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# NNPDF updates and the path toward NNPDF4.1: data, theory, and methodology

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We report on recent advancements in the global determination of the unpolarised proton PDFs by the NNPDF collaboration. Since the previous major release, several improvements have been made in both theoretical frameworks and methodological approaches, supplemented with high-statistic measurements from LHC Run II. On the theoretical front, we present the current state-of-the-art PDF determination which is accurate at  $\alpha\text{N}^3\text{LO}$  and includes a photon PDF with an estimate of the missing higher-order uncertainties (MHOUs). Methodologically, we introduce a novel strategy for the automated determination of the hyperparameters in neural network models based on statistical estimators constructed from an ensemble of models sampling the underlying PDF distribution in model space. We demonstrate the effectiveness of this strategy using modern hardware accelerators and assess the robustness of the resulting uncertainty estimates in comparison with the NNPDF4.0. Finally, on the data side, we evaluate the performance of global PDF fits by confronting them with high-precision LHC data, employing state-of-the-art theoretical predictions. We quantify the goodness-of-fit, considering all sources of experimental and theoretical uncertainties, and provide an objective criterion to decide which PDF sets should be used to interpret available and future measurements.

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