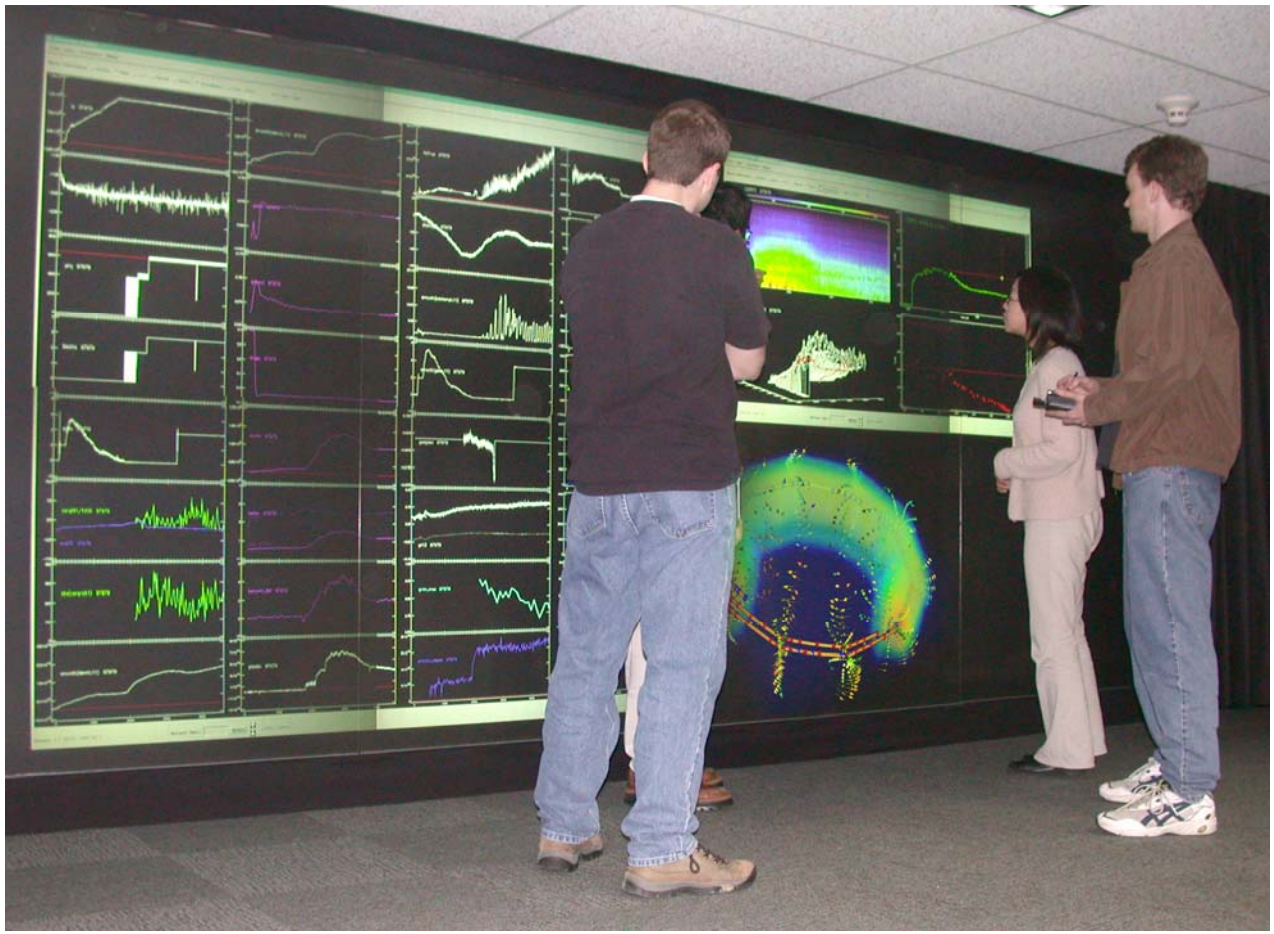
The National Fusion Collaboratory Project



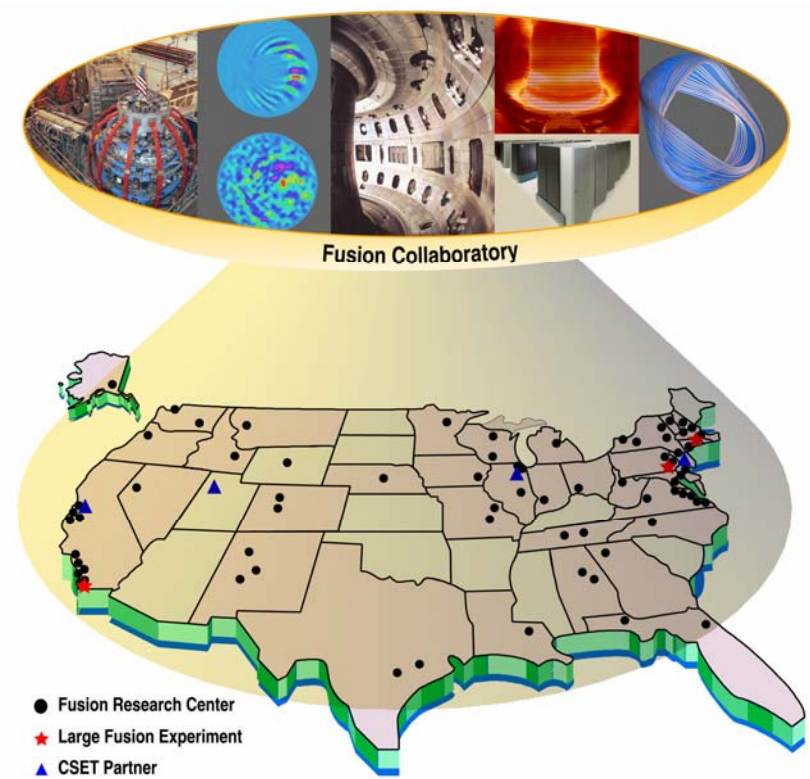
Presented by
David P. Schissel

at
The SciDAC PI Meeting
March 10-11, 2003
Napa, CA

THE NFC PROJECT HAS A DIVERSE TEAM

- ANL: Distributed Systems Lab
  - Kate Keahey, Ian Foster, 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
- 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
  - [illegible]on

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

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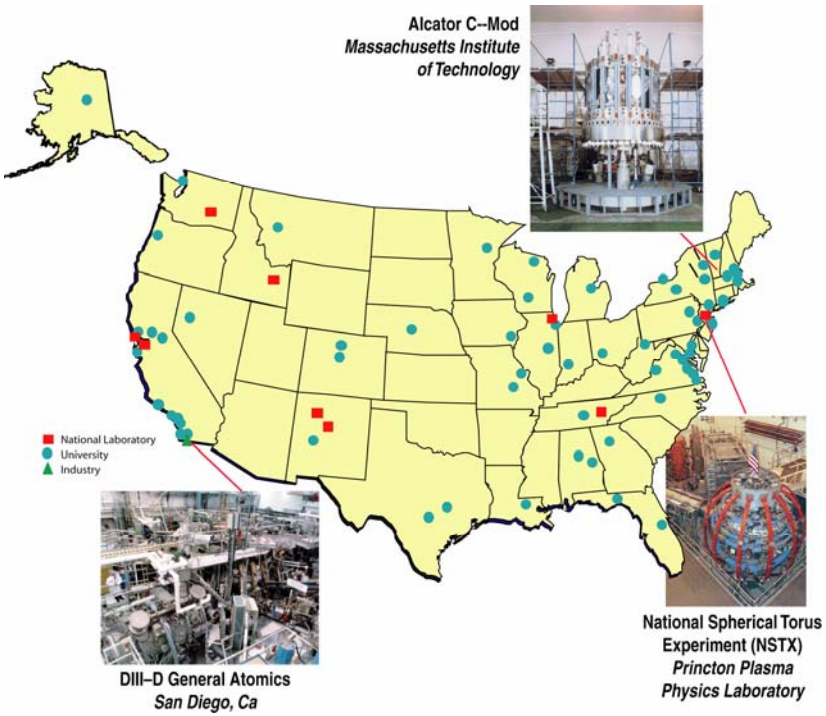
THREE LARGE U.S. EXPERIMENTAL FACILITIES AND A VIBRANT THEORETICAL COMMUNITY

Collaboratory is required to advance fusion science: geographically diverse community (37 states, 3 large experiments), leading to 1 worldwide experiment



- 3 Large Experimental Facilities
  - ~$1B replacement cost
- 40 U.S. fusion research sites
  - Over 1500 scientists
- Efficient collaboration is a requirement!
  - Integrate geographically diverse groups
- One future worldwide machine
  - Not based in US
  - US needs collaboration tools to benefit

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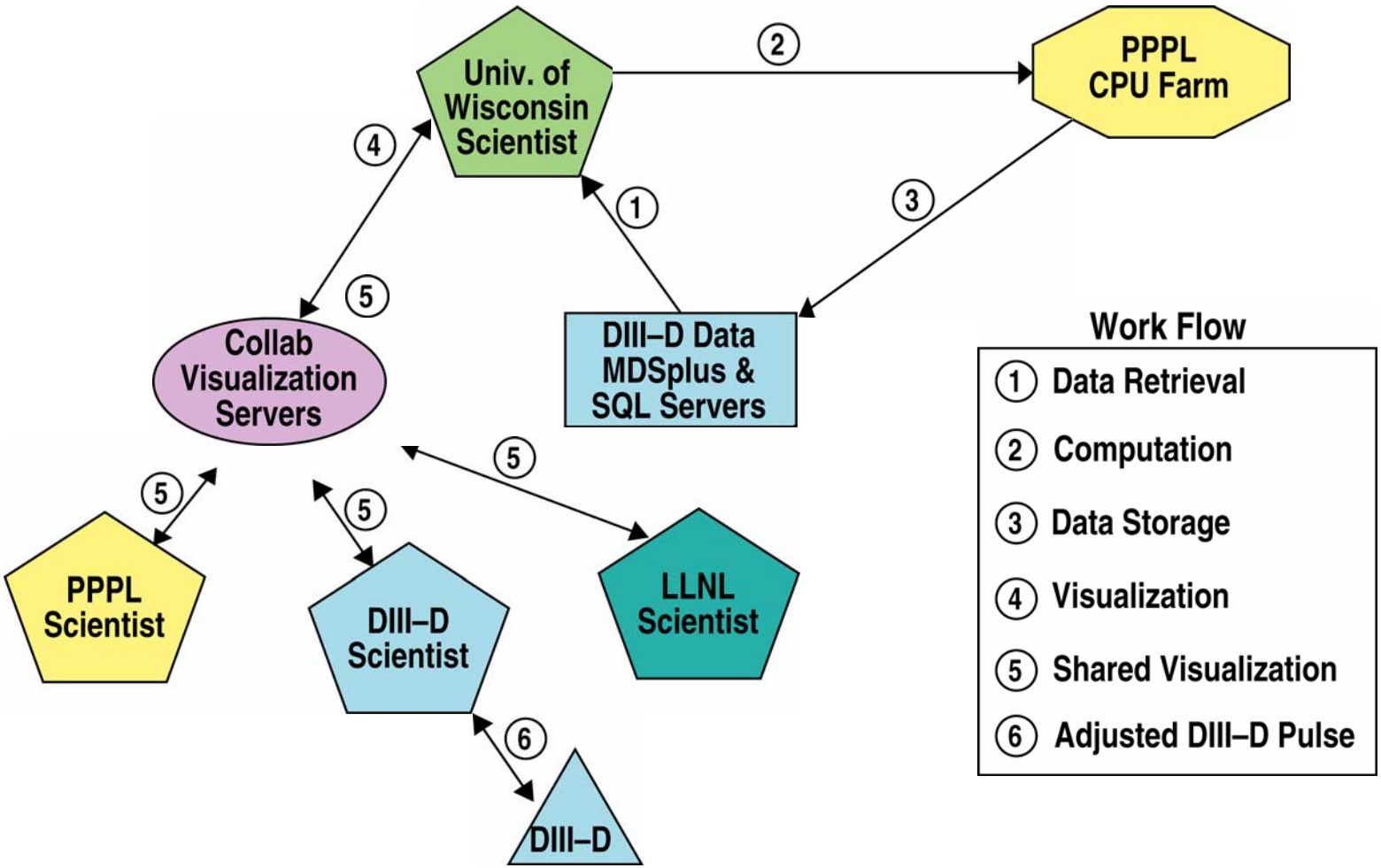
EXAMPLE OF COLLABORATORY BENEFITS: ENHANCED EXPERIMENTAL OPERATIONS



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

- Security (Globus & Akenti)
  - 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 (Globus & MDSplus)
  - Equitable sharing and preemptive data analysis
  - Job scheduling, monitoring, exception handling, and accounting

- Scientific Visualization (SCIRun, AG nodes, Tiled Walls)
  - Increased data quantities and ease of collaboration requires better visualization technology
  - Collaborative control & meeting rooms, and enhanced vis tools

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1ST YEAR NFC ACCOMPLISHMENTS: REMOTE COMPUTING

- 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
  - Sample statistics for October 2002: 300 runs, 1474 CPU hours
- Large demonstrations to the user community at 3 major fusion science meeting
  - 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

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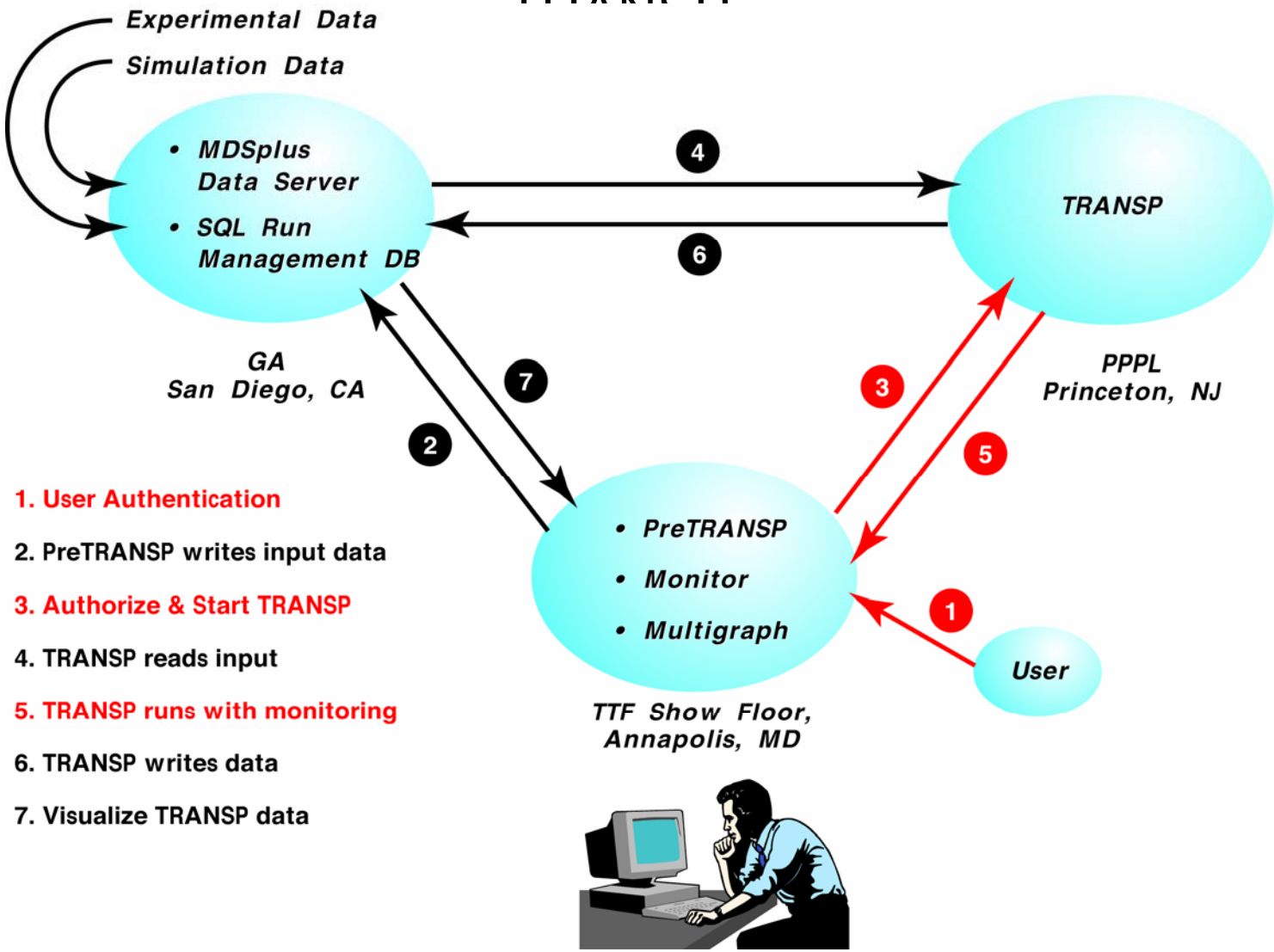
SUCCESSFUL USAGE OF GRID COMPUTING FOR TRANSP



1. User Authentication
2. PreTRANSP writes input data
3. Authorize & Start TRANSP
4. TRANSP reads input
5. TRANSP runs with monitoring
6. TRANSP writes data
7. Visualize TRANSP data

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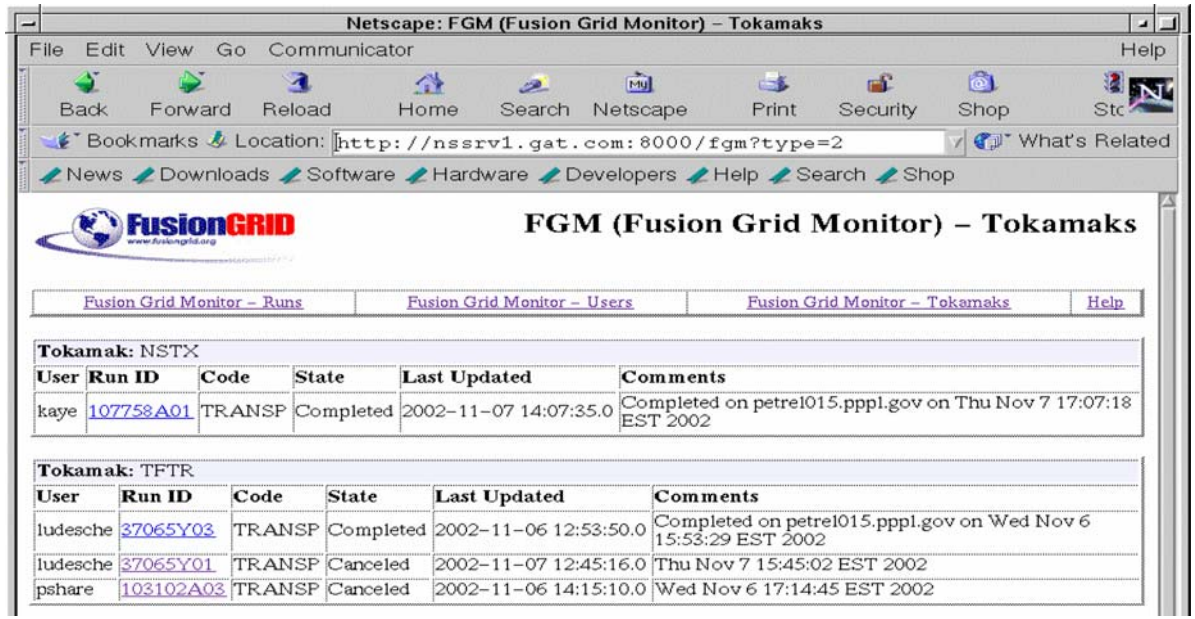
FUSION GRID MONITOR: A FAST AND EFFICIENT MONITORING SYSTEM FOR THE GRID ENVIRONMENT



- Derivative from DIII–D between pulse data analysis monitoring system
- Users track and monitor the state of applications on FusionGrid
  - Output dynamically via HTML, Detailed log run files accessible
- Code maintenance notification
  - Users notified, queuing turned off, code rebuilt, queue restarted
- Built as a Java Servlet (using JDK2.1)

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VISUALIZATION: COLLABORATIVE NATURE OF FUSION RESEARCH NECESSITATES A SHARED VIS ENVIRONMENT

- Strive to dramatically reduce the hurdles that presently exist for collaborative scientific visualization

- Leverage existing technology where possible
  - SCIRun for advanced scientific visualization
  - Access Grid (AG) for large remote audio/video interactions
  - Integrate existing AG collaborative tools with tiled display walls

- Collaborative Control Room
  - Large on–site group interactively work with small to large off–site group

- New visualization software
  - Simultaneous sharing of complex visualization
  - Error representation in complex experimental & simulation data

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1ST YEAR NFC ACCOMPLISHMENTS: VISUALIZATION

- 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 (PIG)
  - 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

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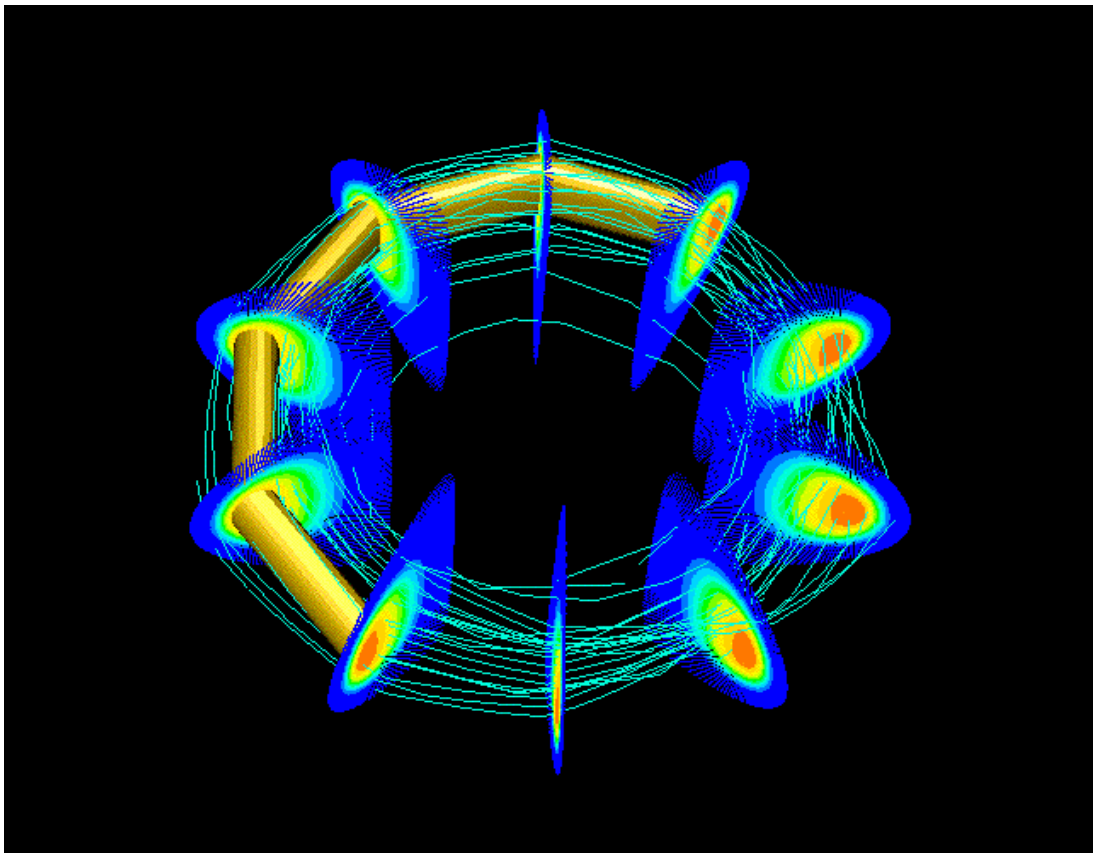
ADVANCED VISUALIZATION USING SCIRun



SCIRun visualization of NIMROD Pressure Simulation

- SCIRun adapted for Fusion
  - Utah Imaging Institute
  - Open source, low cost, customizable
- NIMROD data from MDSplu
  - Testing storage paradigm
- Deployable hardware path
  - Linux vis stations
  - Low cost

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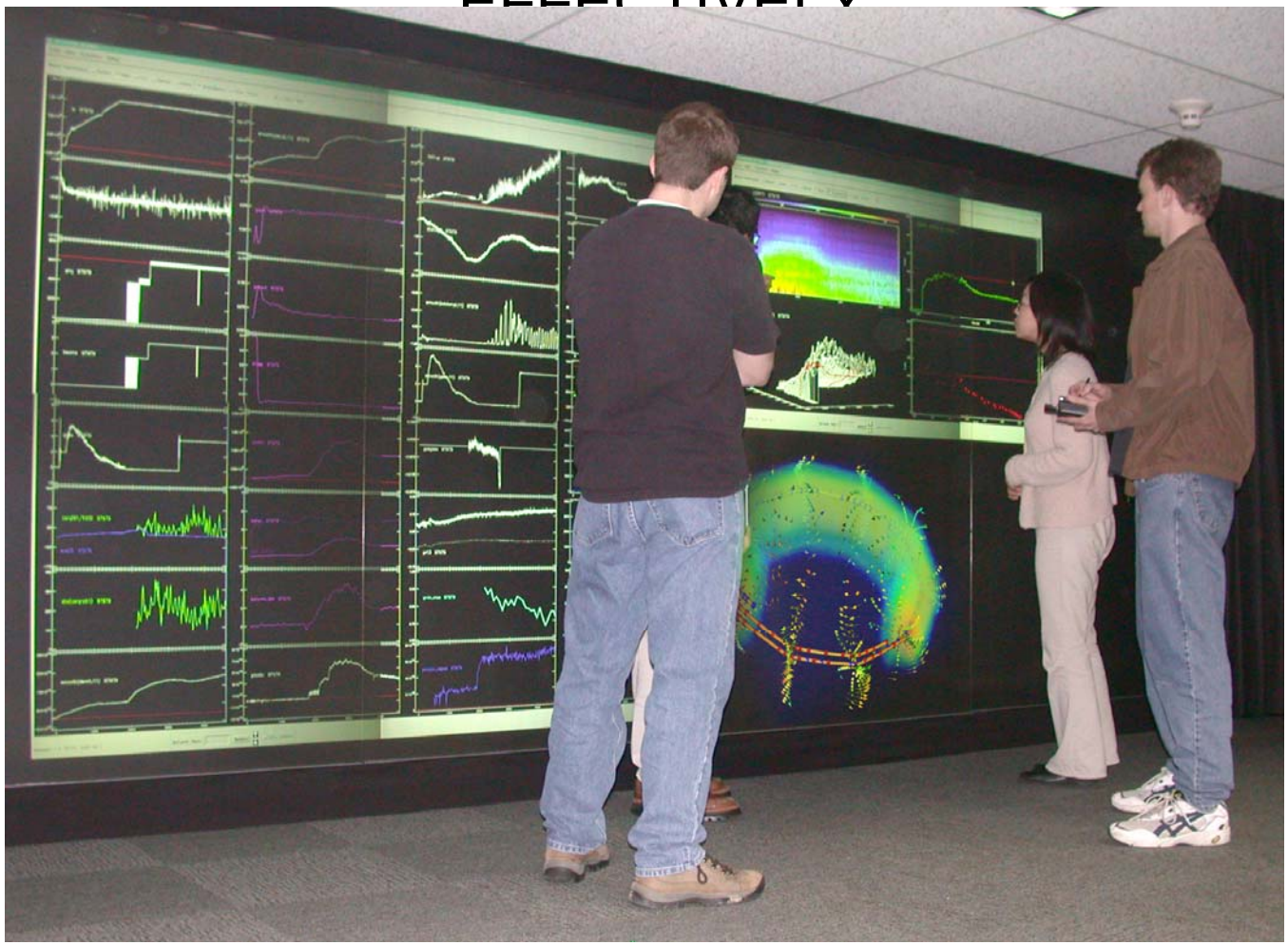
TILED DISPLAY WALLS ALLOW A LARGE GROUP TO EXPLORE INFORMATION IN COLLABORATION MORE EFFECTIVELY



General Atomics Advanced Imagery Laboratory

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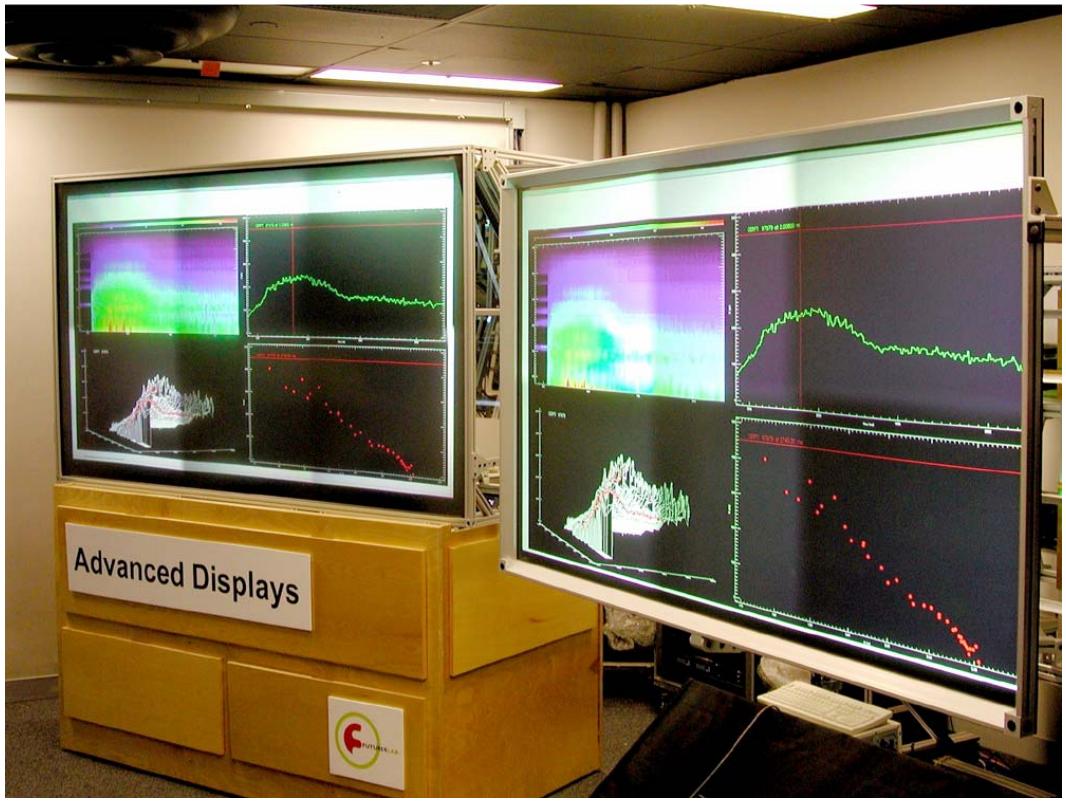
SHARED VISUALIZATION BETWEEN TILED WALLS HAS BEEN DEMONSTRATED



ANL Futures Laboratory

- Workstation to workstation or wall possible – control room communication
- Demonstrated from Chicago – San Diego & PCS – PPPL

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

2002 International Sherwood Fusion Conference – Rochester, NY

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FIRST YEAR'S WORK CULMINATED IN A FULL DEMONSTRATION AT THE NOV 2002 APS/DPP MEETING ATTENDED BY OVER 1000 FUSION SCIENTISTS

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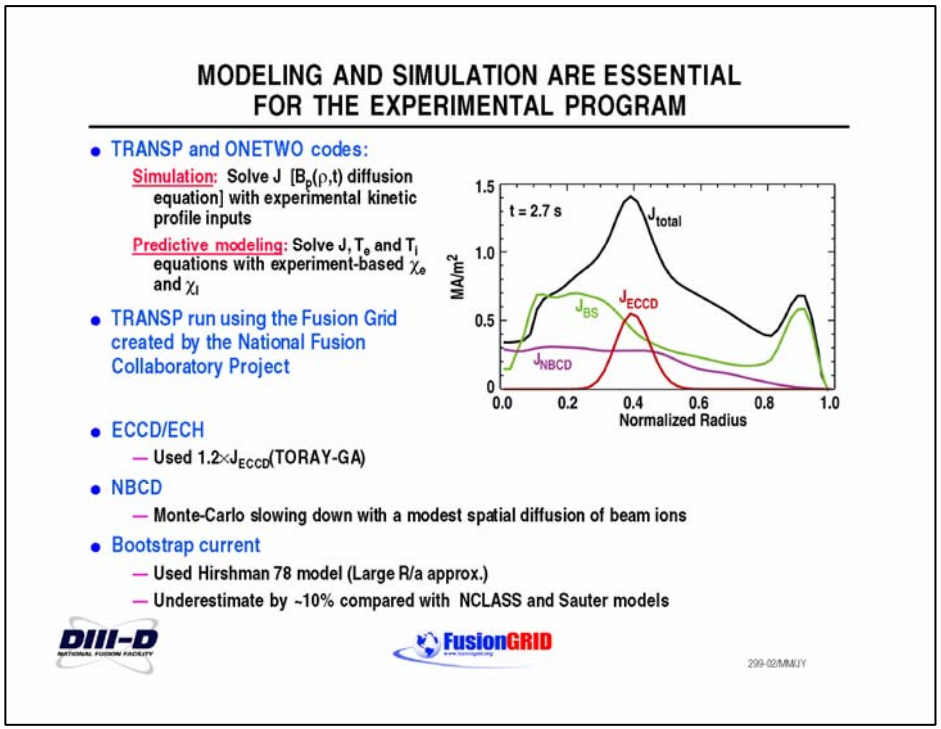
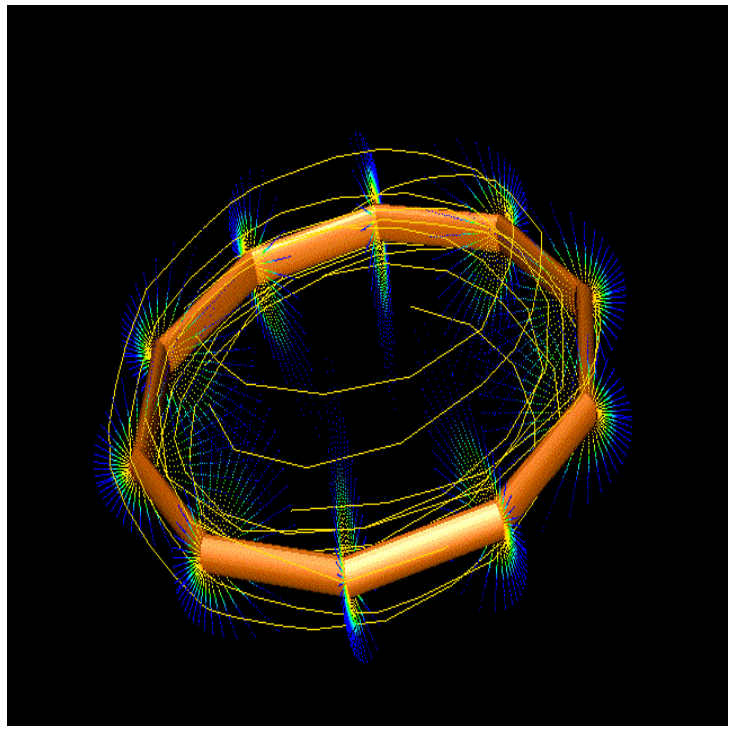
NFC TOOLS USED TO CALCULATE AND PRESENT SCIENTIFIC RESULTS AT THE APS/DPP MEETING

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

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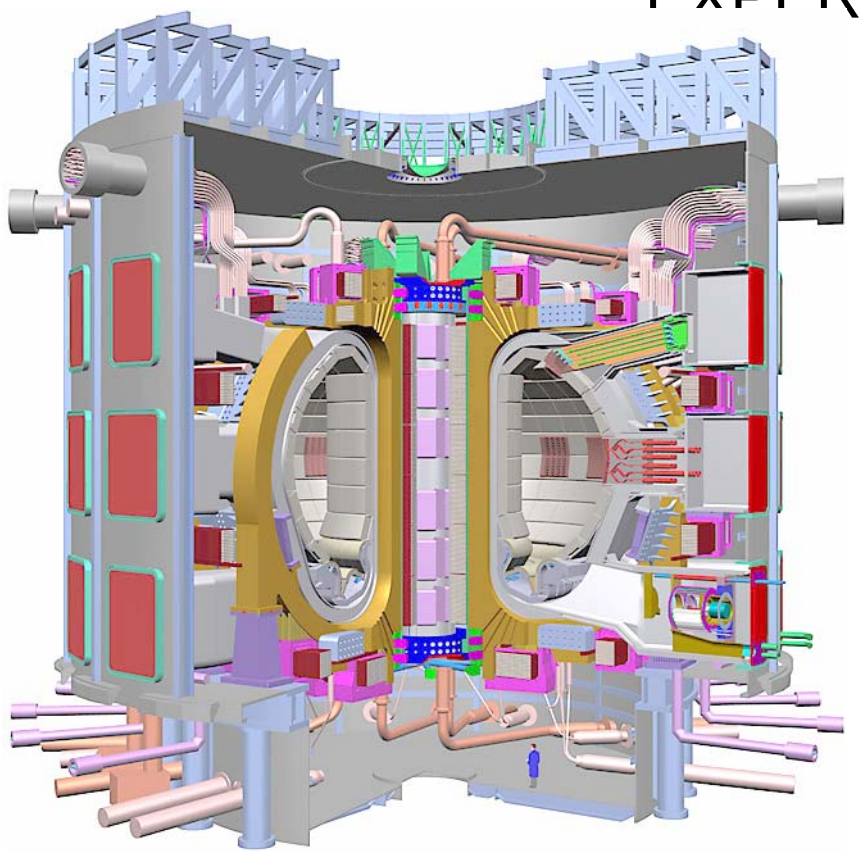
INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR:

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, decisio back to the control room
  - Remote Collaboration!

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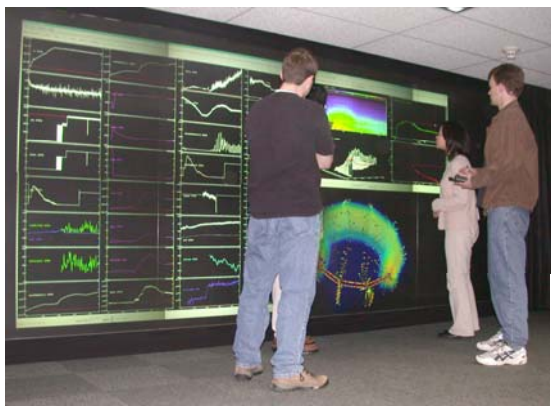
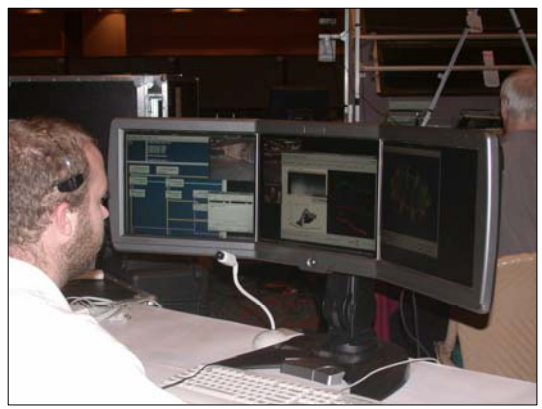
NFC'S TOOLS AND TECHNOLOGIES

- 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 (PIG) 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





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NFC'S COLLABORATIONS AND INTERACTIONS WITH OTHER SCIDAC PROJECTS

- SciDAC Center for Extended Magnetohydrodynamic Modeling
  - NIMROD data in MDSplus visualized by SCIRun presented at APS/DPP
- SciDAC Plasma Microturbulence Project
  - GS2 code being tested on FusionGrid for broader & easier usage
- Plasma Science Advanced Computing Institute (PSACI)
  - Strong endorsement of NFC plans & accomplishments by PSACI PAC
- Data Grid Toolkit; Security & Policy for Group Collaboration; Distributed Security Architecture
  - Secure access, authentication, authorization, Globus GSI/Akenti
- Particle Physics Data Grid; DOE Science Grid
  - Site security,Firewalls, and Grid security; CA for FusionGrid
- Middleware to Support Group to Group Collaboration
  - AG development: user education & testing & feedback
- eServices Infrastructure for Collab Science; Portal Web Services
  - NFC & Fusion science as customer

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CONCLUDING COMMENTS

- The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research
  - Grid computing
  - Shared visualization and communication

- Collaborative technology critical to the success of fusion
  - Experimentally: one large machine in the future – ITER
  - Theoretically: complete plasma simulation – FSP

Imagine a world in which our cars are driven by hydrogen and our homes are heated by electricity from a fusion power plant. It'll be a totally different world than what we're used to. The quality of life will be advanced.

– President George W. Bush, February 6, 2003

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