Helping Develop America's Technological Workforce

QuarkNet

The QuarkNet Collaboration

NSF | U.S. Department of Energy | Office of Science

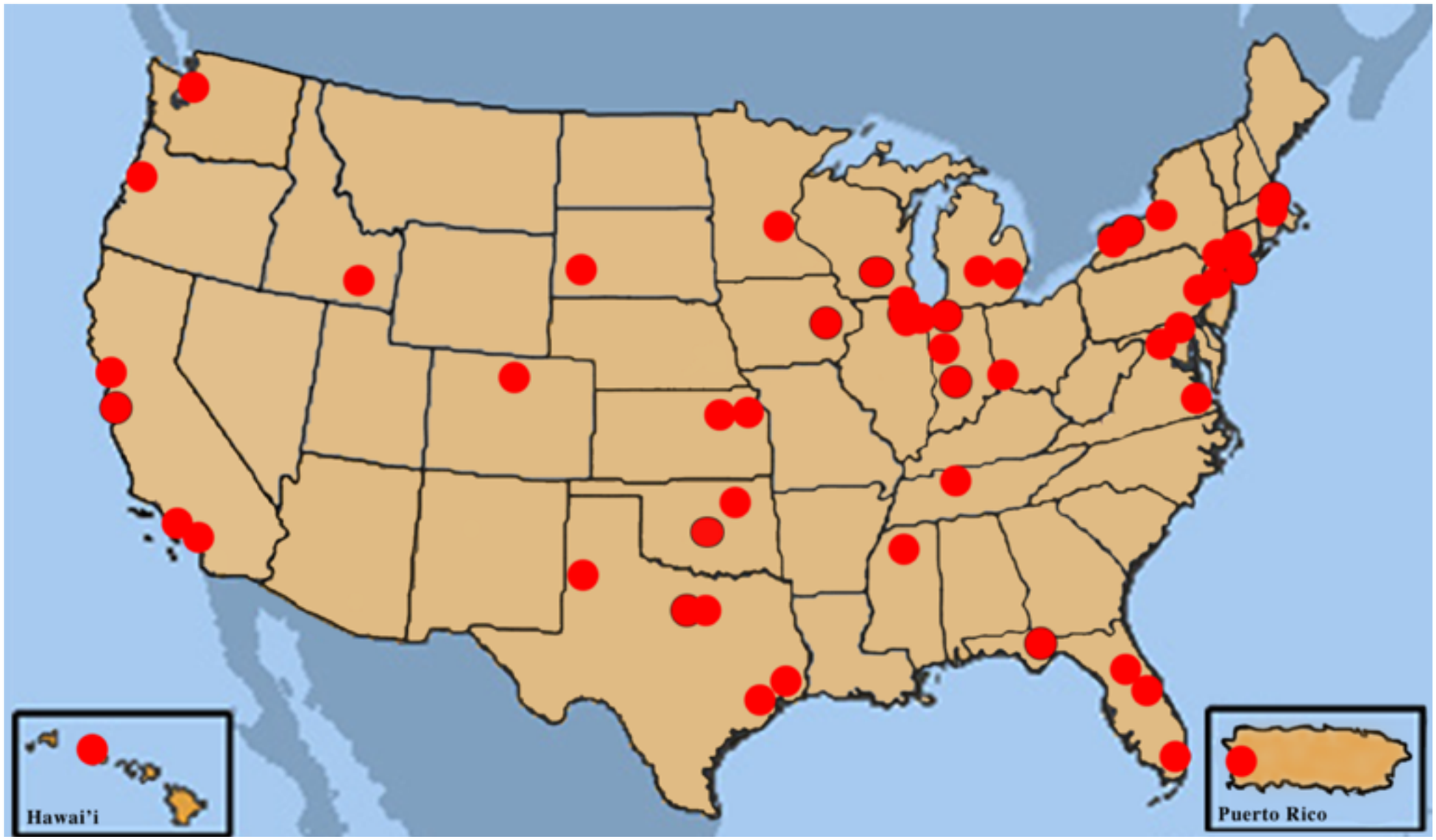
M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

QuarkNet

The QuarkNet Collaboration

50+ Centers at Universities & Labs



M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet 1999-2012

Program Overview

Management

History

Program Enhancements

M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

Vision

A lasting community of researchers that includes high school teachers and students as well as physicists

"Doing science."

School science reflects the practice of science.

Science is what students DO, not what is done to them.

M. Bardeen, Tbilisi, December 2012

QuarkNet

The QuarkNet Collaboration

Impact

Effect of long-term relationship on teachers' professionalism

Effect of students' opportunities and abilities to engage in scientific investigations

M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet 1999-2012

- Program Overview
- **Management**
- History
- Teacher Activities
- Scientific Literacy

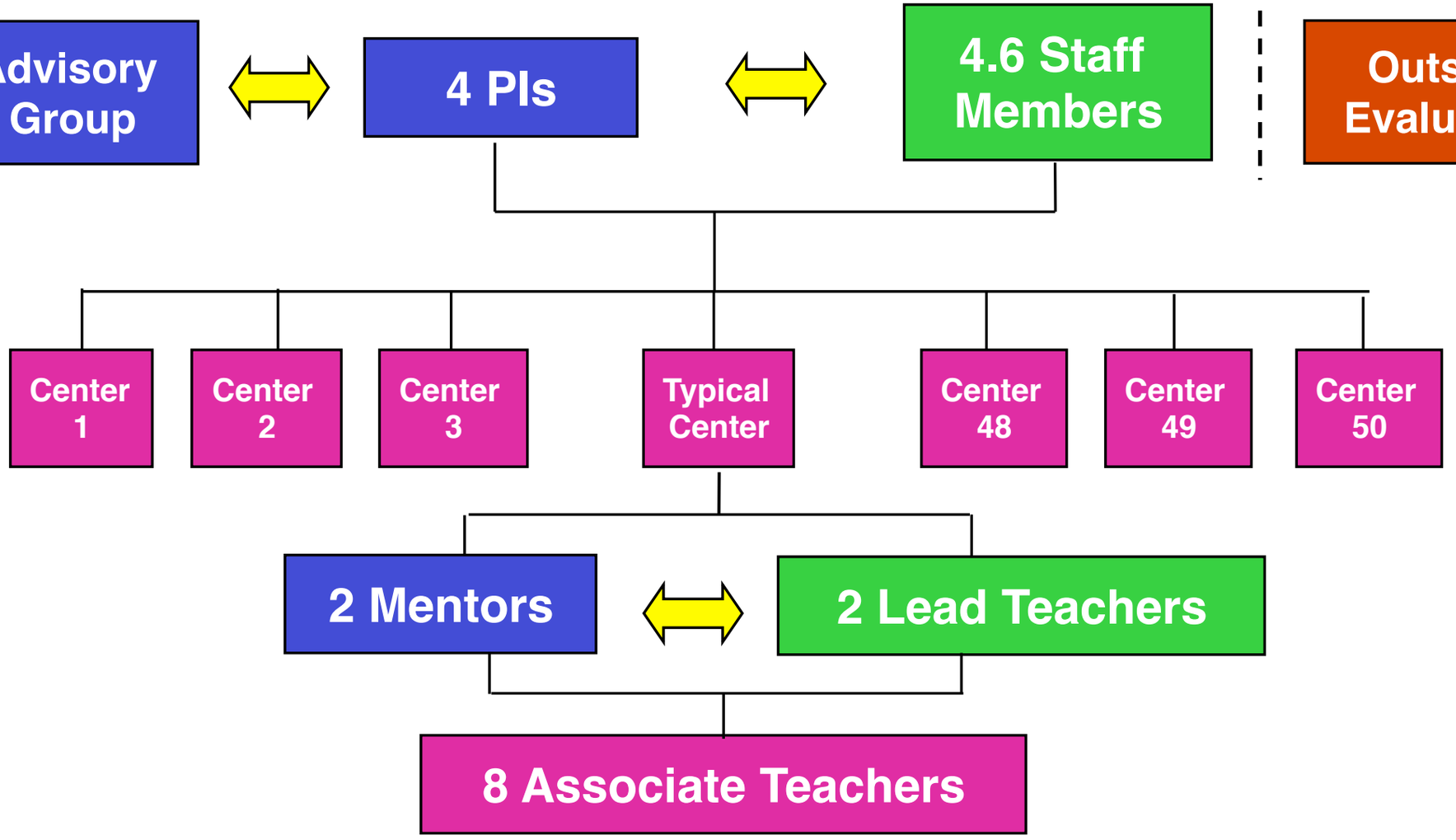
M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

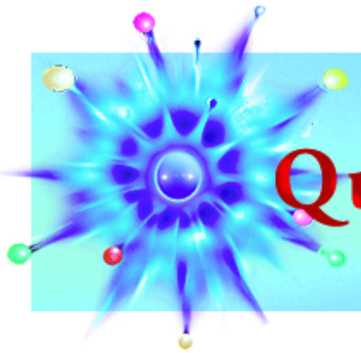
QuarkNet

The QuarkNet Collaboration

Management Chart



M. Bardeen, Tbilisi, December 2012



The QuarkNet Collaboration

Staff Teacher Resonsibilities

Centers

Program areas, e.g., Ken - LHC & Tom - Teaching & Learning

Developing resources

Peer coaching

Broader impacts

Dissemination

Assisting with data collection for evaluators, reporting, reviews, etc.

QuarkNet

The QuarkNet Collaboration

Formative Program Evaluation

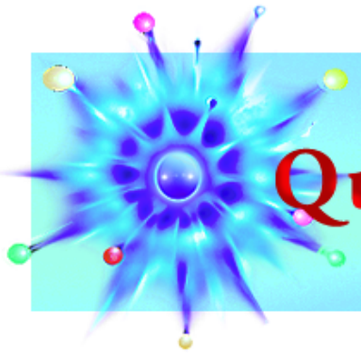
Outside evaluators with assistance from leadership fellows

Metrics - monitoring QuarkNet

Sample evaluation study questions:

- **To what extent does QuarkNet provide opportunities for teachers to learn?**
- **Do teachers use modern physics examples in interactive ways?**
- **Do teachers provide opportunities for students to engage in scientific inquiry?**

. . .



The QuarkNet Collaboration

Using Data to Make Decisions
Study Questions and Contributing Activities

Question	Boot Camp	Cosmic Ray Studies	Masterclass	Centers	Summer Research
1	√	√	√	√	√
2		√	√	√	
3		√	√	√	
4		√	√	√	√
5		√	√		
6				√	

M. Bardeen, Tbilisi, December 2012

The QuarkNet Collaboration

Program Stats

50+ centers at universities & labs

561 teachers

100 mentors

~$1.5M per year

- **Teacher stipends + some extras**
- **Staff salaries & travel**
- **Evaluation**
- **Advisory Board**

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet 1999-2012

- Program Overview
- Management
- History
- Teacher Activities
- Scientific Literacy

M. Bardeen, Tbilisi, December 2012

QuarkNet

The QuarkNet Collaboration

The Beginning

The Context: SSC cancelled; LHC under construction

1997 - Review of particle physics education and outreach

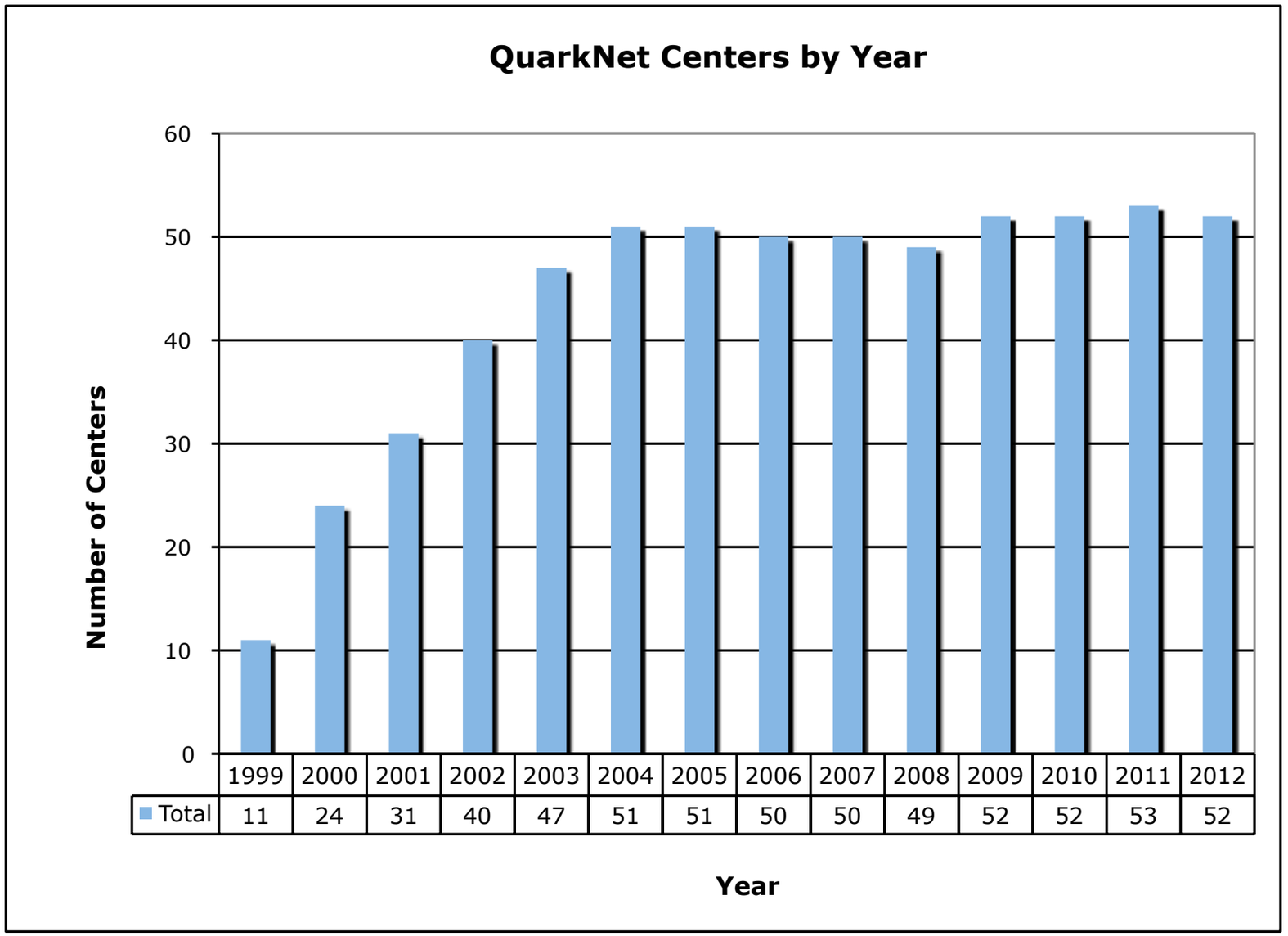
1998 - Request for a coherent, national outreach program

1999 - First QuarkNet centers established

QuarkNet

The QuarkNet Collaboration

Adding Centers

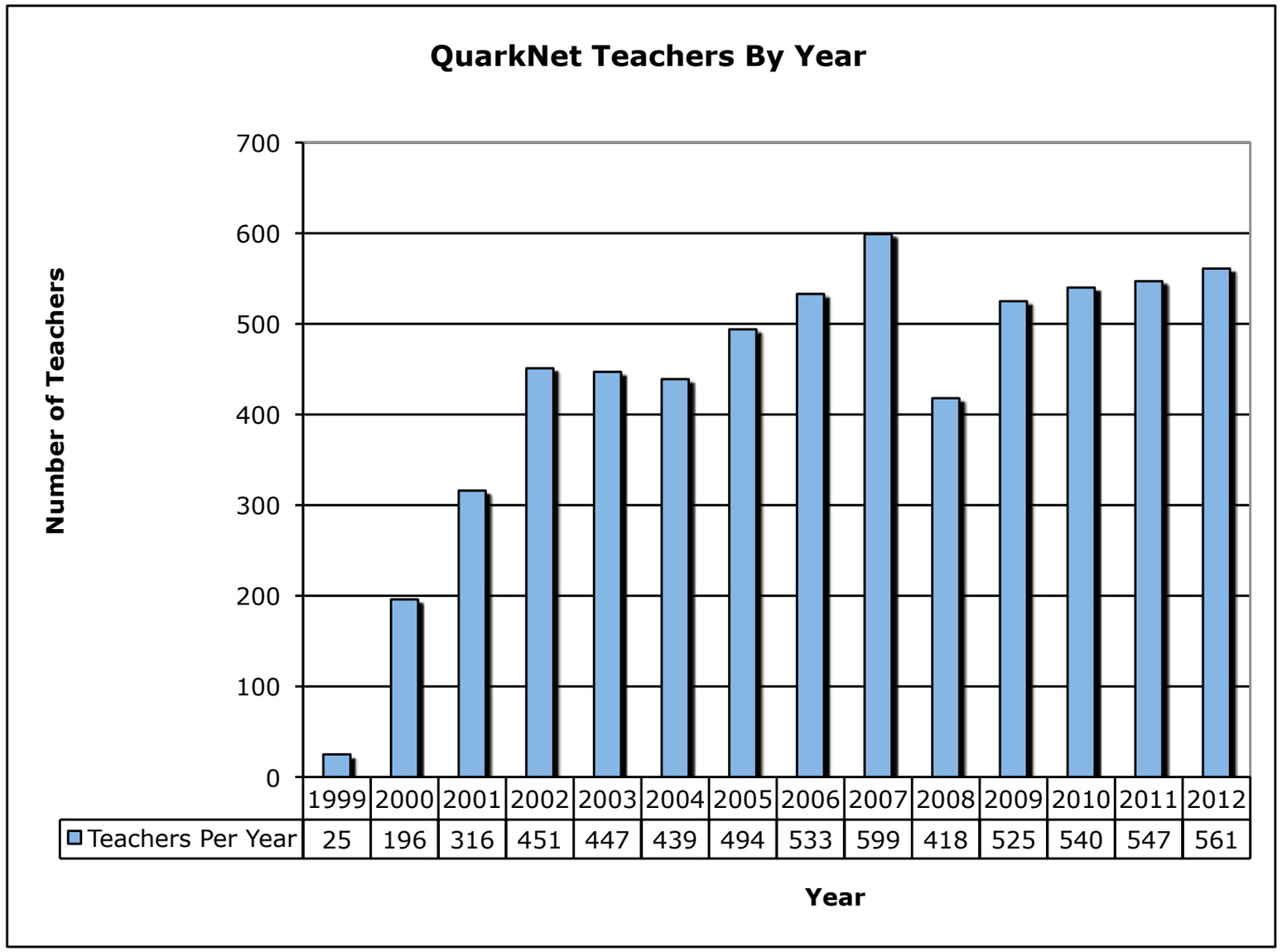


M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet Participants



M. Bardeen, Tbilisi, December 2012

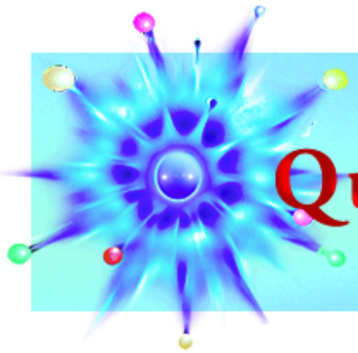
Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet 1999-2012

- Program Overview
- Management
- History
- Teacher Activities
- Scientific Literacy

M. Bardeen, Tbilisi, December 2012



The QuarkNet Collaboration

Multi-Year Program for Each Center

Year I - Research Experience + Boot Camp for 2 teachers

Year II - Summer Institute for up to 10 teachers

Year III & beyond - Learning Community

- **1-week equivalent follow-on only**
- **1-week with student research team**

M. Bardeen, Tbilisi, December 2012

The QuarkNet Collaboration

QuarkNet Learning Communities

1-week follow-on program for all teachers

Optional Programs

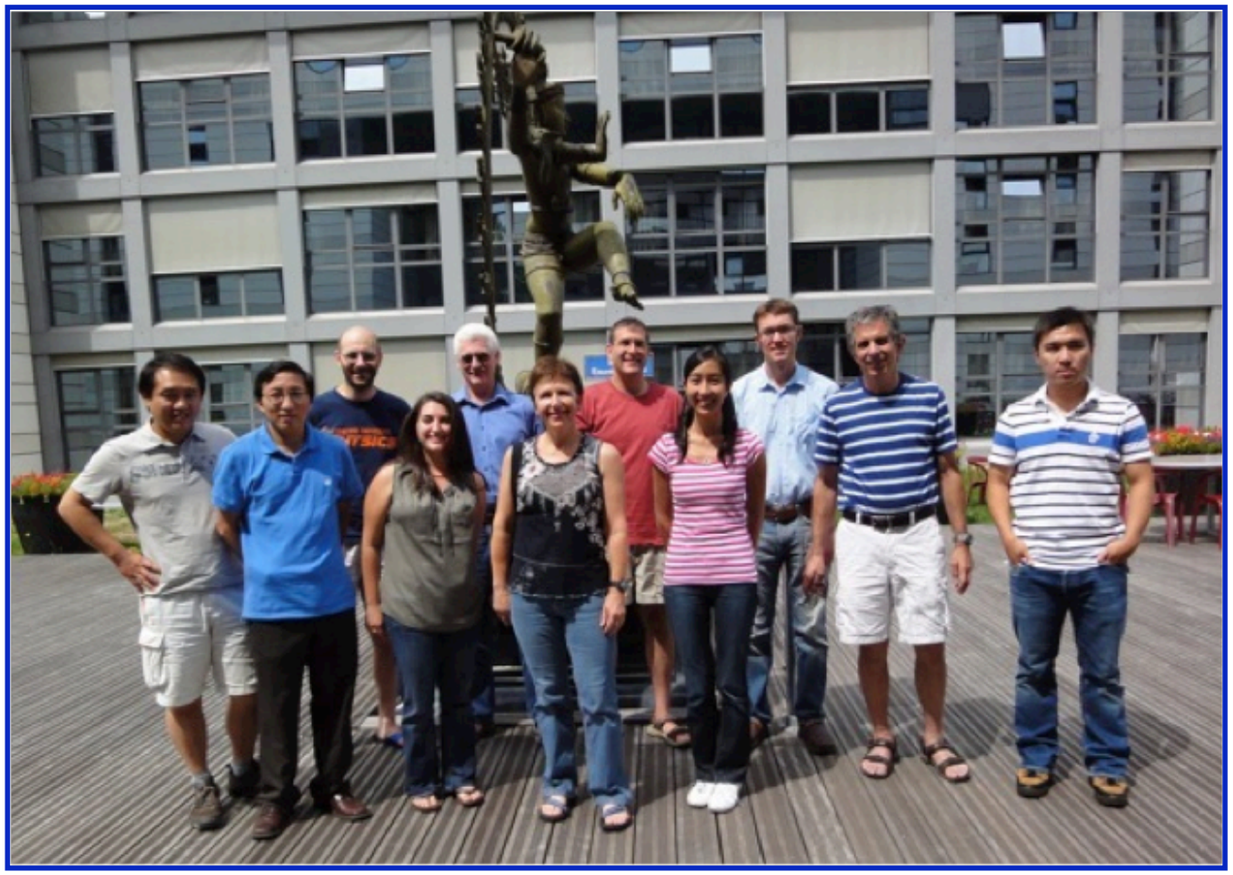
- **For Teachers:**
  - **Boot Camp**
  - **Teaching & Learning Academy**
  - **e-Lab workshops**
- **For Students:**
  - **Summer research team**
  - **Masterclass**
  - **Cosmic Ray Studies**

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

2012 Summer Research at Syracuse University Center

- 2 teachers at CERN
- ROOT-based LHCb event display
- Time in LHCb control room
- Visits to other experiments
- Summer lectures

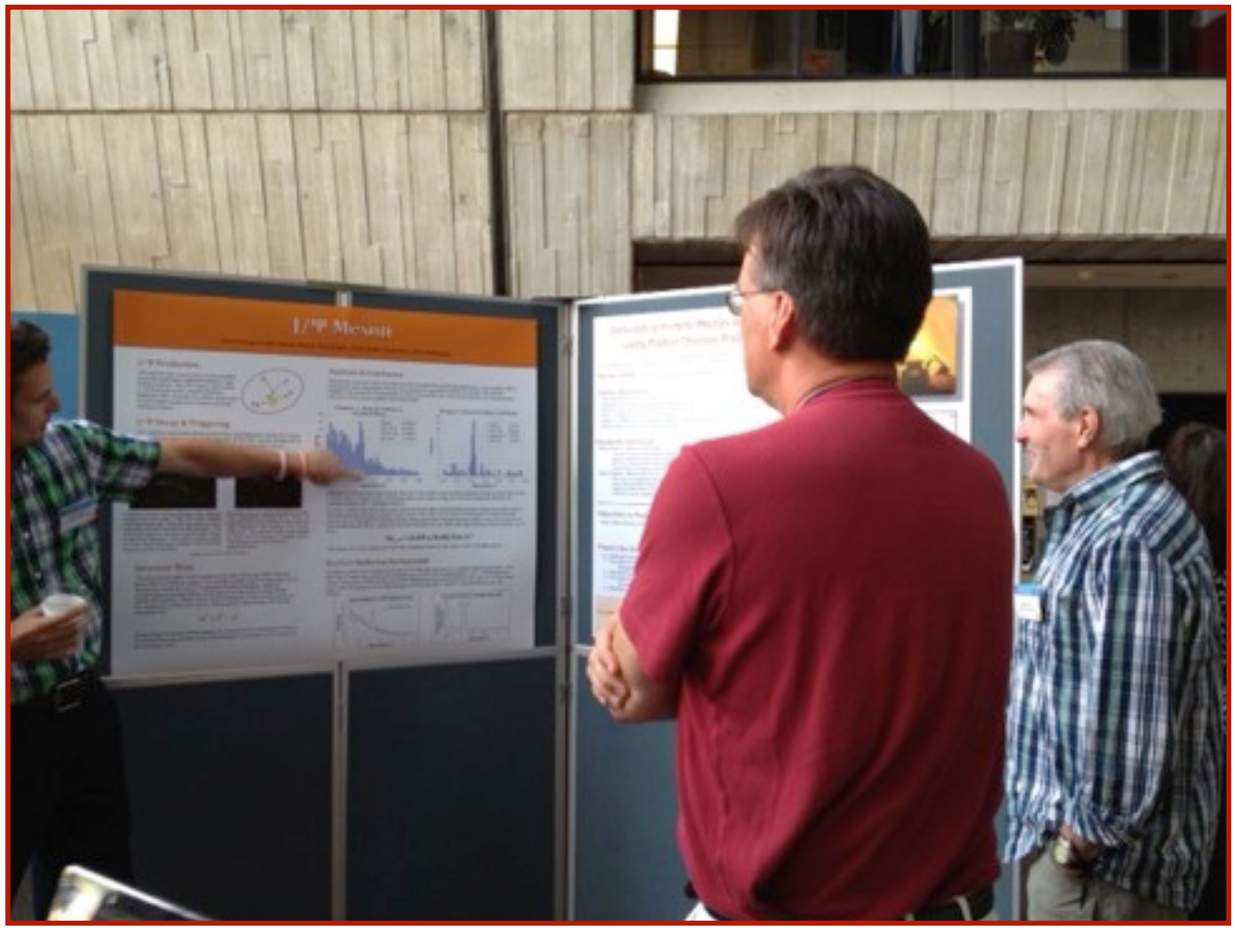


M. Bardeen, DOE/NSF Review, May, 2006

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

2012 Boot Camp



Adult model e-Lab

- CMS data analysis
- Use of elementary physics concepts & techniques
- Conclusions based on statistical evaluation of data
- Research posters
- Pedagogy reflections

M. Bardeen, DOE/NSF Review, May, 2006

QuarkNet

The QuarkNet Collaboration

3-Week Summer Institute @ Black Hills State

- 3-day cosmic ray workshop
- + 1 week with detectors
- Learning to operate planetarium software
- Lectures
- Activities at Homestake Mine
- Building cloud chambers

M. Bardeen, DOE/NSF Review, May, 2006

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

1-week Follow-on @ Hampton University

- Summer workshop
- Masterclasses
- Cosmic ray detectors

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

QuarkNet 1999-2012

- Program Overview
- Management
- History
- Teacher Activities
- **Scientific Literacy**

M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

Scientific discovery is a journey, not an event!

1. What we know
2. Questions we ask
3. Tools we build and use
4. How we know
5. What we learn

M. Bardeen, Tbilisi, December 2012

Helping Develop America's Technological Workforce

QuarkNet

The QuarkNet Collaboration

Data Activities from QuarkNet . . .

. . . that engage high school students.

Research Experiences

Data in Masterclasses

Data in Investigations

M. Bardeen, Tbilisi, December 2012

QuarkNet

The QuarkNet Collaboration

What Students Gain

A broader frame of reference for science:

How scientists discover new knowledge
How they talk about their work

Helping Develop America's Technological Workforce

QuarkNet

The QuarkNet Collaboration

Student Summer Research

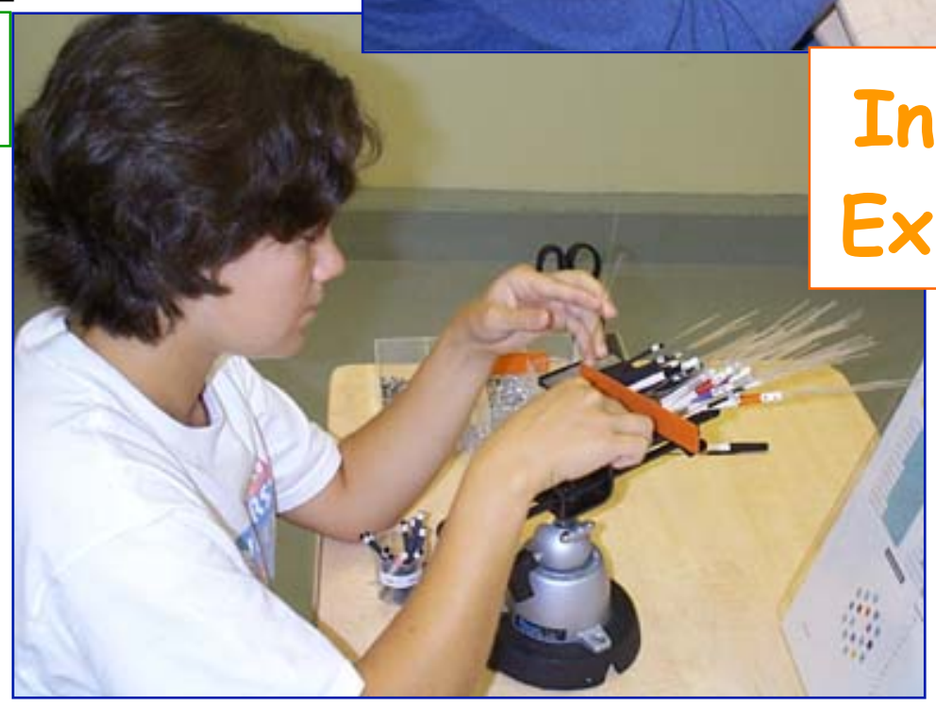
4 students + 1 teacher for 6 weeks

A taste of a succulent future

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

Continually challenged me

Too much fun



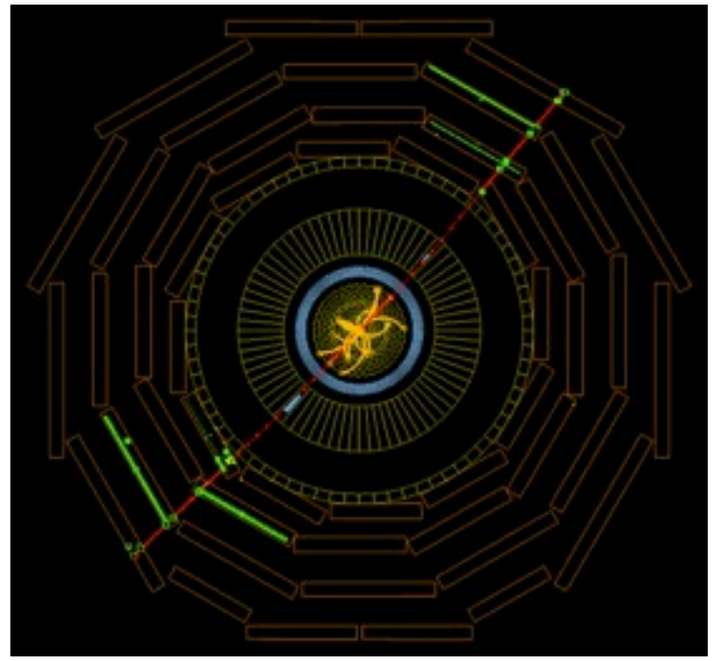
Invaluable Experience

M. Bardeen, DOE/NSF Review, May, 2006

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

CMS & ATLAS Masterclasses



Hands-on data analysis

Presentations

Tours

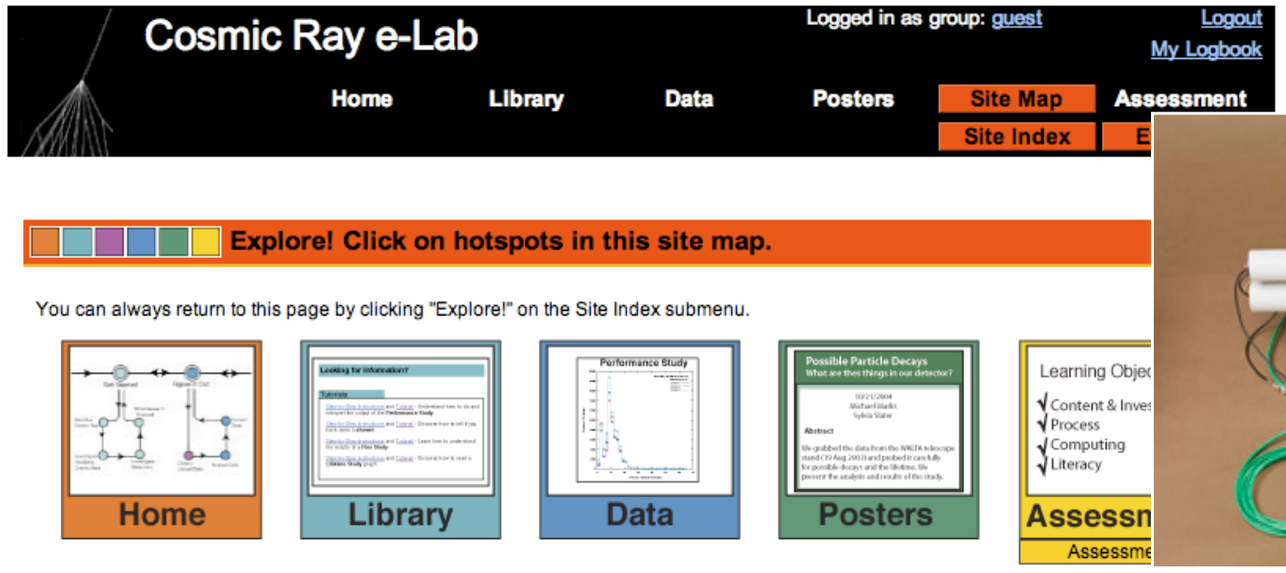
Videoconferences @ CERN or Fermilab

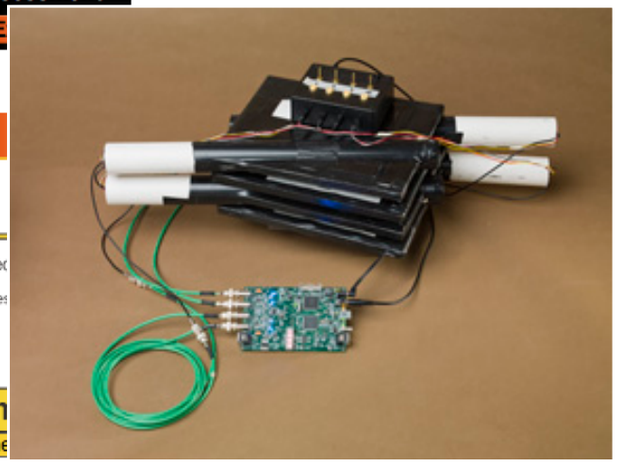
M. Bardeen, DOE/NSF Review, May, 2006

Helping Develop America's Technological Workforce

The QuarkNet Collaboration

Guided Investigations with I2U2





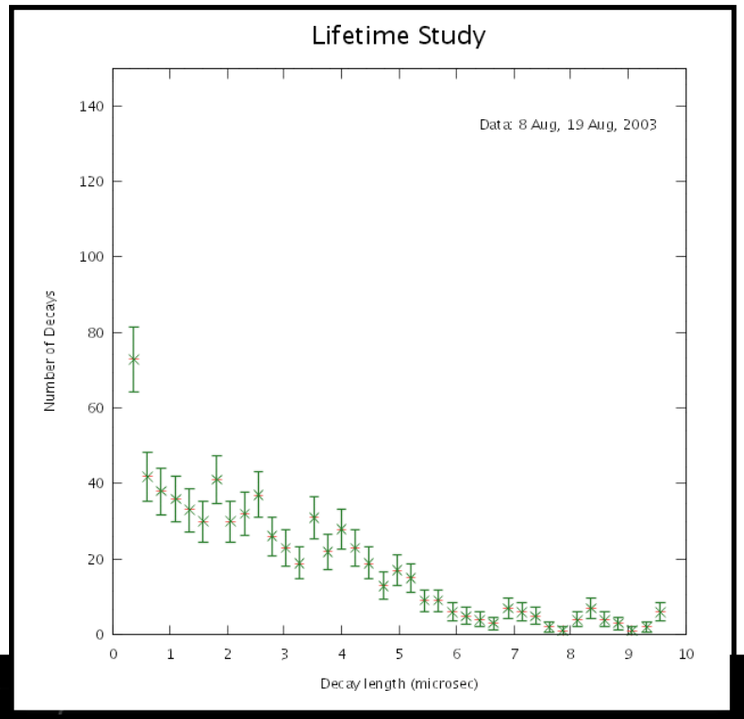
M. Bardeen, Tbilisi, December 2012

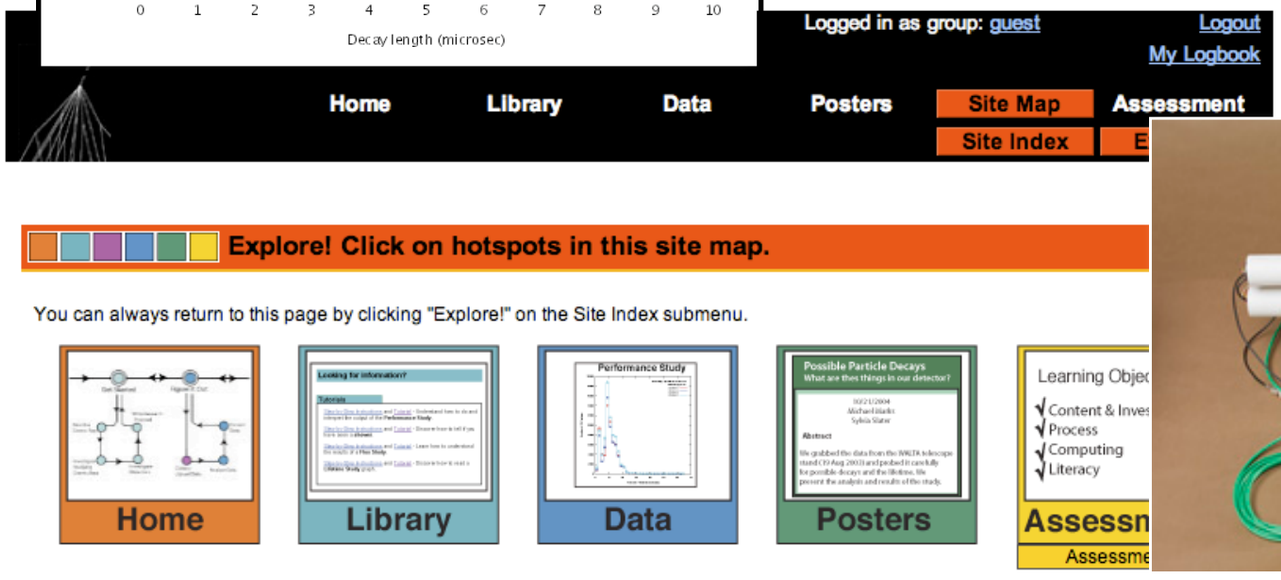
Helping Develop America's Technological Workforce

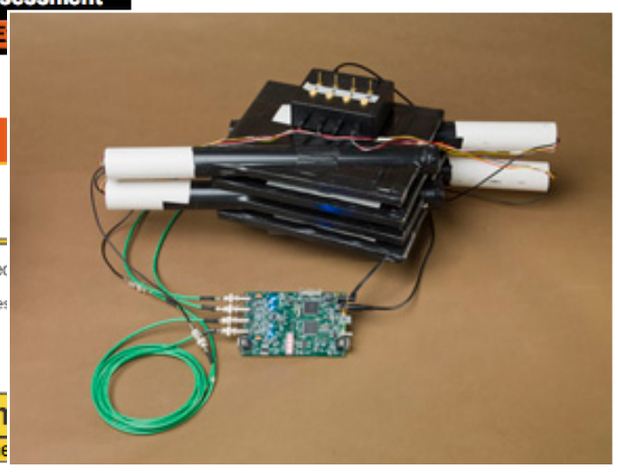
QuarkNet

The QuarkNet Collaboration

Guided Investigations with I2U2







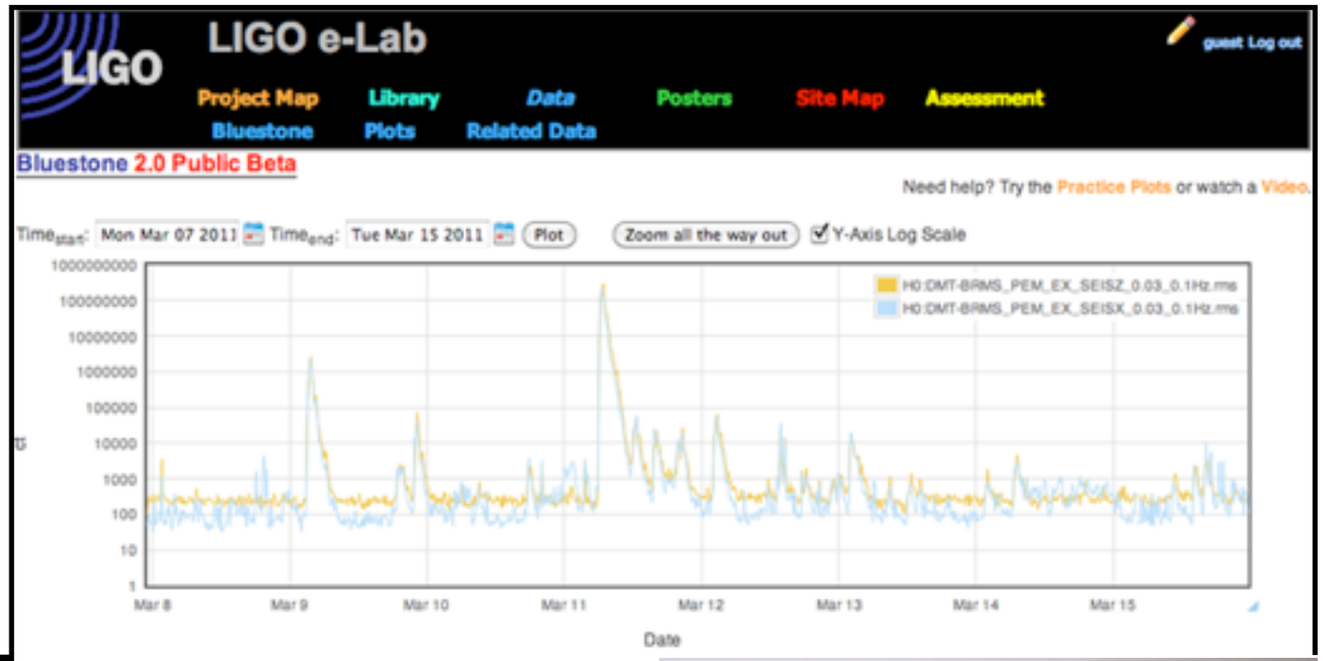
M. Bardeen, Tbilisi, December 2012

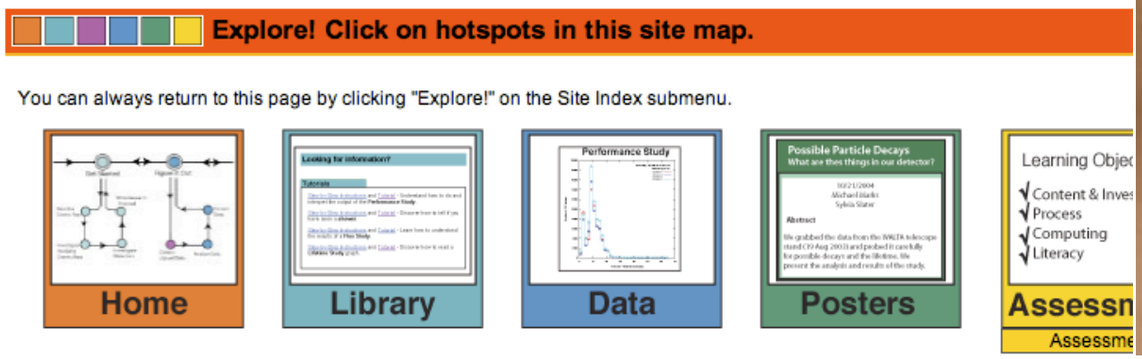
Helping Develop America's Technological Workforce

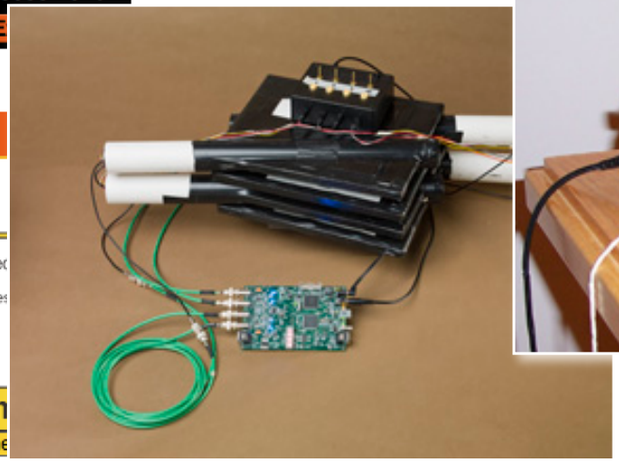
QuarkNet

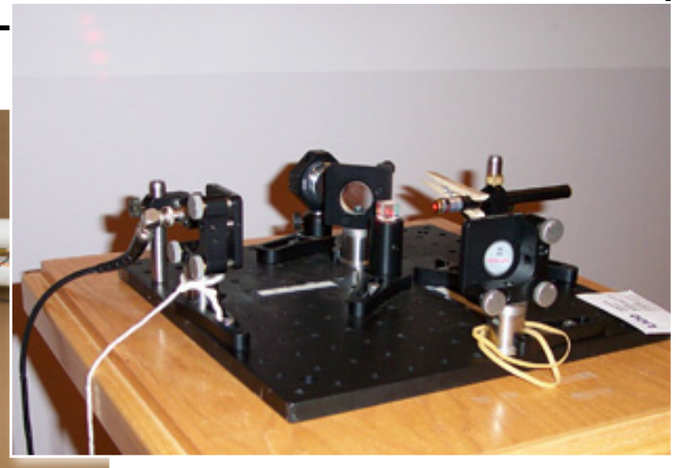
The QuarkNet Collaboration

Guided Investigations with I2U2







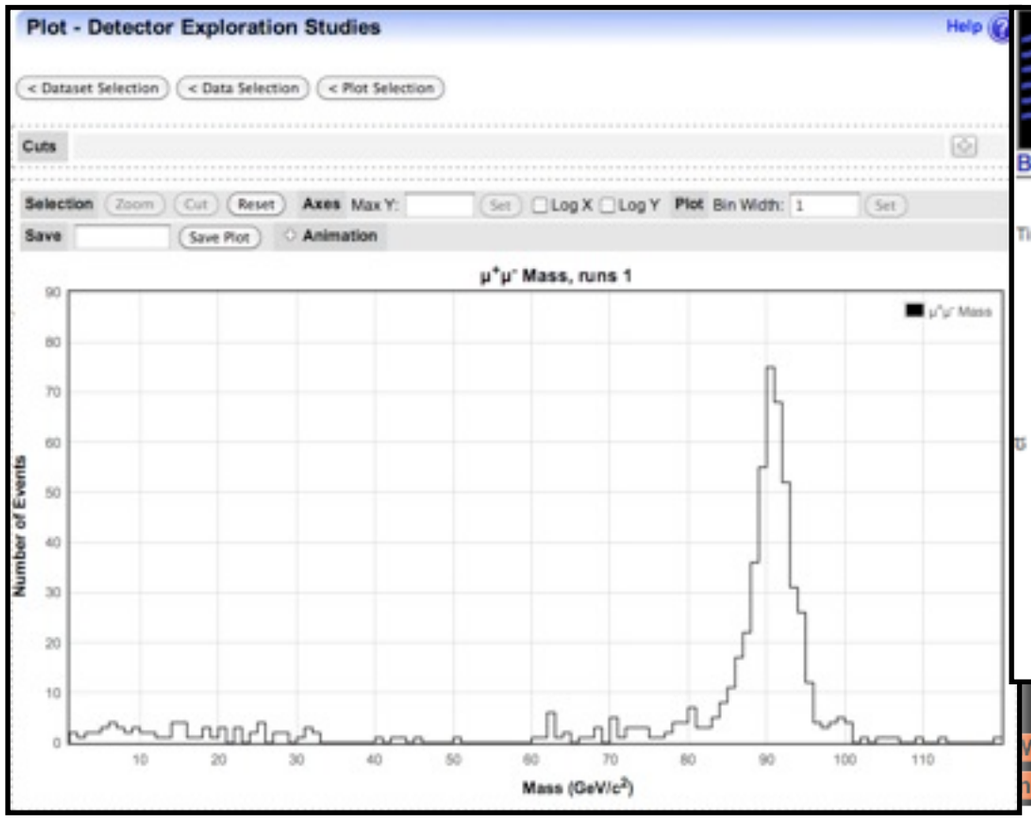


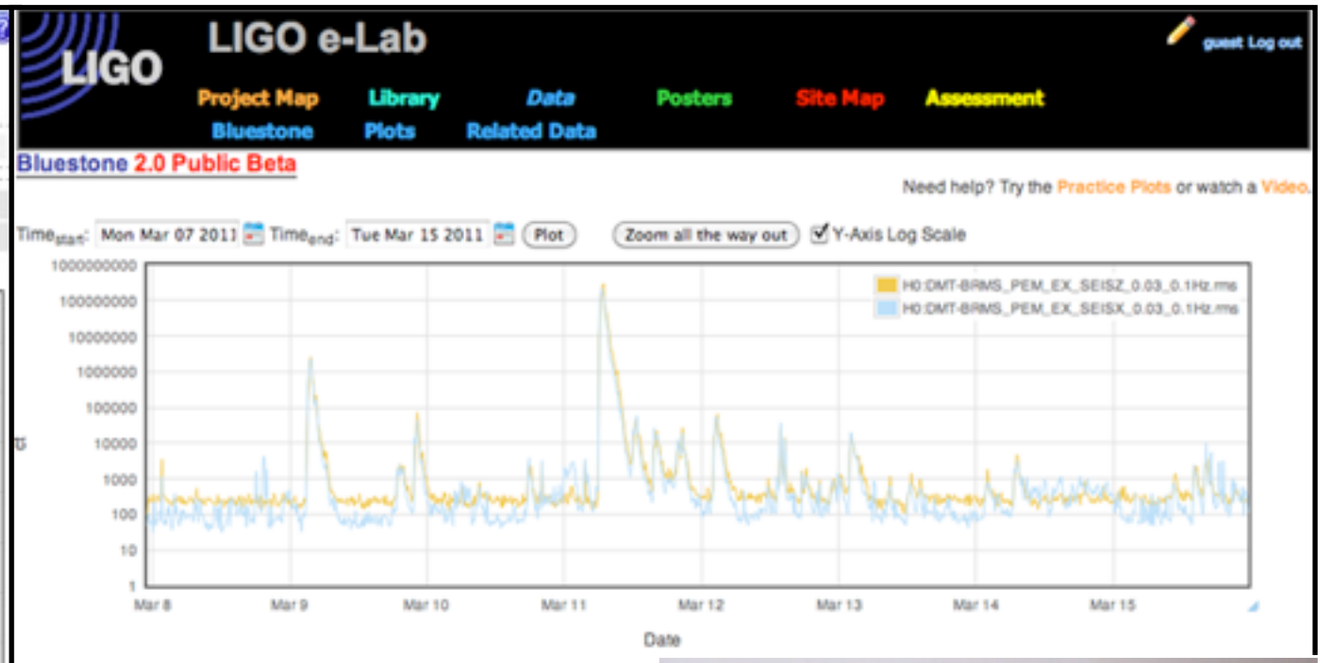
M. Bardeen, Tbilisi, December 2012

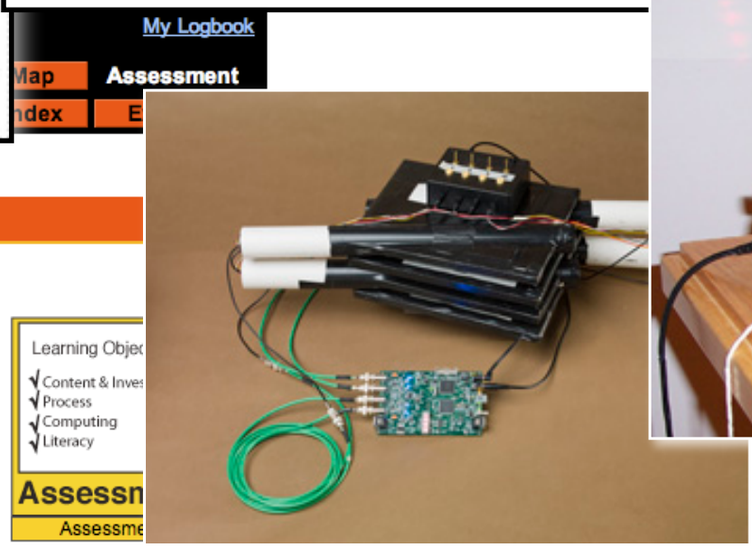
Helping Develop America's Technological Workforce

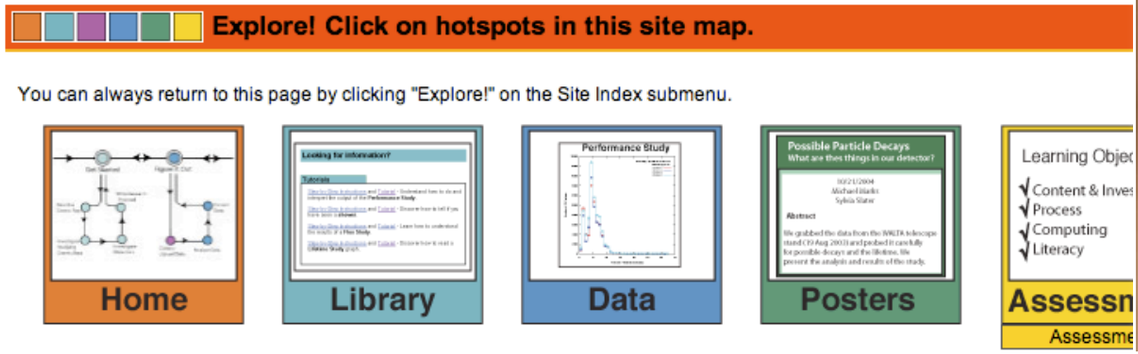
The QuarkNet Collaboration

Guided Investigations with I2U2









M. Bardeen, Tbilisi, December 2012

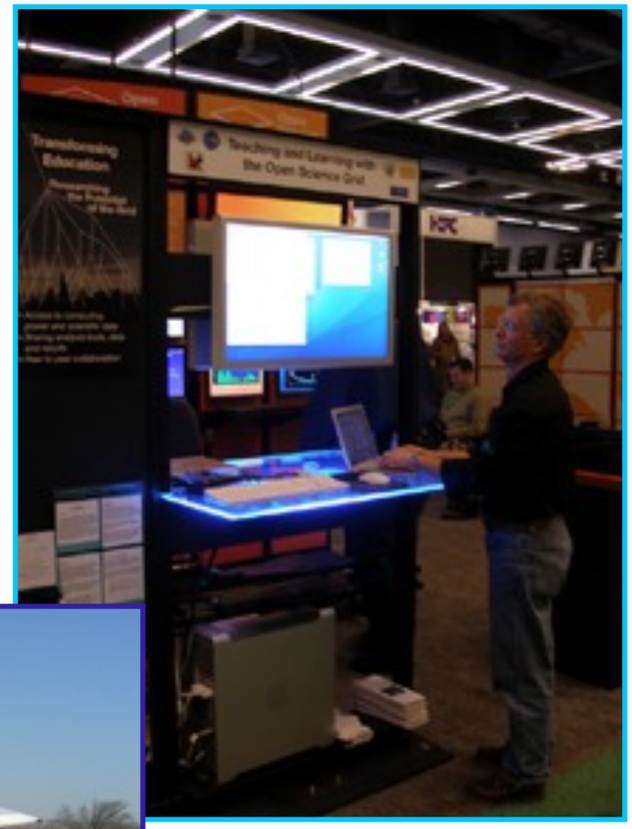
The QuarkNet Collaboration

Cosmic Ray Detector

Teachers' idea

Several prototypes

Data collection led to e-Lab.



M. Bardeen, DOE/NSF Review, May, 2006

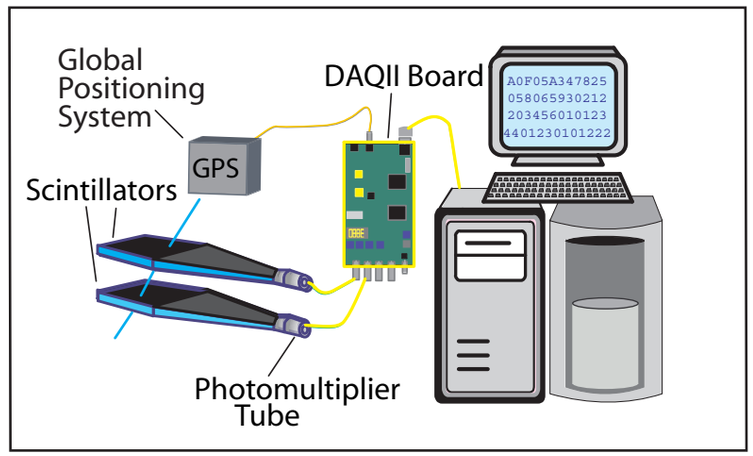
Helping Develop America's Technological Workforce

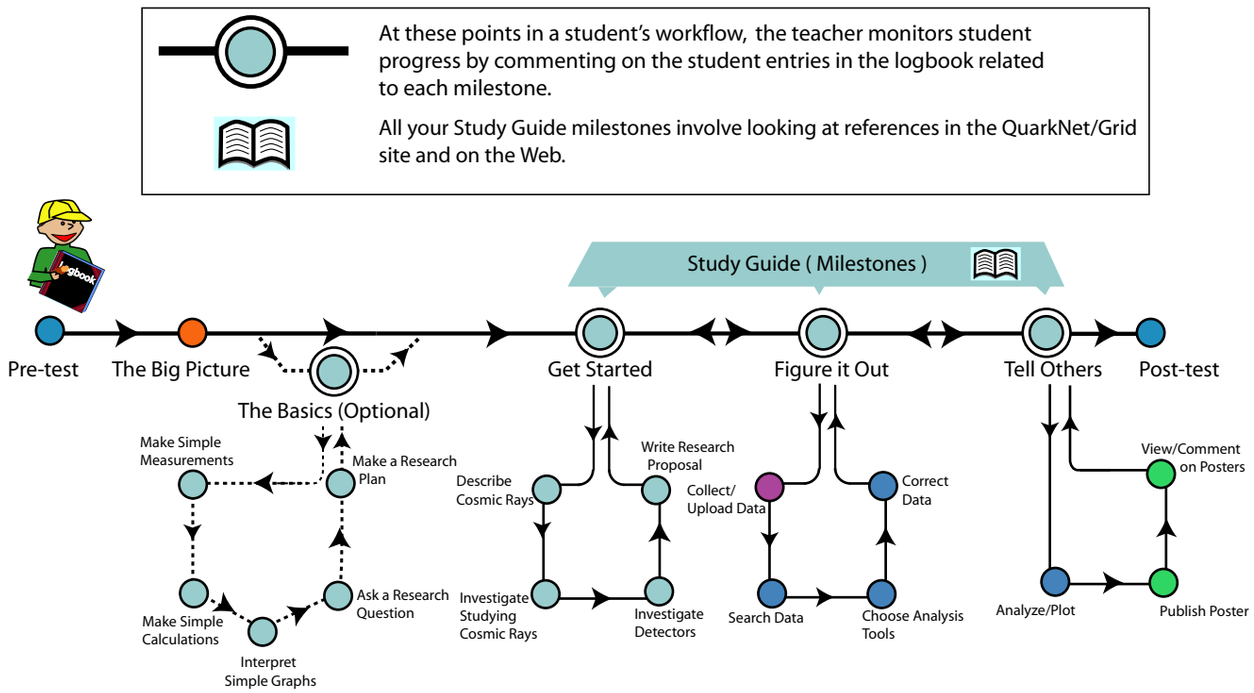
The QuarkNet Collaboration

Cosmic Ray Studies

We have users!

- 1,057 teachers in 1,064 high schools
- 2,273 student research groups
- 1,081 posters
- 705 DAQs in the field





M. Bardeen, DOE/NSF Review, May, 2006

QuarkNet

The QuarkNet Collaboration

QuarkNet, a Partnership

Creates a long-term "research community"

Develops links between experiments & classrooms

Develops professionalism of teachers

Engages students in scientific investigations

Develops scientific literacy

M. Bardeen, DOE/NSF Review, May, 2006