# M3D-C1 ZOOM Meeting

11/23/2020

1. CS Issues
    1. GPU solve status
    2. Local and other systems
    3. Error in linear run with imp_hyper=1
    4. NERSC Time
    5. Changes to github master since last meeting
    6. C. Clauser proposal for reading pellet info
    7. Lyons Proposal for Mesh Adaptation
2. Physics Studies
    1. NaN if mesh extends to negative R
    2. Viscosity in M3D-C1
    3. M3D-C1 involvement in 2021 Theory Performance Target (updated)
    4. DIII-D shot 178555/3055 (Andreas Wingen)
    5. Status of first coupled M3D-C1/LP Simulation .. Lyons/Samulyak
    6. NSTX shot 1224020 (progress?)
    7. Status of other simulations
    8. Other?

# GPU solve status

# Local Systems

- PPPL centos7(11/23)
  - All 6 regression tests PASSED on centos7:
- PPPL greene (11/23)
  - 5 regression tests PASSED
  - No batch file found for pellet
- EDDY (11/16)  (down for hardware repair)
  - All 6  regression tests PASSED
- TRAVERSE(11/16)
  - Code compiles
  - Regression test failed:  split_smb not found in PATH
  - Have not yet tried shipping .smb files from another machine

# Other Systems

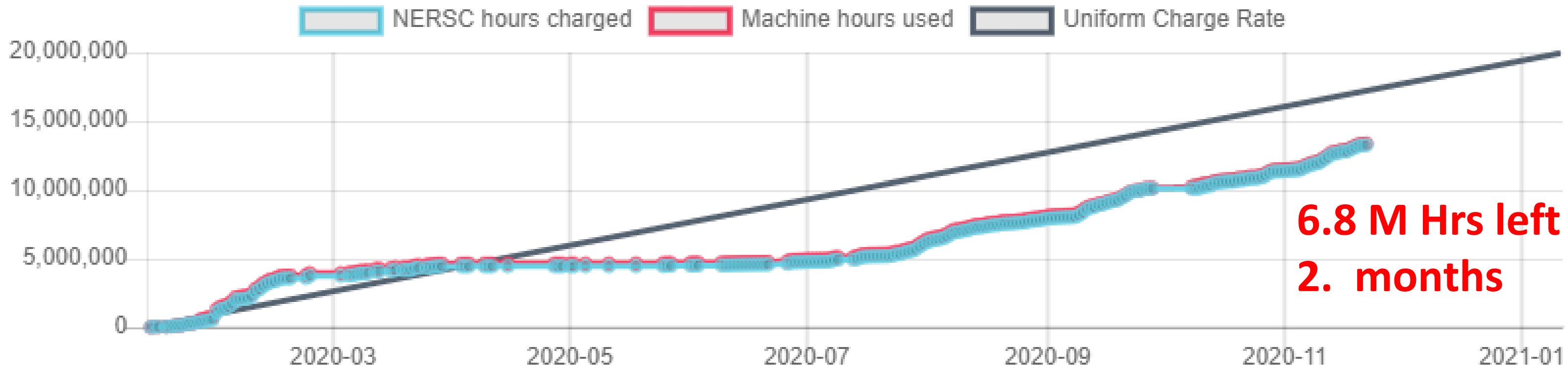
- Cori-KNL (11/16)
  - 6 regression tests passed on KNL
- Cori-Haswell (11/16)
  - 5 regression tests passed
  - KPRAD_RESTART did not pass, but differences are very small in velocity variables. All magnetic and thermal good. Similar difference as Cori-KNL
- PERSEUS
  - All 6 regression tests PASSED on perseus (J. Chen, 9/04/20)
- MARCONI
  - All regression tests PASSED on MARCONI (J. Chen, 9/04/20)
- CORI GPU (10/26)
  - ??

# Bug Report

I moved my failed run to:/pfs/nobackup/jardin/BugReport
There are 2 subdirectories, /Good and /Bad.   The only difference in the C1input files is imp_hyper=0 in /Good (which runs) and imp_hyper=1 in /Bad (which fails)

# NERSC Time

**mp288**




**m3163**

Closed for general use

- New NERSC allocations start Jan 15 2021

# Changes to github master since last meeting

- Usman Riaz
  - 11/17/20: Description of input arguments in the “m3dc1_mesh_adapt”
- Yao Zhou
  - 11/17/20: Phase 2 change of bf to bfp completed.  Need more testing
  - Version number changed to 35 marking bfp changes
- Seegyoung Seol
  - 11/16/20: m3dc1_mesh_adapt (new adaption added)

# C. Clauser proposal for reading pellet info

- Cesar wants to change some pellet parameters at restart time. So, he suggests that the following pellet variables only be read from the restart file if iread_pellet.ge.1:
- pellet_var, pellet_var_tor, pellet_verr, pellet_velphi, pellet_velz, pellet_vx, pellet,vy, cloud_pel, pellet_mix

(note: pellet_vx and pellet_vy are auxialliary variables)

So, if iread_pellet .eq. 0 (default) the values of these in the C1input file at the restart time will be used, allowing them to be changed

In addition, he is adding a new ablation model which sets the ablation rate to a constant. He is using the input variable “pellet_rate” for this

Counter proposal made by Brendan at 1:44 today involving adding new input variable irestart_pellet which defaults to what we have now. The new constant ablation model is fine with Brendan.

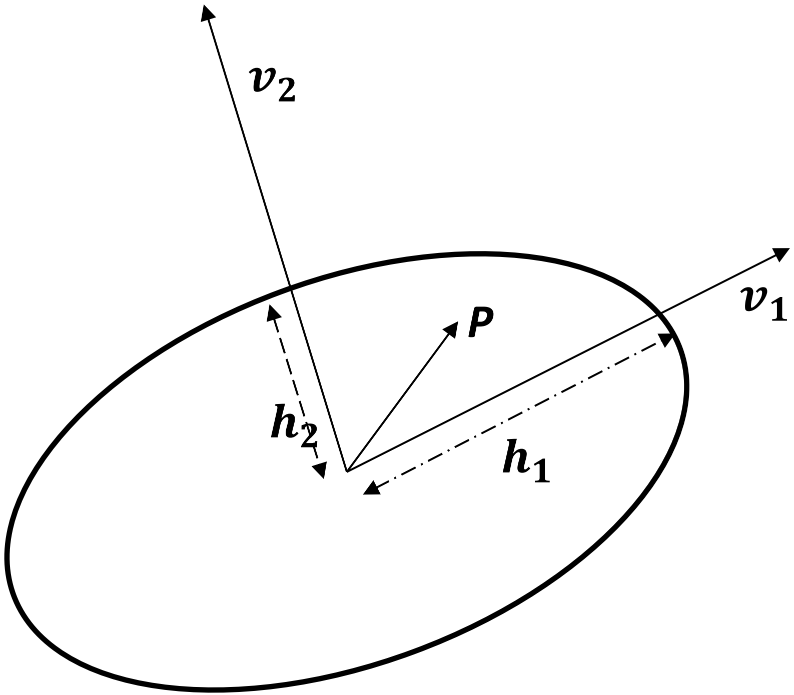
**Who will make changes?**

# Lyons Proposal for Mesh Adaptation

Fortran side will define 4 m3dc1 fields corresponding to $v_1$, $v_2$ (orientation vectors) and $h_1$,$h_2$ (desired mesh sizes in 2 directions)

SCOREC side will then define a new mesh and will interpolate solution onto the new mesh.

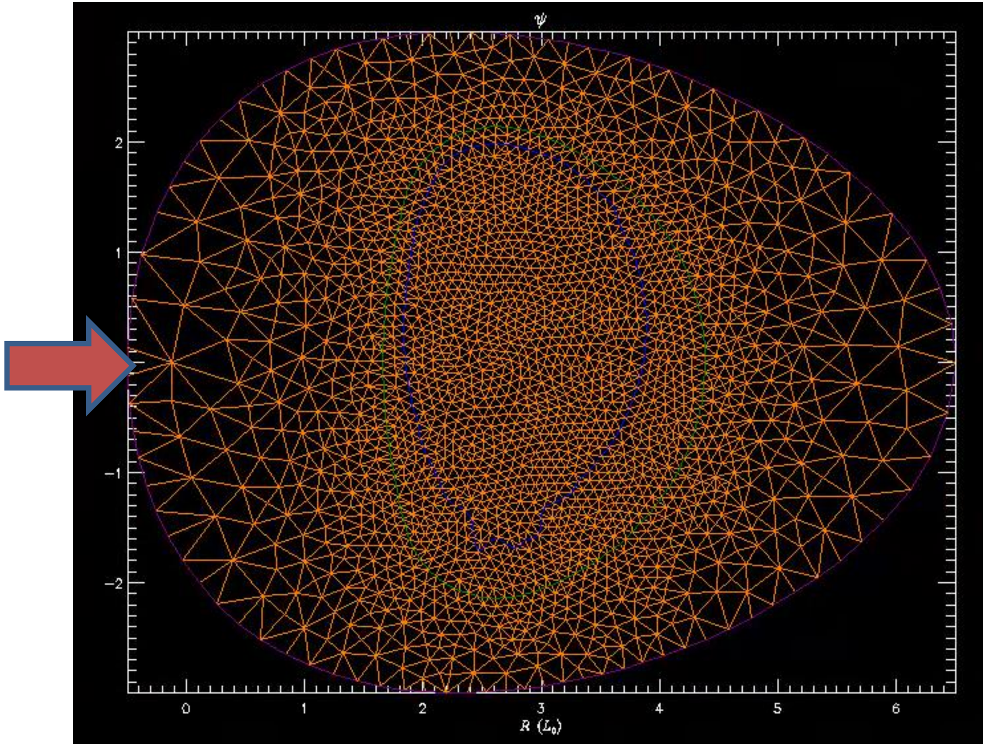
This will work in both 2D and 3D.




Question: Don't you just need the angle of the unit vector $v_1$,$v_2$?

Conf. Call held 11/20/20

# NaN if Mesh extends to negative R




- Setting ntimemax=0 and igs=0 should result in the program producing a file with the fields before the GS iteration begins

- If the mesh extends into negative R, the resulting fields will be incorrect and may contain NaNs and will not plot.

# Viscosity in M3D-C1

$$\mathbf{\Pi_i} = -\mu\left(\nabla\mathbf{V} + \nabla\mathbf{V}^{\dagger}\right) - 2(\mu_C - \mu)(\nabla\bullet\mathbf{V})\mathbf{I} \qquad \mathbf{V} = R^2\nabla U \times \nabla\varphi + \omega R^2\nabla\varphi + R^{-2}\nabla_{\perp}\chi$$

$$\nabla\cdot\overleftrightarrow{\Pi}_i = -\mu\nabla^2\mathbf{V} - \left(2\mu_C - \mu\right)\nabla\left(\nabla\cdot\mathbf{V}\right) \cong \mu\left[\nabla_{\perp}\left(\nabla_{\perp}^2 U + U''\right)\times\nabla\varphi + \left(\nabla_{\perp}^2\omega\right)\nabla\varphi - \nabla_{\perp}\omega' + \nabla_{\perp}\chi''\right]$$
$$+2\mu_C\nabla\left(\nabla_{\perp}^2\chi + \omega'\right)$$

$$\iint d^2R\, \nu_i \nabla\varphi\bullet\nabla_{\perp}\times R^2 \rightarrow \iint d^2R\, R^2\nabla_{\perp}\nu_i\times\nabla\varphi\bullet \quad\rightarrow\quad -\mu\left[R^2\left(\nabla_{\perp}^2\nu_i\right)\left(\nabla_{\perp}^2 U\right) - \left(\nu_i, U''\right)\right]$$

$$\iint d^2R\, \nu_i R^2\nabla\varphi\bullet \quad\rightarrow\quad \iint d^2R\, \nu_i R^2\nabla\varphi\bullet \quad\rightarrow\quad \left[\nu_i\mu\Delta^*(R^2\omega) + 2\mu_C\nu_i\omega''\right] + 2\mu_C\Delta^*\chi'$$

$$\iint d^2R\, \nu_i\nabla_{\perp}\bullet R^{-2} \quad\rightarrow -\iint d^2R\, R^{-2}\nabla_{\perp}\nu_i\bullet \quad\rightarrow\quad 2\mu_C\frac{1}{R^2}\Delta^{\dagger}\nu_i\Delta^{\dagger}\chi - \mu\left(\nu_i,\omega'\right) + 2\Delta^*\nu_I\omega'\left(\mu_c - \mu\right)$$

Looks to be implemented ok, at least in the cylindrical limit! (11/23/20) SCJ

# M3D-C1 involvement in 2021 Theory Performance Target

Q1: thermal collapse simulations with iRFP and NORSE codes. Simulated conditions will be comparable to pre-existing 3D MHD thermal collapse simulations. The dissipation of RE using high-Z impurities in DIII-D will be modeled using KORC incorporating collision operators for partially ionized impurities, time evolving electric and magnetic fields, (2D ?) and spatiotemporal models of impurities.

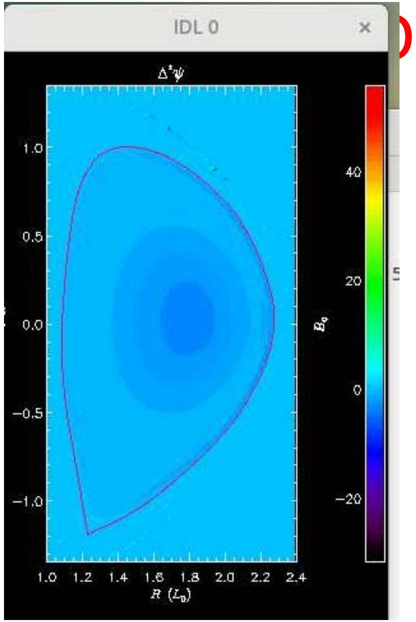
Q2: MHD simulations using M3D-C1 and NIMROD will be analyzed to investigate the time dynamics of the thermal collapse rate and effect of MHD instabilities and stochastic fields on seed formation. KORC will simulate RE transport in stochastic magnetic fields obtained from 3D MHD simulations.

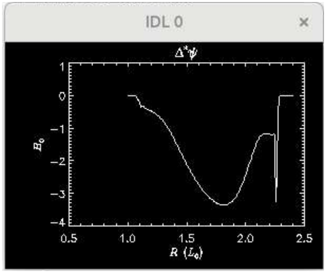
Q3: Run KORC and CQL3D with impurity profiles from M3D-C1 and NIMROD MHD simulations to study effect in 3D impurity fields.

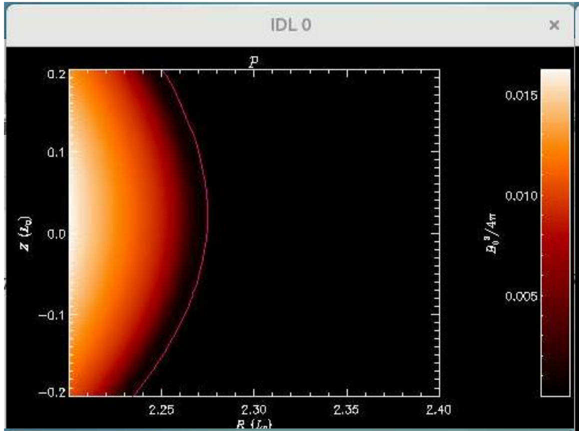
Q4: Self-consistent simulations including thermal quench with impurities injection, RE-MHD coupling, and MHD instabilities will be conducted using M3D-C1 or NIMROD

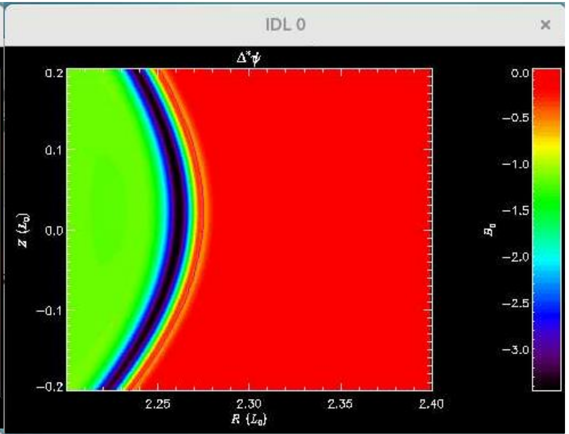
Updated 11/20/20

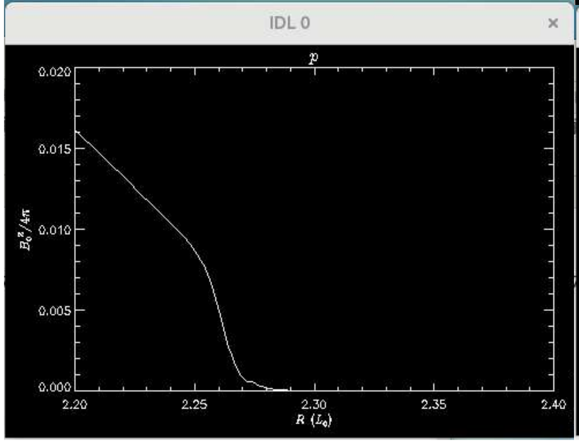
# 178555/3055 (Andreas Wingen)

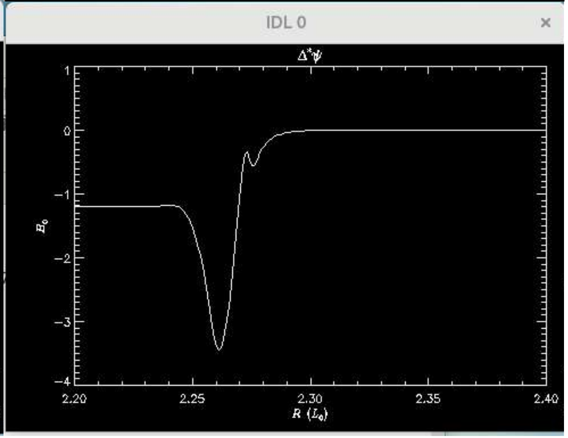


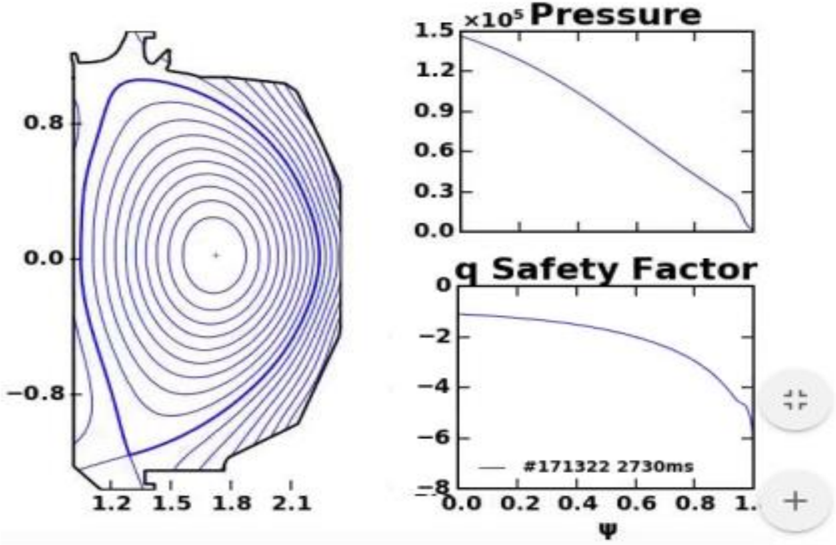



# Status of First Coupled M3D-C1 / LP Simulation

- **Iterate independent simulations of MHD and LP codes**
  - Run pellet injection in MHD code with analytic, Parks ablation formula
  - Send plasma states along pellet path to LP code to compute ablation rate at each point
  - Rerun MHD codes with LP ablation rates
  - Iterate between codes until convergence
- **Test case for DIII-D modeling**
  - 1 mm Ne pellet using extruder parameters
  - 160606, standard case for SPI modeling
  - 171322, super-H target for upcoming small-pellet ablation experiment
  - Latter will be used for predict-first of experiment

**DIII-D 171322 @ 2730 ms**




8/10/20 – proposed

10/5/20 – Brendan sent data from a 2D run

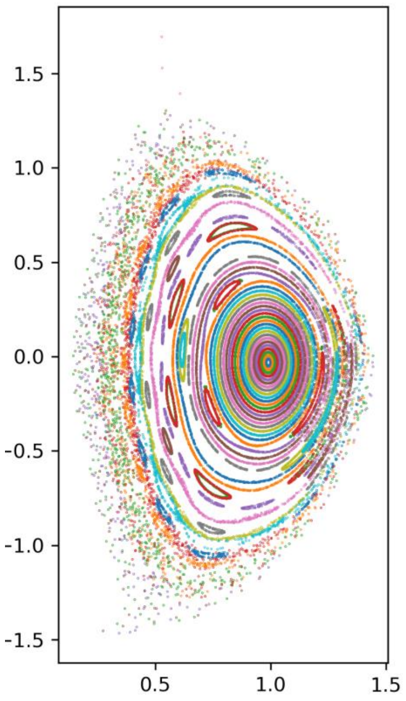
10/7/20 – Roman requested more concise data from around pellet vs time

10/20/20 – Brendan developed and documented postprocessor for LP ablation code.

11/2/20 – Roman said they will use Brendan's data this week and then schedule a ZOOM

**ZOOM to occur 11/24/20 1:00 EST**

# 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

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

# Progress on other shots?

**DIII-D shot 177040** – saturated mode amplitude of (2,1) mode with runaways

- Chang Liu sent progress report, now refining

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?

# That’s All I have

Anything Else ?

# Grad-B drift in M3D-C1—HF side

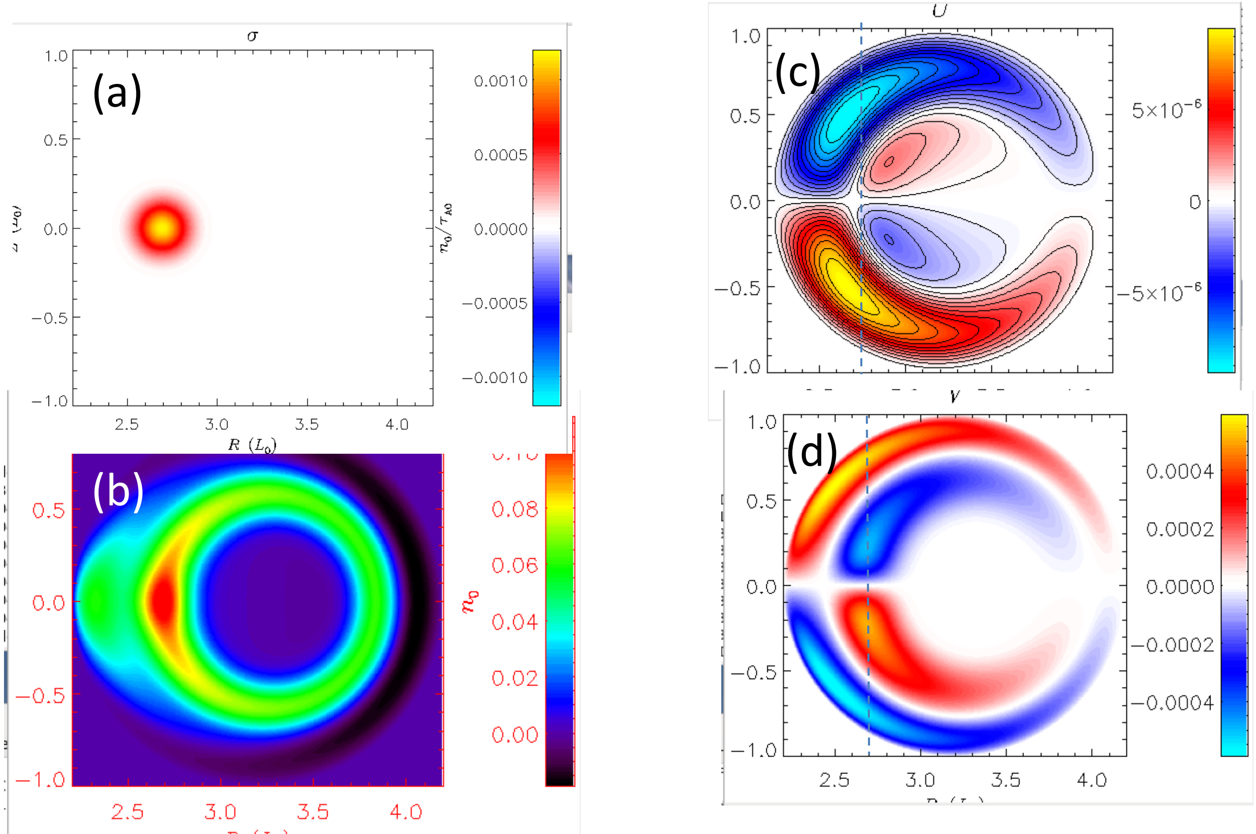
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

(a) Density source in 1F toroidal equilibrium

(b) Change in density after $10^3\ \tau_A$

(c) Poloidal velocity stream function

(d) Toroidal velocity contours



# Grad-B drift in M3D-C1– LF source

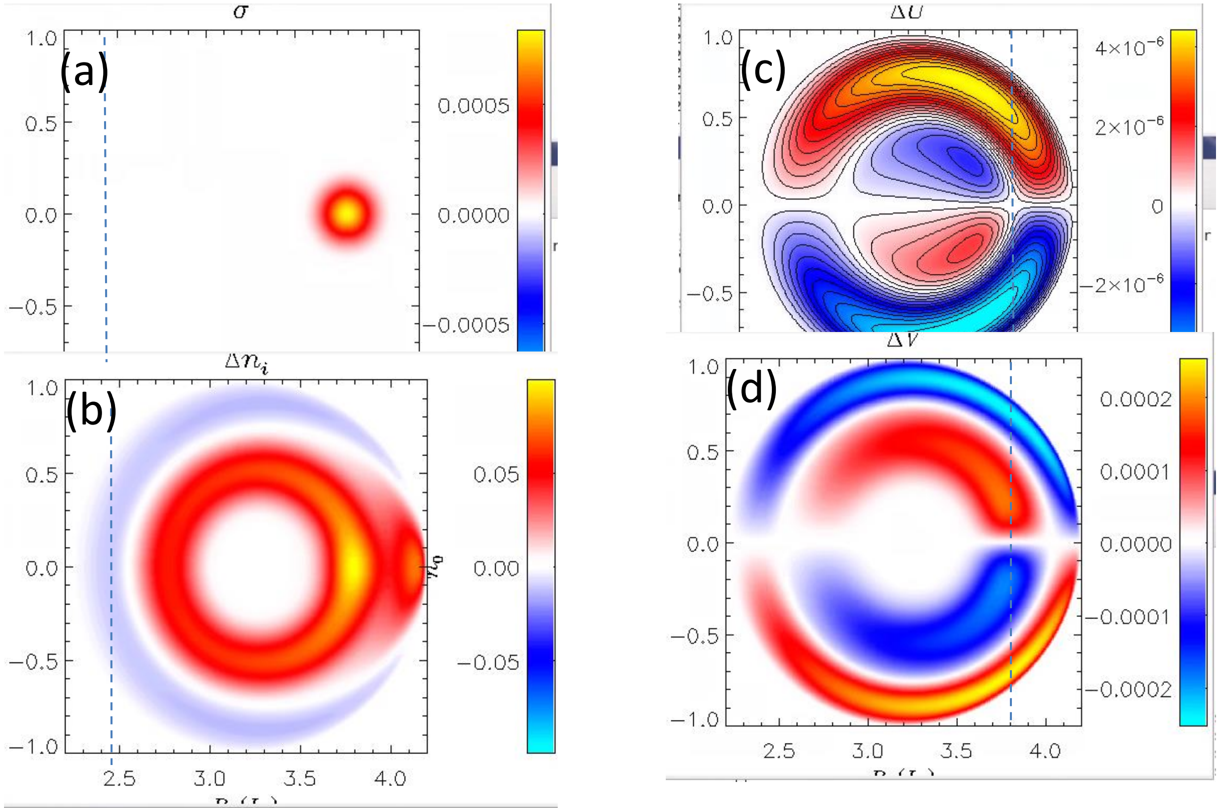
Request to calculate grad-B drift in M3D-C1 and to compare with that being put into the LP Code

(a) Density source in 1F toroidal equilibrium

(b) Change in density after $10^3\ \tau_A$

(c) Poloidal velocity stream function

(d) Toroidal velocity contours



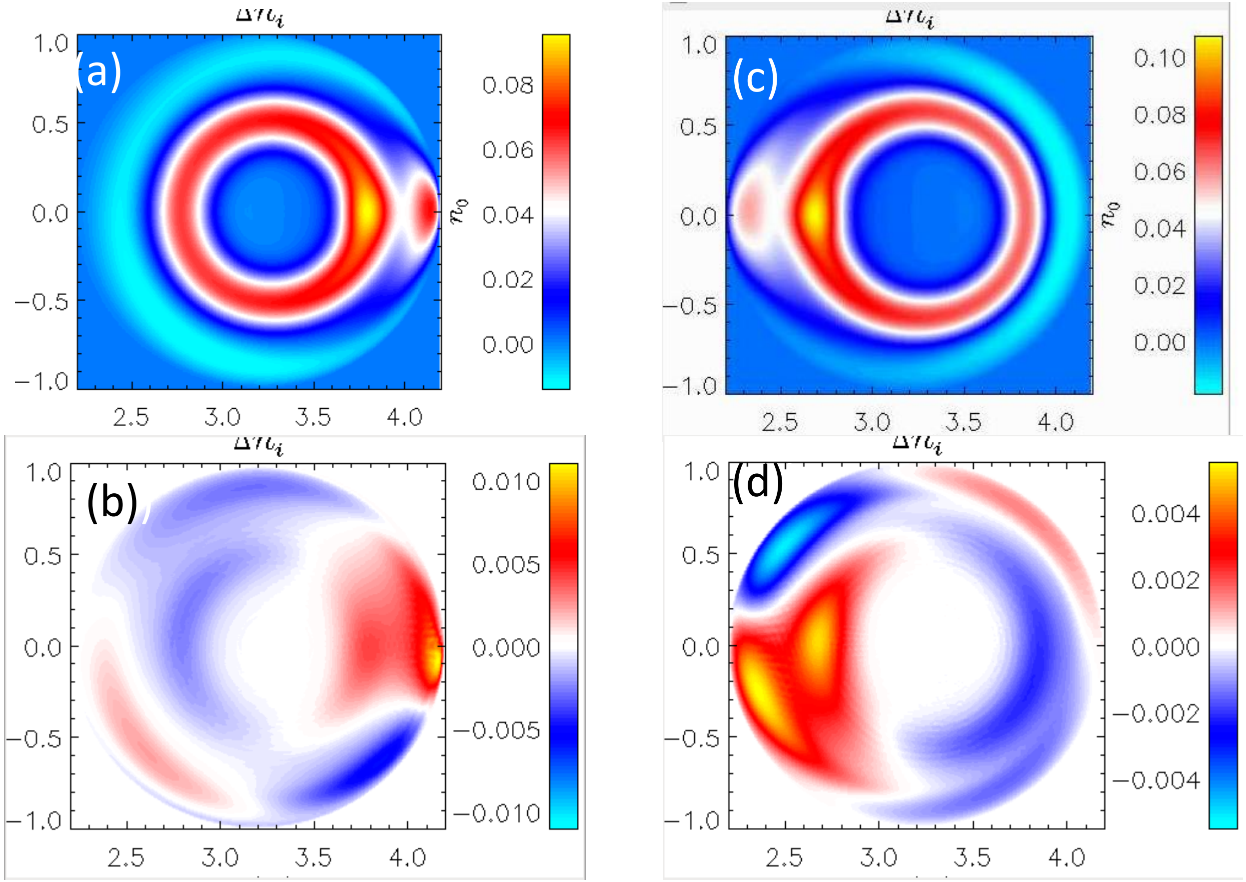
# Grad-B drift in M3D-C1—2F effects

(a) 2F density change after $10^3$ $\tau_A$ for LF side source

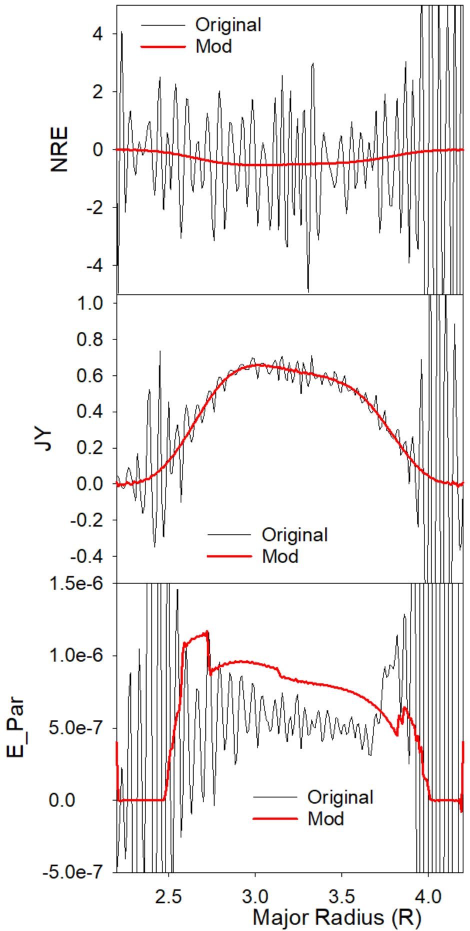
(b) Difference in 1F and 2F density (LF)

(c) 2Fdensity change after $10^3$ $\tau_A$ for HF side source

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



# Sawtoothing discharge with runaway electrons

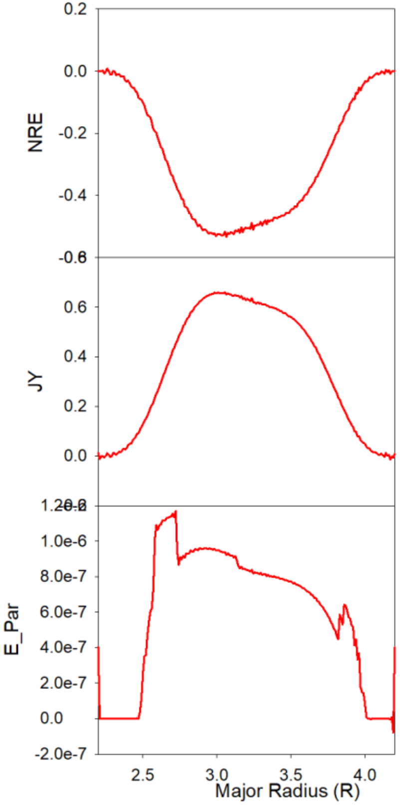



Profiles of nre, jy, and E_par after 30 timesteps

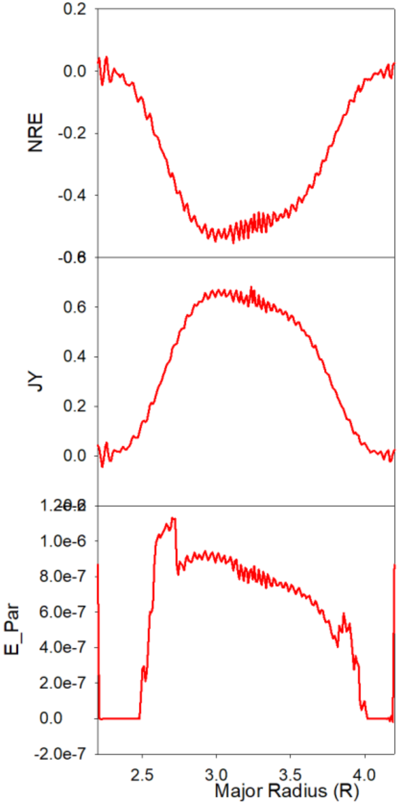
Original: /p/tsc/m3dnl/Isabel/Chen2D
Mod: /p/tsc/m3dnl/Isabel/Chen2D-mod1

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?