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Power Loss in the MAGLIF Post-Hole Convolute

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Introduction

The convolute for MAGLIF experiments has a measurable current loss on order of 2-3 MA[1]. The bulk of this loss is attributed to inefficiencies in the inner MITL and post-hole convolute (PHC) regions. Understanding the mechanisms of convolute power loss is important for improving power coupling into the MAGLIF liner and other targets used on Z. Additionally, mitigating power loss is a must for Next Generation Pulsed Power (NGPP), which could operate at 60-70 MA currents[2].

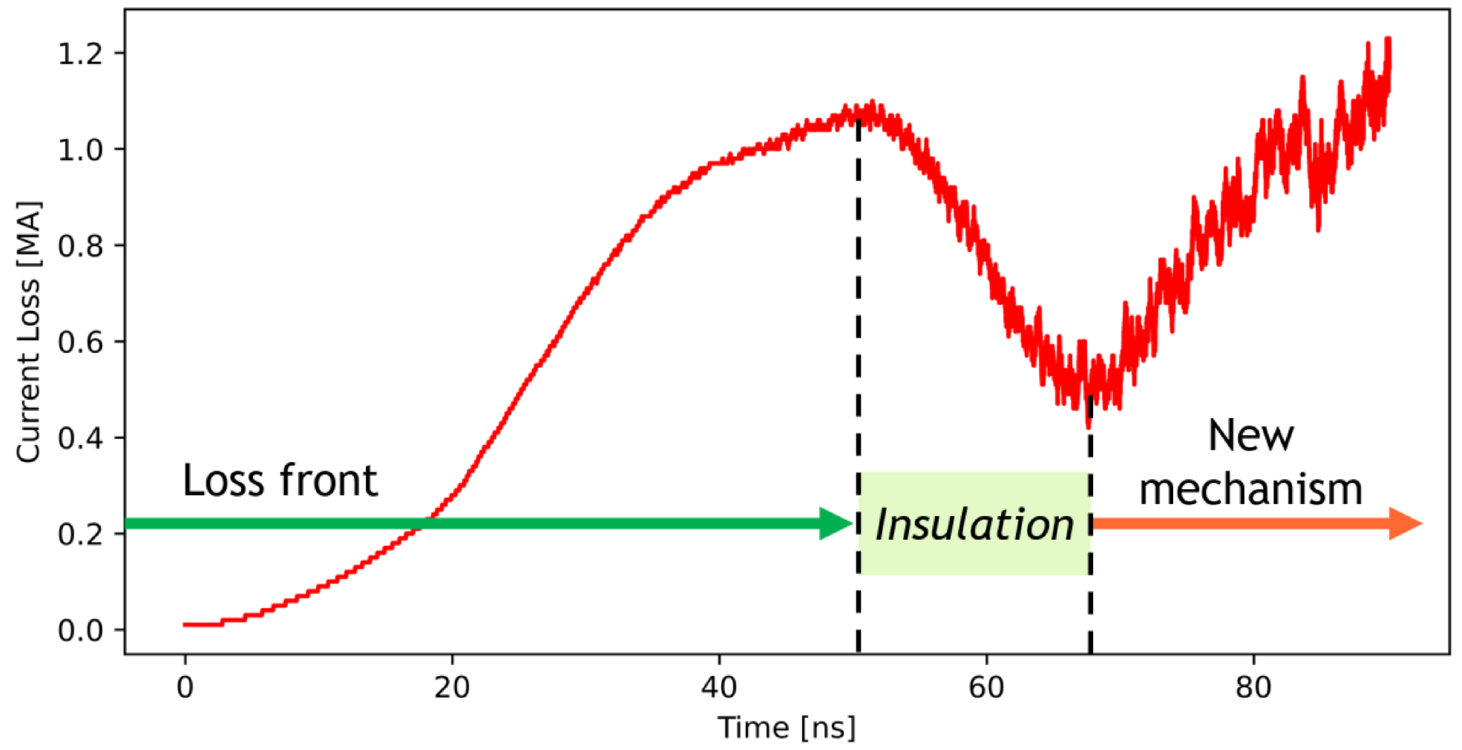

Figure 1. Current loss in post-hole convolute region.

Post-hole convolute

Post-hole convolutes are a required component in current-adding geometries. The hole in the cathode is considered problematic, as it produces magnetic nulls and breaks magnetic insulation for electrons[3]. The presence of electrode plasma in magnetic null regions enables MA current transport.

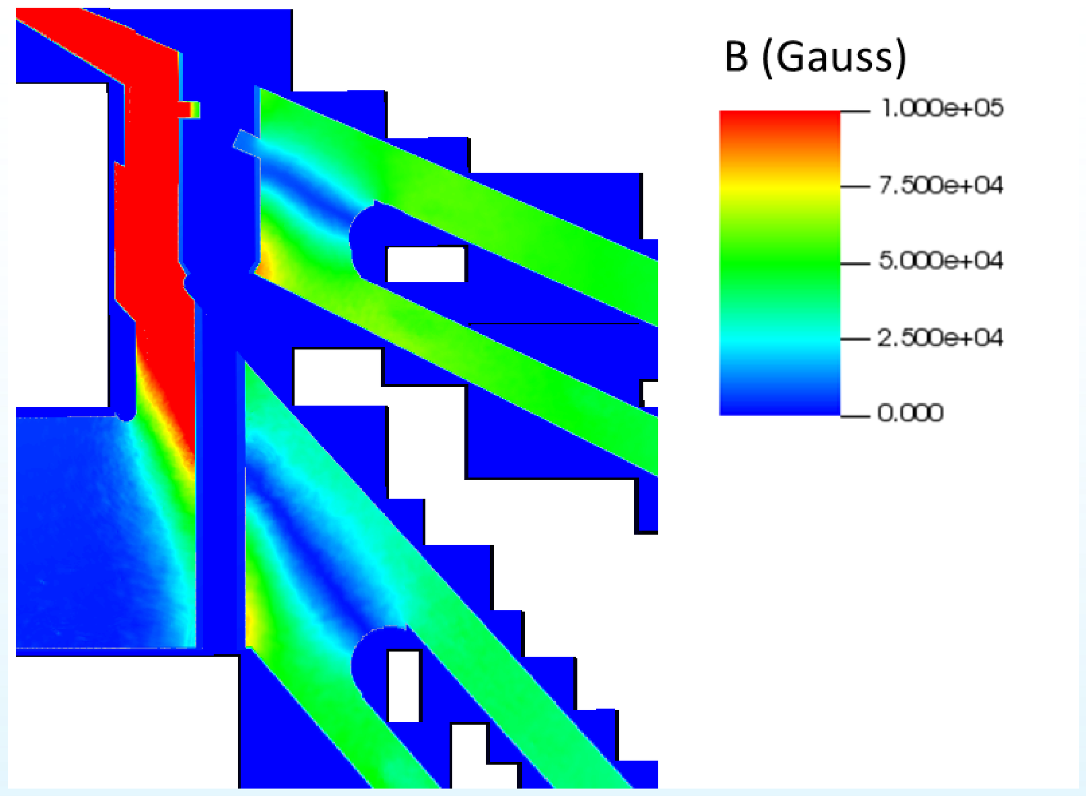

Figure 2. Magnetic nulls in post-hole convolute (t = 80 ns).

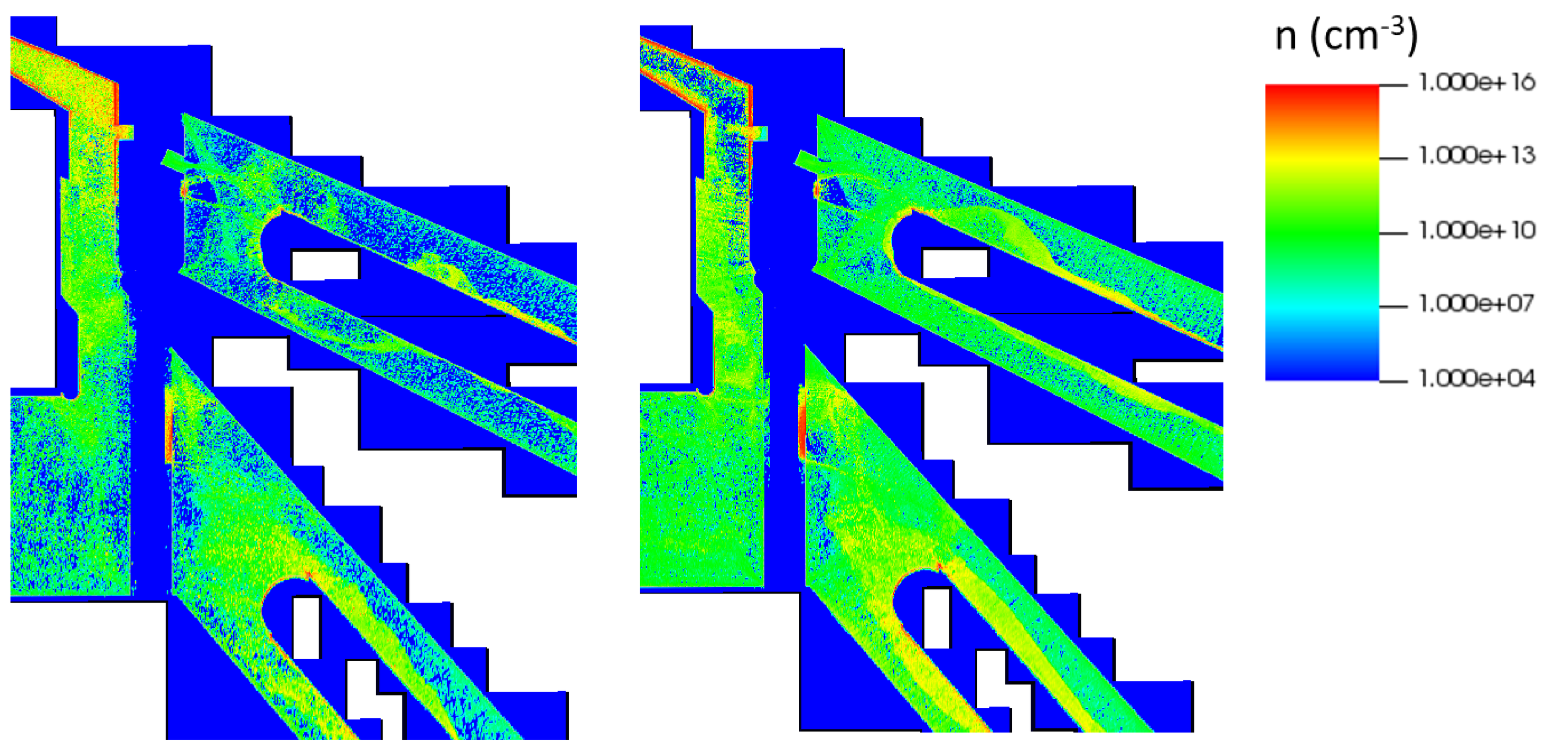

Figure 3. Ion density of H^+ (left) and O^+ (right) at 90 ns.

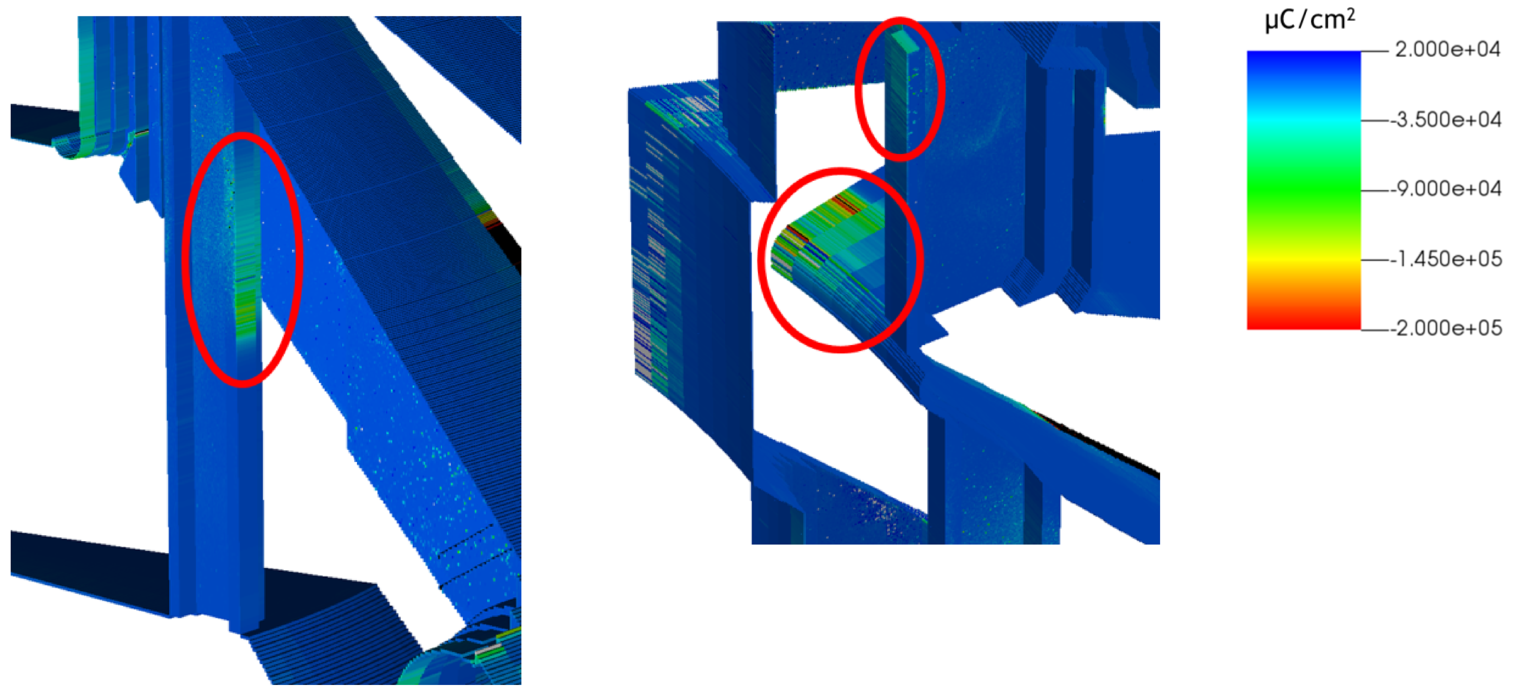

Figure 4. Charge density at electrode surfaces indicating MA/cm[2] current loss (t = 90 ns).

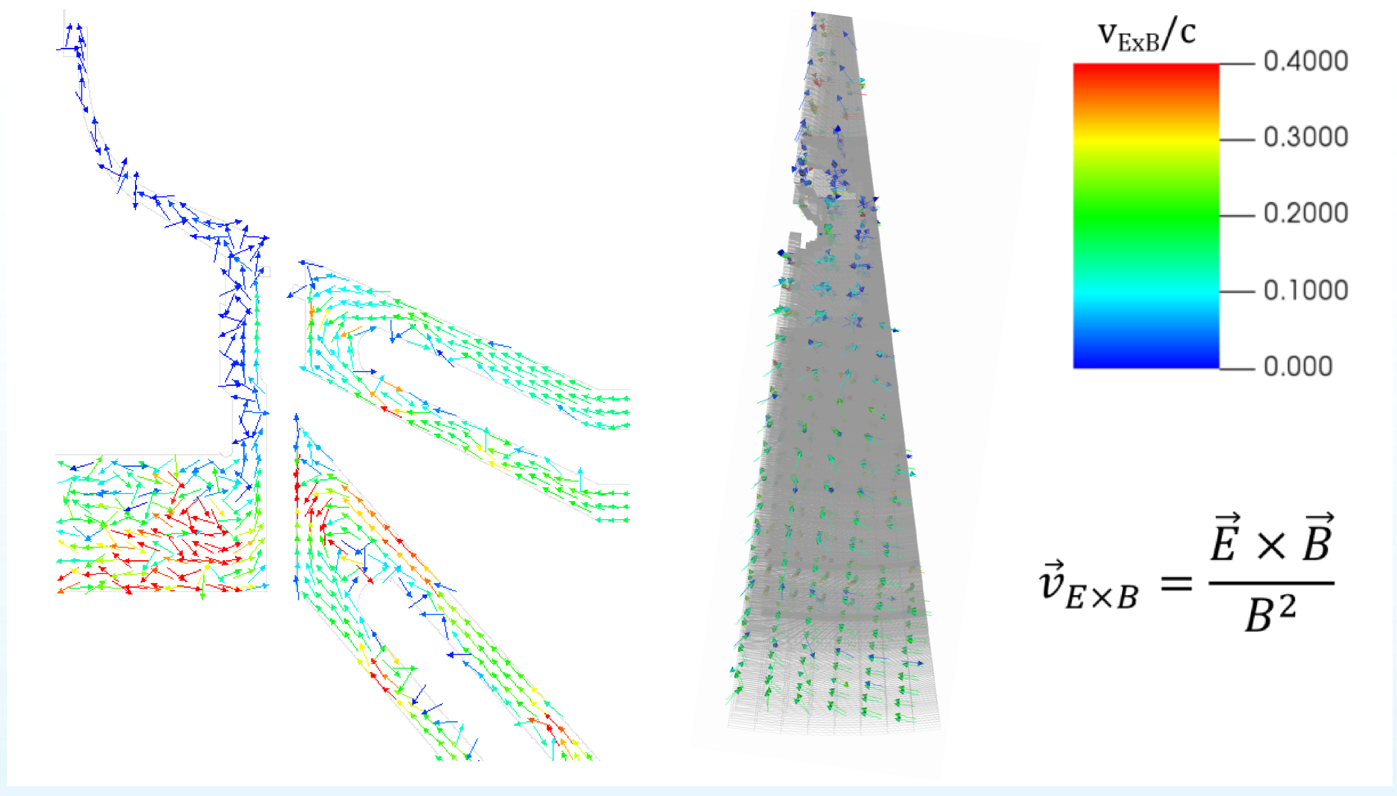

Figure 5. ExB drift vectors in the convolute (t = 90 ns). Note that 0.1 c ≈ 3 cm/ns.

Simulation

The MAGLIF post-hole convolute was kinetically simulated using CHICAGO, a particle-in-cell code. Electrode plasma was modeled from first principles by accounting for thermal desorption, ionization, and fragmentation of H_2O molecules from the anode[4]. Electric and magnetic fields were solved on a finite-difference time-domain (FDTD) mesh. Current and voltage probes monitored power loss across the post-hole convolute. Particles were moved with an magnetically implicit algorithm[5].

Results

Thermal desorption of water creates a significant volume of electrode plasma as seen in Figure 3. The plasma is dominated by H^+ and O^+ ions formed through electron collisions. Heavy ions are uninsulated by anode current and can cross the AK gap and short the transmission line. The electrode plasma (ions & electrons) also ExB drift from the outer MITL to the post-hole convolute (PHC) at a rate on order of 5 cm/ns. Once in the PHC, the plasma-filled volume can deliver MA/cm^2 current densities to the post.

Conclusion

The simulated current loss in the post-hole convolute is consistent with previous simulations completed by Rose et al[3]. However, this simulation allows the organic evolution of electrode plasma via thermal desorption of H_2O from anode surfaces, as opposed to electrode plasma injection. Electrode plasma formed in the outer MITL leads to MA-level current transport within the PHC, demonstrating the need to suppress outer MITL plasma formation.

Acknowledgements

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