(TG4) Plasma instability group report

Date: Dec. 22, 2022

Dec.23, 2022 (K. Nagaoka)

Time: 9:30 – 18:45
Shot#: 186825-186989 (175 shots)

Prior wall conditioning: None
Divertor pump: On
Gas puff: H2, He, Ne, Ar, Pellet: H2
NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(-, 3.8, 4.0, 5.5, 8.7)MW
ECH(56GHz)=ant(1.5-U)=P(0)MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(0.7, 0.8)MW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(0.7, 0.8, 0.8)MW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0, 0, 0, 0)MW
Neutron yield integrated over experiment = (6E+13)

Topics

1. Bootstrap current in the 1/nu and plateau regimes in the inwardly shifted LHD configuration (O. Mitarai / K.Y. Watanabe)
2. Feedback control of detachment with ECRH and impurity gas injection (M. Kobayashi)
3. Core mode control by ECH/ECCD/NBCD (J. Varela /Y. Takemura)

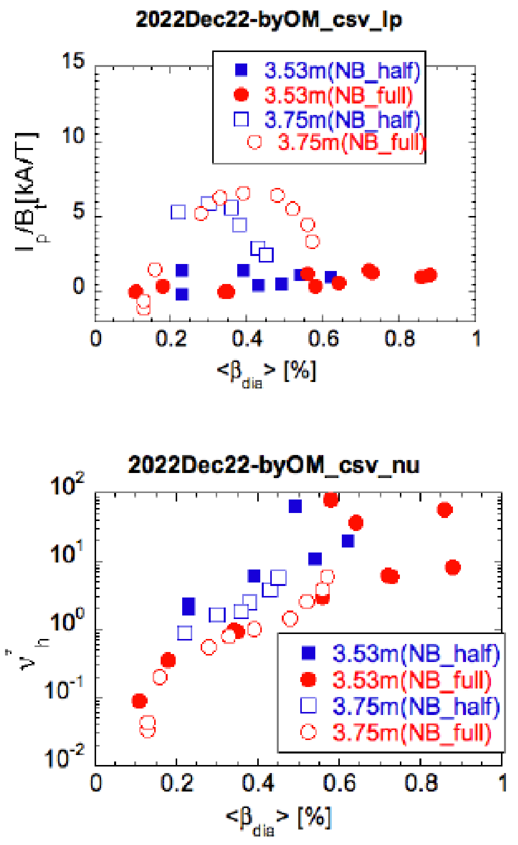
1. Bootstrap current in the 1/ν and plateau regimes in the inwardly shifted LHD configuration

(K. Y. Watanabe, O. Mitarai) 2022.12.22 10:00-13.30

Background and motivation:

So far, we have found that BS current is reduced by almost half in the inwardly shifted LHD configuration (R_{ax}=3.60 m) compared to 3.75 m configuration in the plateau regime. Unfortunately, setting of NBI injection for 3.75m configuration was found to be not so balanced. Therefore, we re-tried 3.75m configuration with complete balanced NBI injection for comparison.

In this campaign we also used the further inwardly shifted configuration of 3.53 m (the Neo-classically optimized configuration) [S. Murakami et al., Nucl Fusion 42 (2002) L19]. BS currents in two configuraions are compared in the same day, which was different from the past experiments. Threfore, we blieve that comparison would be better.



$I_{p\text{-}max}$ and collisionality dependence on beta value (Tentative)

Experimental conditions:

1. (Rax, Polarity, Bt, γ, Bq) = (3.53 m , CW, 2.64T, 1.2538, 100%)
   3.53m (#186832-861),
2. (Rax, Polarity, Bt, γ, Bq) = (3.75 m , CW, 2.64T, 1.2538, 100%)
   3.75m (#186862-895)

Half_(BL2+BL3) and full_(BL2+BL3) are balanced, and injected for 3 second.
Some shots are heated by 3s ECH in addition to NBI.

Tentative Results:

・We observed that the Ip-max (max of Ip during discharge) is clearly decreased in the inwardly shifted configuration. Accurate BS current would be estimated later.

・The Ip-max for 3.75m is decreased with collisionality parameter in the plateau phase.

・It is quite interesting that the Ip-max for 3.53 m is clearly decreased in the 1/ν phase. Careful analysis is needed.

Feedback control of detachment with ECRH and impurity gas injection

20221222

M. Kobayashi, Y. Hayashi, S. Masuzaki

Background and motivation:

- Feedback control system of detachment is being upgraded to use divertor probe signal as an input parameter in stead of a bolometer signal. Long sustainment of the detachment is tried with long pulse NBI experiments.

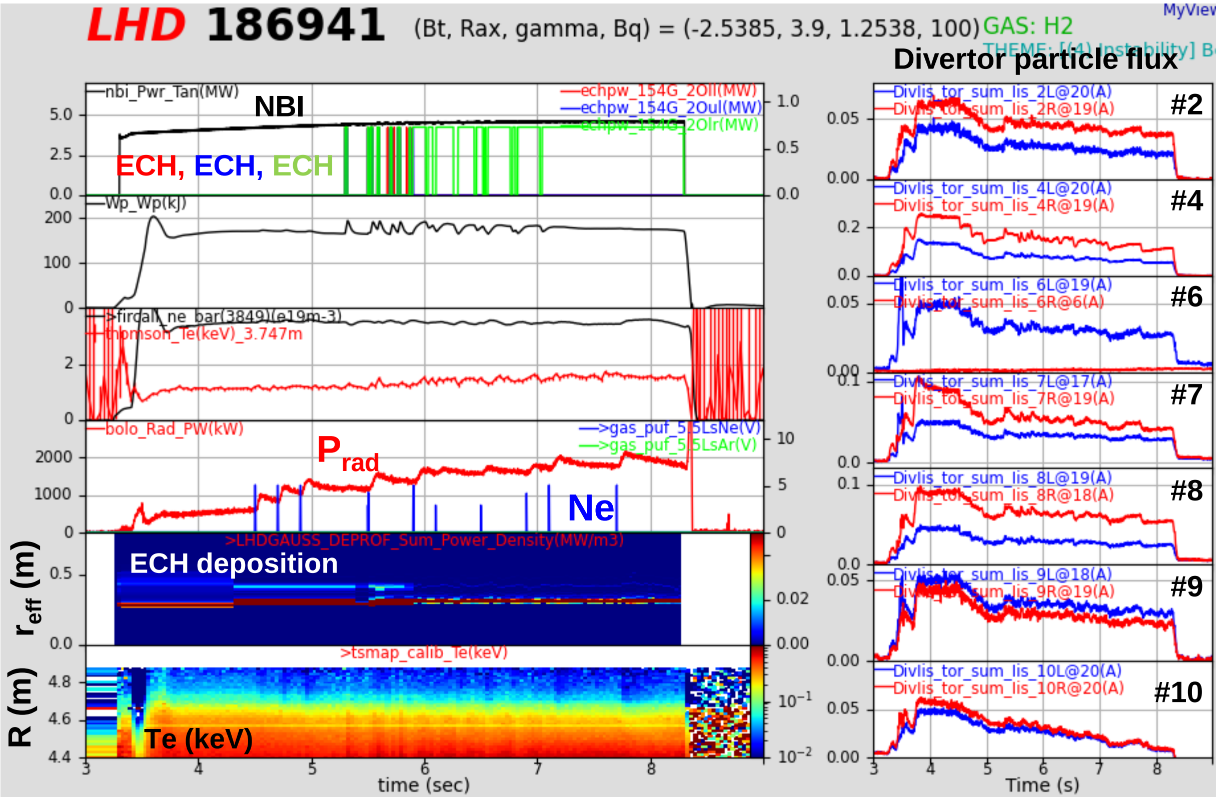
Experimental conditions:

Shot numbers: #184898 - #186941

(R_{ax}, Polarity, B_t, γ, B_q) = (3.9m, CCW, 2.54T, 1.2538, 100 %,), NBI: #2 (2.2MW) , #3 (2.2MW), ECH: 77GHz, 154GHz

Results:

- The divertor probe signal was processed in real-time with FPGA to extract ion saturation current (I_{is}) from probe characteristics. Plasma of n_e=3e19 m-3 was sustained by NBI#2&3.
- Neon was puffed with 5Hz & 5ms pulse (5V) until I_{is} signal lower than 2.2V. ECH 154GHzx3 (~2MW) was injected when I_{is} signal becomes lower than 2.1 to avoid collapse. This was demonstrated in #186941 as shown in the figure. P_{rad} gradually increases up to ~50% of input power. The divertor particle flux decreases in all toroidal section.
- The function of feedback system is confirmed. In future, more sophisticated feedback control can be considered by using AI.



Many thanks to K. Nagahara-san and Y. Mizuno-san for their support of the system development.

High radiation fraction detachment with RMP and Ne seeding

M. Kobayashi

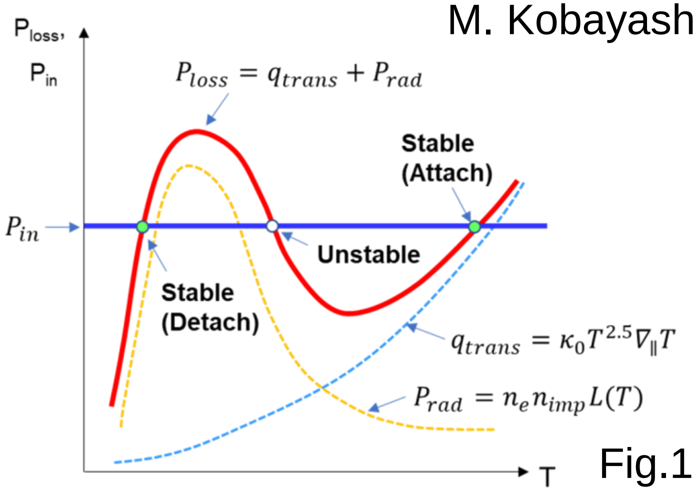


Fig.1

Background and motivation:

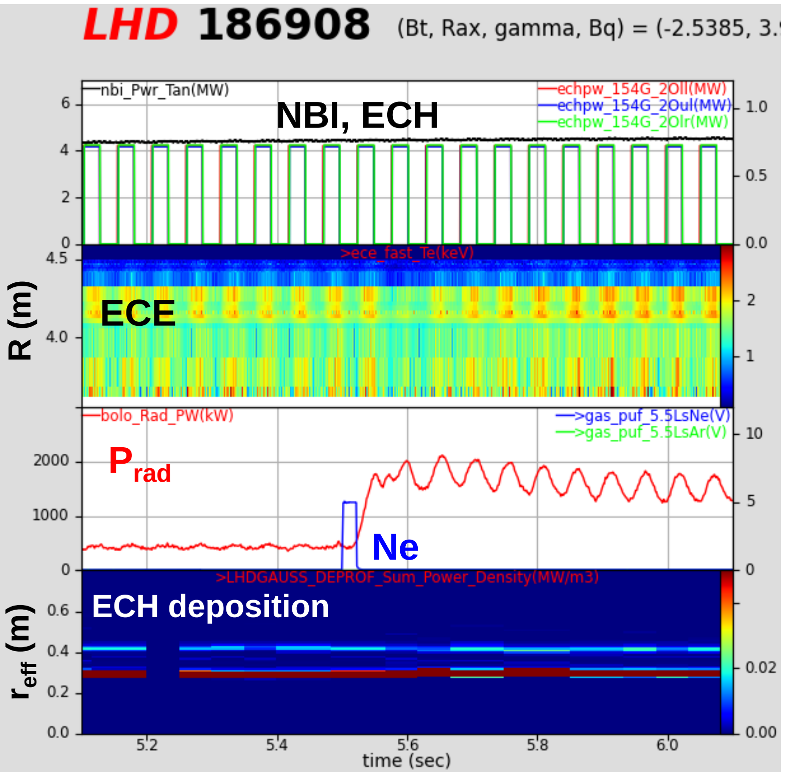
- Detachment is induced by a thermal instability. In a thermal instability, there are three branches as shown in Fig.1: Two stable branches of high and low Te, and one unstable branch of medium Te. Distribution of the branches in space is important to understand the mechanism of detachment stability with & without RMP. In order to study the distribution of the branches, ECH was moderated to impose heat pulse, which should induce different Te response depending on the stable or unstable branches.

Experimental conditions: Same as previous one

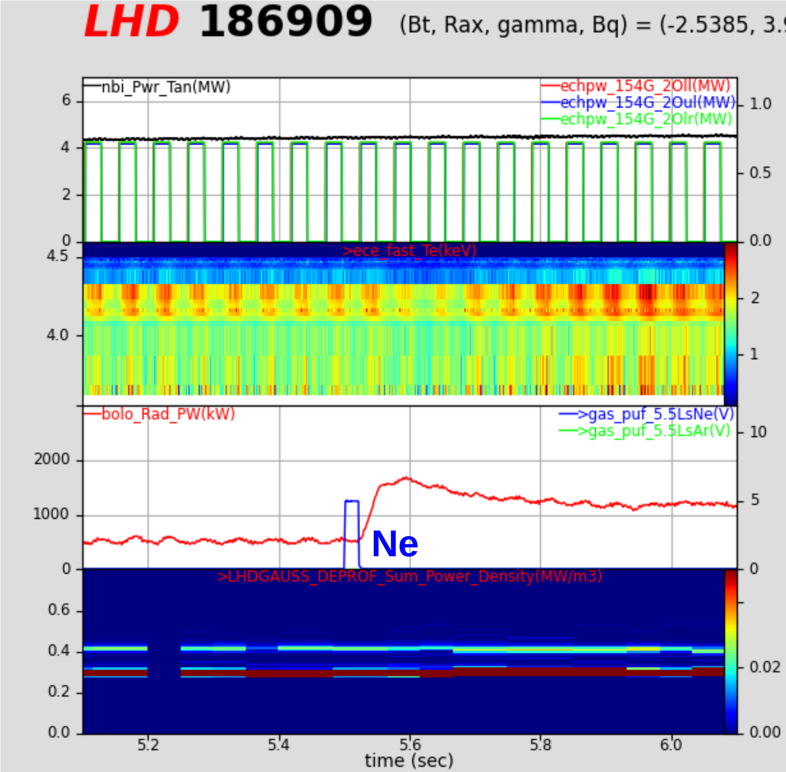
Results:

- Plasma was sustained at 2e19 m^{-3} with NBI. Neon was puffed at 5.5 sec to enhance radiation for both cases with & without RMP application. 154GHz ECH (~2MW) was moderated with 19Hz. RMP phase was scanned for 6-O, 7-O, 1-O, 2-O expansion.
- Clear modulation of Te was observed in ECE signals.
- Oscillation of Prad is enhanced in detached phase with RMP.
- ECE and Thomson data will be analyzed by conditional average.

With RMP



Without RMP



Core mode control by ECH/ECCD/NBCD

(J. Varela, K.Y. Watanabe, Y. Takemura)

Experimental conditions: (R_{ax}, B_t) = (3.5 m, 1.375 T, CCW), γ = 1.2538, and B_q = 100 %,

Shot#: 186942 – 186989 (47 shots)

- Analysis m/n=1/1 PGDM stability using different actuators:

1) ECH 4s on-axis and off-axis.

2) ICRH 4s off-axis.

3) Perpendicular NBIs.

4) RMP fixed and variable I = 0 – 600 A.

- Ctr-NBCD during 4s to further destabilize 1/1.
- Identification of optimized configurations with respect to the stability of PGDM for Different actuators.
- FAR3d simulations to analyze the 1/1 PGDM stability trends.

Shot 186976