(TG4) Plasma instability group report

Dec. 9, 2021 (S. Kamio)

Date: Dec. 8, 2021
Time: 9:40 - 15:00
Shot#: 174466 – 174551 (86 shots)

Prior wall conditioning: No
Divertor pump: On
Gas puff: D2 and H2, Pellet: No
NBI#(1, 2, 3, 4, 5)=gas(D, D, D, D, D)=P(2.5, 1.7, 2.0, 6.8, 7.2)MW
ECH(77GHz)=ant(5.5-Uout (or 1.5U), 2-OUR)=P(703, 792)kW
ECH(154GHz)=ant(2-OLL, 2-OUL , 2-OLR)=P(723, 799, 825)kW
ECH(56GHz)=ant(1.5U)=P(288)kW
ICH(3.5U, 3.5L, 4.5U, 4.5L)=P(0, 0, 0, 0)MW
Neutron yield integrated over experiment = 2.5×10^{16}

Topics

1. Study of velocity distribution of neutral beam and ion cyclotron range of frequency tail ions using the compact neutron emission spectrometer (S. Sangaroon)
2. Connections between ion cyclotron range instabilities in space, stellarator and tokamak plasmas (J. Lestz)

Study of velocity distribution of neutral beam and ion cyclotron range of frequency tail ions using the compact neutron emission spectrometer

S. Sangaroon (MSU), G. Q. Zhong (ASIPP), K. Ogawa, M. Isobe et al.,

Experimental conditions:

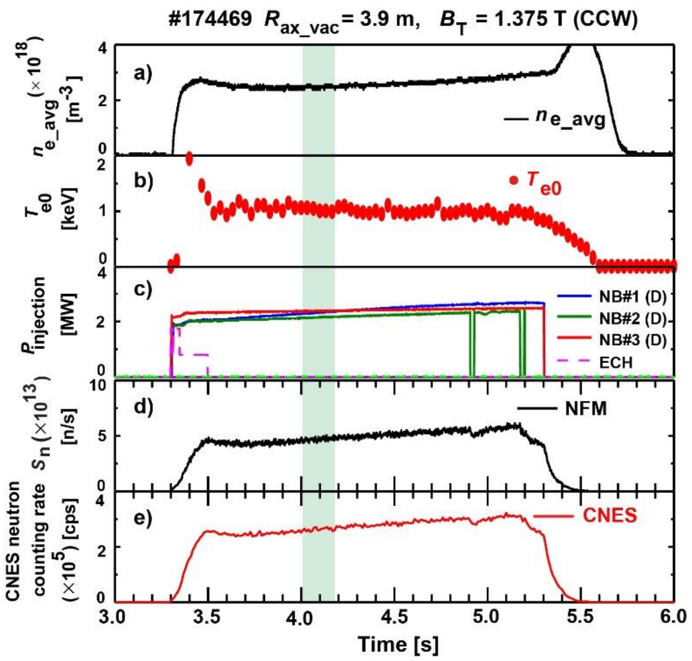
(R_{ax}, polarity, B_T, γ, B_q,) = (3.90 m, CCW, 1.375 T, 1.2538, 100.0%)

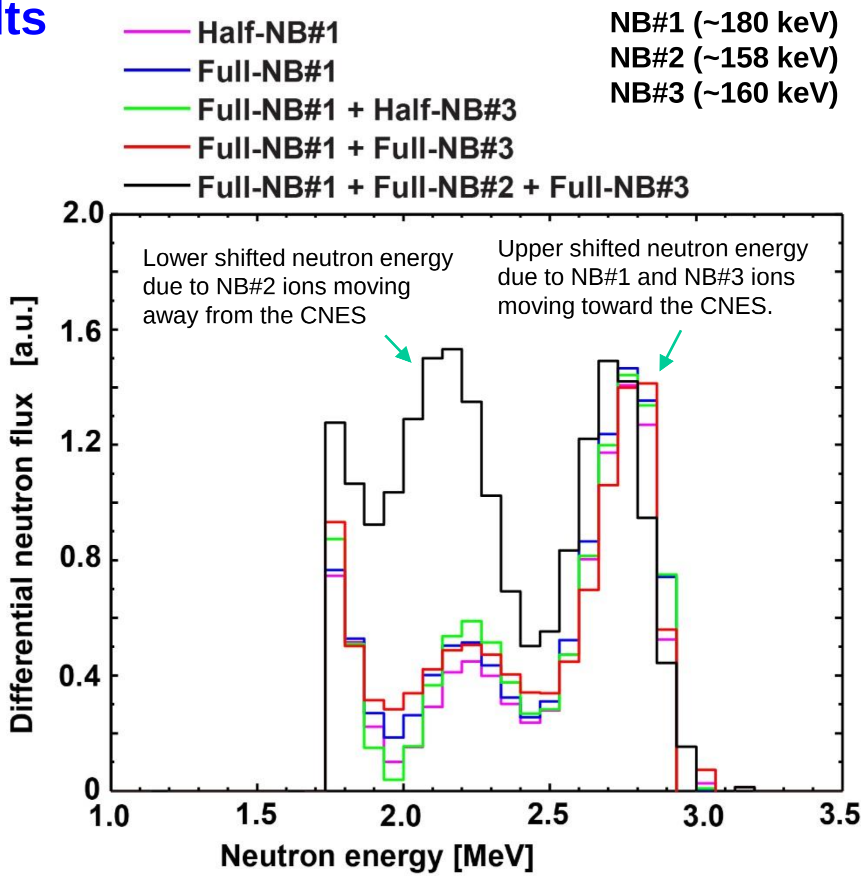
Background and motive

- Measurement of fast ion velocity distribution can contribute the systematic understanding of fast ion confinement in stellarator/helical systems and excitation mechanism of MHD instability.
- In 2020, the tangential compact neutron emission spectrometer (CNES) showed a significant Doppler shift of the neutron energy due to the high-energy tangential NB injections.
- This campaign, we measured neutron energy spectra in different NB power cases.
    - MHD-quiescent discharge (Half-NB#1) to significant fast-ion-driven instability discharge (three Full-NBs).

Results

Full-NB#1 + Full-NB#2 + Full-NB#3





The change of upper-shifted neutron energy due to the change of NB injection power

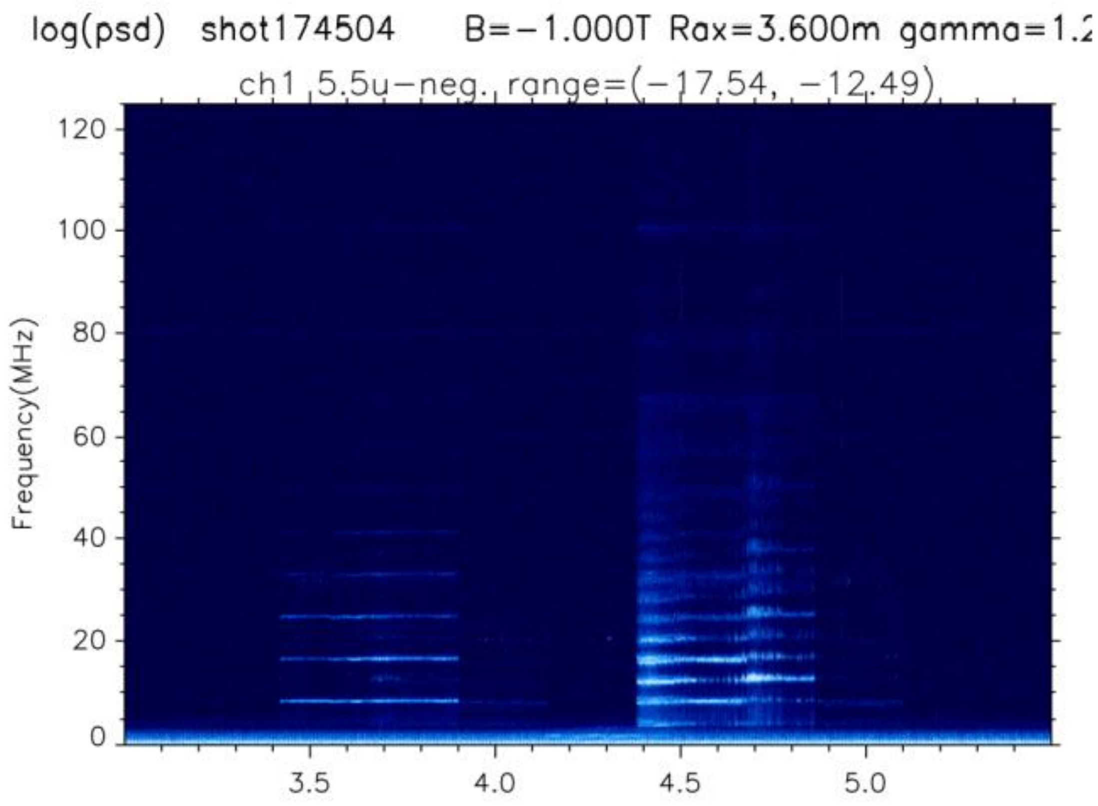
- There were no difference on the neutron energy peak (2.77 MeV) on Half-NB#1, Full-NB#1, and Full-NB#1+ Half-NB#3 cases.
- Slightly higher neutron energy peak (2.80 MeV) was obtained on Full-NB#1 + Full-NB#3 case.
- Slightly lower neutron energy peak (2.70 MeV) was obtained on Full-NB#1 + Full-NB#2 + Full-NB#3 case.

Shift of upper-shifted neutron energy suggests change of fast ion velocity distribution. <= fast-ion-driven MHD instability is one of the candidates?

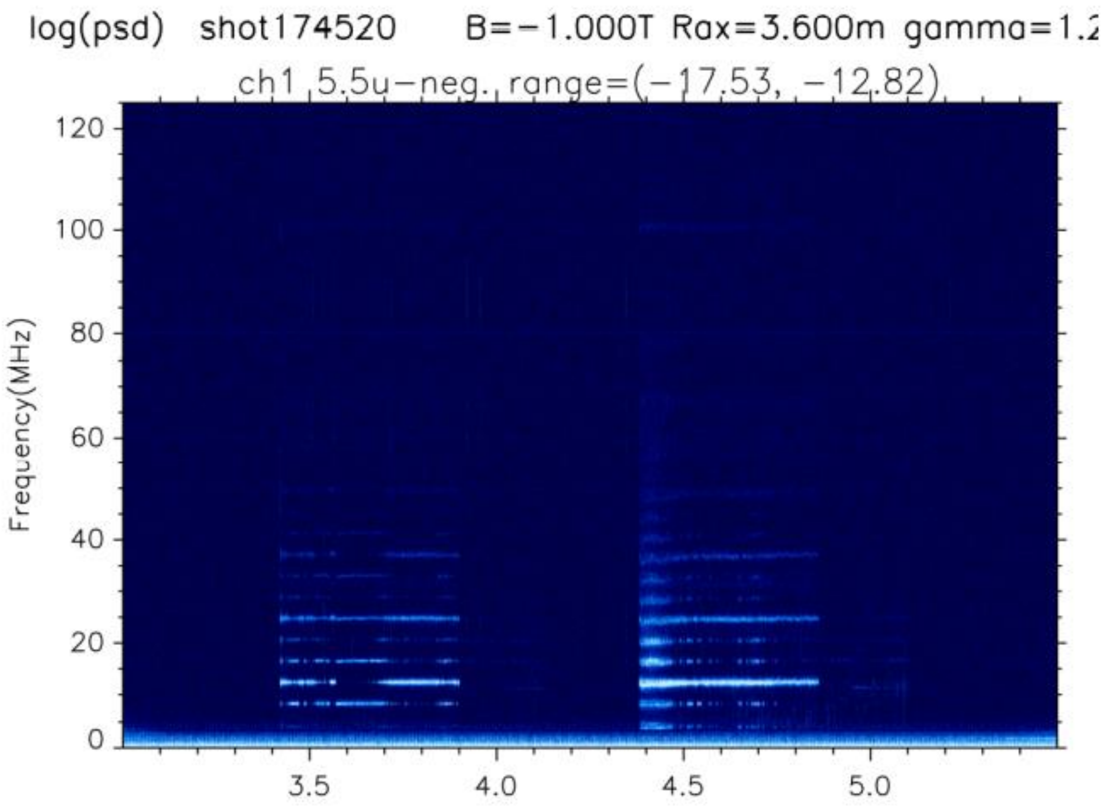
ICE Experiment Overview

- **Goal**: systematically study ion cyclotron emission (ICE) in LHD for controlled comparison with tokamak (DIII-D) and space plasma observations
- Nearly all shots provided good data
  1. Collected data at three fields: $B = 1$ T, 1.375 T, and 2.75 T
  2. Density scan: $n_e = 0.7 - 5 \cdot 10^{19}$ m^{-3}
     - Combined with B scan, allows scan of Alfvén speed $v_A \propto B/\sqrt{n_i}$
  3. Successful ion species mix variation: $n_D/(n_D + n_H) = 50\% - 95\%$
  4. Beam power scan by overlapping NBI-4 and NBI-5
- Fluctuation data: RF spectrometer, high frequency magnetics, low frequency magnetics
- Fast ion data (not yet examined): FILD and FIDA

Wide range of ICE activity observed

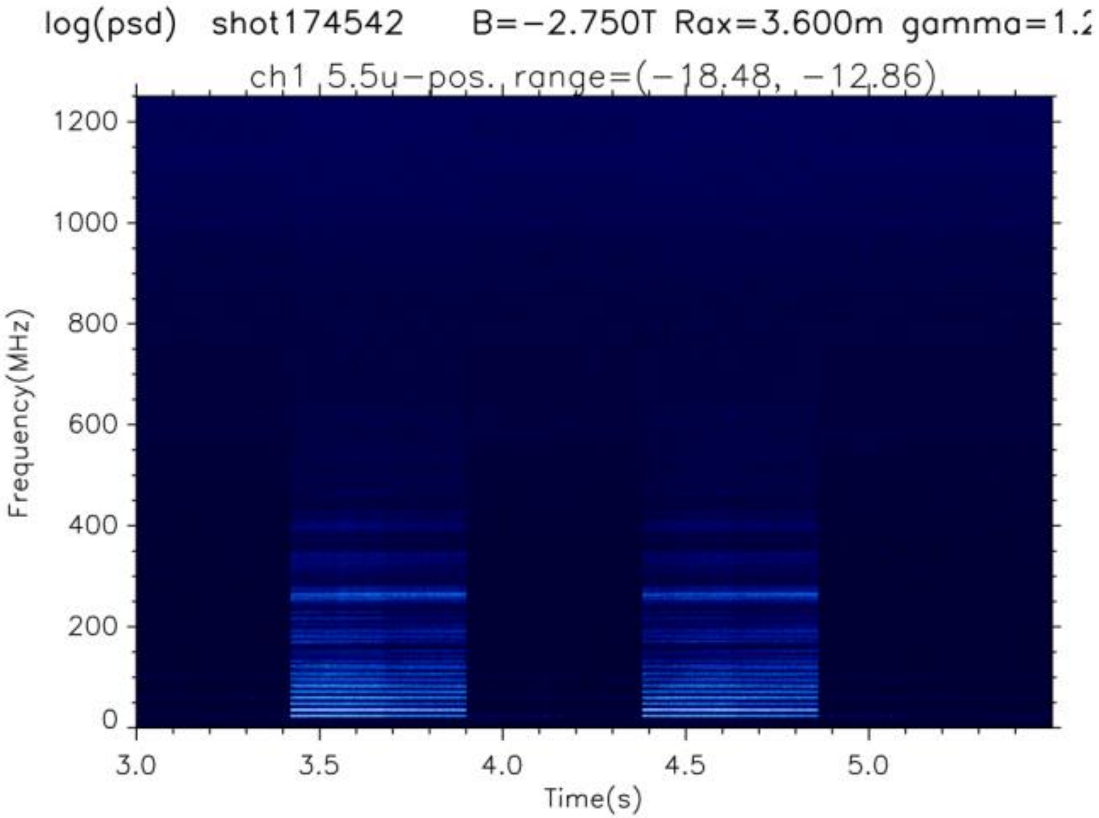


Different ICE activity within same shot

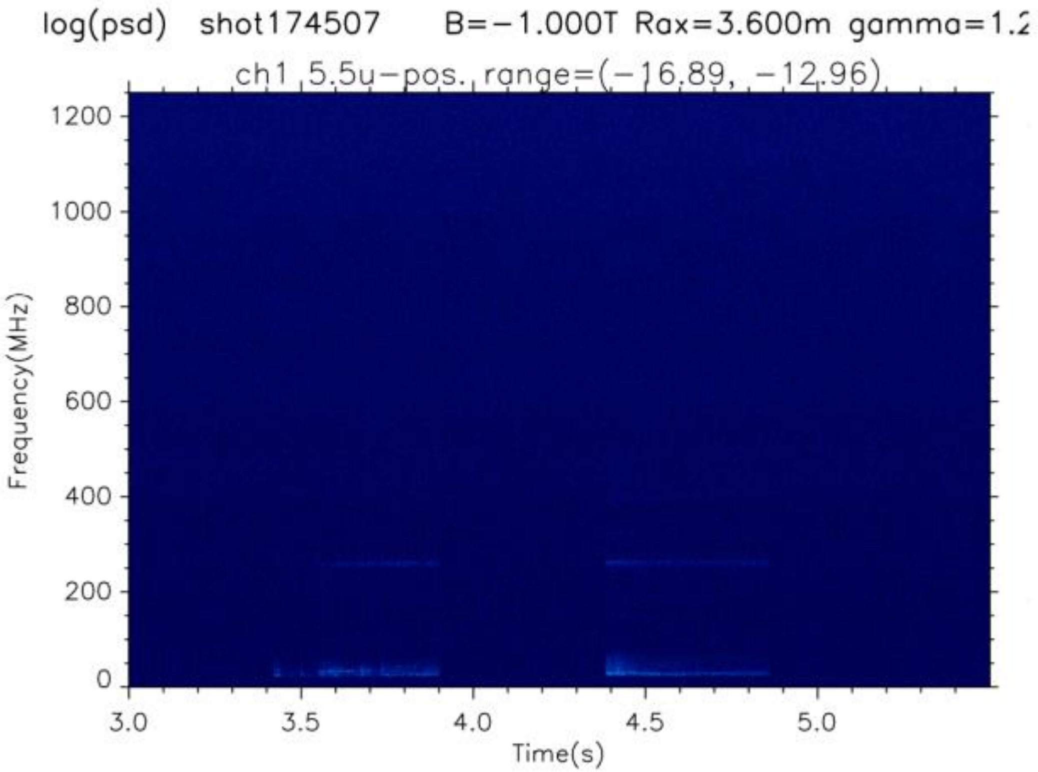


Lower density – modes tend to blink off

Very high frequency (100+ MHz) activity much stronger at higher field strength



$B = 2.75$ T



$B = 1.0$ T