

# M3D- $C^1$ code is replacing M3D for most applications

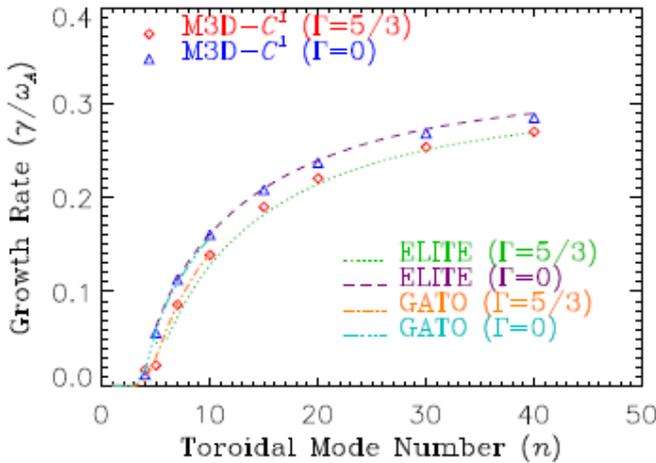
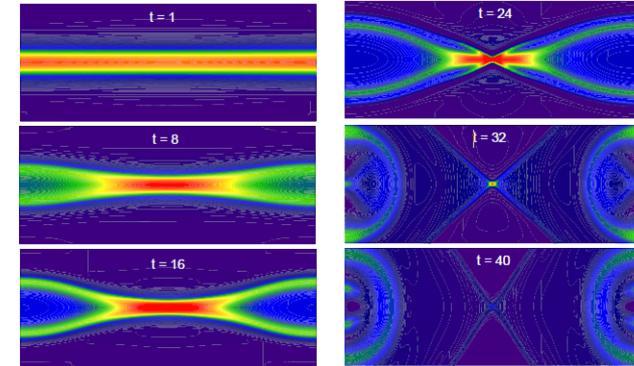
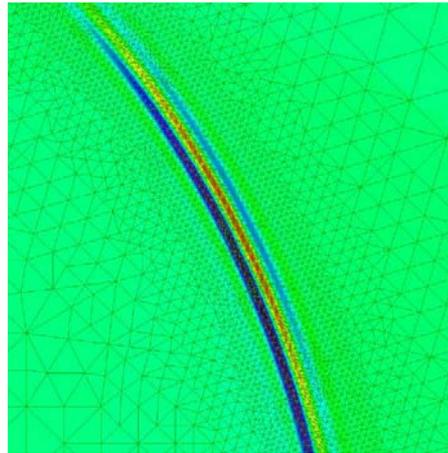
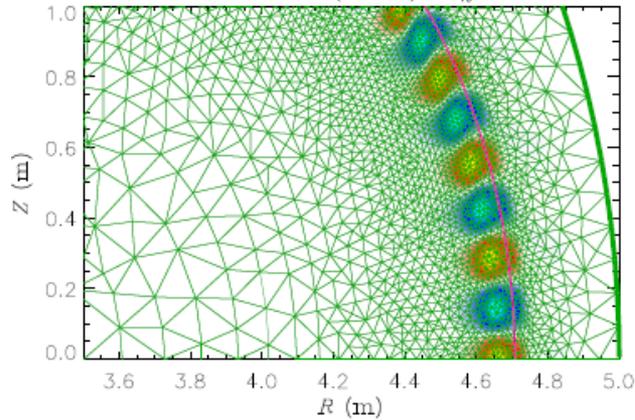
## Linear Mode:

- Resistive Stability
  - High  $S$  (up to  $10^8$ )
  - Includes rotation
  - Can read EQDSK files
- RMP studies
  - Including rotation and 2-fluid
  - Need to work with Ferraro
- Ideal ELMs
  - benchmarked with ELITE
- Resistive Wall Mode
  - soon

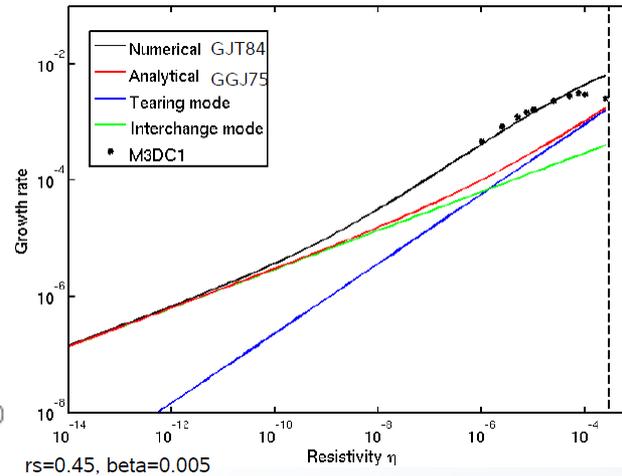
## Non-Linear Mode:

- Improved over M3D
  - High accuracy, larger  $S$
  - Much larger time step
  - Full 2-fluid model
- Sawtooth studies underway
  - extend to transport timescale
  - both periodic and stationary
- NTM studies planned
  - “Ramos” kinetic-extensions provides neoclassical terms

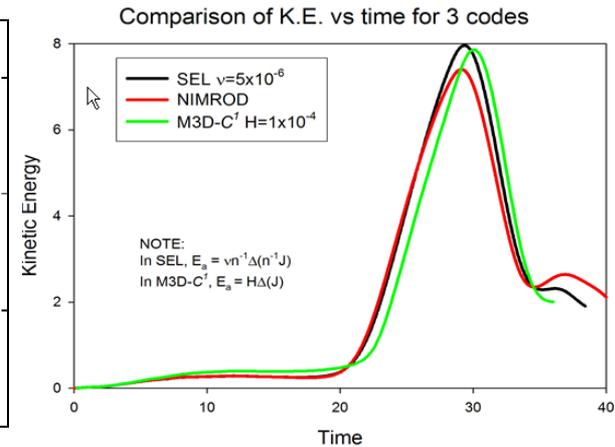
# Extensive benchmarking for ideal, resistive, and two fluid modes



**Ideal MHD**



**Resistive MHD**

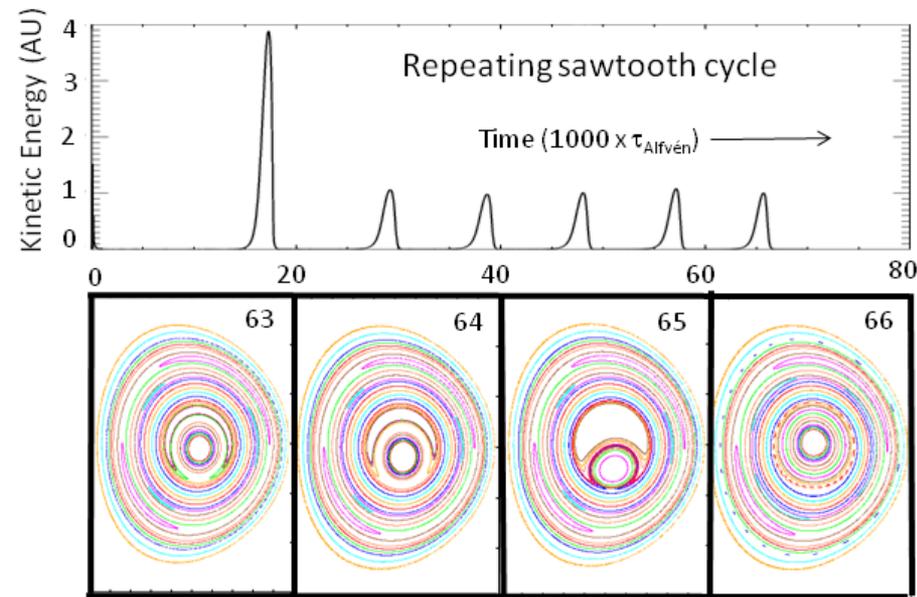


**2-Fluid Reconnection**

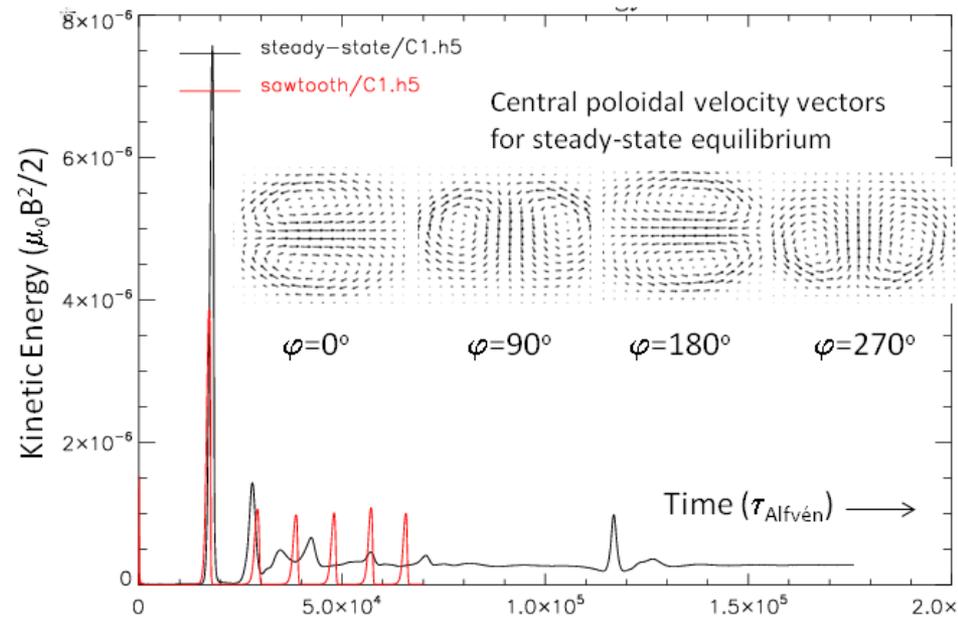
# Generic sawtooth studies are now underway

In these studies, code can take very large time steps  
( $\Delta t = 40 \tau_A$ ) to approach transport timescale:  $10^5 - 10^6 \tau_A$

=> Different behavior for different transport models

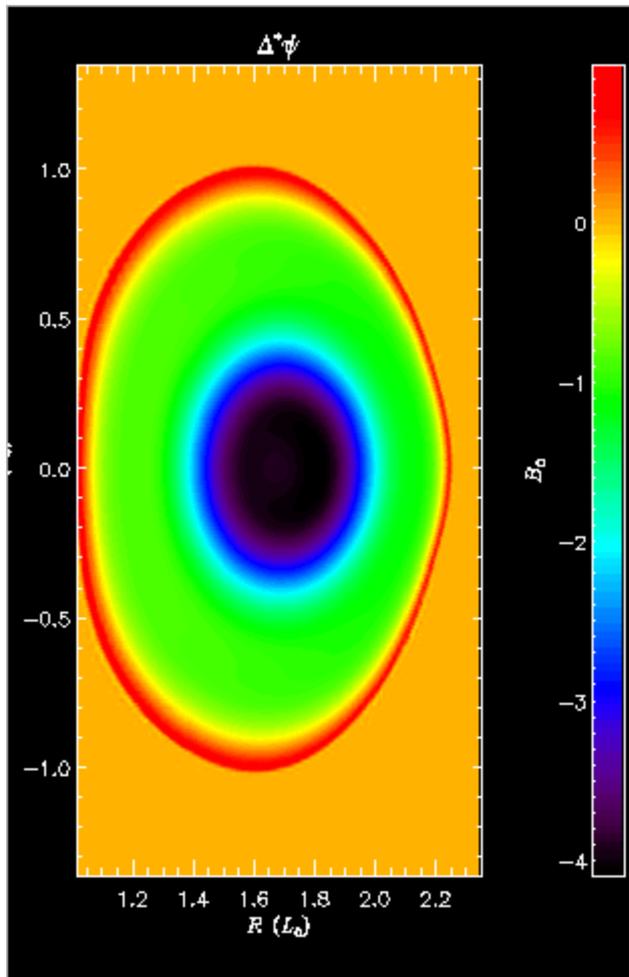


Repeating Sawteeth

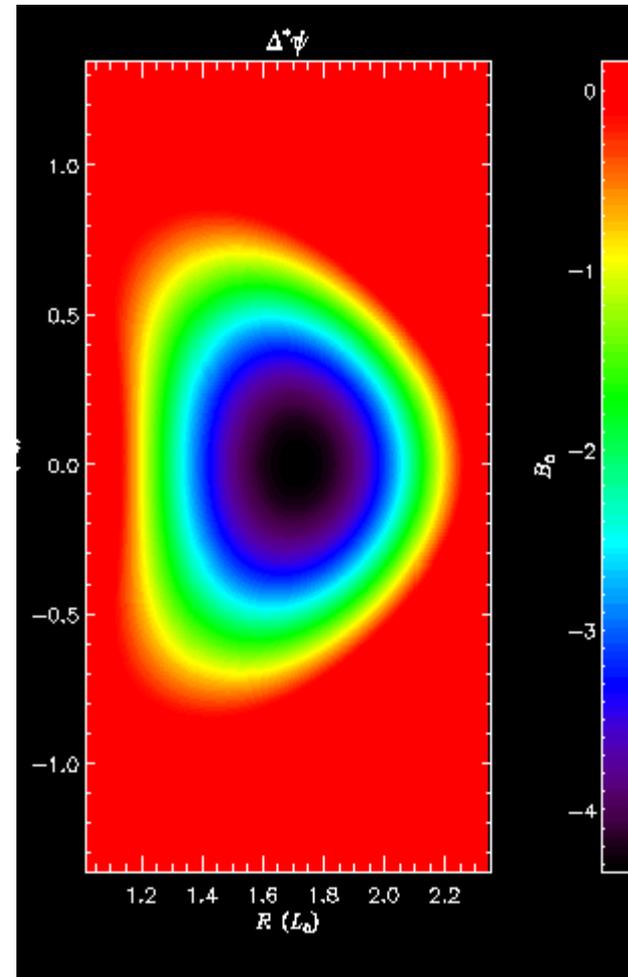


Stationary helical state

Differences in sawtooth behavior for bean-shaped and elliptical-shaped plasmas has been well documented experimentally (Lazarus, Tobias, ...)

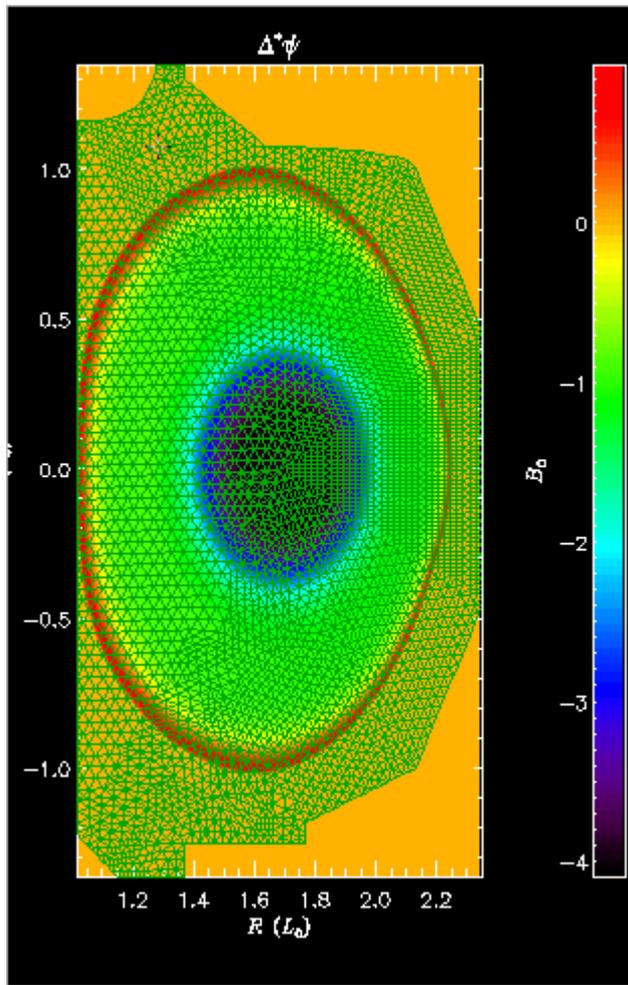


DIII-D shot 118164

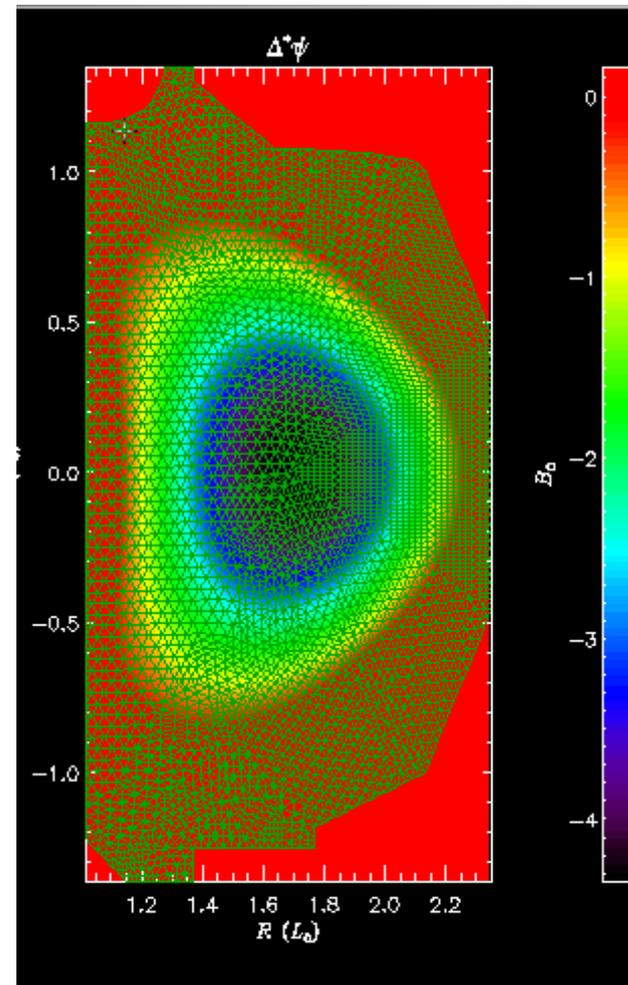


DIII-D shot 118162

We have imported these equilibria from geqdsk files, and inferred the transport properties from the plasma properties...simulations in progress

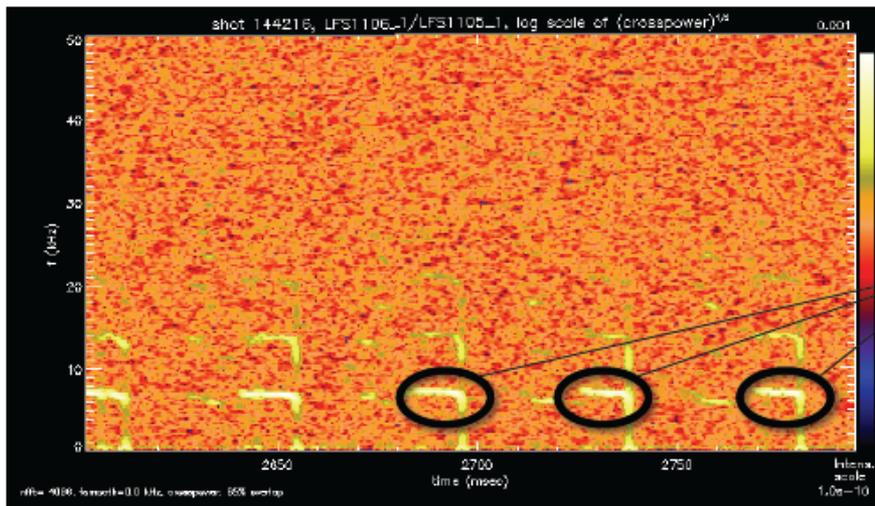


DIII-D shot 118164



DIII-D shot 118162

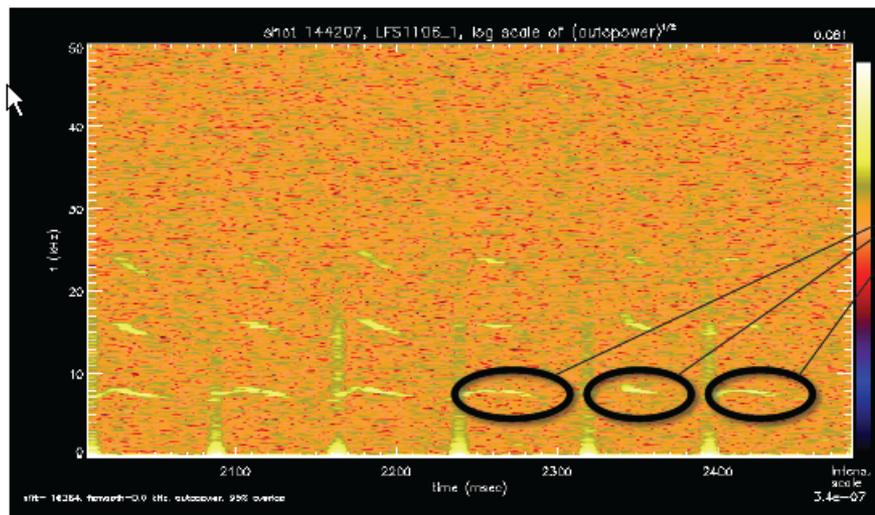
# Goal is to match MHD spectra and 2D ECEI data from Tobias, et al.



Sustained, saturated  
 $m/n=1/1$  mode  
precedes crash

At or above core  
rotation estimate  
from CERQUICK

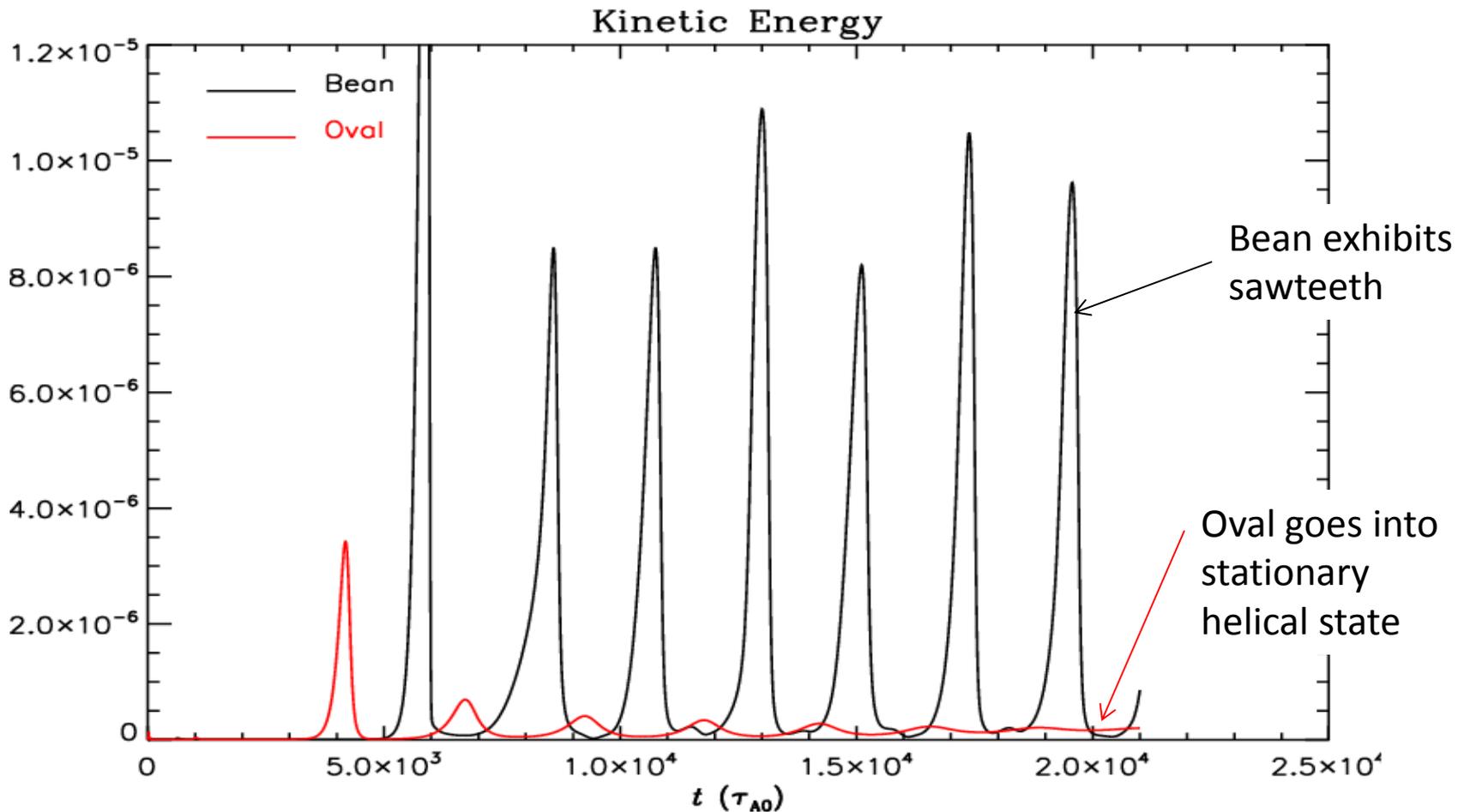
Oval (shots 144215, 16, 17, 19, 20)



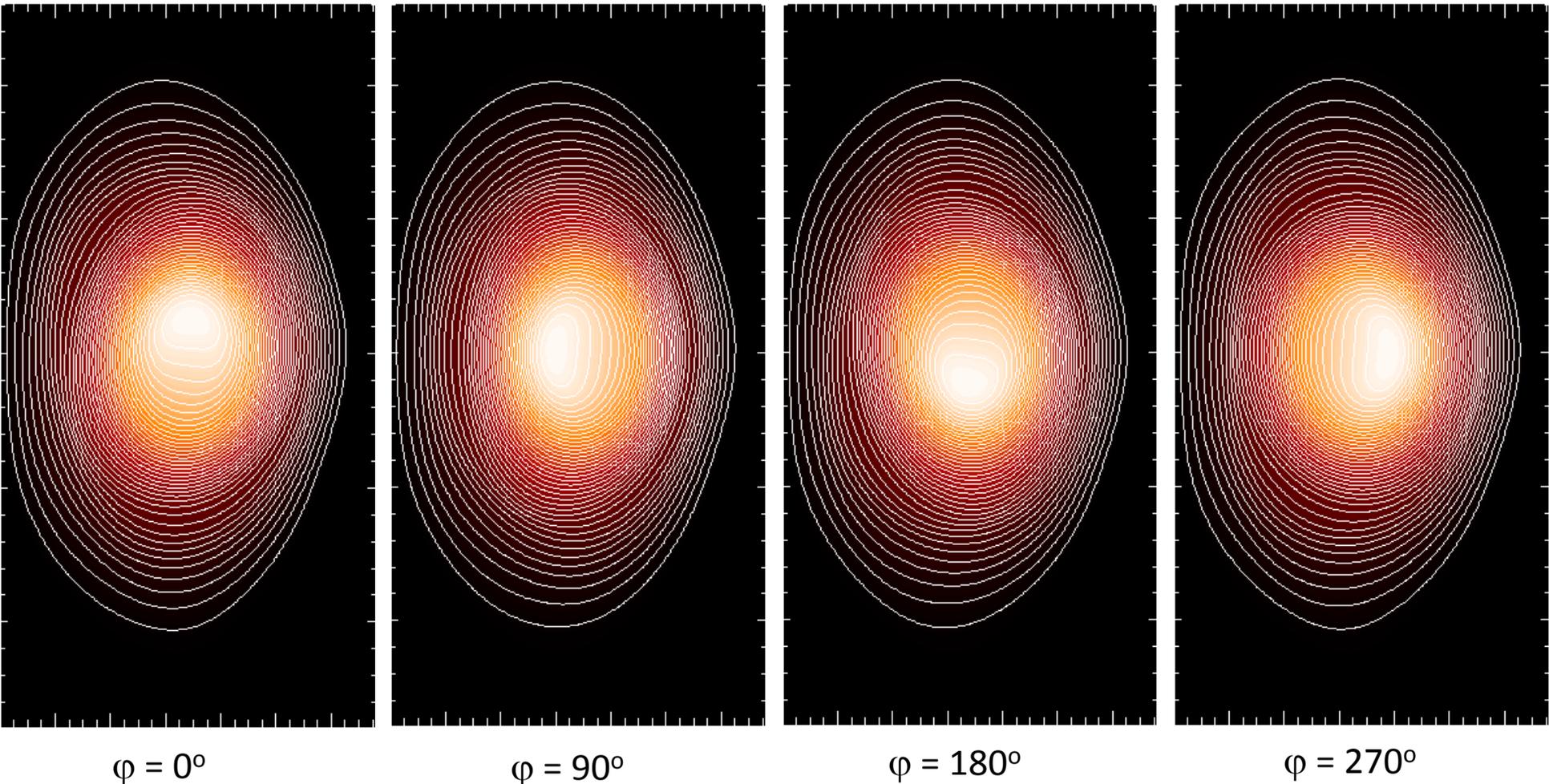
Early “post-cursor”  
type mode. Many  
features qualitatively  
similar to the  
downshifted mode  
observed in the oval  
case.

Bean (shots 144207, 08, 10)

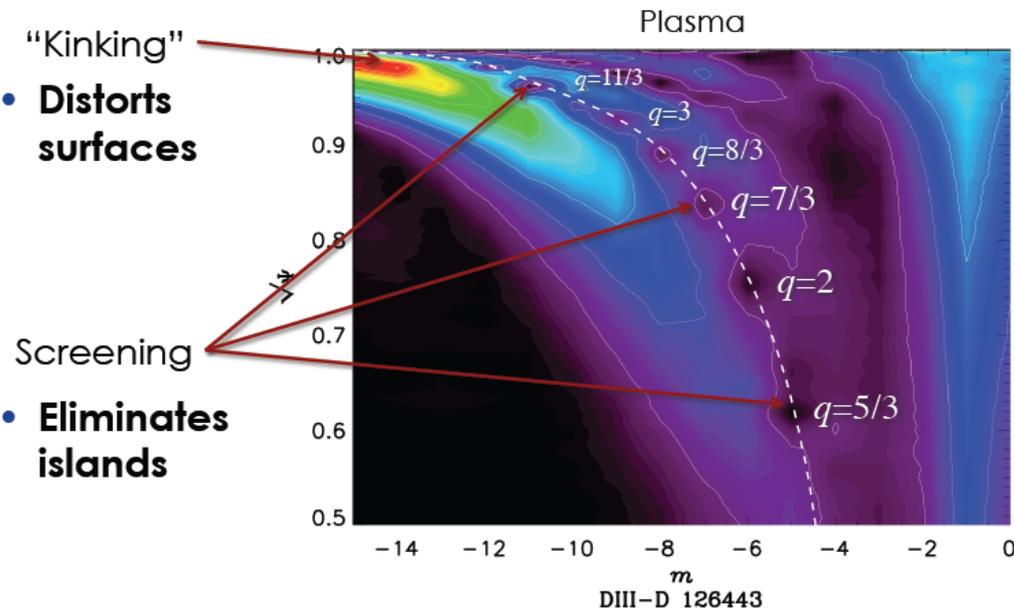
Initial nonlinear studies show dramatic difference between the bean and the oval shaped discharge with the exact same transport parameters!



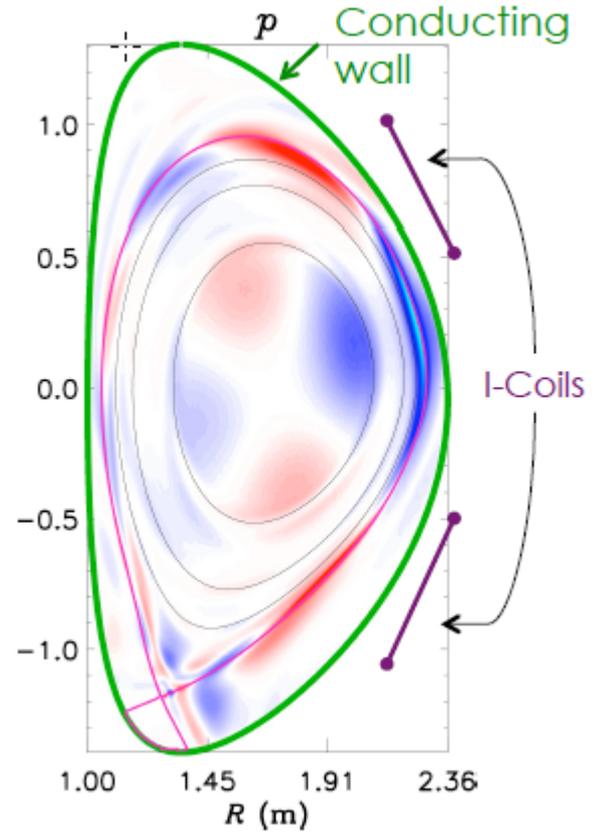
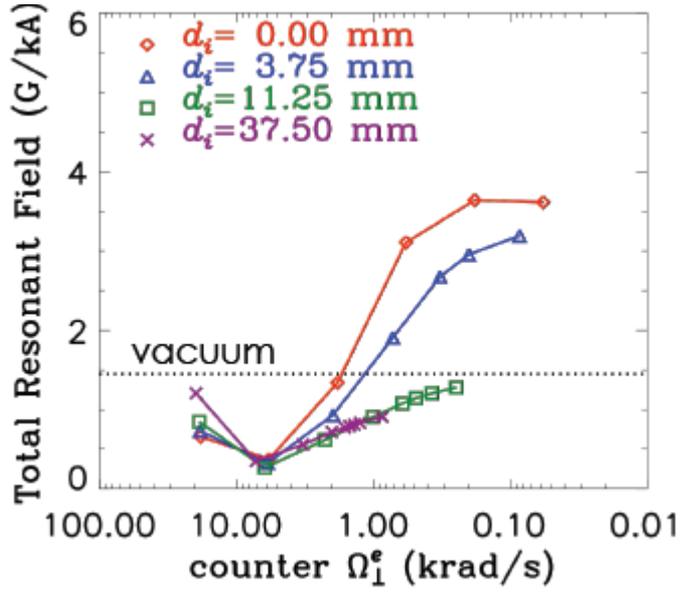
# Pressure contours as a function of toroidal angle for DIII-D Oval (shot 118164)



Stationary on all timescales: resistive, energy confinement, particle ...



Ferraro applying M3D-C<sup>1</sup> to interpret RMP experiments in DIII-D (linear and non-linear)



Screening is max when electron fluid velocity  $\sim 10$  krad/s.  
Amplification at lower velocities for resistive MHD model.

# M3D-C<sup>1</sup> Near Term Plans

- Extend sawtooth studies to 2F model and compare with DIII-D data (with B. Tobias)
- Add kinetic terms to study NTM seeding and growth (with B. Lyons and J. Ramos)
- ELM studies for CPES (with C.S. Chang, L. Sugiyama?)
- Complete resistive wall implementation
- Analysis of ITER RMP coils (N. Ferraro)
- Density limit studies ??