QuarkNet and I2U2
Broader Impacts of Particle Physics

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University of Notre Dame

A challenge…

- An Interesting challenge…
- It is 1998…
  - There is an international physics project called the Large Hadron Collider in Geneva, Switzerland.
    - The project will take over a decade to build.
    - We are expecting to have first collisions of protons on protons at 10TeV CM Energy late in 2009.
  - A graduate student (age 25 in 2009) is…
    - 14 years old…(in 1998)
  - As a scientific researcher…
    - How do you deal with this? How do you attract young students to the excitement of science at the energy frontier?


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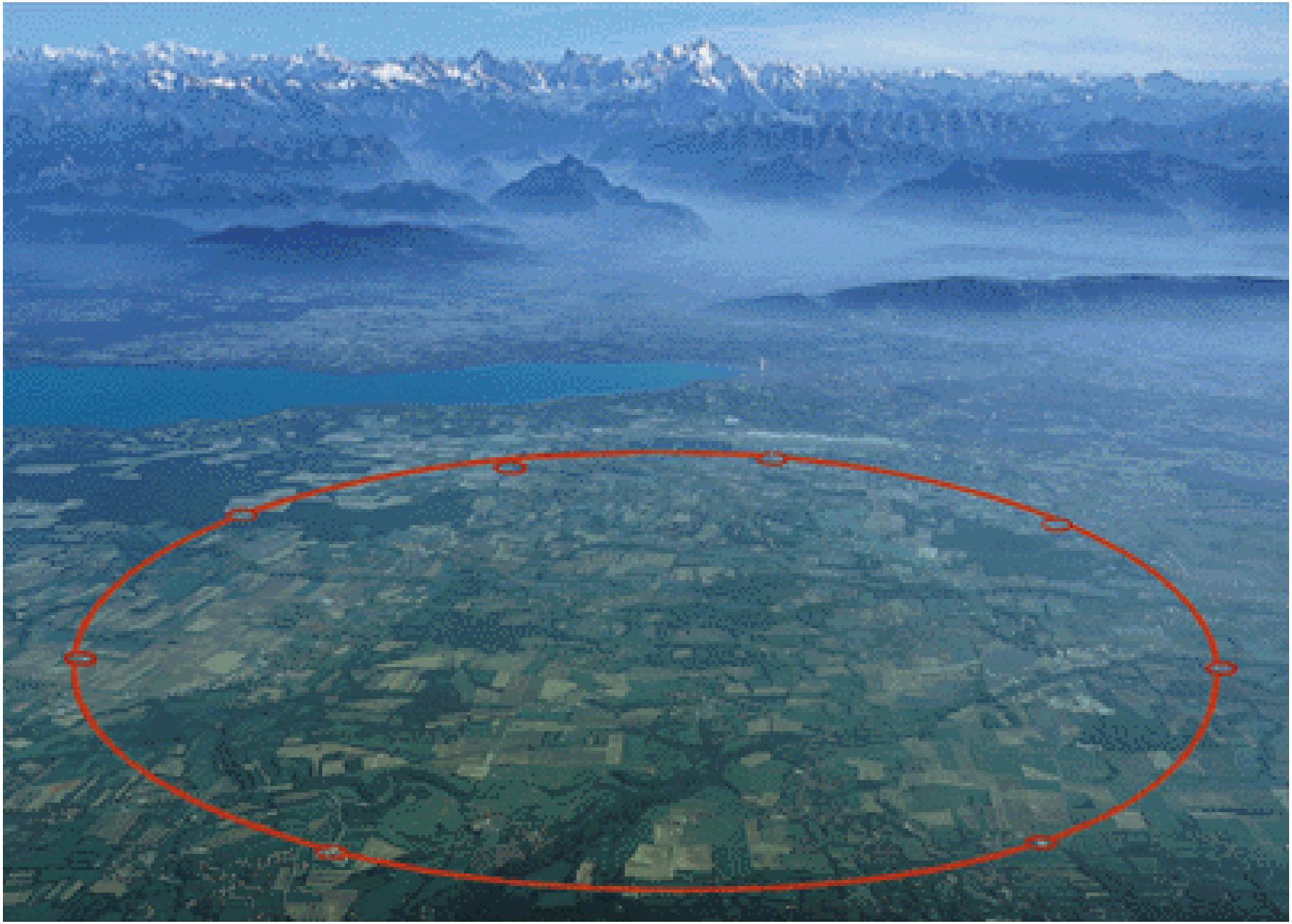
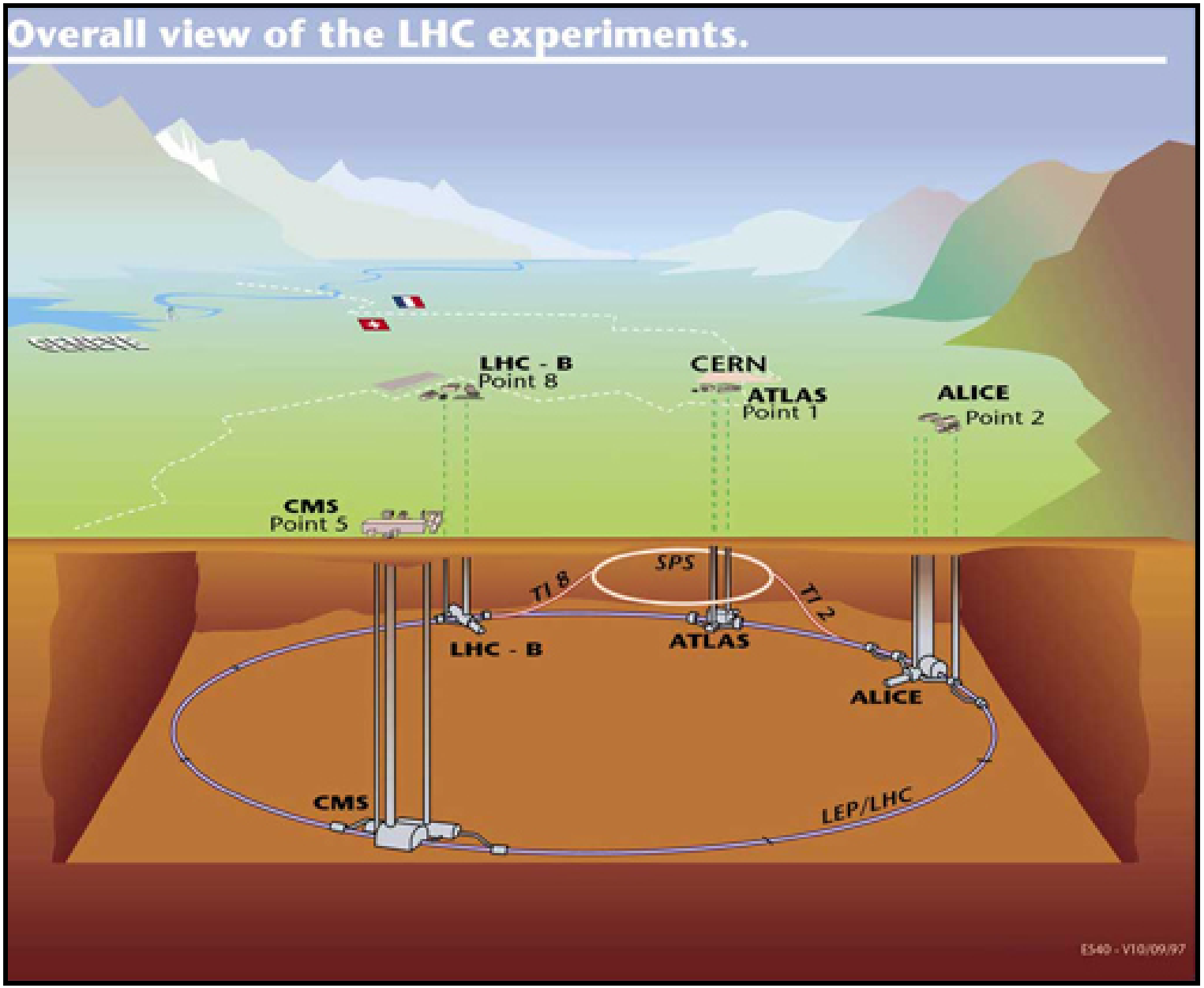
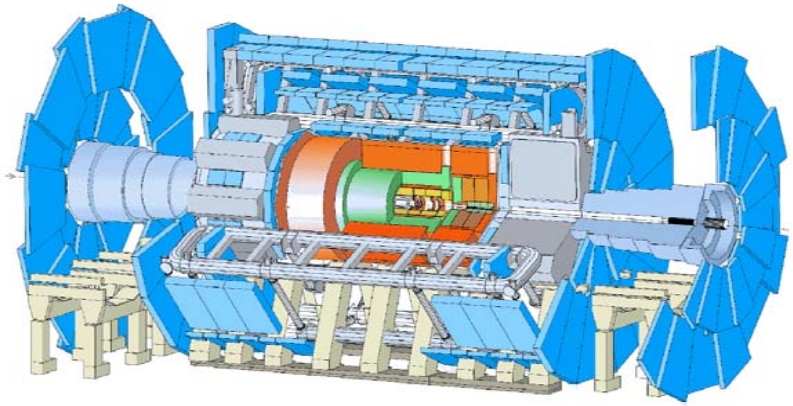
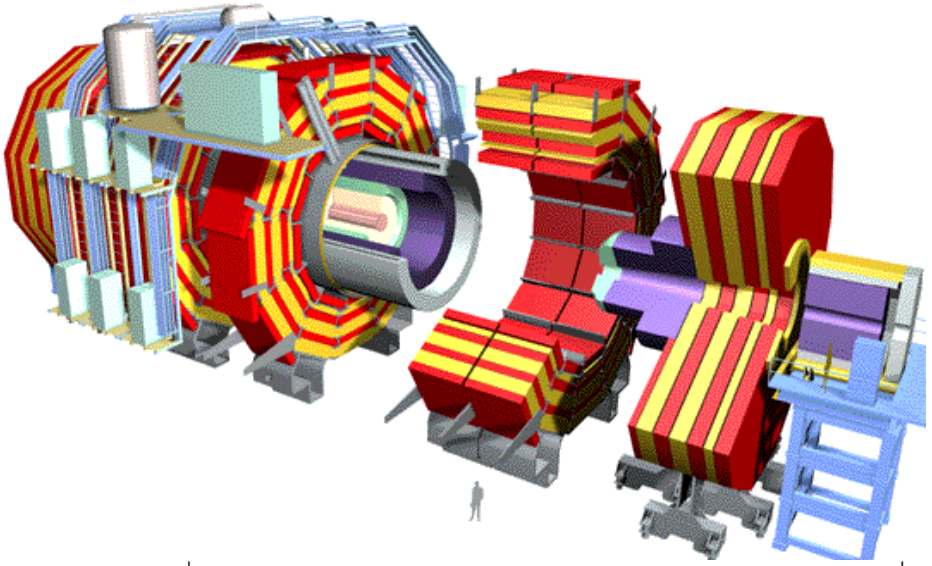
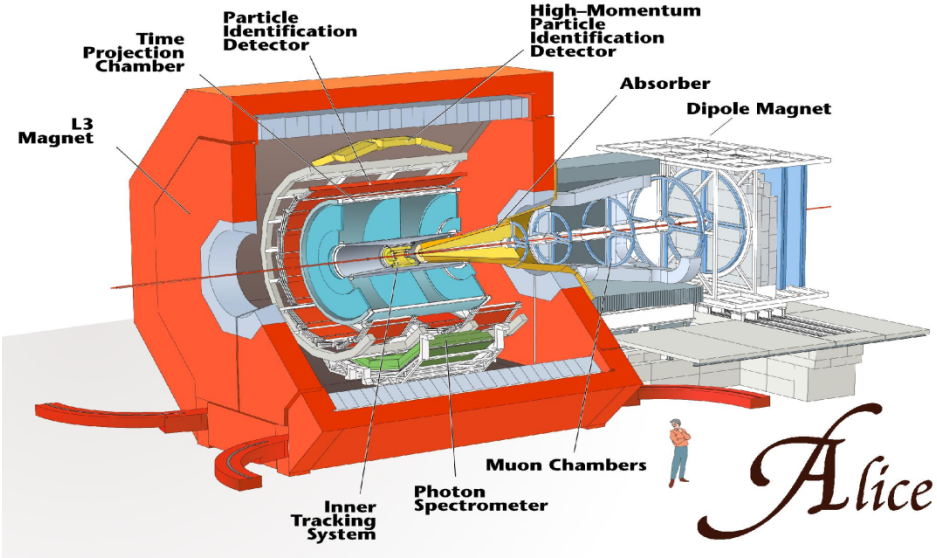


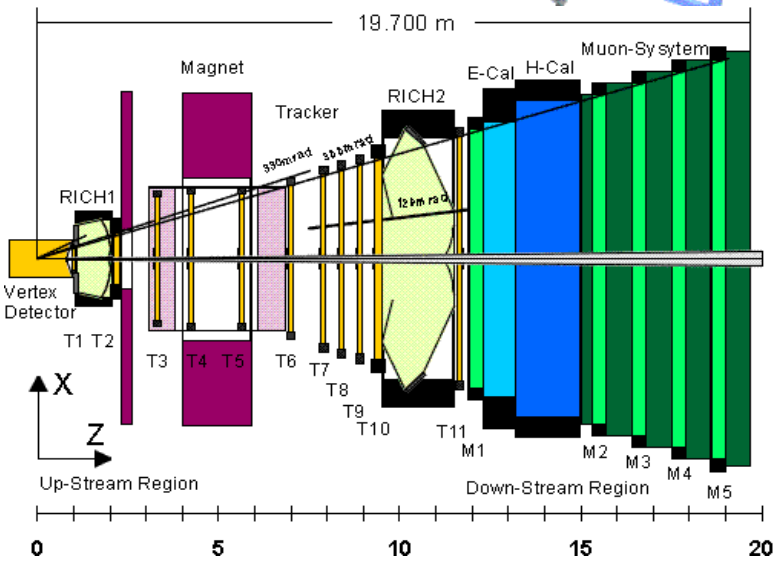

Overall view of the LHC experiments.
LHC - B
Point 8
CERN
ATLAS
Point 1
ALICE
Point 2
CMS
Point 5
SPS
TI 8
TI 2
LHC - B
ATLAS
ALICE
CMS
LEP/LHC
ES40 - V10/09/97

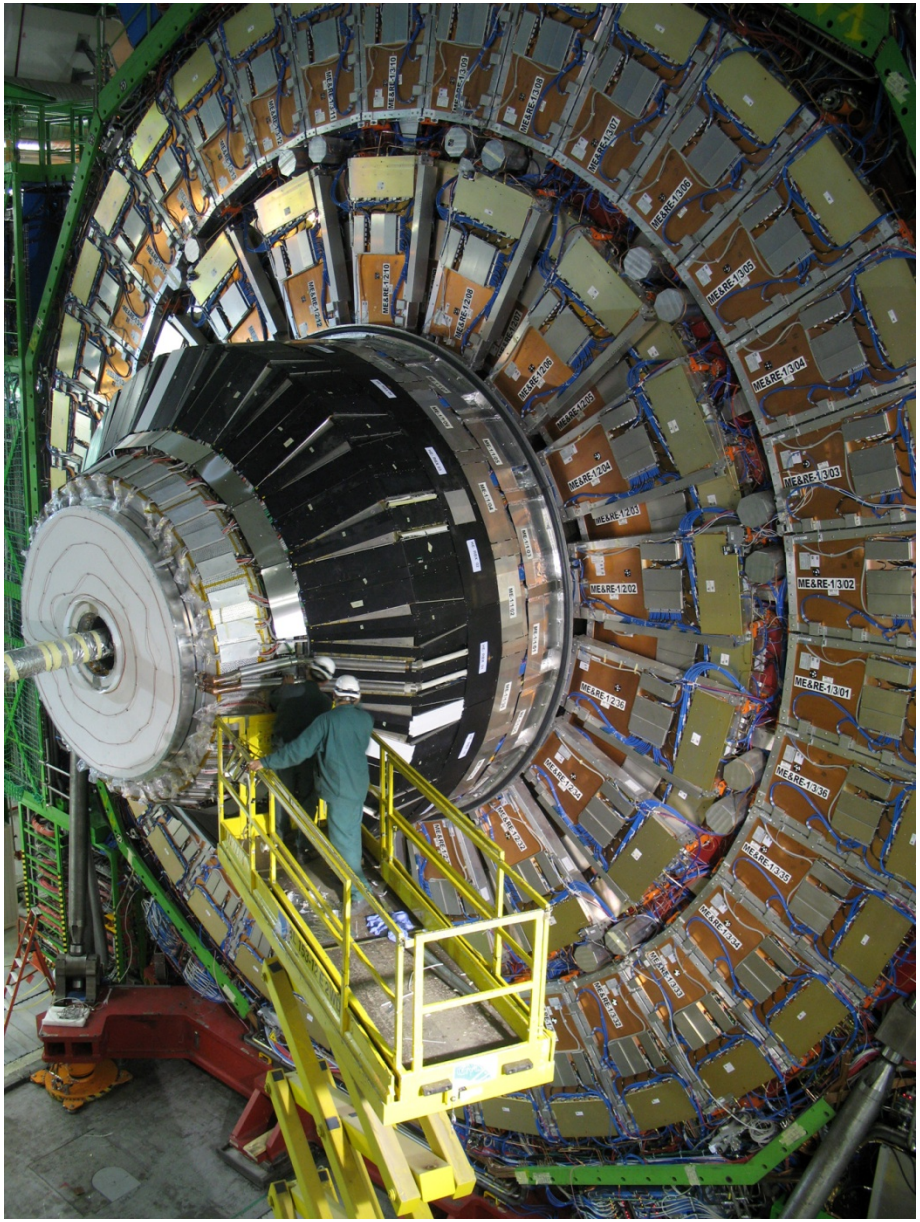
LHC Experiments







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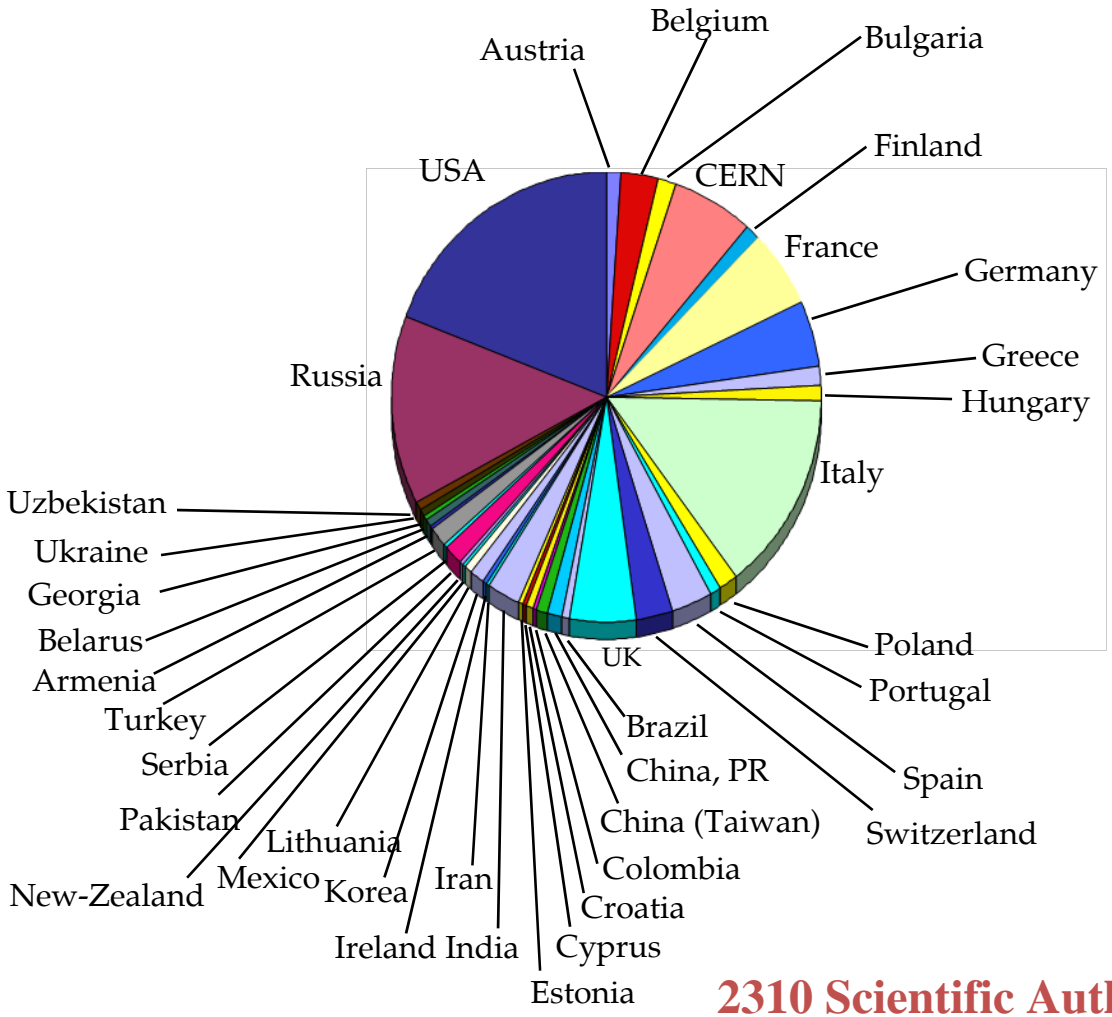
The CMS Collaboration

	Number of Laboratories
Member States	59
Non-Member States	67
USA	49
Total	175

	# Scientific Authors
Member States	1084
Non-Member States	503
USA	723
Total	2310

Associated Institutes	
Number of Scientists	62
Number of Laboratories	9

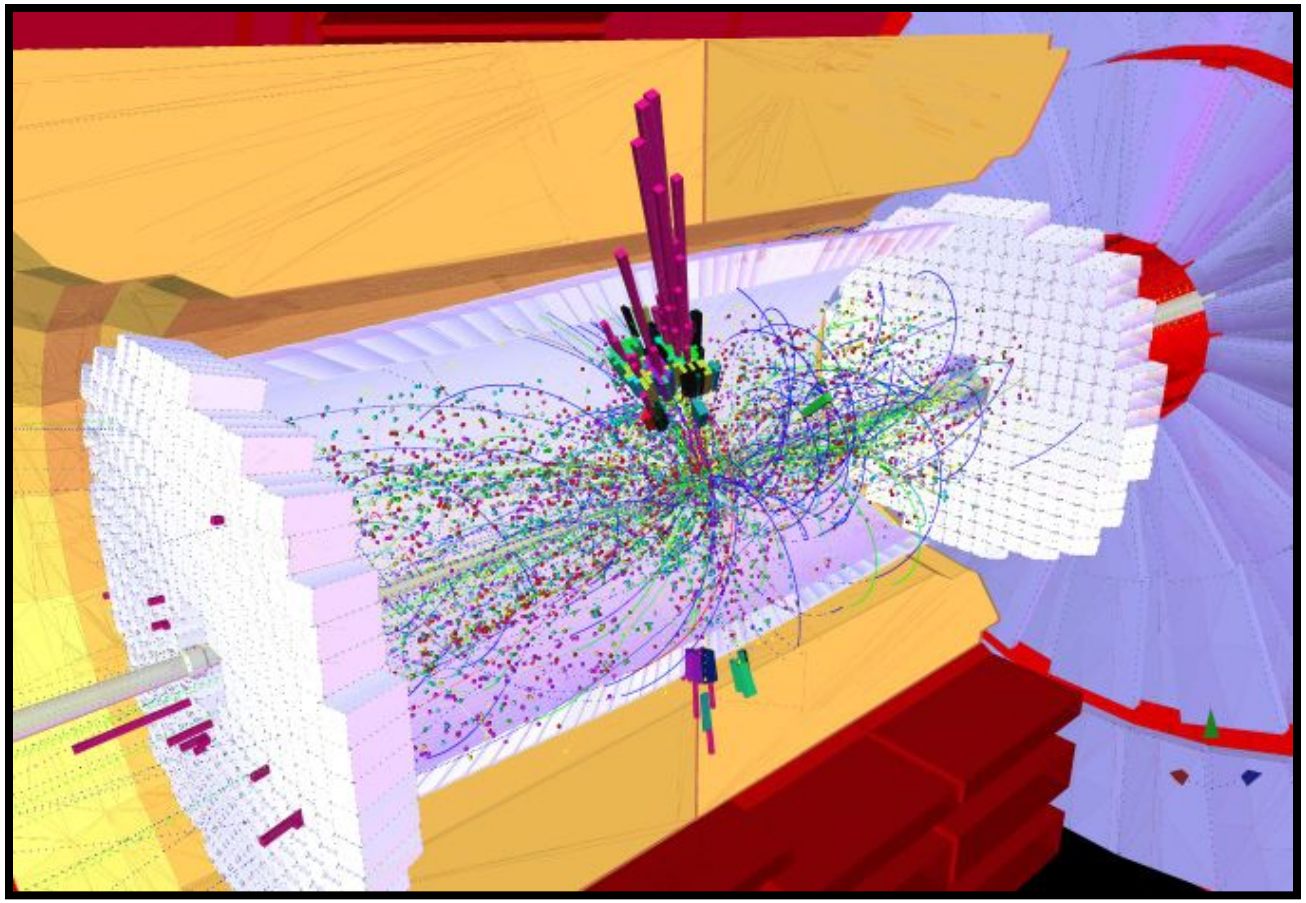


2310 Scientific Authors
38 Countries
175 Institutions

Interesting features

- The collaborations are international
  - Many countries are engaged.
- The US has a major investment in the project.
  - Distributed across many states and Puerto Rico.
- This global distribution of researchers and resources necessitates advances in:
  - Communication tools
  - Analysis tools
  - Simulated data
  - Real data
  - Publication tools

A hypothesized new particle Z'



To do the work…

- More than just physicists are needed…
- Other critical professionals…
  - Extreme engineering
  - Technical skills
  - Managerial skills
  - Research computing skills
  - Networking skills
  - …

- This is an opportunity of a lifetime…
- How do you connect…?

An answer…

- With secondary school teachers
  - They are engaged with the students in and out of class.
- Strategy
  - One-on-one partnership with scientific mentors
  - Direct participants
    - Members of the collaboration
    - Have immersive research experiences
    - Build and operate equipment
    - Develop code, decode and analyze data
    - Recognized in publications
- QuarkNet was born from this concept…
  - While the experiments were being built, we build QuarkNet
  - Enlightened self interest

QuarkNet

52 Centers in 25 states and Puerto Rico

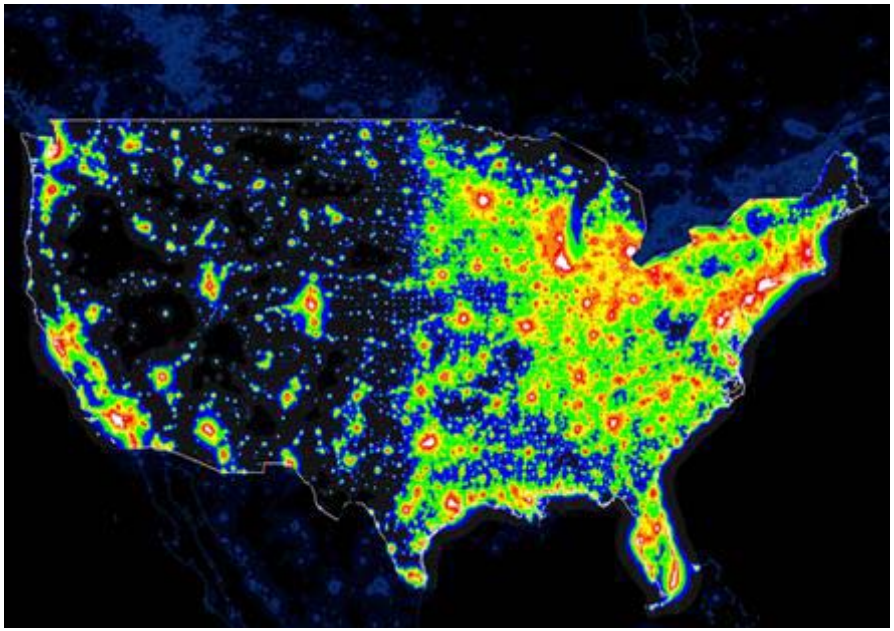
500 HS Teachers
150 Particle Physicist mentors
100 HS Students annually

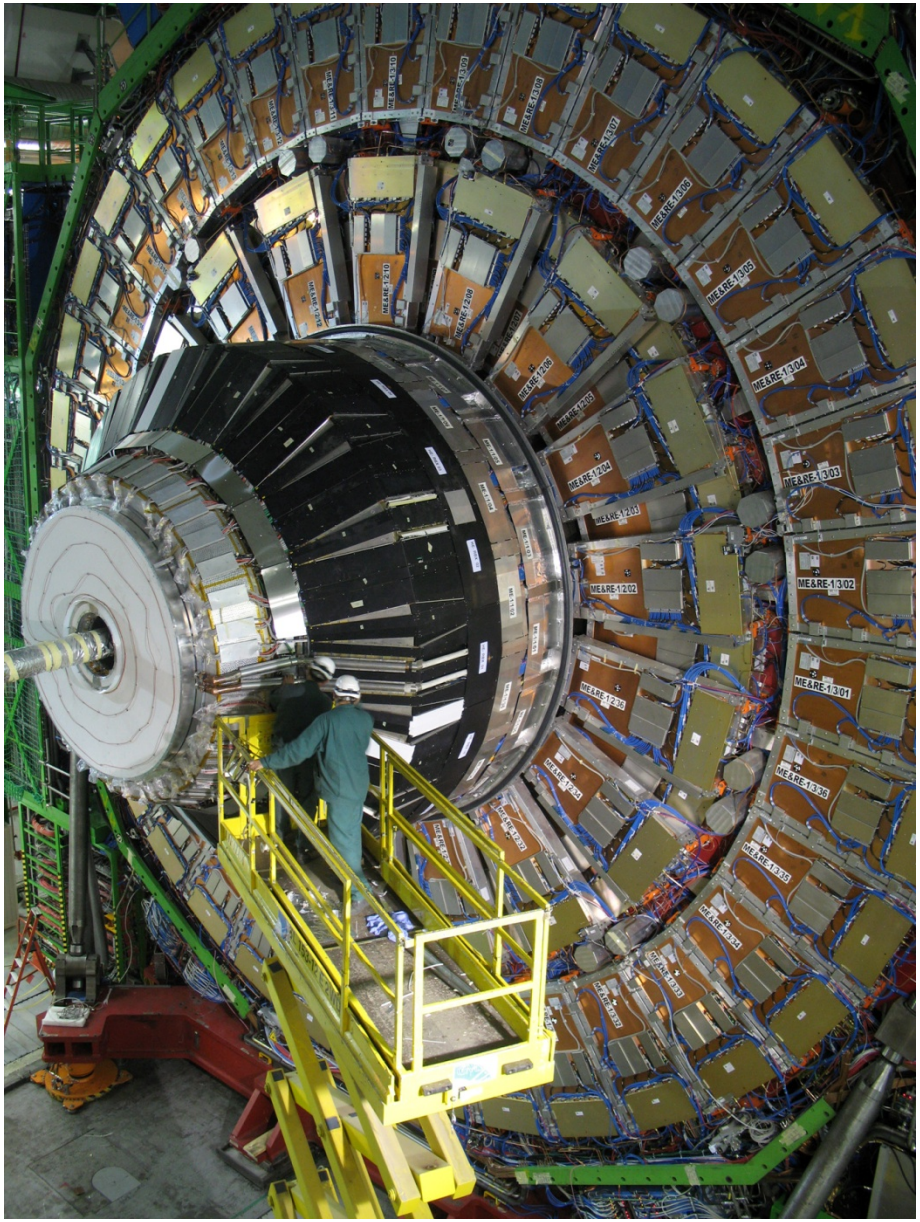
A professional development program for HS Teachers with immersive research experience for HS teachers and students.

A wide spectrum of experiments.

Now in its 12th year. Supported by NSF and DOE

http://quarknet.fnal.gov/

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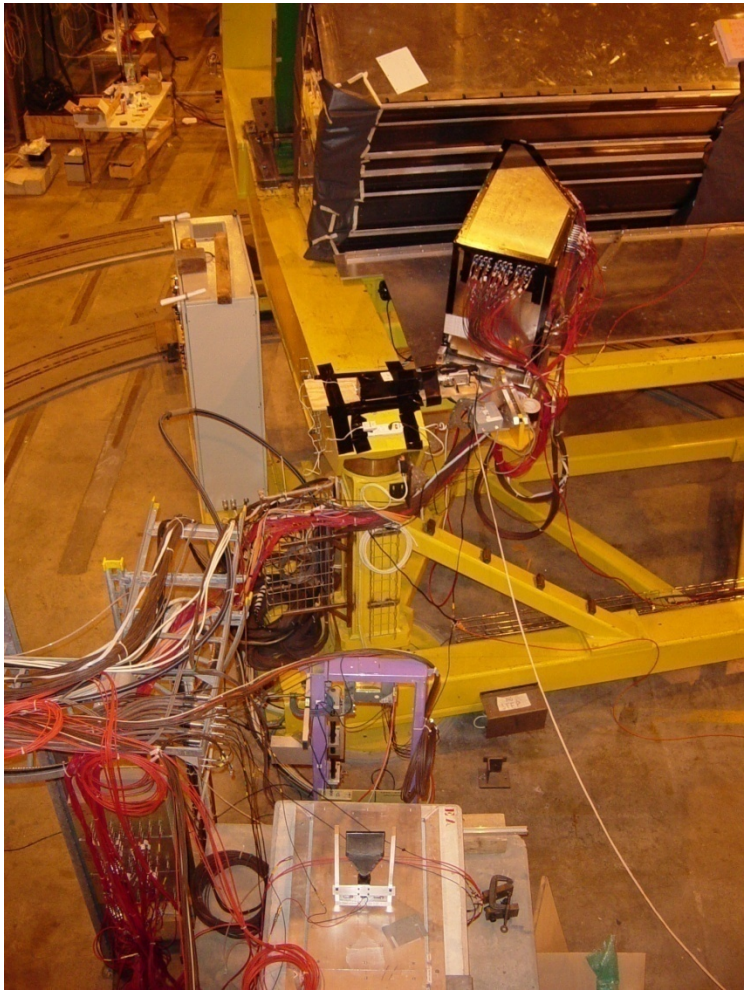
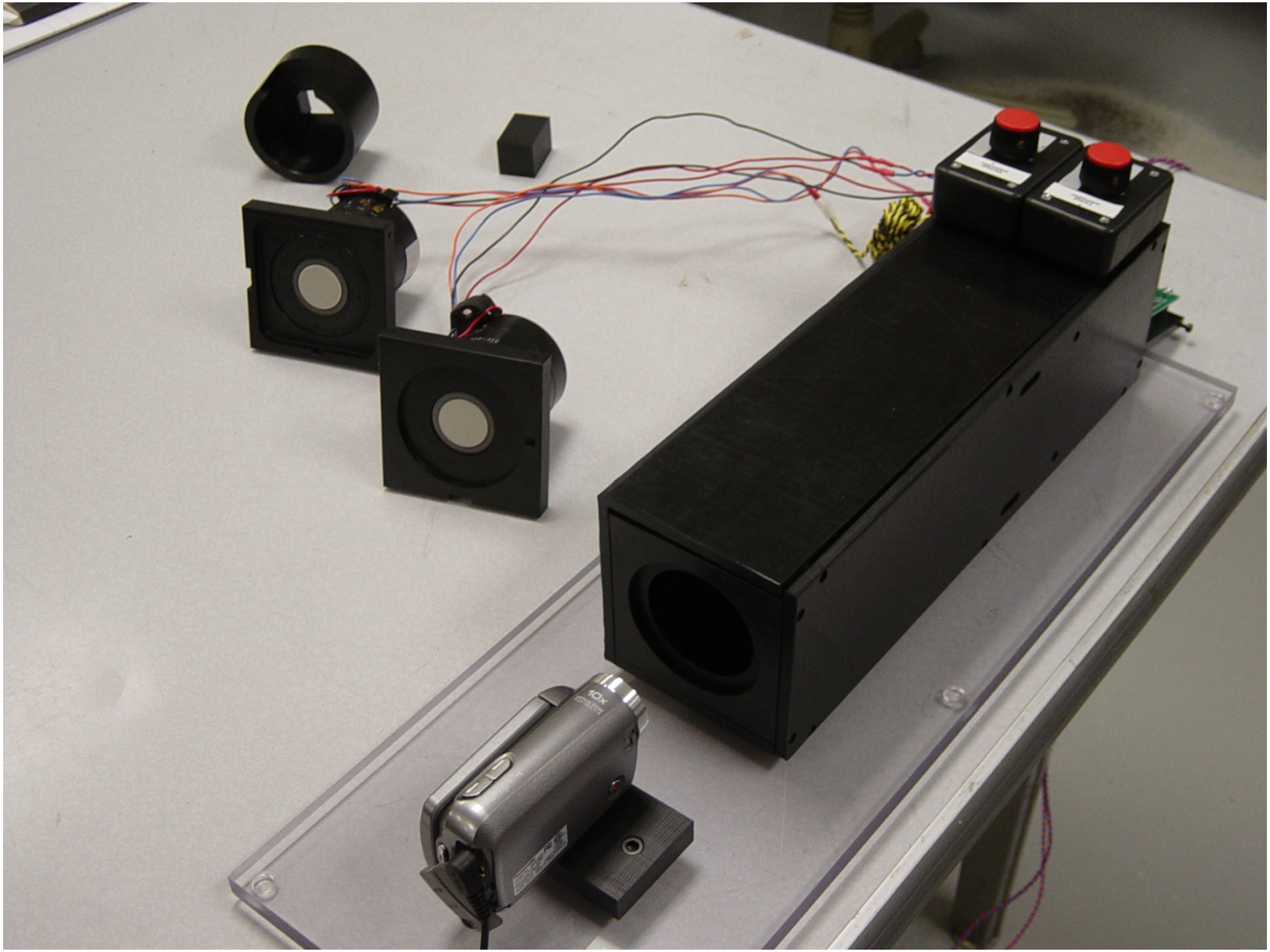
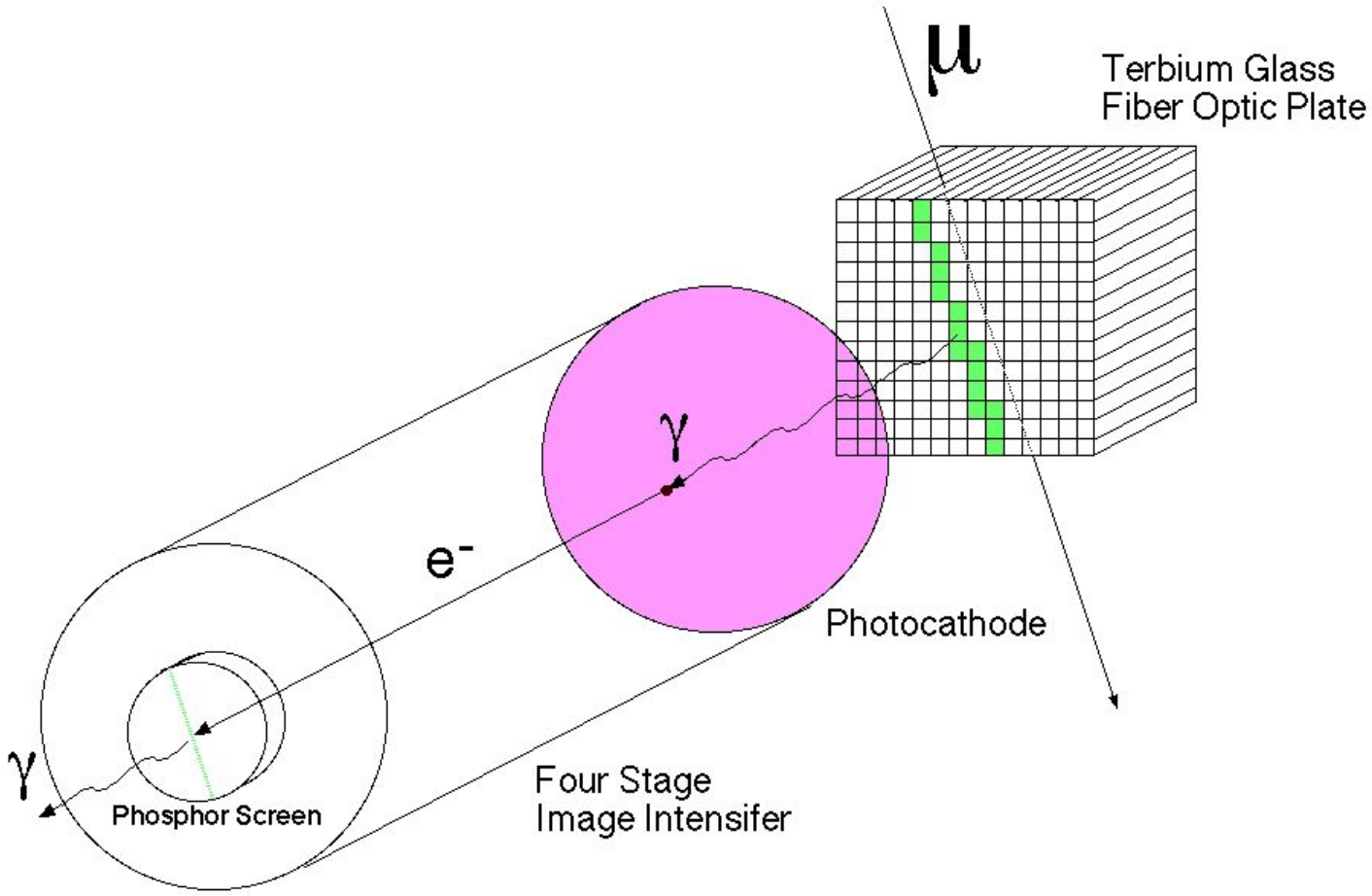
Compact Particle Detectors



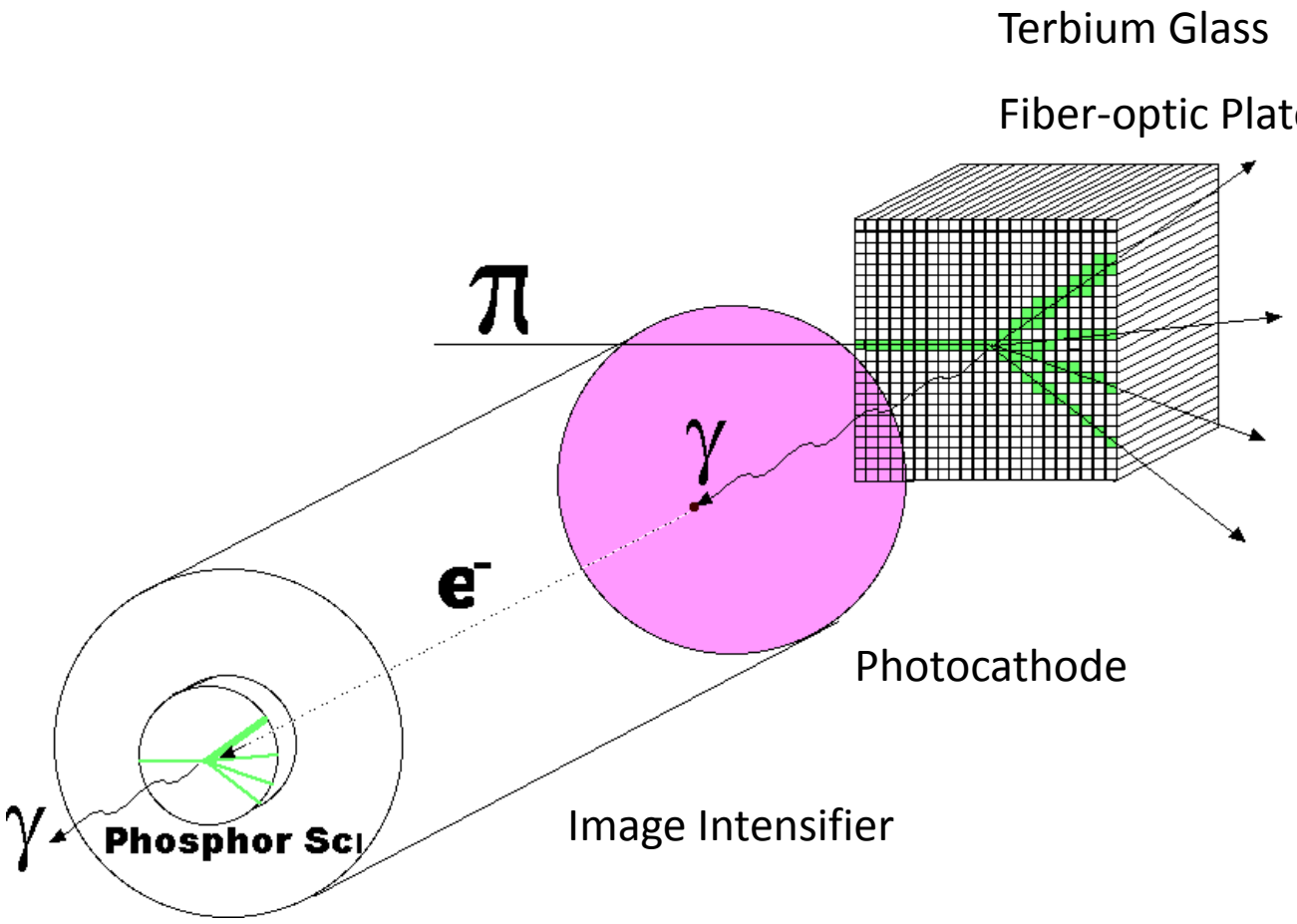
Assembly ↑ CERN Beam →



Schematic of the Apparatus

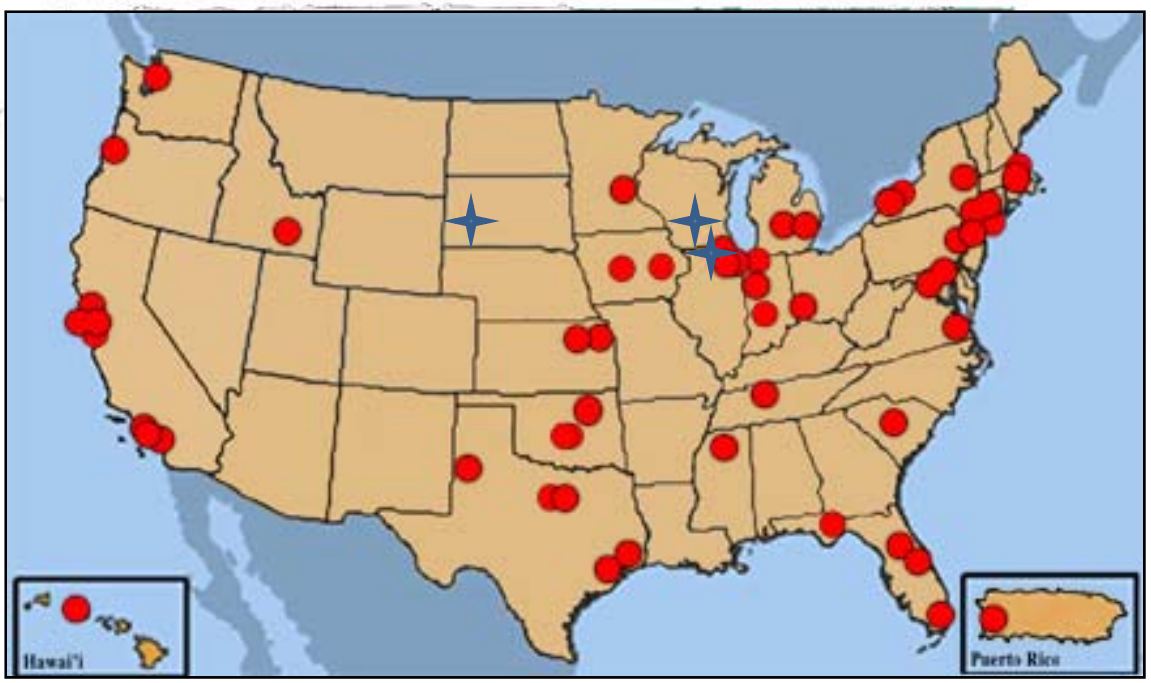


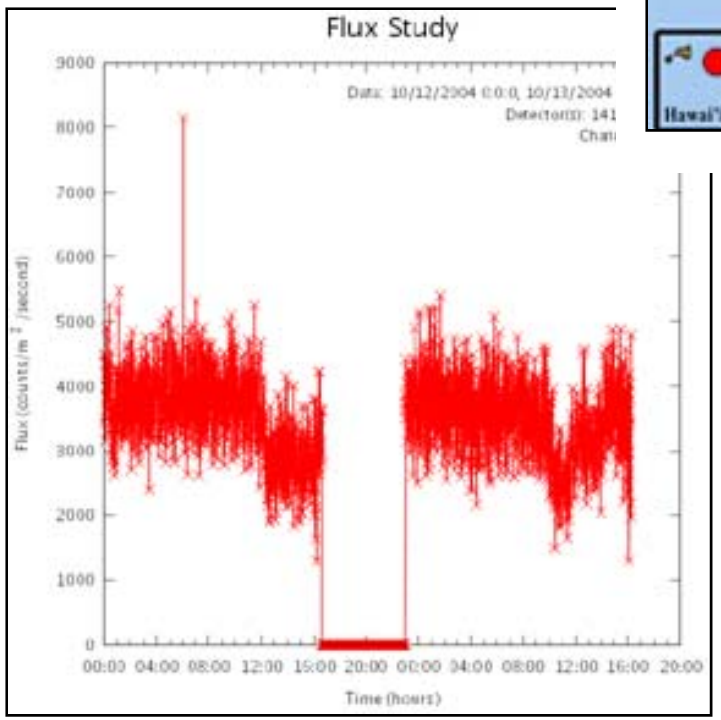
Schematic of use in a particle beam



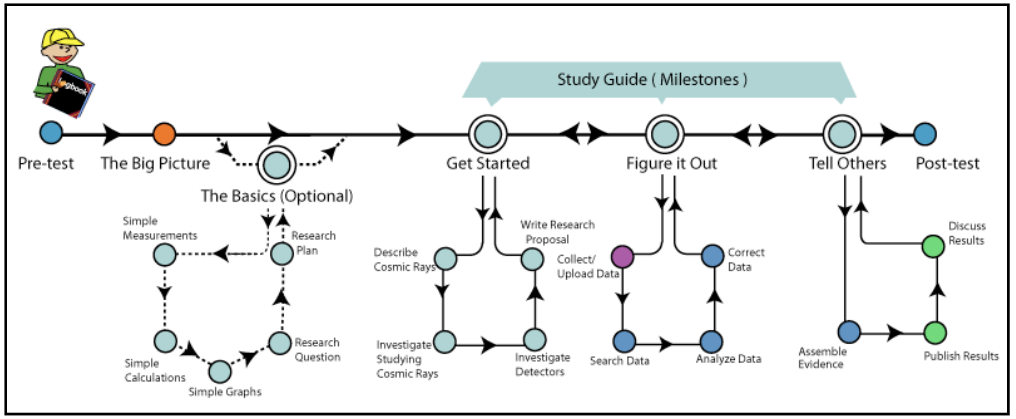
Interactions in Understanding the Universe (I2U2)

- A partnership:
  - Domain sciences and experiments
  - Educators (formal and informal)
  - Computer science including Grid
- Develops tools for student research directly in the classroom or a museums
  - eLabs, iLabs
  - The opportunity is available nationwide (and internationally)

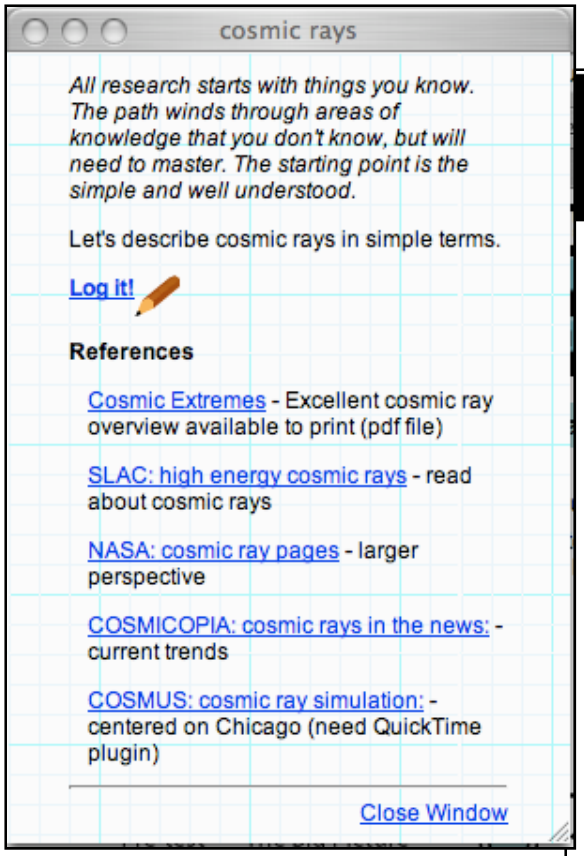


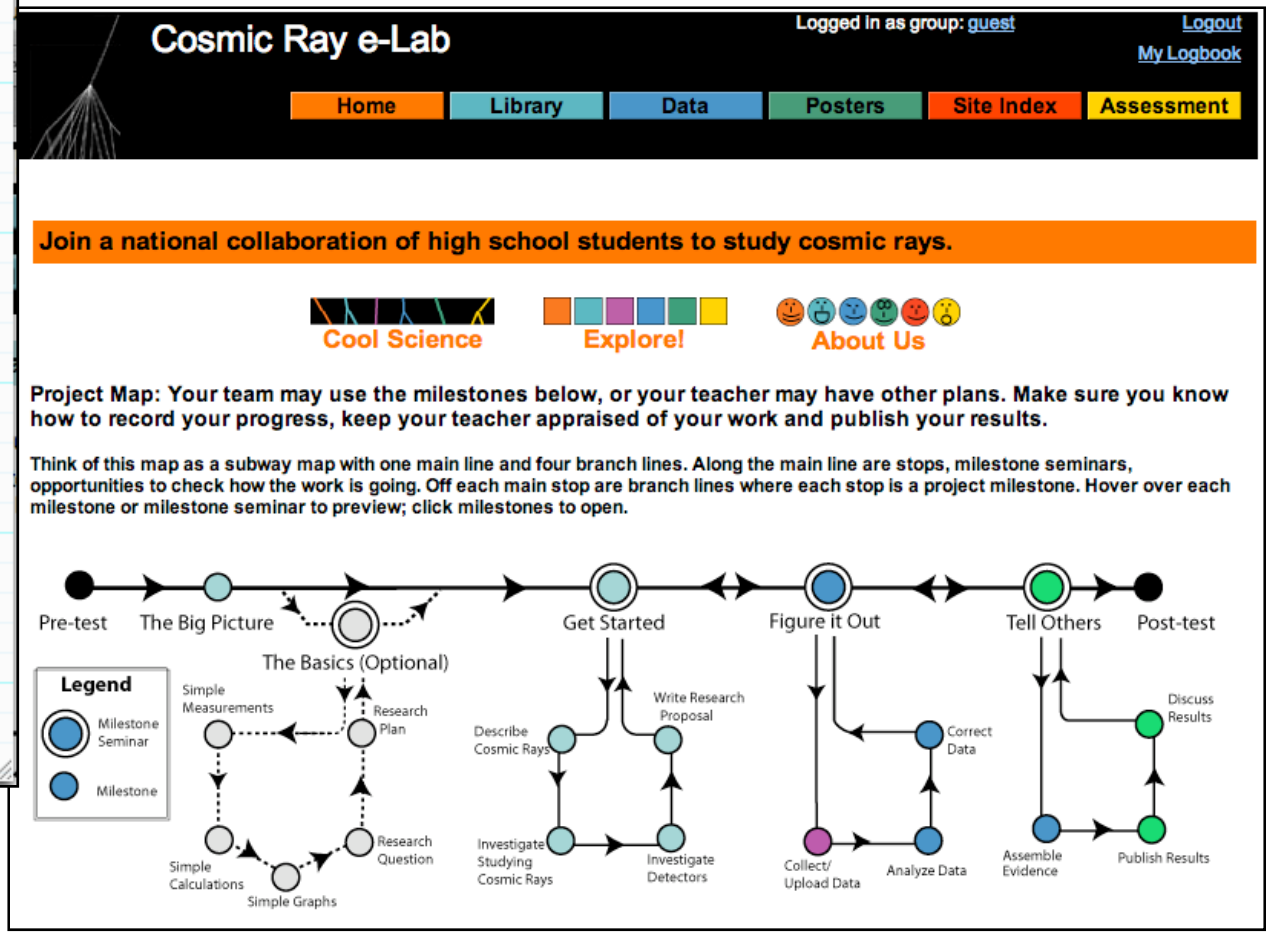


I2U2 - Cosmic Ray Studies



An e-Lab is a Web-based tool that supports student-led, teacher-guided investigations





I2U2

CMS Test Beam e-Lab

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Teacher Home | Student Home | Classroom Notes | Standards | Site Index | Registration

Teacher Home - Bookmark It!

Abstract:

Students can join a scientific collaboration in this series of studies of high-energy collisions from the Large Hadron Collider(LHC) at CERN. We are collaborating with the Compact Muon Solenoid(CMS) Collaboration. From start to finish this is a student-led, teacher-guided project. At the present we have test beam data for analysis. When the LHC starts producing data, students will be able to request data with specific parameters. By using the web and GRID computing technology students will be able to analyze the data. A virtual data portal enables students to share this data and associated analysis code with students and other researchers.

Students use a data base and analysis tool on the website. The Online Graphical ROOT Environment(OGRE) is the analysis tool used to analyze the data they have chosen for their study. Many tutorials are available to build basic scientific skills, to explain the how the detector works, to increase students understanding of subatomic particles, to direct in using the analysis tools and to explain how to use plots to analyze data. Students can then perform any of t
or detector resolution. Students post the results of their studies as online po
Students can review the results of other studies online comparing data and
with other research groups, post comments and questions, prepare summa
scientific research that is often left out of classroom experiments.

View Student Home as a: new student - returning student.

Introduction to Research:

The CMS Project explores the potential of using virtual data grid tools and t
cosmic ray e-Lab, this e-Lab provides an opportunity for:

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Cosmic Ray e-Lab

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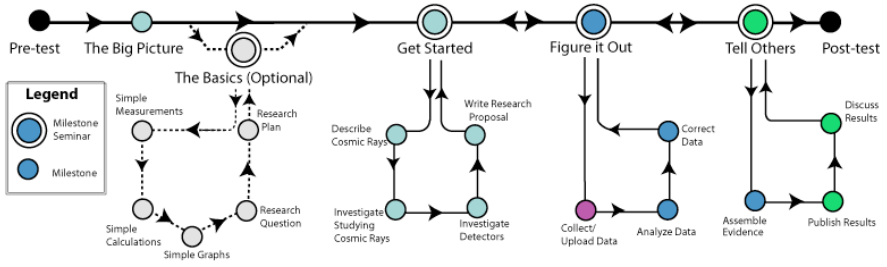
Home | Library | Data | Posters | Site Index | Assessment

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

Cool Science | Explore! | About Us

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

Think of this map as a subway map with one main line and four branch lines. Along the main line are stops, milestone seminars, opportunities to check how the work is going. Off each main stop are branch lines where each stop is a project milestone. Hover over each milestone or milestone seminar to preview; click milestones to open.

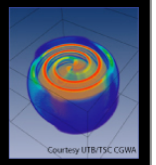


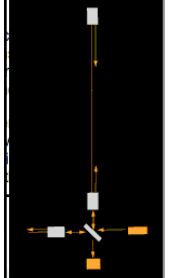
LIGO

Laser Interferometer Gravitational-Wave Observatory

Welcome to the LIGO I2U2 E-Lab

Teacher Home | Student Home





The LIGO E-Lab provides an online environment in which students experience the excitement of scientific collaboration by investigating seismic behavior. Seismic energy from earthquakes, wind, ocean waves and human activity will become visible and meaningful as students plot data from seismometers at LIGO Hanford Observatory

Seismic processes influence the behavior of LIGO's gravitational wave detectors. Inquiry-based E-lab investigations, designed and conducted by students, will connect to LIGO in exciting and authentic ways. Students will learn about LIGO's quest to detect gravitational waves as they analyze the vibrations of the ground underneath LIGO's ultra-sensitive interferometers.

Information common for all e-Labs

This project is supported in part by the National Science Foundation and the Office of High Energy Physics in the Office of Science , U.S. Department of Energy. Opinions expressed are those of the authors and not necessarily those of the Foundation or Department.

QuarkNet

52 Centers in 25 states and Puerto Rico

500 HS Teachers
150 Particle Physicist mentors
100 HS Students annually

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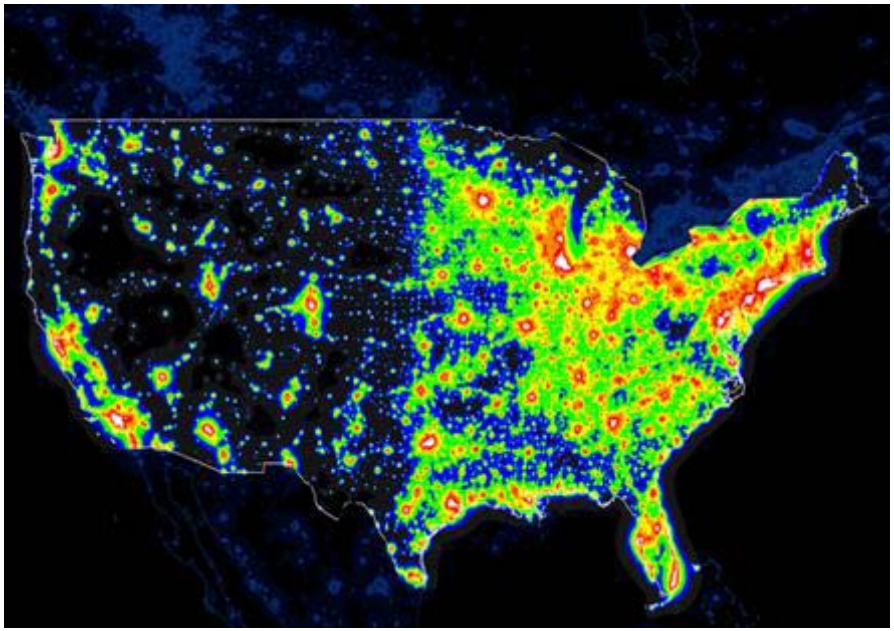
Now in its 12th year. Supported by NSF and DOE

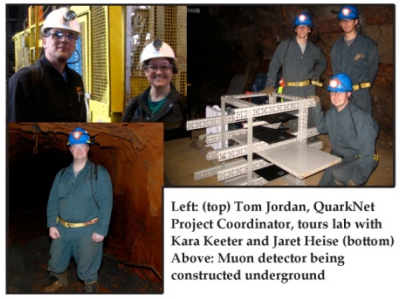
http://quarknet.fnal.gov/



Research at DUSEL
(Deep Underground Science and Engineering Lab)

Mining for New Physics

Dr. Kara Keeter is establishing a nuclear and particle astrophysics program at Black Hills State University that studies the very smallest particles in the universe in order to understand structures as large as stars, supernova, and even galaxies. Two elusive particles, neutrinos and dark matter, are the current subject of intense debate and interest. In fact, national advisory committees list investigating the nature of dark matter and neutrinos among the highest priority questions in particle physics today.



Left: (top) Tom Jordan, QuarkNet Project Coordinator, tours lab with Kara Keeter and Jaret Heise (bottom) Above: Muon detector being constructed underground

Although these particles arrive at the Earth from space, they are so hard to "see" that it is necessary to place the detectors deep underground, to shield from background "noise" found on surface. DUSEL will be among the world's premier locations for such research, and work has already begun at the interim Sanford Lab. BHSU scientists are involved in collaborations with physicists from prestigious institutions throughout the United States and the world to study neutrinos and dark matter.

These internationally-recognized experiments have the potential to change the basic Standard Model of Particle Physics and to forever enhance our understanding of the universe. QuarkNet at Black Hills State University offers teachers a unique opportunity to participate in this ground-breaking research.

Two Main DUSEL Projects

BHSU is involved in two important DUSEL Physics Projects: DARCSIDE and MAJORANA.

DARCSIDE

- Multi-ton Dark Matter Detector using ultrapure liquid argon
- Collaboration includes BHSU, Fermilab, MIT, Princeton, Temple, U. of Houston, U. of Massachusetts at Amherst, and Notre Dame
- We will build a Trace Gas Analyzer based on the latest Cavity Ring-Down Spectroscopy technology
- Our design, in collaboration with the inventor Kevin Lehmann from University of Virginia, will improve upon existing technology
- This is also cruicial to LUX and other collaborations and industry and may be patentable.

MAJORANA

- Neutrinoless Double Beta Decay Detector using germanium crystals
- Collaboration includes BHSU, U. of Washington, Los Alamos, UNC, and many others

BHSU's proximity to DUSEL means we will be vital in the clean room and ultra-low-level background counting facility.

The BHSU Astroparticle Physics team includes: Dr. Kara Keeter, Dr. Dan Durben, Dr. Michael Zehfus, and Dr. Jaret Heise.

The BHSU team holds leadership positions in the 2010 Research Center as well as several pending NSF proposals.

Graduate Credit

QuarkNet offers optional graduate credit in natural science and mathematics through Aurora University, Aurora, IL with whom Fermilab has an ongoing agreement. The current cost is **$75 per credit hour** paid by the enrolling student.

Year 1
The **eight-week** appointment through the "TRAC Teacher Research Program, NSM 5408" carries 4.5 hours of credit.

Year 2
The **three-week** institute through the "QuarkNet Teacher Institute II, NSM 5062" course carries 6 hours of credit.

Year 3
The **one-week** follow-on through the "QuarkNet Teacher Institute III, NSM 6208" course carries 3 hours of credit.

Alternatively, graduate credit is available through BHSU in Physical Sciences. An end-of-project report is required. The current cost is **$50 per credit hour**.

For more information, contact:

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Spearfish, SD 57799-9003

605-642-6490

KaraKeeter@BHSU.edu

Black Hills State University
~Transforming Lives~

QuarkNet at BHSU

QuarkNet is a teacher professional development program funded by the National Science Foundation and the US Department of Energy and administered by Fermi National Laboratory.

Dr. Kara Keeter, Astroparticle physicist, BHSU, is a member of the MAJORANA and the DARCSIDE collaborations.

Summary

- The programs described have been built fundamentally through partnership.
  - These are often non-traditional relationships.
- It requires creative work.
  - In the external communities involved…and in the funding agencies.
- To be successful (and valuable), these efforts need to be sustained for extended periods of time.
- Some useful websites:
  - http://quarknet.fnal.gov/
  - http://www.i2u2.org/

programs are growing…
new programs are appearing…

- QuarkNet
- I2U2
- CHEPREO
- CROP
- LIGO Education Centers
- Several NSF CI-Team Programs
  - Mariachi
  - CyberBridges
- REU/CERN
- RET
- PIRE – KU, KSU, UNeb, UPRM, UIC
- GK12 – NDeRC