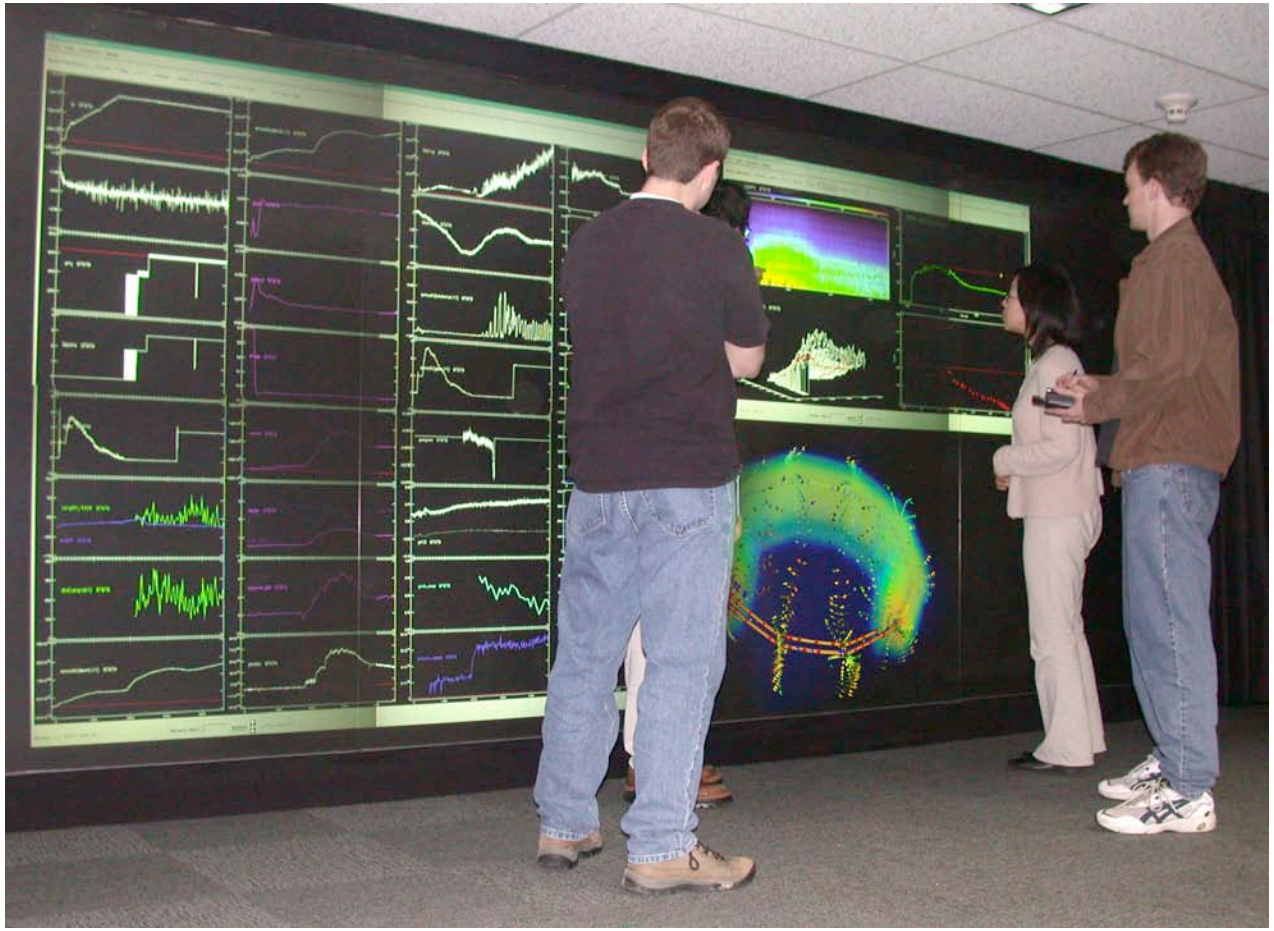
The National Fusion Collaboratory

A MICS/SciDAC National Collaboratory Pilot Project



Presented by
David P. Schissel
Lead–PI

at
The SciDAC PI Meeting
March 22-24, 2004
Charleston, SC

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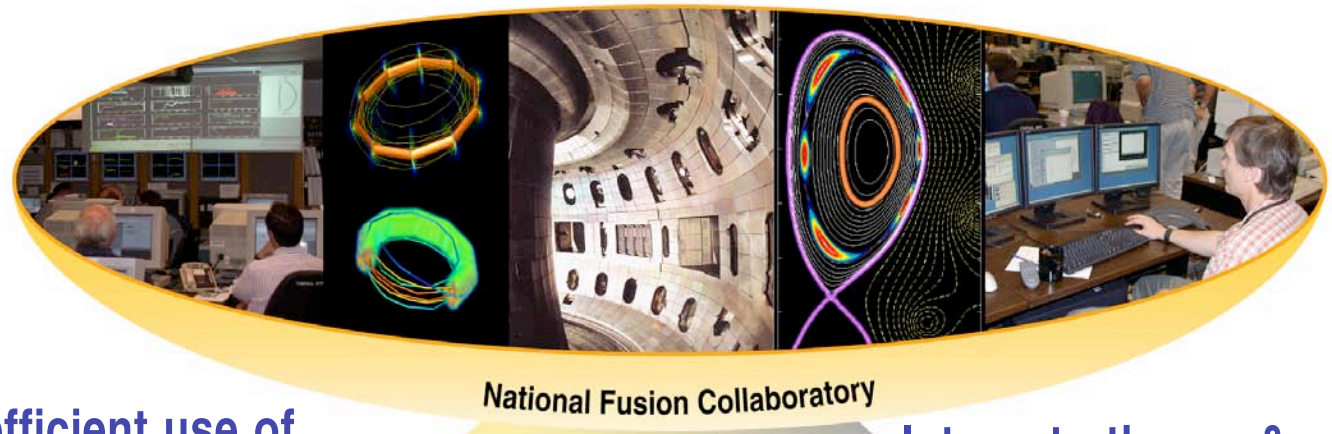
THE GOAL OF THE NFC IS TO ADVANCE SCIENTIFIC UNDERSTANDING & INNOVATION IN FUSION RESEARCH



More efficient use of experimental facilities

Integrate theory & experiment

Create standard tool set

Facilitate multi-institution collaboration

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THE NFC PROJECT HAS A DIVERSE TEAM

- ANL: Distributed Systems Lab
  - Kate Keahey, Ian Foster
- 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, Deb Agarwal
- MIT: C–Mod Fusion Lab
  - Martin Greenwald, Tom Fredian, Josh Stillerman
- Princeton Computer Science
  - Grant Wallace, Kai Li
- 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


NFC'S RELATION TO SCIDAC AND OTHER DOE PROJECTS

- DOE/OFES base program for FES research
  - Skilled computer scientists and computational resources
- Fusion science based SciDAC Programs
  - MHD, Mircoturbulence, and rf heating
- 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
- Global Grid Forum and Common Component Architecture Forum
  - Community wide standards

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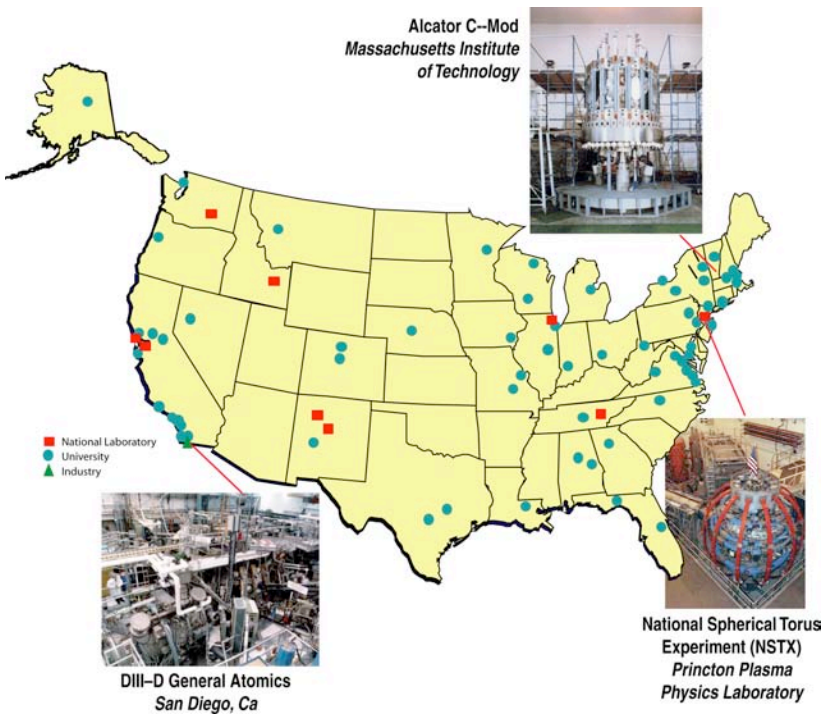
THREE LARGE U.S. EXPERIMENTAL FACILITIES AND A VIBRANT THEORETICAL COMMUNITY

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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ACCOMPLISHMENTS OF THE NFC PROJECT (1)

- FusionGrid created: MDSplus data system secured with Globus GSI
  - Experimental data repositories at 3 main tokamak facilities
  - Large-scale simulation data being stored at NERSC via MDSplus
- FusionGrid released with complete monitoring: TRANSP fusion code remotely accessible via Globus and fine-grain authorization via GRAM/Akenti
  - 1500 simulations run 20 times faster using 10,000 CPU hours
  - 9 different U.S. and European fusion devices
- Large demonstrations to the user community at 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

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ACCOMPLISHMENTS OF THE NFC PROJECT (2)

- GS2 low-frequency turbulence code being tested on FusionGrid
  - Considerably less time to grid-enable the second code
- SCIRun 3D visualization of NIMROD fusion data via MDSplus
  - New capability in 3D visualization & animation via MDSplus data
  - Visualizations used in presentations at major fusion meetings
- AG functional on Tiled Wall, desktop AG released (PIG)
  - Tiled walls being deployed to fusion control rooms
  - PIGs used in control rooms and meeting rooms
- Collaborative Control Room defined and demonstrated
  - Successful SC03 demonstration
  - Presented to ITER project, being considered as model for ITER
- Remote science leadership of JET tokamak in England
  - FusionGrid tools used by San Diego located researcher to lead JET

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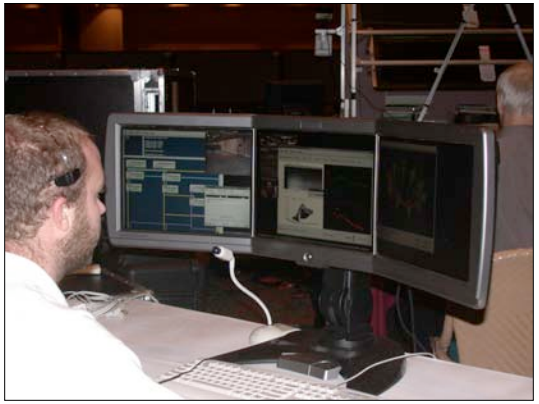
FUSIONGRID'S TOOLS AND TECHNOLOGIES

- Secure MDSplus using Globus GSI available
  - Authentication and Authorization using DOEGrids 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, new walls being installed in control rooms
- Collaborative Tokamak Control Room



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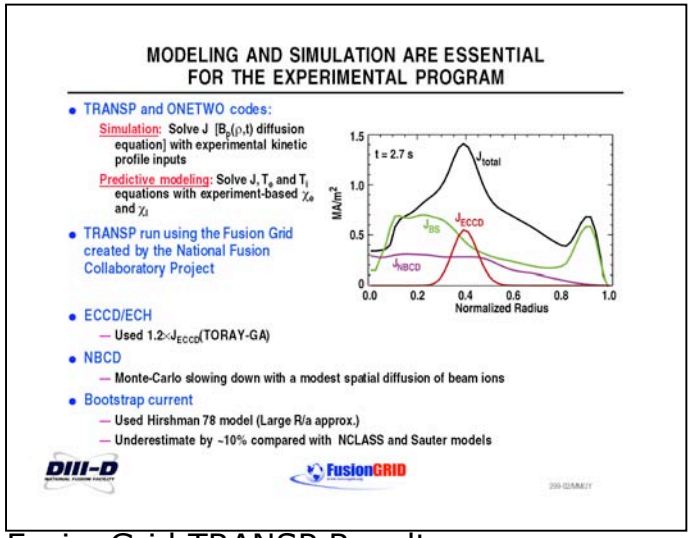
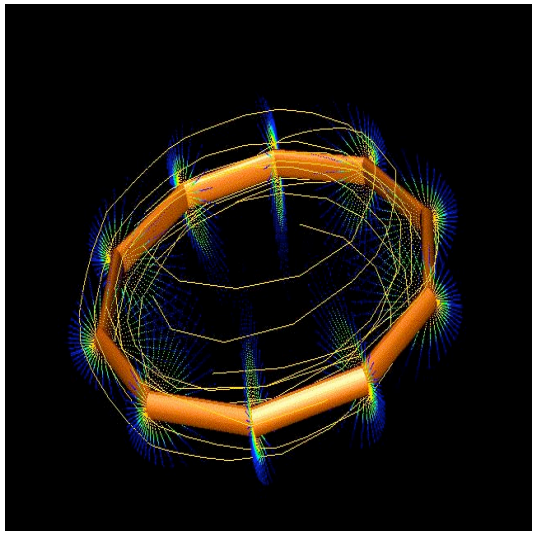
FUSIONGRID: SECURE GRID INFRASTRUCTURE AND SERVICES

- Main MDSplus experimental data repositories on FusionGrid via Globus GSI
- FusionGrid released with complete monitoring: TRANSP fusion code remotely accessible
  - FusionGrid replaced old system, now supports U.S. TRANSP usage
  - Europeans are joining FusionGrid to use TRANSP service
- FusionGrid used for scientific calculations presented at major Fusion science meetings



FusionGrid TRANSP Results


SCIRun Visualization

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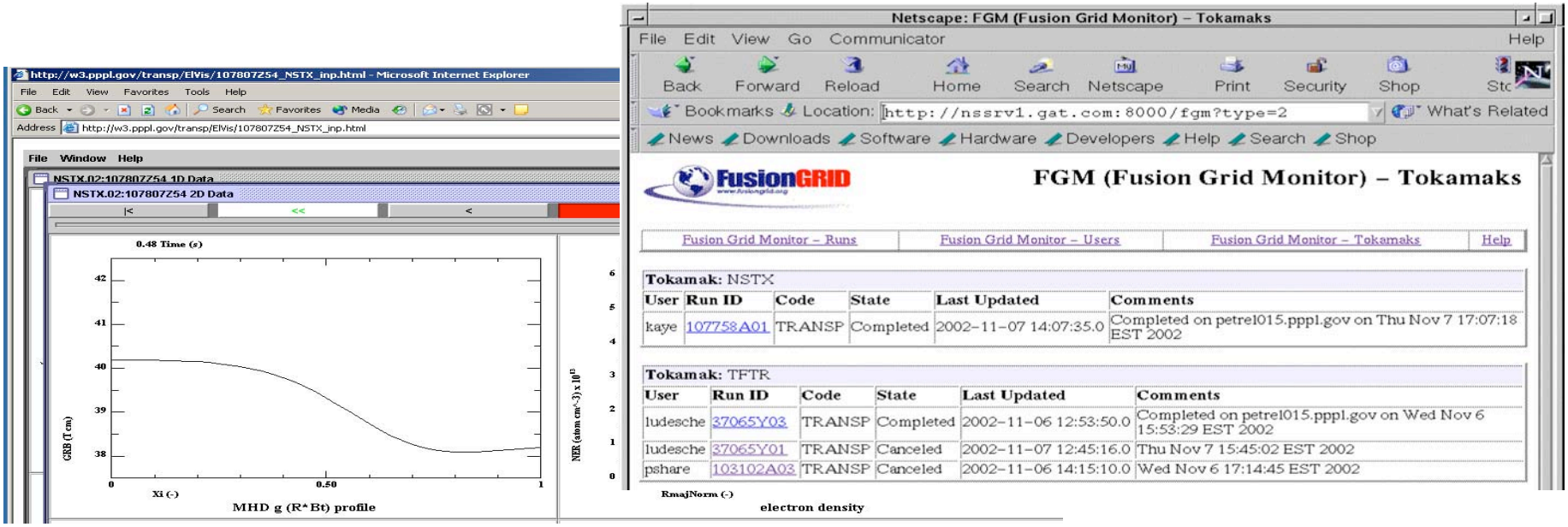
FUSION GRID MONITOR: AN EFFICIENT APPLICATION MONITORING SYSTEM FOR THE GRID ENVIRONMENT



- Users track and monitor the state of applications on FusionGrid
  - Output dynamically via HTML, Built as Java Servlet (JDK2.1)
- Code maintenance notification
  - Users notified, queuing turned off, code rebuilt, queue restarted
- Results of simulation visualized during run
  - Both input and output quantities

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TILED DISPLAYS TESTED IN FUSION CONTROL ROOMS

DIII-D Tokamak Control Room

NSTX Tokamak Control Room

- **Enhanced collaboration within the control room**
  - **Software for application sharing to tiled walls**
- **Very well received by fusion scientists**
  - **Fusion research funds used to purchase tiled walls for control rooms**

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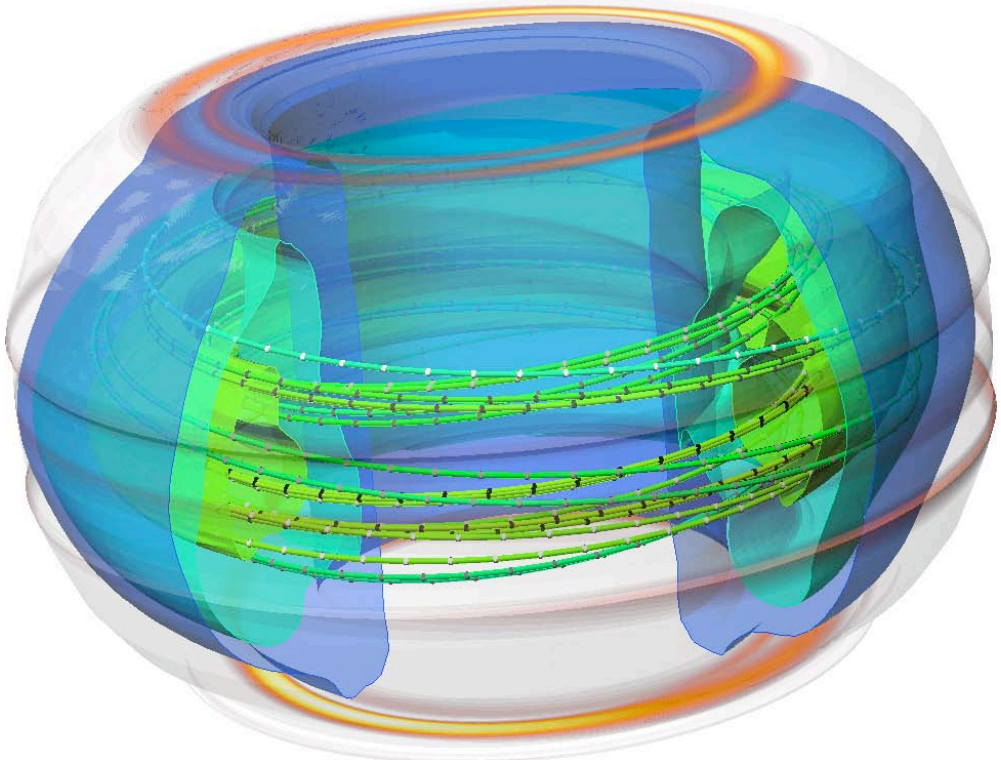
SCIRUN TO VISUALIZE COMPLEX SIMULATIONS FOR BETTER UNDERSTANDING

- Open source, multi-platform capable for a wide user base
- Prototyping data availability securely on FusionGrid via MDSplus
- To facilitate quantitative comparison of simulations & experimental results



NIMROD Simulation of a DIII-D Plasma

Raising the challenge of very large datasets

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ACCESS GRID FOR REAL TIME COMPLEX COMMUNICATION

DIII-D Tokamak Control Room - July 2003

- Tested with off-site scientist to control room
  - Includes application sharing
  - Detailed data analysis discussion
- Feedback indicated the need for a greater control room presence for the off-site scientist

Results of this test, the tiled wall work, and the Grid computing deployment have led to the design of the Collaborative Tokamak Control Room

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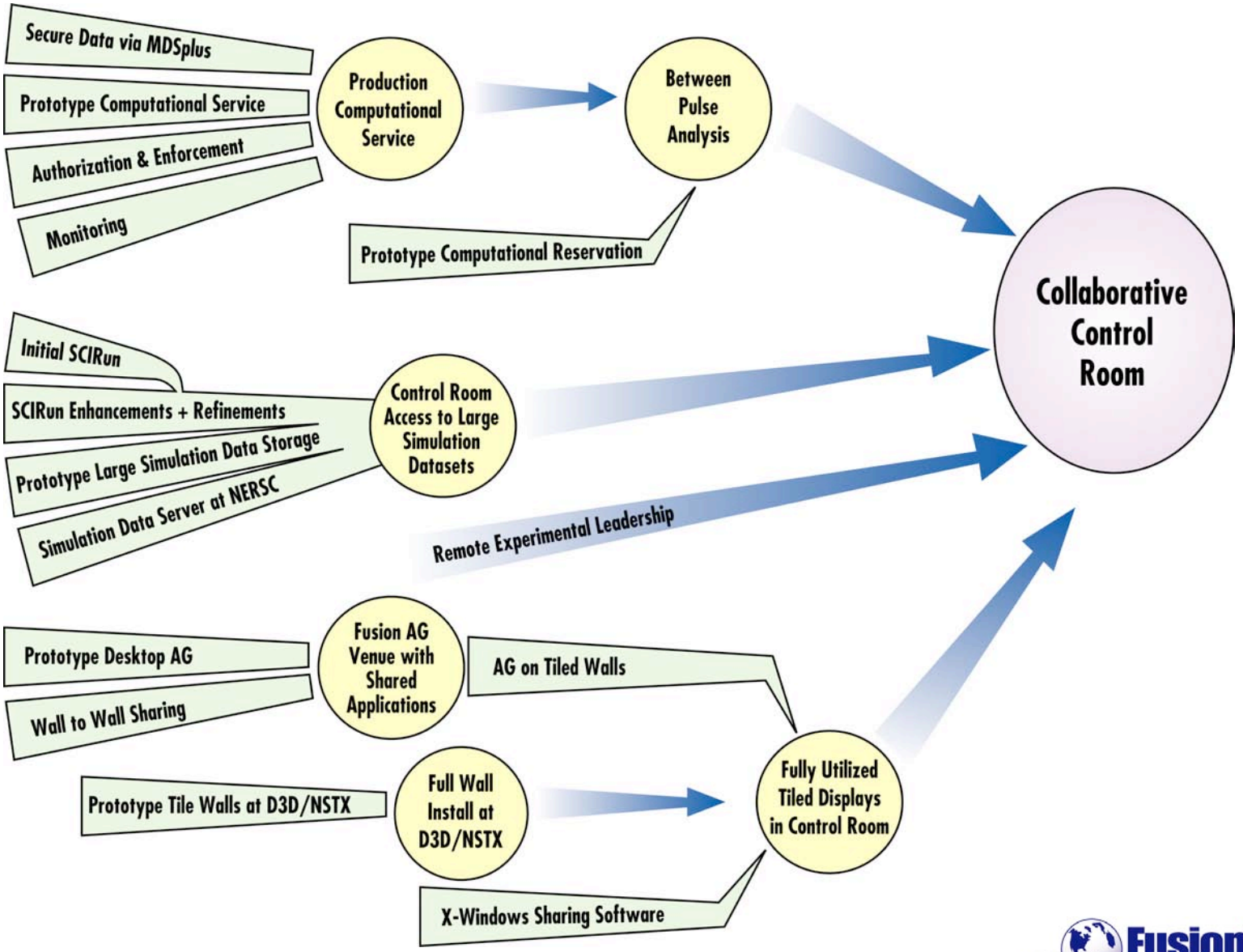
UNIFYING TOWARDS THE COLLABORATIVE CONTROL ROOM



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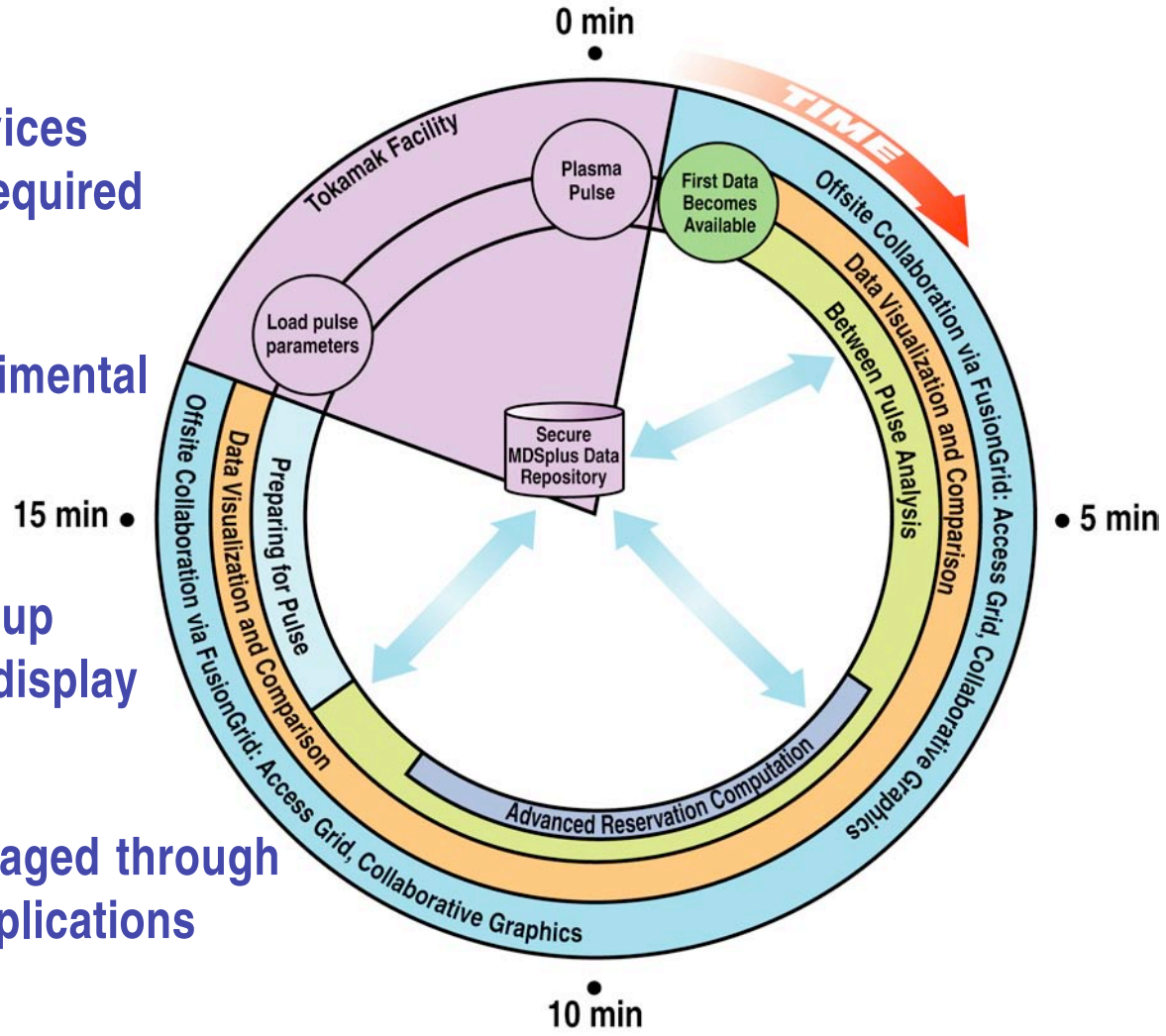
THE COLLABORATIVE TOKAMAK CONTROL ROOM: FULLY INTEGRATE OFF–SITE SCIENTIST INTO THE EXPERIMENT

- Secure computational services that can be scheduled as required
- Rapid comparison of experimental data and simulation results
- Share results within the group by moving apps to shared display
- Remote scientists fully engaged through audio, video, and shared applications



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SC03 DEMO: COLLABORATIVE CONTROL ROOM

- Fully interactive discussions utilizing AG
  - Includes shared applications
- Presence beyond AG communication
  - What one "sees and hears" in the control room
- Enhanced collaboration within the control room
  - Tiled displays and a shared X environment
- Advance reservation computation
  - Between pulse data analysis

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REMOTE LEADERSHIP OF THE JET TOKAMAK IN ENGLAND FROM SAN DIEGO USING FUSIONGRID SERVICES

January 2004, San Diego

- First attempt for real science and it was successful
- Similar collaboration planned: Japan - US and US-Germany

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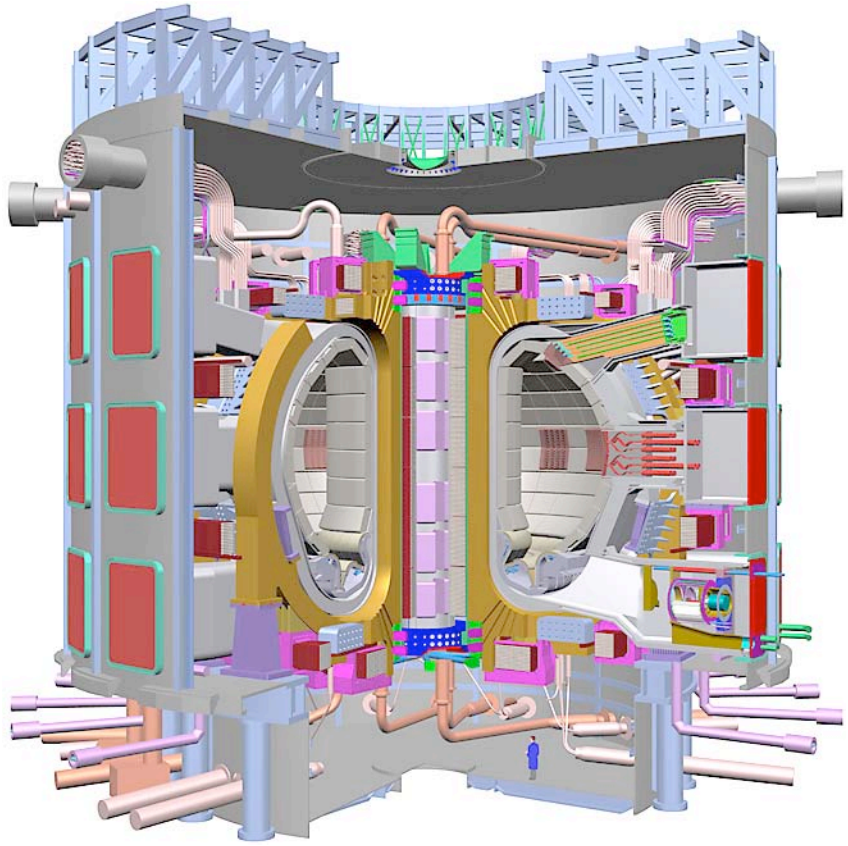
INTERNATIONAL THERMONUCLEAR EXPERIMENTAL REACTOR: NFC TECHNOLOGIES SCALE TO THE NEXT GENERATION DEVICE



- ~$5B class device, over 20 countries
  - Number 1 DOE/OS Facility Priority
- 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 via FusionGrid

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LESSONS LEARNED AND OUTSTANDING ISSUES

- Certificate management for users and developers too difficult
  - This is their first experience with FusionGrid: needs to be positive
- Software infrastructure required for a new service is too complex
  - Need a bare-bones software package that is simple to install
  - FusionGrid utilizes only a fraction of the Globus Toolkit functions
- Difficulties combining Grid-security and Site-security (firewalls)
  - Greatly limiting the potential expansion of the FusionGrid userbase
- Manipulating large multi-dimensional datasets is still a challenge
  - Need to test new approaches
- Users like frequent and rapid prototyping tests
  - They feel involved and it is educational to both sides

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SAME TEAM HAS SUBMITTED A PROJECT RENEWAL

- Fusion community has responded positively to the work of the NFC
  - Encouragement has come from many groups/people
- Ease-of-use is a key area of focus
  - Certificate management, documentation, education, support
  - Ease of creating and adding a new FusionGrid service
  - Robust deployment of SCIRun for daily usage
- FusionGrid computational services
  - The SciDAC funded codes GYRO and TORIC will be added
  - Production deployment of Akenti
- Collaborative tokamak control room
  - Enhanced AG along with control room presence
  - Co-located and remote X sharing to tiled displays
  - Advanced computational reservation on FusionGrid

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CONCLUDING COMMENTS

- The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research
  - FusionGrid: Grid computing for FES
  - Collaborative Control Room: shared visualization & communication

- Collaborative technology critical to the success of the FES program
  - Experimentally: Fewer, larger machines in future (ITER)
  - Computation: Moving toward integrated simulation (FSP)

First on our list is fusion. The prospect of limitless source of clean energy for the world leads with our commitment to join the international fusion energy experiment known as ITER.

– Secretary of Energy Spencer Abraham, November 10, 2003

Introducing the Department's 20-year plan for building the scientific facilities of the future.

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