Reduced transport near rational q-surfaces in DIII-D NCS plasmas

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Introduction

• Spontaneous jumps in core temperature have been observed in a class of DIII-D discharges under steady-state heating conditions

• Discharges are low n_e L-mode with early NBI-->creates hollow current profile and negative central shear (NCS) q profile

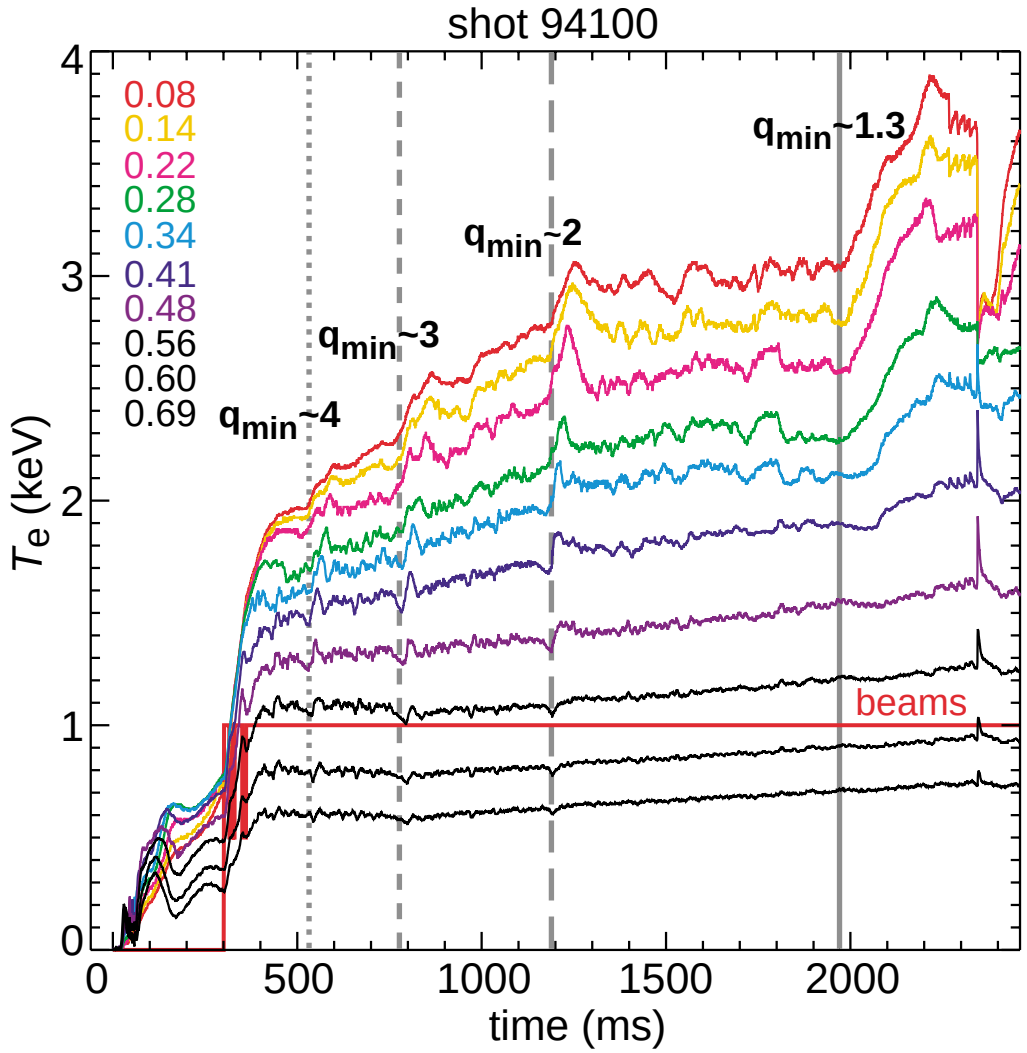
• Temperature changes appear to be related to low-order rational q surfaces in the plasma.

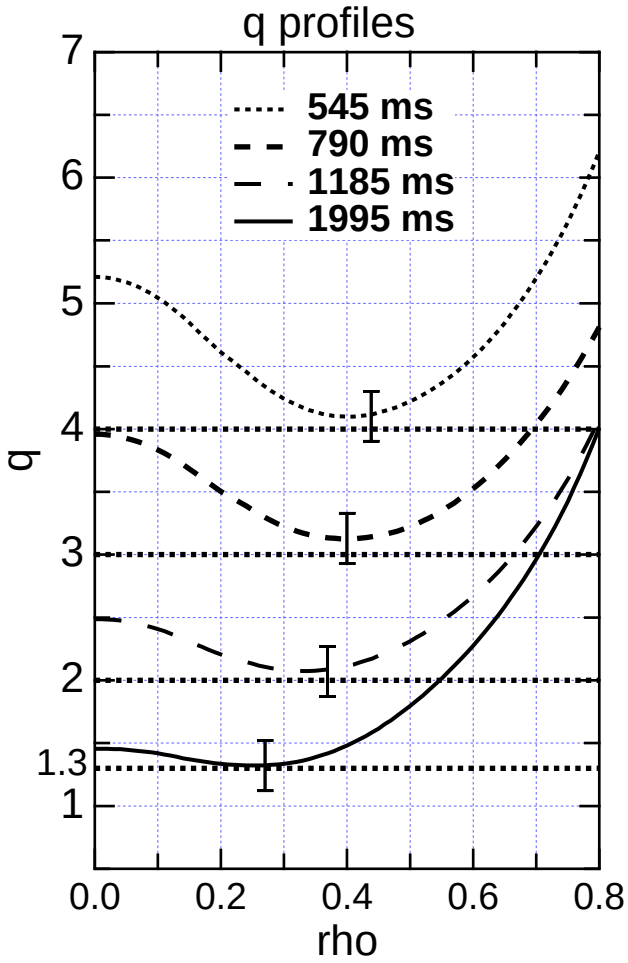
Questions:

– How closely are the temperature jumps connected to low-order q?

– What are the changes in transport implied by the temperature jumps?

Jumps in T_e occur near integer q_{min} in DIII-D NCS discharges





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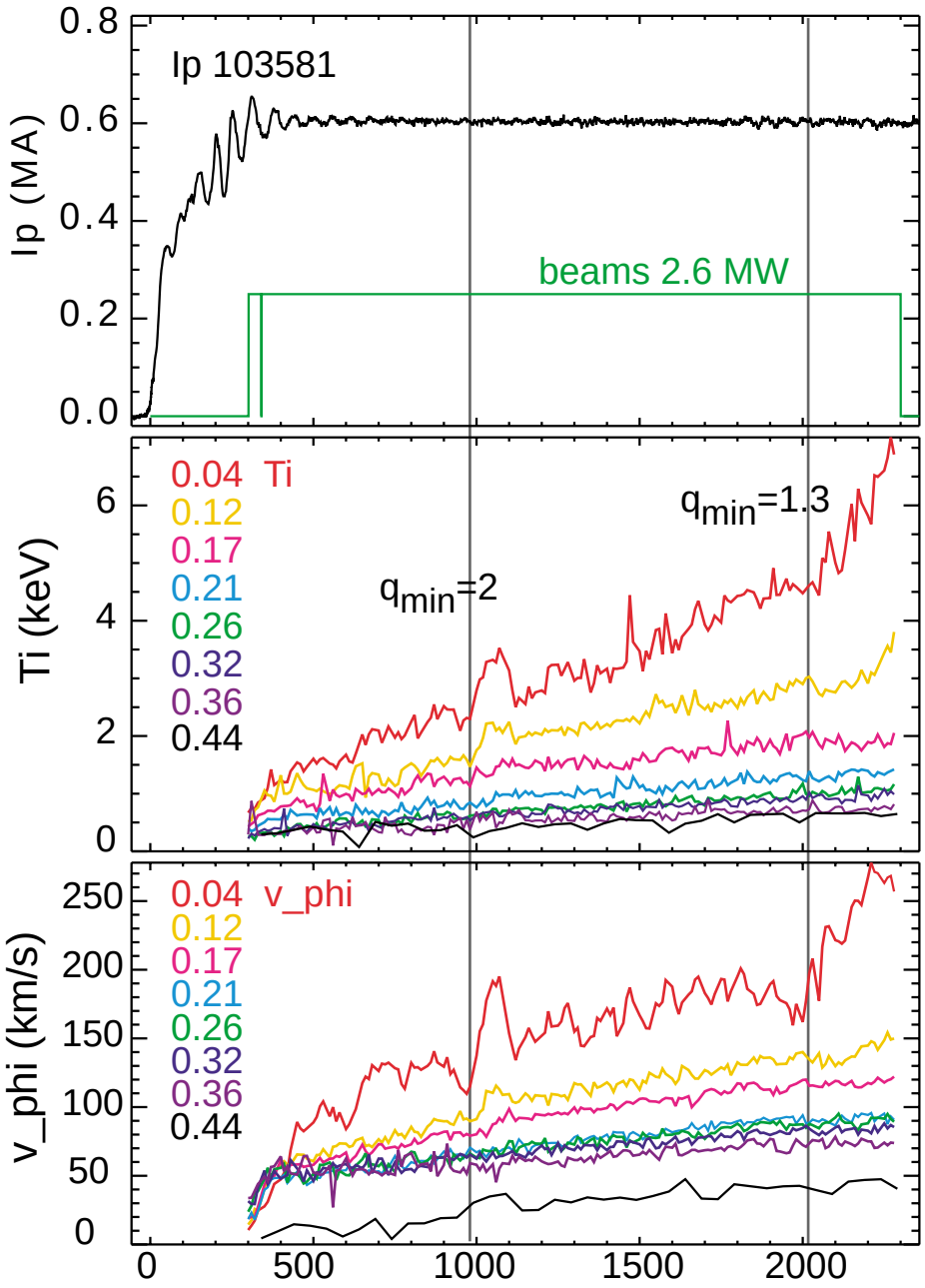
Jumps also seen in T_i, v_ϕ.

These T_e, T_i, v_ϕ excursions are common for low density, low power discharges with early NBI.

The jumps can be step-wise are transient in nature.

As the density is increased in these discharges, the effect goes away.



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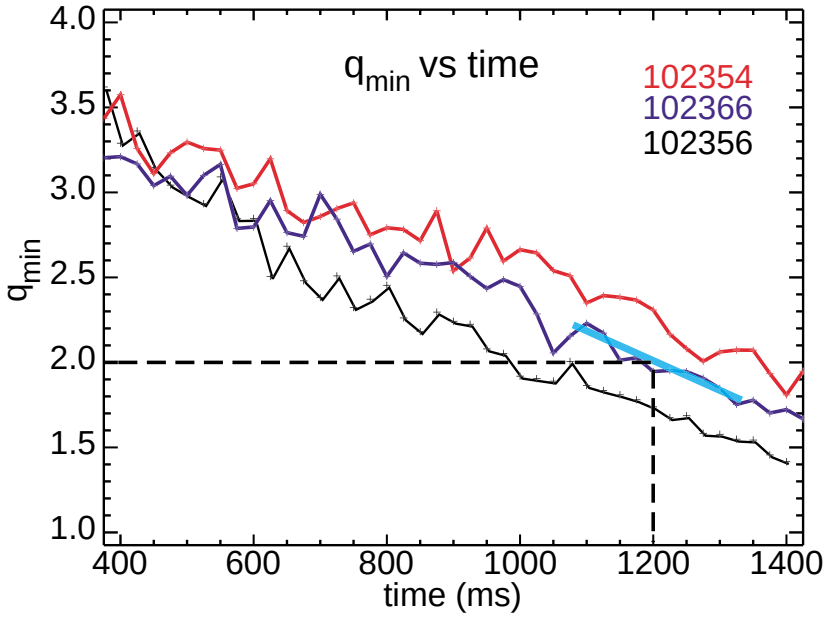
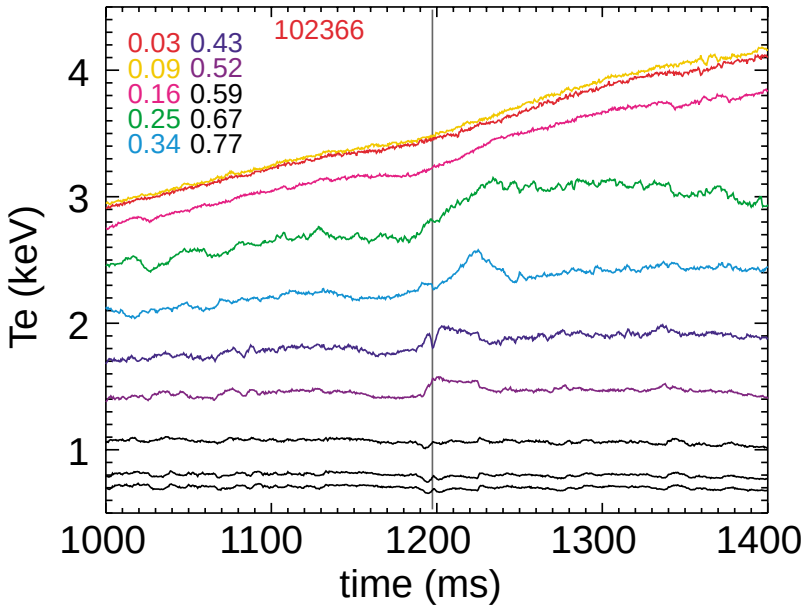
Time histories of q(r) and ECE data are used to correlate times

Evolution of q varies over a series of shots with different densities and beam powers.

Time of q_{min}= rational is determined by interpolation of fits to q_{min} vs time.

ECE data displays a reproducible “hiccup” in the temperature rise.





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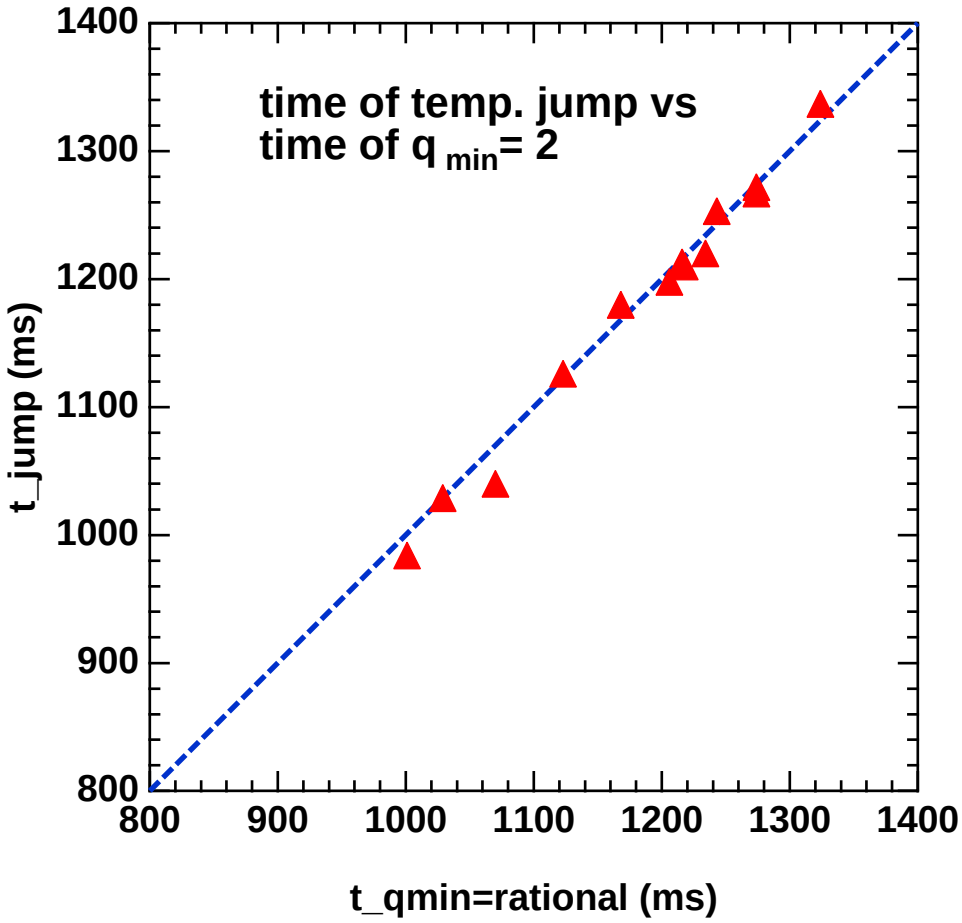
Temperature Kick-ups Correlate with Rational q_{min} Values

- Data are from a dedicated 1 1/2 day experiment.
- The x-axis is the time that q_{min} passes through the rational value, determined from a fit to q_{min} vs time obtained from MSE EFITs.
- The y-axis is the time of the start of the jump in temperature.



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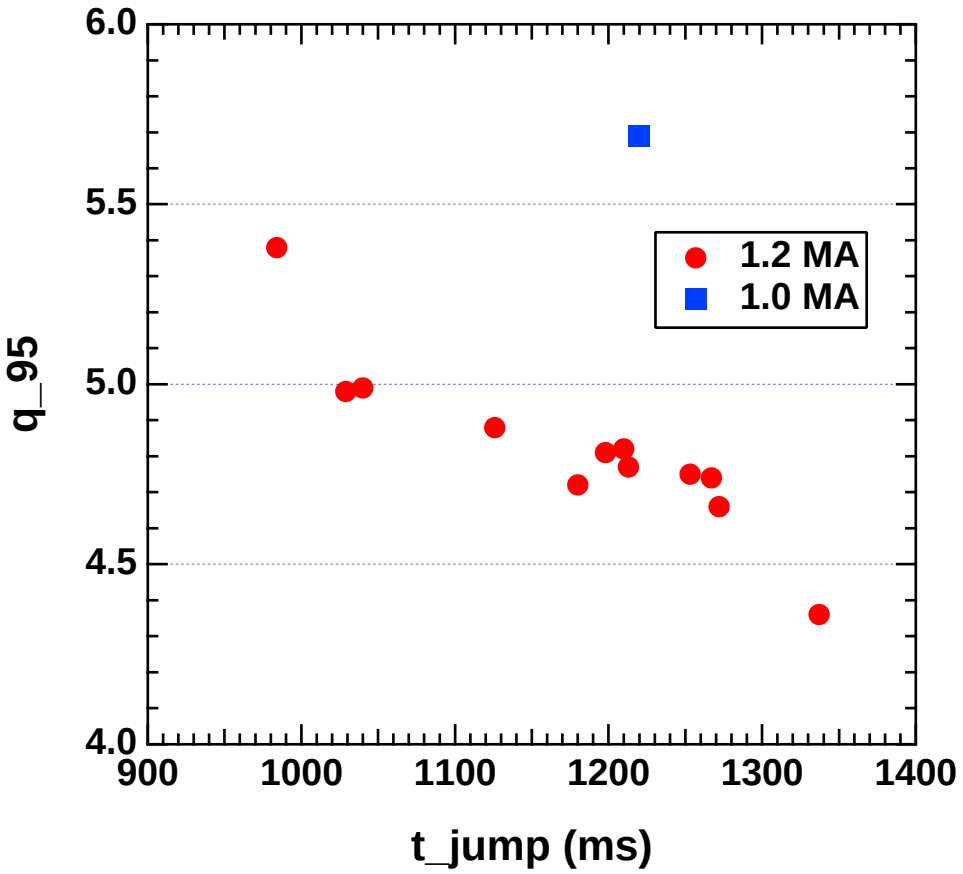
Temperature jumps do not correlate with rational values of q_95

Values of q_{95} determined from linear fit to time sequence EFIT q profiles



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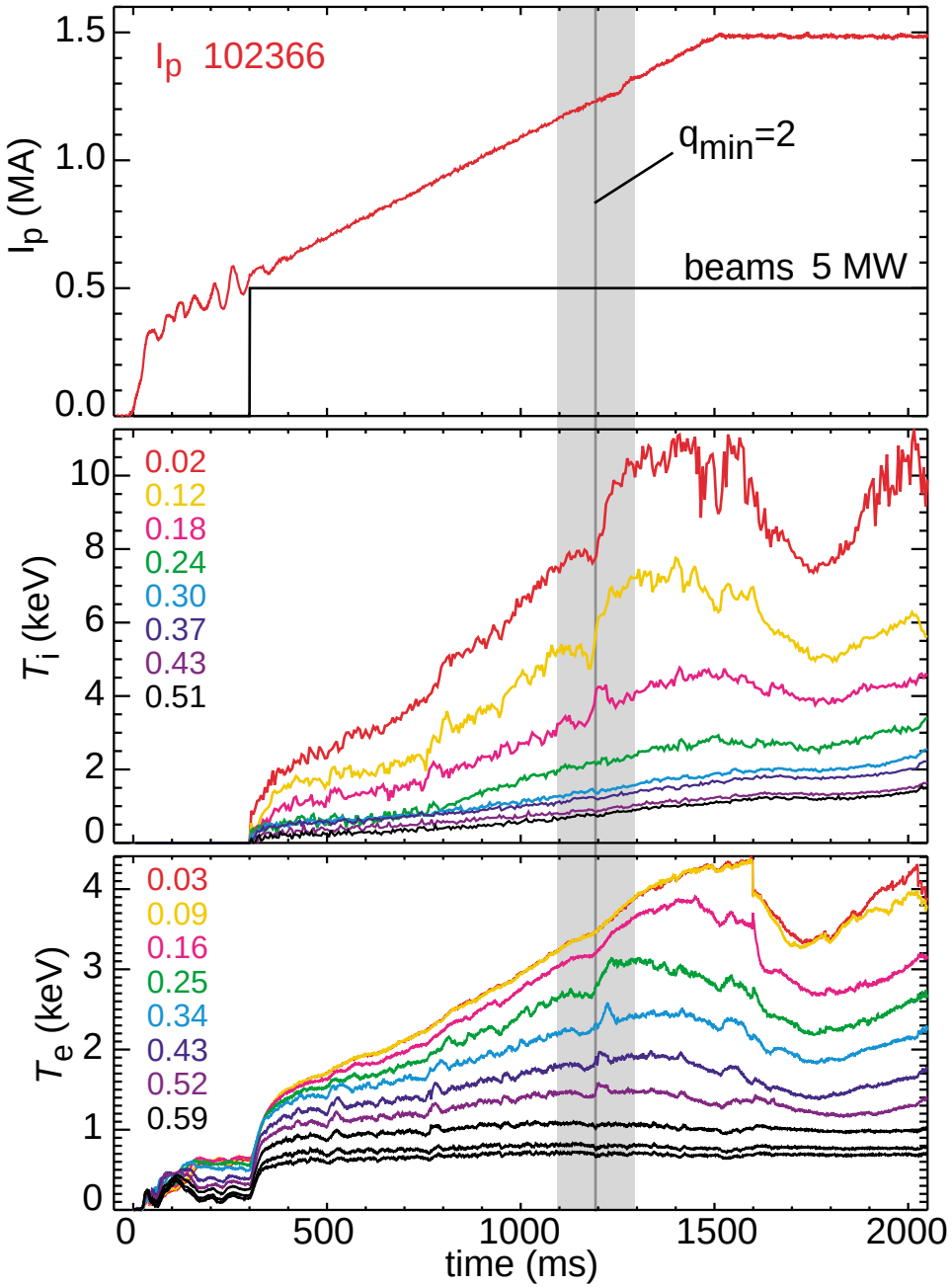
Transport Analysis

- In order to determine where the changes in χ_e are occurring, a simple transport code is employed.
- Inputs are the power to the electrons and the time history of T_e profile from the ECE radiometer.



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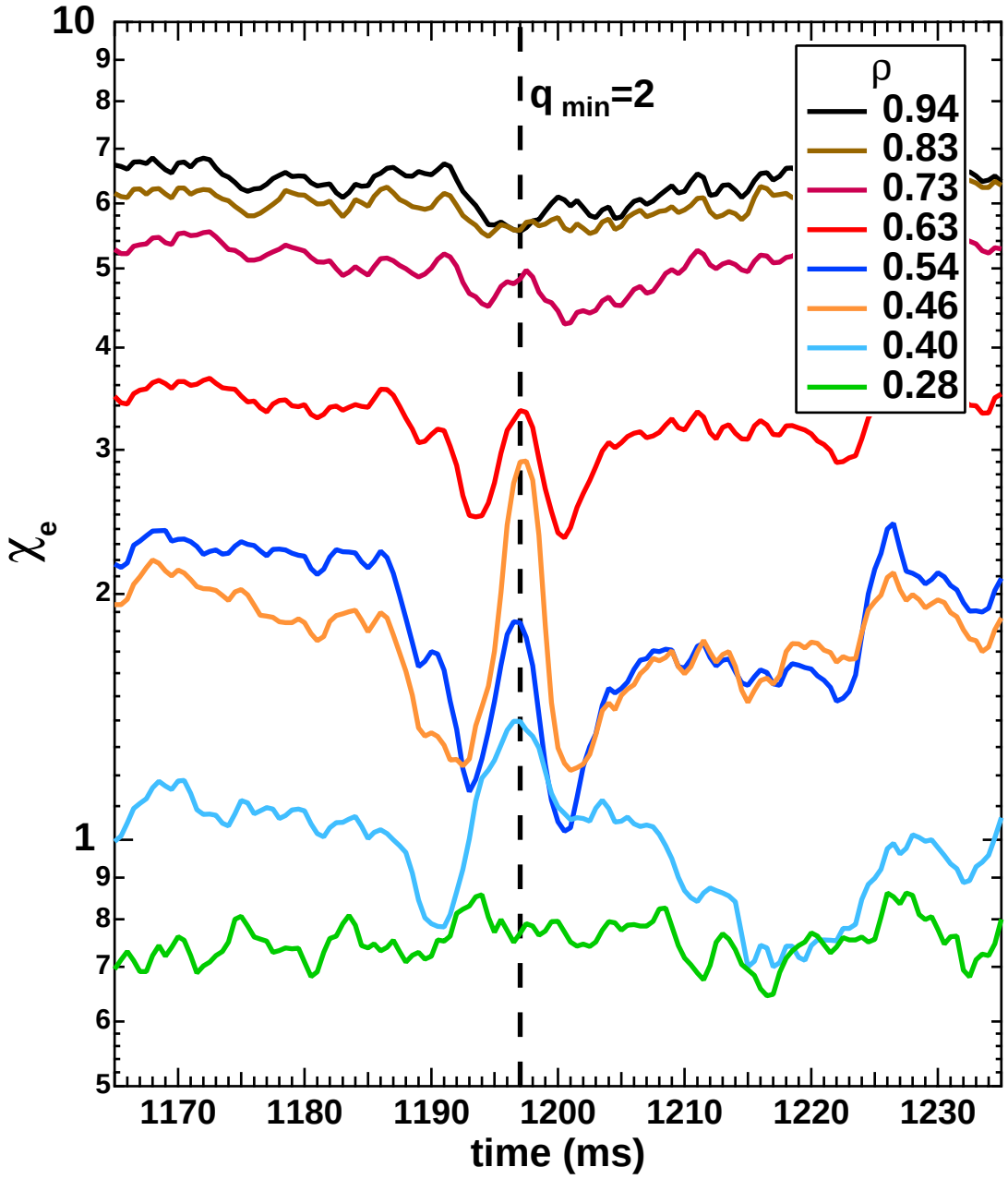
Diffusivity as a Function of Time

Transport coefficients at several radii dip just before and after q_{min} traverses 2.

Transport equation

$$\frac{3}{2}\frac{\partial n_e T_e}{\partial t} + \nabla \cdot q_e = S_e$$

$$q_e = -n_e \chi_e \cdot \nabla T_e$$



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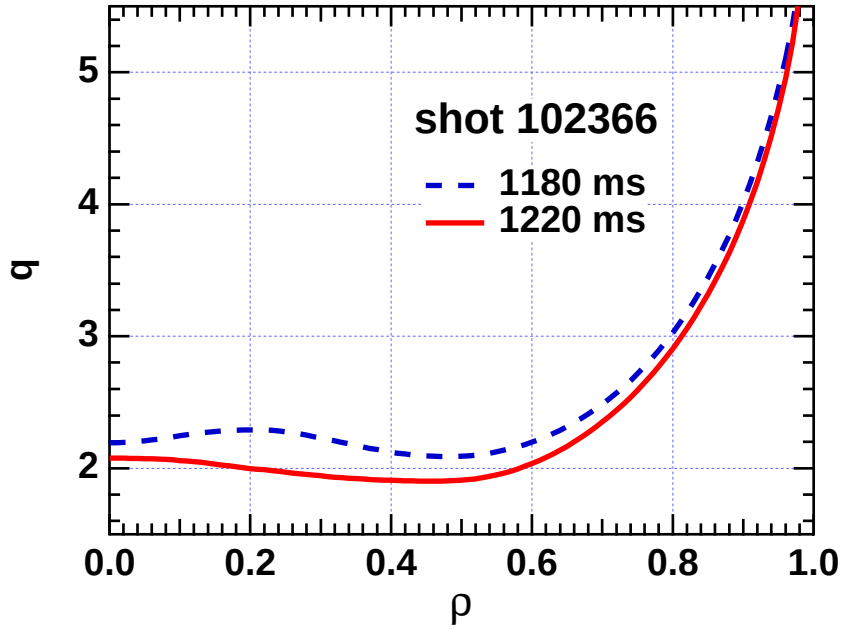
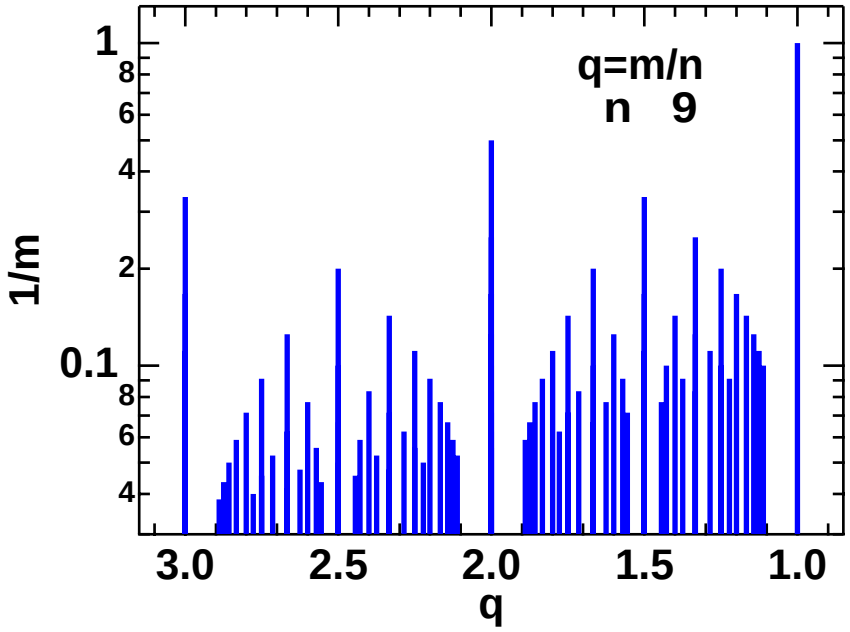
Is transport improvement due to good magnetic surfaces near rational q values?

- EFITs with MSE data show q profiles with the low-shear region just above and just below q=2 bracketing the time of improved transport.
- Lower plot indicates allowed values of q=m/n for low-ordered modes showing gaps near integer and half-integer values.





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Summary

- Both transient and step-wise transitions to improved confinement in low-density NCS discharges are connected with the minimum in the q profile passing near low-order values.
- There is no correlation with rational q_{edge} or q_0 values. Jumps are largest for q_{min} =3, 2, & 1.3 but are also seen for other rational values.
- There is evidence that the transitions are related to good magnetic surfaces near rational q_{min}. Transport is seen to improve at locations away from the low-shear region in simple model simulations.