Resistive MHD Analysis of NSTX shot 124379 with M3D-C^1

J. Breslau, S. Gerhardt, S. Jardin

NSTX Results/Theory Review

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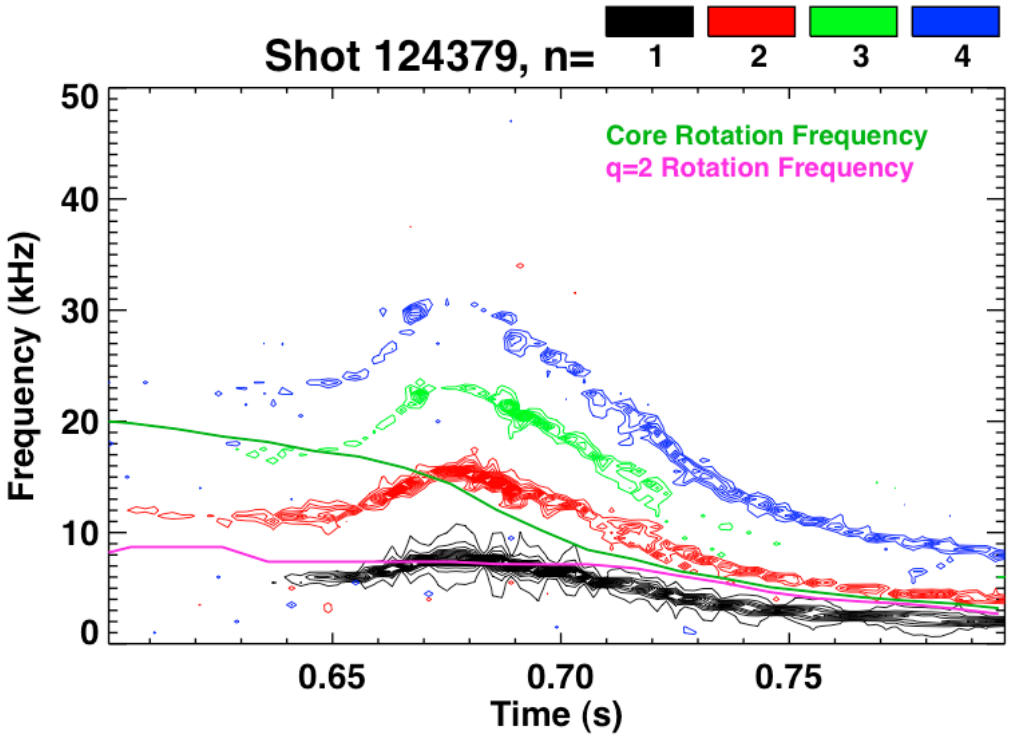
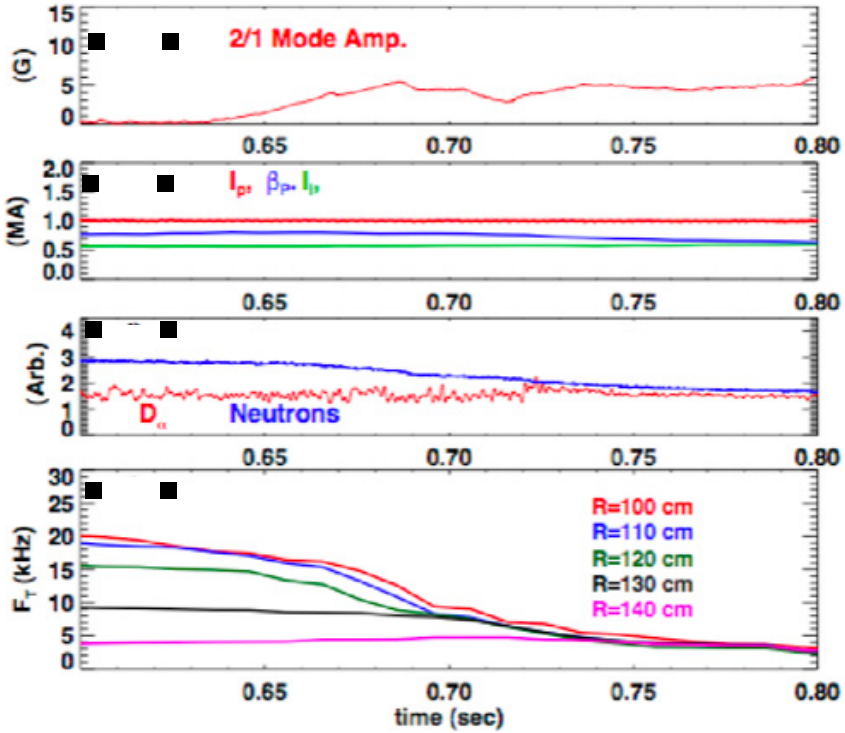
Motivation

NSTX shot 124379 has a steadily growing 2,1 mode with no apparent trigger seen by the USXR, D_α, or neutron diagnostics.

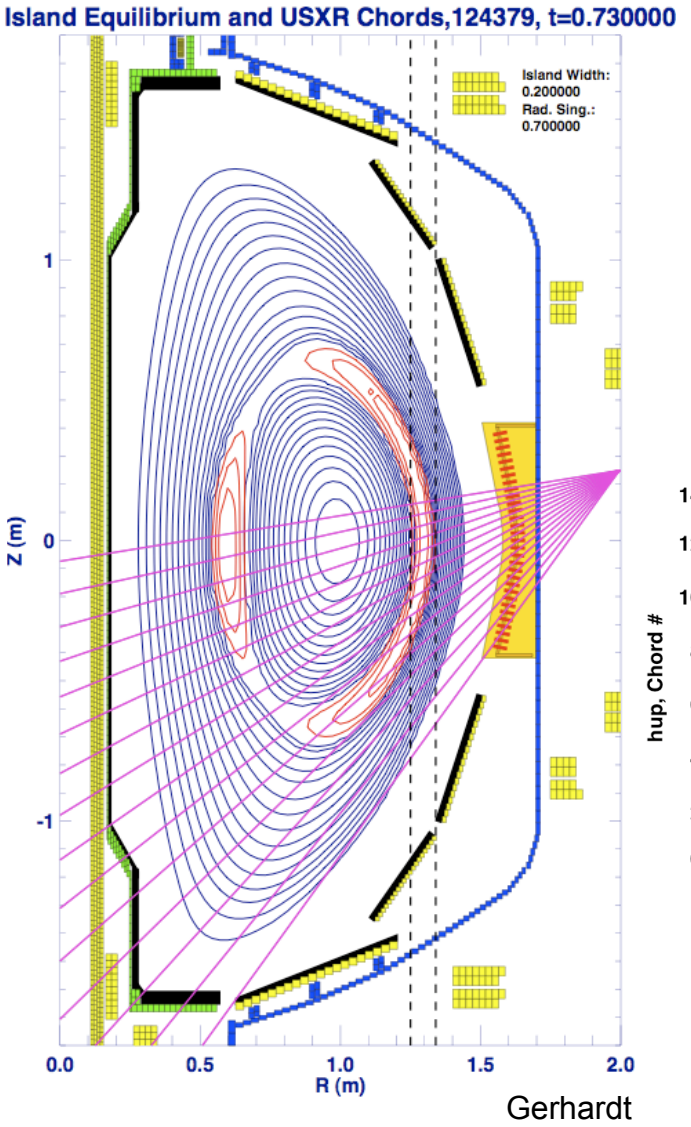




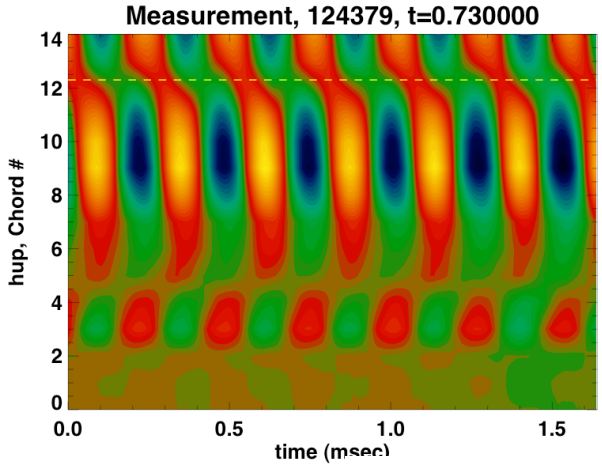
Gerhardt

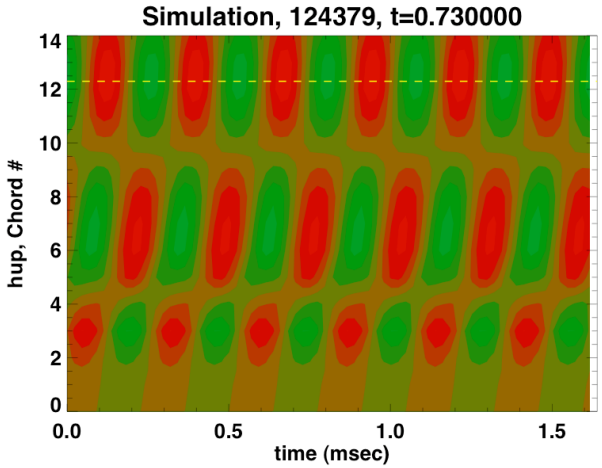
Is it linearly unstable?

Eigenfunction Analysis of Multichord Data Suggests Coupling to 1,1 Ideal Kink

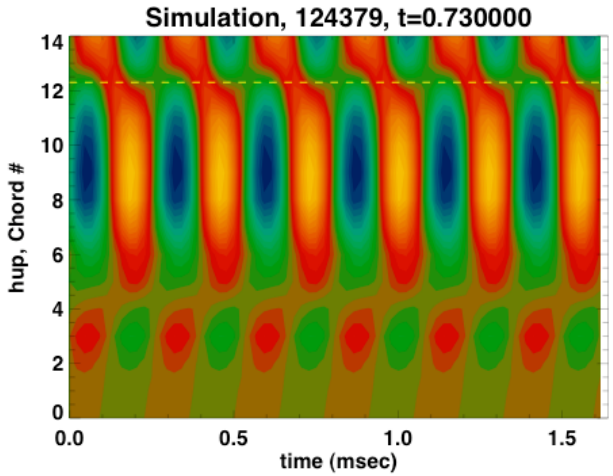


Gerhardt





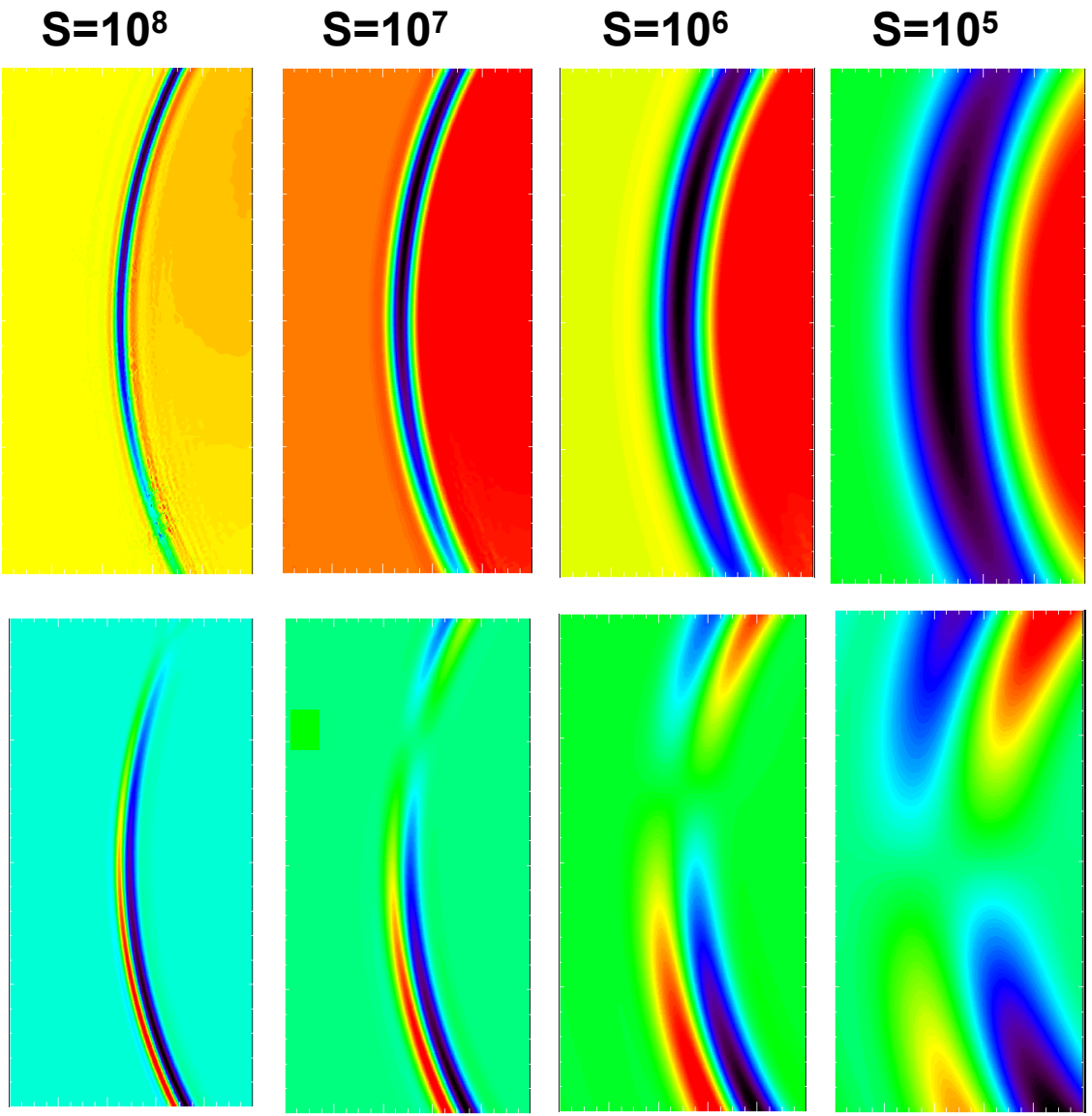
2,1 only



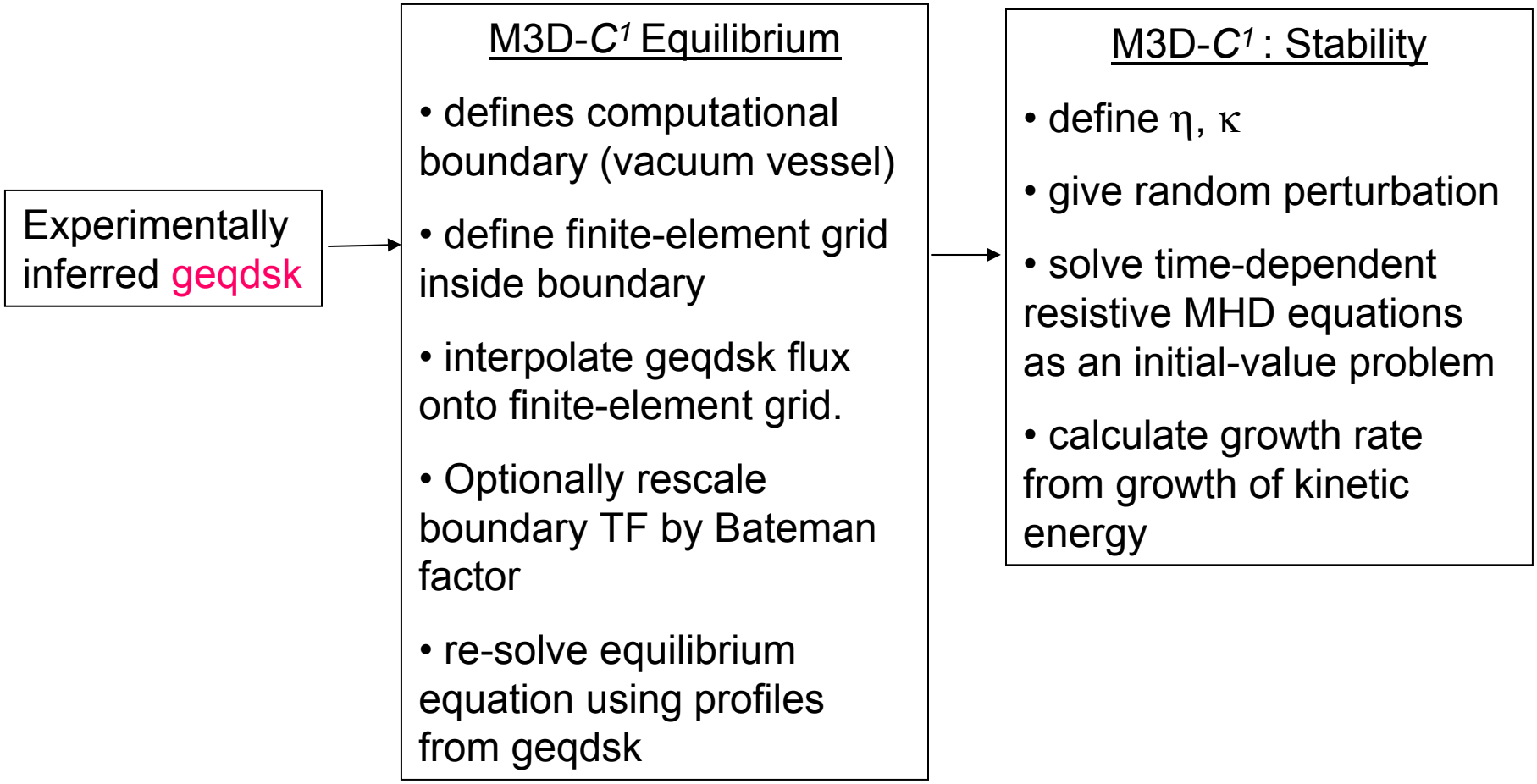
2,1 + 1,1 pert

M3D-C^1 code has higher resolution and implicit time stepping. This will allow studies at higher S values.

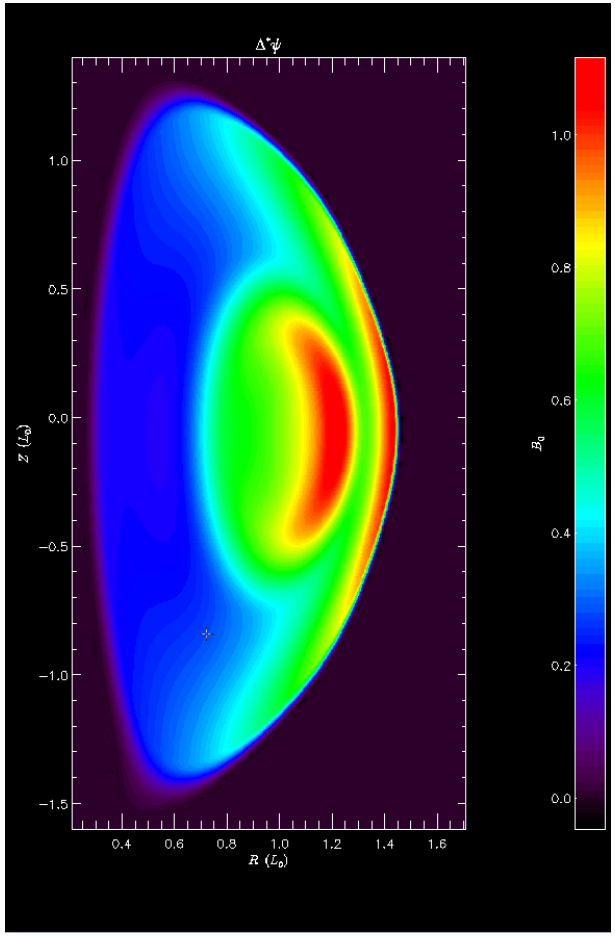
Perturbed current density (top) and vorticity (bottom) for (1,1) tearing mode at different S



Work flow

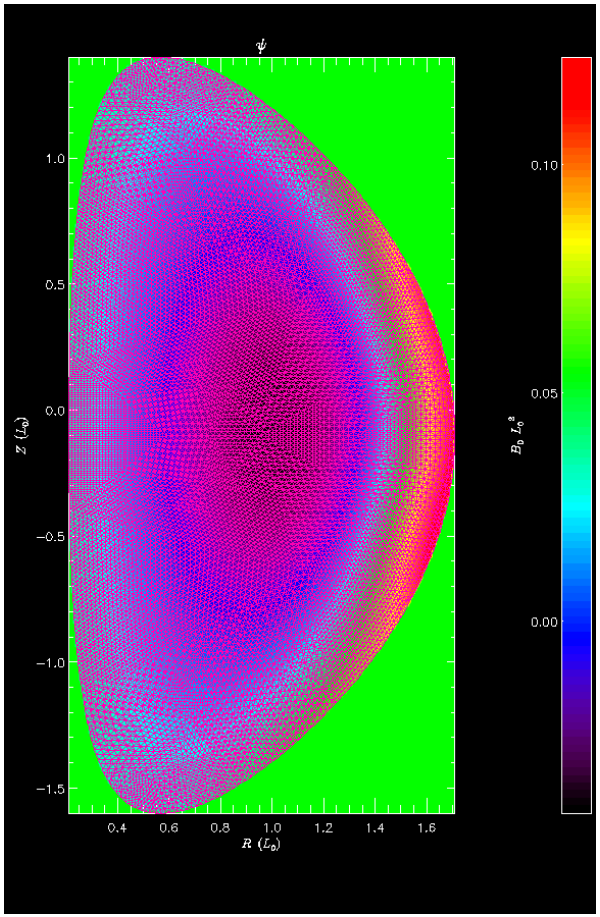

Experimentally inferred geqdsk
M3D-C¹ Equilibrium
• defines computational boundary (vacuum vessel)
• define finite-element grid inside boundary
• interpolate geqdsk flux onto finite-element grid.
• Optionally rescale boundary TF by Bateman factor
• re-solve equilibrium equation using profiles from geqdsk
M3D-C¹ : Stability
• define η, κ
• give random perturbation
• solve time-dependent resistive MHD equations as an initial-value problem
• calculate growth rate from growth of kinetic energy

Run g124379 time slice 640



Equilibrium Current Density

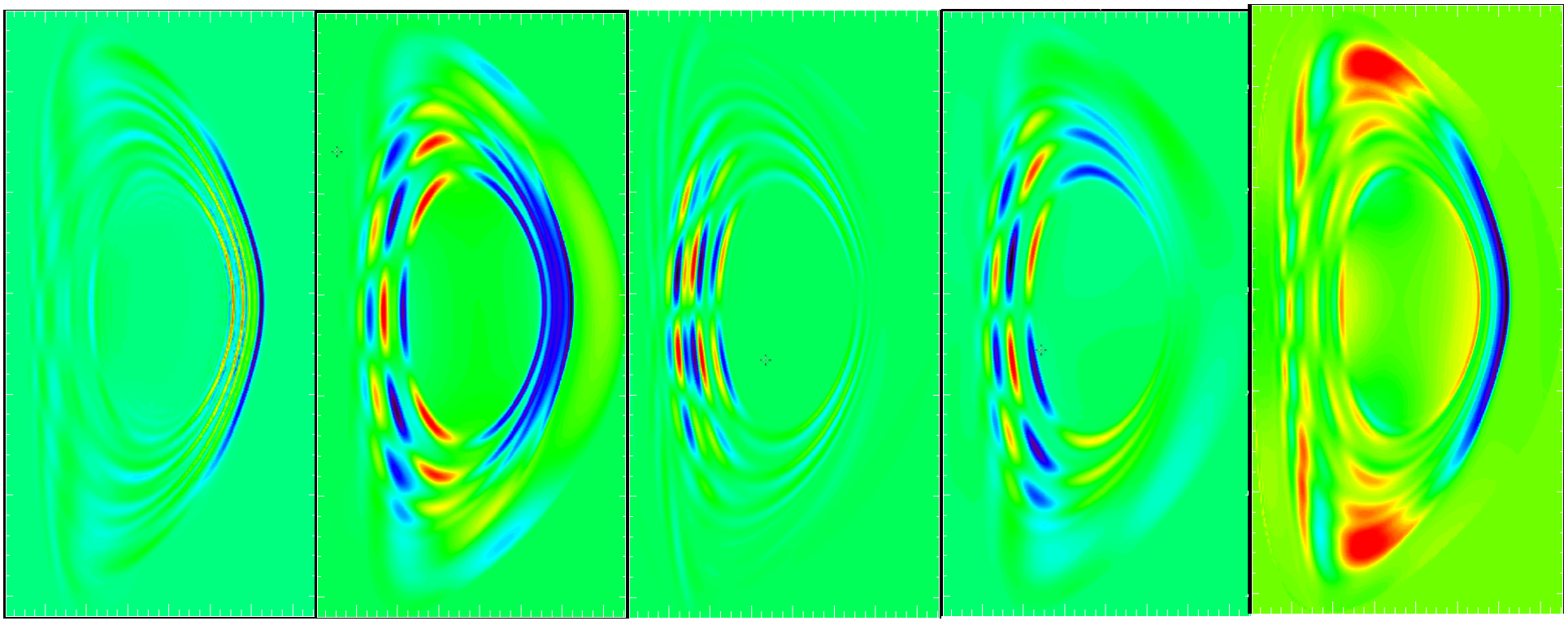
1.3 < q < 12



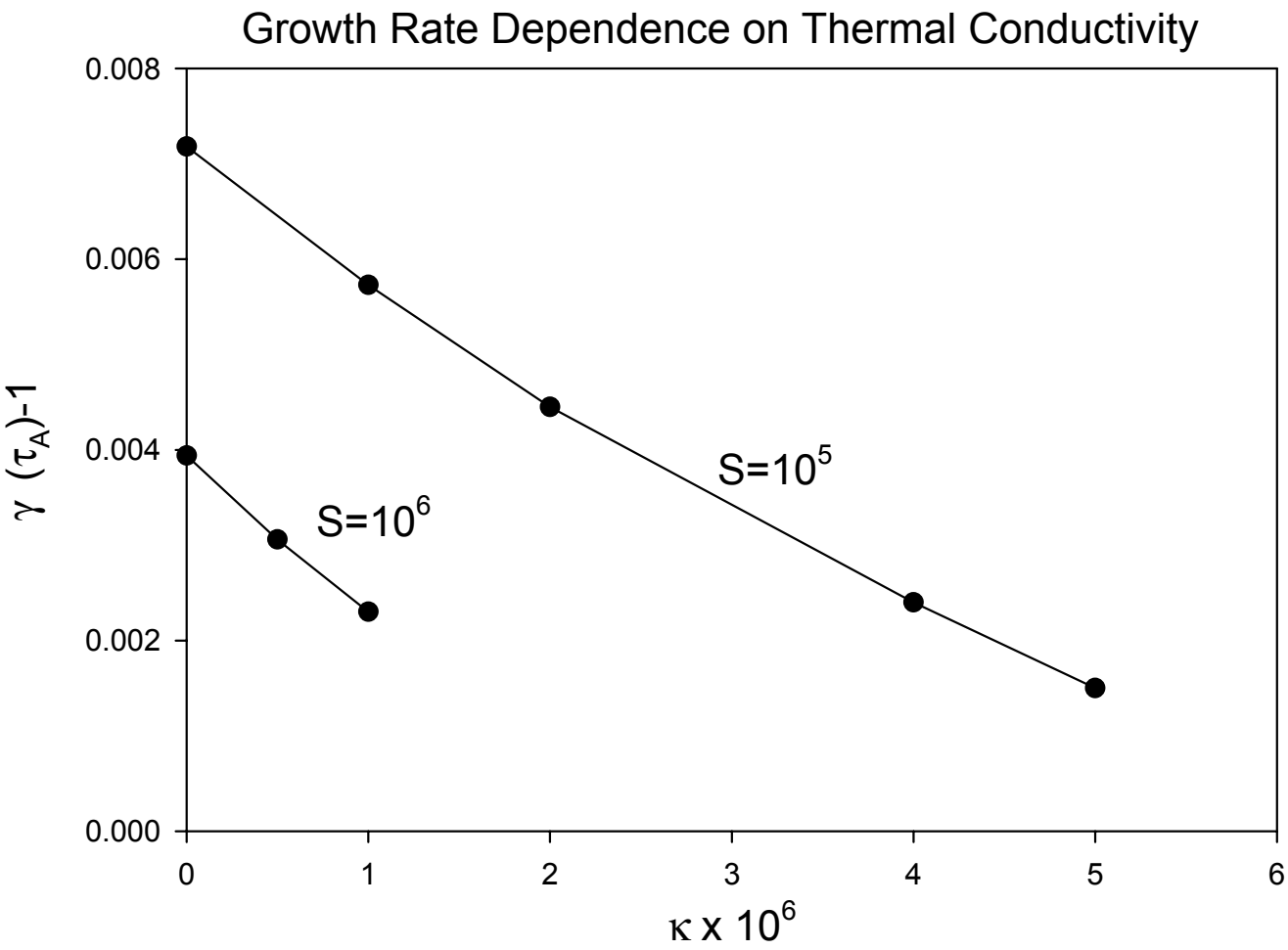
Equilibrium Flux with Mesh

Found an n=1, m>2 mode near the boundary

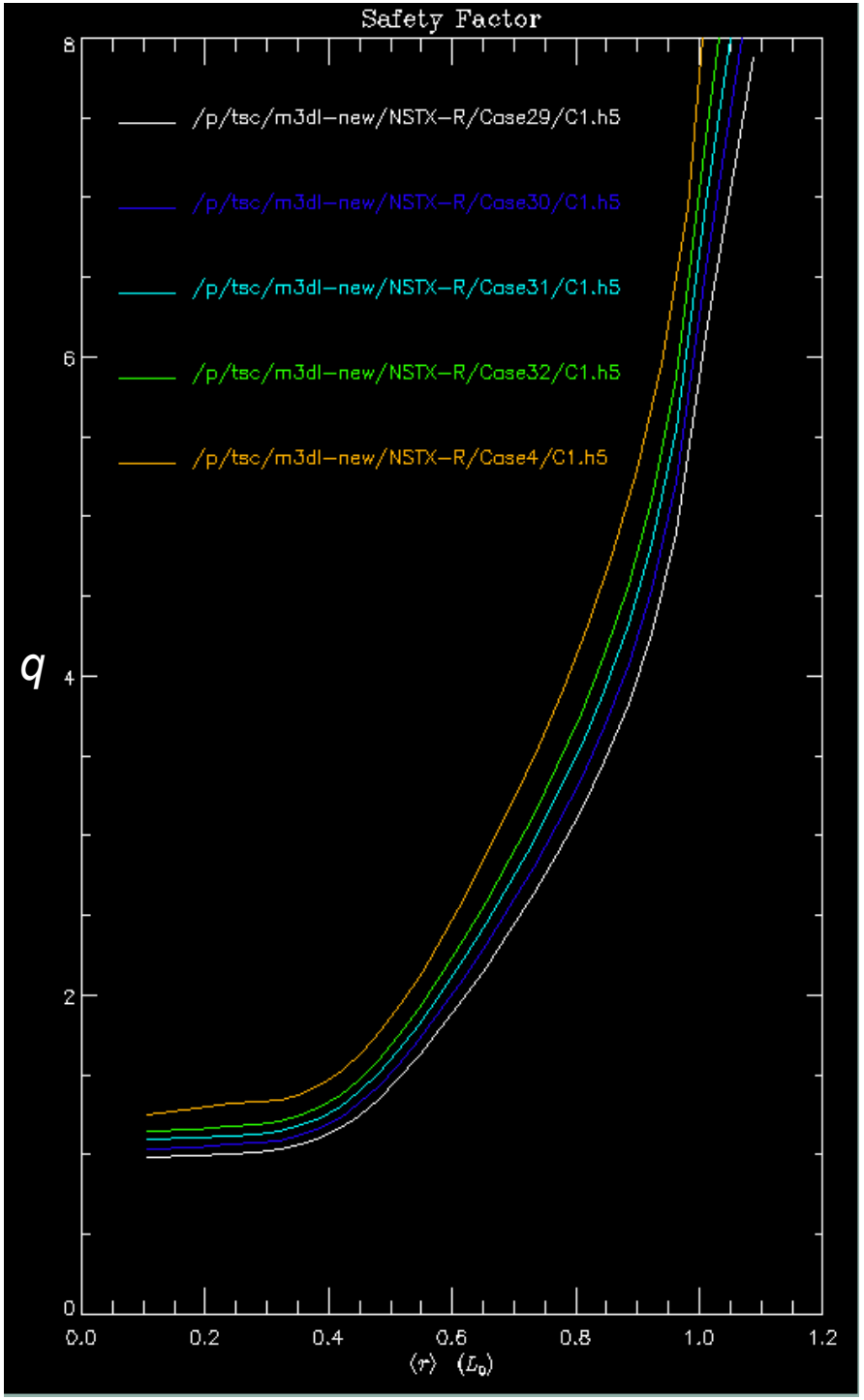
Contours of some perturbed quantities



J_ϕ $\nabla\bullet\mathbf{V}$ $|\nabla\times\mathbf{V}|$ V_ϕ p

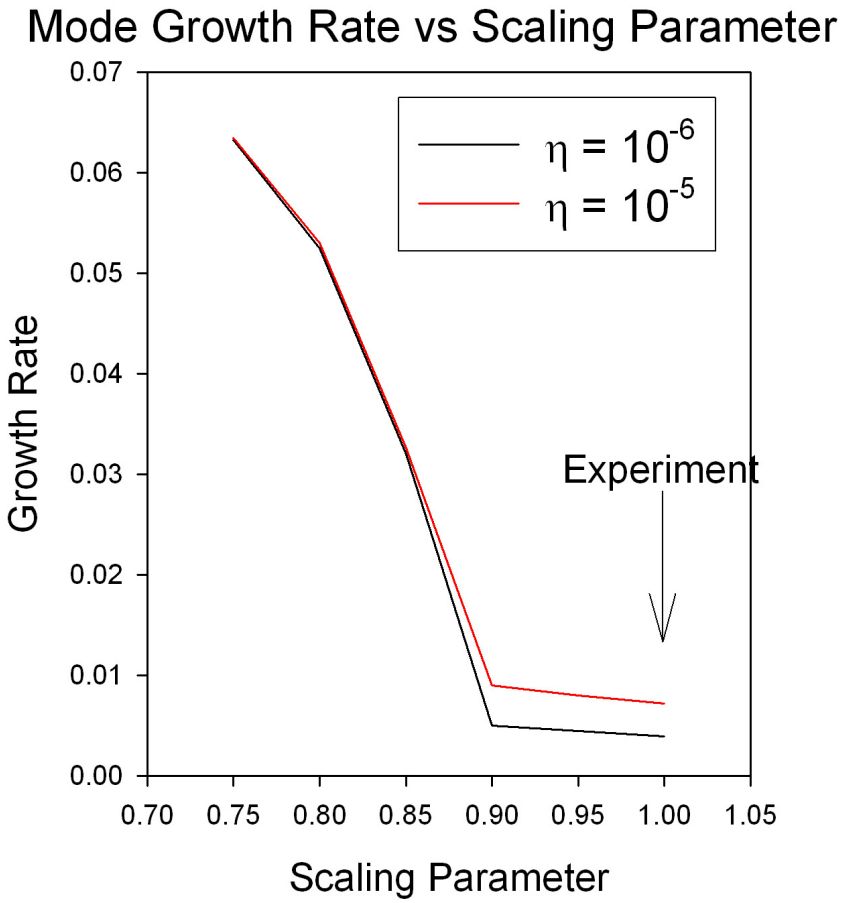


Mode growth rate $\gamma \sim \eta^{1/4}$ and is stabilized by κ (thermal conductivity)



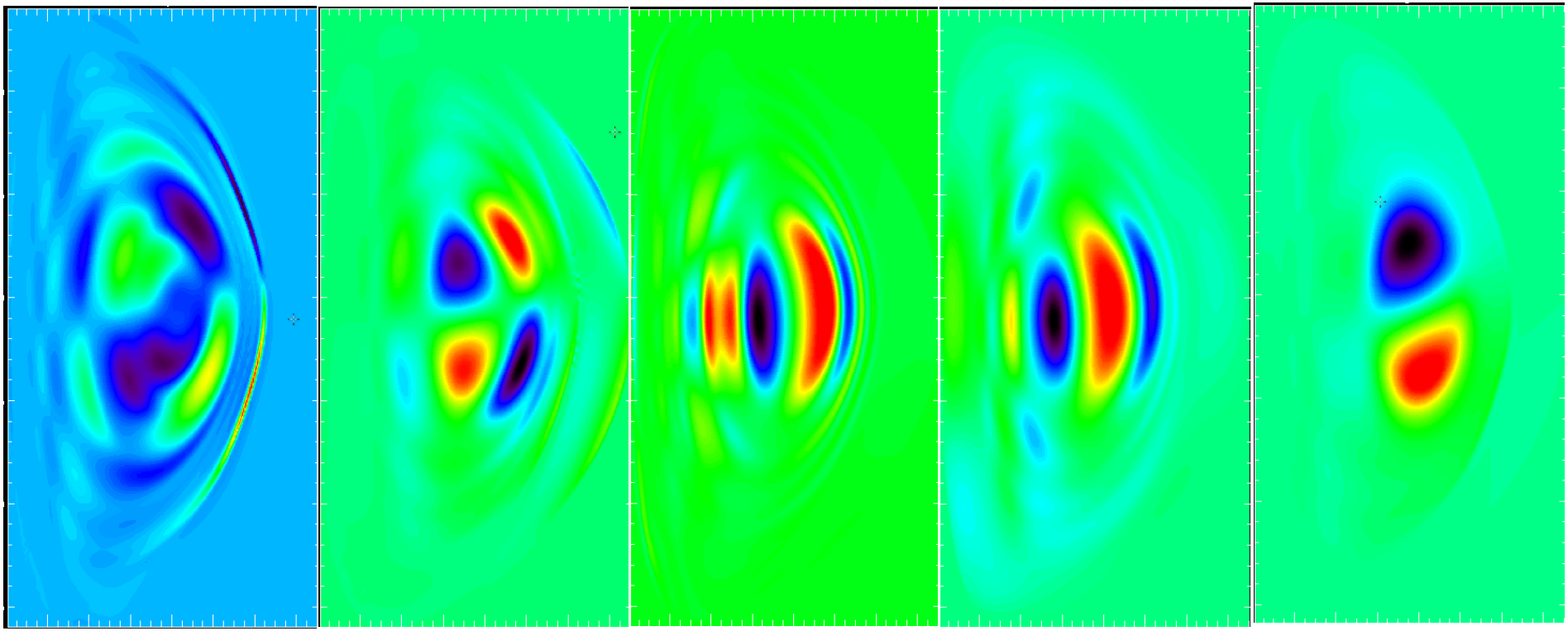
Toroidal field was scaled down, keeping current density constant

q proportional to scaling factor



New mode has much higher growth rate and strong *m*=1 and other low *m* components

Contours of some perturbed quantities



J_ϕ $\nabla\bullet\mathbf{V}$ $|\nabla\times\mathbf{V}|$ V_ϕ p

Summary

- We first found an unstable n=1 mode that was not the experimental mode since
  - It is not of tearing or ideal MHD type.
  - It is stabilized by thermal conductivity.

- The n=1 mode found with slightly reduced q_0 does resemble the experimental mode.
  - Shows m=1 and m=2 components.
  - Internal ideal mode not resonant with q=1.
  - Scaling series suggests experiment is close to (or at) marginal stability for this mode.