# (TG1) Multi-ion group report

Feb. 3, 2022 (G. Motojima)

Date: Feb. 2, 2022
Time: 9:50-13:25, 17:00-18:45
Shot#: 177904-177920 (17 shots), 177952–178024 (73 shots)

Prior wall conditioning: No
Divertor pump: No
Gas puff: $H_2$, N2, Kr, Ne, Ar
Pellet: No

NBI#(1, 2, 3, 4, 5) = gas(H, H, H, H, H/He) = P(4.1, 2.3, 4.3, 5.2, 4.7) MW

ECH(77 GHz) = ant(5.5-Uout, 2-OUR) = P(703, 792) kW
ECH(154 GHz) = ant(2-OLL, 2-OUL , 2-OLR) = P(723, 799, 825) kW
ECH(56 GHz) = ant(1.5U) = P(-) kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.84, 0.73, 0.80, 0.39) MW
Neutron yield integrated over the experiment = $1.0\times10^{12}$ (day total)

Topics

1. Toroidal a/symmetry with N2 seeding at Rax = 3.9 m (B. Peterson)
2. Feature extraction of radiation structure from IRVB images using PCA (K. Mukai)
3. Study of core He density in different pumping condition by using the He beam (G. Motojima, K. Nagaoka)
4. Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum pump operation (C.P. Dhard, D. Naujoks (IPP) et al.)
5. Impurity seeding from inner ports (S. Masuzaki)

# 2022.2.2 Toroidal a/symmetry with $N_2$ seeding at $R_{ax}$ = 3.9 m, -B (CCW)

**Background and objective:**

- Recently bolometers were installed at ports 6-O, 7-O and 10-O in addition to 3-O, 6.5-L and 8-O.
- $N_2$ seeding experiments were performed on Jan. 8,19, 2021 at $R_{ax}$ = 3.6 m and –B, B and on October 19, 2021 at $R_{ax}$ = 3.9 m and B to investigate the toroidal asymmetry of radiation.
- Experiments on October 19, 2021 reproduced with -B
- LID coil applied with 6-0 expansion (-2350,-1680,-3040 A)

**Experimental condition:**

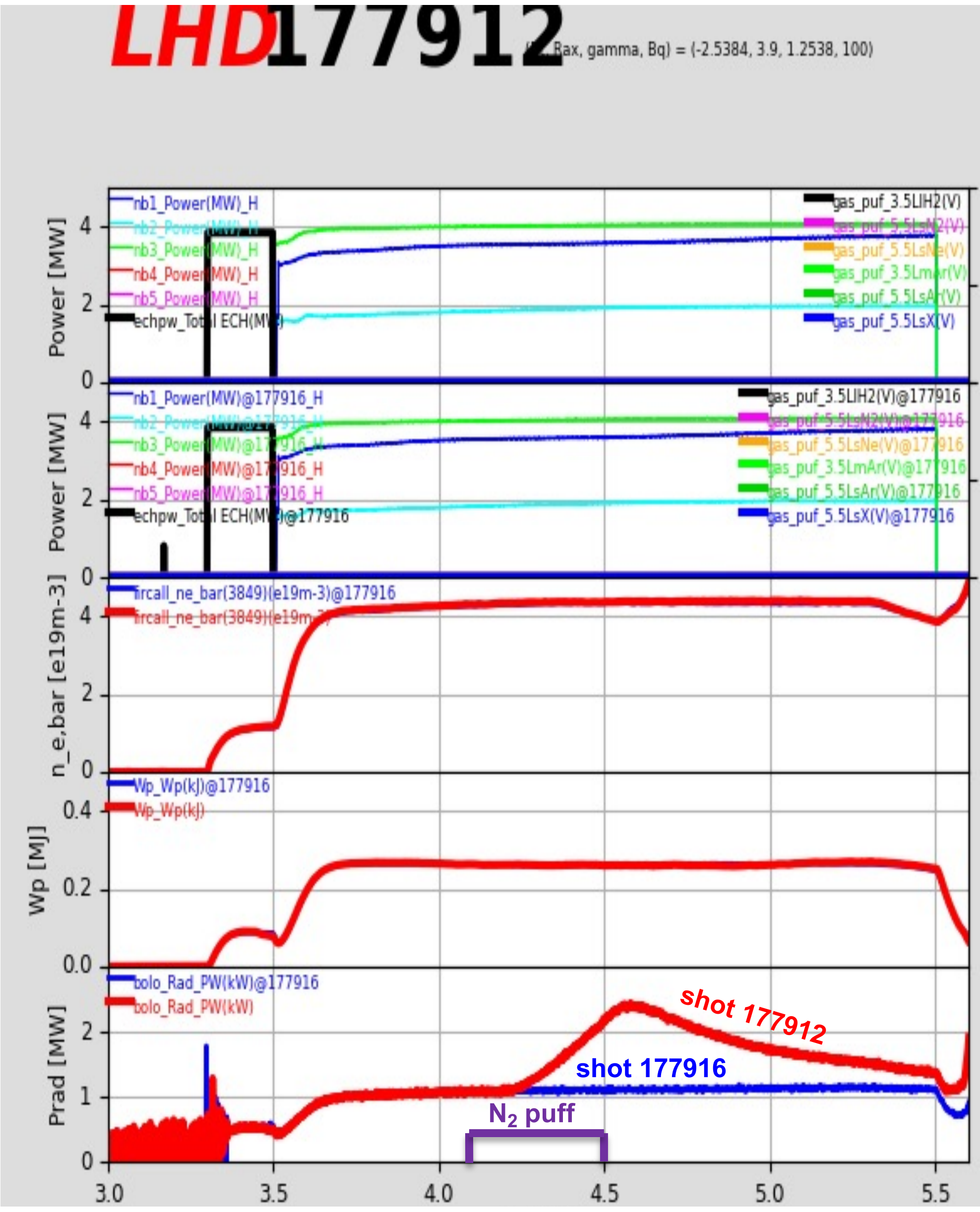
- NBI #1, 2, 3 (NBI 2 is at half power)
- density is held constant during impurity puff at $n_{e,\,bar}$=4 x $10^{19}/m^3$

Shots 177904-177920 (17 shots total, 50 min. of machine time)

- #177904,**16**, 11, **15** : reference shot, no $N_2$ puff
- #177906, **12**, **05** : $N_2$ puff from port 3.5-L,
- #1779**08**, 7, 13, **17** : $N_2$ puff from port 5.5-L
- #177910, 14, **18**, **09** : $N_2$ puff from port 9.5-L

red – LID was applied, **bold** = best shot

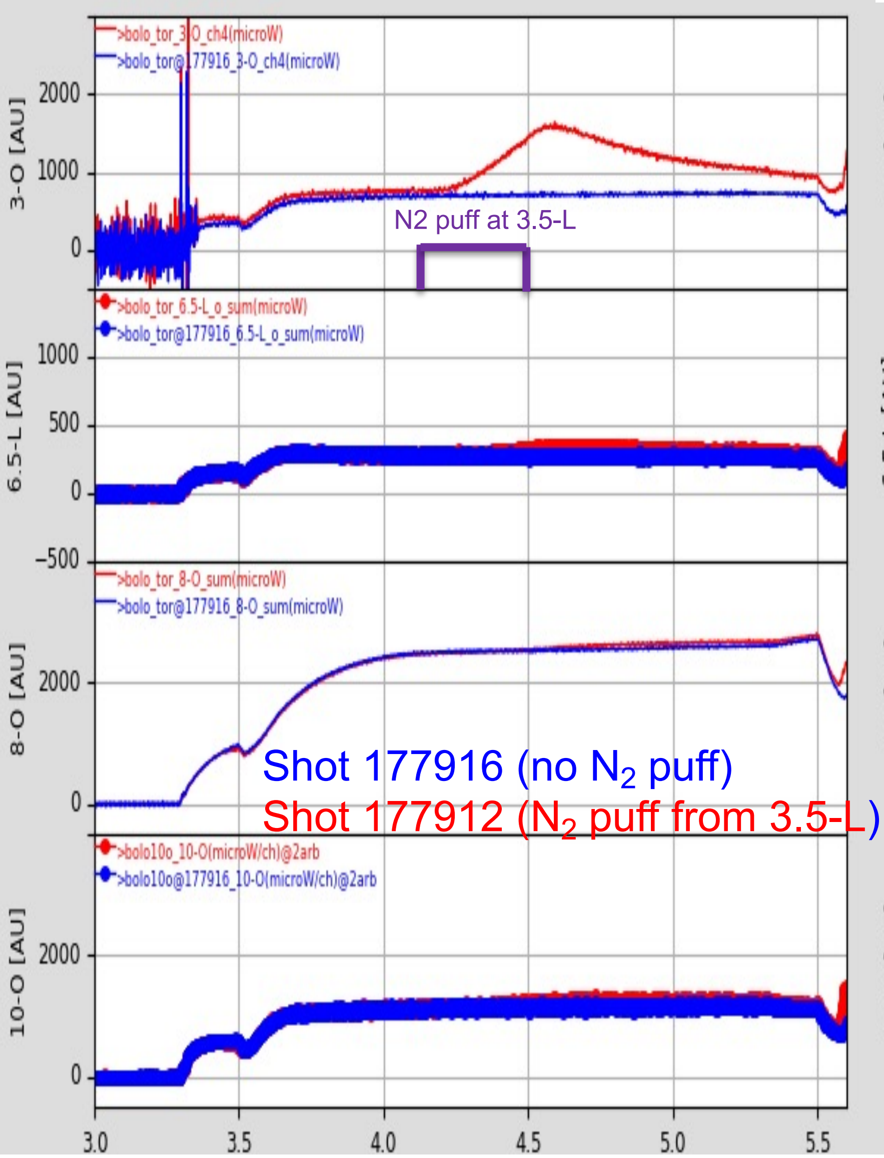
- #177919 NBI calibration shot




Time (s)

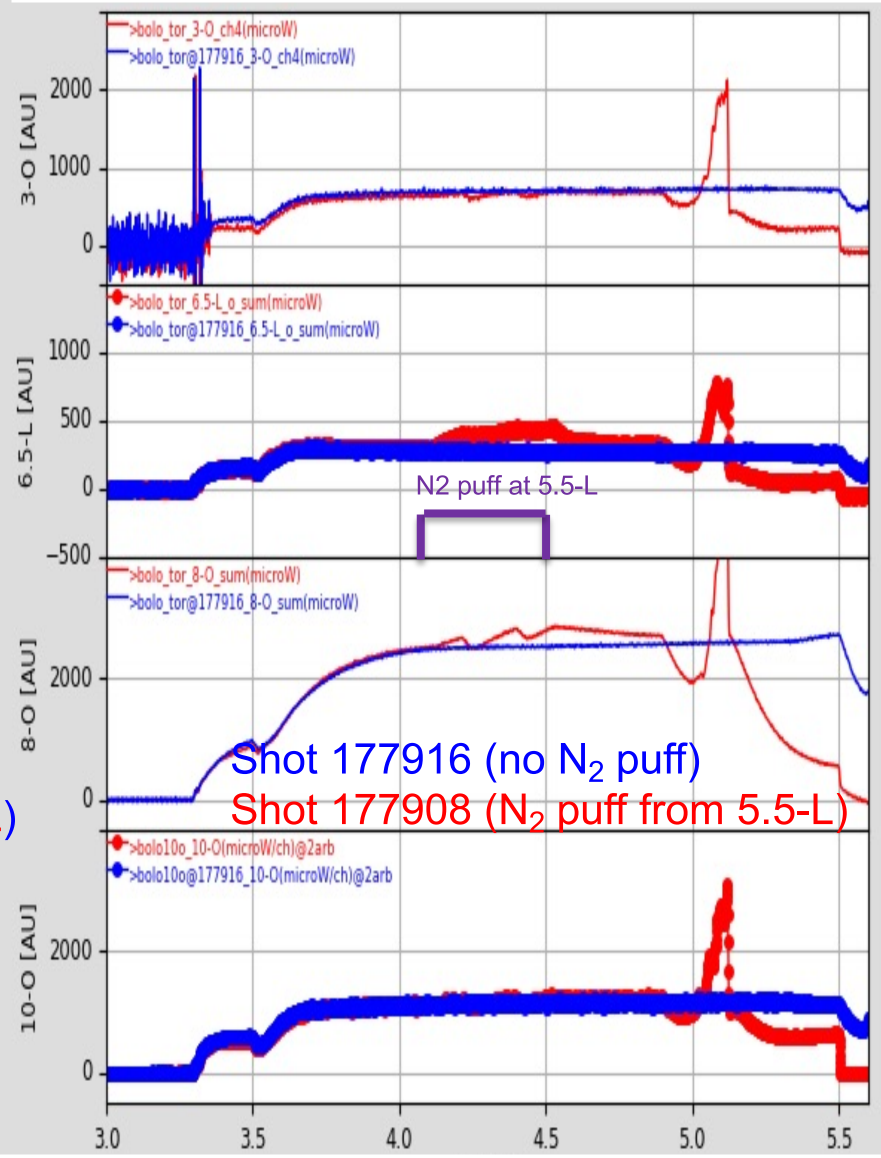
# Radiation increases near $N_2$ puff port

$N_2$ puff at port 3.5-L



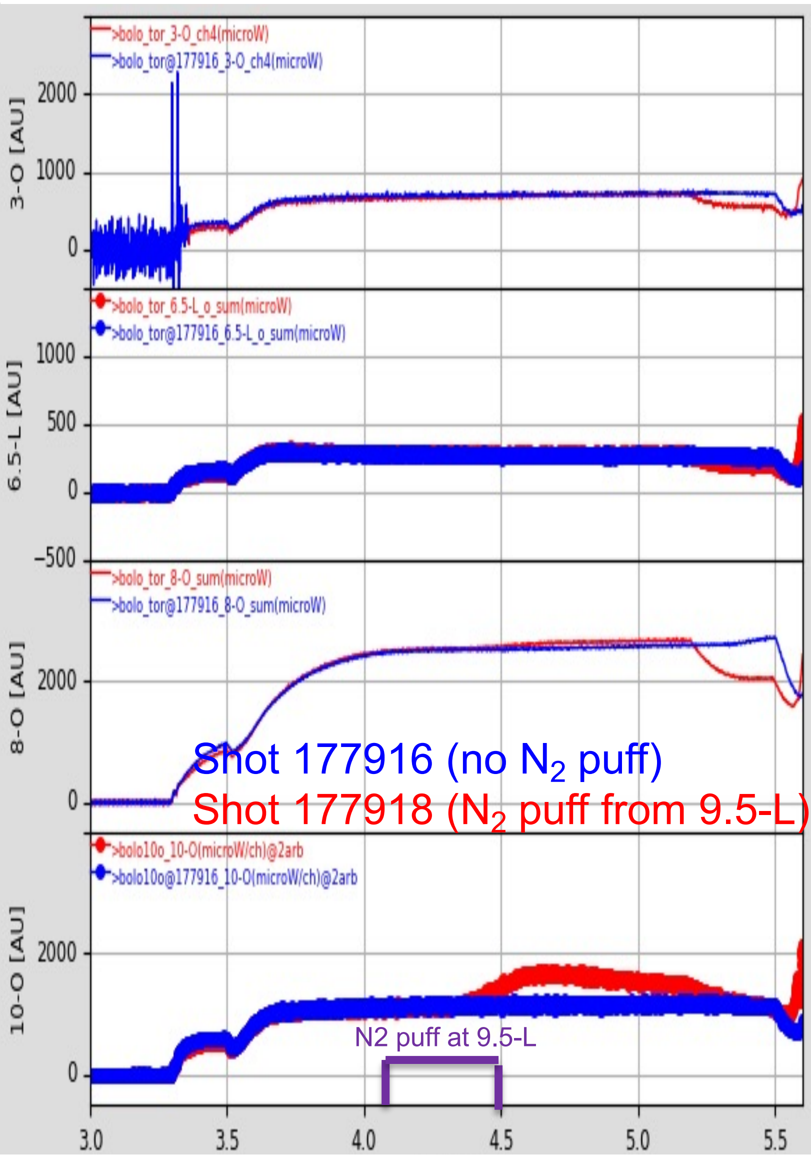

Time (s)

$N_2$ puff at port 5.5-L



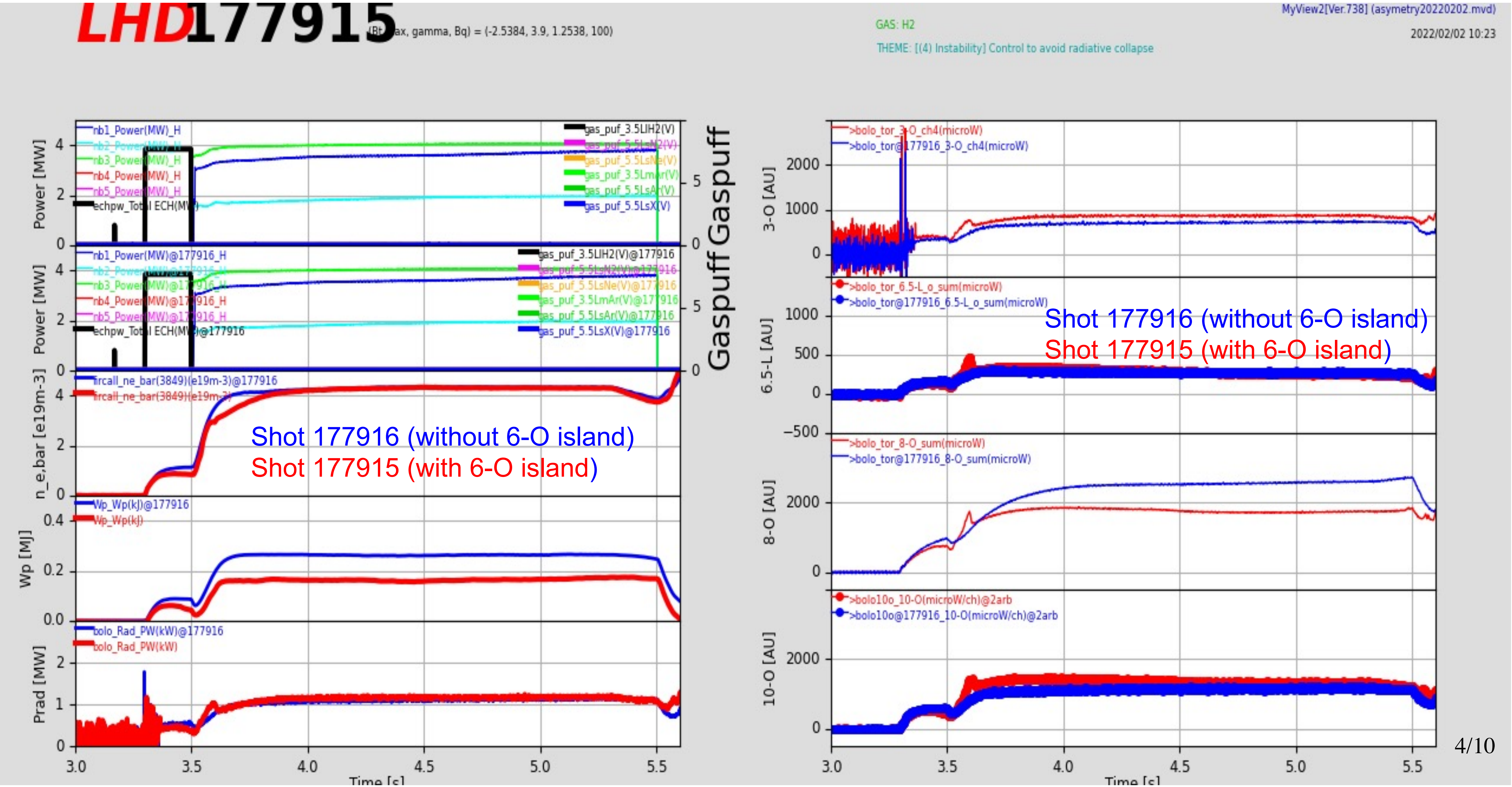

Time (s)

$N_2$ puff at port 9.5-L

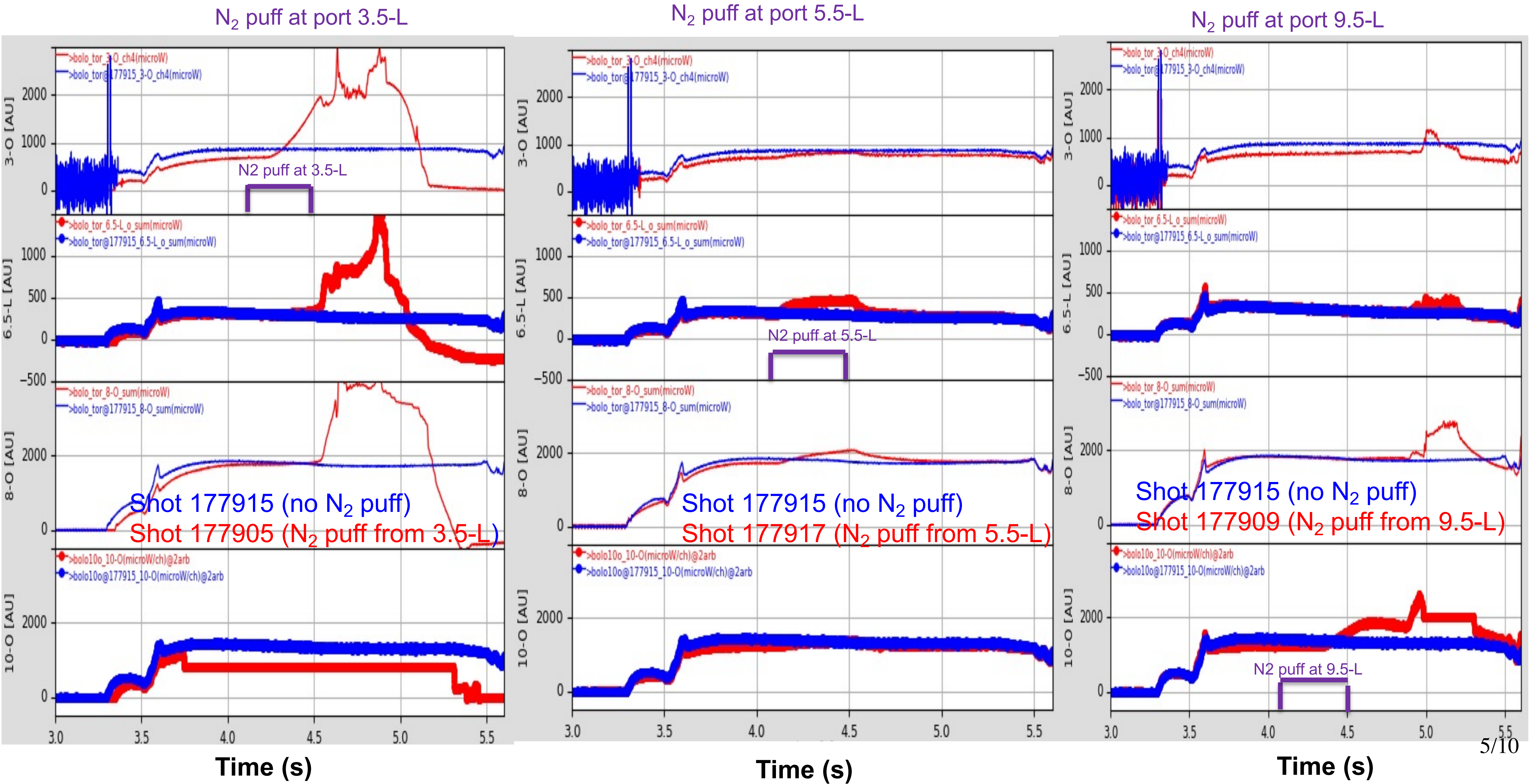



Time (s)

# Toroidal radiation distribution changes with 6-O island (no N2 seeding)



# Radiation increases near $N_2$ puff port (with 6-O island)



# Feature extraction of radiation structure from IRVB images using PCA (piggyback) K. Mukai

## Background and objective

- 3-D localized radiation structure in $N_2$ seeded plasmas could be extracted from IRVB images using principal component analysis (PCA). [K. Mukai *et al.*, ITC30]
- Since the previous study was conducted in $R_{ax}$ = 3.6 m, the same analysis was performed in $R_{ax}$ = 3.9 m.

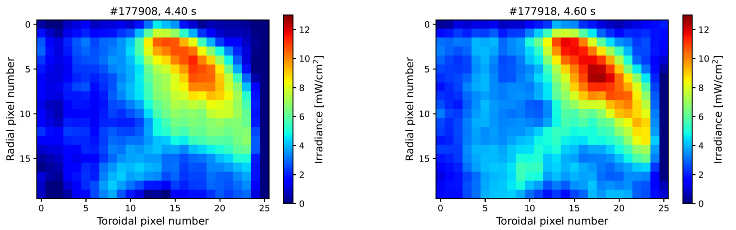
## Analysis condition

- 6.5-U IRVB
- #177916 (w/o $N_2$), #177912 (3.5-L), #177908 (5.5-L), #177918 (9.5-L)
- 400 frames (= 100 frames/shot (3.8 - 4.8 s) x 4 shots)

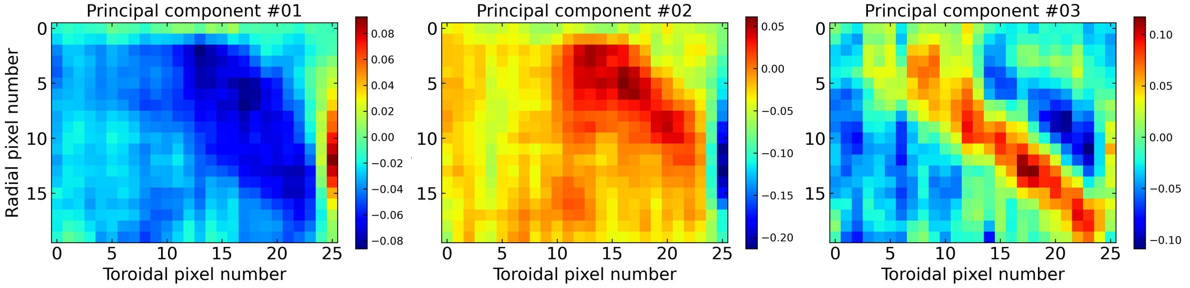
## Results

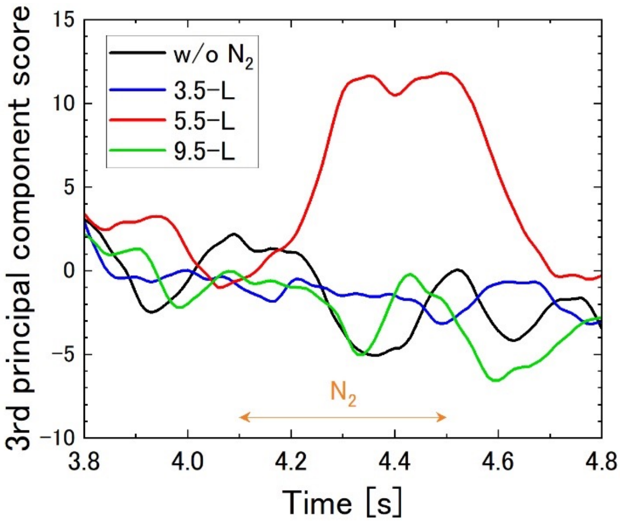
- Radiation images were comparable regardless of the port.
- Using PCA, localized radiation structure could be extracted in $R_{ax}$ = 3.9 m.
- 3rd PC score increased only in the $N_2$ seeding from 5.5-L port.
- The structure of 3rd PC (shown in red) is along the upper edge structure.
- In the case of seeding from 3.5-L and 9.5-L, radiation should be localized out of the FOV of 6.5-U IRVB.

## Radiation images (left: 5.5-L, right: 9.5-L)

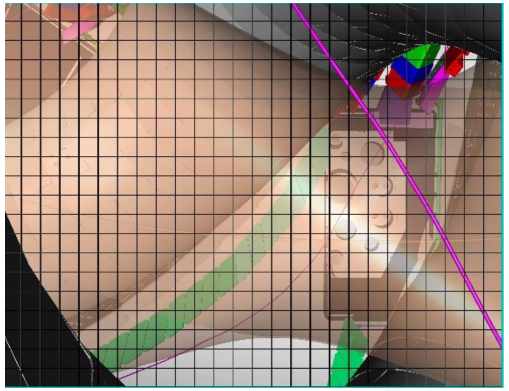



## Principal components (#1 - 3)



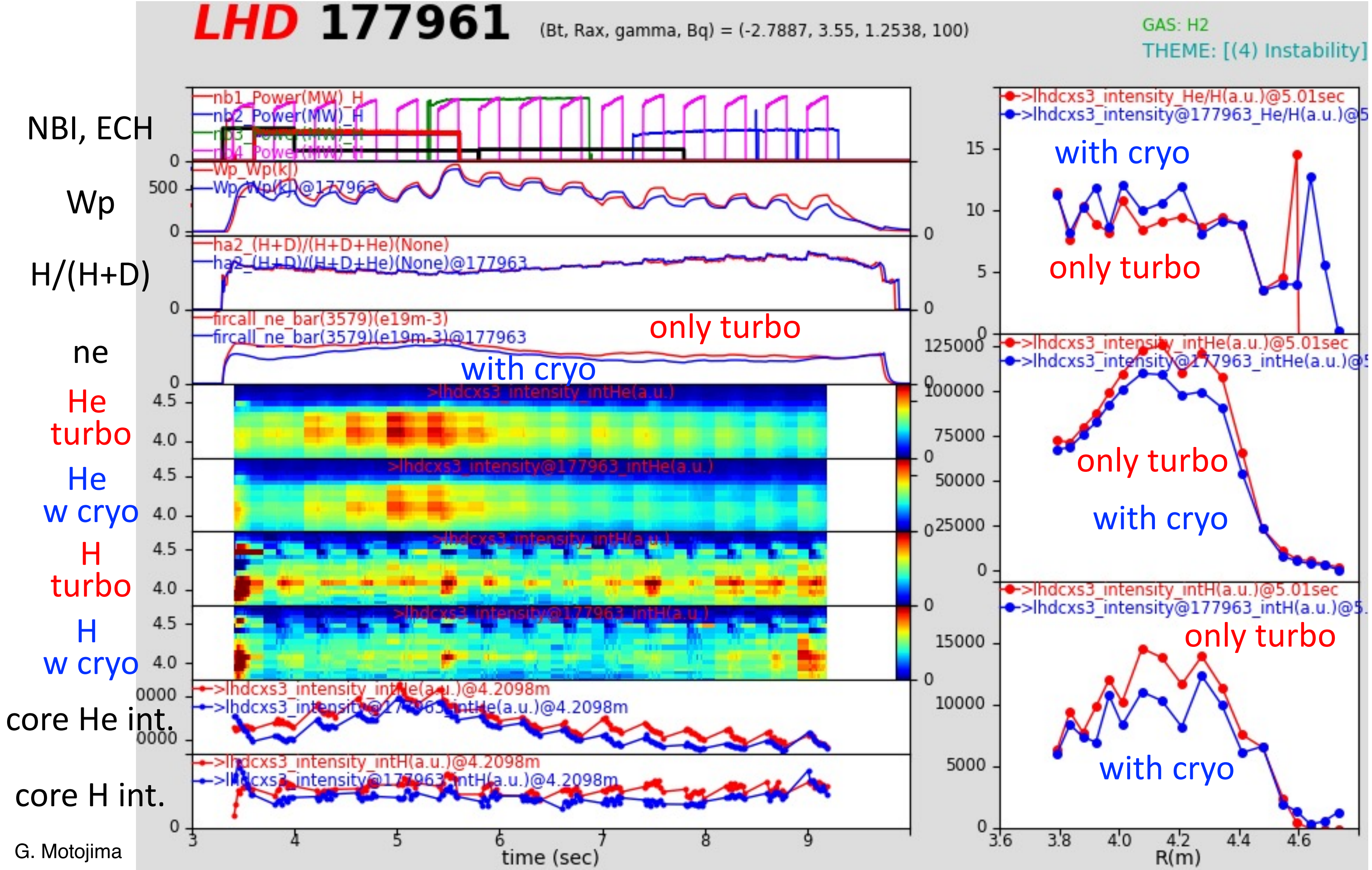




## FOV of 6.5-U IRVB



# Study of core He density in different pumping condition by using the He beam (G. Motojima, K. Nagaoka)

**Magnetic Configuration:** ($R_{ax}$, Polarity, $B_t$, γ, $B_q$) = (3.55 m, CCW, 2.78 T, 1.254, 100.0%)
**Shots: 177952-177976**

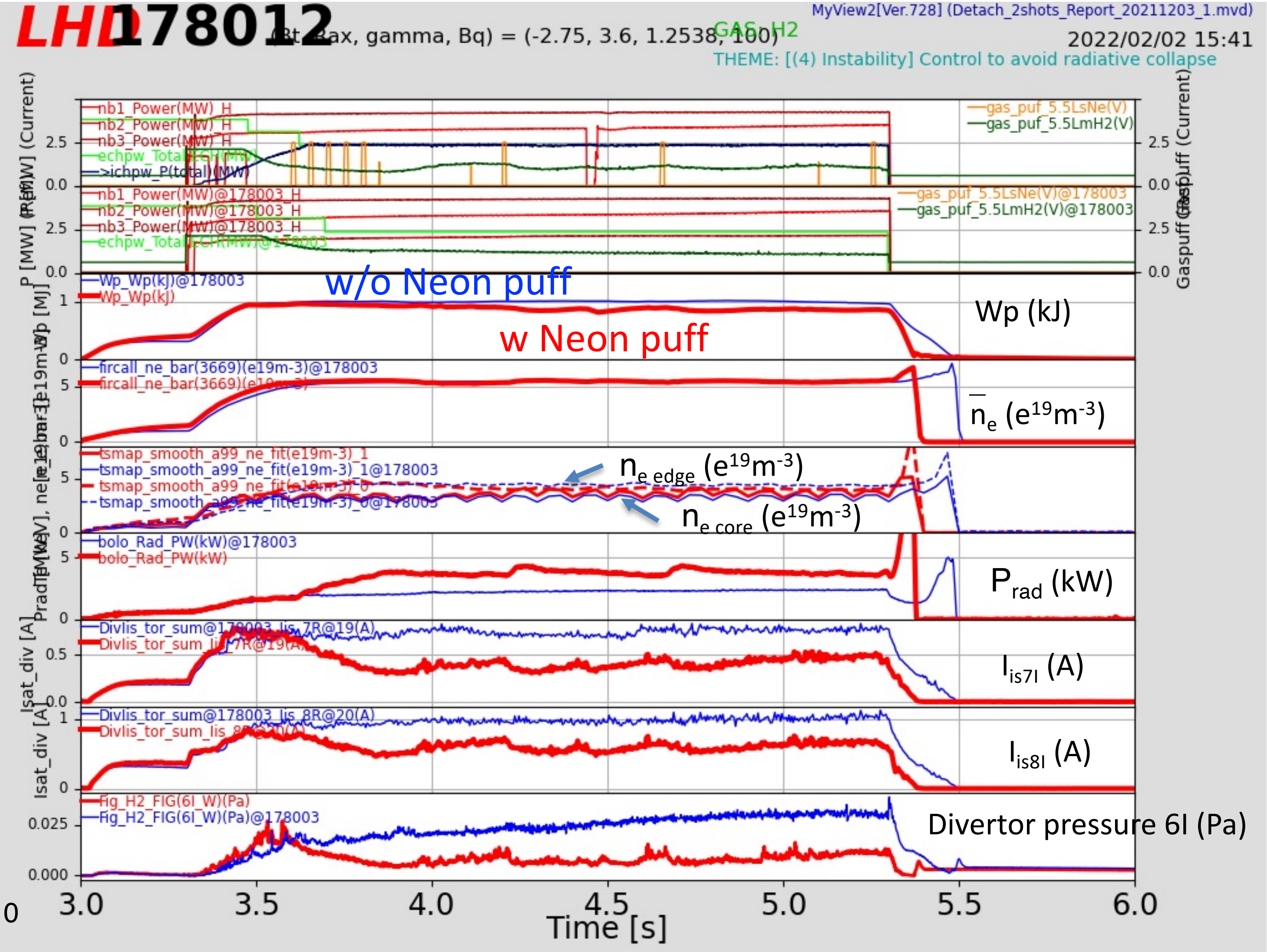



- ✓ Two pumping conditions were applied in He beam injection. **Turbo only** and **with cryo pumps**.
- ✓ The He/H profile does not change so much, while the He and H emission intensity are larger in with only turbo-pump.
- ✓ The decay of the He intensity after He beam injection was observed even with only the turbo pump. The detailed analysis with Madison(WISP)-gauge will be conducted.

# Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum pump operation

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

- ✓ Experimental conditions: Shot No: 177994-178012, $B_t$, $R_{ax}$, $\gamma$, Bq = (-2.75, 3.6, 1.254, 100)



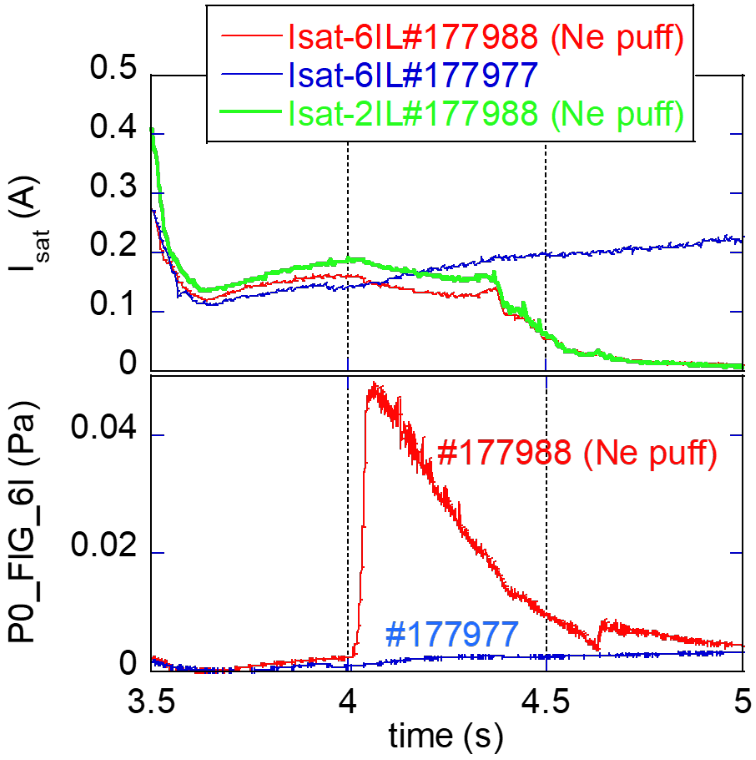

- ✓ Experimental data for the time when the NBI was in the deuterium (D) phase (2021/11/26, 2021/12/3) has been already obtained.
- ✓ In the present study, we have obtained the data when the NBI was in the hydrogen phase (H).
- ✓ In high-density plasmas (5e19 $m^{-3}$), detached plasmas were successfully produced at higher feedback voltages (6V, 20Hz) than in the D phase (2.5V, 5Hz), although careful comparisons need to be made for the heating power of NBI/ECH/ICH.
- ✓ The data without divertor pumping was obtained on this day, and the data with divertor pumping will be obtained on February 3.

# Impurity seeding from inner ports

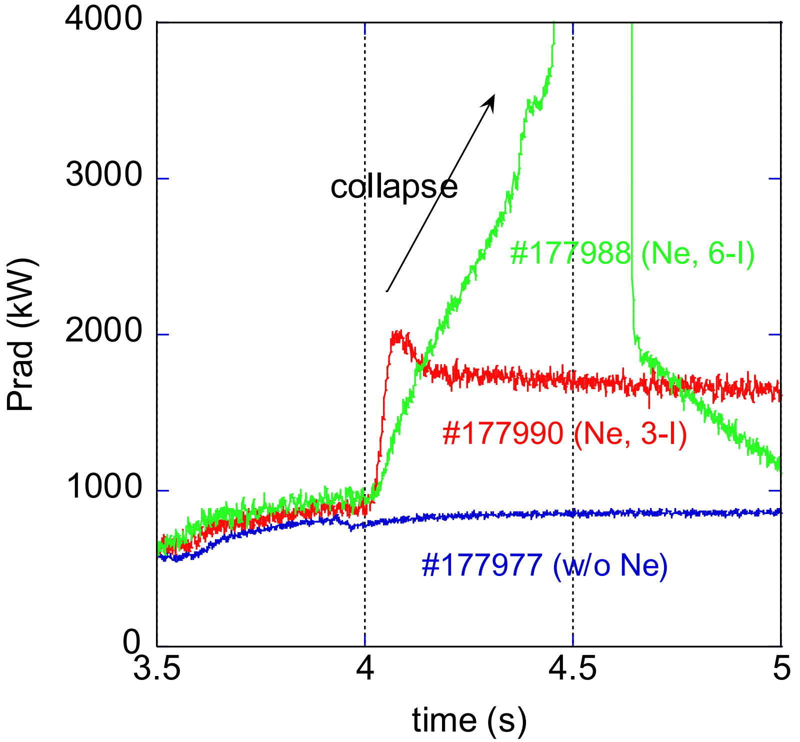
S. Masuzaki

Shot #: 177977-177993, 178013-178024, ($R_{ax}$, $B_t$, $\gamma$, $B_q$) = (3.6 m, -2.75 T, 1.2538, 100.0%)
Working gas: H2, Seeding gas: Ne, Kr
$P_{NBI1,3}$ ~ 4MW, $P_{NBI2}$ ~ 2 MW, $P_{ECH}$ ~ 3.5 MW, $P_{ICH}$ ~ 2 MW

- ✓ Ne and Kr seedings were carried out using new valves at 3I and 6I.
- ✓ In the case of Ne seeding from the 6I valve, neutral pressure in 6I increased and slowly decreased for the low conductance. Even the increase of neutral pressure, the time evolution of ion saturation current at 6I was almost the same as that at other sections.
- ✓ With similar Ne puffing conditions (5V-40ms for 6I and 5V-50ms for 3I), plasma collapsed with the 6I puffing but plasma sustained with the 3I puffing.




Top: Isat at 6I and 2I
Bottom: neutral pressure in 6I

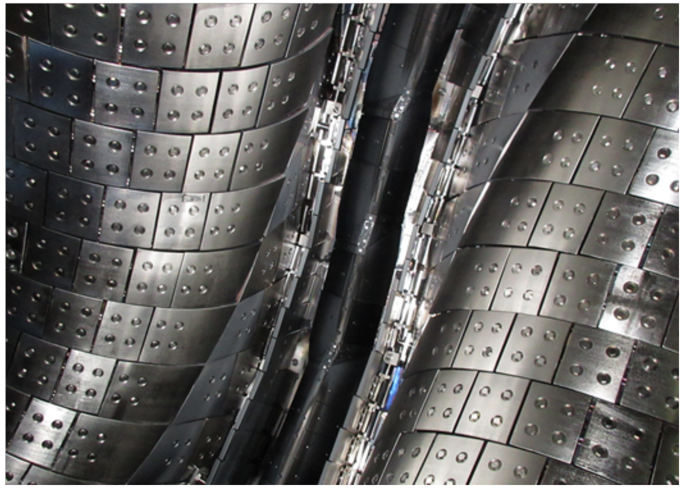


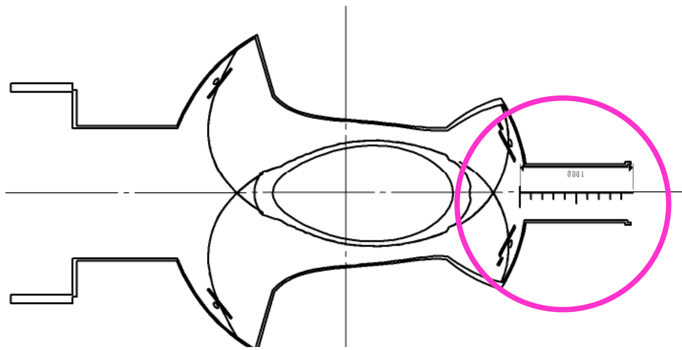

Total radiation

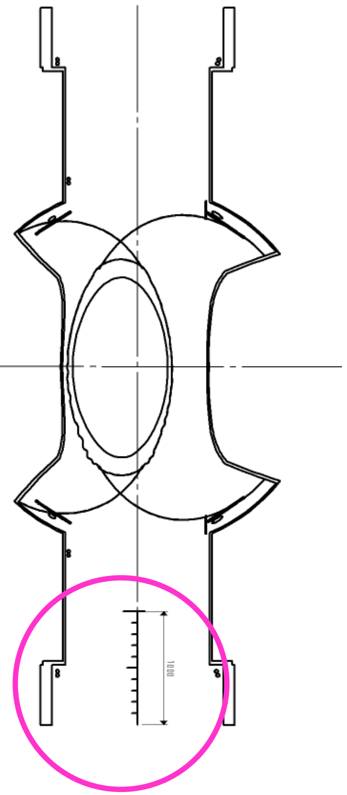
# New gas valves for impurities gases puffing were installed before the 23rd campaign at 3-I and 6-I ports

3I Open divertor

6I Closed divertor







Shorter distance between plasma and valve for I port valves than L port valves.
→ Better controllability?

Comparison of puffing from open and closed divertor
→ Local effect on divertor plasma properties?

Toroidal asymmetry of divertor plasma response?