



Computing at Fermilab

**Fermilab Onsite Review
Stephen Wolbers**

August 7, 2002

Outline



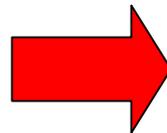
- Introduction
- Run 2 computing and computing facilities
- US CMS Computing
- GRID Computing
- Lattice QCD Computing
- Accelerator Simulations
- Conclusion/Future



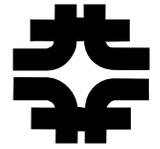


Introduction

- Computing at Fermilab:
 - Serves the Scientific Program of the laboratory
 - Participates in R&D in computing
 - Prepares for future activities
 - Contributes to nationwide scientific efforts
 - Consists of an extremely capable computing facility
 - With a very strong staff

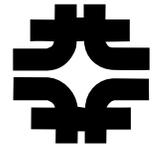


Introduction (2)



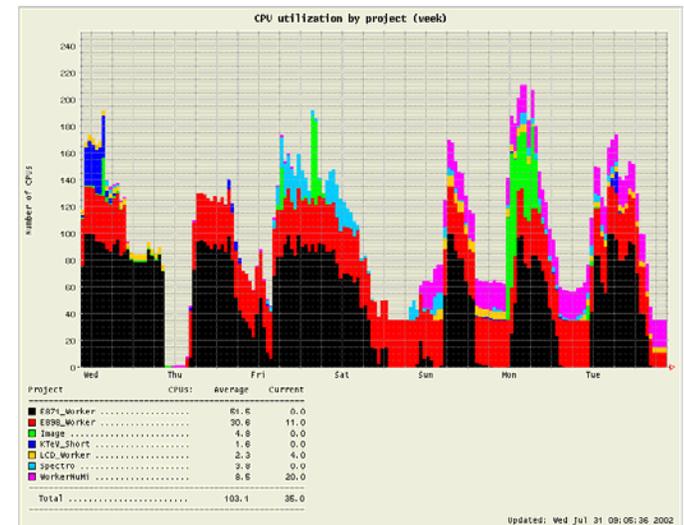
- Fermilab Computing's emphasis has changed to include more participation in non-FNAL and non-HEP efforts.
- Fermilab plans to leverage efforts in computing and expand the "outlook" and involvement with computer scientists, universities and other laboratories.
- Fermilab is in an excellent position to do this because of its involvement in Run 2 (CDF and D0), CMS, lattice QCD, SDSS, and other programs; and because of its strong computing facilities.

Run 2 Computing/Facilities

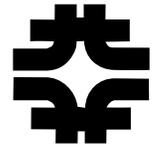


- Run 2 Computing is a major activity of Fermilab Computing Division
- The Computing Division also provides support for and facilities for:
 - Fixed-Target experiments
 - miniBooNE and MINOS
 - SDSS and Auger
 - US CMS
 - R&D efforts for future experiments and accelerators
 - Lattice QCD/theory
 - Data Acquisition

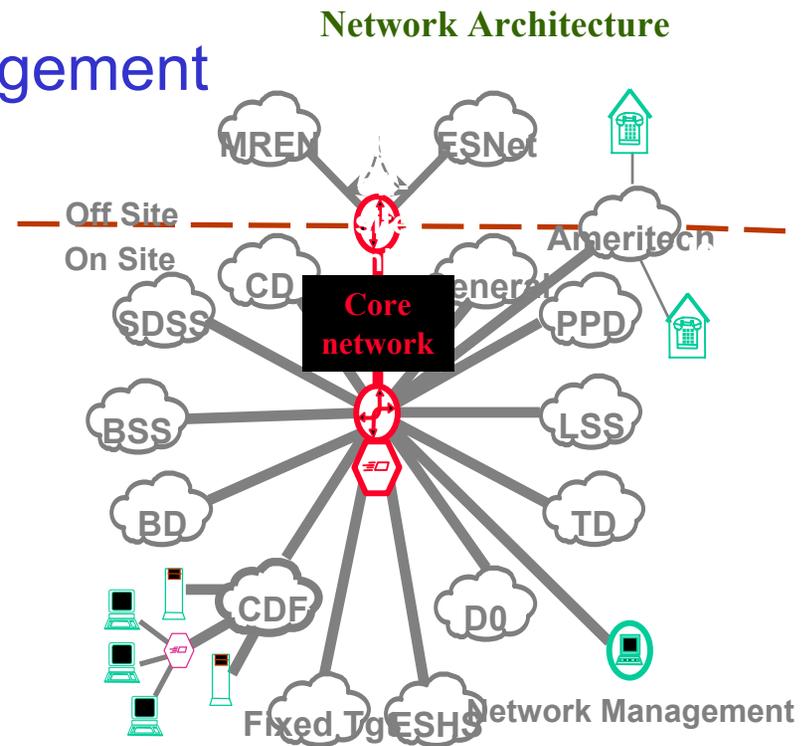
Central Farms Use



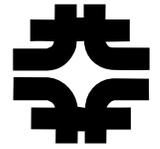
Run 2 Computing/Facilities



- CD also supports and maintains facilities for the laboratory as a whole:
 - Networks
 - Mass Storage/tape management
 - System administration
 - Windows 2000
 - PREP
 - Operations
 - Computer security
 - Electronics Engineering
 - Web
 - Help for Beams Division



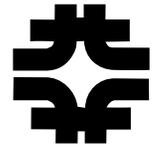
Run 2 Computing/Facilities



- The activities map into facilities at the laboratory:
 - Networks
 - Mass Storage robotics/tapedrives
 - Large computing farms
 - Databases
 - Operations
 - Support



Run 2 Computing/Facilities

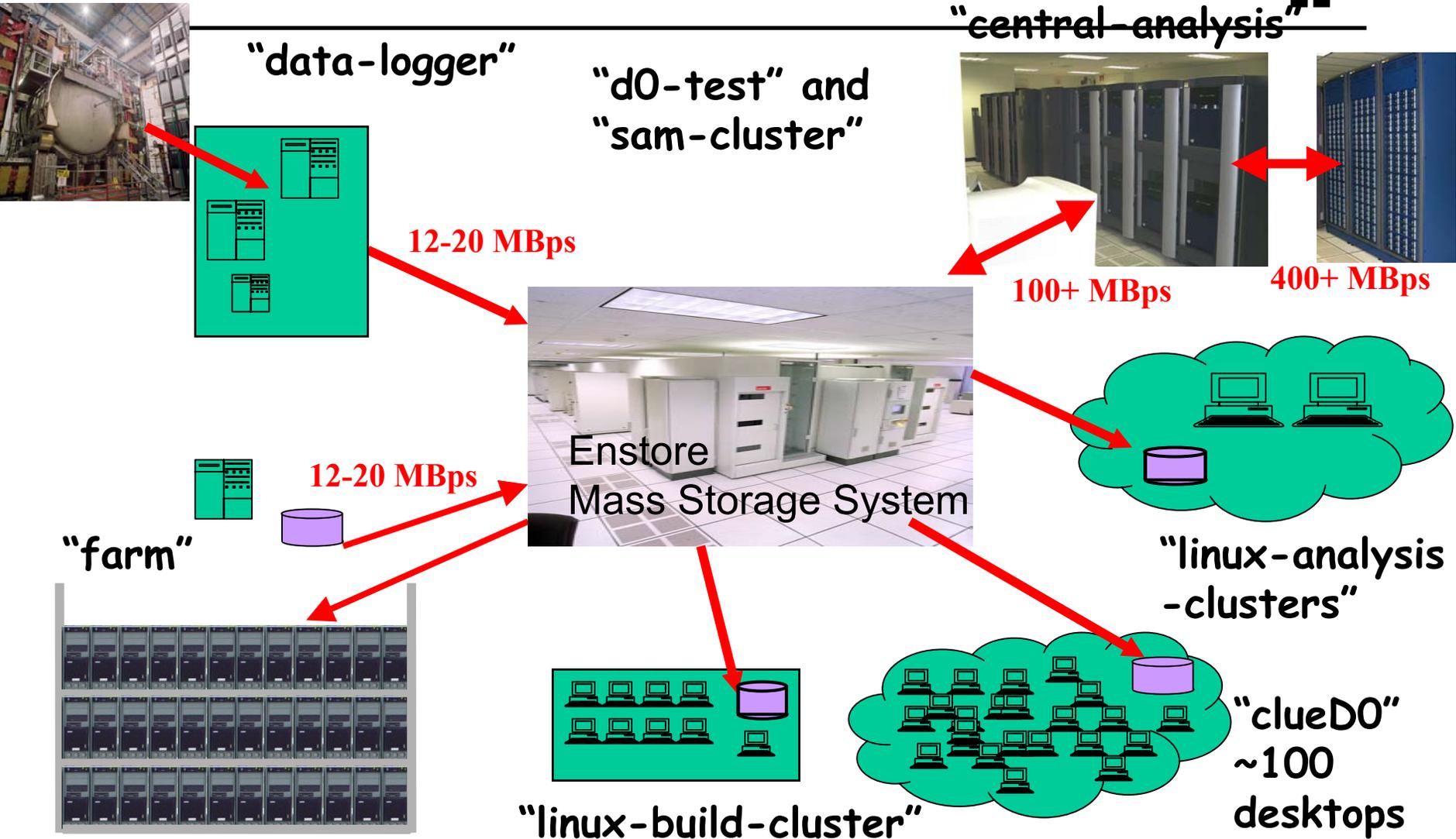


Run 2 Computing/Facilities



- Run 2 computing is a huge effort. Fermilab CD uses Run 2 joint projects to maximize the effectiveness of the CD resources (especially people):
 - Enstore storage management system
 - Reconstruction farms procurement, management and job scheduling
 - Oracle database management
 - C++ code development
 - Compilers and debuggers and code build systems
 - ROOT for analysis
 - SAM data handling system
 - Analysis hardware purchases

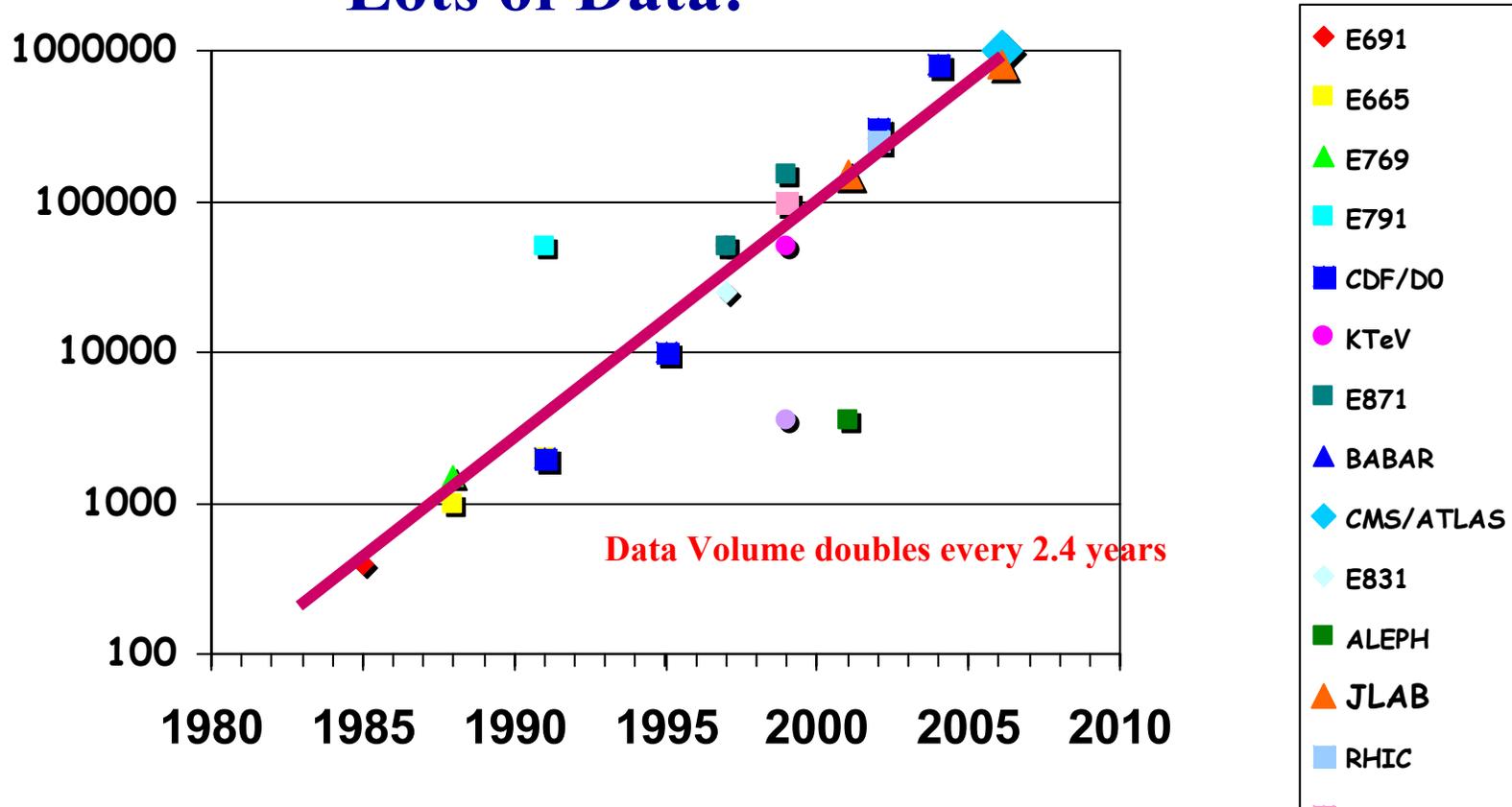
D0 computing systems





Run 2 Computing/Futures

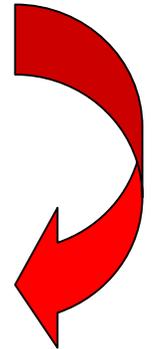
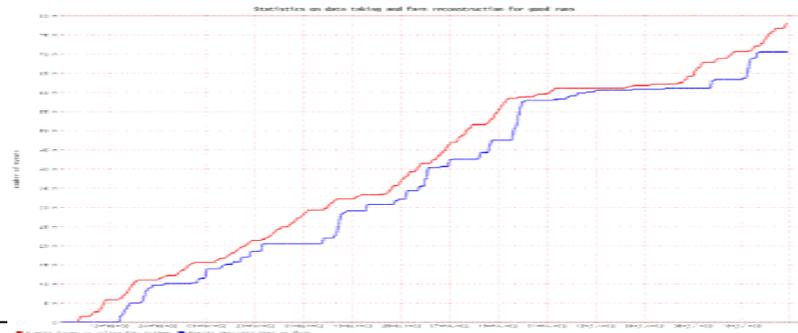
Lots of Data!



Status of Run 2 computing



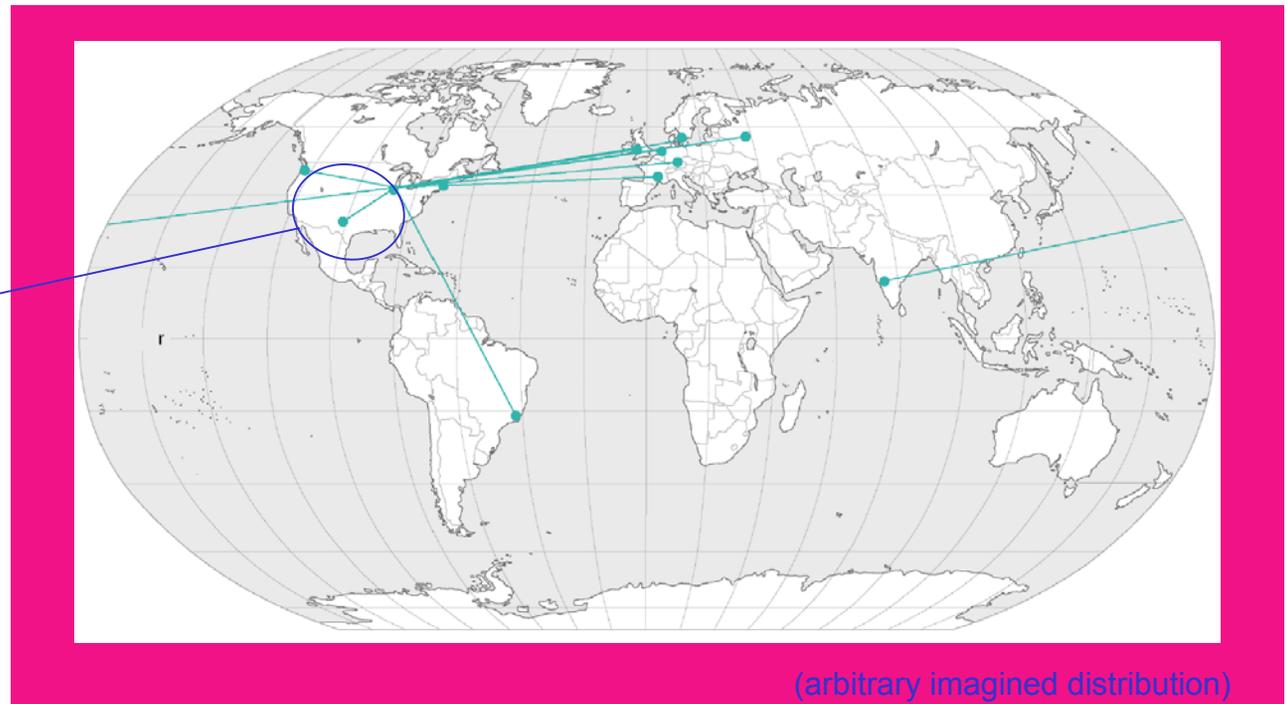
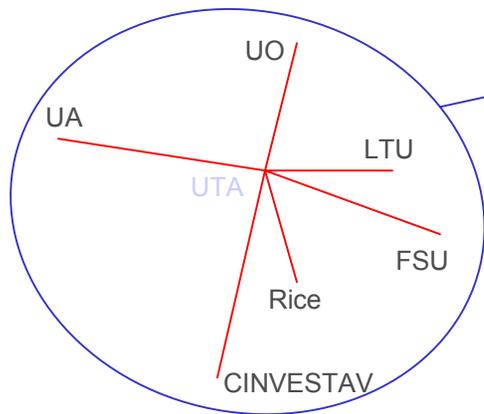
- Total datasets ~ 500 TB /yr /expt (including raw, reconstructed, derived and simulated data)
- **Both experiments** are logging data reliably and moving data in and out of mass storage on a scale well beyond Run 1 capability (several TB's / day)
- **Both experiments** are reconstructing data approximately in real time with reasonable output for start-up analyses
- **Both experiments** are providing analysis CPU to 150-300 users/day



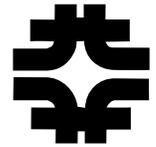


Run 2 Computing

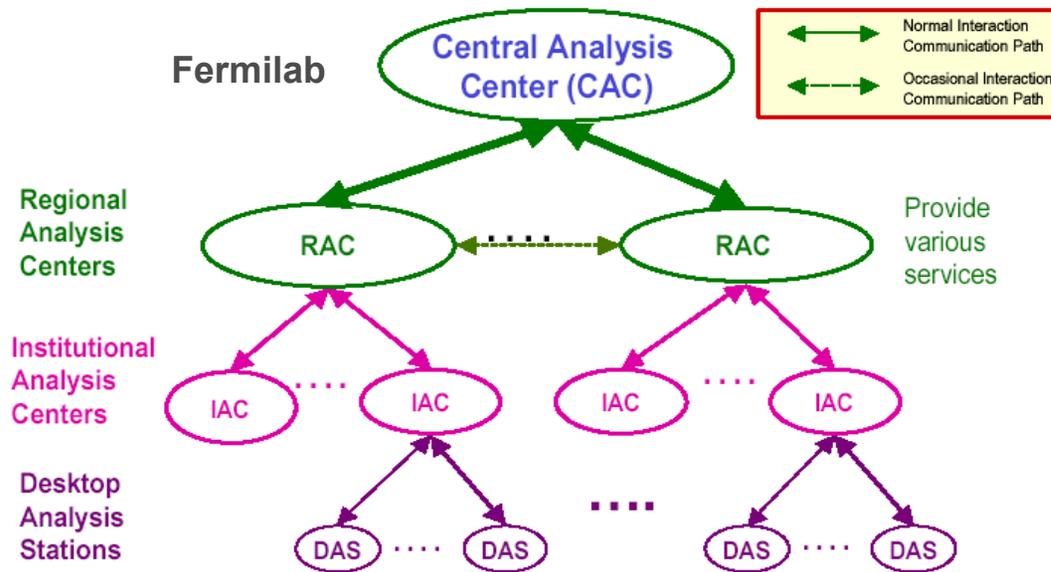
- D0 has a concept of Regional Analysis Centers (RAC's):
 - Distributed analysis around the globe



Run 2 Computing



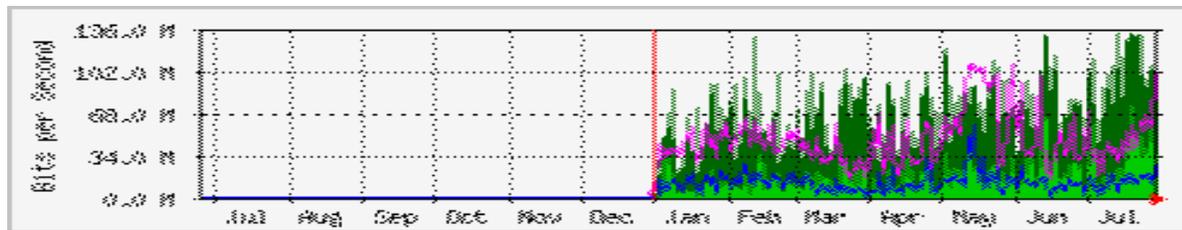
Proposed DØRAM Architecture



June 6, 2002

DØRAC Report
DØRACE Meeting, Jae Yu

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Off-Site
ESNET
Traffic

US CMS Computing



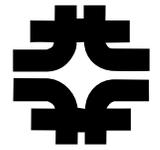
- Fermilab is the host lab of U.S. CMS
- Fermilab hosts the project management for the U.S. CMS Software and Computing Program in DOE
 - L1 project manager (Lothar Bauerdick)
 - L2 projects
 - User Facilities (Tier 1 and Tier 2 centers)
 - Core Application Software

US CMS Computing

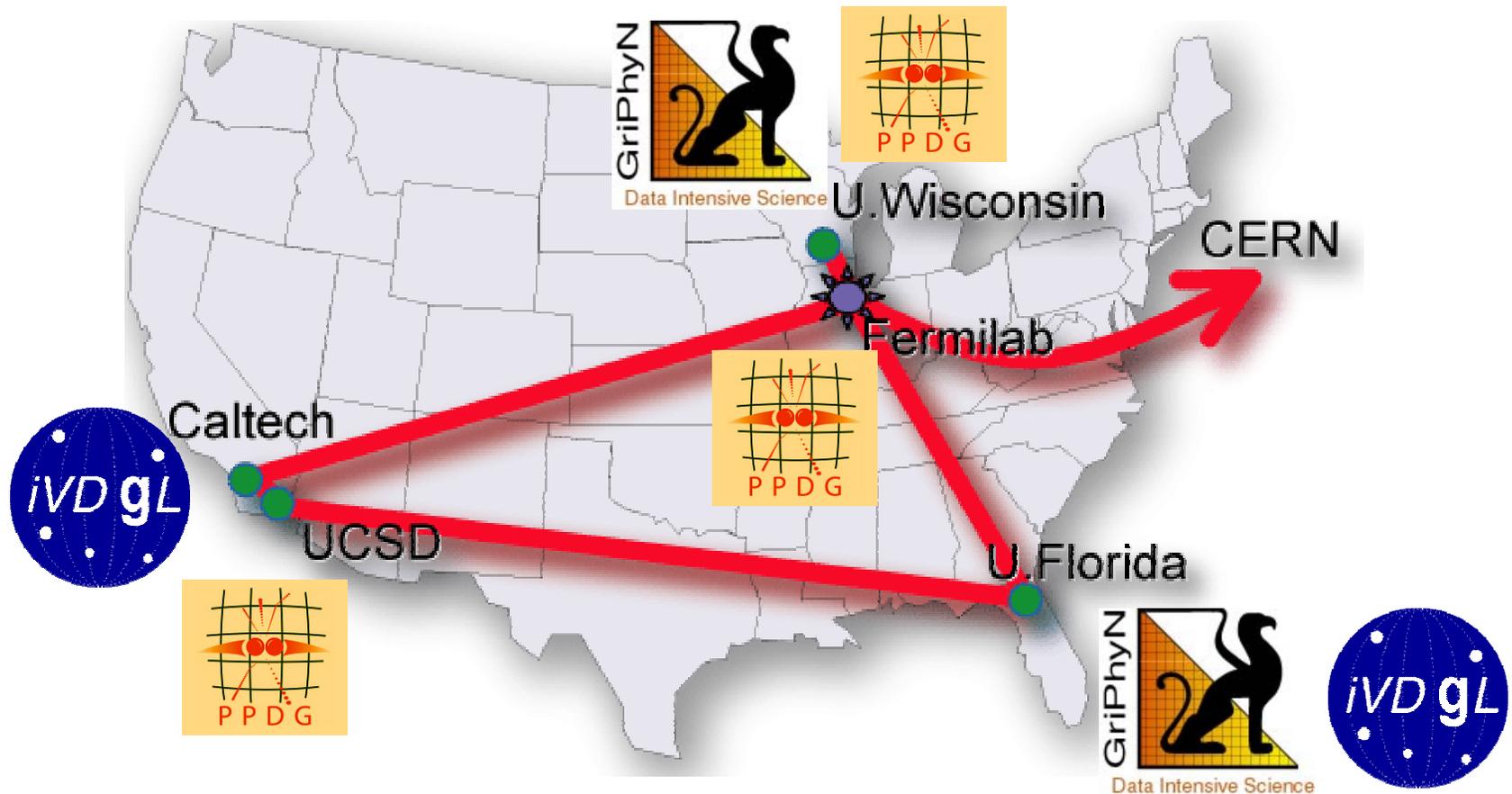


- Fermilab and US CMS has been extremely successful and influential in CMS software and computing
 - Influence on CMS software
 - Framework
 - Persistency
 - CMS distributed production environment
 - Tier 1 and Tier 2 regional centers
 - Tier 1 at Fermilab
 - Tier 2 in a small set of universities

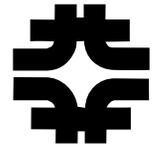
US CMS Computing



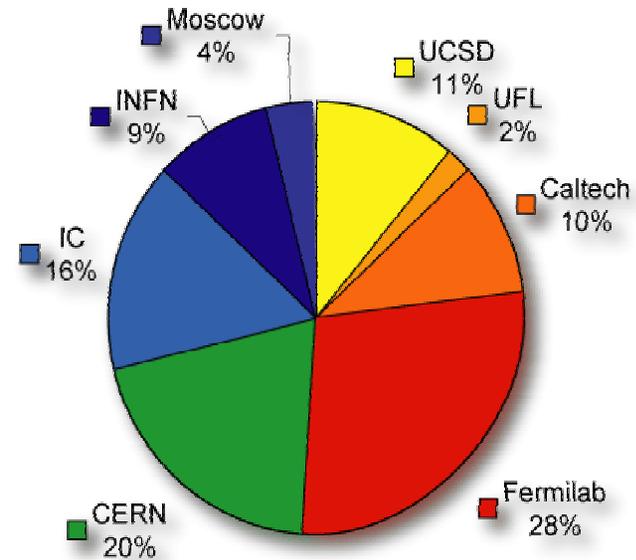
Tier 1/Tier 2 Centers and Prototypes



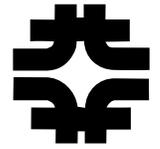
US CMS Computing



- Contribution to CMS is substantial
- Spring production 2002
 - 8.4 million events fully simulated
 - 50% in US
 - 29 TB processed
 - 14 TB in US



US CMS Computing



- The US CMS Software and Computing project has been reviewed and “baselined”
- Funding has been lower than hoped for and this has led to:
 - Slower ramp-up of staff
 - Smaller hardware purchases
 - Fewer projects being completed
- It is hoped that funding will improve so that the necessarily people and facilities can be hired/built to properly prepare for CMS data-taking and physics analysis

GRID Computing



- Fermilab is participating in many GRID initiatives:

- ppdg (DOE SciDAC)
 - Particle physics data grid
 - Fermilab, SLAC, ANL, BNL, JLAB, Caltech, UCSD, Wisconsin, SDSC

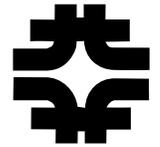


- GriPhyN
 - Grid physics network
- iVDGL
 - International virtual grid laboratory



- GRID activities have been a very natural outgrowth of distributed computing of the large collaborations.

GRID Computing



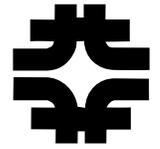
- Working on GRID computing projects has many benefits for Fermilab computing
 - Connection with a leading technology in computing
 - Connection with computer scientists in universities and labs in the US and around the world
 - Interaction and participation in GRID initiatives and software development.
 - Experiment participation in GRID testbeds and production facilities
 - D0, CMS, SDSS, CDF

GRID Computing



- SciDAC funding for Fermilab is devoted to:
 - D0 GRID work
 - CMS production activities
 - Authentication Issues
 - Mass Storage access across the GRID
- SDSS is working on projects associated with
 - SciDAC
 - Griphyn
 - iVDGL

GRID Computing



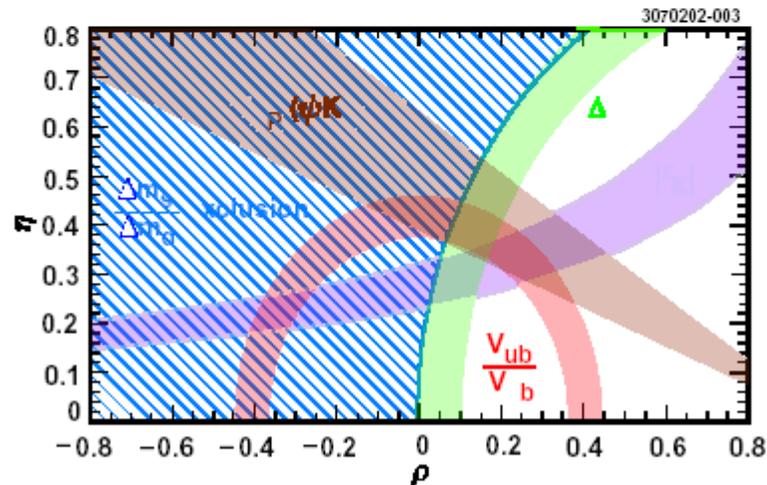
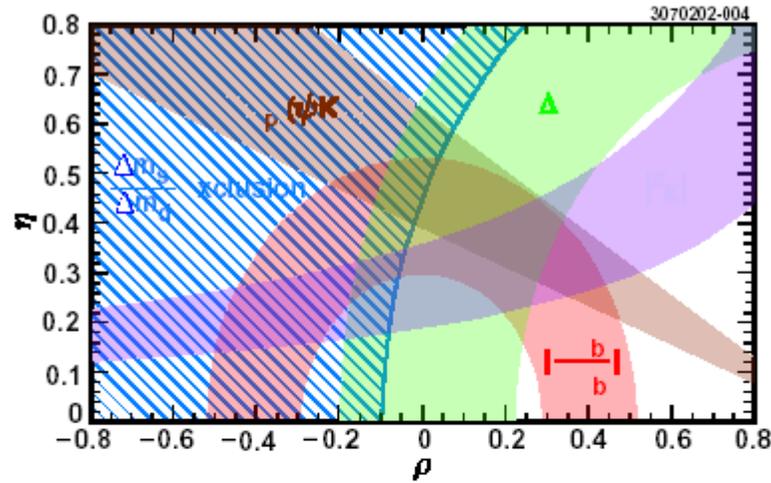
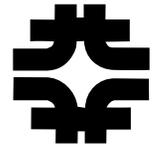
- Fermilab CD is involved in many projects:
 - File Replication, transfers and data management
 - Scheduling of processing and analysis applications
 - Monitoring
 - Authentication
 - Application and application support
- HEP experiments provide excellent testbeds for the GRID middleware:
 - HEP experiments have data
 - HEP experiments have people all over the world that want to access and analyze that data

Lattice QCD



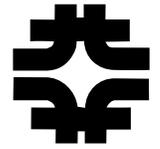
- SciDAC-funded Lattice QCD facility at Fermilab
 - Part of a nationwide coordinated effort to provide facilities and software for lattice QCD calculations (Computational Infrastructure for Lattice Gauge Theory)
 - Fermilab
 - Jefferson Lab
 - Columbia/RIKEN/BNL (QCD on a chip, QCDOC)
 - Fermilab is pursuing PC-based solutions along with software from the MILC collaboration.

Lattice QCD



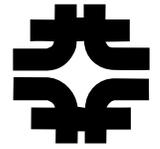
Improvements from
Lattice QCD
Calculations
(B. Sugar)

Lattice QCD



- Fermilab's contributions
 - Large PC clusters
 - Acquisition (128 nodes now)
 - Operation and maintenance
 - Interconnect technologies
 - Commercial/Myrinet
 - Ethernet R&D
 - Software infrastructure
 - Joint effort with MILC collaboration

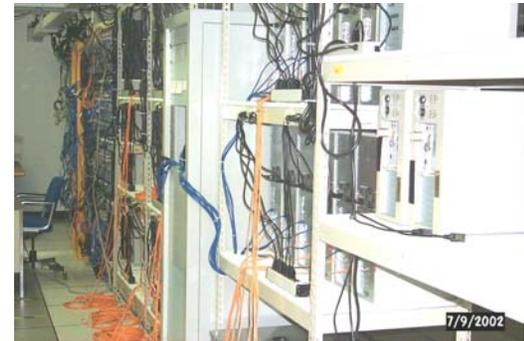
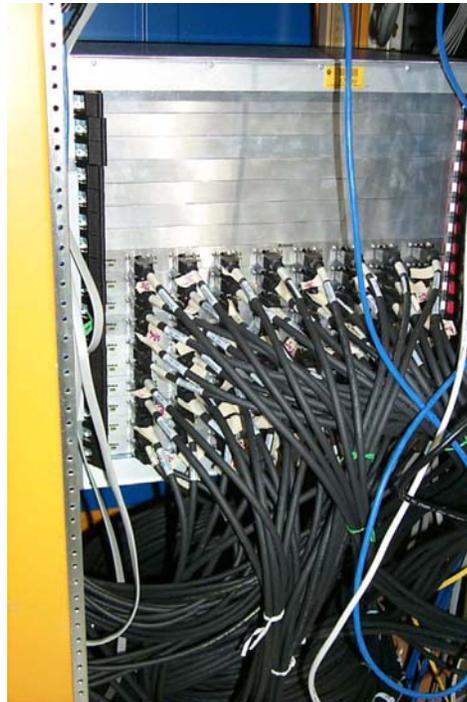
Lattice QCD



Muon Lab



Complex Interconnects



Room To Expand



128 Nodes



Lattice QCD



- Goals
 - Larger clusters
 - 128 more nodes within 6 months (0.5 Tflops)
 - Substantially larger within years (>6 Tflops)
 - Software framework and support
 - Facility for research on Lattice problems

Accelerator Simulations



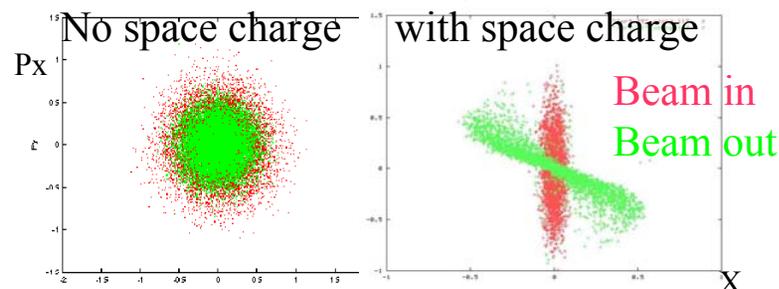
- Fermilab is collaborating on a SciDAC program of accelerator simulations
- Other collaborators:
 - BNL, LANL, LBNL, SLAC, SNL
 - Stanford, UCLA, UCD, USC, Maryland
- Plan to work on many topics
 - Designing next-generation accelerators
 - Optimizing existing accelerators
 - Developing new accelerator technologies

Accelerator Simulations



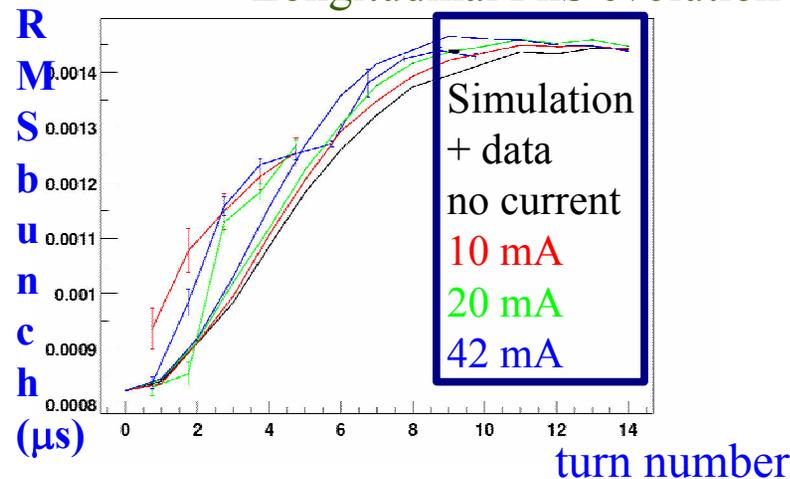
- Incorporate Ionization Cooling modules in Beam Dynamics Codes
- Develop code with 3D space-charge capabilities for circular accelerators
 - (in collaboration with BD theory)
 - Model & study the FNAL Booster.
 - Beam data comparison with simulation: **almost unique in this business!**
 - (in collaboration with Booster group)

Ionization Cooling Channel



1PE: 500 particles, 460 sec 128 PE: 500K particles, 4400 sec

Longitudinal PhS evolution



Summary



- Fermilab Computing is in an excellent position to support the physics program of the laboratory and to participate in and foster partnerships with our collaborators, computer scientists and other institutions.
- By participating in these programs and by building working relationships we are in a position to better extend our capabilities in:
 - Distributed and GRID computing (important for most of our collaborations)
 - Lattice QCD
 - Beam simulations