Enhanced Performance Discharges in DIII-D With an ITB Combined with Impurity Injection

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DIII-D National Fusion Facility

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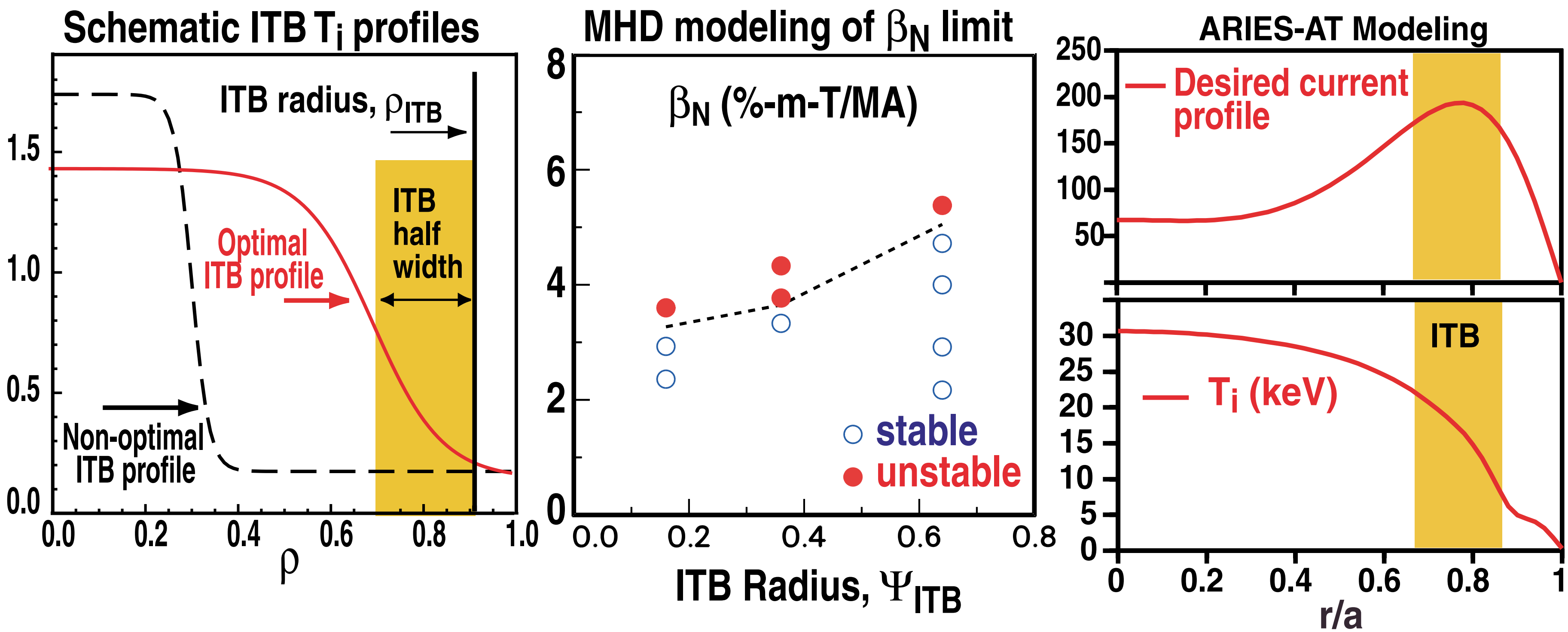
Overview

- **Experiment**
  - **Prior experiments, RI-mode and others, have shown neon injection can improve confinement. This experiment focused on studying the impact of adding neon to discharges with an existing Internal Transport Barrier (ITB).**
- **Goal**
  - **Spatially expand location of ITB by neon injection while maintaining good confinement.**
- **Results**
  - **Improved overall performance in both electrons and ions and expanded the thermal and particle transport barriers.**

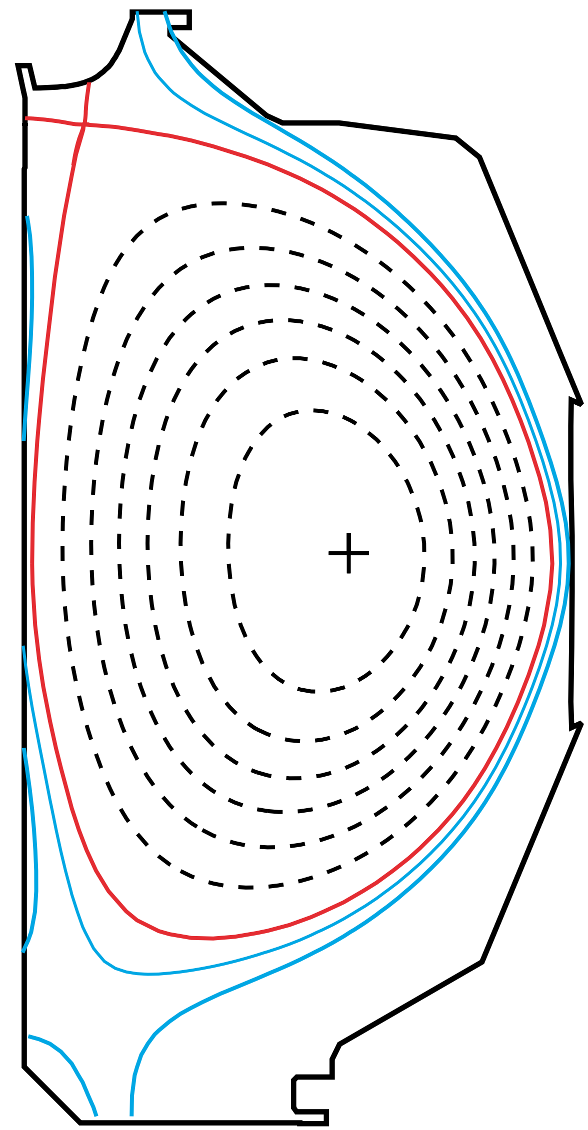
Motivation For Barrier Expansion

- Larger ITB radius and barrier width lead to:
  - Higher fusion performance (larger high confinement volume)
  - Improved MHD stability limits
  - Improved bootstrap current alignment



Discharges With an ITB Were Formed In An Upper Single-Null Configuration

- ITB formed with co-NBI
- ITB Characteristics
  - peaked profiles
  - L-Mode edge
  - weak magnetic shear
  - upper divertor pumping



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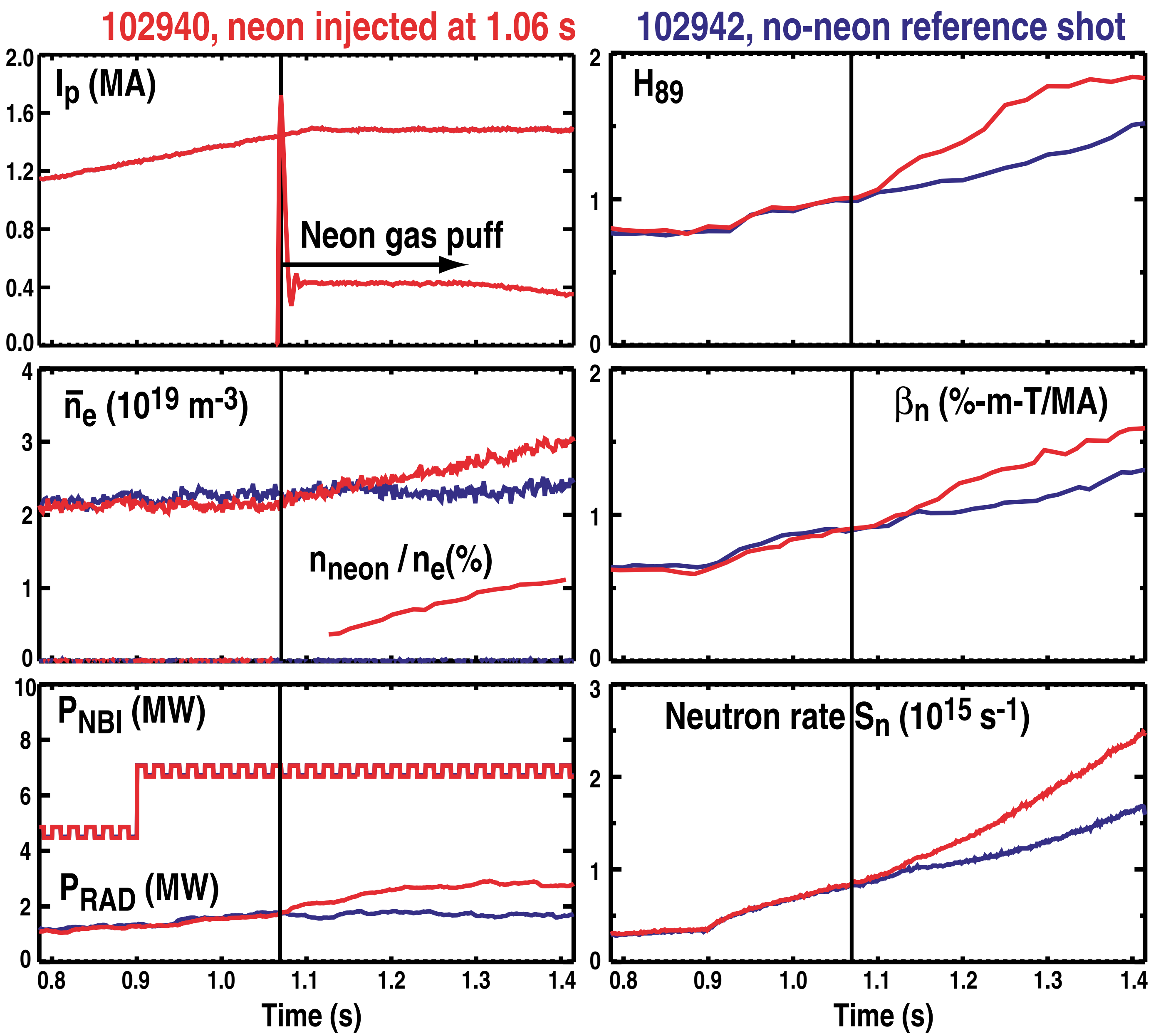
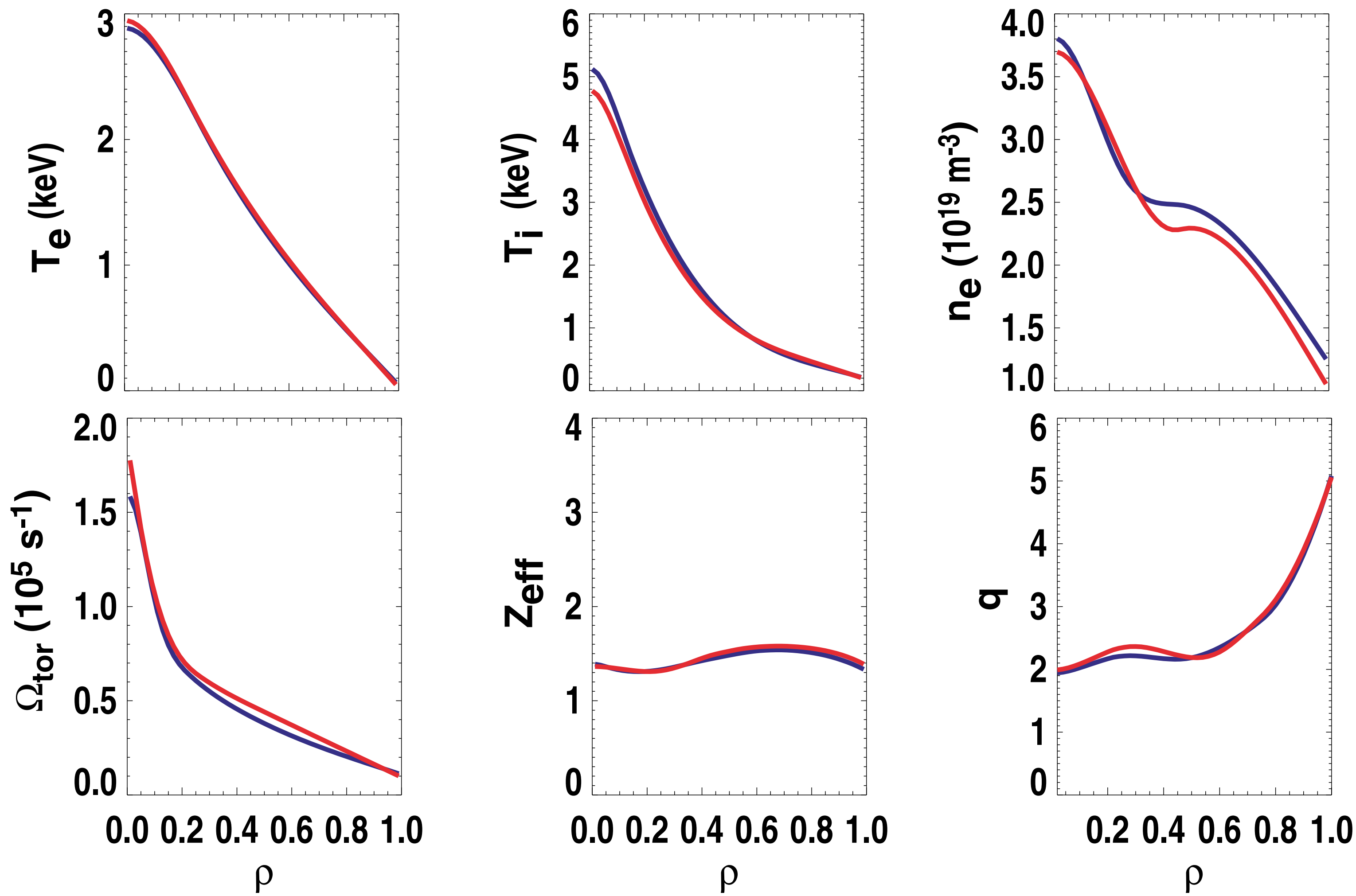
Neon Injection Into ITB Further Improves Performance



- Enhanced Confinement (H_{89}, β, W)
- Increased Neutron rate - increase is predominantly thermal neutrons

Profiles Are Very Similar Before Neon Injection

- **Comparison at 1.0 sec in 102940 and 102942**



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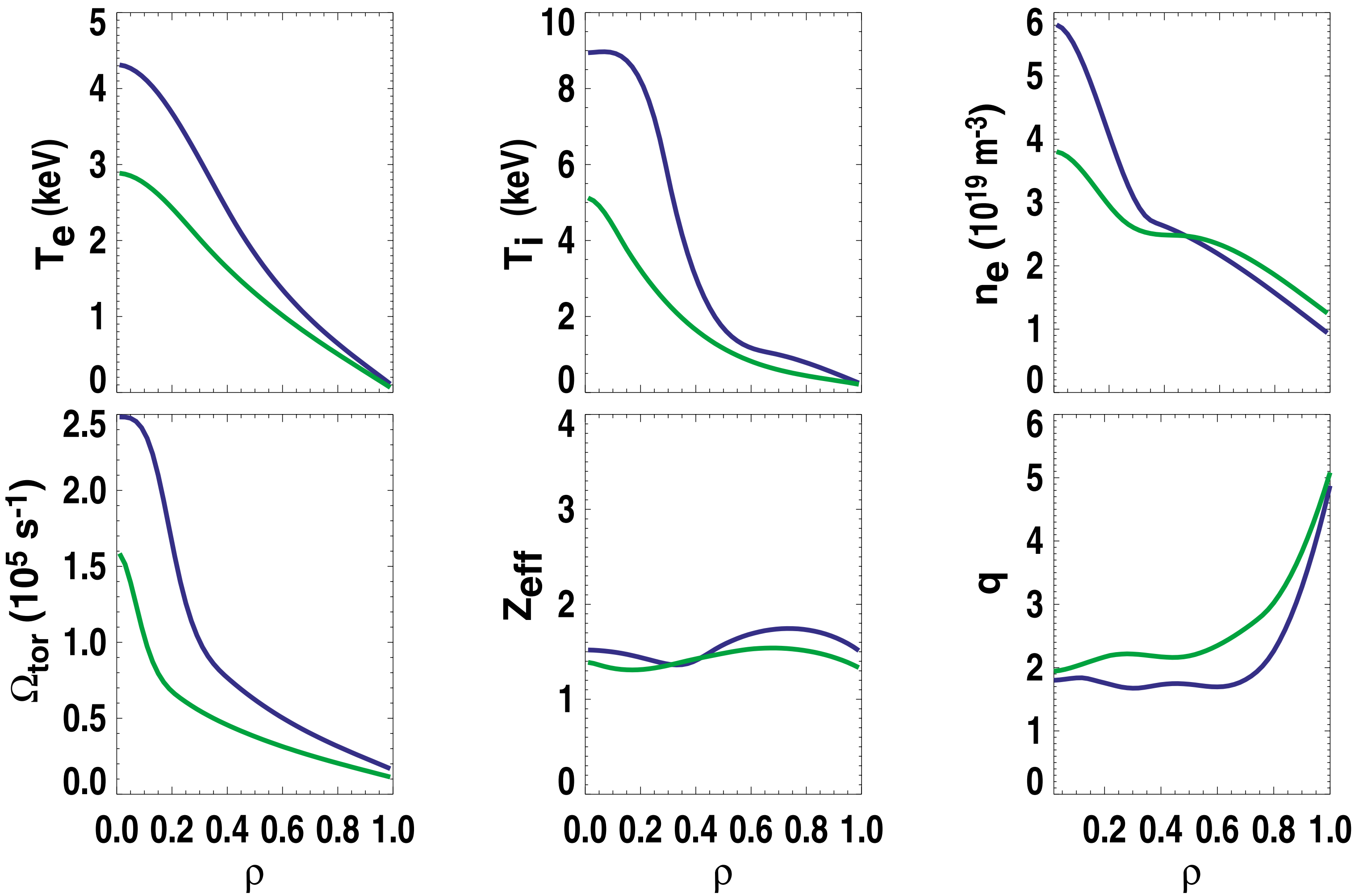
Profiles Become More Peaked Later in Time

- Comparison at 1.4 and 1.0 sec, without neon (102942)



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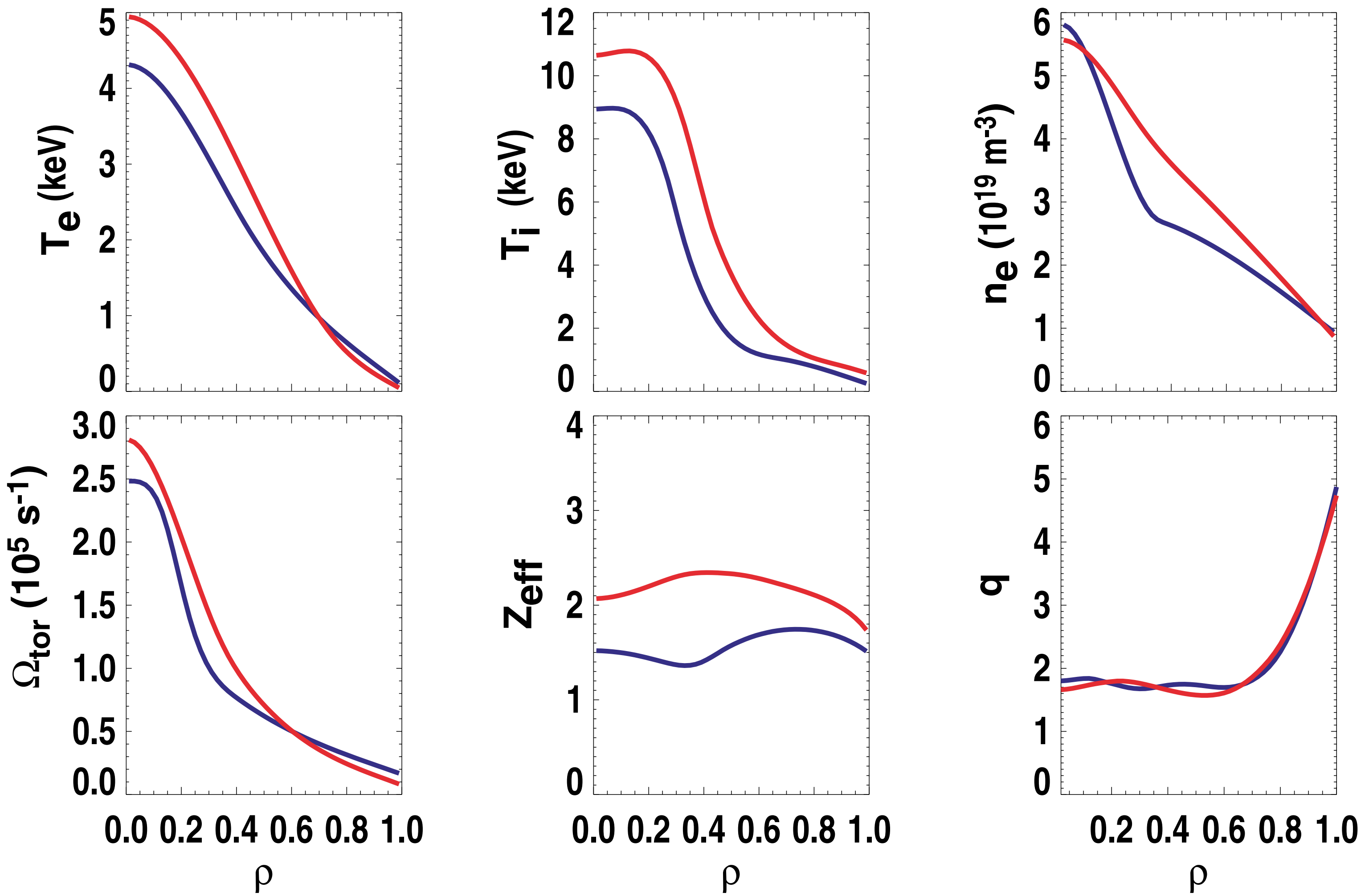
Neon Injection Further Increases and Broadens ITB Profiles

- Comparison at 1.4 sec with (102940) and without (102942) neon



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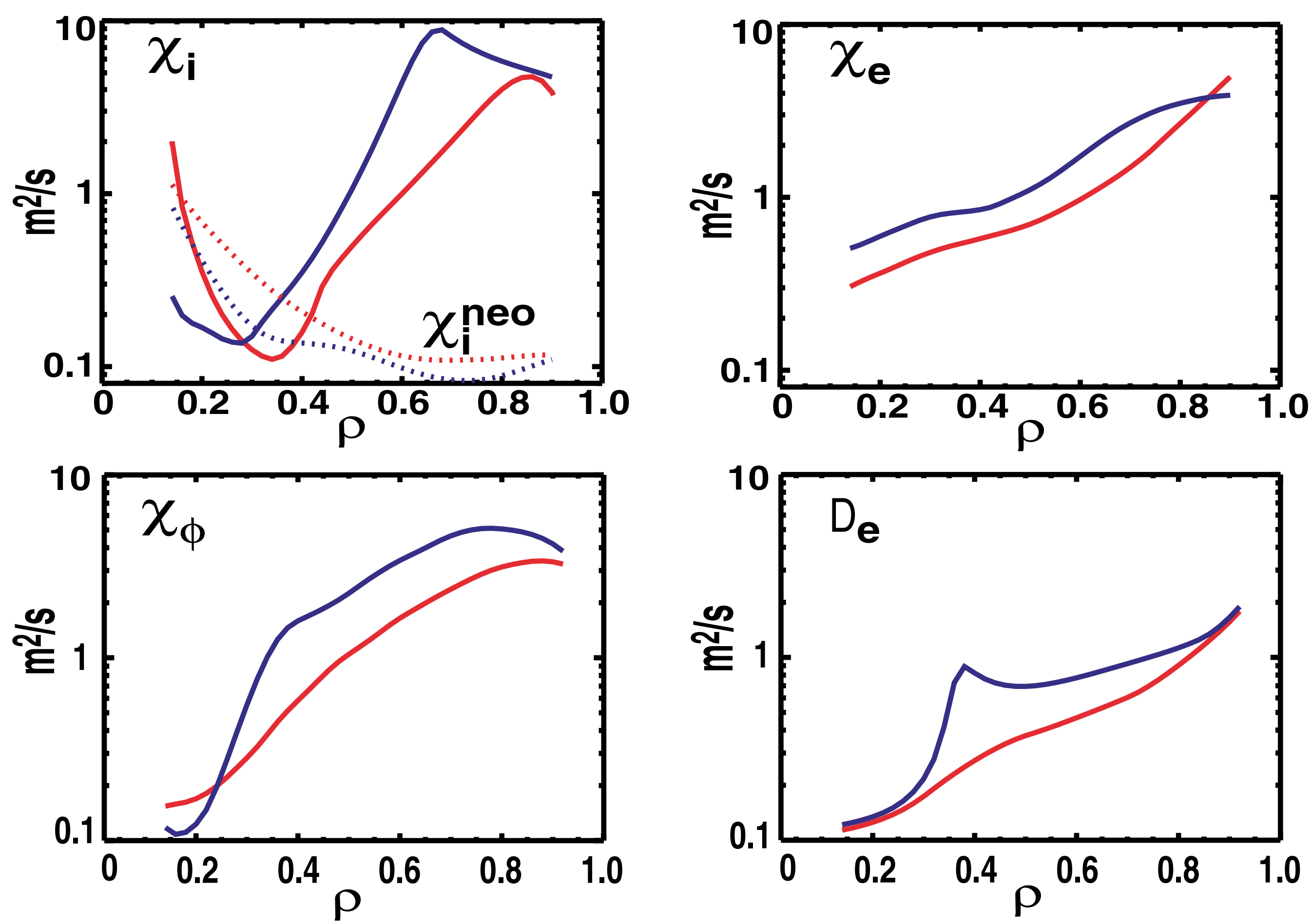
Neon Injection Into Existing ITB Expands The Region of Reduced Transport To ρ ~ 0.8

102940 (neon) and 102942 (no neon) at 1.4 sec



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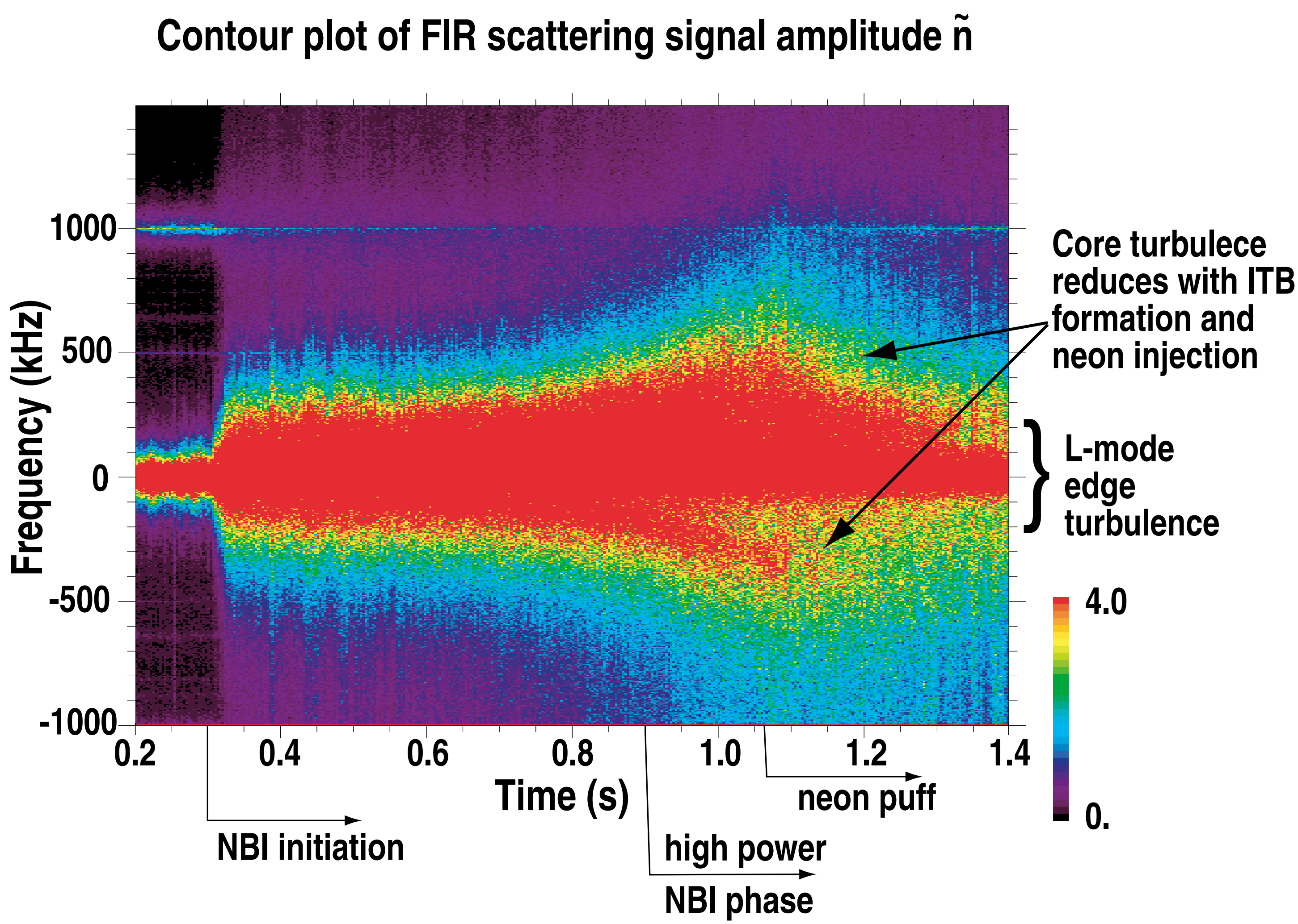
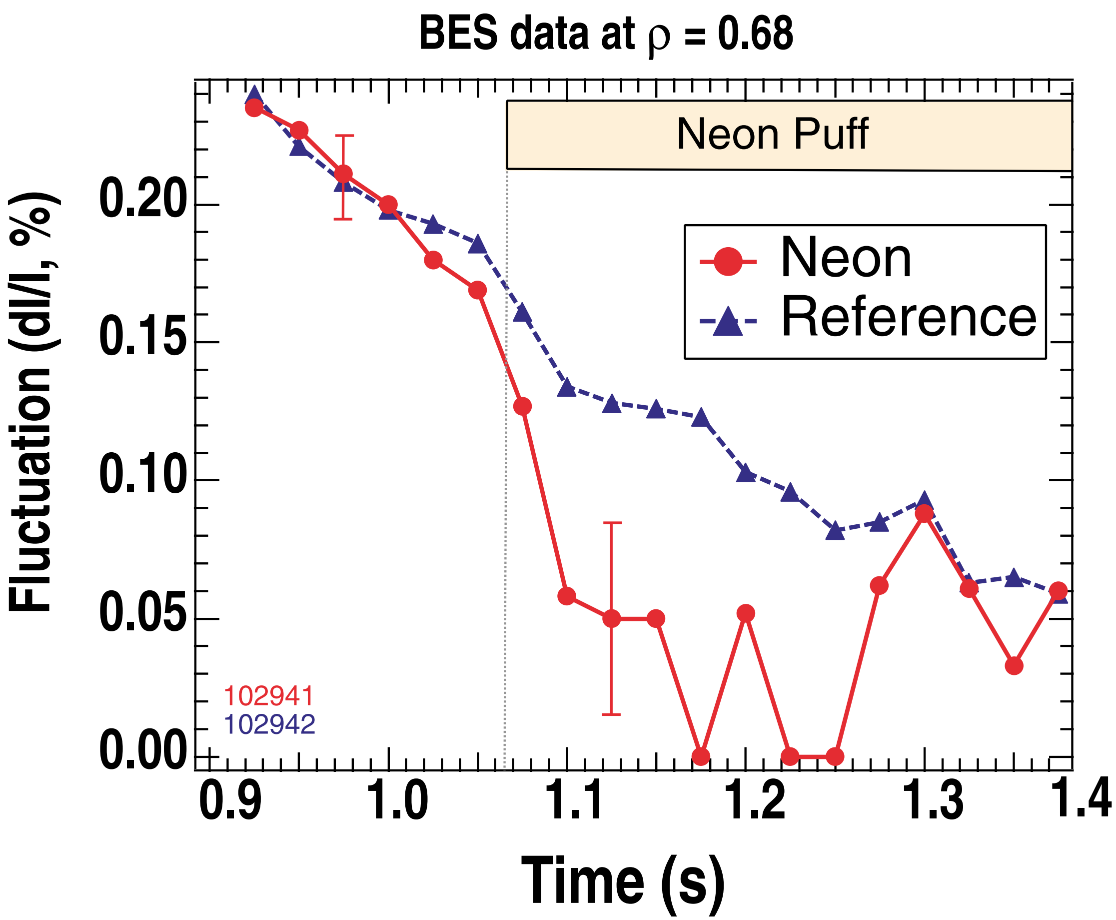
Neon Injection Into Existing ITB Further Reduces Turbulence Across Plasma

- **FIR scattering system monitors turbulence across plasma radius and throughout discharge duration**



Neon Injection Into Existing ITB Further Reduces Turbulence Locally

- **BES system provides local measurement of turbulence levels**



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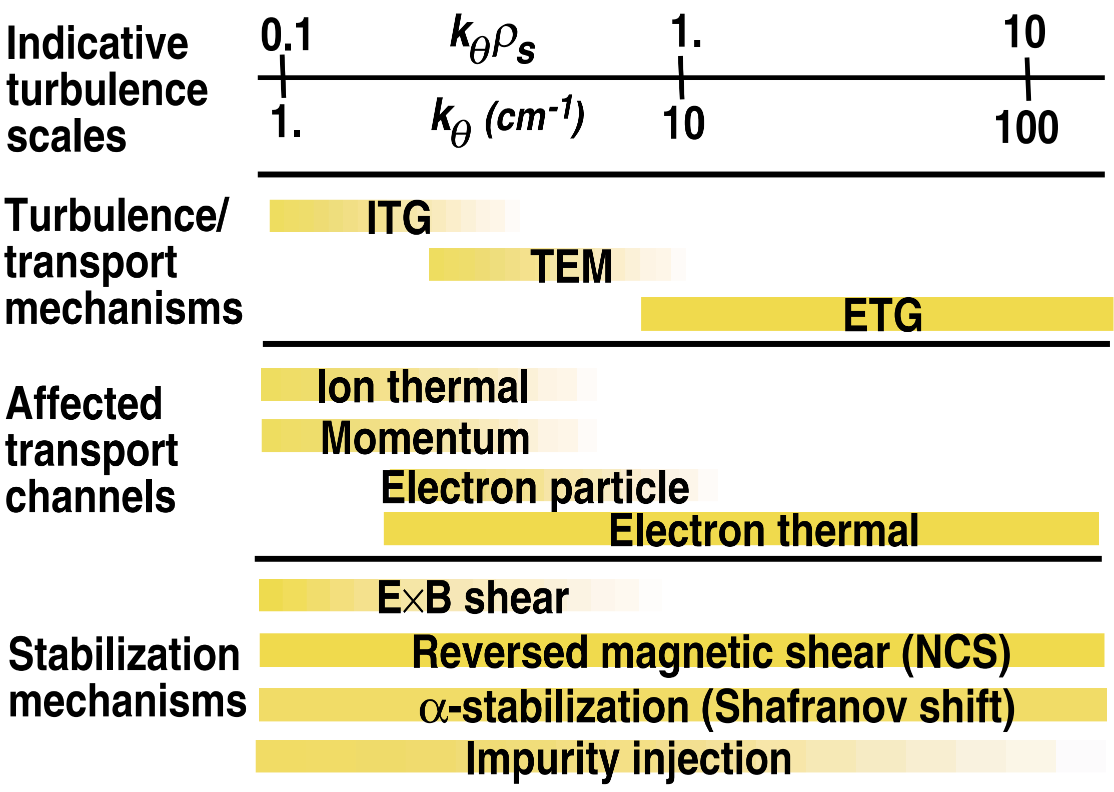
Turbulence Suppression Mechanisms Are Key To Understanding ITB Formation And Control



- **Low-k ITG and TEM modes can be stabilized by ExB flow shear**
- **High-k ETG modes require reversed shear or a strong Shafranov shift for stabilization**

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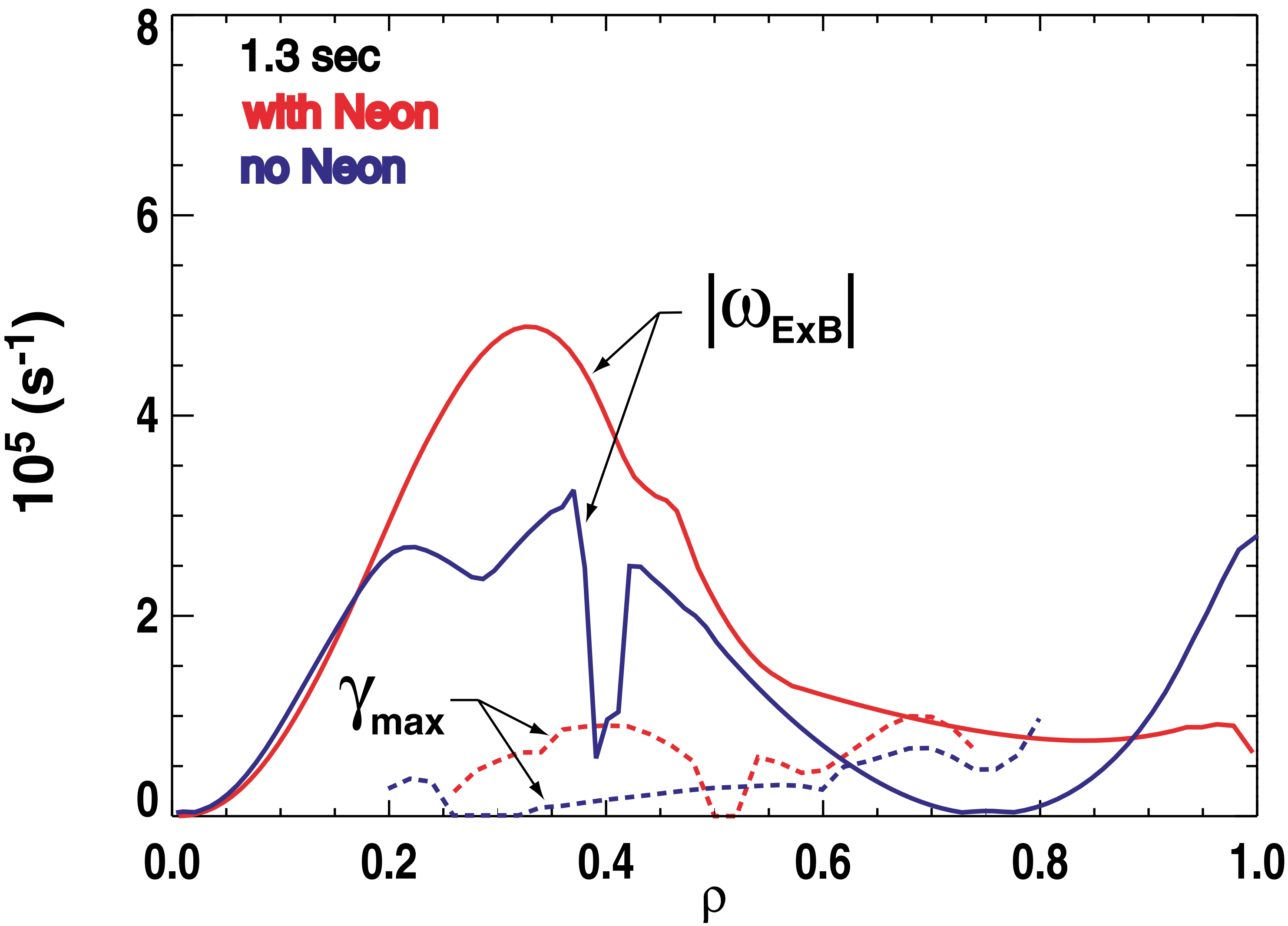
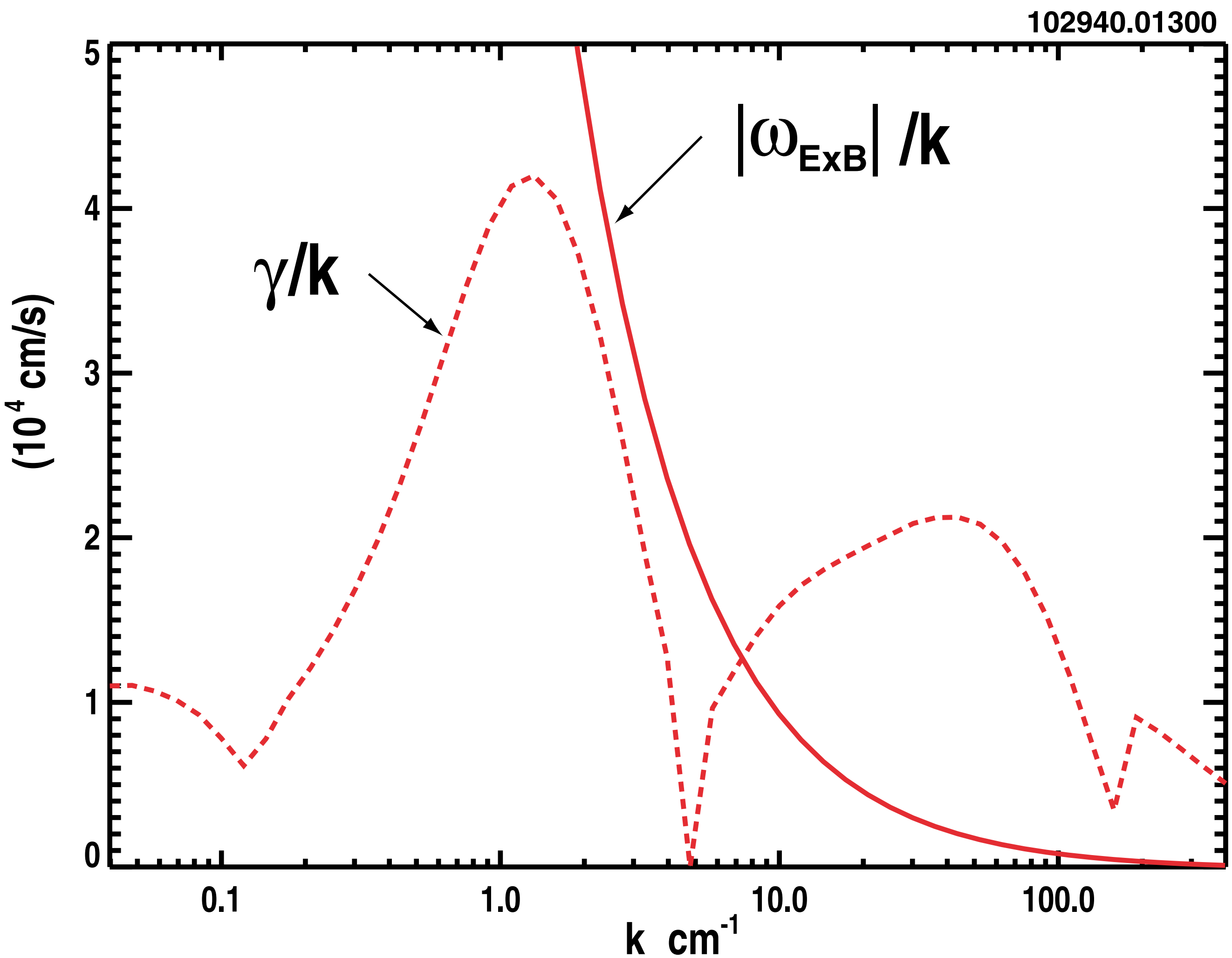
ITB Barrier Expands with Expansion of Region Where ExB Shearing Rate Exceeds Maximum Low-k Growth Rate



- Average Z obtained from Carbon and Neon densities used in growth rate calculations

High-k ETG Modes Are Not Stabilized By ExB Flow Shear

- **Normalized growth rate spectrum and shearing rate at ρ=0.7 for neon case**



Summary

- Neon injection into a discharge with an existing ITB with an L-mode edge and co-NBI improved the overall performance in both ions and electrons and expanded the thermal and particle transport barriers.

- These results can be understood in terms of the suppression of low-k turbulence by enhanced ExB shearing rates caused by neon injection.

- Neon injection is an effective transport barrier control tool for co-NBI.