Particle Transport in RMP H-modes

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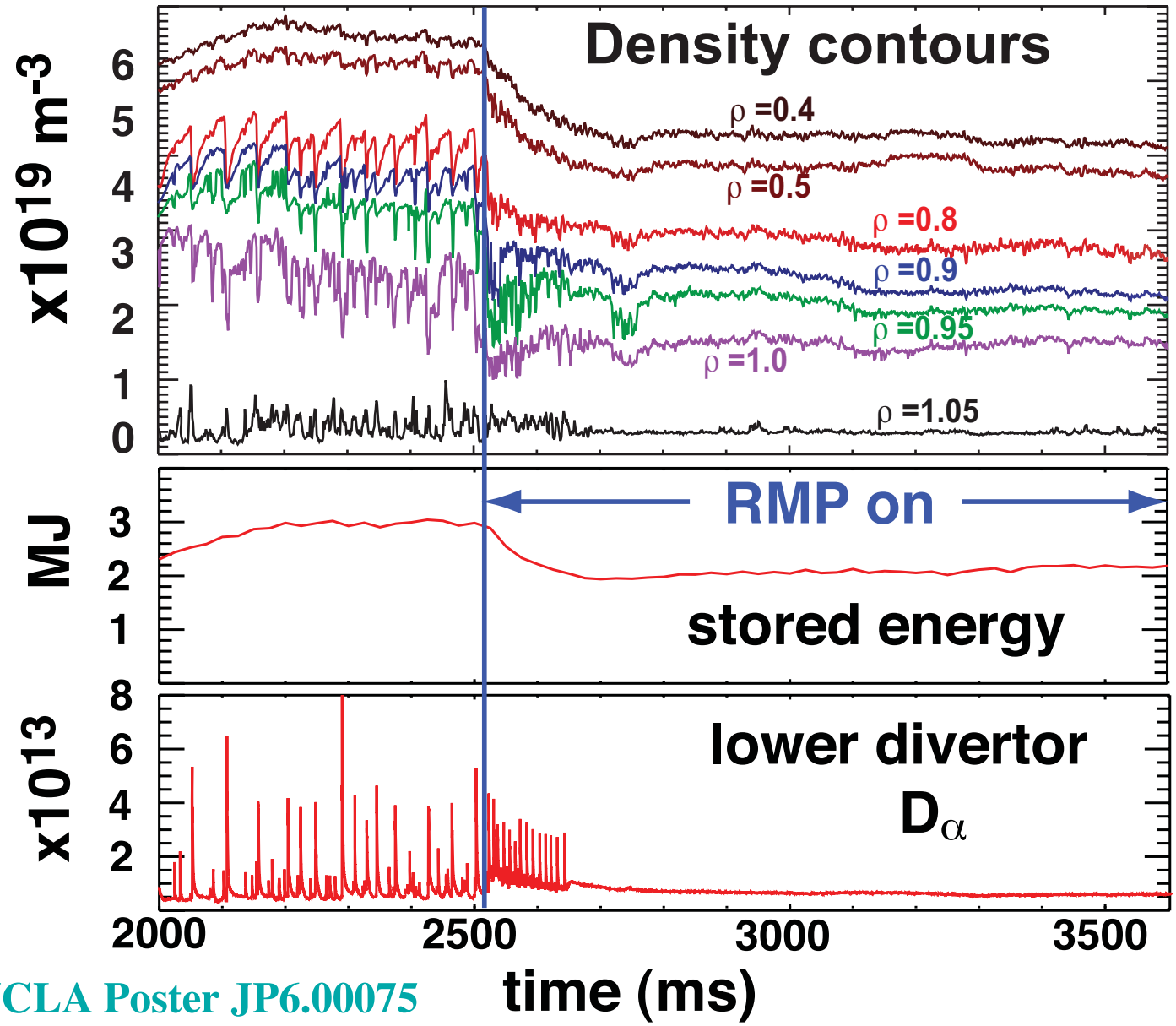
UCSD

Understanding and controlling density pump-out will improve the viability of RMP ELM control in ITER.

- Pedestal n_e decrease plays a significant role in stabilization of Peeling-Ballooning modes
- But core n_e decrease reduces stored energy and core performance (Q_{fus} in ITER)
- Need physics understanding and predictive capability for RMP-induced transport in ITER and other next step devices.



L. Zeng UCLA Poster JP6.00075

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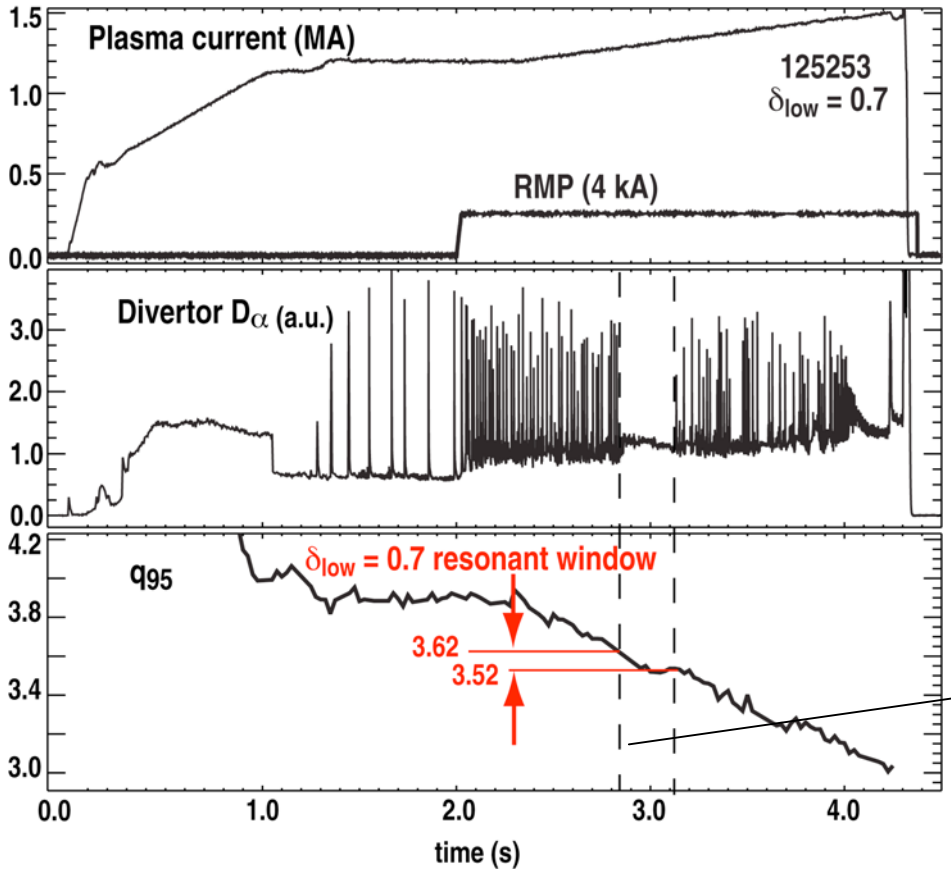
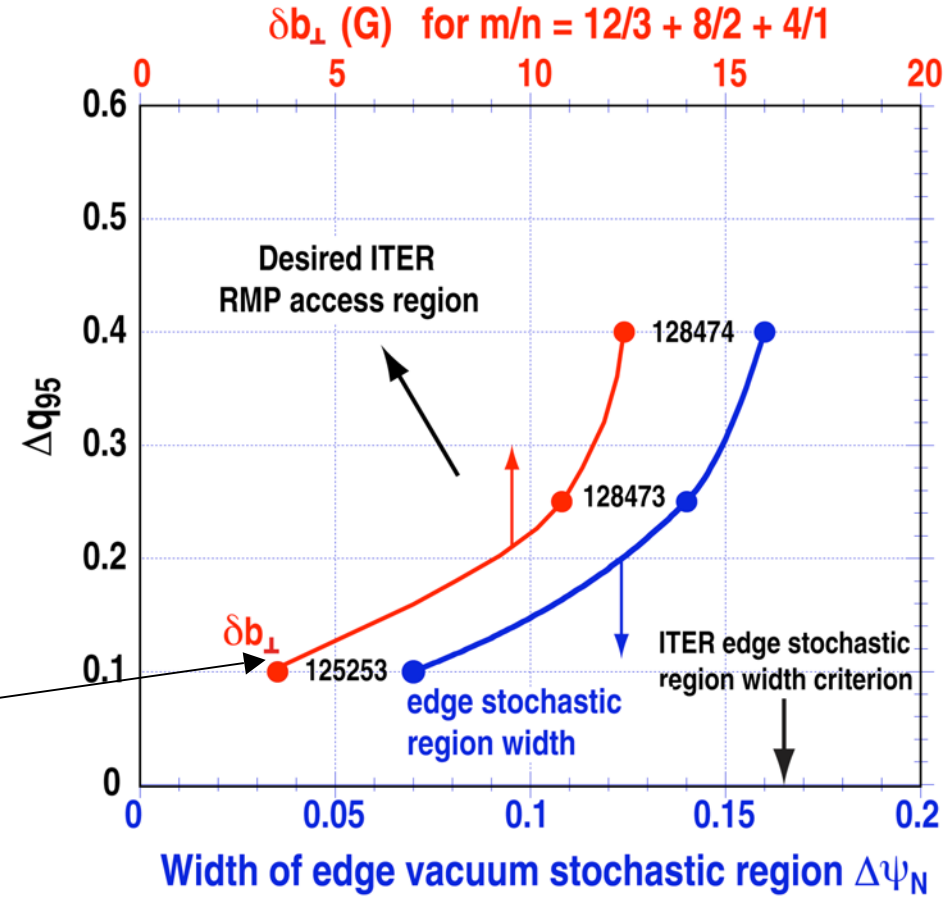
Increasing ELM suppression resonant window Δq_{95} without increasing stochastic layer width $\Delta\psi_N$ is desirable for ITER





- **The n=4 ITER RMP coil design has greater spectral flexibility than the DIII-D I-coil**
  - Expected to provide larger Δq_{95} with smaller edge stochastic region width

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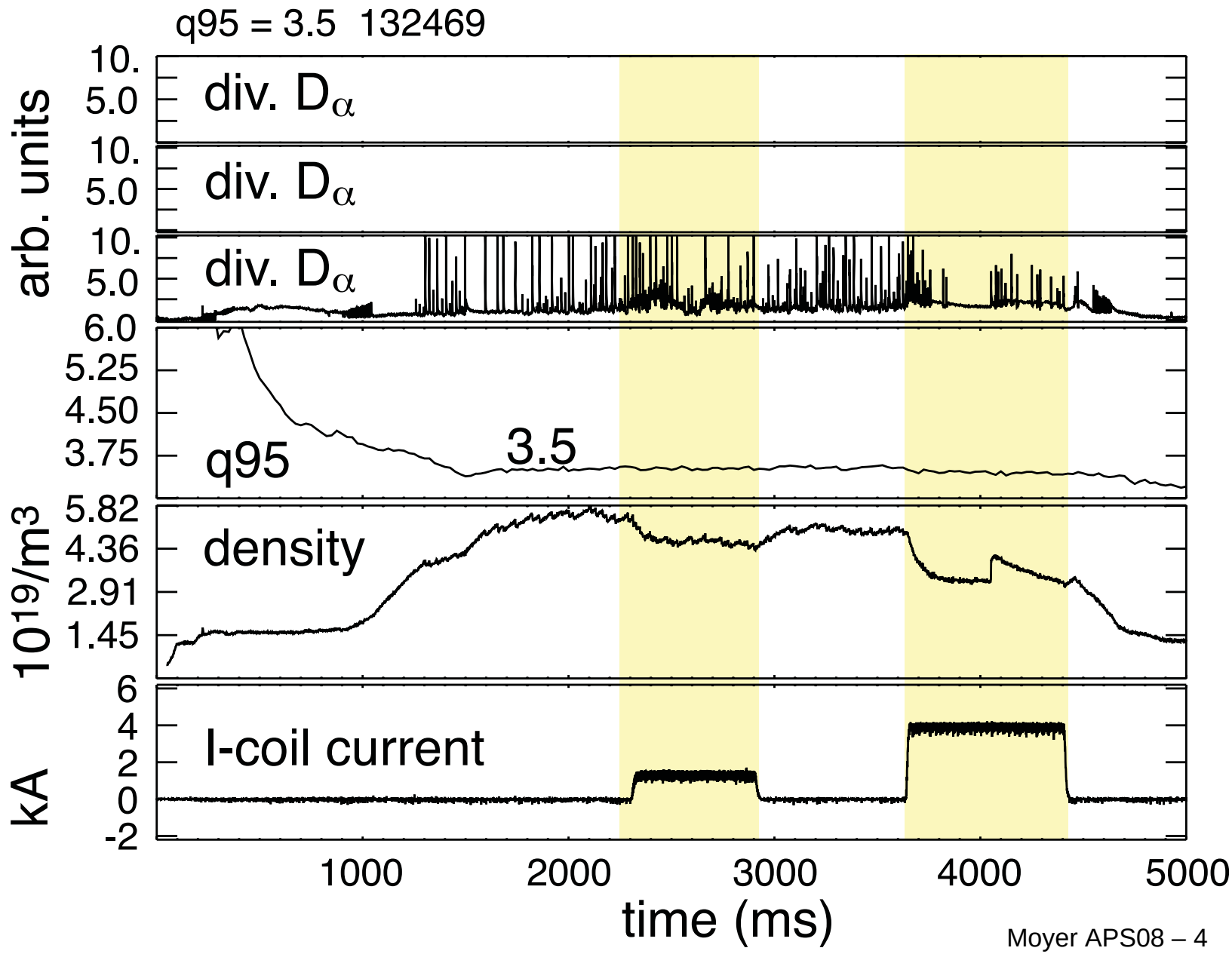
T.E. Evans GA Poster JP6.00070

Density pump-out in DIII-D H-modes has a broader resonance Δq_{95} than ELM suppression.

- For q95 = 3.5 in the resonant window for ELM suppression, density pump-out scales with I-coil current



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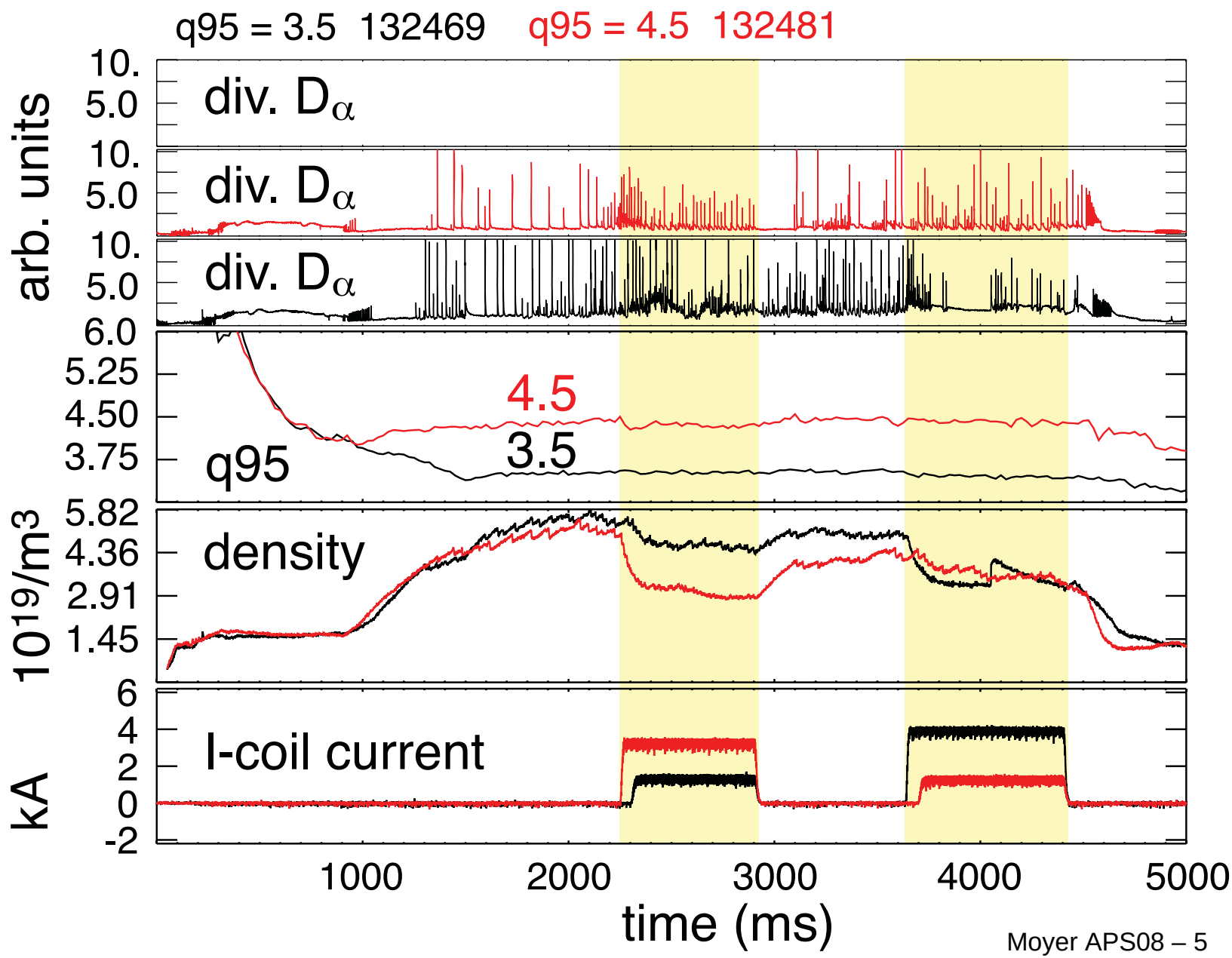

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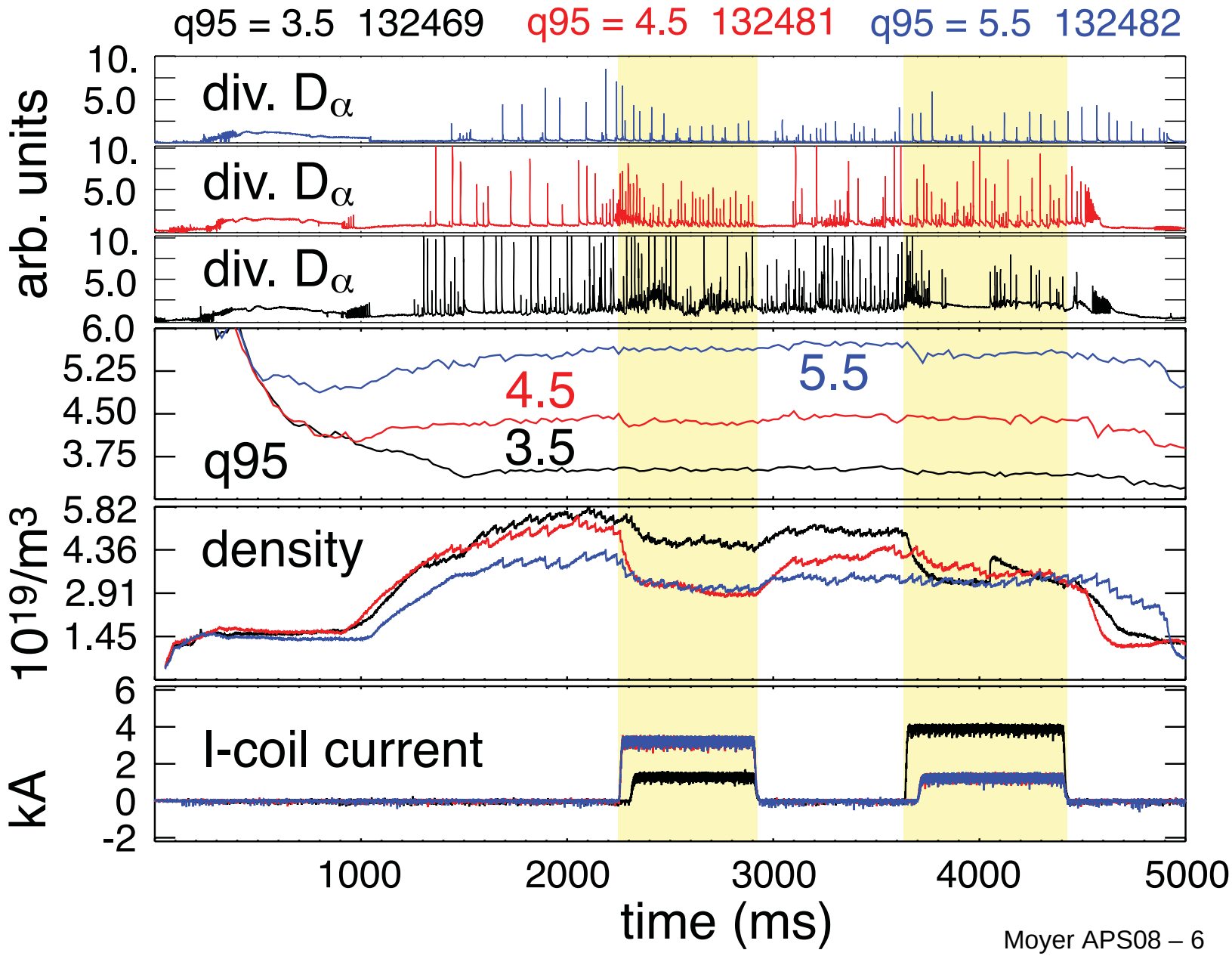
- For q95 = 5.5, pump-out is dramatically reduced but not eliminated.



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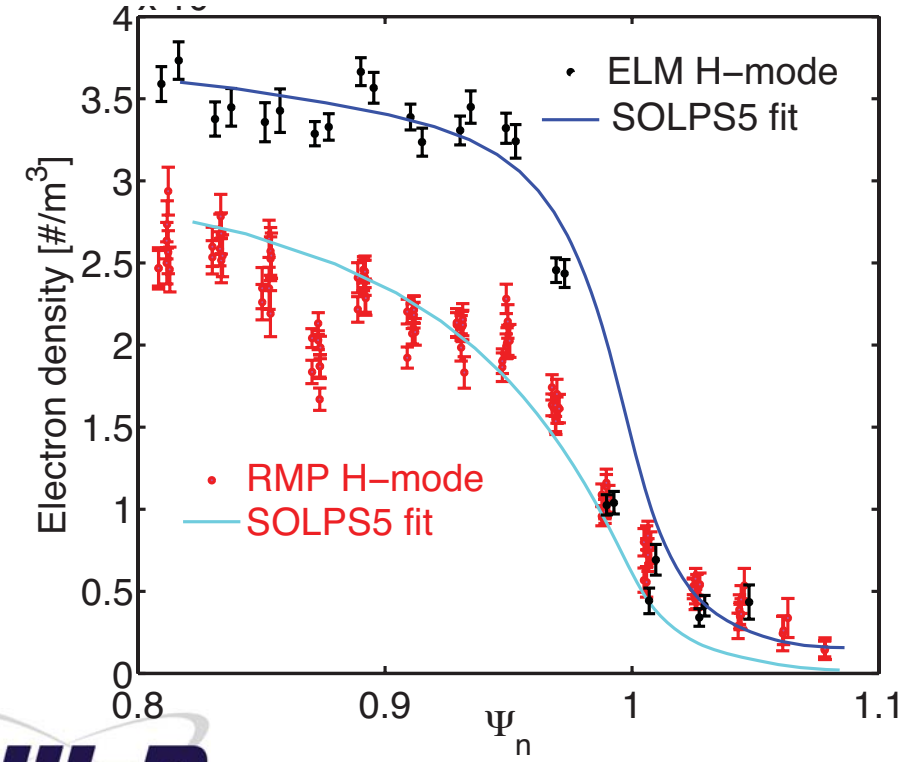
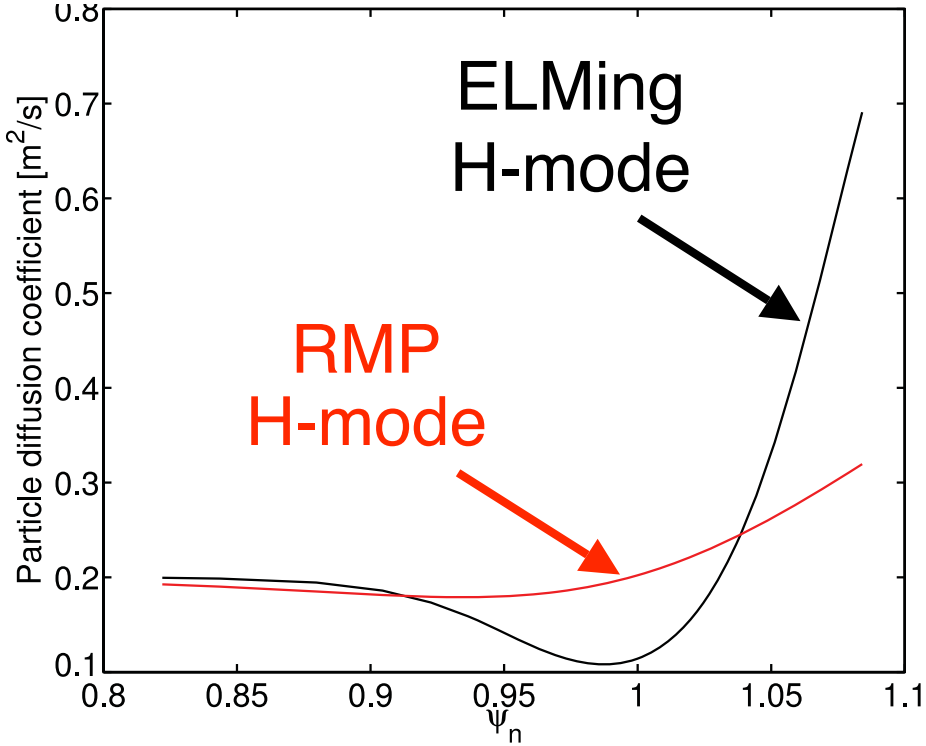
SOLPS modeling suggests that pump-out is due to particle transport changes, not just recycling or pumping changes

- Matching the shape of outboard mid-plane profiles requires changing the particle diffusivity, not just the pumping efficiency or recycling coefficient.
- Particle transport changes are consistent with stochastic field diffusion based on vacuum field model TRIP3D

Fits to outboard mid-plane n_e profiles



Comparison of inferred diffusivities

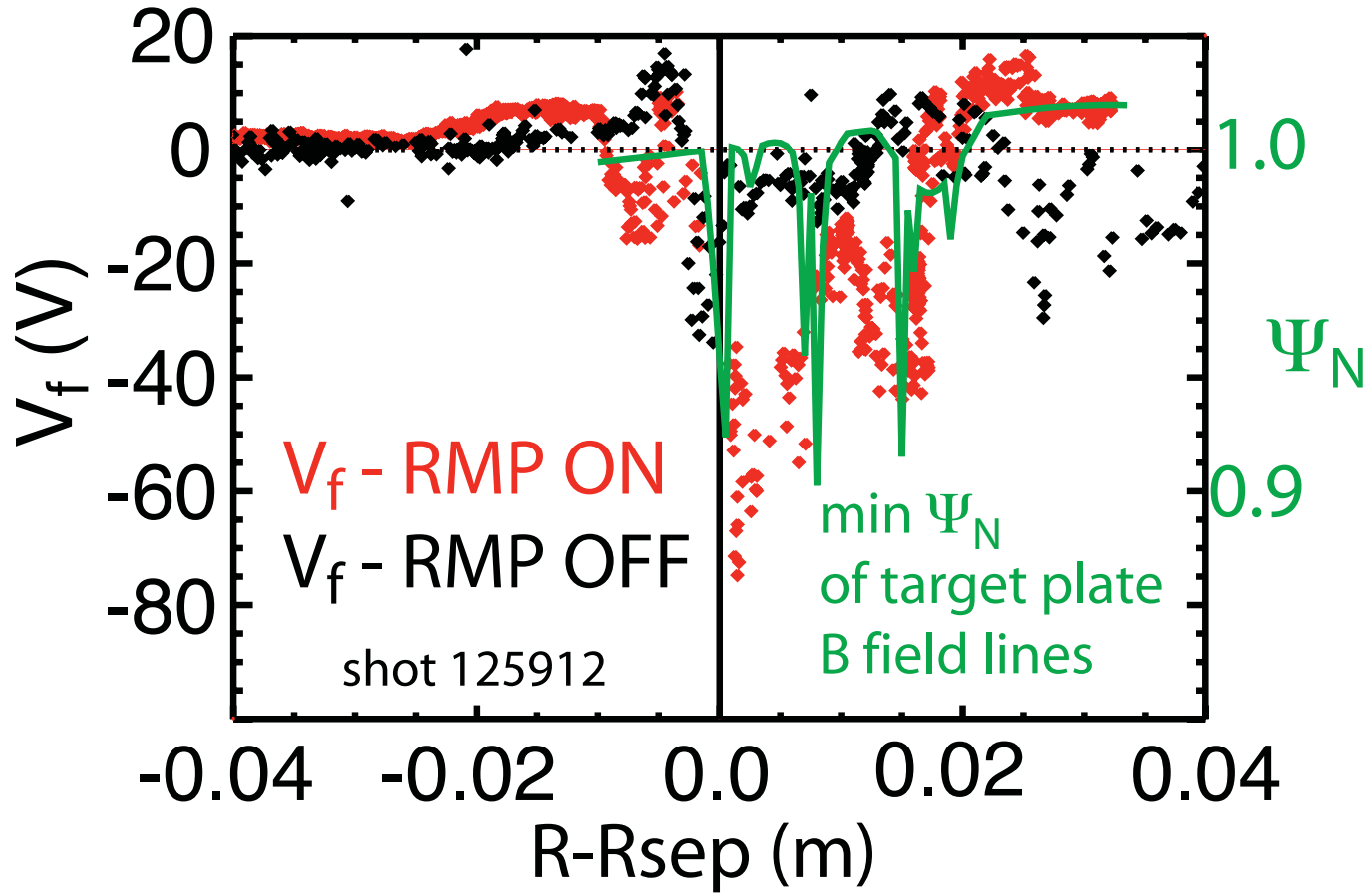


SOLPS modeling: S. Mordijck, Paper JP6.00074

The RMP induces electron losses from the pedestal consistent with the vacuum magnetic field structure

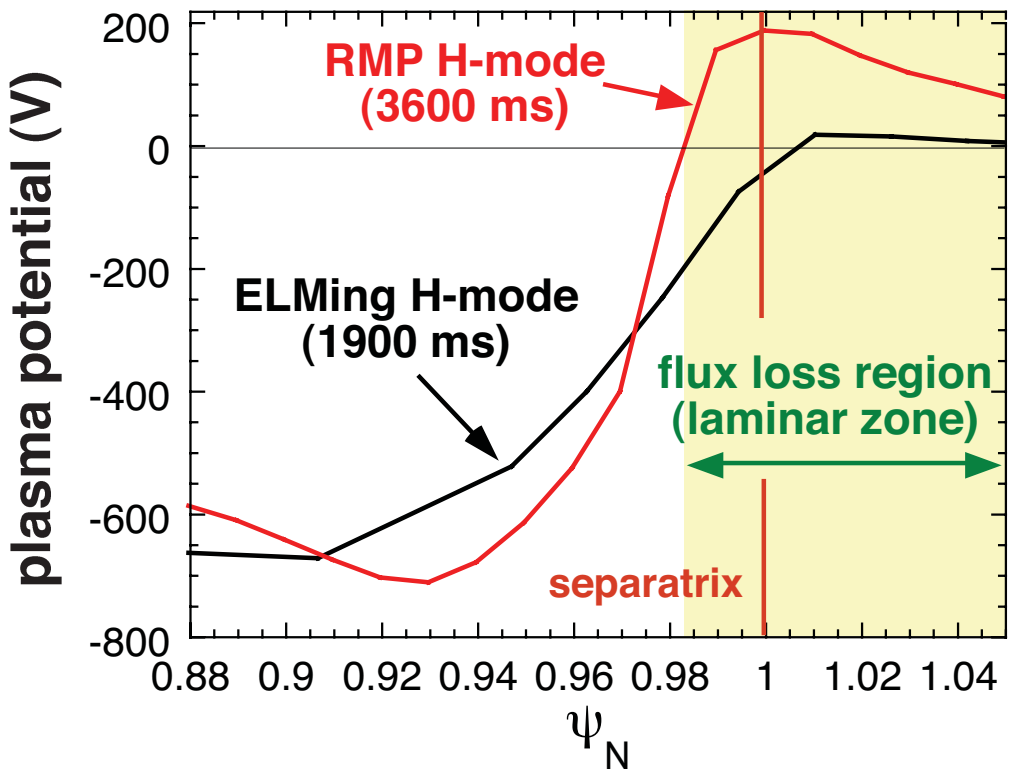
- Calculate the splitting of the inner divertor magnetic footprint using the TRIP3D vacuum magnetic field model.
- The floating potential V_f becomes strongly negative during RMP ELM suppression, consistent with loss of higher temperature electrons from the pedestal [J.G. Watkins, et al., PSI08 in press]

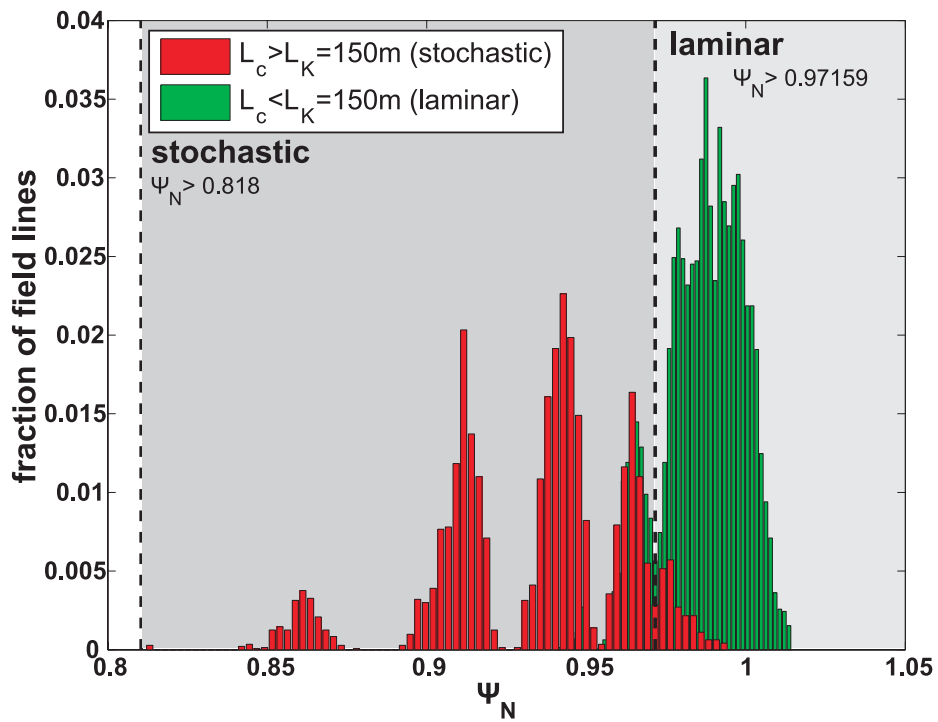
J.G. Watkins
SNL
Poster JP6.00072



Plasma potential changes are consistent with vacuum field modeling of laminar (flux loss) zone.

- Plasma potential becomes positive during RMP for $\psi_N \geq 0.97$–0.98
- Typical laminar zone width in TRIP3D simulations is $\psi_N \geq 0.97$

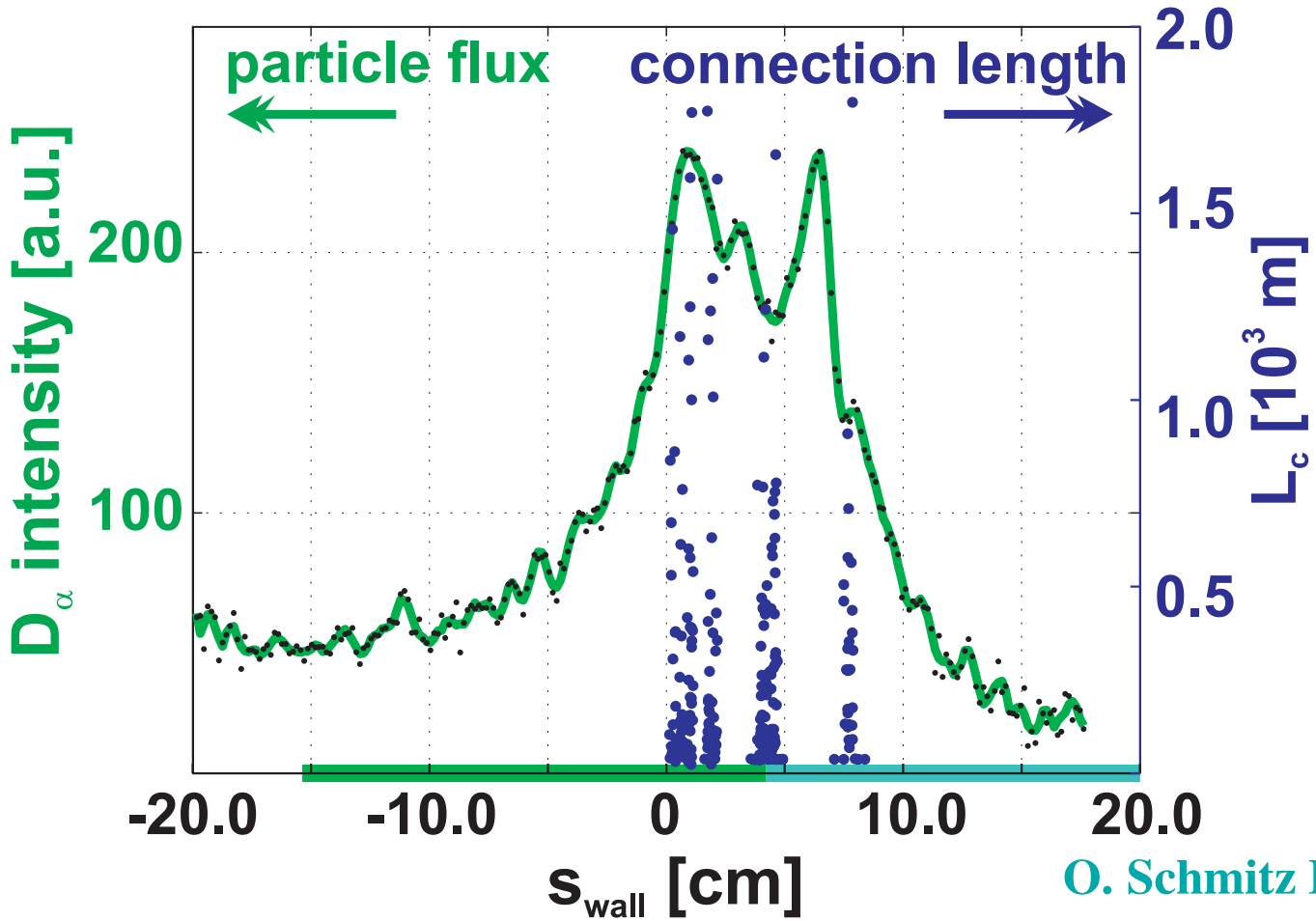




O. Schmitz, FZJ Poster JP6.00069

Ambipolar potential in 3D perturbed equilibrium induces ion losses that follow the vacuum magnetic field footprints

- Particle flux footprint at inner strike point as measured by D_α emission shows multiple peaks at location of magnetic field line footprint as calculated with TRIP3D vacuum field model.

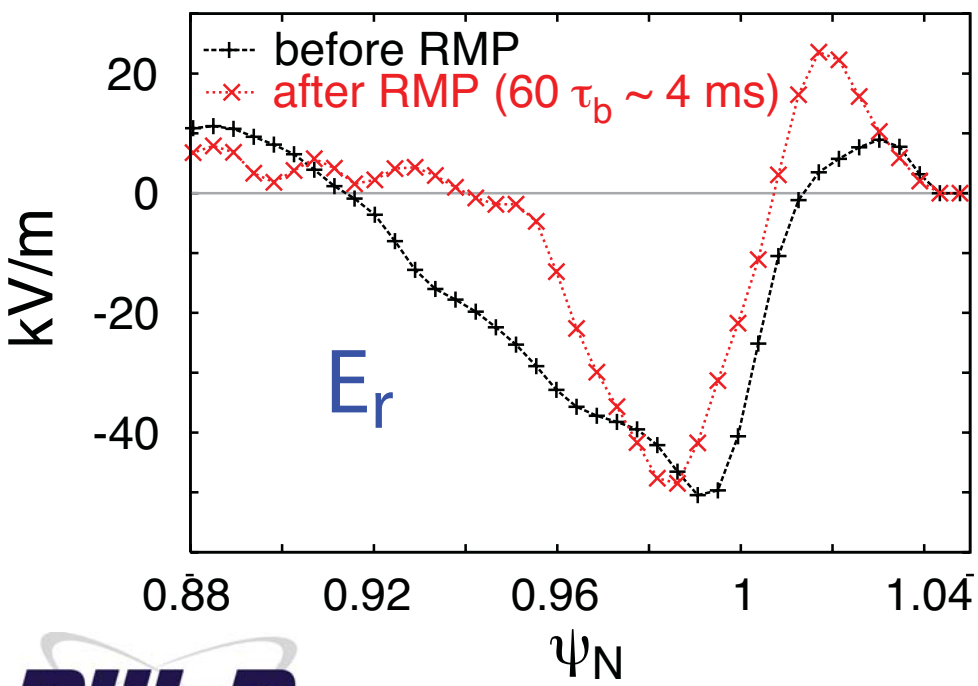


O. Schmitz FZJ
Poster JP6.00069

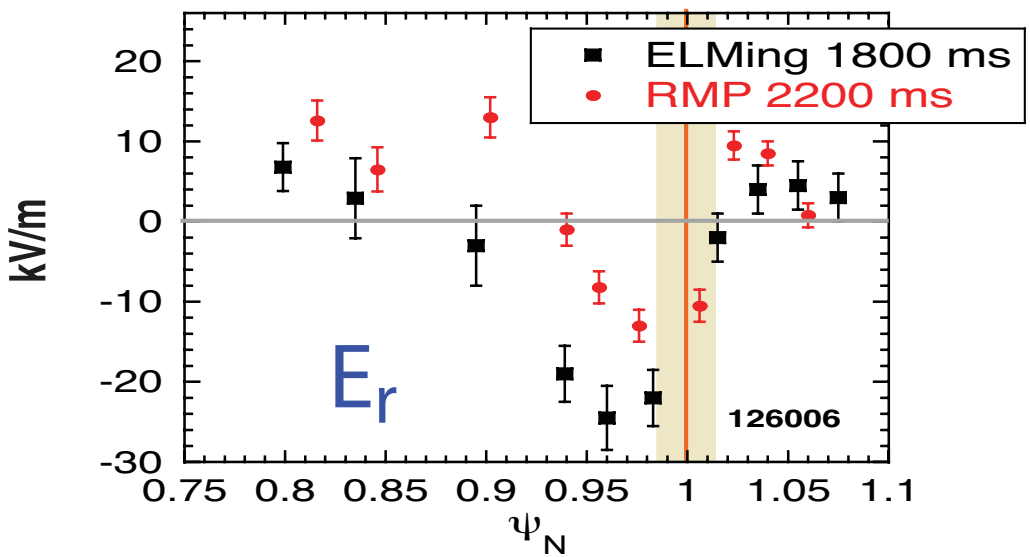
XGC0 kinetic equilibrium evolution code reproduces self-consistent neoclassical E_r in the experiment

- XGC0 is a full-f ion/electron/neutral, kinetic equilibrium evolution code:
- 3D B-field topology, but plasma potential is solved as a function of radius only
- With an ad hoc screening factor on vacuum RMP, reproduces many features of RMP H-modes

XGC0 simulation results



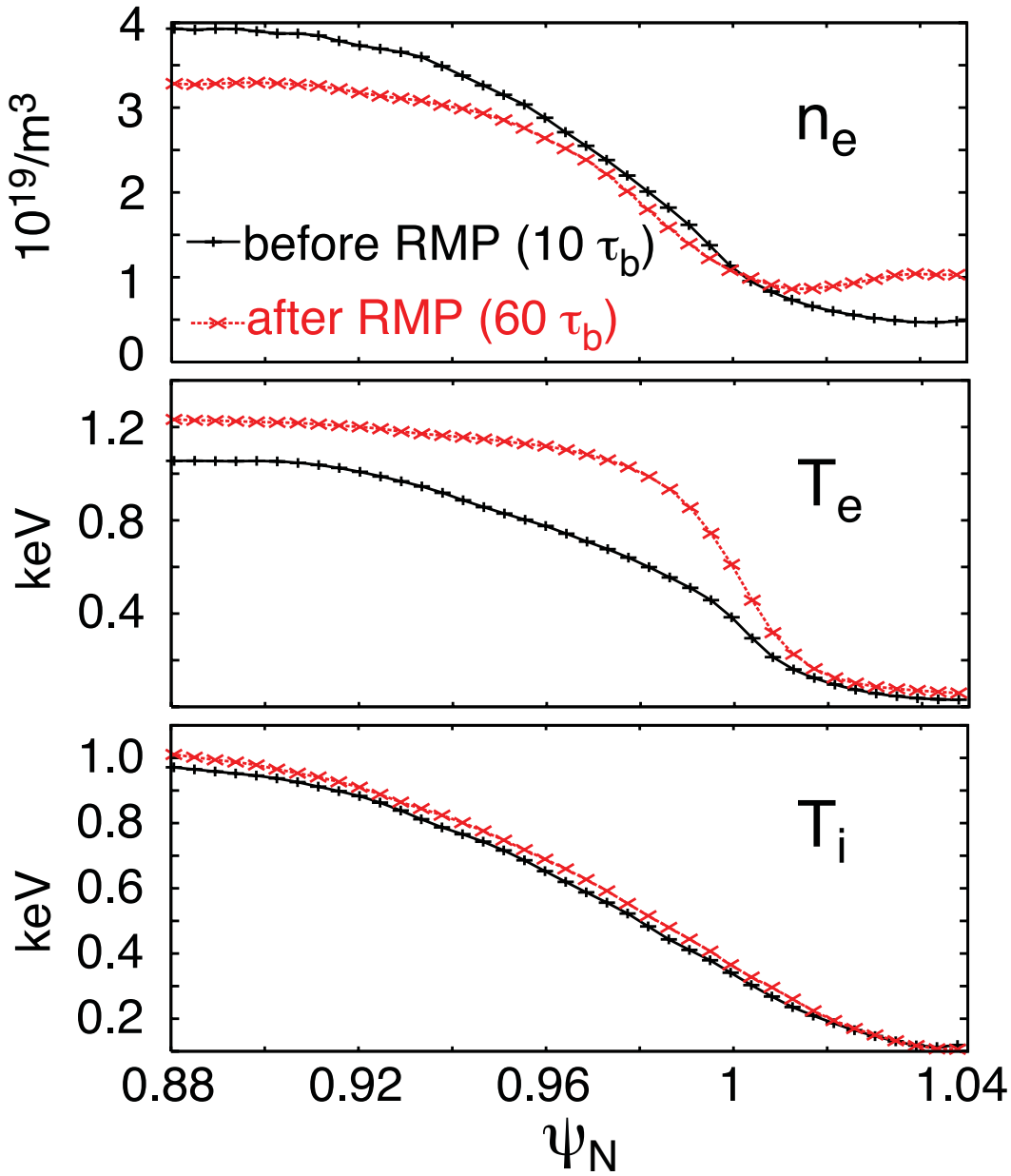
experimental results



XGC0: G. Park, C.S. Chang, NYU Poster JP6.00133

XGC0 reproduces many features of RMP H-modes with an ad hoc screening factor for the vacuum RMP

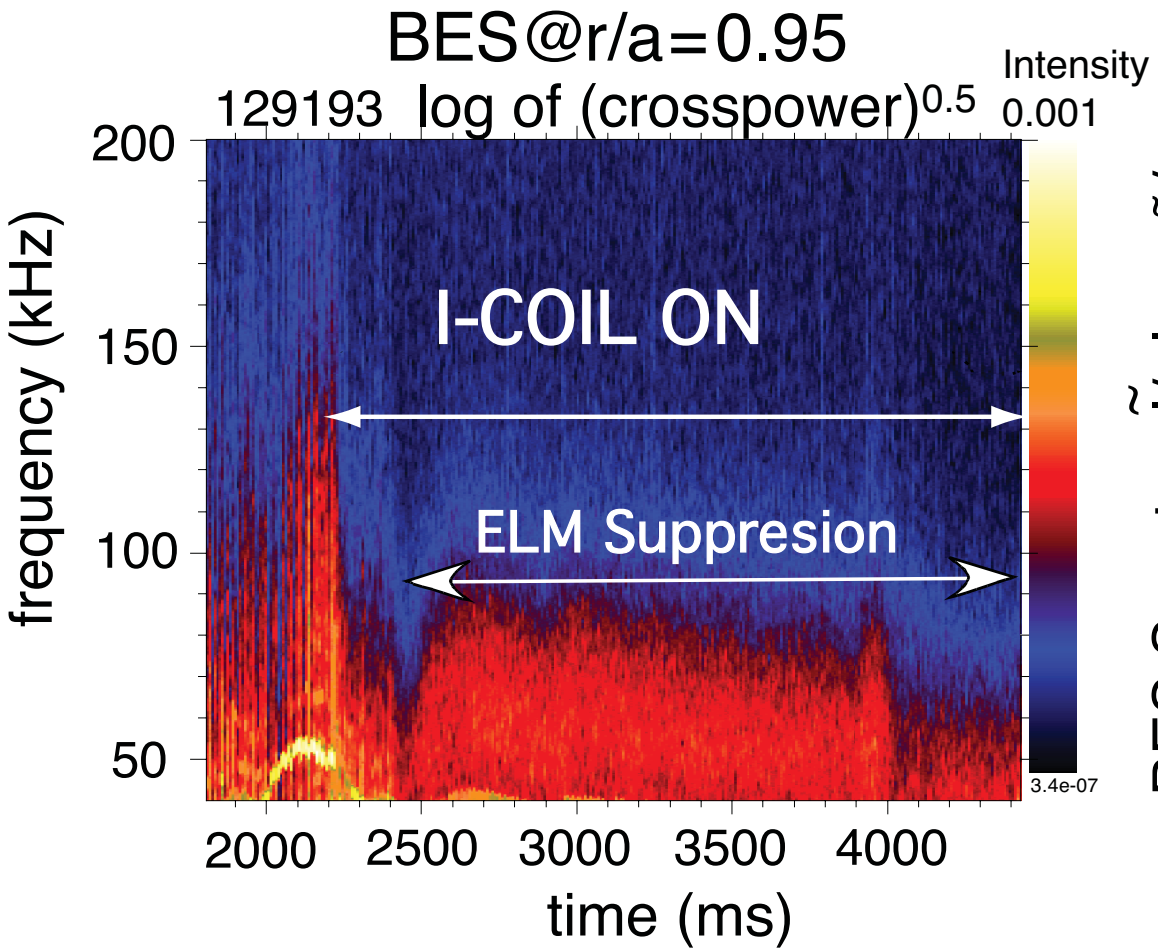
- XGC0 calculates neoclassical transport with self-consistent E_r in realistic geometry
- Pedestal profiles after 60 ion transit times $\tau_b \approx 4$ ms in experiment show qualitative features seen in stationary experimental profiles:
  - At $60\tau_b$, E_r is stationary, but transport and profiles are still evolving

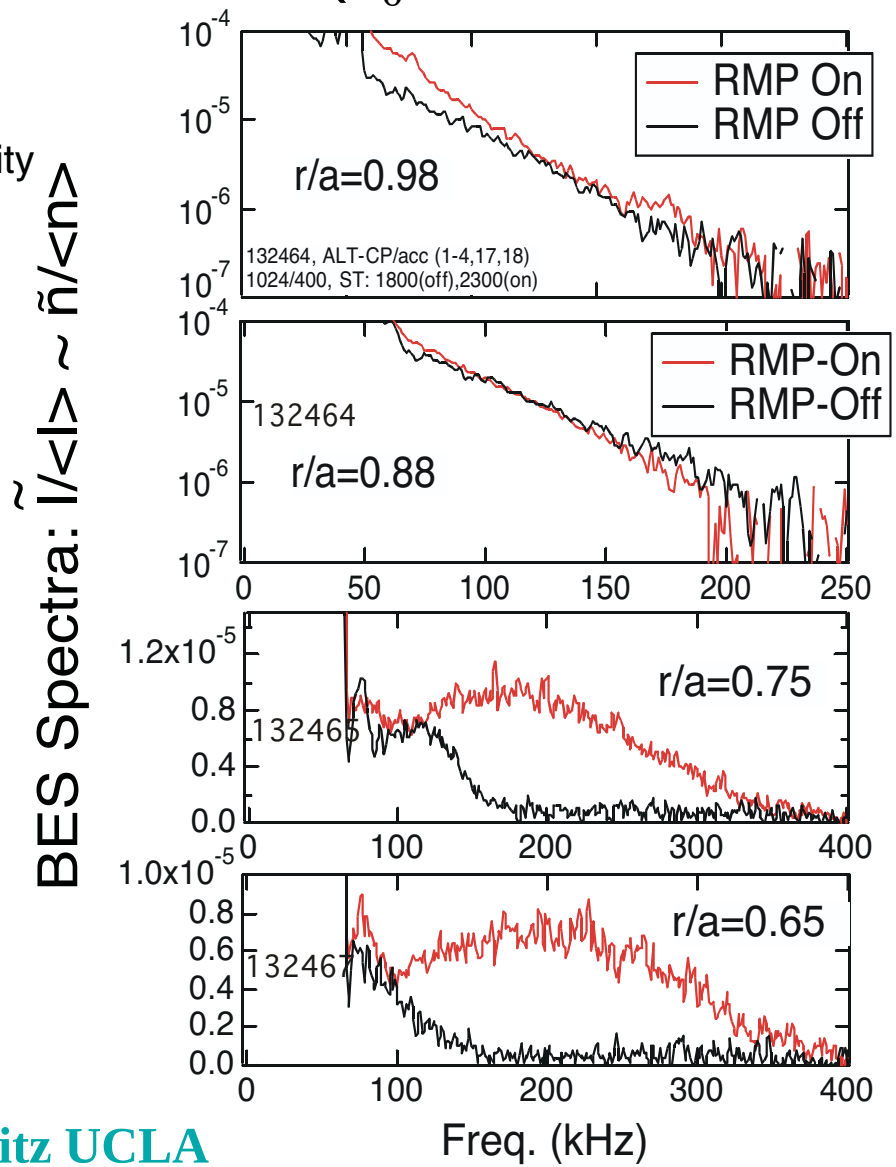


G. Park, C.S. Chang,
NYU Poster JP6.00133

Ion scale fluctuations increase broadband across a wide radial extent 0.65 < ρ < 1 when ELMs suppress

- Similar behavior seen at intermediate scales ($k_\theta \approx$ 4-5 cm^{-1})





BES: McKee UW

Correlation reflectometer: L. Schmitz UCLA

Edge resonant magnetic perturbations suppress ELMs by enhancing particle transport across plasma.

- Pedestal particle transport increase aids stabilization of Peeling-Ballooning modes by reducing pedestal pressure gradient, *but*
- Enhanced core particle transport decreases stored energy more than desired in ITER
  - Need to understand the particle transport in order to optimize the pedestal transport while minimizing the core transport
- RMP establishes a 3D equilibrium with significant flux loss (laminar) zone
  - Evidence for laminar zone from floating potentials at target plates and mid-plane plasma potential changes
- Neoclassical transport in 3D equilibrium leads to enhanced ion transport
  - Particle flux profiles agree with magnetic footprints from vacuum field model
  - Calculated pedestal profiles from XGC0 qualitatively similar to experiment
- Core density is effected by 1.5-2x higher broadband turbulence during RMP across a wide radial extent $0.65 < \rho < 1$ due to E_r shear changes
- Improving radial localization of flux loss (laminar zone) will provide P-B stabilization while minimizing core transport increase
  - New inner wall "S coils" will provide this in DIII-D

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