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ABM news and benchmarks

Sergey Alekhin[*†]
DESY, Platanenallee 6, D–15738 Zeuthen, Germany;
Institute for High Energy Physics,142281 Protvino, Moscow region, Russia
E-mail: sergey.alekhin@desy.de

Johannes Blümlein
DESY, Platanenallee 6, D–15738 Zeuthen, Germany
E-mail: johannes.bluemlein@desy.de

Sven-Olaf Moch
II. Institut für Theoretische Physik, Universität Hamburg Luruper Chaussee 149, D-22761 Hamburg, Germany;
DESY, Platanenallee 6, D–15738 Zeuthen, Germany
E-mail: sven-olaf.moch@desy.de

We report on progress in the determination of the unpolarised nucleon PDFs within the ABM global fit framework. The data used in the ABM analysis are updated including the charm-production and the high-Q^2 neutral-current samples obtained at the HERA collider, as well as the LHC data on the differential Drell-Yan cross-sections. An updated set of the PDFs with improved experimental and theoretical accuracy at small x is presented. We find minimal impact of the t-quark production cross section measured at the Tevatron and the LHC on the gluon distribution and the value of the strong coupling constant α_s determined from the ABM fit in the case of the t-quark running-mass definition. In particular, the value of $\alpha_s(M_Z) = 0.1133 \pm 0.0008$ is obtained from the variant of the ABM12 fit with the Tevatron and CMS t-quark production cross-section data included and the $\overline{\mathrm{MS}}$ value of $m_t(m_t) = 162$ GeV.

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[*]Speaker.

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Recent progress in the analysis of the collider data allows a gradual improvement of the PDF accuracy at small-x being of particular importance for the phenomenology at the LHC. Since the release of the ABM parton distribution functions (PDFs) [1] a new combined HERA data set on semi-inclusive charm production in deep-inelastic scattering (DIS) has been obtained [2]. It provides a complementary constraint on the gluon distribution and allows to benchmark the factorization schemes employed for the description of the heavy-quark contribution to DIS. In addition, the first LHC data on the differential distributions of the charged leptons produced in the Drell-Yan (DY) process [3–6] allow to check the PDFs tuned to the fixed-target data at values of the Bjorken variable $x \sim 0.01$ and factorization scales $\mu \sim 100$ GeV. In these proceedings we discuss an update of the ABM11 analysis including these HERA and LHC data sets. We also add to the analysis the HERA neutral-current data with $Q^2 > 1000$ GeV^2 omitted earlier in the ABM11 fit. The theoretical footing is correspondingly developed by accounting for the contribution due to the Z-boson exchange. We also update the next-to-next-to-leading-order (NNLO) Wilson coefficients for the heavy-quark electroproduction employing those having been derived recently by a combination of the partial NNLO results stemming from threshold resummation and the high-energy limit with the Mellin moments [7] of the massive operator-matrix elements, cf. [8]. The t-quark production at the LHC [9] and Tevatron [10] can potentially also constrain the PDFs, particularly the gluon

Experiment	ATLAS [3]	CMS [4]	LHCb [5]	LHCb [6]
Final states	$W^+ \to l^+\nu$ $W^- \to l^-\nu$ $Z \to l^+l^-$	$W^+ \to e^+\nu$ $W^- \to e^-\nu$	$W^+ \to \mu^+\nu$ $W^- \to \mu^-\nu$	$Z \to e^+e^-$
Luminosity (1/pb)	35	840	37	940
NDP	30	11	10	9
χ^2	34.5(7.7)	11.8(4.7)	13.0(4.5)	11.5(4.2)

Table 1: The value of χ^2 obtained for different samples of the Drell-Yan LHC data with the NNLO ABM11 PDFs. The figures in parenthesis give one standard deviation of χ^2 equal to $\sqrt{2NDP}$.

distribution. However, this constraint is quite sensitive to the t-quark mass m_t. Meanwhile the experimental determination of m_t is performed on the basis of Monte-Carlo studies yet missing the high-order corrections and its result cannot be directly used in comparisons with theoretical precision calculations. Furthermore, the NNLO corrections to the t-quark production cross section [11] depend on the mass definition [12]. Therefore we check the t-quark data [9, 10] both for the case of the pole- and $\overline{\mathrm{MS}}$–masses at different values of m_t. In the remaining part of the proceedings we discuss comparisons of the LHC DY–data with the ABM11 predictions and the incorporation of those data into the ABM fit, outline the ABM12 PDF features, and discuss the impact of the t-quark data on the ABM PDFs and the strong coupling constant [1].

The W- and Z-boson production at the LHC has been studied by their leptonic decays and the most accurate data are obtained for the electron and muon channels in the form of differential distributions of the final-state charged leptons. Confronting these data with the theoreti-

[1]The impact of the charm-production data [2] and related theoretical improvements are described elsewhere [13].

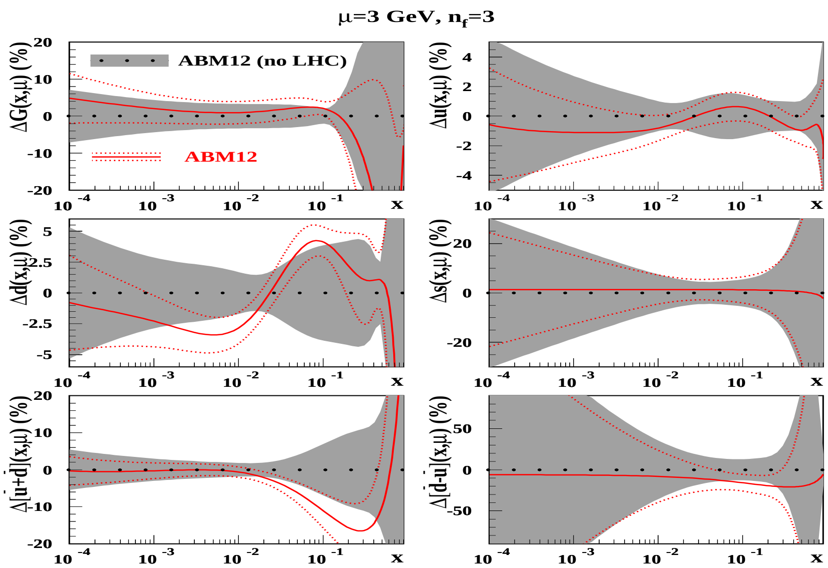

Figure 1: The relative change in the 3-flavor ABM PDFs at the factorization scale of $\mu = 3$ GeV due to the LHC DY data [3–6] (solid curves) in comparison with the uncertainties in the variant of ABM12 fit performed without employing those data (shaded area). The uncertainties in the ABM12 fit are displayed by the dotted curves.

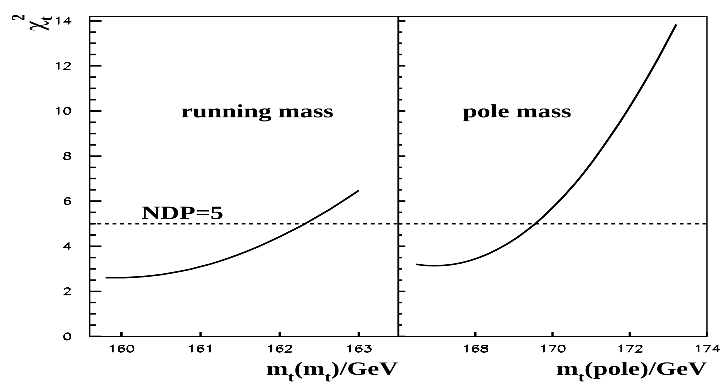

Figure 2: The χ^2 profile for the Tevatron and LHC $t\bar{t}$ cross section data [9, 10] versus the t-quark mass obtained in the variants of ABM12 fit with those data included and different t-quark mass definitions (running mass: left, pole mass: right). The $NDP = 5$ for this subset is displayed by the dashed line.

cal predictions requires fully exclusive calculations which are implemented in two existing codes, DYNNLO 1.3 [14] and FEWZ 3.1 [15]. Taking advantage of both we compute the prediction of the central values with DYNNLO and the PDF uncertainties with FEWZ. The NNLO ABM11 predictions obtained in this way are in good agreement with the DY data by the ATLAS [3], CMS [4], and LHCb [5, 6] experiments with account of the PDF uncertainties [2]. The values of χ^2 are in a good agreement with the number of data points (NDP) for each LHC data sample, cf. Table 1, and the total value of $\chi^2/NDP = 71/60$ is comparable with 1 within its statistical fluctuations

[2]The benchmark of PDFs using the DY LHC data [16] is based on the NLO calculations combined with the NNLO K-factors and performed without taking into account the PDF uncertainties in the statistical analysis.

of $\sqrt{2/NDP}$. Incorporating the DY LHC data into the NNLO PDF fit in a straightforward way requires an enormous computational power. Therefore it is commonly performed using the grids calculated in advance for a wide set of PDFs covering their expected variations. For this purpose we use the DY cross section values calculated for 27 PDF sets encoding the ABM11 uncertainties due to the fitted PDF parameters. In the fit, including the DY LHC data, the cross section value corresponding to a current value of the PDF parameters is computed by linear interpolation between grid values. This approach is well justified if the parameter variations are within their error margins. This holds in our case since the data are in agreement with the previous ABM11 predictions. The change in the PDFs due to the inclusion of the LHC data in general is also obtained within the PDF uncertainties, cf. Fig. 1. The biggest changes are observed at $x \sim 0.1$, the region most sensitive to W/Z–production at the LHC. There the d-quark distribution grows by some 3%. It is also worth noting that its error is reduced dramatically due to the LHC data being free from the impact of nuclear corrections. The non-strange sea quark distribution goes down even stronger, although remaining within the uncertainties and the change in the strange sea is marginal. The value of $\alpha_s(M_Z) = 0.1132 \pm 0.0011$ obtained in the ABM12 fit is in a good agreement with the ABM11 value of $\alpha_s(M_Z) = 0.1134 \pm 0.0011$.

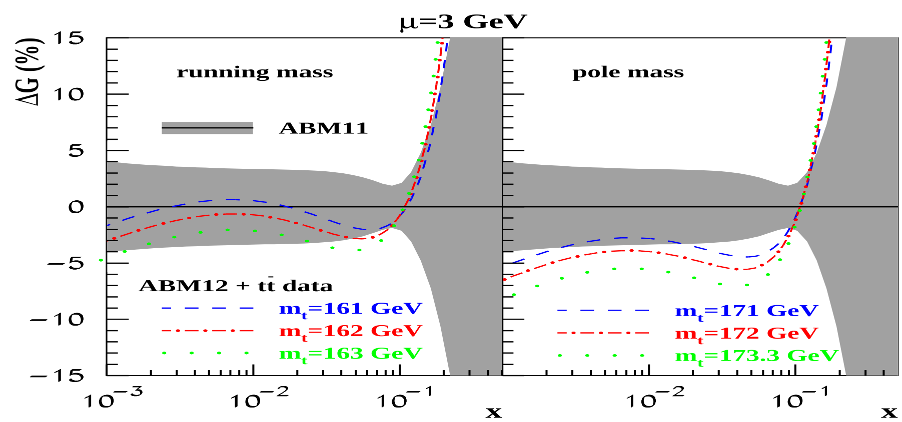

Figure 3: The relative uncertainty of the ABM11 gluon distribution in the 3-flavor scheme at the factorization scale of $\mu = 3$ GeV (grey area) in comparison to its relative change due to inclusion of the $t\bar{t}$ cross section data with the different mass definitions: running mass (left), pole mass (right), and the t-quark mass settings as indicated in the plot.

The ATLAS and CMS experiments collected t-quark samples at the c.m.s. collision energy of 7 and 8 TeV and provided estimates of the $t\bar{t}$ production cross sections [9]. We have checked the combination of these data with those of Tevatron [10] in the ABM12 fit using the pole- and $\overline{\text{MS}}$-masses for m_t. In both cases the QCD corrections up to NNLO are taken into account [11]. However, the running-mass definition has the advantage to provide a better perturbative stability [12]. The t-quark data can be easily accommodated into the ABM fit, taking the running-mass definition, cf. Fig. 2. In case of the pole mass the agreement is worse, particularly at the experimentally measured value of $m_t = 173.3$ GeV [3]. The impact of the t-quark data on the gluon distribution

[3]Note that the benchmarking of the ABM11 PDFs with the t-quark data [17] is performed with the pole-mass definition.

also depends on the value of m_t and on the mass definition, cf. Fig 3. For the running-mass case it does not exceed 1σ in general, while it is bigger for the pole mass. The main contribution to the χ^2 value comes from the ATLAS data, with some overshoot of the ABM predictions. Furthermore, in the variant of the ABM12 fit including only the CMS and Tevatron t-quark data the PDFs are changed to a much smaller extend than with the ATLAS data being included. This displays a certain tension between the ATLAS and CMS data and prevents from including the LHC t-quark data into the fit. Moreover, essential experimental details about systematic error correlations for these data sets and the LHC beam energy uncertainty are still missing. Meanwhile, in the variant of our analysis including the CMS and Tevatron t-quark data only and with the $\overline{\mathrm{MS}}$ value of $m_t(m_t) = 162$ GeV we obtain the value of $\alpha_s(M_Z) = 0.1133 \pm 0.0008$. It is in very good agreement with the result in the ABM11 fit and smaller than the value of $\alpha_s(M_Z) = 0.1187 \pm 0.0027$ obtained by the CMS collaboration referring to the ABM11 PDFs and using the pole-mass definition $m_t = 173.2$ GeV [18].

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