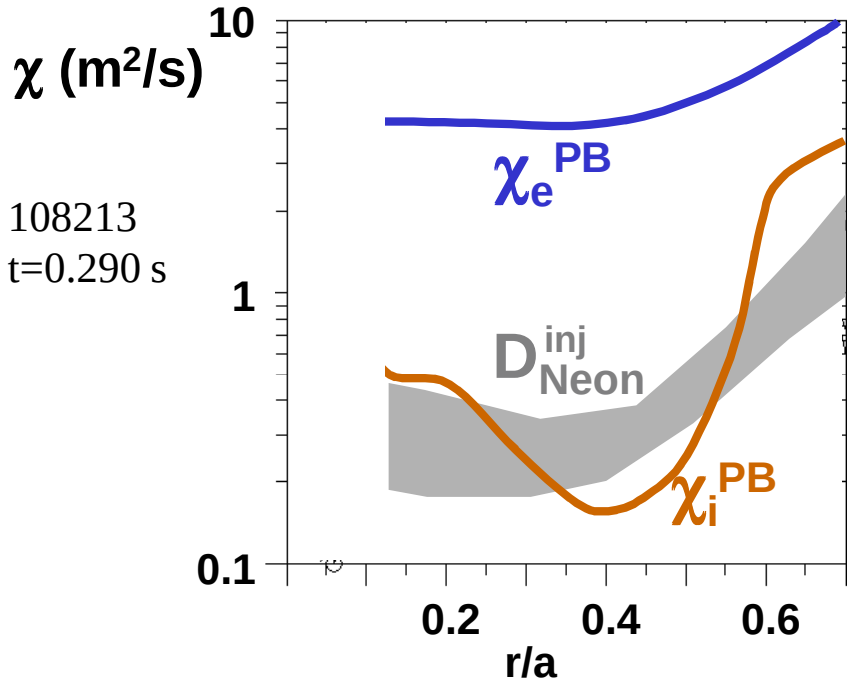
Investigation of improved electron confinement in low density/shear reversal L-mode discharges

D. Stutman, M. Bell, R. Bell, C. Bourdelle, W. Dorland, A. Field, M. Finkenthal, K. Hill, S. Kaye, S. Kubota, B. LeBlanc, F. Levinton, R. Maingi, J. Menard, M. Redi, E. Synakowski, K. Tritz

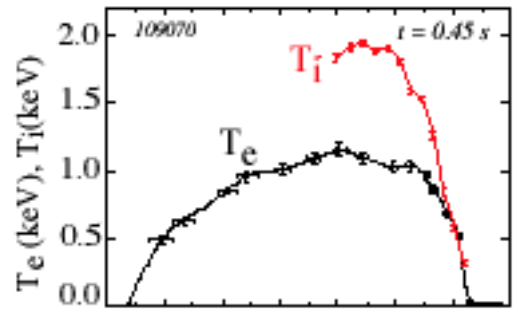
Electron transport typically dominates in NSTX

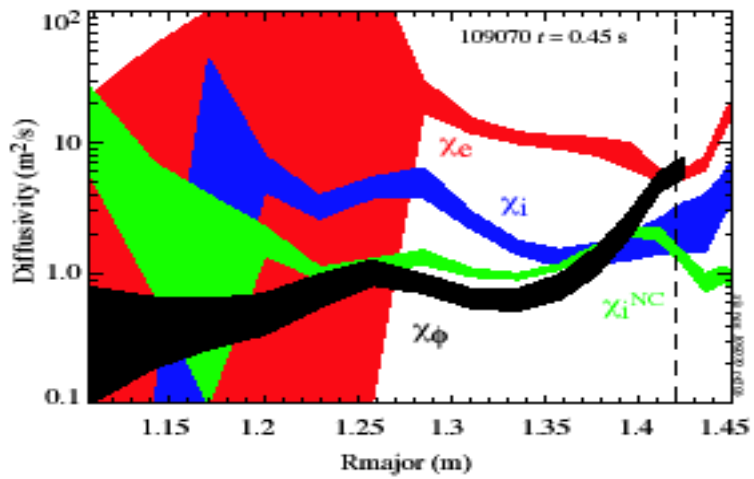
1.6 MW L-mode
Intermediate n_e



- χ_i, D_{imp} < 1 m²/s (≈ neoclassical)
- χ_e > several m²/s

6 MW H-mode
High n_e (B. LeBlanc)

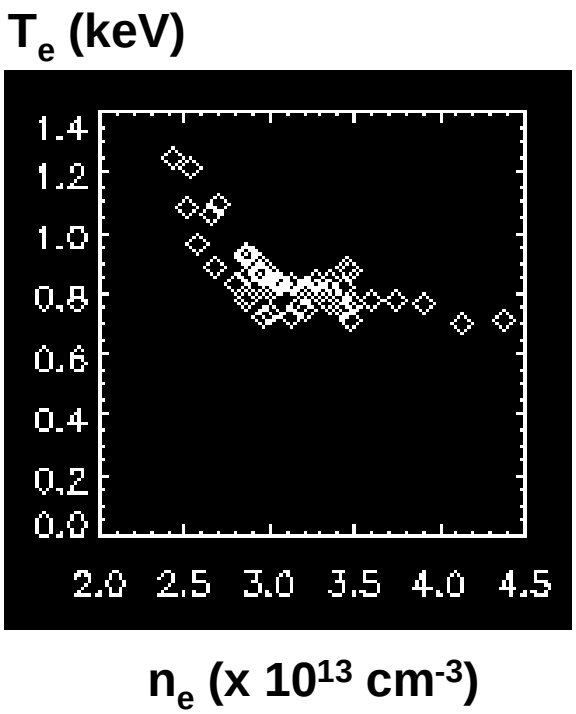


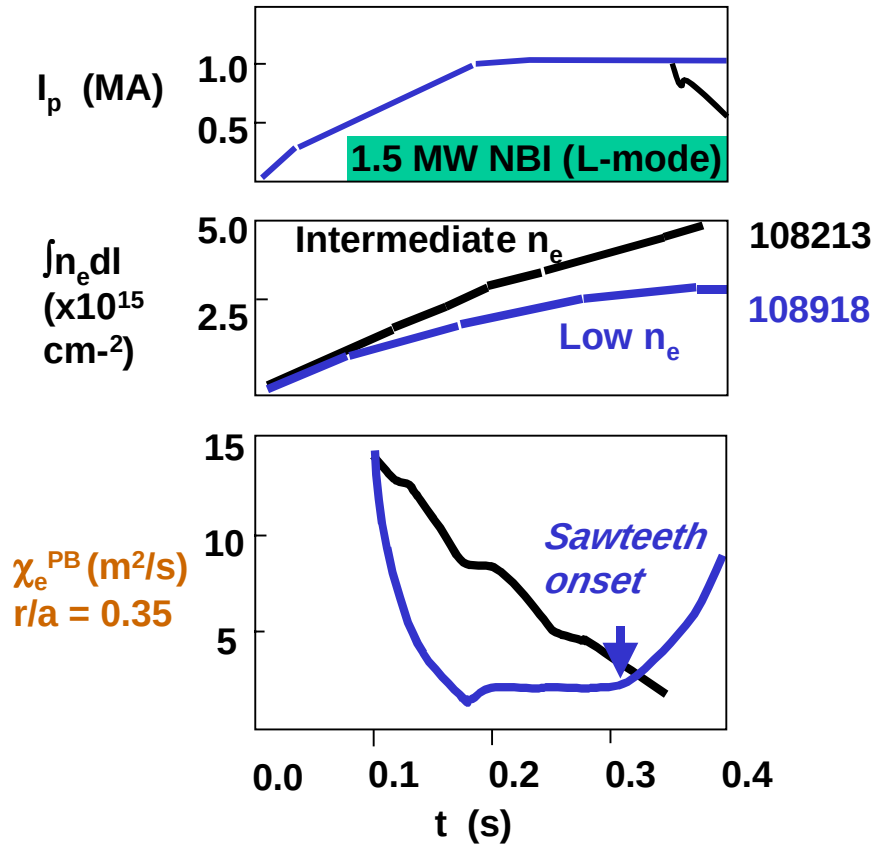


- Very large core χ_e in high n_e H-mode ?

Reduced electron transport observed at low n_e

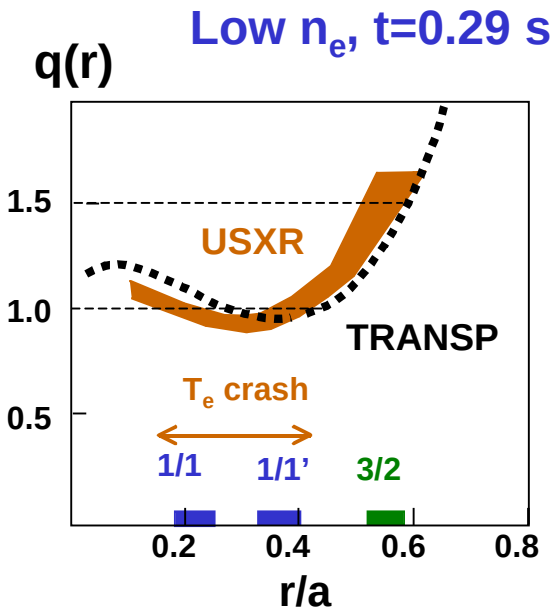
Central T_e as a function of central n_e (0,2-0.3 s average)

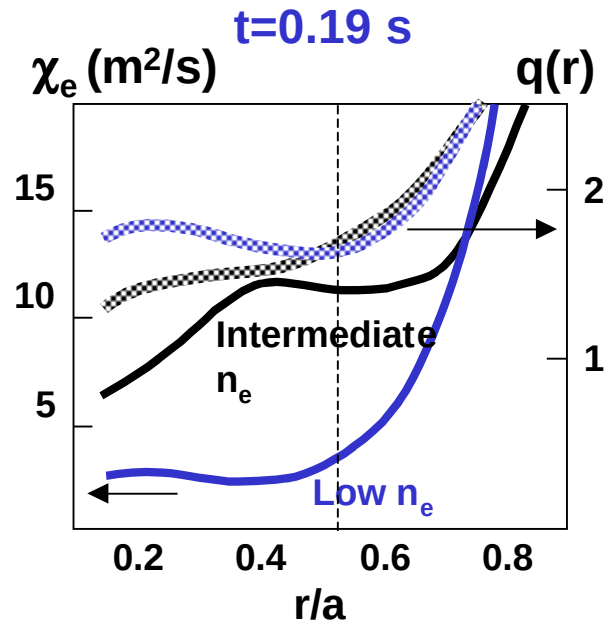




- Large χ_e decrease with early NB injection into low n_e discharges
- χ_e slowly decreases also in intermediate n_e case
- χ_i and D_{neon} nevertheless increase at low n_e (from < $1m^2/s$ to ≈ χ_e)

Evidence for shear reversal in low n_e regime

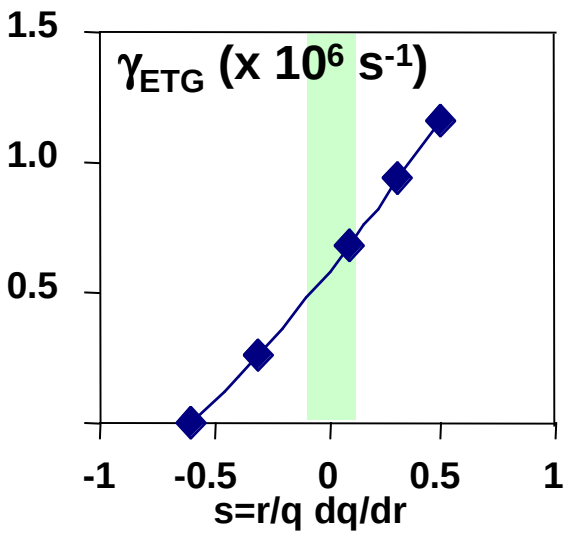




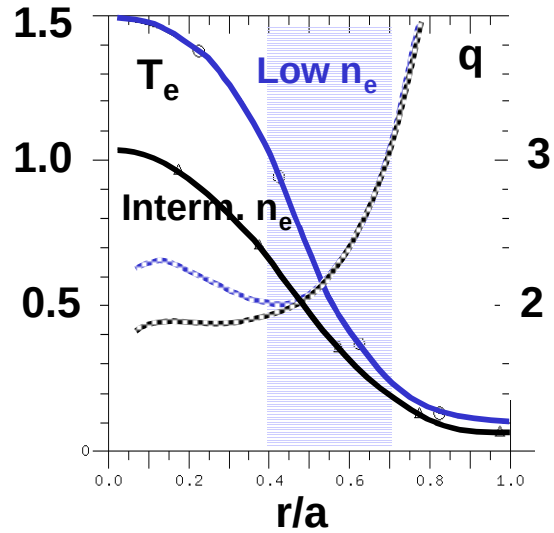
- **Off-axis T_e crashes, two 1/1 modes suggest q reversal at low n_e**
- **High electron transport with $|s| \geq 0$, low transport with $s < 0$**
- **Steady χ_e reduction at intermediate n_e also correlates with shear slowly going negative**
- ***Interestingly, χ_e decreases also well outside region of negative shear***

GS2 microstability assessment (K. Hill, C. Bourdelle)

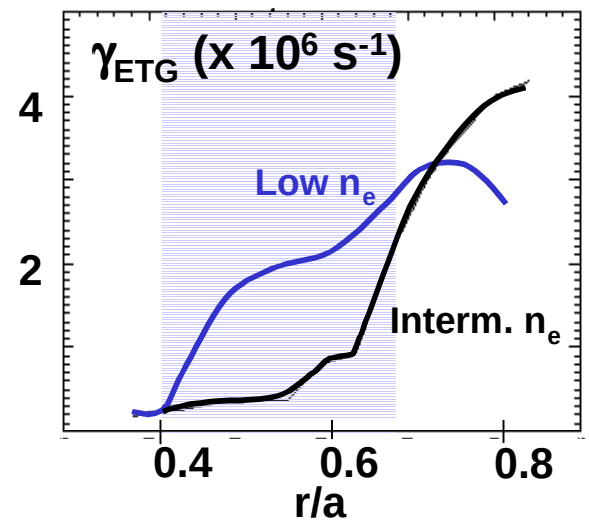
Low n_e, t=0.29 s, r/a=0.45

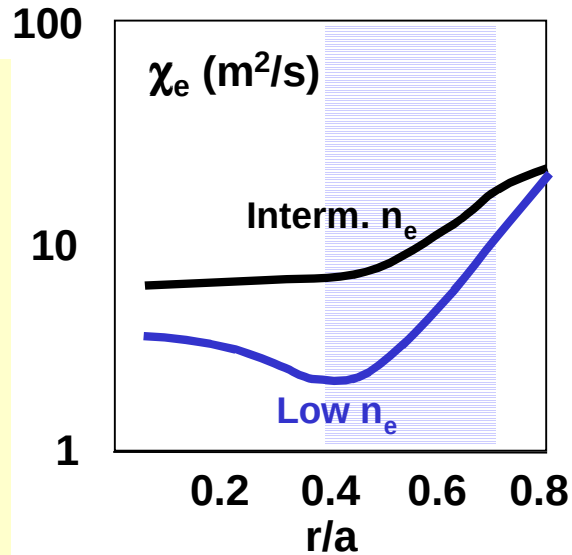


t=0.29 s



t=0.29 s





- s < 0 predicted to suppress ETG modes
- However, γ_{ETG} ($0.4 \leq r/a \leq 0.7$) higher in low n_e shot, while χ_e lower
- Low n_e also a determining factor ?
- μ-tearing activity can decrease with n_e (M. Redi)
- Investigate both s and n_e dependence of χ_e

Goals of proposed XP

Produce conditions promoting s < 0 and s > 0 at low n_e:
if χ_e degrades when s > 0 , this would confirm that negative shear rather than low collisionality is the determining factor

---

Increase the density in discharges having improved χ_e:
if higher collisionality cancels the confinement gain, one can surmise that micro-tearing modes also play a significant role

---

Assess the effects of increased beam and RF power on the T_e profile in conditions of improved χ_e:
- comparison with 'critical gradient' models
- obtain steeper electron and beta profiles towards a 'beta-prime' turbulence stabilization experiment (C. Bourdelle)

Verify and understand the increased ion transport in the improved χ_e regime:
- role of fast particle MHD vs. long-λ density fluctuations

Run plan

1. Restore conditions in which improved χ_e was observed : 4.5 kG, DND, k=1.9, d=0.6, $\langle n_e \rangle \approx 2\ 10^{13}$ cm^{-3}, 1 MA, 5 MA/s, src.C at *90* kV (2 shots).
2. Move beam injection time to ≈ 30 ms, per MAST experience (2 shots)
3. Increase, κ, δ by 10% to promote reversal (2 shots)
4. I_p ramp rate scan: 6, 7, 4, 3 MA/s (8 shots)
5. I_p increase to 1.2 MA at ramp-rate giving highest T_e gain (2 shots)
6. Beam power scan at 1 MA and ramp-rate giving highest T_e gain: C+B @ 0.2 s (2 shots), C+B +A @ 0.2 s (2 shots)
7. At highest sustainable P_{beam}, add RF after χ_e improves: 1.5 MW, 3 MW (4 shots)
8. n_e increase at the ramp rate and P_{beam} giving highest T_e gain: $\langle n_e \rangle \approx 3.5\ 10^{13}$ cm^{-3}, $5\ 10^{13}$ cm^{-3} (4 shots)
9. Add RF to high n_e, low χ_e discharge: 1.5 MW, 3 MW (4 shots)

Total =32 shots (1 1/2 run days)

Experimental tools and conditions

Gradient, height of T_e (R) as in between-shots measure of the electron confinement gain

GEM X-ray imaging + USXR mode identification + TRANSP magnetic diffusion for q-profile estimate

Neon injection in selected shots for particle transport

CHERS Z_{eff}, C profiles needed for TRANSP q-profile estimate

Core turbulence and fast MHD measurements highly desirable

MSE q_0 constraint, lithium pellet conditioning highly desirable