Formation Of The HFSHD At Globus-M2 Tokamak

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ABSTRACT

- **Two Thomson scattering diagnostics** with probing chords situated at inner divertor near X-point and in outer midplane near separatrix.
- **High Field Side High Density** Region (HFSHD) in the lower inner divertor of the Globus-M2 tokamak (R=0.36 m, a=0.24 m) for a wide range of parameters with centrum n_e from 2 10^{19} to 1.4 10^{20} m^{-3}
- **SOLPS-ITER modelling with account of drifts and currents**. The neutral particle behavior with the EIRENE neutral gas transport Monte Carlo code taking into account deuterium atoms, molecules and carbon atoms.

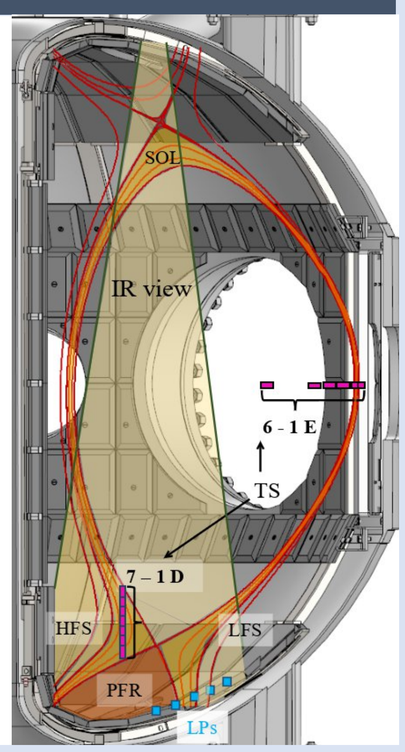
Experimental Setup

Thomson scattering systems (TS):

- **Divertor Thomson Scattering (DTS):** measures T_e, n_e in the divertor region (HFS, near X-point) at seven spatial points.
- **Midplane Thomson Scattering (TS):** measures T_e, n_e in the core and edge along the midplane at six points.
- **Synchronization:** both TS systems synchronized within ~0.1 ms
- The discharge duration provided stable plasma parameters allowing up to five measurements at DTS laser frequency 100 Hz.

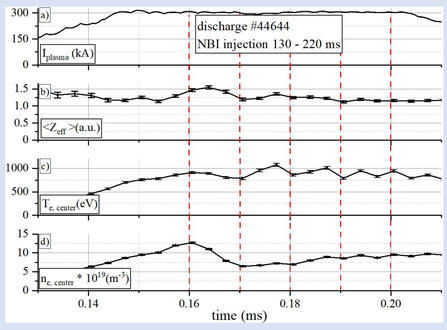
Langmuir Probes: installed on the lower divertor targets to measure local plasma parameters.

IR Camera: monitors strike-point positions (3.5–4.7 μm range, 1200 Hz frame rate).

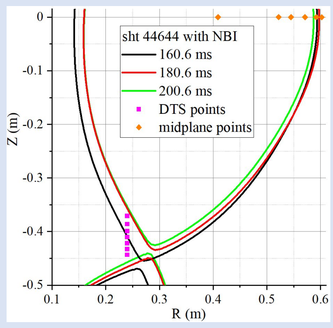


Experimental

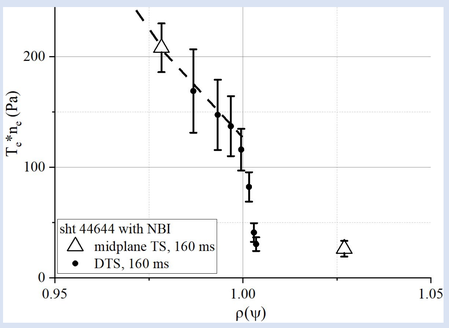
The typical scenario for the last experimental campaign at both Ohmic (OH) and NBI heating with B ~ 0.7 T, I ~300-350 kA was characterized by formation of the divertor configuration at 160 ms, following a noticeable increase of n_e at the high-field side (HFS) of divertor, while n_e on separatrix in middle plane remained constant. main parameters for the typical discharge #44644 with applied 0.7 MW NBI heating chosen for the detailed analysis.



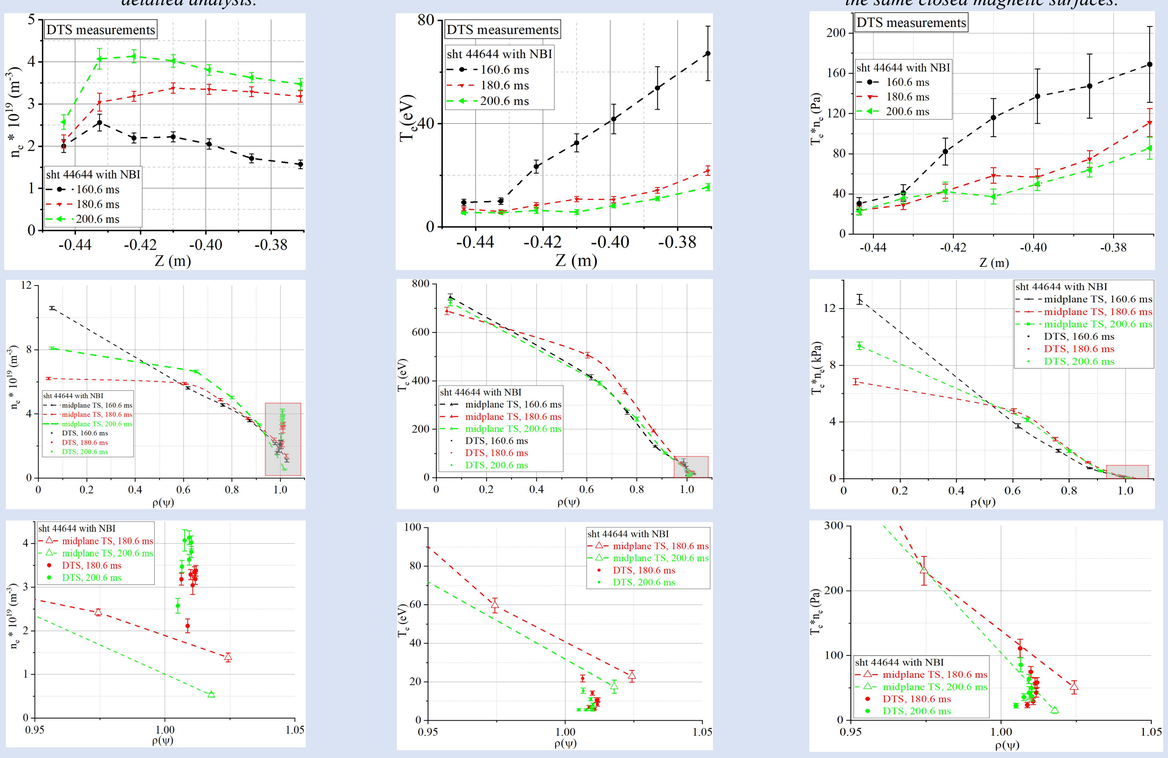
Main parameters for the typical discharge #44644 with applied 0.7 MW NBI heating chosen for the detailed analysis.



Position of separatrix and location of midplane TS and DTS probing points



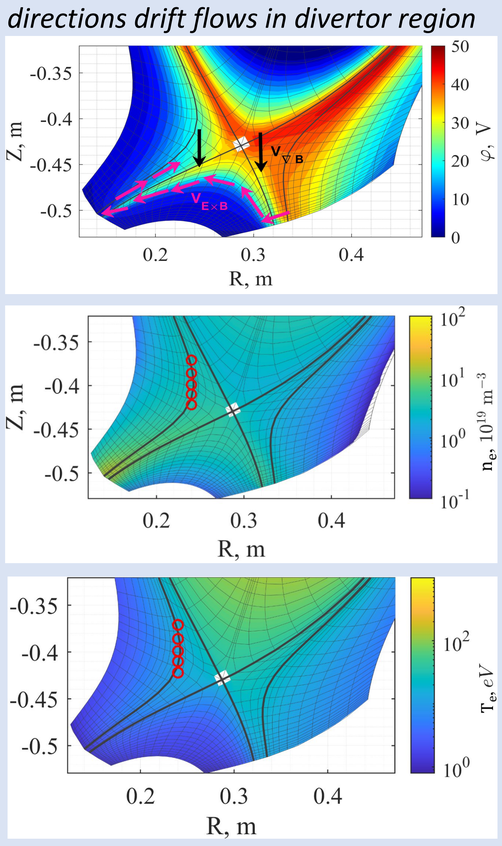
Configuration at 160 ms is appropriate for comparison of DTS and midplane TS data on the same closed magnetic surfaces.



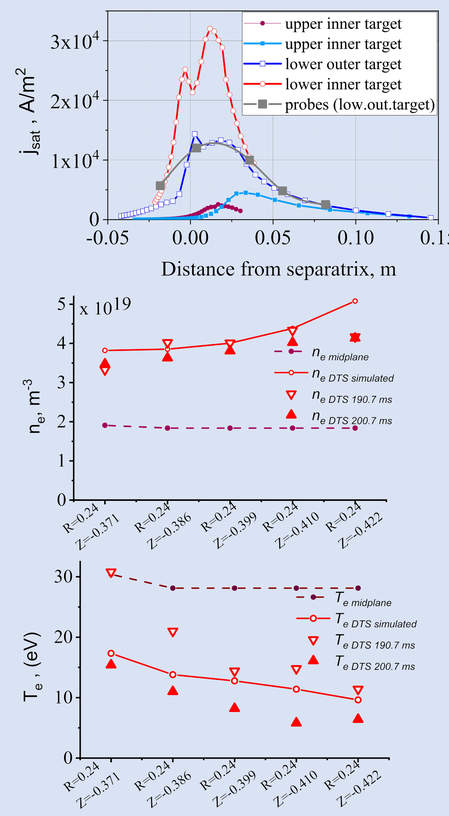
n_e, T_e and p_e measured by DTS and midplane TS plotted as a function of the normalized poloidal magnetic flux, defined as $\rho_\psi = \sqrt{(\psi-\psi_0)/(\psi_l-\psi_0)}$, where ψ is the poloidal magnetic flux, ψ_0 and ψ_l correspond to the magnetic axis and the sepatrix, respectively

MODELLING

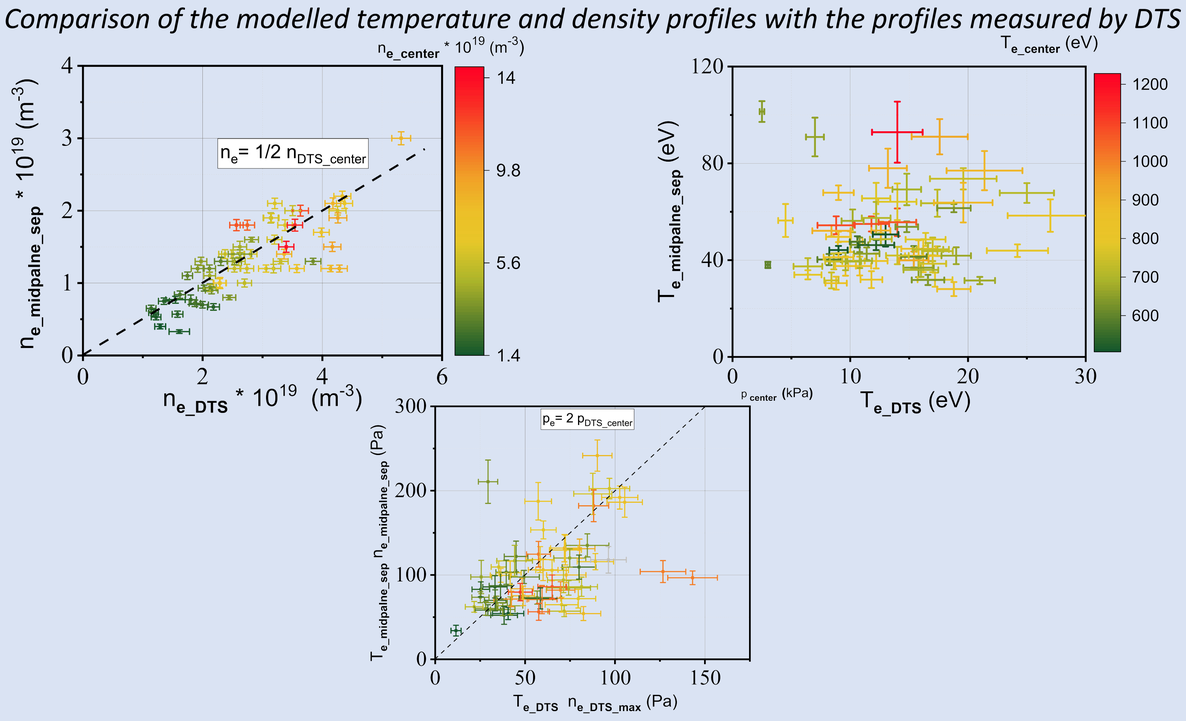
Map of electrostatic potentials and directions drift flows in divertor region



Saturation current calculated for divertor targets compared with probe measurements



Comparison of the modelled temperature and density profiles with the profiles measured by DTS



TS measurements during quasi-stationary phase of 18 discharges (both OH and NBI heating)

CONCLUSION

HFSHD previously discovered on DIIID, JET and ASDEX has now been discovered in Globus-M2 with C walls during quasi-stationary phase of 18 discharges over a wide range of discharge parameters, with the central n_e changing in the range from 2×10^{19} to 1.4×10^{20} m^{-3}, both with and without NBI (0.7 MW). DTS shows increased n_e, maximized at a distance of *~3 cm from X-point* and ~2 cm from the separatrix exceeding by **1.5-3 times** n_e in the outer midplane.

This experimental data showed agreement with simulation by SOLPS-ITER + EIRENE.

Main SOLPS modeling outputs

1) We identify as *primary mechanism* responsible for the formation of HFSHD in Globus-M2 - ***ExB*** drift of ions and electrons towards the region of strong magnetic field below the X-point.
2) The *double null configuration*, characterized by inactive upper X-point, causes formation between the separatrices a region electrically connecting with hotter outer divertor. That lead to the elevated electrostatic potential $\Phi(V)$ (due to $F_{thermal}$) *between the separatrices*. To the contrary, in the far SOL beyond inactive separatrix the thermoelectric current, the T_e and n_e and their variations are low $\varphi(V)$ => formation a big electric field E(V) + corresponding drifts.
3) A phenomenon *unique to spherical tokamaks* is comparatively large ***grad B*** drift, due to big variation of ***B***. The ***grad B*** drift flux crossing the separatrix is **~50%** of ***ExB*** drift flux for inner divertor, and **~30%** of the ***ExB*** flux in outer divertor.

ACKNOWLEDGEMENTS / REFERENCES

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