(TG1) Multi-ion group report

Dec. 17, 2021 (M. Kobayashi)

Date: Dec. 17, 2021
Time: 9:53 – 11:34, 15:41 – 18:45
Shot#: 175382 – 175414 (33 shots), 175490 – 175547 (58 shots)

Prior wall conditioning: No
Divertor pump: On
Gas puff: D2, H2, He IPD: No
LID: No
NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, He)=P(3.9, 3.5, 3.6, 2.2/2.4, 3.3/3.8)MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(723, 799, 825)kW
ECH(116GHz)=ant(2O-LR)=P(-)kW
ECH(56GHz)=ant(1.5-U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.35, 0.35, 0.53, 0.34) MW
Neutron yield integrated over the experiment = 8.7×10^{15}

Topics

1. Investigation of particle transport by optimized multi-sinusoidal modulation (M.van Berkel, K.Tanaka et al.)
2. Commissioning of impurity beam injections with NBI#5 into LHD plasmas (N. Tamura)
   Mixing and non-mixing states of helium ion (K. Ida)
3. Helium removal in helium beam experiments (G. Motojima et al.)

Investigation of particle transport by (multi) sine modulation

R. van Kampen (DIFFER), M. van Berkel (DIFFER),
T. Kinoshita (Kyushu Univ.), H. Sakai (Kyushu Univ.), K. Tanaka (NIFS)

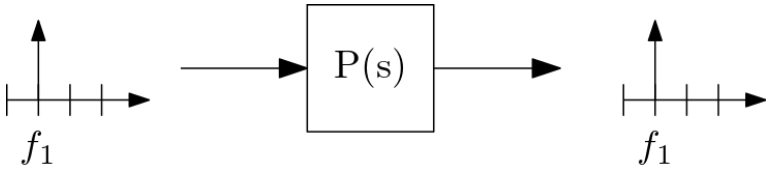
Discharges: $175387 - 175414,\ B = 2.750\mathrm{T},\ R_{\mathrm{ax}} = 3.6\mathrm{m},\ \gamma = 1.254,\ B_{\mathrm{q}} = 100.$

Objectives and Expected Results:

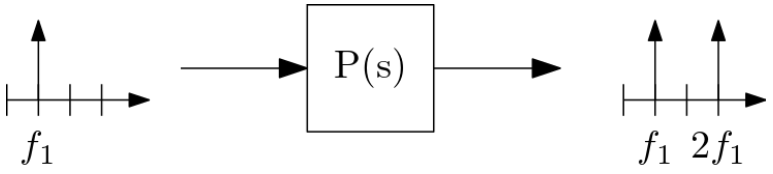
Target Investigation of non linearity of particle transport

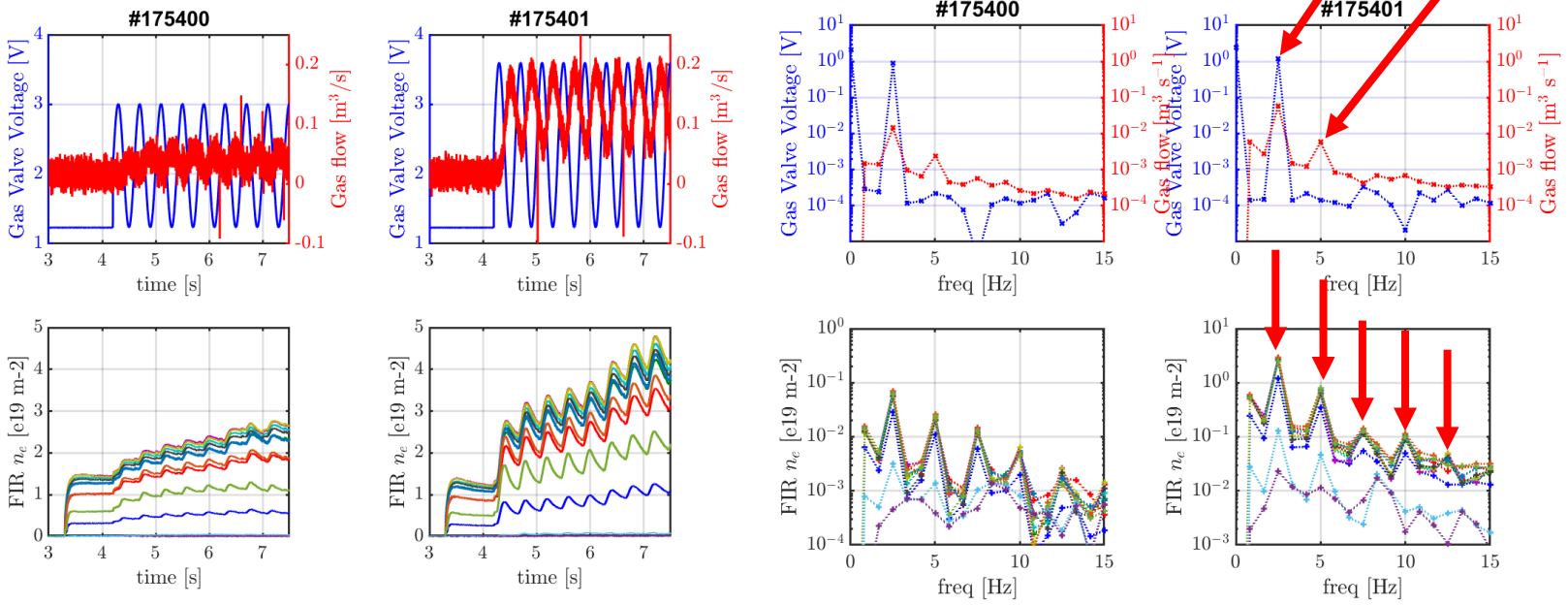
1. Observation of harmonics appearance

linear system:



nonlinear system:





For pure sinusoidal modulation, higher harmonics appeared. However, this is partly due to the non linearity of gas flow system.
Harmonics appears already in flow rate. This makes interpretation complicated and requires further analyses.

Investigation of particle transport by (multi) sine modulation

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Target Investigation of non linearity of particle transport

2. Phase reversal of modulation.

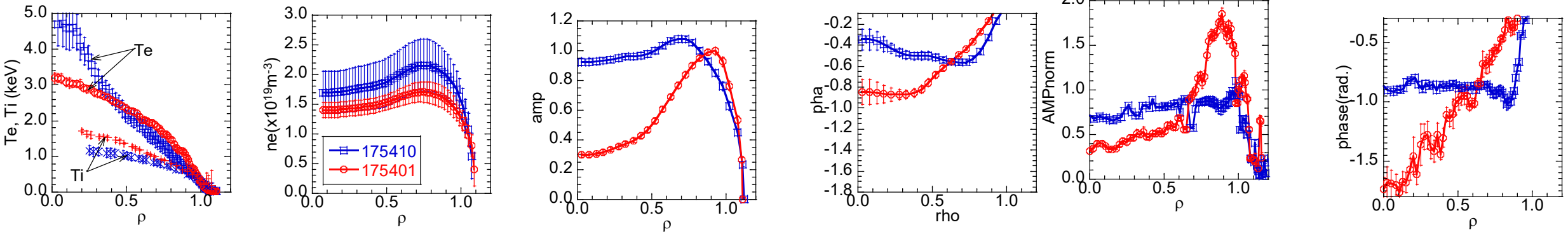
D and V mode can not account for the phase reversal of modulation amplitude.

Case 1 175401 NB 6MW 2.5Hz density modulation for 2sec NB pulse

No phase reversal

Case 2 175410 1.8MW ECRH 1.25Hz density modulation for 3sec ECH pulse (2.5Hz modulation does not penetrate to the core)

Phase reversal



There are some discrepancy between FIR int. and Thomson.
Higher Te/Ti in core may cause phase reversal.
Further analyses will be done.

Commissioning of He beam injection with NBI#5 into LHD plasmas (N. Tamura on behalf of TG1)

Experimental conditions: **(R_{ax}, Polarity, B_t, γ, B_q) = (3.55 m, CW, 2.7889 T, 1.2538, 100.0%)**

Shots: #175490 - #175527

Goal of this experiment

- Commissioning of the He beam injection with NBI#5 into LHD plasmas

Main results of this experiment

- **Thanks to the efforts of NBI group**, **we have achieved a large reduction of He gas influx from the NBI device** (compared to the results on Nov. 19)

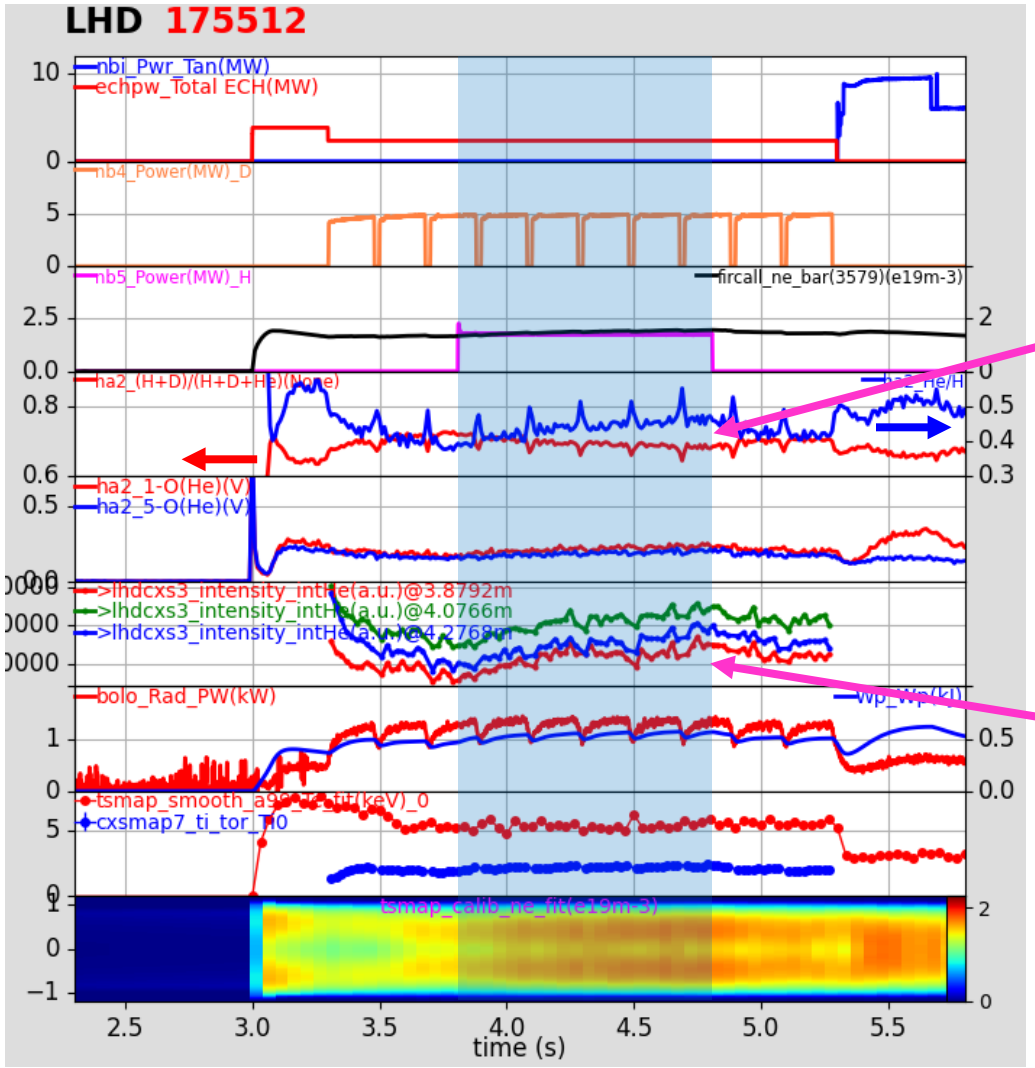
	1 IS (22c)	1 IS (Nov. 19)	1 IS (Dec.17)
Max Int. CXS3(He) (rough)	~ 4e4	~9e4	~5e4

  - ✓ And thus, **we have observed responses of plasma parameters to the He-NBI (see next page)**
- We have again conducted He gas influx calibration with NBI#5, **1) only NBI#5 w/o a beam extraction**, **2) only NBI#5 w/ a beam extraction**, under the situation where the gate valves for cryopumps of LHD are closed
  - ✓ Results will be compared with those on Nov. 19
  - ✓ We will again conduct He gas influx calibration with NBI#5 after the installation (during the 1st week of January) of an additional pumping system at Port 6-O

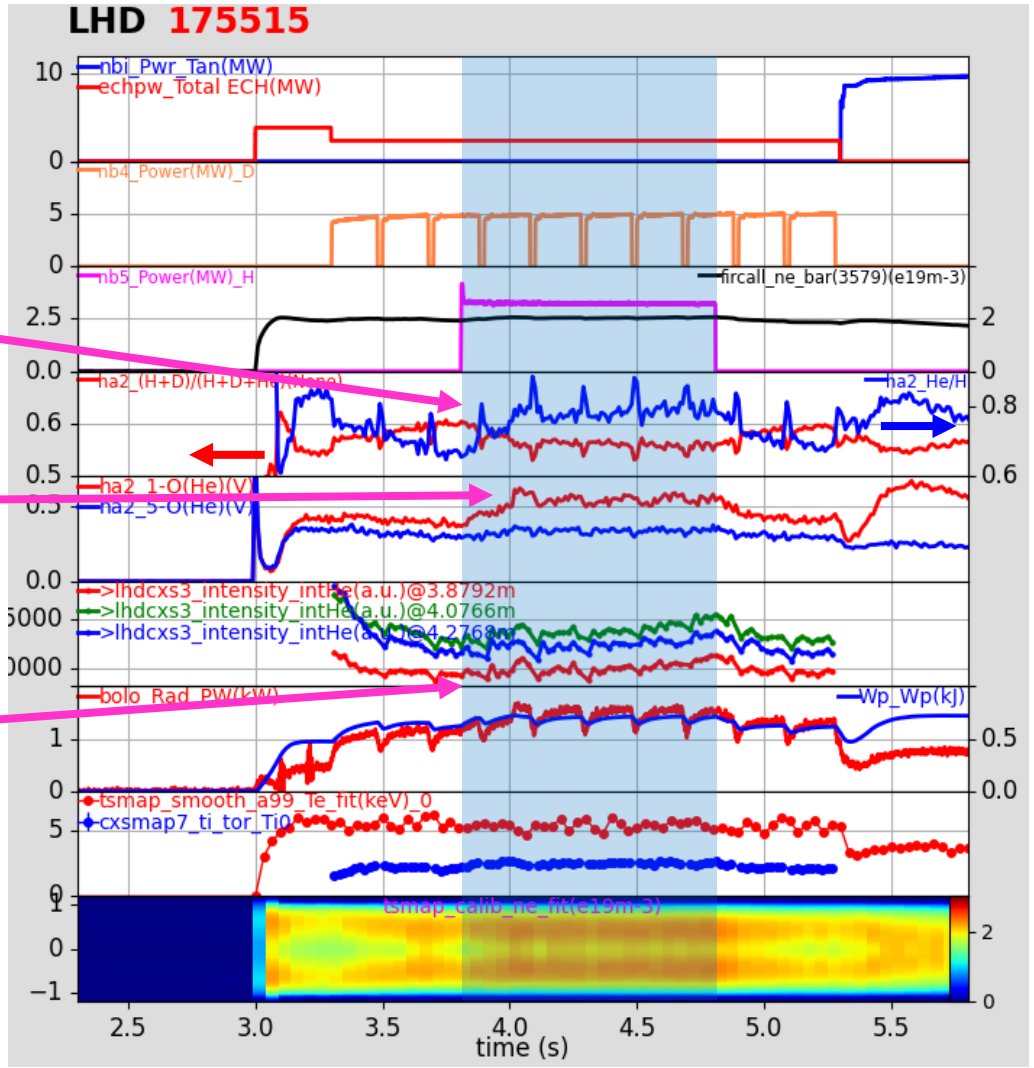
Commissioning of He beam injection with NBI#5 into LHD plasmas (N. Tamura on behalf of TG1)

General comparison of plasma waveforms with He-NBI

He-NBI(1 IS) in the ECH-heated plasma



He-NBI(2 IS) in the ECH-heated plasma

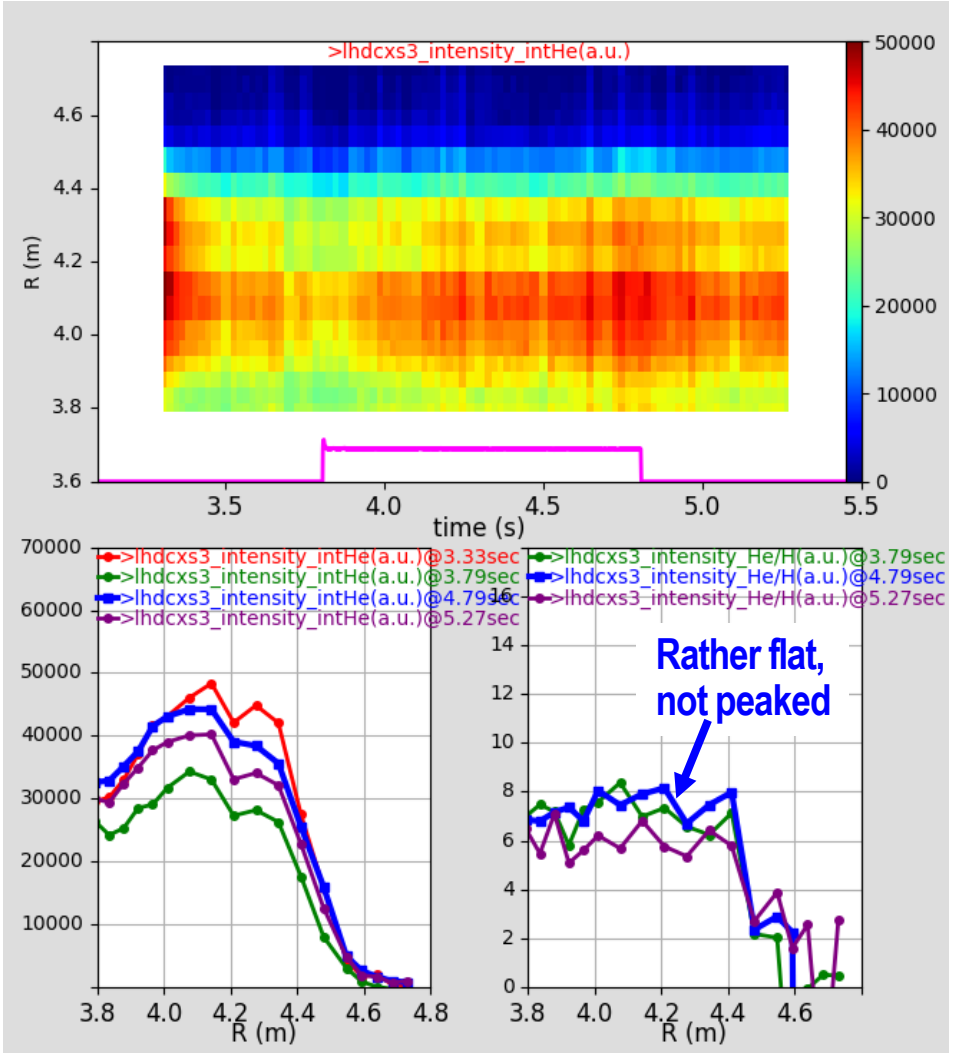


- Due to the He-NBI, Ratios of **(H+D)/(H+D+He)**, **He/H** were clearly changed
- In the case **with 2 IS**, **the increment of He I (Port 1-O)** due to He-NBI was observed
- In the case **with 1 IS**, **CX He II intensities have responded (increased) more clearly**

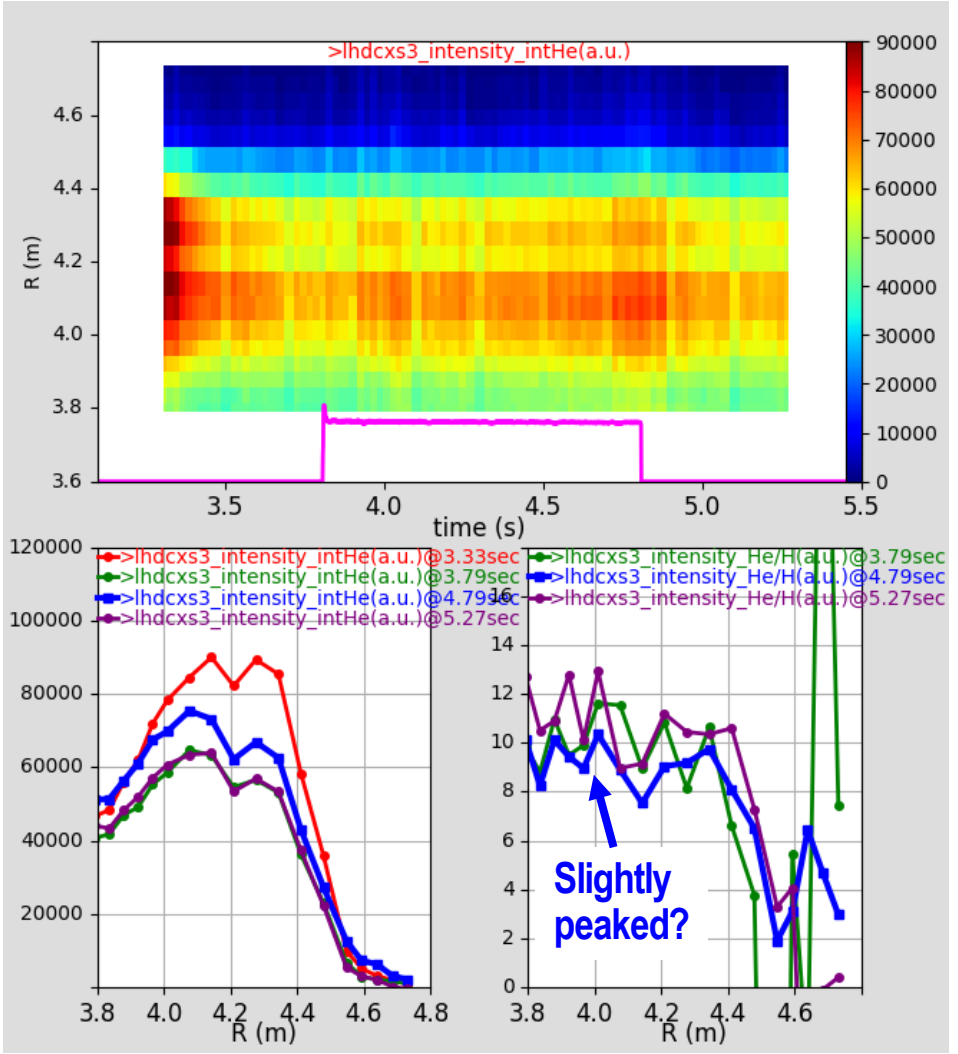
Commissioning of He beam injection with NBI#5 into LHD plasmas (N. Tamura on behalf of TG1)

General comparison of He and He/H profiles with He-NBI

He-NBI(1 IS) in the ECH-heated plasma



He-NBI(2 IS) in the ECH-heated plasma



Notes:

3.33 s – at plasma start-up

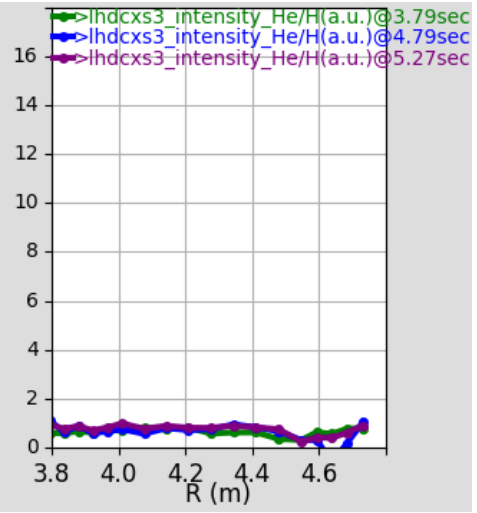
3.79 s – just before He-NBI

4.79 s – just before the end of He-NBI

5.27 s – just before the end of NBI#4 (CXS measurement)

Reference

- D-NB(4 IS) was injected from 3.8 s to 4.8 s during in the (ECH+NBI)-heated plasma



- **The He contamination level seems to be still high. And thus, we must consider a better operation scheme.**

Helium removal in helium beam experiments
(G. Motojima, K. Hanada (Kyushu Univ.), K. Nagaoka)

Magnetic Configuration: (R_{ax}, Polarity, B_t, γ, B_q) = (3.55 m, CW, 2.78 T, 1.2538, 100.0%)
Shots: 175528-175547 (20 shots)
Goal of this experiment:

- To study the wall changeover (divertor, first wall, NBI armor tiles) behavior from He to D

Results:

- The decay of He intensity was investigated after He beam injection (Fig. 1).
  →Reduction of He intensity induced by He beam injection seems changed by the pumping condition, suggesting that the pumping condition (especially turbo pumps) is important for the removal of He. We will add turbo pumps on next Jan.
- We tried to conduct the 10 s ECH/ICH discharges of deuterium after He beam experiments (Fig. 2).
  →Reduction of H/D ratio is enhanced with the increase of target density, suggesting that higher density is efficient for He removal (Fig. 3).
  Relation of He removal and divertor tiles (divertor flux and temperature) will be investigated.

Fig 1. He/H intensity by CXS

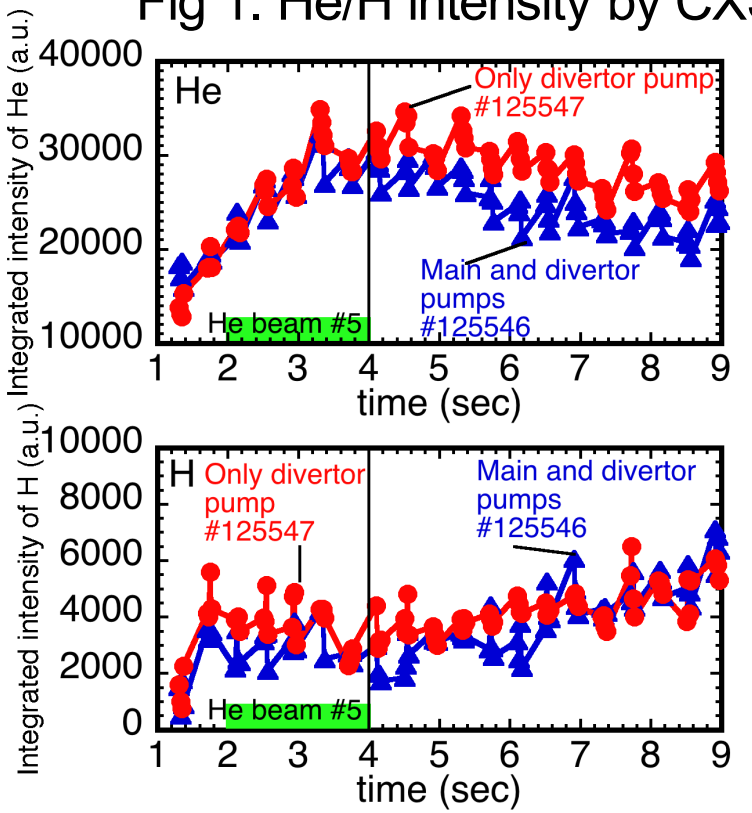


Fig 2.

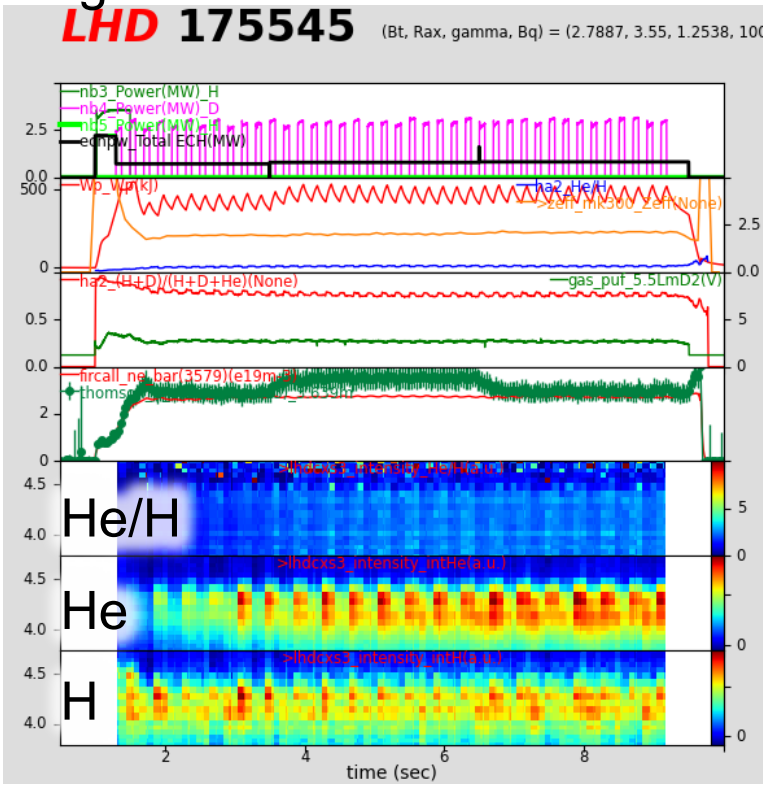


Fig 3.