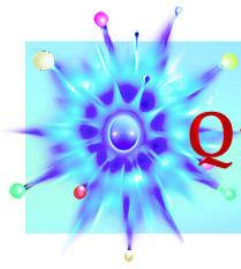


Helping Develop America's Technological Workforce

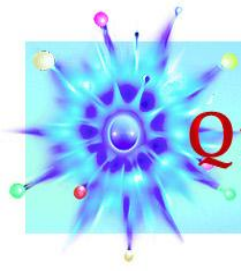


QuarkNet

The QuarkNet Collaboration



**Office of
Science**
U.S. DEPARTMENT OF ENERGY

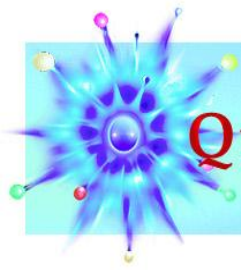


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Our Research Community

Physicists, teachers & their students collaborate on research projects and investigations.

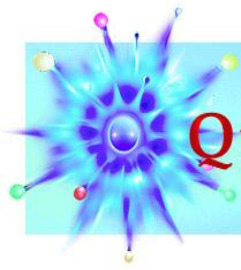




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QuarkNet . . .

- **Supports learning by inquiry.**
- **Provides teachers and students with real research opportunities in particle physics.**
- **Encourages national and international collaboration among students, teachers and scientists.**

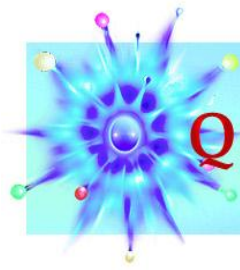


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Vision & Goals

Engagement with Scientific Investigations:

- **Enables teachers to teach basic physics concepts in an exciting & rewarding context.**
- **Builds a teacher's confidence to bring current science into the classroom.**
- **Links high school classrooms with frontier experiments.**
- **Attracts students to careers in science & technology.**
- **Helps develop science literacy.**

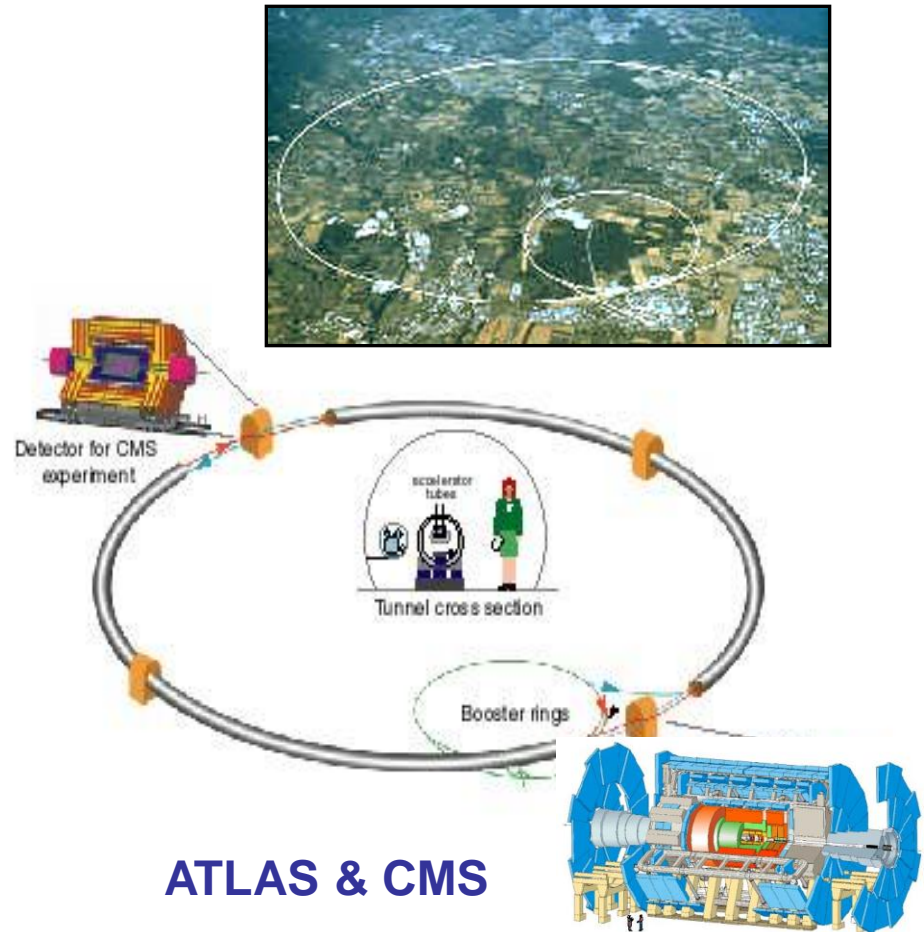


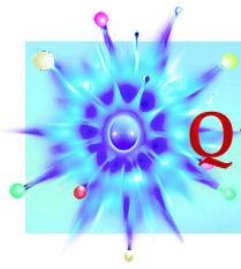
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At CERN

Our understanding of the universe is changing as the LHC and its experiments—ALICE, ATLAS, CMS and LHCb—collect and analyze data.

Join particle physicists to work on physics projects exploring the nature of matter, energy, space and time.

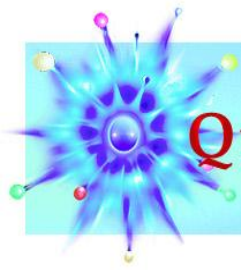




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Active Centers





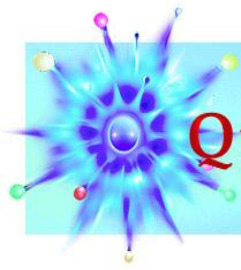
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The Program

At most centers a one-week workshop (with stipend)

Optional Activities

- **Particle Physics Boot Camp**
- **Cosmic Ray Data Exploration**
- **U.S. Particle Physics Masterclass**
- **High School Student Summer Research Teams**

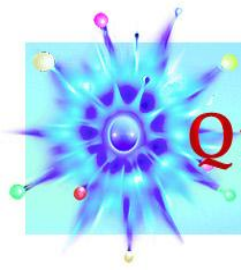


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Boot Camp - Professional Development for Teachers

- **Models student investigation**
- **New lead teachers**
- **“Returning teachers”**
- **Teacher milestones**
- **Research posters**
- **Pedagogy reflections**





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Boot Camp - Professional Development for Teachers

Research teams:

- Explore data to learn about particle physics.
- Use energy and momentum conservation.
- Reconstruct Z decays from event data.
- Present findings in culminating poster session; talks and tours provide background info.

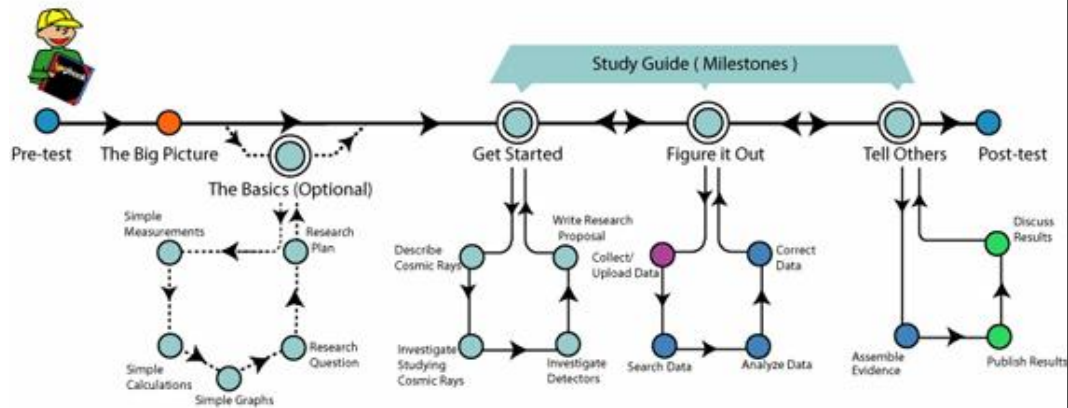
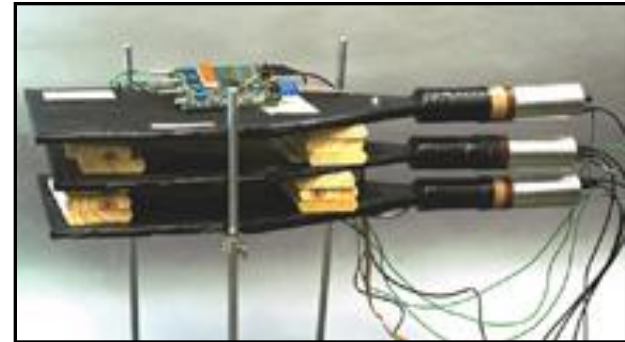




Cosmic Ray Studies

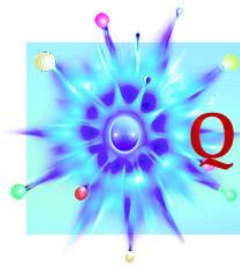
Student investigations:

- Classroom detectors
- Online e-Lab for data analysis & collaboration
- Based on teachers' ideas



e-Lab Study Guide





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Helping Develop America's Technological Workforce

Cosmic Ray Studies

Cosmic Ray e-Lab

Project Map Library Data System Site Map Access

Text Version Cool Science About Us

Home: Join a national collaboration of high school students to study cosmic rays

Project Map: To navigate the Cosmic Ray e-Lab, follow the path; complete the milestones. Hover over a spot to preview; click to open. Along the main line are milestone seminars, opportunities to check what is going. Project milestones are on the four branch lines.

Global Positioning System

guest Log out



DAQ Board

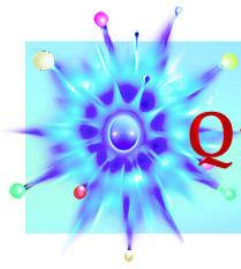
A0F05A347825
058065930212
203456010123
4401230101222

GPS

Scintillators

Photomultiplier Tube





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U.S. Masterclass

Mentors and teachers:

- **Host students for the day.**
- **Teach students to read (LHC) data—ALICE, ATLAS, CMS.**
- **Coach students as they analyze data.**
- **Assist students in interpreting the results.**



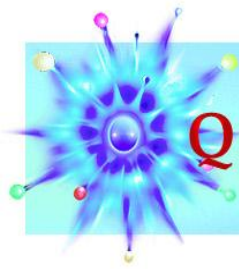


U.S. Masterclass

Student teams:

- Discover the world of quarks and leptons with real data.
- Join a videoconference with students around the world.





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CMS e-Lab:

interpret data

Milestone: : Interpret data.

Scientists often represent their data graphically . .

You have already learned about particles that interact with the CMS detector. Physicists call the interaction an event. Physicists look at these events in data displays either as single or multiple events. Each approach yields important information. The plots below represent the two approaches. Click the plots to learn more about each approach.

Teachers guide students to ask questions that are:

Open-ended.

Data-based.

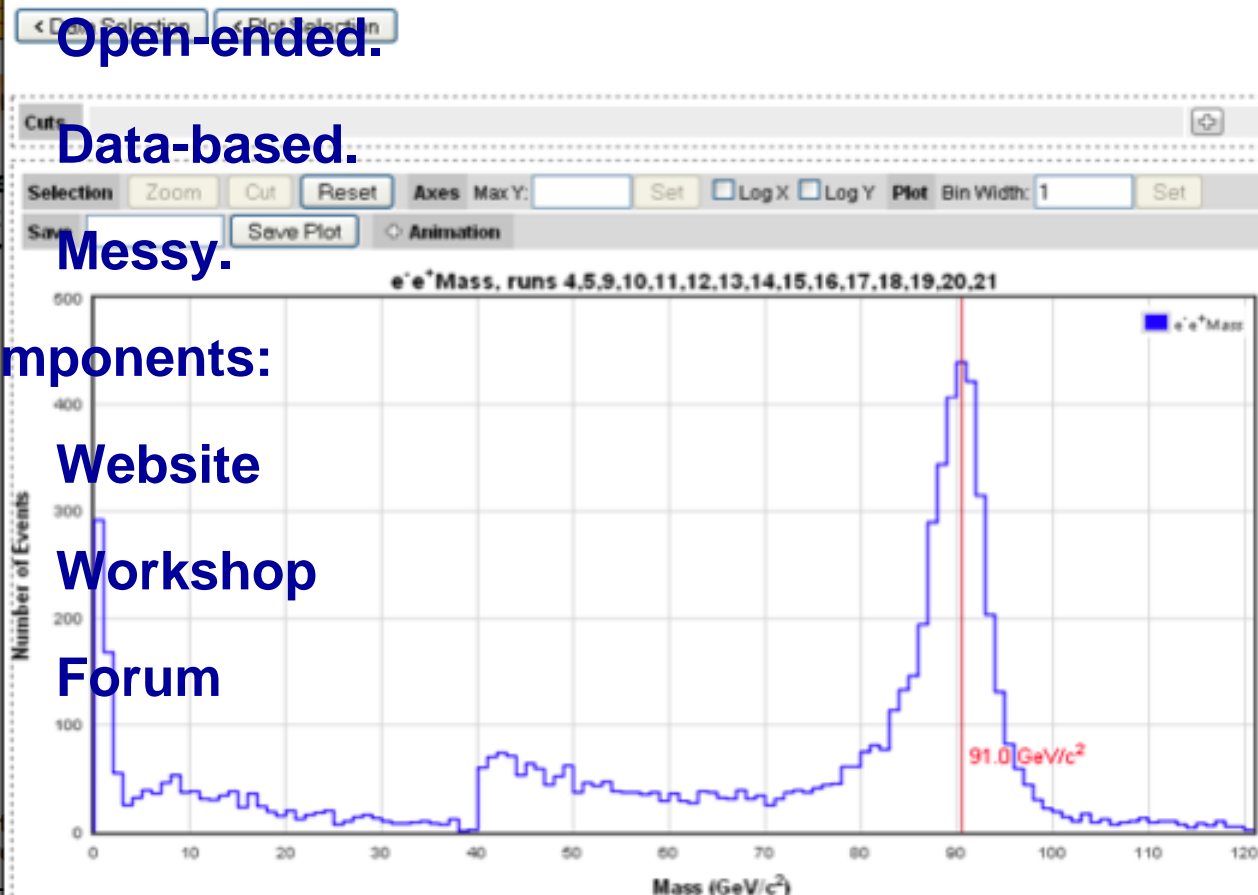
Messy.

Components:

Website

Workshop

Forum



Each 1:
Event Displays

event displays
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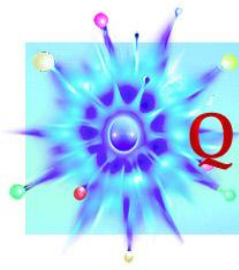
2:
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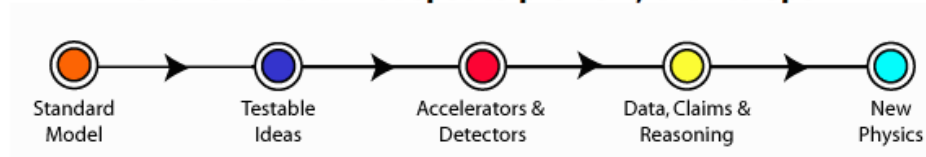
ers, electron and
volved in the
Z decays.
they combine

To Learn More:



The LHC: At the Energy Frontier

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



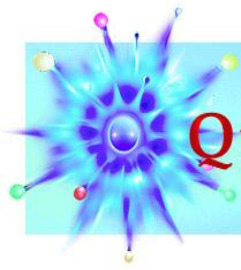
CERN's Large Hadron Collider will open new vistas on the deepest secrets of the universe, stretching the imagination with newly discovered forms of matter, forces of nature and dimensions of space.

The Standard Model is the current framework for our understanding of matter. LHC and its experiments are designed to address fundamental questions not explained by the Standard Model.

Basic research is a journey, not an event. Following along as physicists close in on new physics requires knowledge of LHC physics, accelerator and detector design, and how data inform claims and reasoning.

What is dark matter? What happened to antimatter? Are there extra dimensions of spacetime? These resources provide background information for the next discoveries. [Unit Overview](#) - [Student Resources](#)

<http://quarknet.fnal.gov/projects/lhc/>



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Student Summer Research

Invaluable
Experience



Team: 1 teacher + 4 students

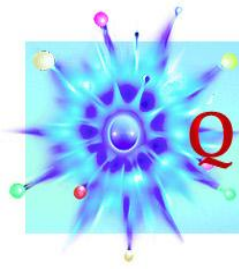
Continually challenged me

Astounded by the beauty &
simplicity of the particles
that define our existence

A taste of a succulent future

Too much fun





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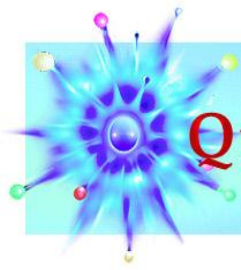
Student Summer Research



**“Quantitative Spectral Analysis”
“The Goldilocks Effect: The
Drake Equation”
“Sample Preparation for Beam
Tests”**



2010



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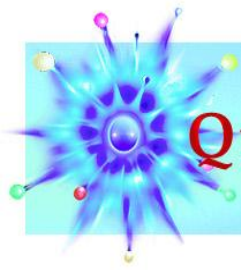
Other Opportunities

Five teachers go to CERN in Geneva, Switzerland for a three-week workshop.

and . . .

Some teachers are part of the Fellows Program.





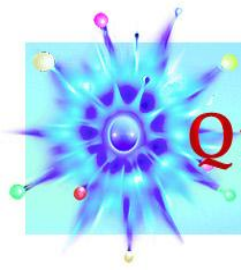
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Impact

Long-term relationships for teachers' professionalism

Students' opportunities and abilities to engage in scientific investigations



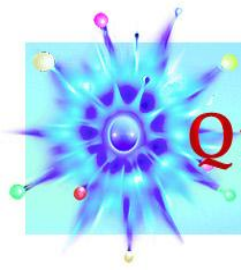


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Teacher Outcomes

QuarkNet teachers will be able to:

- **Discuss and explain particle physics concepts.**
- **Use particle physics examples in an interactive way when teaching subjects such as momentum and energy.**
- **Facilitate student investigations in a manner that follows scientific practices.**
- **Act in leadership roles to the larger education community.**



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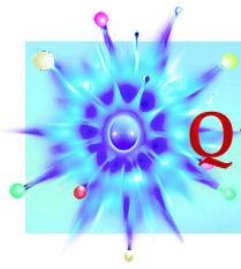
Student Outcomes

Students will be able to:

- **Discuss and explain particle physics concepts.**
- **Discuss and explain how scientific knowledge is developed.**
- **Engage in scientific practices and discourse.**

Unexpected Outcomes

- ***Knowledge of what physicists actually do***
- ***Respect for teachers through their work with physicists***



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By the Numbers

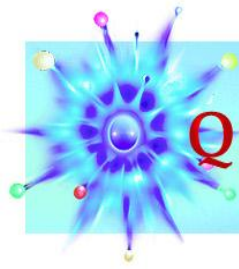
**537 Teachers & Their
Students**

**97 Mentors
53 Centers**

9-11 Experiments

**5.6 Staff
Members
4 PIs**

DOE-NSF



QuarkNet

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QuarkNet Website

<http://quarknet.fnal.gov>