M3D-C1 ZOOM Meeting

7/13/2020

Agenda

1. Announcements
2. CS Issues
    1. Local systems
    2. New system benchmark status – Jin Chen
    3. NERSC Time
    4. Changes to GIT master since last meeting
3. Physics Studies
    1. Non-resonant modes in low shear equilibria – Adelle Wright
    2. Fishbone Benchmark—Chang Liu
    3. Progress on 3D pellet benchmark with NIMROD – B. Lyons
    4. Runaways with sources Chen Z.
    5. M3D-C1 coupling to KORC: Clauser
    6. Summary: Vessel Forces from a VDE in ITER – S. Jardin
    7. Other

Announcements

- Laboratory closed unless authorized
  - Once authorized, need to get single access code at http://rtw-screen.pppl.gov
- IAEA Technical Meeting on Disruptions and their mitigation
  - Send Summary Slide to committee by Tuesday 14 July
  - In “Consequences Section” there will be 2 slots
    - Disruption loads
    - Runaway electron
  - Invited to open new discussion threads
- SciDAC PI meeting scheduled for July 28-30 July 2020 is *cancelled*
  - Replaced by a half-day remote panel session on July 29
- ITPA MHD Meeting October 14-16 2020
  - Fully Remote
- IAEA Fusion Energy Conference postponed to May 2021

Local Systems

- PPPL
  - Problem with writing to /p/m3dc1
  - Move to centos7
    - 2 internal compiler errors when compiling…disappeared when resubmitted

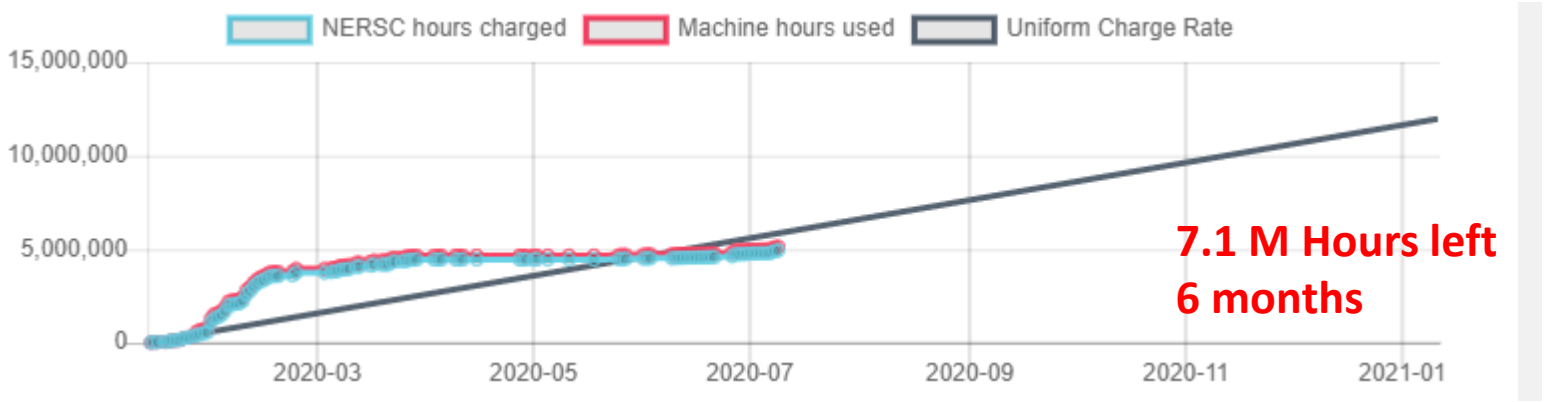
- EDDY
  - Change “module load gsl” to “module load gsl/2.4”
  - Machine will be down 6:00 AM – 2:00 PM
    - Job will not run if time in batch script exceeds 6:00 PM Tuesday

New system benchmark status

Jin Chen ?

NERSC

MP288



M3163

Has not been updated.

- Note NERSC down July 9-14
- We will get SOME new M3163 time, but not as much as last year
- Should be enough mp288 time to last until new PU computer arrives in the fall
- Do not waste time!

Changes to github master since last week

- Ferraro:
  - 07/10/20: Minor bugfixes to plot_flux_average.pro and plot_perturbed_surface.pro
  - 07/08/20: Corrections to README/readme.centos7

Documented changes in NEWDOC-latest: m3dc1.pppl.gov

Non-resonant modes in low shear equilibria

Adelle Wright

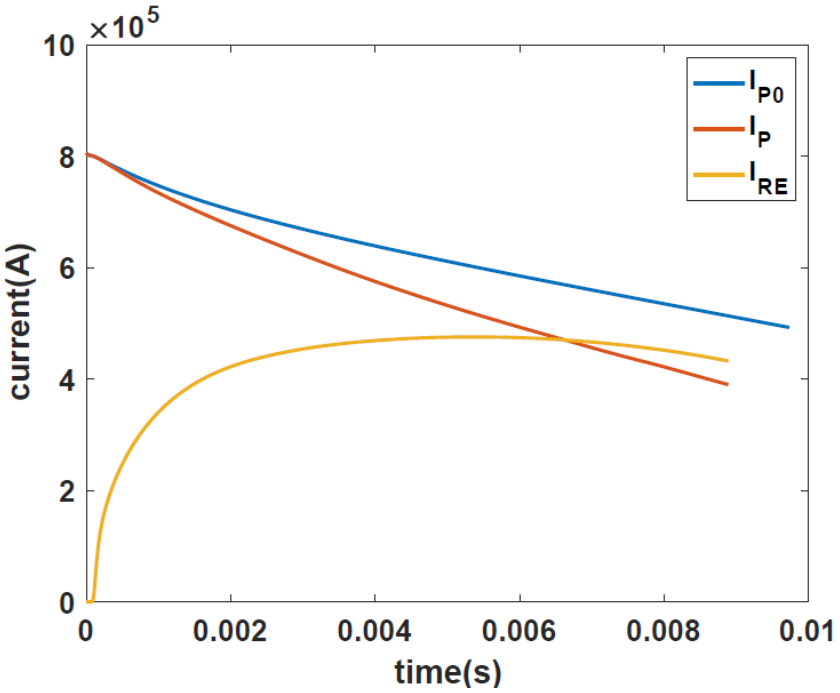
Fishbone Benchmark

Chang Liu

Progress on 3D pellet benchmark

Brendan Lyons

Runaways with Sources

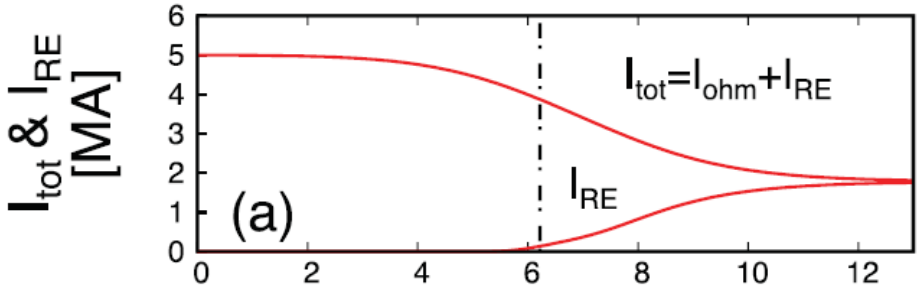


Chen: June 9, 2020

Nucl. Fusion **57** (2017) 066038 https://doi.org

Reduced fluid simulation of runaway electron generation in the presence of resistive kink modes

A. Matsuyama[a], N. Aiba and M. Yagi



$$\frac{\partial n_{\mathrm{RE}}}{\partial t} + (v_{\mathrm{RE}}\mathbf{b} + \mathbf{u}) \cdot \nabla n_{\mathrm{RE}} = S_{\mathrm{Dreicer}} + S_{\mathrm{avalanche}},$$

$$E = \eta(J - en_{\mathrm{RE}}c),$$

1D Runaway Electron Formation

$$\dot{\psi} = \frac{\eta}{\mu_0}\left[\frac{1}{r}\frac{\partial}{\partial r} r \frac{\partial \psi}{\partial r} - \mu_0 R J_{RE}\right] \qquad y = r^2 \qquad \dot{\psi} = \frac{\eta}{\mu_0}\left[4\frac{\partial}{\partial y} y \frac{\partial \psi}{\partial y} - \mu_0 R J_{RE}\right]$$

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

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

$$T_e = 10^3 eV \qquad n_e = 10^{20} m^{-3}$$

$$v_{th} = \left[\frac{T_e \times 2 \times 1.1604\times10^4 K \times 1.3807\times10^{-23} J/K}{9.1094\times10^{-31} kg}\right]^{1/2} = 5.93\times10^5 \sqrt{T_e} ms^{-1}$$

$$\nu_{ee} = \frac{n_0 m^{-3} \times \left(1.6022\times10^{-19} C\right)^4 \times 20}{4\pi\left(8.8542\times10^{-12} Fm^{-1}\right)^2 \left(9.1094\times10^{-31} kg\right)^2 \left(5.93\times10^5 \sqrt{T_e} ms^{-1}\right)^3} = 7.731\times10^{-11} n_0 T_e^{-3/2} s^{-1}$$

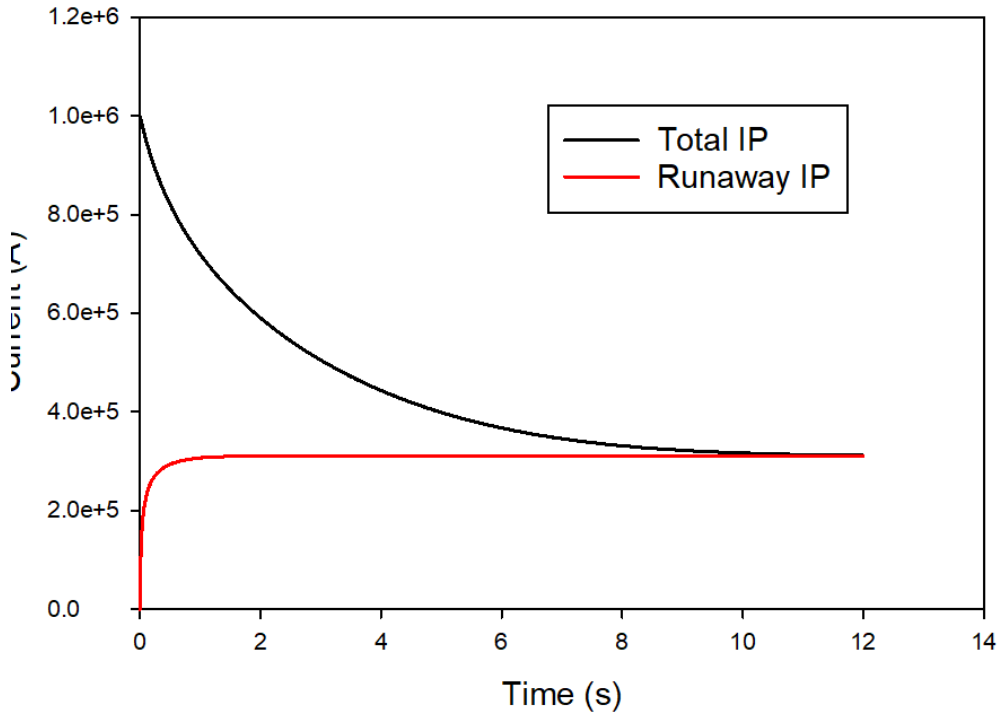
$$E_c = \frac{n_0 m^{-3} \times \left(1.6022\times10^{-19} C\right)^3 \times 20}{4\pi\left(8.8542\times10^{-12} Fm^{-1}\right)^2 \left(9.1094\times10^{-31} kg\right)\left(3.0\times10^8 ms^{-1}\right)^2} = 1.018\times10^{-21} n_0 \, Vm^{-1}$$

$$E = \frac{T_e \times 1.1604\times10^4 K \times 1.3807\times10^{-23} J/K}{\left(9.1094\times10^{-31} kg\right)\left(3.0\times10^8 ms^{-1}\right)^2}(E_{EF} / E_c) = 1.95\times10^{-6} T_e (E_{EF} / E_c)$$

$$\eta = 1.03\times10^{-4} \times 20 \times T_e^{-3/2} \Omega m = 2.06\times10^{-3} T_e^{-3/2} \Omega m \qquad \eta / \mu_0 = \frac{2.06\times10^{-3} T_e^{-3/2}}{4\pi\times10^{-7}} = 1.639\times10^3 T_e^{-3/2} m^2 s^{-1}$$

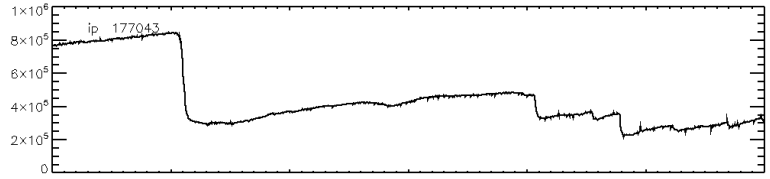
Initial Condition

$$\frac{\partial}{\partial y} y \frac{\partial \psi}{\partial y} = \tfrac{1}{4} R J_0 \left[1 - \left(\frac{y}{a^2} \right)^2 \right], \qquad \psi = \tfrac{1}{4} R J_0 \left[y - \frac{y^3}{9a^4} \right]$$



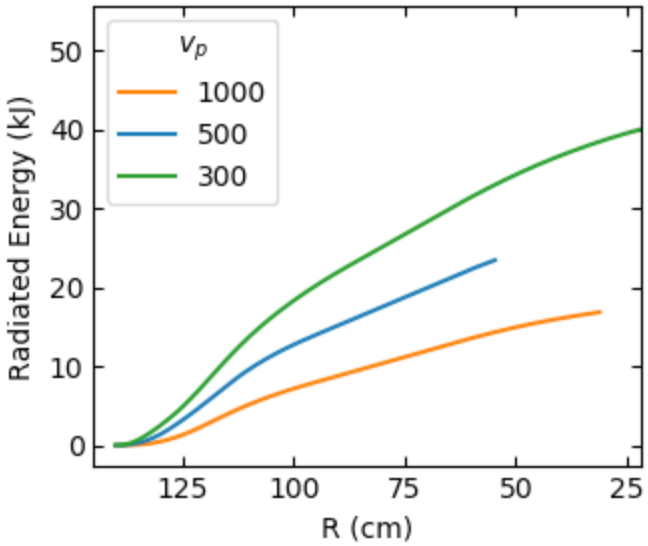
M3D-C1 coupling to RE code KORC

- Plan to target DIII-D shot 177053 after Chen has a full simulation with fluid runaway electrons



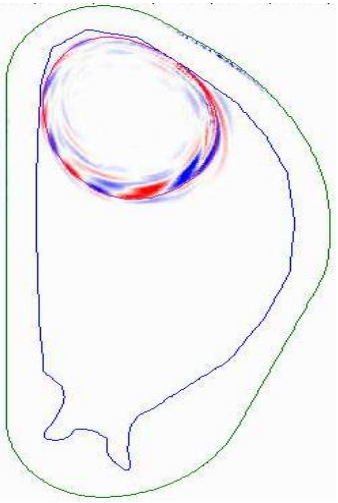
- KORC can now run using fields, densities, and temperatures from M3D-C1 hdf5 files using Nate's Fusion-IO routines

- Cesar trying to increase C-concentration to get stronger TQ and CQ



- Total radiated energy increases as pellet speed decreases
- Try 100 m/s ?
- Also trying uniform distribution in 2D

Summary: Vessel Forces from a VDE in ITER



- Vertical force on ITER VV of 80-100 MN predicted by several codes, both 2D and 3D
  - Net vertical force almost independent of size of halo current
  - However, local stresses will depend on current paths and hence halo current
  - Slower current quenches lead to larger net forces
- Asymmetrical (sideways) forces arise from n=1 mode and associated halo currents
  - Mounting evidence that the m=1,n=1 mode is present in worst case disruptions
- Several 3D MHD codes are now modeling 3D VDEs
  - Requires MHD region, conducting structure, vacuum region
  - 3 Codes have performed verification benchmark exercise
- Code results and analysis shows max force at intermediate value of $\gamma\tau_W$
- JET modeling shows large forces only if q(a) → 1 during disruption
  - Larger sideways forces for slower current quenches
- Simulations of ITER with realistic structure have yet to show large sideways force
  - ITER unlikely to have q(a) < 1 (an large sideways force) during VDE unless Current Quench time is very long: > 200 ms

That’s All I have

Anything Else ?