

# (TG1) Multi-ion group report



Date: Oct. 19, 2021

Oct. 20, 2021 (H. Kasahara)

Time: 9:49 - 12:24, 16:31 – 18:45

Shot#: 170292 – 170341(50 shots), 170413 – 170455 (43 shots)

Prior wall conditioning: No

Divertor pump: Off

Gas puff: He, Ne, H<sub>2</sub>, N<sub>2</sub>, IPD: BN

LID: 3000A (6O, Reverse expansion)

NBI#(1, 2, 3, 4, 5)=gas(H, H, H, H, H)=P(4.0, 3.7, 3.6, 4.0, 5.0)MW

ECH(77GHz)=ant(5.5-U, 2-OUR)=P(0.45, 0.56)MW

ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(0.40, 0.48, 0.48)MW

ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.8, 0.75, 1.0, 0.45) MW

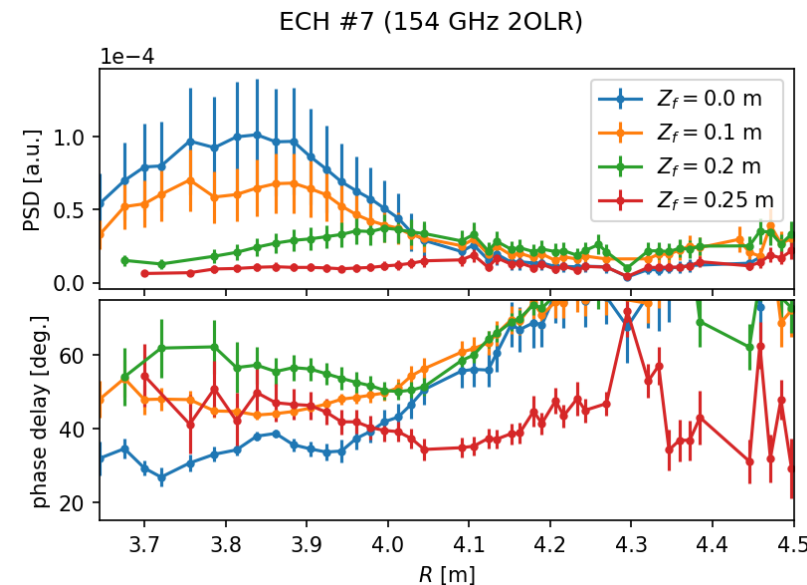
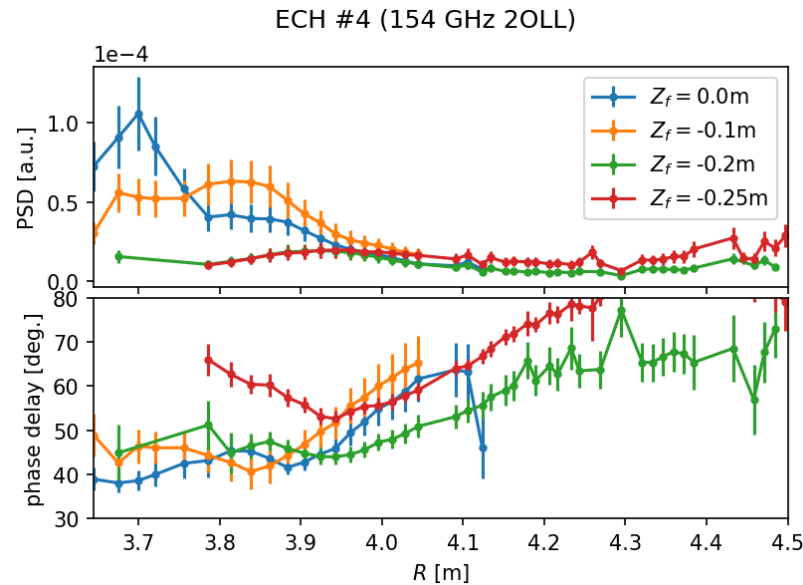
Neutron yield integrated over the experiment =  $3.0 \times 10^{12}$ ,  $1.1 \times 10^{11}$

## Topics

1. Checking the incident direction and the heating position of ECH(R. Yanai)
2. Study of poloidal and toroidal asymmetries during impurity seeding in LHD (B.J. Peterson)
3. The radiation enhancement and triggering the island divertor detachment by direct supply of BN powders into the magnetic island in the LHD peripheral plasma using the IPD (M. Shoji)

**Experimental conditions:**  $(R_{ax}, B_t, \gamma, B_q) = (3.6 \text{ m}, 2.75 \text{ T}, 1.2538, 100.0\%)$

- Scanning the focal point for alignments of #4 and #7 antennas:
  - #4 154 GHz 2-OLL :  $(R_f, T_f) = (3.9 \text{ m}, 0.35 \text{ m}), Z_f = (0.0, -0.1, -0.2, -0.25) \text{ m}$
  - #7 154 GHz 2-OLL :  $(R_f, T_f) = (3.9 \text{ m}, -0.43 \text{ m}), Z_f = (0.0, 0.1, 0.2, 0.25) \text{ m}$



The points of the PSD maximum and the phase bottom for ECE signal with ECH modulation moved to the focal point of the antenna directions. We will compare these results with the ray-tracing results, later.

- Test for ECH boost injection with bolometer signal.

# Toroidal asymmetry with N<sub>2</sub> seeding at $R_{ax} = 3.9$ m, B (CW)

## 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<sub>2</sub> seeding experiments were performed on Jan. 8,19 at  $R_{ax} = 3.6$  m and -B, B to investigate the toroidal asymmetry of radiation.
- Experiment repeated with R=3.9 m. Shot # 170413-31
- LID coil was applied with 6-0 expansion (2351,1679,3041 A)

## Experimental condition:

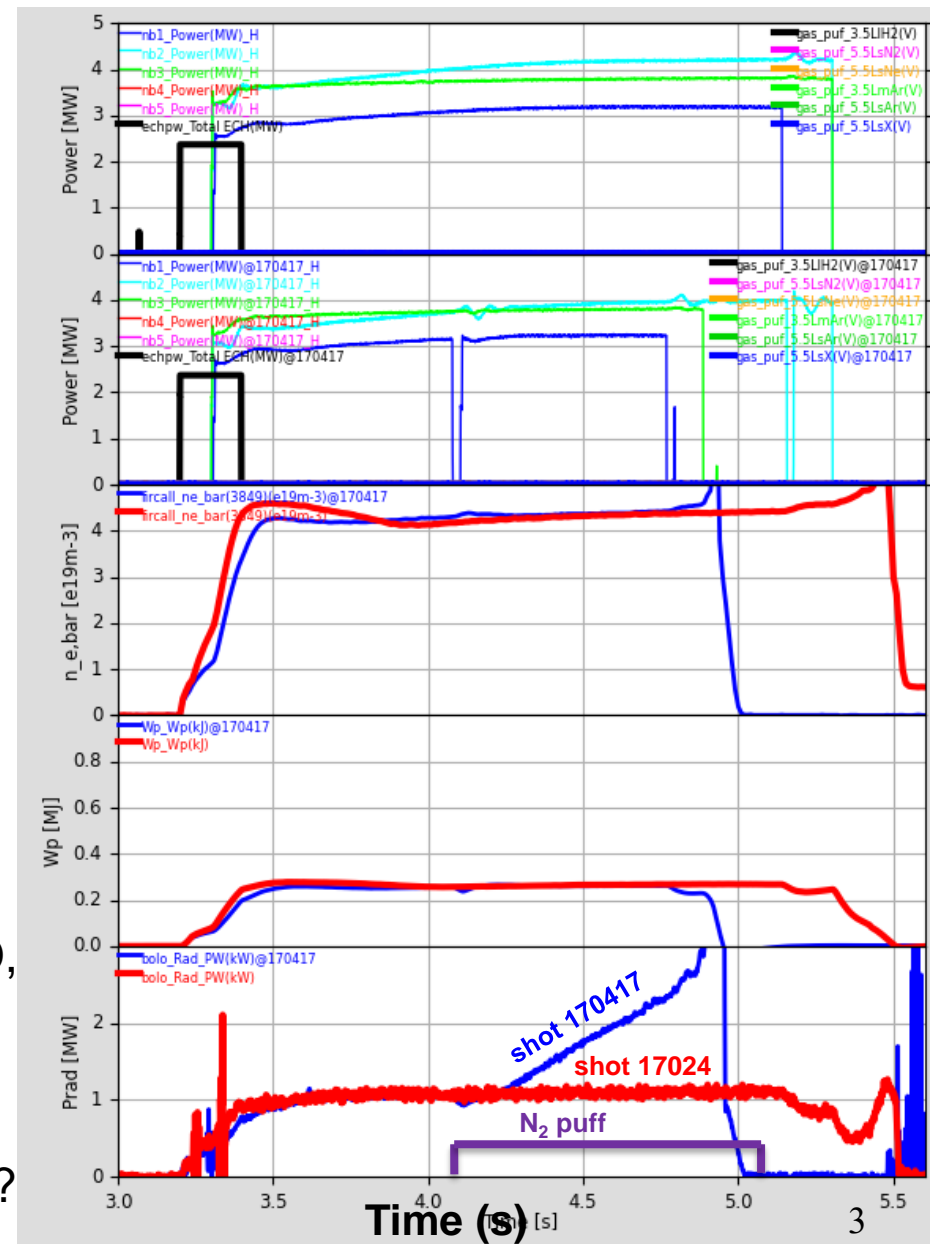
- NBI #1, 2, 3
- density is held constant during impurity puff at  $n_{e, bar} = 4 \times 10^{19}/m^3$
- #170413-5,22,**24** : reference shots, no N<sub>2</sub> puff, #170424 best shot
- #1704**17**,**27**,**31** : N<sub>2</sub> puff from port 3.5-L, shots 17 and **31** best
- #1704**18**,**25**,**26**,**28**,**29**,**30** : N<sub>2</sub> puff from port 5.5-L
- #170416,19,20,**21**,**23** : N<sub>2</sub> puff from port 9.5-L

red – LID was applied, green – N<sub>2</sub> puff 200 ms early, **bold** = best shot

## Results:

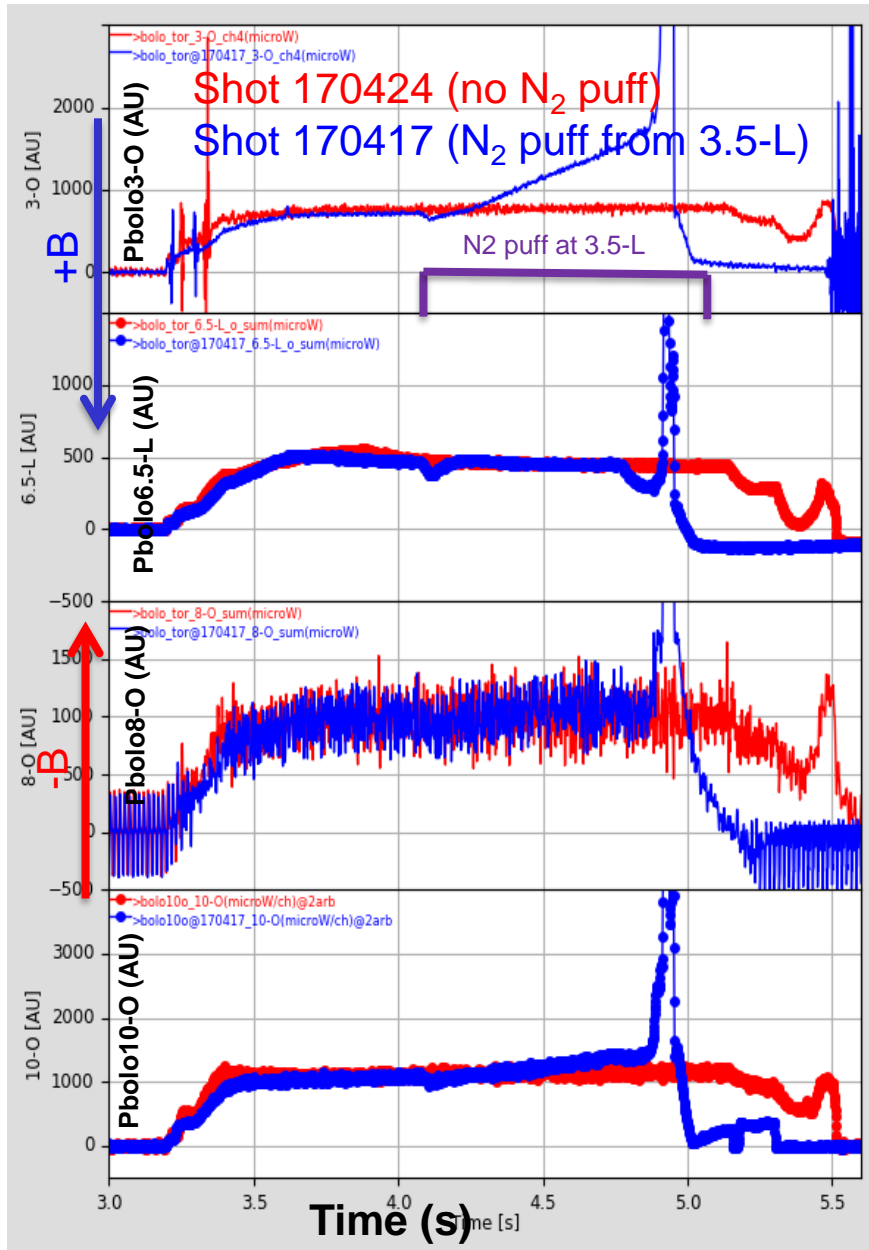
- bolometer data taken with resistive bolometers at 3-O, 6.5-L, 7-O, 8-O, 10-O and IRVB at 6.5-U with N<sub>2</sub> puffed from 3.5-L, 5.5-L, 9.5-L
- toroidal asymmetries in radiation observed in resistive bolometers with N<sub>2</sub>, radiation enhancement in -B direction
- with LID radiation decreases near island o-point, asymmetry enhanced?

B. J. Peterson October 19, 2021

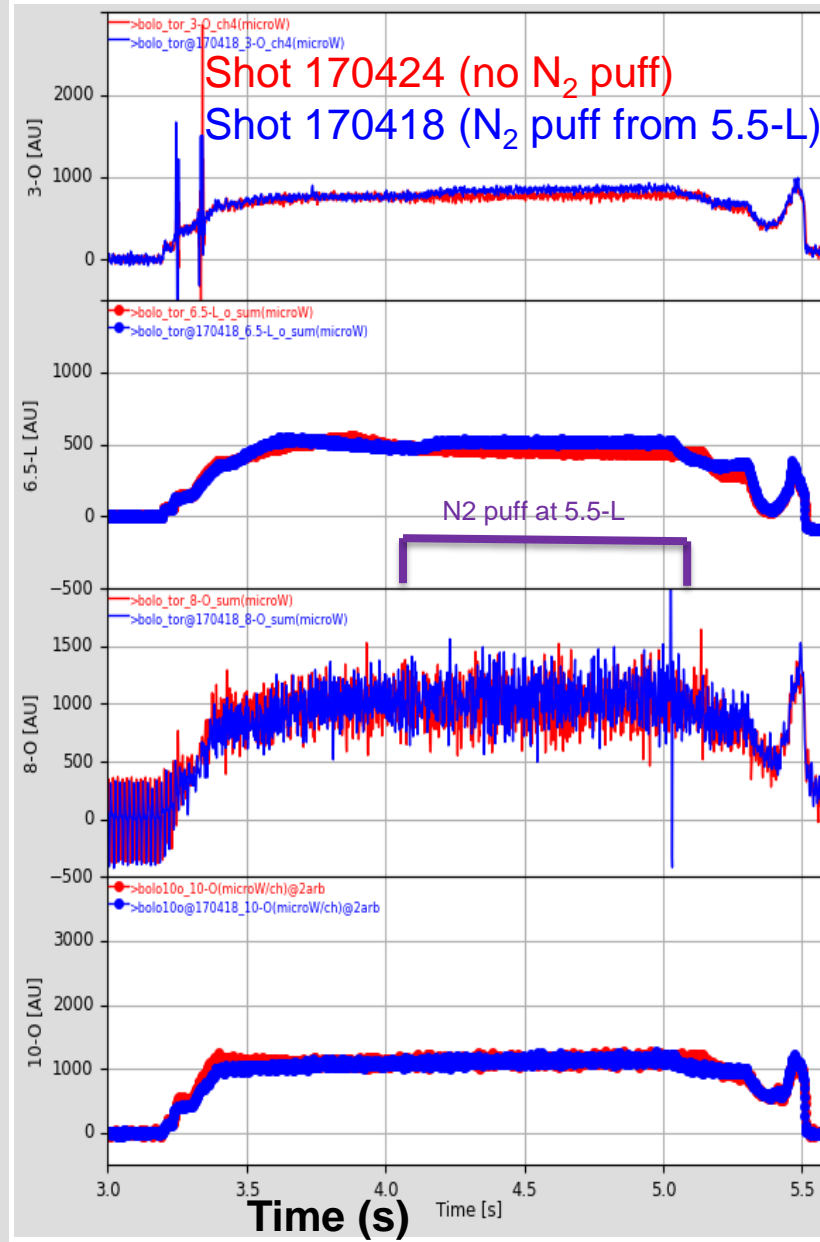


# Radiation increases in direction opposite B from N<sub>2</sub> puff port

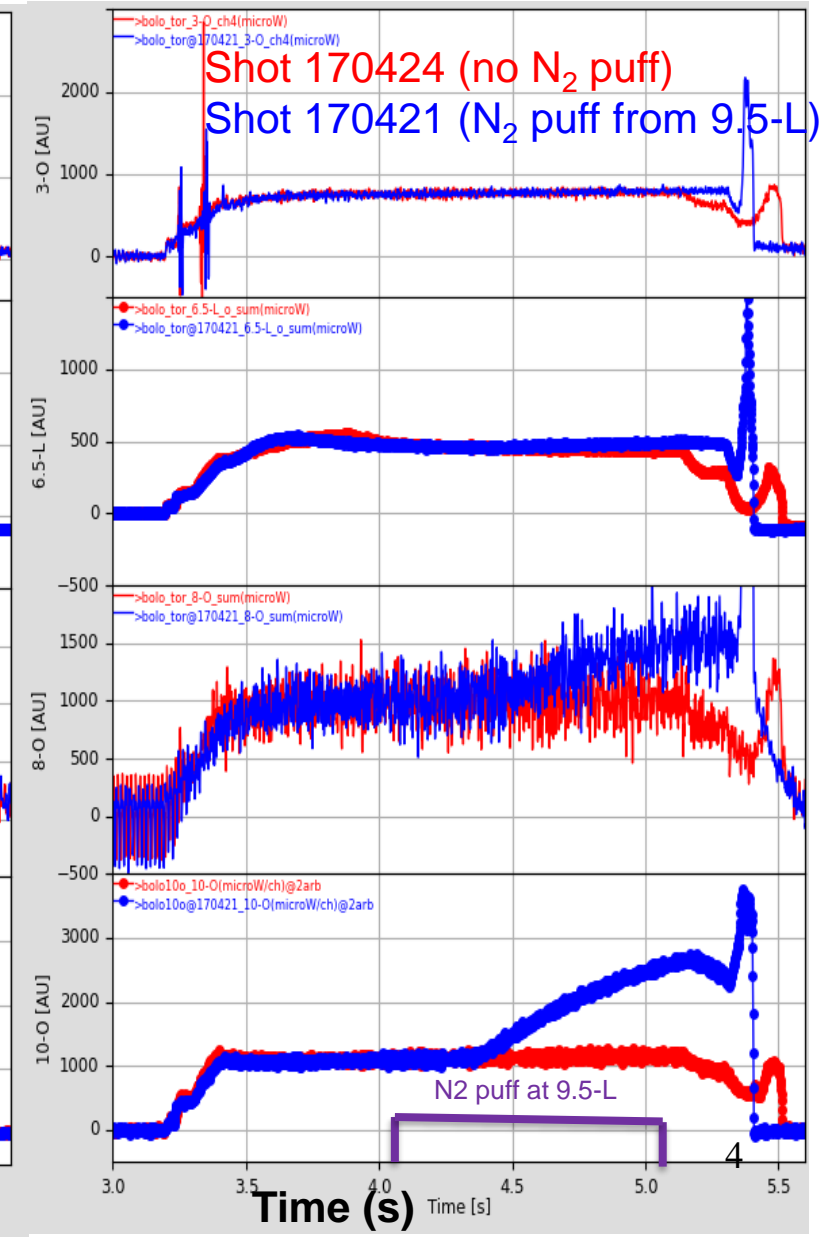
N<sub>2</sub> puff at port 3.5-L



N<sub>2</sub> puff at port 5.5-L

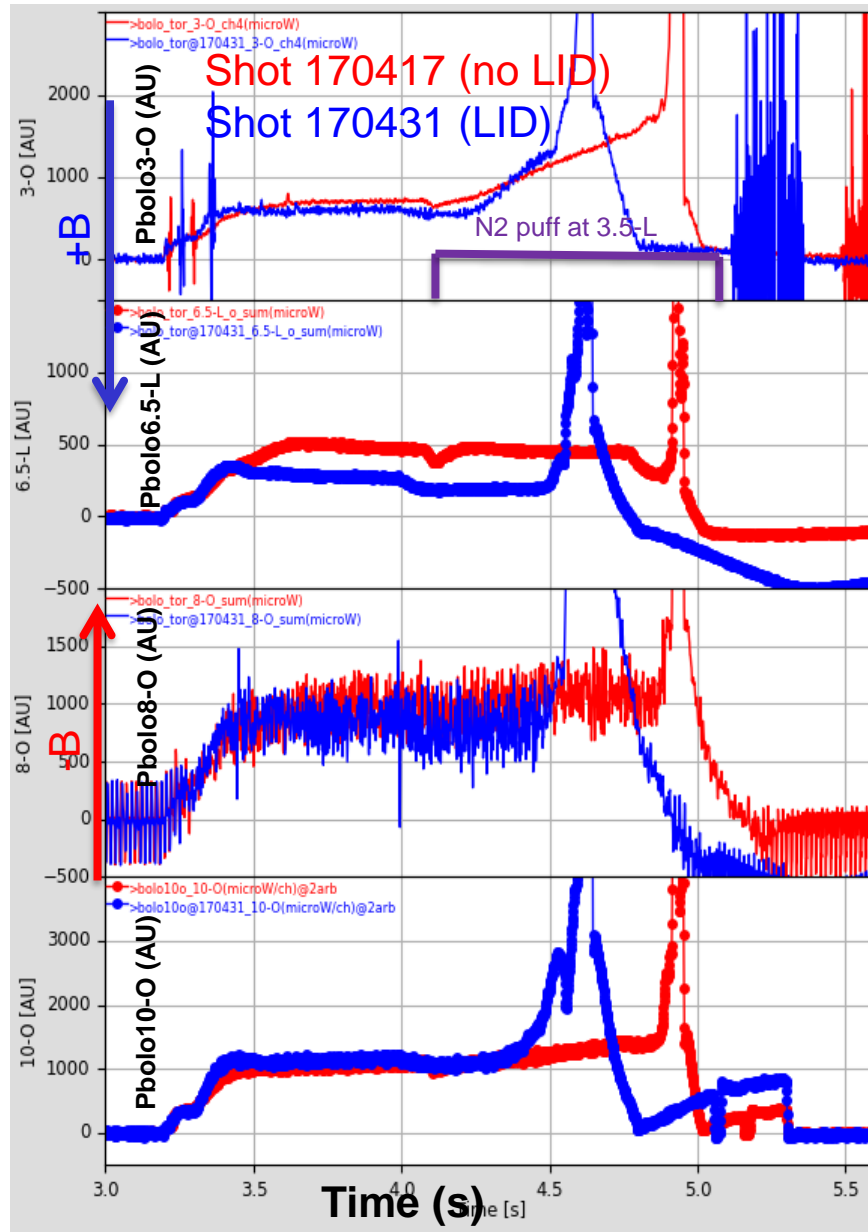


N<sub>2</sub> puff at port 9.5-L

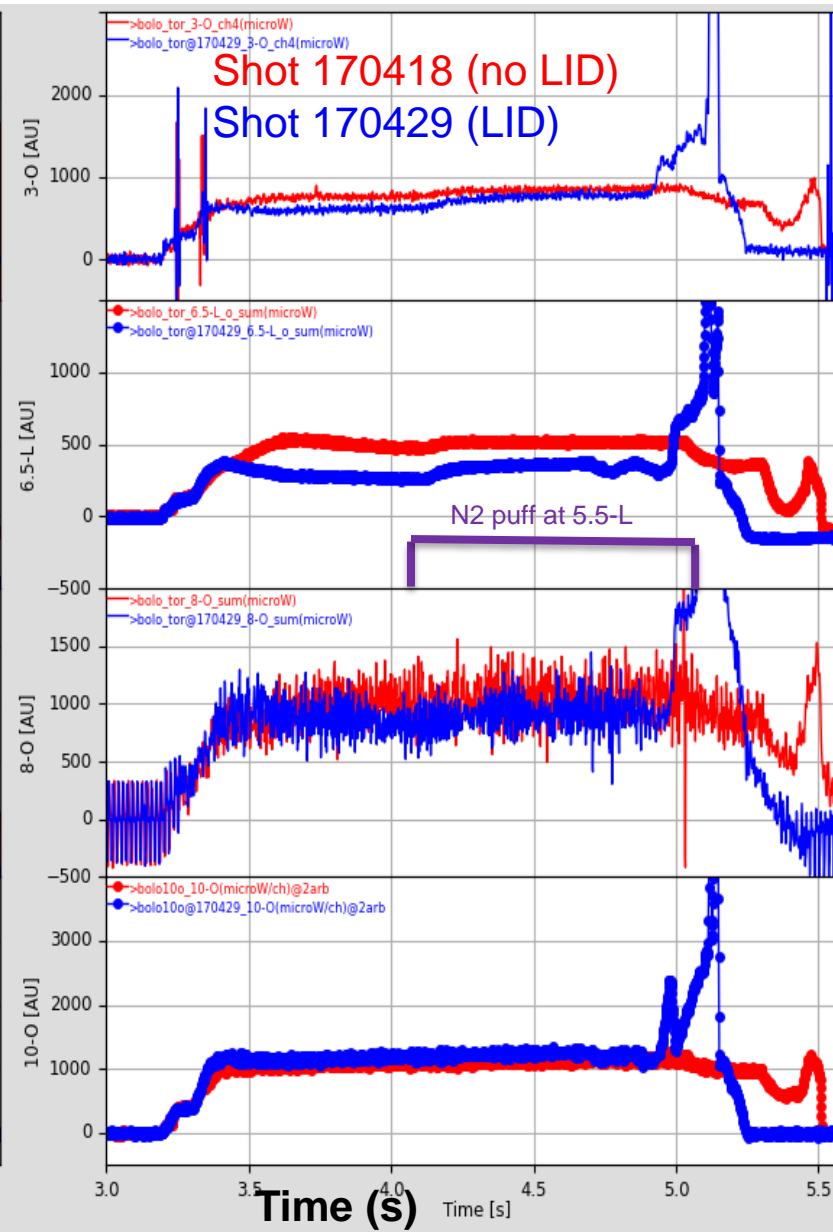


# Radiation decreased near island O-point, but $N_2$ asymmetry enhanced?

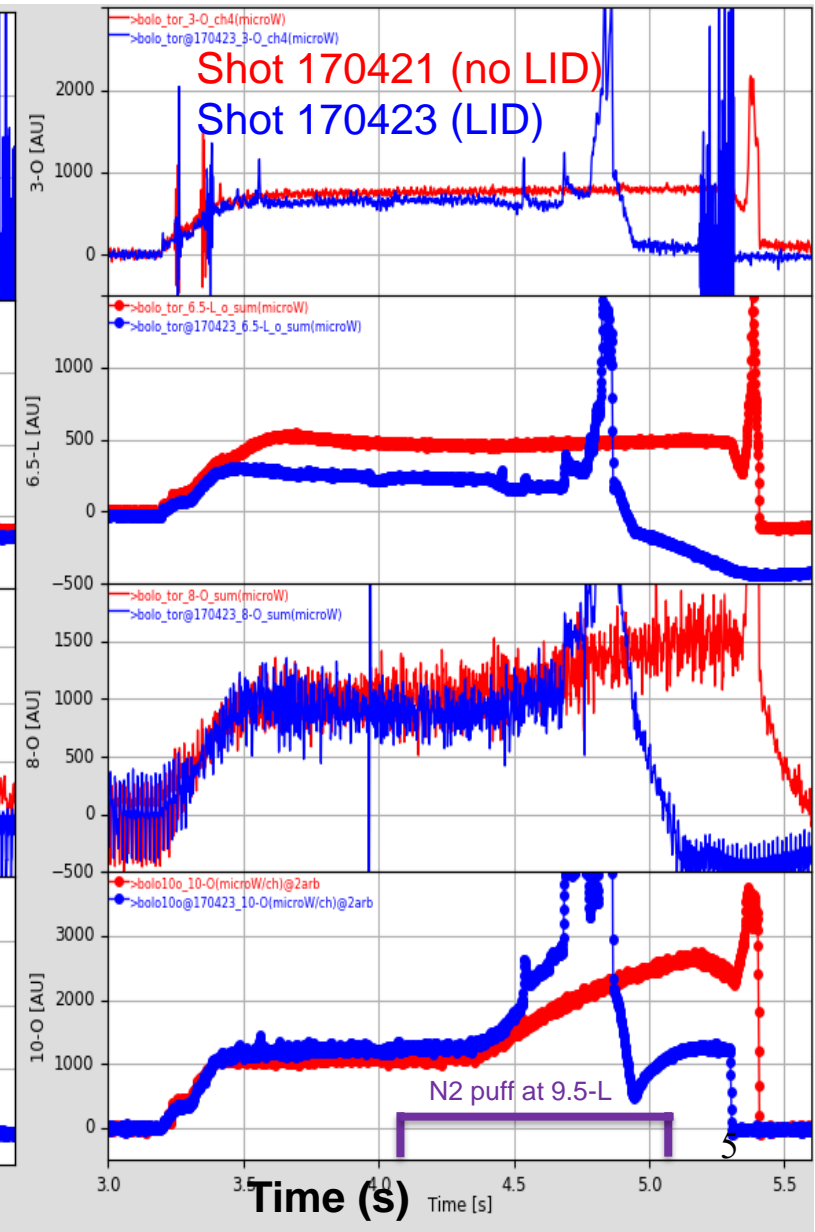
$N_2$  puff at port 3.5-L



$N_2$  puff at port 5.5-L



$N_2$  puff at port 9.5-L





# Radiation enhancement and triggering the island divertor detachment by direct supply of boron-nitride powders into the magnetic island in the LHD peripheral plasma using the IPD (M. Shoji)

## Experimental conditions:

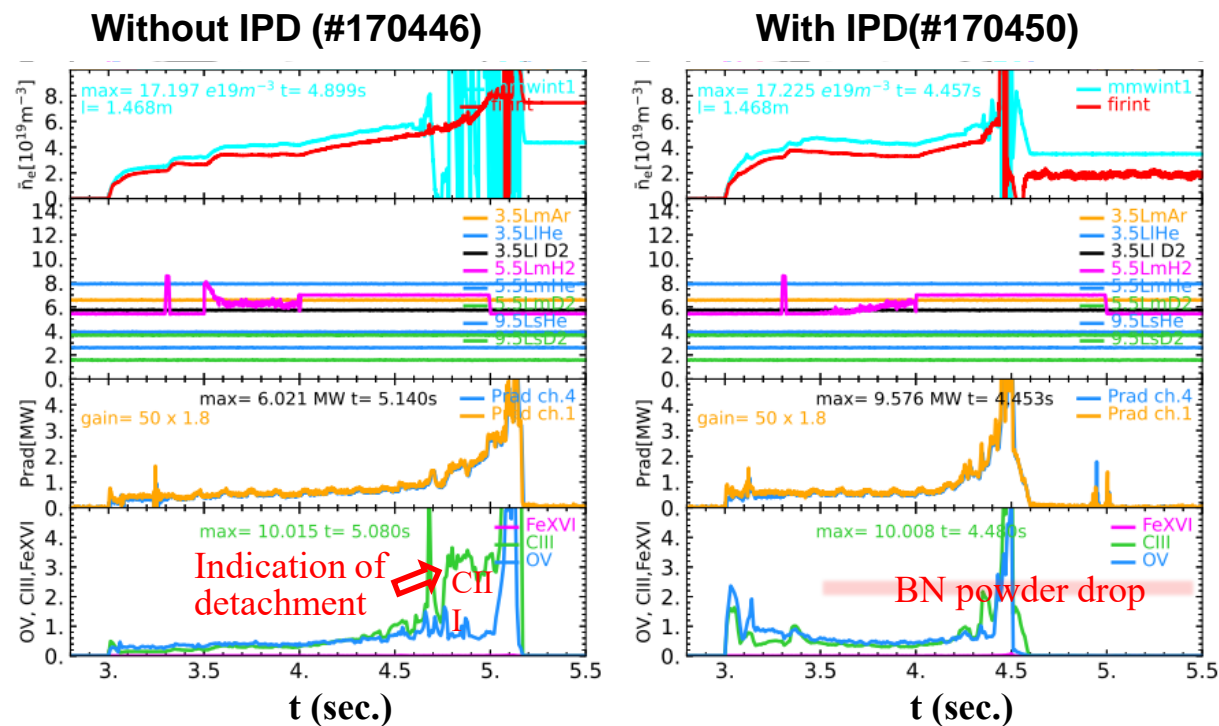
Shot No: #170432 - #170455,  $R_{ax}=3.90$  m,  $B=2.5384$  T,  $n_{e, bar}=1 \sim 6 \times 10^{19} \text{ m}^{-3}$ , (Polarity,  $\gamma$ ,  $B_q$ ) = (CW, 1.2538, 100.0%)  
NBI: #1,2,3,4 (duration is 2 s), H Plasma, IPD: Boron-nitride,  $d=60 \mu\text{m}$  (2.5~4.5 s), RMP: A:-2310 A, B1:-1650 A, B2:-3000 A

## Motivation and objective:

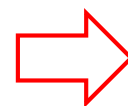
- Triggering of the divertor detachment by direct supply of boron-nitride powders into the magnetic island for showing a promising potential of the IPD
- Demonstration of several advantages of the IPD for sustaining the divertor detachment

## Preliminary results:

- The boron-nitride powders were dropped in a plasma density ramped up phase under the conditions with and without the  $m=1$  magnetic island in the peripheral plasma.
- An indication of the transition to the divertor detachment (stepwise increase in CIII) was observed in the case with the magnetic island (without the IPD).
- It seems that the powder dropping induced the radiation collapse at the time before the transition to the detachment.



Typical wave forms in plasma discharges with RMP



**Optimization (decrease) of the dust dropping rate is necessary for sustaining the divertor detachment.**