# HERAFitter - an open source QCD fit framework

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**Abstract.** The HERAFitter project was established to increase applicability of the QCD analysis in the hadron collider experiments. The framework may be used to extract parton density functions from a variety of experimental measurements and to assess the impact of new data on the parton density determination. It may also be employed to perform data consistency checks and to test theoretical models.
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In the era of hadron colliders the proton parton density functions (PDF) have been gaining an increasing attention. While the parton interactions within a hadron cannot be duly described using perturbative approximation, the factorization theorem helps isolating the hard scattering cross section components which can be determined empirically. Improving precision of PDFs is important as it limits our knowledge of cross sections whether Standard Model (SM) or Beyond SM. The HERAFitter [1] is an open source project created to facilitate QCD analysis of experimental data and to increase accuracy of PDF determination.

A detailed review and comparison of PDF analyses can be found in [2, 3]. The technique of PDF extraction in QCD analysis is based on fitting the experimental data with theoretical predictions. The predictions are obtained with parametrized partonic distributions at a starting scale and then are evolved to the measurement scale using DGLAP evolution [4, 5, 6, 7, 8]. The objective is to utilize as much information from precision data as possible, with an important care regarding treatment of the uncertainties and accounting for possible correlations in order to improve precision of calculations. The means of data fitting, theoretical evaluation, QCD evolution and elaborate uncertainty treatment are all implemented in the HERAFitter framework.

There are several particularities related to PDF extraction procedure. One of them is that different processes have different sensitivity to certain quark densities. This allows a broad range of studies for available experimental data in order to estimate their impact on PDF determination. Second is the universality of partonic distributions which allows to perform valuable cross checks and validation of correlated data analysis.

The HERAFitter framework was built and extended to benefit from these two aspects. The analysis method relies on the $\chi^2$ estimate of how well the theoretical prediction describe experimental data for a given PDF parametrisation. The program allows tests of various ansatz on the PDF parametric form and QCD evolution approaches (DGLAP, dipole models, unintegrated PDFs). Different forms of $\chi^2$ based on the use of nuisance parameters or on the

full covariance matrix can be chosen in the HERAFitter for the minimisation procedure.

The instrumentation to calculate theoretical predictions for a list of significant $ep, pp$ and $p\bar{p}$ processes is provided with a number of options. The DIS processes have several heavy quark flavor schemes implemented in different approximations including the fixed-flavour (FFN) and variable flavour number (VFN) schemes. VFN schemes with various treatments for the heavy quark thresholds include the Thorne Roberts (TR) scheme at LO, NLO and NNLO [9, 10] as provided by the MSTW group, the ACOT scheme at LO and NLO as provided by the CTEQ group. The QCDNUM also provides the calculations of the DIS structure functions in the zero-mass VFN and FFN schemes. The Drell-Yan and jet production processes calculations at fixed order are accessible via fast cross section evaluation tools such as APPLGrid [11] and FastNLO [12]. The data on top-quark production can be matched with Monte Carlo calculations by HATHOR [13]

A number of analysis results obtained using the HERAFitter package have been published recently. This includes: NLO QCD fit based on all published H1 inclusive cross section data [14]; beauty quark mass measurement using ZEUS data [15]; QCD analysis of combined HERA charm data [16]; ATLAS Drell-Yan measurements [17, 18]; PDF determination using CMS and ATLAS inclusive jet data [19, 20]; strange quark density measurements in ATLAS and CMS [21, 22]; Dipole model analysis and TMD gluon density with HERA data [23, 24].

A paper by the HERAFitter developers' team devoted to the study of (N)LO PDFs with correlated uncertainties [25] have been accepted for publication and a general description of the package is prepared for journal submission. A complete list of results as well as the newest releases of the HERAFitter program can be accessed at the official web-page www.herafitter.org.

## References


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