(TG4) Plasma instability group report

Dec. 10, 2021 (K. Nagaoka)

Date: Dec. 9, 2021
Time: 10:00 - 18:45
Shot#: 174615 – 174768 (153 shots)
Prior wall conditioning: None
Divertor pump: On
Gas puff: D2, He,N2, Ne, Ar, Kr, Impurity pellet: C, Tespel: W
NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, D)=P(2.5, -, -, 5, 5)MW
** NBI#2 and #3 were not operational due to the trouble in water cooling system for plasma heating devices.*
Neutron yield integrated over experiment = 8.2×10^{16}

Topics

1. Investigation of divertor detachment using superimposed impurity seeding (K. Mukai)
2. Investigation of asymmetry of divertor particle and heat fluxes profiles (S. Masuzaki)
3. High radiation fraction detachment with RMP application (M. Kobayashi)
4. *Induced plasma termination by W-TESPEL at different masses & its recovery (N. Tamura)

Due to accidental decrease of NBI power, the assigned proposal “Prediction and maintenance of detached plasma by data-driven approach” by H. Yamada, Y. Isobe, M. Kobayashi was postponed to Dec. 10.

Divertor detachment using superimposed impurity seeding

K. Mukai

Background and objective

- (Original) Sustainment of Kr+Ne seeding detachment using feedback control of Ne seeding and divertor pumping with NBIs #1-3.
- Unfortunately, NBIs #2&3 could not be used due to trouble. Therefore, NBIs #1&5A were used for the experiment.
- Kr+Ar seeding was tried to investigate dependence on impurity species.

Experimental condition

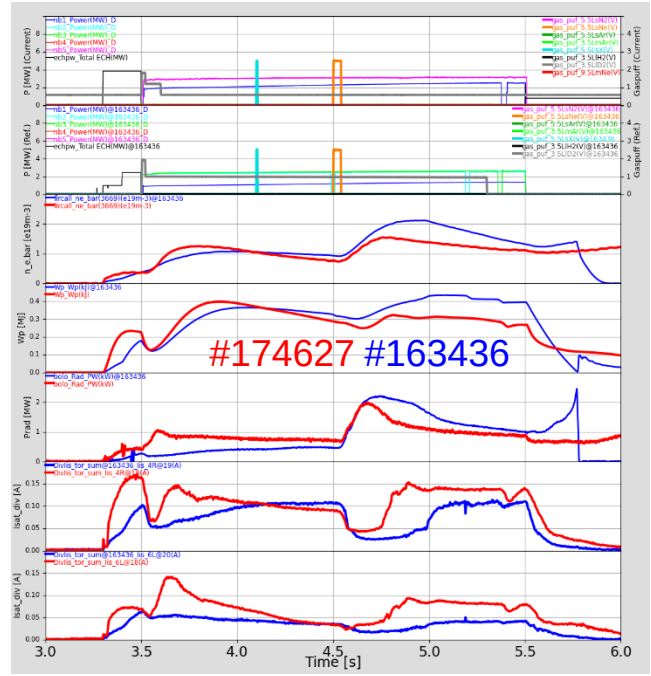
- #174617 ~ #174656 (40 shots)
- (R_{ax}, B_t, γ, B_q) = (3.60 m, -2.75 T, 1.254, 100%)
- NBI #1, 5A ($P_{NBI,\ port}$ ~ 5 MW)
- $n_{e,\ bar}$ ~ 1 x 10^{19} m^{-3}
- Divertor pumping: ON

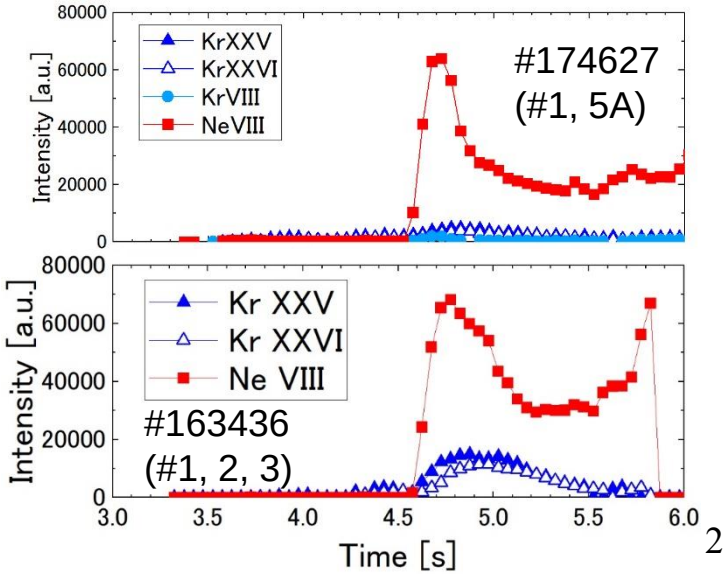
Results (NBIs #1&5A v.s. #1-3)

- Toroidally asymmetric response of $I_{sat,\ div}$ was observed in NBI #1&5A case while the response was symmetry in NBI #1-3 case.
- The asymmetric response is different from N_2 seeding. (ex. 4R and 6L)
- NeVIII enhancement was comparable, however, Kr XXV and KrXXVI enhancement after Ne seeding was smaller than last time.
- Multi-pulse seeding of Ne could not mitigate the asymmetry although the feedback system worked well.

#174627 (#1, 5A)
Kr: 5 ms, Ne: 40 ms

#163436 (#1, 2, 3)
Kr: 5 ms, Ne: 40 ms





Divertor detachment using superimposed impurity seeding K. Mukai

Results (Kr+Ar v.s. Kr+Ne)

- Toroidally symmetric reduction of $I_{sat,\ div}$ was observed in Kr+Ar seeding (almost due to Ar seeding?).
- Time response after Ar seeding is slower than Ne seeding.
- In Kr+Ar seeding, P_{rad} is smaller than that in Kr+Ne seeding, however, local minimum of $I_{sat,\ div}$ was comparable.

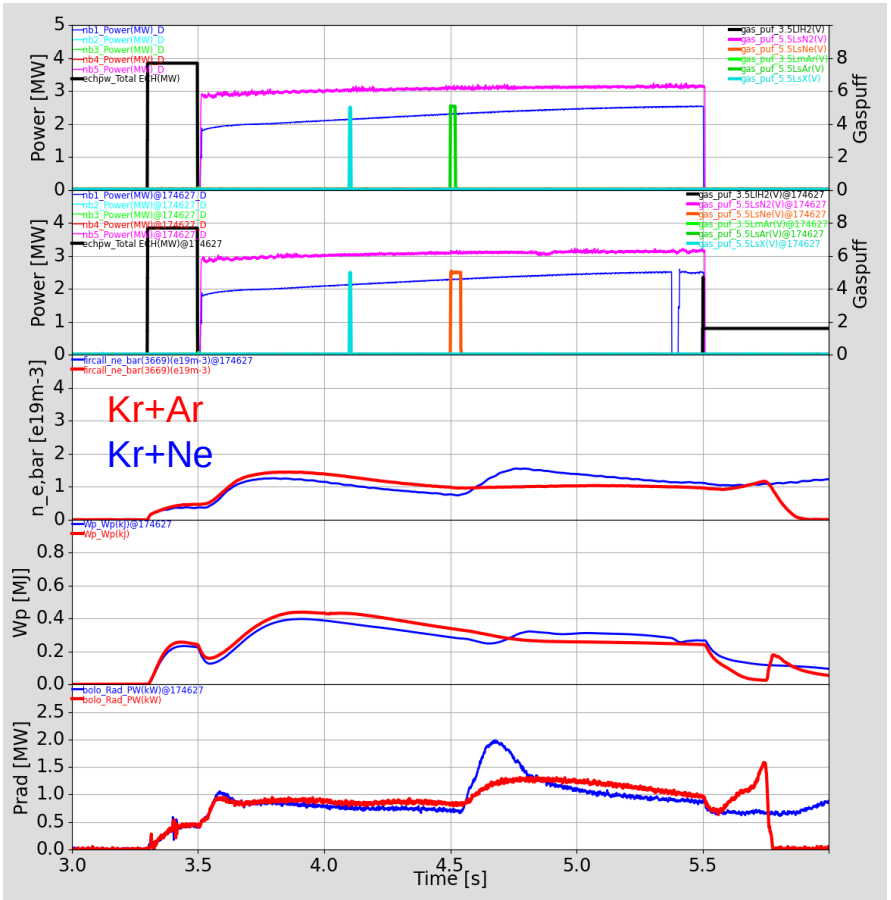
#174650
Kr: 5 ms, Ar: 20 ms

#174627
Kr: 5 ms, Ne: 40 ms

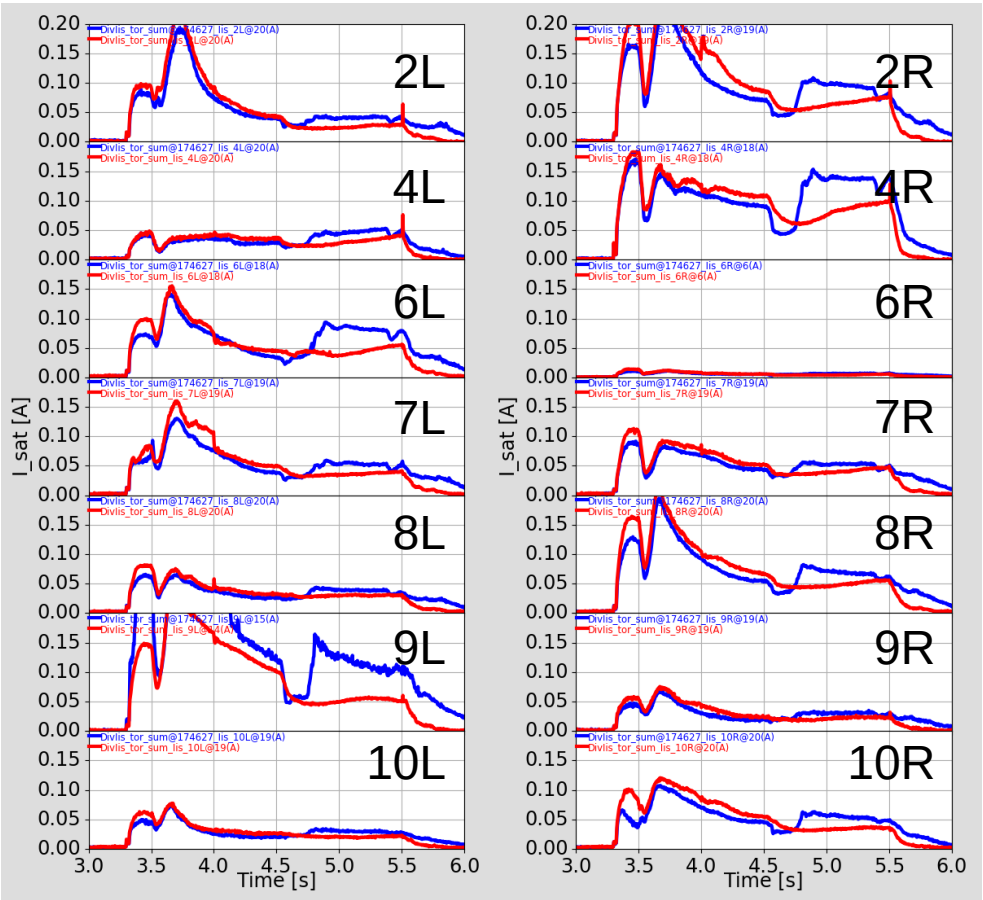
$n_{e,\ bar}$

W_p

P_{rad}



Kr+Ar (174650), Kr+Ne (174627)



Investigation of asymmetry in divertor plasma

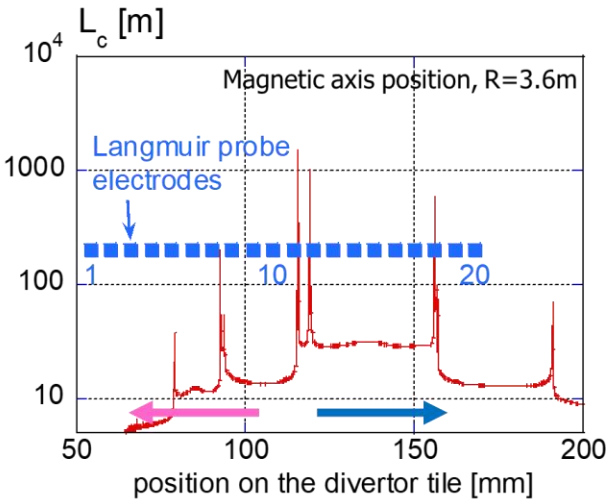
S. Masuzaki

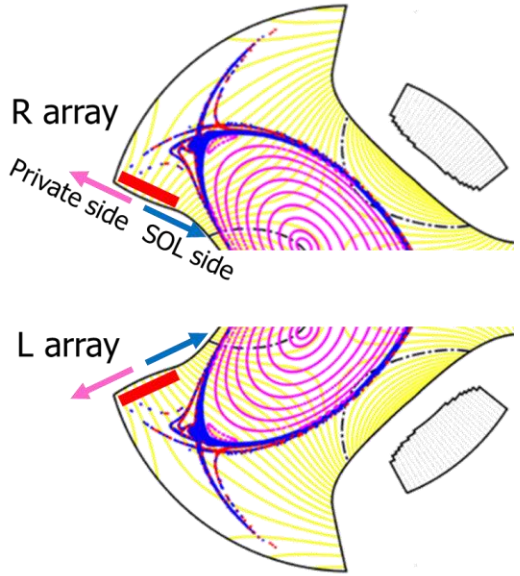
Date of Exp.: 9 December 2021

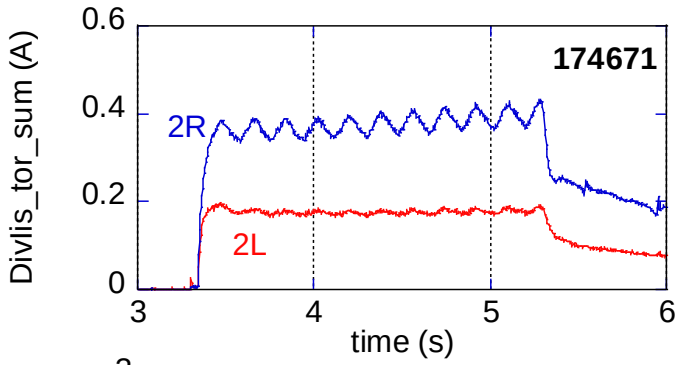
Shot #: 174657 - 174675
(R_{ax}, B_t, γ, B_q) = (3.6 m, CCW 2.75 T, 1.2538, 100.0%)
P_{NBI} (#1) ~ 2.4 MW
P_{NBI} (#4) ~ 7 MW (modulated for CXS), P_{NBI} (#5) ~ 5 MW
ECH ~ 3.8 MW
Working gas: D_2 (5.5L, with feedback control)

Motivation:
- Asymmetry in divertor heat and particle loads between divertor tiles located at symmetric positions has been observed.
- To get data necessary for the understanding of the mechanism causing the asymmetry, divertor plasma parameters were measured using Langmuir probe arrays in various heating schemes in different electron densities.
- Electric field in the edge region is a key parameter of the asymmetry.

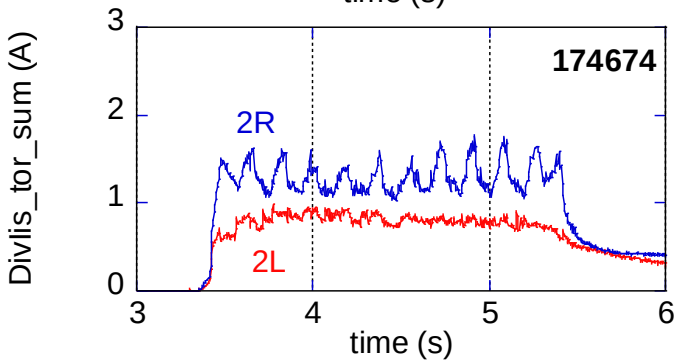
Results:
- Data in CCW Bt condition were obtained.
- In general, degree of the asymmetry is small in low Te plasma and increases with Te but saturates at last.
- On 10 Dec., the same experiments in CW Bt condition will be conducted and obtained data will be compared to corresponding data obtained in CCW Bt condition.
- Electric field data will be provided later.
- Different responses to the modulated NB4 between L and R arrays were observed.







ECH + modulated NB4
n_{ebar} ~ 1E19/m3
$T_{e,LCFS}$ ~ 0.6 keV



NB5 + modulated NB4
n_{ebar} ~ 5E19/m3
$T_{e,LCFS}$ ~ 0.15 keV

High radiation fraction detachment with RMP application

M. Kobayashi, A. Shimizu, T. Oishi et al.

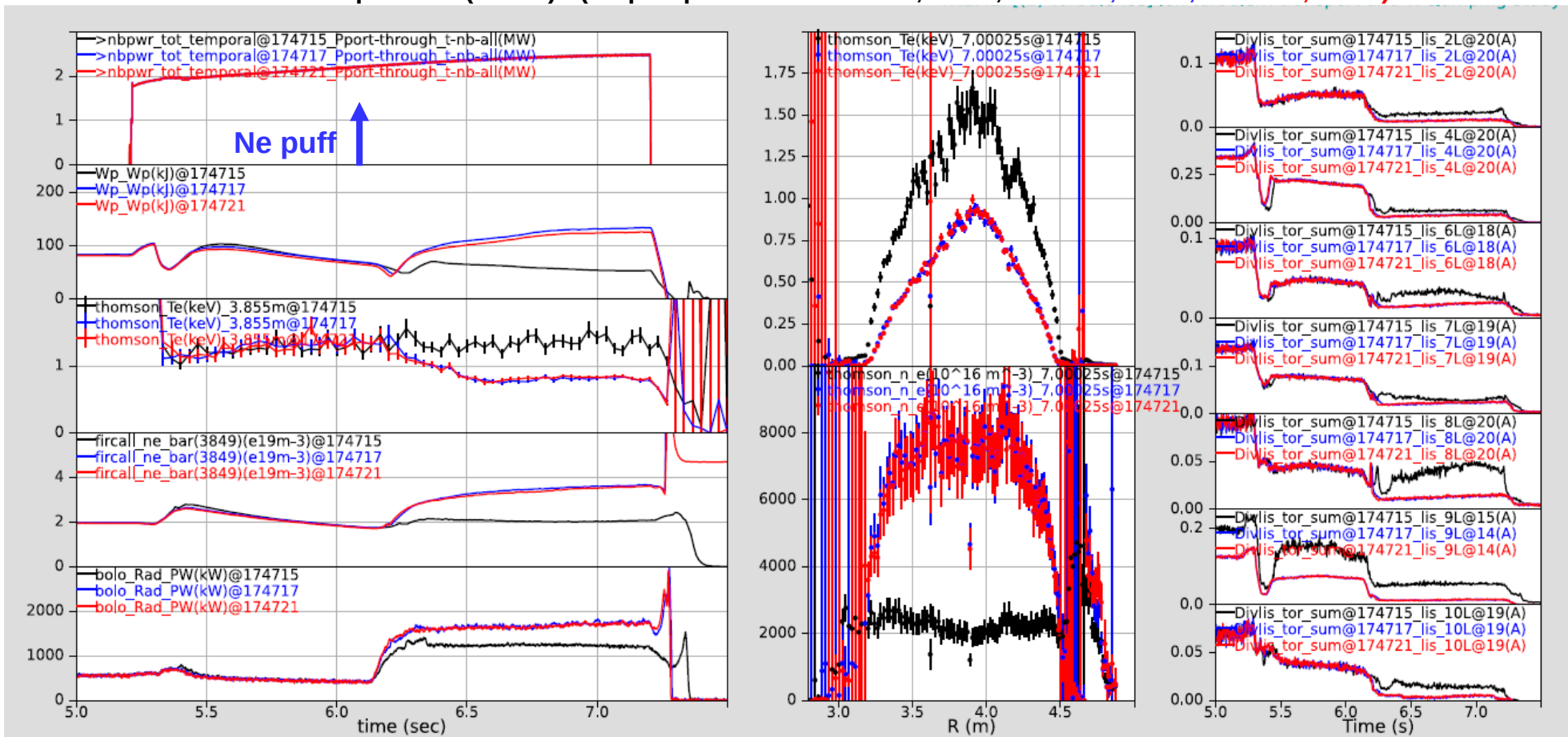
Background & objectives:

In 22nd cycle, high radiation fraction (**90%**) detachment was achieved in the ECRH (~3MW) plasmas with R_{ax}=3.85 m, B=2.66T with RMP (3000A) + Ne puff. But in the NBI (~10MW) plasmas with the same magnetic configuration, only **50%** radiation was achieved. In order to clarify the reason for the difference, scan of NBI power was planned.

Results:

- Due to the trouble of NBI#2 & 3, only NBI#1 was available. The data with NBI#1 (~2MW) was obtained.
- Ne puff was scanned from 5 ms to 20 ms pulse with 5V from 5.5L port.
- In NBI plasmas, the detachment was sustained up to radiation fraction of **72%** (based on the port through NBI power).
- This is higher than 50% with 10MW NBI, but lower than 90% with 3MW ECH.
- No difference between 15ms & 17ms Ne pulse.
- Accurate radiation fraction will be evaluated when NBI power deposition data available.
- There seems power dependence of radiation fraction. NBI power scan between 2 and 10 MW is required.

NBI plasmas (~2MW): (Ne puff pulse with #174715, 10ms, #174717, 15ms, #174721, 17ms)



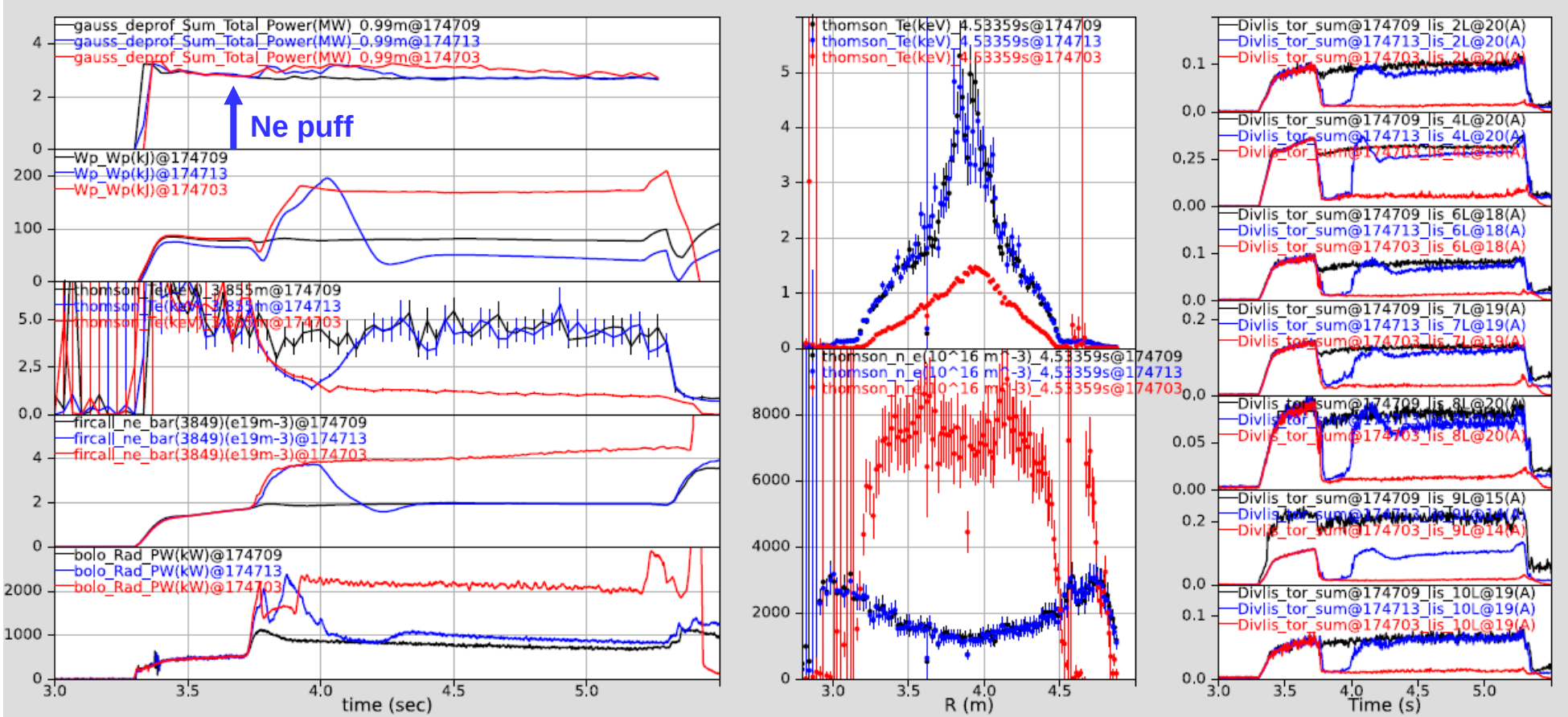
High radiation fraction detachment with RMP application

M. Kobayashi, A. Shimizu, T. Oishi et al.

Results:

- In ECH plasmas, the detachment was sustained up to radiation fraction of **75%** (No change of ECH deposition power up to 4e19 m^{-3}. ECH deposition data correct?).
- The divertor particle flux decreases at all toroidal section. (In the NBI plasmas, sometimes slight toroidal asymmetry appears (previous page).)
- More than 15ms Ne pulse, the plasma collapsed.
- GPI data and EUV Ne spectra profile were obtained. The data will be analyzed later.

ECH plasmas (~3MW): (Ne puff pulse with #174709, 5ms, #174713, 10ms, #174703, 15ms)



Induced plasma termination by W-TESPEL at different masses & its recovery (N. Tamura et al.)

Experimental conditions: (R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CCW, 2.75 T, 1.2538, 100.0%)
Shots: #174723 - #172764

Goal of this experiment

- To reveal time scales in terms of decay times and the spatial distribution of load in order to quantify how much a potential termination affects the machine integrity in potential future helical devices

Main results of this experiment

- **TESPELs with different amounts (4e16, 8e16, 3e17) of W(tungsten) were successfully injected**

✓ **3e17 by using a 600 um shell (shallower penetration)**

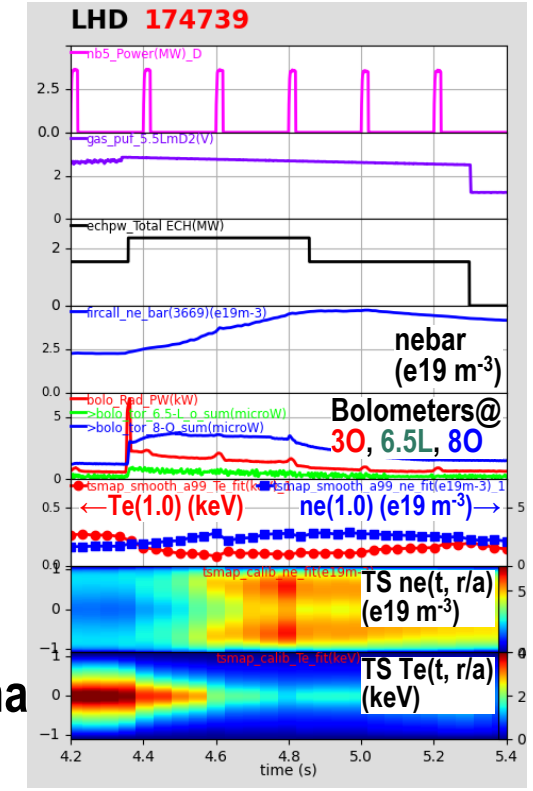
	w/o additional heating	w/ 154 GHz ECH (r/a~0.6)	w/ 154 GHz ECH (r/a~0.0)	w/ NBI#4
ne ~ 1e19	Not conducted	survived	(Failed)	survived
ne ~ 2e19	Not conducted	survived	collapsed	collapsed

✓ **3e17 by using a 900 um ball (deeper penetration)**

	w/o additional heating	w/ 154 GHz ECH (r/a~0.6)	w/ 154 GHz ECH (r/a~0.0)	w/ NBI#4
ne ~ 1e19	Not conducted	survived	survived	Almost collapsed
ne ~ 2e19	Not conducted	collapsed	collapsed	collapsed

- **Impact of ECH deposition location on the recovery from the plasma termination has been observed**

#174739: off-axis for 3e17 (600 um O.D.)



#174740: on-axis for 3e17 (600 um O.D.)