

# Advanced Collaboration and Remote Participation Tools for Nuclear Fusion Research

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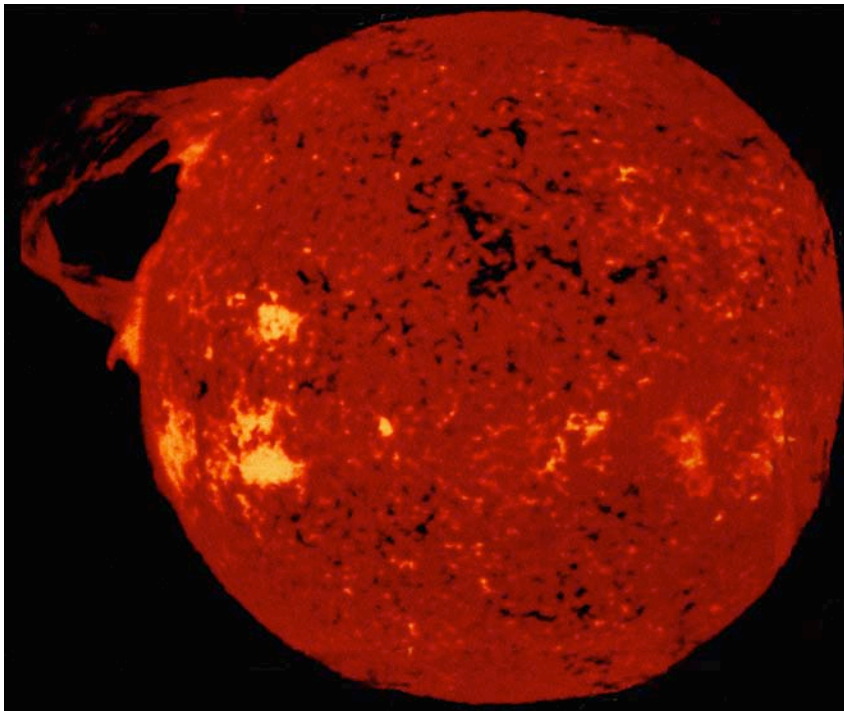
# Acknowledgements

- **The National Fusion Collaboratory Project**
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  - Team: ANL, GA, LBL, MIT, PPPL, Princeton CS, Utah CS
- **The DIII-D National Fusion Facility in San Diego, CA**
  - Funded from DOE/OFES operated by General Atomics

# Overview

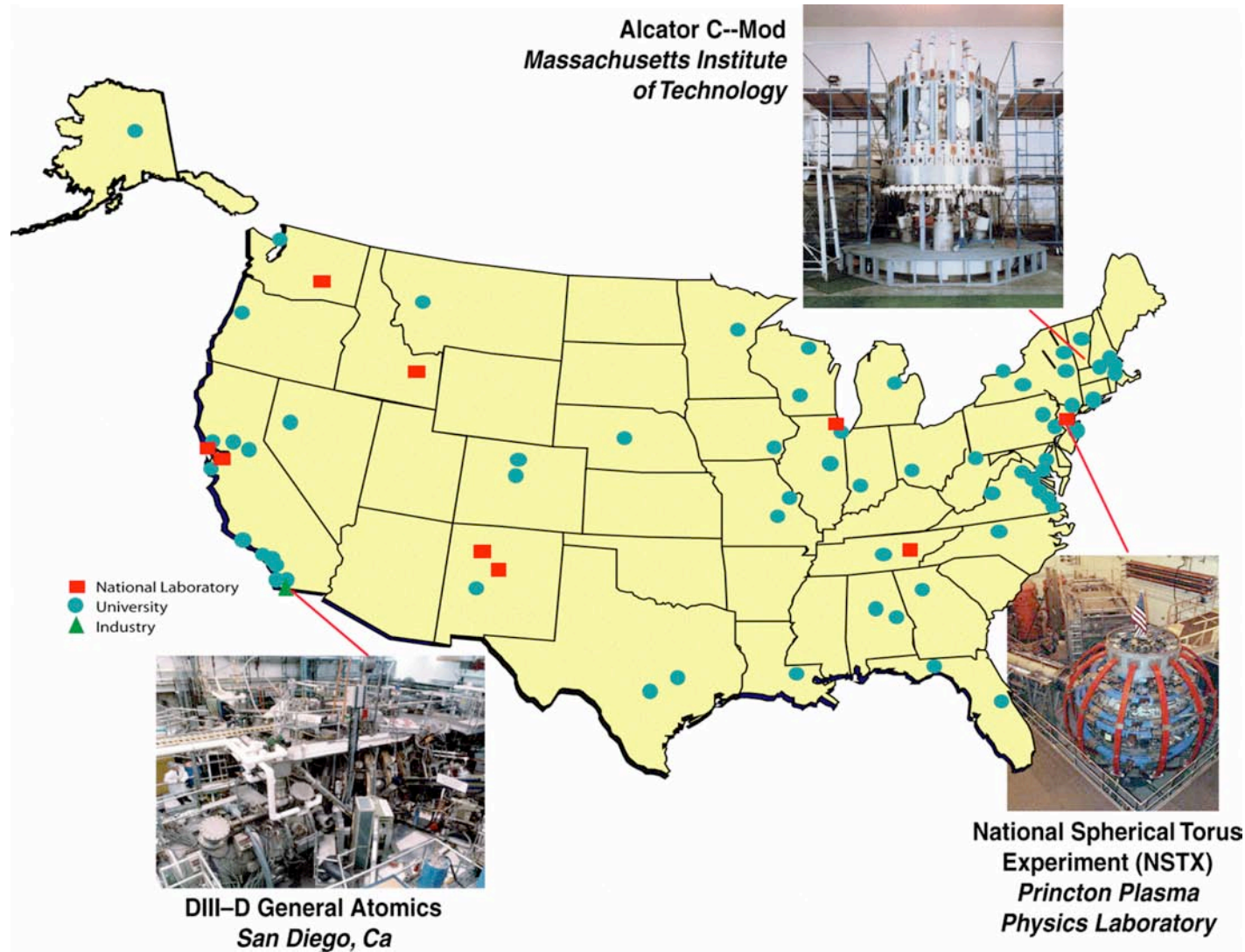
- **Fusion science is a very collaborative effort**
  - Worldwide effort leading to ITER (Japan or France)
- **Experimental fusion science is time critical**
  - Intensive 30 minute data analysis & decision cycle
  - Variety of collaborative tools are presently being utilized
- **Access Grid experience 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



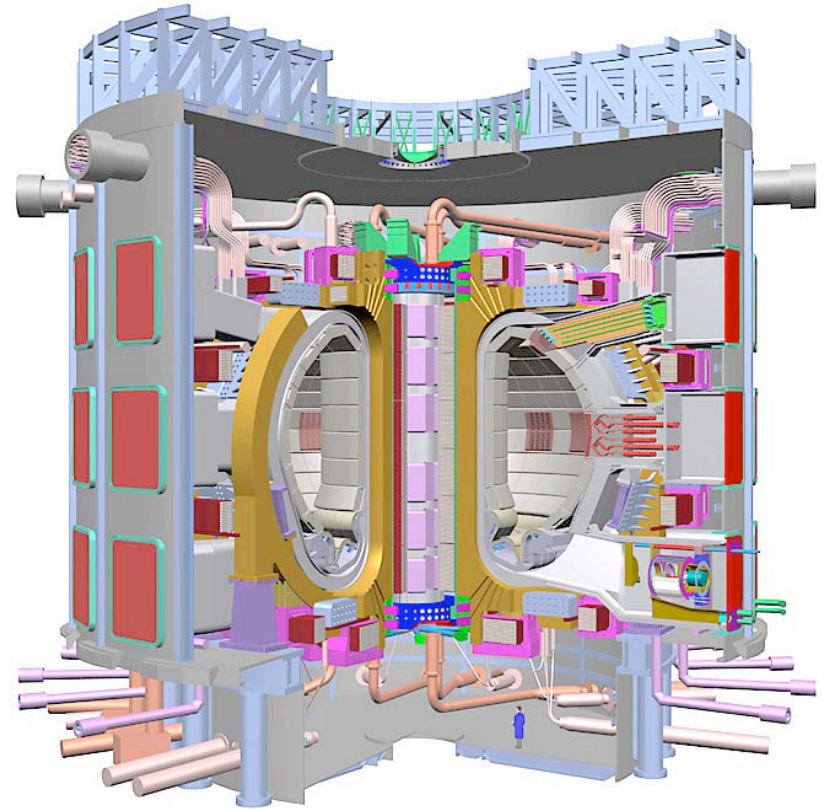
- The sun is powered by a fusion reaction
- Fusion is when you combine two atoms into one atom
  - Energy released
  - A nuclear reaction
- A very hot reaction: plasma
- Fueled by Hydrogen
- High energy density
  - Pickup truck fusion fuel = 21,000 railcars of coal

# 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



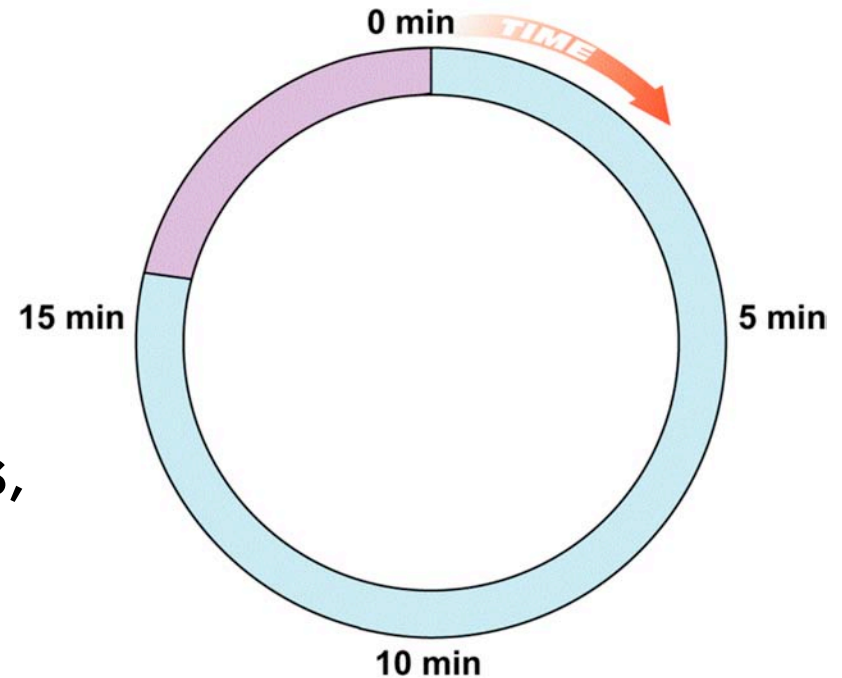
- **Mission Control**
  - All located on site



- **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**

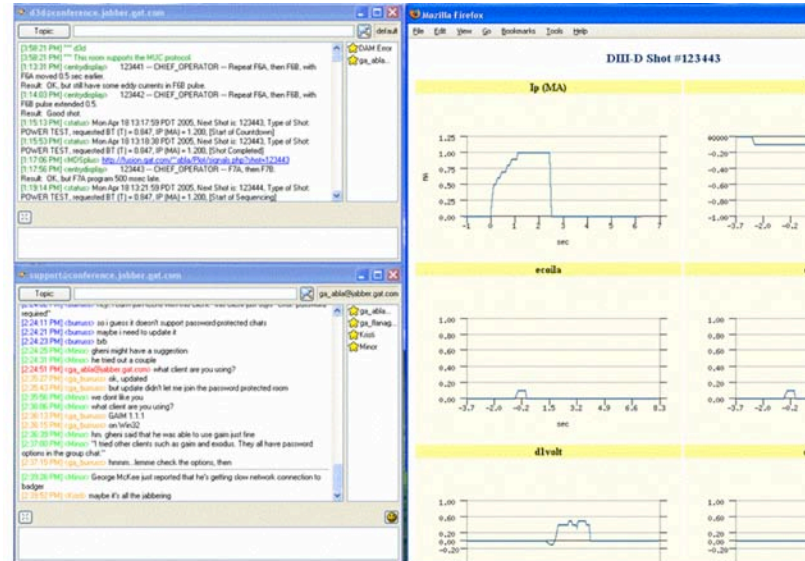
# Display wall facilitates information sharing for both co-located and remote scientists

- 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



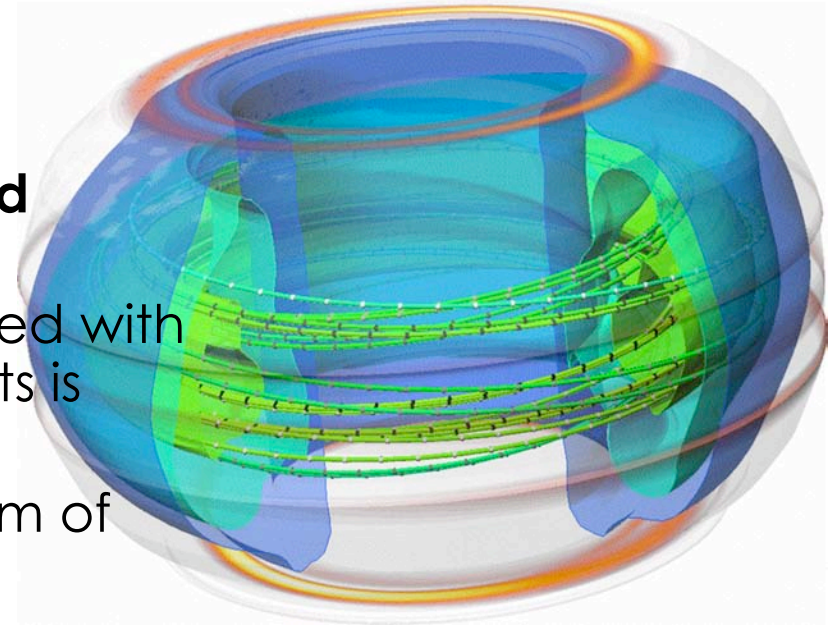
# Instant Messaging adapted for use in experiments to increase sense of presence for remote scientists

- **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**