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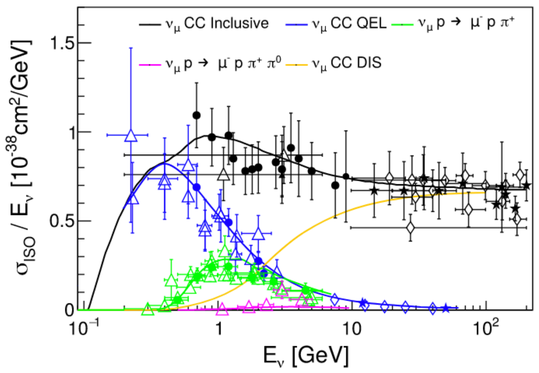
Studies of DIS Models of ν-A Scattering

Noah D. Koliadko, Dr. Timothy Hobbs

Introduction



ν_μ CC cross section

Experiments like DUNE are limited by uncertainties in ν-A cross section predictions. DIS makes an important contribution to the cross section in DUNE's peak-flux region, but it remains incompletely determined. The current models in ν-A event generators like GENIE use decades old theory inputs that can now be tested against more modern QCD-based calculations.

In this project we tested the 2021 update of the Bodek-Yang model, which is commonly used in many neutrino event generators.

Methods

We reproduced the Bodek-Yang model in a flexible Julia code which has the ability to include or exclude all the corrections in their model separately. We then compared the model with both data and structure functions calculated at next-to-leading order.

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Mathematical Background

The Bodek-Yang model uses various phenomenological corrections which are fit to data. The two main ingredients of the model are the $K_i(x, Q^2)$ multiplicative factors and the $\xi_w(M_f = 0)$ and $\xi'_w(M_f = M_c)$ rescaling variables. The non-charm production (ncp) and charm production (cp) parton distribution functions (PDFs) are rescaled with ξ_w:

$$q_{ncp}(x, Q^2) \rightarrow q_{ncp}(\xi_w, Q^2)$$
$$q_{cp}(x, Q^2) \rightarrow q_{cp}(\xi'_w, Q^2)$$

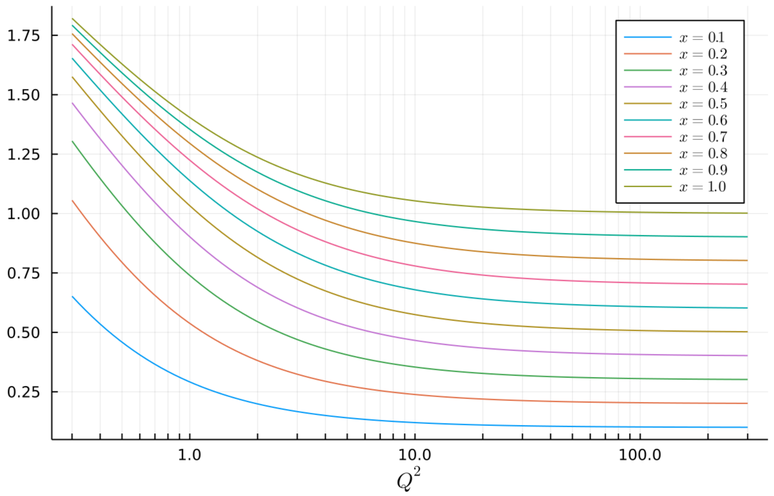
The $K_i(x, Q^2)$ factors are responsible for the low Q^2 corrections, and the ξ_w rescaling variable defined by

$$\xi_w = \frac{Q^2 + M_f^2 + B}{M\nu(1 + \sqrt{1 + Q^2/\nu^2}) + A}$$

purportedly accounts for higher order QCD terms and higher twist effects.

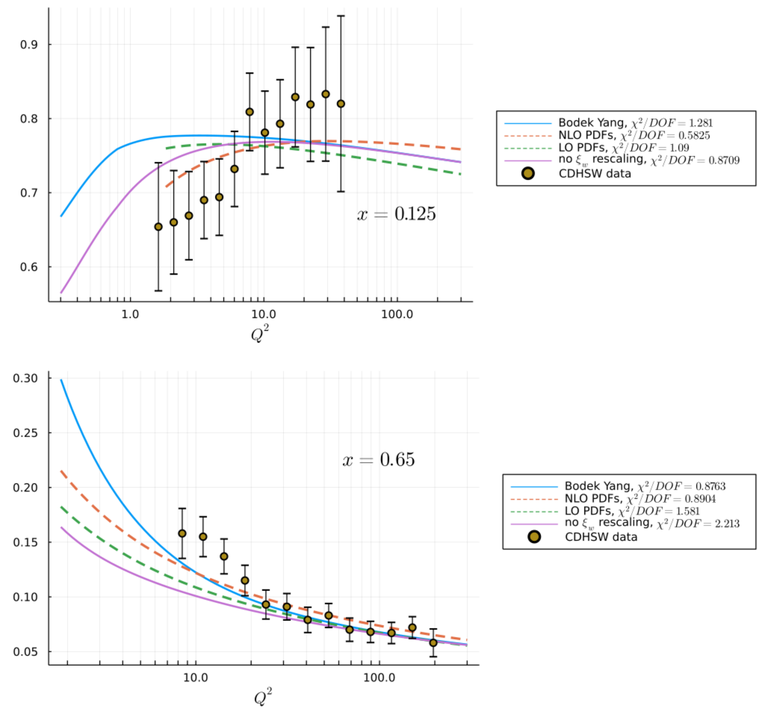
Results

$$\xi'_w\,(M_f = 1.32\,GeV)$$



ξ'_w rescaling variable. This is the rescaling variable used in the charm production components of the structure functions, where $M_f = 1.32$ GeV. For a significant region in x, Q^2 space, we encounter unphysical behavior where $\xi'_w > 1$.

Bodek Yang vs. Data vs. NLO/LO CT18 PDFs (xF_3)



Comparisons of the xF_3 structure functions from the full Bodek Yang model, the Bodek Yang model without rescaling, LO CT18 PDFs, NLO CT18 PDFs, and CDHSW data.

Conclusion

We created flexible Julia code and tested all of the Bodek-Yang model's corrective factors separately. We found that at lower x and low Q^2, the NLO correction suppresses the xF_3 structure function with a nontrivial Q^2 dependence; but this behavior is not fully reflected by the ξ_w prescription. We also looked at ξ_w and ξ'_w themselves, and found unphysical behavior in a significant region of x, Q^2 space for the charm production rescaling variable. This work provides a systematic understanding of the phenomenology of neutrino DIS in event generators and points the way to QCD-based improvements at low Q^2 and high x.