(TG2) Turbulence Topical Group Report

Date: Jan. 26, 2022

Jan. 27, 2022 (T. Tokuzawa)

Time: 9:45 - 18:45

Shot#: 177231 – 177385 (155 shots)

Prior wall conditioning: NO

Divertor pump: ON

Gas puff: H2, He, Ar , Pellet: H2

NBI#(1, 2, 3, 4, 5)=gas(H, H, H, H, H)=P(4.1, - , 4.0, 3.1, 4.6)MW

ECH(77GHz)=ant(5.5-Uout (or 1.5U), 2-OUR)=P(703, 792)kW

ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(979, 930, 986)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 = 2.3×10^{12}

Remarks

The water leak of NBI #2 has been occurred during the experiment.

Topics

1. Investigation of Ti increase with high Z impurity in high Te/Ti condition (H.Takahashi)
2. Ion turbulent transport and Ti clamping study in electron-heated plasmas with varying degree of neoclassical optimization in LHD compared to W7-X (M.Beurskens, K.Tanaka)
3. Heat transport hysteresis with/without e-ITB during the peripheral 1st X-mode MECH (H. Igami)

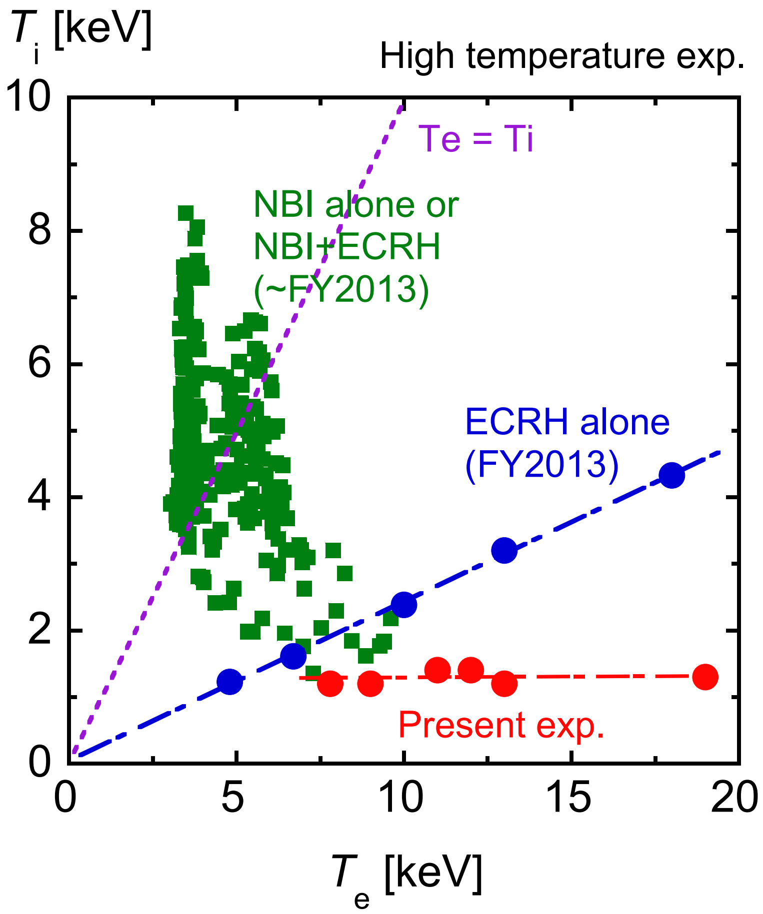
High Ti production under ECH heating dominant (H. Takahashi)

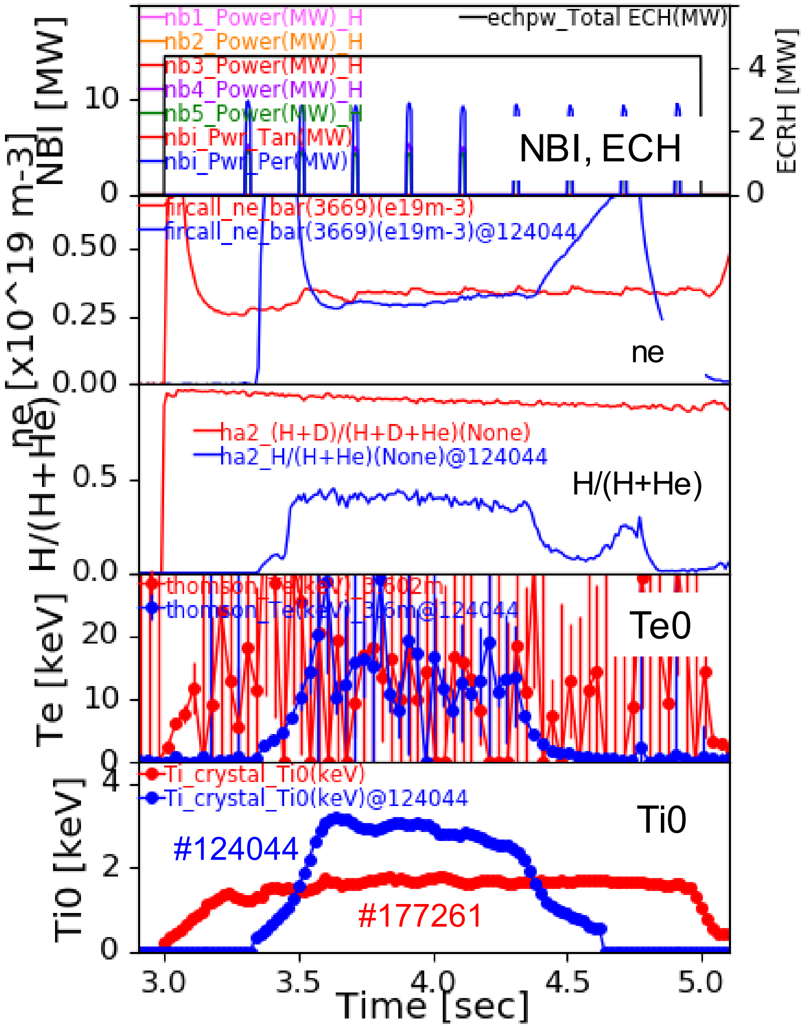
Experimental conditions: (R_{ax}, B_t) = (3.6 m, 2.75 , CW), γ = 1.2538, and B_q = 100 %, #177231-91

Motivation and objective: Clear increase in Ti was observed in ECH-dominant plasma with a relatively large amount of argon injection. The objective is to clarify the effect of impurities or Z on the ion thermal confinement under the high Te/Ti with the low collisionality. This will contribute to the operational scenario construction of Ti increase under the electron heating dominant by α particles in fusion reactors.

Results:

- Te was varied by scanning the density under the fixed ECH power.
- Ti remained constant around 1.4 keV regardless of the change in Te.
- The similar experimental conditions were used as before, such as an amount of Ar injection and ECH power, but the Ti increase in high Te condition could not be reproduced.
- The major difference is the background plasma. It was He dominant in the previous experiment, but was H dominant in this experiment.
- I will check what other differences were there in these experiments.



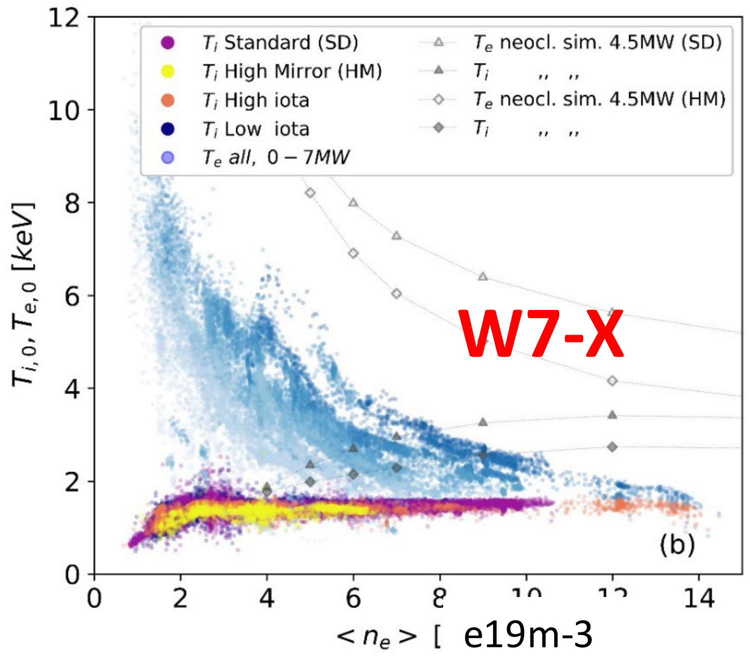


Ion transport under electron (+ion) heating in LHD

W7-X: hydrogen experiments

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

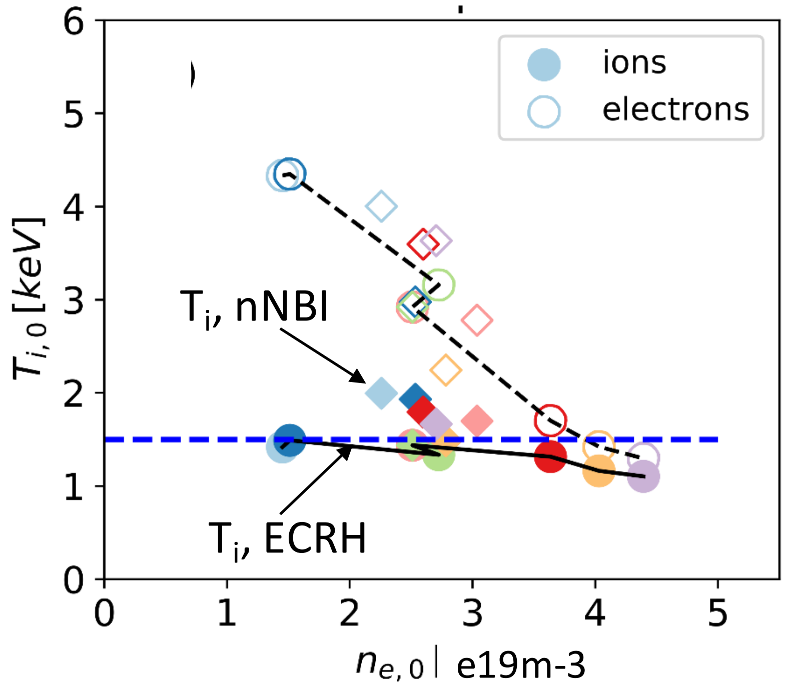
→ Turbulent (ITG) heat transport enhanced by T_e/T_i



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 transport?



On 29 October 2021, equivalent experiments in Deuterium took place for isotope studies

Experiments 26 January 2022, Hydrogen

Configuration	# good pulses (without/with boron)
Rax = 3.60 m 2.85T 177292-177322	27 (16/11)
Rax = 3.53 m 2.9T 177323-177351	28 (13/15)
Rax = 3.80 m, 2.7T 177352-177362	6 (6/0)

Aim:

- Understand physics mechanism of T_i clamping (ion stiffness)
- Configuration scan to vary neocl. transport @ n_{eav}= $3x10^{19}m^{-3}$
- Variation of 3.5 MW ECRH, 9MW nNBI(1 & 3), 8.5MW pNBI(4 & 5)
- Boron powder to control ion stiffness? (Nespoli Nat.Physics 2021).

Result:

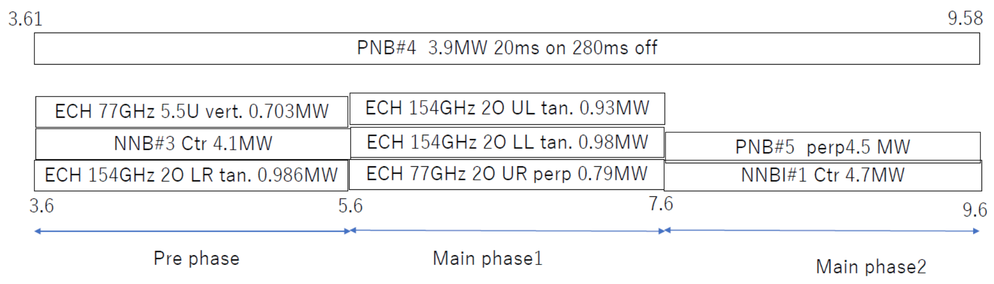
- For 3.6m and 3.53m config: covered almost complete heating scans with and without Boron dropper,
- for 3.8m only limited data without boron.
- It looks like we have good data quality
- Ion heat transport appears stiff in all three configurations (only small variation of T_i)
- Boron may reduce stiffness (slightly) – to be analysed

Issues:

- It took several shots to tune pauffing and heating pattern for good plasma production
- nNBI-2 broken, nNBI-1 often break down, finding right B-level difficult, …

There exists configuration and heating effect of Boron powder

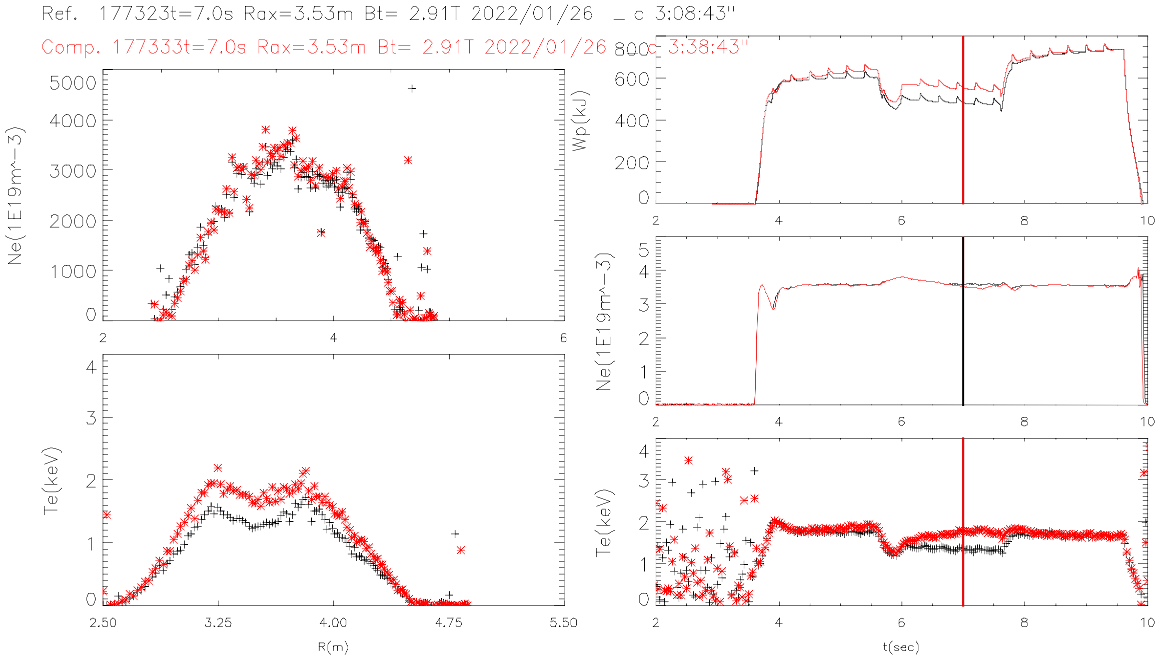
Tanaka3 (w and w/o BPD at Rax=3.53, 3.6 and 3.8m) 1ECRH+1NB->3ECRH>1NNB+1PNB



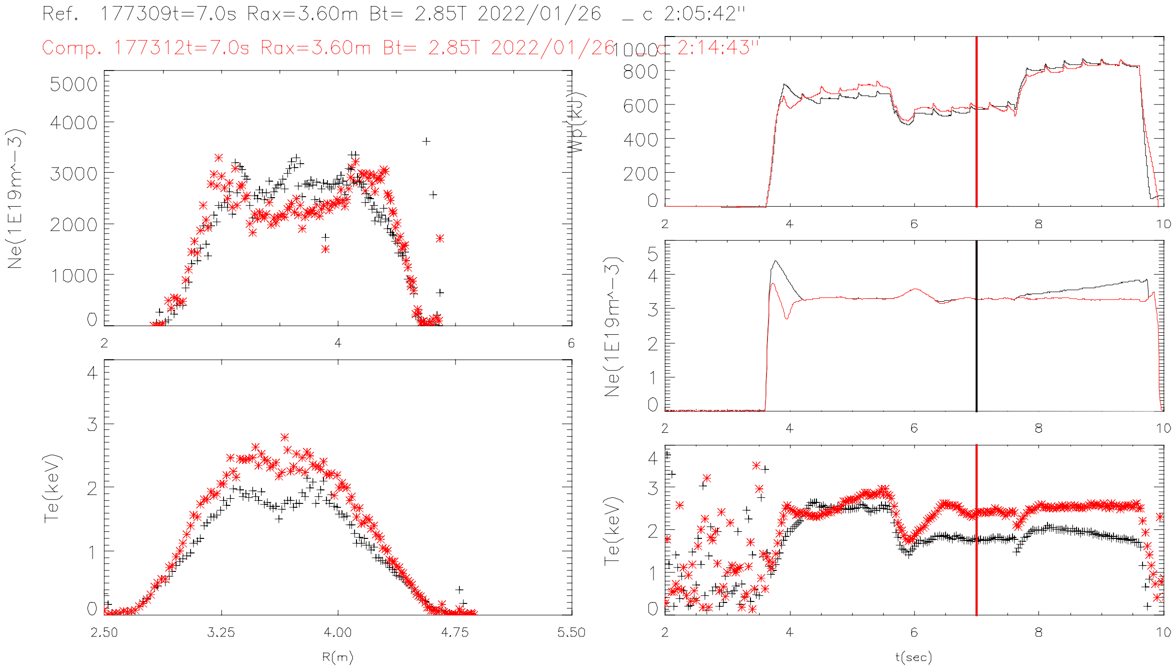
Boron effect is different at different configuration and different heating schema.

Black; without Boron, Red; with Boron

Rax=3.53m, 2.9T



Rax=3.6m, 2.85T



Te is higher in main phase1 (ECRH only) and non difference in main pahse2 (NB only). Stored energy is higher in main phase 1.

Te is higher in main phase1 (ECRH only) and main pahse2 (NB only), while store energy is no difference

Heat transport hysteresis with/without e-ITB during the peripheral 1st X-mode MECH

H. Igami

Shot #: 177363 - 177385

Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.8 m, CW, 2.70 T, 1.2538, 100.0%)

Purpose:

- To clarify whether the structure of the heat transport hysteresis is affected by turbulent fluctuations with/without e-ITB
- To extract the ECH and gradient driven effects on the turbulent transport with/without e-ITB

Experimental result:

Central MECH (r_{eff}/a_{99_abs} ~0.2)

- (a) : Fast heat transport is observed in the central region although e-ITB is formed

Peripheral MECH (r_{eff}/a_{99_abs} ~0.75)

- (c) : Heat transport from the outward to inward becomes faster at r_{eff}/a_{99} < 0.5 with w-ITB
- (d): Inversion of the heat transport is observed around r_{eff}/a_{99}=0.5 without e-ITB

Characteristics of the fluctuations should be checked