(TG1) Multi-ion group report

Nov. 19, 2021 (M. Kobayashi)

Date: Nov. 19, 2021
Time: 11:53 – 18:45
Shot#: 173118 – 173237 (120 shots)

Prior wall conditioning: No
Divertor pump: On
Gas puff: D2 IPD: No
LID: No
NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, He)=P(2.3, 2.1, 2.1, 5.9,)MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(723, 799, 825)kW
ECH(116GHz)=ant(2O-LR)=P(0.0)kW
ECH(56GHz)=ant(1.5-U)=P(0.0)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.52, 0.44, 0.47, 0.35) MW
Neutron yield integrated over the experiment = 2.1×10^{17}

Topics

1. Poloidal in-out Asymmetric Distributions of Core Toroidal Rotation by ECH (W.H. Ko et al.)
2. Commissioning of impurity beam injections with NBI#5 into LHD plasmas (N. Tamura et al.)
3. Verification of helium beam depositions (S. Kamoi et al.)
4. Observation of phase-space distribution of fast helium ions by Fast-ion charge exchange spectroscopy diagnostic (S. Kamio et al.)
5. Helium removal in helium beam experiments (G. Motojima, K. Hanada)

Poloidal in-out Asymmetric Distributions of Core Toroidal Rotation by ECH (by W.H. Ko)

Experimental conditions:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CW, 2.75 T, 1.2538, 100.0%)
ECH modulation with 1.25Hz

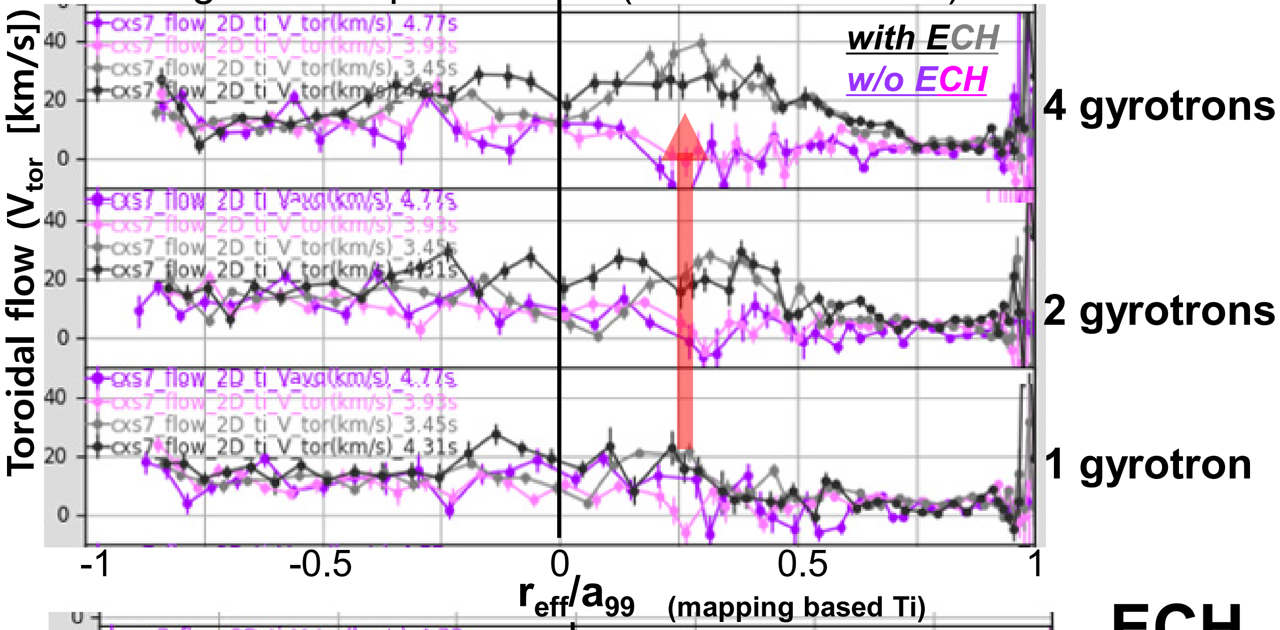
Objective and background:

- Poloidal in-out asymmetric distributions of core toroidal flow were observed in balanced NBI plasma by ECH
- Searching the source of the **ECH-driven flow asymmetry**. (i) Effect of Pfirsch–Schlüter flow, (ii) Asymmetric toroidal rotation by the ECH-driven **asymmetric flux** surfaces [Y Camenen, et al., PPCF (2010)]

Results:

- The lower the density(higher core Ti) and the stronger ECH power with the more on-axis, the more asymmetry distribution of toroidal flow (Fig. 1 & 2.).
- If the direction of the toroidal magnetic field is change, how will the asymmetry of toroidal flow change? → Bt = - 2.75 T in Dec. 8

Fig. 1 ECH power scan (for on-axis case)



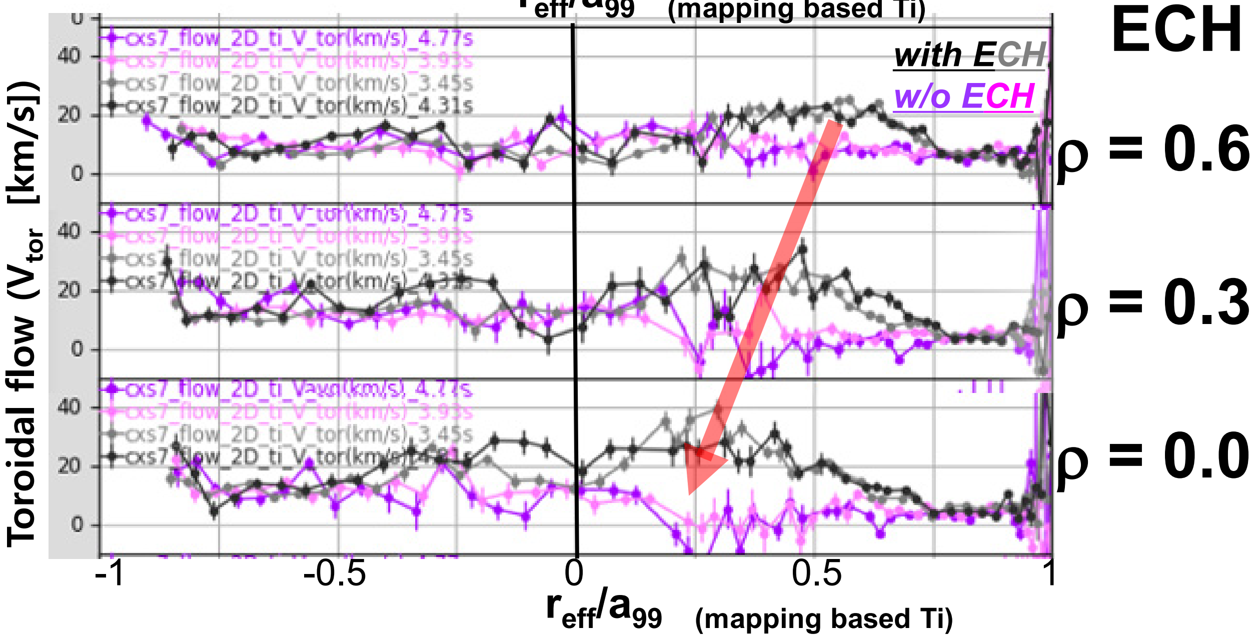


Fig. 2 ECH heating deposition scan

Commissioning of He beam injection with NBI#5 into LHD plasmas (N. Tamura on behalf of TG1)

Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CW, 2.75 T, 1.2538, 100.0%)

Shots: #173149 - #173203

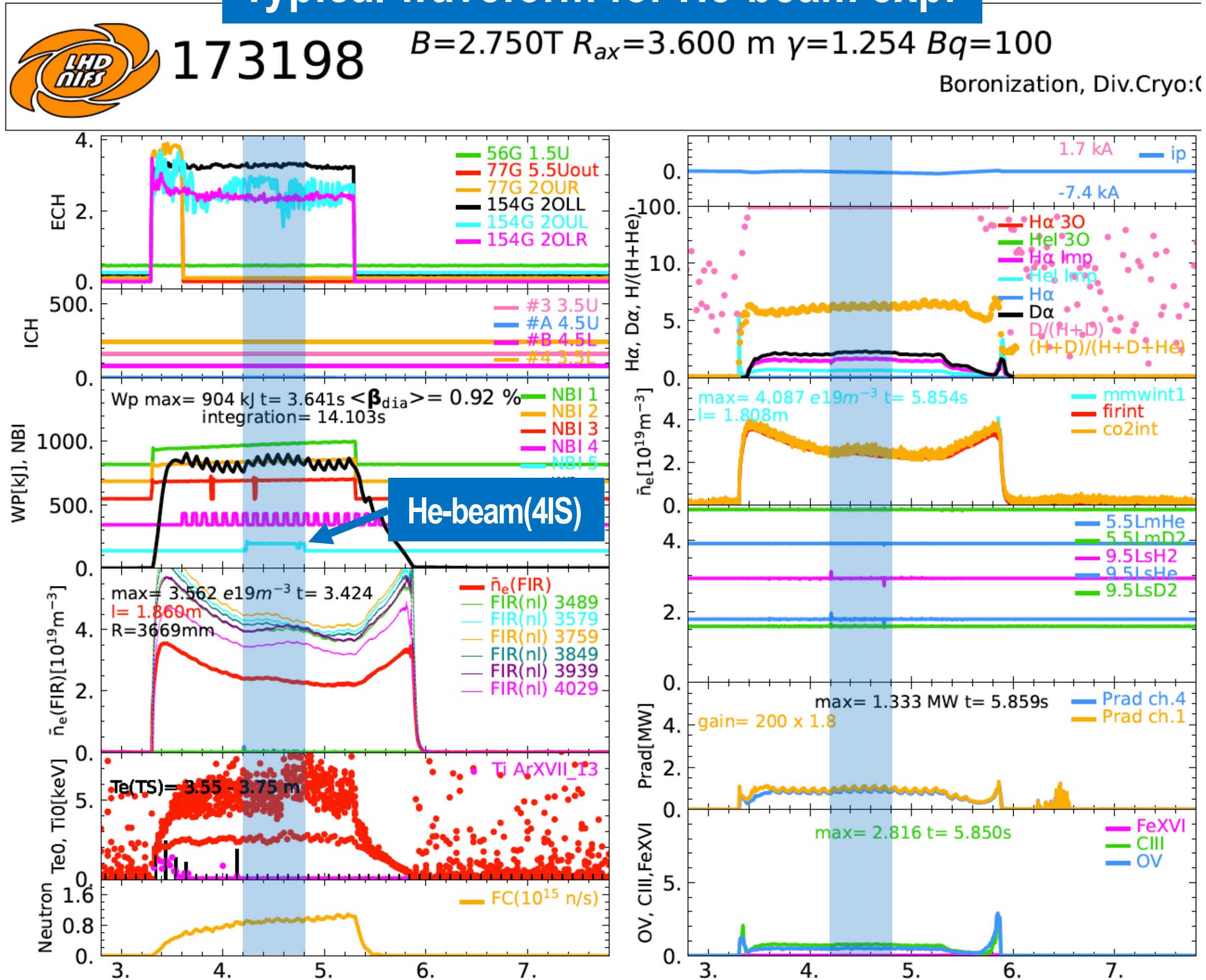
Goal of this experiment

- Commissioning of the He beam injection with NBI#5 into LHD plasmas

Main results of this experiment

- **He beams (with 1, 2, 3, 4 ion source(IS)) have been successfully injected** into the LHD D-plasmas
- From this campaign, NBI#5 can inject He-beam and H/D beam alternatively
  - ✓ Argon arc discharges are needed after the He-beam injection
  - ✓ (He-beam → Ar arc.#1 → Ar arc.#2 → D/H- or He-beam) is the current sequence obtained.
  - ✓ A choice of D/H- or He-beam depends on the He contamination level in the LHD vacuum vessel
- We have also conducted He gas flux calibration with NBI#5, 1) only NBI#5 w/o a beam extraction 2) only NBI#5 w/ a beam extraction, under the situation where the gate valves for cryopumps of LHD are closed

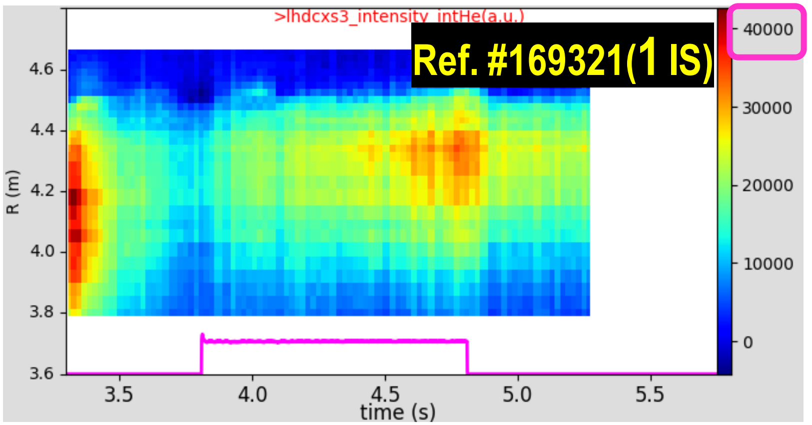
Typical waveform for He-beam exp.



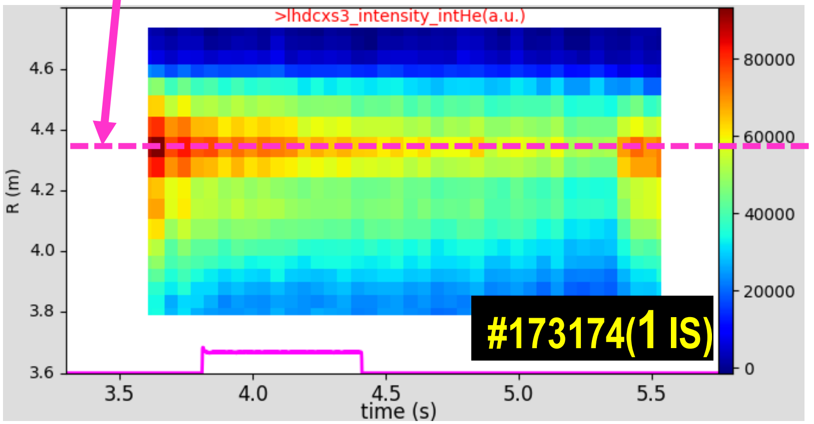
Commissioning of He beam injection with NBI#5 into LHD plasmas (N. Tamura on behalf of TG1)

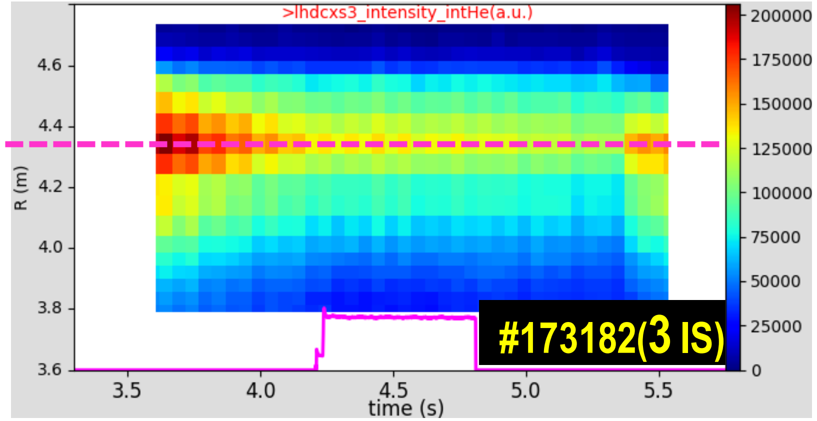
Main results of this experiment (cnt'd)

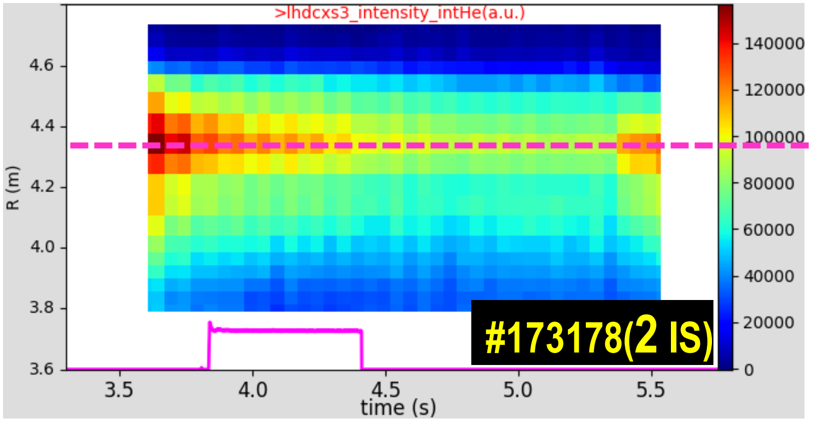
- Under current condition, the impact of He gas flux from NBI#5 is larger than that in the previous campaign

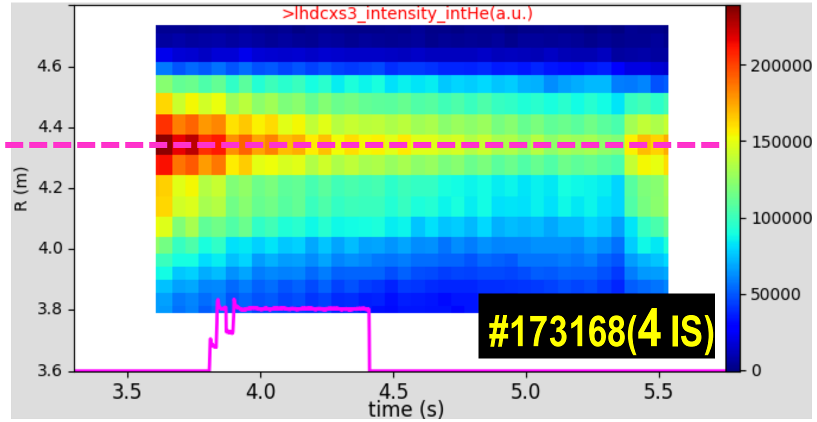


- **Peaks at R ~ 4.35 m** appeared before the He-NBI → not attributed to the beam fueling









	1 IS (22c)	1 IS	2 IS	3 IS	4 IS
Max Int. CXS3(He) (rough)	~ 4e4	~9e4	~17e4	~20e4	~23e4

Next steps

- **Improving the He gas control**
- **Optimizing the setting for He beam, not for D beam** (i.e., optimizing 2IS for He beam & another 2IS for D-beam)

Conduct verification of helium beam depositions with perpendicular NBI

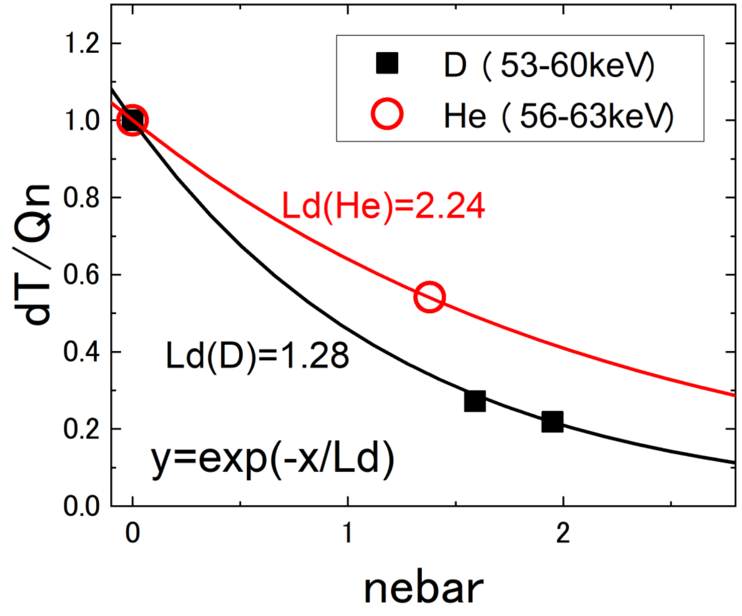
Experimental conditions:
(*R*ax, Polarity, *B*t, *γ*, *B*q) = (3.6 m, CW, 2.75 T, 1.254, 100.0 %)

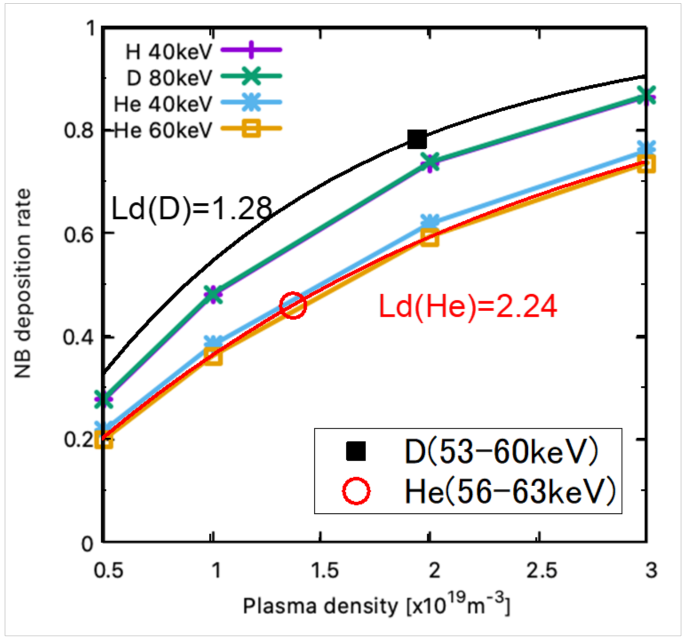
Background and motivation:

Verification of helium beam depositions is inevitable for particle and heat transport analyses. Calculated He beam deposition using HFREYA code with atomic data of He shows that difference of deposition length with Deuterium beam is not significant.

Results:

- The shine-through ratio was evaluated with the temperature increase of TC34 located at armor tile for NBI5, which have no interaction with divertor heat flux.
- Beam calibration shots were performed for both Deuterium beam and Helium beam.
- The beam deposition length was evaluated by the beam shine-through rate. The deposition rate of He beam agree with HFREYA calculations.



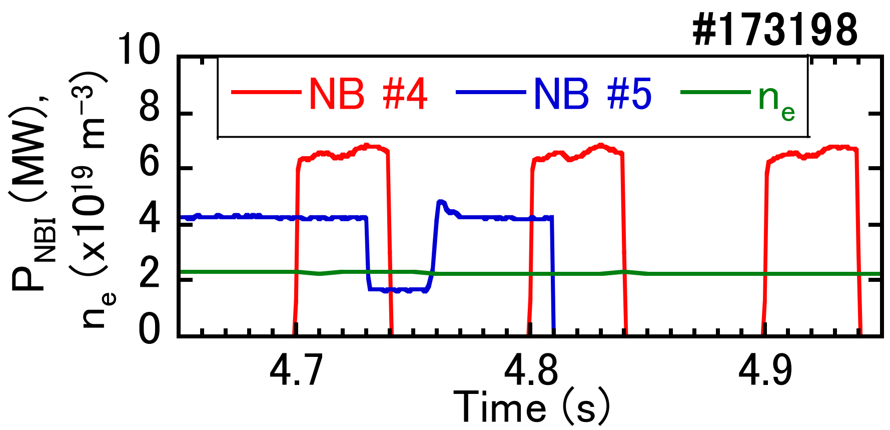


Observation of phase-space distribution of fast helium ions by Fast-ion charge exchange spectroscopy diagnostic

Experimental conditions:
(R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.254, 100%)

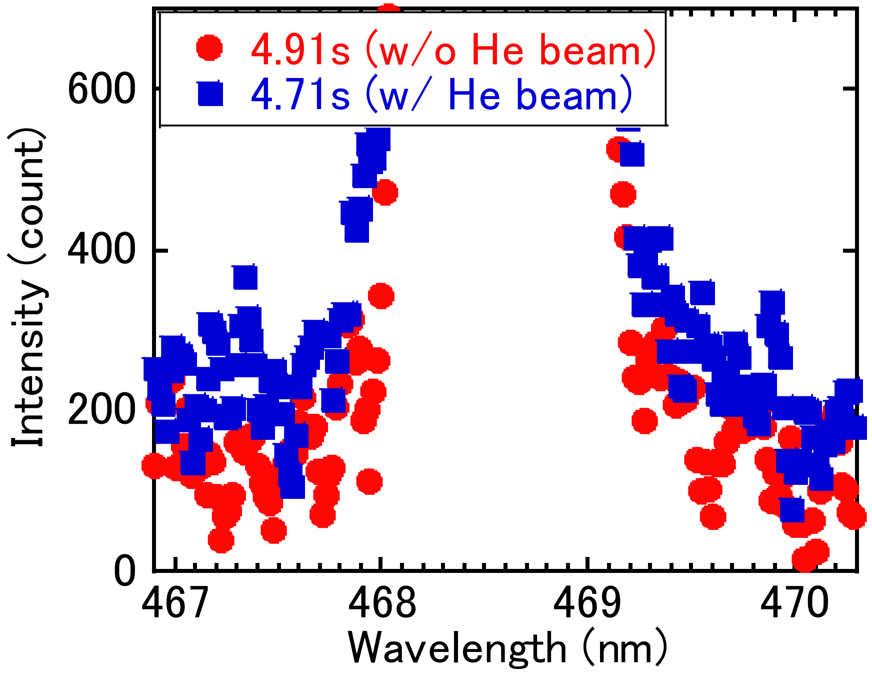
Background and motive

- Phase space profile of fast helium ions is measured by FICXS using NB #4.



Results

- During the NB #5 injection timing, the spectrum of the fast ion component are higher than that of without NB #5.
- We will investigate the different spatial channels.
- In order to analyze the experimental results, a special analysis code will be developed. This will make it possible to study the confinement of fast helium ions by GNET.



Helium removal in helium beam experiments (G. Motojima, K. Hanada (Kyushu Univ.))

Magnetic Configuration: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CW, 2.75 T, 1.2538, 100.0%)
Shots: 173206-173237 (32 shots)
Goal of this experiment:

- To study the wall exchange (divertor, first wall, NBI armor tiles) behavior from He to D

Results:

- We tried to conduct the 40 s ECH/ICH discharges of deuterium (Fig.1).
  → Drastic change of the ratio (H+D)/(H+D+He) was observed in first several shots, in which divertor temperature was relatively lower (Fig. 2). Weakly trapped He is probably released. In latter discharge shots, H/He ratio looks saturated.
  He/H ratio measured by CXS was also decreased in first several shots, however the ratio looks saturated following discharges (Fig. 3).
- D-NBI#5 was injected for the He removal on the NBI armor tiles (Fig. 2).
  → The ratio (H+D)/(H+D+He) was decreased, suggesting that He absorbed in NBI armor tiles was released. Further quantification is required.

Fig 1.

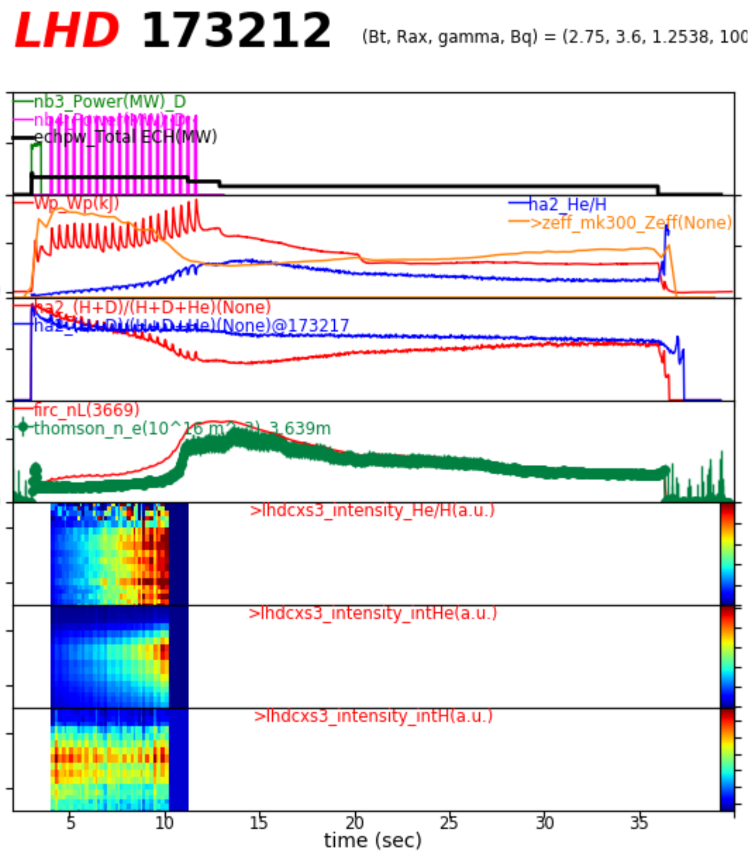


Fig 2.

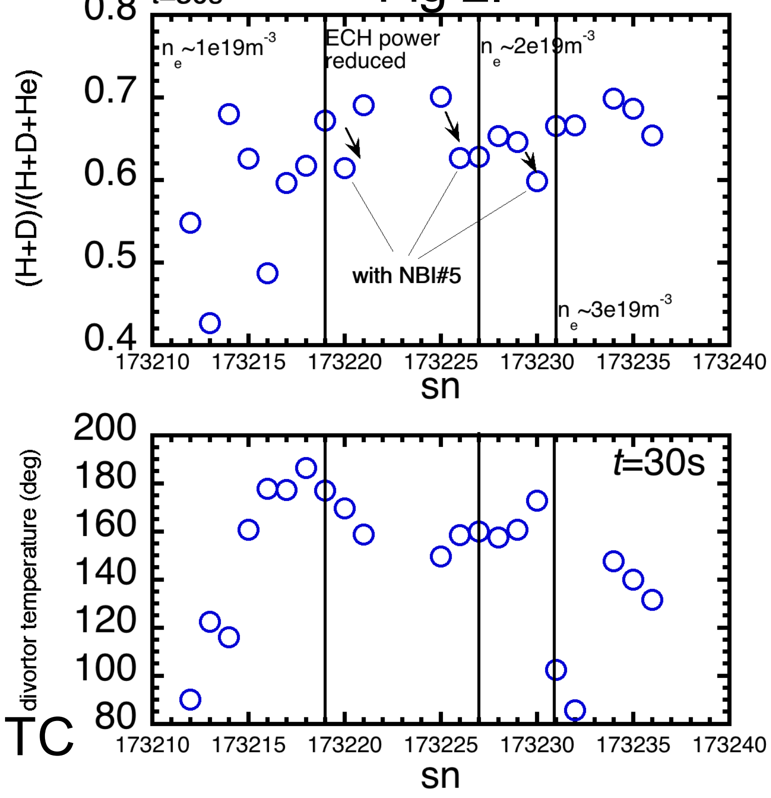


Fig 3. He/H ratio measured by CXS