

# LHAPDF Interface Development

Dimitri Bourilkov

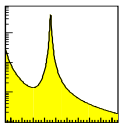
(in collaboration with Craig Group,  
Mike Whalley)

University of Florida

DESY, HERA-LHC Workshop

- **P.D.F. uncertainties and the LHAPDF library version 3**
- **The LHAGLUE interface v3**
- **Checks with Drell-Yan pairs at LHC**
- **Outlook**

e-Print Archive: [hep-ph/0305126](http://hep-ph/0305126)  
<http://cern.ch/bourilkov/heralhc2.{ps.gz,pdf}>



Les Houches Accord P.D.F. work with P.D.F. sets

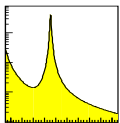
Maintained / developed by Mike Whalley

<http://durpdg.dur.ac.uk/lhapdf/index.html>

Rich set of PDF “families” available: CTEQ, MRST, Fermi, Alekhin, Botje, ZEUS (new)

More new and legacy sets available (CTEQ4, CTEQ5, MRST2003)

- a “fit” to the data is represented by a P.D.F. set with many members; member ZERO is the best fit, the others are used for uncertainties
- uncertainties on observables are estimated by calculating the observable for ALL members of the set (lots of CPU time!)



Developed for LHAPDF v1, now upgraded for v3,  
easier to use with each version.

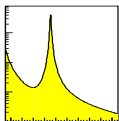
Isolate MC generators from details of LHAPDF li-  
brary, features, names and locations of PDF sets etc.  
Use existing hooks to PDFLIB.

Interfaced to PYTHIA 6.2, HERWIG 6.5 and  
MC @ NLO 2.3

Available as stand-alone application as well

New in v3:

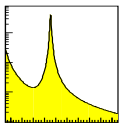
- Will come together with LHAPDF, so the user just needs to link one library.
- New 5-digit numbering scheme to accomodate legacy, new and future PDF sets.
- Option to “freeze“ the PDFs at the edges of validity in  $x$  or  $Q^2$  or to extrapolate them at own risk.



# New 5-digit Numbering Scheme

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Description	LHpdf	LHgrid	Filename/Member	$x_{min}$	$Q_{min}^2$	$Q_{max}^2$
CTEQ6m (central value)	10000	10050	CTEQ6m 0	$10^{-6}$	1.69	$10^8$
CTEQ6 (40 error sets)	10001-10040	10051-10090	CTEQ6 1-40	$10^{-6}$	1.69	$10^8$
CTEQ61 (LO fit/NLO alphas)	10041	-	CTEQ61 0/1	$10^{-6}$	1.69	$10^8$
CTEQ61l (LO fit/LO alphas)	10042	-	CTEQ61l 0/1	$10^{-6}$	1.69	$10^8$
CTEQ61 (central value)	10100	10150	CTEQ61 0	$10^{-6}$	1.69	$10^8$
CTEQ61 (40 error sets)	10101-10140	10151-10190	CTEQ61 1-40	$10^{-6}$	1.69	$10^8$
CTEQ5m (Standard MSbar)	-	19050	CTEQ5m 0/1	$10^{-5}$	1.00	$10^8$
CTEQ5m1 (updated CTEQ5m)	-	19051	CTEQ5m1 0/1	$10^{-5}$	1.00	$10^8$
CTEQ5d (Standard DIS)	-	19060	CTEQ5d 0/1	$10^{-5}$	1.00	$10^8$
CTEQ5l (LO fit)	-	19070	CTEQ5l 0/1	$10^{-5}$	1.00	$10^8$
CTEQ4m (Standard MSbar)	-	19150	CTEQ4m 0/1	$10^{-5}$	2.56	$10^8$
CTEQ4d (Standard DIS)	-	19160	CTEQ4d 0/1	$10^{-5}$	2.56	$10^8$
CTEQ4l (LO fit)	-	19170	CTEQ4l 0/1	$10^{-5}$	2.56	$10^8$
MRST2001nlo (Standard MSbar)	20000	20050	MRST2001nlo 0/1	$10^{-5}$	1.25	$10^7$
MRST2001nlo (lower $\alpha_S$ )	20002	20052	MRST2001nlo 2	$10^{-5}$	1.25	$10^7$
MRST2001nlo (higher $\alpha_S$ )	20003	20053	MRST2001nlo 3	$10^{-5}$	1.25	$10^7$
MRST2001nlo (Jet Fit)	20004	20054	MRST2001nlo 4	$10^{-5}$	1.25	$10^7$
MRST2001lo (LO fit)	-	20060	MRST2001lo 0/1	$10^{-5}$	1.25	$10^7$
MRST2001nlo (NNLO fit)	-	20070	MRST2001nlo 0/1	$10^{-5}$	1.25	$10^7$
MRST2001E (central value)	20100	20150	MRST2001E 0	$10^{-5}$	1.25	$10^7$
MRST2001E (30 error sets)	20101-20130	20151-20180	MRST2001E 1-30	$10^{-5}$	1.25	$10^7$
MRST2002nlo (Standard MSbar)	20200	20250	MRST2002nlo 0/1	$10^{-5}$	1.25	$10^7$
MRST2002nlo (NNLO fit)	-	20270	MRST2002nlo 0/1	$10^{-5}$	1.25	$10^7$
MRST2003cnlo (NLO - restricted)	20300	20350	MRST2003cnlo 0/1	$10^{-3}$	10.0	$10^7$
MRST2003cnnlo (NNLO - restricted)	-	20370	MRST2003cnnlo 0/1	$10^{-3}$	7.0	$10^7$
MRST98 (central gluon/ $\alpha_s$ )	29000	-	MRST98 0/2	$10^{-5}$	1.25	$10^7$
MRST98 (lower gluon)	29001	-	MRST98 1	$10^{-5}$	1.25	$10^7$
MRST98 (higher gluon)	29003	-	MRST98 3	$10^{-5}$	1.25	$10^7$
MRST98 (lower $\alpha_s$ )	29004	-	-	$10^{-5}$	1.25	$10^7$
MRST98 (higher $\alpha_s$ )	29005	-	-	$10^{-5}$	1.25	$10^7$
Fermi2002_100 (101 sets)	30100-30200	-	Fermi2002_100 0-100	?	?	?
Fermi2002_1000 (1001 sets)	31000-32000	-	Fermi2002_1000 0-1000	?	?	?
Alekhin_100 (101 sets)	40100-40200	-	Alekhin_100 0-100	?	?	?
Alekhin_1000 (1000 sets)	41000-41999	-	Alekhin_1000 0-999	?	?	?
Alekhin2002 (LO - cent val)	-	40350	a02_lo_v 0	$10^{-7}$	0.8	$2 \times 10^8$
Alekhin2002 (NLO - cent val)	-	40450	a02_nlo_v 0	$10^{-7}$	0.8	$2 \times 10^8$
Alekhin2002 (NNLO - cent val)	-	40550	a02_nnlo_v 0	$10^{-7}$	0.8	$2 \times 10^8$
Alekhin2002 (LO VFN 15 sets)	-	40351-40365	a02_lo_v 1-15	$10^{-7}$	0.8	$2 \times 10^8$
Alekhin2002 (NLO VFN 15 sets)	-	40451-40465	a02_nlo_v 1-15	$10^{-7}$	0.8	$2 \times 10^8$
Alekhin2002 (NNLO VFN 15 sets)	-	40551-40565	a02_nnlo_v 1-15	$10^{-7}$	0.8	$2 \times 10^8$
Botje_100 (101 sets)	50100-50200	-	Botje_100 0-100	?	?	?
Botje_1000 (1000 sets)	51000-51999	-	Botje_1000 0-999	?	?	?
ZEUS2002 (VFN/TR cent value)	60000	-	ZEUS2002_TR 0	$10^{-6}$	0.3	$2 \times 10^5$
ZEUS2002 (ZM cent value)	60100	-	ZEUS2002_ZM 0	$10^{-6}$	0.3	$2 \times 10^5$
ZEUS2002 (FF cent value)	60200	-	ZEUS2002_FF 0	$10^{-6}$	0.3	$2 \times 10^5$
ZEUS2002 (VFN/TR 22 sets)	60001-60022	-	ZEUS2002_TR 1-22	$10^{-6}$	0.3	$2 \times 10^5$
ZEUS2002 (ZM 22 sets)	60101-60122	-	ZEUS2002_ZM 1-22	$10^{-6}$	0.3	$2 \times 10^5$
ZEUS2002 (FF 22 sets)	60201-60222	-	ZEUS2002_FF 1-22	$10^{-6}$	0.3	$2 \times 10^5$
Unused	70000-99999	70050-9995+	-			



## Consistency Checks

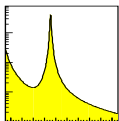
*D. Bourilkov*

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Cross sections with PYTHIA 6.221, Herwig 6.504;  
samples of 10000 events for each PDF member, no  
unfolding of MC errors ( $\sim 0.5\%$ )

No special care to make sure that all input  
(default) parameters are exactly the same - this is  
a technical check, NOT a detailed physics study

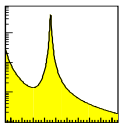
- in general good agreement between PDF sets



# LHC Results

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Cross sections for Drell-Yan in [pb] - LHC 14 TeV				
PYTHIA			HERWIG	
PDF set	LHAGLUE v2	LHAGLUE v3	LHAGLUE v2	v3
CTEQ6	1673 ± 64	1673 ± 64	1636 ± 63	
CTEQ6l	1538	1538	1500	
CTEQ6ll	1647	1647	1608	
CTEQ61(one)	1659 ± 76	1659 ± 76	1624 ± 78	
CTEQ5m	1802	1802	1756	
CTEQ5m1	1711	1711	1667	
CTEQ5d	-	1684	-	
CTEQ5l	-	1642	-	
CTEQ4m	-	1752	-	
CTEQ4d	-	1653	-	
CTEQ4l	-	1640	-	
MRST2001nlo MS	1699	1699	1650	
MRST2001nlo low	-	1692	-	
MRST2001nlo high	-	1740	-	
MRST2001nlo JetF	-	1686	-	
MRST2001lo	1595	1595	1556	
MRST2001nnlo	1656	1656	1617	
MRST2001E	1682 ± 26	1682 ± 26	1645 ± 28	
MRST2002nlo	1693	1693	1652	
MRST2002nnlo	-	1657	-	
MRST2003cnlo	-	1374 ?!	-	
MRST2003cnnlo	-	1399 ?!	-	
MRST98	1684	1684	1639	
Fermi2002_100	1391 ± 28	1391 ± 28	1364 ± 27	
Fermi2002_1000	1418 ± 27	1418 ± 27	1391 ± 27	
Alekhin_100	1763 ± 65	1763 ± 65	1722 ± 64	
Alekhin_1000	1793 ± 64	1793 ± 64	1744 ± 64	
a02_lo_v	1706	1590	1668	
a02_nlo_v	1841	1756	1792	
a02_nnlo_v	1864	1765	1813	
Botje_100	1850 ± 47	1850 ± 47	1802 ± 46	
Botje_1000	1891 ± 46	1891 ± 46	1843 ± 45	
ZEUS2002 VFN/TR	-	1731	-	
ZEUS2002 ZM	-	1749	-	
ZEUS2002 FF	-	1742	-	



- LHAGLUE v3 ready to go together with LHAPDF v3 (release expected soon)
- Many new and legacy PDF sets available
- Easier to use
- All PDF sets/members tested successfully
- Looking forward to user feedback