Honeycomb-like Large Area LaB6 Plasma Source for Multi-Purpose Plasma (MP2) Facility

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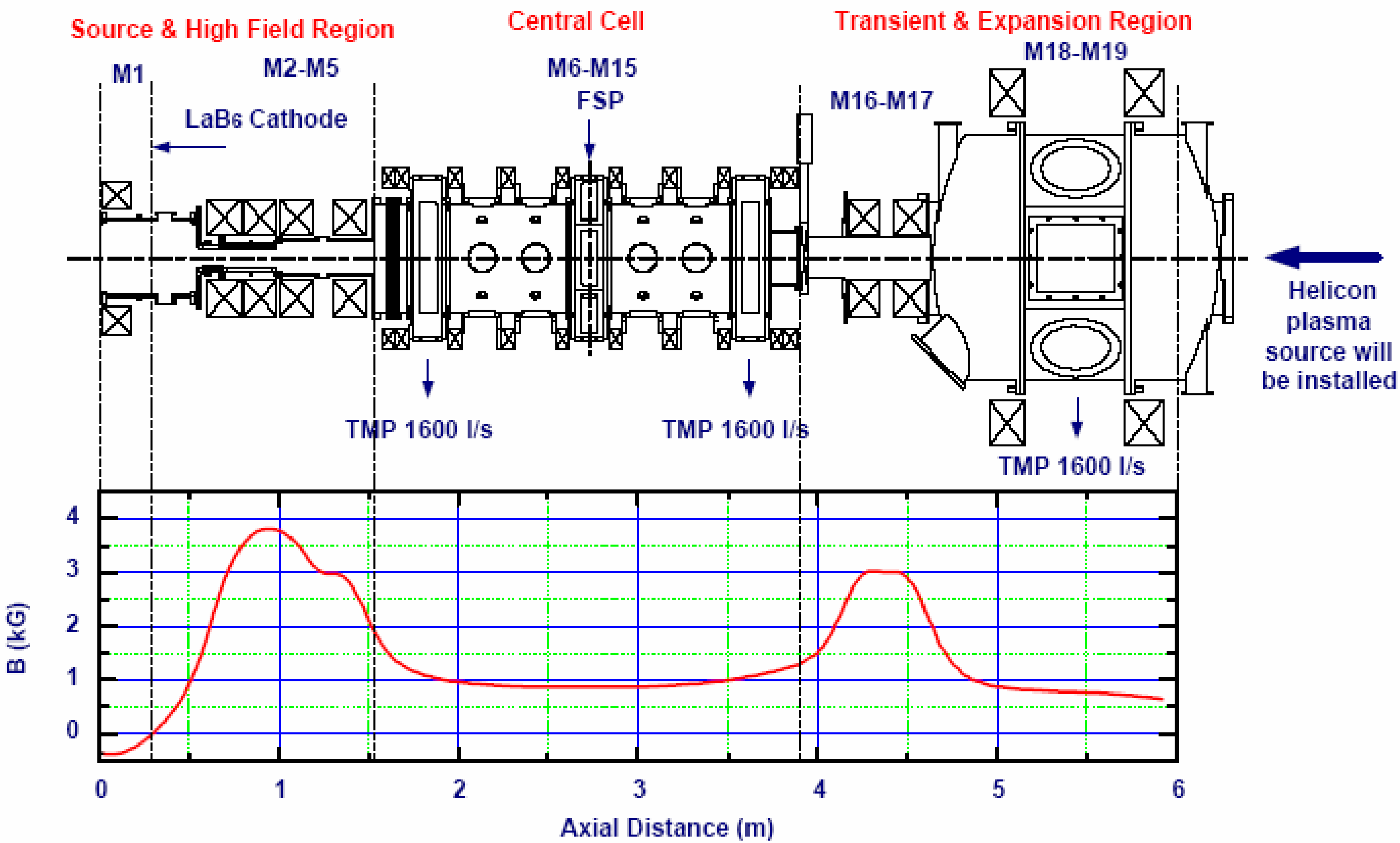
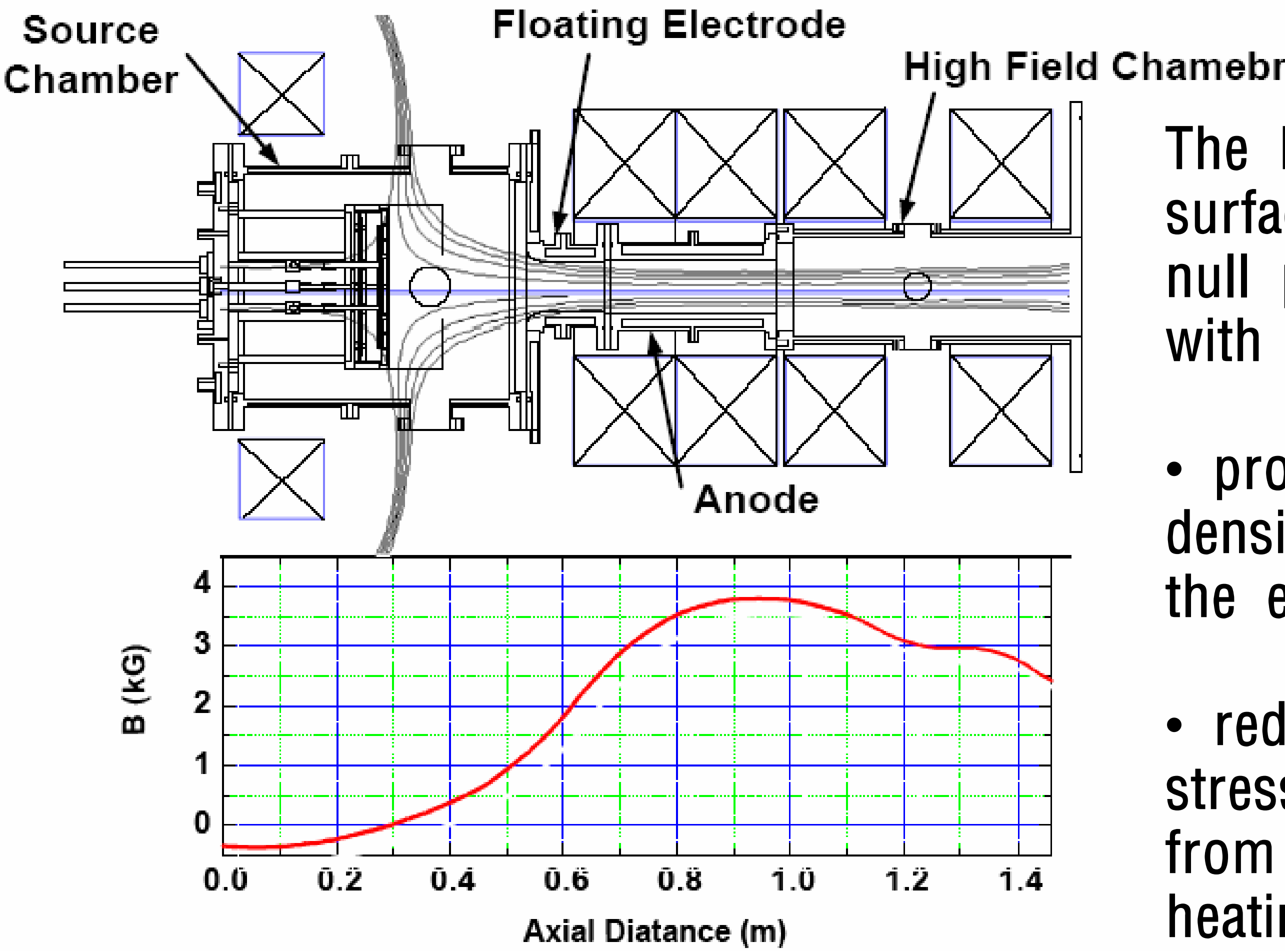
Abstract

Multi-purpose plasma (MP2: length ~ 10 m) facility is developed for divertor plasma simulation, space propulsion, and astrophysical studies with the same concept as Diversified Plasma Simulator (DiPS: length = 3.4 m) with larger scale. As for the divertor plasma simulator, LaB6 plasma source has been developed. Due to fragility of LaB6 against the thermal shock, Honeycomb-like Large Area LaB6 (HLA-LaB6) cathode is designed with the diameter of 23 cm for large and high density plasma generation. Unique features of density profiles will be explained comparing with those of single LaB6 plasma source as in DiPS. The HLA-LaB6 cathode is composed of one inner cathode with 4 inch diameter and six outer cathodes with 2 inch diameter along with separate graphite heaters. The first plasma of HLA-LaB6 is generated with Ar gas and its plasma properties are measured by the electric probes with different discharge current and magnetic field configurations. Plasma density at the middle of central cell reaches up to 2.6×10^{12} cm^{-3} while the electron temperature remains around 3 - 3.5 eV at the low discharge current of 45 A (will be increased up to 400 A) and the magnetic field intensity of 870 G

Overview of MP^2



Detail View of Source Region

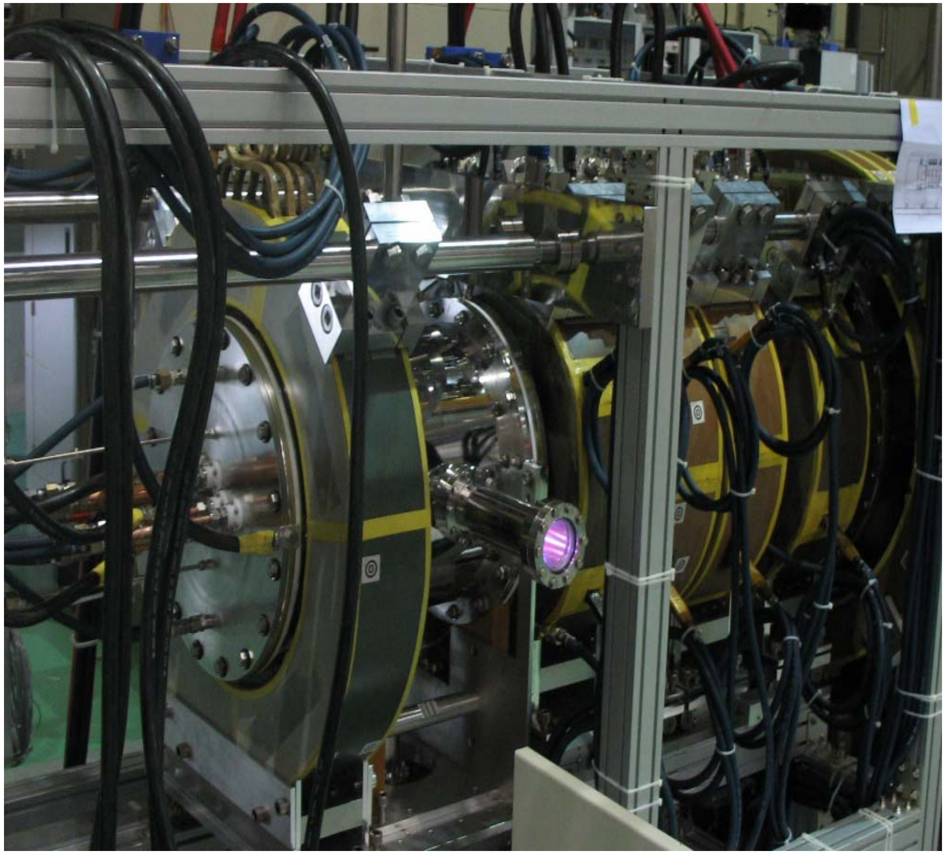


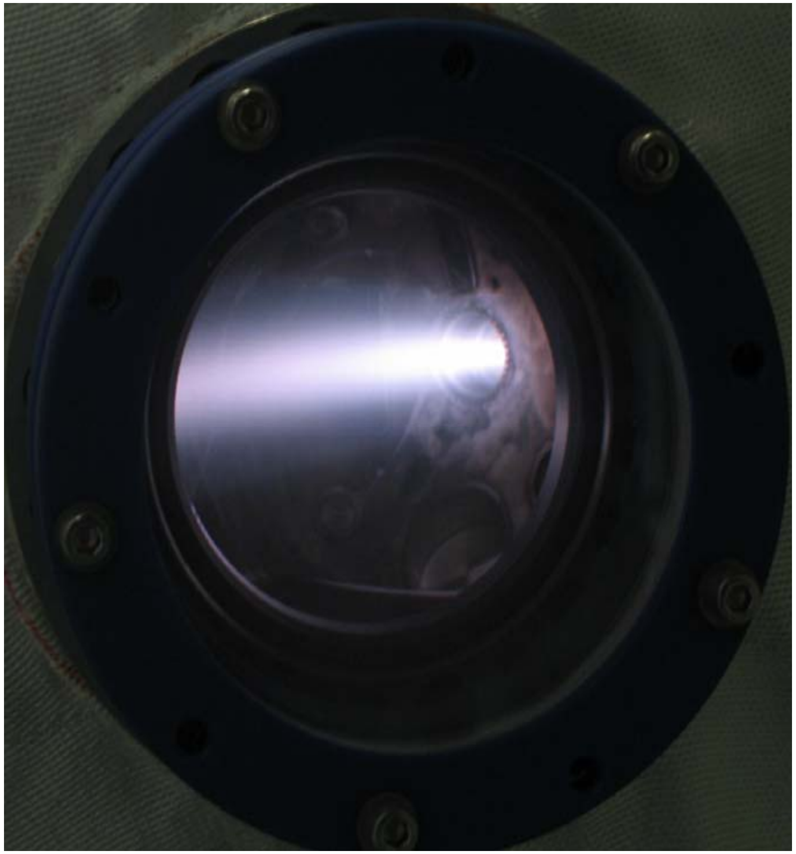
The HLA-LaB6 cathode surface is located at the null point (or minimum B) with cusp magnetic for

- producing the high density plasma by focusing the electrons

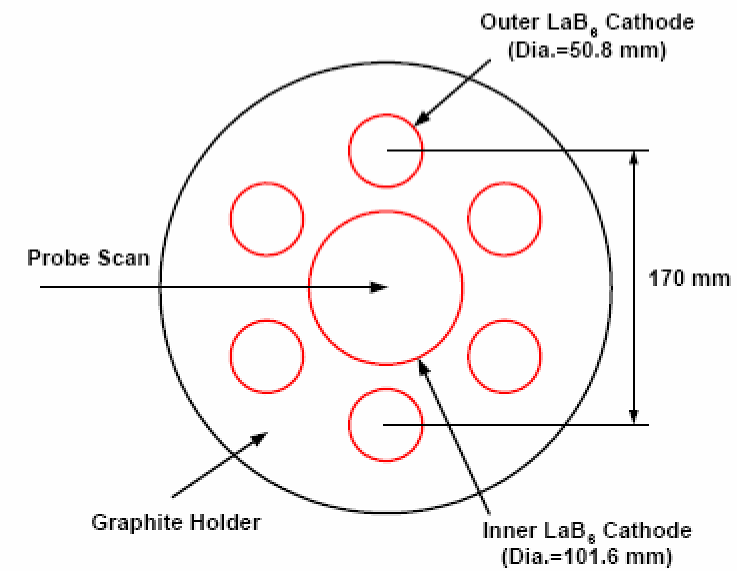
- reducing the thermal stresses on LaB6 surface from ion bombardment heating by diverging the ions with magnetic field lines simultaneously.

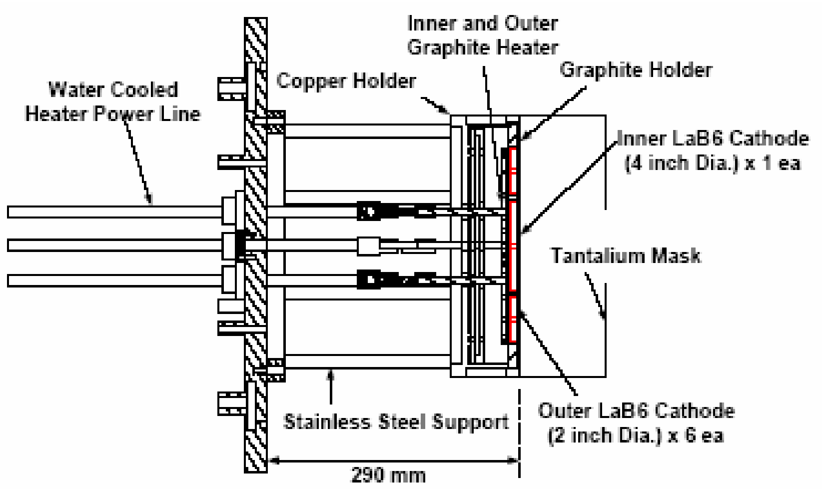
Picture of The First Plasma





Honeycomb LaB$_6$ Source





- ## Honeycomb Geometry
  - Increasing thermal resistance on the non-uniform heating problems
  - Generating large area plasma

- ## Heater Power Supply (P/S)

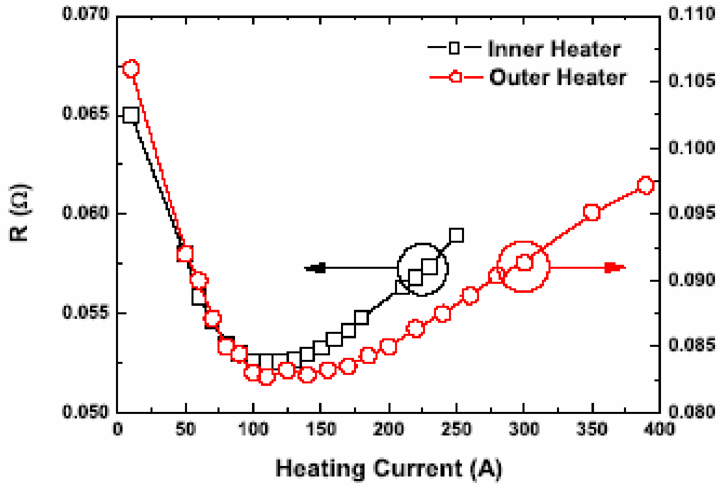
  One P/S for carbon heater to heat LaB6 Center disc
  : DC P/S (30 V / 330 A)

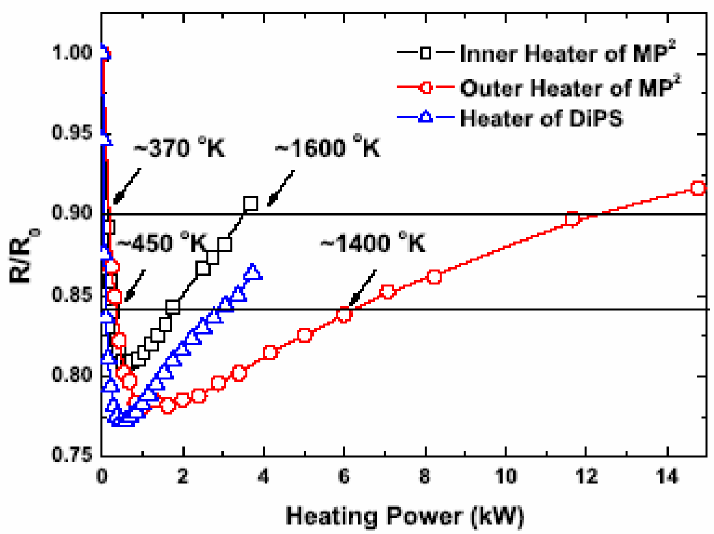
  Four P/S's for carbon (tungsten) heater to heat LaB6 Peripheral discs
  : DC P/S (40 V / 330 A) x 4EA

- ## Discharge Power Supply

  : DC P/S (250 V / 150 A) or
  DC P/S (250 V / 80 A) x 2EA

Resistance of LaB_6 with Discharge Current





Relation between graphite heater resistance

- Heater resistance vs. Heater current
- Normalized heater resistance to the heater resistance at 10 A (R_0 = R at 10 A).
- Maximum Heating Power to the Graphite
  Inner : 6.0 kW
  Outer : 25.0 kW

The First Plasma Generation Conditions

- The first plasma is generated with Ar gas in the following conditions:

- Two magnetic Profiles :
  MF1 [−150 A (M1), 200 A (M2-M5, M16-M19), 350 A (M6-M15)]
  MF2 [−300 A (M1), 400 A (M2-M5, M16-M19), 700 A (M6-M15)]

- Neutral pressures:
  30 mTorr (at source chamber) and 2.5 mTorr (at central cell)

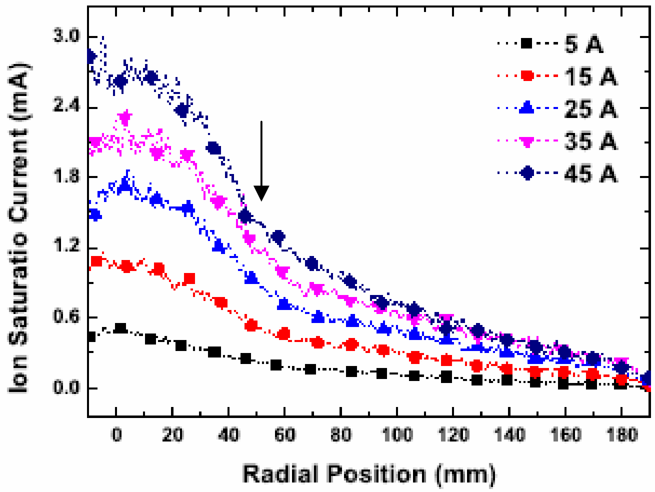
- Discharge voltage of 60 - 65 V, discharge currents of 5 - 45 A (will be increased up to 400 A successively)

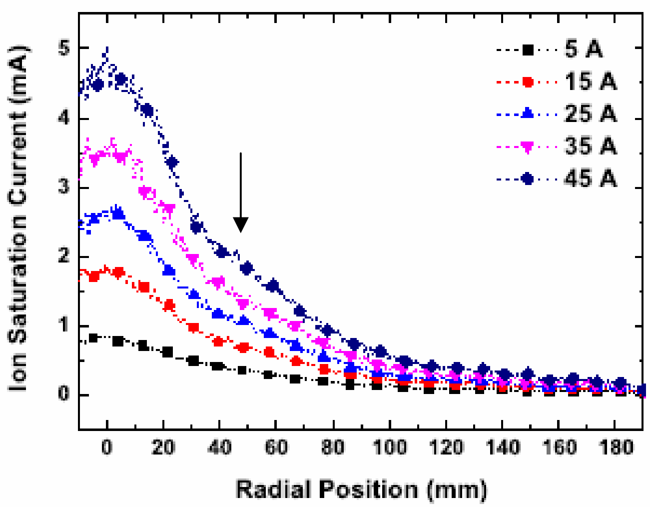
- LaB6 heating powers :
  3.69 kW (250A -14.74 V) for inner heater
  14.79 kW (390A - 37.9 V) for outer heater.

- A Langmuir Probe with the fast scanning probe (FSP) system

- Measuring position is the middle of central cell.

Ion Current profile

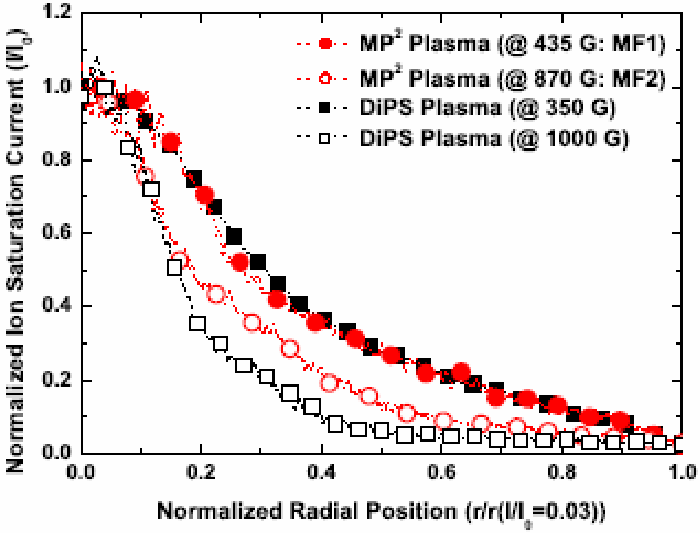


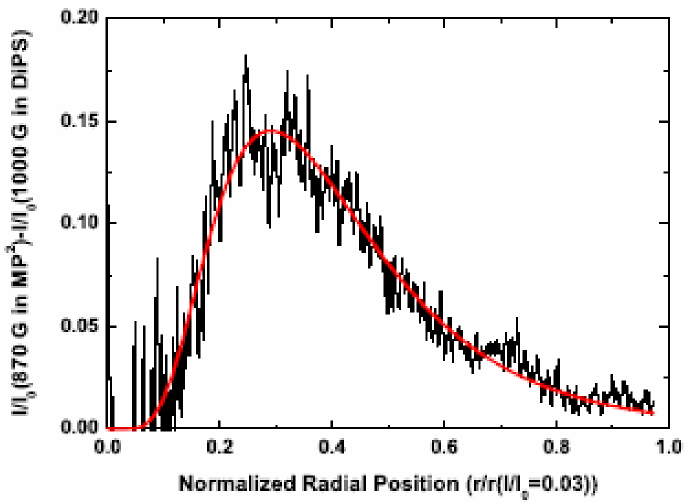


Ion saturation current profiles with different discharge current at two magnetic fields

- MF 1: 435 G at measurement position
- MF 2: 870 G at measurement position.
- Honeycomb geometry reflected to the ion saturation current density profile

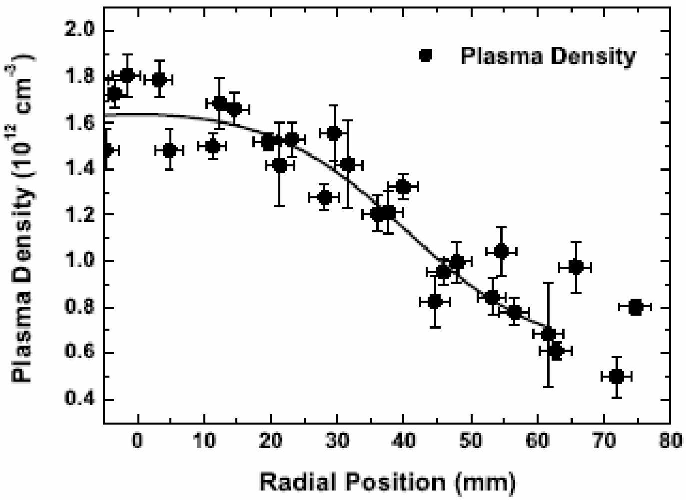
MP2 .vs. DiPS

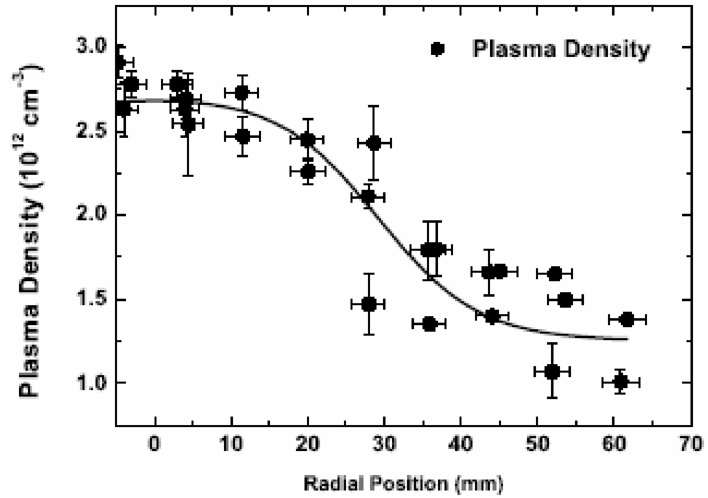




- Normalized ion saturation current profiles of 45 A discharge currents.
- Ion saturation current profile of MP2 and DiPS Plasmas.
- Honeycomb geometry can produce more high density and large area plasma at high B-field.
- At high B-field, diffusion by the outer LaB6 directs to the outward to the chamber.

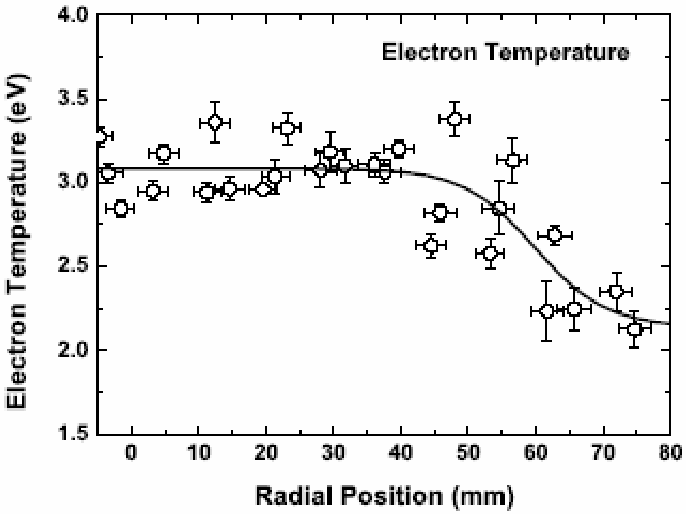
Density & Temperature

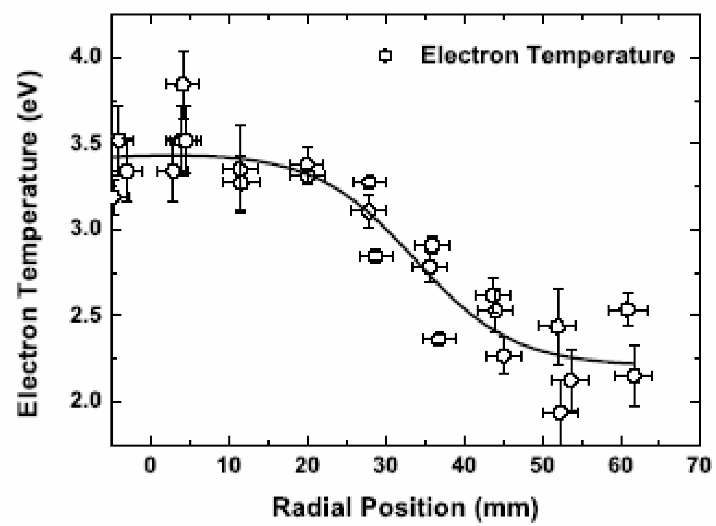




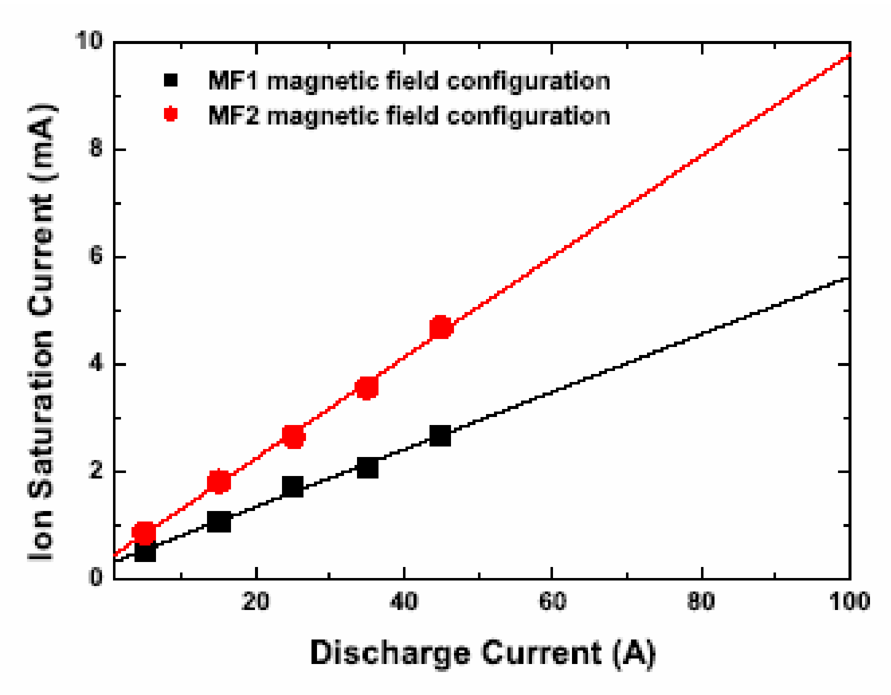
MF1 profile

MF2 profile





Density vs. Discharge Current

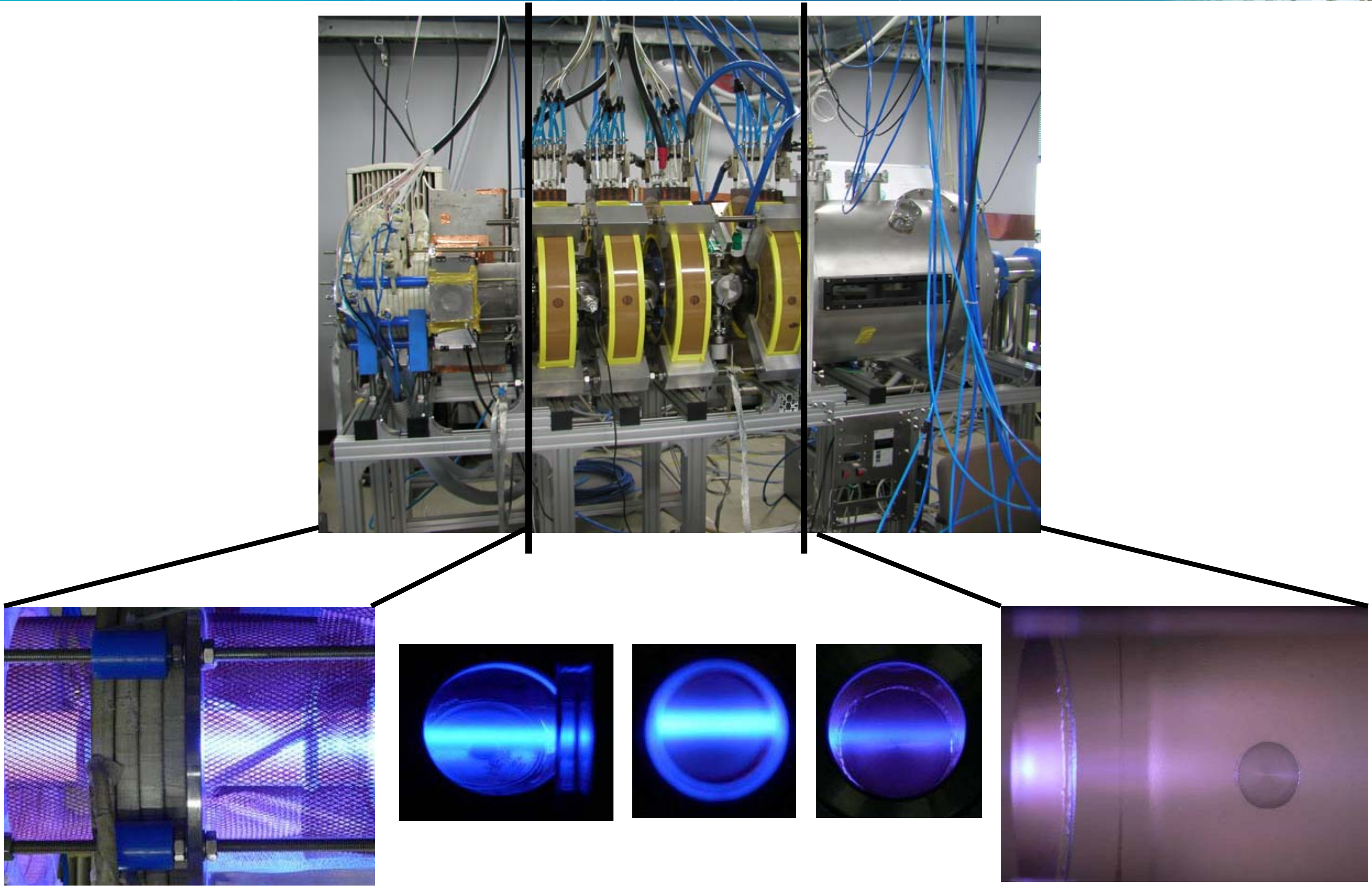


- Plasma density at the center of the chamber is linear with the discharge current.
- The discharge current will be increased to 400 A.
- The expectation of the plasma density at 400 A is as high as 2.2×10^{13} cm^{-3}.
- The ratio ion density to neutral density will be approximately ~ 0.3

Discussion

- We have successfully renovated the HANBIT mirror device to the linear divertor simulator.
- We will devote to the high density plasma in the MP^2.
- We need more plasma parameter monitoring systems, for example Thomson scattering system, in the near future.
- The ion heating experiment will be considered for long term project.
- As the name implies, we will have various plasma sources for the experiments.
- The upgrade program for molten salts experiment will be launched within few years.

Helicon Source



Source Region　　Propagation Region　　Expansion Region