Two Dimensional Li beam imaging to study the magnetic field configuration effects on plasma confinement in spherical tokamak CPD

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SUMMARY

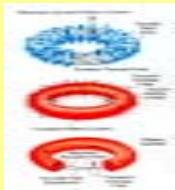
1. Plasma confinement topology has been studied in CPD (R=0.3m, a=0.2m, B=0.25T), under various magnetic field configurations by 2D sheet Li beam imaging technique.
2. It is observed that plasma Initiation takes place at the fundamental resonance position in simple torus configuration.
3. A sharp lower plasma boundary is observed in magnetic null configuration as well as under CS magnetic field, though the boundary positions are different.
4. Magnetic connection length plays an important role in defining the plasma boundary for various magnetic field configurations
5. For CPD the critical connection length for plasma to exist is found to be ~ 5-6 m.

Introduction

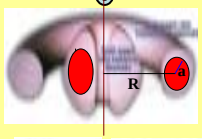
Nuclear fusion is a promising candidate for energy resource

To achieve fusion energy on earth steady state operation of high temperature and high density plasma is required.

Tokamak is one of the prospective devices to confine high temperature and high density plasma

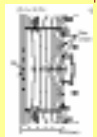


ST concept is considered to be the most attractive reactor concept since it can maintain high beta (β) plasma in a compact shape (R/a < 2).



$\beta = p / (B^2 / 2\mu_0)$

Central solenoidless plasma start-up and sustainment are crucial issues for a ST reactor.

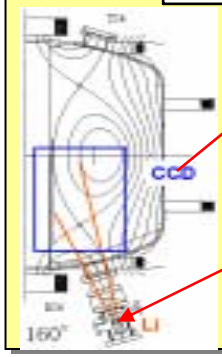


LATE RESULTS

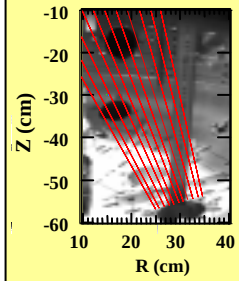
Proposed Start-up field configuration in ITER

CPD And Lithium Imaging System

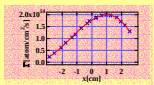
Vacuum vessel radius	0.6m
Center stack radius	0.135m
Toroidal magnetic field (B_T)	0.25 T
Plasma major radius (R)	0.3m
Plasma minor radius (a)	0.2m
Aspect ratio (A)	1.5



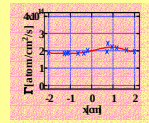
Performance of the sheet Li beam



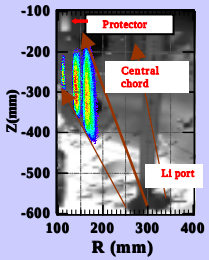
Toroidal 1/e width ~ 4 cm



Radial uniformity < 10% within 4 cm



Plasma Formation in simple torus



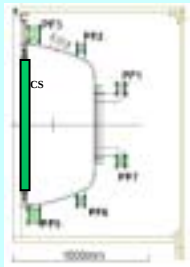
Plasma initially formed at the fundamental electron cyclotron resonance position

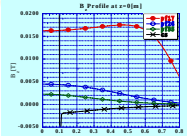
$R_{res} = \mu_0 n I_{TF} / (2\pi B_{res})$

$B_{res} = 0.293$ T for f=8.2 GHz

Then it quickly expands towards the low field side with the increase of RF power

B_z Profile (Z=0) of various coils in CPD

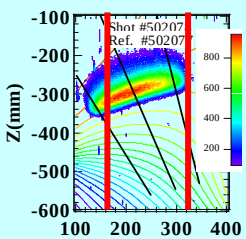


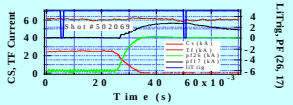


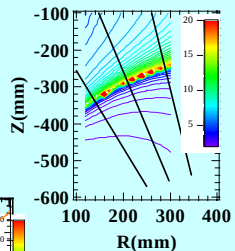
All Coil currents are set to 1.0 kA

Plasma confinement in magnetic null configuration

CS = 25.0 kA; PF26 = -6.0 kA; RF = 50 kW

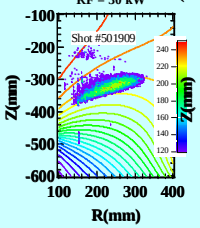




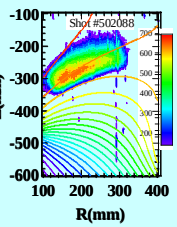


Contour of Connection length (m)
CS : 25 kA
PF26 : 6 kA

RF = 30 kW



CS/PF26 = 15/-3.6

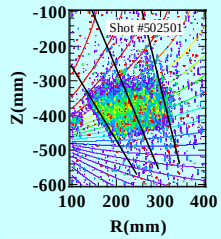


A clear lower boundary is found to exist irrespective of RF power level and coil current magnitude.

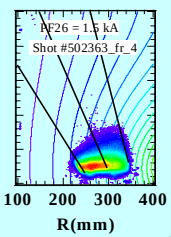
Observed boundary fairly matches with the connection length contour plot.

Plasma confinement in presence of different types of B_z configurations

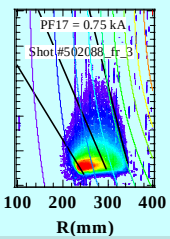
CS = 25.4 kA

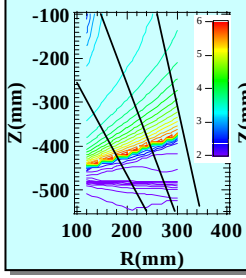


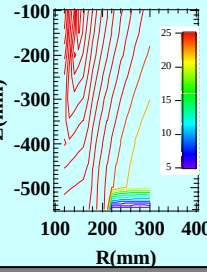
PF26 = 1.5 kA



PF17 = 0.75 kA







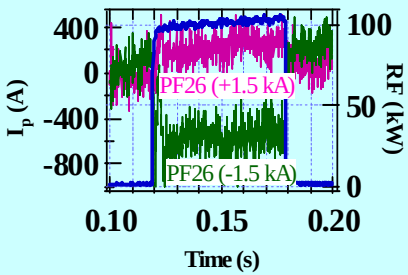
Observed lower boundary for CS configuration is different from null configuration.

No lower boundary observed with PF26 and PF17 coils.

Similar images for PF17 and PF26 configurations, though PF17 has a small negative decay index.

Computed connection length contour data can explain the observed plasma boundary in all cases.

RF driven Plasma Current



Plasma current direction is reversed when PF26 coil current direction is reversed.

No significant change is observed in the plasma lower boundary.

Poloidal field produced by plasma current is significantly small compared to that produced by PF26 coil