Open Science Grid Applications

The LHC and the OSG – Computing the Quantum Universe

The CMS detector being assembled. (CERN)

Discovering what the universe is made of and how it works is the challenge of particle physics. At its foundation is the Standard Model that successfully describes almost all measurements made by particle physicists, yet there are still unanswered questions.

Cosmological observations have shown that most of the matter in the universe is contained in dark matter. This strange type of matter may be composed of heavy particles that were produced in the Big Bang. While most of these particles would have annihilated into pure energy while the universe was still young, some remained. These mysterious particles may be created in the laboratory when the Large Hadron Collider, a new accelerator that will collide protons at higher energies than ever before, begins operating in 2007. If these heavy particles are detected, physicists will be able to study their interactions and gain new insight into the nature of the universe.

The LHC experiments will seek to answer questions about the nature of space and time raised by string theory, such as whether or not extra dimensions exist. Another mystery—how particles acquire mass in the Standard Model--stands a good chance of being solved at the LHC through the discovery of the Higgs boson.

Understanding dark matter and the origin of mass, and searching for extra dimensions of space, requires massive amounts of data—ten petabytes will be collected in 2008 alone. This mountain of data will need to be processed, analyzed and compared with simulations. To meet this challenge, a worldwide distributed computing system unprecedented in scale and complexity is being built for the LHC experiments. The OSG is a vital part of this global system, a worldwide federation of computing grids over which scientists can simulate, process, and analyze data transparently.

The ATLAS collaboration at CERN. (CERN)

DOE Office of Science

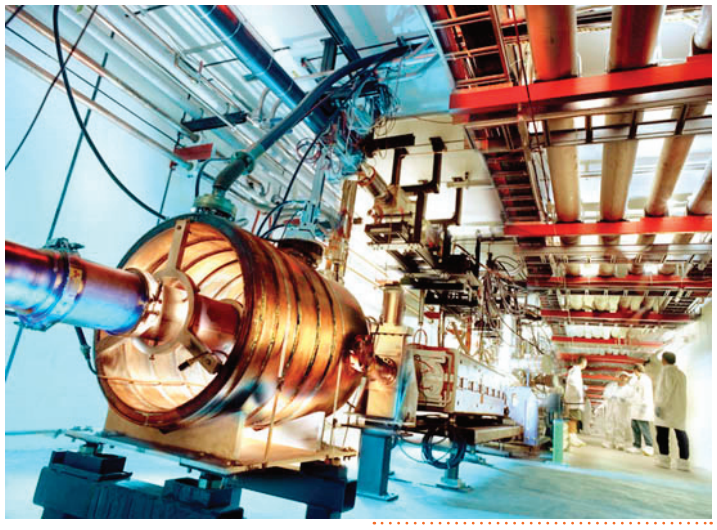
www.opensciencegrid.org

sc05-inserts.indd 1 10/27/2005 7:04:47 PM

Open Science Grid Applications

Processing and Simulating DZero Data

DZero is a high energy physics experiment collecting data from colliding beams of protons and anti-protons at Fermilab. The OSG provides the DZero collaboration with tools and resources that enable the worldwide processing, simulation and transfer of particle physics data.

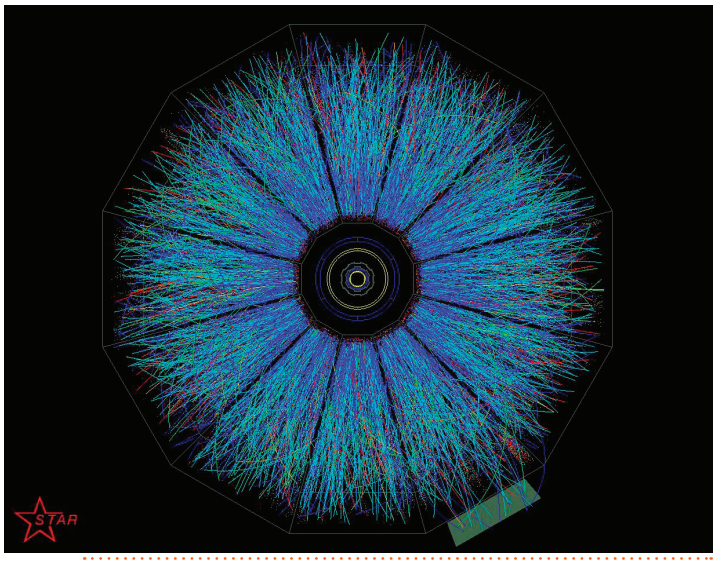


Fermilab's main injector. (Peter Ginter)

Over 600 scientists worldwide use the data from this facility to gain new insights into fundamental questions of the nature of particles and forces. Converting the data from its raw form into information useful for the average scientist is a computationally intensive process. Making the processed data accessible to scientists for study is a challenging storage and data-movement problem. Using grid-enabled data handling and job submission, one billion DZero data events and 100 million simulated events have been processed and are being used for physics analysis in North and South America, Europe and Asia.

Nuclear Physics of the Early Universe

The Relativistic Heavy Ion Collider is a world-class scientific research facility located at Brookhaven National Laboratory. The nuclear physics experiment STAR, the Solenoid Tracker at RHIC, is becoming the world leader in the scientific quest to understand how mass and spin combine into a coherent picture of the fundamental building blocks nature uses for atomic nuclei. STAR also provides unique insight into how quarks and gluons collectively behaved in the very first moments after the birth of the universe.



Collision of two 30-billion electron-volt gold beams in the STAR detector. (Brookhaven National Laboratory/STAR Collaboration)

With 137,000 active sensors leading to hundreds of collision images per second, and reconstruction of one image taking as many as six minutes, STAR's computing challenge is enormous. The task of processing such a deluge of data propelled the collaboration toward a distributed grid computing model. The STAR GRID transparently distributes the data of interest to its remote collaborators, allows opportunistic access to computational cycles provided by the OSG, and makes STAR resources are available to others. Collaborators at national and international universities and laboratories can access STAR resources from their desktop as if they were connected to a virtual cluster.

DOE Office of Science

sc05-inserts.indd 2 10/27/2005 7:04:49 PM