M3D-C1 ZOOM Meeting

02/15/2021

CS Issues

1. stellar.princeton.edu allowing early users
2. Moving files from eddy
3. GPU solve and memory utilization status
4. Mesh adaptation update
5. Local and other systems
6. NERSC Time
7. Changes to github master since last meeting

Physics Studies

1. Next Eric Nardon 3D MHD progress meeting
2. Progress in Lyons 3D MHD-C1/NIMROD mitigation benchmark
3. Carbon Mitigation in NSTX-U (shell pellet)
4. Helical Band to remove runaway electrons
5. RE Benchmark with JOREK
6. Other?

stellar.Princeton.edu allowing early users

Bill Wichser 02/11/21:

- 63 nodes available for testing (6048 cores, 3 x eddy)
- No /scratch filesystem…should be available in March

Jin Chen 02/15/21:

- Code works on stellar and all changes are pushed into git repo
- All regression tests passed except “adapt”
- (Jin not available on today’s call due to conflict)

S. Jardin 02/15/21:

- I was able to compile all versions using Jin’s README/stellar instructions
- I also ran regression tests: all passed except “adapt”
    - MALLOC(): UNSORTED DOURBL LINKED LIST CORRUPTED
- It looks to me we have 10 T in each home directory
- I reran a 32 p case Nate ran on portal

Moving files from eddy

- The goal is to have stellar/scratch available before eddy/scratch disappears, so users can copy files directly

- I was told that if eddy/scratch fails they will not replace it

- Do we need to ask for more space in portal/p/m3dc1 (3.3 T remaining)

- To inquire how much storage space is available in a partition, use the "disk free" command: "df –h ."
  - -h tells it to print out the data in readable form
  - (.) says provide information only for the partition you are in

- df only works for partitions. To find the size of a directory, you can use the "disk usage" command "du –s"
  - -s summarizes the size of all the files in the directory. Without the –s it will tell you the size of every file in the directory.

GPU Solve status

- GPUs give little or no speedup on solves for small problem size
- Larger problem sizes run out of memory
- What is using all the memory???

Jin Chen email 2/2/21:

Memory Utilized: 16.27 GB (estimated maximum)

While matrices only took less than 4GB:

Matrix	118	57	3704181940	0.
Vector	820	151	5383208	0.
Krylov Solver	22	8	3198432	0.

Jin Chen

Mesh adaptation update

- Brendan ?
- Seegyoung? Usman?

Local Systems

- PPPL centos7(02/15/21)
  - 6 regression tests PASSED on centos7:

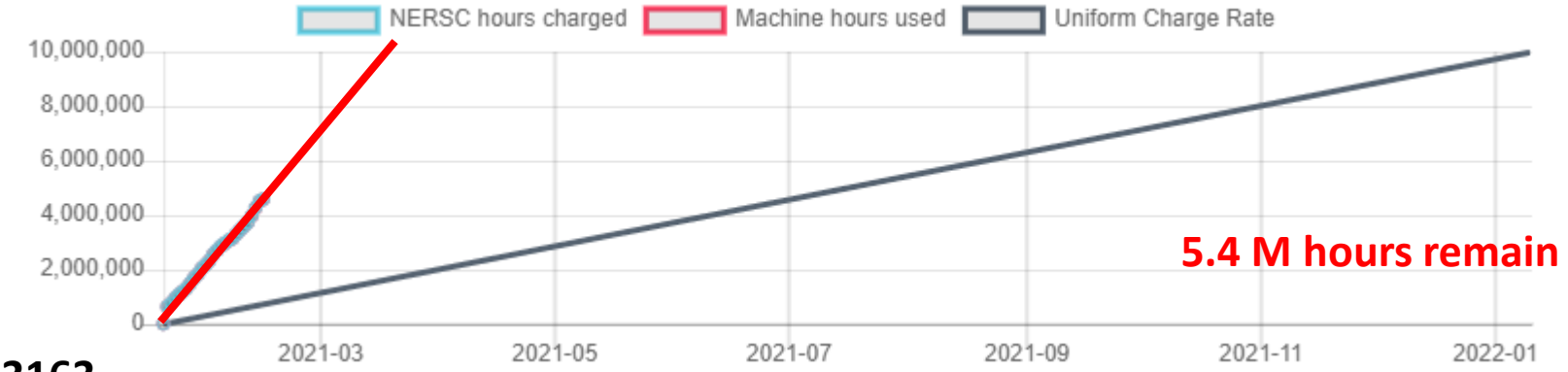
- PPPL greene (02/15/21)
  - 5 regression tests PASSED
  - No batch file found for pellet
- EDDY (2/15/21)
  - 6 regression tests PASSED
- TRAVERSE(1/4/21)
  - Code compiles
  - Regression test failed: split_smb not found in PATH
  - Have not yet tried shipping .smb files from another machine

Other Systems

- Cori-KNL (2/08/2021)
  - 6 regression tests passed on KNL
- Cori-Haswell (2/08/2021)
  - 5 regression tests passed
  - KPRAD_RESTART did not pass, but differences are very small in velocity variables. All magnetic and thermal good. Similar difference as Cori-KNL
  - RMP_nonlin initially failed …: There was an error in partitioning the mesh, but passed on resubmission
- PERSEUS
  - All 6 regression tests PASSED on perseus (J. Chen, 9/04/20)
- MARCONI
  - All regression tests PASSED on MARCONI (J. Chen, 9/04/20)
- CORI GPU (10/26)
  - ??

NERSC Time

mp288



m3163

Closed for general use

- mp288 received 10M Hrs for CY 2021
- We will exhaust this by mid-March at this rate. Transition to stellar (PU/PPPL)
- I plan to not start any new jobs on Cori

Changes to github master since last meeting

- S. Seol
  - 02/09/21: Clean-up & prep-work to remove sequential entity ID assumption
  - 02/09/21: fixing error in run_adapt wrt node id's with adapted mesh
  - 02/12/21: minor fix in vtk mesh file name

- B. Lyons
  - 02/08/21: Update adapt mesh to work on nodes only and to iterate as mesh adapts

Next Eric Nardon 3D MHD progress Meeting

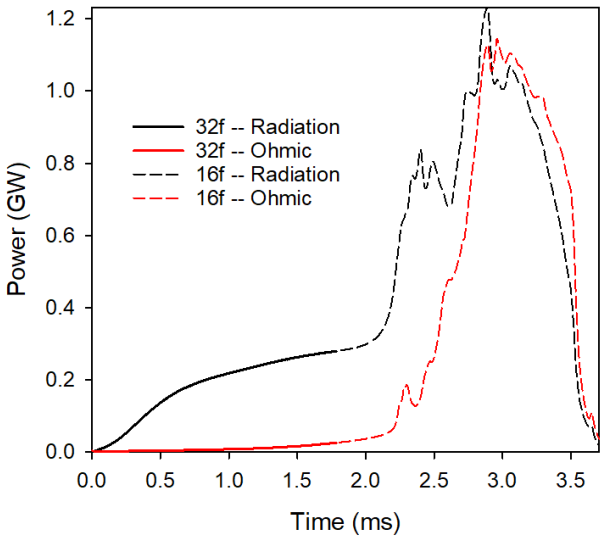
- Week of March 8, 10-12 AM ET, day to be determined

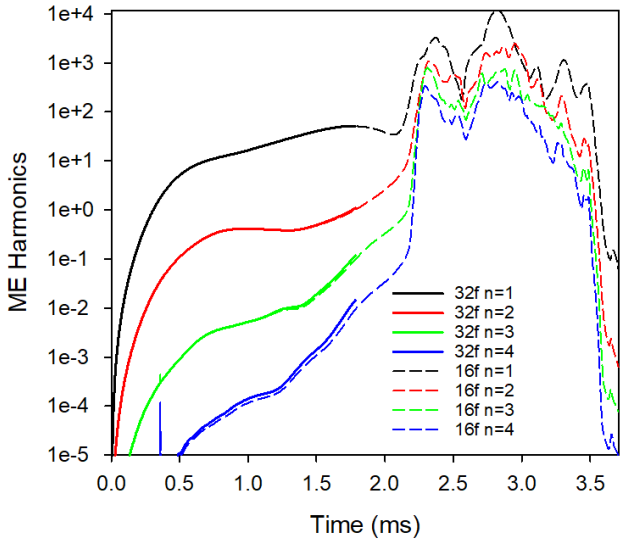
- Brendan Lyons to discuss M3D-C1 progress.

Brendan:

- What cases to present ?
- Progress on coupling to LP code?
- Runaway Electron?

32 vs 16 planes convergence test (now running)

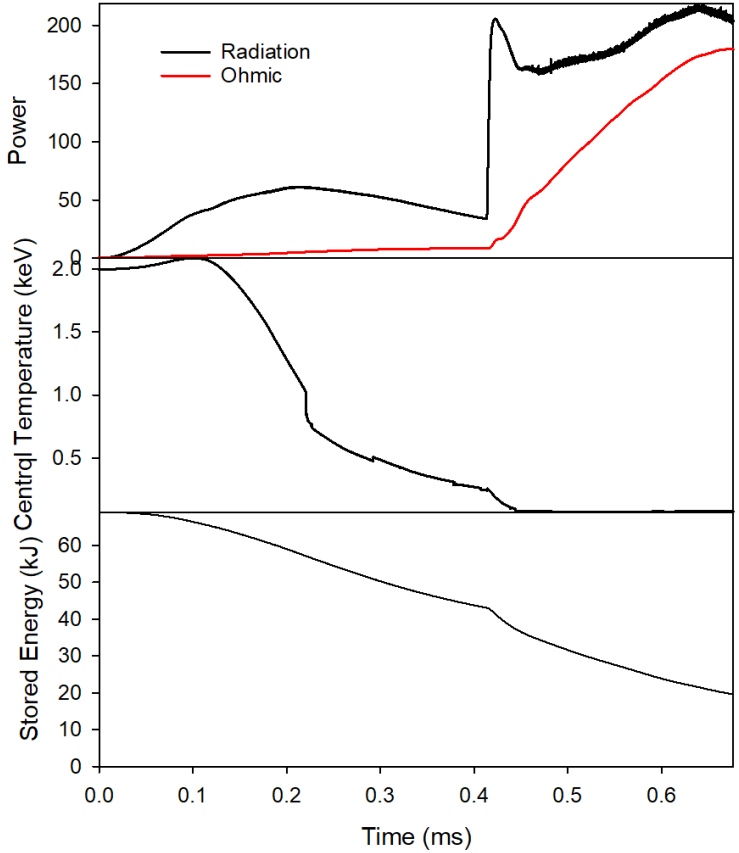




- 16 plane case goes stochastic at t ~ 2.2ms, very close to that of the 8 plane case
- 32 plane case still running on cori

/global/cscratch1/sd/u431/BLH32f

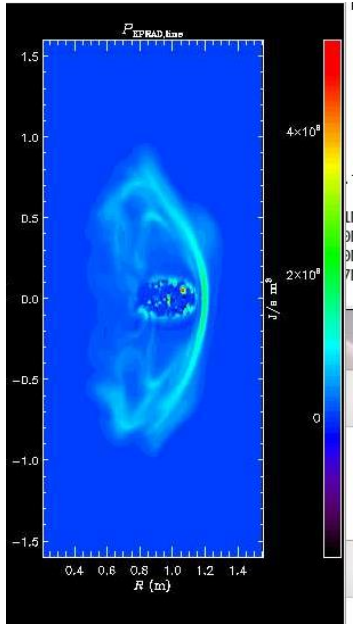
Carbon Mitigation in NSTX-U (shell pellet)



Cesar Clauser

Shell carbon pellet in NSTX (now running)

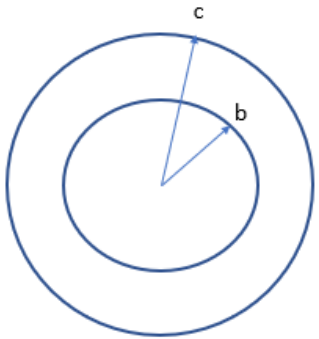
Radiation
t = 0.676 ms



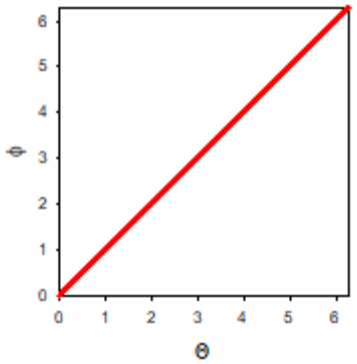
Trying to keep radiation “hot spots” from forming and causing crash by decreasing dt as necessary. Now starting to increase dt at restart.

Helical Band to remove runaway electrons

- Brendan Lyons performed a calculation last year with a conducting helical band that did not show large helical currents
- Want to try and reproduce, first in circular cylindrical geometry.



Circular cylindrical geometry.
Conductor in region
b < r < c



3D helical band of good conductivity at $|\Theta-\phi| < \delta$

#1. Will a purely toroidal voltage from the plasma current decaying drive a helical current in this geometry?

$$\nabla \times \mathbf{E} = 0 \quad \Rightarrow \quad \mathbf{E} = -\nabla\Phi + \frac{V_L}{2\pi}\nabla\phi$$

$$\mathbf{J} = \sigma\mathbf{E}$$

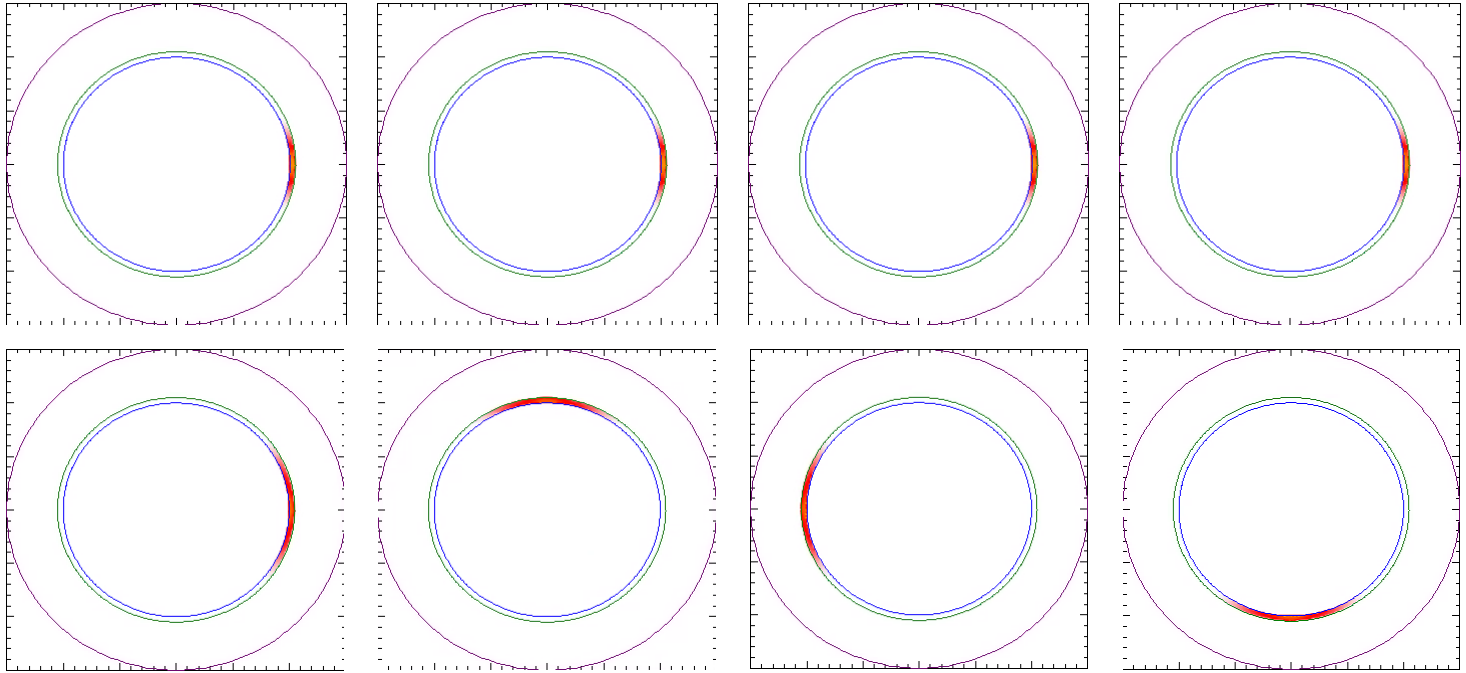
What is driving the current in the θ direction? It can't be Φ unless

$$\int_0^{2\pi} \sigma^{-1} J_\theta d\theta = \int_0^{2\pi} \frac{d\Phi}{d\theta} d\theta = 0$$

Comparison between Straight and helical band

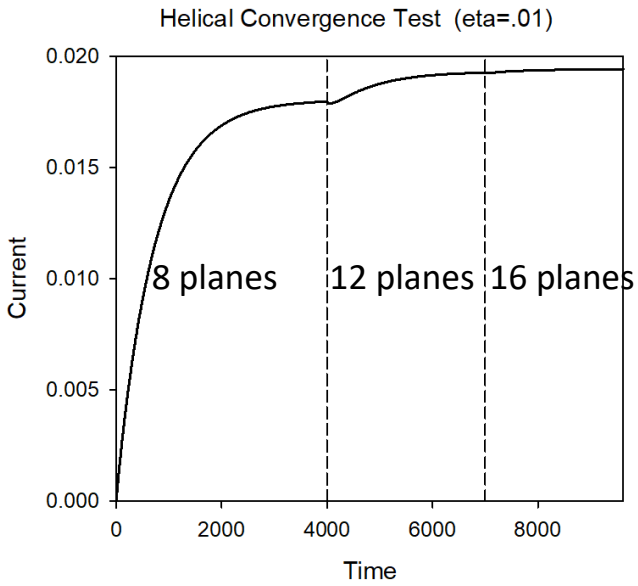
Straight ➔

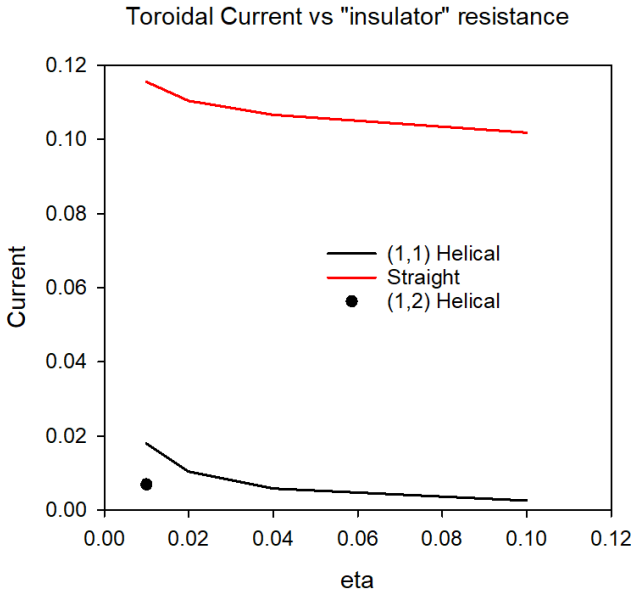
Helical ➔



$\varphi = 0$ $\varphi = \pi / 2$ $\varphi = \pi$ $\varphi = 3\pi / 2$

Some Convergence Tests

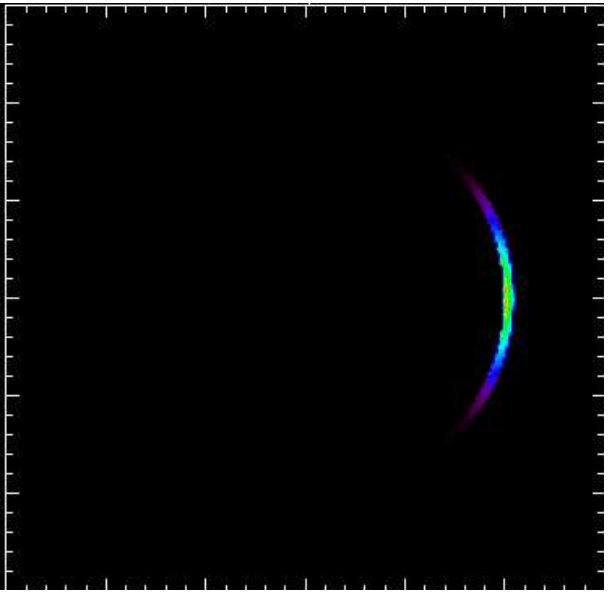


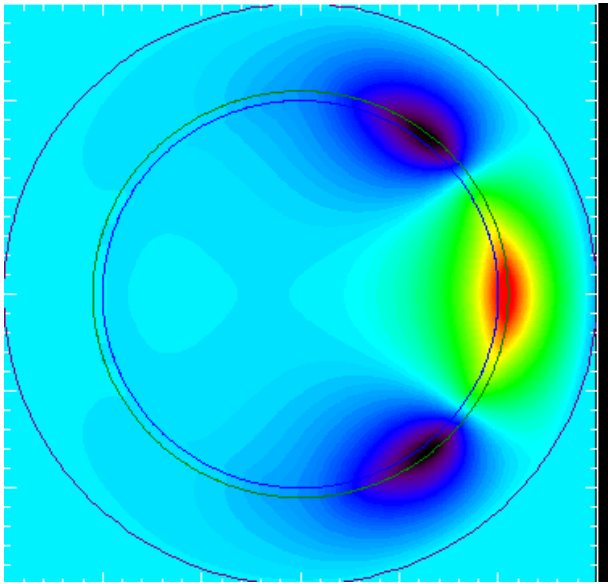


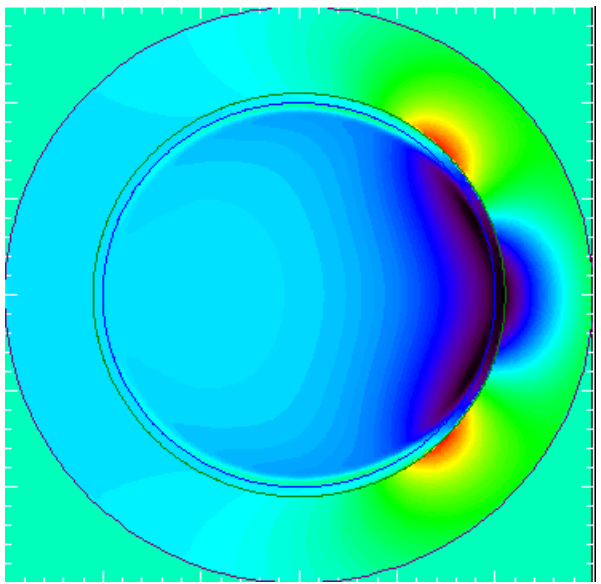
- Wall current appears to be converged in # of planes
- Helical wall current tending towards zero for large values of insulator resistance
- Now testing dependence on boundary conditions (location of ideal wall)
- Helical (1,2) case gives less than half the current of helical (1,1) case

Scalar Electrical Potential Plots

J_φ $\frac{\partial \Phi}{\partial \varphi}$ $\frac{\partial \Phi}{\partial z}$

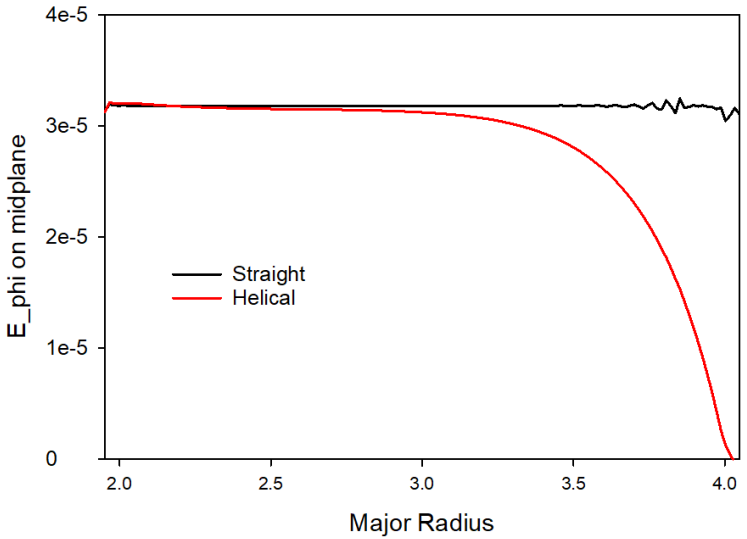






$$\nabla_\perp \bullet \frac{1}{R^2}\nabla\Phi = \nabla_\perp \cdot \eta\left[-\frac{1}{R^2}\nabla F \times \nabla\varphi - \frac{1}{R^2}\nabla f'' \times \nabla\varphi - \frac{1}{R^4}\nabla_\perp \psi'\right]$$

Compare E_phi on midplane at ϕ=0



For straight case: $E_\varphi = V_l / 2\pi R_0$

For helical case: $E_\varphi = V_l / 2\pi R_0 - R_0^{-1} \partial\Phi / \partial\varphi$

The electrical potential arises, opposing the loop voltage, as it is needed to drive the poloidal current

$$\Phi \cong (V_L / 2\pi)\left(\frac{r}{a}\right)^2 \sin(\theta - \varphi)$$

This electrical potential drives the current in the theta direction:

$$J_\theta = \sigma \frac{1}{r}\frac{\partial\Phi}{\partial\theta} = \frac{\sigma V_L}{2\pi a}\left(\frac{r}{a}\right)\cos(\theta - \varphi)$$

$$J_\varphi = \frac{\sigma V_L}{2\pi R_0}\left(1 - \left(\frac{r}{a}\right)^2 \cos(\theta - \varphi)\right)$$

RE Benchmark with JOREK

Chang Liu proposed to V. Bandaru and M. Hoelzl on 2/1/21:
V. Bandaru responded on 2/2/21 with 4 profile files and additional data. Has Chen been able to set up equilibrium?

Artificial Thermal Quench with Dreicer and avalanche sources

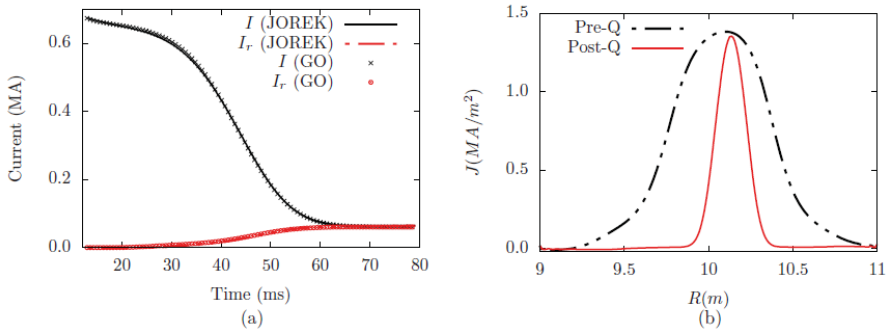
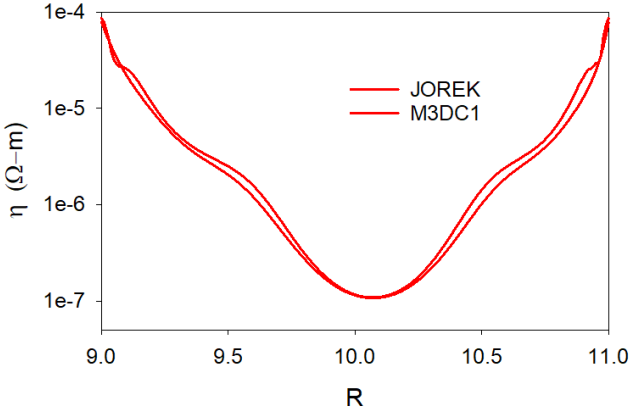
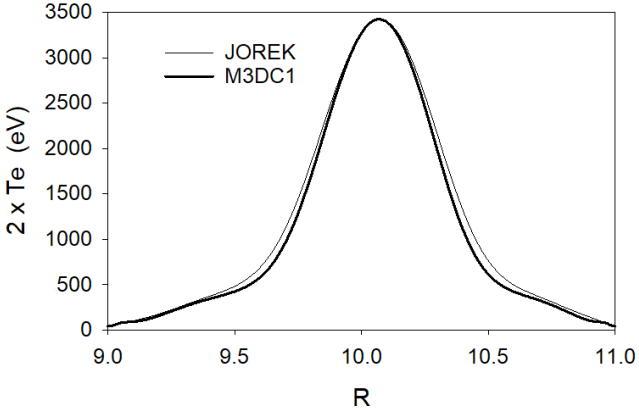


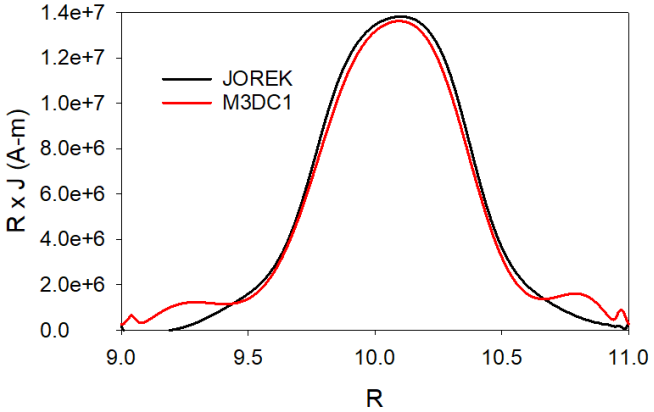
FIG. 3. (a) Time evolution of the total plasma current I and the RE current I_r during the current quench phase. (b) Midplane current density profiles before and after the current quench obtained from JOREK, showing a relatively peaked RE current profile.

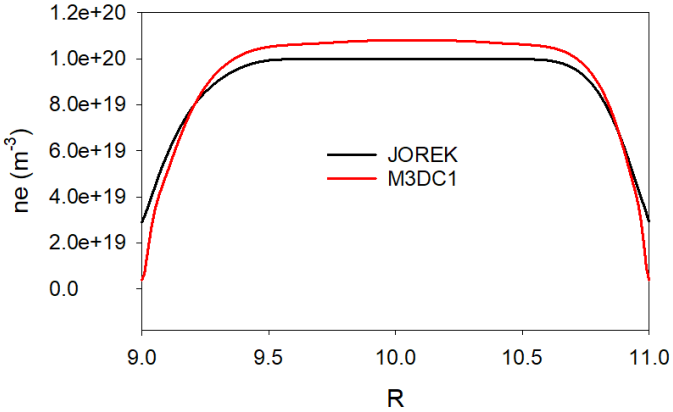
Chen Zhao

Comparison of initial profiles

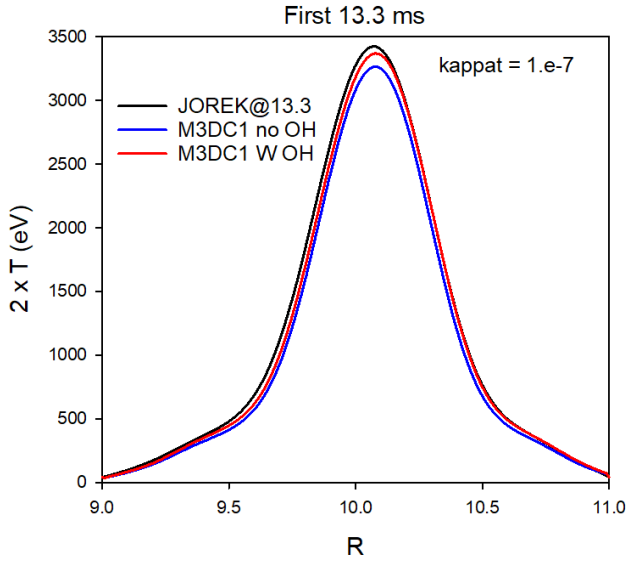


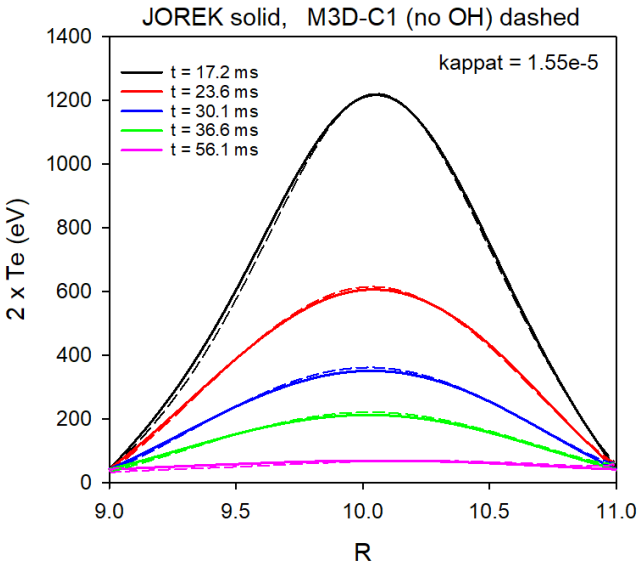






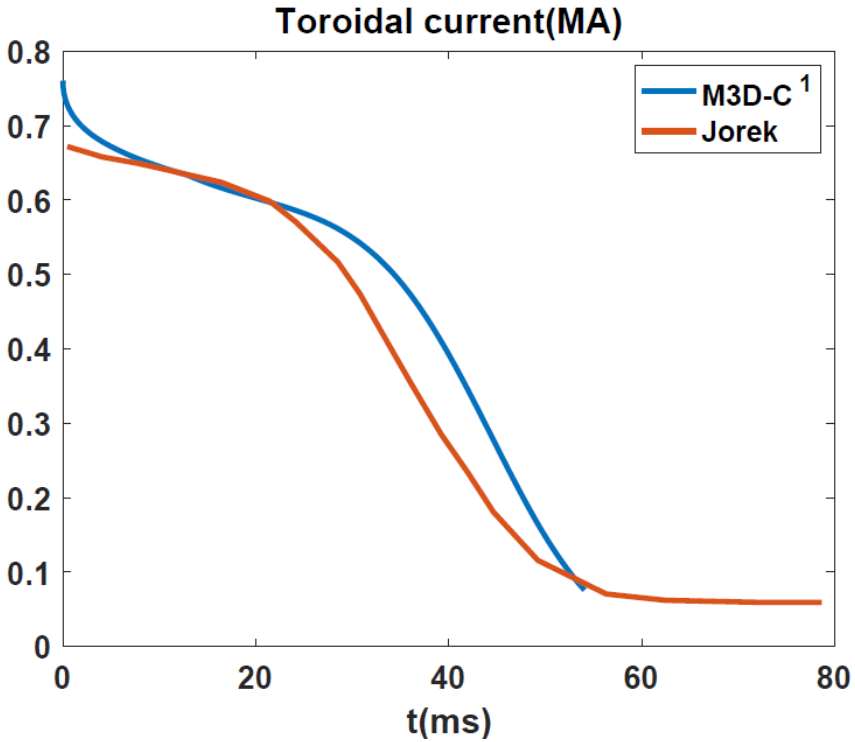
Comparison of T(R) at several times with no runaways

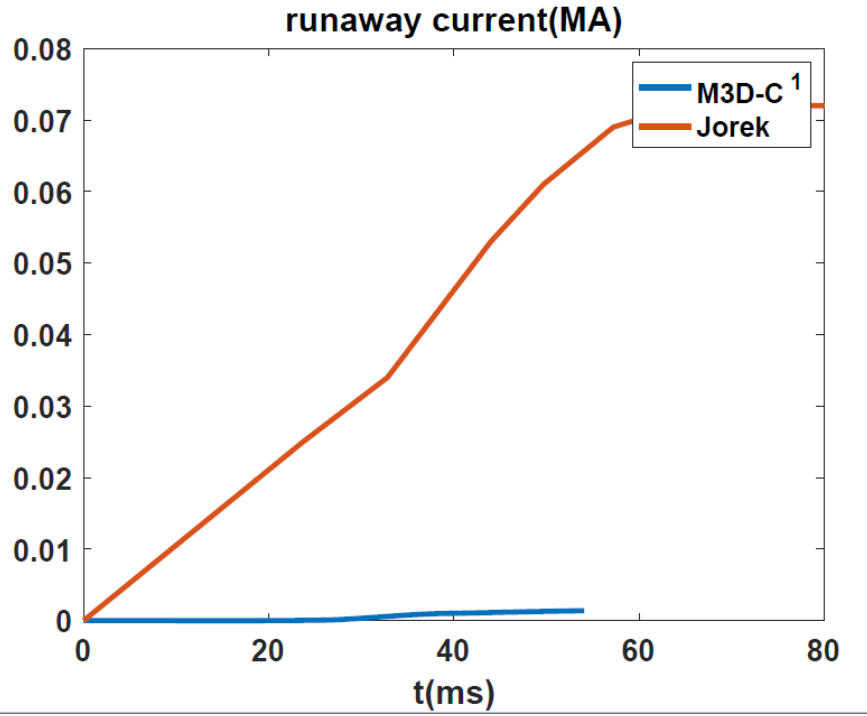




/p/tsc/m3dnl/Bandaru3

Initial results with Runaways (Chen)

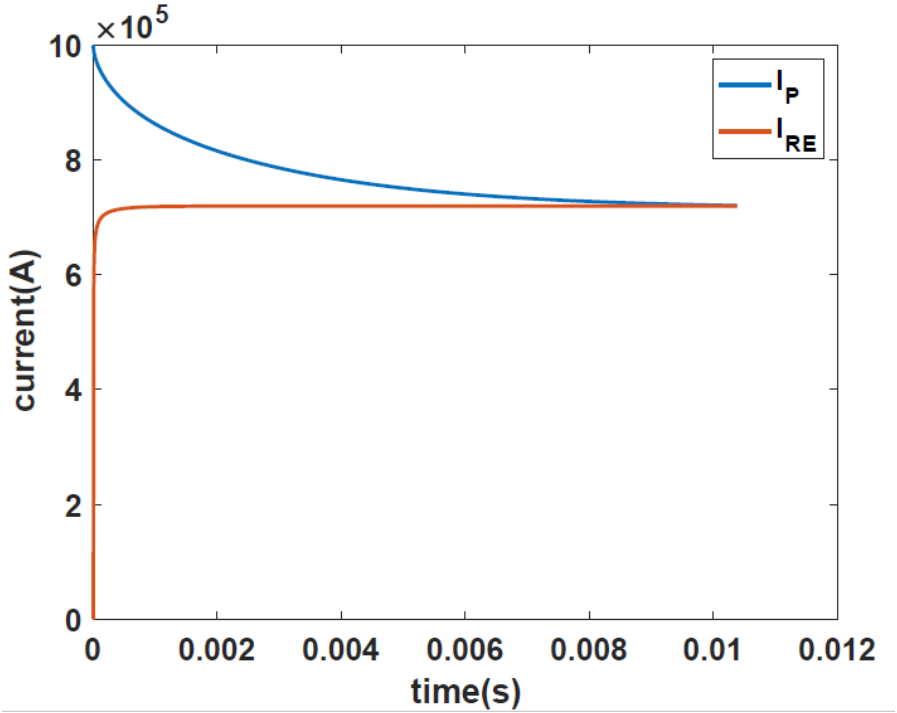


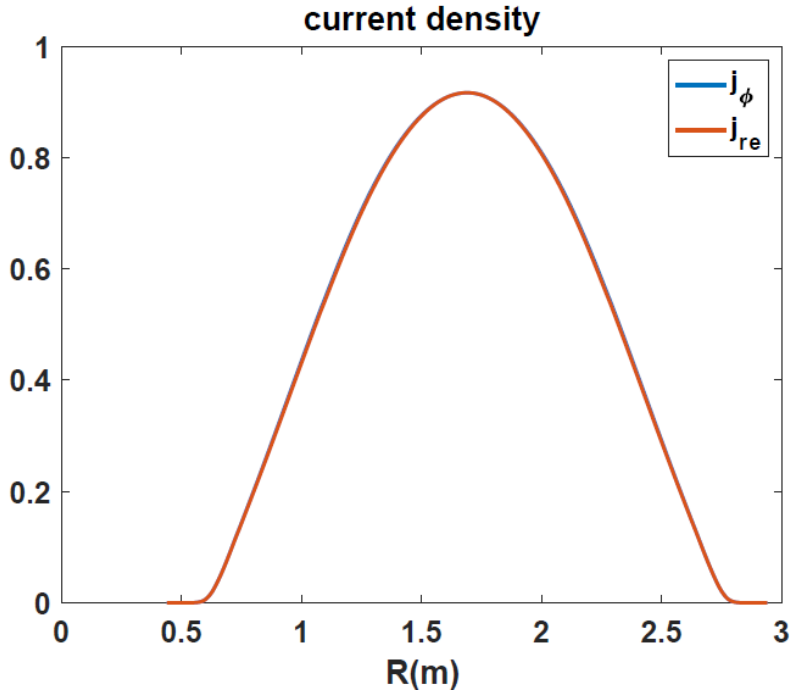


That’s All I have

Anything Else ?

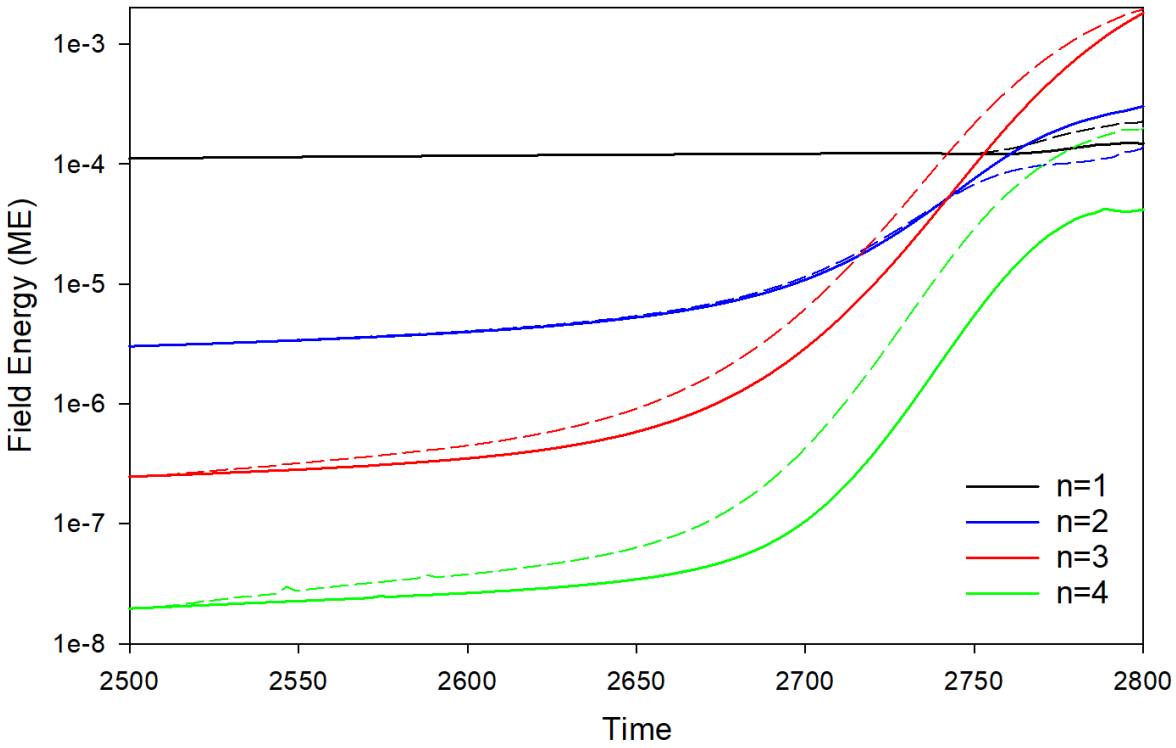
2D (cylindrical) RE with sources (12/19/2020)



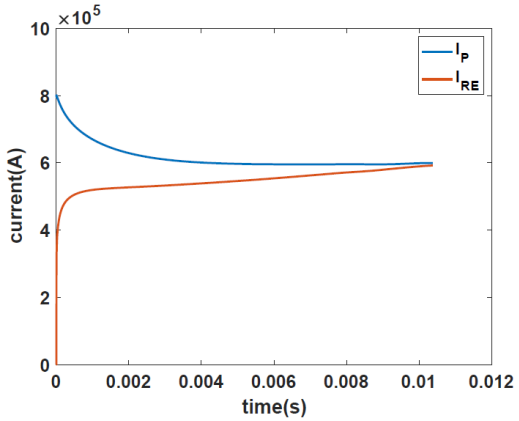


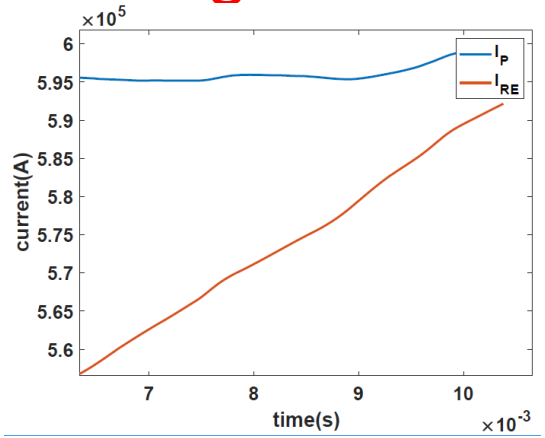
Chen Zhao

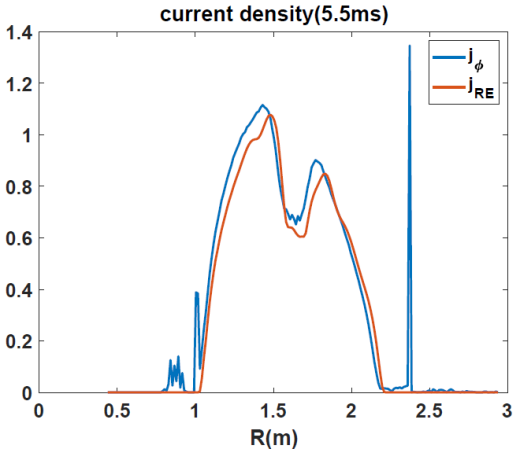
Energy in base case 36742317 (solid) and 16 plane case 37248033 (dashed)

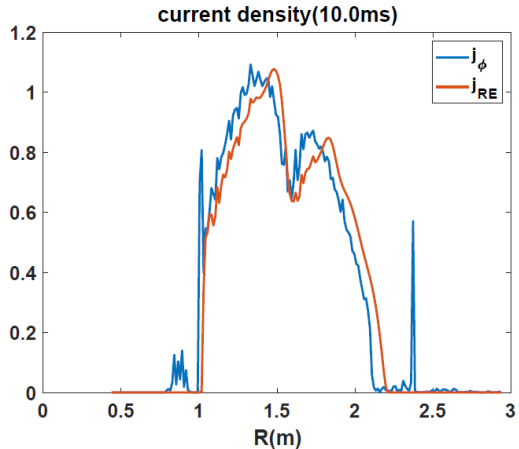


DIII-D 177053 with Argon





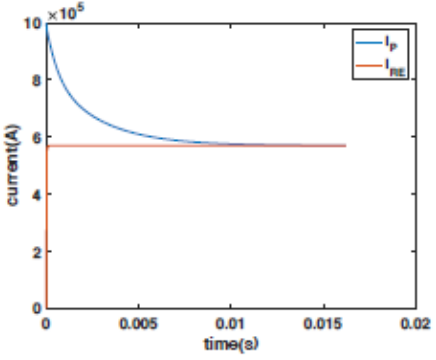


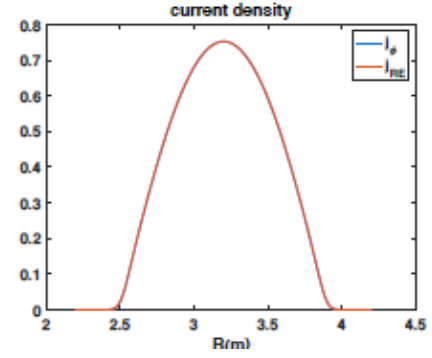


Chen Zhao

Same calculation in a Cylinder

M3D-C1 runaway generation with cylinder geometry





- Parameters: $\beta_0 = 0.15$

$$a = 0.65m$$
$$\mathrm{R} = 1.7m$$
$$B_0 = 1.9T$$
$$\eta = 1.0\times10^{-4}$$
$$n_0 = 1.0\times10^{20}m^{-3}$$
$$c = 150v_A$$
$$N_{elements} = 12261$$
$$\Delta t = 1.0\tau_A$$

- The plasma current was equal with plasma current by the runaway current at about 12ms.
- The radial profile of runaway current profile are exactly same when the plasma current equal to runaway current.

Progress on other shots?

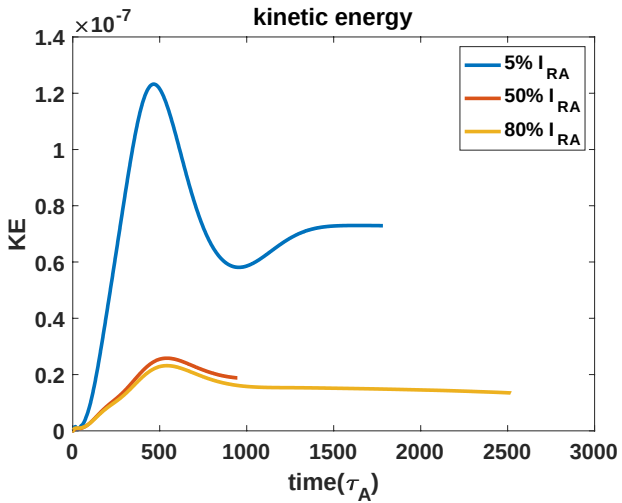
- M3D-C1/NIMROD 3D Benchmark

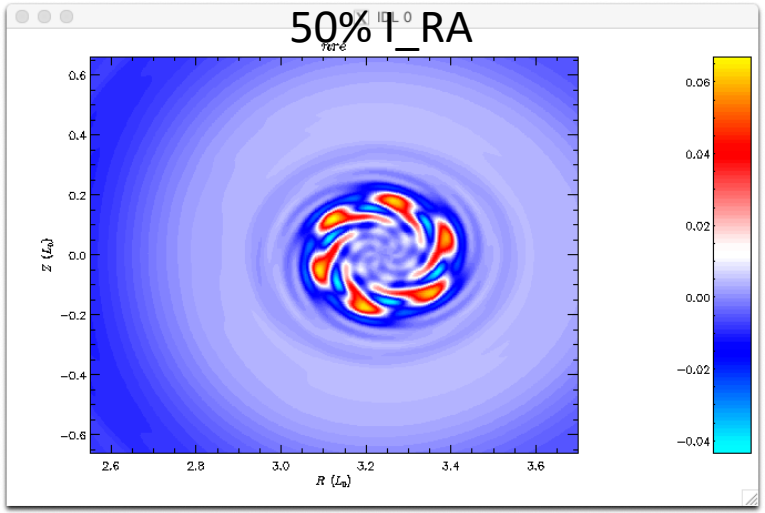
NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes
Chang Liu

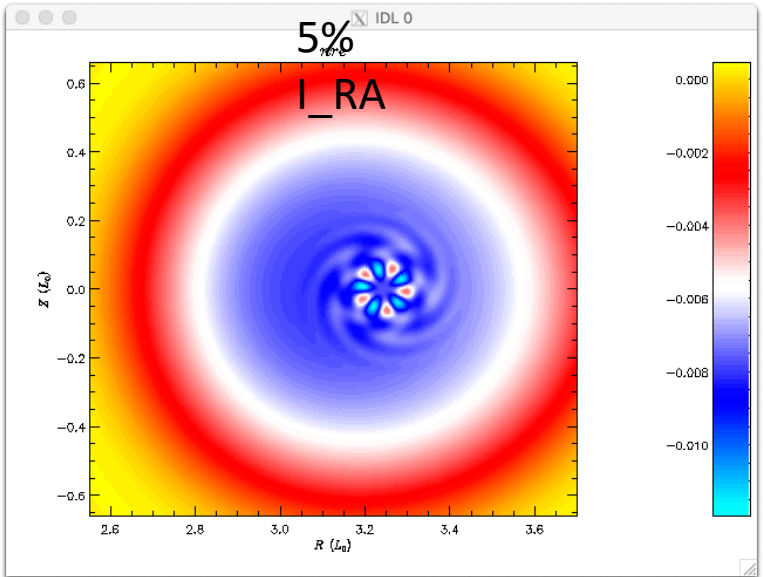
DIII-D Neon pellet mitigation simulation for KORC

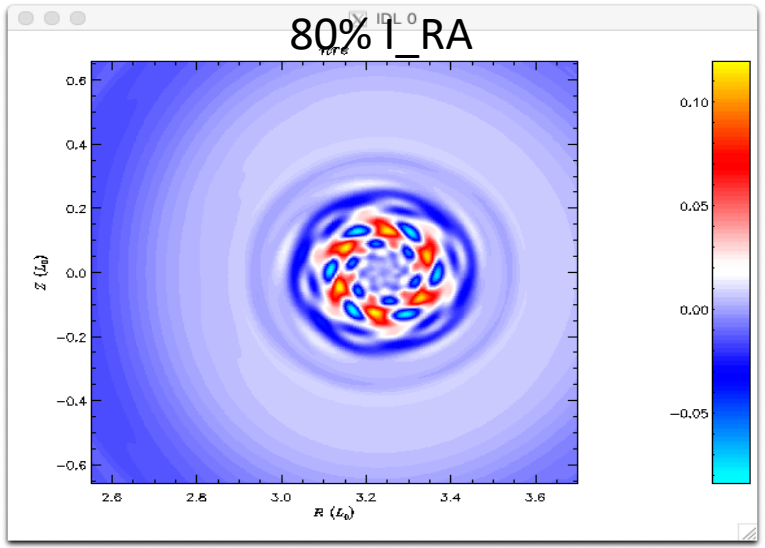
- Brendan Lyons trying to extend 8 plane case to 32 planes

SPARK ? Do we need to do anything?


kinetic energy
×10^-7
KE
time(τ_A)
5% I_RA
50% I_RA
80% I_RA

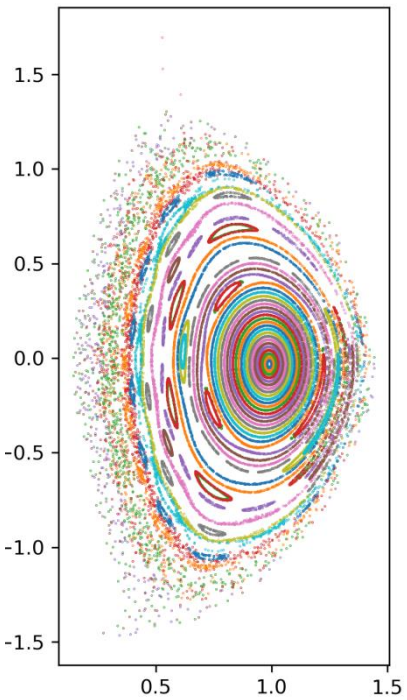

50% I_RA
IDL 0
Z (L_0)
R (L_0)


5% I_RA
IDL 0
Z (L_0)
R (L_0)


80% I_RA
IDL 0
Z (L_0)
R (L_0)

NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes

Chang Liu



- In the original geqdsk file, the equilibrium was poorly converged. New one is much better. Has q(0) = 1.3
- Chang has analyzed new equilibrium (left)
- No ideal (1,1) mode, several tearing modes

- If goal is to get unstable (1,1) mode, likely need to lower q(0)
- Adding sheared toroidal rotation should help stabilize resistive modes.

Grad-B drift in M3D-C1—HF side

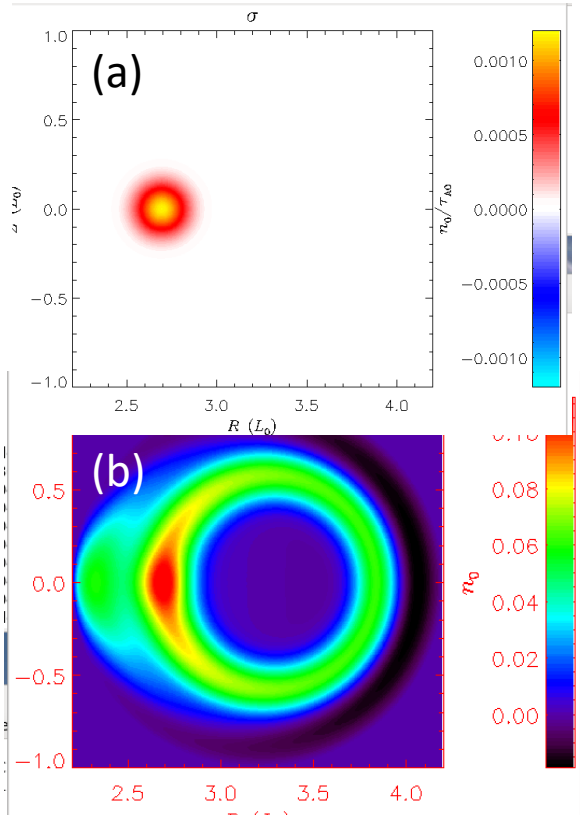
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

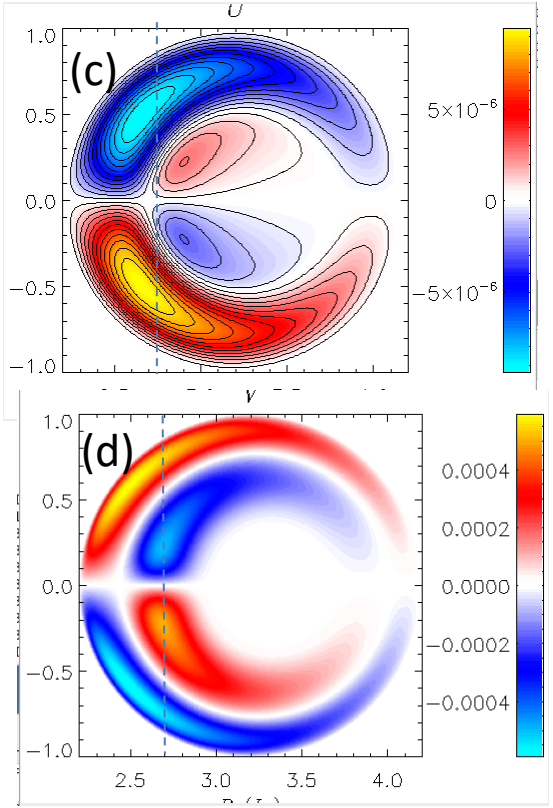
(a) Density source in 1F toroidal equilibrium

(b) Change in density after 10^3 τ_A

(c) Poloidal velocity stream function

(d) Toroidal velocity contours





Grad-B drift in M3D-C1– LF source

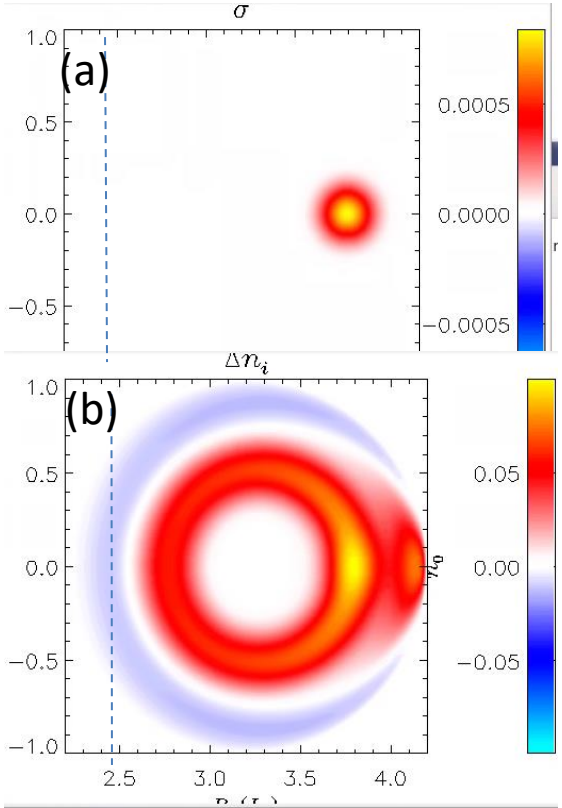
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

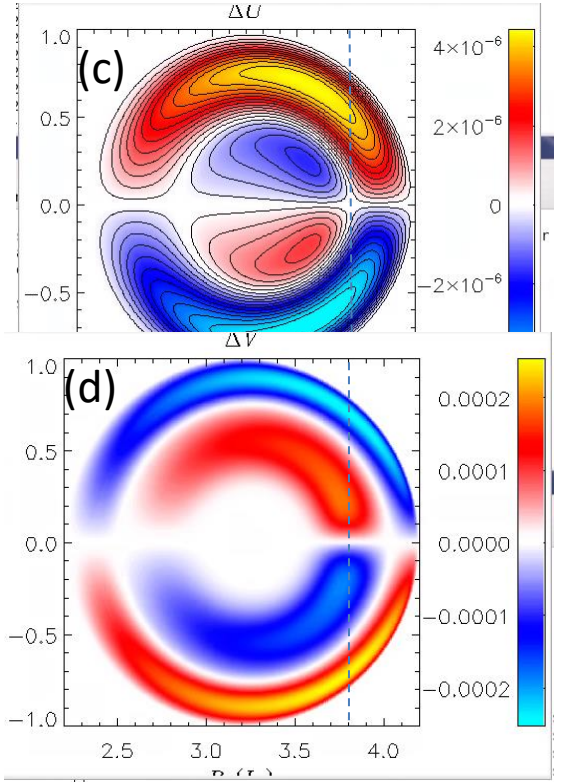
(a) Density source in 1F toroidal equilibrium

(b) Change in density after 10^3 τ_A

(c) Poloidal velocity stream function

(d) Toroidal velocity contours





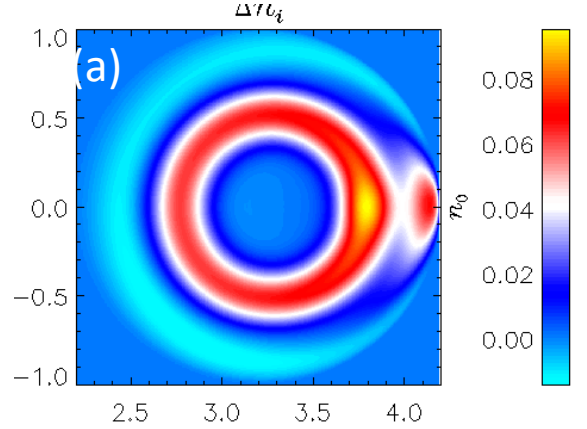
Grad-B drift in M3D-C1—2F effects

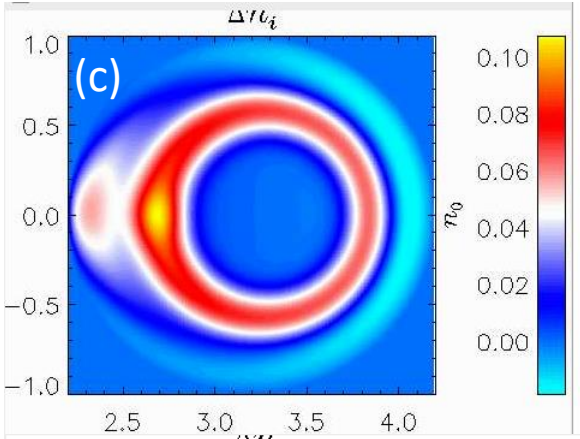
(a) 2F density change after 10^3 τ_A for LF side source

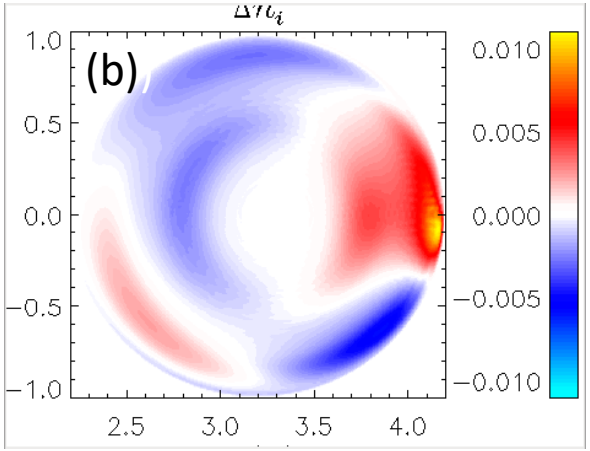
(b) Difference in 1F and 2F density (LF)

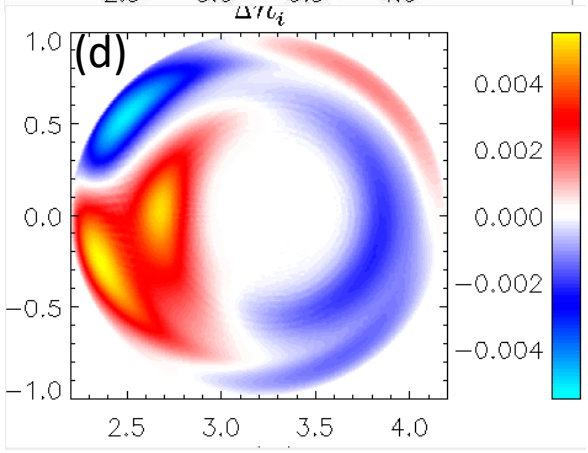
(c) 2Fdensity change after 10^3 τ_A for HF side source

(d) Differencein 1F and 2F density (HF)

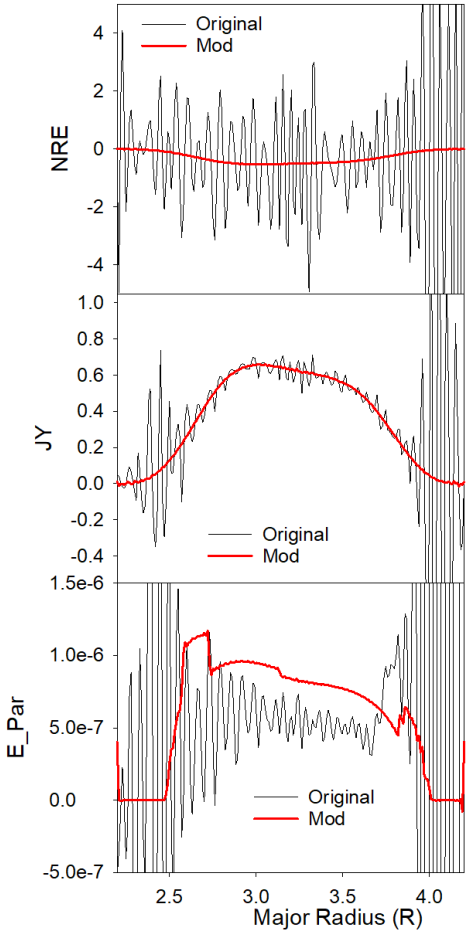








Sawtoothing discharge with runaway electrons

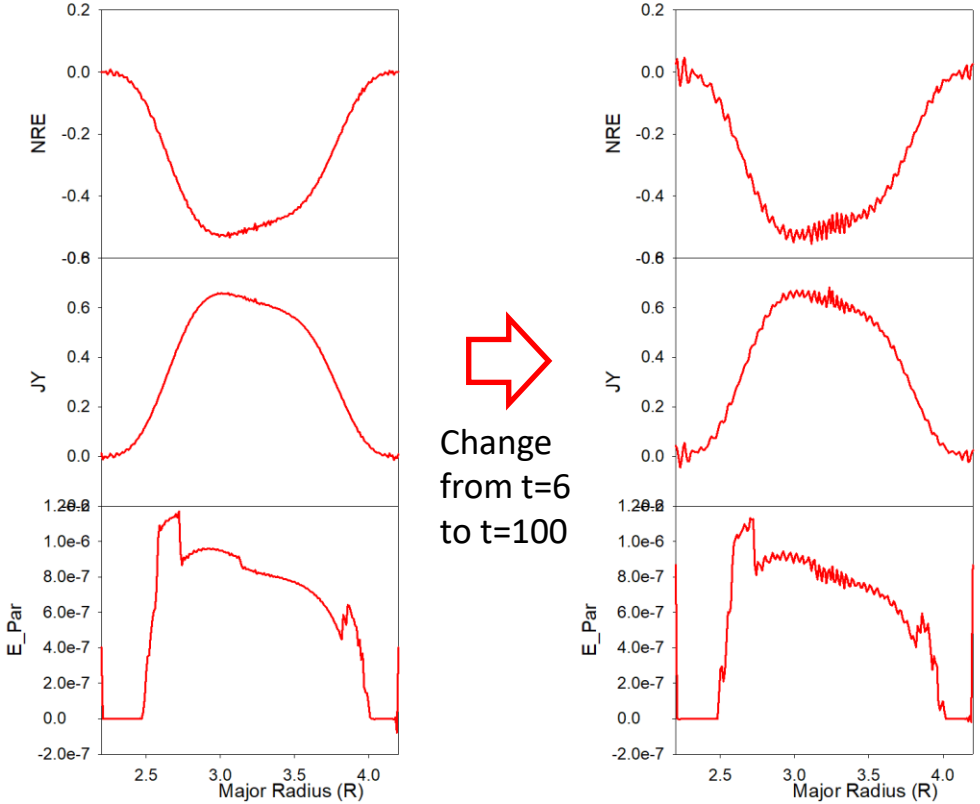


Profiles of nre, jy, and E_par after 30 timesteps

Original: /p/tsc/m3dnl/Isabel/Chen2D
Mod: /p/tsc/m3dnl/Isabel/Chen2D-mod1

Changed:
mesh size
"regular"
"integration points"
ipres=1
cre
pedge
viscosity
denm
equilibrium density

Longer times develops oscillations



- Short wavelength oscillations occur first in nre and then in other quantities (jy, e_par)
- Could we add some smoothing?