(TG1) Multi-ion group report

Nov. 30, 2021 (G. Motojima)

Date: Nov. 26, 2021
Time: 9:50 - 13:00, 15:20-18:45
Shot#: 173526 – 173586(61 shots), 173631-173688(58 shots)

Prior wall conditioning: No
Divertor pump: No
Gas puff: D2, Ne
IPD: YES

NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, D)=P(2.6, 3.3, 3.2, 5.9, 3.8)MW

ECH(77GHz)=ant(5.5-U, 2-OUR)=P(333, 365)kW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(296, 364, 343)kW
ICH(38.47MHz)=ant(3.5U, 3.5L, 4.5U, 4.5L)=P(0.97, 0.78, 0.94, 0.43)MW
Neutron yield integrated over the experiment = 4.0×10^{16}, 7.7×10^{16}

Topics

1. Investigation of the effect of the IPD on the plasma discharges and the divertor detachment in outward magnetic shift configuration (Shoji, Masuzaki)
2. Harmonics cyclotron wave excitation through particle-wave interaction process during high ICRF heating (Kasahara)
3. Test of the forward Thomson scattering measurement (I. Yamada)
4. Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum / NEG pumps operation (C.P.Dhard (IPP), D. Naujoks (IPP), Motojima et al.)

1. Investigation of the effect of the IPD on the plasma discharges and the divertor detachment in outward magnetic shift configuration (M. Shoji)

● Experimental conditions:

Shot No: #173554 - #173580, R_{ax}=3.90 m, B=2.5385 T, $n_{e,\,bar}$=2～6×10^{19} m^{-3}, (Polarity, γ, B_q)=(CW, 1.2538, 100.0%), NBI: #1,2,3,4,5 (duration is 2 s), D Plasma, IPD: Boron (d=140 μm) and Boron nitride (d=60 μm) (2.5～4.5 sec), RMP(6-O): (A:-2579.3 A, B1:-1845.7 A, B2:-3342.3 A) or (A:-703.1 A, B1:-516.4 A, B2:-919.2 A)

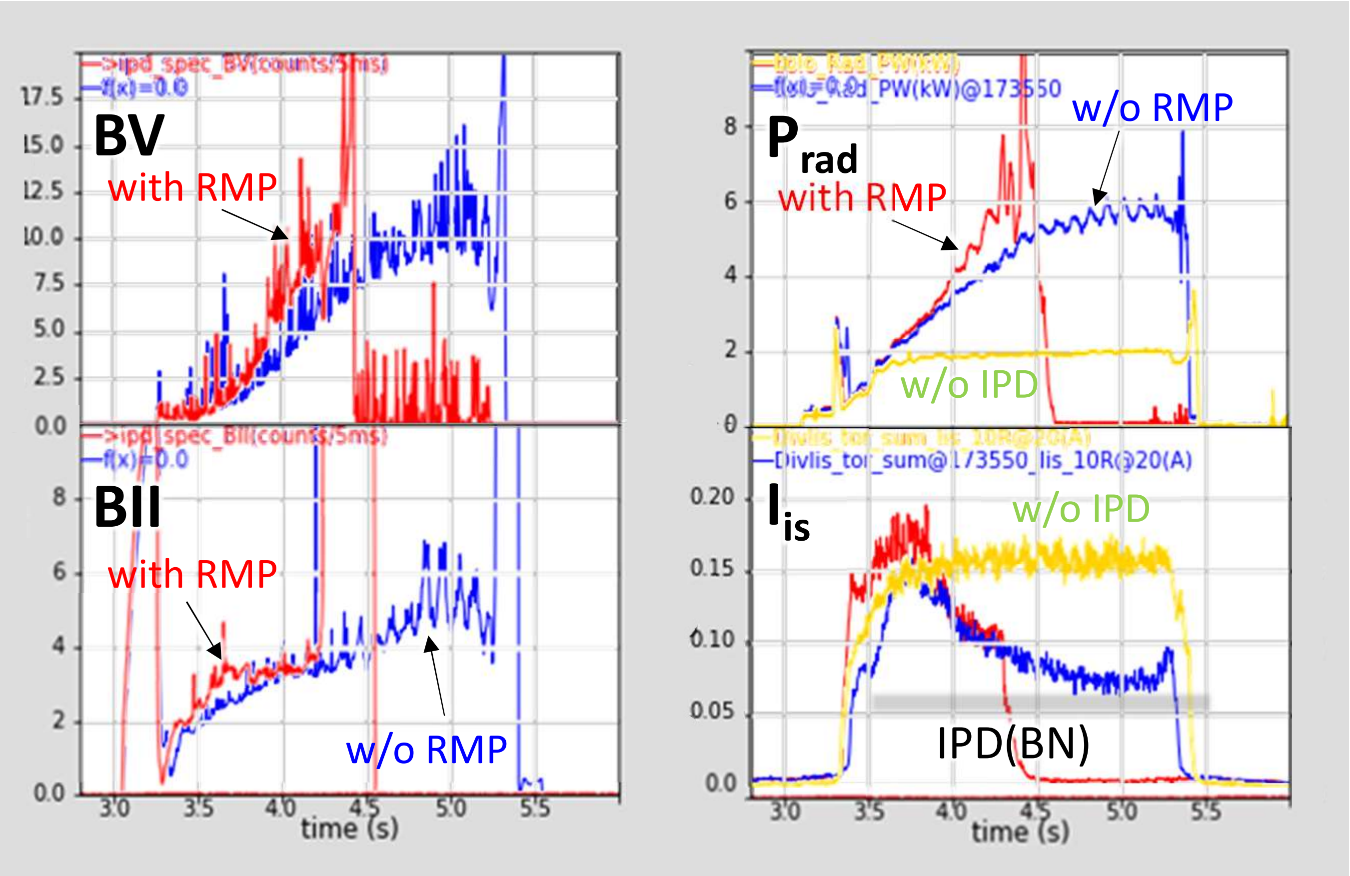
● Motivation and objective:

- Triggering and sustaining the divertor detachment by suppling BN and B dust particles into the magnetic island using the IPD
- Demonstration of the advantages of the IPD for heat load reduction on the divertor plates with the RMP

● Preliminary results:

- BN dust particles were dropped in plasma discharges in the case with & without the RMP for R_{ax}=3.90 m.
- IPD enhanced the radiation power and decreased the ion saturation current on the divertor plates.
- The RMP with BN dust dropping induced radiation collapse during the plasma discharges.
- The RMP with B dust dropping is not effective for reducing ion saturation current compared to w/o RMP.

with RMP (#173549), w/o RMP (#173550), w/o IPD & RMP (#173540)



1. Effects of boron powder dropping in plasma under an outer shifted magnetic configuration (Rax=3.9m)

S. Masuzaki, M. Shoji et al

26 November 2021

Shot #: 173526 - 173586

(R_{ax}, B_t, γ, B_q) = (3.9 m, CW 2.538 T, 1.2538, 100.0%)

P_{NBI} (#1-#3) ~ 2.6 MW, P_{NBI} (#4, #5) ~ 5.6 MW (modulated)

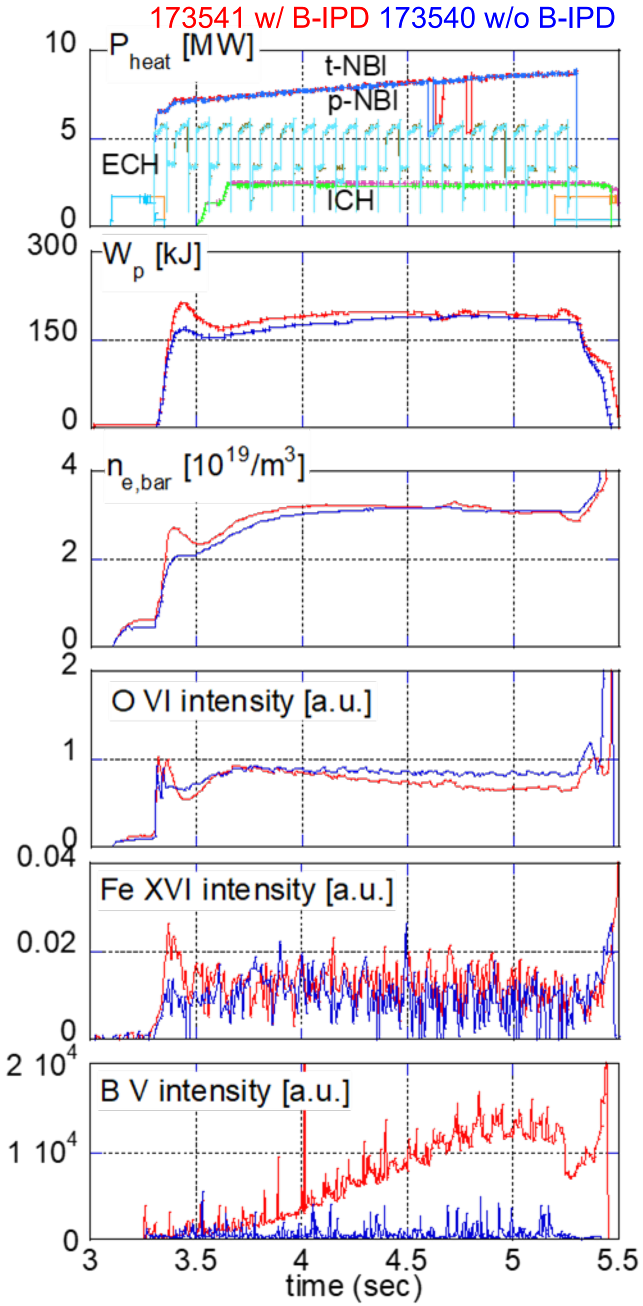
ECH ~ 1.7 MW, ICH ~ 2.4 MW

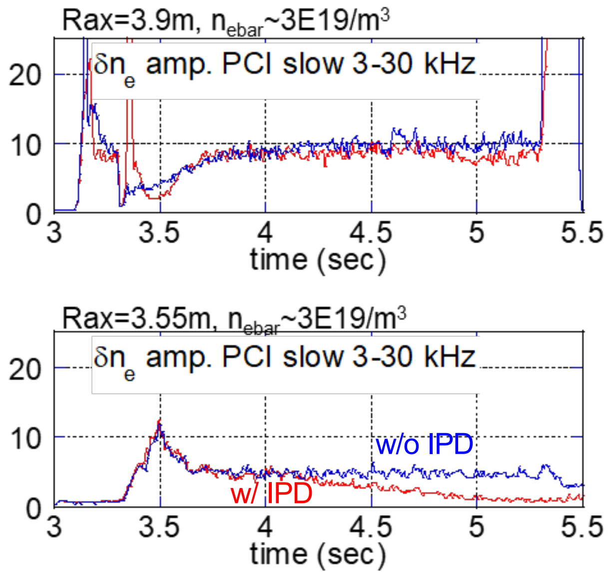
Working gas: D_2 (5.5L, with feedback control)

Impurity powder: B, BN

Results:

- IPDs were conducted successfully.
- Observed effects of B-IPD were as below:
  - Decreases of low-Z intrinsic impurities.
  - No change of Fe XVI
  - No change of Wp
  - Decrease of amplitude of density fluctuation is not clear.
- Effects of B-IPD on plasma confinement and high-Z imp. transport are not clear.





Time evolutions of density fluctuation in Rax=3.9m and 3.55m configurations with similar line averaged density

2. Harmonics cyclotron wave excitation through particle-wave interaction process during high ICRF heating (H.KASAHARA)

Background and objective

- Sub harmonics ICRF waves were observed during second harmonic ICRF heating in D plasma, and strong distortion of the velocity distribution were expected around ICRF resonances (ρ ~ 0.4).
- This is a first challenge to measure the velocity distortion with CXS diagnostics and the technique of 4th order velocity moment (kurtosis).

Experimental Condition (#173631~173662)

- On the standard magnetic configuration (R_{ax}=3.6m, B=2.75T, B_q=100%, γ=1.254), moment data of CXS was stored with BL4 modulation, BL5 constant, and ICRF amplitude modulation in various frequencies.

Results

- Three kinds of amplitude modulation frequencies (5, 20, 40Hz) were performed, and we could not operate for fast modulation frequency (200Hz) with the RF power feedback control.
- There were not clearly dependences for amplitude of ICRF power.

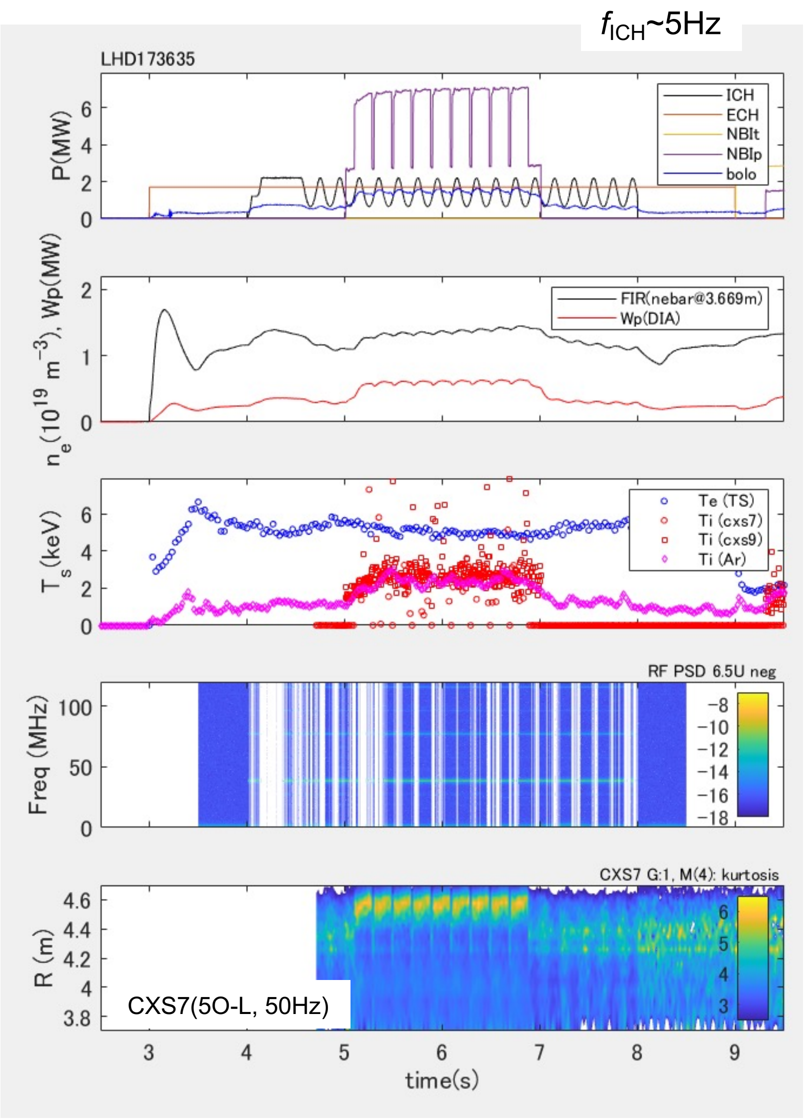


Fig. 1 discharge waveform

Harmonics cyclotron wave excitation through particle-wave interaction process during high ICRF heating (H.KASAHARA)

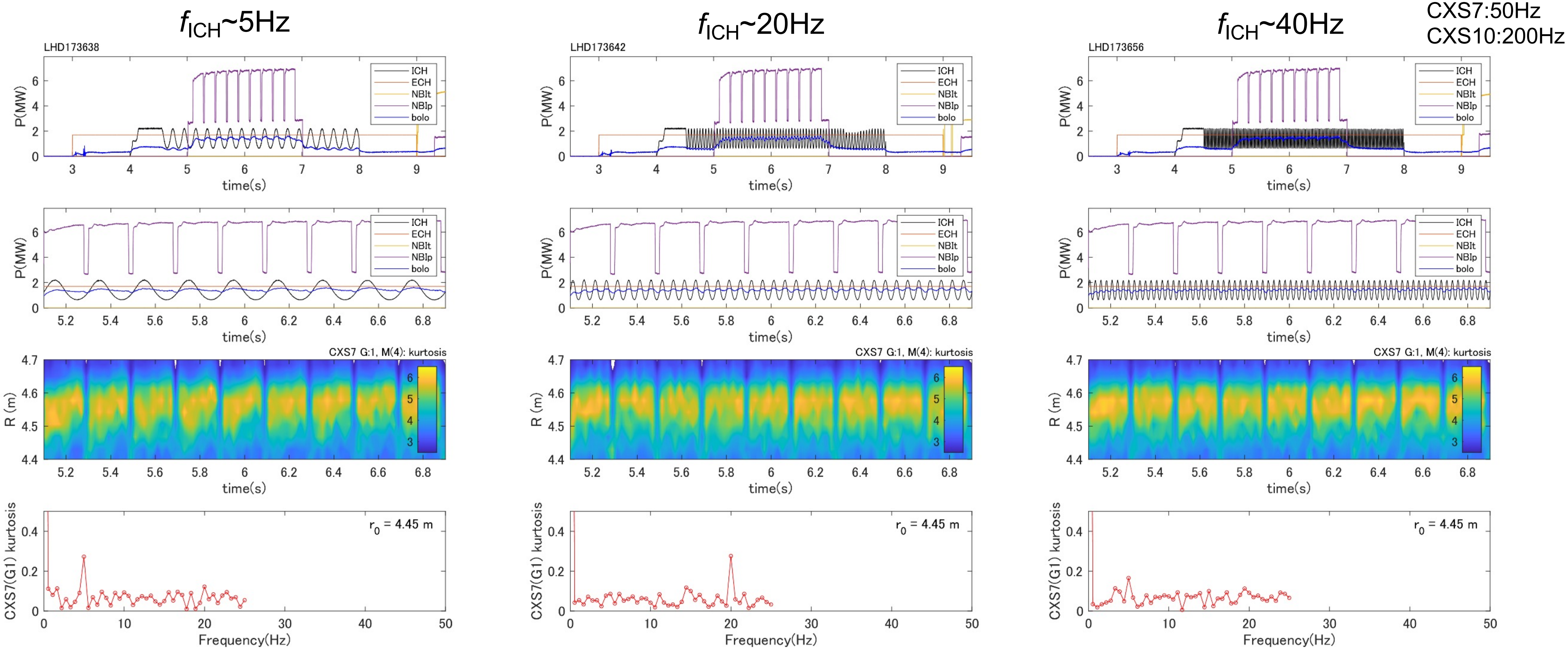


Fig. 2 time evolution for 4th order velocity moment (kurtosis) and these peak frequencies in various amplitude modulation frequencies

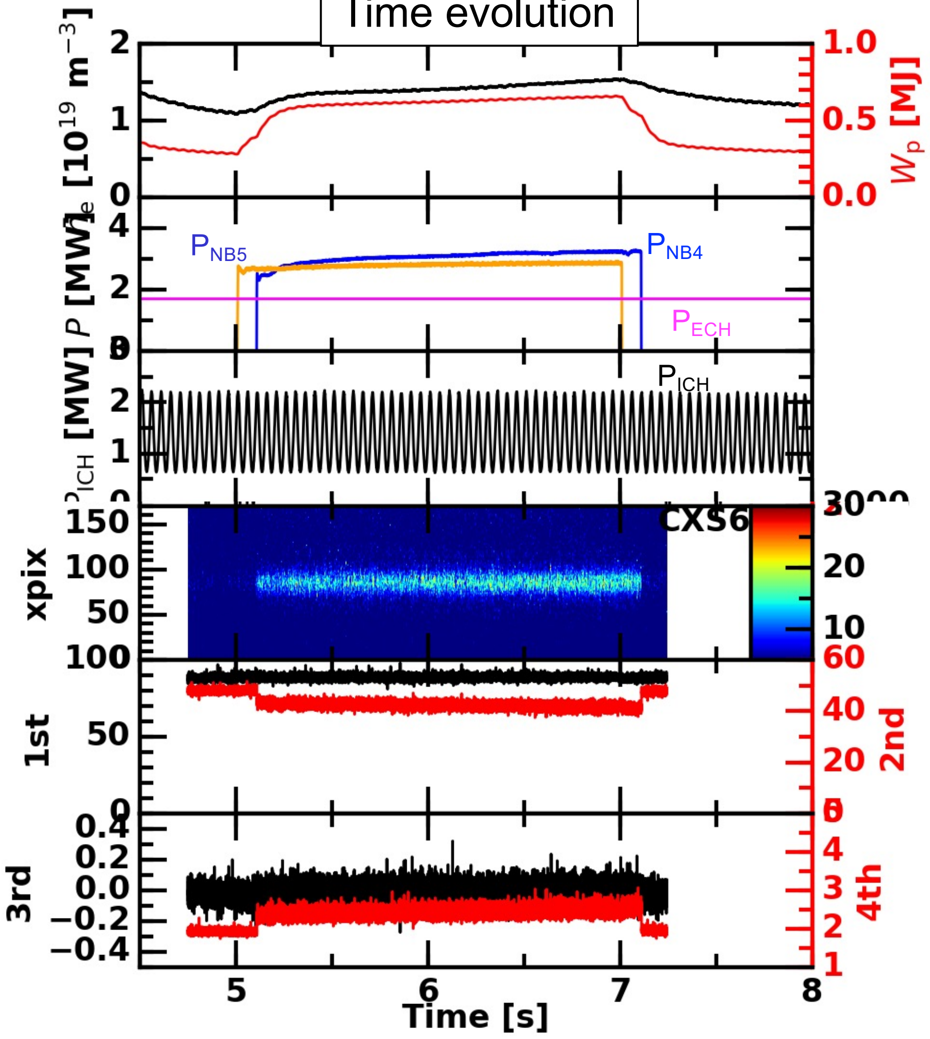
Next step

- As an analysis, we challenge several techniques for conditional average and mask of bulk effect.

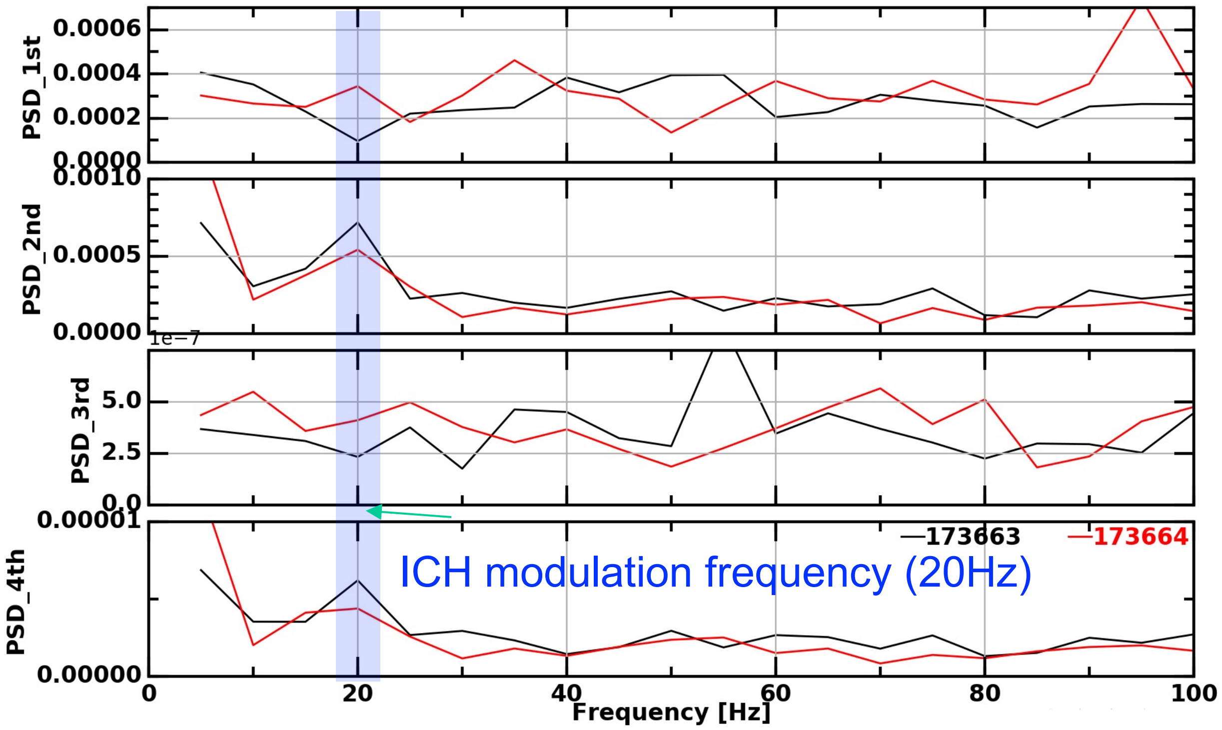
Measurement of perpendicular velocity distribution function by the fast CXS system (cxs6)

Courtesy for T. Kobayashi

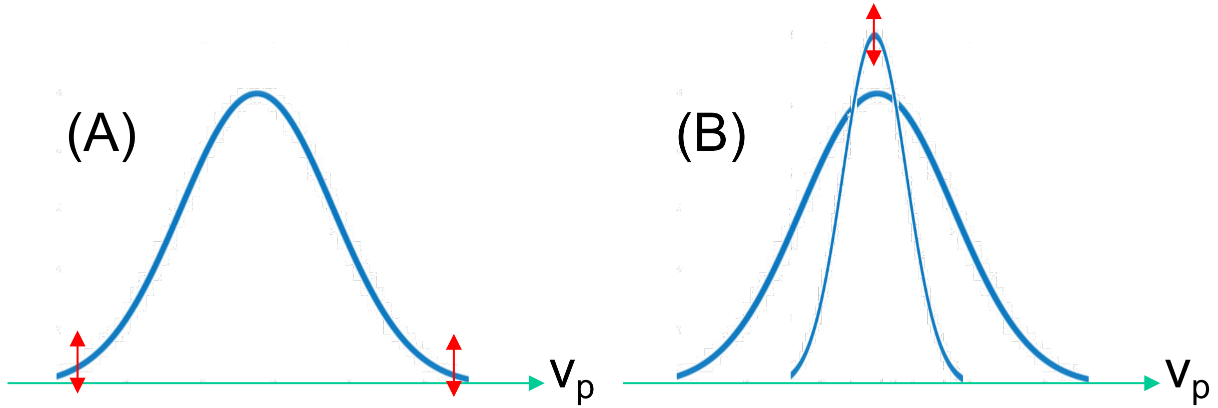
Time evolution



Fourier spectrum of moment signals

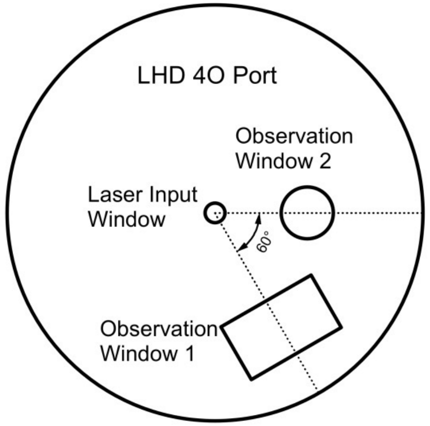


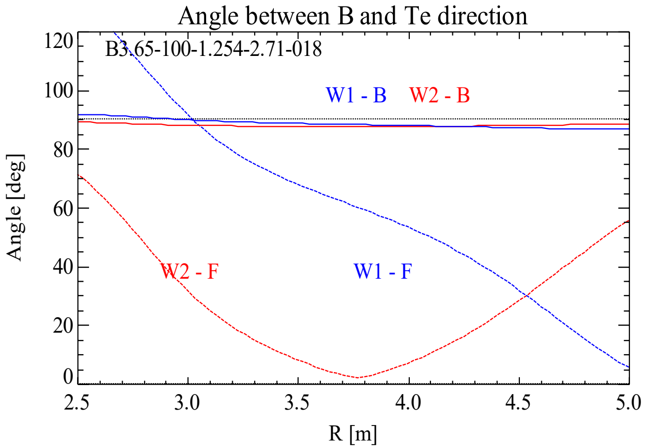
- Modulations in 2nd and 4th order moments by ICH were observed.
- Whether this is due to the velocity tail excitation (A) or the cold component modulation (B) will be analyzed.



3. First result of the forward Thomson scattering measurement on LHD

I. Yamada and H. Funaba





Introduction and motivation

We installed new light collection optics, Window2 and light collection mirror.
In principle, now we can measure four electron temperatures on LHD by using the two windows and two scattering configurations (backscattering and forward scattering).

Window1 – Backscattering

- Usual LHD TS diagnostics. Perpendicular Te is observed.

Window1 – Forward scattering

- The angle between Te and B is ~60 degree at the plasma center.

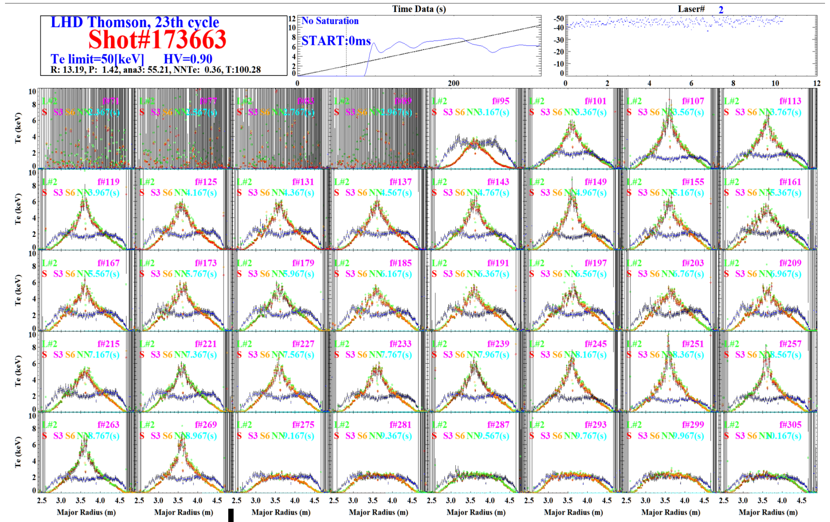
Window2 – Backscattering

- Perpendicular Te is observed.

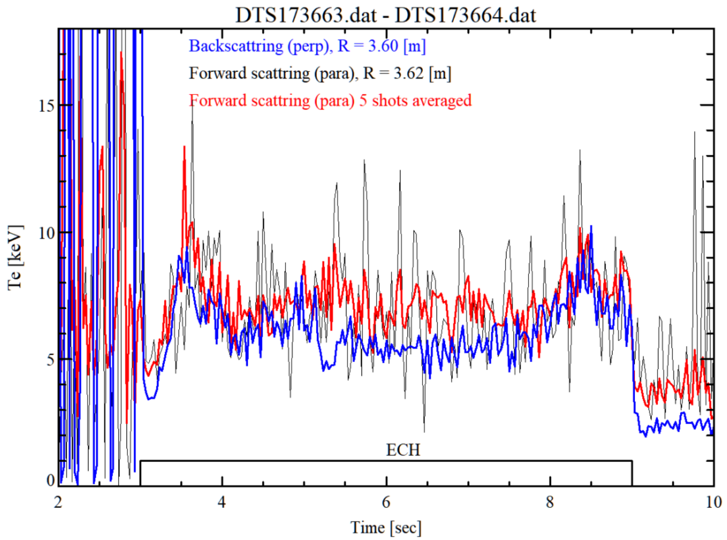
Window2 – Forward scattering

- Parallel Te is observed at the plasma center.

This time, we tried to measure the parallel Te at the center and compared to the perpendicular Te



ECH ON <-| ->OFF



Te^{perp} by ususal TS (#17663)

Te^{para} by the forward TS measurement (#173664)

Averaged Te^{para} (#173664-68)

Plasma shot

Date 2021-11-26:

#173663 (reference shot, usual backscattering TS)

#173664 - #173668 (Forward scattering)

Rax = 3.60 [m,] B = 2.75 [T], γ = 1.254, Bq = 100 [%]

During the ECH phase of 3-9 sec, the Te profile was sharp.
After the ECH ended, the center Te decreased.

Comparison of Te^{parp} and Te^{para} at the plasma center

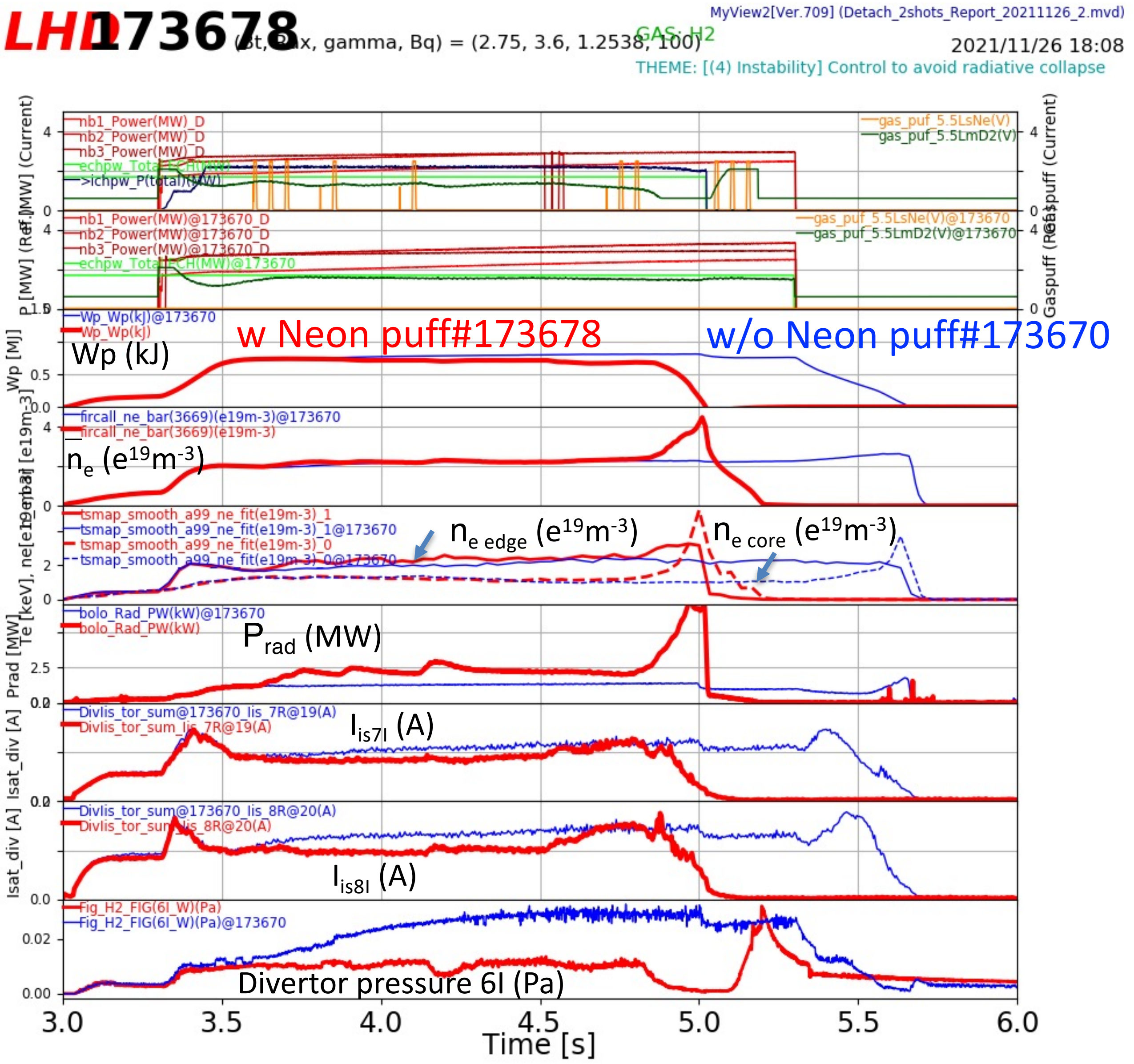
During the ECH phase, center Te^{parp} and Te^{para} show good agreements (~7 keV)within the experimental error.
After the ECH, Te^{perp} seems to decrease more than Te^{para}.
(Te^{perp} (~2.5 keV) < Te^{para} (~4 keV))

This time, we successfully obtained the first result of Te^{para} on LHD.
To obtain the final accurate Te^{para} data, we have to measure the calibration data of the new window2 and new light collection mirror. (For the conventional TS diagnostics, the calibration data have been already obtained and applied.)

4. Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum / NEG pumps operation

C.P. Dhard, D. Naujoks (IPP), G. Motojima, S. Masuzaki, K. Mukai (NIFS)

- ✓ Experimental conditions:
  - ❖ Shot No: 173669-173688
  - ❖ B_t, R_{ax}, γ, Bq = (+2.75, 3.6, 1.254, 100)
- ✓ Motivation and objective:
  - ❖ In-vessel vacuum pumps play an important role for the exhaust of neutral particles in the divertor region resulting into a significant impact on the plasma density control and attaining detached plasma operation.
  - ❖ The role of these pumps become more important during detached plasma condition, when the neutral gas pressure in the sub-divertor region rises significantly during the onset phase of detachment, but can drop during deep detachment, in particular, having high radiation losses in the SOL.
  - ❖ We propose to analyze the performances of the in-vessel pumps in the detached and partially detached plasma operations.
- ✓ Results:
  - ❖ NBI#1-3, ECH and ICH were utilized for heating.
  - ❖ The data set in the case “without divertor pumping” was obtained.
    - Attached vs. Detached with Neon puffing
    - n_e: 2×10^{19}, 5×10^{19} m^{-3}
    - Two main pumps, one main pump
  - ❖ Neon was controlled by feedback signal of radiation power, P_{rad}.
  - ❖ With Ne doped, higher radiation power and lower divertor flux and neutral pressure in divertor region were observed.



G. Motojima