NNPDFs

Stefano Forte

Università di Milano & INFN

FOR THE COLLABORATION: R. D. BALL, V. BERTONE, S. CARRAZZA, C. DEANS, L. DEL DEBBIO, S.F., A. GUFFANTI, N. HARTLAND, J. I. LATORRE, J. ROJO, M. UBIALI
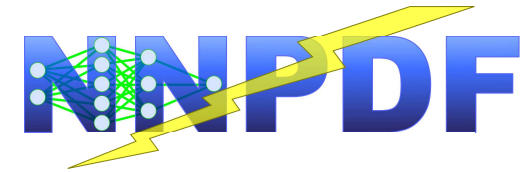
UNIVERSITÀ DEGLI STUDI DI MILANO
DIPARTIMENTO DI FISICA

INFN
Istituto Nazionale
di Fisica Nucleare

PHYSICS AT TeV COLLIDERS

LES HOUCHES, JUNE 9, 2013

NNPDFs
WITH QED CORRECTION

STEFANO FORTE

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THE NAME OF THE GAME

CONSTRUCT A SET OF PDFS WITH:

- QCD CORRECTIONS INCLUDED TO NLO OR NNLO ($O(\alpha_a^2)$ OR $O(\alpha_s^3)$)

- QED CORRECTIONS INCLUDED TO LO ($O(\alpha)$)

- PHOTON PDF OBTAINED FROM FIT TO DIS AND DRELL-YAN (LOW-MASS, HIGH-MASS, ON-SHELL GAUGE-BOSON)

- ALL OTHER PDFS CONSTRAINED BY SAME DATA AS NNPDF2.3 GLOBAL FIT

THE WAY IT IS DONE (BY US)

NNPDF2.3 QED DIS-ONLY FIT
N_{rep} = 500

CONSTRUCTION OF NNPDF2.3 QEDPRIOR AT Q_0^2:

(A) QUARK AND GLUON PDFS FROM NNPDF2.3 GLOBAL
(B) PHOTON PDFS FROM NNPDF2.3 DIS-ONLY

EVOLVE NNPDF2.3 QEDPRIOR UPWARDS FOR ALL Q^2
USE COMBINED QCD+QED DGLAP EQUATIONS

COMPUTE `HORACE+DYNNLO` PREDICTIONS FOR
LHC W, Z PRODUCTION WITH NNPDF2.3 QEDPRIOR

REWEIGHT THE N_{rep} = 500
REPLICAS WITH LHC W, Z DATA

CONSTRUCT THE FINAL NNPDF2.3 QED SET
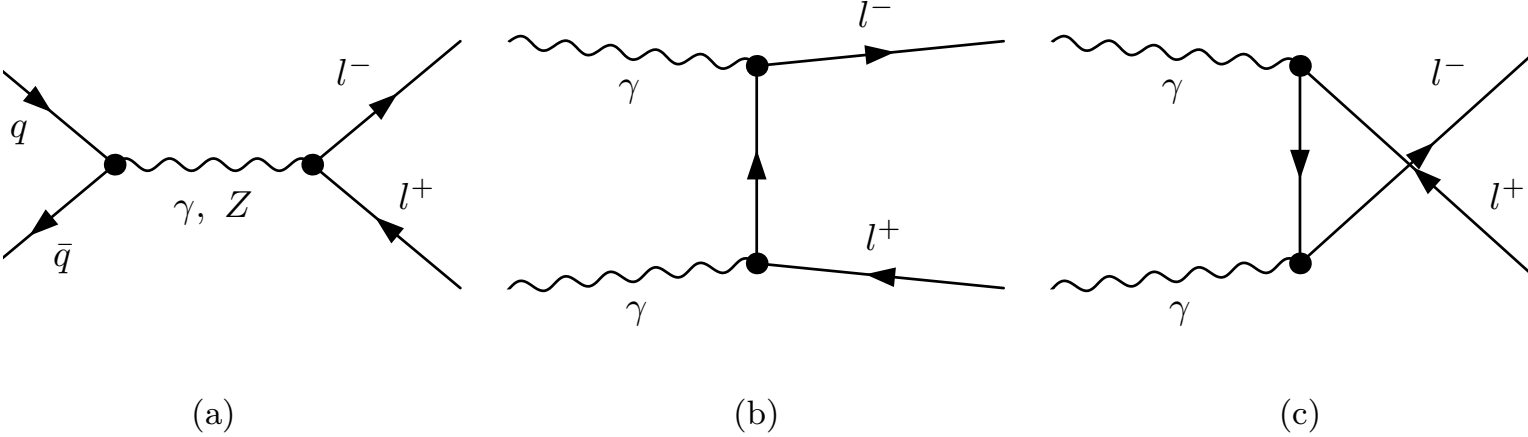BY UNWEIGHTED THE REWEIGHED
PDFS OF THE PREVIOUS STEP

QED CORRECTIONS TO PERTURBATIVE EVOLUTION

- GLAP ANOMALOUS DIMENSIONS COMPUTED TO $O(\alpha_a^2)$ OR $O(\alpha_s^3)$ AND $O(\alpha)$

- PHOTON PDF PARAMETRIZED WITH STANDARD NNPDF NEURAL NETWORK PARAMETRIZATION (2-4-3-1 NN, 37 FREE PARAMETERS)

- EVOLUTION IMPLEMENTED IN `FastKernel` NNPDF EVOLUTION CODE (SOLUTION OF QCD & QED TERMS COMBINED MULTIPLICATIVELY)

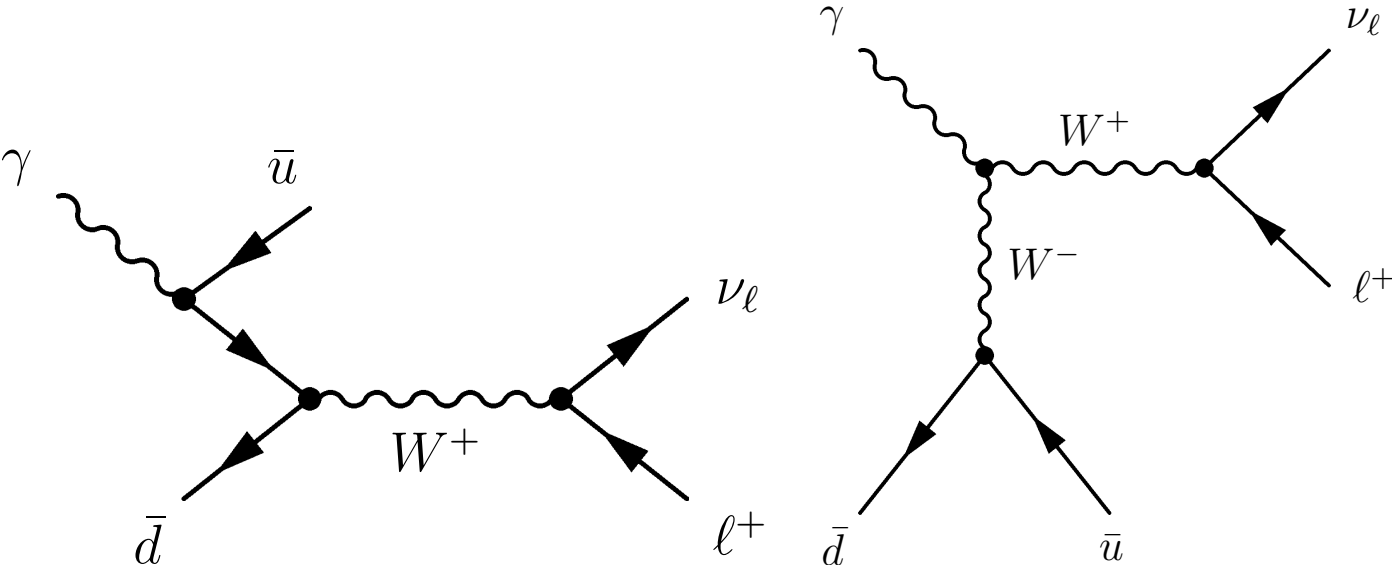- BENCHMARKED AGAINST `partonevolution` (Roth,Weinzierl, 2002-2004)

RADIATIVELY GENERATED γ

$x\gamma(x,Q^2)$

QED CORRNS TO PDFs

QED corrections to PDFs, $Q^2 = 100$ GeV^2
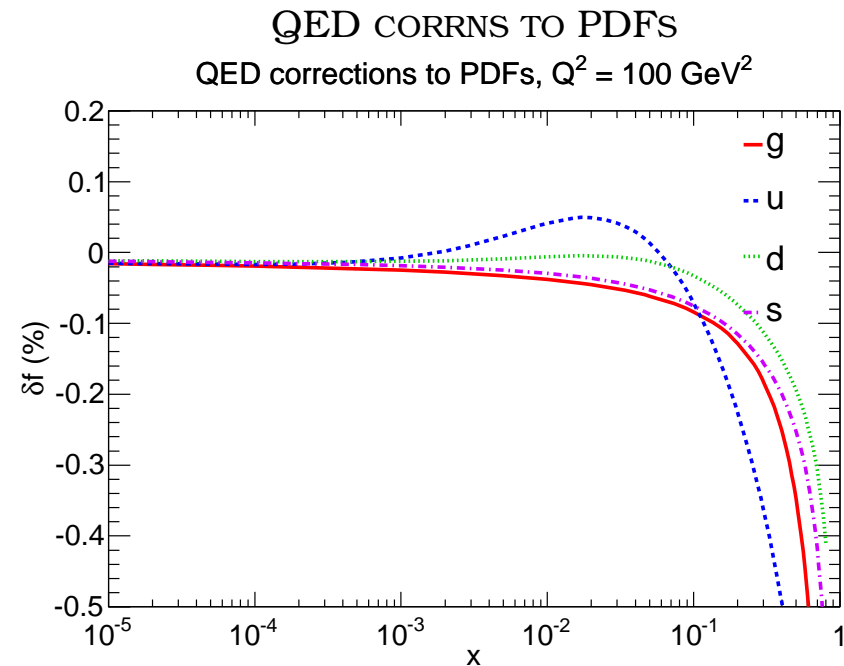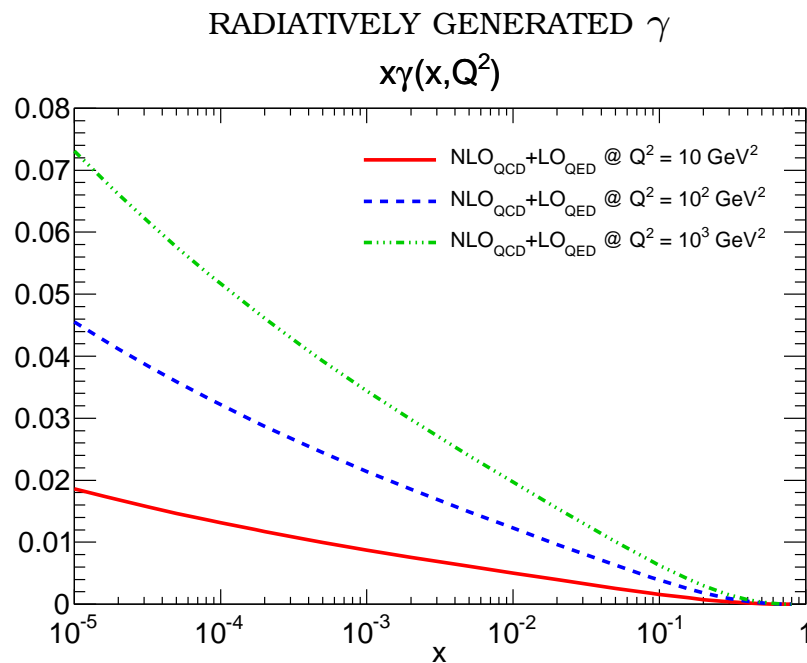
INCLUSION OF THE DRELL-YAN DATA

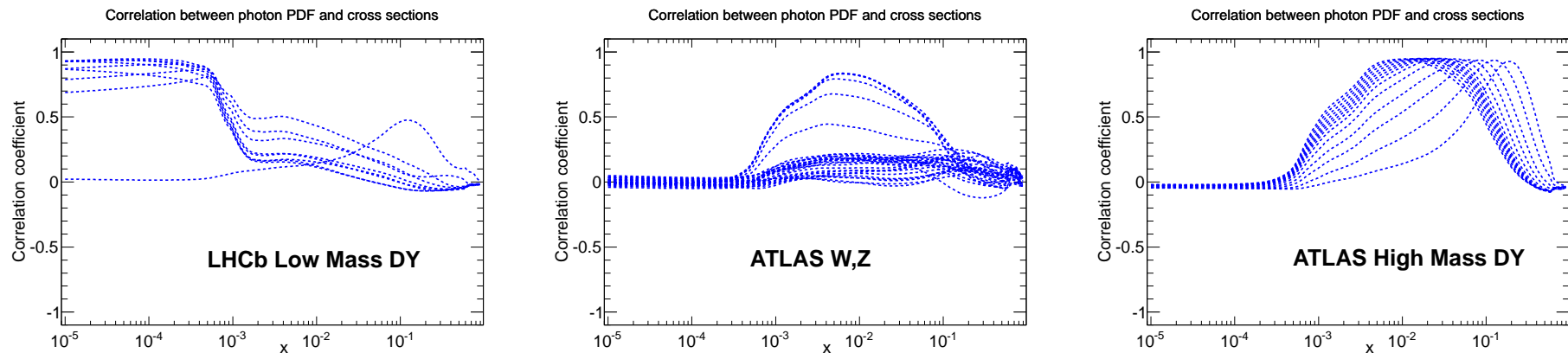## NEUTRAL CURRENT, BORN

(a) (b) (c)

CHARGED CURRENT, BORN (SOME)

THE LHC DATA...

NNPDF2.3QED DATASET

Dataset	Observable	N_{dat}	$[\eta_{\min}, \eta_{\max}]$	$\left[M_{ll}^{\min}, M_{ll}^{\max}\right]$
LHCb γ^*/Z Low Mass	$d\sigma(Z)/dM_{ll}$	9	[2,4.5]	[5,120] GeV
ATLAS W, Z	$d\sigma(W^{\pm}, Z)/d\eta$	30	[-2.5,2.5]	[60,120] GeV
ATLAS γ^*/Z High Mass	$d\sigma(Z)/dM_{ll}$	13	[-2.5,2.5]	[116,1500] GeV

...AND THEIR IMPACT

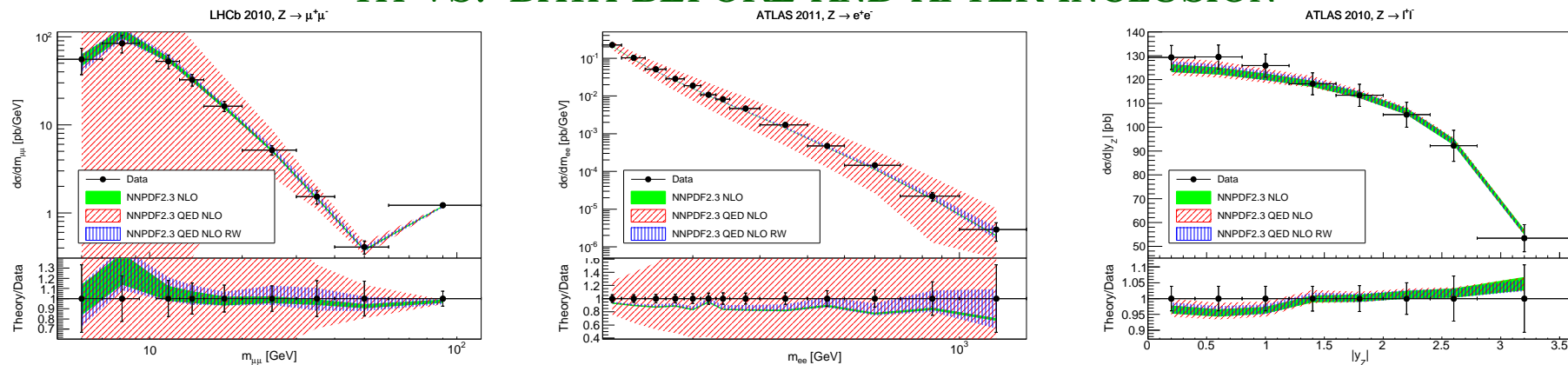### CORRELATION BETWEEN DATA AND γ PDF

THE LHC DATA...

NNPDF2.3QED DATASET

Dataset	Observable	N_{dat}	$[\eta_{\min}, \eta_{\max}]$	$\left[M_{ll}^{\min}, M_{ll}^{\max}\right]$
LHCb γ^*/Z Low Mass	$d\sigma(Z)/dM_{ll}$	9	[2,4.5]	[60,120] GeV
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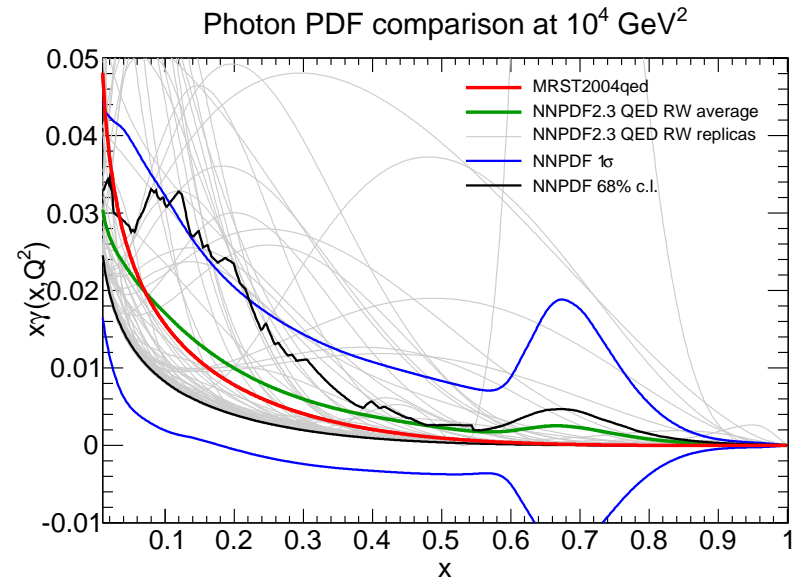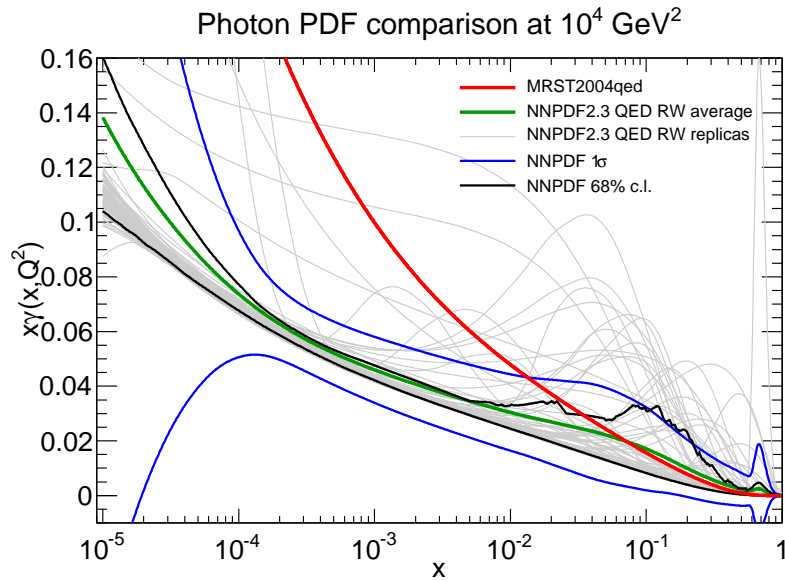### TH VS. DATA BEFORE AND AFTER INCLUSION

- THEORY OBTAINED COMBINING `HORACE` & `DYNNLO` (S.Carrazza et al., in preparation)

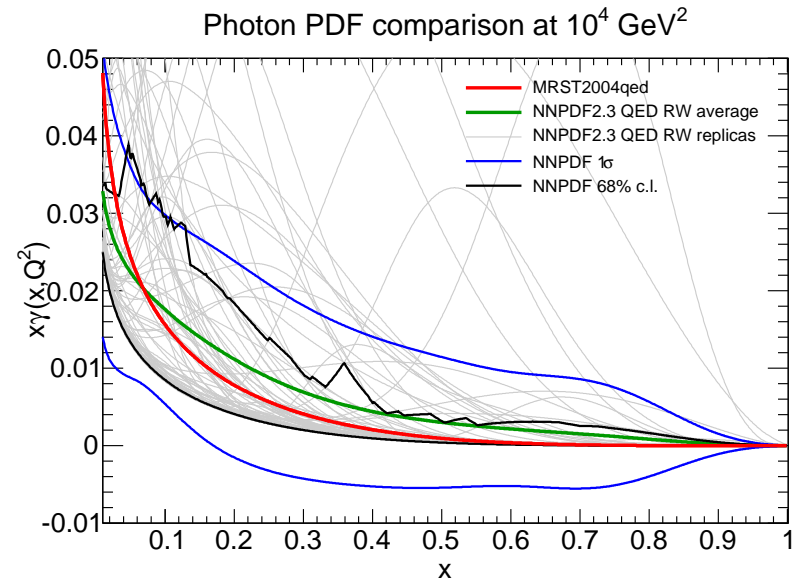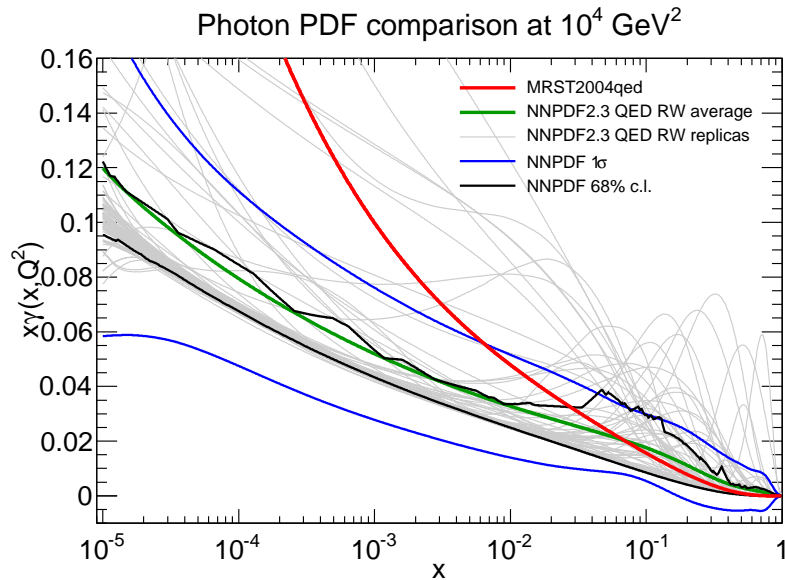- FINAL REPLICA SED PRODUCED USING NNPDF REWEIGHTING/UNWEIGHTING
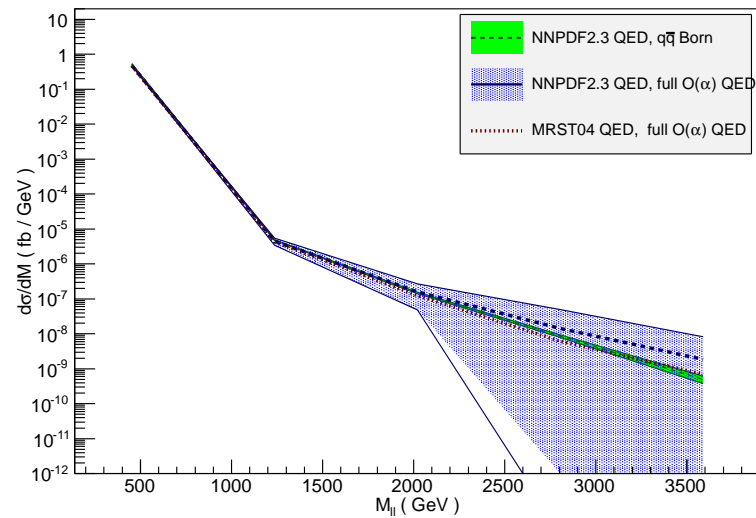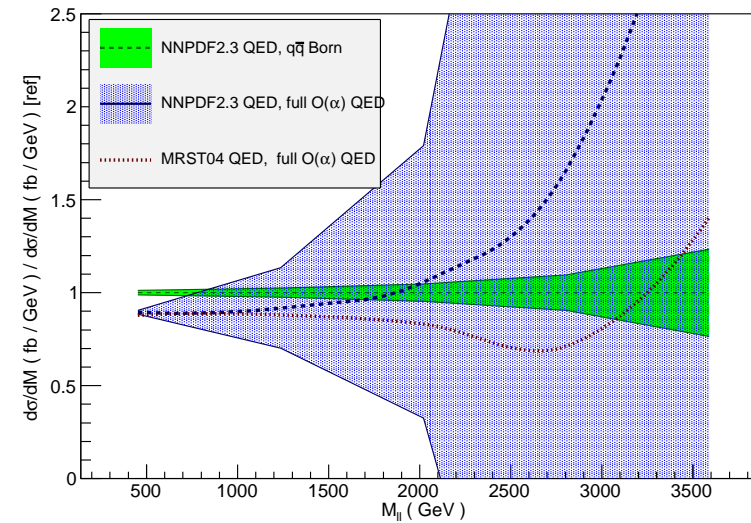
THE PHOTON PDF

NLO RESULTS

Photon PDF comparison at 10^4 GeV^2

Photon PDF comparison at 10^4 GeV^2

NNLO RESULTS

Photon PDF comparison at 10^4 GeV^2

Photon PDF comparison at 10^4 GeV^2

Legend (each panel):
- MRST2004qed
- NNPDF2.3 QED RW average
- NNPDF2.3 QED RW replicas
- NNPDF 1σ
- NNPDF 68% c.l.

IMPACT ON Z PRODUCTION
LHC 8 TeV

gamma*/Z production @ LHC 8 TeV

Legend:
- NNPDF2.3 QED, qq̄ Born
- NNPDF2.3 QED, full O(α) QED
- MRST04 QED, full O(α) QED

gamma*/Z production @ LHC 8 TeV

Legend:
- NNPDF2.3 QED, qq̄ Born
- NNPDF2.3 QED, full O(α) QED
- MRST04 QED, full O(α) QED

LHC 14 TeV

gamma*/Z production @ LHC 14 TeV

Legend:
- NNPDF2.3 QED, qq̄ Born
- NNPDF2.3 QED, full O(α) QED
- MRST04 QED, full O(α) QED

gamma*/Z production @ LHC 14 TeV

Legend:
- NNPDF2.3 QED, qq̄ Born
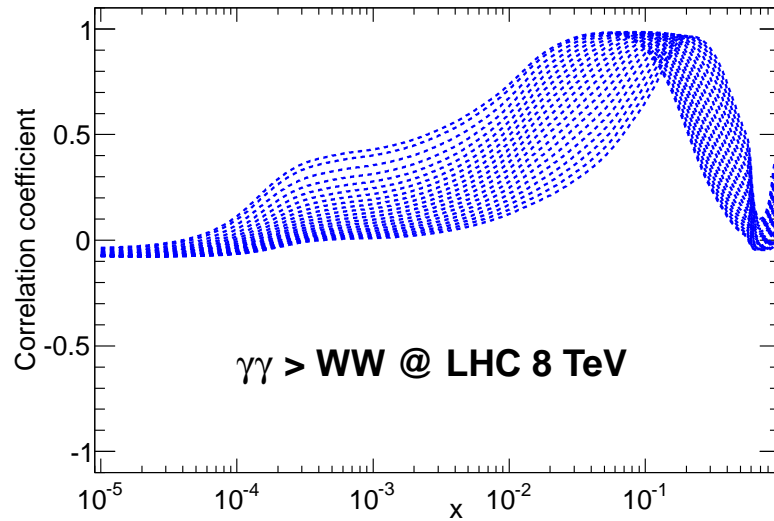- NNPDF2.3 QED, full O(α) QED
- MRST04 QED, full O(α) QED
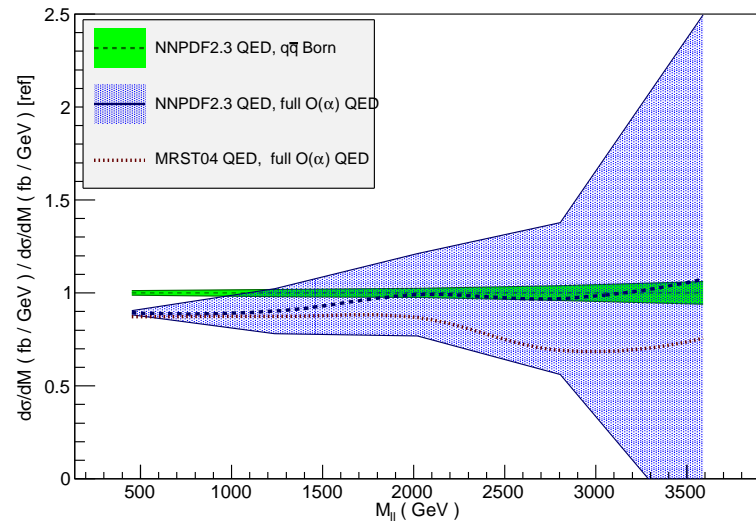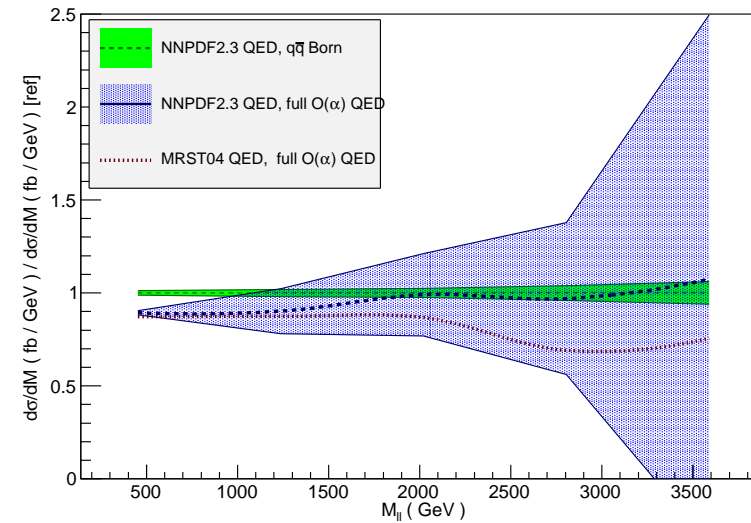
SHOWN AS ABSOLUTE (LEFT) AND RATIO TO $q\bar{q}$ (RIGHT)

IMPACT ON WW PRODUCTION
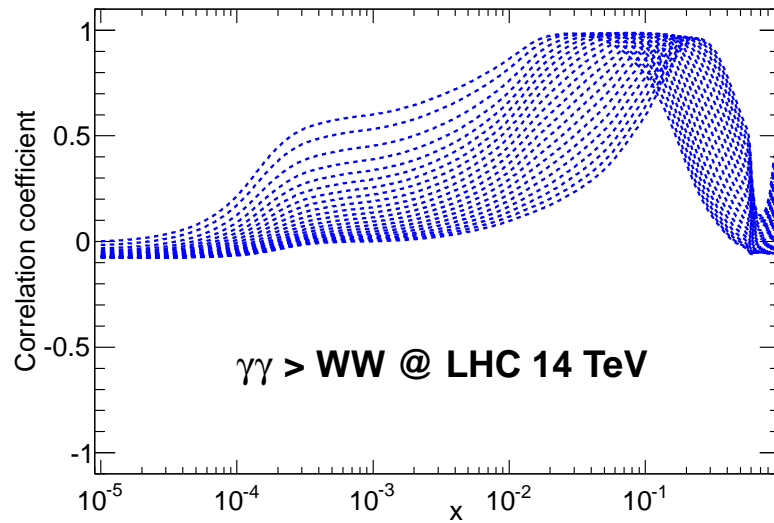## LHC 8 TeV

Correlation between photon PDF and cross sections
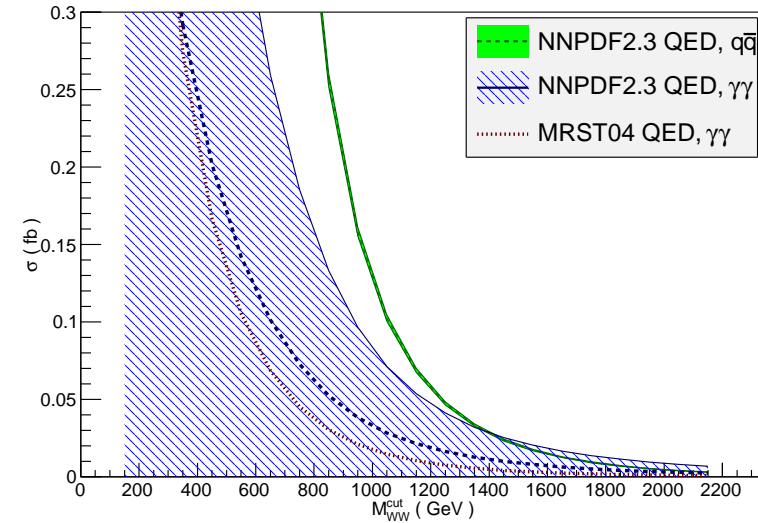
WW production @ LHC 8 TeV

$\gamma\gamma$ > WW @ LHC 8 TeV
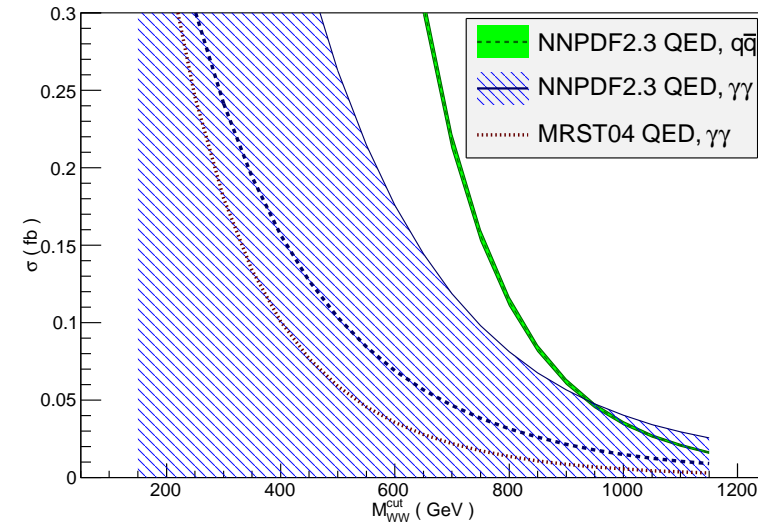
LHC 14 TeV

Correlation between photon PDF and cross sections

WW production @ LHC 14 TeV

$\gamma\gamma$ > WW @ LHC 14 TeV

(LEFT) CORRELATION (RIGHT) CROSS SECTION

DELIVERY

- NNPDF2.3QED NLO AND NNLO SETS AVAILABLE FOR THREE VALUES OF

  $\alpha_s(M_z) = 0.117$, $\alpha_s(M_z) = 0.118$ $\alpha_s(M_z) = 0.119$

- SENT TO LHAPDF

- AVAILABLE FROM NNPDF SITE `http://nnpdf.hepforge.org/`

  (WITH TUTORIAL FOR INSTALLING IN LHAPDF FORMAT)