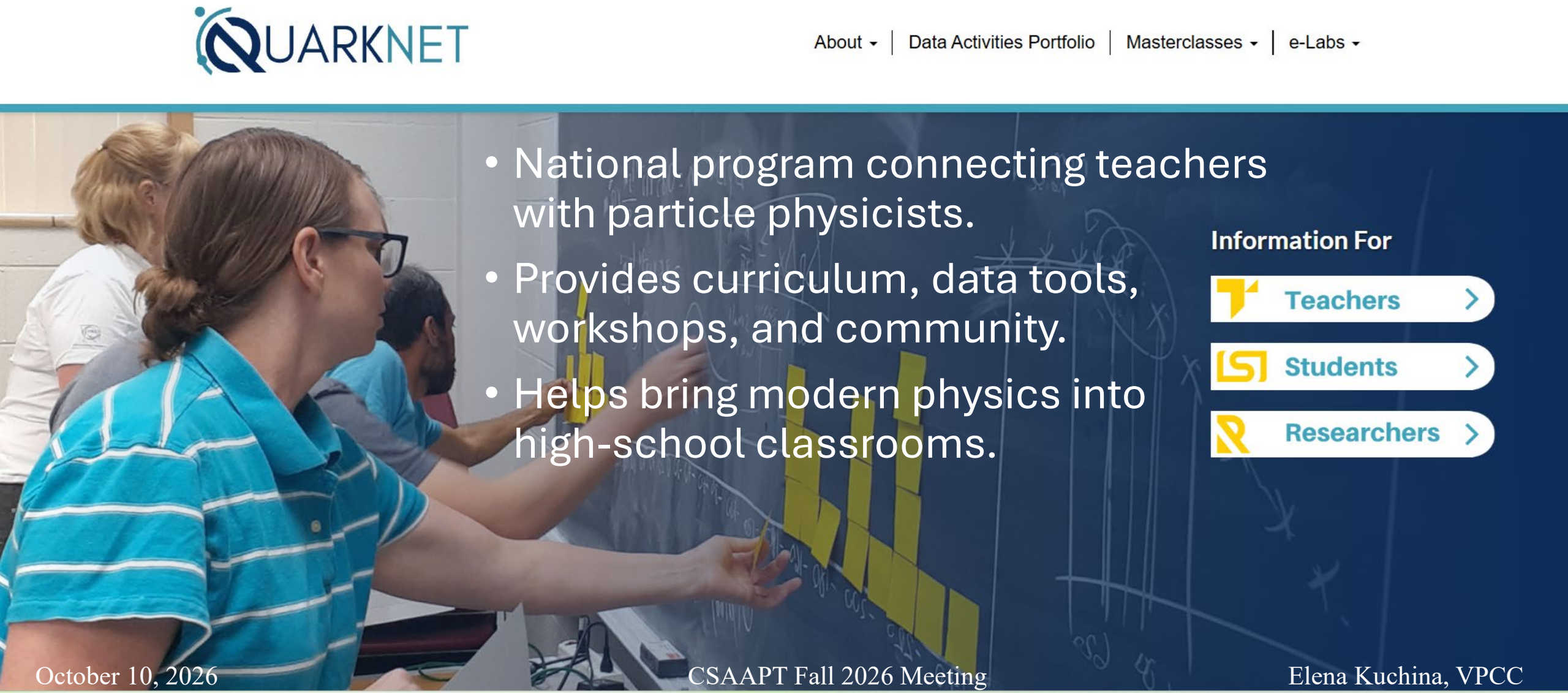
Modern Physics in the Classroom

QuarkNet Demonstrations for High School Teachers

Purpose of This Session

- Highlight how QuarkNet supports teachers.
- Invite participation in local QuarkNet groups, including William & Mary.
- Showcase two hands-on, modern-physics-aligned demos.

What Is QuarkNet?



- National program connecting teachers with particle physicists.
- Provides curriculum, data tools, workshops, and community.
- Helps bring modern physics into high-school classrooms.

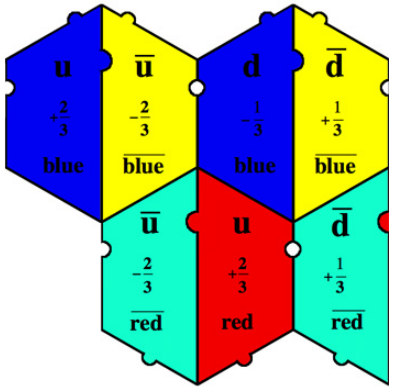


Who We Are

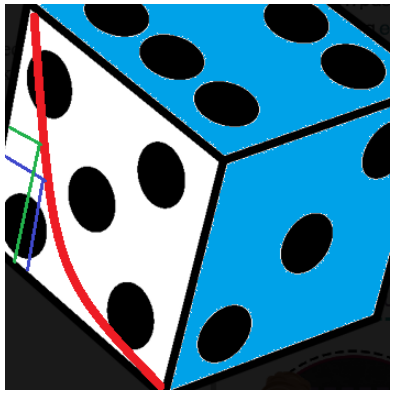
https://quarknet.org/

QuarkNet is dedicated to developing and broadening participation in America's STEM workforce by engaging high school teachers and students in current particle physics research. QuarkNet is a partnership between Fermilab, the University of Notre Dame, and 50 research centers across the United States.

- We are teachers, gaining experience in physics research while developing our talents and classroom effectiveness within a network of peers with whom we grow as professionals.
- We are professional physics researchers, extending our educational impact and engaging with our local communities.
- We are experimental collaborations, sharing our experience and our data with teachers and students.
- We are the QuarkNet staff, a team of dedicated education professionals facilitating these interactions and creating new opportunities for our participants.



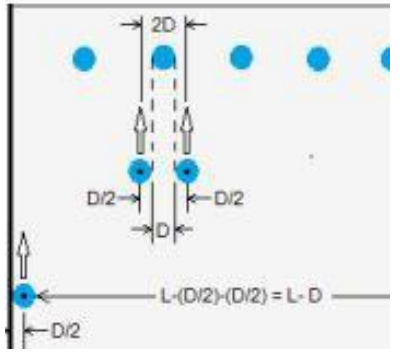
QUARKNET

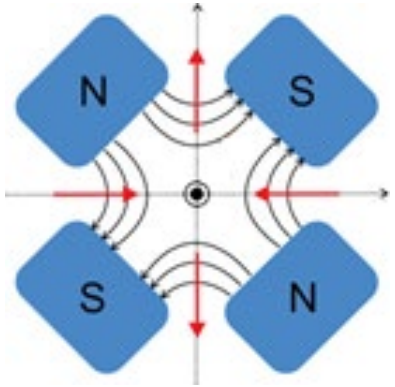


Data Activities Portfolio



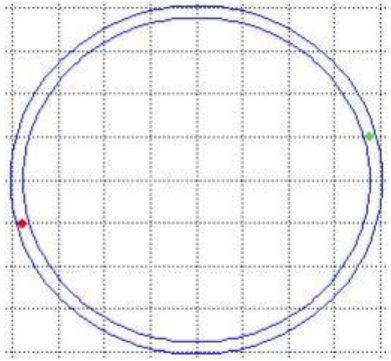
The Data Portfolio is a compendium of particle physics classroom activities organized by Data Strand, Level of student engagement, Curriculum Topics and NGSS Standards. Follow the links provided for information about using the Data Portfolio to plan your students' experience. Level descriptions explain the data analysis skills that students apply at each level: tasks in Level 0 are simpler than those in Levels 1 and 2...





Conservation Laws
Diversity & Inclusion
Electricity and Magnetism
Half-Life/ Mean Lifetime
Instrumentation
Kinematics
Nature of Matter Quantum Mechanics
Special Relativity
Standard model
Waves and interference

Skills:
Developing Models
Graphing
Histograms
Uncertainty
Coding



Opportunity for students in the summer

International Masterclasses

Each year more than 13.000 high school students in more than60 countries come to one of about 225 nearby universities or research centres for one day in order to unravel the mysteries of particle physics. Lectures from active scientists give insight in topics and methods of basic research at the fundaments of matter and forces, enabling the students to perform measurements on real data from particle physics experiments themselves. At the end of each day, like in an international research collaboration, the participants join in a video conference for discussion and combination of their results.



QuarkNet Resources

- Classroom-tested activities and teacher guides.
- Access to real particle-physics data.
- Summer workshops and PD opportunities.
- Online community at quarknet.org.

Opportunity for teachers around the year



World Wide Data Day

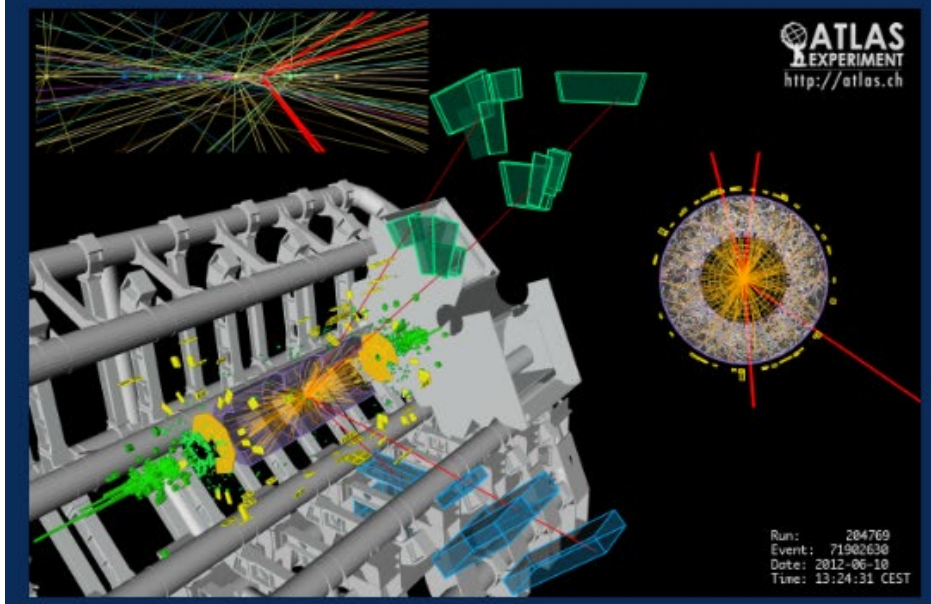
INTERNATIONAL MASTERCLASSES
hands on particle physics

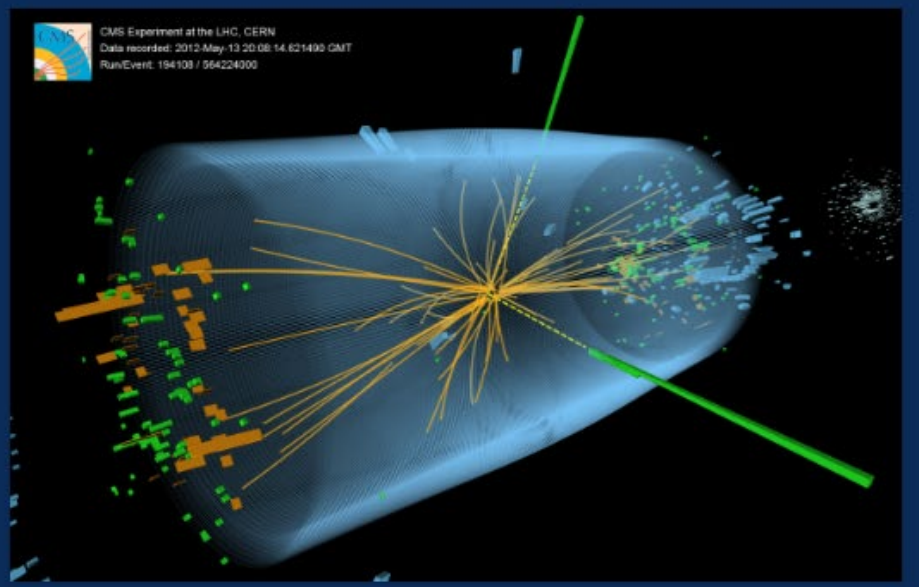
W2D2
World Wide Data Day

World Wide Data Day 2026: 10 November, 00:00-23:59 UTC

World Wide Data Day | ATLAS | CMS | Registration

Registration will open on 02 October, 2026. If you have any questions, please send an e-mail.





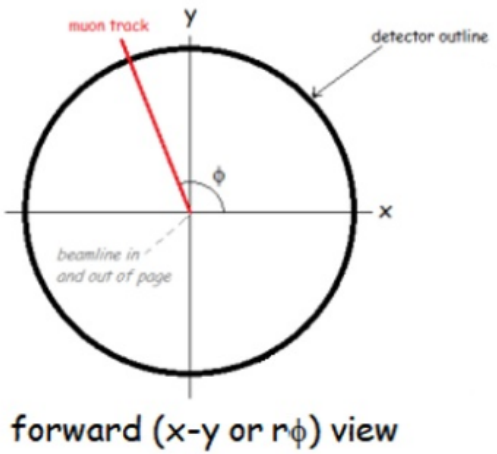
World-Wide Data Day

Experiment (check one): CMS Data set

Materials needed: internet-connected computer, protractor.

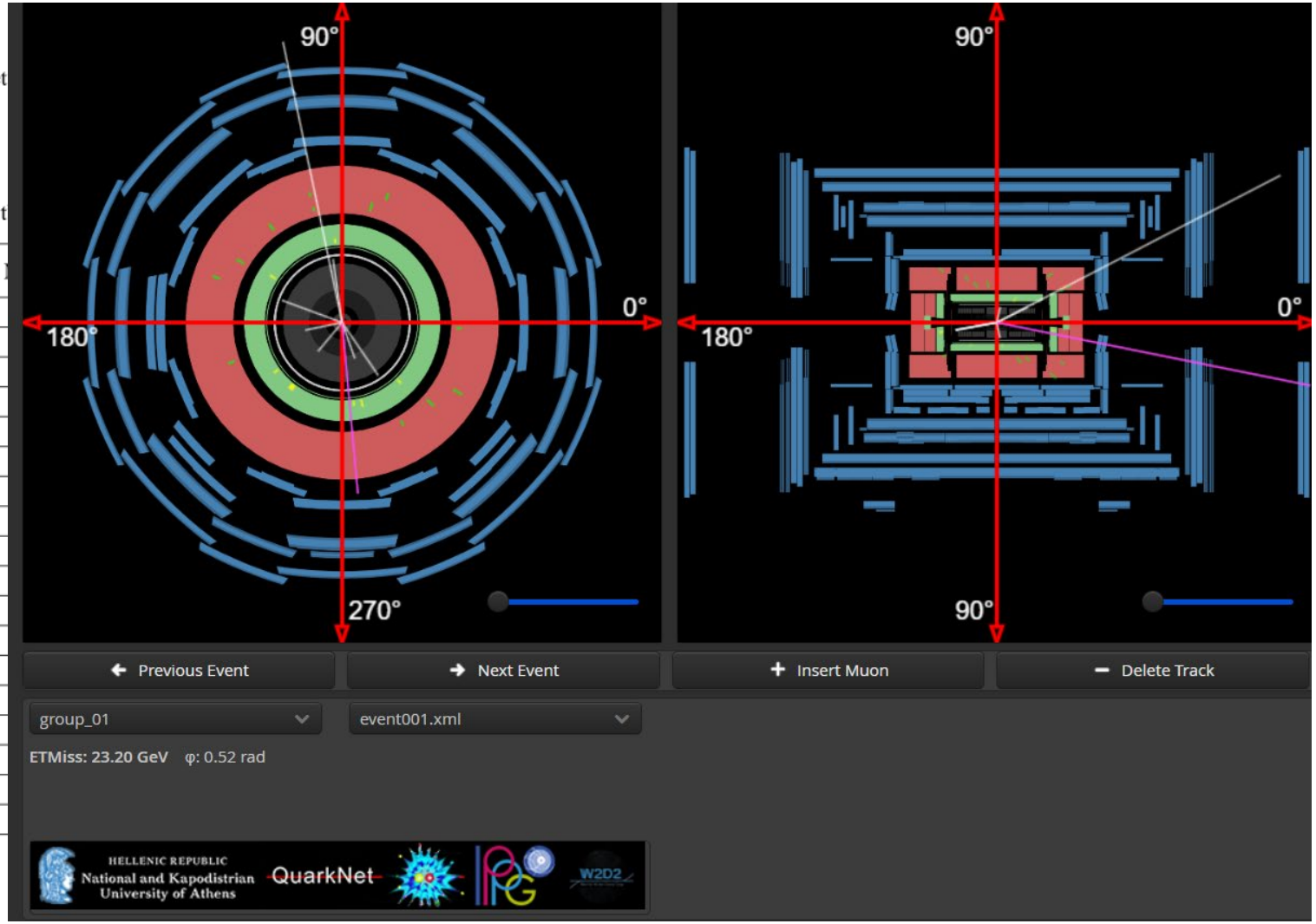
Measurements:

Tallies for angle φ (place tick mark for each angle of muon track measured to one of t



forward (x-y or rϕ) view

Angle (degrees)	Tick
1-20	
21-40	
41-60	
61-80	
81-100	
101-120	
121-140	
141-160	
161-180	
181-200	
201-220	
221-240	
241-260	
261-280	
281-300	
301-320	
321-340	
341-360	

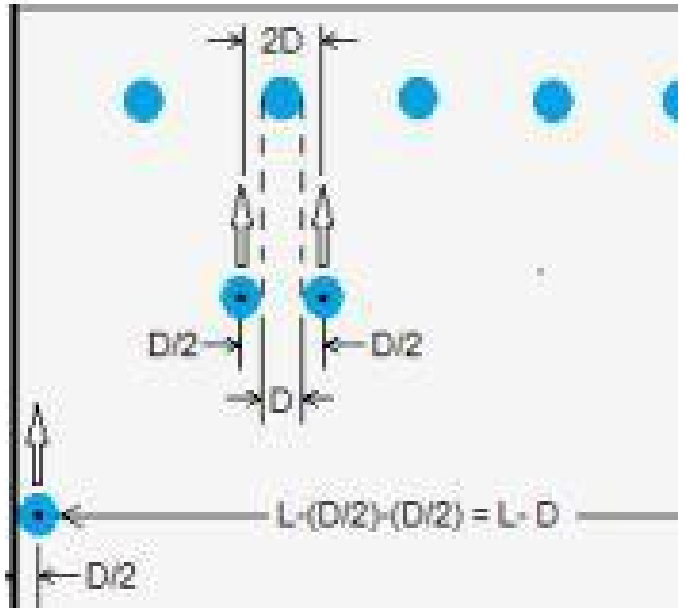


Today’s Demonstrations

1. Rolling with Rutherford — indirect measurement & nuclear discovery.
   - Students experience discovery through data
   - Builds intuition for probability, cross-sections, and nuclear structure.

2. Mean Lifetime Part 1: Dice — randomness, distributions, degrees of freedom.
   - Students learn to organize data and interpret histograms.
   - Supports NGSS: analyzing data, using mathematics, identifying patterns.
   - Easy to scale: dice, spreadsheets, or loaded dice.

Demo 1: Rolling with Rutherford



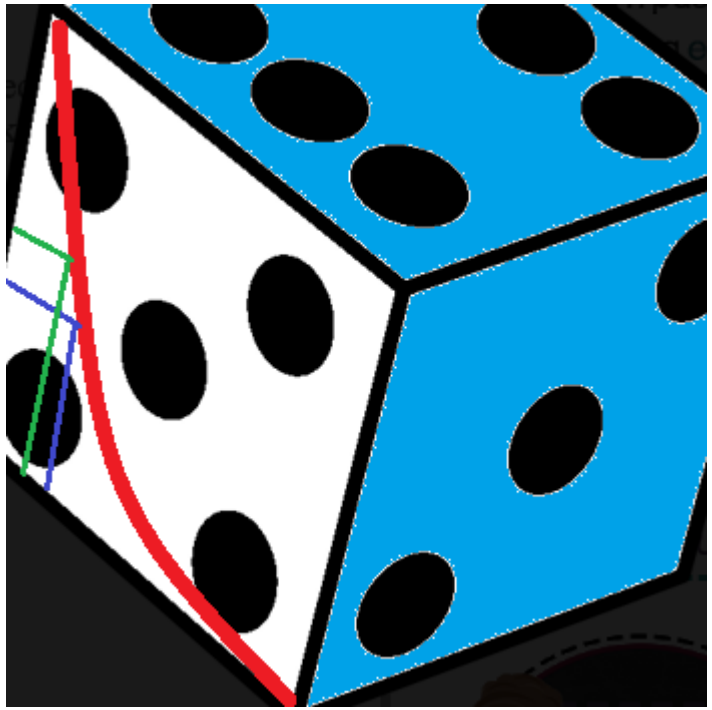
- Students roll a marble toward target marbles.
- Hits vs. misses build a histogram.
- Students infer target size using indirect evidence.
- Mirrors Rutherford's gold-foil experiment.

This activity

- Shows how physicists learn from deflection patterns.
- Makes invisible reasoning visible.
- Connects directly to NGSS practices: modeling, argument from evidence.

Demo 2: Mean Lifetime Part 1: Dice

- Each student begins with one die representing a “particle.”
- Students roll simultaneously; any die showing the designated “decay number” (e.g., a 6) is removed.
- After each roll, students record the number of dice remaining.
- Continue until all dice have “decayed.”
- Construct a decay curve (dice remaining vs. roll number).



Modern Physics in Your Classroom

- Both activities build core skills used in particle physics.
- Students practice indirect measurement, probability, and data interpretation.
- These are the same skills used in real detector experiments.

Join a Local QuarkNet Group

- Connect with mentors and fellow teachers.
- Collaborate on modern-physics lessons.
- Local site: QuarkNet at the College of William & Mary.
- Open to all high-school physics teachers.
- No membership required to use activities.

