

# NEWS FROM PDF4LHC

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PHYSICS AT TEV COLLIDERS

LES HOUCHES, JUNE 7, 2015

$\alpha_s$

## TREATMENT OF $\alpha_s$ NEW SIMPLIFIED PDF4LHC PRESCRIPTION

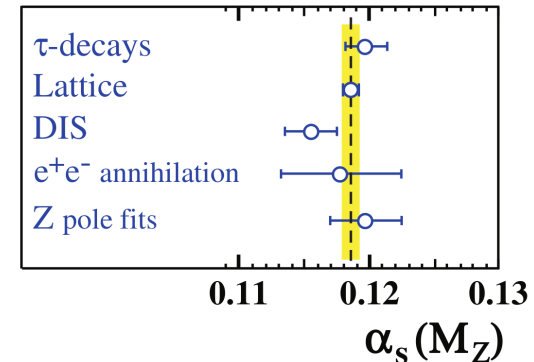
- **SEPARATE**  $\alpha_s$  UNCERTAINTY FROM PDF UNCERTAINTY:  
DETERMINE EACH SEPARATELY AND COMBINE IN QUADRATURE IF NEEDED  
PROVEN TO BE EQUIVALENT TO CORRELATED DETERMINATION, UP TO NONLINEAR TERMS
- **AGREE ON A CENTRAL VALUE AND AN UNCERTAINTY ON  $\alpha_s$**  (SEE BELOW)
- FOR THE DETERMINATION OF THE **PDF UNCERTAINTY**,  
USE PDFs AT THE **(FIXED) CENTRAL VALUE** OF  $\alpha_s$
- FOR THE DETERMINATION OF THE  $\alpha_s$  UNCERTAINTY,
  - **COMPUTE OBSERVABLES** WITH  $\alpha_s$  **SHIFTED** BY ONE  $\sigma$ , WITH **PDFs**  
**CORRESPONDING** TO THE GIVEN FIXED VALUE
  - TAKE **RESULT** AS ONE- $\sigma$   $\alpha_s$  **UNCERTAINTY ON OBSERVABLE**

## THE VALUE OF $\alpha_s$

PDG VALUE (AUGUST 2014):  $\alpha_s(M_Z) = 0.1185 \pm 0.0006$

### COMMENTS (S.F.)

- LATTICE UNCERTAINTY CURRENTLY ESTIMATED BY FLAG (arXiv:1310.8555) TO BE **TWICE THE PDG** VALUE ( $\pm 0.0012$ )
- IT IS AN **AN AVERAGE OF AVERAGES**
- **SOME SUB-AVERAGES** (E.G. DIS) INCLUDE MUTUALLY **INCONSISTENT/INCOMPATIBLE** DATA/EXTRACTIONS



- SOME SUB-AVERAGES (E.G.  $\tau$  OR JETS) INCLUDE **DETERMINATIONS** WHICH **DIFFER** FROM EACH OTHER BY EVEN **FOUR-FIVE  $\sigma$**
- AVERAGING THE **TWO MOST RELIABLE VALUES** (GLOBAL EW FIT &  $\tau$ , BOTH  $N^3$ LO, NO DEP. ON HADRON STRUCTURE) GIVES

$$\alpha_s = 0.1196 \pm 0.0010$$

### NEW PDF4LHC AGREEMENT

- PDG **UNCERTAINTY CONSERVATIVELY MULTIPLIED** BY 2
- **CENTRAL VALUE & UNCERTAINTY ROUNDED:**  
PDF SETS USUALLY GIVEN IN STEPS OF  $\Delta\alpha_s(M_Z) = 0.001$

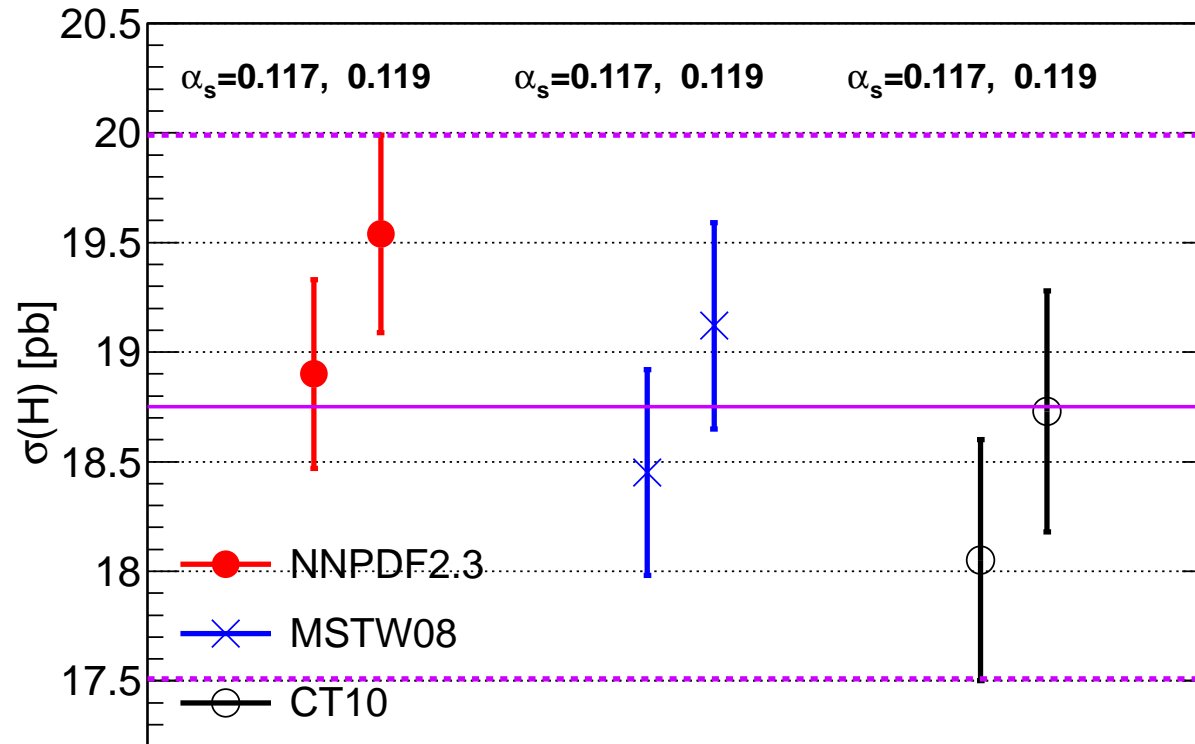
$$\alpha_s(M_Z) = 0.118 \pm 0.001$$

# PDF UNCERTAINTY

# THE OLD PDF4LHC PRESCRIPTION

## HIGGS IN GLUON FUSION

LHC 8 TeV - iHixs 1.3 NNLO - PDF+ $\alpha_s$  uncertainties



- DISCREPANCY NOT UNDERSTOOD DESPITE INTENSIVE BENCHMARKING
- CONSERVATIVE WAY OUT: TAKE THE ENVELOPE OF RESULTS

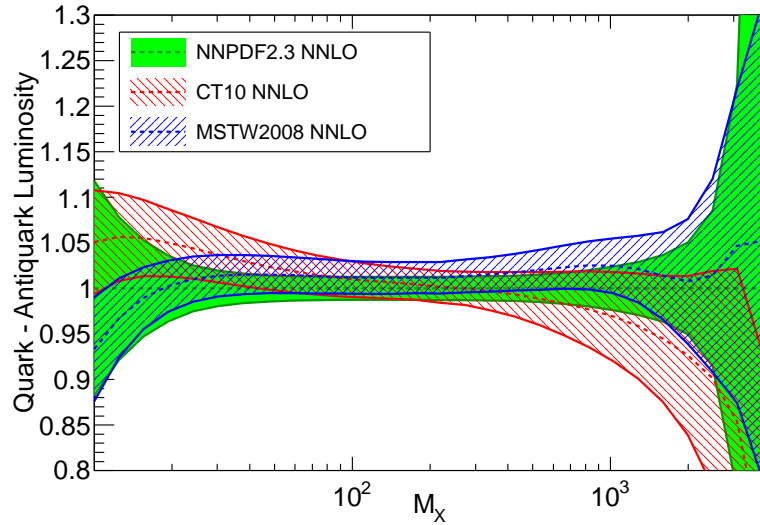
# PROGRESS

## PARTON LUMINOSITIES: IMPROVED AGREEMENT

### QUARK-QUARK

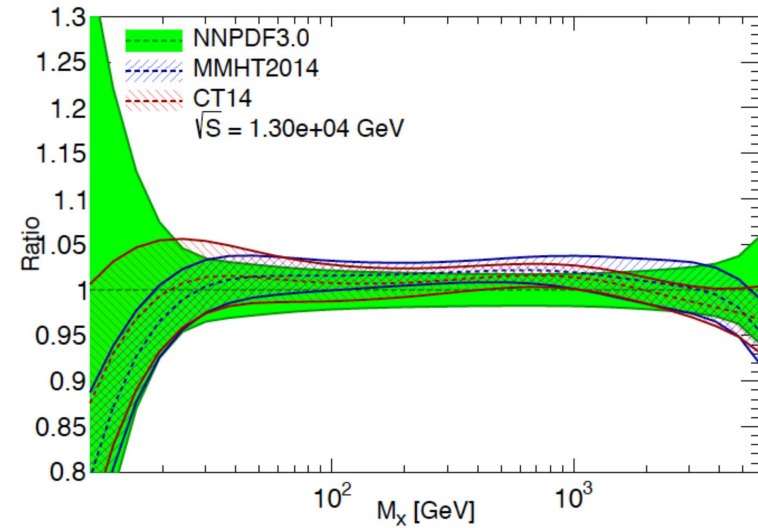
2012

LHC 8 TeV - Ratio to NNPDF2.3 NNLO -  $\alpha_s = 0.118$



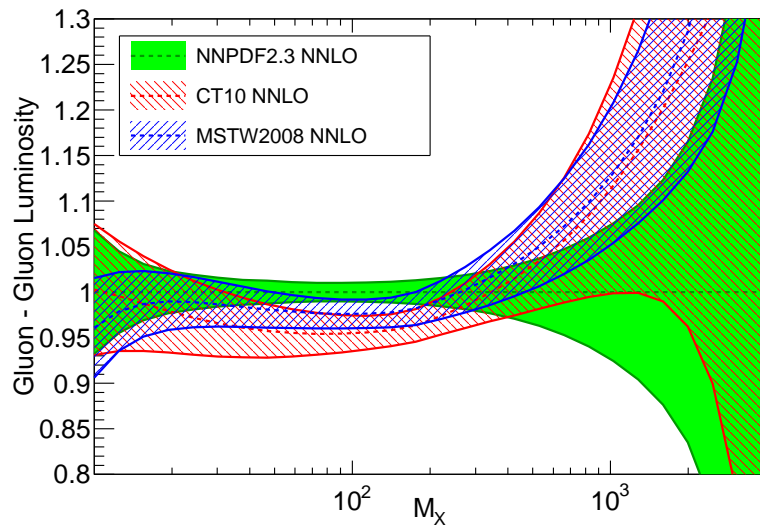
2015

Quark-Quark, luminosity

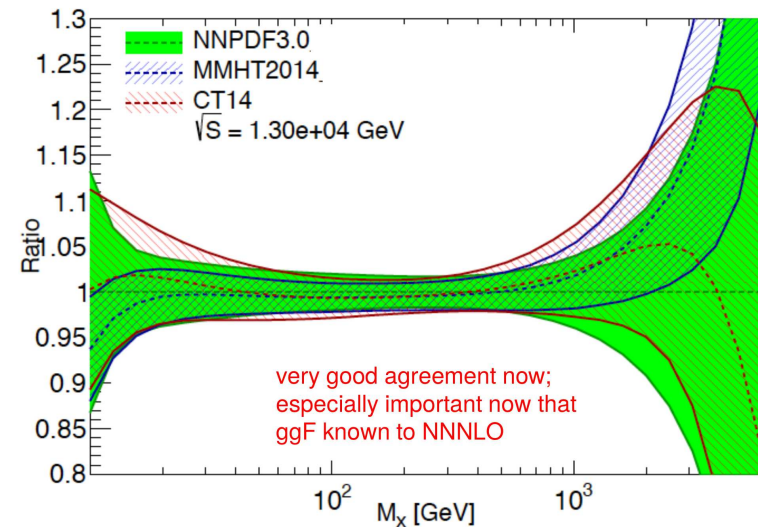


### GLUON-GLUON

LHC 8 TeV - Ratio to NNPDF2.3 NNLO -  $\alpha_s = 0.118$



Gluon-Gluon, luminosity



“progress in convergence between the parton distribution functions will also be needed in order to reduce the theoretical uncertainties below the experimental measurement uncertainties.”

(J.Ellis, arXiv:1504.03654, April 15, 2015)

## PROGRESS! HIGGS IN GLUON FUSION

# A comparison of ggF at NNLO

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	CT14	MMHT2014	NNPDF3.0
8 TeV	18.66 pb -2.2% +2.0%	18.65 pb -1.9% +1.4%	18.77 pb -1.8% +1.8%
13 TeV	42.68 pb -2.4% +2.0%	42.70 pb -1.8% +1.3%	42.97 pb -1.9% +1.9%

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J.HUSTON, PDF4LHC, APRIL 2015

- ALMOST PERFECT AGREEMENT BETWEEN GLOBAL PDF FITS
- COMES OUT OF THE BOX, THANKS TO METHODOLOGICAL IMPROVEMENTS



# THE NEW PDF4LHC PRESCRIPTION

- PERFORM MONTE CARLO COMBINATION OF UNDERLYING PDF SETS
- SETS ENTERING THE COMBINATION MUST SATISFY COMMON REQUIREMENTS
- DELIVER A SINGLE COMBINED PDF SET THROUGH SUITABLE TOOLS

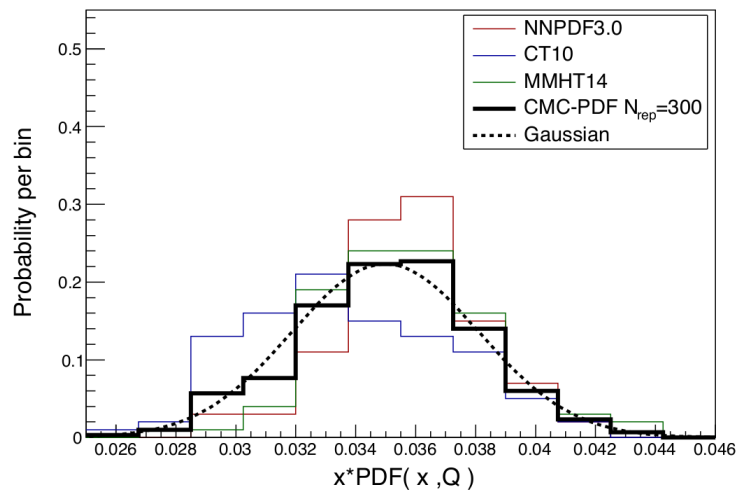
# MONTE CARLO COMBINATION

(Watt, S.F., 2010-2013)

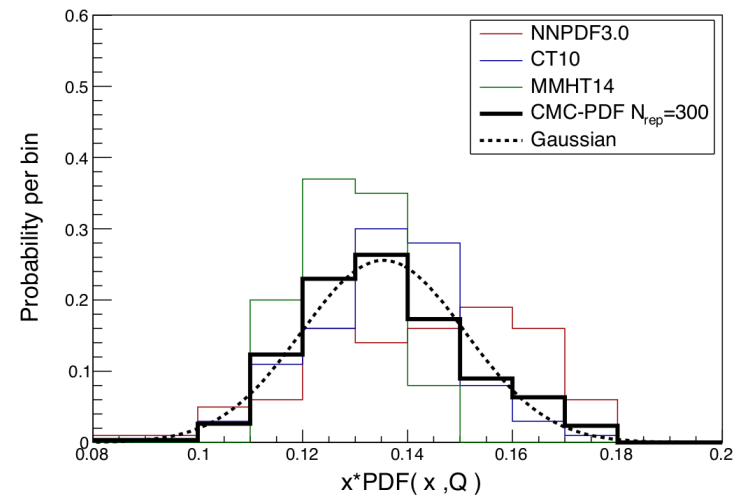
- **CONVERT** ALL SETS INTO **MONTE CARLO**
- **HESSIAN** SETS CAN BE CONVERTED BY PERFORMING **MONTE CARLO IN PARAMETER SPACE** (Watt, Thorne, 2012)
- **COMBINE MONTE CARLO REPLICAS INTO SINGLE SET**

## COMBINED MC SETS FOR ANTIDOWN & STRANGE

$\bar{d}(x=0.20, Q=100 \text{ GeV})$



$s(x=0.05, Q=100 \text{ GeV})$



from 2015 PDF4LHC document, preliminary

## REQUIREMENTS FOR INCLUSION

PDFs TO BE INCLUDED IN THE COMBINATION **MUST SATISFY REQUIREMENTS** WHICH MAKE THEM **COMPATIBLE** DOCUMENT IN PDF4LHC APRIL 2015 INDICO SOME LISTED HERE (SEE DOCUMENT FOR FULL LIST):

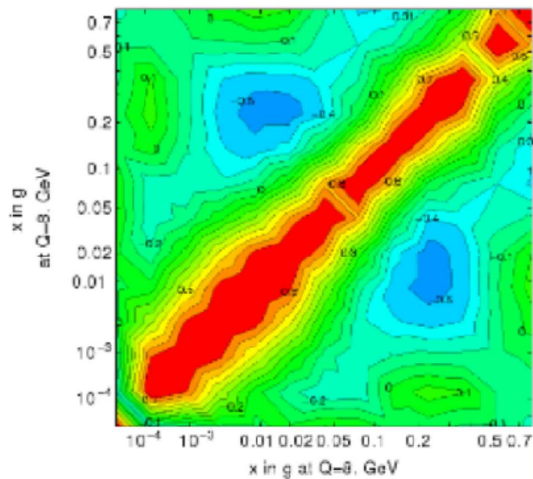
- PROVIDE **RESULTS AT NLO AND NNLO**, WITH NNLO  $\alpha_s$ , EVOLUTION **BENCHMARKED** AGAINST HOPPET OR QCDNUM
- **SEPARATE TREATMENT** OF  $\alpha_s$  AS DISCUSSED
- USE A **GENERAL-MASS VARIABLE FLAVOR NUMBER SCHEME** WITH UP TO 5 FLAVORS
- **CURRENT TECHNOLOGY**: FITS MUST BE BASED ON APPROXIMATELY **COMMON, GLOBAL SET OF DATA** REQUEST TO RELAX THIS (HERAPDF)

# TOOLS FOR DELIVERY

- **COMBINED MC** SET IS **LARGE** (300 REPLICAS)
- **HESSIAN DELIVERY** OFTEN DESIRABLE (PDF UNCERTAINTIES AS NUISANCE PARAMETERS)
- **CMC: GA COMPRESSION** OF MC SET TO A **SMALLER SET** WITH **MINIMAL INFORMATION LOSS** (300  $\rightarrow$  40 REPLICAS)
- **META-PDFs** OR **MC-H PDFs**: **HESSIAN REPRESENTATION** OBTAINED BY **REFITTING** MC REPLICAS WITH **FUNCTIONAL FORM (META)**, OR **REPRESENTING** THEM ON **LINEAR BASIS OF REPLICAS (MC-H)**
- **VALIDATION AND BENCHMARKING** SUCCESSFUL

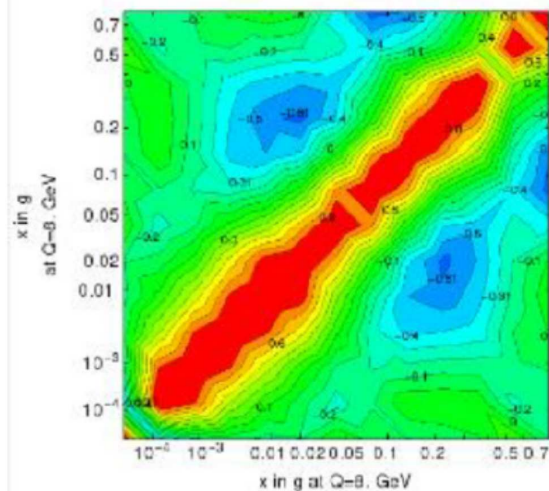
STARTING COMBINED SET

Correlation between CMC300 PDF's



GLUON-GLUON CORRELATION  
COMPRESSED MC SET

Correlation between CMC40 PDF's



META-PDF SET

Correlation between META60 PDF's

