(TG1) Multi-ion group report

Date: Dec. 3, 2021 Dec. 7, 2021 (H. Kasahara)
Time: 13:00– 18:45
Shot#: 174195 – 174299(105 shots)

Prior wall conditioning: No
Divertor pump: On (except for 2-I)
Gas puff: D2, Ne, Pellet: D2, SSGP: H
LID: No

NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, D)=P(2.64, 2.83. 2.73, 8.45, 8.01)MW
ECH(77GHz)=ant(5.5-U, 2-OUR)=P(0.70, 0.79)MW
ECH(154GHz)=ant(2-OLL, 2-OUL, 2O-LR)=P(0.72, 0.80, 0.83)MW
ICH(3.5U, 3.5L, 4.5U, 4.5L) = P(1.0, 0.76, 1.0, 0.55) MW
Neutron yield integrated over the experiment = 5.9×10^{16}

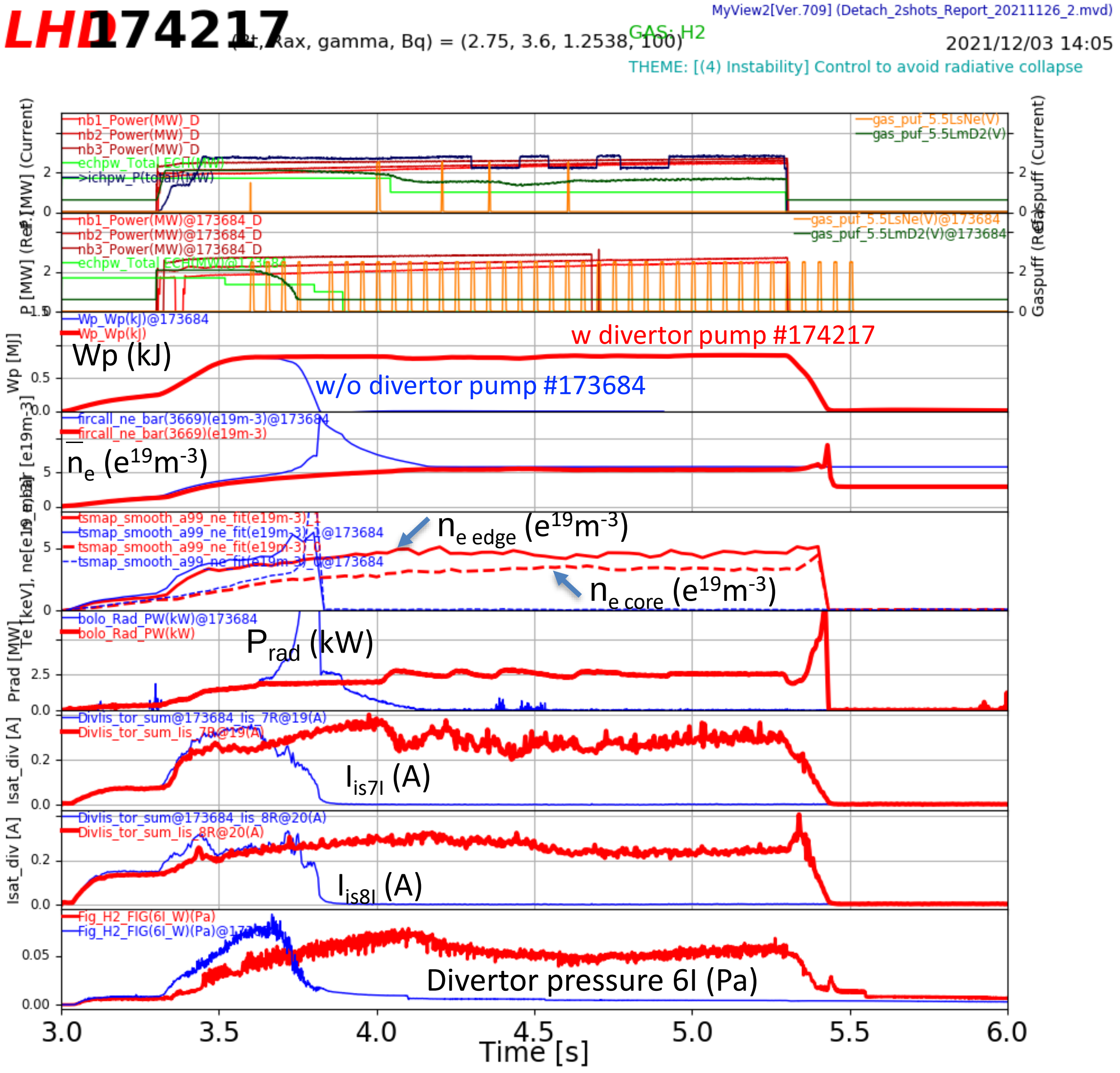
Topics

1. Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum / NEG pumps operation(C.P. Dhard, G. Motojima)
2. High density plasma heating using ICH. ECH and NBI(H. Kasahara)
3. Reconstruction of the 5D phase-space distribution function (M. Nishiura)

Studying the dependence of neutral particle pressures in the divertor region on cryo-vacuum / NEG pumps operation

(C.P. Dhard, D. Naujoks (IPP), G. Motojima, S. Masuzaki, K. Mukai (NIFS))

- ✓ Experimental conditions:
  - ❖ Shot No: 174195-174224
  - ❖ B_t, R_{ax}, γ, Bq = (+2.75, 3.6, 1.254, 100)
- ✓ Motivation and objective:
  - ❖ In-vessel vacuum pumps play an important role for the exhaust of neutral particles in the divertor region resulting into a significant impact on the plasma density control and attaining detached plasma operation.
  - ❖ We propose to analyze the performances of the in-vessel pumps in the detached and partially detached plasma operations with and without divertor pumping.
- ✓ Results:
  - ❖ NBI#1-3, ECH and ICH were utilized for heating.
  - ❖ The data set in the case "with divertor pumping" was obtained.
    - Attached vs. Detached with Neon puffing
    - n_e: 2×10^{19}, 5×10^{19} m^{-3}
    - Two main pumps, one main pump
  - ❖ Neon was controlled by feedback signal of radiation power, P_{rad}.
  - ❖ With divertor pumping, the plasma was sustained even in high density of 5×10^{19} m^{-3} with Neon seeded case.



High density plasma heating in NBI, ECH and ICH (H.KASAHARA)

Background and objective

- High density plasma discharge is desirable in designing a fusion reactor, but it is difficult to heat the plasma center. Challenging high density plasma production by combining various heating methods.

Experimental Condition (#174225~174278)

- Comparison of density and temperature profiles and heating efficiency in various densities on the standard magnetic field configuration(R_{ax}=3.6m, B=2.75T, B_q=100%, γ=1.254) with combining tangential NBI(tNBI), perpendicular NBI(pNBI) and ICH.

Results

- Three tNBIs and double deuterium pellet injections were essential to produce high-density plasmas, and feedback gas puffing alone could not produce high electron densities above 8×10^{19} m^{-3}. (Fig. 1).
- In ICH, Hydrogen supply by SSGP(10ms) was also attempted to predict D(H) minority ion heating, but no result was obtained to increase the hydrogen ratio in the plasma.
- By superimposing ICH on the high-density NBI plasma, a clear increase in the electron temperature at the center of the plasma was confirmed.
- We compared the heating efficiency from "break-in-slope" method for three different heating combinations(1:BL4(tNBIs+BL5), 2:BL5(tNBIs+ICH), 3:ICH(tNBIs+BL5)). The heating efficiency of BL5 was the highest, and BL4 and ICH were comparable.

LHD174267, B_{ax} = 2.75T, R_{ax} = 3.6m B_q = 100%, γ = 1.254

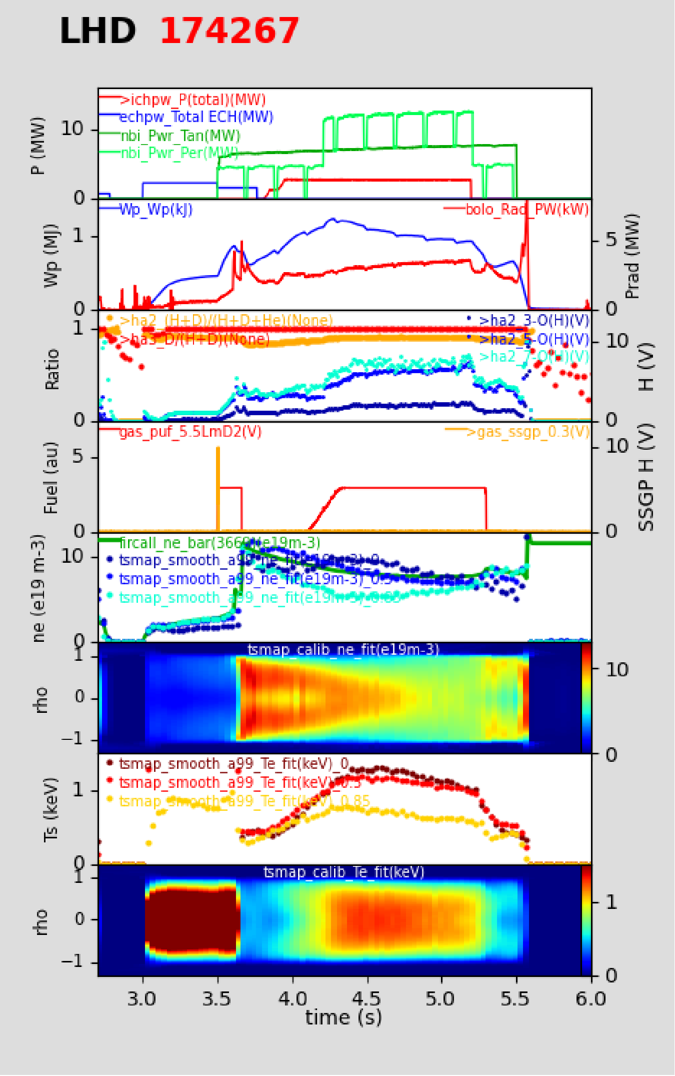


Fig. 1 discharge waveform

High density plasma heating in NBI, ECH and ICH (H.KASAHARA)

B_{ax} = 2.75T, R_{ax} = 3.6m B_q = 100%, γ = 1.254

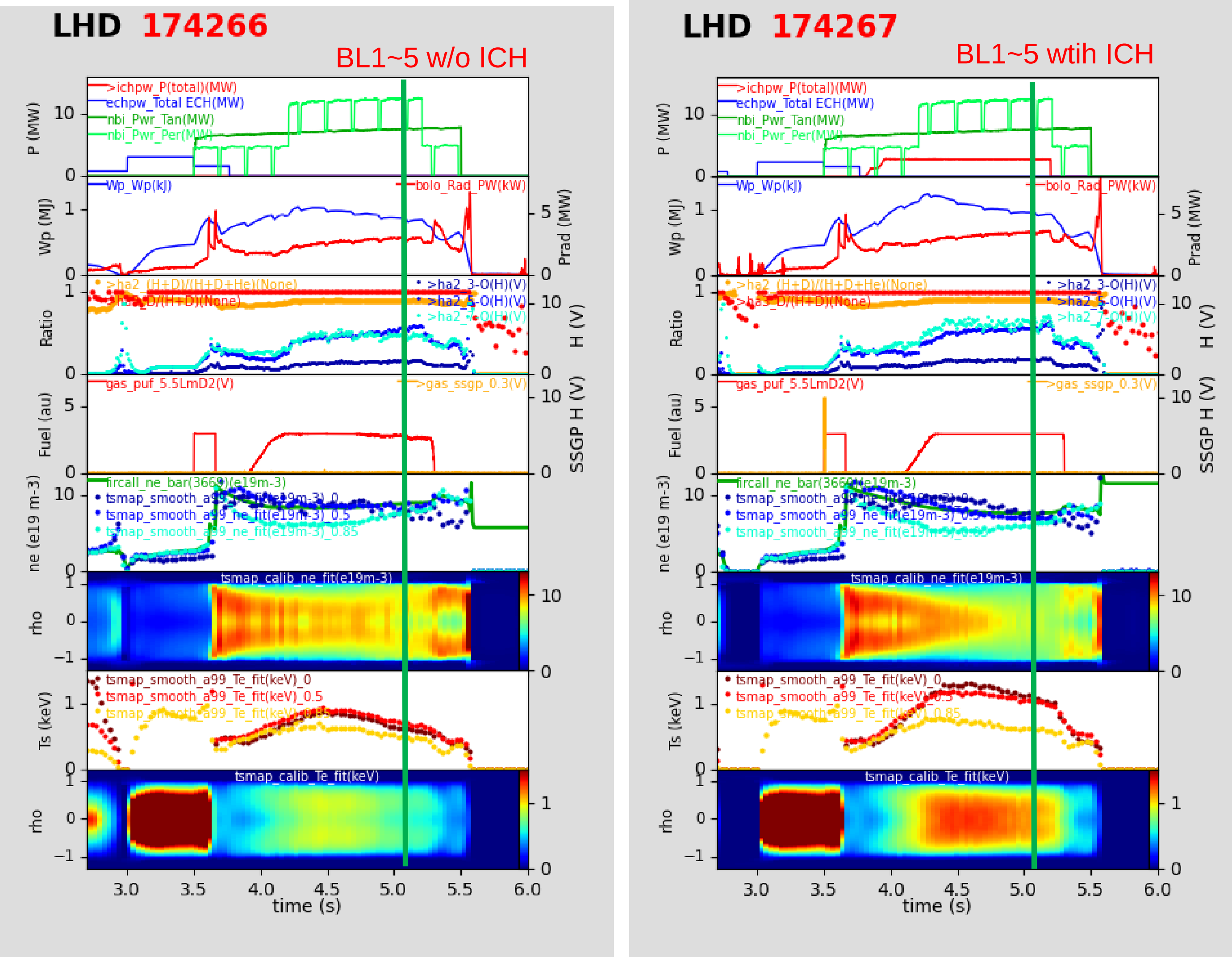
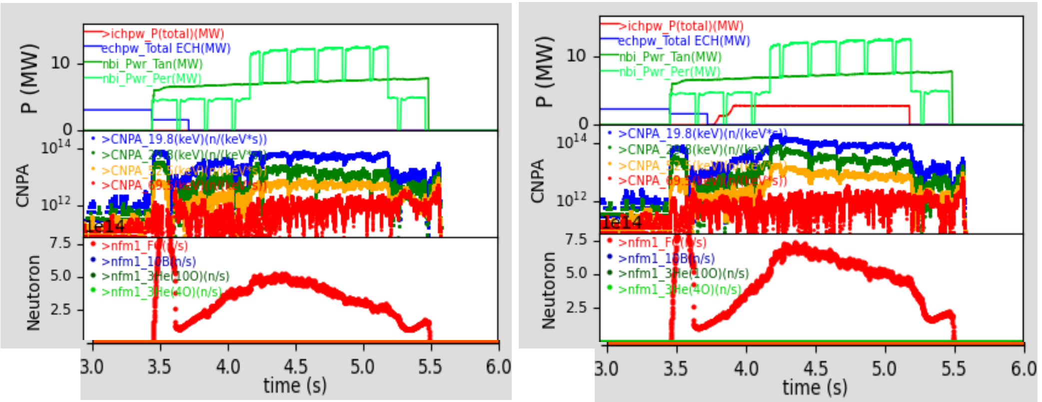


Fig.2 Difference in high density plasma when ICH is superimposed on NBI plasma

Table 1. Typical plasma parameters.

t_0 = 5.08s	174266 (BL1~5)	174267 (BL1~5+ICH)
n_{e0} ($\times 10^{19}$ m^{-3})	7.87	7.74
T_{e0} (keV)	0.63	1.12
Neutron (n/s)	3.05e+14	4.91e+14
P_{NBI} (MW)	20.17	19.98
P_{ICH} (MW)	0	2.80



Neutron count rate increased in proportion to increase in electron temperature

High density plasma heating in NBI, ECH and ICH (H.KASAHARA)

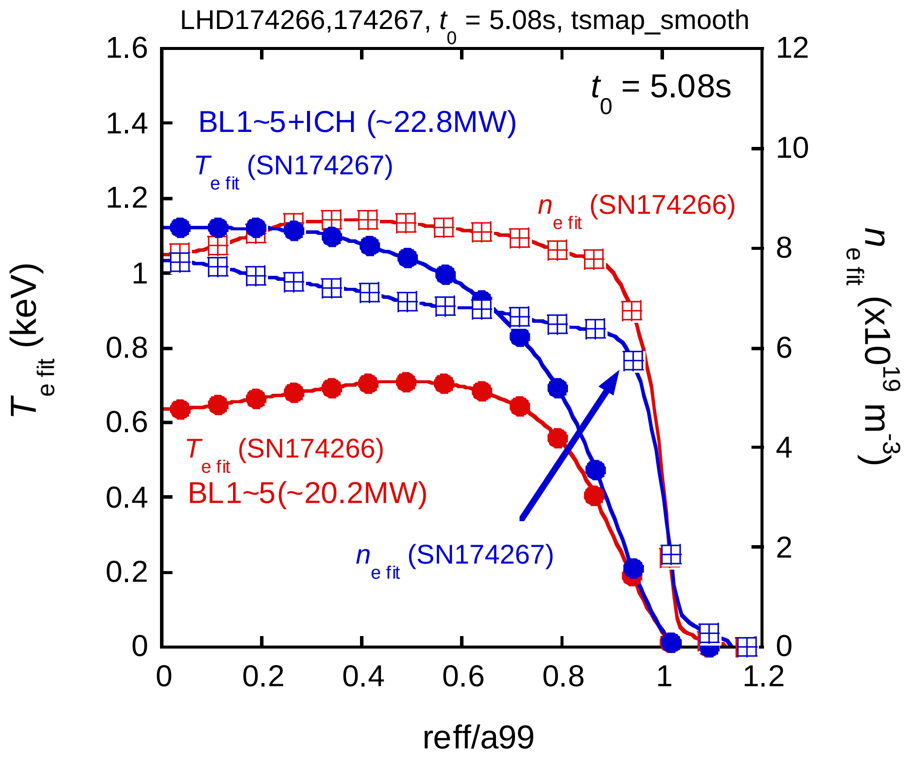


Fig.3 Parabolic electron temperature profile was achieved with the combination of NBI and ICH

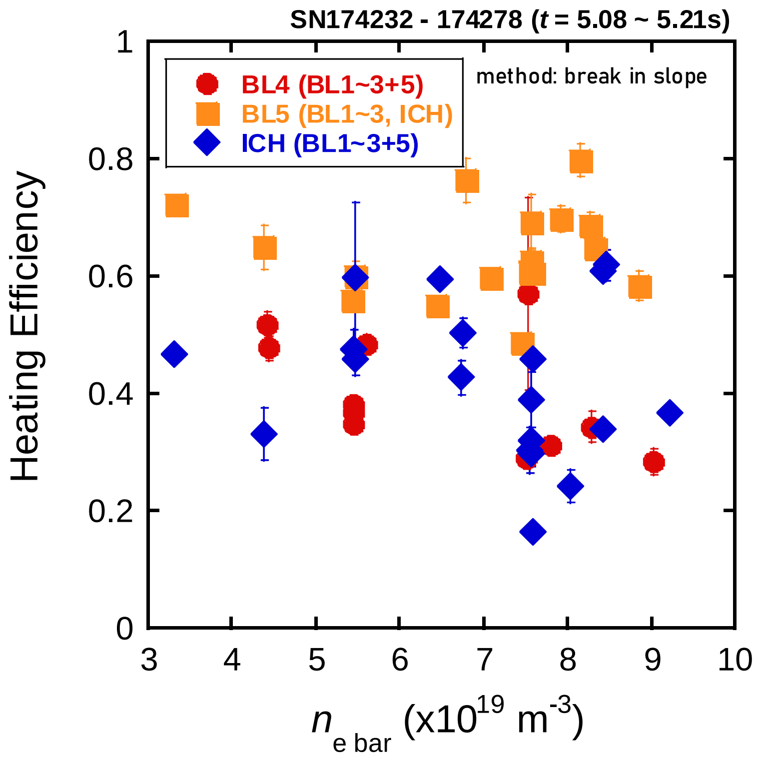
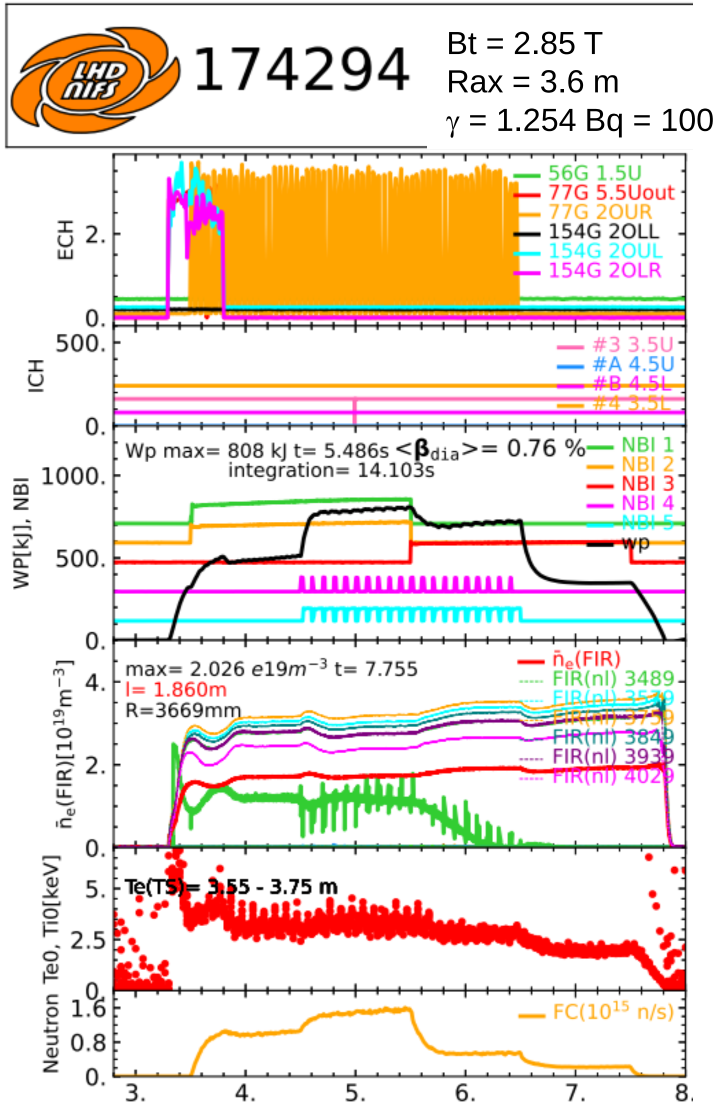


Fig. 4 Heating efficiencies in various electron densities.

5D-velocity space tomography for fast ions

M. Nishiura, D. Moseev, N. Kenmochi, R. Yanai



- #174279 - # 174309 (Rax=3.6m, Bt=2.85T, gamma=1.254, Bq=100%)
- Fast ions was measured by FIDA and neutron diagnostics. Those data are combined for a tomographic inversion to reconstruct a velocity distribution. Denmark group has demonstrated the velocity space analysis combining FIDA and neutron diagnostics (B. Madsen et al., PPCF 62(2020)115019).
- CTS has joined the velocity space analysis in the experiments. However, the data was not obtained during the machine time due to the damage of the CTS receiver.
- The obtained data is used for the velocity space analysis of fast ions.