(TG1) Multi-ion group report

Feb. 18, 2022 (M. Kobayashi)

Date: Feb. 17, 2022
Time: 9:45 -18:45
Shot#: 179200 – 179273 (74 shots)

Prior wall conditioning: No
Divertor pump: Off
Gas puff: H2, He, Ar   IPD: B
LID: Off
NBI#(1, 2, 3, 4, 5)=gas(-, -, -, H, -)=P(-, -, -, 0.6, -) MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(139, 155)kW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(120, 277, 343) kW
ECH(116GHz)=ant(2O-LR)=P(-)kW
ECH(56GHz)=ant(1.5-U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.59, 0.51, 0.59, 0.41) MW
Neutron yield integrated over the experiment = 1.4×10^{11}

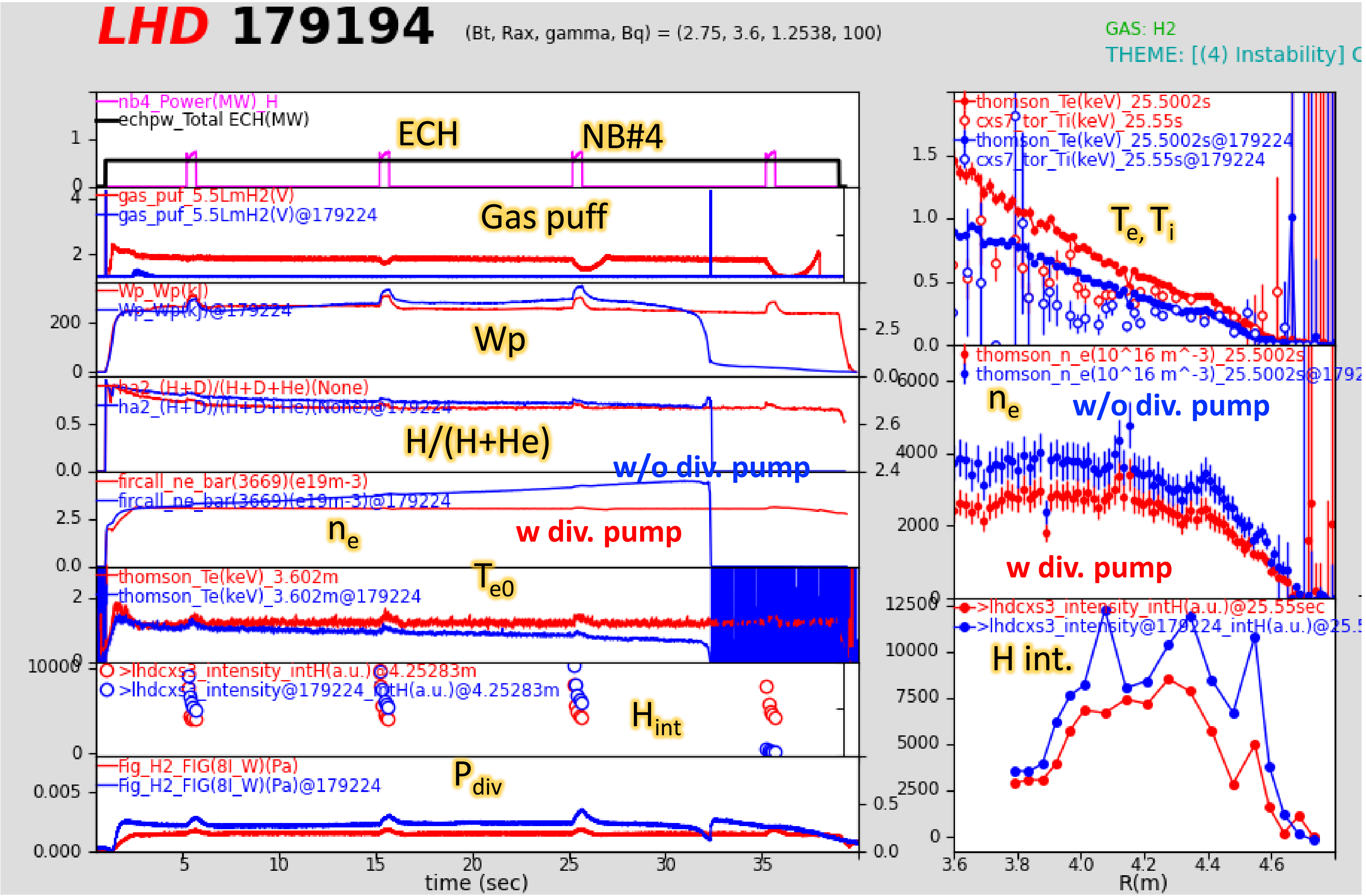
Topics
1. The relation between plasma confinement and neutral particle on divertor condition (G. Motojima)
2. ICRF plasma production in view of IC wall conditioning in W7-X (C.P. Dhard)
3. Time evolution of particle confinement time on long-pulse plasma discharge (H. Kasahara)
4. Steady state particle balance of plasmas with active control of H/D gas-puffing and cryo-pumping (Y. Yoshimura)
5. Partial pressure measurement of neutral gases by the Penning gauge spectroscopy (H. Funaba)
6. Interaction of LHD divertor plasma and pre-irradiated tungsten (M. Zhao, S. Masuzaki)
7. Calibration of the LaB6 pressure gauges (V. Haak, U. Wenzel, G. Motojima)

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: 179217-179226 (10 shots) Div. pump Off, 179194-179196 Div. On



Conditions:

- Div pump on:
  6I, 7I, 8I, 10I (Cryo)& 4I, 9I (SAES).
  Div. Pumping conditions were almost
  full spec **(70-80 m^3/s estimated)**.

Results:

- 40 seconds ECH discharges were conducted with and without divertor pumping in hydrogen plasma.
- The target density was 3×10^{19}.
- The plasma was **sustained well with div. pump**. However, the plasma was not sustained without div. pump due to increase of density.
- We were able to reproduce the improvement in particle controllability by the divertor pump that was recently shown in a paper published in Physica Scripta.

ICRF plasma production in view of IC wall conditioning in W7-X
(C.P. Dhard, D. Naujoks (IPP), A. Goriaev (LPP-ERM/KMS), H. Kasahara(NIFS))

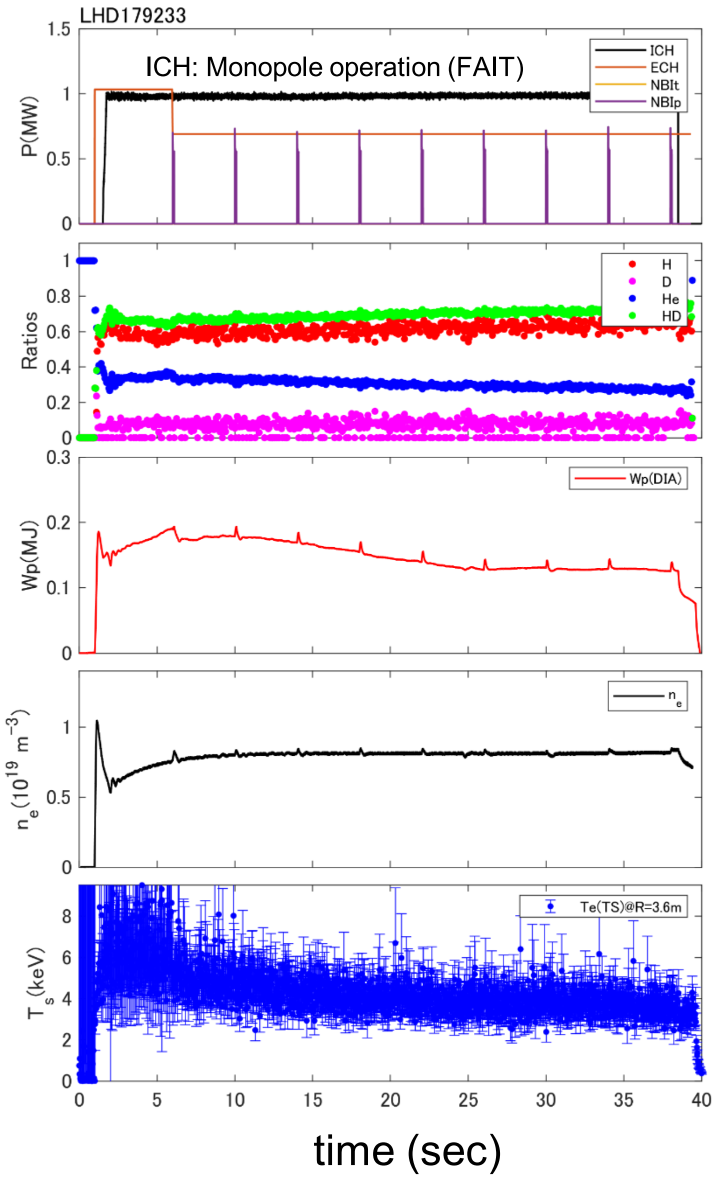
Magnetic Configuration: (Polarity, R_{ax}, B_{ax} , γ, B_q)=(CW, 3.6, 2.75T, 1.2538, 100%)
Shots: #179227 ~ #179250 (24 shots)

The goal of this experiment

In order to accelerate the hydrogen removal from the first wall in W7-X, we have investigated wall condition techniques with repeated long-pulse He discharge using the ECH and the ICH in B of 2.75T.

Main results of this experiment

- Long-pulse He plasma with the duration time of 39s was provided using ECH and ICH, and NBI blip(0.1s ON/ 3.9s OFF, t = 6s ~) was conducted to measure H and He profiles in the plasma.
- There was no clearly increases in Hydrogen concentration in one NBI blip, and Hydrogen contamination seems to be small.
- Helium concentration was gradually decreased during 39s discharge with the increase of Hydrogen concentration, Hydrogen removal seems to be accelerated during He plasma discharge.



Time evolution of particle confinement time on long-pulse plasma discharge
(H. Kasahara, Y. Yoshimura, S. Masuzaki, G. Motojima)

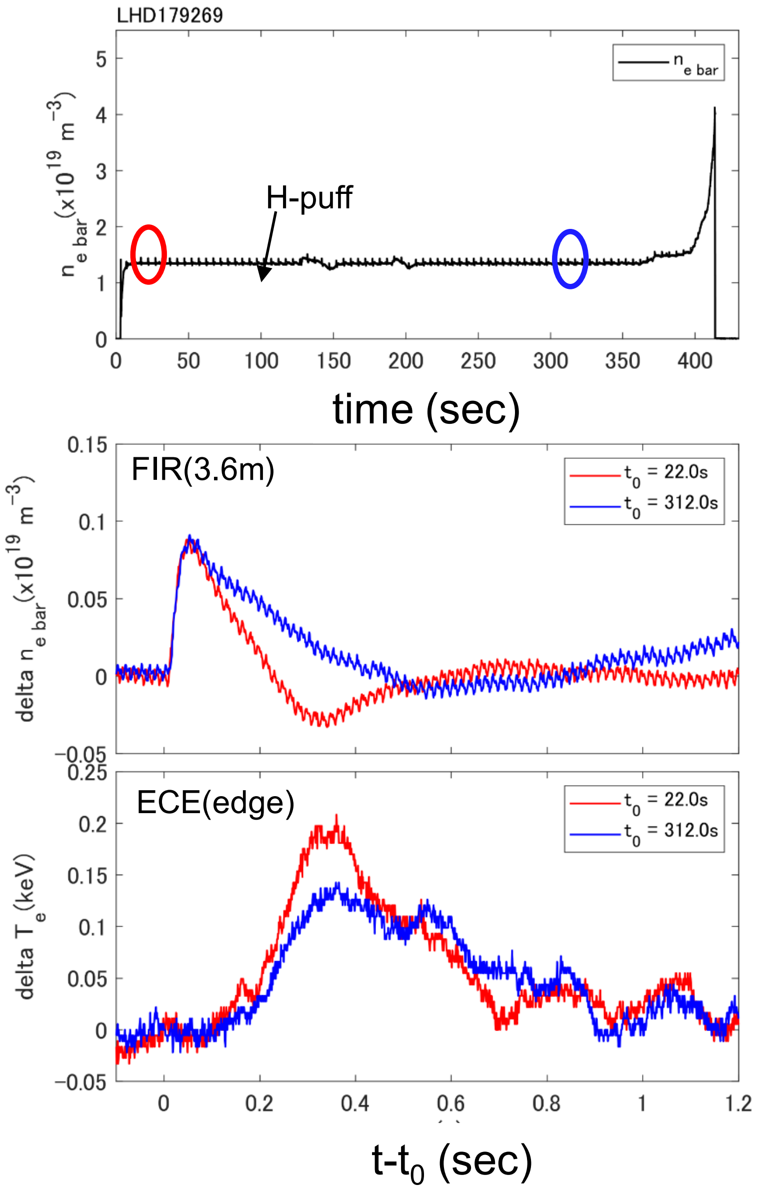
Magnetic Configuration: (Polarity, R_{ax}, B_{ax} , γ, B_q)=(CW, 3.6, 2.75T, 1.2538, 100%)
Shots: #179251 ~ #179270 (20 shots)

The goal of this experiment

To study the relationship between particle confinement time and plasma-wall interaction in long-pulse discharge, we will evaluate the time evolution of particle confinement time by superimposed Hydrogen gas fueling by gas-puffing.

Main results of this experiment

- Repeated He Long-pulse discharge, plasma duration was extended to 400 sec, and high power ICRF operation was favorable to extend plasma duration.
- When divertor temperature measured by thermocouple was clearly increased with the increase of ICRF power. In some cases, gradually density rising was observed, and it seemed to start the out-gassing from divertor tiles.
- We will conduct the particle confinement time for the repeated superimposed Hydrogen fueling, and the comparison for the time evolution of Hydrogen confinement time between D and He plasmas.



Improvement of time resolution of measurement in long pulse discharge

Y. Yoshimura, H. Kasahara, S. Masuzaki

Experimental conditions: #179251 - #179273

(Polarity, R_{ax}, B_t, γ, B_q) =
(CW, 3.6 m, 2.75 T, 1.2538, 100%) (~#179270)
(CW, 3.67 m, 2.75 T, 1.2538, 100%) (#179271~)

ECH Power:
77GHz#1 (5.5-Uo) = 0.139MW
77GHz#2 (2-OUR) = 0.155MW
154GHz#4 (2-OLL) = 0.12MW
154GHz#5 (2-OUL) = 0.277MW (~#179263)
154GHz#5 (2-OUL) = 0.091MW (#179264~)
154GHz#7 (2-OLR) = 0.343MW

ICH power:

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

Results:

The longest pulse duration was 420s at #179269.

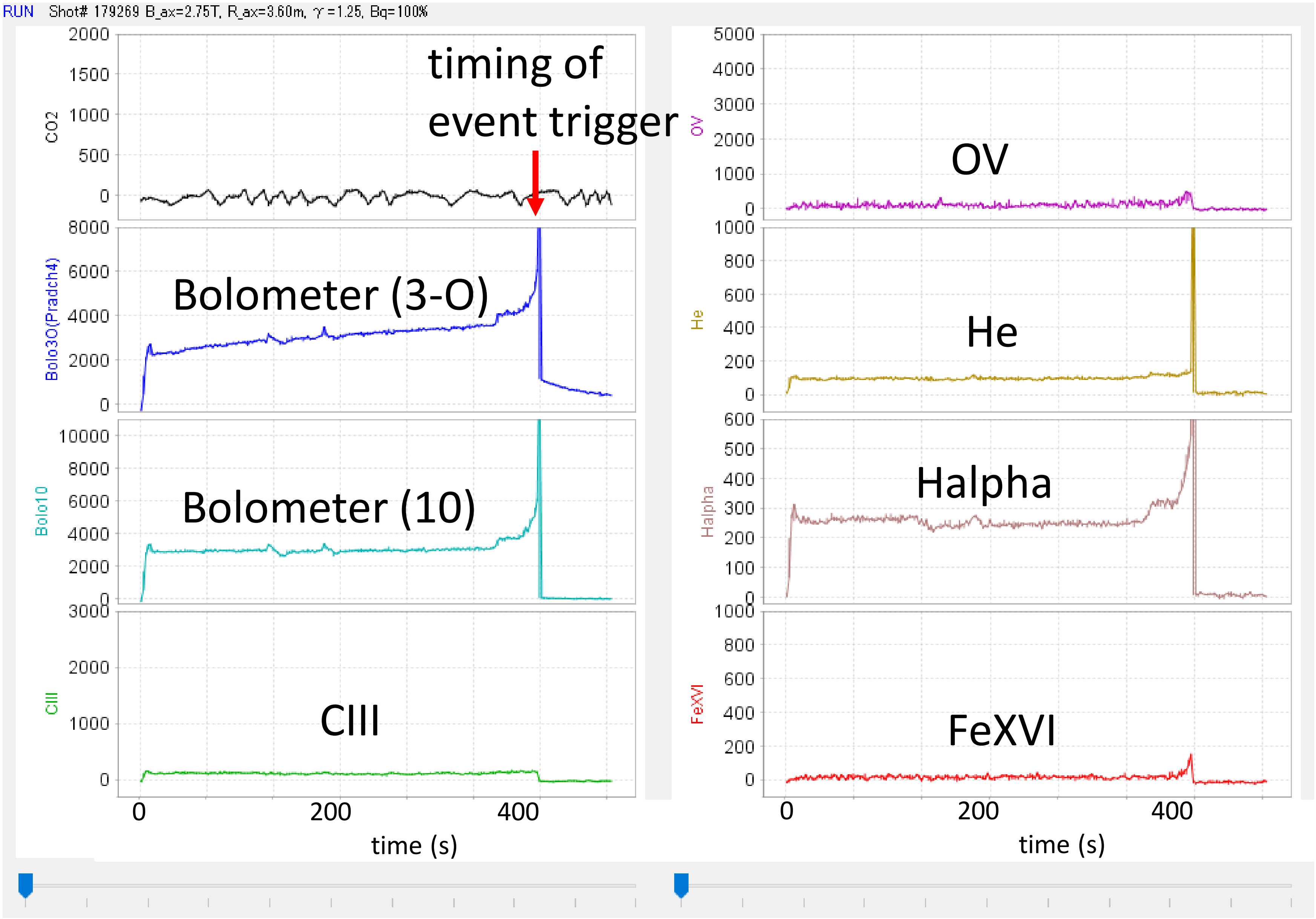
Event (increase in Prad signal at termination)-triggered fast Thomson scattering, phase contrast imaging (PCI), and CO2 interferometer measurements were performed.

Boron powder dropping and ICH power boost worked for suppression of unwanted density increase to some extent.

Change in magnetic configuration resulted in earlier termination by density increase.

Special thanks to Yokoyama-san (Tokyo Univ.) and Masahiro Kobayashi-san for their contributions to the event trigger system

Waveforms of radiations in the discharge #179269



Calibration of Wisconsin In-situ Penning (WISP) Gauge

Experimental conditions:

1. (R_{ax}^{VAC}, Polarity, B_t, γ, B_q) = (3.67 m, CW, 2.75 T, 1.254, 100.0%)
   (18:15 – 18:45) no plasma
   Gas and Pressure : H_2 and He, 0.01 – 0.5 Pa

Purposes:

(1) The WISP gauge was newly installed at 6I in order to measure the partial pressure of H_2 and He.
(2) In order to compare the pressure calibration with the previous result at the beginning of the 23rd cycle, the vacuum vessel was filled with hydrogen and helium gases.

Results:

Figure 1 shows the calibration results of 17 Feb. 2022 and 12 Oct. 2021. The green data include small amount of hydrogen. The optics was not changed. However, the optical fiber once removed accidentally from the SMA connector of WISP due to tension. The data obtained on 17 Feb. 2022 are almost similar with the results of 12 Oct. 2021.
It is considered the conditions were not changed in the 23rd cycle.

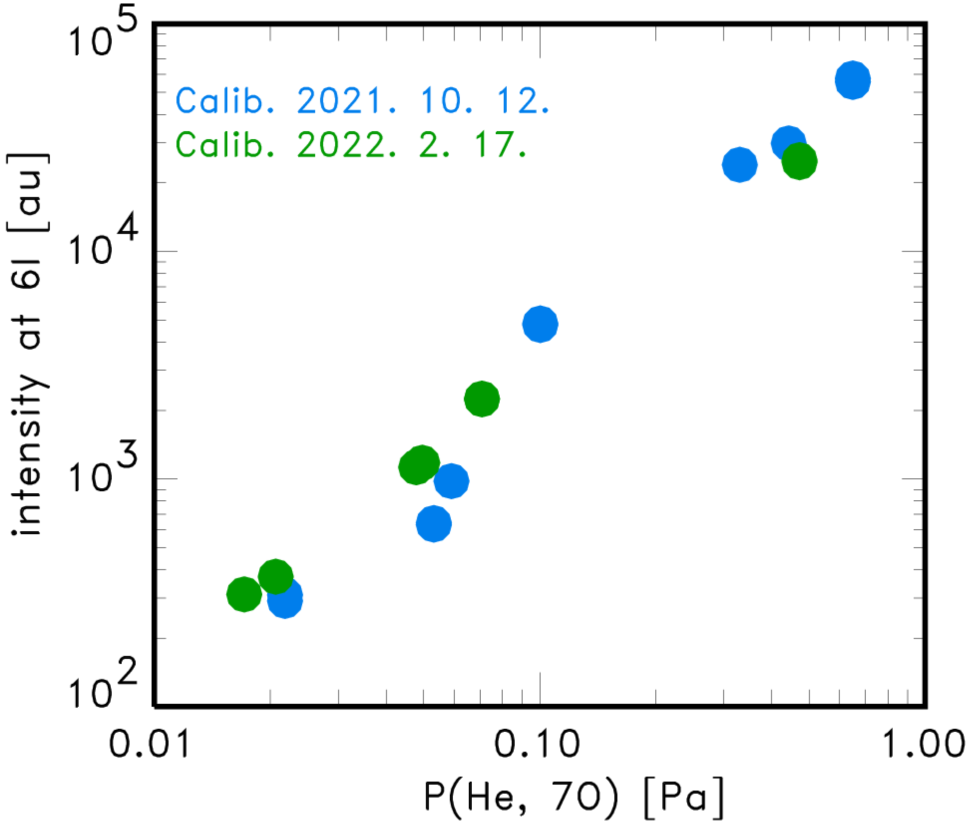


Fig. 1. Helium pressure calibration results of WISP at 6I

Interaction of LHD divertor plasma and pre-irradiated tungsten
(M. Zhao, S. Masuzaki)

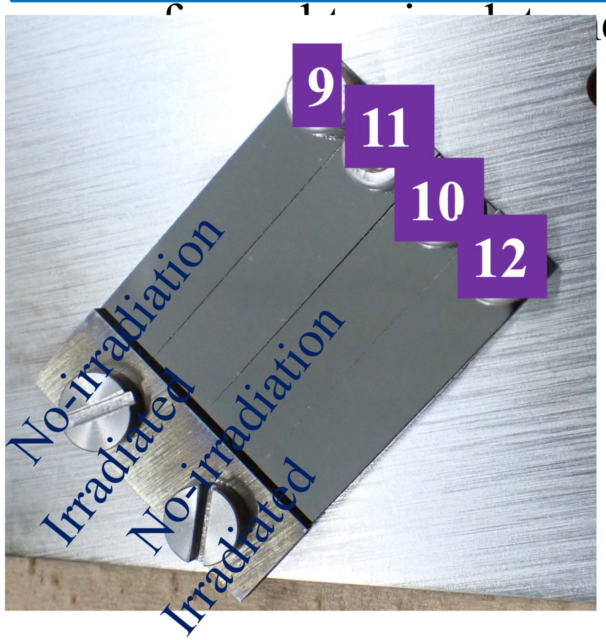
Motivation: Influence of irradiation defects on the formation of nano structure in W at strike point.

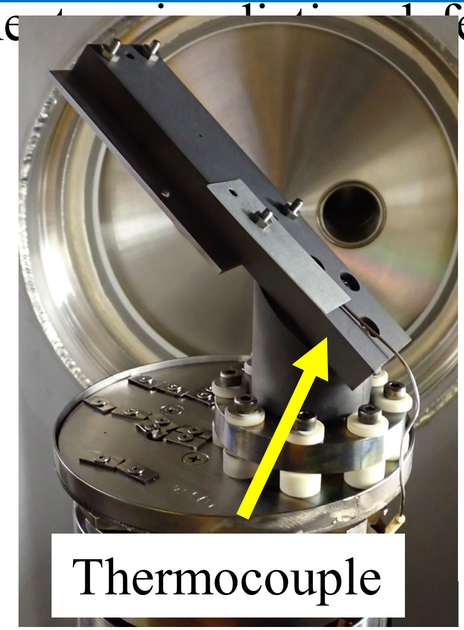
W tiles with irradiation and without irradiation were exposed to LHD plasma with He puffing.

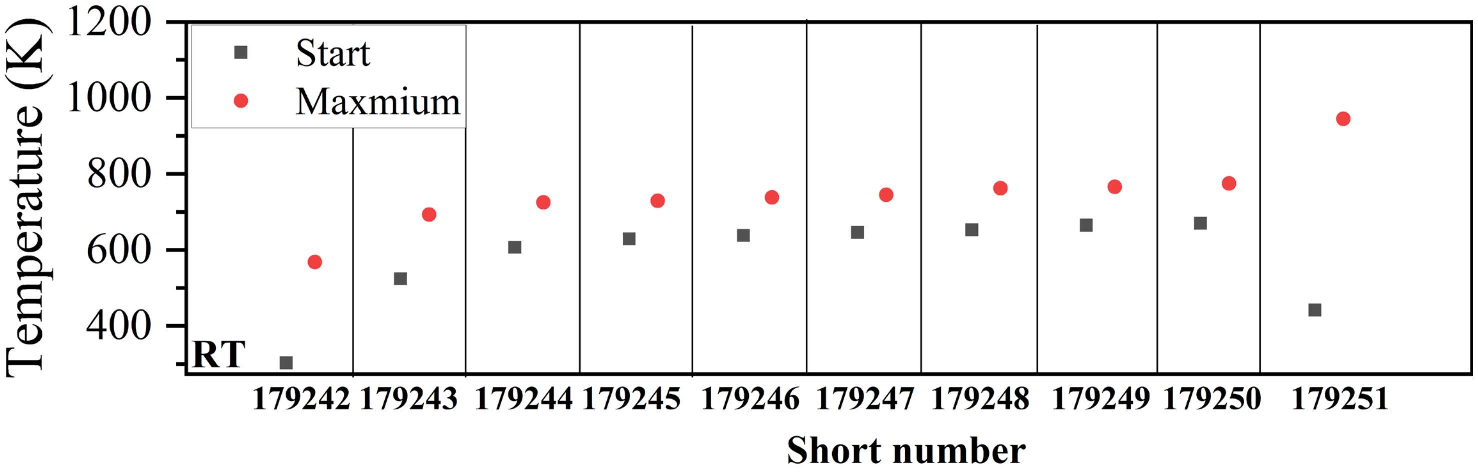
- ☐ **Material**: Mirror finish ITER grade W tiles (28 × 6 × 1).
- ☐ **Iron (Fe) ion irradiation** with peak damage 1dpa was … ects.

LHD experiment

- ☐ Experiment time: 2022/02/17.
- ☐ Shot number: #179242-#179251.







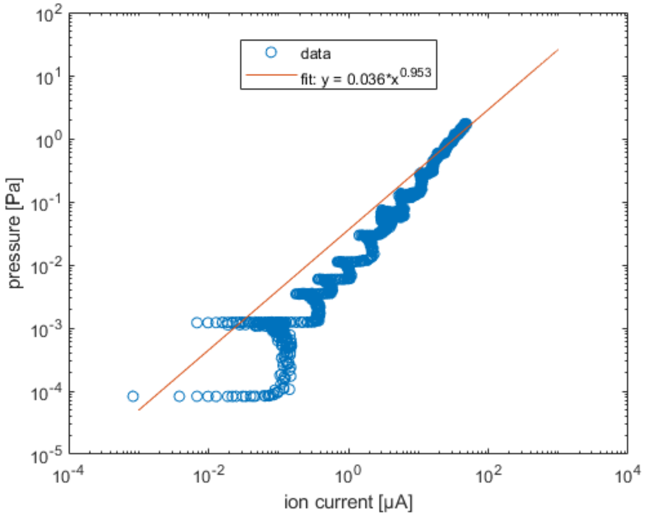
Maximum temperature is 945 K in #179251.

Next plan:

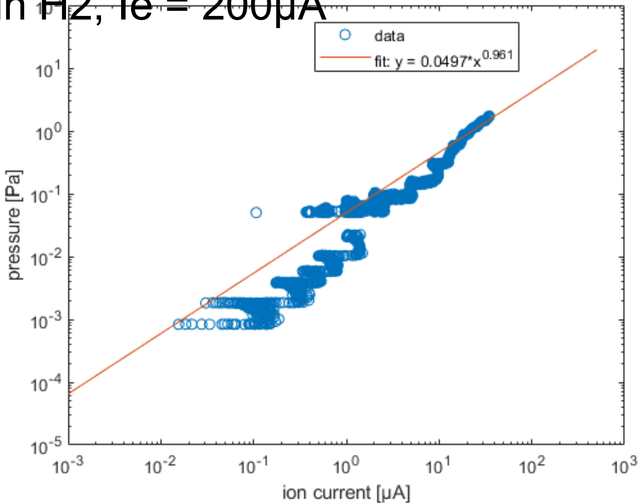
- ☐ SEM and TEM will be used to study the He plasma induced nano structure in W and pre-irradiated W.

Calibration of the LaB6 pressure gauges (V. Haak and U. Wenzel)

Special thanks to LHD experiment group



Calibration of cathode 7I before (7th October, top) and after the campaign (17th February, bottom) in H2, Ie = 200µA



date	Electron current	Fit function	Sensitivity
7th Oct	50 µA	P = 0.09*I^0.90	0.63 /Pa
17th Feb	50 µA	P = 0.14*I^0.95	0.32 /Pa
7th Oct	200µA	P = 0.036*I^0.95	0.25 /Pa
17th Feb	200µA	P = 0.050*I^0.96	0.18 /Pa

- Calibration of the pressure gauges before (7th Oct) and after the campaign (17th Feb) in H2, D2 and He at different electron currents
- Calibration results in H2 from cathode 7I are compared here
- Exponential fit functions as well as sensitivity changed slightly for higher electron currents (200µA)
- Stronger deviation from the original calibration function for 50µA