

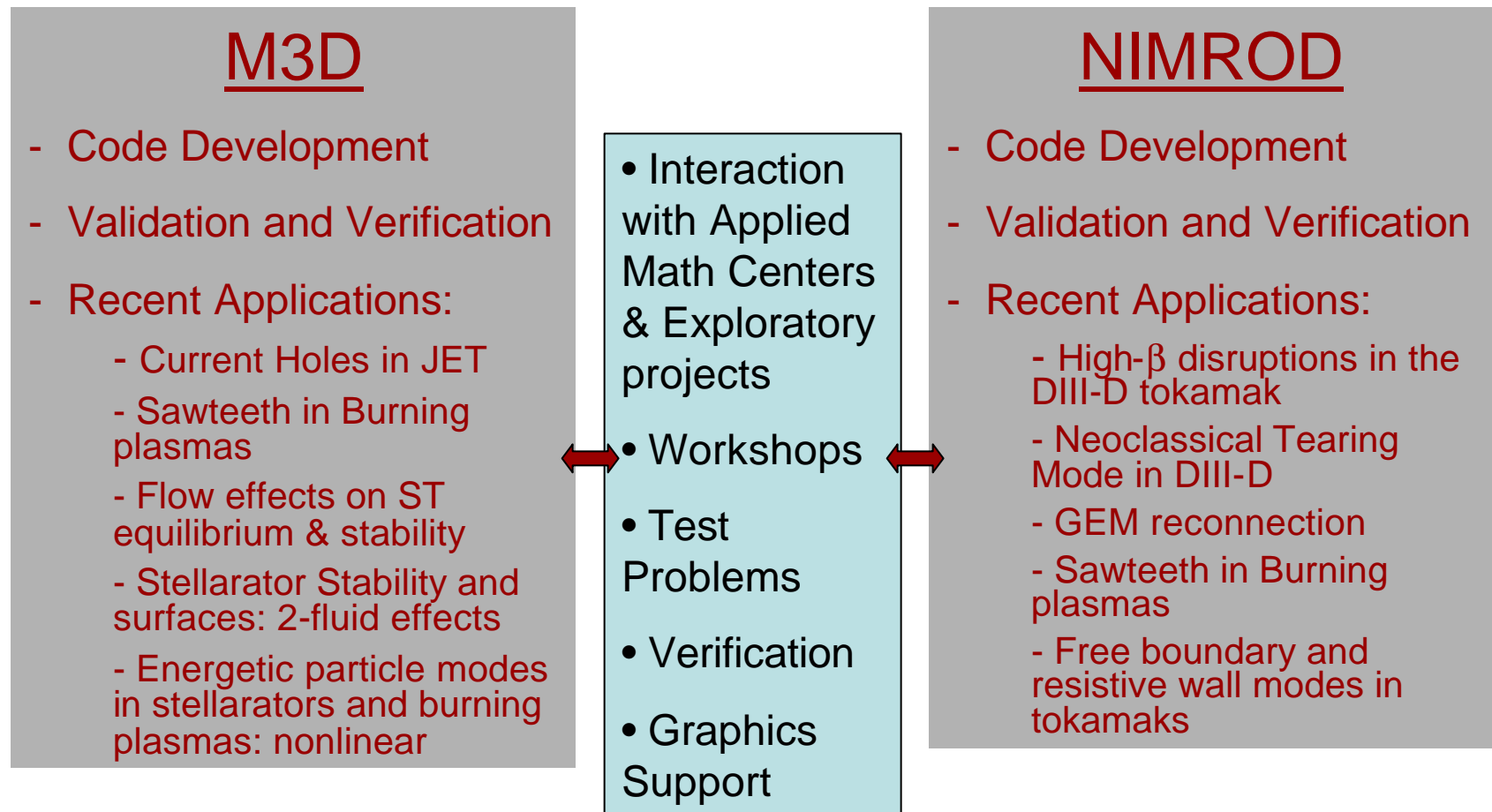
CEMM Presentation
Fusion SciDAC PAC Meeting
PPPL
June 3, 2002

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|---|--------|----------------------------|-------------|
| ➔ | 10 min | Overview Presentation | S. Jardin |
| | 20 min | Recent results from NIMROD | D. Schnack |
| | 20 min | Recent results from M3D | W. Park |
| | 20 min | Reconnection using AMR | R. Samtaney |
| | 20 min | discussion | |



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Overview of the Center for Extended MHD Modeling



CEMM Workshops and Major Presentations

- Held CEMM meeting in Rochester preceding Sherwood (04/21/02)
- MHD Workshop planned Aug 19,20 2002 (F. Waelbroeck organizer)
- Major Presentations
 - 2 CEMM Oral talks at 2002 Sherwood
 - 1 2002 IAEA oral talk, 2 posters, contributed to another oral
 - 2 (or 3) 2002 APS Invited talks
 - Invited SIAM talk (July 02) as part of SciDAC session
- CEMM calculation (by Breslau, et al.) explained JET “current hole”...led to PPCF paper and experimental IAEA oral
- Request by Europeans to use NIMROD/M3D for non-axisymmetric halo current calculation
 - R.Paccagnella from Padova Italy will visit in late June
 - Stemmed from Karl Lackner’s interest in CEMM presentation at ITPA MHD workshop in Feb 2002 in Japan



Code Development Highlights:

- **NIMROD**

- Available in SAIC CVS repository, fully functional on NERSC SP3, interfaced with MDS+ data storage, AVS visualization package
- Nonlinear vacuum region with resistive wall being tested for RWM
- Code works well for small equilibrium flows. Algorithmic changes for improved behavior with strong flow have been worked out but not implemented yet....leads to non-symmetric matrices
- Adding ability to invert nonsymmetric matrices by coupling with AZTEC (& PETSc). Also needed for 2-fluid algorithms.

- **M3D**

- Available in PPPL CVS repository, fully functional on NERSC SP3 and PPPL cluster, AVS visualization package
- 2-fluid and stellarator options now merged and compatible
- Hybrid fluid/particle option also now running with MPI on NERSC SP3



Interaction with Applied Math Centers & Exploratory projects

TOPS Center (ODU)

- Direct comparison between PETSc and HYPRE routines for solving sparse linear systems
- Comparing Algebraic Multigrid (AMG) from HYPRE, Incomplete LU (ILU) from HYPRE, Additive Schwarz (ASM) from PETSc
- Additional discussions on restructuring, investigating non-linear solvers (Newton-Kyrlov)

Sandia Linear Solvers group (S. Plimpton)

- Evaluating AZTEC linear solvers in NIMROD
- Extends capabilities to non-symmetric/non-Hermitian systems

TSTT Center (RPI)

- Evaluating higher order finite elements by interfacing with SCOREC software
- Initially using simplified 2D MHD problem , but similar in structure to M3D
- Discussions regarding spectral elements

ADPEC Center (LBL)

- Incorporation of MHD into Chambo Parallel AMR framework
- Initial application to reconnection problem
- R. Samtaney to report on progress

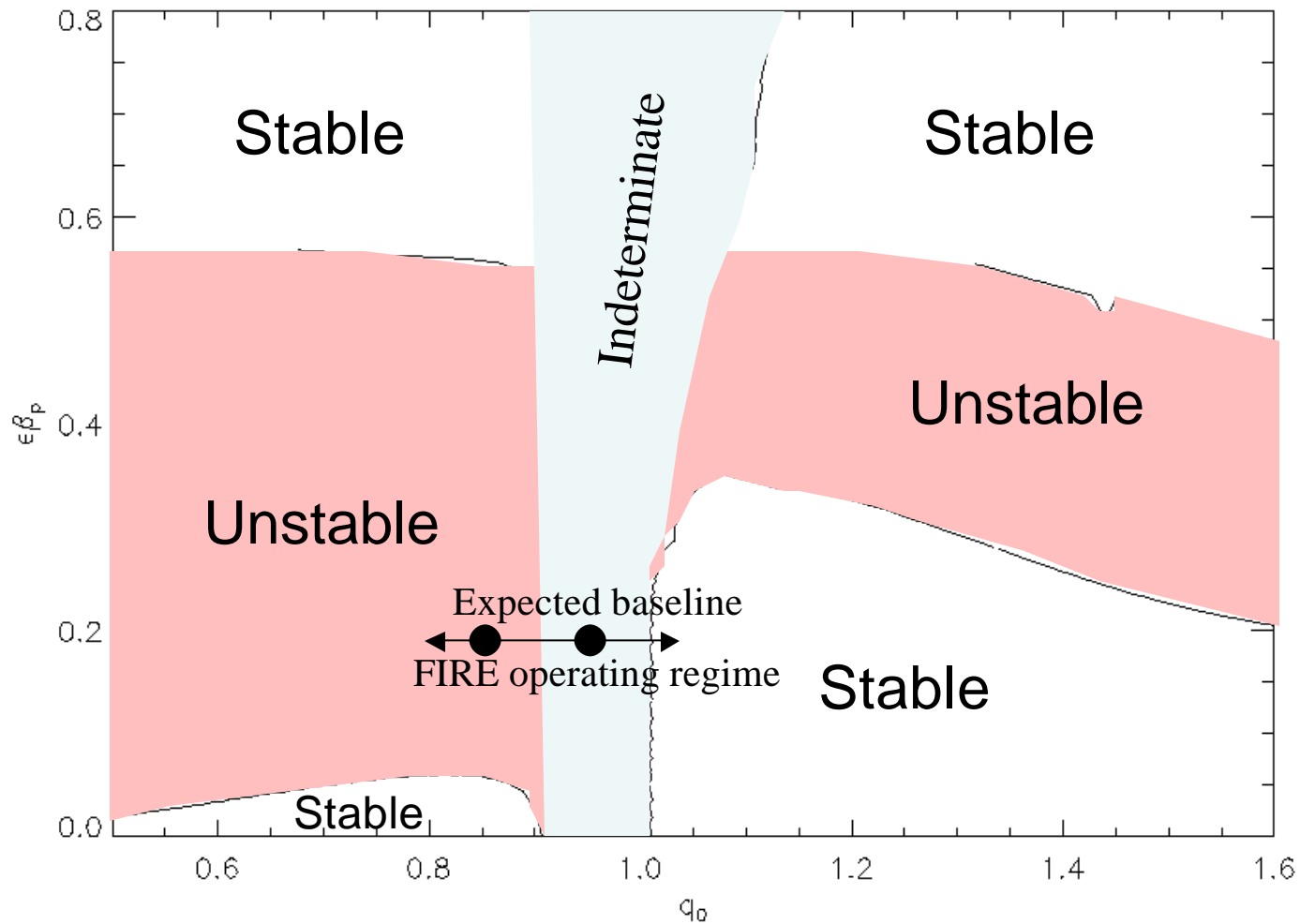


CEMM Sawtooth Campaign

- The behavior of the $(m=1, n=1)$ mode resonant at $q=1$ (sawtooth) has been called out as a critical uncertainty for the 3 Snowmass burning plasma designs
- Both NIMROD and M3D involved in this activity
- Ideal MHD, resistive dissipation, Hall-Reconnection, 2-fluid stabilization, energetic particle stabilization all important
- One goal is to improve on Porcelli model for integrated modeling codes such as TSC, TRANSP, and Baldur
- Initial results show this to be a complex problem rich in physics

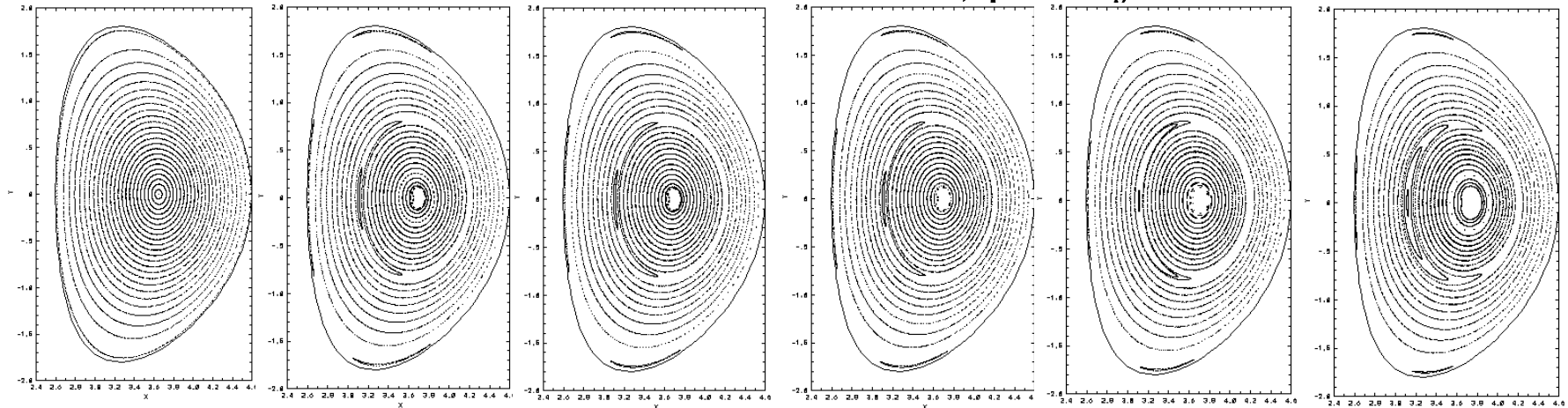


Initial (1,1) mode Linear Stability Map (from PEST)
for q-profiles with low central shear



FIRE Series 16: resistive MHD ($q_0 = 0.85; \mathbf{b}_p = 0.388$)

Flux Surface Puncture Plots, plane $f = 0$:



Initial state,
 $t=703.89$

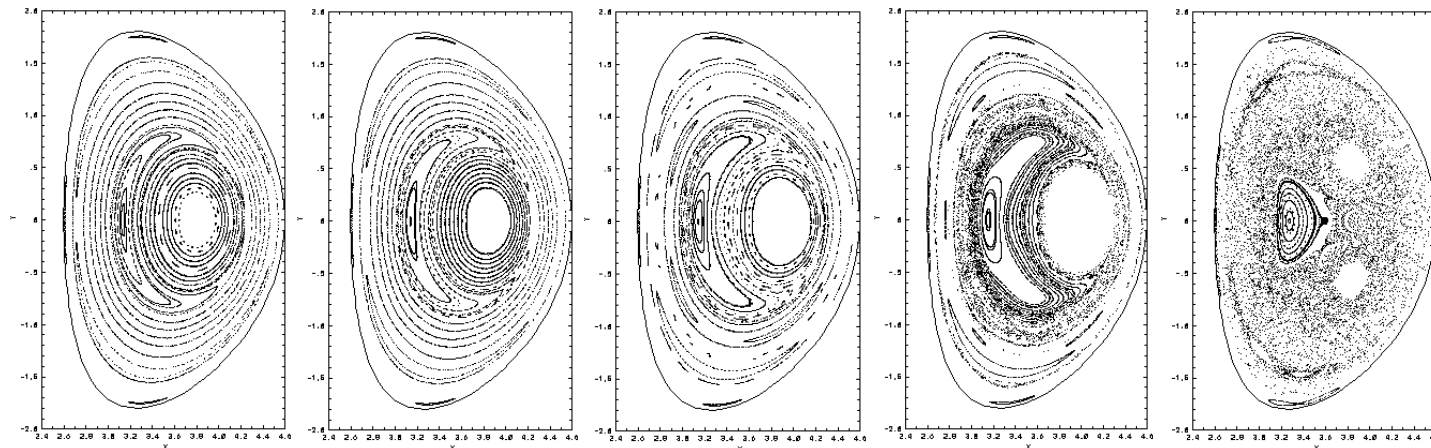
Pert. added,
 $t=703.89$

$t=704.88$

$t=714.87$

$t=764.87$

$t=828.83$



$t=892.76$

$t=912.78$

$t=932.76$

$t=952.34$

$t=990.43$

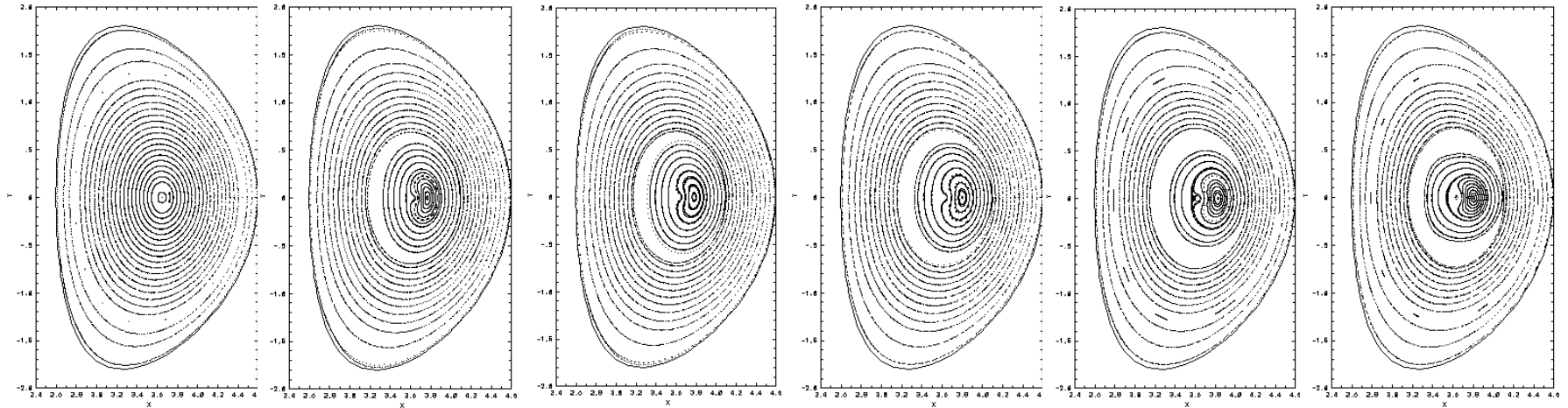
Stochastic!



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FIRE Series 18: Resistive MHD ($q_0 = 0.94; \mathbf{b}_p = 0.365$)

Flux Surface Puncture Plots, plane $f=0$:



Initial state,
t=1533.32

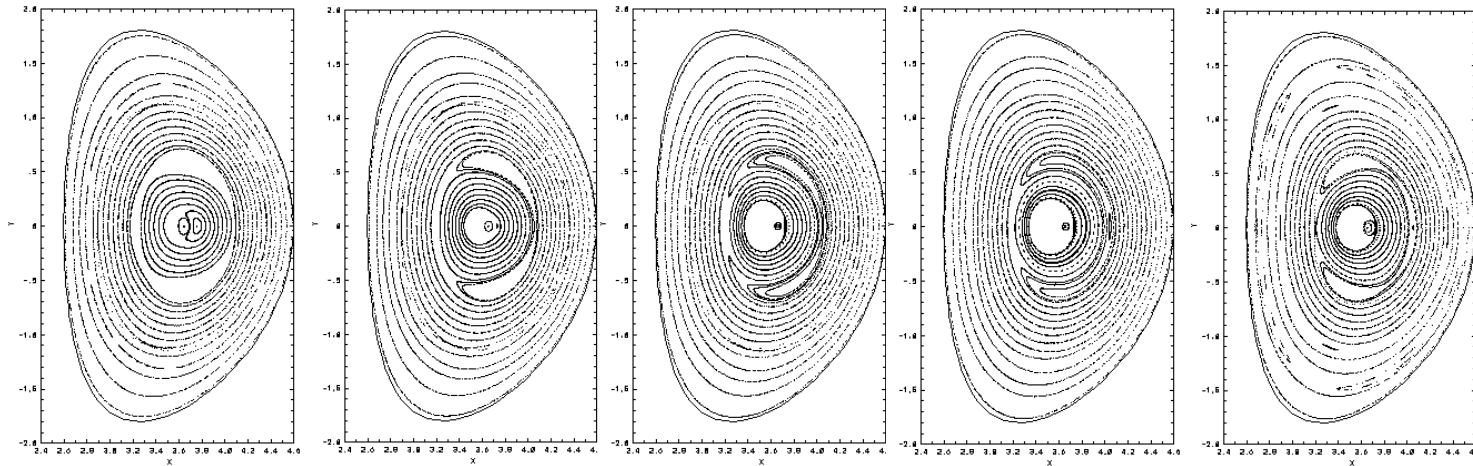
Pert. added,
t=1533.32

t=1583.22

t=1683.24

t=1883.13

t=2133.11



t=2383.11

t=2633.30

t=2883.34

t=3133.21

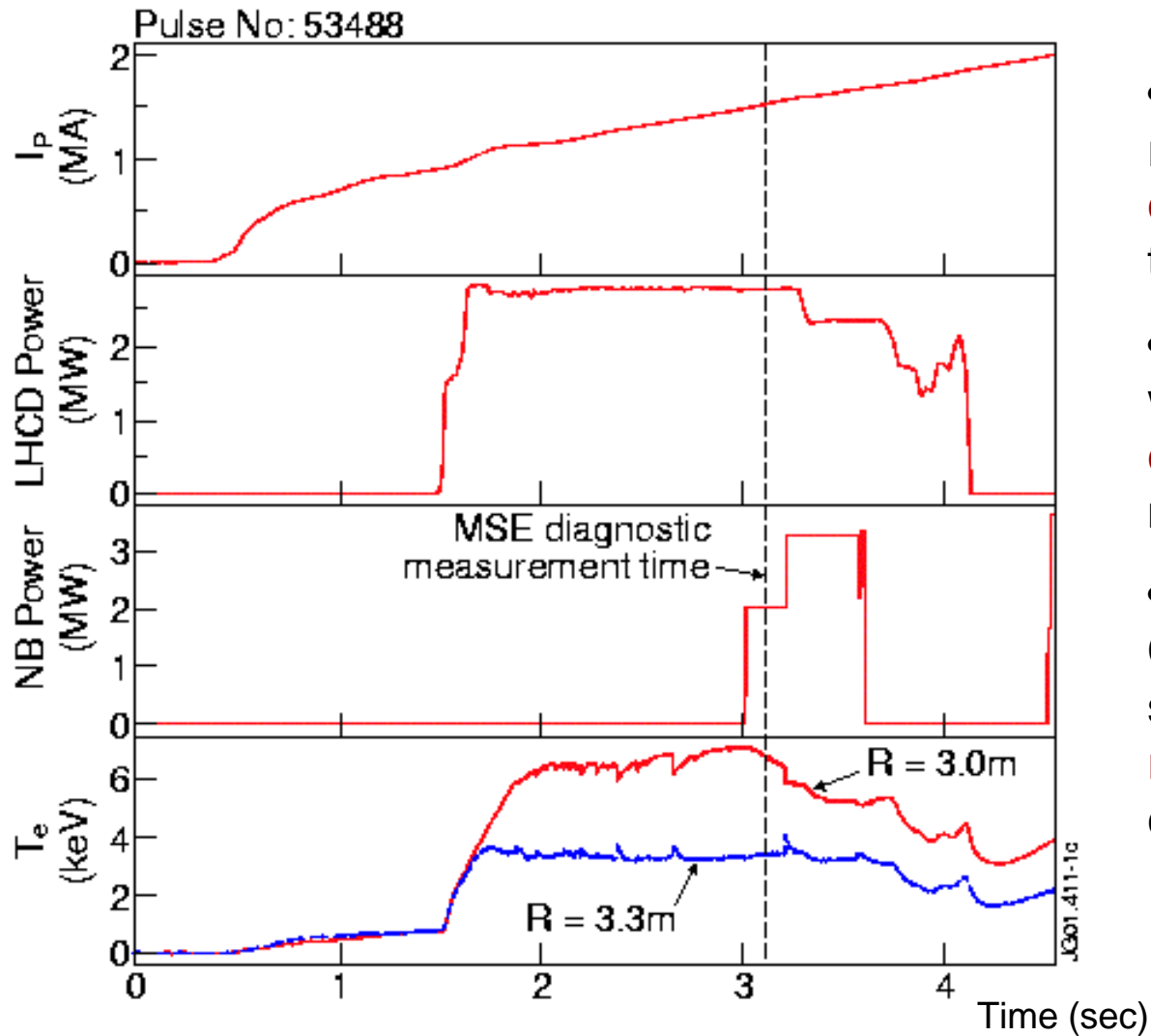
t=3383.24

saturates!



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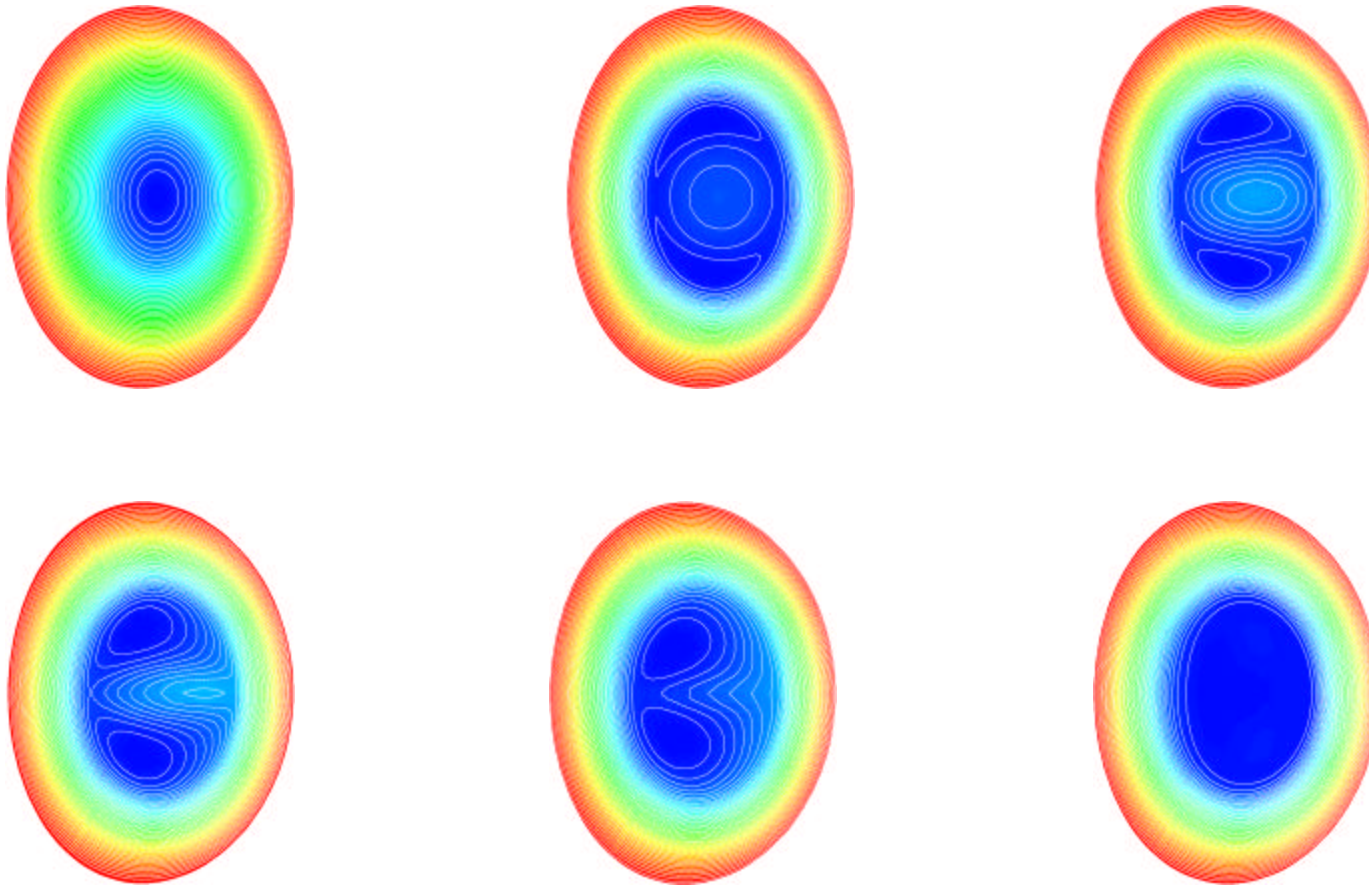
Interpretation of JET Current-Hole Experiments



- LHCD during current rampup **should drive central current negative** according to 1D transport codes
- Careful measurements with MSE showed **central current was zero**...but not negative
- This was explained by CEMM calculation which showed an **axisymmetric reconnection** event clamps current at zero

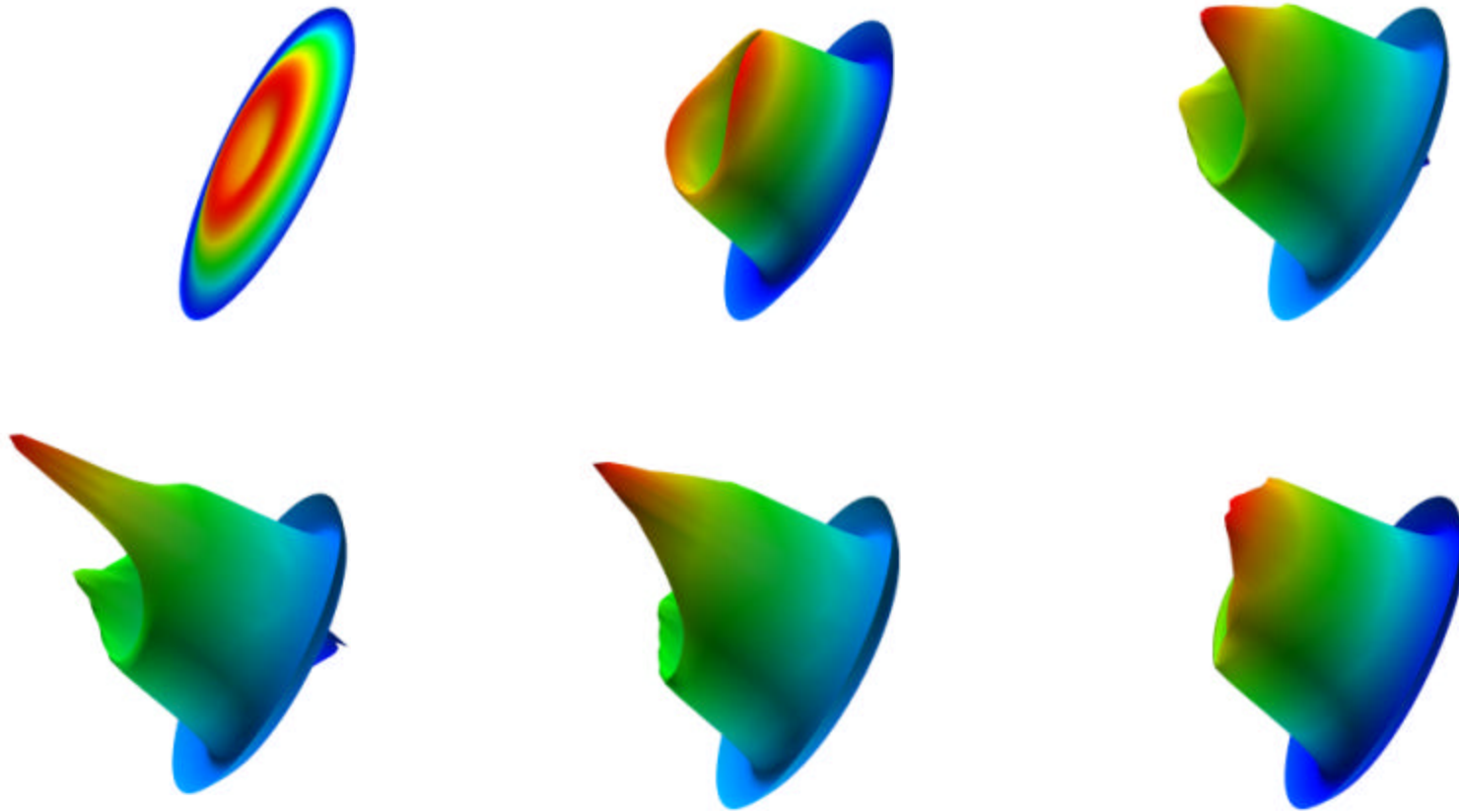


Poloidal Magnetic flux surfaces during the sawtooth cycle



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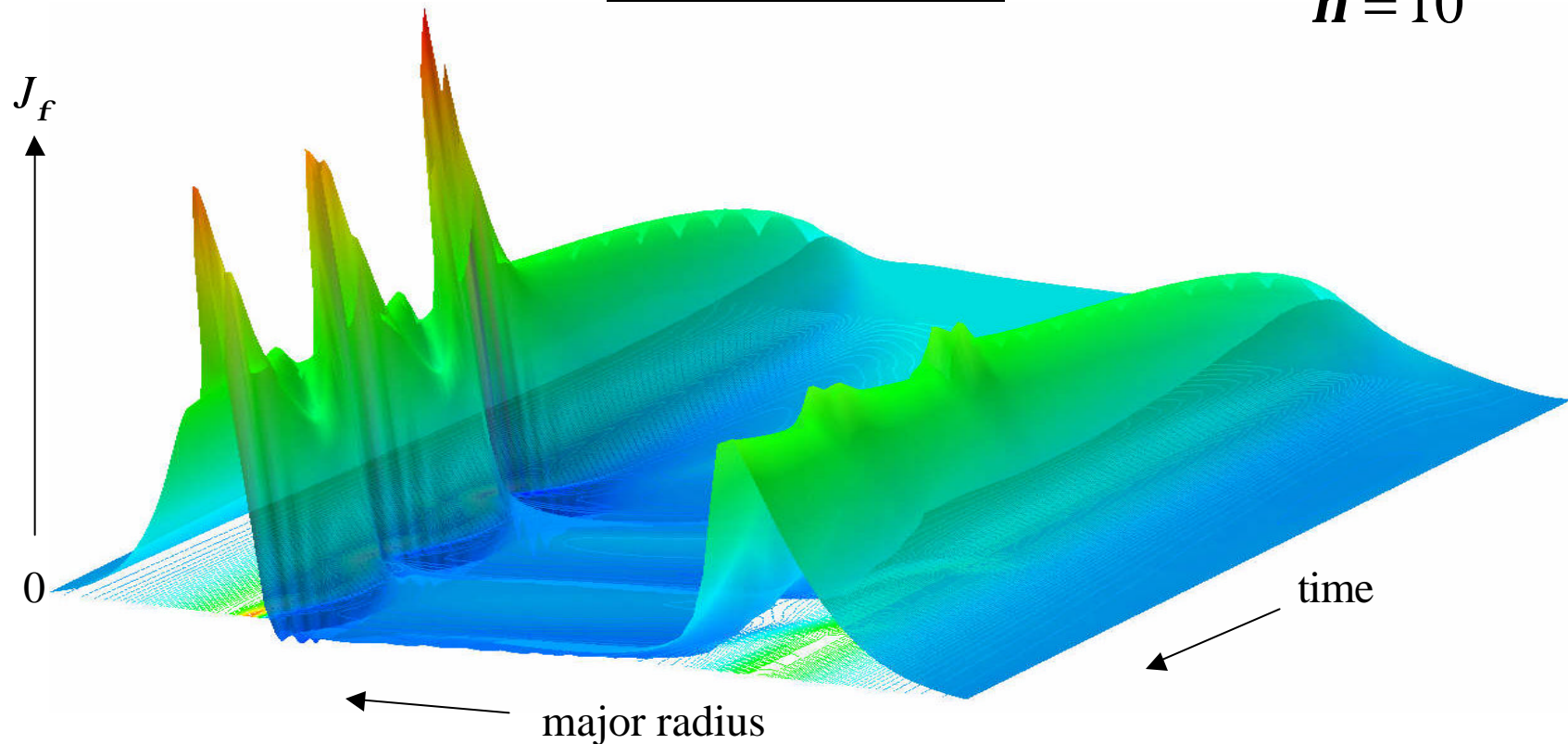
Toroidal current density during the sawtooth cycle



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Current Density History at Midplane

$$h = 10^{-4}$$



- Repeated reconnection events keep current flat in center.
=> PPCF Paper, APS Invited Talk, IAEA Oral talk



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