

Plasma Density Measurements Inside a Laboratory Model Hall Thruster Using a Resonance Probe Diagnostic

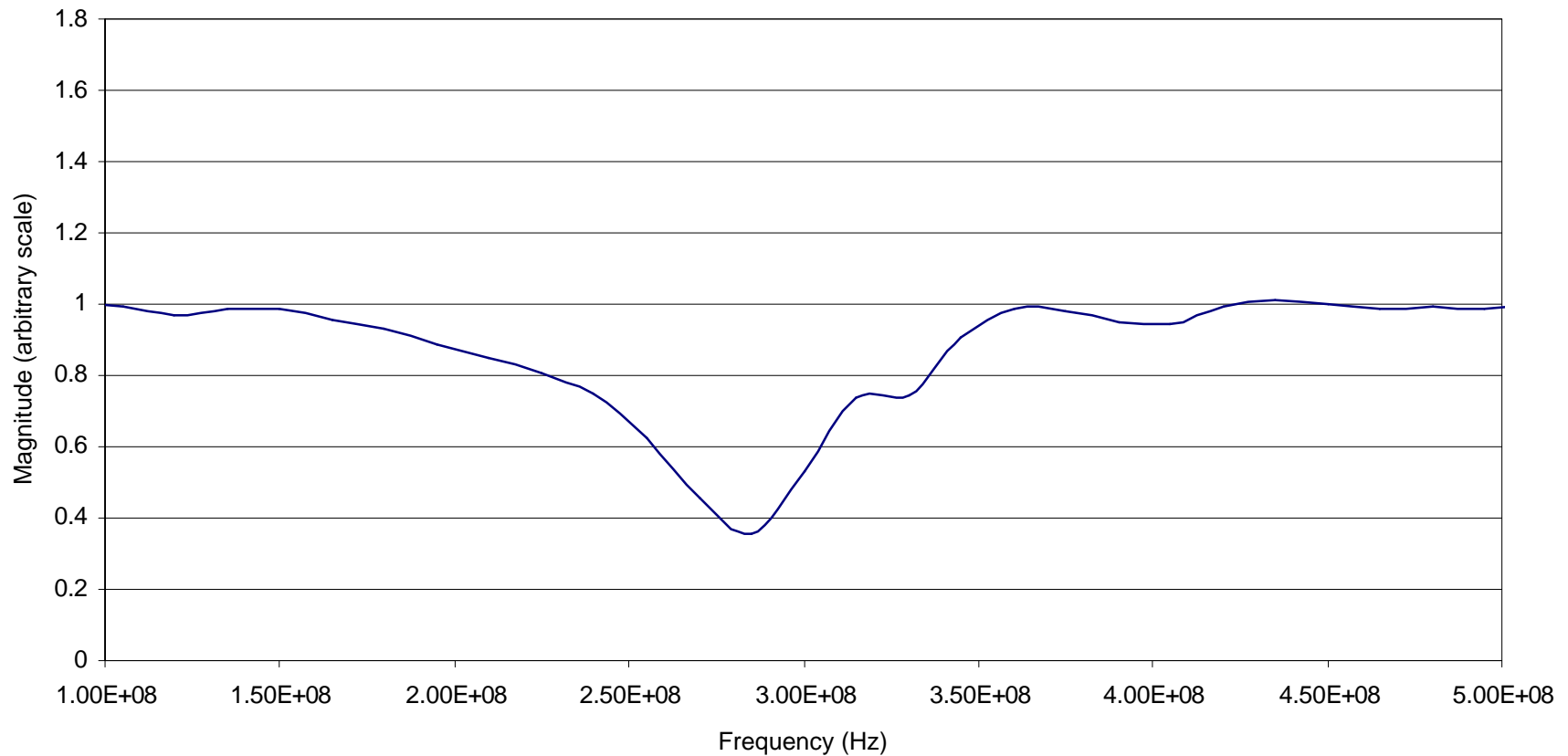
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Resonance Probe Trace





Plasma Models



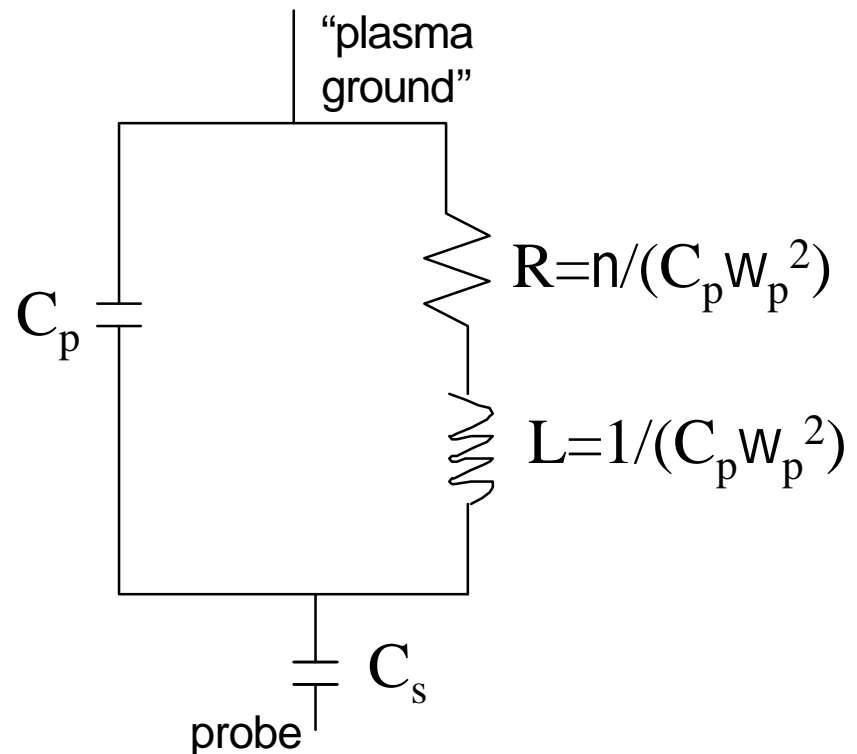
Old Model:

Resonance at upper hybrid frequency

$$\omega_{uh}^2 = \omega_p^2 + \omega_{ce}^2$$

$$\omega_p^2 = e^2 n_e / \epsilon_0 m_e$$

New Model:





Resonance Formula



$$\left(\frac{\omega_r}{\omega_p}\right)^2 = \frac{(2 + V) - \left(\frac{n}{\omega_p}\right)^2 (1 + V) - \sqrt{\left[\left(\frac{n}{\omega_p}\right)^2 (1 + V) - (2 + V)\right]^2 - 4(1 + V)}}{2(1 + V)}$$

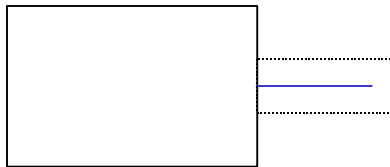
$$\zeta = C_s / C_p$$

ν = electron-neutral collision frequency

ω_r = resonant frequency ω_p = plasma frequency



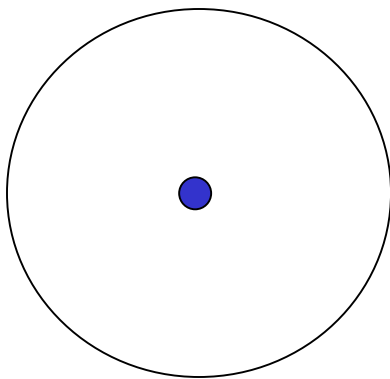
Capacitance Modeling



- Assume a thin sheath

~ 5 times Debye length

$$C_s = \epsilon_0 A_p / s$$



- Probe is small compared to bulk plasma

Model as spherical capacitor

$$C_p = 4\pi\epsilon_0 r$$



Finding z and n



Combining the expression for the Debye length,
 $l_D = (e_0 K T_e / n e^2)^{1/2}$, with the expressions for C_s and C_p gives:

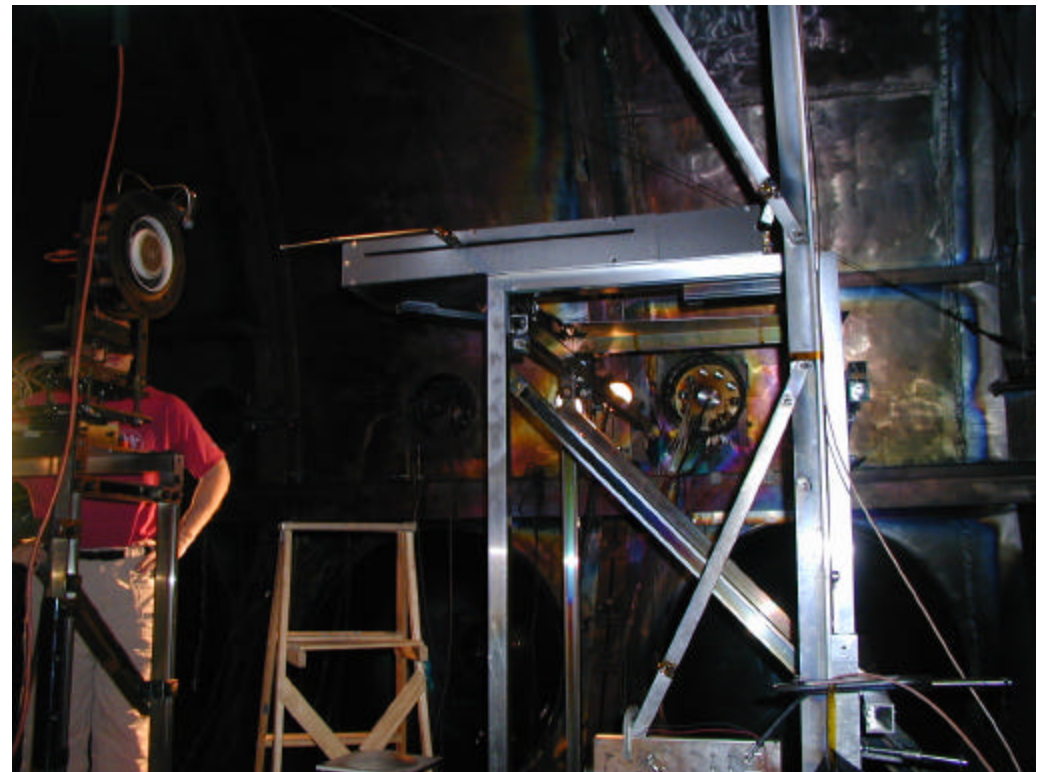
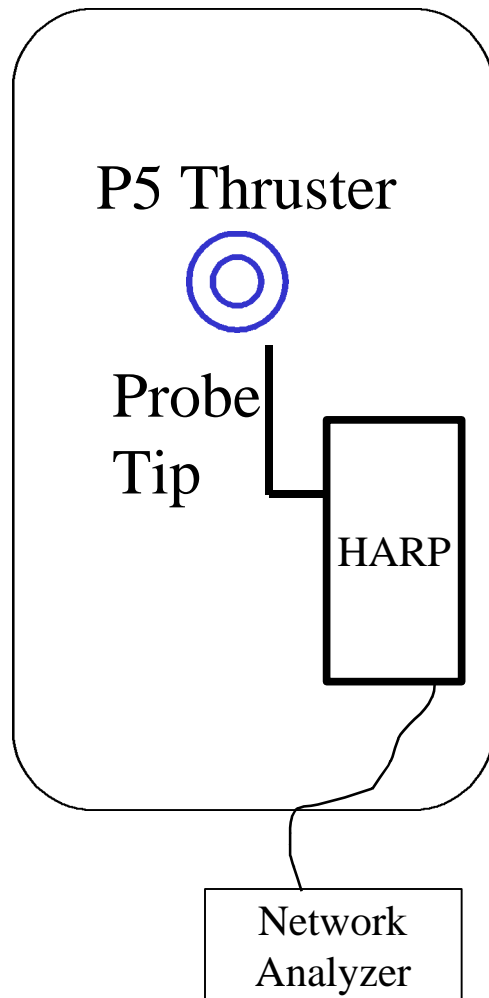
$$V = \frac{w_p}{10} \sqrt{\frac{m_e A_p}{K T_e \rho}}$$

The collision frequency is estimated using the half-width of the resonant peak:

$$\Delta w = \sqrt{2n}$$

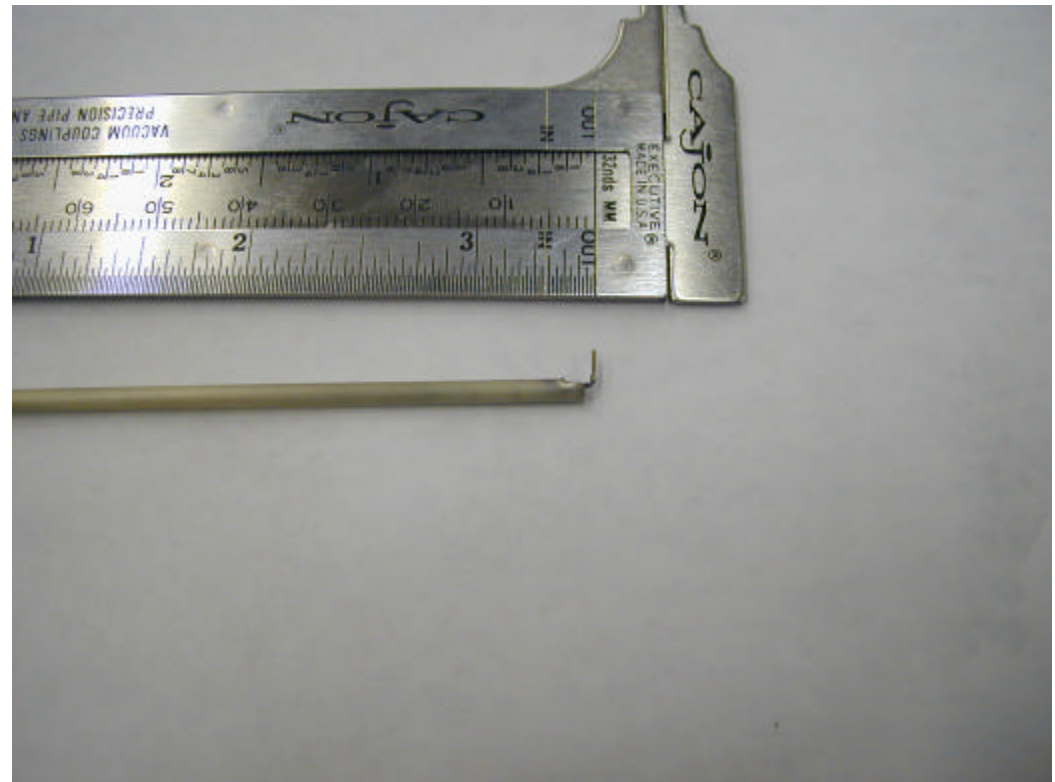
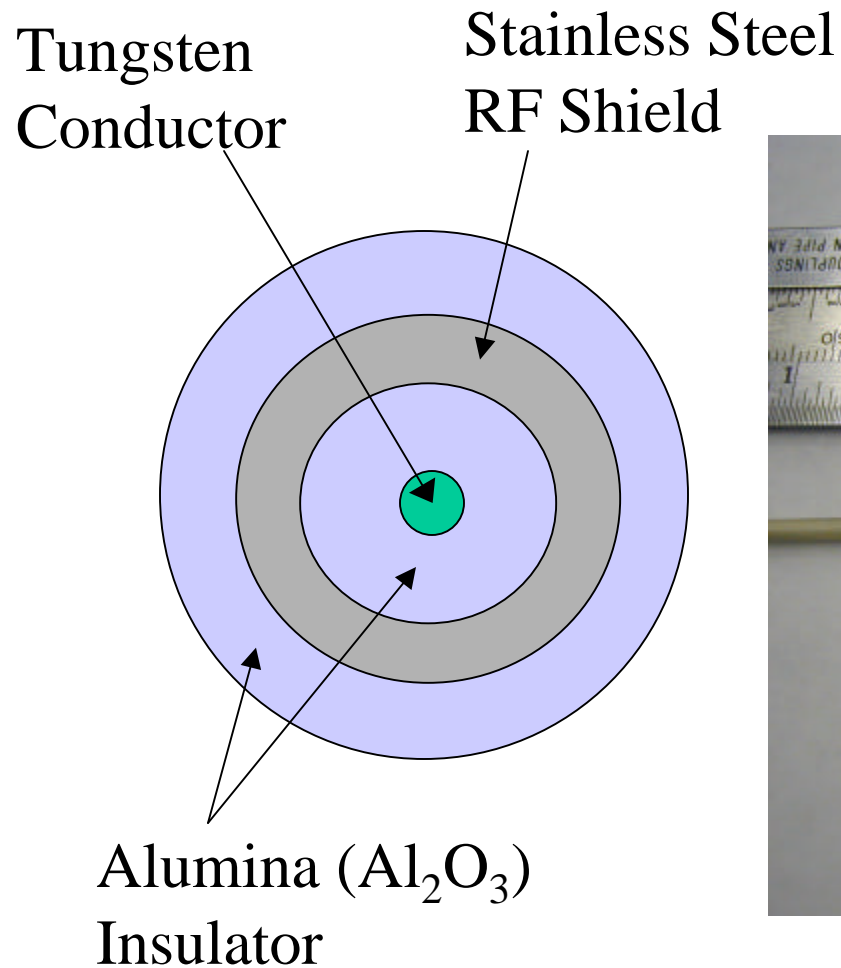


Experimental Setup 1



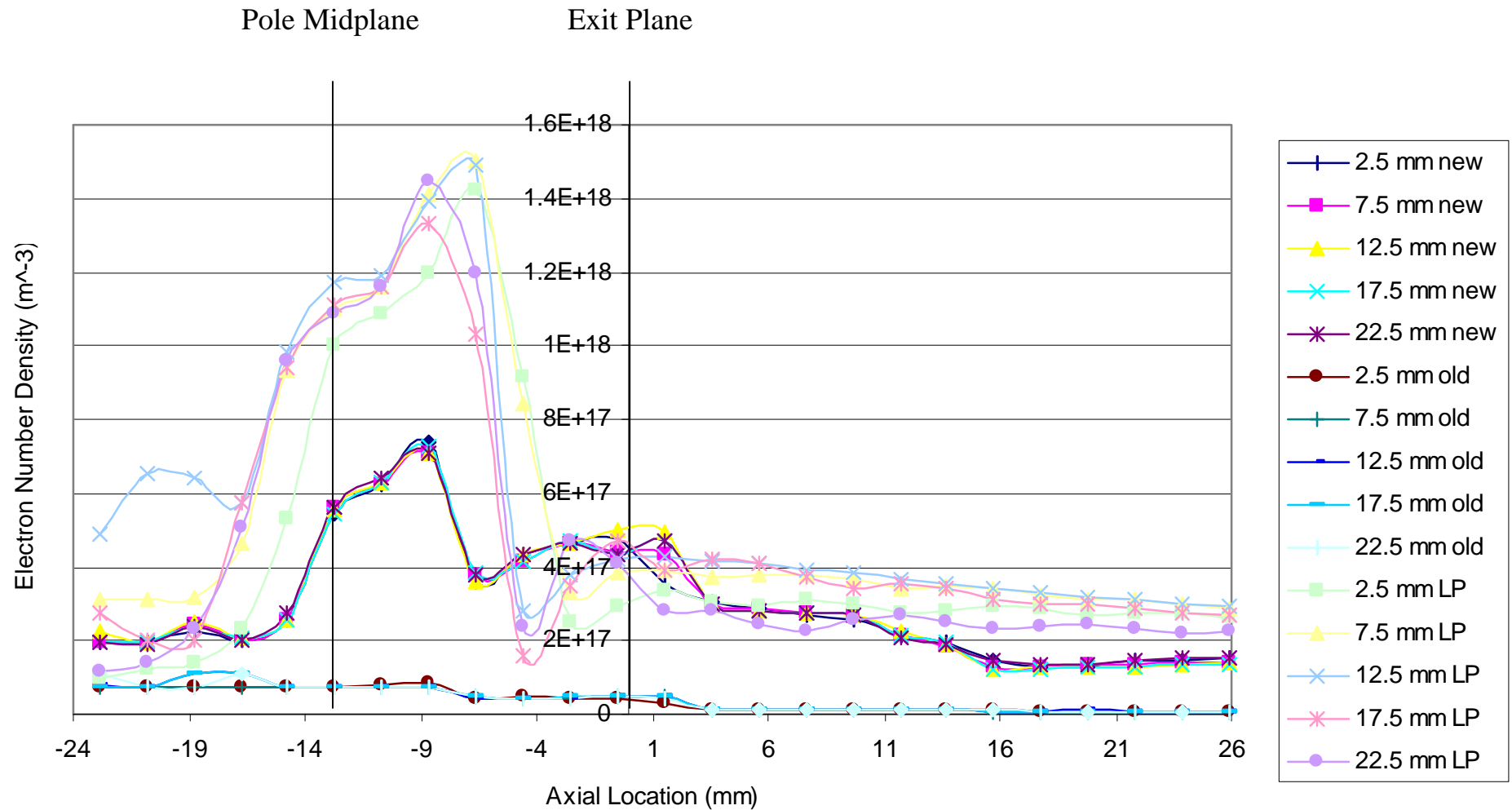


Experimental Setup 2





Results





Conclusions



- The resonance probe is a valuable tool for measuring plasma densities where high spatial and temporal resolution is required.
- This diagnostic can be used as a substitute for the Langmuir probe.
- It is theoretically possible to measure collision frequency, electron number density, and electron temperature with the resonance probe.