Advanced Collaboration and Remote Participation Tools for Nuclear Fusion Research

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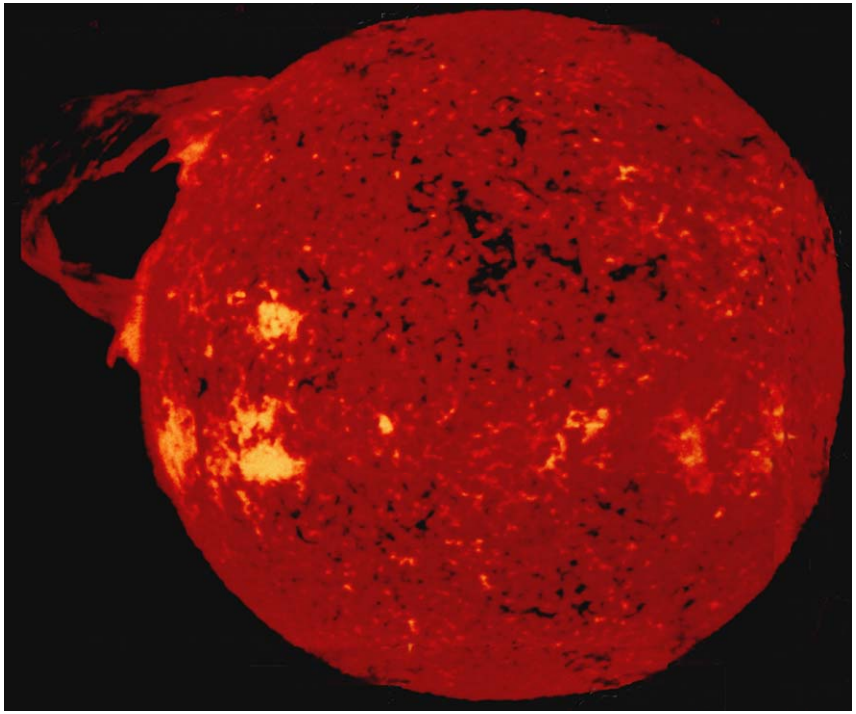
Overview

- **Fusion science is a very collaborative effort**
  - Worldwide effort leading to ITER (Japan or France)
- **Experimental fusion science is time critical**
  - Intensive 30 minute data analysis & decision cycle
  - Variety of collaborative tools are presently being utilized
- **Access Grid experience has the potential to satisfy fusion's worldwide collaboration needs**
  - Reliable collaborative framework for fusion experiments
  - Easy to use from ad-hoc small meetings to experiments
  - Integrated framework for all fusion software tools

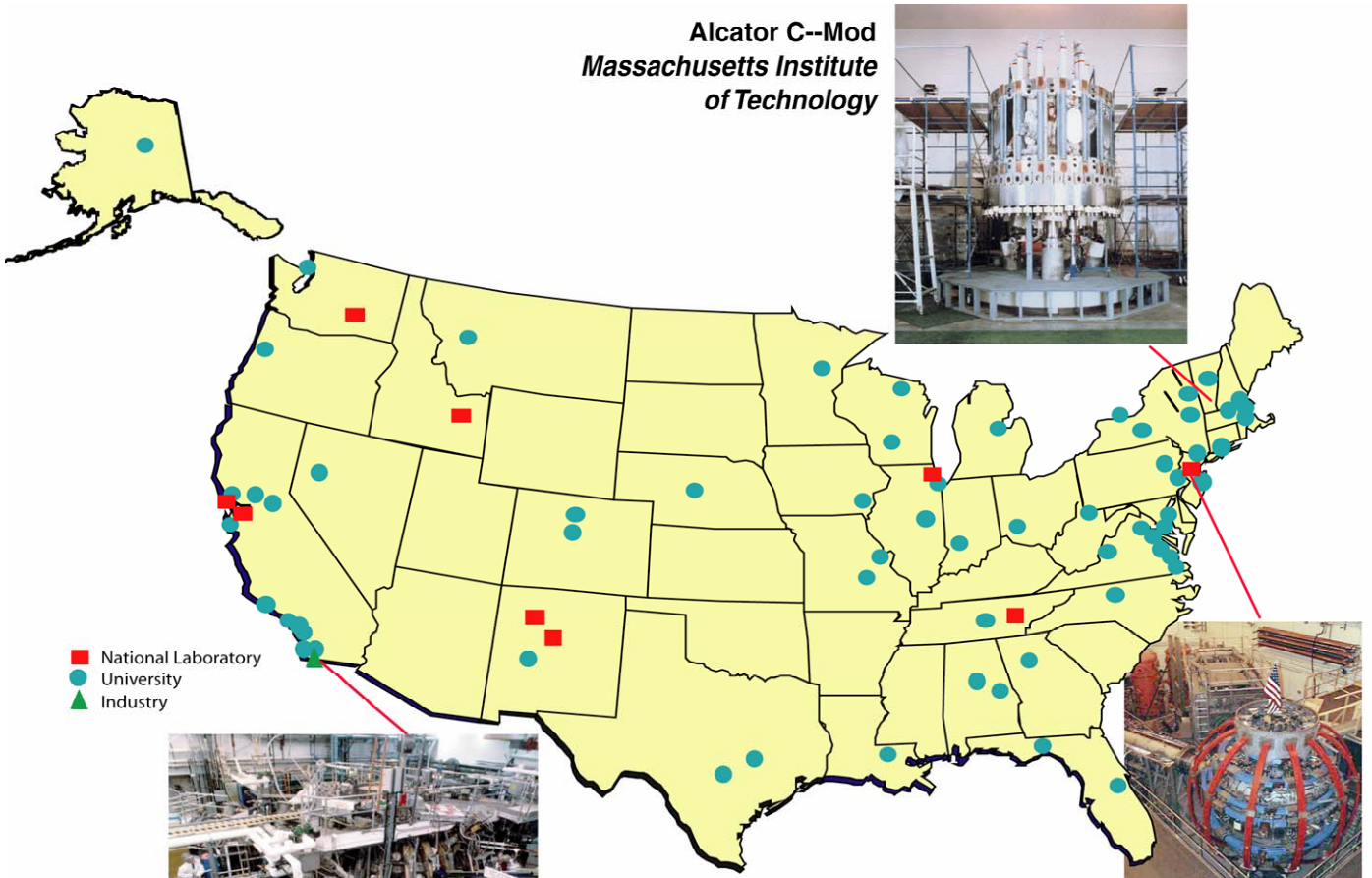
Fusion research seeks deployment of an environmentally and economically attractive power plant



- **The sun is powered by a fusion reaction**

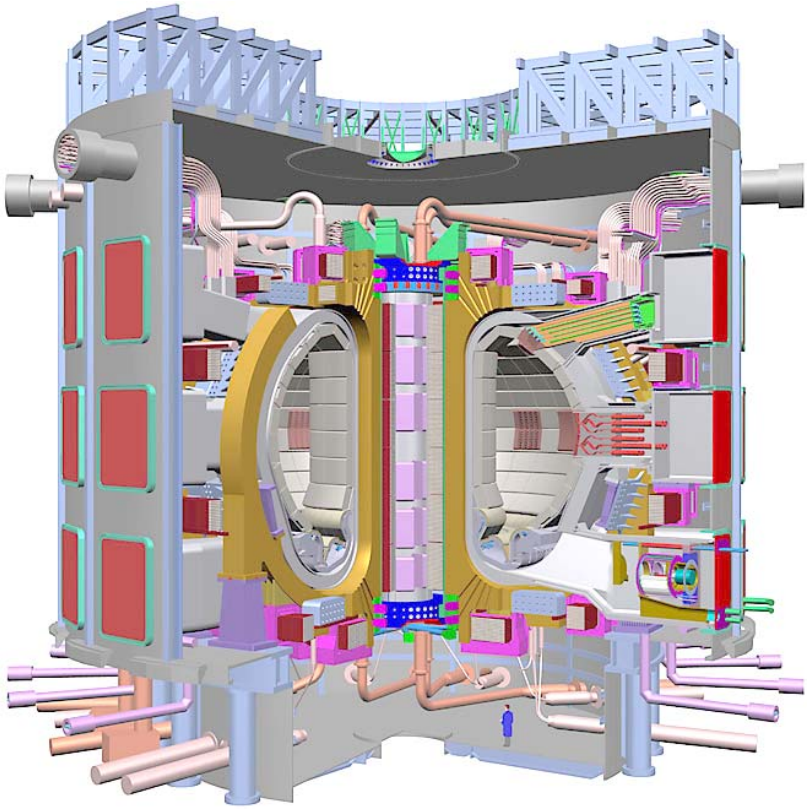
- **Fusion is when you combine two atoms into one atom**
  - Energy released
  - A nuclear reaction
- **A very hot reaction: plasma**
- **Fueled by Hydrogen**
- **High energy density**
  - Pickup truck fusion fuel = 21,000 railcars of coal

Three large U.S. experimental facilities and a vibrant theoretical community



Remote participation & collaboration will soon be even more critical to the U.S. fusion science community

- **Today there are several fusion reactors located worldwide**
- **Next-generation fusion device (ITER) will not be in the U.S.**
  - Can't ask all fusion personnel to move there
- **Fusion facilities are big, expensive, and complex**
  - $0.5 Billion to replace DIII-D
  - $5+ Billion to build ITER
- **Must be able to work remotely**
  - Scientists, engineers, designers, computer scientists



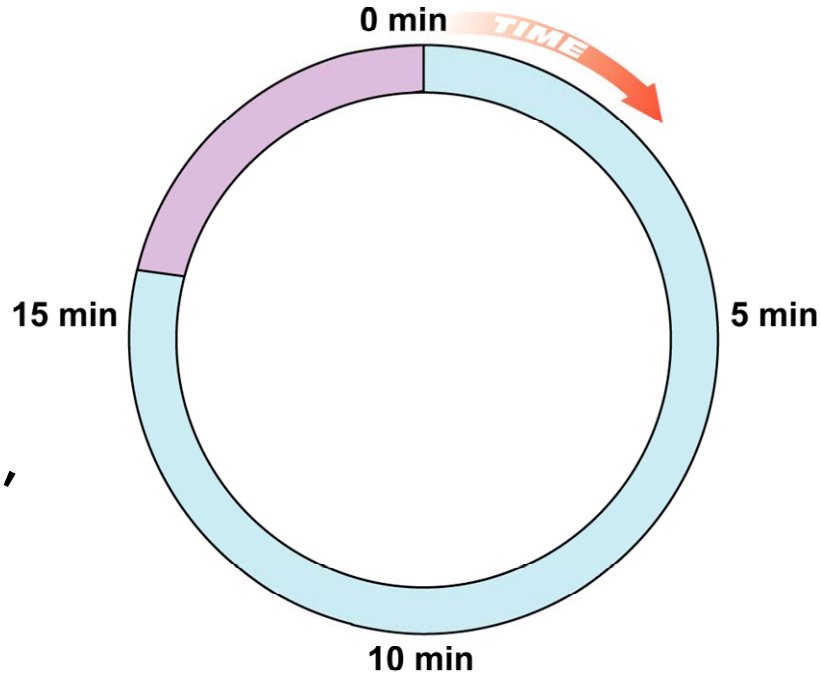
Fusion experimental science is a large team effort

- **Mission Control**
  - All located on site

- **DIII-D Control room**
  - Worldwide participation

Fusion experiments: like doing a space shuttle launch every ~20 minutes

- Fusion experiments consist of a series of pulses, or "shots"
- A "shot" is when you turn on the device for a few seconds
- Take a shot, analyze results, plan next shot, set new device parameters, take next shot…



Access Grid is being used in the control room

- **Access Grid (AG) is used in the control room**
  - Remote collaboration
- **Example: DIII-D Fusion Facility in San Diego has an AG node in the control room**
- **Used for remote participation during an experiment**
- **Running the machine is expensive, so reliability is crucial**

AG has been used to lead remote experiments

- In 2004, a scientist in San Diego led an experiment located at JET in the UK
- Performed data analysis
- Interacted with researchers located in the JET control room

- Established the feasibility of remote experiment through Access Grid
- Now routine: Japan, Germany, England, U.S.

Scientists also use AG for meetings

- AG is also being used by fusion scientists to attend remote meetings
- Some meetings are interactive, but most are simple broadcasts
- Example: the 10-minute "morning meeting" before start of experiment

Other collaborative tools are in use

- **AG framework does not meet all the collaborative needs of fusion scientists**
- **Other collaborative tools are in use to fill a need identified by the fusion scientists**
  - Satisfying a need

VRVS has web interface and Mac support

- **Web interface**
- **No network issues**
  - No "operator"
- **Easy to install**
  - Example: DIII-D morning meeting
- **Macintosh client**

Remote eyes: a controllable camera

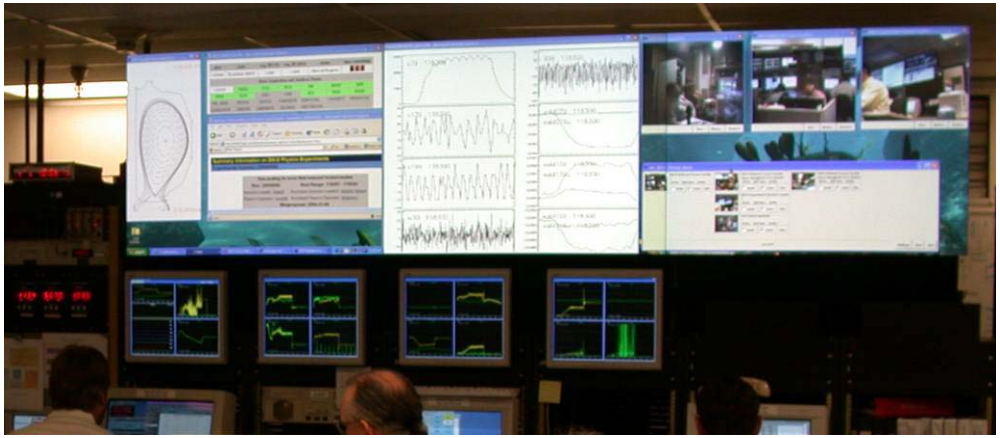
- **Added a web cam to the DIII-D control room**
- **Controllable through a web interface**
- **Lets you "look around" the control room**
  - Example: I want to see if a particular scientist is in the control room
- **Control interface is from Sony, not AG**
- **Can this be integrated with AG?**
  - Part of the AG experience

Electronic logbook used for real-time and historically searchable record of experiment

- **The electronic logbook is used by scientists to store their comments about the experiment**
- **Builds a shared document for an experiment**
- **Entering a comment triggers an event that updates other logbooks**
  - No polling for updates
- **Used to communicate status**
- **Entries are permanent & SQL searchable**

Display wall facilitates information sharing for both co-located and remote scientists

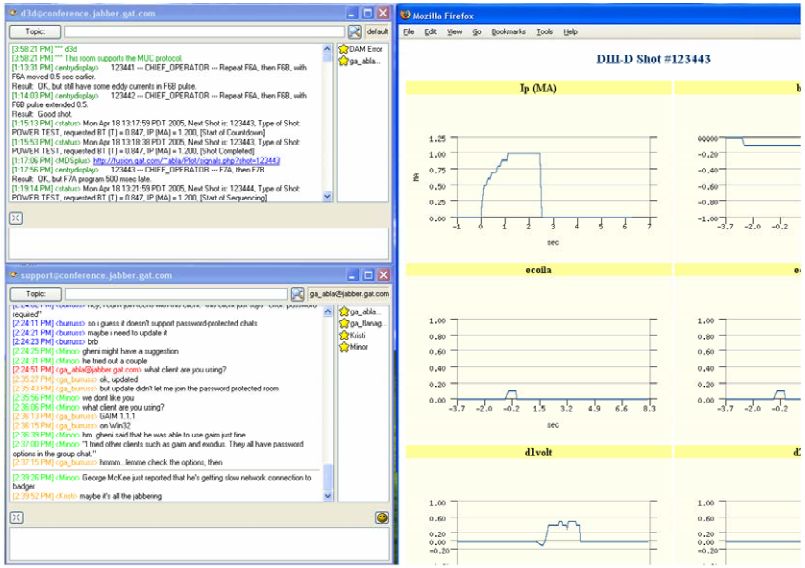
- Local and remote scientists can share their results by displaying images on the tiled display wall in the DIII-D control room
- Replaces "lets all gather around my monitor"



- Also used to display broad-interest information such as movie of plasma shape, analysis monitor
- Example: scientist in UK sent image to wall, then used remote control camera to look at image and make sure image was displayed

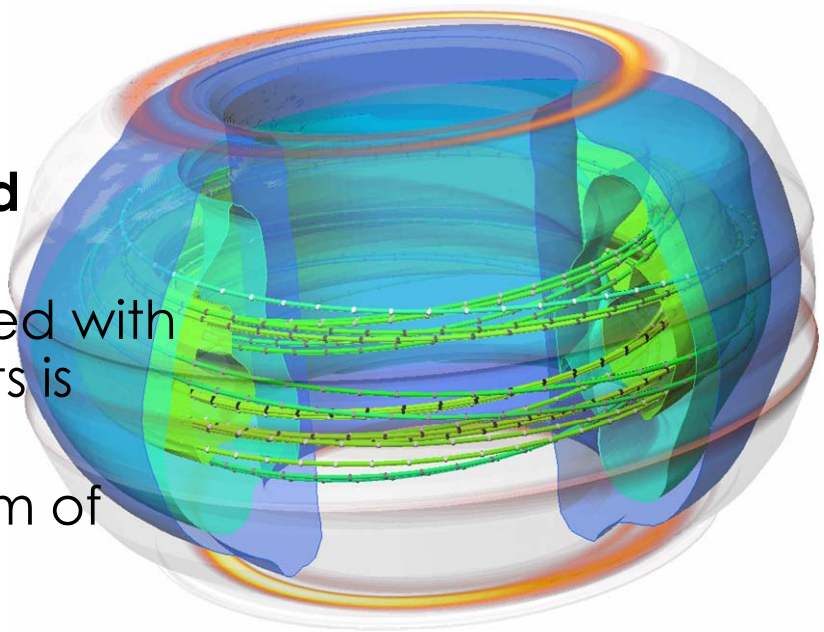
Instant Messaging adapted for use in experiments to increase sense of presence for remote scientists

- **Jabber server installed at DIII-D**
- **Data sent to Jabber:**
  - Electronic logbook entries
  - Data analysis monitoring information
  - Shot status information
  - Regular chat from scientists



Next steps: integrate tools with AG

- **Efficient collaboration needs much more than audio/video conferencing**
  - Visualization software sharing
  - Real-time status info about experiment and team activity
- **Many fusion-specific codes would benefit from integration**
  - Visualization codes can be used with SharedVNC, but sharing events is more interactive
  - Shared application mechanism of AG can be used to develop collaborative applications
- **How are existing applications to be integrated?**
  - Developed in IDL, Fortran, Java



Next steps: experiment-aware AG

- **Current AG shared application mechanism assumes data to be shared already exist**
  - Some images are generated on the fly
  - Plasma shape movie is generated on the fly by data analysis codes
  - Codes crunch numbers, generate movie of what plasma looked like for the shot
  - Need to stream this data to AG

Next steps: increased accessibility → more users

- **Most fusion scientists at DIII-D use Mac**
  - Now AG works on Mac OS X
  - Looking forward to trying AG on Mac
  - Should expand the user base
- **Will set up Multicast/Unicast bridge services**
  - Some Firewalls/routers do not really support Multicast
  - Many switches don't support it either
  - More people can try out AG if they do not need multicast by easily using bridges

Next steps: increase reliability of the experience

- Because of all the possible points of failure (network, etc.) reliability is not high enough for experimental operations
- ITER = $1 Million / shot
- Miss a shot, miss a million dollar opportunity
- DIII-D shots are an order of magnitude less expensive, but still not cheap
- Delays are expensive
- Any solution for use in experimental operations must be very reliable

Next steps: an easier and more reliable experience

- **Increased reliability and quicker setup time is also needed for meetings**
  - Light-weight web client to receive only broadcast
- **Smaller fusion research groups cannot dedicate personnel to running AG nodes or debugging network problems**
  - No "operator"
- **With short meetings, a 10-minute delay means you have missed the entire meeting**
  - Example: DIII-D morning meeting
- **Recording of AG meetings**
- **Even if the bus showed up 95% of the time, would you rely on it to get you to work?**

Concluding remarks

- **AG framework allows integration of fusion software tools**
- **Near term improvements**
  - Recording
  - Light weight web client to receive broadcast
  - Out of band communication (e.g. Jabber)
- **Longer term improvements**
  - Expanded application integration environment
- **Bridging software critical to fusion infrastructure**
  - Eliminate multicast
- **New DIII-D campaign starts April 2006**