



# Celebrating 30 Years of K-12 Educational Programming at Fermilab (Engaging Students in Our Science)

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M. Bardeen, DPF, Providence, August 2011



Saturday, August 6, 2011

# Why Bother? What Leon Says



“What I get out of it is to see the world (one more time) through the unclouded eyes of children.”



Saturday Morning Physics  
“Why not use the magnificence of Fermilab to dazzle (and capture) high school kids?”

# Why Bother? What Teachers Report



“Sprinkled” activities during the year

Tried new teaching practices  
& curriculum



Taught year-long theme:  
“Search for Higgs”

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# Why Bother? What Teachers Report



What makes it to my classroom:

Data

Computer simulations

What high school students would call "sweet"

Bob Grimm

Impact in my classroom:

Prompts student questions about HEP research

Reloads curriculum

Empowers students

Pete Bruecken



Things my students remember

Talking about Fermilab and CERN

Researching the Higgs Boson

I helped work on building ATLAS.

Deborah Roudebush

M. Bardeen, DPF, Providence, August 2011

# Opportunities: Win-Win-Win Relationships

## For physicists:

Sharing an excitement and passion for science  
Inspiring the next generation of scientists . . . and  
tomorrow's taxpayers

## For teachers:

Reloading the curriculum  
Being appreciated as teachers

## For students:

Learning about today's science  
Experiencing science in action

# What Students Say



“QuarkNet has taught me that patience, common sense, and maturity will often serve you better than a book ever will. Through working on intellectually challenging activities, such as testing pods, programming software, and writing webpages, **we learned that mistakes are not dead ends, but simply stepping stones.**”

Ting Wu, Illinois Mathematics and Science Academy,  
Aurora, IL

# What Teachers Say

“The scientist in me recognizes that while I (and other science teachers) do a great job in showing kids the 'wow' of science, we don't do good job in educating kids about real scientific research. (My students) had the chance to do real research. They were frustrated with me in the beginning because they encountered problems that they couldn't easily solve and I didn't have the answers to give them. They expected cookbook answers, but I was as in the dark as they were. At one point I said to them, 'You have been taught the scientific method, now use it!' I wish you could have seen the astonished look on their faces. **I have watched them transform from high school science students to research scientists.**”

Carol Baker, Alan Shepard High School, Palos Heights, IL  
writing about QuarkNet cosmic ray studies

# What Volunteers Say



“I loved studying physics in college. I started looking at the world differently, and it became a much more interesting place. I think science education is very important—you've got to be able to tell what's real and what people are just trying to sell you. Not to mention that the world needs people to provide innovative solutions to real problems. **I love spending time with the kids.** I like to be silly and have some fun—**always trying to spark an interest!**”

Anne Heavey, Fermilab Computing Division

# Challenges

Finding the right level

Fitting content into the curriculum  
(standards, common core, testing, time)

Finding ways to engage teachers and students

Preparing “publication quality” materials

HOW is as Important as What!

Needs Assessment – Ask teachers.

Program Development – Partner with teachers.

Program Conduct – Put peers in lead positions.

Program Assessment – Get participant feedback.



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# What's Effective?

Engagement and exploration!

In the short term—creating interest

In the longer term—building understanding  
and relationships

Working directly with students or teachers

Welcome **Educators** Physicists Students Visitors



Welcome to the website of the Fermilab Science Education Office. Click on the different audience tabs to find science education resources and information about our activities suitable for you. Click the videos to see the audiences in action.

Use the navigation bar at the top and bottom to learn more about us and our programs.

#### Quick Links to Programs

- [Tours](#)
- [QuarkNet](#)
- [LInC Online](#)
- [Science Adventures](#)
- [Teacher Workshops](#)
- [Saturday Morning Physics](#)

#### Quick Links to Resources

- [Lederman Science Center](#)
- [Teacher Resource Center](#)
- [Data-based Investigations](#)
- [Fermilabyrinth](#)
- [Prairie Resources](#)
- [Web-based Materials](#)

Fermilab Ed Site    
Google™ Custom Search



Calendar for

January, 2009

- 21 Get to Know Fermilab Guided Tour
- 24 Lego Engineering
- 26 Get to Know Fermilab Guided Tour

[More...](#)

#### Education Office News

- [Ask-a-Scientist resumes February 1, 2009](#)
- [Summer intern wins first place at SERCh](#)

#### New Web Content

- [Vida Goldstein - 2008 Distinguished Educator Awardee](#)
- [Jean Slaughter Awarded Director's Volunteer Award](#)

[More...](#)

## Research Experiences

Academic Year High School Interns  
QuarkNet Summer Research (Student/Teacher  
Teams)  
TARGET  
TRAC

## Field Trips/High School Tours

Lederman Science Center  
Physics Science Experiences  
Beauty and Charm  
Phriendly Physics  
Prairie Science Experiences  
Insects at Work in Our World  
Prairie - Our Heartland  
Particles and Prairies  
Tours

## Teacher Resource Center

Resource Collections  
Workshops  
Chem West

## Classroom Resources

**Classroom Presentations**  
Data for Students  
I2U2 e-Labs & Science Investigations  
Online Resources  
**What is scientific research?**

## Classes for Kids

Prairie Rangers  
Saturday Morning Physics  
Science Adventures  
Scout Programs

## Special Events for Kids and Families

DUSEL Education Collaboration  
QuarkNet Masterclass  
STEM Career Fair  
Wonders of Science  
**Family Open House**  
Family Outdoor Fair

## Awards (Supported by Friends of Fermilab)

Fermilab Science Award  
Fermilab Science Scholarship  
Program Scholarships

## Professional Development for Teachers

Fermilab/U Chicago QuarkNet Center  
I2U2 Teacher Workshop  
Physics Experiences Teacher Workshops  
Prairie Experiences Teacher Workshops  
Prairie Workshops  
QuarkNet Boot Camp  
QuarkNet Outreach  
Summer Secondary Science Institutes

[ed.fnal.gov](http://ed.fnal.gov)

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# Discovery Science

 **Fermilab** Bringing Science Education to You!

[Education Home](#) | [Fermilab](#) | [For Teachers](#) | [For Students](#)

## Fermilab: Where Physicists Unravel Mysteries of the Universe

Hover over each hot spot to preview; click to open.



### A Gateway to Scientific Discovery



It is the dawn of a new era in particle physics. Physicists have incorporated decades of observations and results into the Standard Model, a framework for our current understanding of matter. Even and as they continue to refine it, they are aware that it leaves fundamental questions unanswered. To probe the frontier beyond the Standard Model, particle physicists turn to instruments that break the old barriers of energy, precision and intensity to explore new frontiers in particle physics.

Physicists look for new science by looking for the unexpected. They publish results explaining claims with evidence from Fermilab data so that others can put those results to the test. New understandings lead to new fundamental questions and a

new world of discovery.

What is dark matter? What happened to antimatter? What are the neutrinos telling us?

While scientific breakthroughs may seem to occur suddenly, Eureka!, in fact years of research are behind discoveries such as the top quark mass, the construction of the Tevatron or the availability of the World Wide Web.

The resources in this project map provide background information for the next discoveries. Follow along as physicists unravel mysteries of particle physics.

[Search Programs](#) - [Search Science Adventures](#) - [Calendar](#) - [About](#) - [FAQ](#) - [Fermilab Friends](#) - [Fermilab Home](#)

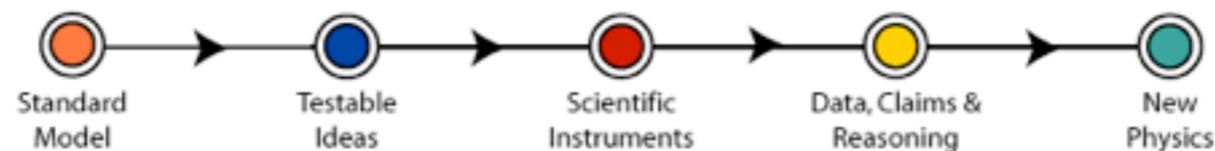
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## Fermilab: Where Physicists Unravel Mysteries of the Universe

Hover over each hot spot to preview; click to open.



### **The Standard Model explains much but leaves many unanswered questions.**

#### Activities

[Higgs Reception](#) - Classroom simulation of the Higgs cartoon

[Run II Website](#) - Run II data analysis of W and Z as precursor to the search for Higgs

#### Additional Resources

[Quantum Universe](#) - The quest to explain the universe (from interactions.org)

[Questions for the Universe](#) - Includes videos of physicists explaining mysteries of particle physics (from Fermilab)

[Frontiers of Particle Physics](#) - Fermilab's physics program (from Fermilab)

[Higgs Cartoon](#) - Cartoon analogy explaining the Higgs mechanism as a cocktail party (D. Miller and CERN)

[Search for Higgs News Stories](#) - *CERN Courier* and *Fermilab Today* articles from 1999 to 2011.

[Time Machine](#) - Completing the journey back to the beginning of time (CERN video, 1998)

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# Discovery Science

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## Fermilab Discovery Science Student Resources

**Fermilab: Where Physicists Unravel Mysteries of the Universe**

Hover over each hot spot to preview; click to open.

Standard Model   Testable Ideas   Scientific Instruments   Data, Claims & Reasoning   New Physics

**The Standard Model explains much but leaves many unanswered questions.**

**Getting to Higgs Where's Higgs?**  
Higgs News Stories

**EXPLORING THE MYSTERIES OF THE UNIVERSE**  
Exploring Universe's Mysteries

**LHC The Time Machine**  
LHC-Time Machine

**Higgs Cartoon**

**Questions for the Universe**

**A subatomic venture**  
Subatomic Venture

**Run II Discovery**

Search Programs - Search Science Adventures - Calendar - About - FAQ - Fermilab Friends - Fermilab Home

# Providing Resources

**US/LHC**  
Particle Physics at Discovery's Horizon

About the LHC | The US and the LHC | Teachers and Students | Images | Resources | News | Contacts | Search

Home > Teachers and Students

**Teachers and Students**

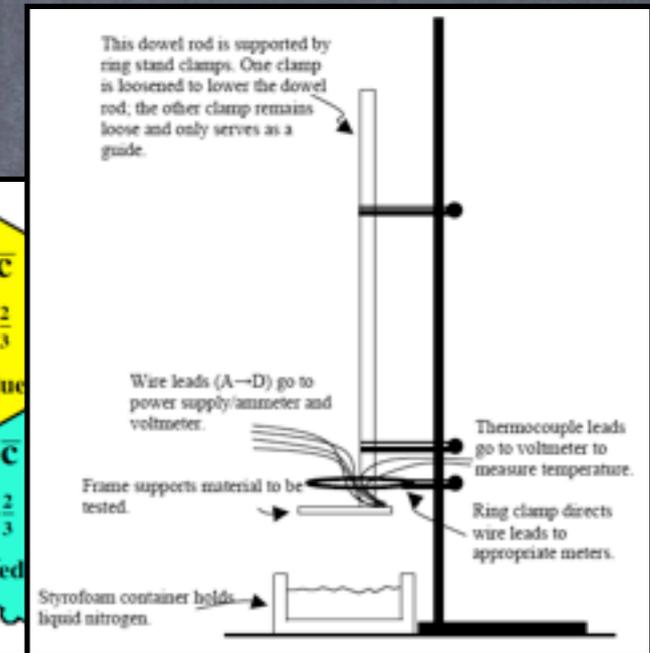
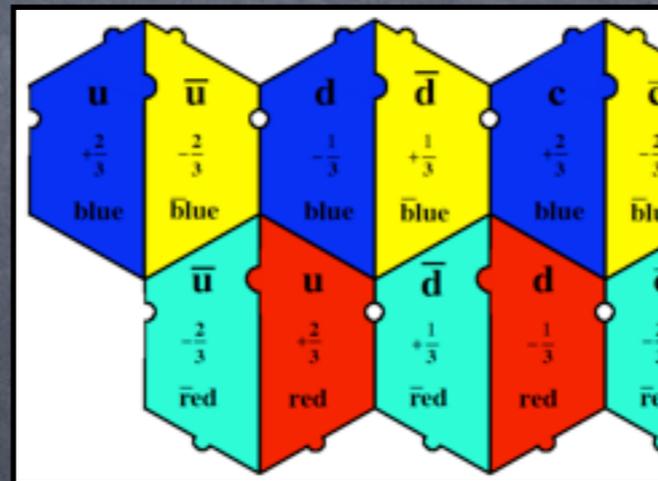
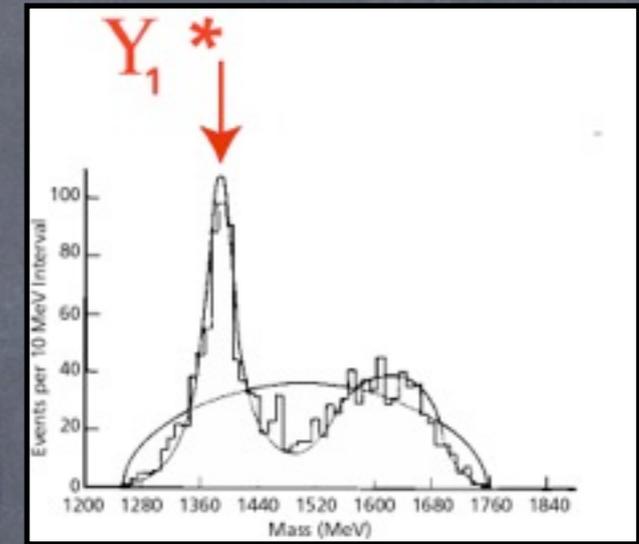
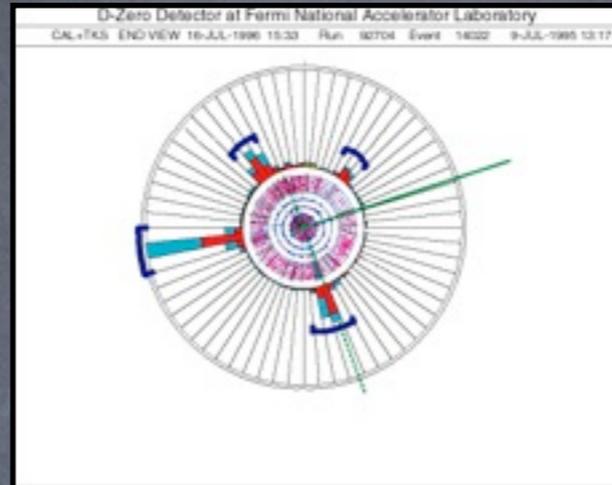
This is the dawn of an exciting age of new discovery in the study of elementary particles and their interactions. The current theoretical framework of the fundamental nature of matter, known as the Standard Model, explains much, but leaves many unanswered questions. What is dark matter? What happened to antimatter? Are there extra dimensions of spacetime? Are there new symmetries of nature? Are there new, as yet unobserved, forces? What is responsible for mass? The Large Hadron Collider (LHC), a huge scientific instrument at CERN, will provide the highest-energy particle collisions produced in a laboratory to six experiments that hold the potential to answer these questions.

**Event of the Week, 12/17/2010: CMS sees Z's in collisions of Pb**

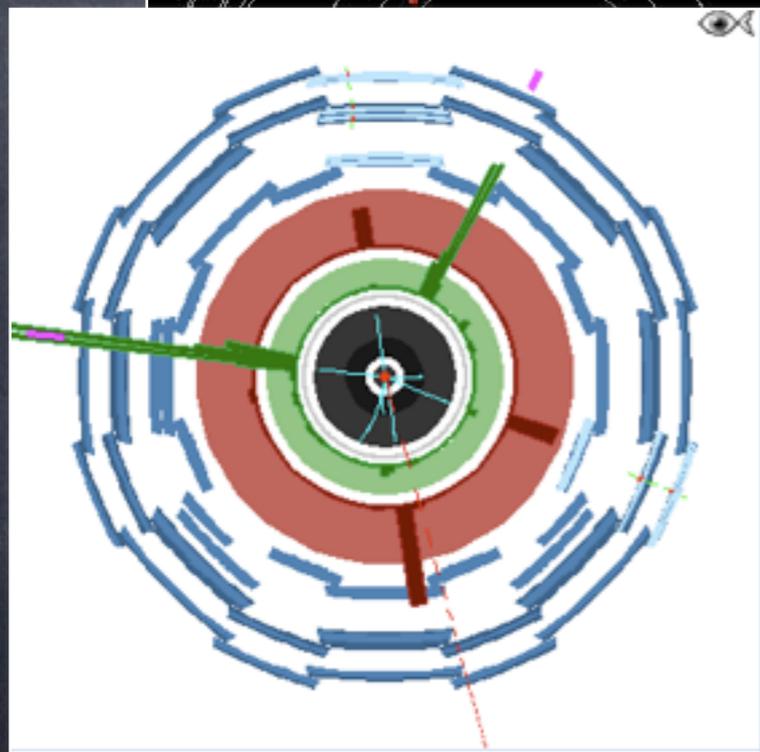
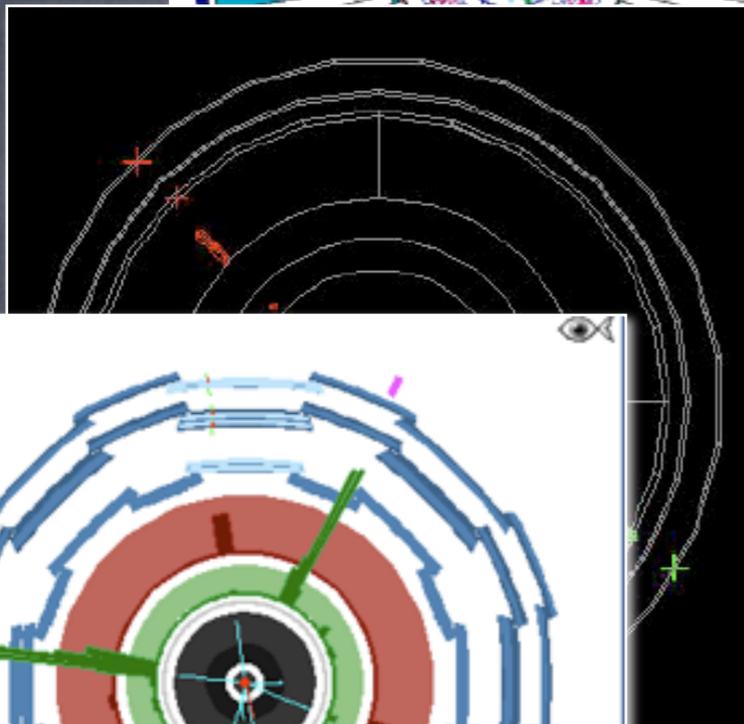
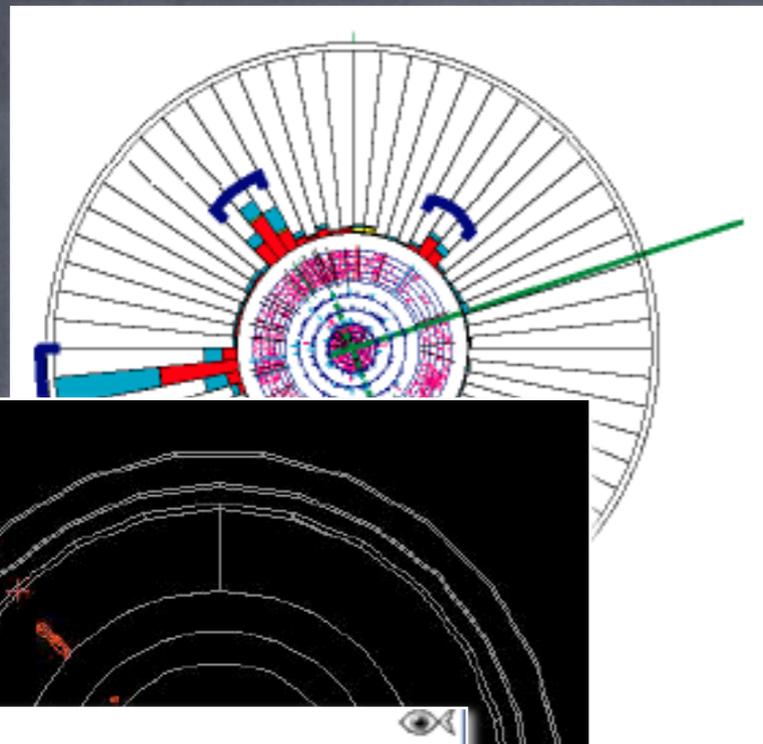
*(Web Experiments at LHC, CERN. Data generated from Run 1 (2010-2013) 2010-02-01. Run Dates: 12/08/10 - 02/08/11. LHC Machine: PP)*

**In this section:**

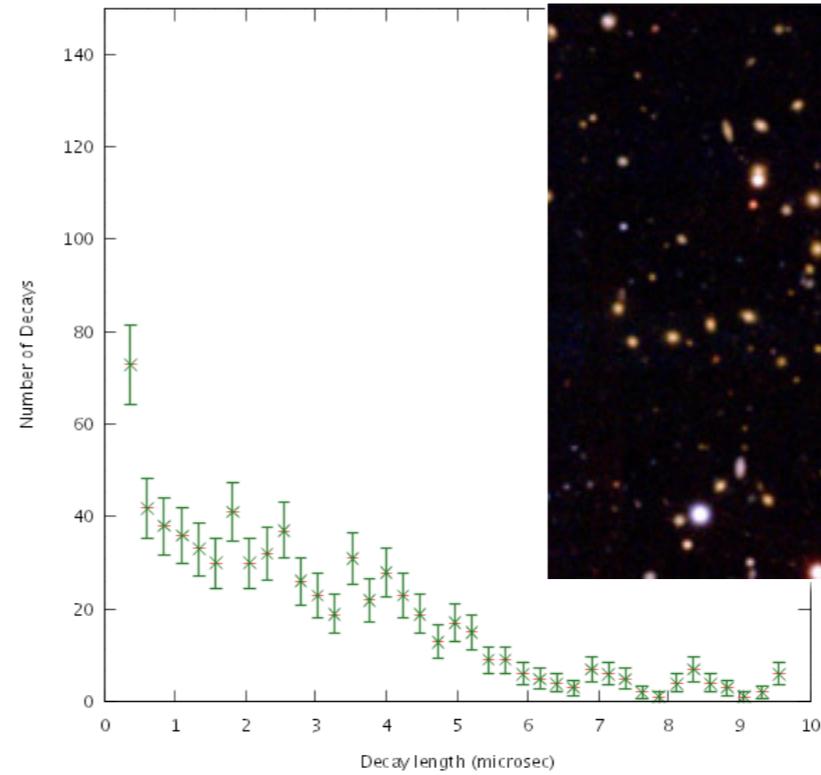
- Teachers & Students Home
- What questions will the LHC address?
- LHC Physics
- Anatomy of the LHC
- Analyze LHC Data
- LHC Live
- LHC Event of the Week



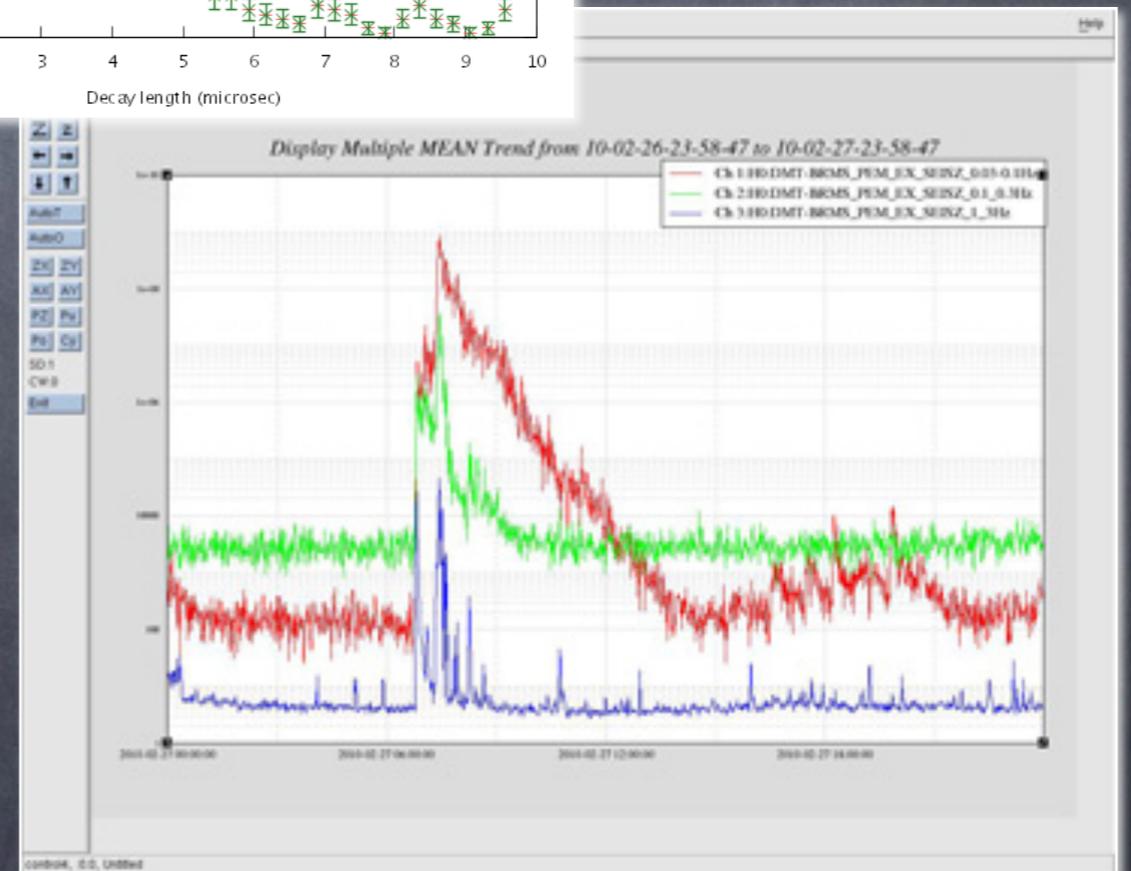
# Engaging Students in Science



Lifetime Study



Data for Students



# Engaging Students in Science



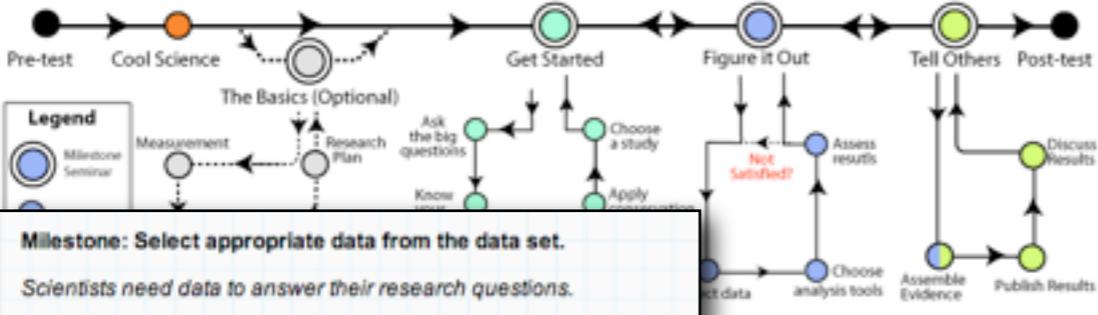
**CMS e-Lab**

Project Map Library Data Posters Site Map Assessment

Text Version Cool Science About Us

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](#)



**Milestone:** Select appropriate data from the data set.

Scientists need data to answer their research questions.

CMS data comes in runs of varying length and consists of events. Physicists filter the data so they can look at specific event types (e.g., events with two muons).

Your study question will guide the data you choose.

Click on "Calibration" under "Data" in the navigation bar to select simulated data.



Click on "Exploration" to select experimental data.

This [screencast demo](#) shows how to use the analysis tool.

Keep track of data appropriate for your inquiry in your logbook. Exploring the available data may lead you to refine or revise your study.

[Log It!](#)

You can always return to this page by clicking "Explore!" on the Site Index sub-menu.

Home

Library

Data

Posters

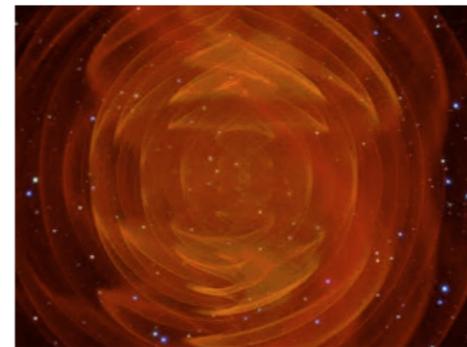
Assessment



**LIGO e-Lab**

Build Your Own Research Project Using Professional Science Data

Join a national collaboration of students to study LIGO seismic data.



Orbiting Black Holes Creating Gravitational Waves  
Credit: HENZE, NASA

LIGO seeks to detect gravitational waves from orbiting black holes, neutron stars and other sources. Scientists must distinguish gravitational waves from "noise" caused by seismic waves passing through the ground underneath LIGO's detectors.

**Log in**

Username:

Password:

To explore our website, [log in as guest](#).

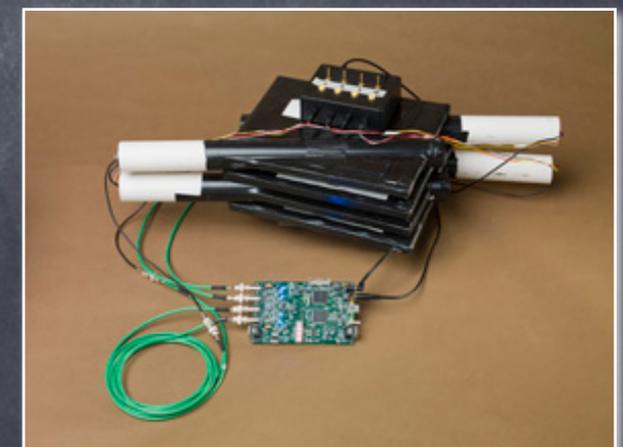
[Need a student login?](#)

Ask your teacher.

[Need a teacher login?](#)

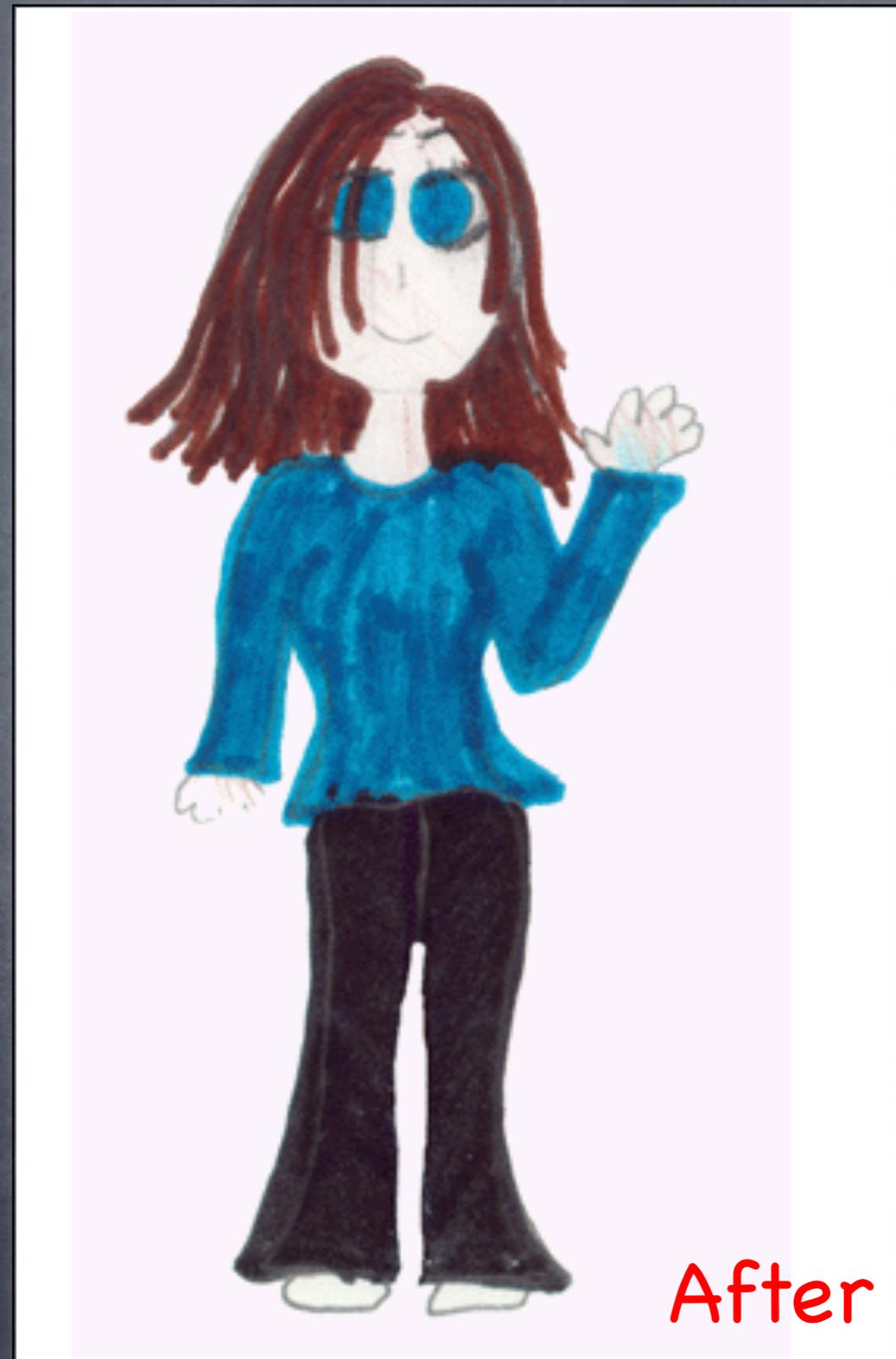
Contact [e-labs@fnal.gov](mailto:e-labs@fnal.gov).

## Online Investigations with I2U2



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# Engaging Younger Students



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# Family Open House



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# Presentations

Cryo Show  
Charge!  
Forces and Motion  
Light and Color



st 2011

# Tours and Ask-a-Scientist

Gave tours to visiting college students soon after moving to Fermilab full time  
Soon added Q&A sessions with student visitors



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# Classroom Presentations

## Charge! Electricity and Magnetism



**Particle Accelerators at Home!**

- Cathode Ray Tubes, the original kind of TVs, are particle accelerators!
- We need a volunteer!
  - Magnets don't just effect other magnets, they also bend moving charge
  - Electromagnets in your TV make a single electron beam draw a moving picture

**Fermilab**

# Community Outreach Chicago's Lab Fest



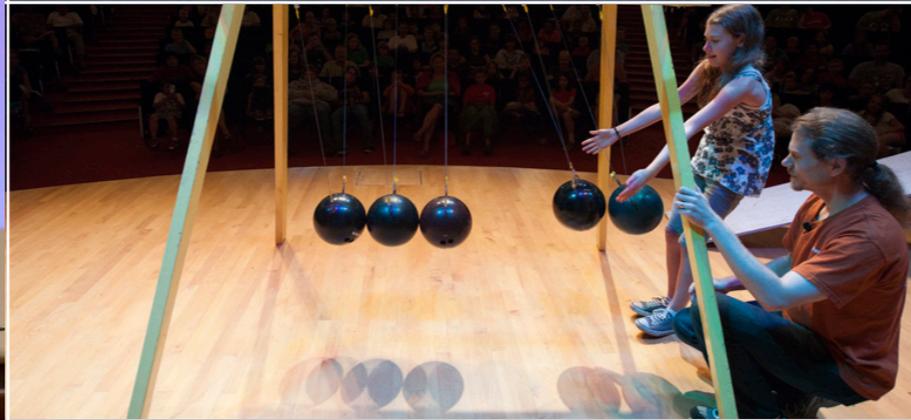
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# Family Open House

## The **FUN**damentals!

- Newton's Laws of Motion
- Energy
- Momentum
- The Laws of Spin
- Charge
- Electricity
- Magnetism
- $E=mc^2$
- **Particle Physics!**

## Physics of Spinning Toys FUNdamentals of Physics





Thanks Leon!



Bringing Science Education to You!

[ed.fnal.gov](http://ed.fnal.gov)

Thanks Leon!