(TG3) Spectroscopy Topical Group Report

Oct. 28, 2021 (M. Yoshinuma)

Date: Oct. 27, 2021
Time: 9:54- 18:45
Shot#: 171091 – 171261 (171 shots) [FIR adjustment 171144, 171145]

Prior wall conditioning: NO
Divertor pump: ON (w/o 2I)
Gas puff: H, D, Ne, N
Pellet: Ni, Fe, H, Ne

NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(4.6, 4.3, 4.0, 5.0, 4.9)MW

ECH(77GHz)=ant(5.5-Uout (and 1.5U), 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(723, 715, 727)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 = 1.1×10^{16}

Topics

1. Evaluation Zeff in LHD (Y.Kawamoto, T.Oishi)
2. Sustainment of divertor detachment by using feed back controlled impurity seeding (S.Masuzaki)
3. Establishing atomic database of L-shell transitions of the Fe-peak elements with LHD (H.Yamaguchi, I.Murakami, T.Kawate)
4. Diagnostics of relativistic electrons by Thomson scattering in high electron temperature plasmas (H.Funaba)
5. Ablation of high Z (neon) and hydrogen cryogenic pellets and its implication to ITER DMS design (A.Matsuyama, R.Sakamoto)

Evaluation of Z_{eff} in LHD (Y.Kawamoto)

Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CW, 2.75T, 1.254, 100.0%)(# 171093 - #171140)

[What I research]

Mission: Evaluation of Z_{eff} in LHD

This experiment: With our evaluation system, I examined that 'When high-Z impurity is seeded, Z_{eff} gets high.'

[What I did] (7.5-L port spectrometer measurement)

Comparison between

'Z_{eff} with N_2(Ne) gas puff' and 'Z_{eff} without N_2(Ne) gas puffed'

・"unchanged" high density with D gas feedback (n_{e_avg}>4.0×10^{19}m^{-3})

・ N_2, Ne gas puffed ・NB1,2,3 injected ・D/(D+H)~0.8

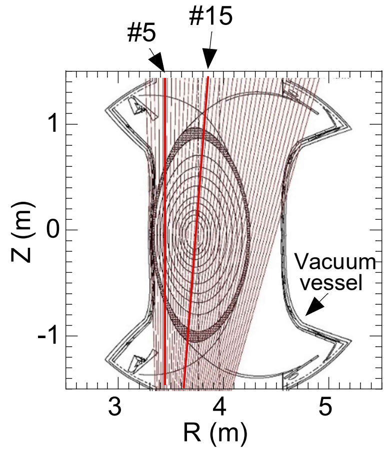


Fig.1 sightline (7.5-L)

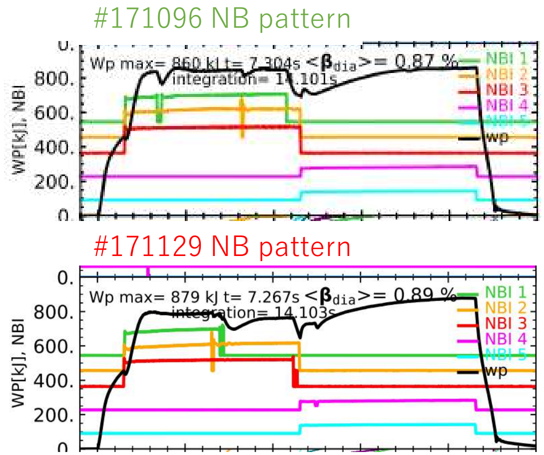


Fig.2 NB pattern

[What I found]

Z_{eff} increasing due to High-Z impurity seeding was observed

・Green-hatched area in Fig. 4, Z_{eff} increased through Sightline=15(through the axis) when N_2 seeded, whereas, Z_{eff} was unchanged through Sightline=8.

・Pink hatched area in Fig. 4, Z_{eff} decreased after NB#1 off regardless of whether N_2 seeded or not.

・After NB1,2,3 off (NB4,5 on) phase, there is no difference between Z_{eff} with N_2 seeded and Z_{eff} without N_2 seeded.

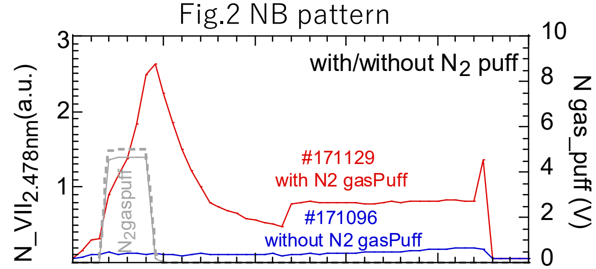


Fig.3 N_2 gas puff pattern and N_2 radiation

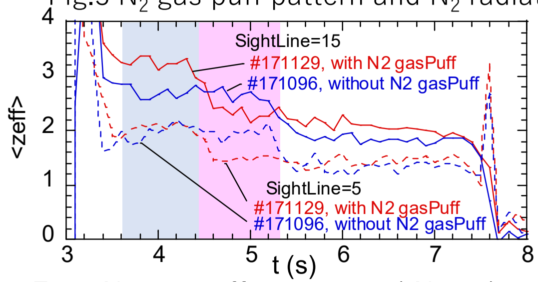


Fig.4 N_2 gas puff pattern and N_2 radiation

[What I do next]

Detail investigation of obtained experimental data

・N_e seeded discharge, different N_2 amount, different timing of N_2 seeded etc.

・Analysis of special distribution (using 7.5L spectrometer for Z_{eff} and EUV spectrometer for N, Ne).

Try to get experimental data under the others conditions

・Next machine time, I will try to conduct this study using hydrogen or He gas main plasma. (12/17)

Sustainment of divertor detachment by using feedback-controlled impurity seeding

S. Masuzaki

Shot #: 171147 - 171204

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

P_{NBI} (#1 - #3) ~ 4 MW, P_{NBI} (#4 - #5) ~ 5 MW

Working gas: D_2 (5.5L, with feedback control)

Seeding gas: Ne (5.5L, with feedback control)

Results:

The improved feedback-controlled impurity gas-puff (5.5Ls Ne) was utilized to sustain a divertor detachment.

- The control checked P_{rad} (total radiation power measured at 3-O) with a checking frequency (5 – 20 Hz in this exp.)

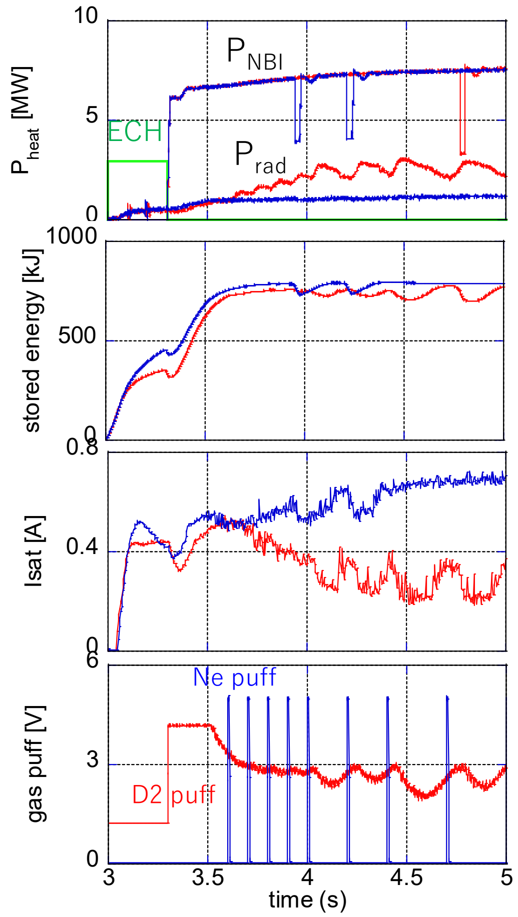
- If P_{rad} was less than a target P_{rad}, a pulse voltage (5V, 15ms) drove the piezo valve.

Although the control has not been fully optimized, a divertor detachment state was sustained by the gas-puff without large degrading of stored energy.

Application of the gas-puffing to a long pulse discharge with ECH and ICH is planned.

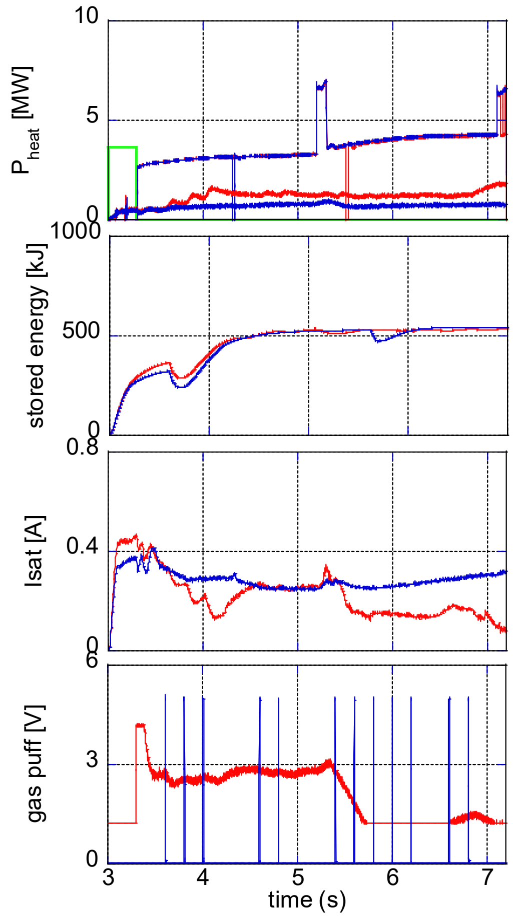
PID control of imp. gas-puff is also planned.

w/ Ne (171176), w/o Ne (171175)



P_{NBI}~ 6-7.5MW, $n_{e,bar}$ ~ 4E19/m^3
Target P_{rad}: 3 MW
Checking frequency: 10 Hz

w/ Ne (171201), w/o Ne (171199)



P_{NBI}~ 3 - 4MW, $n_{e,bar}$ ~ 3E19/m^3
Target P_{rad}: 1.4 MW
Checking frequency: 5 Hz

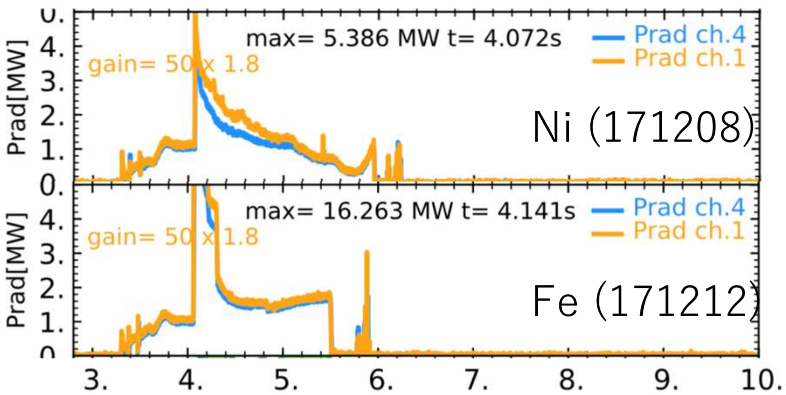
Establishing atomic database of L-shell transitions of the Fe-peak elements with LHD

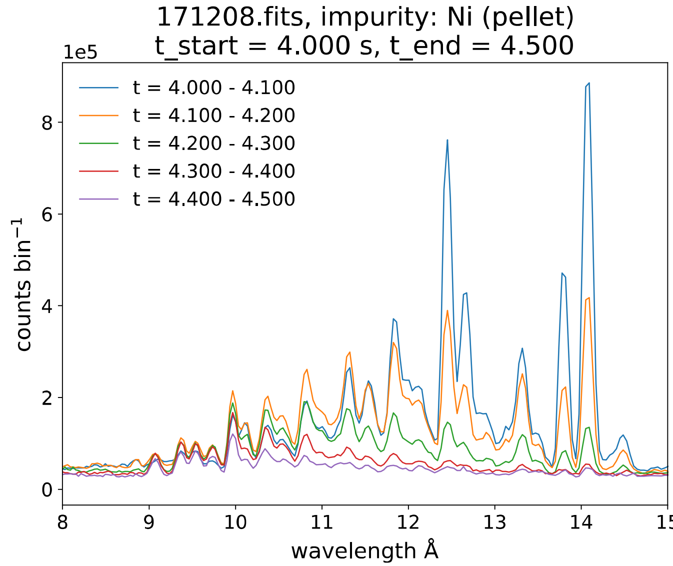
Proponent: H. Yamaguchi, (ISAS/JAXA), Y. Ohshiro (Univ. Tokyo), I. Murakami, T. Kawate, et al. (NIFS)

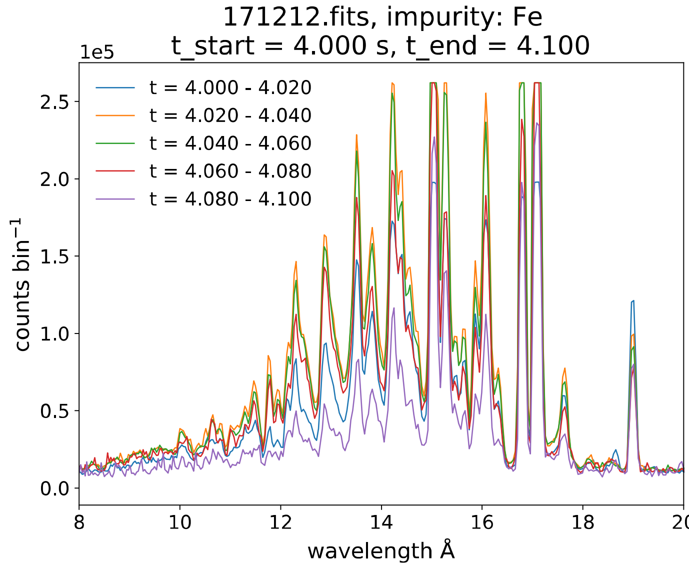
Background: Accurate atomic data are essential for high-resolution spectroscopy in X-ray astronomy, e.g., constraining physics of shock heating and cooling processes. We have conducted the LHD experiment to measure the wavelength and temperature-dependent ion population of Fe-group elements using their L-shell transitions.

Experimental conditions: #171205-171215, NBI #1-#3, ECH, H2 gas; B = 2.75 T, R_{ax} = 3.6 m, γ = 1,2538, B_q = 100%; Ni or Fe impurity pellet was injected at 4.0 s with an electron temperature of ~4 keV.

Results: Various emission lines of Ni and Fe were resolved. It was also confirmed that the ion population changed with time due to the variation of the electron temperature. Several strong lines of Fe were saturated, suggesting that too much Fe were injected.







Diagnostics of relativistic electrons by Thomson scattering in high electron temperature plasmas

Experimental conditions:

1. (R_{ax}^{VAC}, Polarity, B_t, γ, B_q) = (3.60 m, CCW, 2.75 T, 1.254, 100.0%)
   (# 171216 - #171247) ECH power: 3.6MW
   Thomson scattering : In forward configuration, or overlapping of Laser#1, 2

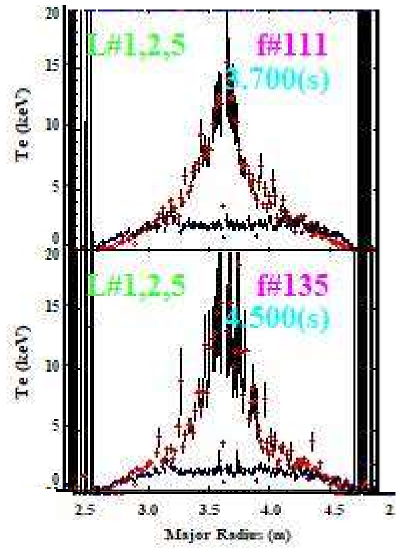


Fig. 1. Te profiles at 3.7 and 4.5s in #171238.

Background and Motivation:

(1) The spectrum of the Thomson scattered light is shifted blue side by the relativistic effects. As the electron temperature measurement higher than 15 keV, the forward scattering geometry is preferable, since the peak of the spectrum of back scattering become close to 600nm.

(2) It is considered that the difference between the results of the forward and backward scattering may be affected by the high energy component .

Results:

Plasmas with Te > 15 keV were obtained by ECH and NBI+ECH in low electron density region of $5 \times 10^{18} m^{-3}$. Signals by the back and forward scattering are acquired even in channel 3 at the central region. As the magnitude is small, integration of the signals from similar plasmas will be made.

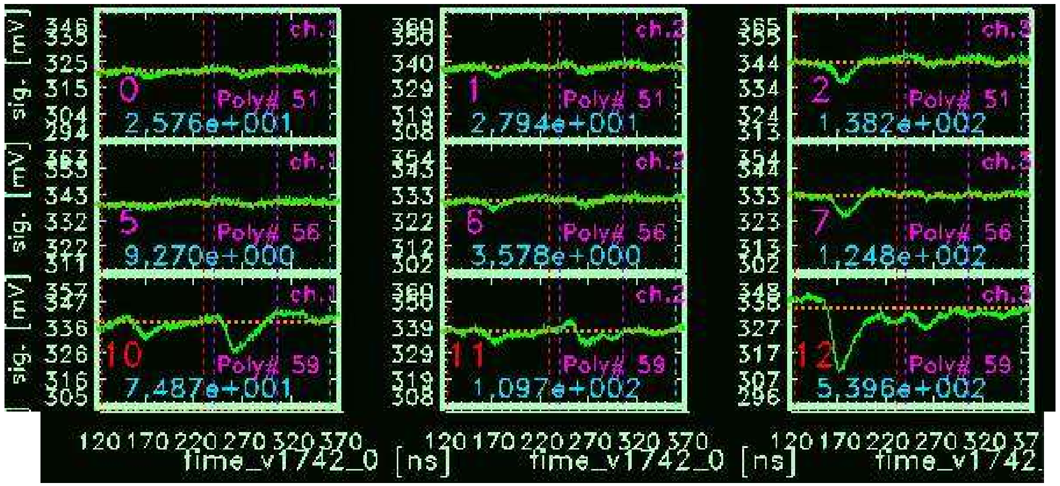


Fig. 2. Signals of ch. 1, 2 and 3 of Poly#51, 56, 59 in #171235.

Ablation study of neon and hydrogen cryogenic pellets used by ITER DMS

A. Matsuyama (QST), R. Sakamoto

Experimental condition:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.254, 100.0%)

Objective and method:

- ITER Disruption Mitigation System (DMS) will inject a mixture of hydrogen and neon by means of Shattered Pellet Injection (SPI).

➔ Single fragment size ~ mm = LHD pellet size

- Injection timing of 10% Ne doped pellets from 3-O were adjusted to observe the plasma profile immediately after the ablation to understand the pellet assimilation process.

Results (#171249 - #171261)

- Fig 1: Pellet penetration database was created for both NBI and ECH heated plasmas, showing reasonable agreement with model predictions.
- Fig 2: Spectroscopic data after pellet injection was also obtained.
- Fig 3: Radially filamented structures of both n_e and T_e were clearly observed at 0.4 ms after the end of ablation emission (#171256, ECH phase). This is first observation of n_e rise profile after single Ne-doped pellet injection – useful for model validation in support of ITER DMS design.

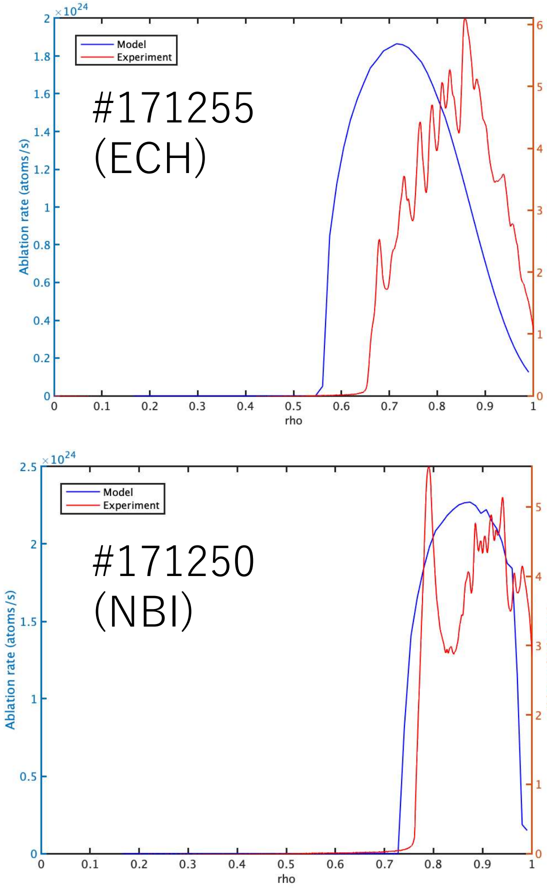


Fig. 1

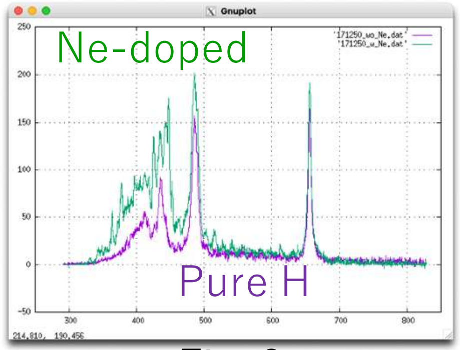


Fig. 2

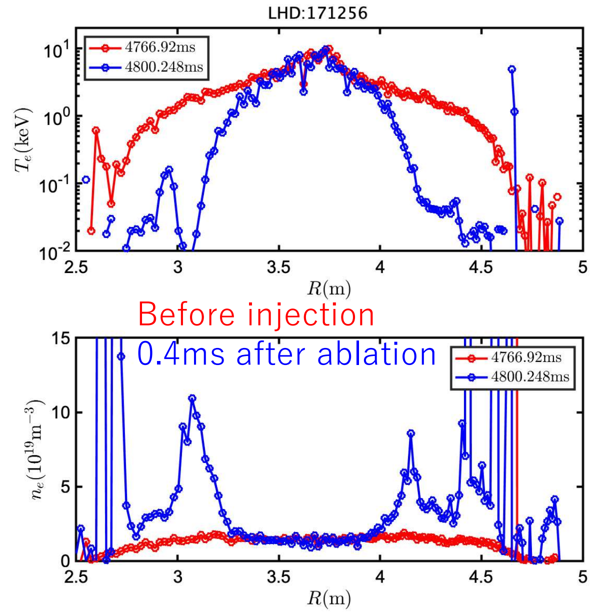


Fig. 3