# **Machine Report from Heliotron J**

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## **The Heliotron J Device**







#### ✓ Specifications

- Single helical coil (I=1), two kinds of toroidal coil, and three pairs of poloidal coil
- ▶ B<sub>t</sub> ≤ 1.5 T,
- $\succ$  0.4 ≤  $\iota/2\pi$  ≤ 0.65, weak magnetic shear

#### ✓ Heating systems

- ECH: P < 0.4 MW, f = 70 GHz</p>
- ➢ NBI: P < 1.6 MW, E < 30 keV (H), co and ctr</p>
- $\blacktriangleright$  ICRF: *P* < 0.8 MW, antenna disassembled
- ✓ Particle fueling systems
  - Gas puffing (conventional, high-intensity)
  - Hydrogen pellet
- $\checkmark$  Achieved plasma parameters
  - hightarrow n<sub>e</sub> < 1x10<sup>20</sup> m<sup>-3</sup>





We have recently conducted plasma experiments from the viewpoint of confinement, transport, MHD, turbulence, and edge plasma physics.

- High-density improved modes
  - High-intensity gas puffing (HIGP) for ITB formation
  - Dynamics of plasma reconfiguration after pellet injection
- Effect of magnetic configuration on energy confinement, transport, and MHD stability
  - Effect of edge magnetic configuration
  - Application of "Available Energy" to global energy confinement
- L-H transition physics
- Pellet ablation physics
- Turbulence measurement
- MHD study (Pressure-driven modes, EP-driven modes)
- Impurity transport
- Stochastic acceleration of MeV electrons using non-resonant microwaves





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## Formation Process of ITB in NBI+HIGP Plasma



- The formation of e-ITB is observed in NBI plasmas with high-intensity gas puffing (HIGP) at the magnetic field of B > 1.15T.
- A peaked ion temperature profile is also observed at the magnetic field of B=1.41T.



C. Wang, PPCF2024 C. Wang, to be submitted



CWGM, June 3rd, 2025



### **Improvement of Heat Transport Inside ITB**



- The core  $\chi_{e}$  is much reduced in the high magnetic field cases (B=1.41T and B=1.28T).
- The core  $\chi_i$  is reduced only in the B=1.41T case. ٠
- The 4/7 rational surface may be related to the ITB formation. •



R. Seki et al., PFR. 6, 2402081  $\frac{P_j V dr - \langle \nabla r \rangle V' u_j n_j T_j - \frac{3}{2} V' \Gamma_j T_j}{\langle \nabla r^2 \rangle n_j \nabla T_j}$ 



S. Kobayashi JPS Meeting 2025

CWGM, June 3rd, 2025







#85214



- $\checkmark$  Plasma shrinking and re-expansion
  - The radiation region shifts inward and then returns to the outside
    I Plasma shrinking and re-expansion
  - This expansion terminated with sudden onset of magnetic fluctuation
  - Classified into three phases
    - (i) Shrinking phase
    - (ii) Expansion phase
    - (iii) Saturation phase (Wp and MP are saturated in this phase)

Ogihara, Sci. Rep. 2025





- Rotational transform can be scanned from 0.47 to 0.63 with keeping the magnetic shear weak
- Rotational transform control strongly affects the magnetic configuration, particularly edge magnetic structure
- Low-order rational surfaces such as 4/8 and 4/7 appear in some configurations.





0.58

0.56

0.50

0.52 kA

-4/8

0.0

1/2<sup>11</sup>

# **Change from Divertor to Limiter Configuration** by Plasma Current

Expansion of confined region

1.2

R[m]

1.6

1.4



Co plasma current increases iota, expanding the confined region and changing the edge magnetic topology from divertor to limiter configuration.

0.2

0.0

-0.2

-0.4

ш

N

with

laxis

0.0 kA

0.4 kA

0.8 kA

1.2 kA

1.0



CWGM, June 3rd, 2025

Estimation including magnetic axis current

STD

1.2*kA* 

0.2

0.1

r[m]



## **Plasma Diagnostics in Heliotron J**

Langmui

Directional probe

BES



#### **Diagnostics in operation**

- Magnetics<sub>III/OV (upper)</sub>
- Nd:YAG Thomson scattering system
- Submillimeter wave inteferometer
- CXRS (Ti, toroidal and poloidal flows)
- AXUV . CXRS(poloidal)
- Doppler Reflectometer
- ECE
- Imaging bolometere array
   Visible camera
- Multiple Langmuir Probes
- Divertor probes
- Near Infrared spectroscopy
- Fast imaging camera
- Stark broadening spectroscopy
- Digital oscilloscope
- Scintillators for MeV electrons

#### **Diagnostics under preparation**

- CXRS (poloidal flow)
- Comb reflectometer
- Multi-channel poloidal reflectometer
- Stark broadening spectroscopy
- 2D beam emission spectroscopy
- Multi-channel SX system

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- Vertical ECE · Rogowski coil
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Laser blow-off system

•  $H\alpha$  array (poloidal)

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Optical vortex ECH system
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Visible monitor
 Visible spectroscopy

Visible spectroscopy

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    Mirnov coil
    MW interferometer
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- The "Bidirectional Collaboration Program" with NIFS has been renamed to the "Fundamental Facility-Type Collaboration Research Program" as of April 2025, with a duration of at least 3 years.
- We will commence the experimental campaign in September 2025.
- Main experimental purposes
  - Dependence of energy confinement and transport on magnetic configuration
  - Comparison with theory, such as "Available Energy"
  - Improved confinement using HIGP and/or pellet injection
  - -Turbulence study using reflectometer, ECE, and Langmuir probes
  - -MHD study (pressure-driven modes, EP-driven modes)
  - Impurity transport
  - Stochastic acceleration by non-resonant microwave heating
- Your experimental proposals are very welcome!