





DOE National Fusion Collaboratory

Michael E. Papka

Argonne National Laboratory / University of Chicago

Motivation

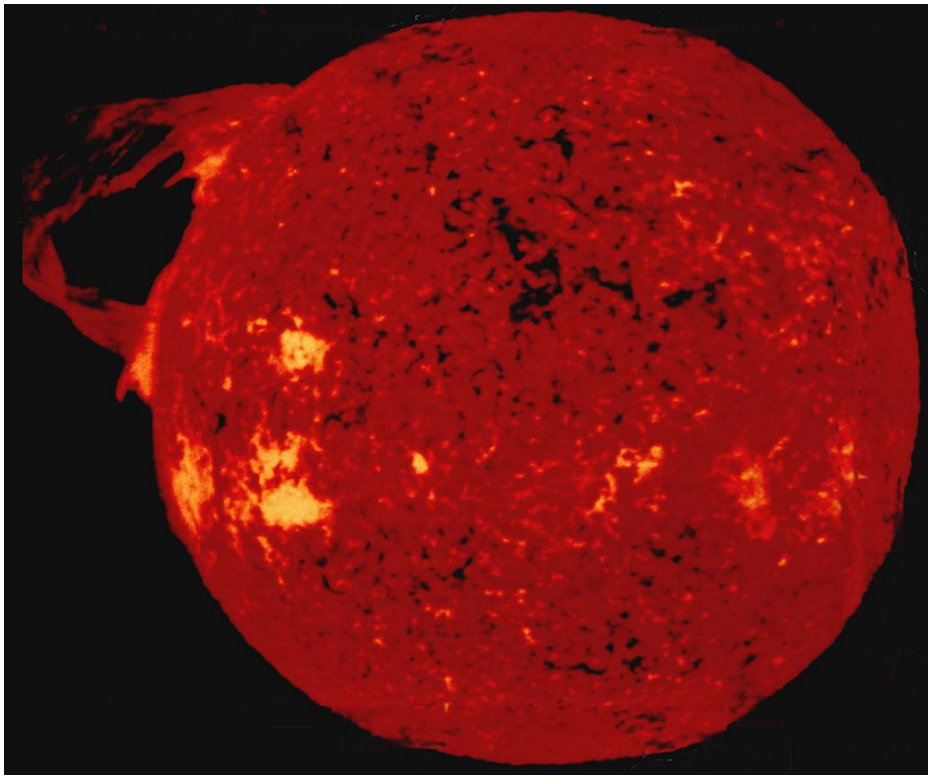
- Make HVD accessible to more individuals
  - More science
- Make time using HVD more productive
  - More science
- Tie computational resources to HVD
  - More science
- Exploit advances in data representation
  - More science

Outline

- What is Fusion?
- How is an Experiment Done?
- Experimental Fusion Process
  - Preparation
  - Experiment
- Showcase Demo
- What Next?

What is Fusion?

- Joining two light nuclei ($E=mc^2$)
  - Pickup truck fusion fuel = 21,000 railcars of coal



- Like charges repel
  - High velocity (temperature)
- High temp removes electrons
  - Plasma
- Long term goal – develop reliable energy system that is environmentally and economically sustainable
  - One international machine ITER is next step

Present Fusion Experiments

- Leader onsite
- Remote participation possible
  - No connection to control room
  - Phone
  - Fax
- Local information on individual consoles

International Fusion Community

US Labs

ANL (Argonne, IL)
INEL (Idaho Falls, ID)
LANL (Los Alamos, NM)
LLNL (Livermore, CA)
ORNL (Oak Ridge, TN)
PNL (Richland, WA)
PPPL (Princeton, NJ)
SNL (Sandia, NM)

US Industries

CompX (Del Mar, CA)
CPI (Palo Alto, CA)
Creare (Hanover, NH)
Digital Finetec (Ventura, CA)
FAR Tech (San Diego, CA)
HiTech Metallurgical (San Diego, CA)
IR&T (Santa Monica, CA)
Orincon (San Diego, CA)
SAIC (La Jolla, CA)
Surmet (Burlington, MA)
Thermacore (Lancaster, PA)
TSI Research (Solana Beach, CA)

US Universities

Alaska (Fairbanks, AK)
Auburn (Auburn, Alabama)
Cal Tech (Pasadena, CA)
Colorado School of Mines (Golden, CO)
Columbia (New York, NY)
Georgia Tech (Atlanta, GA)
Hampton (Hampton, VA)
Lehigh (Bethlehem, PA)
Maryland (College Park, MD)
MIT (Boston, MA)
Palomar (San Marcos, CA)
New York U. (New York, NY)
Texas (Austin, TX)
UCB (Berkeley, CA)
UCI (Irvine, CA)
UCLA (Los Angeles, CA)
UCSD (San Diego, CA)
U. New Mexico (Albuquerque, NM)
Washington (Seattle, WA)
Wisconsin (Madison, WI)

Russia

Ioffe (St. Petersburg, Russia)
Keldysh (Udmurtia, Moscow, Russia)
Kurchatov (Moscow, Russia)
Moscow State (Moscow, Russia)
Triniti (Troitsk, Russia)
Gycom (Nizhny Novgorod, Russia)

European Community

Cadarache (St. Paul-lez, Durance, France)
Consorzia RFX (Padua, Italy)
Culham (Culham, Oxfordshire, England)
Frascati (Frascati, Lazio, Italy)
FOM (Utrecht, The Netherlands)
IPP (Garching, Greifswald, Germany)
JET-EFDA (Oxfordshire, England)
KFA (Julich, Germany)
Kharkov IPT, (Ukraine)
Lausanne (Lausanne, Switzerland)
Chalmers U. (Goteberg, Sweden)
Helsinki U. (Helsinki, Finland)
U. Naples (Naples, Italy)
U. Strathclyde (Glasgow, Scotland)
U. Wales (Wales)

Japan

JAERI (Naka, Ibaraki-ken, Japan)
JT-60U
JFT-2M
Tsukuba University (Tsukuba, Japan)
NIFS (Toki, Gifu-ken, Japan)
LHD

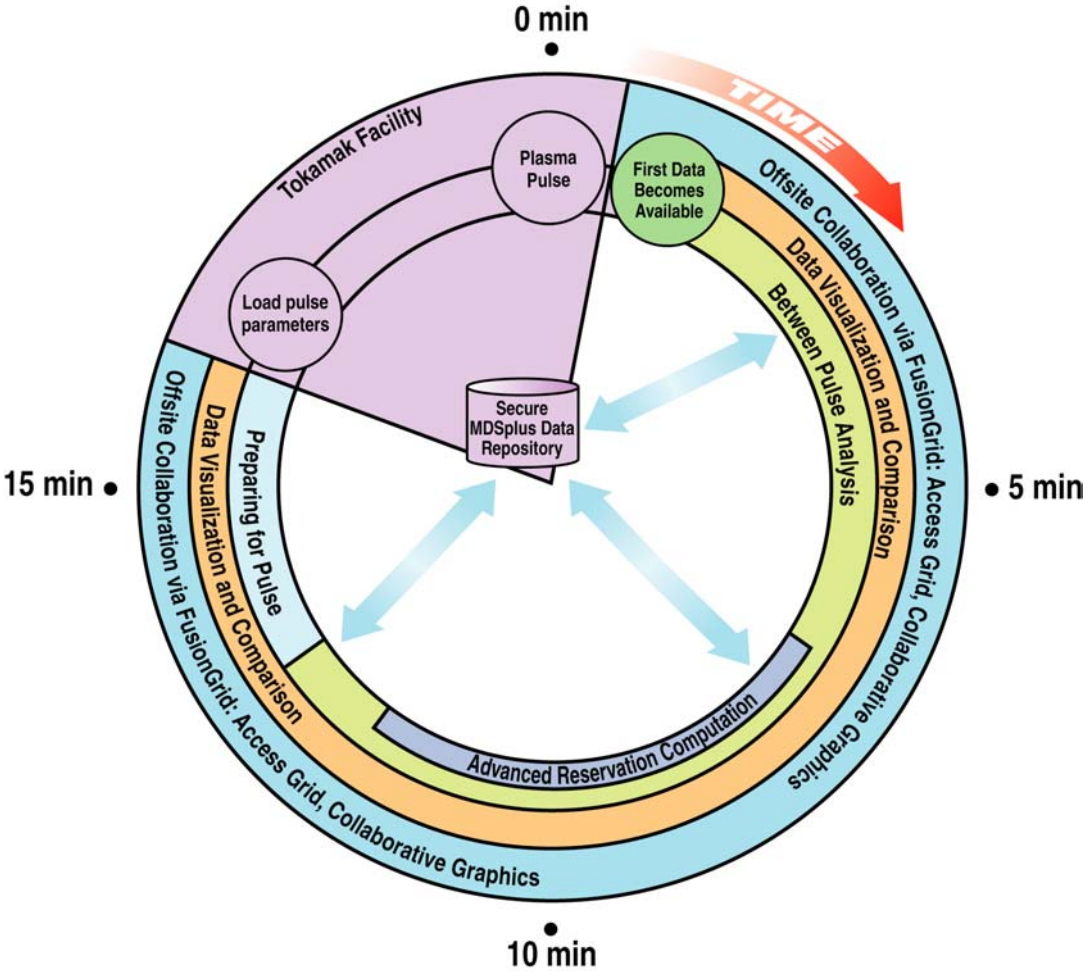
Other International

Australia National U. (Canberra, AU)
ASIPP (Hefei, China)
KAIST (Daegon, S. Korea)
KBSI (Daegon, S. Korea)
National U. (Taiwan)
Nat. Nucl. Ctr. (Kurchatov City, Kazakhstan)
SWIP (Chengdu, China)
U. Alberta (Alberta, Canada)
U. of Kiel (Kiel, Germany)
U. Toronto (Toronto, Canada)

Showcase Demo

- Live shot "First time ever"
- Separate web displays
  - Real-time display of instruments
  - Data analysis monitor
  - Shot cycle
  - Logbook
- AG infrastructure
  - Video
  - Shared applications
- Documents
  - Shot plan
  - Mini proposal

Collaboratory Enabled Shot Cycle



What Next?

- Enable remote scientist
  - Deployment of environment to more users
- Integration of information
  - More information than typical screen can accommodate
- Expose information as services
  - Diagnostic output of instrument
- Conversion of analysis codes to service
  - Make available current offline tools into between shot services

Research Forum Meeting

- Only opportunity to get time on Tokamak
- 500+ entries last year
- 116 days of operation this year
- ~1 in 5 selected
- First year AG enabled
- Proposal archived in venue

Mini Proposal

- 5 - 10 page proposal
- Connection of experiment to theory
- Requires approval
- Preliminary shot plan
- Proposal archived in venue
- Connection of proposal to logbook

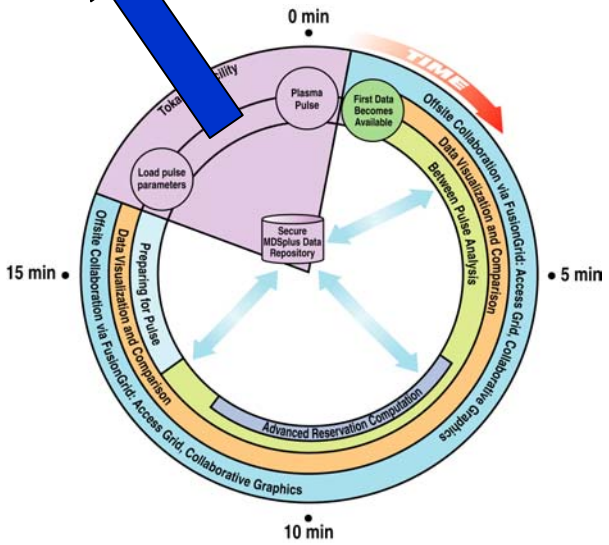
Project Plan

- Detailed plan of the days experiments
- Covers exact configuration of Tokamak
  - Settings
  - Data priorities
- Often not available in electronic form
- Should be in electronic form
- Should be tied to Tokamak configuration
- Should be tied to data collection devices
- Should be tied to analysis resources

Virtualization of Fusion

3. (3) Again start as in step 1, but at 2200 ms ramp Ip down at a rate of 0.1 MA/s to 1.2 MA. Include R_{midout} sweep as above.
4. (4) Start as in Step 1, but at 2200 ms, ramp I_p up at 0.5 MA/s from 1.3 to 1.5 MA. Include r_{midout} sweep as above.
5. (5) Start as in Step 1, but at 2200 ms, ramp I_p up at 0.2 MA/s from 1.3 to 1.5 MA. Make sure that good edge Thomson data, not overlapping with ELMs, is obtained.

Fusion Venue



Virtual Control Room

- Virtualization of Tokamak data collection
  - Device specific backend, common user front end
  - Flexible presentation of information
  - Exposed to common Grid resources
  - Automatic generation of advanced analysis
  - Automatic scheduling of Grid resources

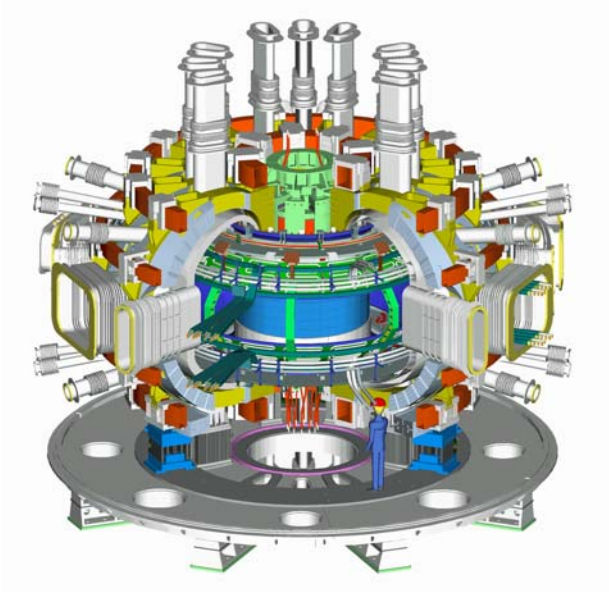
Virtual Control Room

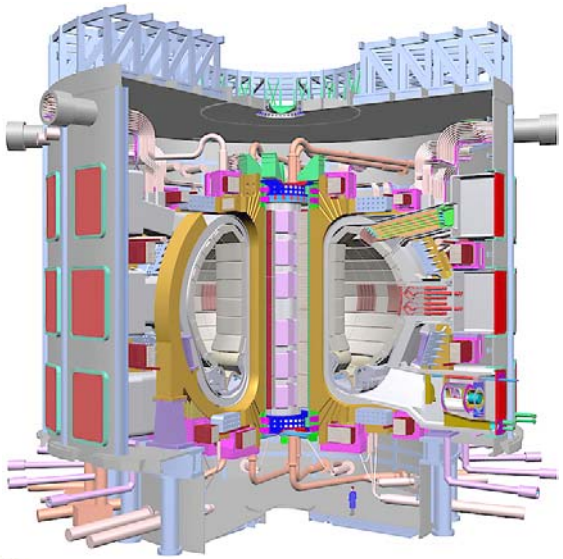
- Prioritization of Tokamak sensors
  - Based off electronic work flow from daily shot plan
  - Updating Tokamak configuration quickly when experimental changes happen
- Multiple real time monitors
  - Making Tokamak results available instantly locally and remotely

Virtual Control Room

- High resolution tiled displays
  - Sharing interesting data quickly between local scientists
  - Allowing remote scientist to remote windows to control room
  - Enhanced between shot simulations
- Audio solutions for control room scenario
  - Enhancing the experience, not detracting
  - Creating one-on-one audio channels

Next Generation Devices





- Pulsed experiment with simulations
  - ~TBs of data in 30 minutes
- Non-U.S. located devices
  - Collaboration for max U.S. benefit
- Successful operation requires
  - Large simulations, shared vis, decisions back to the control room
  - Remote Collaboration via FusionGrid
- Virtual control room concept being discussed as model for these devices
  - ITER: France or Japan
  - KSTAR: Korea

Credits

- David P. Schissel, Ian Foster, Kate Keahey, Ti Leggett, Rick Stevens, Von Welch, Eliot Feibush, Scott A. Klasky, Tina Ludescher, Douglas C. McCune, Lewis E. Randerson, Gheni Abla, Justin Burruss, Sean Flanagan, Qian Peng, Kai Li, Grant Wallace, Mary R. Thompson, Christopher R. Johnson, Allen Sanderson, Thomas W. Fredian, Martin J. Greenwald, Stuart Sherman, Josh A. Stillerman

- This work was performed under the auspices of the U.S. Department of Energy, Office of Advanced Scientific Computing.