M3D-C1 ZOOM Meeting

04/19/2021

CS Issues

1. GPU solve status
2. Mesh adaptation update
3. stellar .Princeton.edu
4. Perlmutter Early users and NERSC Time
5. Changes to github master since last meeting
6. Regression tests

Physics Studies

1. M3D-C1 modeling of pellet ELM triggering in low collisionality discharges
2. Interfacing M3D-C1 and LPC
3. ITER disruption modeling with more resistive vessel
4. Update on M3D-C1-S Yao Zhou
5. Carbon Mitigation in NSTX-U w shell pellet Clauser/Jardin
6. Self-consistent simulation of resistive kink with runaway electrons – Chang Liu
7. Effect of Avalanche term on DIII-D 177053.. Chen Zhao
8. Effect of resistive wall on the thermal quench – Hank Strauss
9. Helical band to suppress runaways
10. Other

In attendance

Brendan Lyons
Yao Zhou
Cesar Clauser
Nate Ferraro
Hank Strauss
Mark Shephard
Jin Chen
Adelle Wright
Andreas Kleiner
Chang Liu
Chen Zhao
Usman Riaz
Seegyoung Seol

GPU Solve status

Jin Chen email April 12

1. Segmentation fault was fixed with the help from Yang using openmpi instead of cuda aware openmpi

2. A small test case has been set up for campus support group to dig into the reason why cuda aware openmpi caused the fail (fixed as of 4/19/2`)

3. A large size test case has been set up for LBL group to do GPU profiling on TRAVERSE

4. Application has been submitted to use CORI-GPU VAST file system to find out if there are any benefits

Jin Chen

Mesh Adaptation Update

RPI?
Brendan Lyons ?

stellar.princeton.edu

- /scratch/gpfs/yourname now available, 1 TB limit shared with traverse
- /home directory , 100 GB limit
- /projects/M3DC1/yourname 10 TB total for all users
- Visualization node for PPPL: ssh stellar-vis2

Final Configuration: 296 Intel nodes, 100-140 dedicated to PPPL Should be ready by end of April

All users meeting held Tuesday April 12:
Dorland said “whole device modeling” projects would have priority. **Today he confirmed that M3D-C1 is a WDM code.** People should fill out web form, check WDM
Presently do NOT plan to keep statistics by code

EDDY will be shut down noon Wed April 21. Essential to move remaining files of interest NOW

Perlmutter Early Users

Selected members of the NESAP Tier 2 teams will be the first group of users allowed access to the NERSC Perlmutter system during the Early Science phase. Initially there is a limit of 10 NESAP users per NESAP project.

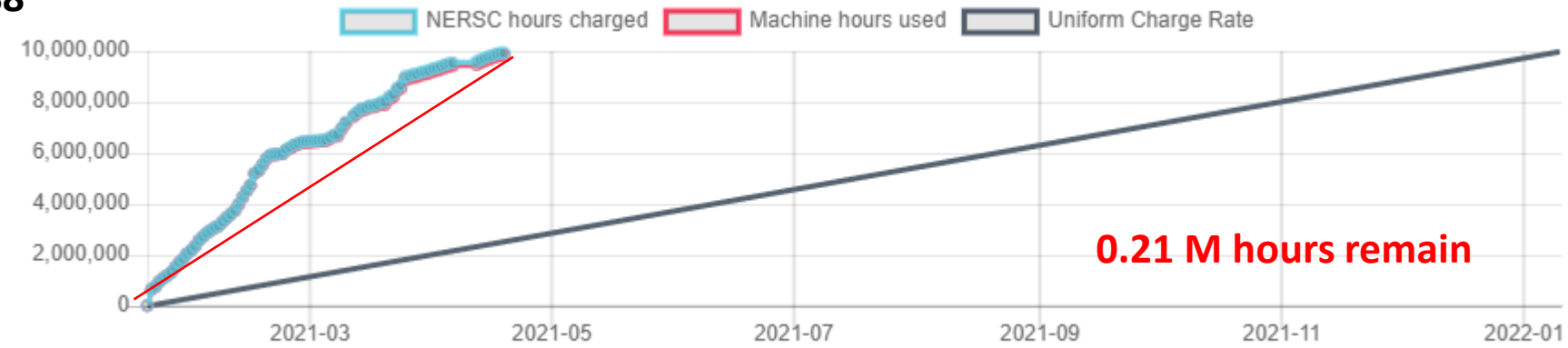
Assuming no further delays, the tentative plan is for NESAP Tier 2 teams to be able to have access to Perlmutter sometime in June.

Early users for mp288:

Jin Chen
Seegyoung Seol
Chang Liu
Nate Ferraro
Steve Jardin
Nan Ding
Yang Liu
Others?

NERSC Time

mp288



m3163

Closed for general use

- mp288 received 10M Hrs for CY 2021
- We will exhaust this by the end of April at this rate. (May get more time)
- Jardin will contact John Mandrekas to inquire if more time is available
- Transition to stellar (PU/PPPL)

Changes to github master since 03/28 !

- **Brendan Lyons:**
  - **04/01/20: Add IDL routine for plotting Poincare output of fusion-io trace**
  - **04/02/20: Expand movie field capabilities**
    - **Overlay pellet location**
    - **Overlay velocity field**
    - **Make movie rotating through toroidal angle**
  - **04/08/20: Add ability to plot traces for all pellets simultaneously**
  - **04/13/20: Add optional multiplicative factor on ablation rate**

- **Nate Ferraro:**
  - **04/16/20: Updated plot_scalar.pro to handle text output of scalar arrays**

- **Seegyoung Seol**
  - **04/07/20: field transfer for 3D adapted mesh implemented**

Local Systems

- PPPL centos7(04/19/21)
  - 6 regression tests **PASSED** on centos7:
- PPPL greene (04/19/21)
  - 5 regression tests **PASSED**
  - No batch file found for pellet
- STELLAR (04/19/21)
  - 6 regression tests **PASSED** on stellar
- TRAVERSE(03/29/21)
  - Code compiles
  - Regression test failed: split_smb not found in PATH

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)
  - ??

M3D-C1 modeling of pellet ELM triggering in low-collisionality discharges

- Preprint by A. Wingen (ORNL)
- Linear and non-linear simulations
- Linear simulation with ipellet=1 perturbs only the density profile. Large enough perturbation excites an unstable mode

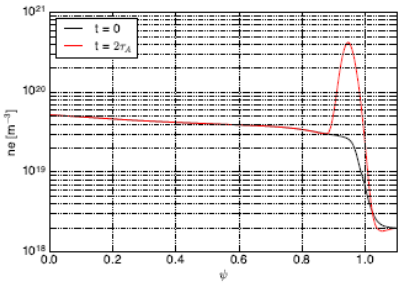


Figure 2. (Color online) Electron density along the minor radius at $Z = 0$ from the magnetic axis outwards. Black: without pellet, red: with pellet ablation

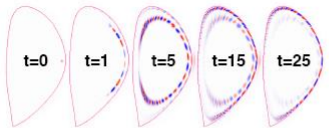


Figure 3. (Color online) Temporal evolution of n = 9 mode structures within the plasma after an initial perturbation by a pellet of size 0.72 mm, injected at the outboard midplane. The time is measured in Alfén time.

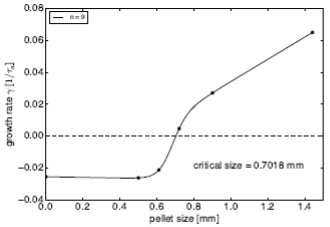
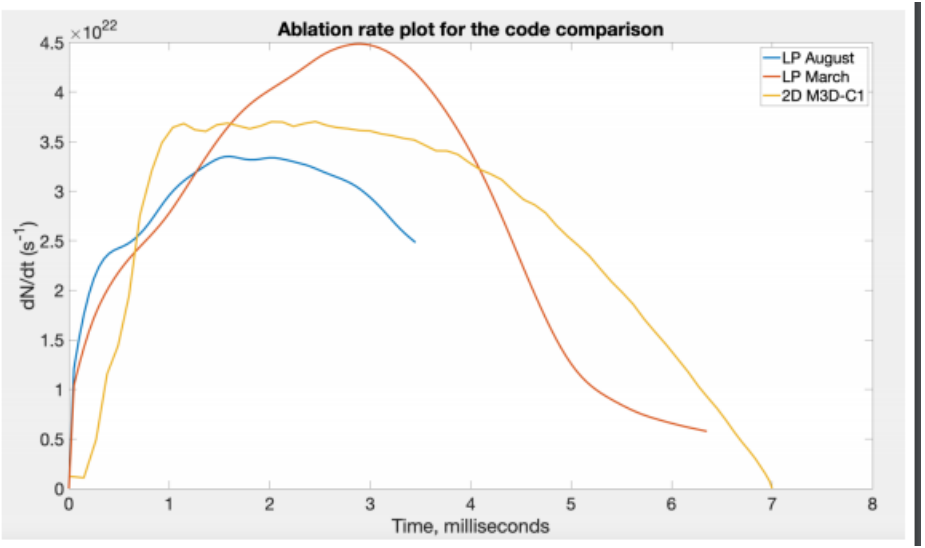


Figure 5. (Color online) Linear growth rate dependence on pellet size for the most unstable mode, $n = 9$, in Fig. 4.

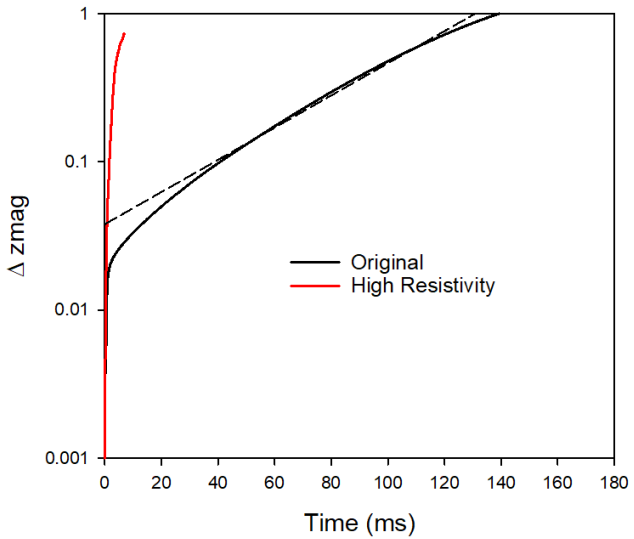
Q: How does a density perturbation excite a MHD mode?

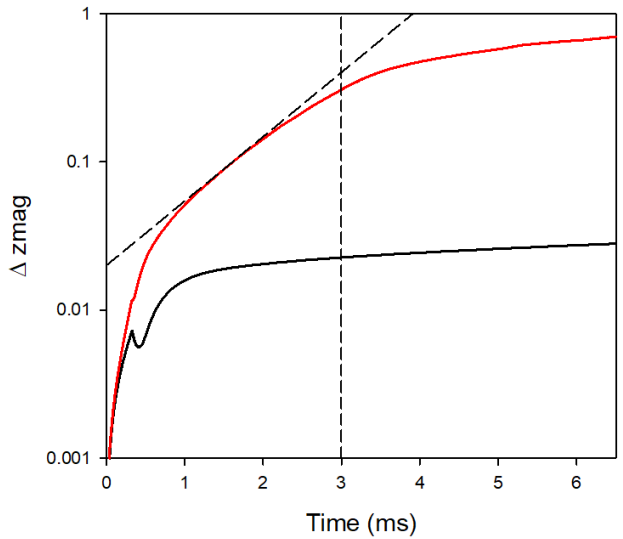
Interfacing M3D-C1 and LPC

- Zoom meeting was held 04/08/21 with Roman Samulyak and students
- Presentation posted on m3dc1.pppl.gov
- Small differences between m3dc1 pellet model and LPC local model
- Brendan to see what data is available for single neon pellet ablation test
- Daisuke Shiraki will address our group next Monday



ITER disruption with more resistive vessel





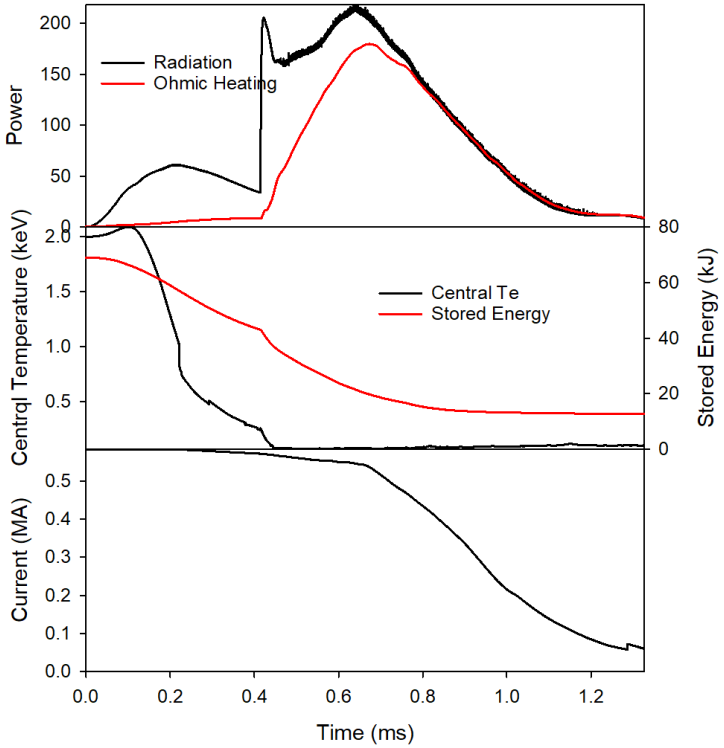
- Increased all vessel resistivities by 100
- Growth rate went from .025 ms^{-1} to 2.0 ms^{-1}
- New case greatly slows down after contact with wall is made

Update on M3D-C1-S

- Yao found that the velocity matrix iteration would only converge for large values of viscosity for the stellarator version

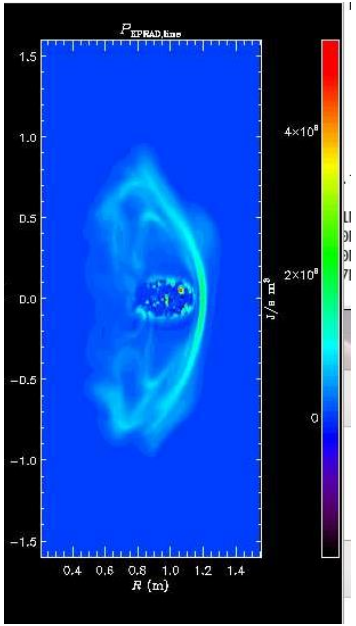
- He then implemented a variable viscosity option (ivisfunc=21) which uses the VMEC surface label as a radial coordinate
- He reported on 4/9/21 that this allowed convergence with significantly lower viscosity in the bulk while keeping it high at the boundary

Carbon Mitigation in NSTX-U (shell pellet)



Shell carbon pellet in NSTX (now running)

Radiation
t = 0.73 ms

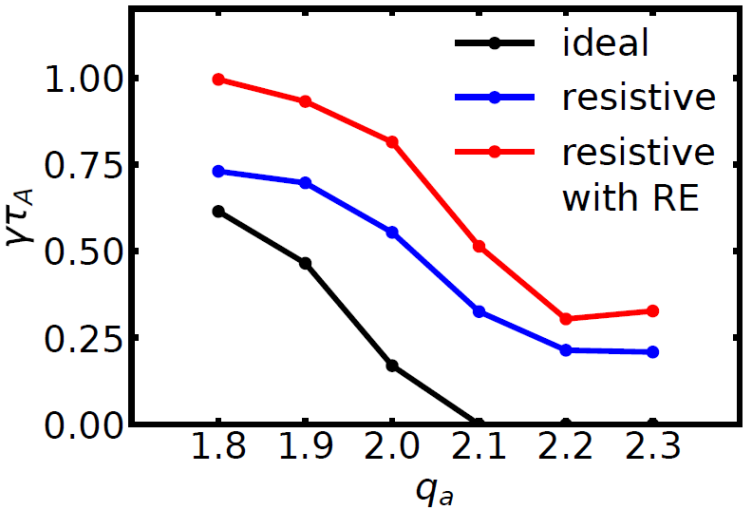


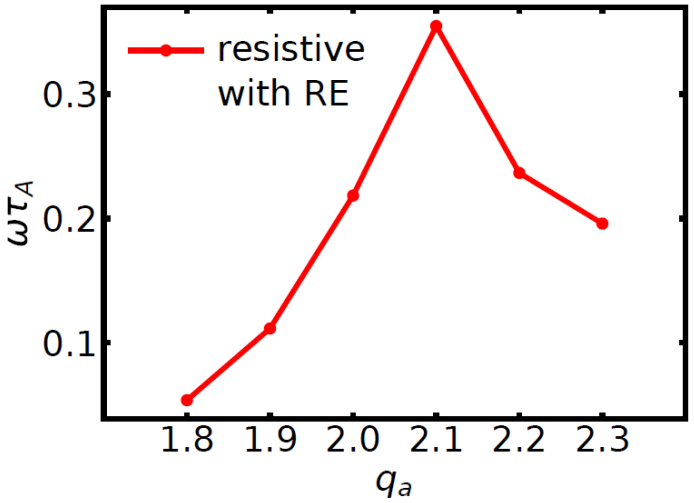
This run is essentially done and can be incorporated into Cesar's paper

Cesar Clauser

Self-consistent simulation of resistive kink instabilities with runaway electrons

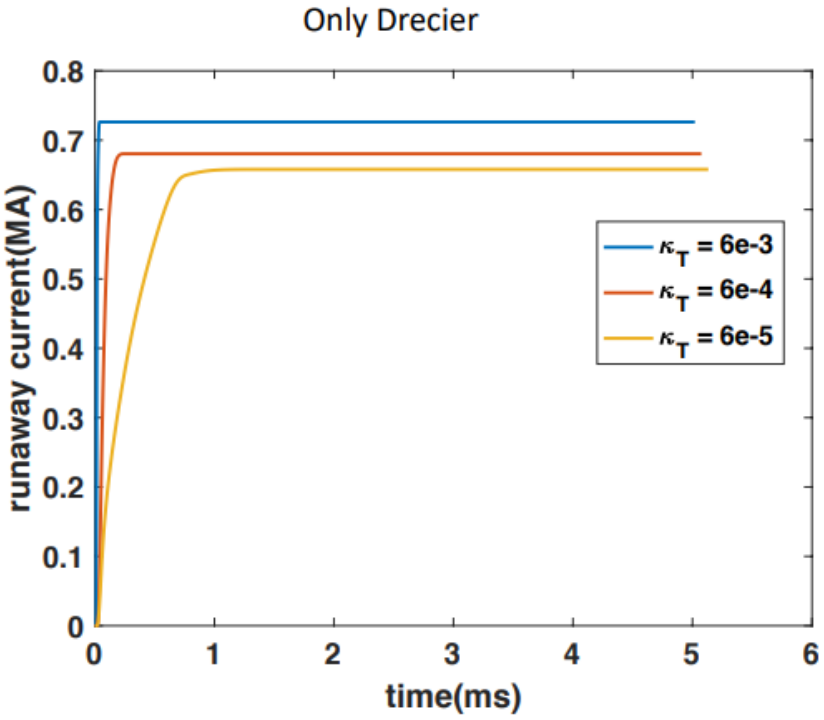
- Chang Liu, et al manuscript

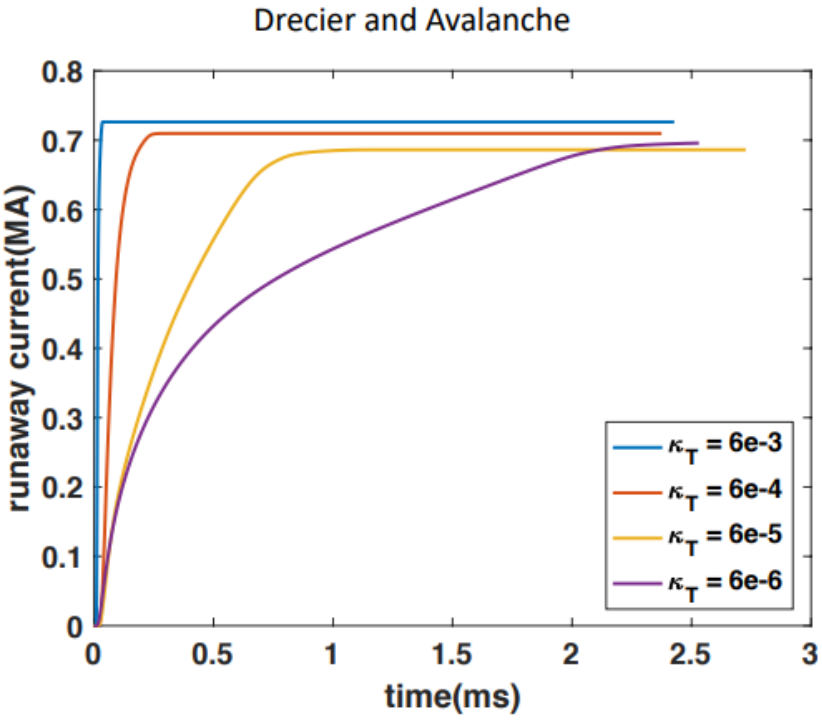




- Chang generated stability plots by Bateman scaling the qa=2.0 equilibrium (same current density but scaled toroidal field)
- Why is this so different from MARS plot (next vg)

Effect of Avalanche term on DIII-D 177053





Chen Zhao

Next Steps

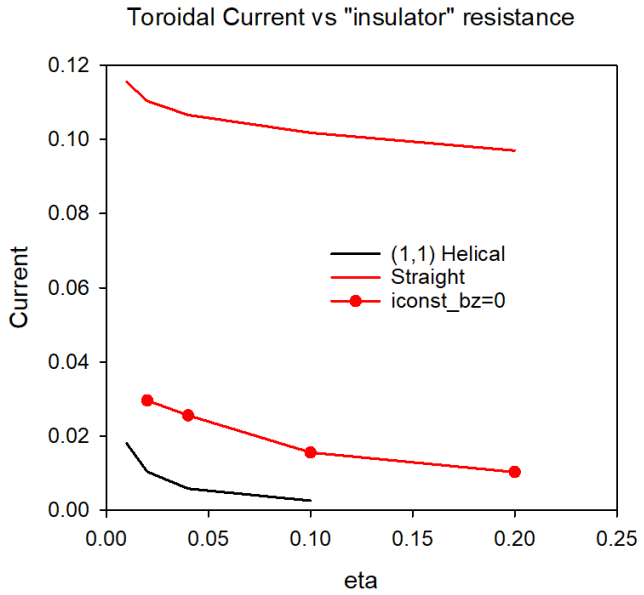
- NIMROD is interested in doing a benchmark of the runaway source calculations. I gave them Chen's equilibrium and results

- I asked Carlos Paz-Soldan to help us identify a series of DIII-D shots where runaways are generated. Still waiting to hear. (he did indicate that he's working on it)

Effect of resistive wall on the thermal quench

- H. Strauss to present

Helical resistive band to suppress runaways



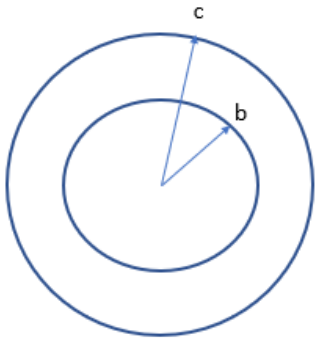
- I have asked Matthias Hoelzl if he could try and reproduce this with the STARWALL code. He seems interested

That’s All I have

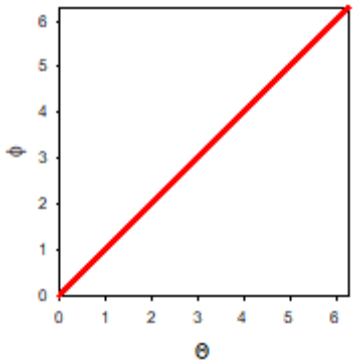
Anything Else ?

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?

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

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

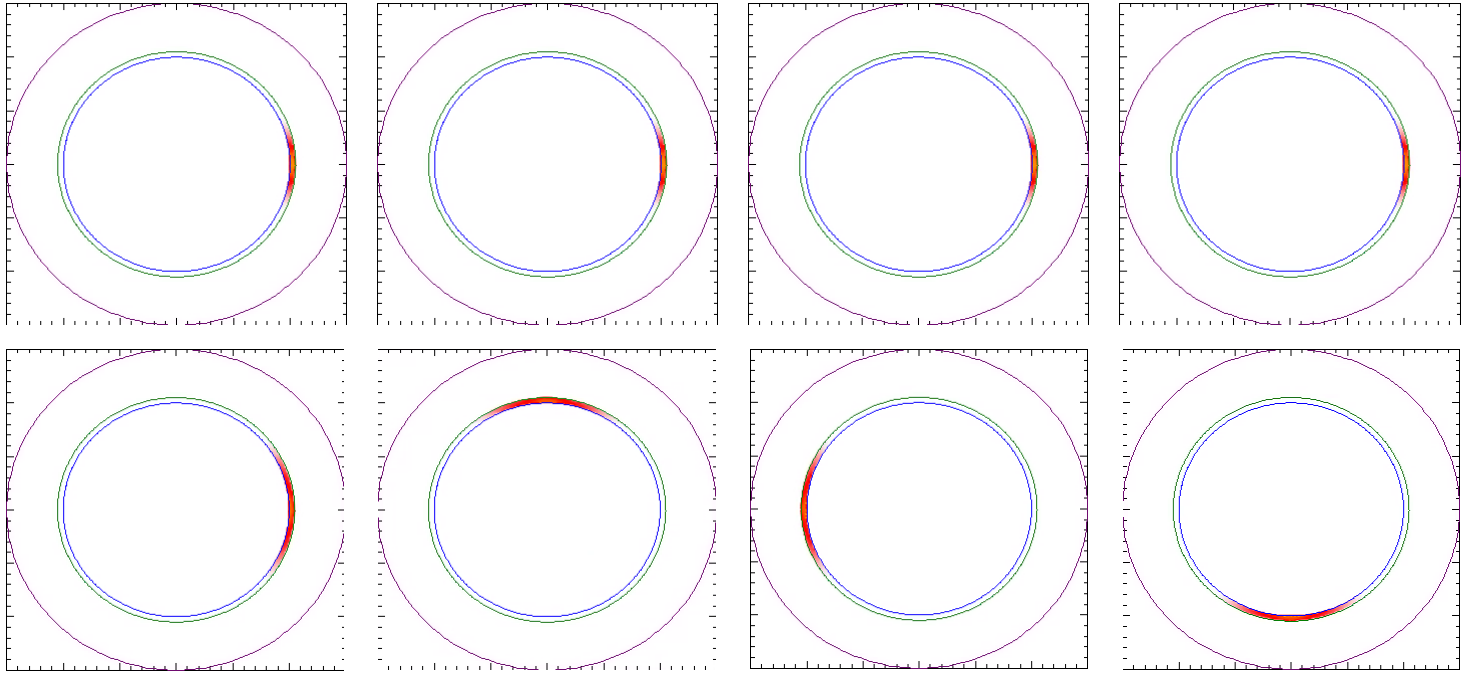
What is driving the current in the θ direction? It can't be Φ unless

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

Comparison between Straight and helical band

Straight ➔

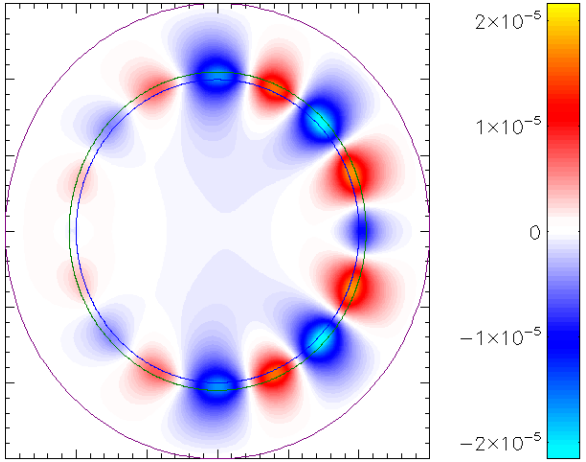
Helical ➔



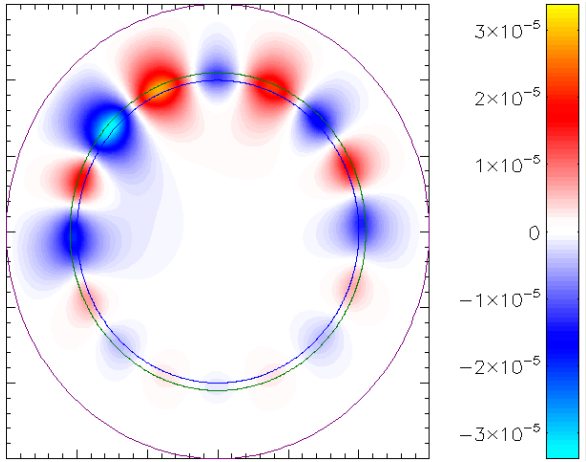
$\varphi = 0$ $\varphi = \pi / 2$ $\varphi = \pi$ $\varphi = 3\pi / 2$

Φ_φ

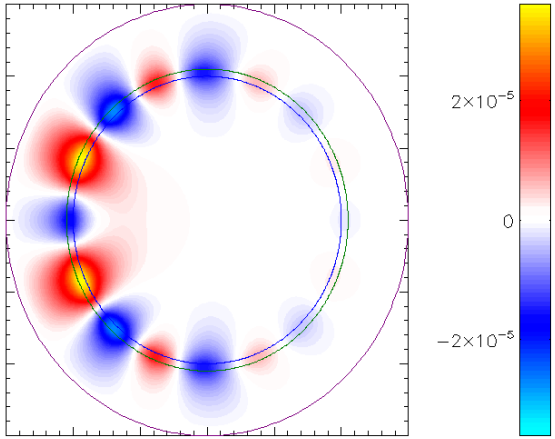
φ = 000°



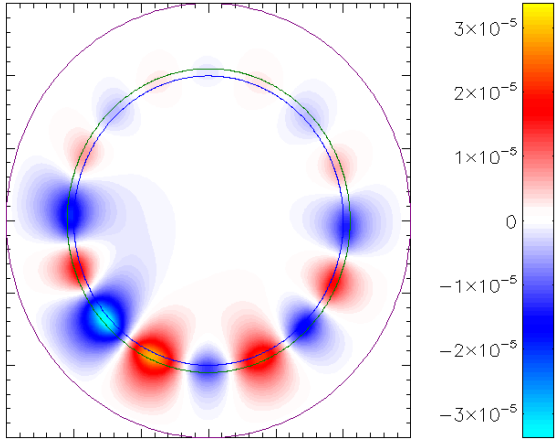
φ = 090°



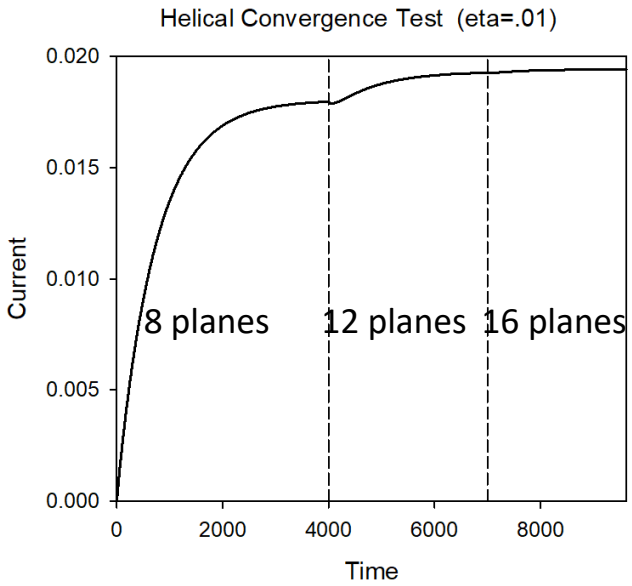
φ = 180°

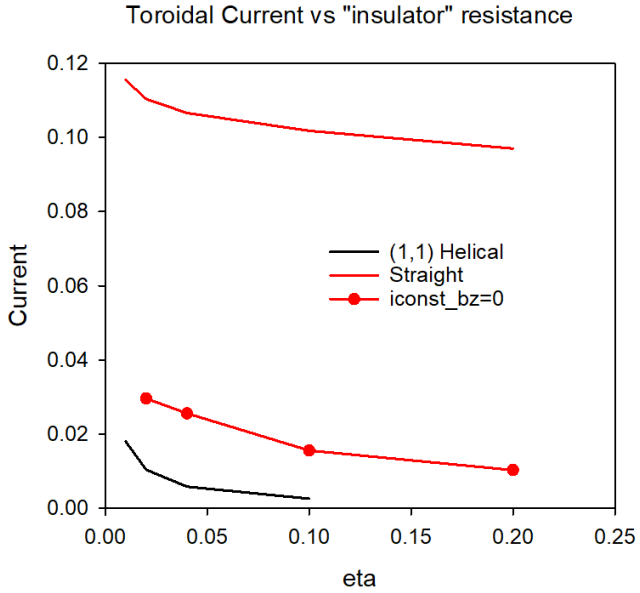


φ = 270°



Some Convergence Tests

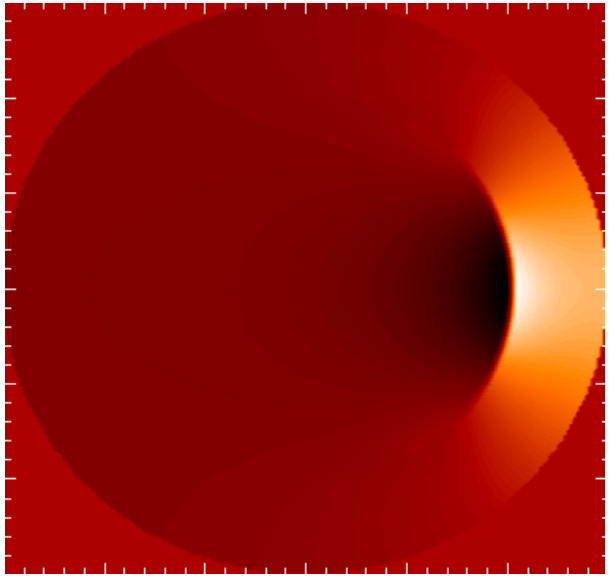




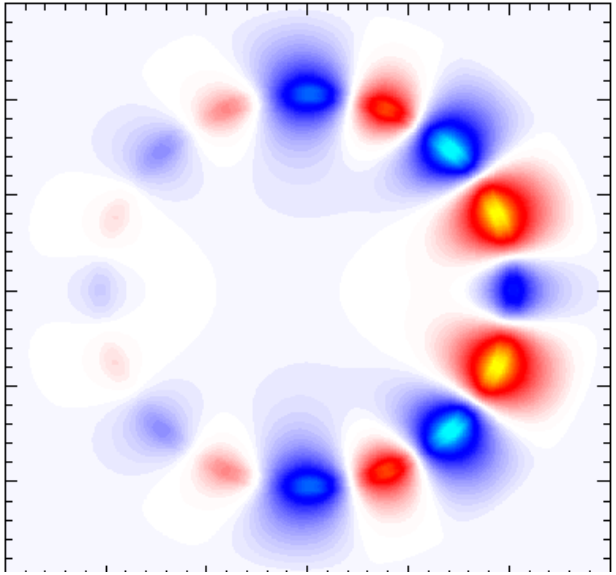
- Wall current appears to be converged in # of planes
- Helical wall current tending towards zero for large values of insulator resistance
- Now testing dependence on boundary conditions (location of ideal wall)
- Helical (1,2) case gives less than half the current of helical (1,1) case
- Iconst_bz=0 increases current, but still far below straight case

Plots for iconst_bz=0

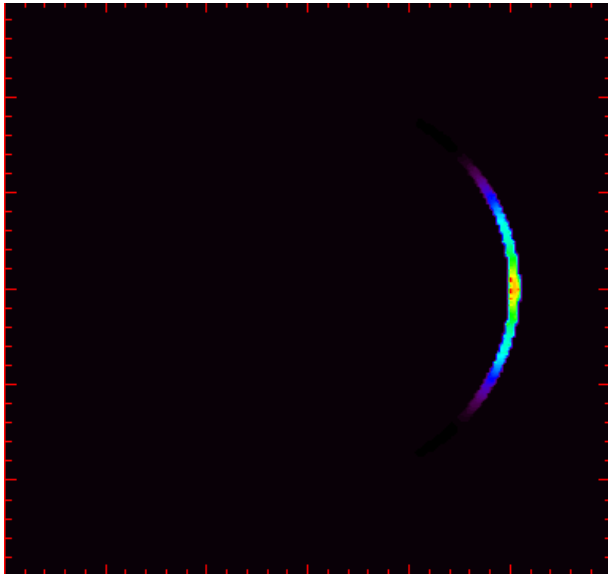
I



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



J_{φ}



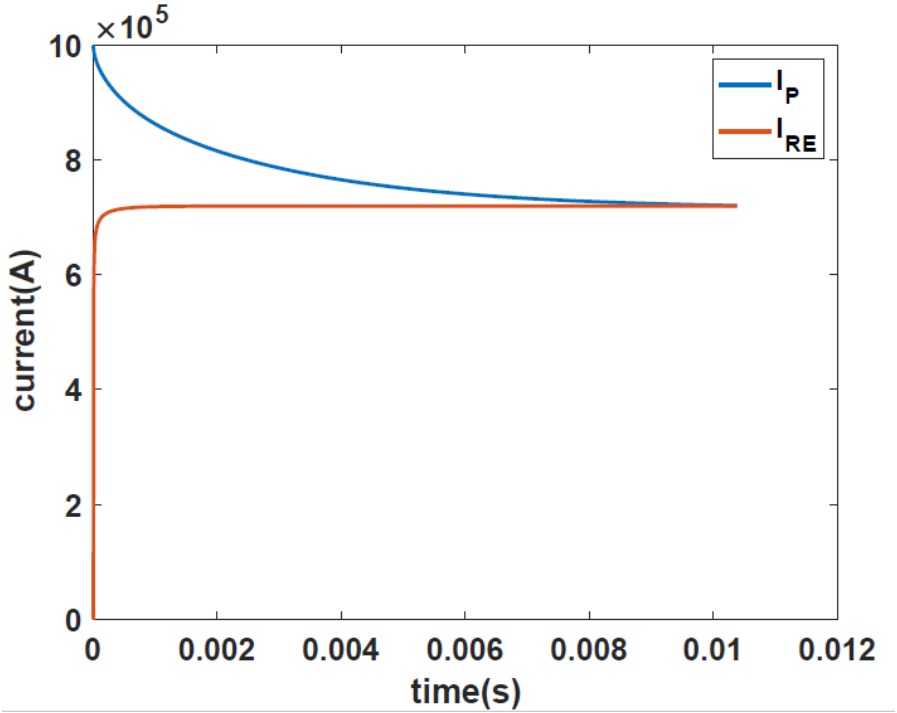
$$\nabla_{\perp} \bullet \frac{1}{R^2} \nabla \Phi = \nabla_{\perp} \cdot \eta \left[-\frac{1}{R^2} \nabla F \times \nabla \varphi - \frac{1}{R^2} \nabla f'' \times \nabla \varphi - \frac{1}{R^4} \nabla_{\perp} \psi' \right]$$

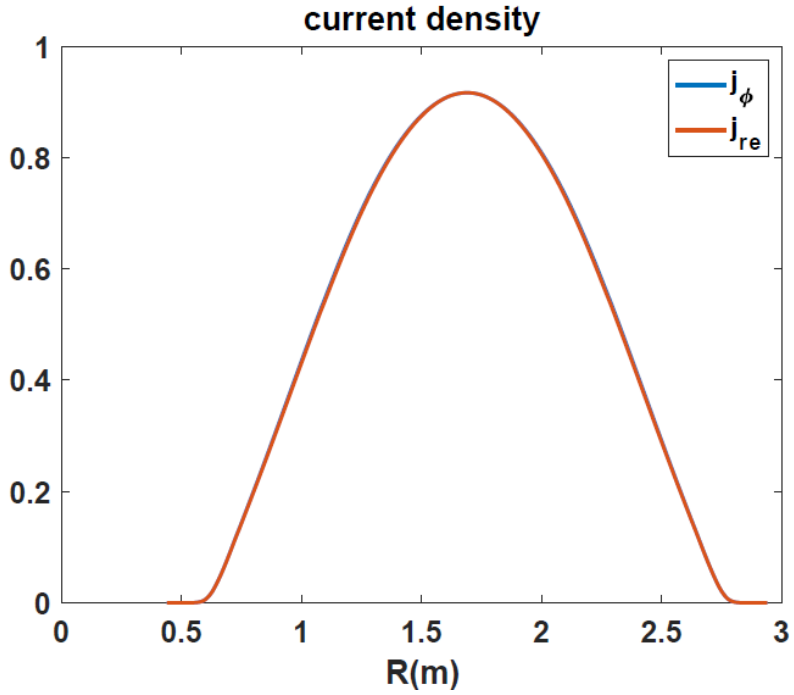
Local Systems

- PPPL centos7(02/22/21)
  - 6 regression tests PASSED on centos7:

- PPPL greene (02/15/21)
  - 4 regression tests PASSED
  - RMP_nonlin timed out (but gave correct results)
  - 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

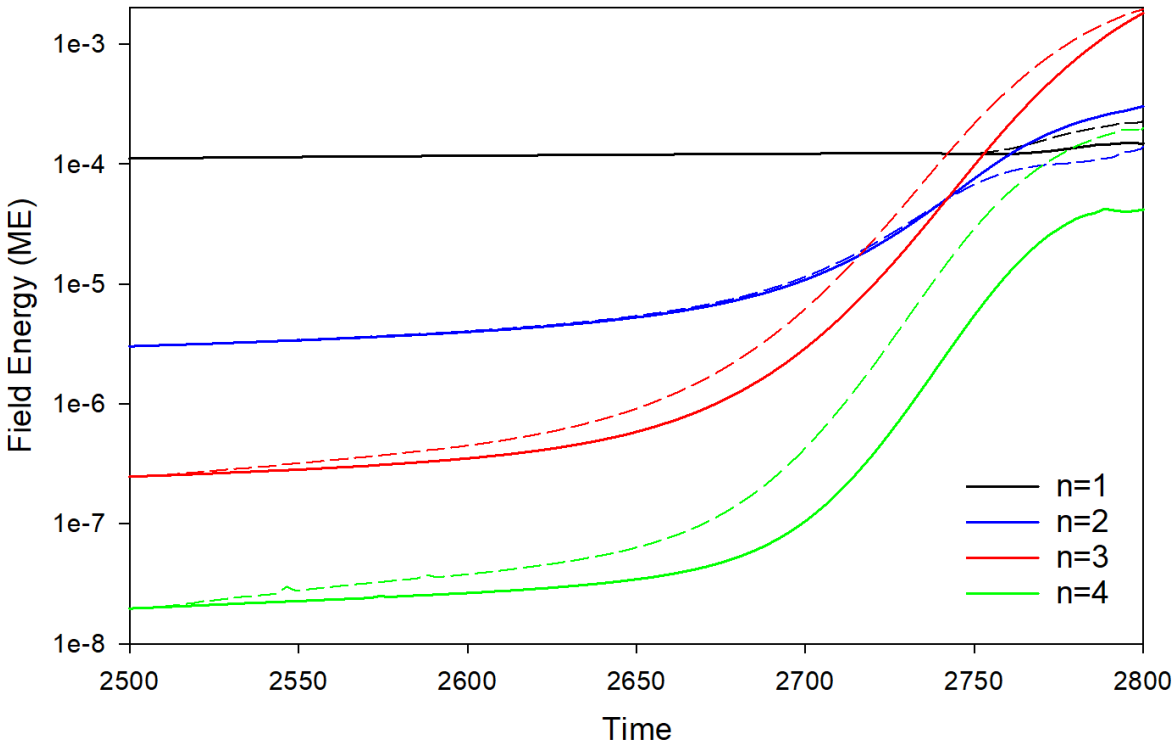
2D (cylindrical) RE with sources (12/19/2020)



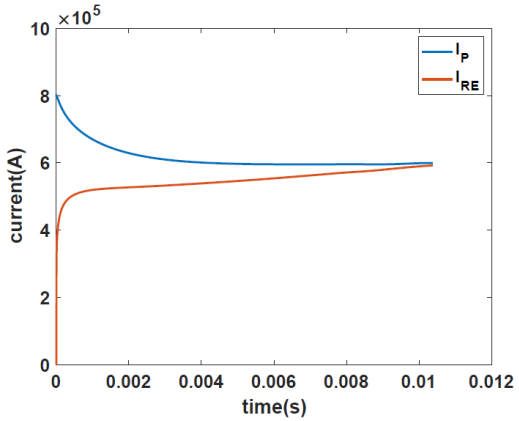


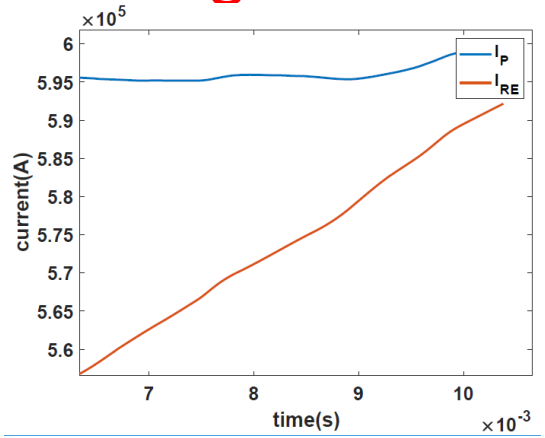
Chen Zhao

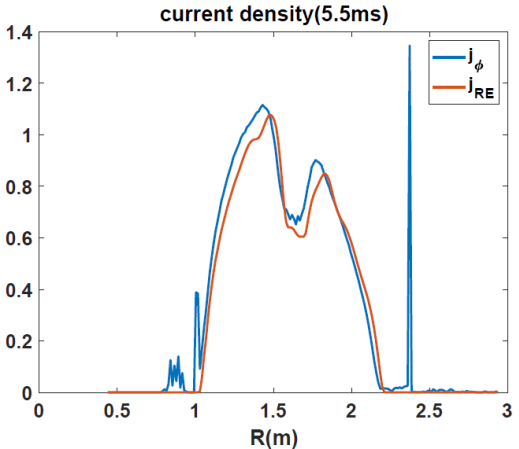
Energy in base case 36742317 (solid) and 16 plane case 37248033 (dashed)

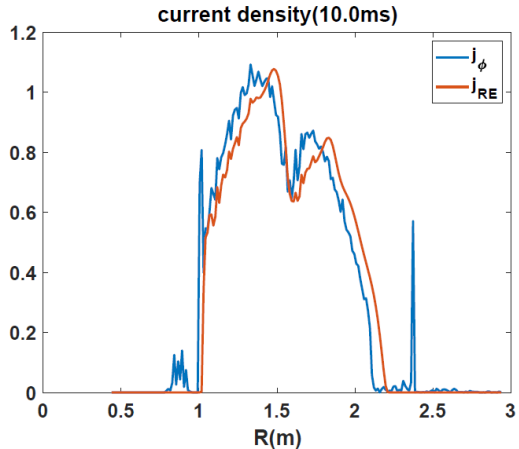


DIII-D 177053 with Argon





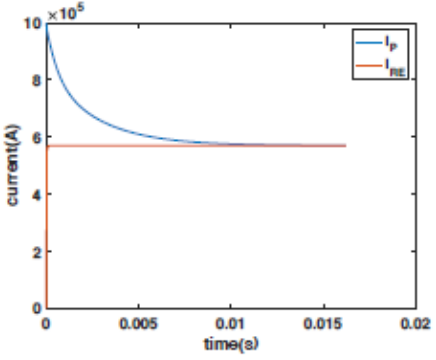


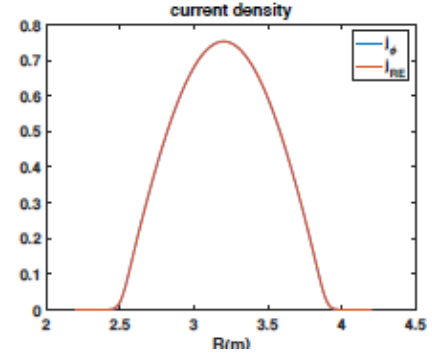


Chen Zhao

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?

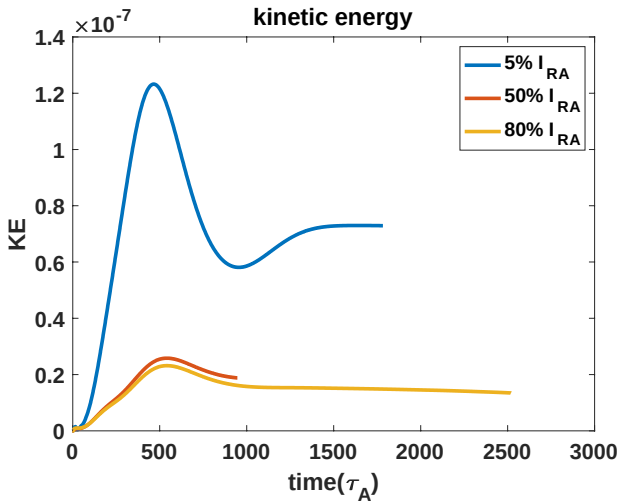
- M3D-C1/NIMROD 3D Benchmark

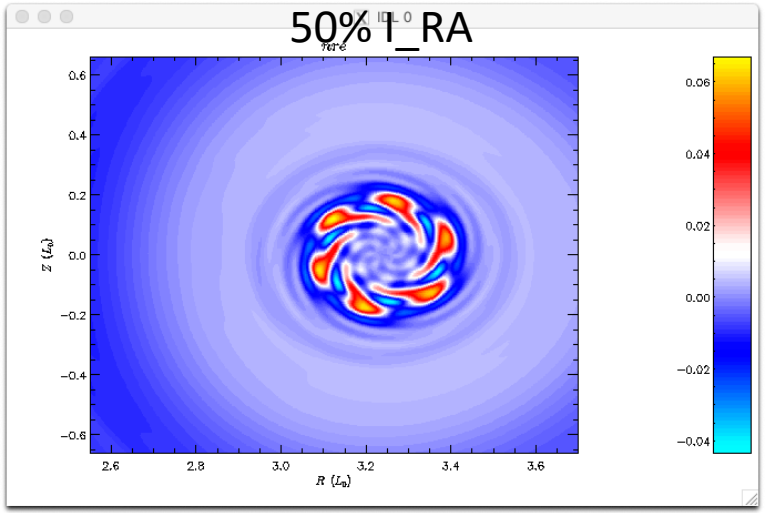
NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes
Chang Liu

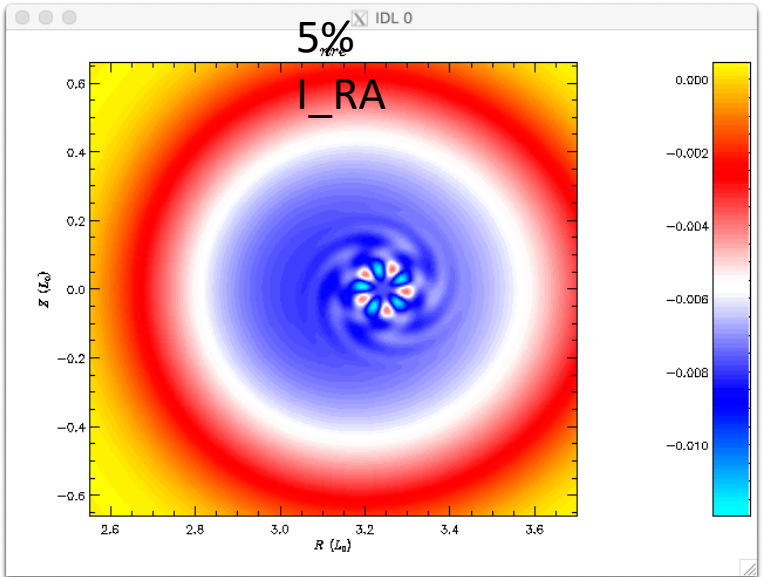
DIII-D Neon pellet mitigation simulation for KORC

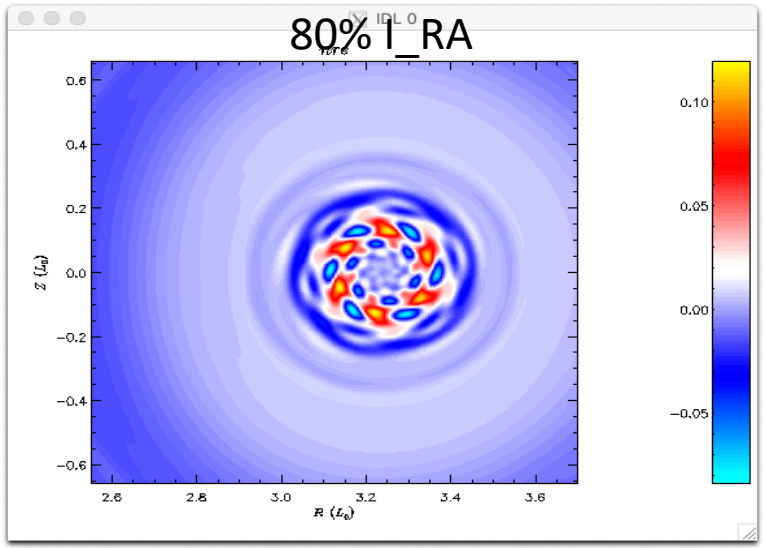
- Brendan Lyons trying to extend 8 plane case to 32 planes

SPARK ? Do we need to do anything?


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

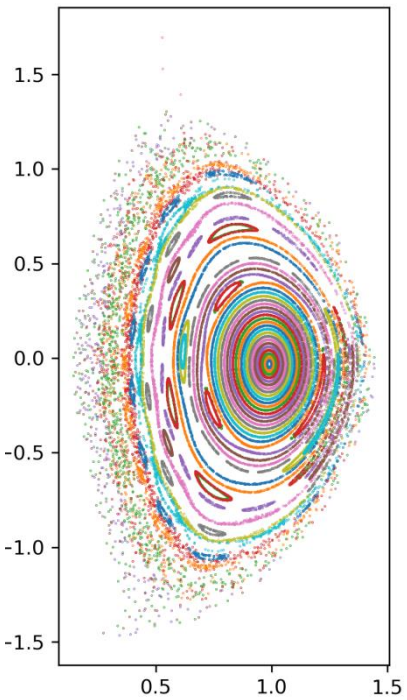

50% I_RA
IDL 0
Z (L_0)
R (L_0)


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

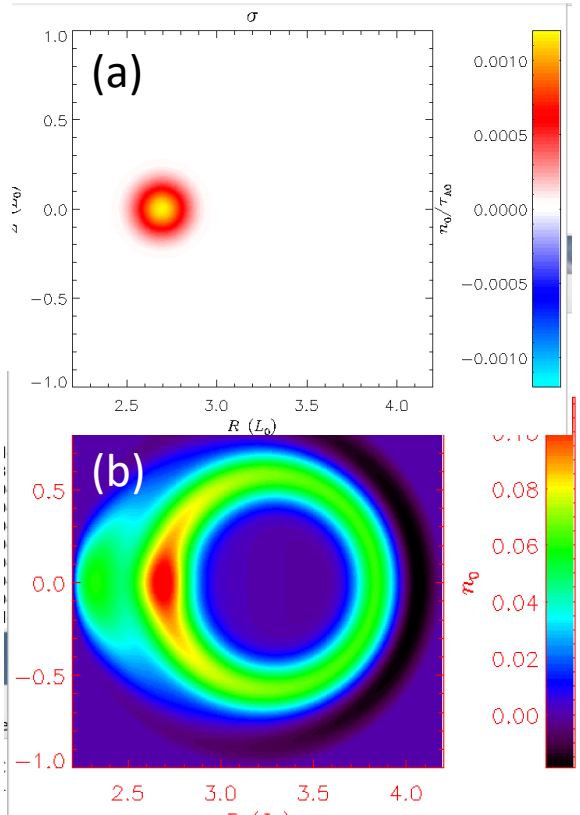
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

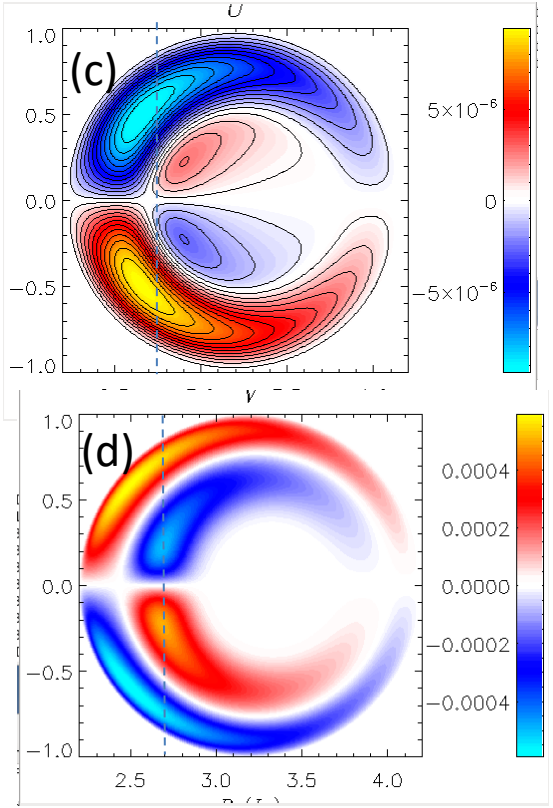
(a) Density source in 1F toroidal equilibrium

(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

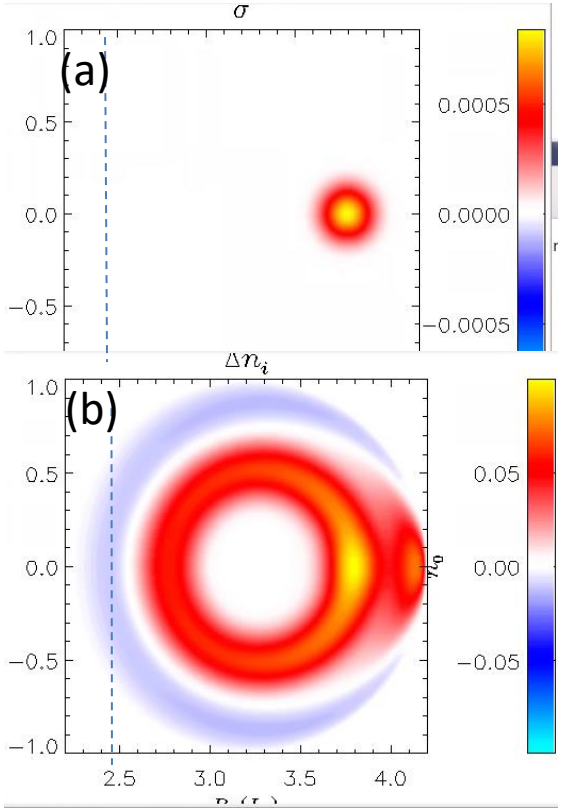
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

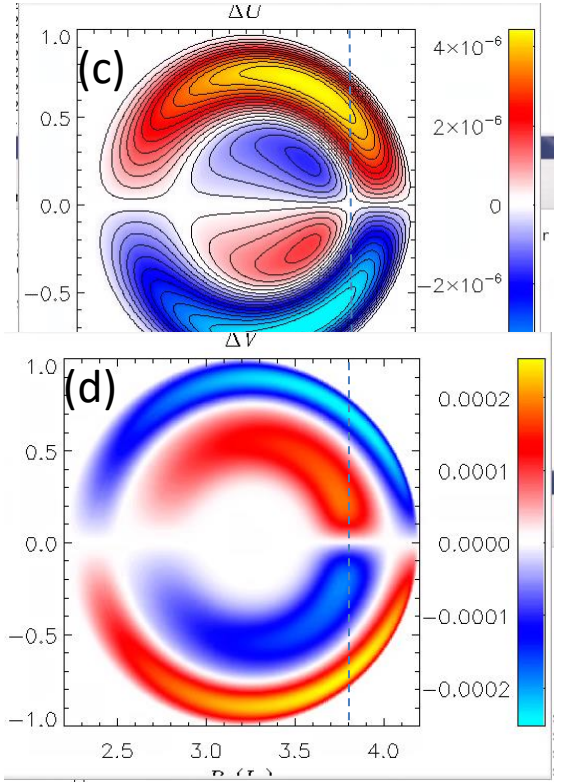
(a) Density source in 1F toroidal equilibrium

(b) Change in density after 10^3 τ_A

(c) Poloidal velocity stream function

(d) Toroidal velocity contours





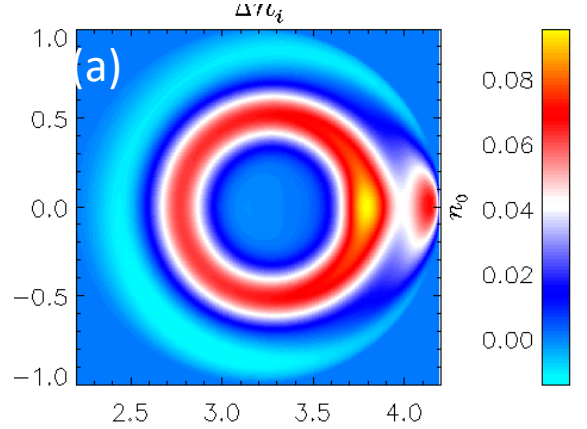
Grad-B drift in M3D-C1—2F effects

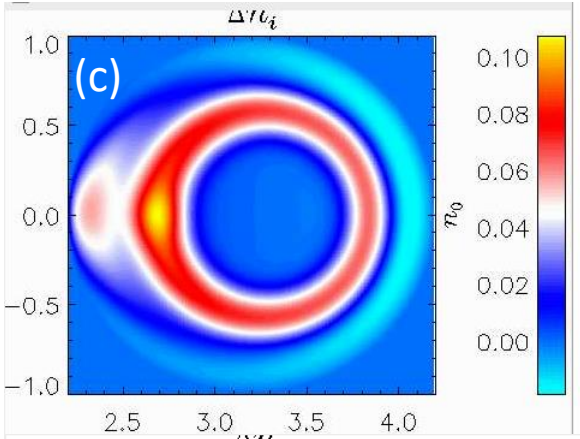
(a) 2F density change after 10^3 τ_A for LF side source

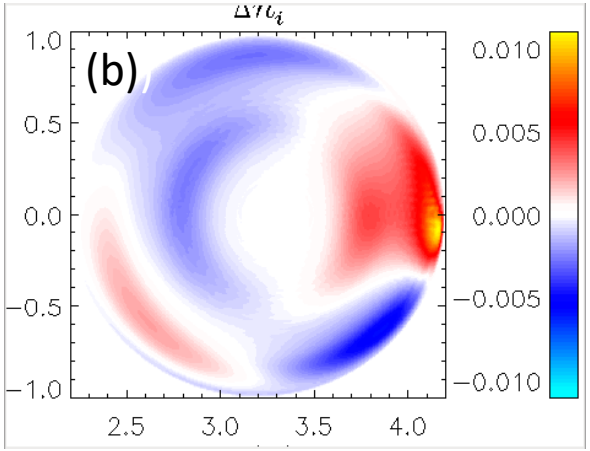
(b) Difference in 1F and 2F density (LF)

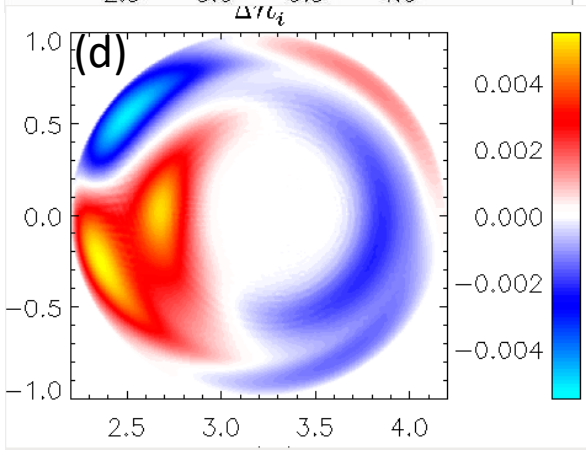
(c) 2Fdensity change after 10^3 τ_A for HF side source

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

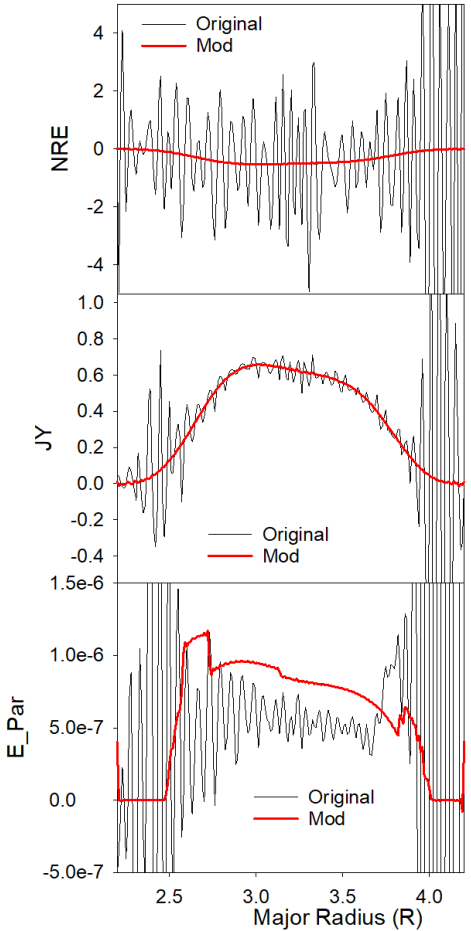








Sawtoothing discharge with runaway electrons

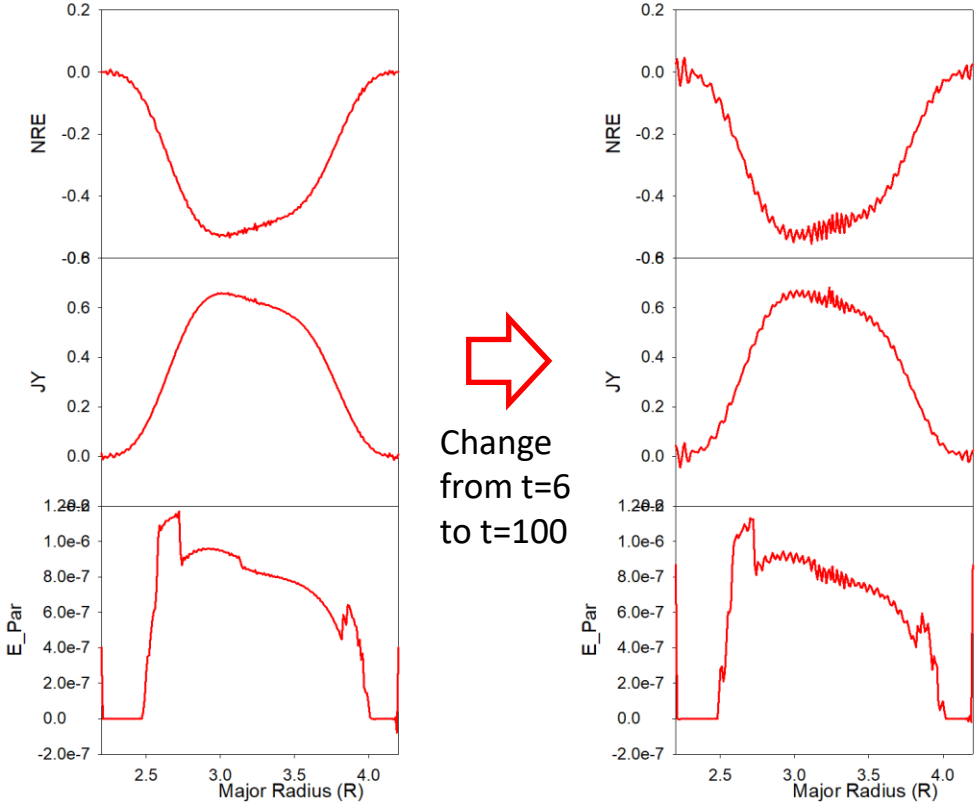


Profiles of nre, jy, and E_par after 30 timesteps

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?