

Outlook: the PDF4LHC initiative

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This document demonstrates the vast amount of progress that has taken place in the last years on pinning down the PDFs of the proton, as well as the dramatic increase in awareness of the impact of PDFs on the physics program of LHC experiments. The HERALHC workshop has acted as a regular forum for working meetings between the experiments, PDF phenomenologists and theorists. In the course of this workshop, it was realized that the momentum on the PDF studies should be kept and perhaps even focused more on the LHC, in order to continue the discussions, investigations and further work towards improving our knowledge on the PDFs.

Clearly, LHC will need the best PDFs, especially for precision measurements, setting of limits in searches, and even for discoveries. Ideally the ATLAS and CMS (and LHCb and ALICE) analyses should follow a common procedure for using PDFs and their uncertainties in their key analyses. Such a common procedure, across the experiments, is being used in other contexts, such as significance estimates in searches. Also, changing frequently the PDFs in the software of the experiments, e.g. for cross-checks or the determination of error bands, is often non-trivial (e.g. due to the inter-connection with parameter choices for underlying event modeling, showering parameters and so on) and sometimes impractical if CPU intensive detector simulations are involved. LHC studies therefore will need both good central values for the PDFs to start with, and a good estimate of the associated uncertainties.

This has triggered the so called PDF4LHC initiative. PDF4LHC offers a discussion forum for PDF studies and information exchange between all stake-holders in the field: the PDF global fitter groups, such as CTEQ and MSTW; the current experiments, such as the HERA and Tevatron ones; QCD theorists and the LHC experimental community. The PDF4LHC initiative started in 2008. More details and links to the meetings so far can be found on the PDF4LHC web site [1].

The mission statement of PDF4LHC is:

- Getting the best PDFs, including the PDF uncertainties, based on the present data.
- Devise strategies to use future LHC data to improve the PDFs.

All this needs a close collaboration between theorists and those that are preparing to make the measurements. In order to reach the first goal, the PDF4LHC forum aims to stimulate discussions and trigger further comparison exercises across the PDF community, in order to select one or a limited number of possible strategies that can be adapted to determine and use PDFs. For the second goal, PDF4LHC should also be a forum for discussions on how to include measurements from the LHC to constrain PDFs: what should be measured at LHC, and correspondingly calculated in theory. Such measurements include W and Z production and asymmetries, di-jet production, hard prompt photons, Drell-Yan production, bottom and top quark production, Z -shape fits and Z +jets measurements. One expects that some of these channels can already be studied with first data, hence we need to prepare for that well in advance.

The following issues are part of the program for in depth discussions via topical workshops, some of which took place already in 2008 [1].

- Data to be included in the PDFs. Would we get better results with a selection of data to be used? New data will become available such as $F_L(x, Q^2)$, and combined data from H1/ZEUS. Can we extract more from the data?

- Determination of PDF uncertainties, including the statistical treatment of the data.
- Theoretical uncertainties and regions/processes where they matter: higher-order corrections; heavy flavour treatment; low- x (and high- x) resummation; other PDFs like unintegrated PDFs (and GPDs).
- PDFs for usage Monte Carlo generators.

One can expect that the LHC experiments most likely will be using for most of their studies the PDF sets and errors that are delivered by either one of the CTEQ or MSTW family. Hence it is important that the lessons learned from exercises on studies of the systematics on PDFs will be adapted by these main global PDF providers. PDF4LHC aims to advice the experiments in the use for PDFs for the LHC, based on the discussions, results and future consensus at the forum. The experience and results from HERAPDFs, and PDFs from other groups, like the Neural Net or Alekhin ones are extremely valuable in this discussion and will serve as crucial input in studies to demonstrate how well we actually know the parton distributions. Several important benchmark exercises have been already performed and are reported in section 3 of this report.

A special case are the PDFs for Monte Carlo generators. For experiments it is important that generated events be kinematically distributed close to the distribution of the real data, such that the simulated and reconstructed Monte Carlo events can be used in a straightforward way to calculate efficiencies for e.g. experimental cuts in an analysis. In case the initially generated distribution does not resemble the data close enough, the Monte Carlo samples need to be reweighted, with all its possible drawbacks. Since calculations based on LO Matrix Elements and LO PDFs are known not to describe the data well, and NLO Matrix Element based generators to date have so far only a restricted number of processes implemented, studies are ongoing on so called “improved LO” PDFs, which try to cure some of the LO PDF drawbacks. Examples are given in [2]. This is yet another part of the discussions in the PDF4LHC forum

In short, it is crucial that the work started here continues, with discussions and studies on PDFs and their uncertainties, the impact of the upcoming data on future PDF determinations and more, all with special focus on the needs for the LHC. The PDF4LHC initiative will offer a framework to do all this.

References

- [1] The web page of the PDF4LHC forum can be found at <http://www.hep.ucl.ac.uk/pdf4lhc/>.
- [2] A. Sherstnev and R. S. Thorne, *Different PDF approximations useful for LO Monte Carlo generators*. Preprint 0807.2132, 2008.