

HERAFitter Users Meeting

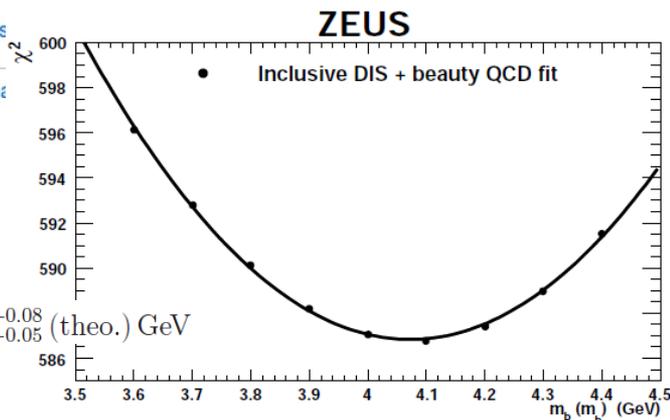
28th of July 2014

- News
- Developments and Preparation for the New Release
- Today's agenda

HERAFitter Usage:

Date	Group	Reference	Title
NEW 05.2014	HERA/ZEUS	arxiv:1405.6915	Measurement of beauty and charm production in deep inelastic scattering at HERA and measurement of the beauty-quark mass
NEW 05.2014	ggH benchmark HERAPDF, CT, NNPDF, MSTW	arxiv:1405.1067	Les Houches 2013: Physics
NEW 04.2014	LHC/ATLAS	arXiv:1404.1212	Measurement of the low- m_b ATLAS detector

$$m_b(m_b) = 4.07 \pm 0.14 \text{ (fit)}^{+0.01}_{-0.07} \text{ (mod.)}^{+0.05}_{-0.00} \text{ (param.)}^{+0.08}_{-0.05} \text{ (theo.) GeV}$$



General HERAFitter paper:

- comments received during the second draft circulation implemented
- remaining questions/suggestions will be discussed in the dedicated meeting (today)
- final version (EPJC) is planned to be ready by the next User's meeting

HERAFitter

Open Source QCD Fit Project

Version 0.91 (svn 1533)

S. Alekhin^{16,17}, O. Behnke¹, P. Belov^{1,12}, M. Botje¹⁸, D. Britzger¹, S. Camarda¹, A.M. Cooper-Sarkar², K. Daum^{29,30}, C. Diaconu³, J. Feltesse¹⁹, A. Gizhko¹, A. Glazov¹, A. Guffanti²⁰, M. Guzzi¹, F. Hautmann^{13,14,15}, A. Jung³¹, H. Jung^{1,32}, V. Kolesnikov⁴, H. Kowalski¹, O. Kuprash¹, A. Kusina²¹, S. Levonian¹, K. Lipka¹, B. Lobodzinski²⁸, K. Lohwasser¹⁶, A. Luszczak⁵, B. Malaescu²⁴, R. McNulty²⁷, V. Myronenko¹, S. Naumann-Emme¹, K. Nowak¹, F. Olness²¹, E. Perez²³, H. Pirumov¹, R. Plačakytė¹, K. Rabbertz⁶, V. Radescu¹, R. Sadykov⁴, G. Salam^{25,26}, A. Sapronov⁴, A. Schöning¹⁰, T. Schörner-Sadenius¹, S. Shushkevich¹, W. Slominski⁷, H. Spiesberger²², P. Starovoitov¹, M. Sutton⁸, J. Tomaszewska⁹, O. Turkot¹, A. Vargas¹, G. Watt¹¹, K. Wichmann¹

Date	Conference/Workshop	Presenter	Link	Remarks
17.11-21.11.2014	HiX2014	V. Radescu (TBC)	HERAFitter talk	invited talk
29.09-03.10.2014	Proton Structure in the LHC era	HERAFitter team	lecture/tutorials	PDF event at DESY
10-16.09.2014	Diffraction 2014	R. Placakyte	HERAFitter talk	talk accepted
08-12.09.2014	ISMD2014	R. Sadykov (TBC)	HERAFitter talk	talk accepted
01-05.09.2014	ACAT	A. Saponov	HERAFitter talk	abstract accepted
25-29.08.2014	QCD@LHC	V. Kolesnikov	HERAFitter talk	abstract accepted
25-29.08.2014	PANIC14	speaker	HERAFitter talk	abstract accepted
28.7-06.08.2014	ICNFP2014	H. Pirumov	HERAFitter talk	abstract accepted
21-26.07.2014	BEACH2014	A. Saponov	HERAFitter poster	abstract accepted as poster
2-9.07.2014	ICHEP2014	A. Cooper-Sarkar	HERAFitter talk	abstract accepted
17-21.06.2014	LowX2014	R. Placakyte	HERAFitter talk	abstract accepted
16-19.06.2014	QCD@WORK2014	H. Pirumov, M. Guzzi	PDF talk	HERAFitter slides adverts
2-7.06.2014	LHCP2014	P. Starovoitov	HERAFitter talk	abstract accepted
18-23.05.2014	Blois2014	O. Kuprash	HERAFitter talk	abstract accepted
16.05.2014	PDF4LHC	H. Pirumov	HERAFitter talk on PDF correlations between orders	abstract accepted
5-8.05.2014	Pheno2014	S. Glazov	HERAFitter talk	HERAFitter project and studies
28.04-02.05.2014	DIS2014	H. Pirumov, M. Lisovyi	HERAFitter talk , talk on PDF correlations between orders	2 abstracts accepted: HERAFitter project and studies
22-29.03.2014	MoriondQCD	V. Radescu	HERAFitter talk	stable release
16-22.02.2014	Lake Louise Winter Institute	S. Camarda	HERAFitter poster	HERAFitter project overview

www.terascale.de/pdf2014

Proton Structure in the LHC Era - School and Workshop

from 29 September 2014 to 02 October 2014 (Europe/Berlin) *DESY Hamburg*
Europe/Berlin timezone

Enhancing discovery potential: QCD precision measurements at the LHC (A. Cooper-Sarkar) <i>SR 4a/b, DESY Hamburg</i> 09:00 - 10:00	The precise part of the factorization: theory calculations at NLO and NNLO (M. Schulze, CERN) <i>SR 4a/b, DESY Hamburg</i> 09:00 - 10:00
Break <i>SR 4a/b, DESY Hamburg</i> 10:00 - 10:30	Coffee break <i>SR 4a/b, DESY Hamburg</i> 10:00 - 10:30
Determination of Strong coupling constant and PDFs (G. Dissertori, time TBC) <i>SR 4a/b, DESY Hamburg</i> 10:30 - 11:30	Jets in hadron collider at highest order (N. Glover, Durham) <i>SR 4a/b, DESY Hamburg</i> 10:30 - 11:30
The tricky part of the factorization: Parton Distribution Functions (D. Soper) <i>SR 4a/b, DESY Hamburg</i> 11:30 - 12:30	The number of flavors and the quark masses (S.-O. Moch time TBC) <i>SR 4a/b, DESY Hamburg</i> 11:30 - 12:30
Lunch break <i>SR 4a/b, DESY Hamburg</i> 12:30 - 14:00	Lunch break <i>SR 4a/b, DESY Hamburg</i> 12:30 - 14:00
HERAFitter: data vs predictions <i>SR 4a/b, DESY Hamburg</i> 14:00 - 16:00	Fast grids techniques. FastNLO <i>SR 4a/b, DESY Hamburg</i> 14:00 - 15:30
Coffee Break <i>SR 4a/b, DESY Hamburg</i> 16:00 - 16:30	coffee break <i>SR 4a/b, DESY Hamburg</i> 15:30 - 16:00
HERAFitter: PDF determination using DIS data <i>SR 4a/b, DESY Hamburg</i> 16:30 - 18:00	Fast grid techniques: APPLGrid <i>SR 4a/b, DESY Hamburg</i> 16:00 - 17:30
	Top-pair production in the fits: Diftop <i>SR 4a/b, DESY Hamburg</i> 17:30 - 18:30

→ school will be followed by the two-days workshop

A new HERAFitter release is planned in September

TARGET: end of September for the Proton Structure Event at DESY

Developments in the new release include:

- significantly improved drawing tools
- treatment of multi-dimensional data (virtual grids)
- improvements and additional flexibility in the χ^2 and covariance matrix code
- additional options in parametrisation styles (mixed HERA - CTEQ)
- added interface to LHAPDF6
- new data added (Tevatron, CMS)

Other planned deliverables for the next release (if in time):

- QED+QCD PDFs with a new QCDNUM version
- DiffTop (fastNLO version related)
- removed dependence on CERNLIB and related libraries (lapack, ...)
- additional scripts and interface improvements

→ *user's feedback on troubleshooting (comparability of libraries, scripts, additional options, etc) is welcomed*

Improvements to drawing tools

bin/DrawPdfs [options] dir1[:label1] [dir2:[label2]] [MC:dirpattern:[label3]] [...]

Monte Carlo replica directories:

To specify a pattern of directories containing Monte Carlo replica use the prefix "MC:" as in "MC:dirpattern".

NEW OPTIONS

general options:

- help
Show this help
- outdir <output directory>
Specify output directory
- eps
Plots are saved in eps format
- root
Save all the plots in a root file
- splitplots-eps
Produce also additional eps files for each plot
- splitplots-pdf
Produce also additional eps and pdf files for each plot
- splitplots-png
Produce additional png files for each plot
- colorpattern <1-3>
Select among 3 additional color patterns
- thicklines
Thicker lines in all plots (better for small plots in slides)
- lowres
Low resolution logo (smaller file)
- highres
High resolution logo (paper quality)
- no-version
Do not show version on logo

options for pdf plots:

- no-pdfs
PDF plots are not produced
- bands
Draw PDF uncertainty band
- filledbands
Filled uncertainty bands, usefull for sensitivity studies
- ratorange min:max
Specify y axis range in PDF ratio plots
- xrange min:max
Specify x axis range in PDF plots, default minimum and maximum x are determined by settings in the first reference directory
- no-logx
Linear x scale in PDF plots
- absolute-errors
Plot absolute pdf uncertainties centered around 0 in PDF ratio plots
- relative-errors
Plot relative pdf uncertainties centered around 1 in PDF ratio plots
- q2all
Plot PDF at all stored values of Q2. By default PDF are plotted only at the starting scale Q0
- pdfplots-per-page <N>
Number of rows and columns of PDF plots per page, default value is 2

Improvements to drawing tools

bin/DrawPdfs [options] dir1[:label1] [dir2:[label2]] [MC:dirpattern:[label3]] [...]

NEW OPTIONS

options for data plots:

- no-data
Data plots are not produced
- therr
Plot theory errors if available
- points
Plot theory as displaced marker points (vertical error bars) instead of continuous lines (with dashed error area)
- theory <label>
Change the "Theory" legend to the specified label
- 2panels
Plot additional right bottom panels with pulls
- 3panels
Plot additional right mid panels with theory+shifts
- only-theory
Do not plot data
- ratio-to-theory
Use theory as reference for ratio plots
- diff
Plot difference of theory-data instead of ratio theory/data

options for shifts plots:

- no-shifts
Shifts plots are not produced
- shifts-per-plot <N>
Number of shifts shown in each plot, default is 30, max is 40
- shifts-height <N>
Height reserved for each shift in points, min is 20, max is 200

options for tables:

- no-tables
Chi2 and parameter tables are not produced
- chi2-nopdf-uncertainties
When chi2 is evaluated with the LHAPDFError routine, this option will add to the chi2 table the chi2 evaluated without PDF uncertainties within brackets
- helvet-fonts
Use helvetica fonts in tables (default is palatino)
- cmbright-fonts
Use Computer Modern Bright fonts in tables (default palatino)

Statistical option for PDF error bands in PDF plots and parameter errors in parameter table.

apply to MC-replica and MC error PDF
The "asym" option applies also to asymmetric hessian error PDF

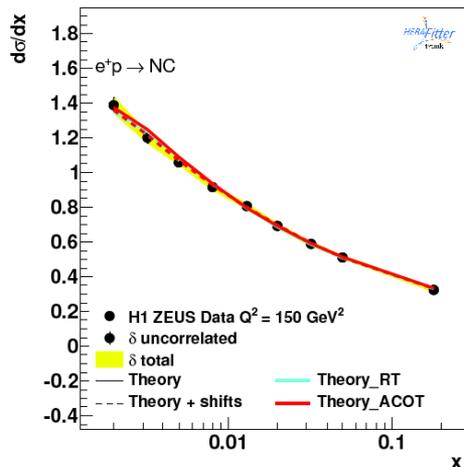
- To set the options for a directory, use the syntax
[MC:]<option1:>[option2:]directory[:label]
Example: DrawPdfs MC:68cl:asym:MYMCReplicaRuns
- median
Use median instead of average for the central values of PDF and parameters
 - 68cl
Evaluate 68 cl for PDF and parameters uncertainties
 - 90cl
Evaluate 90 cl for PDF and parameters uncertainties
 - asym
Evaluate asymmetric errors when possible

Improvements to drawing tools

bin/DrawPdfs [options] dir1[:label1] [dir2:[label2]] [MC:dirpattern:[label3]] [...]

NEW OPTIONS

options for data plots:



--ratio-to-theory

Use theory as reference for ratio plots

--diff

Plot difference of theory-data instead of ratio theory/data

options for shifts plots:

--no-shifts

Shifts plots are not produced

--shifts-per-plot <N>

Number of shifts shown in each plot, default is 30, max is 40

--shifts-height <N>

Height reserved for each shift in points, min is 20, max is 200

options for tables:

'Bg'	0.198 ± 0.017	$0.167^{+0.066}_{-0.063}$
'Cg'	8.19 ± 0.29	$8.0^{+1.1}_{-1.1}$
'G5'	-100.00	-100.00
'G6'	-100.00	-100.00
'Buv'	0.766 ± 0.011	$0.742^{+0.038}_{-0.037}$
'Cuv'	2.993 ± 0.063	$2.53^{+0.38}_{-0.33}$
'uv4'	-3.67 ± 0.12	$-4.72^{+0.77}_{-0.64}$
'uv5'	-100.00	-100.00
'uv6'	2.926 ± 0.051	$3.30^{+0.13}_{-0.15}$
'Bdv'	0.450 ± 0.018	$0.407^{+0.058}_{-0.049}$
'Cdv'	9.32 ± 0.15	$10.20^{+0.80}_{-0.88}$

The "asym" option applies also to asymmetric hessian error PDF

To set the options for a directory, use the syntax

[MC:]<option1:>[option2:]directory[:label]

Example: DrawPdfs MC:68cl:asym:MYMCReplicaRuns

--median

Use median instead of average for the central values of PDF and parameters

--68cl

Evaluate 68 cl for PDF and parameters uncertainties

--90cl

Evaluate 90 cl for PDF and parameters uncertainties

--asym

Evaluate asymmetric errors when possible

Treatment of the multi-dimensional data (Virtual grids)

kfactor is a term which denotes an array of K -factors corresponding to the data bins. The TermSource for this term must point to a file with the K -factor table, containing three columns: bin lower and higher edges, and the K -factor value. The comments starting with “#” are ignored.

applgrid term tells the parser to initialize the APPLgrid grid for the cross section evaluation. The grid options are defined with additional options in DataInfo and CInfo.

virtgrid can be used if the fit is performed on the multidimensional measurement results. The TermSource in this case is a text file with a virtual grid definition. Consider for example the data are a triple differential measurement of a cross section in X , Y and Z observables. Internally the theory prediction for such measurement is represented as a linear array – a sequence of applgrids for Z , each corresponding to the hyperbin in X and Y . The virtual grid file in this case is a table, where each row denotes the hyperbin with its edges, APPLgrid file location and number of bins in it:

X_0^{low}	X_0^{high}	Y_0^{low}	Y_0^{high}	path/to/applgrid_0_0.root	$M(0; 0)$
X_0^{low}	X_0^{high}	Y_1^{low}	Y_1^{high}	path/to/applgrid_0_1.root	$M(0; 1)$
...					
X_0^{low}	X_0^{high}	$Y_{N_Y}^{\text{low}}$	$Y_{N_Y}^{\text{high}}$	path/to/applgrid_0_ N_Y .root	$M(0; N_Y)$
X_1^{low}	X_1^{high}	Y_0^{low}	Y_0^{high}	path/to/applgrid_1_0.root	$M(1; 0)$
X_1^{low}	X_1^{high}	Y_1^{low}	Y_1^{high}	path/to/applgrid_1_1.root	$M(1; 1)$
...					
$X_{N_X}^{\text{low}}$	$X_{N_X}^{\text{high}}$	Y_0^{low}	Y_0^{high}	path/to/applgrid_ N_X _0.root	$M(N_X; 0)$
...					
$X_{N_X}^{\text{low}}$	$X_{N_X}^{\text{high}}$	$Y_{N_Y}^{\text{low}}$	$Y_{N_Y}^{\text{high}}$	path/to/applgrid_ N_X _ N_Y .root	$M(N_X; N_Y)$

Treatment of the multi-dimensional data (Virtual grids)

→ description in manual and README

Changes required the data files:

```

TheoryType      = 'expression'
TermName       = 'V', 'A'
TermType       = 'virtgrid', 'applgrid_norm'
TermSource     = 'path/to/virtgrid.txt' ,
                'path/to/applgrid.root'
TheorExpr     = 'V/sum(A)'

```

An example of virtgrid.txt file:

#	y1	y2	applgrid	n_grid_bins
0.0	0.3		theoryfiles/atlas/Jets2010-vg/R04/eta1.root	17
0.3	0.8		theoryfiles/atlas/Jets2010-vg/R04/eta2.root	17
0.8	1.2		theoryfiles/atlas/Jets2010-vg/R04/eta3.root	17
1.2	2.1		theoryfiles/atlas/Jets2010-vg/R04/eta4.root	16
2.1	2.8		theoryfiles/atlas/Jets2010-vg/R04/eta5.root	13
2.8	3.6		theoryfiles/atlas/Jets2010-vg/R04/eta6.root	10
3.6	4.4		theoryfiles/atlas/Jets2010-vg/R04/eta7.root	7

Additional flexibility in the χ^2 code

Nuisance representation for data with uncertainties in the covariance form

→ often is more compact vs covariance matrix

→ needed for Toy MC uncertainty propagation

For statistical correlations, the matrix typically has close to diagonal form. Use this, for separation of the uncorrelated component, which is required for the χ^2 definition.

$$C = [C - f\text{diag}(C)] + f\text{diag}(C) = \Gamma\Gamma^T + f\text{diag}(C)$$

Here the factor $0 < f \leq 1$ is chosen such that the matrix $C - f\text{diag}(C)$ remains positive-definite. The factor is found iteratively using bisection method.

Steering:

```
&CovarToNuisance
  ! Global switch for using nuisance param representation for covariance mat.
  LConvertCovToNui = .false.

  ! Tolerance -- zero means exact transformation
  Tolerance = 0.0

  ! The following lines allow to adjust error scaling properties (default: :M)
  DataName      = 'CMS electon Asymmetry rapidity', 'CMS W muon asymmetry'
  DataSystType = ':A', ':A'
&End
```

→ separate representation implemented for different covariance information (syst, stat, full, syst-corr, stat-corr), some types can be mixed together, e.g. stat and syst

New parametrisation style in HERAFitter

→ a hybrid parametrisation combining CTEQ-style for valence quarks:

$$f(x) = a1 * \exp(a4 * x) * (1 - x) ** a3 * x ** a2 * (1 + \exp(a5) * x + \exp(a6) * x ** 2)$$

and HERA-style for the rest (g, Ubar, Dbar)

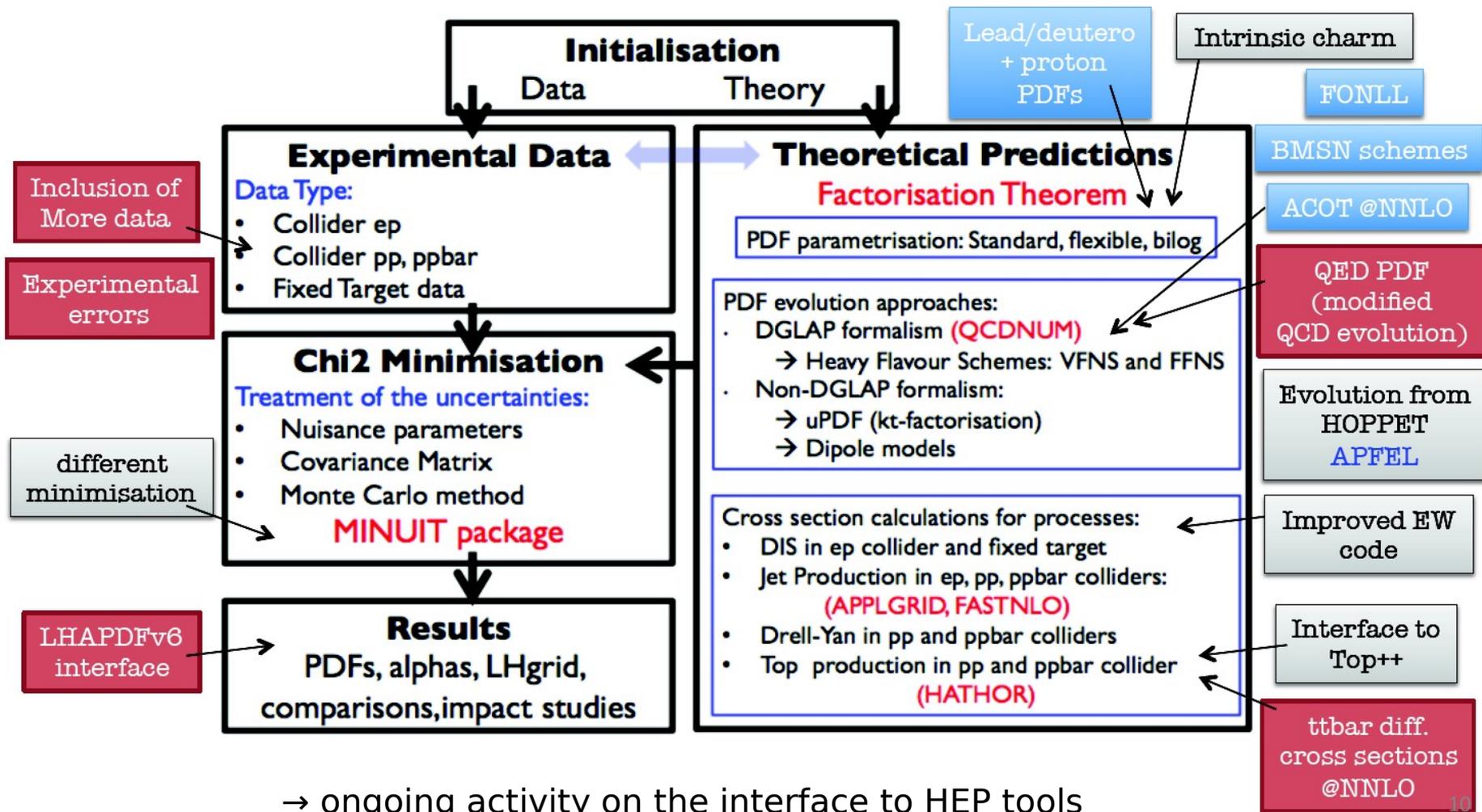
```
! PDF parameterisation style. Possible styles are currently available:
! 'HERAPDF' -- HERAPDF-like with uval, dval, Ubar, Dbar, glu evolved pdfs
! 'CTEQ'    -- CTEQ-like parameterisation
! 'CTEQHERA' -- Hybrid: valence like CTEQ, rest like HERAPDF
! 'CHEB'   -- CHEBSHEV parameterisation based on glu, sea, uval, dval evolved pdfs
! 'LHAPDF00' -- use lhapdf library to define pdfs at starting scale and evolve with
! 'LHAPDF'  -- use lhapdf library to define pdfs at all scales
! 'DDIS'   -- use Diffractive DIS
! 'BiLog'  -- bi-lognormal parametrisation
```

input_steering/minuit.in.txt.CTEQHERA

```
set title
new 13p HERAPDF
parameters
 1 'Ag'      0.0000  0.
 2 'Bg'     -0.226958  1.126400e-03
 3 'Cg'      7.4980  1.749400e-02
 7 'Aprig'   1.3622869  8.384000e-03
 8 'Bprig'  -0.2870788  9.282100e-04
 9 'Cprig'   25.  0.
11 'Auv'     0.0000  0.
12 'Buv'     0.66851  3.400300e-03
13 'Cuv'     1.6607  1.550700e-02
14 'uv4'    -7.0765  2.559700e-02
15 'uv5'   -100.00  0.000000e+00
16 'uv6'     4.2377  1.340400e-02
21 'Adv'     0.0000  0.
22 'Bdv'     0.59948  7.818000e-03
23 'Cdv'    14.017  1.436900e-01
24 'dv4'    15.506  2.258100e-01
25 'dv5'   -100.00  0.000000e+00
26 'dv6'   -100.00  0.000000e+00
33 'CUbar'   3.7124059  2.586100e-02
41 'ADbar'   0.170713  4.155600e-04
42 'BDbar'  -0.159491  3.024600e-04
43 'CDbar'   2.89758  4.442000e-02

*set print 3
*call fcn 3
migrad 200000
hesse
set print 3
input_steering/minuit.in.txt.CTEQHERA
```

Schematic representation of ongoing and planned developments in HERAFitter:



Today's agenda:

HERAFitter User's meeting

Monday, 28 July 2014 from 14:30 to 18:00 (Europe/Zurich)
at Test
DESY: SR 03a

Description ONLY If default VIDYO fails ----- a backup VIDYO LINK:

Extension 9265520

Meeting PIN 2323

Auto-join URL <http://vidyoportal.cern.ch/flex.html?roomdirect.html&key=QpFaaSZLsTe1>

Video Services Vidyo public room : HERAFitter_Users_meeting [More Info](#) | [Join Now!](#)

Monday, 28 July 2014

- | | |
|---------------|--|
| 14:30 - 14:50 | Status 20'
Speakers: Voica Ana Maria Radescu (Deutsches Elektronen-Synchrotron (DE)), Ringaile Placakyte (Deutsches Elektronen-Synchrotron (DE)) |
| 14:50 - 15:20 | Proton structure and tensor gluons 30'
Speaker: Georgios Savvidis (Nat. Cent. for Sci. Res. Demokritos (GR))
Material: Slides  |
| 15:20 - 15:40 | News from aMCFAST 20'
Speakers: Valerio Bertone (CERN), Juan Rojo Chacon (University of Oxford (GB)) |