Classroom Cosmic Rays: Detectors and Analysis

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Cosmic Ray Studies

- The Collaboration
- The Hardware
- Typical Setup
- Student Use and Tabletop Experiments
- e-Lab Data Portal
- Conclusions and Future Work
Cosmic Ray Studies

- We want students to think critically by engaging science questions that are:
  - open-ended.
  - answered by data.
  - messy.

We help teachers learn how to do this.
The Collaboration

- QuarkNet started in 1998 as an outreach program for the U.S. particle physics community.

- We have grown to 52 centers and > 550 active teachers.

- Some teachers asked for hardware.

- QuarkNet provides hardware to teachers in the project. (red at left)

- Others have purchased the hardware at our cost. (blue at left)
The Hardware

- Four channels of A2D
- PMT pulse edges are matched to a local clock.
- The local clock is synced to GPS time.
- Selectable trigger logic
- User-accessible scalars to check rates
- Scintillation-based counters
Teacher Workshops

- 108 teacher workshops since 2004
- Three to five days in duration
- Detector assembly
- Guided practice
Typical Setup

- Counters are in the classroom for easy access.
- Students can ask their own questions—such as:
  - Are there more cosmic ray muons during the day than there are at night?
  - Will the muons penetrate this thick steel table?
  - Are there more cosmic ray muons during thunderstorms?
Allow access to "inscrutable data"

Users just want to get to the physics.
e-Lab: an Electronic Laboratory

- An e-Lab is a web-based tool that allows:
  - Data uploads
  - Data blessing
  - Analysis tools
  - Publication of findings
  - On-line logbooks
  - Collaboration
e-Lab: an Electronic Laboratory

- Users can:
  - Search data
  - Select files
  - Set analysis parameters
  - Interpret results
  - Save plots
e-Lab: an Electronic Laboratory

Workflows include:

- Performance
- Flux
- Shower
- Lifetime

Users can also access intermediate files for analysis in spreadsheets or with their own code.
e-Lab: an Electronic Laboratory

- Provides a “metro map” to researching a topic
- Each “station” is clickable and yields additional resources.

*Milestone: Assemble evidence for your results.*

*Scientists must convince each other that their conclusions make sense. Data, analysis and interpretation are tools that show the research details and defend results.*

*Look at the plots you saved using the View Plots submenu under Data. Also check your logbook for plots that support or do not support your ideas. Based on your notes, list plots that you think should appear in your published results.*

*Log it!*

*To Learn More:*

**Defend your research**, from MacSci Network
e-Lab: an Electronic Laboratory

- Provides a student logbook
- Entries are linked to “stations” on the metro map.
- Teachers can read and comment on entries.
e-Lab: an Electronic Laboratory

- Users can “publish” findings.
e-Lab: an Electronic Laboratory

- By the numbers
- 1800 student research groups
- 900 teacher accounts
- 700 posters
- 31,000 raw data files
Conclusions and Future Work

- Our students *explore* high-energy cosmic rays.
- Our teachers use e-Lab scaffolding to *guide* our students.
- They can study performance, lifetime, flux, shower.
- We can build new analysis workflows.
- We are seeking collaborators and partners.

http://www.i2u2.org/elab/cosmic