



Race & Associates, Ltd.

University of Cincinnati Implementation Plans 2023-2025

The following pages provide examples of implementation plans (2023-2025) created by participating teachers during the workshops across three years. Plans are numbered to preserve the identity of the individual teacher.

August 2026

UC QuarkNet Implementation Plans

June 2023

Group 1: Teacher #1

*I have a “short” list of what I will be using, but one of them that I will put to use right away is calculating the **Z Mass Activity**.*

- I'll use it in the first two weeks of AP Physics I during what I call “Unit 0.”
- Introduces the concept of vectors, uses trig functions and relates conservation of mass (symmetry) in physics.
- Great way to get mathematical relationships incorporated and to use multiple equations to find final answers that require more than one step.
- Excellent way to incorporate advanced concepts that might not otherwise be covered in the curriculum

Group 2: Two Teachers

- In chem and physics, use something with the particle cards (in chem with quantum mechanics)
- Ivets with physics. I plan to use these throughout the year at the end of major units as additional resource for self assessment
- Make own ivets for dimensional analysis
- Data activities portfolio on quarknet site
- Physics continue to integrate colab notebooks into the course (one per unit) and create new notebooks for pre-calc courses (not sure of the timeline)
- World Data Day in Science department and make it a celebration
- Honors physics classes will begin using the Z mass activity as part of their unit on momentum
- Look into hosting a masterclass, probably after school or on a testing day

Group 3: Two Teachers

| | Physical Science | | |
|-----------------|--|--|---|
| Activity | Mean Lifetime Part 1 Dice - rolling dice serve as a model for decaying particles | Use google sheets to create a graph from data | Make 1 IVET and post to LMS https://www.compadre.org/IVET/Tutorial.cfm?ID=KM1 Track student progress and analyze data regarding success rate |
| Time | January | 1x per quarter at minimum | One IVET within the first 9 weeks of school. |
| Why? | Review isotopes, probability, and graphing. Could discuss nuclear forces and particle decay. Easy to obtain materials. Use of quantitative and qualitative data analysis | Builds skills required for “high-stakes” testing environments such as ACT and End of Course Science Testing. Continued analysis of quantitative data which is useful in all science content. | <ul style="list-style-type: none">● Allows students to learn at their pace outside of the classroom.● Allows students who need more time/more visualization to access this material as often as needed.● The IVET approach allows all students to have the opportunity to review content with the ability to assess their progress. |

Group 4: Two Teachers

“Cosmic Club Plan”: Club that meets once every two weeks for the entire year

- August-October: Making sure Cosmic Ray Detector is in working order and students have access to data. Activities to do during Cosmic Club meetings BEFORE World Wide Data Day: Histogram activities such as Rolling with Rutherford and Detector Measurement activities such as Z mass angle measurement.
- November: Participate in World Wide Data Day (pulling students out at convenient time to videoconference)
- November-December: Participate in International Cosmic Day. Compare Cosmic Detector results to Cosmic Watch results; possible videoconference with other schools
- January-February: Analyze events in CMS, Atlas, Minerva, possibly LHCb? For students to vote on which Masterclass they will do as a group.
- March: Prepare and Participate in Masterclass that was voted on by students
- April (meetings stop once AP exams start): analyzing muon, J/psi, or top quark mass from publicly available CERN data.

Group 5: Two Teachers

College Prep

Lesson 1 from Step Up for 1st day activity to introduce options for students who are still in the exploring phase.

Shuffling the deck at the of the year during AP exams as a sorting/critical thinking activity and coincides with the end of year topics.

AP Physics 1

Calculate the the Z_{mass} after momentum unit before we introduce Energy as a scaffolding activity and review of spreadsheet skills.

Would like to try IVET after first unit on constant velocity before the unit test as a method of problem solving. To make at least one IVET before the end of the year.

8th graders

If I could get access, I would introduce one of the coding activities: Either probability or temperature during state testing in April as an introduction activity. It gives some students a chance to show off skills.

Honors Physics

During conservation of momentum, using the Z-Mass activity to show real world applications of conservation of mass and energy. So January or February.

Higgs activity to further spreadsheet skills. Could occur at any time of the year.

IVETs for students that need more assistance on particular problems.

Using python or some code to solve a variety of physics problems. Anytime throughout the year.

Physical Science (9th graders)

Shuffling the Deck as another way to organize something (Early in the school year when introducing periodic table)

Implementation Plans

QuarkNet, University of Cincinnati, July 2024

Name:

School:

| Ideas | When/Where in school year: |
|---|--|
| "How does the Universe Work?" pg 15 from Topics in Modern Physics | First day of school |
| Rolling with Rutherford | January - prior to discussing atomic structure in detail |
| Cloud chamber using instructions from CERN S'cool lab | February - during unit on radioactive decay |
| 3D printed Quarks | January/February - after introducing nucleus of an atom |

Name

School

Ideas: Cloud Chamber on Club Fair

When and where in school year: 8/22

WWDD with Cosmic Club

Between 9:30-10 am

International Muon Week (Using our Cosmic Ray Detector) [elab](#)

Starting in January

Cosmic Club participating in the Masterclass held at UC


February-March depending on when Conor and/or Phil want to hold it

Could we think of an experiment to present to the Test Beam at Fermi?

April-May

Ideas:

When and where in school year:

| | |
|---|---|
| <p>Rolling with Rutherford</p> <p>Mass of U.S. Pennies</p> <p>Signal and Noise: The Basics</p> <p>World Wide Data Day</p> | <p>Data Analysis Unit for Math</p> <p>Problem Solving Class</p>  |
| <p>Cloud Chamber</p> <p>Piano Tuner Question</p> | <p>Science Club build? Beginning of the year</p> |
| <p>How Speedy are These Muons?</p> | <p>Kinematics Unit in Physics</p> |
| <p>Calculate the Z Mass</p> | <p>Vector Intro/Conservation of Momentum</p> |

| Ideas: | When / What Course: |
|---|--|
| World Wide Data Day Activities | Fall 2024 & Nov 14 / H. Physics 1 |
| Rolling with Rutherford - To introduce data analysis and model refinement | Day 1 / Advanced Physics 2 & Fall 2024 prior to WWDD / H.Physics 1 |
| "Large" Cloud Chamber - Intro to Atomic & Particle Physics Unit, Making Tracks 1 Fish Tank/Baking Pan IOP directions | Spring 2025 / Advanced Physics 2 (maybe start with small cloud chamber first) |
| Half-Life Lab with "Beer" Foam | Spring 2025 / Advanced Physics 2 |
| FeynHex Activity | Spring 2025-after SM Intro / Adv Physics 2 |
| Considering using Particle Physics/Accelerators as theme for course—spring trip to visit Fermilab | Advanced Physics 2 |

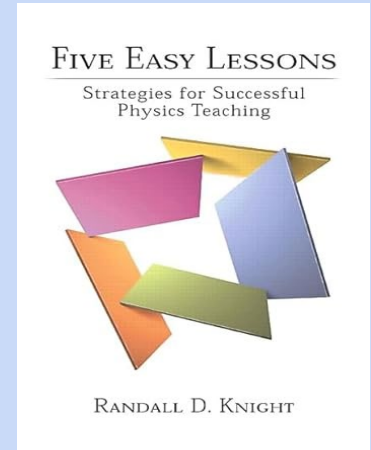
Ideas: Moving AP Physics/ Honors Physics into less of a lecture driven course and towards more active learning. This requires students to have more discussion. Class time is used to discuss ideas and clarify points of confusion, demonstrate process and practice doing physics with all members of the class being included. This is going to be a big change for them and for me as well, so some practice and flexibility will be required.

I want to use the “Quarknet: Changing the Culture” to help me get started with how to proceed appropriately with inclusive discussions.

[Changing the Culture](#)

[Link to 5 Easy Lessons](#)

When and where in school year: AP Physics throughout the year but the Quarknet activity would be in the first week.



Ideas: I want to have my students in Science Club help me build a cloud chamber. Then I want to use it with the and in my Nuclear Unit.

When and where in school year: In the Nuclear Unit of CCP Chemistry which should be near the end of October.

Making Tracks



Ideas: In advanced chemistry courses including the Mean Lifetime activity as part of half life decay. Currently I do a lab in which M&M's decay into Sweetarts, which decay into Skittles, which become Red Hots. (Keeping the number of particles straight can be difficult for even advanced students.) The activity does not actually calculate a $\frac{1}{2}$ life time for any of the "Candy Isotopes." The Mean Lifetime activity could be modified and incorporated into the Candy decay lab.

(I couldn't find my link for the lab but when I do I will post it. Similar labs are on TPT [teacherspayteachers.com](https://www.teacherspayteachers.com))

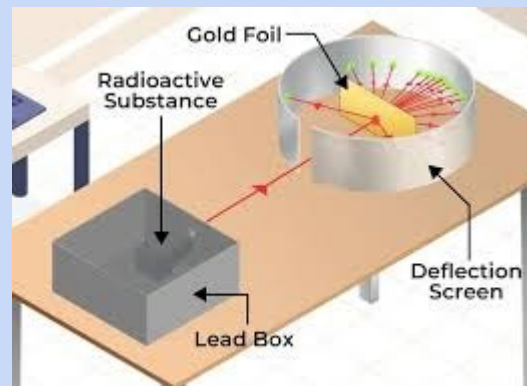
[Mean Lifetime Part 1](#)

When and where in school year: In the Nuclear Unit of CCP Chemistry which should be near the end of October.

Ideas: Incorporating the Rolling With Rutherford into our lecture on modeling the atom. I typically do a timeline diagram of the atom through history and this would be a perfect way to use inferences along with the use of calculations to determine what we can not see.

Rolling With Rutherford

**When and where in school year:
In the Fundamental of
Chemistry unit of Honors
Chemistry which should be
near the end of October but it
will be fun to get my lower and
higher levels involved too.**



Ideas: This activity is a great way to learn/review how to create and use histograms along with learning the concepts of isotopes.

Mass of US Pennies



When and where in school year: In the Atoms, Ions, and Isotopes unit taught in mid September in Chemistry



**Ideas: Rolling with Rutherford
from Data Activities Portfolio. This
is a great activity that introduces a
scientific breakthrough via
mathematics**

**When and where in school
year: Early in the year
(Physics) when basic
mathematics is
reviewed/discussed**



**Ideas: Shuffling the particle deck.
This is a great activity that
introduces some of the elementary
particles in the standard model
while developing pattern
recognition skills.**

**When and where in school
year: (Chemistry) - 2nd
quarter during the
introduction of the atomic
model**



Ideas: Cloud chamber demonstration

**When and where in school year: (Chemistry and Physics)
- Early in year during discussion of topics/fields treated by chemists and physicists**



**Ideas: How many piano tuners are
in Cincinnati question and
subsequent discussion on
assumptions and bias**

**When and where in school
year: (Chemistry and
Physics) - Early in year
during discussion of mindset**





Ideas: Mass of US Pennies

Students in small groups given random pennies from which they collect data (qualitative- date, design, corrosion and quantitative- mass) then create an individual histogram.

They then combine their data with the rest of the class, create the histogram and discuss what the data shows.

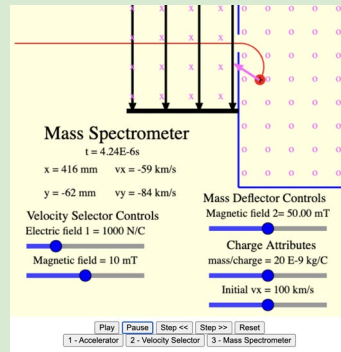
When and where in school year:

I have done a similar activity in my Chemistry classes with the objective to learn about density; I may enhance it with parts of this. When: first quarter.

I think this would make a great intro activity in my physics classes- reminding everyone about collecting data, graphing and analyzing at the start of the year- and then use it to refer back to when we explore particle physics second semester. (I have the students record all they do in a composition book/lab notebook, and I love a reason to have them reflect on what they have recorded in the past!)

Ideas: Making It 'Round the Bend

Qualitative Data collection from an online interactive. Students can explore the interactive and see how altering the parameters changes the trajectory of the particle.



When and where in school year:

This will be great to have as an inquiry activity to introduce how magnetic and electric fields are related, and how momentum can be qualitatively estimated from the angle of the particles curve.

Ideas: Number of Piano Tuners...

This is great for introducing what factors need to be known to set up an experiment/solve a problem.

This is a great way to practice dimensional analysis.

When and where in school year:

Astronomy and Physics classes early in the school year. (First week?)

Ideas: Citizen Science Research

World Wide Data Day, Master class, [Zooniverse](#) and the other opportunities that Coner put on our agenda. :)

I strive to make as much of my students' time be conducting meaningful research.

When and where in school year:

Astronomy and Physics classes; Second Quarter and onward throughout the year.

I have had my Astronomy students present their research at a poster session in the Spring, near the end of the school year.

Name

Ideas: Mass of U.S. Pennies, Brassing Pennies & Rolling Pennies

I would like my students to understand the reasons why the penny material has changed. In the past I have had my students change the color of “old” pennies into silver and gold. This can be done before we brass them. Also as part of experimenting with the mass, I will have my students roll the pennies into flat discs. The new pennies get a cool pattern as the different materials mix. Students will learn how to build histograms and it will help them with their other classes.

When and where in school year:

This is a two day project, I would do this right before a holiday where students are ready to get out of school. It is easy learning concepts that are fun to implement.

Ideas: Implement thinking and problem solving with questions such as, “How many hair salons are there in Cincinnati?” and sorting the Elementary Particles cards. The focus is on how the student comes up with their answer not the correct answer.

When and where in school year:

Name **Claudia M Brown**

School **Winton Woods High**

Ideas: I want to have my students help me build a cloud chamber. I will actually do this with the chemistry teacher. Having my students witness the particles that are constantly falling will be a great experience for them.

I also believe most of the students at my school will be interested in seeing the cloud chamber therefore we will put it in the space next to the chemistry lab at my school.

When and where in school year:

| Ideas | When and Where in School Year |
|---|--|
| How does the Universe Work Activity (from Marty's old QuarkNet resources) | First day of school, all physics and precalculus |
| Histogram the Basics to introduce the concept and some of the basic terminology (bins, frequency, etc) and review process of claim, evidence, reasoning | End of week 1 Honors Physics |
| Rolling with Rutherford to build on Histogram lesson, introduce science w/o direct measurement | Week 2 or 3 Honors Physics |
| Shuffling the Particle Deck followed by brief lesson introducing the Standard Model (use videos to support) | Week 4 of Honors Physics |

| Ideas | When and Where in School Year |
|--|--------------------------------------|
| Conservation of Momentum: Calculate the Z Mass to reinforce conservation laws, intro particle physics units, 2 dimensional p calcs | AP Physics week 6 |
| Goal #1: Increase use of Google Colab notebooks throughout all courses, particularly importing and analyzing data from phyphox | Throughout course (AP Physics) |
| Goal #2: Require all students (in groups) to do a study and present results using the cosmic ray detector once during the school year. | Throughout course (H. Physics) |
| For students interested: FeynHex and Masterclass | |

Implementation Plans

University of Cincinnati, Wednesday 30 July 2025

Teacher(s): 1

Class: 9th grade physical science

When to present: February

Description: cloud chambers

Students will study atomic structure, then decay, the cloud chambers will provide evidence for charged particles and decay

Students complete a project on radioactive decay. One option is using the CRD. Taking a deep dive on understanding the cloud chamber will be an additional project option.

Teacher(s): 1 and 2

Class:

Community Master Class



When to present:

March 2026

Description: Use the LHCb material used during our center workshop. Some students will be tasked with creating a colab notebook to analyze the data. Other students will have access to this [notebook](#). Also would like to try integrating student json files into one classwide json file.

Teacher(s): 3

Class: Math Problem Solving

| When to present: | Description |
|--------------------|--|
| November | World Wide Data Day |
| Data Analysis Unit | Histograms: The Basics Rolling with Rutherford Mass of U.S. Pennies Signal and Noise: The Basics Mean Lifetime |

Teacher(s): 3 (con't.)

Class: Physics

| When to present: | Description |
|------------------|---|
| Kinematics Unit | How Speedy are these Muons Jupyter Notebooks and PhyPhox Data Collection |
| Momentum | Calculate the Z Mass Cloud Chamber |
| Energy | Event Display from 2025 UC Quarknet D0 Lifetime Jupyter Notebook |

Teacher(s): 3 (con't.)

Class: Science Club

| When to present: | Description |
|------------------|--|
| August | Borrow Heidi's Cloud Chamber as demo |
| September | Trial Build Cloud Chamber |
| October | <u>Making Tracks I</u> <u>Shuffling the Particle Deck</u> <u>https://quantumtocosmos.ca/#/scale</u> |
| November | <u>Introduction to Coding Using Jupyter</u> <u>Plotting a Consensus</u> |
| December | <u>Introduction to Coding Using Jupyter</u> <u>What Heisenberg Knew</u> |

Teacher(s): 4 Cloud Chambers / Cosmic Rays

Class: Astronomy, Physics, Chemistry

When to present:

Physics: When discussing Momentum

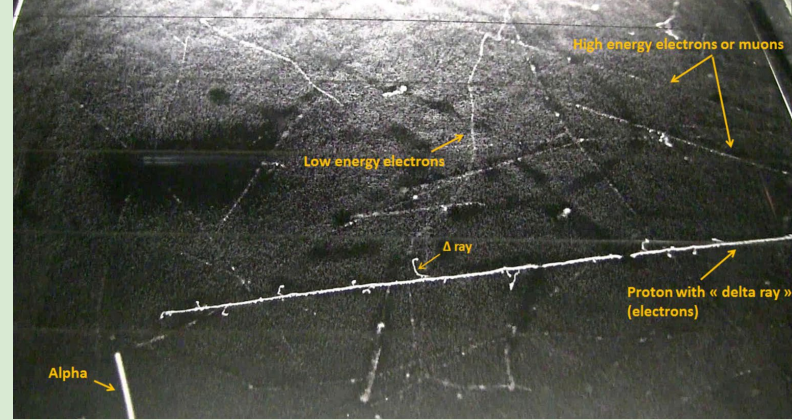
(alpha) behave differently

than lighter particles (electrons)

Nuclear Physics (I never get to this, but this would be a way to connect it)

Chemistry: When discussing radioactive decay

Astronomy: When discussing the atmosphere and link to solar cycles



heavier particles

Teacher(s): 4 (con't.)

Cloud Chambers / Cosmic Rays

Class: Astronomy, Physics, Chemistry

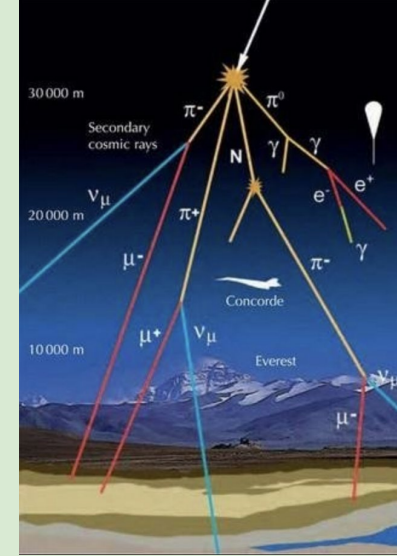
Descriptions:

I would like to coordinate all three preps so setting up the cloud chamber and then using it through each class all in one day.

Chemistry: What can we find that increases alpha or beta particles?

Physics: Conceptually connecting the mass of the particle and the path
Connect to WWDD

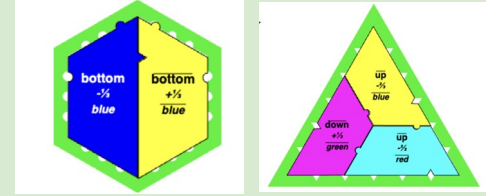
Astronomy: Connect with Solar Cycle [Analyze Oulu Data](#) Explore Origins



Teacher(s): 4 (con't.) Heidi Data Activities Portfolio and Last Year's Wonderful (forgotten) Implementation Plans

Class: Physics, Chemistry (Astronomy)

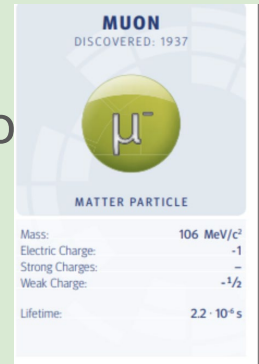
Quark Workbench: Physics and Chemistry ([online](#))



When: Early in the year; Purpose: Understand the fundamental particles

Shuffling the Particle Deck: Physics and Chemistry (Astronomy?)

When: After Workbench Activity Purpose: Further understanding of fundamental particles (Astronomy: with cloud chamber activity)



Name: Teacher 4
(con't.)

Ideas: Mass of US Pennies

Students in small groups given random pennies from which they collect data (qualitative- date, design, corrosion and quantitative- mass) then create an individual histogram.

They then combine their data with the rest of the class, create the histogram and discuss what the data shows.

School:

When and where in school year:

I have done a similar activity in my Chemistry classes with the objective to learn about density; I may enhance it with parts of this. When: first quarter.

I think this would make a great intro activity in my physics classes- reminding everyone about collecting data, graphing and analyzing at the start of the year- and then use it to refer back to when we explore particle physics second semester. (I have the students record all they do in a composition book/lab notebook, and I love a reason to have them reflect on what they have recorded in the past!)

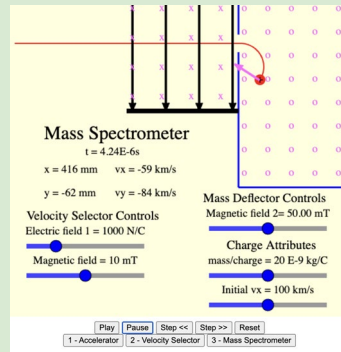


Name: Teacher 4 (con't.)

School:

Ideas: Making It 'Round the Bend

Qualitative Data collection from an online interactive. Students can explore the interactive and see how altering the parameters changes the trajectory of the particle.



When and where in school year:

This will be great to have as an inquiry activity to introduce how magnetic and electric fields are related, and how momentum can be qualitatively estimated from the angle of the particles curve.

Name: Teacher 4 (con't.)

School:

Ideas: Number of Piano Tuners...

This is great for introducing what factors need to be known to set up an experiment/solve a problem.

This is a great way to practice dimensional analysis.

When and where in school year:

Astronomy and Physics classes early in the school year. (First week?)

Name: Teacher 4 (con't.)

School: Talawanda

Ideas: Citizen Science Research

World Wide Data Day, Master class, [Zooniverse](#) and the other opportunities that Coner put on our agenda. :)

I strive to make as much of my students' time be conducting meaningful research.

When and where in school year:

Astronomy and Physics classes; Second Quarter and onward throughout the year.

I have had my Astronomy students present their research at a poster session in the Spring, near the end of the school year.

Teacher(s): 5

Class: College prep physics

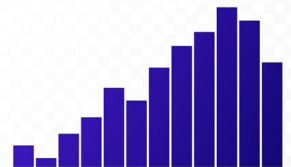
When to present: first few weeks during Linear motion section

Description: gathering data to create histogram started with Data activities portfolio

Homework: Watch video; student collect data-

1. google form-walk 100 meters, record time-also someone else
 2. Discuss how to present data (talk about analyzing large amount of of data to fin; use example about grades in a class histogram by hand in class
 3. Homework: Draw one for our data that we collected.
- Circle back to this topic at end of semester; end of year

Histogram



Teacher(s): 5 (con't.

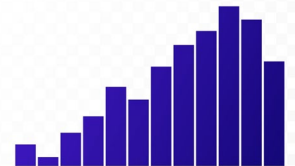
Description: gathering data to create histogram started with Data activities portfolio

| Range ?? | frequency |
|----------|-----------|
| 1-100?? | |
| Or 1-50 | |
| 51-100 | |

Histogram

Homework: Watch video; student collect data-
create a histogram

https://docs.google.com/document/d/1ZsJnouQo0AiR_sxxTMpsQ3|FRo4WIU/edit?usp=sharing



Teacher: 2 (additional plan)

Class: Honors Precalc

| When to Present | Description |
|---|--|
| Unit 4: Exponential/Logarithmic Functions | Dice Mean Lifetime Activity (Data Portfolio) |
| | |

Teacher: 2 (additional plans)

Class: Immersive Modern Physics (Minimester)

| When to Present | Description |
|---|--|
| Day 1: Historical Foundations of Modern Physics and Experimental Design | <ol style="list-style-type: none"><li data-bbox="1078 416 1812 497">1. Histogram and Rolling with Rutherford Activity from the Data Activities portfolio<li data-bbox="1078 503 1812 585">2. An introduction to coding in Python: choose notebooks from Coding Camp 1 |

Teacher: 2 (additional plans)

Class: Immersive Modern Physics (Minimester)

| When to Present | Description |
|---|---|
| <p>Particle Physics Days (December 2025)</p> <p>2-3 days=approx 15 contact hours</p> <p>Additional time at the end of the course for preparation of research presentation</p> | <p>Masterclass experience for students:</p> <ol style="list-style-type: none">1. Begin with Workbench Assignment/Particle Deck Activity2. Lecture/Guest Speaker: Introduction to Standard model and detector physics3. Build and observe Cloud Chamber (Data Activities portfolio)4. LHCb Masterclass activities (or other detector) done in sheets5. Shift into Colab (rough notebook, give students assignment to develop code)6. Final research presentation (admin at school)7. Possible University visit |

Teacher(s): 6

Class: College Prep Chemistry

| Activity | When to Present | Description |
|------------------------|--------------------------------------|---|
| Histograms: The Basics | Intro to Chemistry Unit | Will use with students to practice collecting data, charting data, then referencing data to practice the CER model of making conclusions about data. |
| Mass of US Pennies | Matter and the structure of the atom | After intro unit, students can use this activity to practice making quantitative/qualitative observations, collecting data, practice CER model of making conclusions, and modeling data using a histogram. Can use in conjunction with the density of pennies activity and/or Isotopes of Pennium Lab from HASPI Medical Chemistry- pages 21-25 |

Teacher(s): 7

Class: Cosmic Club

When to present: Once every 5 days (9:40-10:05 am), after A3 and advisement

Description: Curriculum: Cloud Chamber or Cosmic Ray Detector (depending on location) as marketing tool to have kids sign up. Beginner Activities first few weeks: Z mass, Rolling with Rutherford, Quarkbench (Great to use in tandem with Particle Cards!)

WWDD prep begins October 10th (we would do both the Atlas and CMS measurements. WWDD videoconference occurs during our meeting time on November 20th :)

Introduce Cosmic Ray Measurements before Christmas, perhaps set up study over Christmas Break (Interesting orientation of paddles? Set a particularly low or high trigger ratio?)

After Winter Break: Analyze data from Cosmic Study *depending on possible changing of members*

Spring Masterclass availability (9:40-10:05 am) February 24th, March 3rd, March 10th (Tuesdays), March 18th, April 1st (Wednesdays)

Home Stretch: FeynHex/Feynman diagrams, advanced cosmic studies, using 1 k or 10 dimuon events to look for J/psi meson, any other data set where momentum vectors and energy measurements are combined into a file (similar to data camp, etc.)

Teacher(s) 8

Class: AP Physics C

When to present: Start of the Year (Kinematics)

Description: Use the Cosmic Ray Detector to do a time of flight experiment to measure the speed of muons.

Teacher(s) 8 (con't.)

Class: Cosmic Club

When to present: ????

Description: Have the students do a performance study with the CRD to enable them to learn about how the CRD works. It would be beneficial to do the Signal and Noise activity from the Data Activity Portfolio prior to the study.

Teacher(s) - 8 (con't.)

Class: AP Physics 1

When to present: End of the Momentum Unit

Description: Z Mass activity from the data portfolio.

Teacher(s) - 8 (con't.

Class: CP Physics

When to present: Kinematics

Description: How Speed are These Muons? From the Data Activity Portfolio.