The long road to PDF4LHC21: a few introductory remarks

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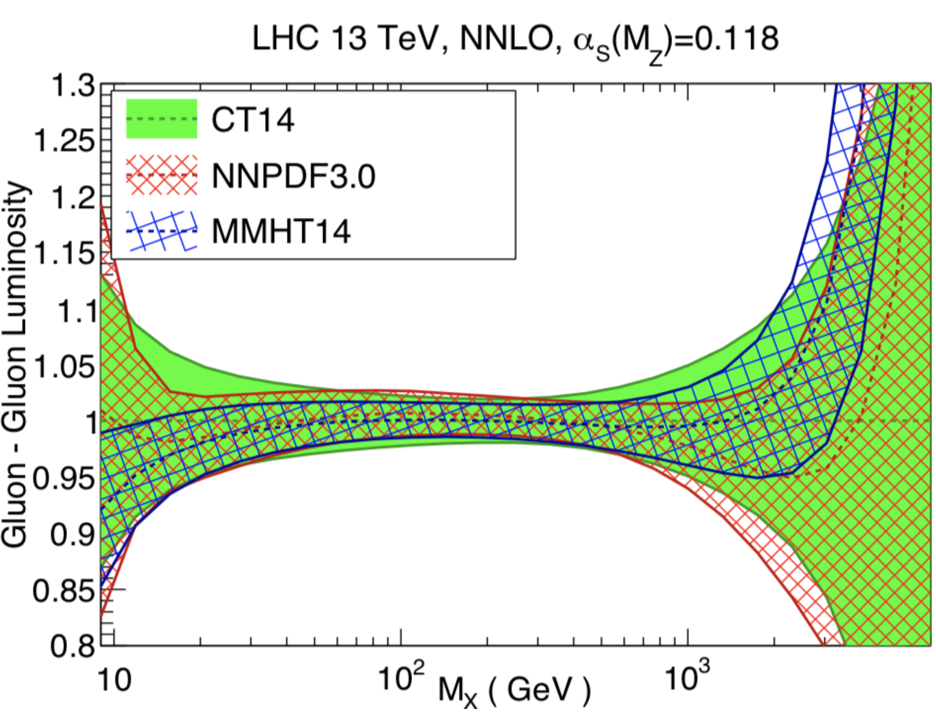
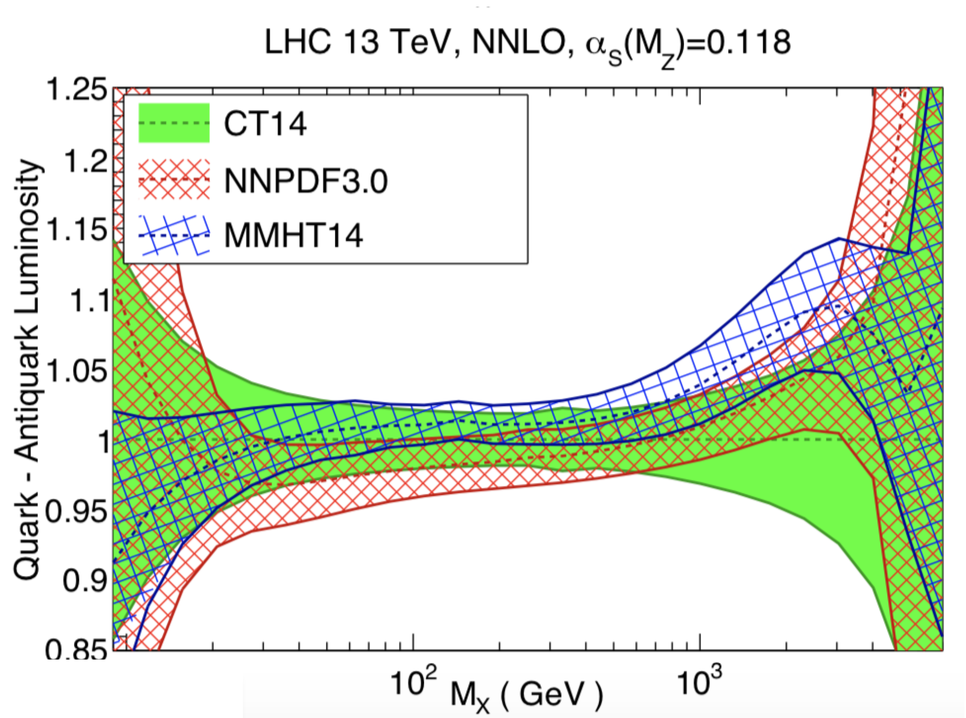
PDF4LHC15

- a combination of CT14, MMHT2014, NNPDF3.0
  - 1 year benchmarking exercise comparison of above PDFs
  - 300 Monte Carlo replicas generated for each of the above PDFs
  - condensed to Hessian sets with from 30-100 members for distribution to users with central PDFs and error PDFs representing the three published PDFs
  - good (too good?) agreement for gluon-gluon luminosity





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OUTP-15-17P
SMU-HEP-15-12
TIF-UNIMI-2015-14
LCTS/2015-27
CERN-PH-TH-2015-249

PDF4LHC recommendations for LHC Run II

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Abstract:

We provide an updated recommendation for the usage of sets of parton distribution functions (PDFs) and the assessment of PDF and PDF+α_s uncertainties suitable for applications at the LHC Run II. We review developments since the previous PDF4LHC recommendation, and discuss and compare the new generation of PDFs, which include substantial information from experimental data from the Run I of the LHC. We then propose a new prescription for the combination of a suitable subset of the available PDF sets, which is presented in terms of a single combined PDF set. We finally discuss tools which allow for the delivery of this combined set in terms of optimized sets of Hessian eigenvectors or Monte Carlo replicas, and their usage, and provide some examples of their application to LHC phenomenology.

This paper is dedicated to the memory of Guido Altarelli (1941-2015), whose seminal work made possible the quantitative study of parton distribution functions.

1372 citations

PDF4LHC15 PDFs useful for situations where a combination of PDFs might be helpful, such as Monte Carlo extrapolations to new LHC energies

not a replacement for use of individual PDFs for comparison to LHC data

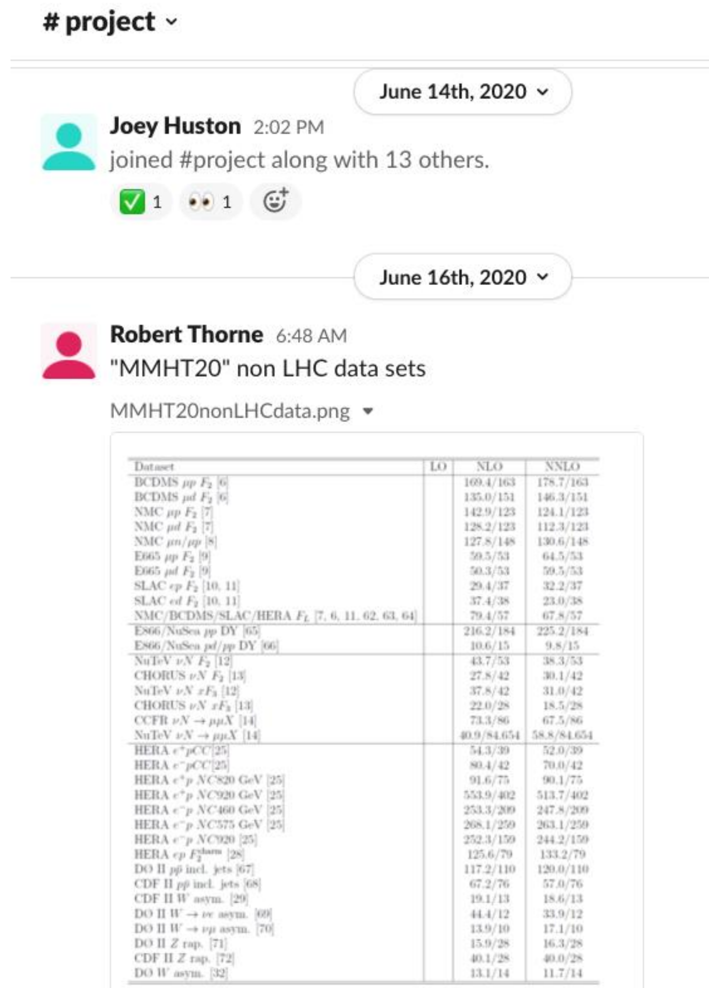
…in the meantime

- New critical data sets from the LHC on Drell-Yan, top, jets, W/Z+jets
- NNLO predictions available for all of above allowing this data to be included in PDF fits
  - transferring NNLO information to global PDF fits still a bit of an issue, i.e. precision of K-factors, availability of grids
- New NNLO PDFs available (CT18, MSHT20, NNPDF3.1->NNPDF4.0 in the timescale of this study) that make use of this LHC data
  - additional technical improvements to the PDF fits
- These PDF sets will be used for the construction of PDF4LHC21

Benchmarking

- Understand the origins of any differences of PDFs
  - due to variations of experimental input, different theory choices, fitting methodologies…
  - so for benchmarking, use common theory settings (i.e. perturbative charm, m_{charm}=1.4 GeV, s=sbar at input scale, $\alpha_s(m_Z)$=0.118, positive-definite PDFs, no deuteron or nuclear corrections…)
- …and start with reduced set that contains targeted data which should be enough to provide information on all PDFs, but with an uncertainty larger then for the full PDF fits->expect agreement among the 3 PDF groups
- Then a final combination of the 3 PDFs using the same Monte Carlo replica techniques we used in 2015
- Two resultant PDFs: a 100 member MC replica set, and a 40 member Hessian set

This has been going on for a while, with meetings ~every two weeks… but we learned a lotf



Dataset	LO	NLO	NNLO
BCDMS μp F_2 [6]		169.4/163	178.7/163
BCDMS μd F_2 [6]		135.0/151	146.3/151
NMC μp F_2 [7]		142.9/123	124.1/123
NMC μd F_2 [7]		128.2/123	112.3/123
NMC $\mu n/\mu p$ [8]		127.8/148	130.6/148
E665 μp F_2 [9]		59.5/53	64.5/53
E665 μd F_2 [9]		50.3/53	59.5/53
SLAC ep F_2 [10, 11]		29.4/37	32.2/37
SLAC ed F_2 [10, 11]		37.4/38	23.0/38
NMC/BCDMS/SLAC/HERA F_L [7, 6, 11, 62, 63, 64]		79.4/57	67.8/57
E866/NuSea pp DY [65]		216.2/184	225.2/184
E866/NuSea pd/pp DY [66]		10.6/15	9.8/15
NuTeV νN F_2 [12]		43.7/53	38.3/53
CHORUS νN F_2 [13]		27.8/42	30.1/42
NuTeV νN xF_3 [12]		37.8/42	31.0/42
CHORUS νN xF_3 [13]		22.0/28	18.5/28
CCFR $\nu N \to \mu\mu X$ [14]		73.3/86	67.5/86
NuTeV $\nu N \to \mu\mu X$ [14]		40.9/84.654	58.8/84.654
HERA e^+pCC [25]		54.3/39	52.0/39
HERA e^-pCC [25]		80.4/42	70.0/42
HERA e^+p NC820 GeV [25]		91.6/75	90.1/75
HERA e^+p NC920 GeV [25]		553.9/402	513.7/402
HERA e^-p NC460 GeV [25]		253.3/209	247.8/209
HERA e^-p NC575 GeV [25]		268.1/259	263.1/259
HERA e^-p NC920 [25]		252.3/159	244.2/159
HERA ep F_2^{charm} [28]		125.6/79	133.2/79
DO II $p\bar{p}$ incl. jets [67]		117.2/110	120.0/110
CDF II $p\bar{p}$ incl. jets [68]		67.2/76	57.0/76
CDF II W asym. [29]		19.1/13	18.6/13
DO II $W \to \nu e$ asym. [69]		44.4/12	33.9/12
DO II $W \to \nu\mu$ asym. [70]		13.9/10	17.1/10
DO II Z rap. [71]		15.9/28	16.3/28
CDF II Z rap. [72]		40.1/28	40.0/28
DO W asym. [32]		13.1/14	11.7/14

This meeting

- …is to show the results of this effort as it winds up
- Two talks:
  - Tom Cridge: benchmarking process and combination
  - Emanuele Nocera: phenomenology with the PDF4LHC21 PDFs
- The writeup is well-advanced,with hopes to post it on the archive in the near future

except we still can't seem to get totally rid of him