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Experimental Investigation of Hall Thruster Magnetic Field Topography

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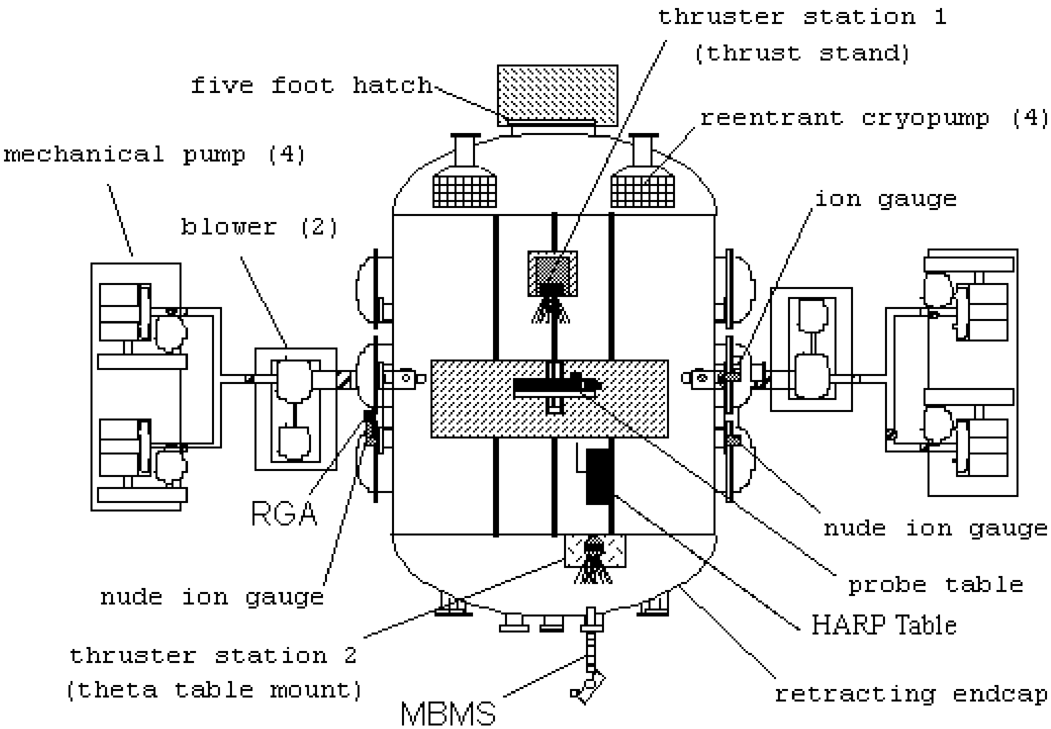
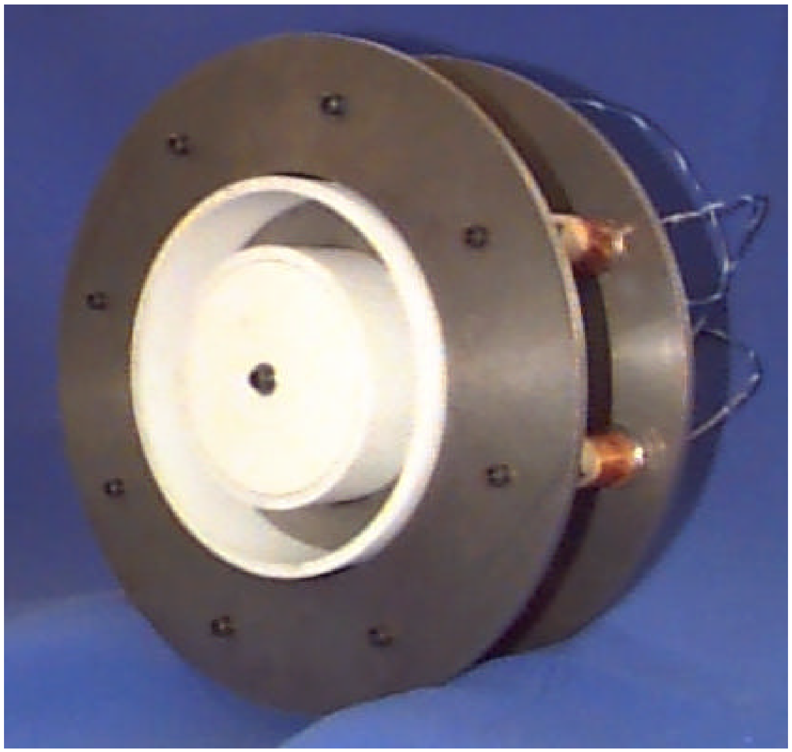
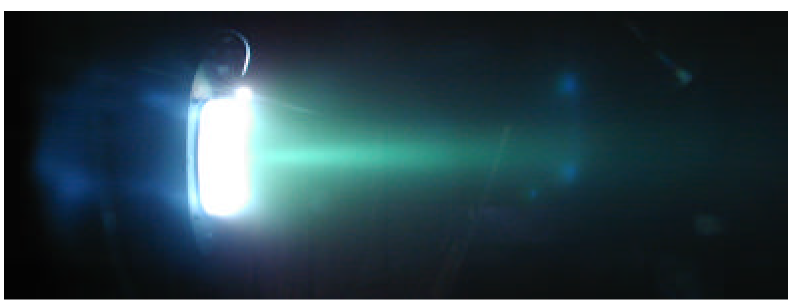
Large Vacuum Test Facility

- PEPLs 6 m by 9 m vacuum chamber
- Base Pressure of $2*10^{-7}$ Torr on Air, with pumping speed of 300,000 L/s
- Operating Pressure of $5.1*10^{-6}$ Torr (Thruster Power Level of 1.6 kW) on Xenon, with pumping speed of 140,000 L/s
- Thruster mounted in center of chamber on two-axis linear positioning system



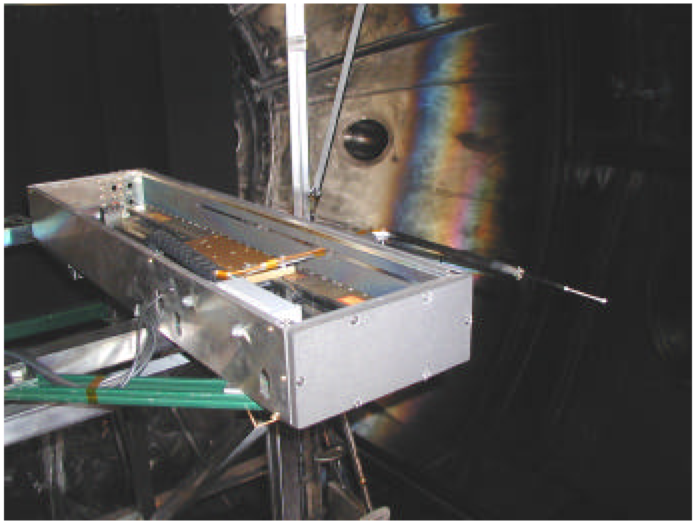
U-M/AFRL P5
5 kW Hall Thruster

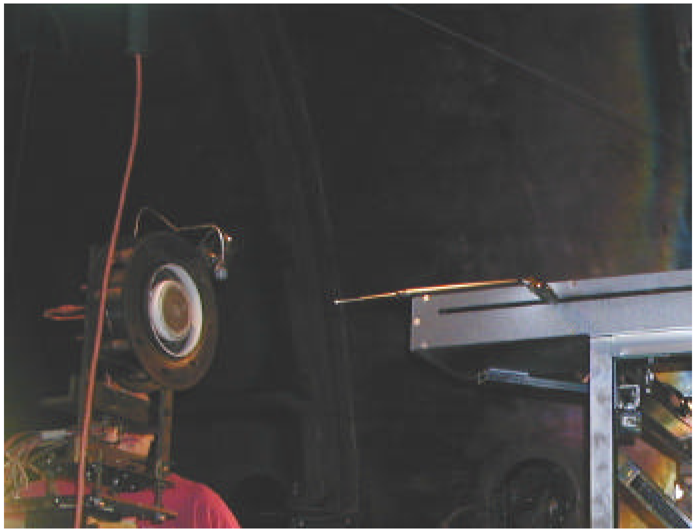




- Developed by PEPL and AFRL
- Comparable thrust, specific impulse, and efficiency of commercial thrusters
- 1.6 kW: 300 V, 5.4 A operating conditions with a thrust of 95 mN, Isp of 1550 sec., and efficiency of 48 %
- 3 kW: 300 V, 10 A operating condition with a thrust of 180 mN, Isp of 1650 sec., and efficiency of 51%

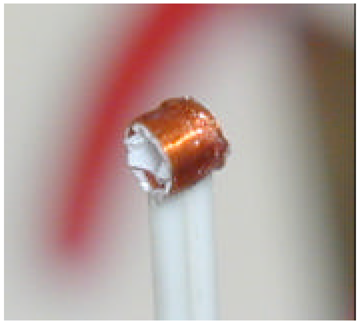
High-Speed Axial Reciprocating Probe (HARP) Positioning System



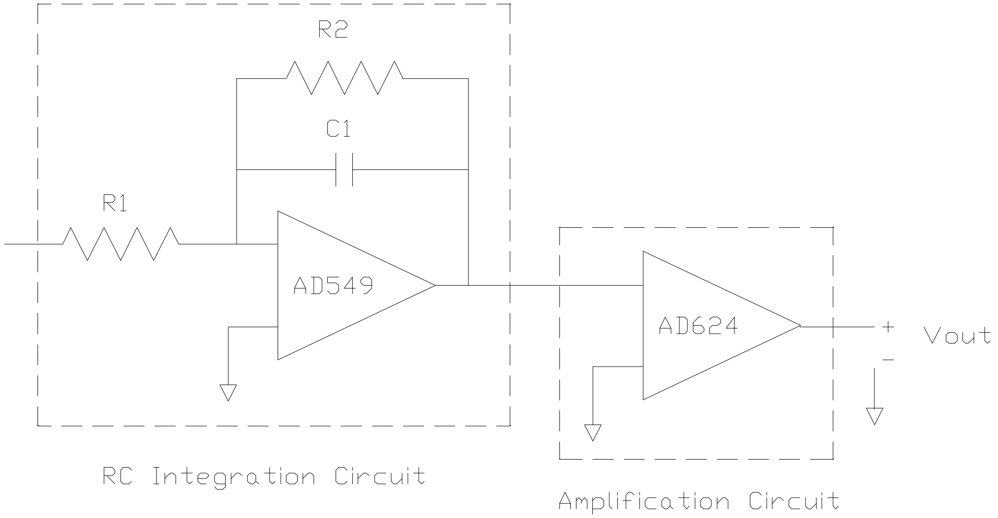


- Goal of the HARP system is to minimize the perturbation to the plasma in the discharge channel of a Hall thruster
- Residence time of a probe in the discharge channel is less than 80 ms
- Short probe exposure time to the plasma reduces probe heating, thus cooling is not required
- Short probe exposure time to the plasma reduces possible probe ablation and sputtering

B-Dot Probe/Circuit Design and Theory



- Coil Inner Diameter: 2.4 mm
- Number of Turns: 86



- Outer Probe Diameter: 4.3 mm
- Outer Probe Width: 4.0 mm

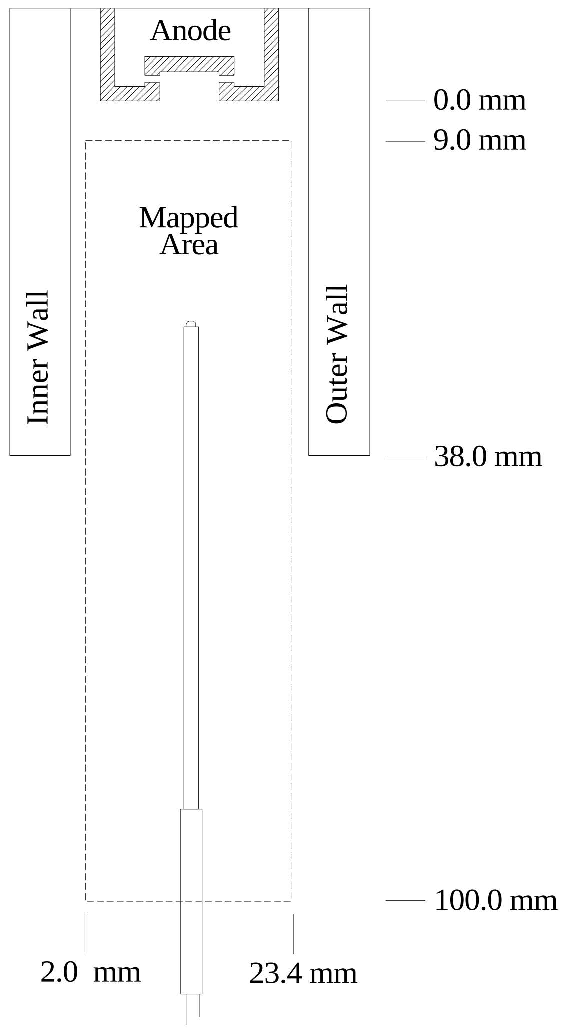
B-dot Probe Output Voltage

$$V = nA\frac{dB}{dt}$$

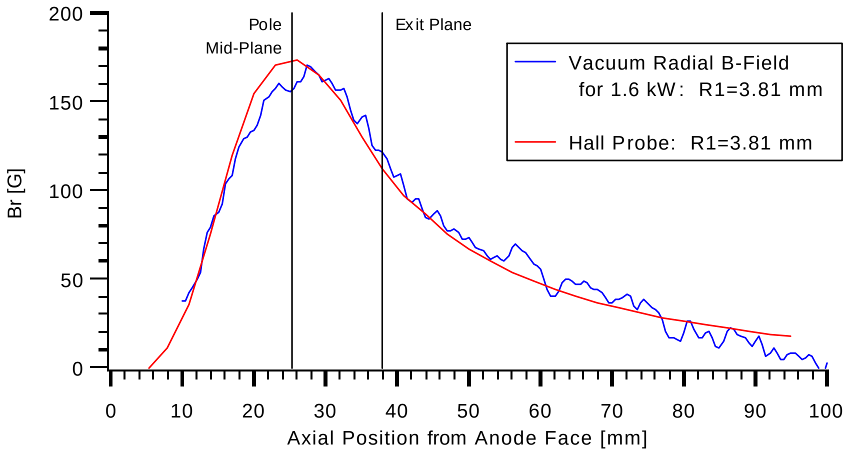
After Integration:

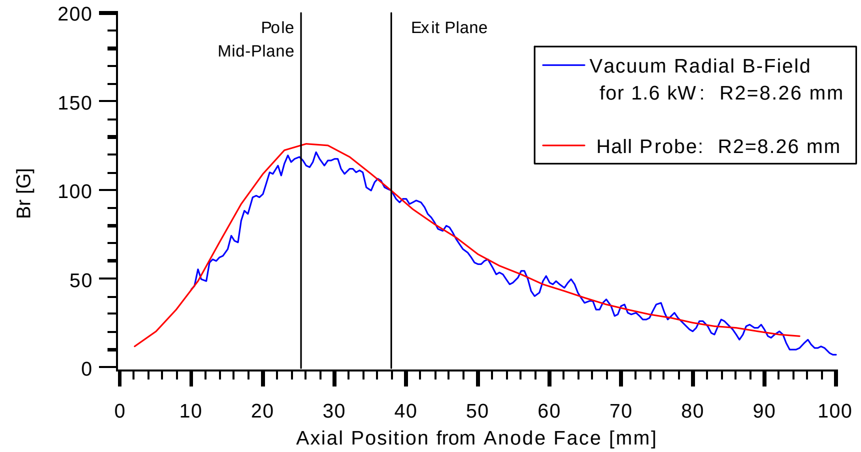
$$V = \frac{nA}{RC}B$$

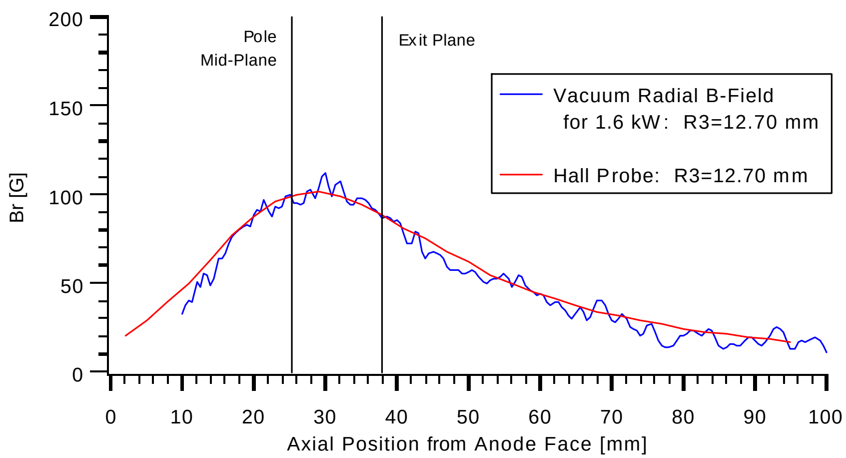
Data Collection Area

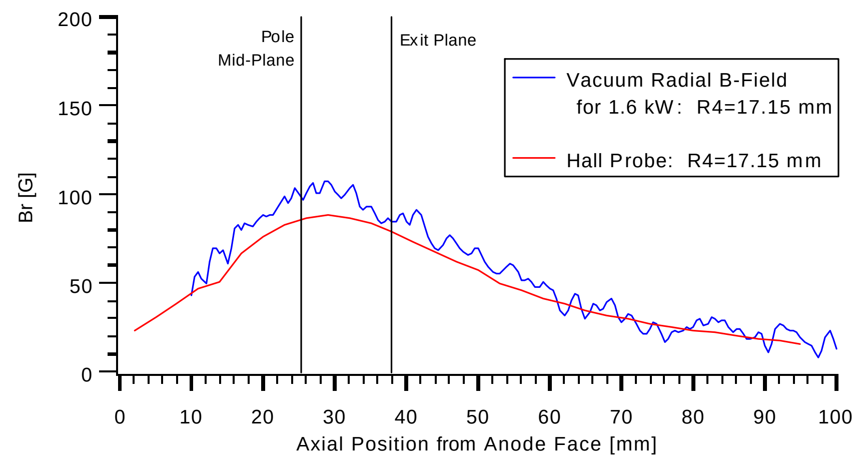


Experimental Results for the 1.6 kW Power Condition: Vacuum Case









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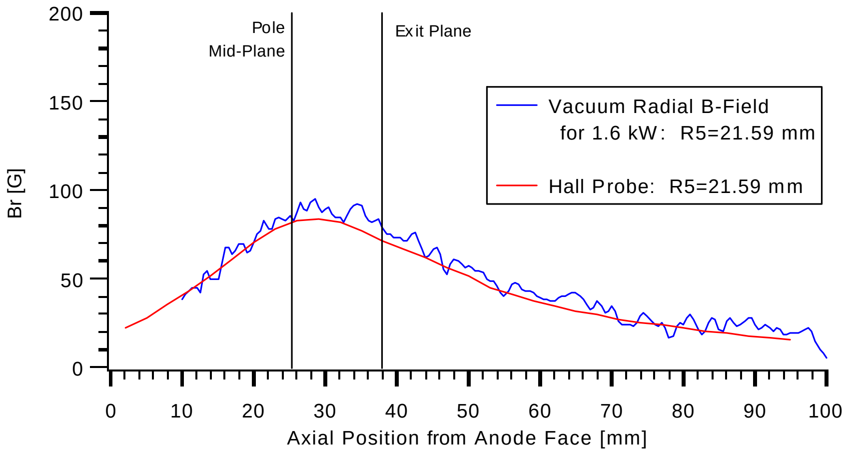
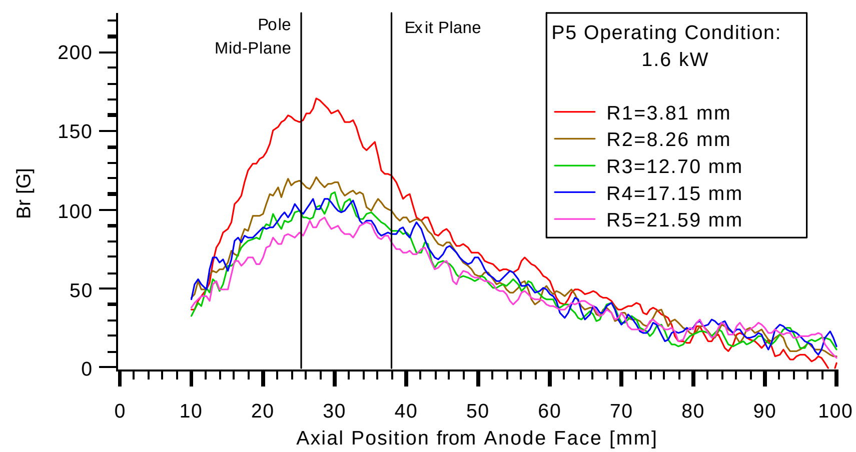
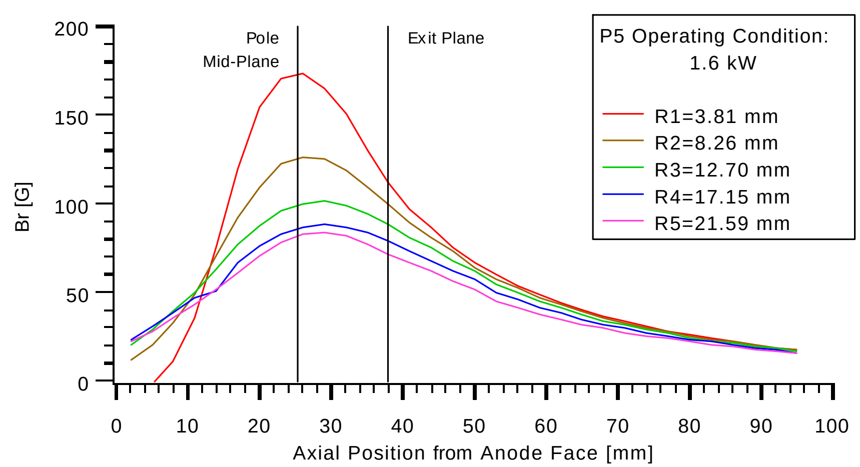
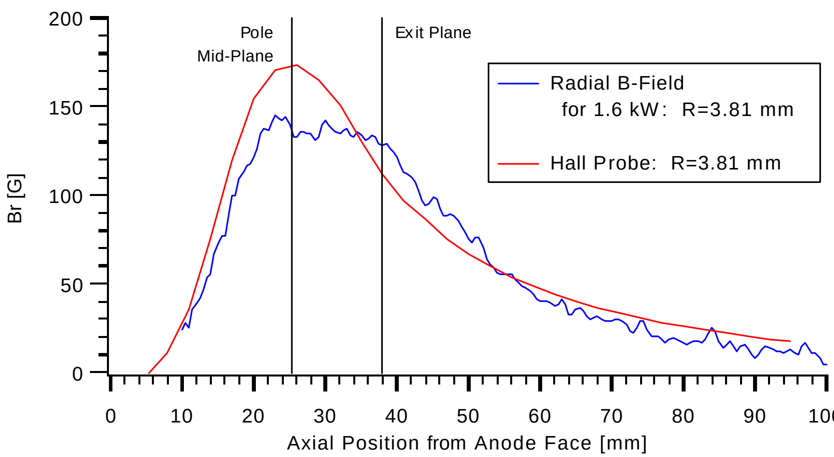
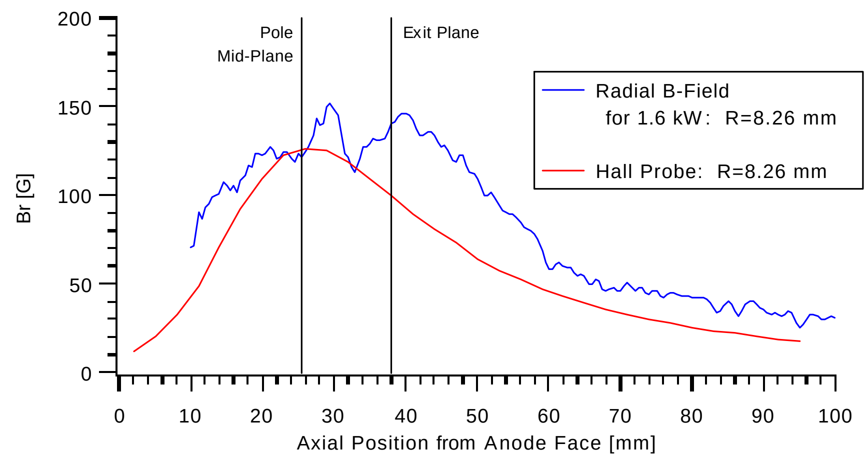


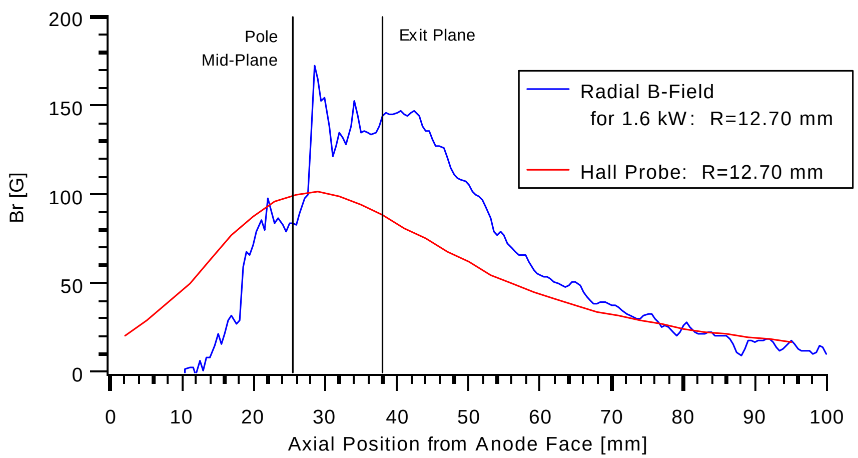


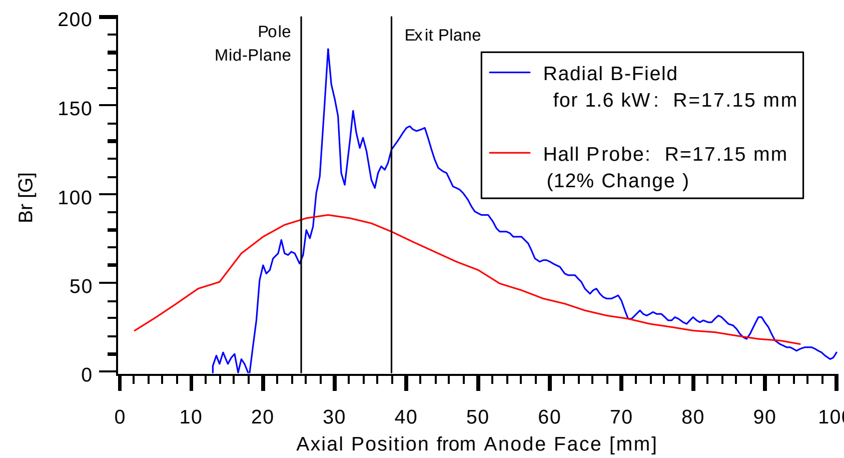


Experimental Results for the 1.6 kW Power Condition: Plasma Case









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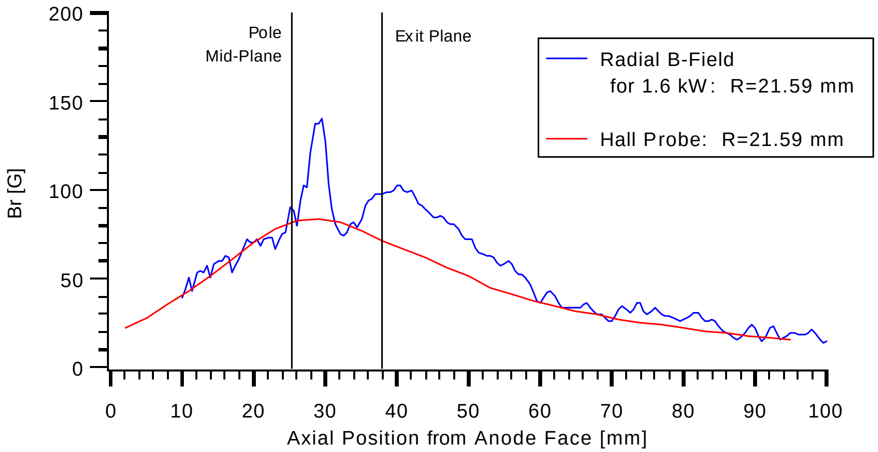
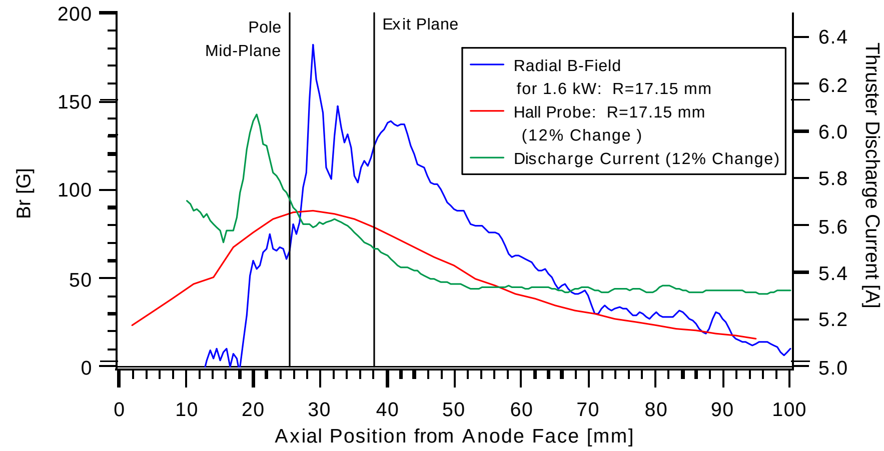
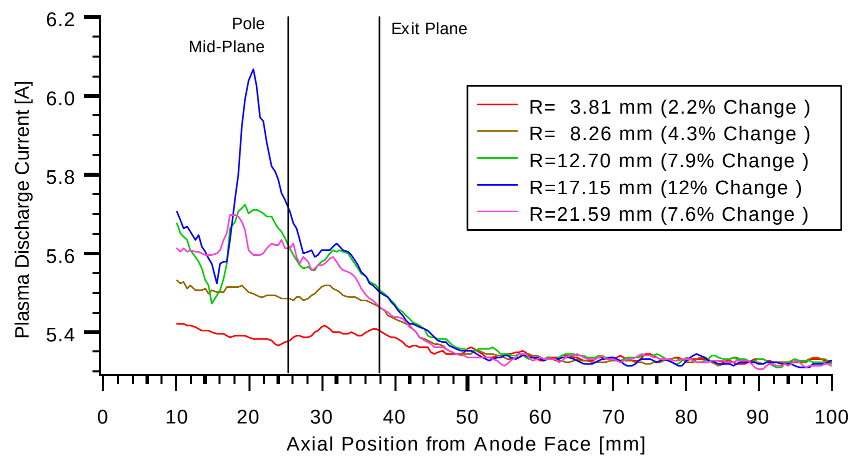


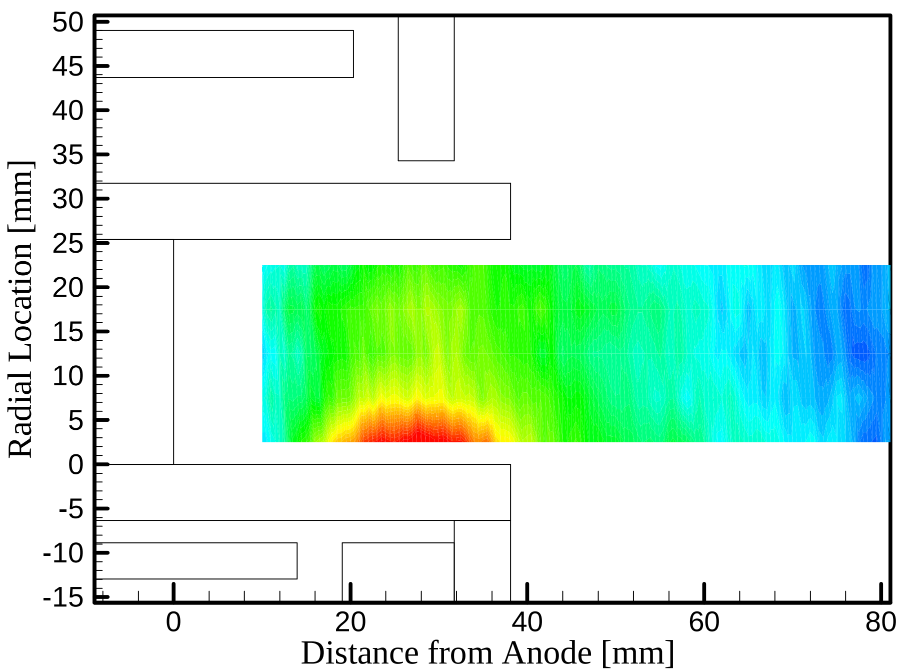


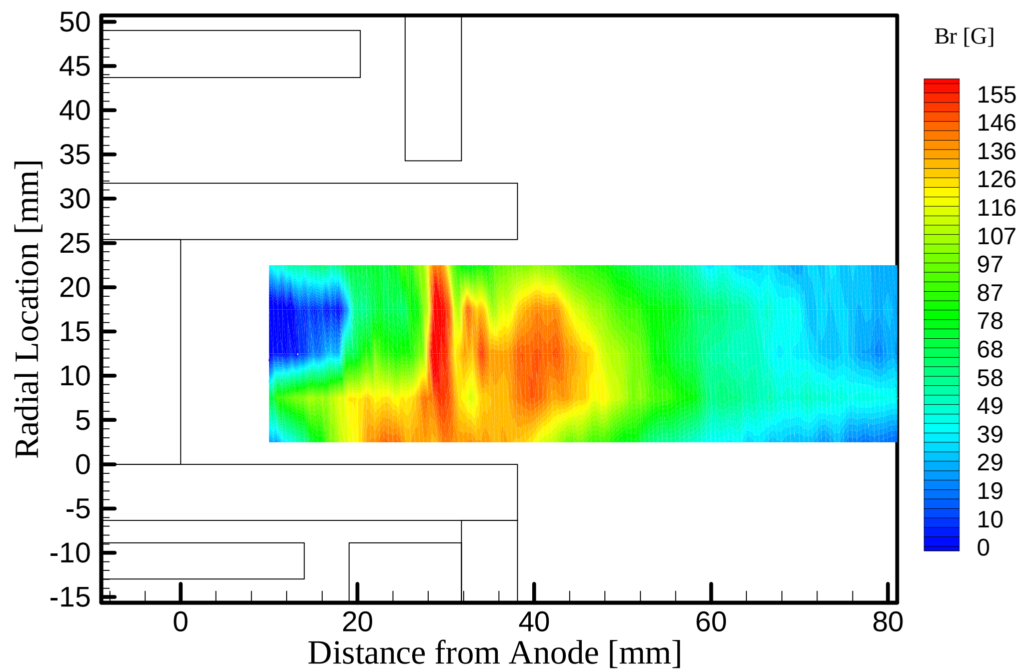


Experimental Results for the 1.6 kW Power Condition: Vacuum & Plasma

Vacuum Radial Magnetic Field

Radial Magnetic Field with Plasma





Conclusions & Future Work

- Radial Magnetic Field for the 1.6 kW Plasma varies from the Vacuum Field Measurements
- Results Impact Efforts to Design Next-Generation Hall Thrusters in that Current Modeling Packages may not Accurately Predict Operational Magnetic Field Topography
- Magnetic Field Variation Corresponds Spatially with Estimated Location of Maximum Electron ExB Drift Velocity
- Future Work will Involve Measurements at Higher Thruster Power Levels as well as the Measurement of Axial and Azimuthal Magnetic Fields

Hall Current Topography