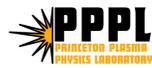


Building the National Fusion Grid

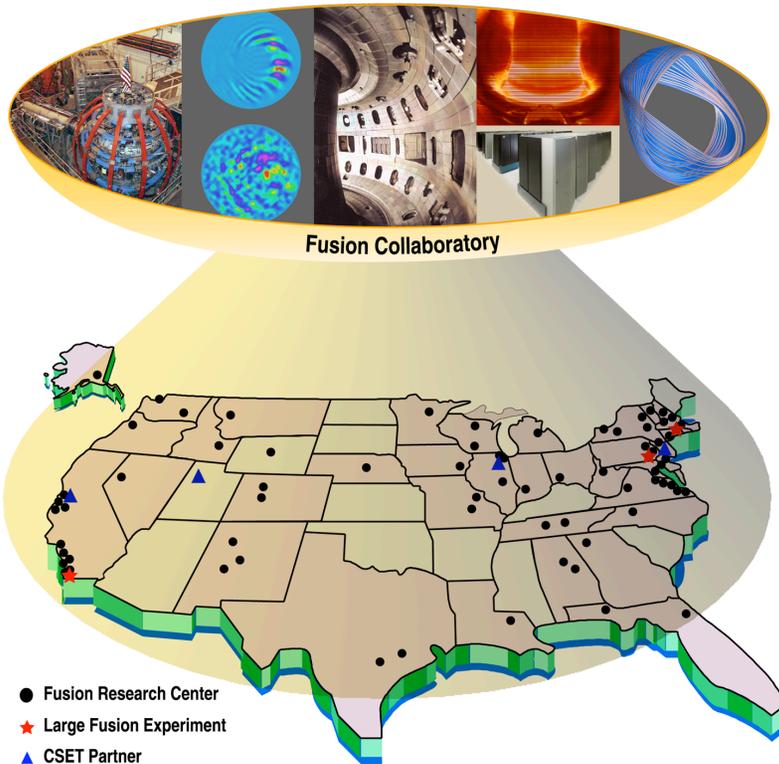


Presented by
David P. Schissel

at
**2003 Joint US-European
Transport Task Force Meeting
Madison, WI**



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

- **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

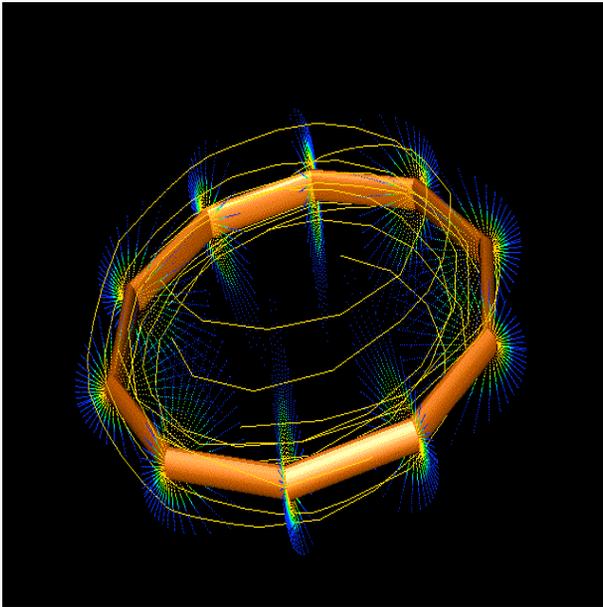
- **Access is stressed rather than portability**
- **Users are shielded from implementation details**
- **Transparency and ease-of-use are crucial elements**
- **Shared toolset enables collaboration between sites and across sub-disciplines**
- **Knowledge of relevant physics is still required of course**

VISION – SECURITY INFRASTRUCTURE

- **Strong authentication identifies users (currently based on X.509 certificates from the DOE Grids CA)**
- **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

- **Maximum interactivity for visualization of very large datasets**



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

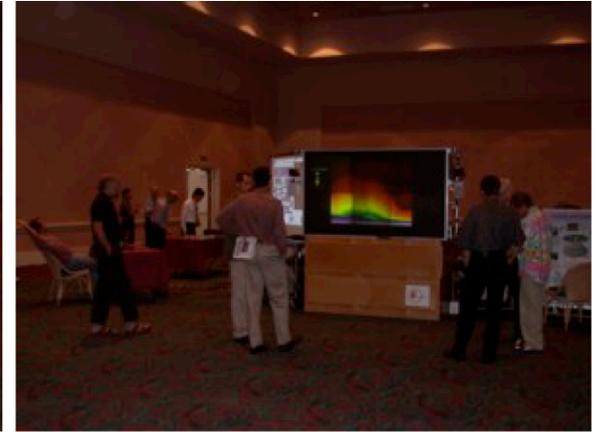
FUSION SCIENCE PROGRAMS' INPUT ACTIVELY SOUGHT

- **Presence at scientific meetings in April 2002 and APS/DPP in November 2002**
 - Both the experimental and theoretical user community
 - First of their kind demonstrations at these meetings

- **Demonstrations to the large experimental teams**
 - Shared visualization ANL to San Diego and PCS to PPPL

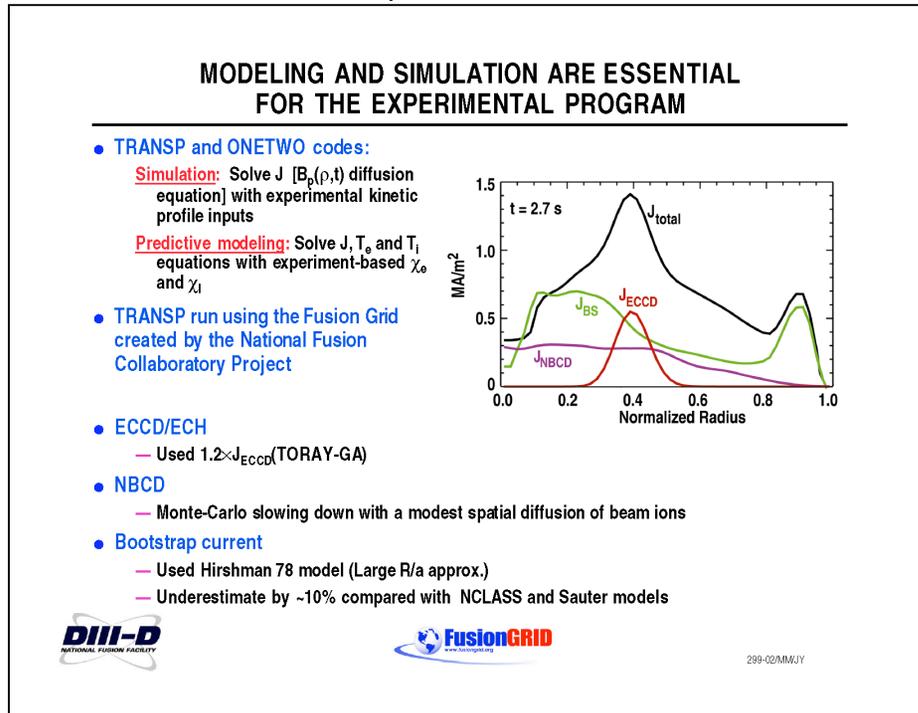
- **Comments and discussions with Oversight Committee**
 - Represents broad cross-section of fusion community

FIRST YEAR'S WORK CULMINATED IN A FULL DEMONSTRATION AT THE NOV 2002 APS/DPP MEETING



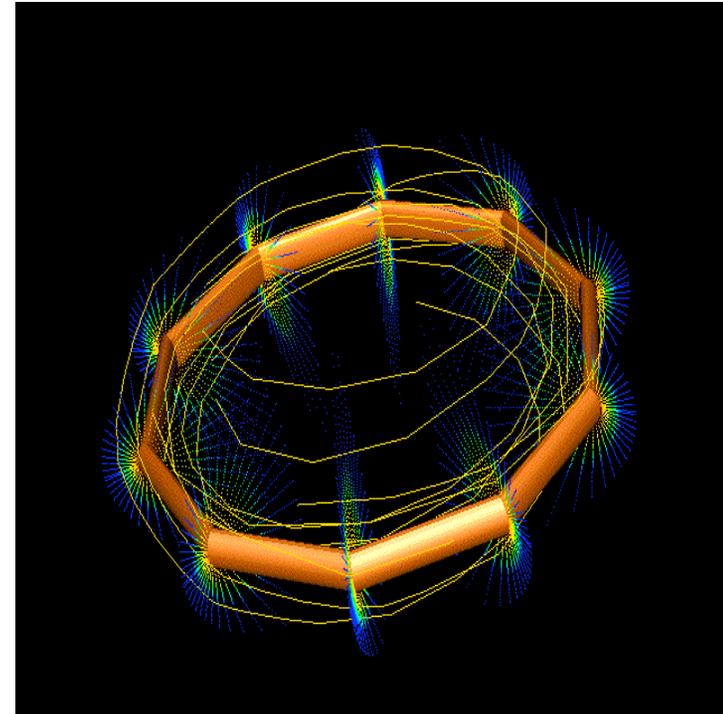
NFC TOOLS USED TO CALCULATE AND PRESENT SCIENTIFIC RESULTS AT THE APS/DPP MEETING

M. Murakami 2002 APS/DPP



Greater number of TRANSP calculations than previously possible via FusionGrid

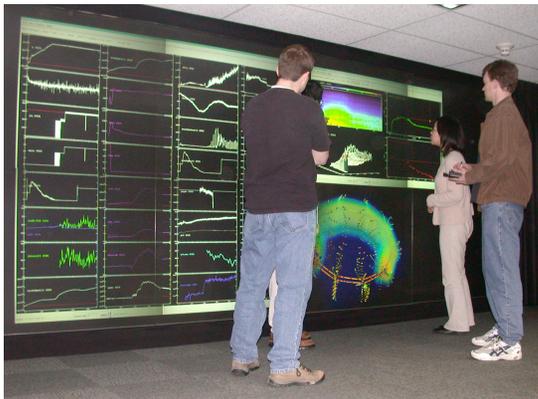
D. Brennan 2002 APS/DPP



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

NFC'S TOOLS AND TECHNOLOGIES

- **Secure MDSplus using Globus GSI available**
 - Authentication and Authorization using DOE Grids 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



A GRID IS A COLLECTION OF HARDWARE & SOFTWARE RESOURCES SHARED BY ONE PROJECT

The Grid refers to the infrastructure that enables the integrated collaborative use of high-end computers, networks, databases, and scientific instruments owned and managed by multiple organizations.

- **Resource owners decide which of their resources to contribute**
 - Authentication keeps the Grid secure
- **Not all Grid members can use all resources**
 - Authorization allows finer grain access control to resources
- **Single sign-on keeps eliminates the need to log into multiple machines**
 - User logs into the Grid only one time
 - Delegated credential accompanies all resource requests

MDSplus IS WIDELY USED IN THE FUSION COMMUNITY



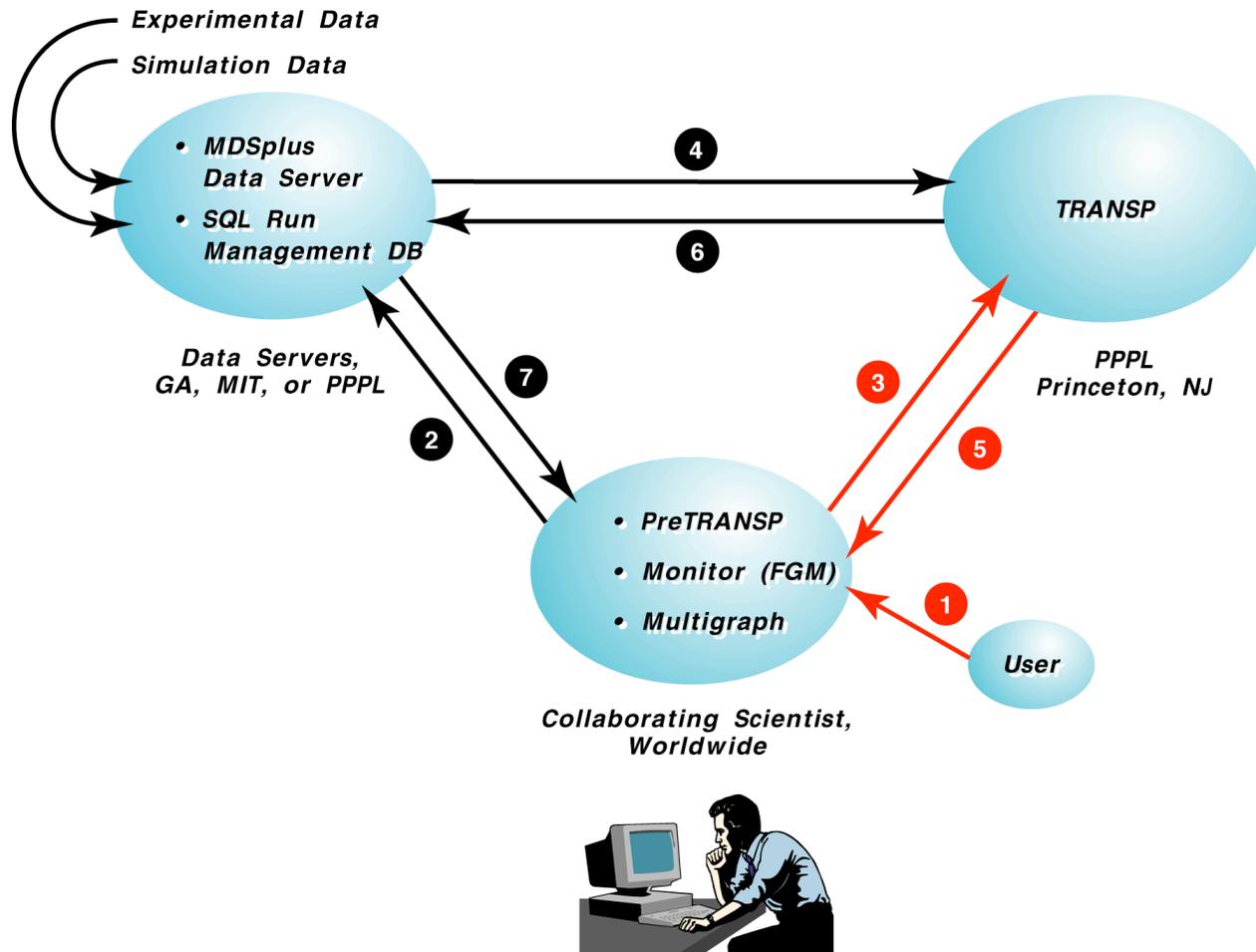
MDSplus Servers Installed at Fusion Sites

- | | |
|---|--|
| Asdex-U (Max-Planck, IPP, Germany) | LDX (MIT, Cambridge) |
| CHS (NIFS, Toki, Japan) | MST (U. of Wisconsin, Redmond) |
| C-Mod (MIT, Cambridge) | MTF (LANL, Los Alamos) |
| CTX (Columbia U.- NYC) | Nimrod (NERSC - Oakland, CA) |
| DIII-D (GA, San Diego) | NSTX (PPPL, Princeton, NJ) |
| FRX-L (LANL, Los Alamos) | PISCES (UCSD, San Diego) |
| FTU (Frascati, Italy) | RFX (IGI, Padua, Italy) |
| gs2 (U. Md. - College Park, Md) | T-10 (Kurchatov, Moscow, Russia) |
| H1 (ANU, Canberra, Australia) | TCS (U. of Washington, Seattle) |
| HANBIT (Taejon, Korea) | TCV (EPFL, Lausanne, Switzerland) |
| HBT-EP (Columbia U.- NYC) | TH-7U (Tianjin U., China) |
| HIT (U. of Washington, Seattle) | TIP (U. of Washington, Seattle) |
| ITPA Database Group | ZAP (U. of Washington, Seattle) |
| JET (Culham, UK - EFDA) | |

MDSplus ENHANCEMENTS FOR COLLABORATORY

- MDSplus is the data management system for FusionGrid
- MDSplus data system secured with Globus GSI
 - Underlying technologies are X.509 certificates/SSL
- Will use MDSplus layer to secure PC based relational database (SQL Server)
- Parallel MDSplus I/O – gridpst (Grid parallel socket tunnel)
- Important shared fusion codes modified to use MDSplus for I/O
 - EFIT, TRANSP, gs2, NIMROD
- Looking at remote job submission through MDSIP

TRANSP IMPLEMENTED AS FUSION GRID SERVICE



TRANSP – Tools for time dependent analysis & simulation of tokamak plasmas

TRANSP SERVICE

- **Advantages of Grid implementation**
 - Remote sites avoid costly installation and code maintenance
 - PPPL maintains and supports a single production version of code on well characterized platform
 - Trouble-shooting occurs at central site where TRANSP experts reside
 - Benefits to users and service providers alike
- **Production system: since October 1, 2002**
 - 16 processor Linux cluster
 - Dedicated PBS queue
 - Tools for job submission, cancellation, monitoring
 - 21 Grid certificates issued, 7 institutions (1 in Europe)
- **Four European machines interested**
 - JET, MAST, ASDEX-U, TEXTOR
 - Concerns: understanding software, firewalls, grid security

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

Fusion Grid Monitor - Tokamaks

[Fusion Grid Monitor - Runs](#) [Fusion Grid Monitor - Users](#) [Fusion Grid Monitor - Tokamaks](#) [Help](#)

Tokamak: NSTX

User	Run ID	Code	State	Last Updated	Comments
kaye	107758A01	TRANSP	Completed	2002-11-07 14:07:35.0	Completed on petrel015.pppl.gov on Thu Nov 7 17:07:18 EST 2002

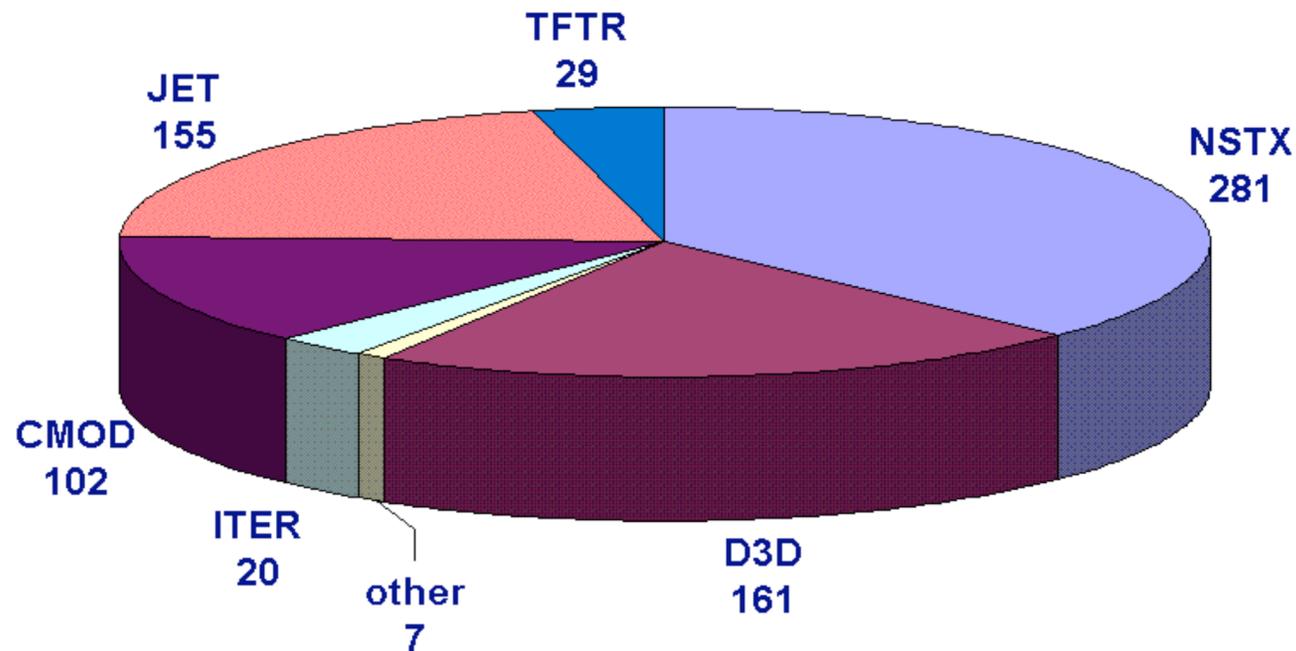
Tokamak: TFTR

User	Run ID	Code	State	Last Updated	Comments
ludesche	37065Y03	TRANSP	Completed	2002-11-06 12:53:50.0	Completed on petrel015.pppl.gov on Wed Nov 6 15:53:29 EST 2002
ludesche	37065Y01	TRANSP	Canceled	2002-11-07 12:45:16.0	Thu Nov 7 15:45:02 EST 2002
pshare	103102A03	TRANSP	Canceled	2002-11-06 14:15:10.0	Wed Nov 6 17:14:45 EST 2002

- 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)

FUSION GRID TRANSP RUN PRODUCTION

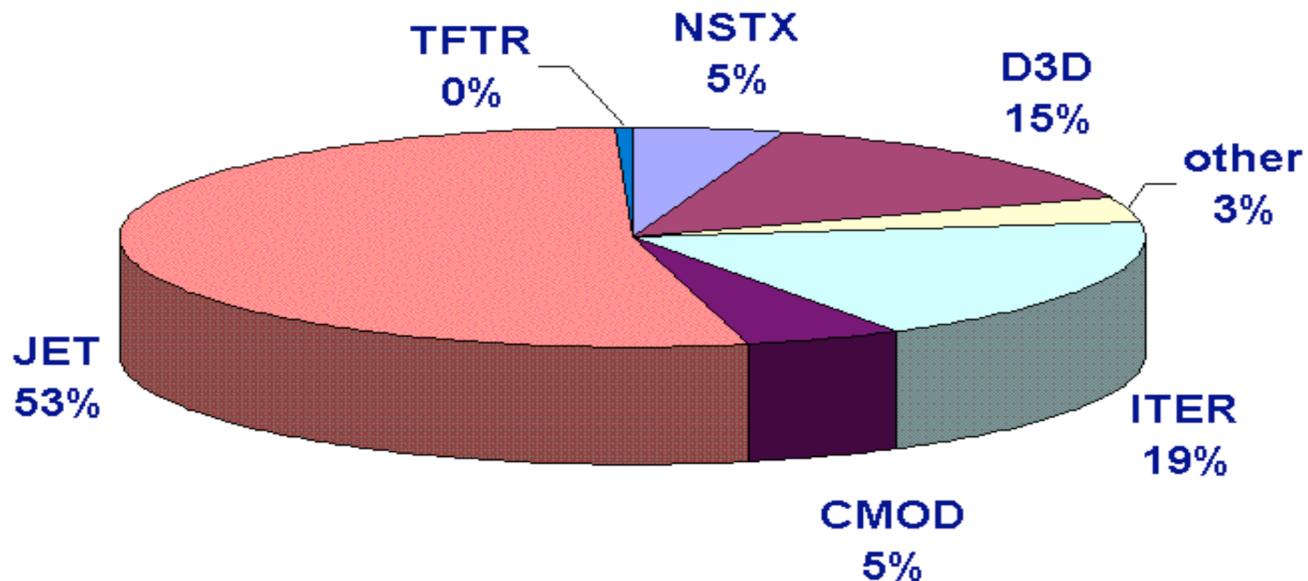
755 Runs: Oct. 1, 2002 – Mar. 21, 2003



Research Users: CMod, DIII-D, NSTX projects; PPPL Collaborations.

FUSION GRID TRANSP SERVER UTILIZATION

4,657 CPU Hours: Oct 1, 2002 – Mar 21, 2003.



1.7GHz Pentium-4 (Linux) – capacity for 16 concurrent runs.

HOW TO JOIN FUSIONGRID

- **Each user and host on FusionGrid is represented by an X.509 certificate and its corresponding private key**
 - Used by Globus SSL (GSI) to establish authenticated, secure connections between two processes on two different machines
 - Registration Authority (human) verifies request is valid
 - Certificate Authority (CA) software issues X.509 certificates
- **Requesting a user certificate**
 - FusionGrid uses the DOE Grids C A
 - <http://www.doe grids.org/pages/cert-request.htm>
 - Export certificate where Globus can find it
- **Install Globus client software**
 - Install the DOE Grids CA certificate

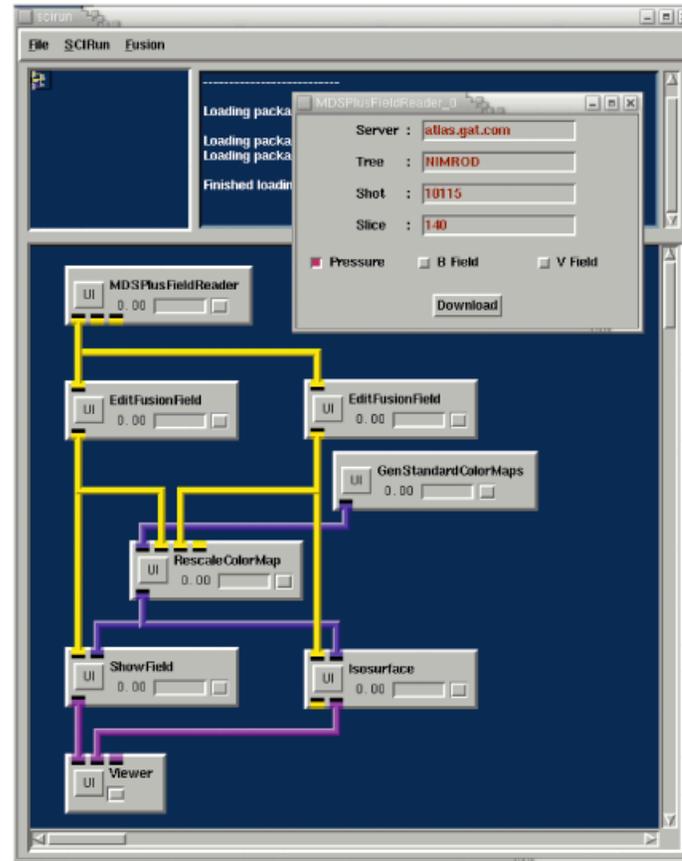
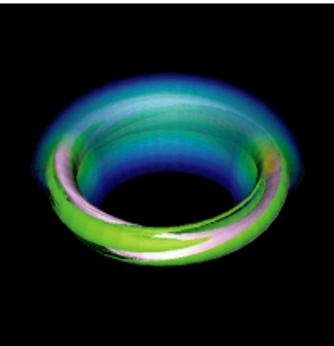
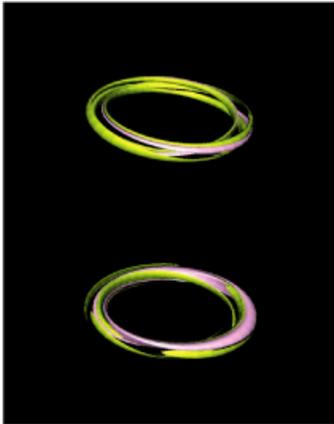
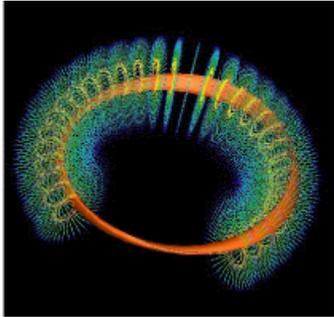
PLACING A RESOURCE ON FUSIONGRID

- **Globus must be installed on the server to be placed on FusionGrid**
 - Resource can be a code or an MDSplus data server
- **The Distinguished Name (DN) of each person allowed to use the resource must be specified**
 - Allows for control of who may use the resource
- **Finer grain access control can be accomplished with Akenti software**
 - Allows restricted access to a limited set of executables
- **NFC Project will help anyone interested in contributing a FusionGrid resource**

COLLABORATIVE NATURE OF FES 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
 - ELVis, java based graphics for TRANSP and other sources
 - VNC and DMX for sharing any X graphics code
- **New visualization software**
 - Simultaneous sharing of complex visualization
 - Error representation in complex experimental & simulation data

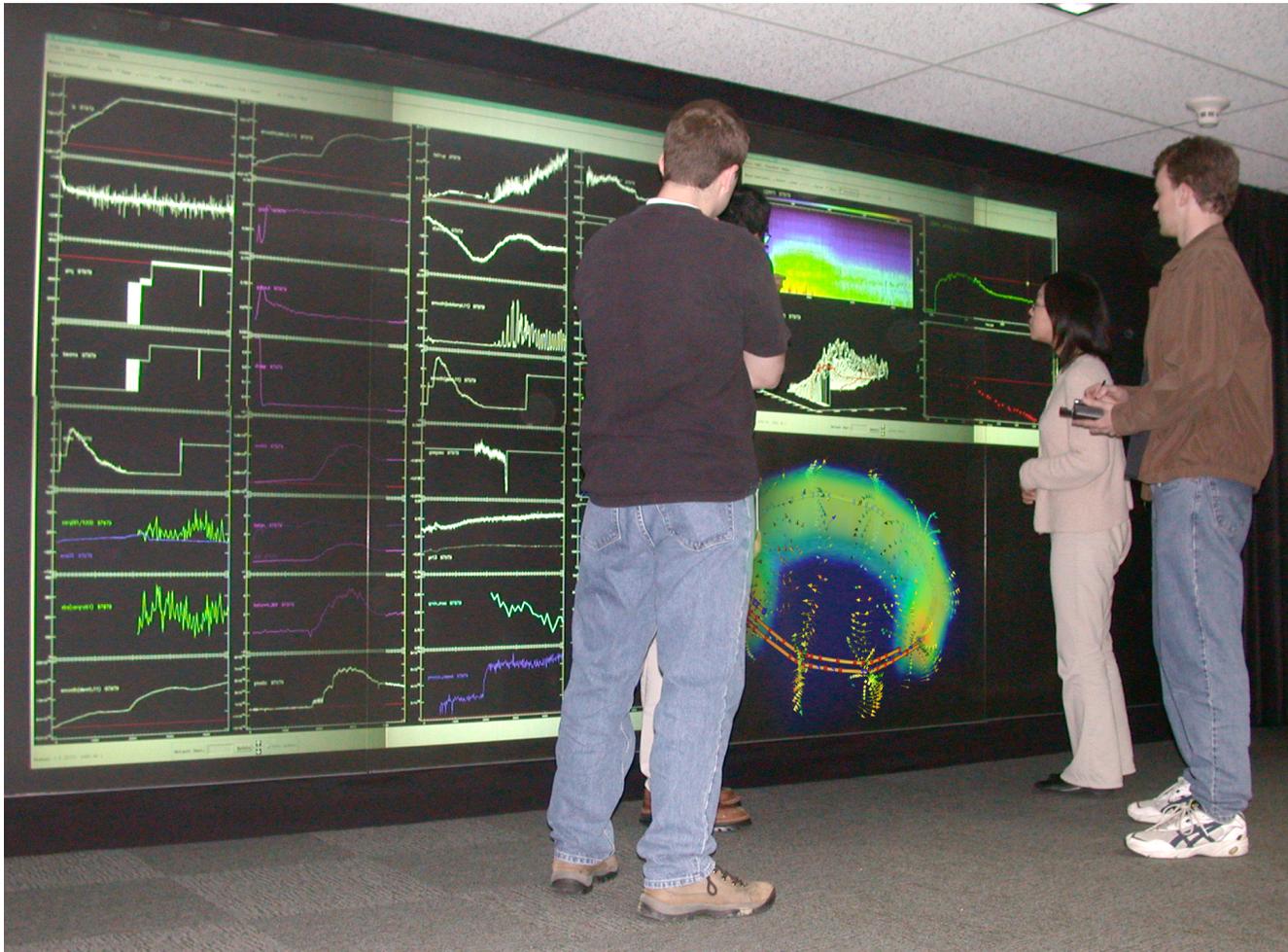
ADVANCED VISUALIZATION USING SCIRun



- SCIRun adapted for Fusion
 - Utah Imaging Institute
 - Open source, low cost
 - Runs on low-cost platforms
- NIMROD data from MDSplus
 - Testing storage paradigm
- Raises challenge of very large data sets

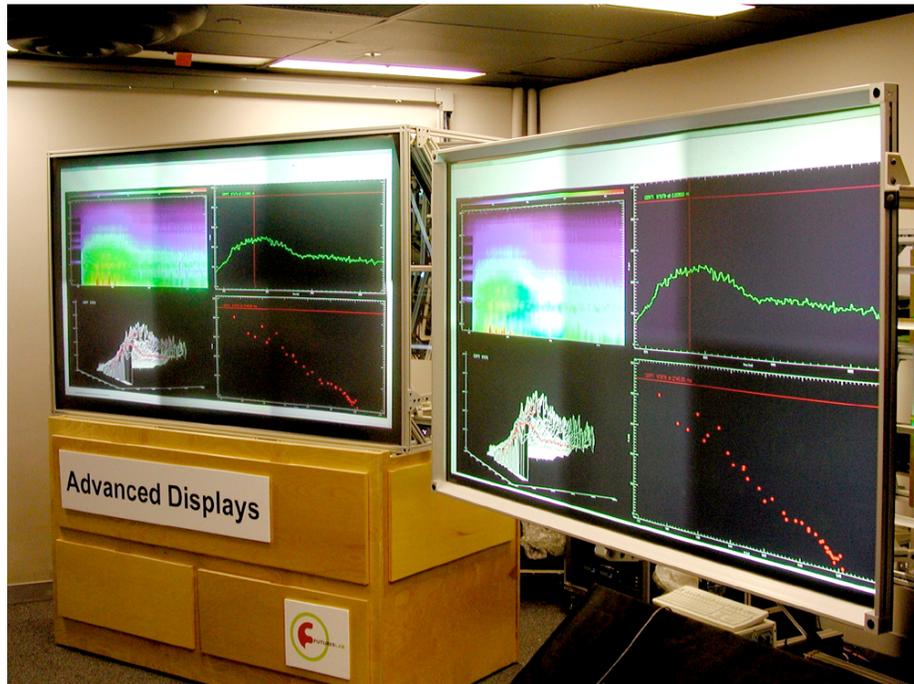
SCIRun visualization of NIMROD Pressure Simulation

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

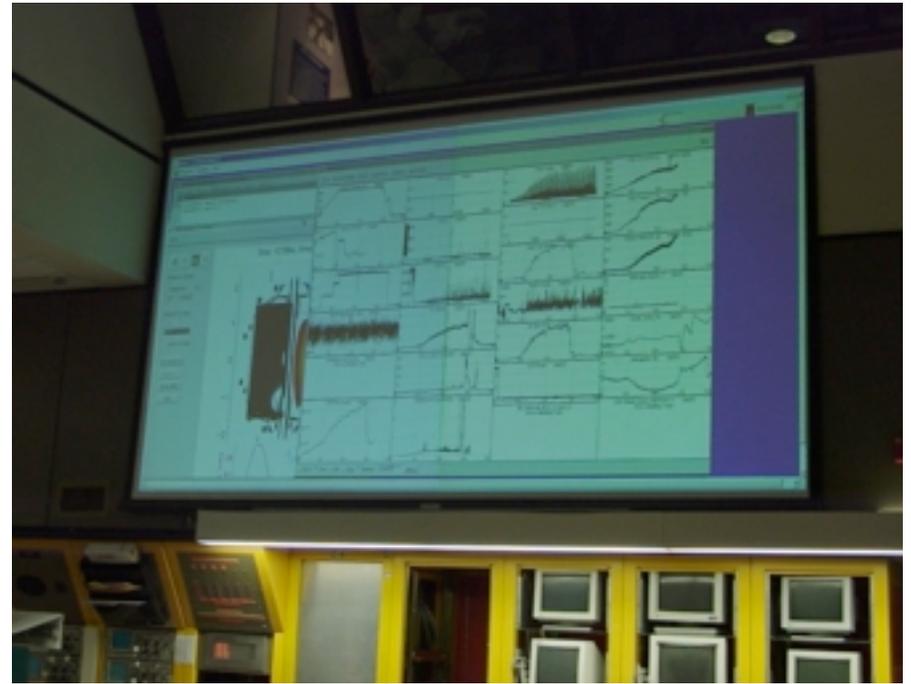


General Atomics Advanced Imagery Laboratory

COLLABORATIVE CONTROL ROOM FOR FUSION EXPERIMENTS



Shared Tiled Walls at ANL



Testing Tiled Wall at NSTX Control Room

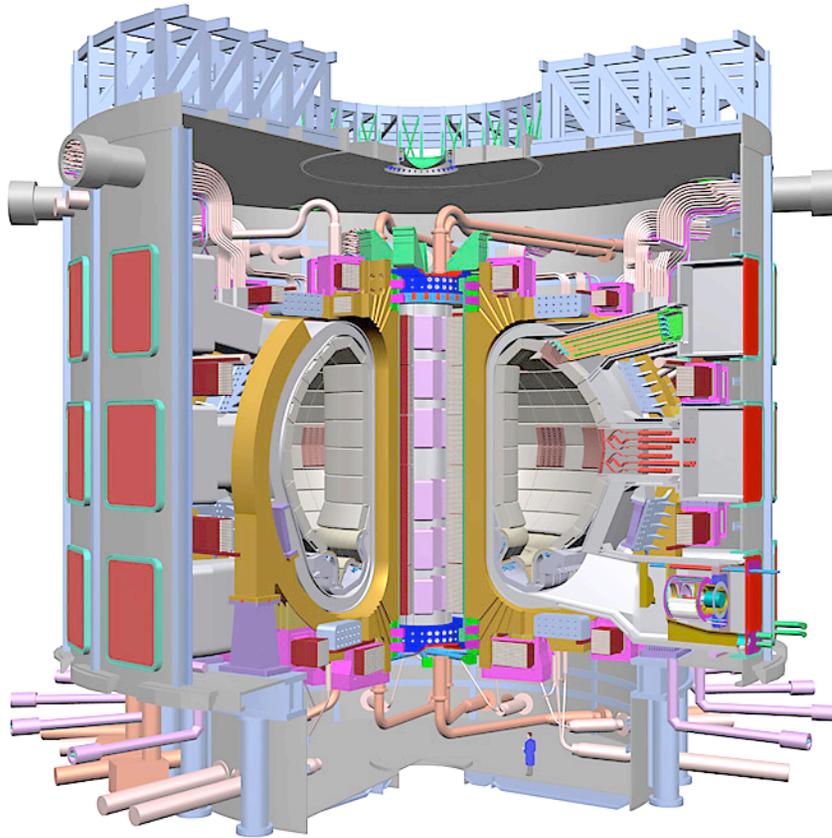
- Workstation to workstation or wall possible – control room communication
- Demonstrated from Chicago – San Diego & PCS – PPPL with VNC, DMC, ELVis
- Investigating deployment in NSTX control room

REMOTE COMMUNICATION WITH PERSONAL AG NODE



- Targeted for the small research center
 - For one to one and one to many interactions
- Usage example: communication to a tokamak control room
 - Includes sharing of complex visualization

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!

1ST YEAR NFC ACCOMPLISHMENTS (1)

- 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 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

1ST YEAR NFC ACCOMPLISHMENT (2)

- **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

ISSUES FOR FUTURE WORK

- **Ease-of-use and Ease-of-installation still need a lot of work**
- **Still have conflict on site security versus Grid security**
- **Globus undergoing major transformation**
 - **Can “lighter weight”, small footprint software provide some of the needed capabilities**
- **Toolset “hardening” required**
- **Manipulating very large multi-dimensional data sets is still a challenge**
 - **Need to test new approaches**

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 FE program**
 - Experiments: fewer, larger machines in future (e.g. ITER)
 - Computation: moving toward integrated simulation

- **User feedback critical to the success of the NFC Project**
 - Tools are to assist the researcher push their science forward