Dipole Assisted Inertial Electrostatic Confinement

Yoshikazu Takeyama, Robert Thomas, G.H. Miley

Fusion Studies Laboratory
University of Illinois at Urbana - Champaign

Trends in Fusion Research, Washington DC ,
March 10, 2005

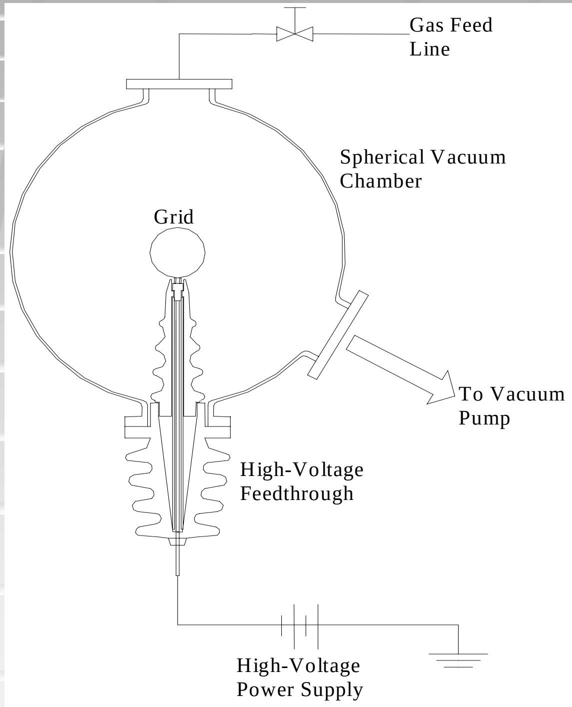
Contents

- Introduction
- Experimental Setup
- Plasma Diagnostics
- Preliminary Results and Analysis
- Conclusion

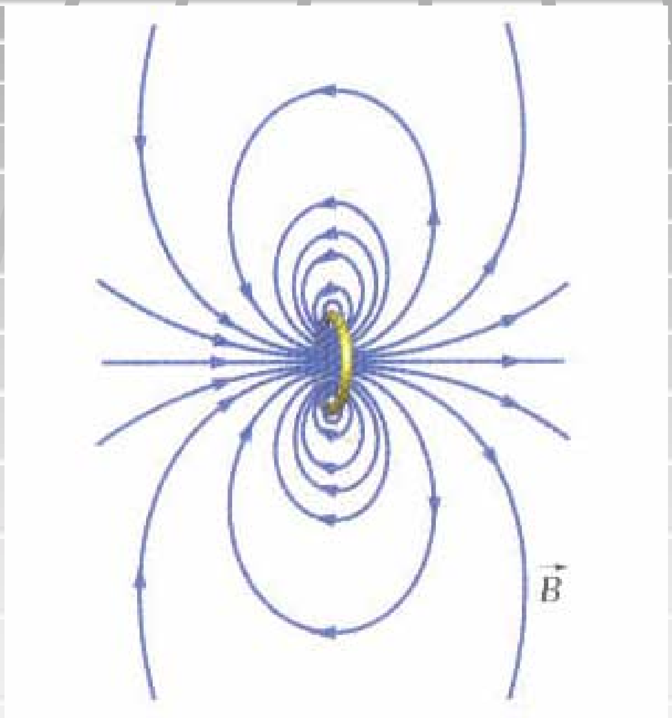
Dipole Assisted IEC

- Dipole Fields Enhance Plasma Density in the Center Region of the IEC
- Combined IEC and Dipole Confinement Properties Reduce Plasma Losses
- Provides Control of potential at the center region of IEC
- Compliments aspects of Levitated Dipole Experiment (LDX) Being Conducted at MIT and Columbia

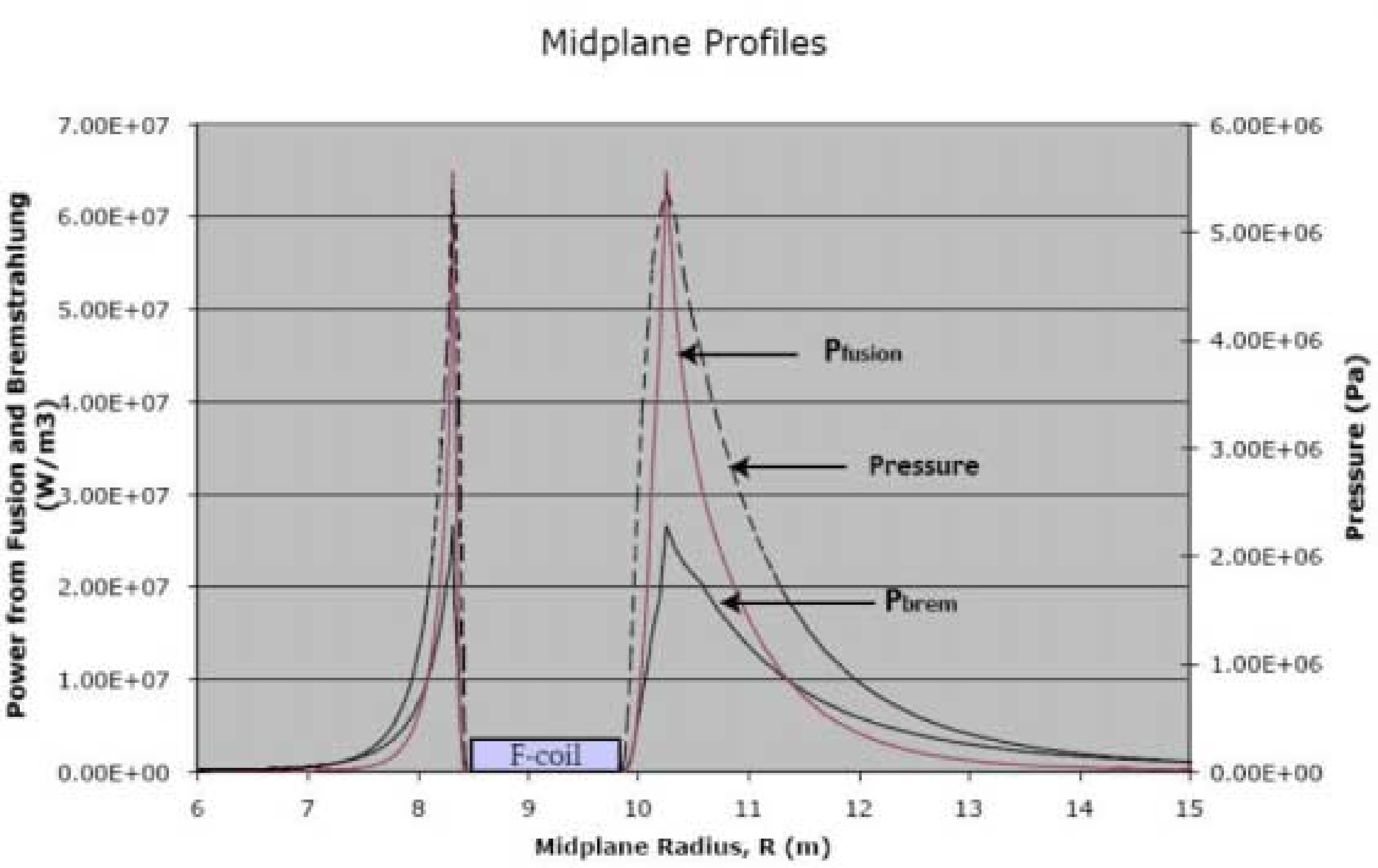
The "pure IEC" uses beam convergence in spherical geometry



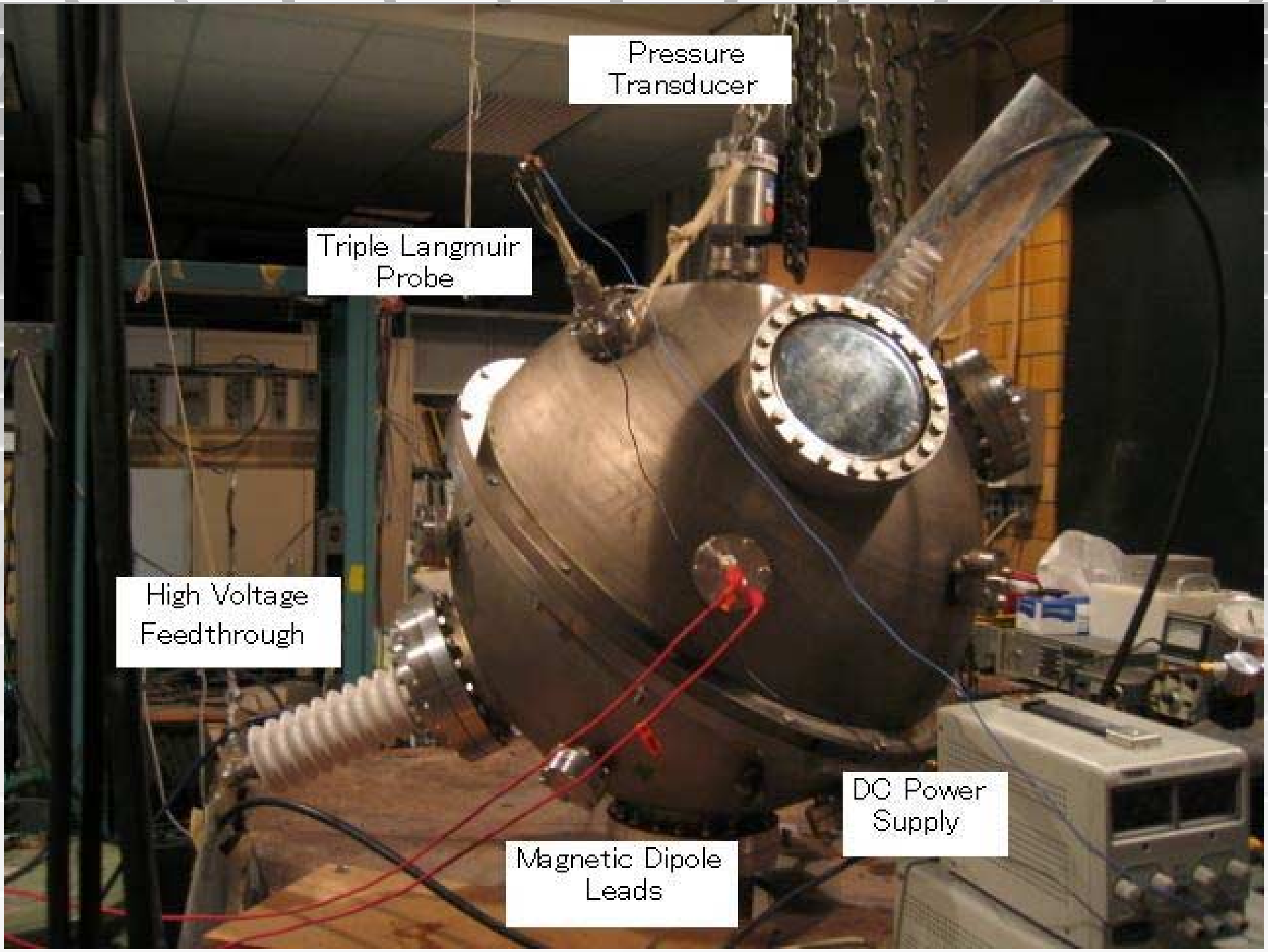
The “pure Dipole” has most plasma in a weak field region



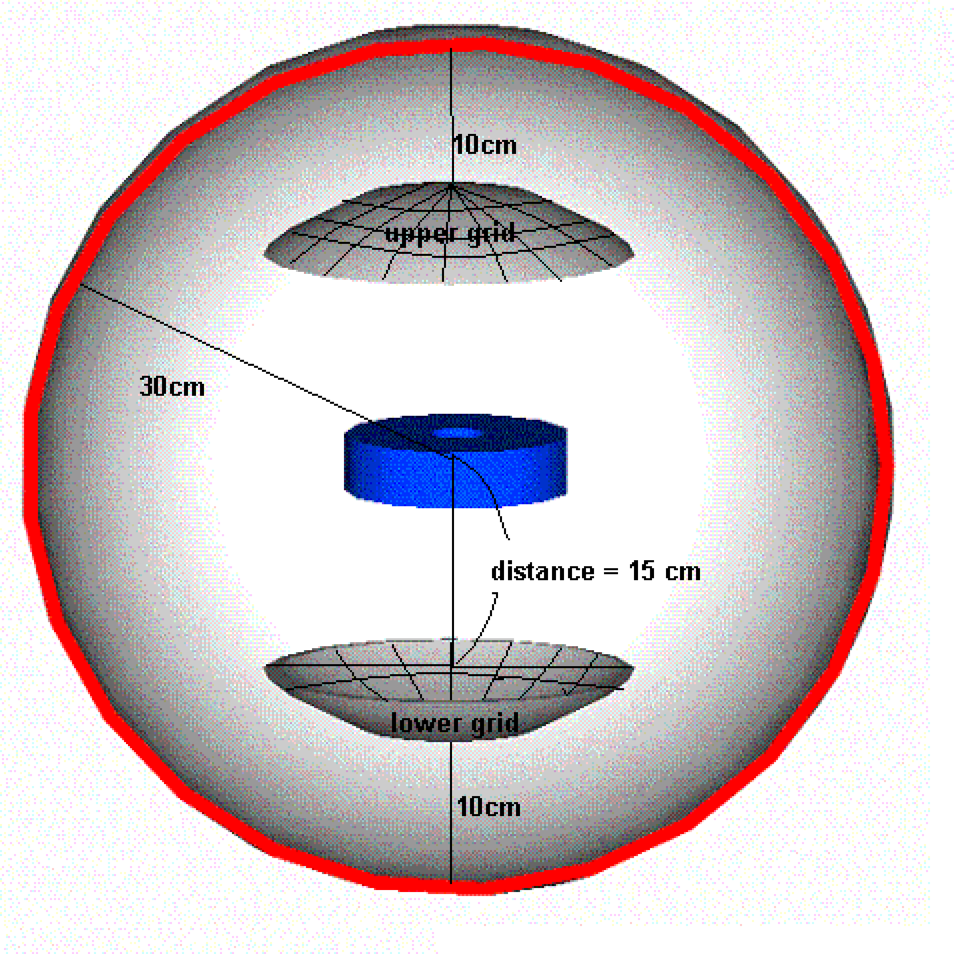
The area of bad curvature that can drive the plasma unstable begins from the mid-plane pressure peak outward to the chamber wall. This is illustrated for the LDX experiment at Columbia/MIT



Dipole IEC Experimental Device



Dipole Assisted IEC Schematic

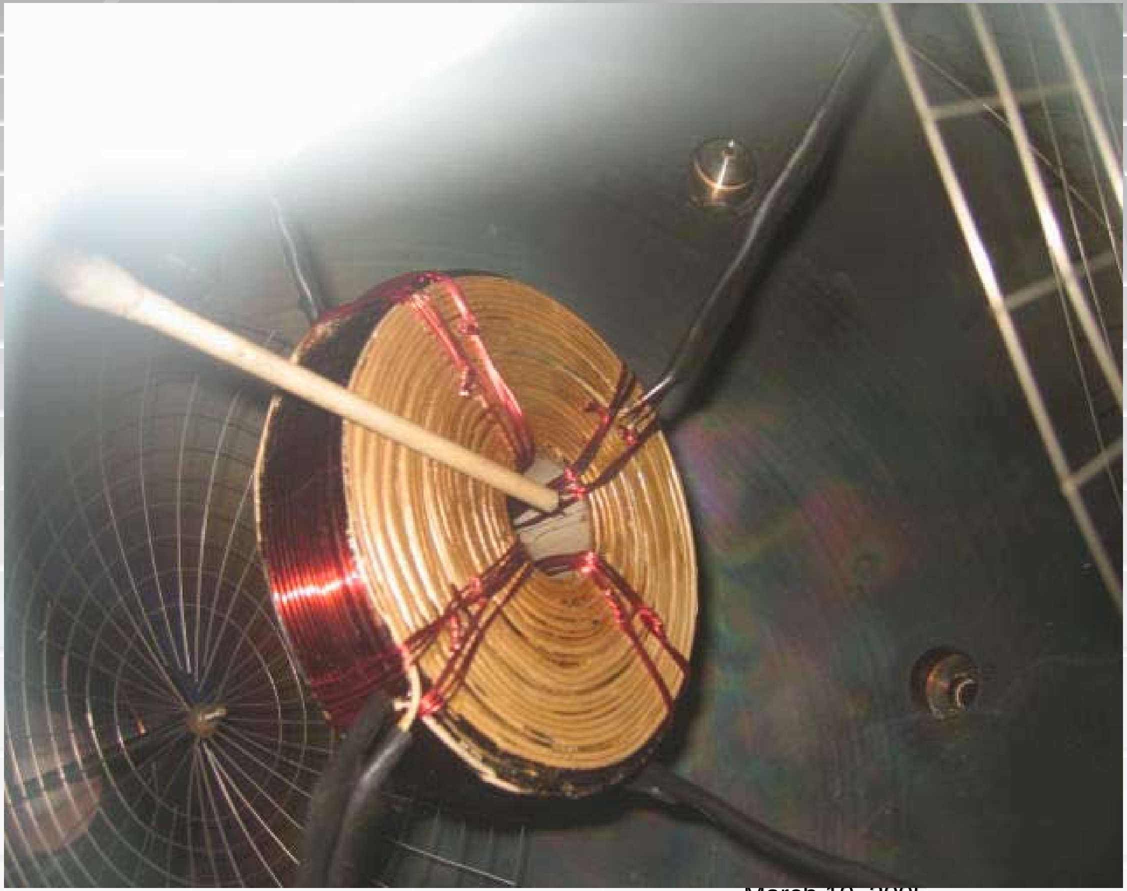


Coil

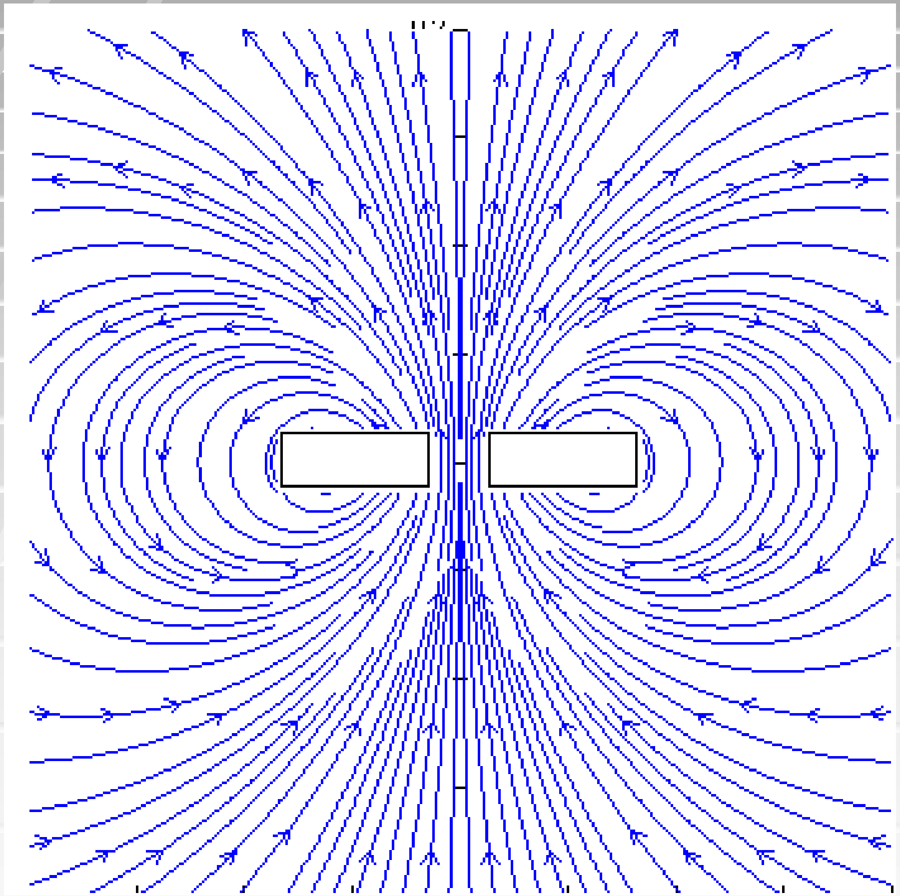
Inner Radius = 2 cm
Outer Radius = 8cm
Height = 4cm

20cm radius
2cm x 1cm spacing

Double probe is inserted from the side and measurement is done on the surface of dipole coil

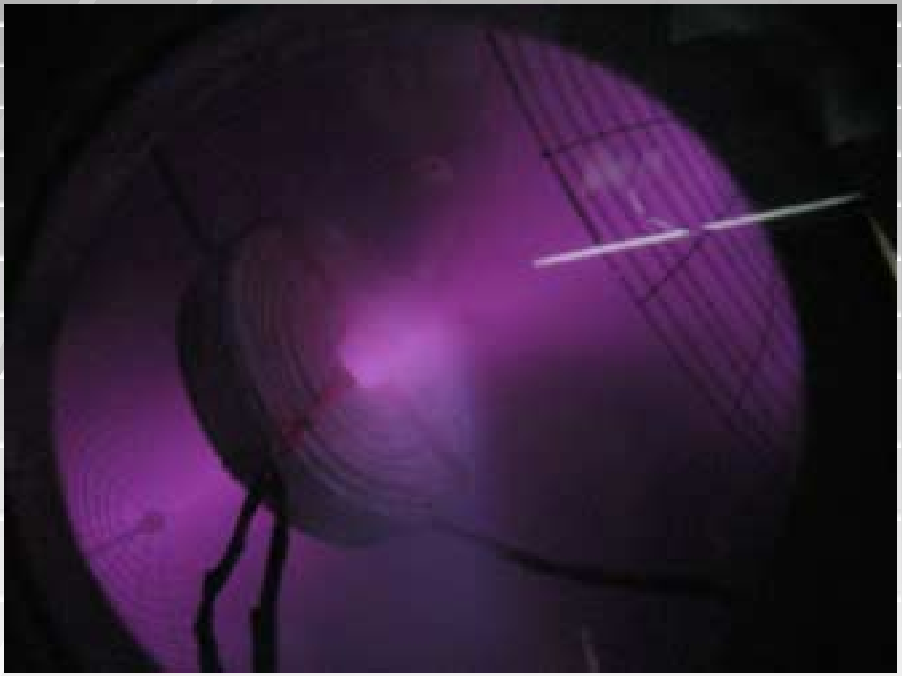


Dipole Field Produced by Coil provides the focus of ion beam

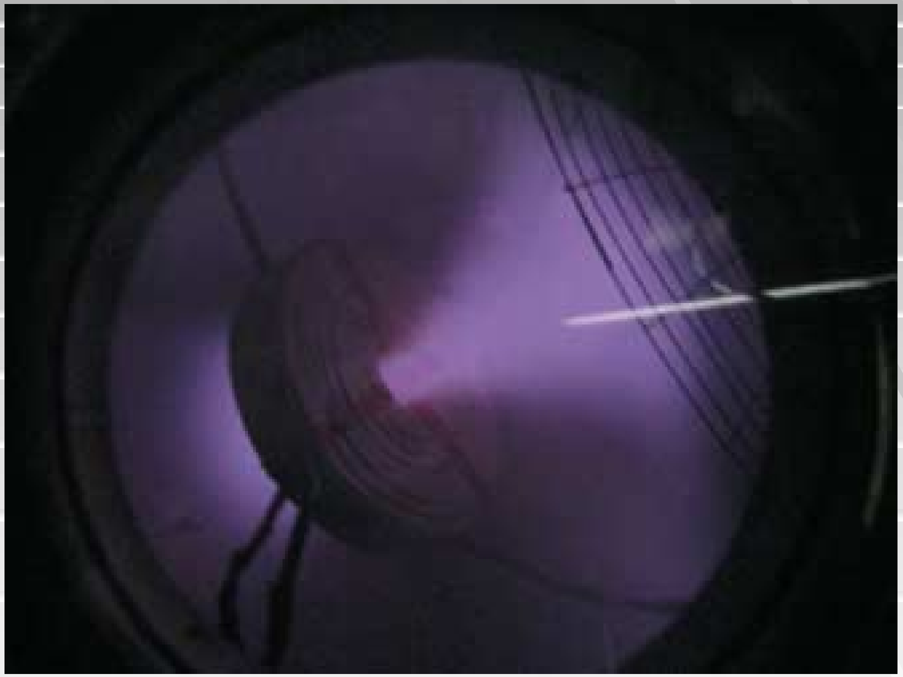


- 12 gage of Square magnet wire
  - (copper)
- 17 x 26 turns of Coil.
- Current varied in the range of 0~20Amp.
- Maximum field strength of 0.1 T At the center of dipole

Plasma More Focused Through Center With Field On

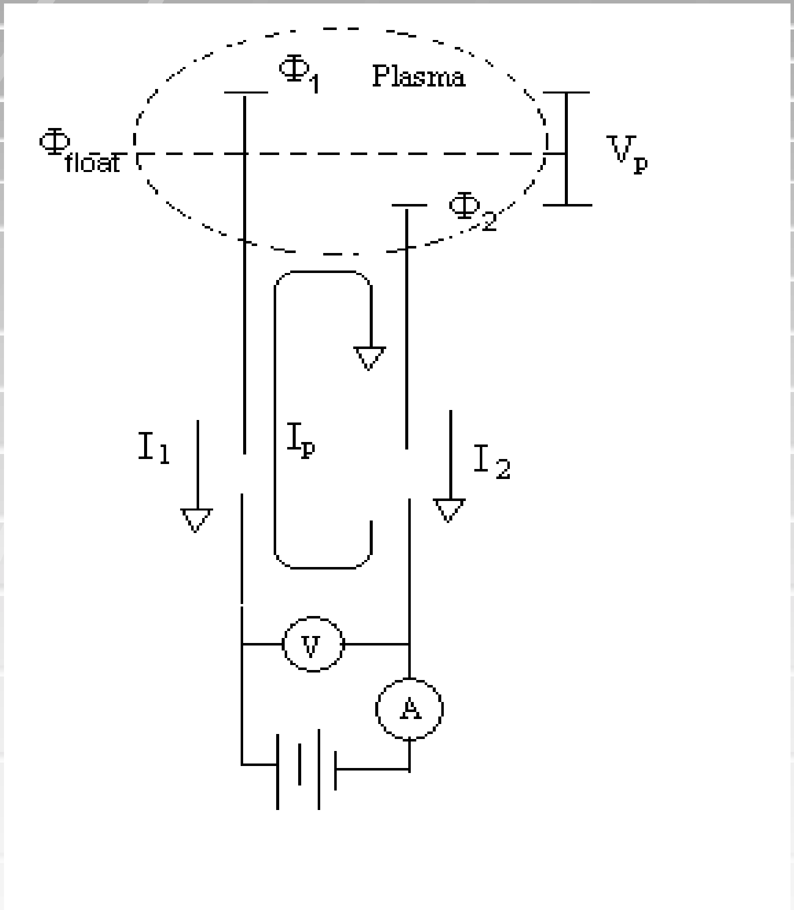


B-Field Off



B-Field On

Double Probe Used to Determine Values of T_e and n_e



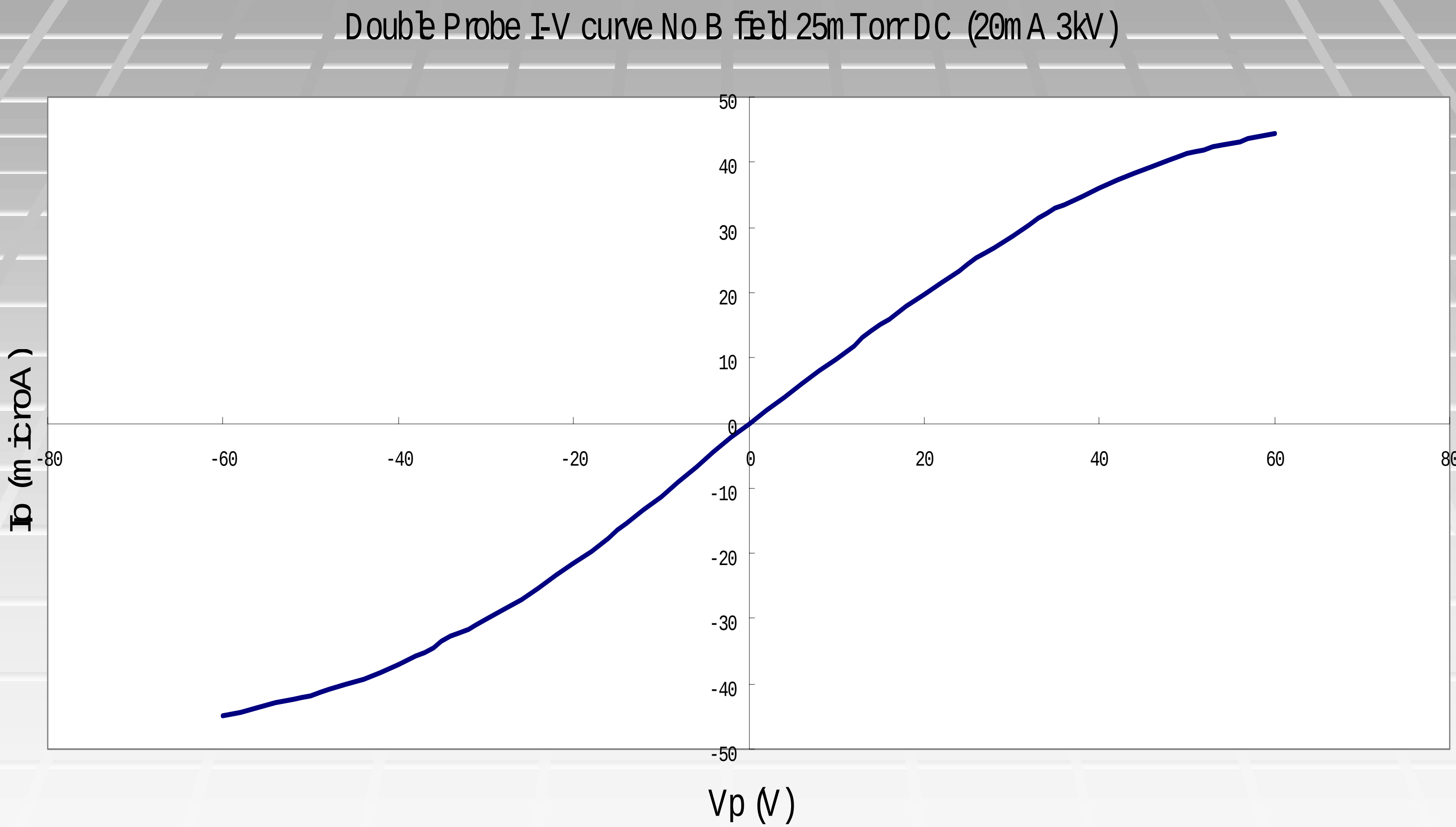
Basis of Selection

- **Less disturbance of Plasma than single**
- **Well suited for IEC operating condition with presence of magnetic field**
- **Capable of measuring properties of non-Maxwellian plasma.**

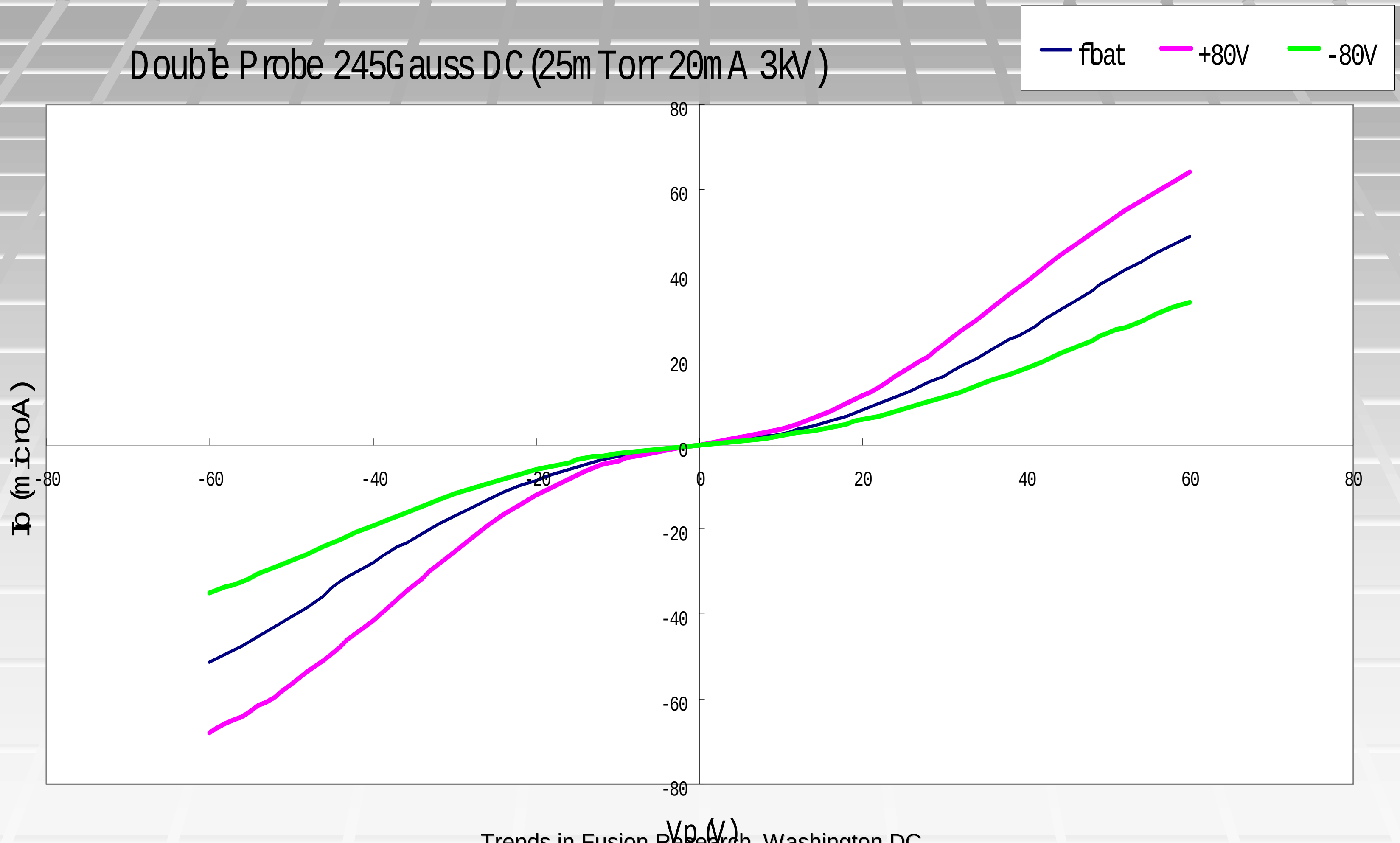
Operating Conditions

- Pressure Varied from 20 – 80 mmTorr
- Discharge Voltage 3 kV – 500 V
- Central Potential Bias up to +- 160 V
- Magnetic Field in Dipole Center Varied from 0 – 800 Gauss

Double Probe I-V Curve is used to determine T_e and n_e.(B=0). Valid for Maxwellian distribution.



I-V curve (B-Field on) is used to Determine Distorted Maxwellian Distribution Function



Analysis of I-V curve to determine f(v) and n_e. Find density increases up to 30x and temp up to 5x.

$$\frac{dI_{probe}}{V_{probe}} = \frac{se^2}{m} f(v) \Big|_{\sqrt{\frac{eV_p}{m}}}$$

$$n_e = \int_v^{v+dv} \left(\frac{m}{se^2} \frac{dI_{probe}}{dV_{probe}} \right) dv$$

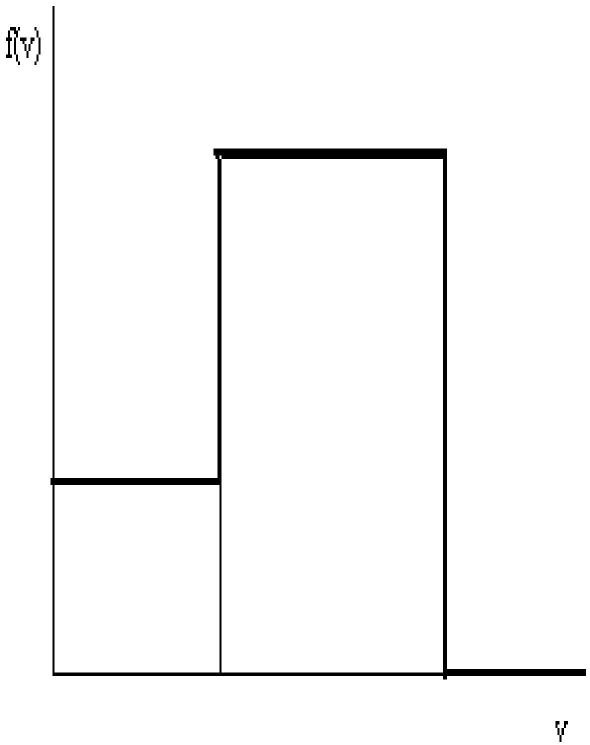


Fig.Shifted-Maxwellian Distribution function

Control of center line potential is done by biased inner ring in dipole opening.

- CL potential can block ion flow unless controlled.
- Biases to 80 V tested.
- Improved density up to 40x.

Conclusions

- Results confirmed that Dipole Fields Enhance Plasma Density in the Center Region of the IEC
  - Presence of B-Field(245 G) increases the electron density at the center. 25 times higher density.
- Results confirmed Control of potential at the center region of IEC
  - Presence of bias +80 V enhances the electron density by factor of 40
- Encouraging results suggest future scale up of experiment to fusion conditions feasible.

Future Work to include….

- Optimization studies of magnetic field for operating condition.
  - Optimize the shape of coil to enhance the density increase.

- Analyze and Optimize Control potential at the center.

- Develop the physics model of dipole assisted IEC