Exploring Unique NSTX Capabilities and Phase Space Local Structures Control in Energetic Particle Research

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for EP SFG

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PPPL
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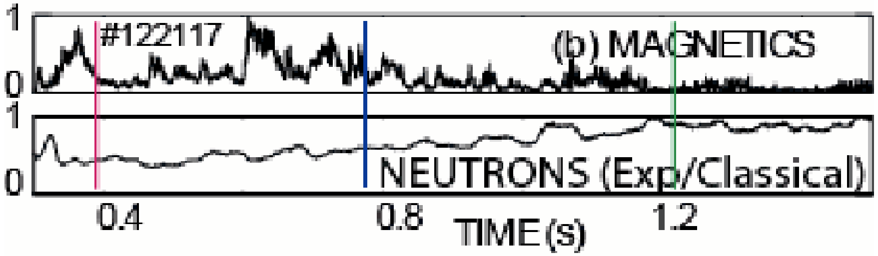
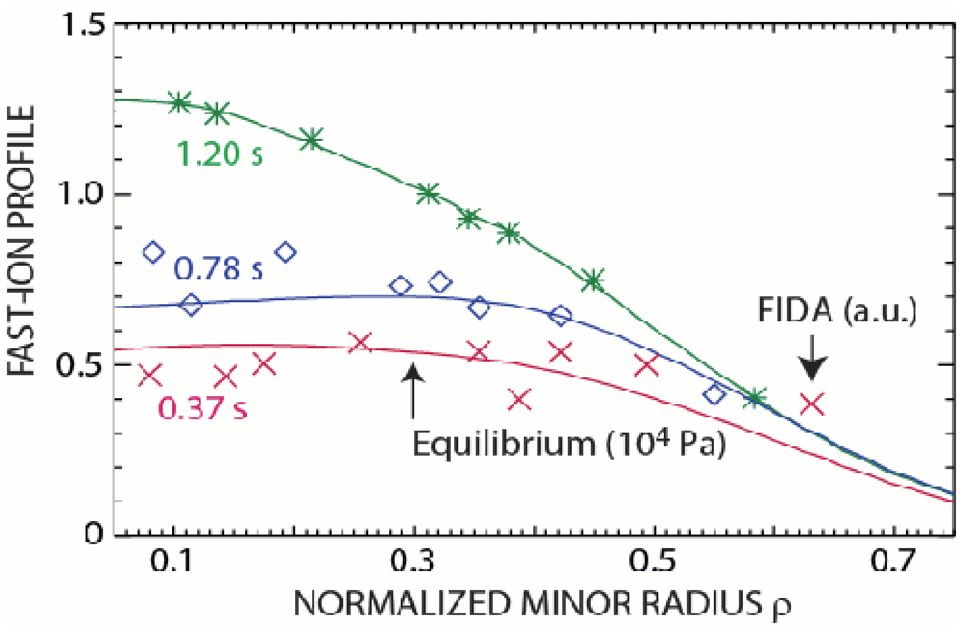
The Fast-ion Density Gradient is Flattened

W.Heidbrink, IAEA'06





- The profile remains flat during the strongest Alfven activity
- As the activity weakens the profile peaks but is still broader than classically predicted

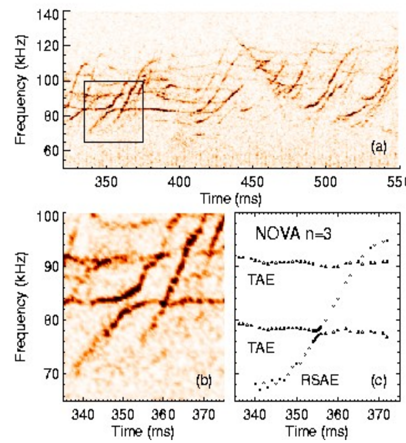
There is no even remote agreement with theories on AE role in EP transport.
ORBIT => amplitudes are too low
delta B/B ~ 10^-4.

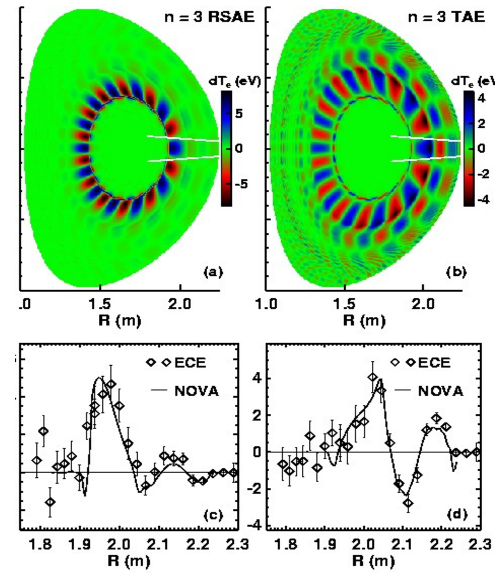
**For this comparison, the FIDA density profile is normalized to the equilibrium profile at 1.20 s.*

Need to advance NSTX research in EP area through internal amplitude measurements

Multichannel, high resolution diagnostics are needed (standard): with sensitivity 10^-4 and f~200kHz and ~2MHz.

DIII-D internal mode structure





- Mode profile:
  USXR arrays capable of 10 kHz.
  Might be able to do 20x better with significant investment:
  is sensitivity an issue?
- FIReTIP: can we increase sensitivity and number of channels
- high-k is of interest as well;
  coupling to kinetic waves can be studied.

Advance NSTX research through fast ion distribution/loss measurements

- NPA/FIDA should complement each other:
  - cross machine comparisons with DIII-D is required.
-
- Augment NSTX loss measurements with (many?) thin foil Faraday cups:
  - need to assess EP losses vs. redistribution,
  - can complement NPA/FIDA measurements.

Multi-mode transport is of high priority for both theory and experiments: need to study beyond 3 year period

Theory challenges:

ORBIT/NOVA coupling is capable to address some transport issues
is being applied for DIII-D experiments,
multi-mode transport requires theory breakthrough:
measured amplitudes are too low.

M3D has more complete nonlinear model (nonperturbative modes and dynamics)
need to improve numerical efficiency
need to compare/benchmark with theory and experiment.

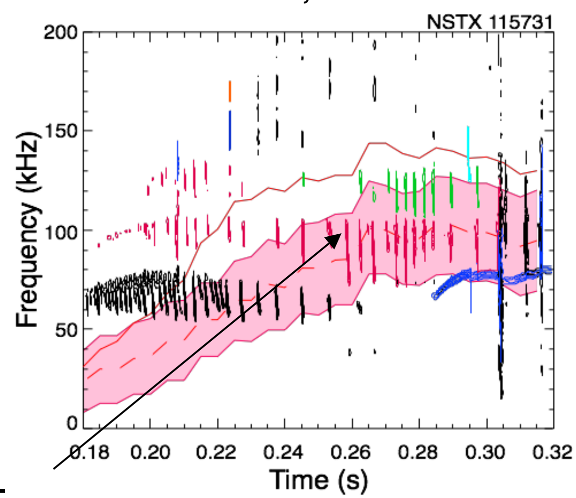
Experimental challenges:

internal structure, amplitude (reflectometers are good for L-mode plasmas)
diagnostics need to be upgraded to allow fast measurements
mode identification: fishbones/Alfven-acoustic modes(+JET results)/EPMs;
fast ion effects, losses;
data base;

Must explore unique NSTX (high) regimes in studies of new instabilities such as RSAEs and BAAEs (example)

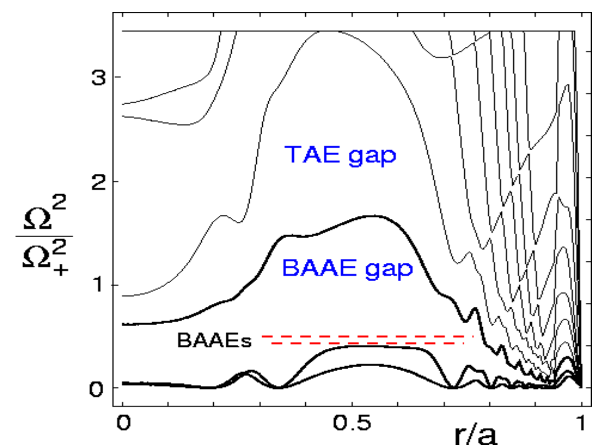
- BAAEs couple two fundamental MHD branches - new.
- Collaboration is potentially extendable to other devices JET ...

NSTX BAAEs, f=103kHz



BAAEs

NOVA on BAAE gap in NSTX



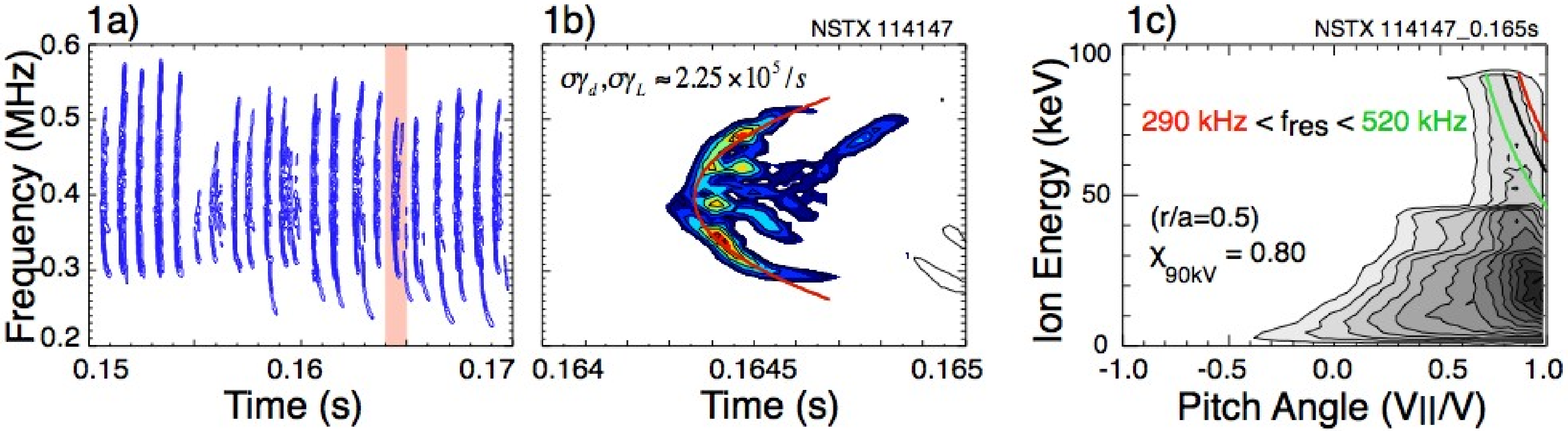
Rotation, kinetic effect are to be studied.

Potentially diagnostic tool for plasma pressure, q, Ti...

Affect phase space EP distribution to change instability dynamics

- Example: angelfish corresponds to EP coherent structures and is affected by RF.
- Engineering of fast-ion phase space can suppress deleterious instabilities.
- Potentially important tool for EP instability studies.
- Interaction with Wave/particle group is essential

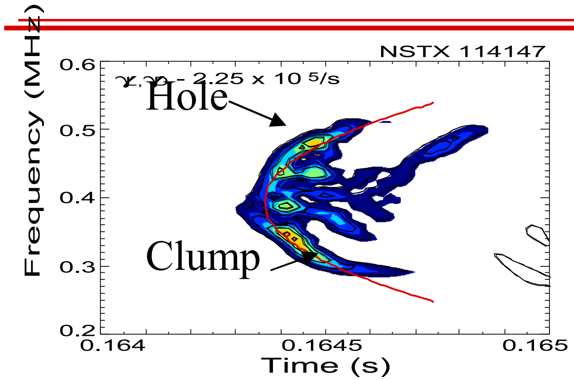
TRANSP

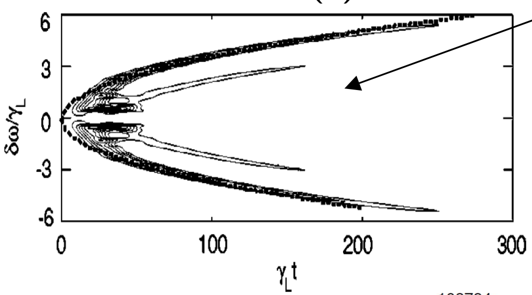


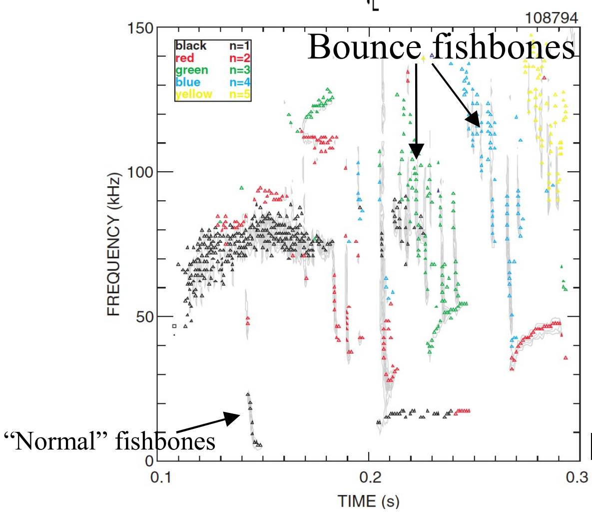
Possible studies may include:

- How RF can effect EP transport: in r vs. in v.
- HYM should provide insight into nonlinear EP effects on CAE/GAEs.
- Stochastic effects has to be studied.
- Energy/alpha channelling.

Bounce resonance fishbone and hole-clump pair mode unique to NSTX







- Hole-clump pair mode observed (Fredrickson) driven by energetically inverted velocity space distribution
- Predicted by Berk Breizman, Petviashvili (PoP, '99)
- Bounce resonance fishbones arise because

$$w_b/w_p = r/\rho \sqrt{2r/R}/q^2$$

which goes down with ρ^*_{fast} as well as with aspect ratio

- High n modes are bounce resonance, n=1 regular precession resonance fishbone (Fredrickson, Chen, White, NF '03)