NNPDF Benchmark Partons

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NNPDF approach: a reminder

- take a MonteCarlo sample of experimental data;
- fit a redundant parametrization on each replica of the sample;
- stop the minimization before learning statistical noise;
- average over the replicas to get the final result.

preliminary: what does it mean?

1. a small MonteCarlo sample is used ($N_{rep} = 100$);
2. still missing checks of statistical stability against parameters:
   - choice of the interpolating function (# of PDF parameters, preprocessing);
   - minimization speed/accuracy (stopping range, max # of iterations);
   - randomness (PDF initializations, seeds);

statistically stable: what does it mean?

given two fits, in the limit $N_{rep} \to \infty$

$$\langle \mathbf{d[g]} \rangle \to \langle \mathbf{d}[\sigma_{\mathbf{g}}] \rangle \to \langle \mathbf{d}[\rho_{\mathbf{g}}] \rangle \to \mathbf{1}$$

where

$$\langle d[g] \rangle = \sqrt{\left\langle \frac{\left(\langle g \rangle_{(1)} - \langle g \rangle_{(2)} \right)^2}{\sigma^2[g^{(1)}] + \sigma^2[g^{(2)}]} \right\rangle_{dat}}$$

$$\langle g_i \rangle_{(1)} \equiv \frac{1}{N_{rep}^{(1)}} \sum_{k=1}^{N_{rep}^{(1)}} g_{ik}^{(1)} \,, \quad \sigma^2[g_i^{(1)}] \equiv \frac{1}{N_{rep}^{(1)}(N_{rep}^{(1)} - 1)} \sum_{k=1}^{N_{rep}^{(1)}} \left(g_{ik}^{(1)} - \langle g_i \rangle_{(1)} \right)^2$$

benchmark: what does it mean?

- HERA-LHC: done by S. Alekhin and R. Thorne in the last workshop;
- H1: discussed at PDF4LHC with S. Glazov and V. Radescu.

- the set up for the HERA-LHC benchmark is done (up to agreements);
- the set up for the H1 benchmark is done (up to agreements);
- before benchmarking against someone else, we do it against ourselves;
- some differences in some settings just to ease this first exercise.

Note: all results with 1σ error bands.

HERA-LHC: experimental data

ref

$Q^2 > 2\ GeV^2, W^2 > 12.5\ GeV^2$

Name	Data points	Target
NMC_pd	153	F_2^d/F_2^p
NMC	245	F_2^p
SLAC	47 (47)	$F_2^{p(d)}$
BCDMS	333 (248)	$F_2^{p(d)}$
ZEUS97	240	$\tilde{\sigma}^{NC,+}$
H1lx97	80 + 55	$\tilde{\sigma}^{NC,+}$
H197	130 (25)	$\tilde{\sigma}^{NC(CC),+}$
H199	126 (28)	$\tilde{\sigma}^{NC(CC),-}$
H100	147 (28)	$\tilde{\sigma}^{NC(CC),+}$
ZEUS02	92	$\tilde{\sigma}^{NC,-}$
ZEUS03	90	$\tilde{\sigma}^{NC,+}$
CHORUS	471 (471)	$\tilde{\sigma}^{\nu(\bar{\nu})}$
Total	3055	

bench

$Q^2 > 9\ GeV^2, W^2 > 15\ GeV^2$

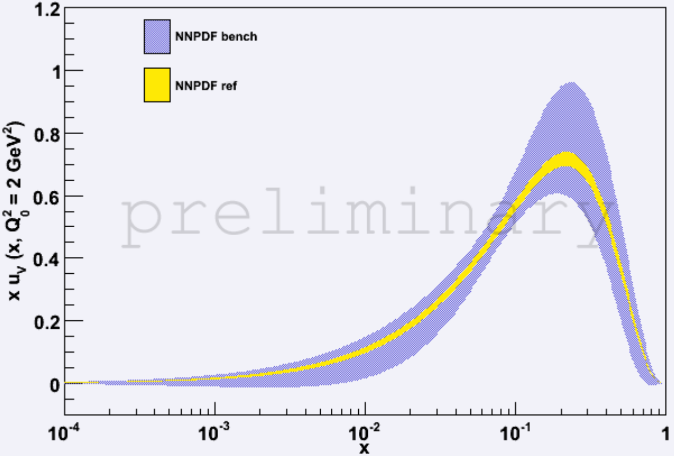
Name	Data points	Target
NMC_pd	73	F_2^d/F_2^p
NMC	95	F_2^p
BCDMS	322	F_2^p
ZEUS97	206	F_2^p
H1lx97	77	F_2^p
Total	773	

theoretical assumptions

	ref	bench
Evolution	Fully Truncated	Iterated
$Q_0^2\,(GeV^2)$	2	**2**
Heavy Quarks	ZM-VFN	ZM-VFN
$m_c\,(GeV^2)$	$\sqrt{2}$	$\sqrt{2}$
$m_b\,(GeV^2)$	4.3	4.5
$\alpha_s\,(M_Z)$	0.119	**0.119**
PDFs	$\Sigma,\ g,\ T_3, V,\ \bar{d}-\bar{u}$	$\Sigma,\ g,\ T_3, V$
$C_s = \frac{s+\bar{s}}{\bar{u}+\bar{d}}$	0.5	**0.5**
TMC	included	

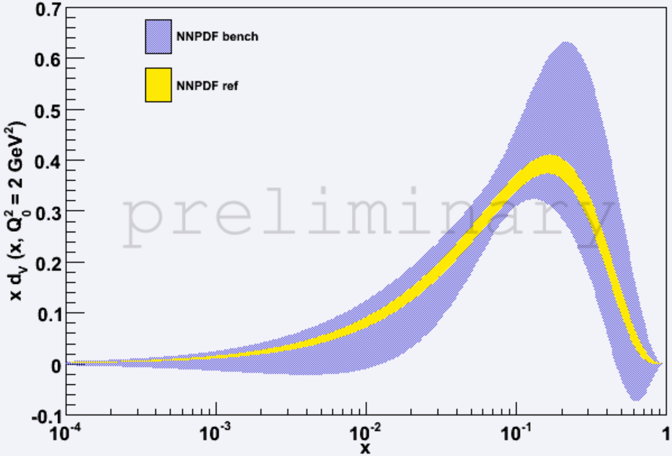
$+$ Momentum and valence sum rules

results



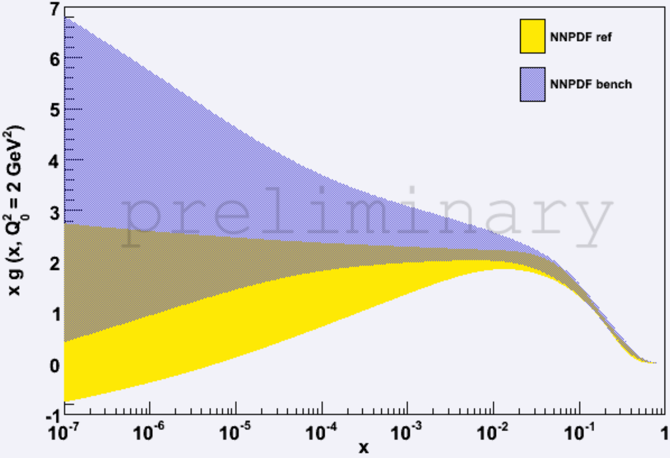
u-valence

results



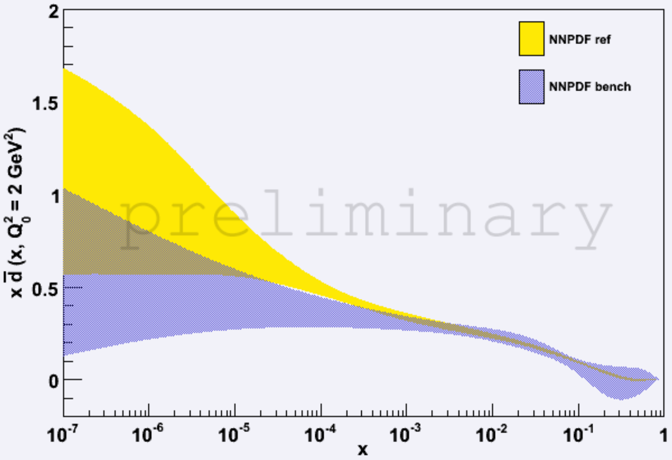
d-valence

results



gluon

results


NNPDF ref
NNPDF bench
preliminary
$x\,\bar{d}\,(x, Q_0^2 = 2\ \mathrm{GeV}^2)$
x
2
1.5
1
0.5
0
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1

sea

H1: experimental data

ref

$Q^2 > 2\ GeV^2, W^2 > 12.5\ GeV^2$

Name	Data points	Target
NMC_pd	153	F_2^d / F_2^p
NMC	245	F_2^p
SLAC	47 (47)	$F_2^{p(d)}$
BCDMS	333 (248)	$F_2^{p(d)}$
ZEUS97	240	$\tilde{\sigma}^{NC,+}$
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ZEUS02	92	$\tilde{\sigma}^{NC,-}$
ZEUS03	90	$\tilde{\sigma}^{NC,+}$
CHORUS	471 (471)	$\tilde{\sigma}^{\nu(\bar{\nu})}$
Total	3055	

bench

$Q^2 > \mathbf{2}\,\mathrm{GeV}^2$

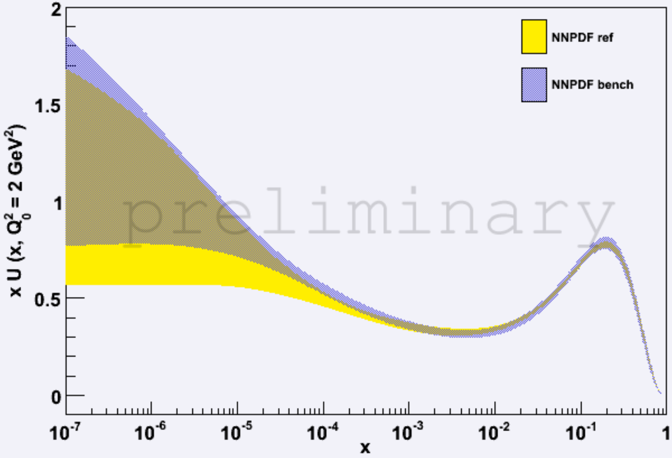
Name	Data points	Target
H1lx97	80 + 55	$\tilde{\sigma}^{NC,+}$
H197	130 (25)	$\tilde{\sigma}^{NC(CC),+}$
H199	126 (28)	$\tilde{\sigma}^{NC(CC),-}$
H199hy	13	$\tilde{\sigma}^{NC,-}$
H100	147 (28)	$\tilde{\sigma}^{NC(CC),+}$
Total	632	

theoretical assumptions

	ref	bench
Evolution	Fully Truncated	Iterated
$Q_0^2\,(GeV^2)$	2	**2**
Heavy Quarks	ZM-VFN	ZM-VFN
$m_c\,(GeV^2)$	$\sqrt{2}$	$\sqrt{2}$
$m_b\,(GeV^2)$	4.3	4.5
$\alpha_s\,(M_Z)$	0.119	0.1185
PDFs	$\Sigma,\ g,\ T_3, V,\ \bar{d}-\bar{u}$	$\Sigma,\ g,\ T_3, V,\ \bar{d}-\bar{u}$
$C_s = \frac{s+\bar{s}}{\bar{u}+\bar{d}}$	0.5	**0.5**
TMC	included	

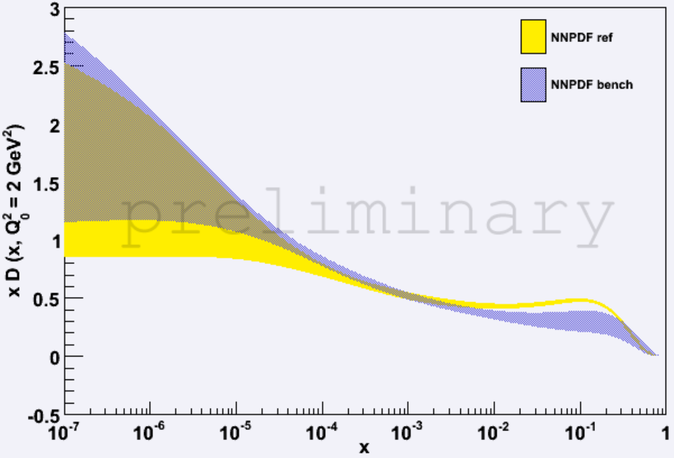
$+$ Momentum and valence sum rules

results


NNPDF ref
NNPDF bench
preliminary
x U (x, Q_0^2 = 2 GeV^2)
2
1.5
1
0.5
0
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
x

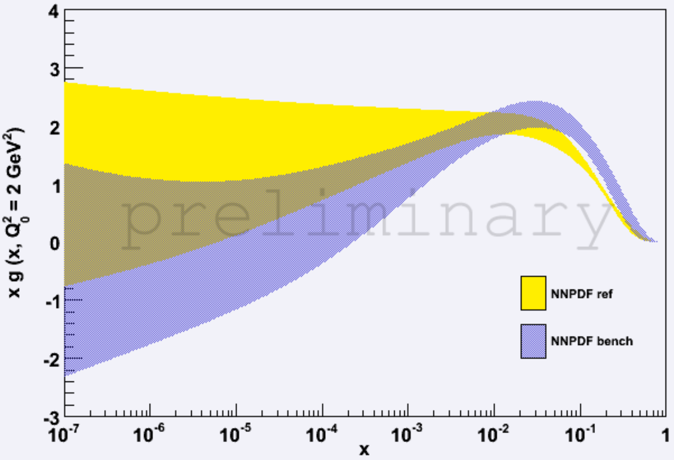
$$U = u\,(+c)$$

results


NNPDF ref
NNPDF bench
preliminary
x D (x, Q_0^2 = 2 GeV^2)
x
3
2.5
2
1.5
1
0.5
0
-0.5
10^{-7}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1

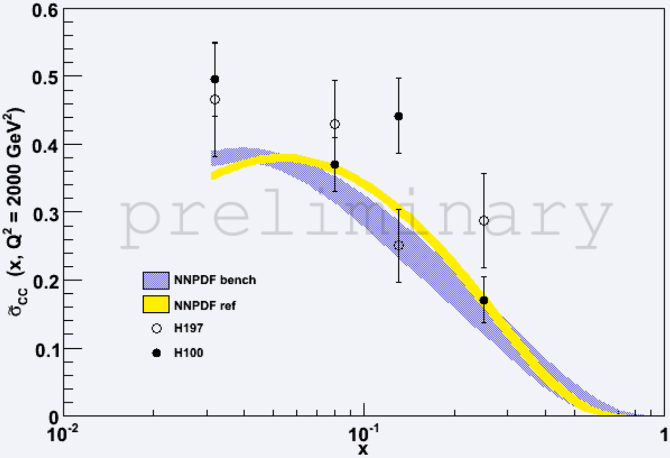
$$D = d + s$$

results

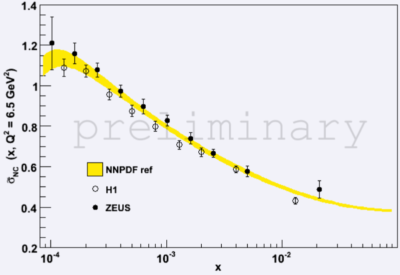


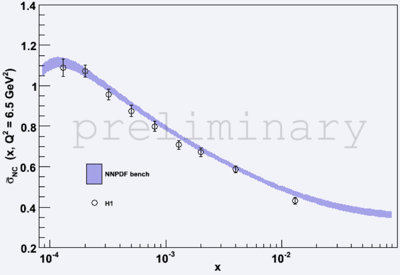
gluon

details: CC data



details: small-x data





perspectives

to do:

- run the HERA-LHC benchmark with $Q_0^2 = 1\, GeV^2$;
- run H1 benchmark with H1 flavour assumptions and cuts;

to be agreed:

- which fixed α_s for the HERA-LHC benchmark?
- which χ^2 for the H1 benchmark?
- which input PDFs to parametrize for both?

a suggestion:

- do the same and compare.

perspectives

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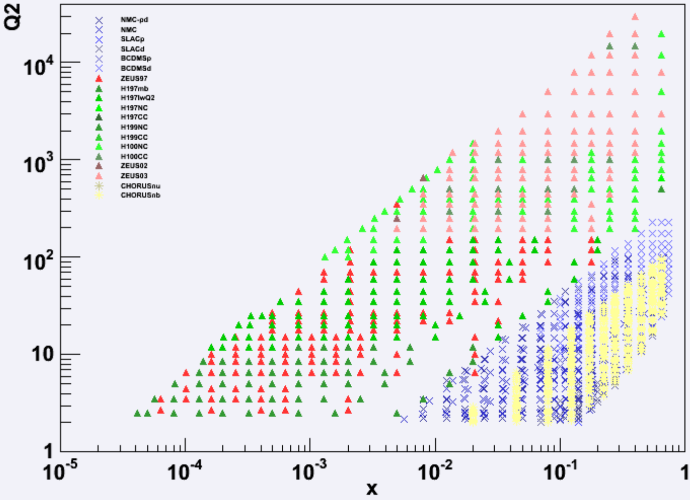
kinematics


Q2
10^4
10^3
10^2
10
1
NMC-pd
NMC
SLACp
SLACd
BCDMSp
BCDMSd
ZEUS97
H197mb
H197lwQ2
H197NC
H197CC
H199NC
H199CC
H100NC
H100CC
ZEUS02
ZEUS03
CHORUSnu
CHORUSnb
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
x

Error propagation: Data → Parametrization

- Monte Carlo sampling of data (generation of replicas of experimental data)

$$\mathcal{D}_i^{(art)(k)} = \left(1 + r_N^{(k)}\sigma_N\right)\left[\mathcal{D}_i^{(exp)} + r_i^s\sigma_i^{stat} + \sum_{l=1}^{N_{sys}} r^{l,(k)}\sigma_i^{sys,l}\right]$$

where σ_i are the experimantal errors, and r_i are random numbers choosen accordingly to the experimental correlation matrix.

Error propagation: Parametrization $\longrightarrow$ Observables

- Expectation values:

$$\langle \mathcal{F}\left[g(x)\right]\rangle = \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} \mathcal{F}\left(g^{(fit)(k)}(x) \right)$$

- Errors:

$$\sigma_{\mathcal{F}[g(x)]} = \sqrt{\left\langle \mathcal{F}\left[g(x)\right]^2 \right\rangle - \langle \mathcal{F}\left[g(x)\right]\rangle^2}$$

- Correlations between pairs of different parton distributions at different points:

$$\langle u(x_1) d(x_2) \rangle = \frac{1}{N_{rep}} \sum_{k=1}^{N_{rep}} u^{(fit)(k)}(x_1) d^{(fit)(k)}(x_2)$$

χ^2

Experiment	Set	$\chi^2_{\rm dat}$
NMC-pd		1.59
	NMC-pd	1.59
NMC		1.71
	NMC	1.71
SLAC		1.29
	SLACp	1.46
	SLACd	0.99
BCDMS		1.67
	BCDMSp	1.84
	BCDMSd	1.31
ZEUS97		1.29
	ZEUS97	1.29
H1		1.24
	H197mb	2.61
	H197lwQ2	0.96
	H197NC	0.93
	H197CC	0.85
	H199NC	1.13
	H199CC	0.66
	H100NC	1.23
	H100CC	1.34
ZEUS02		0.76
	ZEUS02	0.76
ZEUS03		1.24
	ZEUS03	1.24
CHORUS		1.37
	CHORUSnu	1.37
	CHORUSnb	1.18

Experiment	Set	$\chi^2_{\rm dat}$
ZEUS97		1.08
	ZEUS97	1.08
H197lwQ2		0.92
	H197lwQ2	0.92
NMCp		1.39
	NMCp	1.39
NMC-pd		1.38
	NMC-pd	1.38
BCDMSp		1.28
	BCDMSp	1.28

Experiment	Set	$\chi^2_{\rm dat}$
H1		1.05
	H197mb	1.07
	H197lwQ2	0.92
	H197NC	0.78
	H197CC	1.16
	H199NC	0.98
	H199CC	0.77
	H199NChy	1.91
	H100NC	0.97
	H100CC	1.87