MINERvA Data Preservation: Enabling Muon Fuzz Analysis

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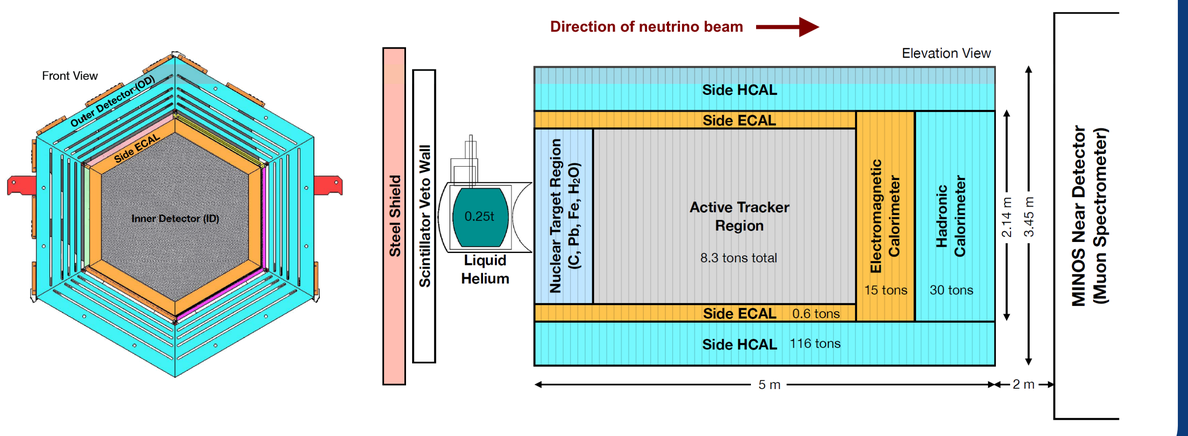
What is MINERvA?

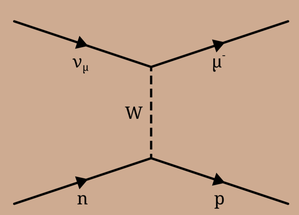
MINERvA is a neutrino detector at Fermilab to explore how different nuclei affect neutrino interactions. It's directly along the NuMI neutrino beam and has a number of different target materials (Fe, Pb, C, He, Water).

It took data from 2010-19 - now the focus is on "Data Preservation" and final analyses of data.

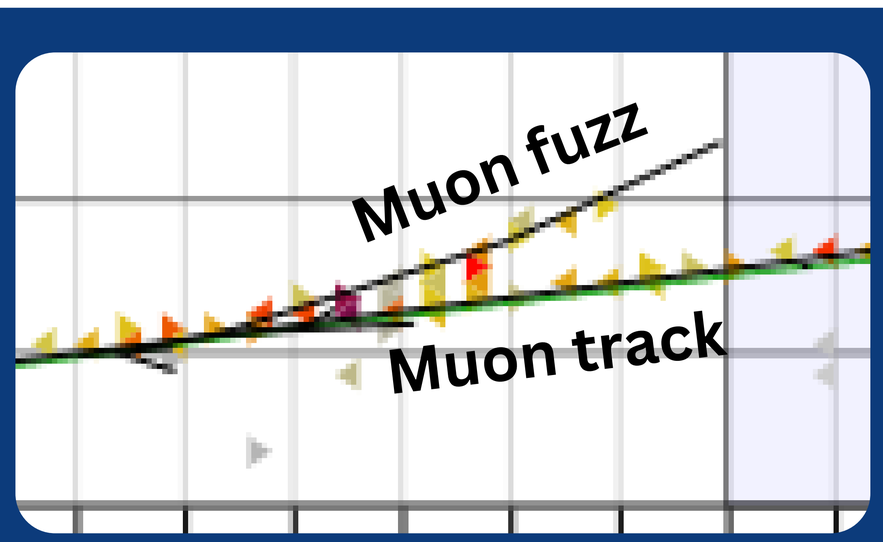


What is Muon Fuzz?

When a neutrino interacts in MINERvA, it often produces a muon. **Muon fuzz refers to bremsstrahlung photons or scattered electrons produced as muons transit the detector.** This is called the muon fuzz because it comes off the muon track like strands of fuzz.



The neutrino energy is estimated by summing the energy of the particles it produces, the muon fuzz may be misrecognised and thus can throw off our estimates.

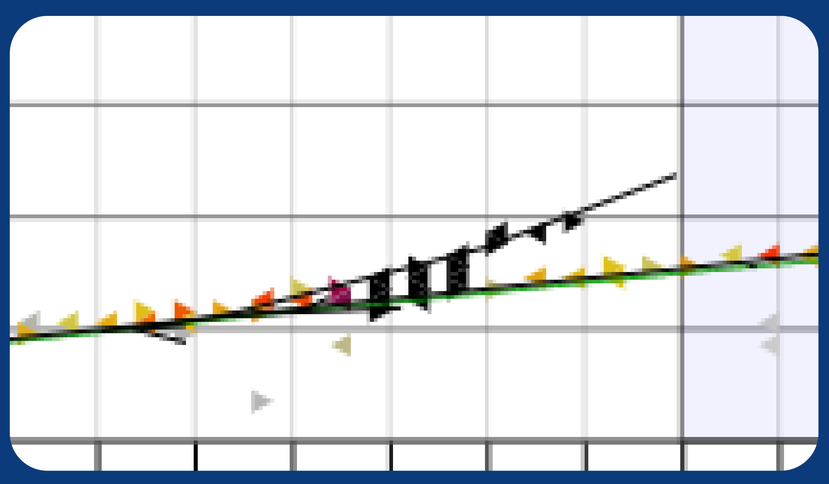


Fuzz Validation

Some muon fuzz will travel away from the muon track and some will travel essentially directly along the track.

At MINERvA we already have means of identifying the fuzz that travels away from the track, but none for those along it.

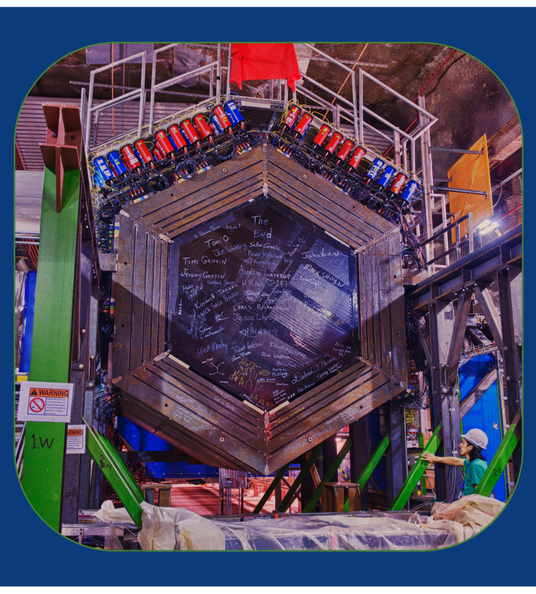
I validated these existing methods by modifying the MINERvA event display to highlight the hits that our techniques tell us are the muon fuzz and then visually inspecting the results together with other validation plots.



Motivations

Monte Carlo simulations are used extensively throughout particle physics, from estimating uncertainties to driving design choices, but, we know that they aren't perfect. We can evaluate and improve them by comparing them with actual experimental results. This has already been done at MINERvA for the fuzz that moves away from the muon track but is yet to be done for the fuzz that travels along the muon track, however, this has been proposed as a future analysis.

The first step is to extract everything on the muon track, from there we can isolate the fuzz from the muon, and only then can we do this analysis. In order to do this extraction, I modified the software framework used to generate analysis files from raw event data.



Results & validation

The modified software now outputs calibrated energy, time, and positional information for every cluster along the muon track, which can now be used for the proposed fuzz analysis and beyond.

Muon energy deposition in matter is well-known ∴ fuzz component ≈ observed energy - expected muon energy.

As before, I modified the MINERvA event display to visually validate my changes, additionally, I have produced validation plots and presented this work to the MINERvA collaboration for feedback and review.