Center-Level Portfolio: Fermilab/University of Chicago/College of DuPage

The following table, proposed implementation plans by participating teachers, and when available other examples are intended to provide an overall narrative about how and in what ways program participation has influenced teachers in using QuarkNet content and materials in their classrooms (and in-after class events). The value of these qualitative reviews is to expand on the instructional practices measured quantitatively via Teacher Survey responses to specific sets of questions/self-reported by teachers providing narrative examples of implemented or planned instructional practices in teachers' classrooms and in schools. This evaluation approach is consistent with the use of *authentic assessment* to evaluate performance, "teaching for understanding and application rather than for rote recall" (Darling-Hammond & Snyder, 2000, p. 523).

In keeping with Darling-Hammond, Hyler and Gardner (2017), we do not naively expect a single workshop (or event) to have a measurable impact on teachers' knowledge and subsequent classroom implementation. A characteristic of effective professional development is a program of sustained duration, providing "multiple opportunities for teachers to engage in learning around a single set of concepts or practices; that is rigorous and cumulative" (Darling-Hammond, et al., 2017, p. 15). As such, the table summarizes responses by teachers over the course of several program years and likely several QuarkNet programs and/or events.

These responses come from the Teacher Survey (either the full or update version) where each row represents the responses to open-ended questions from the same teacher over time. Also, each row starts with the original responses to the first time a teacher completes his/her full teacher. If a particular box in the table is blank, it likely means that that teacher did not participate in an event for that program year (or, the center may not have had a major event that year). The table provides the essence of these responses; a given response, as presented, may be a direct quote, a paraphrase, or lightly edited; the intent is to convey the overall idea or its essence from that particular teacher.

Because these are responses to open-ended questions, teachers are free (and encouraged) to provide information that he or she thinks most relevant. Each highlighted response is intentionally anonymously to respect the principles of collecting evaluation data (*Guiding Principles for Evaluators*, American Evaluation Association) and to help encourage teachers to respond frankly to these questions. If a reader is familiar with a given center, it may be possible to "reverse engineer" the identify of a particular teacher. We encourage readers to respect this anonymity. At various times, we may have identified a given teacher by name and/or school; when this happens the written approval of that teacher has been obtained. It is also important to note that the full breath of a response by a given teacher may not be fully articulated in this table. For example, responses related to how QuarkNet may have advanced the knowledge of a given teacher or bolstered a collegial network among participants are likely discussed elsewhere in subsequent evaluation reports.

The table is followed by examples of implementation plans, and at times teacher presentations and student presentations when available. The intent of providing these examples is to deepen the narrative as to what and how teachers have planned (and have used) QuarkNet content and materials in their classrooms and in-after class events (e.g., Physics Club). Examples from Annual Center annual reports may be highlighted as well.

Table
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/ UC	2019	2020	2021	2022
	The LIGO data workshop is one I can use in my Earth Science class this year. Analyzing and interpreting data is good practice for the SAT test.		I intend to use QuarkNet lessons for atomic modeling, data analysis, half-life, and diversity and inclusion. Examples: Dice, Histograms and Probability; Histograms: The Basics; Changing the Culture; Rolling with Rutherford; Mean Lifetime Part 1: Dice; Histograms: Uncertainty; Mean Lifetime Part 2: Muons; Mean Lifetime Part 3: MINERvA.	
	Neutrino Data Workshop, I'll be using a great deal of these... dice, basic histograms, missing neutrino.			
	Lots of useful information for implementation. I have used techniques that involve looking at real data. Very useful, real-life applications that encourage students to learn about things that we don't usually touch on (like neutrinos). While I sometimes forget some of the activities, they are awesome applications of real science happening.			I used a few of the data activities in class such as the conservation of momentum with the D-Zero detector, the quark zoo, and simulating decay with dice. Examples: I have used Conservation of Momentum, simulating decay with dice, the particle zoo. The activities are pretty high level and are not always accessible for the average student. I would love to have more activities that could be used in a self-contained or inclusion classroom
	Both, they are able to provide me with things I can use in class, physics or chemistry. I have had students build histograms. I recommend it (DAP) because it provides a way for students to understand how data is gathered and analyzed. Excellent presentation. This was nice to see it aligned to standards already.			
	Histogram Basics			
	The Neutrino Data workshop helped me by providing ways I can teach my students different topics of data acquisition and interpretation.			

Table (con't.)
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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/UC	2019	2020	2021	2024
	Neutrino Data workshop and applying the labs. e-Lab and electronic posters. The exercises and labs are practical and useful ways to teach students how to apply prior knowledge or new knowledge in real life. the entire staff who worked to put on these workshops have done an incredible job organizing the day activities and sticking to the planned outcomes. The tours as well as the classroom activities have been invaluable. Great efforts in showing us how the slice that we are working on fit into the big picture!	#13		
	QuarkNet teacher's workshop. QuarkNet Conferences in person, specifically with the format of physicist speakers, HS student presentations, tours of Fermilab experiment sites, meeting engineers, mixing with science teachers in break out pair or small group sessions. dice and pennies to demonstrate variety and mean and then gather in bar graphs. Philosophical openness to future answers via application of Physics to medicine, I.e. MRI technology. To encourage students who learn by different methods. Express what's in it for the students-promote careers in research, engineering and other applications of science. To encourage students and others science teachers to utilize resources available through NSA. Keep stipends for teachers. Keep up incorporating the tours of buildings doing the cutting edge research projects. We actually need to focus on this more with teacher and then students, to know the why. Physics matters why and then talk about the discoveries in CATscan for medical applications and with how knowledge of physics can help the environment.			e-Labs and masterclasses. Examples of the standard model of particles. My favorite parts are the tours, the vital comradery between teachers and the students talking about their research.
	The data analysis lessons in all the workshops and QuarkNet lessons because they translate to all classes at all levels. Rolling with Rutherford; Quark Work Bench Histogram: the Basics Mean Lifetime Dice They are lessons which use data from real experiments and show students how physics principles are applied.			

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/UC	2019	2021	2022	2024	2025
	Data Camp--As a camper in 2011, my mind was opened to the use of big data and being able to frame the work around the fundamental laws I had already been teaching in my physics classes. Around the Bend (F=qvB) Quark Workbench (in prepping students for Masterclass) Top Quark (conservation of p) CMS e-Lab (extension for students who are ready to do mass reconstruction plots, usually post AP exam). These provide a great array of high energy physics activities that bring students into current physics and give them a chance to contextualize the big ideas from classical physics. QuarkNet, and specifically Data Camp, achieves all of these goals, as they have been instrumental in driving how the Data Camp experience is designed and conducted. Building community is critical to many physics teachers, and QuarkNet provides an effective structure for those communities. QuarkNet is a robust and critical vehicle to provide teachers with targeted PD that places them in a position to build authentic learning experiences for their students.	I have used particle colliders when discussing momentum conservation, I have used some e-labs and have brought students to Masterclasses over the year. Examples: Workbench to solidify thinking about quarks Calculate the Z mass Mean lifetime and dice. Great opportunity to boost student collaboration and to model scientific thinking		I have used some of the QuarkNet portfolio resources in my classroom over the years. Currently I am teaching 9th grade physics, and touch on the material when we do conservation of momentum and energy. Rolling with Rutherford Quark Workbench And I would like to try the Step Up lessons (new), The new updated portfolio looks great and I hope to use it more frequently.	
	Data collection, pooling class data, measurement, graphing skills. In Middle school, these are important skills that the kids need to develop for high school and beyond. The half-life dice lab I believe would be the most helpful. I would recommend it to the middle school teachers I work with. It does help me explain how the science used in the class is used in real life, as well as how to analyze the data.	I have used the penny mass lab with my students. Graphing and bins discussed. The introduction to coding. The graphing using coding. Penny lab both weight and half life.	python Notebooks, penny lab, Rutherford	Last year I incorporated the Cosmic Ray Muon into my STEM class when explaining 3d printing. I have used some of the labs on QuarkNet in previous classes including the rolling with Rutherford and penny lab. Penny lab, Rolling with Rutherford, particle card sort, indirect measurements	Graph Reading and Analysis for Elementary Penny lab, Rolling with Rutherford

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/UC	2019	2020	2021	2022	2023
	All. Data analysis histogram making	I use the activities to assist lower-level ability students in graphing, data analysis and other low level of written work. Examples: Mean Lifetime Part 1; Mass of Pennies.	I intend to use these experiences to support career exploration, and to show students that what we cover in class is only a very small part of our world. Examples: Dice histograms, and Probability, Mass of Pennies.	I intend to use the information to supplement ideas on careers in science and current events. Example: Mass of Pennies.	data collection and exactness. Where to round decimals to? good resources different than other inservices
	summer high school interns. by virtue of time spent and exposure to physics research. Pennies, dice, histograms, workbench, top quark, CRMD. connecting current physics research (with data) to high school students.	data activities, CMRD detector, Cosmic Ray e-lab, using in Physics and Chemistry classes, as well as club extra curricular, informal settings. histograms, mean lifetimes, Heisenberg. good stuff, working to integrate, remote learning opportunities.	teaching with data, great stuff plan to incorporate google colab coding activities into Physics and Chemistry classes. pennies, dice, histograms, STEP UP.	Portfolio Activities into Modern/Honors/AP level Physics classes, and Modern/Honors Chemistry classes. Mass of Pennies, Histogram, STEP UP. Working to incorporate QuarkNet activities in science courses, as appropriate.	
	Hands on analysis of data to understand neutrinos Hands on analysis of real data!				
	International Cosmic Day because it seems like a one day lesson type deal. I think it (DAP) is an awesome resource, especially for teachers with fewer deadlines and smaller common teaching teams. I would like to do some this year after the AP Test.				

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/UC	2019	2020	2021	2022	2023
	Hands on student activities related to real physics. Real life science allowing students to have hands on experience. Dice, MINERvA, Particle family cards.	Activities for my AP Physics and Honors Physics classes. Discussions about the standard model! Examples: Dice activity mean lifetime of muon from cosmic-ray detectors 2 muon and 4 muon analysis of CMS experiment. Always gives me new and good ideas. Love being able to meet with like minded teachers to discuss the logistics of teaching, especially in these strange times		Real life data analysis and experience with science. Data analysis of CMS neutrino data and analysis. Enjoying it, most students are positive about the real life experiences.	
	(All comments are from the 2019 Program Year the first year of full survey) Neutrino Data Workshop, first one and it included a very good introduction to many of the other programs. I hope to use the e-labs and data activities discussed in the Neutrino Data workshop in my classes. All of the various teaching methods were very helpful. This is a wonderful workshop in that it introduced me to many resources and ways of teaching that can be used in my classes. I hope to be able to bring some of these resources back to the Computer Science Teaching community at my school and in the Chicagoland area. At my school district, computer science is now a required class and many of the introduced topics and methodologies can be very useful. I thought the instruction and tours were outstanding. I hope to continue to participate and contribute to the community.				

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Responses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab/ UC	2019	2021	2022	2023	2024	2025
	In the Neutrino Data Workshop, the usage of histograms for data collection can transfer over to my teaching situation quite easily. This will be helpful in getting students to determine whether or not their data is valid or not. The activities are well thought out and valuable for student learning. everything was great! I will definitely be coming back next year. I thoroughly enjoyed my time in the QuarkNet workshop and plan to implement as much as I can this upcoming school year. #4					
	The neutrino data workshop is valuable in giving access points to all levels of physics/math students. Activity levels that I experienced were varied to capture the mind of learners who know nothing about physics. Mass of a penny, Histogram basics, and Dice, Histograms and Probability. These activities allow students to complete a lab without a lot of equipment or extensive understanding of physics while allowing students to get practice with skills they will need at high levels of all science and math. Any activities that can expose our students to "real" science (read: non-perfect regressions, errors in data, set with no events) allowing them to struggle with the ambiguity in those instances will only build more resilient and flexible thinkers.					

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year	Subsequent Program Year
Fermilab /UC	2019	2020	2021	2022	2023	2024	2025
	Data Camp was amazing and helped me show how statistics was used in real life environ-ments. PPGraphing, studying large quantities of data, statistics. Very easy to work with (DAP) and got students engaged in math they did not understand when taught in classic ways.	I plan to use cosmic ray and first lab in my class. Examples: The coin measurement lab. The dice rolling lab. The BMC lab. I used them as data capture and analysis. I would like more Zoom meetings as a group to discuss how we are using the data in our classroom and remote teaching.	I have used the lessons on portability. I have used the data from various e-labs as analysis material for my class. I have used the analysis for the Boson Higgs. I have used the data analysis for dice rolling and coin flipping. I will use this this year again as the data is amazing for teaching graphing and data. I have used the QuarkNet material more often in my math classes than in science. For whatever reason, the students push back on authentic data in my physical science class, but the same students happily use it in math.	I have used the e-labs and masterclass lessons to teach statistics and data science as well as python and Jupyter notebooks. Examples: Use of Jupyter notebooks I use constantly to help students make a connection between math, science and computer science. I personally used the labs quite a bit but found the Jupityr notebook lessons to be the most useful to me.	Measuring the mass of pennies	Bringing together space science and physics. Examples: LHC Masterclass, Bowling with Rutherford, the particle cards, LIGO e-lab. The QuarkNet material from 2010 to 2017 and 2020 to today were essential to teaching students about the connection between math and science. It also helped them to discover how scientists work and has lead a few of my students to persue a career in science and computer science that they thought they were not capable of.	I plan to incorporate my QuarkNet experience by using real particle physics data—such as from the LHC or cosmic ray detectors—to help students explore concepts like conservation of momentum and energy. For example, during our unit on forces and motion, students will analyze LHC collision events to see how missing transverse energy suggests the presence of neutrinos, reinforcing both conservation laws and the structure of the Standard Model. This real-world data makes abstract physics concept. I plan to use the following activities from the Data Activities Portfolio in my classroom: 1. **Plotting and Interpreting Histograms** – This ties directly into our unit on data analysis and will help students understand how bin size affects interpretation, especially when working with experimental data. 2. **Momentum Conservation in Collisions (using LHC data)** – This will be used during our unit on Newton's laws and conservation principles, giving students a chance to apply physics

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Center	Program Year (Year of Full Survey)	Subsequent Program Year	Subsequent Program Year
Fermilab/ UC	2020	2021	2022
	The Muon workshop was is the only one I've been to, though I have been to other workshops outside of QuarkNet. I found the workshop both informative and practical. It was great that it was hosted by physicists and physics teachers. The activities are relevant to both current research as well as topics covered in a high school physics class. They show, through interactive lessons, that the physics is relevant outside of their usual classroom routine. Thank you for the informative, useful, and well-run workshop!	When teaching conservation of momentum and energy, I was able to use the Muon Decay CMS experiment with my students. This illustrated how these important laws of physics are used in current research. Examples: Muon Decay Radioactive Decay Dice Experiment. QuarkNet has by far provided the most interesting and useful Professional Development for physics that I have seen thus far. Thank you.	I have used a few QuarkNet activities in my classroom, and I hope to use more in the future. I have used the histograms and probability activity, the muon decay activity and my students collected data for world wide data day. In the future, I hope to use what I have learned about Python in my classroom. The ultimate goal is to incorporate particle physics and coding activities throughout the entire year. Examples: Histograms and probability using dice, World Wide Data Day. I am very grateful for QuarkNet. I have been to many PDs in my time as a teacher, and these are by far the most interesting, applicable, and fun. QuarkNet gives us materials and ideas that are relevant to our classes yet are on the cutting edge. I also enjoy being able to meet and work with other physics teachers. I am the only physics teacher in my school, so hearing other ideas about teaching physics is always nice.
	The whole workshop was great. I loved the hands-on, and actually doing the calculation was very helpful. The dice and understanding half-life. The listing of the activities is so impressive. I was so impressed with the workshop.	How does one incorporate this summer QuarkNet experiences into my classroom by incorporating the simple coding schemes into the curriculum; e.g., when teaching statistics. This year I really like the Probability program that we did Wednesday. Present examples that are culturally relevant to relate to the students. I can definitely incorporate this in my math class and the star catalog program for analysis and visualization. I liked the pair programming . I would incorporate this process. Thank you for giving me time to reflect on how to implement this in my classroom.	the ISLE curriculum, especially with motion; I like to use some of the materials (linear algebra). I intend to use the material from the data lab in my class, especially when talking about conservation laws, application of basic science and creating histograms. Learn how to draw space-time diagrams particles, mass of U.S. pennies. (T)he importance of doing basic research and guiding students to know how to manipulate data to tell a story, was my first local attendance and every day I learned something new, The experience was awesome. of the importance to do basic research and guiding students to know how to manipulate data to tell a story, **From 2025:** asked to create a Quantum Information Science (QIS) course at local university for this coming Spring. From my wonderful experiences as a teacher in the CERN Program (8/2024), coding as a student/ facilitator, I anticipate incorporating some particle physics concepts into the class as labs/demonstrations/real-world examples.
	Great data analysis		
	These workshops provide valuable data analysis activities. I've used the penny activity for many years. This year I will add the dice half life activity and try to incorporate the MINERvA mean lifetime experiment. They are well written and allow for students to analyze real world data.		
	I use the dice activity to teach histograms and probability.		

Table (con't.)
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Center	Program Year (Year of Full Survey)	Subsequent Program Year
	2020	2021
Fermilab/UC	First time in QuarkNet, so I have not had the opportunity yet. It seems to be a great collection of activities that can either be used as is or as starting points for your own activities.	
	The progression of the muon virtual workshop was very similar to the way I would present it to my students. I now can give reliance to data collection and statistics from a local real world example. It also used similar distance learning tools and techniques that I will use this year. I need time to evaluate the Data Activities that I will use this year, but I love the mean lifetime of the muon activity. It will be more meaningful to my students than what I currently teach.	I will use the Google Collaboratory Jupyter Notebooks to add a data science exploratory to principles of engineering. Examples: I have used the activities with Histograms and Dice, Mean Lifetime. This is a great opportunity. I appreciate the content and time of all of the fellows, guest speakers, and teachers. I noticed that I have modeled my learning environment and teaching strategies.
	Program Year (Year of Full Survey	
	2020	
	CMS Data workshop gives me the opportunity to learn more to bring back to the classroom. I would like to intro the dice activity as well as the conservation of momentum properties of the muons during proton to proton collisions.	
	graphing and data collection. Students try to minimize what they do. I think there is a lot of activities that could be pulled into my AP1 class. This hits a lot of the SEP in NGSS. I would have liked more time to go through the teaching guides but I can do that on my own. I understand that time was at a minimum for this workshop. I just finished the workshop today so I have not been able to implement QuarkNet into my curriculum yet.	
	Modeling mean lifetime of a particle with dice was very helpful. It is accessible to my students, and requires very few materials to implement. I would recommend them because they require minimal materials and are accessible. It was a very helpful program, and I feel like I learned a lot about how to extend a physics curriculum. Due to the workshop being hosted online, the feeling of community or networking was not so strong. I understand that this was unavoidable due to covid-19, and I'm very grateful to have been included.	
	Program Year (Year of Full Survey)	
	2021	
	One workshop associated with data collection that led to the discovery of the Higgs Boson. I used this in my Honors Chemistry Course in my unit on discovery of subatomic particles/how a cloud chamber led to this information. My students constructed their own cloud chambers. I used both natural cosmic radiation as well as samples of radioactive Uranium to detect vapor trails. I used material from the Cosmic Ray activities. My students built their own Cosmic Ray Cloud Chambers. The materials and instructions are clear and easy to recreate with simple resources. I teach Honors Chemistry and I use the AMTA Modeling curriculum. This curriculum stresses the use of DATA BASED inquiry. Patterns from graphs of data provide the evidence and mathematical proportions that gave rise to all of the constants they use in the "plug and chug" formulas. Students own the entire process and not only the end results (the constants they often must memorize but have no idea where they came from). Learning like a scientists does, experiences the uncertainty in every single measurement made in science allows the student to understand the meaning of scientific inquire and provides students confidence in the process.....scientists don't ever know exact answers... every inquiry creates another question. Big Picture are ideas provide the BOTTOM-LINE..what does this mean to me as a student. . Why is this important...before going into the nitty gritty. Grabs the students attention and provides a platform to jump into the deep drive of data (evidence) for the phenomena presented to them. Because I teach my Honors Chemistry class using the Modeling curriculum from the AMTA website, QuarkNet's data-based learning has been a key resource for my unit on Atomic Modeling. I have used the cloud chamber activity each year.	

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey
and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Subsequent Program Year
Fermilab/UC	2021	2024
	I really liked the 2021 Workshop because I learned python and how to use this in the classroom. I will use the half-life pennies this year. I am connected to many professionals and other teachers. QuarkNet is very hands on. I like that I can apply these skills to the classroom. I learned beginning python to use in my classroom from when teaching half-life.	
	Not used any (new to program).	
	Not used yet but would recommend. I trust Fermilab quality of work and thank their staff/researchers for that.	
	By far this Coding WS has been the best ever because of its applicability and implementability on several class levels. I intend to use this WS right away but have not done so yet. Managing data is something ALL students of science (and Physics in particular) need to learn to do- including proper manipulation and interpretation. Simple exposure to data is also extremely important and can transcend job barriers (finance, science, etc.) I really enjoyed this most recent series of sessions...The exposure to the notebooks-style of python learning has been the best of any of my attempts to learn Python coding. Plus, I can see a direct link to implementation of this style/method in my own classroom, at varied levels.	Because, no matter how much you attend, you will exit knowing more than you did before- as long as you enter with open mind and pay attention and participate.
	Program Year (Year of Full Survey)	Subsequent Program Year
	2022	2024
	They were all helpful. The coding camp helped me with the python so I can use it better in class, and the others encouraged me to introduce physics and particle physics, as well as careers in physics, to my students. Rolling with Rutherford when I was teaching 8th grade, and the pennies one. I would recommend them because they are good hands on activities to use in the classroom. Some of the math and statistics aren't really applicable to my grade, but to regular physics classes they would be. There is excellent information about real physics and real experiments. It's very exciting. So far there hasn't been too much sharing about the pathways in the Data Portfolio, or sharing about individual classroom practices, but it was still a good time. Instructional strategies were not explicitly detailed, however if we use our experiences as an example, an accurate display of inquiry based learning was exhibited. QuarkNet has helped me to become interested in showing my students about particle physics and physics in general, as well as my own interest in physics, including my current Master's program in Science Education with an emphasis in physics. This would never have happened without QuarkNet.	The trainings I've had, didn't really go over them. I haven't really been exposed to them except for 5 years ago or so. QuarkNet has done a lot to make me feel confident about teaching science, especially since I didn't major in science. It has encouraged me to advocate for physics and physics careers with my students. As I continue in QuarkNet activities, I look forward to becoming even more knowledgeable about particle physics and discovering more ways to engage my middle school in particle physics as a part of their physical science units, and to using the coding as a regular activity in my classroom. Thank

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey
and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

<table>
<tr><td>Center</td><td colspan="2">Program Year (Year of Full Survey)</td></tr>
<tr><td rowspan="8">Fermilab/UC</td><td colspan="2">2022</td></tr>
<tr><td colspan="2">Rolling with Rutherford & Measuring the mass of a penny will be most helpful in my engineering classroom. The activities we did were relevant to higher level students especially. I teach engineering and some activities are more difficult to implement in my classroom. QuarkNet has not had an impact on my classroom YET as this is my first year in the program. I do plan to implement some relevant material in my engineering classes.</td></tr>
<tr><td>Program Year (Year of Full Survey)</td><td>Program Year (Year of Full Survey)</td></tr>
<tr><td>2022</td><td>2024</td></tr>
<tr><td>e-Labs and activities are useful to bring more hands on activities. Quark puzzle, Rolling with Rutherford. Hands on, good directions and examples. I am just in the first day, but I am excited to learn from the group.</td><td>I have used QuarkNet Data activities and Coding activities in my Modern Physics class. The entire unit was built on the activities including Rolling with Rutherford, Card deck, Quark workbench, Top quark from D zero, Z boson, and several coding activities with two muon decays. I used Rolling with Rutherford, Top Quark, Z boson, Quark bench and card deck. Students are more actively engaged in learning new concepts through data activities. I think the activities are really good and I think more physics teachers should use them so that students have access to modern science</td></tr>
<tr><td>I have not yet but plan to this upcoming fall. I think it gives a different perspective.</td><td>I plan to incorporate analyzing data through coding. I teach geometry so I rarely incorporate data. This camp experience pushed me into doing that. The lesson I just created which will have students see where pi comes from when calculating the area of a circle and circumference of a circle. This was such an awesome experience. I am so amazed at how much I grew. I think feeling safe played a huge part. I felt safe to ask for assistance when it was needed. Also, hearing from others.</td></tr>
<tr><td>Using more coding exercises to make their learning permanent. This is my first year. I recommend (DAP) because learning will be permanent.</td><td></td></tr>
<tr><td>My initial QuarkNet workshop gave me some activities to introduce particle physics with my students. The coding camp 1 workshop has greatly helped me understand how to implement coding into my classes. I have used the 'Rolling with Rutherford' activity with my physical science class to understand how Rutherford's experiment worked. I have used card games to introduce quarks and how they combine to make particles. I think that the activities are great, but even I am not sure how to use some of the activities that I have not been trained on. Being at the workshop is almost necessary to be able to talk with other teachers that have used the activities or are planning to implement them in the classes. There are so many resources that I never knew existed. I fell that I got a new skill here as well. The coding camp has opened a world that I can let my students explore</td><td></td></tr>
<tr><td>I have only been to one and I received some ideas for a couple of activities - the one on Rutherford's model of the atom - that I can use this school year. I haven't recommended because I haven't had a chance to look through everything.</td><td></td></tr>
</table>

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	Program Year (Year of Full Survey)
Fermilab/UC	2023	2025
	The collection of data activities are a wonderful and useful resource for teachers to use and modify for incorporating into our own classrooms. Very helpful! To have the opportunity to learn from and ask questions of actual researchers in the field was invaluable for increasing my understanding and knowledge which I can then bring to my students in the classroom. The approach of guided-inquiry that we practiced falls exactly within the goals of my teaching methods, so the lessons we experienced are perfect examples of what we can bring to our own classes.	
	The workshop I did was a great introduction to the work that Fermilab does with neutrino research. I was able to brush up on my particle physics understanding as well as apply some coding analysis. Example: Shuffling the Particle Deck. Great variety of activities that cover different topics at different levels. I like how the portfolio is organized to align with the NGSS standards. As with most conferences, it was a good opportunity to connect with other professionals and hear what strategies/activities they use in their own classrooms. In addition, I loved learning about current physics with the scientist and student talks. It inspired me to try to add more modern physics into the curriculum at my school.	Since we follow the AP curriculum pretty closely, it has been difficult to incorporate modern topics. However, I have found ways to do mini activities in the following topics so far: - Centripetal Forces and Circulator Motion (Accelerators) - Conservation of Momentum (Hidden Neutrino Activity) - Nature of Science (Mystery Box Activity) I plan to include more topics and activities during the E&M curriculum. In addition, I will be presenting about my experience at CERN/QuarkNet to Physics Club. I hope to continue participating in more teacher workshops to strengthen my own understanding of particle physics, and to engage students with more learning strategies in these topics as well. Looking forward to collaborating with more colleagues!
	Coding experience. Probability. They are really great extension to any related topic activity. It is an awesome opportunity for the teacher community.	More coding opportunities. Penny lab. It is a great opportunity.
	Program Year (Year of Full Survey)	Program Year (Year of Full Survey)
	2024	2025
	I have only been to one. I learned quite a bit that I can take back to my students. This is the first time I have attended so I will have to work to incorporate this into my curriculum for next school year. I have had a wonderful experience so far. All of the instructors, researchers, machinists, and students have been incredible. Great experience to meet and interact with everyone so far. I haven't had the opportunity yet to implement what I have been taught, but I hope it will make an impact with my students	We will use e-Labs in AP physics 2 to analyze real life data and discuss the relationship between mass and energy. I did not use the activities directly last year, but I used ideas found within the activities. It was a great experience. Especially hearing from the scientists that work at Fermilab.

Table (con't.)
Self-reported Use of Data Activities Portfolio Activities: Based on Reponses from the Full Survey
and then Responses from the Update Survey in Subsequent Years **Fermilab/University of Chicago Center**

Center	Program Year (Year of Full Survey)	
	2024	
Fermilab/UC	Cosmic e-Lab workshop, it was a good introduction to potential exploration activities for high school science students. The use of the data for analysis and critical thinking about how the data is related is valuable for science teaching. The instructional material should enhance the student learning experience. It makes it easier to focus on the learning objectives and outcomes. It was very informative and motivating.	
	Penny Mass activity. It's a chance to work with authentic data. It would be good to discuss more classroom implementation. It's amazing to be exposed to the cutting edge ideas.	
	Program Year (Year of Full Survey)	Subsequent Program Year
	2024	2025
	I have only attended 1 workshop so I have no other reference to compare. New to program so again, no current context yet. Very informative first workshop. I can definitely see myself attending future QuarkNet workshops held at Fermilab. More resources are always good.	The data portfolio activities offer accessible options for teachers. Some of the data activities can be applied to a huge range of levels of students. The e-Lab data is also an interesting way for students to analyze graphs without knowing exactly what they are looking at. Energy, mass and momentum is a very relevant activity that I plan to use in my physics classroom. Calculate z-mass can be used to explore vector addition/subtraction as well.
	It's my first. Not used any yet. I am just getting aware of these- only second day! Depends on my experience! Still unfolding	I will use the "speedy muon" activity with my AP students this year. With my regular physics students I will adapt the activity. I also plan to use the radio telescope activity in my independent study section of AP 2. I gained a much improved sense of particle physics, general relativity, astrophysics and the processes of science from this week.
	I only have one! But I have found it useful in understanding the many types of background, experiences and jobs involved in working on these projects – which helps me better understand how to advise and direct students. I was invited to come although I teach low-level physics – so some of this didn't seem as related to what I teach as higher level physics teachers. Having community is helpful. The methods we use to teach are already in place and while QuarkNet supports this, it didn't make me more able/likely to work that way because it's our established method of teaching. That doesn't reflect poorly on QuarkNet! What I did find were many more ways to incorporate real-life scenarios to use when trying to give students ideas about how science is done in the real world and some of the things scientists run into, rule out, etc. That's incredibly useful. It also gave an incredibly valuable view of the many types of jobs and content knowledge areas that are involved in these projects – which is incredibly helpful in advising and guiding my students.	The coding camp training has resulted in me being able to and prepared to introduce my middle school students to coding and have it integrated into their curricular topic. All statements apply to our science classrooms with or without QuarkNet. Planning to use: 1) Introduction to Coding using Jupyter 2) Research Using Coding 3) Mass of US Pennies.
	Data analysis. This is real life application	
	Cosmic Ray Workshop, great intro to cosmic rays and e-Labs. Use within AP2 for labs and data analysis.	The e-labs will be added to the standard model portion of our content and to the linear motion as well. CMS e-labs.
	It is always good for students to see real world examples to learn from. Over all these are great programs but are hard to incorporate in an AP Classroom due to time restrictions. It is always good to connect with the larger science community and interact with peers and local scientists. I really enjoy the QuarkNet team and working with other physics teachers around the area.	

The next several pages offer data plot examples from teachers who participated in a QuarkNet mini-workshop given at the Northern Illinois Conference for Science teachers (November 2023). Posted implementation plans created by teachers participating in the 2025 CMS e-Lab workshop (July 2025) are presented in a supplemental document to this portfolio.

ALTAS Published Mass Plots generated from data analyzed by teachers in 90-minute Masterclass, Northern Illinois Science Educators Conference, November 13, 2023

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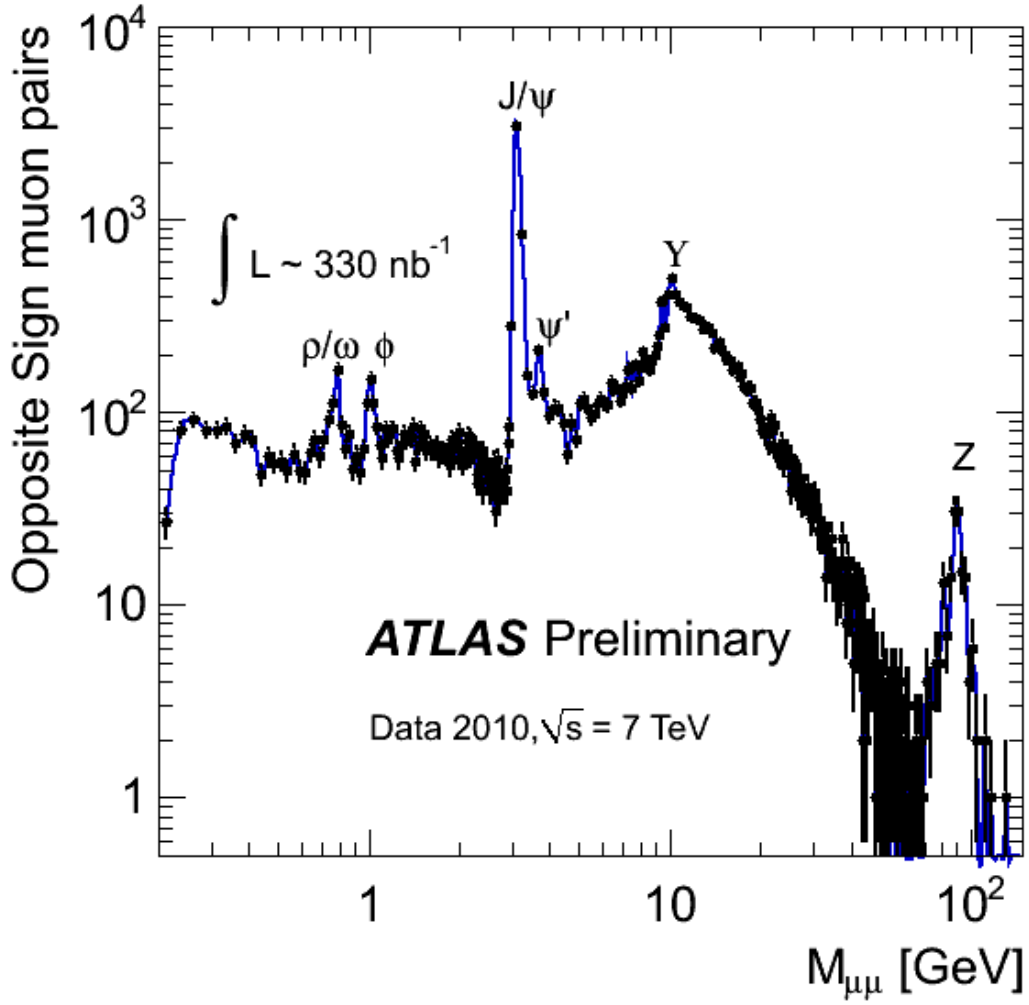

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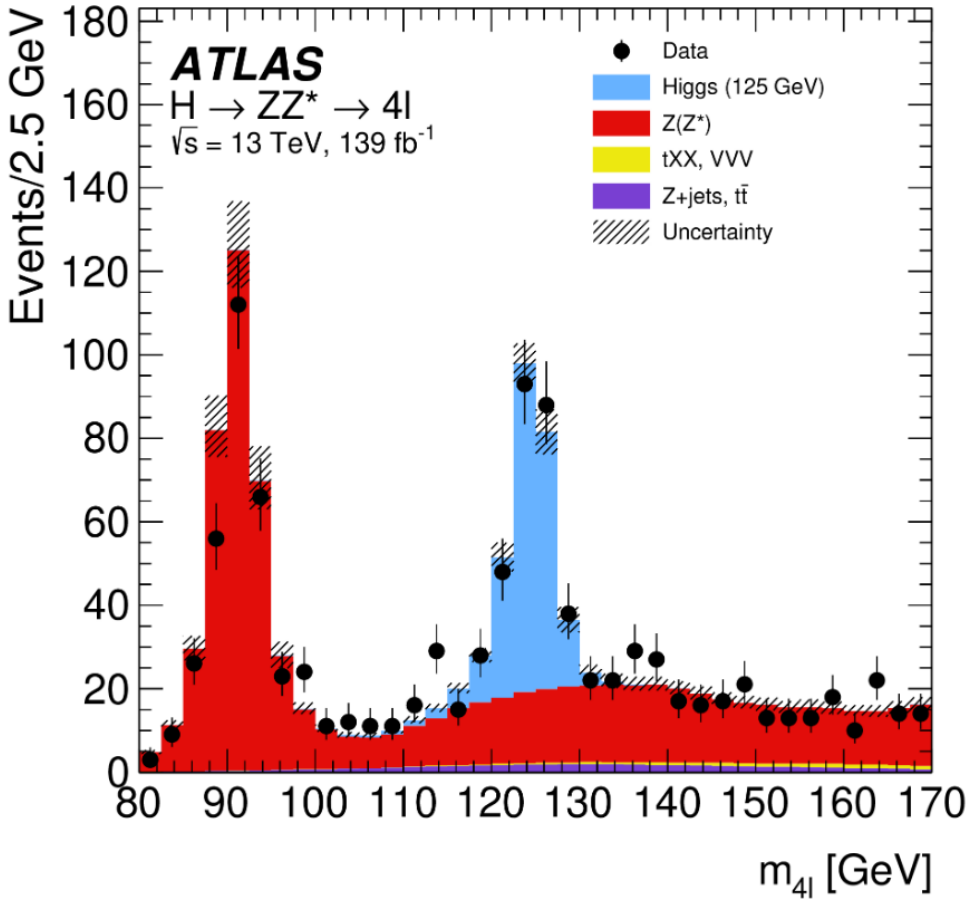
4-lepton



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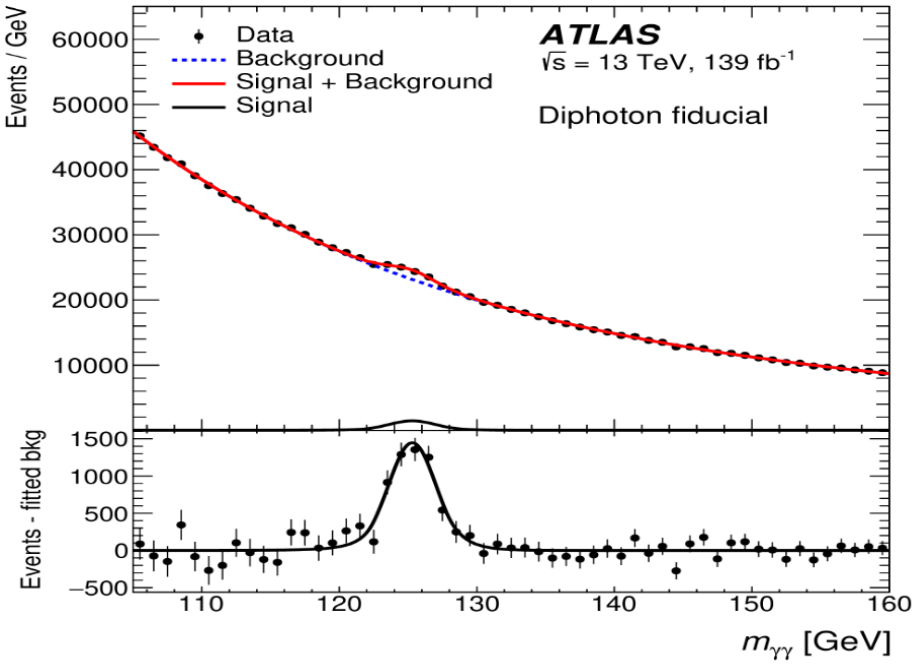

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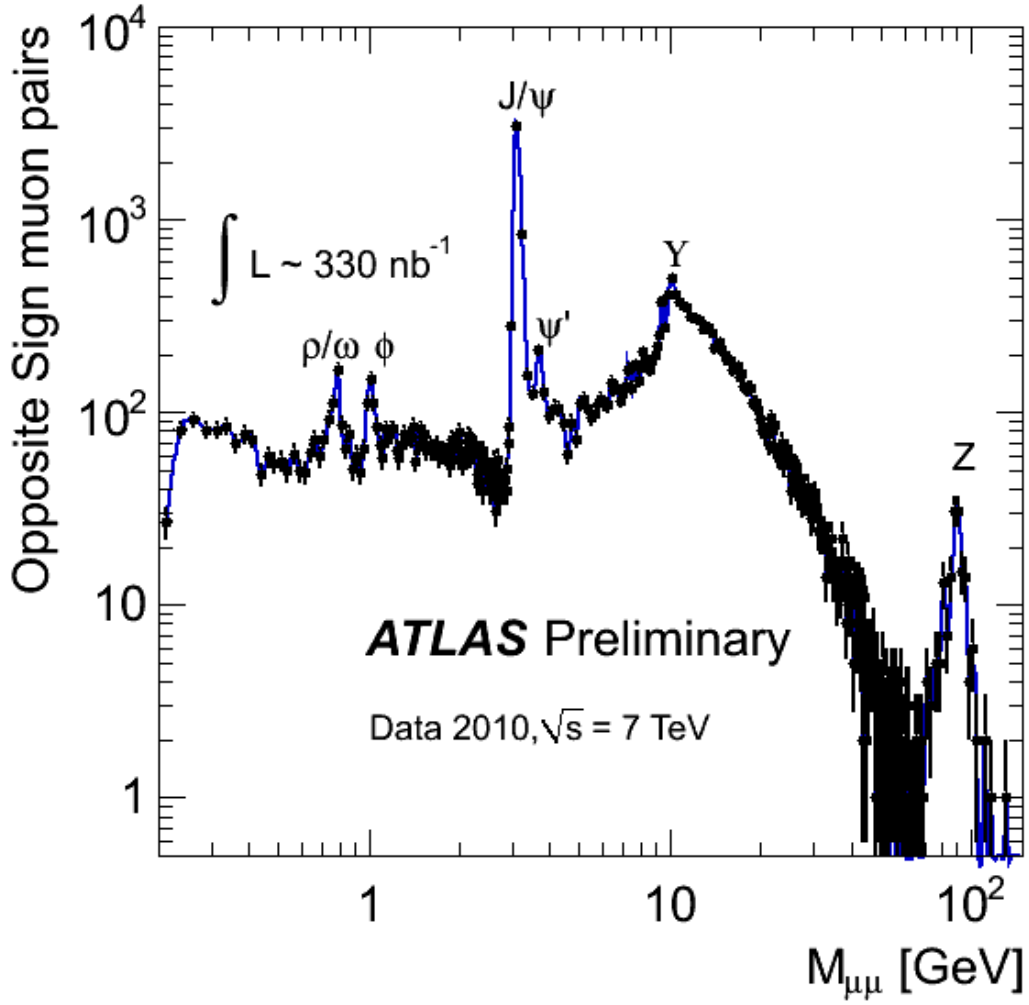

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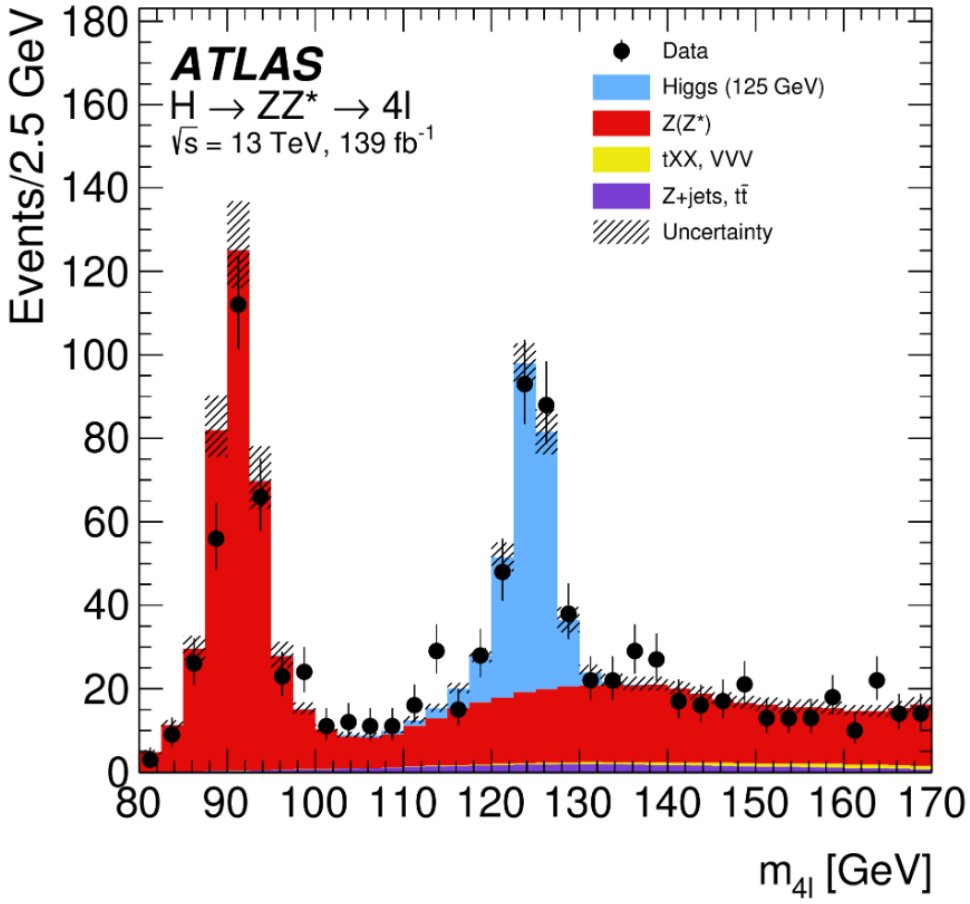

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