

Pulsed Power Accelerator Design with COMSOL Multiphysics®

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Introduction: We have developed Thor: a pulsed power accelerator for performing dynamic material experiments. The machine generates 6-8 mega-amperes of current in 200-500 nanoseconds. This current is delivered to a convolute section and load. The load is a stripline that is used to generate material pressures of over 1 Mbar (10^{11} Pa=100 GPa).

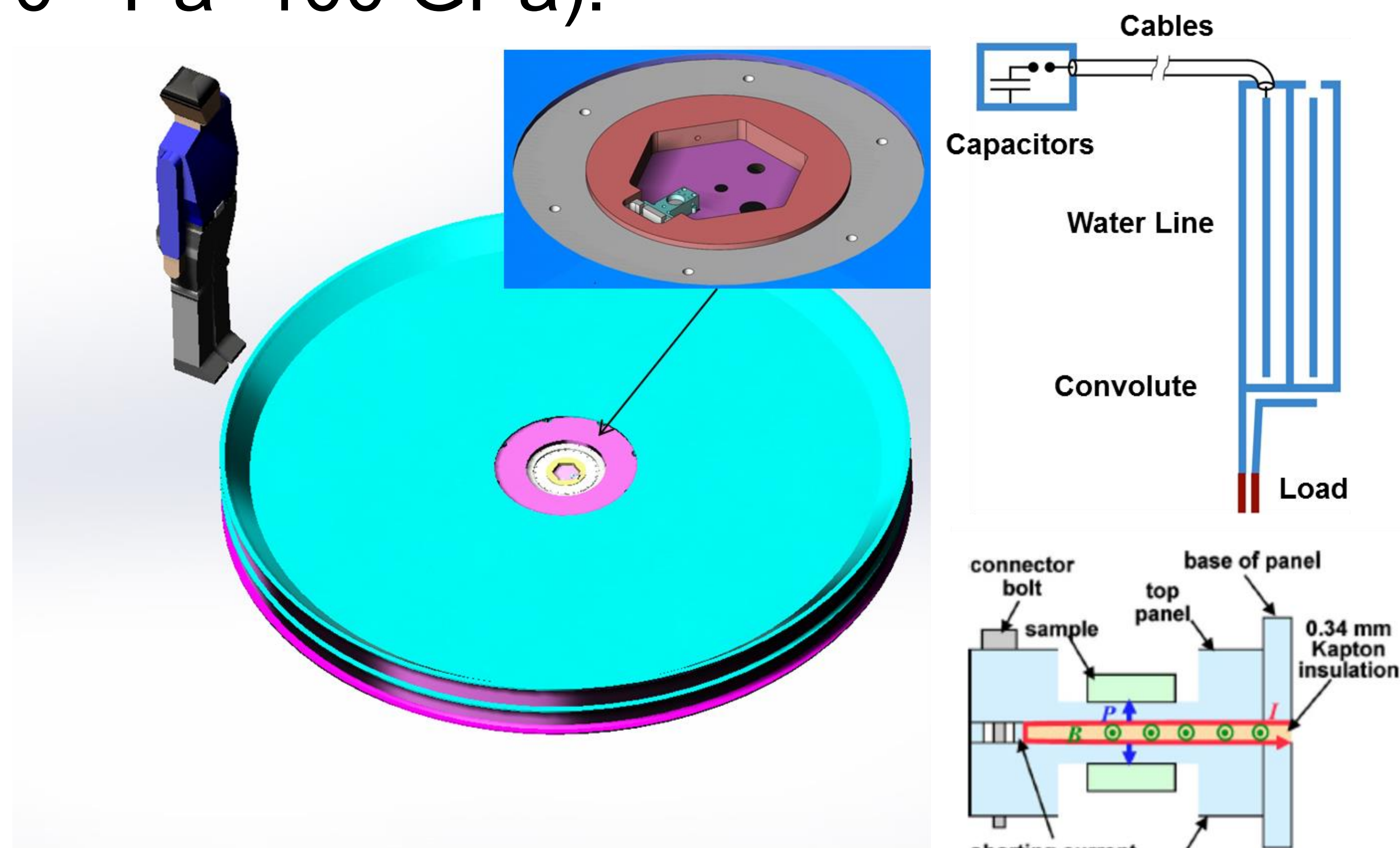


Figure 1. Thor device. Current is concentrated into a stripline in the center section(left). The resulting magnetic fields produce a pressure used to compress samples. (lower right).

Computational Methods: The design was developed using the RF and AC/DC modules. Electrostatic calculations were used to determine E-field distributions. Frequency dependent B-field calculations were used to determine impedance (Z) and inductance (L).

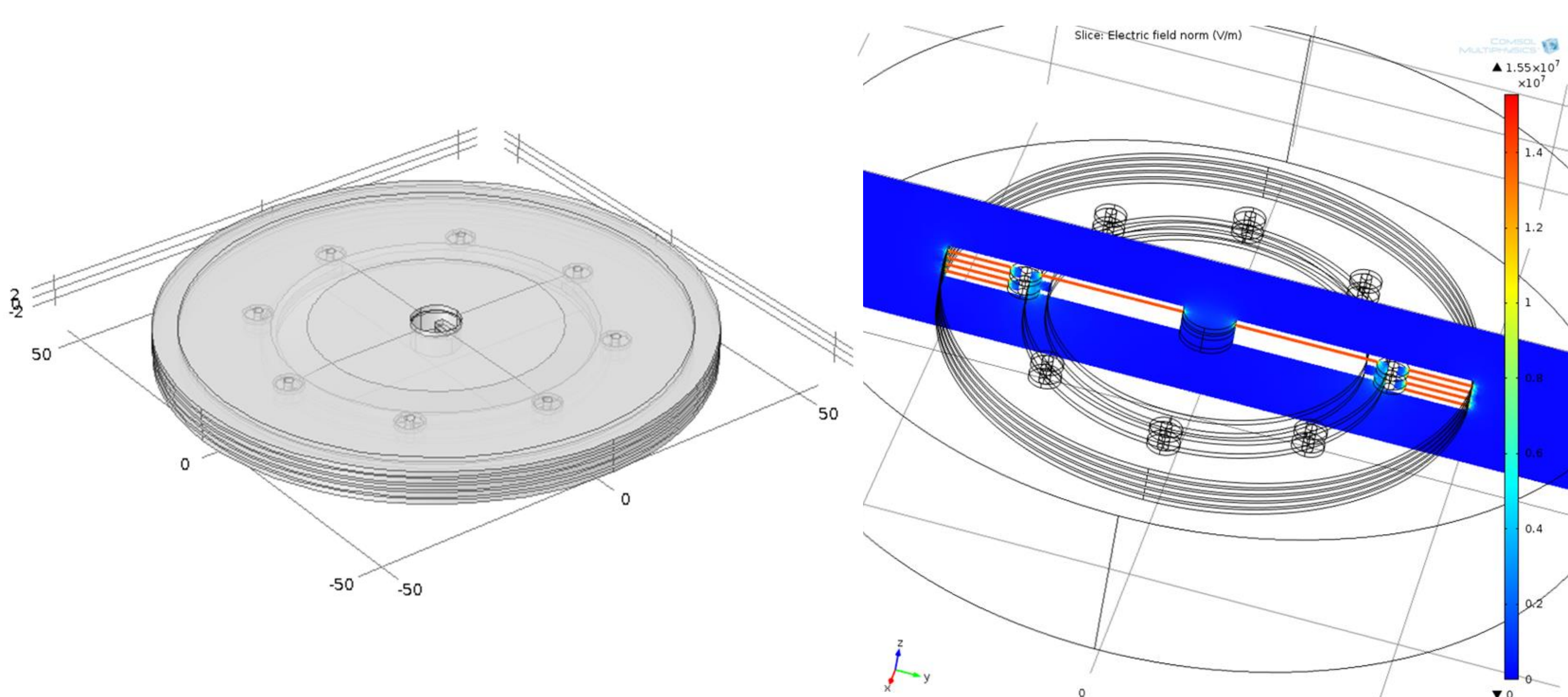


Figure 2. Simulation geometry (left) and electric field magnitude (right). Electrodes are either given a voltage or current feed boundary condition.

Results: COMSOL is used to calculate the electric field strength and Z or L of the power flow structures.

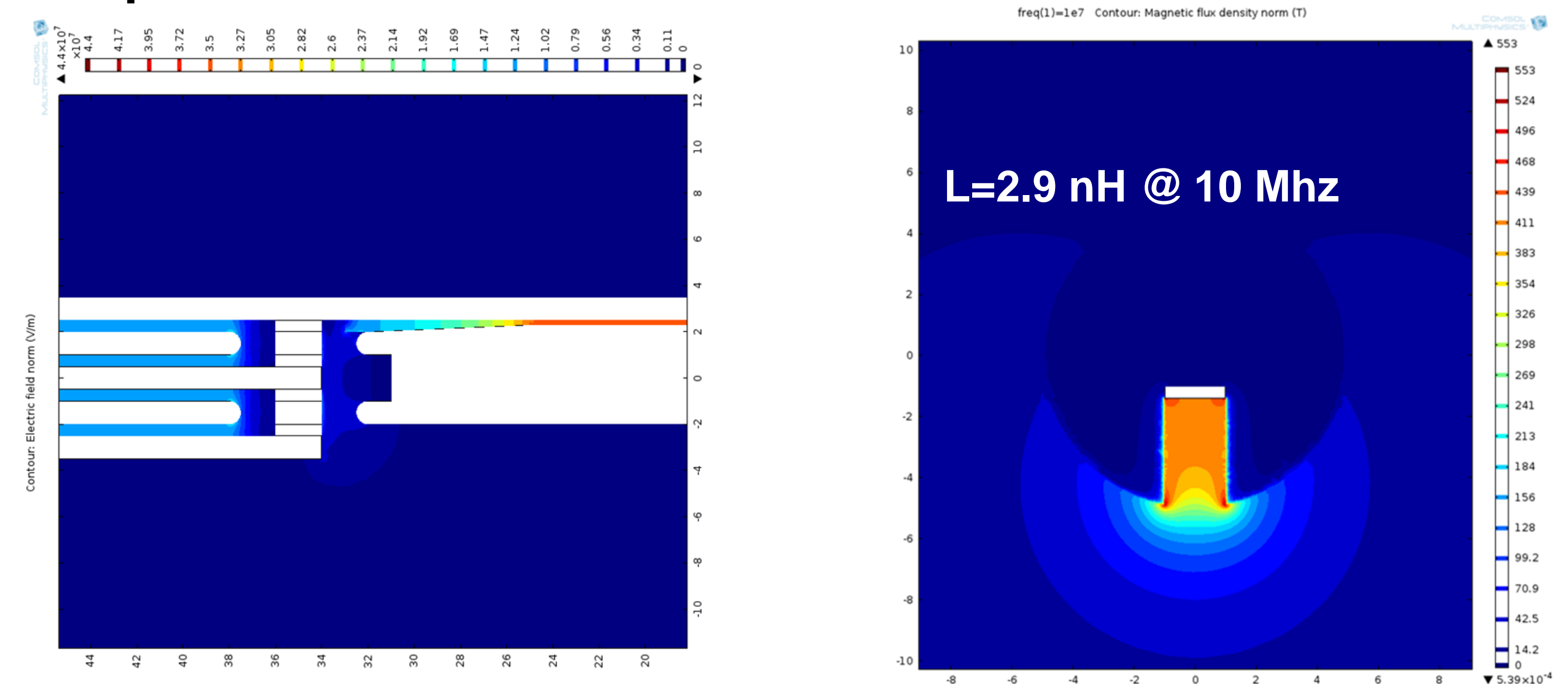


Figure 3. Electric fields in the convolute region.

Figure 4. Magnetic fields at load.

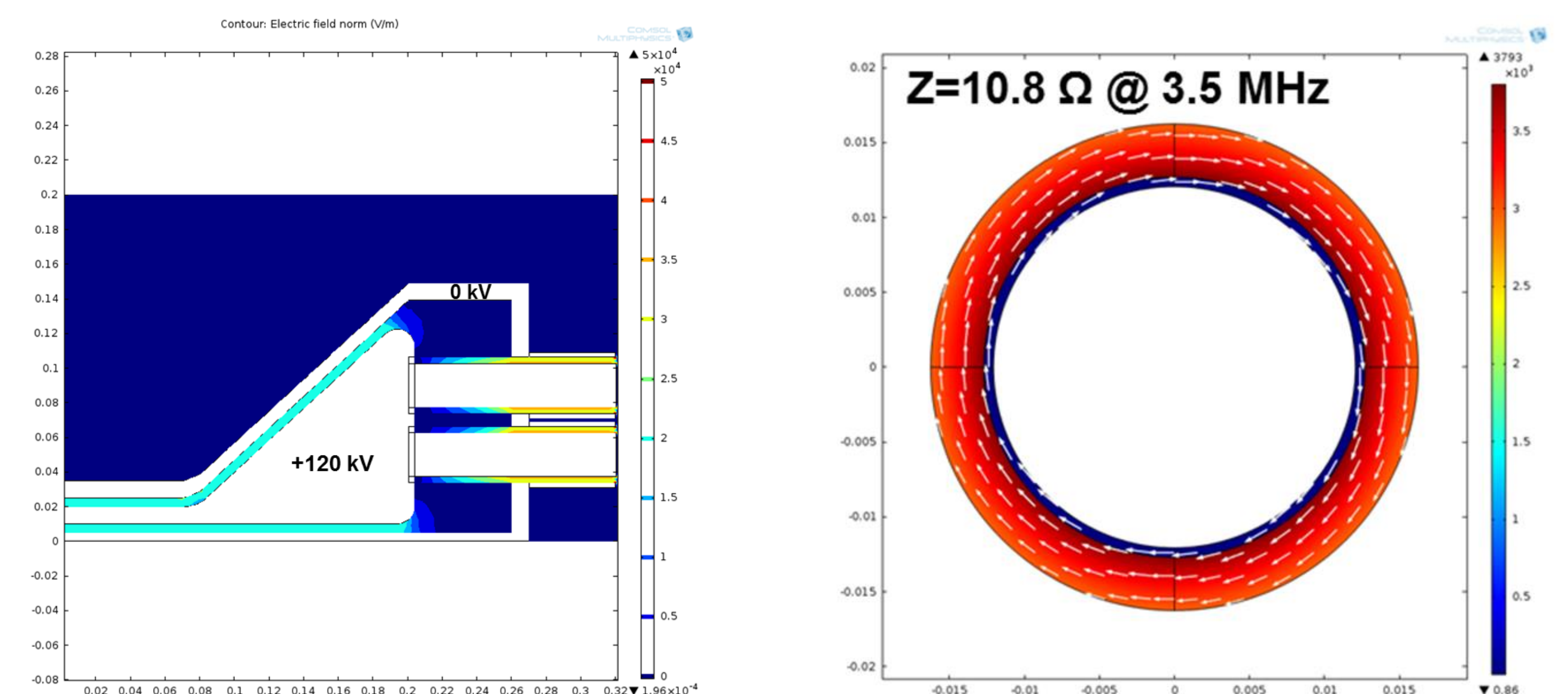


Figure 5. Electric fields at the cable connection.

Figure 6. Calculation of Z for the coaxial cable.

Conclusion: COMSOL was used to optimize the design by maximizing power delivery while maintaining margin against electrical breakdown. Calculated circuit parameters such as Z and L were used in a (MHD) code. Using this approach, 50% of capacitor energy can be delivered to the load.

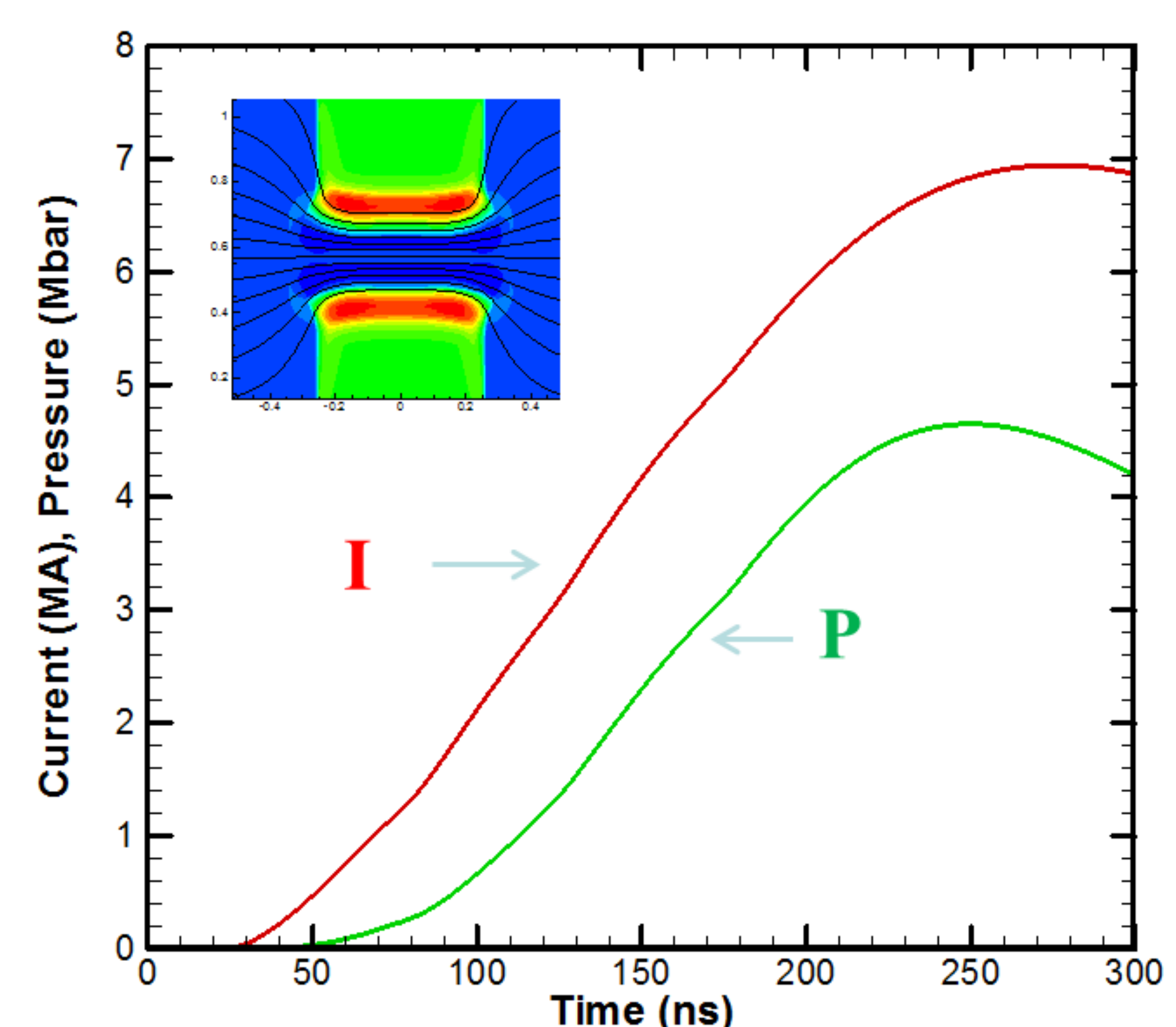


Figure 7. Calculation of current (I) and pressure (P) in a stripline geometry using a magnetohydrodynamic (MHD) code. 80 kJ are transferred to the load with a maximum pressure of 5 Mbar (500 GPa).