Microstability and Flow Shear Analysis of High-Performance JET ITB Plasma

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- JET has achieved high performance, large radius ITBs using early LHCD
- Gyrokinetic analysis performed
- $\gamma_{ExB} \approx \gamma_{lin}$ at formation of sustained ITB in core
- correlation of γ_{ExB} and γ_{lin} weak at large radii

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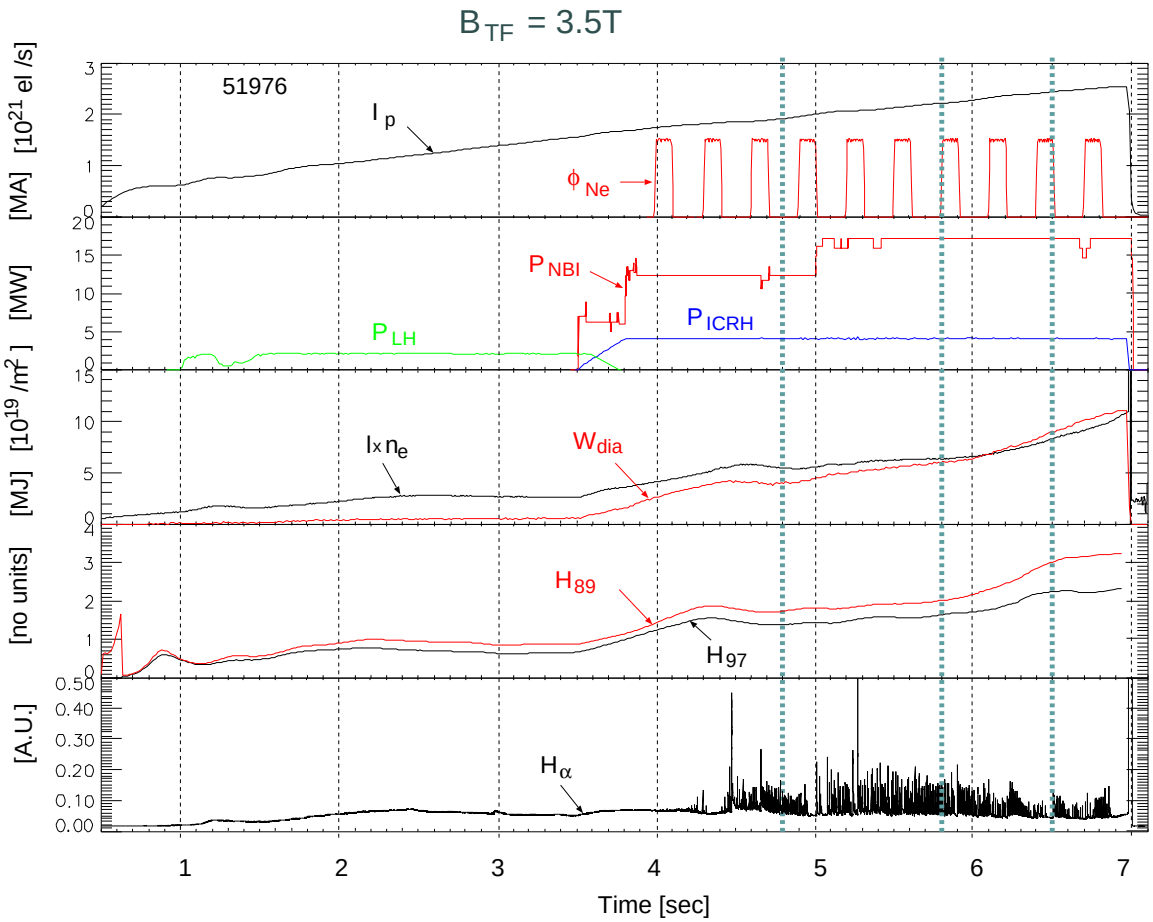
Outline

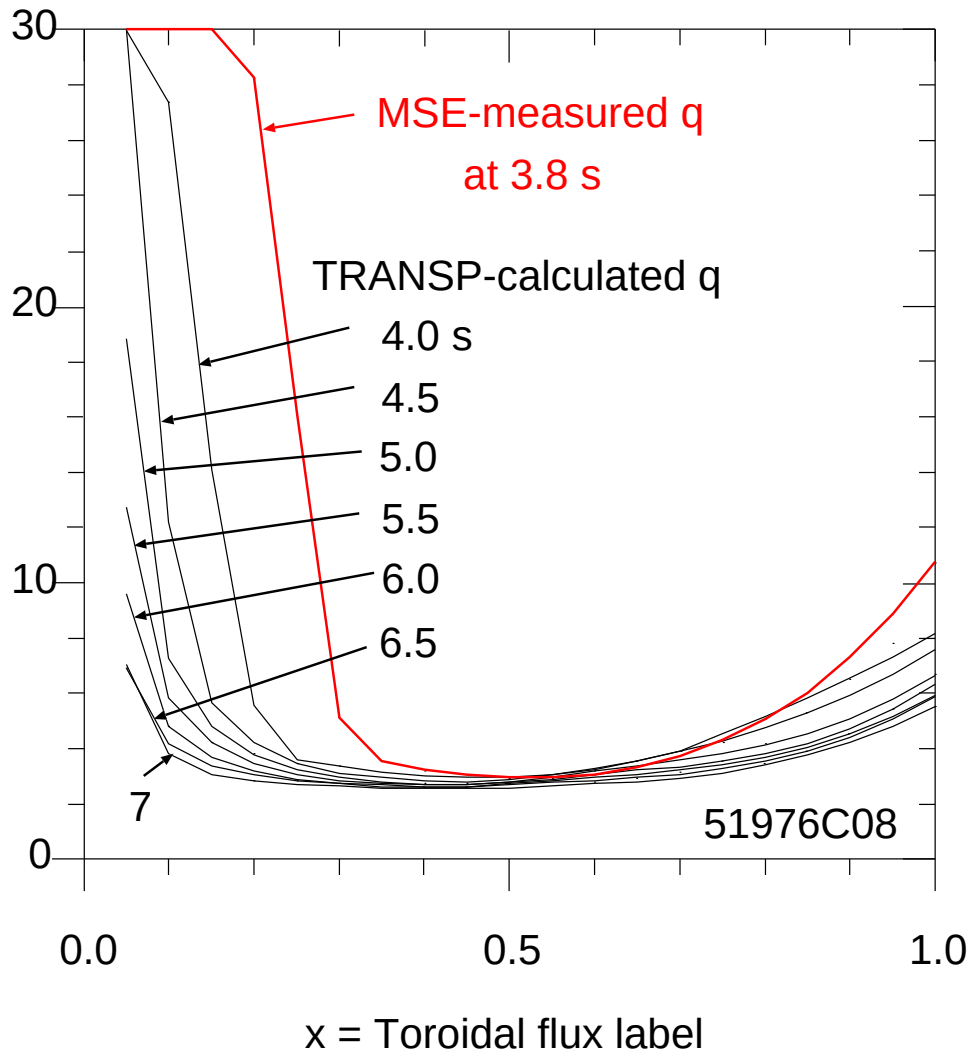
- Description of 51976 with high performance, highly reversed shear, and large radius ITB
- Transport analysis
  1. low χ_i/χ_{nc} in core
  2. accumulation of impurity
- Microstability analysis
  1. γ_{lin} decreasing in the plasma core
  2. γ_{ExB} increasing
- Conclusions

Waveforms of 51976 achieving high H

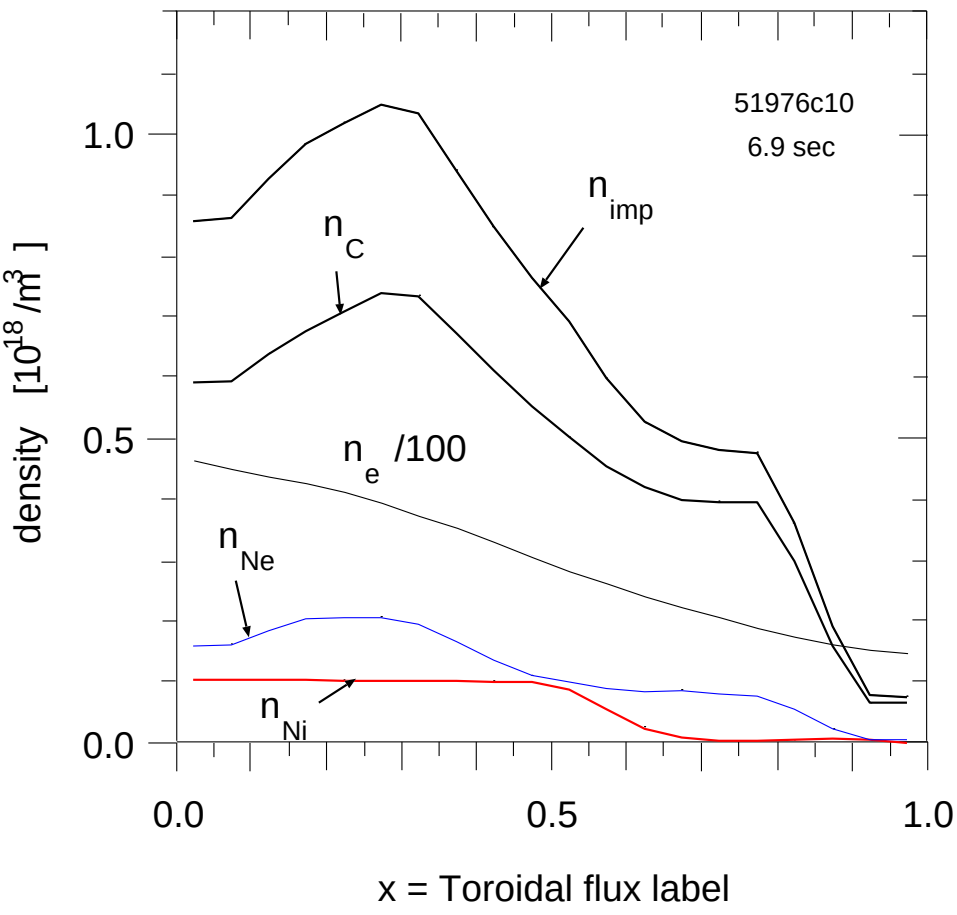


- LHCD to form q
- rampup of I_p and P_{aux}
- Neon puffing to control ELMs and edge

Highly reversed q profile with broad minimum

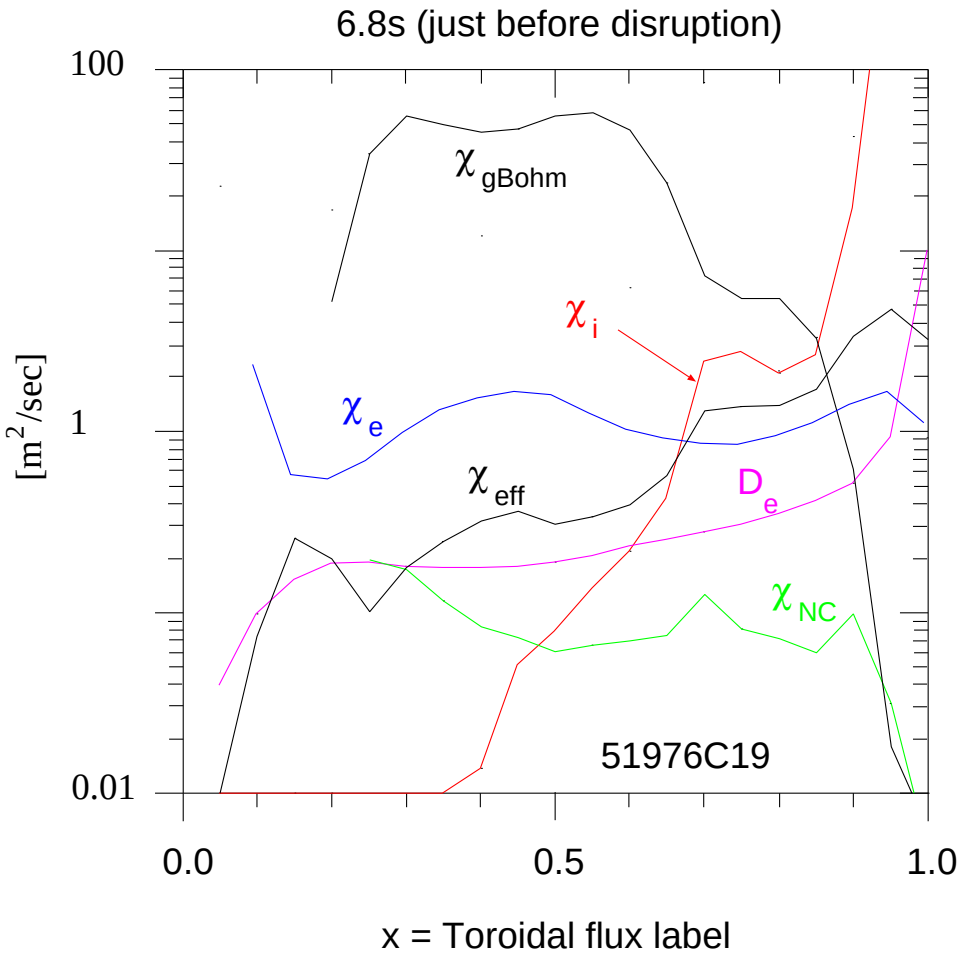


Accumulation of impurity?



- TRANSP has been upgraded to handle arbitrary number of impurities

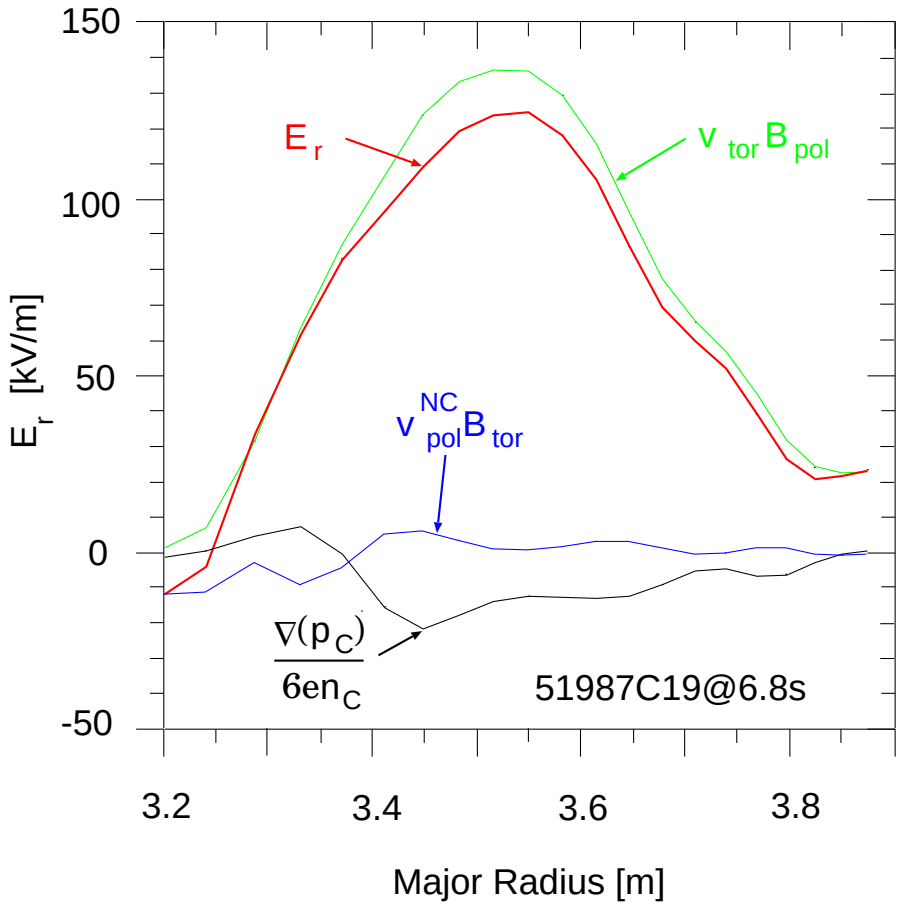
Transport coefficients late in discharge



- In core $\chi_i < \chi_{NC}$ of Houlberg, Shaing, $et\ al.$
- χ_e and D_e remain large

Radial electric field late in discharge

Radial electric field computed from measured carbon toroidal and computed neoclassical poloidal rotation



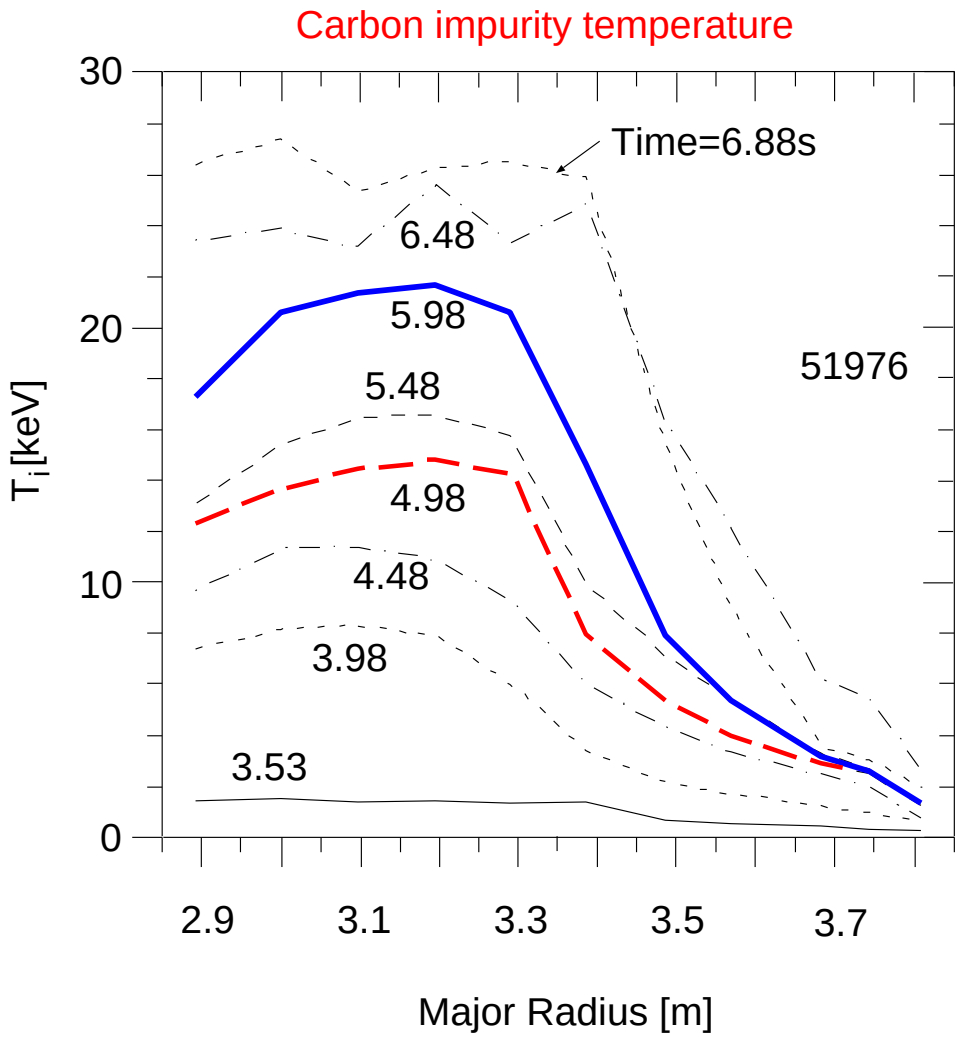
- Assume neoclassical for v_{pol}
- v_{tor} dominates

Chronology

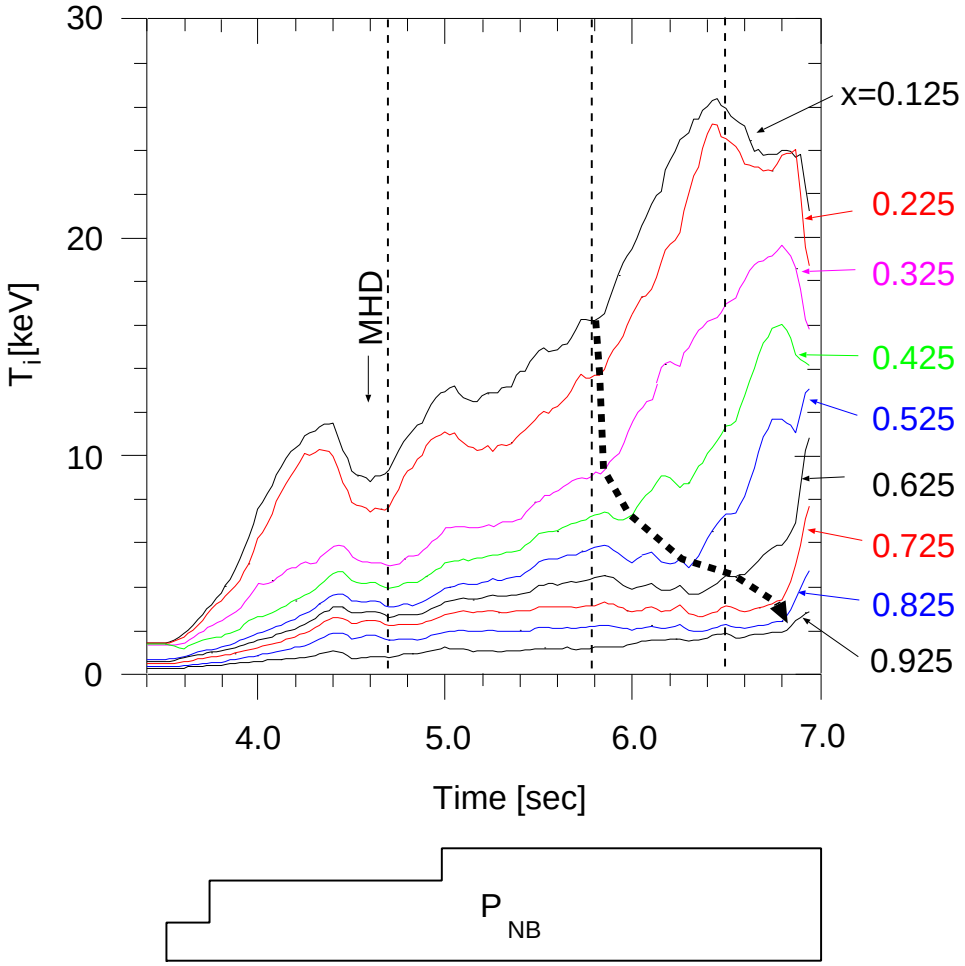
Time	MHD	q_{min}	foot of ITB	χ_i/χ_{nc}
4.7	reduction	2.8	forms near 3.4 m	drops everywhere
5.8	low	2.7	slides outward	drops for x$<$0.5
6.5	increase	2.7	$\rightarrow$3.7 m	drops
6.9	disruption	2.7	3.7m	drops for x$\sim$0.8

- 4.7 s: weak ITB forms in core after burst of MHD
- 5.0 s: reduction of ITB with increase of P_{NB}
- 6.5 s: strong ITB forms and expands to large radii
- 6.9 s: external current-driven mode $\rightarrow$ giant ELM $\rightarrow$ disruption

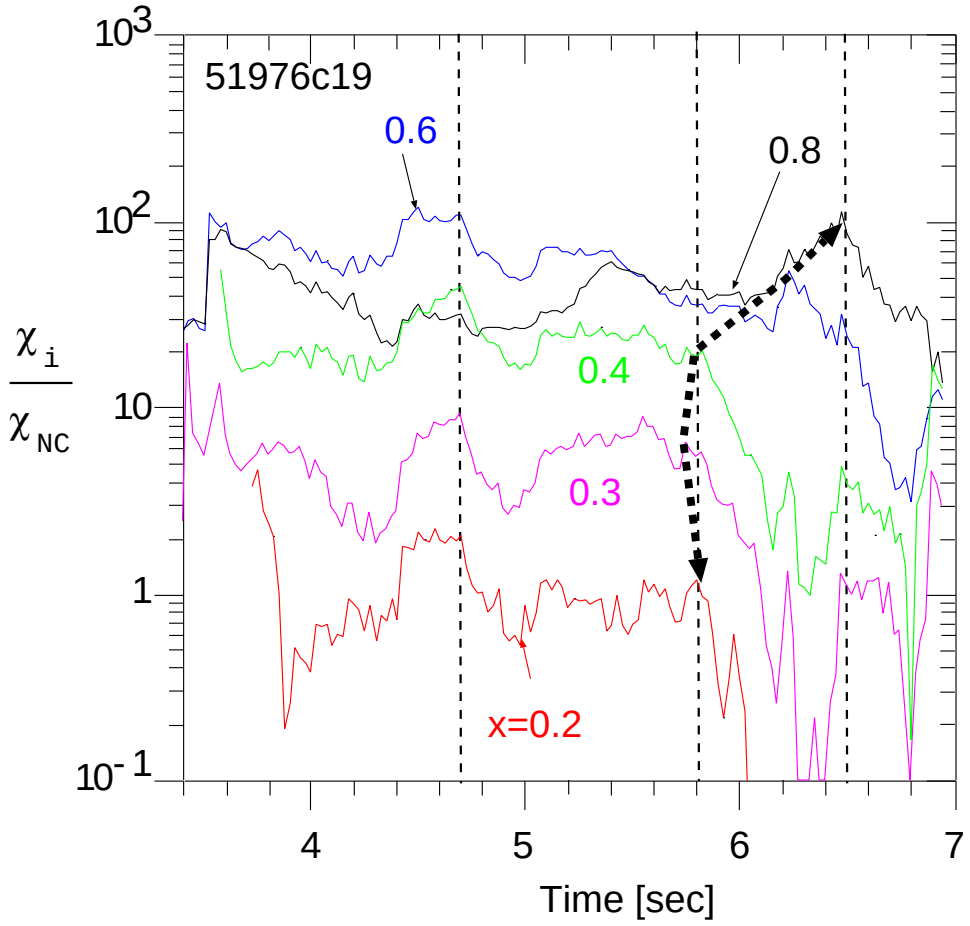
ITB footprint moves out to a large radius



ITB footprint moves out to a large radius

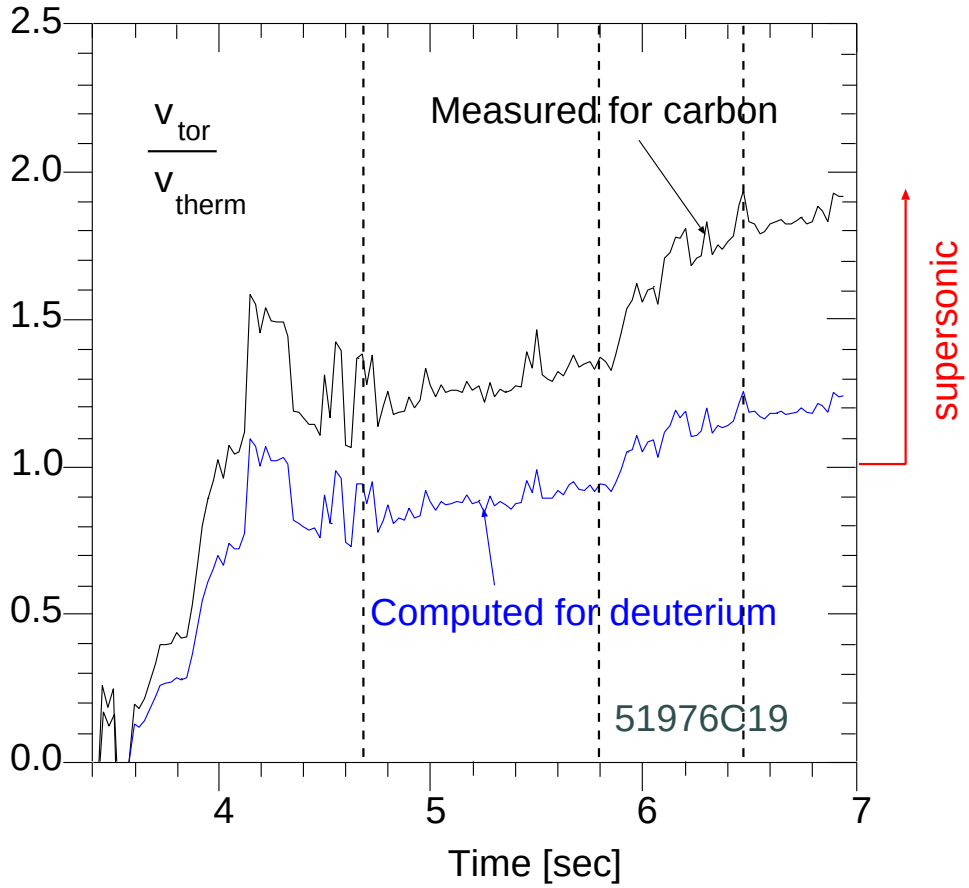


χ_i/χ_{NC} small inside half radius



- χ_{NC} from Houlberg, Shaing, Hirshman, and Zarnstorff

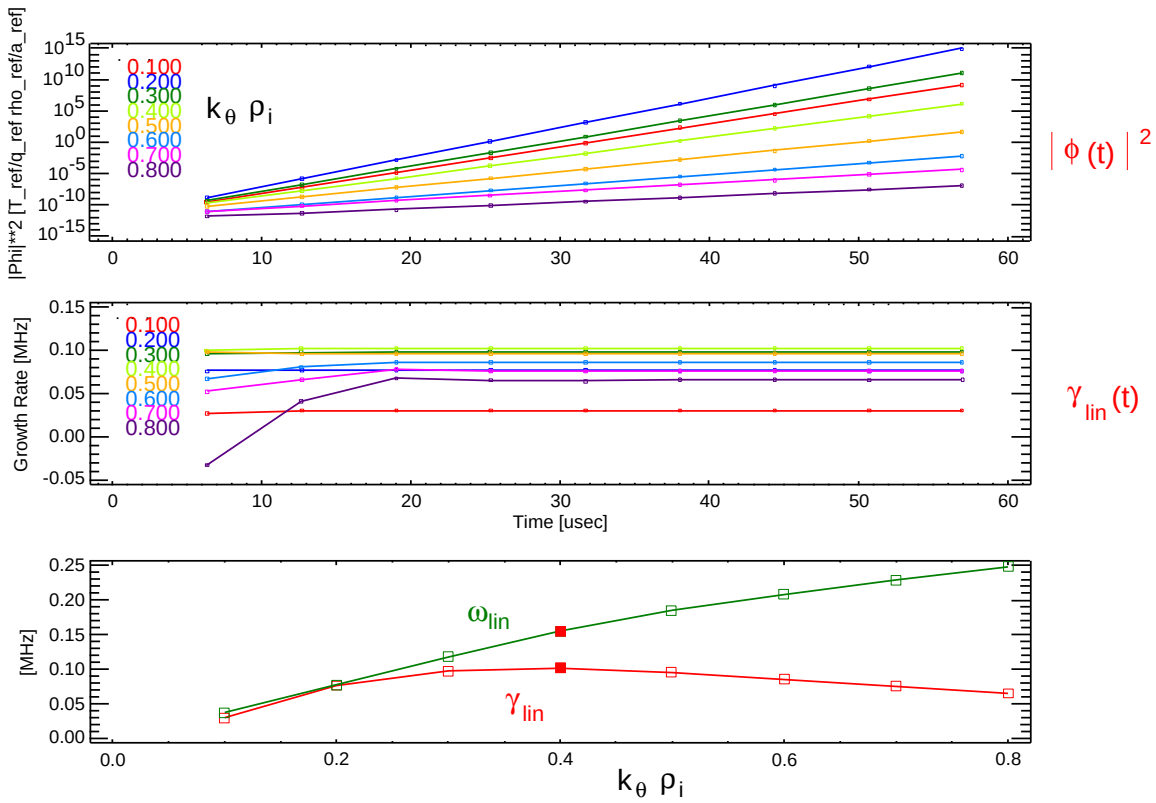
Large toroidal Mach number due to co-NBI



- stabilizing or destabilizing?
- poloidal asymmetry of impurity?
- shocks?

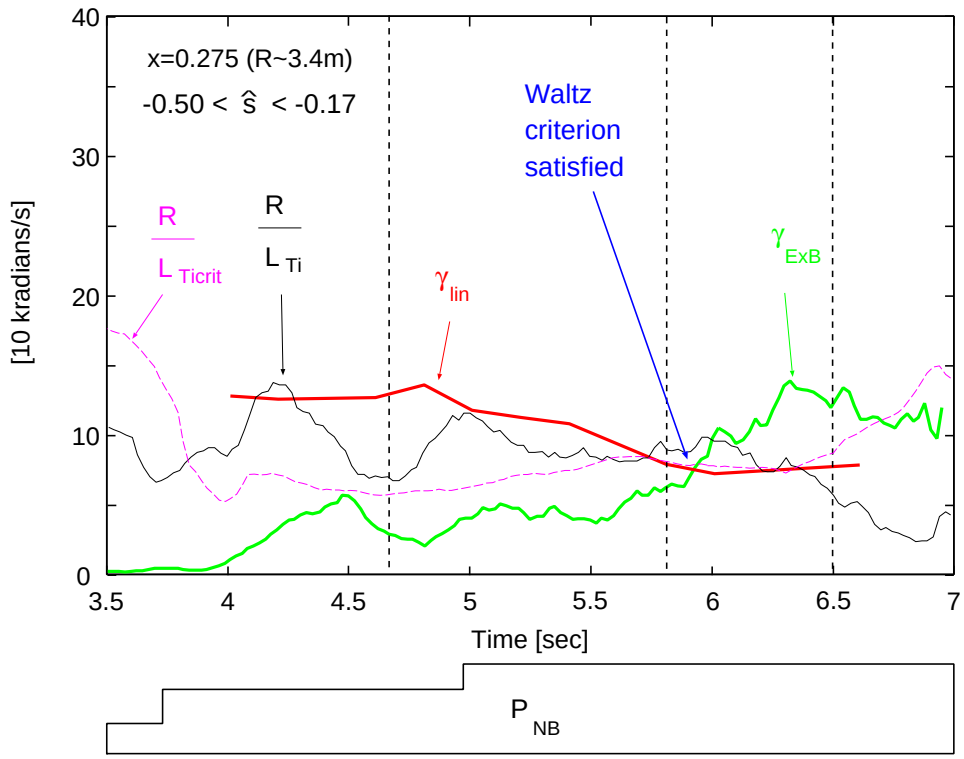
GS2 Results

- New tool for viewing gs2 results from Ernst
- example at 4.8s, x=0.575 (R=3.59m)

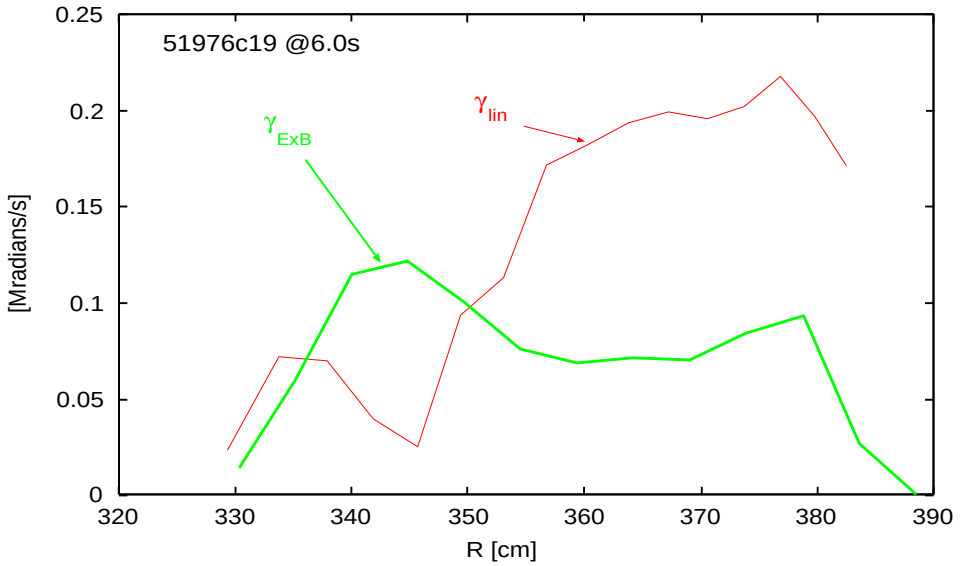


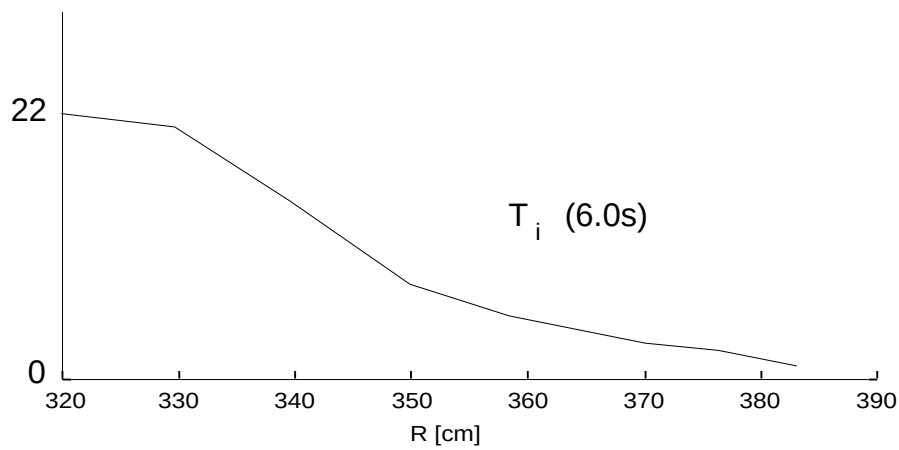
In the core γ_{lin} decreases while γ_{ExB} increases

- $T_i(x = 0.275)$ starts rapid increase around 5.8 s
- compare γ_{lin} with γ_{ExB} from Hahm-Burrell
- γ_{ExB} crosses γ_{lin} around 5.9 s



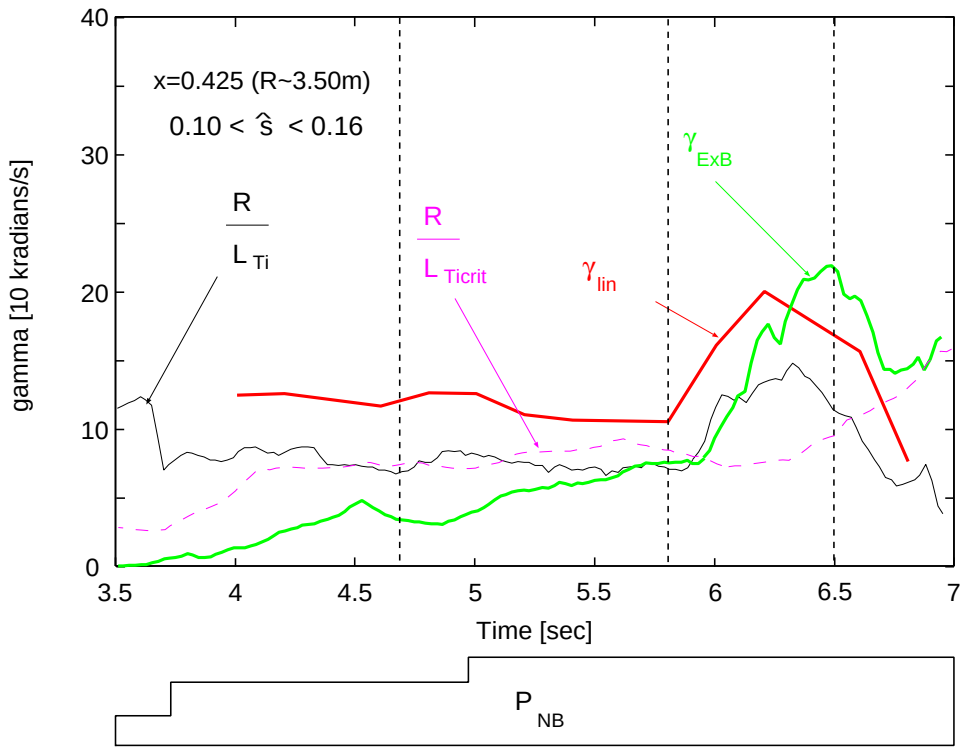
$\gamma_{ExB} > \gamma_{lin}$ near the ITB at 6.0 s





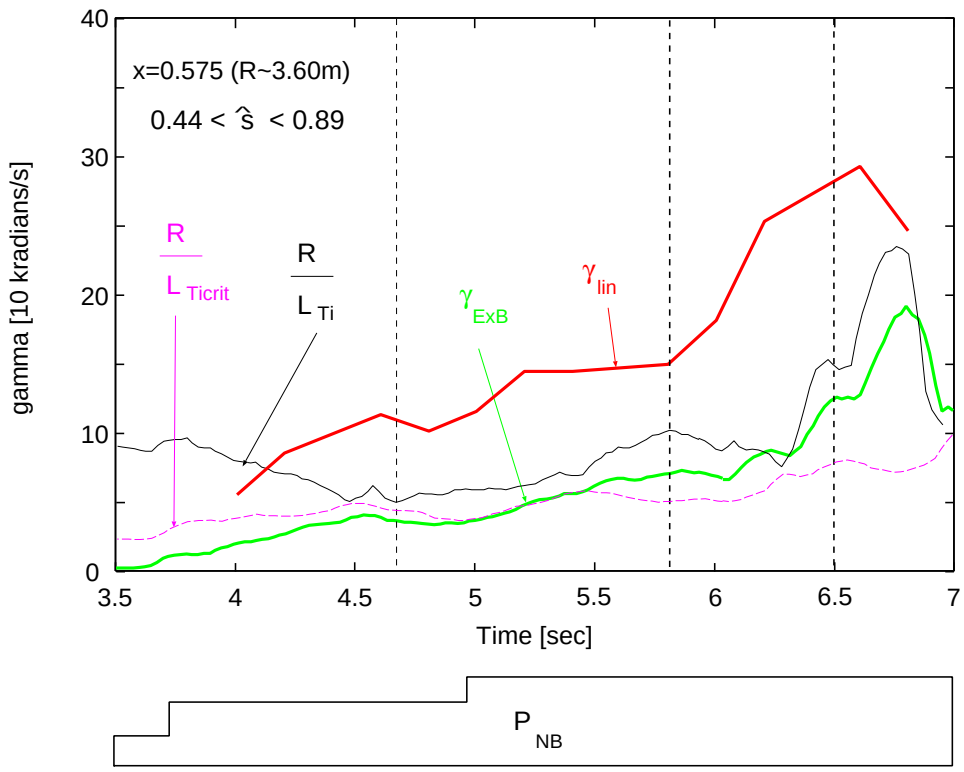
Further out $\gamma_{lin} > \gamma_{ExB}$ until late

- $T_i(x = 0.425)$ starts rapid increase around 6.0 s
- but γ_{ExB} doesn't cross γ_{lin} until 6.3 s



Even further out $\gamma_{lin} > \gamma_{ExB}$ until late

- $T_i(x = 0.575)$ starts rapid increase around 6.5 s
- γ_{ExB} remains less than γ_{lin}



Conclusions

- TRANSP and linear GS2 analysis has been conducted for a high performance JET ITB plasma
- find low χ_i/χ_{nc} in core
- $\gamma_{ExB} \approx \gamma_{lin}$ in the core when the strong ITB forms
- At larger radii the correlation of $\gamma_{ExB} \geq \gamma_{lin}$ with ITB formation is weak
- (opposite of what is found in JET ELMy H-mode plasma)
- Future plans:
  1. analysis using FULL code
  2. vary inputs to study dependencies
  3. non-linear GS2 runs
  4. incorporate up/down asymmetric flux tube geometry
  5. study more plasmas