

The impact of LHC neutrino-ion collisions in PDF determination

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Proton-proton collisions at the LHC generate a high-intensity collimated beam of neutrinos in the forward direction, up to energies of several TeV. The observation of these neutrinos by FASER ν and SND@LHC, and the proposal of a purpose-built Forward Physics Facility (FPF) for the High-Luminosity LHC (HL-LHC), motivate scientific inquiries of this hitherto unavailable particle beam. The impact of neutrino deep-inelastic scattering (DIS) measurements at the LHC on the parton distribution functions (PDFs) of protons and heavy nuclei is assessed by generating projections for FASER ν and SND@LHC at Run III, as well as for the FPF experiments FASER ν 2, AdvSND, and FLArE. Up to one million electron- and muon-neutrino DIS interactions within detector acceptance are expected by the end of the HL-LHC run, covering a kinematic region in x and Q^2 that overlaps with that of the Electron-Ion Collider. Estimating the impact of these DIS projections in global (n)PDF analyses, specifically PDF4LHC21, NNPDF4.0, and EPPS21, reveals a significant reduction of PDF uncertainties, in particular for strangeness as well as the up and down valence PDFs. The LHC neutrino data is demonstrated to have the potential to improve theoretical predictions for core processes at the HL-LHC, such as Higgs production, without requiring modifications to the LHC accelerator infrastructure.

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