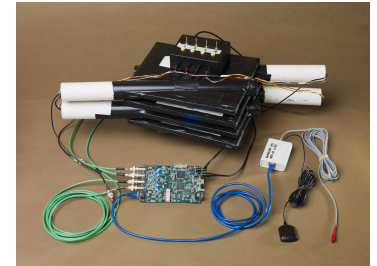
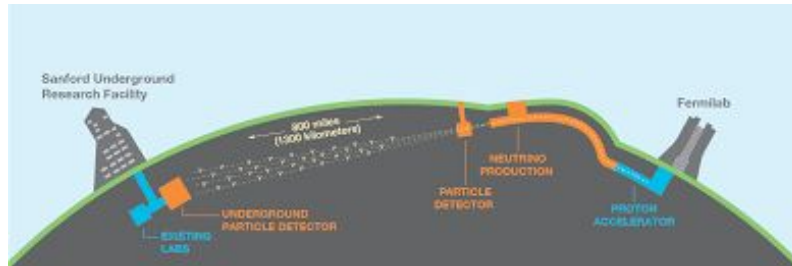
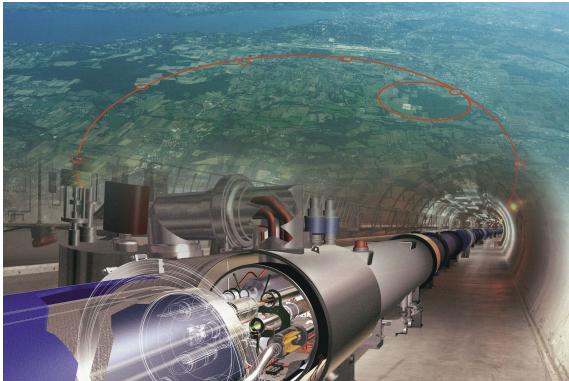
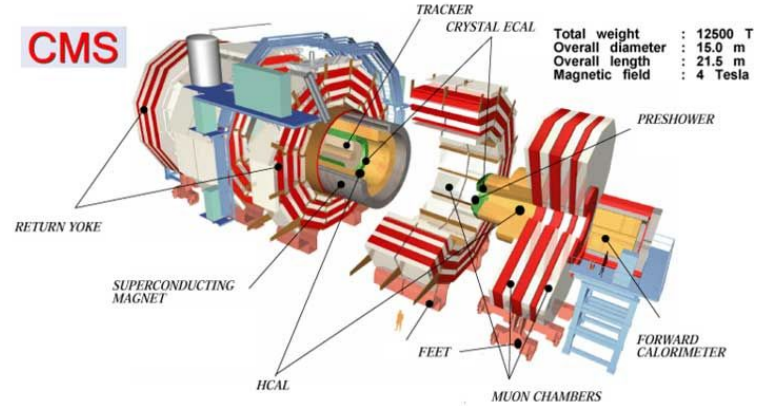
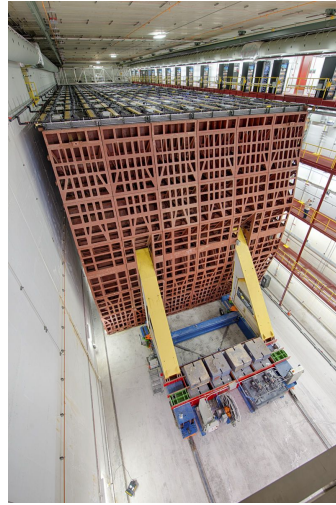


What is QUARKNET ?



How does QuarkNet work?

Outline:

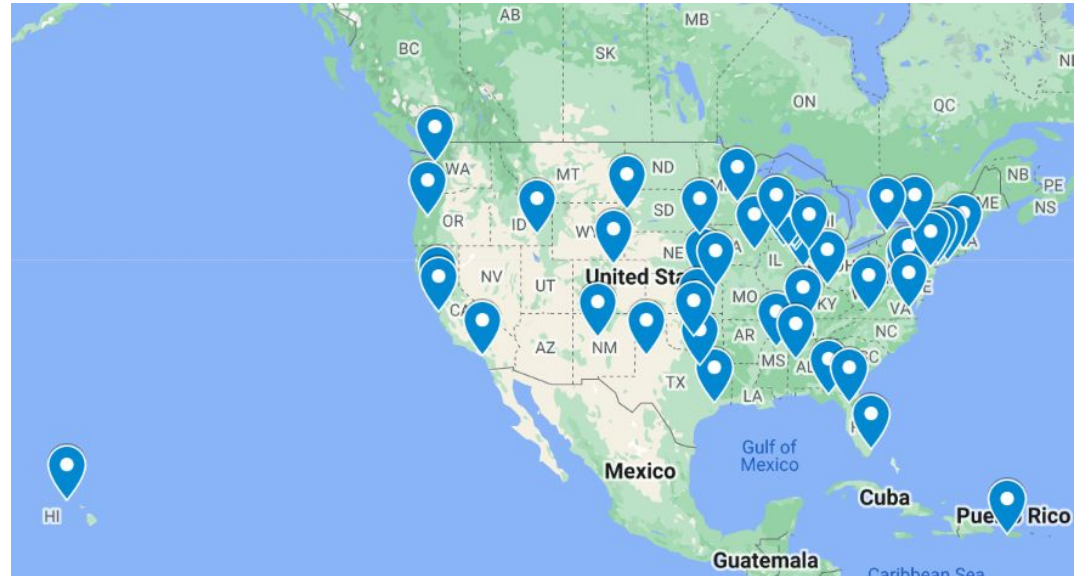
- Long-term national PD program *based at centers*
- 50 centers across the US (from PR to HI)
- Serving:
 - teachers (camps, fellows, CERN programs, networking)
 - and their students (IMC, cosmics, DAP)
- Creating particle physics content and methods with teachers



Program Overview

A national program at the local level

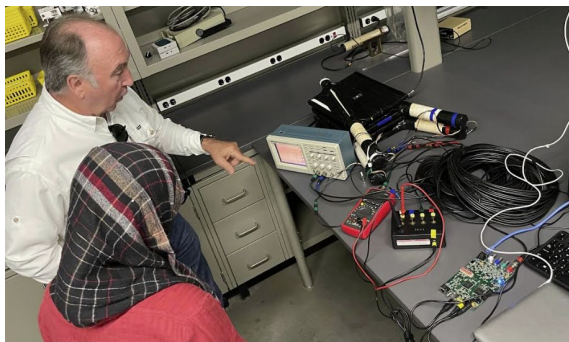
- **~5 PI's and national staff**
- **~50 QuarkNet centers across the U.S.**
- **~500 teachers**





Program Overview

QuarkNet happens at the centers ...



... and at the national level.

- **Teachers**
 - **Coding and Data Camps**
 - **Fellows: Coding, T&L, LHC, Neutrino**
 - **CERN Summer Programs**
- **Students and Teachers**
 - **International Masterclasses in Particle Physics**
 - **Cosmic Ray Studies**
 - **Data Activities Portfolio**
- **quarknet.org**



Program Overview

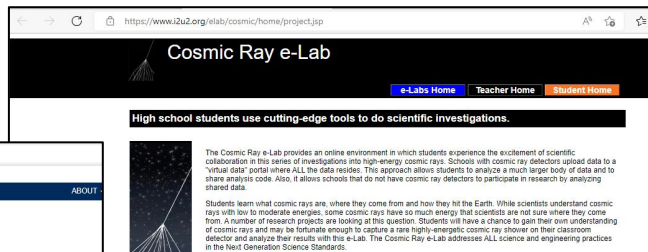
National Opportunities





Program Overview

Resources



https://quarknet.org/data-portfolio

Data Activities Portfolio

The Data Portfolio is a compendium of particle physics classroom activities organized by data strand and level of student engagement. Follow the links provided for information about using the Data Portfolio to plan your students' experience. Level descriptions explain the data analysis skills that students apply at each level: tasks in Level 0 are simpler than those in Levels 1 and 2. While each level can be explored individually, students who start in one level and progress to more complex levels experience increasingly engaging and challenging tasks. These activities are aligned with NGSS Standards if, particularly, NGSS Practices.

Your students can follow a path through activities in a data strand to better understand practices that lead to discovery. Each pathway provides connections between topics routinely covered in physics class and particle physics content and methods. Use the pull-down menus (Curriculum Topics and Strand) to find activities related to the content you are currently covering. Watch this screencast to learn more about sorting these activities.

We want your feedback on how the activities worked for you. Please complete the survey to help us improve our activities.

Data Strand:
 Level:
 Curriculum Topics:
 NGSS Practices:

| ACTIVITY NAME | DATA STRAND | LEVEL | CURRICULUM TOPICS | NGSS PRACTICES |
|---|---------------------------|---------|--|----------------|
| The Case of the Hidden Neutrino Students use momentum conservation to examine the decay of top-antitop pairs to determine what is missing from the event. | LHC, Neutrino | Level 1 | Conservation Laws, Special Relativity, Standard Model, Skills: Developing Models, Skill: Uncertainty | 2, 4, 5, 6, 7 |
| Energy, Momentum, and Mass Students examine data to find how energy, momentum, and mass are related. | Cosmic Ray, LHC, Neutrino | Level 1 | Conservation Laws, Electricity & Magnetism, Special Relativity, Skill: Data Analysis | 2, 4, 5, 7, 8 |



High school students use cutting-edge tools to do scientific investigations.

The Cosmic Ray e-Lab provides an online environment in which students experience the excitement of scientific collaboration in this series of investigations into high-energy cosmic rays. Schools with cosmic ray detectors upload data to a "virtual data" portal where ALL the data resides. This approach allows students to analyze a much larger body of data and to share analysis code. Also, it allows schools that do not have cosmic ray detectors to participate in research by analyzing shared data.

Students learn what cosmic rays are, where they come from and how they hit the Earth. While scientists understand cosmic rays with low to moderate energies, some cosmic rays have so much energy that scientists are not sure where they come from. A number of research projects are looking at this question. Students will have a chance to gain their own understanding of cosmic rays and may be fortunate enough to capture a rare highly-energetic cosmic ray shower on their classroom detector and analyze their results with this e-Lab. The Cosmic Ray e-Lab addresses ALL science and engineering practices in the Next Generation Science Standards.

[Information common for all e-Labs](#)
[Check out our online resources](#)

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.

International Masterclasses

19th International Masterclasses 2023

Cosmic Rays / e-Lab Analysis

Hardware: Maintain hundreds of teachers' CRMDs

e-Lab Analysis:

- **In-school and multi-school Projects**
- **Pyramid muon tomography**

e-Lab Software: analysis code and event displays

New efforts: Cosmic Watches, radio horns, pixel tracker



Program Overview

Data Activities: Snapshot in Time

| In the Beginning (2017) | End of Grant (2022) | Now (2023) |
|------------------------------|-------------------------------------|-------------------------------------|
| 14 Activities | 38 Activities | 39 Activities |
| Variety of structures | Specific Structure | Specific Structure |
| No Protocol | Protocol Aligned with PD Criteria | Protocol Aligned with PD Criteria |
| Level 1-3 | Level 0 - 4 | Level 0-4 |
| No Teacher Answer Key | Teacher Answer Key in Teacher Notes | Teacher Answer Key in Teacher Notes |
| Assessment | Assessment with Answers | Assessment with Answers |
| No Coding Activities | Two Coding Activities | Three Coding Activities |
| No Spanish Language Versions | Five Spanish Language Activities | Nine Spanish Language Activities |



Program Overview

QuarkNet is about ...

- **Particle physics**
 - **Physics we teach**
 - **Methods and skills**
 - **Ideas and opportunities**
- **Teamwork and network**
- **Teacher Professional Development**

