(TG3) Spectroscopy Topical Group Report

Dec. 21, 2021 (T. Kawate)

Date: Dec. 21, 2021
Time: 9:30 – 18:45
Shot#: 175548 – 175707 (160 shots)

Prior wall conditioning: H_2
Divertor pump: On
Gas puff: H_2, D_2, He, Ne
Pellet: $CaAl_2O_4$ (TESPEL)

NBI#(1, 2, 3, 4, 5)=gas(H, H, H, D, D)=P(3.1, 4.2, 3.9, 5.2, 4.5)MW

ECH(77GHz)=ant(5.5-Uout (or 1.5U), 2-OUR)=P(710, 790)kW
ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(970, 920, 980)kW
ECH(56GHz)=ant(1.5U)=P(-)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L)=P(-, -, -, -)MW
Neutron yield integrated over the experiment = 3.6×10^{15}

Topics

1. Calibration of Solar EUV Spectrometers and Validation of Diagnostic Capability for Solar High-Temperature Plasmas by LHD Experiments (H. Hara, I. Murakami)
2. Polarization spectroscopy for the study of anisotropy in the electron velocity distribution function (M. Goto)
3. Study of deuterium molecular band emission in LHD: excited and ground state population as function of divertor conditions (S. Brezinsek, M. Goto, M. Kobayashi)
4. Deuterium retention in damaged tungsten (M. Zhao, S. Masuzaki)
5. ablation of high Z and hydrogen cryogenic pellets and its implication to ITER DMS design (A. Matsuyama, R. Sakamoto)

Ca TESPEL Injection for emission line diagnostics

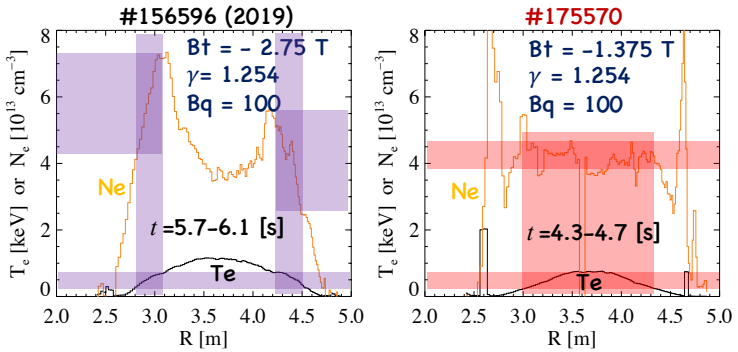
H. Hara, Murakami, I., Kawate, T., Oishi, T., et al.

Objectives:

- Validation of plasma diagnostic capability by Ca emission line ratios for studying the solar corona

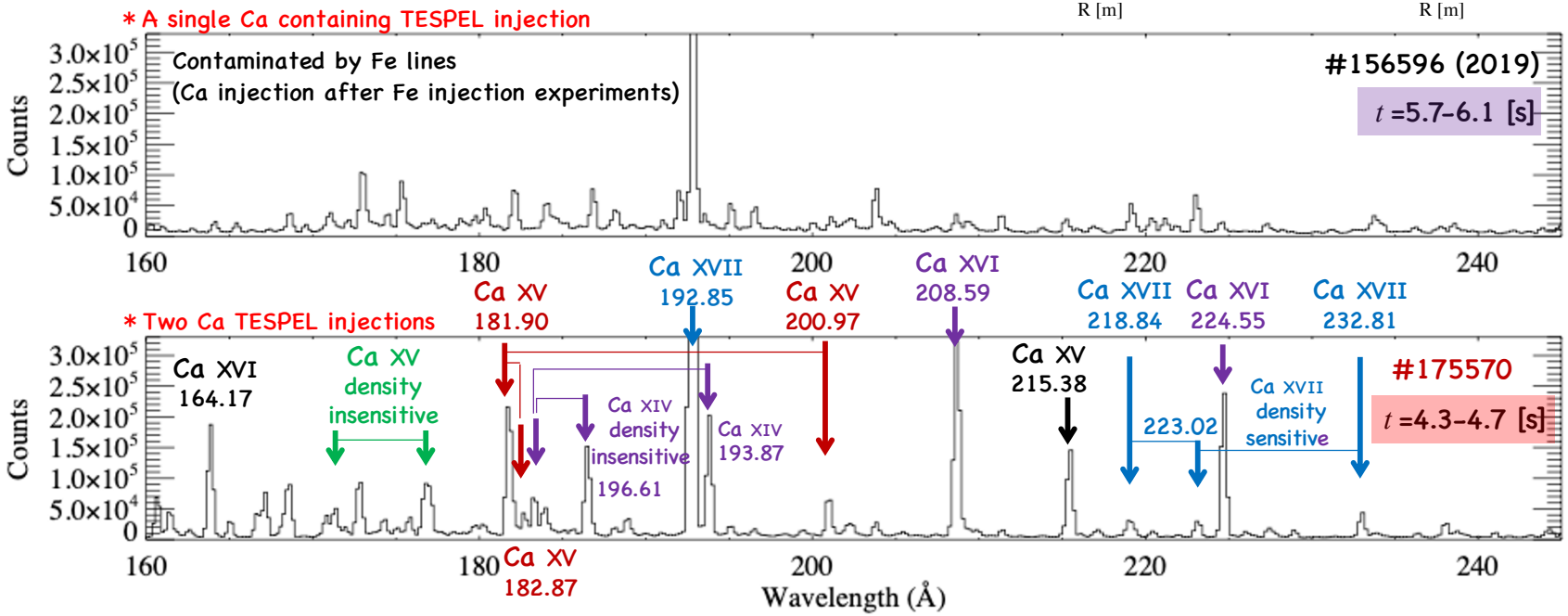
Experimental Conditions:

- H gas, Bt=-1.375 T, γ=1.254, Bq=100
- Ca contained TESPEL injection at 4.25 sec
- #175550-#175580 (31 shots)



Results:

- We have clearly detected Ca XVII, Ca XVI, Ca XV & Ca XIV lines.
- Ca XV density-sensitive line pairs have successfully been observed by a low-temperature plasma condition.



Polarization spectroscopy for the study of anisotropic EVDF

Experimental conditions:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.9 m, CCW, 2.538 T, 1.2538, 100.0%), (3.6 m, CCW, 2.75 T, 1.2538, 100.0%)

Objective and method:

- Quantitative relationship between polarization of hydrogen Lyman-α line and anisotropic EVDF is being investigated.
- By rotating a polarizer, different polarization angle spectra are observed in the course of time for a steady state phase of each discharge (Fig. 1).
- Data are collected for a wide density range and for different magnetic configurations.

Results:

- By introducing a toroidal aperture which limits the field of view in the toroidal direction, the absolute polarization degree looks to be decreased.
- Density dependence is still observed (Fig. 2).
- No clear difference is observed between R_{ax} = 3.6 m and 3.9 m cases (Fig. 3).

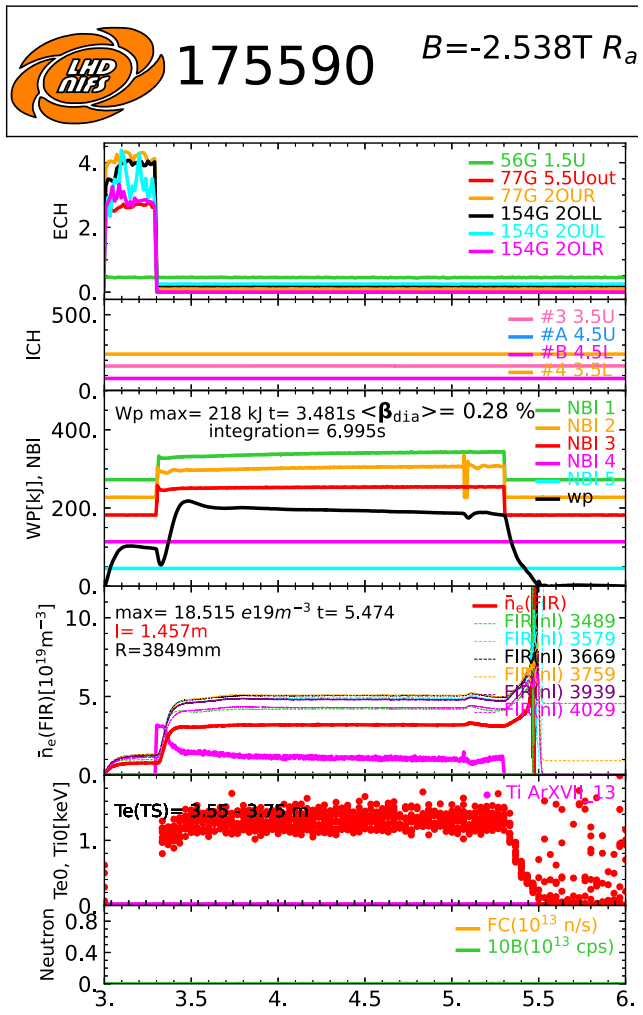


Fig. 1

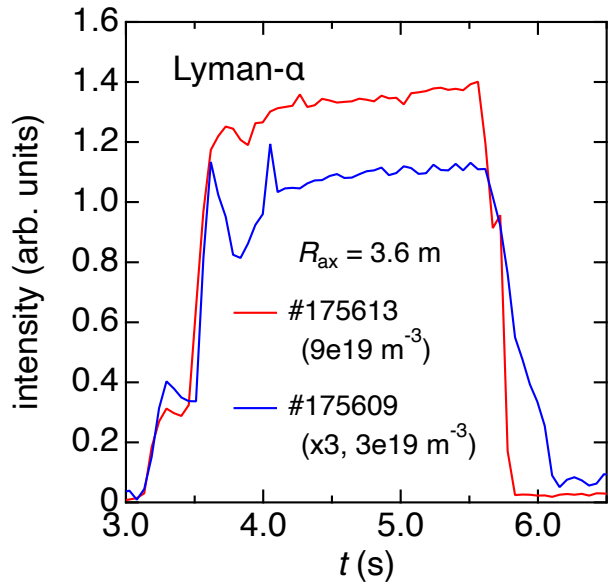


Fig. 2

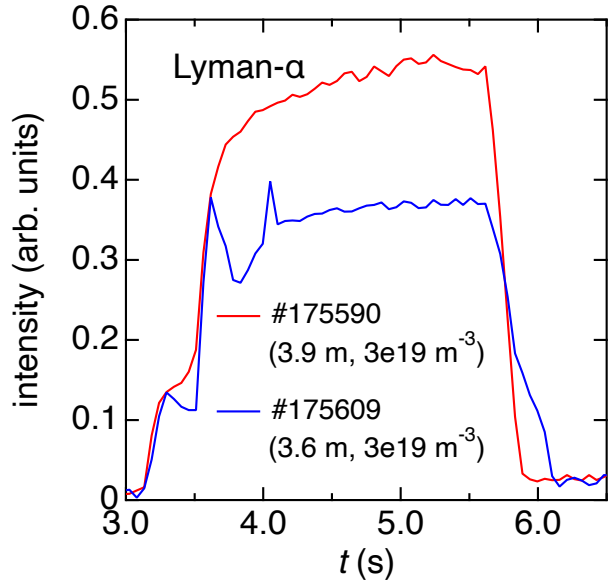
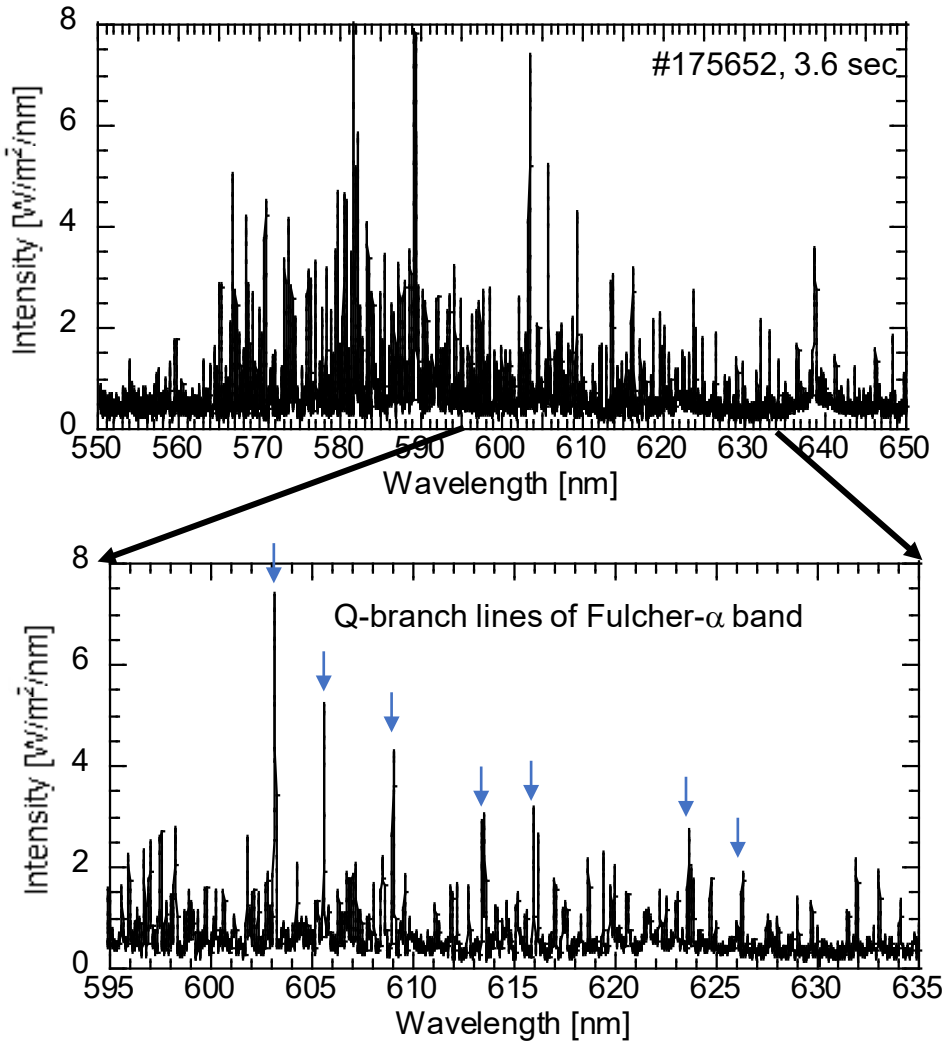


Fig. 3

Study of deuterium molecular band emission in LHD: excited and ground state population as function of divertor conditions (S. Brezinsek, M. Goto, M. Kobayashi et al.) 2021.12.21

Background & Objectives:
Hydrogen molecule plays an important role in the divertor detachment through their rotational & vibrational states. The present experiment has been conducted to obtain database of the molecular spectra to evaluate rotational & vibrational temperature in various divertor plasma conditions.

Results: Dataset of NBI & density scan was obtained as shown in the table. The molecular spectra were measured with several spectrometers in visible and VUV range. Figure shows an example of the Fulcher-α band spectra obtained by the Echelle spectrometer viewing the divertor region. Q-branch lines are identified. Detailed analysis will be conducted in future.



NBI#

n_e (10^{19} m^{-3}) \	1	3	1,2	5	4,5	2,3,4	1,2,3	2,4,5	1,2,3,4	2,3,4,5	1,2,3,4,5
1	175655, 175656	175655, 175656, 175657	175567				175629		175639 (i), 175640		175641
3		175654	175654	175637, 175638, 175640		175637	175628, 175630,		175638		175643
5				175636	175630, 175631		175631		175636		175644(i), 175645
7			175653	175635	175632		175632	175648	175635	175647	175649, 175658(i), 175659(i)
10					175633		175633		175634		175650(i), 175652

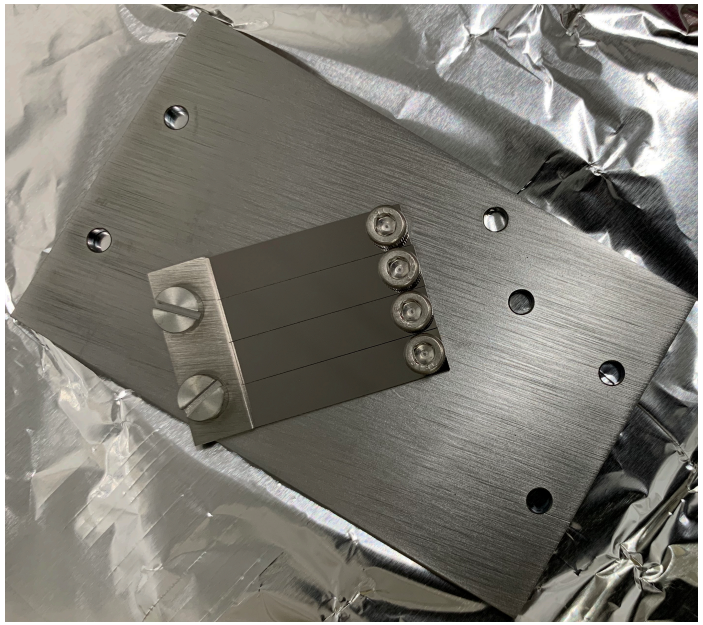
(i) means NBI breakdown

Deuterium retention in damaged tungsten (D/He mixture plasma)

Motivation: Distribution of hydrogen isotopes retention in tungsten at LHD divertor strike line.

D/He mixture plasma exposure for W titles was conducted.

- **Material**: Mirror finish ITER grade W tiles (28×6×1).
- **Iron (Fe) ion irradiation**, with peak damage 1dpa, was performed to simulate neutron irradiation defects.



LHD experiment

- Experiment time:2021/12/17.
- Shot number: #175661-#175679.
- Sample exposure: #175675-#175679.
- NBI-1, NIB-2, NBI-3: ~3.7 MW.
- B=2.750T, Rax=3.6 m, **γ**=1.254, Bq=100.

- #175661-#175664, high density D plasma was conducted to reduced H content.
- #175665-#175673, adjust He ratio in plasma by discharge with or without He puffing.
- #175674, NBI training.
- ##175675-#175679, W samples were exposed to D/He mixture plasma.

Next plan:

- D and T retention, deposition, microstructure modification will be studied by IP, NRA, RBS, SEM, TEM, TDS.

Ablation study of neon and hydrogen cryogenic pellets used by ITER DMS

A. Matsuyama (QST), R. Sakamoto

Experimental condition:

(R_{ax}, Polarity, B_t, γ, B_q) = (3.6 m, CCW, 2.75 T, 1.254, 100.0%)

Objective and method:

- **ITER Disruption Mitigation System (DMS)** will inject a mixture of hydrogen and neon by means of Shattered Pellet Injection (SPI) and the extrapolation of the performance relies on the pellet ablation study.
- This work is aimed at observation of the pellet penetration depth (ablation) and post-injection plasma profiles (assimilation)
  - On 21 cycle – Pure Ne doped pellets into NBI pulses
  - On Exp. Oct 27 – 10 % Ne doped pellets into NBI/ECH pulses
  - On Exp. Dec 21 (yesterday) – < 5% Ne doped pellets into NBI/ECH pulses

→ Expect better resolution of the TS data with decreasing neon fraction (T_e>20 eV)

Results (#175680 - #175707)

- By decreasing neon fraction and tuning the experimental setup, the post-injection profiles have clearly been measured. Preliminary analysis supported smaller outward transport of the ablated material for neon mixed pellets. → Deeper material deposition was clearly measured for the first time (major objective of this work has been achieved.)
  - Analysis of fast TS data would be quite interesting.
- Pellet ablation database will support the experimental results quantitatively:
  - Pellet penetration depth has been measured for various conditions (ECH/NBI, density scan, multiple injection)

Future plan

- Pure neon injection into ECH discharges to complete the database

Pure hydrogen (ECH) | 5% Neon mixed (ECH)

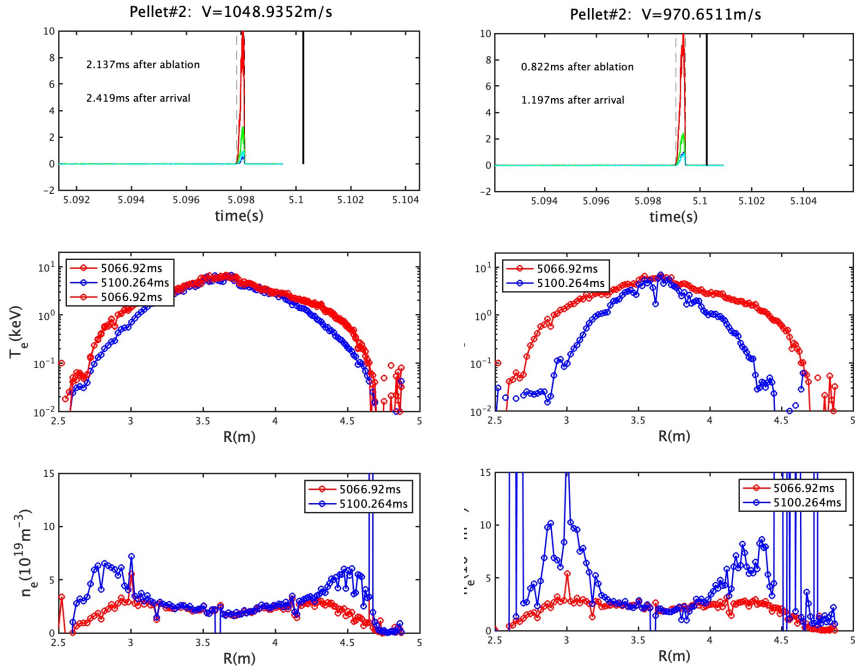


Fig. 1 T_e & n_e profiles after injection

Tab. 1 Status of pellet ablation database

	NBI	ECH
Pure H	12/21 + many shots	12/21 + 21-22cycle
< 5% Neon	12/21	12/21
10% Neon	10/27	10/27
Pure Ne	21 cycle	x