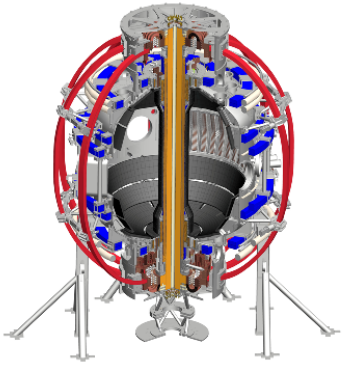
R(17-4): Assess high-frequency Alfvén Eigenmode stability and associated transport

EP Group

Research Milestone Status Meeting
PPPL, B318
March 31, 2017

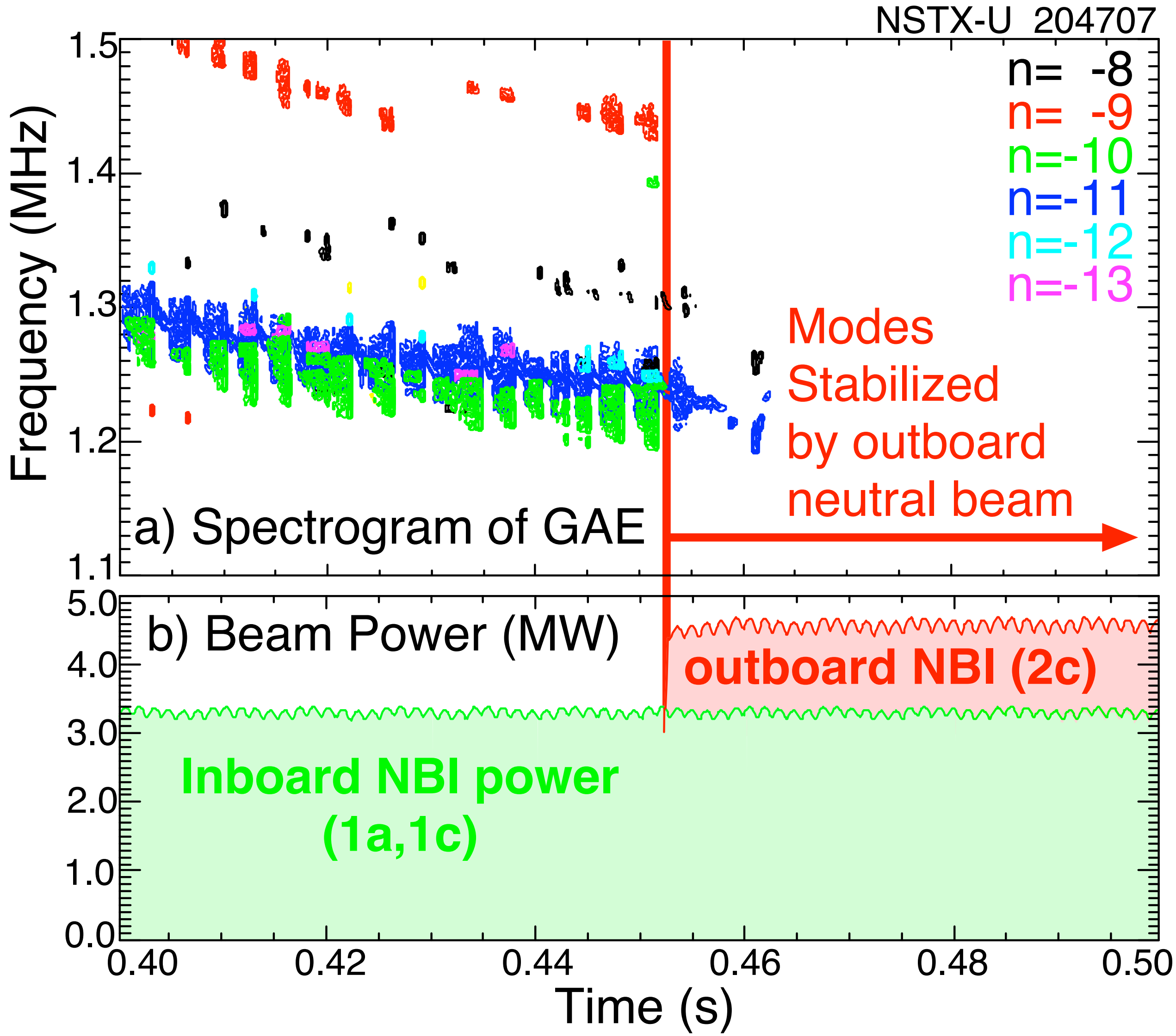
PPPL



Status of GAE suppression analysis

- PRL on suppression of ctr-propagating GAE with BL#2 sources is with the referees, but some questions remain:
  - Which outboard source is best for suppression?
  - Does beam voltage or power matter?
  - Are the BL#2 sources stabilizing because they change the spatial gradient of fast ions, or because the BL#2 ions are higher pitch, and thus intrinsically stabilizing?
  - Will suppression still work for very unstable plasmas, *e.g.,* for NSTX-like conditions (lower field, higher beam voltage)?
    - Can we use this suppression method to demonstrate a strong correlation between virulent GAE/CAE activity and core electron temperature flattening?
  - Some predictions may be made with HYM or analytic theory, but some will need NSTX-U

Typical example GAE suppression



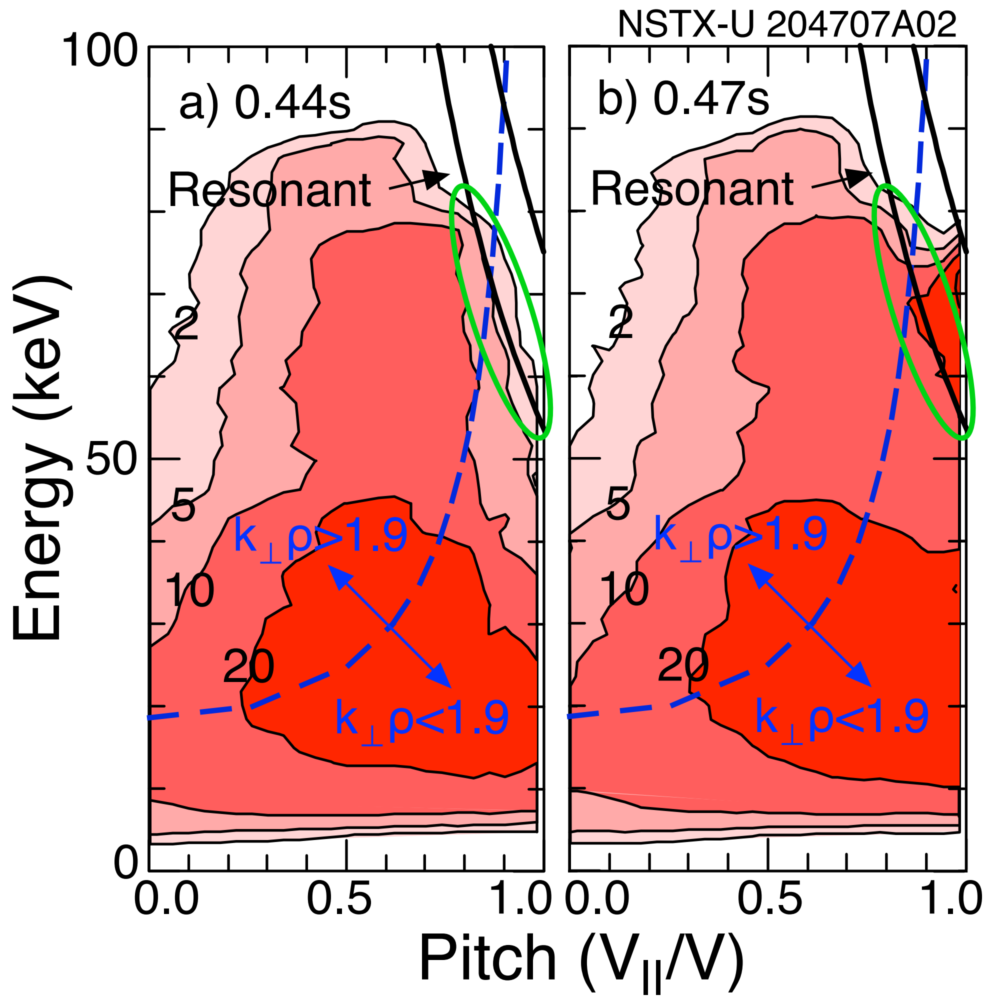
Analytic theory might give guidance on where to apply HYM

- Fast ions can be stabilizing/ destabilizing depending:

  Stable : $0 \le k_\perp \rho_\perp \le 1.9$

  Unstable: $1.9 \le k_\perp \rho_\perp \le 4$

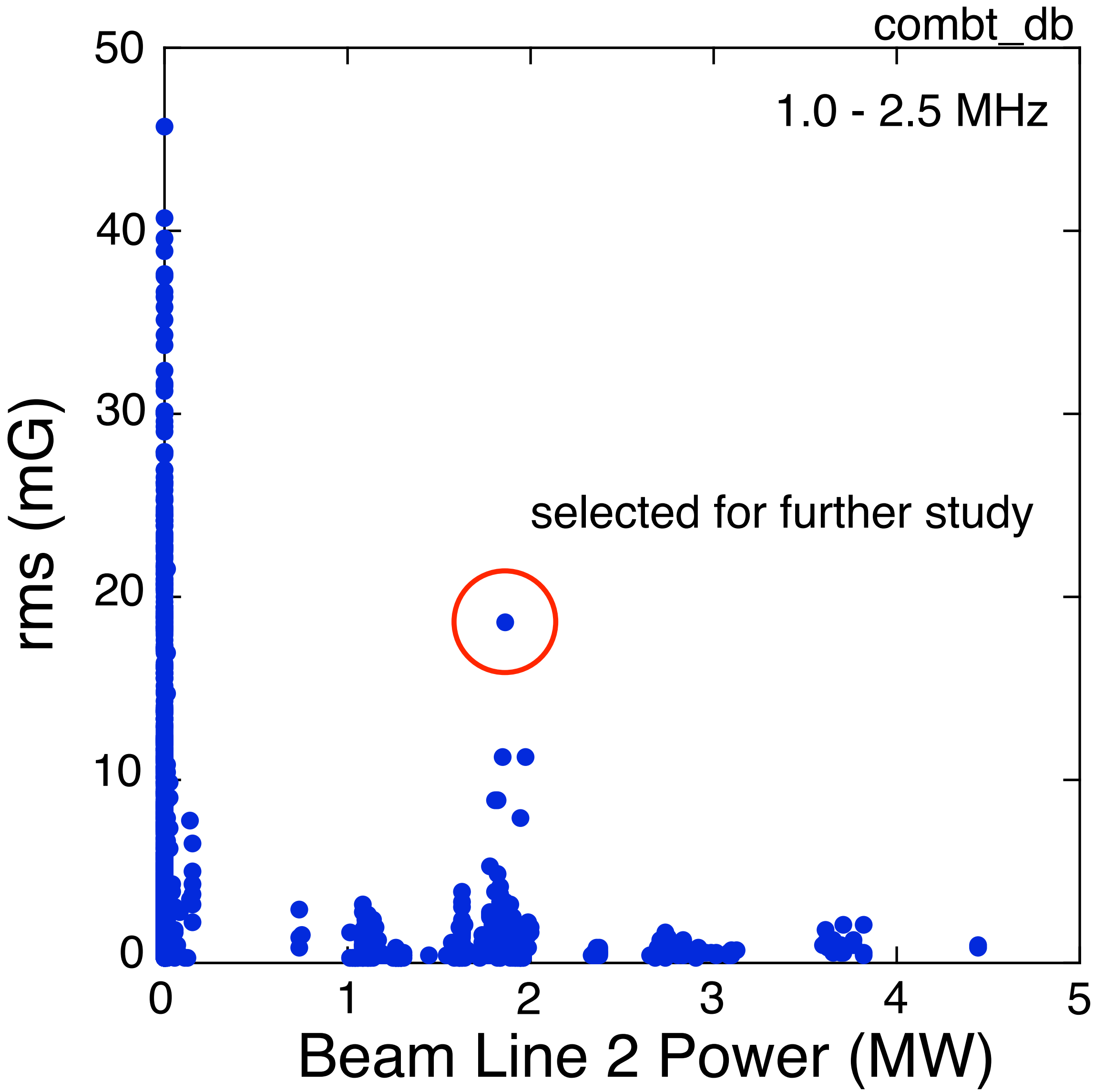
- Resonant outboard beam ions with pitch > 0.9 have small $\rho_\perp$, are stabilizing by this theory.
- Estimates based on dispersion relation and resonant condition suggest that 65keV outboard beam ions might be just marginal to reach resonant condition.
- NSTX (low field) parameter regime *might* be very different.



(Gorelenkov, NF 2003)

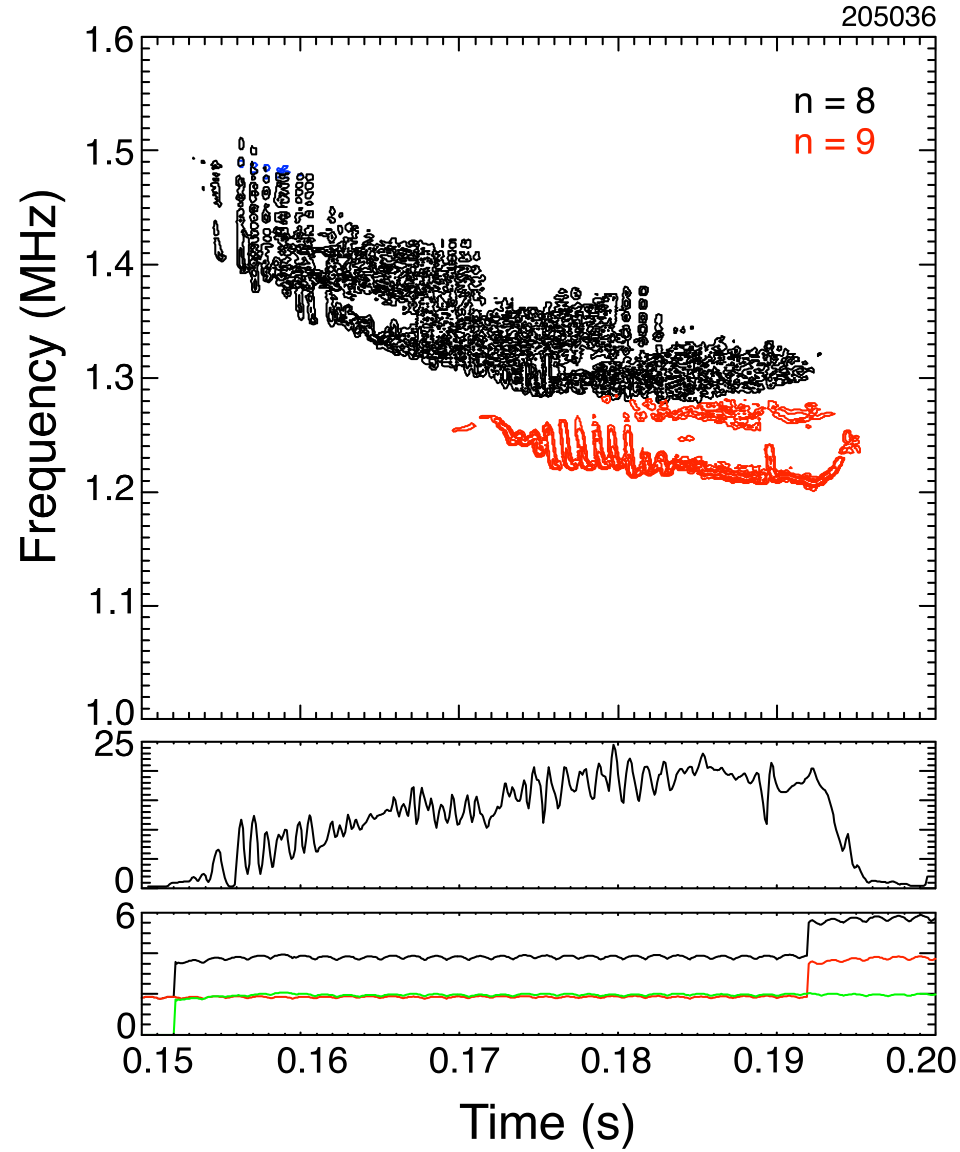
There are exceptions to full suppression

- This is, at present, a blind database – all (most) shots have not been looked at.
- Shot circled in red is being TRANSPed to get fast ion distribution.
- Has 1c & 2c, both at ≈ 2MW.
- more than 7000 pts.



Relatively strong GAE with 1c & 2c

- What is different about this shot?
- Lowish toroidal mode number.
- Early with low density.
- Most perp of the outboard sources, but other cases have seen suppression with 2c.
- Possibly 2c had high shine-through?

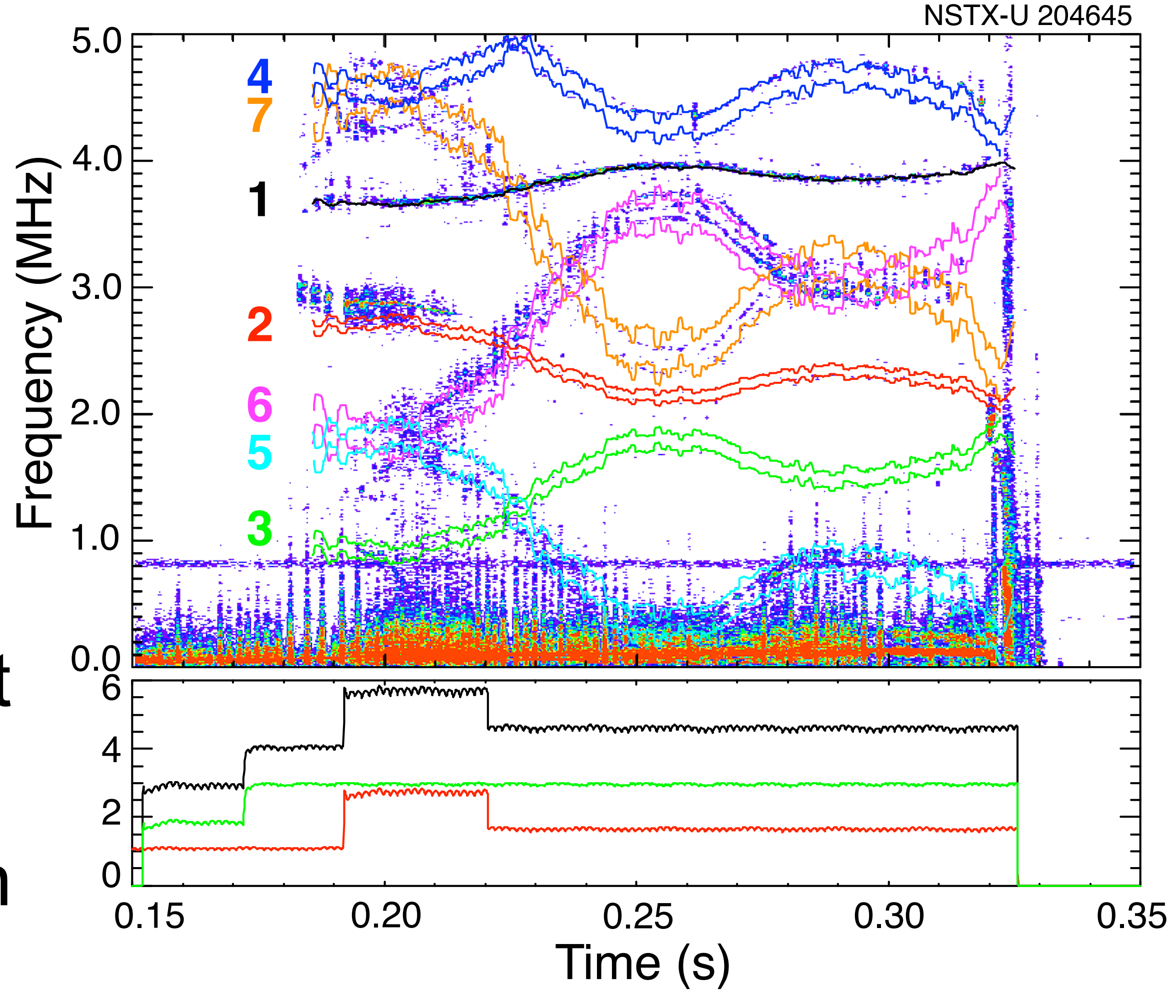


25MHz bandwidth ICE diagnostic being planned

- Ion Cyclotron Emission paper progressing
  - Lacks theoretical model
- Characteristics suggest an unstable mode – not incoherent emission
  - Emission is spatially coherent, argues for mode.
  - Emission is ‘bursty’, not cw. Argues for an unstable mode.
    - what defines unstable mode frequency?
  - Emission doesn’t follow Alfvénic scaling
    - not Alfvén eigenmode?
  - Like conventional ICE, higher harmonics have largest amplitudes
  - ST-ICE maps to internal transport barrier?
    - What physical characteristics define the plasma edge?

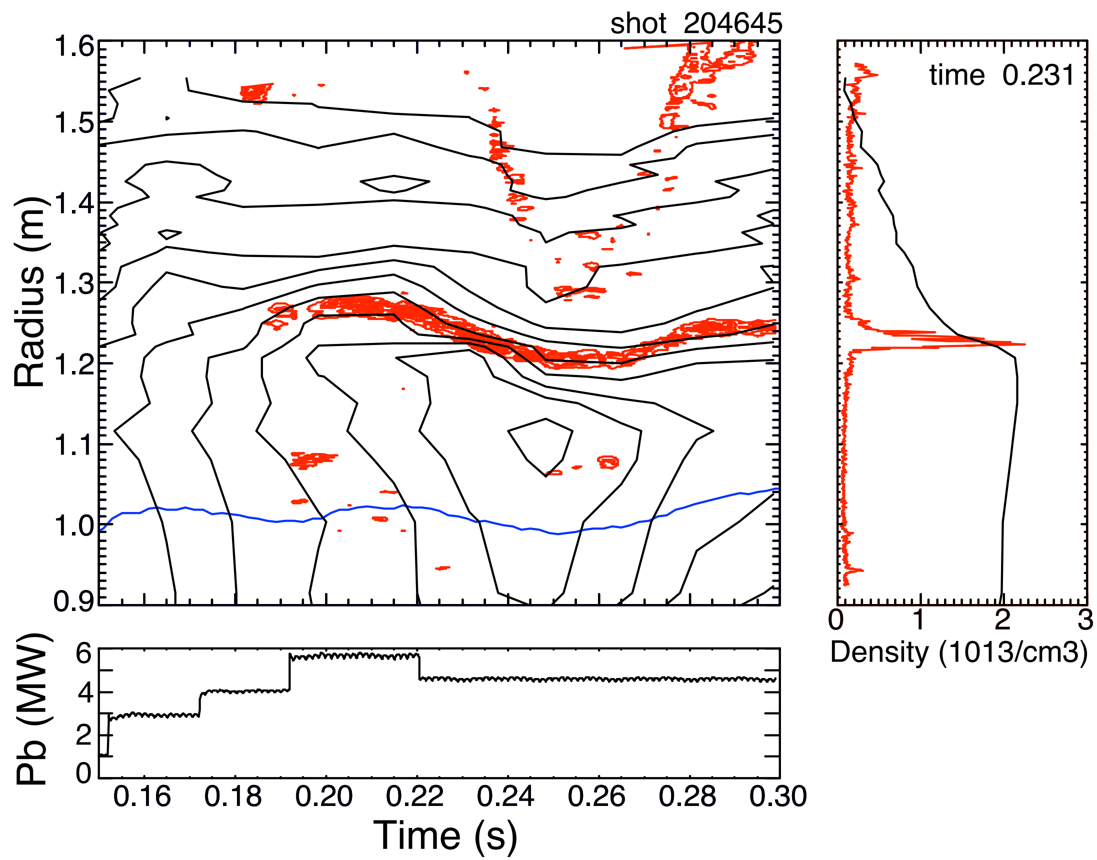
Aliased harmonics, up to 7th, can be extracted in some shots

- Compensating for roll-off in coil response, largest amplitude harmonic is the 6th.
- Harmonics appear independent – emission or different modes?
- Similar story seen in old (2002) 10MHz NSTX data.



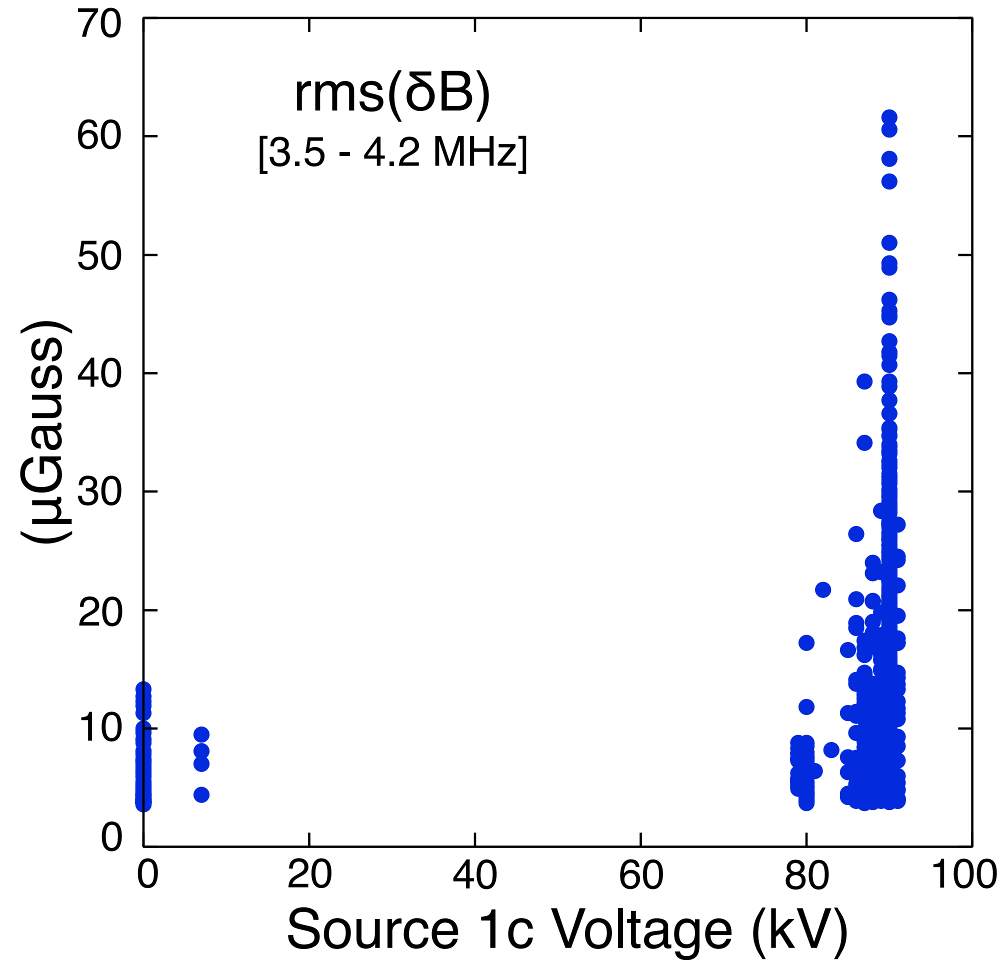
Emission maps to internal transport barrier (in most cases)

- In this case, frequency changes as plasma shifts inwards.
- Mirnov spectrogram mapped to profile of ion-cyclotron frequency.
- Strong localized internal density gradient – not so much on T_e.



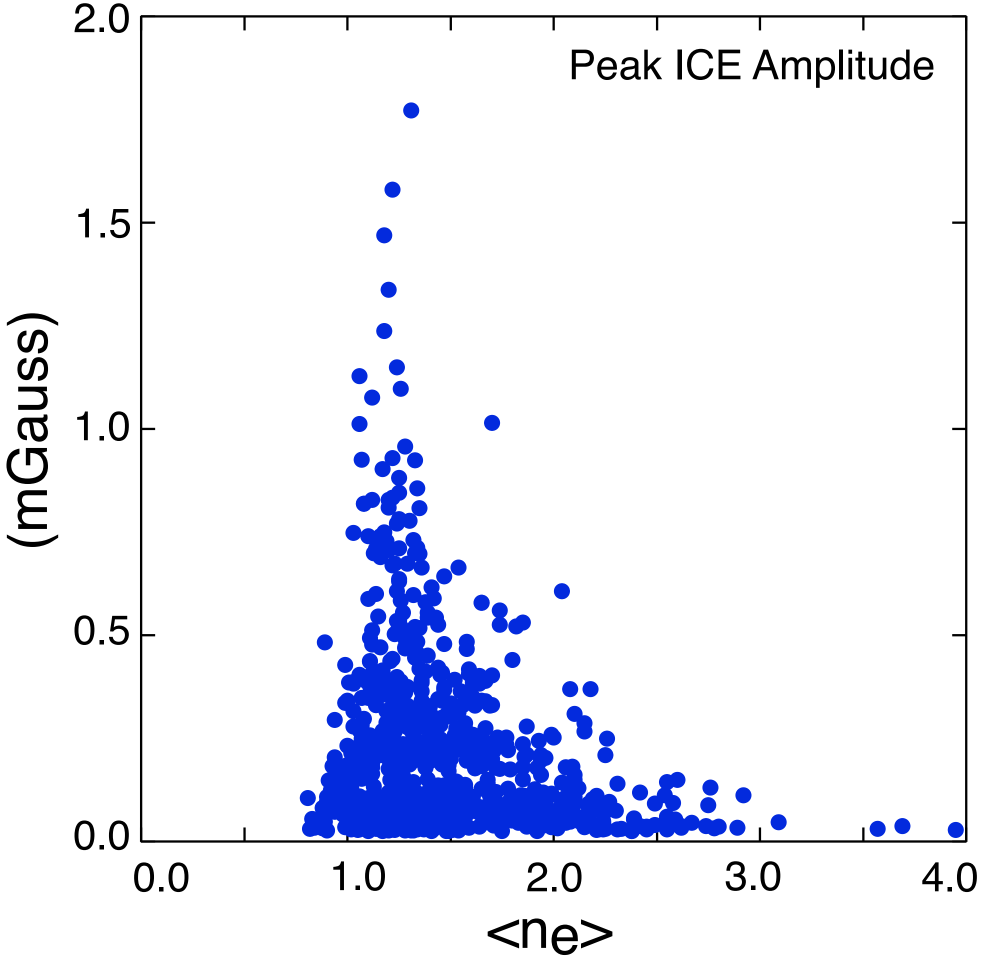
Strongest ICE correlated with source 1c – the most perpendicular source

- Consistent with emission model?
- ICE seen with other sources, just not as strong.
- Roughly 800 samples in database (around Thomson scattering times).
- ICE in NSTX doesn't seem to care as much?

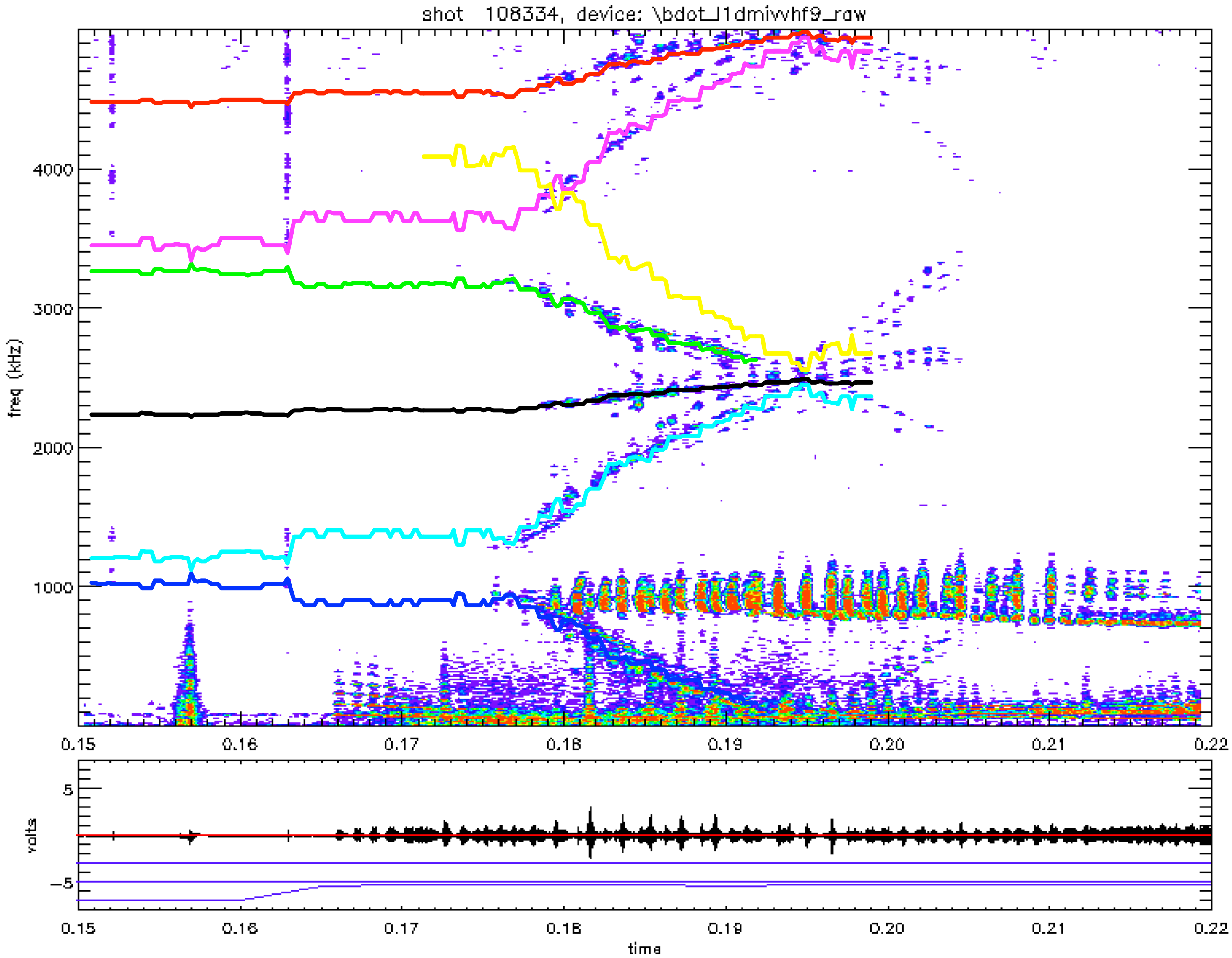


ICE mostly visible early (before 0.35s)

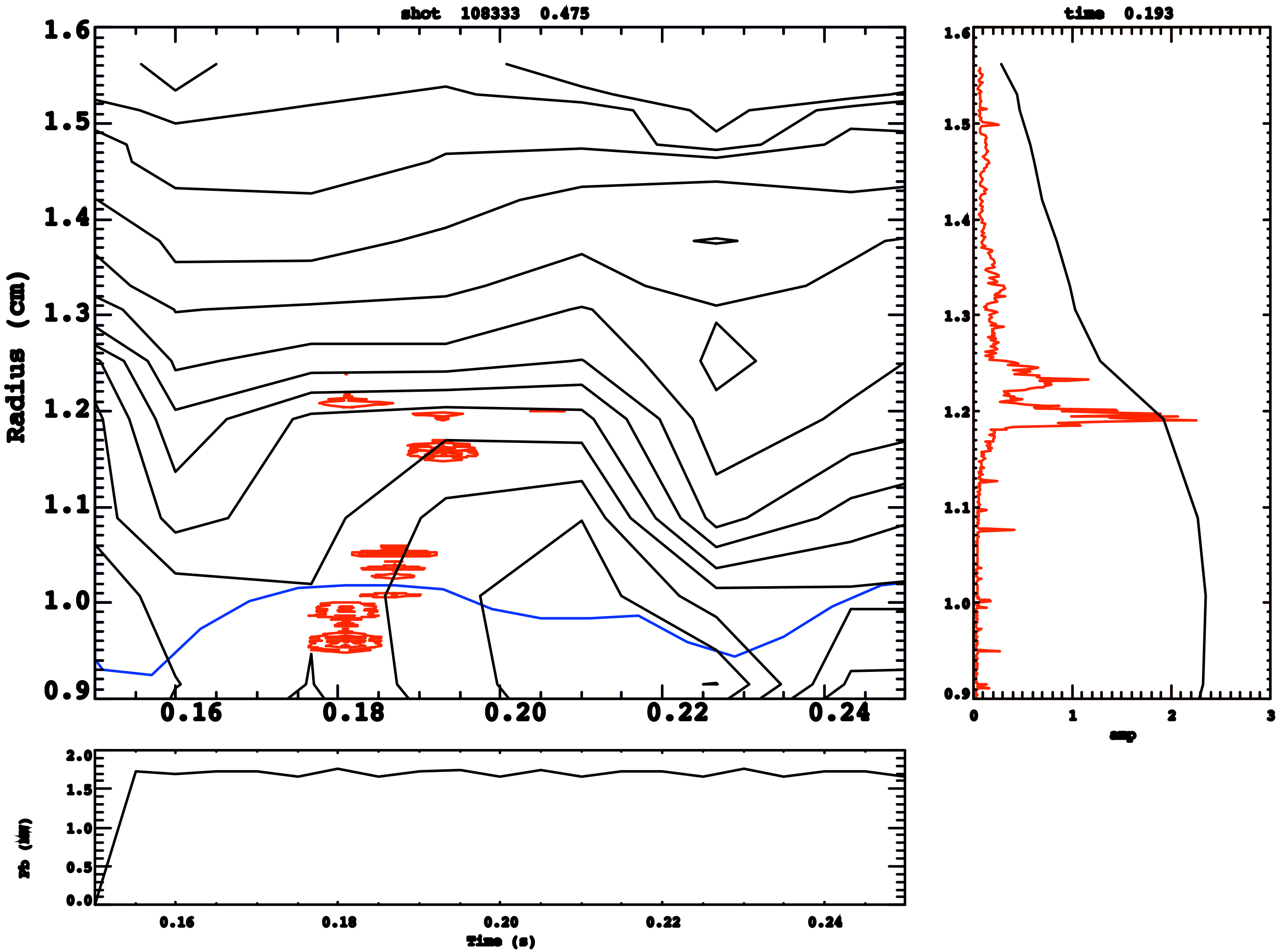
- Consistent with amplitude falling off with density.
- Plasma ‘edge’ defined by density in conventional tokamaks?
- TRANSP runs to see if scales with β_{fast}?
- Can ICE be correlated with any confined fast-ion distribution parameters?



ICE w/harmonics on 108334



Also maps into plasma



ICE of interest to broader community

- Can we learn something of confined (or lost) fast ions by measuring ICE.
  - Probably not without some theoretical framework.
- Several (?) competing theories.
  - Maybe more than one kind of "ICE"?
- Is ST ICE something completely different?
  - Seems more likely that all ICE is related.

- Next steps to continue looking for correlation of ICE with fast-ion distribution function parameters.