(TG1) Multi-ion group report

Jan. 7, 2022 (H. Kasahara)

Date: Dec. 24, 2021, Time: 9:50-18:45
Shot#: 175960 – 176034(75 shots)

Prior wall conditioning: No, Divertor pump: Yes
Gas puff: D2, H2, Ne, IPD: Yes (B-powder)
NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(0,0,0,0.65,0)MW

ECH(77GHz)=ant(5.5-U, 2-OUR)=P(0.14, 0.16)MW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(0.21, 0.20, 0.34)MW
ICH(38.47MHz)=ant(3.5U, 3.5L, 4.5U, 4.5L)=P(0.57,0.44,0,0)MW
Neutron yield integrated over the experiment = 6.2×10^{14}

Topics

1. Particle control with and without divertor pumping (G. Motojima)
2. Ne seeding in long-pulse discharges (S. Masuzaki)
3. B powder dropping in long pulse discharges (S. Masuzaki, Y. Yoshimura)
4. Improvement of time resolution of measurement in long pulse discharge (Y. Yoshimura)
5. Fast ion tail measurement during the steady-state operation with deuterium plasma (S. Kamio)
6. Investigation of time evolution of particle confinement time and improvement of time resolution of measurement in long pulse discharge (H. Kasahara and Y. Yoshimura)

High voltage power supply for 4.5 Antenna had trouble, and ICH was carried out only by using 3.5 Antenna. (The power supply was repaired at 28th Dec.)

Particle control with and without divertor pumping (G. Motojima, S. Masuzaki)

Magnetic Configuration:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.60 m, CW, 2.75 T, 1.2538, 100.0%)

Shots: 175978-175997 (20 shots)

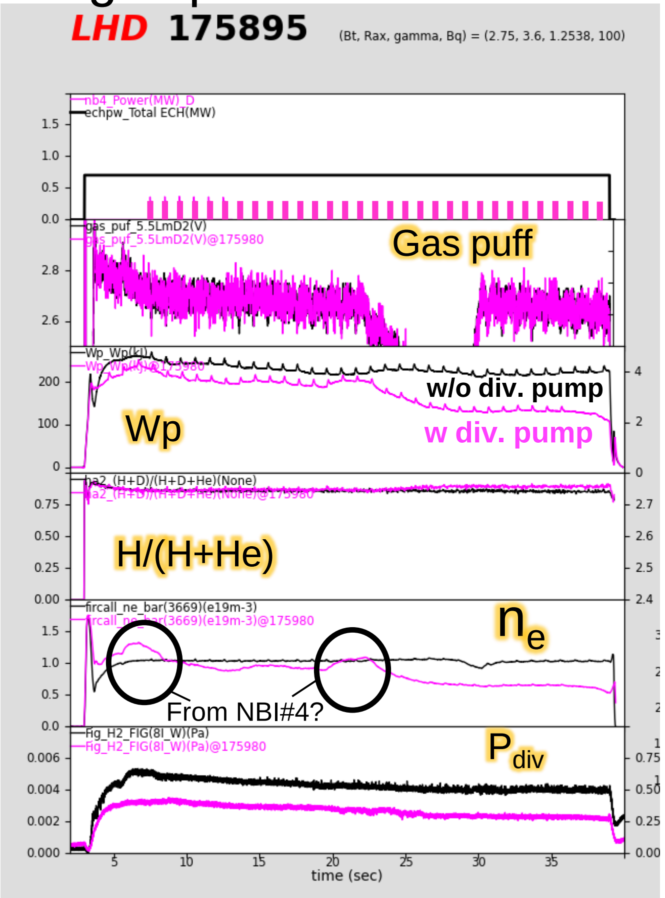
Goal of this experiment:

- To study the effect of divertor pumping on particle control

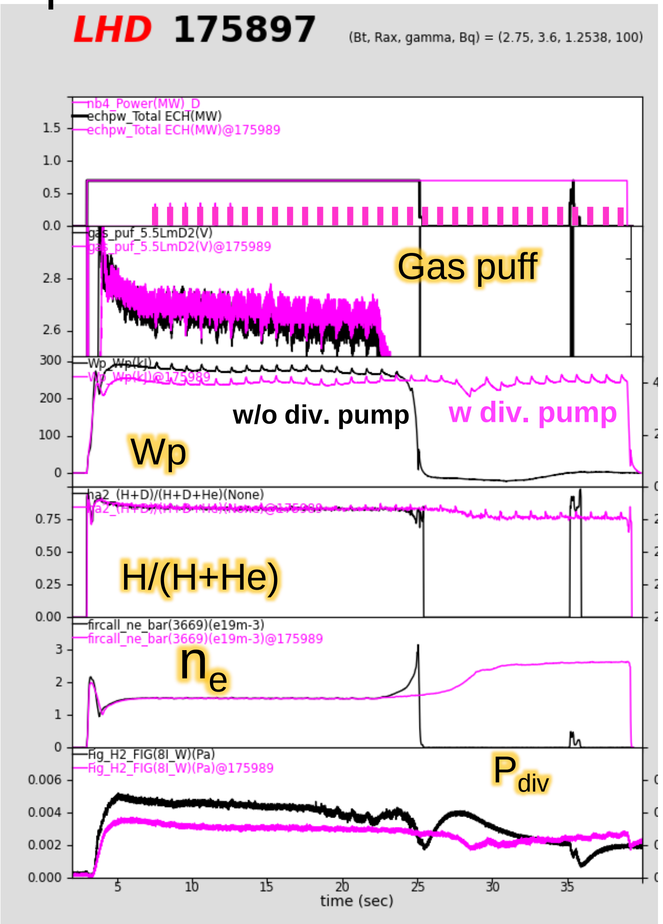
Results:

- 40 seconds ECH/ICH discharges were conducted with and without divertor pumping. 4.5U/L ICH was not available in the case with divertor pumping.
- In the complete same gas puff control, lower density is attained in the case with divertor pumping. Also, neutral particles presumably introduced from NBI#4 was clearly observed.
- In the feedback gas puff control, longer pulse discharge was possible in the case with divertor pumping.

Same gas puff control at ~1x10^{19} m^{-3}



gas puff feedback control at 1.5x10^{19} m^{-3}



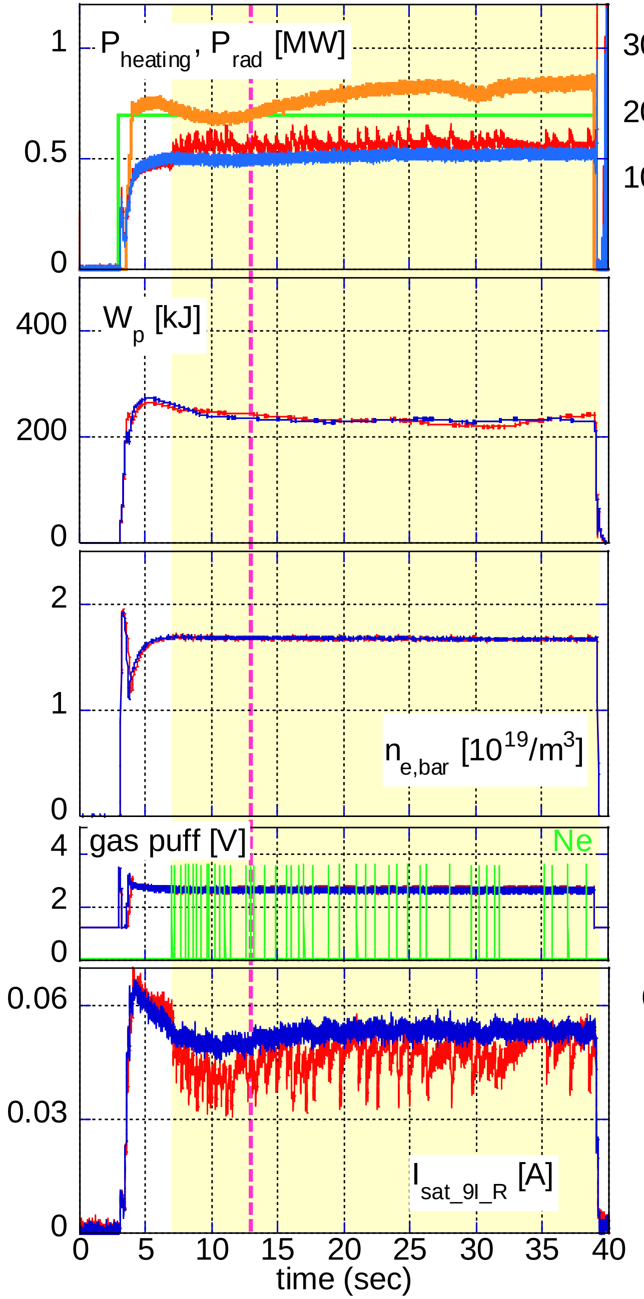
Ne seeding in long pulse discharges

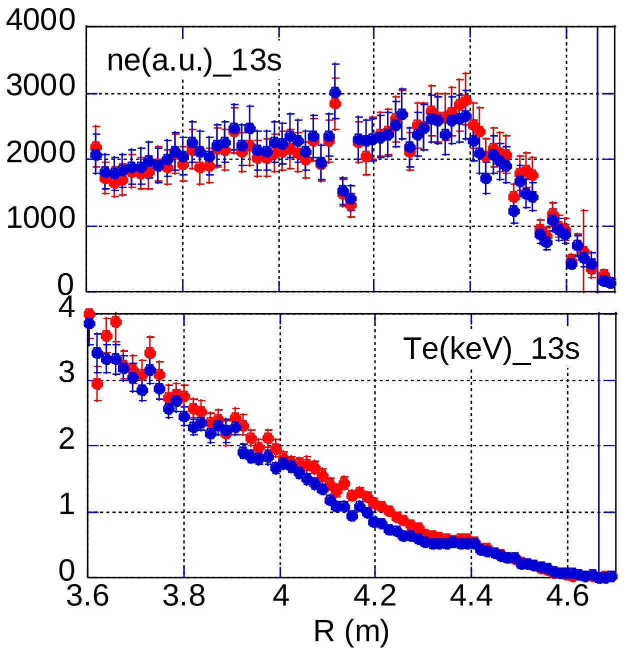
S. Masuzaki

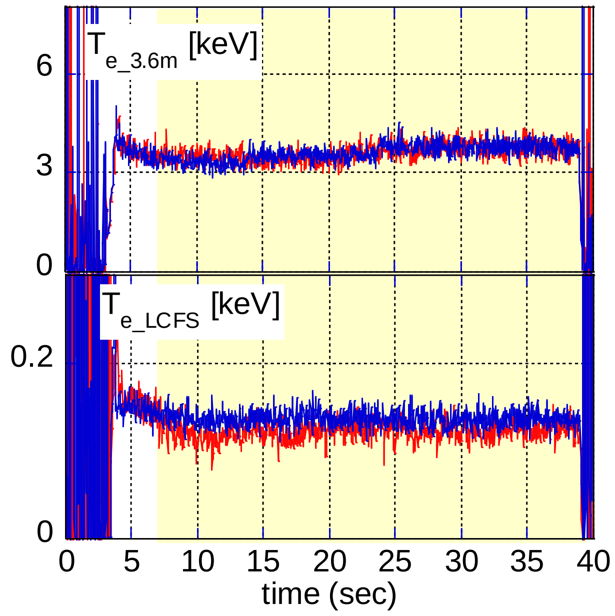
Shot #: 175999-176008
(R_{ax}, B_t, γ, B_q) = (3.6 m, 2.75 T, 1.2538, 100.0%)
Working gas: D2
P_{ECH} ~ 0.7 MW
P_{ICH} ~ 1.0 MW

- ✓ Ne gas was seeded from 5.5L port with feedback-control using bolometer signal.
- ✓ P_{rad} increased ~10% with the condition of the Ne puff as below: pulse height=3.5V, pulse width=7ms, sampling=10Hz, target Prad=0.64MW
- ✓ Divertor particle flux slightly decreased. Toroidal asymmetry was observed in the decrease.
- ✓ Te at LCFS slightly decreased.
- ✓ Divertor heat flux will be analyzed.

w/ Ne #176007, w/o Ne #176001



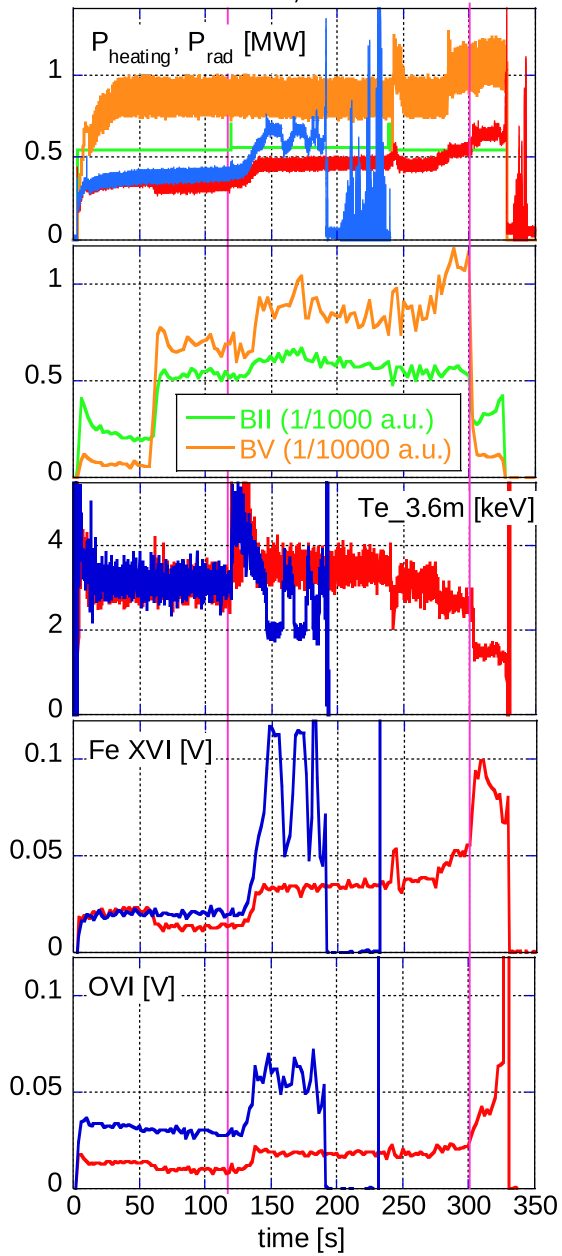




B powder dropping in long pulse discharges

Y. Yoshimura, S. Masuzaki

w/ IPD #176033, w/o IPD #176028



Shot #: 176014-176018, 176028-176034
$(R_{ax}, B_t, \gamma, B_q)$ = (3.6 m, 2.75 T, 1.2538, 100.0%)
Working gas: D2
P_{ECH} ~ 0.7 MW
P_{ICH} ~ 1.0 MW

- ✓ Boron powder was dropped from t=60s to 300s.
- ✓ A cumulative effect of the boron powder was observed in oxygen content in plasma.
- ✓ Fe XVI emission intensity was decreased during the powder dropping.
- ✓ Total radiation power seems to be dominated by Fe emission.
- ✓ With the termination of the dropping, Fe XVI emission increased and Te decreased rapidly. Then, oxygen emission increased and the discharge was terminated.

Improvement of time resolution of measurement in long pulse discharge

Y. Yoshimura

Experimental conditions: #176009 - #176034

(Polarity, R_{ax}, B_t, γ, B_q) = (CW, 3.6 m, 2.75 T, 1.2538, 100%)

ECH Power:

77GHz#1 (5.5-Uo) = 0.139MW
77GHz#2 (2-OUR) = 0.155MW
154GHz#4 (2-OLL) = 0.205MW
154GHz#5 (2-OUL) = 0.203MW
154GHz#7 (2-OLR) = 0.343MW

ICH power:

3.5-U = 0.49MW
3.5-L = 0.49MW

NBI#4 for CXS measurement:
0.5s injections at every 3 min.

Results:

The longest pulse duration obtained in Dec. 24th was 536s at #176024.

Event (increase in bolometer signal at termination)-triggered phase contrast imaging (PCI) measurement was performed.

Special thanks to Yokoyama-san (Tokyo Univ.) and Masahiro Kobayashi-san for their contributions to the PCI triggering

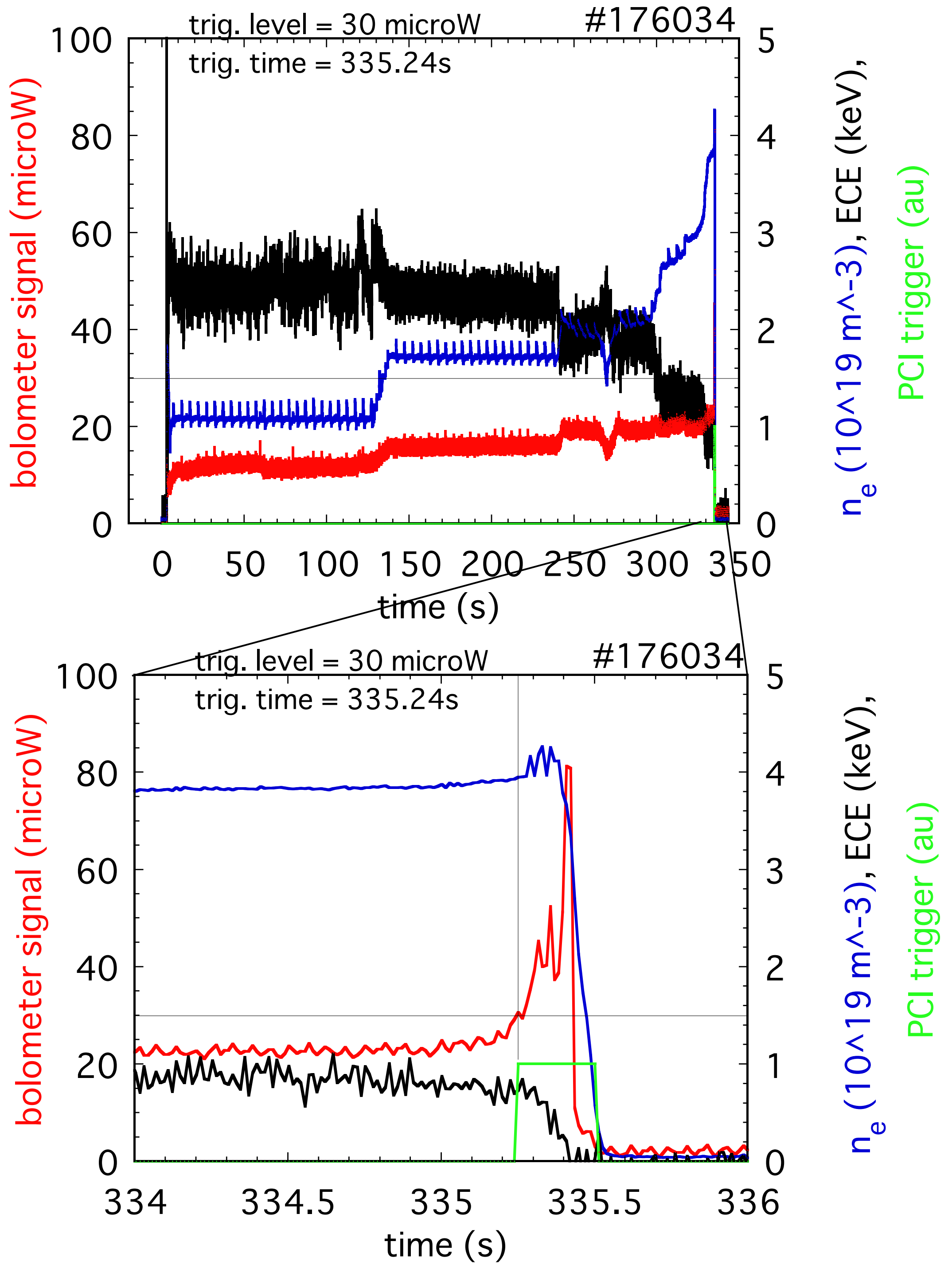
Event-triggering for PCI measurement

In this 335.5s discharge #176034, PCI triggering threshold level of bolometer signal was set at 30 μW to detect plasma termination timing.

At around 335.2s, gradual increases in line average electron density and bolometer signals, and gradual decrease in near-center ECE data start.

At 335.24s the bolometer signal went over threshold level of 30 μW, and a trigger signal was sent to PCI system.
The same triggering system was applied for fast Thomson scattering measurement on Dec. 23rd.

Event-triggered PCI and FTS data are under analysis.



Fast ion tail measurement during the steady-state operation with deuterium plasma

S. Kamio

Experimental conditions:

(R_{ax}, polarity, B_T, γ, B_q,) = (3.60 m, CCW, 2.75 T, 1.2538, 100.0%)

Background and motive

- In the steady-state operation sustained by ICRF heating, the fast-ion tail can be clearly measured with long integration time.
- The charge exchange cross-sections of fast-ions and neutral particles are different, and the dependence of neutral species can be experimentally investigated during the steady-state operation.

Results

- The fast-ion tails were compared with those of the helium discharge at about the same electron density. However, the ICRF injection power was about half of the experiment with helium.
- The counting rate of observed fast-ion tails was much lower than in the case of helium discharge.
- Unfortunately, the fusion born tritons and protons could not be observed during the steady-state experiment.

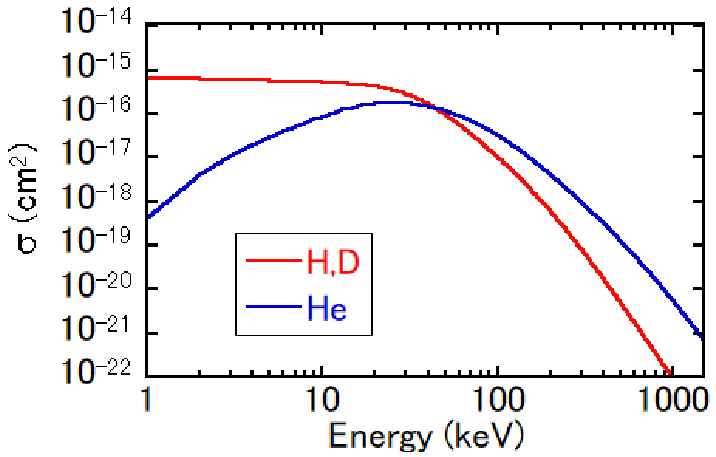


Fig. 1 Charge exchange cross-section of fast proton and various neutral gas species.

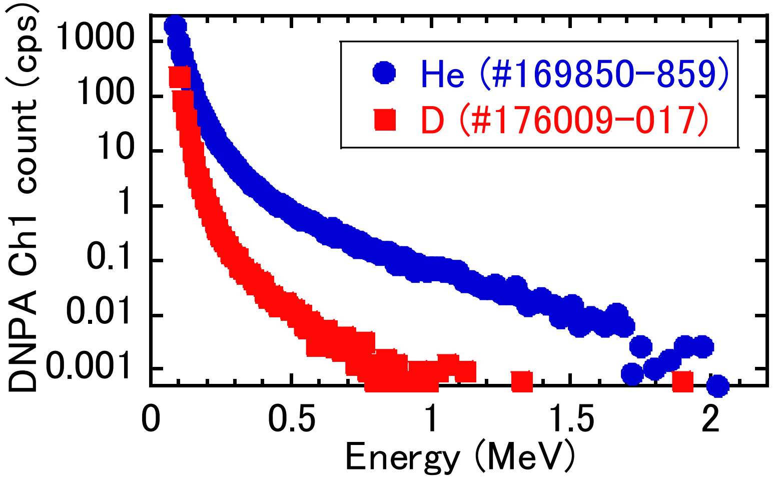


Fig. 2 Fast-ion tail measured by DNPA Ch1.

Investigation of time evolution of particle confinement time and improvement of time resolution of measurement in long pulse discharge (H. Kasahara and Y. Yoshimura)

Experimental conditions: #176010 - #176034

(Polarity, R_{ax}, B_t, γ, B_q) = (CCW, 3.6 m, 2.75 T, 1.2538, 100%)

ECH Power:

77GHz (5.5-Uo, 2-OUR) = (0.14, 0.16)MW, 154GHz#4 (2-OLL, 2-OUL, 2-OLR) = (0.21, 0.20, 0.34)MW

ICH power:

#3.5 Antenna ($0.66^b/0.57+0.50^b/0.44$)MW, #4.5 Antenna (0.0+0.0) = 0MW

b:boost

Results:

Plasma termination was happened with the density rising, and rising time "T" and multiple factor of density rise "a" (Fig. 1) were estimated with the density rising model(a*exp{(t-t1)/T} + b*(t-t2) + c).

Duration time was up to 536 sec on D plasma operation(Fig. 2), and it's termination was caused by radiation collapse with the increases of electron density and the intensity of CIII and FeXVI (Fig. 3). In 400s, the intensity of C and H or D were frequently increased, it seems to start exfoliation of C flakes.

By repetitive gas-puffings of H, interesting behavior of particle confinement time was observed with higher density operation (Fig. 4). There were two particle confinement times (longer and shorter).

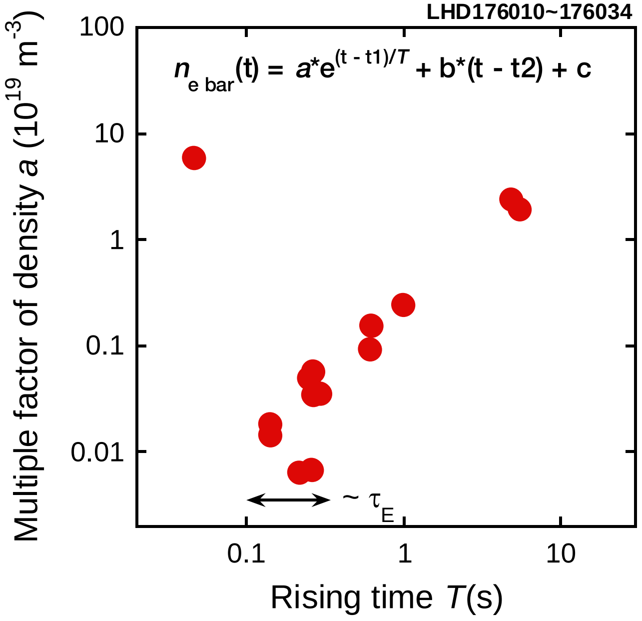


Fig. 1. Density rising time vs Multiple factor of density rise at the plasma termination events.

Time evolution of response of CIII intensity and plasma termination

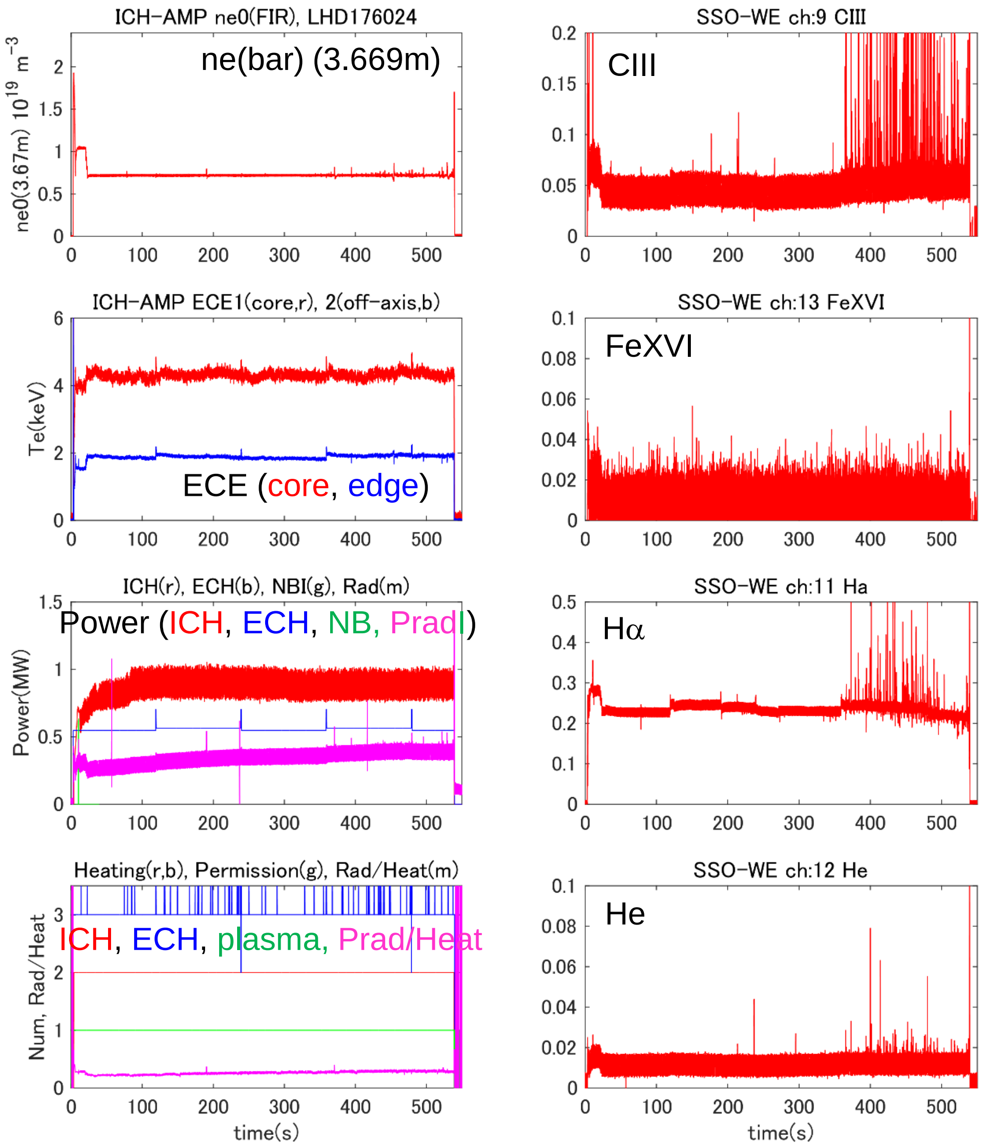


Fig. 2 Long-pulse duration for D plasma.

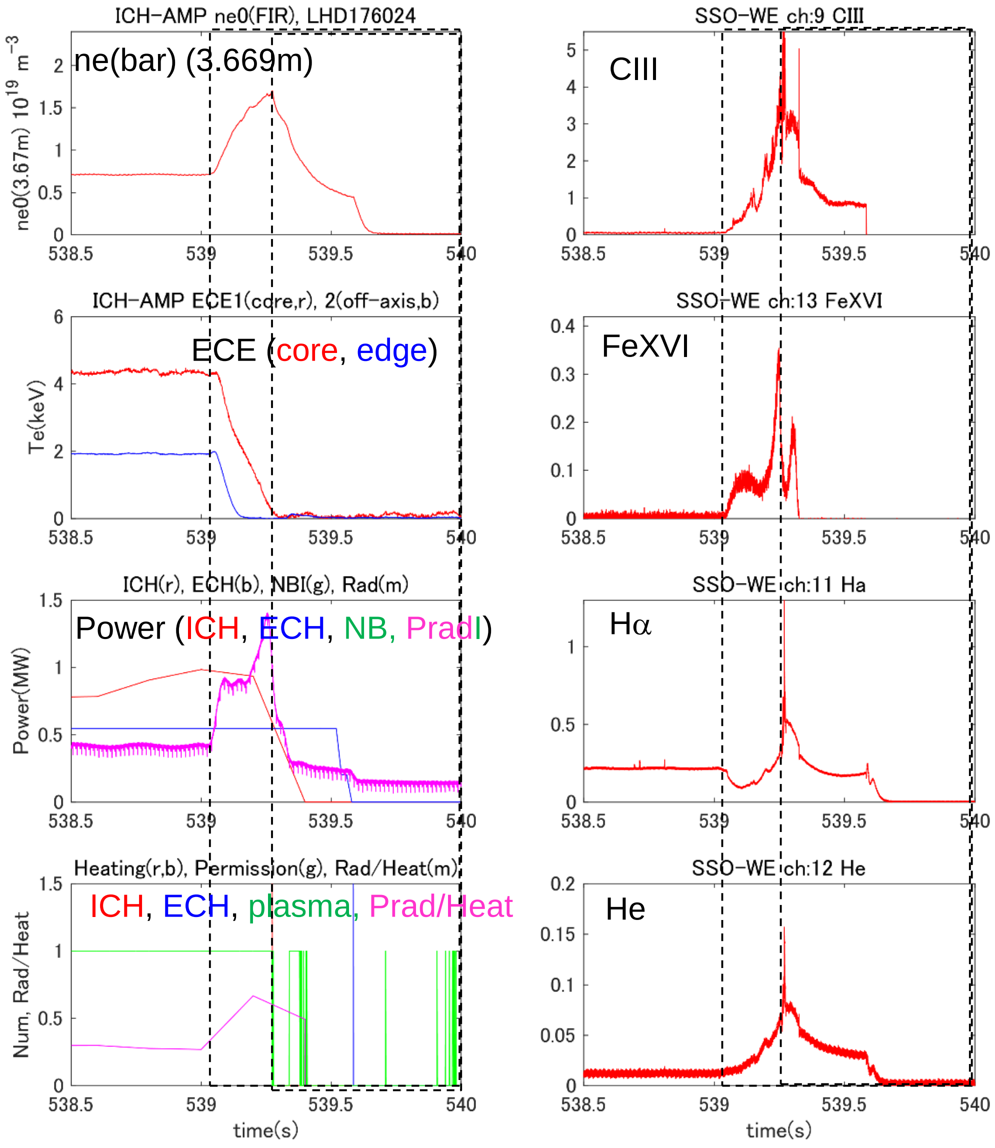
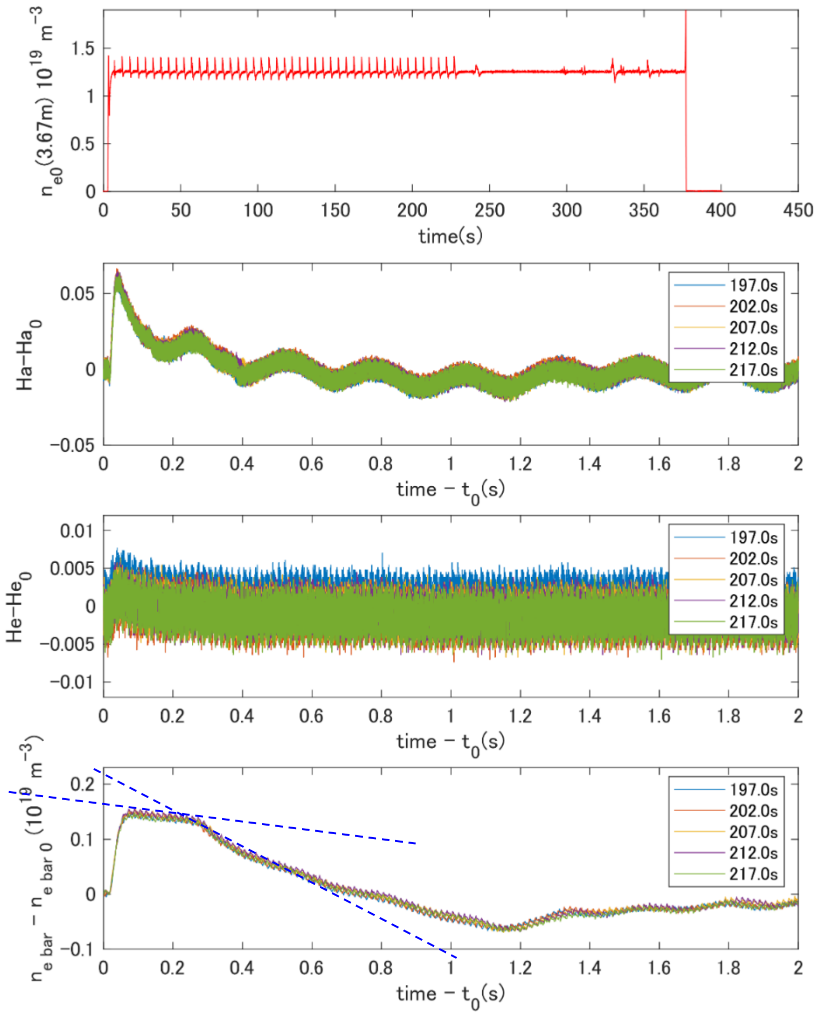


Fig. 3 Time evolution of plasma termination.

Time evolution of particle confinement by superimposed Hydrogen gas puffing (5V, 5ms/0.2Hz)

n_e(bar) ~ 1.2×10^{19} m^{-3}

LHD176013, t_0 = 197 ~ 217s



n_e(bar) ~ 0.7×10^{19} m^{-3}

LHD176030, t_0 = 197 ~ 217s

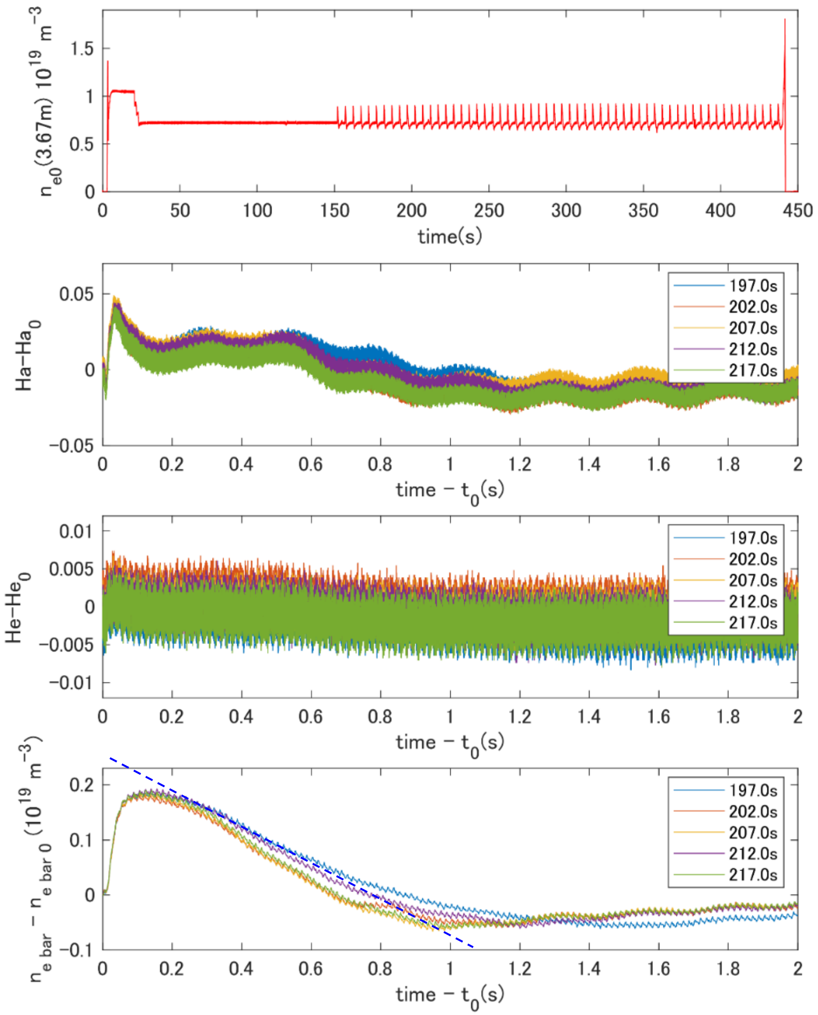


Fig. 4 Time evolution of particle confinement by superimposed Hydrogen gas puffing

Time evolution of particle confinement by superimposed Hydrogen gas puffing(5V, 5ms/0.2Hz)

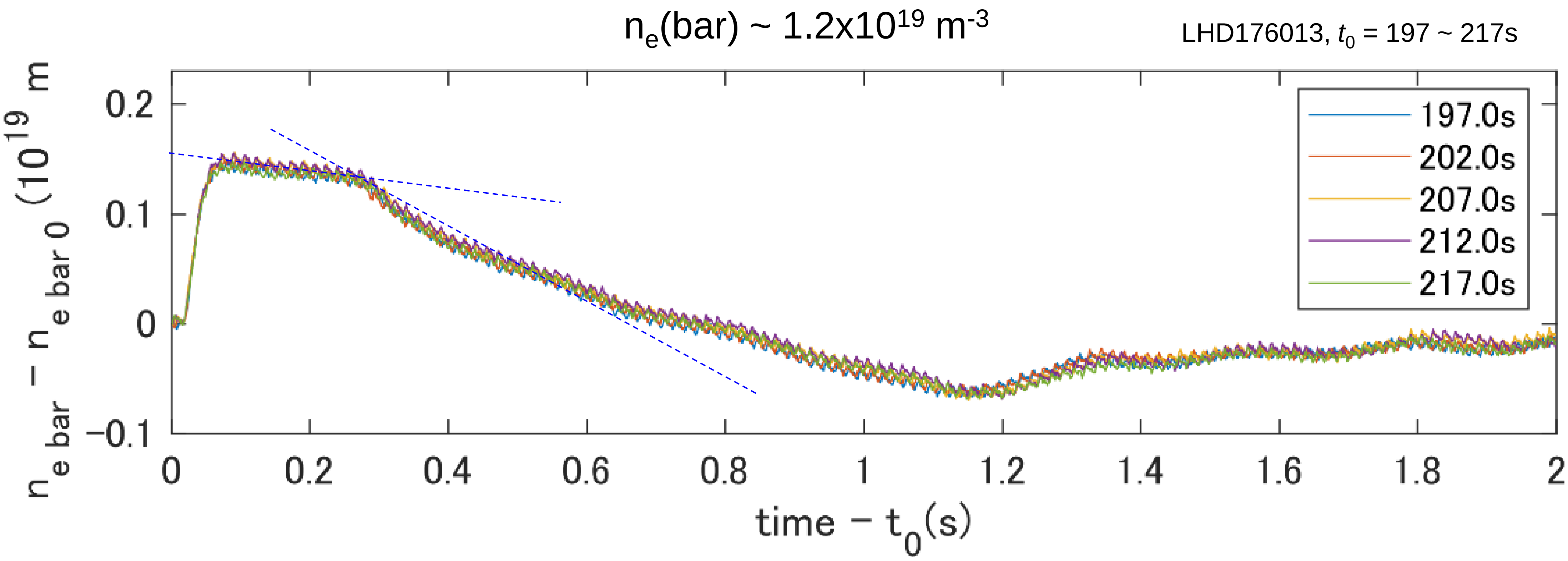
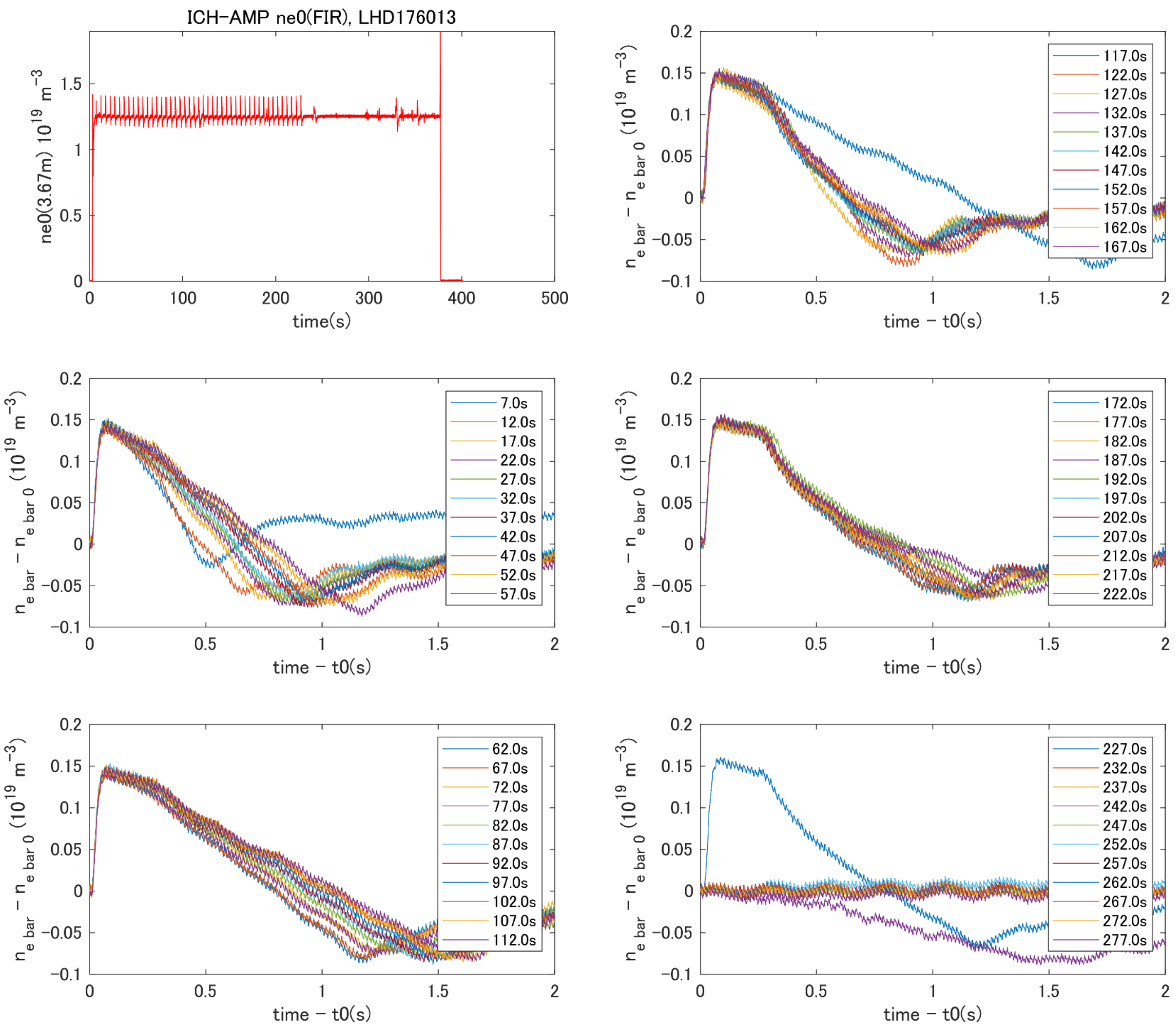


Fig. 4 Time evolution of particle confinement by superimposed Hydrogen gas puffing (ZOOM)

Time evolution of particle confinement by superimposed Hydrogen gas puffing(5V, 5ms/0.2Hz)



n_e(bar) ~ 1.2×10^{19} m^{-3}

Fig. 5 Time evolution of particle confinement by superimposed Hydrogen gas puffing