Long-Time Correlations in Core/Edge Density Fluctuations in the DIII-D Tokamak and NSTX Spherical Torus

M. Gilmore, C.X. Yu†, T.L. Rhodes, W.A. Peebles, and L. Zeng

Electrical Engineering Dept., University of California, Los Angeles, USA

† Dept. of Modern Physics, University of Science and Technology of China, Hefei, PRC

Thanks to the DIII-D and NSTX Teams, D.E. Newman, W.M. Nevins, and X. Xu

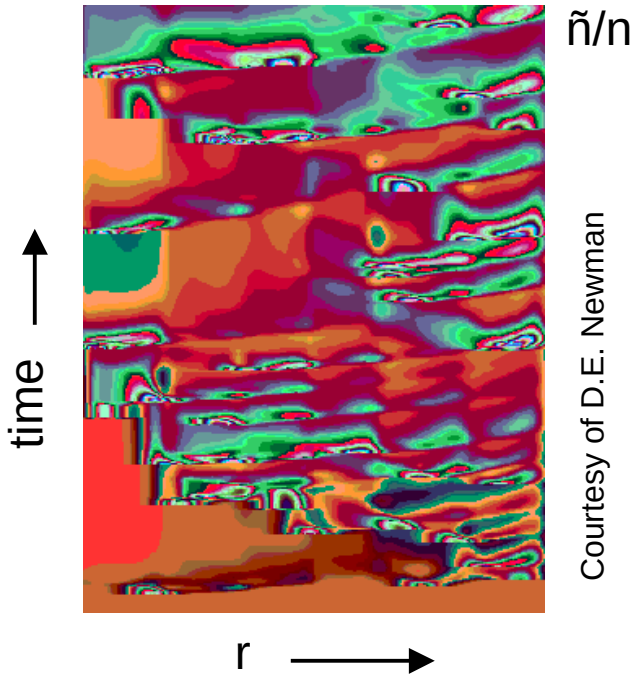
Presented at the 43rd Annual
APS Division of Plasma Physics Meeting
Long Beach, CA
Oct 29-Nov 2, 2001

UCLA DIII-D NATIONAL FUSION FACILITY NSTX

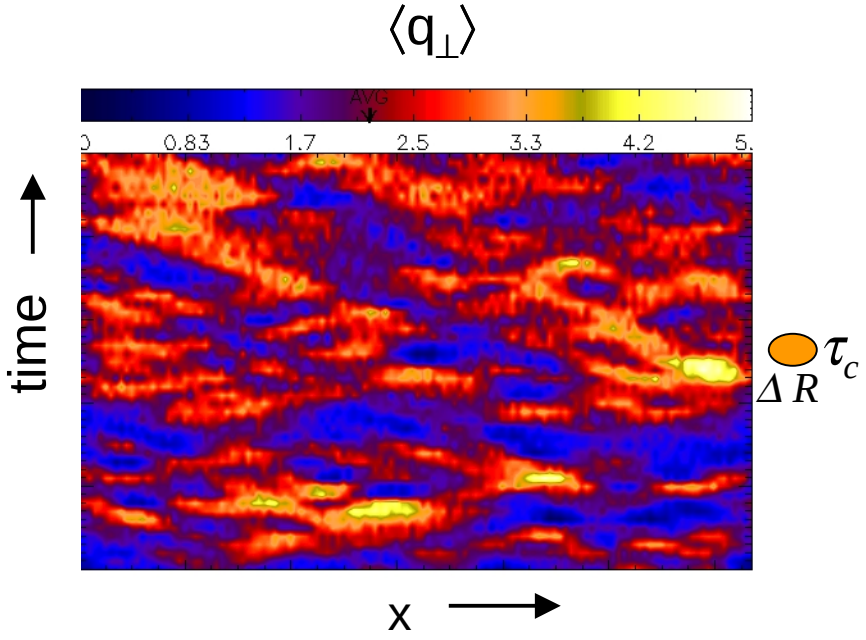
Motivation

Long-range correlations (time, space) - *thought to significantly affect cross-field transport* - have been predicted in

- Self-organized criticality (SOC)-based models (“avalanches”)
- Gyrokinetic simulations (radially-extended “heat pulses”, “streamers”))
- Analytical standard turbulence-based models



Courtesy of D.E. Newman



Courtesy of W.M. Nevins

Turbulent Time-Scales and Hurst Parameters

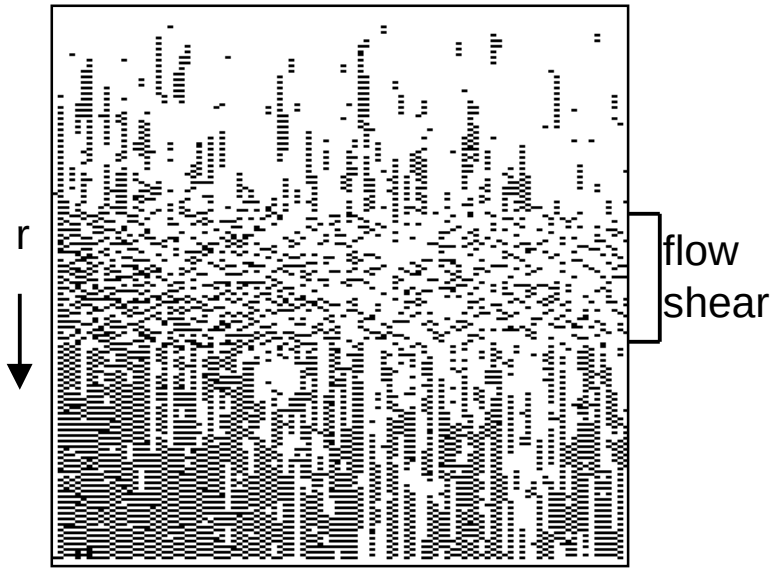
- Three time scales of turbulent transport:
  - Short times: "local" turbulence, τ_L
  - Intermediate times: "mesoscale", τ ~ 100-1000's τ_L
  - Long-times: "system-scale" events

- The Hurst Parameter, H, is a self-similar scaling exponent: 0 < H < 1

  e.g. $S_q(\tau) = C_q \tau^{qH(q)}$, where

  - H > 0.5 indicates persistence or long-time correlation
  - H = 0.5 indicates an uncorrelated purely random process
  - H < 0.5 indicates anticorrelation

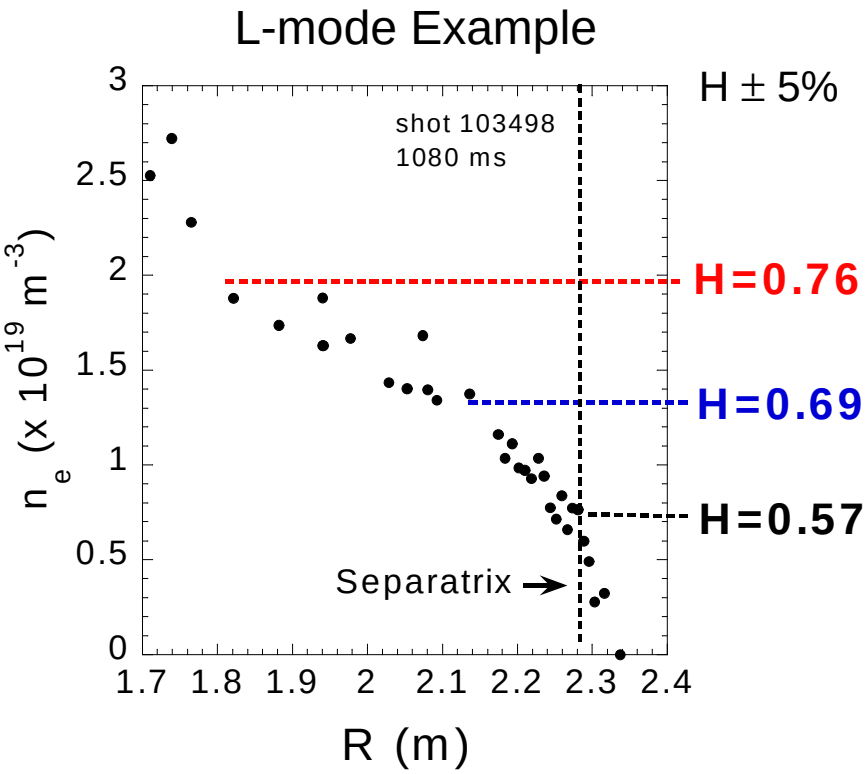
Sheared flow decorrelation of avalanches:
No shear: H = 0.83; With shear: H = 0.57



Courtesy of D.E. Newman

DIII-D Core Plasmas Show Long-Time Correlations

- Midplane density fluctuations monitored by O-mode homodyne reflectometry



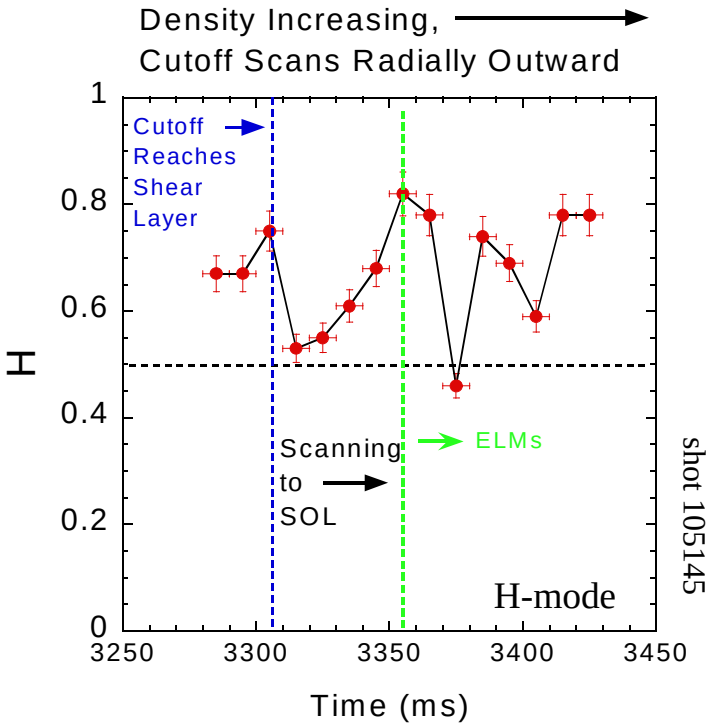
• H = 0.6 - 0.8 in the core under a variety of conditions: ohmic, L-mode, H-mode, ITB, QDB

UCLA

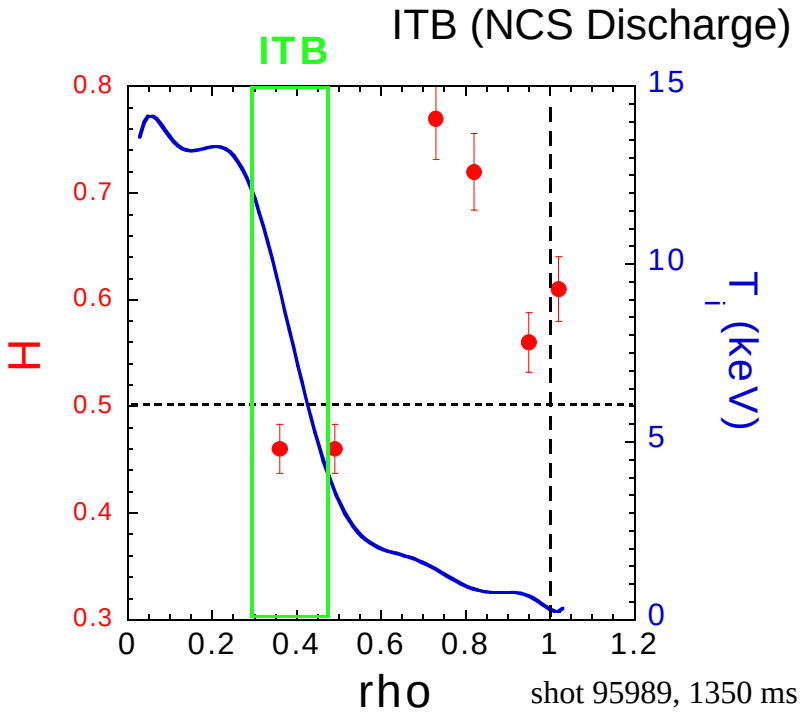
DIII-D NATIONAL FUSION FACILITY

Sheared Flow Layers (Edge, Internal) Show Reduced Persistence

Edge



Internal



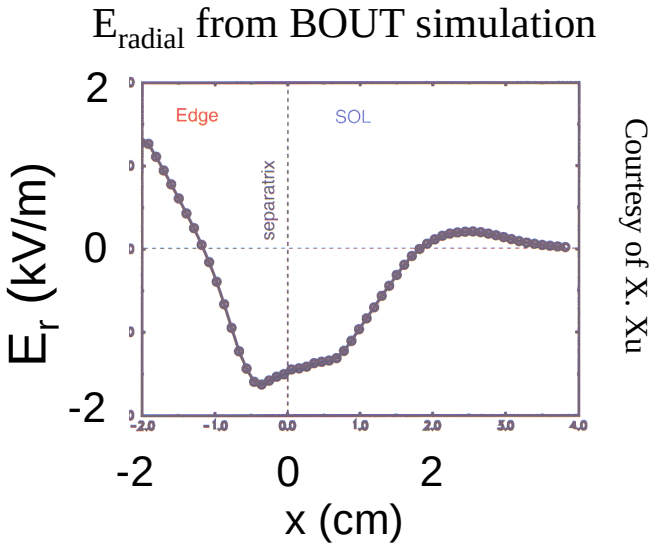
- **L-modes have shown similar reductions in H at ρ ~ 0.9**
- **RI-mode and QDB discharges have also shown reduced H at the ITB**

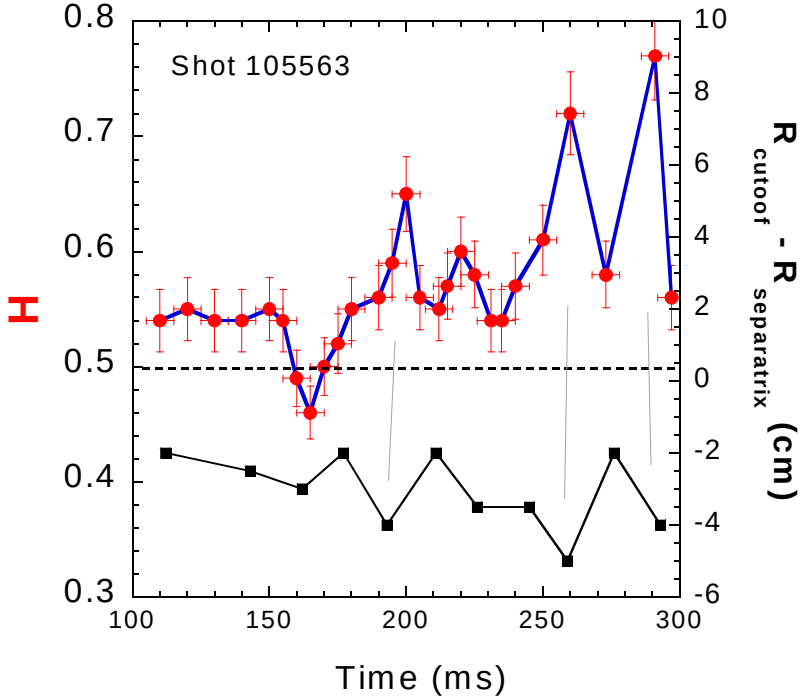
UCLA

DIII-D NATIONAL FUSION FACILITY

NSTX Plasmas Show Long-Time Correlations and Reduced Persistence Near the Separatrix (Preliminary)

- H = 0.6 - 0.75 in L-mode
- Variations in H associated w/ proximity to separatrix. Can be interpreted as a shear flow effect.





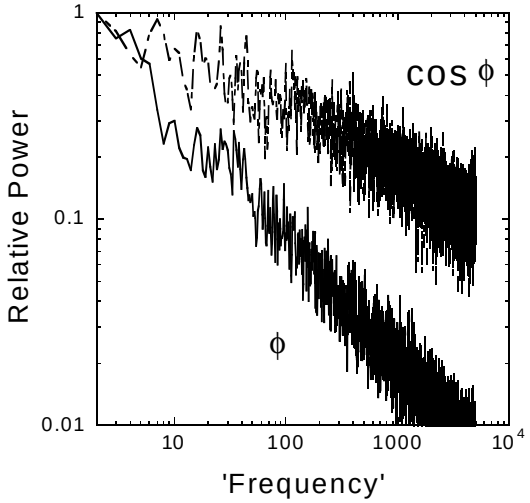
- 20-30 GHz O-mode homodyne reflectometer: $\rho \approx 0.8$ - 1, midplane

Summary

- Long-time correlations in density fluctuations have been investigated in DIII-D and NSTX using O-mode homodyne reflectometry.
- Long-time correlations, ($H \approx 0.6$ - 0.8), found in core and edge density fluctuations in DIII-D under a variety of conditions (ohmic, L-mode, H-mode, ITB, QDB).
- Reduced persistence ($H \sim 0.5$) found in both edge and internal sheared-flow layers in DIII-D
- (Preliminary) Long-time correlations found in NSTX L-mode edge ($\rho \sim 0.8$ - 1.0) and reduced persistence observed in edge sheared flow region.

What about the reflectometer cos ϕ nonlinearity?

- $\tilde{\phi} \propto \tilde{n}$
- $\cos \tilde{\phi}$ spectrum different from $\tilde{\phi}$ spectrum



- However, homodyne spectra,

$$I(t) = \tilde{A} \cos \tilde{\phi}$$

have shown strong similarity to probes