Edge Stability of Small-ELM Regimes in NSTX*

A. Sontag[1], J. Canik[1], R. Maingi[1], J. Manickam[2], P. Snyder[3], R. Bell[2], S. Gerhardt[2], S. Kubota[4], B. LeBlanc[2], T. Osborne[3], K. Tritz[5]

[1]ORNL, [2]PPPL, [3]GA, [4]UCLA, [5]JHU

NSTX

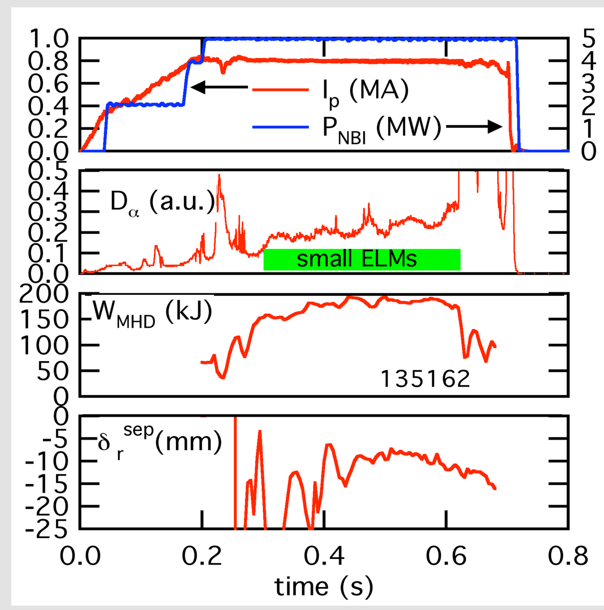
*This work was supported by U.S. DOE Contracts DE-AC05-00OR22725, and DE-AC02-09CH11466

Small-ELM regime observed coincident with edge instability

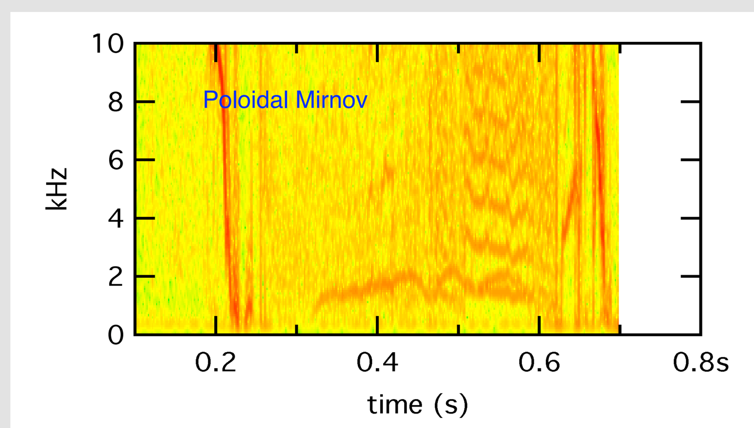
- Low-frequency (< 10 kHz) oscillations observed coincident with Type-V ELMs
  - observed in many shots on NSTX
  - δW_{MHD} << 1% per ELM
  - downward bias required (δ_r^{sep} < -5 mm)
    - consistent with previous observations*

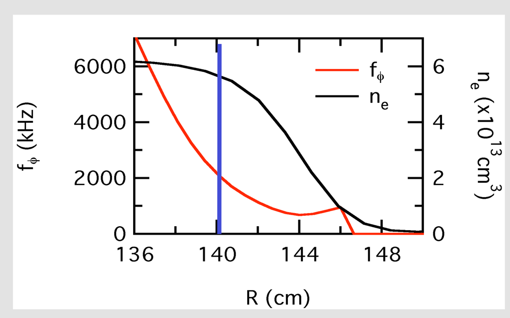
*R. Maingi, et al., Nucl. Fusion **45** (2005) 264.

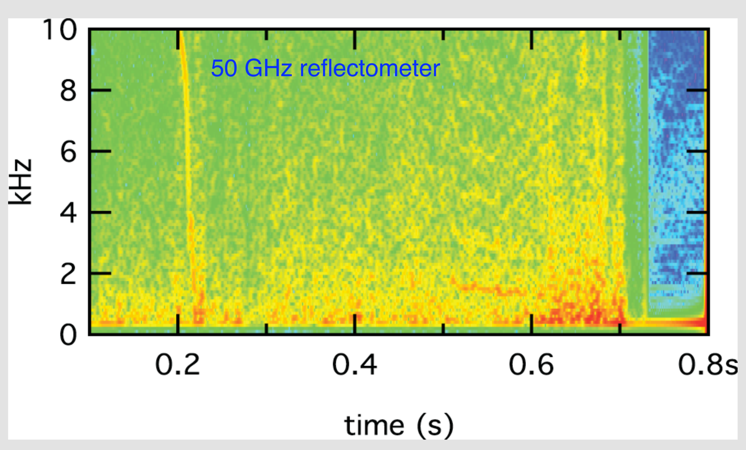
  - ST equivalent to EHO?
    - EHO allows access to ELM-free QH-mode at standard-A
      - possible saturated kink
      - rotation has complex role
      - edge collisionality important
    - EHO provides edge transport, reduces peeling-ballooning instability drive

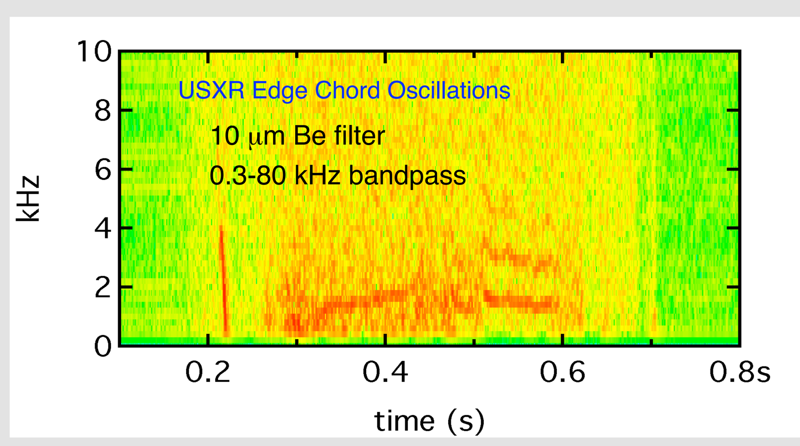


- NSTX edge mode observed in multiple diagnostics
  - poloidal Mirnovs indicate n=1
    - multiple harmonics observed
  - rotating with plasma just inside pedestal
  - USXR indicates mode near plasma edge
    - oscillations peak just inside pedestal
    - 10 μm Be filter used to eliminate edge radiation
    - unfiltered USXR shows ELM spikes independent of coherent mode
  - edge reflectometer shows density fluctuations
    - 50 GHz channel has cutoff in pedestal
    - increased ne fluctuations at same frequencies as Mirnovs and USXR observe



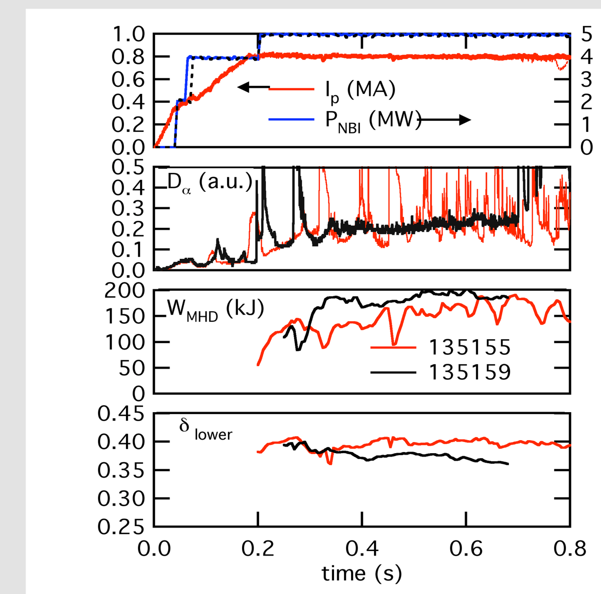


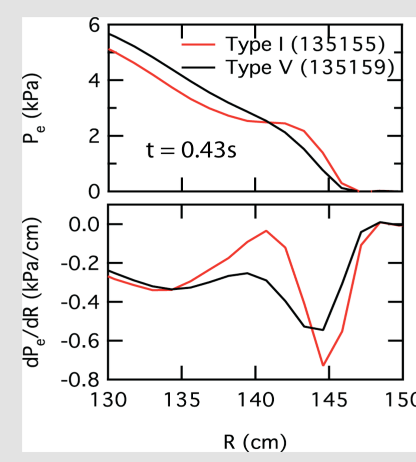


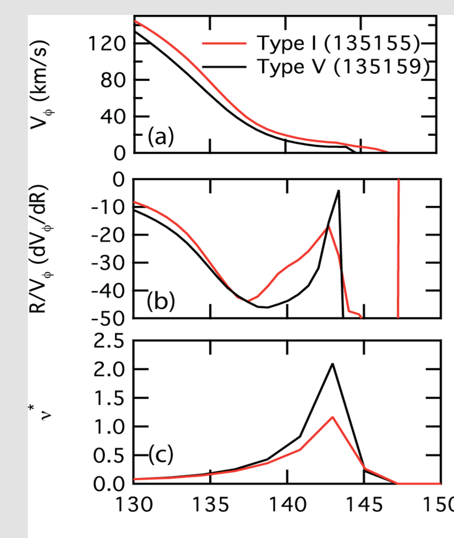


Similar shots examined to determine cause of small-ELM transition

- Small-ELM transition coincident with δ ramp-down
  - both shots have Type-I ELMs prior to 0.3 s
  - other shape parameters held constant
- δ_r^{sep} reduction well after transition
- Peak pedestal pressure shifted inward
  - Type-I profiles taken just before ELM growth
- Pressure gradient more constant with reduced peak
  - greater dP_e/dR at mode location (R ~ 142 cm)
- Rotation magnitude similar
  - increased rotation shear at mode location for Type-V case
- Edge collisionality increased in Type-V case
  - consistent with previous observations*

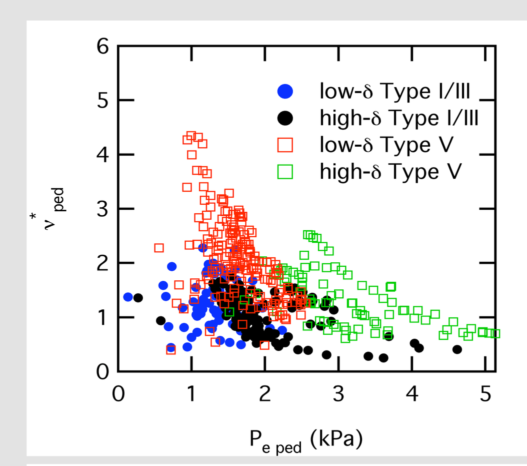


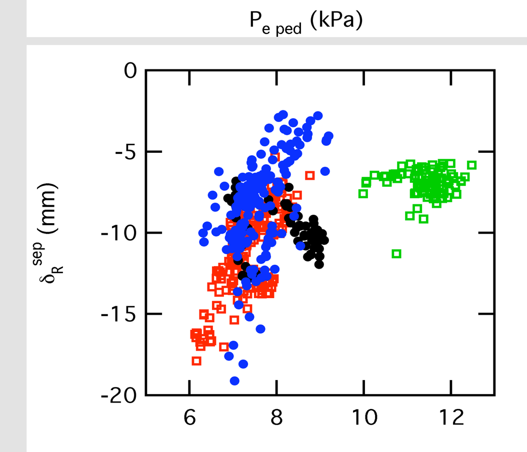


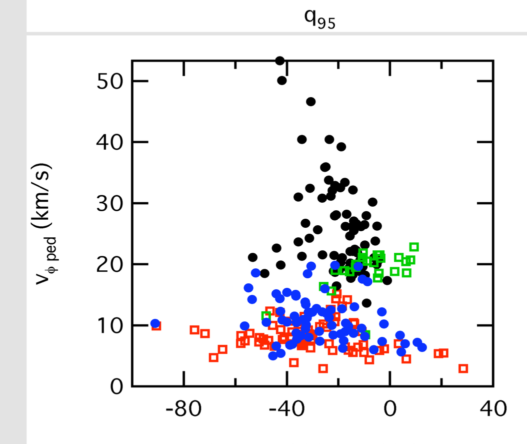


Wider range of shots indicates low-δ_r^{sep}, high ν^* favorable for Type-V

- Increased edge collisionality correlated with Type V ELMS
  - some overlap due to ambiguity of R_{ped} and variation of time in ELM cycle for this calculation
  - small-ELM shots have consistently higher $P_{e\ ped}$
    - P_e also increasing with δ as expected
- δ_r^{sep} < -5 mm necessary but not sufficient for Type V ELM access
  - Type I found at large negative δ_r^{sep} as well
  - Type V space also covers wide range of q_{95}
    - 6 < q_{95} < 12
    - 2.0 < κ < 2.7 & 0.3 < δ < 0.9
- Pedestal rotation and rotation shear not correlated with Type V access in NSTX
  - poloidal Mirnovs indicate n=1
    - multiple harmonics observed
- More detailed database study underway
  - only use Type I points in last 50-90% of ELM cycle
  - use mTanh fit to determine pedestal location



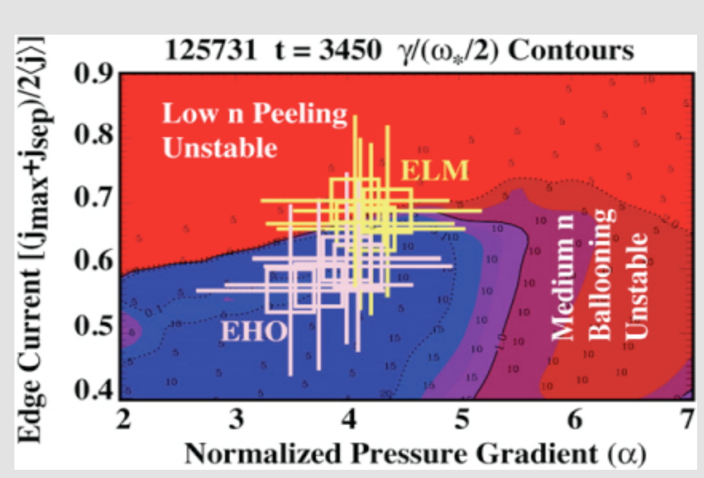




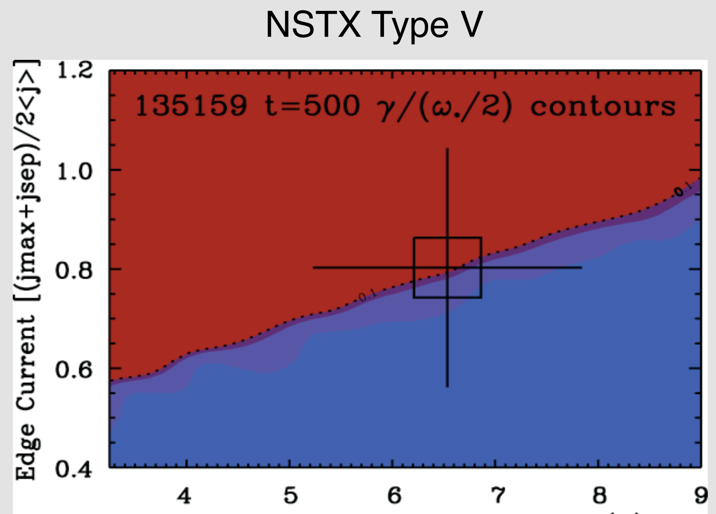
Stability analysis required to determine characteristics that allow small-ELM access

- Increased collisionality indicates that lower j_{BS} allows access to Type V ELMs
  - increased edge current found to cause ELMs rather than EHO on DIII-D
  - NSTX is typically on peeling (current driven) side of stability curve
    - ST geometry naturally leads to higher j_{BS} than at standard-A
- Increased edge pressure may indicate pressure driven internal mode for edge instability
  - j_{BS} driving internal kink but not external?
  - mode growth leads to increased transport and allows saturation
    - need stability calculation to determine drive for edge mode
    - non-linear modeling to determine mode saturation mechanism
- Initial stability calculations underway
  - ELITE calculations for Type V discharge indicates closer to peeling boundary than EHO
    - n = 3 most unstable
  - initial PEST calculations without MSE or tanh edge also show n = 3 most unstable
  - need to add MSE to ELITE
  - need to add MSE and tanh edge to PEST

DIII-D



NSTX Type V



Summary

- Edge instability observed coincident with small-ELM transition
  - observed in many NSTX discharges
  - appears to have similar role to EHO at normal-A
- No correlation with toroidal rotation or rotation shear
  - need to examine ExB shearing rate
- Increased collisionality (ν_e^* > 2) and δ_r^{sep} < -5 mm needed for Type-V ELMs
  - Type V cases have increased pedestal pressure
- Detailed stability analysis underway
  - role of edge current
  - role of edge pressure
  - peeling-ballooning vs. internal mode
  - saturation mechanism

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Supported by U.S. DEPARTMENT OF ENERGY