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Realization of divertor configuration discharge in J-TEXT tokamak

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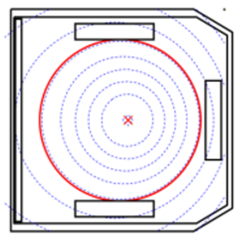
Motivation-extent operation region

Major Radius （R）	1.05 m
Minor Radius （a）	0.25-0.27 m
Toroidal Field （B_t）	1.2-2.2 T
Plasma Current （I_p）	≤220 kA
Plasma density （n_e）	(0.5–5)×10^{19} m^{-3}
Confinement time	~20 ms
Flattop time	~ 500 ms



- ☐ **3 limiter targets: limiter configuration**
- ☐ **DV winds & target: Divertor configuration**

From 2016 to 2018
- ✓ establishment of divertor power supply
- ✓ installation of the HFS divertor target
- ✓ Construction of relevant diagnostics
- ✓ Equilibrium calculation and position stability analysis
- ✓ Stable control strategy

Apparatus and method

Divertor winds and target Construction

◆ **Divertor windings:**

- ☐ Divertor(DV) coils: -4，8，-4turns

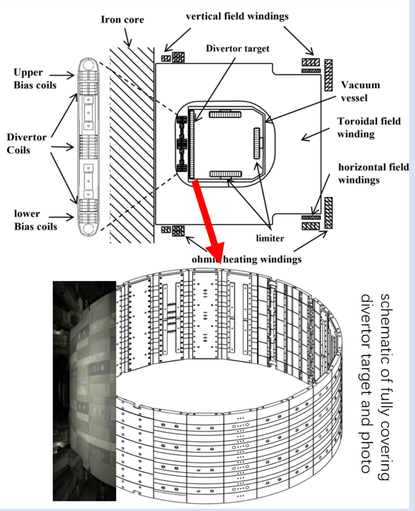
  I_{DV}: up to 25kA/500ms.
- ☐ Bias(BS) coils: 3，-3turns

  I_{BS}: up to 2kA/1ms

◆ **Divertor target**

- ☐ 26 vertical tile array with 15 imbricated tiles
- ☐ graphite coated with silicon carbide
- ☐ Cylinder:

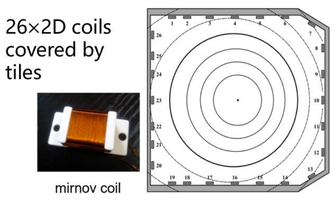
$\Phi = 1508mm, r_{target} = 296mm,\ R_0 = 1050mm$



Diagnostics

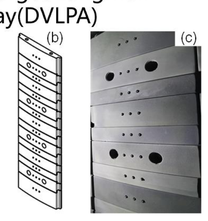
◆ Rectangular poloidal array of magnetic probes(RAMP)

- ➢ 26×2D coils covered by tiles



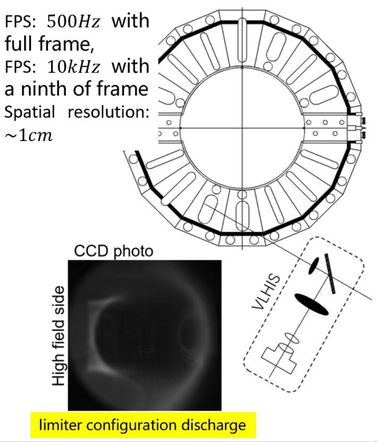
◆ Divertor target Langmuir probe array(DVLPA)

- ➢ 3 × 15 probe tips
- ➢ embedded in tiles



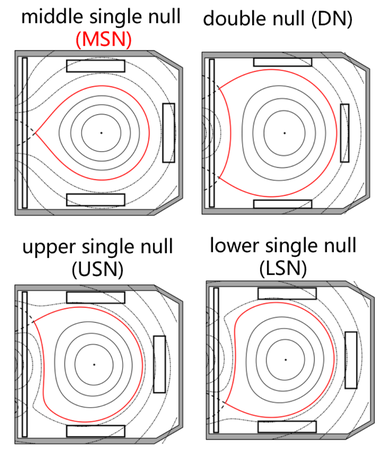
◆ Visible light high-speed imaging system(VLHIS)

- ➢ FPS: $500Hz$ with full frame,
- ➢ FPS: $10kHz$ with a ninth of frame
- ➢ Spatial resolution: $\sim 1cm$



Equilibrium and stability

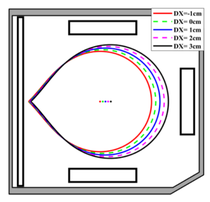
2-D spool model + EFIT



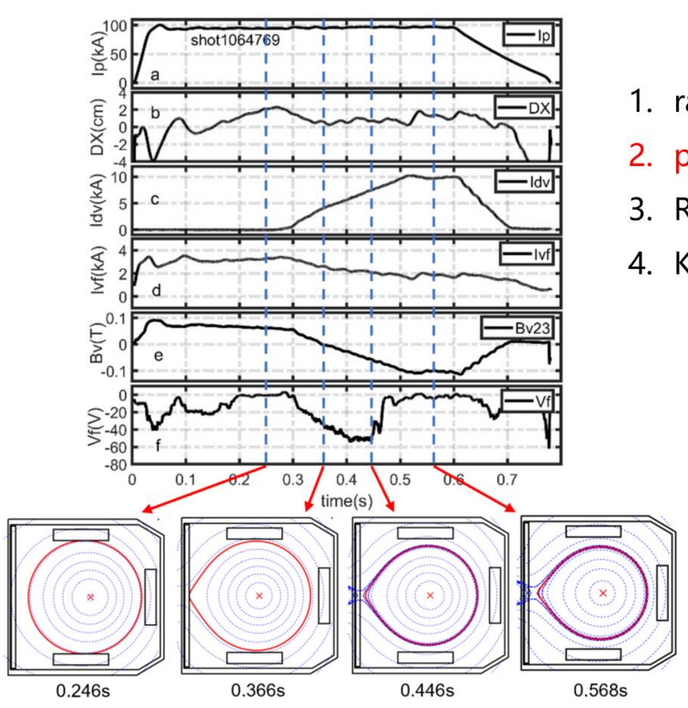
In-out instability(n) vs DX in MSN

DX(cm)	-1	0	1	2	3
Ip(kA)	120	120	120	120	120
Ivf(kA)	1.56	1.73	1.90	2.05	2.19
Idv(kA)	12	12	12	12	12
Elongation (κ)	0.83	0.83	0.83	0.84	0.84
Triangularity (δ)	-0.16	-0.16	-0.16	-0.16	-0.16
field decay (n)	1.97	1.86	1.76	1.67	1.58

R > R0:
- ✓ More stable
- ✓ Larger volume



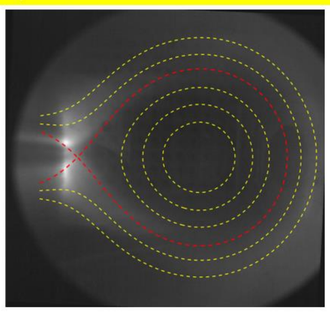
MSN Divertor configuration discharge

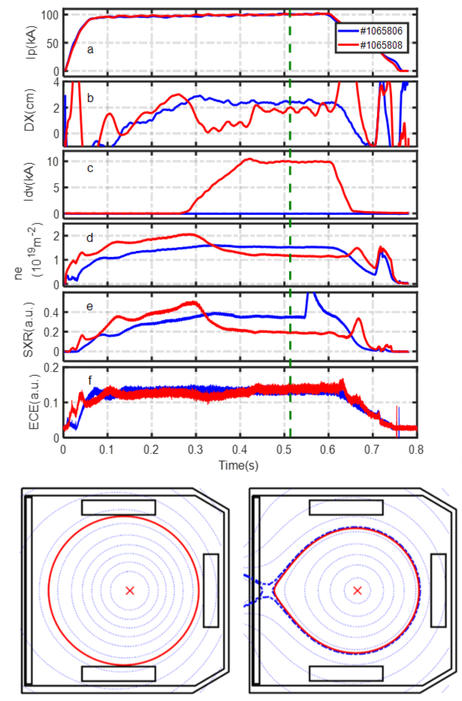


Discharge scenario

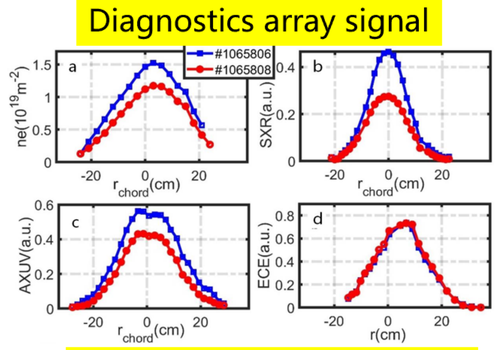
1. ramp-up of the plasma current
2. push DX to 2cm
3. Rise DV current
4. Keep current flattop

Visible imaging & equilibrium flux distribution

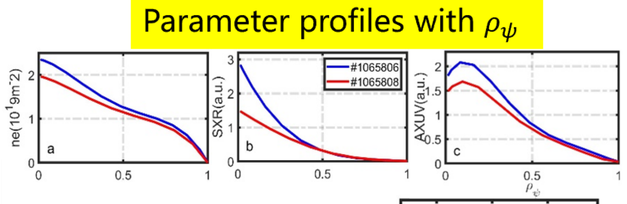




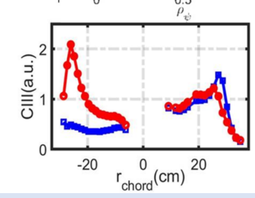
Diagnostics array signal



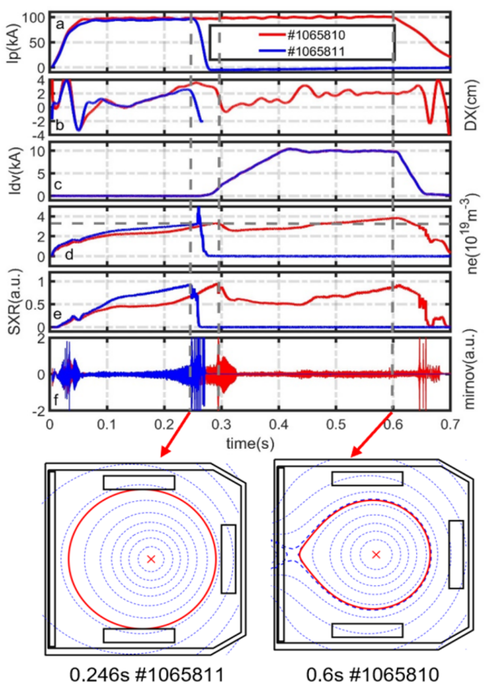
Parameter profiles with ρ_ψ



CIII signal of HFS and LHS arrays:



High-density experiment

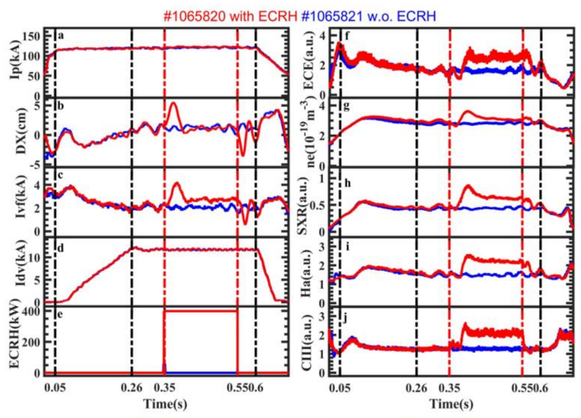


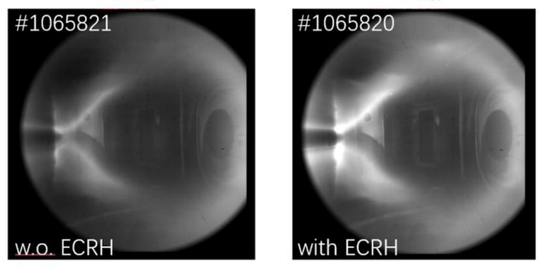
◆ Density limit in limiter configuration: to $3.1 \times 10^{19}\mathrm{m}^{-3}$ at 0.25s, 63.3% of $n_G = 4.9 \times 10^{19}\mathrm{m}^{-3}$,

◆ High density in divertor configuration: to $3.8 \times 10^{19}\mathrm{m}^{-3}$ at 0.6s; modified to $4.9 \times 10^{19}\mathrm{m}^{-3}@b = 0.2m$ 76.5% of $n_G = 6.4 \times 10^{19}\mathrm{m}^{-3}@\kappa = 0.87$ &$S = 0.137m^2$

magnetohydrodynamic instability:
- ◆ High level and mode locked in limiter
- ◆ lower level in divertor

ECRH experiment





- ◆ ECRH: 400kW, from 0.35s to 0.55s
- ◆ resonant layer: $\mathrm{R}_{\mathrm{resonate}} = 1.07cm$
- ◆ electron temperature & density increased
- ◆ radiation from the H_α and CIII : more intensitive
- ◆ more heat on the divertor target
- ◆ intensive recycling & serious release of impurity

Summary

- ➢ **Base on a series of preparations such as the divertor power supply, the divertor target and relevant diagnostics, the divertor configuration discharge has been realized for the first time in J-TEXT tokamak.**
- ➢ **according to the relevant diagnostics and an equilibrium flux distribution reconstruction, a controllable MSN divertor configuration is formed with a X-point on the high field side.**
- ➢ **High density experiment and auxiliary heating experiment have been attempted in the divertor configuration. 76.5% of the Greenwald density limit is achieved. In the ECRH experiment, the electron temperature and density are enhanced, while more heat load on divertor target causes intensive recycling and serious release of impurity.**