The QuarkNet Project

Goal of QuarkNet

QuarkNet will involve 100,000 students from 600 US high schools in:

- Web-based analysis of real data.
- Collaboration with students worldwide.
- Remote control of television cameras in experimental areas.
- Visits by student representatives to the experiments.

Through inquiry-oriented investigations students will learn kinematics, particles, waves, electricity and magnetism, energy and momentum, radioactive decay, optics, relativity, forces, and the structure of matter.

Project Overview I

QuarkNet provides professional development and on-going support for physics teachers who get involved in the program. The professional development occurs in many different ways during a teacher's involvement, these include:

The summer of the first year:

- A one-week meeting at Fermi National Accelerator Laboratory (Fermilab) in Illinois, during which the teachers work closely with other physics teachers and attend seminars given by acclaimed scientists.
- A seven-week research appointment at a research institution near the teacher's home in which a pair of teachers works closely with mentor physicists.
- Membership in our e-mail list server which hosts discussions on many issues related to teaching and learning physics.

The balance of the first year:

- Frequent meetings with their mentor during the academic year.
- Regular visits to the teacher's classroom by a member of the QuarkNet Staff; this individual is an experienced physics teacher who can provide both coaching and content support.
- Communication with the colleagues that they meet at Fermilab via the e-mail list server.

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Project Overview II

The teachers continue in the program by recruiting up to ten more local physics teachers to participate during the following summer. The number of teachers working at these QuarkNet Centers is now twelve. The professional development work continues:

The summer of the second year:

• A three-week workshop at the local research institution designed by the original pair of teachers and attended by all twelve.

• Membership in the e-mail list server which hosts discussions on many issues related to teaching and learning physics.

The balance of the second year:

• Frequent meetings with their mentor during the academic year.

• Regular visits to the teacher's classroom by a member of the QuarkNet Staff; this individual is an experienced physics teacher who can provide both coaching and content support.

• Communication with their teaching colleagues via the e-mail list server.

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Project Overview III

- These teachers also access on-line activities and datasets designed to allow high-school students to investigate introductory physics through the lens of particle physics. QuarkNet staff and teachers create these on-line learning materials and share them via QN web server.
- QuarkNet also funds teacher mini-grants so that participants can purchase equipment, software or other material to help teach material. We can also support travel to meetings so that participants from different research institutions can remain in contact.
- QuarkNet receives support from the United States National Science Foundation, the United States Department of Energy, as well as ATLAS, CMS and Fermilab.

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Staff Teacher I

Five staff teachers will lead and coordinate the project. One of them will act as the project coordinator who will be responsible for the day-to-day management of the project. The staff teachers will help establish and build the capacity of the partnerships of physicists and teachers. Each staff teacher will develop a close relationship with mentors and teachers at assigned centers, visit each assigned center at least once a year (new centers will require more visits) and keep in touch via e-mail, phone, etc.

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Staff Teacher II

With guidance from the PIs, the staff will:

- Develop guidelines for and assist teams of teachers and physicists to develop and implement programs.
- Help to create online and hard-copy resources, maintain the Website, and provide support for teachers using online resources.
- Help teachers create experiments that use computers for data acquisition and processing.
- Hold mentor orientation meetings, lead teacher institutes, reunion weekends at Fermilab and at AAPT meetings.
- Provide peer coaching for teachers including classroom visits.
- Give program presentations at professional meetings.
- Gather data to assess the project as requested by the outside evaluator.

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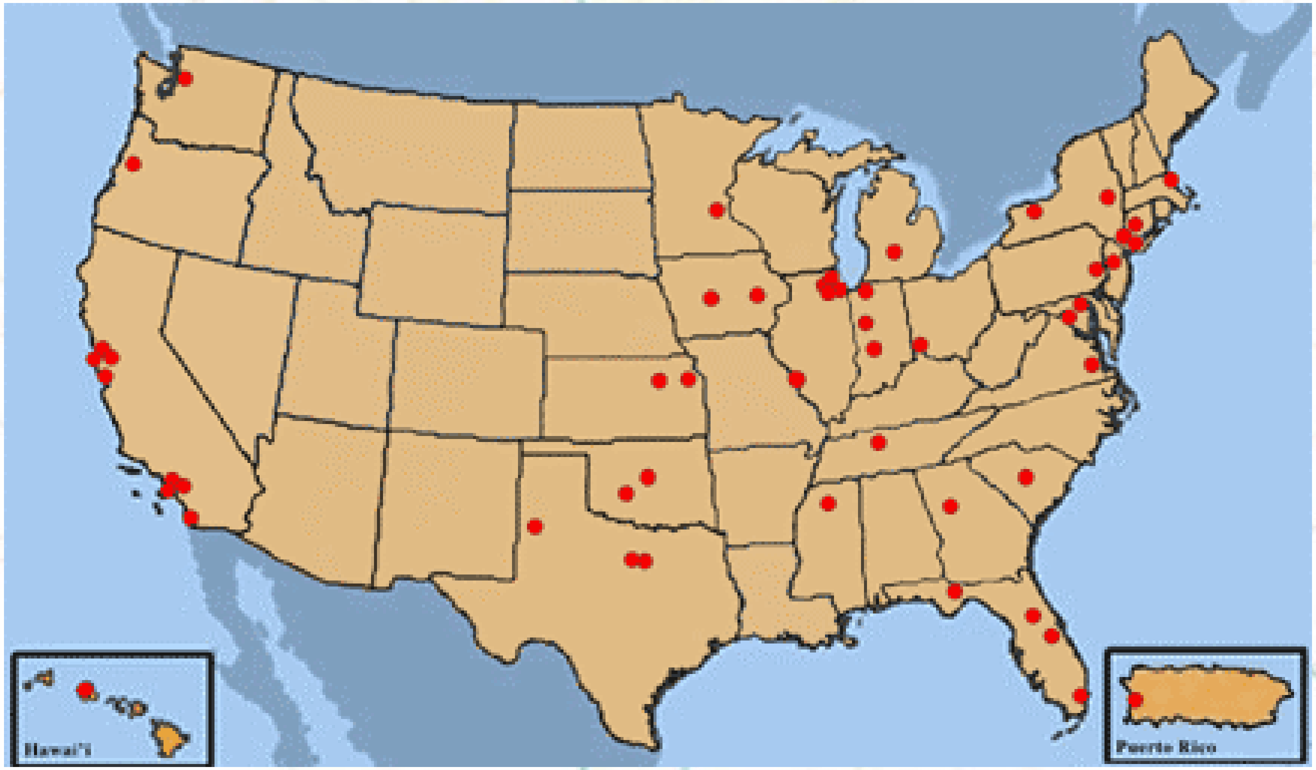
Active QuarkNet Centers I



Active QuarkNet Centers II

1999 Centers

Boston University & Northeastern University
D0 and CDF at Fermilab
Florida State University
Indiana University
Iowa State University & University of Iowa
Langston University & University of Oklahoma
Notre Dame University
SUNY Stony Brook
University of California at Santa Cruz
University of Rochester
University of Texas at Arlington

2000 Centers

Brookhaven National Laboratory
Columbia University/Nevis Labs
Hampton University
Michigan State University
Southern Methodist University
SUNY Albany
University of California at Irvine
University of California at Riverside
University of Chicago
University of Florida
University of Illinois - Chicago
University of Pennsylvania
University of Washington

2001 Centers

Argonne National Laboratory
Florida Institute of Technology
Iowa State University & University of Iowa
Lawrence Berkeley National Laboratory
Rutgers University
Texas Tech University
University of Kansas
University of Mississippi

2002 Centers

Johns Hopkins University
Stanford Linear Accelerator Center
Stanford University
University of Cincinnati
University of Maryland
University of Minnesota
University of Oregon
University of Pittsburgh
University of South Carolina
Vanderbilt University

2003 Centers

Florida International University
Georgia State University
Kansas State University
Purdue University
University of California at Los Angeles
University of California at San Diego
University of Hawa'ii
University of Puerto Rico

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Florida Tech Workshop, 1st Year, 1st Week

QuarkNet at Florida Tech, Physics and Space Sciences

	MONDAY June 10	TUESDAY June 11	WEDNESDAY June 12	THURSDAY June 13	FRIDAY June 14
9:00 10:00	7th floor Welcome, introductions, goals, plans, discussion Laszlo Baksay, Chair	S524 Panel on High School Physics Classroom Experience Laszlo Baksay, facilitator	S524 Discussion on Physics Teachers Training and Curriculum Debbie Blenis	S524 Discussion on International High School Physics (Choose teacher presentations) Laszlo Baksay, lead	S423 Lab apparatus, techniques, electronics, equipment Lee Caraway
10:30 11:00	History of FIT 7th floor Gordon Patterson	Lib Particle Accelerators Rainer Meinke	127EC Review of Fundamental Physics Concepts Hamid Rassoul	Lib Wavelike Properties Hamid Rassoul	Lib Particlelike Properties Hamid Rassoul
12:00	Lunch break*	Lunch Break*	Lunch Break*	Lunch Break*	Lunch Break*
13:00 **14:30**	Group photo S412 Overview of Particle Physics (History and Philosophy) Marcelo Alonso Tour FIT Facilities Scott Wilson	**Lab** S413 Wave optics Gyongyi Baksay Klaus Dehmelt	**Lab** S413 Michelson interferometer Gyongyi Baksay Klaus Dehmelt	**Lab** S414, S419 1.Electron Spin Resonance 2.Gamma Ray Spectroscopy 3. Measurement of charge to mass ratio of the electron e/m Marcus Hohlmann Ming Zhang	**Lab** S414, S419 1.Electron Spin Resonance 2.Gamma Ray Spectroscopy 3. Measurement of charge to mass ratio of the electron e/m Marcus Hohlmann Ming Zhang
15:30	S210 **QuarkNet** Laszlo Baksay	S210 Overview PSS, HEP Laszlo Baksay	S210 Introduction to the world of HEP via the Web Marcus Hohlmann	S210 The Particle Adventure Marc Baarmand	S210 The Standard Model of Particle Physics Marc Baarmand
16:30- **17:00**	S524 Synthesis Laszlo Baksay	S524 Synthesis Laszlo Baksay	S524 Synthesis Marcus Hohlmann	S524 Synthesis Marc Baarmand	S524 Synthesis Laszlo Baksay

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Florida Tech Workshop, 1st Year, 2nd Week

QuarkNet at Florida Tech, Physics and Space Sciences

	MONDAY June 17	TUESDAY June 18	WEDNESDAY June 19	THURSDAY June 20	FRIDAY June 21
9:00	Discussion and Coffee S524 Laszlo Baksay	Discussion and Coffee S524 Laszlo Baksay	Discussion and Coffee S524 Laszlo Baksay	Discussion and Coffee S524 Laszlo Baksay	Discussion and Coffee S524 Laszlo Baksay
9:15	S423 Lab apparatus, techniques, electronics, equipment Lee Caraway	Instrumentation in Particle Physics: 127EC Photomultipliers Leonardo Almeida Fiber optics Talal Quareshi	Instruments in Part. Phys.: Gas detectors 127EC Klaus Dehmelt Neutron Detection Maher Al-Dayeh	127EC High Energy Physics Experiments: The HERA-B experiment at DESY Marcus Hohlmann	**Research Lab** S523/ S419/ S414 1. Finding the Z boson (data analysis) Gyongyi Baksay Klaus Dehmelt
10:30	Break	Break	Break	Break	Break
10:45 11:30	Lib Beyond the Standard Model Marc Baarmand	127EC Solar Energetic Particles Joseph Dwyer	127EC Space Weather Hamid Rassoul	High Energy Physics Experiments: 127EC The CMS/CERN and D0/FNAL experiments Marc Baarmand	2. Work in CMS Lab Gyongyi Baksay Klaus Dehmelt 3. Cosmic Ray Telescope Marcus Hohlmann
12:00	**Lunch break***	**Lunch Break***	**Lunch incl. Pres + VIPs**	**Lunch Break***	**Lunch Break***
13:00	**Research Lab** S523/ S419/ S414 1. Finding the Z boson (data analysis) Gyongyi Baksay Klaus Dehmelt 2. LABVIEW Lee Caraway 3. Cosmic Ray Telescope Marcus Hohlmann	**Research Lab** S523/ S419/ S414 1. Finding the Z boson (data analysis) Gyongyi Baksay Klaus Dehmelt 2. LABVIEW Gyongyi Baksay Klaus Dehmelt 3. Cosmic Ray Telescope Marcus Hohlmann	**Research Lab** S523/ S419/ S414 1. Finding the Z boson (data analysis) Gyongyi Baksay Klaus Dehmelt 2. Work in CMS Lab Gyongyi Baksay Klaus Dehmelt 3. Cosmic Ray Telescope Marcus Hohlmann	**Research Lab** S523/ S419/ S414 1. Finding the Z boson (data analysis) Gyongyi Baksay Klaus Dehmelt 2. Work in CMS Lab Gyongyi Baksay Klaus Dehmelt 3. Cosmic Ray Telescope Marcus Hohlmann	**Teacher presentations** -Finding the Z boson -Labview -Cosmic ray telescope Rachel Power,Nora Stackpole,Kathy Thompson, Terry Barchfeld, Rusty Davidson, Henry Helwig, Bryan LaRose, Joe Laub, John Weis Laszlo Baksay, facilitator
15:15	Journal Break	Journal Break	Journal Break	Journal Break	Journal Break
15:30	S210 The Sloan digital sky survey and image processing Zsolt Frei, Hungary/Princeton	Instrumentation in Particle Physics: CCD's S210 Matt Wood Radioactivity Gemin Keshishian	ARL The MagLev Project Laszlo Baksay Hector Gutierrez James Gering	S210 High Energy Cosmic Rays Ming Zhang	Workshop summary S7th Continuation in school year; Program outlook Laszlo Baksay, facilitator
16:30- 17:00	S524 Synthesis Laszlo Baksay	S524 Synthesis Laszlo Baksay	S524 Synthesis Laszlo Baksay	S524 Synthesis Laszlo Baksay	

Material for the Classroom

- **Applying Ohm's Law**
- Discovering New Particles: **Catchin' Some Z's**
- **Measuring Single Photons** with Photo multiplier Tubes
- **Run II Website** with streamed video Web casts and classroom
- Building Accelerator Analogs
- **Building Cosmic Ray Detectors**

Cosmic Ray Muon Detectors
Particle Physics Using Nature's Accelerator

Step 1: Construction

Step 2: Commissioning

Step 3: Operation

Step 4: Experimentation

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Step 1: Construction

In Summer 2003 a group of 13 teacher started the construction of twelve Scintillator detectors.

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Step 2: Commissioning

After construction, first steps of commissioning were undertaken.






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Step 3: Operation

The operation of Scintillator detectors were tested on a prototype by Georgia Karagiorgi and Julie Slanker.

- 2 scintillation detectors developed at Fermilab
- 2 PMT tubes
- 2 PM bases
- Coincidence logic board

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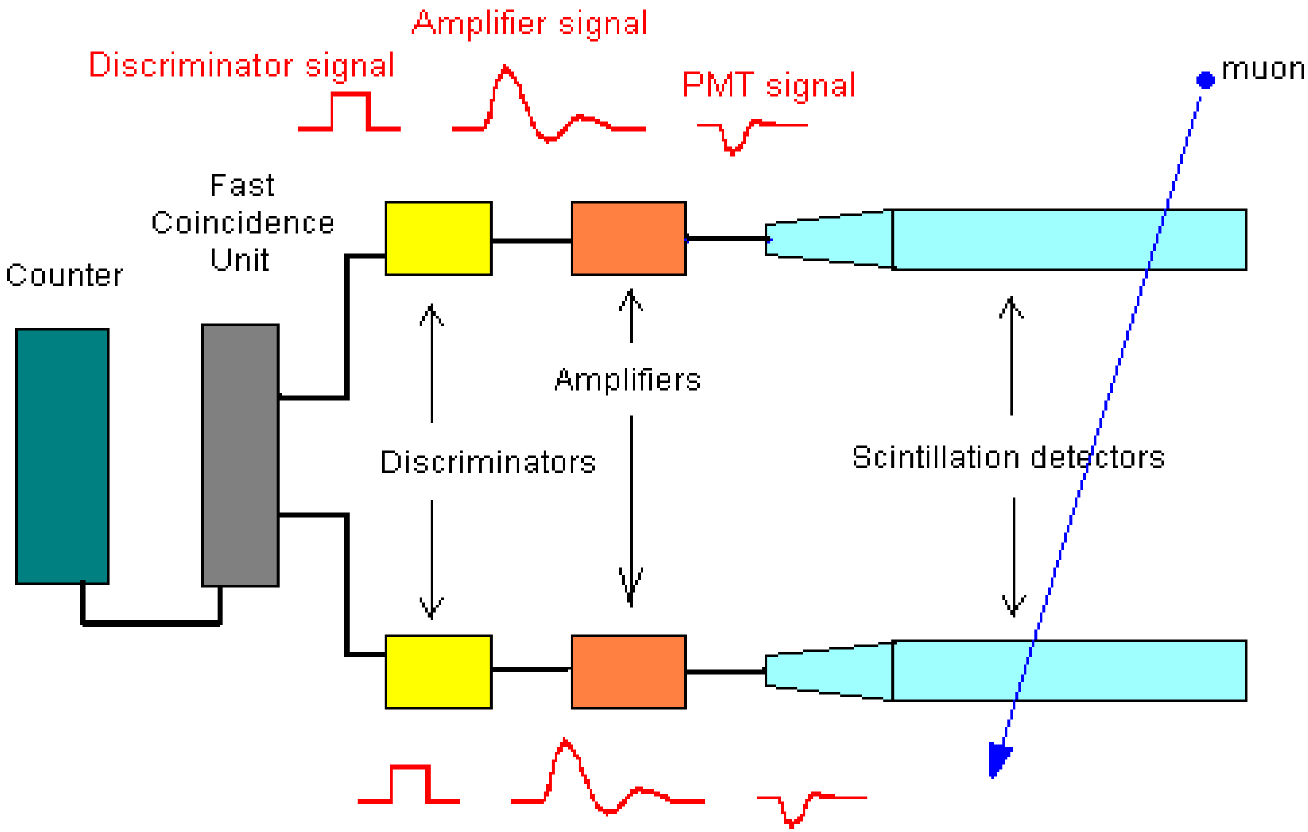
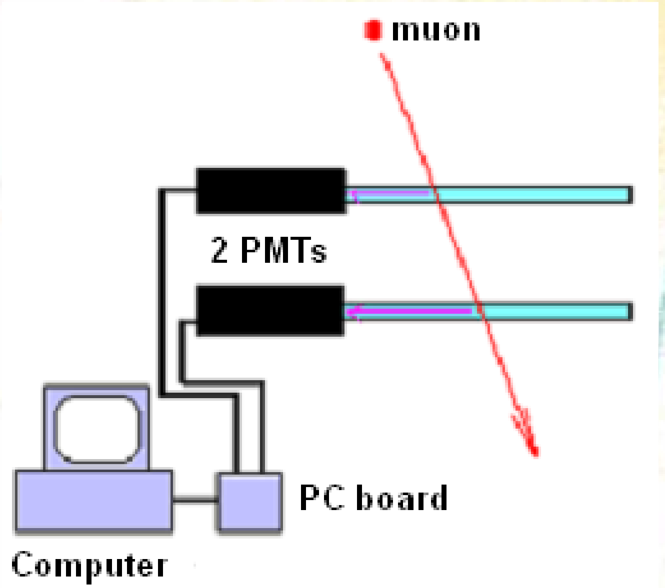
Step 3: Operation



The setup is such that the counter is recording "coincidences", i.e. signals sent from both discriminators at the same time

Step 3: Operation

The PC board recognizes a coincidence when the two signals are received within 160ns



This technique

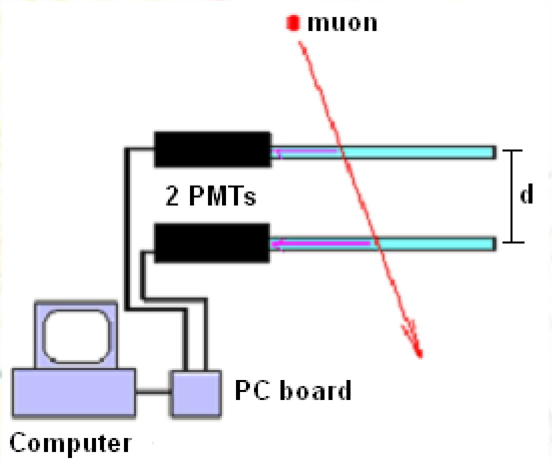
- results in **elimination of background noise**
- offers a great number of possible experiments

Step 3: Operation

Flux

Muons reach the surface of the Earth with typically constant flux Fμ.

$$F_\mu = \frac{(\text{count rate})d^2}{(\text{area of top panel})(\text{area of bottom panel})}$$



$F_\mu = 0.48\ \text{cm}^{-2}\text{min}^{-1}\text{sterad}^{-1}$ (PDG theoretical value)

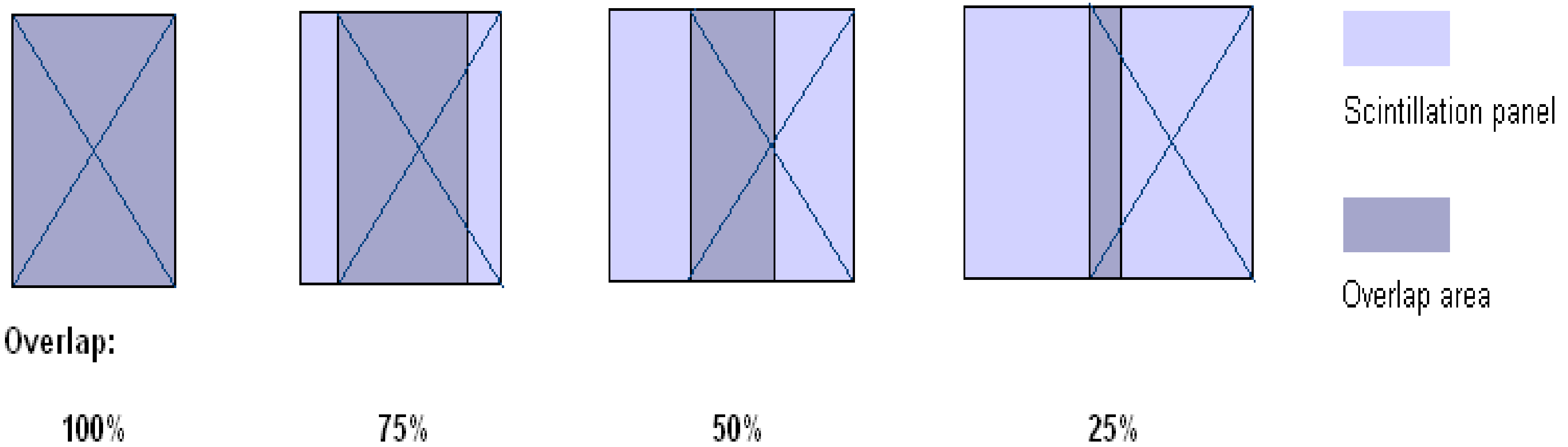
Count rate: $0.585\text{cm}^{-2}\text{min}^{-1}$ (horizontal detectors)

Our experimental value: 36min^{-1} (8% efficiency)

Step 3: Operation

Investigation of count rate variation

With overlap area

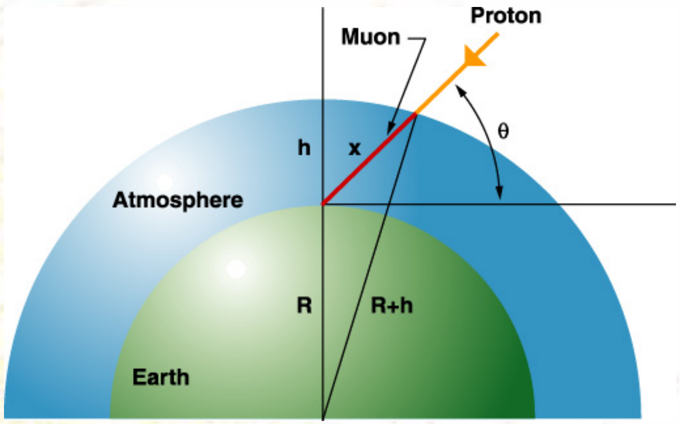


Step 3: Operation

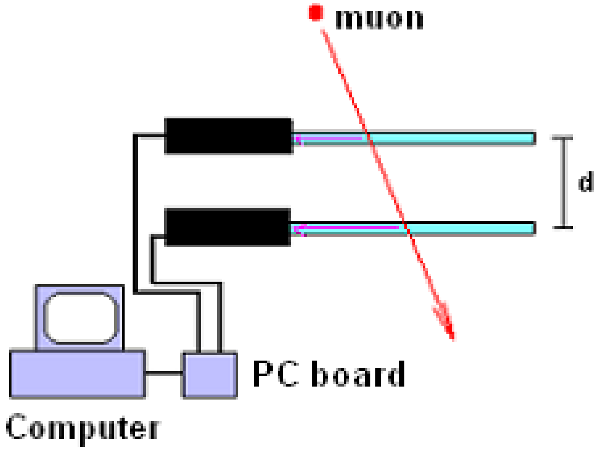
Investigation of flux variation

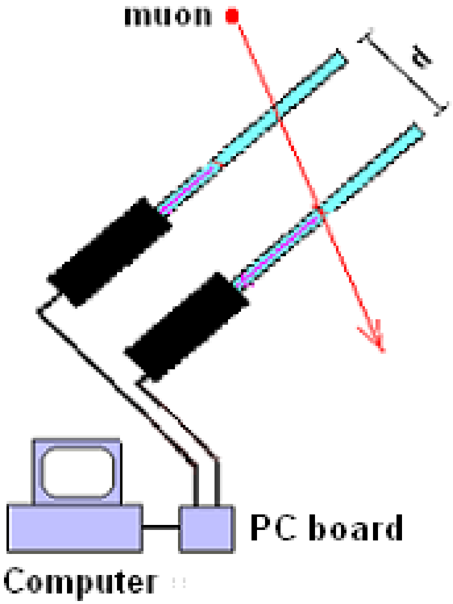
With angle θ with respect to

the horizon



$F_{\mu} \sim \cos^2 \theta$



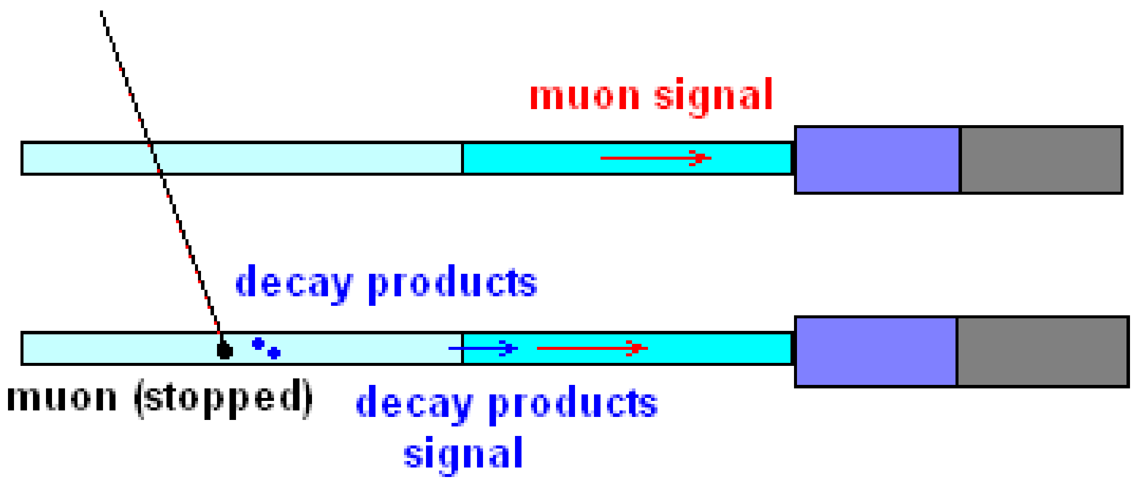


Step 4: Experimentation

Muon lifetime experiment

Using the coincidence logic board, low energy (decaying) muon events on the computer were recorded .

These events are called “doubles.”



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Step 4: Experimentation

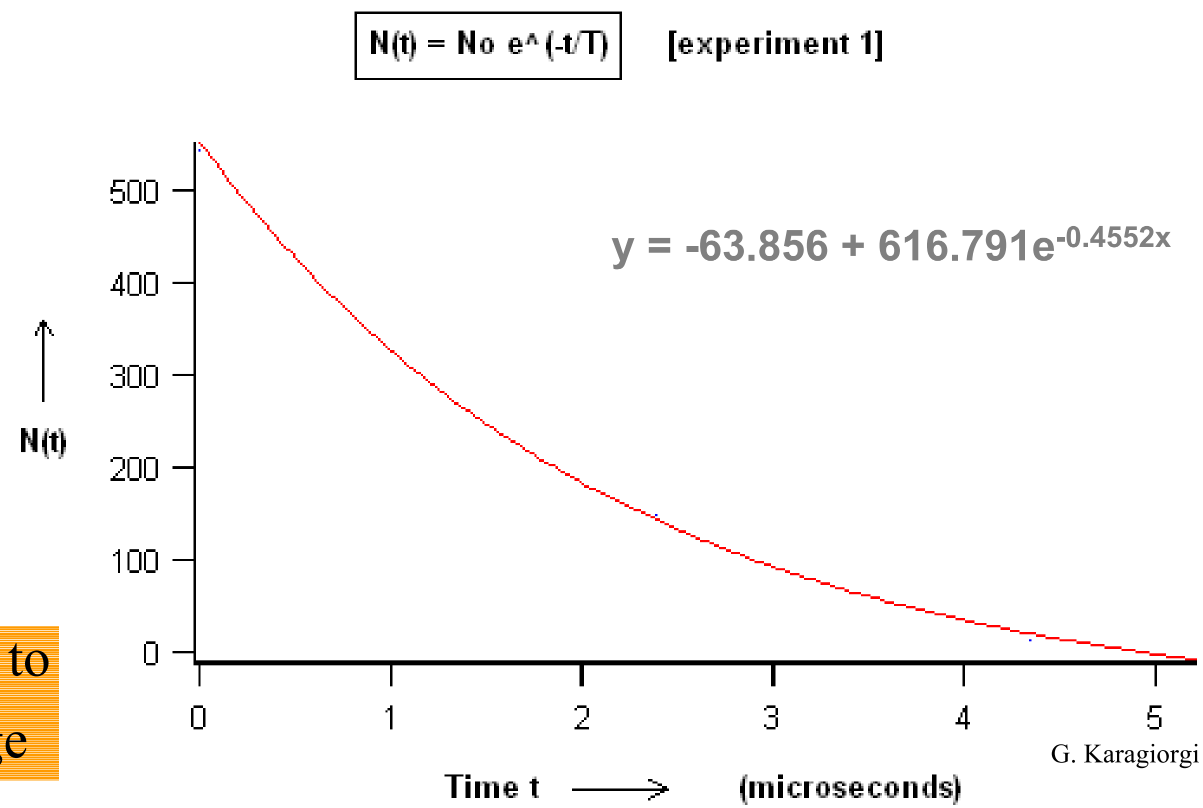
Muon lifetime experiment→ impressive results.

Results:

Lifetime T:
T = 2.1965μs

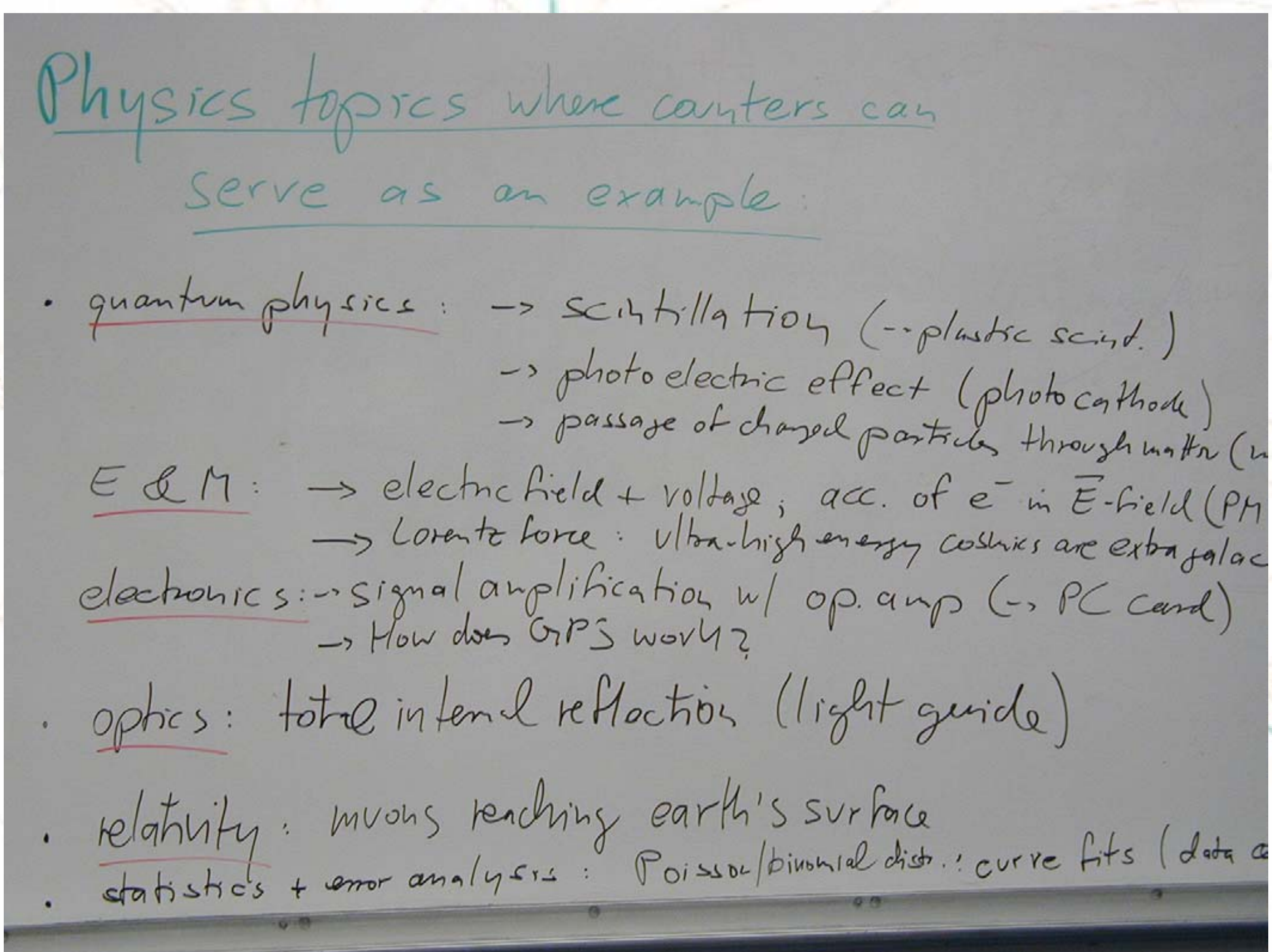
T_{th} = 2.1970μs

⇒ closer than 0.1% to the WORLD average



G. Karagiorgi and J. Slanker

The counters for the classroom



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North American Large area Time coincidence Arrays (NALTA)

Searching for high energy cosmic rays using sparse arrays of simple detectors.

NALTA is a collaboration of experimental groups in Canada and the United States engaged in the study of high energy cosmic rays. What makes NALTA unique is the involvement of high-schools and colleges in this endeavor.

ALTA (Alberta Large area Time coincidence Array), University of Alberta, Edmonton Alberta, Canada.

CHICOS (California HIgh school Cosmic ray ObServatory), Caltech, UC/Irvine and Cal State/Northridge, California, USA.

CROP (the Cosmic Ray Observatory Project), University of Nebraska, Lincoln, NE, USA.

WALTA (WAshington Large area Time coincidence Array), University of Washington, Seattle, WA, USA.

SALTA (Snowmass Area Large-scale Time coincidence Array), during the Snowmass 2001 particle physics conference to be held in July there was a 1 week workshop for teachers and students after which the SALTA detectors were installed in the Roaring Fork Valley area of Colorado.

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NALTA


Beaufort Sea
75°
Baffin Bay
60° Alaska
Davis Strait
Gulf of Alaska
Labrador Sea
Canada
Hudson Bay
Edmonton
ALTA
45°
UBC
Montreal
Seattle
Carleton
WALTA
North Eastern
Pacific Ocean
CROP
Atlantic Ocean
Snowmass
Lincoln
SALTA
Los Angeles
30°
CHICOS
United States
Mexico
Mexico City

NALTA

How does NALTA work?

All of the NALTA experiments use arrays of fairly simple particle detectors,

- plastic scintillator read out by photo-multiplier tubes, placed at participating sites
- Use of high-schools and colleges means that the distribution of sites is both non-uniform and fairly sparse, generally no more then a few sites per hundred square kilometers
- Normally a few individual detectors are grouped at each site and read out by a common electronic system.
- A shower triggering these individual detectors results in a “local” coincidence which is “time stamped” to very high accuracy using the Global Positioning Satellite system (GPS). Using the timing difference between the individual detectors the direction the shower must have come from is also estimated allowing one to roughly “point” back along the track of the original cosmic ray.
- The data from all the detector stations is periodically uploaded to the central site of the experiment in question and using the GPS times a search is made for coincidences between events at different locations. This is the signature for either a large area shower caused by a single primary cosmic ray particle or multiple coincident showers caused by a correlated group of cosmic rays.
- The GPS timing is accurate enough to allow “pointing” to be done between different detector locations which can be cross checked with the local pointing information to determine if more then one primary was involved.

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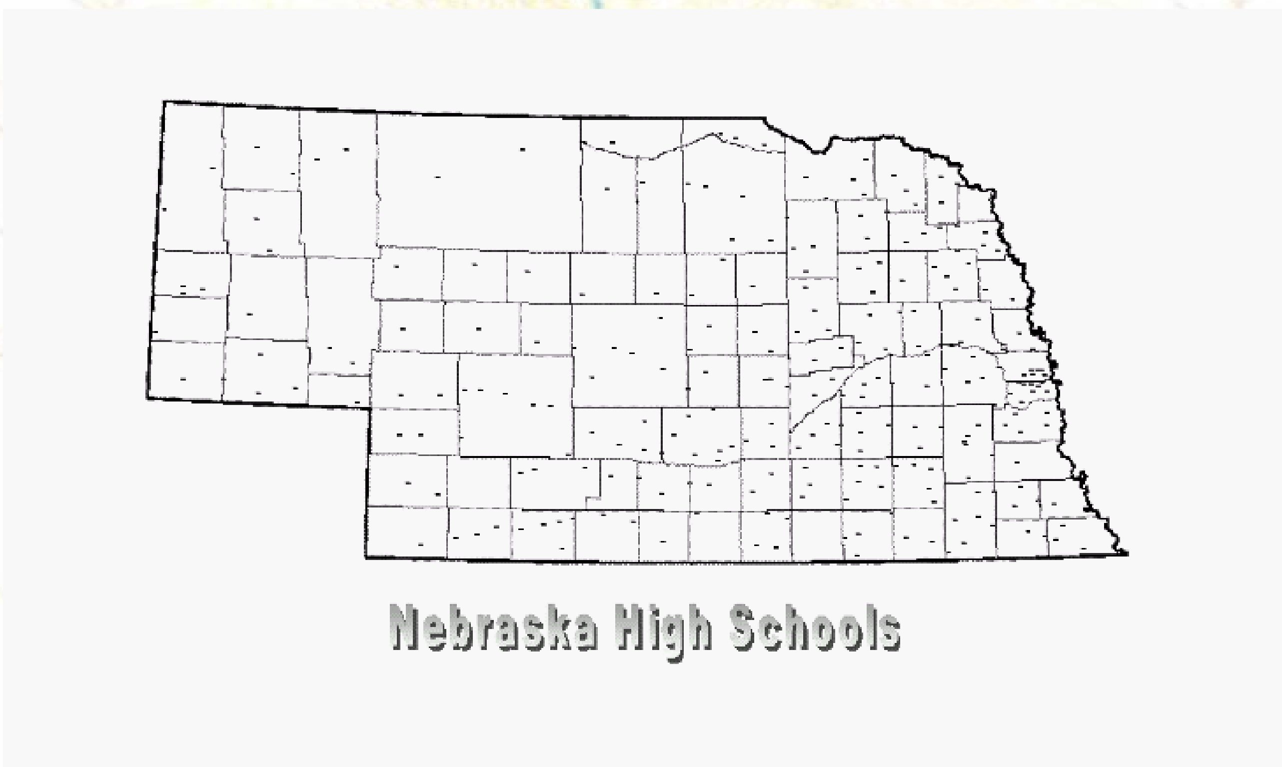
The Cosmic Ray Observatory Project

CROP is a statewide outreach project whose goal is to involve Nebraska high school students, teachers, and college undergraduates in a multi-faceted, hands-on research effort to study extended cosmic-ray air showers. High-energy ($E > 10^{18}$ electron volts) cosmic rays which continuously strike the earth's atmosphere from outer space create avalanches of daughter particles which cover areas up to 50 square miles on the earth's surface.



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The Cosmic Ray Observatory Project

CROP uses the detectors from the decommissioned Chicago Air Shower Array CASA.

Outlook

Florida High schools will become a member of **NALTA,**

- **FALTA ?**
- **FLOPPY ?**
- **FRANK ?**
- **???**

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Collaborations

QuarkNet centers connected to high-energy experiments operating at

- CERN in Switzerland
- Fermilab in Illinois
- SLAC in California, and others.

Physicists mentor and collaborate with high school teachers.
Through these collaborations:

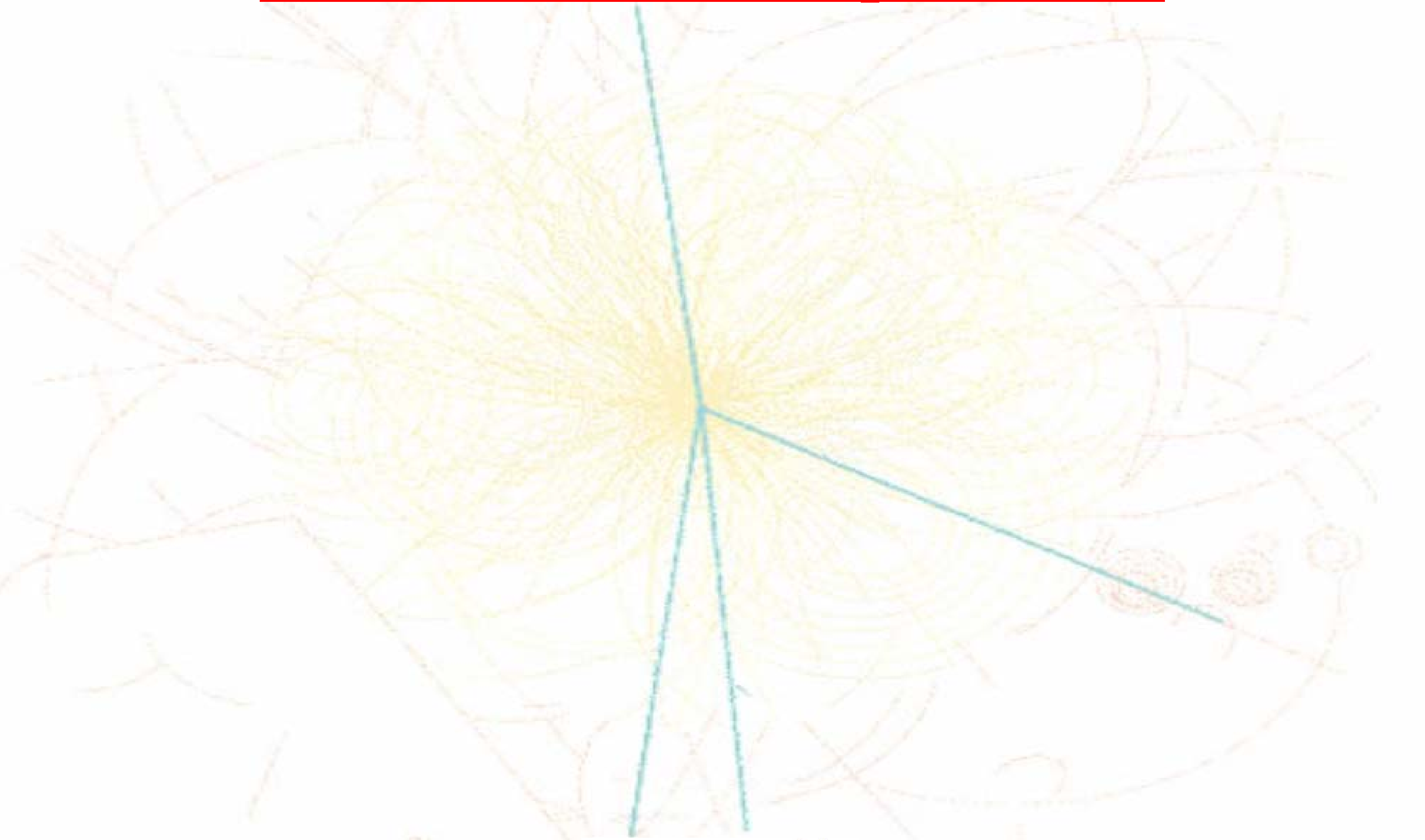
- Students learn fundamental physics as they analyze live online data and participate in inquiry-oriented investigations.
- Teachers join research teams with physicists at a local university or laboratory.

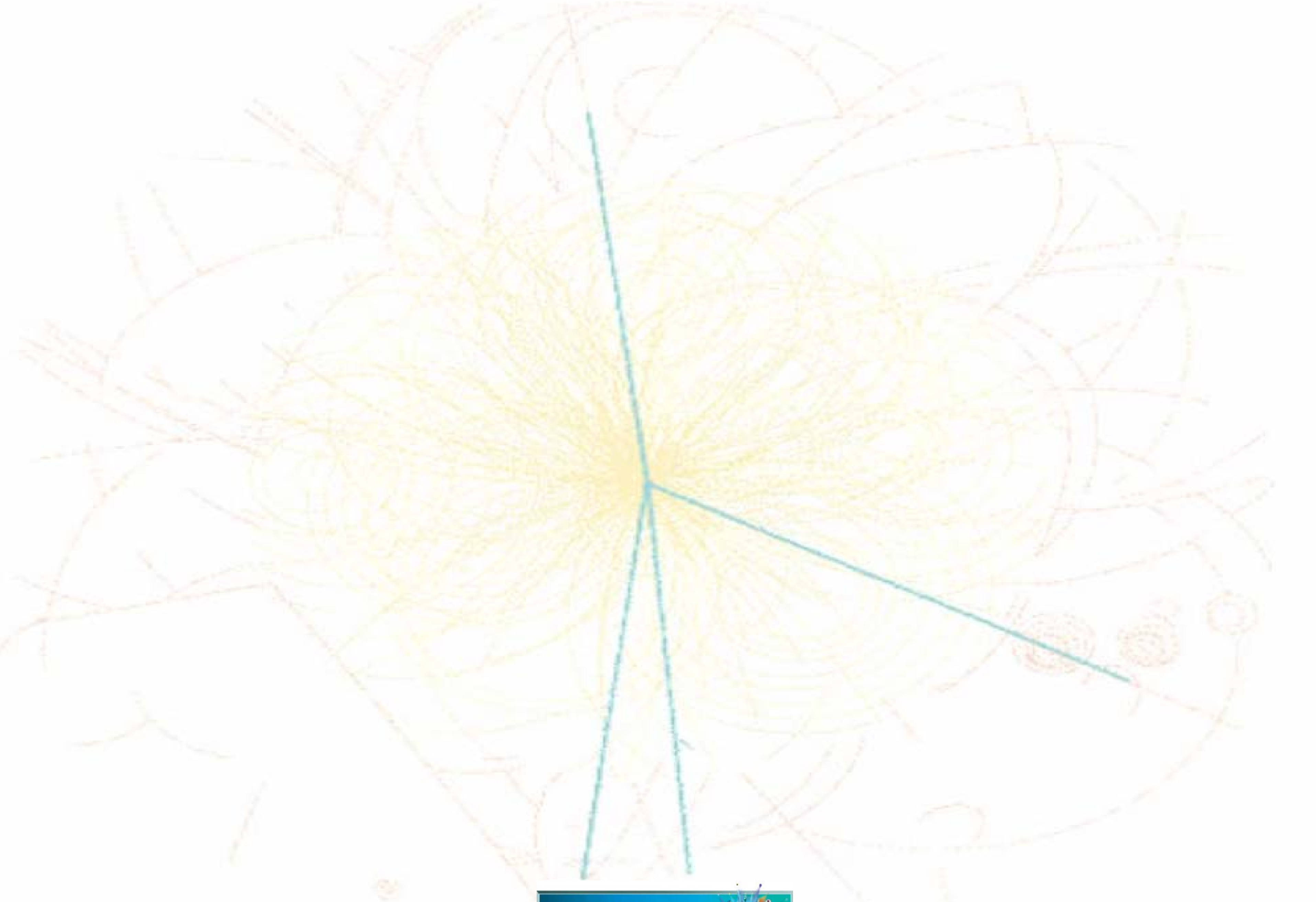
Basic Concepts

- CERN LHC
  - 2005 +
  - ATLAS
  - CMS
- Tevatron Run 2
  - 2000 +
  - CDF
  - DØ

- Long Time Duration Projects
- Substantial Funding Requirements
- Enthusiastic and Skilled Workforce Required
- Public Awareness Needed, Education and Outreach
- Education Component to Funded Research
- Coherence
- Inquiry-based instruction

CERN and LHC-experiments





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- Based on hadron calorimetry for CMS.
  - Long project duration to attract participants from local schools.
  - Collaboration with other universities and labs (national and international).
- Readout boxes for scintillation tile calorimetry.
  - Teachers learn about detectors and calorimeters and their application in particle physics and for the CMS experiment.
- Teachers/students participate in the detector construction project, 3-4 year duration.
  - Fabrication and Q/C studies.
  - Assembly tests at Fermilab, beam tests and assembly at CERN.
- Teachers and students participate on-line and off-line in analysis and other group activities over the lifetime of the CMS project
  - Participation in group milestones, experimental milestones, and LHC turn-on.
  - Awareness of other important physics, scientific, and cultural milestones.

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