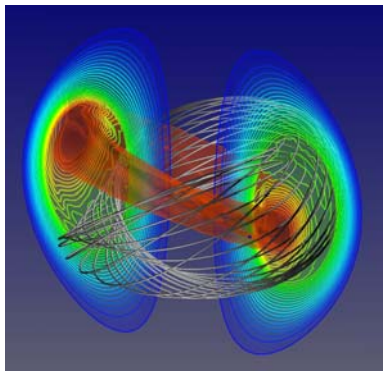
# Future Directions of M3D Workshop

Welcome!

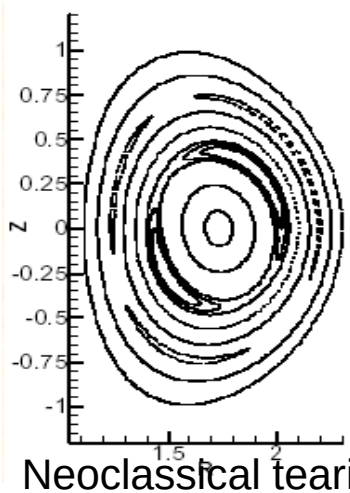
March 19-21, 2007

Princeton Plasma Physics Laboratory

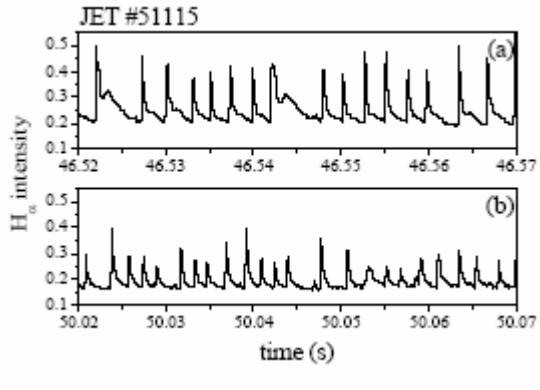
# Essential MHD Phenomena that require Global 3D Extended MHD calculations



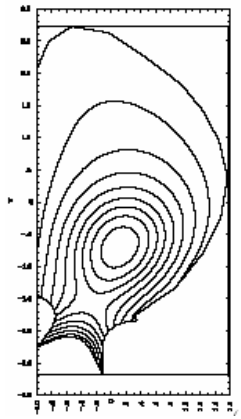
"sawtooth oscillations"



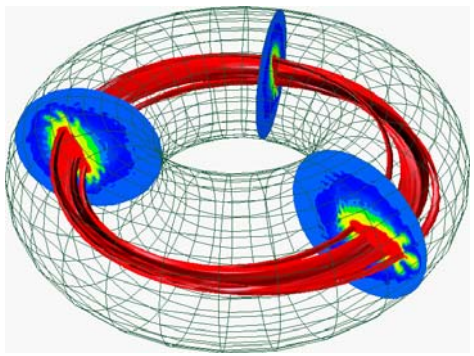

Neoclassical tearing modes and interaction of coupled island chains.



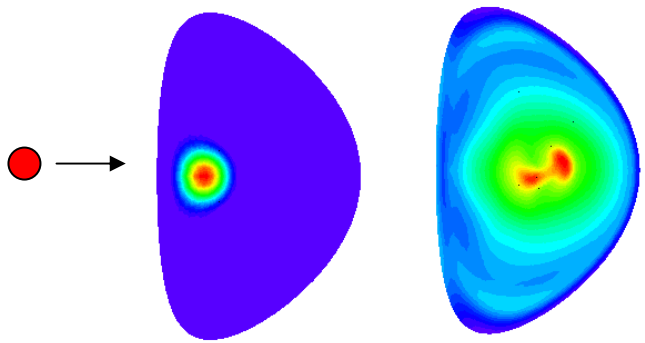

Edge Localized Modes



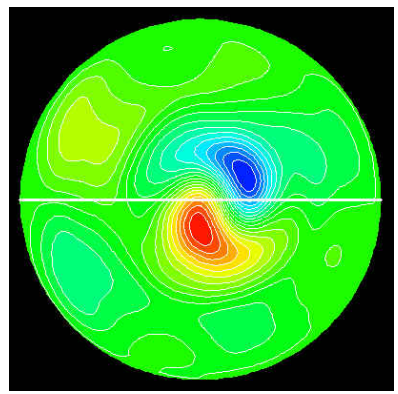
Disruption forces and heat loads during VDE



Disruptions caused by short wavelength modes interacting with helical structures.



Mass redistribution after pellet injection



Energetic Particle modes

# M3D

- The M3D code is a unique resource that has a long history of being used for scientific discovery in fusion research
- However, needs improvement and modernization
  - More efficient spatial representation
  - More implicit time stepping
  - Better parallel scaling
  - Improved Physics Models

Also…needs to be done in such a way that we have incremental new science results

# SciDAC Renewal proposal

Proposals for development of codes to model macro-scale dynamics in fusion-grade tokamak plasmas should address relevant physics issues in 3-dimensional extended magnetohydrodynamics (MHD), such as:

1. full nonlinear sawtooth oscillation modeling in fusion-grade plasmas,
2. tearing mode and NTM excitation and control in high-beta plasmas,
3. nonlinear evolution and control of RWMs, including toroidal flows,
4. effects of fast ions on MHD phenomena in tokamak plasmas,
5. edge MHD-type instabilities and their non- linear evolution,
6. two-fluid and kinetic effects on MHD modes,
7. the onset and evolution of major disruptions,
8. differences in modeling resulting using different closures,
9. differences in scalability to teraflop and petaflop computing scales resulting from differences in numerical treatments and finally
10. Validation and Verification of nonlinear results.

"Strong team effort focusing on a single (integrated) code will be given preference."

# More on Call for Proposals

- In addition to descriptions of the physical models in the codes, proposals should include information on the proposed mathematical algorithms, computer science methods, and data management and visualization techniques.
- researchers should include information on the readiness of their codes to run on today's terascale computing facilities
- should discuss their plans for taking advantage of the emerging availability of petascale resources.
- A strong verification and validation (V&V) component is essential for this effort and therefore researchers should discuss their V&V plans in sufficient detail. In addition, since cross-benchmarking of different codes is an indispensable and often-used verification tool for large-scale simulation codes, successful researchers are expected to share data and other supporting information in a timely fashion with other researchers.
- Researchers should also discuss their plans for forming substantive partnerships that integrate applied mathematics and computer science enabling technologies with their proposed efforts.

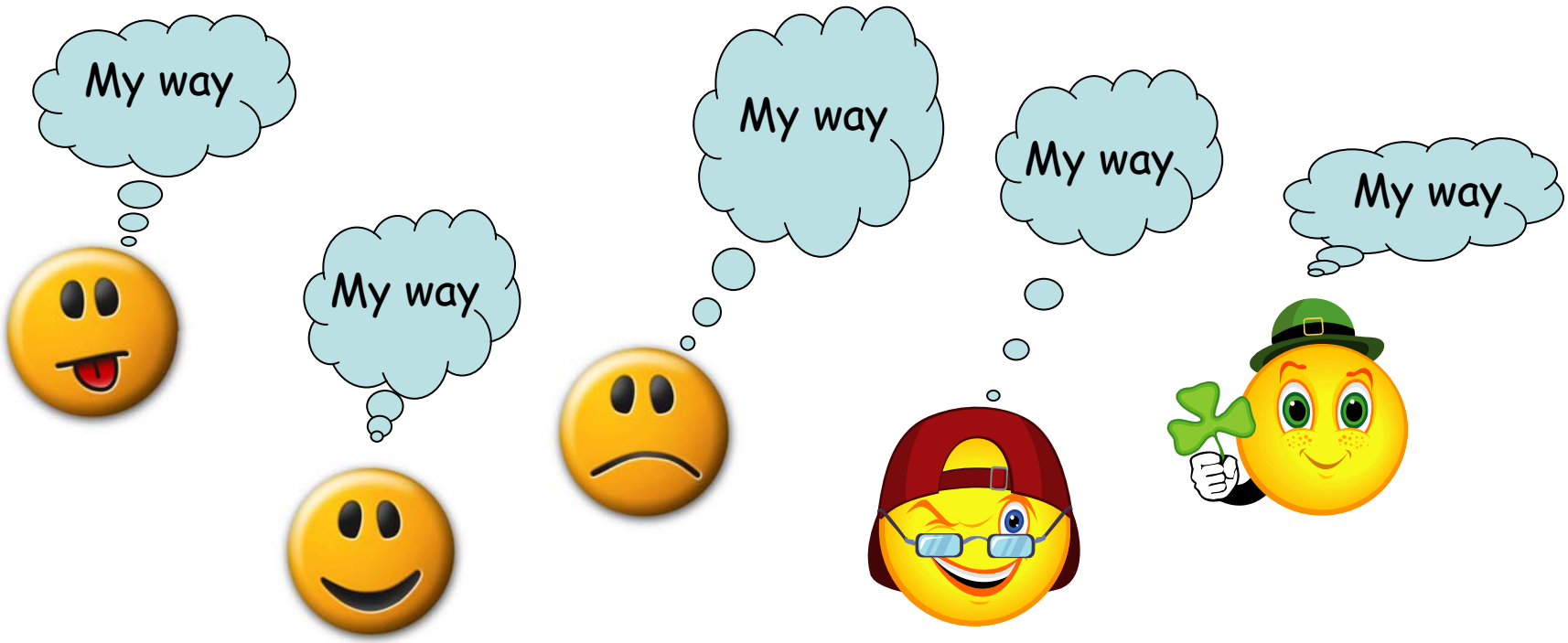
# We need to form an effective team and use this to develop an improved 3D Extended MHD code

- Need to develop a common vision of what we want to accomplish
- Individuals and subgroups need to be clear about what they can contribute in order to achieve the common vision
- Probably can't do this all in the next 3 days, but we can make a good start.

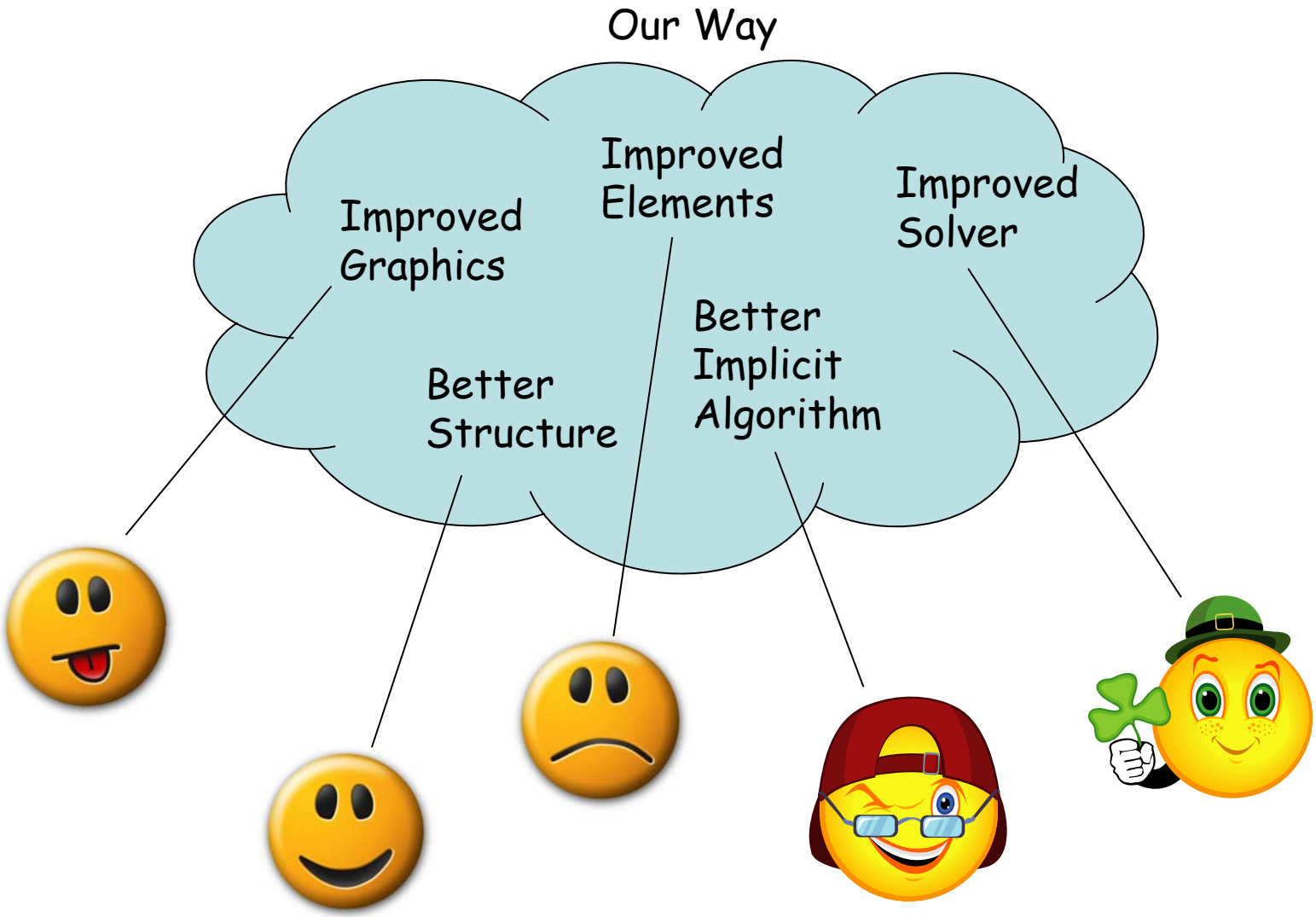
# Some miscellaneous thoughts for an effective team

- The best way will always prevail (eventually)
  - if not by us, then by others
  - this should be the overriding criteria
- We can learn a lot from each other
  - Teams of physicists + cs/math experts are more powerful that either alone
- Most of what we are working on is not original
  - It is an new application of an existing technique
  - Try and not get too emotionally tied to one method
    - If it is truly new, publish the idea and move on
    - Don't be on a mission to push one technique just because you have a history with that method

This is not a functional team




Sure, I'd like to work on the M3D project




This is what we are striving for…each contributing to a common vision!

# Agenda

**Monday March 19th:**

| | |
|---|---|
| 9:15 - 9:30 | Jardin: Introduction and need for consolidation and coordination |
| 9:30- 10:30 | Breslau: Present status of M3D |
| 11:00 -11:30 | Chen: Scaling studies and bottlenecks of M3D |
| 11:30- 12:00 | Jardin: A coarse-grained roadmap for M3D code development |
| 1:00 - 3:00 | Discussion led by Jansen: Types of Elements |
| 3:15 – 5:15 | Discussion led by Keyes: Strategies for implicit solves |
| 5:15 | adjourn |

**Tuesday: March 20th**

| | |
|---|---|
| 9:00- 9:30 | Hudson: Prospects for (approximate) field aligned coordinates |
| 9:30- 10:00 | Chance: Coupling a resistive Wall to M3D |
| 10:00 -10:45 | Strauss: Introduction of Spectral Elements to M3D |
| 11:15- 12:00 | Fu: Making the Shear Alfven wave implicit in M3D |
| 1:00- 1:45 | Glasser: LANL's Spectral Element Code and Relation to M3D |
| 1:45- 2:30 | Samtaney preconditioned JFNK |
| 3:00- 3:45 | Jardin: M3D-*C1* approach to an implicit, high-order M3D code |
| 3:45 | Discussion of options and status |

**Wednesday Morning: March 21st**

| | |
|---|---|
| 9:00-12:00 | Development of a more detailed roadmap for M3D development in next 5 years |