(TG2) Turbulence Topical Group Report

Nov. 2, 2021 (T. Kobayashi)

Date: Oct. 29, 2021
Time: 9:40 – 18:45
Shot#: 171388 – 171543 (156 shots)

Prior wall conditioning: No
Divertor pump: On except for 2-I
Gas puff: D_2, Ar
Pellet: None

NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(2.5, 4.0, 2.0, 7.5, 4.0)MW

ECH(77GHz)=ant(5.5-Uout (or 1.5U), 2-OUR)=P(940, 1040)kW
ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(980, 930, 980)kW
ECH(56GHz)=ant(1.5U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L)=P(-, -, -, -)MW
Neutron yield integrated over the experiment = 4.0×10^{15}

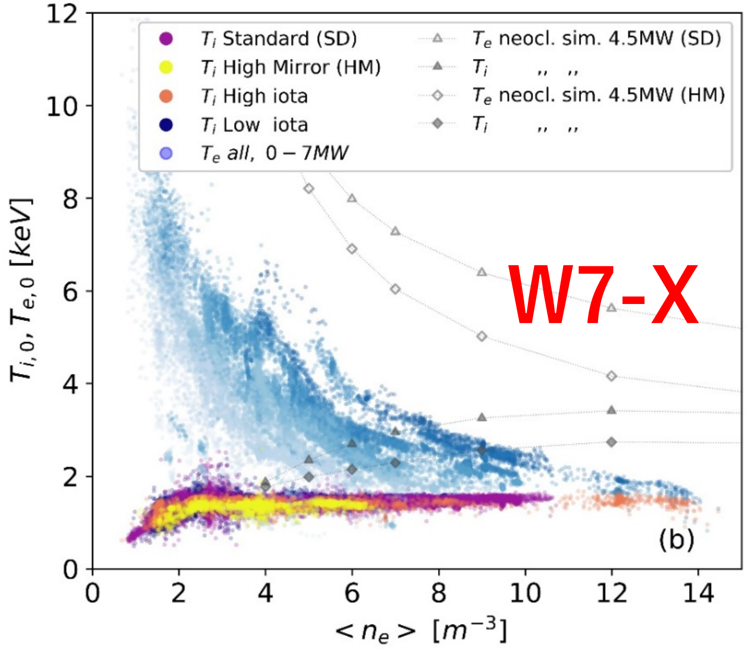
Topics
1. Ion transport under electron heating in LHD (M. Beurskens and K. Tanaka)
2. Study of turbulence pulse properties during the minor collapse events of e-ITB (N. Kenmochi)
3. Investigation of turbulence response in E-ITB and SDC plasma
   (H. Sakai (Kyushu Univ.), T. Kinoshita (Kyushu Univ.), K. Tanaka)

Ion transport under electron heating in LHD

W7-X: hydrogen experiments

- ECRH plasmas show clamped T_i ~ 1.5keV,
- independent of ε_{eff} (magnetic configuration)

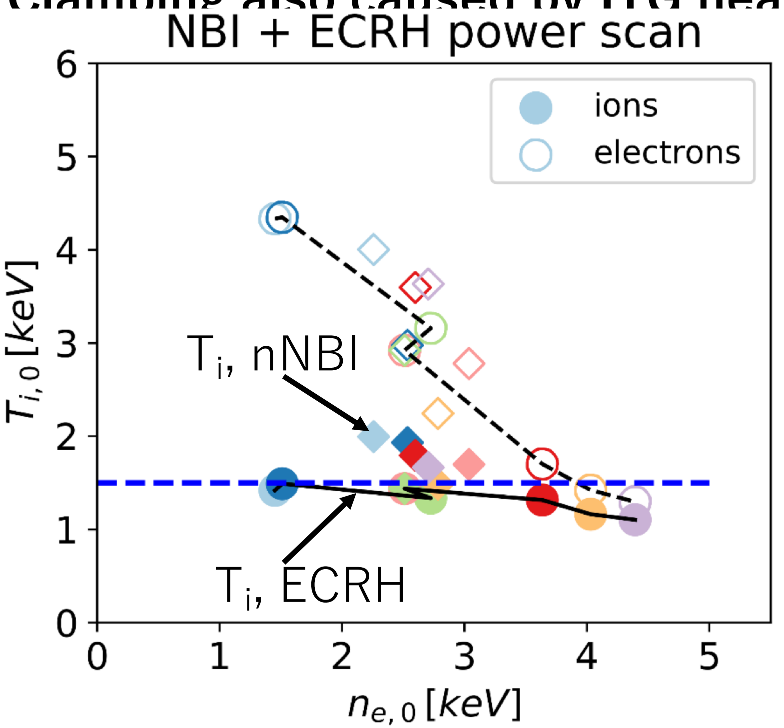
→ Turbulent (ITG) heat transport enhanced by T_e/T_i



LHD 15-1-2021: hydrogen in R_{ax} = 3.6 m configuration

- ECRH plasmas (3MW), T_i ~ 1.5keV, clamped
- N-NBI plasmas (< 10MW), T_i > 1.5keV (>30% ion heating)

→ Clamping also caused by ITG heat tra



Experiments 29 October 2021, Deuterium

- (a) Inward shift config Rax=3.6m : 37 pulses
- (b1) Very inward shift configuration Rax=3.5 : 28 pulses
- (b2) Very inward shift configuration Rax=3.53 : 20 pulses

- Heating pattern 1 + 3:

	PNB5 2sec
ECH 154GHz tan 1MW 2sec	NNB1 2sec
ECH 154GHz tan 1MW 2sec	NNB2 2sec
ECH 154GHz tan 1MW 2sec	NNB3 2sec
Heating patternH1-4	Heating patternH3-4

Heating pattern 2:

PNB5 2sec
NNB1 2sec
NNB2 2sec
NNB3 2sec
ECH 154GHz tan 1MW 2sec
ECH 154GHz tan 1MW 2sec
ECH 154GHz tan 1MW 2sec

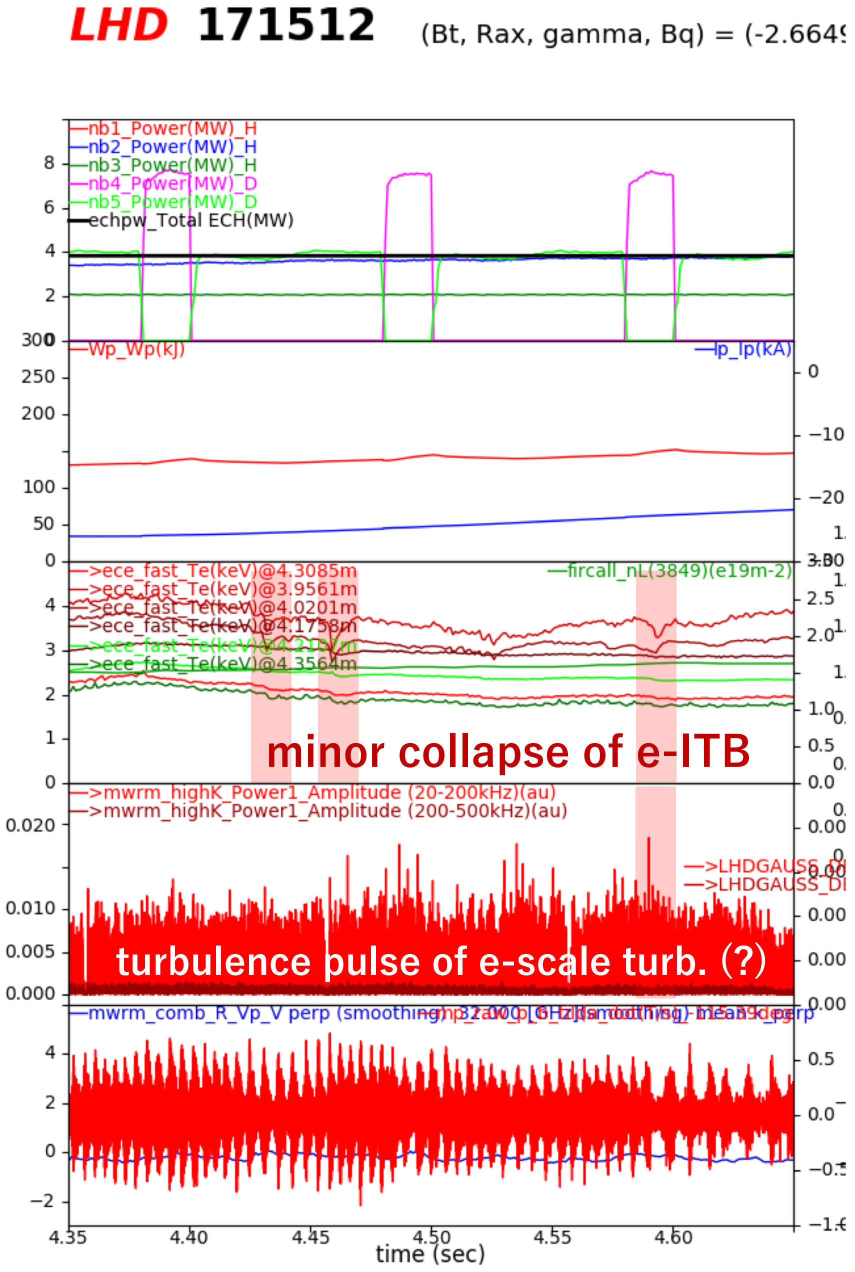
Heating patternH2-4

- Most combinations of ECRH (0-3MW) and nNBI (0 - 10MW) have been obtained for (a), (b1) and (b2) for 2-3 density levels (1.5e19, 3e19 and some 4.5e19 m^{-3})

- Variation of T_i =1.5 – 2keV is still very limited across these scans for all three configurations.
- Ion heat transport study is ongoing. (will be reported in December)
- In January, equivalent experiments in Hydrogen will take place for isotope studies and W7-X comparisons

Study of turbulence pulse properties during the minor collapse events of e-ITB

(N. Kenmochi)



Experimental conditions:

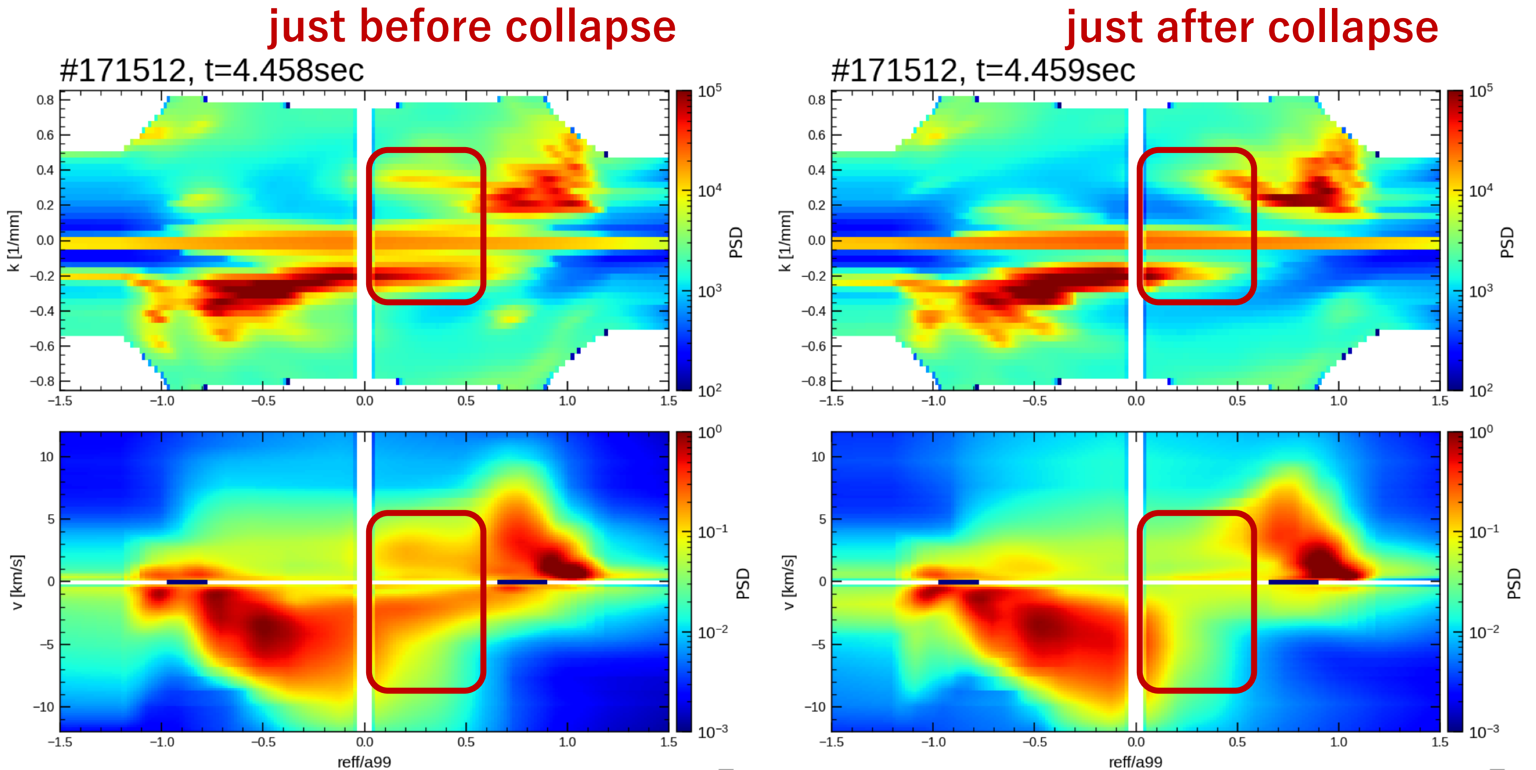
(R_{ax}, Polarity, B_t, γ, B_q) = (3.85 m, CCW, 2.6649 T, 1.2538, 100.0%)

Co. to Ctr. current drive at center region (# 171505 - #171527), Deuterium plasma

Objective: Investigation of e- and i-scale turbulence property at the avalanche events

Results:

- ✓ The minor collapse of e-ITB was repeatedly observed, while less frequently than that of R_{ax}=3.6 m.
- ✓ The measurement position of e-scale turbulence was scanned in a shot-to- shot basis.
- ✓ The i-scale turbulence was measured in the whole plasma region by the PCI.
- ✓ High-speed Thomson scattering (20 kHz) measurement was successfully operated.
- ✓ The relationship between T_e profile, heat pulse, and turbulence will be investigated.



Investigation of turbulence response in e-ITB and SDC plasma

H. Sakai (Kyushu Univ.), T. Kinoshita (Kyushu Univ.), K. Tanaka

Target 171528-17543, Rax=3.85m, g=1.254, BQ=100%, Bt=-2.66T

Investigations of turbulence in electron-ITB (e-ITB) and particle-ITB (p-ITB, SDC with pellet injection) were aimed. The turbulence response in ion-ITB have already been reported in the past publication (K. Tanaka et al, PFR2010, K. Tanaka et al, NF2017). However, the turbulence responses in e-ITB and p-ITB have not been investigated yet. In the series of experiments, Rax=3.85m Bt=2.66T was selected in order to access to e-ITB and p-ITB region by PCI. However, due to the limit of machine time, only three successful p-ITB/SDC shots were obtained. The turbulence response in e-ITB can be investigated from the shots obtained in Kenmochi san's experiment in the same day. Also, several shots for configuration effects of Ti clumping was obtained.

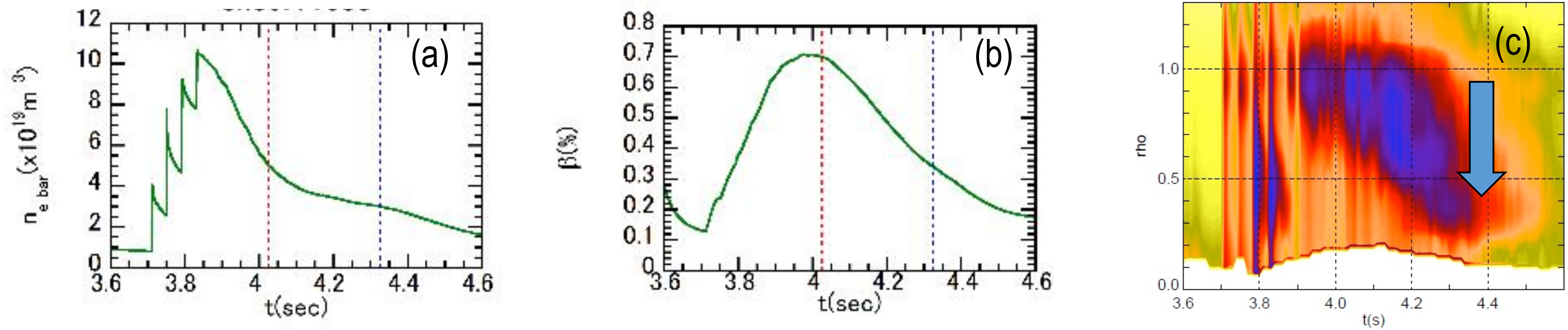


Fig.1 Time response of (a) line average density, (b) diamagnetic beta and (c) turbulence amplitude with 10ms time resolution. In (c), only electron diamagnetic direction in laboratory frame is shown. Blue and red dashed lines indicate the timings to show profile in Fig.2

After final pellet injection, beta increased and the highest beta was achieved at t~4.0sec. The turbulence response in p-ITB/SDC was successfully obtained. As shown in (c), the peak of the turbulence amplitude is ρ=0.9 till the highest beta timing (~4.05s) and it moves inwardly.

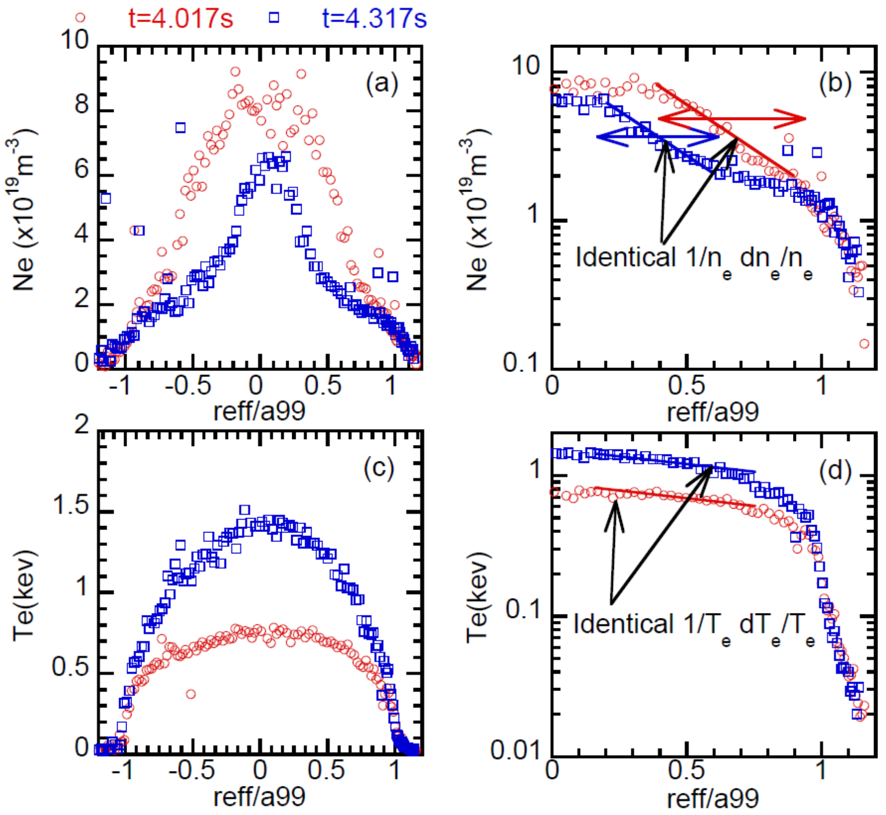


Fig.2 Ne and Te profiles at t=4.017sec (highest beta timing) and t=4.317 (peaked density timing)
In (b) and (d), identical logarithmic gradients are shown by plain lines.

Figure 2 shows *Ne and Te profiles at t=4.017sec (highest beta timing) and t=4.317 (peaked density timing) . In ne profile, steep normalized n_e gradient region moves inwardly from t=4.017 to 4.317sec, while normalized Te gradient stays almost constant.*

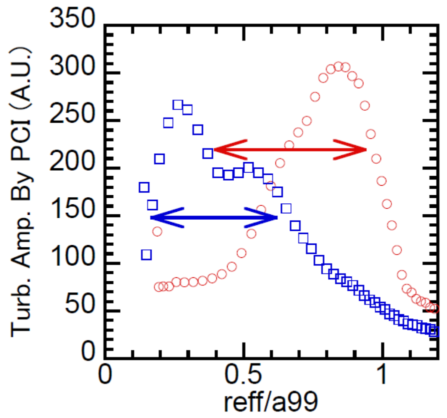


Fig.3 Turbulence amplitude profiles at t=4~4.05 and t=4.3~4.305sec Lines with arrows indicate steep density gradient region shown in Fig.2(b)

Figure 3 shows turbulence amplitude profiles at t=4~4.05sec and t=4.3~4.304sec. The dominant turbulence amplitude corresponds to steep density gradient region shown by lines with arrows.
Density profile in central region at ρ<~0.5 becomes peaked at t=4.317sec associated with increase of the turbulence. Detail analysis of particle transport and turbulence simulation will be done in order to reveal underlying physics mechanism.