Forging New, Non-Traditional Partnerships among Physicists, Teachers and Students

quarknet.i2u2.org

Marjorie Bardeen, Fermilab

(mbardeen@fnal.gov)
Context
The Collaboration
Benefits
Others too
“... to make science education more closely resemble the way scientists work and think. ... students will gradually deepen their understanding of scientific ideas by engaging in practices that scientists and engineers generally use.
“The practices better explain and extend what is meant by ‘inquiry’ in science and the range of cognitive, social, and physical practices that it requires.”

Next Generation Science Standards: [http://www.nextgenscience.org](http://www.nextgenscience.org)
. . . lends itself to non-traditional education (outreach) programs.

Large collaborations & facilities
Long development & run times

Central management with distributed work nationally & internationally

(more than 160 U.S. universities, institutes & labs)
QuarkNet – starting its 19\textsuperscript{th} year

A long-term professional development program for physics teachers supported by the particle physics research community

50+ centers at universities & labs across the U.S.
82 physicists as volunteer mentors
563 active teachers & their students

+ international outreach

M. Bardeen, ICNFP, July 2016
What makes it non-traditional? It’s . . .

- About building lasting relationships.
- 18 years old.
- A partnership between physicists & teachers top to bottom.
- An open door for teachers into our research community.
- About teachers & student teams making meaningful contributions to HEP experiments.
- Bringing 21st century physics into classrooms.

M. Bardeen, ICNFP, July 2016
Engagement with Scientific Investigations

- Research internships
- Research-based workshops
- Masterclasses
- Cosmic ray detectors
- Access to online datasets
- Data-based instructional materials
- Ongoing support
Where Teachers “Meet QuarkNet”

- Contact point within a distributed program
- Participants form their center
- Meet local interests and needs
- Supported by staff teachers
- Variety of formats and activities
Year 1: Teacher Research Experiences

- Construct & test detector components.
- Analyze data & conduct simulation studies.
- . . . .
Year 2: Typical Activities

All include a study of particle physics:
- Lectures
- Experiments
- Data analysis
- Tours

All include classroom transfer:
- Activities
- Investigations
- Lesson plans
- Demos
Year 3+: Three Basic Formats
+ Student Research Teams

- Physics Alliance
- One-week workshop (summer/several days during the academic year)
- An expanded program with a QuarkNet one-week program as the core
Learning Fundamental Physics by:

- Covering topics in 21st century physics.
- Analyzing real data delivered online.
- Collaborating with students worldwide.
- Participating in inquiry-oriented investigations.
- Experimenting using classroom cosmic ray detectors.
- Visiting research groups & experiments.
Participating in International Masterclasses

- Students + Physicists + Teachers → Masterclass Institute
- $N$ institutes on one day ($N < 5$)
  - Learn about particles physics.
  - Analyze data and combine. → Upload results.
- Videoconference with CERN or Fermilab
- March is “Masterclass season.”

M. Bardeen, ICNFP, July 2016
Studying Cosmic Rays

Hands-on experience with tools just like particle physics experiments

Detectors - Analysis Tools - Collaboration

M. Bardeen, ICNFP, July 2016
Opportunities to:

• Learn science by doing science, not just reading about science.
• Go right to the experts; talk directly with physicists.
• Collaborate with students worldwide.
• Experience the environment of a scientific collaboration.
• Conduct their own scientific investigations.

M. Bardeen, ICNFP, July 2016
Opportunities to:

• Share their passion for particle physics.
• “Recruit” the next generation of scientists . . . and new students for their department.
• Get help in their ongoing research from an interested and eager team.
• Use sophisticated cosmic ray experiments to inspire undergraduate and graduate students.
Opportunities to:

- Learn from the challenges and opportunities of teaching high school physics.
- Reach out to their communities.
- Participate in a credible, impactful outreach program that is highly regarded by our funding agencies.
Opportunities to Work:

• With physicists who are passionate about the work they do.
• With real data . . . with all of the joys and frustrations that accompany that.
• On "real-world" problems that don't necessarily have clear "back of the book" answers.
• On building things! (e.g., detector components or classroom cosmic ray detectors)
Opportunities to:

• Study topics in 21st century physics.
• Learn science by doing science, not just reading about science.
• Have a sense of wonder about the universe.

• Challenge even the brightest students.
• Motivate students to potentially pursue physics or some STEM field.
QuarkNet – a strong outreach program that benefits teachers, students & physicists

“The QuarkNet program offers a unique way to extend the excitement of particle physics to teachers and students everywhere in the United States. It is a jewel of the NSF portfolio.”

Could you adapt our model?

M. Bardeen, ICNFP, July 2016
Teilchenwelt, Germany (2010)
http://www.teilchenwelt.de

HISPARC, The Netherlands (2001)
http://www.hisparc.nl

Institute for Research in Schools, UK (2016)
http://www.researchinschools.org