

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?



At the **World Economic Summit** in Davos 2011

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

At the **World Economic Summit** in Davos 2011

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

Notice both the very beginning and the ending.



August 2011

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.

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.

**NRC study led
by Helen Quinn
(quoted here)**

“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.

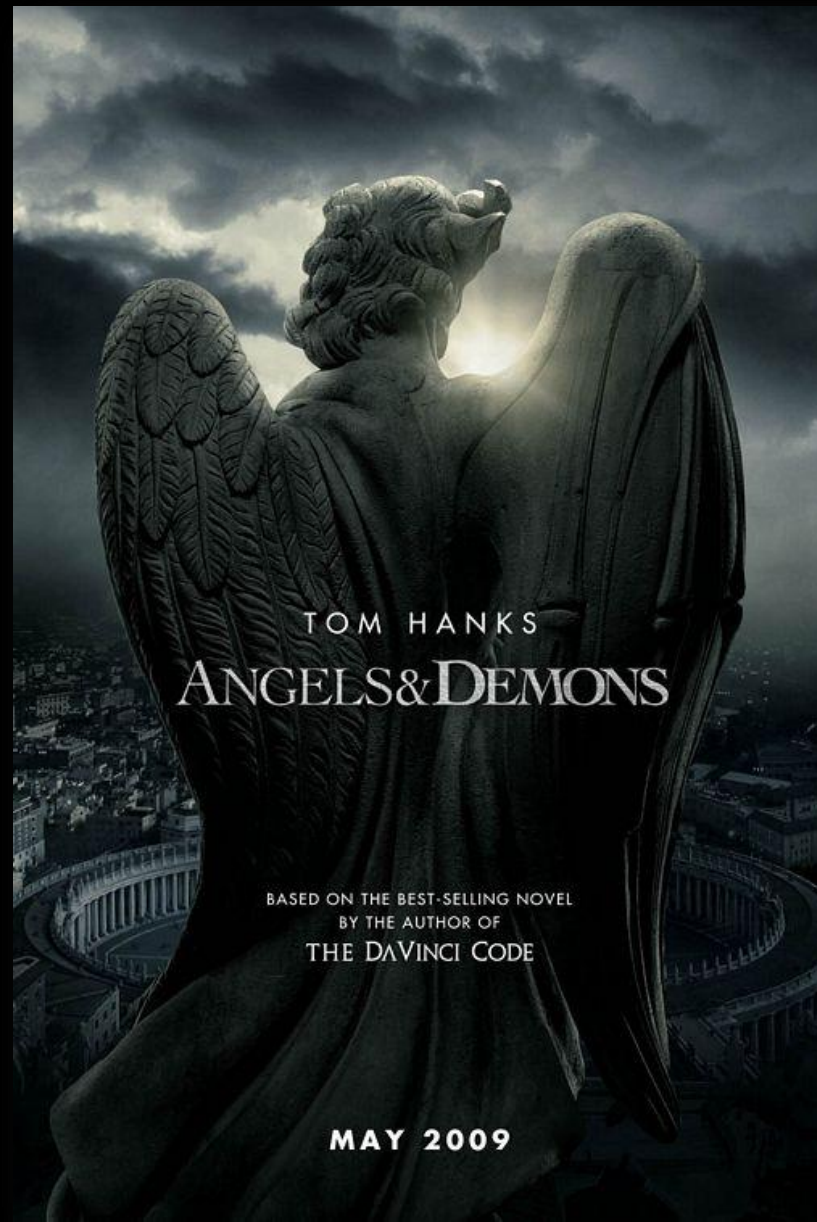
It is the latest in decades of efforts to improve the science knowledge of American students, who have typically ranked in the middle of the pack on international comparison



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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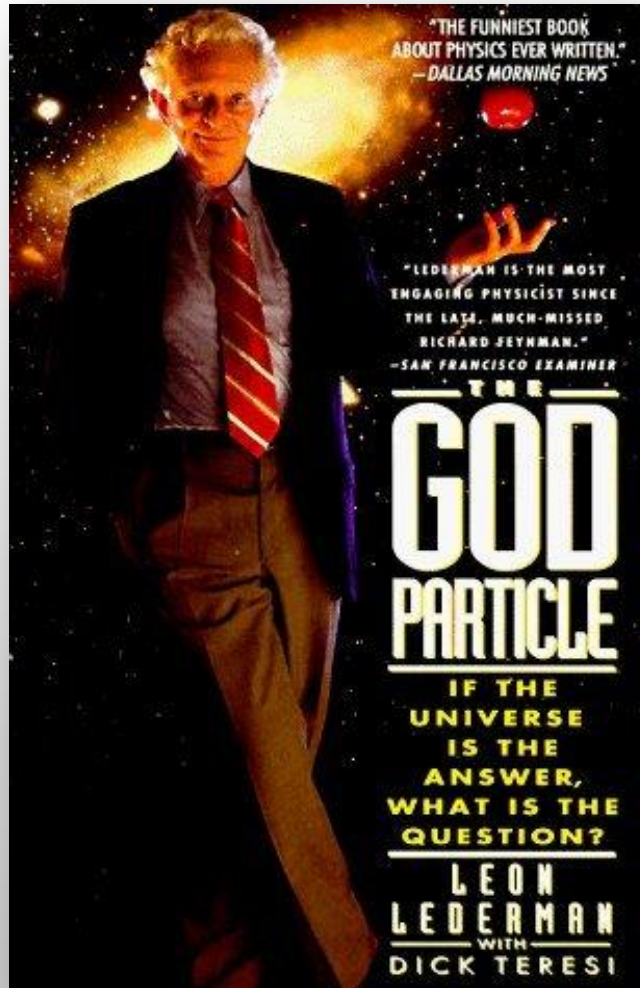
Angels & Demons

director Ron Howard and Tom Hanks



DPF Meeting – Michael Barnett – August 2011

How does Hollywood present particle physics?



DPF Meeting – Michael Barnett – August 2011

How does Hollywood present particle physics?



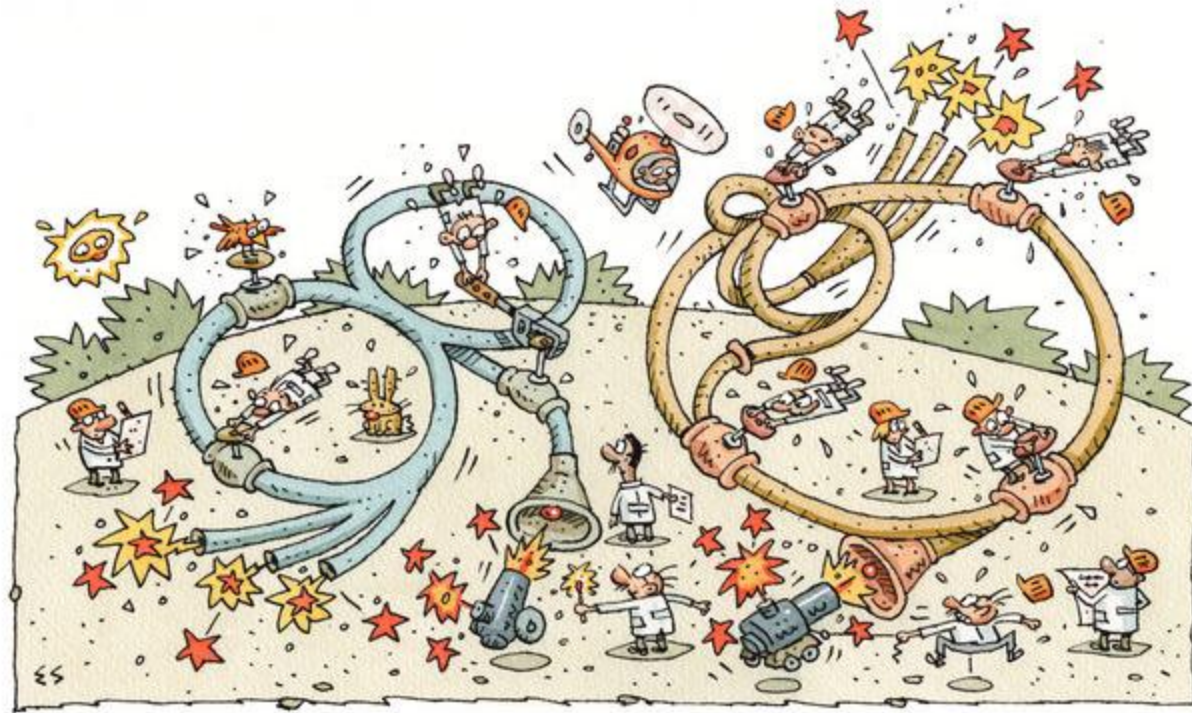
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The New York Times

2 August 2011

NEWS ANALYSIS

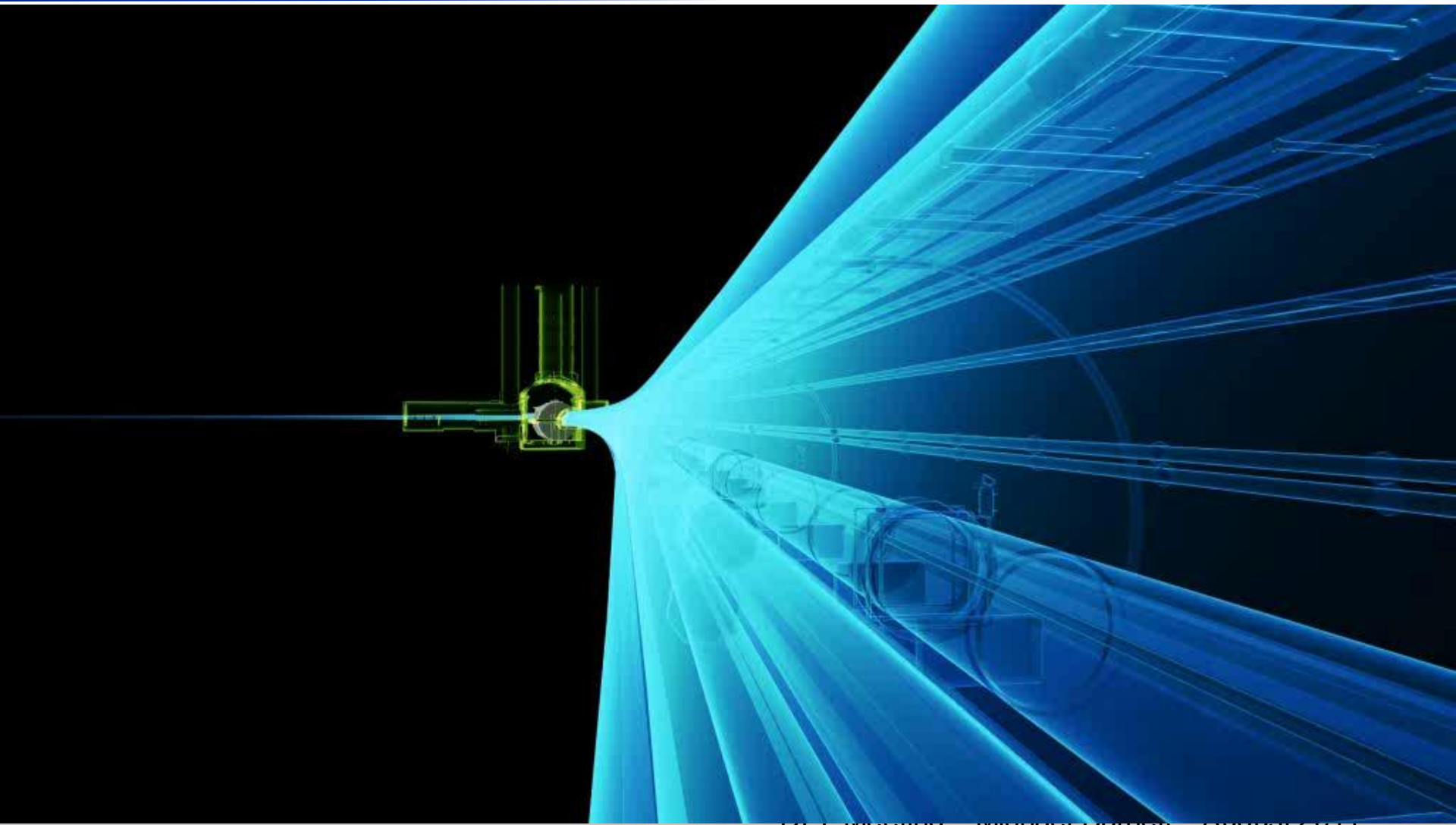
Particle Accelerators Full of Spin and Fury, Signifying Something



Elwood H. Smith



Collisions à la ATLAS



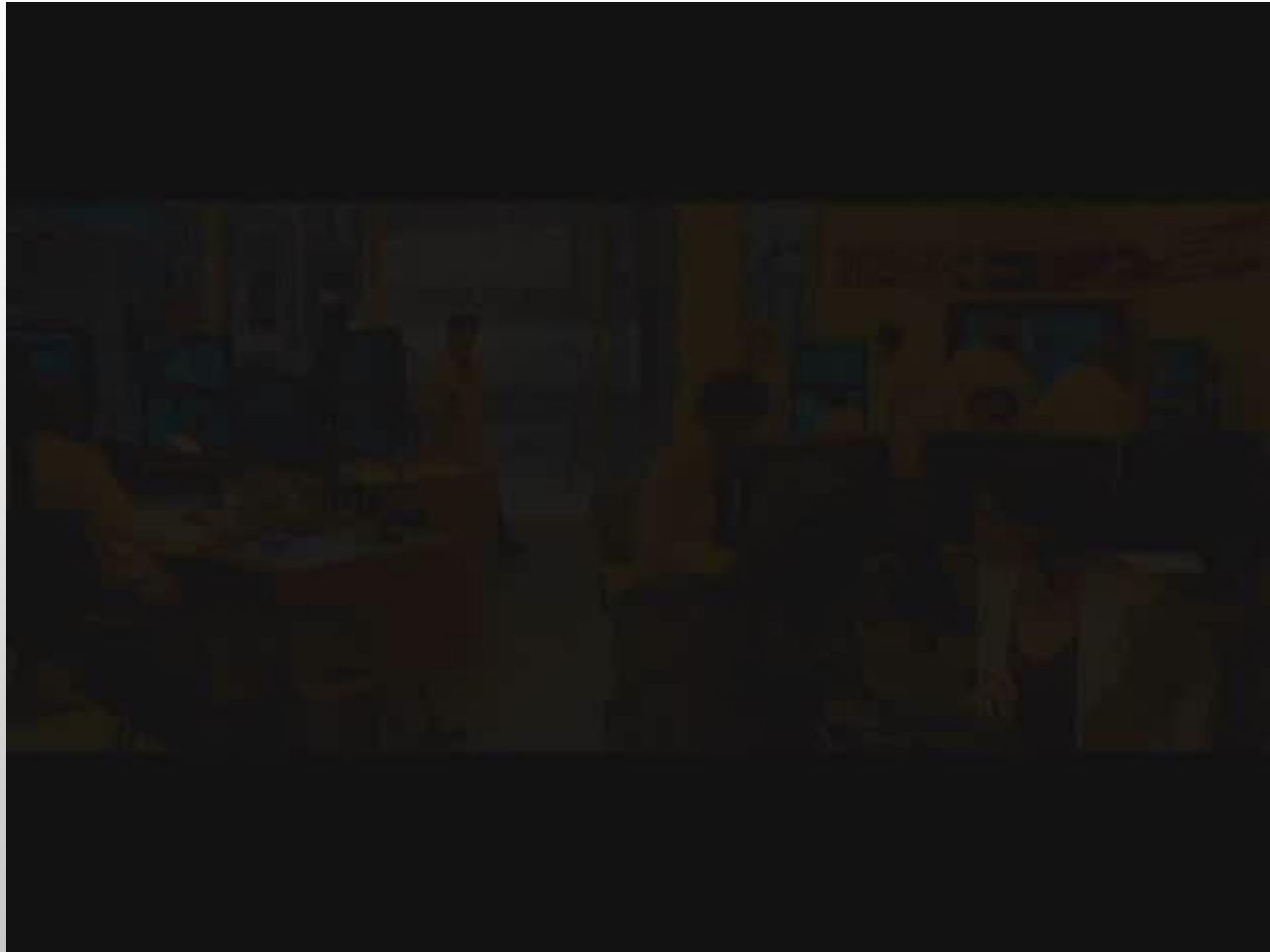
D11 Meeting - Michael Barnett - August 2011



Collisions à la Hollywood



Collisions à la Hollywood



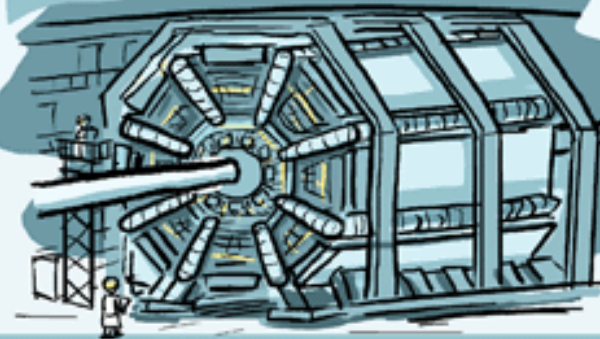
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TERESA'S ROLE IN THIS ARMY OF SCIENTISTS IS TO STAND IN THE FRONT LINES AGAINST THE ONSLAUGHT OF DATA THAT IS GENERATED.

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SURROUNDING THE COLLISION POINT IS A GIGANTIC STRUCTURE CALLED A.T.L.A.S...



...MADE OF LAYERS UPON LAYERS OF SENSORS...

WITH OVER 160 MILLION CHANNELS OF DATA...

OUTPUTTING ABOUT 1 MILLION GIGABYTES PER SECOND.

TERESA WORKS ON ONE OF THE FIRST LAYERS OF FILTERS THAT SCREEN THE DATA IN REAL TIME FOR EVENTS THAT MATCH THE THEORETICAL PREDICTIONS.

WHAT HAPPENS TO ALL THE OTHER DATA?

WE THROW IT OUT.



BEING A GOOD PHYSICIST IS KNOWING HOW TO APPROXIMATE--

YOU HAVE TO DECIDE WHAT IS IMPORTANT AND WHAT CAN BE IGNORED.



APPARENTLY, THIS IS ALSO TRUE IN THEORY:

WE THROW OUT EQUATION TERMS ALL THE TIME. IN QUANTUM PHYSICS EVERYTHING IS POSSIBLE, BUT NOT EVERYTHING IS LIKELY.





WWW.PHDCOMICS.COM/TV

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

30 March 2011, Wednesday, 18:00



Playbill Calendar
July 2011



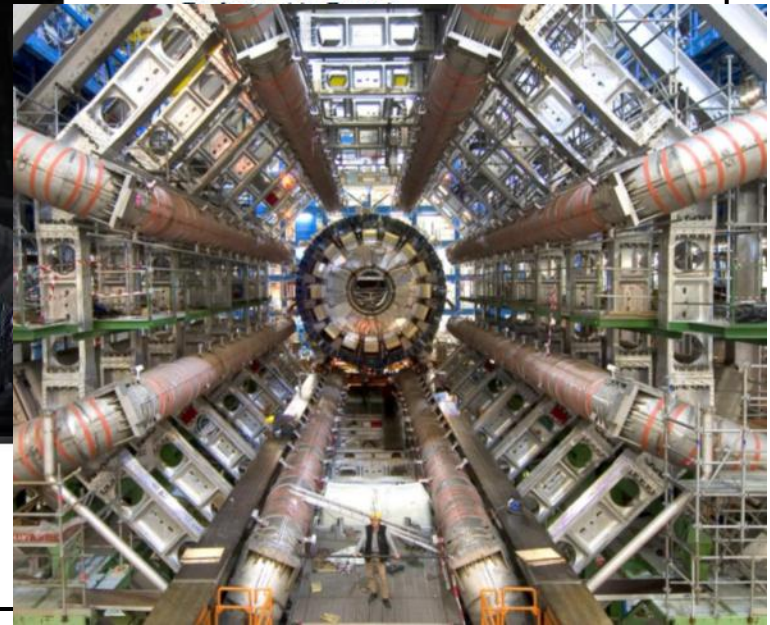
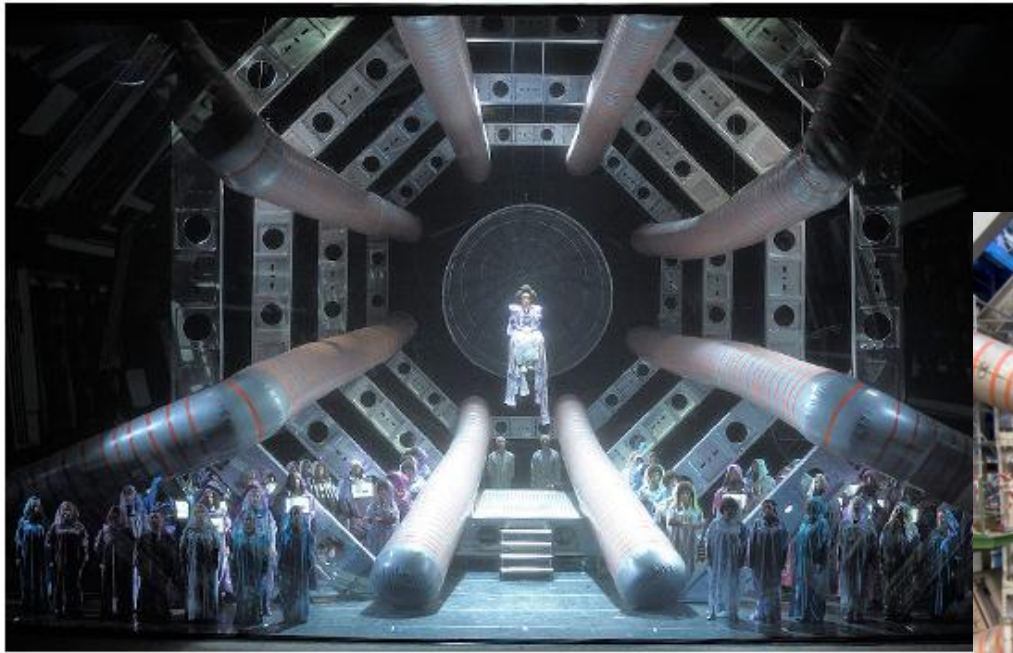
version



Mariinsky Theatre
1 Theatre Square

Les Troyens

grand opera in five acts
Music by Hector Berlioz
Libretto by the composer after motifs from Virgil's
Aeneid



Cast

Énée: Sergei Semishkur

Credits

Musical Director: Valery Gergiev

Impacts can be unexpected



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Impacts can be unexpected

Forthcoming (November) Muppets movie
From the trailer



Impacts can be unexpected

DPF Meeting – Michael Barnett – August 2011

Contemporary Physics Education Project

FUNDAMENTAL PARTICLES AND INTERACTIONS

Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

This poster details the Standard Model of particle physics. It is divided into two main sections: **FERMIONS** and **BOSONS**.

- FERMIONS:** Includes a table for Leptons (electron, muon, tau) and Quarks (up, down, charm, strange, top, bottom), listing their mass, charge, and spin.
- BOSONS:** Includes a table for Gauge Bosons (photon, gluon, W, Z) and the Higgs boson, listing their mass, charge, and spin.

Other features include a diagram of a particle interaction, a table of interaction properties, and a section on particle decays.

PLASMA PHYSICS AND FUSION

Fusion
Physics of a Promising Energy Source

This poster explores the physics of fusion energy. It features a central image of the Earth with a sunburst effect.

- ENERGY SOURCES & CONSIDERATIONS:** Compares fusion to other energy sources.
- PLASMA - THE 4th STATE OF MATTER:** Explains the properties of plasma.
- THE IMPORTANT FUSION PRODUCTS:** Shows the reaction of deuterium and tritium.
- HOW FUSION REACTIONS BEGIN:** Discusses the challenges of achieving fusion.
- CREATING THE CONDITIONS FOR FUSION:** Details the requirements for temperature and pressure.
- ACHIEVING FUSION CONDITIONS:** Shows various experimental approaches like tokamaks and inertial confinement.

THE HISTORY AND FATE OF THE UNIVERSE

THE HISTORY AND FATE OF THE UNIVERSE
From one and eight major stages in the evolution of the universe

This poster illustrates the timeline of the universe from the Big Bang to the future. It includes sections on:

- The Big Bang and Inflationary Universe:** The beginning of space and time.
- The Formation of the First Stars and Galaxies:** The early structure of the universe.
- The Formation of the Solar System:** The birth of our planet.
- The Future of the Universe:** Scenarios for the long-term fate of the cosmos.

NUCLEAR SCIENCE

Nuclear Science

This poster covers the fundamentals of nuclear science. It features a central image of a nucleus with a rainbow spectrum.

- Development of the Atom:** Historical models from Dalton to Bohr to quantum mechanics.
- Radioactivity:** Types of radiation (alpha, beta, gamma) and their properties.
- The Nucleus:** Structure and stability of atomic nuclei.
- Nuclear Energy:** Applications of nuclear reactions, including fission and fusion.

Charts appear in Movies

DONNIE DARKO

Thirteen Conversations
About One Thing

HULK

Charts appear on TV



PHOTO GALLERIES

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



2
Annual budget: \$1,200,000,000
Construction cost: \$7,820,000,000
Staff: 2,500
Physical size: 17-mile circumference
Scientific utility: 8
WIIFY: 1
Wow factor: 9

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

Most Popular **BBC News**

Shared **Read** Video/Audio

Norway youth camp attack kills 84	1	} Norway attacks
Ohio ex-Marine murdered 11 women	2	
As it happened: Norway attacks	3	
Profile: Anders Behring Breivik	4	
latest	5	
South Sudan rebel leader killed	6	
White House debt talks collapse	7	} Debt talks
Sunday Mirror phone-hacking claim	8	} Phone hacking
Higgs hunt results excite scientists	9	
Norway's far right not a spent force	10	

Elsewhere on the BBC

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Education/Outreach programs across HEP

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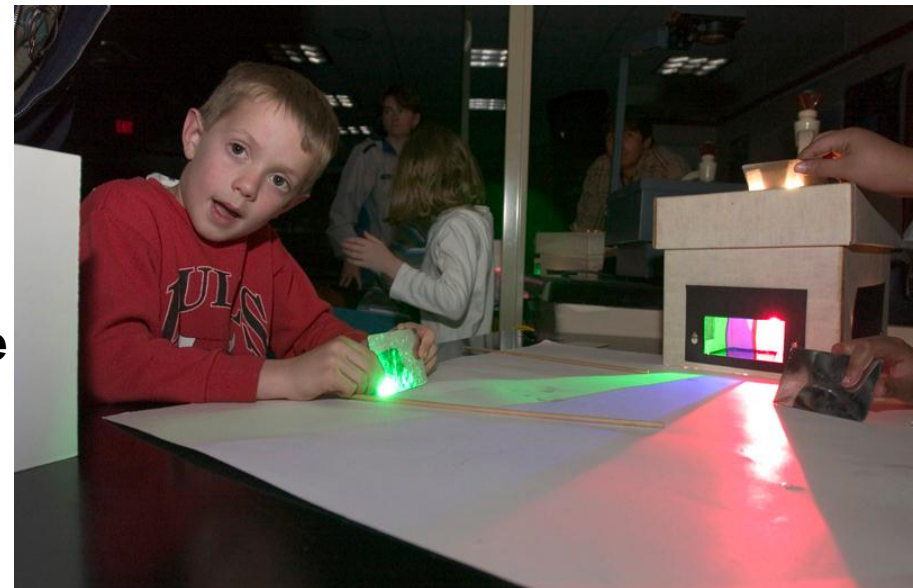
Education at Fermilab

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.





Rob Roser shows physics teachers CDF up close and personal.



The Dave Schmitz and Michael Cooke show at Millennium Park

CMS e-Lab

[Project Map](#)
[Library](#)
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[Site Map](#)
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Home: Join a national collaboration of high school students to study CMS data.

Project Map: To navigate the CMS e-Lab, follow the path; complete the milestones. Hover over each hot spot to preview; click to open. Along the main line are milestone seminars, opportunities to check how your work is going. Project milestones are on the four branch lines. [Getting Around the e-Lab](#)

Milestones (text version)

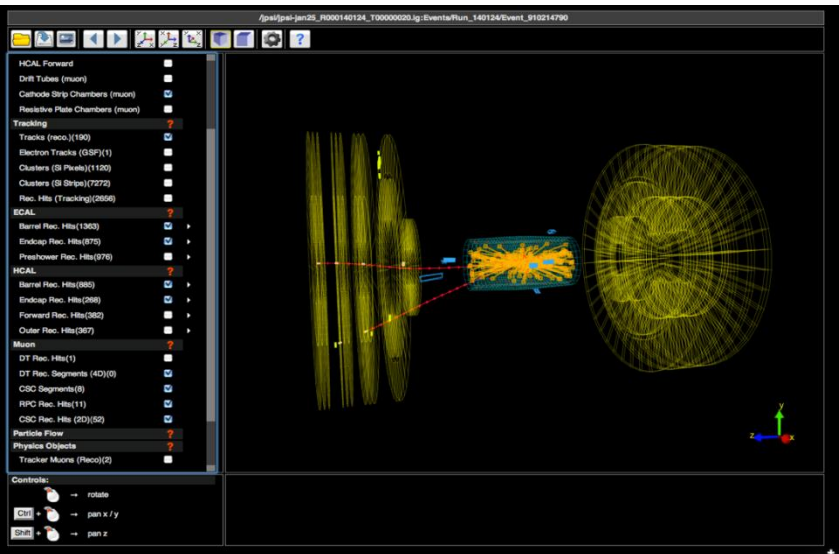
Your team may use the milestones above, or your teacher may have other plans. Make sure you know how to record your progress, keep your teacher apprised of your work and publish your results.

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.

Investigating the Mass of a Z-Particle

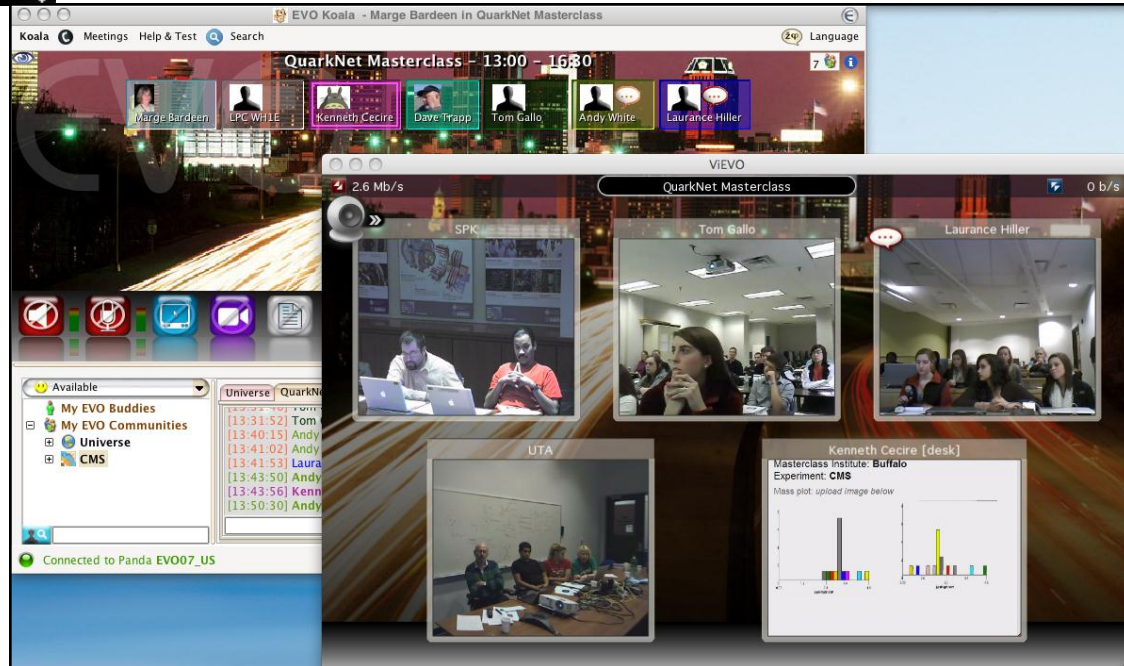
Abby Compton and Abby Klein



- 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.

CMS Masterclass (2011)

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



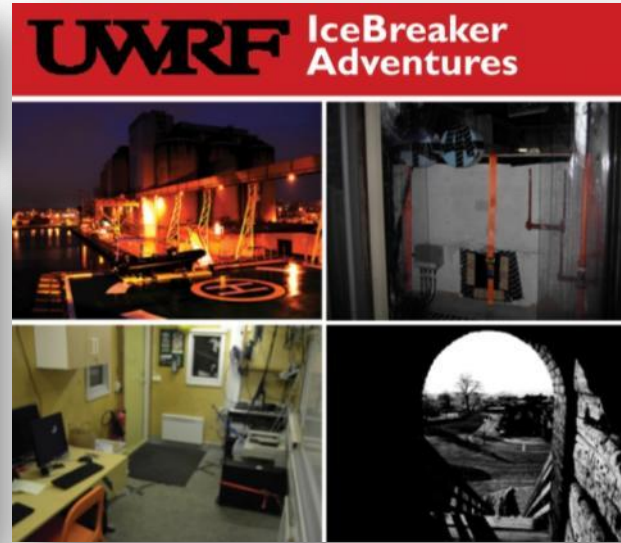


Adler Planetarium, Chicago, Illinois

- 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



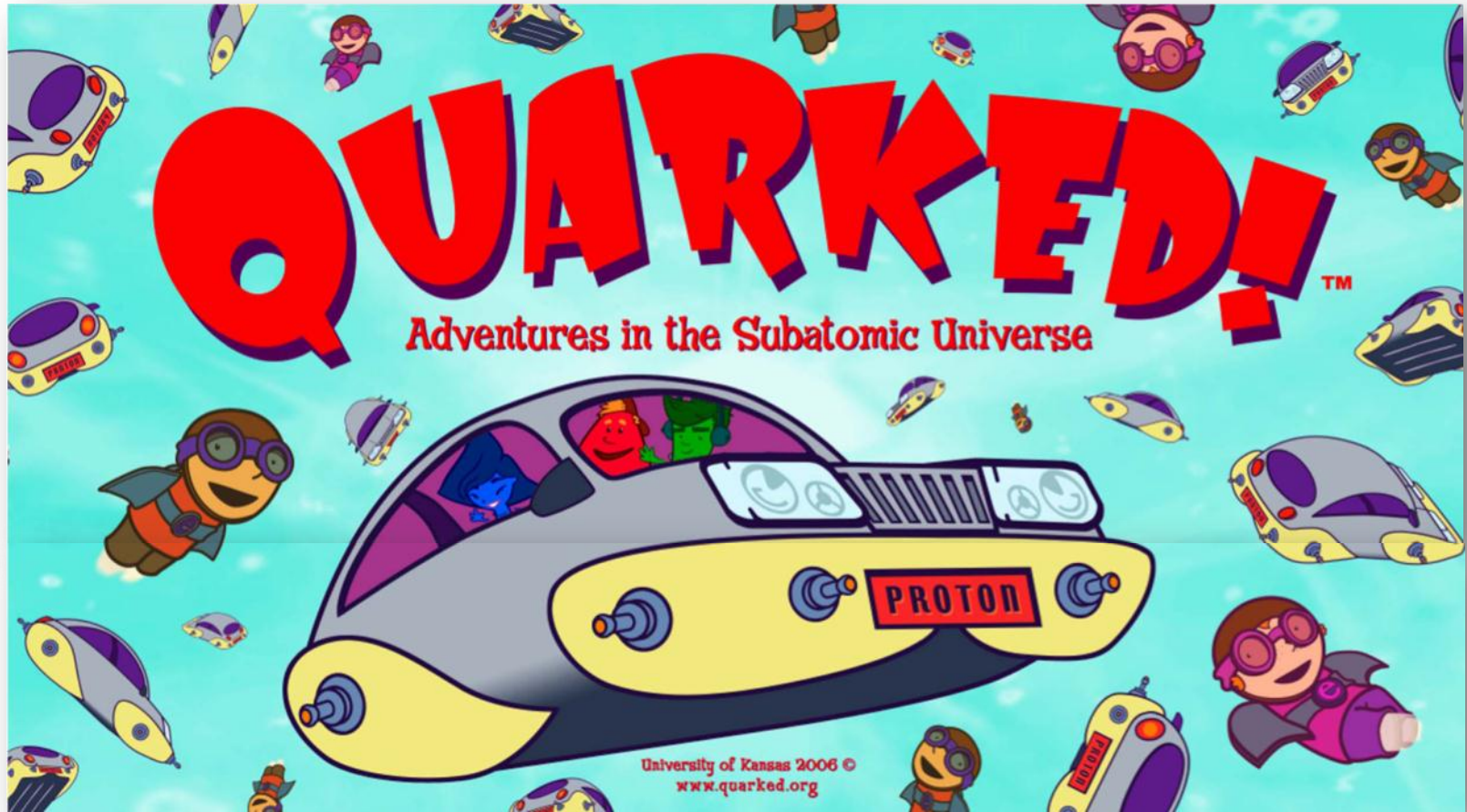
- www.blog.icecube.wisc.edu
- www.expeditions.udel.edu/antarctica/blog-dec-1-2010.html
- www.naardezuidpool.ugent.be/blog.1.html
- www2.uwrf.edu/icecube/icebreaker.htm

- **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



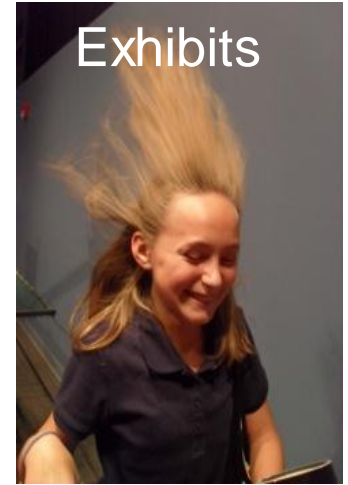
Why this age group?

- 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

High-tech gravitational
wave research labs



5000 sq. foot Science
Education Center



Exhibits

Tours



K-12



Teacher development

Exhibits



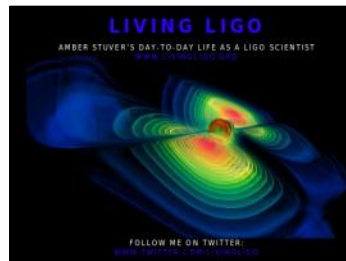
Science Fairs and Festivals



Web



Blogs

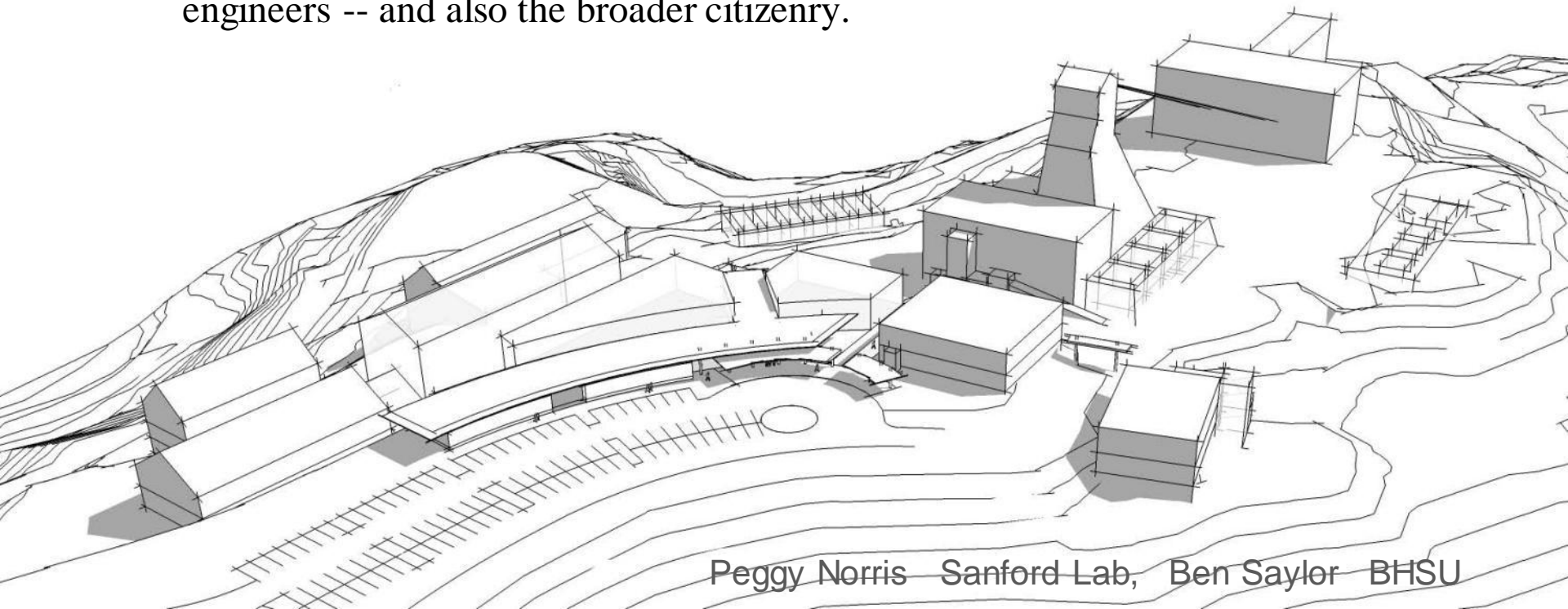


Games



Student training

- 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.



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.

- ✦ 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



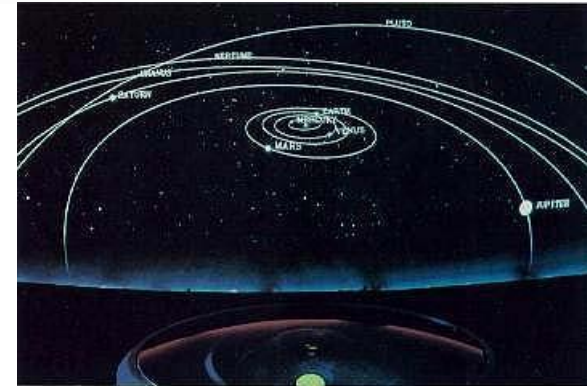
Reinhard Schwienhorst, Michigan State University

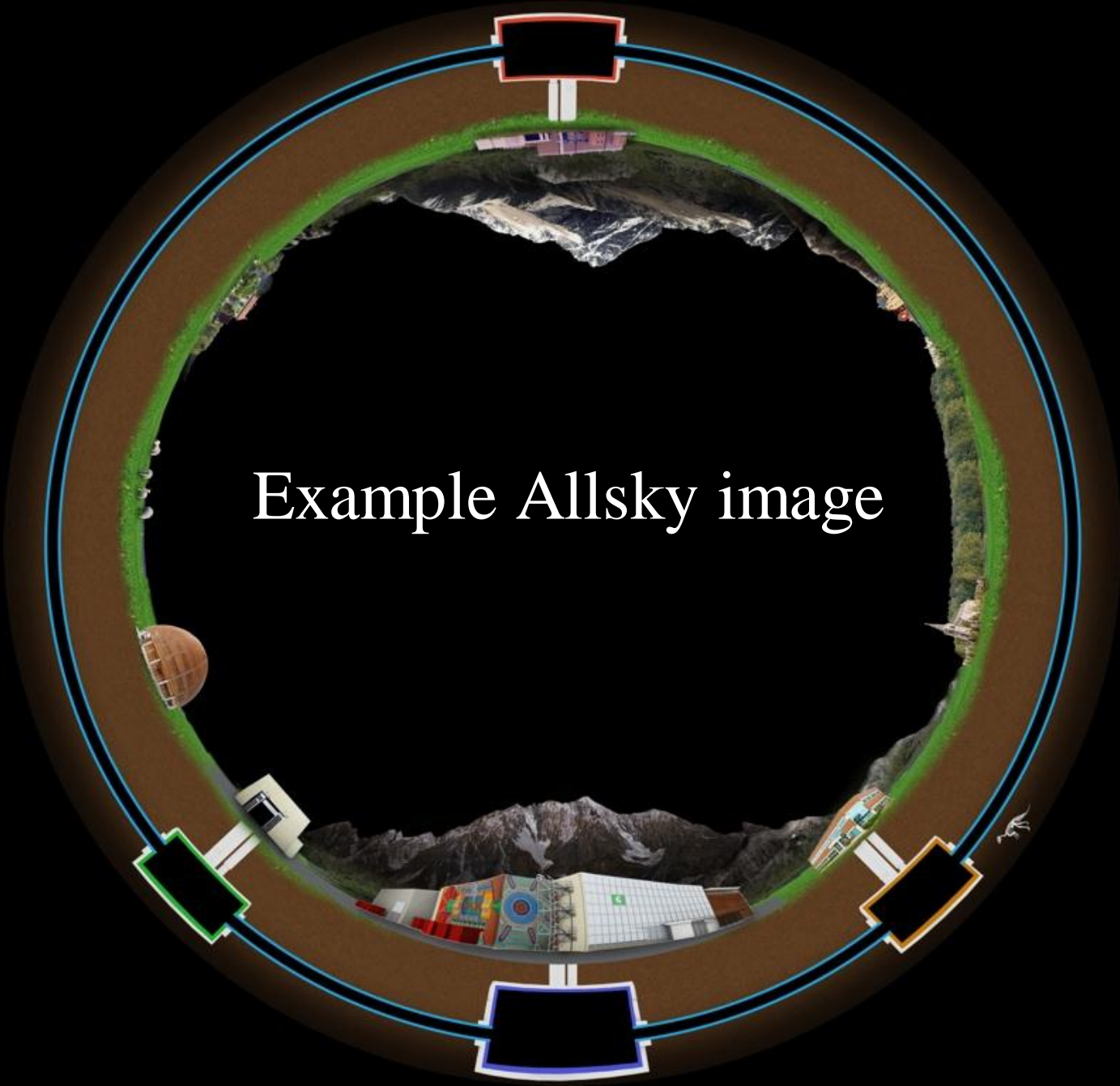
✦ Planetarium display environment

- 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

- 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



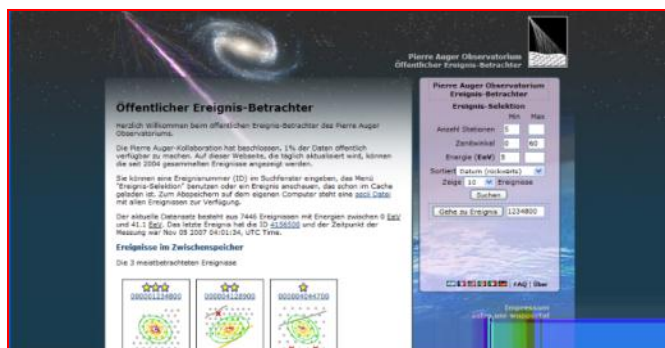
Donation of electric heaters

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

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.

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



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

Plain English Summaries (ATLAS)

Like Send 47 people like this. Be the first of your friends.

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.

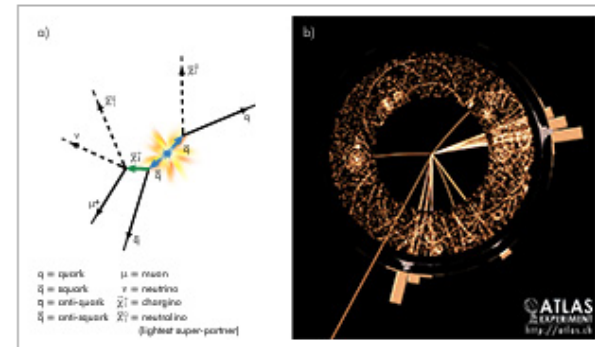
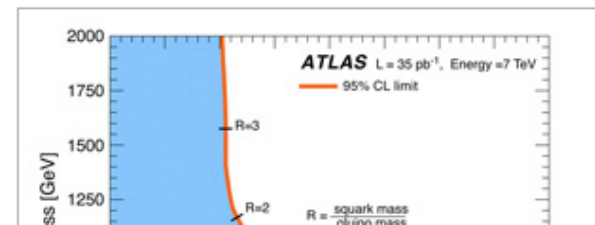


Fig.1 (Click picture for a larger version)

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 $\tilde{\chi}^\pm$) 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

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