ABM news

S.Alekhin (*IHEP Protvino & DESY-Zeuthen)*

(in collaboration with J.Blümlein, K.Daum, K.Lipka, and S.Moch)

- Determination of the c-quark mass
- OPENQCDRAD 1.6
- Tevatron and LHC jet data
- α_s update

sa, Blümlein, Daum, Lipka, Moch hep-ph/1212.xxxx

sa, Blümlein, Moch hep-ph/1211.2642

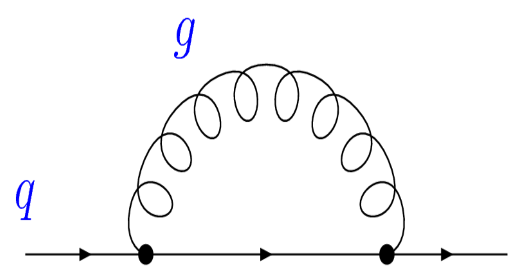
PDF4LHC, CERN, 7 Dec 2012

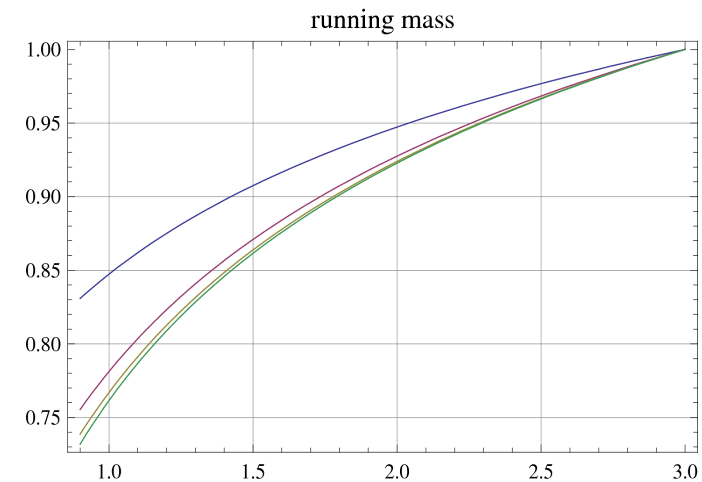
Running mass in DIS: generalities

The pole mass is defined for the free (*unobserved*) quarks as a the QCD Lagrangian parameter and is commonly used in the QCD calculations

$$\mathcal{L} \quad = \quad -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \sum_{\text{flavors}} \bar{q}\,(\mathrm{i}\not{D} - m_q)\, q$$

$$\not{p} - m_q - \Sigma(p, m_q)\Big|_{p^2 = m_q^2}$$

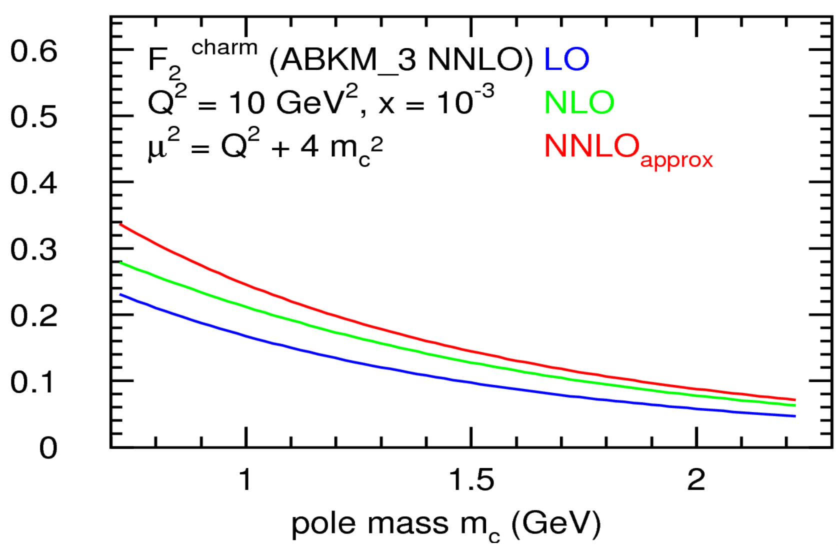


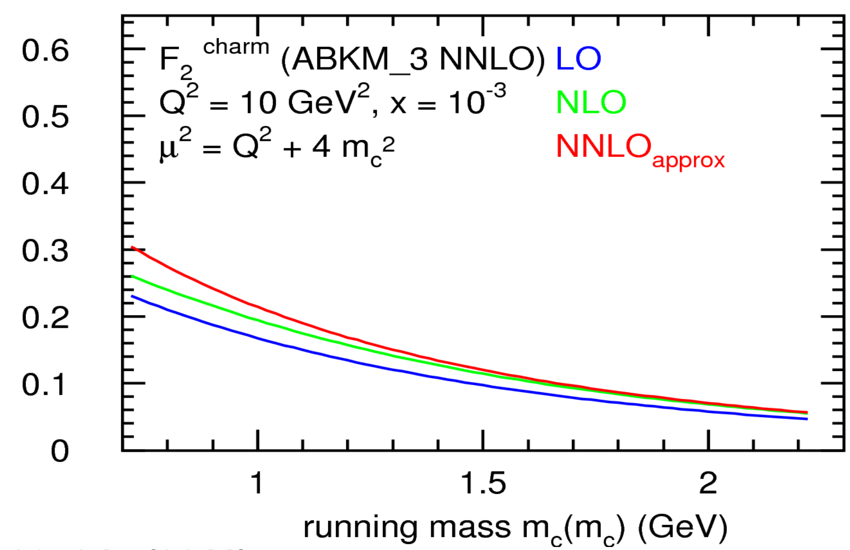


The quantum corrections due to the self-energy loop Integrals receive contribution down to scale of O(Λ_{QCD})

→ sensitivity to the high order corrections, particularly at the production threshold

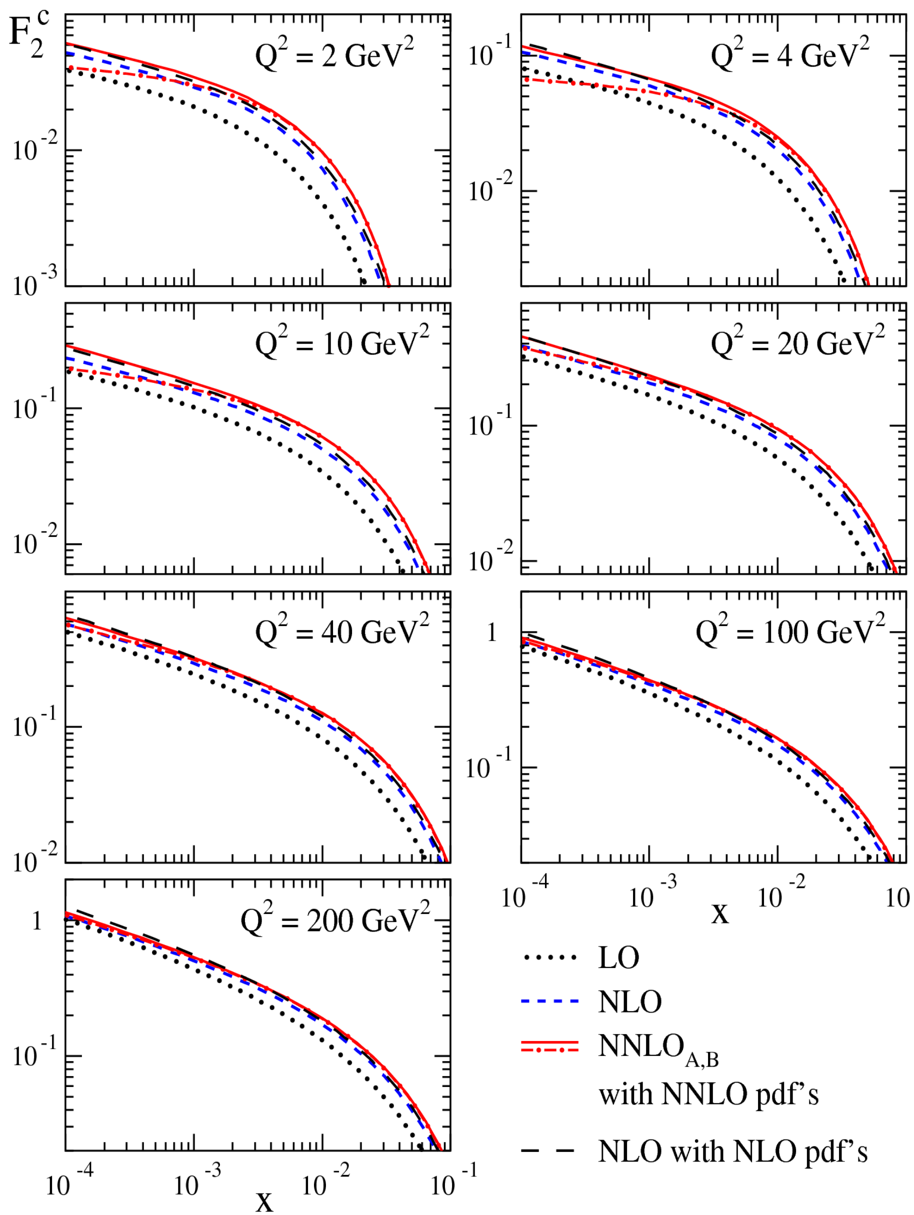
$$\mu^2 \frac{d}{d\mu^2} m(\mu) \; = \; \gamma(\alpha_s) m(\mu)$$





sa, Moch PLB 699, 345 (2011)

State-of-art massive NNLO coefficients



- The NNLO log terms are known due to the recursive relations
- The constant NNLO term stem from:
  - the threshold resummation terms including the Coulomb one
  - high-energy asymptotics obtained with the small-x resummation technique

Catani, Ciafaloni, Hautmann NPB 366, 135 (1991)

  - available NNLO Mellin moments for the massive OMEs

Ablinger at al. NPB 844, 26 (2011)

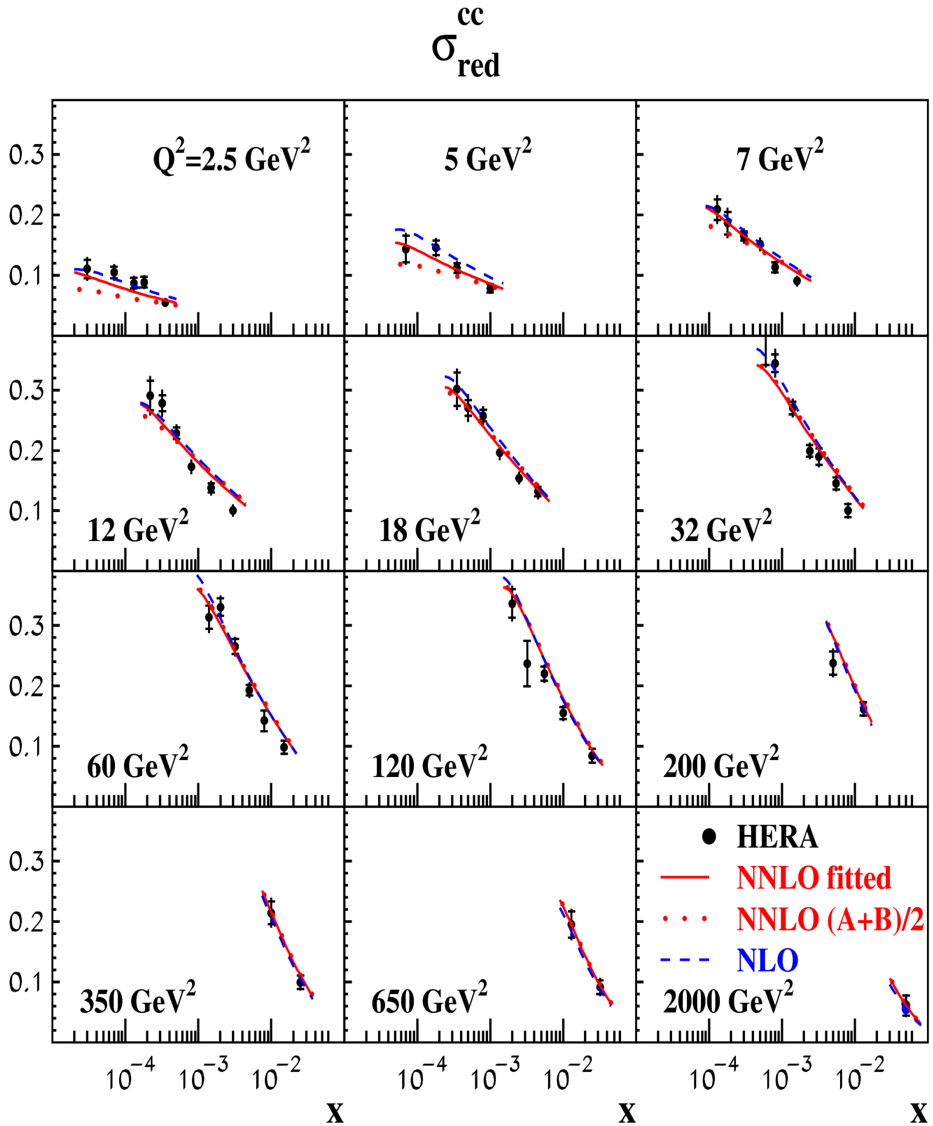
Bierenbaum, Blümlein, Klein NPB 829, 417 (2009)

- The uncertainty in the NNLO coefficients is due to matching of the threshold corrections with the high-energy limit → two options for the coefficients are provided
- Further improvement should come from additional Mellin moments

Blümlein at al. in progress

Kawamura, Lo Presti, Moch, Vogt NPB 864, 399 (2012)

c-quark mass from the ABM11 fit



sa, Blümlein, Daum, Lipka, Moch hep-ph/1212.xxxx

	ABM11	JR	MSTW08	NN21
NLO	1.21	1.21	1.12	1.01
NNLO	1.28	1.27	1.29	-

From the variant of ABM11 fit including the HERA charm data: **H1+ZEUS hep-ex/1211.1182**

$m_c(m_c)$=1.15±0.04(exp.) GeV NLO

$m_c(m_c)$=1.24±0.03(exp.)+0-0.07(th) GeV NNLO

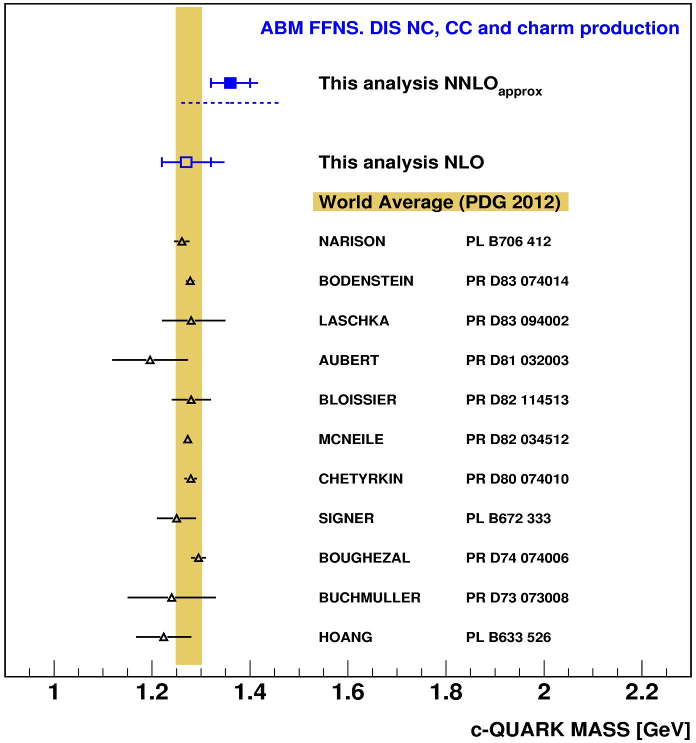
The constant term in the massive NNLO Wilson coefficients is modeled as a linear combination of the options A and B provided by KIPMV

The data prefer option A, the option B is clearly disfavored. The dominant uncertainty in $m_c(m_c)$ at NNLO is due variation of the massive Wilson coefficients between options A and (A+B)/2

From the HERA fit:
$m_c(m_c)$=1.26±0.05(exp.) GeV NLO
(cut on Q^2, impact of the dimuon νN data, PDFs).

Values of $m_c(m_c)$ obtained from the HERA charm data with PDFs fixed are in good agreement at NNLO, at NLO it deviates for the PDFs obtained with the GMVFN scheme

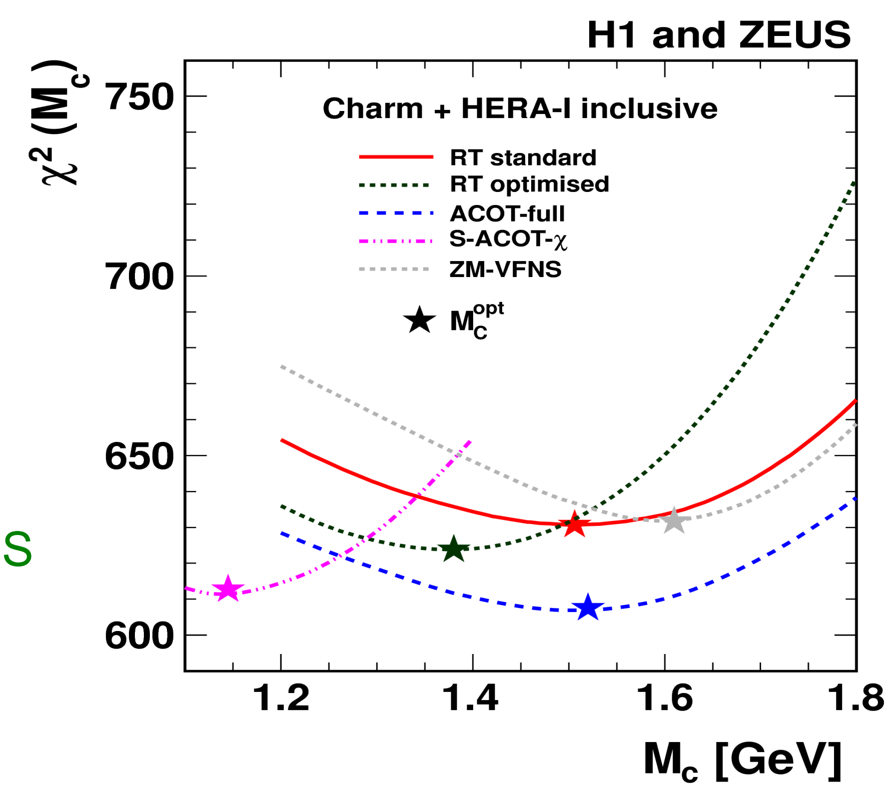
c-quark mass in different schemes



sa, Daum, Lipka, Moch hep-ph/1209.0436

In contrast, the values of pole mass m_c used by different groups and preferred by the PDF fits are systematically lower than the PDG value

	MSTW	NNPDF	JR	CTEQ	PDG
m_c(GeV)	1.40	$\sqrt{2}$	1.3	1.3	1.66



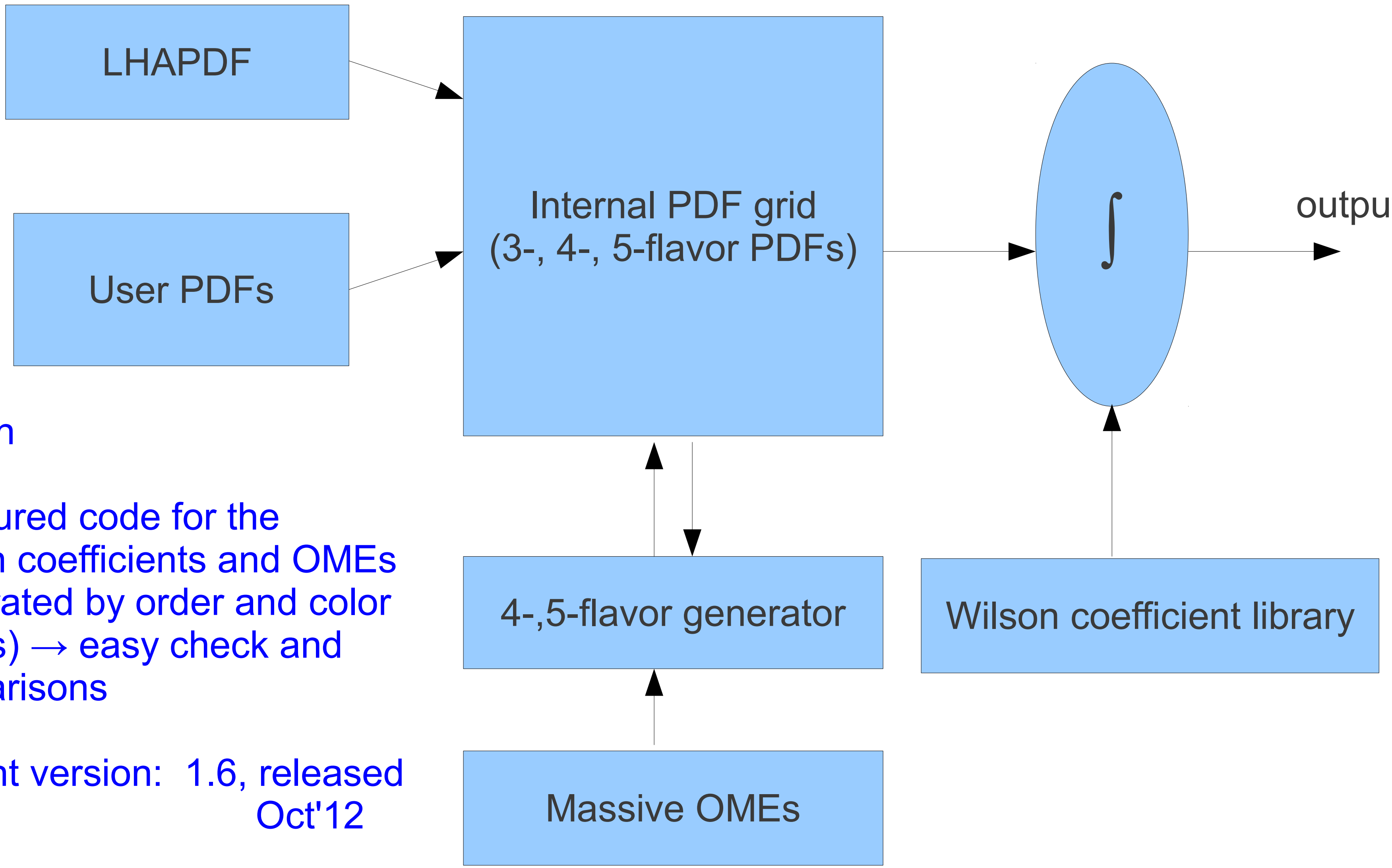
Good agreement of $m_c(m_c)$ obtained from DIS in the FFN scheme with the e+e- results

Wide spread of the m_c obtained in different version of the GMVFN schemes → quantitative illustration of the GMVFNS uncertainties

H1+ZEUS hep-ex/1211.1182

OPENQCDRAD

www-zeuthen.desy.de/~alekhin/OPENQCDRAD



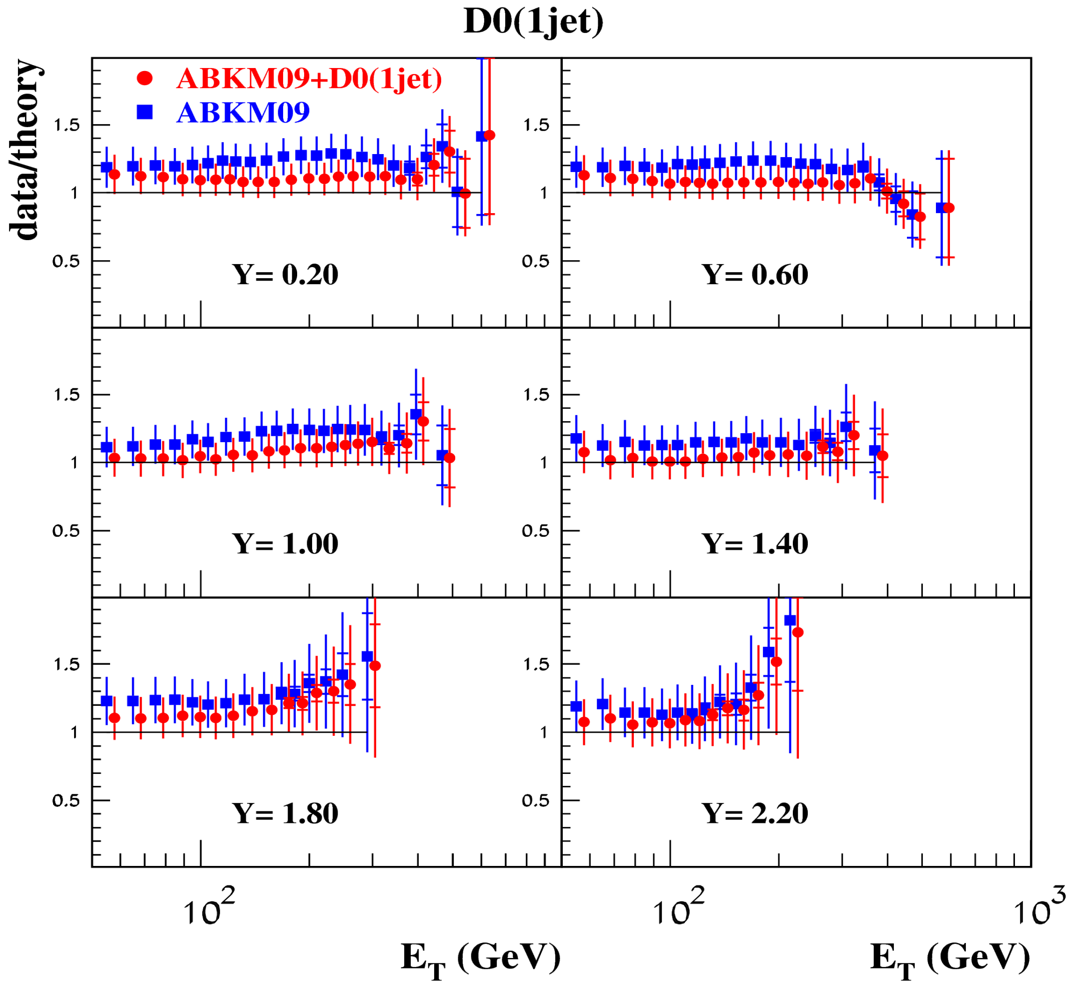
Fortran

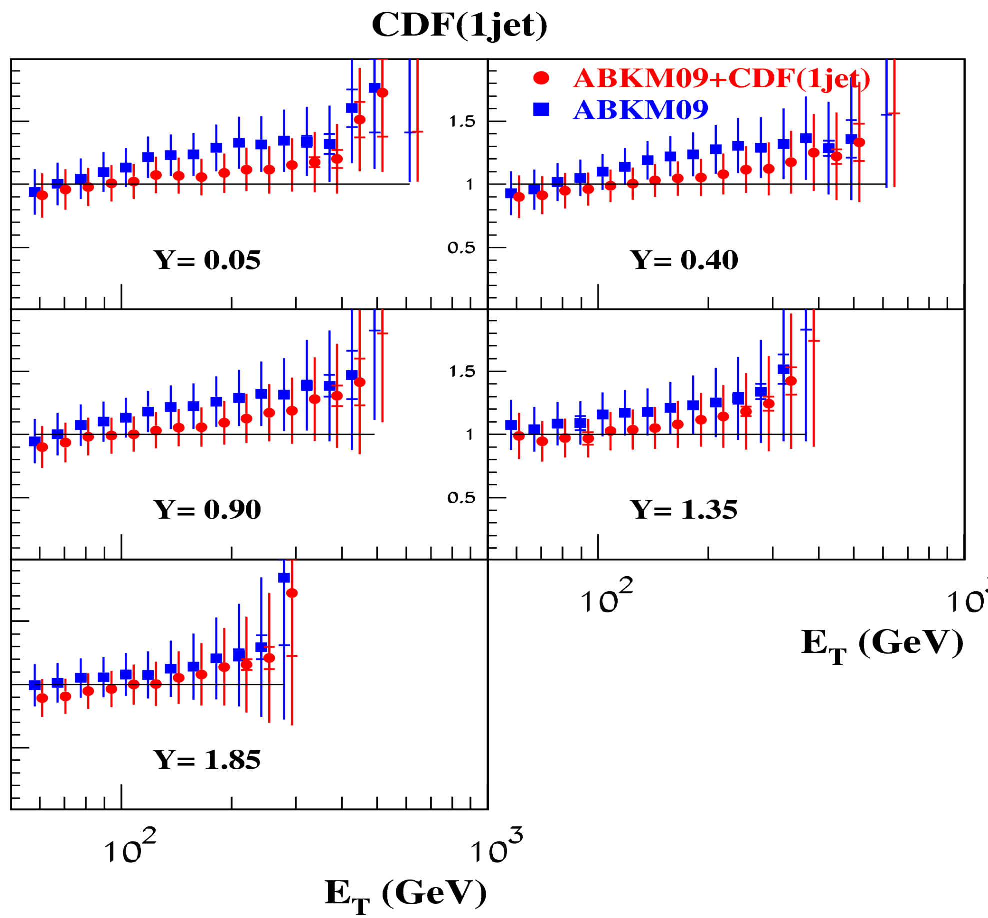
Structured code for the Wilson coefficients and OMEs (separated by order and color factors) → easy check and comparisons

Current version: 1.6, released Oct'12

- Updated massive NNLO Wilson coefficients — **Kawamura, Lo Presti, Moch, Vogt NPB 864, 399 (2012)**
- Z-exchange term up to NNLO — **Klein, Rieman ZPC 24, 151 (1984)**; **Zijlstra van Neerven NPB 383, 525 (1992)**

Inclusive Tevatron jets





$\alpha_s(M_Z)$(NNLO)

sa, Blümlein, Moch [hep-ph 1007.3657]

ABKM09	0.1135(14)
+ D0(1jet):	0.1149(12)
+ D0(2jet):	0.1145(9)
+ CDF/k_T	0.1143(9)
+ CDF/cone	0.1134(9)

The analysis was criticized since the so-called nuisance parameters obtained from comparison of the ABKM09 predictions with the TEVATRON data are quite big in places

Thorne, Watt JHEP 1108, 100 (2011)

Basic of statistics

$$y_i = f_i(\vec{\Theta}) + \mu_i \sigma_i + \sum_{k=1}^{N_{syst}} \lambda_k s_{k,i}^{rel} f_i(\vec{\Theta}),$$

The data sample with statistical and correlated systematical errors

$$\chi^2 = \sum_i \frac{[f_i - (1 - \sum_k \eta_k s_{k,i}^{rel}) y_i]^2}{\sigma_i^2} + \sum_{k=1}^{N_{syst}} \eta_k^2.$$

Statistical estimator taking into account the error correlations (used by CT and MSTW)

$$r_k = \sum_{k'=1}^{N_{syst}} A^{-1}{}_{kk'} B_{k'},$$

The nuisance parameters providing minimum of the estimator functional

$$A_{kk'} = \delta_{kk'} + \sum_i \frac{s_{k,i} s_{k',i}}{\sigma_i^2}$$

$$B_{k'} = \sum_i \frac{(y_i - f_i)}{\sigma_i^2} s_{k',i}.$$

$$\chi^2_{min} = \sum_i \frac{(f_i - y_i)^2}{\sigma_i^2} - \sum_{k=1}^{N_{syst}} r_k B_k.$$

The minimal value of estimator

$$\chi^2 = \sum_{ij} (y_i - f_i) E_{ij} (y_j - f_j).$$

is same as the one of covariance matrix estimator

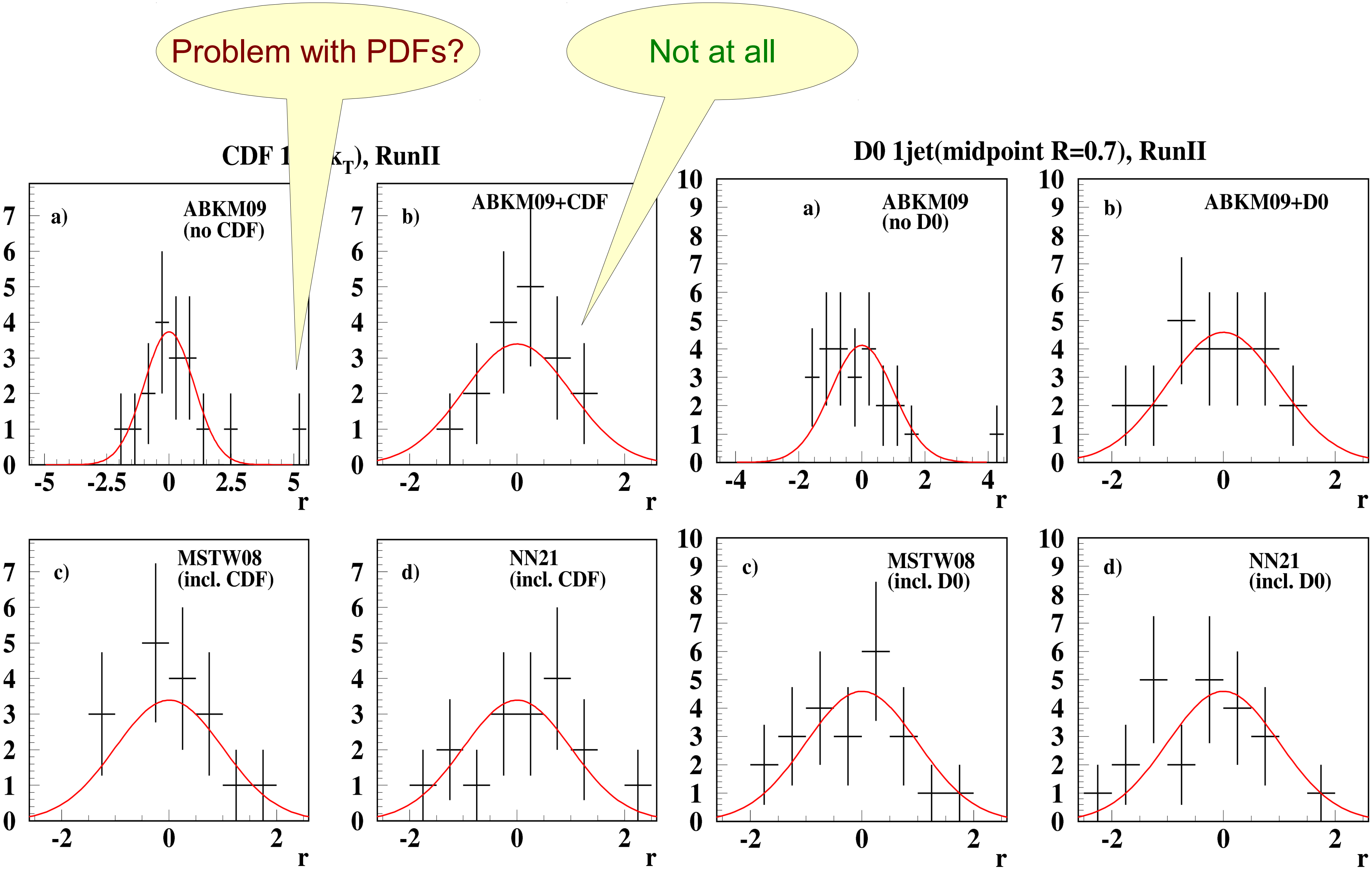
$$\left(C^{add}\right)_{ij} = \sigma_i^2 \delta_{ij} + \sum_{k=1}^{N_{syst}} s_{k,i} s_{k,j}.$$

with the covariance matrix $C=E^{-1}$ (used by NNPDF)

Works only for additive systematics, for the multiplicative ones is biased

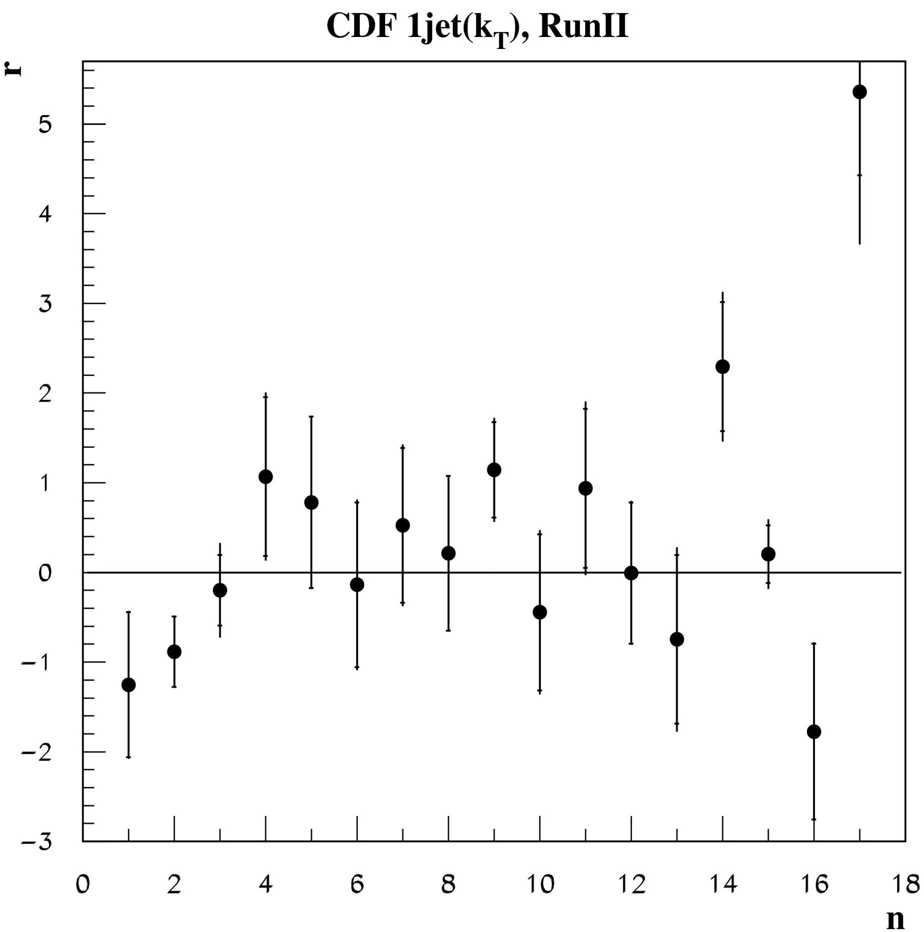
D'Agostini hep-ph/9512295
Nadolsky DIS2010

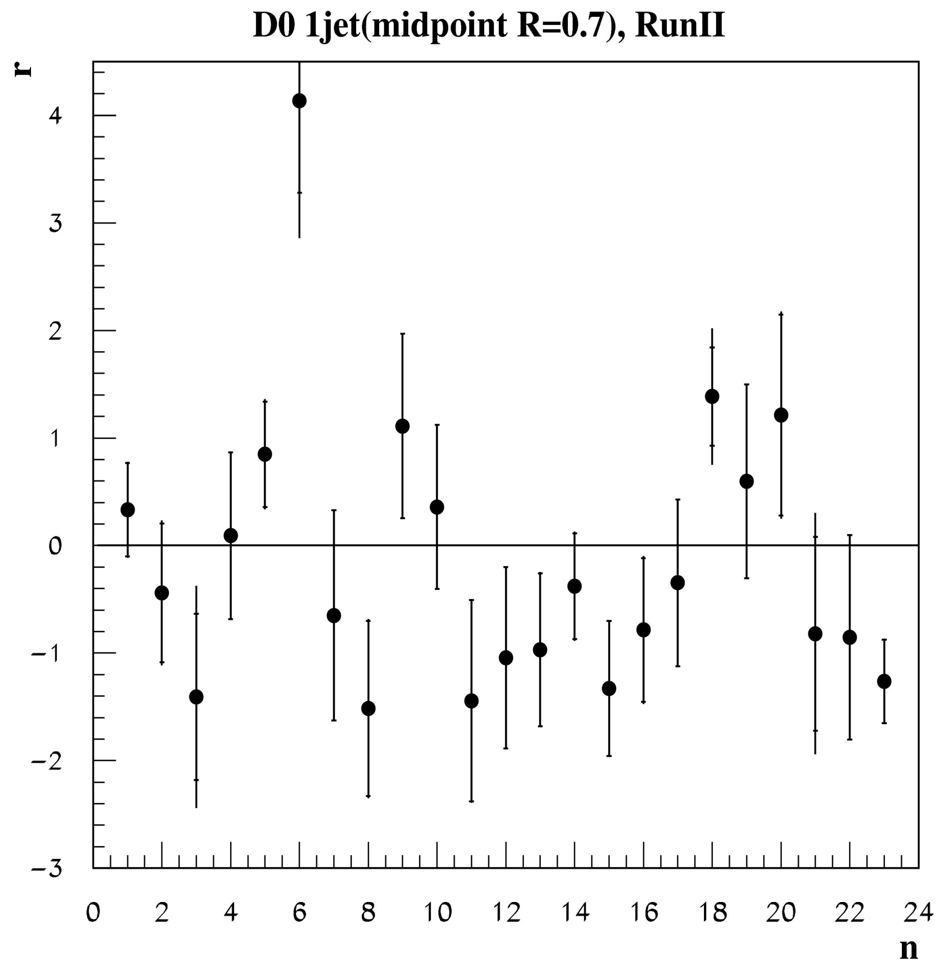
Nuisance parameters for the Tevatron jet data



Extreme values of the nuisance parameters do not appear once data are included in the fit

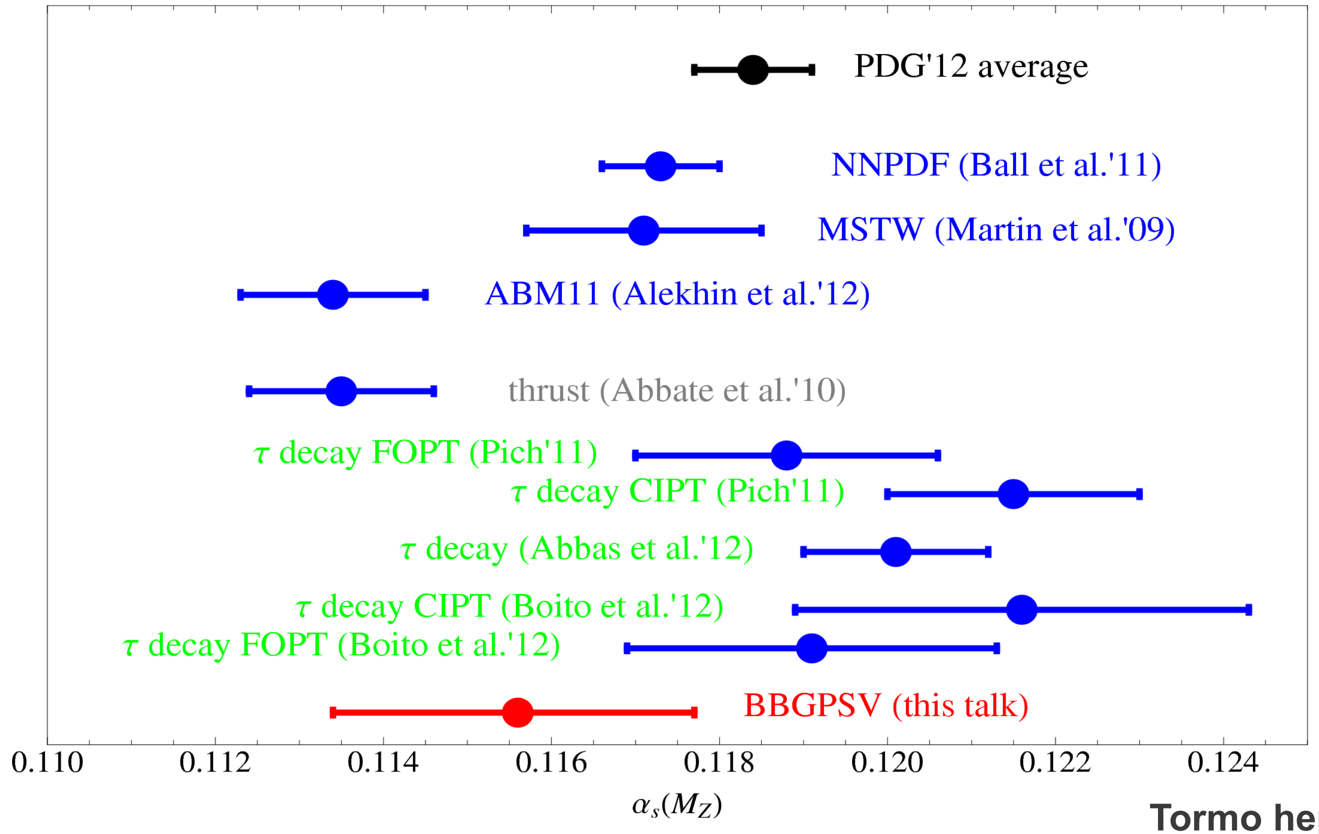
Nuisance parameter uncertainties





The uncertainties are due to the errors in the data(inner bars) and in PDFs

α_s news



Tormo hep-ph/1211.4578

$\alpha_s(M_z)$=0.1140±0.0004(exp)±0.0013(hadr) ±0.0007(pert) e+e-,NNLO

Abbate et al. hep-ph/1204.5746

$\alpha_s(M_z)$=0.1131,+0.0028,-0.0022 e+e-, NNLO

Gerhrmann, Luisoni, Monni hep-ph/1210.6945

$\alpha_s(M_z)$=0.1151±0.0047(exp)±...... ATLAS, NLO

Malaescu, Starovoitov EPJC 72, 2041 (2012)

Benchmark of α_s in PDF fits

	$\alpha_s(M_z)$ at NNLO	Target mass corr.	High-twists	Error correl.
ABM	0.1134±0.0011	+	+	+
NNPDF(DIS)	0.1166±0.0008	+	-	+ -
MSTW08	0.1171±0.0014	-	-	-

The differences are mainly due to treatment of the DIS data, the jet data pull MSTW value down

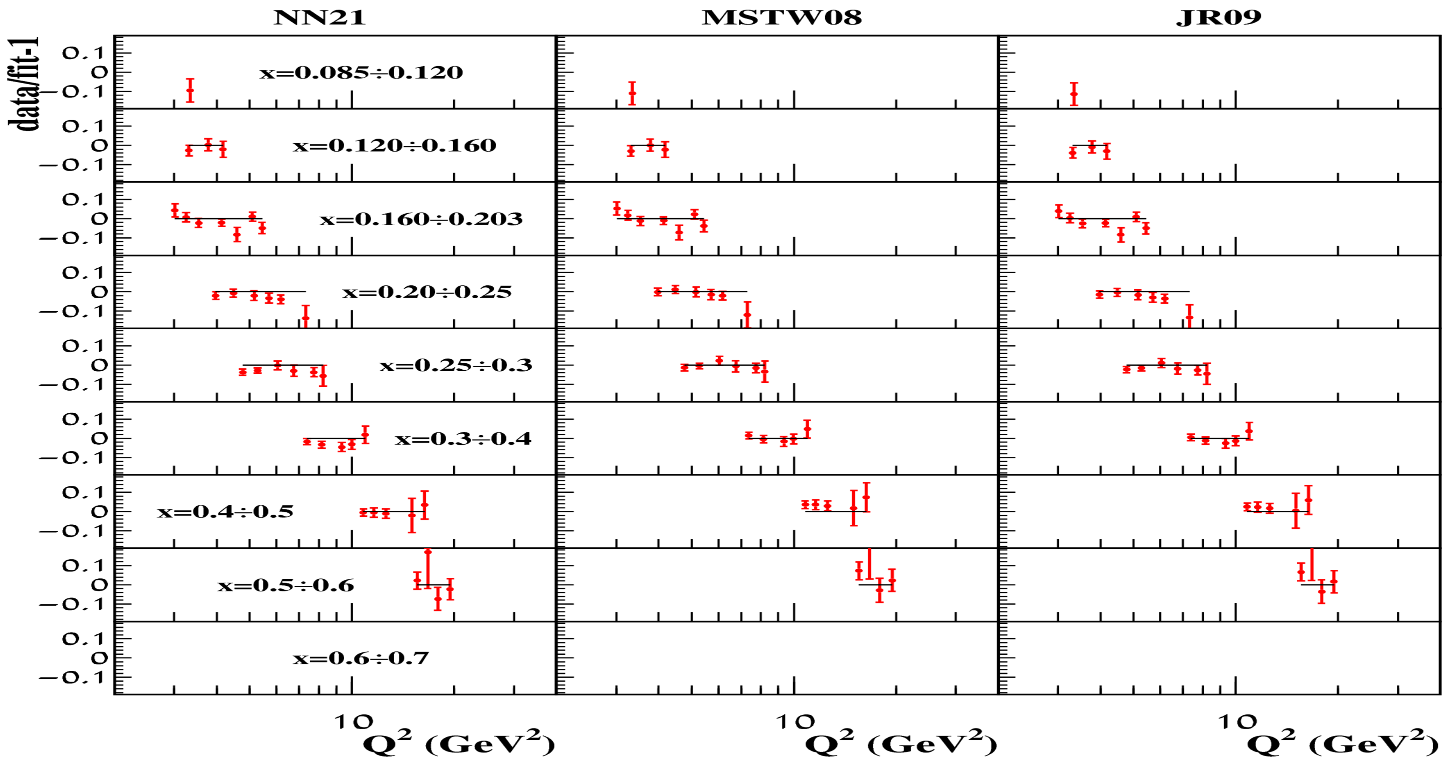
	Combined HERA data		H1/ZEUS separate data	
Variant of our ansatz	ABM11	NNPDF(DIS)	ABKM09	MSTW08
Nominal	0.1134(11)	?	0.1135(14)	?
No HT, $W^2>12.5$ GeV^2	0.1191(6)	0.1166(8)		
No correlation in NMC and HERA data errors			0.1164(14)	
+No HT, $W^2>20$ GeV^2 $Q^2>10$ GeV^2				0.1171

- *We approach NNPDF and MSTW with the modified ansatz*
- *Checks of the statistical bias is underway*

Benchmark of data in PDF fits

SLAC DIS data on F_2 averaged over beam energies (commonly used in PDF fits except ABM11)

- NNL0 QCD
- 3-flavour scheme (c-quark contribution is irrelevant)
- proton target
- the errors are combined in quadrature
- Q2>3 GeV^2, W^2>12.5 GeV^2+M_p^2 (to “get rid of the high-twist terms”) no high-twist terms, target-mass corrections included (NNPDF ansatz)

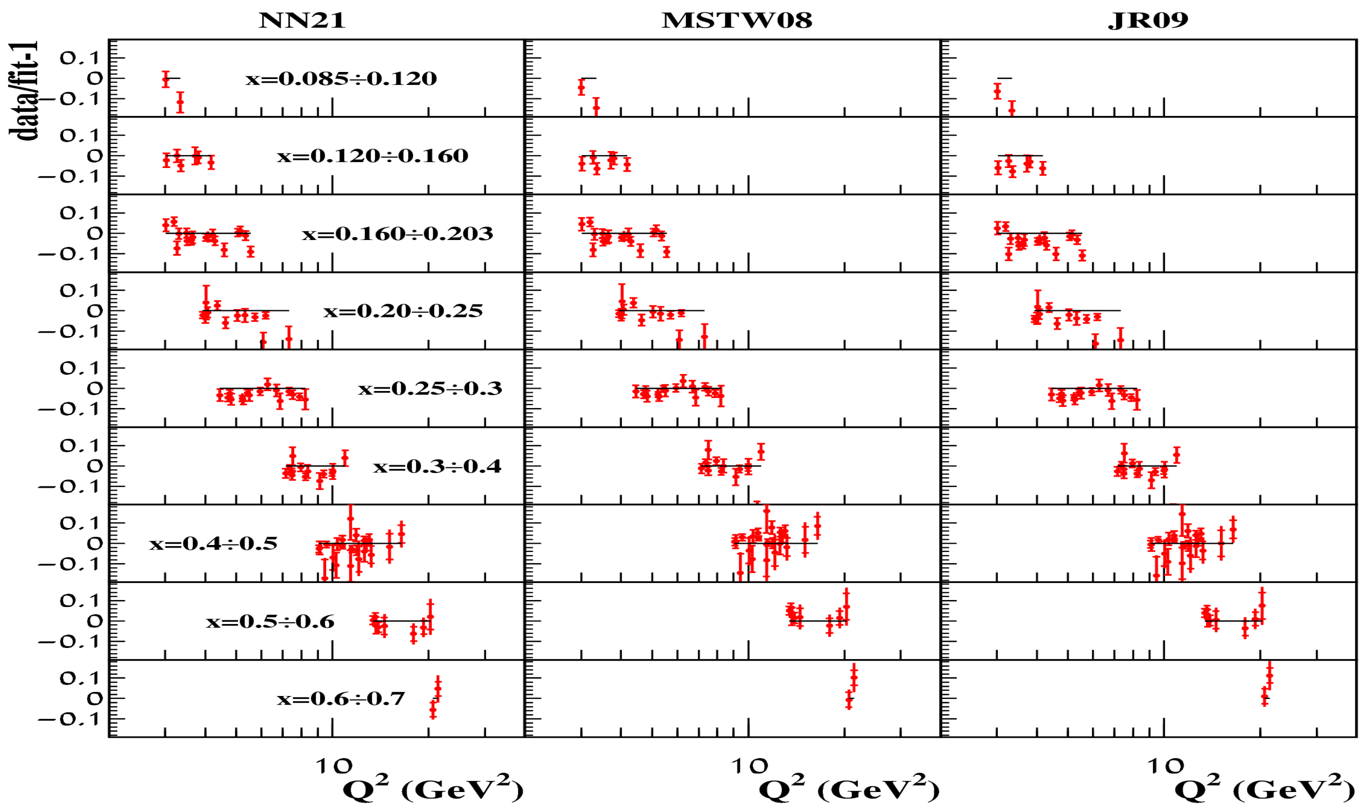


X^2/NDP	53/37=1.4 (c.f.1.01 in NNPDF paper)	35/37 Data x 1.0078 (MSTW atsatz)	42/37

Benchmark of data in PDF fits (cont'd)

SLAC DIS data on c.s.

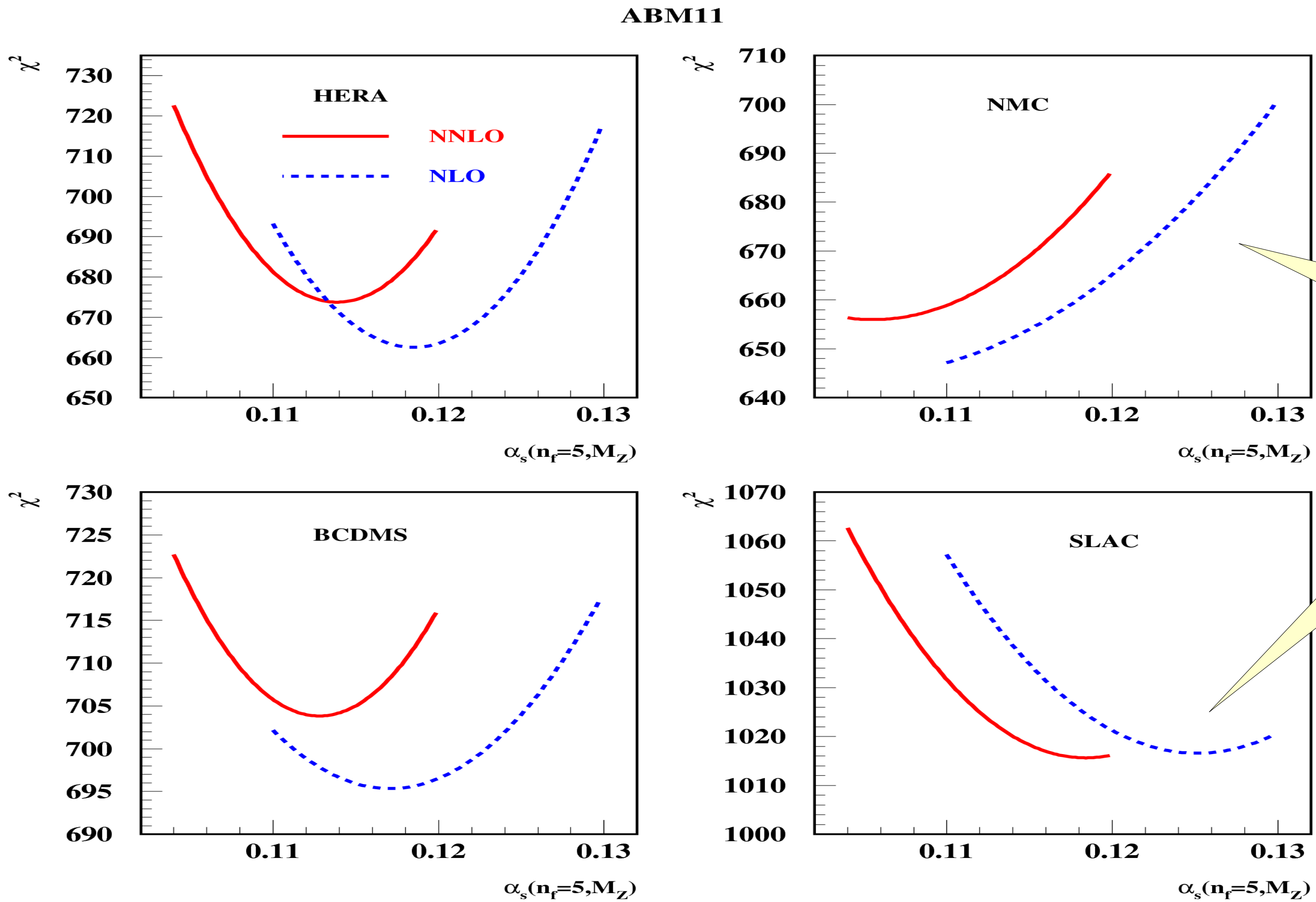
- NNL0 QCD
- 3-flavour scheme (c-quark contribution is irrelevant)
- proton target
- the error correlations are taken into account
- Q2>3 GeV^2, W^2>12.5 GeV^2+M$_p^2$ (to “get rid of the high-twist terms”) no high-twist terms, target-mass corrections included (NNPDF ansatz)



X^2/NDP 147/99 170/99 170/99

Data X 1.0078
(MSTW ansatz)

Another way to get rid of HT terms



Sensitive to HT terms

sa, Blümlein, Moch
PRD D86, 054009 (2012)
EPJC 71, 1723 (2011)

The HERA and BCDMS data are insensitive to the HT contribution and are quite complementary in the α_s fit

H1 Collaboration EPJC 21, 33 (2001)]

With the NMC and SLAC dropped $\quad \alpha_s(M_z)=0.1133\pm0.0011$ (NNLO)

0.1184 ± 0.0011 (NLO)

Summary

- The values of

$m_c(m_c)$=1.15±0.04(exp.) GeV NLO
$m_c(m_c)$=1.24±0.03(exp.)+0-0.07(th) GeV NNLO

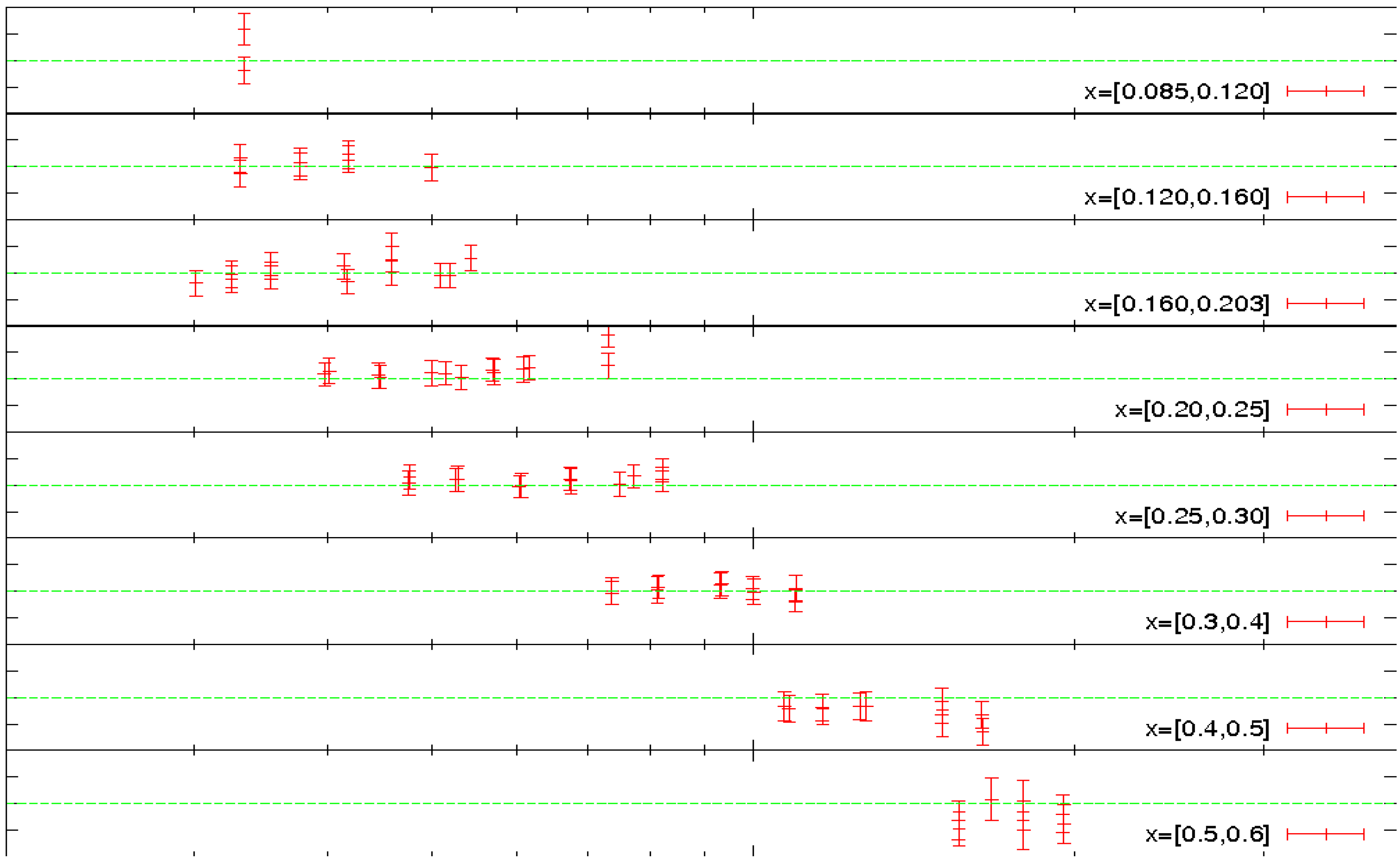
obtained in the variant of ABM11 including HERA charm data are in good agreement with the e+e- data → the FFN scheme provides good description of the existing DIS data

- Update of OPENQCDRAD
  – recent version of the massive DIS Wilson coefficients
  – Z-exchange DIS terms
- The Tevatron nuisance parameter issue is irrelevant
- The value of

$\alpha_s(M_z)$=0.1133(11)

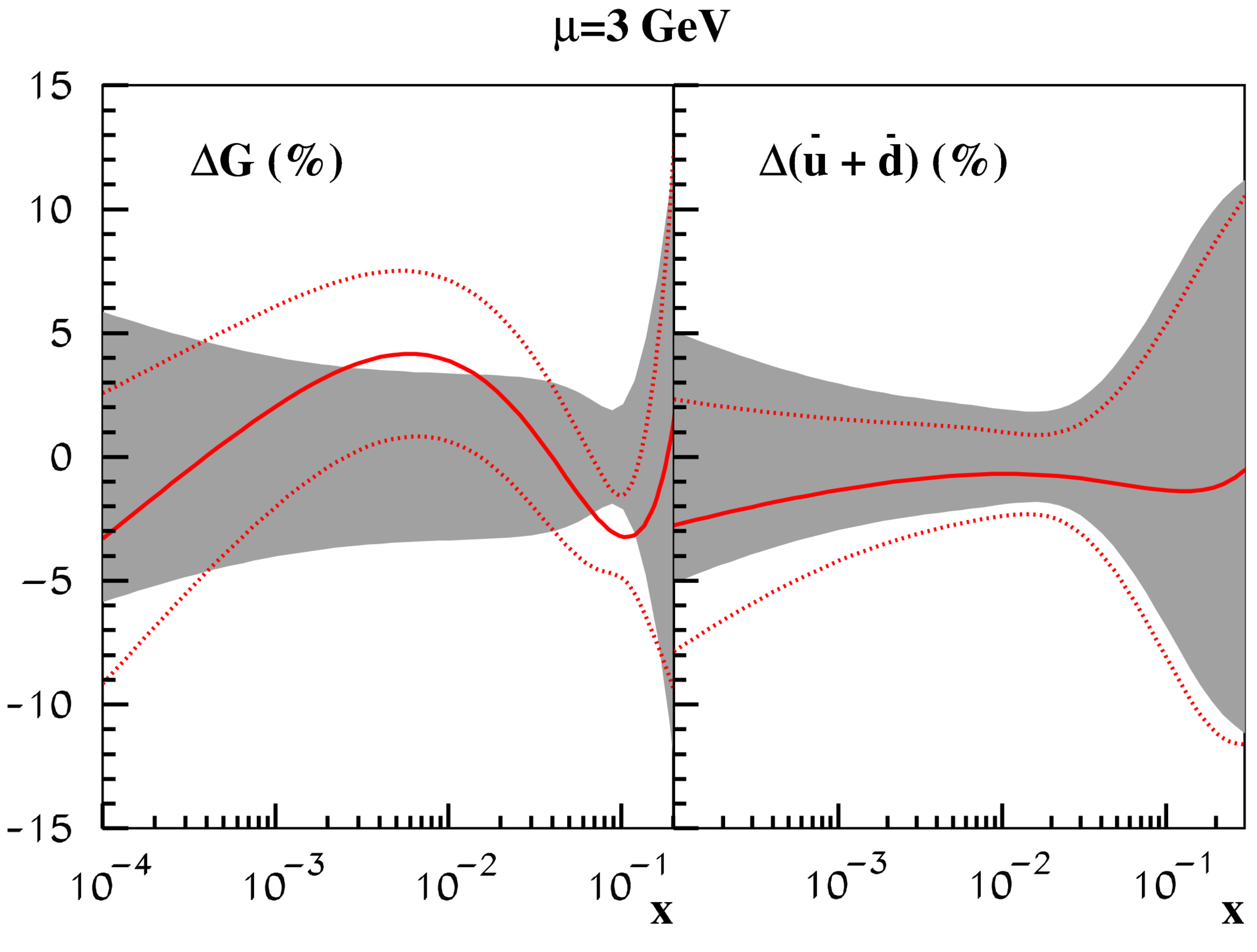
obtained in the version of ABM11 fit free from the high-twist term impact is in a good agreement with the earlier ABM11 value of 0.1134(11).

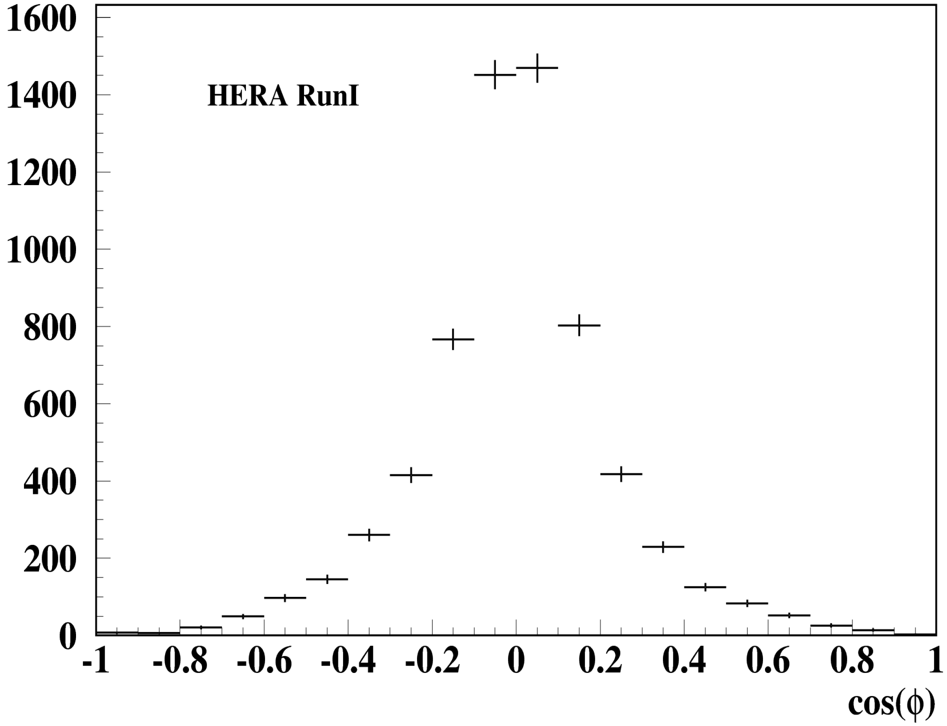
Extras



Courtesy of S.Forte

Change in the ABM11 PDFs due to the HERA charm data





Distribution of the angle between the systematic error vectors

$$\cos(\phi_{kk'}) = \frac{\sum_i s_{k,i} s_{k',i}}{\sqrt{\sum_i s_{k,i}^2 \sum_i s_{k',i}^2}}.$$

is quite different for the HERA and Tevatron jet data