L-Mode NCS Discharges with Expanded ρ_{qmin}

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Poster CP1.87

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Motivation

- The motivation of the experiment was to expand the radius of the various ITBs while maintaining high q_{min} and obtain higher β and better bootstrap alignment
- Discharges with Negative Central (magnetic) Shear (NCS) are of interest due to their improved stability against a variety of MHD phenomena

Motivation (Con't)

- High q_{min} leads to a large bootstrap current, important for AT scenarios
- L-mode is also attractive for AT scenarios as it reduces the divertor heat fluxes
- Another motivation is to study whether large ρ_{qmin} influences the characteristics of the ITBs

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Overview

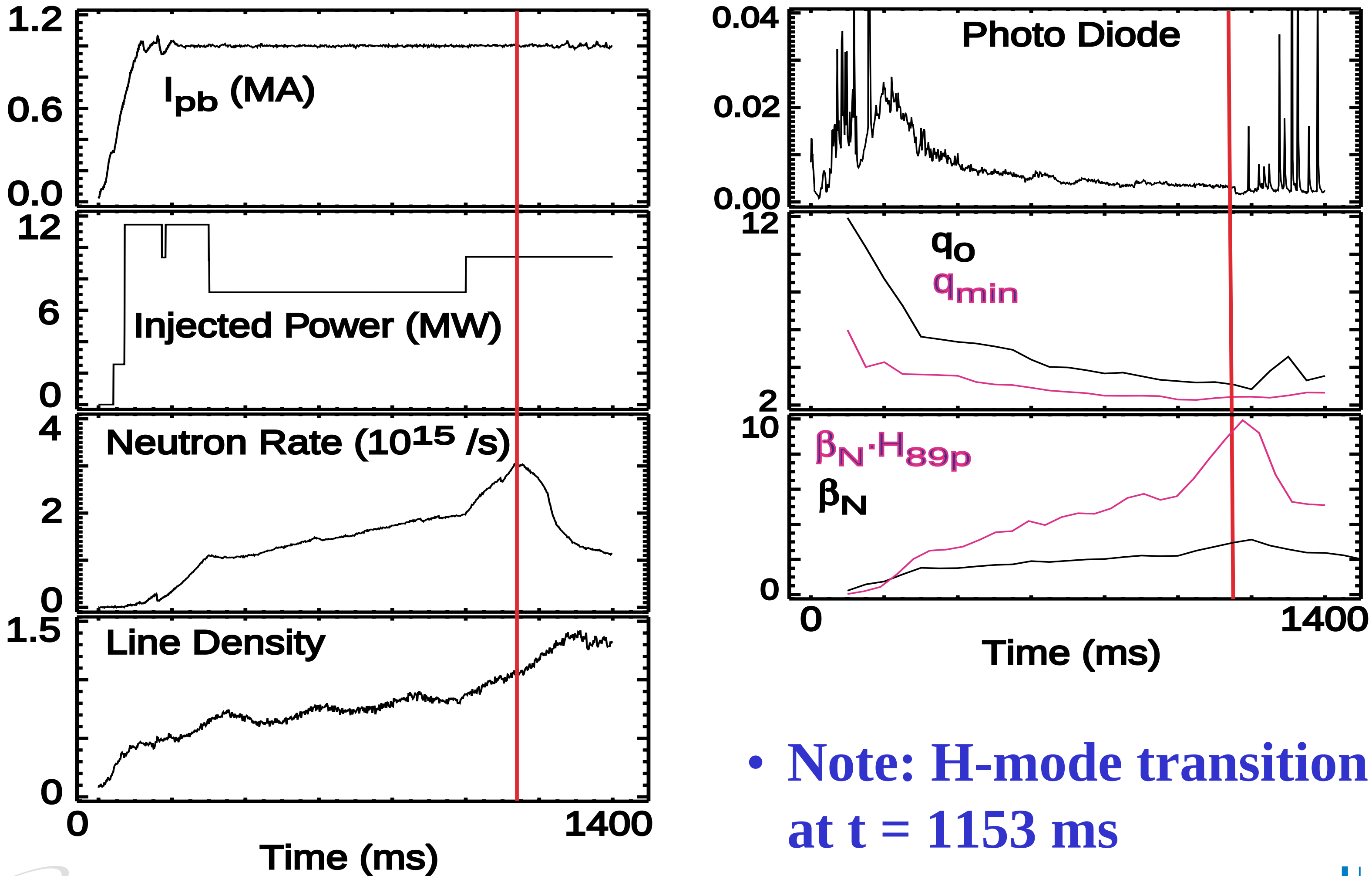
- Analysis for a single high performance shot is presented
- Key points:
  - Improved performance obtained
  - Little or no correlation of the barrier location with q_{min} in particular and q-profile in general
  - Discharge is stable to ideal modes, but strong MHD activity is still observed

Peak Performance is Twice that of a Standard L-mode Discharge

- Peak Performance
  - $\beta_N \cdot H_{89} = 8$
  - $\beta_N = 2.8$
  - $\rho_{qmin} = 0.55$
  - $q_{min} = 2.3$
  - $q_0 = 4.3$
  - $\dot{N} = 3.1\text{x}10^{15}$ n/s
- Duration ~ 0.75 s

- L-mode
- ITBs in
  - T_e (ρ ~ 0.6 - 0.7)
  - T_i (ρ ~ 0.45 - 0.55)
  - n_e (ρ ~ 0.45 - 0.6)
  - ω_{ExB} (ρ ~ 0.45 - 0.5)

Discharge Evolution



- **Note: H-mode transition at t = 1153 ms**

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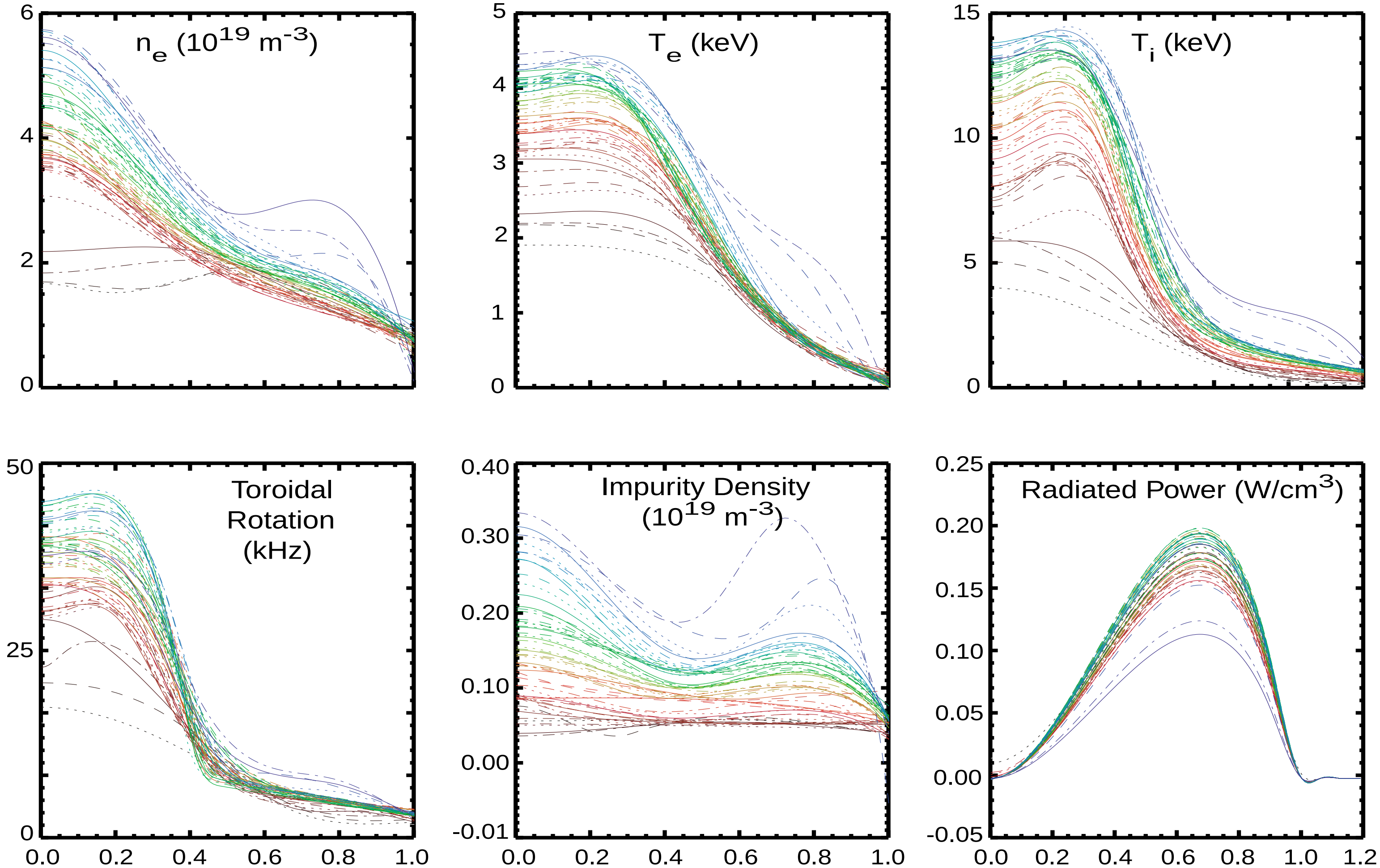
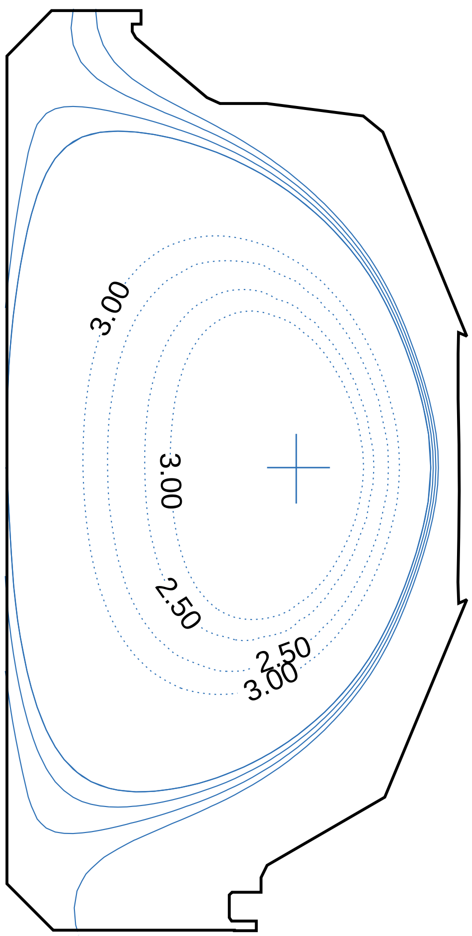
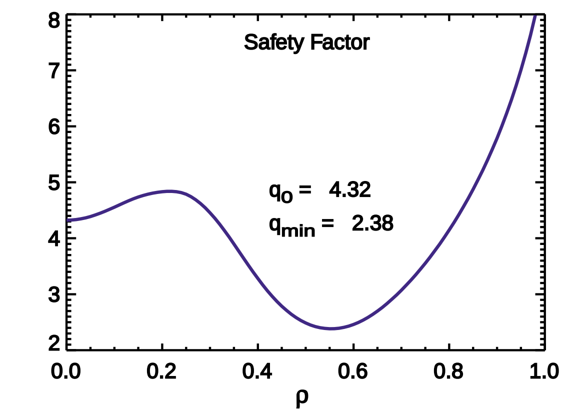
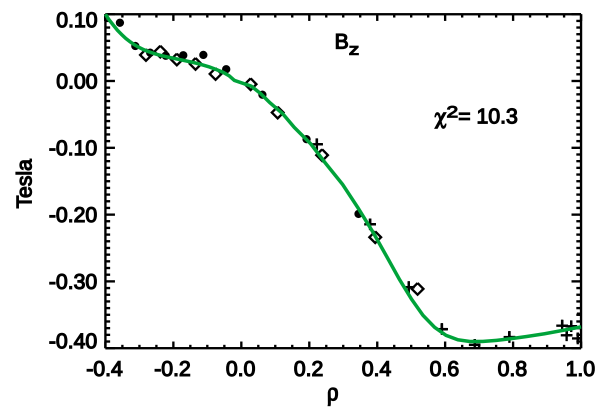
Profile Evolution (0-1200 ms)

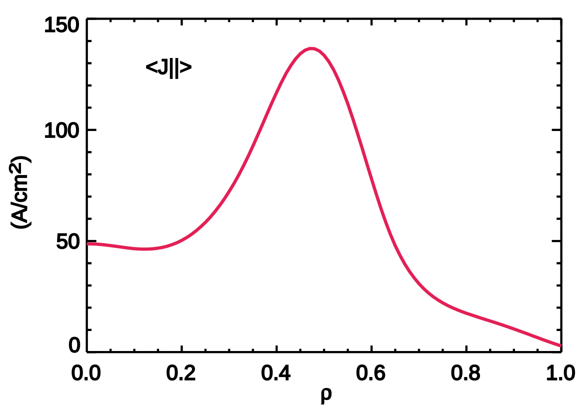


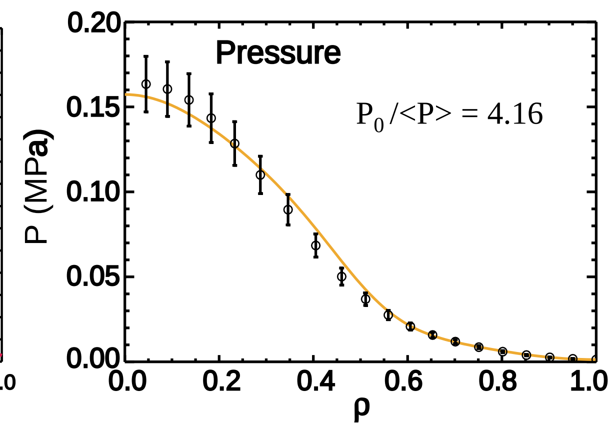
Equilibrium is Highly Shifted with Low Current in Core





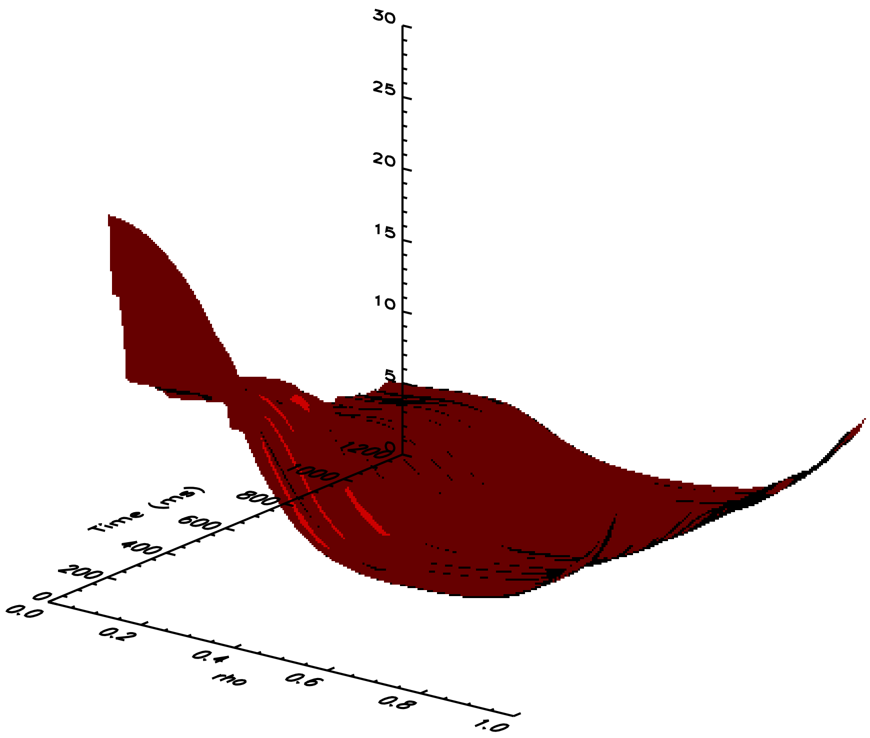


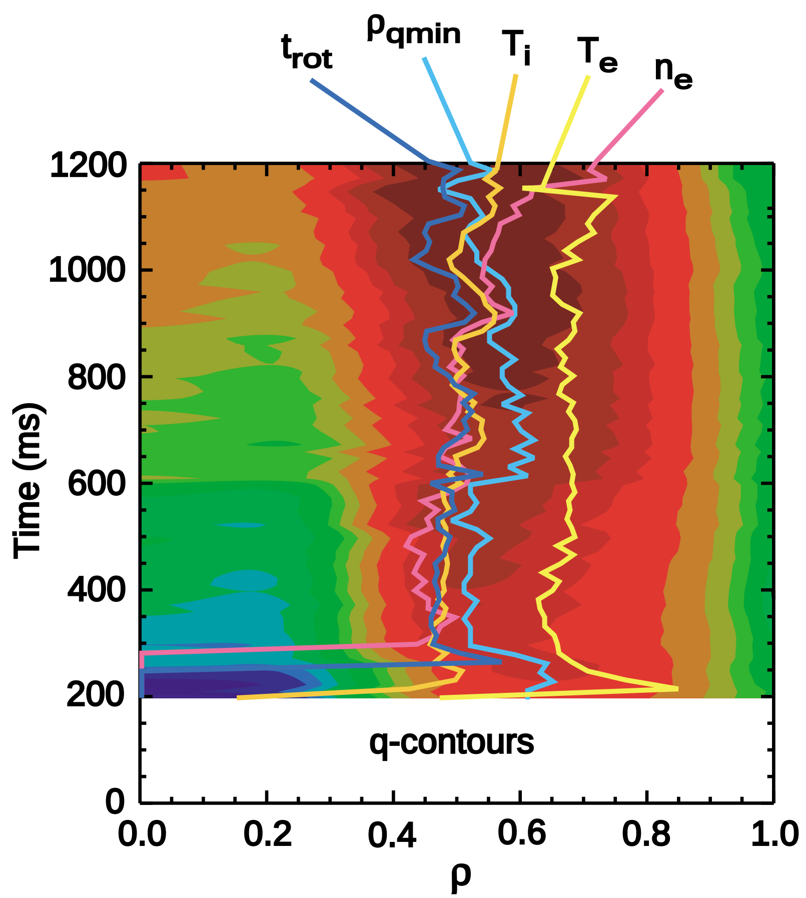




Shot: 98482 Time: 1140 ms

Barrier Locations are not Well Correlated with q_{min}





Comments

- Barrier location is determined from profiles
- $\rho_{Ti} < \rho_{qmin} < \rho_{Te}$
- Temporal location of the T_e-barrier is independent of q_{min}
- Location of the T_i-barrier is strongly correlated with the location of the gradient in the toroidal rotation
- Location of the T_i-barrier is not well correlated with q_{min}

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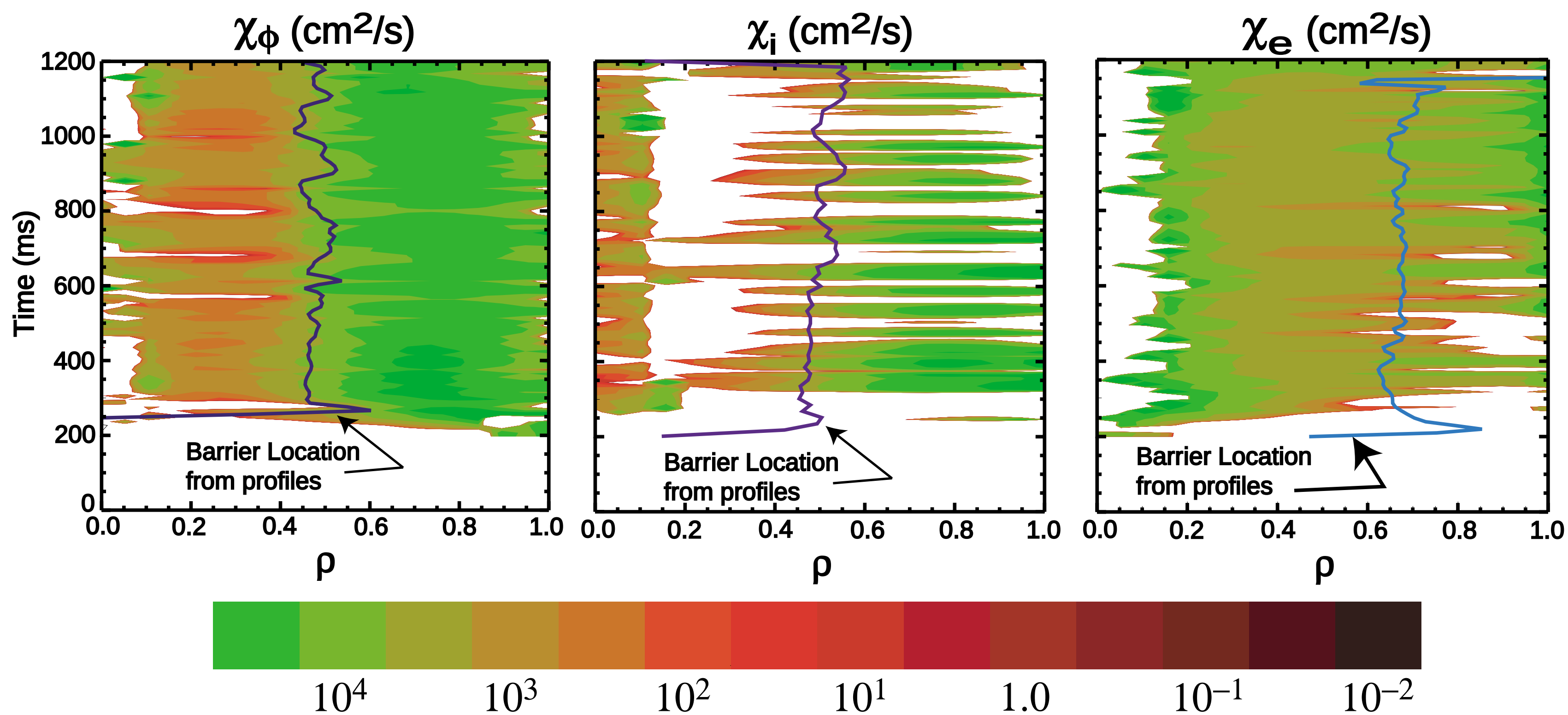
Transport

- Discharge was modeled both with TRANSP and CORSICA
- Ion power balance is dominated by flow from the ions to the electrons, as is typical of L-mode discharges
- Electron power balance is dominated by conduction
- Ion transport analysis is compromised by the presence of MHD activity

Profile Barrier Locations Consistent with Transport Calculations



- Barriers as found from profile fits correspond to locations of large gradients in transport coefficients

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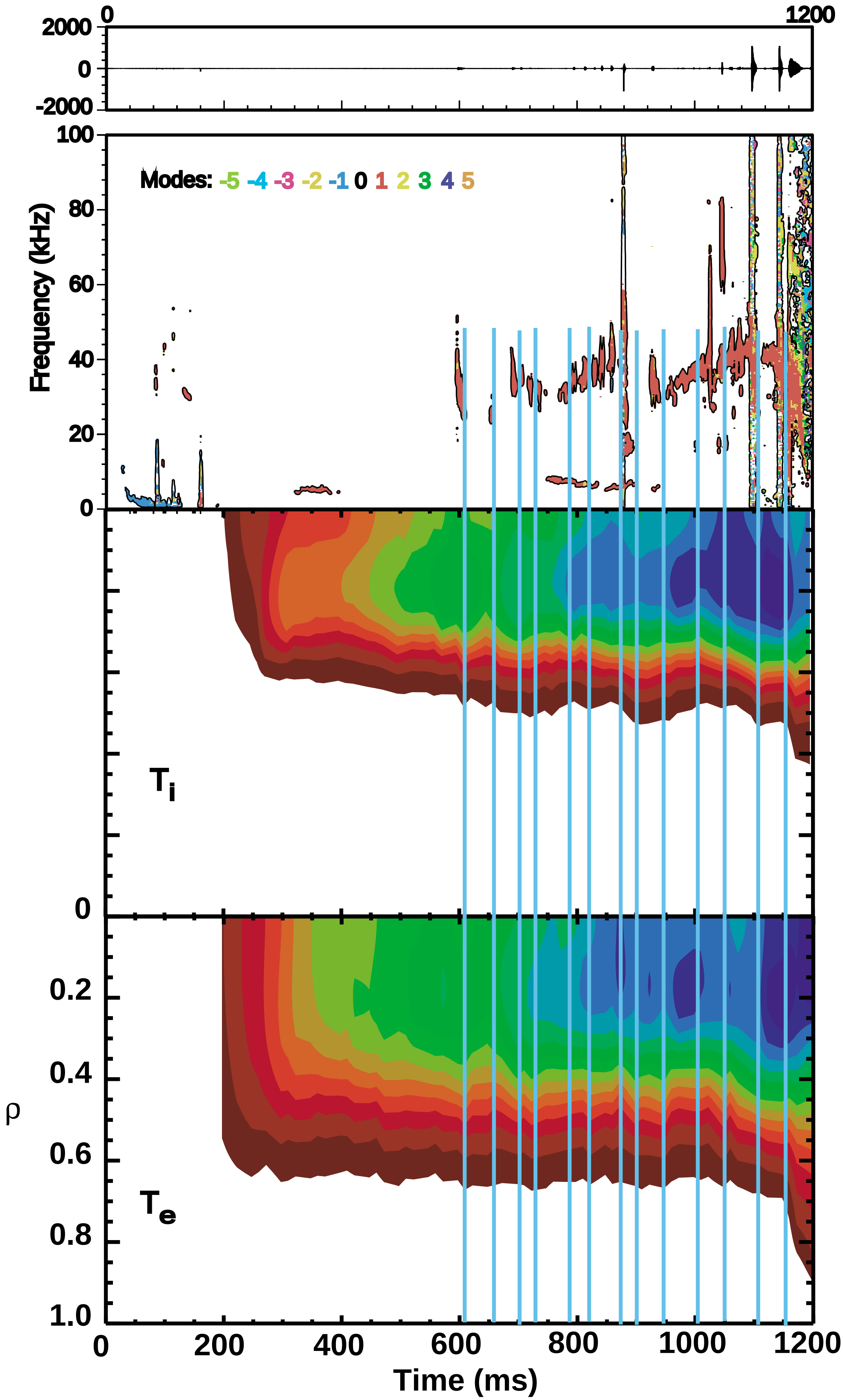
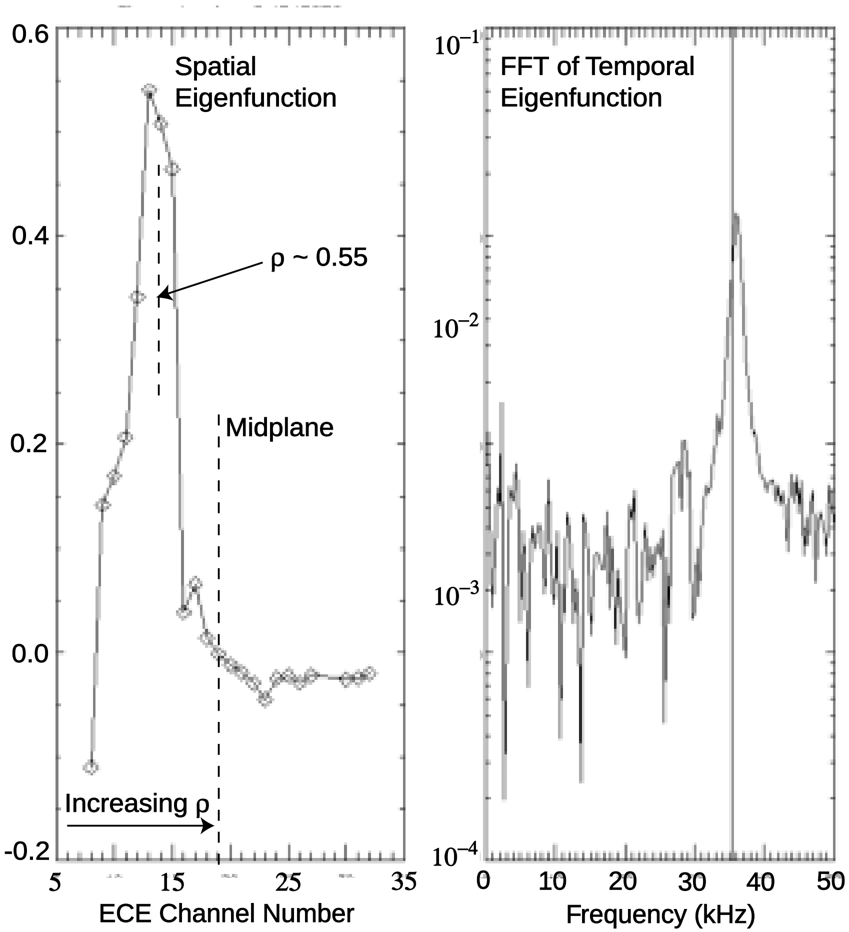
Strong MHD Activity Perturbs Equilibrium and Profiles

- Large amplitude (~80 G at wall) bursts of n = 1 MHD activity are observed late in the L-mode phase
- Bursts are well correlated with shifts in equilibrium and profiles
- Activity is associated with gross plasma displacements
- The bursts appear to flatten the profiles and may increase the radius of the ITBs



0
1200
2000
0
-2000
100
Modes: -5 -4 -3 -2 -1 0 1 2 3 4 5
80
60
40
20
0
Frequency (kHz)
Ti
0
Te
0.2
0.4
0.6
0.8
1.0
ρ
0
200
400
600
800
1000
1200
Time (ms)

Spatial Structure of Mode



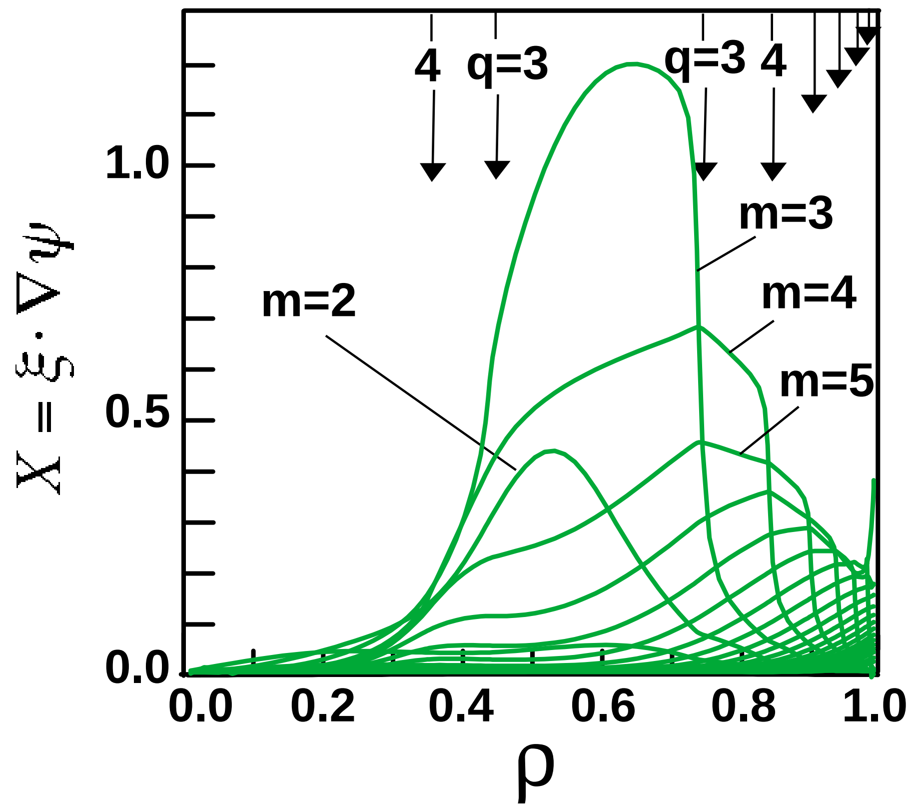
- Mode is peaked at ρ ~ 0.55

- SVD analysis compliments of Tim Luce

Good Ideal Stability is Obtained

- The broad pressure profile contributes to the good ideal stability and allows access to the high achieved β
- Also contributing to the stability is the lower than usual peaking factor: $P_0 / \langle P \rangle = 4.1$
- Observed activity is likely either an n = 1 resistive interchange mode or a resistive kink
- Growth rate is ~1 ms, consistent with resistive modes
- No evidence of TAE modes

GATO Results



- Stability analysis consistently shows that ideal modes are stable in the presence of a wall and unstable with no wall

L-mode Phase Terminates with an MHD triggered transition to H-mode

- As the discharge evolves, the central pressure rises due to the transport barriers
- MHD activity increases, which at first marginally increases the radius of the barriers
- Finally, a very large amplitude MHD event triggers a transition to H-mode
- Despite the MHD activity, the discharge does not disrupt

Comments & Conclusions

- Shot is similar to previous NCS L-mode discharges but with generally improved performance
- Due to the small central poloidal field, energetic ions are not well confined.
- Multiple barriers exist (T_e, T_i, Toroidal Rotation) at differing values of ρ
- Ideal stability is consistent with calculations

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Comments & Conclusions (Con't)

- The location of the ITBs is not well correlated with q_{min}
- MHD activity is varied and very complex
- The presence of the strong MHD activity compromises the transport analysis