Sensitivity of TEM and ITG Modes to Temperature and Density Gradient Scale Lengths and Collisionality

by

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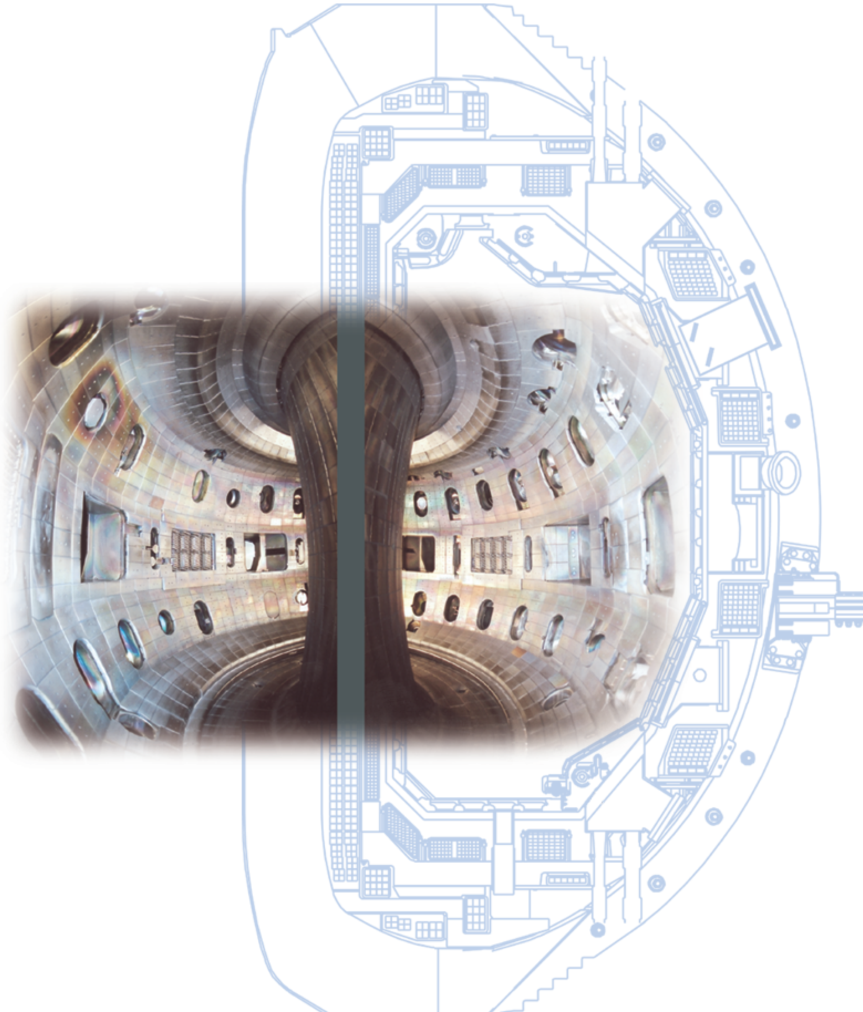
General Atomics



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Motivation and Introduction

- Find most sensitive drive terms for trapped electron mode turbulent activity that can be exploited experimentally
- Manipulate the drive terms to turn TEM on and off to allow correlation between TEM activity and turbulent fluctuation measurements, transport calculations and code simulations
- Employ TGLF linear driftwave stability code for sensitivity study of important drive terms
- Use experimentally obtained profiles for reference case in the sensitivity study

Reference Case

- L-mode discharge

  I_p = 0.8 MA

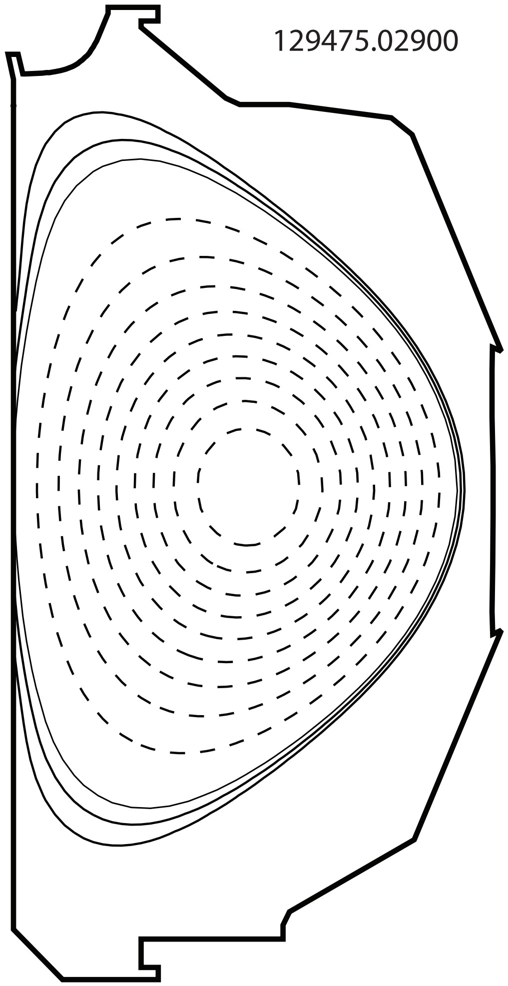
  B_T = 2 T

  $n_e = 1.9 \times 10^{19}$ m^{-3}

  q_{95} = 6

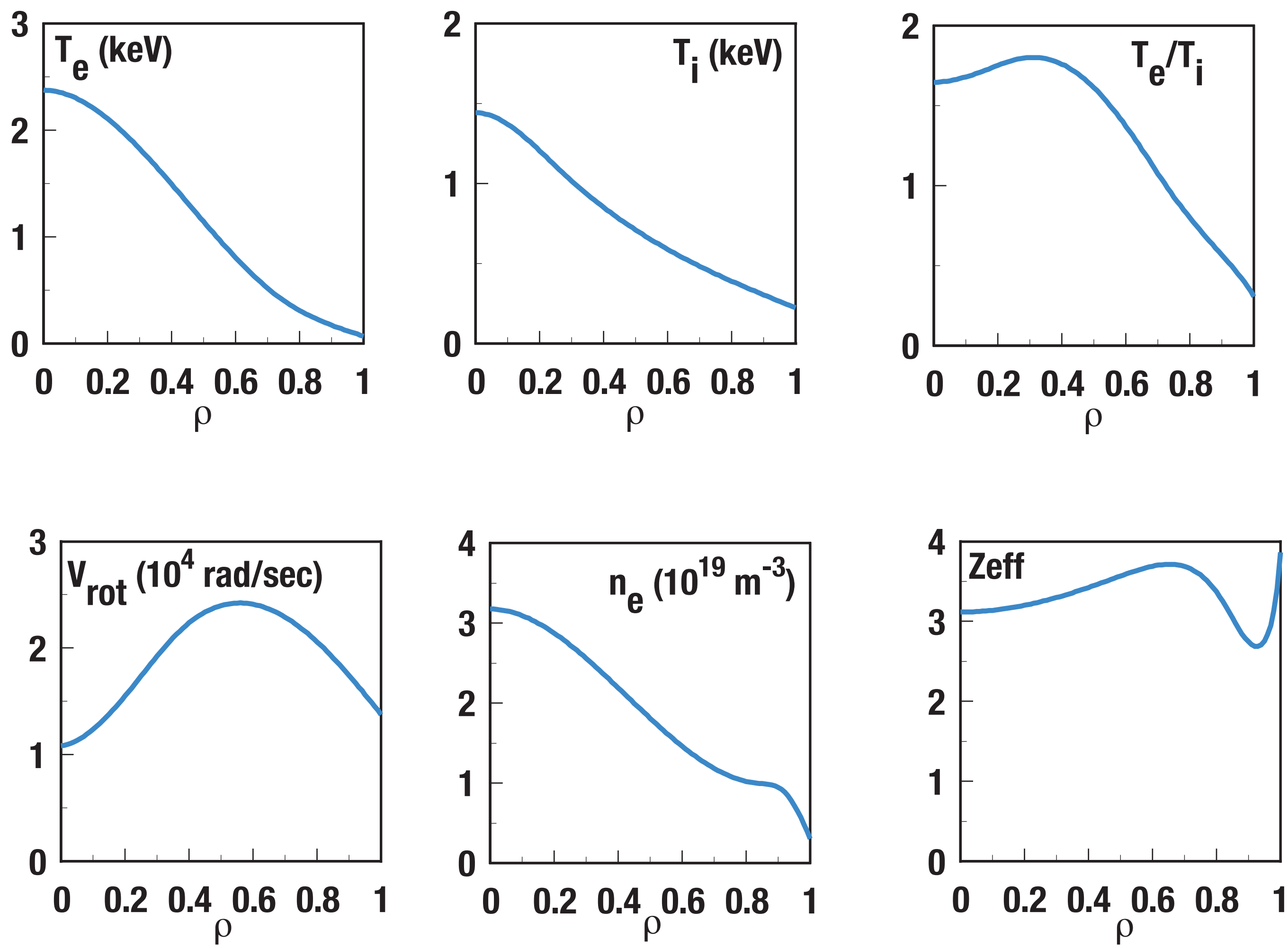
  1 MW ECH

- Fluctuation diagnostics optimized for viewing r/a ~ 0.5



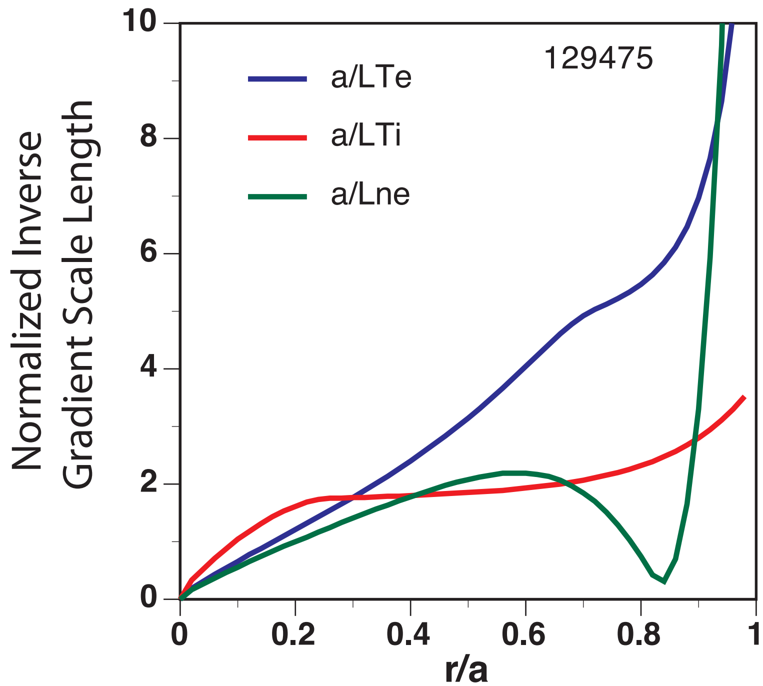
Reference Case Experimental Profiles

L-mode discharge 129475



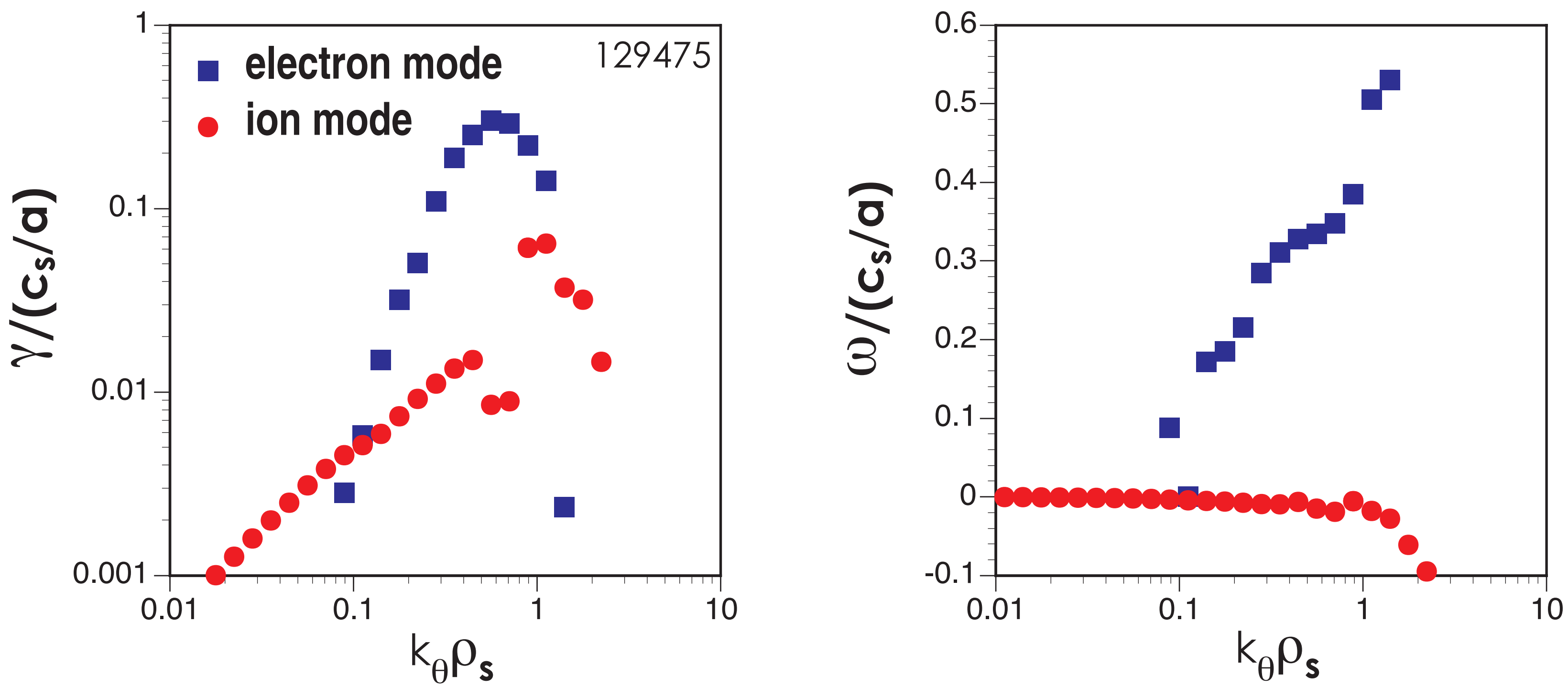
Normalized Inverse Gradient Scale Lengths

- a/L_{T_e} is larger than a/L_{T_i} at the plasma midradius
- a/L_{n_e} is smaller than a/L_{T_e} but still a significant contributor to TEM activity



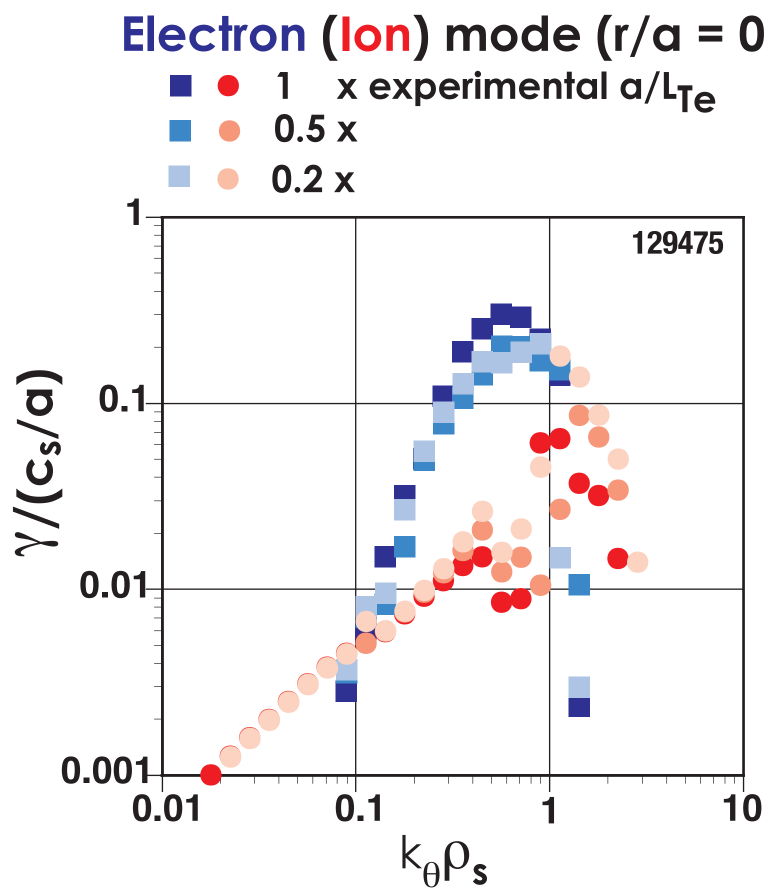
TEMs Have Dominant Growth Rate at r/a = 0.5

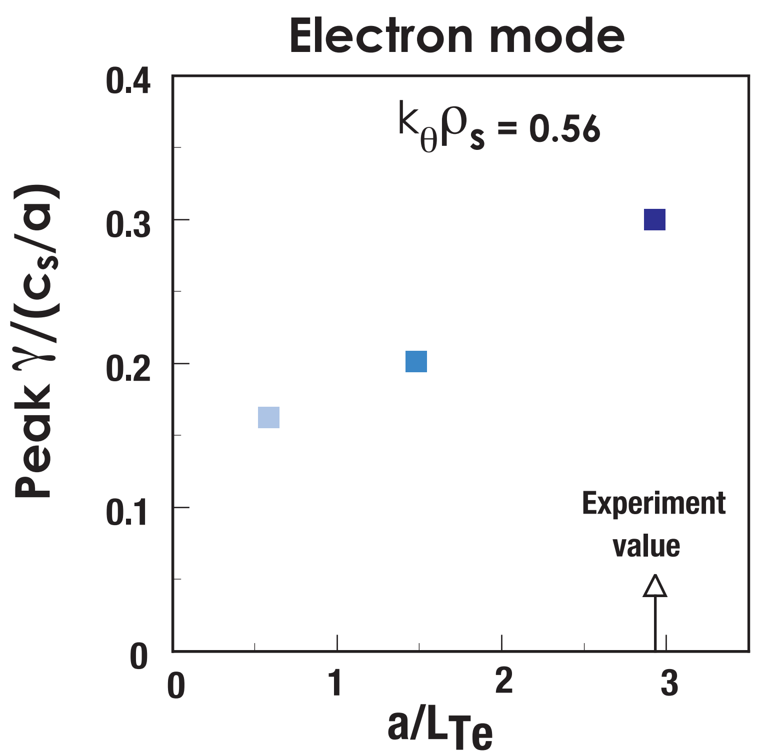
- **Electron growth rate peaks at wavenumbers associated with trapped electron modes**



Growth Rates Are Only Moderately Sensitive To a/L_{Te}

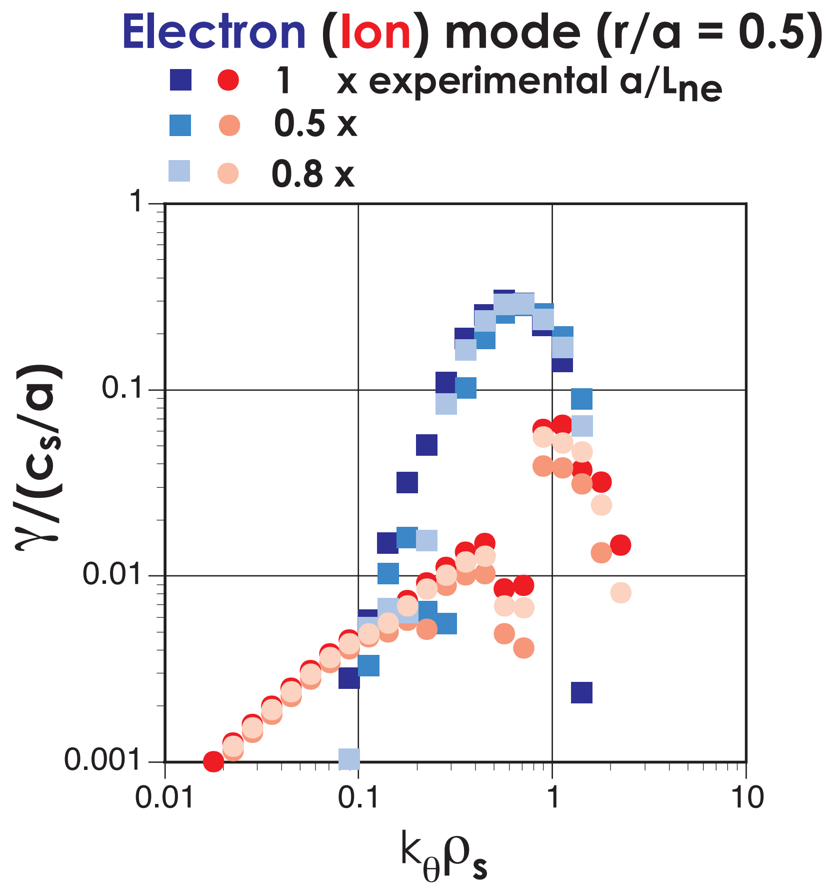
- Value of a/L_{Te} at $r/a = 0.5$ was arbitrarily reduced from the experimental value to determine the growth rate sensitivity
- Estimate 33% decrease in peak growth rate for factor 2 decrease in a/L_{Te}

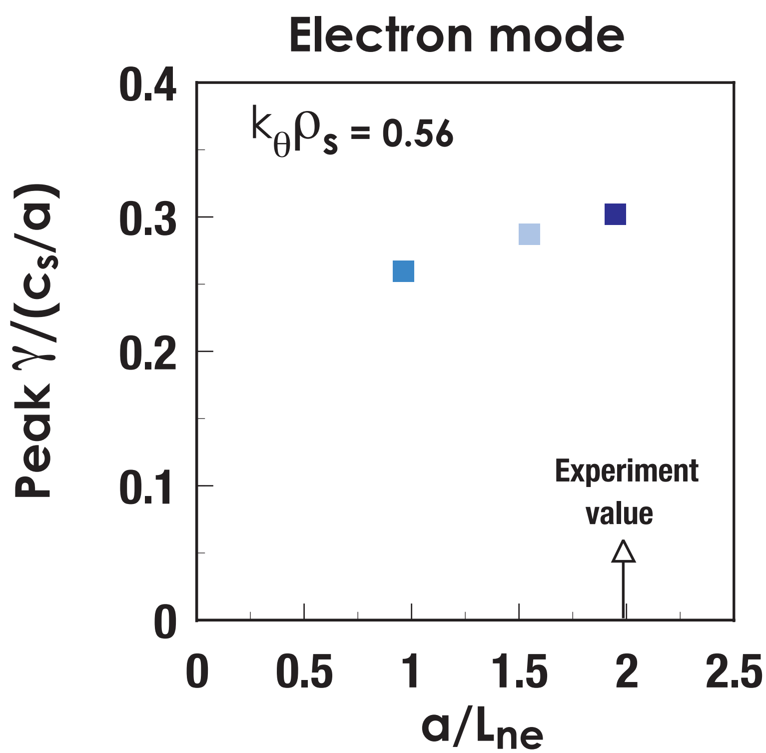




Growth Rates Are Insensitive To Density Gradient Scale Length

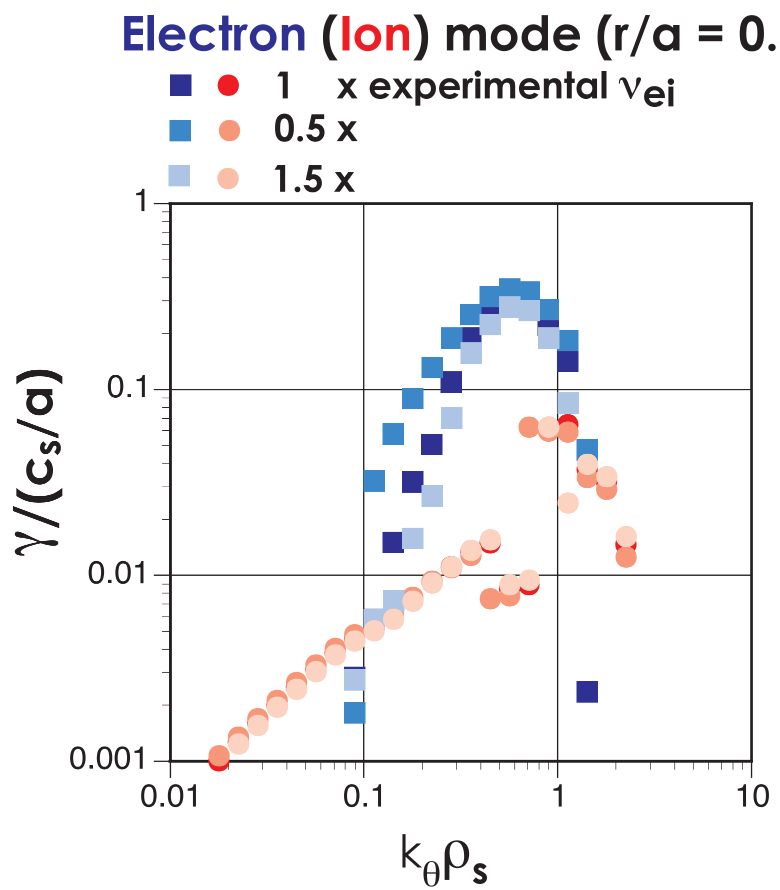
- Value of a/L_{ne} at $r/a = 0.5$ was arbitrarily changed from the experimental value to determine the growth rate sensitivity
- Estimate 14% decrease in peak growth rate for factor 2 decrease in a/L_{ne}

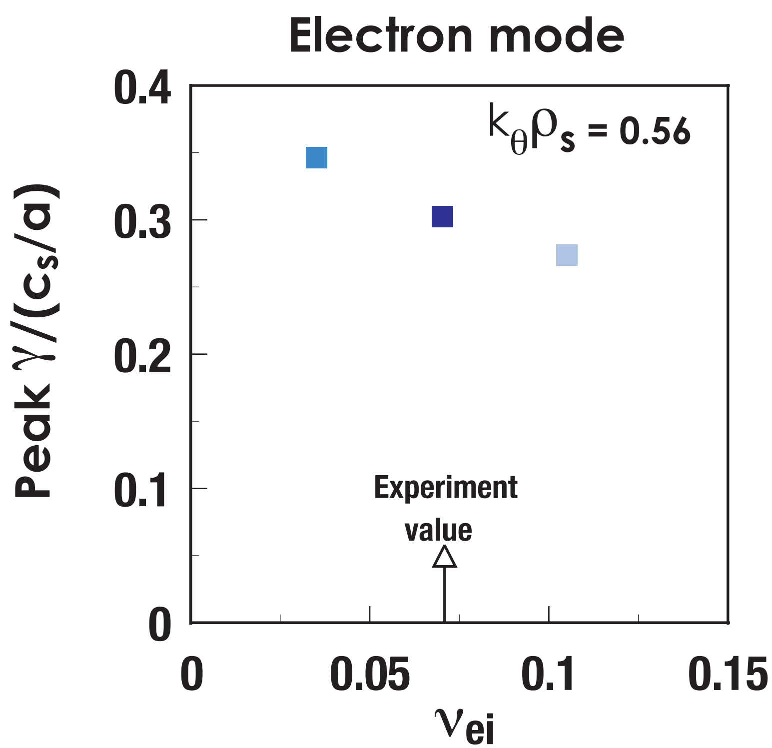




Growth Rates Are Insensitive To Collisionality

- Value of ν_{ei} at r/a = 0.5 was arbitrarily changed from the experimental value to determine the growth rate sensitivity
- Estimate 15% increase in peak growth rate for factor 2 decrease in ν_{ei}

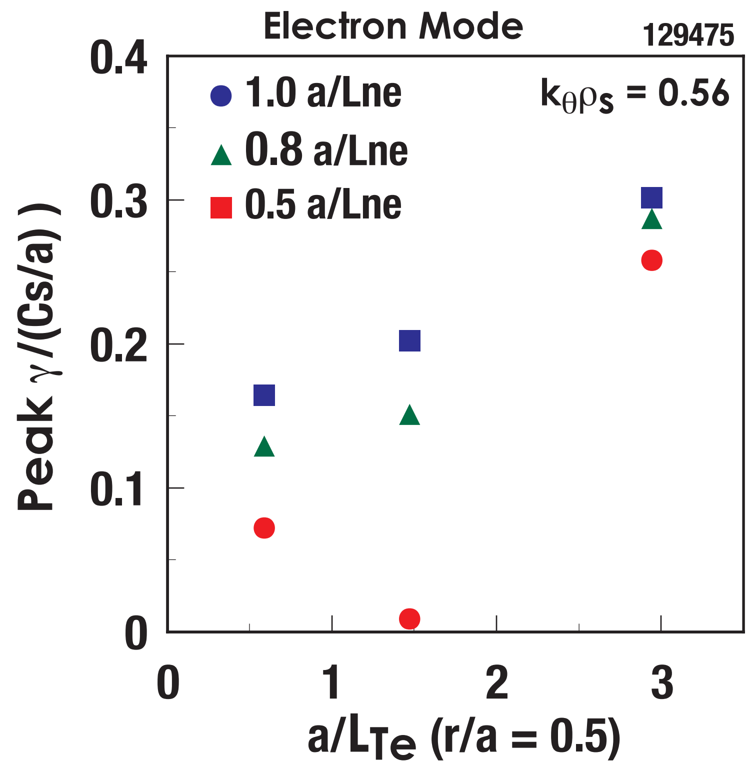




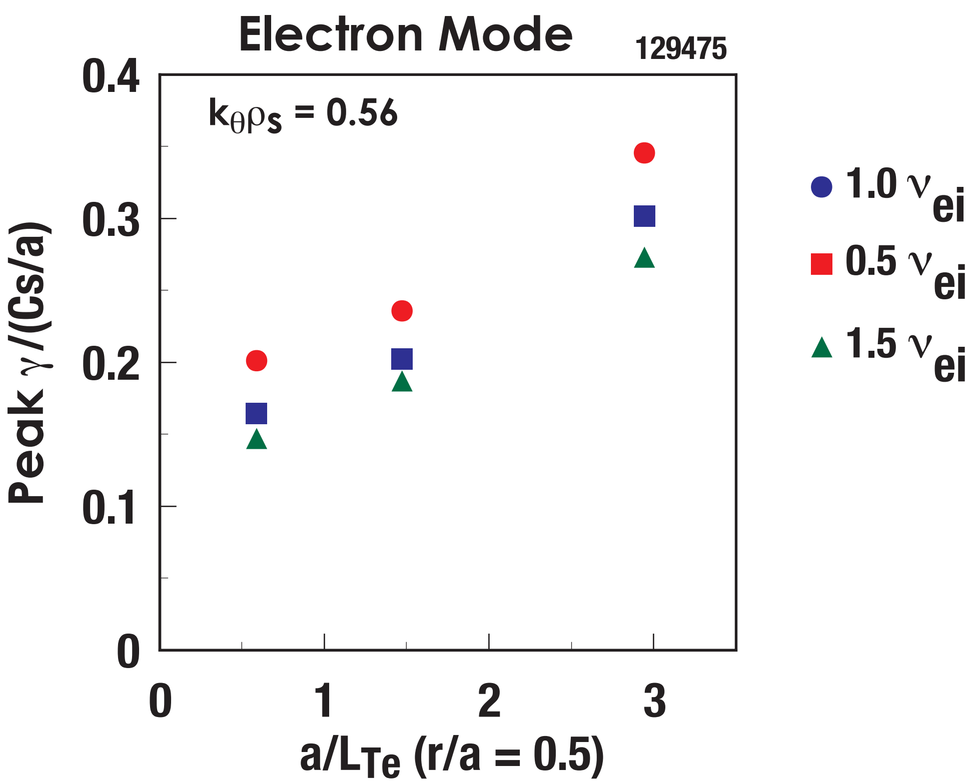
Growth Rate Sensitivity To a/L_{Te} Can Be Significantly Enhanced

- By decreasing the density gradient scale length a factor of 2, the growth rate sensitivity to the temperature gradient scale length can be enhanced by a factor of 3
- At 0.5 x a/L_{ne}, the electron mode growth rate at 0.5 x a/L_{Te} is reduced to where the ion mode dominates at $k_\theta \rho_s = 0.56$
- Note at 0.5 x a/L_{ne} the peak growth rate reverses its trend and increases with decreasing a/L_{Te} for $a/L_{Te} < 1.5$

    - Reducing the density gradient drive makes TEM activity more sensitive to the temperature gradient drive



Growth Rate Sensitivity To a/L_{Te} Is Not Significantly Changed By Varying Collisionality

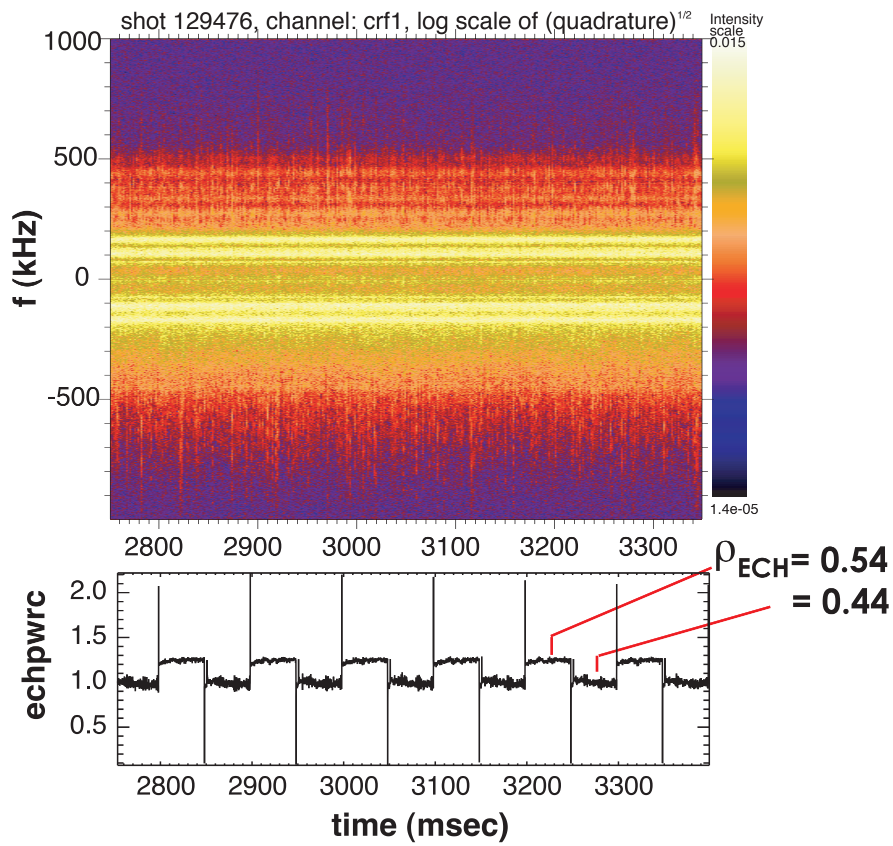


Experiment Planned Based On Enhancing Sensitivity to a/L_{Te}

- Previous experiment in L-mode discharges showed no change in turbulent activity when a/L_{Te} was reduced by a factor 1.8

- New experiment planned based on enhancing sensitivity to a/L_{Te} by reducing a/L_{ne}
  - run lower q discharge to obtain flatter density profile
  - what is impact on TEM growth rate of reduced shear due to lower q?

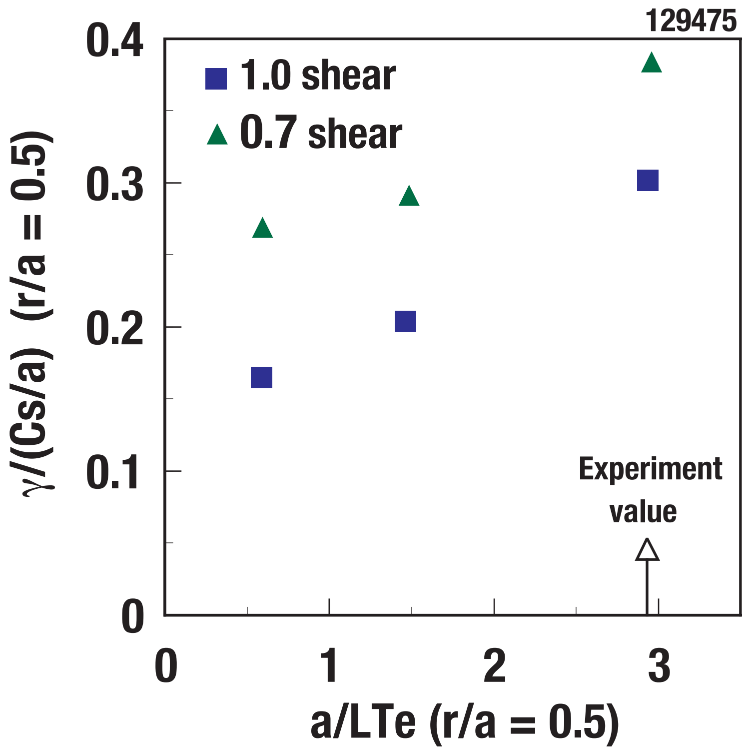
Doppler Backscattering $k_\theta \sim$ 4-6 cm^{-1}

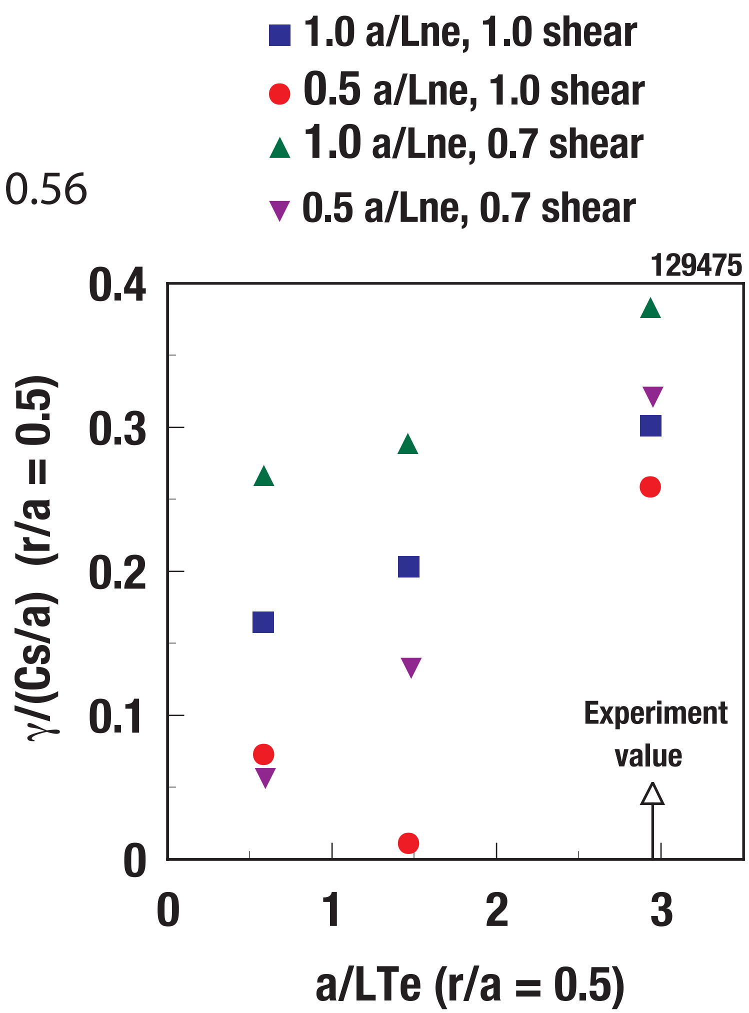


Reducing Magnetic Shear Increases Growth Rates and Makes Them Less Sensitive to a/L_{Te}

- With lower shear the growth rate is still expected to drop a factor of 2.4 when a/L_{Te} is halved

$k_\theta \rho_s = 0.56$





Conclusions

- For the EC heated, L-mode discharge studied TEM growth rates peak at $k_\theta \rho_s \sim 0.5 - 0.6$ and dominate over ITG modes at $r/a = 0.5$
- The growth rates are a factor 2 more sensitive to the temperature gradient scale length than to the density gradient scale length or to collisionality. However, there is not a strong sensitivity to the temperature gradient scale length at the experimental gradient scale lengths obtained.
- By reducing the density gradient scale length a factor of 2, the growth rate sensitivity to the temperature gradient scale length can be enhanced significantly, a factor of 3 more sensitive.
  – reducing the density gradient drive makes the TEMs more sensitive to the temperature gradient drive
- A new experiment has been proposed based on enhancing the sensitivity to the temperature gradient scale length.
  – magnetic shear must be reduced to flatten the density profile
  – this will somewhat reduce the enhanced growth rate sensitivity to the temperature gradient scale length