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X-Band Iris Loaded PBG Accelerator

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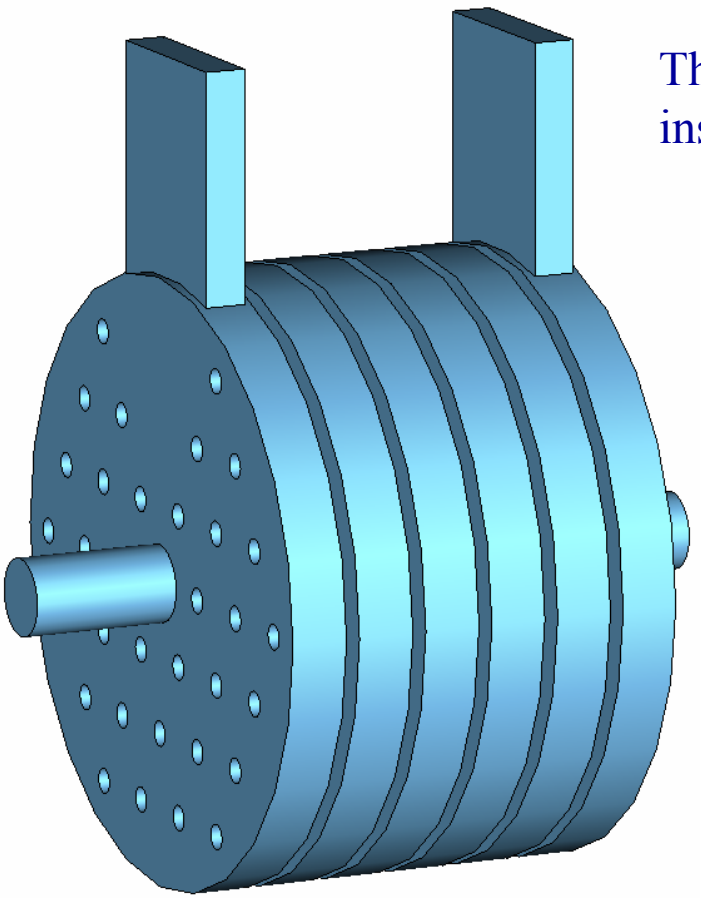
Introduction



MAIN ADVANTAGE OF THE PBG ACCELERATOR:

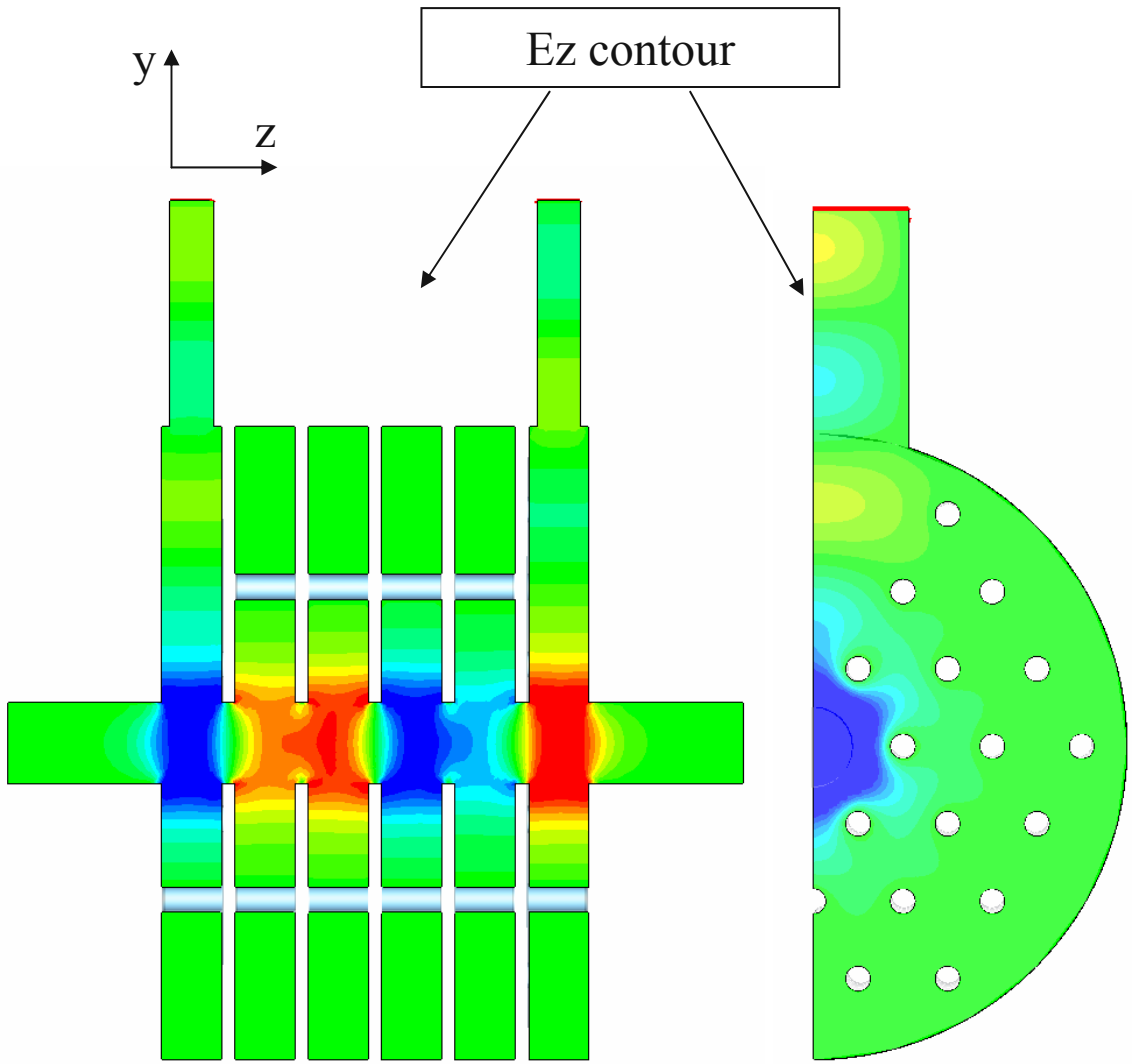
The absence of all HOMs will greatly reduce beam instabilities [1].

- Being constructed by Tsinghua University, China
- A larger group velocity 0.05c is reached to reduce the filling time
- Temperature rise due to pulsed heating is analyzed
- Beam test on 3-cell SW PBG cavity is introduced

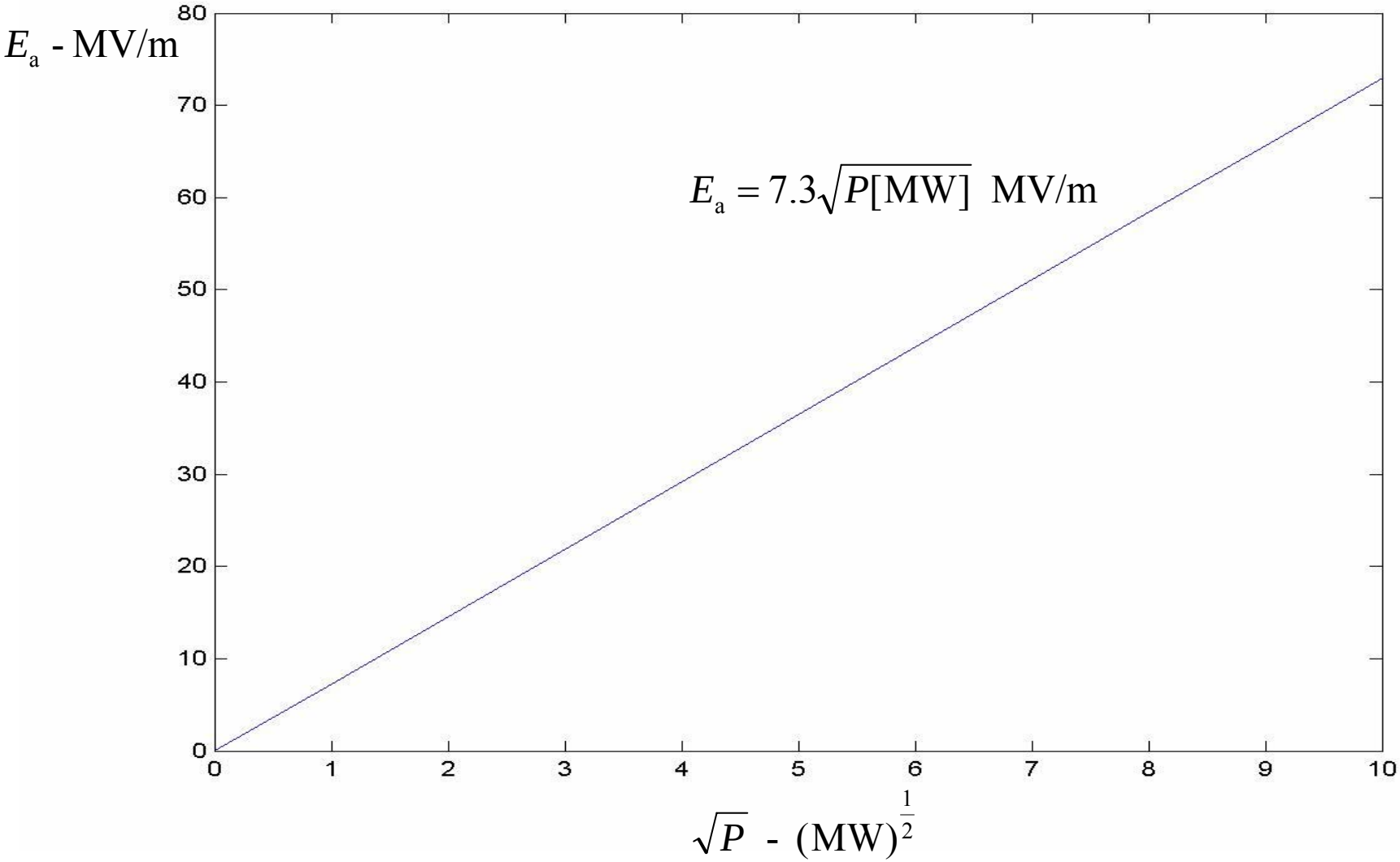
[1] Evgenya I. Smirnova et al, Demonstration of a 17-GHz, High-Gradient Accelerator with a Photonic-Band-Gap Structure, PRL 95, 074801 (2005)

Field Distribution in the Iris-loaded PBG Structure

Mode	$2\pi/3$	
freq (GHz)	11.424	
v_g/c	0.049	Group velocity
t_f (ns)	3.5	Filling time
R/Q (KΩ/m)	11	
Q_w	5287	Wall Q-factor
Ea (MV/m)	$7.3\sqrt{P[\mathrm{MW}]}$	Accelerating gradient
a (mm)	1.57	Rod radius
b (mm)	10.76	Rod spacing
d (mm)	9.61	Iris diameter
m (mm)	5.04 ~ 7.04	Shorter side of input waveguide
n (mm)	22.86	Longer side of input waveguide
L (mm)	7.04	Length of each cell
t (mm)	1.71	Iris thickness



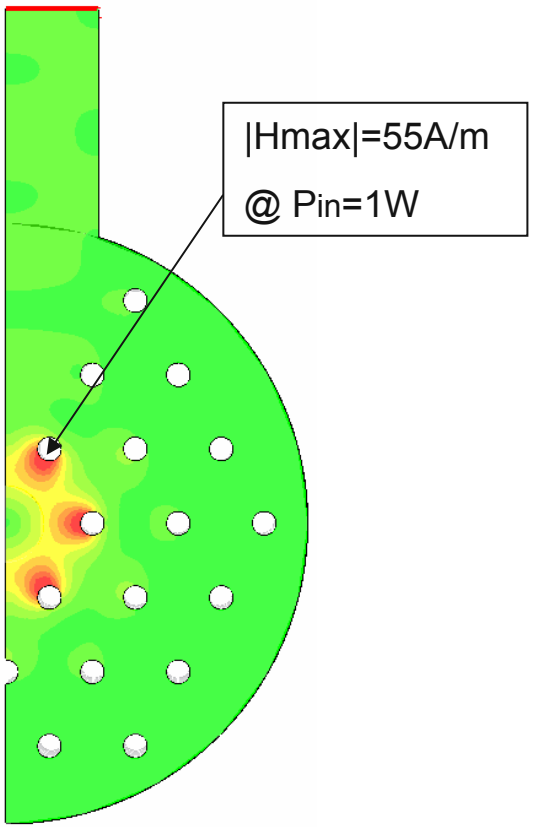
Accelerating Gradient for Given Power

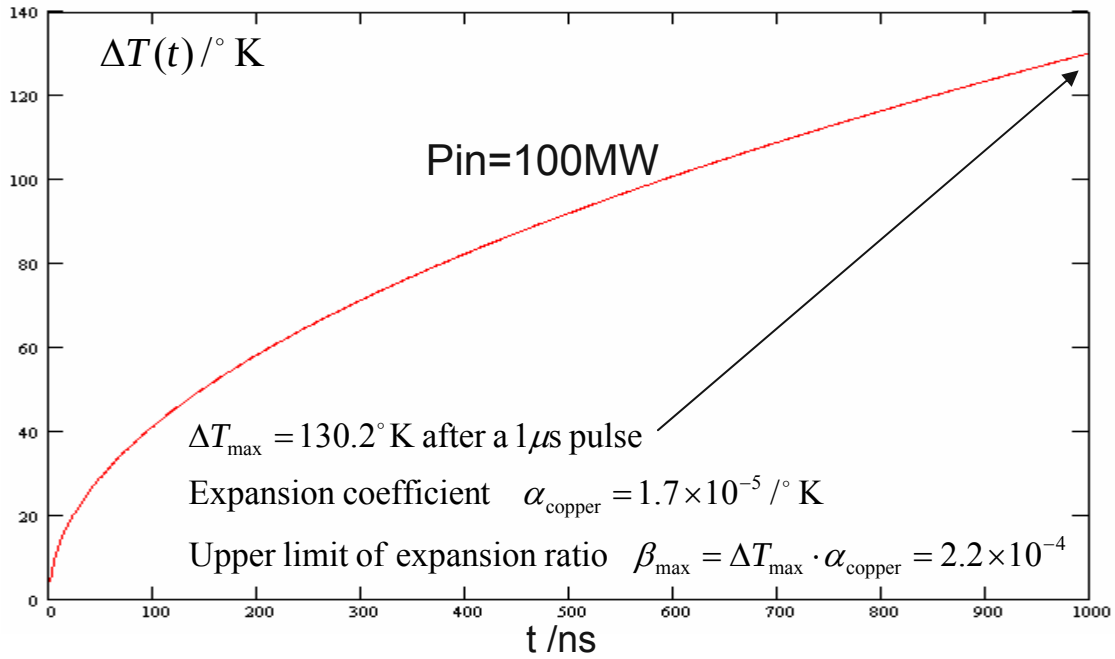


Temperature Rise due to Pulsed Heating

$$\Delta T(t) = \frac{1}{2\sqrt{\pi\rho}} \int_0^t \frac{dt'}{\sqrt{t-t'}} \cdot \frac{R_S \mid H(t) \mid^2}{\sqrt{ck}}$$

ρ - mass density, R_S - surface resistance, c - heat capacity, k - heat conductivity [2]



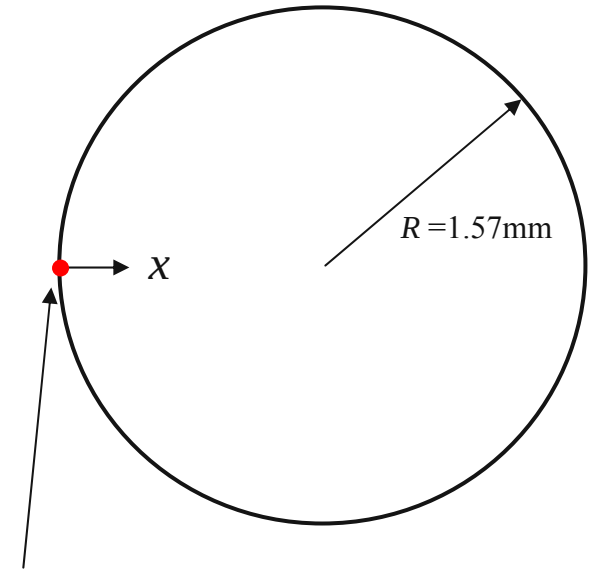


[2] David P. Pritzkau et al, Possible High Power Limitations From RF Pulsed Heating, SLAC-PUB-8013, November 1998

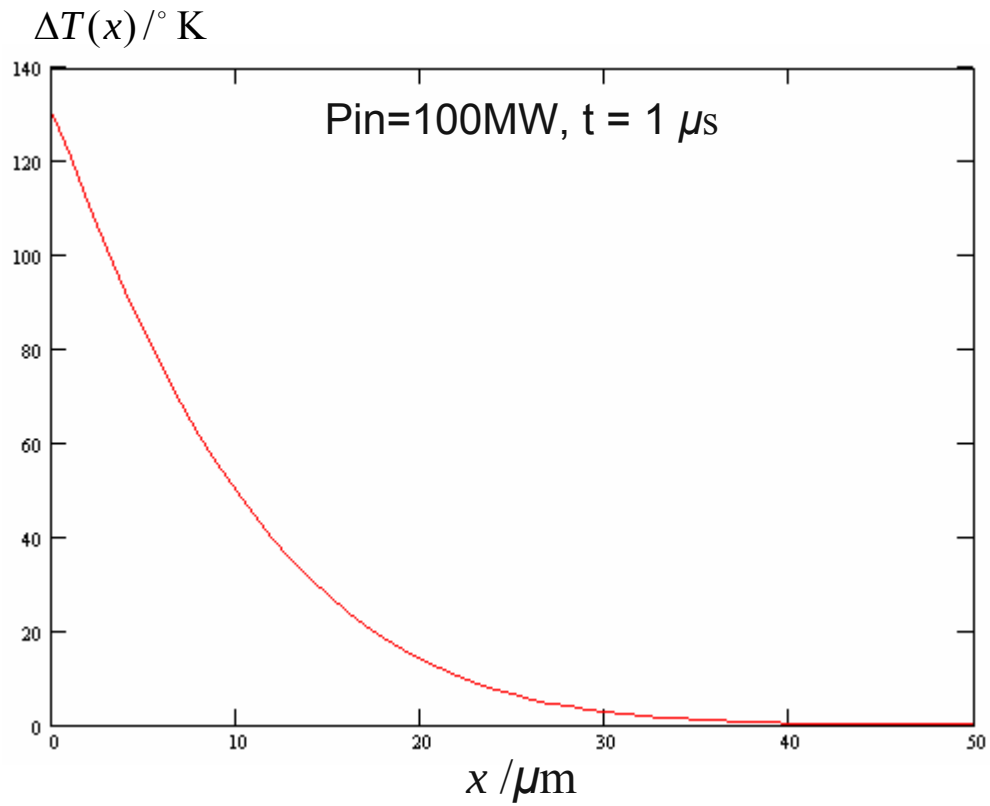
Temperature Rise inside an Innermost Rod

$$\Delta T(x,t) = \frac{1}{2\sqrt{\pi\rho}} \int_0^t e^{-\frac{c\rho \cdot x^2}{4k(t-t')}} \cdot \frac{dt'}{\sqrt{t-t'}} \cdot \frac{R_S \,|\, H(t) \,|^2}{\sqrt{ck}}$$

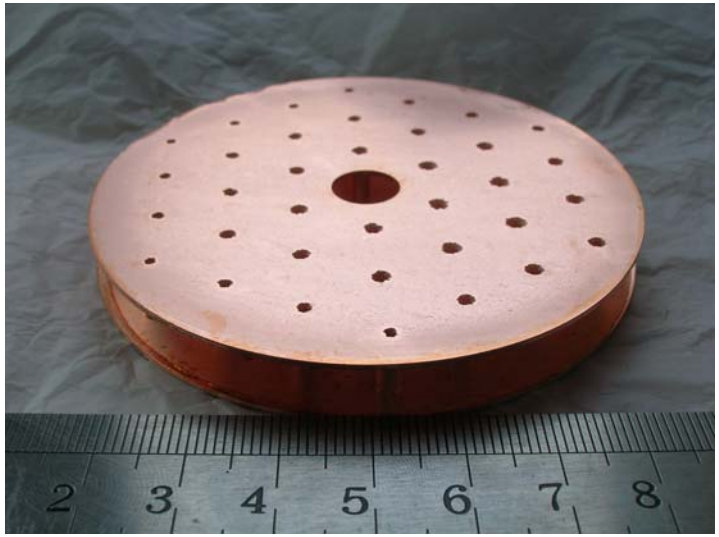
Cross section of an innermost rod

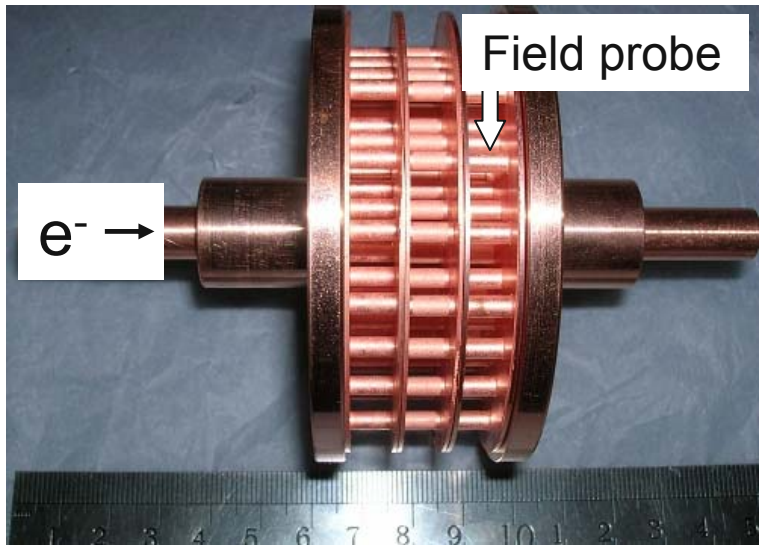


"Hottest-spot" on the surface with maximum H- field



High Gradient Test on 3-cell 11.4GHz PBG Standing Wave Structure

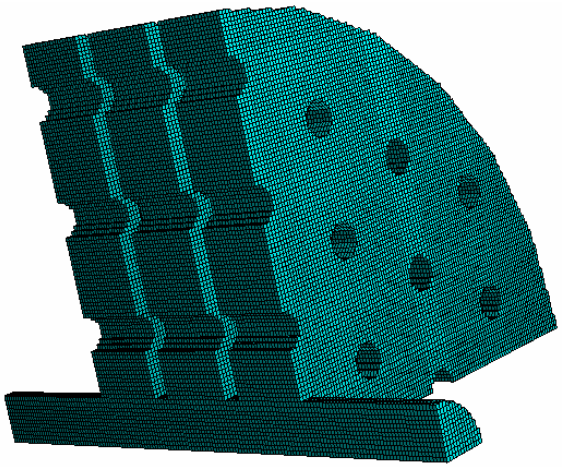


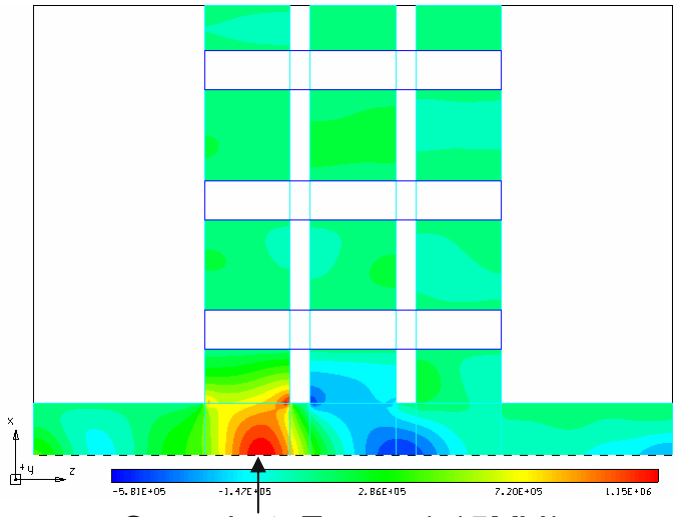


- When an electron beam travels on the axis through the PBG SW structure consisting of three cells, three main SW modes will be excited.
- The maximum gradient occurs in the first or third cell, which is contributed by all the three SW mode.
- The maximum gradient is calculated as

Ez_{max} = 0.777MV/m/nC (σ_z=2mm).

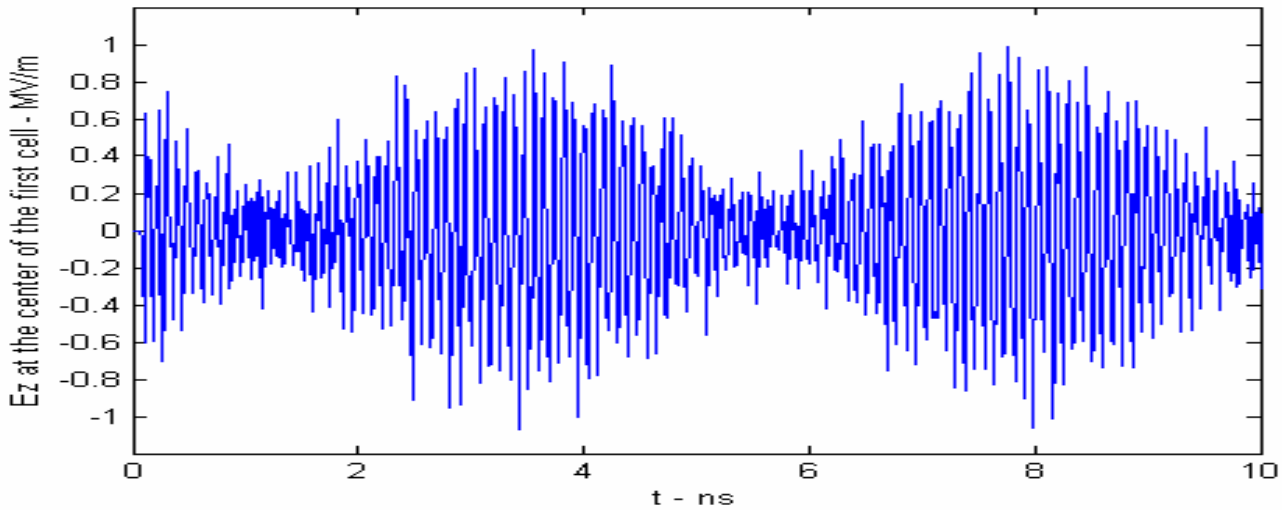
MAFIA T3 Simulation on the 3-cell PBG SW Structure (q=1nC, σ_z=2mm)





Snapshot: Ez_{peak}=1.15MV/m

Ez at the center of the first cell



FUTURE WORK

- Beam experiment on the 3-cell SW iris loaded PBG structure;

- With 100nC charge passed through, the excited gradient will be 77MV/m, corresponding to 100MW of power.