NIMROD Simulations at the PSI Center

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PSI Center NIMROD Simulations

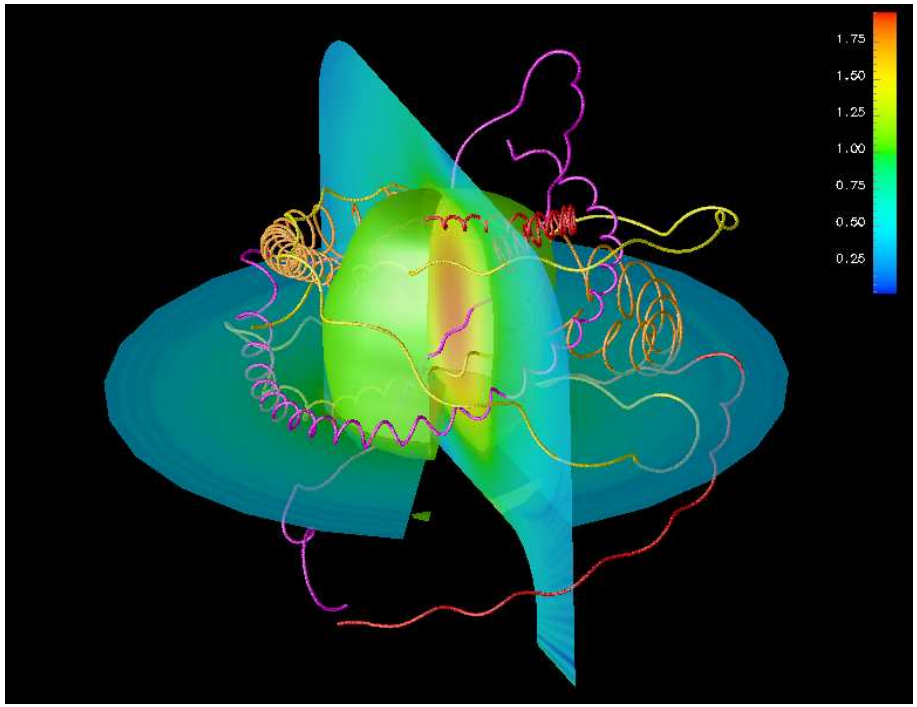
- MST - study of FLR effects on tearing modes
- LDX - interchange instability studies (transferred to J. Kesner)
- SSX - stability in an oblate flux conserver
- FRC - formation and translation
- ZaP - 3D stability of Z pinch with flow
- Bellan's Box - near future plans to take another stab

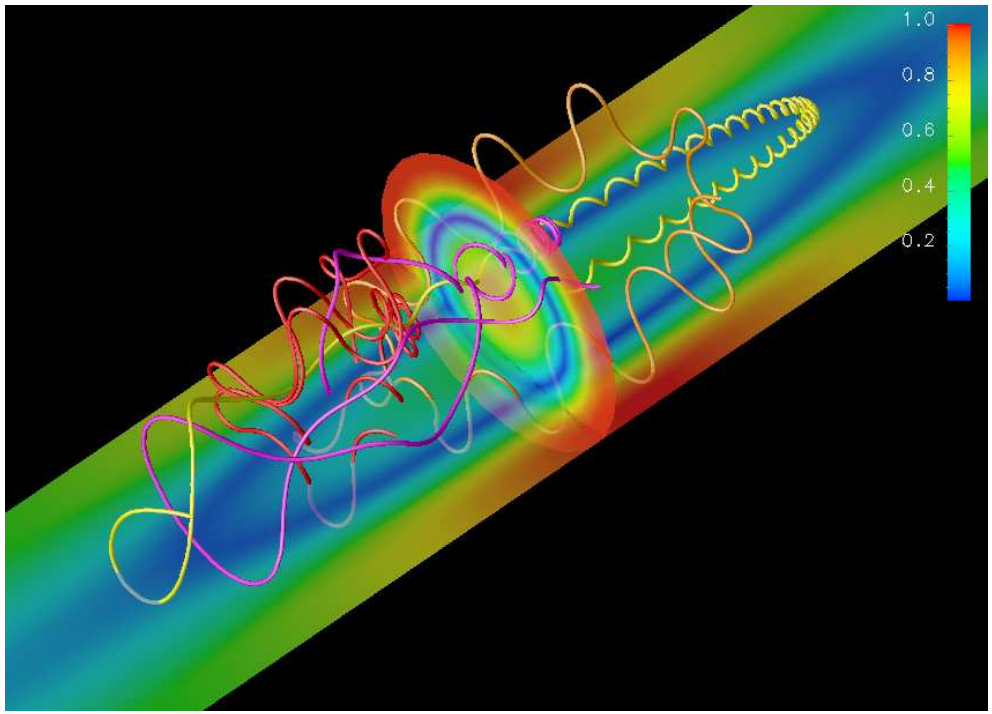
The Miscellany

- migrate PSI Center to nimdevel
- beginning simulations to study stabilizing effects of shaped flux conserver for SSX
- FRC simulations continue, nothing new since ICC
  - translation/compression studies
  - FRC thruster work
  - rotating magnetic field studies
  - effects of energetic particles
- HIT-SI simulations continue
- ZaP simulations beginning with simple Z pinch w/ flow
- focus on better gridding and boundary conditions
  - undergrad (B. Haynor) developing visual grid diagnostics and eventually tools to manipulate the grid
  - extend the lagr_edge stuff

Ion Orbits Nontrivial in ICC Devices

- nontrivial orbits in ICCs





FLR effects on Tearing Modes in RFPs

- V. A. Svidzinski[a] has show increasing stabilization with increasing ρ/a
- do some simulations
  - alpha model equilibrium $\nabla \times \mathbf{B} = \mu \mathbf{B} \quad \mu = 2\Theta \left[1 - \left(\frac{r}{a}\right)^{\alpha_0}\right]$
  - parameters for straight cylinder

    $a = .5\text{m}$, $B_0 = .3\text{T}$, $\Theta = 1.75$, $\alpha_0 = 3$,

    $S = 1.e4$, $ka = 2$, $\gamma\tau_A = 1.3e-3$
  - Boris push with orbit averaging to accommodates disparate time scales
  - energetic ion density profile $\propto \exp\left[-\left(\frac{r}{0.45a}\right)^2\right]$
  - initialize with mono-energetic particles $\delta(\mathbf{v}_\perp - \mathbf{v}_0)$, only $\mathbf{v} \times \delta\mathbf{B}$ in weight equation
  - use **only** perpendicular pressure for comparison with theory

[a] V. A. Svidzinski and S. C. Prager, "Effects of particles with large gyroradii on resistive magnetohydrodynamic stability", PoP **11** 980, 2004

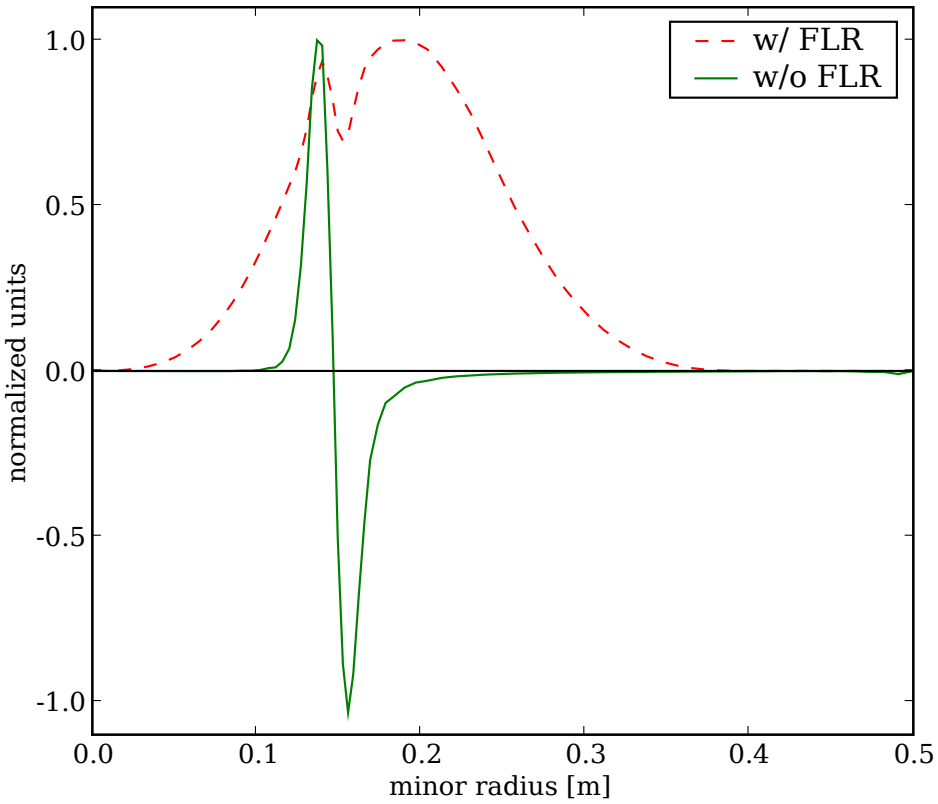
FLR Stabilization of RFP Tearing Mode

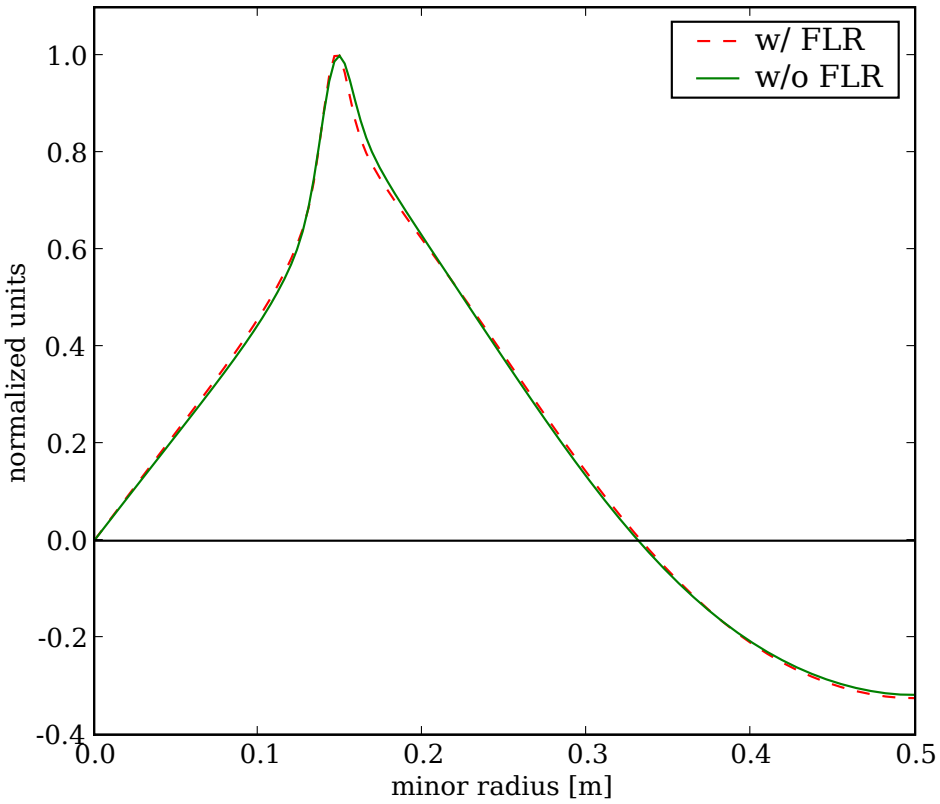
- stabilization with increasing $\mathbf{v}_\perp$

v_0(m/s)	L/a	$\gamma\tau_A$
base case	-	1.3×10^{-3}
1.0×10^6	.14	1.0×10^{-3}
1.5×10^6	.21	5.4×10^{-4}
2.0×10^6	.28	1.5×10^{-4}
2.5×10^6	.35	5.1×10^{-5}

- stabilization at $L/a \simeq 1/3$, where L is the Larmor diameter

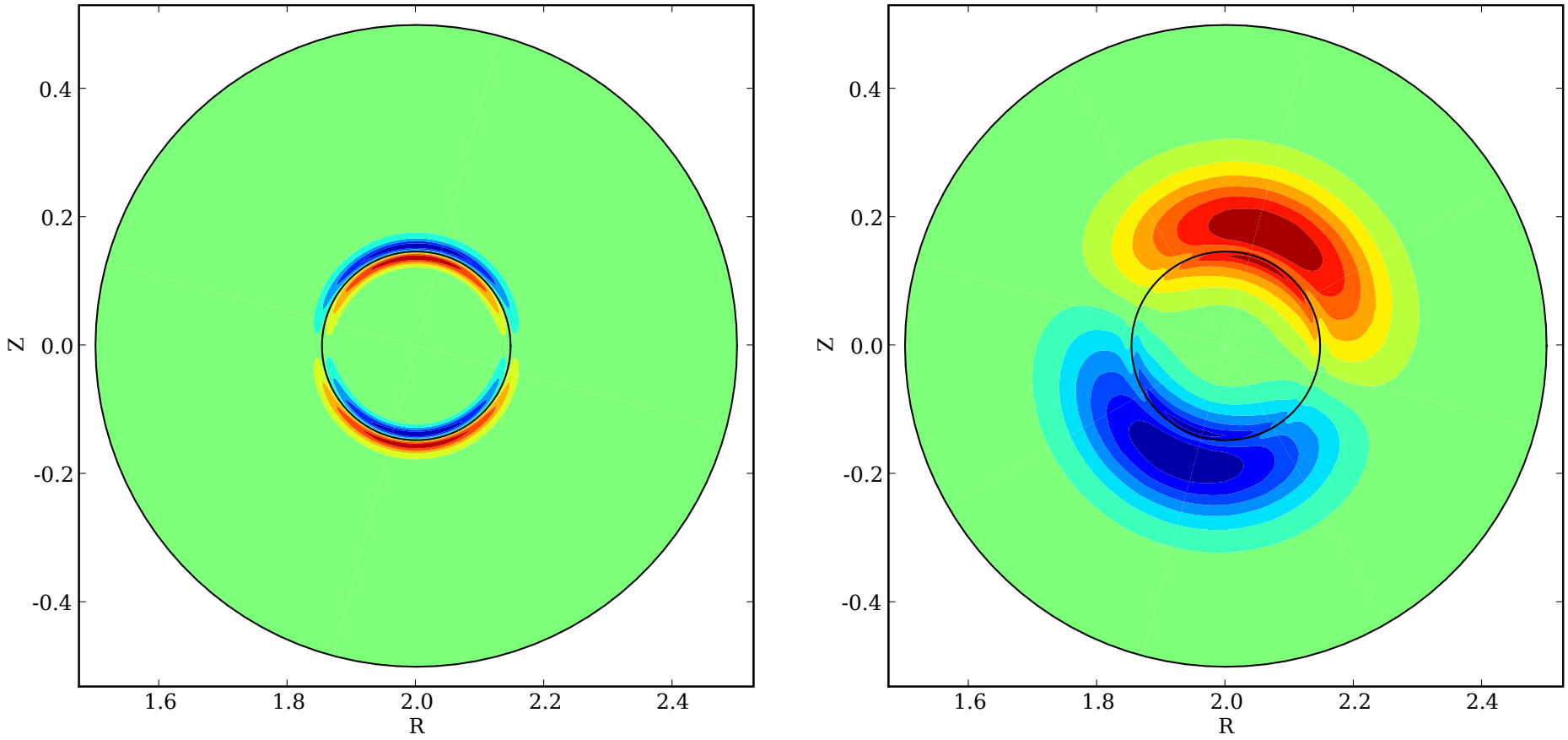
FLR Broadens Tangential Velocity Eigenmode Structure





- tangential velocity eigenmode substantially altered (left)
- magnetic eigenmode unaltered (right)

Comparison of V_ϕ Eigenmode

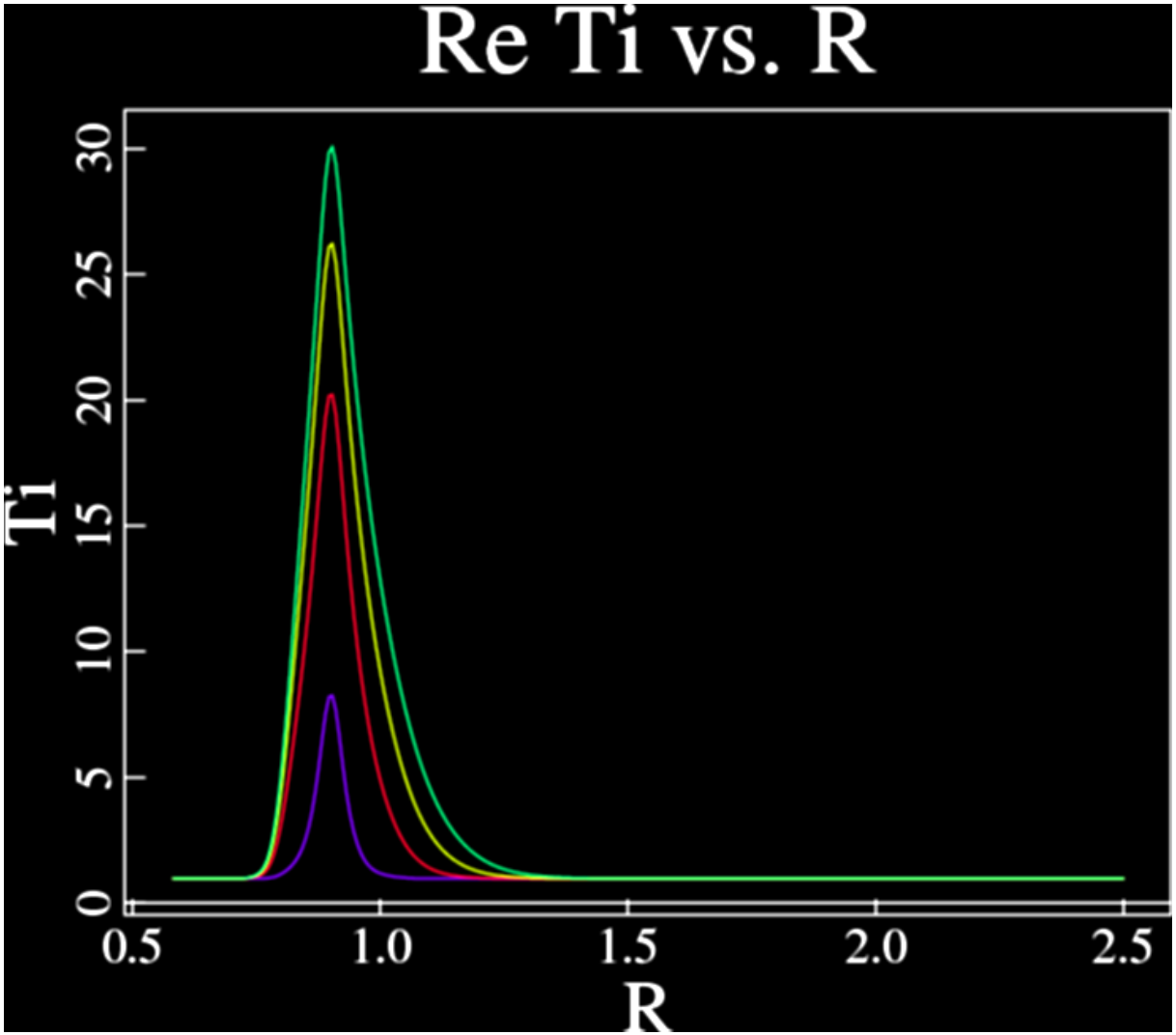


- inner circle shows resonance surface

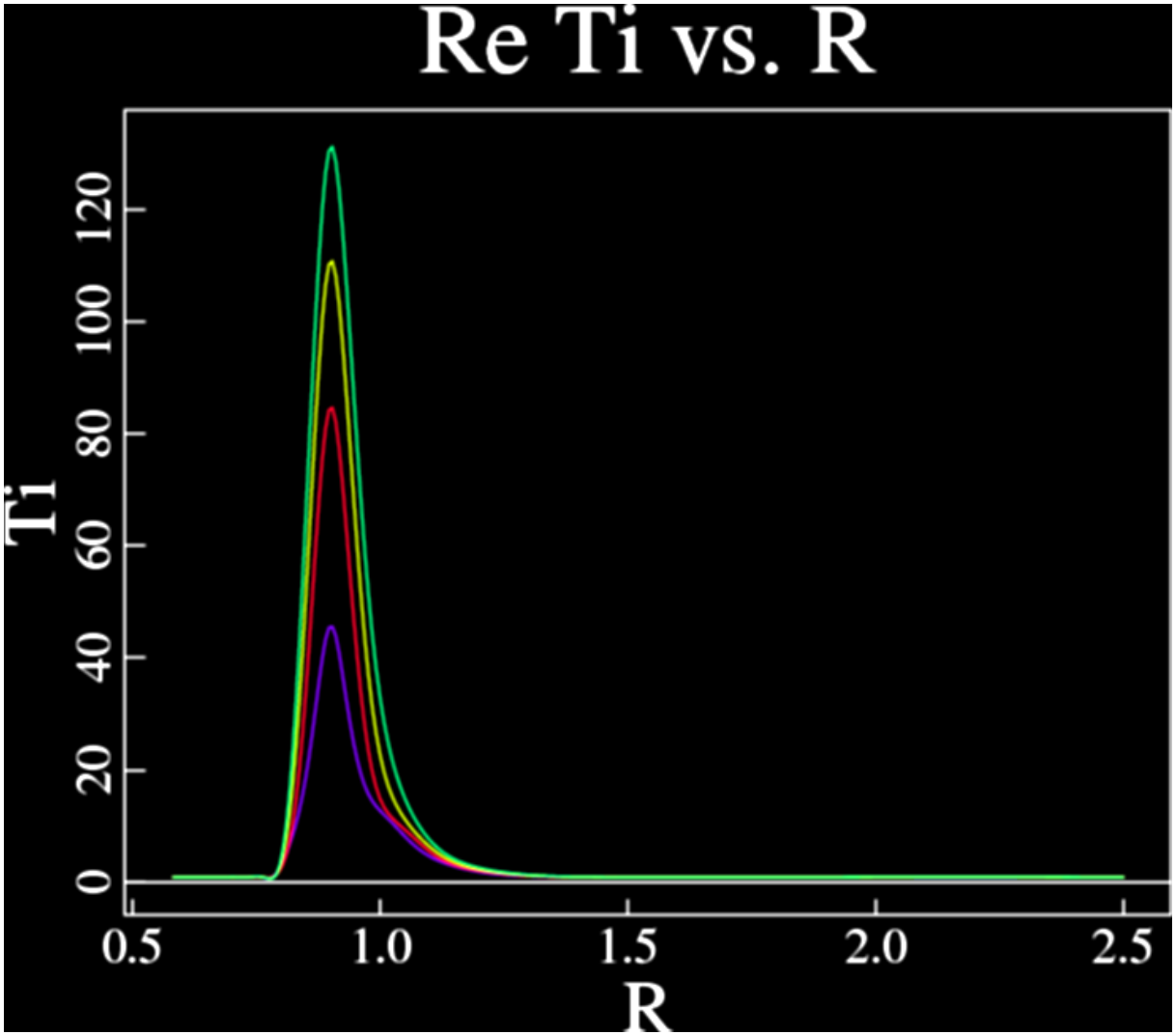
Growing Equilibria with a heat source

- evolve only $n = 0$
- begin with a dipole field from a current filament inside cryodonut
- use heat source Q $\propto \exp\left(-\frac{(r-r_T)^2}{r_w^2}\right)\exp\left(-\frac{(z-z_T)^2}{z_w^2}\right)$
- $r_T \simeq .9m, r_w \simeq .3 - .5cm, z_T = 0., z_w = .2cm$ and $\chi_{\|} = 1 \times 10^6, \chi_{\perp} = 1$
- 3 phases
  - apply initial heating with largish $\chi_{\perp} = 100$
  - reduce $\chi_{\perp} = 10$ continue to heat
  - settling phase where heating is reduced
    - balance $\chi_{\perp} = 10$ with Q
    - large number diffusivity to flatten density

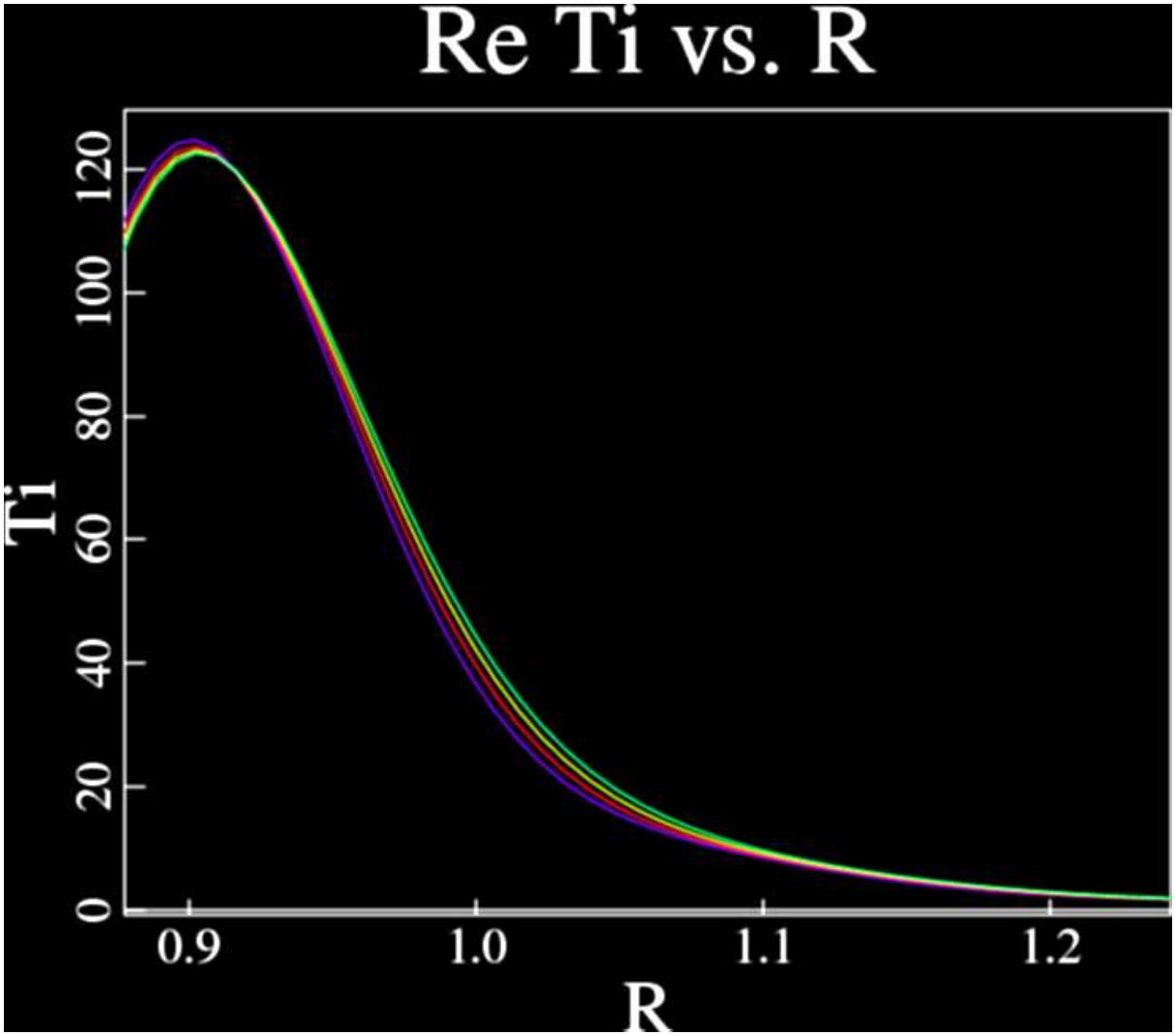
Profile of Ti for preheat



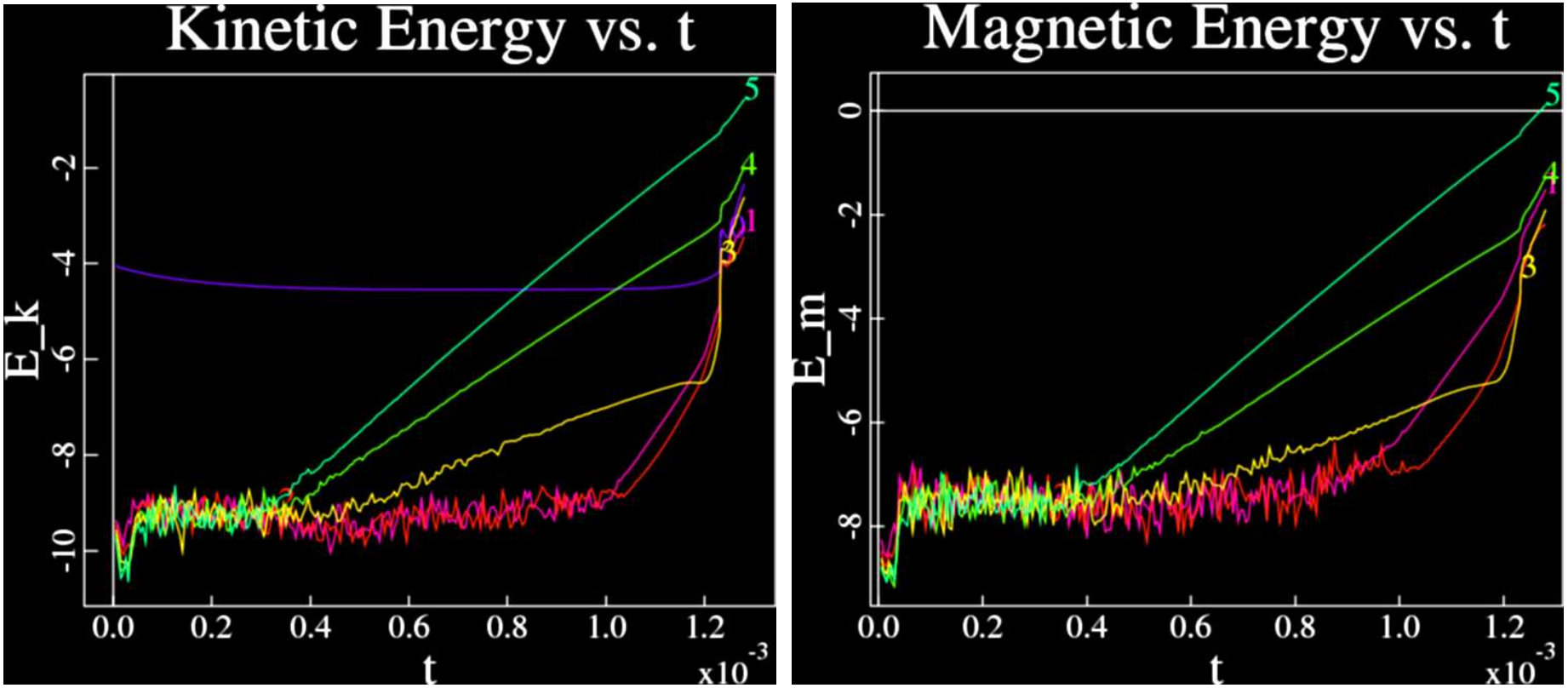
Profile of Ti for growing phase



Profile of Ti for settling phase

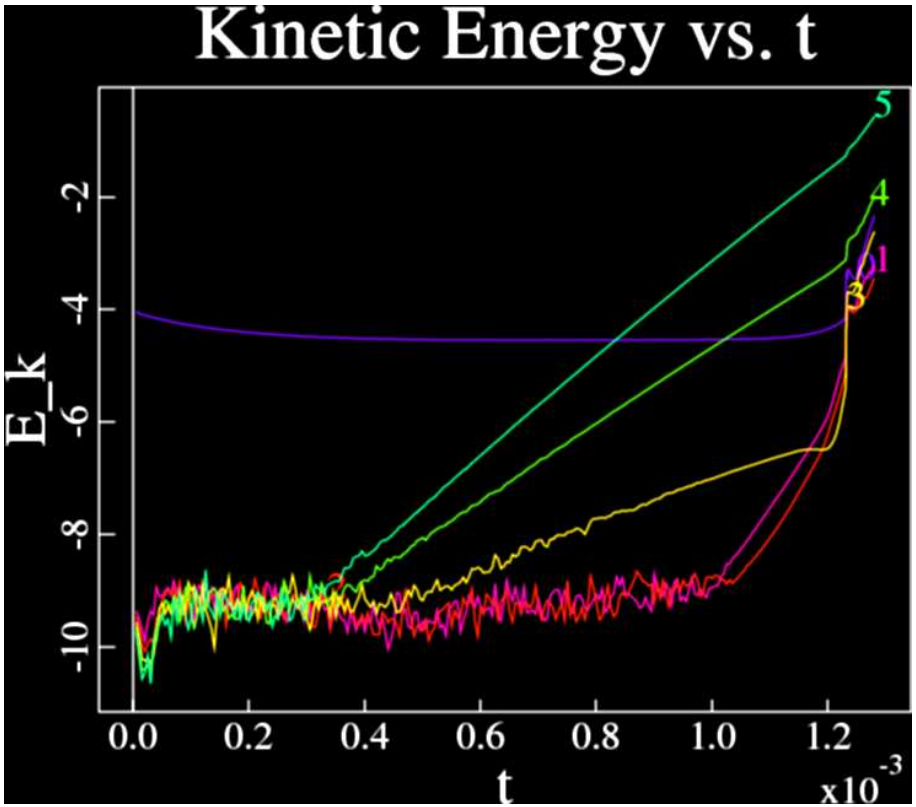


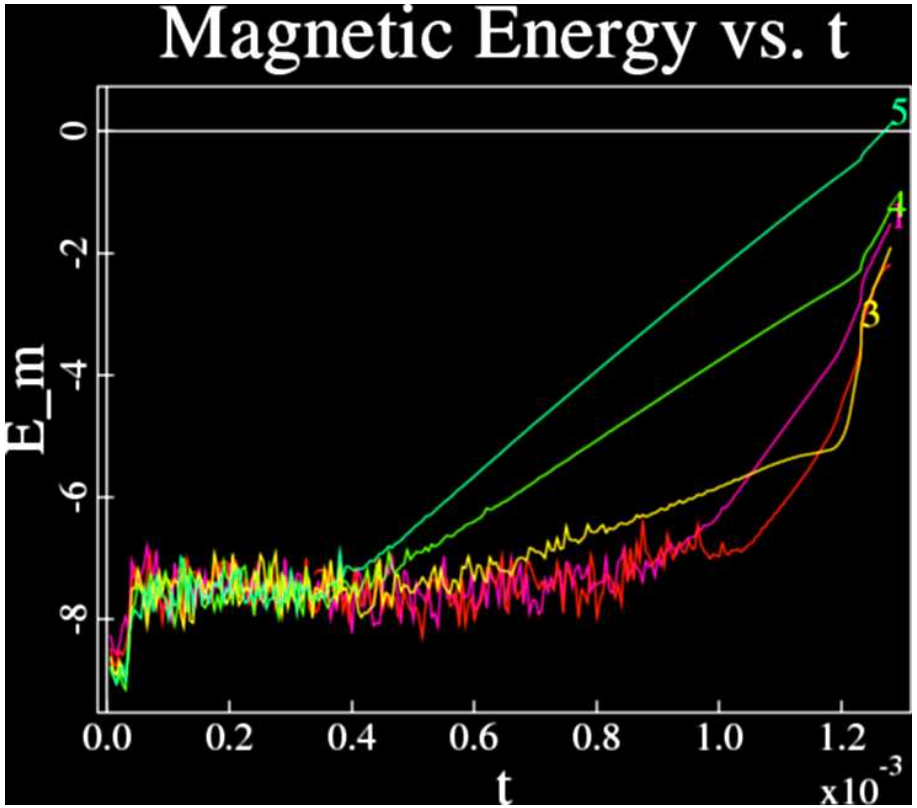
Nonlinear lphi=4 simulations through linear phase



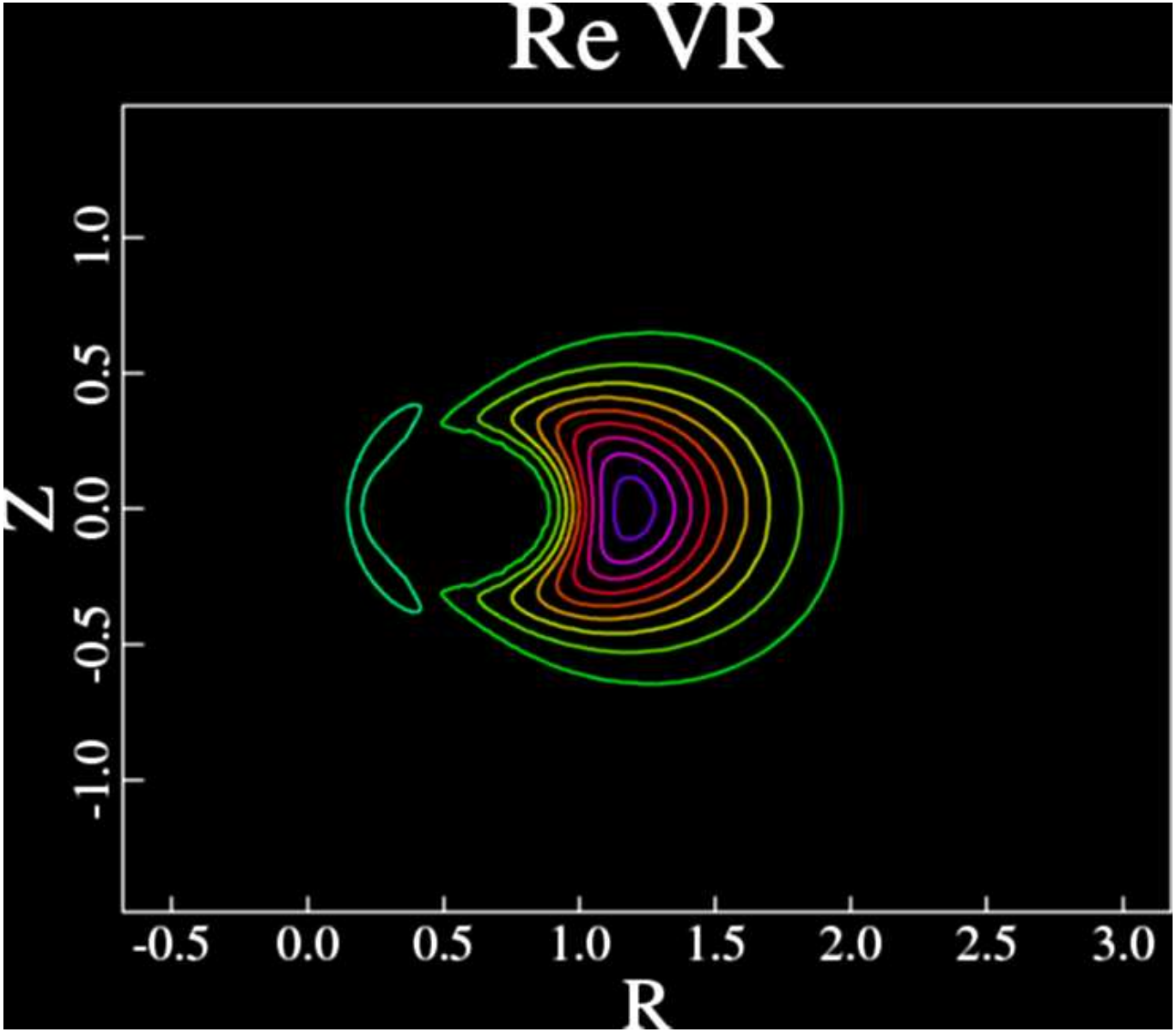
- calculations transferred to J. Kesner

Nonlinear lphi=4 simulations through linear phase

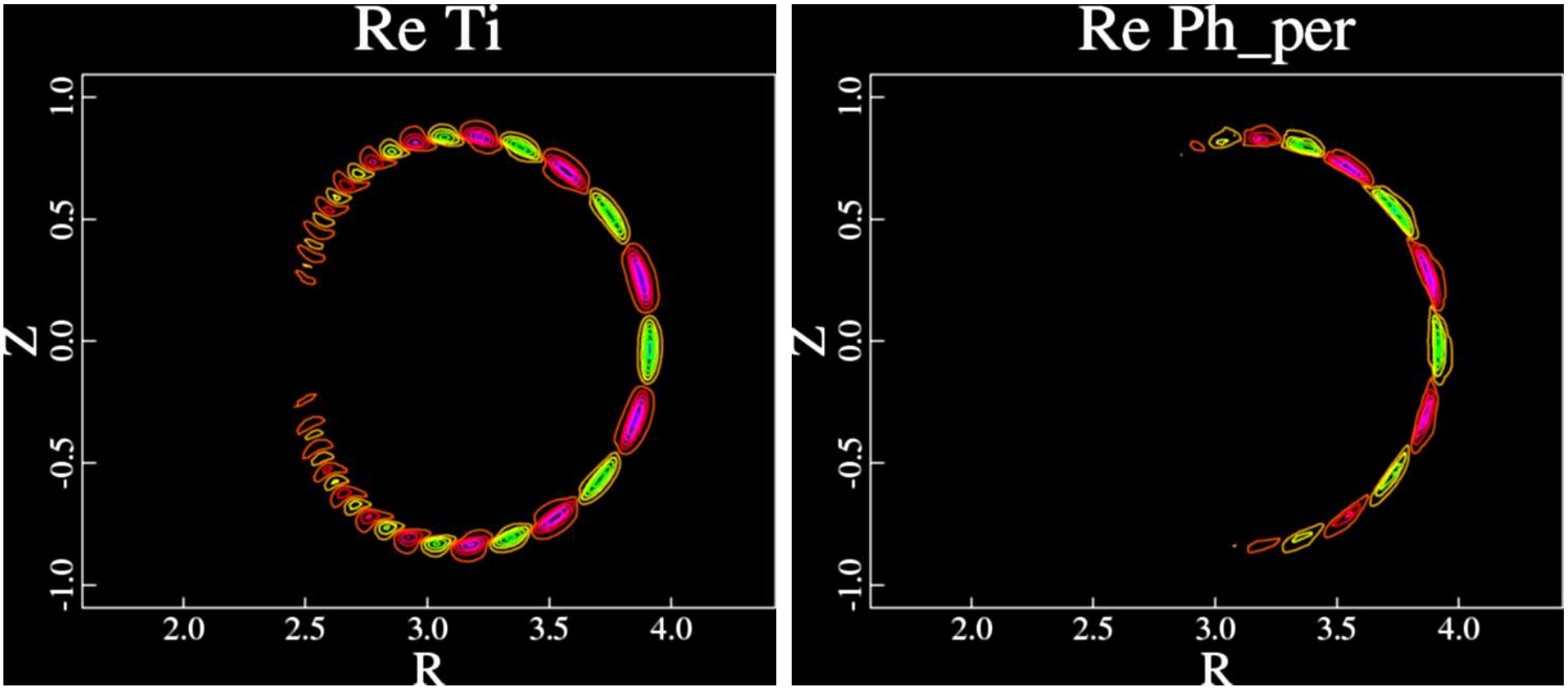




n=5 eigenmode



Beginning study of energetic particle effect on ballooning modes



- this is only a technology demonstration
- need consistent f_{eq}