



# A Neutrino Pathway to Particle Physics Outreach and Education

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U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science



 **Fermilab**

# Overview



## What is a masterclass?

“Particle physicist for a day”

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



## International Masterclasses 2019 and beyond

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

*2020 has been a little different.*



# Masterclasses Expand



## New measurements, e.g.

- CMS upgrade
- Belle II
- Particle therapy



## Neutrino measurements

- MINERvA – Operational since 2019
- MicroBooNE – Test Summer 2020
- We are looking for more. → Ultimate goal is DUNE.

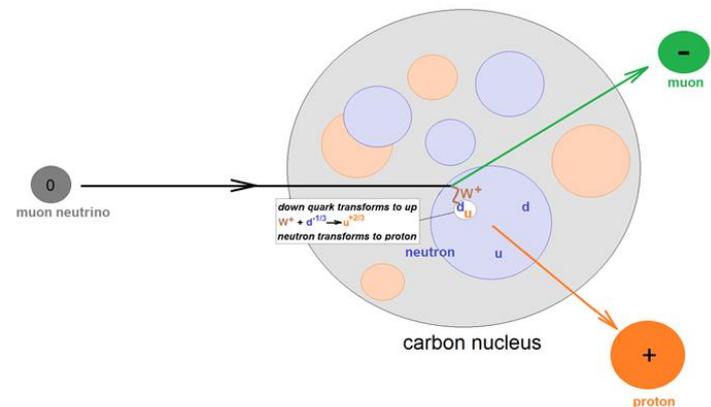
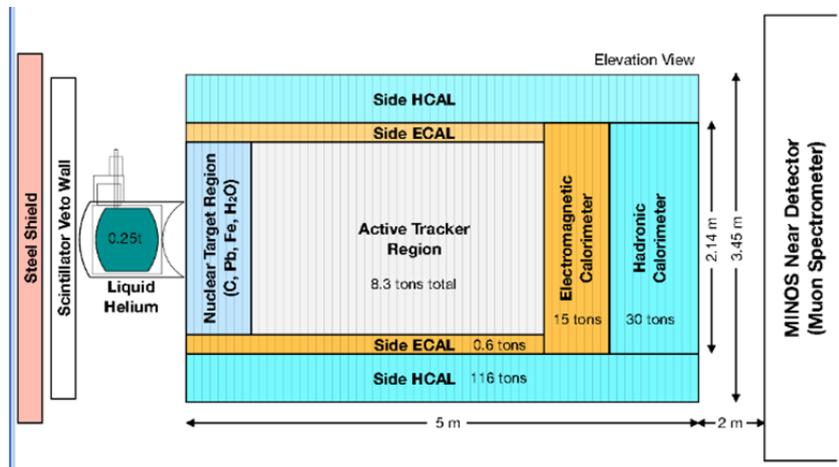


# MINERvA Neutrino Masterclass

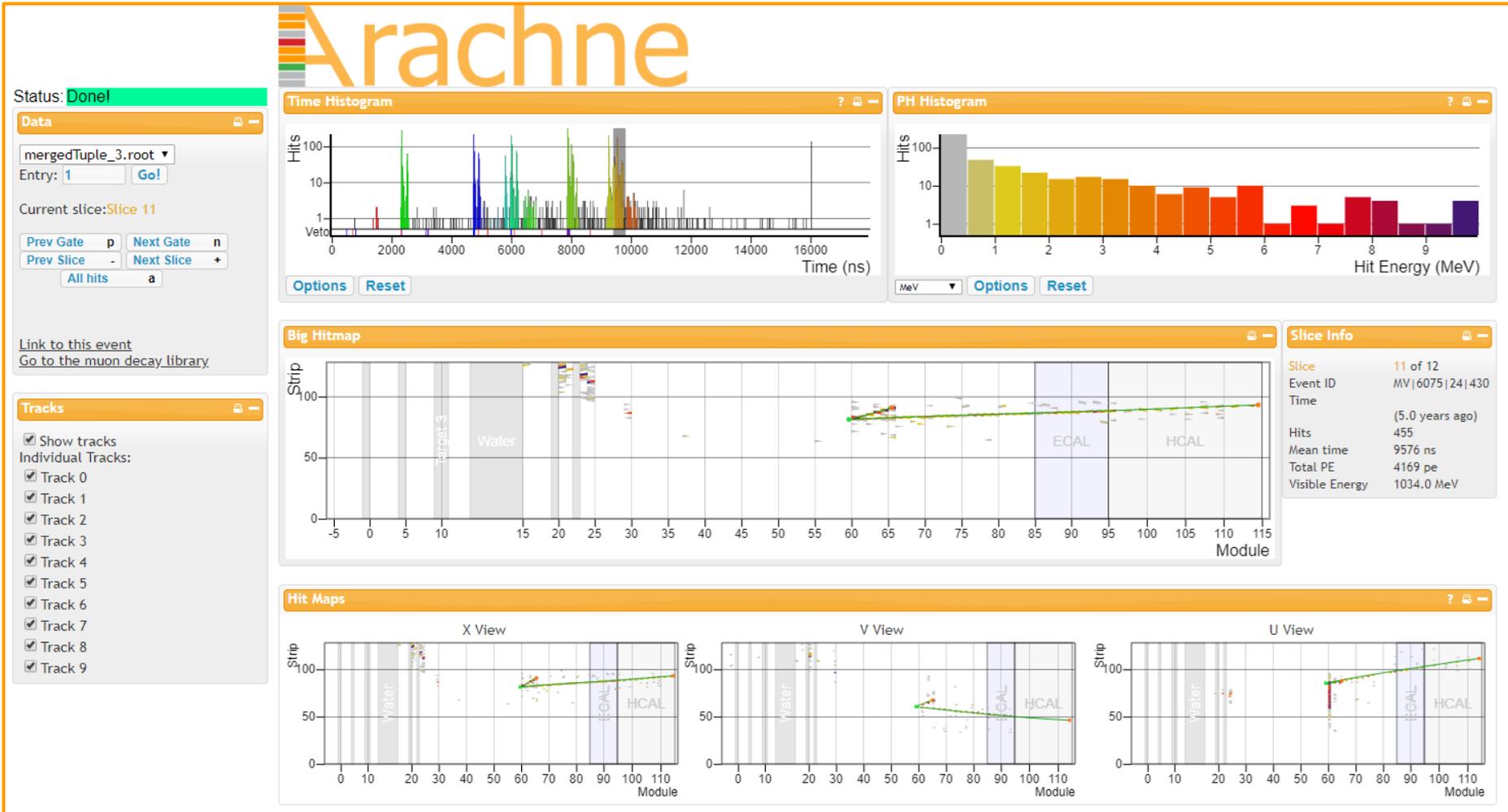


## What it is:

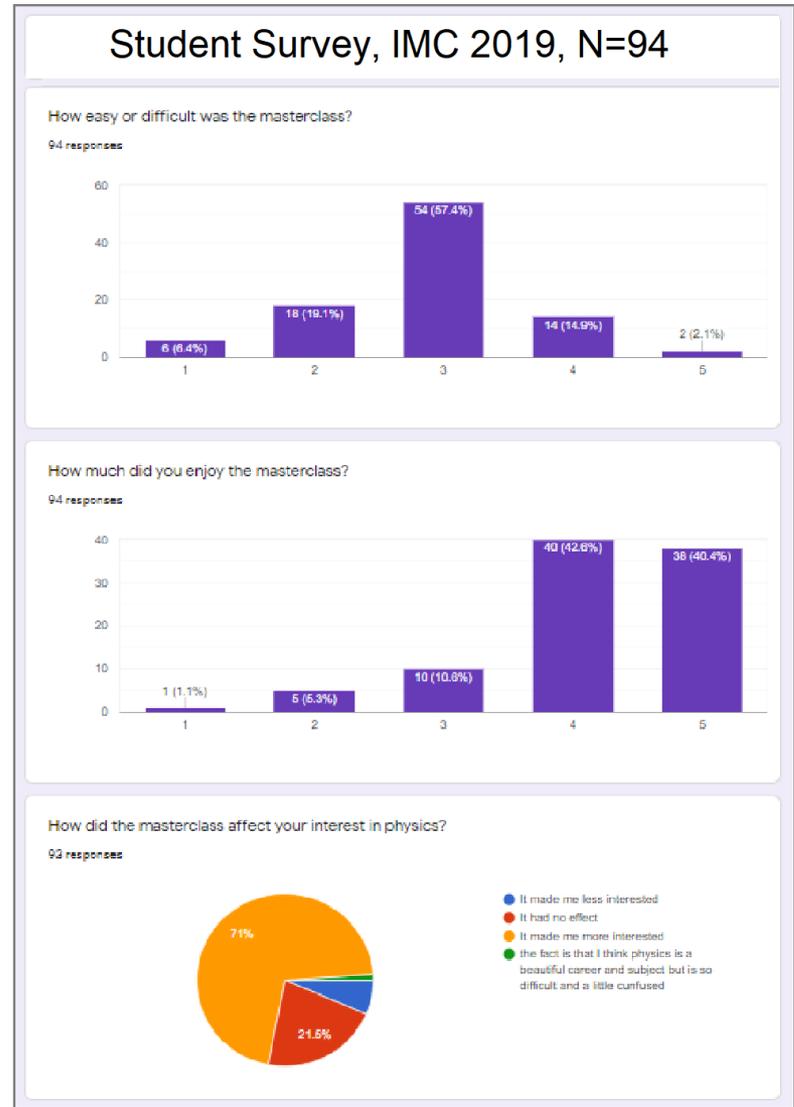
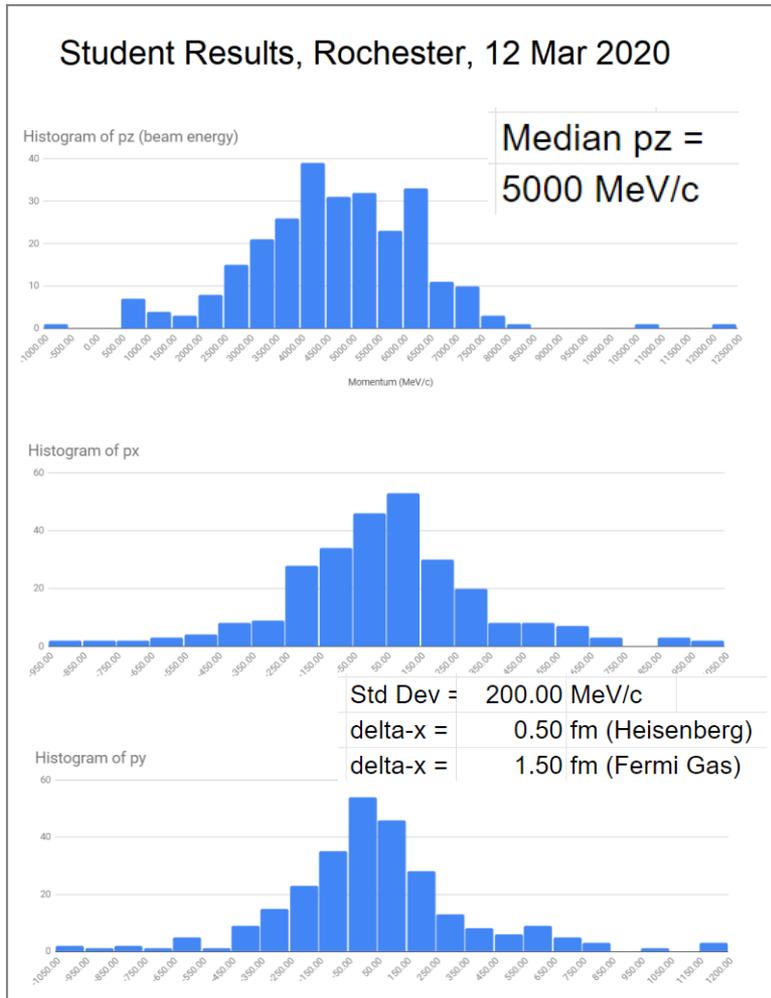
- Muon neutrinos from NuMI interact with carbon target.
- Using momentum conservation, students:
  - Measure beam energy.
  - Discover Fermi motion of neutrons in nucleus.
  - Measure carbon nucleus to test interaction model.



# MINERvA Neutrino Masterclass - Event Display



# MINERvA Neutrino Masterclass – Results



# Interesting Future

## MINERvA

- Working well; will continue.
- More masterclass institutes sought
- Learn more on website:  
<https://indico.fnal.gov/event/22340/>

## MicroBooNE

- Focus on instrumentation:
  - Electron drift lifetime → Liquid argon purity
  - Electron drift velocity
- To be tested by QuarkNet, Summer 2020
- Roll out IMC 2021.



MINERvA Neutrino Masterclass

From March 19, 2020 to April 4, 2020

Overview

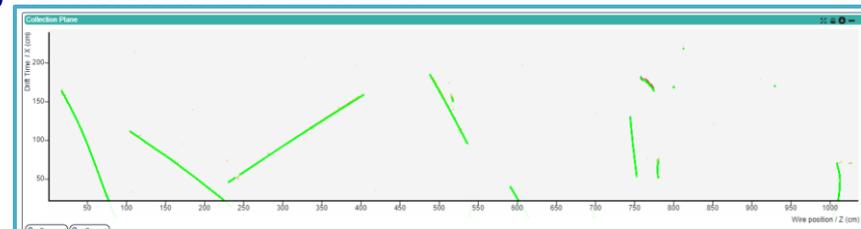
- Introduction
- Measurement
- Events
- MINERvA Experiment at Fermilab
- All Things Neutrino
- Library
- International Masterclasses

The MINERvA Neutrino Masterclass is where students, working with teachers and physicists, get to be neutrino-physicists-for-a-day. In this masterclass they will:

- learn about MINERvA and particle physics
- make a measurement of how neutrinos interact with the atomic nucleus
- pool their results
- discuss results with their peers in the masterclass and across the world in a masterclass videoconference.

It will help to know more about International Masterclasses and what we mean by a "masterclass". We know that a violin or a flute masterclass is - students learning their art with a master musician - but what is it in the context of particle physics?

WHAT IS A MASTERCLASS?



*...and ~~look for~~ help us build more in coming years!*