CC $\nu_\mu$ 1 $\pi^+$ production at MINERvA tracker

New Perspectives 2022 Conference

Everardo Granados

División de Ciencias e Ingenierías
Universidad de Guanajuato

June 21, 2022
The MINERvA experiment (Main INjector ExpeRiment \( \nu \)-A)

- Neutrino cross section measurements in 5 different materials.
Introduction

NuMI Beam

- The data taken by the detector is divided in two eras, Low Energy era (LE) and Medium Energy era (ME).
- LE \( < E_\nu > = 3\text{GeV} \) (2010-2012)
- ME \( < E_\nu > = 6\text{GeV} \) (2013-2019)
MINERvA Experiment

- MINERvA data analysis
  - Reduce flux uncertainties
  - Reduce cross section uncertainties
- Exclusive Analysis
- Inclusive Analysis
Signal definition

- CC $\nu_\mu A \rightarrow \mu^- \pi^\pm X$ at MINERvA Tracker analysis.
Differential Cross Section

\[
\left( \frac{d\sigma}{dx} \right)_\alpha = \sum_j U_{j\alpha} \left( N_{\text{data},j} - N_{\text{bgd},\text{data},j} \right) \frac{A_{\alpha}(\Phi T)(\Delta x)}{A_{\alpha}(\Phi T)(\Delta x)}
\]

Unfolding  \rightarrow  Events Selected  \rightarrow  Backgrounds

- Acceptance
- Flux
- Targets
- Bin-width
Event Selection

- Vertex in the tracker.
- $\mu^-$ has to match in MINOS.
- At least one hadron track.
- One michel electron.
- $dE/dx$ Particle Identification.
- $W_{exp} = m_N^2 - Q^2 + 2m_N E_{had} < 1.4$ GeV.

$dE/dx$ simulated profiles for protons (Top) and pions (bottom).  
Nucl. Inst. and Meth. A743 (2014) 130
Event Selection for LE Analysis

- Event selection for $T_\pi$ and $\theta_\pi$.

The shape if the predicted events and data events look similar.

- 3474 events for data
What’s coming next for the ME era?

- Cross section CC $1\pi^+$ production in the MINERvA tracker analysis in ME era.
- Other analyses:
  - Cross section CC $1\pi^+$ production in the MINERvA nuclear targets.
  - Untracked CC $1\pi^+$ in the MINERvA tracker.
  - 2D cross section CC $1\pi^+$ production in the MINERvA tracker analysis.
- And more ...

Event selection for the $CC1\pi^\pm$ ME era analysis (Data = 18761 events). Top plots: Signal (Match cuts, match signal definition) and background (Match cuts, no Match signal definition) for MC events. Bottom plots: Signal and background breakdown.
Conclusions

- More MINERvA analyses are coming!!
- CC $1\pi^+$ are very important to:
  - Improve nuclear models.
  - Reduce uncertainties
  - And more ...
- The MINERvA Collaboration has a large data set to be analysed.
- A lot things to be discovered ...

Thank you!!