Analysis of XP-435: NSTX/MAST Joint XP on ITB formation

Aims of analysis of XP-435:

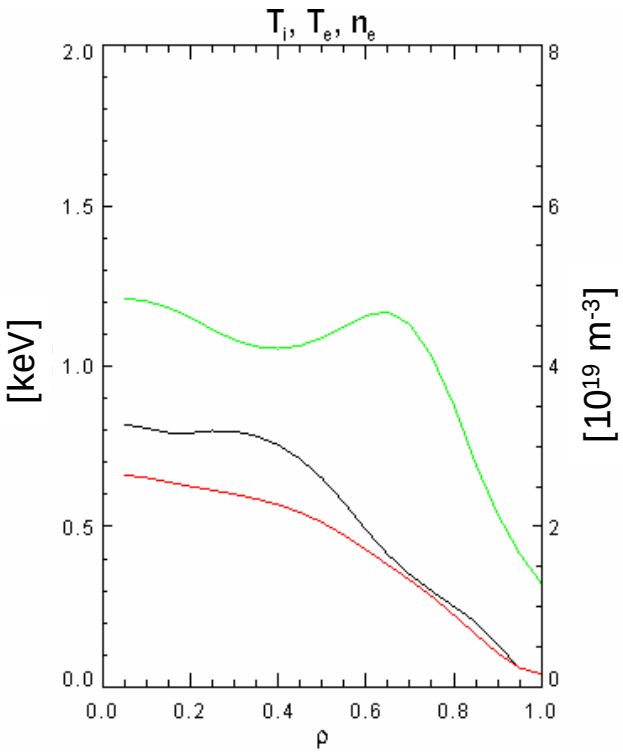
- Reliably identify ion-ITB location, e.g. minimum χ_i or $(dL_T/dr)_{max}$
- Determine evolution of ion-ITB location
- Characterize plasma parameters at ion-ITB, e.g. M_ϕ, s, T_i/T_e, ρ_s^*/L_T, etc
- Determine scaling of f_ϕ, M_ϕ, etc with applied NBI torque and power
- Compare with simple 0D model of angular momentum balance

Progress with analysis of XP-435, 7-11.02.05:

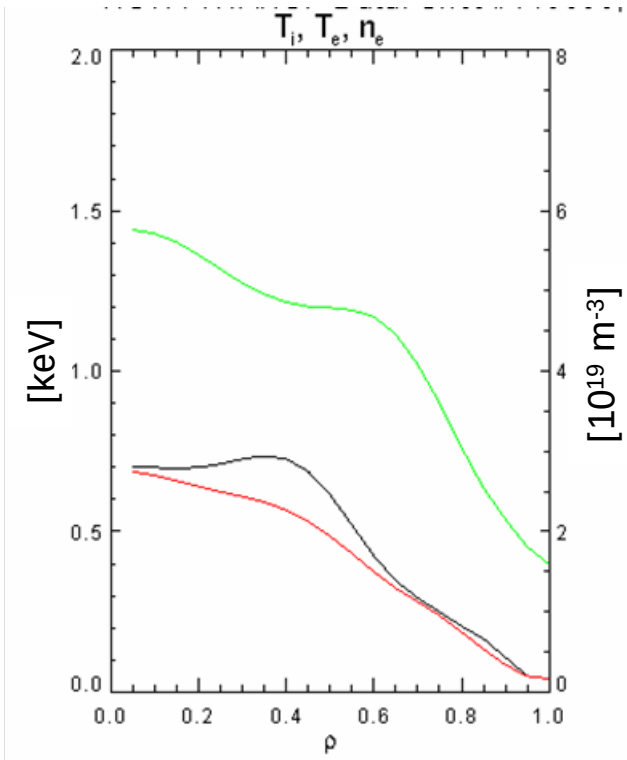
- Read raw NSTX TS and CHERS data into IDL
- Read NSTX TRANSP output files into IDL using MDS+
- Modified MAST TRANSP post-processing code for NSTX
- Comparison of 4 MW cases with A+B/90 keV and A+B+C/70 keV NBI

Analysis of XP-435: Comparison of 4 MW, 90 and 70 keV shots

#113850, 4 MW, A+B/90 keV



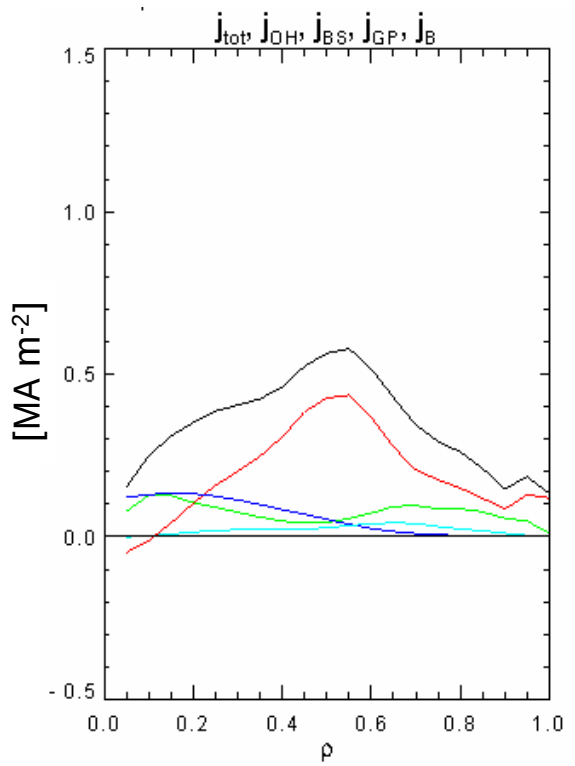
#113865, 4 MW, A+B+C/70 keV

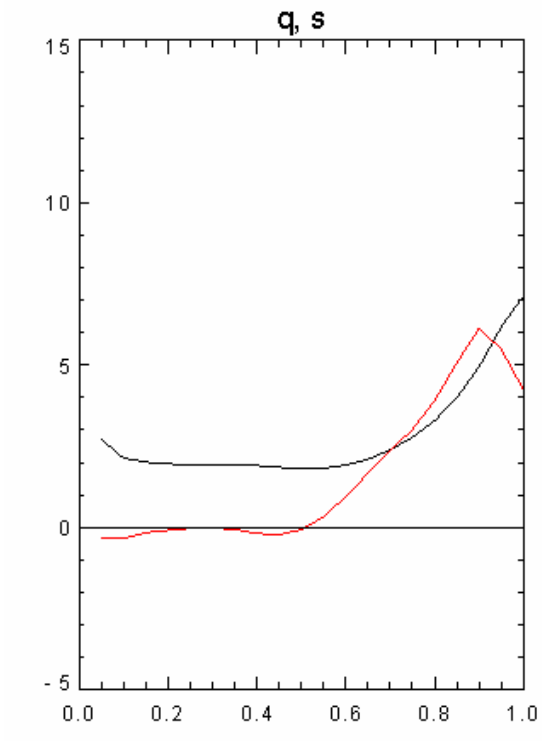


- Lower energy case has higher $n_e(0)$ from beam fuelling, $\Gamma_b = Q_b/eE_b$

Analysis of XP-435: Current density, q and shear profiles

#113850, 4 MW, A+B/90 keV

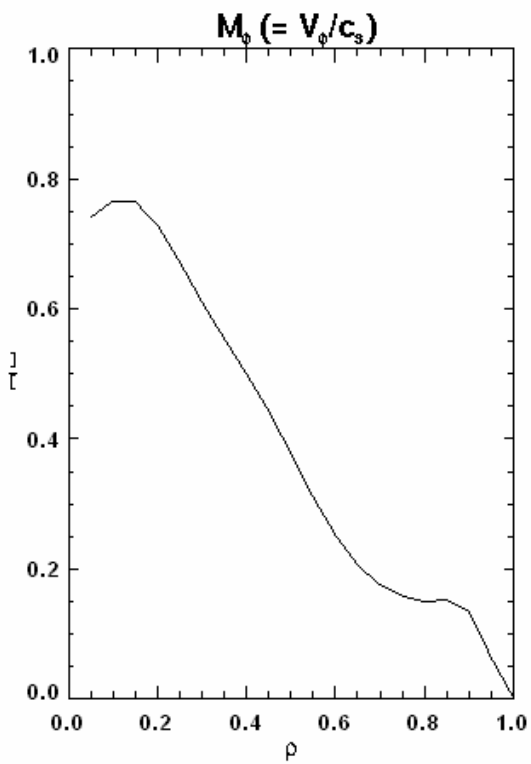




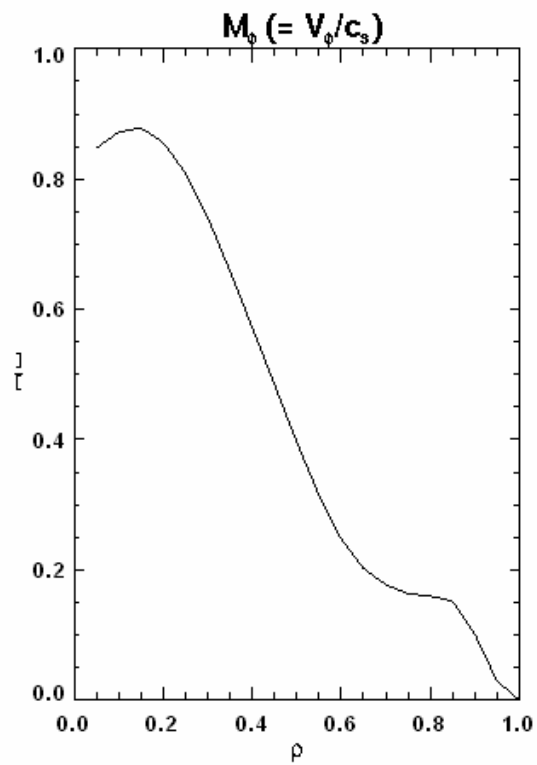
- Hollow current profile due to NBI heating during current ramp
- Slightly reversed q profile and weak central shear favours micro-stability

Analysis of XP-435: Toroidal Mach number

#113850, 4 MW, A+B/90 keV



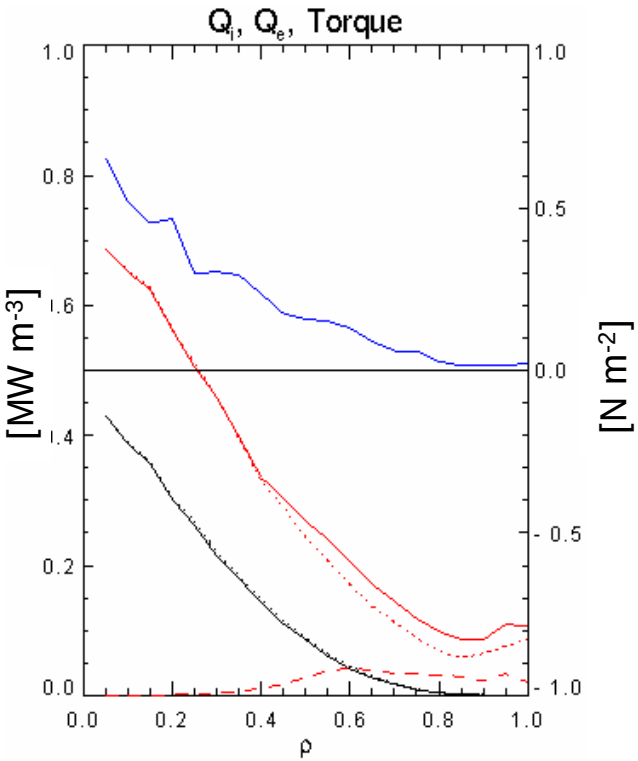
#113865, 4 MW, A+B+C/70 keV



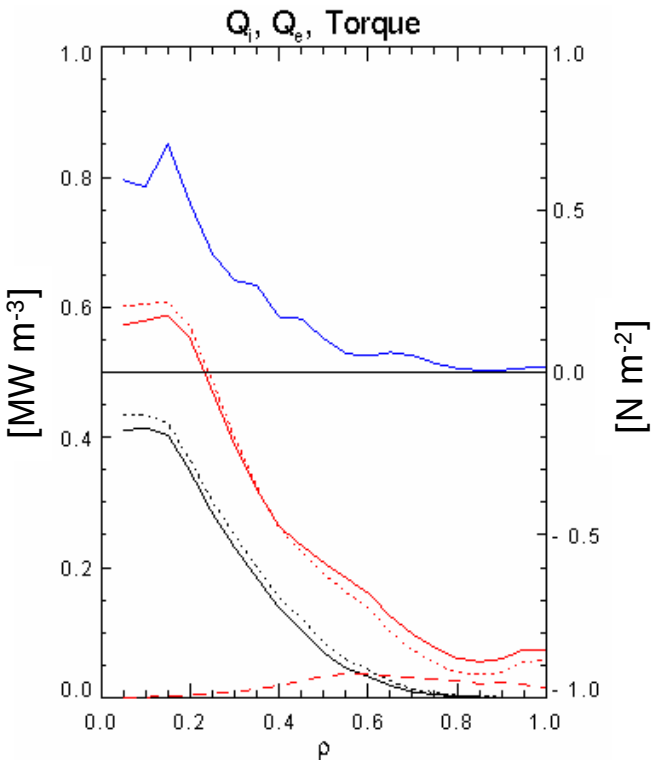
- Slightly higher toroidal Mach number for lower energy case
- $\gamma_m/\omega_{SE} \sim M_\phi$ in highly rotating NBI driven plasma

Analysis of XP-435: NBI power densities and torque

#113850, 4 MW, A+B/90 keV



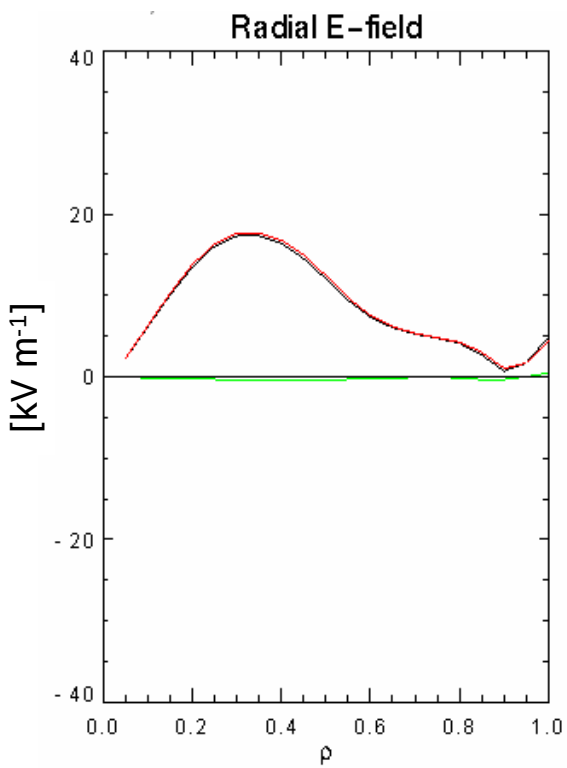
#113865, 4 MW, A+B+C/70 keV



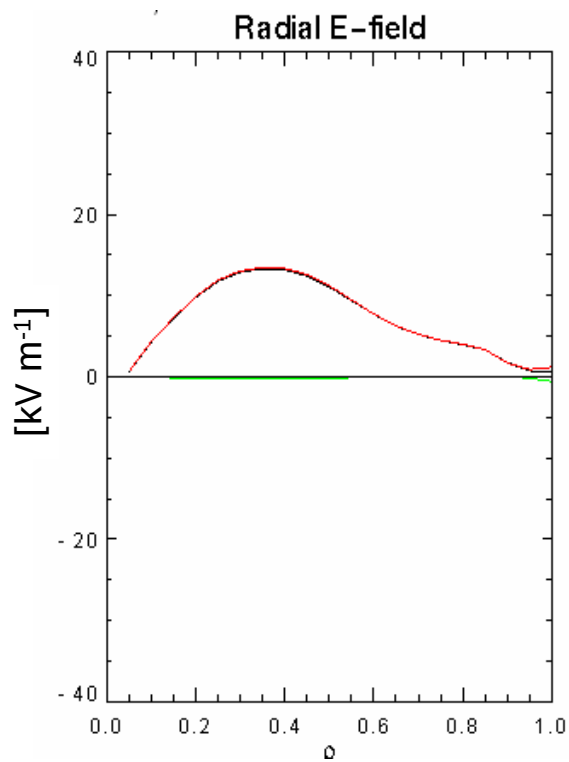
- Similar electron and ion power and torque deposition in low/high energy cases
- Slightly higher electron heating in 90 keV case

Analysis of XP-435: Radial E-field

#113850, 4 MW, A+B/90 keV



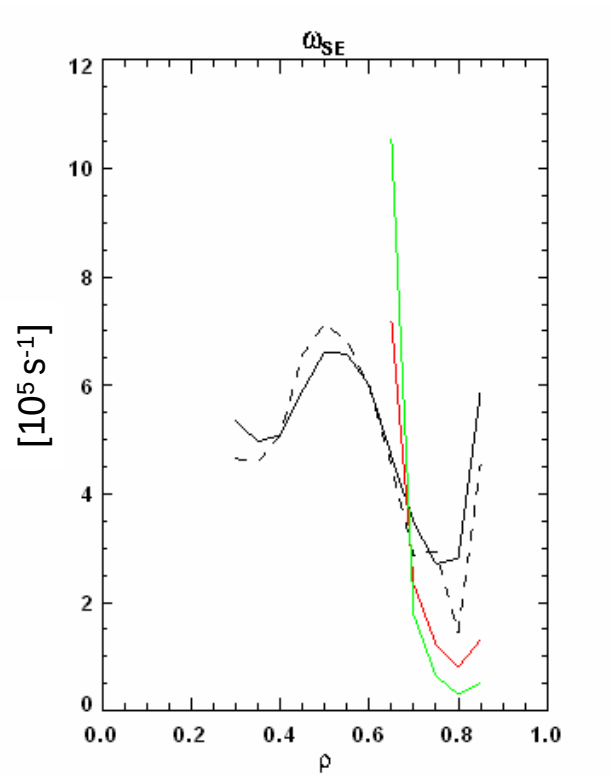
#113865, 4 MW, A+B+C/70 keV



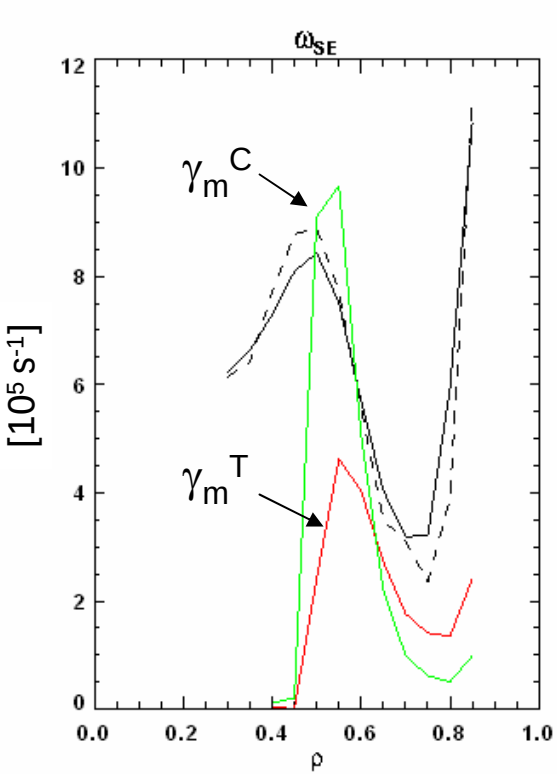
- Radial E-field dominated by toroidal rotation ($V_\phi B_\theta$)
- Pressure gradient term very small (different on MAST?)

Analysis of XP-435: ExB shearing rate and ITG growth rate

#113850, 4 MW, A+B/90 keV



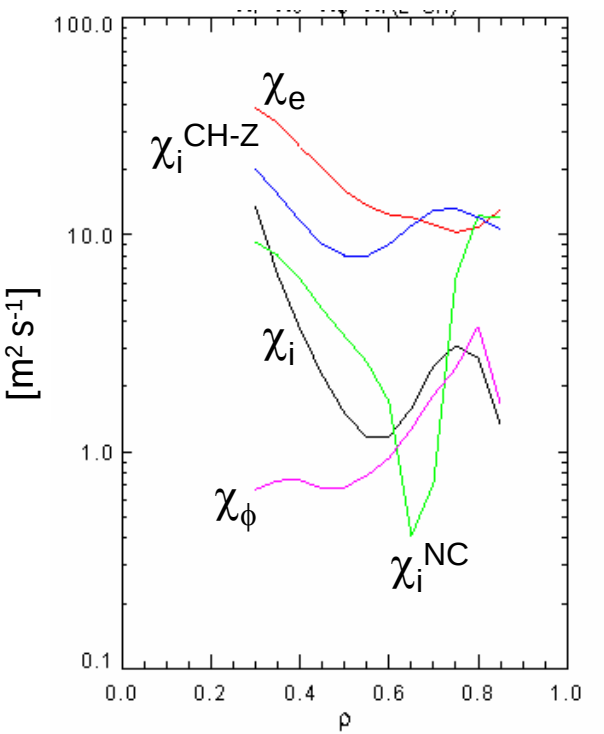
#113865, 4 MW, A+B+C/70 keV



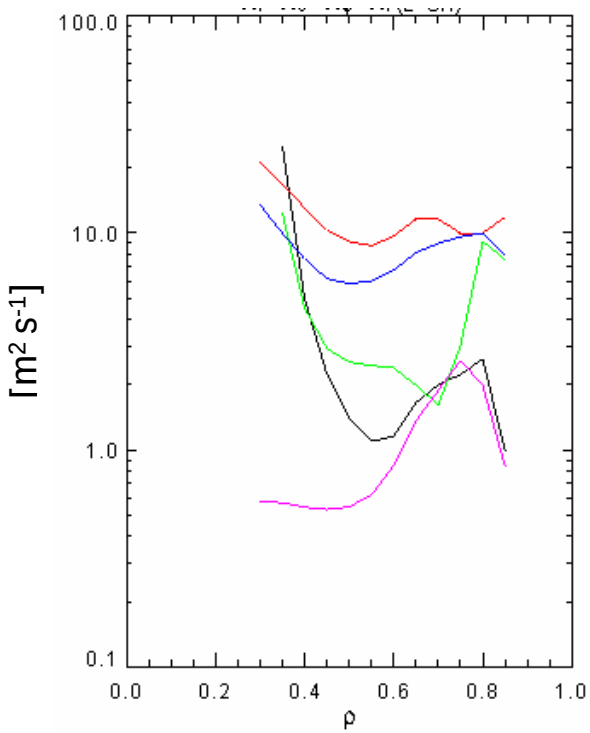
- Higher ExB shearing rate in lower energy case
- Analytic ITG growth rate γ_m (ref: Rogister) < ExB shearing rate

Analysis of XP-435: Transport coefficients

#113850, 4 MW, A+B/90 keV

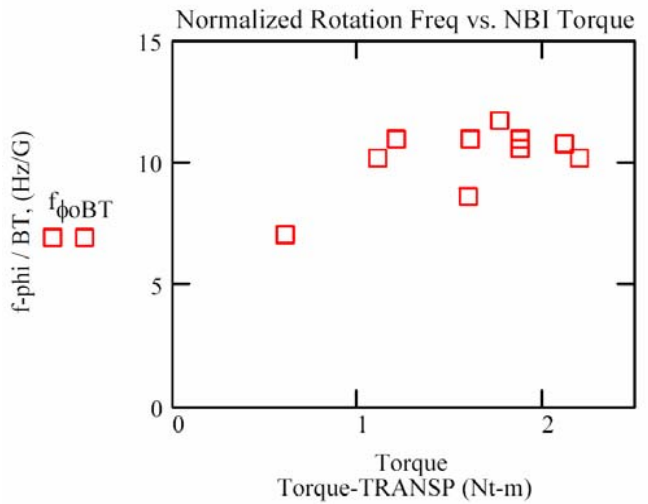


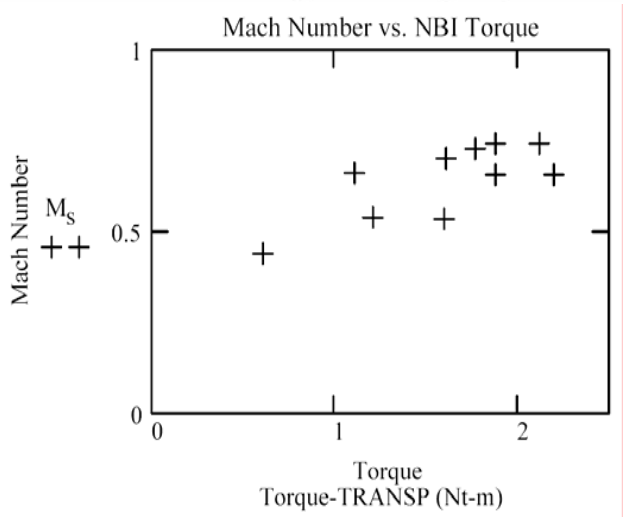
#113865, 4 MW, A+B+C/70 keV



- Reduced χ_i in region of high ExB flow shear and low magnetic shear
- $\chi_i \sim \chi_i^{NC}$, $\chi_\phi < \chi_i$, $\chi_e > \chi_i$ but $\chi_i^{CH\text{-}Z} > \chi_i^{NC}$? Sensitivity to in-out mapping?

Analysis of XP-435: Scaling analysis





Simple 0D momentum balance with dominant tangential NBI heating:

Applied torque: $T_\phi = R_0 Q_b \sqrt{2m_b / eE_b}$

If NBI fuelling dominates in core:

Rotation frequency: $\omega_\phi = \sqrt{\frac{2eE_b}{m_b}} \cdot \frac{\tau_\phi}{\tau_p} \cdot \frac{1}{R_0}$

If NBI heating dominates and $T_i = T_e$, $Q_i = Q_e$:

Toroidal Mach number: $M_\phi = \sqrt{\frac{3\tau_p}{\tau_E}} \cdot \frac{\tau_\phi}{\tau_p}$

Independent of NBI power and energy!

Insight into ratios of τ's?