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A new statistical model for estimating PDF uncertainties

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Parton distribution functions (PDFs) form an essential part of particle physics calculations. Currently, the most precise predictions for these non-perturbative functions are generated through fits to global data. One difficulty that several PDF fitting groups encounter is the presence of tension in data sets that appear to pull the fits in different directions. Several methods to capture the uncertainty in PDFs in presence of seemingly inconsistent data sets have been proposed and are currently in use. These methods are important to ensure that the uncertainty in PDFs are not underestimated. Here we propose to update these methods by introducing a generalized statistical model inspired by unsupervised machine learning techniques, namely the Gaussian Mixture Model (GMM).
Using a toy model of PDFs, we demonstrate how the GMM can be used to faithfully reconstruct the probability distribution function in PDF space which can in turn be used to accurately determine the uncertainty on PDFs. We further show how this statistical model reduces to the usual likelihood function for a consistent data set.

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