Enhancing LHC discovery potential.

probing quantum chromodynamics using measurements of the CMS experiment

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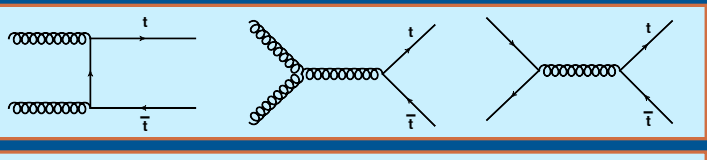
Understanding of the processes in proton-proton collisions at the LHC implies precise knowledge of the underlying theory, quantum chromodynamics, and its fundamental parameters like quark masses, strong coupling as well as the parton distribution functions (PDFs), describing the proton structure. Current precision of Higgs cross section measurements and many searches for new physics are limited by the accuracy of these parameters. High rates of electroweak bosons, heavy quarks and jets provide unique opportunity to better probe QCD at the LHC and in turn enhance its discovery potential.

Measurement of top-quark mass, m_t, and strong coupling constant, α_s, using top-quark pair production at CMS

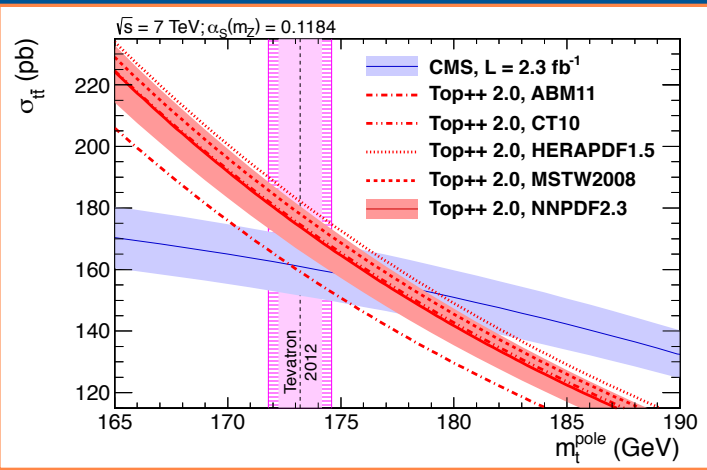
Top-quark pairs at the LHC are produced predominantly in gluon-gluon fusion. The cross section σ_{tt} depends on the value of m_t, α_S, and the gluon PDF.



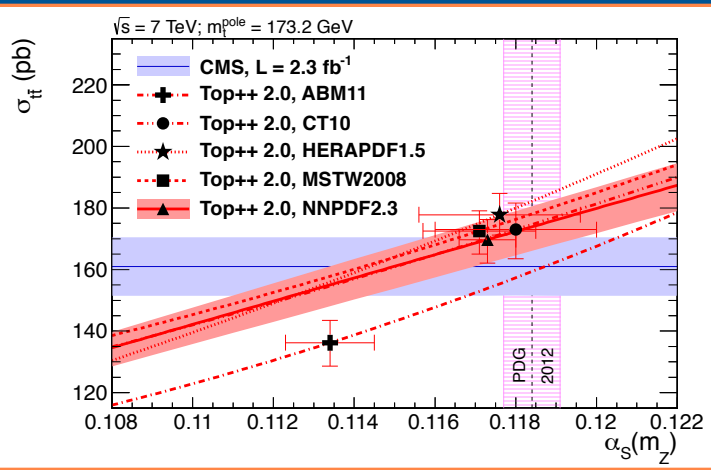
CMS Collaboration, Phys. Lett. B728 (2013) 496:

The inclusive cross section for top-pair production as measured by the CMS experiment at $\sqrt{s}$ = 7 TeV is compared to the QCD prediction at NNLO using five PDF sets. The pole mass of the top quark, m_t, and the strong coupling constant, α_S, are extracted.

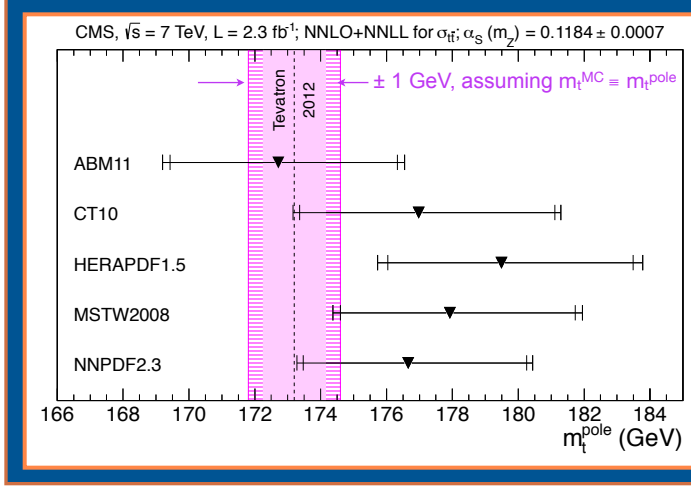
Top-pair cross-section as a function of m_t

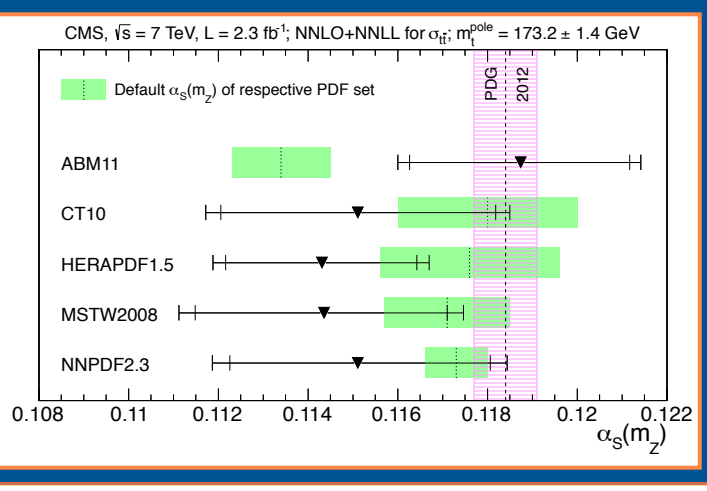


Top-pair cross-section as a function of $\alpha_S(M_Z)$



Both m_t and α_S alter the prediction for the top-pair production cross section. For the determination of of α_S , m_t is fixed to the Tevatron average and for the extraction of m_t , α_S is fixed to the world average. For each PDF set, the most probable values of m_t and $\alpha_S(M_Z)$ are obtained.





Results agree with the world average

Consistent for different PDFs. Using NNPDF2.3:

pole mass of the top quark m_t=176.7 $^{+3.8}_{-3.4}$ GeV

strong coupling $\alpha_S(M_Z)$=0.1151 $^{+0.0033}_{-0.0032}$

The first determination of α_S (M_Z) from top-quark production. Theory uncertainty (scale variation) ~1%

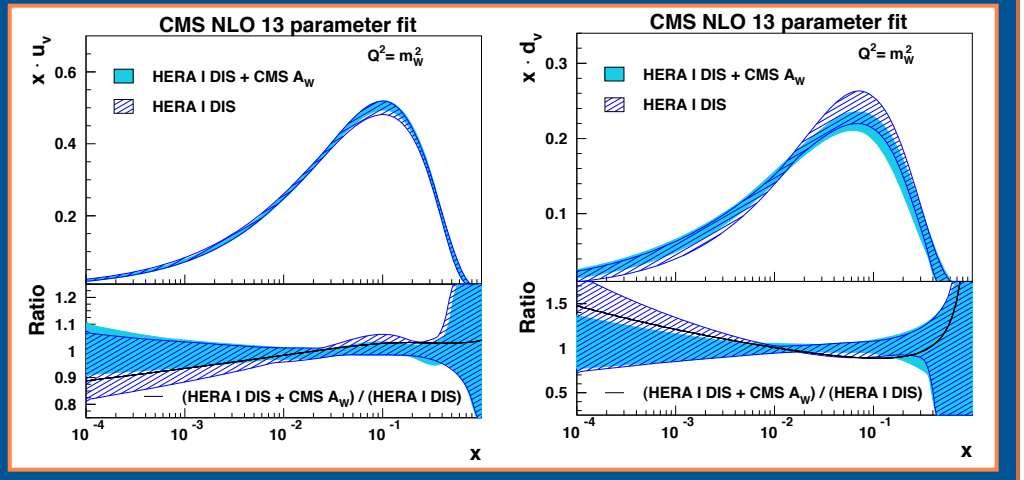
Precise LHC measurements are used to improve constraints on the proton PDFs. The LHC experiments are supplied by the open-source QCD analysis framework **HERAFitter** [https://www.herafitter.org]. This program allows for detailed studies of the impact from different measurements on determination of the QCD parameters and tests of various theory approaches.

Improved determination of the valence-quark distributions

Lepton charge asymmetry in W-boson production at LHC probes *u* and *d* quarks

$$A_W = \frac{W^+ - W^-}{W^+ + W^-} \approx \frac{u_v - d_v}{u_v + d_v + 2u_{sea}}$$

CMS Collaboration, arXiv:1312.6283.

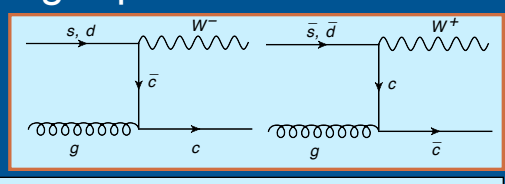


The CMS measurements of the muon charge asymmetry in W-boson production at $\sqrt{s}$ = 7 TeV are for the first time included in a QCD analysis.

Strong impact on the PDFs is demonstrated.

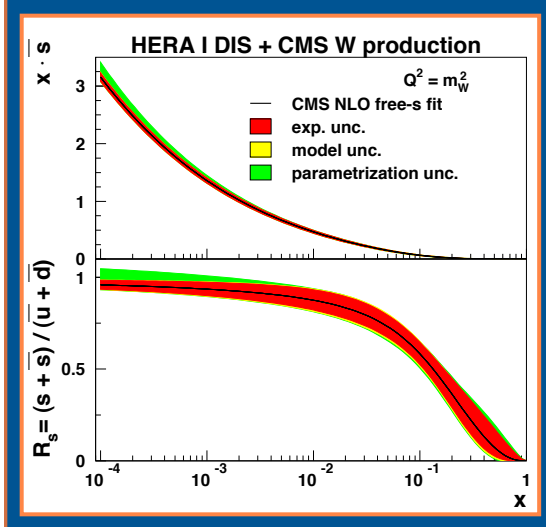
Determination of the strange-quark distribution

Associated W+c production at the LHC probes strange quarks directly



CMS Collaboration, arXiv:1312.6283:

The CMS measurements of the muon charge asymmetry in W-boson production and associated W+c production at $\sqrt{s}$ = 7 TeV are for the first time included in the QCD analysis at NLO. The strange-quark distribution and the strangeness fraction in the proton are determined.



Strangeness suppression

$$\kappa_s(Q^2) = \frac{\int_0^1 (\bar{s}(x,Q^2) + s(x,Q^2))dx}{\int_0^1 (\bar{u}(x,Q^2) + \bar{d}(x,Q^2))dx}$$

determined at NLO:

κ_s(20 GeV^2)=0.52 $^{+0.18}_{-0.15}$

agrees with results of neutrino scattering experiments

Determination of strangeness in the proton using collider data

Presented results, as well as started activities entering the POF III period encompass studies of diversity of physics processes in hadronic collisions, which will enhance the discovery potential of the LHC and deepen the insight into the basics of the matter structure at the highest finesse.

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