M3D-C1 ZOOM Meeting

03/01/2021

CS Issues

1. GPU solve and memory utilization status (LBL, Jin Chen)
2. stellar.princeton.edu status
3. Mesh adaptation update (RPI, Brendan Lyons)
4. NERSC Time
5. Changes to github master since last meeting

Physics Studies

1. Description of Characteristic Method for advancing RE – Chang Liu
2. Carbon Mitigation in NSTX-U (shell pellet)
3. RE Benchmark with JOREK .. Chen Zhao
4. Helical band to remove runaway electrons
5. Other?

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

stellar.Princeton.edu allowing early users

All M3DC1 users with eddy accounts should now be able to log into stellar

- No /scratch filesystem…should be available in March
- 100GB limit in /home directory /projects/M3DC1/… available (how big?)
- Code often hangs … have not yet reported it
- Runs typically 30% - 50% faster than eddy

Brendan Lyons: Will Globus be available?
Adelle Wright: requested bbcp multi-stream data transfer.

Nate Ferraro: modules m3dc1/1.12 and m3dc1/devel are available

S. Jardin 02/15/21 and today:

- I also ran regression tests: all passed except “adapt”
  - MALLOC(): UNSORTED DOURBL LINKED LIST CORRUPTED

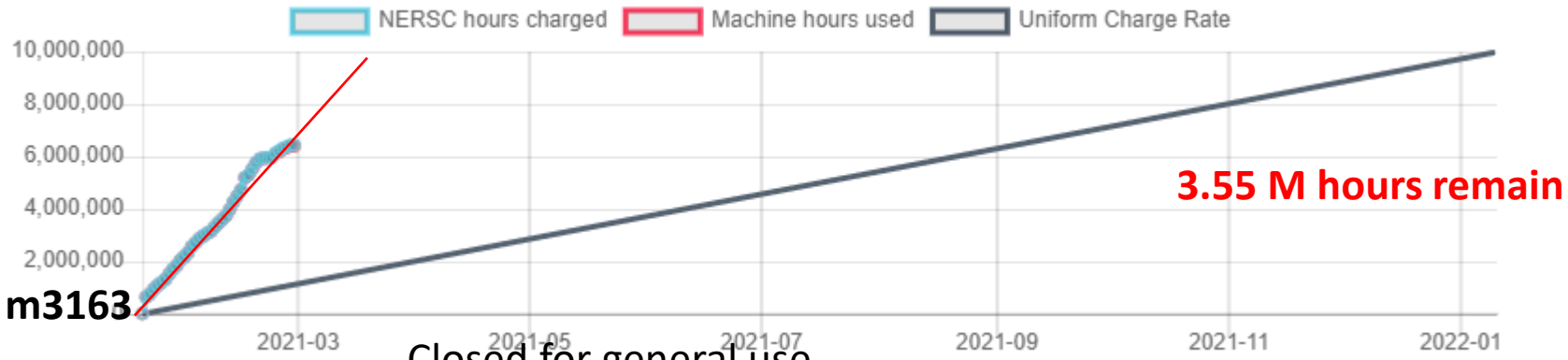
Mesh adaptation update

- Seegyoung scheduled special zoom call on this Friday 3/5 4:00 PM ET

Anything else?

NERSC Time

mp288



m3163

Closed for general use

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

Changes to github master since last meeting !

Seegyoung Seol

- 02/24/21: minor changes for 3D adaptation

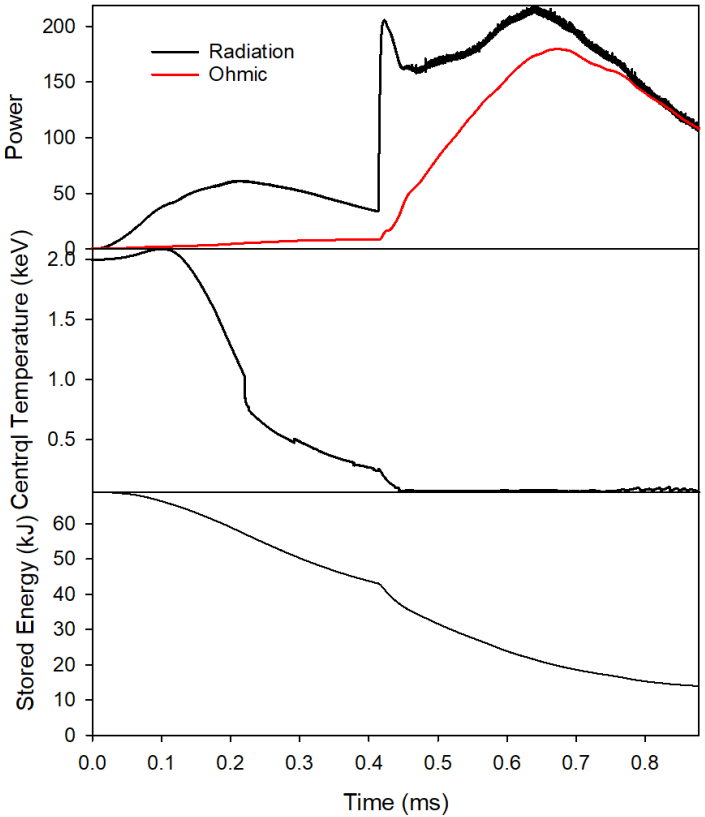
Nate Ferraro

- 03/01/21: Added “devel” module for stellar

Characteristic method for runaway electrons

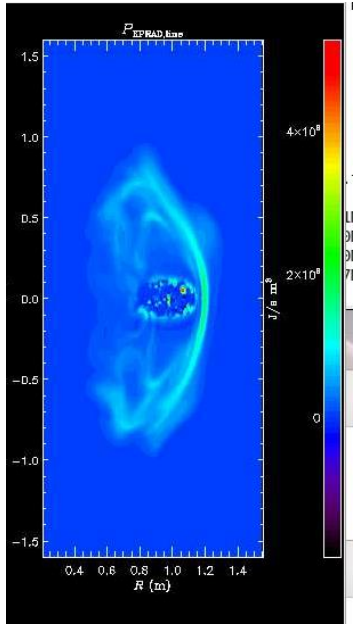
Chang Liu to present

Carbon Mitigation in NSTX-U (shell pellet)



Shell carbon pellet in NSTX (now running)

Radiation
t = 0.73 ms



Trying to keep radiation “hot spots” from forming and causing crash by decreasing dt as necessary.
Current quench has begun: 0.7 → 0.35 MA

Cesar Clauser

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

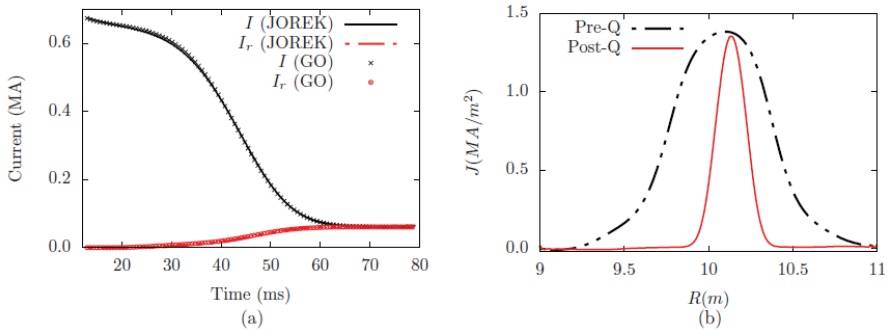
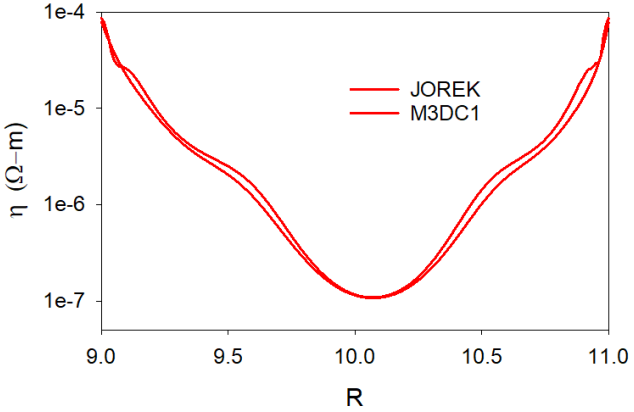
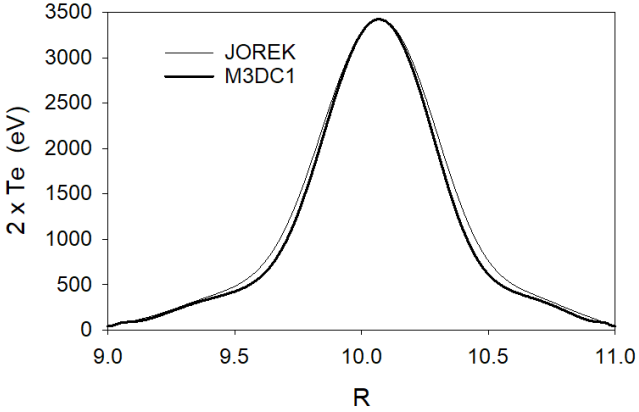


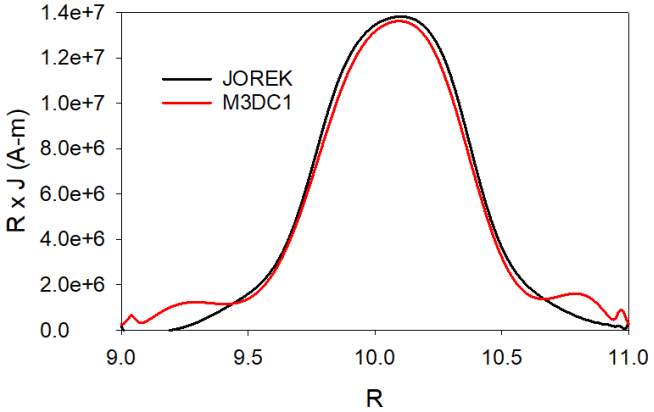
FIG. 3. (a) Time evolution of the total plasma current I and the RE current I_r during the current quench phase. (b) Midplane current density profiles before and after the current quench obtained from JOREK, showing a relatively peaked RE current profile.

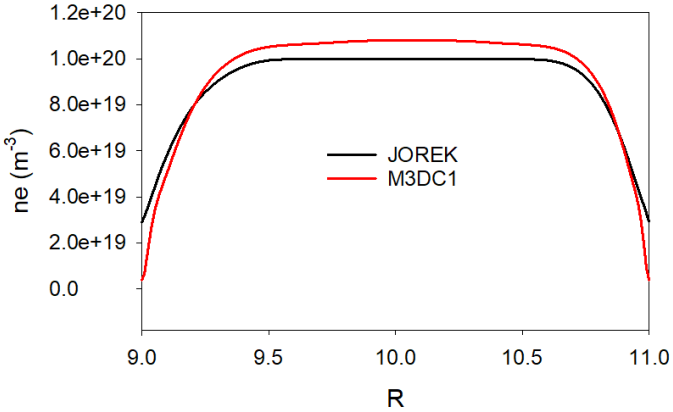
Chen Zhao

Comparison of initial profiles

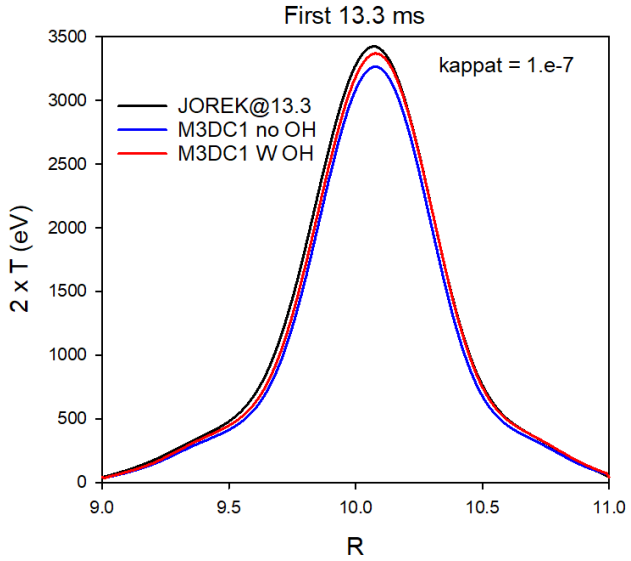


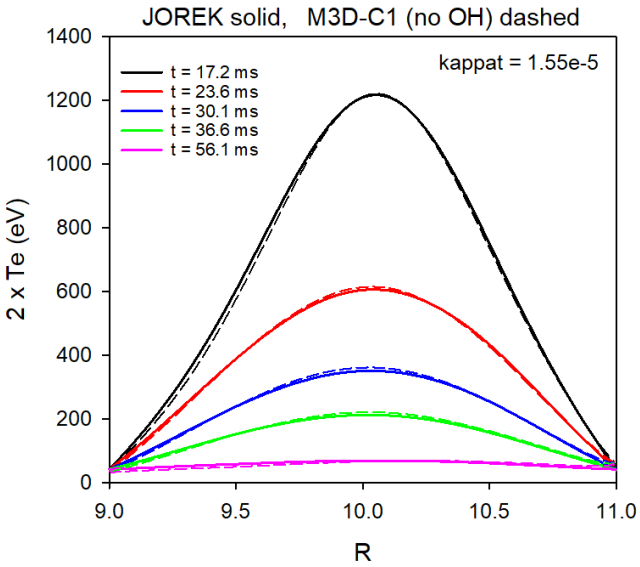






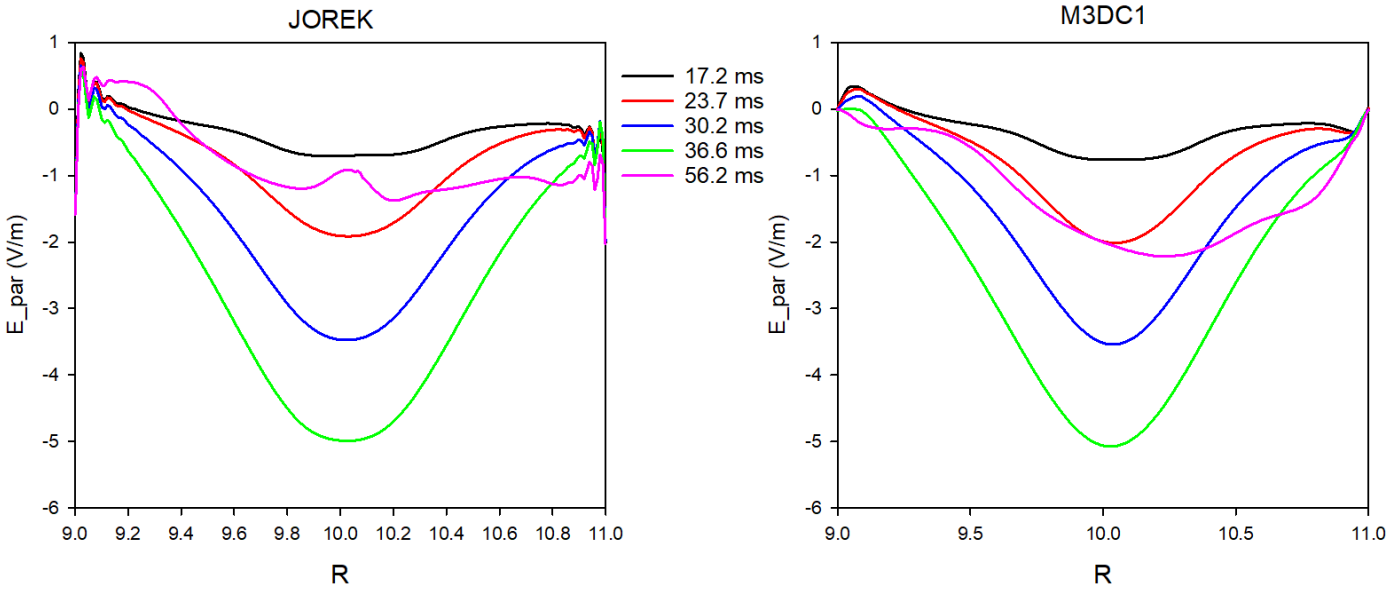
Comparison of T(R) at several times with no runaways



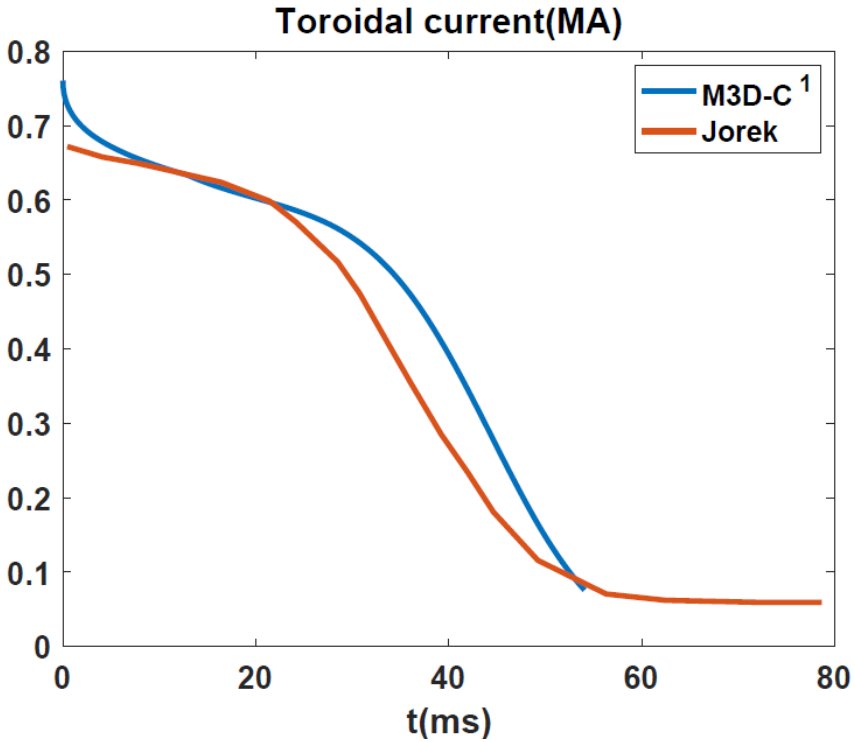


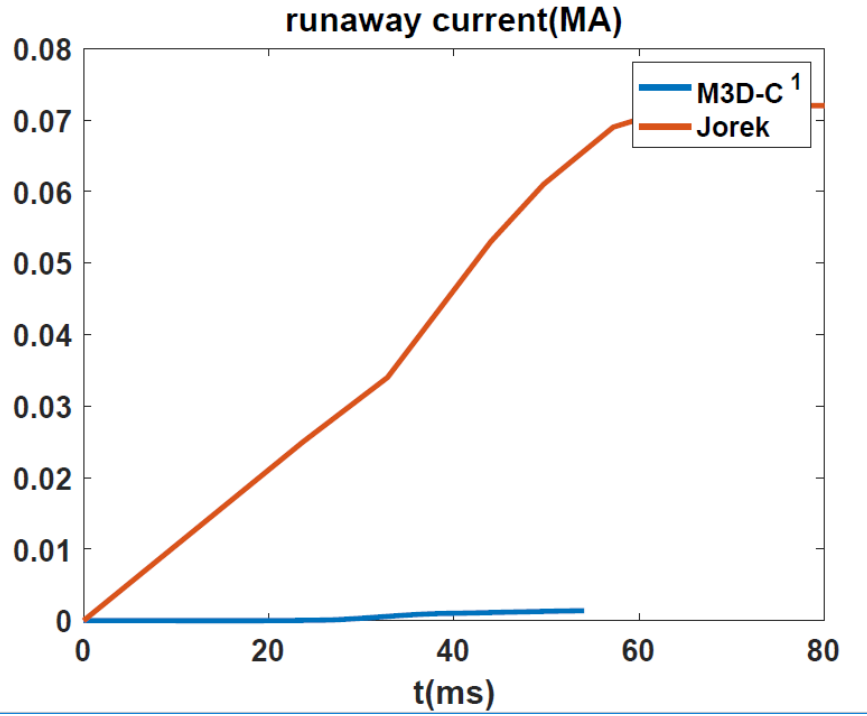
/p/tsc/m3dnl/Bandaru3

Comparison of E_par

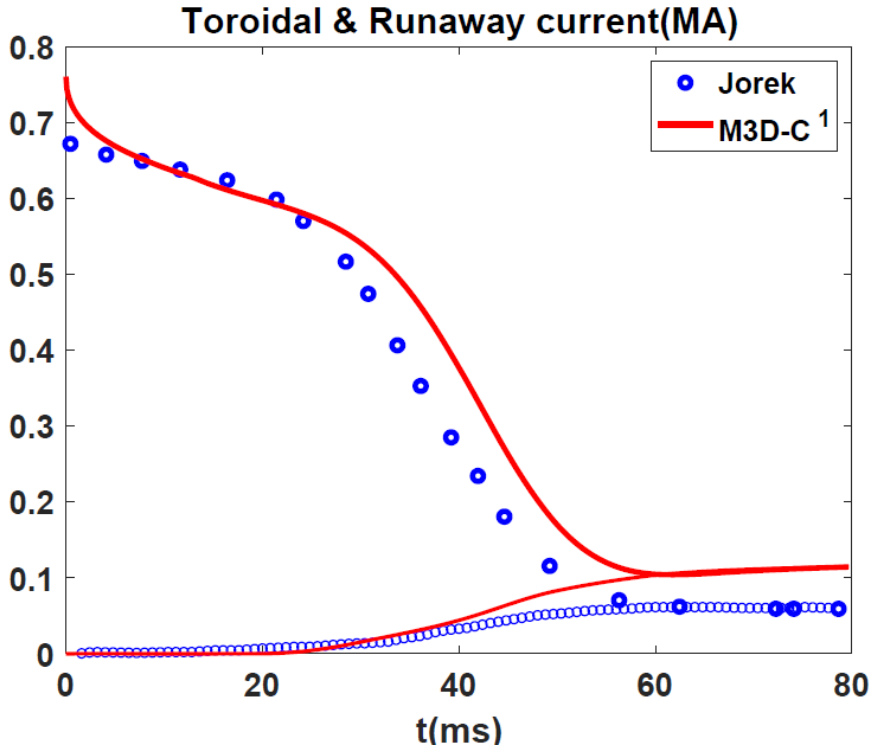


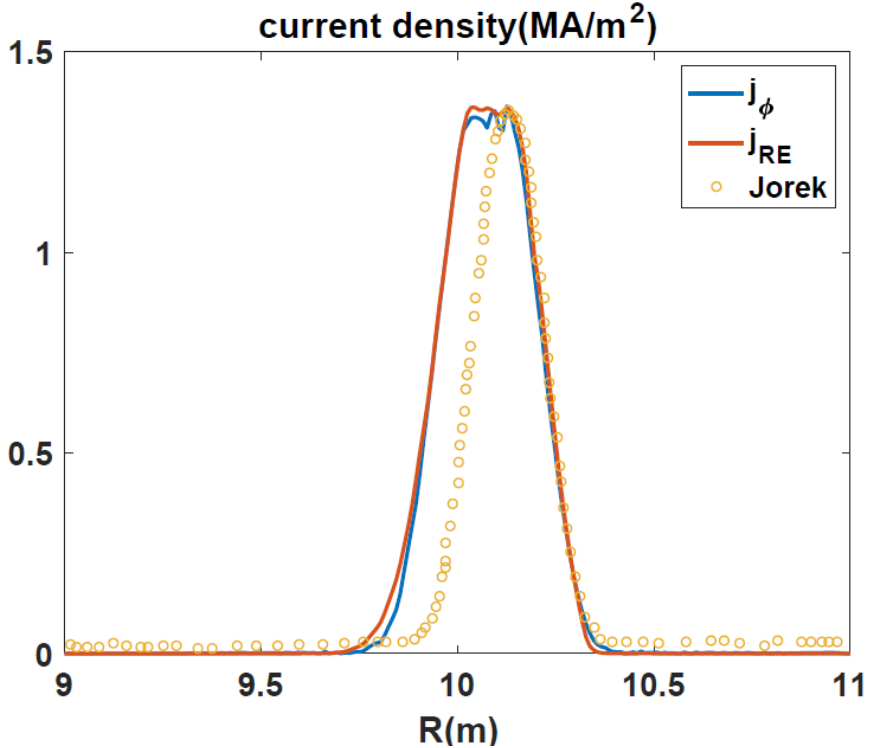
Initial results with Runaways (2/15/21) (Chen)





More recent results (2/26/21) (Chen)





What is difference in old vs new?

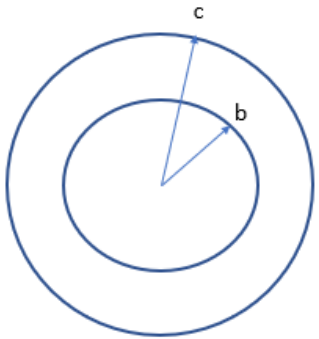
$$\frac{dn_r}{dt} = n_e \nu_{ee} E^{-3(1+Z)/16} \exp\left[-1/(4E) - \sqrt{(1+Z)/E}\right] \qquad \nu_{ee} = n_e e^4 \ln\Lambda / 4\pi\varepsilon_0^2 m_e^2 v_{th}^3 \qquad v_{th} = \sqrt{2T_e / m_e}$$

$$E = (T_e / m_e c^2)(E_{EF} / E_c) \qquad E_c = n_e e^3 \ln\Lambda / 4\pi\varepsilon_0^2 m_e c^2 \qquad E_{EF} = \frac{\eta}{\mu_0}\left[\frac{4}{R}\frac{\partial}{\partial y} y \frac{\partial \psi}{\partial y} - \mu_0 J_{RE}\right]$$

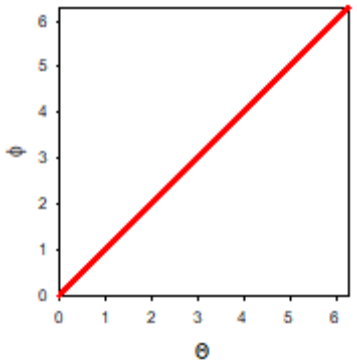
(2x) Inserting this factor of 2 (as was done for the newer results) gives much better agreement. This could be due to the difference in ln Λ . JOREK used ln Λ = 10

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?

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

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

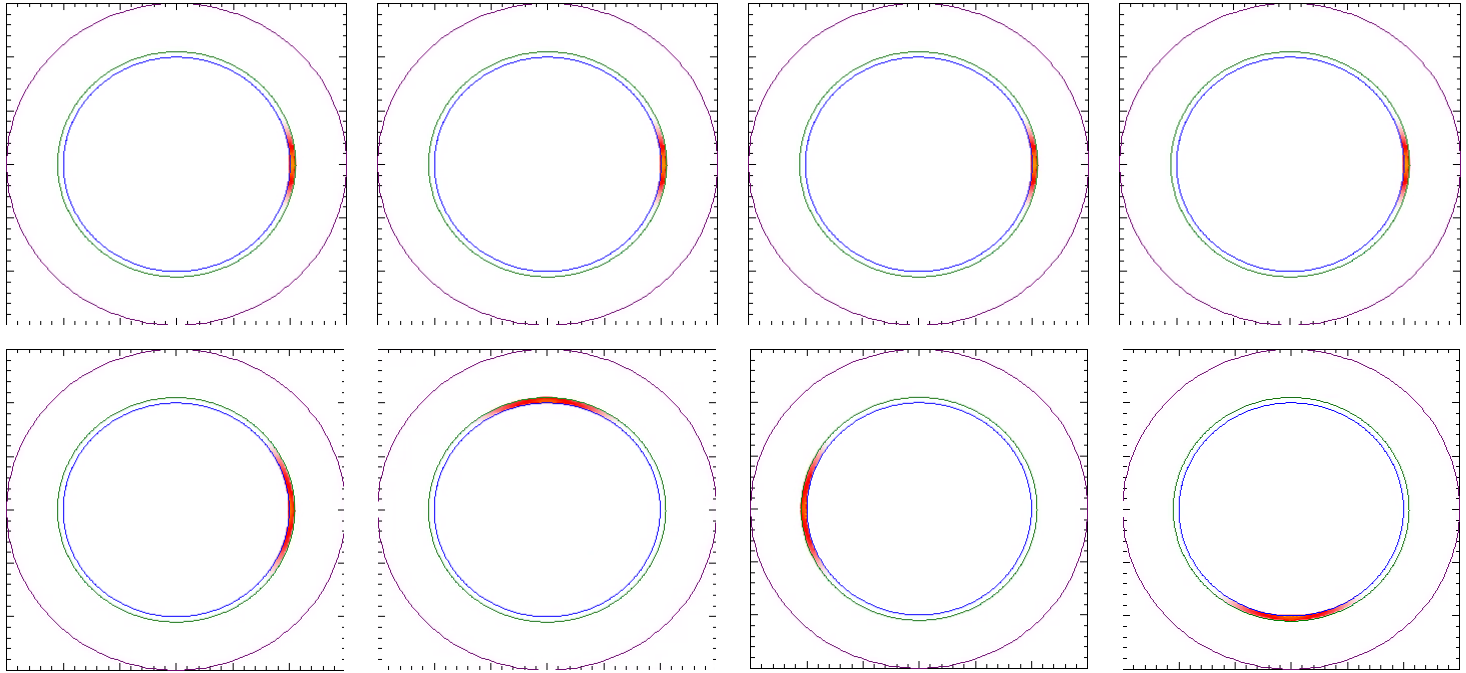
What is driving the current in the θ direction? It can't be Φ unless

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

Comparison between Straight and helical band

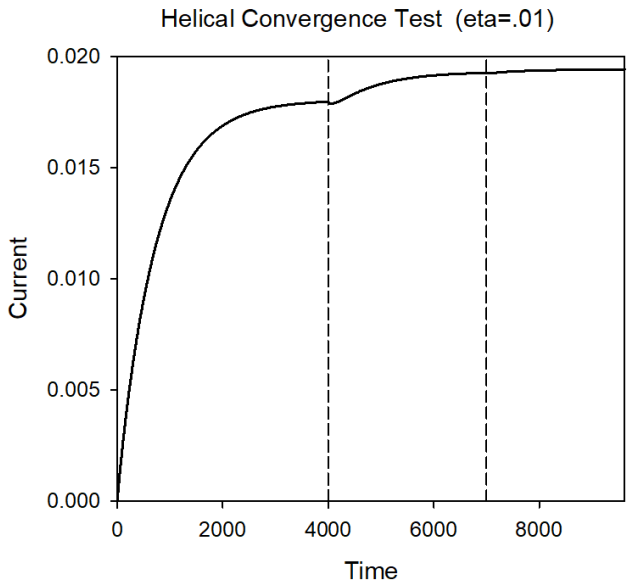
Straight ➔

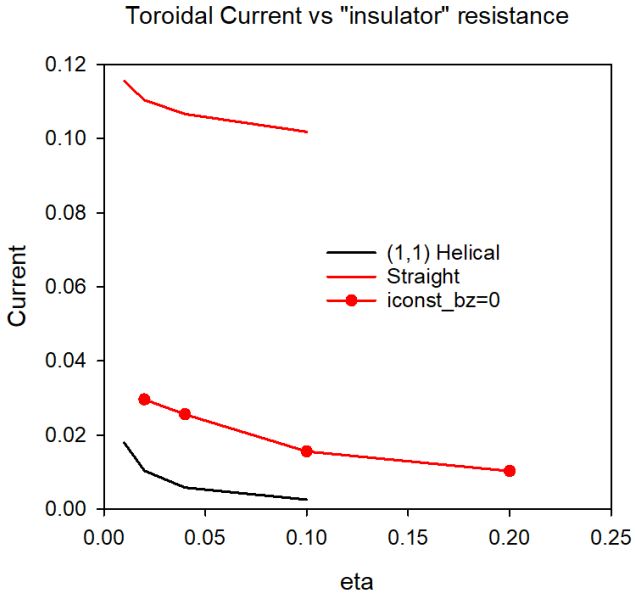
Helical ➔



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

Some Convergence Tests

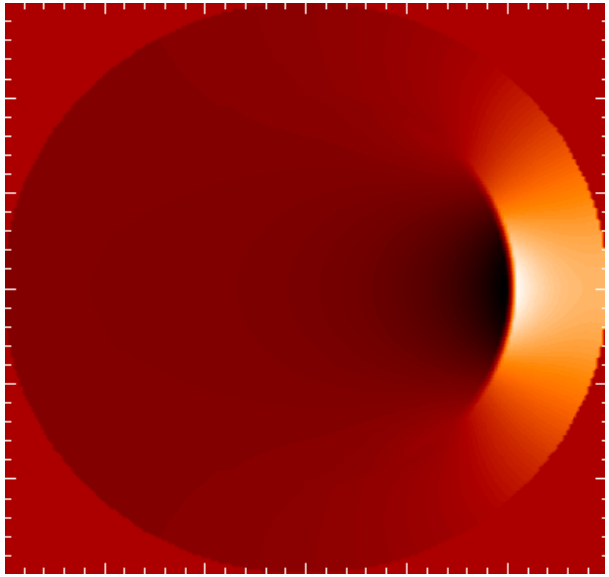




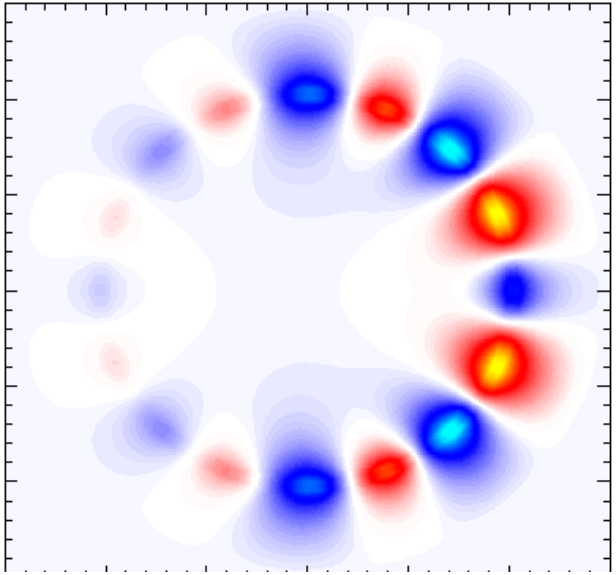
- Wall current appears to be converged in # of planes
- Helical wall current tending towards zero for large values of insulator resistance
- Now testing dependence on boundary conditions (location of ideal wall)
- Helical (1,2) case gives less than half the current of helical (1,1) case
- Iconst_bz=0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

Plots for iconst_bz=0

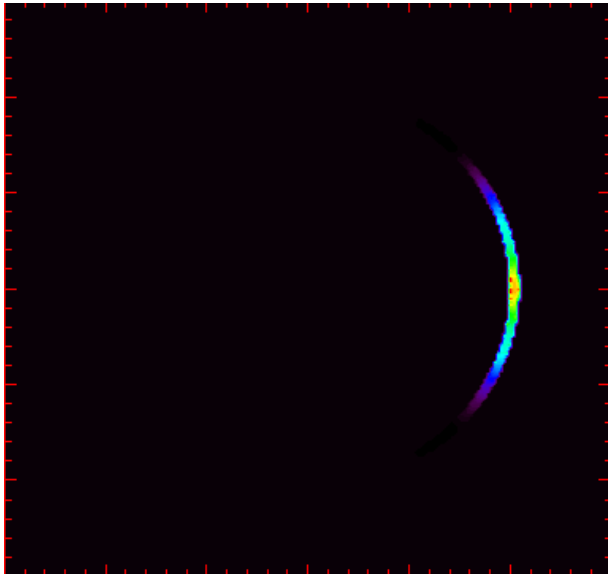
I



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



J_{φ}



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

That’s All I have

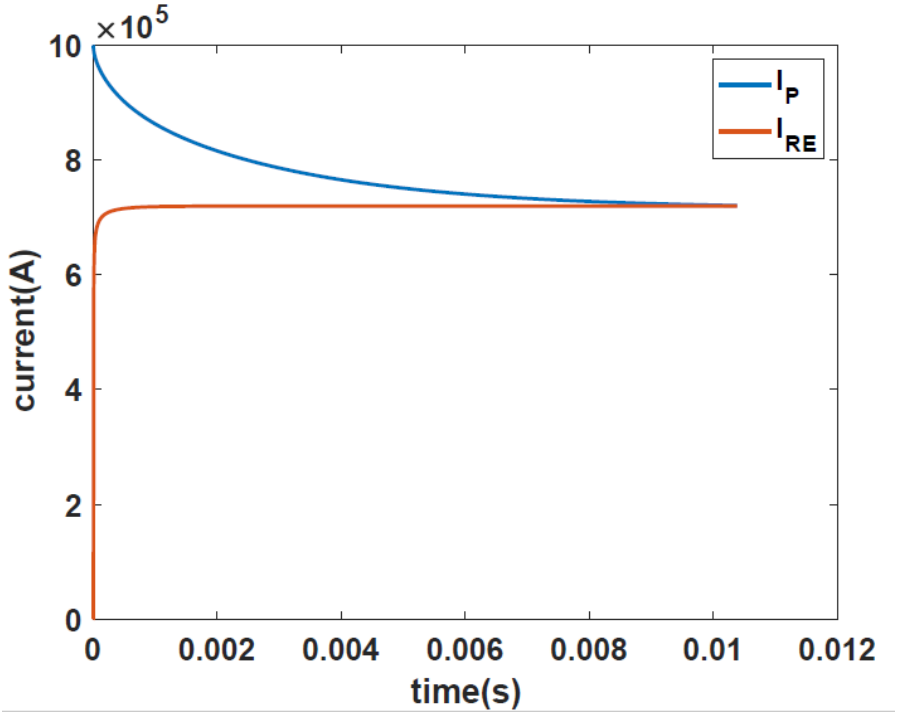
Anything Else ?

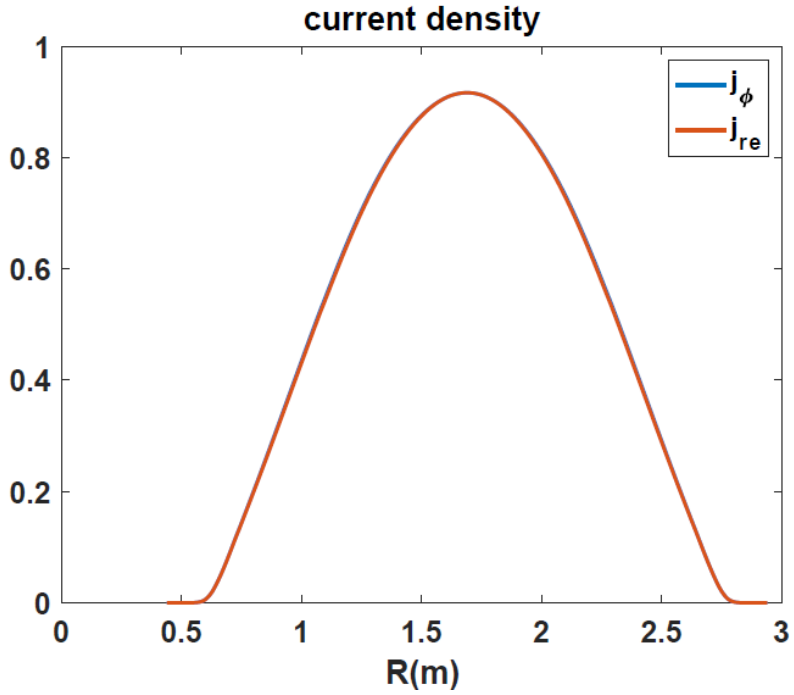
Local Systems

- 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

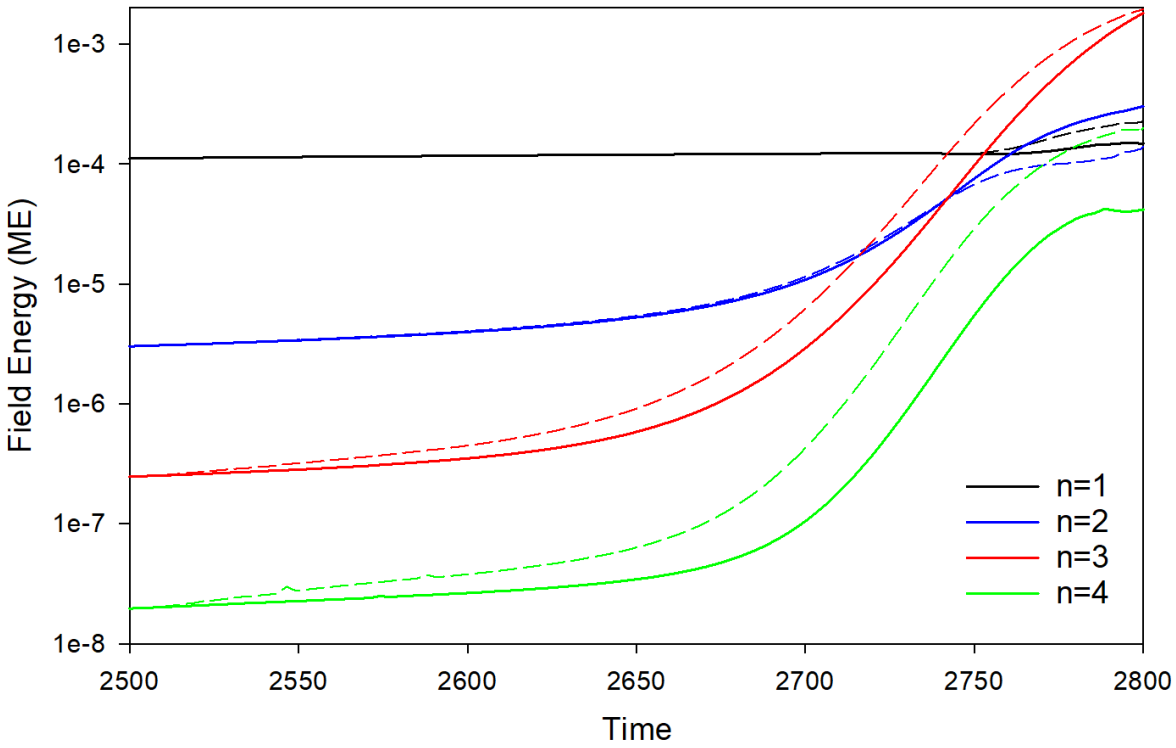
2D (cylindrical) RE with sources (12/19/2020)



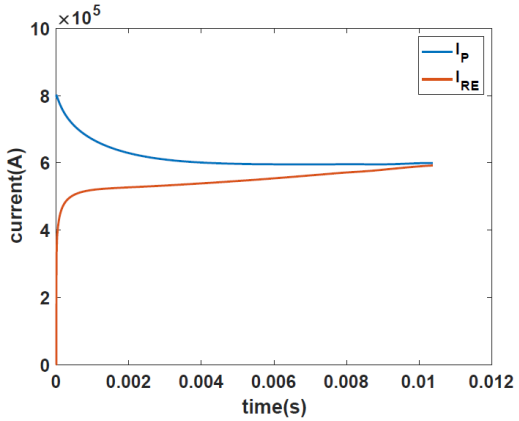


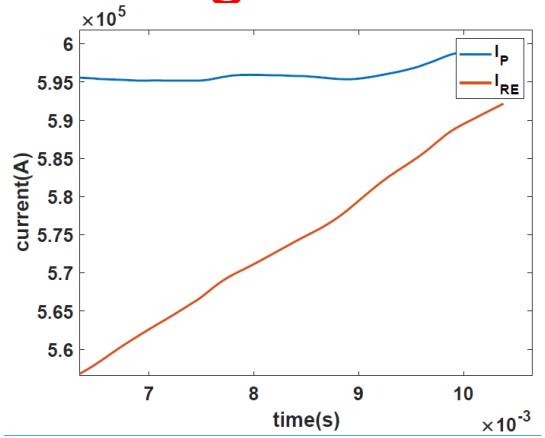
Chen Zhao

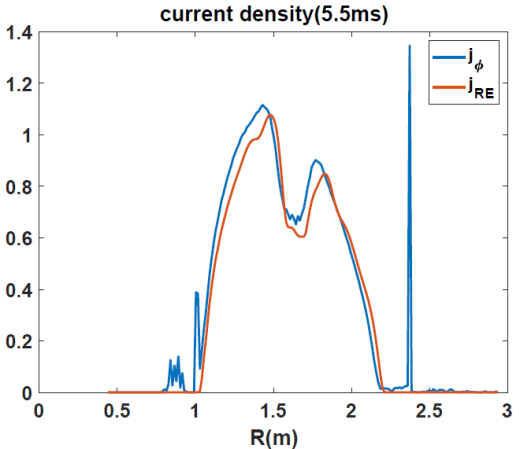
Energy in base case 36742317 (solid) and 16 plane case 37248033 (dashed)

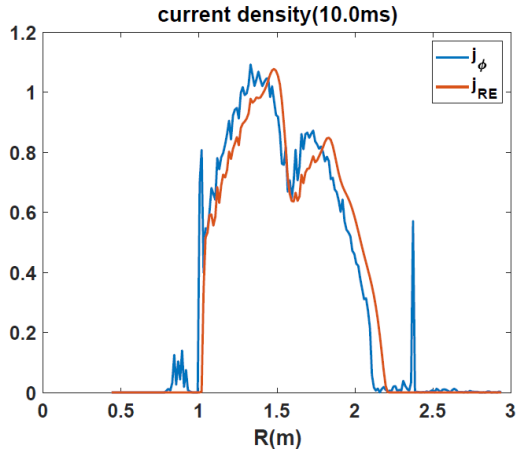


DIII-D 177053 with Argon





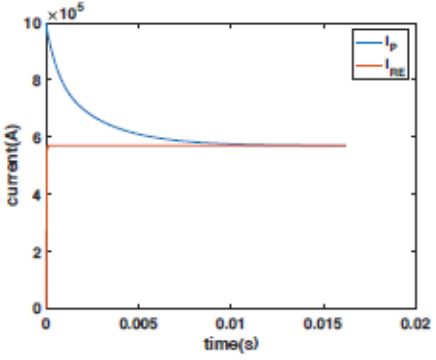


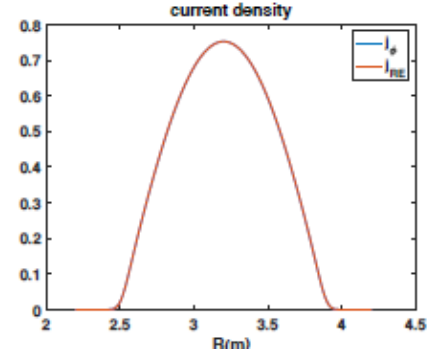


Chen Zhao

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?

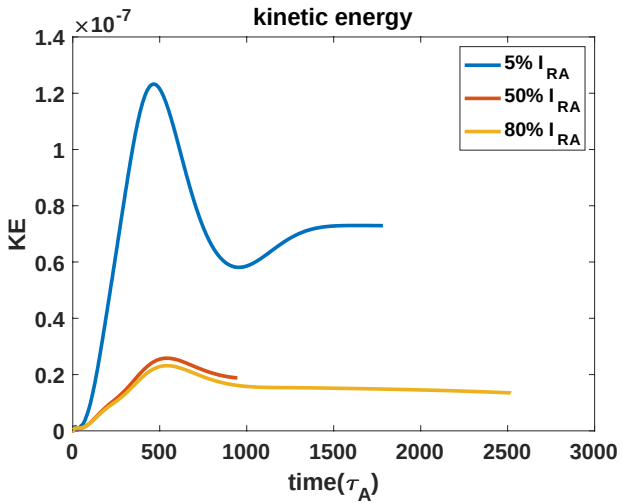
- M3D-C1/NIMROD 3D Benchmark

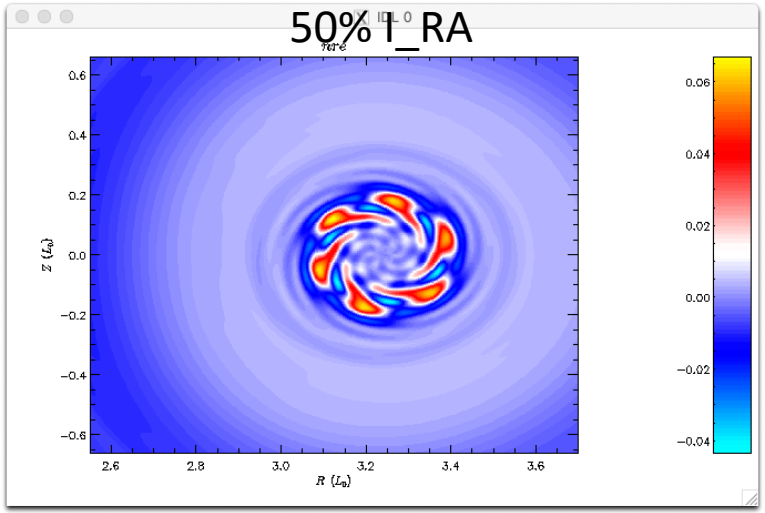
NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes
Chang Liu

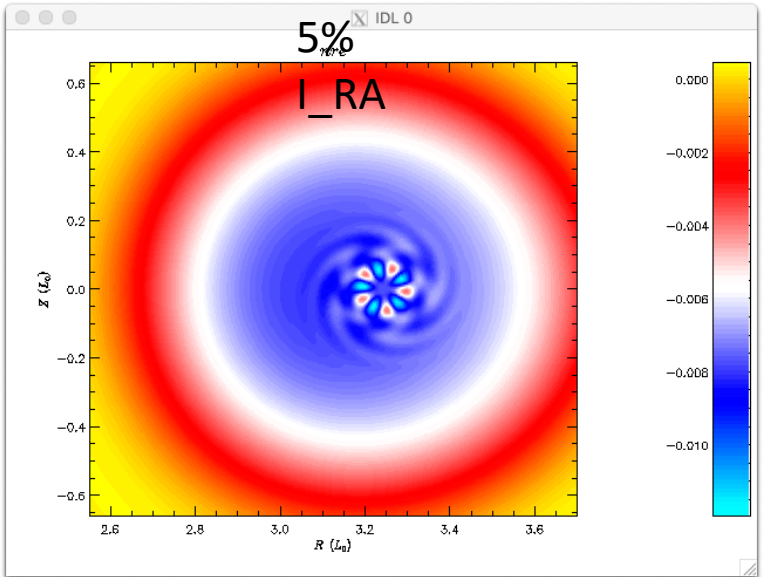
DIII-D Neon pellet mitigation simulation for KORC

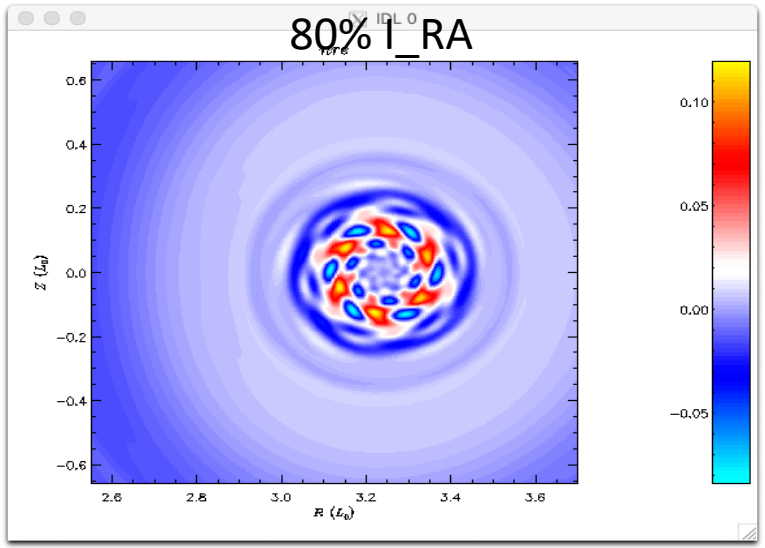
- Brendan Lyons trying to extend 8 plane case to 32 planes

SPARK ? Do we need to do anything?


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

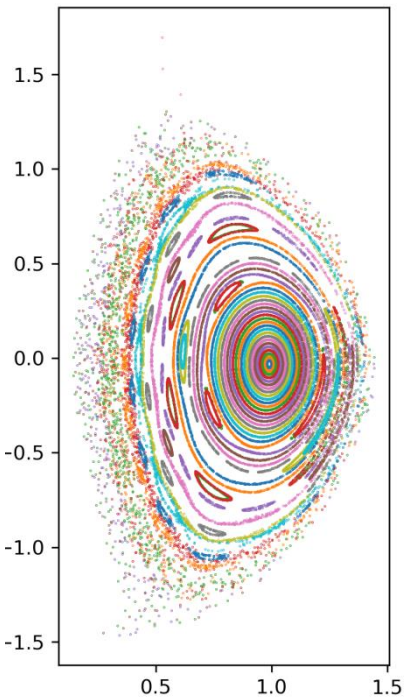

50% I_RA
IDL 0
Z (L_0)
R (L_0)


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

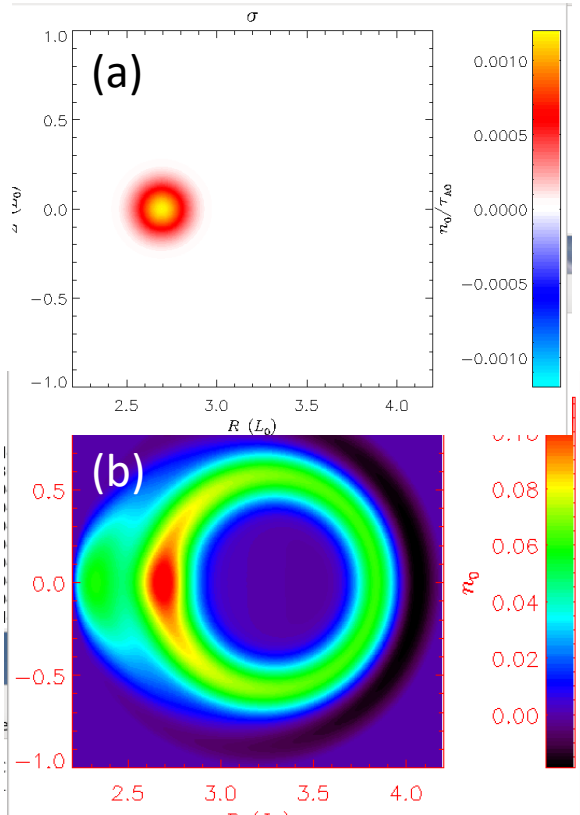
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

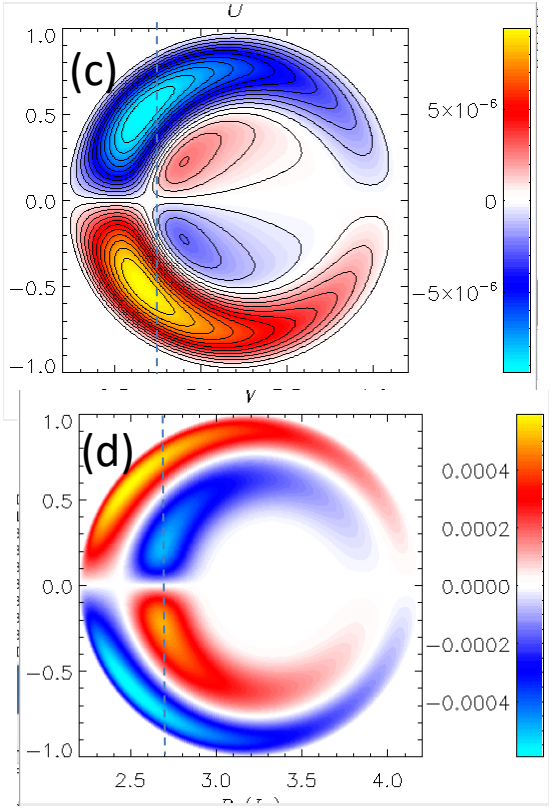
(a) Density source in 1F toroidal equilibrium

(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

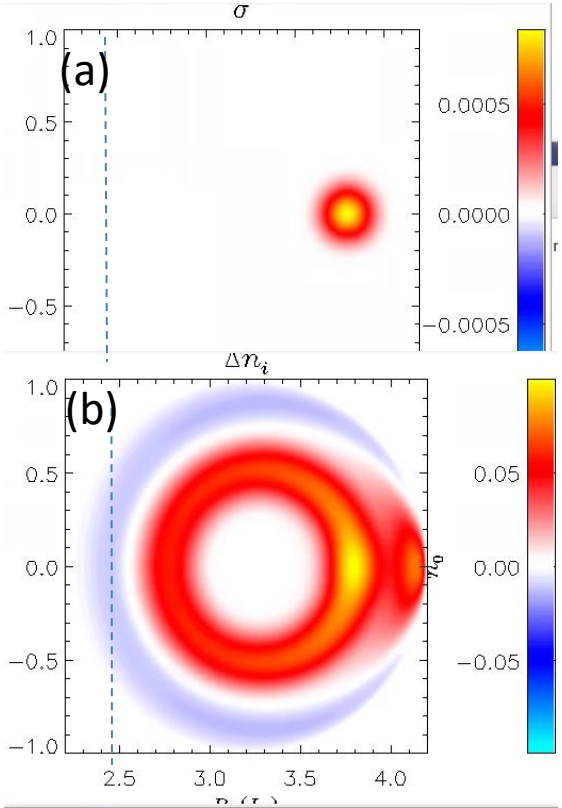
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

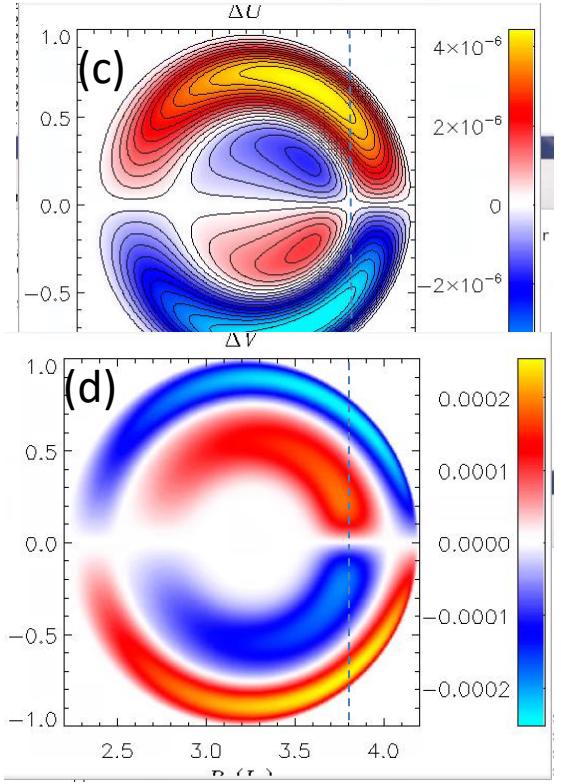
(a) Density source in 1F toroidal equilibrium

(b) Change in density after 10^3 τ_A

(c) Poloidal velocity stream function

(d) Toroidal velocity contours





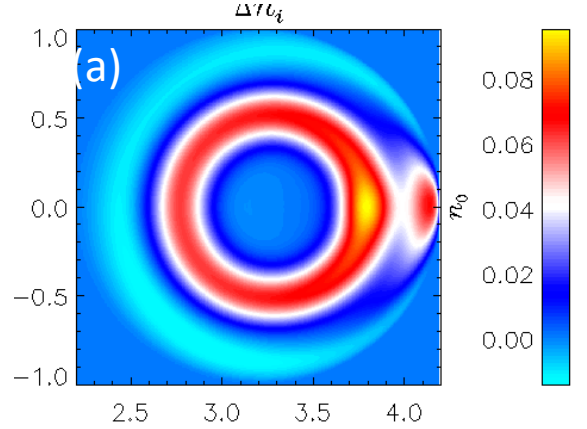
Grad-B drift in M3D-C1—2F effects

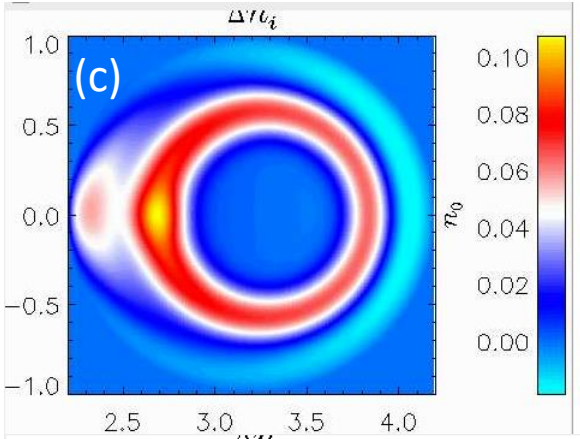
(a) 2F density change after 10^3 τ_A for LF side source

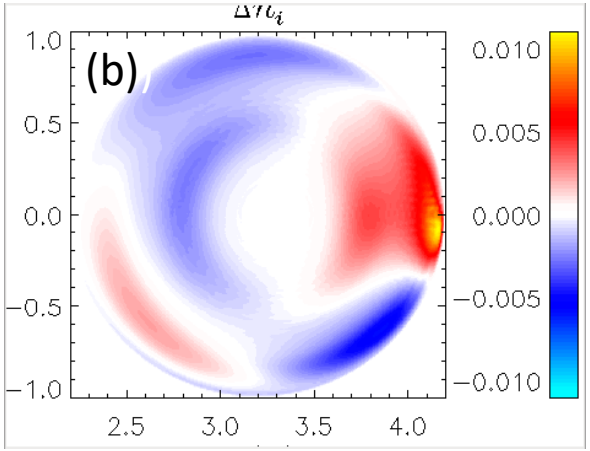
(b) Difference in 1F and 2F density (LF)

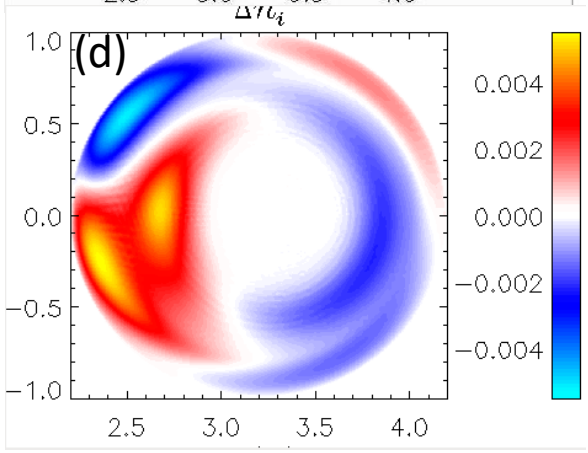
(c) 2Fdensity change after 10^3 τ_A for HF side source

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

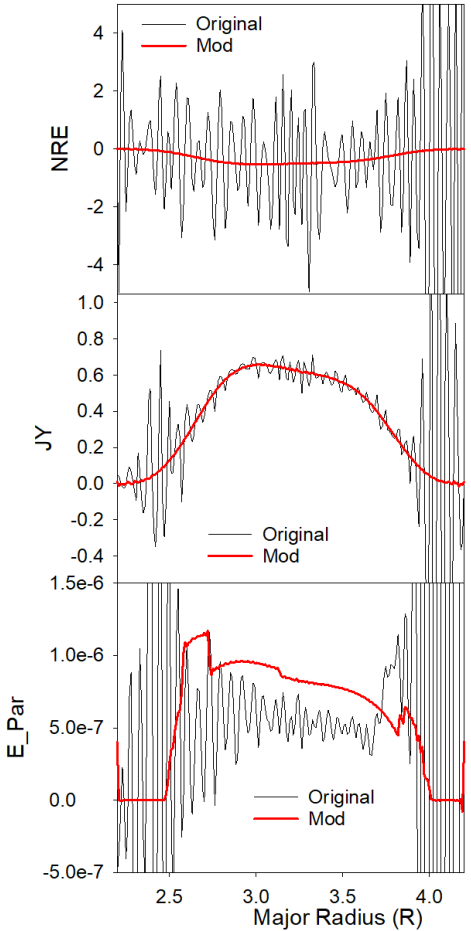








Sawtoothing discharge with runaway electrons

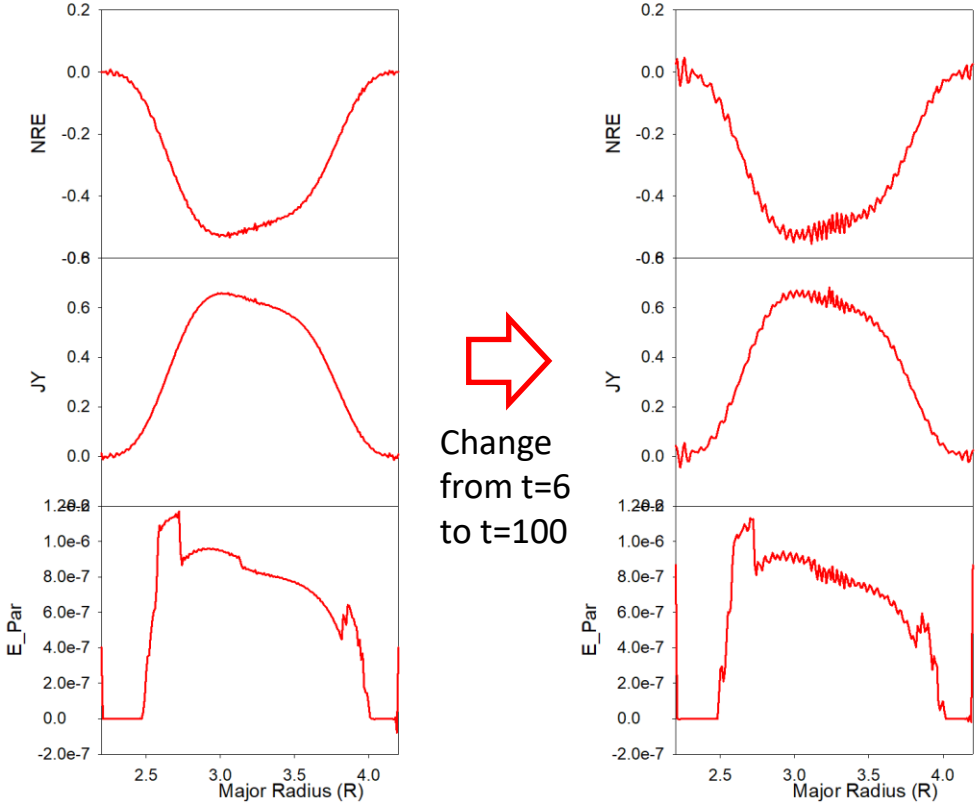


Profiles of nre, jy, and E_par after 30 timesteps

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?