Center-Level Portfolio: Fermi Lab Center/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 anonymous 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
	No response		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.	
	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.		Real life data analysis and experience with science. Data analysis of CMS neutrino data and analysis.
	This is my first time participating in QuarkNet. I thoroughly enjoyed my time in the QuarkNet workshop and plan to implement as much as I can this upcoming school year.			
	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.			
	I'll be using a great deal of these... dice, basic histograms, missing neutrino.			
	I have used techniques that involve looking at real data.			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.
	I have had students build histograms.			
	e-Lab and electronic posters			
	Hands on analysis of data to understand neutrinos			
	Rolling with Rutherford; Quark Work Bench Histogram: the Basics Mean Lifetime Dice			
	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).	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		

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
	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.				
	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
	Pennies, dice, histograms, workbench, top quark, CRMD	Muon Decay Radioactive Decay Dice Experiment. When teaching conservation of momentum and energy, I was able to use the Muon Decay with my students. This illustrated how these important laws of physics are used in current research,	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.	Histograms and probability using dice Muon decay World wide data day. 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.	Mass of Pennies Dice, Histograms & Probability Histograms Energy, Momentum, and Mass STEP UP, Culture, Careers, Women MINERvA, mean lifetime. students often need more exposure to variation in data, and benefit from expanded understanding of current physics research.

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
	Pennies, dice, histograms, workbench, top quark, CRMD	Muon Decay Radioactive Decay Dice Experiment. When teaching conservation of momentum and energy, I was able to use the Muon Decay with my students. This illustrated how these important laws of physics are used in current research,	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	Histograms and probability using dice Muon decay World wide data day. 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.	Mass of Pennies Dice, Histograms & Probability Histograms Energy, Momentum, and Mass STEP UP, Culture, Careers, Women MINERvA, mean lifetime. students often need more exposure to variation in data, and benefit from expanded understanding of current physics research.
			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		The data analysis portions. Having data for students to work with (graphing, identifying trends, analyzing relationships). Examples: Rolling with Rutherford, muons.
	The half-life dice lab I believe would be the most helpful.		I have used the penny mass lab with my students. Graphing and bins discussed. Future examples: The introduction to coding. The graphing using coding. Penny lab both weight and half life.	Python notebooks, penny lab, Rolling with Rutherford.	Rolling with Rutherford. The data analysis portions. Having data for students to work with (graphing, identifying trends, analyzing relationships). The data sets are extensive so there is a lot that can be used.

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	2020	2021	2022	2023	2024
	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 student 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.					Rolling with Rutherford, Python sample activity, bar graphing penny weights. Arranging the deck of cards using parts of the standard model. My favorite parts are the tours, the vital comradery between teachers and the students talking about their research.
	The half-life dice lab I believe would be the most helpful.		I have used the penny mass lab with my students. Graphing and bins discussed. Future examples: The introduction to coding. The graphing using coding. Penny lab both weight and half life.	Python notebooks, penny lab, Rolling with Rutherford.	Rolling with Rutherford. The data analysis portions. Having data for students to work with (graphing, identifying trends, analyzing relationships). The data sets are extensive so there is a lot that can be used.	Last year I incorporated the Cosmic Ray Muon into STEM class when explaining 3d printing. I have used some of the labs on QuarkNet in previous classes including Rolling with Rutherford and penny lab. Other examples: particle cards; indirect meas.

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	2020	2021	2022	2023	2024
		Data activities, CMRD detector, Cosmic Ray e-lab, using in Physics and Chemistry classes, as well as club extracurricular, informal settings. Examples: Histograms, mean lifetimes, Heisenberg	Teaching with data, great stuff plan to incorporate google colab coding activities into Physics and Chemistry classes. Examples: Pennies, dice, histograms, STEP UP.	Portfolio activities into Modern/Honors/AP level Physics classes, Modern/Honors Chemistry classes. Examples: Mass of Pennies, STEP UP.		
	Graphing, studying large quantities of data, statistics	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 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 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.	Measuring the mass of pennies	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.
	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).	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				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.

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
Fermilab/UC	2020	2021	2022
		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.	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
	The dice and understanding half-life.	My intention is how do you intend to incorporate this summer QuarkNet experiences into your 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. I can definitely incorporate this in my math class and the star catalog program for analysis and visualization.	I really like the ISLE curriculum, especially with motion and I like to use some of the materials (linear algebra) from Dr. X. 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.
	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.		
	I use the dice activity to teach histograms and probability.		
		I will use the Google Colaboratory Juptyer Notebooks to add a data science exploratory to principles of engineering. Examples: I will use the activities with Histograms and Dice, Mean Lifetime	
	I would like to intro the dice activity as well as the conservation of momentum properties of the muons during proton to proton collisions.		
	First time in QuarkNet, so I have not had the opportunity yet.		

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**

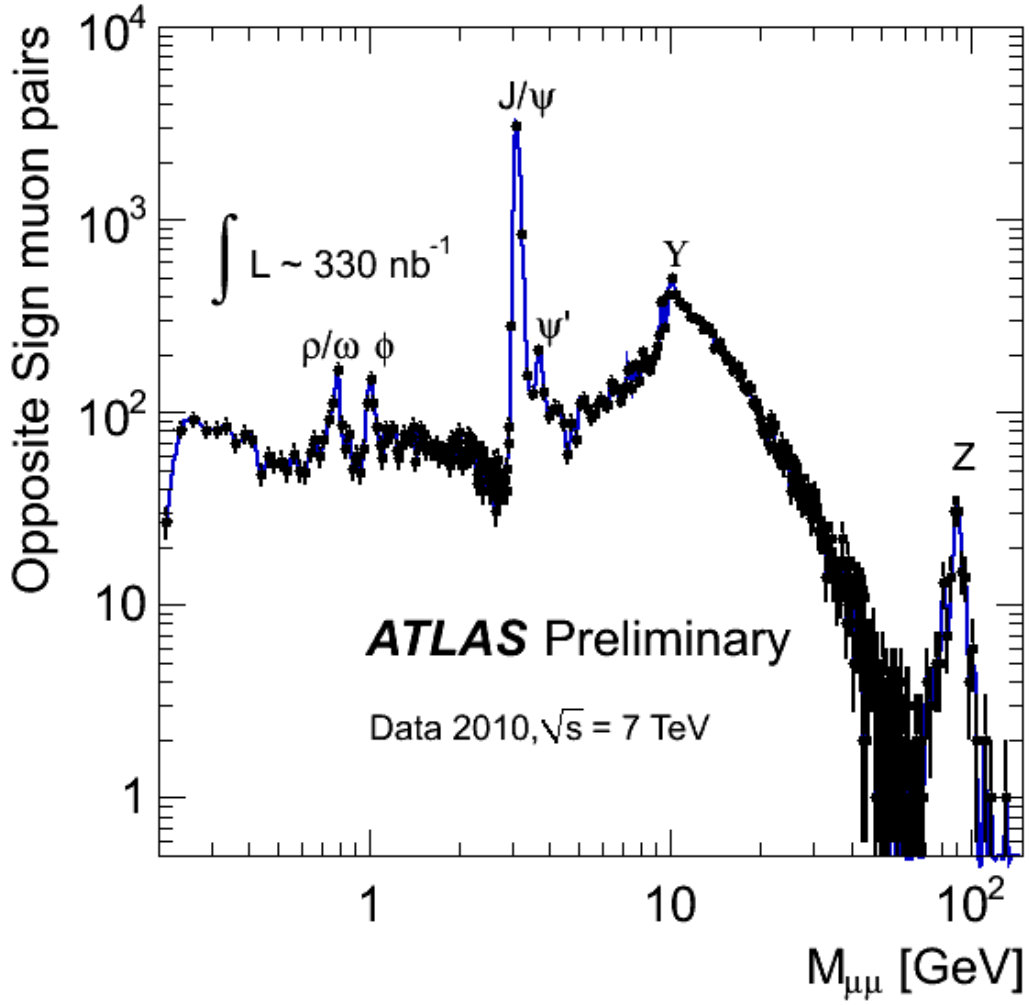
Center	Program Year (Year of Full Survey)	Subsequent Program Year
Fermilab/UC	2021	2024
	I will use the half-life pennies this year.	Because, no matter how much you attend, you will exit knowing more than you did before- as long as you enter with open mind and pay attention and participate.
	Intend to use this WS right away but have done so yet.	
	I used material from the Cosmic Ray activities. My students built their own Cosmic Ray Cloud Chambers.	
	Not used any.	
	Program Year (Year of Full Survey)	Program Year (Year of Full Survey)
	2022	2023
	Rolling with Rutherford when I was teaching 8th grade, and the pennies one.	
	Rolling with Rutherford & Measuring the mass of a penny will be most helpful in my engineering classroom.	
	Quark puzzle, Rolling with Rutherford.	Particle deck, quark deck (I did 3D printed and 2D puzzle) - students really enjoyed these. I am planning to do more CMS data activities in the future
	I have not yet but plan to this upcoming fall.	Particle deck, quark deck (I did 3D printed and 2D puzzle) - students really enjoyed these. I am planning to do more CMS data activities in the future. Activities are content appropriate and well wrtten. I also like the teacher instruction and resources
	This is g my first year.	
	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.	
	Program Year (Year of Full Survey)	
	2023	
	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!	
	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.	
	Probability. They are really great extension to any related topic activity.	

Note: Each row presents responses from the same individual teacher from a given center. Empty table cells indicate that the teacher did not participate in QuarkNet in that subsequent program year(s). Or, less likely did not complete the Update Survey; or did not answer specific questions about the use of DAP activities in their classrooms.

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.

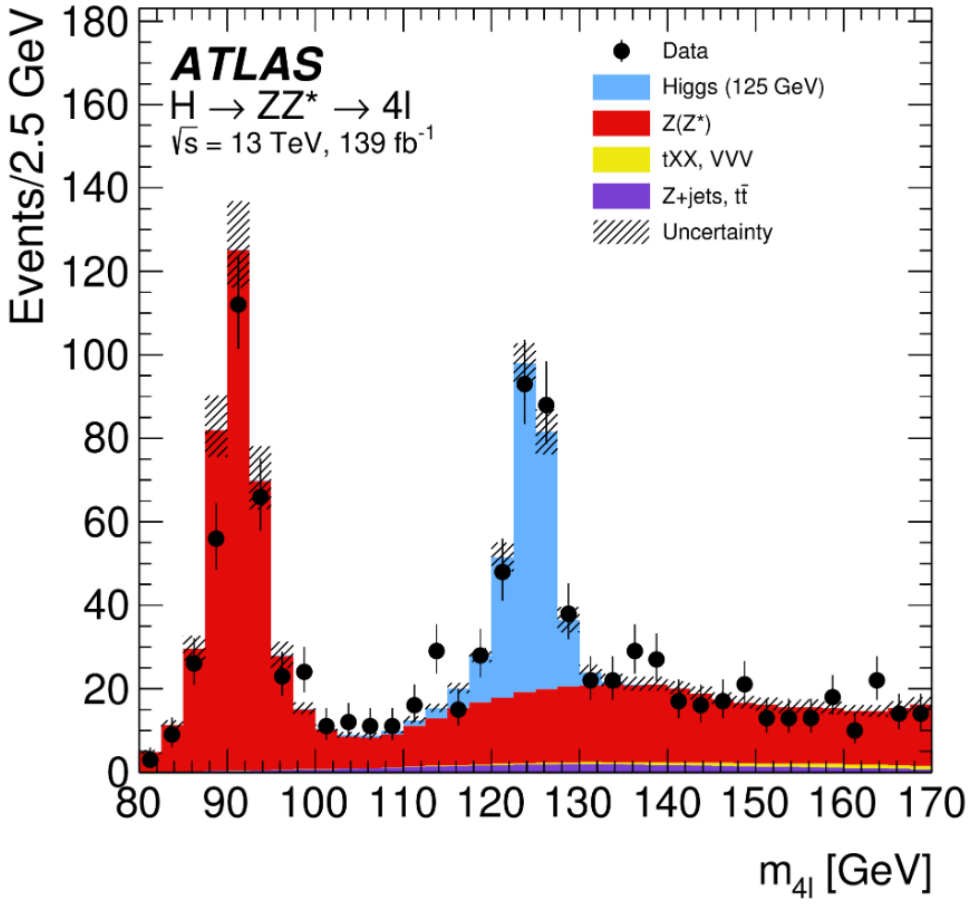
ALTAS Published Mass Plots generated from data analyzed by teachers in 90-minute Masterclass, Northern Illinois Science Educators Conference, November 13, 2023

Dimuon

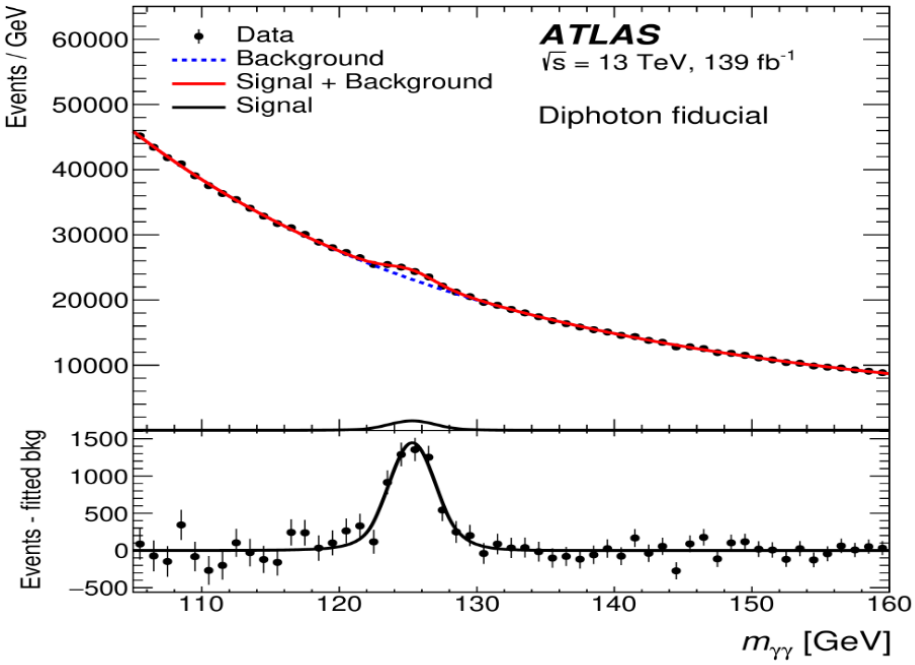


ALTAS Published Mass Plots generated from data analyzed by teachers in 90-minute Masterclass, Northern Illinois Science Educators Conference, November 13, 2023

4-lepton



ATLAS diphoton



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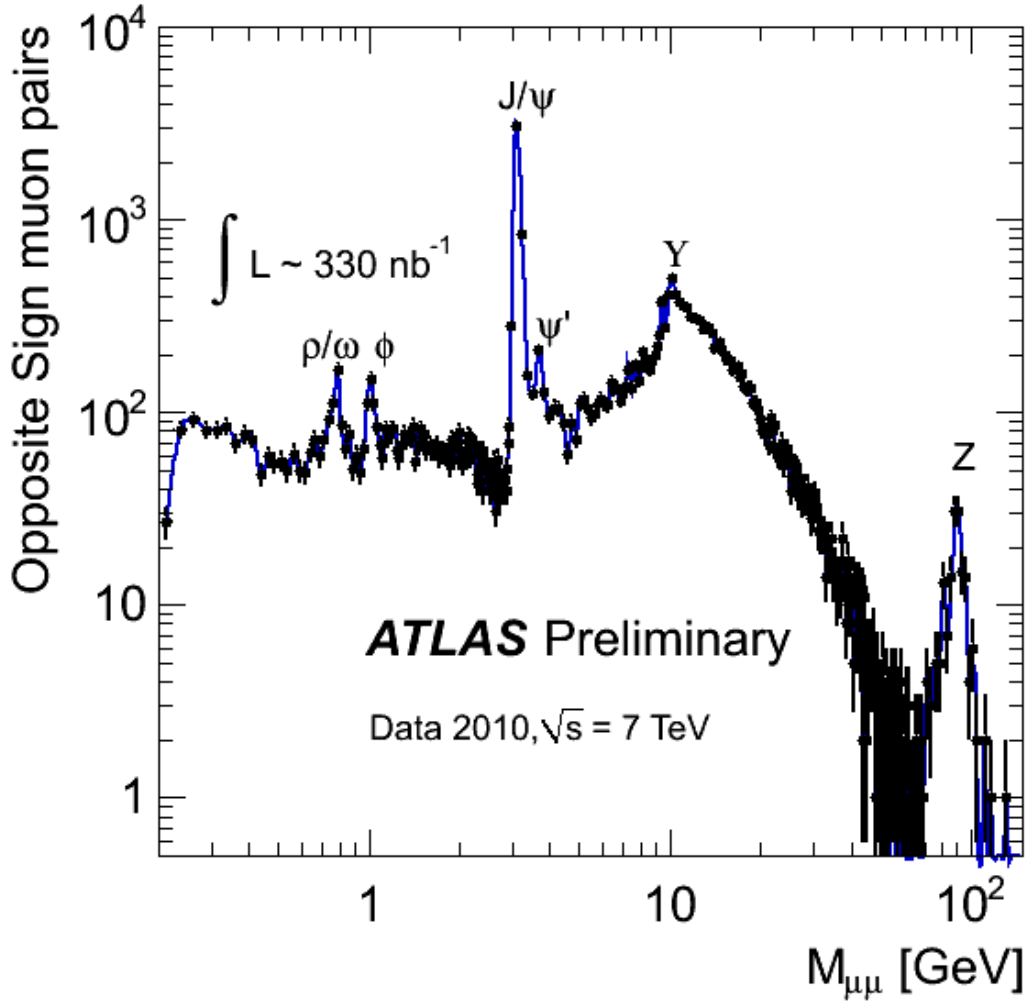

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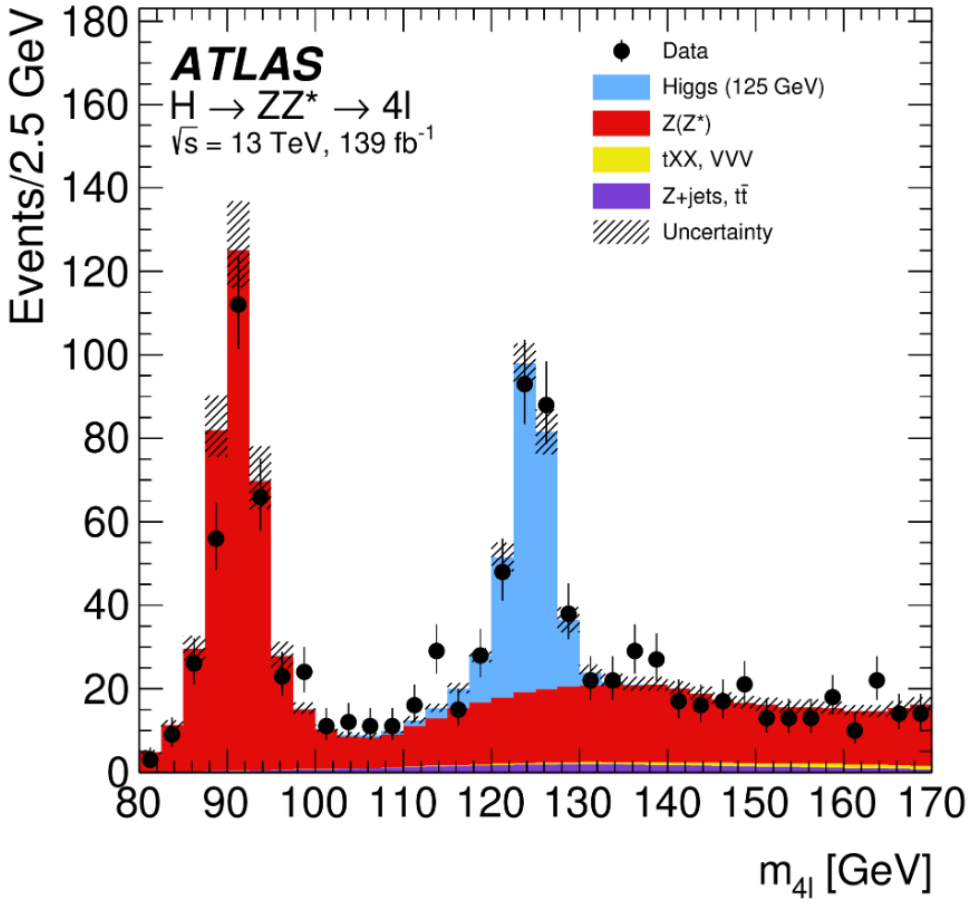

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