Exploration of improved electron confinement in low density/shear reversal L-mode discharges (XP 303)

Authors: D. Stutman, R. Bell, C. Bourdelle, D. Darrow, M. Finkenthal, S. Kaye, B. LeBlanc, J. Menard, D. Pacella, B. Stratton, E. Synakowski, K. Tritz

Presents:

D. Stutman

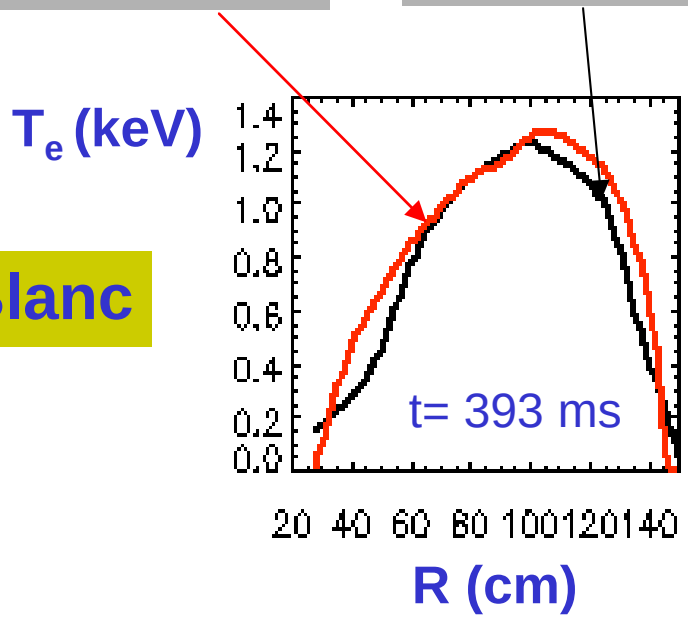
Johns Hopkins University

Electron confinement is a major challenge in NSTX

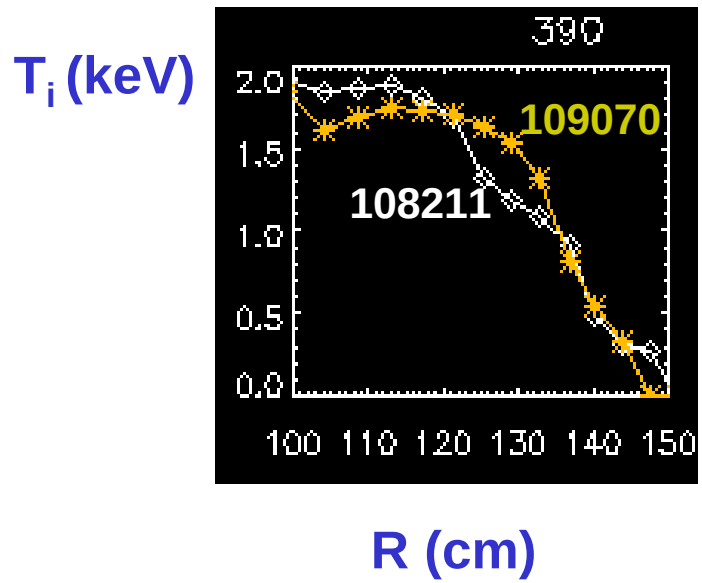
6 MW H-mode 109070

1.7 MW L-mode 108211

B. LeBlanc

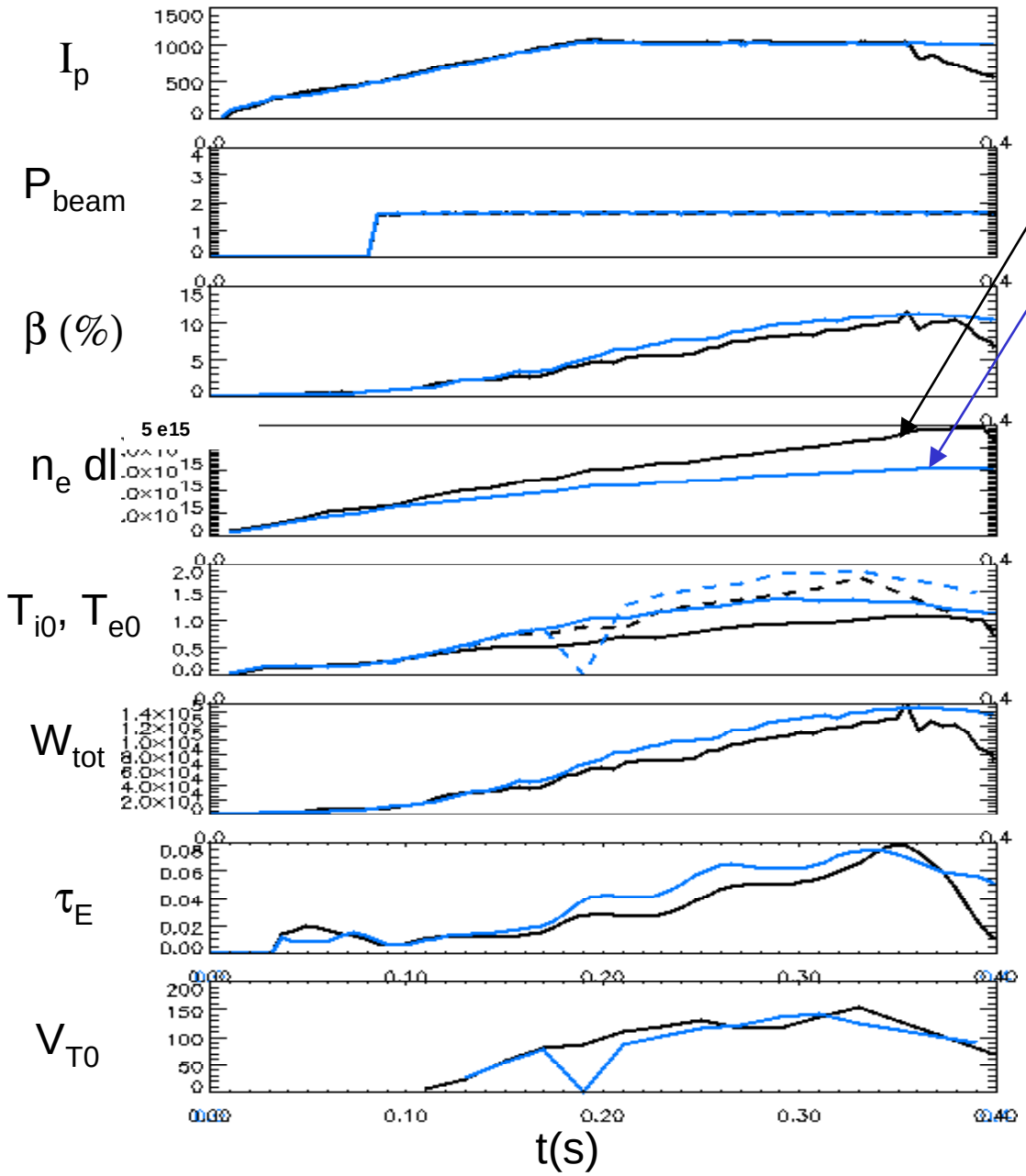


R. Bell



- **Stiff T_e profiles in (almost) all conditions**
- **Poor electron confinement limits also the ion channel**

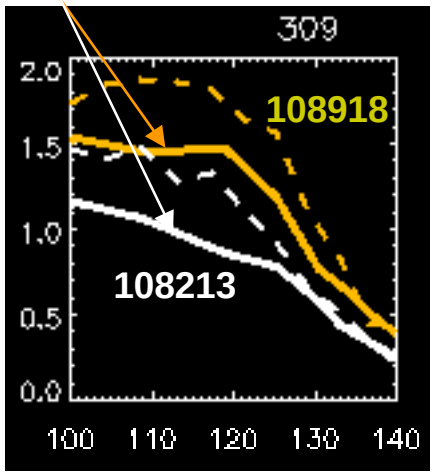
Electron temperature significantly increases at low n_e



108213 (C/4.5 kG)

108918 (C/4.5 kG)

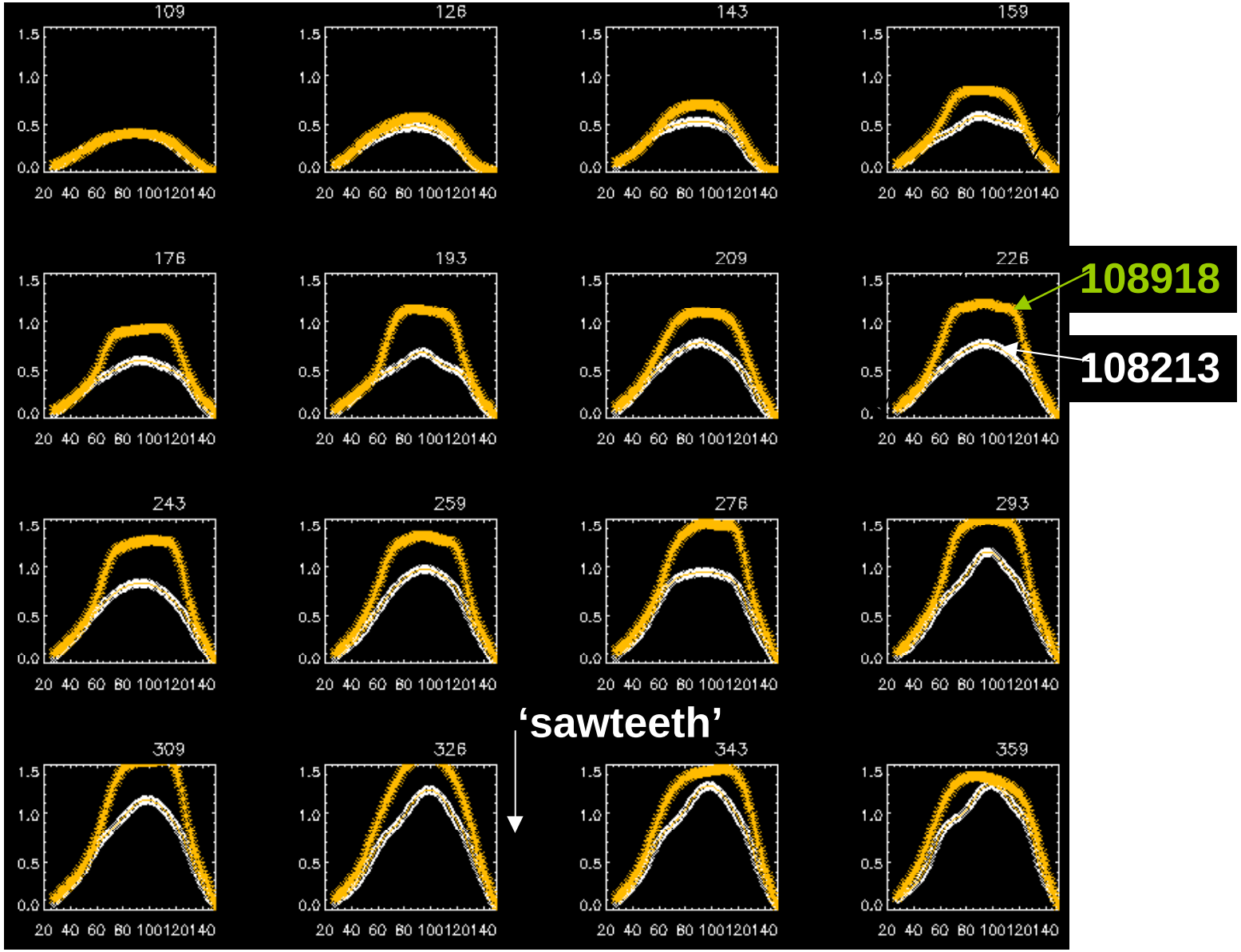
T_e, T_i (keV)



- **Ion temperature also significantly increases**

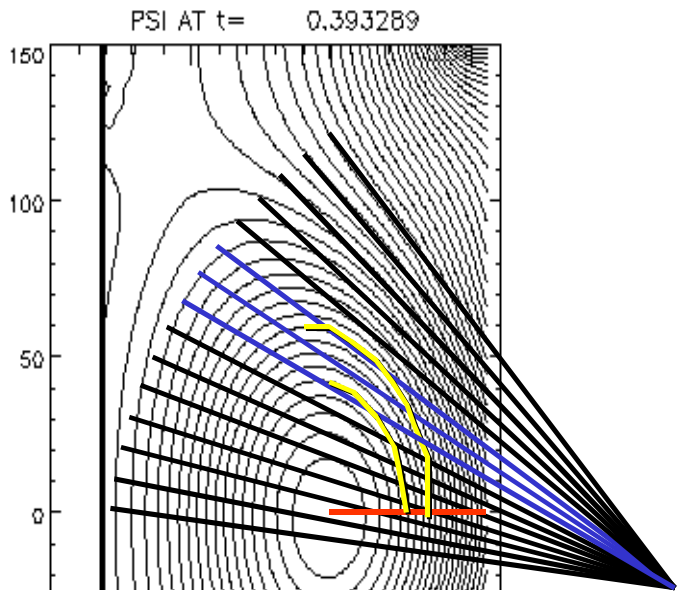
High T_e with broad profile from early in the shot

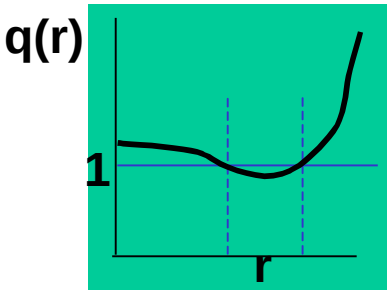
T_e (keV)

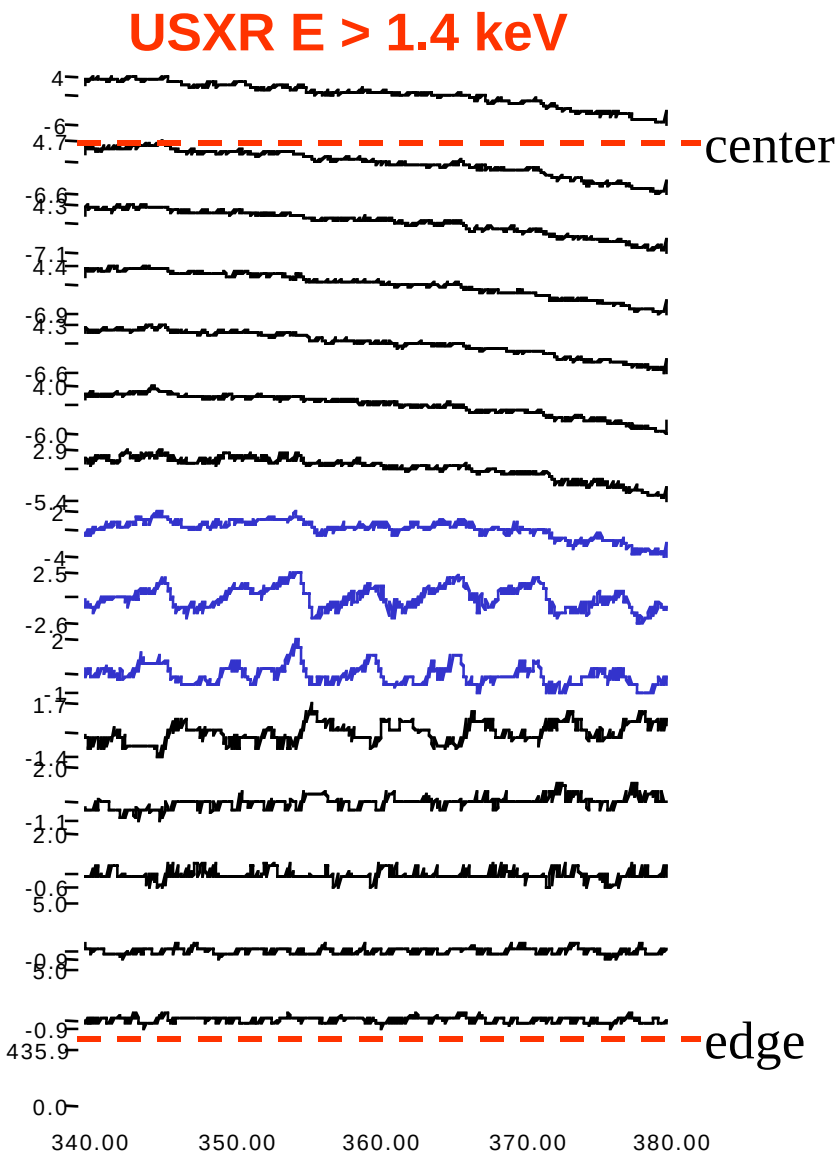


R(cm)

Shear reversal suggested by off-axis sawteeth



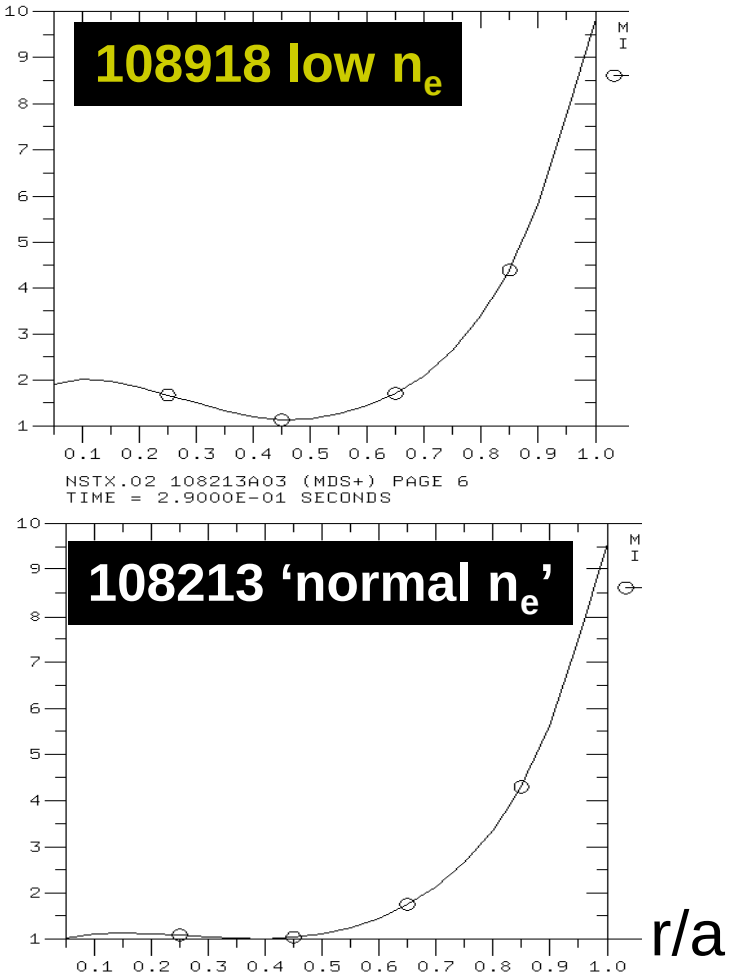




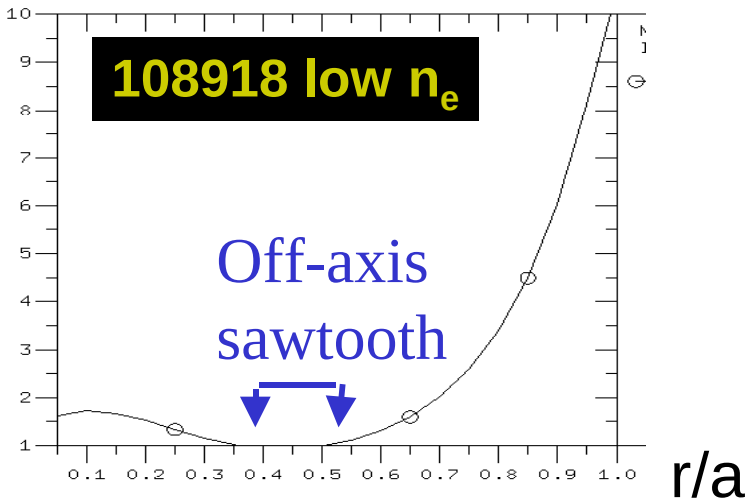
TRANSP predicts strong reversal for high T_e case

S. Kaye

TRANSP Q profile
(magnetic diffusion) at t=290 ms

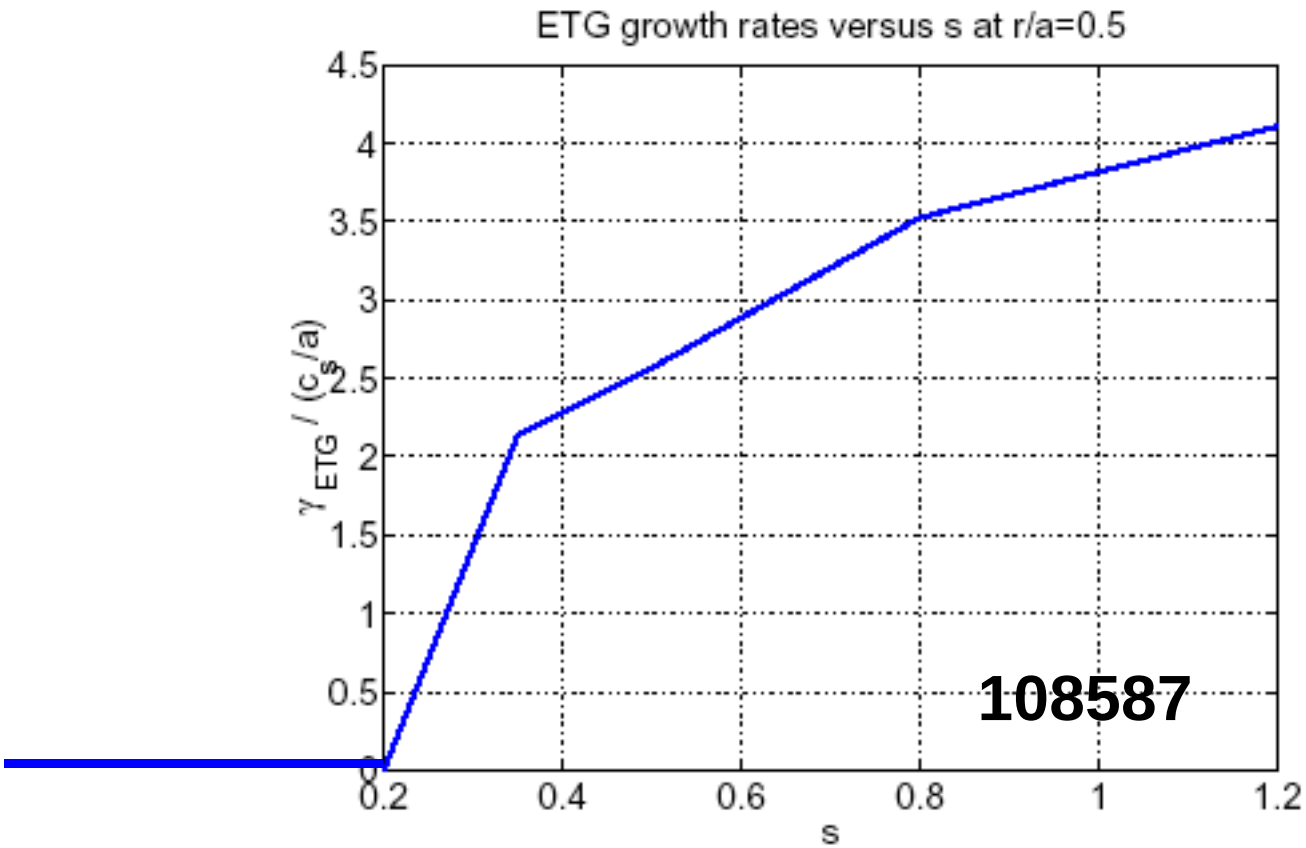


TRANSP Q profile
at t=400 ms



- **The TRANSP q=1 surfaces agree with those from USXR**

ETGs strongly suppressed for low or negative ‘s’



C. Bourdelle

- **Shear reversal most likely explanation for improved electron confinement in these discharges**
- **Increased beam penetration, reduced collisionality less likely**

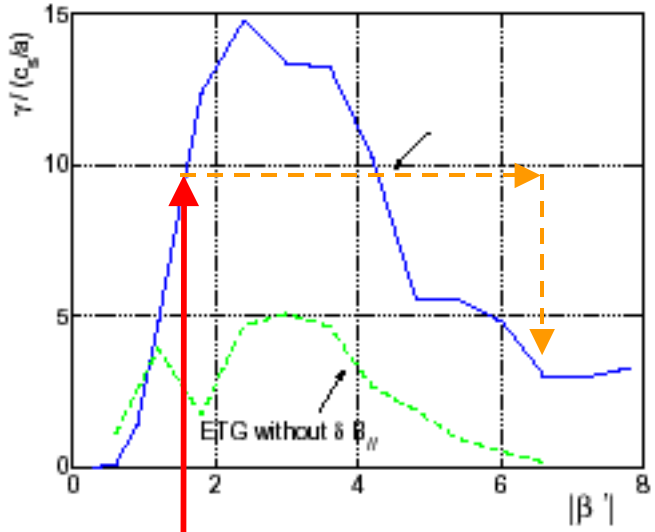
Goals of XP 303

- Explore response of T_e profile to increased beam power in low n_e/ reversed shear discharges (less stiff ?)
- Optimize / verify shear through I_p ramp-rate scan
- Explore response of T_e profile to NBI + RF heating
- Optimize low n_e/ reversed shear plasma for high W_{tot} and beta
- Attempt to further increase electron/global confinement through beta-prime mechanism

Shear reversal assisted beta-prime mechanism

C. Bourdelle

ETG growth rate



We are here

- ETG (and ITG) growth rates predicted to decrease at high β'
- Positive feedback possible
- Reaching high β' is the problem
- Transient shear reversal may enable 'tunneling' to high β'
- Once there, feedback takes over
- Possible benefits:
  - broad P(r) L-mode as an alternative to the H-mode (no ELMs, less α loss ?)
  - improved H-mode electron confinement

Scans to be performed

- Beam power scan at 5.5 kG
  (higher field for q_0 >1 and less confinement degradation)

- I_p ramp-rate scan

- RF power scan at optimal I_p ramp-rate and P_{NB}

  ⇓

  Low n_e/reversed shear discharge optimized for high beta

- Increase beta-prime by lowering B_t at fixed q_{cyl}
  (confinement is B_t independent)

Accompanying experiments

- Neon injection for ion transport

- GEM SXR imaging (D. Pacella) + magnetic code (K. Tritz) for q(r)

Proposed run plan

Beam power scan at fixed (5 MA/s) I_p ramp rate

I_P (MA)	B_T (T)	Src	Power (MW)	n_e-bar ($10^{19}m^{-3}$)			Neon
1	5.5	A	1.6	2.5	x	x	x
1	5.5	B	2.4	2.5	x	x	x
1	5.5	A+B	4	2.5	x	x	x

I_p ramp rate scan at fixed (2.4 MW) beam power

I_P (MA)	B_T (T)	Src	Ramp (MA/s)	n_e-bar ($10^{19}m^{-3}$)			Neon
1	5.5	2.4	4	2.5	x	x	x
1	5.5	2.4	6	2.5	x	x	x
1	5.5	2.4	7	2.5	x	x	x

Run plan continued

RF power scan at optimized beam power and I_p ramp-rate

I_P (MA)	B_T (T)	Src	RF Power	n_e-bar ($10^{19}m^{-3}$)	Neon		
1	5.5	2.4	1	2.5	x	x	x
1	5.5	2.4	2	2.5	x	x	x
1	5.5	2.4	4	2.5	x	x	x

Beta scan at fixed q_{cyl} in shear-reversal optimized regime

I_P (MA)	B_T (T)	Src	Power (MW)	RF Power	n_e-bar ($10^{19}m^{-3}$)	Neo		
1	5.5	B(+A)	2.4 (4)	TBD	2.5	x	x	x
0.85	4.5	B(+A)	2.4 (4)	TBD	2.5	x	x	x
0.7	3.85	B(+A)	2.4 (4)	TBD	2.5	x	x	x

Total =36 shots (1 1/2 days)

Operational/diagnostic requirements

- RF coupling to DND L-mode plasma (optimal inner gap ? LSN ?)
- Density/impurity influx during RF (well conditioned antenna)
- Turbulence correlation length measurement into deeper plasma regions at low n_e
- GEM detector/SXR camera important for a shear reversal estimate
- MSE and Li pellet wall conditioning are highly desirable

Summary

- Exploration of new electron confinement regimes will enable better understanding of causes for stiff electron transport

- Experiments may break ground for shear reversal assisted improvements of electron confinement

- A complementary 1/2 day XP
  'Effect of beta changes on electron confinement in standard L-mode discharges' will later be presented