INVESTIGATION OF THE LONGITUDINAL FIELD COMPONENT INSIDE THE GTEM 1750

H.M. LOOE, Y. HUANG
B.G. LOADER, M.J. ALEXANDER, W. LIANG

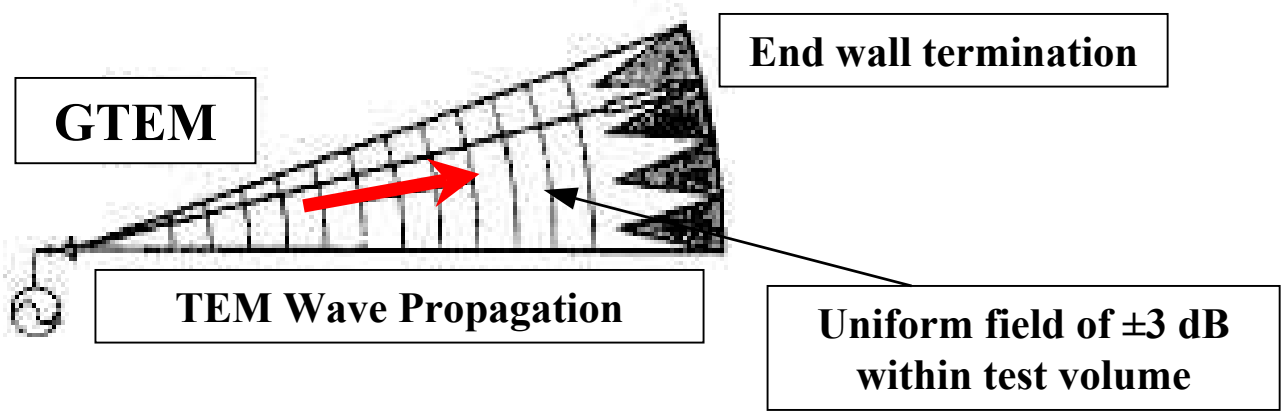
The University of Liverpool, UK
National Physical Laboratory, UK

NPL
National Physical Laboratory

Introduction

GTEM (Gigahertz Traverse Electromagnetic) Cell

- Cost-effective electromagnetic compatibility (EMC) testing
- Results compares favourably with full/semi-anechoic chamber

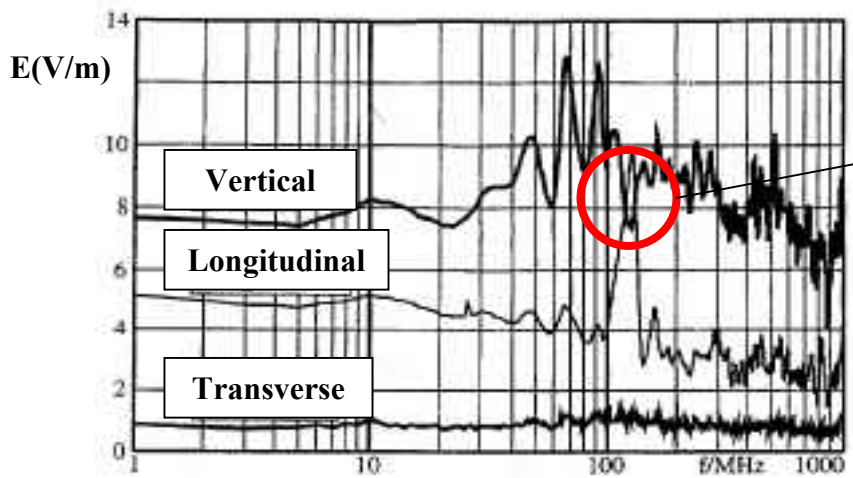


Anomalies in large GTEM Cell

- Significant longitudinal field component at a few frequencies

  ⇒ limits the accuracy of GTEM

  ⇒ poor correlation with OATS measurements



Strong longitudinal component at frequency 123 MHz !!!

Typical GTEM Cell Response

Numerical Modelling

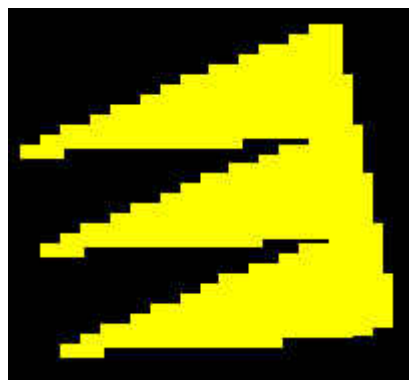
Finite Difference Time Domain (FDTD) Method

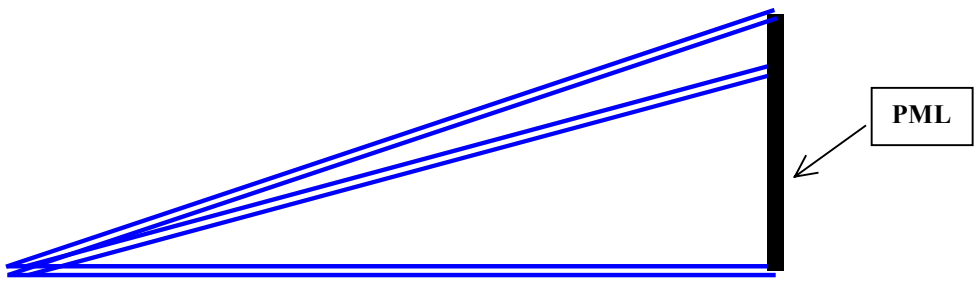
- Provide direct solution of Maxwell's curl equations
- Useful in solving electromagnetic problems
- Suitable for wide-band simulation

Route for modelling

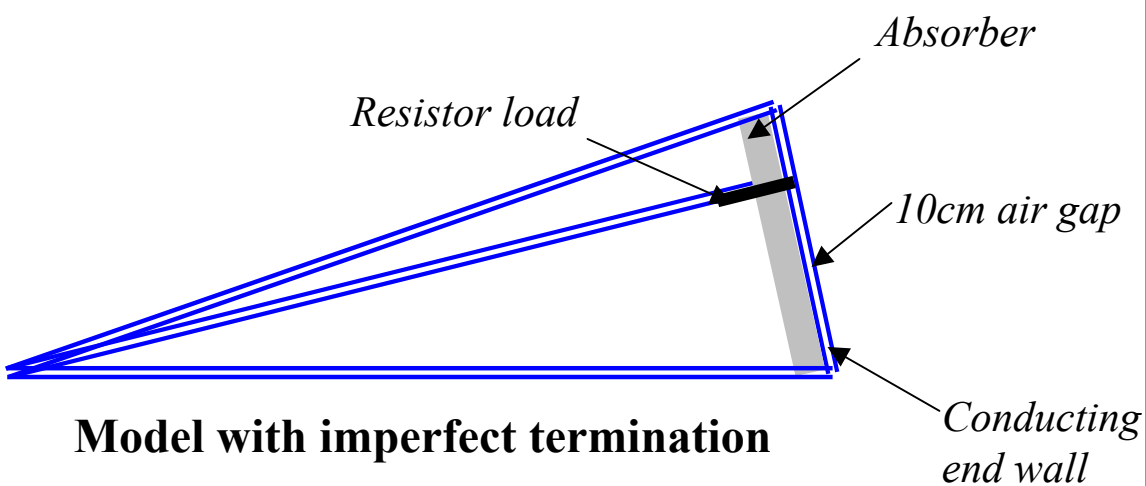
1. Model the feed region for GTEM cell
2. Model GTEM with matched boundary on end wall termination

   $\Rightarrow$ Perfect matched layer (PML)
3. Investigate the effect of imperfect termination on end wall
4. Analyse the configuration of the resistor board and radio absorbent material (RAM) used to terminate GTEM
5. Incorporate a realistic model with resistive and RAM in the GTEM numerical model



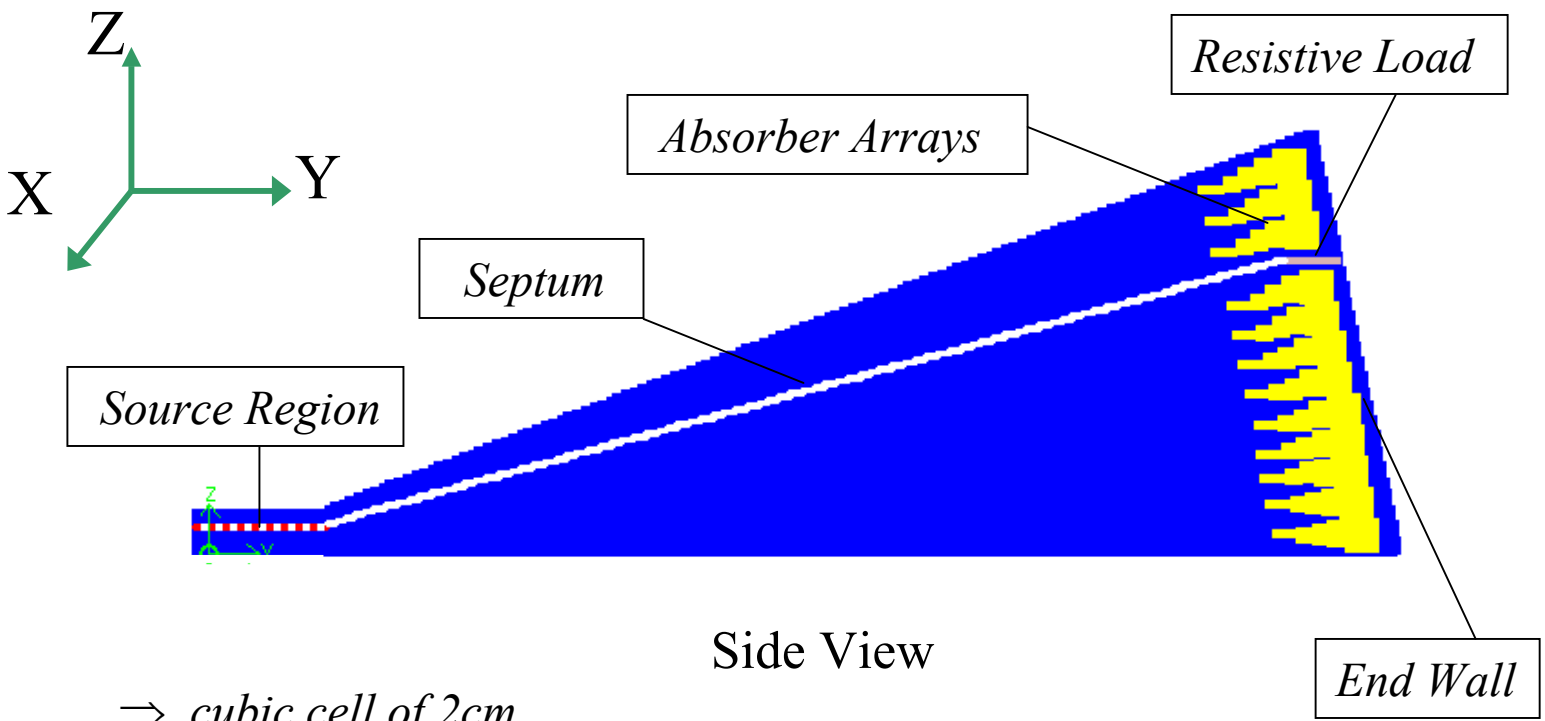


Model with perfect matched layer



Model with imperfect termination

GTEM Cell Model



Side View

⇒ *cubic cell of 2cm*

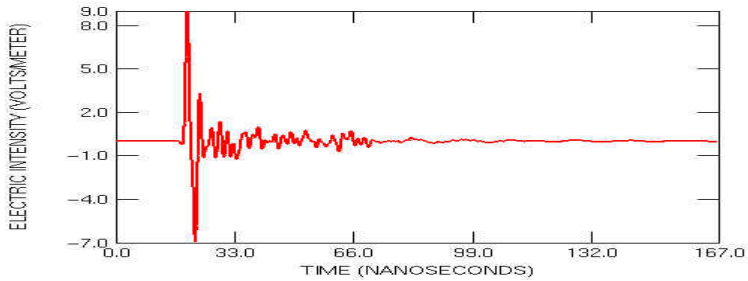
⇒ *formed by over 1800 blocks and 11,150,000 cells*

⇒ *most surfaces are metal except for resistor string and pyramidal absorbers*

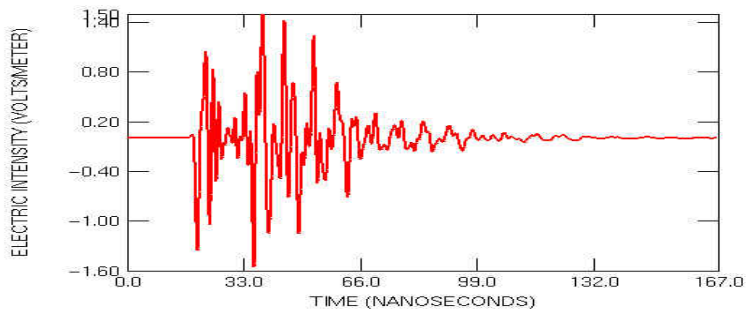
Time Domain Solutions

Simulated results at 1.38m septum and 0.69m probe heights

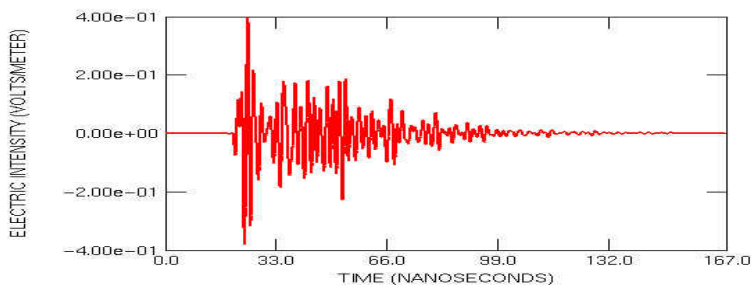
Ez



Ey

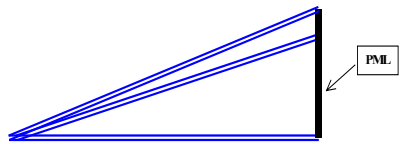


Ex



Frequency Domain Analysis

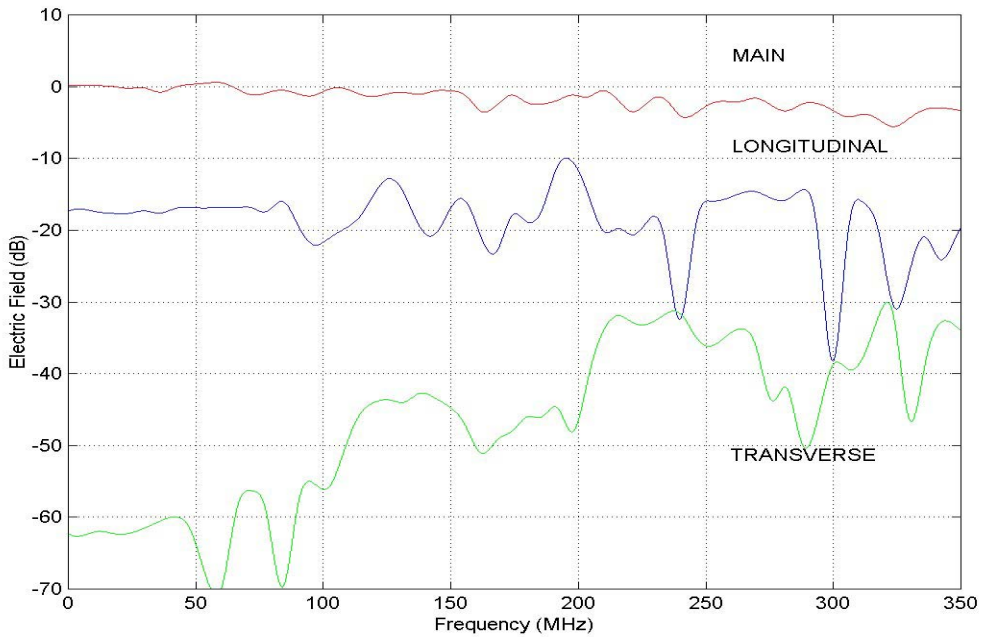
1. GTEM terminated by PML on the end wall



$\Rightarrow$ Well-polarised field

$\Rightarrow$ No unusual behaviour of longitudinal component

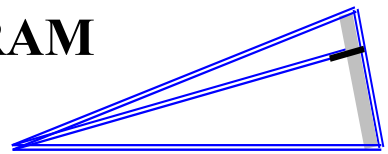
Computed GTEM 1750 normalised electric field components



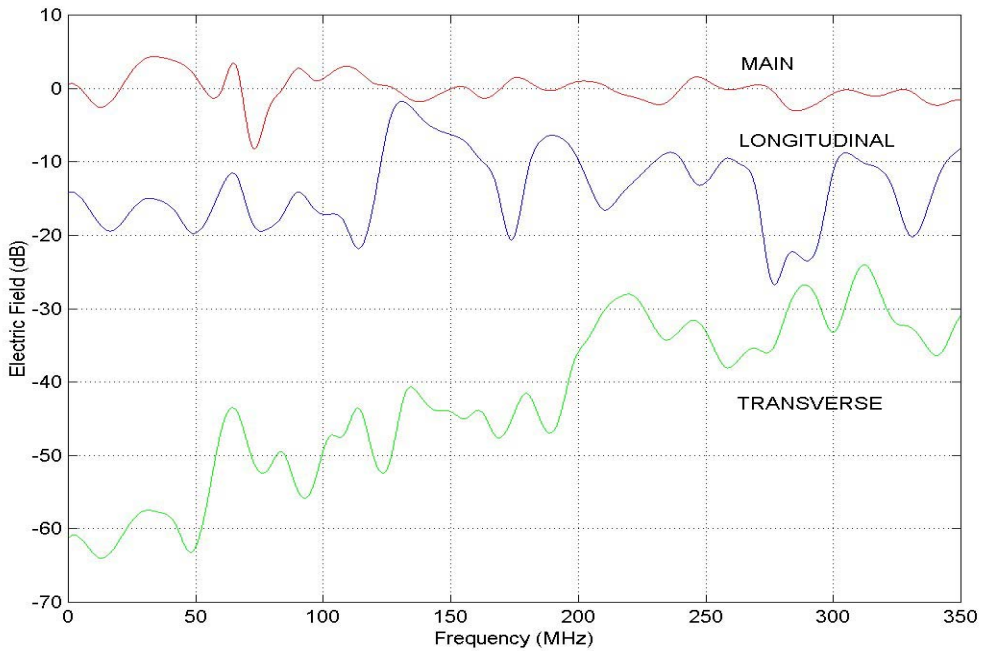
Frequency Domain Analysis

2. GTEM terminated by resistor board and loaded RAM

$\Rightarrow$ Strong longitudinal component observed

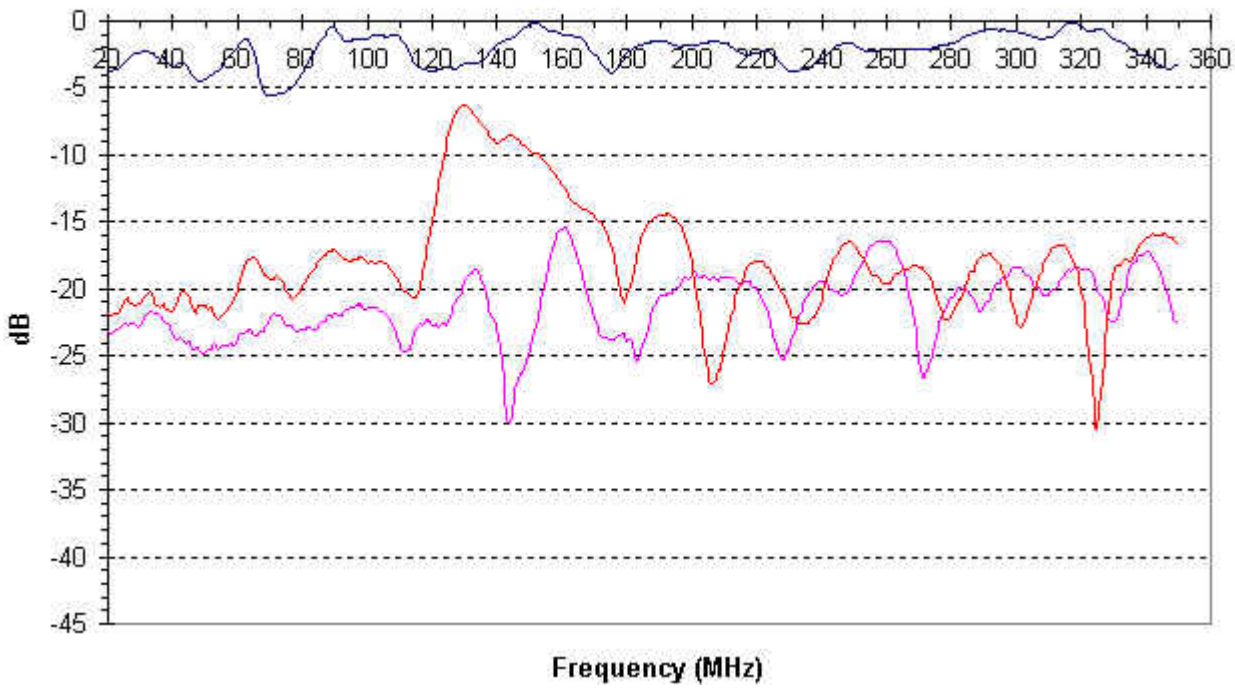


Computed GTEM 1750 normalised electric field components at 1.38m and 0.69m probe heights, 5.85m away from the apex



Validating of Results

MEB GTEM 1750 Measurement Performed in NPL:
Normalised Electric Field Components

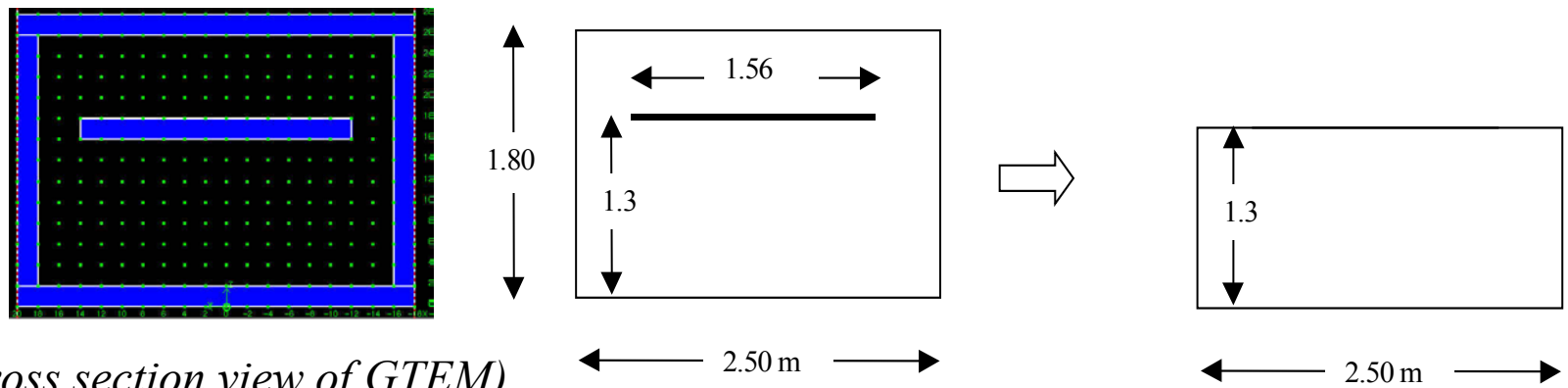


Analytical Analysis

Consider GTEM test region as a rectangular coaxial transmission line where the inner conductor is off-set

⇒ Difficult to obtain the cut-off frequencies of higher order modes

⇒ Approximation of the GTEM cross section as waveguide



(Cross section view of GTEM)

Analytical Analysis

Based on waveguide theory:

$$f_c = 150\sqrt{(m/a)^2 + (n/b)^2} = \frac{150}{y}\sqrt{(m/0.521)^2 + (n/0.272)^2} \quad MHz$$

Mode	f_c MHz
TE_{10}	59.98
TE_{11} TM_{11}	129.60
TE_{20}	119.96
TE_{21} TM_{21}	166.10
TE_{01}	114.89
TE_{30}	179.94

⇒ Cut-off frequency for TM11 is exactly the frequency of strong longitudinal component observed

⇒ This cut-off frequency approach could not explain large longitudinal component or other frequencies and locations

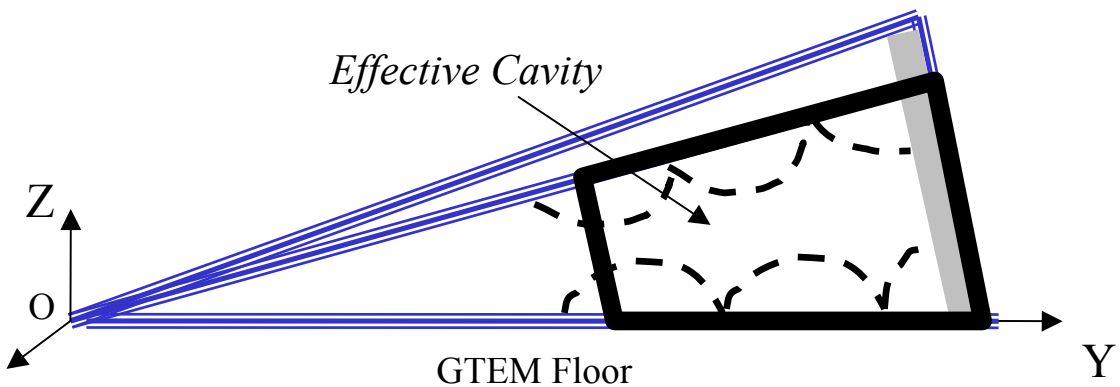
Analytical Analysis

Consider GTEM end section as tapered rectangular cavity loaded with RAM

⇒ Cross section may be considered as a reflector due to cut-off

⇒ Large longitudinal component resulted from TM resonance modes inside the cavity

⇒ TM 111 mode (135MHz for y=4.85m and 123MHz for y=5.85m)



Discussions

Generation of higher order modes

- Discontinuities inside the GTEM
- Inefficient of RAM to absorb and to attenuate RF energy at low frequencies

Solution

- Adding ferrite to the bottom of pyramidal absorber on the end wall
- Damp resonance and reduce longitudinal component

Conclusions and Future Works

Analysing GTEM 1750 Cell performance through numerical modeling has been successful

- Verification of the cause of strong longitudinal component behaviour
- Investigate GTEM performance of ferrite lining at the end wall