LesHouchesAccordPDF
Status Report and Future Plans

MC4LHC Workshop
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Mike Whalley
IPPP, Durham, UK

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Outline

- Introduction & Recap - what is LHAPDF
- Installation of LHAPDF - download/install
- Using LHAPDF
- PDF sets included in LHAPDF
- Changes to the C++ wrapper
- The Memory Problem
- User Defined PDF sets
- Future Plans

Introduction & Recap
the beginning

The story so far….

- 2001 Les Houches meeting – LHAPDF interface was conceived to enable the usage of (the then newly emerging) PDF sets with uncertainties in a uniform manner.

- It was also to be viewed as a potential successor to PDFLIB.

- 2002 Walter Giele (Fermilab) produced the first LHAPDF (Fortran) code:-

  - On-the-fly evolution to higher Q scales starting from the parameterised fits at the fitting scale Q0.
  - A PDF sets could contain multiple members (eg error sets)
  - Very compact and easily updated – just add new parameters.
  - Incorporated 2 evolution codes QCDNUM and CTEQ's own.

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Introduction & Recap
some problems and their solution

(big) BUT …..

in order to have a usable PDFLIB replacement there were problems.

- The parameterisations were not always available for all sets.
- The specific evolution code used by the authors was not always available.
- It was slow in some circumstances – especially the initialisation phase.

so (in 2003*) …..

A hybrid was developed which incorporated:

- using the interpolation grids and codes given by the PDF authors (.LHgrid)
- plus Walter's elegant on-the-fly evolution method. (.LHpdf)

(*This is when I became involved)

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Introduction & Recap
making a complete solution

ALSO …..

In order to have a comprehensive PDFLIB replacement there were other features needed:-

- To enable easy incorporation into existing programs: an (alternative) interface which looked like PDFLIB (ie PDFSET, STRUCTM, etc..)
- Availability of other key PDF sets, eg. photons and pions.
- Availability of some older nucleon PDF sets for comparisons.
- Ability to calculate Nuclear PDFs.
- Ability to add a user's own PDF set.
- Ability to use more than one PDF set in the same programme without having to re-initialise each time.

Over the intervening time all the above - and more - have been added in various stages.

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Who has responsibility now for LHAPDF ?

- MW - Durham
  - PDF fortran code, PDF grid files, documentation, new releases etc...

- Andy Buckley - (ex-Durham, now Edinburgh)
  - gnu autotools and libtool distribution, C++ wrapper, python code, etc...

Timeline of the development of LHAPDF

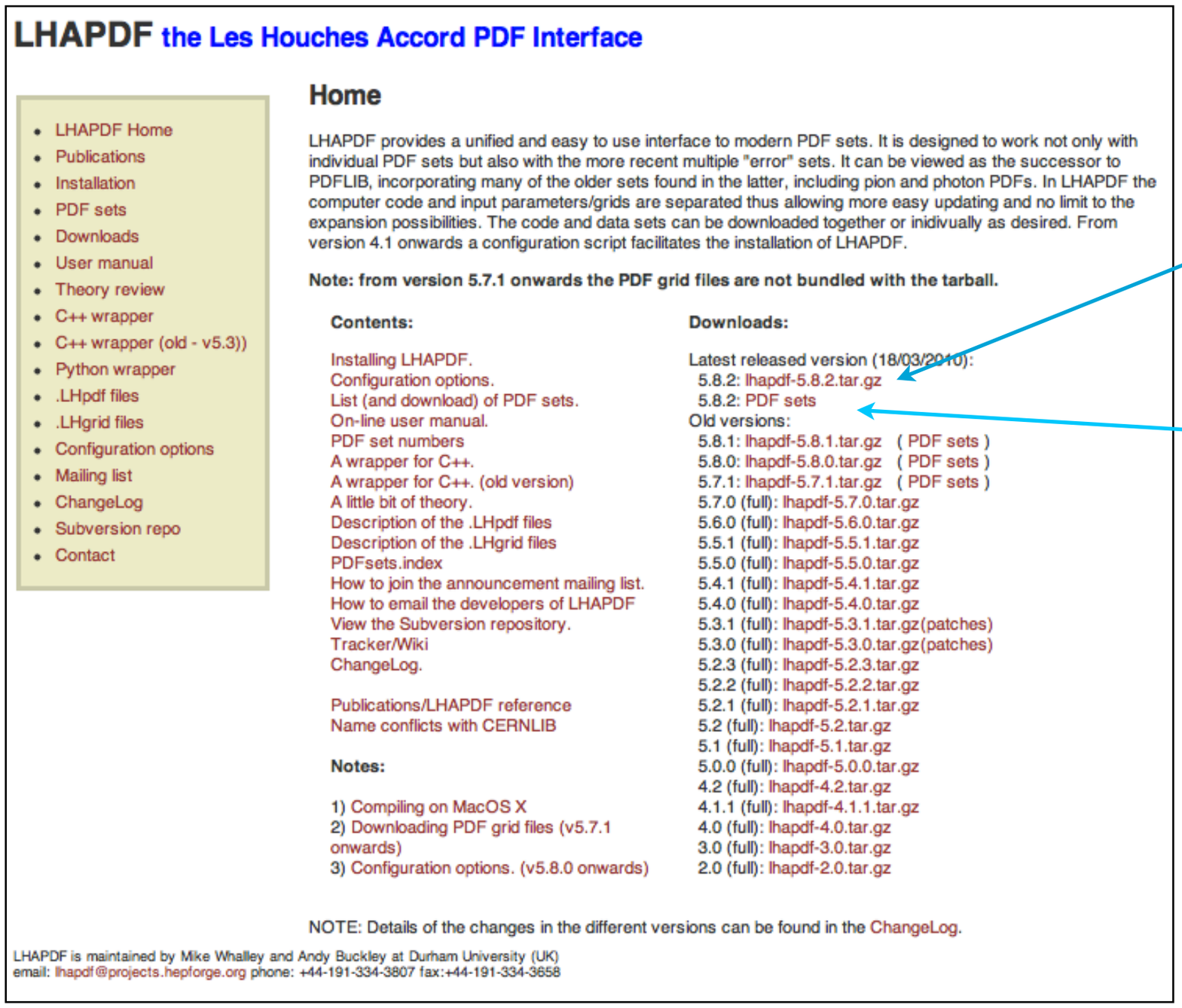
2002	V1	Original implementation by WG	
2003	V2	PDF grid interpolation method + single compilation	
2004	V3	PDFLIB-like LHAglue wrapper + numbering scheme	
2005	V4	Pion/Photons + changed file structure	
	V4.1 V4.2	Moved into hepforge + gnu auto-tools Makefile generation	
2006 2007 2008	V5.0 V5.1 V5.2 V5.2.1 V5.2.2 V5.2.3 V5.3.0 V5.3.1	Multi-PDFset initialization + Bug fixes + libtools library building + New PDF sets + Nuclear PDFs + User PDFs …. etc…	
2009 2010	V5.4.0 V5.4.1 V5.5.0 V5.5.1 V5.6.0 V5.7.0 V5.7.1 V5.8.0 V5.8.1 V5.8.2	‘lite’ versions added for low-memory option Removed bundling of pdf sets with tarball Introduce building for specific pdf sets only User defined grid files+interpolation	cteq66 MRST2007lomod,MRSTMCal HERAPDF01,NNPDF10,GJR. JR09FFnnlo,NNPDF11 MSTW... JR09VFnnlo HERAPDF10 NNPDF20 abkm09 CT09MCx

Downloading and Installing LHAPDF

- Since V4.1 LHAPDF has been hosted by hepforge*
- We do not provide precompiled system specific libraries.
- Use the gnu build system, autotools to construct a configure script capable of constructing a Makefile to build LHAPDF on the specific system. Then use gnu libtool to build both the static and dynamic shared libraries libLHAPDF.a and libLHAPDF.so which can be used in linking to a user's programme.
- There is the option of installing either to a standard location /usr/local or to a location of the user's choice (--prefix option).
- Tested on a variety of systems and compilers including:
  f77, g77, gfortran, f95, ifort - SL4, fedora 5, ubuntu, mac OS X, solaris, amd64

* hepforge is a part of the CEDAR project providing a development environment for hep projects (see next slide).

LHAPDF Installation



LHAPDF the Les Houches Accord PDF Interface

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- User manual
- Theory review
- C++ wrapper
- C++ wrapper (old - v5.3))
- Python wrapper
- .LHpdf files
- .LHgrid files
- Configuration options
- Mailing list
- ChangeLog
- Subversion repo
- Contact

Home

LHAPDF provides a unified and easy to use interface to modern PDF sets. It is designed to work not only with individual PDF sets but also with the more recent multiple "error" sets. It can be viewed as the successor to PDFLIB, incorporating many of the older sets found in the latter, including pion and photon PDFs. In LHAPDF the computer code and input parameters/grids are separated thus allowing more easy updating and no limit to the expansion possibilities. The code and data sets can be downloaded together or inidivually as desired. From version 4.1 onwards a configuration script facilitates the installation of LHAPDF.

Note: from version 5.7.1 onwards the PDF grid files are not bundled with the tarball.

Contents:

Installing LHAPDF.
Configuration options.
List (and download) of PDF sets.
On-line user manual.
PDF set numbers
A wrapper for C++.
A wrapper for C++. (old version)
A little bit of theory.
Description of the .LHpdf files
Description of the .LHgrid files
PDFsets.index
How to join the announcement mailing list.
How to email the developers of LHAPDF
View the Subversion repository.
Tracker/Wiki
ChangeLog.

Publications/LHAPDF reference
Name conflicts with CERNLIB

Notes:

1) Compiling on MacOS X
2) Downloading PDF grid files (v5.7.1 onwards)
3) Configuration options. (v5.8.0 onwards)

Downloads:

Latest released version (18/03/2010):
5.8.2: lhapdf-5.8.2.tar.gz
5.8.2: PDF sets
Old versions:
5.8.1: lhapdf-5.8.1.tar.gz (PDF sets)
5.8.0: lhapdf-5.8.0.tar.gz (PDF sets)
5.7.1: lhapdf-5.7.1.tar.gz (PDF sets)
5.7.0 (full): lhapdf-5.7.0.tar.gz
5.6.0 (full): lhapdf-5.6.0.tar.gz
5.5.1 (full): lhapdf-5.5.1.tar.gz
5.5.0 (full): lhapdf-5.5.0.tar.gz
5.4.1 (full): lhapdf-5.4.1.tar.gz
5.4.0 (full): lhapdf-5.4.0.tar.gz
5.3.1 (full): lhapdf-5.3.1.tar.gz(patches)
5.3.0 (full): lhapdf-5.3.0.tar.gz(patches)
5.2.3 (full): lhapdf-5.2.3.tar.gz
5.2.2 (full): lhapdf-5.2.2.tar.gz
5.2.1 (full): lhapdf-5.2.1.tar.gz
5.2 (full): lhapdf-5.2.tar.gz
5.1 (full): lhapdf-5.1.tar.gz
5.0.0 (full): lhapdf-5.0.0.tar.gz
4.2 (full): lhapdf-4.2.tar.gz
4.1.1 (full): lhapdf-4.1.1.tar.gz
4.0 (full): lhapdf-4.0.tar.gz
3.0 (full): lhapdf-3.0.tar.gz
2.0 (full): lhapdf-2.0.tar.gz

NOTE: Details of the changes in the different versions can be found in the ChangeLog.

LHAPDF is maintained by Mike Whalley and Andy Buckley at Durham University (UK)
email: lhapdf@projects.hepforge.org phone: +44-191-334-3807 fax:+44-191-334-3658

Download the latest version from here

Note that the PDF sets are separate

- tar -xzf lhapdf.5.8.2.tar.gz
- configure .....
- make
- make install

http://projects.hepforge.org/lhapdf/

Configuration Options

```
configure --help
```

```
configure --prefix=$home/local
```

defines installation directory
default = /usr/local (needs root)

If you don't want various features (or they don't work on your machine) then you can always disable them:

```
--disable-lhaglue       build without PDFLIB compatibility routines
--disable-ccwrap        build without C++ wrapper
--disable-old-ccwrap    build without deprecated C++ wrapper
--disable-doxygen       don't try to make Doxygen documentation
--disable-pyext         don't build Python module (default=build)
--disable-octave        don't try to make Octave interface
```

more about these later.....

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Downloading and installing LHAPDF

installation schematic

lhapdf-5.8.2.tar.gz

tar –xzf

lhapdf-5.8.2/

examples/
src/
(Makefile)
configure
libtool
INSTALL
ccwrap/
ChangeLog
README
PDFsets.index

examples
Example1.f
lhapdf-example1
Makefile

src
.f files
.inc files

ccwrap
LHAPDF.cc
.h/.cc/.f files

configure –prefix=$home/local/ → make → make install → make clean

WARNING!
Do not install in the build directory

$home/local/ bin/ lhapdf-getdata
lib/ libLHAPDF.a
libLHAPDF.so
.....
share/ lhapdf/PDFsets.index
include/LHAPDF/LHAPDF.h
.....

Using LHAPDF
PDF set initialization

The location of the PDFsets files have to be specified either:

in the argument of InitPDFset('*fully-qualified-name*')

or, in this order of precedence:

- **call SetPDFPath(*'/path/to/PDFsets'*)**
- Environmental variable **$LHAPATH**
- Determines itself using **binreloc** (5.4.0 onwards)

Selecting which PDFset to use:

call InitPDFset('*fully-qualified-name'*)

call InitPDFsetByName('*name'*)

Which PDFset member to use:

call InitPDF(*member*)

'native' LHAPDF

parm(1)='DEFAULT'
value(1)=*lhaglue number*

parm(1)='PYTHIA'
parm(1)='HERWIG'

Input lhaglue number through specific parameters

call PDFSET(*parm,value*)

LHAglue/PDFLIB-like

PDFsets numbers for lhaglue

http://projects.hepforge.org/lhapdf/

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Publications/LHAPDF reference

User supplied Tips & Tricks:

1) Importing lhapdf-wrapper into ROOT

NOTE: Details of the changes in the different versio

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email:m.r.whalley@durham.ac.uk phone:+44-191-334-3807 fax:+44-191-334-3658

A PDF set numbers and names

Notes:

- **When using the LHAGLUE initialization method:**
  - The columns headed .LHpdf and .LHgrid give the set numbers to use with LHAGLUE
- **When Using the direct LHAPDF initialization routines:**
  - The .LHpdf and .LHgrid columns show the availablity of the respective files
  - The File Name and Member columns give the names to use in the direct LHAPDF initialization routines.
  - .LHpdf or .LHgrid has to be appended to the File Name depending the availability of that file (as indicated in the table) and wishes of the user.

Proton PDFs

r>

PDF set	.LHpdf	.LHgrid	File Name	Member	Xmin	Xmax	Q2min GeV^2	Q2max GeV^2
CTEQ6m (central value)	10000	10050	cteq6m	0	10^{-6}	1	1.69	10^8
CTEQ6 (40 error sets)	10001-10040	10051-10090	cteq6 | cteq6mE	1-40	10^{-6}	1	1.69	10^8
CTEQ6l (LO fit/NLO alphas)	10041	-	cteq6l	0/1	10^{-6}	1	1.69	10^8
CTEQ6ll (LO fit/LO alphas)	10042	-	cteq6ll	0/1	10^{-6}	1	1.69	10^8
CTEQ61 (central value)	10100	10150	cteq61	0	10^{-6}	1	1.69	10^8
CTEQ61 (40 error sets)	10101-10140	10151-10190	cteq61	1-40	10^{-6}	1	1.69	10^8
CTEQ6AB (20 sets, variable alphas)	-	10250-10269	cteq6AB	0-19	10^{-6}	1	1.69	10^8

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Available PDF sets

Individual files can be downloaded from the right hand two columns

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Nucleon PDF Set Summary			
PDF set	Members	.LHpdf File(set number)	.LHgrid File(set number)
ABKM09 NLO (3flv)	26	-	abkm09_3_nlo.LHgrid(40650-)
ABKM09 NLO (5flv)	26	-	abkm09_5_nlo.LHgrid(40750-)
ABKM09 NNLO (3flv)	26	-	abkm09_3_nnlo.LHgrid(40850-)
ABKM09 NNLO (5flv)	26	-	abkm09_5_nnlo.LHgrid(40950-)
Alekhin02 LO	15	-	a02m_lo.LHgrid(40350)
Alekhin02 NLO	15	-	a02m_nlo.LHgrid(40450)
Alekhin02 NNLO	15	-	a02m_nnlo.LHgrid(40550)
Alekhin00	100	Alekhin_100.LHpdf(40100-)	-
Alekhin00	1000	Alekhin_1000.LHpdf(41000-)	-
Botje99	100	Botje_100.LHpdf(50100-)	-
Botje99	1000	Botje_1000.LHpdf(51000-)	-
CT09MCS (2lp a_s,mom sum rule.)	1	-	CT09MCS.LHgrid(10770)
CT09MC1 (1lp a_s,mom sum rule viol.)	1	-	CT09MC1.LHgrid(10771)
CT09MC2 (2lp a_s,mom sum rule viol.)	1	-	CT09MC2.LHgrid(10772)
CTEQ6lg (light-gluino)	8	-	cteq6lg.LHgrid(10670-)
CTEQ66a (cteq66a)	4	-	cteq66a.LHgrid(10660-)
CTEQ66c (cteq66c)	4		cteq66c.LHgrid(10650-)
CTEQ66alphas (cteq66 alphas var.)	5		cteq66alphas.LHgrid(10595-)
CTEQ66 (cteq66)	44		cteq66.LHgrid(10550-)
CTEQ65s (strange)	8	-	cteq65s.LHgrid(10460-)
CTEQ65c (cteq65c)	7		cteq65c.LHgrid(10450-)
CTEQ65 (cteq65)	40		cteq65.LHgrid(10350-)
CTEQ6AB (cteq6AB - variable alphas)	20		cteq6AB.LHgrid(10250-)
CTEQ61 (cteq61m + errors)	41	cteq61.LHpdf(10100-)	cteq61.LHgrid(10150-)

LHAPDF is maintained by Mike Whalley and
email: lhapdf@projects.hepforge.org phone:

ASCII readable
flat text file

PDFsets.index file

Installed into the
share/lhapdf
directory

```
19060 1 4 47 cteq5d.LHgrid  1  1.  100000000.  1.E-05  1. CTEQ5d(Standard_DIS)
19070 1 4 46 cteq5l.LHgrid  1  1.  100000000.  1.E-05  1. CTEQ5l(Leading_Order)
19150 1 4 34 cteq4m.LHgrid  1 2.56  100000000.  1.E-05  1. CTEQ4m(Standard_MSbar)
19160 1 4 33 cteq4d.LHgrid  1 2.56  100000000.  1.E-05  1. CTEQ4d(Standard_DIS)
19170 1 4 32 cteq4l.LHgrid  1 2.56  100000000.  1.E-05  1. CTEQ4l(Leading_Order)
20001 1 0 0 MRST2001nlo.LHpdf  1  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20002 1 0 0 MRST2001nlo.LHpdf  2  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20003 1 0 0 MRST2001nlo.LHpdf  3  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20004 1 0 0 MRST2001nlo.LHpdf  4  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20051 1 0 0 MRST2001nlo.LHgrid  1  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20052 1 0 0 MRST2001nlo.LHgrid  2  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20053 1 0 0 MRST2001nlo.LHgrid  3  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20054 1 0 0 MRST2001nlo.LHgrid  4  1.25  10000000.  1.E-05  1. MRST2001(NLO)
20060 1 0 0 MRST2001lo.LHgrid  1  1.25  10000000.  1.E-05  1. MRST2001(LO)
20070 1 0 0 MRST2001nnlo.LHgrid  1  1.25  10000000.  1.E-05  1. MRST2001(NNLO)
```

http://projects.hepforge.org/lhapdf/

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View the Subversion repository.
Tracker/Wiki
ChangeLog.

Latest released version (16/11/2007):
5.3.1 (full): lhapdf-5.3.1.tar.gz
5.3.1 (no pdf files): lhapdf-5.3.1-nopdf.tar.gz
Old versions:
5.3.0 (full): lhapdf-5.3.0.tar.gz(patches)
5.2.3 (full): lhapdf-5.2.3.tar.gz
5.2.2 (full): lhapdf-5.2.2.tar.gz
5.2.1 (full): lhapdf-5.2.1.tar.gz
5.2 (full): lhapdf-5.2.tar.gz
5.1 (full): lhapdf-5.1.tar.gz

LHnumber NType Ngroup Nset LHname LHmember q2min q2max xmin xmax comment

old PDFLIB numbers

NOTE: Details of the changes in the different versions can be found in the ChangeLog.

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email:m.r.whalley@durham.ac.uk phone:+44-191-334-3807 fax:+44-191-334-3658

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Using LHAPDF
routines to evaluate PDFs

call evolvePDF(*x,q,f*)

call evolvePDFp(*x,q,p2,ip2,f*)

call evolvePDFa(*x,q,a,f*)

call evolvePDFphoton(*x,q,f,photon*)
(mrst2004qed set only)

'native' LHAPDF

call STRUCTM(*x,q,upv,dnv,usea,dsea,str,chm,bot,glu*)

call STRUCTP(*x,q2,p2,ip2,upv,dnv,*……)

call STRUCTA(*x,q,a,upv,dnv,*……..)

beware the q2 here!

LHAglue/PDFLIB-like

f(-6,6)	0=gluon (-)1=(anti)down (-)2=(anti)up (-)3 =(anti)strange (-)4=(anti)charm (-)5=(anti)bottom (-)6=(anti)top

upv – up valence
dnv – down valence
dsea – up sea
dsea – down sea
etc…

all are x*pdf

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lhaglue numbering scheme

PDFsets included 5.8.2

10000 -> CTEQ
CT09MCx,cteq66,cteq66a,cteq66c,cteq65s, cteq65c, cteq6AB, cteq65 cteq61, cteq6,cteq5, cteq4

20000 -> MRST/MSTW
MSTW2008.....,MRSTMCal, MRST2007lomod, MRST2006nnlo, MRST2004qed, MRST2004FF, MRST2004, MRST2003c, MRST2002, MRST2001, MRST98

30000 -> Fermi
Fermi_100/1000

40000 -> Alekhin/ABKM
abkm09_3_nlo, abkm09_5_nlo, abkm09_3_nnlo, abkm09_3_nnlo
Alekhin_100/1000, Alekhin2002

50000 -> Botje
Botje_100/1000

60000 -> HERA/ZEUS
HERAPDF10_EIG, HERAPDF10_VAR, HERAPDF01
zeus2005, zeus2002

70000 -> H1
H12000

80000 -> (G)JR/GRV
JR09VFnnlo, JR09FFnnlo, GJR..., GRV98

90000 -> NNPDF
NNPDF10, NNPDF11, NNPDF12, NNPDF20

xxxx = .LHpdf
xxxx = .LHgrid
xxxx = both

Plus pdfs for
300 - photon
200 - pion
as in PDFLIB

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The memory problem

LHAPDF Version	Memory Size mbytes
2.0	97
3.0	101
4.0	114
5.2.0	128
5.3.0	298
5.4.0	457
5.5.1	473
5.6.0	975
5.7.0	1529
5.7.1	1546
5.8.0	1564
5.8.2	1803

```
Tasks: 156 total,   2 running, 154 sleeping,   0 stopped,   0 zombie
Cpu(s): 12.5%us,  7.4%sy,  0.0%ni, 76.3%id,  0.0%wa,  0.3%hi,  3.5%si,  0.0%st
Mem:  24727012k total, 12998360k used, 11728652k free,   501544k buffers
Swap: 50331640k total,        0k used, 50331640k free, 11601184k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
15548 whalley   20   0 1803m  60m 1480 R   92  0.2   0:03.00 lt-lhapdf-examp
 8364 whalley   20   0 70028 1884 1080 S   65  0.0   0:02.04 sshd
 8379 whalley   20   0 18992 1308  932 R    1  0.0   0:00.40 top
    1 root      20   0  4020  892  600 S    0  0.0   0:01.44 init
    2 root      15  -5     0    0    0 S    0  0.0   0:00.00 kthreadd
```

As more and more PDF sets have been added to LHAPDF the 'memory footprint' has gradually increased - latest version 5.8.2 needs 1.8 Gbytes.

This is clearly unacceptable!

The reason is that each set of PDFs has its own separate allocation of fortran arrays to store the PDF grids, even if they are not actually read in or used.

The problem is exacerbated by:
a) the storage of the multiple members in a PDF set.
b) the increase in array sizes to handle the multi-set initialisation.

Configuration Options

To help alleviate the ‘memory problem,’

```
configure --enable-low-memory
```

selects ‘lite’ option
only one member/set can be used

```
configure --with-max-num-pdfsets=1
```

turns off multi-set initialisation

```
--enable-pdfsets=LIST   comma-separated list of pdf sets to include. Options
                        are: mrst mrst06 mrst98 mrstqed cteq grv nnpdf mstw
                        gjr h1 zeus hera alekhin botje fermi hkn pions
                        photons user
```

LHAPDF Memory footprint mbytes

PDF GROUP	FULL	LOW-MEMORY	ONE-SET
mrst	222	72	59
mrst06	120	24	22
mrst98	67	67	58
mrstqed	197	26	21
cteq	102	38	24
grv	20	20	19
nnpdf	551	57	56
mstw	573	34	24
gjr	42	21	20
h1	26	20	19
zeus	67	67	56
hera	121	92	76
alekhin	95	68	58
botje	67	67	57
fermi	67	67	57
hkn	37	21	21
pions	20	20	20
photons	20	20	19
user	71	71	61
(ALL-one-set)			1127
ALL	1803	181	137

PDF groups

--enable-pdfsets=LIST

LIST is comma separated list of group names, positive or negative.

LOW-MEMORY

--enable-low-memory

ONE-SET

--with-max-num-pdfsets=1

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C++ wrapper (ccwrap)

Initially provided by Stefan Gieseke for V2 and updated through to V5.
Recently revamped by Andy Buckley.

It consists of:

ccwrap/LHAPDF.cc
ccwrap/LHAPDFfw.f
include/LHAPDF.h
include/LHAPDF/LHAPDFfw.h
include/LHAPDF/FortranWrappers.h
include/LHAPDF/LHAPDFConfig.h

The standard LHAPDF installation procedure now compiles the C++ routines into the standard libLHAPDF static (.a) and dynamic libraries (.so), along with the compiled Fortran routines installed in the /lib directory.

Previously it was a separate library libLHAPDFWrap

Can be disabled with configure –disable-ccwrap

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A C++ wrapper for the LHAPDF library

5.4

Introduction

The **LHAPDF** library provides a set of C++ wrapper functions for its Fortran subroutines. New users should browse this documentation and take a look at the `CCTest1.cc` and `CCTest2.cc` example program source files, which are good examples of how the wrapper is used.

Recent changes

The **LHAPDF** wrapper has been improved in several ways for the **LHAPDF** v5.4 release:

- String passing to the Fortran functions from C++ now correctly passes the hidden length argument, fixing problems on 64 bit systems;
- The `LHAPDFWrap` class has been deprecated in favour of a set of wrapper functions in the `LHAPDF` namespace. The class interface was misleading, since no persistent state was involved and two class instances would not have been independent;
- Proper C++ `std::string` arguments can now be used for set names: `char*` string arguments can still be passed, due to implicit conversion via the string(char*) constructor.

Credits

- Originally by Stefan Gieseke.
- Adapted for LHAPDFv4 by Mike Whalley.
- Adapted for LHAPDFv5 by Craig Group/Mike Whalley.
- v5.4: Fortran portability, tidying, extensions and conversion to namespaced functions by Andy Buckley.
- v5.4.1: Rationalised init functions and deprecated "M" functions by Andy Buckley.
- v5.5.1: Added PDFSetInfo set metadata struct, and associated querying based on reading the PDFsets.index file.

LHAPDF is maintained by Mike Whalley and Andy Buckley at Durham University (UK)
email: lhapdf@projects.hepforge.org phone: +44-191-334-3807 fax:+44-191-334-3658

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email: lhapdf@projects.hepforge.org phone: +4

Namespace List | Namespace Members

LHAPDF Namespace Reference

Namespace containing all the **LHAPDF** wrapper functions. More...

Classes

class **PDFSetInfo**
Structure containing metadata about a PDF set. More...

Enumerations

enum **Flavour** {
TBAR = -6, **BBAR** = -5, **CBAR** = -4, **SBAR** = -3,
UBAR = -2, **DBAR** = -1, **GLUON** = 0, **DOWN** = 1,
UP = 2, **STRANGE** = 3, **CHARM** = 4, **BOTTOM** = 5,
TOP = 6, **PHOTON** = 7
}
*Enum of flavours which map to **LHAPDF** integer codes. Useful for improving readability of client code. Note that these codes can't be used to access elements of returned `vector<double>`, which don't use the **LHAPDF** scheme (they use "LHAPDF code + 6").*

enum **SetType** { **EVOLVE** = 0, **LHPDF** = 0, **INTERPOLATE** = 1, **LHGRID** = 1 }
Distinction between evolution or interpolation PDF sets. Enum to choose whether evolution (i.e. `LHpdf` data file) or interpolation (i.e. `LHgrid` data file) is used.

enum **Verbosity** { **SILENT** = 0, **LOWKEY** = 1, **DEFAULT** = 2 }
Level of noisiness.

Functions

Global setup functions

C++ wrapper (ccwrap)

selecting the pdf set and member

```
#include “LHAPDF/LHAPDF.h”

#use namespace LHAPDF;

initPDFSet(int setid, int member)
initPDFSet(string name, SetType type, int member)
initPDFSet(string name, int member)

usePDFMember(int member)
```

older, deprecated methods:

```
initPDFbyName(string name, int member)
initPDFbyName(string name, SetType type, int member)

initPDFSetByName(string name, SetType type)

initPDF(int member)
```

evaluating the pdfs

(vector) xfx*(double x, double q*);
(double) xfx*(double x, double q, int fl*);
(vector) xfxp*(double x, double q, double p2, int ip2*);
(double) xfxp*(double x, double q, double p2, int p2, int fl*);
etc… xfxa(…
xfxphoton(…

Plus a complete set with ‘M’ at the end of the method name and an extra ‘int nset’ as the first argument for the set number.eg: xfxM*(int nset, double x, double q*);

‘*int fl*’ is the parton flavour (0 =gluon etc..) and these methods return a single double for that flavour, otherwise a vector is returned.

C++ wrapper (ccwrap)
other methods

Include:

(int) numberPDF(); ← returns number of PDF members in set

(void) getDescription(); ← prints the PDF description

(double) alphasPDF(*double q*); ← returns alphas for the PDF set

(double) getLam4();
(double) getLam5();

(double) getXmin(*int member*);
(double) getXmax(*int member*);
(double) getQ2min(*int member*);
(double) getQ2max(*int member*);

} returns the various parameters

Plus the usual set with suffix ‘M’ and extra first argument ‘int nset’ for multiset use.

(void) setVerbosity(Verbosity noiselevel) 0=SILENT,1=LOWKEY,2=DEFAULT
(void) setPDFPath(string path)
(void) setParameter(string parm) EXTRAPOLATE, NOSTAT

User's own PDF sets

wrapper routine

Within LHAPDF there is a dummy wrapper routine which a user can use as a basis to construct their own PDF sets and run within the LHAPDF framework. This is wrapUSER.f and is called from the wrapevolve.f routine.

subroutine USERevolve(x,Q,f)
…code to calculate xfx()

entry USERread(nset)
…code to read in and set up grid files

entry USERalfa(alfas,Q)
…code to return alphas

entry USERinit()
…initialization code for whole set

entryUSERpdf()
…initialization code for member

end

subroutine evolvePDFM(nset,x,Q,f)
…..
If(name(nset).eq.'USER') call USERevolve(x,Q.f)

entry readevolve(nset)
….
If|(name(nset).eq.'USER') call USERread(nset)
….

etc…

Recognises the name USER in the 'evolution:' section of the input .LHgrid or .LHpdf file

User's own PDF sets
.LHpdf and .Lhgrid files

This must be constructed for the particular circumstance of the PDF depending of the method used and details of the parameters or grid.

Details based on examples are given on the web site, but generally the following sections are present:

'Version' '5.3' <- always the first line
'Description:' <- following lines describe the PDFs
'Alphas:'
'Evolution:'
'QCDParams:'
'MinMax:'
'Parametrization:'
'Parameterlist:'
'End:'

Input information about the evolution and for .LHgrid the grid files themselves

For .LHpdf type details of the parameterization

LHAPDF – .LHpdf files

http://projects.hepforge.org/lhapdf/

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LHAPDF is maintained by Mike Whalley at Durham University (UK)
email:m.r.whalley@durham.ac.uk phone:+44-191-334-3807 fax:+44-191-334-36

Description of .LHpdf files

All text strings must be enclosed in single quotation marks.

The example shown here is from the MRST2002nlo.LHpdf file

The first line declares the earliest version of LHAPDF with which the files works, in the following way:

```
'Version' '5.0'
```

Next follows a section giving a description of the PDF set. It starts with the line `'Description:'` followed by an arbitrary (max 20) number of lines. This is the text that is printed out with the `call description()` command.

```
'Description:'
'MRST fit: hep-ph/0211080'
'This set has 1 member PDFs. '
' mem=1 --> MRST2002nlo: Best fit (alpha_S=0.119)'
'Note that the best fit (mem=0) has been set equal'
'to MRST2002nlo'
```

Next is a section, starting with the line `'Evolution'`, which defines the evolution method to be used. It is followed by a number of other lines. The first of these lines has three parameters. (1) the order of the evolution, (2) the Q^2 of the PDF fit and (3) the renormalization factor, which for all the sets so far is 1.0. The next line declares the evolution code to be used, in this case `QCDNUM_MRST`. Other options are `QCDNUM`, `QCDNUM_ZEUS_TR`, `QCDNUM_ZEUS_ZM` and `EVLCTEQ`. For the varieties of QCDNUM evolution there is a final line in this section which defines the QCDNUM grid parameters, as file name, number of x bins, xmin, xmax, number of Q2 bins, Q2min and Q2max.

```
'Evolution:'
'nlo',1.0,1.0
'QCDNUM_MRST'
'MRST.large.grid',400,1d-6,1d0,112,1.d0,1d10
```

User defined grid sets

Version 5.8.2 contains code to allow users to run their own .LHgrid files without having to rebuild LHAPDF.

At present it contains 3 polynomial interpolations based on the POLINT routine. Quadratic, Cubic and Quartic.

The .LHgrid file must be constructed according to a defined prescription and use the ‘evolution’ names:

USERGRIDQ2
USERGRIDQ3
USERGRIDQ4

These correspond to the lhaglue (pdflib) numbers with names

99002 USERGRIDQ2.LHgrid
99003 USERGRIDQ3.LHgrid
99004 USERGRIDQ4.LHgrid

There is a maximum of 201*201 x/Q grids points (user definable).

Format of the USERGRIDx.LHgrid files

(blank lines only for clarity)

```
'Version' '5.8'

'Description: '
'USERGRIDQ3 -- test with HERAPDF10'

'Alphas:'
'Variable','nlo','EvolCode'
1,91.187,1.40,4.75,180.0

'MinMax:'
0,1
1.E-06,1.,1.0,200000000.

'QCDparams:'
0,1
0.200,0.1520

'Parameterlist:'
'list',0,1
0.1176

'Evolution:'
'nlo',1.0,1.0
'USERGRIDQ3'

0,0,161,161,7,8,0,2,1,-2,-1,3,4,5

  1.0000E+00  1.1269E+00  1.2699E+00  1.4310E+00  1.6126E+00  1.8172E+00  2.0478E+00
 ....      23x7 Q values
 ....
 9.7666E+07  1.1006E+08  1.2402E+08  1.3976E+08  1.5750E+08  1.7748E+08  2.0000E+08

 1.0000E-06  1.1220E-06  1.2589E-06  1.4125E-06  1.5849E-06  1.7783E-06  1.9953E-06
 ....      23x7 X values
 ....
 6.9183E-01  7.3282E-01  7.7625E-01  8.2224E-01  8.7096E-01  9.2257E-01  9.7724E-01

 4.4510E-01  4.2490E-01  4.0660E-01  3.9000E-01  3.7480E-01  3.6080E-01  3.4840E-01
 ....      23x7 alphas values
 ....^
 7.1670E-02  7.1320E-02  7.0980E-02  7.0640E-02  7.0300E-02  6.9970E-02  6.9640E-02

-2.8676E+00 -2.8383E+00 -2.8094E+00 -2.7809E+00 -2.7528E+00 -2.7250E+00 -2.6977E+00
-2.6706E+00 -2.6438E+00 -2.6173E+00 -2.5911E+00 -2.5651E+00 -2.5392E+00 -2.5136E+00
-2.4880E+00 -2.4626E+00 -2.4373E+00 -2.4121E+00 -2.3869E+00 -2.3617E+00 -2.3364E+00
-2.3112E+00 -2.2858E+00 -2.2604E+00 -2.2347E+00 -2.2089E+00 -2.1830E+00 -2.1568E+00
-2.1303E+00 -2.1035E+00 -2.0763E+00 -2.0489E+00 -2.0210E+00 -1.9926E+00 -1.9637E+00
-1.9343E+00 -1.9044E+00 -1.8740E+00 -1.8427E+00 -1.8107E+00 -1.7781E+00 -1.7447E+00
-1.7104E+00 -1.6752E+00 -1.6390E+00 -1.6019E+00 -1.5639E+00 -1.5245E+00 -1.4840E+00
-1.4423E+00 -1.3995E+00 -1.3553E+00 -1.3094E+00 -1.2622E+00 -1.2135E+00 -1.1634E+00
-1.1114E+00 -1.0575E+00 -1.0020E+00 -9.4470E-01 -8.8567E-01 -8.2408E-01 -7.6059E-01
-6.9514E-01 -6.2770E-01 -5.5791E-01 -4.8555E-01 -4.1106E-01 -3.3444E-01 -2.5567E-01
-1.7412E-01 -9.0244E-02 -4.2798E-03  8.3732E-02  1.7385E-01  2.6642E-01  3.6067E-01
 4.5646E-01  5.5360E-01  6.5207E-01  7.5109E-01  7.8082E-01  8.3057E-01  8.8037E-01
 9.3011E-01  9.7972E-01  1.0291E+00  1.0781E+00  1.1268E+00  1.1751E+00  1.2227E+00
```

161 X and 161 Q grid points with 7 entries per row.
8 parton sets in order defined by the numbers
0,2,1,-2,-1,3,4,5

-6	tbar
-5	bbar
-4	cbar
-3	sbar
-2	ubar
-1	dbar
0	gluon
1	down
2	up
3	str
4	chm
5	bot
6	top

PDF values for
8 partons {
161 Q points {
23x7 X points {

'End:'

Future Plans

Continue to maintain and support LHAPDF with:

- addition of new PDFs when they become available
- updates to Fortran software as necessary

Propose to do a re-write of the core of LHAPDF in C++ to take advantage of dynamic memory allocation.

This new C++ version would:

- only use the .LHgrid form
- have built in interpolation routines and allow users to use their own
- allow flexibility for the PDF producer to define the x/Q2 grids.
- link to the existing Fortran wrapper codes

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version 4.1 onwards a configuration script fa

Note: from version 5.7.1 onwards the PD

Contents:

3.0 (full): lhapdf-3.0.tar.gz
2.0 (full): lhapdf-2.0.tar.gz

NOTE: Details of the changes in the different versions can be found in the ChangeLog.

LHAPDF is maintained by Mike Whalley and Andy Buckley at Durham University (UK)
email: lhapdf@projects.hepforge.org phone: +44-191-334-3807 fax:+44-191-334-3658

LHAPDF-announce — LHAPDF announcements

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Pick a password:	
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email: lhapdf@projects.hepforge.org phone: +44-191-334-3807 fax:+44-191-334-3658

```
Changelog for LHAPDF
--------------------

5.8.2 - 17/3/2010

    * New PDF sets:   NNPDF20_100     (90800-90900)
                      NNPDF20_1000    (97000-98000)

                      abkm09_3_nlo    (40650-40675)
                      abkm09_5_nlo    (40750-40775)
                      abkm09_3_nnlo   (40850-40875)
                      abkm09_5_nnlo   (40950-40975)

                      CT09MCS         (10770)
                      CT09MC1         (10771)
                      CT09MC2         (10772)

                      cteq66alphas    (10595-10599)

    * Addition of USER grid file option (wrapusergrid)

    * Fix bugs 1) using multisets with lite options
               2) alphas values in gjr non zero sets
               3) MST2006 idef option in wrapevolve

5.8.1 - 11/12/2009

    * Added Octave interface, by Philip Ilten.

    * Added new sets HERAPDF10_EIG.LHgrid
                     HERAPDF10_VAR.LHgrid

5.8.0 - 07/10/2009

    * Adding the JR09VFnnloE pdfsets.

    * Adding --enable-sets=LIST option

    * Adding --incdir, --libdir, --cppflags and --ldflags arguments to lhapdf-config.

    * Adding definition of $datarootdir to lhapdf-config. Thanks to Thorsten Ohl for the bugfix.
```

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Note: from version 5.7.1 onwards the PDF grid files

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LHAPDF is maintained by Mike Whalley and Andy Buckley at Durham University (UK)
email: lhapdf@projects.hepforge.org phone: +44-191-334-3807 fax:+44-191-334-3658

LHAPDF manual

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