M3D-C1 ZOOM Meeting

5/18/2020

Agenda

1. Announcements
2. CS Issues
    1. 3D Seg fault
    2. Local adaption status-Seegyoung
    3. NERSC Time
    4. other
3. Physics Studies
    1. 3D ITER VDE Force calculation status
    2. 3D Benchmark—Updated Force Calculaton
    3. Fluid runaway electrons: stability and sources – Chen Zhao
    4. Other

Announcements

- CTTS talk series Schedule
  - 4/29 Chang Liu M3D-C1-K (posted)
  - 5/6 NIMROD CS
  - 5/13 Sovinec/Jardin 3D VDE benchmark (posted)
  - 5/20 Eric Howell NTM with NIMROD
  - 5/27 Roman Samulyak SPI simulations
  - 6/3 Chen Zhao MHD stability with RE
  - 6/10 Cesar Clauser Mitigation in NSTX with EMPI
  - 6/17 Charlson Kim NIMROD SPI Simulations
  - 6/24 open
- web site now open: m3dc1.pppl.gov
  - Contains documentation and vgs from weekly meeting
- Discussion with ORNL on M3D-C1/KORK coupling Tues@11:00?

3D Seg Fault

When running the 3D code, I have gotten a Segmentation Violation at seemingly random time steps. When I resubmit, it either runs ok or fails at the same place but at a different timestep. The last lines of output when it fails are always the same:

```
 Advancing Temperature--end
  Advancing Fields
      -- Reuse Preconditioner
[70]PETSC ERROR: ----------------
```

This happened to me using SuperLU_dist on cori_knl, and also using mumps on eddy. Because this is not reproducible it will be hard to find, but it could have something to do with changes you made to allow reusing the preconditioner.

Jin: on eddy, copy
/home/jinchen/SRC/M3DC1/unstructured/eddy.mk

Jin Chen

Mesh Adaptation Status

- Edge Splitting

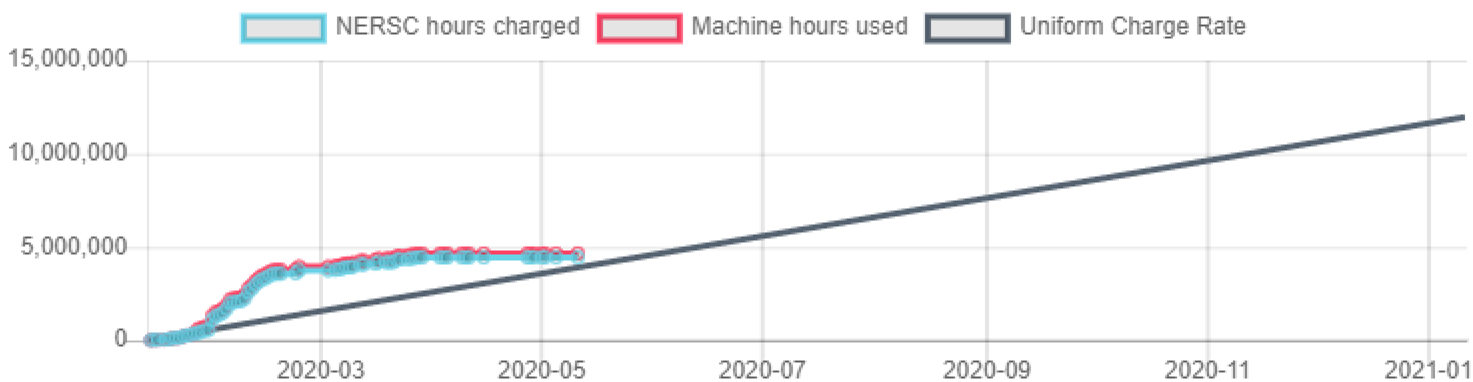
Need: $\phi, \phi_R, \phi_Z, \phi_{RR}, \phi_{ZZ}, \phi_{RZ}$, and their toroidal derivatives (in 3D)

The first 3 of these (and the last) can be obtained by differentiating the polynomial $\phi(R,Z)$ in either of the two original triangles.

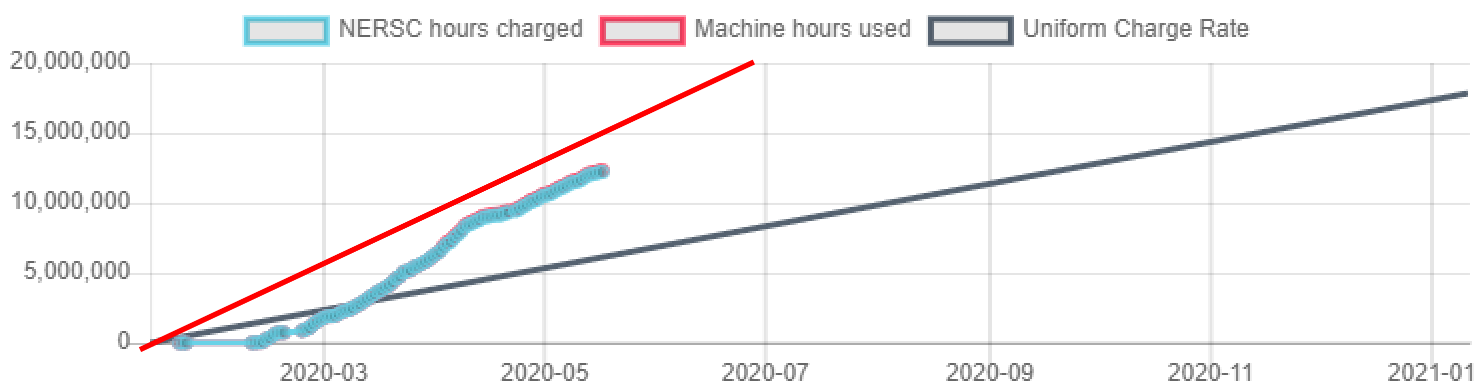
For the remaining DOF, ϕ_{RR} and ϕ_{ZZ}, can we evaluate them from evaluating the polynomials in each side and take the average?

NERSC

MP288



M3163

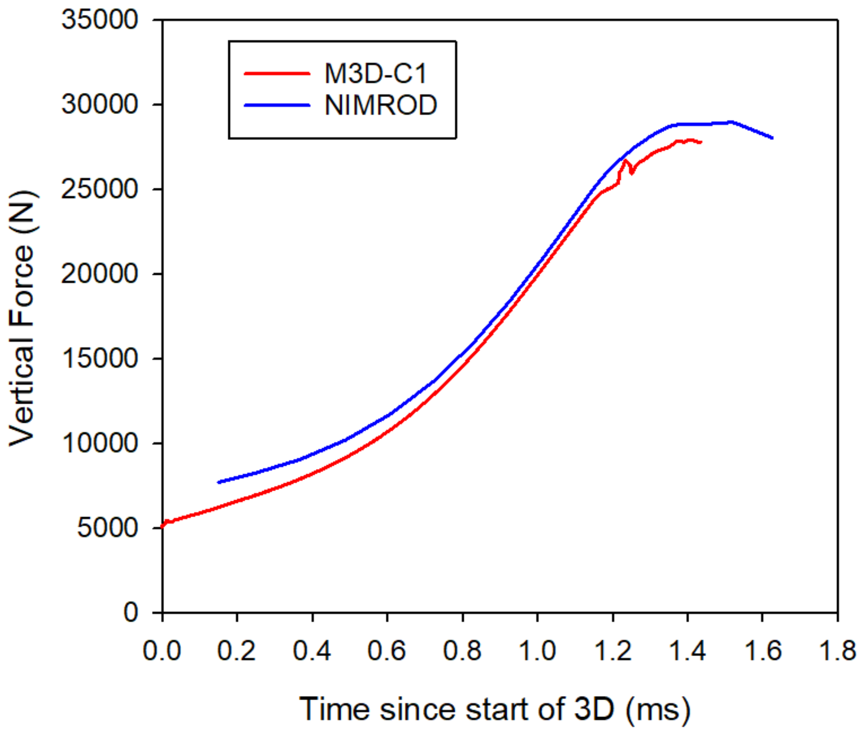


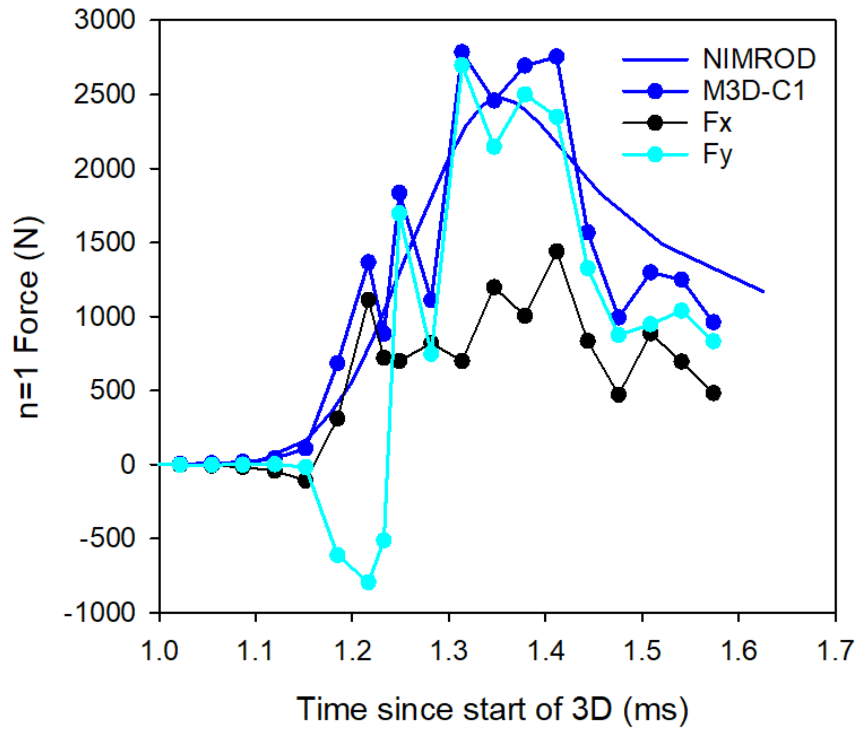
Need to use less mp288.   m3163 approaching linear usage rate

Add to batch file: #SBATCH –account=3163

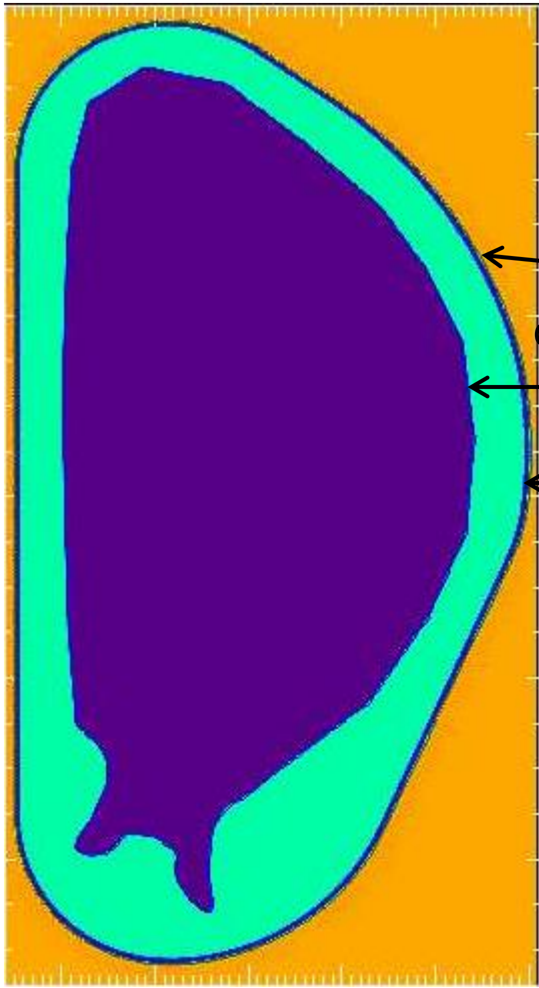
(clauser, kleiner, lyons, strauss)

3D VDE Benchmark—Updated Force Calculation



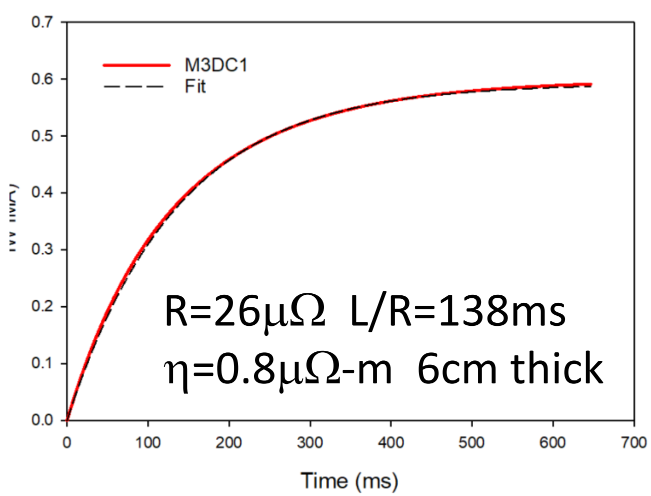


3D ITER VDE – coupling to CARIDDI



$$\frac{1}{R^2}(\nu_i,\dot{\psi}) = -\frac{\eta_T}{R^2}\Delta^*\nu_i\Delta^*\psi + \frac{\eta_P}{R^2}\left[\frac{1}{R^2}(\nu_i,\psi'') + [\nu_i, f'''] + [\nu_i, F']\right] + \frac{\eta_P'}{R^2}\left[\frac{1}{R^2}(\nu_i,\psi') + [\nu_i, f''] + [\nu_i, F]\right]$$

$$\frac{\nu_i}{R^2}\dot{F} = -\frac{\eta_P}{R^2}(\nu_i, F) - \frac{\eta_P}{R^2}(\nu_i, f'') + \frac{\eta_P}{R^2}[\nu_i,\psi']$$



L/R test with no plasma

New variables for poloidal resistivity of wall

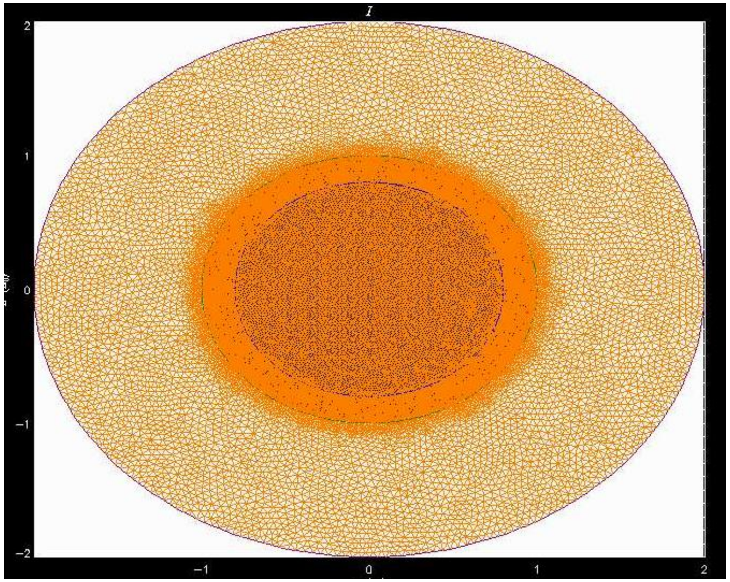
eta_wallRZ
wall_region_etaRZ

Defaulted to eta_wall and wall_region_eta

Toroidal Field Diffusion Test Problem

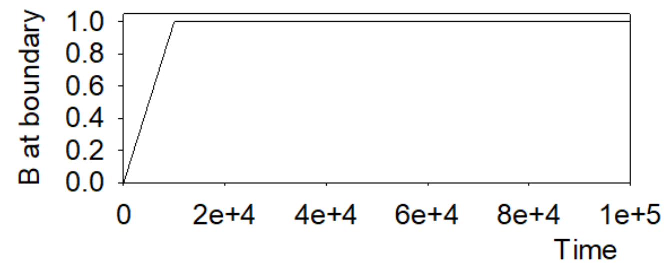
vloopRZ

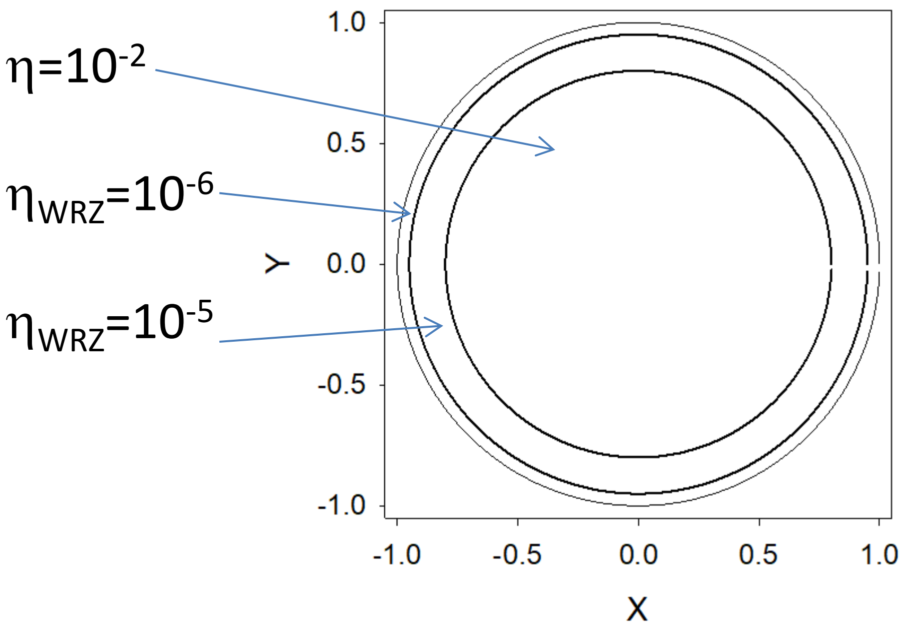
Circular cylinder

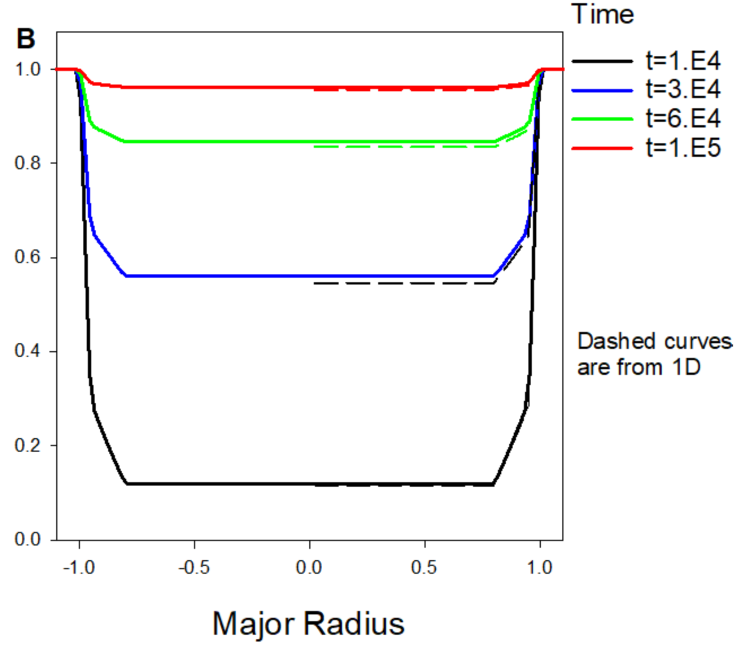


$$\dot{B} = \frac{1}{r}\frac{\partial}{\partial r}\eta r\frac{\partial B}{\partial r} = 4\frac{\partial}{\partial y}\left[\eta y\frac{\partial B}{\partial y}\right] \qquad y = r^2$$

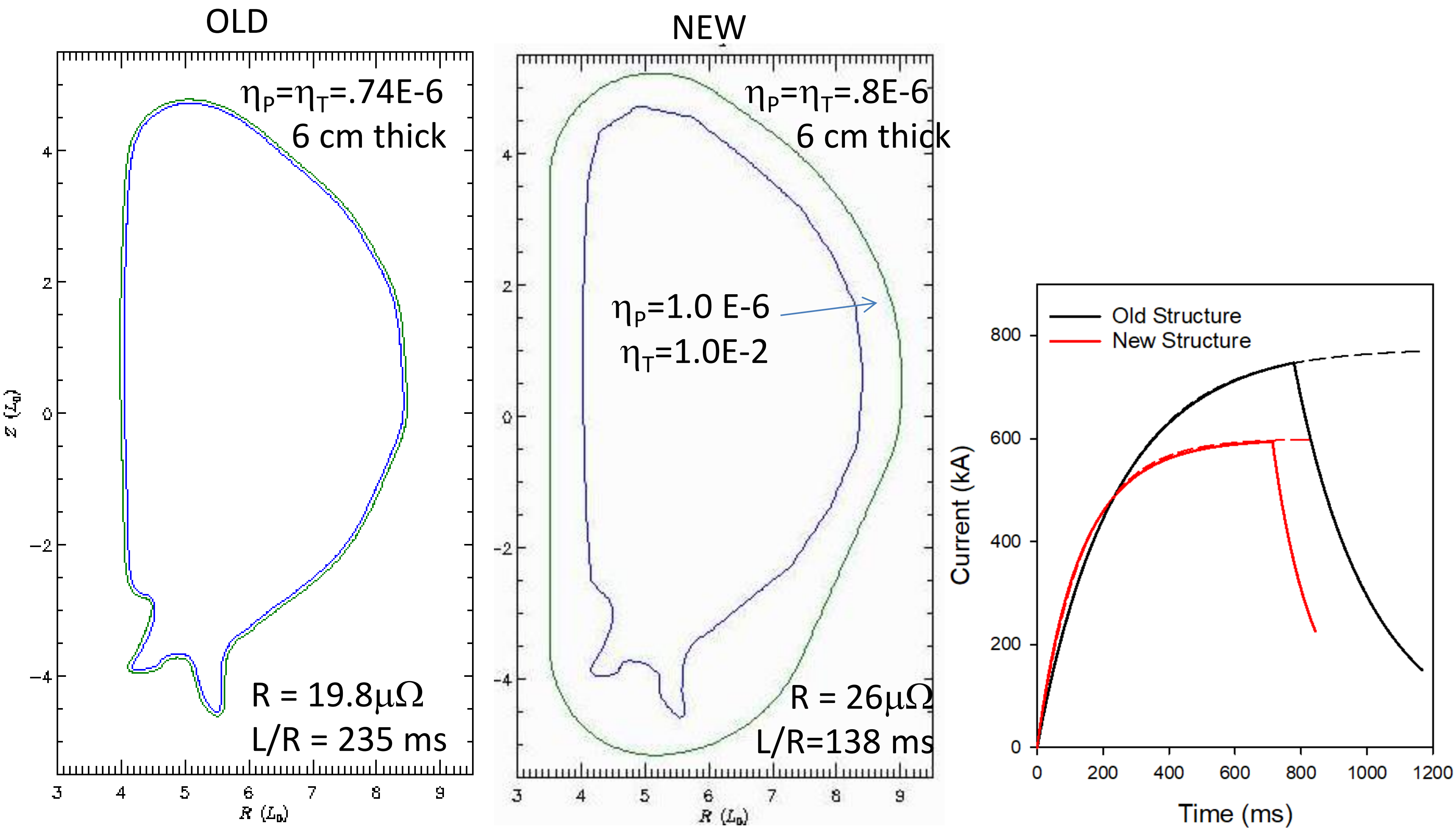
$$-B_{j+1/2}^{n+1} + 4\frac{dt}{dy^2}\begin{bmatrix}(\eta y)_{j+1}\left(B_{j+3/2}^{n+1} - B_{j+1/2}^{n+1}\right) \\ -(\eta y)_j\left(B_{j+1/2}^{n+1} - B_{j-1/2}^{n+1}\right)\end{bmatrix} + B_{j+1/2}^{n} = 0$$



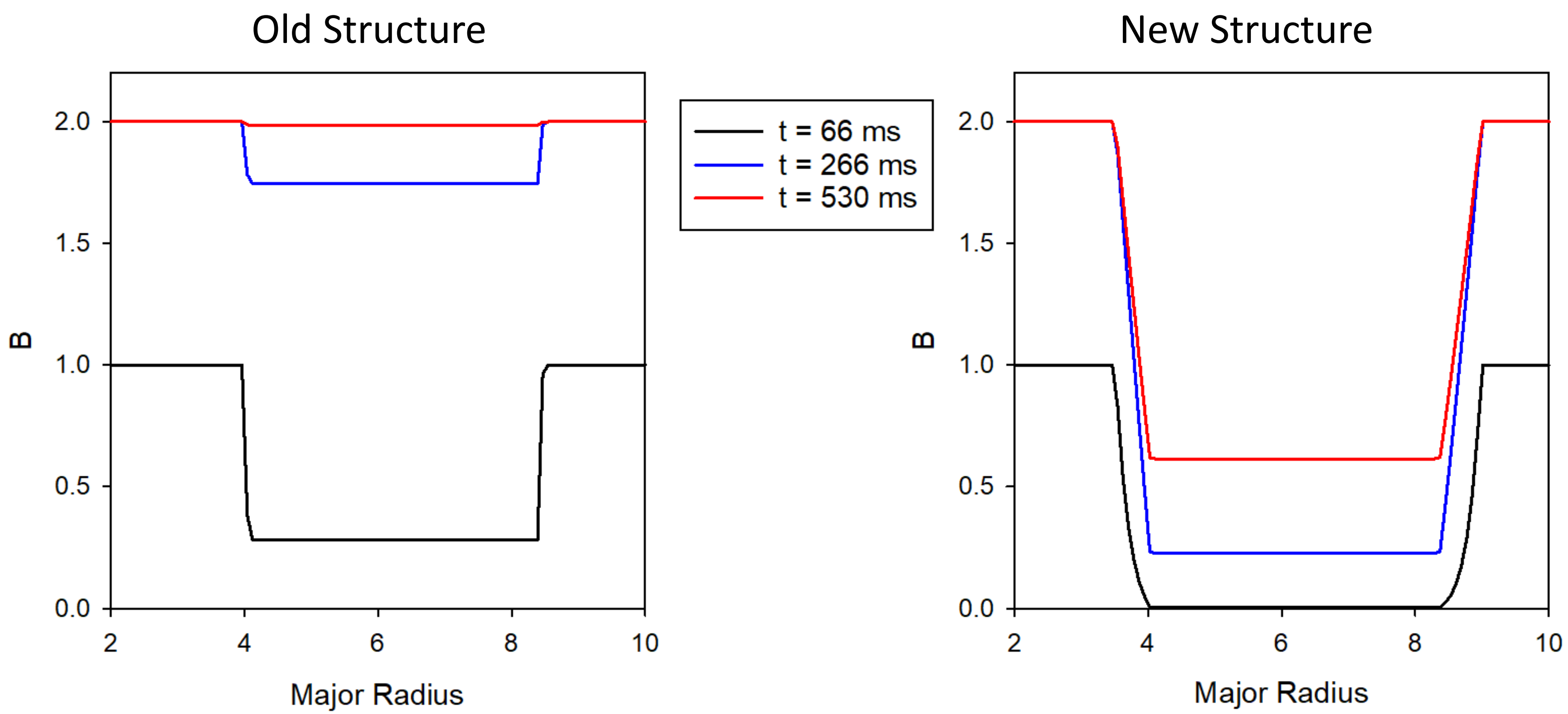




Comparison of Old and New Structures

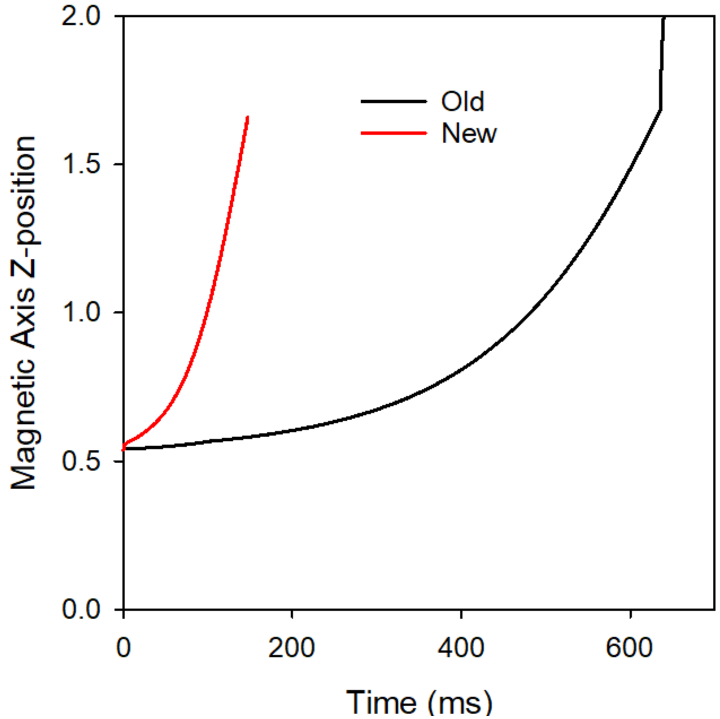


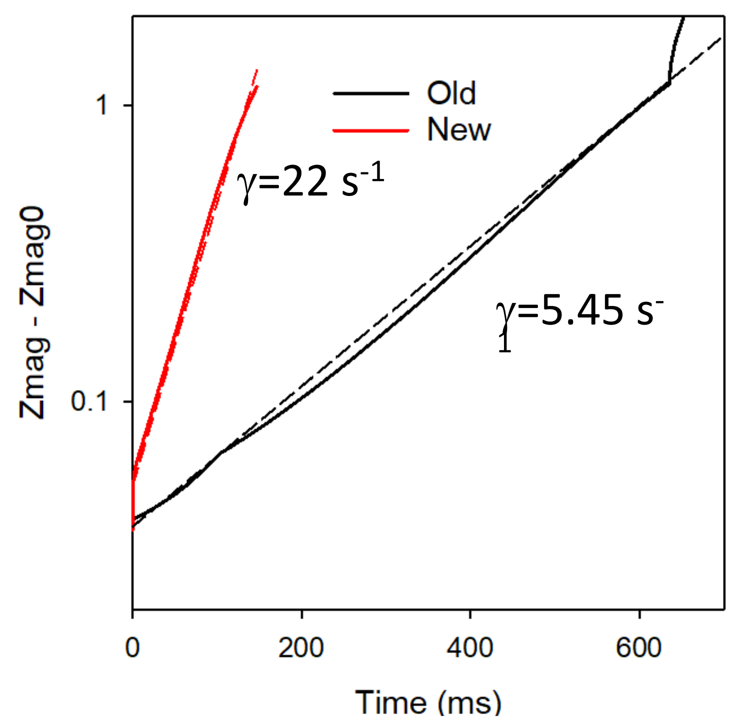
Comparison of Toroidal Field Diffusion



Vacuum toroidal field linearly ramped up from 0 to 2 in 133 ms.
Plotted is the mid-plane field at 3 times for the old and new structure

Z-motion of magnetic axis is much faster





Old: γ x L/R = 1.28

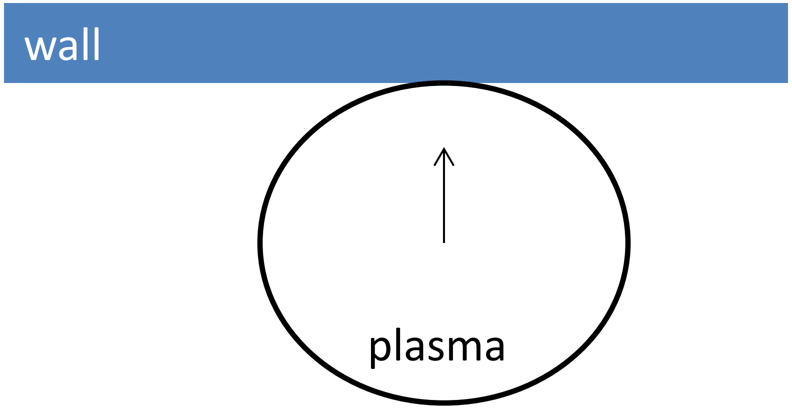
New: γ x L/R = 3.03

Ratio of VDE time to current quench time matters

$$q(a) \cong 2\pi \frac{B_T a^2}{R\mu_0 I_p}$$

$$Z_p = Z_0 e^{\gamma_{VDE} t}$$

$$I_p = I_{p0} e^{-\gamma_{CD} t}$$



q(a) will decrease durring the current quench

only if $\gamma_{VDE} > \frac{1}{2}\gamma_{CD}$

if q(a) doesn't increase during the current quench,

there will be very little MHD activity and sideways force

MHD Stability with Runaway Electrons

Simulation of MHD instabilities with fluid runaway electron model in M3D-C^1

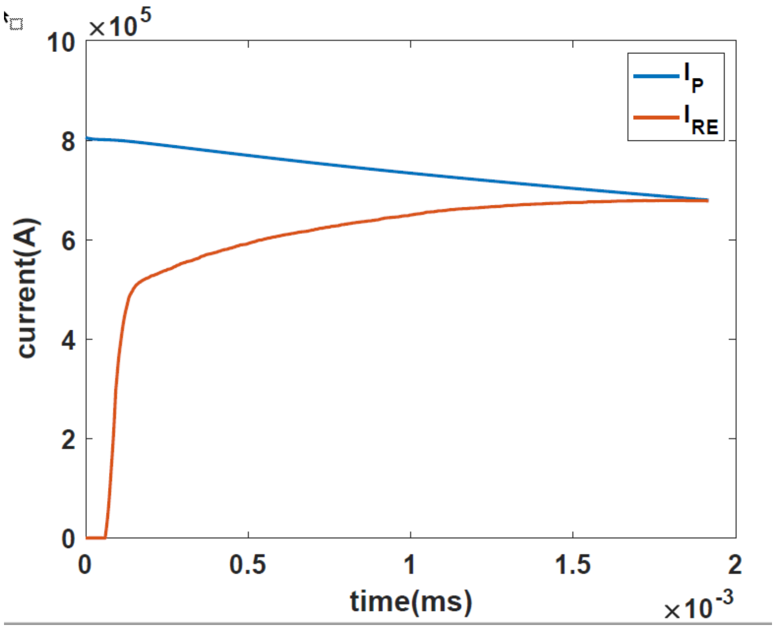
C Zhao[1], C Liu[1], S C Jardin[1], N M Ferraro[11]
Princeton Plasma Physics Laboratory, P.O. Box 451, Princeton, New Jersey 08543-0451, US

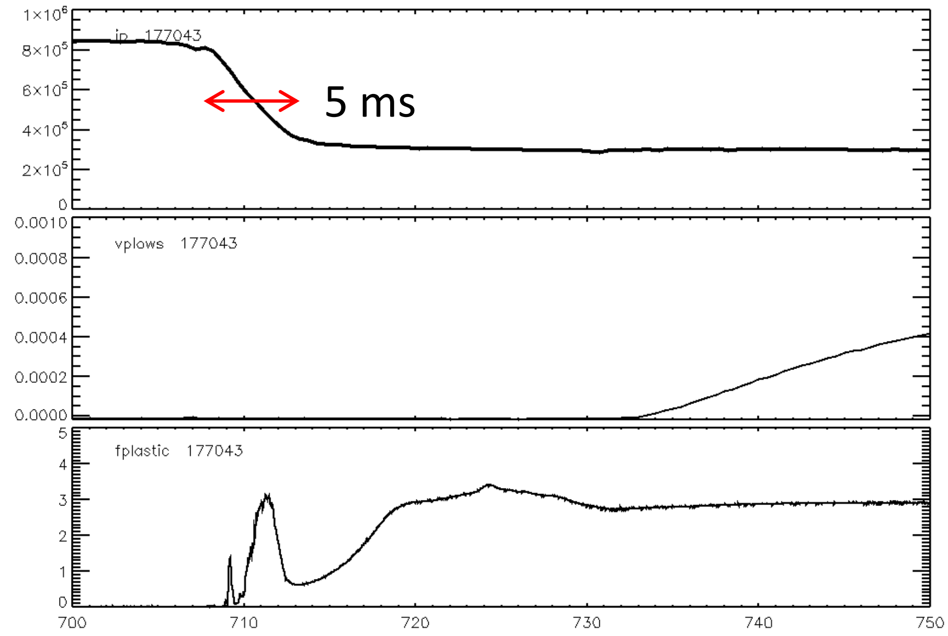
(Dated: 9 May 2020)

Runaway electrons may be generated in a tokamak during the start up, during normal operation and during a plasma disruption. During a disruption, runaway electrons can be accelerated to high energies, potentially damaging the first wall. To predict the consequences of runaway generation during a disruption, it is necessary to consider resonant interactions of runaways with the bulk plasma. Here we consider the interactions of runaways on low mode number tearing modes. We have developed a fluid runaway electron model for the 3D MHD code M3D-C^1[Jardin,et al. J Comput. Sci Discovery 6 014002 (2012)]. To benchmark, we have reproduced the MHD linear tearing mode results (with runaway electrons) in a circular cylinder presented in previous analytic studies[[Helander, P., et al, Phys. Plasmas 14 144102 (2007)] and have extended them here with a numerical eigenvalue calculation. We find that the low mode number tearing mode has a rotation caused by the MHD - runaways interaction, and the perturbed toroidal current scale length is much smaller with runaways than without and decreases as the runaway speed increases.

- Chen's NF submission received 2 very favorable reviews
- Made small revisions as suggested by reviewers and resubmitted

Fluid Runaway Electrons with Source





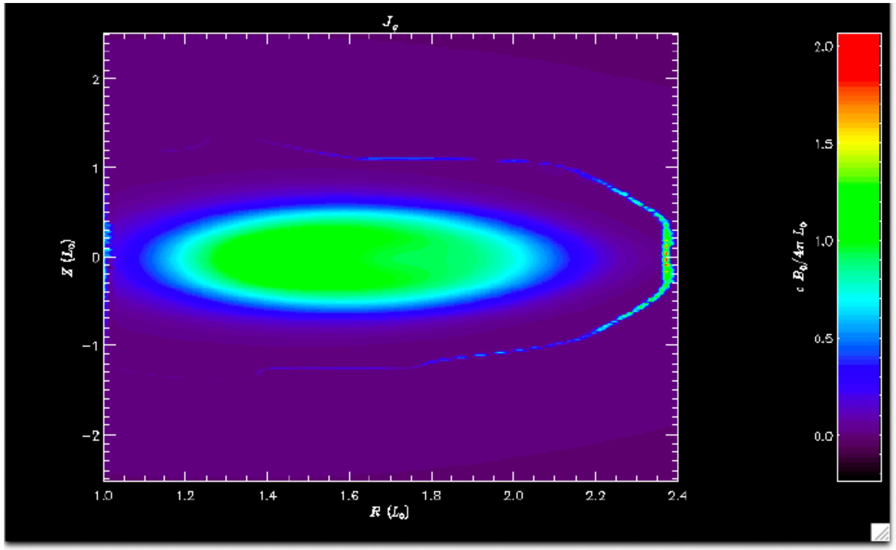
$$f\left(n_{RE}^{n+1}\right) = n_{RE}^{n+1} - n_{RE}^{n} - \delta t n_e \nu_{ee} \mathrm{E}^{-3\left(1+Z_{eff}\right)/16} \exp\left[-\frac{1}{4\mathrm{E}} - \sqrt{\frac{\left(1+Z_{eff}\right)}{\mathrm{E}}}\right] = 0$$

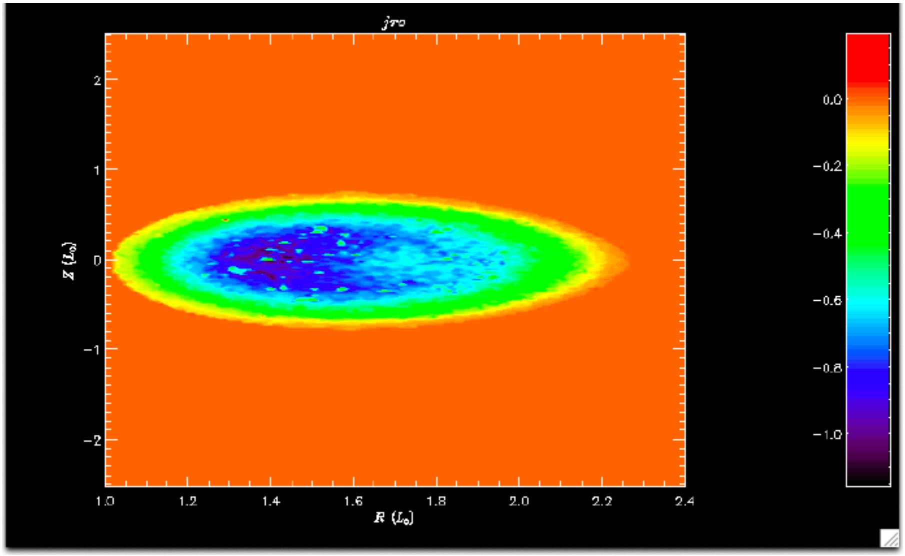
let n^l be the l^{th} approximation to n_{RE}^{n+1}

Newton's method corresponds to: $n^{l+1} = n^l - f \,/\, f'$

Chen Zhao

Jphi and JRE at final time





That’s All I have

Anything Else ?