M3D-C1 ZOOM Meeting

11/29/2021

CS Issues

1. Perlmutter status
2. Mesh adaptation update
3. NERSC Time
4. Changes to github master since last meeting
5. Regression tests
6. Progress on multi-grid in φ preconditioner
7. Software License discussion

Physics Studies

1. Status of SBL studies
2. Update on EAST studies

In attendance

Steve Jardin
Adelle Wright
Jin Chen
Andreas Kleiner
Brendan Lyons
Chen Zhao
Nate Ferraro
P Sinha
Seegyoung Seol
Usman Riaz
Morteza Siboni
Mark Shephard

Perlmutter status

From Jin Chen (10/25/21)

- PETSc, SCOREC Library, PUMI Library and M3DC! Have been compiled
- Code fails at runtime with segfault
  - Comes from scorec library when it tries to allocate memory for matrices
- Seegyoung now has access also

Mesh adaptation update

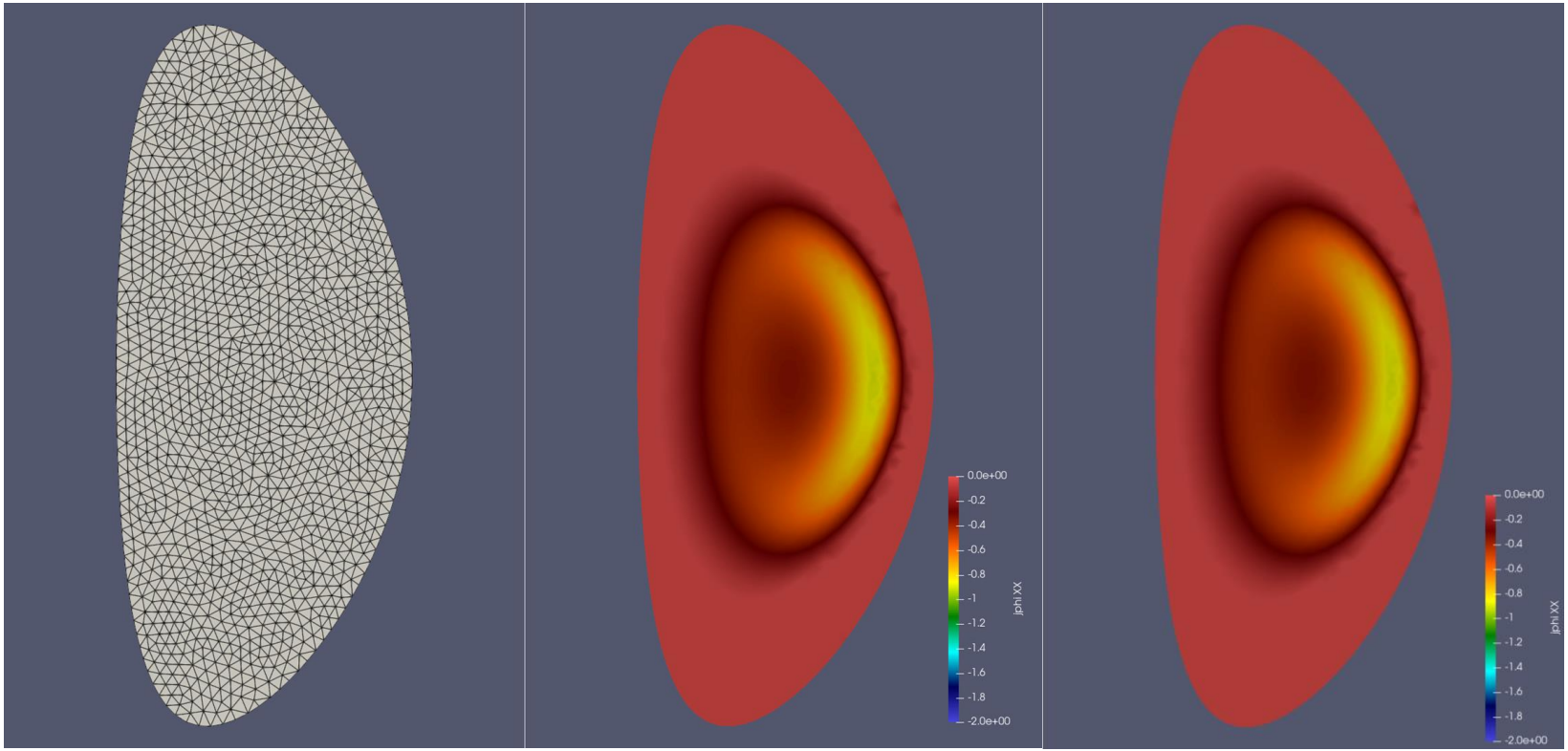
Morteza to share slides.

M3DC1 Adapt

spr-based adaptive solution of the pellet test case

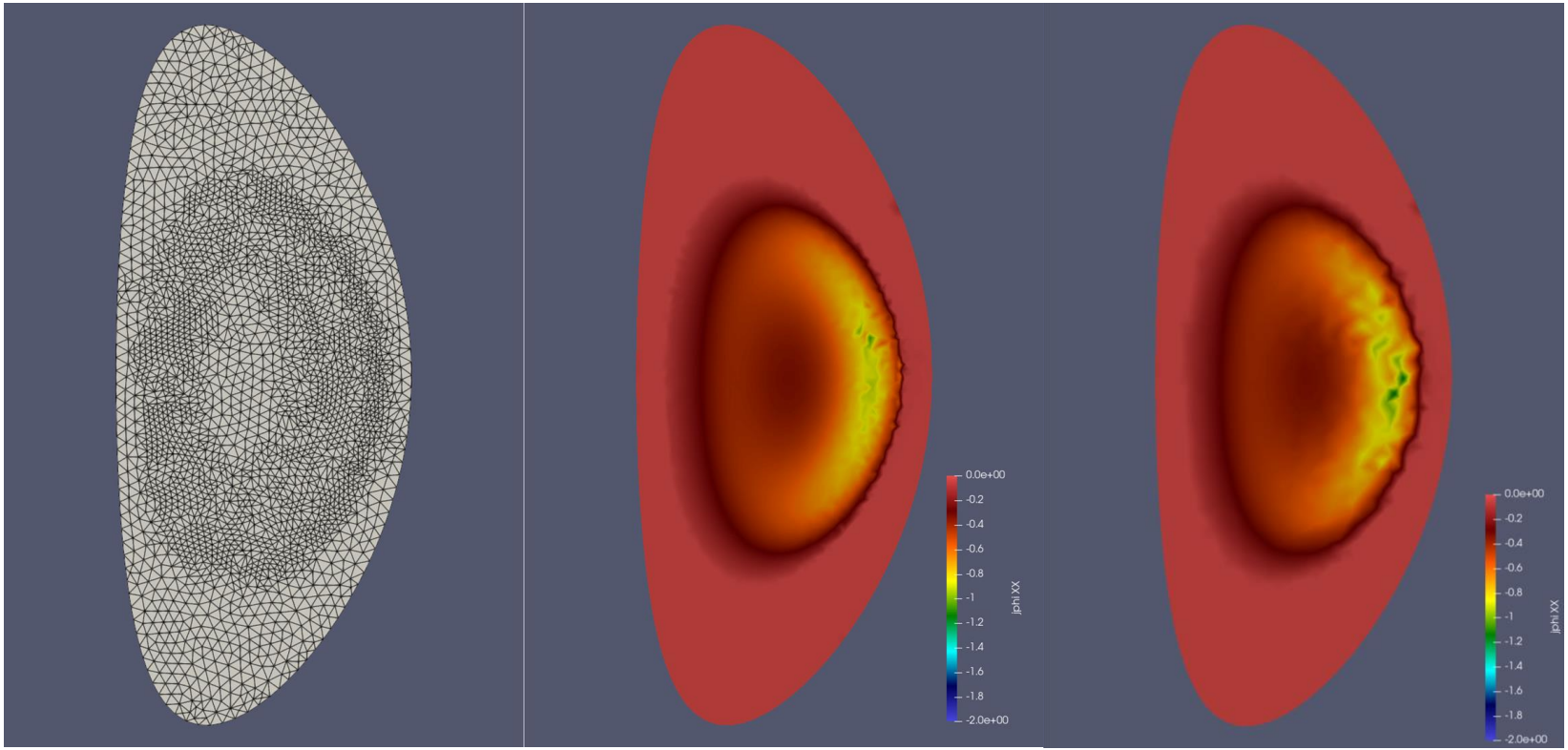
- field used for spr error estimation $\mathrm{grad}(\psi)$
- spr and adapt are called every 10 time steps
- case is run for 500+ time steps
- mesh/field (jphi) are shown at time steps 10, 110, 210, 310, 410, 510
- result are shown for solve on the initial mesh and adaptive solve runs

Meshes/Solutions at ntime=10



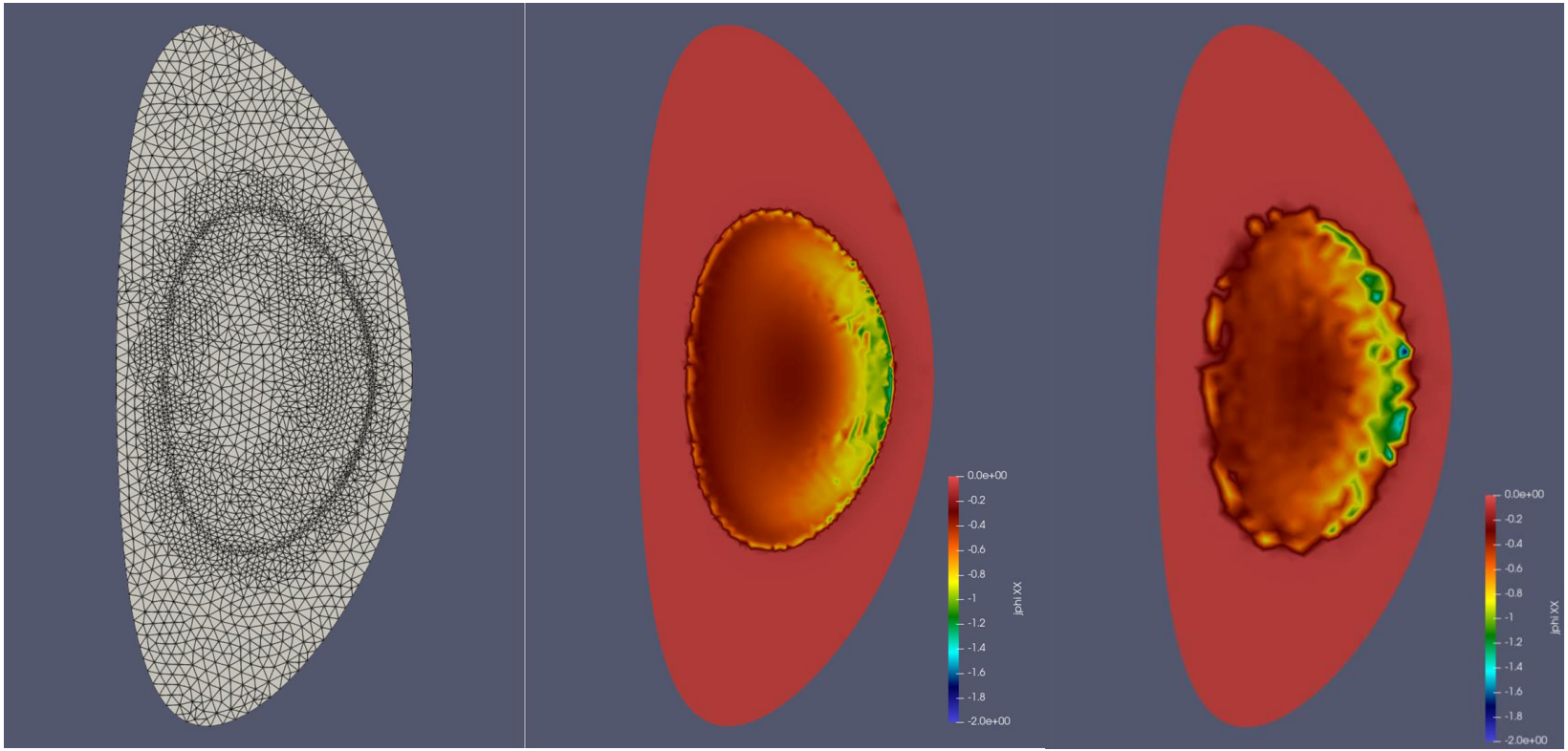
mesh adaptive-solve solve-only

Meshes/Solutions at ntime=110



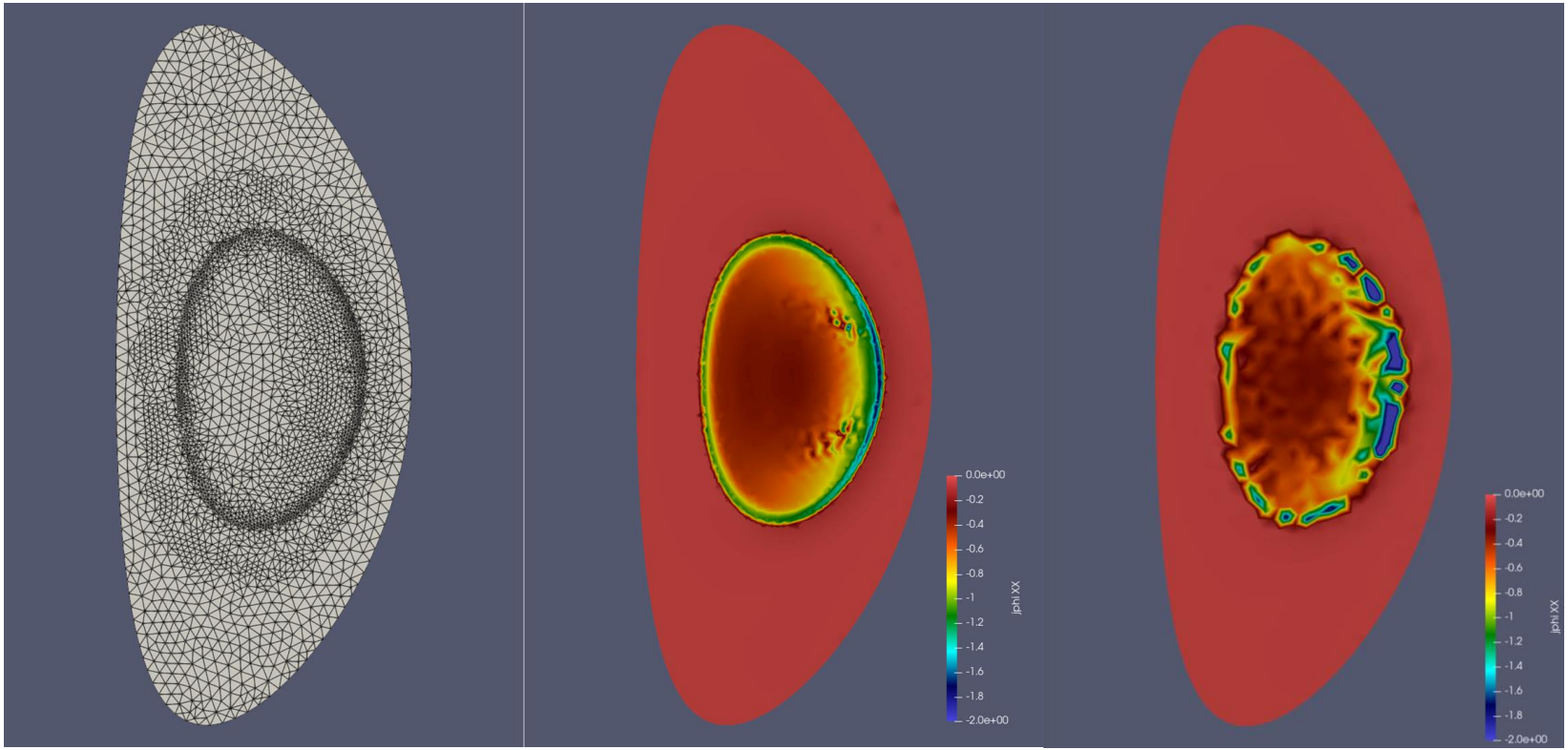
mesh adaptive-solve solve-only

Meshes/Solutions at ntime=210



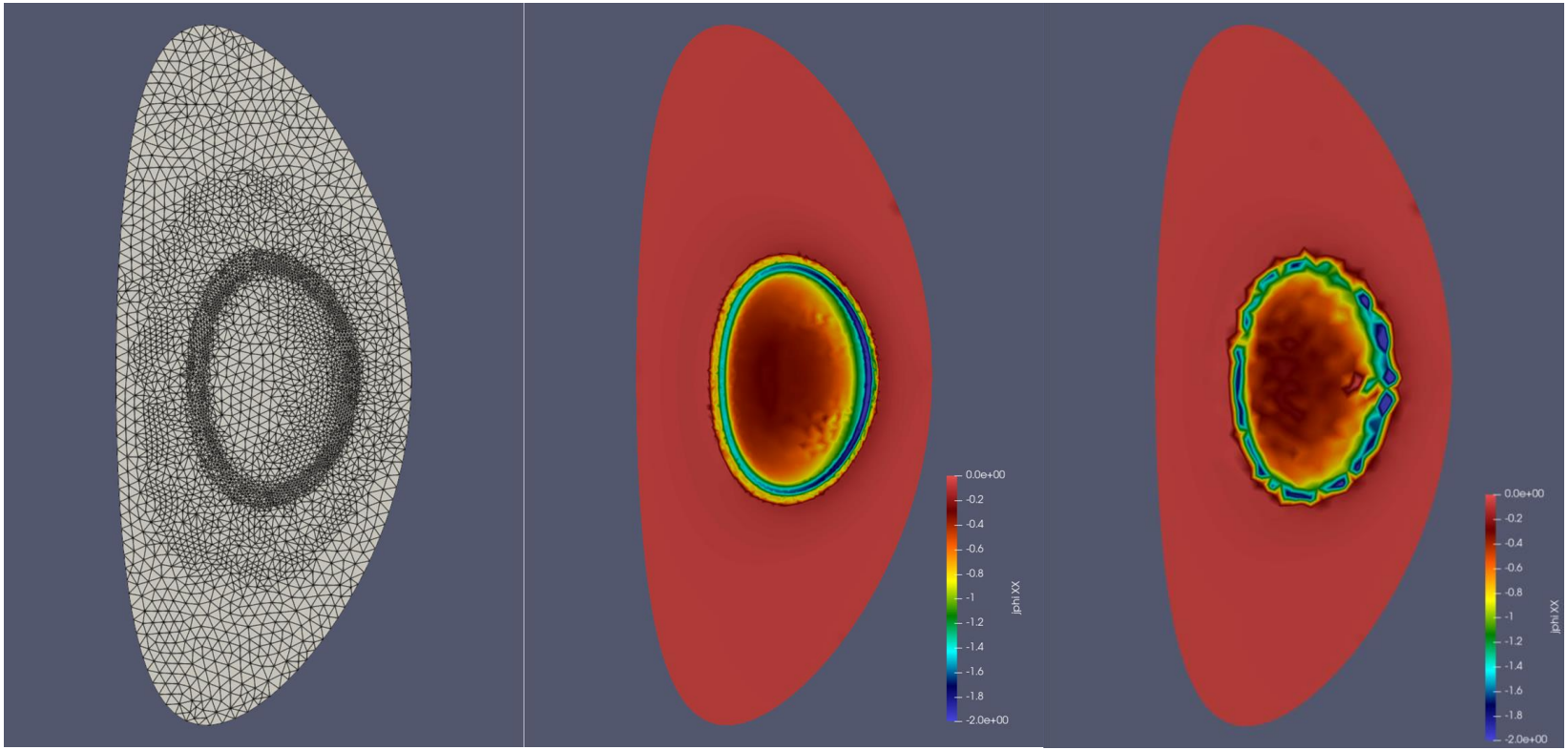
mesh adaptive-solve solve-only

Meshes/Solutions at ntime=310



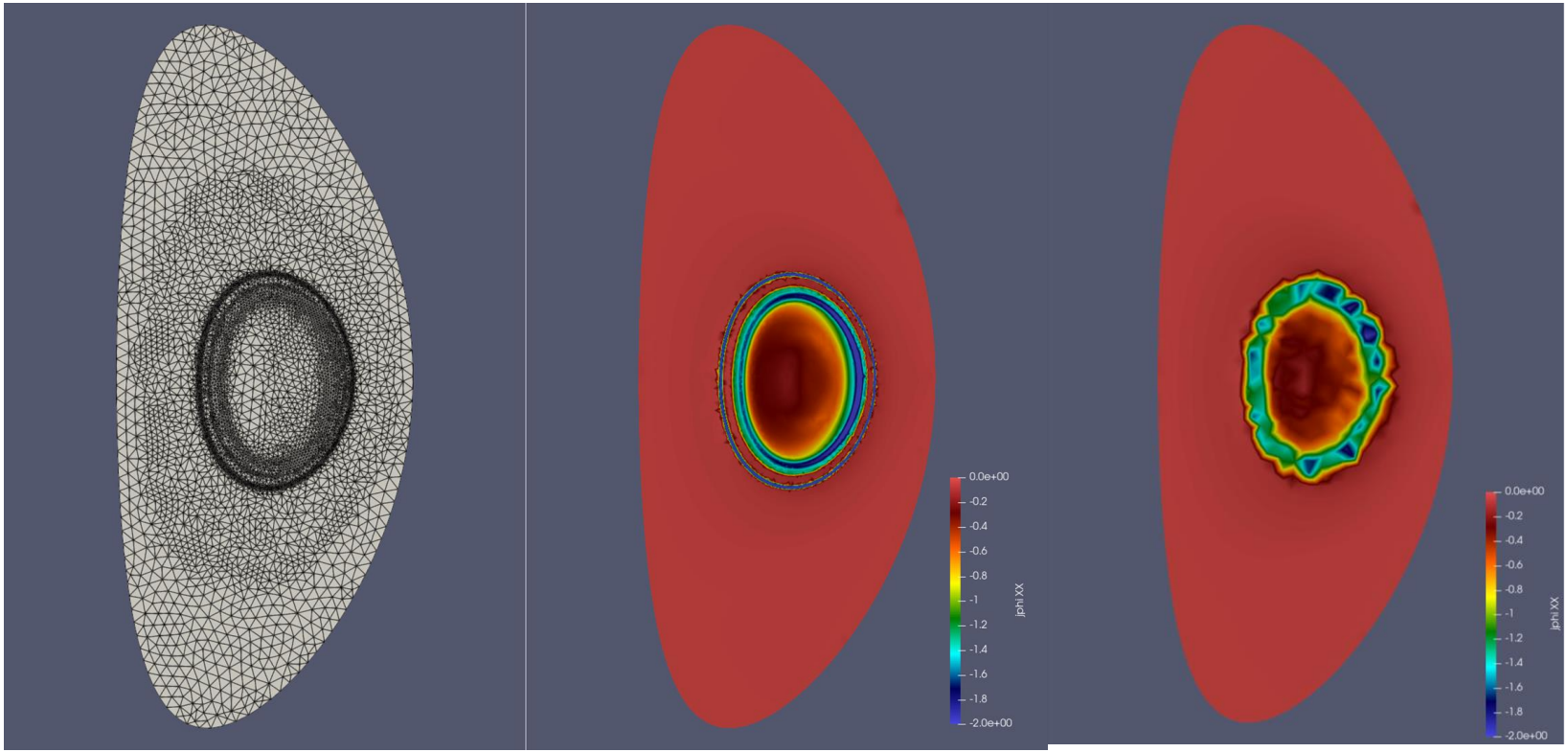
mesh adaptive-solve solve-only

Meshes/Solutions at ntime=410



mesh adaptive-solve solve-only

Meshes/Solutions at ntime=510



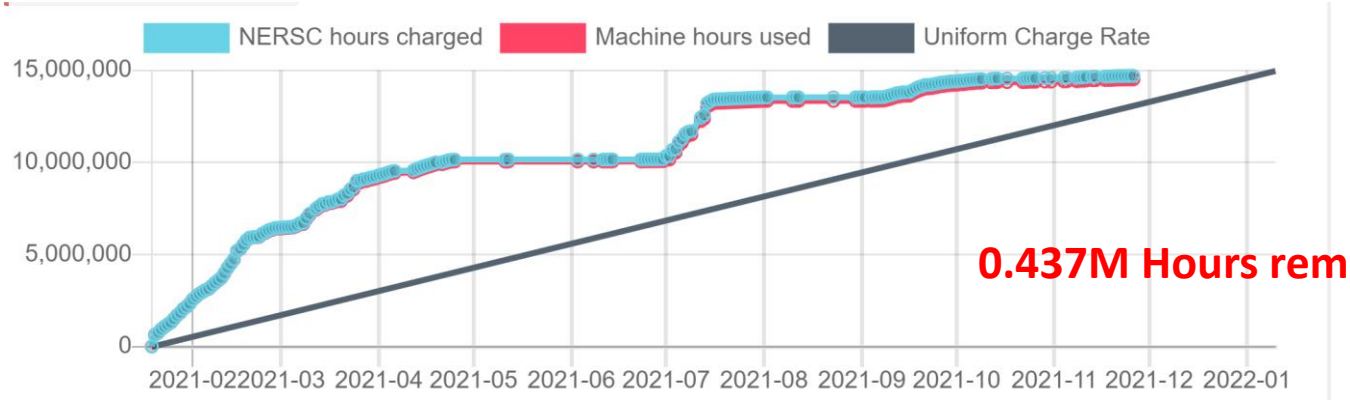
mesh adaptive-solve solve-only

Some Notes

- Visualizations are done in Paraview using only the field values at the vertex nodes (i.e., linear interpolation within each triangle)
- A solve-only run diverges at time step ~900.
- An adaptive-solve run (with coarsening off) diverges at a much later time step ~1200.
- An adaptive-solve run (with coarsening on) diverges at time step ~550. This is most likely the result of the solution transfer not preserving some critical quantities.

NERSC Time

mp288



0.437M Hours remaining!

- mp288 received 10M Hrs for CY 2021, + 5M Hrs additional
- Pearlmutter time will not be charged for this FY
- We are NESAP Tier 2. . Phase-I w GPUs We have been given a repo m3984
- N9ES-N2 M3D-C1: J. Chen , C. Liu, S. Seol are early users

Changes to github master since 11/01/21

SeegYoung Seol:
11/14/21: adding config.sh, makefile, and readme for stellar-intelmpi

Nate Ferraro
11/15/21: Updated plot_at_boundary.pro to do contour plots when multiple time slices are selected

Local Systems

- PPPL centos7(11/26/21)
  - 7 jobs PASSED
- PPPL greene (11/26/21)
  - 5 jobs PASSED
- STELLAR (11/26/21)
  - 6 regression tests **PASSED** on stellar
  - adapt **FAILED** field energies off by 0.02%
- TRAVERSE(11/26/21)
  - 6 regression tests **PASSED**
  - adapt **FAILED** should have passed. Energies are ok. Only gr_rate off

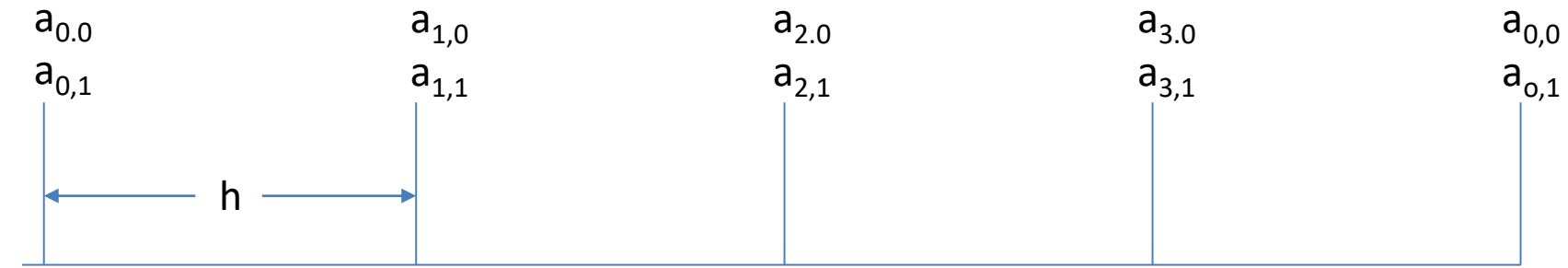
Other Systems

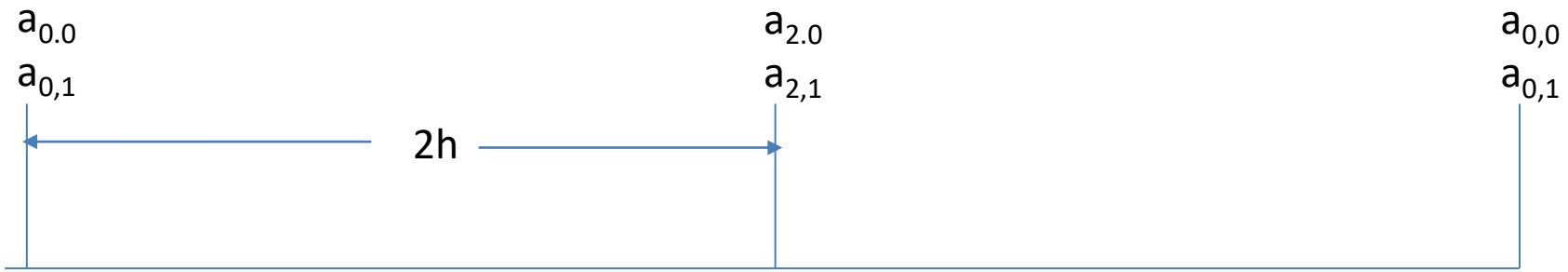
- Cori-KNL (11/27/2021)
  - 7 regression tests **PASSED** on KNL
- Cori-Haswell (11/27/2021)
  - 7 regression tests **PASSED** on cori
- MARCONI
  - All regression tests PASSED on MARCONI (J. Chen, 9/04/20)

Progress in multi-grid in φ preconditioner

Sam Williams (LBL) has shown some interest in developing a 1D (in φ) preconditioner for the M3D-C1 solves.

- He has asked if we could construct a matrix for the coarsened grid from the matrix we have for the finer grid?





Do we want M3D-C1 to be an “open source” code?

- Open source: eg, MIT license agreement (next slide)
  - Just protects us against liability lawsuits

- Alternative license agreement (after next slide)
  - We retain ownership of the code

MIT Open-Source Software License

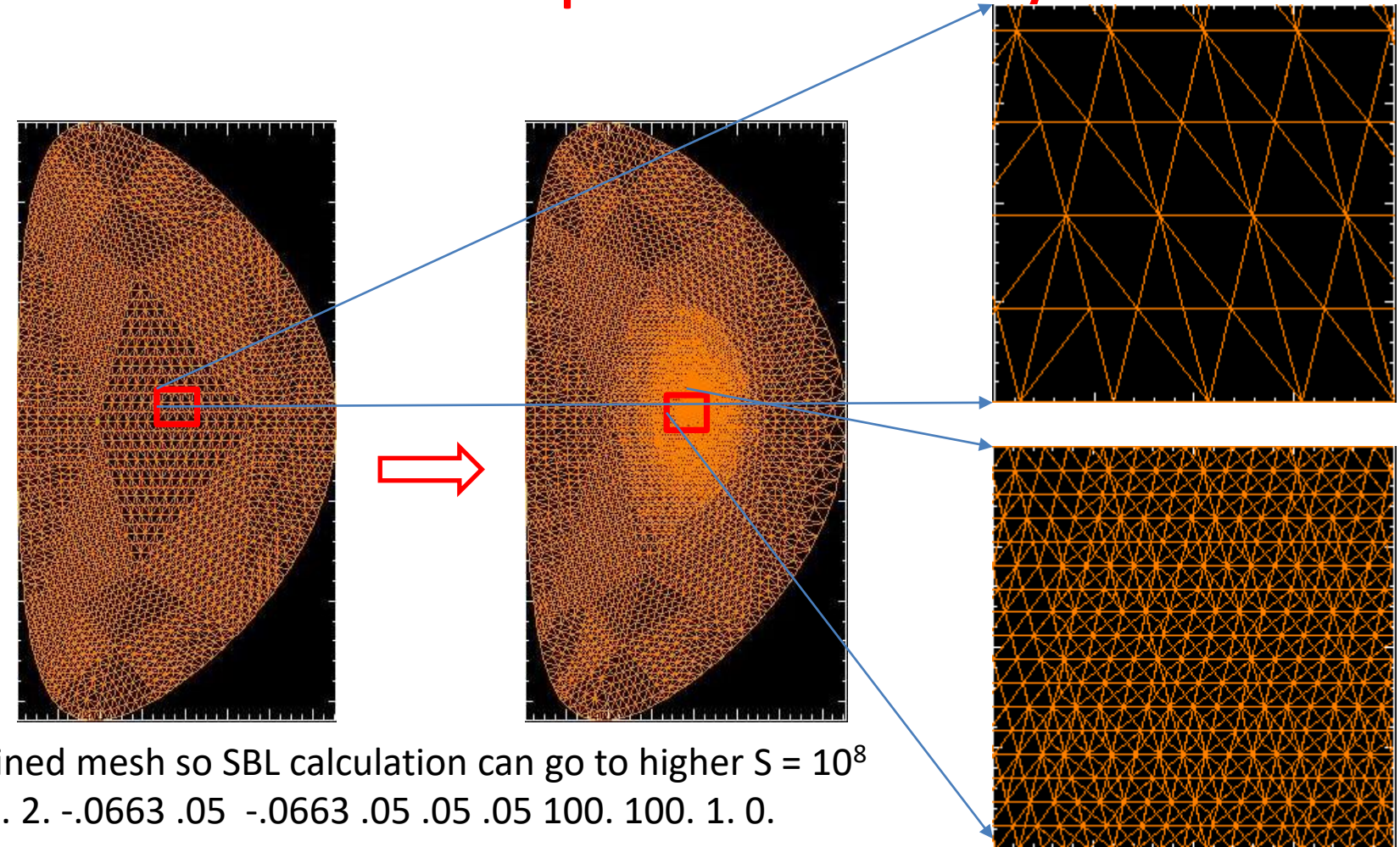
Possible other License agreement

1. User agrees (1) not to change the name of the code and (2) to cite one or more of the original references in all publications for which the code is used to generate data.

2. Any changes that the user makes in the code must be done in collaboration with one of the original code authors and must be made available to the entire user community.

3. The user will not distribute the code to a third party.

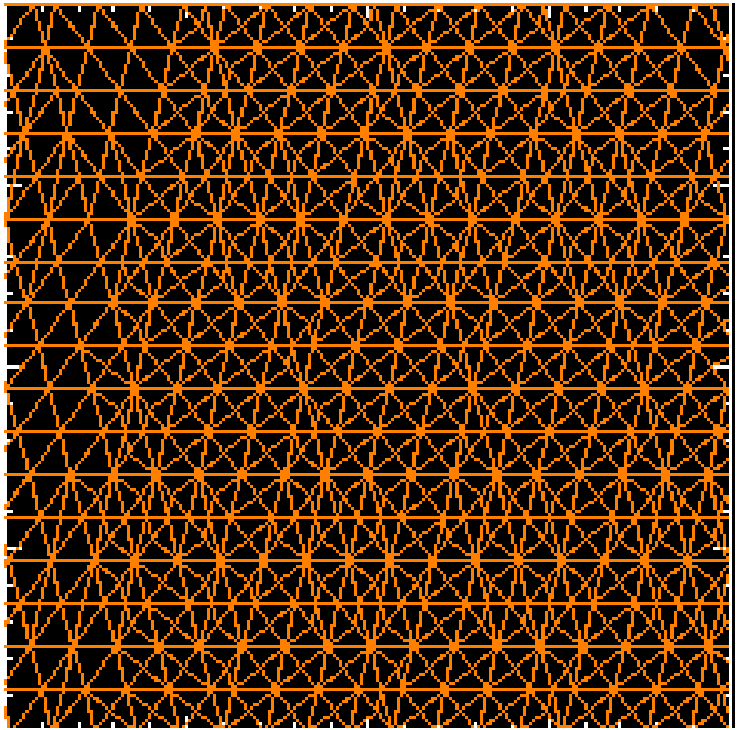
Mesh Adaptation for SBL study

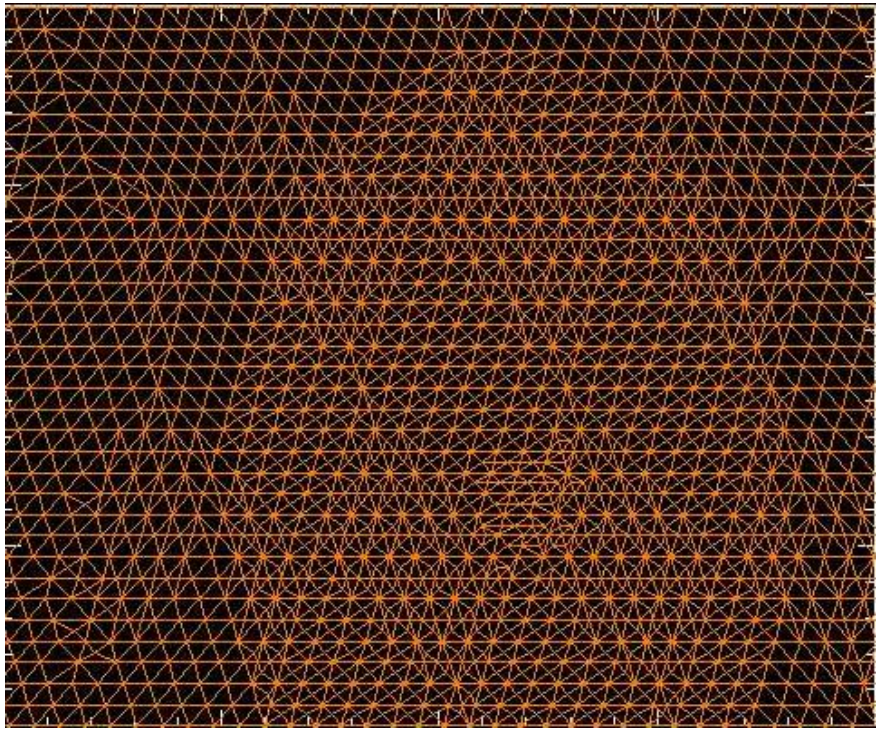


Refined mesh so SBL calculation can go to higher S = 10^8

1. 2. 2. -.0663 .05 -.0663 .05 .05 .05 100. 100. 1. 0.

Central mesh density doubled again for convergence check

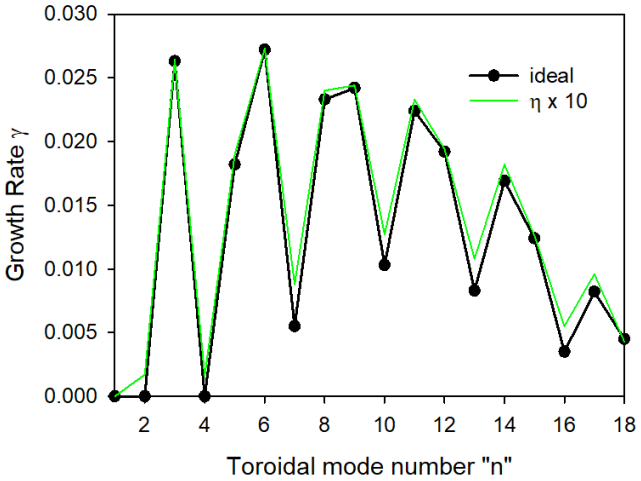


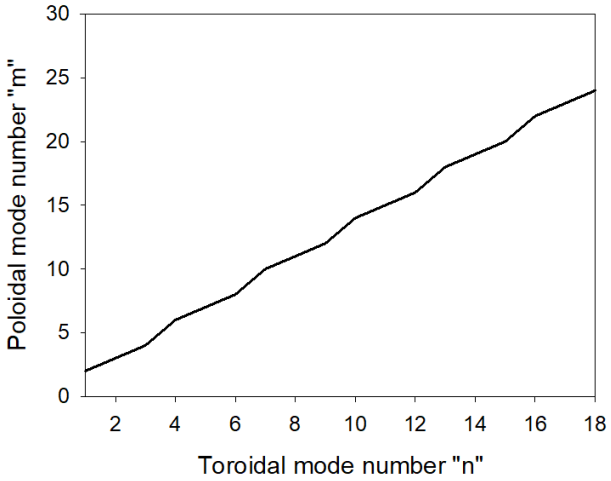


1. 2. 2. -0.07277 .05 -0.07277 .05 .05 .05 100. 100. 1. 0.

Initial time linear stability results

NSTX Shot #124379 @ 640ms

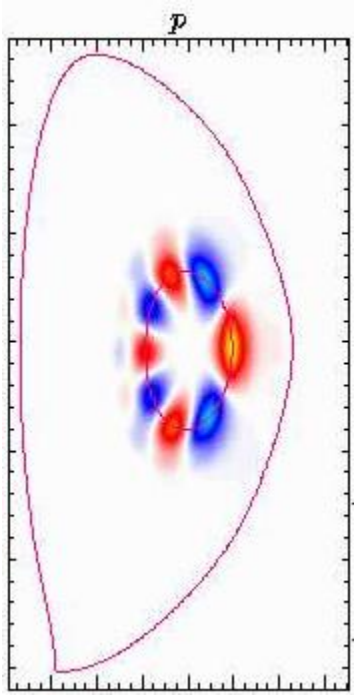




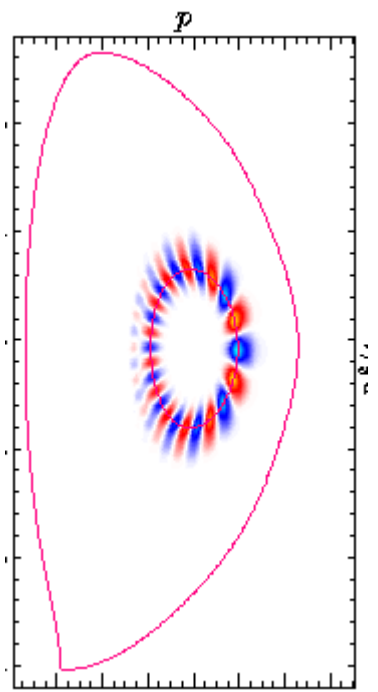
- Initial EFIT equilibrium unstable to many modes
- Dominant poloidal mode number m = (4/3) n

Typical linear mode structure

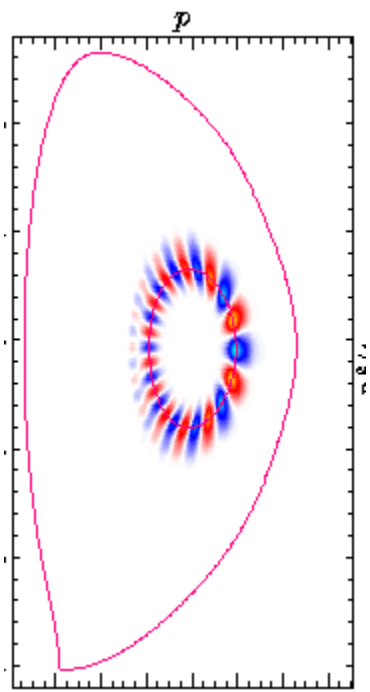
q_con = 1.4 shown



n = 3

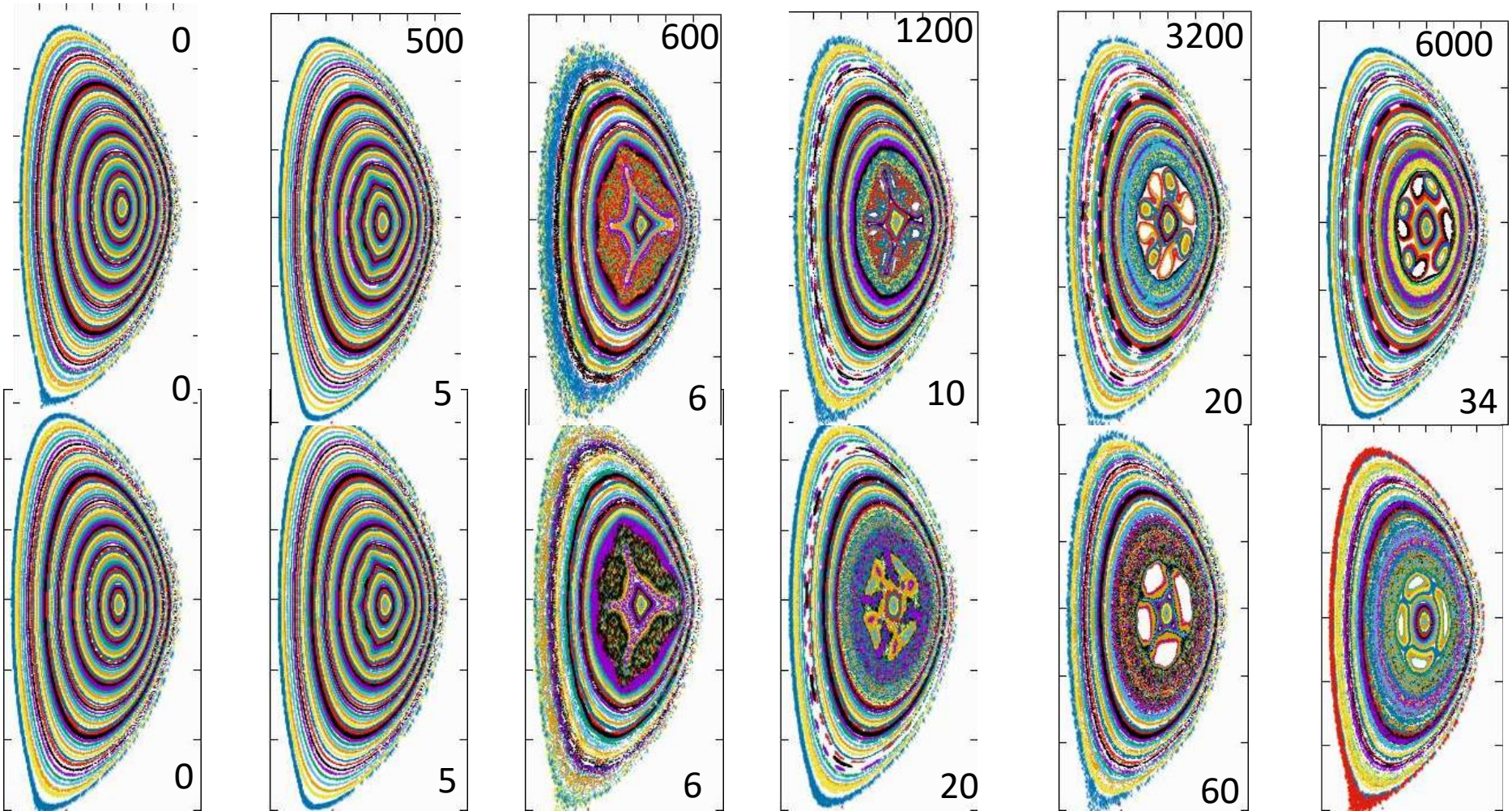


n = 9

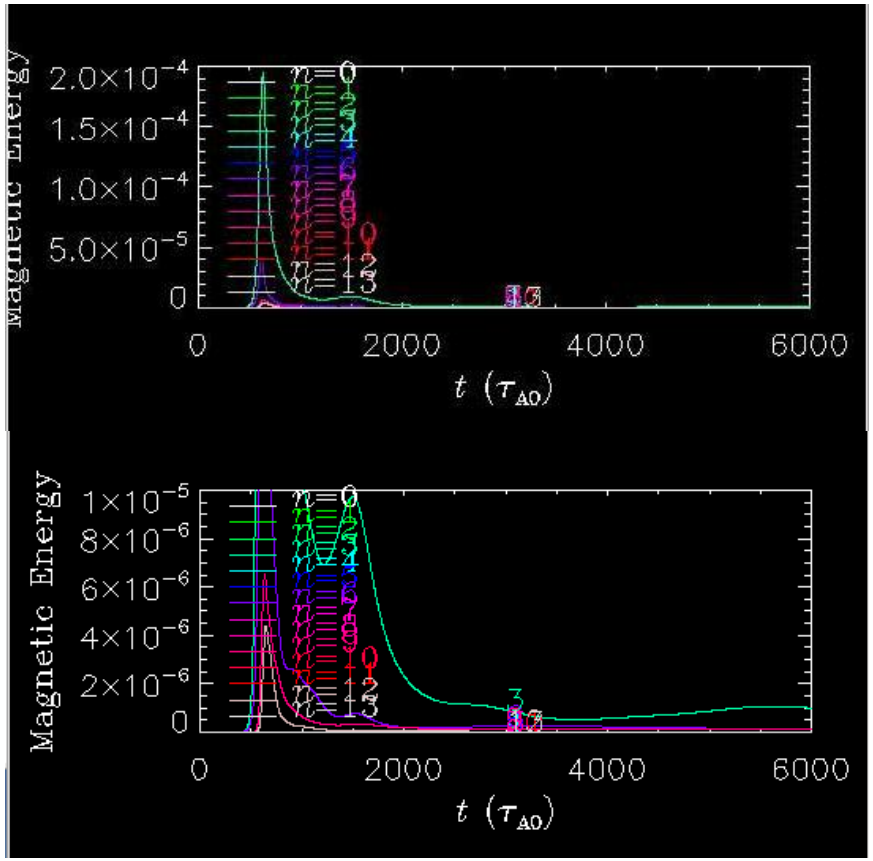


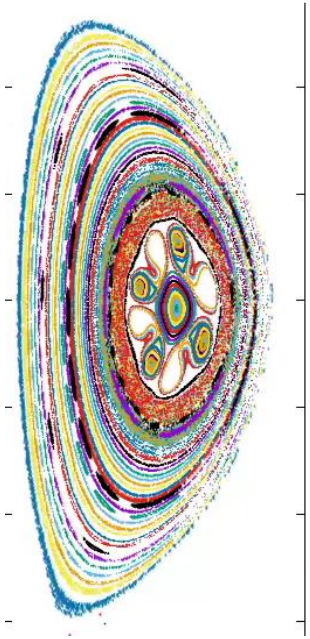
n = 15

Comparison of Poincare Plots (fine grid on bottom)



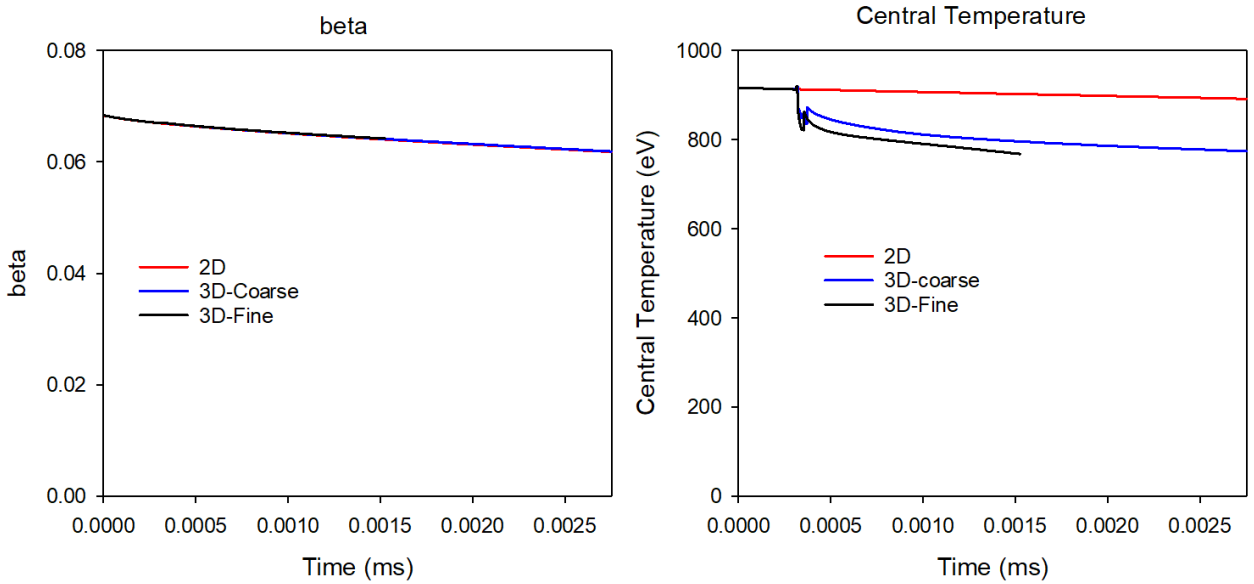
Will initially unstable equilibrium return to axisymmetry?





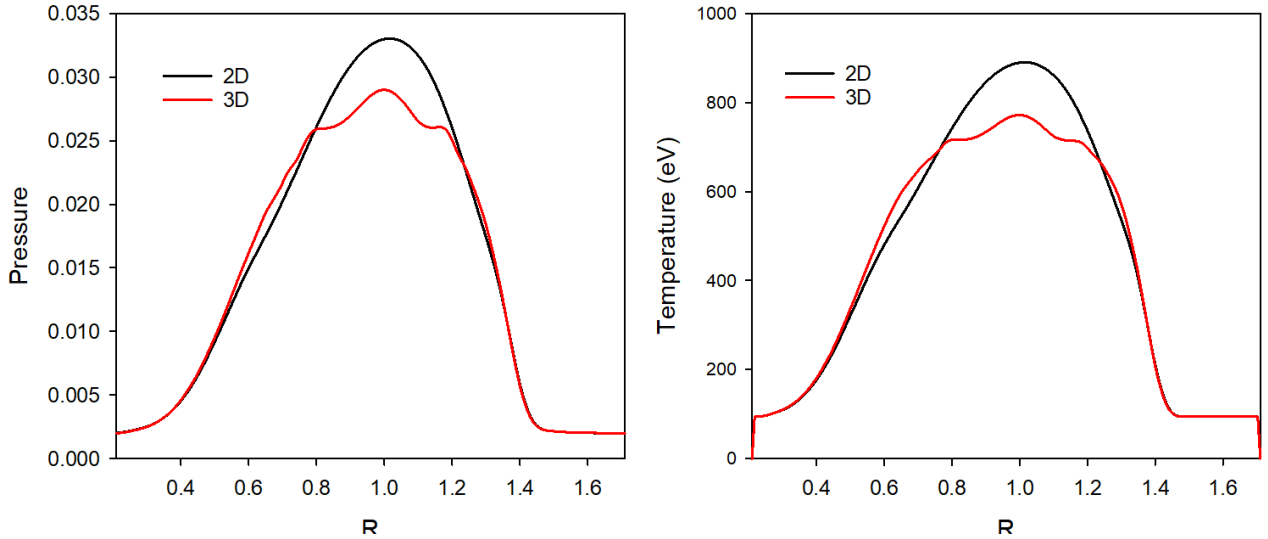
From magnetic energy and Poincare plot, looks to be a long time (4,3) island

Time history of β and Te in 2D and 3D



Global β almost the same in 2D and 3D, but central Te lower in 3D. This could have significant implications for stability and transport calculations

Comparison of p and Te, 2D vs 3D



As a result of MHD instability, the 3D run produced extra transport in the center. Volume averaged β's are the same, but Te(0) lower in 3D

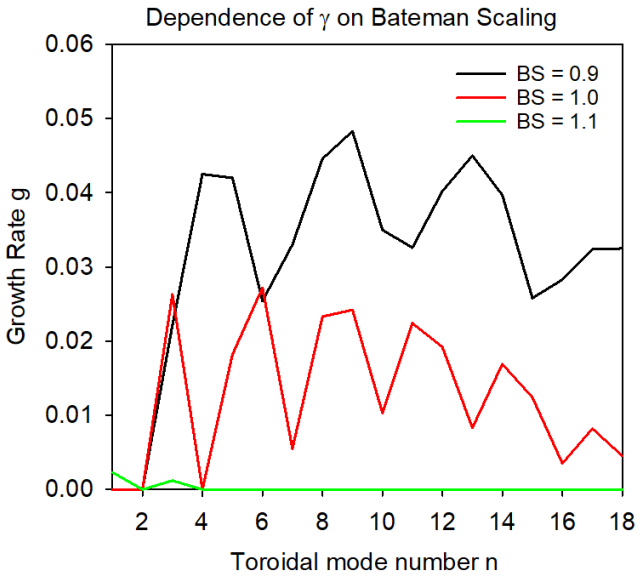
Bateman scaling study

To generate a family of equilibrium with similar q-profiles but different q(0) values, we apply the bateman scaling.

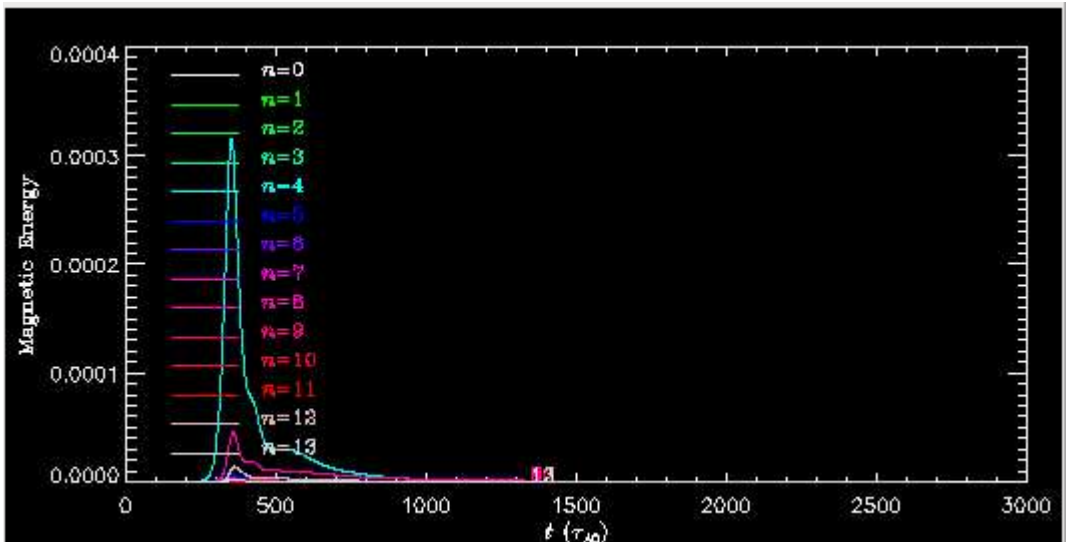
$\Rightarrow$ Keeps p' and FF' fixed (same current profile) but changes the value of F (varies the toroidal field). Note that β will also change.

$\Rightarrow$ batemanscale	q(0)	β
1.0	1.3	6.8%
0.9	1.2	8.2%
1.1	1.4	5.8%

Linear Stability Results



Now running the BS=0.9 case. Looks like it will also saturate and find a new stable 3D equilibrium!

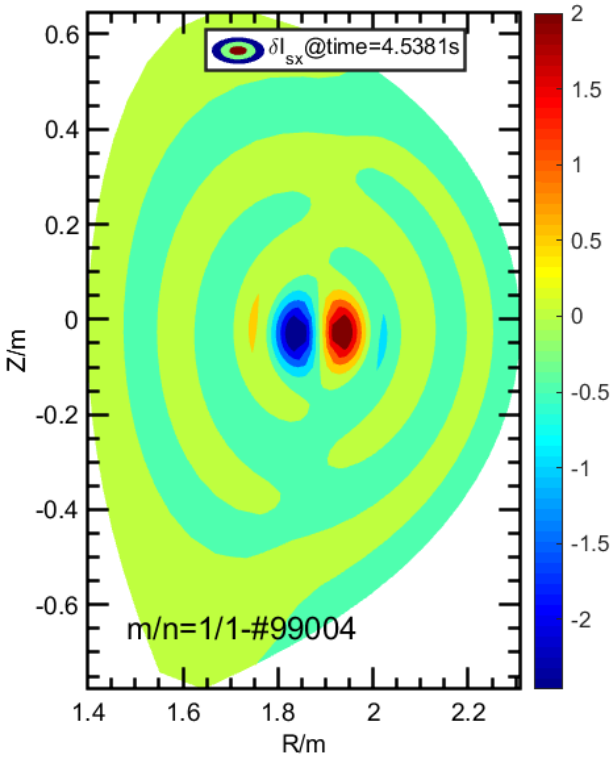


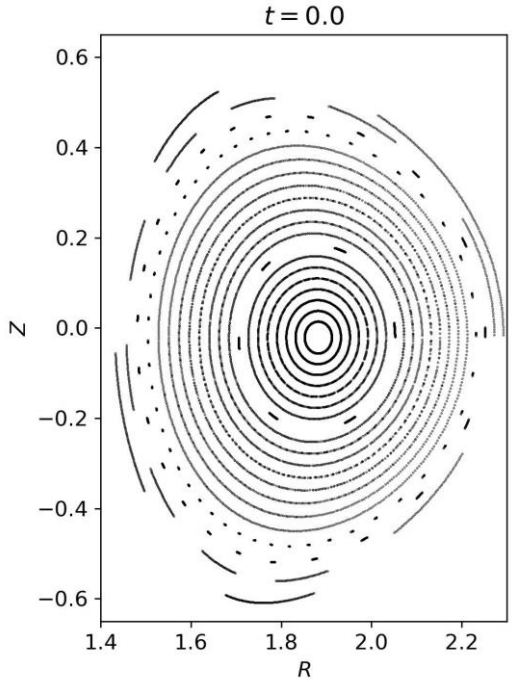
EAST Update

From Yao: 11/25/21

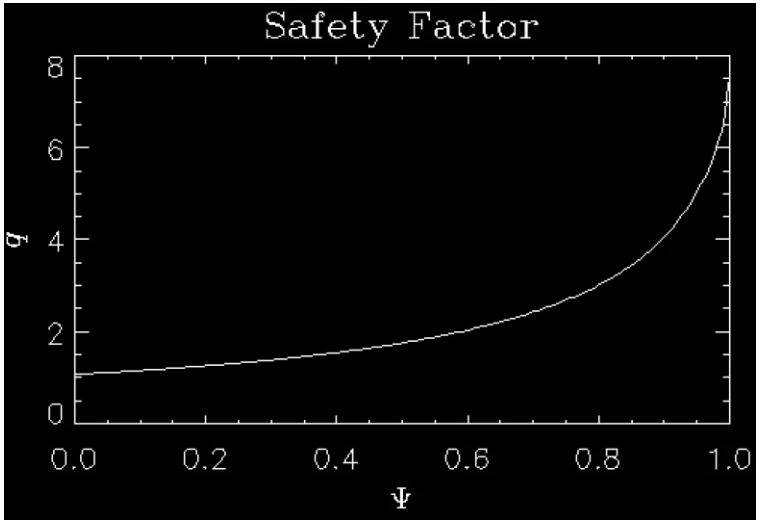
I ran some 3D nonlinear simulations using the EAST equilibria from Liqing and the results are not that surprising. When q0 is below one we get resistive kinks like in the video attached. This case corresponds to positive loop voltage(/scratch/gpfs/yaozhou/east/data_2/positive) and we see a complete crash with rotating cores. In contrast, when q0 is above one as in the negative loop voltage case (/scratch/gpfs/yaozhou/east/data_2/negative) we do not get an instability.(These simulations have no source and ~T^(-3/2) resistivity.) I am wondering whether by slightly adjusting the latter case we could set up a weakly driven resistive kink that saturates without a complete crash. What do you think?

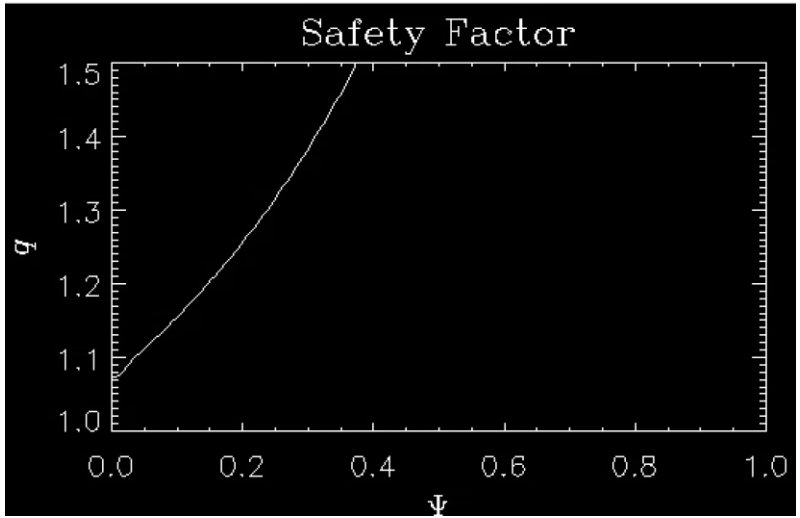
EAST: Positive VL case





Negative loop voltage case …. No instability





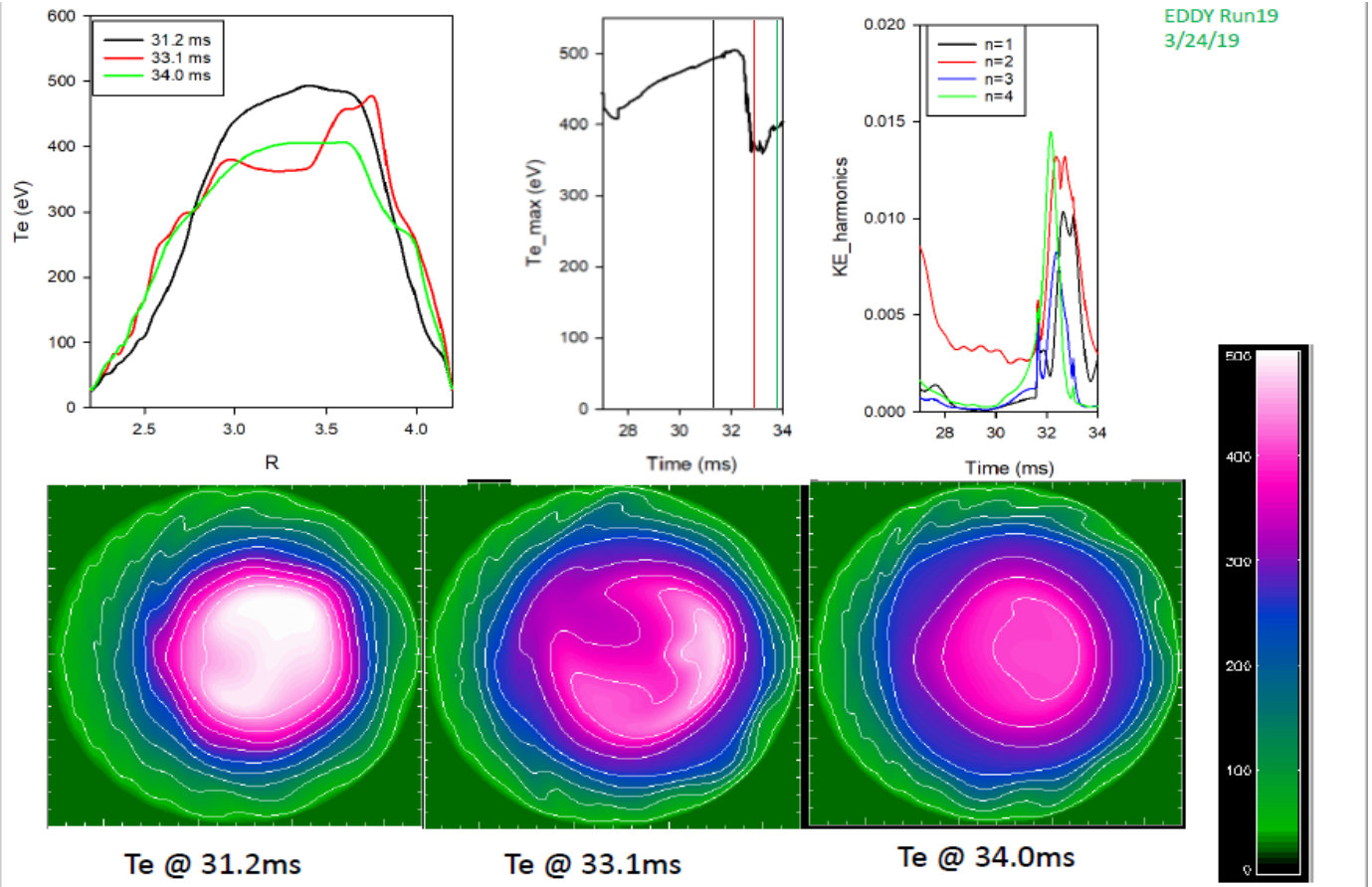
I wrote back asking if the data could be fit by a q-profile that had less shear in the center. Then it would likely be unstable to a (1,1) interchange with other (n,n) components with n>1

Follow-on email

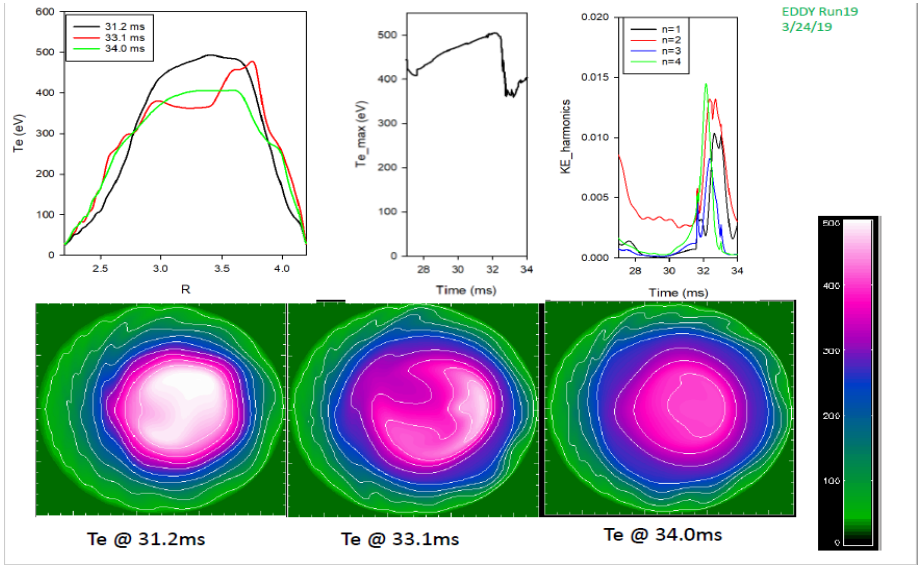
11/29/21 from Yao:

Thanks for the response. What you said may be possible, but it is unclear to me how an interchange mode could lead to coexisting hot and cold cores like Liqing's soft X-ray data shows. Do you have an example simulation with (1,1) interchange so that I could look at how the core temperature evolves in this scenario? Thanks!

Clearly shows fast crash due to higher-n modes



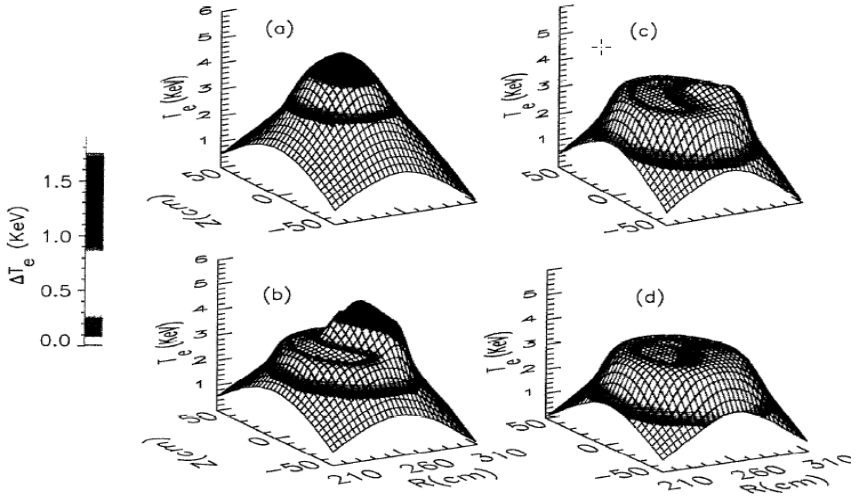
Note similarities with published TFTR crash data



Investigation of magnetic reconnection during a sawtooth crash in a high-temperature tokamak plasma

M. Yamada, F. M. Levinton,[a] N. Pomphrey, R. Budny, J. Manickam, and Y. Nagayama[b]
Princeton Plasma Physics Laboratory, Princeton University, Princeton, New Jersey 08543

(Received 2 March 1994; accepted 9 June 1994)

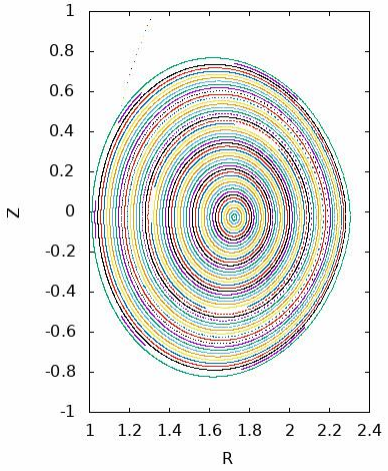


That’s All I have

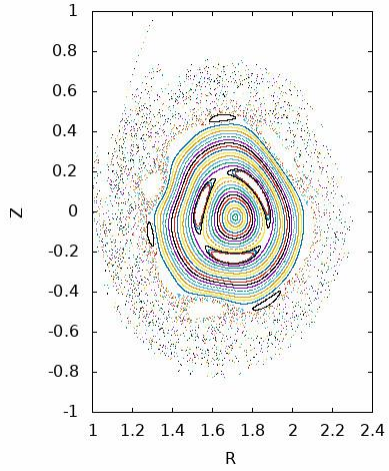
Anything Else ?

Poincare plot (0ms~4ms)

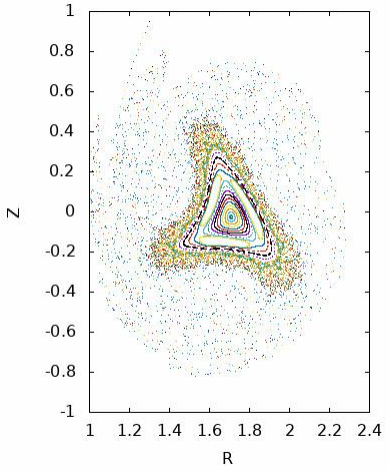
0ms



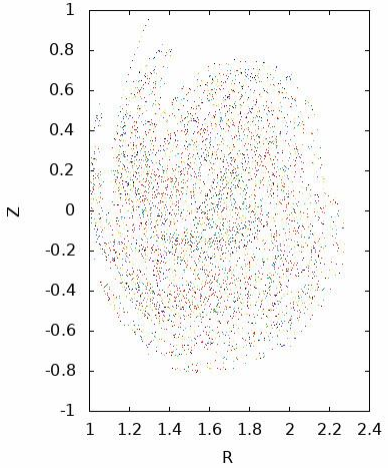
1ms



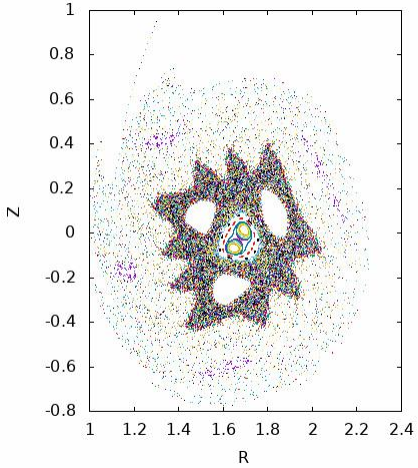
2ms



3ms

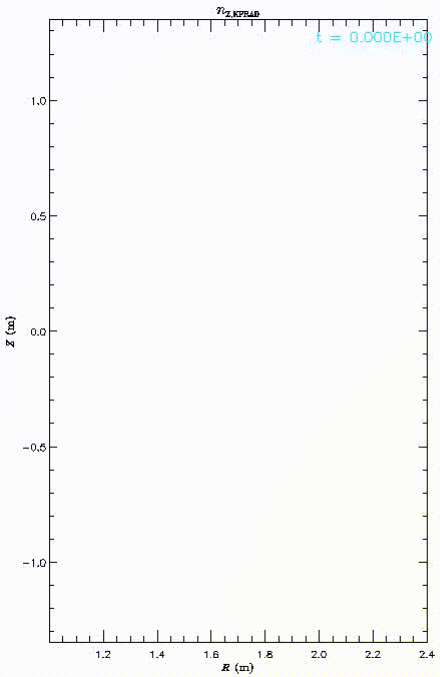


4ms

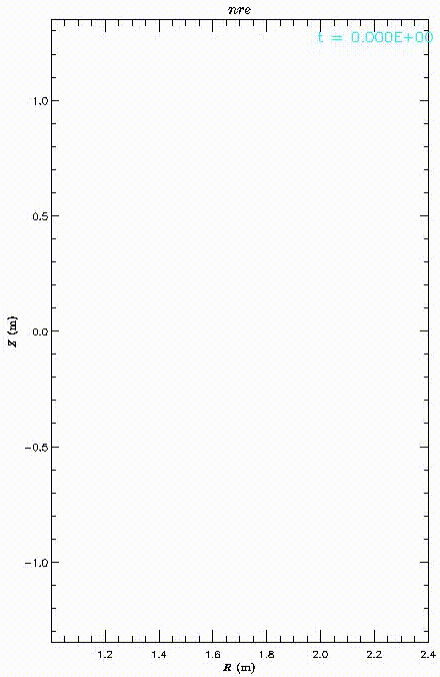


- There is a 3/2 mode at q~1.5 surface when t~1ms.
- The magnetic field becomes all stochastic at about 3ms.
- At t~4ms the 3/2 mode at q~1.5 surface comes back and there is a new mode in the center which I think induced by the runaway current but not sure.

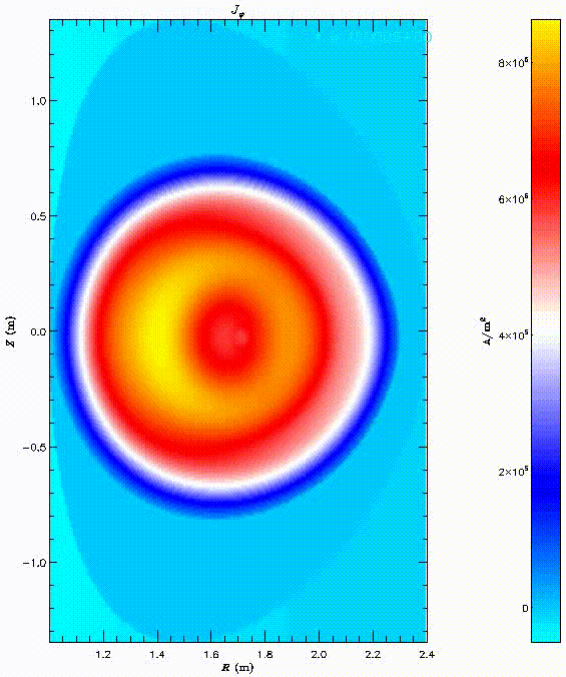
Pellet density 0-4ms



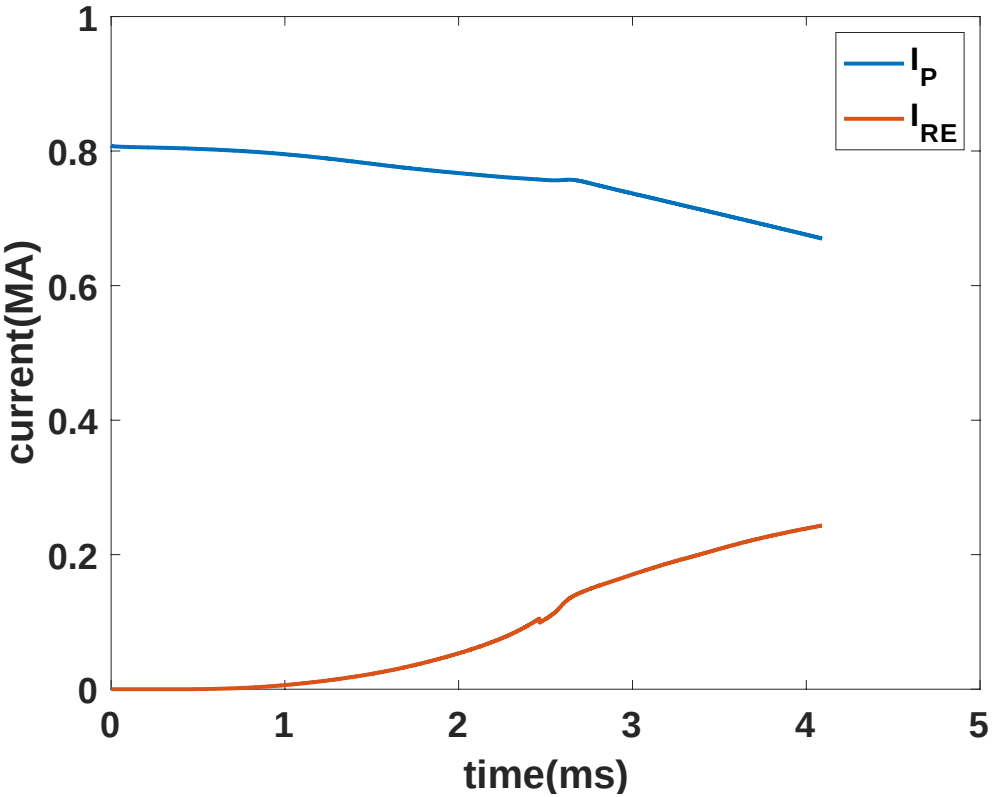
Runaway density 0-4ms



Toroidal current 0-4ms



- The runaway electrons generated first near the pellet.
- The runaway electrons is concentrated in the center which I think maybe related to the 4ms Poincare plot previous slice.

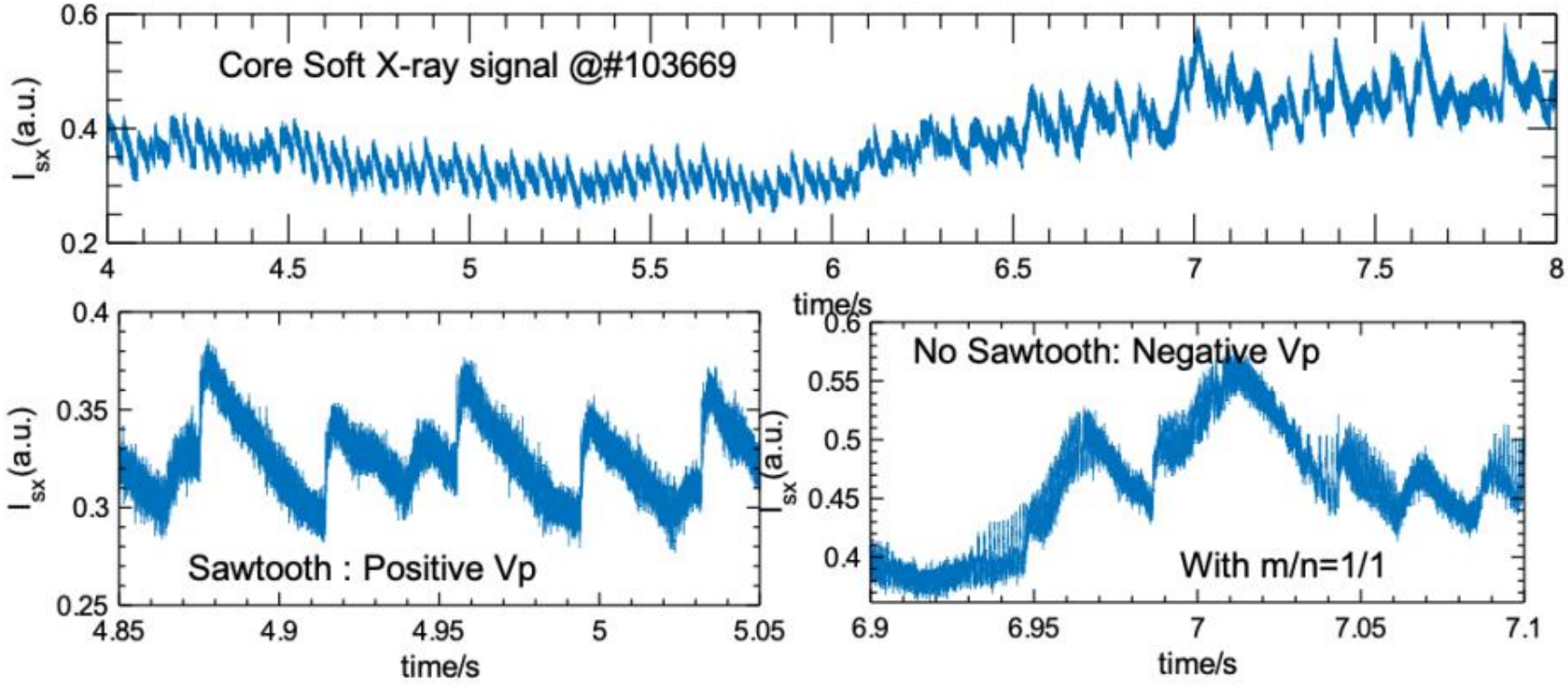


- The growth rate of both runaway current and toroidal current have changed at about 2.7ms which the magnetic field becomes fully stochastic.

RWM/RWTM Study

Hank Strauss to present.

Soft X-ray diagnostic #103669



The 'inverted' sawtooth shown in Core SXR signal, is due to the formation of hollow SXR profile.

New adapt option

Author: Morteza H. Siboni <hakimm2@rpi.edu>
Date: Tue Sep 21 16:16:15 2021 -0400

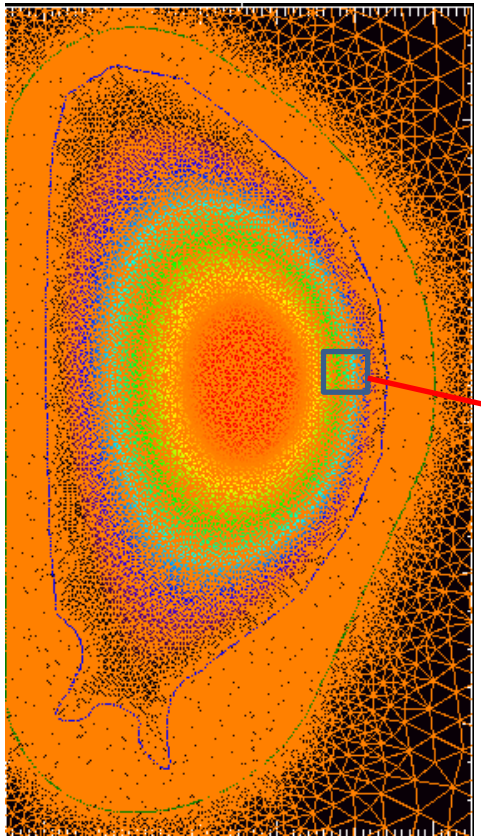
Updates the new logic for adapt_by_field

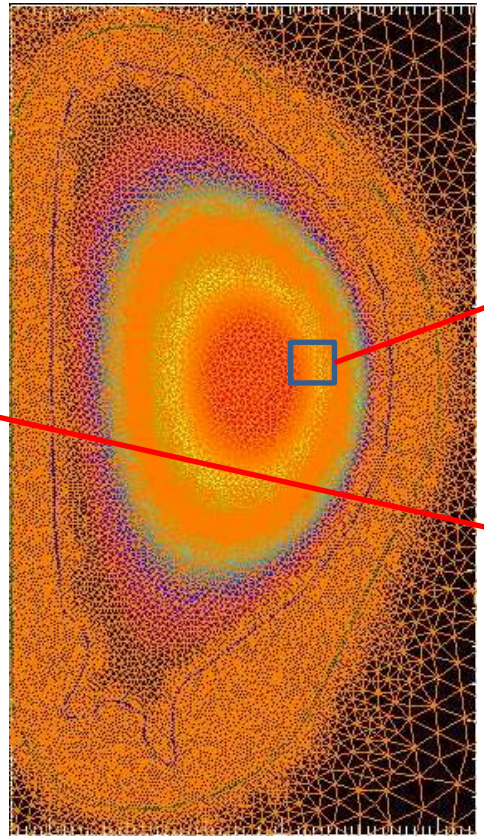
The 14th parameter in sizefieldParam (if exists) should be either 0 or 1 and with this change the following behaviours can be expected

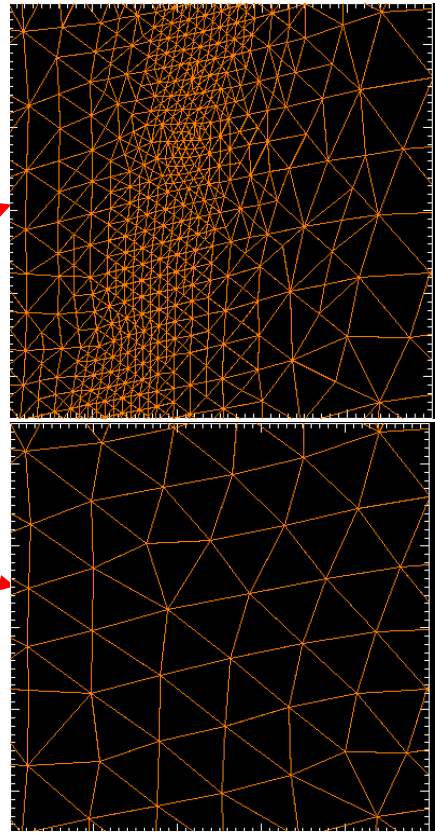
(1) if there are 13 parameters things will work as before
(2) if there are 14 parameters the last parameter should be either 0 or 1 (any other value will cause an error).
  (2a) value of 1 will leave coarsening "on"
  (2b) value of 0 will turn coarsening "off"
(3) if there are more than 14 or less than 13 parameters in "sizefieldParam" this will cause an error.

1. 2. 2. .01 .4 .01 .4 .1 .1 .01 .02 .05 .5 0

Testing on ITER equilibrium -- 1



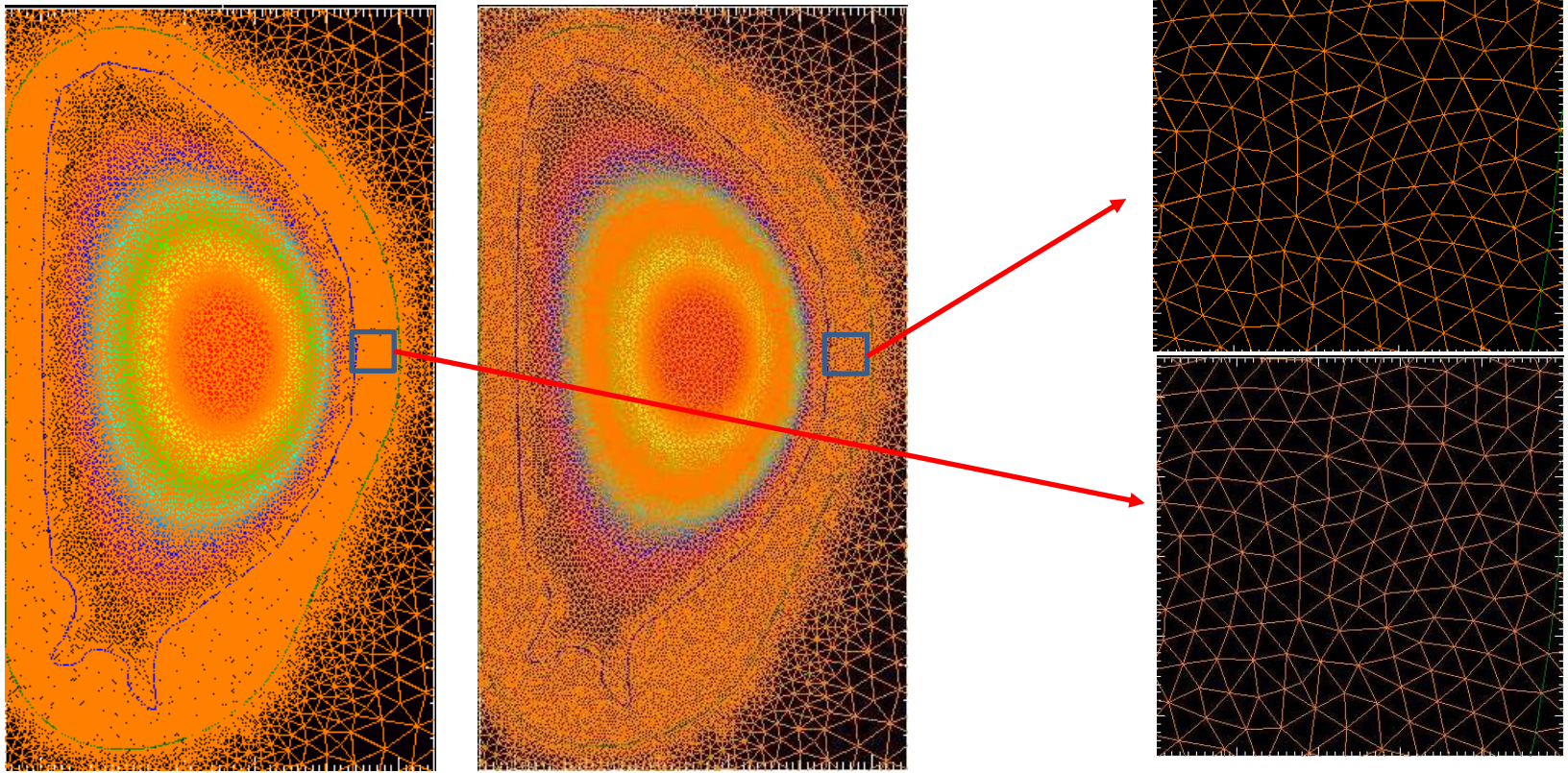




/p/tsc/m3dnl/ITER/NewMesh/Eq2 and …/Adapted

Refines plasma region ok

Testing on ITER equilibrium -- 2

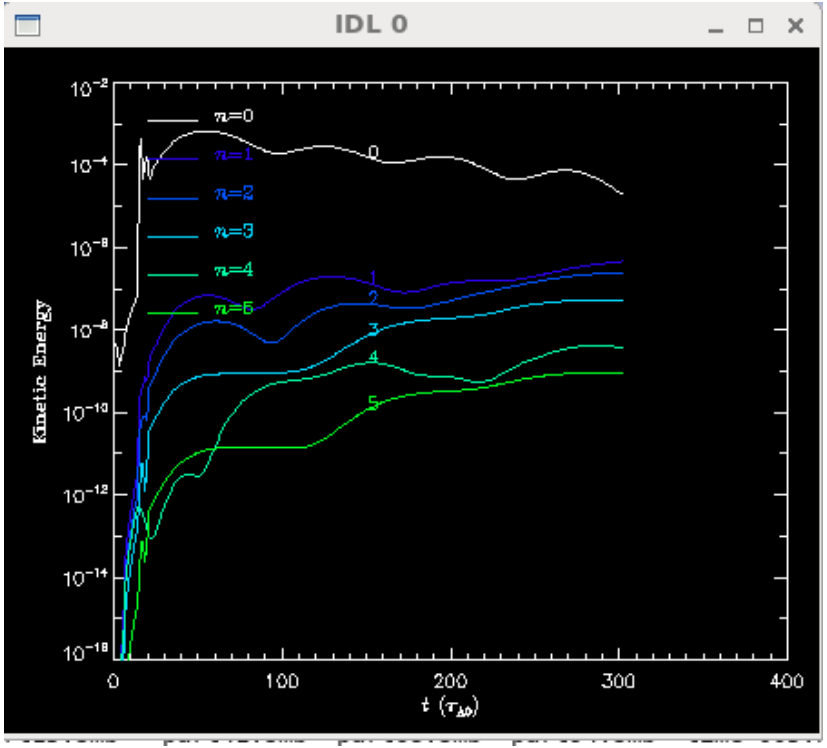


/p/tsc/m3dnl/ITER/NewMesh/Eq2 and …/Adapted

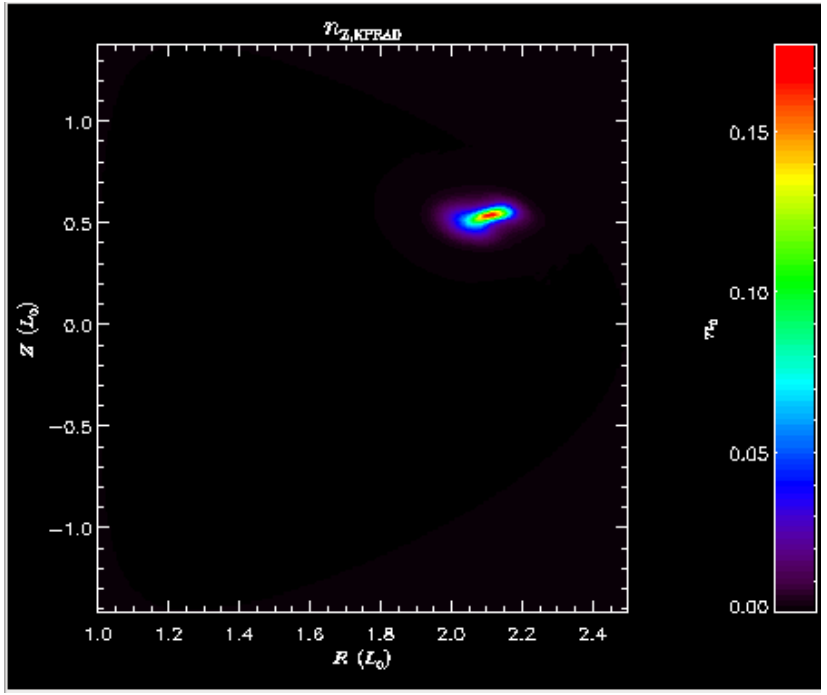
Leaves wall zones untouched!

DIII-D Pellet injection case goes unstable (without RE)

plot_hmn



plot_field, 'kprad_totden'



Could the impurity density be going negative?

See /scratch/gpfs/cz12/kprad2_test

Chen Zhao

Chen Zhao paper in preparation

Simulation of the runaway electron plateau formation during current quench

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[3] Max Planck Institute for Plasma Physics, Boltzmannstaße, Garching, Germany

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- Now only contains formulation and 2 test problems (1 cylindrical and 1 with JOREK)
- No section on experimental comparisons or on sawtooth
- Need some discussion on validity of Dreicer model (from Chang)
- Add section on comparison with characteristics model of advancing runaways?