CBPF
Centro Brasileiro de Pesquisas Físicas

MINERvA in 10 minutes!

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(On behalf of the MINERvA Collaboration)

New Perspectives
Fermilab – July 20, 2020

What is MINERvA ?

- MINERvA is a dedicated neutrino scattering experiment in the NuMI beamline at Fermilab

Main goals:

- Understand the nature of neutrino-nucleus interactions:
  - Identification of nuclear effects
  - Measure exclusive and inclusive final states, and correlations of those with leptons

- Compare measurements with Monte Carlo predictions to improve the models.

MINERvA week 2020

The NuMI beam

- 120 GeV protons coming from the Main Injector interacts with graphite producing pions and kaons
- The magnetic horns focus the mesons produced
- The target and second magnetic horn can be moved relative to the first horn to produce different energy spectra

$$\pi^+ \rightarrow \mu^+ + \nu_\mu$$
$$K^+ \rightarrow \mu^+ + \nu_\mu$$

- Absorbers for the remaining hadrons

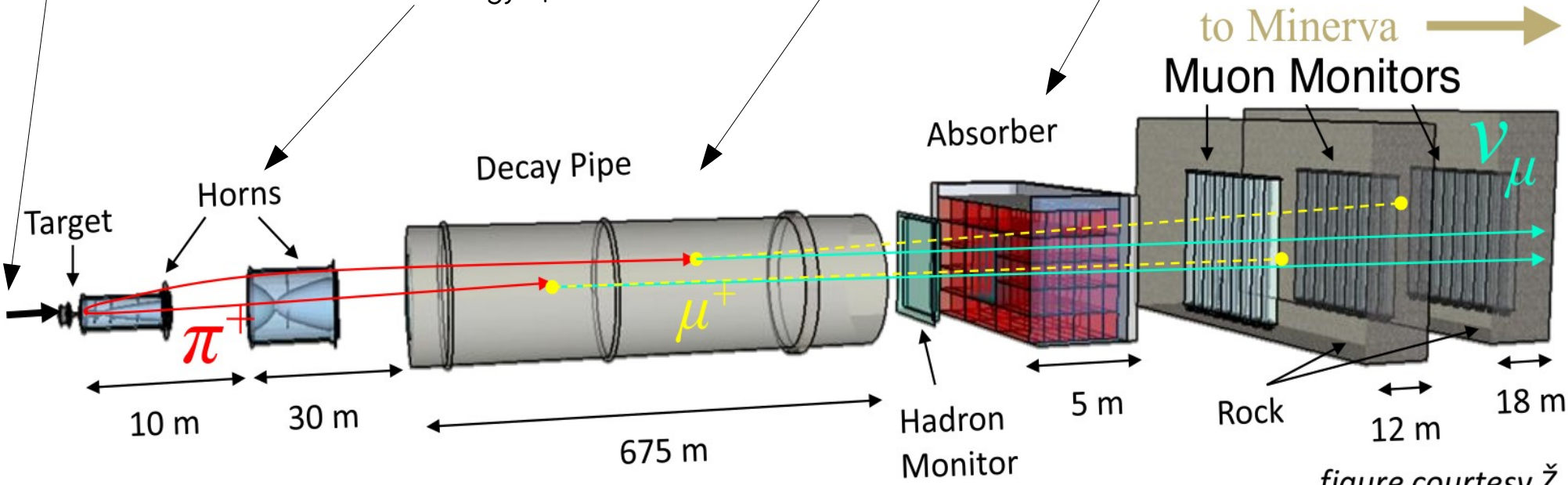
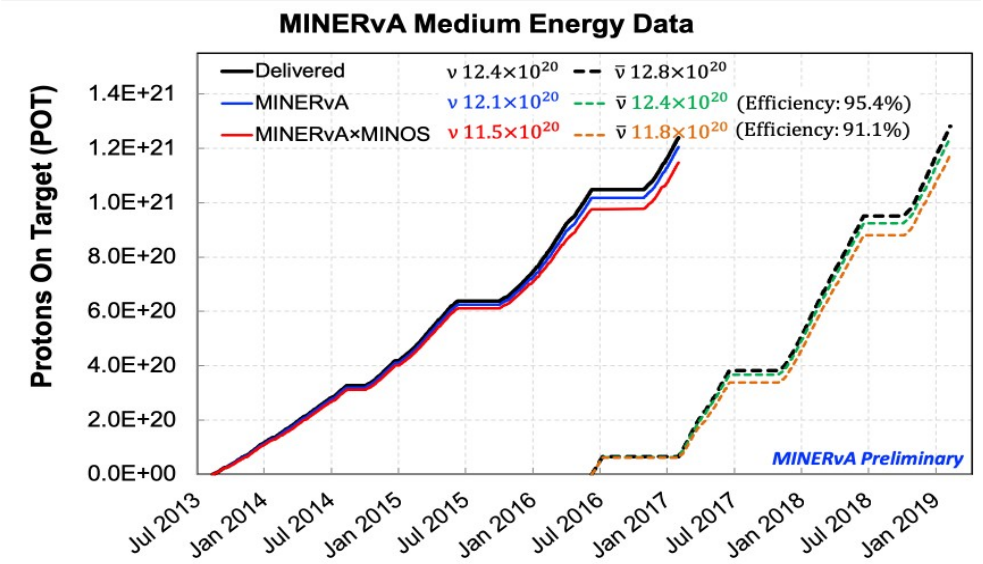
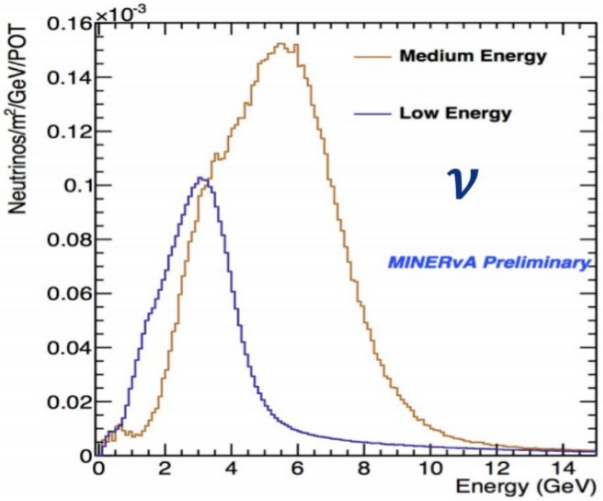


figure courtesy Ž. Pavlović

The NuMI beam entering MINERvA

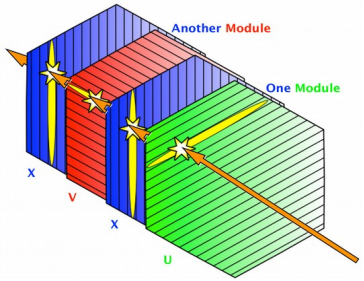
- Two beam exposures were completed, each with $< E_\nu >$ around 3 GeV and 6 GeV
- End of data taking was on February 2019



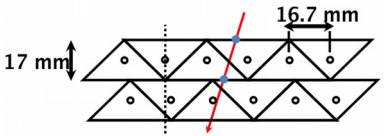


Mode	ν POT	$\bar{\nu}$ POT
Low Energy	4.0e20	1.7e20
Medium Energy	12.1e20	12.4e20

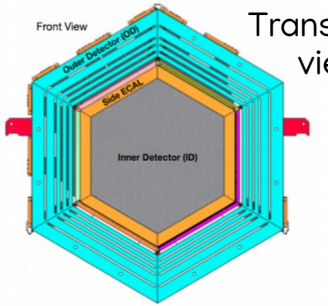
The MINERvA Detector



Three views of scintillator bars give unambiguous 3D track reconstruction



Triangular strips arranged to give a better position resolution



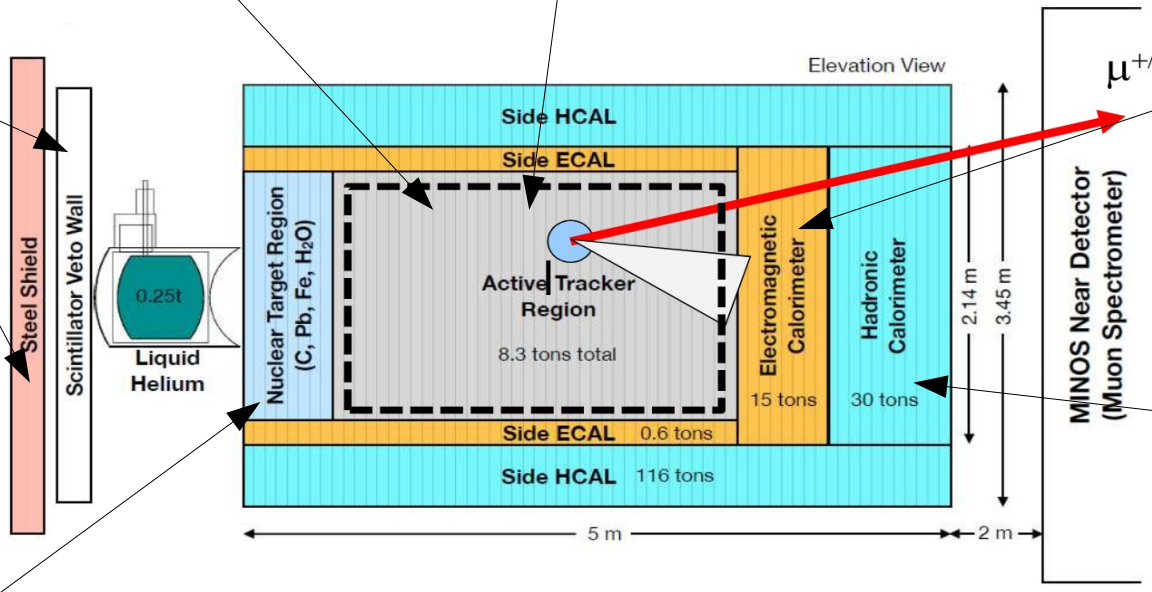
Transversal view

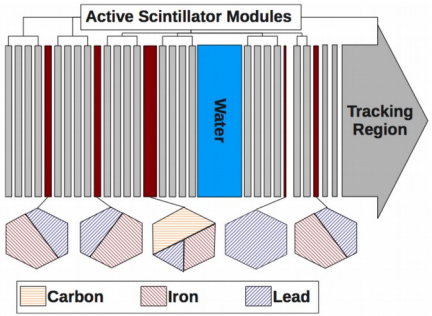
Shield from low energy hadrons and tag muons produced in the rock

Beam

Lead and scintillator sheets: contains and measure electromagnetic particles.

Steel and scintillator sheets: contains and measure Hadronic particles.



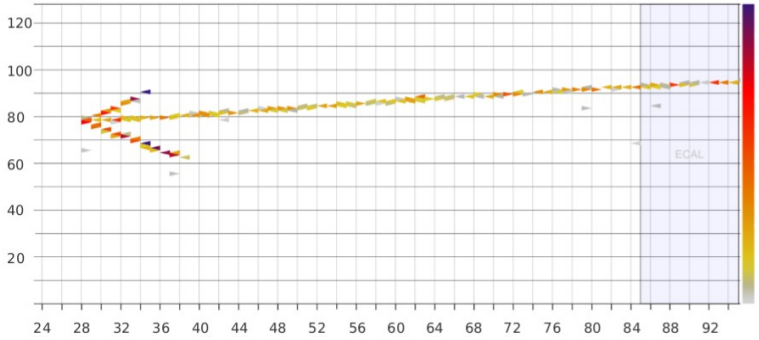


What do we see in the detector ?

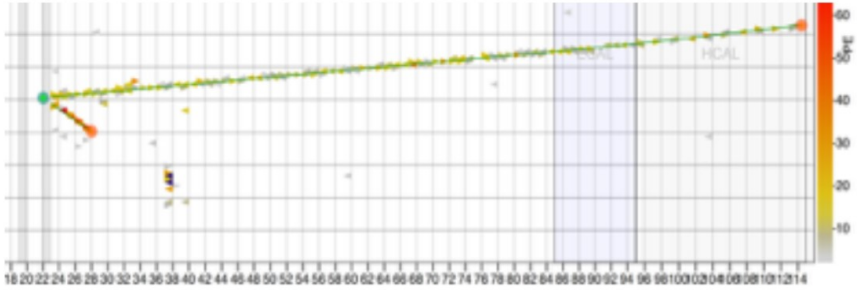
We can only see the products of the interactions

Examples of candidates:

Pion Production $\nu_\mu + p \rightarrow \mu^- + \pi^+ + p$



Muon Neutrino Quasi-elastic $\nu_\mu + n \rightarrow \mu^- + p$



Color = Energy deposited

- We must determine neutrino energy from the final state energy
- The final lepton ($\mu^+ \; or \; \mu^-$) is measured by MINOS and the rest of the particles are measured by the MINERvA calorimeters

Recent Publications

1. MINERvA Collaboration, Double-differential inclusive charged-current ν_μ cross sections on hydrocarbon in MINERvA at $< E_\nu > \sim 3.5\ GeV$. Phys.Rev.D. 101 (2020) 11, 112007.

2. MINERvA Collaboration, Nucleon binding energy and transverse momentum imbalance in neutrino-nucleus reactions. Phys. Rev. D 101 (2020) 9, 092001.

3. MINERvA Collaboration, High-Statistics Measurement of Neutrino Quasielasticlike Scattering at 6 GeV on a Hydrocarbon Target. Phys. Rev. Lett. 124 (2020) 12, 121801.

4. MINERvA Collaboration, Probing Nuclear Effects with Neutrino-induced Charged-Current Neutral Pion Production. ArXiv: 2002.05812.

5. MNERvA Collaboration, Constraint of the MINERvA medium energy neutrino flux using neutrino-electron elastic scattering. Phys.Rev.D 100(2019) 9,092001.

6. MNERvA Collaboration, Measurement of $\bar{\nu}_\mu$ charged-current single π^- production on hydrocarbon in the few-GeV region using MINERvA. Phys.Rev.D. 100(2019) 5, 052008.

7. MINERvA Collaboration, Measurement of Quasielastic-Like Neutrino Scattering at E_ν~3.5 GeV. Phys.Rev.D 99(2019) 1, 012004.

8. MINERvA Collaboration, Neutron measurements from antineutrino hydrocarbon reactions. Phys.Rev.D 100(2019) 5,052002.

9. MINERvA Collaboration, Tuning the GENIE Pion Production Model with MINERvA data. Phys.Rev.D 100(2019) 7,072005.

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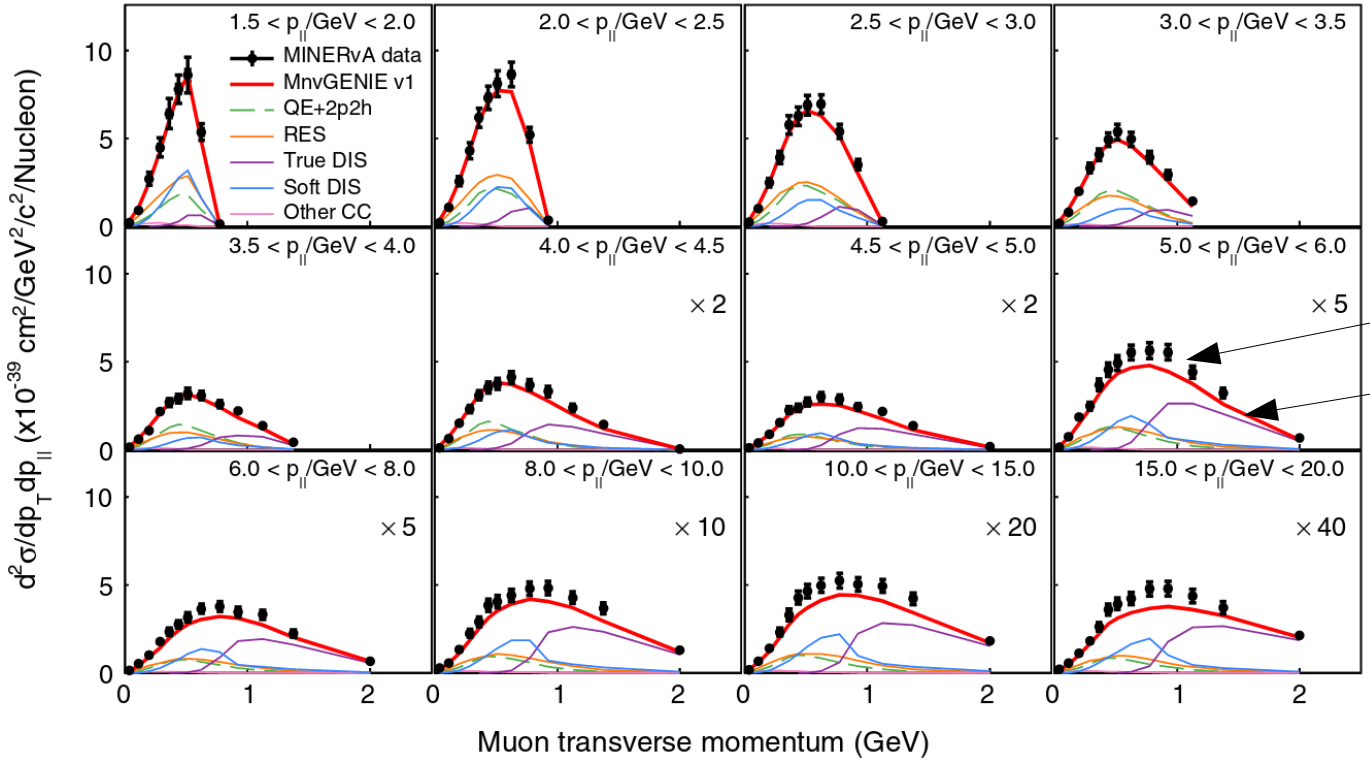

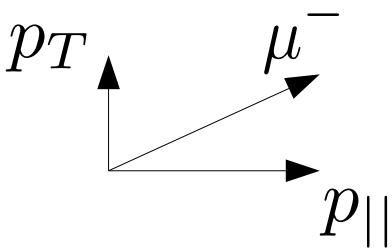

DATA

Modified GENIE prediction

There is some discrepancy between Data and MC

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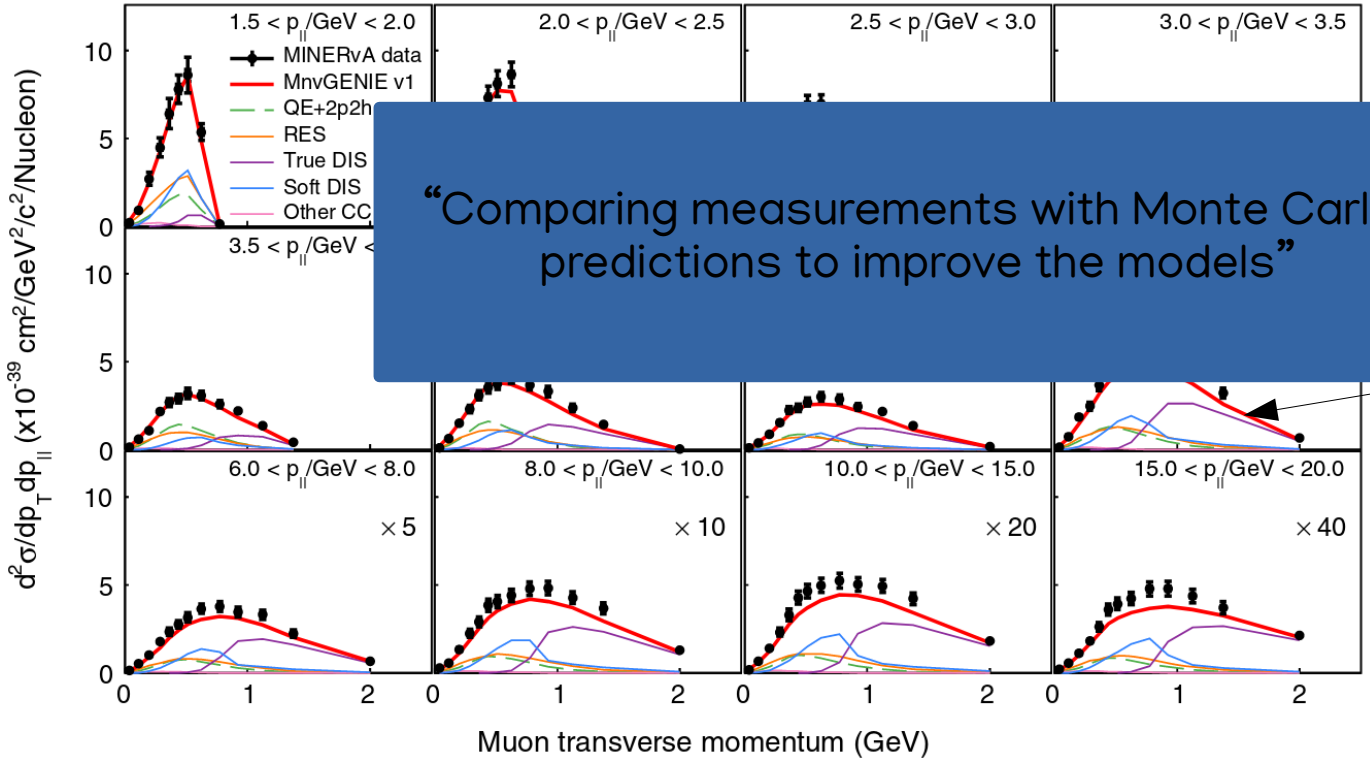
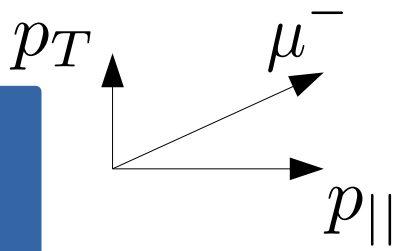


"Comparing measurements with Monte Carlo predictions to improve the models"



DATA

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Summary

- We want to make high precision measurements of neutrino interaction cross sections off a variety of different nuclei
- Results will continue improving model descriptions which are important for oscillation experiments
- MINERvA has been exposed to two neutrino beam modes ($< E_\nu >$ around 3 GeV and 6 GeV)
- We use MINERvA (hydrocarbon scintillator and calorimeters) and MINOS (muon spectrometer) to reconstruct our events
- Still more results will be coming from the medium energy data set !

Thanks!