Mode conversion losses due to gap in smooth wall circular waveguide

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Outline

- Introduction
- Losses in a transmission line
- Waveguide Gap 2D model in COMSOL
- COMSOL Simulation Results
- Comparison with theory
- Conclusions

Introduction

- ECE (Electron cyclotron emission) Diagnostic is one of the primary tool for measurement of electron temperature in ITER*. The EC radiation is transmitted from the plasma to the diagnostics hall via transmission lines, which are about 40 m long.

- The ITER ECE transmission line consists of straight waveguide sections, Miter Bends, **waveguide gaps**, polarization splitter box, waveguide pump-out tee etc .

We have studied the mode conversion losses in transmission line using RF module of COMSOL Software

* ITER is an international fusion reactor which is being constructed under the collaborative efforts of seven participating parties (termed as domestic agencies) namely China, European Union, India, Japan, South Korea, Russia and the United States of America. It is being constructed at Cadarache, France. The main objective of ITER is to demonstrate the scientific and technical feasibility of a controlled fusion reaction and thus producing about 500 MW of fusion power by Deuterium - Tritium Plasma.

Losses in transmission line

➢ Types of losses in a transmission line

1. Coupling

It occurs when EM wave from antenna couples to TL

2. Ohmic

It is due to absorption of EM radiation in the wall material

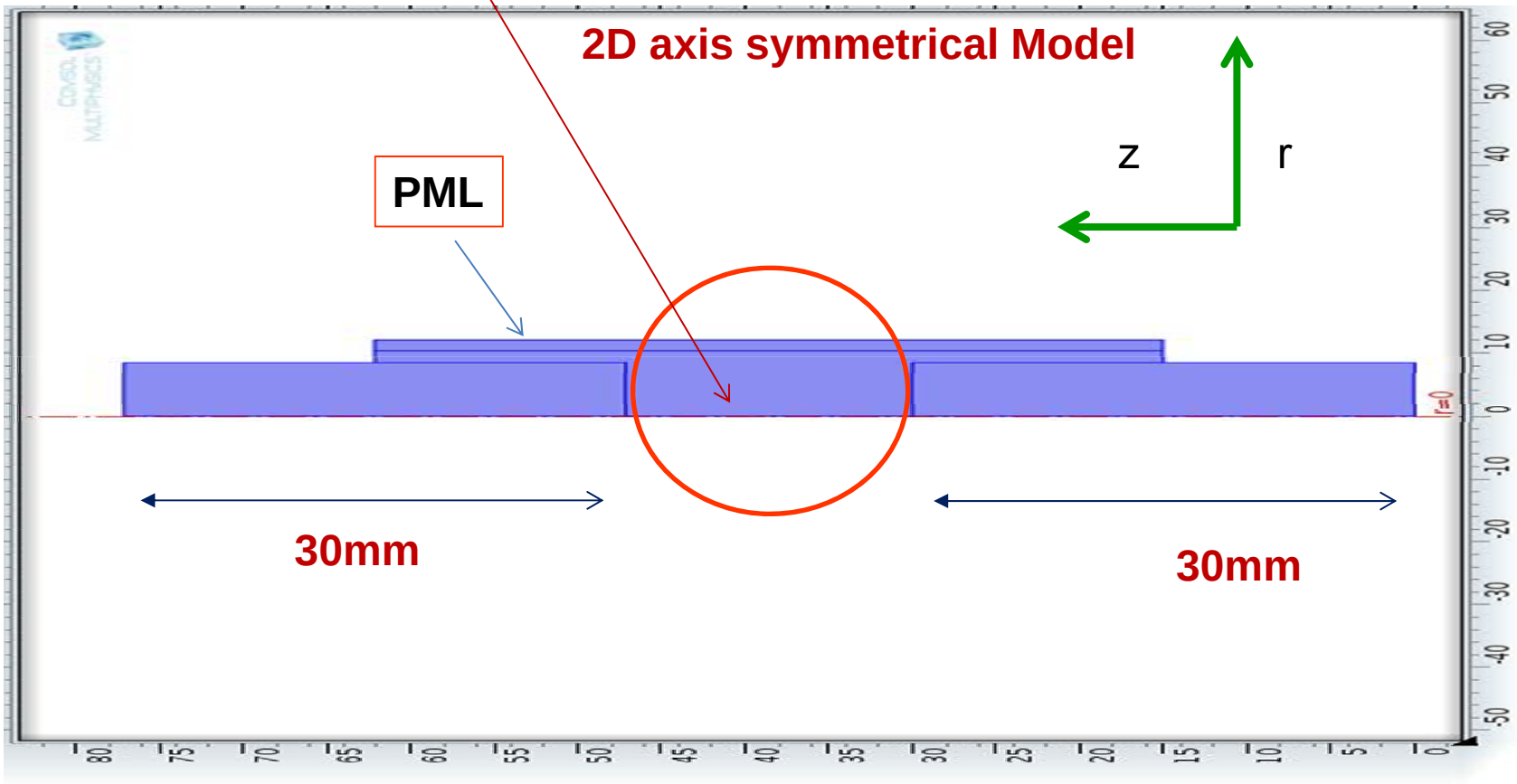
3. Mode conversion

It occurs due to MBs ,Gaps, tilts & other discontinuities etc.

Waveguide gap 2D model

Geometry

- Diameter of Smooth wall circular Waveguide (D) 17.12 mm
- Launching Mode TE_{01}
- Frequency 170GHz (1.76 mm)
- Diameter / free space wavelength ~ 10
- Gap length (L_g) 17.12 mm
- PEC walls



Waveguide gap 2D model

Mesh structure

Mesh

Geometric Entity Selection

Geometric entity level: Entire geometry

Statistics

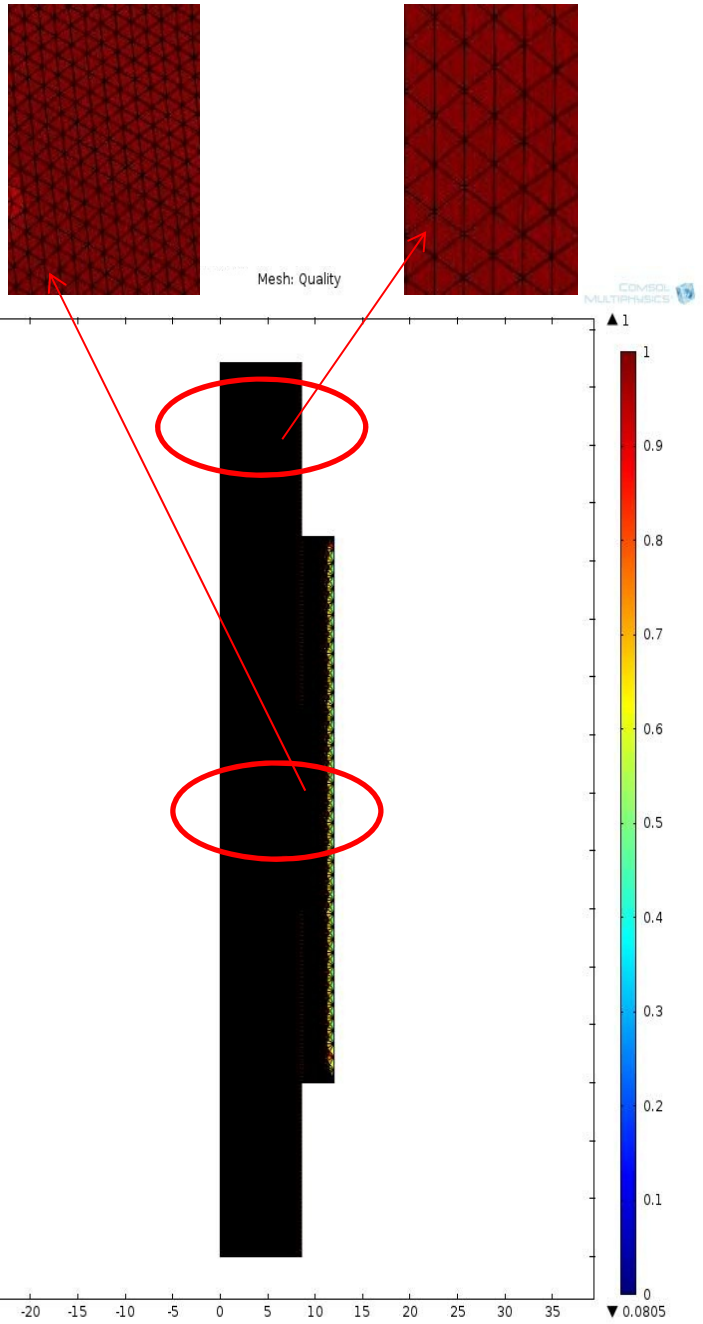
Complete mesh

Element type: All elements

Triangular elements:	356809
Edge elements:	2595
Vertex elements:	16

Domain element statistics

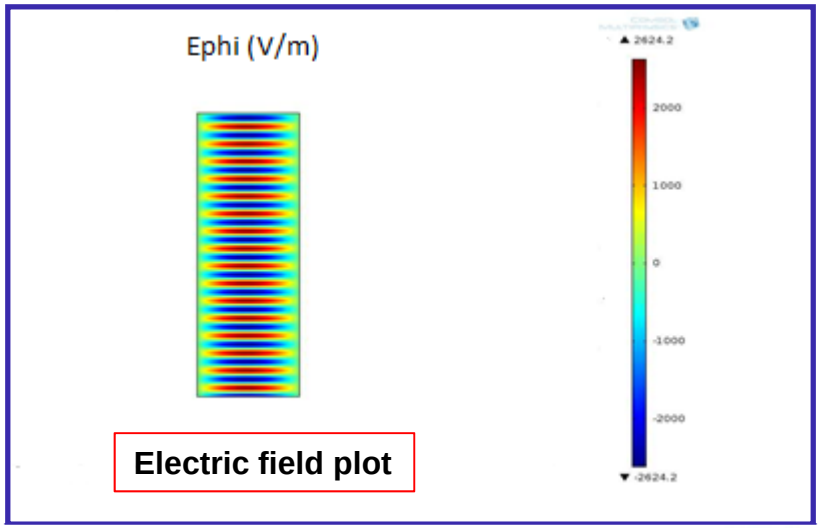
Number of elements:	356809
Minimum element quality:	0.08055
Average element quality:	0.9829
Mesh area:	821.6 mm^2



The model is meshed at 175GHz & mesh size across the gap is λ/30. The remaining structure is meshed with λ/20 Where λ is free space wavelength.

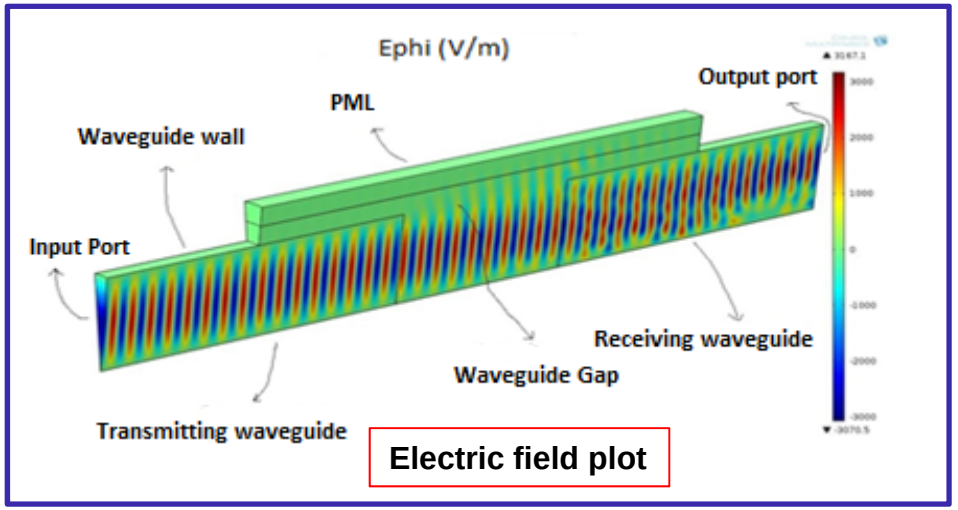
Results

Without gap

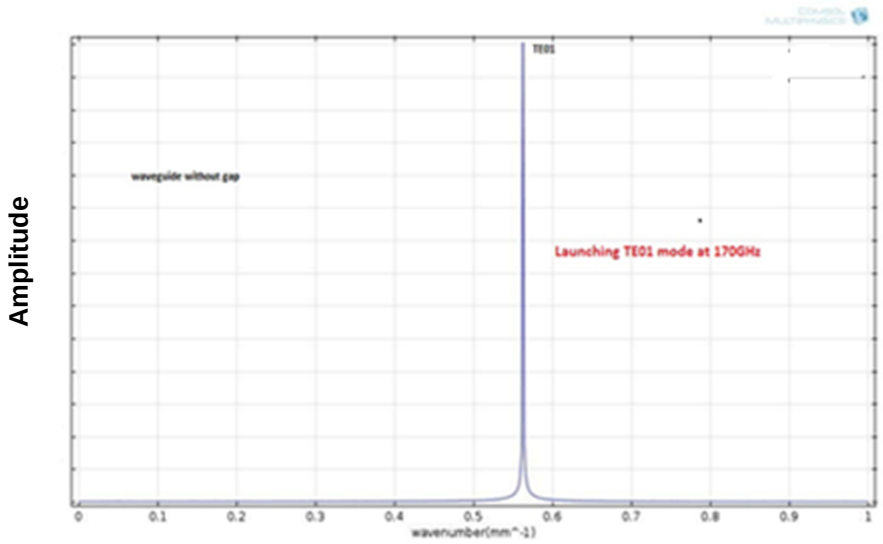


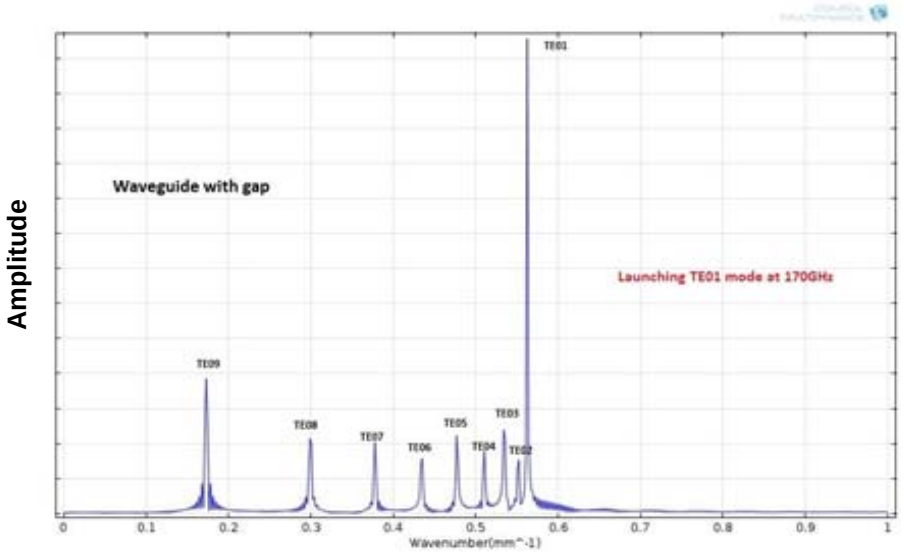
Electric field plot

With Gap (New Modes)



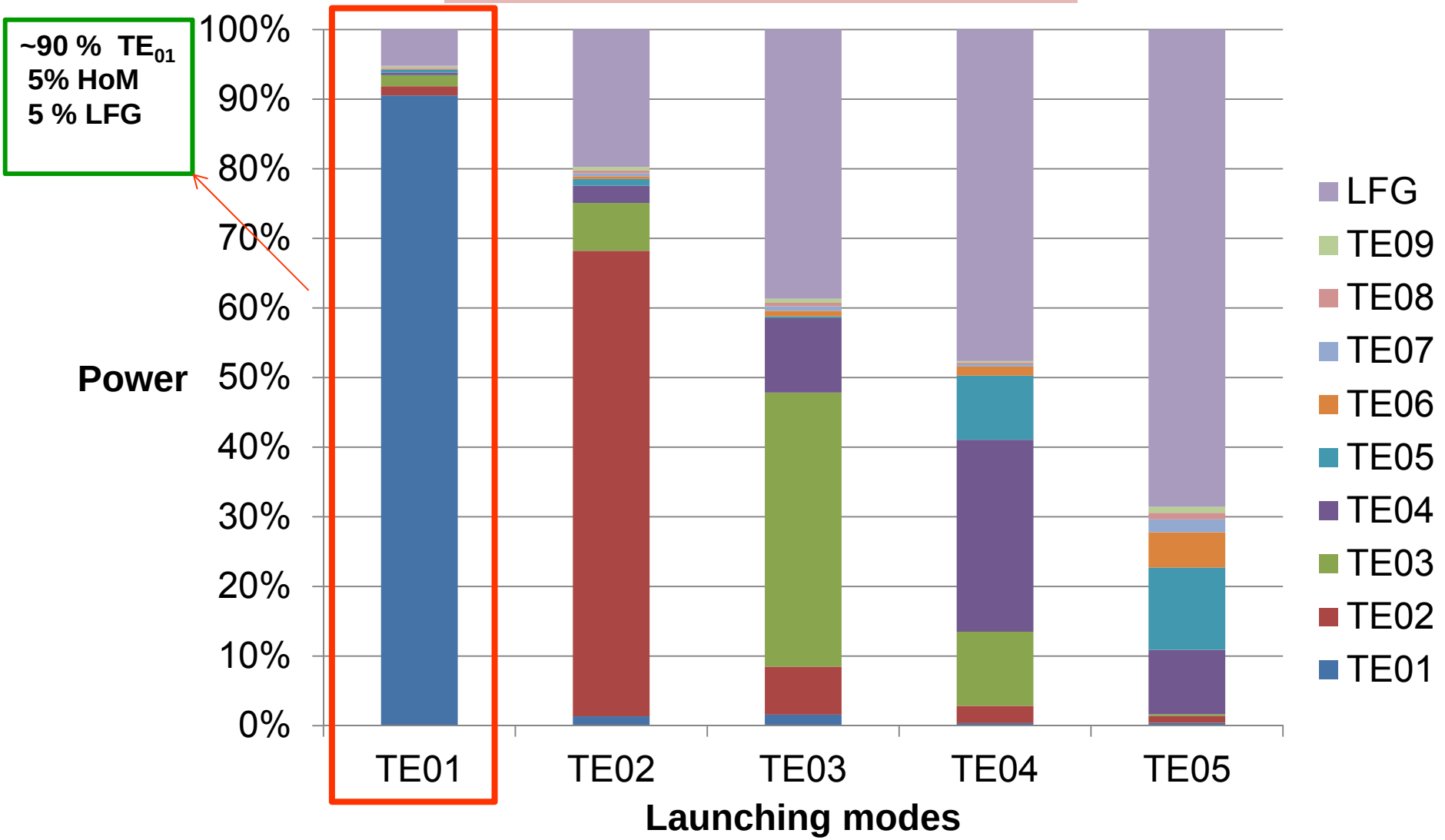
Electric field plot



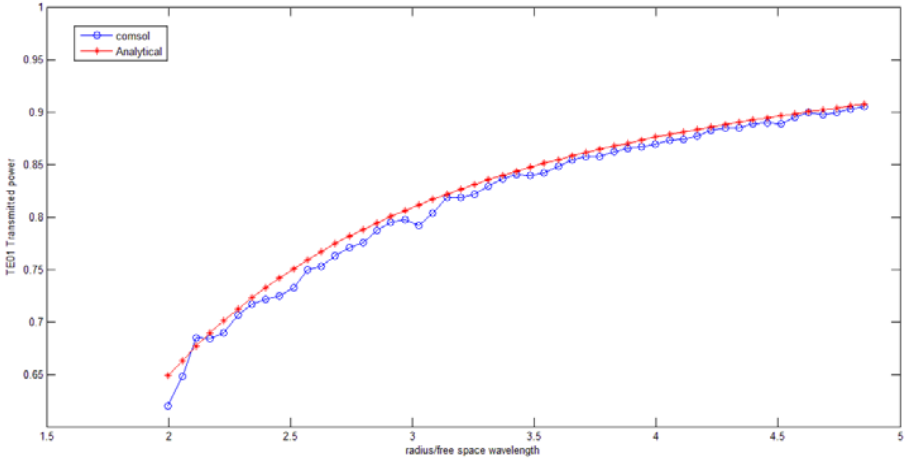


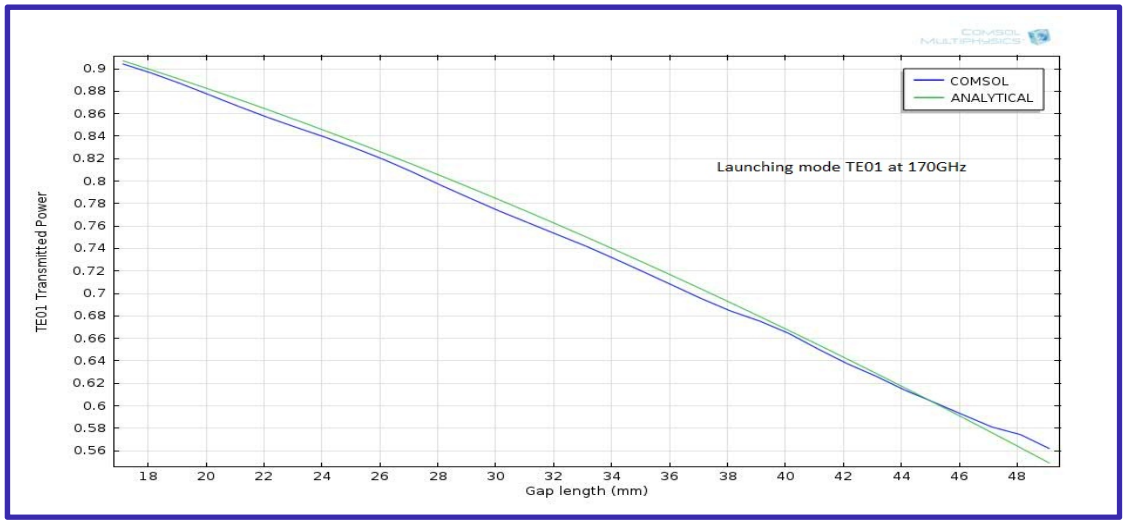
Results

Distribution of power in different modes



Comparison with theory





Transmission is given by *

$$\cong 1 - 0.0676 x_1^2 \left(\frac{L\lambda}{2a^2}\right)^{\frac{3}{2}}$$

L gap length
a radius of WG
λ free space wavelength
x_1 Bessel's root of 0 order 3.832 for TE_{01} mode

**** J.L Doane & C.P Moeller, Int.J.Electronics,VOL.77,pp.489,1994***

Conclusions

- TE_{01} is the lowest attenuated mode in an oversized waveguide
- Generation of Higher order modes across the waveguide gap
- When higher order modes are launched, more power goes in to the neighboring modes & Leakage power also increases
- Simulation results are matching reasonably well with theory

Thanks for your attention