M3D-C1 ZOOM Meeting

01/19/2021

CS Issues

1. GPU solve status (J. Chen)
2. Mesh Adaptation status RPI/Brendan
3. New Princeton/PPPL Computer status
4. Local and other systems
5. NERSC Time
6. Changes to github master since last meeting

1. Physics Studies
    1. Progress in 3D M3D-C1/NIMROD benchmark
    2. Helical band to remove runaway electrons (Brendan)
    3. Resistive Kink with RE current in DIII-D shot 177040 (Chang)
    4. Carbon Mitigation in NSTX-U (shell pellet)
    5. DIII-D RE shot 177053 (with Argon) Chen
    6. Sawtoothing discharge with Runaway Electrons(Chen)
    7. Other?

GPU Solve status

Mesh Adaptation Status

01/17/21: RPI Email to Brendan

“The capability to adapt 2D meshes is ready and everything is updated in the git. Please find attached the document describing the procedure to use the capability along with a few examples of meshes.”

Brendan now testing.

New Princeton/PPPL Computer

01/18/21:

“all parts have been ordered and many/most have arrived. They’ve been uncrating parts and racking it for a few days now. That process is much slower than usual because of covid restrictions. I am pretty sure it will be online "soon", though, as all the work that remains is underway.”

Local Systems

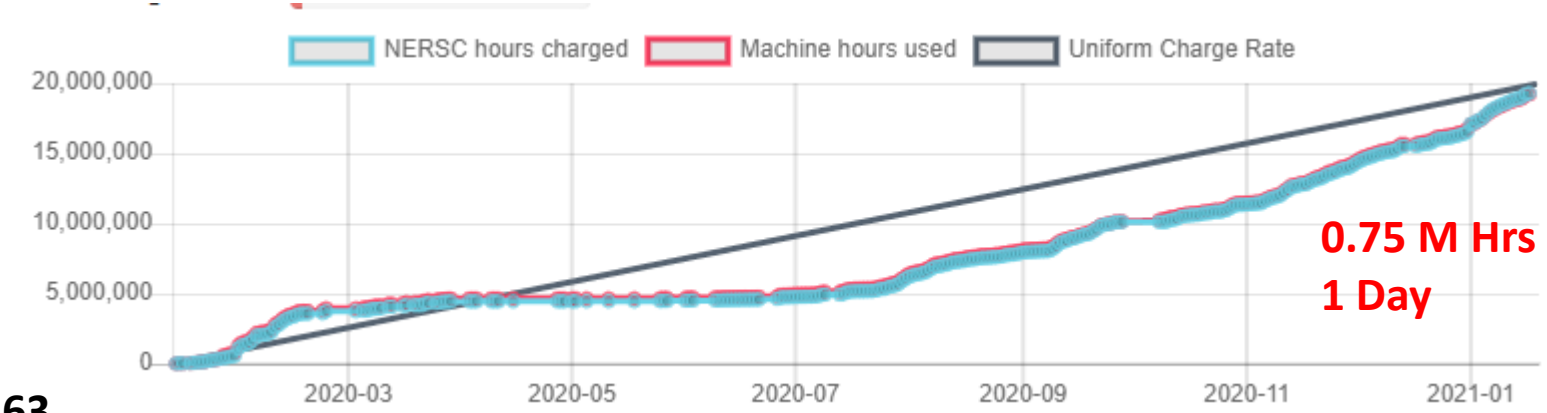
- PPPL centos7(1/19/21)
  - All 6 regression tests PASSED on centos7:
- PPPL greene (1/19/21)
  - 5 regression tests PASSED
  - No batch file found for pellet
- EDDY (1/19/21)
  - All 6 regression tests PASSED
- TRAVERSE(1/4/21)
  - Code compiles
  - Regression test failed: split_smb not found in PATH
  - Have not yet tried shipping .smb files from another machine

Other Systems

- Cori-KNL (1/4/2021)
  - 6 regression tests passed on KNL
- Cori-Haswell (1/4/2021)
  - 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
- 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

- New NERSC allocations start 10:00 AM ET Jan 20, 2021:
- mp288 received 10M Hrs for CY 2021
- Perlmutter will be arriving in CY 21 and there will be no charge

Changes to github master since last meeting

- S. Seol
  - 01/06/21 Checking in Usman's m3dc1_mesh_adapt development
  - 01/06/21 adding unit test for m3dc1_mesh_adapt
  - 01/07/21 minor clean up for m3dc1_meswh_adapt
  - 01/07/21 modifying adapt unit test to load mesh model & pumi mesh
  - 01/10/21 modified field setting for adaption as per Morteza's input
  - 01/11/21 fixing error in adaptation unit test
  - 01/13/21 solution transfer added to m3dc1_mesh_adapt
- S. Jardin
  - 01/16/21: Corrected idl jy plot for itor=0
  - 01/18/21 changed wall_curr diagnostic for itor=0
- U. Riaz
  - 01/16/21 Updated Test Case tested with ITER
  - 01/18/21 Minor correction in adaptation workflow
- N. Ferraro
  - 01/15/21 Added functions for reading and plotting NEO input data
- B. Lyons
  - 01/05/21: Add helical resistance to wall resistivityRZ
- C. Clauser
  - Irestart pellet merge and fine-tuning

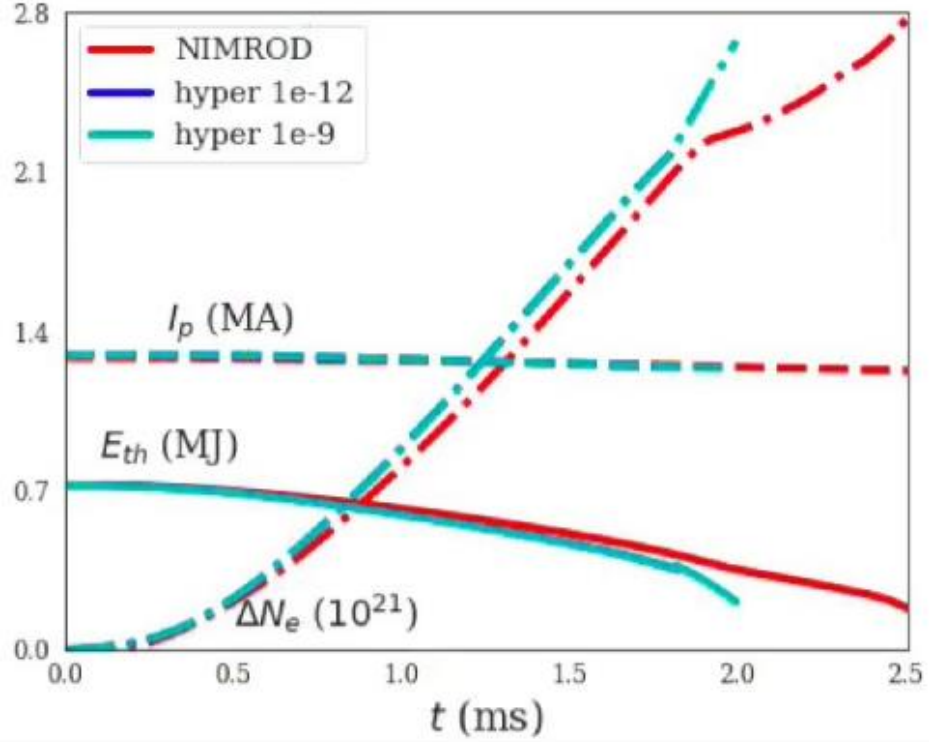
B. Lyons 3D Benchmark case with NIMROD

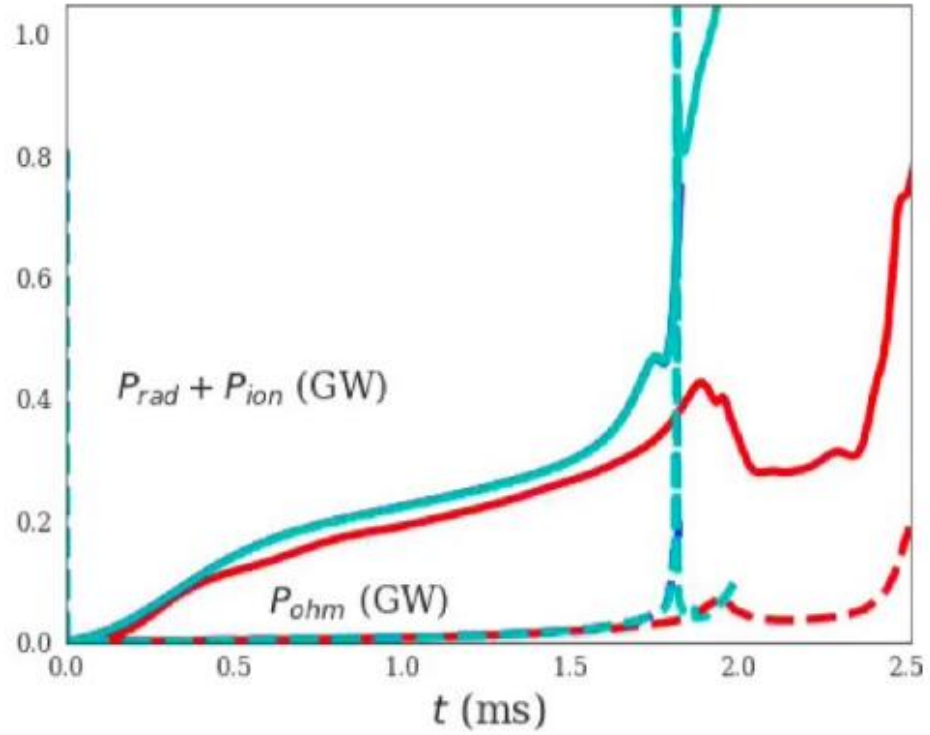
- Original baseline case has denm = 6.5 e-8, hyper=1.e-12
  - Fails at t=2800 (1.8ms), P_ohm gets very large, ke_hmn blow up

- Tried some variations:
  - Decrease dt by 10 ….did not help
  - Increase planes from 8 to 16…did not help
  - Increase amupar by 100 ….did not help
  - Increase hyper to 1.e-9…ke_hmn does not blow up, but still has large P_ohm spike
  - Increase denm: produces stable runs to completion for denm > 2. e-6, hyper=0.5e-9

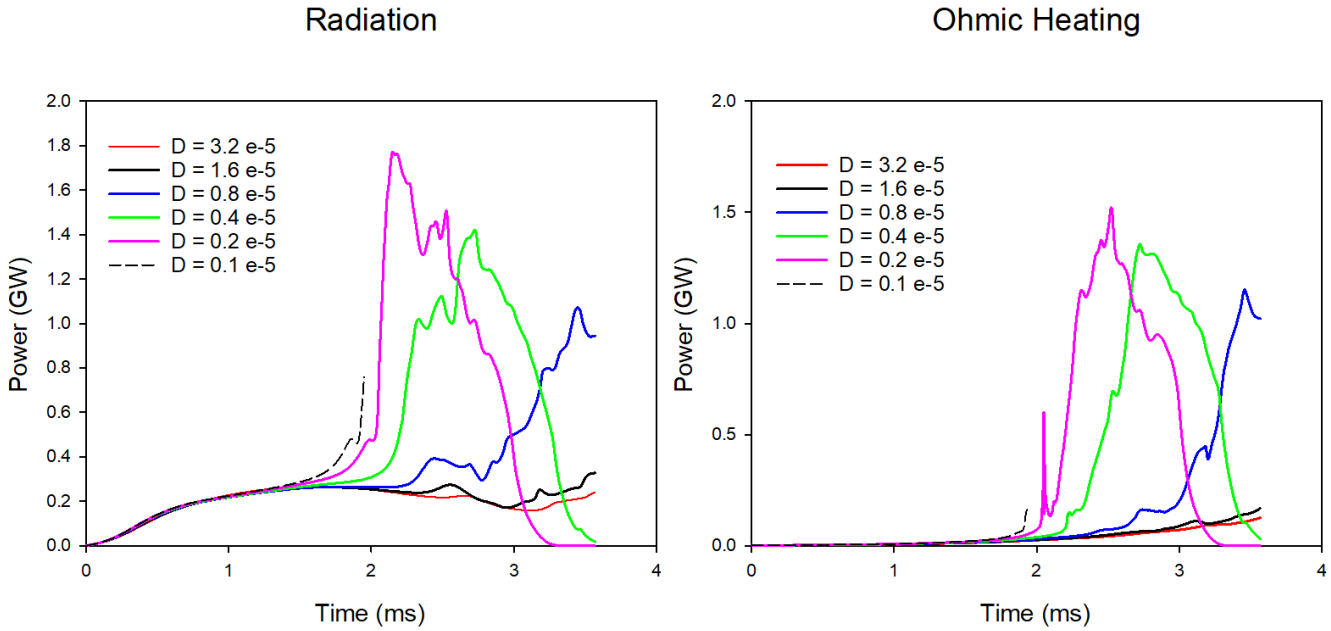
- Scan of denm and hyper on following pages
  - Suggest new base case with denm=4.e-6, hyper=0.5e-9
  - Now performing scan on number of planes, nplanes

Old Baseline: Comparison of 0D quantities with NIMROD





Scan of denm for hyper = 0.5e-9

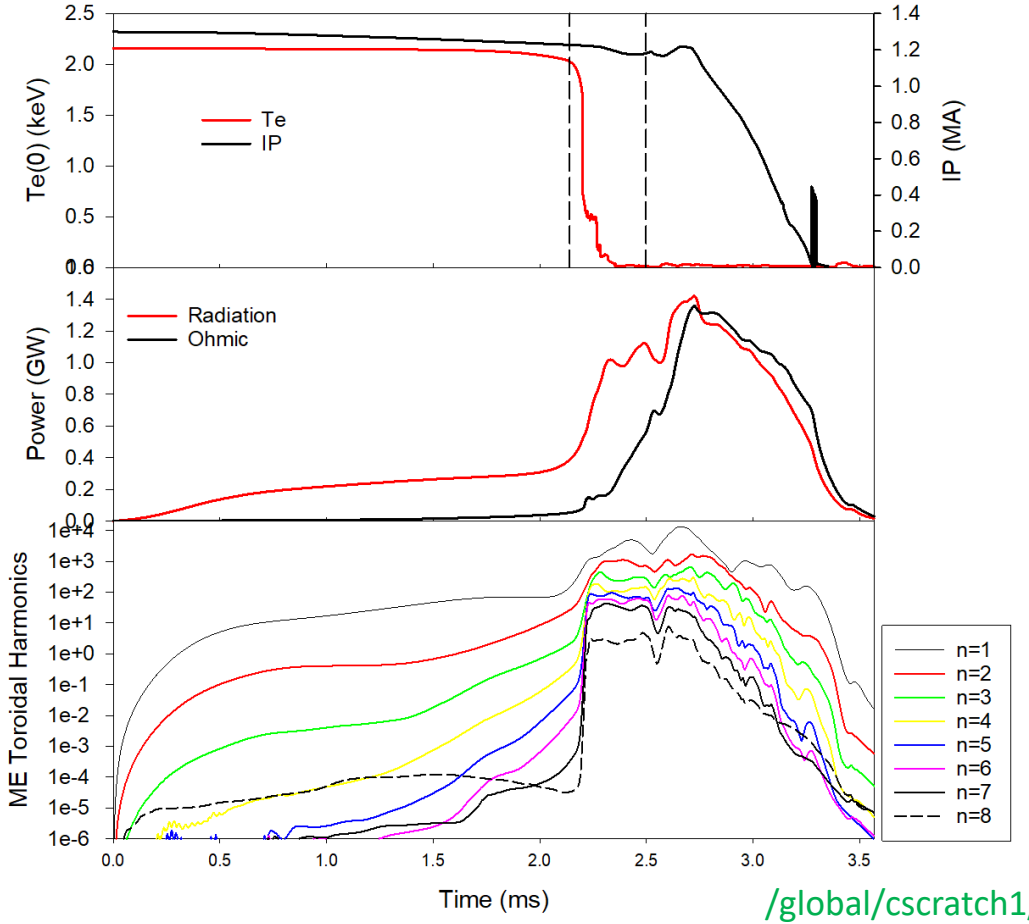


Case	denm
c	3.2e-5
d	1.6e-5
e	0.8e-5
f	**0.4e-5**
g	0.2e-5
h	0.1e-5

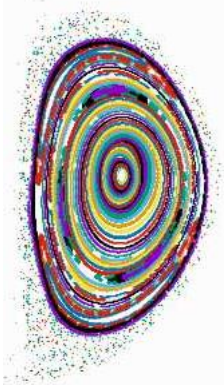
- If denm is too large, never get large radiation spike
- If too small, code blows up

Submission directories: /project/projectdirs/mp288/Jardin/m3dnl/Brendan8c, etc
Run directories: /global/cscratch1/sd/u431/BLH8c, etc

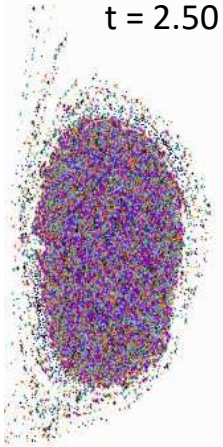
More Details on case “f” with denm= 4.05 e-6



t = 2.32 ms

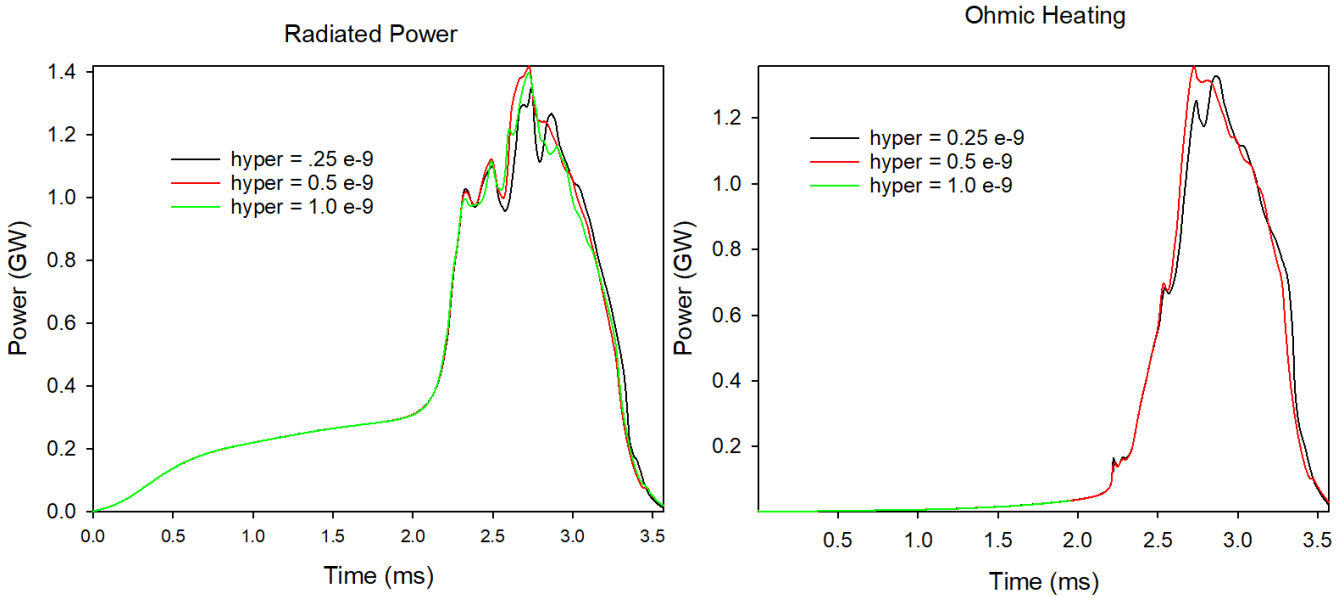


t = 2.50 ms



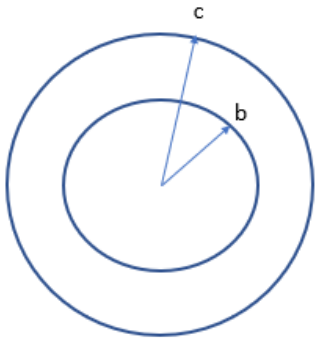
/global/cscratch1/sd/u431/BLH8f

Scan of “hyper” for case f shows only very weak dependence

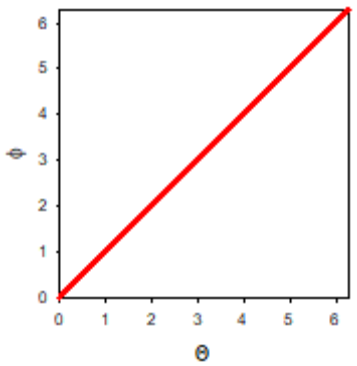


Helical Band to remove runaway electrons

- 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?

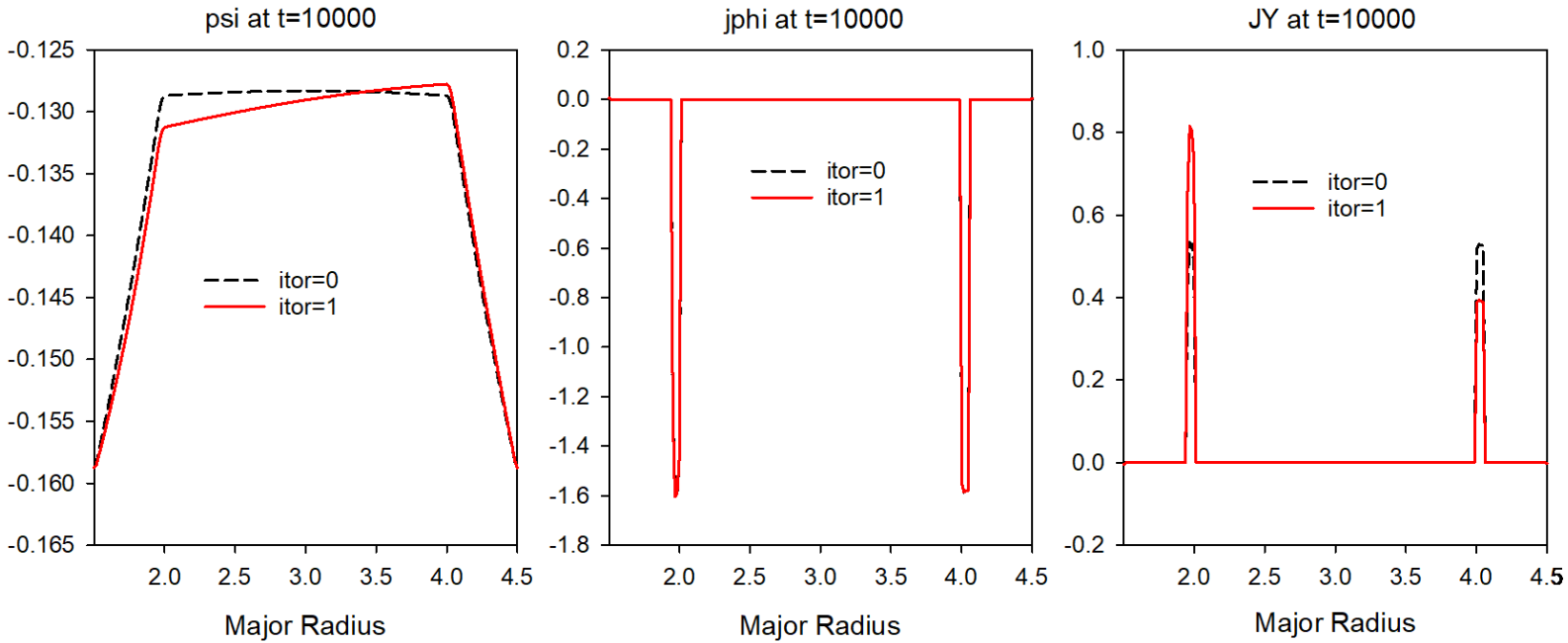
$$\nabla \times \mathbf{E} = 0 \quad \Rightarrow \quad \mathbf{E} = -\nabla\Phi + \frac{V_L}{2\pi}\nabla\phi$$

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

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

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

Step #1: Compare cylinder and torus for axisymmetric vessel



Midplane plots for same applied voltage

/scratch/gpfs/liuchang/177040_3d_re1_new_40

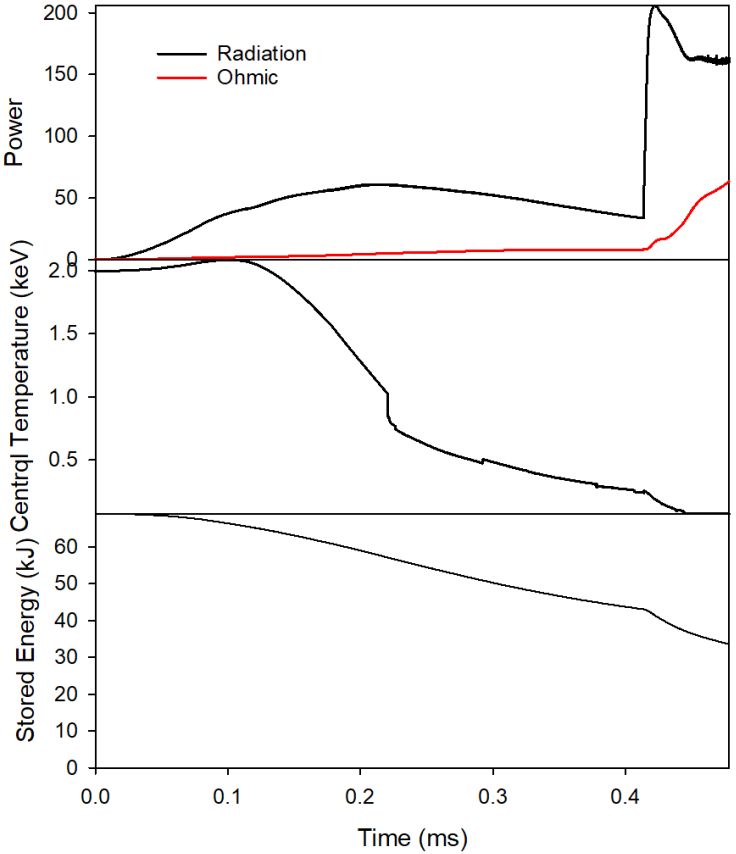
Resistive Kink with RE current in DIII-D shot 177040

Chang Liu and Chen Zhao to make presentation to GA Disruption group this Thursday

- Mode saturates at δB ~ 1000 G causing loss of 95% of runaways
- Characteristic method for runaway convection using GPUs. What machine?

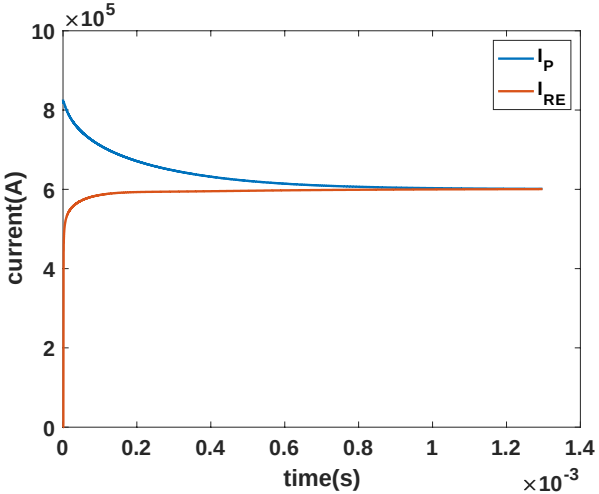
NL data at: /scratch/gpfs/liuchang/177040_3d_re1_new_40

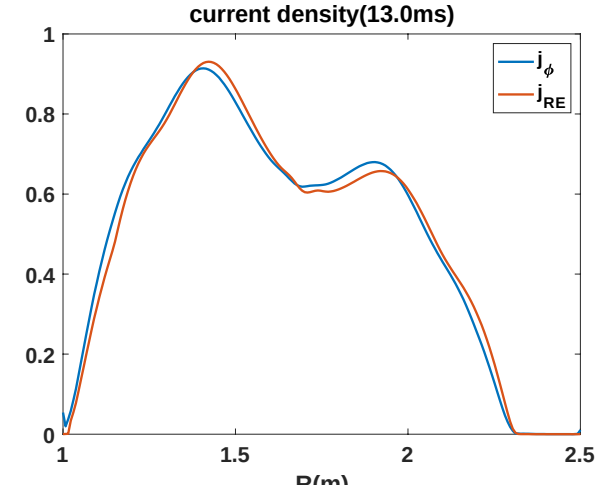
Carbon Mitigation in NSTX-U (shell pellet)



Shell carbon pellet in NSTX (now running)

DIII-D shot 177053 w/o wall current





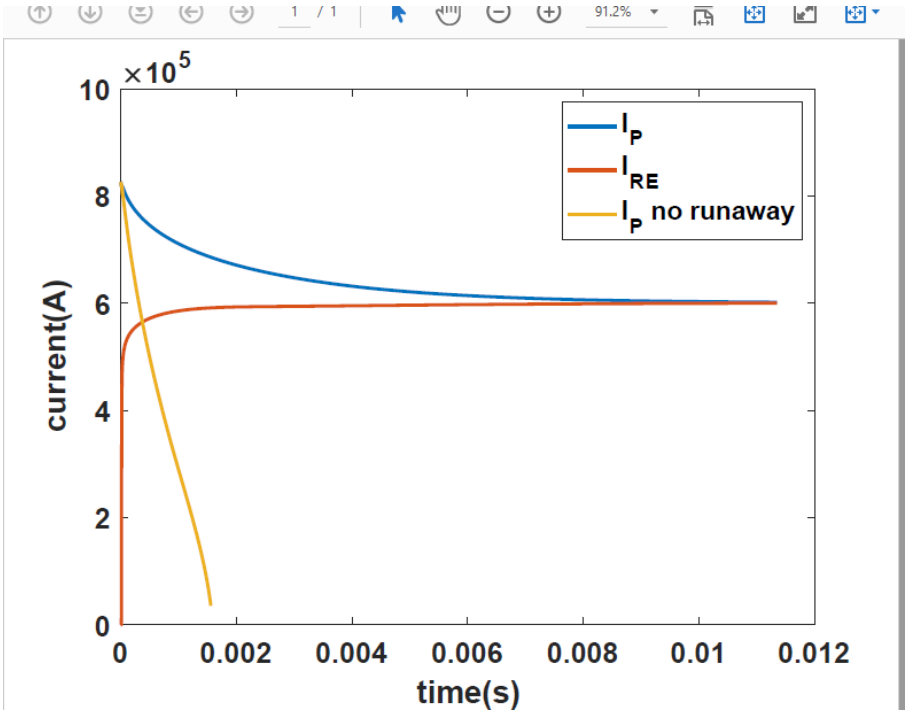
Chen Zhao

- DIII-D geometry with 3% Argon impurity
- Diffusion/Convection = 1% , Jadv=0.
- Parameters:

$$\beta_0 = 0.15$$
$$\kappa_T = 6 \times 10^{-3}$$
$$\kappa_R = 6 \times 10^{-1}$$
$$a = 0.65m$$
$$\mathrm{R} = 1.7m$$
$$B_0 = 1.9T$$
$$n_0 = 3.0 \times 10^{19} m^{-3}$$
$$c = 150 v_A$$
$$N_{elements} = 61610$$
$$\Delta t = 1.0 \tau_A$$

- The result is smooth. The plasma current also have a little inward shift. The plasma current and runaway current are not exactly same because of the inward shift. But the total plasma current and runaway current will become equal at t~10ms.
- I think the previous jagged result maybe caused by the wall current or the lack of resolution. Since the previous N_elements is only 13000.

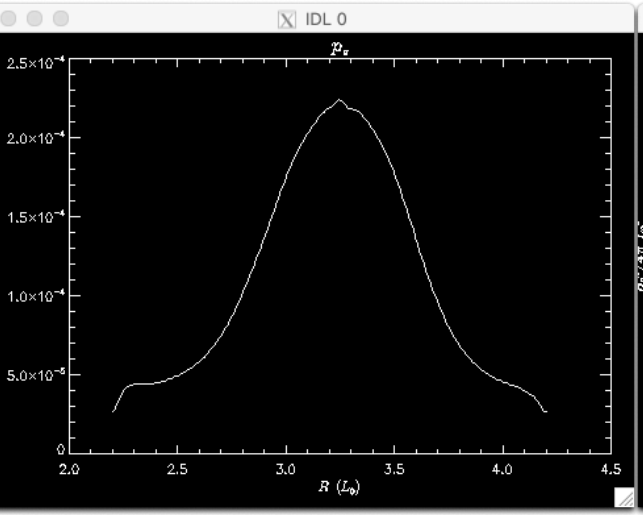
DIII-D RE shot 177053 with Argon w/wo RE



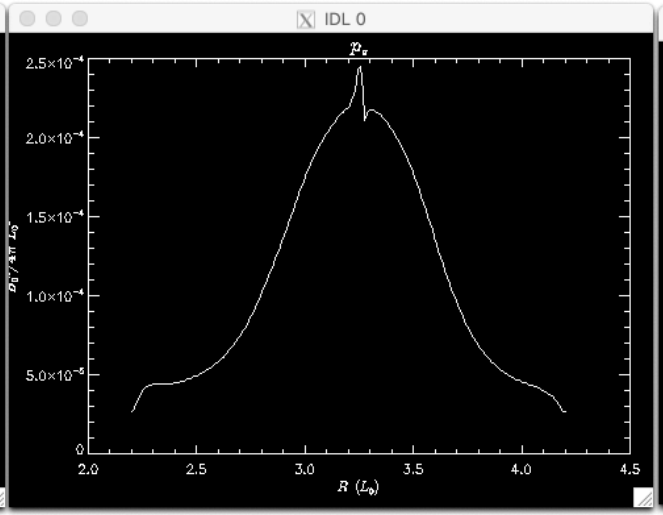
- Now running in 3D to test stability

Chen Zhao

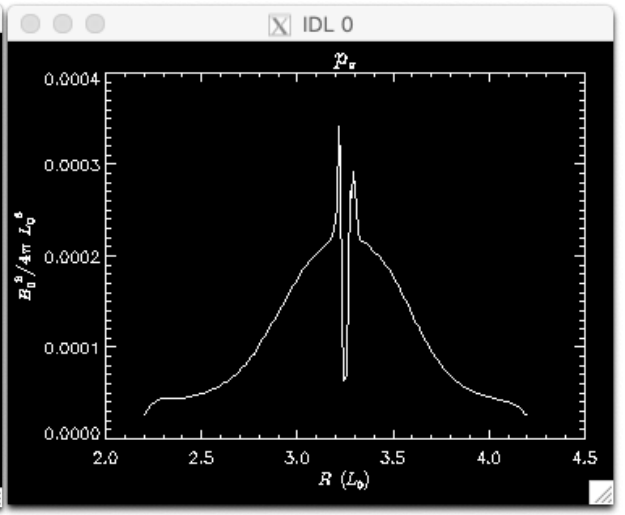
Sawtoothing discharge with Runaway Electrons



t=5831tau_A



t=5832tau_A

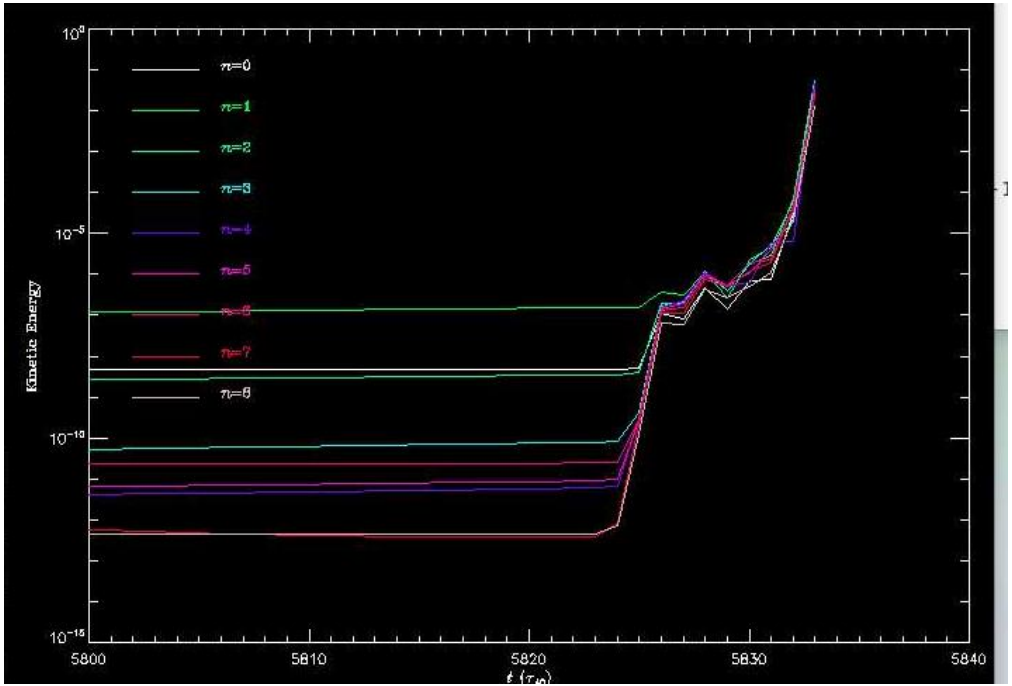


t=5833tau_A

/global/cscratch1/sd/chenzhao/Chen2D-mod2/

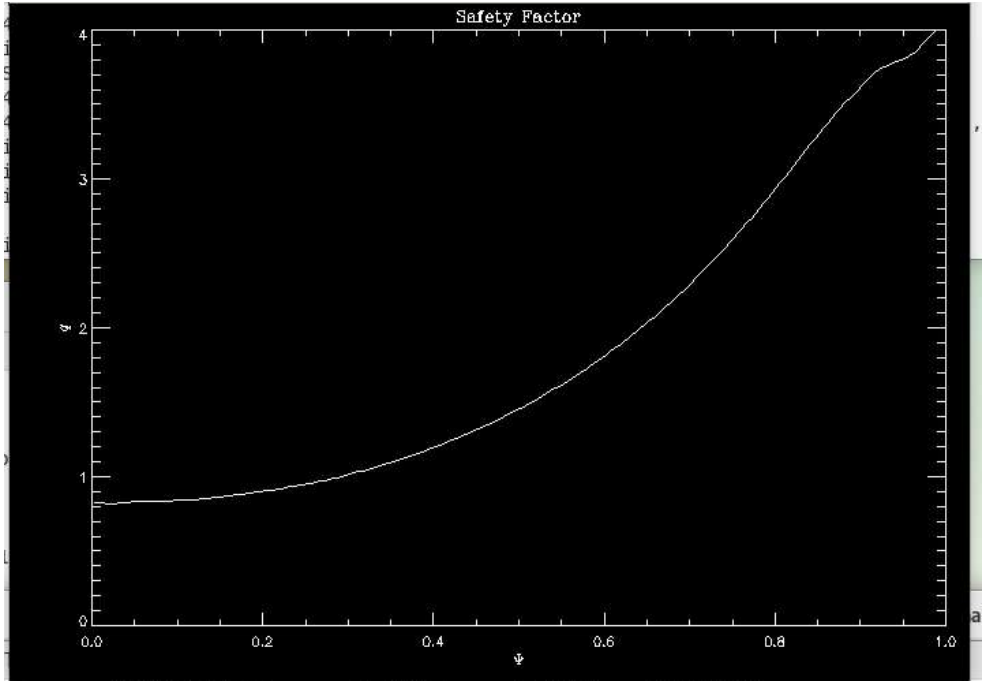
Chen Zhao

Sawtoothing discharge with Runaway Electrons



Idl: plot_hmn shows it goes unstable at t=5824. This may be a physical instability [(1,1) mode] initially, but then becomes numerically unstable. Need to better resolve in time (and space?)

Sawtoothing discharge with Runaway Electrons

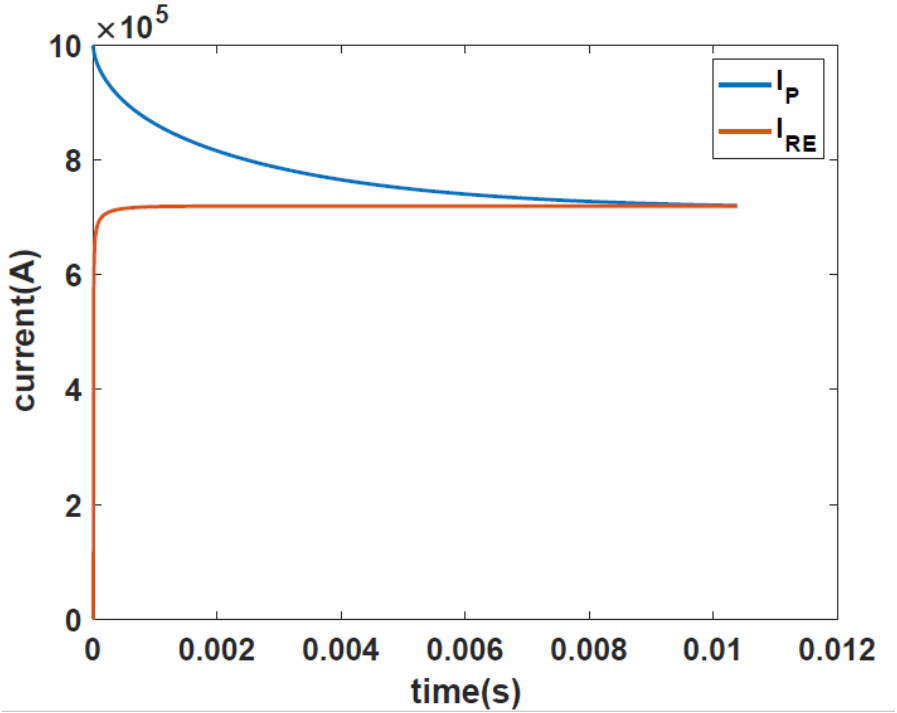


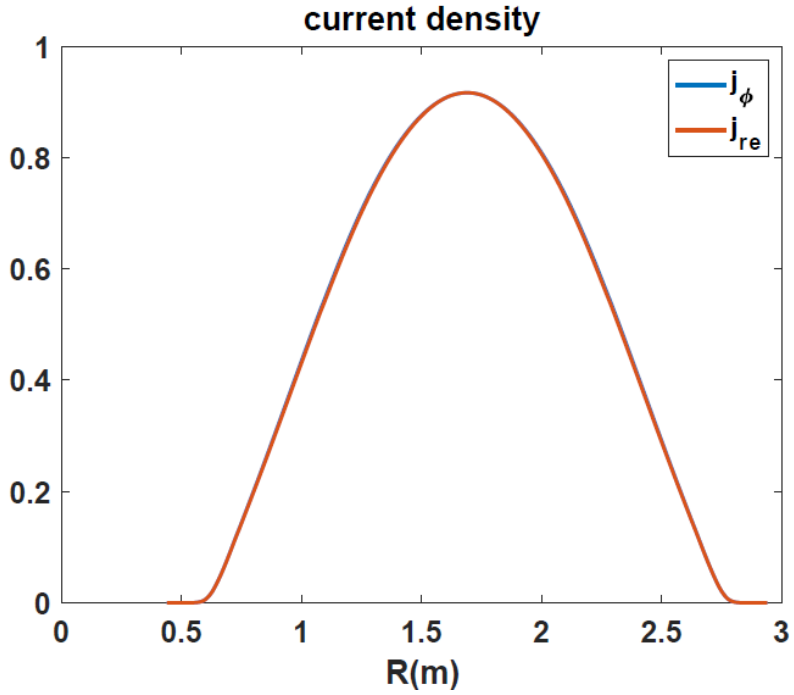
q-profile at time 5824. q(0) ~ 0.8. I would suggest comparing this to a run without RE. In Isabel's sawtoothing cases, q(0) never dropped below 0.9 ….New physics?

That’s All I have

Anything Else ?

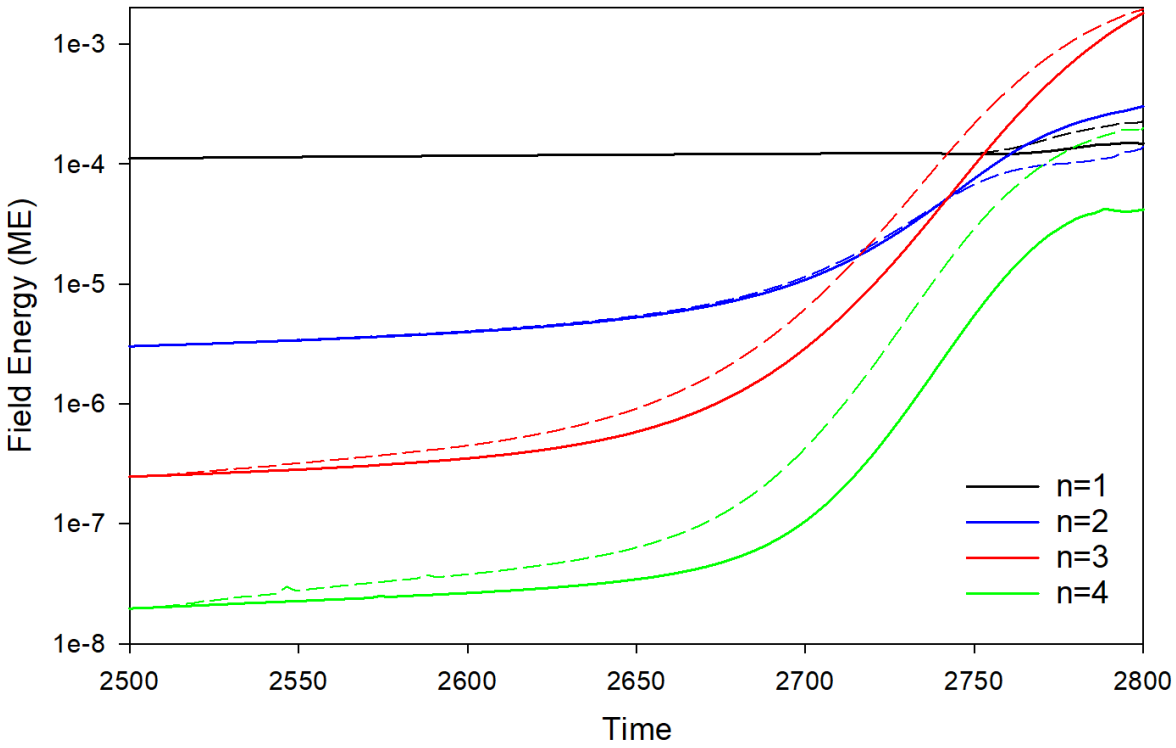
2D (cylindrical) RE with sources (12/19/2020)



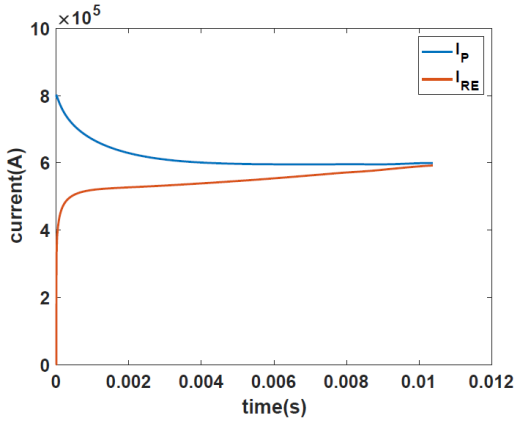


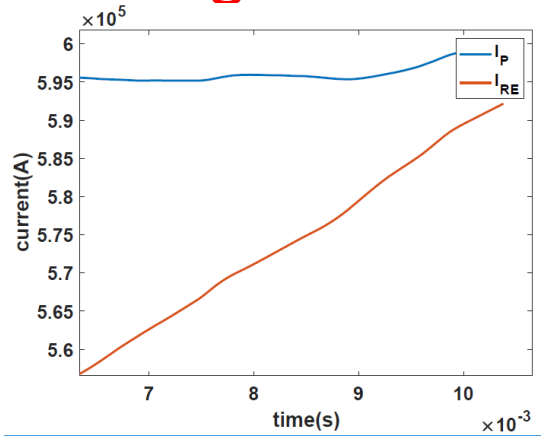
Chen Zhao

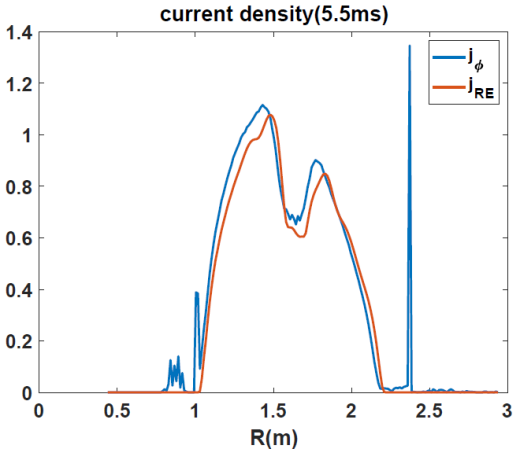
Energy in base case 36742317 (solid) and 16 plane case 37248033 (dashed)

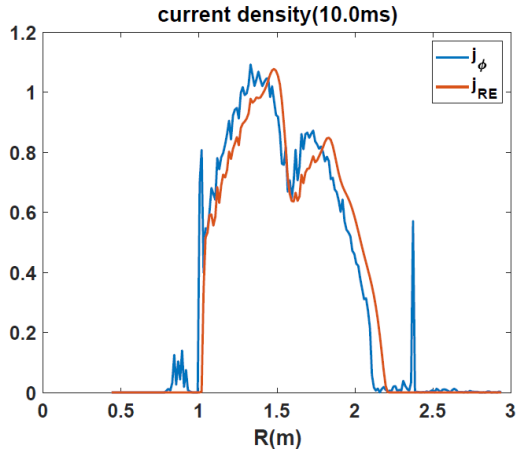


DIII-D 177053 with Argon





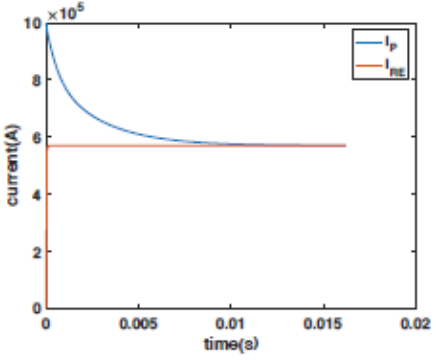


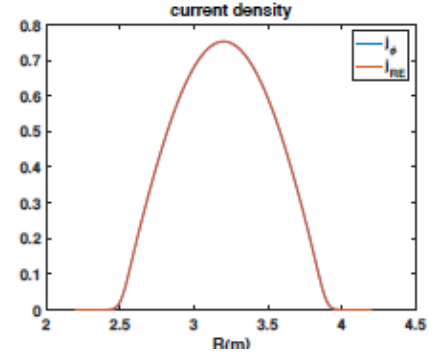


Chen Zhao

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?

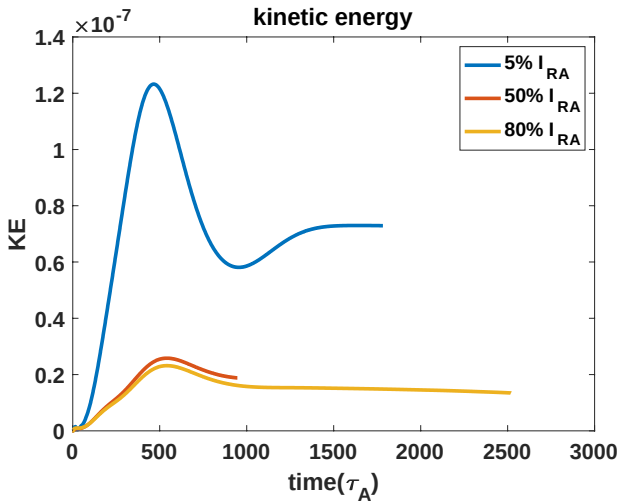
- M3D-C1/NIMROD 3D Benchmark

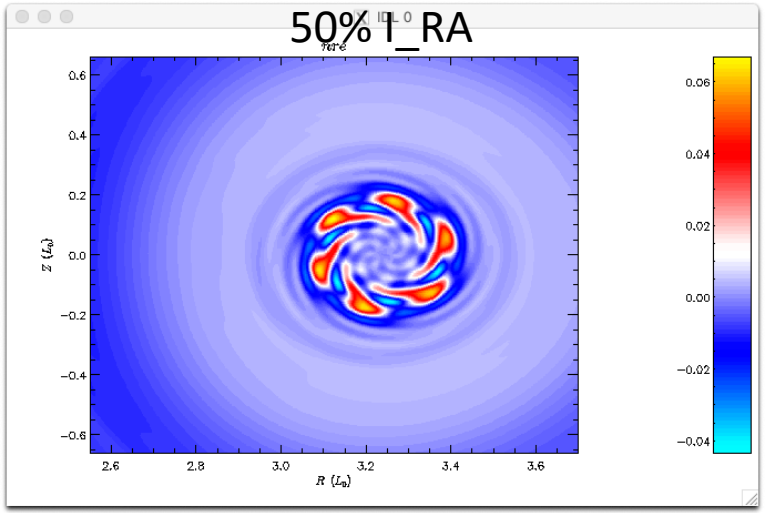
NSTX shot 1224020 – Fast ion transport with coupled kink and tearing modes
Chang Liu

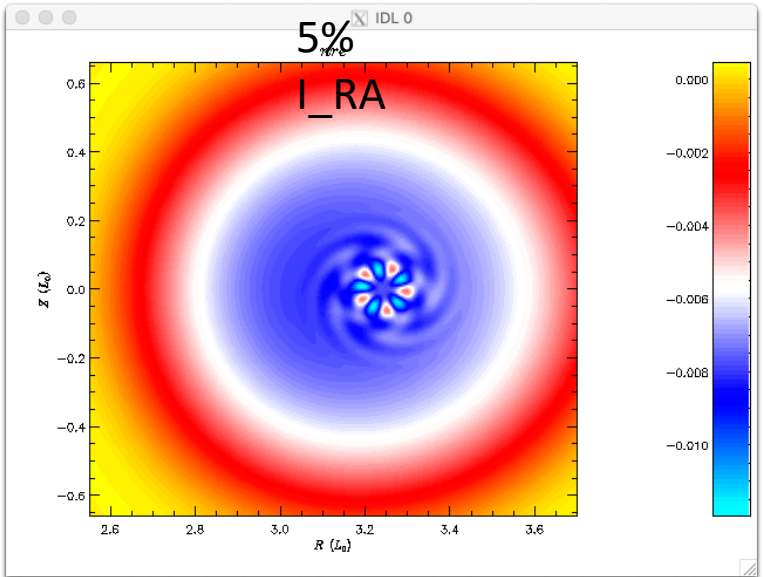
DIII-D Neon pellet mitigation simulation for KORC

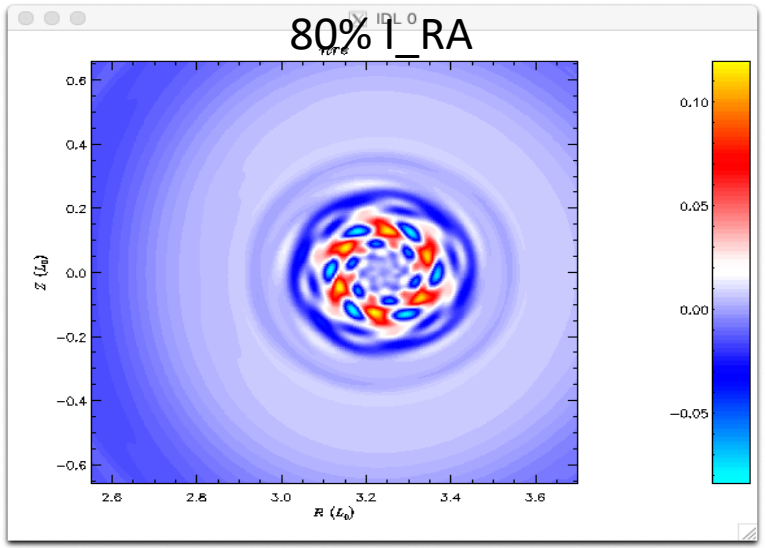
- Brendan Lyons trying to extend 8 plane case to 32 planes

SPARK ? Do we need to do anything?


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

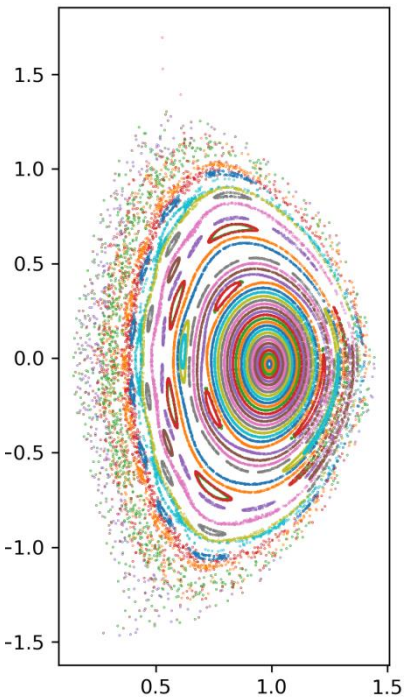

50% I_RA
IDL 0
Z (L_0)
R (L_0)


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

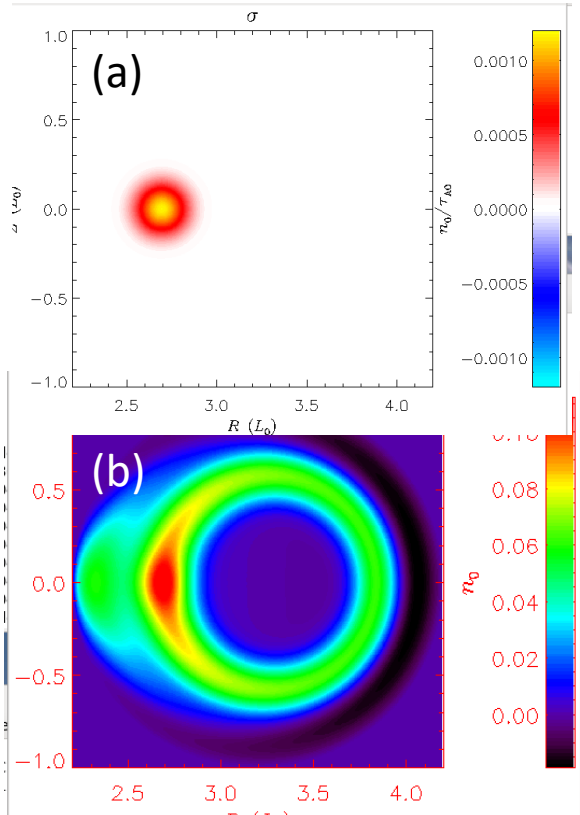
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

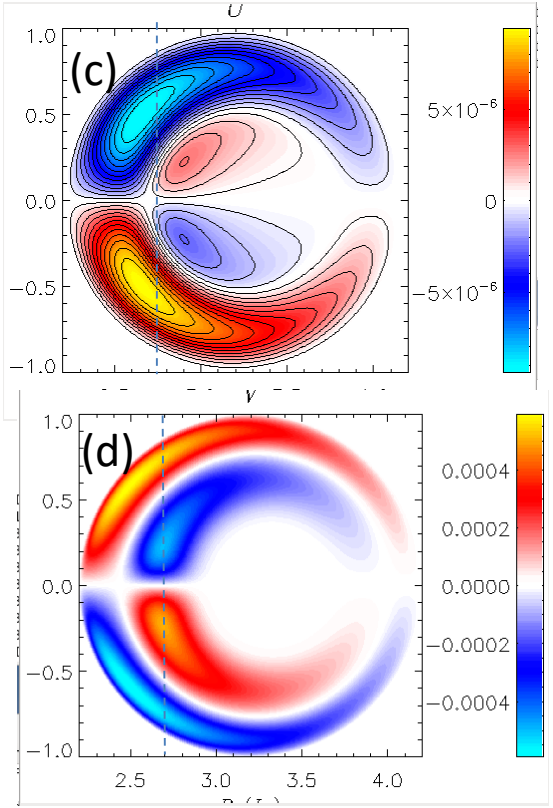
(a) Density source in 1F toroidal equilibrium

(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

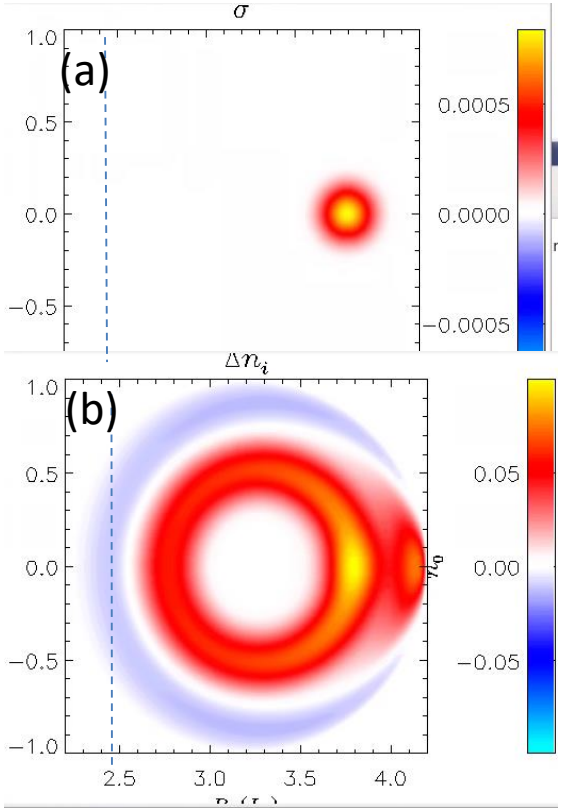
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

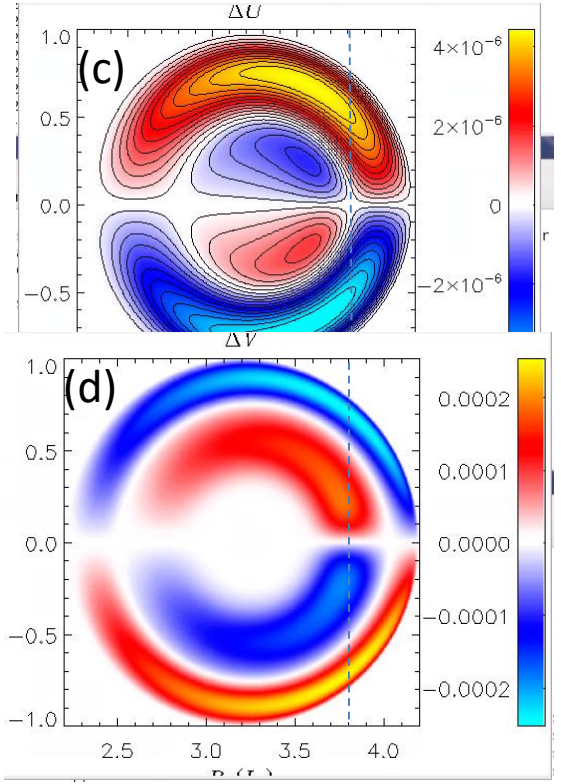
(a) Density source in 1F toroidal equilibrium

(b) Change in density after 10^3 τ_A

(c) Poloidal velocity stream function

(d) Toroidal velocity contours





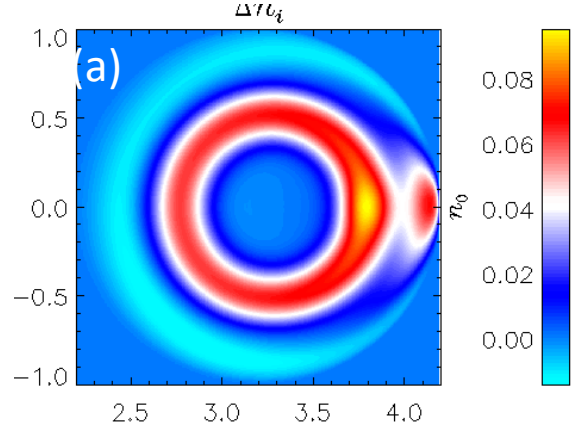
Grad-B drift in M3D-C1—2F effects

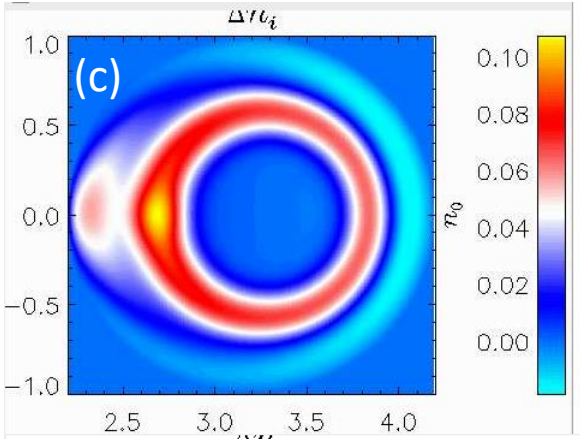
(a) 2F density change after 10^3 τ_A for LF side source

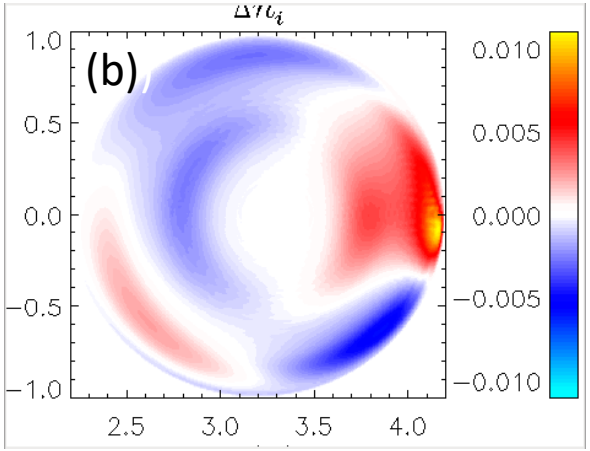
(b) Difference in 1F and 2F density (LF)

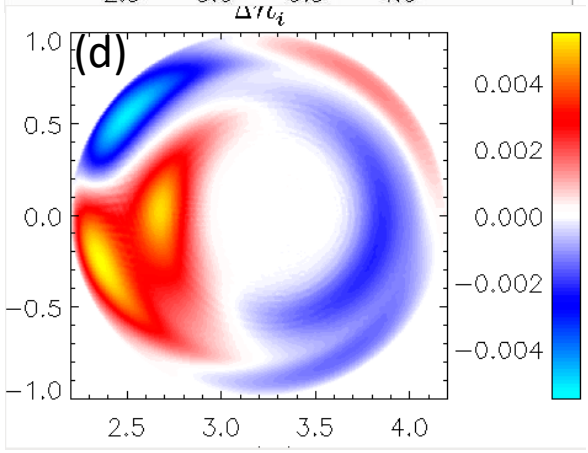
(c) 2Fdensity change after 10^3 τ_A for HF side source

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

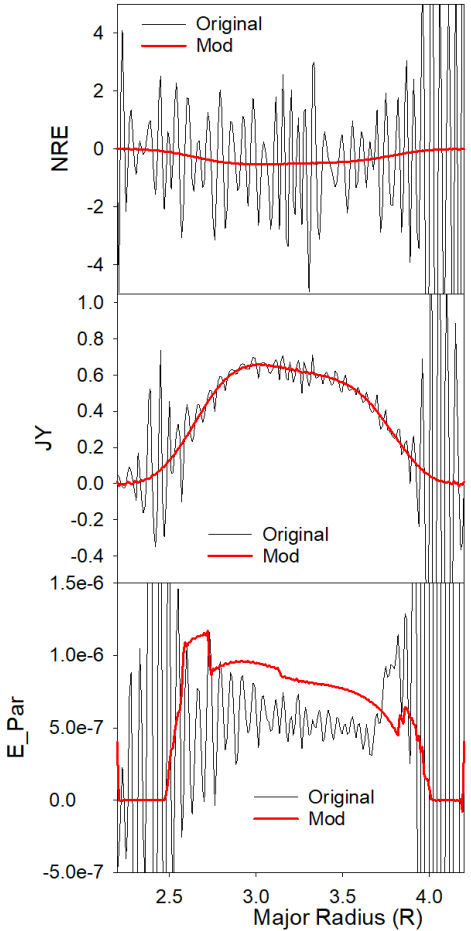








Sawtoothing discharge with runaway electrons

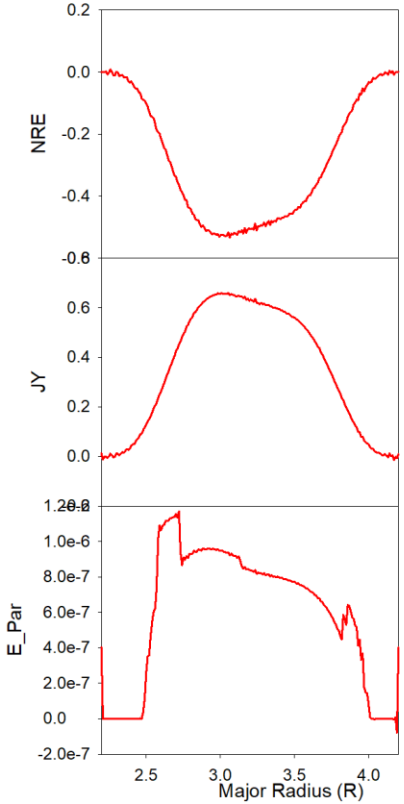


Profiles of nre, jy, and E_par after 30 timesteps

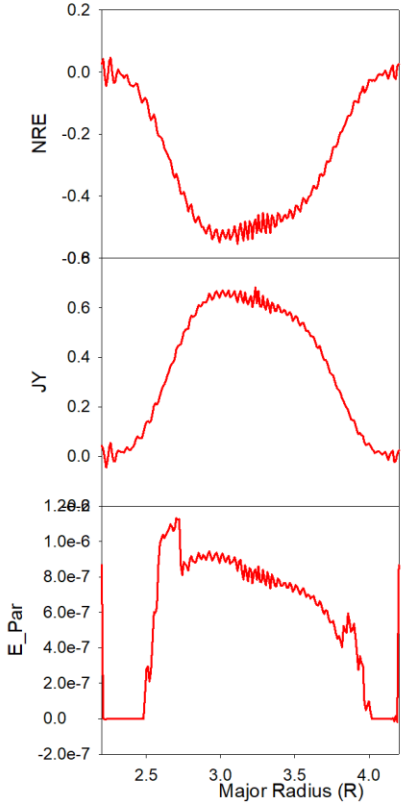
Original: /p/tsc/m3dnl/Isabel/Chen2D
Mod: /p/tsc/m3dnl/Isabel/Chen2D-mod1

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

Longer times develops oscillations



Change from t=6 to t=100



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