# (TG1) Multi-ion group report

Jan. 12, 2022 (M. Kobayashi)

Date: Jan. 12, 2022
Time: 9:48 – 15:11
Shot#: 176038 – 176132 (95 shots)

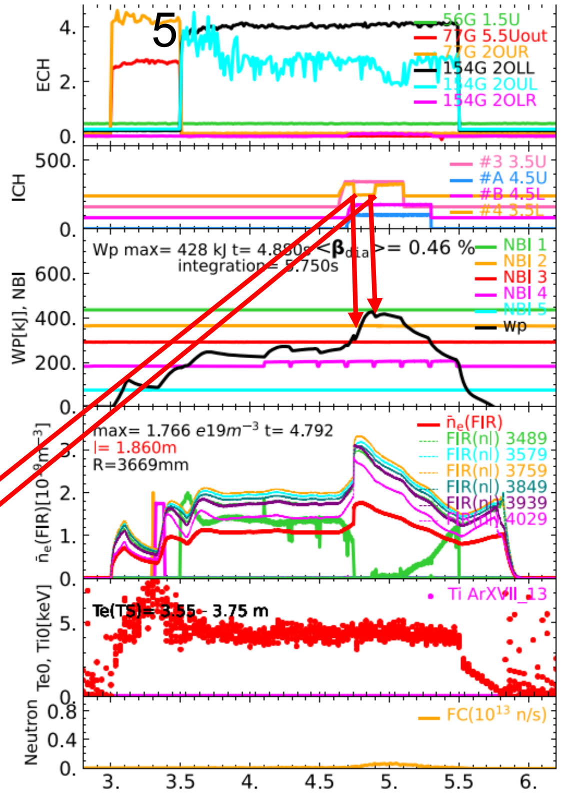
Prior wall conditioning: D2
Divertor pump: On
Gas puff: D2, H2   IPD: No
LID: No
NBI#(1, 2, 3, 4, 5)=gas(H, H, H, H, )=P(3.5, 2.6, 3.8, 1.8/1.7, /) MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(979, 930, 986) kW
ECH(116GHz)=ant(2O-LR)=P(-)kW
ECH(56GHz)=ant(1.5-U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(0.845, 0.774, 0.749, 0.408) MW
Neutron yield integrated over the experiment = $1.6 \times 10^{14}$

Topics
1. Effect of the 3-ion ICRF heating on impurity exhaust in stellarators (D. Moseev, H. Kasahara)
2. (Deuterium) Exposure of material (W-alloys) samples into the edge plasma by means of the LHD manipulator (C.P. Dhard, S. Masuzaki)
3. Isotope effects in high-density ECH plasma after hydrogen isotope ice pellet injections (T. Tsujimura)

# ICRF-facilitated impurity exhaust, 12.01.2022
# [Moseev, Kasahara, Tamura]

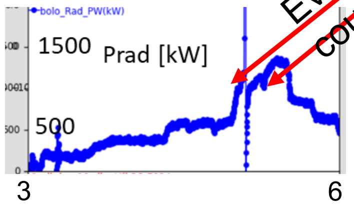
**Background:**
Coupling of ICRF to impurity may lead to targeted exhaust. 3-ion ICRF scheme, which depends on H/D ratio, was successfully tried at LHD in Dec. 2020.

17605
5



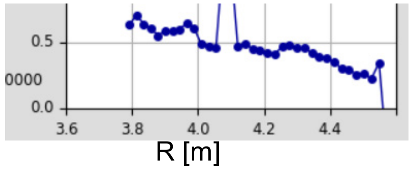

t
[s]

176055

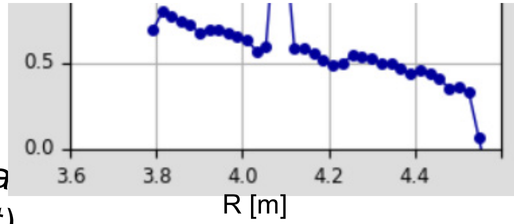



Evidence of poor coupling

176055, H/(H+D) ratio @ @5s




176065, H/(H+D) ratio @ 5.03 s




H/(H+D) ratio when NBI4 ha source A (left) and A+B(right)

**Current experiments: look promising, waiting for CXS impurity profiles**
Similar experiments are being conducted with H/D ratio and Tespel with 2 different impurities: Li and F. Teflon was also available.

NBI4 worked either with only source A and with sources A and B. H/D ratio influenced insignificantly, generally rather high. Sometimes problems with RF coupling from single-strap antenna.

**To-do:**
Impurity analysis is yet to be performed as soon as data is available

# Exposure of W alloys samples to divertor plasma

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

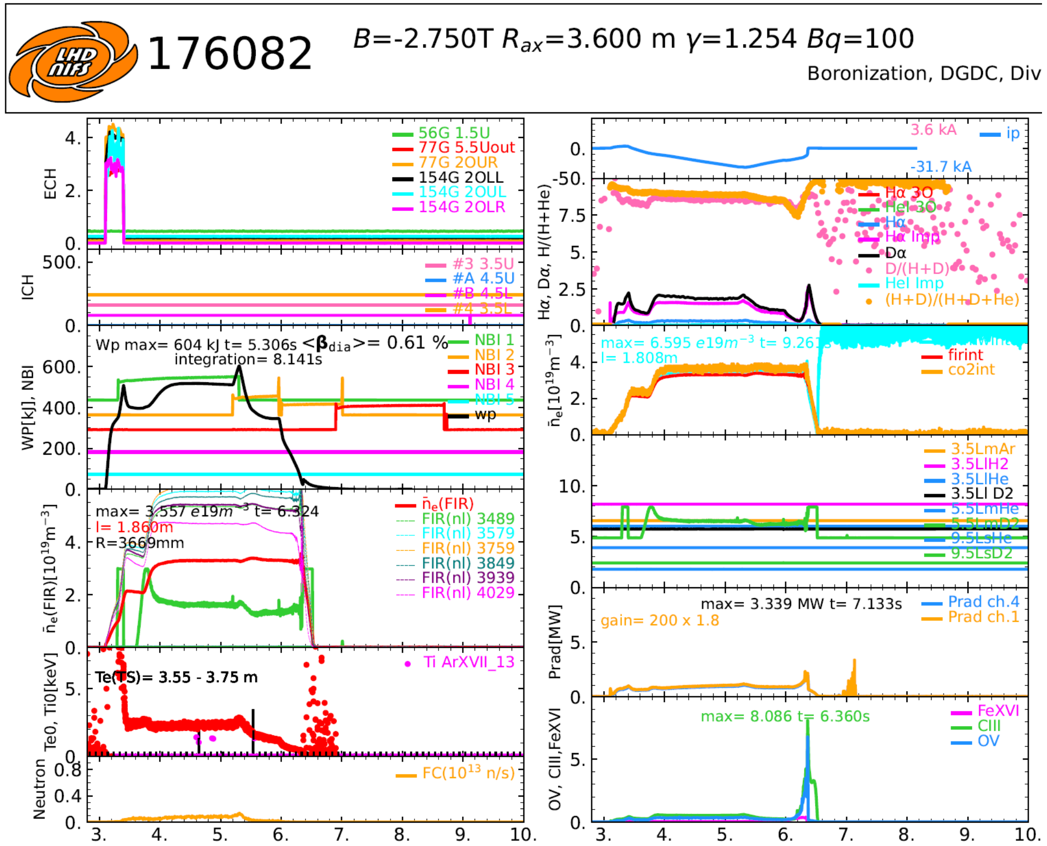
Shot #: 176074 - 176094
($R_{ax}$, $B_t$, $\gamma$, $B_q$) = (3.6 m, -2.75 T, 1.2538, 100.0%)
Working gas: D2
$P_{NBI\text{-}1}$ ~ 3.7 MW, $P_{NBI\text{-}2}$ ~ 2.7 MW, $P_{NBI\text{-}3}$ ~ 3.7 MW
Three t-NBIs were injected in a “train”-style

**Motivation**

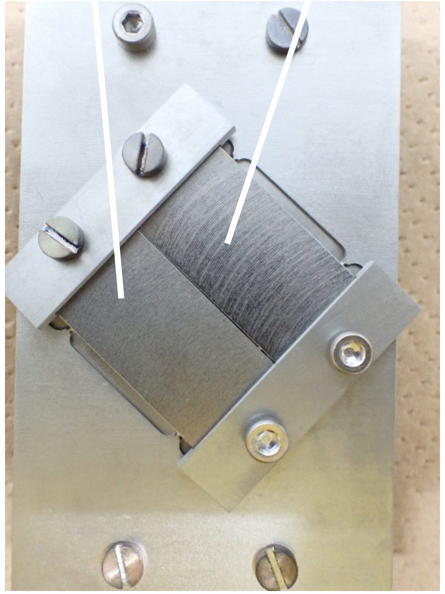
- Tungsten is an appearing as a potential material for fusion reactor application. However,, because of its hardness and brittleness it is not so easy to manufacture thin tiles with edges in the order of 1-2 mm. W-alloys are being explored to overcome these problems.
- In this experiment, W-alloys samples are exposed to the LHD divertor plasma to investigate influences of them on plasma operation, and effects of the exposure on samples properties.

**Results**

- ✓ Two W alloys (W-Cu/Ni, W-Fe/Ni) samples were exposed to divertor plasma using the manipulator at 10.5L port.
- ✓ Total ~60s exposure was conducted.
- ✓ Line averaged density was kept to be ~ 3E19/m3.
- ✓ No influences on plasma operation.
- ✓ Line emission of W is not significant,
- ✓ Surface analyses will be conducted soon.




Summary of a typical discharge in this exp.




W alloys
(before exposure)

# Isotope effects in high-$n_e$ ECH plasma after hydrogen isotope ice pellet injections

T. Tsujimura

**Experimental conditions:**

($R_{ax}$, $B_t$, $\gamma$, $B_q$) = (3.60 m, CCW 2.85 T, 1.2538, 100.0%)

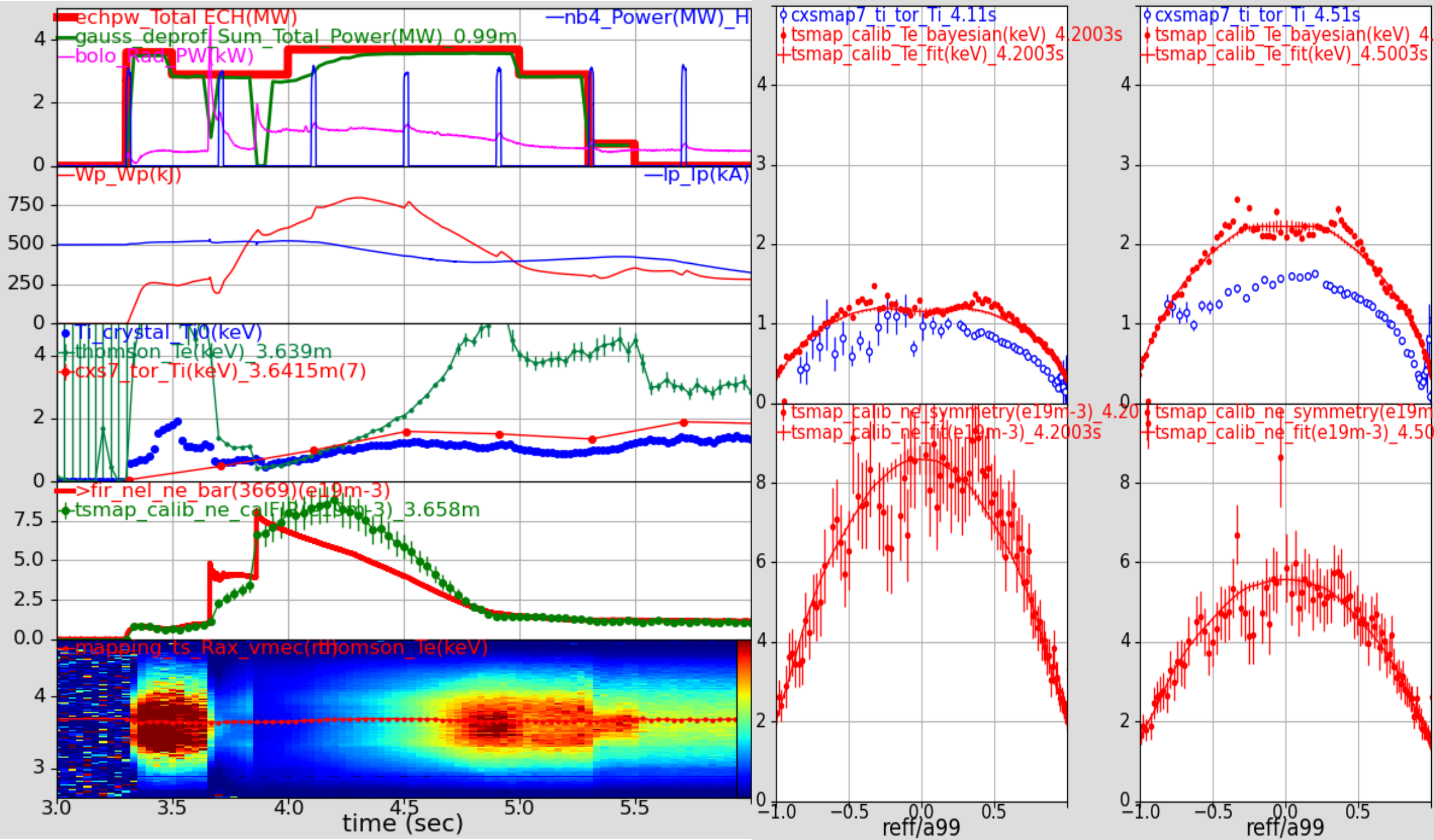
**Results:**

- Typical discharge is shown in the figure at the right (#176113).
- High-$n_e$ ECH plasma was sustained after injection of two D pellets together with D gas puff.
- D rich condition was obtained: D/(D+H) ~ 0.8.
- Max. $n_{e0}$ ~ 8x10$^{19}$ m$^{-3}$, $T_{e0}$ ~ $T_{i0}$ ~ 1 keV
- Thermal relaxation from electrons to ions increased $T_{i0}$ ~ 1.5 keV at $T_{e0}$ ~ 2 keV, $n_{e0}$ ~ 5x10$^{19}$ m$^{-3}$.
- $n_e$ peaked, $T_e$ flat or hollowed, $T_i$ peaked

**Motivation:**

- In this campaign, the third 154-GHz gyrotron is functional in full power.
- In contrast to 21$^{st}$ campaign, experimental data in wide ranges of ECH power and $n_e$ were accumulated to discuss isotope effects in high-$n_e$ ECH plasma.

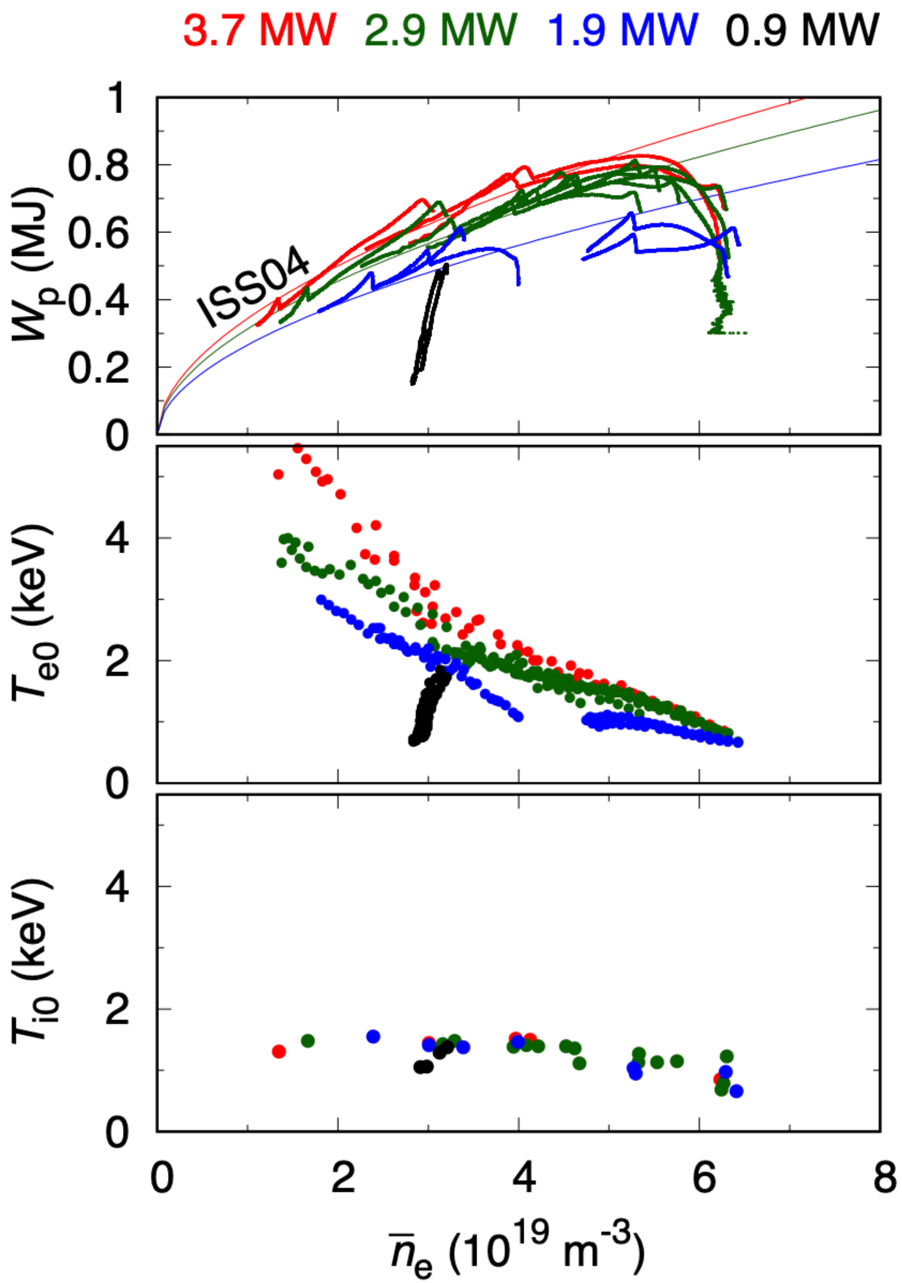
#176113



## Results (cont.):

- Injection power $P_{ECH}$ was scanned from 0.9 MW to 3.7 MW with one 77 GHz perpendicular injection and three 154 GHz oblique injection.
- $n_{e,bar}$ was scanned from 1x to 6x$10^{19}$ $m^{-3}$ by changing the number of pellets: one or two.
- $W_p$ was almost along ISS04.
- $T_{i0}$ was almost 1-1.5 keV in the scanned $n_e$ range as $T_{e0}$ decreased.

- H pellet experiments are planned in next week.
- $n_e$ fluctuations were measured with PCI and DBS to discuss ion scale turbulence.
- Power balance analysis will be performed in comparison with neoclassical and turbulent transport.
- Comparison with W7-X pellet discharges is desirable.




plotted from 4.0 s to 5.0 s in [176102, 176103, 176104, 176106, 176109, 176111, 176112, 176113, 176114, 176116, 176118, 176120, 176121, 176122, 176123, 176125, 176128]

$$P_{ei} \propto \frac{Z_i^2 {n_e}^2}{m_i T_e^{3/2}} (T_e - T_i)$$