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NSTX

xp706: β suppression of Alfvén Cascades on NSTX

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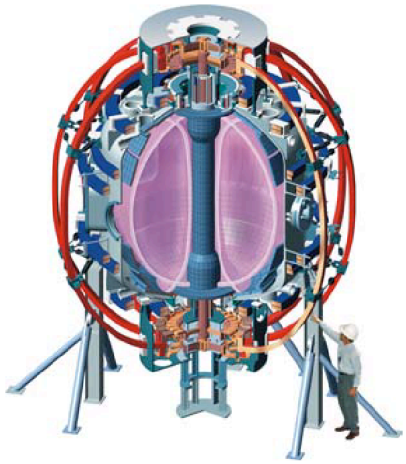
E D Fredrickson, N A Crocker, N N Gorelenkov, W W Heidbrink, S Kubota, F M Levinton, H Yuh, R E Bell

2007 NSTX Results Review

July 23-24, 2007, PPPL



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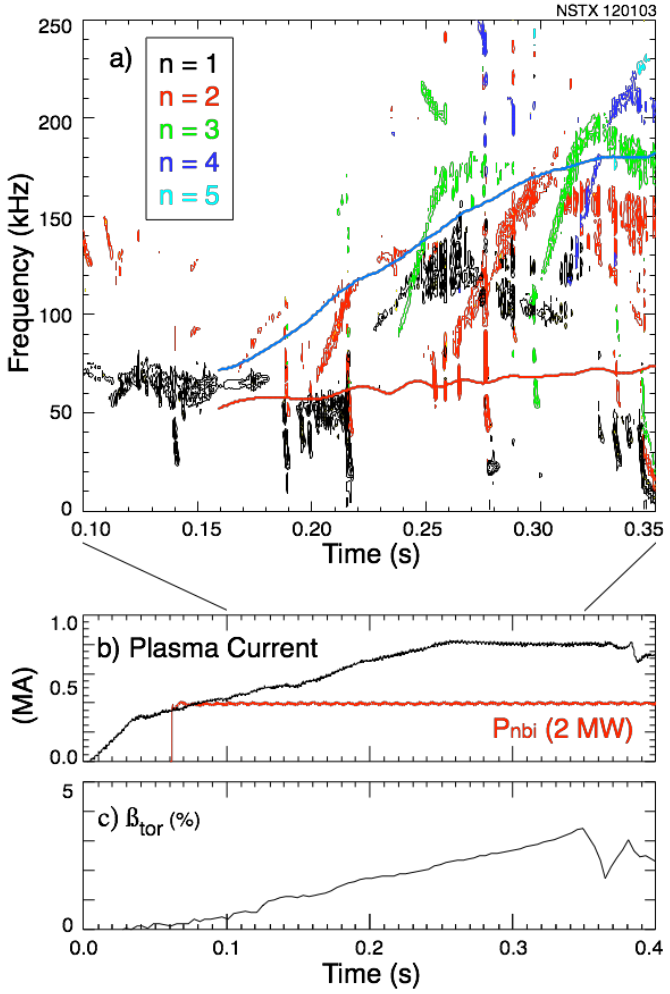
Primary goals of this XP

- Obtain MSE data contemporaneously with modes.
- Use of "non-resonant n = 3 braking" to slow rotation, reduce rotational shear to simplify interpretation.
- Exploration of GAM/BAE frequency scaling (existence constraint for Cascades).
- NPA to look for affect on fast ion transport (fast ion losses blamed on rsAE in DIII-D).
- Additional reflectometer channels used to improve localization of mode.
- Document evolution to TAE at chirp saturation.
- Use Argon puffing to improve SXI sensitivity (for JH and tangential cameras).

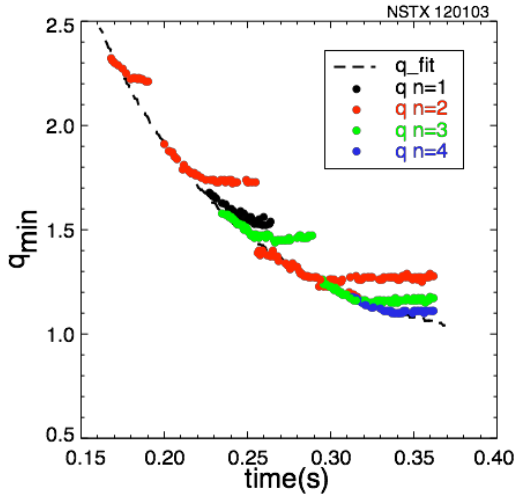
- completed, - partially completed, - very limited data

Experiment motivated by observation of Alfvén Cascades at very low β



- Mode frequency sweeps upwards, saturates near TAE frequency (blue curve), mode onsets near Geodesic Acoustic mode frequency, red curve.
- Observations support recent theoretical models suggesting AC modes couple to Geodesic Acoustic modes.
- Alfvén Cascade modes should be absent in all but the lowest β regimes for ST's

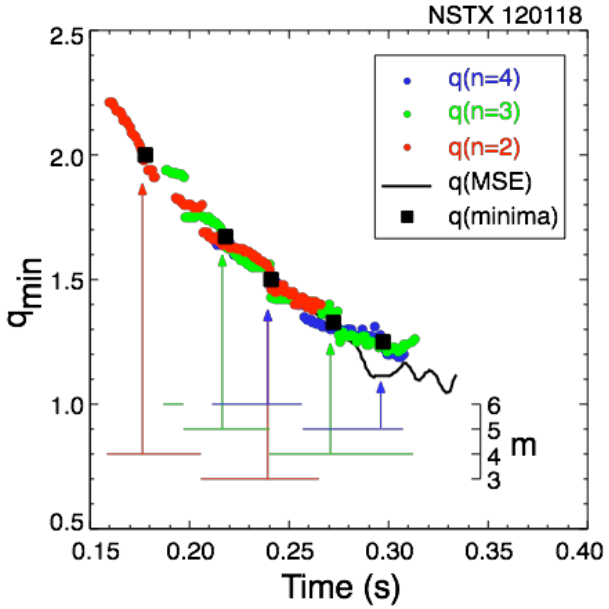
$\beta_e(0.25s) \approx 1.2\%$



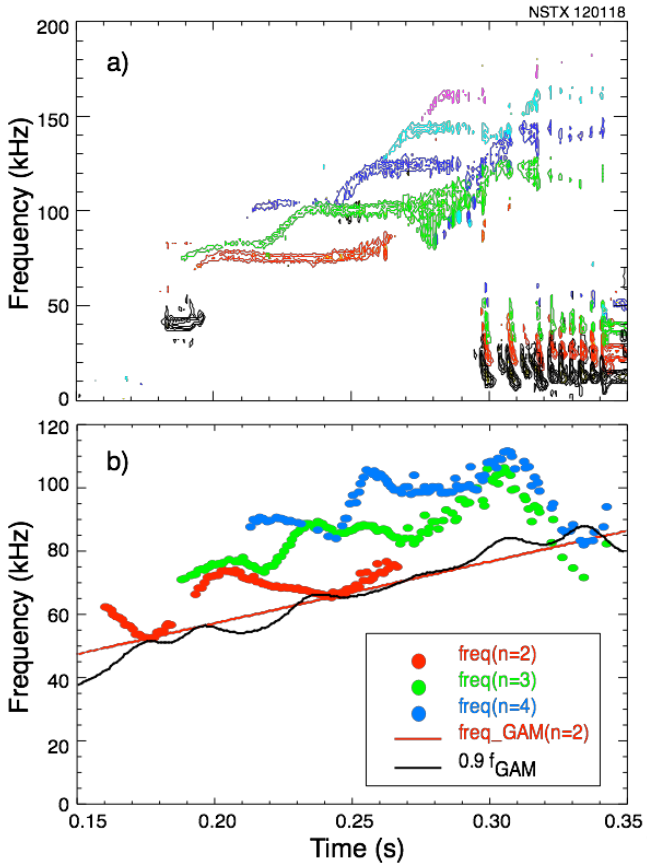
Range of frequency sweep decreases at higher density, β

- In subsequent shots the density was increased (here ≈ 3×10^{13}/cm^3 at 0.3s), which resulted in higher β (≈ 8%)
- The TAE frequency drops, but the onset frequency remained roughly constant (when corrected for the Doppler shift).
- At intermediate β, the modes are also present during the downward chirping phase

$\beta_e(0.25s) \approx 5\%$



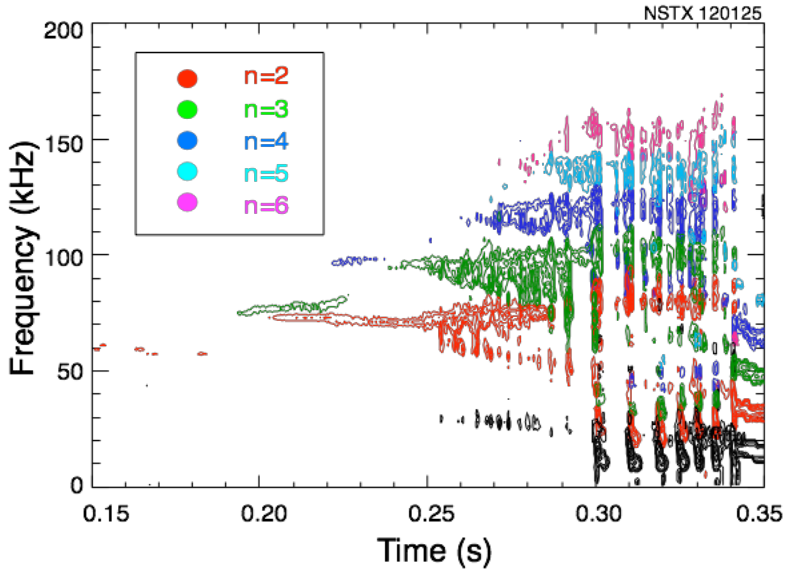
- Solid black line is the Geodesic Acoustic Mode frequency - the expected onset frequency for ACs



At higher density, β, frequency sweeps are absent

- TAE modes appear, disappear and re-appear at different frequencies.
- As q_{min} drops, poloidal harmonic content of TAE also changes.
- Also suggests that TAE are more stable when q_{min} is near rational.
- Rotation frequency of order mode frequency confuses interpretation of data

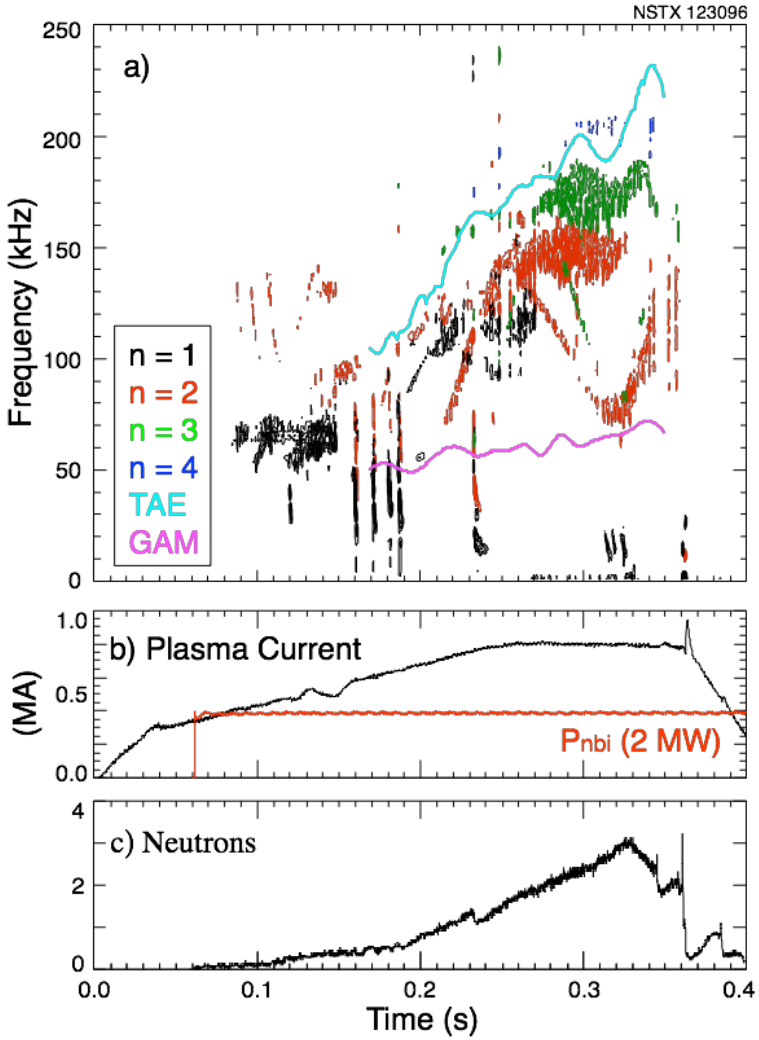
$\beta_e(0.25s) \approx 7\%$



- TAE give way to fishbone-like energetic particle modes - probably as q_{min} approaches one

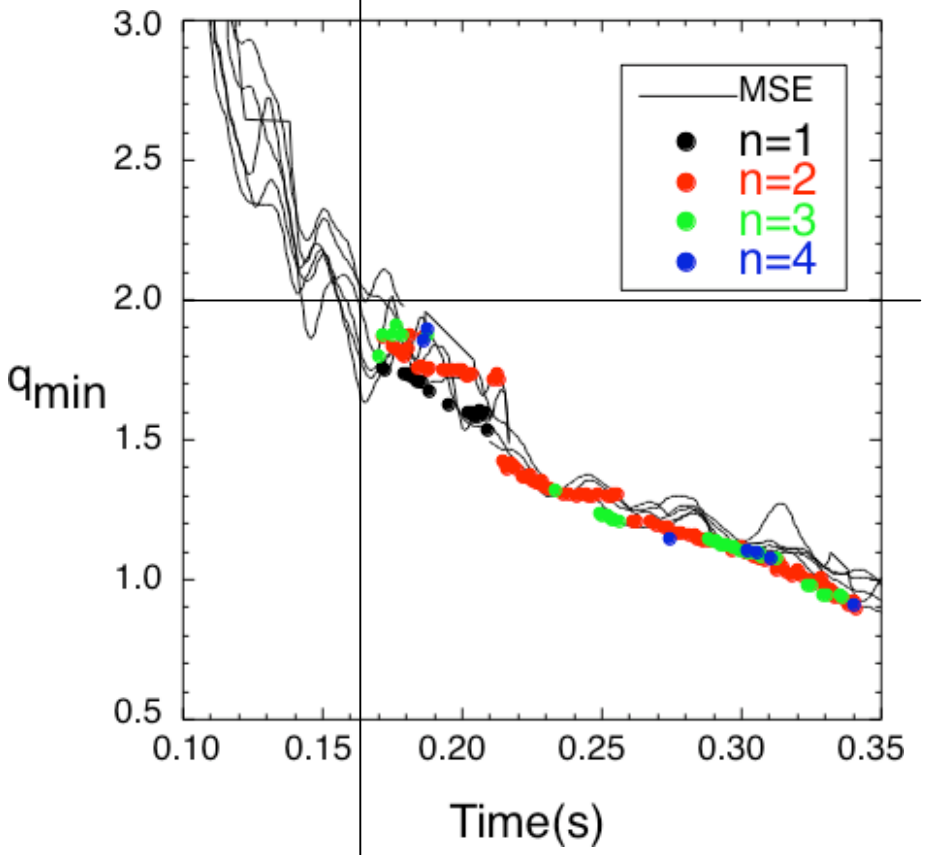
Experiments were repeated to get MSE data for q-profile evolution

- Alfvén Cascades now show clear downward frequency sweep.
- Both n = 2 and 3 downward sweep minima at about 325 ms suggest "Grand Cascade", or q_{min} = 1 crossing.
- After AC frequency peaks and begins downward sweep, TAE appear, again suggesting TAE least stable between rational q_{min}'s.
- Cyan curve shows approximate TAE-gap center frequency at q_{min}.
- Magenta curve show approximate Geodesic Acoustic Mode frequency.



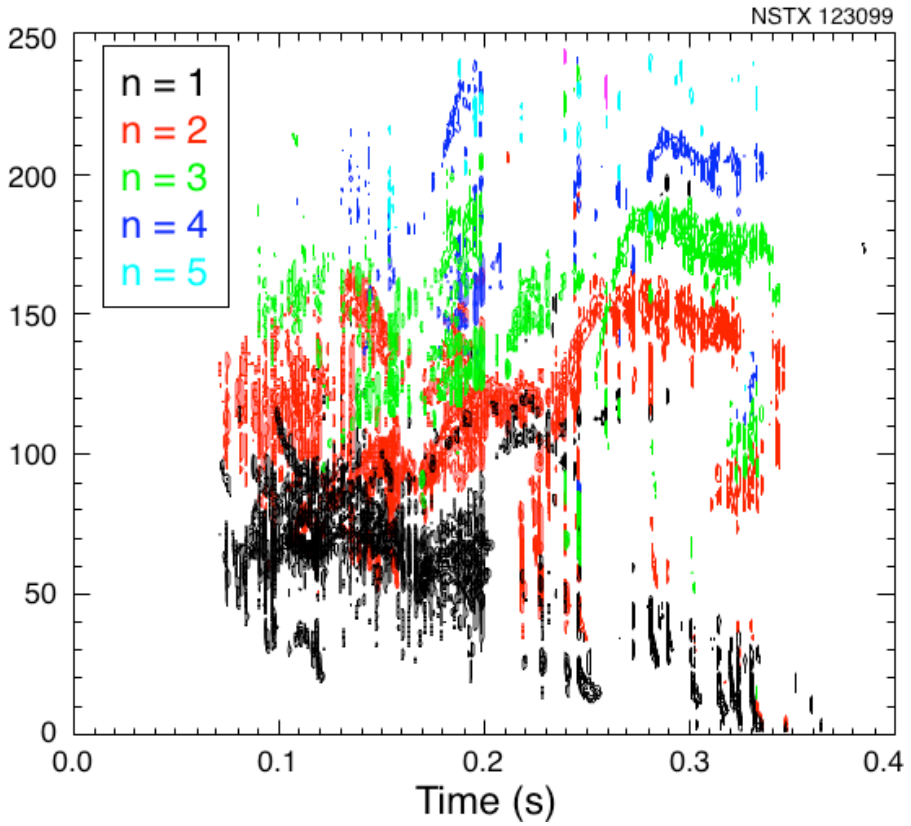
q_{min} evolution deduced from MSE data similar for all shots

- Multiple black lines show q_{min} evolution from sequence of 9 shots with various timings for sources A and C.
- Overlaid colored circles are q_{min} inferred from the AC modes on page 8.
- AC modes before 200 ms were not clear, and analysis is very uncertain, but n=1 mode after ≈120 ms could indicate q_{min} = 3 crossing, in agreement with MSE data.



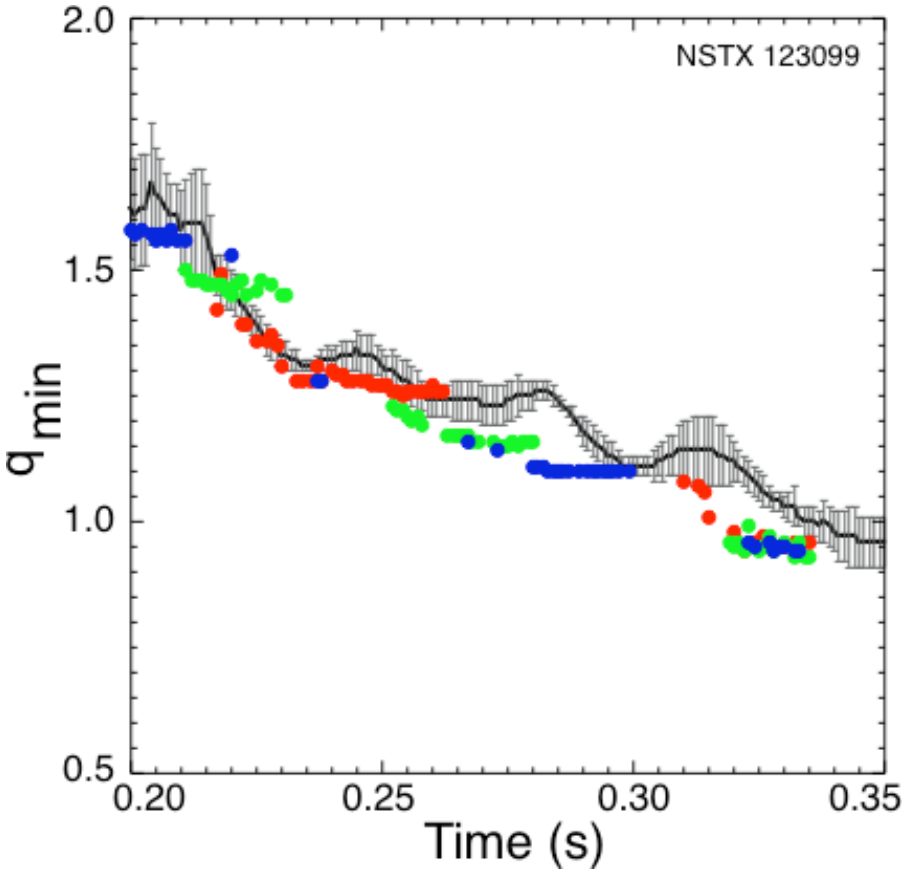
More tangential source gives stronger chirping

- Source A (for MSE) substituted for source C before 200 ms.
- Chirping obscures or suppresses Alfvén Cascades.
- AC modes appear afterward.
- Downward sweep not evident, but GAMs possibly still visible 310 to 340 ms.
- Evolution of q profile documented over many shots by changing timing of source A and source C injection.



Alfvén cascades have similar timing, q_{min} evolution is similar

- The q_{min} is slightly lower than measured with MSE, but more consistent with onset of n = 1 fishbone-like energetic particle modes.
- Alfvén Cascade modes only give q_{min} evolution during frequency sweeping phase, when frequency saturates in TAE gap, inferred q_{min} saturates also.



Summary of results

- Alfvén Cascade modes are found only in very low β plasmas (obtained at low density) on NSTX.
- Range of frequency sweep is reduced as β is raised, in agreement with theory.
  - Onset frequency approximately GAM frequency
  - Saturation frequency approximately TAE frequency
- MSE data obtained contemporaneously with modes agrees with q_{min} deduced from mode frequency sweeps.
- Analysis of internal mode structure data (reflectometers, soft x-ray cameras, interferometers) and
- Comparison with NOVA modeling.
- Look for change in mode structure at saturation or onset