THE FLAVOUR STRUCTURE OF THE PROTON AND ITS IMPLICATIONS FOR W AND Z PRODUCTION AT THE LHC

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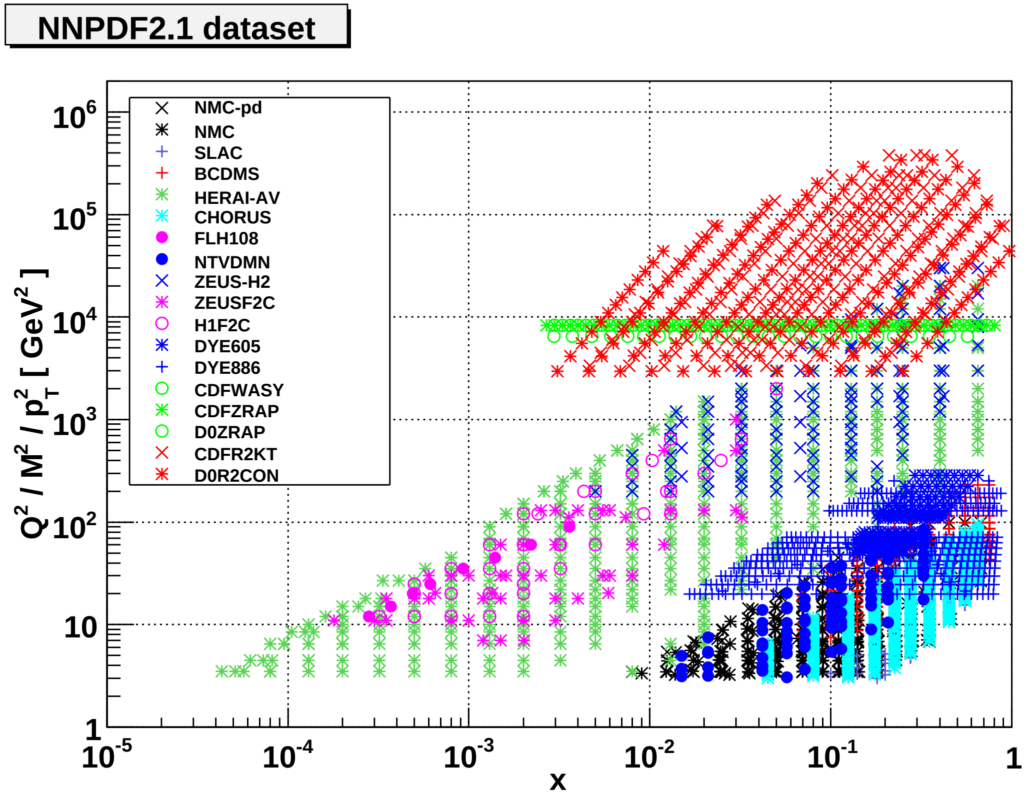
CHALLENGES FOR PRECISION PHYSICS AT THE LHC

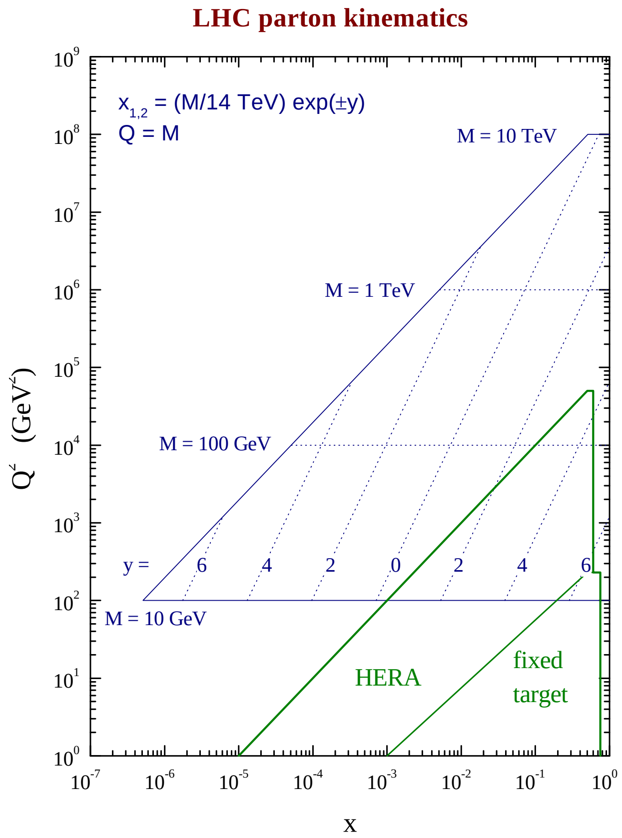
PARIS, DECEMBER 16, 2010

DATASETS IN A GLOBAL PDF DETERMINATION

NNPDF2.1 data set



LHC kinematics



- CURRENT GLOBAL PDF FITS INCLUDE
  - DIS: NEUTRAL AND CHARGED CURRENT, CHARGED LEPTON AND NEUTRINO BEAMS, INCLUSIVE AND CHARM-TAGGED
  - DRELL-YAN: FIXED TARGET AND COLLIDER, NEUTRAL γ^* AND Z AND CHARGED CURRENT W PRODUCTION
  - INCLUSIVE JETS
- WHAT IS THE IMPACT OF INDIVIDUAL DATA?
- WHAT DO WE NEED AND WHAT DO WE EXPECT FOR LHC?

SUMMARY

- METHODOLOGY:

  MONTE CARLO PDFS

- THE ROLE OF DRELL-YAN DATA:

  FROM THE TEVATRON TO THE LHC

- FLAVOURS:

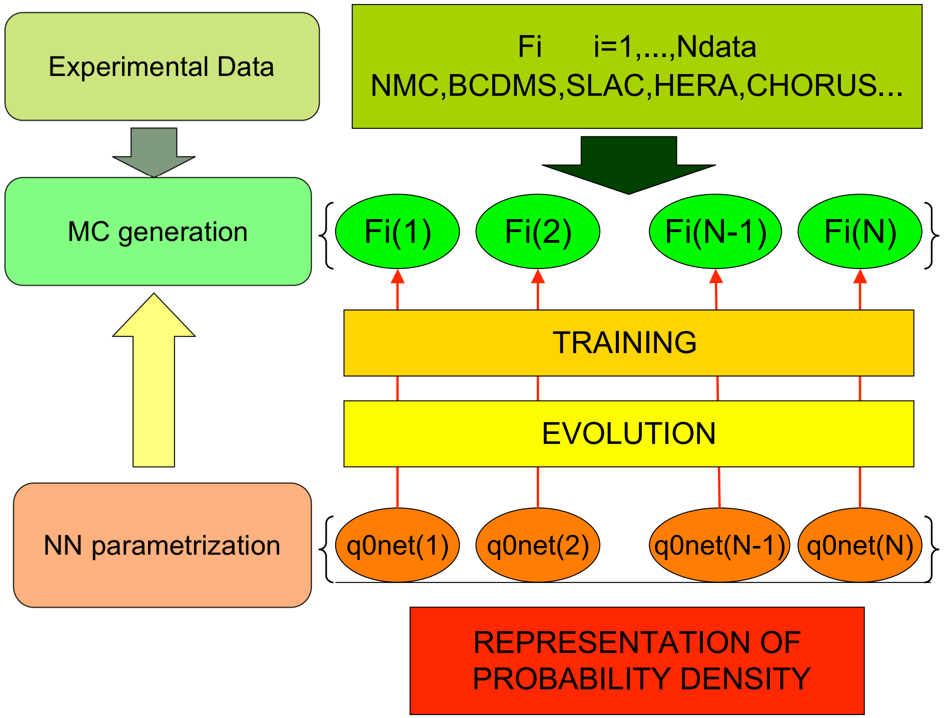
  ONE BY ONE

- TOWARDS THE LHC

METHODOLOGY: MONTE CARLO APPROACH

BASIC IDEA: MONTE CARLO SAMPLING OF THE PROBABILITY MEASURE IN THE (FUNCTION) SPACE OF PDFs

- START FROM MONTE CARLO SAMPLING OF DATA SPACE
- EACH PDF$\leftrightarrow$ NEURAL NETWORK PARAMETRIZED BY 37 PARAMETERS (NNPDF2.0: $37 \otimes 7 = 259$ PARMS)
  "INFINITE" NUMBER OF PARAMETERS$\Rightarrow$ CAN REPRESENT ANY FUNCTION
- FIT STOPS WHEN QUALITY OF FIT TO RANDOMLY SELECTED "VALIDATION" DATA (NOT FITTED) STOPS IMPROVING



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CAN DETERMINE BOTH 68C.L.& 1-σ

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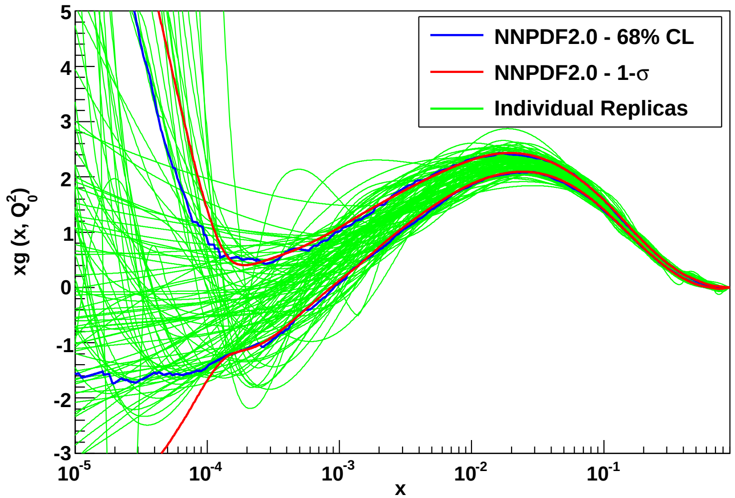

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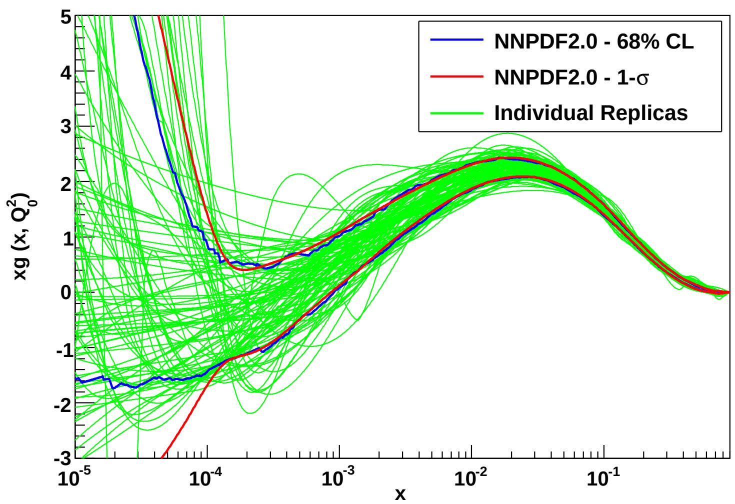


MOTIVATION

- VERY REDUNDANT PARAMETRIZATION (ALL PDFS ON SAME FOOTING)
- NON-GAUSSIAN DISTRIBUTION OF RESULT POSSIBLE
- MOMENTS OF DISTRIBUTION OF RESULTS (CORRELATIONS) EASILY DETERMINED
- RESULTS AMENABLE TO BAYESIAN REWEIGHTING
- CAN DETERMINE DISTANCE BETWEEN RESULTS OBTAINED FROM DIFFERENT DATA

DIS VS. DRELL-YAN

DIS

NC $F_1{}^{\gamma} = \sum_i e_i^2 \, (q_i + \bar{q}_i)$

NC $F_1{}^{Z,\,\text{int.}} = \sum_i B_i(Q^2/M_Z^2)\,(q_i + \bar{q}_i)$

NC $F_3{}^{Z,\,\text{int.}} = \sum_i D_i(Q^2/M_Z^2)\,(q_i + \bar{q}_i)$

CC $F_1^{W^+} = \bar{u} + d + s + \bar{c}$

CC $-F_3^{W^+}/2 = \bar{u} - d - s + \bar{c},$

DRELL-YAN

γ $\frac{d\sigma}{dM_X^2\,dy}(M_X^2, y) = \frac{4\pi\alpha^2}{9M_X^2 s} \sum_i e_i^2 L^{ii}(x_1^0, x_2^0)$

W $\frac{d\sigma}{dy} = \frac{\pi G_F M_V^2 \sqrt{2}}{3s} \sum_{i,j} |V_{ij}^{\text{CKM}}| L^{ij}(x_1^0, x_2^0)$

Z $\frac{d\sigma}{dy} = \frac{\pi G_F M_V^2 \sqrt{2}}{3s} \sum_i \left(V_i^2 + A_i^2\right) L^{ii}(x_1^0, x_2^0)$

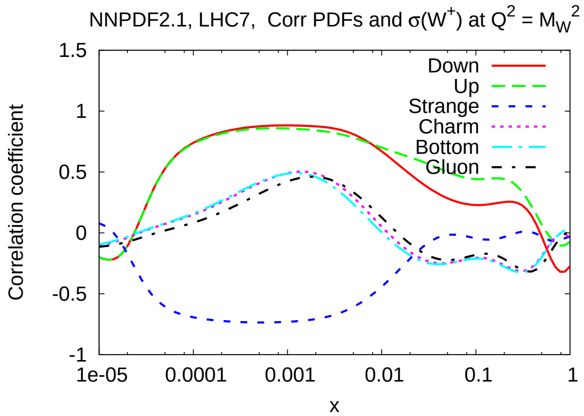
$$L^{ij}(x_1, x_2) \equiv q_i(x_1, M_X^2)\bar{q}_j(x_2, M_X^2) + q_i(x_2, M_X^2)\bar{q}_j(x_1, M_X^2)$$

- FIXED TARGET DIS $\Rightarrow$ SINGLET-TRIPLET SEPARATION $F_2^p - F_2^d = \frac{1}{3}[(u^p + \bar{u}^p) - (d^p + \bar{d}^p]$
- HERA THREE INDEPENDENT COMBINATIONS OF PDFS (NC+CC WITH $e^{\pm}$), ONE MORE FROM Q^2 OF Z CONTRIBUTION $\Rightarrow$ u, $\bar{u}$, $d + s$, $\bar{d} + \bar{s}$
  - F_2^c $\Rightarrow$ CHARM
- NEUTRINO DIS $\Rightarrow$ FOUR COMBINATIONS OF PDFS (NC+CC WITH ν, $\bar{\nu}$)
  - “DIMUON” $F_2^{\nu,\,c}$, $F_2^{\bar{\nu},\,c}$ $\Rightarrow$ STRANGE AND ANTISTRANGE
- FIXED TARGET DRELL-YAN (P AND NUCLEAR TARGETS) $\Rightarrow$ ANTIUP/ANTIDOWN SEPARATION
- W AND Z PRODUCTION $\Rightarrow$ UP/DOWN FLAVOR ASYMMETRIES; STRANGENESS

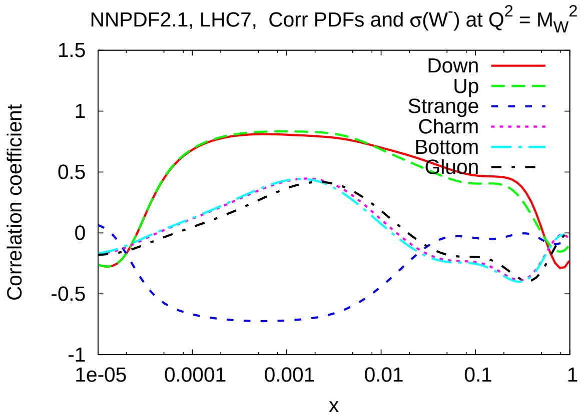
CORRELATIONS BETWEEN DRELL-YAN DATA AND PDFS

LHC

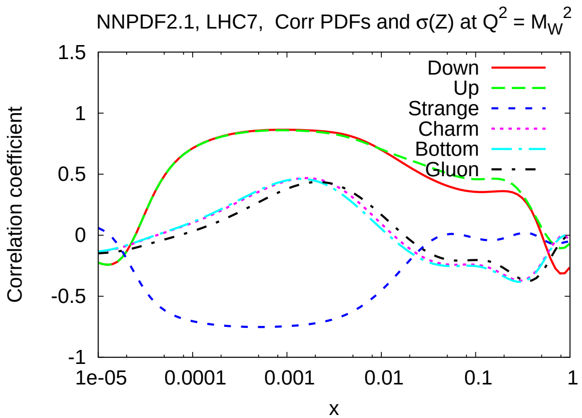
W^+



W^-

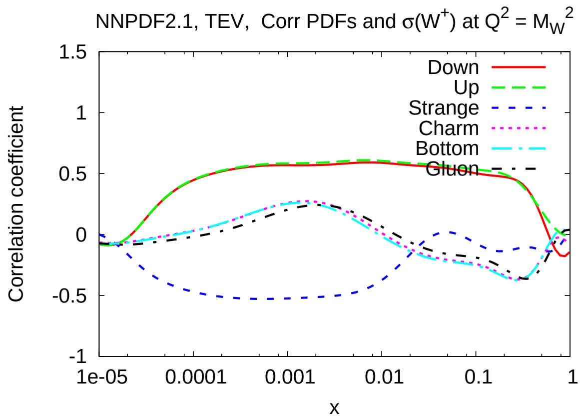


Z

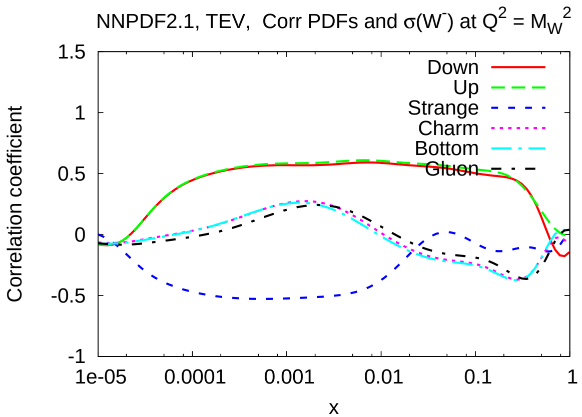


TEVATRON

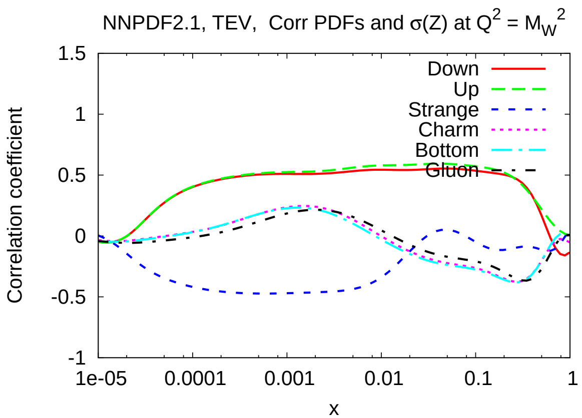
W^+



W^-



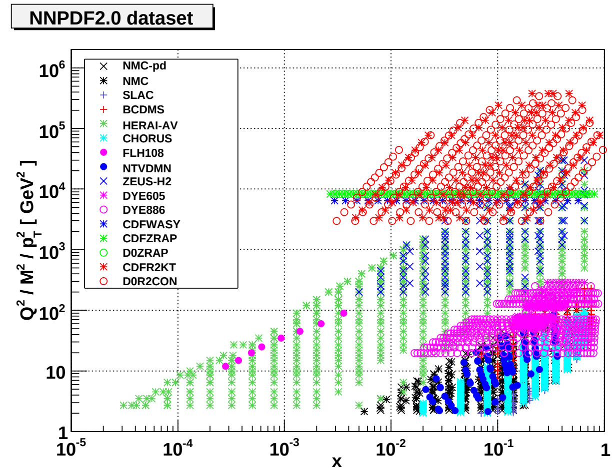
Z



- VALENCE $\Rightarrow$ LARGE CORRELATION AT LARGE x (~ 0.1, SMALLER AT LHC)
- LIGHT SEA $\Rightarrow$ LARGE CORRELATION AT SMALL x ($\lesssim 0.01$)
- GLUONS & HEAVY FLAVORS $\Rightarrow$ WEAK CORRELATION, MOSTLY AT MEDIUM-SMALL x

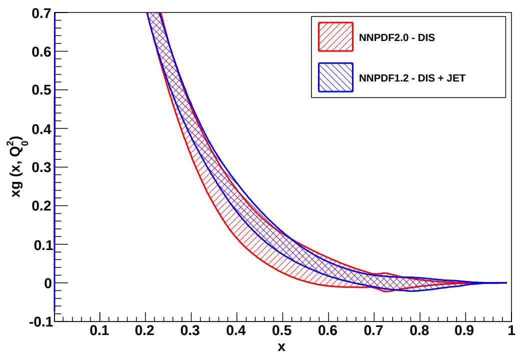
THE IMPACT OF JET DATA (NNPDF2.0)

	DIS	DIS+JET	NNPDF2.0
χ^2_{tot}	1.20	1.18	1.21
NMC-pd	0.85	0.86	0.99
NMC	1.69	1.66	1.69
SLAC	1.37	1.31	1.34
BCDMS	1.26	1.27	1.27
HERAI	1.13	1.13	1.14
CHORUS	1.13	1.11	1.18
FLH108	1.51	1.49	1.49
NTVDMN	0.71	0.75	0.67
ZEUS-H2	1.50	1.49	1.51
CDFR2KT	**0.91**	**0.79**	0.80
D0R2CON	**1.00**	**0.93**	0.93
DYE605	7.32	10.35	0.88
DYE866	2.24	2.59	1.28
CDFWASY	13.06	14.13	1.85
CDFZRAP	3.12	3.31	2.02
D0ZRAP	0.65	0.68	0.47



- HIGH E_T JET DATA WELL REPRODUCED EVEN WHEN NOT FITTED $\Rightarrow$ LARGE x GLUON WELL DETERMINED BY SCALING VIOLATIONS!
- SIGNIFICANT IMPROVEMENT IN LARGE x GLUON ACCURACY

GLUON



THE IMPACT OF DRELL-YAN+ W-PROD. DATA (NNPDF2.0)

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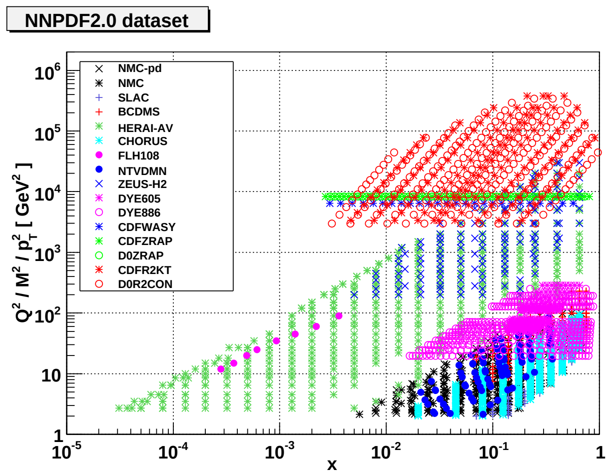
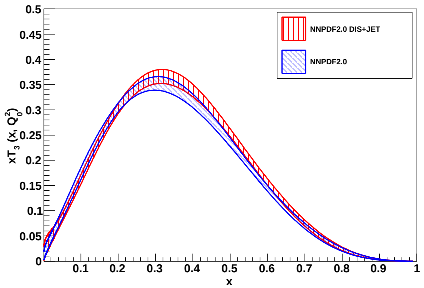
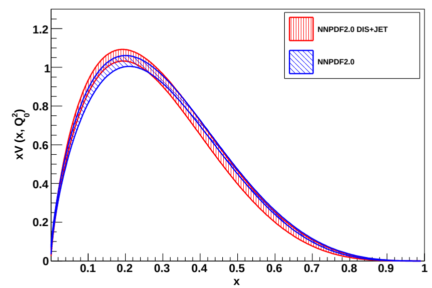


ISOTRIPLET

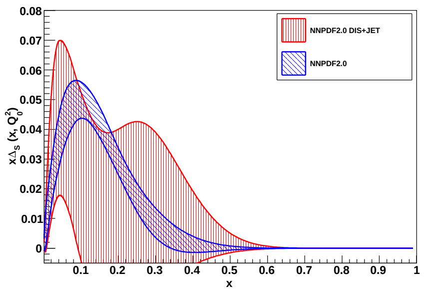


VALENCE

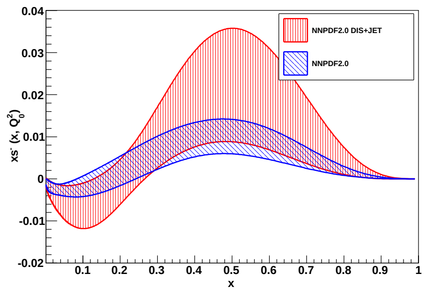


- VERY SUBSTANTIAL IMPROVEMENT IN FIT QUALITY WHEN DATA INCLUDED $\Rightarrow$ SOME PDF COMBINATIONS POORLY DETERMINED WITHOUT THESE DATA
- HUGE IMPROVEMENT IN SEA ASYM $\bar{u}-\bar{d}$ & STRANGENESS $s-\bar{s}$
- SIGNIFICANT IMPROVEMENT IN TOTAL VALENCE $(\sum_i (q_i - \bar{q}_i))$ & ISOTRIPLET $(u+\bar{u}-(d+\bar{d}))$

$\bar{d}-\bar{u}$



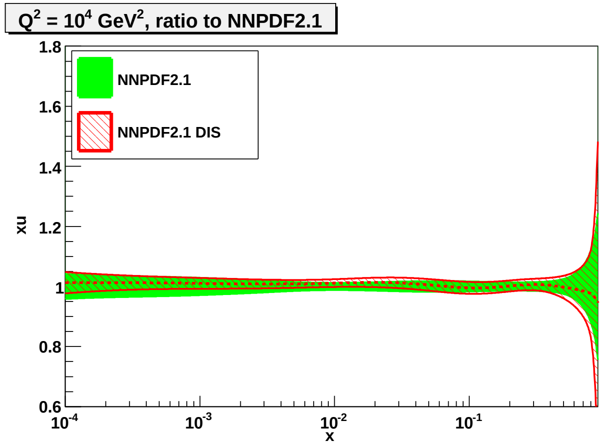
$s-\bar{s}$



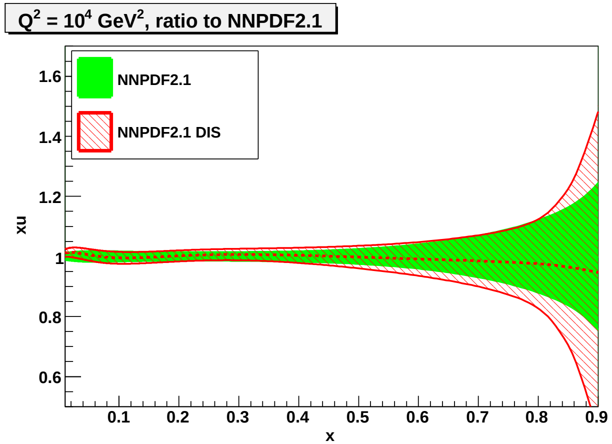
THE IMPACT OF DRELL-YAN DATA

UP

SMALL x



LARGE x

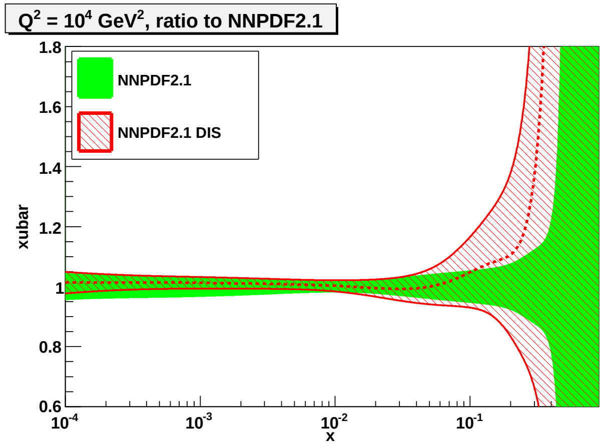


- VERY WELL DETERMINED BY DIS FOR ALL x
- MARGINAL IMPROVEMENTS AT LARGE x (DRIVEN BY JET DATA)

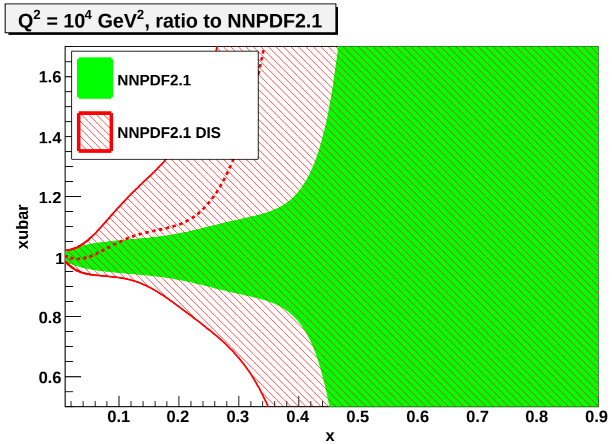
ANTIUP

- WELL DETERMINED BY DIS DATA AT SMALL x
- DRAMATIC IMPROVEMENT IN ACCURACY AT LARGE x
- SIZABLE IMPACT ON CENTRAL VALUE

SMALL x



LARGE x



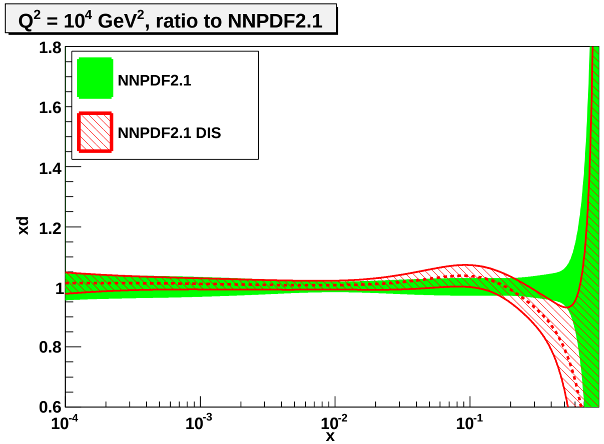
LHC

- LITTLE AMBIGUITY/HARD TO IMPROVE FOR UP
- SIGNIFICANT IMPROVEMENT/SOME AMBIGUITY FOR ANTIUP IN MEDIUM-SMALL $0.01 \lesssim x \lesssim 0.1$ REGION

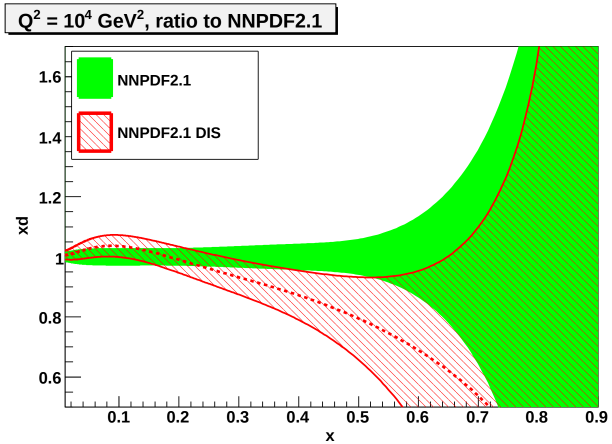
THE IMPACT OF DRELL-YAN DATA

DOWN

SMALL x



LARGE x

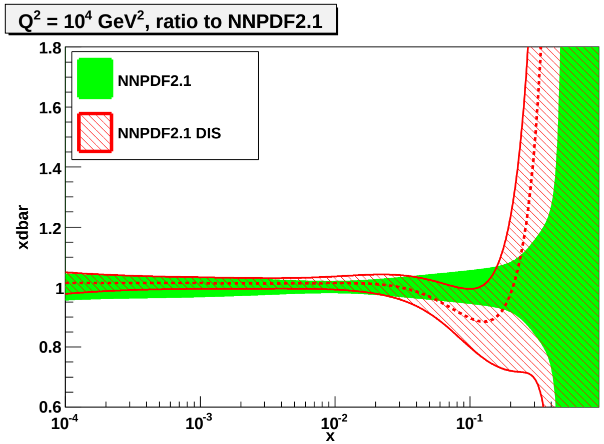


- WELL DETERMINED BY DIS AT SMALL X x
- SOME IMPROVEMENTS IN ACCURACY AT LARGE x
- TENSION BETWEEN DIS AND DY AT LARGE x

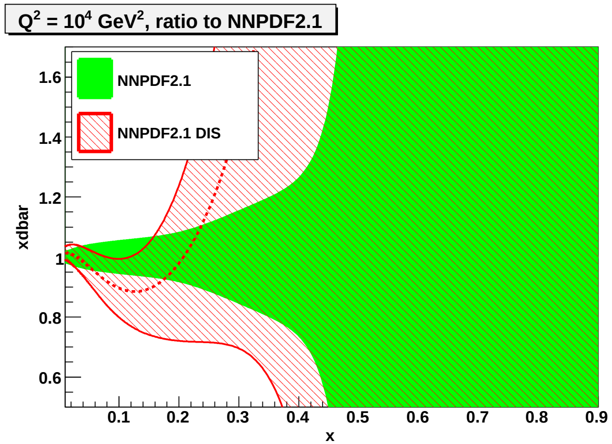
ANTIDOWN

- AT SMALL x ALL FLAVORS ARE ALIKE $\longrightarrow$ WELL DETERMINED BY DIS DATA
- SOME TENSION BETWEEN DIS AND DY AT MEDIUM-SMALL x
- DRAMATIC IMPROVEMENT IN ACCURACY AT LARGE x

SMALL x



LARGE x



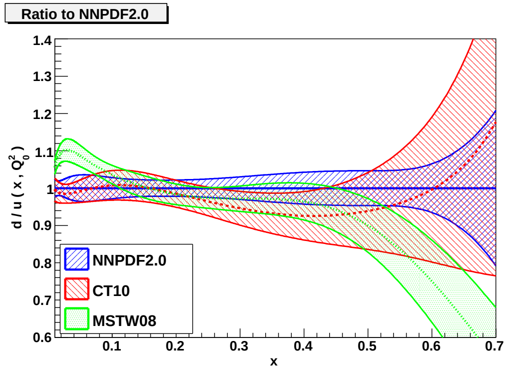
TENSION?

- SHAPES OF THE d QUARK FAVORED BY DIS AND DY DATA DO NOT AGREE
- IS THERE A PROBLEM WITH THE u/d RATIO?

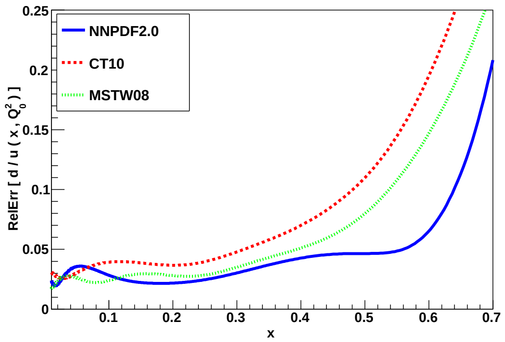
THE UP/DOWN RATIO

COMPARISON BETWEEN PDF SETS

u/d AT $Q^2 = 2$ GEV^2



RELATIVE UNCERTAINTY

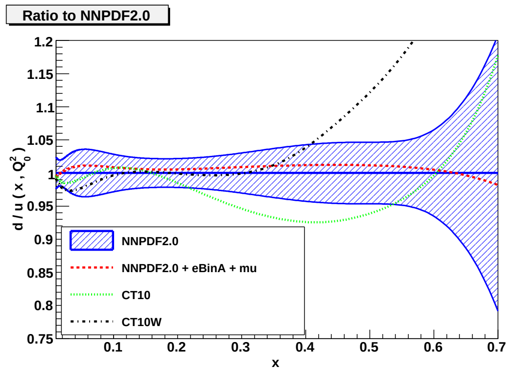


- u/d RATIO IN DIS DOMINATED BY BCDMS AND NMC DATA KNOWN TO HAVE CONSISTENCY PROBLEMS
- PERHAPS NUCLEAR CORRECTIONS & HIGHER TWISTS PLAY A ROLE IN NMC & BCDMS
- DIFFERENT PDF SETS BASED ON THE SAME DATA (BUT WITH DIFFERENT FIT QUALITY) IN PARTIAL DISAGREEMENT

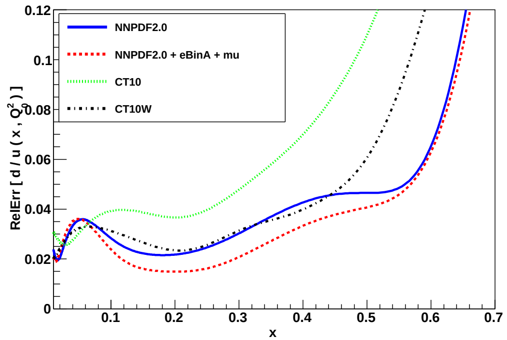
THE RUN II W ASYMMETRY DATA

- PRECISE D0 RUN II LEPTON-LEVEL DATA INCLUDED VIA REWEIGHTING
- NNPDF: SIZABLE IMPROVEMENT IN FIT QUALITY
- CTEQ: NO GLOBALLY CONSISTENT FIT FOUND: CT10W WITH W DATA, CT10 WITHOUT

u/d AT $Q^2 = 2$ GEV^2



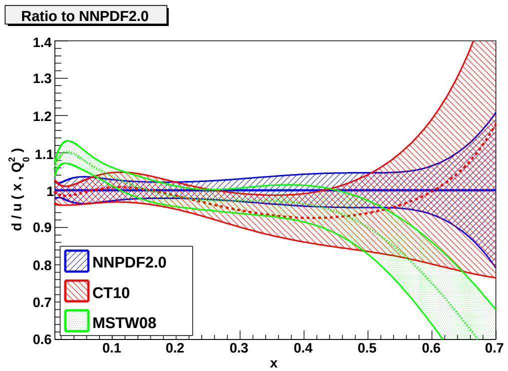
RELATIVE UNCERTAINTY



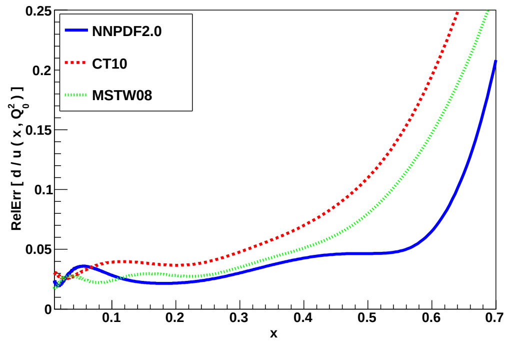
THE UP/DOWN RATIO

COMPARISON BETWEEN PDF SETS

u/d AT $Q^2 = 2$ GEV^2



RELATIVE UNCERTAINTY



- u/d RATIO IN DIS DOMINATED BY BCDMS AND NMC DATA KNOWN TO HAVE CONSISTENCY PROBLEMS
- PERHAPS NUCLEAR CORRECTIONS & HIGHER TWISTS PLAY A ROLE IN NMC & BCDMS
- DIFFERENT PDF SETS BASED ON THE SAME DATA (BUT WITH DIFFERENT FIT QUALITY) IN PARTIAL DISAGREEMENT

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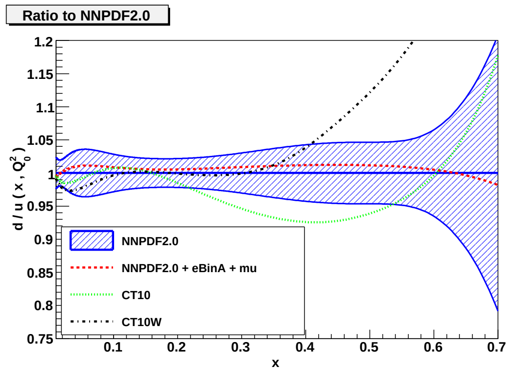
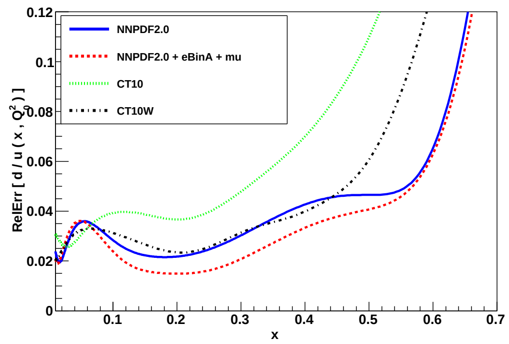


RELATIVE UNCERTAINTY

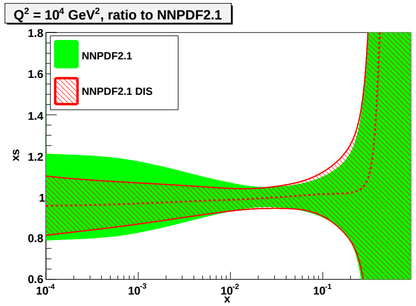


FIRST LESSON FOR LHC

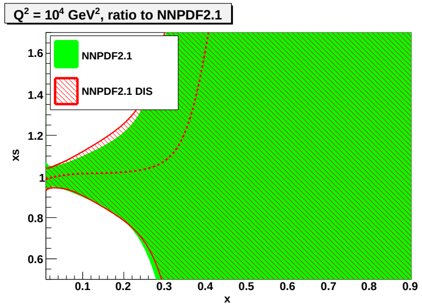
- PRECISE W ASYMMETRY DATA DETERMINE THE u/d RATIO ACCURATELY
- EVENTUALLY, IT WOULD BE BETTER TO DO WITHOUT NMC/BCDMS DATA (NO LOW Q^2 DATA, NO NUCLEAR TARGETS)

STRANGENESS

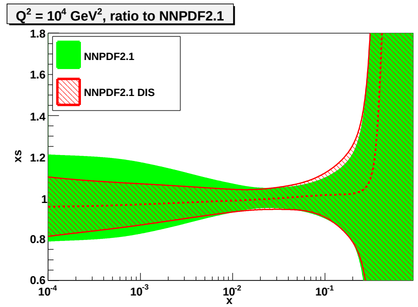
s SMALL x



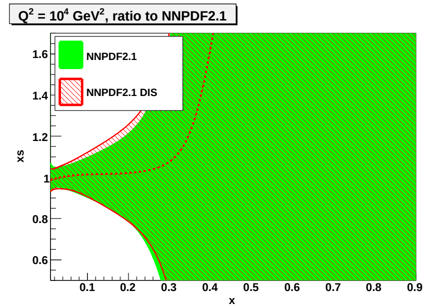
s LARGE x



$\bar{s}$ SMALL x



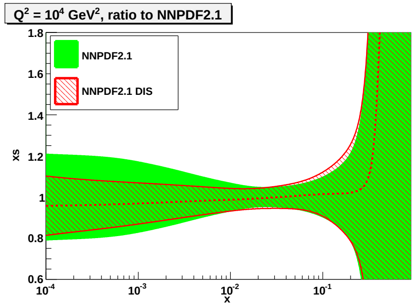
$\bar{s}$ LARGE x



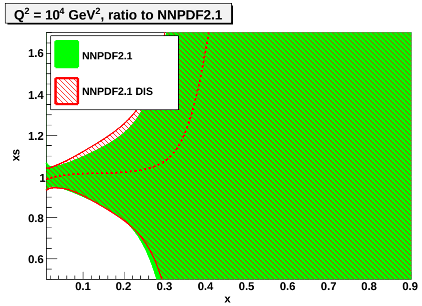
- STRANGENESS WELL DETERMINED BY NEUTRINO DATA
- MODERATE IMPACT OF DRELL-YAN DATA ON x SHAPE

STRANGENESS

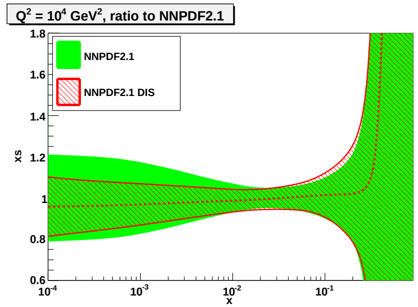
s SMALL x



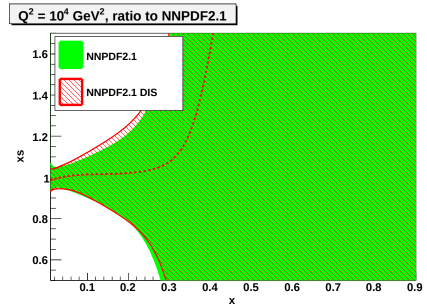
s LARGE x



$\bar{s}$ SMALL x



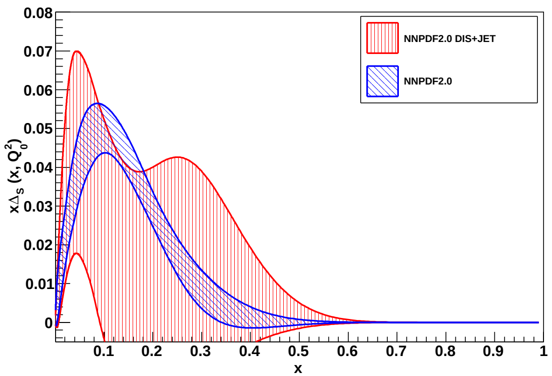
$\bar{s}$ LARGE x



- STRANGENESS WELL DETERMINED BY NEUTRINO DATA
- MODERATE IMPACT OF DRELL-YAN DATA ON x SHAPE

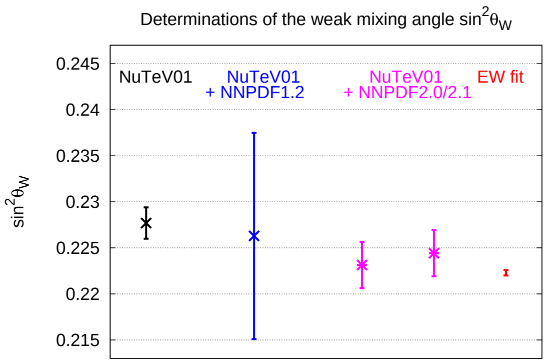
BUT: THE STRANGENESS ASYMMETRY AND THE NUTEV ANOMALY

$s - \bar{s}$



- IMPACT OF DRELL-YAN SIGNIFICANT ON THE $s - \bar{s}$ STRANGENESS ASYMMETRY, ESPECIALLY 2ND MOMENT
- PROVIDES A SOLUTION TO THE PROBLEM OF THE NUTEV ANOMALY
- DEFINITIVE SOLUTION WITH LHC DATA

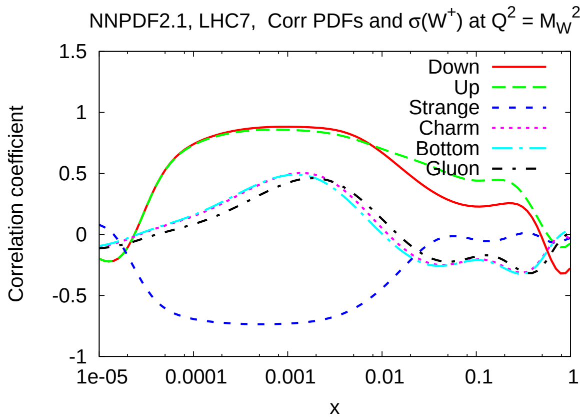
$\sin^2 \theta_w$



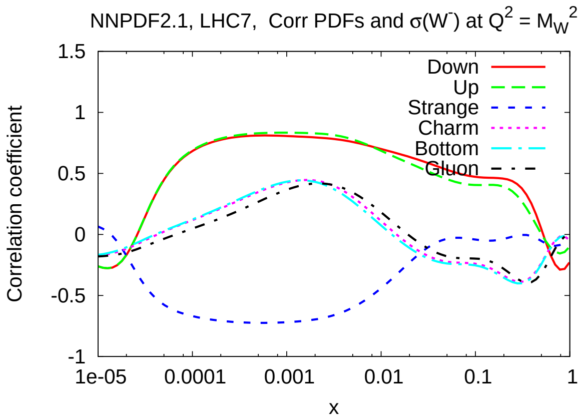
HEAVY FLAVOURS AND THE GLUON

RECALL CORRELATION PROFILES...

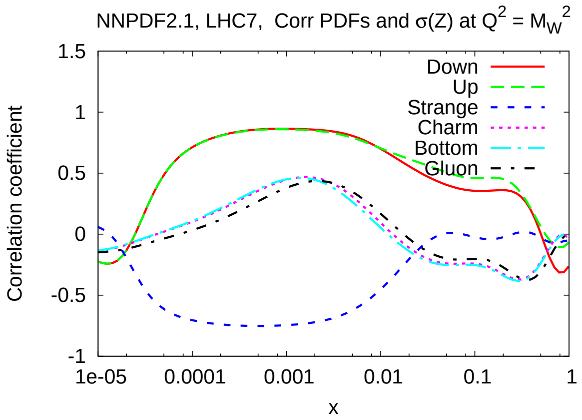
W^+



W^-



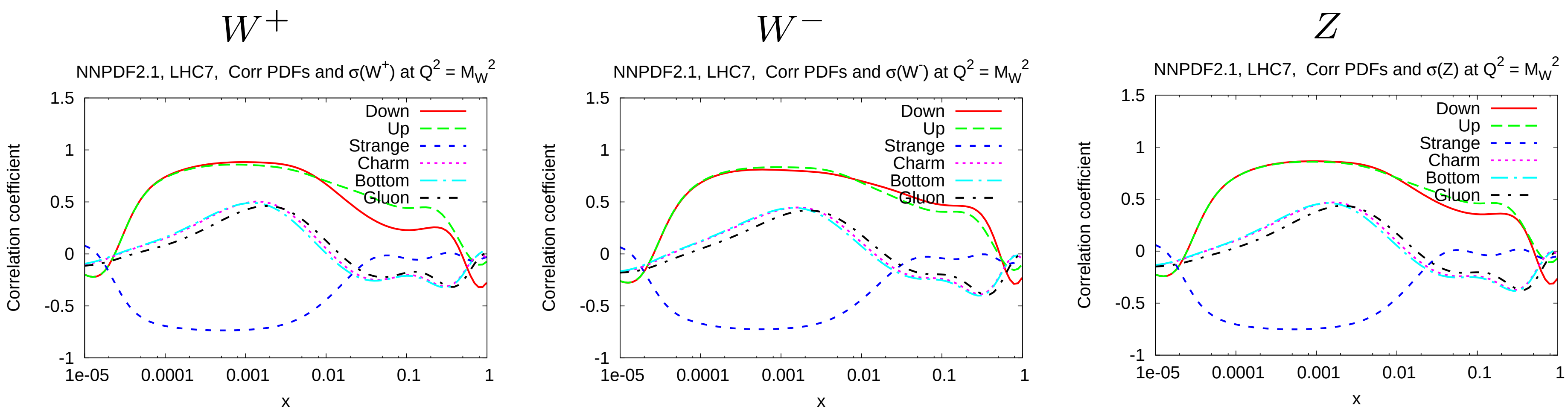
Z



- HEAVY QUARKS RADIATIVELY GENERATED
  POSSIBLE INTRINSIC COMPONENTS SMALL, LOCALIZED AT LARGE x AND WITH MODERATE IMPACT AT HIGH Q^2
- BEHAVIOUR OF HEAVY FLAVOURS DETERMINED BY THE BEHAVIOUR OF THE GLUON $\Leftrightarrow$ SAME CORRELATION PROFILES
- W AND Z PRODUCTION HAVE A MINOR IMPACT ON GLUON AND HQ $\Rightarrow$ ESSENTIALLY UNCHANGED FROM DIS ONLY TO DIS+DY PDF FIT
- HOWEVER MOMENTUM SUM RULE CONSTRAINS TOTAL QUARK SINGLET COMPONENT $\Rightarrow$ MORE CHARM, LESS LIGHT QUARKS ETC.

HEAVY FLAVOURS AND THE GLUON

RECALL CORRELATION PROFILES...



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- HOWEVER MOMENTUM SUM RULE CONSTRAINS TOTAL QUARK SINGLET COMPONENT $\Rightarrow$ MORE CHARM, LESS LIGHT QUARKS ETC.
- $\Rightarrow$ UNCERTAINTY IN TOTAL HEAVY COMPONENT CAN LEAD TO UP TO $\sim 2\%$ UNCERTAINTY ON W, Z CROSS SECTIONS

CHARM: THE IMPACT OF THRESHOLD BEHAVIOUR

- MODERN PDF SETS USE A MATCHED TREATMENT OF HEAVY QUARKS (GM-VFN SCHEME):
  QUARK MASS RETAINED UP TO FINITE N^kL ORDER IN α_s, MASSLESS CONTRIBUTIONS RETAINED TO ALL ORDERS IN α_s UP TO FINITE N^nL LOG LEVEL ($\alpha_s^{m+n} \ln^n \frac{Q^2}{m_h^2}$).
- VARIOUS MATCHING SCHEMES AVAILABLE (ACOT, FONLL, TR,...): DIFFER IN THE TREATMNENT OF SUBLEADING TERMS (& IN AVAILABLE ORDERS)

UNCERTAINTIES

- MASS UNCERTAINTY POSITION OF THE THRESHOLD $\Rightarrow$ EVOLUTION LENGTH: THE VALUE OF m_h $\rightarrow$ DETERMINES THE SIZE OF THE HEAVY COMPONENT (EVOLUTION LENGTH)

CHARM: THE IMPACT OF THRESHOLD BEHAVIOUR

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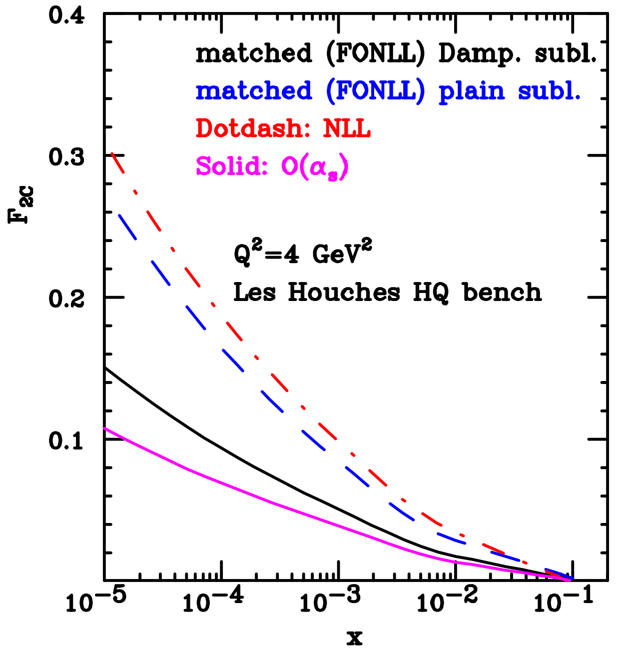
- VARIOUS MATCHING SCHEMES AVAILABLE (ACOT, FONLL, TR,...): DIFFER IN THE TREATMNENT OF SUBLEADING TERMS (& IN AVAILABLE ORDERS)

THE CHARM STRUCTURE FUNCTION

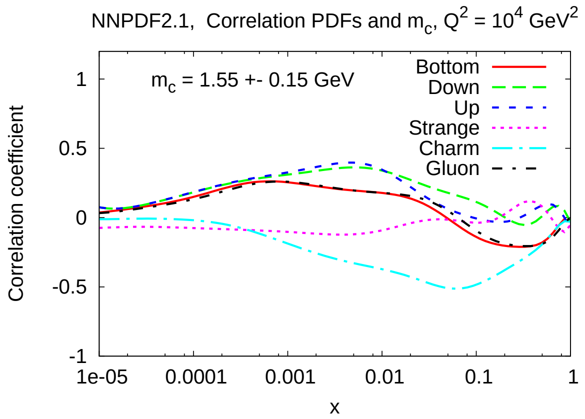


UNCERTAINTIES

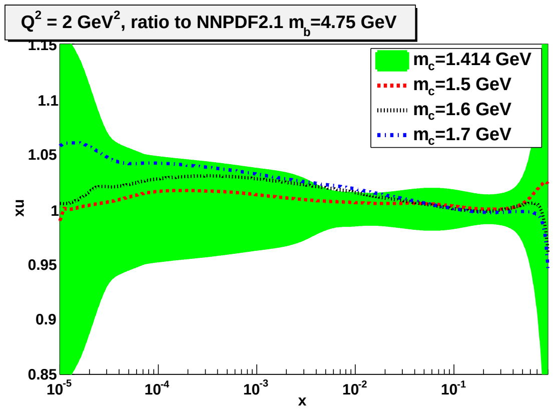
- MASS UNCERTAINTY POSITION OF THE THRESHOLD $\Rightarrow$ EVOLUTION LENGTH: THE VALUE OF m_h $\rightarrow$ DETERMINES THE SIZE OF THE HEAVY COMPONENT (EVOLUTION LENGTH)
- THRESHOLD UNCERTAINTY: IMPACT OF SUBLEADING TERMS SIZABLE AT THRESHOLD $\rightarrow$ CHANGE OF "INITIAL" CONDITION AFFECTS THE SIZE OF THE CHARM COMPONENT AT ALL SCALES

CHARM: POSITION OF THE THRESHOLD

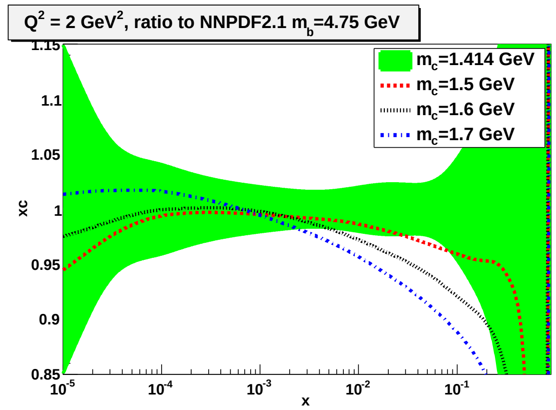
CORRELATION m_c/PDFs



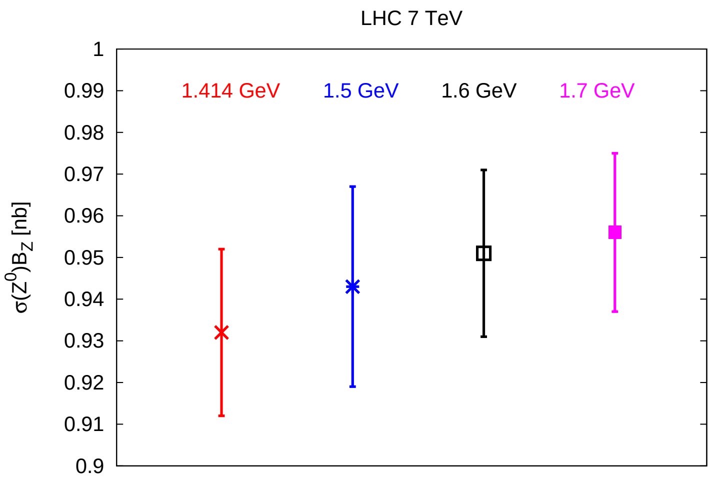
DEP. OF CHARM ON m_c



DEP. OF UP ON m_c



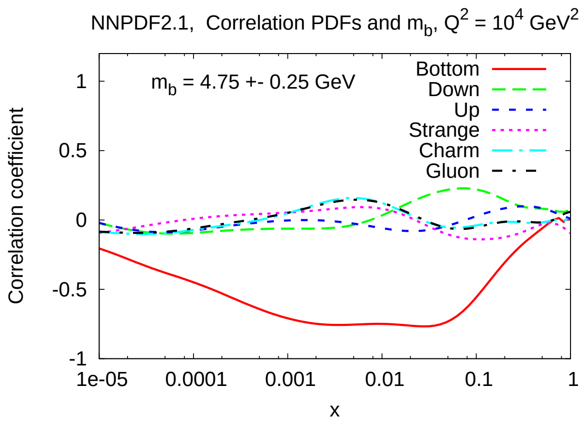
DEP. OF σ_Z ON m_c



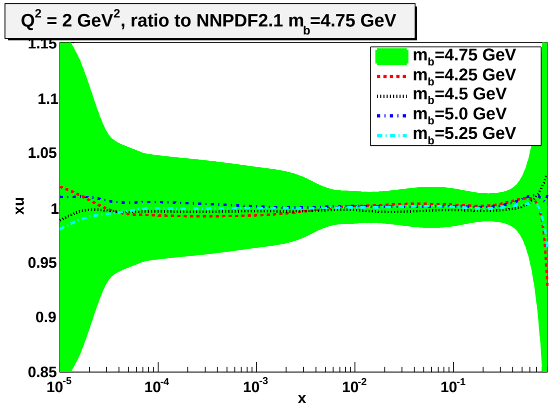
- LARGER m_c $\rightarrow$ LESS EVOLUTION $\rightarrow$ LESS CHARM (NEGATIVE CORRELATION)
- LESS CHARM $\rightarrow$ MORE UP AND DOWN
- $\rightarrow$ W AND Z CROSS SECTIONS AFFECTED (INCREASED)

BOTTOM: POSITION OF THE THRESHOLD

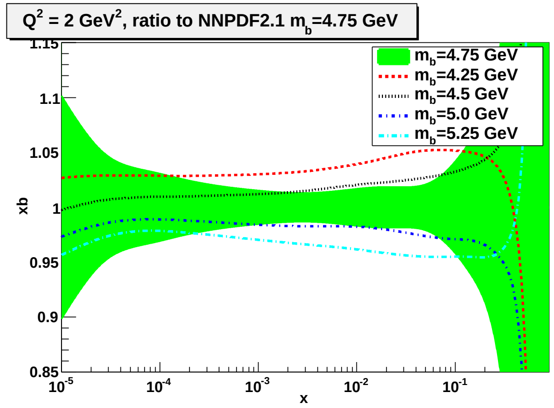
CORRELATION m_c/PDFs



DEP. OF CHARM ON m_c



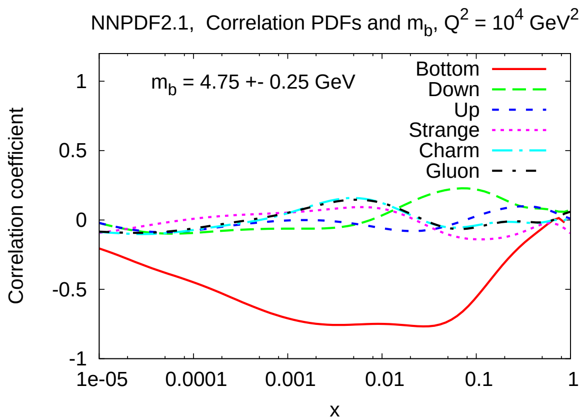
DEP. OF UP ON m_c



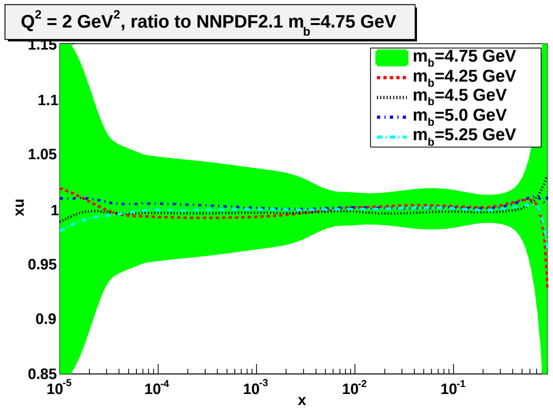
- LARGER m_n $\rightarrow$ LESS EVOLUTION $\rightarrow$ LESS BOTTOM (NEGATIVE CORRELATION)
- EFFECT ON LIGHT PDFs VERY SMALL, EFFECT ON σ_W, σ_Z BELOW 1% LEVEL
- LARGE EFFECT ON BOTTOM-DRIVEN OBSERVABLES:

BOTTOM: POSITION OF THE THRESHOLD

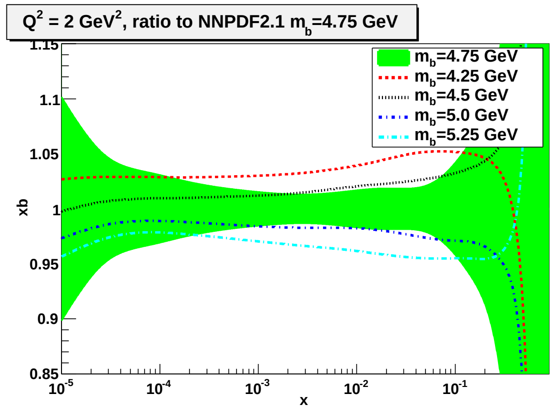
CORRELATION m_c/PDFs



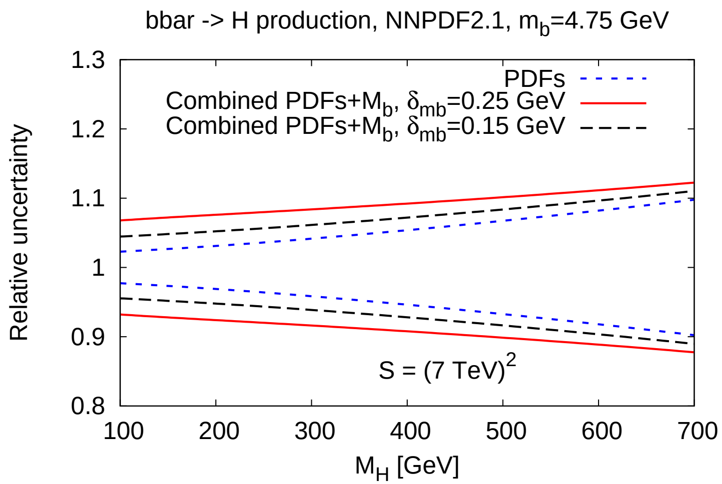
DEP. OF CHARM ON m_c



DEP. OF UP ON m_c



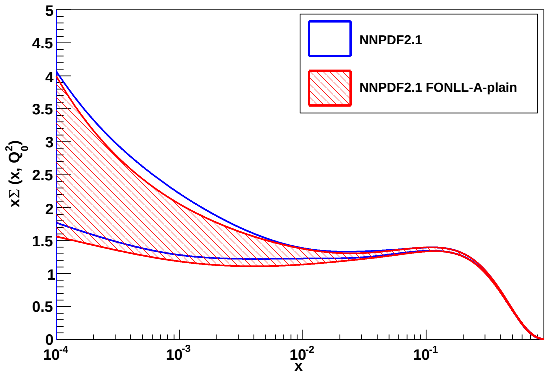
RELATIVE UNC. ON $b\bar{b} \to H$



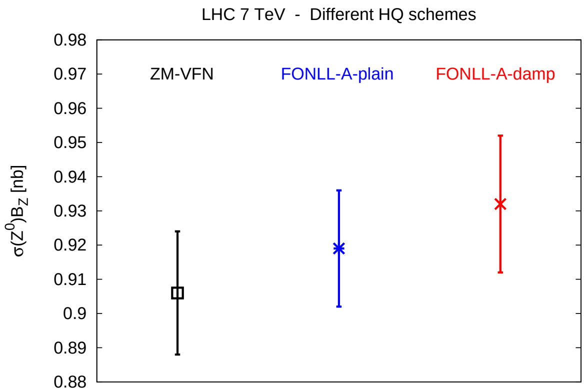
- LARGER $m_n \to$ LESS EVOLUTION $\to$ LESS BOTTOM (NEGATIVE CORRELATION)
- EFFECT ON LIGHT PDFs VERY SMALL, EFFECT ON σ_W, σ_Z BELOW 1% LEVEL
- LARGE EFFECT ON BOTTOM-DRIVEN OBSERVABLES:
  EXAMPLE: $b\bar{b} \to H$ IN THE MSSM

HQ AMBIGUITIES ON DRELL-YAN AT LHC

CORRELATION m_c/PDFS



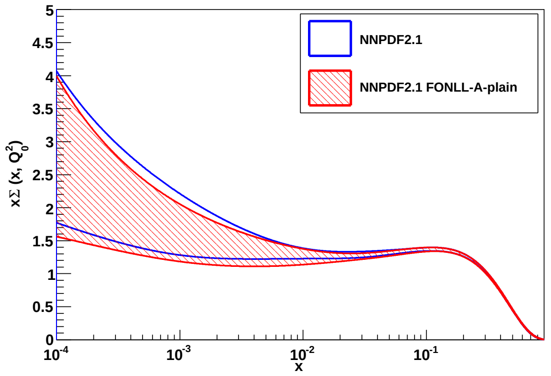
DEP. OF CHARM ON m_c



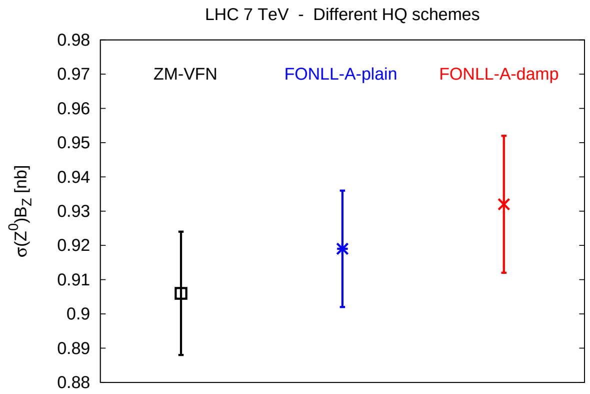
- FURTHER UNCERTAINTY ON CHARM $\longrightarrow$ LIGHT PDFS DUE TO SUBLEADING TERMS AT THRESHOLD
- DAMPED SUBLEADING TERMS $\Rightarrow$ LESS CHARM $\Rightarrow$ MORE LIGHT QUARKS (LARGER σ_Z)

HQ AMBIGUITIES ON DRELL-YAN AT LHC

CORRELATION m_c/PDFS



DEP. OF CHARM ON m_c



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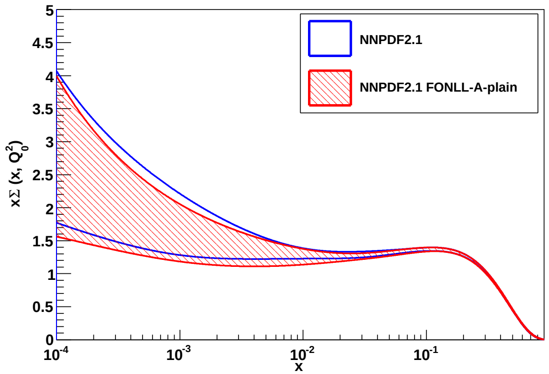
TOTAL UNCERTAINTY

- PDF+m_c+THRESHOLD SUBL TERMS
- $\Delta m_c = 0.1$ GEV (PDG POLE MASS $\sim$ 0.15 GEV, HOWEVER UNCERTAINTY CAN BE REDUCED BY CLEVER USE OF $\overline{MS}$ MASS (ALEKHIN, MOCH, 2010))+
- PDF UNCERTAINTY INCREASED BY $\sim$ 30% DUE TO HQ AT LHC7 ($\sim$ 40% AT LHC14)

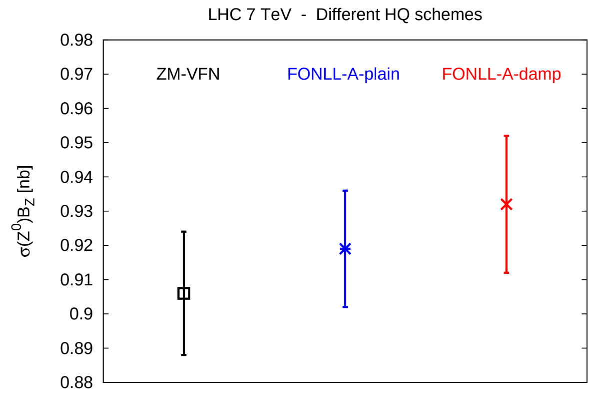
LHC 7 TEV	$W^+B_{l\nu}$ [NB]	$W^-B_{l\nu}$ [NB]	$Z^0B_{l\bar{l}}$ [NB]
$m_c = 1.414$ GEV	5.99 ± 0.14	4.09 ± 0.09	0.932 ± 0.02
$m_c = 1.5$ GEV	6.06 ± 0.17	4.14 ± 0.12	0.943 ± 0.024
$m_c = 1.6$ GEV	6.11 ± 0.14	4.17 ± 0.10	0.951 ± 0.020
$m_c = 1.7$ GEV	6.14 ± 0.14	4.19 ± 0.09	0.956 ± 0.019
$\delta_{\rm PDF}$	0.14	0.09	0.019
$\delta_{\rm PDF+m_c}$	0.15	0.10	0.021
$\delta_{\rm PDF+m_c+GM}$	0.19	0.12	0.025
$\rho\,[\sigma, m_c]$	0.44	0.41	0.48

HQ ambiguities on Drell-Yan at LHC

correlation m_c/PDFs



dep. of charm on m_c



- further uncertainty on charm → light PDFs due to subleading terms at threshold
- damped subleading terms ⇒ less charm ⇒ more light quarks (larger σ_Z)

total uncertainty

- PDF+m_c+threshold subl terms
- $\Delta m_c = 0.1$ GeV
(PDG pole mass $\sim$ 0.15 GeV, however uncertainty can be reduced by clever use of $\overline{MS}$ mass (Alekhin, Moch, 2010))+
- PDF uncertainty increased by $\sim$ 30% due to HQ at LHC7
($\sim$ 40% at LHC14)

LHC 7 TeV	$W^+B_{l\nu}$ [nb]	$W^-B_{l\nu}$ [nb]	$Z^0B_{l\bar{l}}$ [nb]
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second lesson for LHC

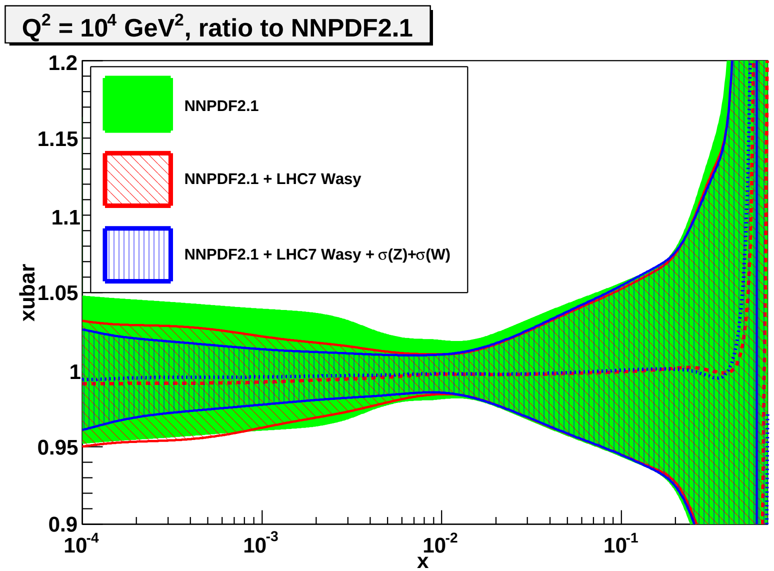
- HQ mass & threshold behaviour affect high energy observables through the size of the charm and bottom PDFs
- combined HERA data will lead to much improved knowledge of both
- however, eventually, it would be better to determine the c and b size at LHC without having to rely on low-energy data

THE IMPACT OF DRELL-YAN AT LHC

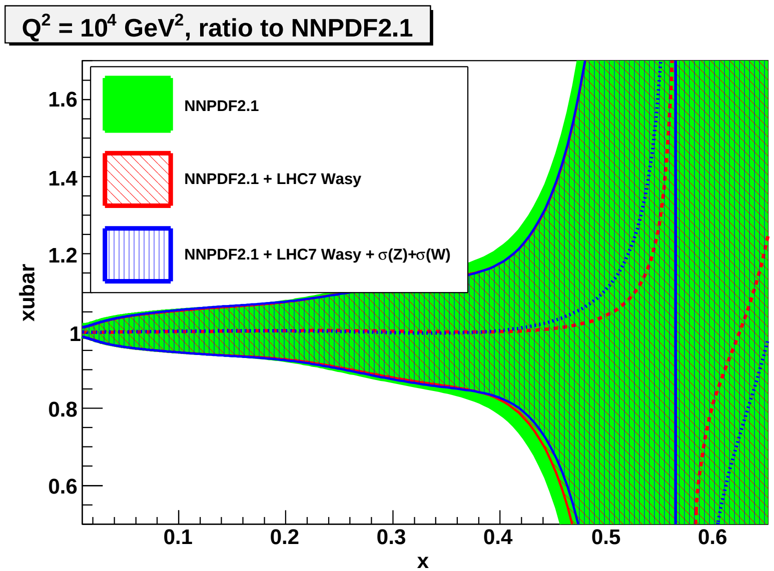
TEST THE IMPACT OF LHC 7TEV W AND Z DATA USING REWEIGHTING IN THE FOLLOWING "TOY" SCENARIOS:

- W ASYMMETRY MEASURED WITH $\sim 5\%$ ACCURACY AT ATLAS (KINEMATICS COURTESY OF A. GLAZOV) $\Rightarrow$ SIGNIFICANT IMPROVEMENT FOR ALL FLAVORS AT SMALL x
- W ASYMMETRY + TOTAL W AND Z CROSS-SECTIONS MEASURED TO 2% ACCURACY $\Rightarrow$
  - FURTHER IMPROVEMENT AT SMALL x
  - NOTE EFFECT SEEN ON ALL FLAVORS AND ANTIFLAVORS

ANTIUP SMALL x



ANTIUP LARGE x



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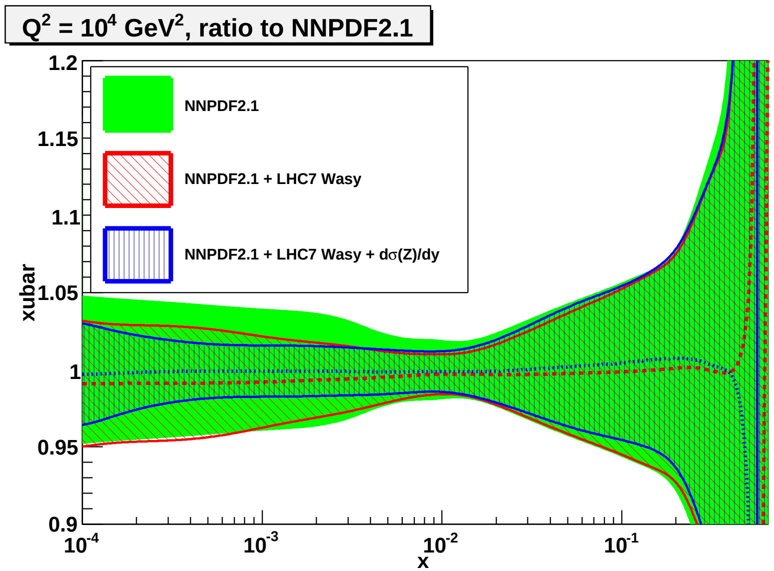
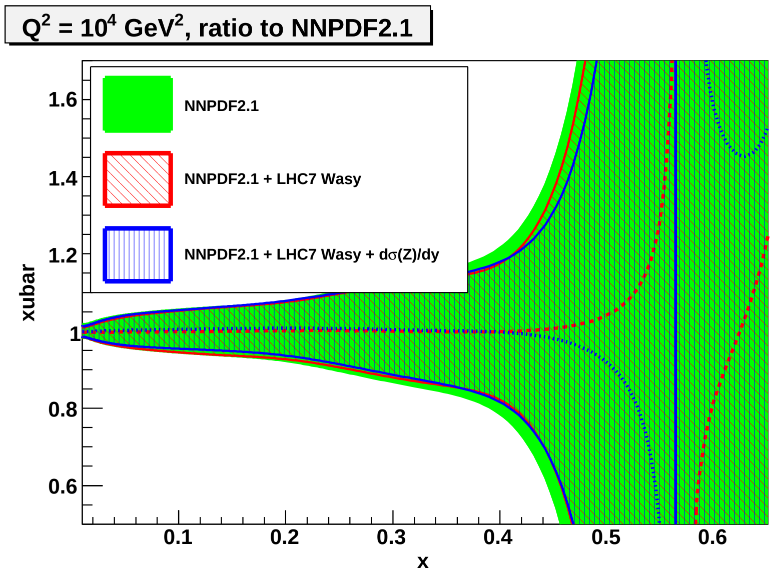
- W ASYMMETRY + Z RAPIDITY DISTRIBUTION TO 2% ACCURACY $\Rightarrow$
  - YET MORE IMPROVEMENT AT SMALL x NOW ALSO SOME IMPROVEMENT AT LARGE x
  - NOTE EFFECT SEEN ON ALL FLAVORS AND ANTIFLAVORS

ANTIUP SMALL x



ANTIUP LARGE x



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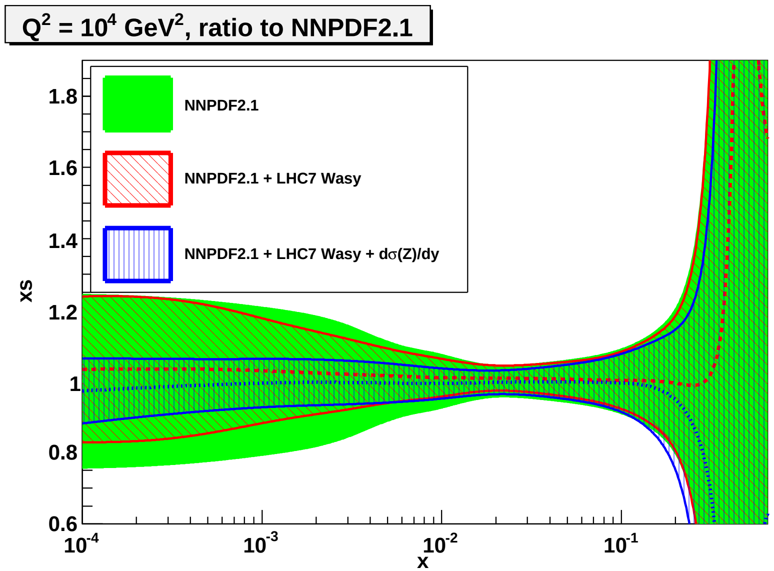
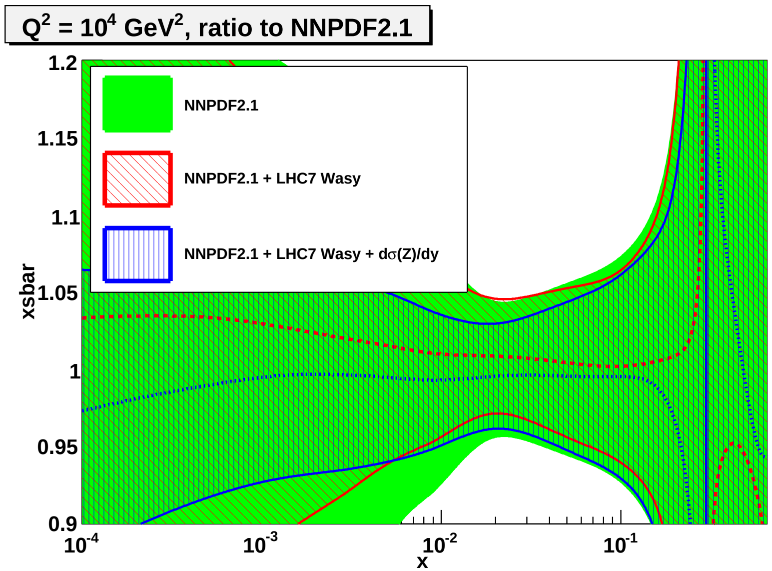
  - YET MORE IMPROVEMENT AT SMALL x NOW ALSO SOME IMPROVEMENT AT LARGE x
  - NOTE EFFECT SEEN ON ALL FLAVORS AND ANTIFLAVORS $\Rightarrow$ ACCURATE DETERMINATION OF STRANGENESS

STRANGE SMALL x



ANTISTRANGE SMALL x



SUMMARY

- ACCURATE DETERIMINATION OF THE LIGHT FLAVOUR STRUCTURE POSSIBLE USING HERA+LHC DATA ONLY

  $\rightarrow$ NO LOW ENERGY DATA!

- LHC CAN LEAD TO ACCURATE DETERMINATION OF THE HEAVY FLAVOUR COMPONENTS

  $\rightarrow$ NO LOW ENERGY DATA!

- HIGH-ENERGY DIS DATA FROM A FUTURE LHEC COLLIDER WOULD ALLOW A PDF DETERMINATION COMPLETELY FREE OF LOW-ENERGY UNCERTAINTIES