NuMI ν-Ar cross-section measurements @ ICARUS

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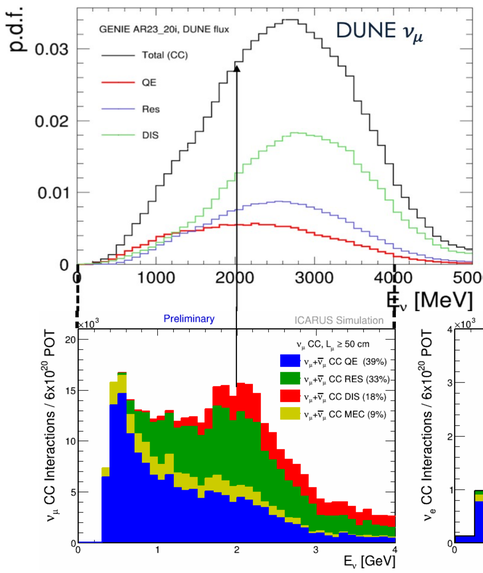
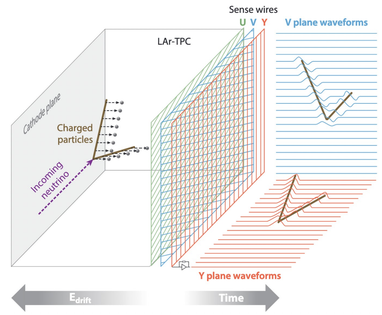
Introduction and Motivations

ICARUS is the far detector of the SBN program and is the largest active mass LArTPC presently in operation. One of its primary goals is the search for sterile neutrinos via ν_e appearance[1]. In addition, ICARUS is situated 5.7° off-axis from the NuMI beamline. This feature provides the basis for important ν-LAr cross-section measurements and tests of models in an energy range overlapping both SBN's oscillation search and part of DUNE's spectrum. ICARUS will therefore produce important contributions to present and future LArTPC based experiments.



NuMI in ICARUS expects to have ν-Ar interactions in the DUNE energy range (above 2 GeV).

NuMI at ICARUS has excellent statistics to make cross-section measurements for quasi-elastic and pion production scattering, for both ν_e and ν_μ. The NuMI ν_e spectrum covers the majority of the phase space relevant for the DUNE far detector, including that for the first oscillation peak. For ν_μ offers excellent coverage as well. ν-Ar measurements help constrain cross-section systematics and nuclear effects for the oscillation analysis via event selection and energy estimates.

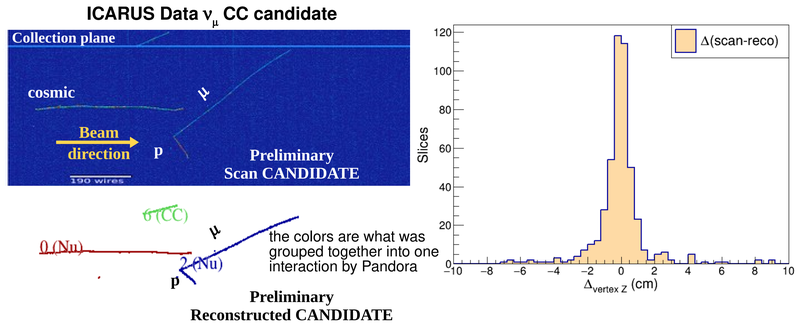


The LArTPC detector technology is illustrated on the left [2]. Several technology improvements were introduced, aiming to improve the achieved performance of previous runs.

ICARUS is located on the surface, a cosmic tagger and overburden have been installed to reduce and tag the abundant cosmic background events.

Reconstruction and Event Selection

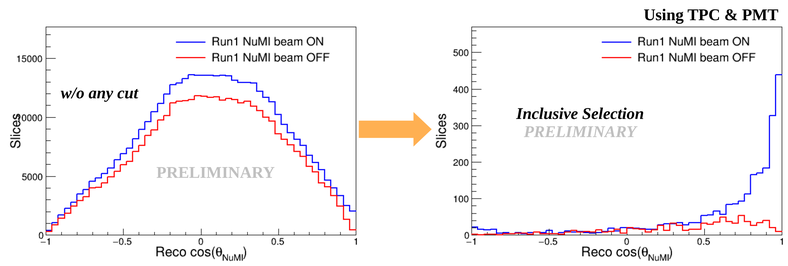
TPC and PMT reconstruction are performed on the interactions (ν, cosmic, etc.) present in each event. TPC event reconstruction uses Pandora [3] to reconstruct 3D particle trajectories from the hits on TPC wire planes; reconstruct interaction vertices and particle hierarchy; as well as classify particles as track-like or shower-like.



Selection considers the reco output and looks for ν-like interactions with a μ-like track (ν_μ).

Current Status and Progress

Currently, ICARUS is collecting physics-quality data. The NuMI cross-section working group is analyzing charged current ν_μ interactions for inclusive selection, and 1μNp samples in data and simulation.



Cosine of the NuMI beam direction and the track direction. On the left, the distributions have no selection cuts, in blue the neutrino beam data, and in red the non-beam data. On the right, the distributions have all the selection criteria. The non-beam data distributions were scaled by 1.7, according to the livetime in run 1.

For the inclusive selection, we studied the kinematics of the μ, without imposing constraints on the hadronic system. In this analysis, after applying a set of selection criteria, which uses the TPC information and the geometry of the reconstructed interaction (e.g. the vertex must be contained in the fiducial volume of the detector), we observe very few background events (red distribution).

We are starting to study the backgrounds for the 1μNp0π sample. Signal events does not contain pions in the final state, while background events does.

Acknowledgments

We would like to acknowledge our ICARUS collaborators, without whom this would not be possible, as well as SBND collaborators with whom the SBN program is made possible.

References

[1] Abratenko, P. et al. Eur. Phys. J. C 83, 467 (2023).

[2] P. Machado, O. Palamara, and D. Schmitz. Annu. Rev. Nucl. Part. Sci. doi: 10.1146

[3] Pandora [Multi-Algorithm Pattern Recognition Software] (2013). https://github.com/PandoraPFA