(TG1, 2, 4) Plasma multi-ion, turbulence, instability group report

Dec. 16, 2021 (T. Kobayashi)

Date: Dec. 15, 2021
Time: 10:10 – 18:45
Shot#: 175086 – 175224 (139 shots)

Prior wall conditioning: H2
Divertor pump: None
Gas puff: D_2, H_2, He, Ar
Pellet: TESPEL, C-pellet

NBI#(1, 2, 3, 4, 5) = gas(H, H, H, D, D) = P(3.7, 3.5, 3.4, 6.2, 6.0) MW

ECH(77 GHz) = ant(5.5-Uout (or 1.5U), 2-OUR) = P(703, 792) kW
ECH(154 GHz) = ant(2-OLL, 2-OUL , 2-OLR) = P(979, 930, 986) kW
ECH(56 GHz) = ant(1.5U) = P(-) kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.40, 0.35, 0.69, 0.42) MW
Neutron yield integrated over the experiment = 9.6×10^{15}

Topics

1. Transport in the isotope mixture plasma (K. Ida)
2. Transport study in ECRH superposed ion ITB plasma (H. Nakano)
3. Isotope mass effects on sustainment of e-ITB plasma (N. Kenmochi)
4. Dependence of electron ITB threshold condition on isotope mass (T. Kobayashi)
5. Non-linearity of transport and turbulence in mixture plasma (T. Kinoshita(Kyushu Univ.), K. Tanaka)
6. Mixture-induced phase transitions in multi-ion transport (Dinklage(IPP), N. Tamura)

Isotope effect on ion-ITB plasma (Ti(0) ~ 4 keV)

K.Ida and M.Yoshinuma

P_{NBI}

Wp

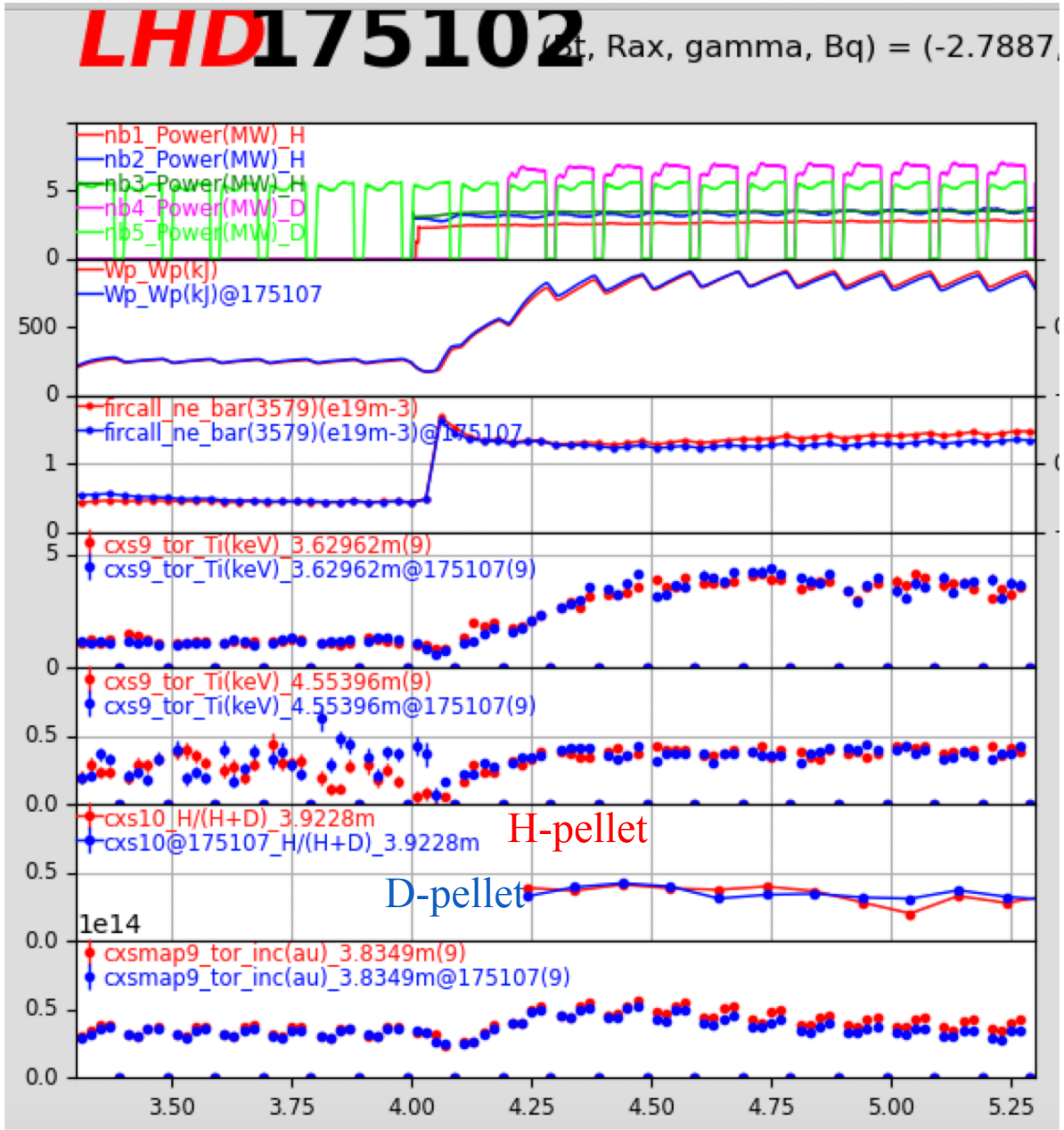
ne_bar

Ti(0)

Ti(edge)

H/(H+D)

n_C



Isotope effect on ion-ITB plasma is studied by comparing the ion temperature after the H-pellet and D-pellet.

Hydrogen fraction by pellet was not succeeded.
H/(H+D) = 0.4 for H-pellet
H/(H+D) = 0.4 for D-pellet
The fraction is determined by wall recycling

The stored energy and electron density are slightly higher for D-pellet than that for H-pellet discharge

The central ion temperature is almost identical between H-pellet and D-pellet discharge

Carbon concentration is similar between H-pellet and D-pellet.

The H/(H+D) will be measured before the pellet injection

H/D ratio scan experiment: High T_i discharge with off-axis ECRH (H. Nakano)

Background and Objective

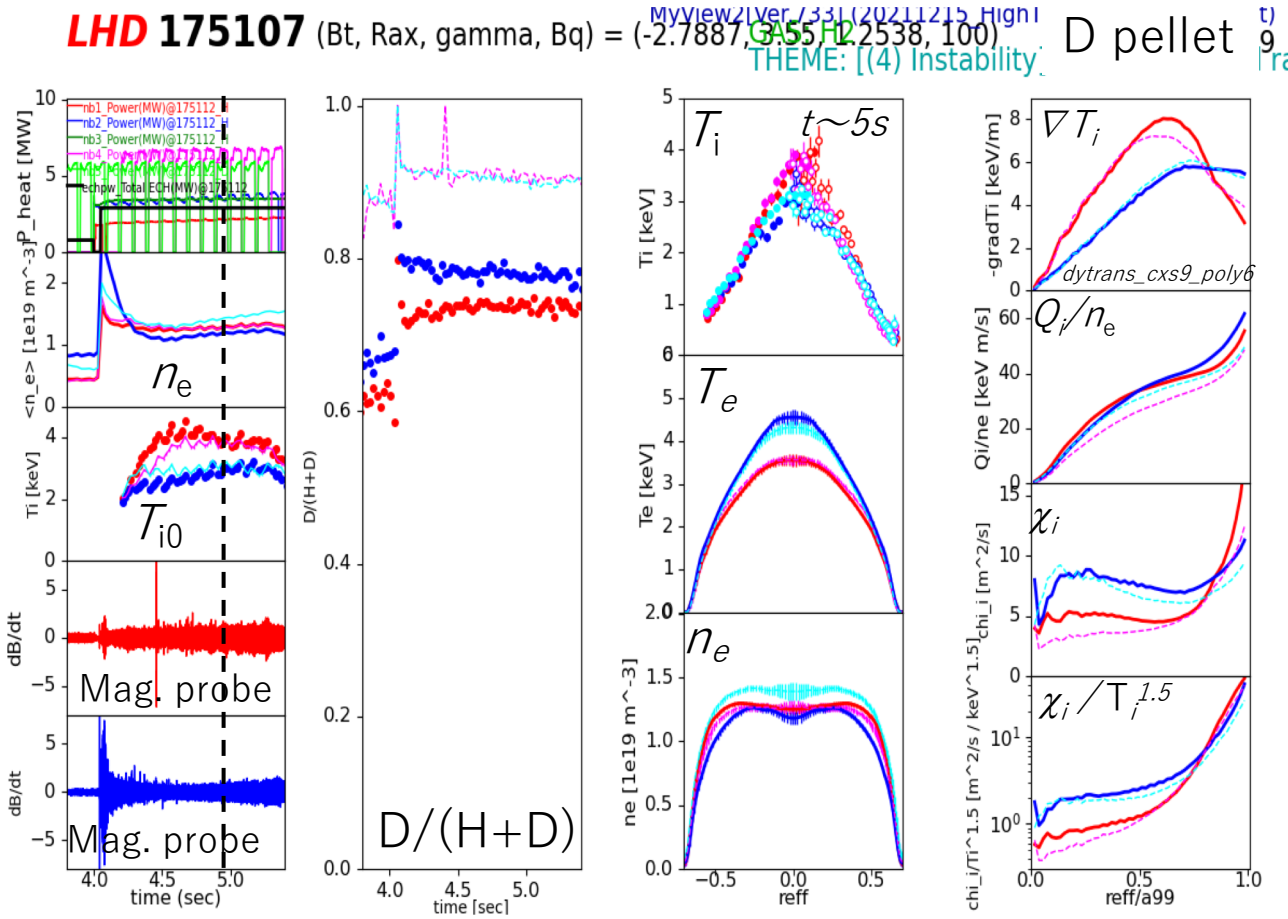
- The ECRH superposition in peripheral region to the high T_i discharge with He puff, carbon pellet, and full power NBI (#1-3:H, #4-5:D) improved the thermal confinement.
- Influence of the H/D ratio on the high T_i discharge with the off-axis ECRH is studied

Experimental Condition (Second Day)

- The off-axis ECRH superposed high T_i discharge with hydrogen and deuterium pellet.

Results

- A lower D/(H+D) ratio compared with yesterday (first day) one was performed.
- Similar effects of the off-axis ECRH on the confinement were shown in higher (yesterday) and middle (today) D/(H+D) ratios, e.g.: Lower T_{i0}, $\nabla T_{i,\ core}$, and $\chi_{i,\ periphery}$, and higher T_{e0}, $\nabla T_{i,\ periphery}$, $Q_i/n_{e,\ periphery}$, and $\chi_{i,\ core}$,
- However, slight differences of the effects by D/(H+D) ratio were observed. Lower D/(H+D) ratio experiment tomorrow will present whether the differences are systematic.



ECRH	rho	Pellet	LHD#
x	-	D/H	175107
o	0.6	D/H	175112

Light color lines show results in higher D/(H+D) ratio (yesterday).

Isotope mass effects on sustainment of e-ITB plasma

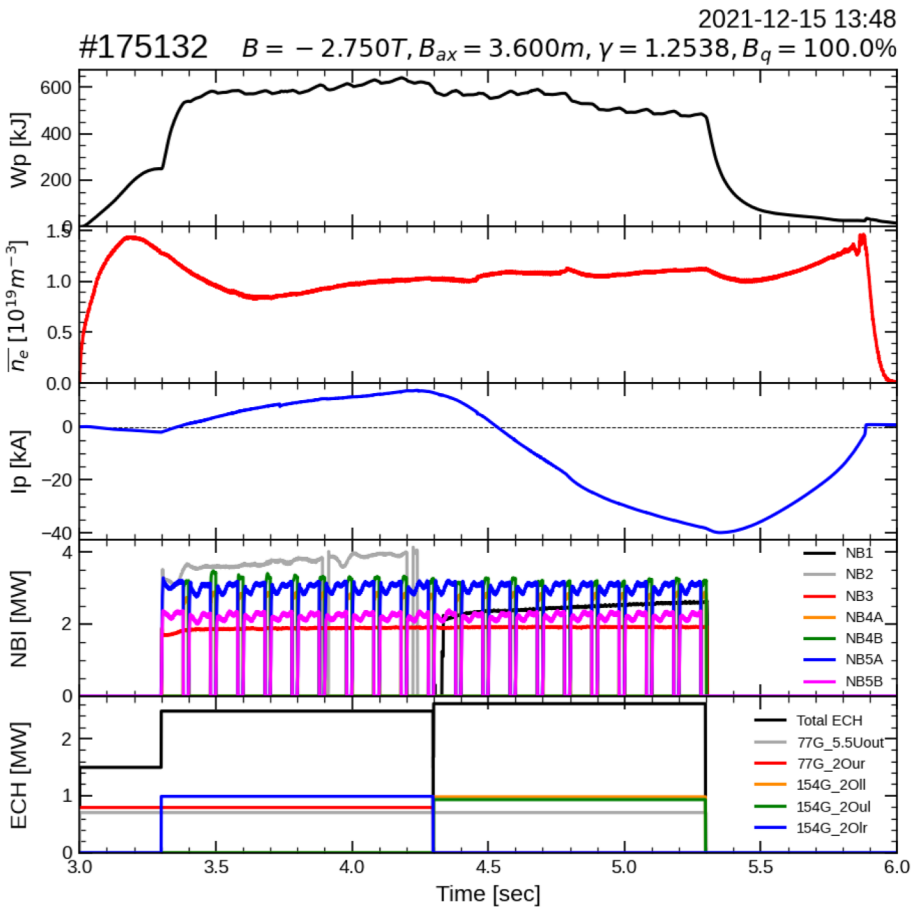
(N. Kenmochi)

Experimental conditions:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.2538, 100.0%)

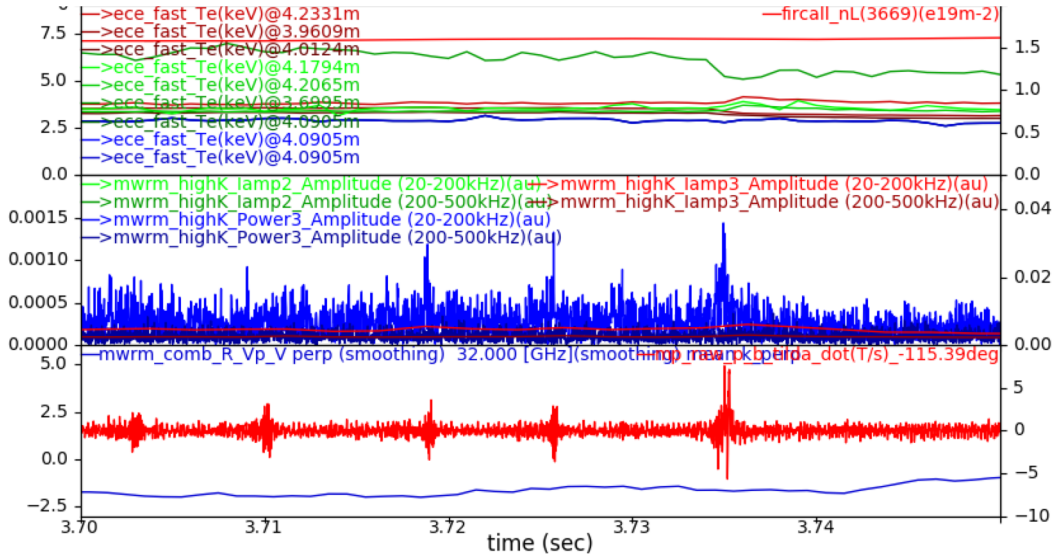
Co. to Ctr. current drive at center region (#175121 - #175142), Deuterium plasma

Objective: To clarify the isotope mass effect of the eITB sustainment and turbulence/heat pulse propagation.



Results:

- ✓ D/(H+D) = 0.76
- ✓ Minor collapse of eITB was observed around m/n=1/2 magnetic island.
- ✓ The electron-scale turbulence and magnetic fluctuation rapidly increase just before the minor collapse.
- ✓ The measurement position of e-scale turbulence was scanned in a shot-to-shot basis.
- ✓ High-speed Thomson scattering (20 kHz) measurement was successfully operated.
- ✓ The relationship between T_e profile, heat pulse, and turbulence will be investigated.



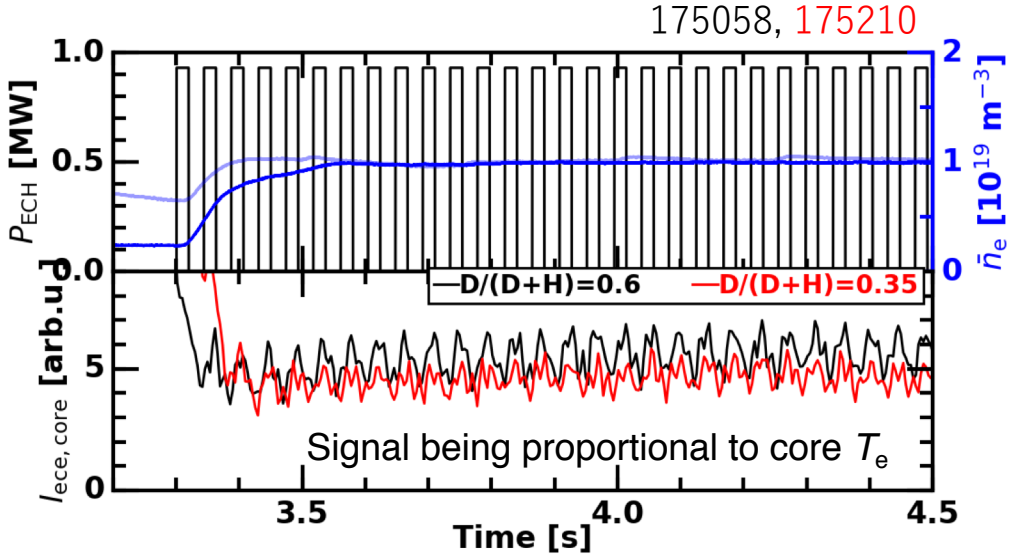
Isotope effects in threshold condition for electron ITB

T. Kobayashi

Shot #: 175161-175172, 175205-175214
Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.2538, 100 %)

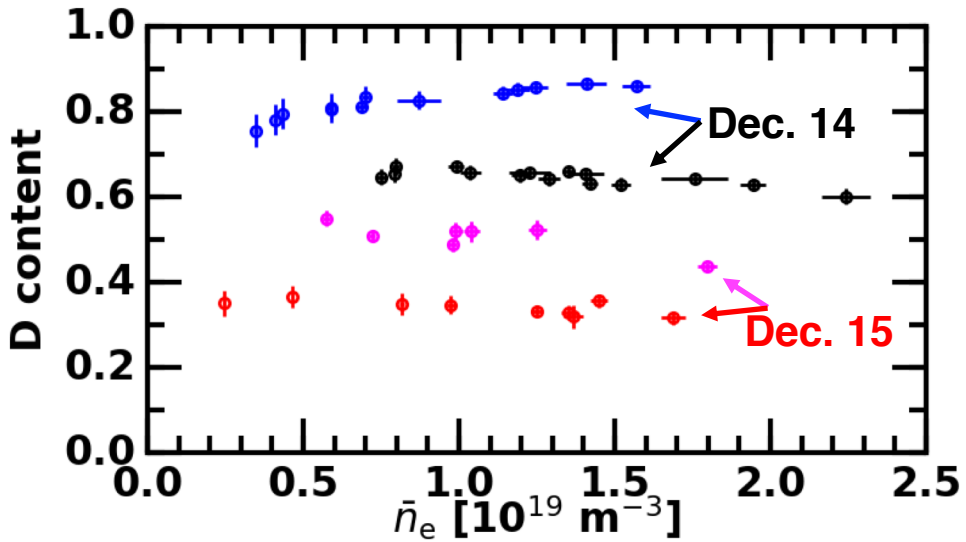
Motivation

- In previous study, the threshold condition for electron ITB formation was found to be eased in deuterium plasmas than hydrogen plasmas.
- How the electron ITB threshold condition depends on the deuterium content is investigated.



Results

- Consecutive formation and deformation of electron ITB were realized by a modulation ECH.
- Line averaged density was scanned in shot-to-shot basis at D/(D+H)~0.5 and 0.35.
- A set of conditioning discharges (high density discharges) were performed to systematically reduce the D/(D+H) condition.
- A signature that the ITB strength was reduced as D/(D+H) was decreased.



Nonlinearity of transport and turbulence in mixture plasma (T.Kinoshita)

Experimental condition

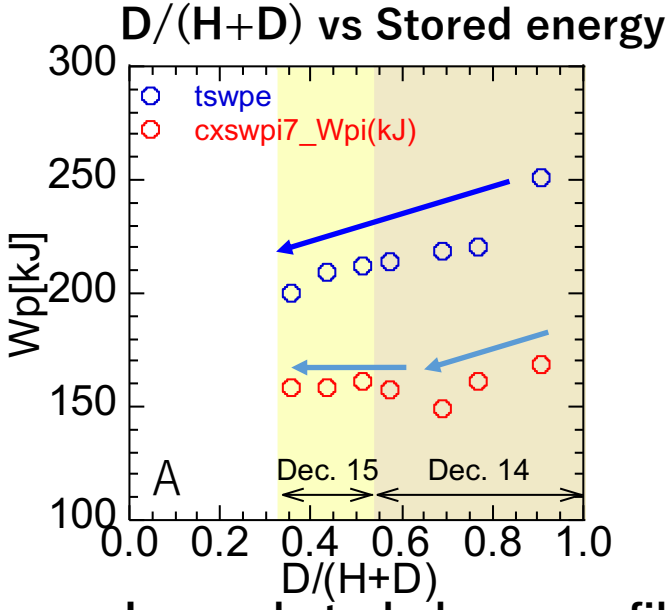
(Rax, Polarity, Bt, γ, Bq) = (3.6 m, CCW, 2.75 T, 1.2538, 100.0%)
175151 - 175160 (10 shots) : D/(H+D) = 0.5
175215 - 175224 (10 shots) : D/(H+D) = 0.35-0.45

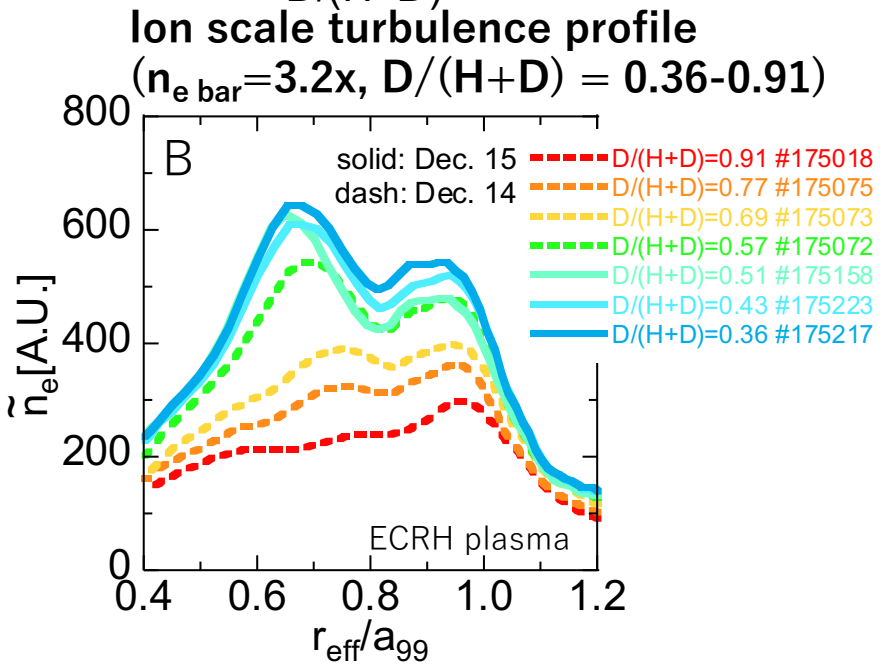
Motivation

- In pure H and D plasma, isotope effect of plasma confinement was observed at n_{e_bar}>3.0x10^{19}m^{-3}.
- Investigation of ion mass dependence of plasma confinement is helpful to understand turbulence characteristics in LHD, and to predict the performance in the future DT mixture plasma.
- We obtained the data with D/(H+D) = 0.6 - 0.9 on Dec. 14.

Initial result

- We successfully obtained turbulence data at the following conditions.
  - ✓ $n_{e\ bar}$=1.0 - 4.0x10^{19}m^{-3} with D/(H+D) = 0.5
  - ✓ $n_{e\ bar}$=3.2, 3.9x10^{19}m^{-3} with D/(H+D) = 0.3 - 0.45
- Electron stored energy decreases with decreasing D/(H+D). (Fig. A)
- Ion stored energy is deceased with decreasing D/(H+D) for 0.5 < D/(H+D), and to be constant for 0.3 < D/(H+D) < 0.5.
- Ion scale turbulence measured by PCI was enhanced with decreasing D/(H+D) for 0.5 < D/(H+D), however, saturated for 0.3 < D/(H+D) < 0.5. (Fig. B)





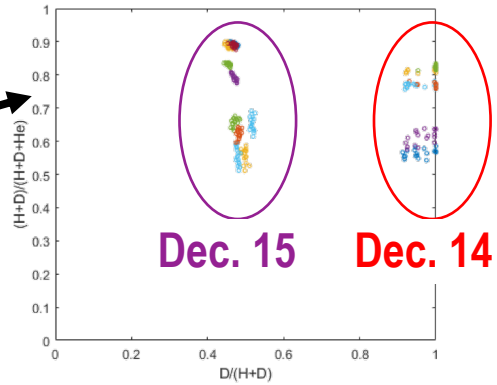
Mixture-induced phase transition in multi-ion transport (A. Dinklage, N. Tamura et al.)

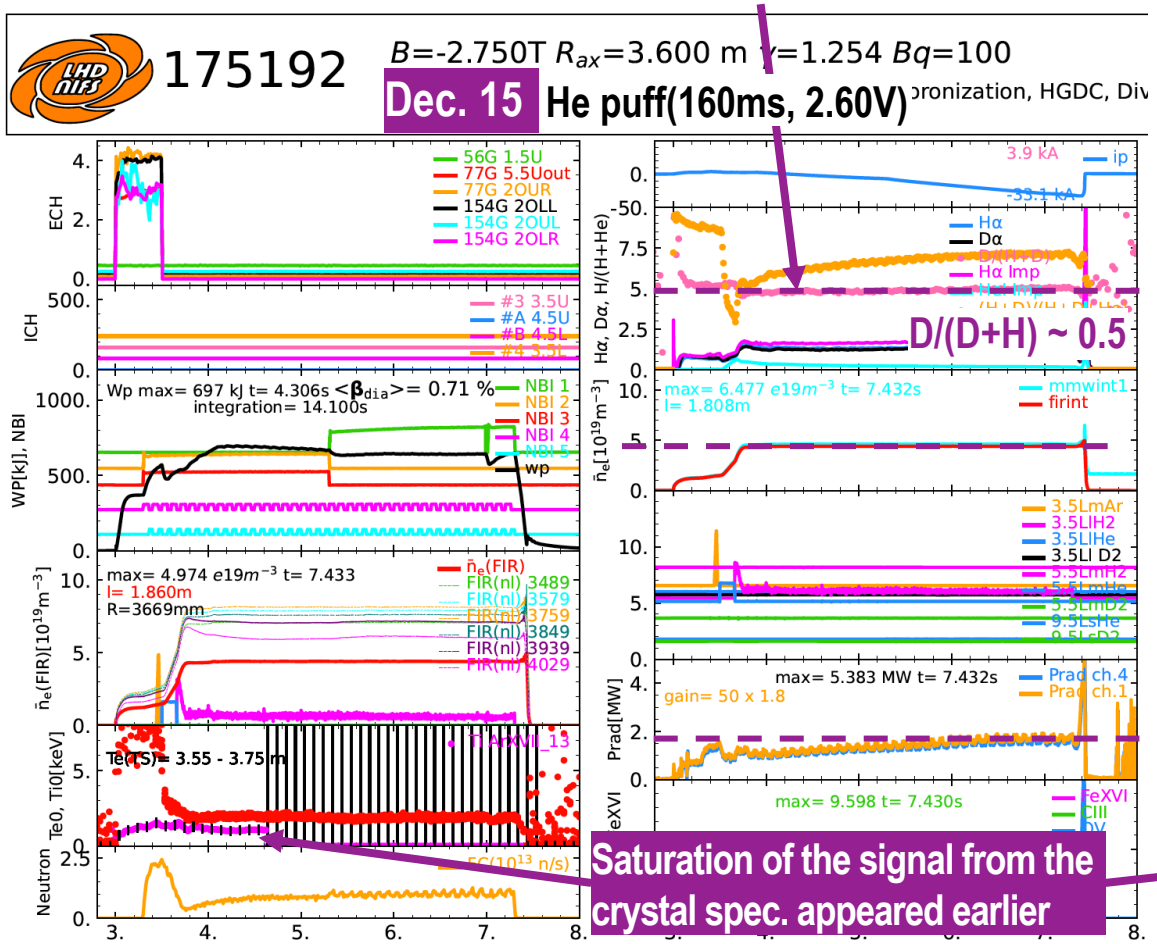
Magnetic Configuration: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CCW, 2.75 T, 1.2538, 100.0%)
Shots: 175173-175194 (22 shots)
Goal of this experiment:

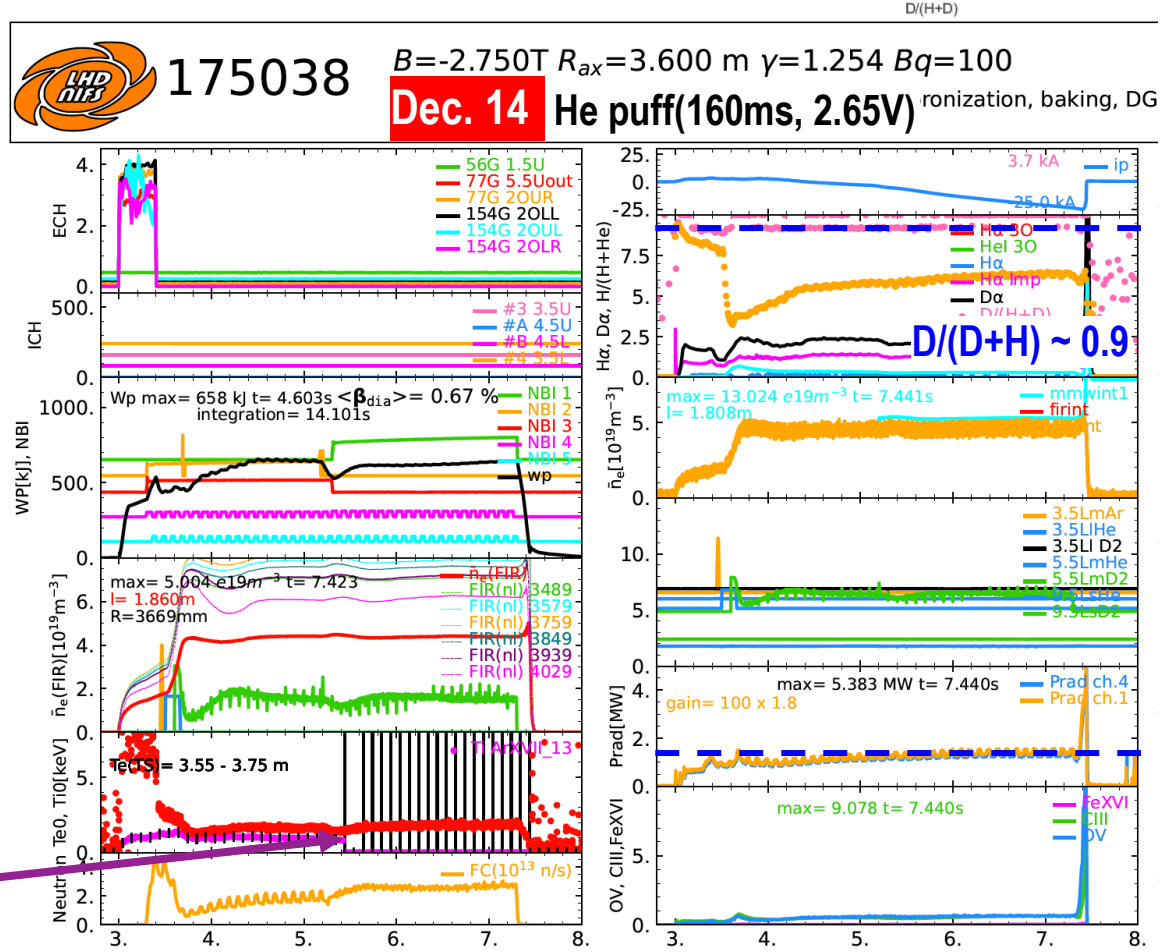
- To study the change of the impurity accumulation window in H/D/He-mixed plasmas

Results:

- We tried to change the He contents in the plasma by using different gas puff settings around n_{e_bar} of 4e19 m^{-3} under the **H/D-mixed condition**







Saturation of the signal from the crystal spec. appeared earlier