

# Building the U.S. National Fusion Grid: The National Fusion Collaboratory Project

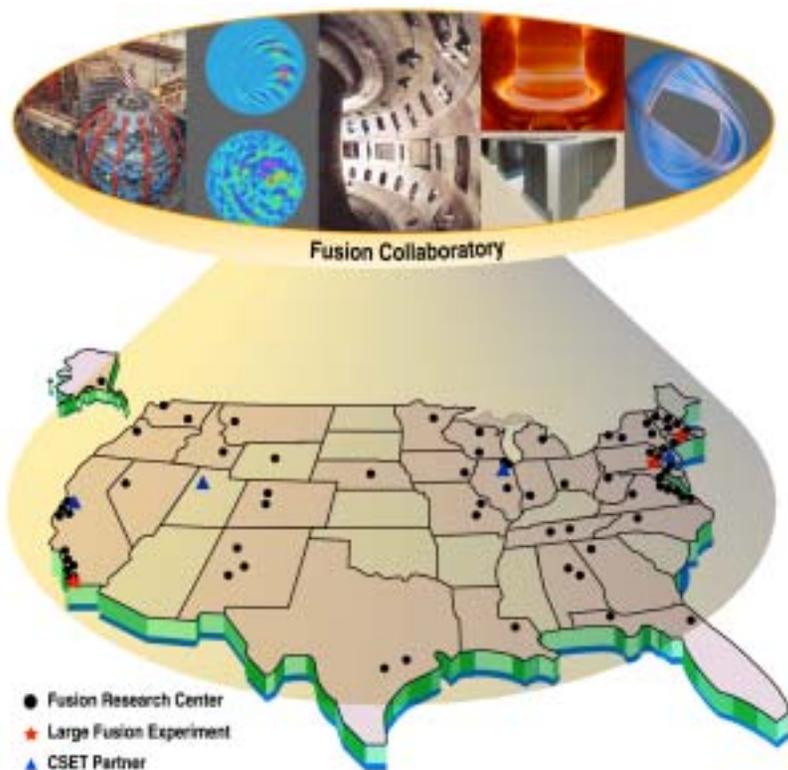


Presented by  
David P. Schissel

at  
4th IAEA TM  
Control, Data Acquisition,  
and Remote Participation  
for Fusion Research  
San Diego, CA



# THE GOAL OF THE NFC IS TO ADVANCE SCIENTIFIC UNDERSTANDING & INNOVATION IN FUSION RESEARCH



- **Experimental Facilities**
  - More efficient use resulting in greater progress with less cost
- **Theory & Modeling**
  - Integrate theory & experiment
- **Facilitate multi-institution collaboration**
  - Integrate geographically diverse groups
- **Create standard tool set**
  - To build in these services in the future

# VISION FOR THE FUSION GRID

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- **Data, Codes, Analysis Routines, Visualization Tools should be thought of as network accessible services**
- **Shared security infrastructure**
- **Collaborative nature of research requires shared visualization applications and widely deployed collaboration technologies**
  - **Integrate geographically diverse groups**
- **Not focused on CPU cycle scavenging or “distributed” supercomputing (typical Grid justifications)**
  - **Optimize the most expensive resource - people’s time**

# **VISION – RESOURCES AS SERVICES**

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- **Access is stressed rather than portability**
- **Users are shielded from implementation details**
- **Transparency and ease-of-use are crucial elements**
- **Shared toolset enables collaboration between sites and across sub-disciplines**
- **Knowledge of relevant physics is still required of course**

# VISION – SECURITY INFRASTRUCTURE

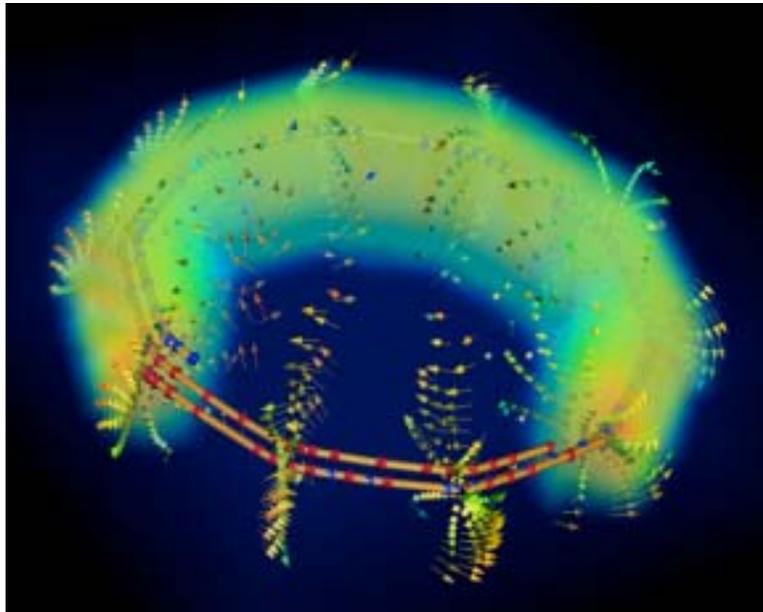
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- **Strong authentication identifies users**
- **Distributed authorization allows stakeholders to control their own resources**
  - **Facility owners can protect computers, data, and experiments**
  - **Code developers can control intellectual property**
  - **Fair use of shared resources can be demonstrated & controlled**

# VISION – VISUALIZATION AND A/V TOOLS

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- Maximum interactivity for visualization of very large datasets



- Use of extended tool sets for remote collaboration
  - Flexible collaboration environment
  - Shared applications

# THE COMPUTER SCIENCE RESEARCH NECESSARY TO CREATE THE COLLABORATORY IS CENTERED AROUND THREE AREAS

- **Security**

- Valuable resources need to be protected: data, codes, & vis tools
- Collaboratory requires authentication, authorization, and encryption
- Mutually authenticate both users and resources

- **Remote and Distributed Computing**

- Equitable sharing and preemptive data analysis
- Job scheduling, monitoring, exception handling, and accounting

- **Scientific Visualization**

- Increased data quantities and ease of collaboration requires better visualization technology
- Collaborative control & meeting rooms, and enhanced vis tools

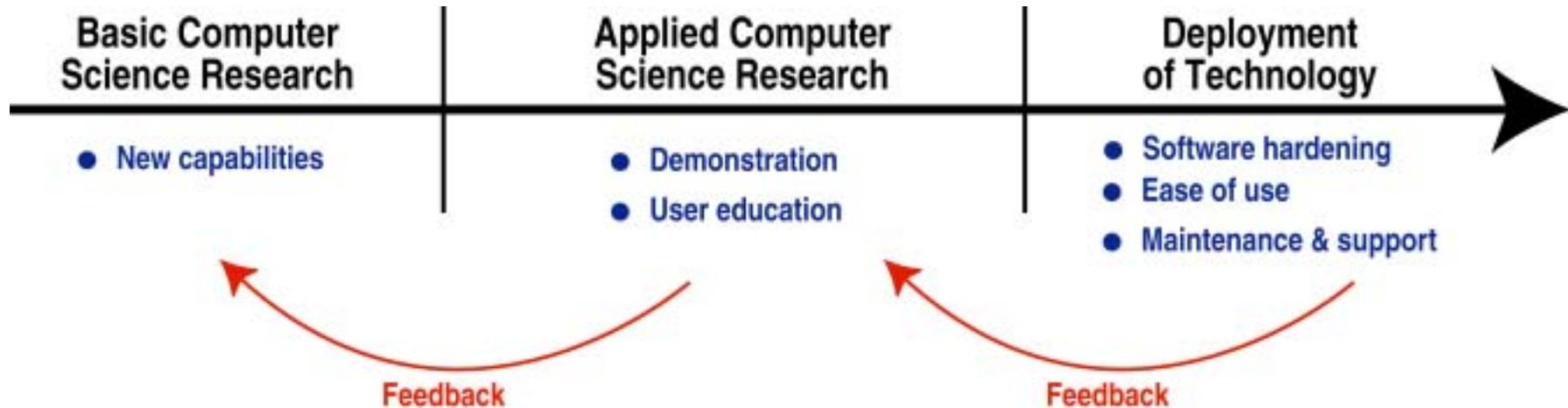
# THE NFC PROJECT HAS A DIVERSE TEAM

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- **ANL: Distributed Systems Lab**
  - Kate Keahey, Ian Foster, Sam Lang, Sam Meder, Von Welch
- **ANL: Futures Lab**
  - Mike Papka, Justin Binns, Ti Leggett, Rick Stevens
- **General Atomics: DIII-D Fusion Lab**
  - David Schissel, Gheni Abla, Justin Burruss, Sean Flanagan, Qian Peng
- **LBNL: Distributed Systems**
  - Mary Thompson, Abdeliah Essiari
- **MIT: C-Mod Fusion Lab**
  - Martin Greenwald, Tom Fredian, Josh Stillerman
- **Princeton Computer Science**
  - Adam Finkelstein, Kai Li, Grant Wallace
- **Princeton Plasma Physics Lab: NSTX Fusion Lab**
  - Doug McCune, Eliot Feibush, Tina Ludescher, Scott Klasky, Lew Randerson
- **U. of Utah: Scientific Computing and Imaging**
  - Allen Sanderson, Chris Johnson



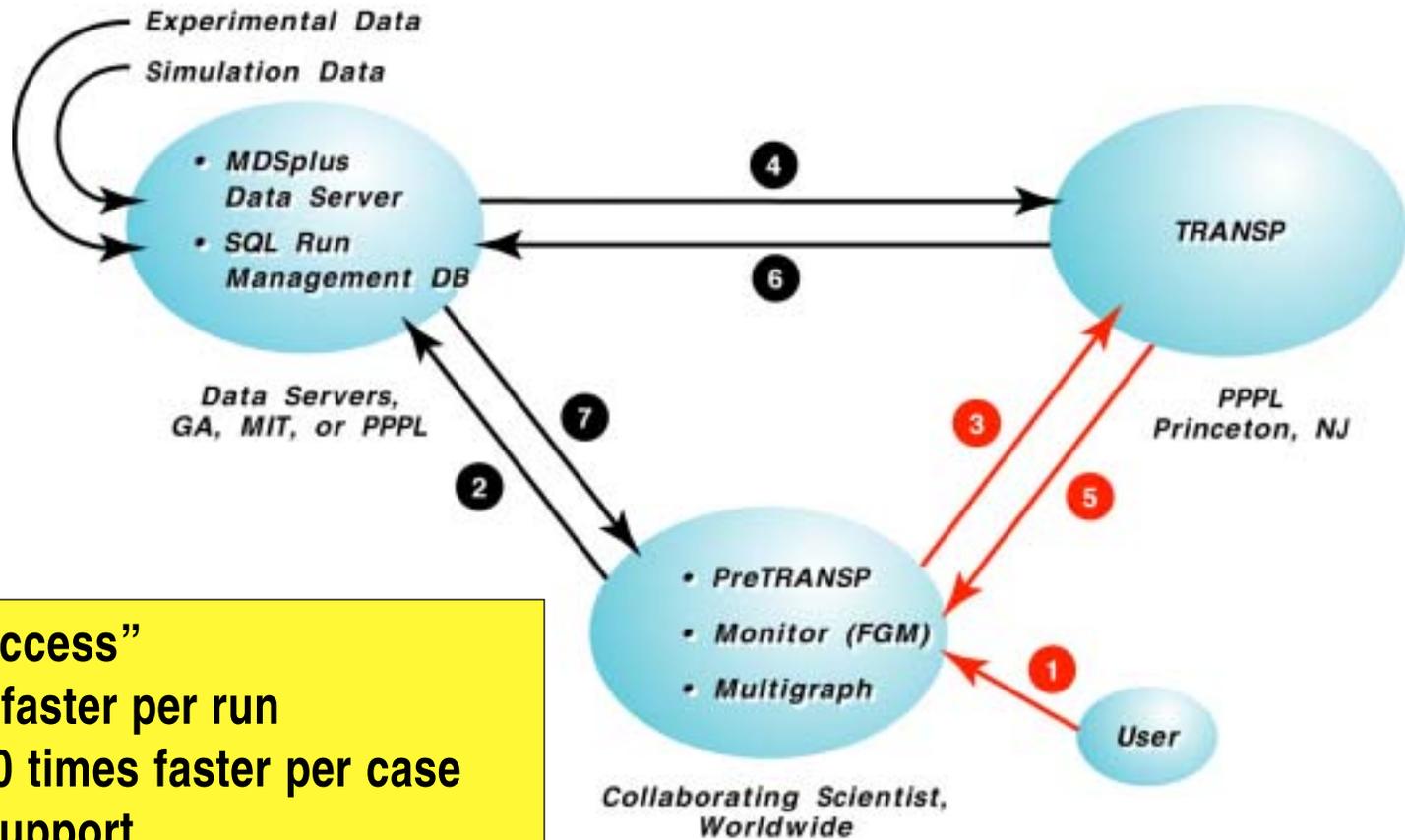
# THE NFC PROJECT IS INTEGRATING BASIC COMPUTER SCIENCE RESEARCH WITH DEPLOYMENT TO THE END USER



- Close coupling between basic and applied is valuable
  - Feedback easier with unified team

- Last step critical to advancing domain science
  - Publication in domain specific journal

# SUCCESSFUL GRID COMPUTING FOR FUSION SCIENCE



“This is a success”

- 4 times faster per run
- Up to 20 times faster per case
- Better support



# NFC ACCOMPLISHMENTS: REMOTE COMPUTING

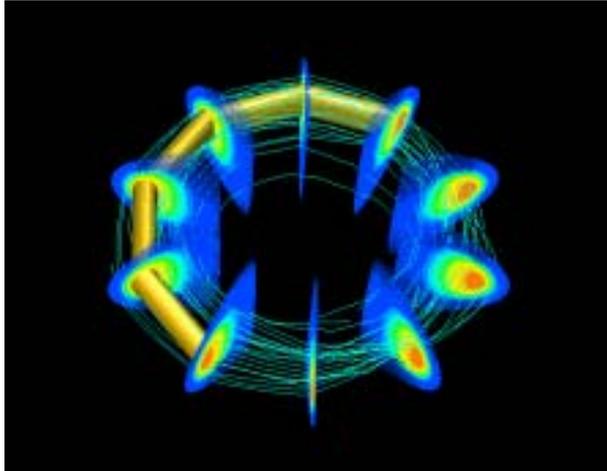
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- FusionGrid created: MDSplus data system secured with Globus GSI
- FusionGrid released with complete monitoring: TRANSP fusion code remotely accessible via Globus/Akenti and fine-grain authorization via GRAM
  - FusionGrid replaced old system, now supports U.S. TRANSP usage
  - Since October 2002: 900 runs
- Large demonstrations to the user community at 3 major fusion science meetings
  - Both user education and user feedback to the NFC team
- FusionGrid used for scientific calculations presented at the APS/DPP Mtg
  - Advancing the science
- Prototyped: between pulse pre-emptive scheduling, parallel MDSplus I/O
- GS2 low-frequency turbulence code being tested on FusionGrid
  - Considerably less time to grid-enable the second code



# SUCCESSFUL EDUCATION AND FEEDBACK ON POTENTIAL VISUALIZATION CAPABILITIES FOR FUSION SCIENCE

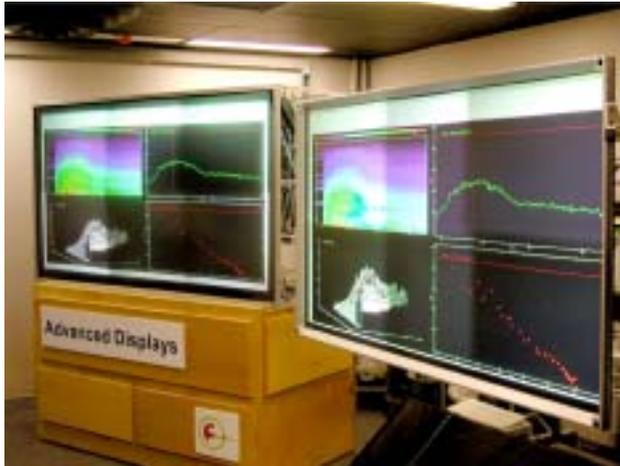
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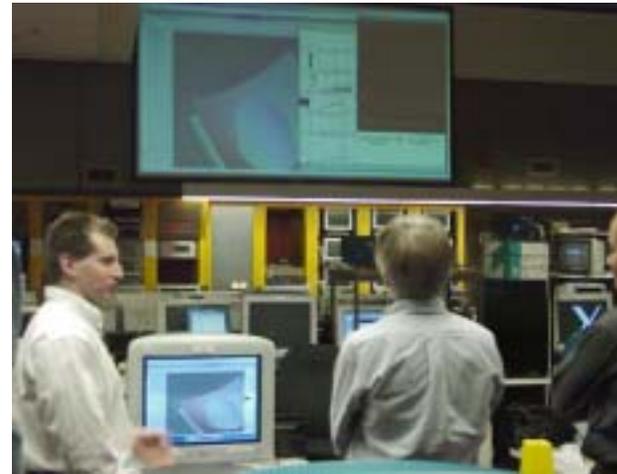
SCIRun visualization of NIMROD Data



Personal Access Grid



Shared Tiled Walls at ANL



Testing Tiled Wall at NSTX Control Room

# NFC ACCOMPLISHMENTS: VISUALIZATION

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- **SCIRun 3D visualization of NIMROD fusion data via MDSplus**
  - New capability in 3D visualization & animation via MDSplus data
- **SCIRun visualizations used for scientific work presented at APS/DPP**
  - Advancing the science
- **Access Grid functional on Tiled Wall as well as small scale system**
  - Allows investigation of diverse AG usage in fusion science
- **Collaborative Visualization: Wall to wall/workstation (VNC, DMX), ELVis**
  - Detailed analysis back into the control room
  - Collaborative working meetings

# GRID COMPUTING AND VISUALIZATION DEMONSTRATIONS EDUCATED THE USERS AND GAVE THE NFC FEEDBACK

2002 International Sherwood Fusion Conference – Rochester, NY



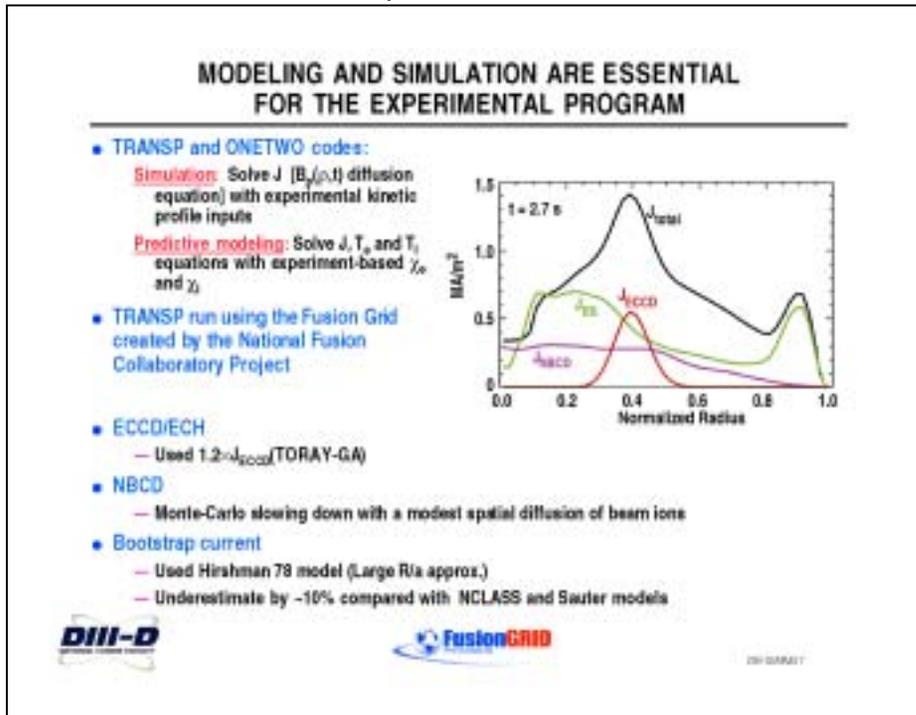
# MAJOR DEMONSTRATION AT THE NOV 2002 APS/DPP MEETING ATTENDED BY OVER 1000 FUSION SCIENTISTS

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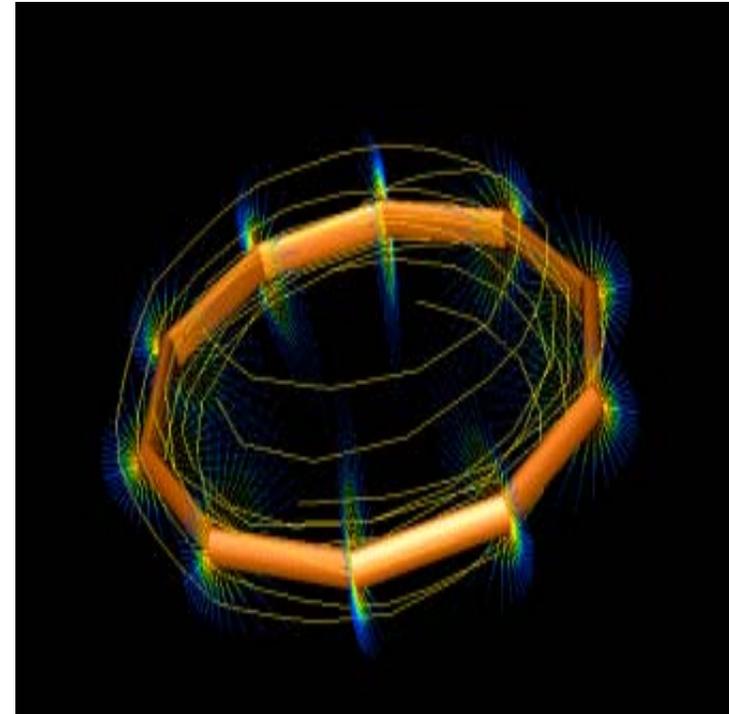
# NFC TOOLS USED TO CALCULATE AND PRESENT SCIENTIFIC RESULTS AT THE APS/DPP MEETING

M. Murakami 2002 APS/DPP



Greater number of TRANSP calculations than previously possible via FusionGrid

D. Brennan 2002 APS/DPP

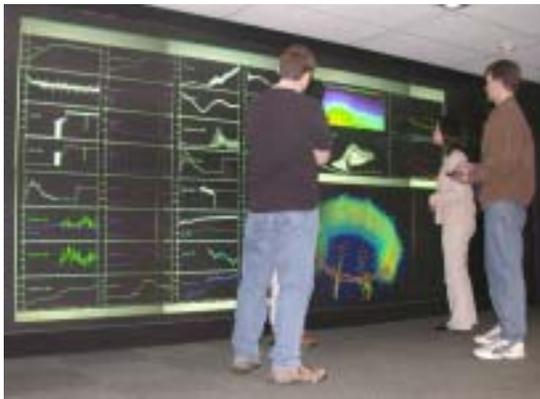


New capability in 3D visualization & animation via MDSplus stored data

# NFC'S TOOLS AND TECHNOLOGIES

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- **Secure MDSplus using Globus GSI available**
  - Authentication and Authorization using DOE CA
- **TRANSP available for worldwide usage on FusionGrid**
  - Beowulf cluster, client application, complete job monitoring
  - Secure access by Globus GSI, Akenti, DOE Grids CA
- **Personal Access Grid software and specifications available**
  - Installed at MIT and GA; PPPL has large AG node
- **SCIRun for 3D visualization including MDSplus stored Fusion data**
- **Toolkits for sharing visualization wall to wall and on AG**
  - Tiled walls at GA and PPPL



# WWW.FUSIONGRID.ORG

## PROJECT WEB SITE FOR COMMUNICATION AND SERVICES

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The National Fusion Grid is a [SciDAC](#) Collaboratory Pilot project to create and deploy collaborative software tools throughout the magnetic fusion research community. The goal of the project is to advance scientific understanding and innovation in magnetic fusion research by enabling more efficient use of existing experimental facilities and more effective integration of experiment, theory, and modeling.

### Project News:

#### GS2 Testing on FusionGrid:

March 2003, The second computational code on FusionGrid is being tested. [more »](#)

#### APS/DPP Meeting:

November 11 - 15, 2002, The US magnetic fusion scientist community gathered in Orlando, FL for their annual meeting. [more »](#)

#### Collaboratory Project Review: May 29

& 30, The Collaboratory Project will be reviewed in an open forum by an expert panel. [more »](#)

#### SuperComputing 2002: November 16 -

22, 2002, The Collaboratory demonstrated new capabilities. [more »](#)

Visit the Collaboratory Project archives for more [project news](#).

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[about the fusion\\_grid](#) | [fusiongrid research](#)

Last modified 04/29/03. Comments? [webmaster](#)



# **NEAR TERM FOCUS: SECURITY & EASE OF USE**

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- **Security (certificates & Firewalls)**

- Easy management for administrators, developers, users
- Must identify a workable solution for the diverse Fusion community
- Work with ESnet, DOE Science Grid, Fusion security people
- International usage
- Other authentication models (e.g. SecureID)

- **Authorization**

- Easy management of policy for administrators & service providers
- Finer granularity

- **FusionGrid packaging and support**

- Easier to install and manage system (one step rpm)
- Investigate light weight solution



## NEAR TERM FOCUS: SECURITY & EASE OF USE (2)

- **New services for FusionGrid**
  - Codes GS2, GYRO at the TCF, DCON
  - Faster data movement for larger datasets
  - Graphical extensions to FGM
  - MDSplus server at NERSC
- **On demand computation requires resource management**
  - Support for between plasma pulse data processing
  - Policy enforcement and dynamic accounts
- **Creating a new way of working: code developers and users**
  - New paradigm for resource sharing: accessibility versus portability
  - Tutorials and workshops (TTF, Sherwood, APS, lab visits)
  - Expanding documentation and web site

# THRUST OVER NEXT 18 MONTHS: SCIRun EASE OF USE

- **SCIRun and MDSplus**

- Usage for large datasets for interactive visualization
- MDSplus server at NERSC
- SCIRun as a service

- **SCIRun ease of use**

- Generalized MDSplus reader extending to all data
- 2D graphics
- Animation

- **SCIRun extensions and integration**

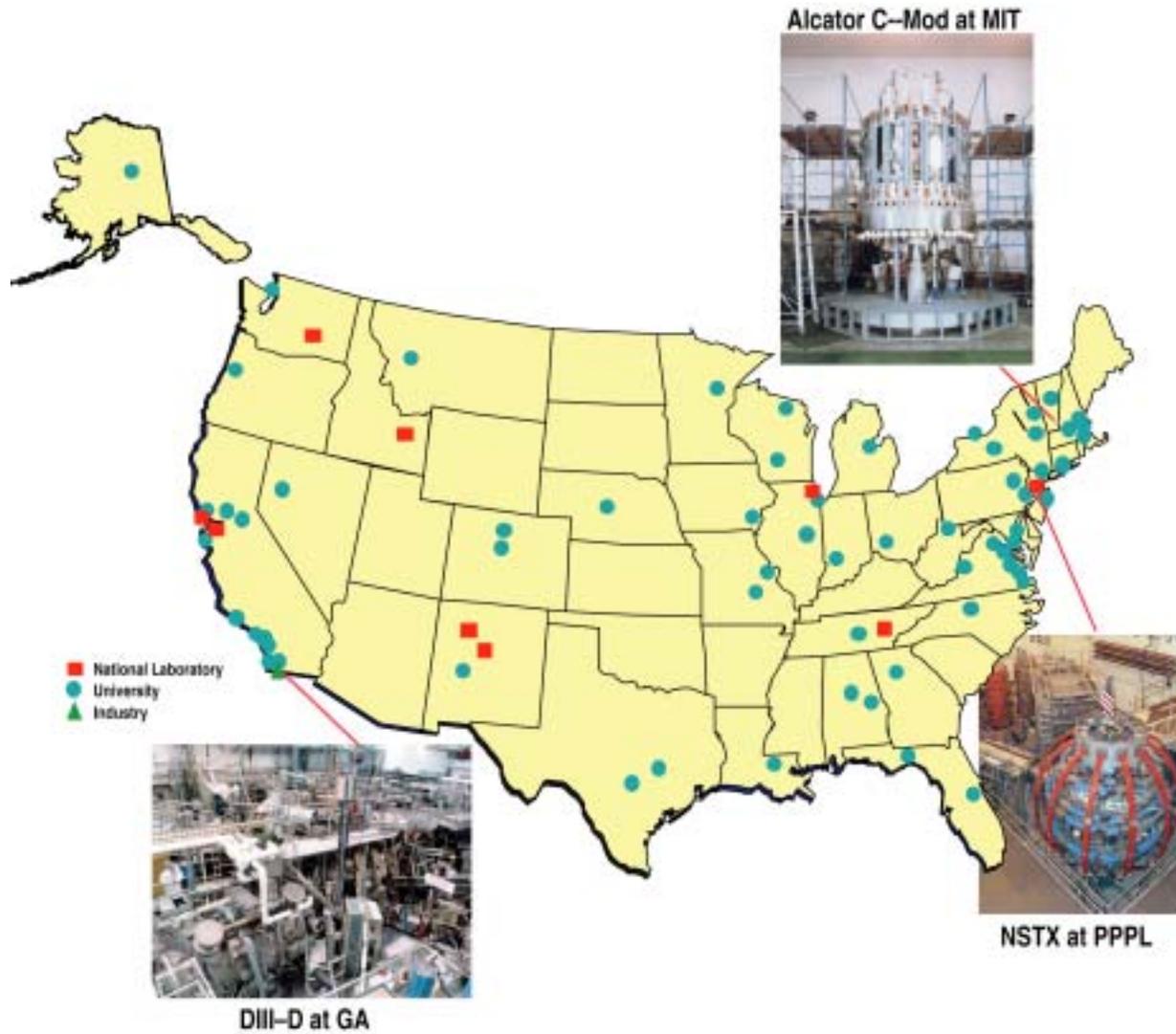
- Tiled wall and AG
- Uncertainty visualization

# **NEAR TERM FOCUS: COLLAB USAGE MODALITY**

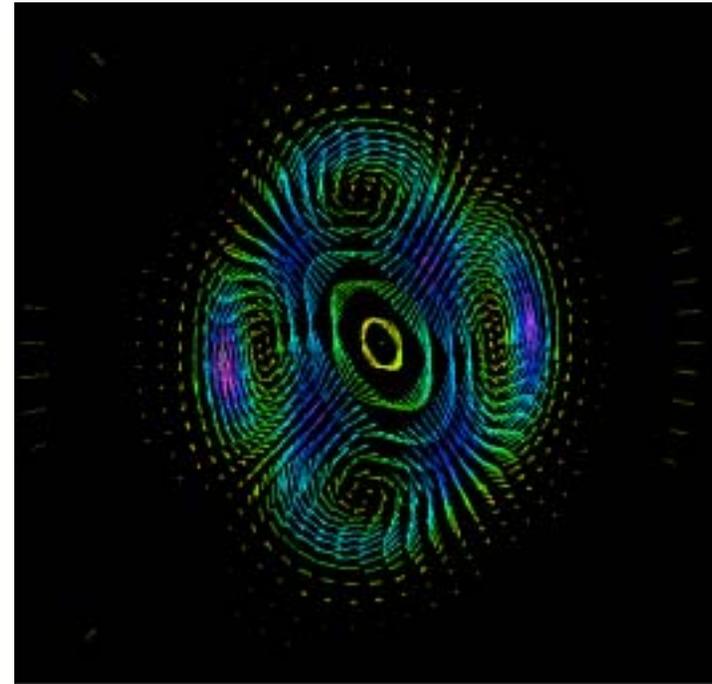
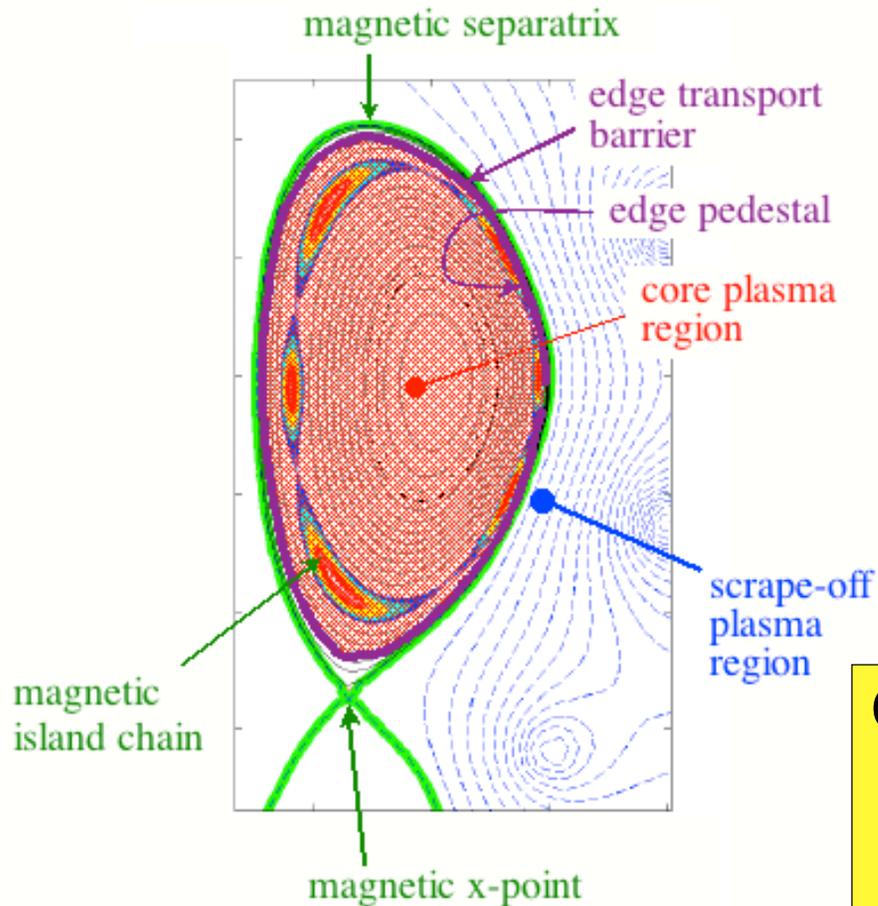
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- **Tiled wall: ease of use**
  - Real world usage in NSTX and DIII-D control rooms
  - Display and computer hardware evaluation
  - Multi-user control and control room issues
  - Interface and control issues for administration
- **Access Grid technology**
  - Real world C-Mod & DIII-D: meetings & control room
  - Flexible shared collaborative environment for one on one
  - Large scale AG node in control room?
  - Integrate with existing security model
  - Tiled wall integration
- **Creating a new way of working**
  - AG tutorials and workshops (TTF, Sherwood, APS, lab visits)
  - Expanding documentation and web site

# POTENTIAL NEW CUSTOMERS BEYOND OUR PRESENT SET



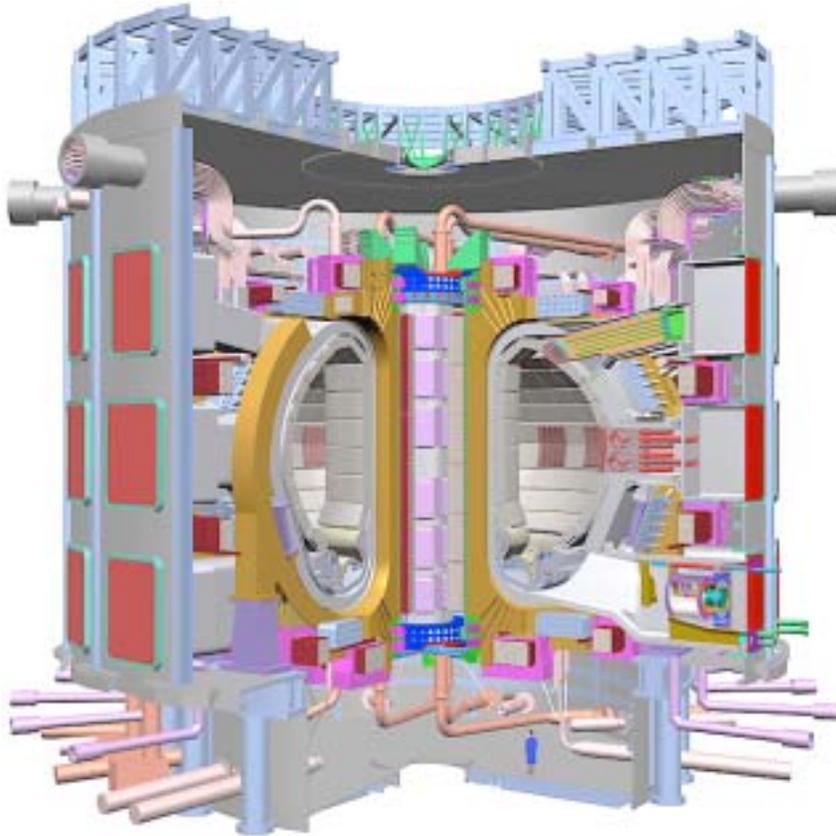
# FUSION SIMULATION PROJECT (FSP): INTEGRATED SIMULATION & OPTIMIZATION OF FUSION SYSTEMS



## Goals of joint OFES & OASCR Program:

- Comprehensive models
- Architecture for integration
- Computational infrastructure

# INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR: THE NEXT GENERATION WORLDWIDE FUSION EXPERIMENT



- ~\$5B class device, over 20 countries
  - Thousands of scientists, US rejoining
- Pulsed experiment with simulations
  - ~TBs of data in 30 minutes
- International collaboration
  - Productive engaging work environment for off-site personnel
- Successful operation requires
  - Large simulations, shared vis, decisions back to the control room
  - Remote Collaboration!

# CONCLUDING COMMENTS

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- **The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research**
  - Grid computing
  - Shared visualization and communication
- **Positive response from our user community**
  - Helping to advance fusion research
- **Collaborative technology critical to the long term success of fusion**
  - Experimentally today: 3 large facilities
  - Experimentally tomorrow: new large non-U.S. facility (e.g. ITER)
  - Computationally today: numerous simulation codes
  - Computation tomorrow: begin integrated simulation