Education and Outreach

In Particle Physics

Michael Barnett (LBNL)

This version has videos that will not work on the online Indico agenda.

Contact Michael Barnett for more information about the videos.

To begin:

How does the outside world view us?

Bill Clinton and the sense of wonder

At the World Economic Summit in Davos 2011

Asked about the next 20 years, Clinton turned to science.

Notice both the very <u>beginning</u> and the <u>ending</u>.

Bill Clinton and the sense of wonder

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Asked about the next 20 years, Clinton turned to science.

Notice both the very beginning and the ending.

Bill Clinton and the sense of wonder

The details were wrong but Clinton came away with:

"a sense of wonder"

This is what I think we should seek via our outreach efforts.

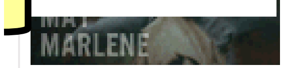
NRC study led by Helen Quinn (quoted here)

New Approach Proposed for Science Curriculums

By KENNETH CHANG
Published: July 19, 2011

A new framework for improving American science education calls for paring the curriculum to focus on core ideas and teaching students more about how to approach and solve problems rather than just memorizing factual nuggets.

"That is the failing of U.S. education today, that kids are expected to learn a lot of things but not expected to be able to use them," said Helen Quinn, a retired physicist from the SLAC National Accelerator Laboratory in Menlo Park, Calif., who led an 18-member committee that spent more than a year devising the framework.



One of the big goals, the committee said in a 282-page report, is "to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science."

The report, released Tuesday by the National Research Council, also pushes for incorporating engineering into what is taught to students in elementary school through high school.

It is the latest in decades of efforts to improve the science knowledge of American students, who have typically ranked in the middle of the pack on international comparison

A new framework for improving American science education calls for paring the curriculum to focus on core ideas and teaching students more about how to approach and solve problems rather than just memorizing factual nuggets.

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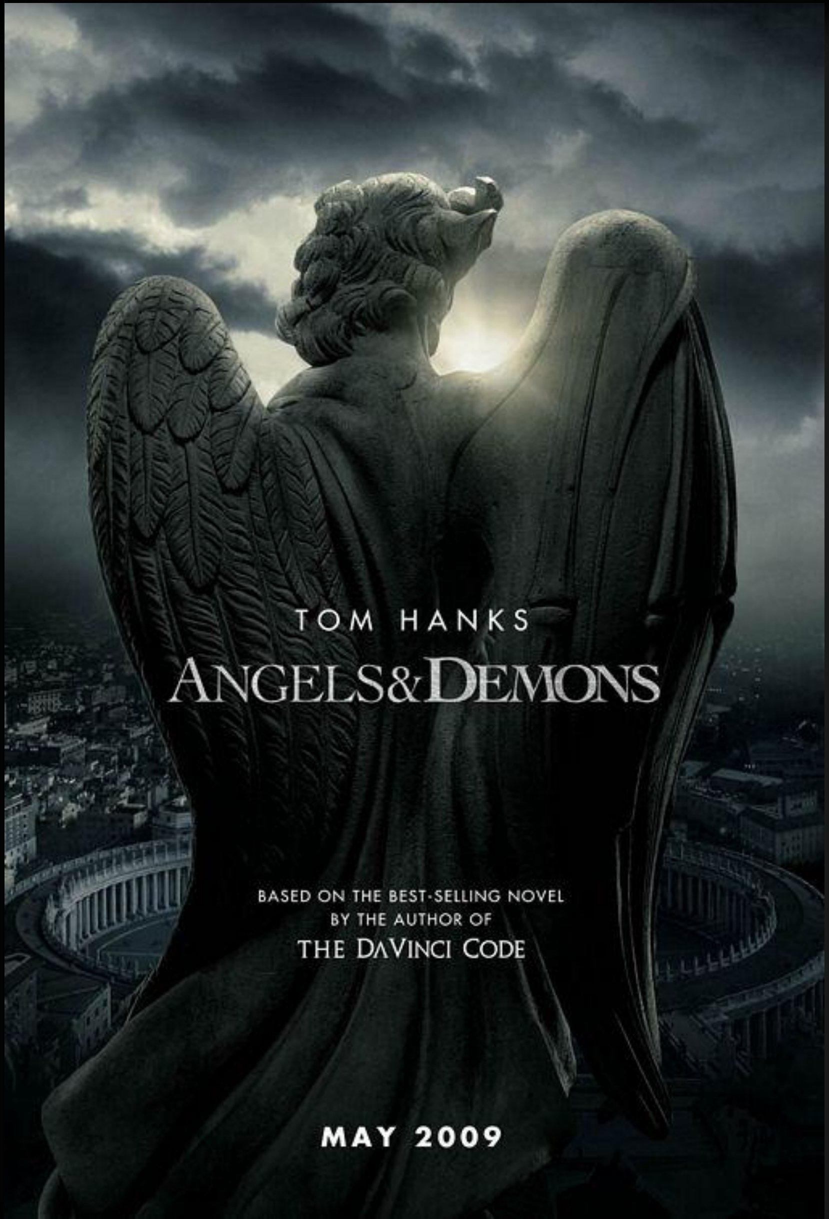
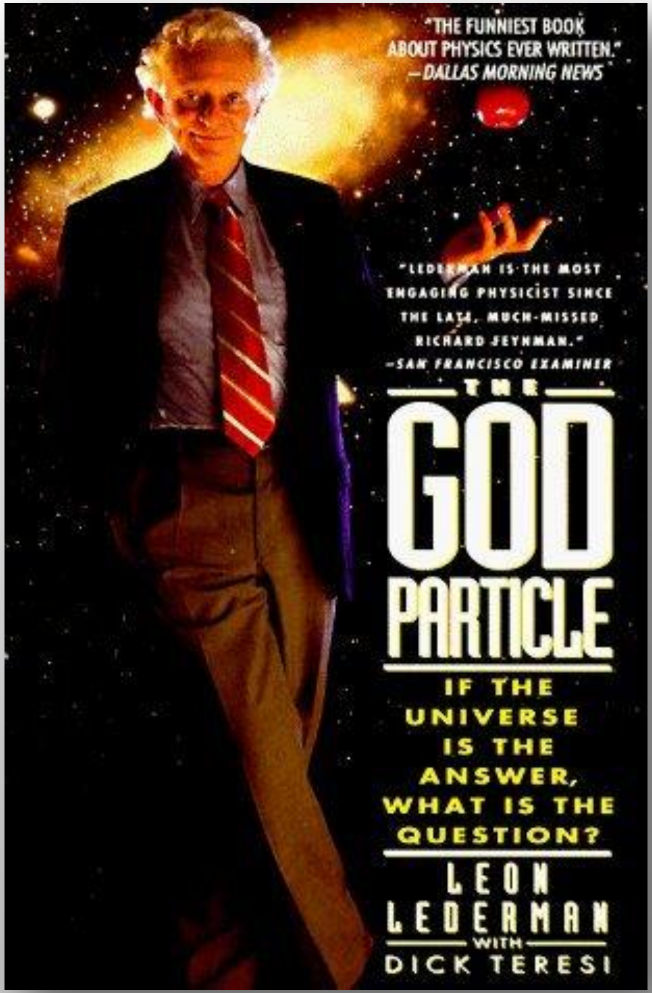
Angels & Demons director Ron Howard and Tom Hanks commenting on LHC



Angels & Demons
director Ron Howard and Tom Hanks

How does Hollywood present particle physics?



DPF Meeting – Michael Barnett – August 2011

How does Hollywood present particle physics?

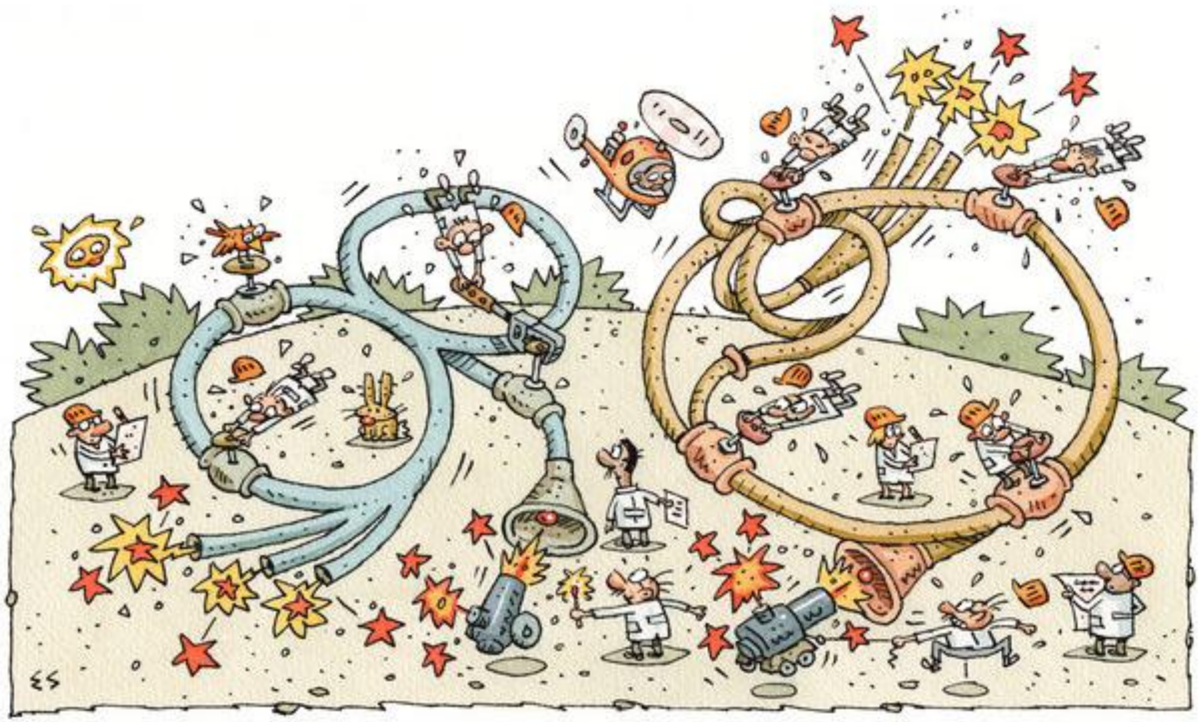
Collisions à la New York Times

The New York Times

2 August 2011

NEWS ANALYSIS

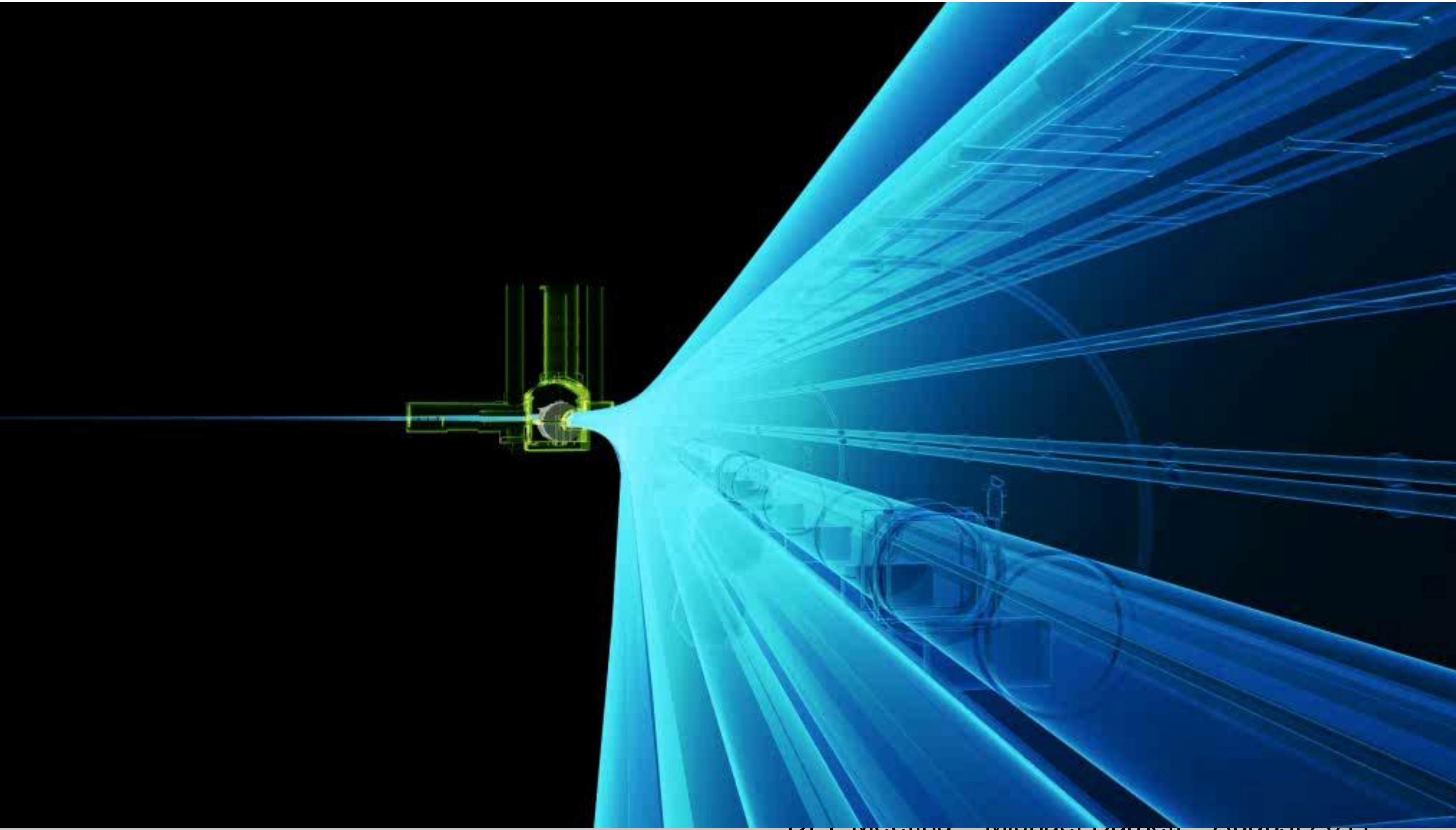
Particle Accelerators Full of Spin and Fury, Signifying Something



Elwood H. Smith

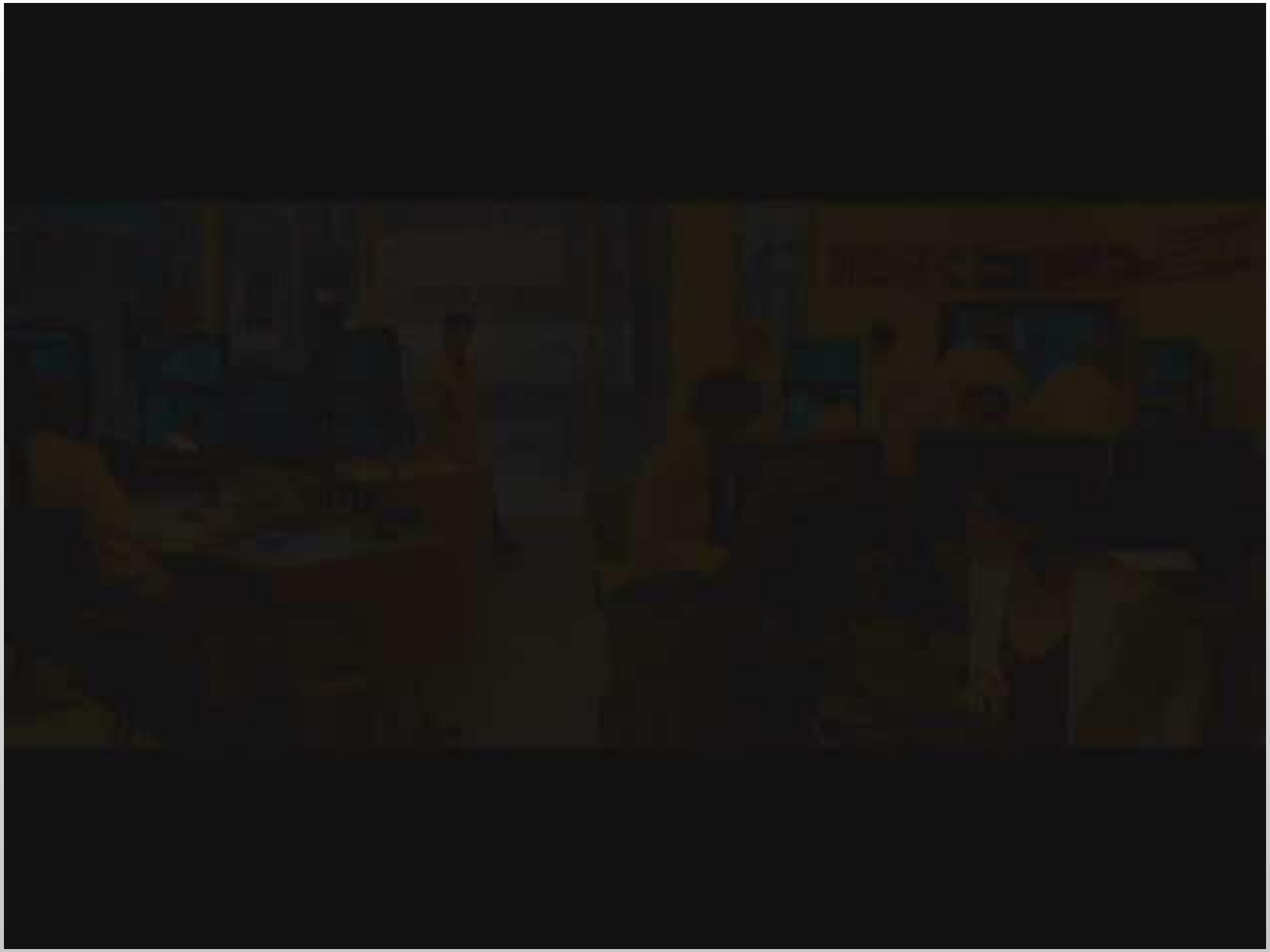
Collisions à la ATLAS

Collisions à la ATLAS

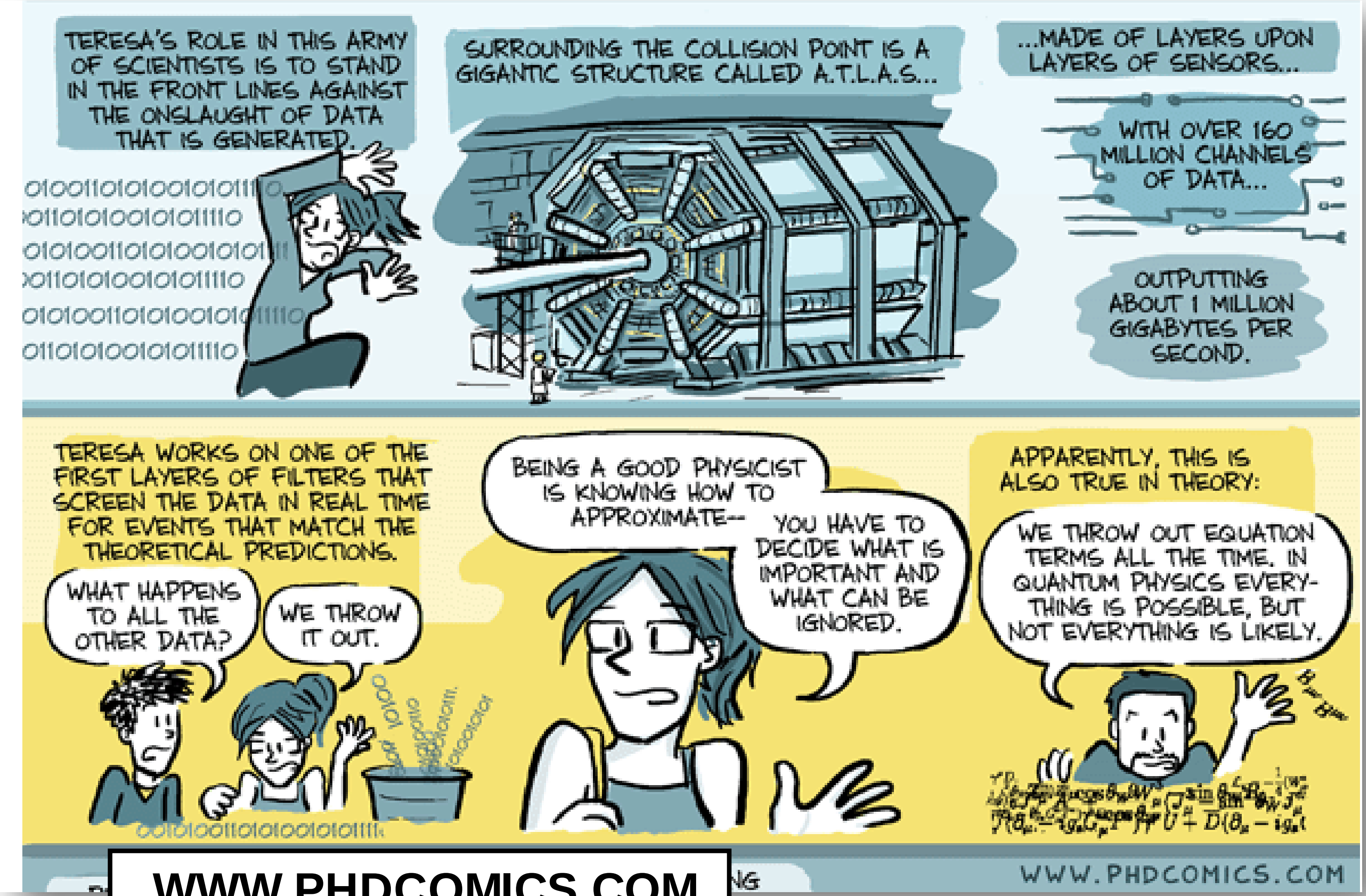


Collisions à la Hollywood

Collisions à la Hollywood



PhD Comics on Dark Matter



WWW.PHDCOMICS.COM

PhD TV

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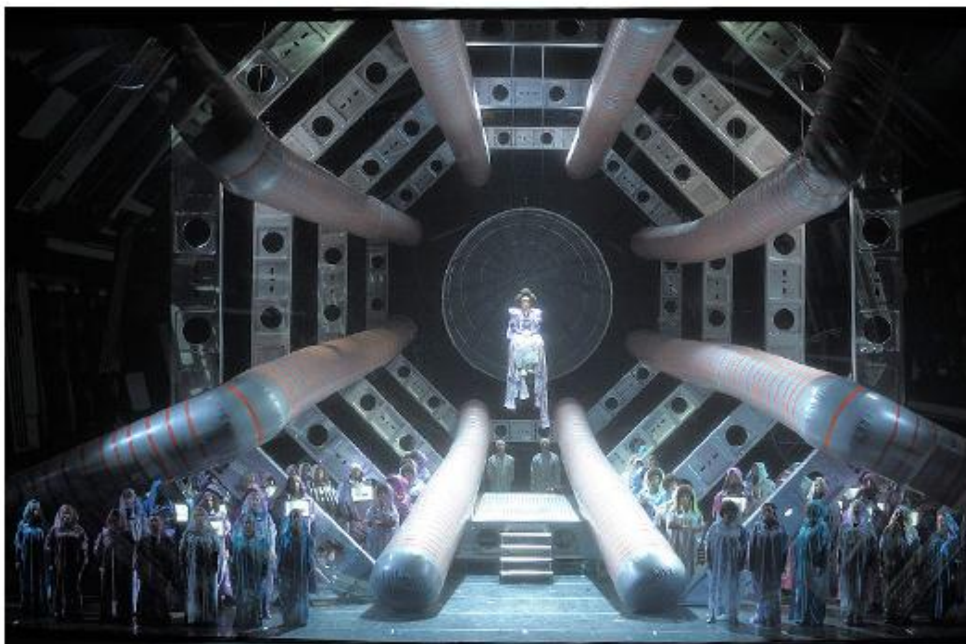
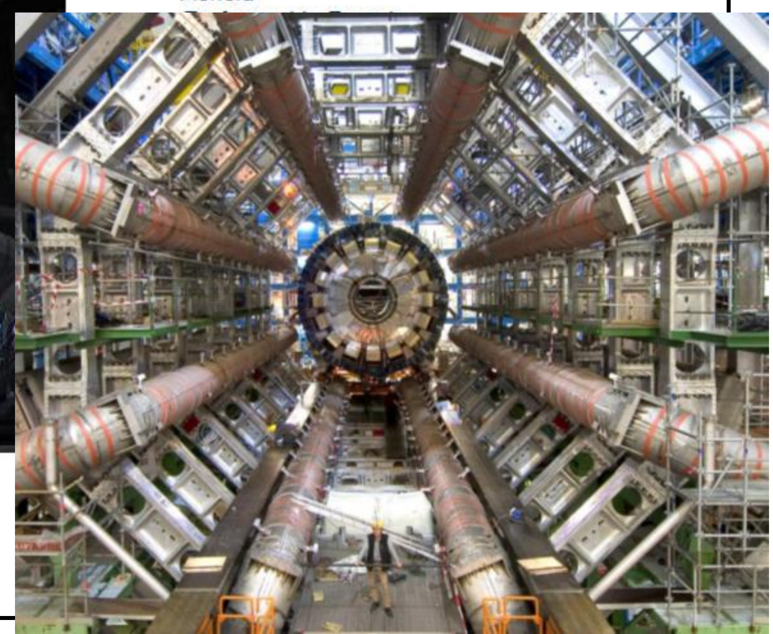
Impacts can be unexpected

The opera Les Troyens by Berlioz,
as shown in Valencia, St. Peterburg and Warsaw





Impacts can be unexpected

Impacts can be unexpected

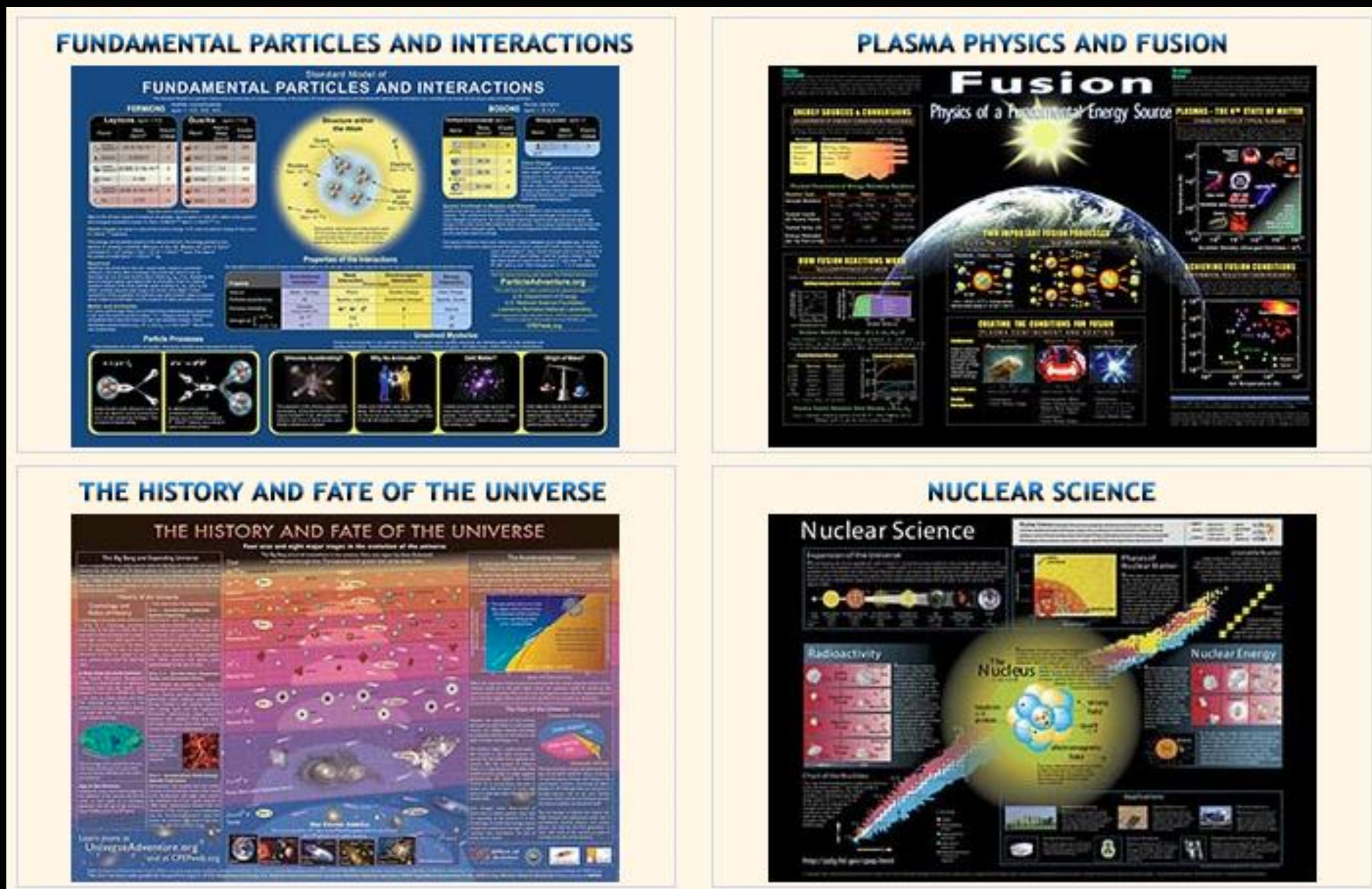
Forthcoming (November) Muppets movie

From the trailer

Impacts can be unexpected

Impacts can be unexpected

Contemporary Physics Education Project



http:// CPEPphysics.org

Impacts can be unexpected

Charts appear in Movies

Donnie Darko

Thirteen Conversations About One Thing

Hulk

Charts appear on TV

The Big Bang Theory

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FACEBOOK DIGG STUMBLEUPON REDDIT PRINT

Big Science: The Universe's Ten Most Epic Projects

By Gregory Mone, Brooke Borel, Katherine Bagley and Jennifer Abbasi Posted 7.16.11 at 8:06 pm 11 Comments

IMAGE 9 OF 10

2: The Large Hadron Collider

Maximilien Brice/CERN

A proton accelerator to find the elusive god particle

Buried 330 feet beneath the border of Switzerland and France, the Large Hadron Collider is the world's largest particle collider. The facility requires 700 gigawatt-hours of energy and some $1 billion annually to run. More than 10,000 researchers, engineers and students from 60 countries on six continents contribute to the LHC's six standing projects, which are designed to unlock the fundamental physics of the universe.

Scientific Utility

What exactly is dark matter? Are there extra dimensions in space? Does the Higgs boson, commonly referred to as the "God particle," exist? How did the universe form? The LHC's six particle detectors record and visualize the paths, energies and identities of subatomic particles, which may answer some of these questions. The ATLAS project's detector, for example, is searching for collision events in which there appears to be an imbalance of momentum—an indication of the presence of the supersymmetric particles thought to make up dark matter. The Compact Muon Solenoid project complements ATLAS by searching for supersymmetry and the elusive Higgs boson. LHC-Forward will simulate high-energy cosmic rays, and LHC-Beauty will provide information on why the universe is made up of matter rather than antimatter. TOTEM tracks proton collisions and provides data on the proton's inner structure. And ALICE will track quark-gluon plasmas, similar to experiments conducted at the Relativistic Heavy Ion Collider (also on this list).

What's In It For You

Though the LHC has brought black-hole alarmists out of the woodwork, the project will have little effect on our day-to-day lives, unless your family and friends are the type to discuss the origins of the universe over dinner.

TAGS

Science

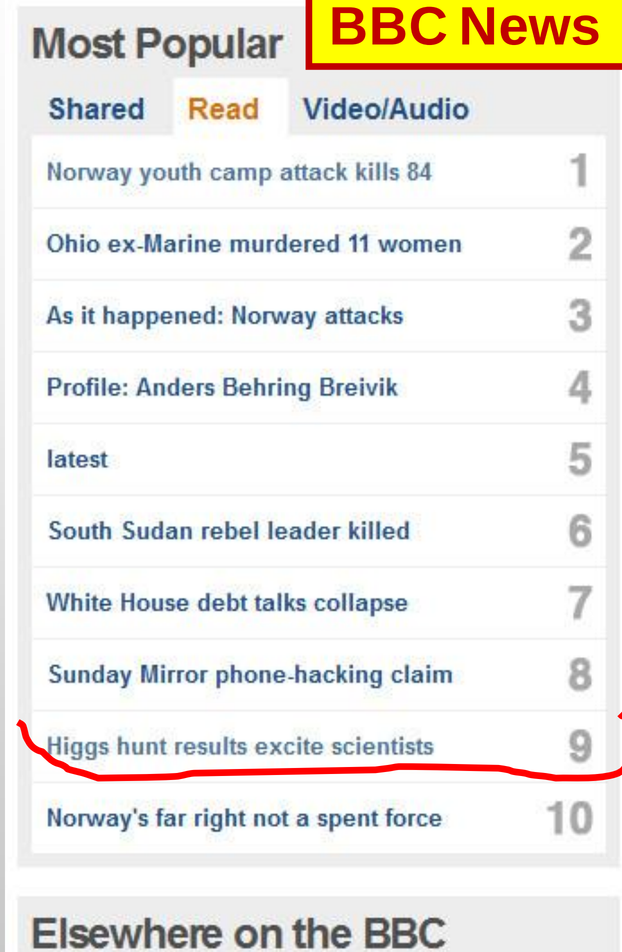
IMAGE 9 OF 10

Popular Science magazine

t – August 2011

Following EPS meeting

BBC News



Norway attacks

Debt talks

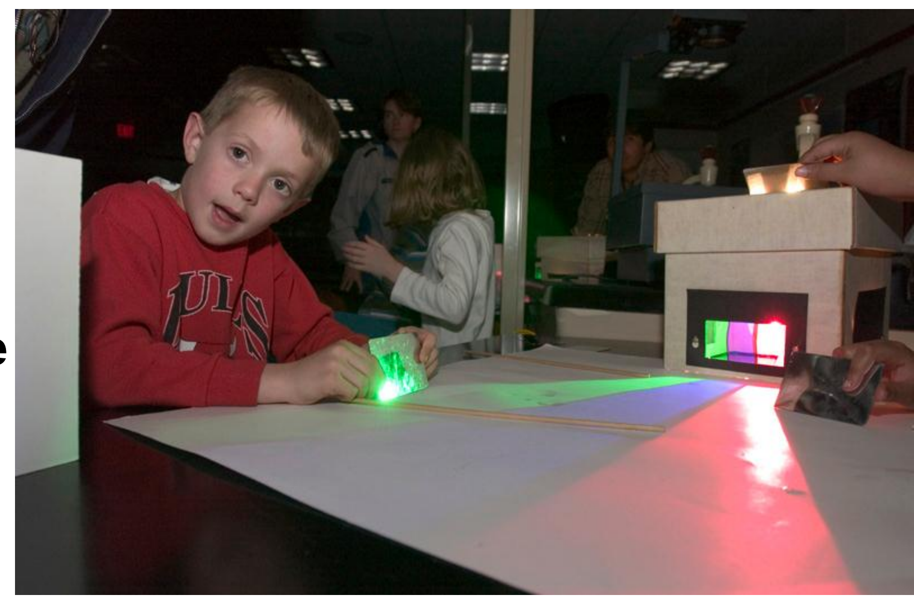
Phone hacking

Education/Outreach programs across HEP

Education at Fermilab
A Legacy of Leon Lederman

Leon began Saturday Morning Physics in 1980 to "use the magnificence of Fermilab to dazzle (and capture) high school kids."

Studying light at the Lederman Science Center.

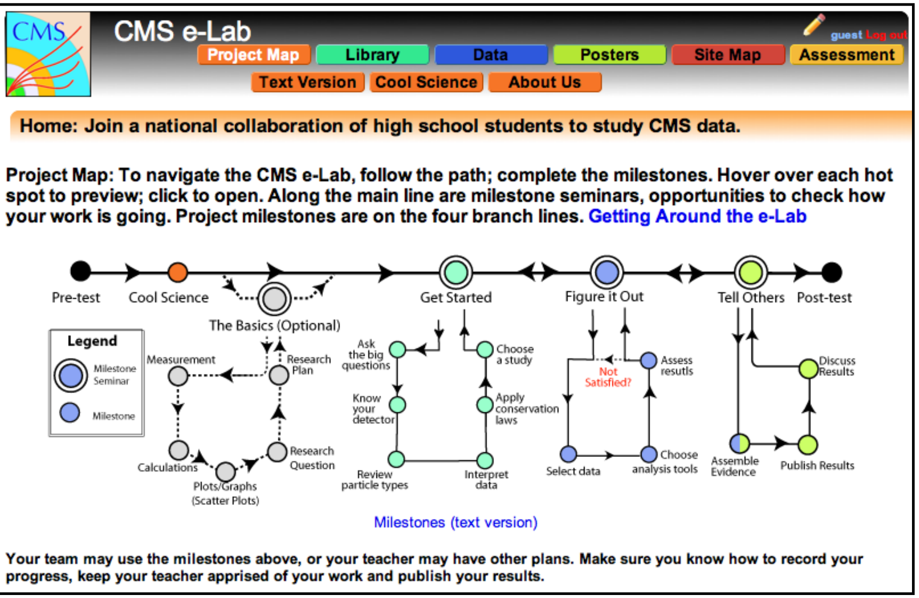


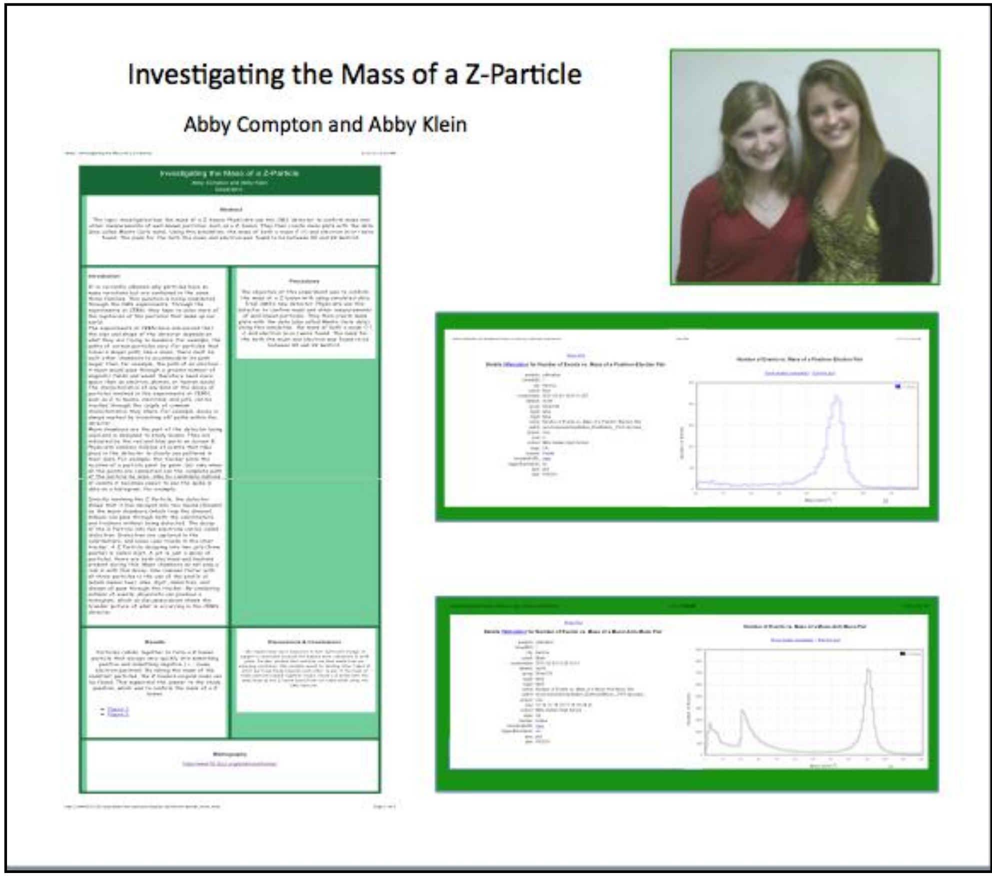
Education Programs at Fermilab

Rob Roser shows physics teachers CDF up close and personal.

The Dave Schmitz and Michael Cooke show at Millennium Park

CMS eLab



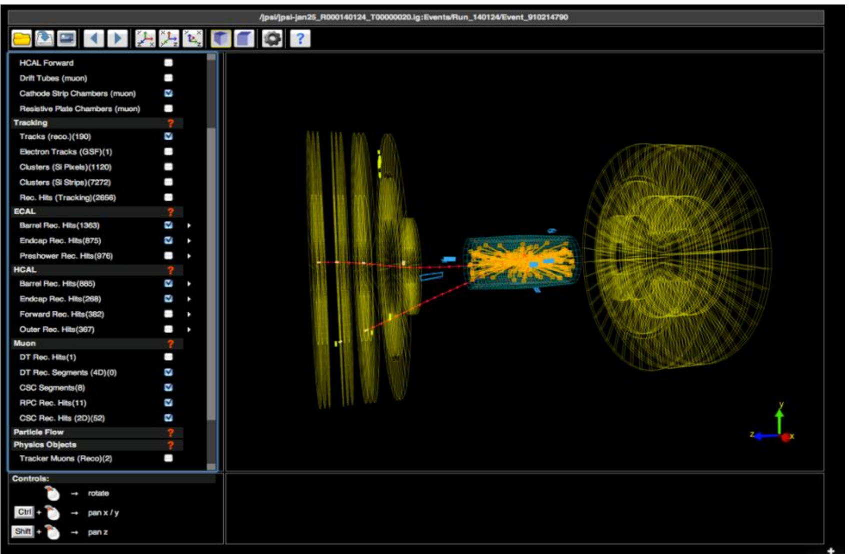


The CMS e-Lab allows students to analyze data to calibrate the detector and participate in discovery science.

Calibrating the detector to "rediscover" previous measured results is an important part of the early scientific activity at CMS.

Michael Fetsko Mills Godwin High School, VA

CMS Masterclass



- Physicists look at CMS particle collisions in event displays to see what happened or in histograms of multiple events

- On Masterclass Day, students are physicists for a day.

<u>**CMS Masterclass (2011)**</u>

- **197 students in the U.S. (based on survey)**
- **13 Institutes in the U.S.**
- **plus approx 30 non-US Institutes**

IceCube Informal Learning

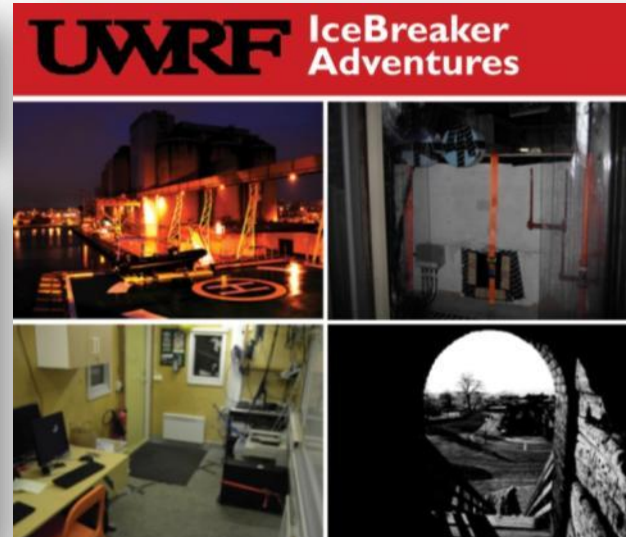
Adler Planetarium,
Chicago, Illinois

- **Dynamic display of real data**
- **~500,000 visitors per year**

Hands-on Ice Drilling Activity,
Madison, Wisconsin

- **Simulates building the IceCube detector**
- **Appropriate for all ages**

IceCube Blogs



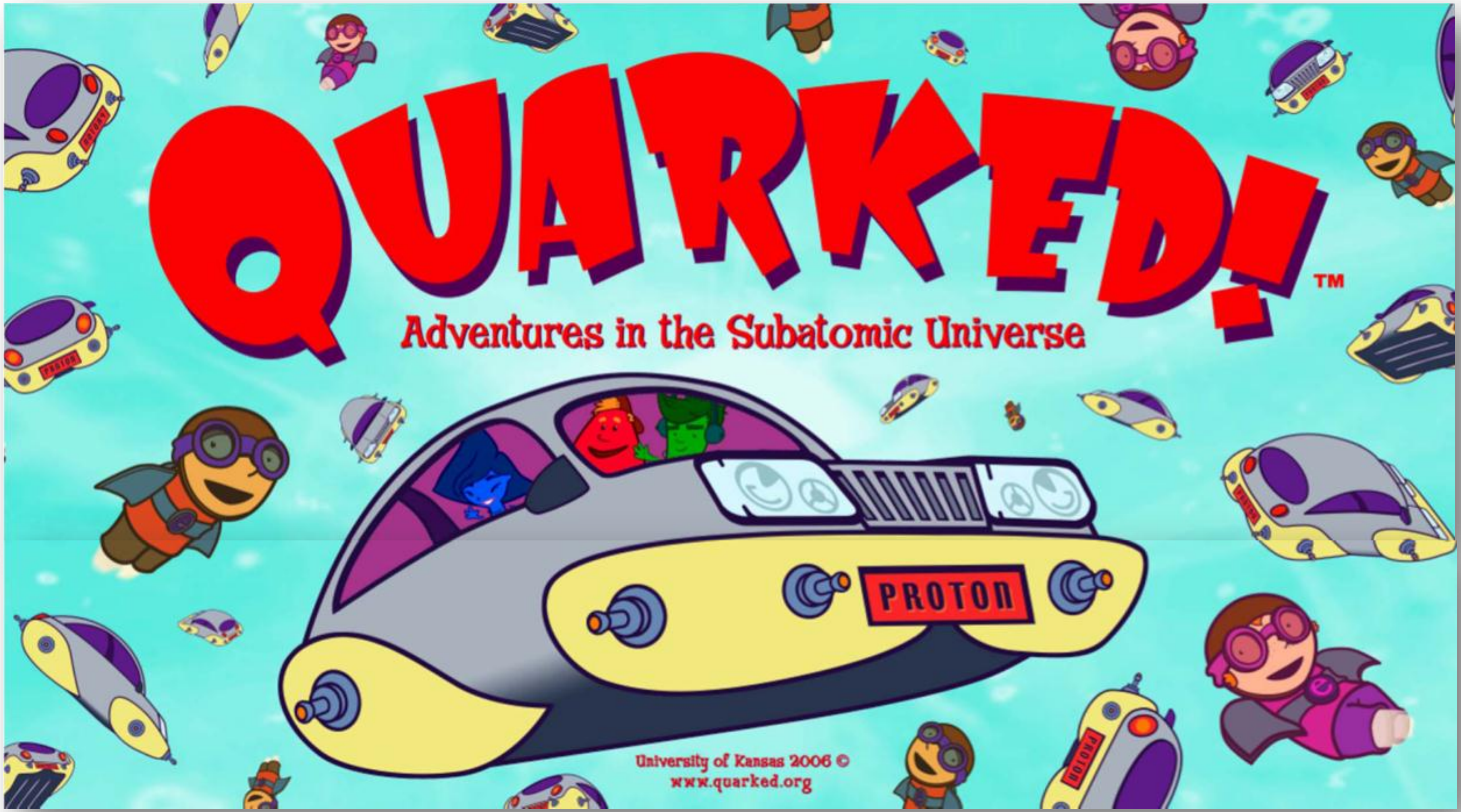
www.blog.icecube.wisc.edu
www.expeditions.udel.edu/antarctica/blog-dec-1-2010.html
www.naardezuidpool.ugent.be/blog.1.html
www2.uwrf.edu/icecube/icebreaker.htm

IceCube Broadcasts from the South Pole

- Wintering over at the Pole
- Hot water drilling
- Computing, running and maintaining the IceCube detector

Curriculum:

- Introduce particle physics
- Access to real IceCube data
- Generalize concepts to illustrate abstract ideas



Alice Bean University of Kansas

What is the Quarked Project?

- **Quarked is a science-based multimedia project for kids (focus on ages 7-12) and others that includes:**
  - An interactive web site www.quarked.org
  - Hands on activities elementary school program
  - Other Educational Outreach

QUARKED!
Adventures in the Subatomic Universe
University of Kansas © 2005

Why this age group?

- At this stage kids are open to everything and don't know that physics is hard.

- **Can you engage elementary and middle school aged children with concepts related to particle physics?**

- Over 5000 children participated from Kansas, Missouri, Colorado in hands on shows
  - Assessment done with students and their teachers
- Website continues to have over 5000 visitors/month

LIGO Lab Outreach and Louisiana Science Education Center

High-tech gravitational wave research labs

5000 sq. foot Science Education Center

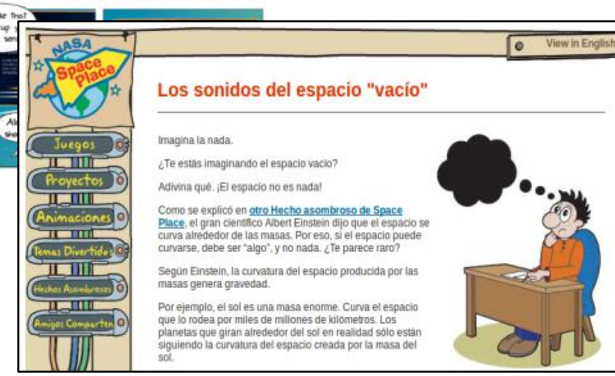
K-12

Teacher development

Tours

LIGO Scientific Collaboration nationwide outreach

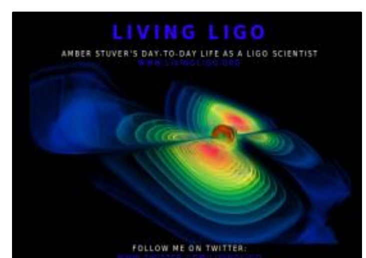
Web



Exhibits

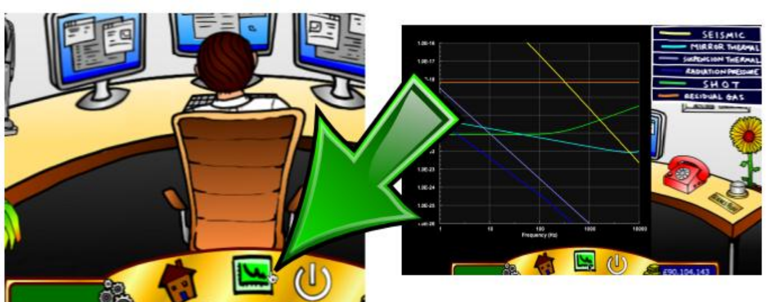
Science Fairs and Festivals

Blogs



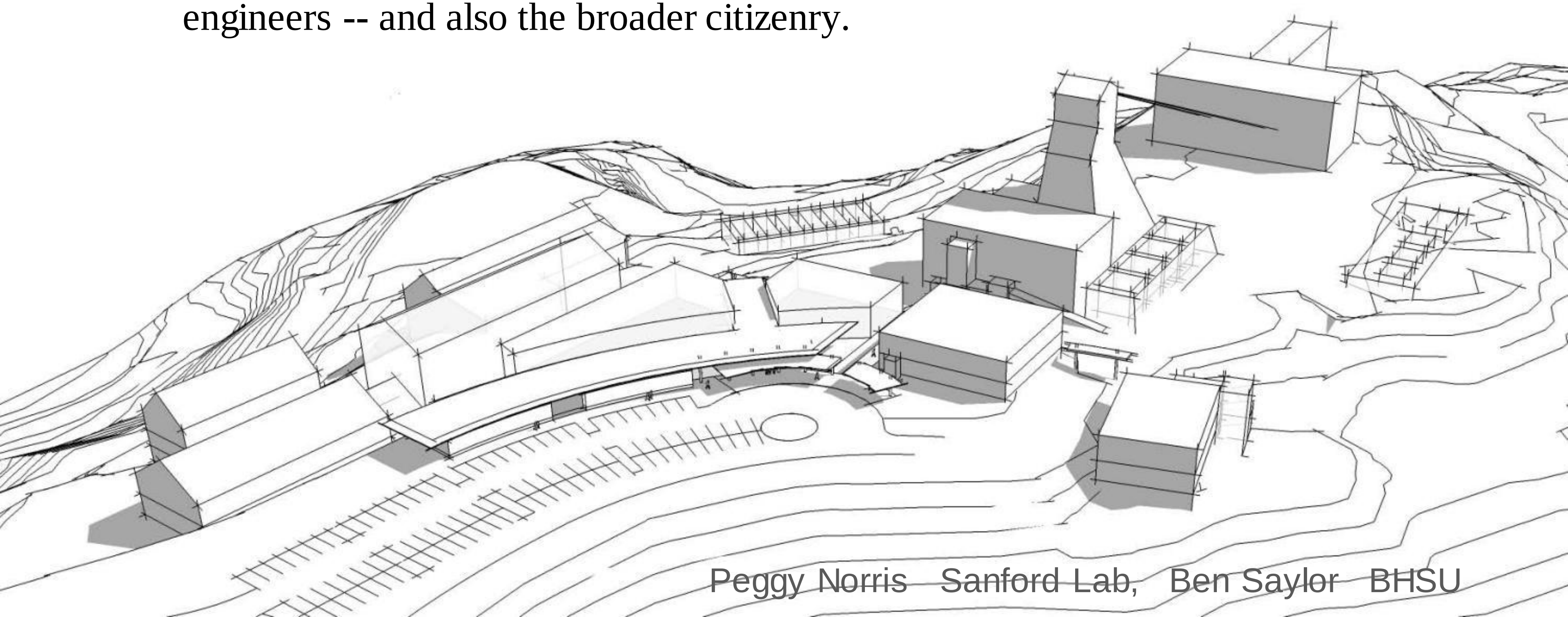
Student training

Games



Sanford Underground Lab at Homestake

- Planning is underway for the Sanford Center for Science Education (SCSE)
  - Leveraged by a substantial pledge from philanthropist T. Denny Sanford, the SCSE will be the education and outreach arm of DUSEL or its DOE equivalent
  - The SCSE is envisioned to feature and leverage the science and engineering of the underground lab to excite and help prepare the next generation of scientists and engineers -- and also the broader citizenry.



Peggy Norris Sanford Lab, Ben Saylor BHSU

Early activities build partnerships and capacity, and test content for a variety of audiences

The 2011 Davis-Bahcall Scholars - ten high-achieving students from across the state - pose with teachers from the Black Hills State University Quarknet Center after spending an afternoon at Sanford Lab calibrating several cosmic ray muon detectors with Bob Peterson of Fermilab. Photo by Matt Kapust

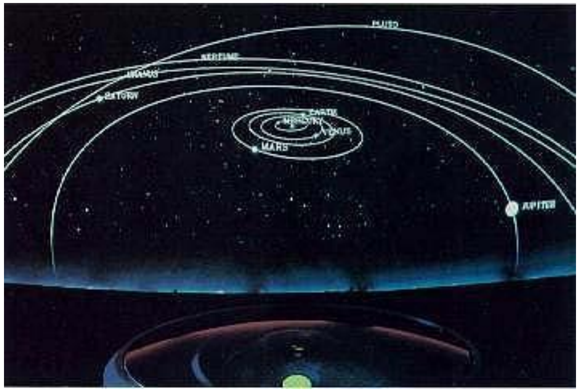
Special efforts are made to serve American Indian audiences, approximately 10% of the regional population

Sanford Lab partnered with University of Nebraska Medical Center and Black Hills State University to sponsor a science camp for middle school students from reservations in Nebraska and South Dakota in June 2011. Photo by Matt Kapust.

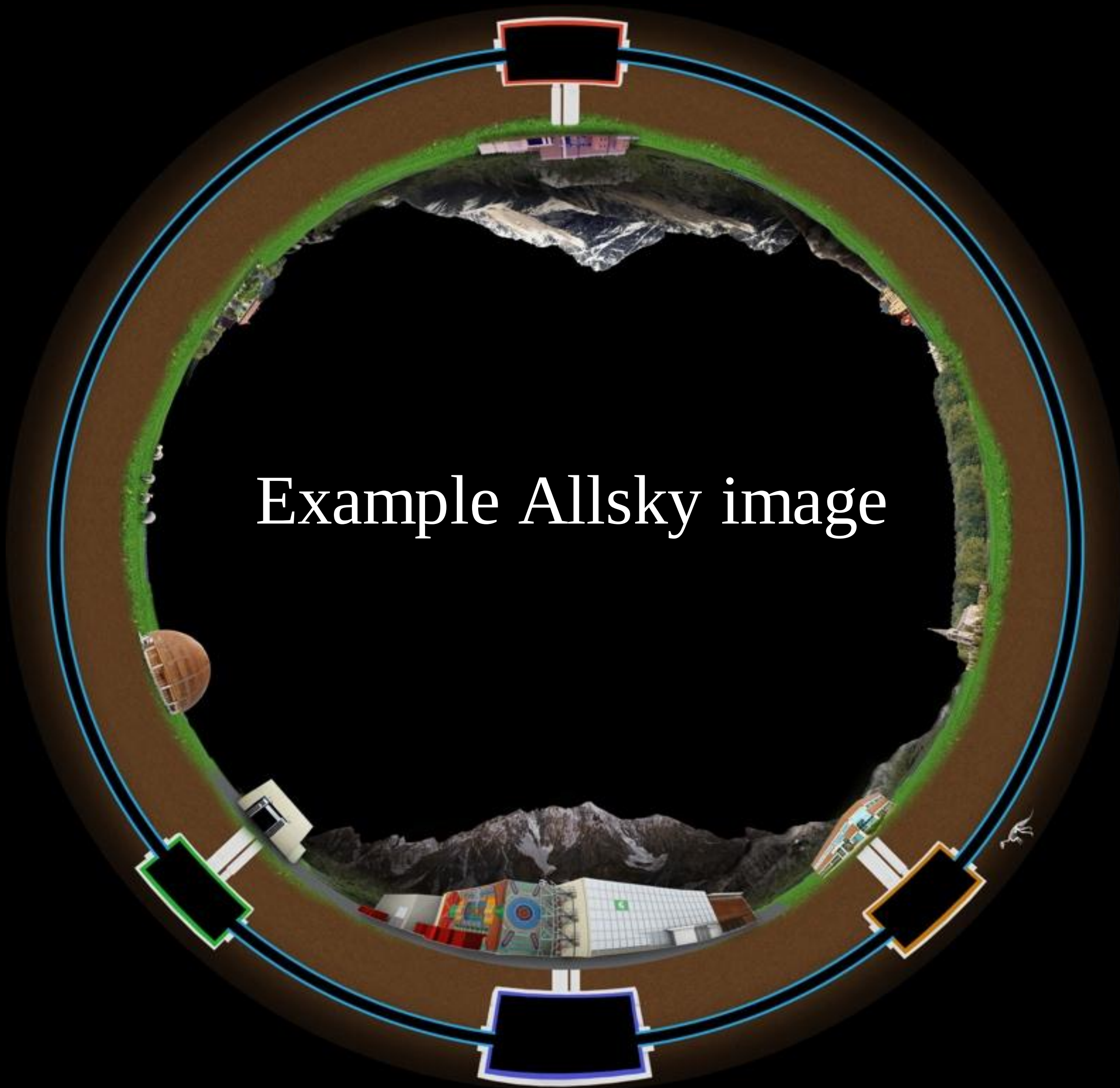
MSU Planetarium outreach project

- Outreach component of NSF CAREER grant
  - Bring ATLAS, LHC, HEP to Planetarium audience
  - In close cooperation with Abrams Planetarium at MSU
- Already produced a 5-minute planetarium clip
  - Plays at the end of each public show
- Working on full planetarium show
  - To debut this fall

ATLAS at the planetarium



- Planetarium display environment
  - Together with video projector, slide projectors
- Show design by MSU students:
  - Undergraduates, professors, graduate student,…
  - With support from experts:
    - Professional writing professor
    - Communication graphics and design professor
    - Planetarium show developer


Example Allsky image

Highlights of Education/Outreach at the Pierre Auger Observatory

Malargüe, Mendoza Province, Argentina

PIERRE AUGER OBSERVATORY

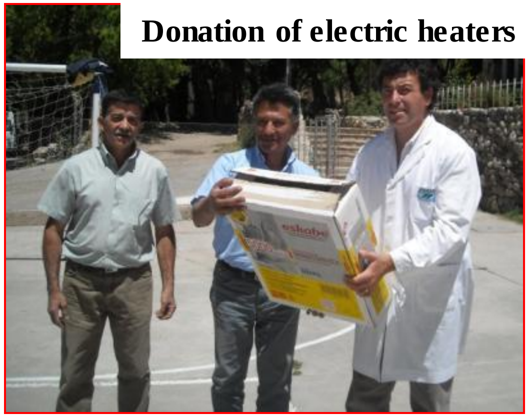
- Over 10 years of outreach in Mendoza and beyond
- Positive impact in communities
- Collaboration takes part in local traditions
- Fosters sense of partnership in Auger's scientific mission

Malargüe Day Parade November 2010

Auger Visitor Center in its headquarters has hosted over 65,000 visitors since opening in 2001

Collaboration partnered with Mendoza Province to construct the new James Cronin School in Malargüe in 2007

Science presentation

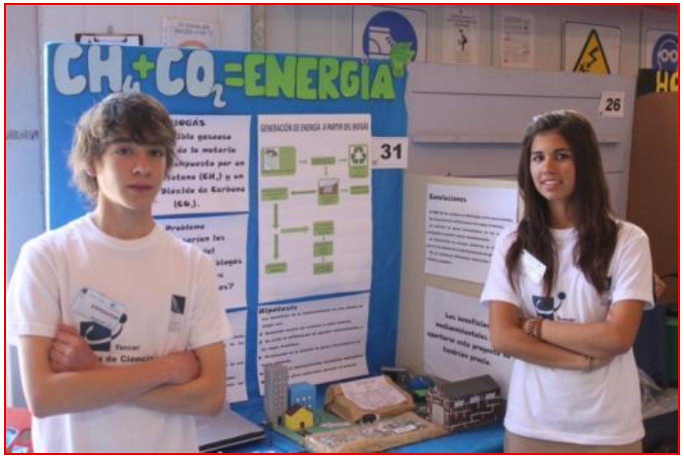


Donation of electric heaters

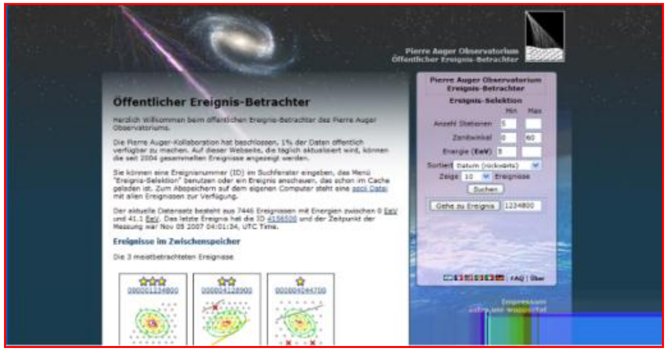
Rural Schools Program: Observatory staff volunteer to bring cosmic ray science and infrastructure improvements to remote schools that cannot travel to Malargüe

G. Snow / Nebraska

Highlights of Education/Outreach at the Pierre Auger Observatory



The Collaboration sponsored 3-day Science Fairs at the Observatory in 2005, 2007, 2010 drawing student and teacher teams from all over the Province. Collaborators serve as judges.



Students use reconstructed air shower data released online for science fairs and independent research projects.

Collaborators offer courses in hands-on science instruction to local teachers

http://www.auger.org (5 languages, 4000 hits per year)

Plain English Summaries (ATLAS)

Is Nature Supersymmetric? First Data from the ATLAS Experiment.

24 May 2011

String Theory predicts a new symmetry, called "supersymmetry", that could shed light on some of today's mysteries of fundamental particles and interactions. In supersymmetry, every particle-type should have a "shadow" particle called a super-partner that (in general) has a much higher mass. The ATLAS Experiment has analyzed the first year of its LHC data and searched for evidence of these super-partners of ordinary matter.

In the proton collisions of the LHC, new heavy particles (the super-partners) could be produced. These super-partner particles would subsequently decay in a variety of ways, such as shown in Fig. 1, leaving many different telltale signals that ATLAS has sought to detect. Collision events with a so-called "momentum imbalance" are the key signature for the production of super-partner particles.

According to the law of momentum conservation, the momentum of all particles produced in the collision perpendicular to the proton-proton axis should exactly balance. An imbalance of the momentum would point to "missing" particles — particles that interact extremely weakly with matter. This imbalance occurs because the final decay products include particles that leave the detector without being detected (because they interact extremely weakly with matter). For the case of supersymmetry, these particles are the lightest super-partner particles (the "neutralino" $\tilde{\chi}_1^0$).

Since the neutralino $\tilde{\chi}_1^0$ does not decay at all, it is a permanent component of our universe. This particle might be the so-called dark matter that is 80% of all matter in the Universe. Therefore, these searches could shed light on the nature of dark matter. More about dark matter is here, and see the link to "PhD comics" therein.

The measurement of the momentum balance requires the precise reconstruction of all types of measurable particles and a combination of the many component devices of ATLAS. This makes it one of the most challenging measurements at ATLAS.

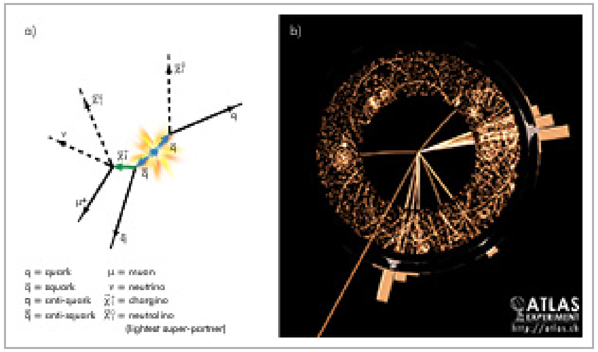
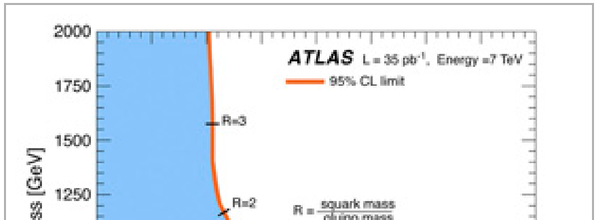


Fig.1 (Click picture for a larger version)

Fig. 1a): In this example, the collision of two protons results in the production of a squark and an antisquark (the super-partner of the quark and its antiparticle). These decay into lighter particles, one of which (a "chargino", written as $\tilde{\chi}_1^{\pm}$) also decays into still more particles. The chargino and squark are written with a tilde over them, which indicates that they are super-partner particles. The decays happen so quickly that no tracks are left in the ATLAS detector from the squark and chargino. In the end, two of the neutralinos $\tilde{\chi}_1^0$ (lightest super-partner particles) survive, because there are no lighter super-partners into which they can decay.

Fig. 1b): This figure shows an example of the momentum imbalance resulting from collision events such as in Fig. 1a). The two incoming (colliding) protons were perpendicular to this image, and the collision happened at the center. The visible particles are those that came out of the collision at the center. The solid bars on the outside show the areas where most of the energy went. It is clear that most of the momentum (and energy) went to the bottom and right. This imbalance was due to the lightest super-partner particles (and the neutrino) going undetected to the upper left. They leave no tracks and deposit no energy. This momentum imbalance is a signature for new particles.



The end