(TG4) Plasma instability group report

Nov. 9, 2021 (K. Nagaoka)

Date: Nov. 5, 2021
Time: 9:30 - 18:45
Shot#: 171861 – 172008 (157 shots)

Prior wall conditioning: None
Divertor pump: On
Gas puff: D2, Pellet: No, Tespel: empty-tespel, IPD: B, C
NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(4.2, 4.2, 3.6, 8, 10)MW
Neutron yield integrated over experiment = 1.3×10^{16}

Topics

1. Confinement improvement and turbulence suppression in high beta plasmas with impurity powder injection (M. Zarnstrov/Y. Suzuki)
2. Observation of Landau damping (K. Ida)
3. Experimental analysis of beta-driven stochastization in the LHD helical divertor (A. Knieps/Yunfenf Liang/Y. Suzuki)
4. Observation of spatial structure change in the plasma edge during L-H mode transition (T. Tokuzawa)

Impurity Power Injection in High β

M. Zarnstorff, Y. Suzuki, F. Nespoli, N. Ashikawa, R. Lunsford, et al.

Impurity powder injection into B = 1T, Rax = 3.55m; 56 GHz ECH breakdown. High-β low collisionality scenario similar to [S.Sakakibara et al, NF 57 (2017) 066007], with gas fueling.

Plan:

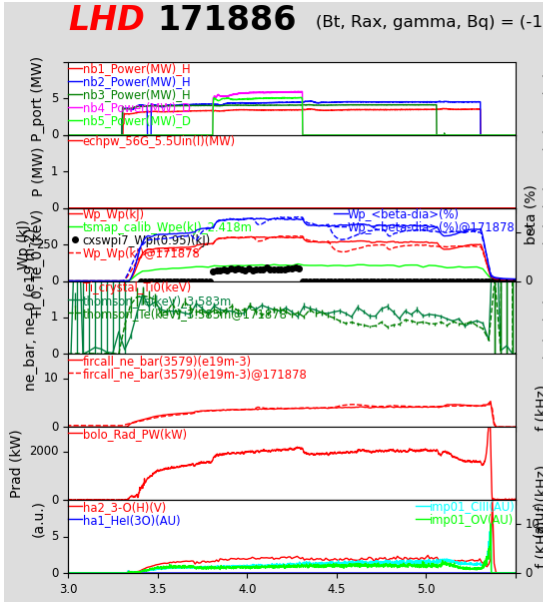
1. ✔ baseline shot without impurity injection *with density scan to assess effect*
2. ✔ Scan B injection rate, 4 levels
3. Repeat best plasma and injection rate with C ✔, BN, and Li powders
4. For impurity with largest effect, scan injection rate (3 more levels)
5. ✔ Shots with modulated perp-NBI, for CXRS impurity transport measurements
6. Repeat for both H and D plasmas and NBI. (Transport affected by ion mass ratio)
7. Two shots in each condition, for repeatability and contingency (44 shots total)

Results: Scaning with B injection

- Highest β achieved ~ 2.5% at highest density requested $\bar{n}_e$~ 4e19
- Density scan with 150 μm boron injection at ~ 30 mg/sec showed no change from no impurity injection, except at low density where B-injection increased density
- Scan of boron injection rate (five points from ~1 mg/s to ~120 mg/s) also showed very little difference

171886
(Boron
30mg/s)

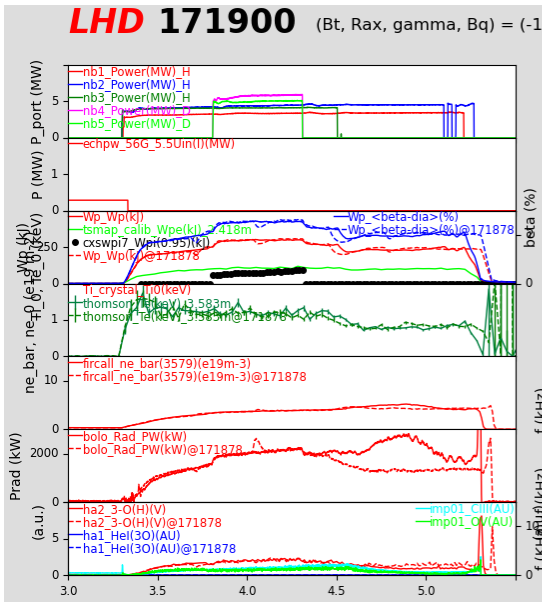
171878
(no imp.)



β

$\bar{n}_e$

P_{rad}



171900
(Boron
120 mg/s)

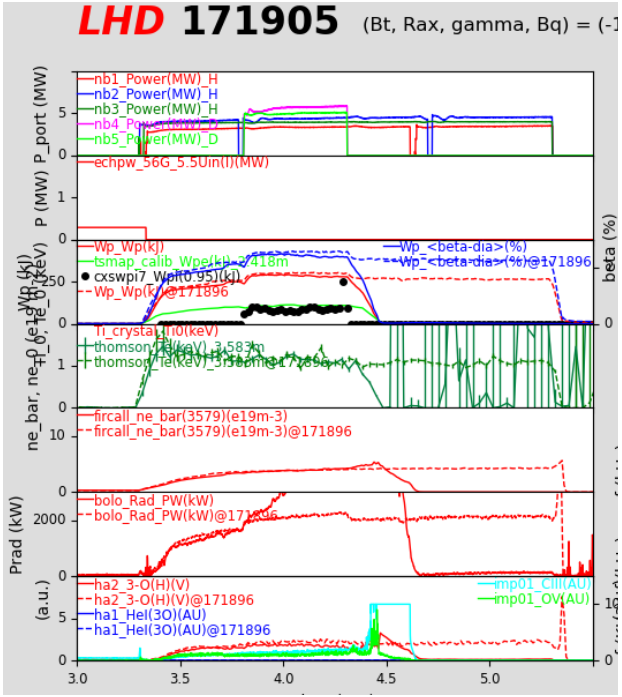
171878
(no imp.)

Results: Carbon vs Boron injection

- Injection of 120 μm Carbon vs 150 μm Boron powder were very different, using the same drive voltage (5.3 V) on power dropper
- Carbon caused a very large increase in the radiated power and some decrease in β

171905
(Carbon, 4.3 V)

171896
(Boron, 4.3 V,
~50 mg/s)



β

$\bar{n}_e$

P_{rad}

Need to Complete Impurity Scan

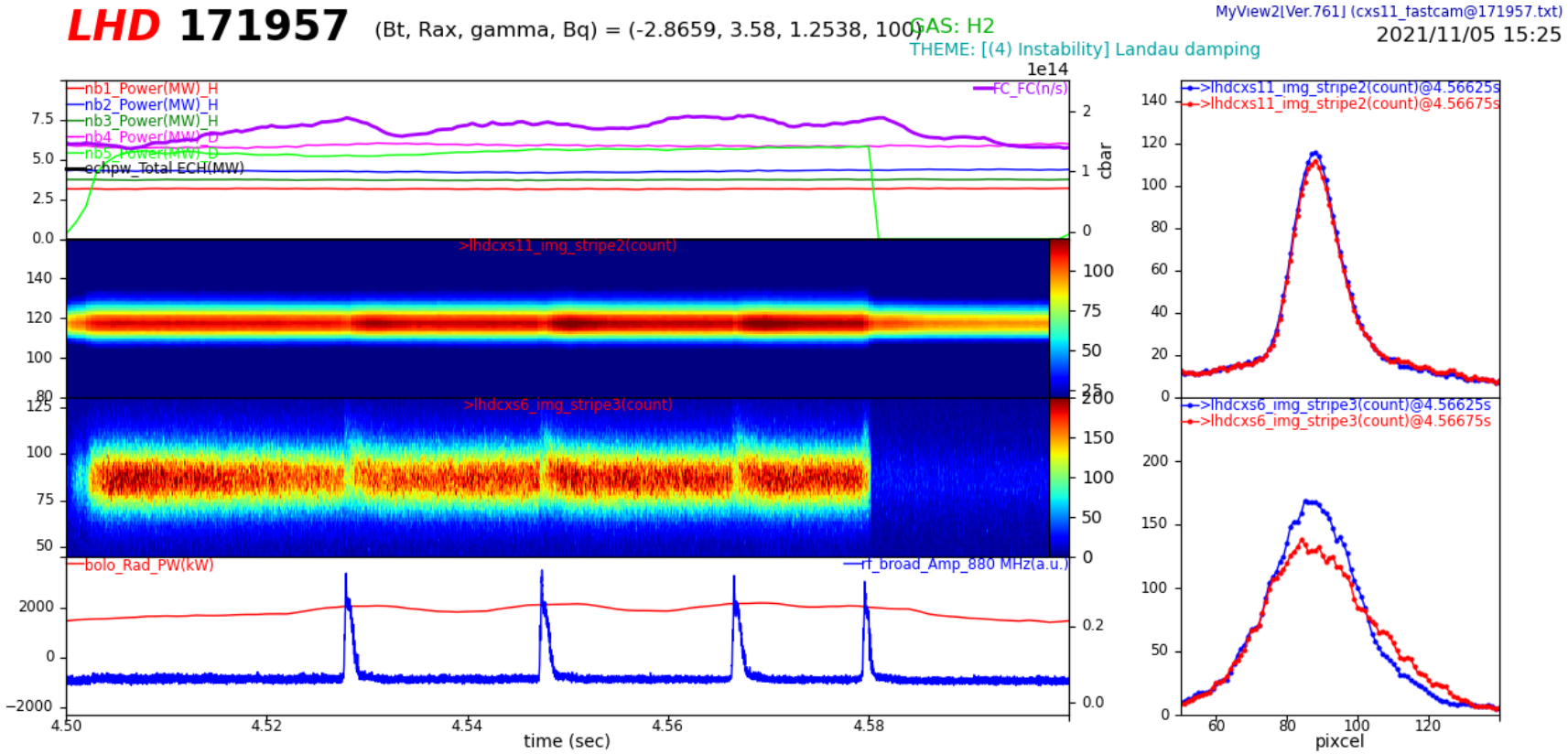
- In other experiments, Lithium injection had the largest effect on confinement and transport (NSTX, DIII-D, EAST)

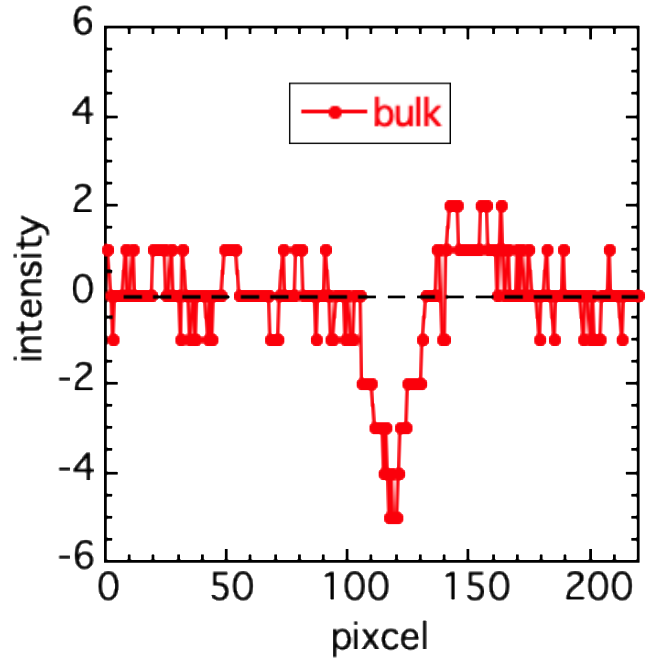
- Need to wait for Lithium availability on LHD to complete Lithium and Boron Nitride injection comparisons, to test mass dependence effects on high-β confinement and transport.

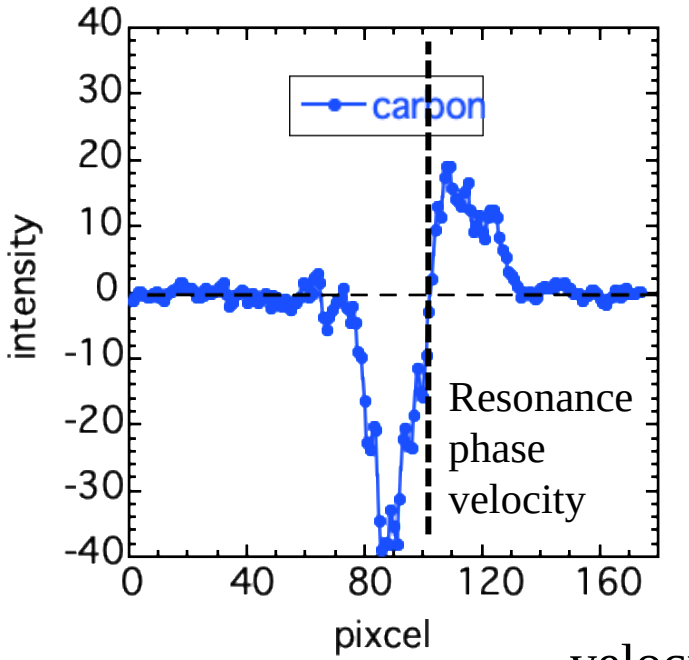
Bipolar signature of distortion in velocity distribution (evidence of Landau damping)

K. Ida

Bipolar signature (simultaneous increase/decrease of population across the resonance phase) of distortion was observed both in carbon and bulk ion velocity distribution







K.Ida M.Yoshinuma

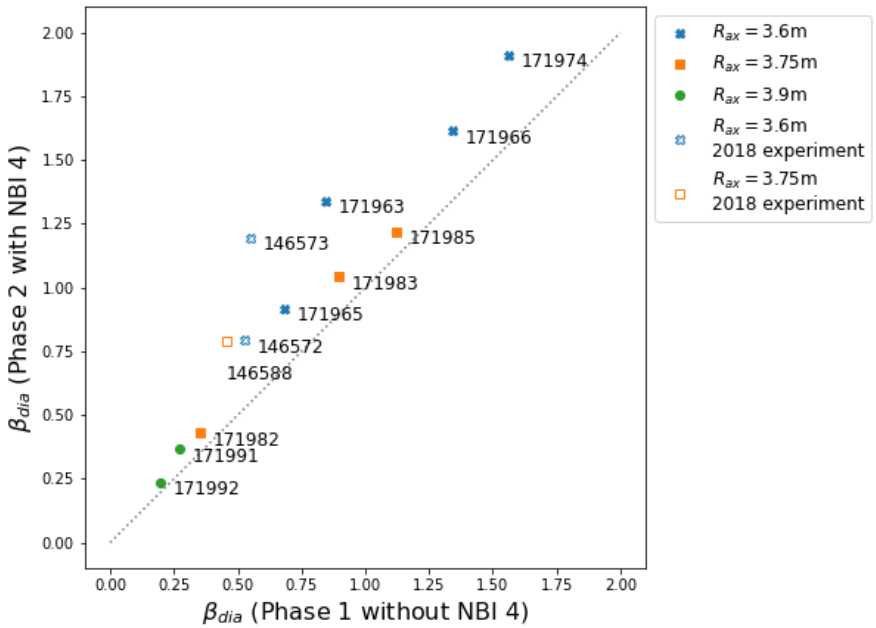
velocity

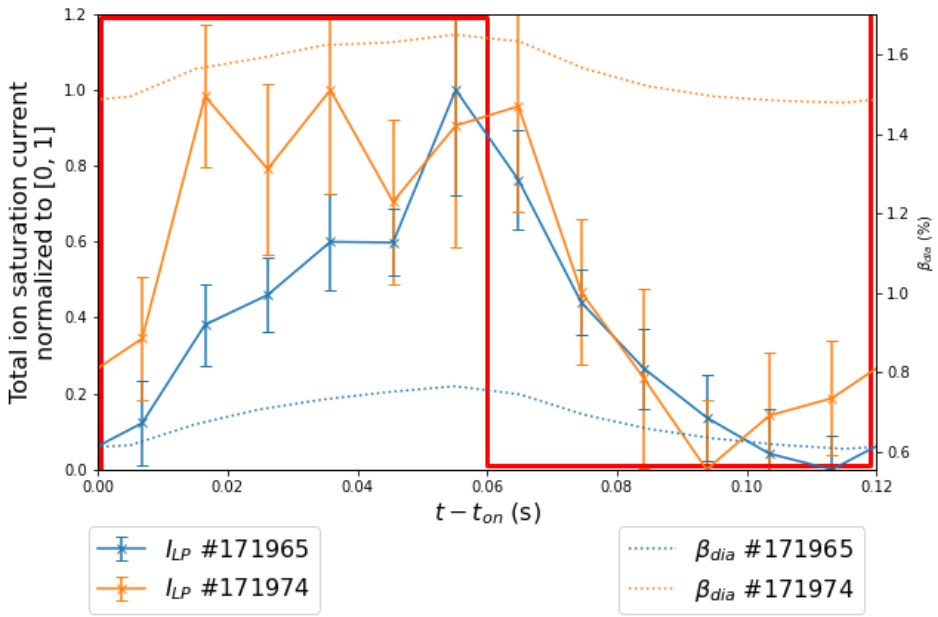
3. Beta effects on edge transport

A. Knieps /Y. Liang/Y. Suzuki

Shot #: 171963 **-** 167995

Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.6/3.75/3.9 m, CCW, 1 T, 1.2538, 100.0%)





Background & Approach:

- Aim of experiment: Characterize relationship between plasma beta and edge transport timescales in the LHD helical divertor
- Methodology: Modulate NBI 5 during multi-stage plasma operation and observe evolution of ion saturation current measured by divertor Langmuir probes, additionally inject TESPEL into steady NBI heating

Result:

- Switching from ECH to NBI as modulation source allowed raising plasma beta from 1.2% to 1.8% while maintaining clear response on divertor LP

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A. Knieps /Y. Liang/Y. Suzuki

Shot #: 171963 **-** 167995

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NBI experiment:

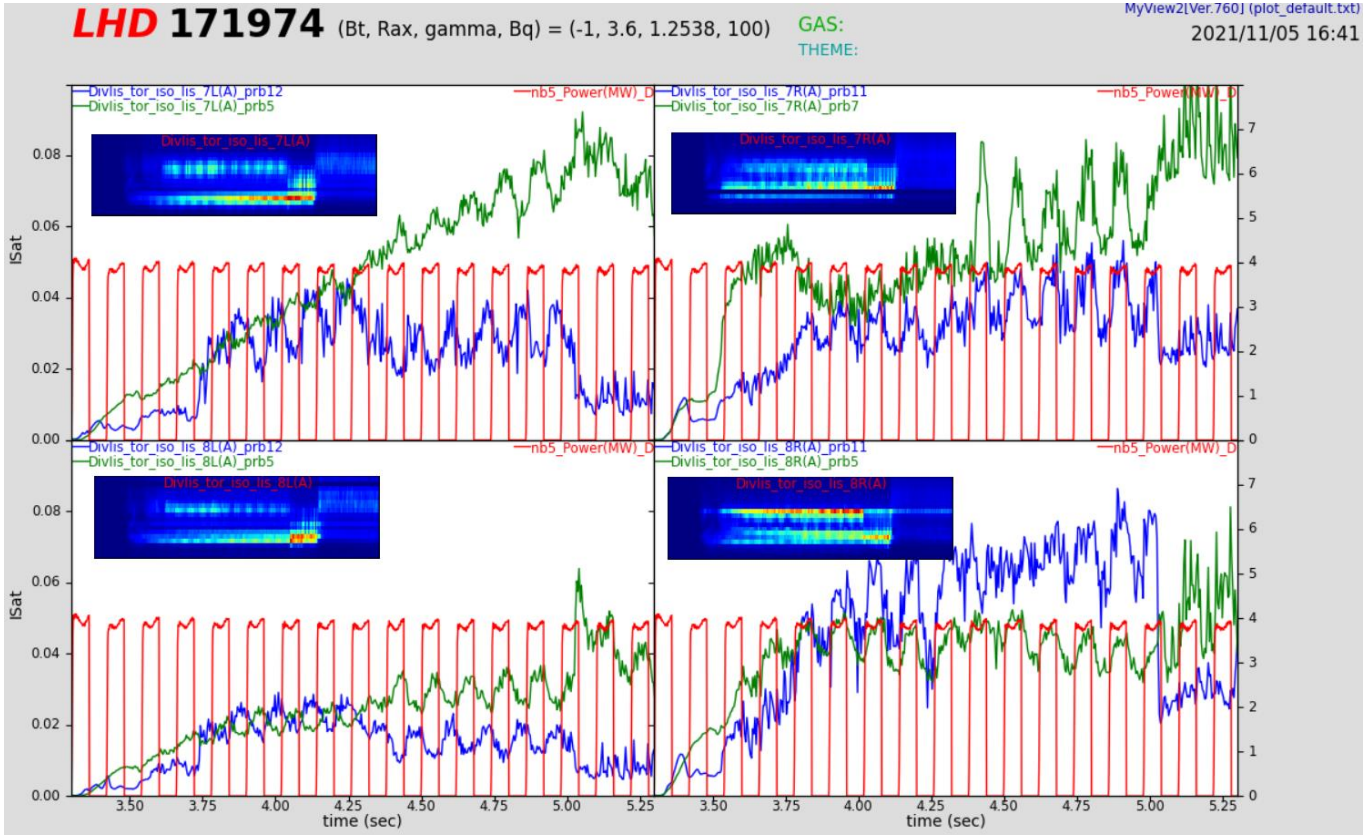
- Result of NBI modulation shows similar behavior to ECH modulation in 2018 experiment
- Once again out-of-phase responses in left divertor and in-phase responses in right divertor

TESPEL experiment:

- Due to issues with NBI 2 during this part of the experiment, only the Rax = 6m case could be studied
- No observable divertor LP response to TESPEL (analysis of more diagnostic data required to identify reason, possibly local cooling by TESPEL is too weak)

Next steps:

- Investigate additional diagnostic data (saddle loop, fast Thomson scattering, spectroscopy, requires discussion with diagnostic experts)
- Compare in detail to 2018 experiment



Observation of spatial structure change in the plasma edge during L-H mode transition (T. Tokuzawa)

Experimental conditions: #171995 - #172008 (14 shots)
(Polarity, R_{ax}, B_t, γ, B_q) = (CCW, 3.9 m, 1.0 T, 1.2538, 100.0%)
LID current = cancel: 110A (#171995 - #172003),
enlargement : 1920A (#172004 - #172008)

Background and motivation:
Since the start of the deuterium campaign, L-H transition experiments have been performed mainly around Rax=3.60m. To clarify the role of edge stochasticity, Rax=3.90 m experiments are carried out.

Results:

- ELM-like phenomena were observed in several shots.
- The effect of the sharp density gradient formed by the enhanced edge-island structure was investigated.
- GPI and BES measurements were performed. In the future, we plan to investigate the effect of changes in the edge structure in detail.