PLASMA SCIENCE ADVANCED COMPUTING INITIATIVE

BUDGET PLANNING MEETING

W. M. TANG

- Status Report
- Future Opportunities
- Timetable

Germantown, Maryland

6 APRIL 2000

ADVANCED COMPUTING GOALS

- **Create and imbed *scientific knowledge in new simulation tools* needed to help achieve fusion as a viable energy source**

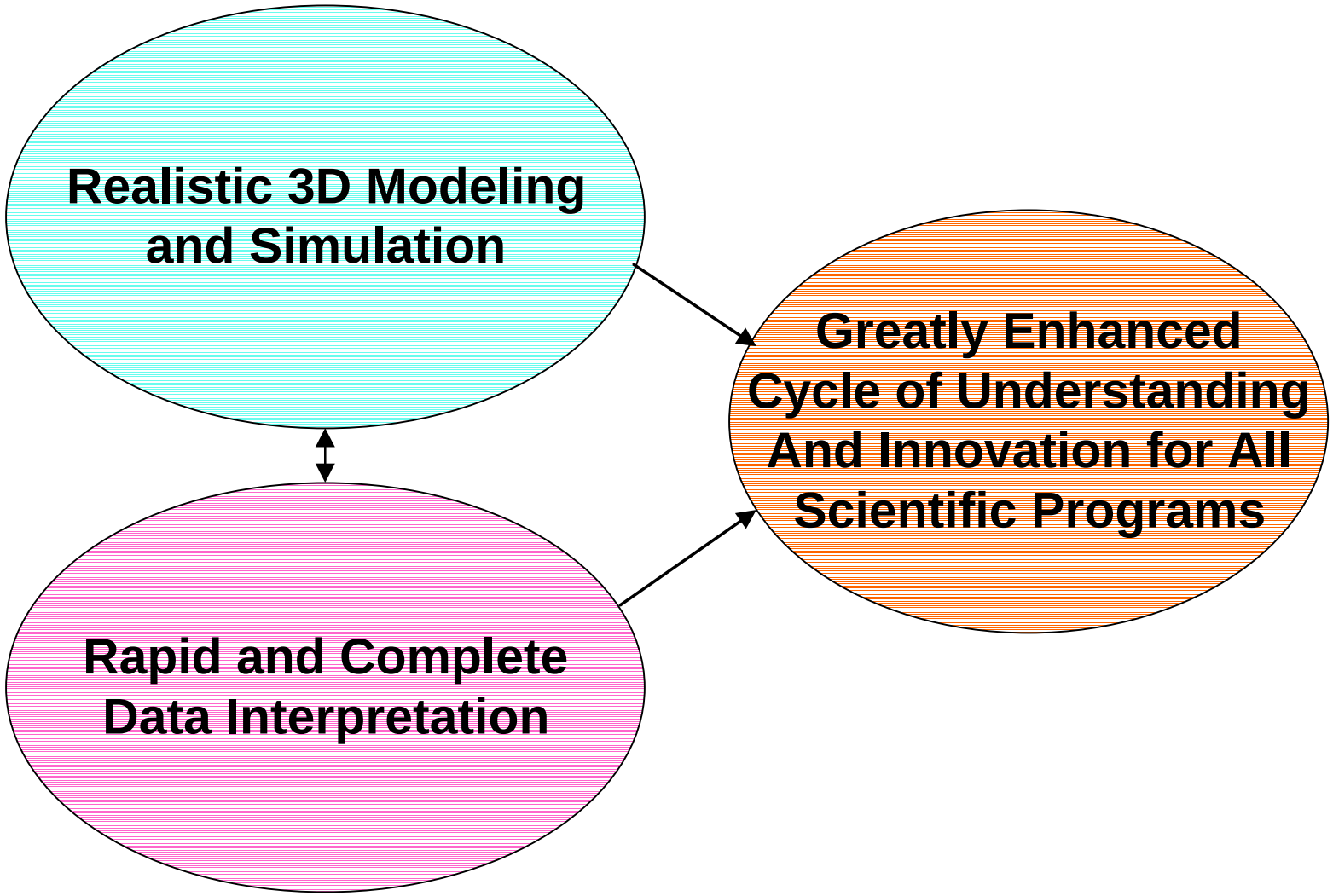
- **Enable effective *integration of experiment, theory and modeling* to advance scientific understanding and innovation**
  - ***leads to improved plasma performance and promising new designs***

- **Help attract, train, & assimilate *young talent* essential for the future**

PSACI RESEARCH PROGRAM

- **Enhance physics capabilities in most scientifically advanced simulation codes**
- **Research, development, & deployment of better mathematical models & computational methods for optimal utilization of modern supercomputing resources**
  - **Parallel programming for scalability of modern MPP's**
  - **Advanced visualization for higher-dimensionality data**
  - **Object-oriented architecture for community access**
- **Build advanced, shared diagnostics to provide better bridge between simulation, theory & experimental communities**

IT / ADVANCED COMPUTING ENABLES:



PRESENT STATUS

- **OFES established the Plasma Science Advanced Computing Initiative (PSACI) during FY'00:**

  -- Builds on groundwork from Fusion SSI (Scientific Simulation Initiative) in '99 (FES White Paper, strong PAC, ….)

  -- Pilot Programs in Turbulent Transport and MHD Simulations received excellent Peer Reviews & were launched ($800K) in March, '00

  -- $3M designated for FY'01 to support these and possible new research areas such as IFE, Boundary Physics, Integrated Modeling, ….

  -- OFES investment complements new DOE Office of Science Initiative for *"Scientific Discovery through Advanced Computing"* (SDAC) *which has replaced SSI*

  -- *Connection to outside community:* FES now in good position to be solid member of broader DOE scientific portfolio with access to new funding in SDAC Program

FY00 PSACI COMPONENTS

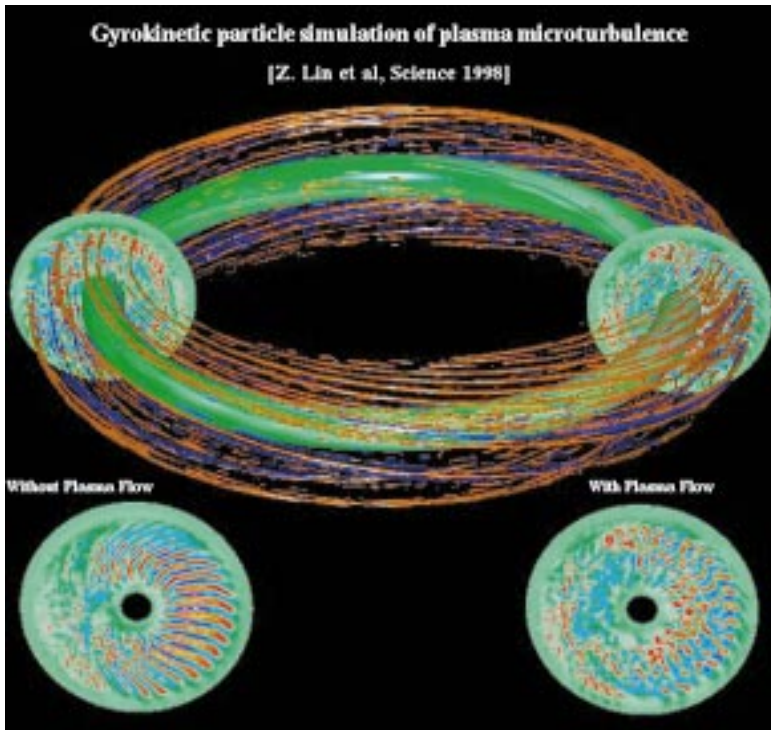
- **Fusion Energy Science Applications**
  - ***Microscopic Turbulence and Transport Simulation***
    [W. Nevins, PI -- $500K + transition of NTTP (B. Cohen)]
    - ***Team includes LLNL, PPPL, U. Maryland, GA, UCLA, U. Colorado***
  - ***Macroscopic Simulation of Fusion Plasmas***
    [S. Jardin, PI -- $300K + tie-in to OFES investments in NIMROD & M3D]
    - ***Team includes PPPL, SAIC, LANL, GA, U. Wisconsin, NYU, MIT, U. Colorado, SNL***

TURBULENCE SIMULATIONS: TARGETED DELIVERABLES

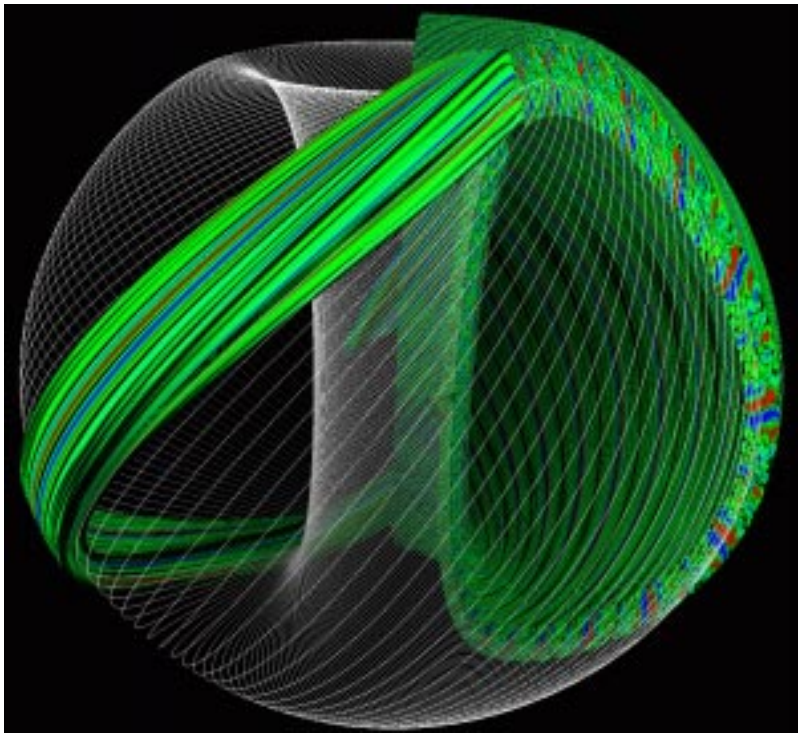
- ⇒ **Mutually benchmarked, well diagnosed, microturbulence codes -- Global and Flux-Tube Fully-kinetic Physics**
- ⇒ **Advanced data analysis and visualization capability**
- ⇒ **Prototype national database for storing code output**
- ⇒ **Better understanding of turbulent transport to aid interpretation & planning of experiments**
- ⇒ **Firm base for further expansion with possible support from new DoE Advanced Scientific Computing Program funding (“SDAC”)**

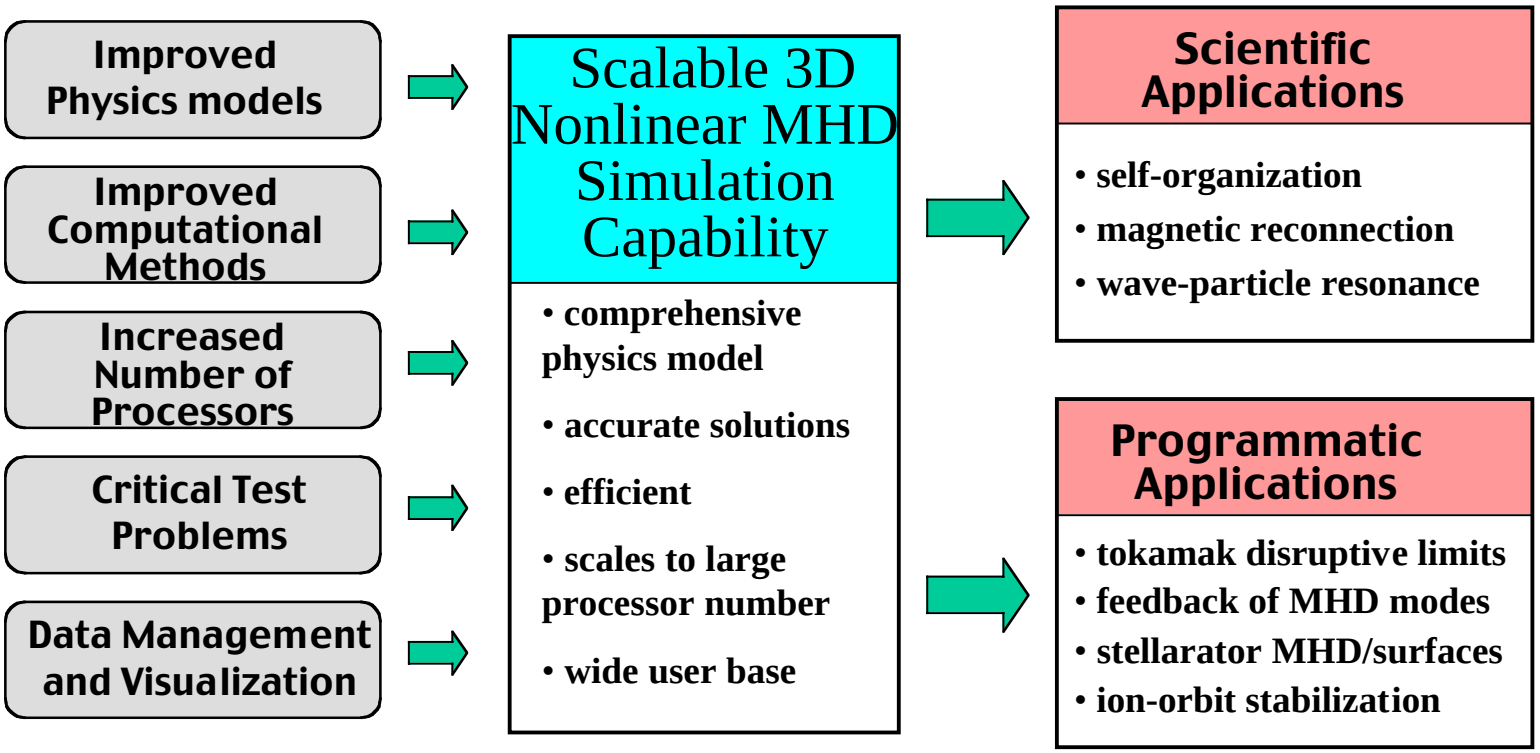
Geometric Representation

Global



Flux Tube

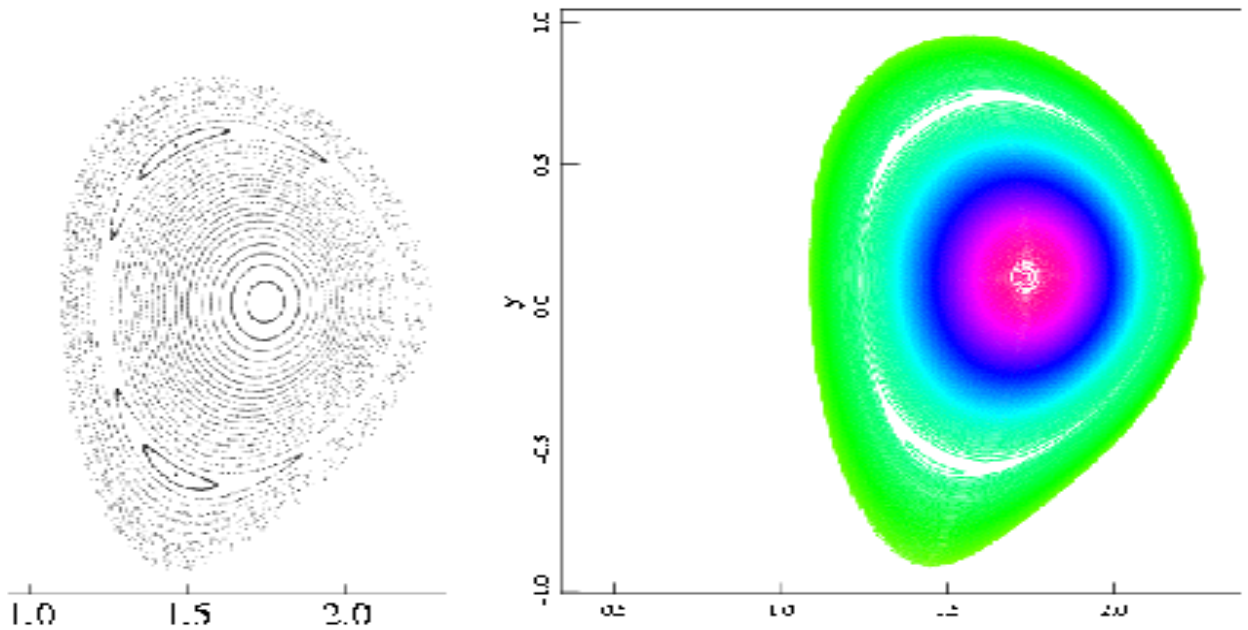




MACROSCOPIC SIMULATION OF FUSION PLASMAS:

Elements of Proposed Workscope

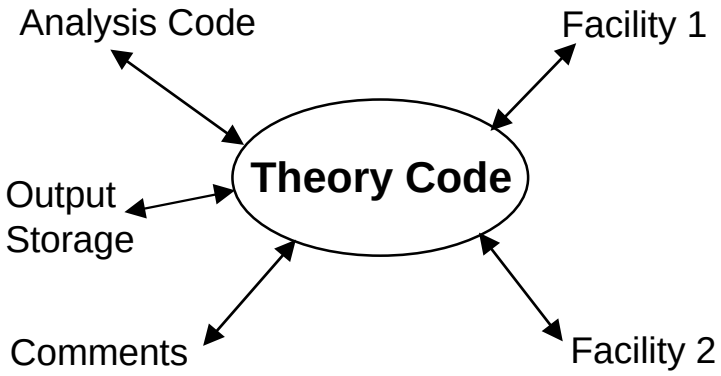
Neoclassical Tearing Mode (NTM) Analysis Capability



- **Self-consistent closure for Neo-classical Fluid Eq.'s being developed & applied to NIMROD and M3D**
- **Results to be cross-benchmarked & validated against experimental results**
- **Enable assessment of NTM impact on beta limit for long-pulse, high-performance tokamaks**

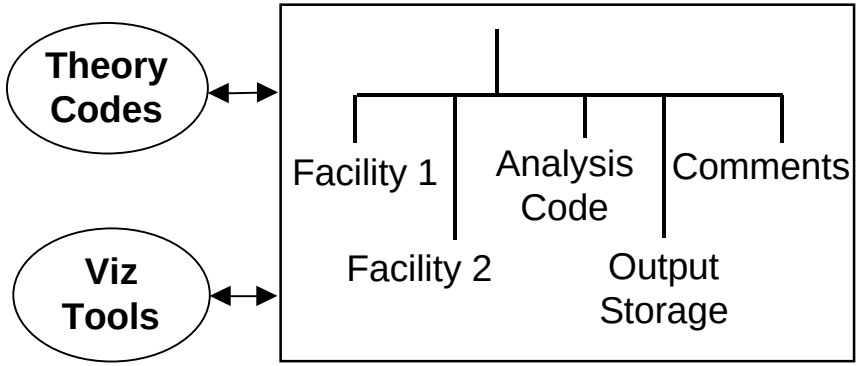
MPS plus WOULD SIMPLIFY COMMUNITY DATA ACCESS

Conventional Storage



- Each code needs its own interface
- Must know data format and file location
- Each code has its own graphics tool
- Hard to share results

MDS plus



- One interface to many data types
- Only need location of data in tree
- Utilize existing visualization tools
- Easy to share results with both the theoretical and experimental communities

How to Deal with Highly Dimensional Data
⇒ Advanced Visualization

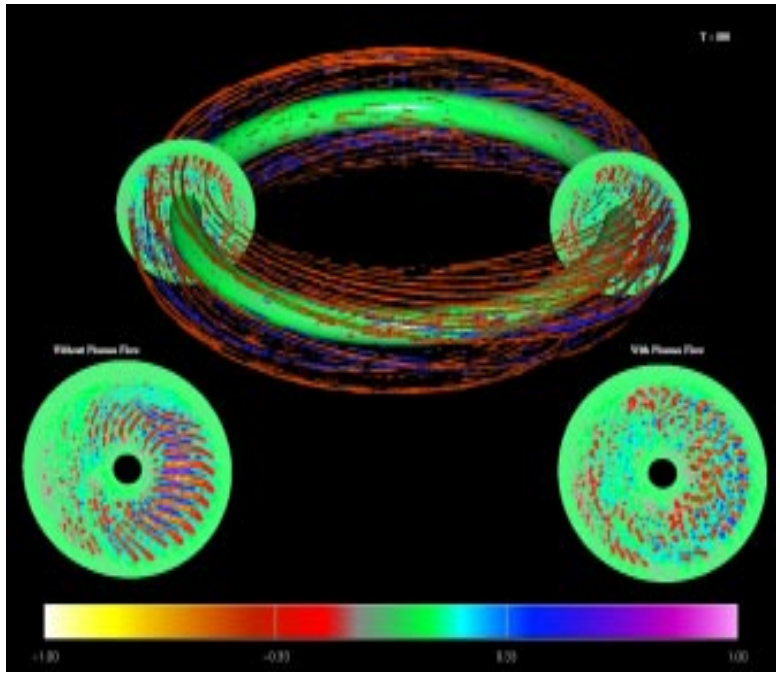
Computer Simulation Data:

- **3-D + time (configuration space)**
- **5-D + time (phase space)**

Experimental Data:

- **2-D + time (turbulence imaging)**

Analysis often increases dimensions (e.g., wavelet or bispectral analysis)



Goal: ***Move from --***

"Expert makes visualization"

to --

Modern visualization as routine part of data analysis by users

PSACI Program Advisory Committee

William Kruer, PAC Chairman, Distinguished Laboratory Fellow, LLNL
James Callen, Professor of Engineering Physics, U. of Wisconsin
Ronald Cohen, Head, MFE Theory Program, LLNL
Ronald Davidson, Professor of Astrophysical Sciences, Princeton U.
John Dawson, Professor of Physics, UCLA
Patrick Diamond, Professor of Physics, UCSD
James Drake, Professor of Physics & Astronomy, U. of Maryland
Richard Hazeltine, Director of IFS, U. of Texas at Austin
Russell Hulse, Nobel Laureatte and Distinguished Laboratory Fellow, PPPL
*Kenneth Kliewer, Director, Center for Computer Sciences, ORNL
*Kai Li, Professor of Computer Sciences, Princeton U.
*William McCurdy, Assoc. Lab. Director for Computing Sciences, LBNL
*Steven Orszag, Professor of Mathematics, Yale U.
Marshall Rosenbluth, Professor of Physics, UCSD
*Bruce Ross, Dep. Director and Head of Computing, Geophysical Fluid Dynamics Laboratory

SAMPLE FEEDBACK FROM PAC

"Strong Support for PSACI"

(1) central to future of this field in the US including key role in making case for future experimental facilities -- *cost-effective assessment of new ideas*

(2) present PSACI effort *vital for future access to advanced computing resources* -- *with or without* programs such as SSI and successors

(3) continue to build on recently-established positive image in the scientific community that this *field is ready for terascale computing*

PROPOSED TIMETABLE

- **Announce opportunites for coming year & encourage teaming within community (Sherwood Meeting, March 2000)**

- **Call (in April) and collect (in May) short (1 or 2 page) "intent to submit" descriptions from community**

- **Conduct next PAC Meeting (in June) to review progress on this year's projects; assess potential new areas of investment**

- **With input from PAC recommendations and PSACI Management Team assessments, OFES sends out solicitations for proposals in appropriate topical areas (in July)**

- **Peer review of proposals (in September)**

- **Funding distributed for selected proposals (in October)**

CONCLUSIONS

- **Plasma Science has excellent opportunity to take advantage of the exciting advances in Scientific Computing (coupled to Experiment and Theory) to accelerate scientific understanding and innovation in fusion research**

- **Positive Visibility/Stature of Plasma Science will be significantly enhanced by inclusion in the overall DOE Office of Science Advanced Computing Program**