NNPDF1.0: benchmarks

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NNPDF1.0

- NNPDF1.0 details can be found in `arXiv:0808.1231`;
- NNPDF1.0 will be available in a next release of LHAPDF; while waiting, LHAPDF v. 5.4.0 + NNPDF1.0 is online @

  `http://sophia.ecm.ub.es/nnpdf/`
- HERA-LHC, may 2008: benchmark against ourselves;
- PDF4LHC, sept. 2008: benchmark against other collaborations;
- all the following results were obtained with 100 replicas (enough to study central values and errors, 1000 are needed for correlations).

benchmarks

issues:

- how do we propagate errors from data to the parametrization?
- how do we propagate errors from the parametrization to an integral?
- how does the parametrization affects the minimization?
- how do we access the error associated to the parametrization?
- how do *new* data sets affect a fit?

how do we answer to these questions?

- in principle, fix all the *variables*, and vary just one;
- in practise, it is not that easy ...

PDF errors

- MC method ($N_{set} = N_{replica}$)

$$\sigma_{\mathcal{F}} = \left(\frac{N_{set}}{N_{set} - 1} \left(\langle \mathcal{F}[\{q\}]^2 \rangle - \langle \mathcal{F}[\{q\}] \rangle^2 \right) \right)^{1/2}$$

- Hessian method ($N_{set} = N_{eigenvector}$)

$$\sigma_{\mathcal{F}}^{hepdata} = \frac{1}{2C_{90}} \left(\sum_{k=1}^{N_{set}/2} \left(\mathcal{F}[\{q^{(2k-1)}\}] - \mathcal{F}[\{q^{(2k)}\}] \right)^2 \right)^{1/2}$$

with

$$C_{90} = 1.64485$$

outline

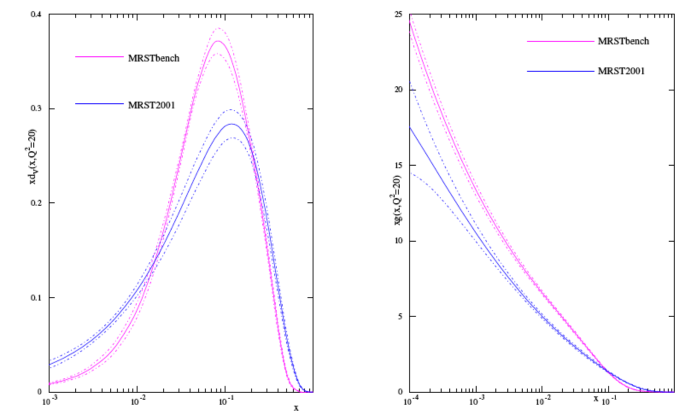
1. evolution code benchmark;
2. HERA-LHC benchmark;
3. H1 benchmark;
4. standard candles;
5. final remarks.

evolution code benchmark - a reminder

accuracy of our PDF evolution for different PDF combinations at NLO in the ZM-VFNS compared to hep-ph/0204316:

x	$\epsilon_{\rm rel}(u_v)$	$\epsilon_{\rm rel}(d_v)$	$\epsilon_{\rm rel}(\Sigma)$	$\epsilon_{\rm rel}(\bar{d}+\bar{u})$	$\epsilon_{\rm rel}(s+\bar{s})$	$\epsilon_{\rm rel}(g)$
$N_{\rm iter}=6$						
10^{-7}	$2.2\ 10^{-5}$	$8.1\ 10^{-6}$	$4.9\ 10^{-6}$	$1.5\ 10^{-5}$	$1.2\ 10^{-6}$	$2.2\ 10^{-5}$
10^{-6}	$6.3\ 10^{-6}$	$3.2\ 10^{-6}$	$9.8\ 10^{-6}$	$1.1\ 10^{-5}$	$5.4\ 10^{-6}$	$3.0\ 10^{-6}$
10^{-5}	$1.8\ 10^{-5}$	$1.4\ 10^{-5}$	$8.3\ 10^{-6}$	$3.0\ 10^{-6}$	$3.6\ 10^{-6}$	$1.4\ 10^{-6}$
10^{-4}	$3.1\ 10^{-5}$	$1.6\ 10^{-5}$	$3.6\ 10^{-5}$	$4.3\ 10^{-5}$	$3.3\ 10^{-5}$	$3.2\ 10^{-5}$
10^{-3}	$1.8\ 10^{-6}$	$1.2\ 10^{-5}$	$5.9\ 10^{-6}$	$5.8\ 10^{-6}$	$8.9\ 10^{-6}$	$3.6\ 10^{-6}$
10^{-2}	$2.8\ 10^{-5}$	$1.5\ 10^{-5}$	$4.7\ 10^{-5}$	$4.3\ 10^{-5}$	$4.6\ 10^{-5}$	$8.2\ 10^{-5}$
0.1	$3.2\ 10^{-6}$	$1.3\ 10^{-5}$	$3.0\ 10^{-6}$	$9.4\ 10^{-6}$	$2.1\ 10^{-5}$	$5.1\ 10^{-7}$
0.3	$1.9\ 10^{-6}$	$2.4\ 10^{-5}$	$6.5\ 10^{-6}$	$1.0\ 10^{-5}$	$3.2\ 10^{-6}$	$2.6\ 10^{-6}$
0.5	$1.70\ 10^{-5}$	$1.3\ 10^{-5}$	$1.5\ 10^{-5}$	$1.3\ 10^{-5}$	$3.0\ 10^{-6}$	$3.5\ 10^{-6}$
0.7	$7.0\ 10^{-5}$	$8.0\ 10^{-6}$	$5.9\ 10^{-5}$	$8.9\ 10^{-6}$	$2.4\ 10^{-5}$	$9.9\ 10^{-6}$
0.9	$1.4\ 10^{-5}$	$6.2\ 10^{-6}$	$1.3\ 10^{-5}$	$7.4\ 10^{-4}$	$1.8\ 10^{-3}$	$5.1\ 10^{-5}$

HERA-LHC: hep-ph/0511119



the tolerance criterium allows a good treatment of incompatible data, but it is by definition tuned on data and parametrizations.

HERA-LHC: experimental data

NNPDF1.0

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

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 (29)	$\tilde{\sigma}^{NC(CC),+}$
ZEUS02	92 (26)	$\tilde{\sigma}^{NC(CC),-}$
ZEUS03	90 (30)	$\tilde{\sigma}^{NC(CC),+}$
H1lx97	135	$\tilde{\sigma}^{NC,+}$
H197	130 (25)	$\tilde{\sigma}^{NC(CC),+}$
H199	139 (28)	$\tilde{\sigma}^{NC(CC),-}$
H100	147 (28)	$\tilde{\sigma}^{NC(CC),+}$
H108	8	F_L
CHORUS	471 (471)	$\tilde{\sigma}^{\nu(\bar{\nu})}$
Total	3161	

NNPDF_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

	NNPDF1.0	NNPDF_bench
Evolution	Fully Truncated	Iterated
Pert. Order	NLO	NLO
$Q_0^2\,(GeV^2)$	2	**2.25**
Heavy Quarks	ZM-VFN	ZM-VFN
$m_c\,(GeV)$	$\sqrt{2}$	1.5
$m_b\,(GeV)$	4.3	4.5
$\alpha_s\,(M_Z)$	0.119	**0.112**
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

HERA-LHC: $\chi^2/d.o.f.$

- **NNPDF1.0**

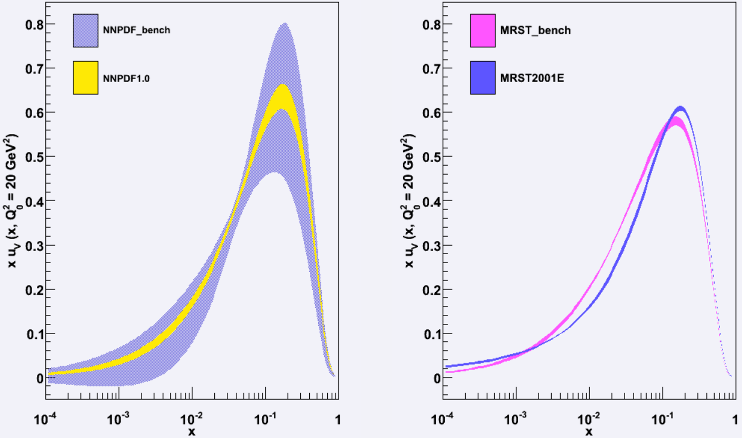
Name	χ^2
NMC_pd	1.53
NMC	1.70
BCDMS	1.59
ZEUS	1.11
H1	1.03
SLAC	1.27
CHORUS	1.40
FLH108	1.62
Total	1.34

- **NNPDF_bench**

Name	χ^2
NMC_pd	1.28
NMC	1.47
BCDMS	1.33
ZEUS97	1.11
H1lx97	1.05
Total	1.26

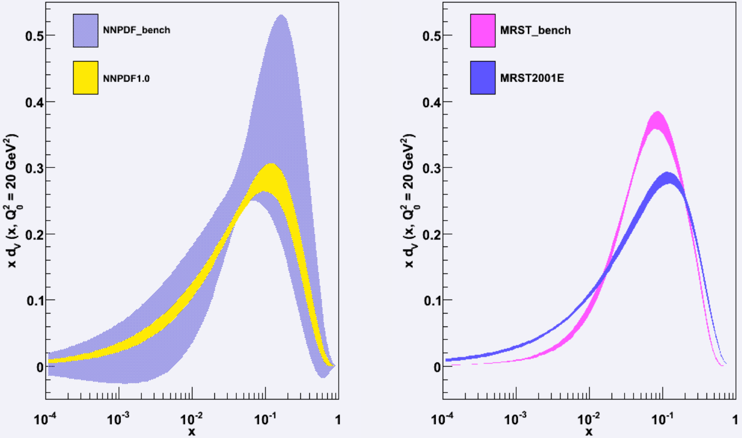
HERA-LHC: $u_V(x)$

same central values, different error bands



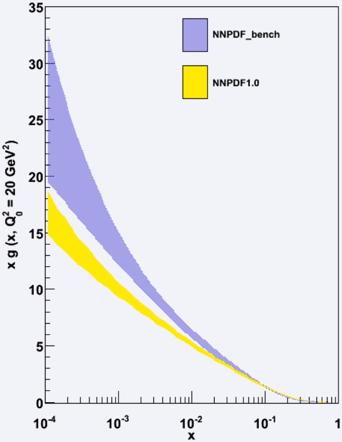
HERA-LHC: $d_V(x)$

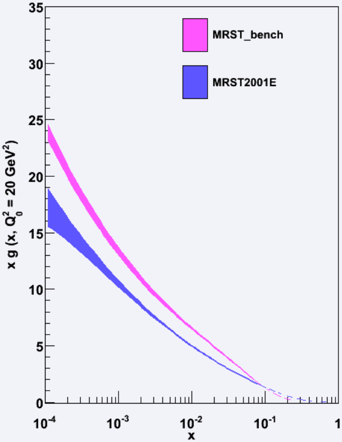
same central values, different error bands



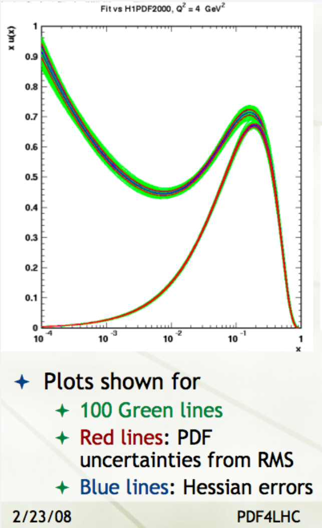
HERA-LHC: $g(x)$

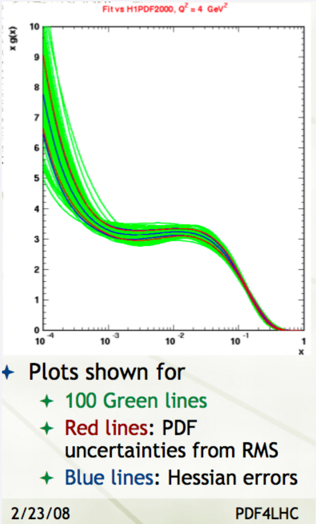
same central values, different error bands





H1 benchmark (radescu's talk @ pdf4lhc)





H1: experimental data

NNPDF1.0

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

Name	Data points	Target
NMC_pd	153	F_2^d/F_2^p
NMC	245	F_2^p
SLAC	47 (47)	$F_2^{p(d)}$
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H1lx97	135	$\tilde{\sigma}^{NC,+}$
H197	130 (25)	$\tilde{\sigma}^{NC(CC),+}$
H199	139 (28)	$\tilde{\sigma}^{NC(CC),-}$
H100	147 (28)	$\tilde{\sigma}^{NC(CC),+}$
H108	8	F_L
CHORUS	471 (471)	$\tilde{\sigma}^{\nu(\bar{\nu})}$
Total	3161	

NNPDF_bench

$Q^2 > 3.5\ GeV^2$

Name	Data points	Target
H1lx97	80 + 35	$\tilde{\sigma}^{NC,+}$
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	614	

theoretical assumptions

	NNPDF1.0	NNPDF_bench
Evolution	Fully Truncated	Iterated
Pert. Order	NLO	NLO
$Q_0^2\,(GeV^2)$	2	4
Heavy Quarks	ZM-VFN	ZM-VFN
$m_c\,(GeV)$	$\sqrt{2}$	1.96
$m_b\,(GeV)$	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	0.33 $(+f_c = 0.15)$
TMC	included	

$+$ Momentum and valence sum rules

H1: $\chi^2/d.o.f.$

NNPDF1.0

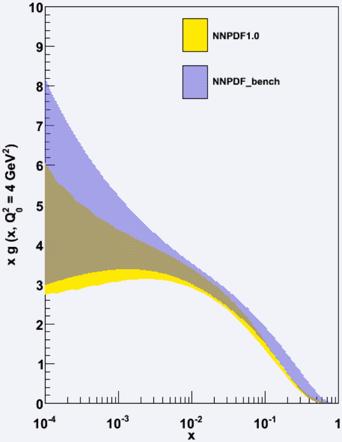
Name	χ^2
NMC_pd	1.53
NMC	1.70
BCDMS	1.59
ZEUS	1.11
H1	1.03
SLAC	1.27
CHORUS	1.40
FLH108	1.62
Total	1.34

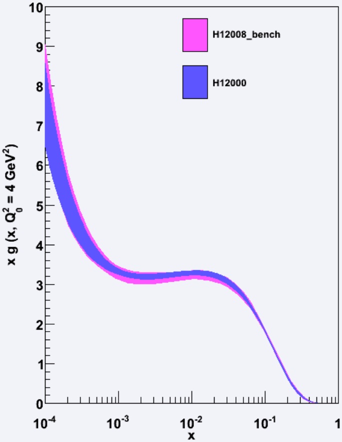
NNPDF_bench

Name	χ^2
H197mb	0.82
H197lowQ2	0.87
H197NC	0.80
H197CC	0.97
H199NC	1.01
H199CC	0.84
H199NChy	0.35
H100NC	1.00
H100CC	1.38
Total	0.96

H1: $g(x)$

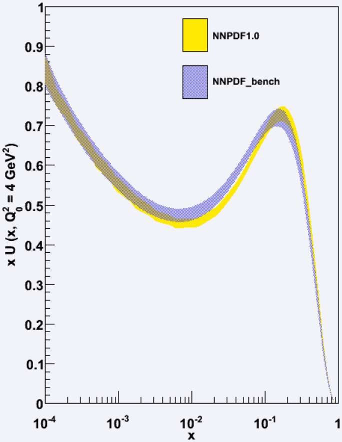
differences in the evolution code, in the input parametrization and in the minimization/stopping → different central values and different error bands

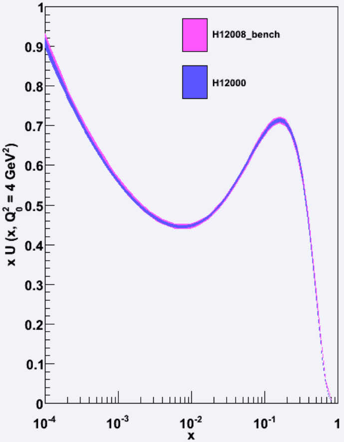




H1: $U(x)$

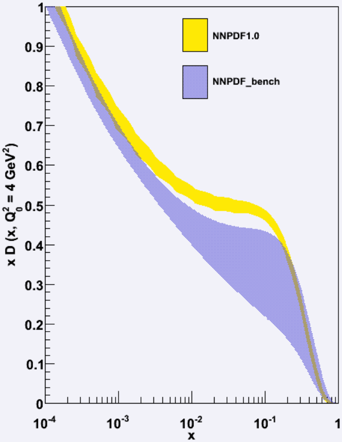
differences in the evolution code, in the input parametrization and in the minimization/stopping → similar central values and different error bands

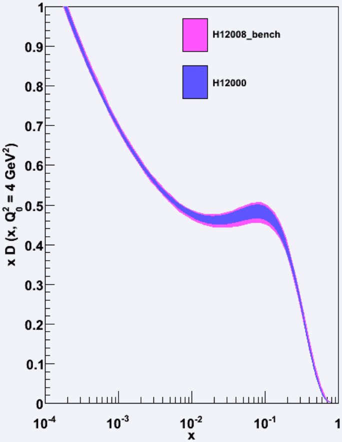




H1: $D(x)$

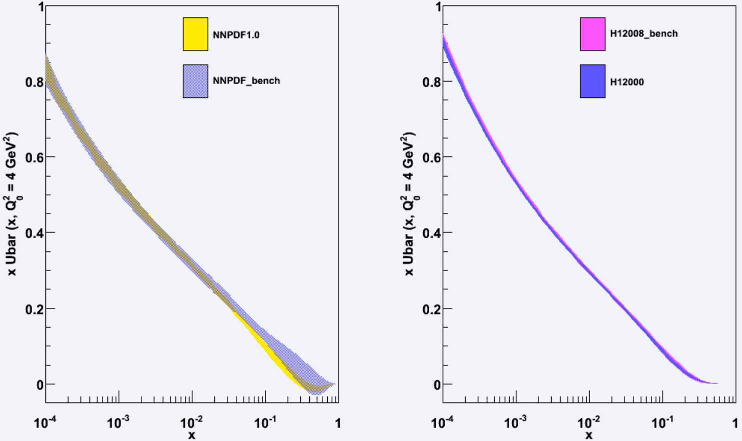
differences in the evolution code, in the input parametrization and in the minimization/stopping $\rightarrow$ different central values and different error bands





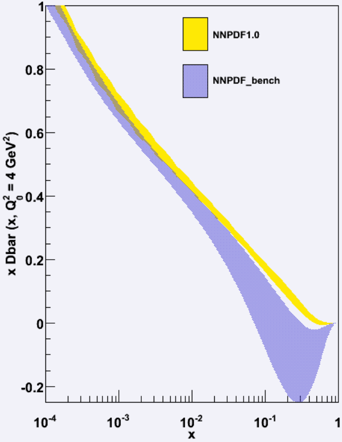
H1: $\bar{U}(x)$

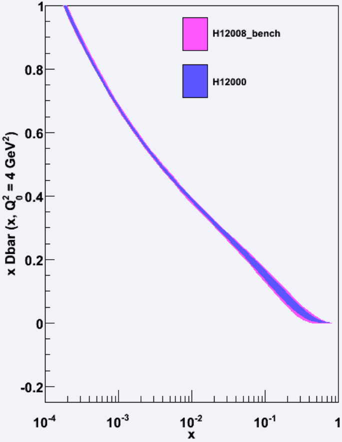
differences in the evolution code, in the input parametrization and in the minimization/stopping $\rightarrow$ similar central values and different error bands



H1: $\bar{D}(x)$

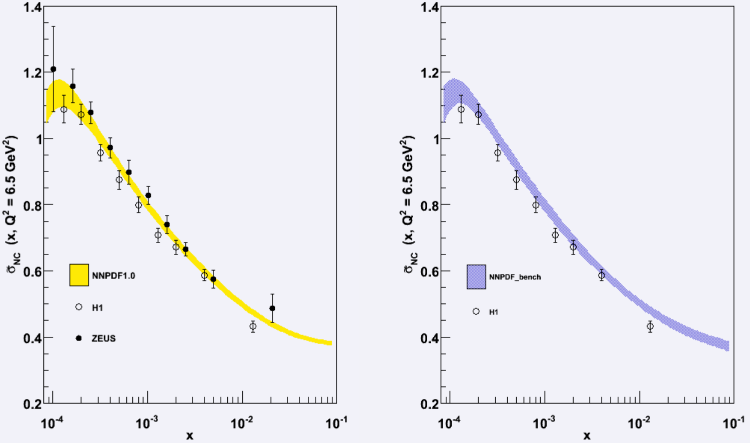
differences in the evolution code, in the input parametrization and in the minimization/stopping → different central values and different error bands





H1: error reduction

if data are hardly compatible, no error reduction is observed



standard candles - addendum

	$\sigma_{W^+}\mathcal{B}_{l^+\nu_l}$	$\Delta\sigma_{W^+}/\sigma_{W^+}$	$\sigma_{W^-}\mathcal{B}_{l^-\nu_l}$	$\Delta\sigma_{W^-}/\sigma_{W^-}$	$\sigma_Z\mathcal{B}_{l^+l^-}$	$\Delta\sigma_Z/\sigma_Z$
NNPDF1.0	11.83 ± 0.26	2.2%	8.41 ± 0.20	2.4%	1.95 ± 0.04	2.1%
CTEQ6.1	11.65 ± 0.34	2.9%	8.56 ± 0.26	3.0%	1.93 ± 0.06	3.1%
MRST01	11.71 ± 0.14	1.2%	8.70 ± 0.10	1.1%	1.97 ± 0.02	1.0%
CTEQ6.5	12.54 ± 0.29	2.3%	9.19 ± 0.22	2.4%	2.07 ± 0.04	1.9%

these results have been evaluated with MCFM modifying its standard input as follows:

```
'tota'     [part 'lord','real' or 'virt','tota']
91.187d0   [scale:QCD scale choice]
-1d0       [facscale:QCD fac scale choice]
```

when we evaluate the W cross sections, while for the Z also

```
1d0        [m34min]
```

in order to allow for benchmarks, let's set and deliver a given set for MCFM inputs.

summary

- standard polynomial fits may underestimate the error band when there are incompatibilities, thus enforcing the need of some tolerance criterium to take them into account;
- standard polynomial fits may underestimate the error band in the extrapolation region due to a rigid parametrization;
- NNPDF technique is suitable to study how much the error band depends on incompatible data and how much on parametrization bias;
- a conservative set is coming soon with the cuts decided in July

$$Q^2 > 10\, GeV^2 \,, x > 10^{-4} \,, W^2 > 20\, GeV^2 \,.$$

NNPDF1.0: arXiv:0808.1231