HIIPER Space Propulsion Simulation Using Plasma Module

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INTRODUCTION: HIIPER (Helicon Injected Inertial Plasma Electrostatic Rocket) is simulated by coupling magnetic fields with plasma and electromagnetic waves. Charged particle tracing is used to determine ion trajectories through the resulting electric and magnetic fields within the helicon tube and vacuum chamber. Particle trajectories pinpoint adverse sections in the design leading to significant ion losses [1][2].

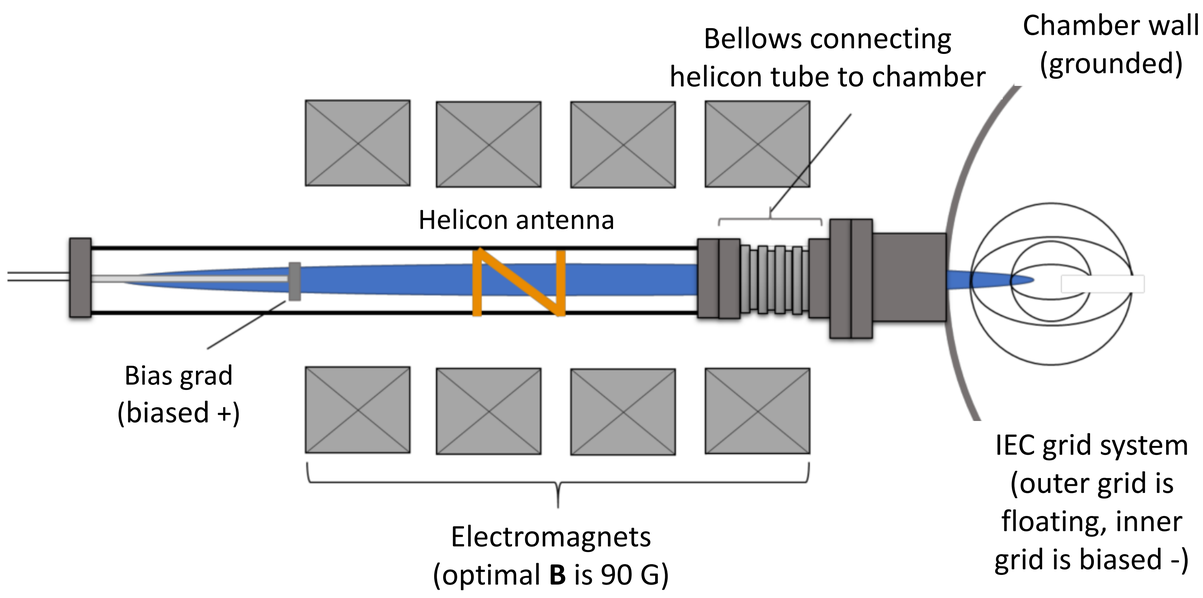

Figure 1. HIIPER diagram

COMPUTATIONAL METHODS: The model is separable into three parts: magnetics, plasma and electromagnetic waves, and charged particle tracing. Helicon waves are not explicitly included. The computational pipeline and model diagram is as follows:

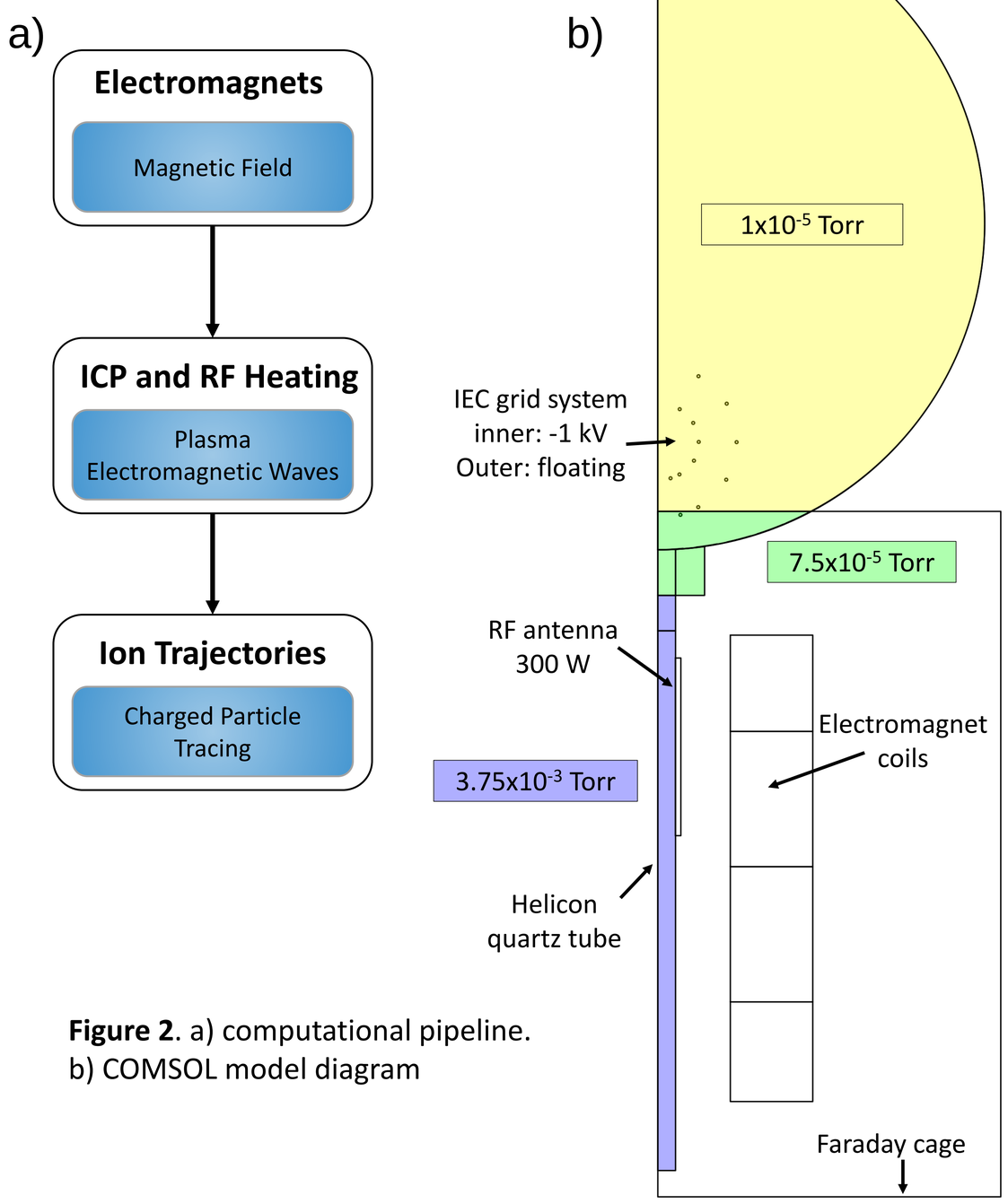

Figure 2. a) computational pipeline. b) COMSOL model diagram

RESULTS: Simulation capable of modeling the system including the effects of the magnetic coils and plasma coupling to the RF antenna. Electron density is localized at the antenna with a magnitude analogous to a helicon mode plasma – $1x10^{19}$ electrons/m^3. Ion trajectories plotted for 200 ions placed near the maximum ion density.

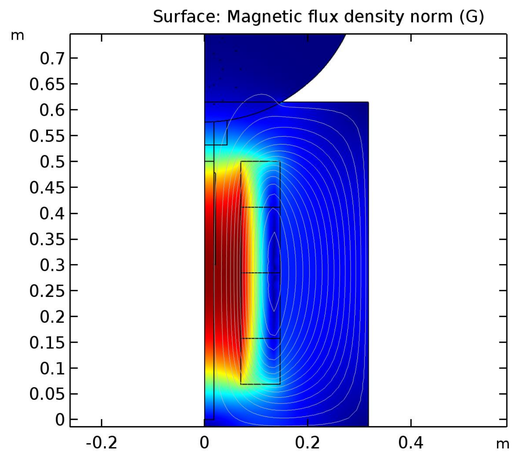

Figure 3. Magnetic flux density

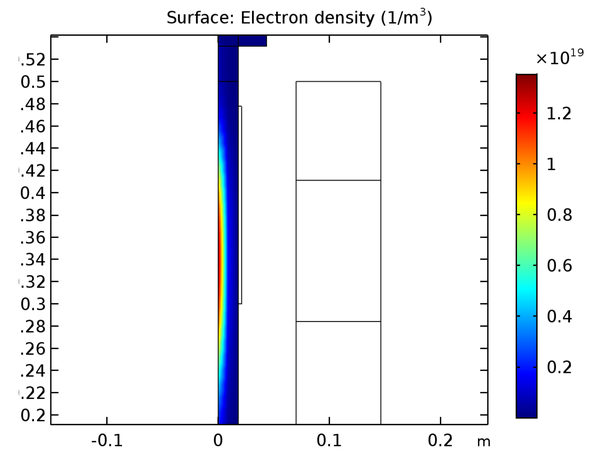

Figure 4. Electron density

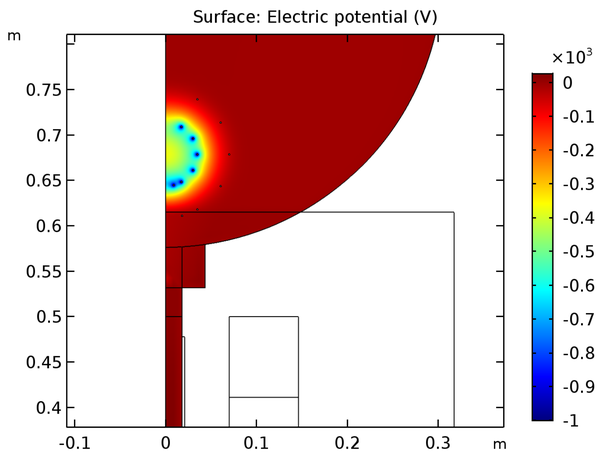

Figure 5. Electric potential

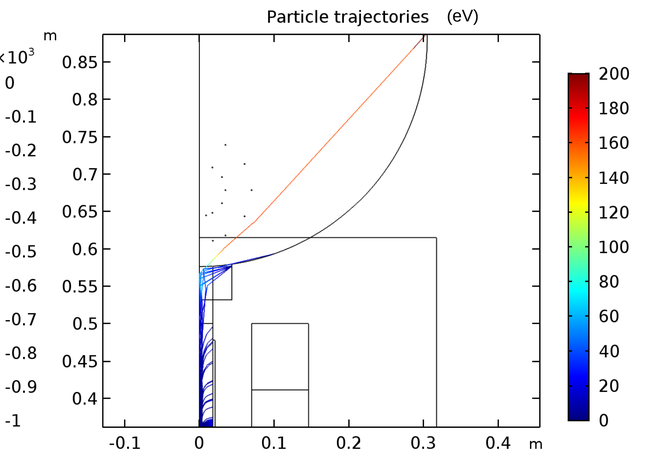

Figure 6. Ion trajectories

CONCLUSIONS: The simulation suggests that nearly all of the ions are lost to the walls before exiting the helicon tube. The model did produce electron densities on the order found with Langmuir probes, however, the Langmuir probes were at the exit of the helicon tube and did not analyze near the antenna. A more thorough examination with the Langmuir probe is needed to validate the model. Extraction electrodes are being implemented to overcome the drastic ion losses – Fig. 7.

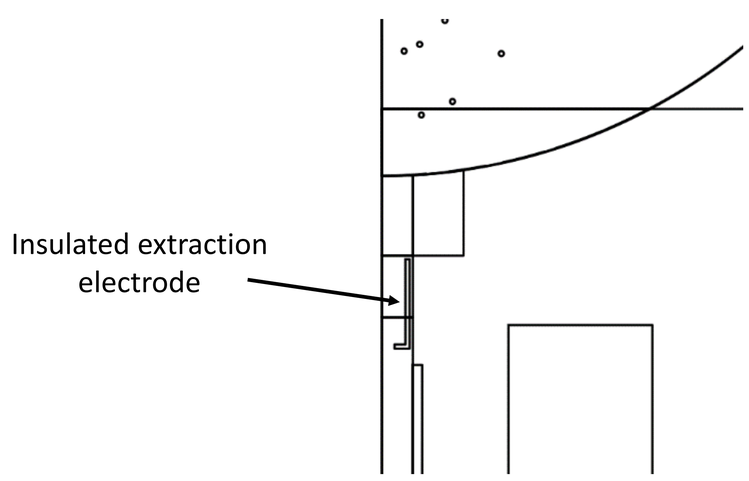

Figure 7. Schematic with extraction electrode

REFERENCES:

1. D. M. Ahern *et al.*, "Experimental Studies of the Helicon Injected Inertial Plasma Electrostatic Rocket (HIIPER)," *53rd AIAA/SAE/ASEE Jt. Propuls. Conf.*, no. July, pp. 1–12, 2017.
2. Z. Chen, D. Ahern, and G. H. Miley, "HIIPER Space Propulsion Simulation Using AC/DC Module," in *2017 COMSOL Conference in Boston*, 2017.