Chimera Events for Performance Studies of the MicroBooNE Deep Learning-based Low Energy Excess Search

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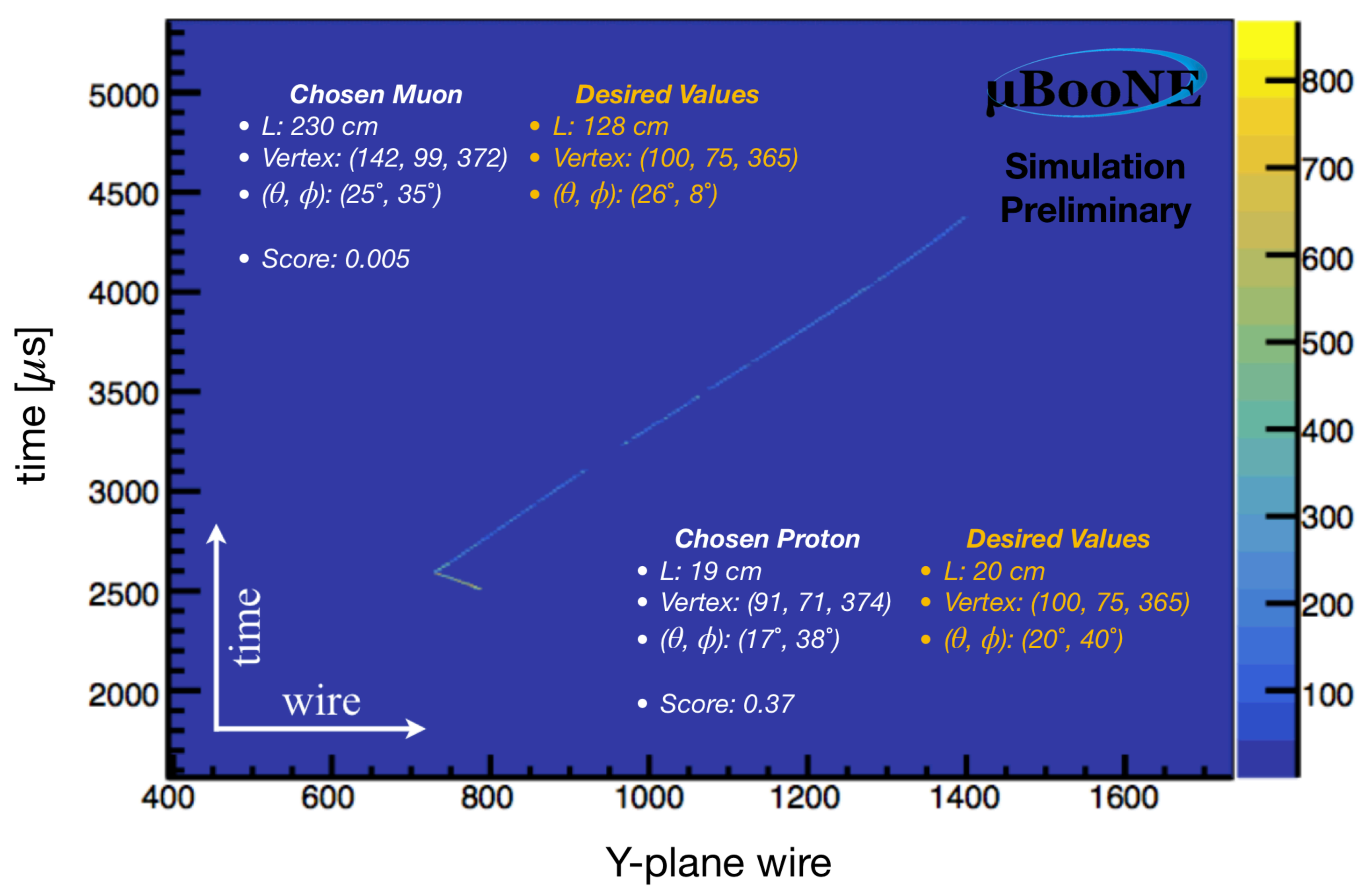
1). MicroBooNE

- The MicroBooNE detector is a Liquid Argon Time Projection Chamber (LArTPC) located on the Booster Neutrino Beamline (BNB) at Fermilab.
- A primary aim is to investigate charged-current quasi-elastic (CCQE)-like excess of events observed by MiniBooNE at 200-600 MeV [1].
- Deep-learning-based tools are used to perform the low energy excess (LEE) search.
- We identify neutrino interactions with a final state of 1 lepton, 1 proton, 0 mesons.
- Introduce chimera events (Figure 1) to help with systematics.

Figure 1: The first chimera event!



2). Creating a Chimera Event

- First, select a candidate muon and proton.
- We use a maximum likelihood method to determine a best match for each particle.
- Combine images of a muon and proton event to create a chimera event (Figure 2):
  - Proton is shifted to line up with muon at vertex.
  - Wire regions without signal (in blue) are added in union in the final chimera event.

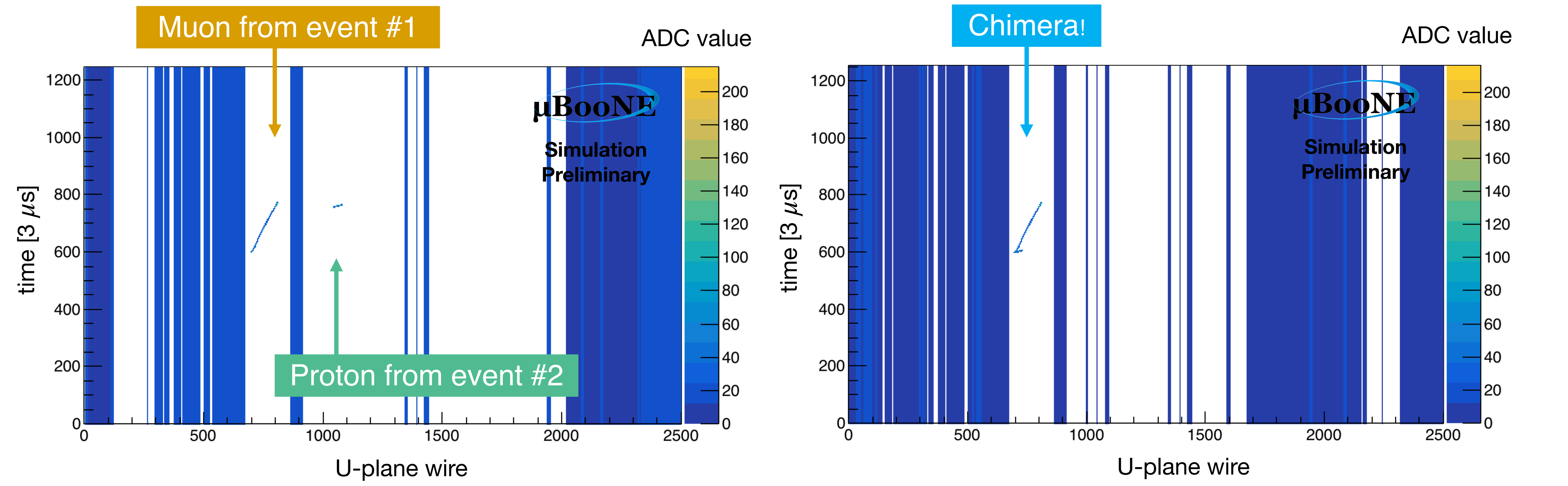


Figure 2: Demonstration of pixel shifting

3). Current Scope and Strengths

- Possible to work entirely with data to test systematic uncertainties relating to data/simulation discrepancy.
- Can explore effects on shortening tracks, introducing dead regions near vertex, etc.
- Have limitations with position-dependent quantities (e.g. space charge effect).

4). Track Matching Performance

- Positive linear correlation seen between the input, "desired" value of parameter and the value chosen by the likelihood algorithm (Figure 3).
- Width depends on parametrized weights given to each individual variable.
  - X, Y, Z position of vertex, θ and ϕ angles of muon and proton, and length of muon and proton.

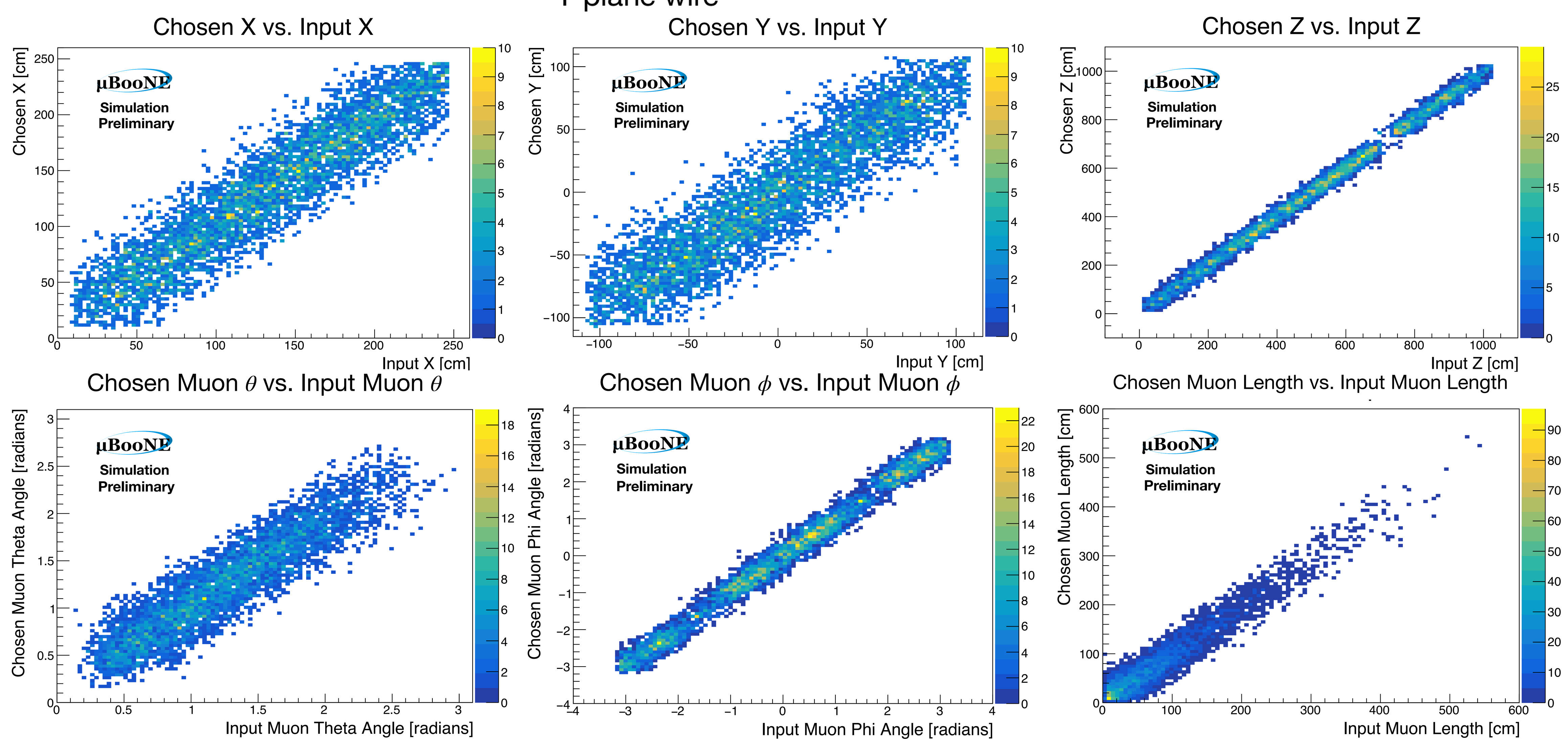


Figure 3: Muon track Selection performance

5). Conclusion and Future Plans

- Demonstrated proof-of-principle approach to creating ν_μ chimera events using simulated ν_μ interactions overlaid onto cosmic data.
- Future plans are to create a large sample of both ν_μ and ν_e events using data.
- Will be used for systematic studies in MicroBooNE going forward.

References and Acknowledgements:

1. MiniBooNE Collaboration, Improved Search for $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ Oscillations in the MiniBooNE Experiment, Phys. Rev. Lett. 110, 161801

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