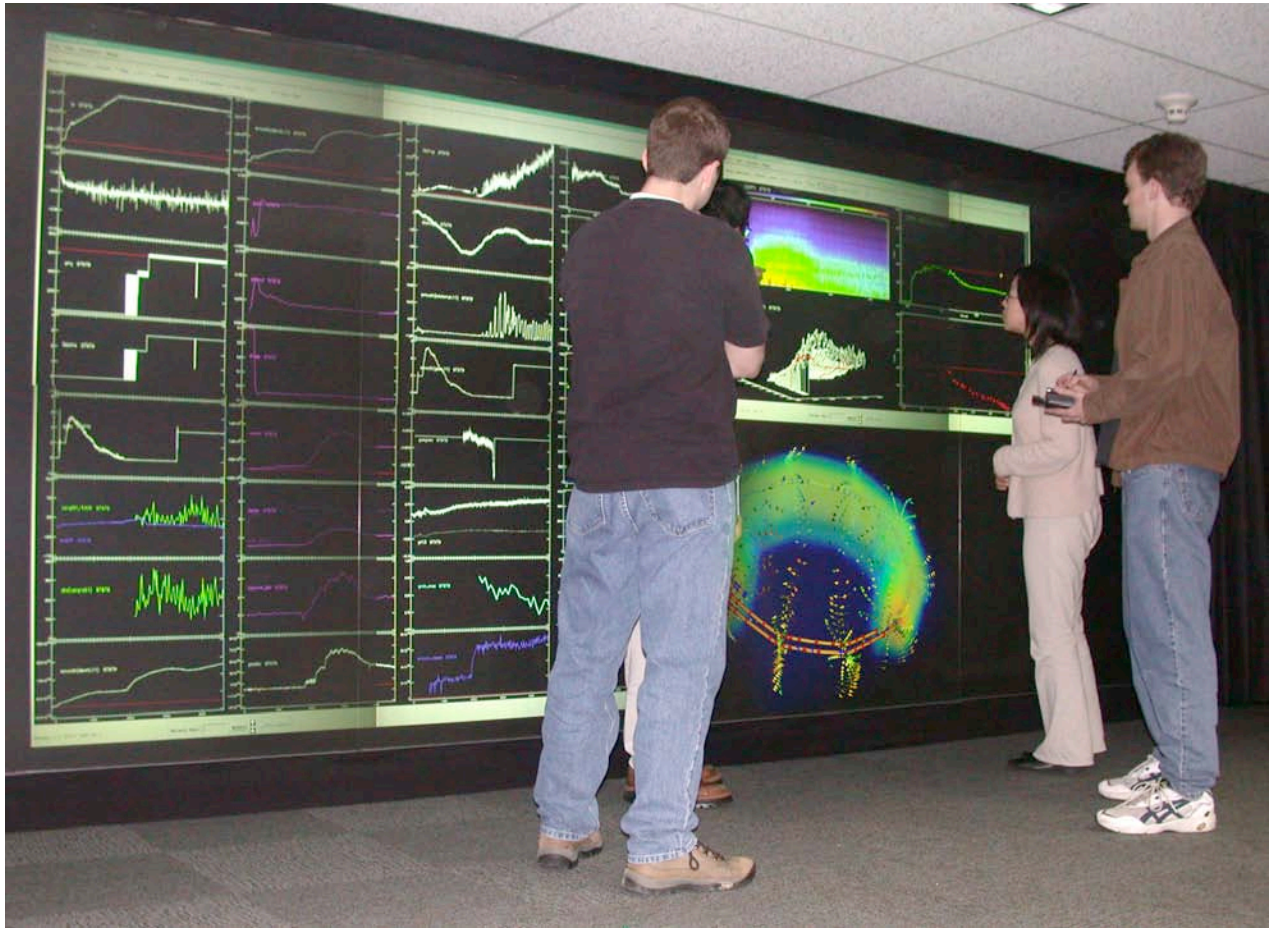
The National Fusion Collaboratory

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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PRESENTATION'S KEY POINTS

- SciDAC has changed the culture of collaborative FES research
  - FusionGrid services being used to benefit daily FES research
- The collaborative control room is being realized
  - Secure computational resources scheduled as required
  - Rapidly compare experimental data to simulation results
  - Share individual results with the group via shared displays
  - Fully engaged remote scientists with audio, video, shared displays
- Collaborative technology critical to the success of the FES program
  - Experimental: Fewer, larger machines in future (ITER)
  - Computation: Moving toward integrated simulation (FSP)

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THE NFC IS HELPING TO ACHIEVE SCIDAC GOALS

- Create a collaboratory software environment to enable geographically distributed scientists to work effectively together as a TEAM and to facilitate remote access, through appropriate hardware and middleware infrastructure, to both facilities and data

Lead with the science:
Ultimate goal of advancing research in science central to the DOE mission

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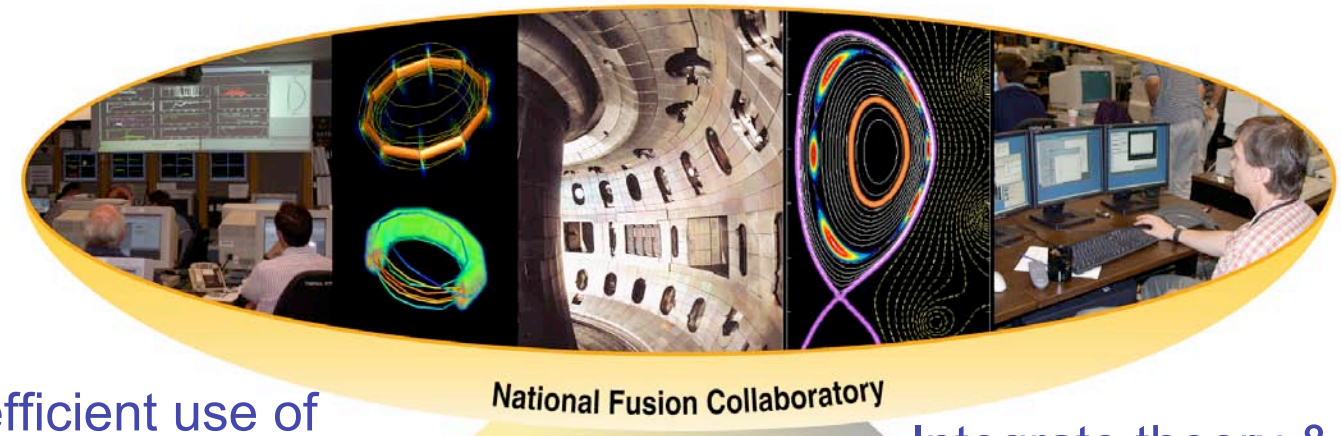
THE GOAL OF THE NFC IS TO ADVANCE SCIENTIFIC UNDERSTANDING & INNOVATION IN FUSION RESEARCH



More efficient use of experimental facilities

Integrate theory & experiment

Create standard tool set

Facilitate multi-institution collaboration

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THE NFC IS BEING SUCCESSFUL FOR FUSION SCIENCE

- Success is not defined by demos or papers published
  - Although these are important aspects of the project
- Success is defined by positive impact on the science
  - True metric is the actions of the fusion scientists
- A main fusion code is *only* available via NFC Grid computing
- The fusion program is spending its *own* money to purchase equipment and to support the usage of new NFC functionality
- A fusion scientist decided to *remain in San Diego* and use NFC technology to lead the fusion experiment in England

There is no going back:
SciDAC has changed FES collaborative culture

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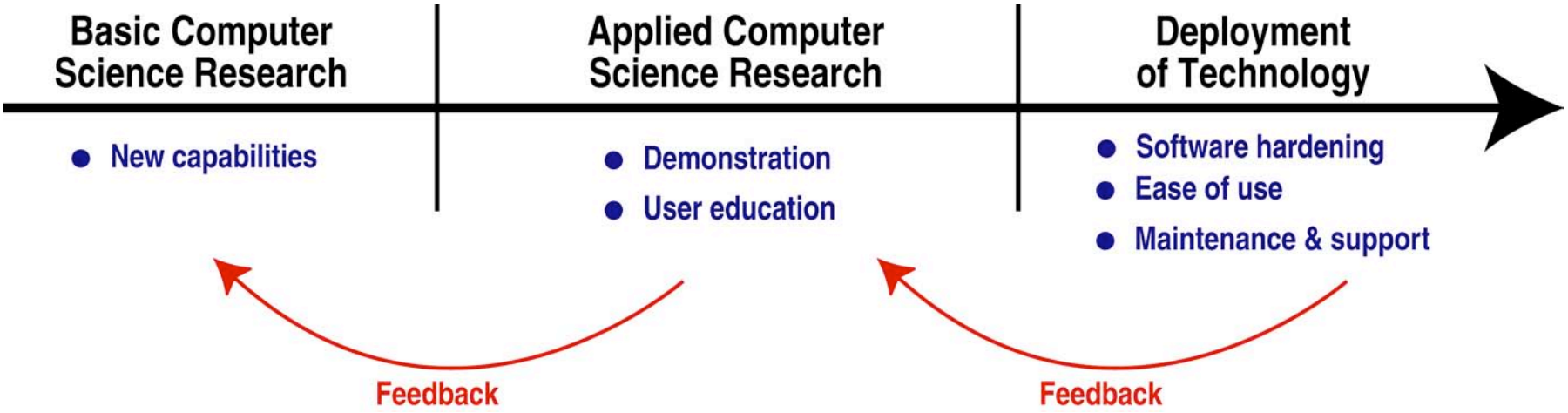
THE NFC PROJECT BENEFITS FROM A DIVERSE TEAM

Synergistic benefits derived from interdisciplinary interactions



- ANL: Distributed Systems Lab
- ANL: Futures Lab
- General Atomics: DIII-D Fusion Lab
- LBNL: Distributed Systems
- MIT: C–Mod Fusion Lab
- Princeton Computer Science
- PPPL: NSTX Fusion Lab
- Utah: Scientific Computing & Imaging

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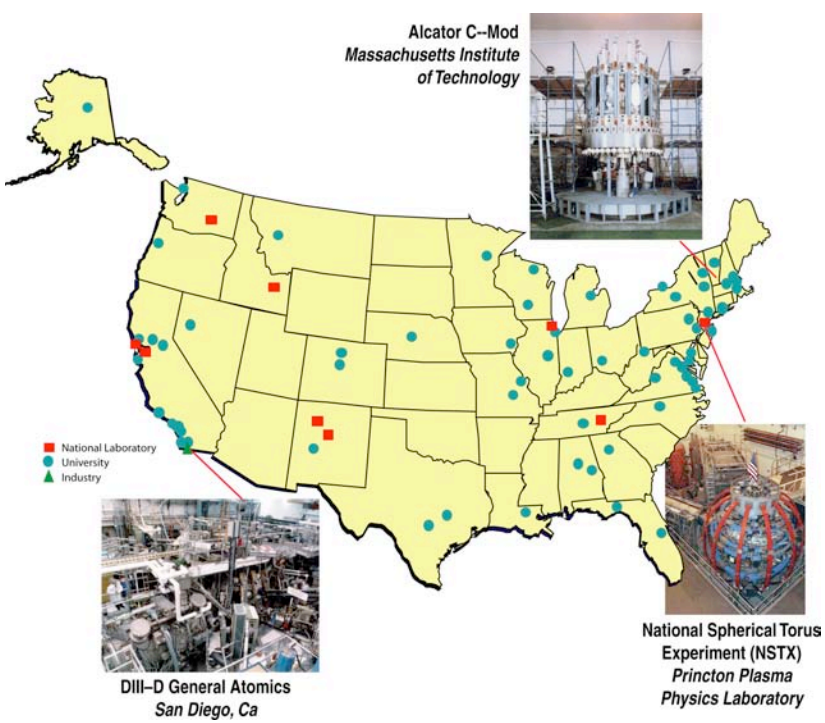
THREE LARGE U.S. EXPERIMENTAL FACILITIES AND A VIBRANT THEORETICAL COMMUNITY

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 required!
  - Integrate geographically diverse teams
- One future worldwide machine
  - Not based in US
  - US needs collaboration tools to benefit

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EXPERIMENTAL SCIENCES PLACES A LARGE PREMIUM ON RAPID DATA ANALYSIS IN NEAR-REAL-TIME

DIII-D Control Room

- Pulsed experiments
  - 10s duration plasma every 20 minutes
- 20-40 people in control room
  - More from remote locations
- 10,000 separate measurements/plasma
  - kHz to MHZ sample rates
  - Between pulse analysis

- Not batch analysis and not a needle in a haystack problem
  - Rapid “real-time” analysis of many measurements
- More informed decisions result in better experiments
  - The collaborative control room

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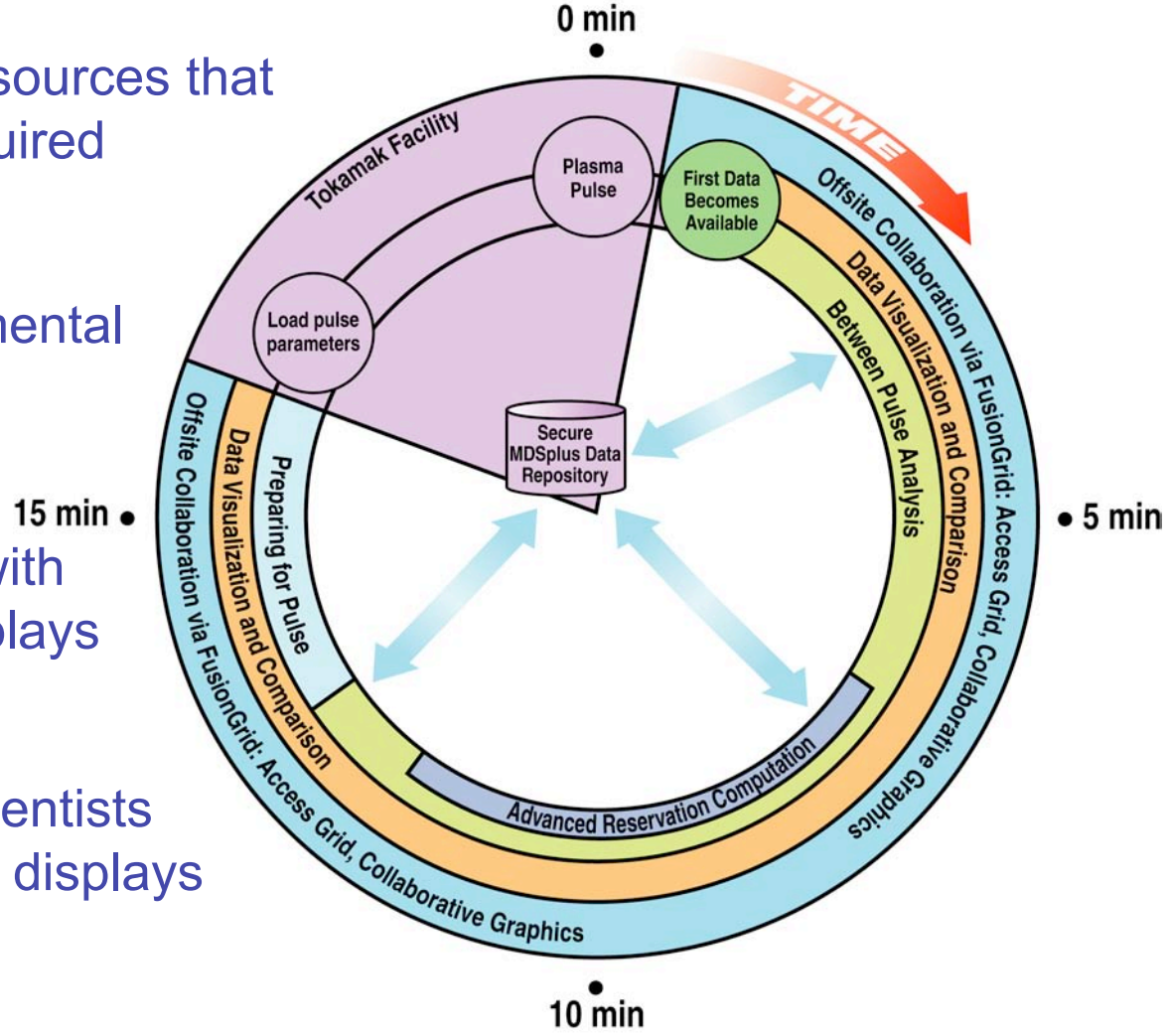
THE COLLABORATIVE CONTROL ROOM IS FUNDAMENTAL TO ADVANCING FUSION SCIENCE

- Secure computational resources that can be scheduled as required
- Rapidly compare experimental data to simulation results
- Share individual results with the group via shared displays
- Fully engaged remote scientists with audio, video, shared displays



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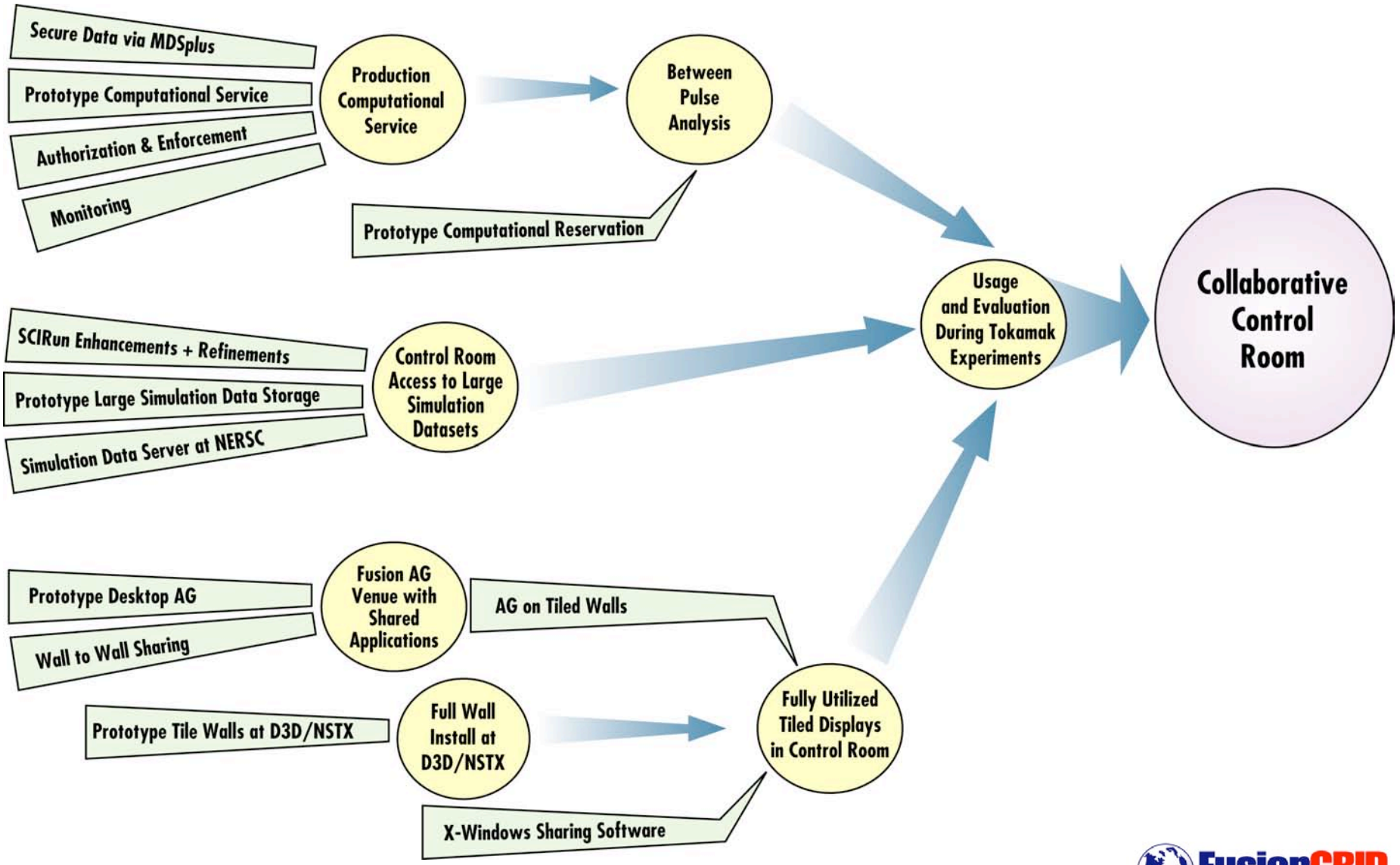
WORK TOWARDS THE COLLABORATIVE CONTROL ROOM



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FUSIONGRID: SECURE ACCESS TO FUSION DATA

- MDSplus: remote access based on client-server model
  - In use for over 10 years (robust)
- MDSplus experimental data repositories on FusionGrid via Globus GSI
  - X.509 certificates
- Worldwide access for FusionGrid members
  - Non-U.S. MDSplus repositories can be made available as required

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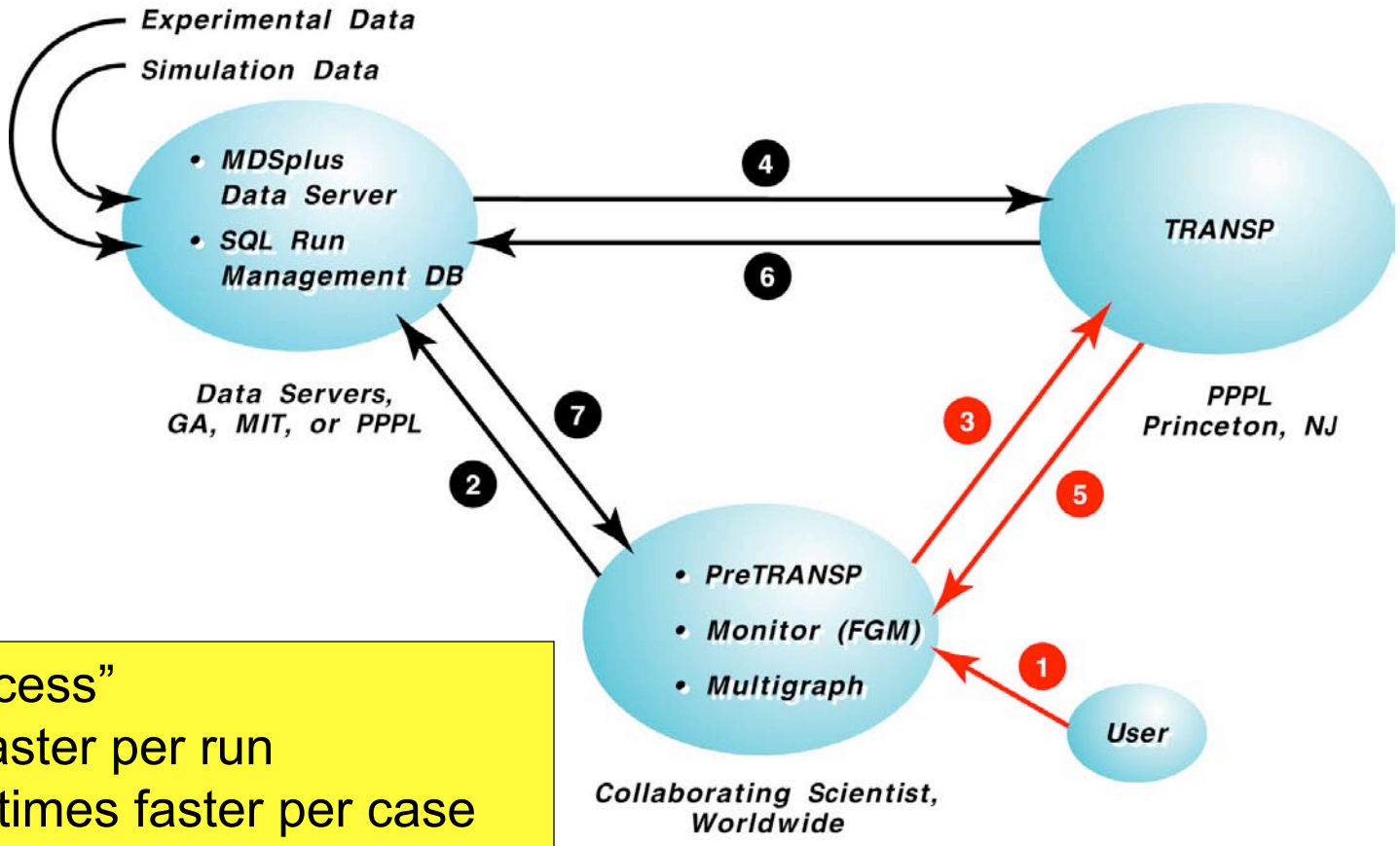
SUCCESSFUL GRID COMPUTING FOR FUSION SCIENCE



"This is a success"
- 4 times faster per run
- Up to 20 times faster per case
- Better support

The U.S. TRANSP Service
- 1,500 cases, 10,000 CPU hrs
- 9 fusion experimental machines

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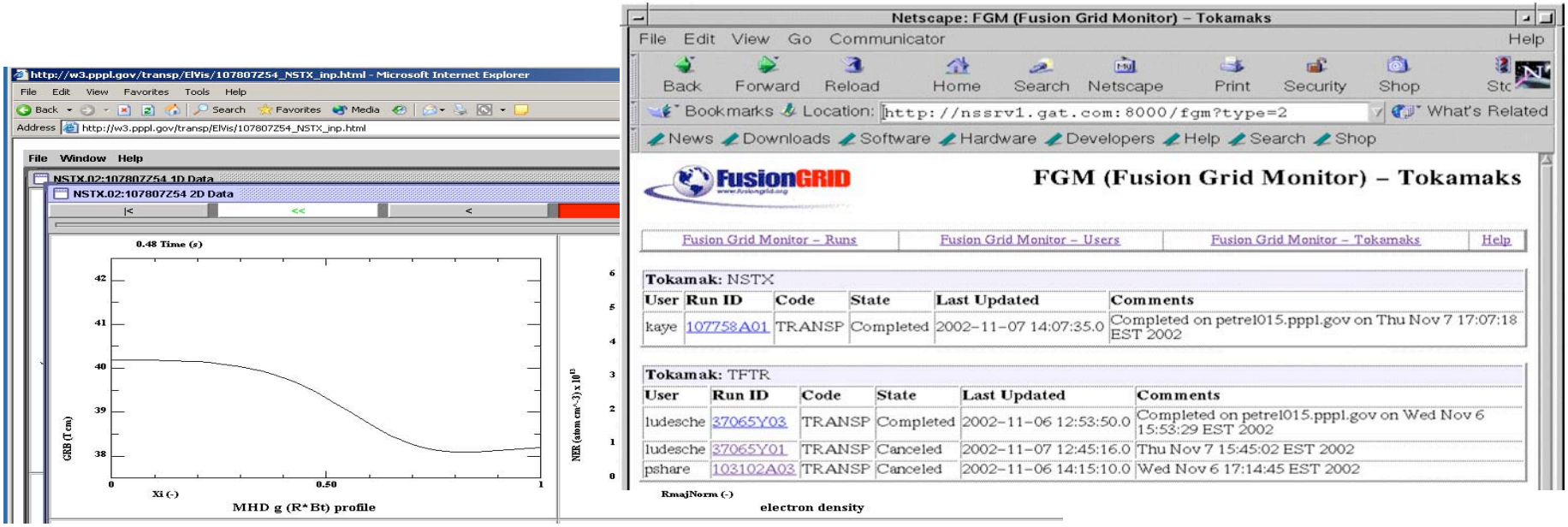
FUSION GRID MONITOR: AN EFFICIENT APPLICATION MONITORING SYSTEM FOR THE GRID ENVIRONMENT



- 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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ADVANCED RESERVATION COMPUTATION FOR DATA ANALYSIS TO SUPPORT EXPERIMENTAL SCIENCE

- Long-term vision: SciDAC code on supercomputer between pulses
  - Data management
  - Network QoS
  - Visualization
  - CPU scheduling
  - Faster CPUs and algorithms
- End-to-end agreement being prototyped in the NFC project
  - CPU reservation
  - Network transfer agreements based on simple prediction
- FusionGrid service TRANSP will be tested between pulses
  - First such capability for FES research

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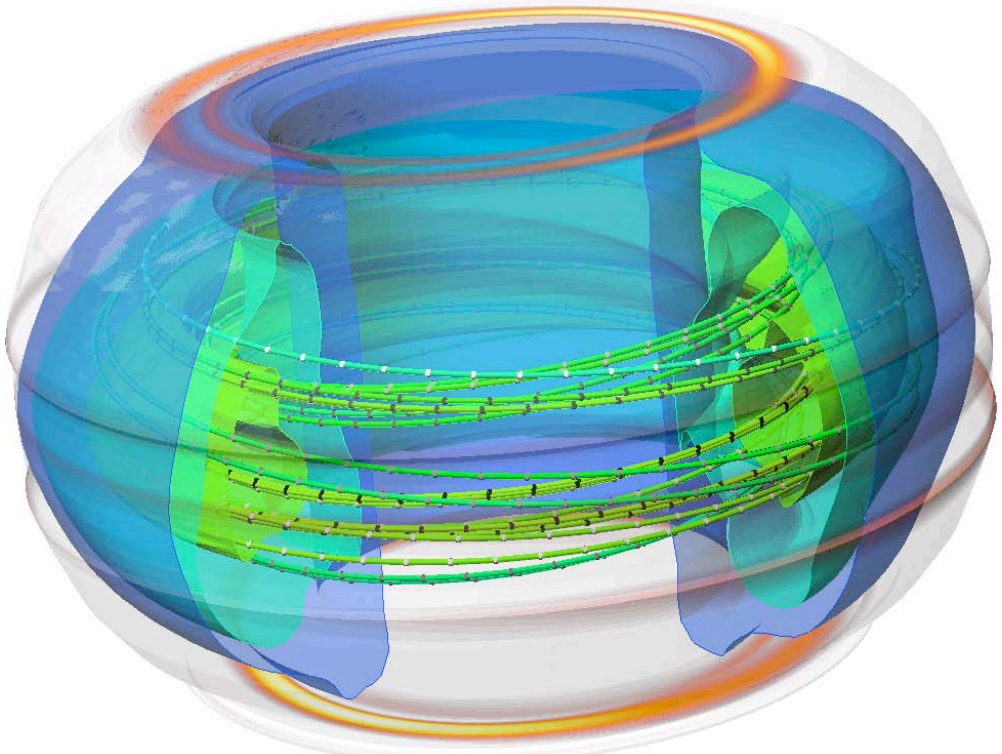
SCIRUN TO VISUALIZE COMPLEX SIMULATIONS FOR BETTER UNDERSTANDING

- Open source, multi-platform capable for a wide user base
- To facilitate quantitative comparison of simulations & experimental results



SciDAC CEMM NIMROD Simulation of a DIII-D Plasma

Raising the challenge of very large datasets
- MDSplus
- Storage method
- Data location
- Parallel I/O

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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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ACCESS GRID: 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

Personal Interface to the Grid (PIG) motivated by Fusion research

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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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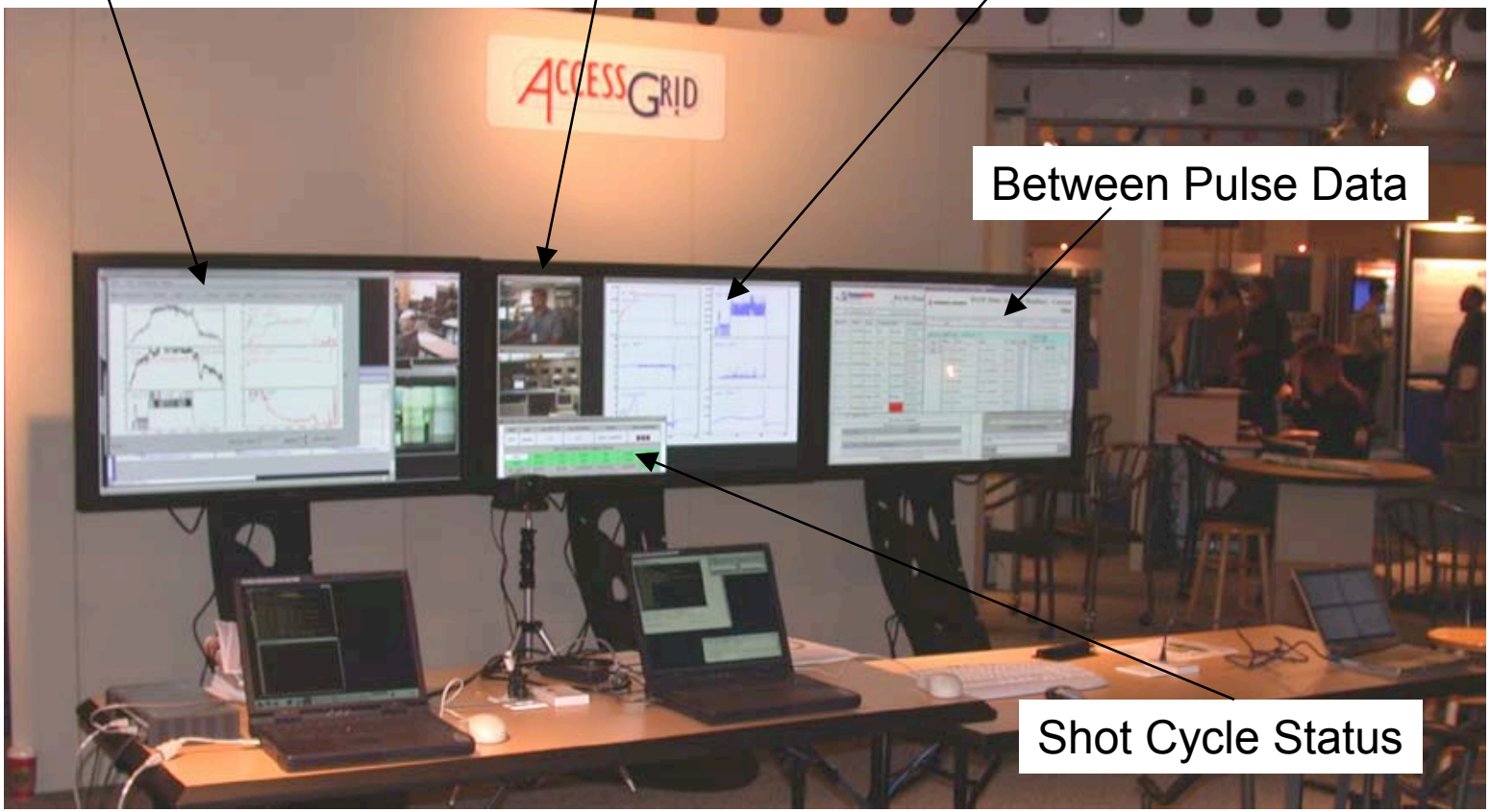
COLLABORATIVE CONTROL ROOM: A SENSE OF PRESENCE



SuperComputing 2003, Phoenix AZ

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

January 2004, San Diego

Working with JET and the UK e-Science Programme

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

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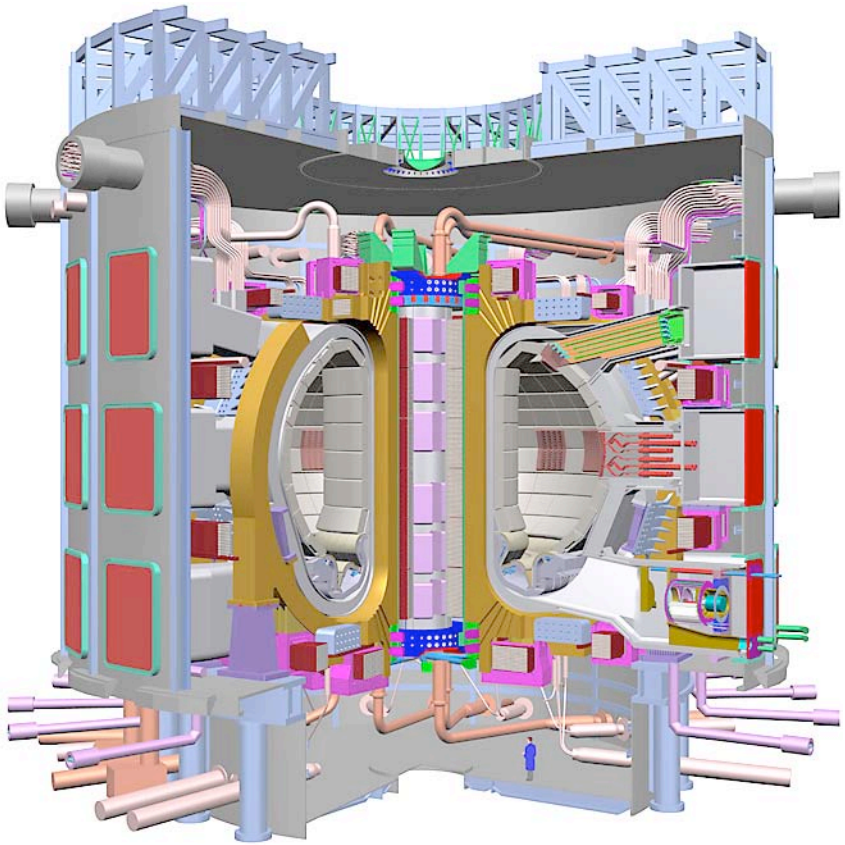
ITER:
NFC TECHNOLOGIES SCALE TO THE NEXT DEVICE



- ~$5B class device, over 20 countries
  - Number 1 DOE/SC Facility Priority
  - International collaboration
- Pulsed experiment with simulations
  - ~TBs of data in 30 minutes
- Successful operation requires
  - Large simulations, shared vis, decisions back to the control room
  - Remote Collaboration via FusionGrid
- NFC technology being considered as the model for ITER

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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
  - Simple for the non-specialist (Professor & grad student)
- 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
- Control room presence is more than audio/video & shared apps
  - Include things one sees & hears when physically in control room
- 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
  - Efficient data management of large simulation datasets
- 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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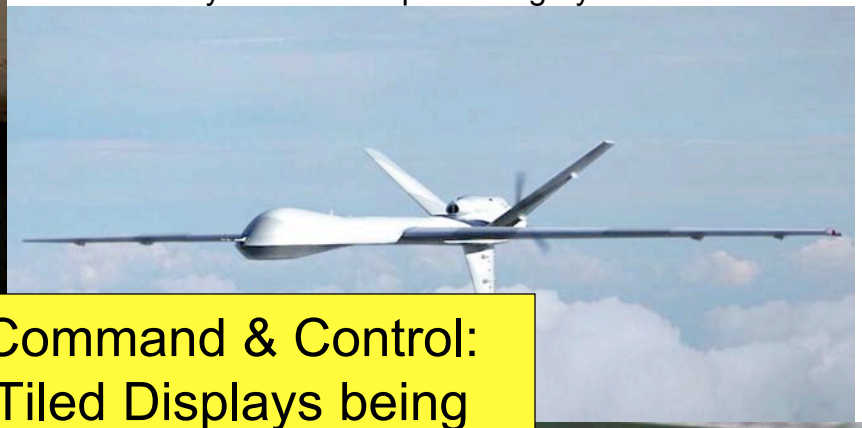
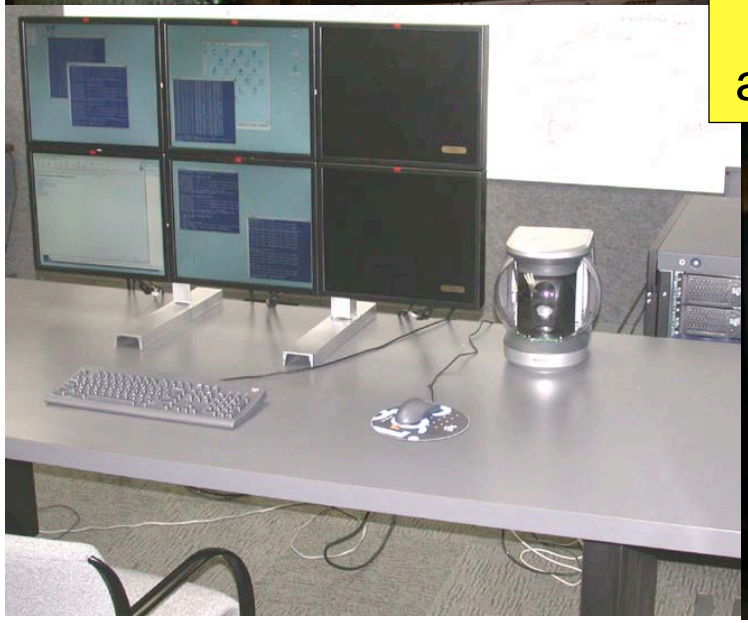
SCIDAC IS HAVING AN IMPACT BEYOND DOE/SC

Predator & Lynx-SAR 30Mpixel Imagery



Command & Control: Tiled Displays being explored for Defense and Homeland Security



Ultra-high resolution optical imagery

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CONCLUDING COMMENTS

- The National Fusion Collaboratory Project is implementing and testing new collaborative technologies for fusion research
  - FusionGrid services being used to benefit daily FES research
- Clear vision forward to the collaborative control room
  - Concept encompasses most if not all collaborative FES needs
- Collaborative technology critical to the success of the FES program
  - Experimental: 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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