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

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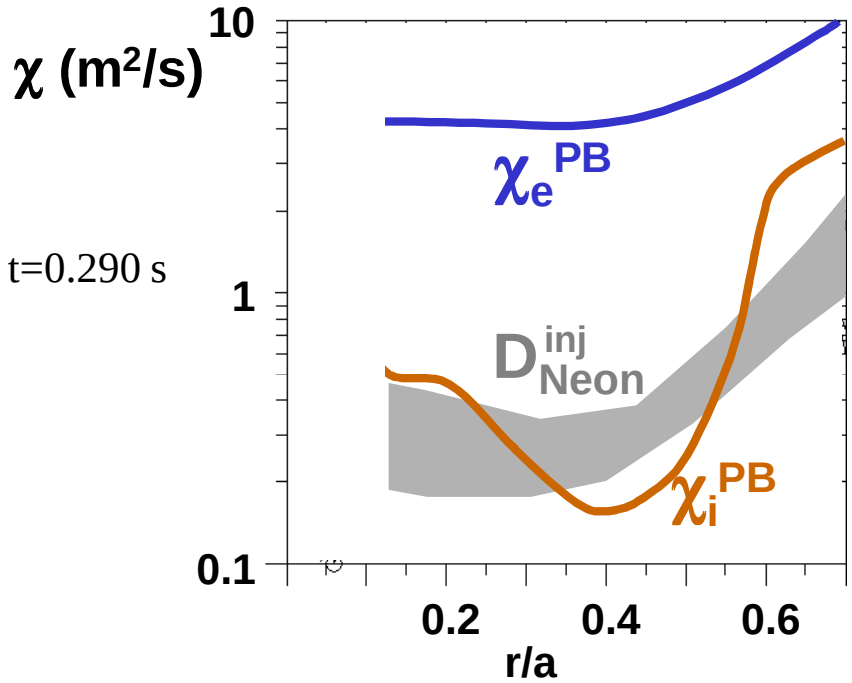
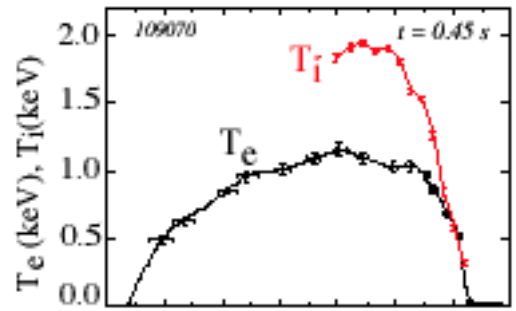
Electron transport typically strong in NSTX

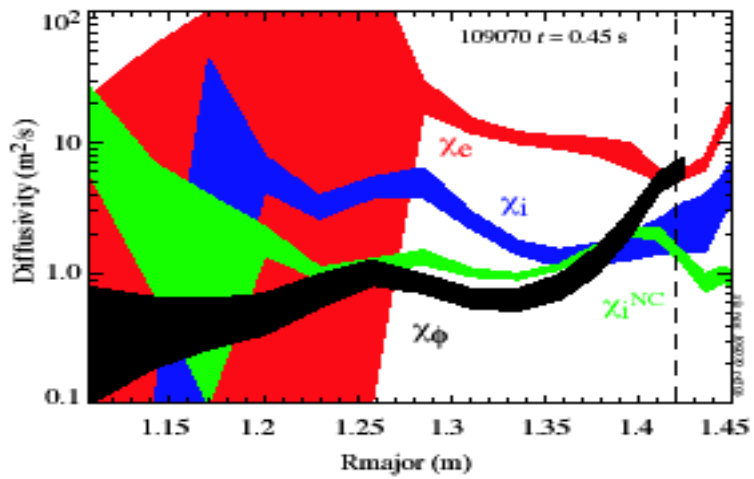
1.6 MW Intermediate n_e L-mode (#108213)



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

6 MW , high n_e H-mode #109070 (B. LeBlanc)

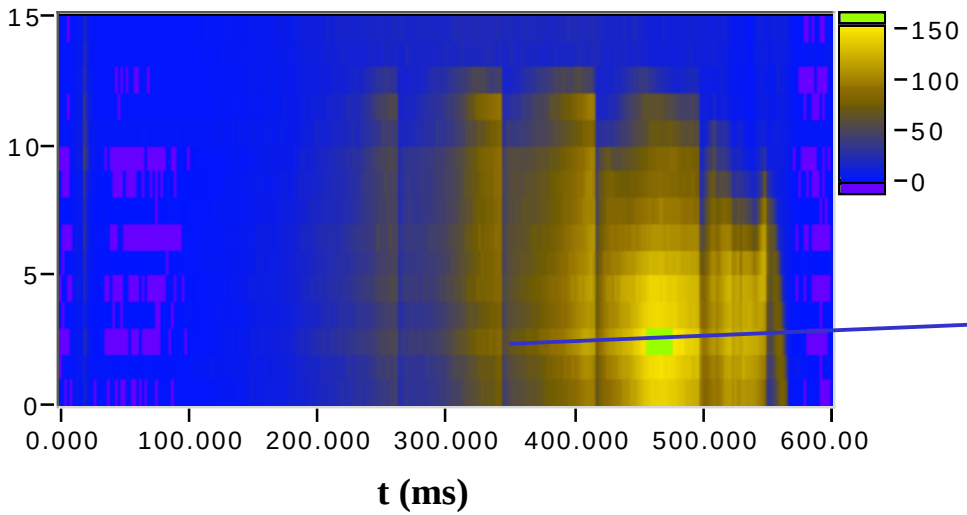


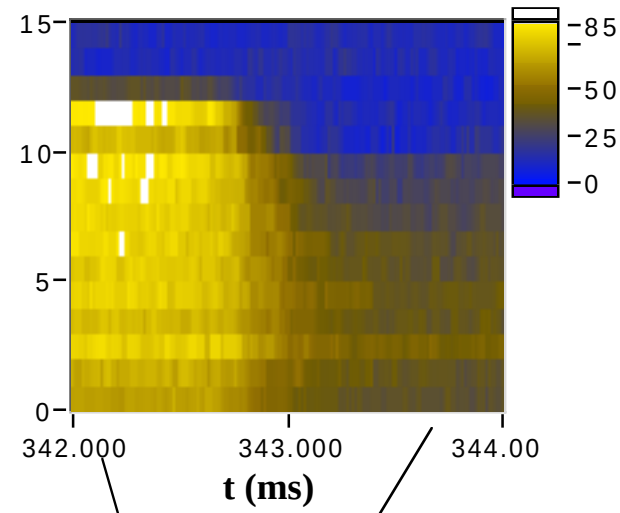


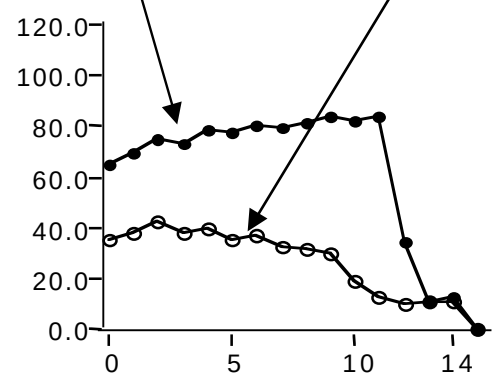
- Flat T_e <-> large core χ_e
- Same in 2004

Stiff transport can affect stability

USXR E > 1.4 keV



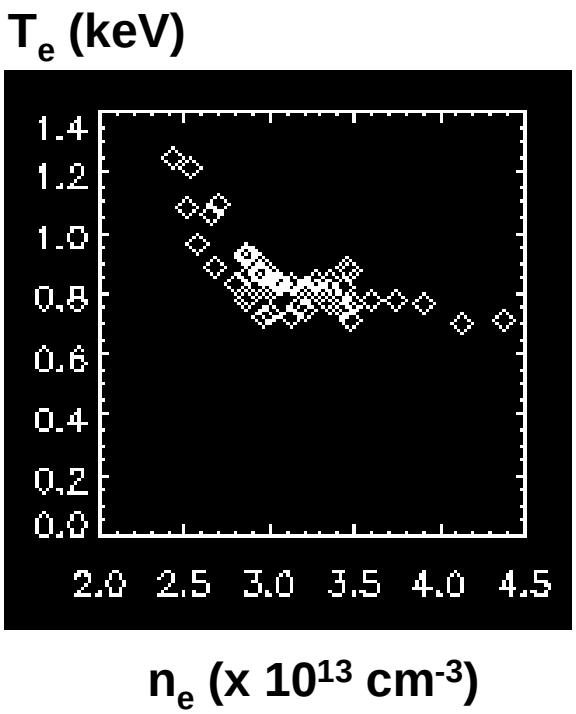


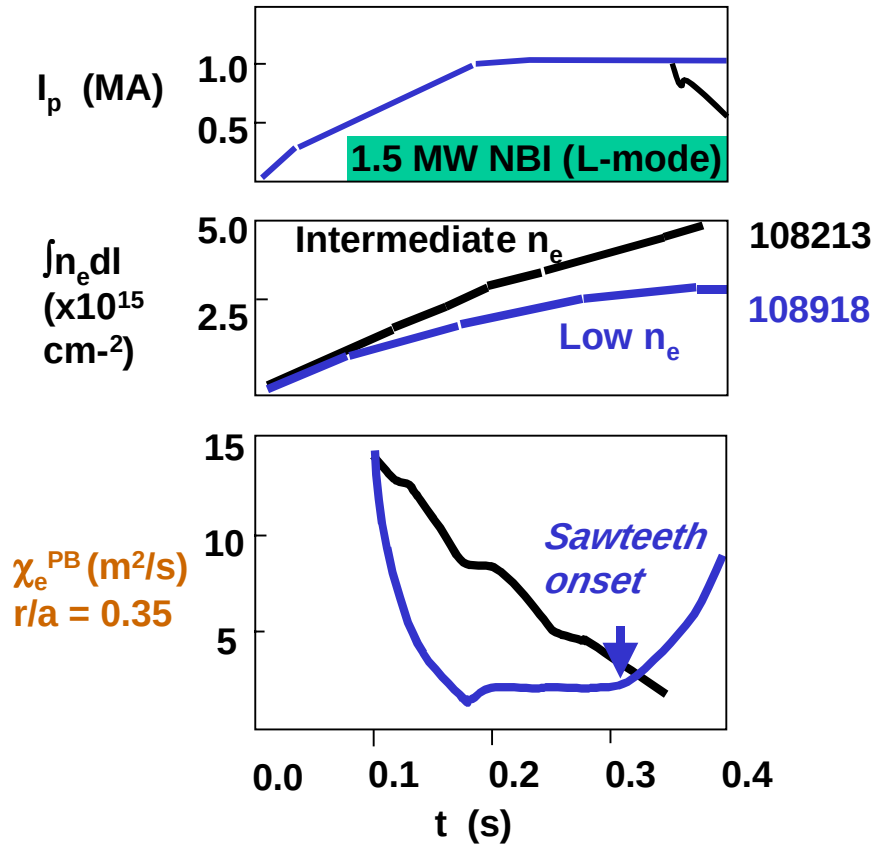


- **Stiff electron transport in H-mode likely explains large core T_e crash after peripheral T_e perturbation by ELM**

Reduced electron transport at low n_e

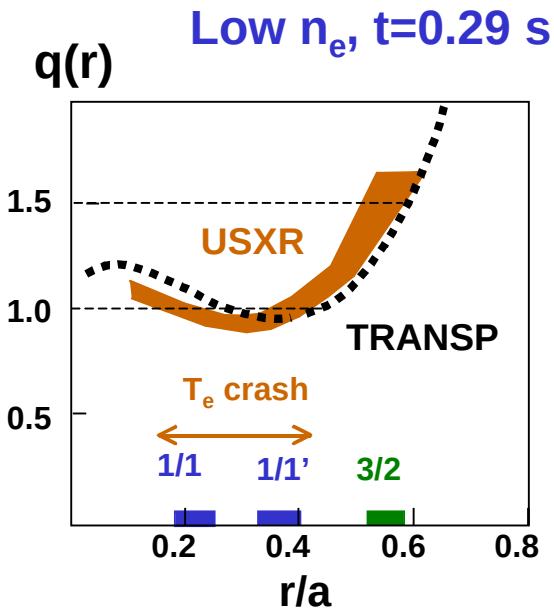
Central T_e as a function of central n_e (0,2-0.3 s average)

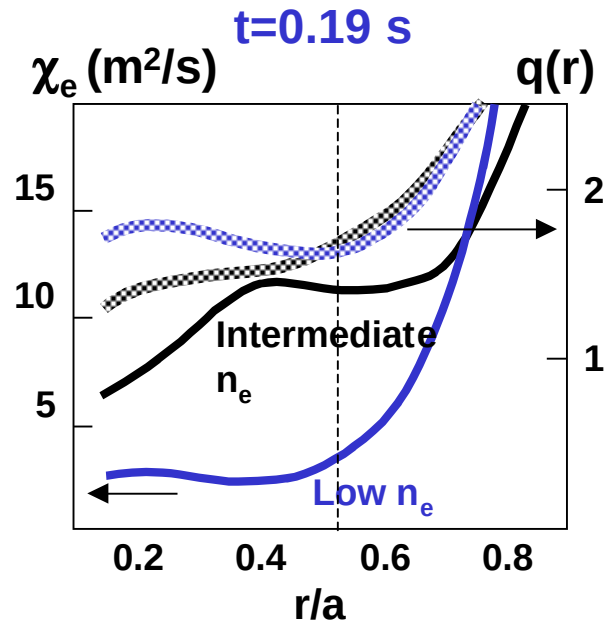




- Large χ_e decrease with early NB injection into low n_e discharges
- χ_e slowly decreases also in intermediate n_e case
- χ_i and D_{neon} nevertheless increase at low n_e (from < 1m^2/s to ≈ χ_e)

Evidence for shear reversal at low n_e

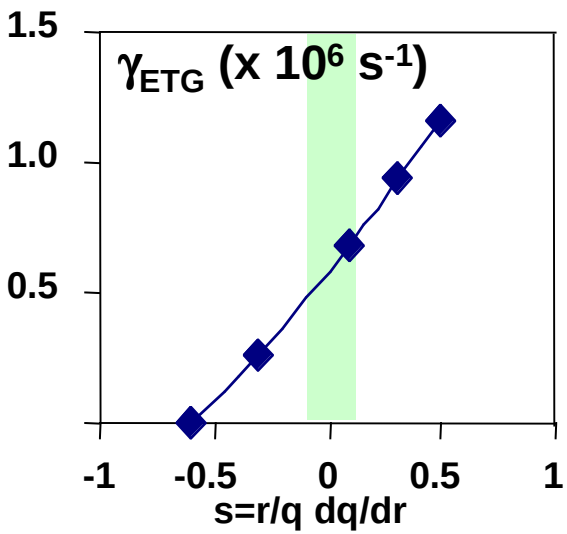




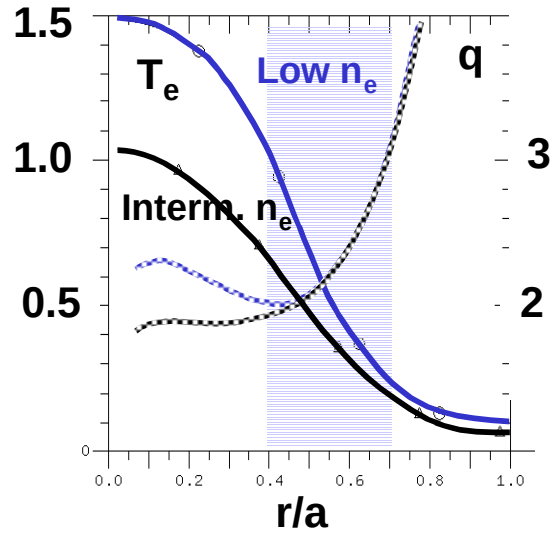
- **Off-axis T_e crashes, two 1/1 modes suggest q reversal at low n_e**
- **High electron transport with $|s| \geq 0$, low transport with $s < 0$**
- **Steady χ_e reduction at intermediate n_e also correlates with shear becoming increasingly negative**
- ***However, χ_e decreases also well outside region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

GS2 microstability (K. Hill, C. Bourdelle)

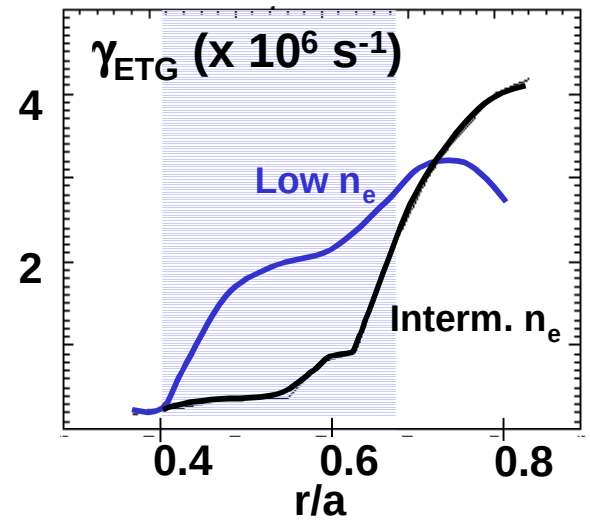
Low n_e, t=0.29 s, r/a=0.45

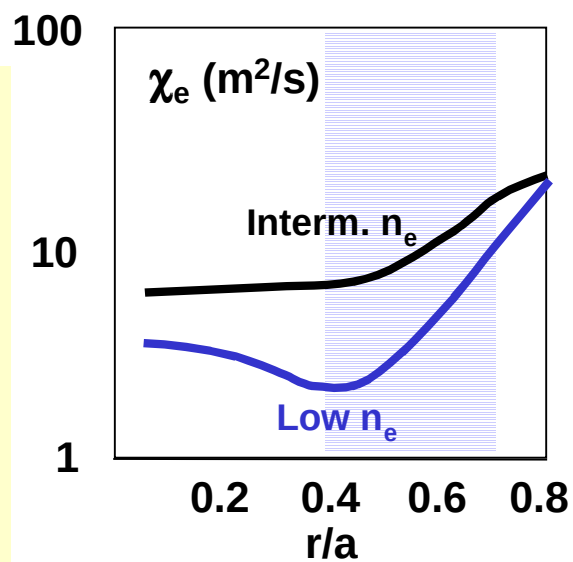


t=0.29 s



t=0.29 s





- s < 0 suppresses ETG modes
- However, between 0.4 ≤ r/a ≤ 0.7 χ_e lower in low n_e shot although γ_{ETG} higher
- 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

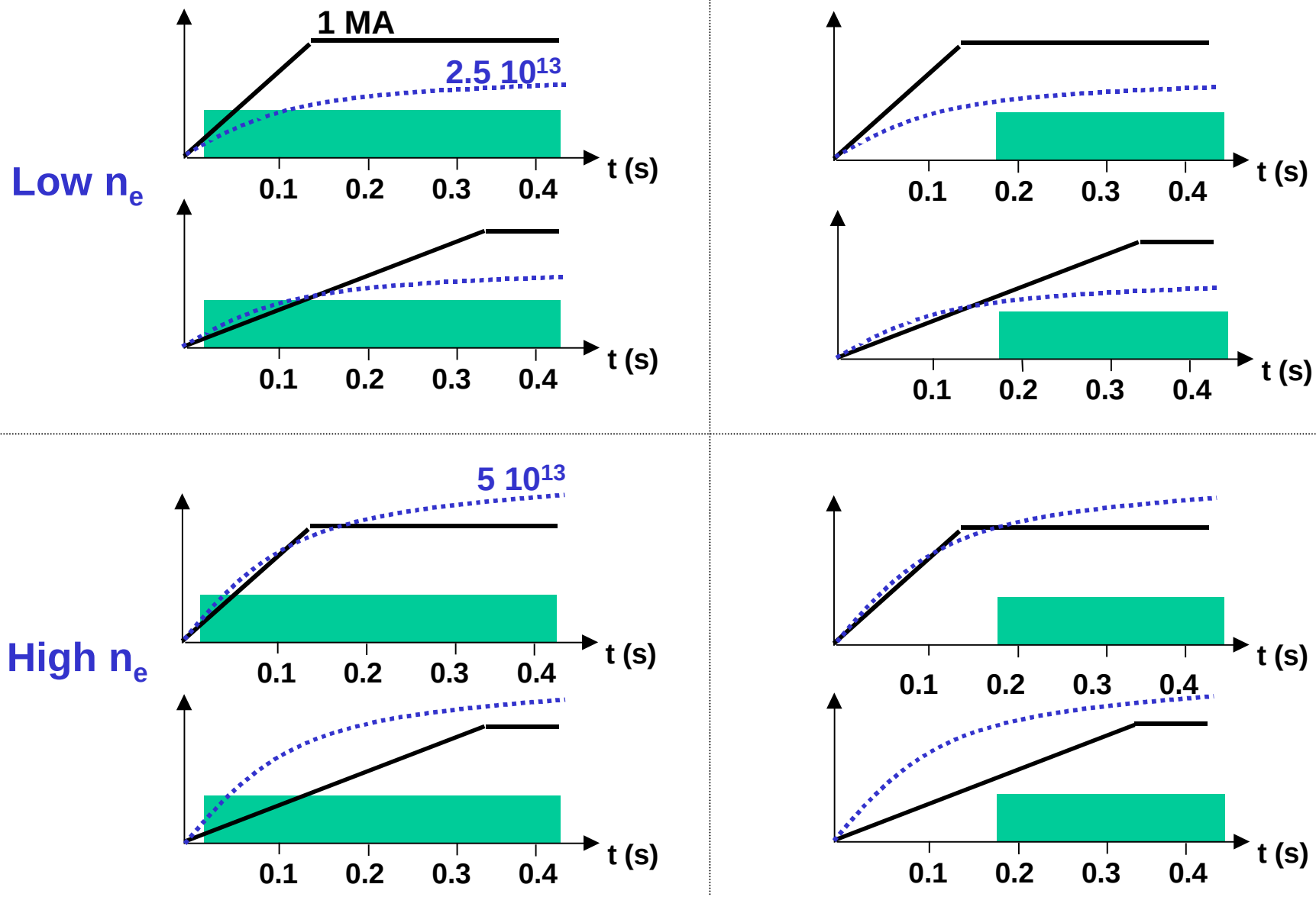
XP: compare electron transport in four conditions

- low density & strongly reversed q ← **Low χ_e**
- low-density & ≈ flat q ← **?**
- high density & ≈ flat q ← **High χ_e, (normal regime)**
- high density & strongly reversed q ← **?**

- **Ramp-rate, beam timing, N_e and P_{beam} scan in L-mode**
- **Assess also ion transport changes**

Ramp-rate change with early beam

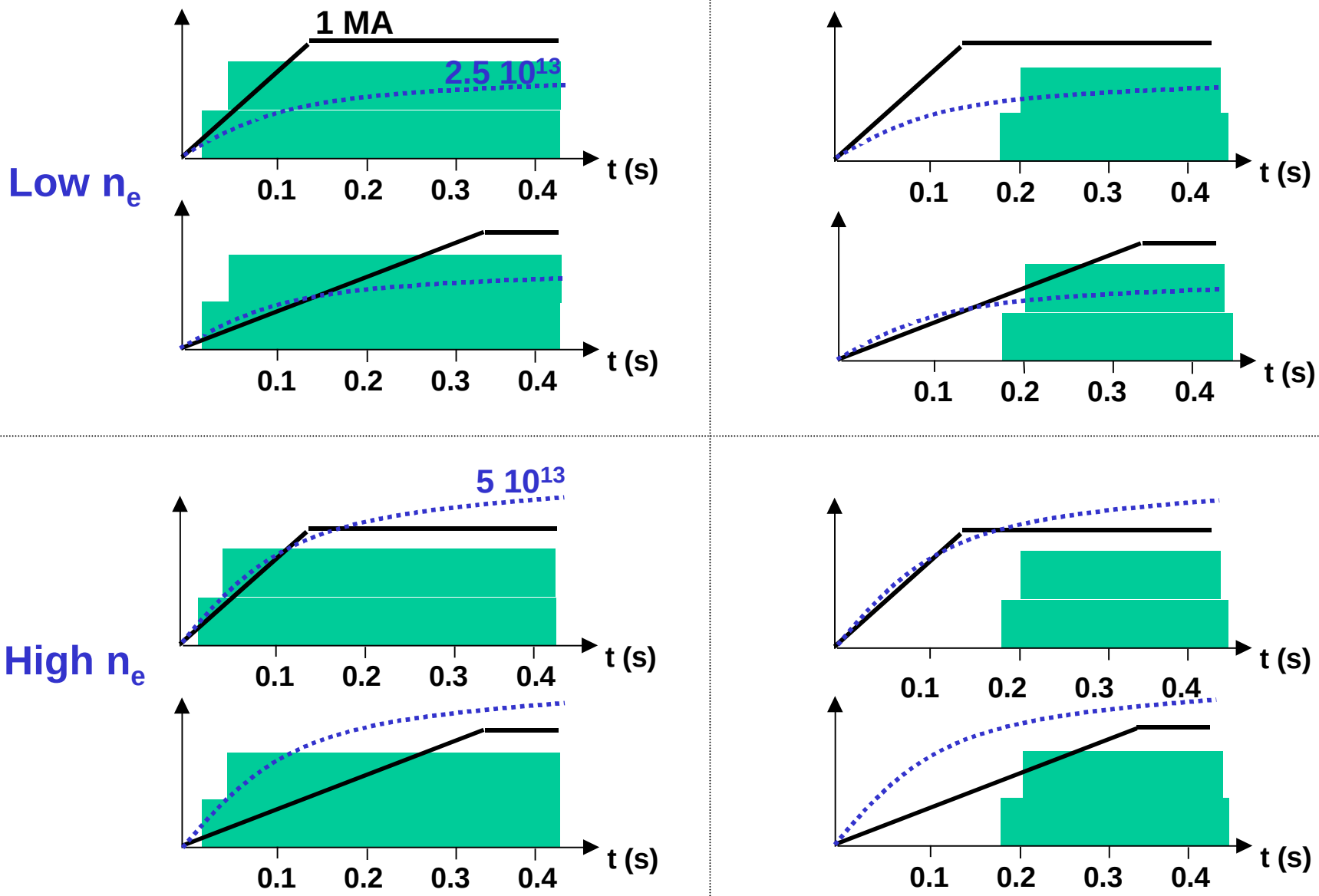
Ramp-rate change with late beam



- L-mode throughout for density control

Ramp-rate change, two early beams

Ramp-rate change, two late beams



- Higher power to assess response of T_e profile

Run plan (1 day)

1. Restore improved χ_e #108918 (1 MA, 5 MA/s, 4.5 kG, DN, κ=1.9, δ=0.6, *1 cm inner gap,* $\langle n_e \rangle \approx 2.5\ 10^{13}\ cm^{-3}$, src. C at *1.5 MW,*)
2. Early beam (t ≈ 30 ms)
3. Increase ramp-rate to ≈ 6 MA/s

4. Low n_e / high ramp rate / early beam
5. Low n_e / low ramp rate (≈ 3 MA/s) / early beam
6. Low n_e / low ramp rate / late beam (t ≈ 180 ms)
7. Low n_e / high ramp rate / late beam

8. Double beam power (C+B = 3 MW) and repeat 4-7

9. Double N_e and repeat 4-7 with two beams

10. At high N_e repeat 4-7 with one beam

Total = 16 useful conditions

The early beam / two beam conditions will be executed with priority

Run plan (1/2 day at 6 kG)

Goals:

A) Maximize beta/stored energy/pulse length at high field through improved electron confinement

B) Attempt beta-prime stabilization through B_t ramp-down

1. Reproduce highest electron confinement shot from Day 1 at 6 kG

2. Increase beam power to 6 MW

3. Add RF power

4. B_t ramp-down

Experimental conditions

- 5 min GDC / He discharge / 5 min GDC to ensure low N_e control

- Avoiding (early) H-modes:
  - 1 cm inner gap
  - use LFS gas puff
  - if still H-mode, use lower dome puff
  - also consider 10 min GDC + Ne puff from Bay K top

- Use gradient, height of T_e (R) for between-shot measure of electron confinement gain

Experimental tools

MSE q_0 constraint + EFIT for relative q-profile changes

Also use USXR mode identification + TRANSP magnetic diffusion

CHERS Z_{eff}, C profiles for TRANSP

Core turbulence and fast MHD measurements highly desirable