Race & Associates, Ltd.

Virgina Center
Hampton University
College of William and Mary
George Mason University

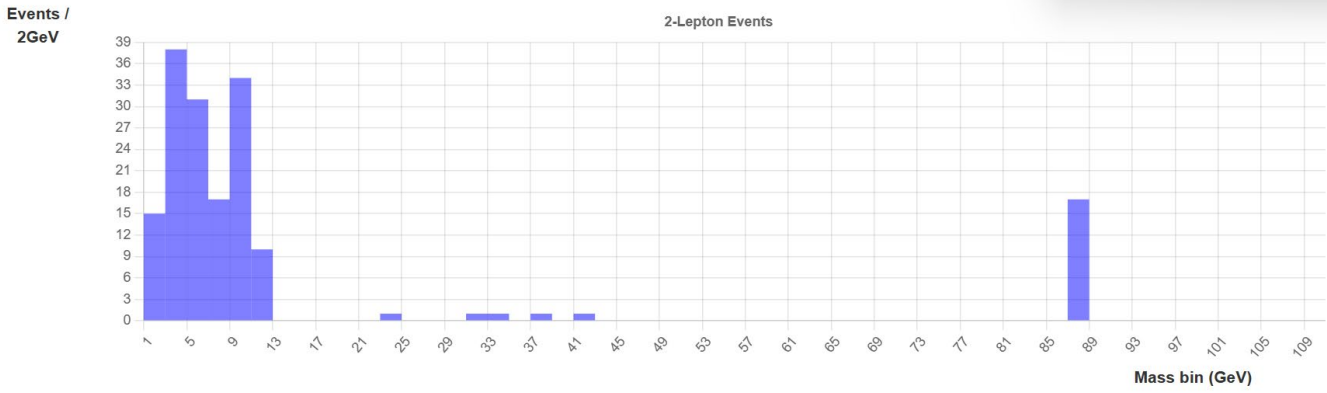
Student Work and Implementation Plans 2023 and 2025

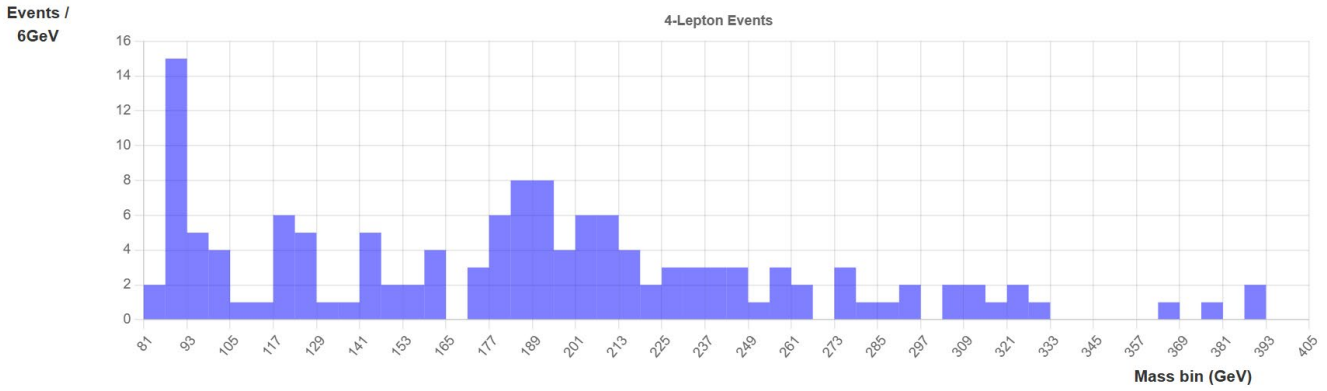
Data analyzed by students participating in a CMS Masterclass (2023) and implemented plans created by participating teachers from the 2025 summer workshop are presented.

August 2026

Results from CMS data analyzed by 20 students from Virginia and Maryland high schools who participated in a CMS Masterclass held on March 11, 2023.

Masterclass: FNAL-11Mar2023A
location: Williamsburg2023





Implementation Plans

Tuesday 29 July 2025

Teachers #1& 2

Class: Any Level and/or part of Physics Club meeting

When to present: Part of intro to Particle Physics (before Masterclass), As a follow-up to Cloud chamber demo and discussion, as part of discussion of cosmic rays in the history of particle physics / the Standard Model.

Description: Demo during class / stations experiment: (Watches - calibration, altitude, inside/outside, solid angle or zenith angle, 1/R^2 with a source), DIY cloud chamber w/making tracks 1 or 2, Rolling w/Rutherford, Quark workbench / particle cards, Quantum3 app on Apple App store, Dice probability w/ Histograms

Description: Physics Club will design experiments that they can complete using the cosmic watches. I plan on starting with a Vintage Fiestaware source (or other radioactive source) and measuring distance vs. rates experiment (add graphing/linearizing) and then ask them to design their own experiments.

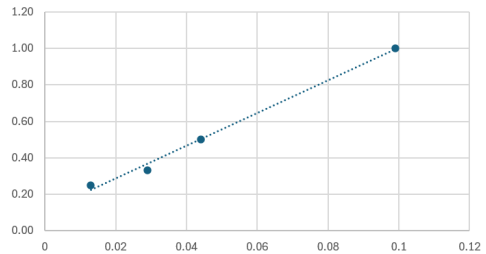
Teachers #3&4

Class: Any Science class, independent research project

When to present: Beginning of the year, after AP/SOL testing, after school

Description: Open ended experimental design, investigating factors affecting rate of change particle events, by varying time, distance or angle, location of paired or unpaired cosmic watch, weather/solar activity and practice linearizing data. Identifying discrepant events, error analysis, and alternate explanations

Separation (measured in boxes)	total count (at 20 coincident counts)	rate of main detector (at 20 coincident counts)	rate of secondary detector (at 20 counts)	invere separation squared
0	494	2.723	0.12	0
1	598	2.88	0.099	1.00
2	1241	2.764	0.044	0.50
3	1906	2.775	0.029	0.33
4	4129	2.776	0.013	0.25
5	2662	0.693	0.02	0.20



Teacher #5

Class: Junior Research

When to present: In preparation for the W2D2

Description: Introduced as a cosmic particles detector and connection made with the tracks seen in the diffusion cloud chambers. Students are invited to exercise scientific method to investigate factors that would influence the counting rates, starting with the brainstorming session and joining groups that would select a specific factor.

All the topics in their scientific research will be circling back to the cosmic watch, demonstrating how same environment could be use by multiple groups of scientists taking turns.

Teacher #6

Class: First year Physics, or Chemistry

When to present: Standalone activity (not really dealing with momentum or energy concepts, so can put in if there's a random class before a holiday break)

Description: Use a single Cosmic Watch to measure the Total Count and the Count Rate when you vary the distance from a radioactive source. For example, I varied the distance between source and Cosmic Watch by half the height of the Watch. I measured at 30 second intervals for up to 5 minutes, at each position. The count rates were consistent for each time interval, so the warning in the Teacher Notes write up (saying that you need to take data for 10 minutes at each setting) didn't seem to be a big issue (the R squared values were all approximately 1).

Teacher #7

Level: ICGSCE Physics, CIE AS /A Level

Materials: Two QN constructed Cosmic Watches, Phyphox

Instructions:
The AS and A Level students will be instructed to construct 3 experiments to collect data on detected charged particles at
1) Normal conditions in the Cayman Islands (specify latitude, longitude and altitude)
2) Electrical Storm or Orientation/Angle of Detection
3) Any other variations students can think of based on their knowledge of physics (magnetic field, altitude (difficult in CI ?)

The AS and A Level students will then analyze the data to determine if there is relationship between variables and rate of detection.
1) Include a graph of the results
2) Statistical analysis for strength of any relationship and determination of error.

The AS and A level will demonstrate the experiment and explain the relevance of the Cosmic Watch data to the GCSCE students during the electromagnetism unit. Additional experimentation will also be done by the International Masterclass club.