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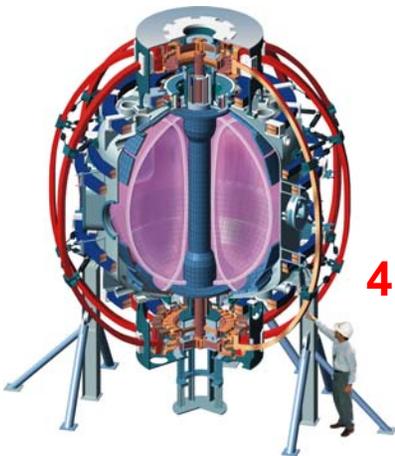


# Enhanced electron confinement in low density beam heated NSTX discharges

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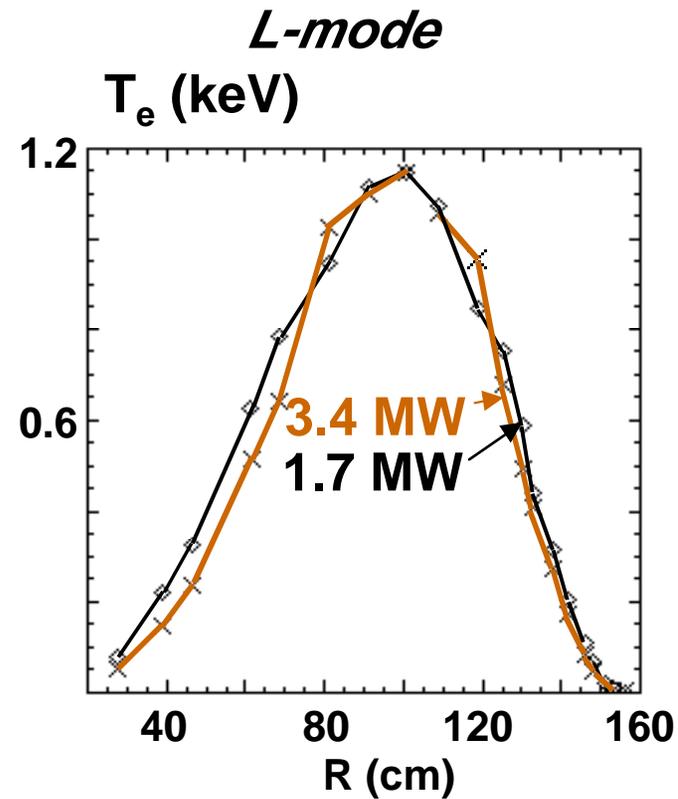
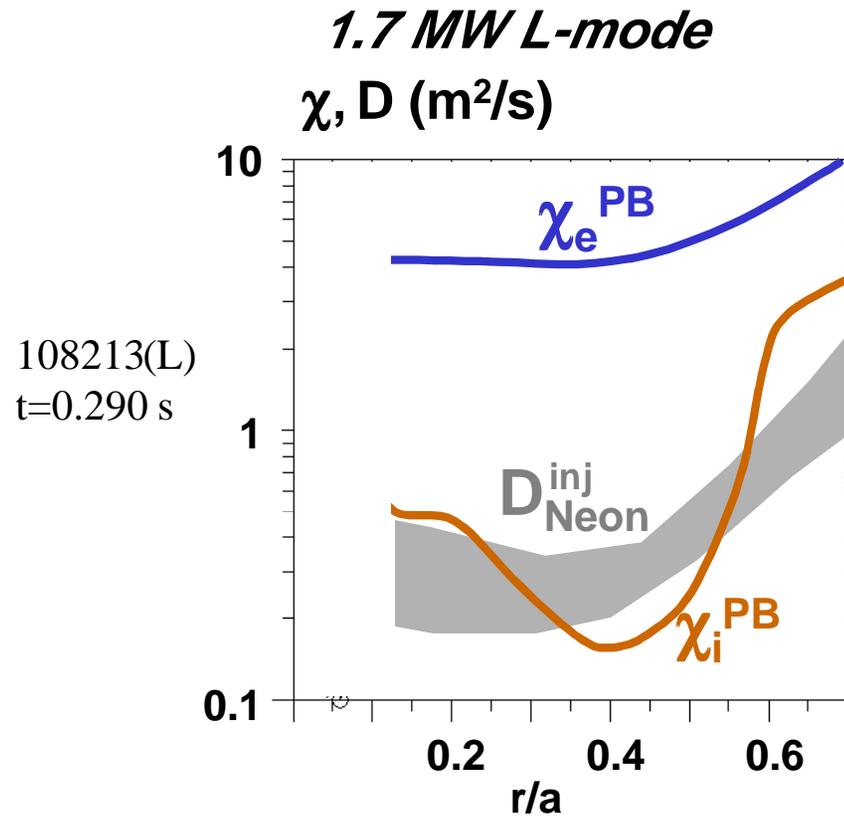
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# Outline

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- **Improved electron confinement in low density L-mode**
- **Evidence for magnetic shear reversal**
- **Comparison with microstability predictions**
- **Ion transport in improved electron confinement regime**

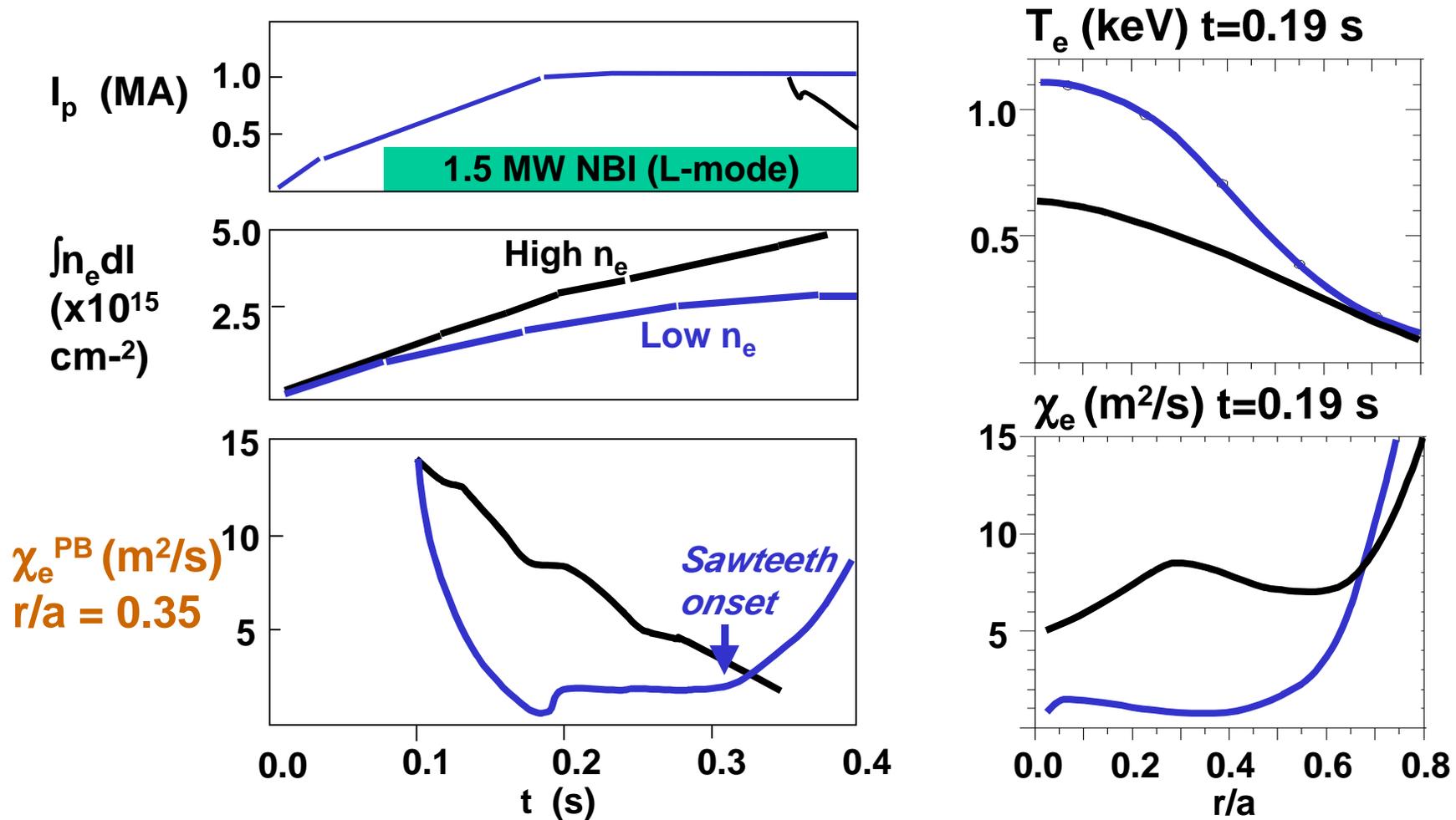
# Electron transport typically dominates in NSTX



- $\chi_i, D_{imp} < 1$  m<sup>2</sup>/s ( $\approx$  neoclassical)
- $\chi_e >$  several m<sup>2</sup>/s

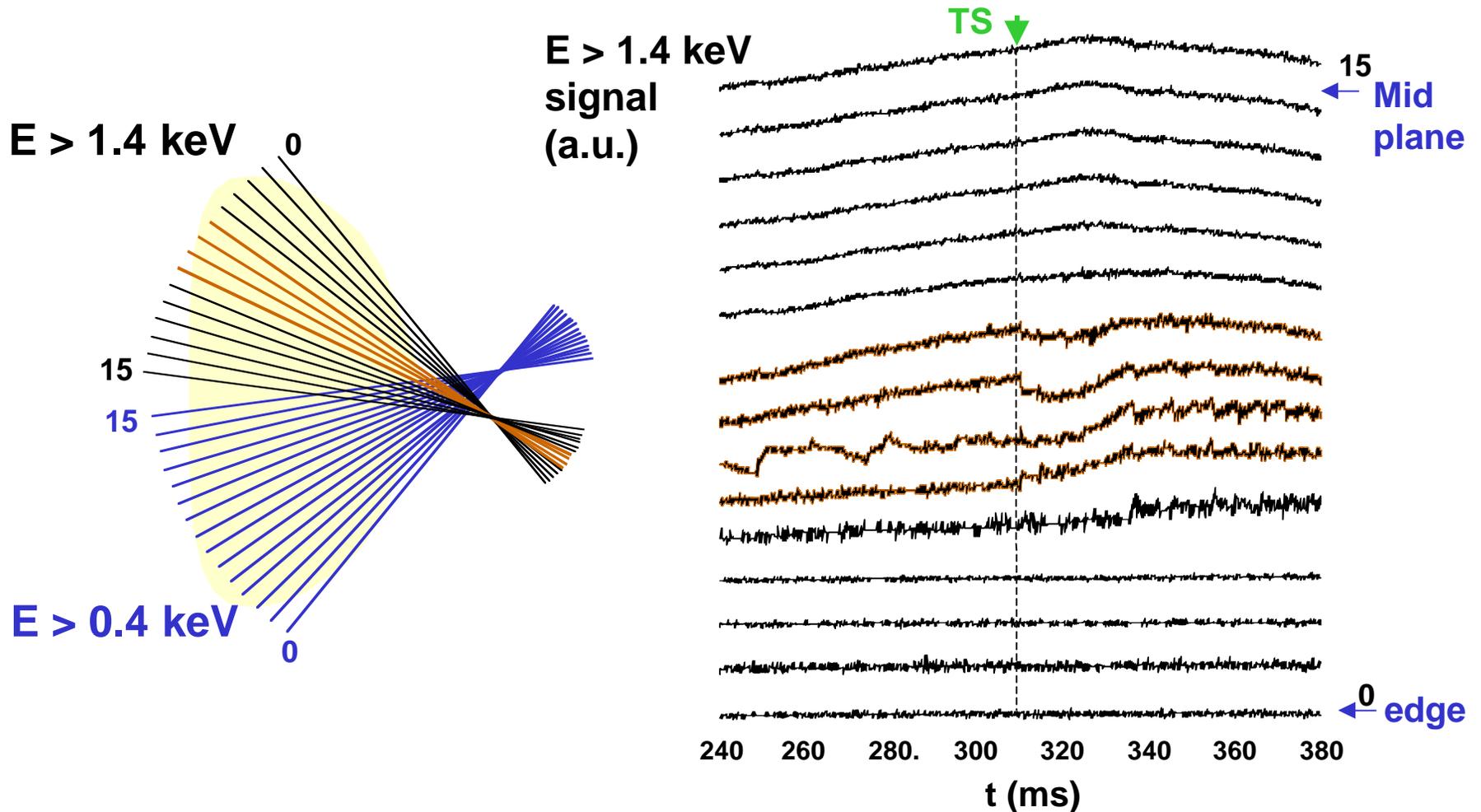
- Stiff  $T_e$  profiles

# Reduced electron transport regime observed



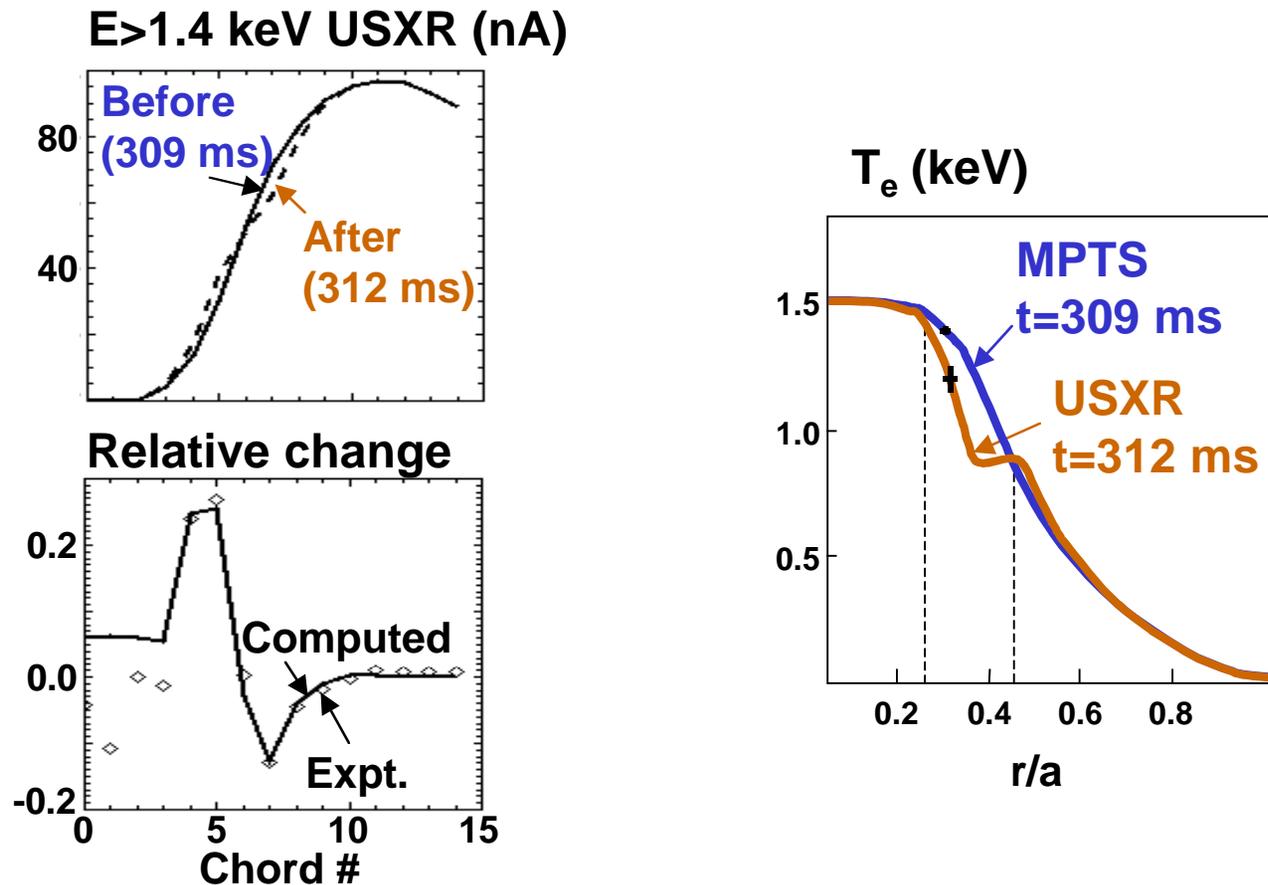
- Large  $\chi_e$  decrease with early NB injection into low  $n_e$  discharge
- $\chi_e$  slowly decreases also in high  $n_e$  shot

# Evidence for shear reversal in low $n_e$ regime



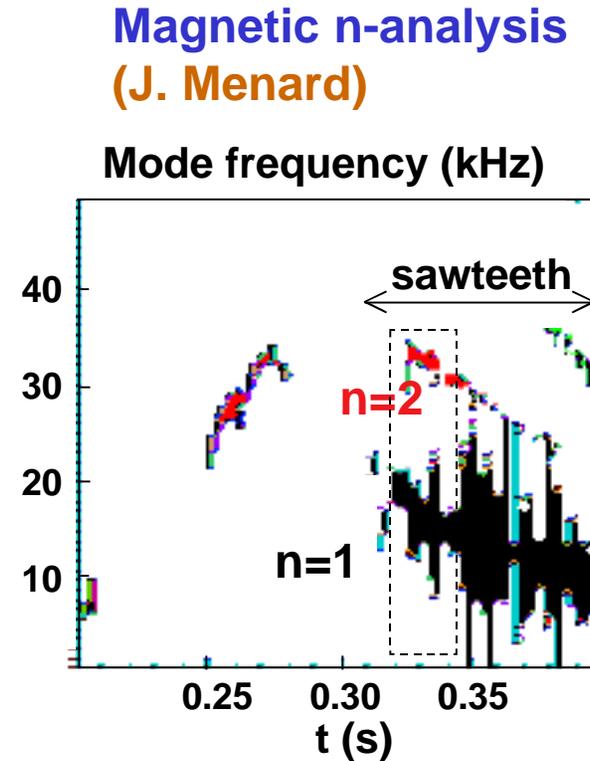
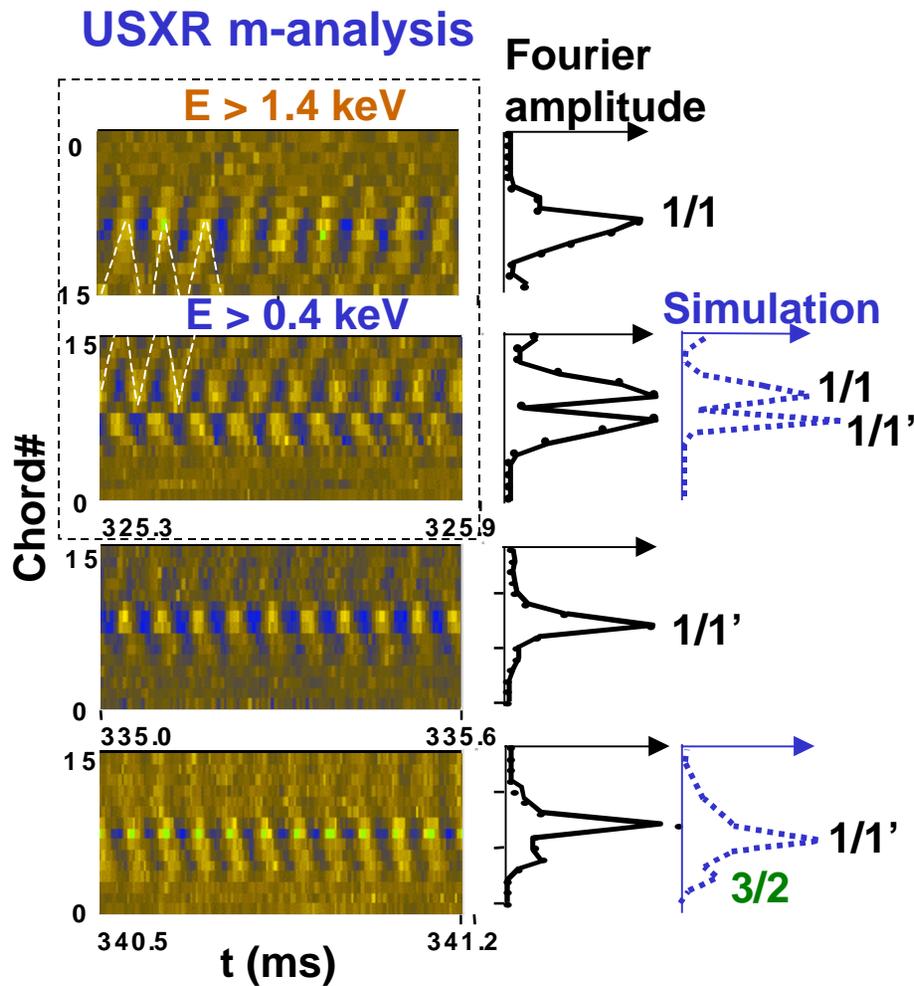
- USXR/magnetics/TRANSP analysis for  $q(r)$  estimate
- Off-axis 'sawteeth' in USXR emission from low  $n_e$  discharge
- 'Two-color' measurement enables unfolding  $T_e$ ,  $n_e$  perturbation

# USXR modeling indicates off-axis $T_e$ crashes



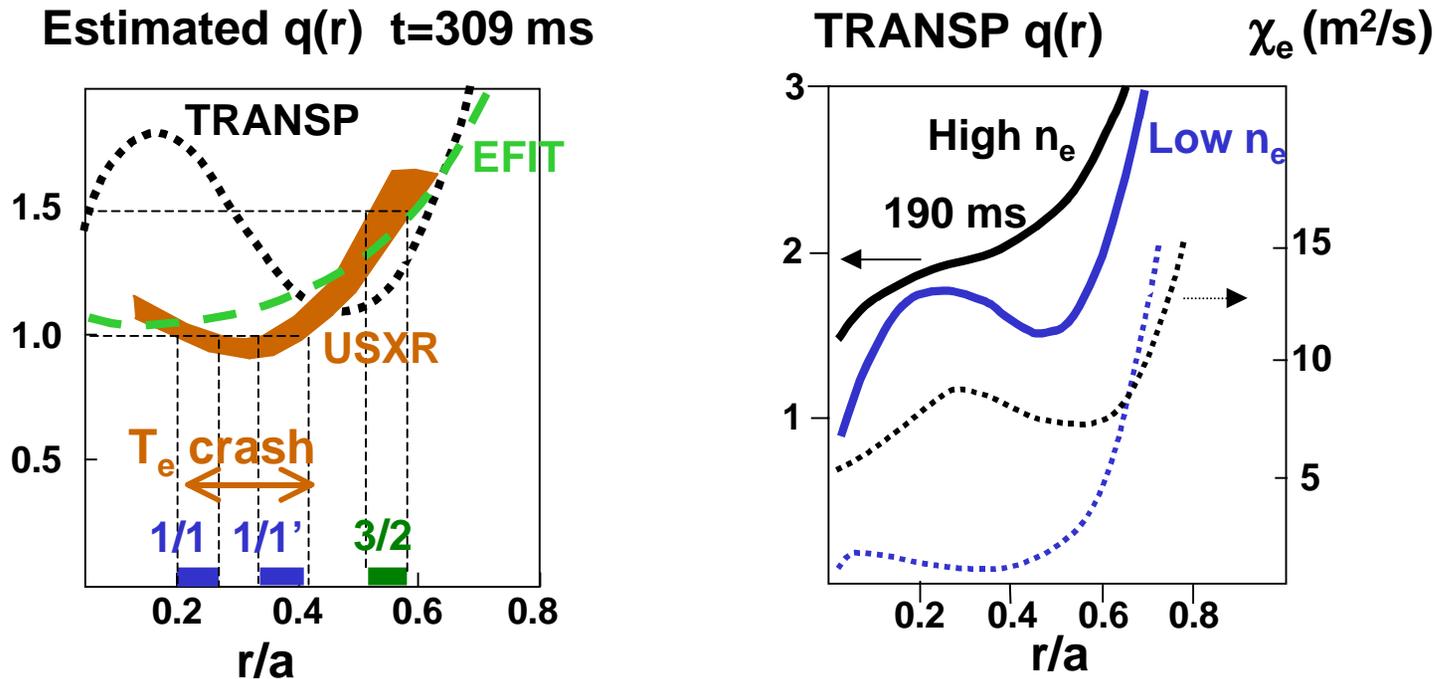
- $T_e$  profile after crash from MIST modeling of *'two-color'* USXR data
- Off-axis ( $0.25 < r/a < 0.45$ )  $T_e$  crashes suggest reversed  $q$ -profile

# Mode analysis indicates two 1/1 surfaces



- Fourier analysis of USXR and magnetic data for mode localization
- Two 1/1 modes at  $r/a \approx 0.22$  and  $r/a \approx 0.36$
- 3/2 mode around  $r/a \approx 0.55$

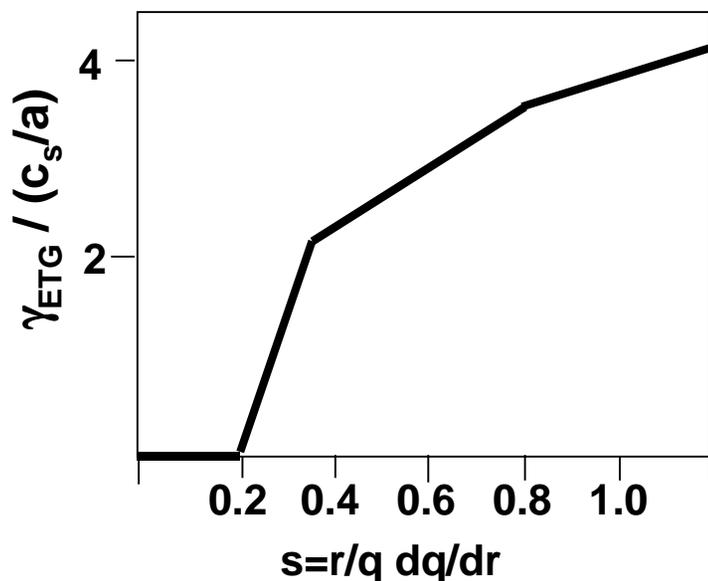
# Estimated q-profile is reversed



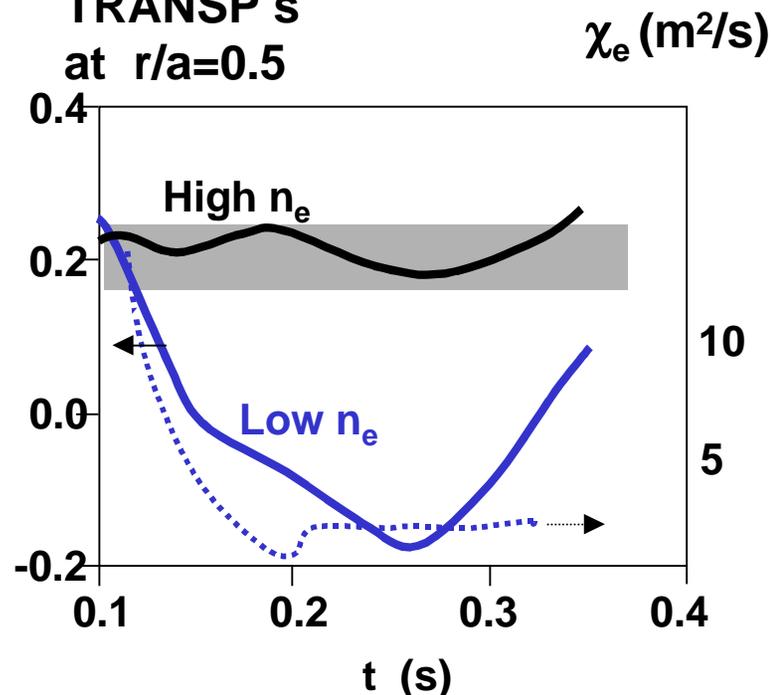
- Both USXR and TRANSP estimate negative/low shear
- USXR  $q_0$  is lower (likely due to current penetration at reconnections)
- Large difference in early q-profiles (TRANSP) correlates with large difference in early  $\chi_e$
- Slow  $\chi_e$  reduction in high  $n_e$  shot also correlates with decreasing shear
- $s \lesssim 0$  at mid-radii likely cause for improved electron confinement

# Theory predicts ETGs suppressed by reversal

ETG growth rates at  $r/a=0.5$   
(C. Bourdelle, GS2)

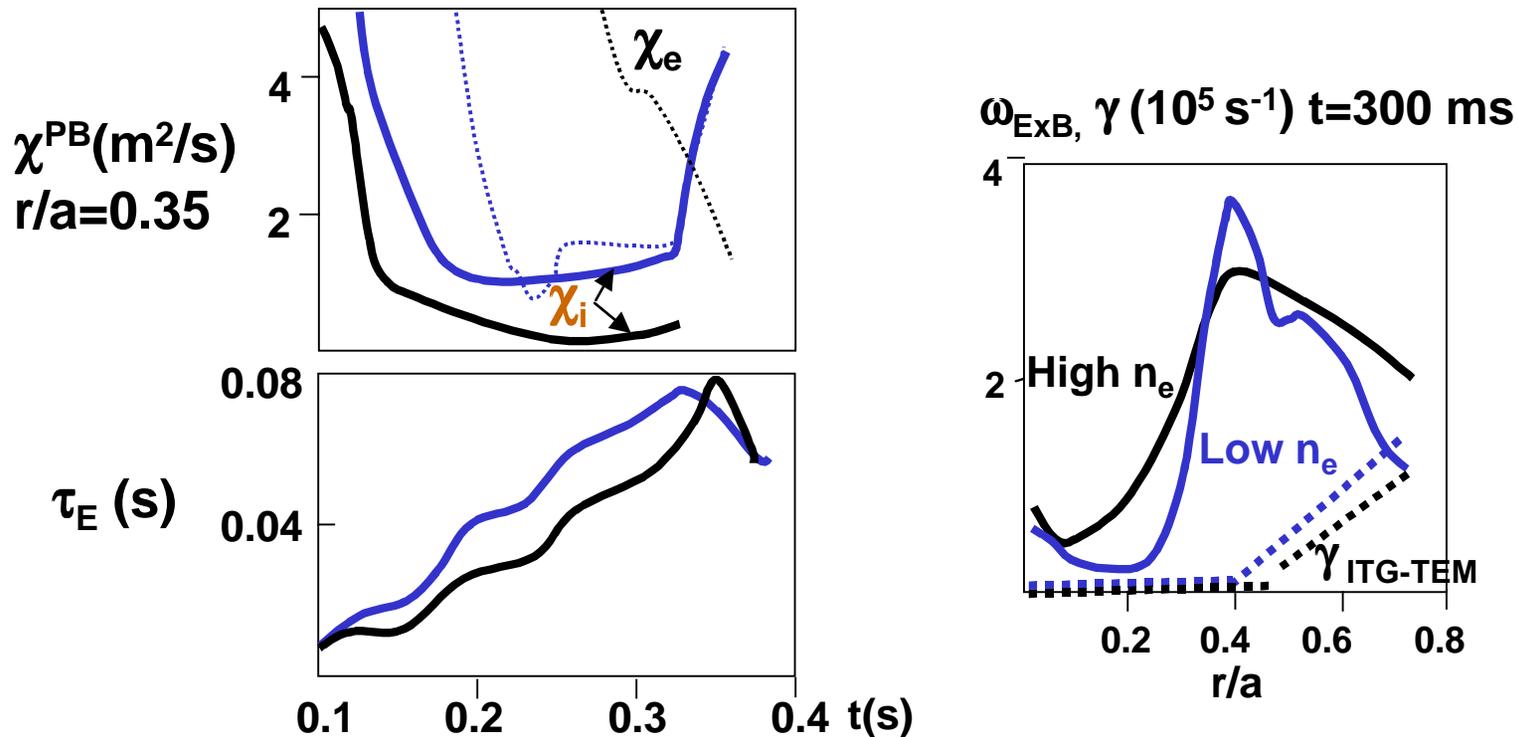


TRANSP  $s$   
at  $r/a=0.5$



- Microstability calculations indicate step-like ETG dependence on shear
- $\chi_e$  evolution roughly consistent with GS2 and TRANSP predictions
- ETG modes likely drive for NSTX electron transport
- $\chi_e$  invariant with magnetic field (*Stutman et al APS02*) also consistent with ETG scaling

# Ion transport increases in reduced $\chi_e$ regime



- $\chi_i, D_{Neon}$  increase to  $\approx \chi_e$  in low density discharge
- Global confinement nevertheless increases (up to  $\approx 2.5 \times \tau_{89-P}$ )
- Decreased core  $\omega_{ExB}$  in low  $n_e$  shot (flatter  $V_t$  profile)
- ITG-TEM growth rates increase 30-40% (decreased  $T_i/T_e$ )
- However,  $\omega_{ExB}$  still exceeds  $\gamma_{ITG-TEM}$  over most of the radius
- Inverse correlation between electron and ion turbulence ?

# Summary

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- Much improved electron transport when  $s \lesssim 0$  inferred
- Strong ETG suppression predicted for negative/low shear
- Magnetic shear may be the determining factor for NSTX global confinement
- Very accurate  $q(r)$  diagnostic needed if ETG growth rates have predicted steep dependence on  $s$
- Increased ion transport at the same time
  - not well explained by modest increase in ITG-TEM growth rates and decrease in ExB shear; other mechanisms ?
- **Very good confinement in NSTX if electron channel is improved; shear reversal followed by  $\beta'$  stabilization ?**