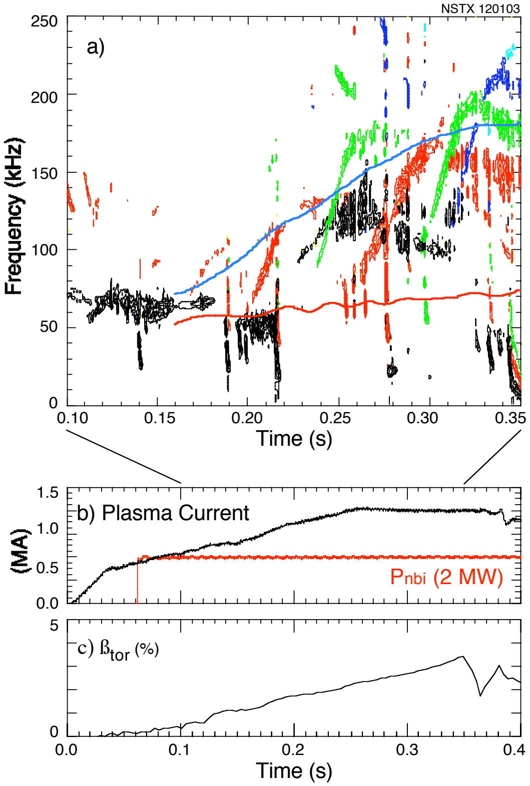
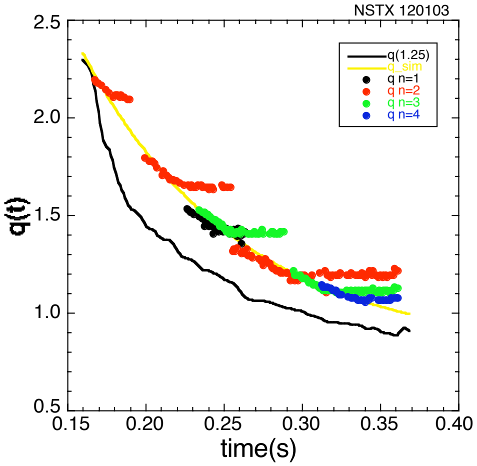
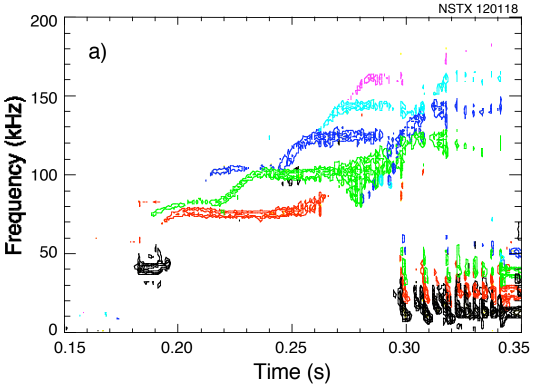
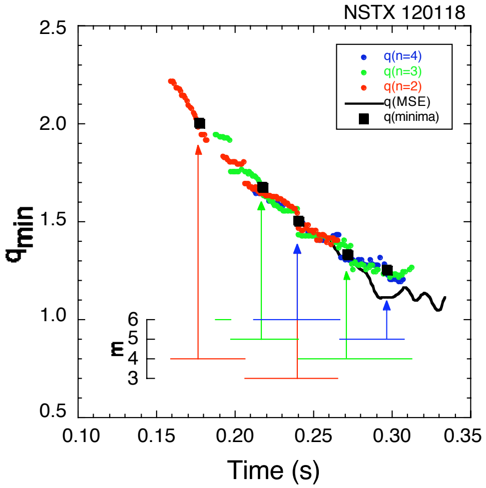
1) Alfvén Cascades

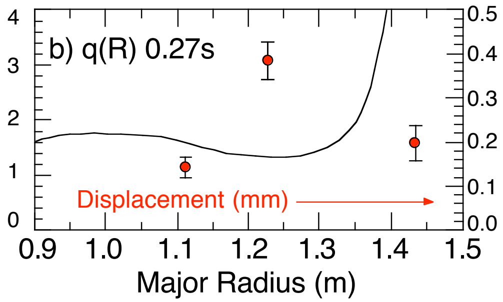


- Localized to low shear region near q_{min} in reversed shear plasmas
- Frequency chirp reveals evolution of q_{min}.
- Suppressed for $\beta/q_{min}^2 > 3\%$.
- Reference shots 120103/120118. 800kA, 4.5 kG, source C, well conditioned machine, Helium gas puffing.







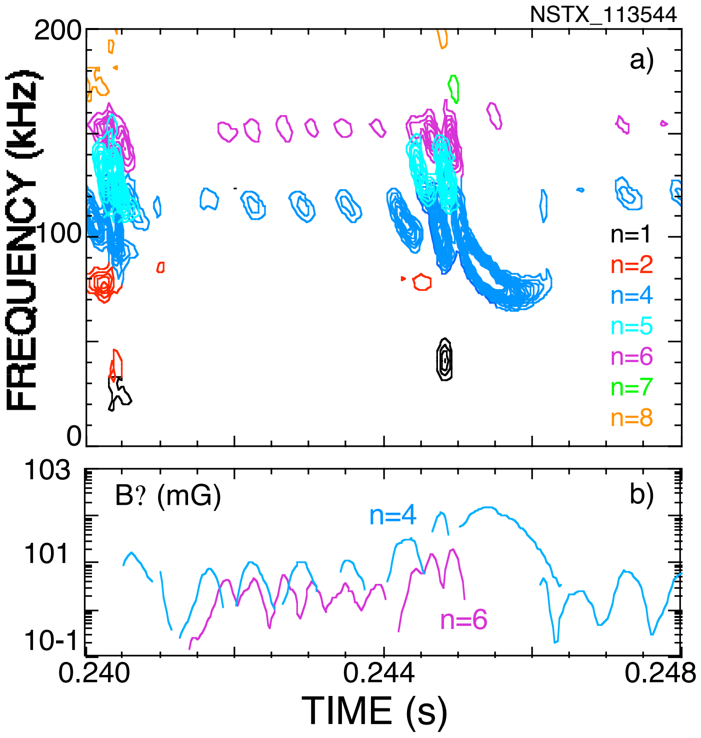


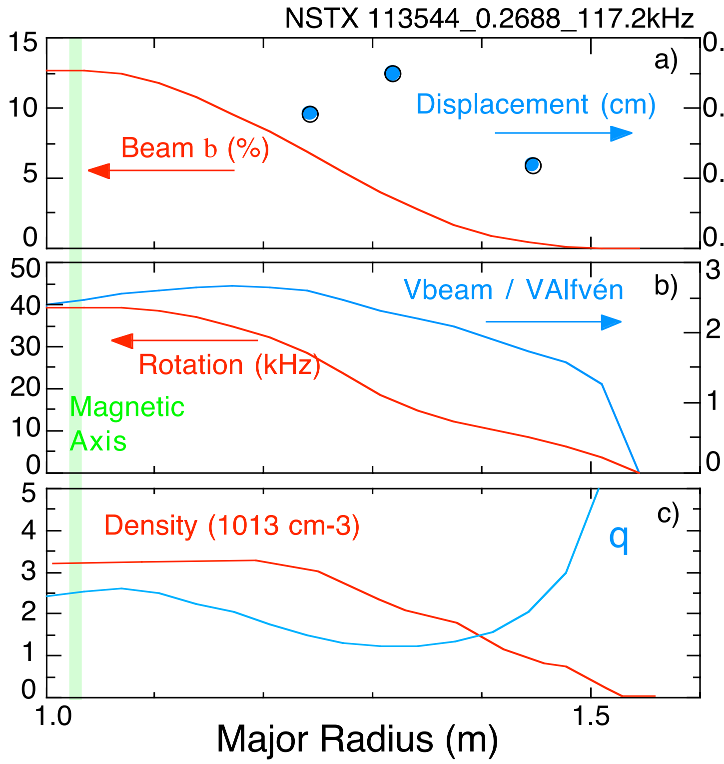
Goals for Alfvén Cascade XP

- Verification that modes are Cascades
  - MSE data in low density shot (120103)
- β-scaling of frequency chirp
  - Density scan to vary β
  - Repeat with higher toroidal field, allowing higher density - better for reflectometers?
- Document change in mode structure when mode frequency saturates
  - Higher field? Peak density ≈ 3.5×10^{13}.

2) TAE Avalanches

- Phase-space island overlap with multiple modes leads to large fast ion losses.
- Overlap triggers "avalanche" where multiple modes are destabilized.
- Relevant to small ρ* regime





Goals for Avalanche XP

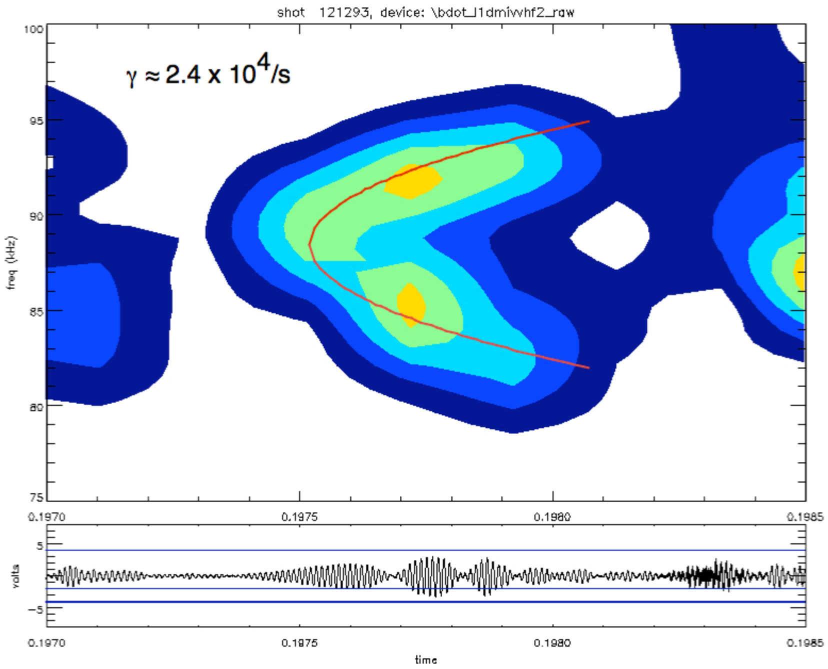
- Measure radial eigenfunction, amplitude of multiple modes
  - Many reflectometer channels desirable
  - Calculate fast ion transport with ORBIT
- Use q-profile, other equilibrium profile data to simulate modes with NOVA.
  - Estimate phase-space island size, overlap condition.
- Document affect on fast-ion confinement
  - NPA scan
  - sFLIP and Faraday cups

3) Alfvén-Acoustic Modes

- Measure mode structure and amplitude with multiple reflectometers/interferometers.
- Document equilibrium evolution to understand mode onset conditions, conditions for mode suppression.
- NPA/sFLIP/ssNPA and neutrons to document effect on fast ion confinement.

4) TAE Hole-clumps

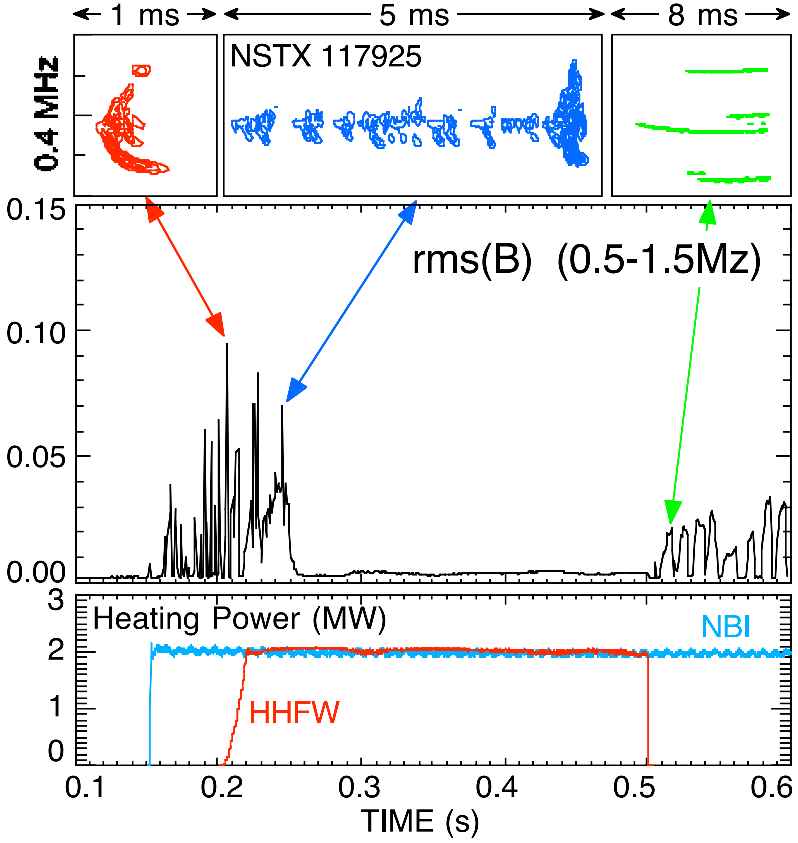
- Recent discovery - may be difficult to reproduce
- Hole-clumps directly give information on stability, fast ion phase space diffusivity



- Goals for TAE hole-clump XP
  - Reproduce conditions under which hole-clumps are seen.
  - Try to extend realm of occurrence (other sources, beam energies, density profiles, etc)
  - Document amplitude (if possible) with reflectometers (to determine phase-space island size, independent measure of growth rate).

5) HHFW stabilization of Angelfish

- Engineering of fast-ion phase space can suppress deleterious instabilities.
- Growth rate estimates from Nova (TRANSP input), empirical fast-ion HHFW heating with NPA and Hole-clump theory give self-consistent estimate of threshold power for suppression of ≈ 2 MW.



- Previous HHFW experiments find mode suppression at about this power level, in some cases.
- Don't have controlled HHFW power scans.
- Evidence that equilibrium is changing over long HHFW heating period.

Hole-clump suppression goals

- Repeat experiment, obtain *complete* data set under same conditions.
- Heating power scan to validate threshold condition.
- Shorter HHFW high-power periods to monitor changes in equilibrium fast ion parameters vs. HHFW suppression.
- Reflectometer data to identify mode.

6) CAE stochastic heating

- Early theoretical history
  - '75 Smith&Kaufman proposed stochastic ion heating by oblique ES wave
  - '77 Karney&Bers, stochastic ion heating by perpendicular ES wave
  - '78 Karney, ion heating in lower hybrid wave
  - '79 Hsu,Matsuda,Chu&Jensen, parallel standing wave
  - '81 Drake&Lee, Lower hybrid drift wave and multiple waves
- Experimental documentation of stochastic thermal ion heating:
  - '87&'91 McChesney,Stern&Bellan, stochastic ion heating with drift-Alfvén wave*
    - *'85 Fredrickson&Bellan, discovery of large amplitude drift-Alfvén wave
  - '93&95 Bailey,Bellan&Stern, thermal-ion equilibrium distributions
  - '98 Sanders,Bellan&Stern, transport effects on distribution function
- NSTX opportunity:
  - Direct, RF heating of thermal ions.
  - Estimate power required (a few kW to create observed mode amplitude?)
  - Evaluate coupling ($\approx \lambda_{pol}/2$ over RF antenna from Mirnov array)
  - Approximately 10 times more power to reach stochastic threshold.

CAE stochastic ion heating goals

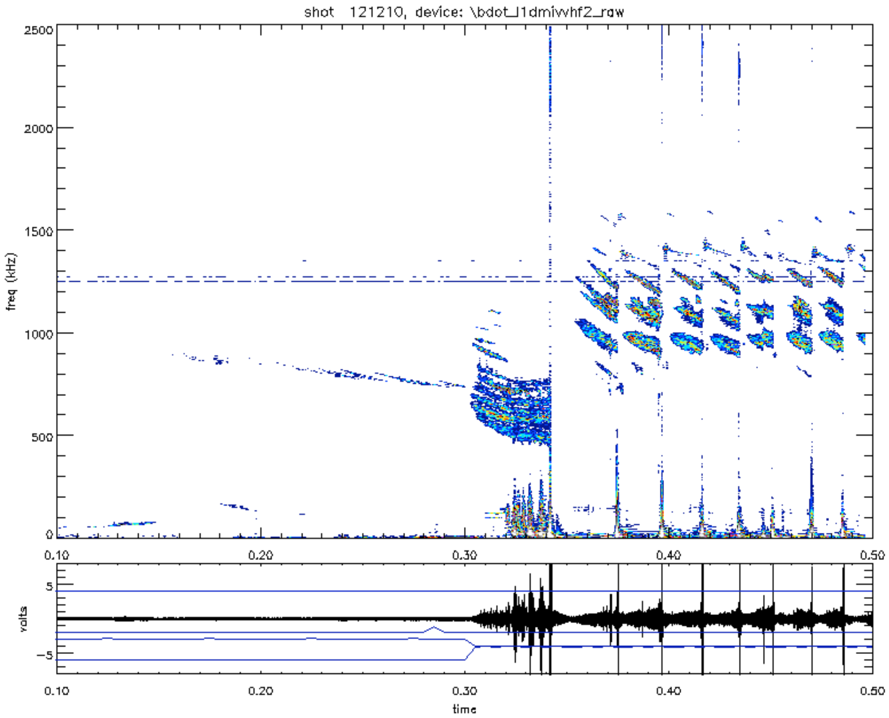
- Part A
  - Document coupling of RF antenna strap to NBI-excited CAE.
  - Measure antenna loading in *AE quiescent regime (possibly ohmic shot, maybe with *AE present)

- Part I
  - Scan RF beat frequency through CAE/GAE resonances, detect response with reflectometers or Mirnov coils (possibly ohmic shot, possibly quiescent beam-heated shot, or maybe with *AE present)

7) *AE-quiescent regime for bootstrap/beam-driven current benchmark

- Best shot from XP608 last year; *AE activity level very low.
- First run-day after loss of NB

- $T_e(0) \approx 0.8$ to 1.2 keV between 0.2s and 0.3s
- $n_e(0) \approx 3$ to $4 \times 10^{13}/\text{cm}^3$ in same time range.
- Higher density might further reduce activity.



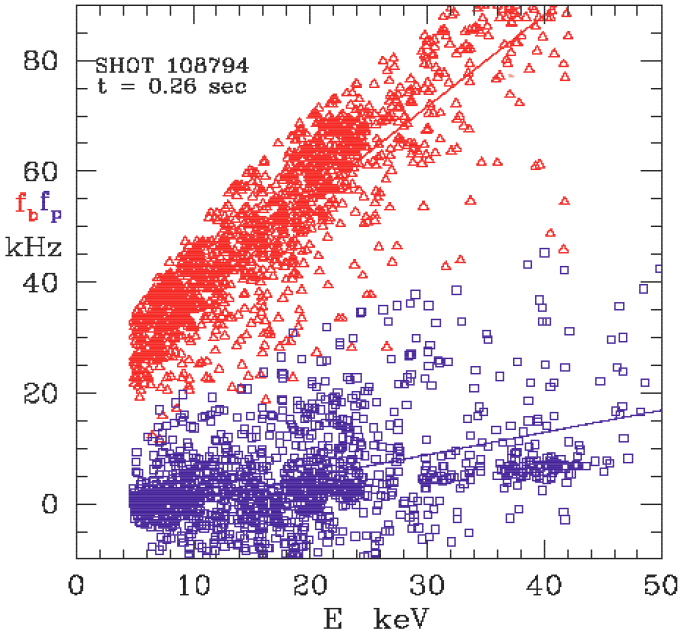
*AE quiescent regime goals

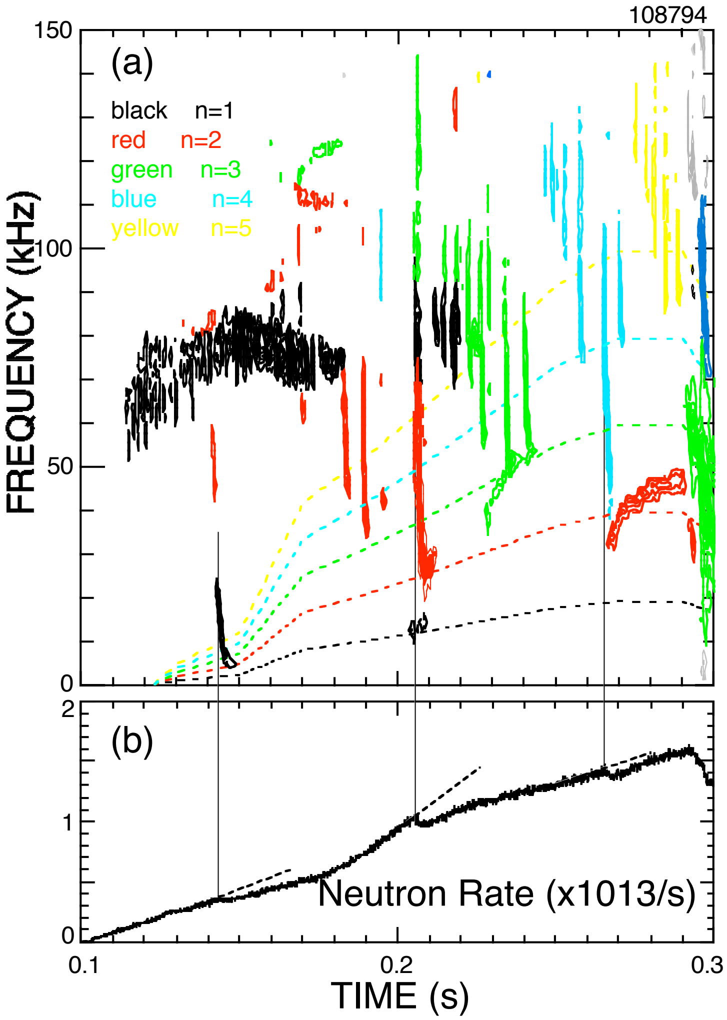
- Important to benchmark TRANSP beam/bootstrap current models in low aspect ratio.
- Important to benchmark threshold conditions for fast ion driven instabilities.
- Important for scaling to quiescent reactor, if desired.

- (Secondary goal to develop plasmas suitable for magnetic turbulence studies.)

8) Bounce-resonance fishbones

- Strongly chirping, fishbone-like modes, with n>1.
- Frequency is too high for precession resonance, but matches bounce frequency.





Goals for bounce-fishbones

- Reproduce conditions under which bounce-resonance fishbones are seen.
- Measure q-profile with MSE
- Measure mode structure (tangential soft x-ray camera to measure m?)
- Collect sufficient data to benchmark ORBIT fast ion loss simulations.

New Tools

- Reflectometers
- Fast NPA
- Faraday cups
- Fida?
- Nova-Orbit
- M3D