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

Dec. 15, 2021 (N. Kenmochi)

Date: Dec. 14, 2021
Time: 9:30 - 18:45
Shot#: 174927 – 175085 (159 shots)

Prior wall conditioning: D2
Divertor pump: OFF
Gas puff: H2, D2, He, Ar, Pellet: H2, D2, C
NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(3.2, 3.4, 3.4, 7.3, 6.2)MW
ECH(77GHz)=ant(5.5-Uout (or 1.5U), 2-OUR)=P(0.70, 0.79)MW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2-OLR)=P(0.98, 0.93, 0.99)MW
ECH(56GHz)=ant(1.5U)=P(0)MW
ICH(3.5U, 3.5L, 4.5U, 4.5L)=P(0.78, 0.70, 0.75, 0.52)MW
Neutron yield integrated over experiment = 1.6×10^{16}

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

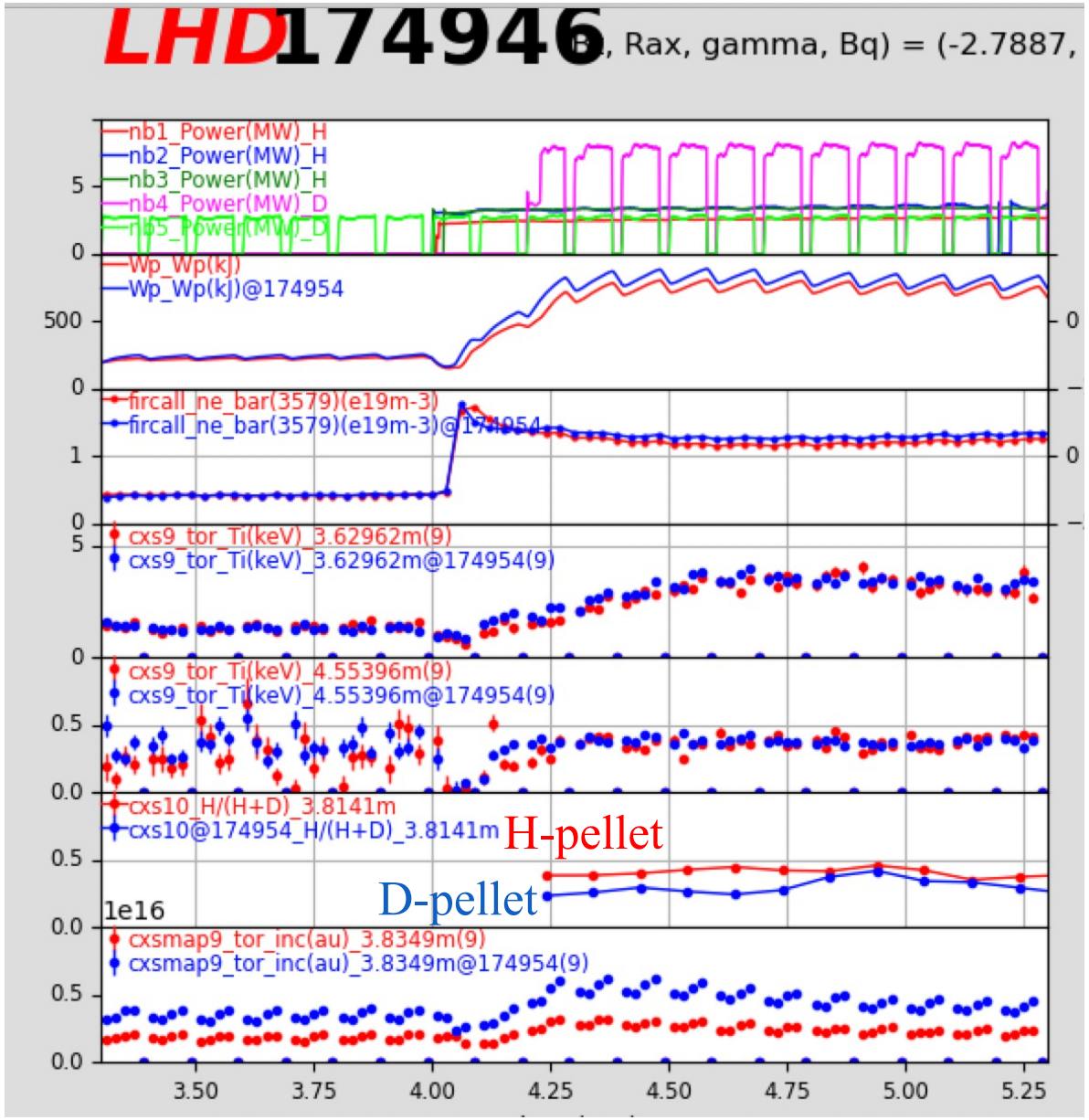
ne_bar

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 was controlled by pellet.
H/(H+D) = 0.4 for H-pellet
H/(H+D) = 0.2 for D-pellet

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 higher for D-pellet discharge (partly due to after effect)

Similar experiment for higher H/(H+D) will be done lather

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 from peripheral region, and then increased T_i in whole region (#165765, R_{ax} = 3.58 m, B_t = 2.7654 T). An objective is how the H/D ratio affects the confinement in the high T_i discharge with the off-axis ECRH superposition.

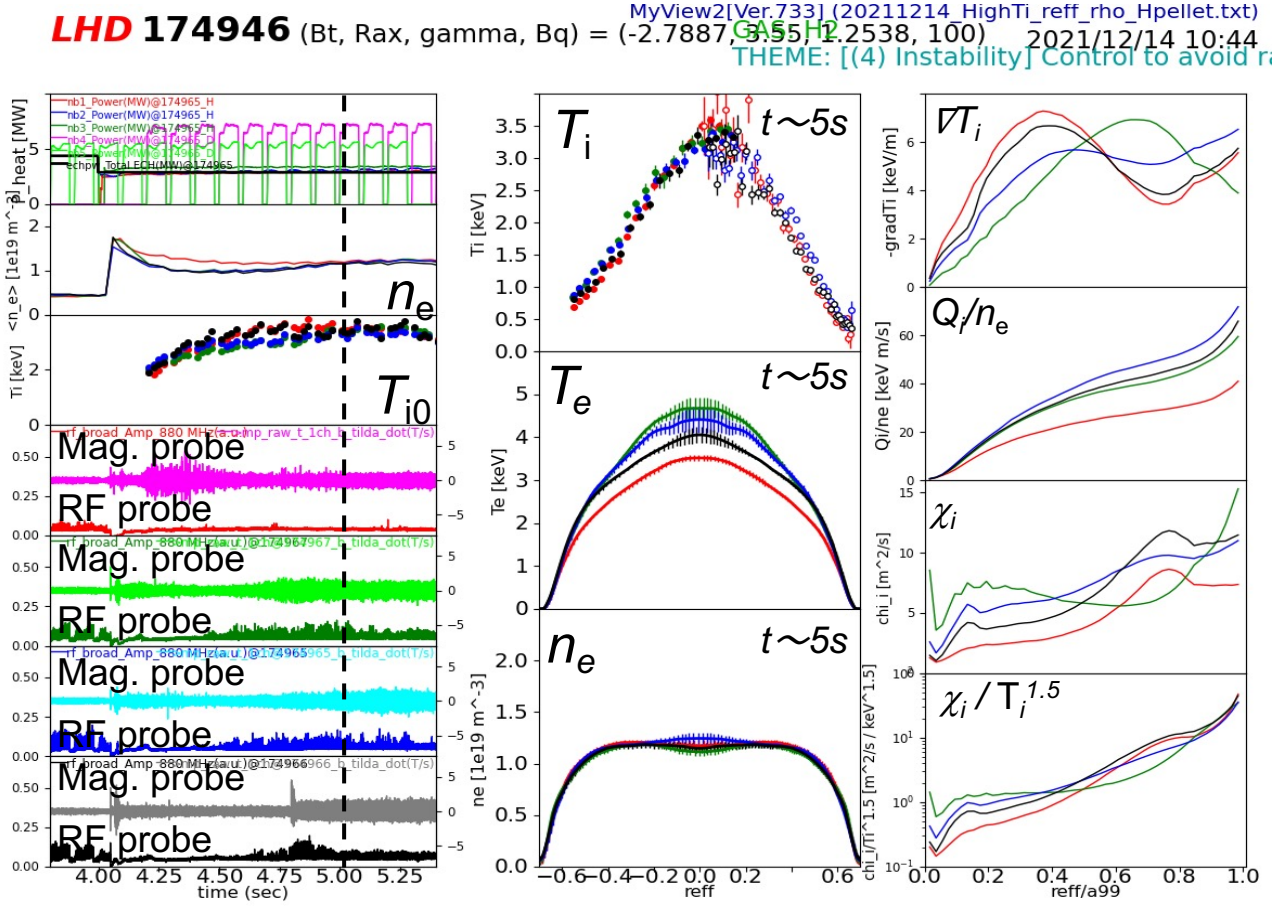
Experimental Condition (#1749xx - #174968)

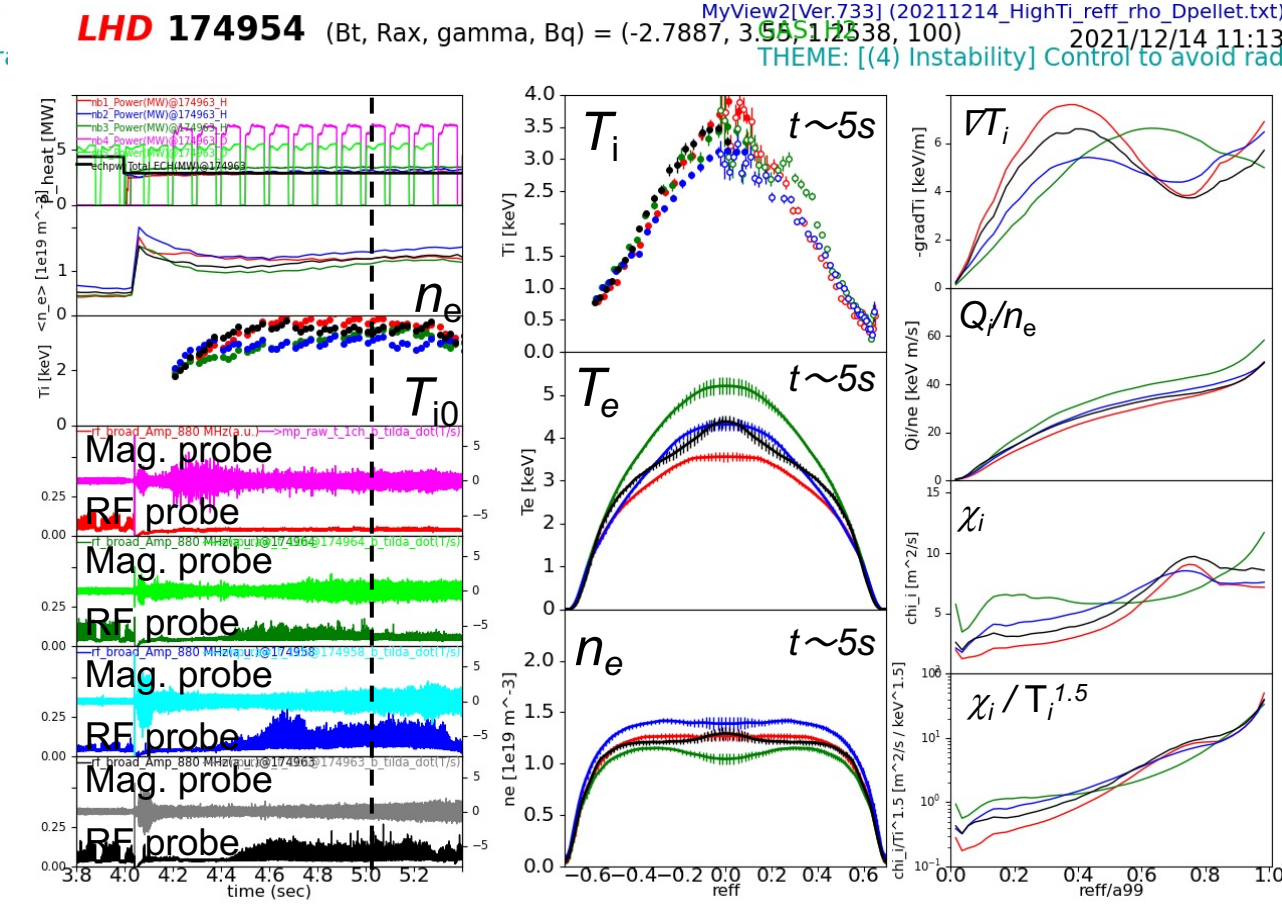
- Magnetic configuration is R_{ax} = 3.55 m, B_t = 2.7887 T, gamma = 1.2538, and B_q = 100 %. Discharges were maintained with NBIs with typical high T_i discharge pattern, and the off-axis ECRH (rho = 0.4, 0.6, 0.8) were superposed. Hydrogen and deuterium ice pellets and carbon pellet injections were scheduled, but the carbon pellet could not used today.
- The experiments were conducted with a piggyback experiment with the H/D ratio scan experiment in high T_i discharge with the pellets without the off-axis ECRH.

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

Results

- The off-axis ECRH superposition seems to decrease the magnetic fluctuations but degrade the confinement in both hydrogen and deuterium pellets. Reasons of the degradation are not known, but candidates might be pellet species, H/D/He ratio, magnetic configuration especially magnetic axis etc. It will be found whether the reason is the H/D ratio in following two days.





D pellet

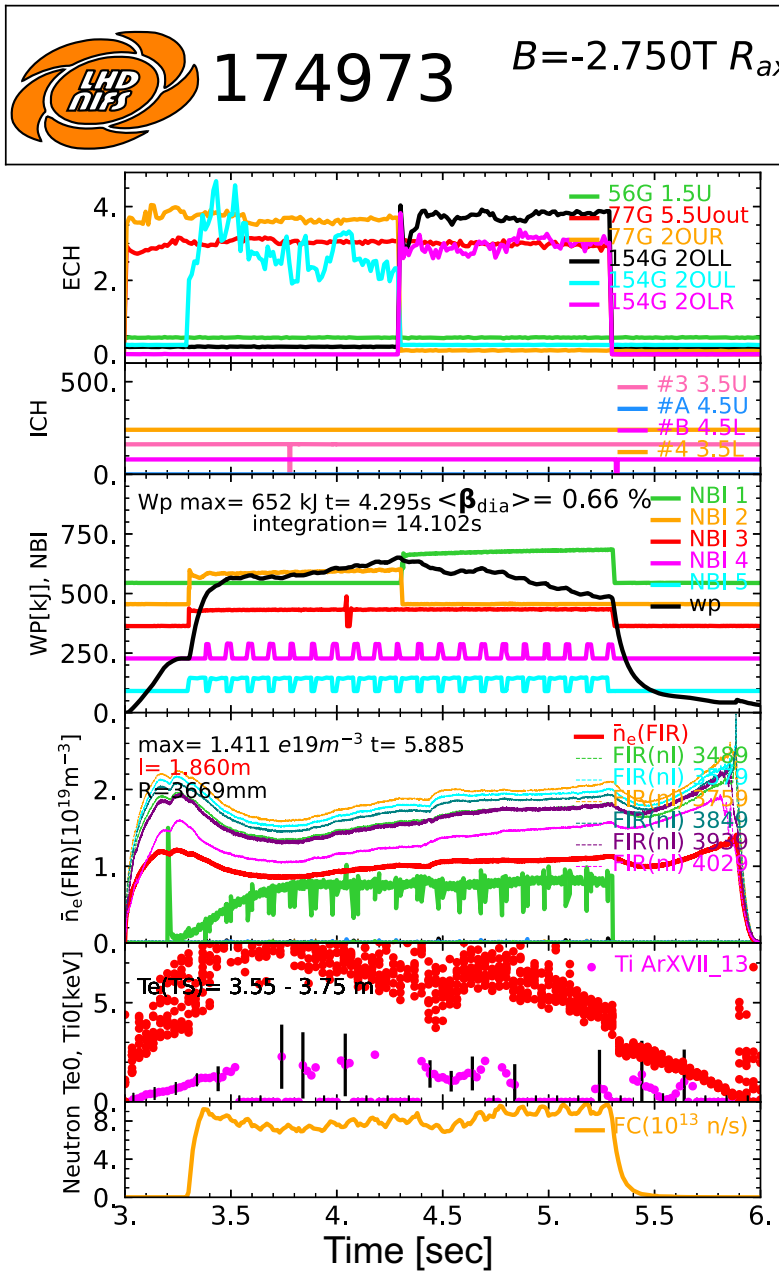
rho	Pellet	LHD#
x	D/H	174954/174946
0.4	D/H	174964/174967

rho	Pellet	LHD#
0.6	D/H	174958/174965
0.8	D/H	174963/174966

H pellet

Isotope mass effects on sustainment of e-ITB plasma

(N. Kenmochi)



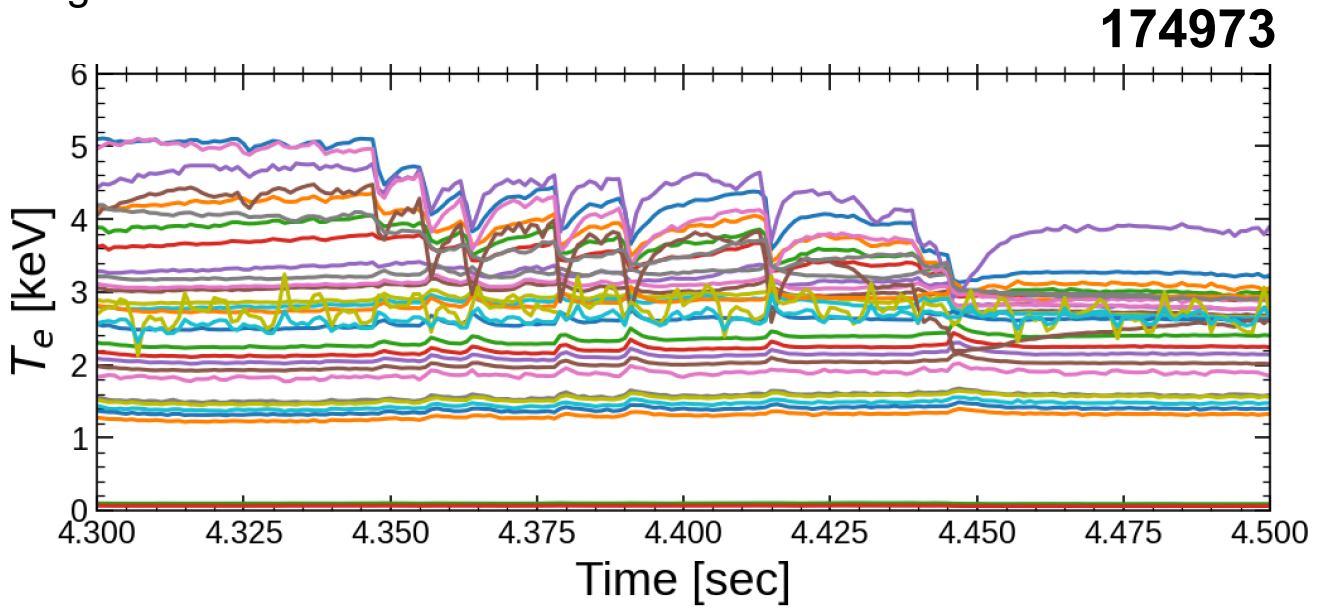
Experimental conditions:

(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 (# 174970 - #174992), Deuterium plasma

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

Results:

- ✓ D/(H+D) = 0.88
- ✓ Minor collapse of eITB was observed around m/n=1/2 magnetic island.
- ✓ The measurement position of e-scale turbulence was scanned in a shot-to-shot basis.
- ✓ The relationship between T_e profile, heat pulse, and turbulence will be investigated.



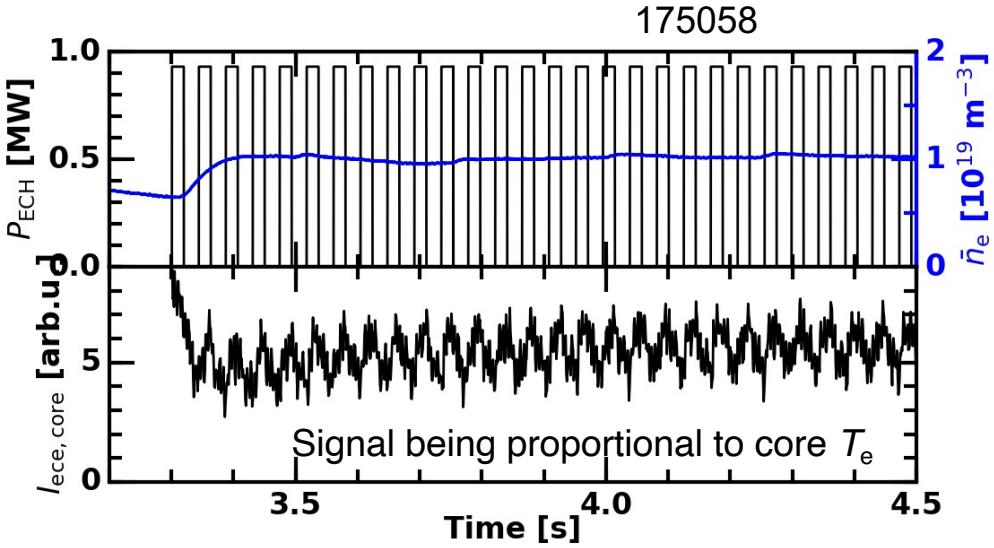
Isotope effects in threshold condition for electron ITB

T. Kobayashi

Shot #: 174993-175005, 175056-175070
Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.2538, 100 %)

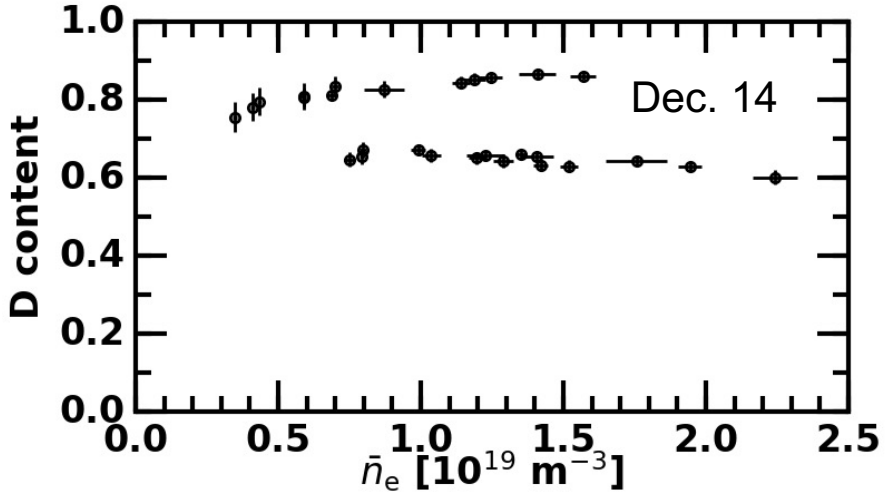
Motivation

- 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)~0.8 and 0.6.
- A set of conditioning discharges (high density discharges) were performed to systematically reduce the D/(D+H) condition.
- The threshold condition will be explored by analyzing the Thomson scattering data and ECE data.



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: 175019-175042 (24 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 **D-dominated condition**

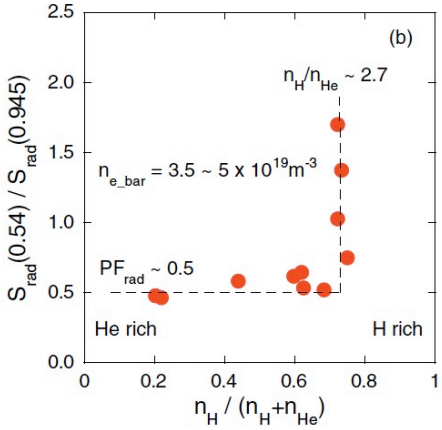
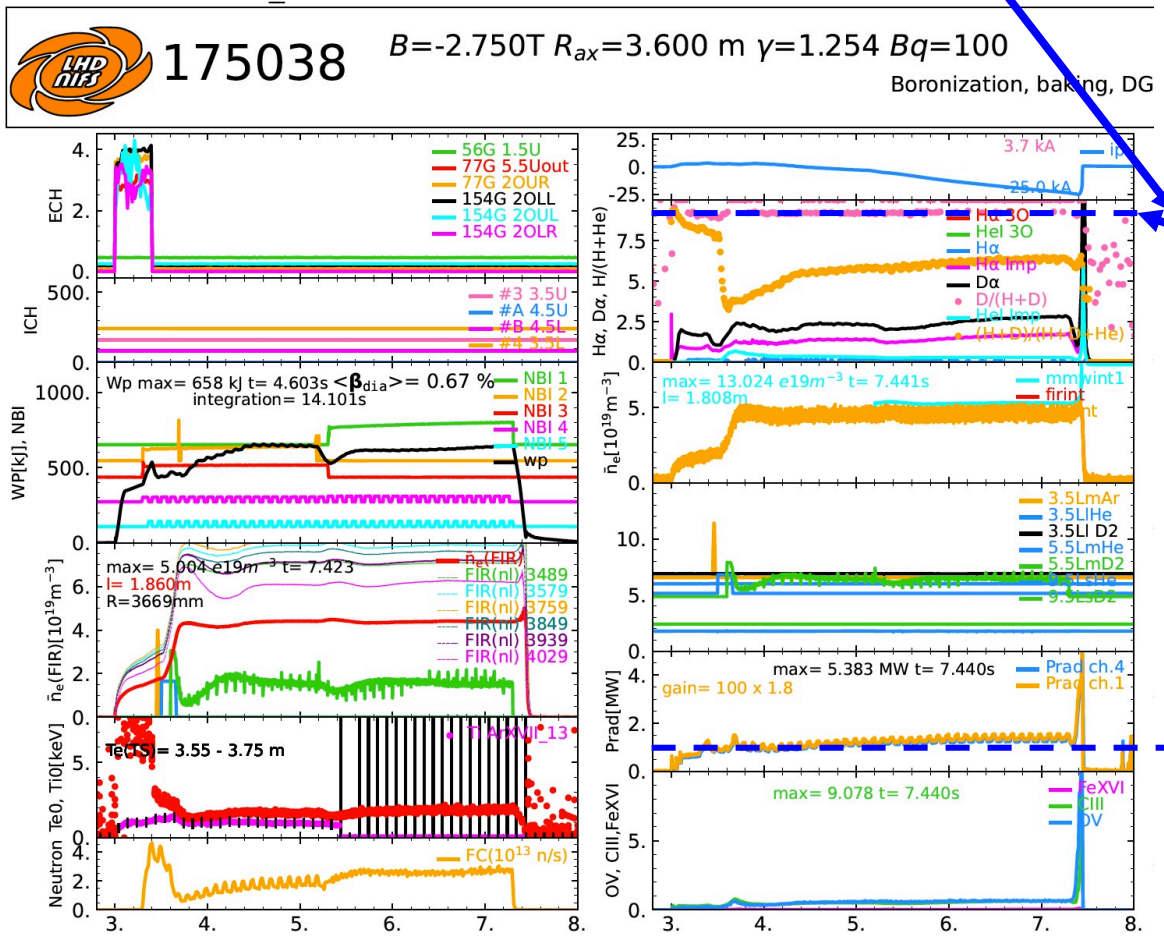
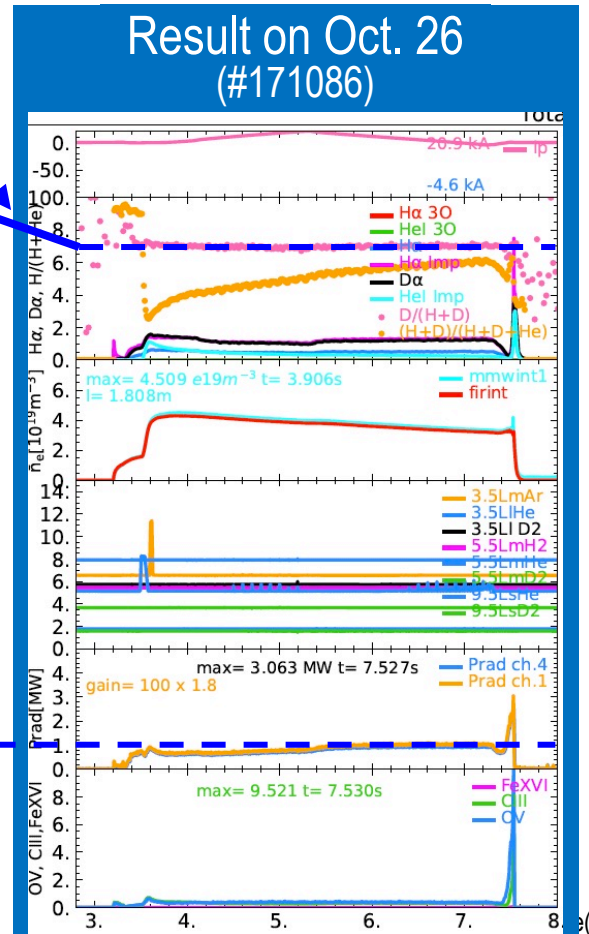


Fig.6 from Y. Nakamura+, NME 12 (2017) 124.





- **Argon** as an impurity tracer, has been injected from Port 3.5L (5 V, 15 ms)
- In terms of the **impurity accumulation**, Ar XVI and Ar XVII profiles measured with CXS will be investigated
  - ✓ He II profile measured with CXS will be also investigated

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%)
175006 - 175018 (13 shots) : D/(H+D) = 0.9
175071 - 175085 (15 shots) : D/(H+D) = 0.6-0.8

Motivation

- In pure H and D plasma, isotope effect of plasma confinement was observed at n_{e_bar}>3.0x$10^{19}m^{-3}$.
- 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.

Initial result

- We successfully obtained turbulence data at following conditions.
  - ✓ $n_{e\ bar}$=1.0 - 4.0x$10^{19}m^{-3}$ with D/(H+D) = 0.9
  - ✓ $n_{e\ bar}$=3.2, 3.9x$10^{19}m^{-3}$ with D/(H+D) = 0.6 - 0.9
- Electron and ion stored energy decrease with with decreasing D/(H+D). (Fig. A)
- Ion scale turbulence measured by PCI was enhanced with decreasing D/(H+D). (Fig. B)