

**QuarkNet**

# Physics class: we'll get to the good stuff in June

INAAPT April 2019 Meeting

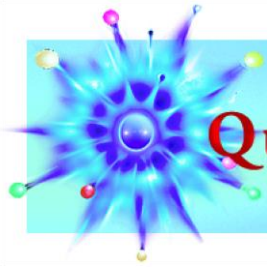
K. Cecire, University of Notre Dame  
[kcecire@nd.edu](mailto:kcecire@nd.edu)



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science





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## Who is this guy?

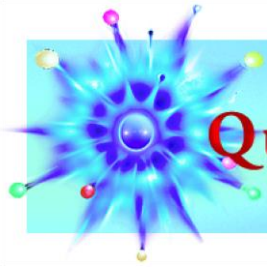
### Ken, me:

- High School physics teacher for about 20 years - private and public
- QuarkNet staff member for 20 years - Hampton University, then Notre Dame
- Married, 5 children (sort of grown), 4 grandchildren so far
- Co-Coordinate International Masterclasses (more on that)



My avatar on <https://quarknet.org>.

- Active in AAPT, current chair of COCP

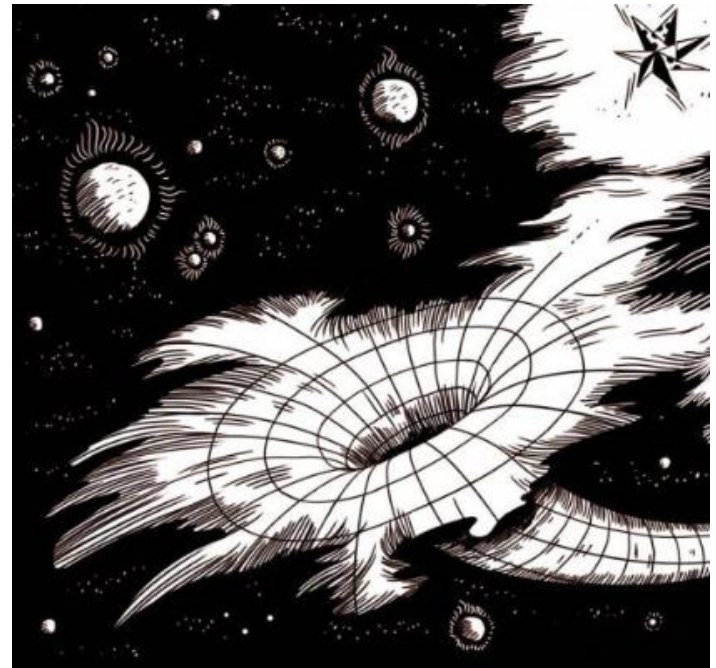


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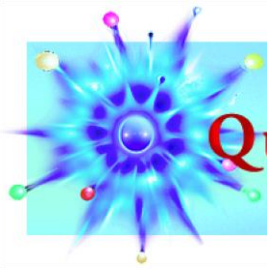
**Personal note.**



**Dad, recently.**

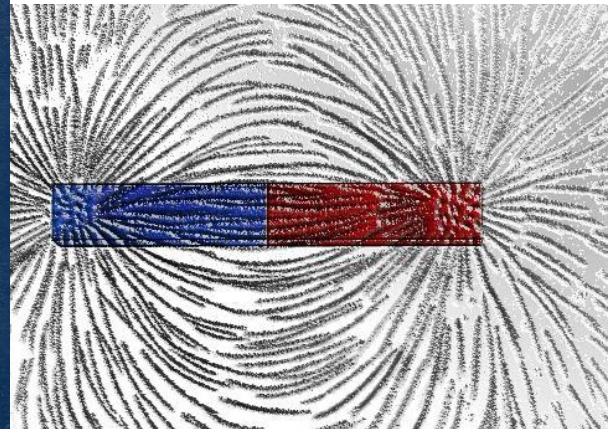
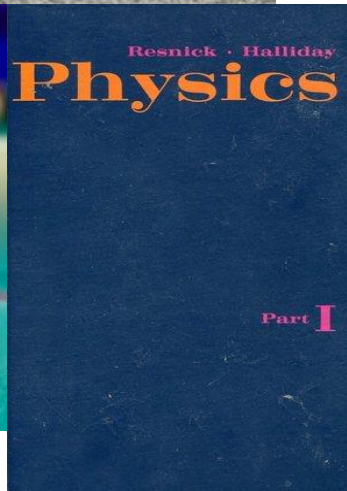
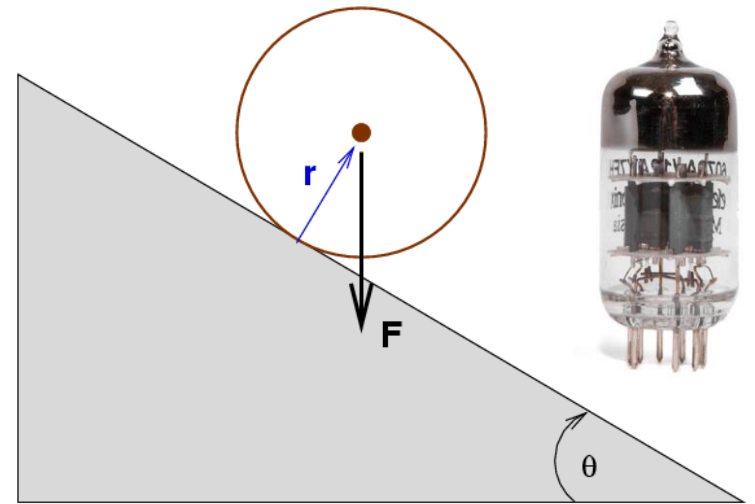


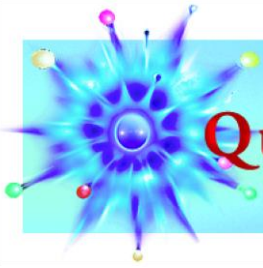
**Inside my brain, 1974.**



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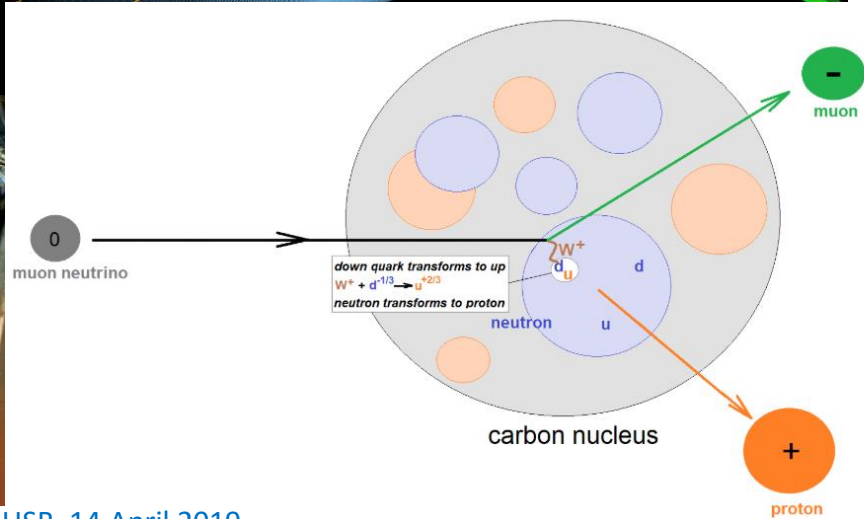
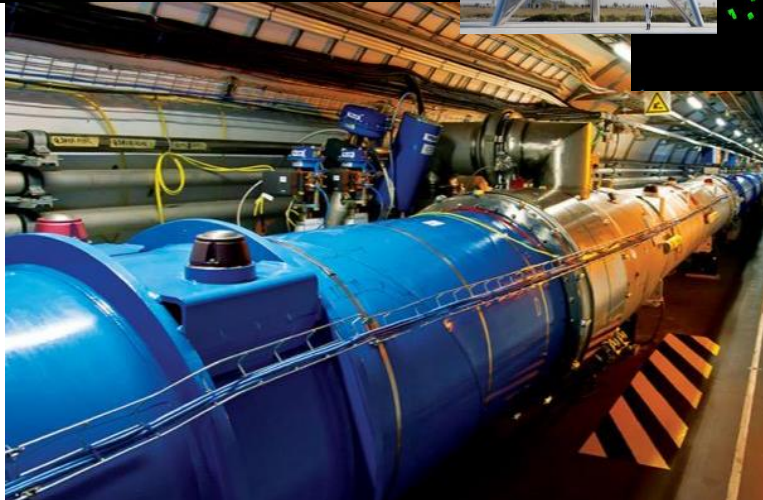
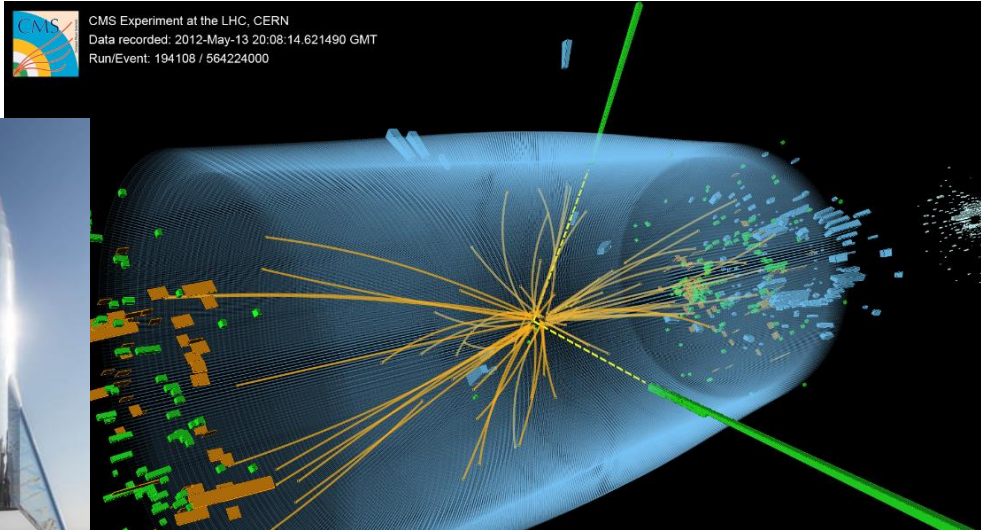
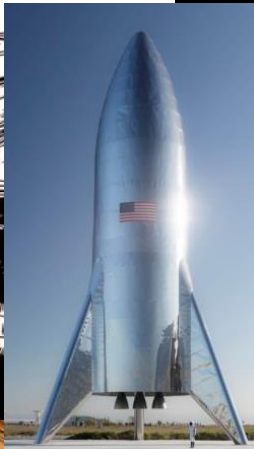
Awesome physics.

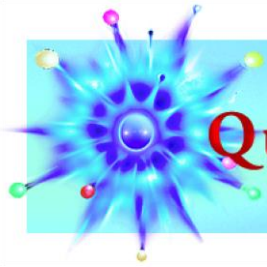




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# Awesome physics.





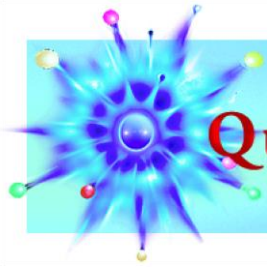
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They are the same\*.

\*Aside from some details, like relativity and quantum mechanics.

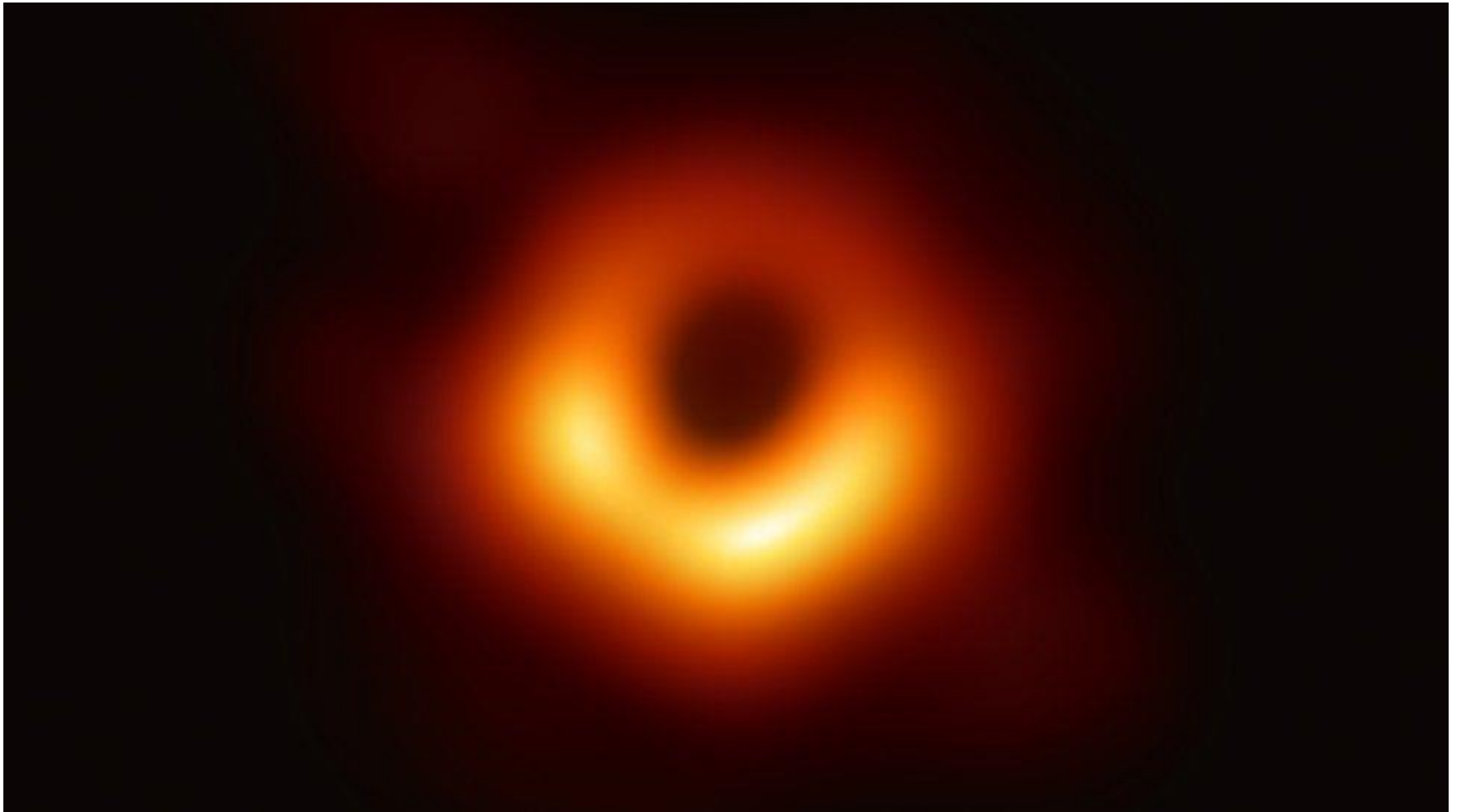
## QuarkNet is about:

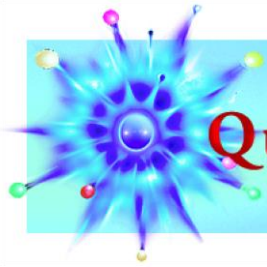
- Particle Physics
- Physics education reform
- Modeling best practices
- Professional development
- Connecting 21<sup>st</sup> century forefront physics to students and teachers by means of
  - Actual physics in the curriculum
  - Authentic **data**
  - Encountering exciting physics and physicists
- *Particle physics is our model!*



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**And we will not be swayed.**





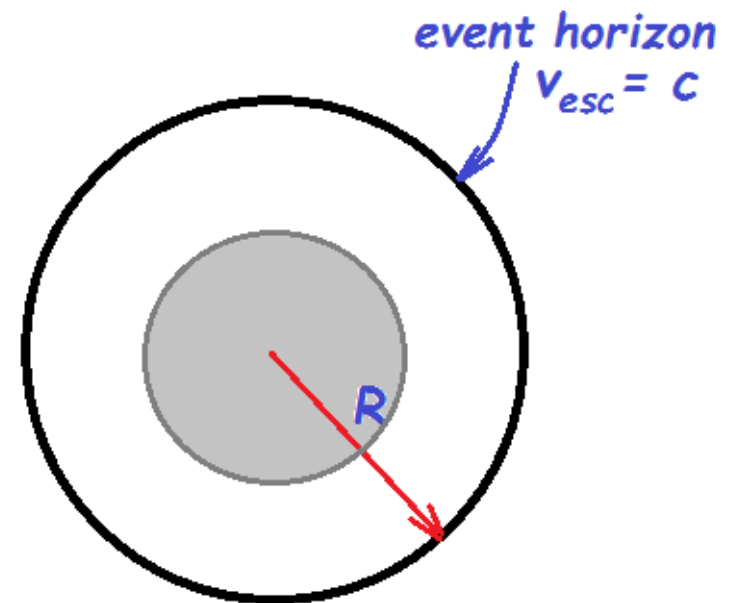
*For we teachers...*

**Event horizon of a black hole:**

$$\frac{1}{2} mv^2 = \frac{GMm}{R}$$

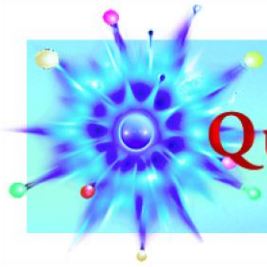
$$\frac{1}{2} c^2 = \frac{GM}{R}$$

$$R = \frac{2GM}{c^2}$$



*Black hole of mass M*

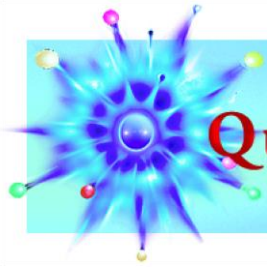




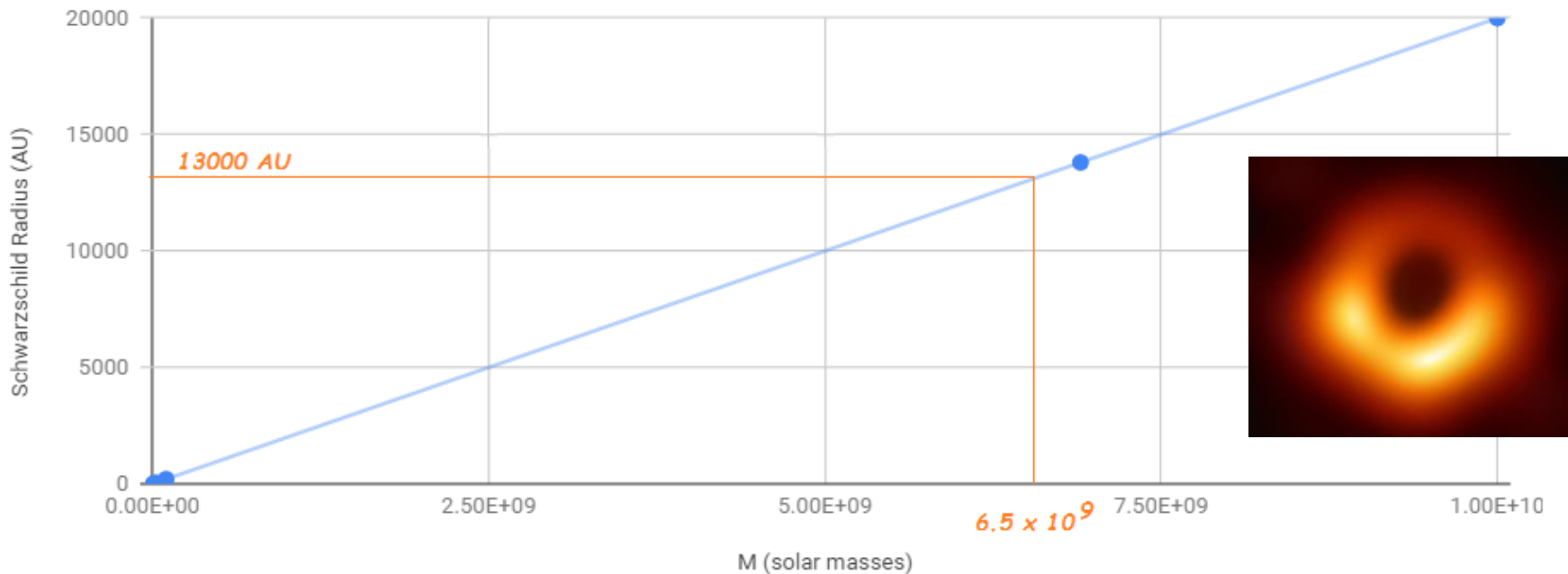
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**Put together data.**

<b>Black hole</b>	<b>Solar Masses</b>	<b>Event Horizon (AU)</b>	<b>log M/M<sub>s</sub></b>	<b>log R/(1 AU)</b>
Sag A	4.60E+06	9.2	6.66	0.96
M108	2.40E+07	48	7.38	1.68
M85	1.00E+08	200	8.00	2.30
CID 947	6.90E+09	13800	9.84	4.14
NGC 1281	1.00E+10	20000	10.00	4.30

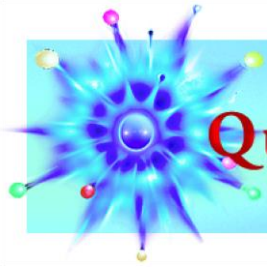


## Supermassive black holes



*black hole diameter = 2 x 13000 AU = 26000 AU = 39 billion km*

*R<sub>shadow</sub> = 2.5 R<sub>s</sub> = 33000 AU = 50 billion km*



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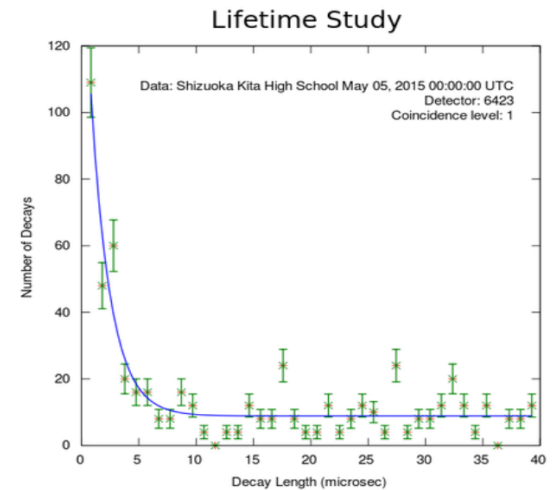
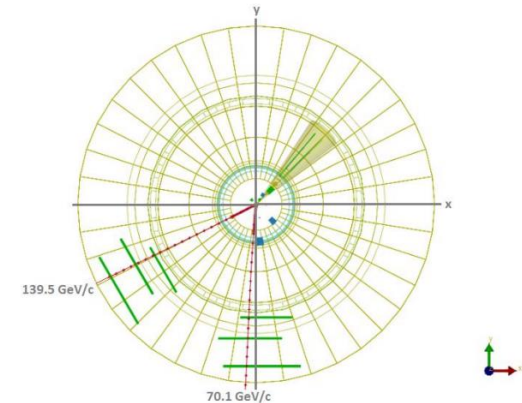
# Data Activities Portfolio

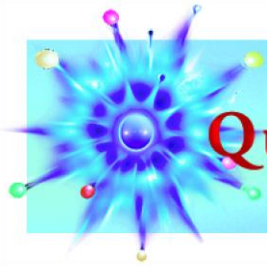
**But, really, we do particle physics.  
With activities from our Data  
Activities Portfolio, teachers and  
students can:**

- Calculate the mass of the top quark or Z boson using vector addition.
- Find the size of a proton using wave diffraction.
- Find muon lifetime from student-taken data,
- Use histograms to model data analysis done by physicists.

Find it at <https://quarknet.org>.

Run 148031 Event 447172799





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# More Opportunities

**It is great to be part of QuarkNet!**

**Centers:**

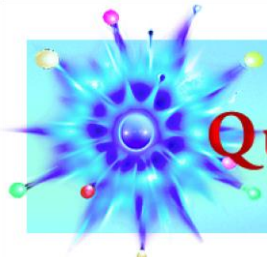
- Notre Dame
- Purdue
- Purdue Northwest
- Cincinnati
- IU Bloomington

**You do not have to be in QN for:**

- The Data Activities Portfolio ✓
- World Wide Data Day
- International Masterclasses
- e-Labs.

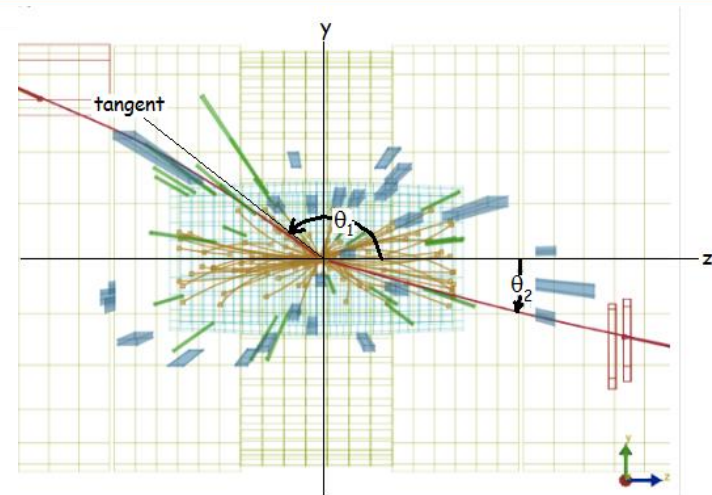
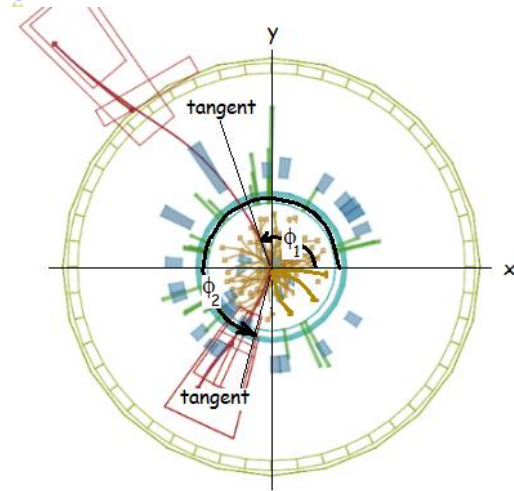
Find out more at <http://tiny.cc/qnin19>.



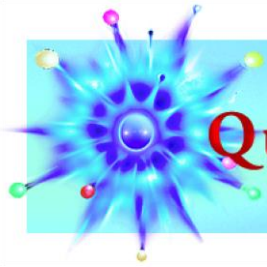


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# World Wide Data Day



- Simple measurement with real CERN data, ~90 min
- Discuss with physicists, other students in videocons
- One 24-hr “shift” each autumn
- Do from your school, connect worldwide
- Use histograms to model data analysis done by physicists. (Did we say that already?)
- Results: simple but profound!



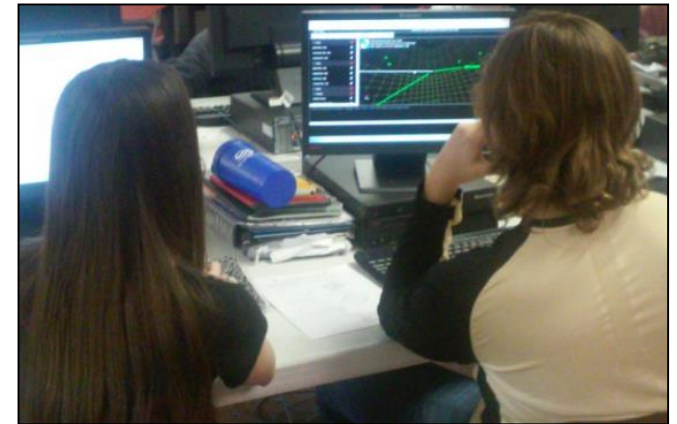
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# International Masterclasses

## What is a masterclass?

“Particle physicist for a day”

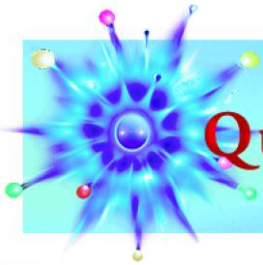
- Intro
- Tour
- Analyze authentic particle data.
- Videoconference



## International Masterclasses 2019 and beyond

- > 50 Countries
- > 10<sup>4</sup> Students
- 4 CERN experiments
- 1 new Fermilab neutrino experiment
- More on the way

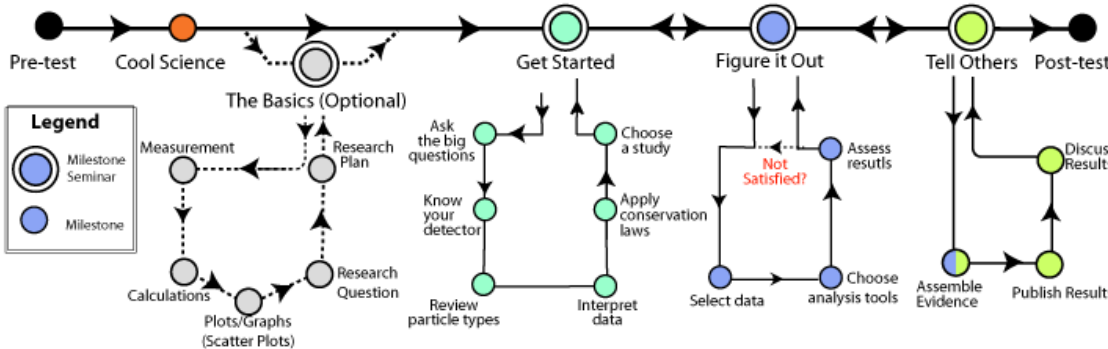
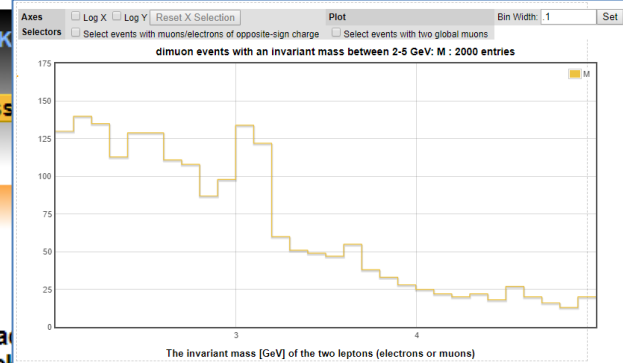




Home: Join an international collaboration of high school students to study CMS data.

### View News Alert

Project Map: To navigate the CMS e-Lab, follow the path; complete the milestones. Hover over each spot to preview; click to open. Along the main line are milestone seminars, opportunities to check how your work is going. Project milestones are on the four branch lines. [Getting Around the e-Lab](#)



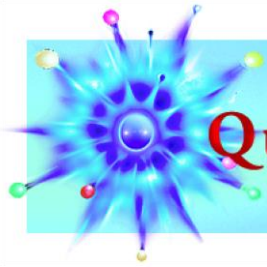
Milestones (text version)

Your team may use the milestones above, or your teacher may have other plans. Make sure you know how to record your progress, keep your teacher apprised of your work and publish your results.

## Two flavors:

- CMS (data from CERN)
- Cosmic ray (data from classroom detectors)

All in the browser!  
Use it anywhere!



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# So what now?

## Stay in touch

- [kcecire@nd.edu](mailto:kcecire@nd.edu)
- 574-631-3343

## Visit

- 929 North Eddy Street,  
South Bend (but we are  
moving in August)

## Try it out:

- <http://tiny.cc/qnin19>
- I will help. It's my job.
- *Anyone want to develop the  
black hole measurement?*

**Ask questions.**

