Emission in the ion cyclotron range of frequencies (ICE) on NSTX(-U)

E. D. Fredrickson, N. N. Gorelenkov, R. E. Bell, A. Diallo, B. P. LeBlanc, M. Podestà

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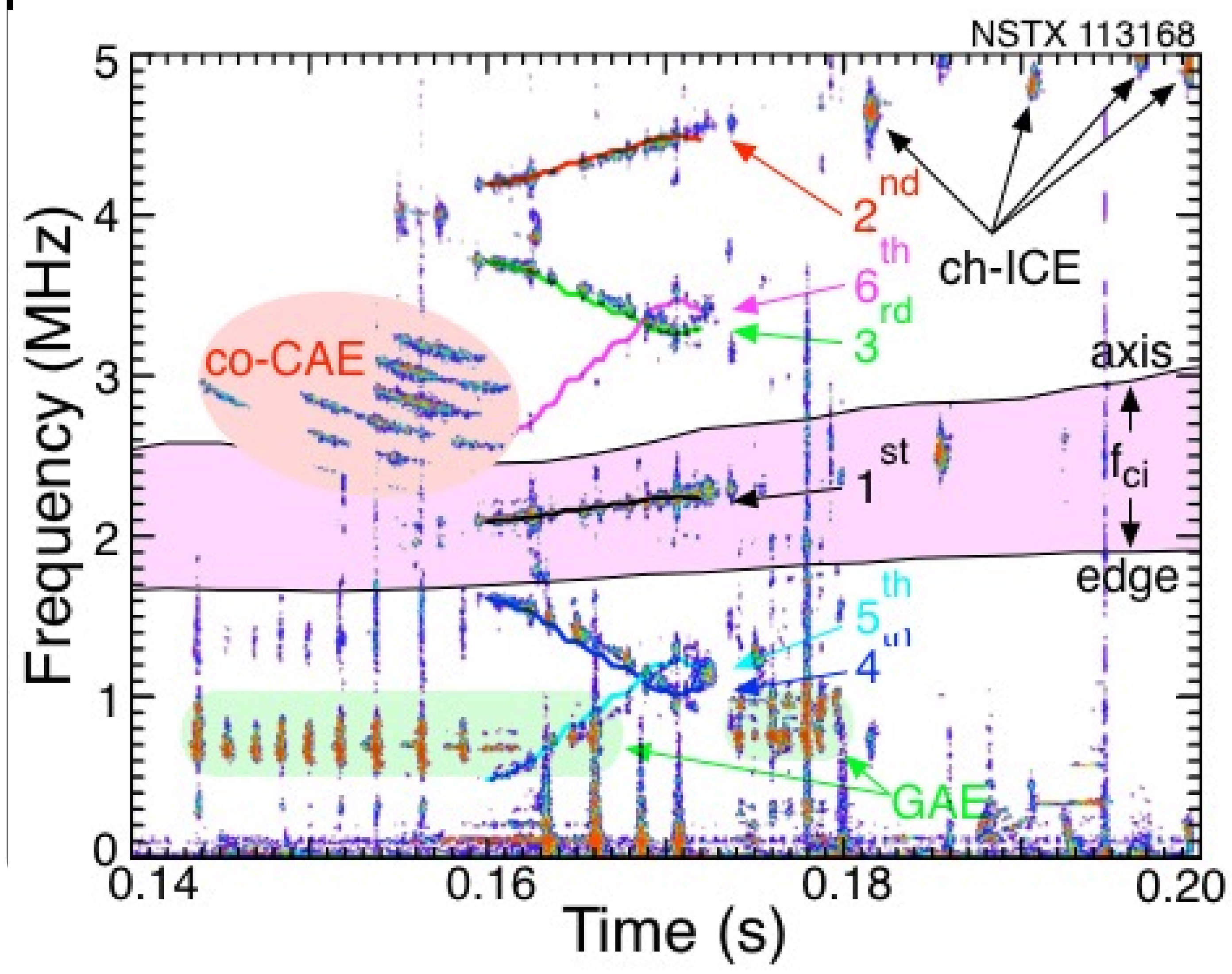
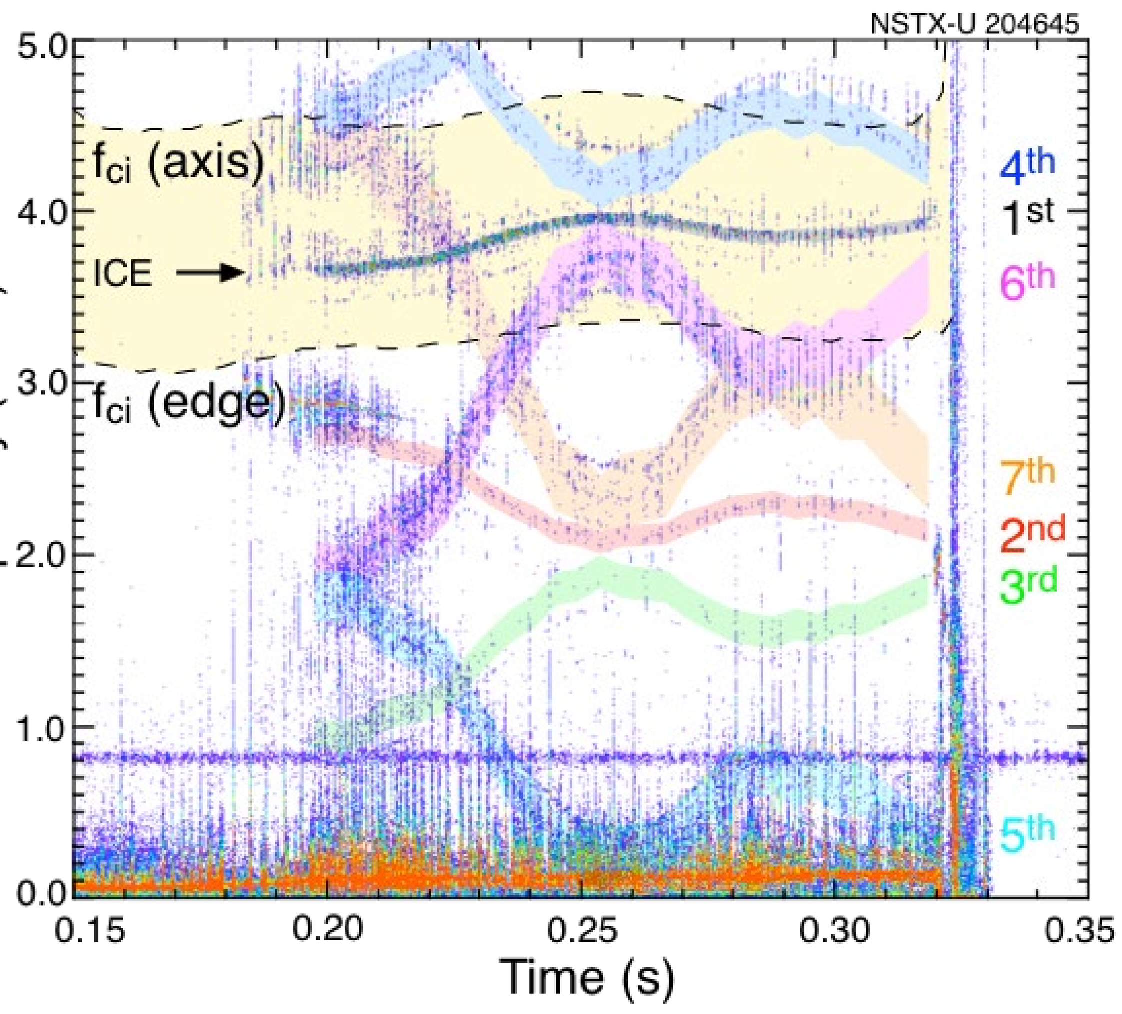


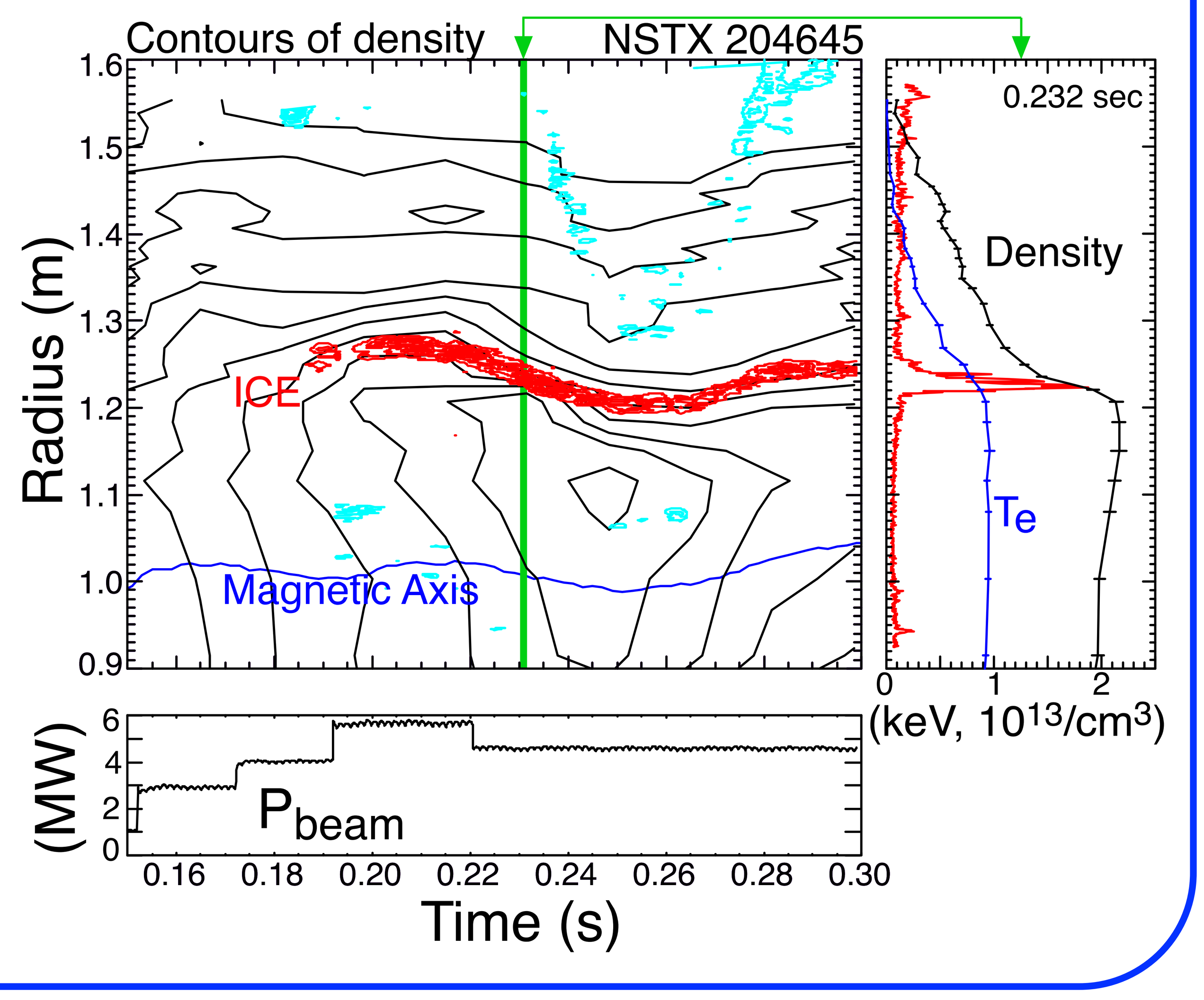
ICE, CAE, GAE are all seen in NSTX and NSTX-U

- The figure at left shows co-propagating Compressional and Global Alfvén Eigenmodes (CAE and GAE), Ion Cyclotron Emission (ICE) and chirping ICE (ch-ICE) all in one NSTX plasma.
- In addition to ICE and ch-ICE, qualitatively different ICE from plasmas with magnetic wells and non-bursting ICE has also been seen.
- ICE appears to be a distinctly different instability than co-propagating Compressional Alfvén Eigenmodes (CAE), which can occupy a similar frequency range, and the two can co-exist.
- The observed ICE frequency doesn't correspond to either the core cyclotron frequency, nor that at the plasma edge.

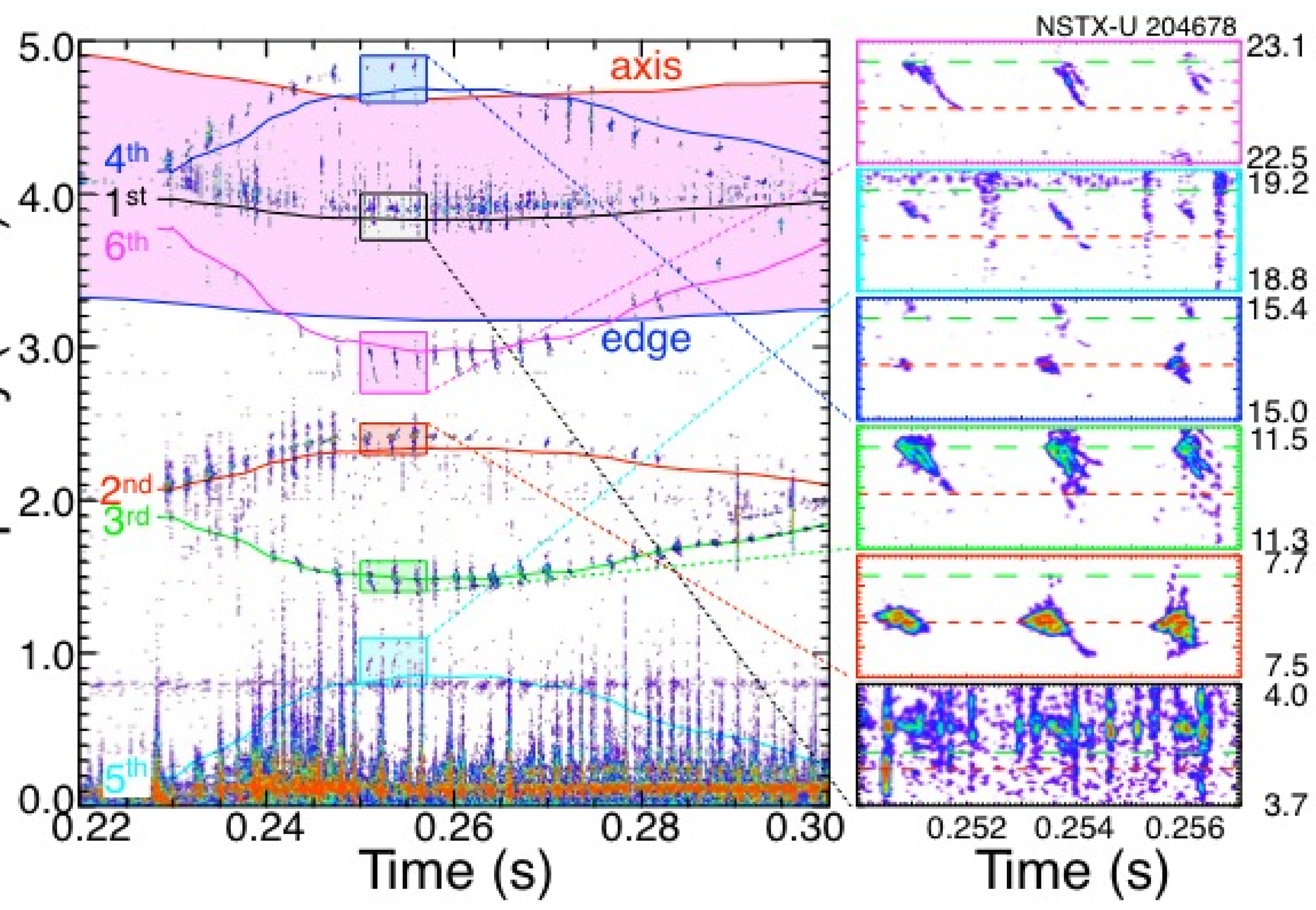
Most commonly seen ICE on NSTX(-U) similar to ICE on conventional tokamaks, but maps to half-radius



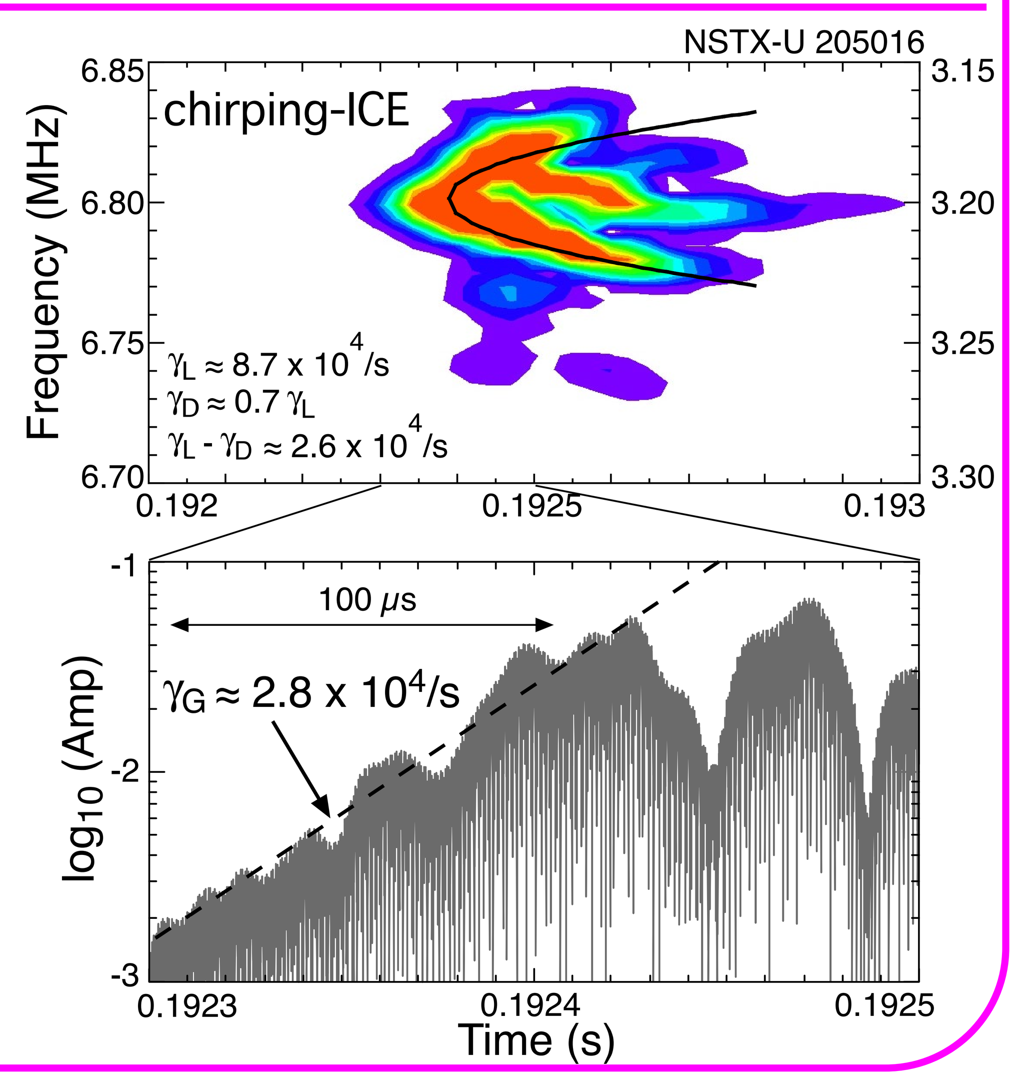
- In the example at left, the frequency of the ICE harmonics varies in time, correlated with a radial shift of the plasma up and down the magnetic field gradient.
- The radial location of the ICE origin, defined by the location where the ICE frequency matches the local beam-ion cyclotron frequency, is shown on the right.
- Here, the fluctuation frequency spectrum has been time-dependently mapped to the ion-cyclotron radial profile.
- This definition of the ICE origin is seen to be correlated with a region of strong density gradient (also with a strong velocity gradient).



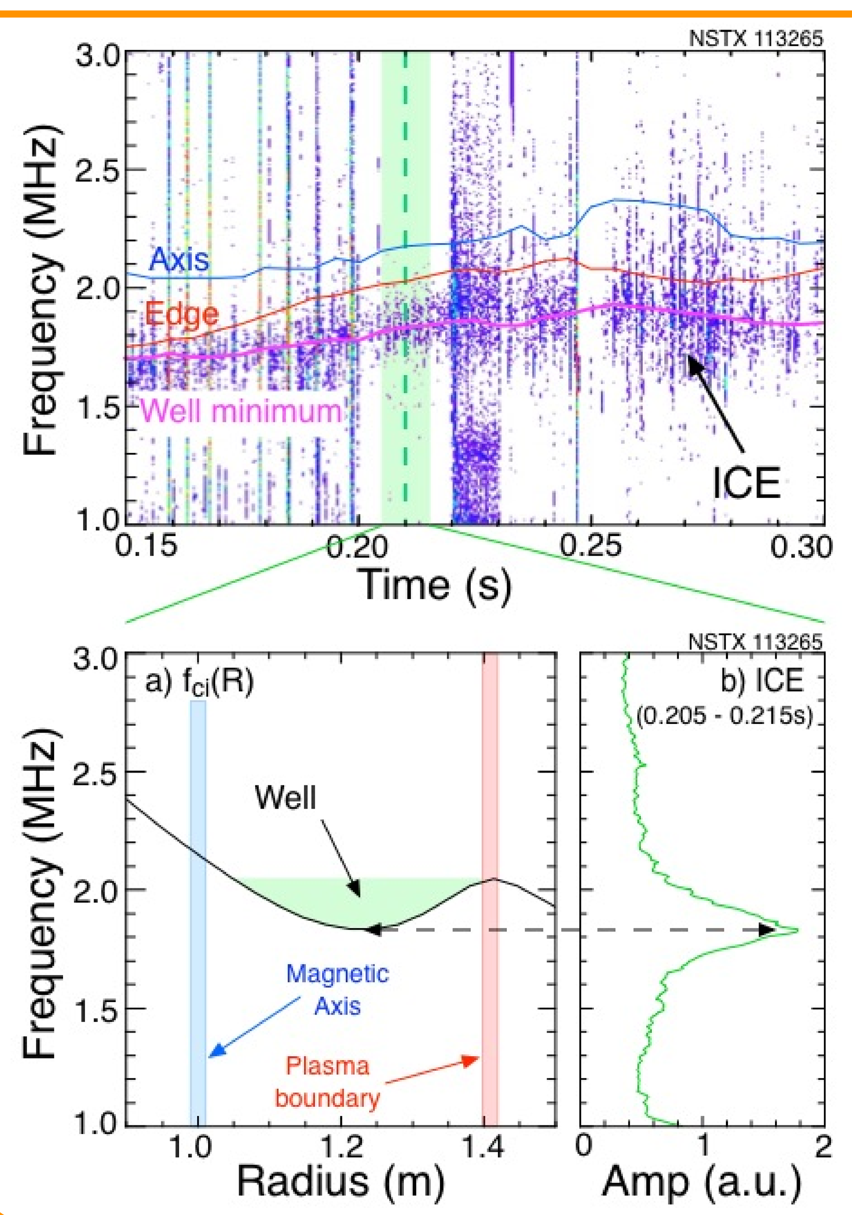
Most ICE on NSTX(-U) appears in short bursts, but only one type also chirps in frequency



- The chirping ICE is predominantly 2nd and higher even-harmonics, although the 3rd and 5th odd-harmonics have also been seen. No chirping 1st harmonic ICE bursts have been found.
- The duration of the bursts of chirping ICE is longer than the non-chirping ICE bursts.
- The chirping is most commonly uni-directional (down), but bi-directional frequency chirps have also been seen.
- The growth rate determined from the frequency chirps is in reasonable agreement with a direct determination of growth rate.



Broad ICE frequency peak seen with well



- In low-field (2.2kG), high current (1.4MA), high beta (35%) plasmas a local magnetic well forms on the outboard plasma side.
- ICE is seen over a broad frequency range roughly spanning the range of cyclotron frequencies in the magnetic well.
- The peak of this emission corresponds to the minimum ion cyclotron frequency in the magnetic well.

Summary of experimental observations

- Ion cyclotron emission has been seen on NSTX(-U).
- While several qualitatively different types of ICE have been seen on NSTX(-U), none have frequencies corresponding to the edge or core beam-ion cyclotron frequency – in contrast to observations on conventional tokamaks.
- The location of the resonant fast-ions deep in the plasma suggest that the drive for the ICE is strong to overcome the cyclotron damping on the thermal ions.
- The chirping of 2nd harmonic ICE raises the possibility that ICE is more like an Energetic Particle Mode (EPM) than a weakly damped eigenmode excited by a small population of resonant fast ions.