THE NATIONAL FUSION COLLABORATORY

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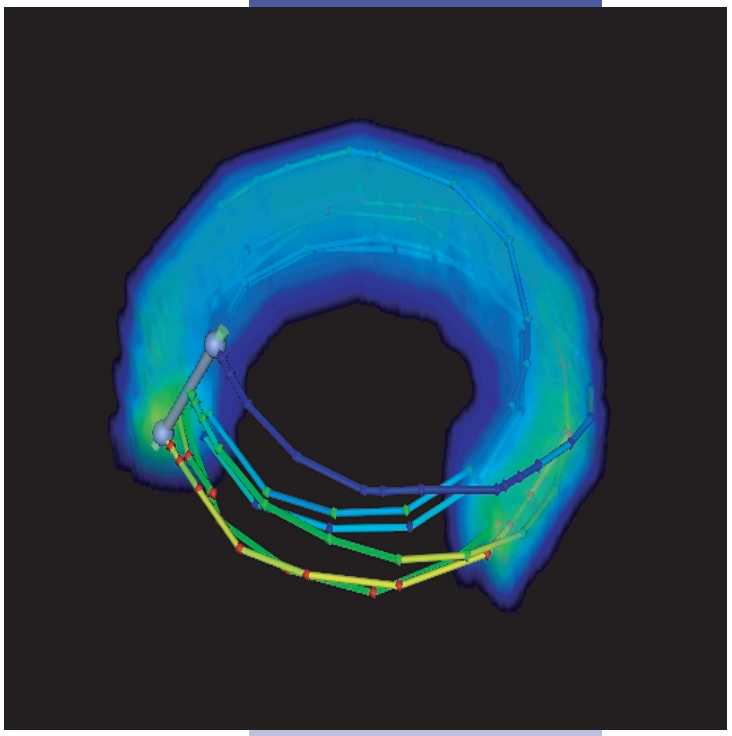

NIMROD simulated pressure stored in MDSplus and visualized with SciRUN

Presented at
US–Korea Bilateral Advanced Physics and Control Collaboration Meeting

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A NEW THREE YEAR PROJECT HAS STARTED TO CREATE A NATIONAL FUSION COLLABORATORY

- The fusion Collaboratory represents a fundamental paradigm shift for the fusion community

- All data, analysis and simulation codes, and visualization tools will be thought of as network services

- The use of resources (data, codes, visualization tools) is separated from their implementation freeing the researcher from the need to know, in detail, how resources are implemented

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

- Enable more efficient use of existing experimental facilities through more powerful between pulse data analysis resulting in a greater number of experiments at less cost
- Allowing more transparent access to analysis and simulation codes, data, and visualization tools, resulting in more researchers having access to more resources
- Enable more effective integration of experiment, theory, and modeling
- Facilitate multi–institution collaborations
- Create a standard tool set for remote data access, security, and visualization allowing more researchers to build these services into their tools

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THE COLLABORATORY WILL CREATE & DEPLOY COLLABORATIVE SOFTWARE TOOLS FOR THE FUSION COMMUNITY

- Create transparent and secure access to local/remote computation, visualization, and data servers
- Develop collaborative visualization that allows interactive sharing of graphical images among control room display devices, meeting room displays, and with offices over a wide area network
- Enable real–time access to high–powered remote computational services allowing such capabilities as between pulse analysis of experimental data and advanced scientific simulations

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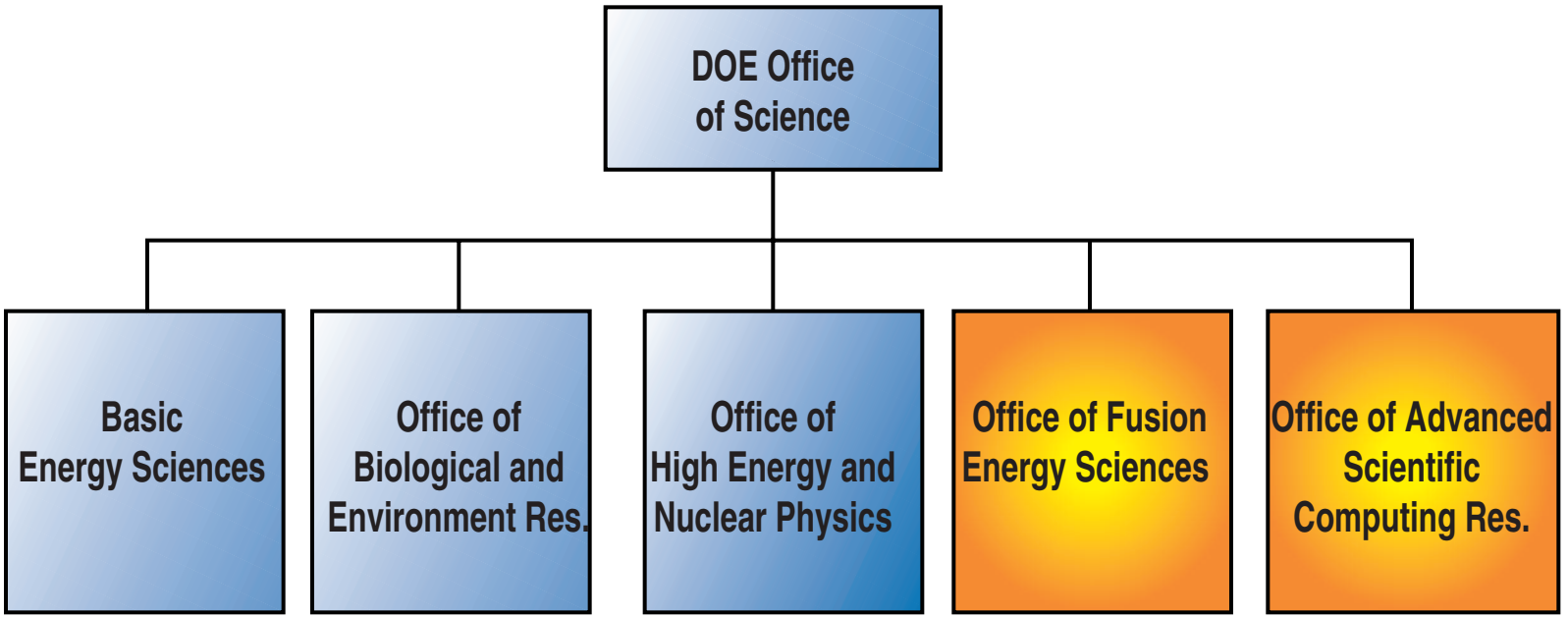
DEPARTMENT OF ENERGY/OFFICE OF SCIENCE: SCIENTIFIC DISCOVERY THROUGH ADVANCED COMPUTING (SciDAC)



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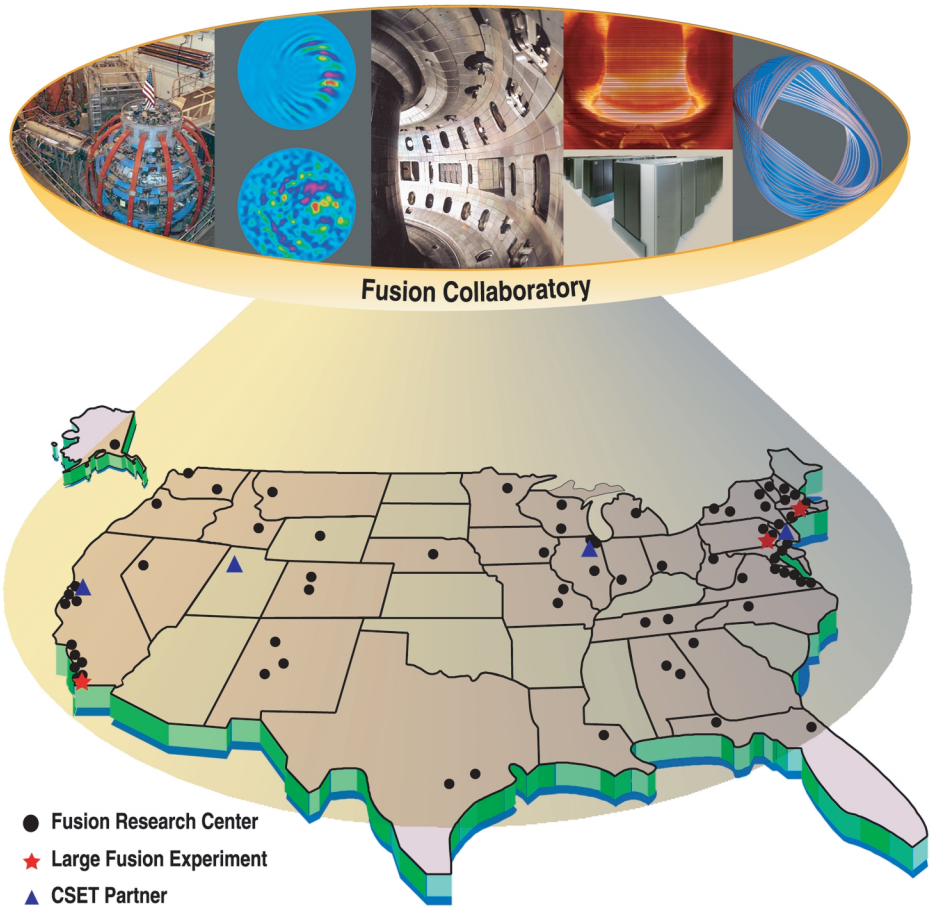
THE COLLABORATORY WILL EMBRACE 40 US SITES IN 37 STATES



- The Collaboratory will be created by a diverse team
  - 3 large fusion experiments
    - C–Mod, DIII–D, NSTX
  - 4 computer science centers
    - ANL, LBNL, Princeton U., U. of Utah
- Coordinated with the user community
  - Main experimental sites
  - Theory & simulation community
- A 3 year effort costing $5.4 million
  - For software, not hardware

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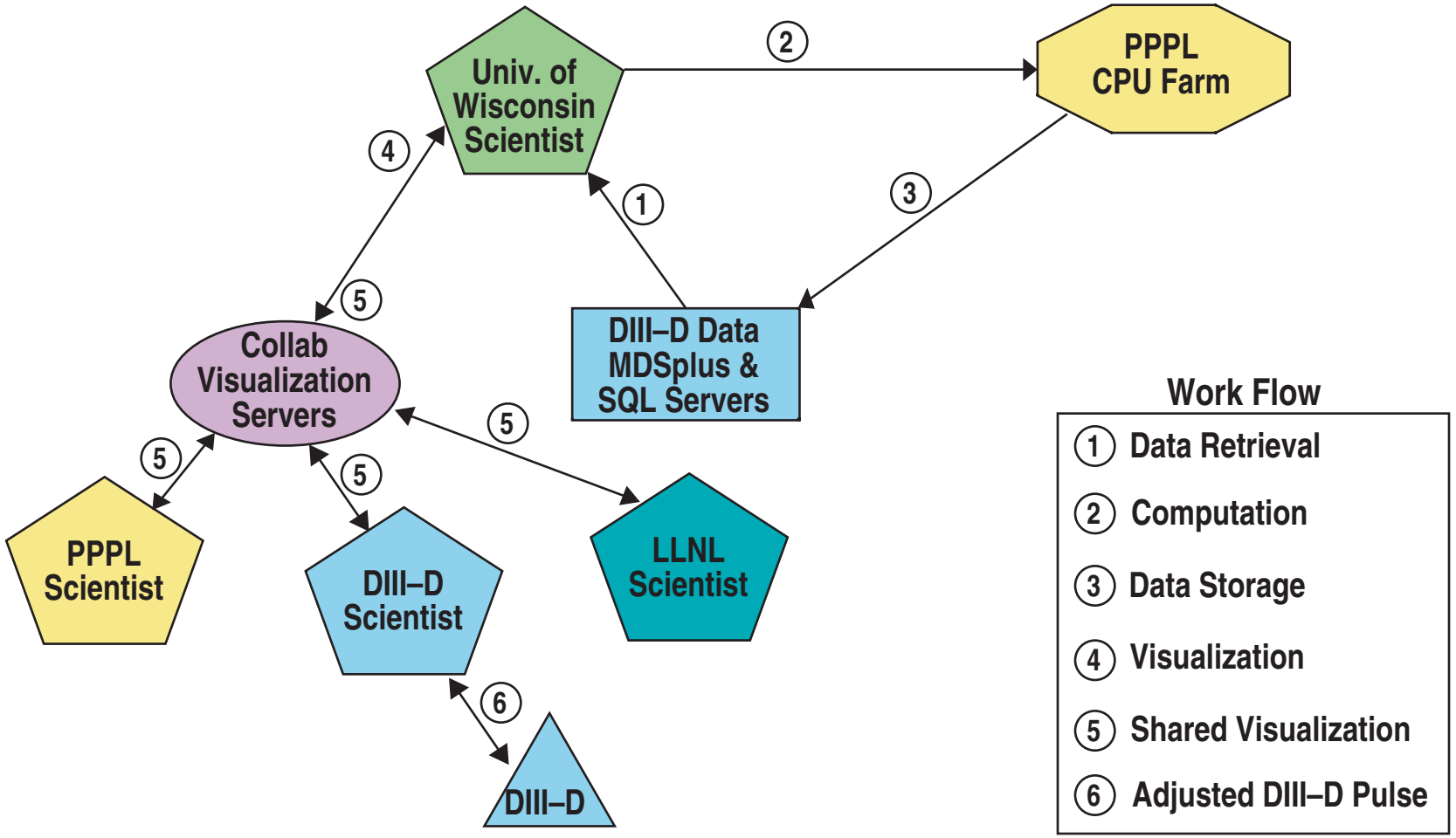
EXAMPLE OF COLLABORATORY BENEFITS: ENHANCED EXPERIMENTAL OPERATIONS



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MDSplus PROVIDES A COMMON, SHARED NETWORK ENABLED INTERFACE TO ALL DATA

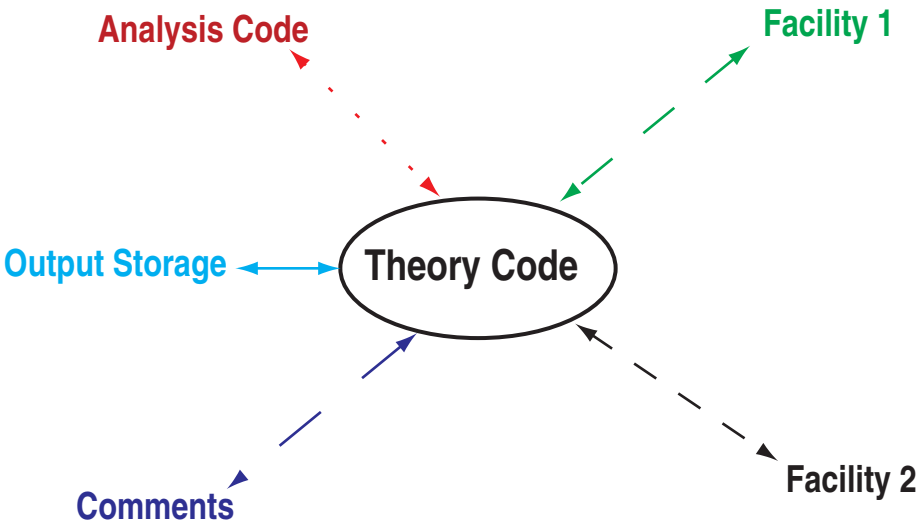
- MDSplus is a data system jointly developed by MIT, LANL, & Padova Italy
  - Provides for acquisition, storage, access, and organization of data
  - Client/server system utilizing TCP/IP
  - Can store experimental, simulation & theoretical data
- Presently used to serve data at 4 sites in US and 8 worldwide
  - Includes the 3 large US tokamaks
  - Clients at many sites
- Many physics analysis codes have been or are being integrated with MDSplus
  - Transport: MIST, ONETWO, TRANSP
  - MacroStability & Equilibrium: DCON, EFIT, M3D, NIMROD, PEST
  - MicroTurbulence: GS2

MDSplus CHARACTERISTICS

- Hierarchical and self descriptive
- Supports a variety of primitive data types
  - Byte, word, long, float, double, complex, string, expressions, actions
  - Built in expression evaluator (TDI)
- Remote access available currently from
  - Fortran, C/C++, Java, Python, IDL, Matlab, and labview
- Tools exist for quick display of data and structure
  - X–windows and Java scope & traverser
  - IDL tools (ReviewPlus, Pslice, JETDSP, etc.)
  - Matlab tools
- Supported platforms (so far)
  - AIX, Cray Unix, Digital Unix, HP/UX, Irix, Linux, Mac OS, Sun OS, VMS, Win32 (windows 9x, NT, 2000)

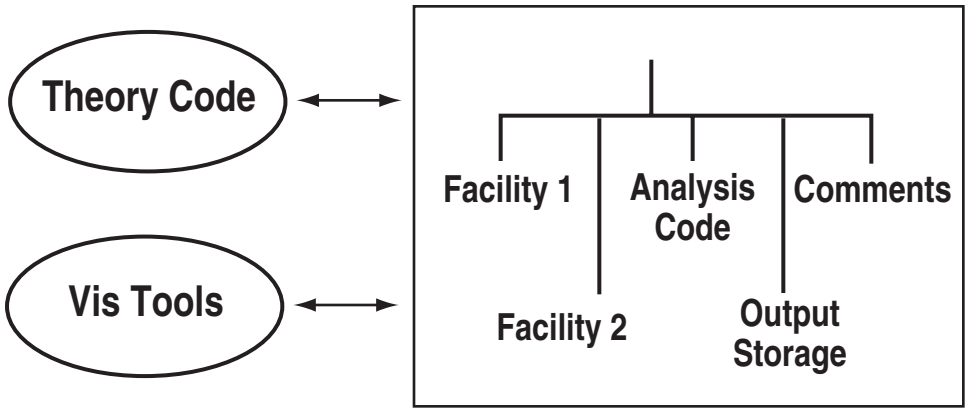
MDSplus WILL UNIFY DATA ACCESS FOR THE THEORETICAL COMMUNITY JUST AS IT HAS FOR THE EXPERIMENTAL COMMUNITY

Conventional Storage



- Each code needs it own interface
- Must know data format and file location
- Each code has its own graphics tool
- Hard to share results

MDSplus



- One interface to many data types
- Only need location of data in tree
- Utilize existing visualization tools
- Easy to share results with both the theoretical and experimental community

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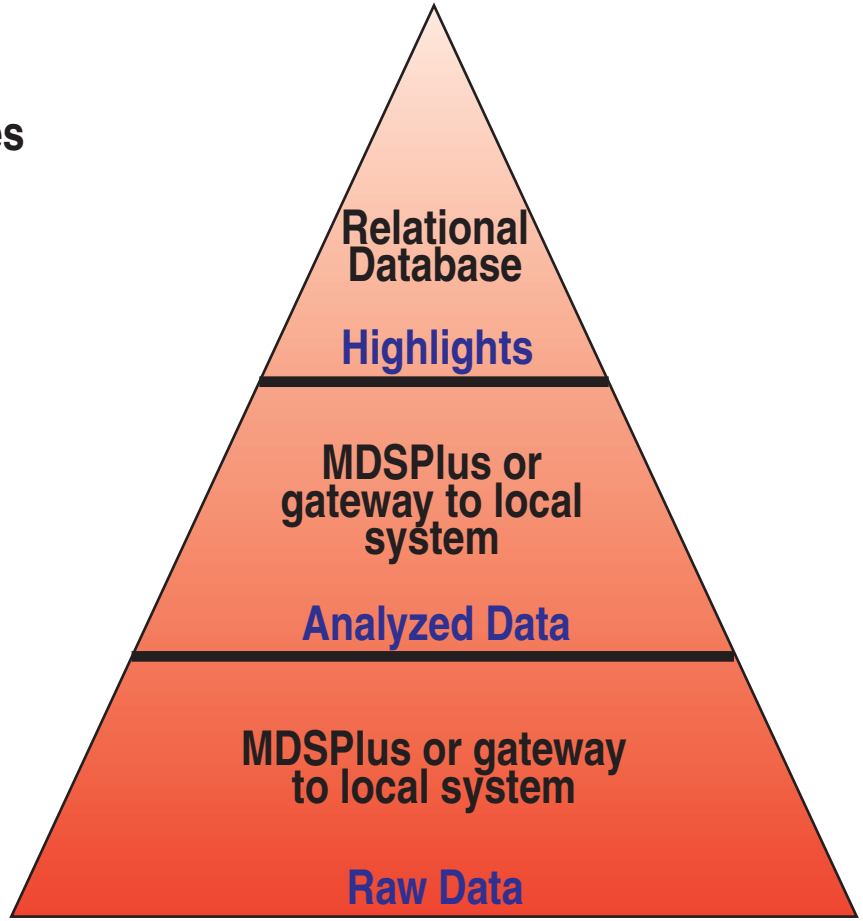
A RELATIONAL DATABASE WORKS IN CONCERT WITH MDSplus

- MDSplus stores or is a gateway to all the data
  - Not optimized for queries across multiple pulses
- Relational DB stores highlights of the data
  - Optimized for queries
  - Drill down to smaller dataset
- Requirements of relational DB
  - Archival storage of data highlights
  - Track code runs
  - Interface to visualization software
  - Flexible schema evolution
  - Transparent access across WAN



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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 will require authentication, authorization, and encryption
  - Fair use of shared resources
- **Remote and Distributed Computing**
  - Share the community's computational resources
  - Job scheduling, monitoring, exception handling, and accounting
- **Scientific Visualization**
  - Increased data quantities and ease of collaboration requires better visualization technology
  - Collaborative control rooms & meeting rooms, and enhanced vis tools

SECURITY: THE COLLABORATORY WILL UTILIZE THE GLOBUS SECURITY INFRASTRUCTURE & AKENTI AUTHORIZATION SERVICE

- Globus (www.globus.org) is a research and development project focused on enabling the application of Grid concepts to scientific computing
- The Grid refers to an infrastructure that enables the integrated, collaborative use of high–end computers, networks, databases, and scientific instruments owned and managed by multiple organizations
- Akenti (www-itg.lbl.gov/Akenti/) is an access control system designed to address the issues raised in allowing restricted access to distributed resources which are controlled by multiple organizations
- Existing fusion codes will be modified to use this infrastructure
- The middleware tools will be extended to meet Collaboratory needs

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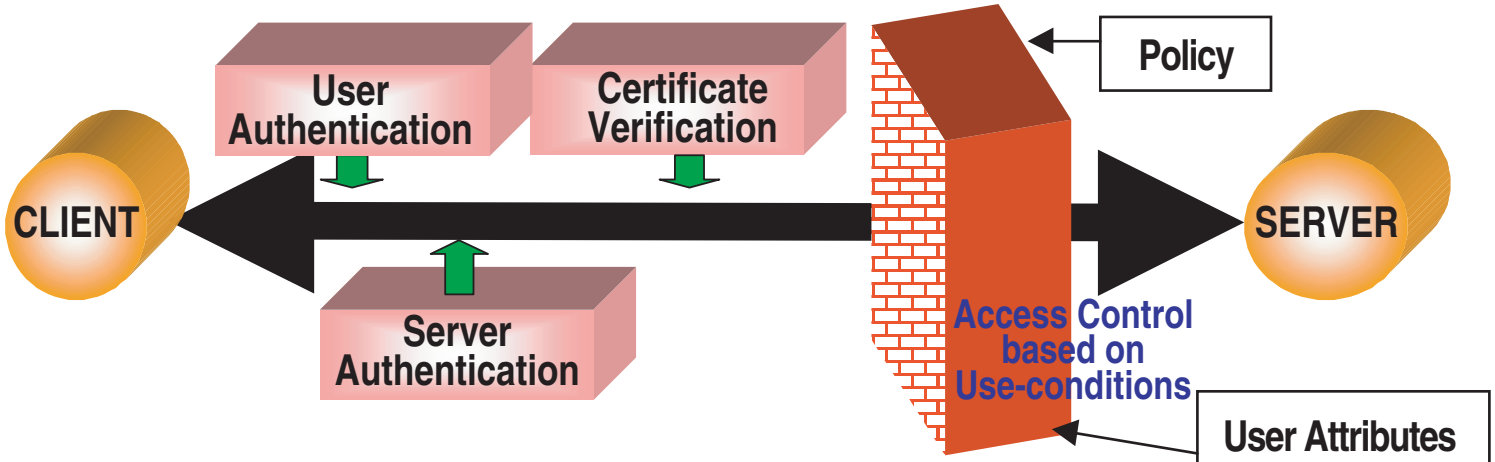
ACCESS CONTROL ENFORCES AN AUTHORIZATION POLICY

- Clients attempt to access resources controlled by servers
- Access control policy: prior authorization decisions for client access to resources
- Public-key infrastructure and secure message protocols provide confidentiality, message integrity, and user identity authentication



S. S. Mudumbai, et al.

REMOTE & DISTRIBUTED COMPUTING: ACCESS TO POWERFUL DATA ANALYSIS & SIMULATION CODES AS NETWORK SERVICES

- Fusion codes will run on hardware appropriate for each code
  - Fast serial workstations – midrange parallel clusters – supercomputers
- Collaboratory will enable detailed time dependent transport and stability analysis between pulses
  - Equitable sharing and preemptive data analysis
- Globus can provide for the required capabilities
  - Create grids connecting computational resources with users
  - Track the capabilities of resources within a grid
  - Specify the resource needs of user's computing tasks
  - Mutually authenticate both users and resources

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SUBSTANTIAL SETUP FOR APRIL FUSION SCIENCE MEETINGS BUT THE EXERCISE PROVED VALUABLE

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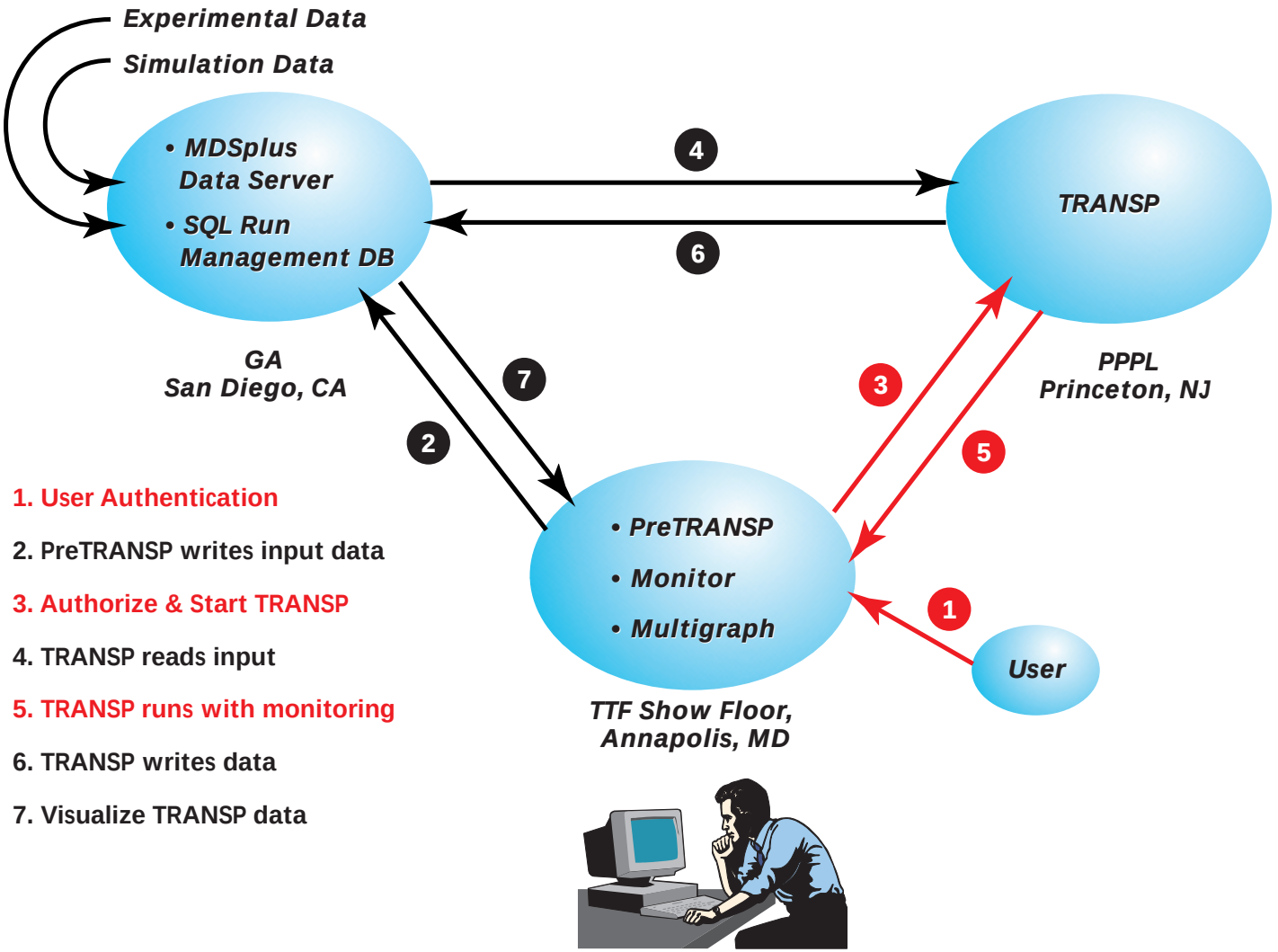
SUCCESSFULL DEMONSTRATION OF GRID COMPUTING AT APRIL FUSION SCIENCE MEETINGS



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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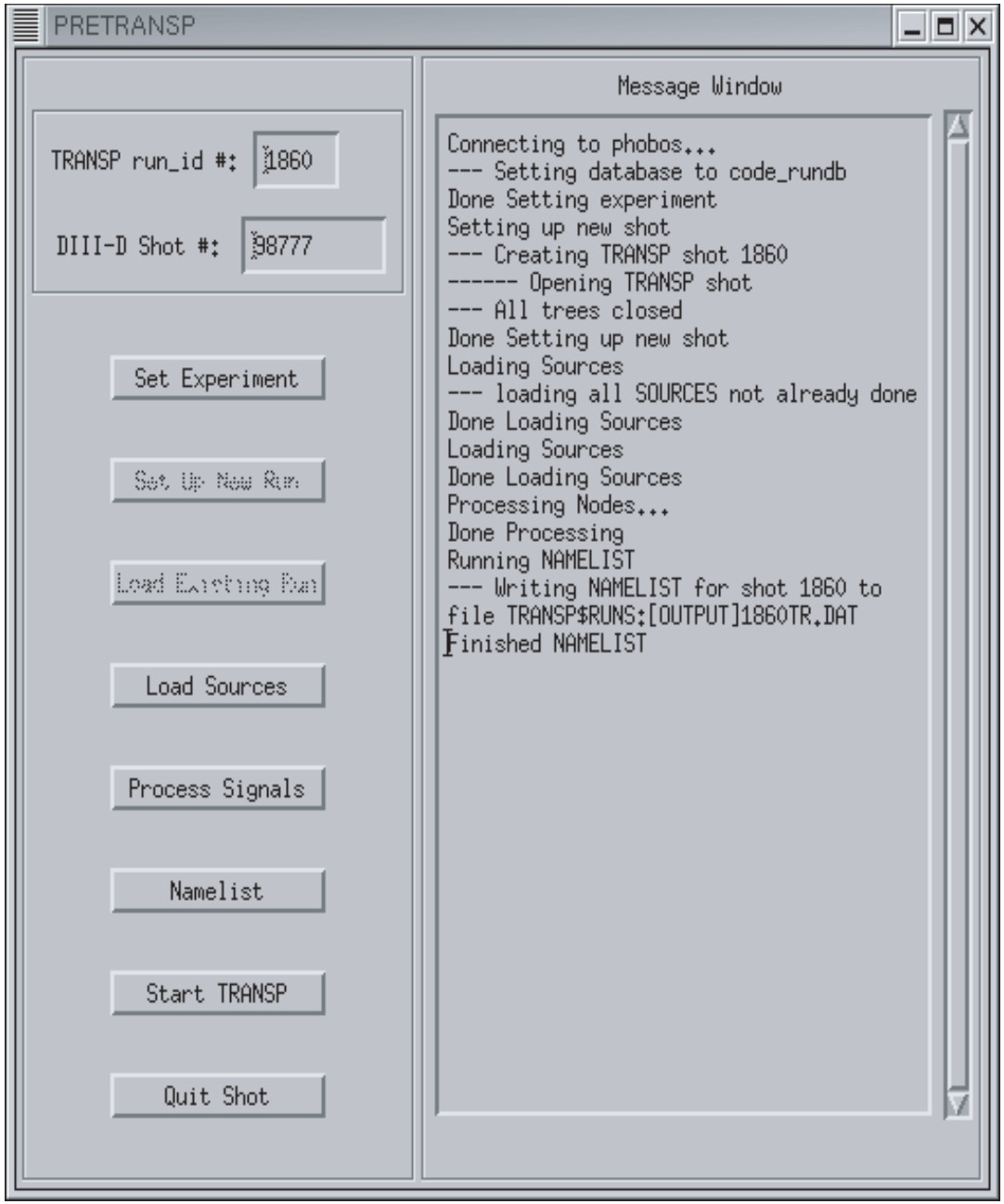
A GUI WAS CREATED TO SETUP AND LAUNCH A TRANSP RUN

- First log onto the Grid
- Prepare data for TRANSP run and store inputs in MDSplus
- Submit TRANSP run
- Monitor state of run
- TRANSP writes data to MDSplus
- Visualize TRANSP data



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A VARIETY OF VISUALIZATION TOOLS BROUGHT THE DEMO ALIVE

- US map to visualize demo & make it real
- Monitor run via a web browser
- Visualize results using IDL based tool

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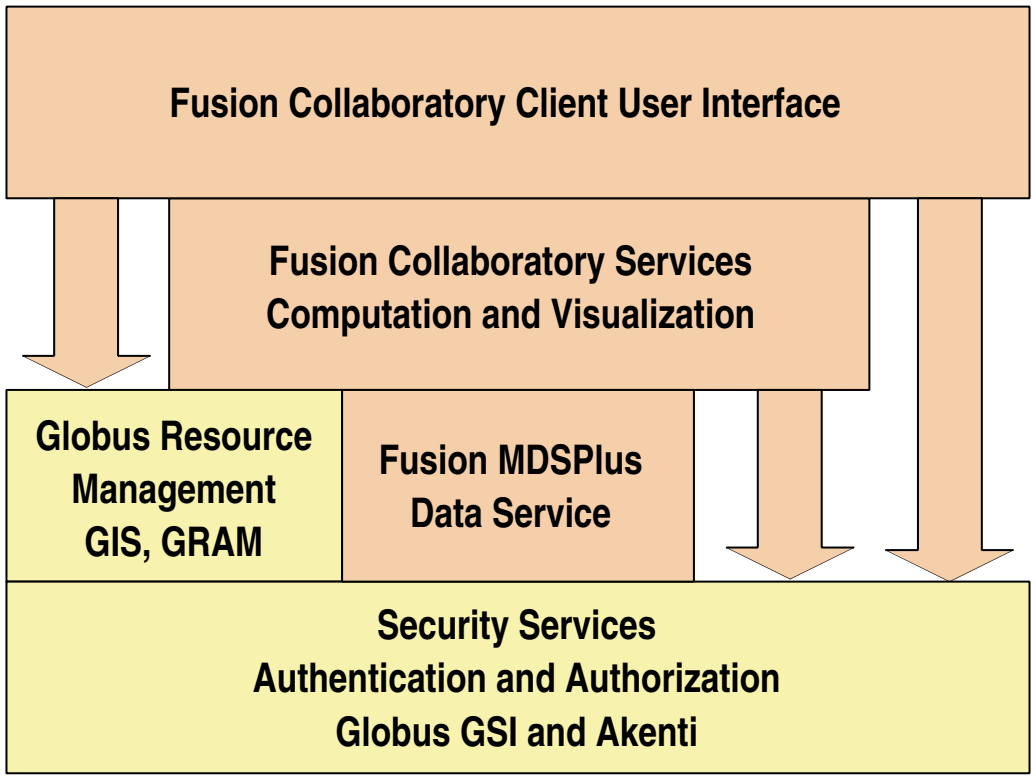
SERVICES ARE LAYERED TO HIDE COMPLEXITY WHILE PROVIDING POWERFUL TOOLKITS FOR DEVELOPERS

- MDSplus will provide the common data access for the Collaboratory
- Globus and Akenti will provide the necessary middleware



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

- Strive to dramatically reduce the hurdles that presently exist for collaborative visualization
- Leverage existing technology where possible
  - Workspace docking using the Access Grid (AG)
  - Integrate existing AG collaborative tools with tiled display walls
- Collaborative Control Room
  - Large on–site group to interactively work with small to large off–site group
- New visualization software
  - Simultaneous sharing of complex visualizations
  - Error representation in complex experimental and simulation data

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TILED DISPLAYS WALLS ALLOW A LARGE GROUP OF SCIENTISTS TO EXPLORE INFORMATION IN COLLABORATION MORE EFFECTIVELY

- Access Grid (www.accessgrid.org) compliments and extends the data grid
  - Ensemble of network, computing and interaction resources that supports group to group collaboration and communication
- Display wall research has focused on low–cost commodity components

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SMALL DESK TOP ACCESS GRID NODE HAS BEEN DEMONSTRATED

ANL

- Targed for the small research center
  - For one to one and one to many interactions
- Usage example: communication to a tokamak control room

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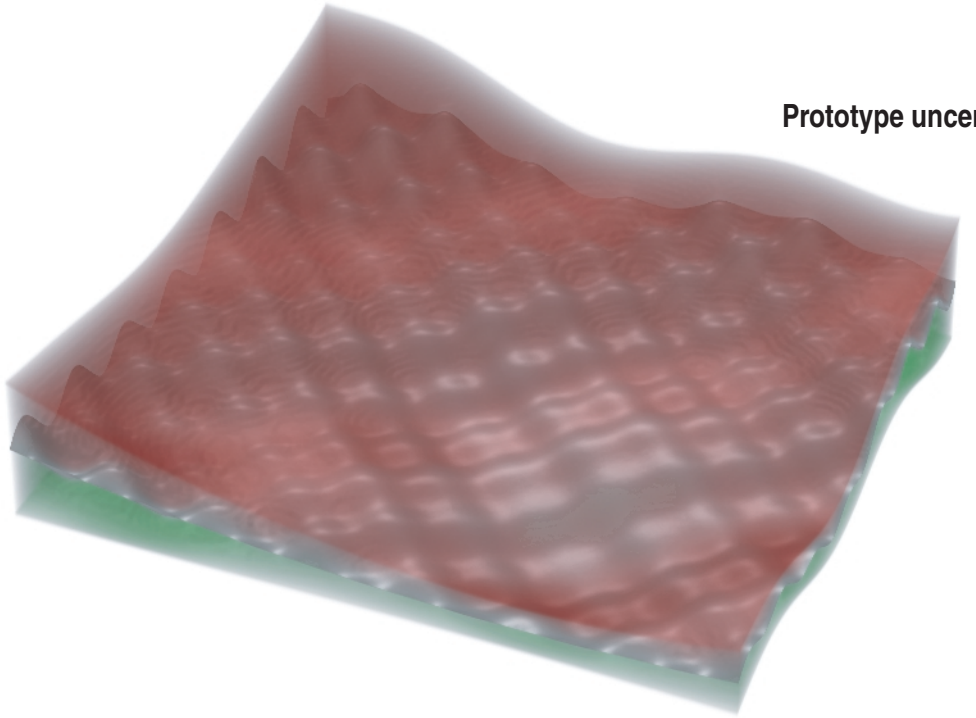
VISUALIZATION TOOLS WILL BE CREATED THAT REPRESENT A SIGNIFICANT INCREASE IN EFFICIENCY FOR THE FUSION COMMUNITY



Prototype uncertainty visualization
courtesy U. of Utah

- Provide visualizations that incorporate and compare data from multiple experimental and simulation sources and to reflect uncertainty information to aid in data analysis
- Collaborative visualization tool will be created for experimental operations giving both local and remote teams an interactive, big picture view of the vast amount of data

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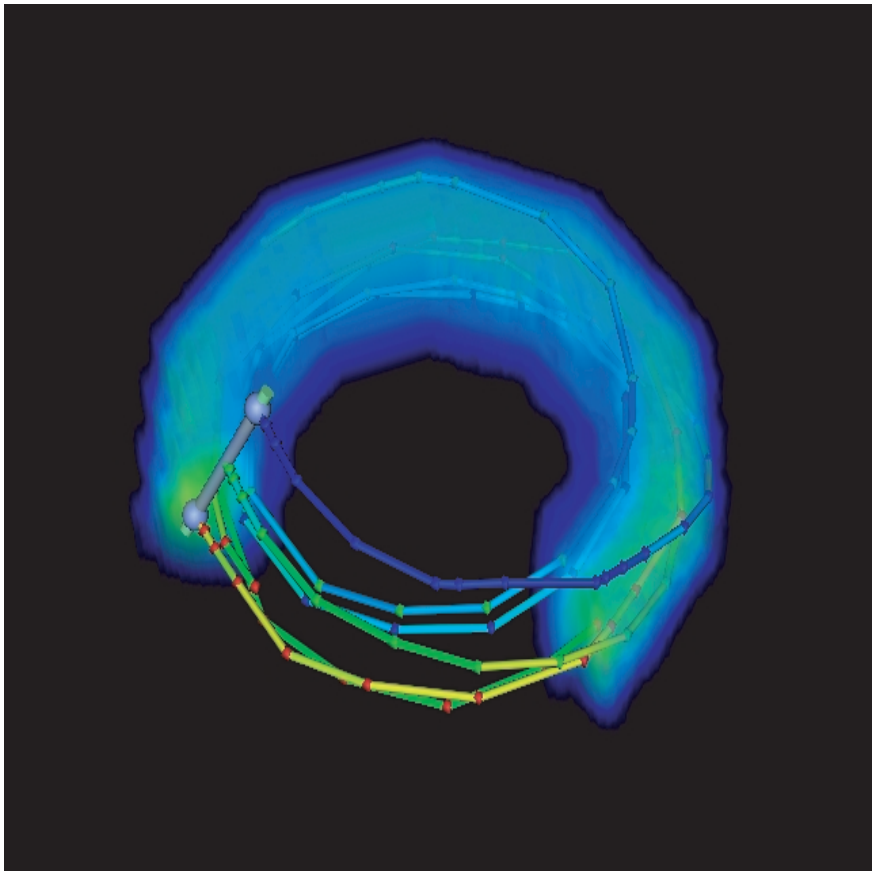
ADVANCED VISUALIZATION TOOLS BEING CREATED



U. of Utah - NIMROD pressure with magnetic field stream lines

- Quantiative 3D visualization – SciRUN
- Designed for general use
- Can be remotely shared
- To be demonstrated at Sherwood

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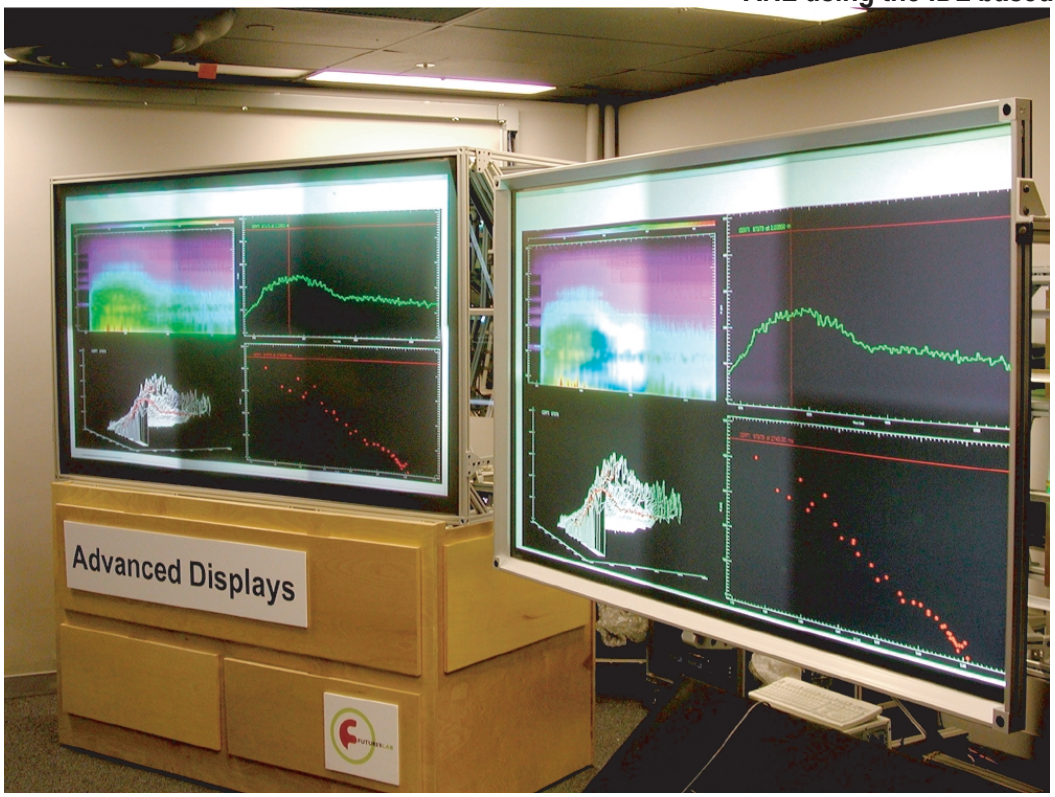
SHARED VISUALIZATION BETWEEN TILED WALLS HAS BEEN DEMONSTRATED

ANL using the IDL based tool ReviewPlus



- Workstation to Wall and Wall to Wall is possible - communicate to the control room
- To be demonstrated at APS/DPP 2002 in Orlando

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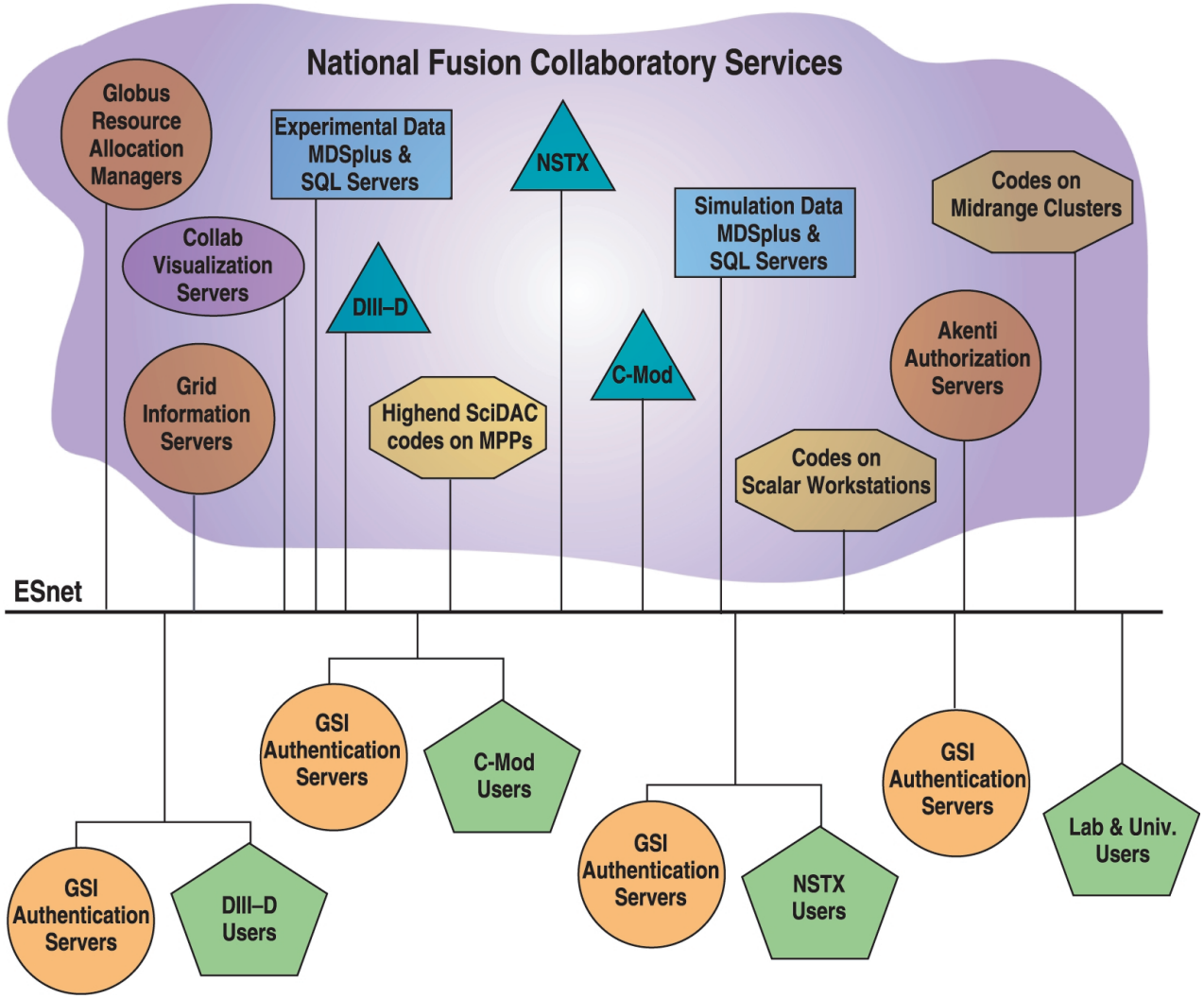
CREATE A UNIFIED FRAMEWORK SO DATA, CODES, VIS TOOLS ARE AVAILABLE SECURELY & TRANSPARENTLY OVER THE INTERNET



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SUMMARY

- A 3–year project to create a Fusion Collaboratory has begun
- Team effort comprised of fusion scientists and computer scientists
- The collaboratory will enable networked real–time data analysis and instantaneous communication amongst geographically dispersed teams of experimentalists and theoreticians
- The goals of the KSTAR and Collaboratory Projects are similar
  - Expect this can be a very fruitful area of collaboration
  - Would like to pursue areas of mutual interest for US–Korea bilaterial work
- More information at http://www.fusiongrid.org/

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