NSTX
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Study of Parametric Dependence of High-k Turbulence on NSTX

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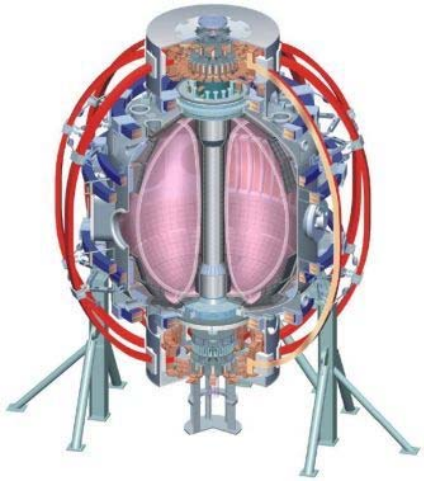
2010 NSTX Results and Theory Review
November 30th, 2010



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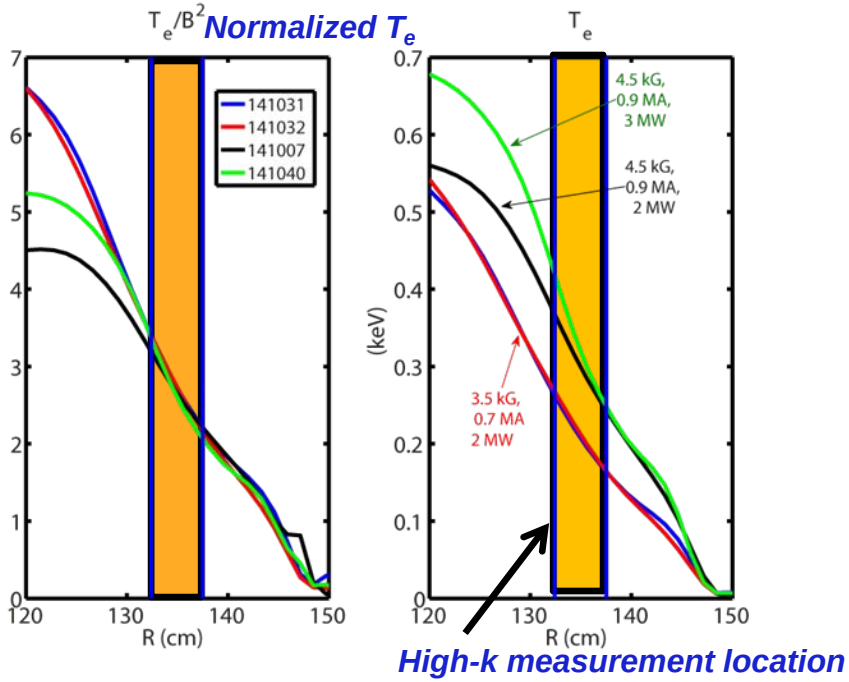
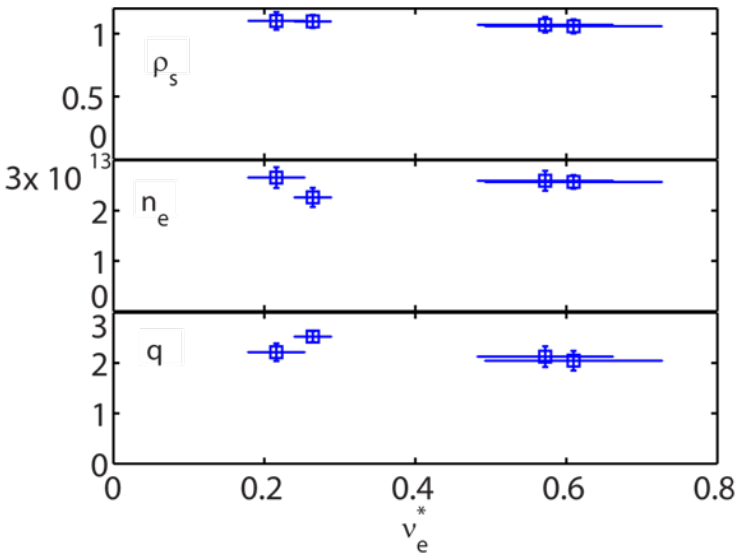
Outline

- High-k turbulence has collisionality dependence (XP 1037)
  - Factor of three change in collisionality achieved
  - Local ρ_e, β_e , n_e and q kept approximately constant
  - Turbulence spectral power decreased as collisionality increases.

- Steep density gradient has been observed to stabilize electron-scale (high-k) turbulence.
  - Large density gradient increase induced by an ELM event
  - Density gradient stabilization most effective on longer wavelength modes ($k_\perp \rho_s \lesssim 10$)

A Factor-of-Three Local Collisionality Scan Achieved



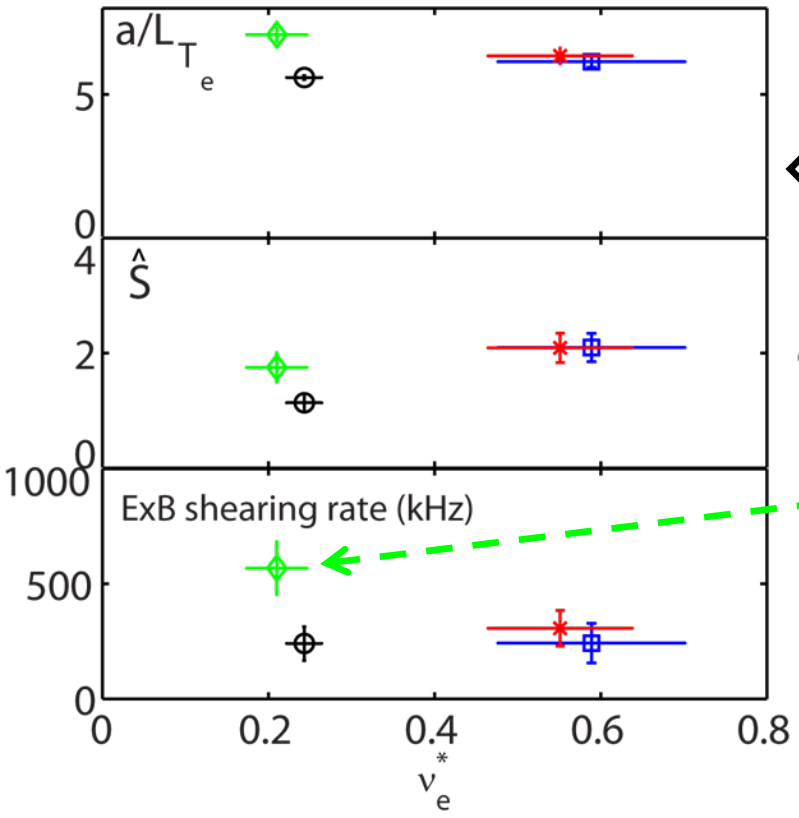


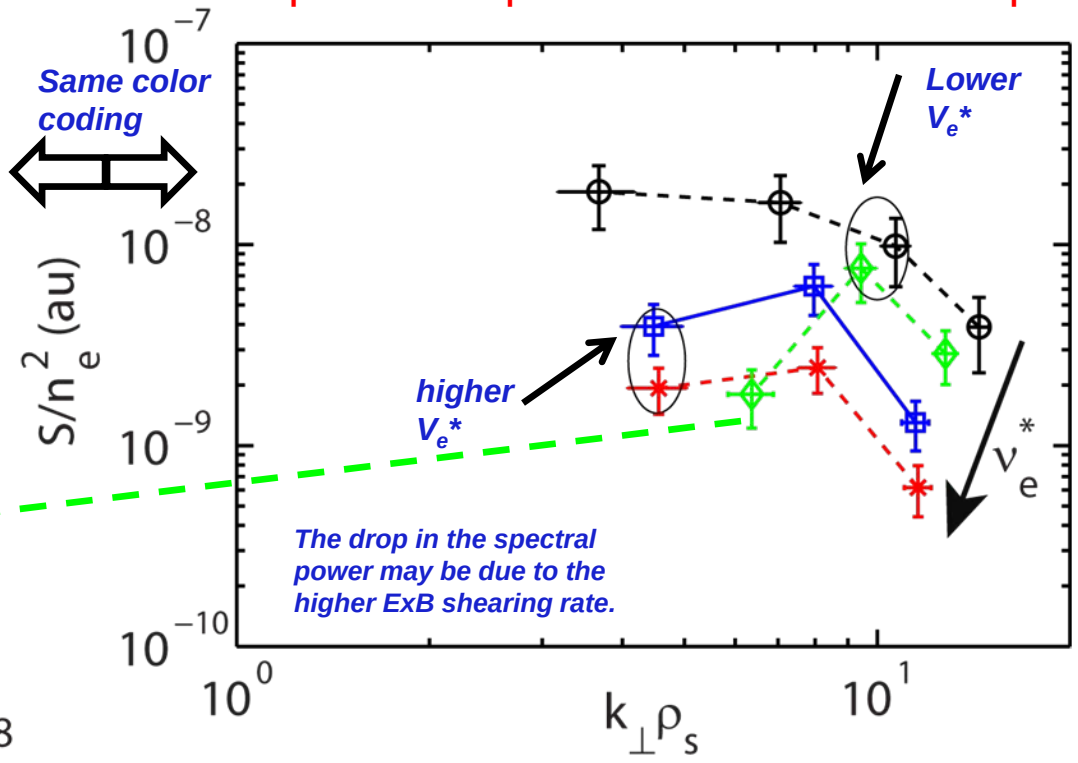
- Time points chosen so that $T_e \propto B^2$ was well maintained from R=130-145 cm: local v_{e^*} was varied with constant ρ_e and β_e .
- I_p and B_T were varied with a constant ratio to keep constant q.
- Neutral beam power was adjusted to have a better match in T_e profile.
- The scan was carried out with (I_p(MA), B_T (kG))=(0.7,3.5), (0.9,4.5) and (1.1,5.5).
- (1.1 MA, 5.5 kG) shots have much high density and Z_{eff} and are not used.
- Factor of three change in v_{e^*} is achieved.
- ρ_s , n_e and q have only small variations against v_{e^*}.

High-k Turbulence Power Seems to Increase as v_{e*} Decreases

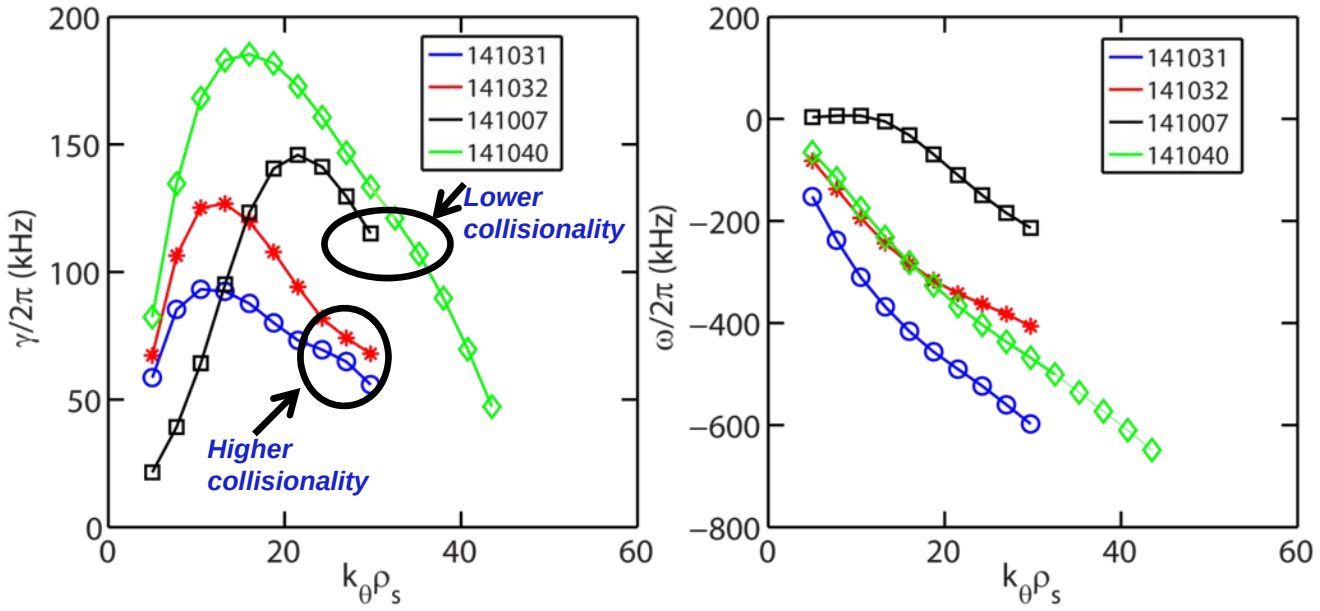
- T_e gradient variations are up to 30%.
- Variation in magnetic shear is larger, up to 90%.
- Variation in ExB shearing rate can be up to factor of two.

- High-k turbulence power appears to increase as v_{e*} decreases at $k_\perp \rho_s$ >9.
- The same relationship may hold for $k_\perp \rho_s$ <9 if ExB shearing stabilization is taken into account.
- Larger variation in v_{e*} and 2D k spectrum will be important to pin down the relationship



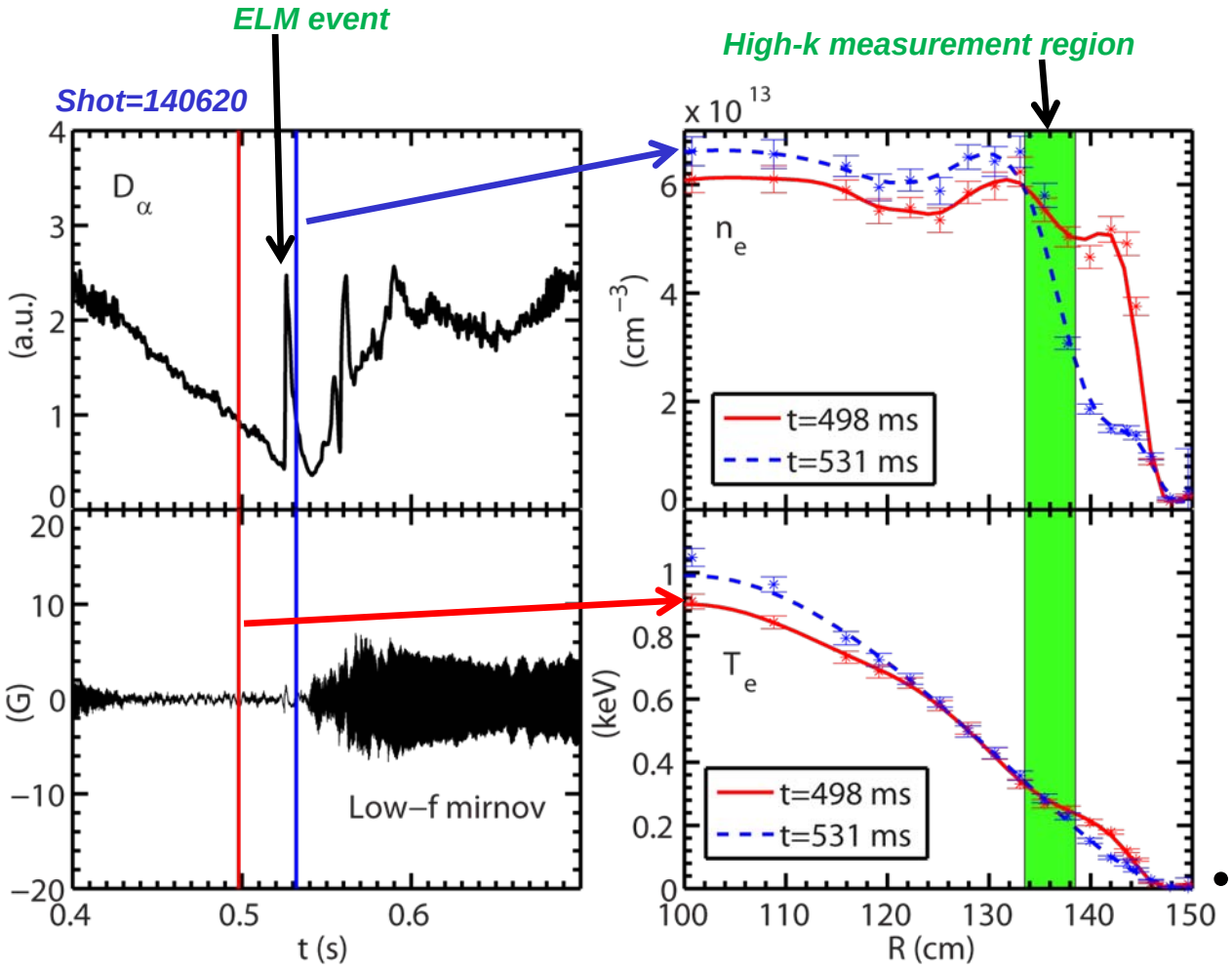


ETG Turbulence Linearly Unstable in All These Discharges



- Stability Analysis was performed with the GS2 code (Kotschenreuther et al., 1995)
- Maximum ETG growth rates are higher for the lower collisionality cases with the same trend as wavenumber spectral power.
- Nonlinear simulations will be conducted.

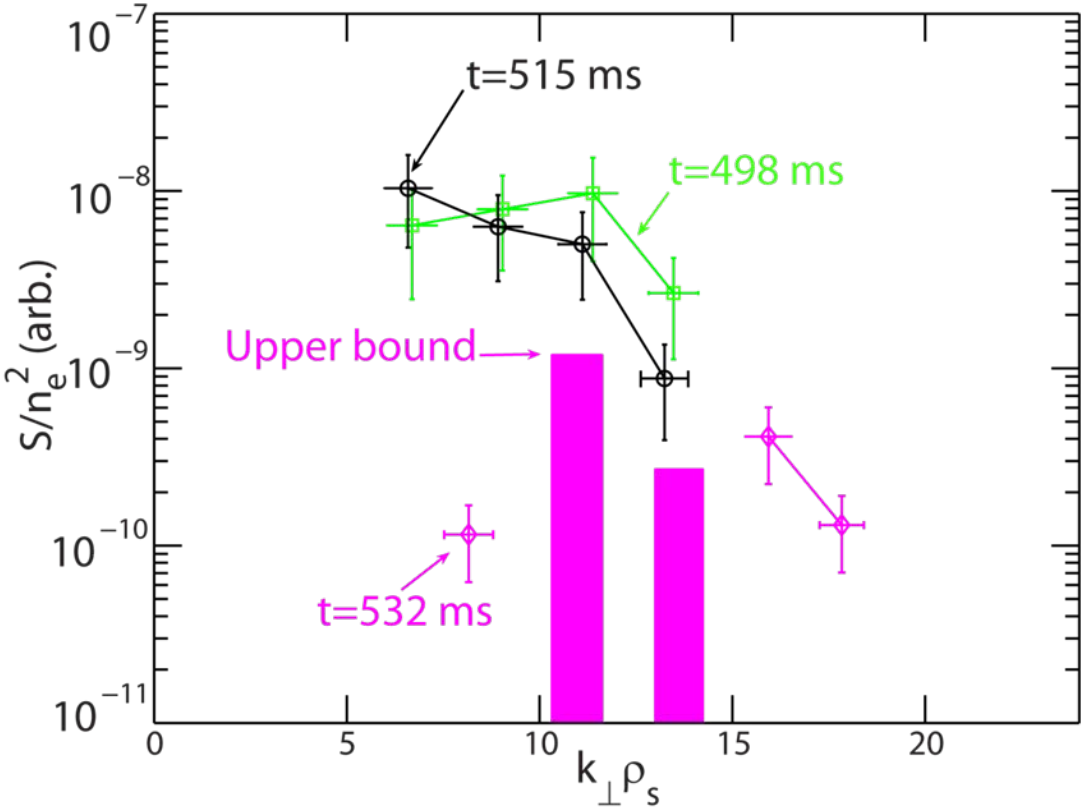
Large Density Gradient Induced by an ELM Event



- After the ELM event:
  - Large density gradient developed in the high-k measurement region.
  - Electron temperature gradient also increases.
  - Electron density has only a moderate decrease.
  - Electron temperature remains essentially constant.
- No large MHD mode appears before and right after the ELM event.

The Spectral Power of Modes at Smaller Wavenumber is Significantly Reduced

- Significant decrease in wavenumber spectral power is observed for modes with longer wavelength, $k_\perp \rho_s \lesssim 10$.
- The spectral power of the large wavenumbers, $k_\perp \rho_s \gtrsim 15$, is unaffected.
  - The decrease in scattered signals after the ELM event in those channels mainly come from the fact that they measure larger wavenumbers.
- Simultaneous operation of all five channels is essential to this observation.



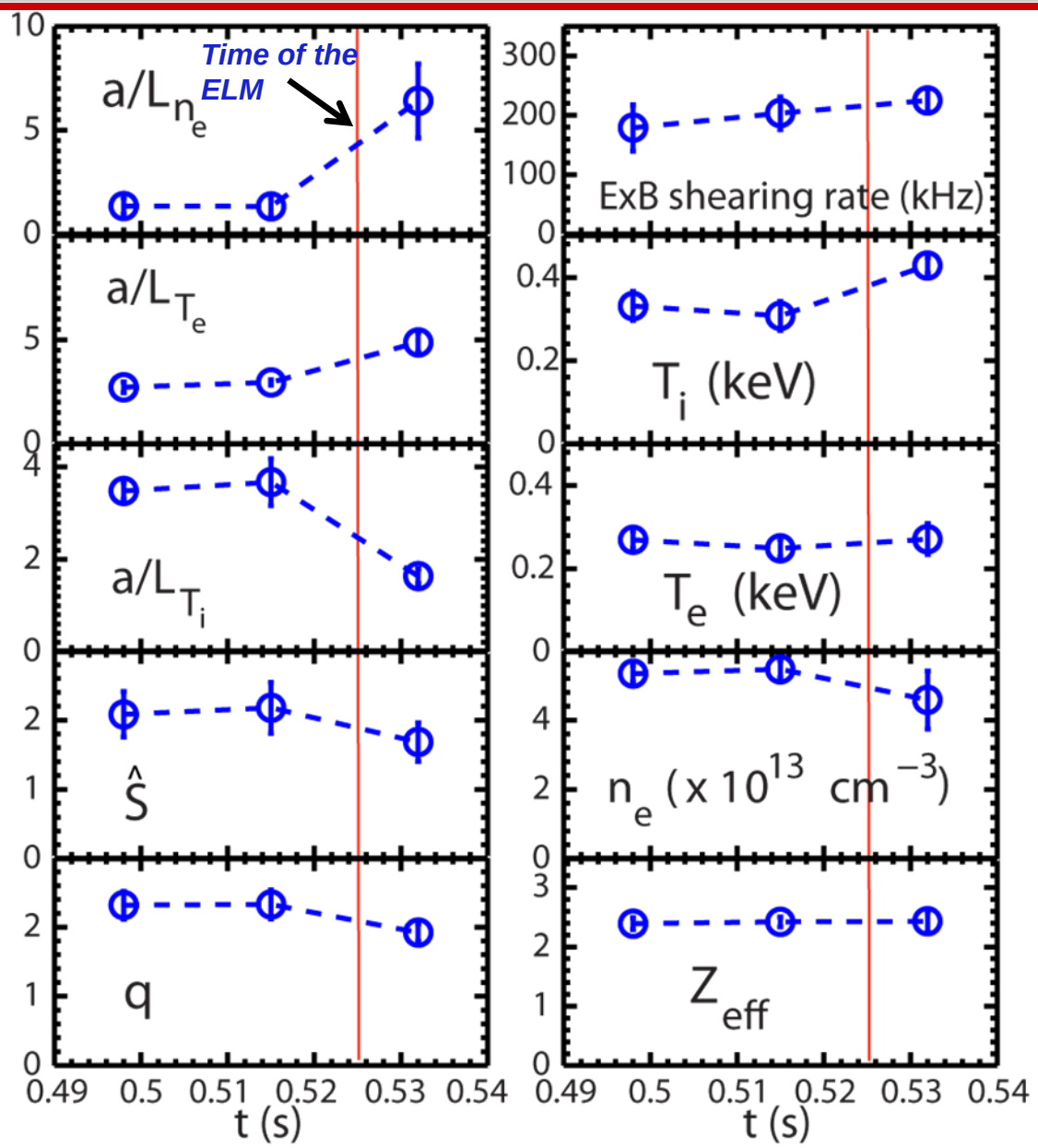
Summary

- High-k turbulence has collisionality dependence and the measured spectral power decreases as collisonality increases with the same trend as in linear growth rate.

- Stabilization effect of large density gradient induced by an ELM event and simultaneous confinement improvement have been observed
  - Significantly reduction of high-k fluctuations at smaller $k_\perp$, $k_\perp \rho_s \lesssim 10$, and spectral power at large $k_\perp$, $k_\perp \rho_s \gtrsim 15$, is not affected.
  - Linear stability analysis demonstration of the stabilization effect of large density gradient

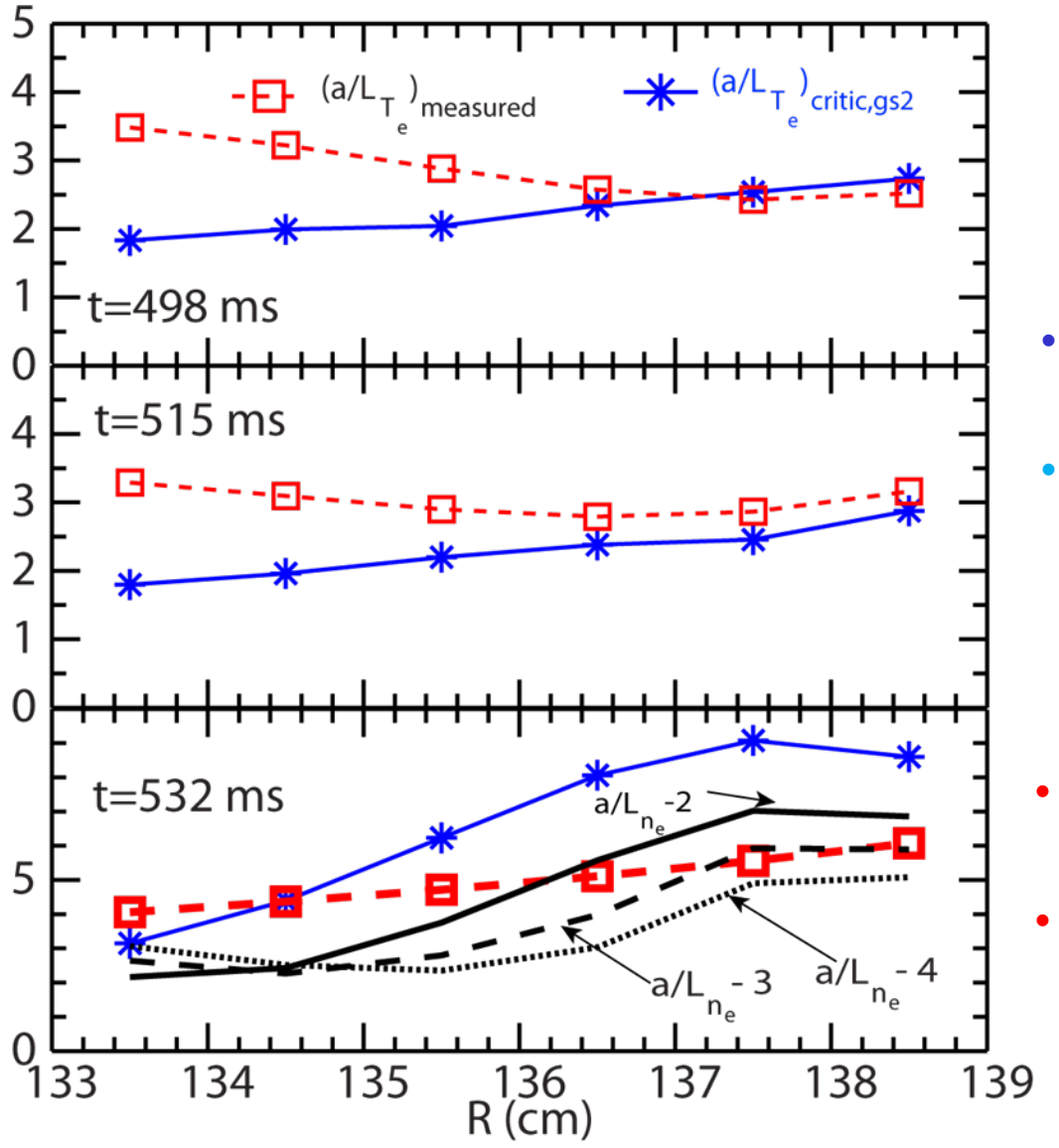
Backup slides

Other Important Equilibrium Quantities Have Small Changes After the ELM Event



- The normalized density gradient (by last closed flux surface minor radius) has a factor of 5 increase after the ELM event.
- The normalized T_e gradient increases by about 60% and the normalized T_i gradient decreased by about 60%.
- The ion temperature has a 40% increase.
- All other quantities have change no more than 25%.

Linear Stability Analysis Showing the Stabilization of ETG Modes After the ELM Event



a/L_{T_e} measured

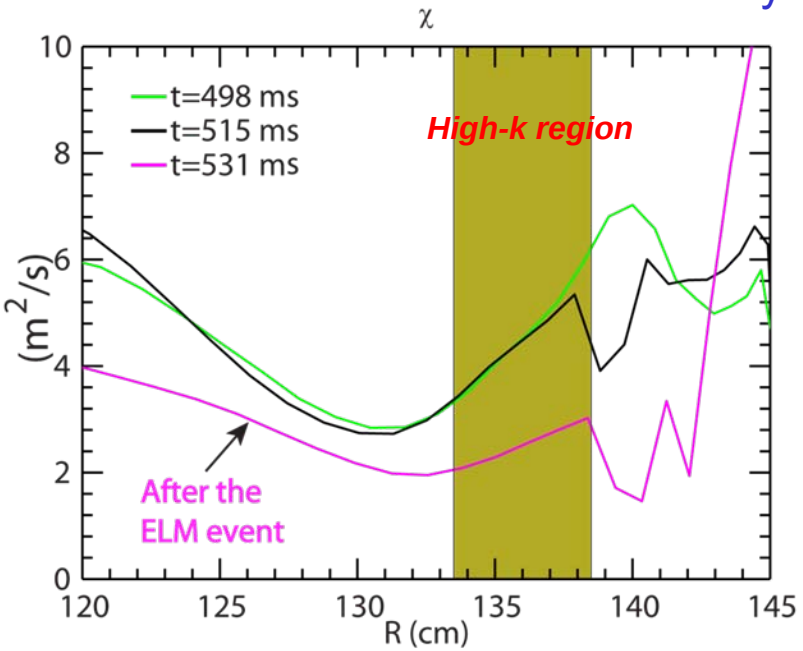
$(a/L_{T_e})_{critic}$ by GS2

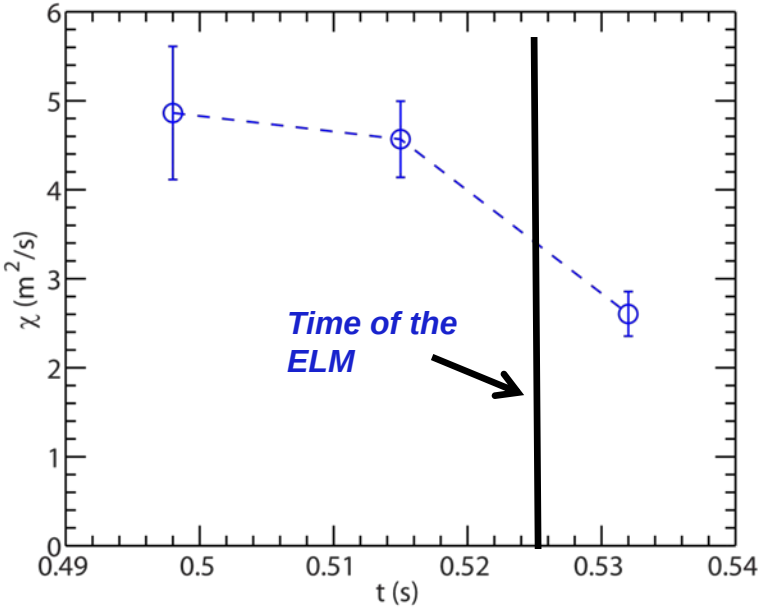
- Before the ELM, ETG is largely unstable.
- Stability Analysis was performed with the GS2 code (Kotschenreuther et al., 1995)

- After the ELM, ETG is largely stable.
- With manually decreased a/L_{n_e}, ETG is largely unstable again.

Plasma Confinement Improved after the ELM Event

- Plasma thermal diffusivity is decreased by about a factor of 2 after the ELM event.
  - Large density and higher ion temperature leads to strong coupling between electron and ions.
  - One-fluid effective thermal diffusivity is ued to show the confinement improvement.





- This increase correlates well with the decrease of the spectral power of the longer wavelength modes.