High Power Magnetron Simulation using Eigenmode Solver

EMPro Application Example

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Highlights of This Application

Overview

Cavity magnetrons are commonly used in microwave ovens and in various radar applications. This example shows Eigenmode simulations of a high power Magnetron. The Magnetron is constructed of two concentric cylinders. The output cylinder has corrugations in its inner wall (these corrugations some times is called Vanes). The central cylinder is perfect conductor rod. The cylindrical cavity has 8-slot corrugated walls. The sizes of the cavities determine the resonant frequency, and thereby the frequency of emitted microwaves. However, the frequency is not precisely controllable and it requires an eigenmode simulation to determine all the frequencies for different modes.

Typical Applications

- High Power Microwave Amplifiers using Magnetron
- Microwave Owen and Radar

Problem and Solution Overview

Problem

The cavity magnetron is a high-powered vacuum tube that generates microwaves using the interaction of a stream of electrons with a magnetic field. The sizes of the cavities determine the resonant frequency, and thereby the frequency of emitted microwaves. It's a challenging task to know and precisely control resonant frequencies . Eigenmode simulation is required to know all the frequencies for different modes.

Solution

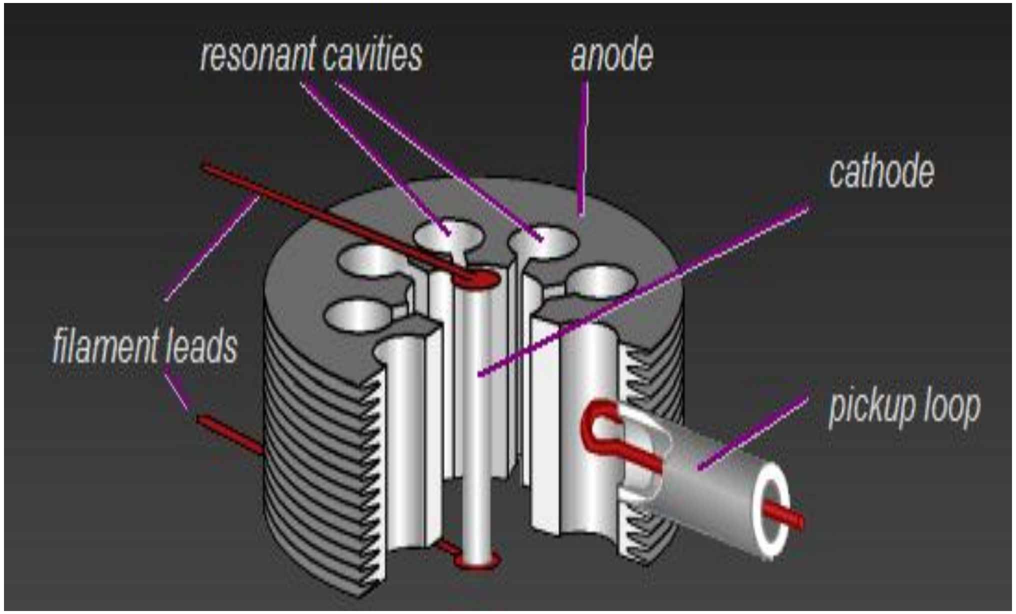
The Eigenmode Solver of EMPro can be used to simulate closed resonant structures. Primary results are, besides the field distribution of the modes, the Eigen frequencies of the structure and Q values. Typical application areas are the determination of the poles of a highly resonant filter structure, Q-value calculation, and the design of accelerating cavities like Magnetrons. Using eigenmode simulation, resonant frequencies and Q values have been analyzed for first 10 modes.

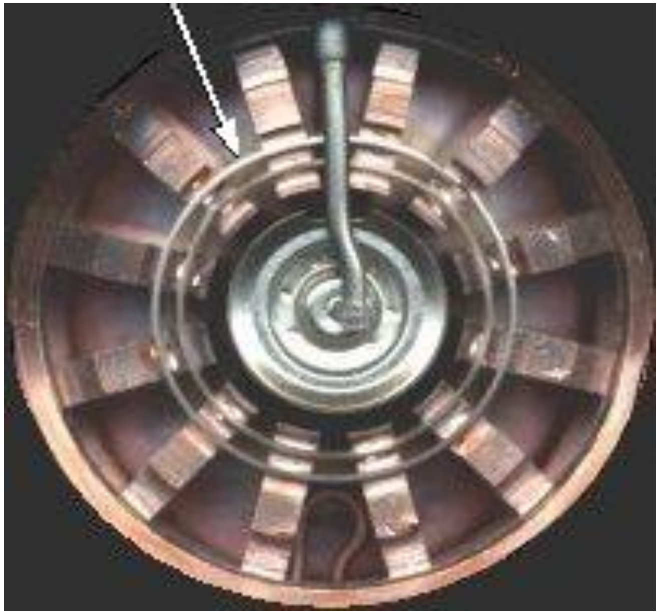
Value Delivered

Designers can quickly design and tune magnetron design parameters to get desired resonance frequencies using the Eigenmode solver in EMPro.

Magnetron Example

The **cavity magnetron** is a high-powered vacuum tube that generates microwaves using the interaction of a stream of electrons with a magnetic field. Cavity magnetrons are commonly used in microwave ovens and in various radar applications. The sizes of the cavities determine the resonant frequency, and thereby the frequency of emitted microwaves. However, the frequency is not precisely controllable



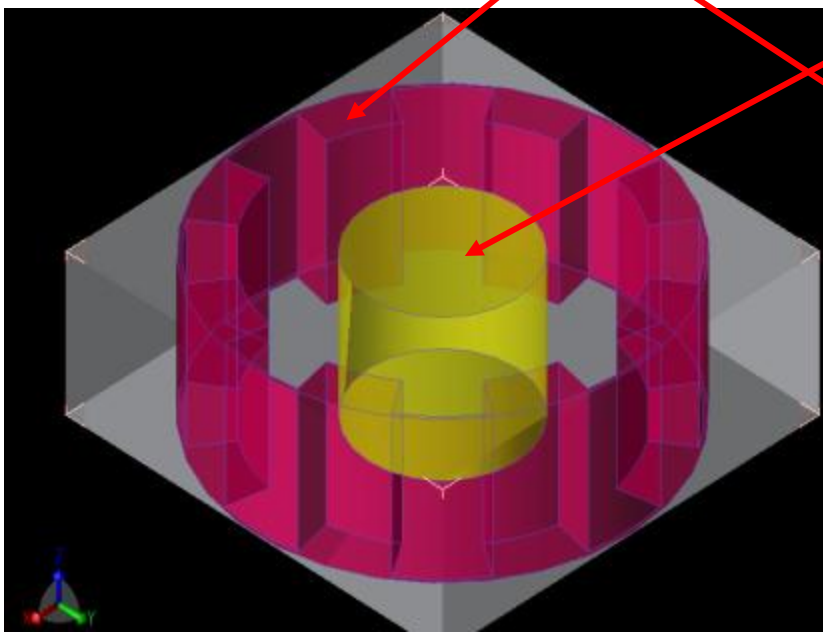


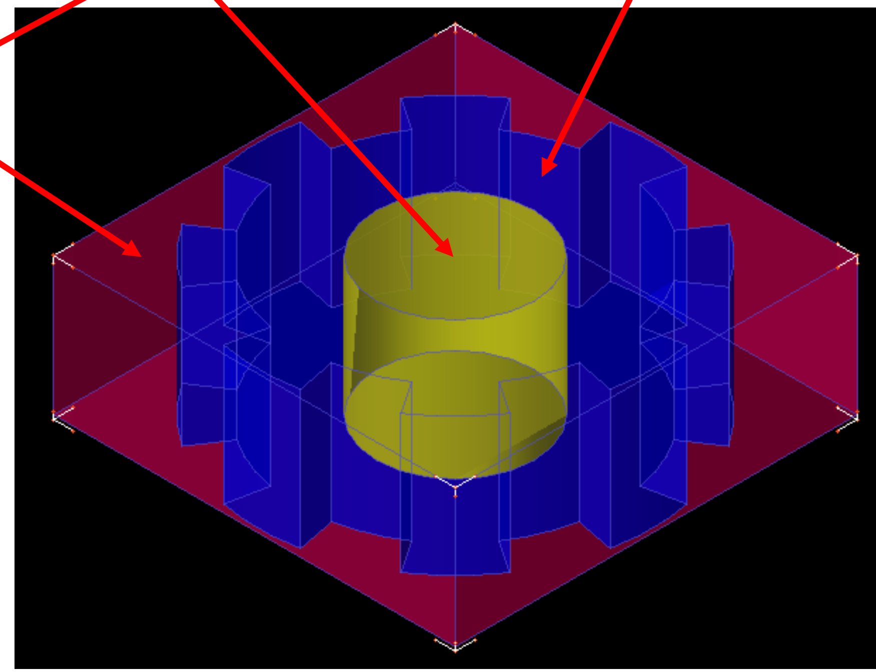
Magnetron Design in EMPro

Outer Cavity

Inner Cylinder

Air between inner
and outer cavity

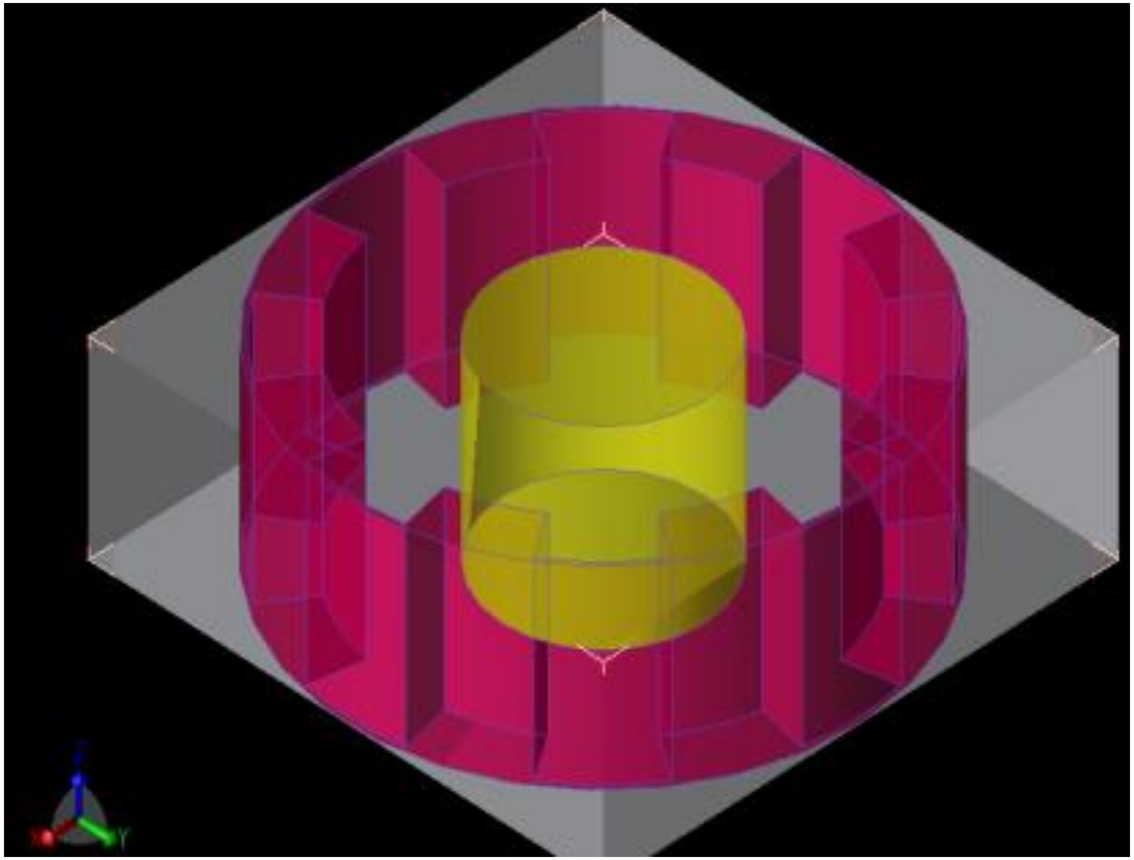




Cavity Magnetron with
Circular outer cylinder

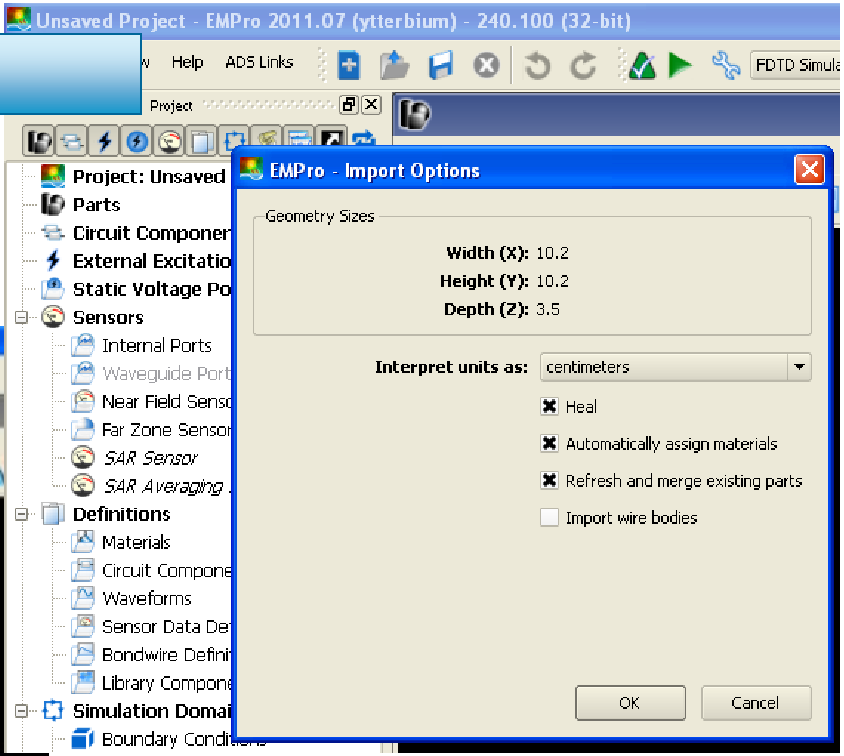
Equivalent Magnetron
design in EMPro

Magnetron Design in EMPro

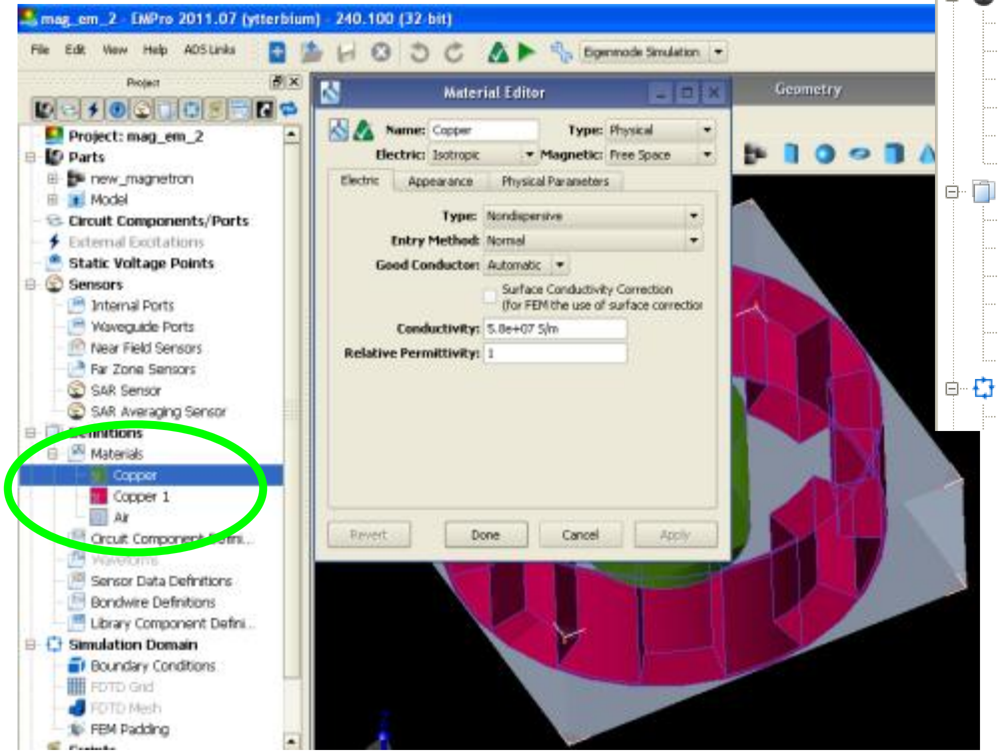


EMPro Simulation Steps for Magnetron

1 Design or import SAT File import



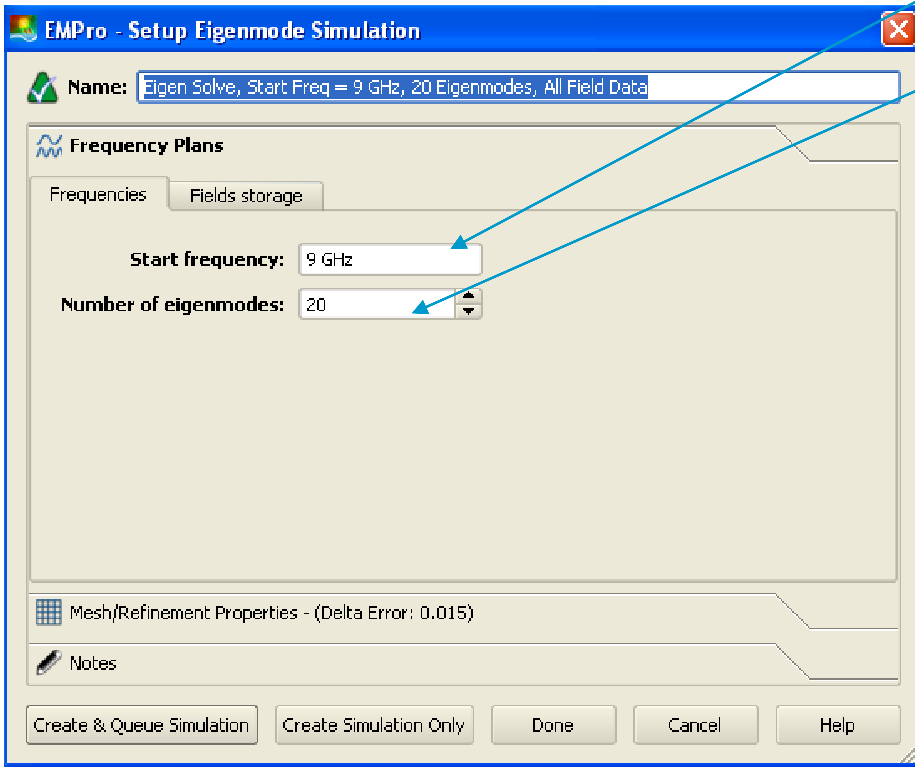
2 Assign Materials



3 Select Solver as Eigenmode

Simulation Setup in EMPro

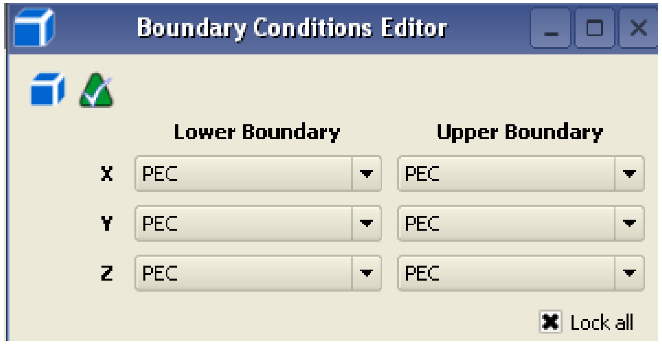
4 Simulation Setup



Select start frequency 9 GHz

Number of Eigenmode : 20

5 Set all boundaries as "PEC"



6 Make all Padding as "0"

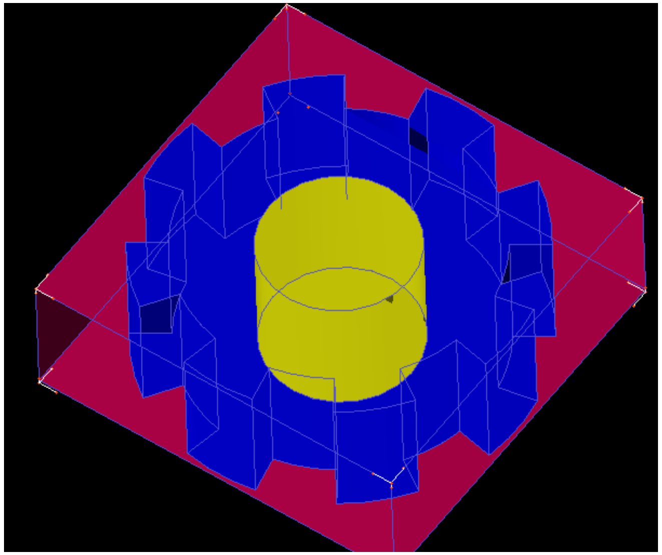
7 Simulate and View result

Simulate and view the result in EMPro

Simulated Data

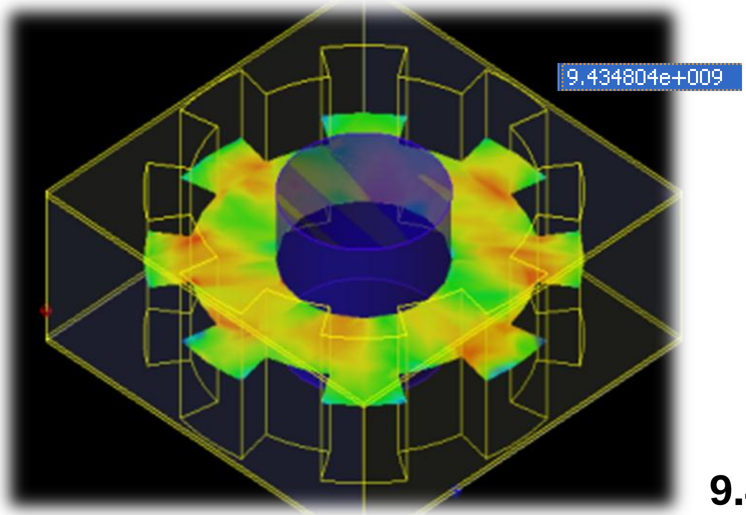
Eigenfrequencies | Q values

1. 9.175303e+009 | 1.193399e+004
2. 9.187439e+009 | 1.179808e+004
3. 9.249755e+009 | 2.181145e+004
4. 9.347056e+009 | 1.012978e+004
5. 9.351875e+009 | 1.016099e+004
6. 9.434804e+009 | 1.112086e+004
7. 9.441002e+009 | 1.118816e+004
8. 9.472190e+009 | 1.859983e+004
9. 9.475078e+009 | 1.854990e+004
10. 9.533969e+009 | 1.037507e+004
11. 9.680015e+009 | 1.521767e+004
12. 9.692147e+009 | 1.499778e+004
13. 9.731631e+009 | 1.448455e+004
14. 9.740181e+009 | 1.458486e+004
15. 9.751138e+009 | 1.456886e+004
16. 9.820047e+009 | 1.602751e+004
17. 9.828213e+009 | 1.098586e+004
18. 1.017007e+010 | 1.217140e+004
19. 1.022859e+010 | 1.195162e+004
20. 1.023253e+010 | 1.202306e+004

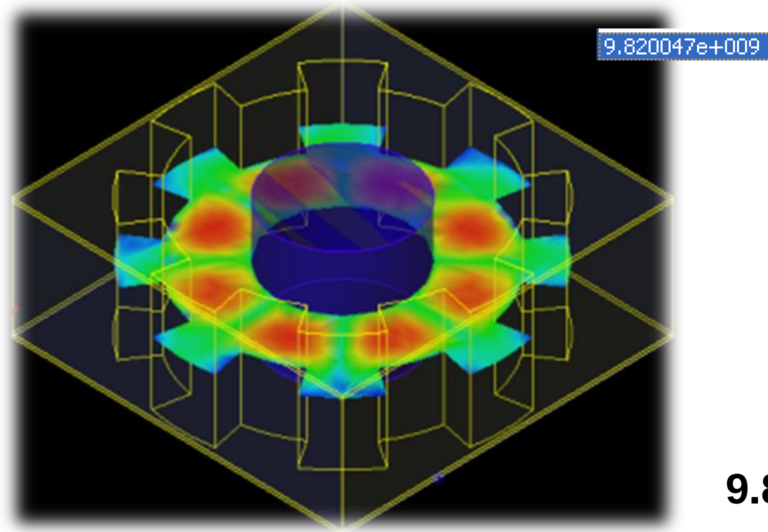


Simulation Time : 1 Min 17 sec
Solver : Eigenmode (Direct solver)
Max number of unknown: 24472

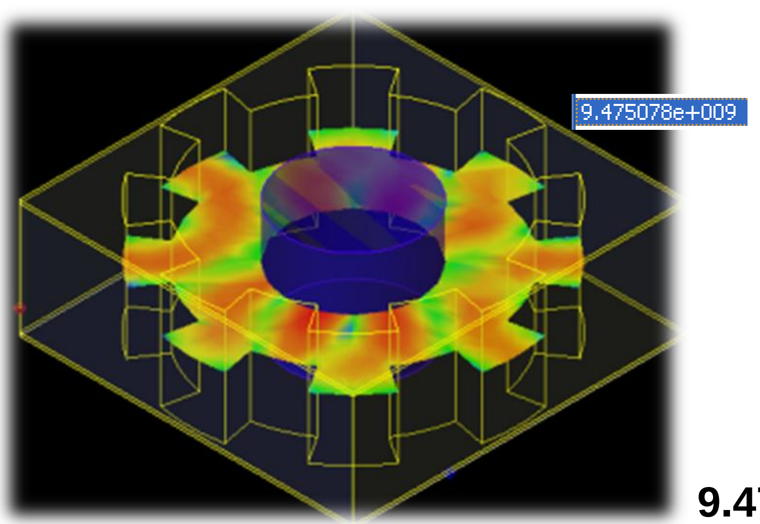
Filed plot of Different Modes of Magnetron



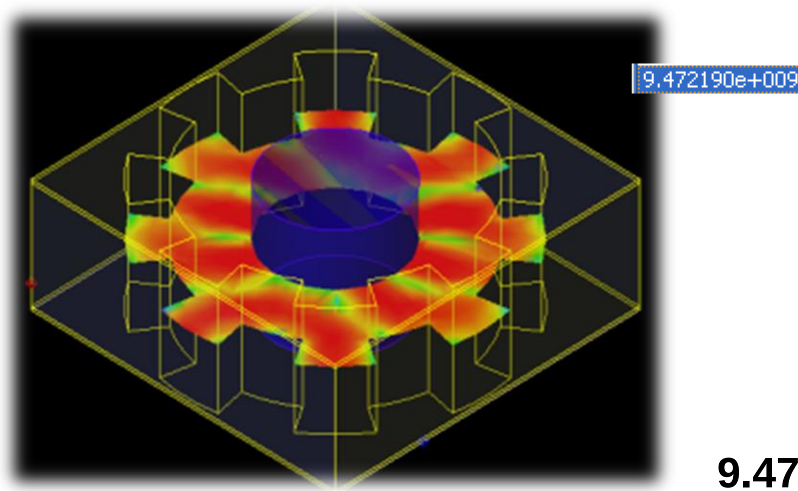
9.43 GHz



9.82 GHz



9.475 GHz



9.472 GHz