Centre de Recherches en Physique des Plasmas

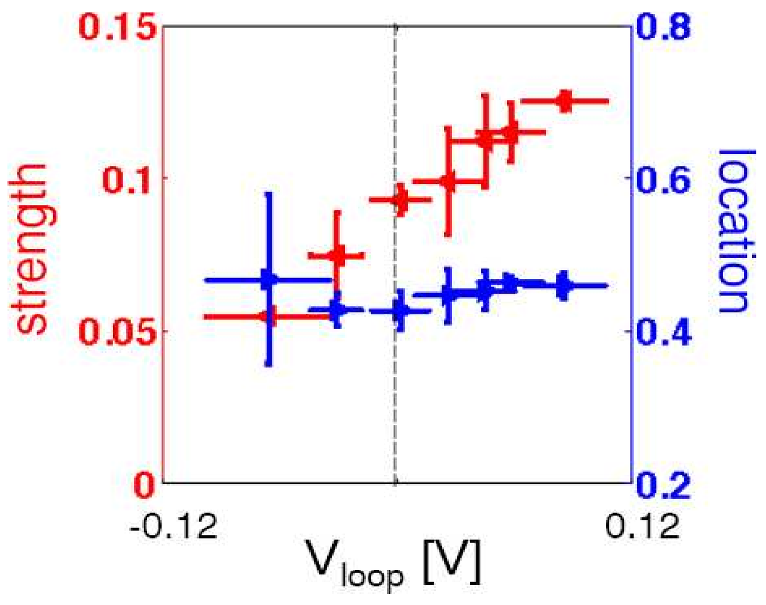
Barriers in the TCV Tokamak

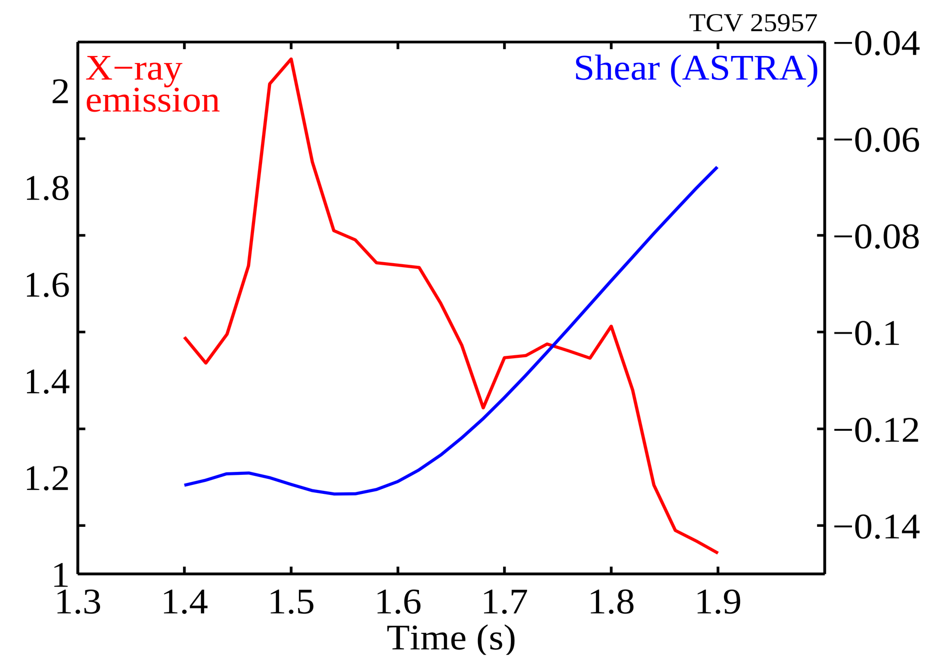
Ecole Polytechnique Fédérale de Lausanne

R. Behn, M.A. Henderson, A. Marinoni, G.P. Turri, C. Zucca, and the TCV team

Ecole Polytechnique Fédérale de Lausanne, CH-1015 Lausanne, Switzerland

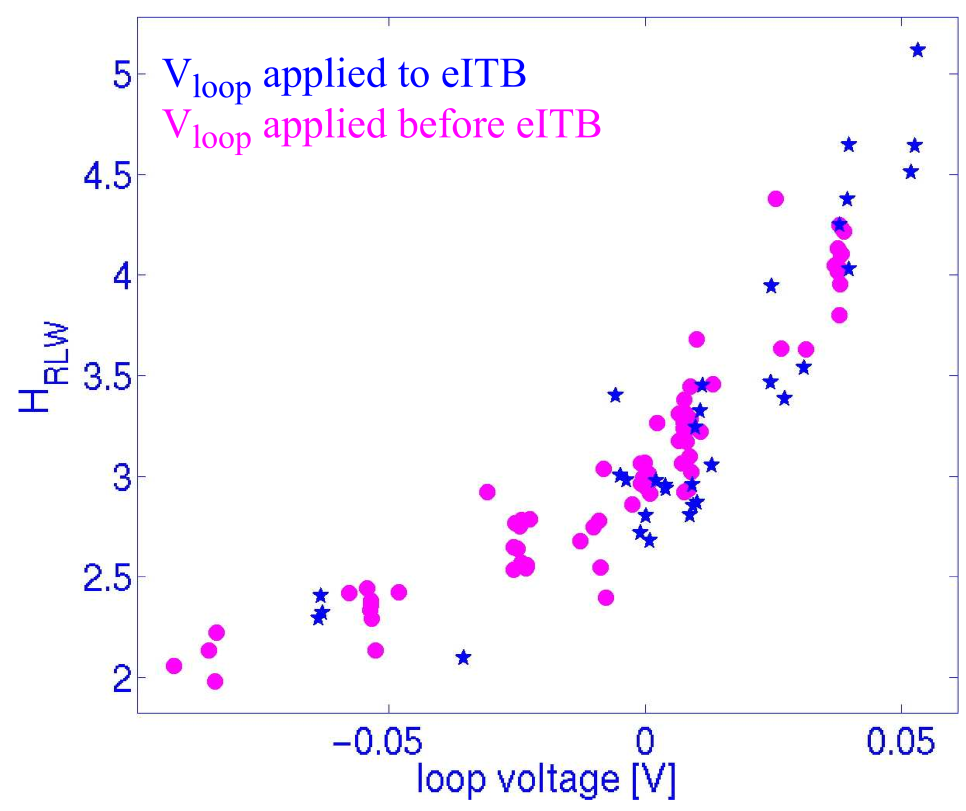
- Current injection affects barrier strength (ρ_s/L_T) but not its location
- Transient effect of Ohmic current penetration: positive current initially deepens current hole, then reduces it once it has fully penetrated
- Effect reflected in confinement evolution





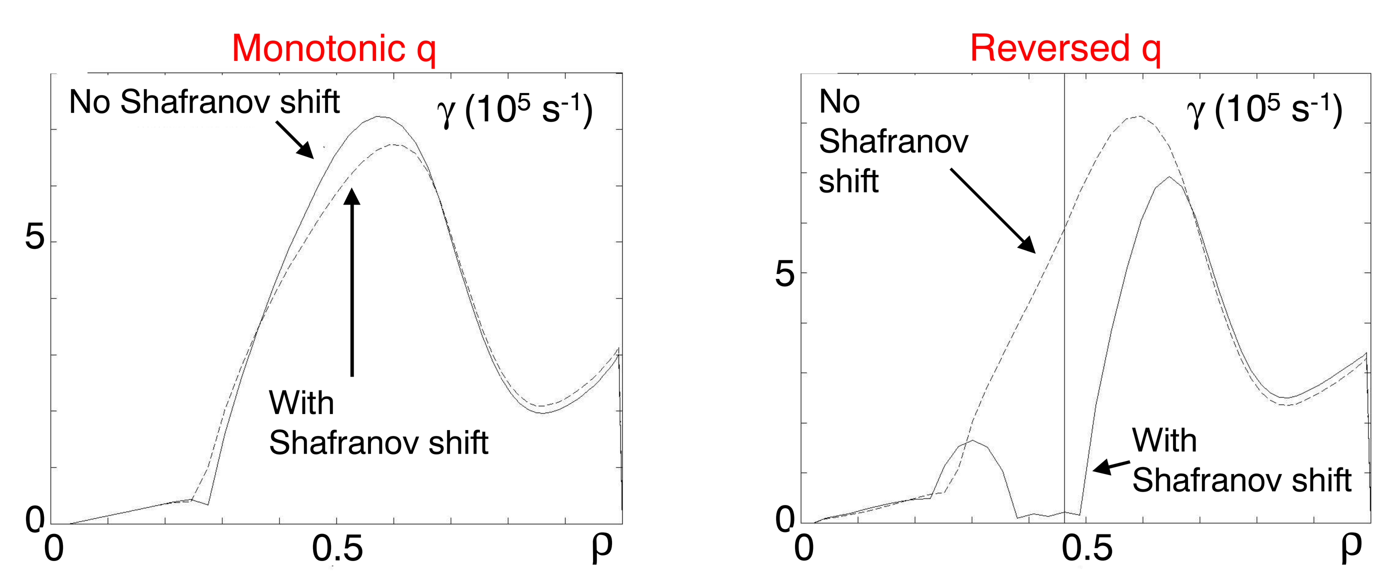
Insensitivity to rational q surfaces

- Smooth dependence of confinement enhancement factor on loop voltage
- Independence of H_{RLW} on history of loop voltage
- ⇨ rational q surfaces do not play a role in barrier formation

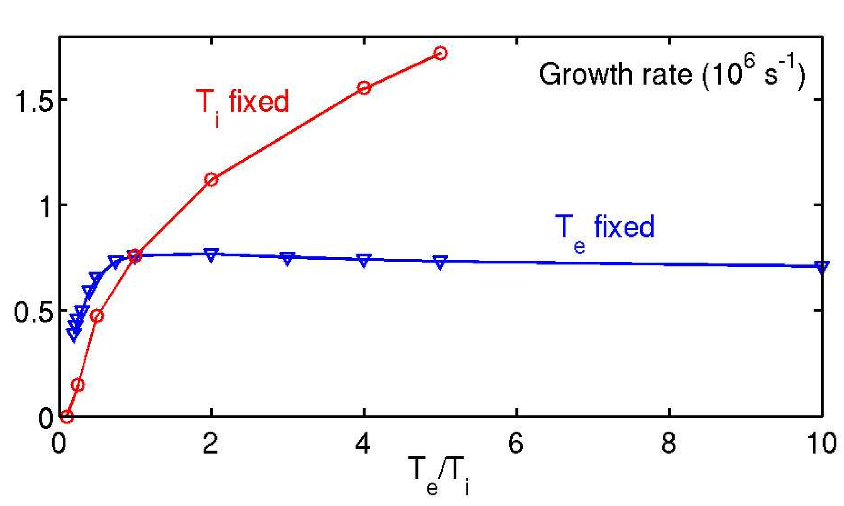


Corroboration by numerical modeling

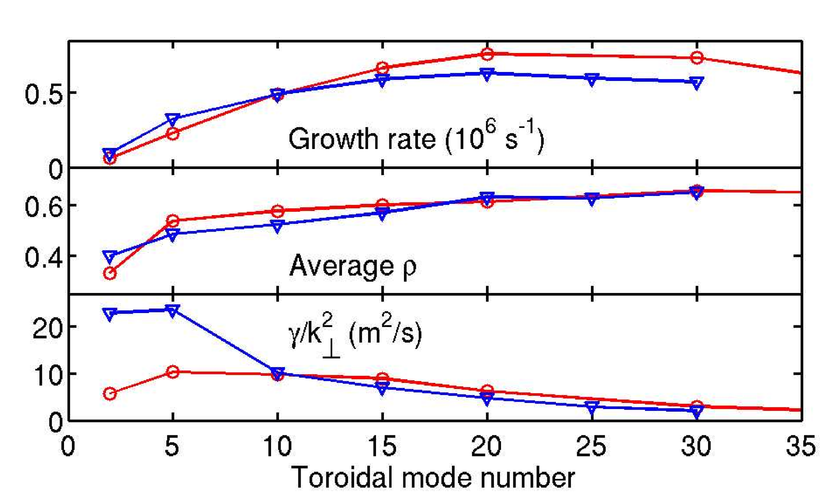
- **Gyro-Landau-fluid modeling (GLF23)**: instability suppression near q'=0
- The dominant effect is the Shafranov shift effect on the trapped-electron toroidal precession



Insensitive to T_i

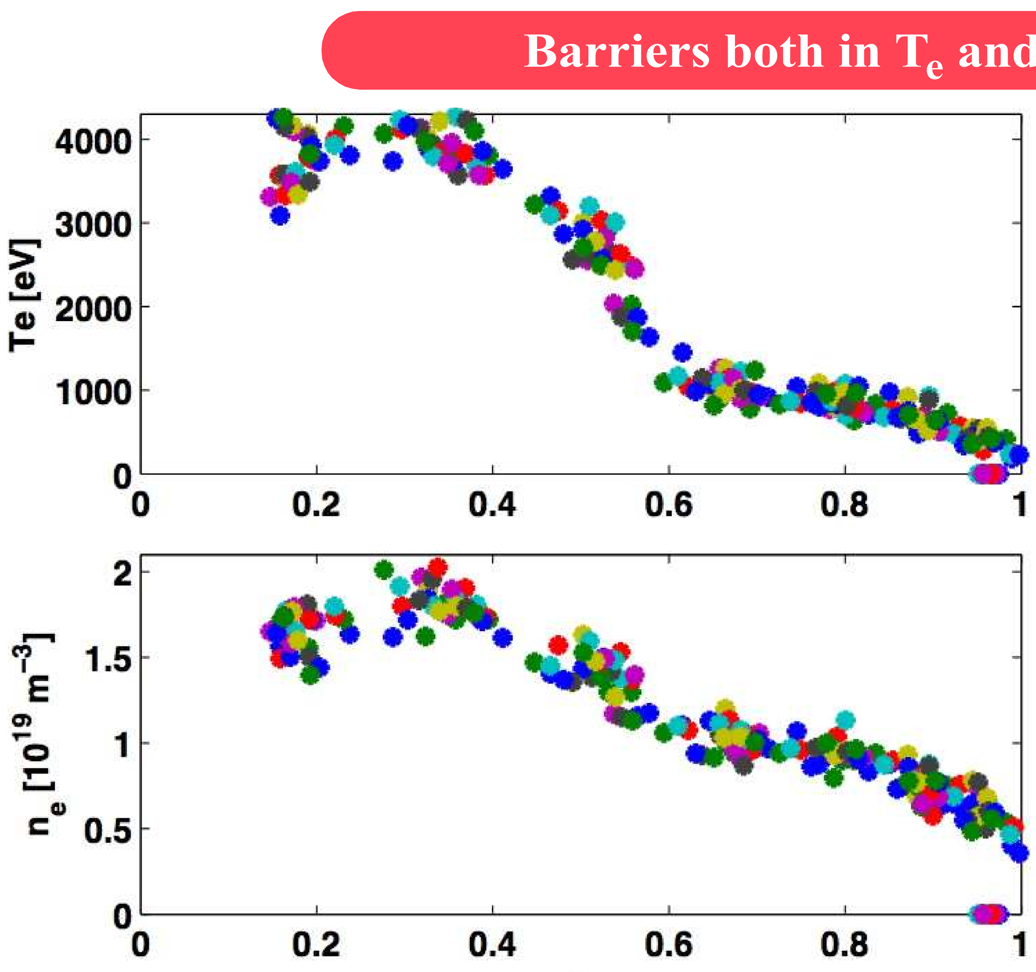


- **Gyrokinetic modeling: global collisionless linear code LORB5**
- Suppression of low-n TEM modes consistent with reduction of χ_e



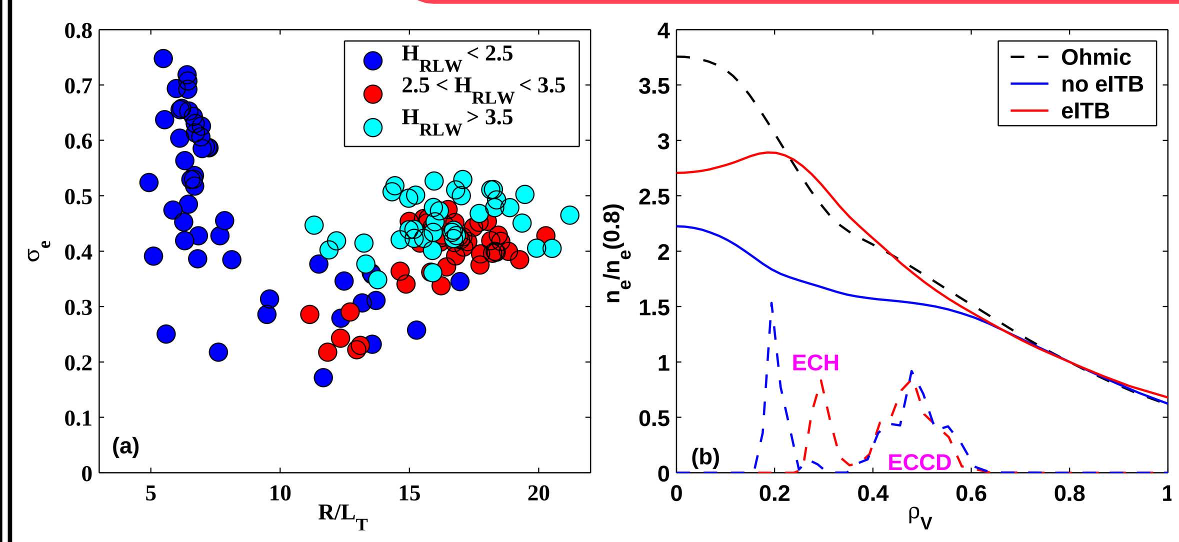
The characteristics of eITBs

Barriers both in T_e and n_e



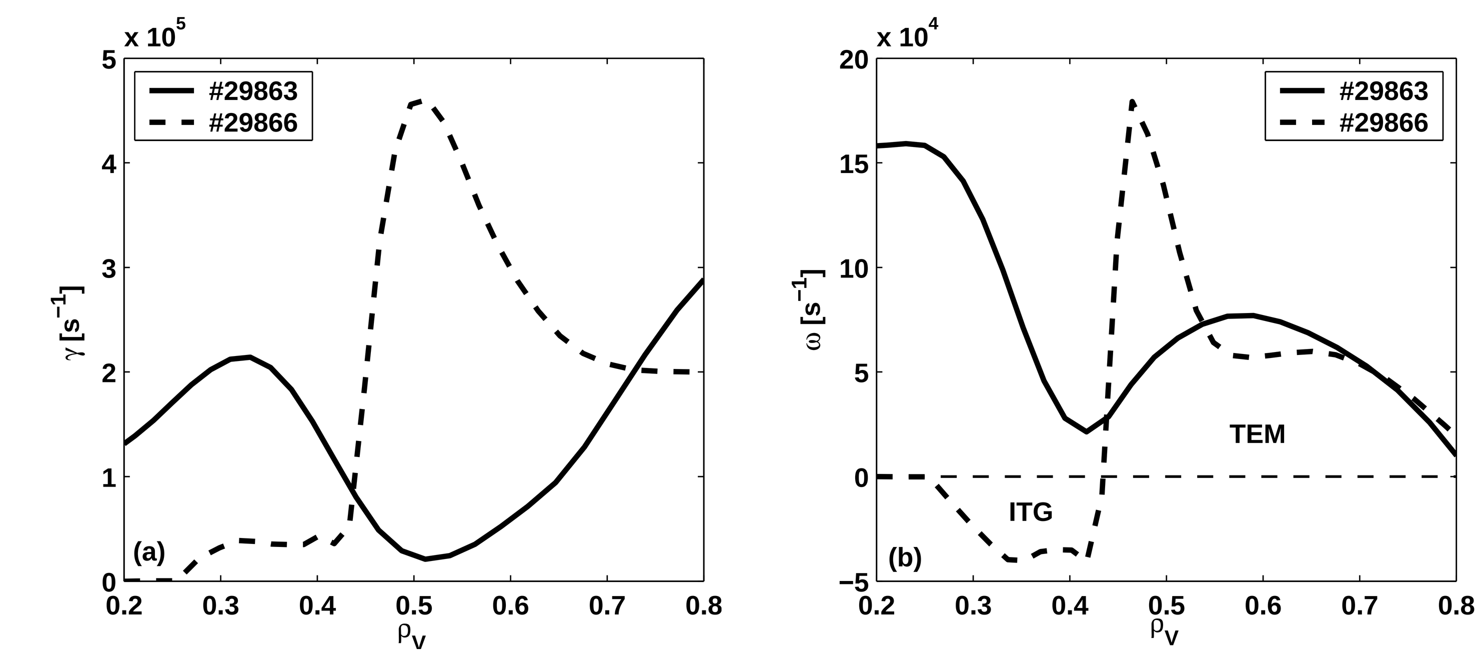
Measurement with Thomson scattering, with effective spatial resolution enhanced by vertical plasma sweep

$1/\eta_e$ = 0.4-0.5 for all barriers

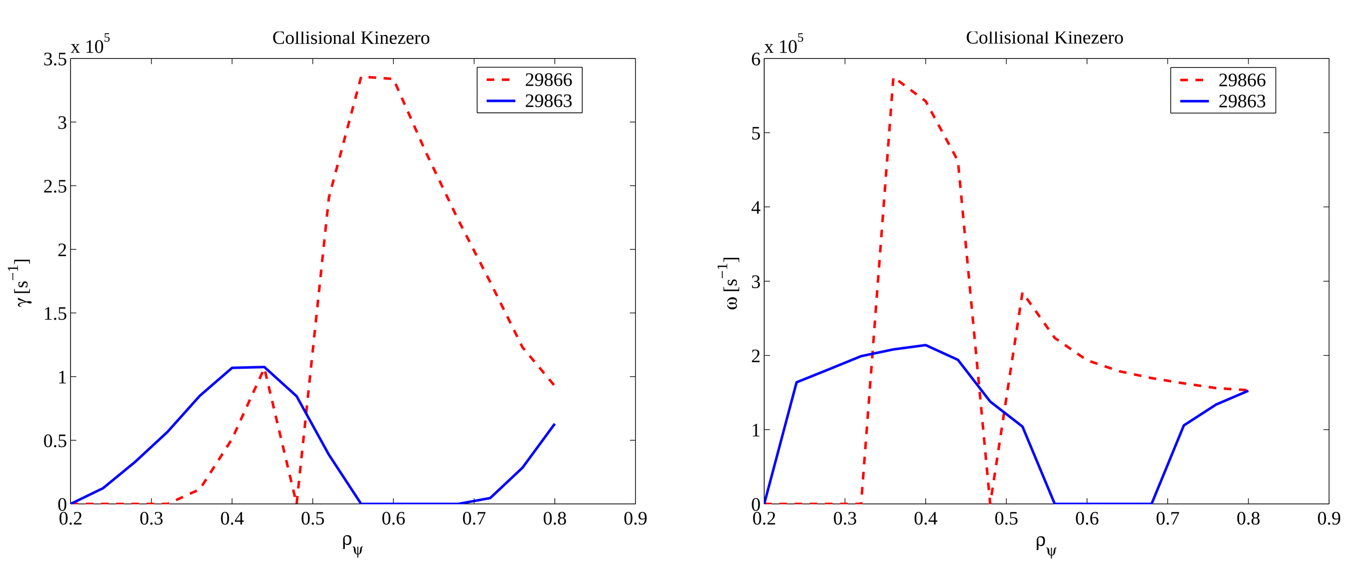


- Vast spread in $1/\eta_e$ = dln(n_e)/dln(T_e) at low R/L_{Te}
- $1/\eta_e$ tends asymptotically to 0.4-0.5 at high R/L_{Te}
- Transport still well above neoclassical

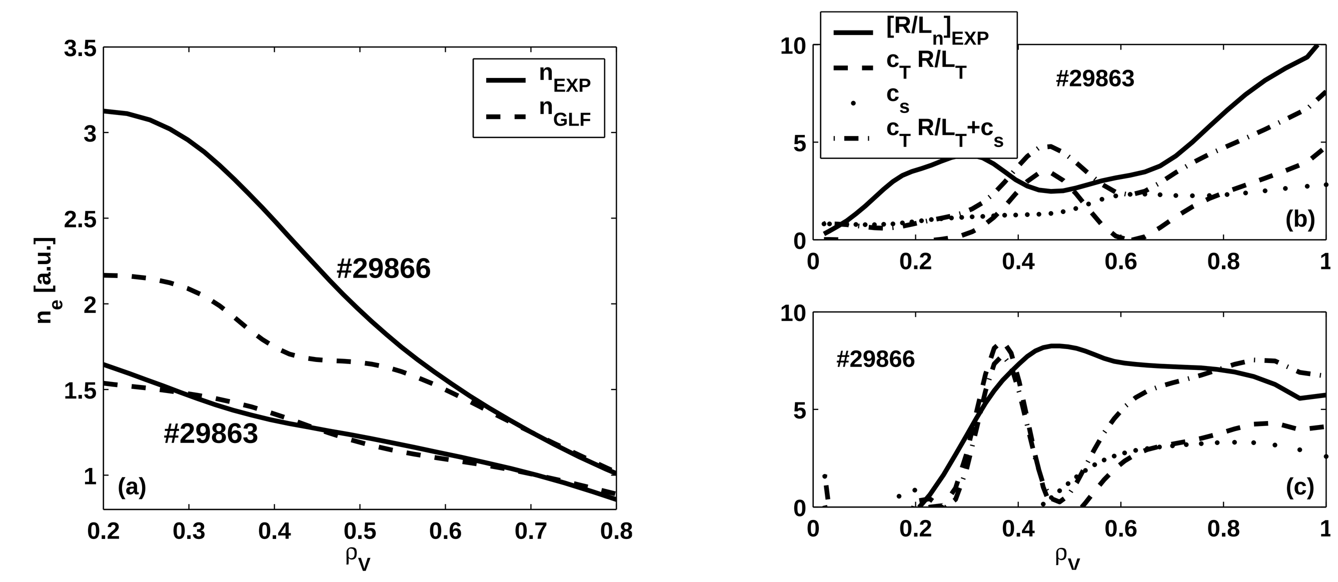
GLF23 predictions



KINEZERO (collisional linear eigenvalue code) predictions



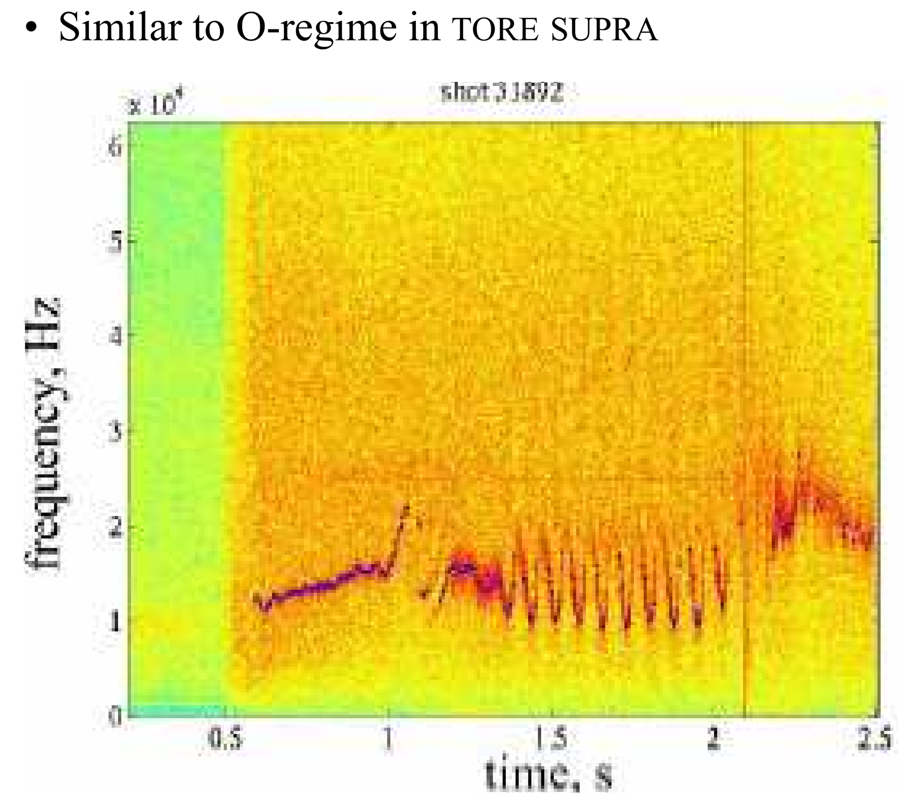
- $1/\eta_e = c_T + L_{Te}\, c_s$ (c_T = turbulent thermodiffusion, c_s = turbulent equipartition)
- the second term is quenched in eITB (c_s=0 at zero shear, and multiplied by L_{Te})
- turbulent thermodiffusion remains significant even though TEMs are stabilized, because it has a maximum at very low γ
- ⇨ η_e reproduced well except at the barrier location
- parallel dynamics not included ($k_{||}$=0): this could possibly resolve the discrepancy



The interplay of eITBs and MHD

Slow temperature oscillations (O-regime)

- Slow (~10 Hz), m=n=0 oscillations observed in eITBs (both inductive and noninductive)
- Accompanied by m/n=3/1 or 2/1 MHD modes, with amplitude oscillating 180° out of phase to T_e
- MHD degrades barrier ⇨ gradients are reduced ⇨ MHD drive is quenched: semi-stable cycle
- Similar to O-regime in TORE SUPRA



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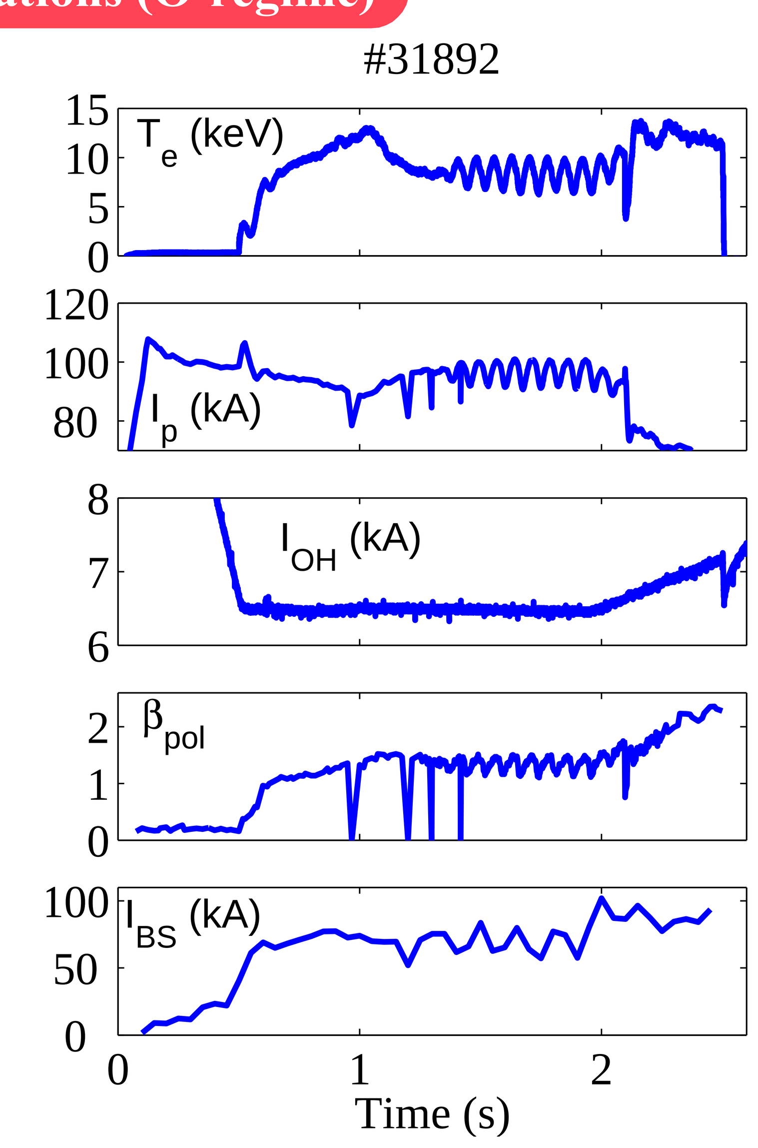

Conclusions

- eITBs obtained in TCV with ECRH in a variety of conditions, from noninductive to inductive, from steady-state to transient
- A negative central shear is crucial to the formation and existence of eITBs
- Ohmic perturbation experiments have proven the dependence of the confinement enhancement on the depth of the current hole
- eITBs occur in both temperature and density, with a fixed ratio of the two gradients
- Numerical modeling has succeded in reproducing several features of eITBs
- Slow temperature oscillations can arise from interplay of MHD and eITB