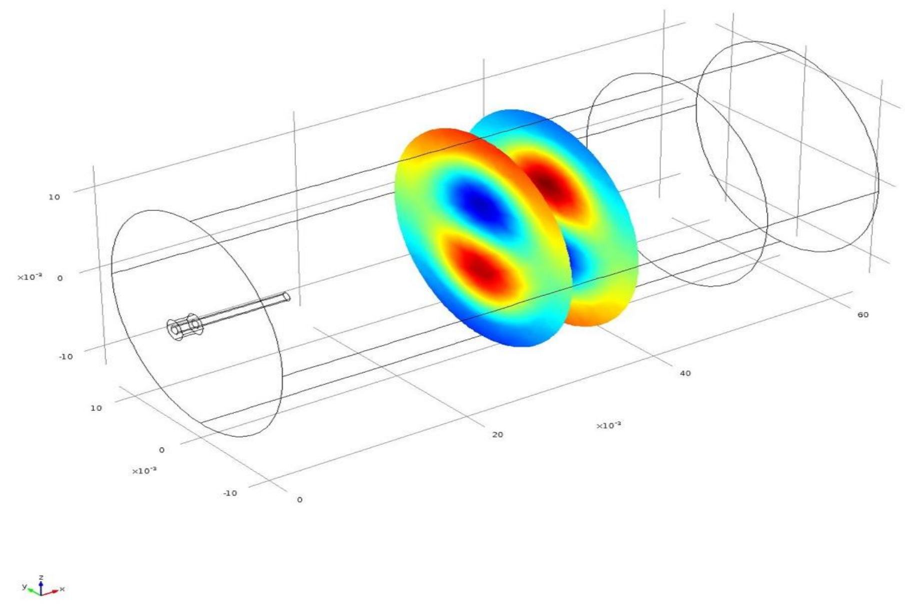


$$f_d = 2f\frac{v}{c}cos\theta$$

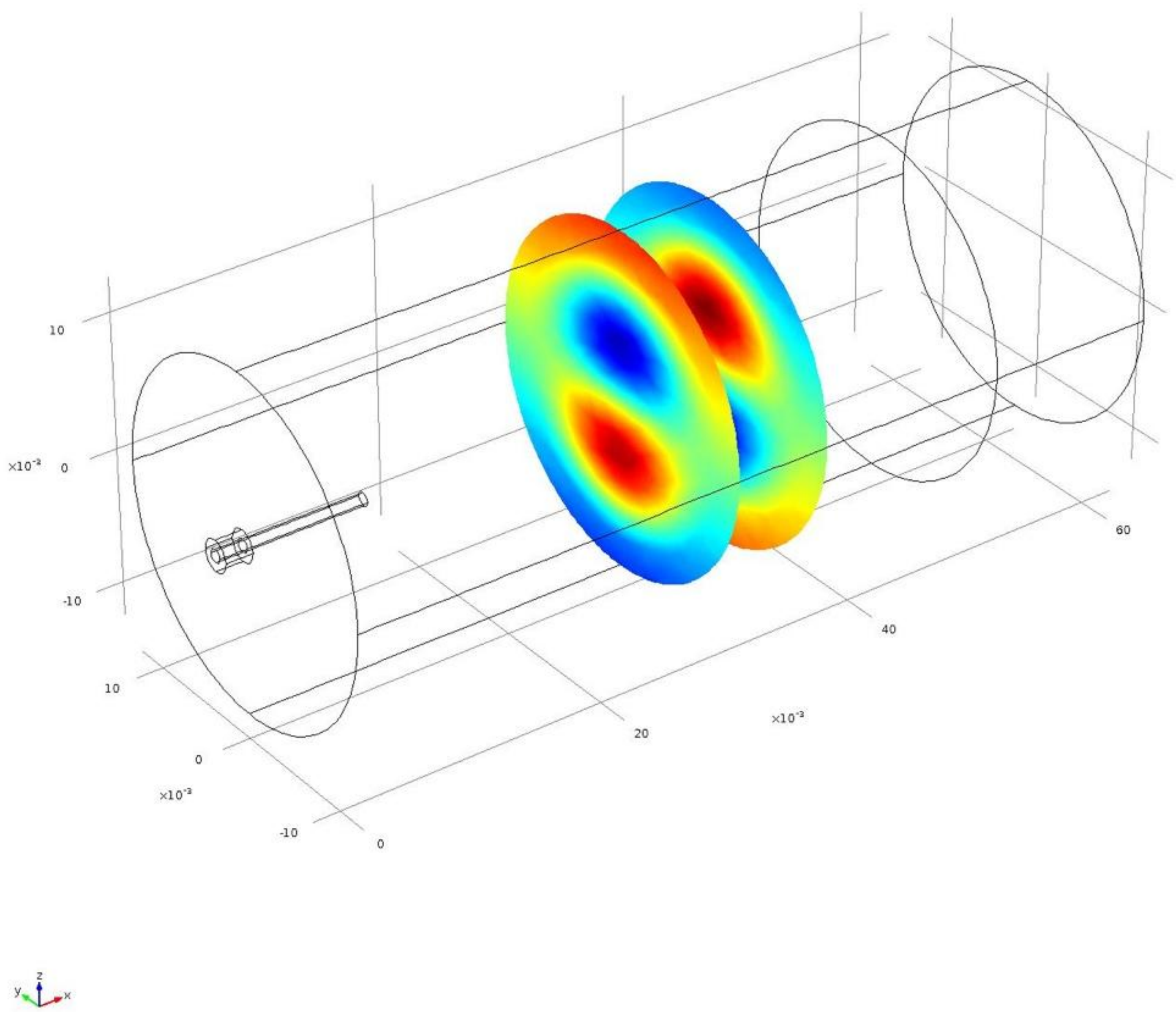
Total energy density as a function of position

Step 2: coaxial transmission line to cylindrical waveguide

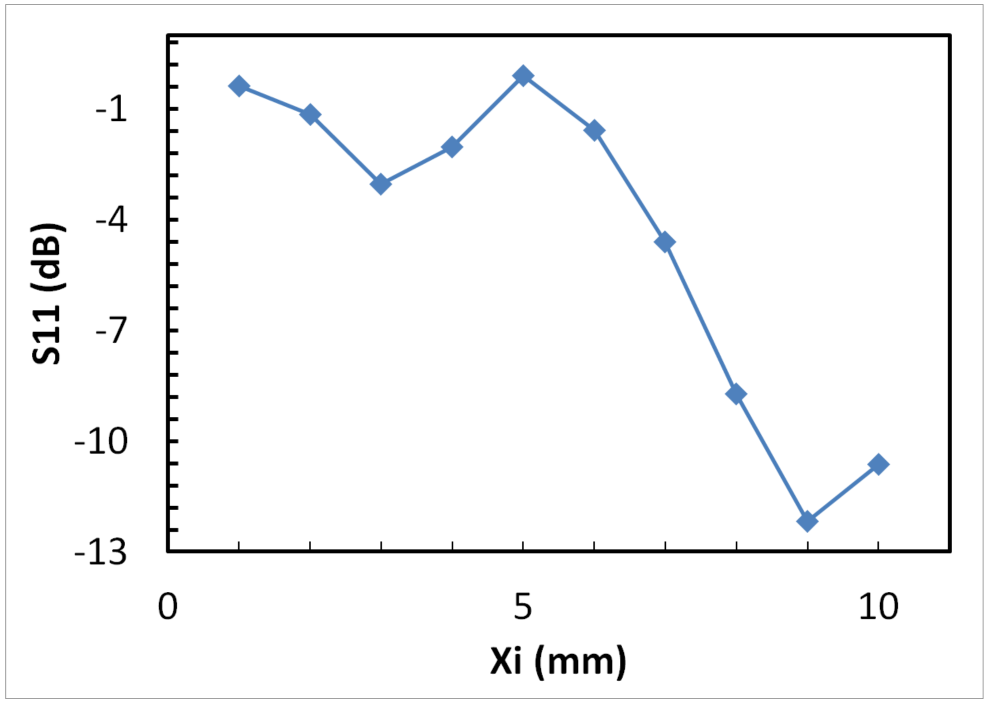
- **Operating frequency f=10 GHz**
- **Characteristic impedance Z=50 ohm**
- **Cylindrical waveguide: alumina , d = 1 inch** $\varepsilon_r = 9$
- **Cartesian perfectly matched layer (PML)**
- **Three designs tried to get** TE_{11} **mode**



design 1: axial launcher



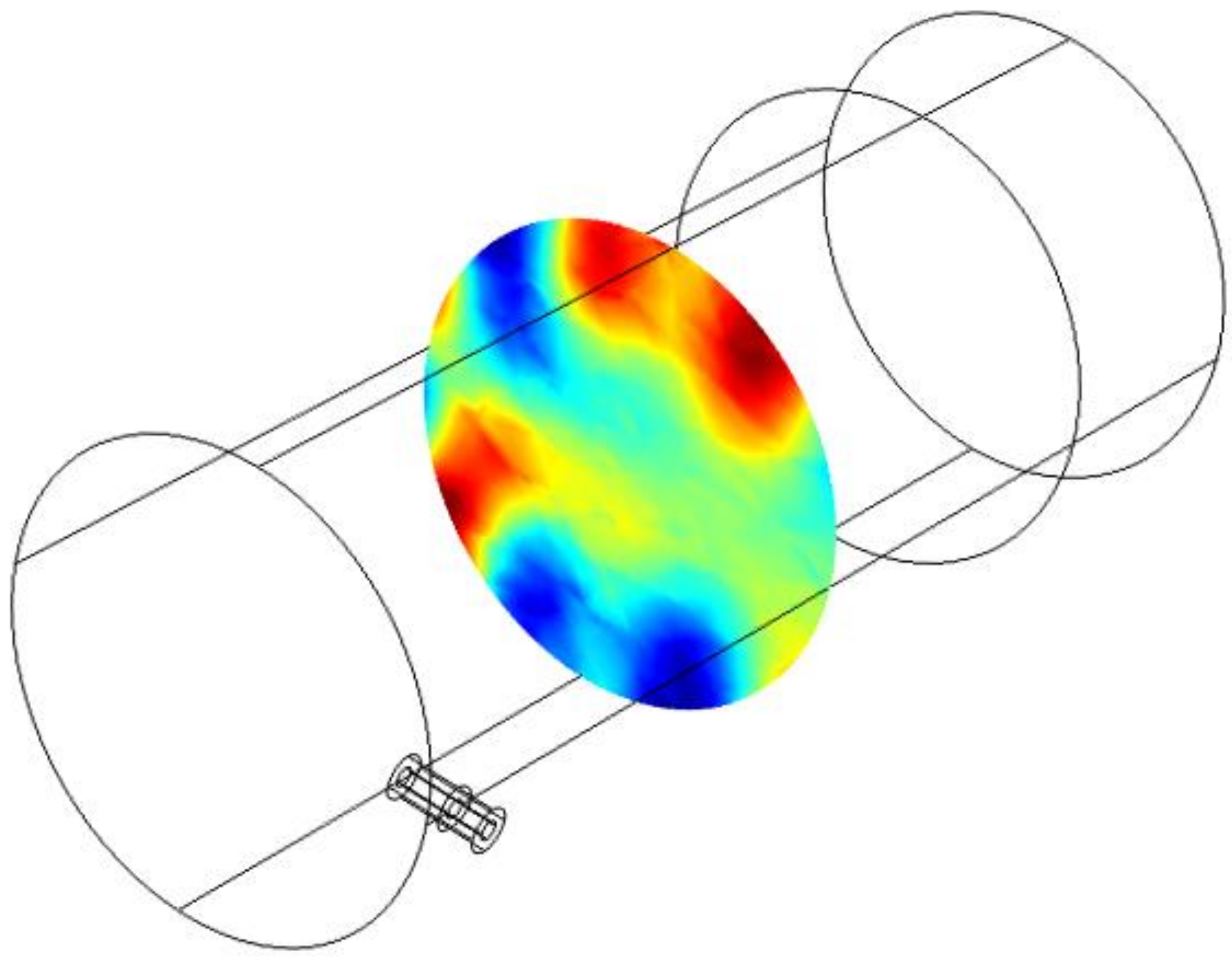
z component of the electric field in the cylindrical waveguide



S11 as a function of protrusion

TE01 mode

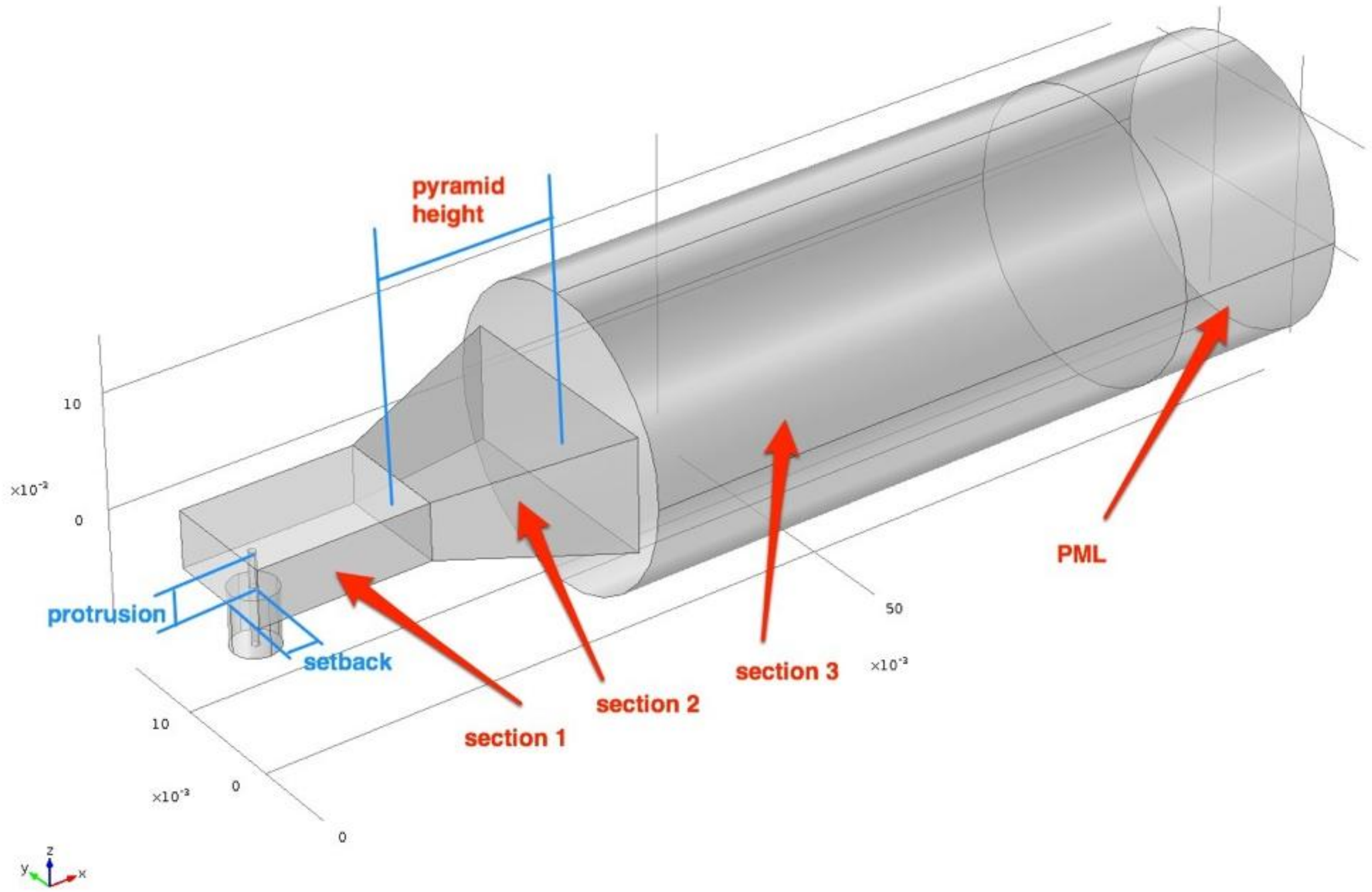
design 2: edge launcher



z component of the electric field in the cylindrical waveguide

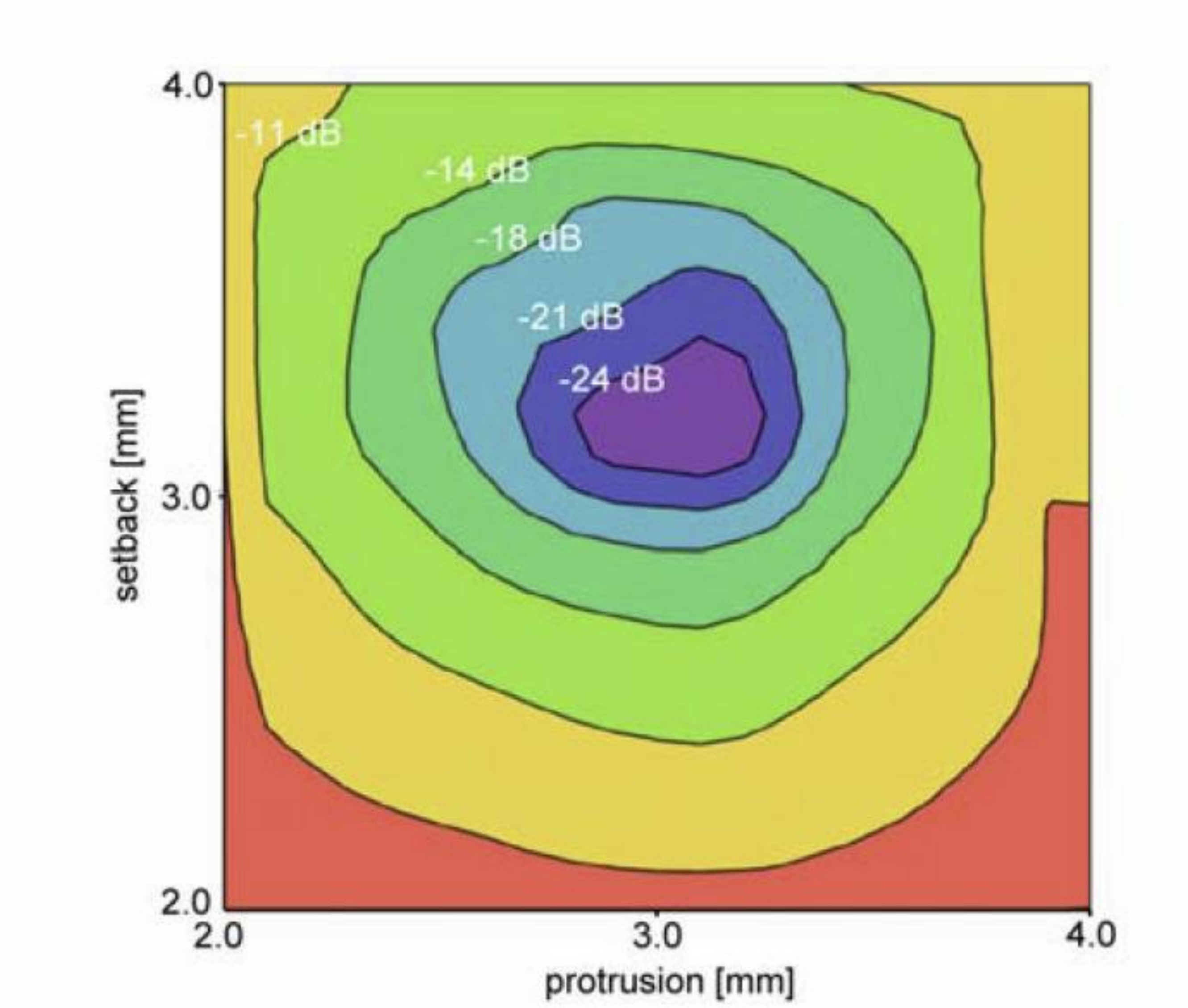
not TE11 mode

design 3: tapered launcher

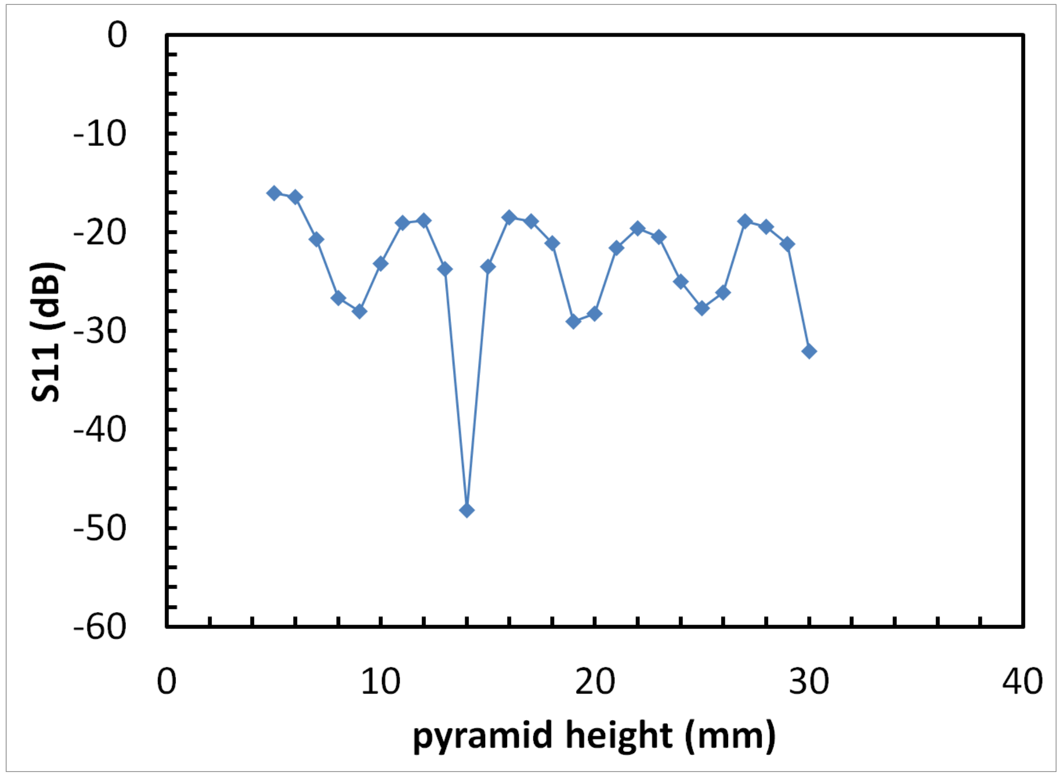


tapered launcher geometry

design 3: tapered launcher

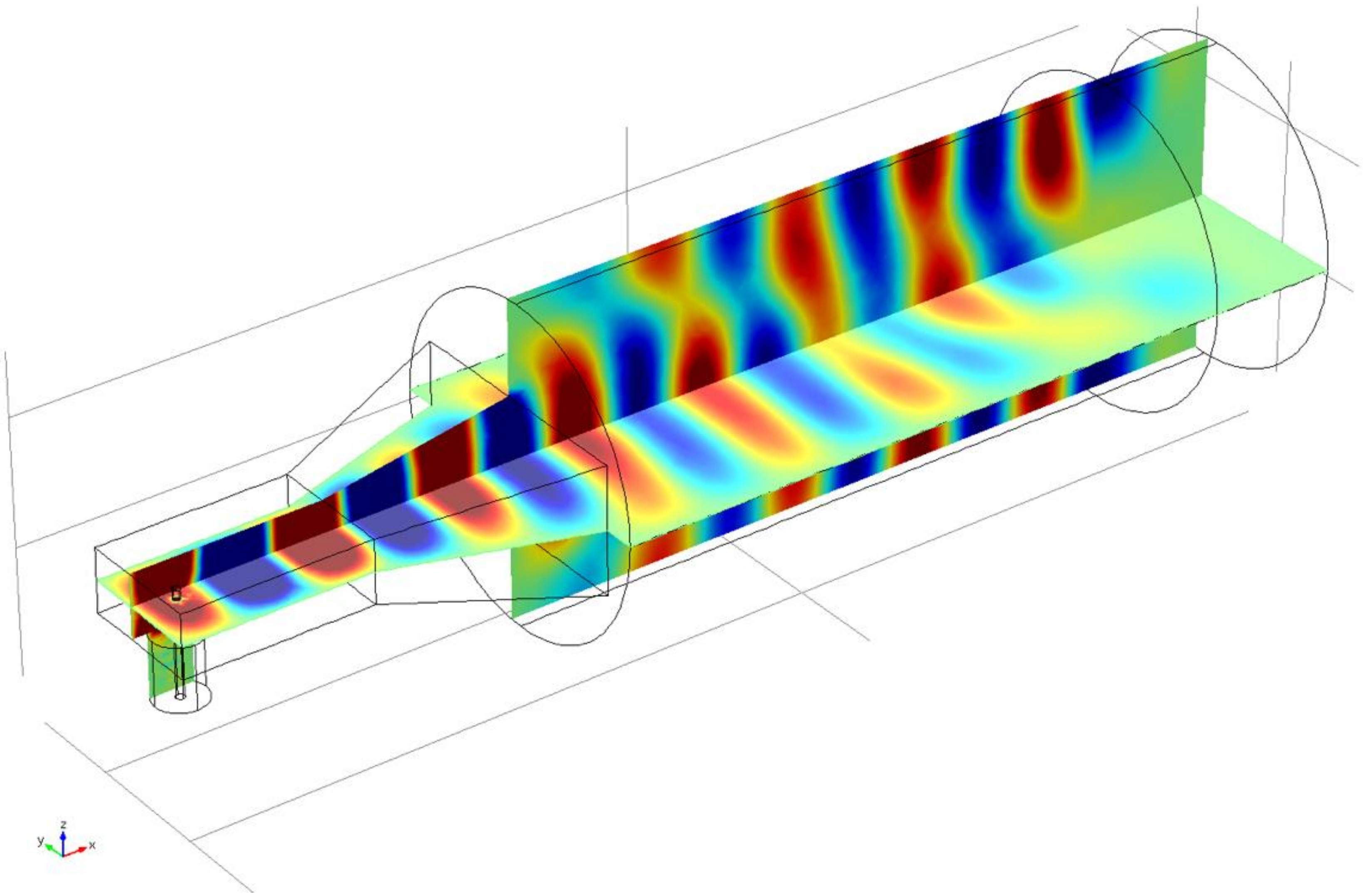


S11 as a function of probe protrusion and spacing from the back wall for the tapered launcher



S11 as a function of pyramid height

coaxial cable to cylindrical waveguide design 3: tapered launcher



x component of the electric field in the tapered launcher

TE11 mode launched

CONCLUSIONS

- Launcher designed for a microwave Doppler flowmeter using finite element simulation applied with COMSOL
- TE11 mode desired for efficient launching from the cylindrical waveguide into the flow region
- Tapered launcher used efficiently to couple microwave energy from a coaxial transmission line to a cylindrical waveguide

ACKNOWLEDGEMENTS

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THANK YOU!