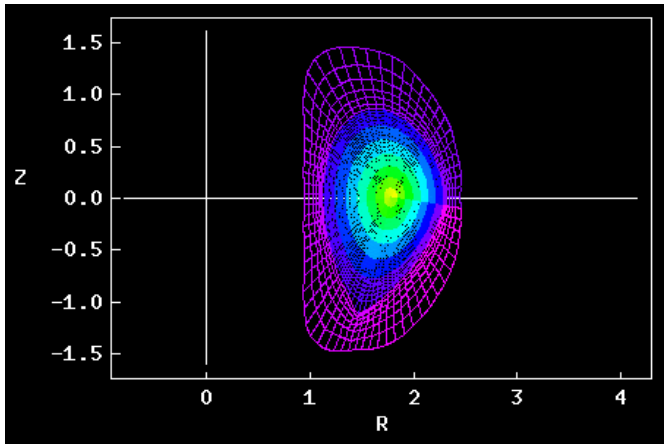
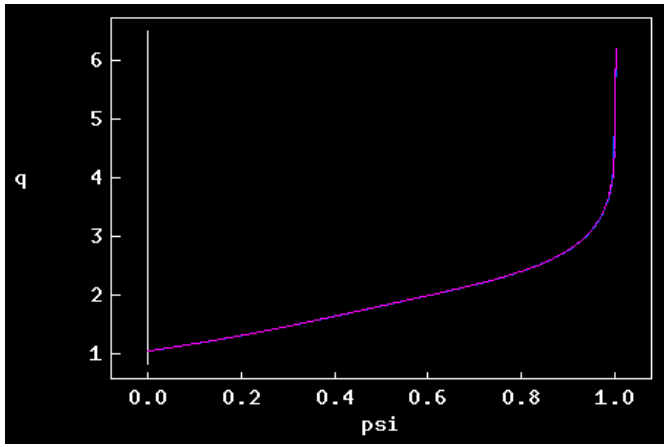
D3D, shot#137611 t=1950ms - 1MJ, 1.5MA

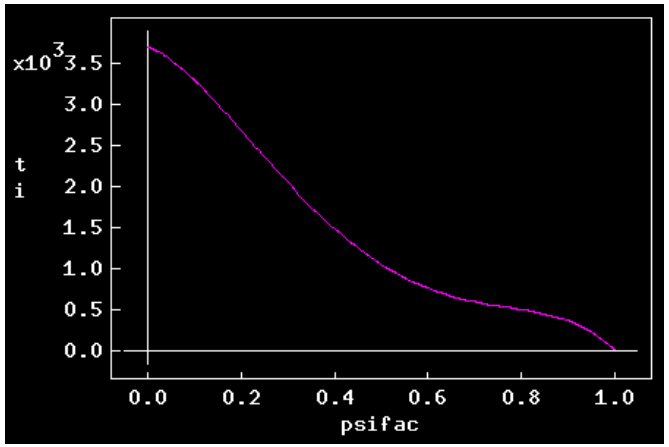
NIMROD grid



q vs ψ_n



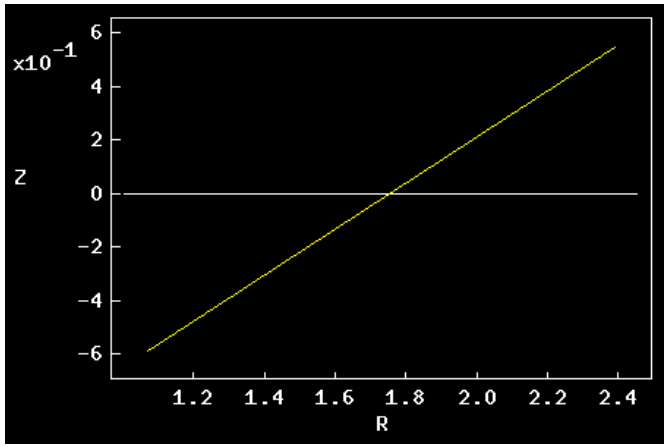
T vs ψ_n



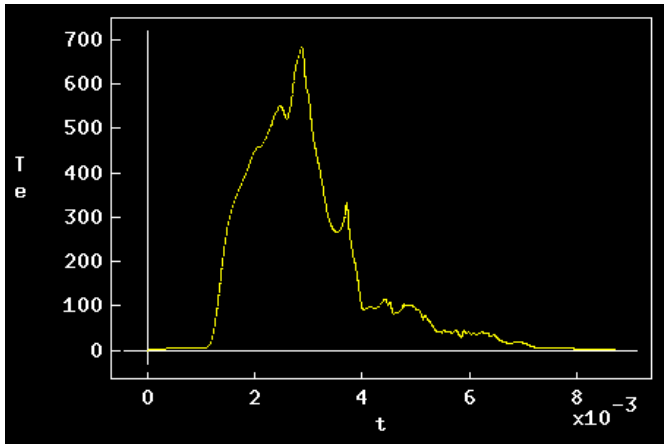
- q>1, peak T=3.6keV, single fluid rMHD
- n_d=20m/s^2, $S_0 \simeq 10^8$, Pr$\simeq 10^4$, $\kappa_{\parallel} = \left(\frac{T}{100eV}\right)^{5/2} \times 10^7$
- temperature dependent resistivity and thermal conduction
- Ohmic and viscous heating
- one temperature for all species : ions, electrons, all impurities
- instant thermalization
- 0-D coronal equilibrium radiation/impurity model
- advance densities of each charge state with single fluid velocity

Fragment Diagnostics Detail Ablation and TQ

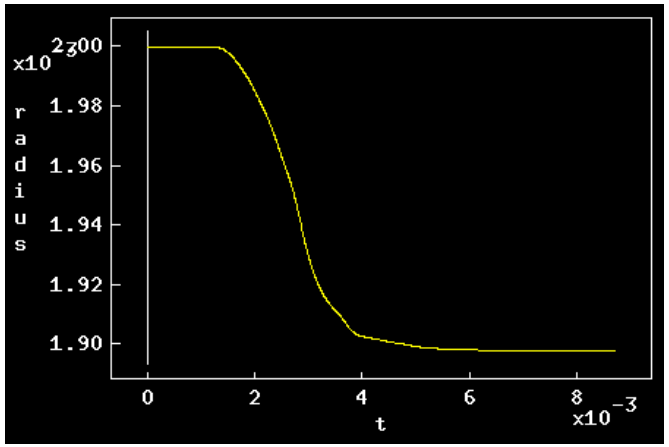
fragment trajectory



fragment temperature vs time



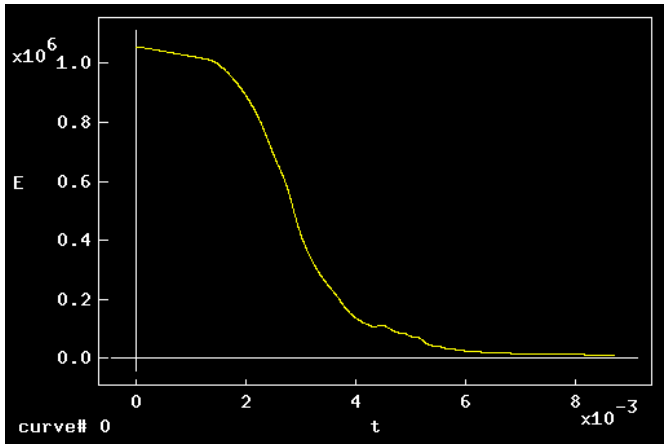
fragment radius vs time



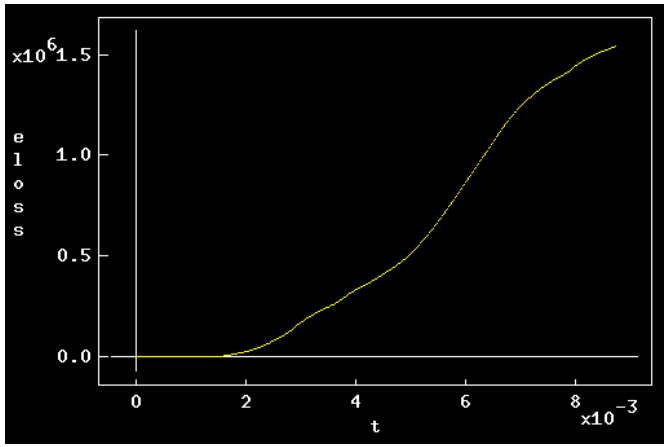
- SPI PIC model deposits moving source of neutral impurities onto grid
- single fragment simulation: r_{frag}=2.0mm∼200Torr·L, v=200m/s
- straight line trajectory ($\mathbf{F}_{frag} = 0$, easy to modify)
- PIC evaluates local temperature and density to compute ablation
- PIC tracks size of fragment, ablation reduces size of fragment
- ablation rate a function of density, temperature, and size
- temperature collapses before fragment reaches axis
- fragment survives TQ

SPI Power Diagnostics

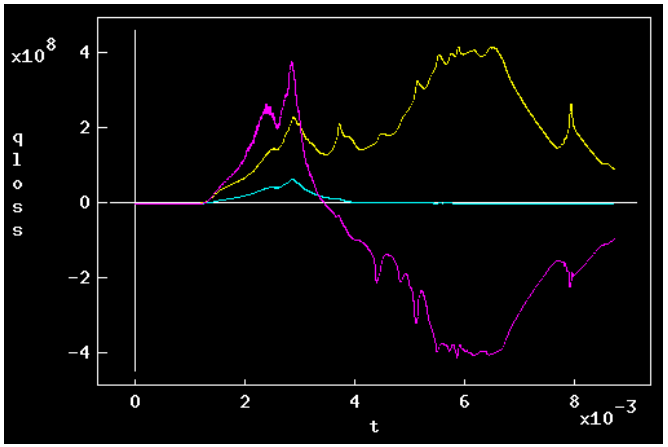
Thermal Energy(J)



Radiated Energy(J)



Power(W) vs time

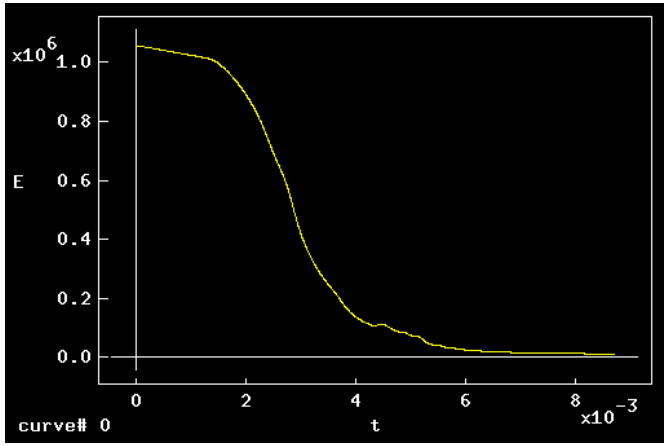


radiation,ionization,dilution

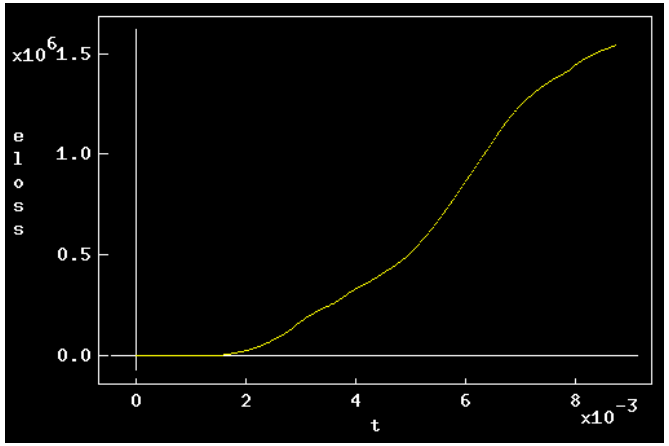
- t=0-2ms fragment crossing vacuum
- t=2-4ms active ablation, 90% T.E. lost but only 30% radiated
- t=5-6ms tail of TQ, radiation peaks
- **note** symmetry in radiation and dilution(+Ohmic) heating after 4ms
  - negative dilution is actually increase in Ohmic heating
  - late time Ohmic heating drives increase in radiation
- increasing Ohmic heating has two components
  - increase in resistivity with decreasing temperature
  - currents generated as pressure collapses

Thermal Quench and Current Quench Overlap

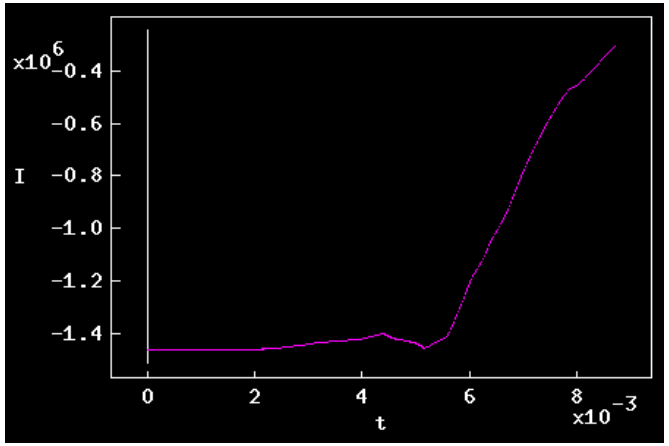
Thermal Energy(J)



Radiated Energy(J)

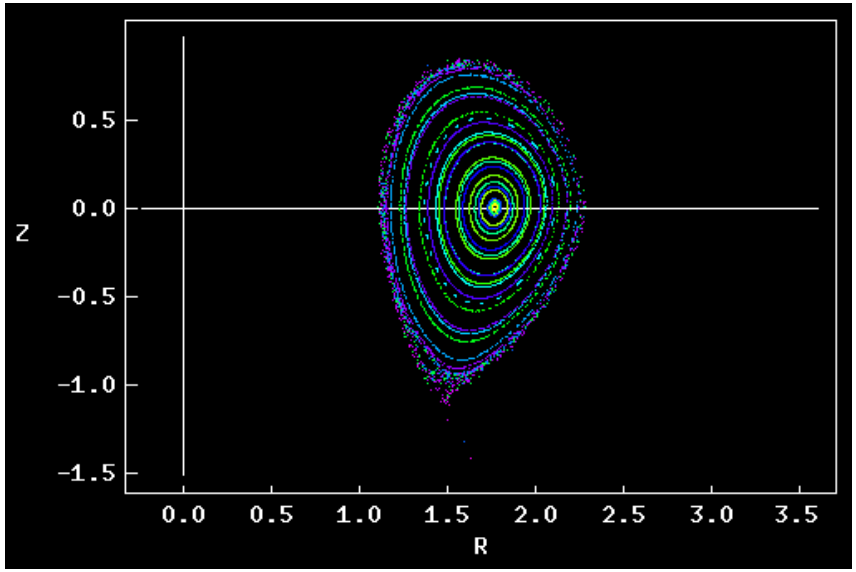


Plasma Current(A) vs time

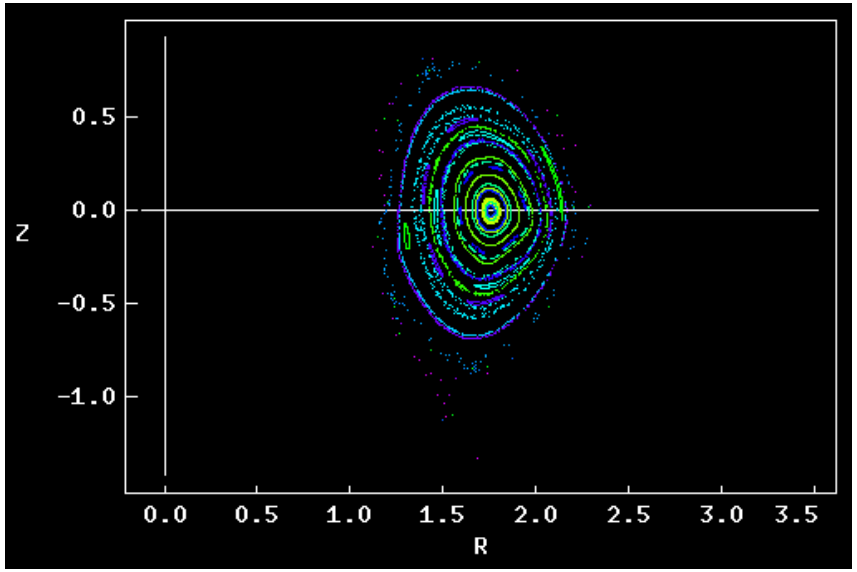


- not much ablation after t=4ms
- radiated energy exceeds thermal energy at t>6.5ms
- at t=6.5ms, current has decayed appreciably
- current quench begins at t=5ms, overlap with tail of TQ
- peak in radiation / steeper slope in radiated energy at t$\simeq$[5-7]ms
- overlap may be sensitive to diffusion parameters
- note the modest change in current throughout TQ

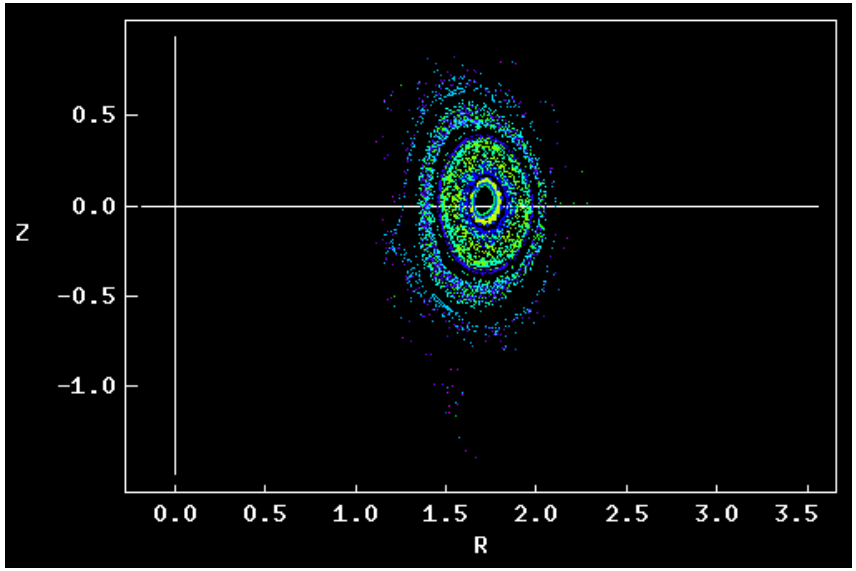
Poincare Show Islands and Flux Surface Breakup



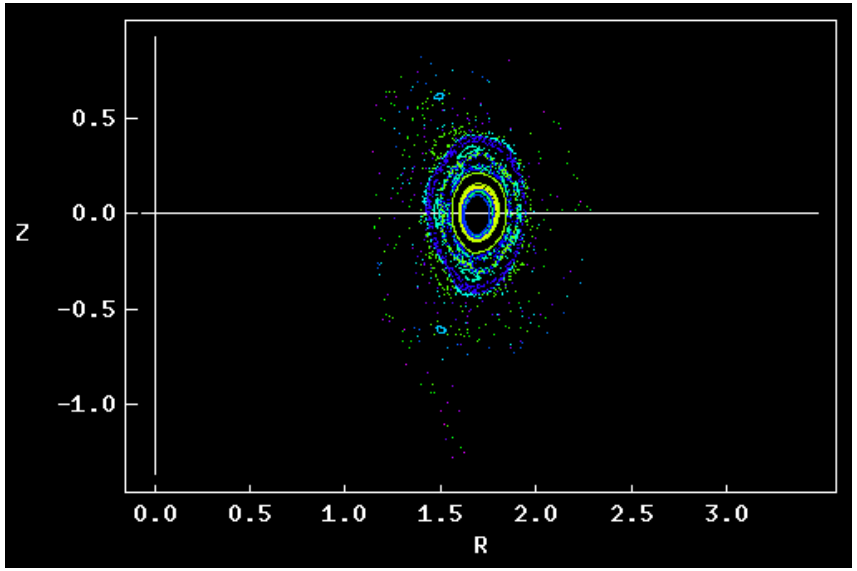
t=2.0ms



t=2.50ms



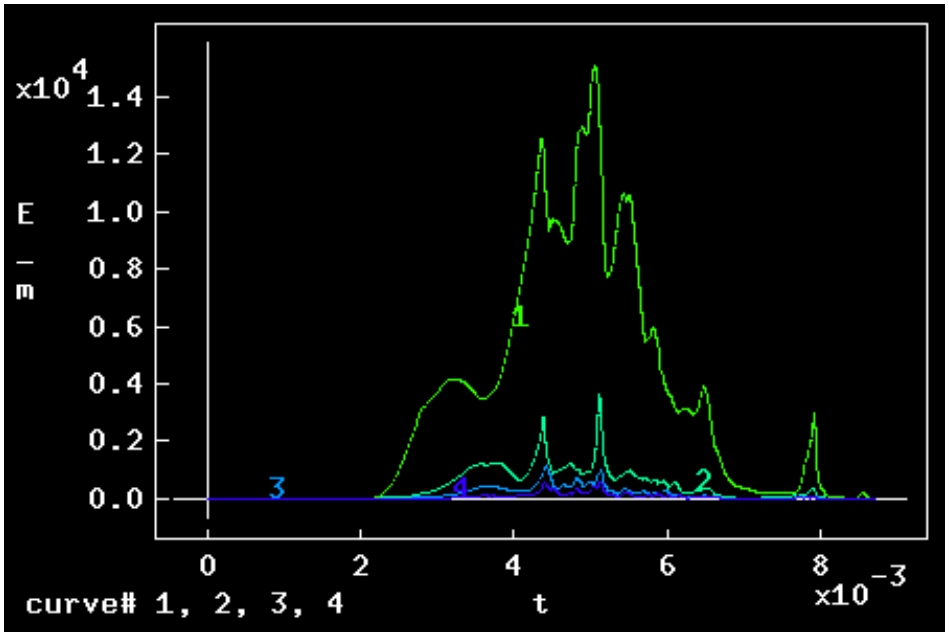
t=3.0ms



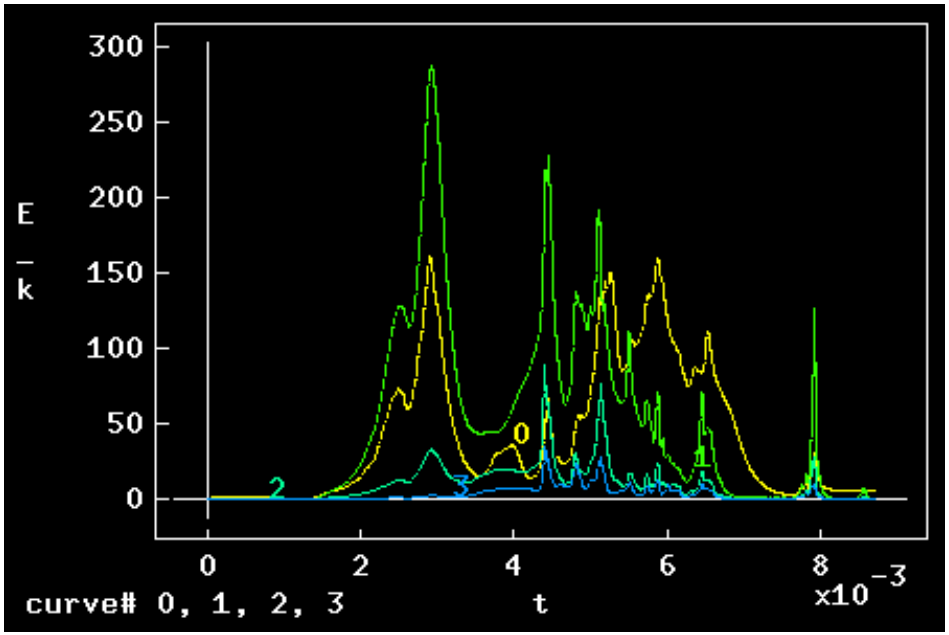
t=3.50ms

Energy Spectrum Shows n=1 Mode Dominates

n=[1,2,3,4] magnetic energy



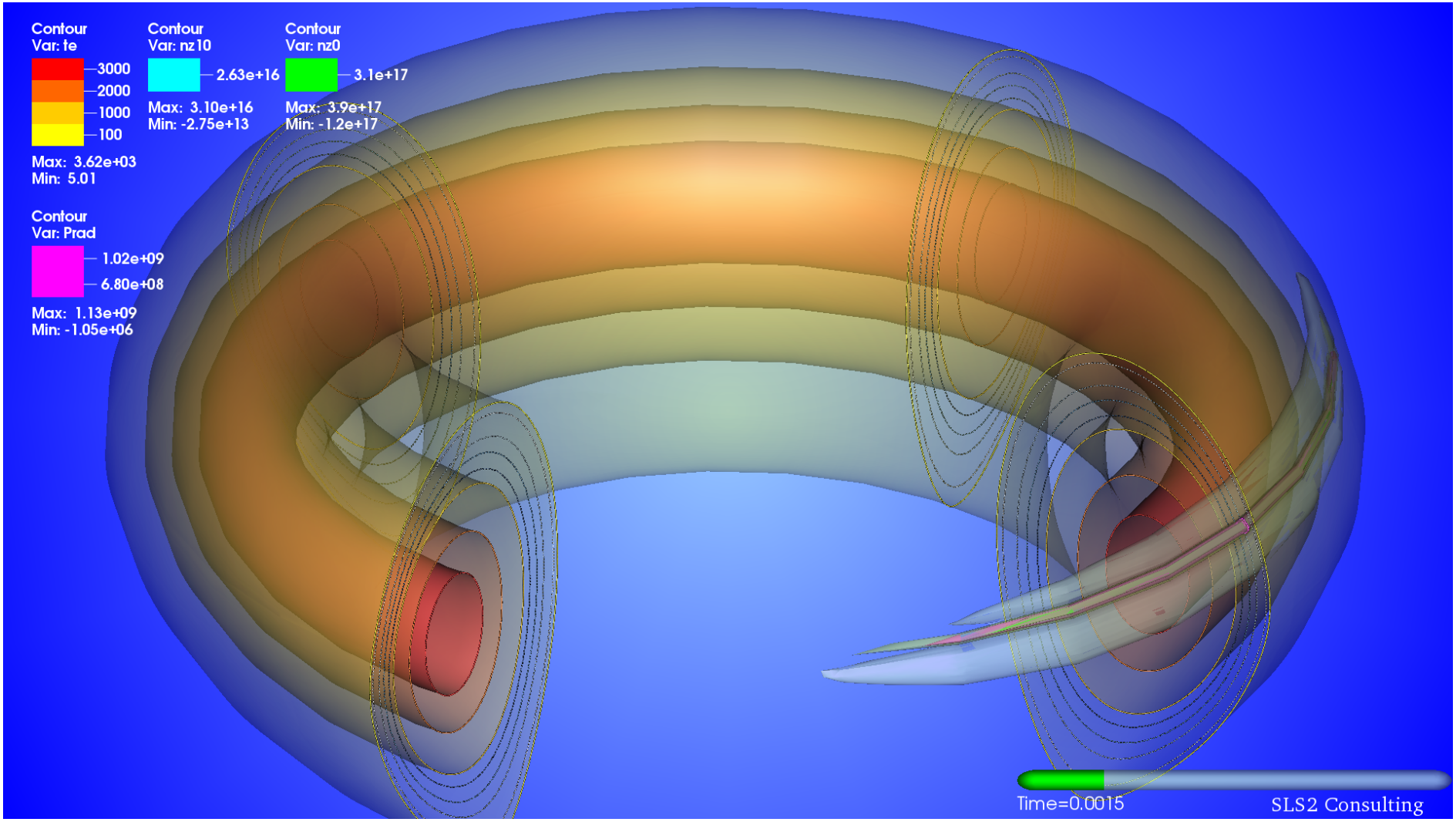
n=[0,1,2,3] kinetic energy



- n=1 mode dominates, not surprising since injector is n=1
  - try 3-fold symmetric injector
- initially, outer m-modes (filaments)
- m-mode cascades down q profile
- significant peak at t=3ms (look for event in animation)

D3D H-mode, shot#137611 t=1950ms, 1MJ, 1.5MA

https://youtu.be/DHuQzeQKzEM

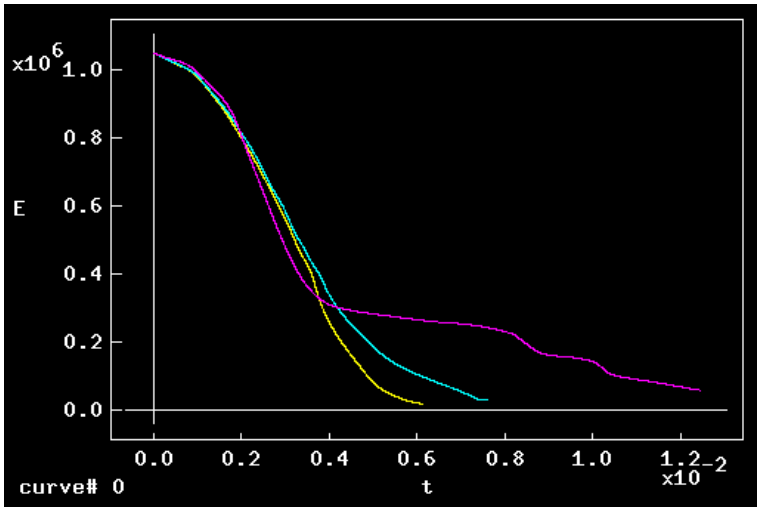


animation shows thermal quench mediated by (1,1)

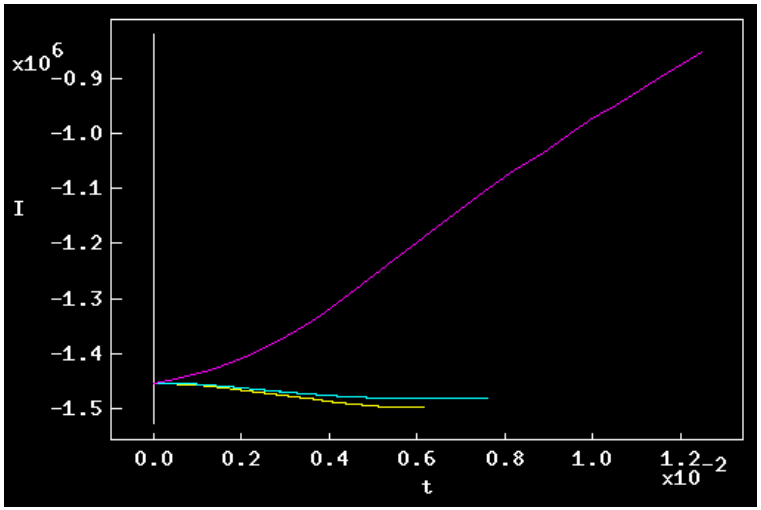
Constant Resistivity Study Shows Ohmic Runaway

but similar radiation, elecd=[0.1,1.0,10.0]

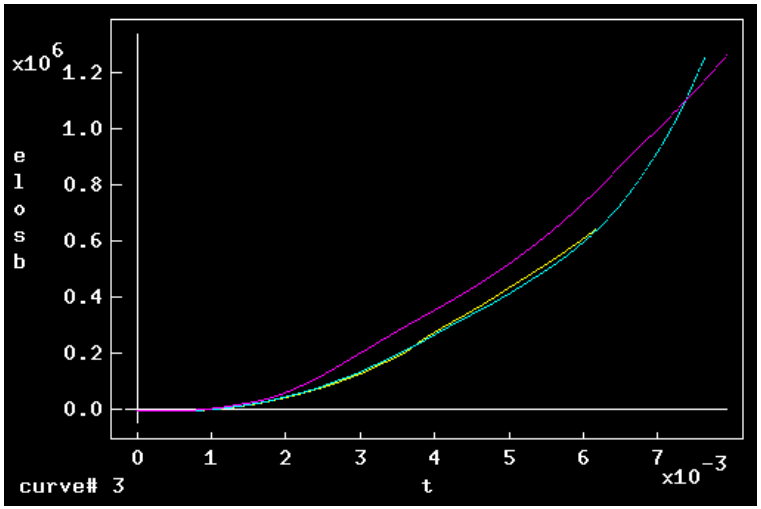
Thermal Energy(J)



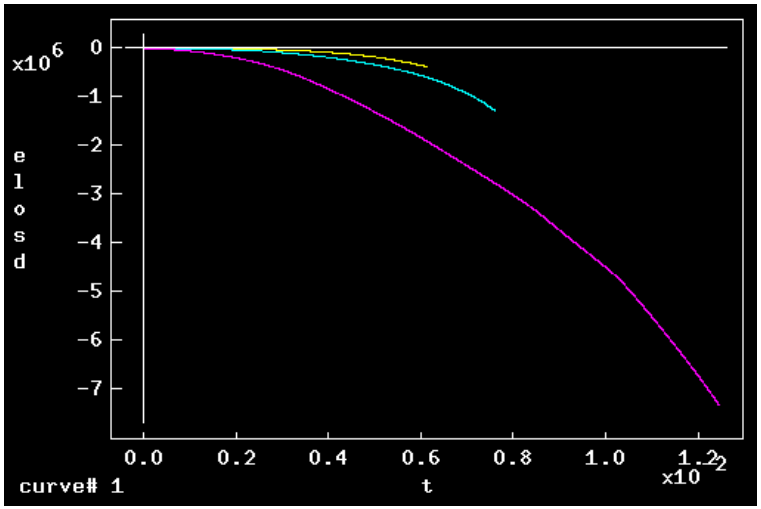
Plasma Current(A)



Line Radiation(J)



Ohmic Heating(J)



NIMROD SPI Simulations Progressing

- D3D SPI simulations going well
- single fragment SPI shows complete thermal quench
- n=1 mode dominates, look at 3-fold injector
- modest radiation during main thermal collapse
- strong radiation seen with Ohmic collapse of plasma
- ongoing studies to examine dependence on diffusion parameters
  - core dynamics requires low resistivity
  - low ceiling on resistivity (high floor on S) to prevent Ohmic runaway
  - thermal conduction parameters are probably important too
- tricky to correctly resolve range of temperature dependent dynamics
  - can't ignore the low temperature stuff
- gets worse with ITER
- L-mode simulations are numerically less challenging
- examine additional D3D equilibria : ITER baseline, Super-H mode
- preliminary results show slower pellet is less "disturbative"