MS-TP-22-10

Impact of heavy quark and quarkonium data on nuclear gluon PDFs

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(Dated: March 16, 2022)

A clear understanding of nuclear parton distribution functions (nPDFs) plays a crucial role in the interpretation of collider data taken at the Relativistic Heavy Ion Collider (RHIC), the Large Hadron Collider (LHC) and in the near future at the Electron-Ion Collider (EIC). Even with the recent inclusions of vector boson and light meson production data, the uncertainty of the gluon PDF remains substantial and limits the interpretation of heavy ion collision data. To obtain new constraints on the nuclear gluon PDF, we extend our recent nCTEQ15WZ+SIH analysis to inclusive quarkonium and open heavy-flavor meson production data from the LHC. This vast new data set covers a wide kinematic range and puts strong constraints on the nuclear gluon PDF down to $x \lesssim 10^{-5}$. The theoretical predictions for these data sets are obtained from a data-driven approach, where proton-proton data are used to determine effective scattering matrix elements. This approach is validated with detailed comparisons to existing next-to-leading order (NLO) calculations in non-relativistic QCD (NRQCD) for quarkonia and in the general-mass variable-flavor-number scheme (GMVFNS) for the open heavy-flavored mesons. In addition, the uncertainties from the data-driven approach are determined using the Hessian method and accounted for in the PDF fits. This extension of our previous analyses represents an important step toward the next generation of PDFs not only by including new data sets, but also by exploring new methods for future analyses.

CONTENTS

I. INTRODUCTION

Parton distribution functions (PDFs) are fundamental quantities required to calculate predictions for processes involving hadronic initial states. The QCD parton model has been widely tested and proven useful in making predictions for a wide range of experiments at SLAC, HERA, TeVatron, RHIC and LHC. Additionally, the physics programs of future experiments like the EIC and the proposed FCC will rely heavily on this framework.

While the proton PDFs have been constrained with great precision [1–13], there is still significant room for improvement in the uncertainties of nuclear PDFs (nPDFs) [5, 14–23]. In particular, the gluon PDF has been the focus of recent nCTEQ studies [24,

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