HERAFitter Overview

Marseille, February 2012

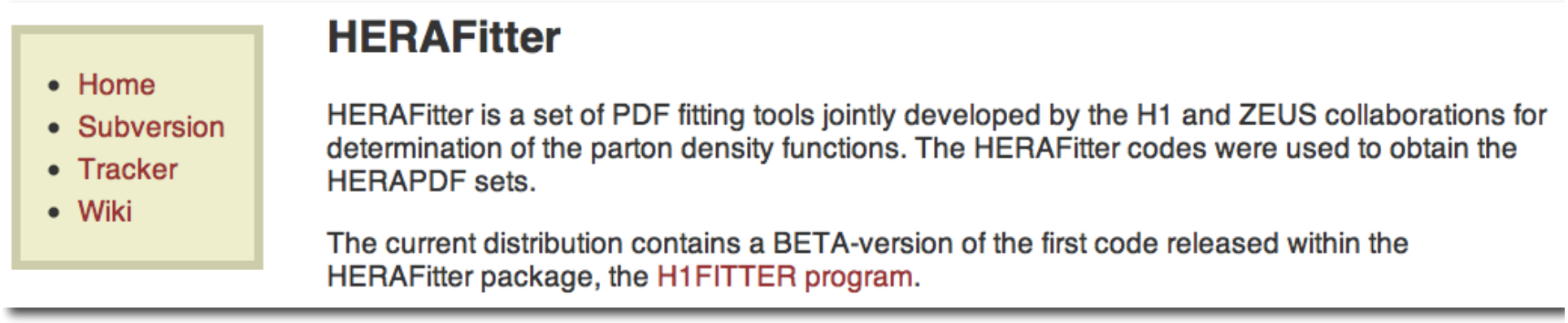
HERAFitter Package

- HERAFitter is a common initiative of H1 and ZEUS collaborations to provide an open source framework containing PDF fitting tools
  - Ready platform to analyze new data and their impact within experiments
  - Can be used for benchmarking exercises (consistent tests among various theories)

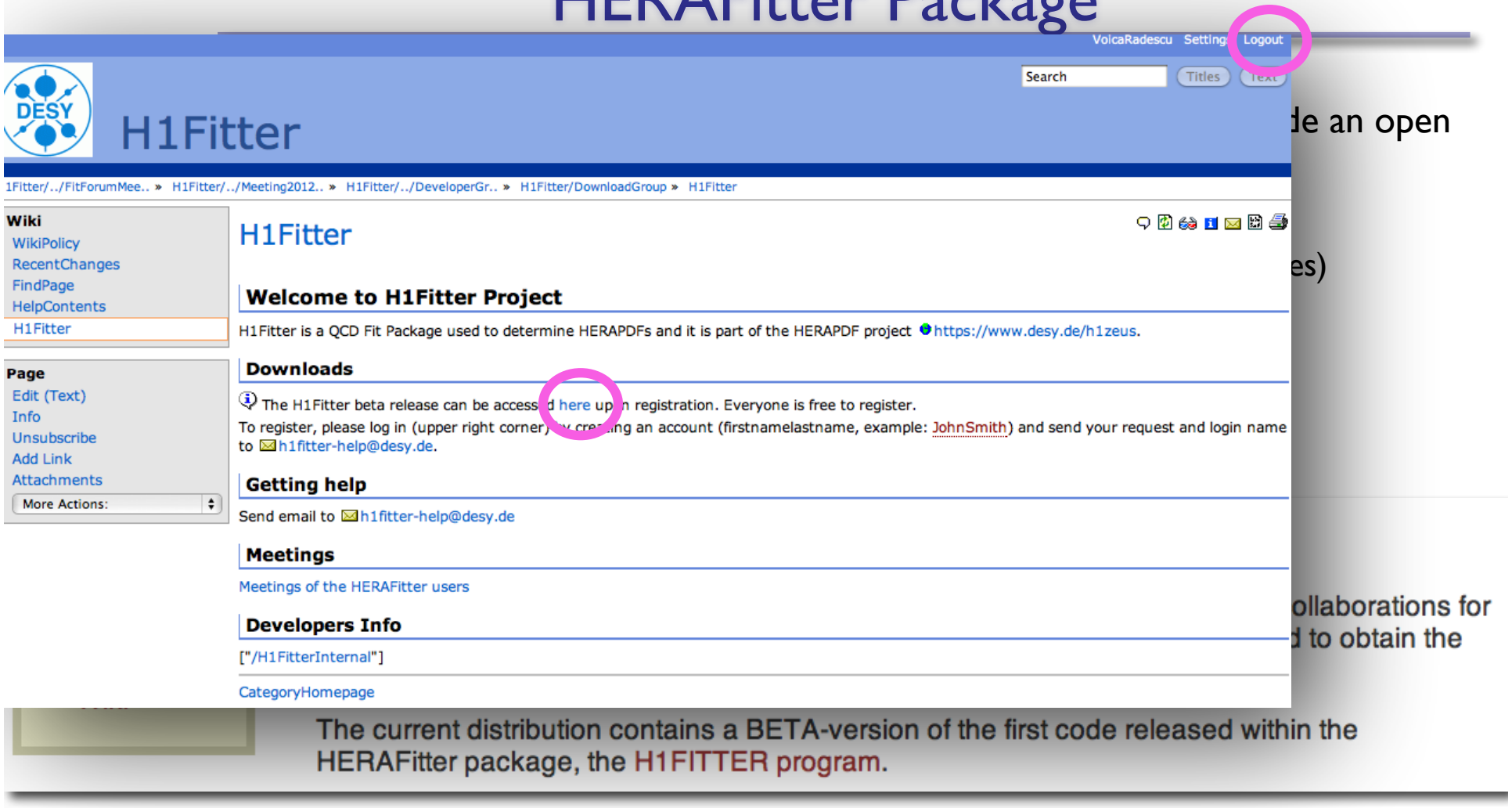
- The beta release can be accessed through the HEPFORGE site:

  http://projects.hepforge.org/herafitter

  And it requires the QCDNUM package [M. Botje] for evolution



HERAFitter Package

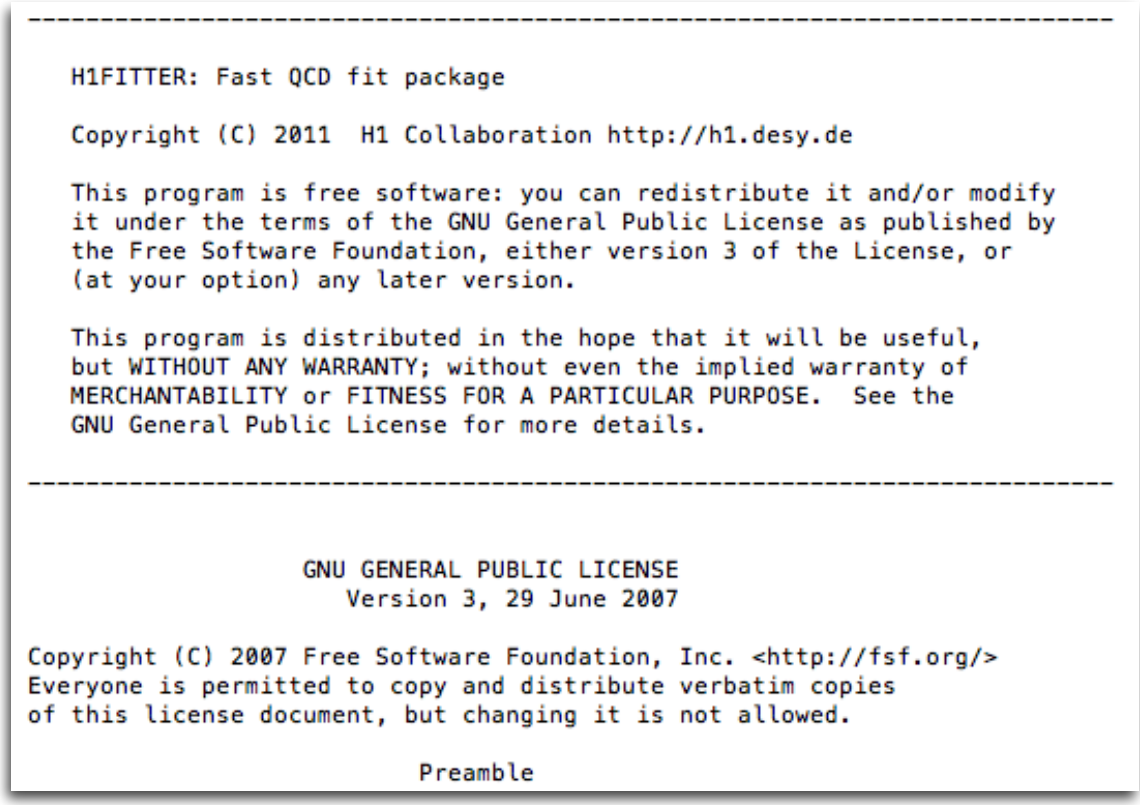


~35 downloads so far.

For beta release download we require registration to provide feedback in case of problems.

Beta package: License, References, and Readme

- LICENSE
  - (under GNU GPL v3)
- REFERENCES
- README
  - Header with Release version
  - Installation
    - Pre-requirements
    - Mini manual
      - Steering cards
      - Inclusion of data files
      - Data files format
      - Minuit cards
      - Applying cuts
      - Understanding the output



```
--------------------------------------------------------------------------------

   H1FITTER: Fast QCD fit package

   Copyright (C) 2011  H1 Collaboration http://h1.desy.de

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   it under the terms of the GNU General Public License as published by
   the Free Software Foundation, either version 3 of the License, or
   (at your option) any later version.

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                       Version 3, 29 June 2007

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                            Preamble
```

Beta package: License, References, and Readme

- LICENSE
  - (under GNU GPL v3)

- REFERENCES

- ```
  If you use the H1FITTER package in a scientific publication, please consider adding the
  following references. The main citations list contains the papers which should be cited
  for any use of the H1FITTER program. In addition, some citations are required depending
  on the modules, data and theory tables used in the program.

  ==================
    Main citations
  ==================

  H1Fitter
  ---------
  1) "Combined Measurement and QCD Analysis of the Inclusive e+- p Scattering Cross Sections at HERA."
  By H1 and ZEUS Collaboration (F.D. Aaron et al.). DESY-09-158, Oct 2009. 61pp.
  Published in JHEP 1001:109,2010.
  e-Print: arXiv:0911.0884 [hep-ex]

  2) "A Precision Measurement of the Inclusive ep Scattering Cross Section at HERA."
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  e-Print: arXiv:0904.3513 [hep-ex]

  QCDNUM  ( evolution code )
  -------
  "Fast QCD Evolution and Convolution", M. Botje,
  NIKHEF-10-002, May 2010. 74pp.
  Published in Comput.Phys.Commun.182:490-532,2011.
  e-Print: arXiv:1005.1481 [hep-ph]

  ==================================
   Citations depending on the usage
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e-Print: arXiv:1005.1481 [hep-ph]

==================================
 Citations depending on the usage
==================================
```

- Example of usage:

  If I am to use HERAFitter package using some new data and I select for the PDFSTYLE of the parametrisation (in steering.txt) "10p HERAPDF" and RT scheme then I should use the following references for citations:

  - Main citations:
    - 1) "Combined Measurement and QCD Analysis of the Inclusive e+- p Scattering Cross Sections at HERA." By H1 and ZEUS Collaboration (F.D. Aaron et al.). DESY-09-158, Oct 2009. 61pp. Published in JHEP 1001:109,2010. e-Print: arXiv:0911.0884 [hep-ex]
    - 2) "A Precision Measurement of the Inclusive ep Scattering Cross Section at HERA."By H1 Collaboration (F.D. Aaron et al.). DESY-09-005, 2009. 35pp. Published in Eur.Phys.J.C64:561-587,2009. e-Print: arXiv:0904.3513 [hep-ex]
    - 3) "Fast QCD Evolution and Convolution", M. Botje,NIKHEF-10-002, May 2010. 74pp. Published in Comput.Phys.Commun.182:490-532,2011. e-Print: arXiv:1005.1481 [hep-ph]
  - Additional citations:
    - "An NLO QCD analysis of inclusive cross-section and jet-production data from the zeus experiment" By ZEUS Collaboration (S. Chekanov et al.). DESY-05-050, Mar 2005. 37pp. Published in Eur.Phys.J.C42:1-16,2005. e-Print: hep-ph/0503274
    - "An Ordered analysis of heavy flavor production in deep inelastic scattering" R.S. Thorne, R.G. Roberts. RAL-TR-97-049, Sep 1997. 48pp. Published in Phys.Rev.D57:6871-6898,1998. e-Print: hep-ph/9709442
    - "A Variable-flavor number scheme for NNLO" R.S. Thorne. CAVENDISH-HEP-2006-01, Jan 2006. 17pp. Published in Phys.Rev.D73:054019,2006. e-Print: hep-ph/0601245

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```
-----------------------------------------------
   H1FITTER   --- PDF fit program from HERA.
-----------------------------------------------

BETA-RELEASE VERSION: 0.1.0

H1FITTER has been used as one of the main software packages for the
determination of the HERAPDF1.0 set proton parton densities. HERAPDF
is a common initiative by the H1 and ZEUS collaborations to provide
precision QCD analyses of the combined HERA data sets.

The current package includes code to fit DIS inclusive cross section
data, Drell-Yan and inclusive jet processes (using APPLGRID and FastNLO
interfaces). The program is distributed under the GPL v3 license, see
LICENCE file for more details. The program was developed by the H1
collaboration. It uses the QCD evolution package QCDNUM developed by
M. Botje. Parts of the code were contributed by non H1 members:
-- VFNS from R. Thorne,
-- DY LO+k-factor calculation from A. Sapronov
-- PDF error estimation from J. Pumplin
-- DIS electroweak corrections from H. Spiesberger

If the results obtained with the program are to be included in a scientific
publication, please use the citations as suggested by the REFERENCES file.

For support information, please visit https://znwiki3.ifh.de/H1Fitter

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                Installation and Usage Instructions
```

Functionality HERAFitter Beta Release

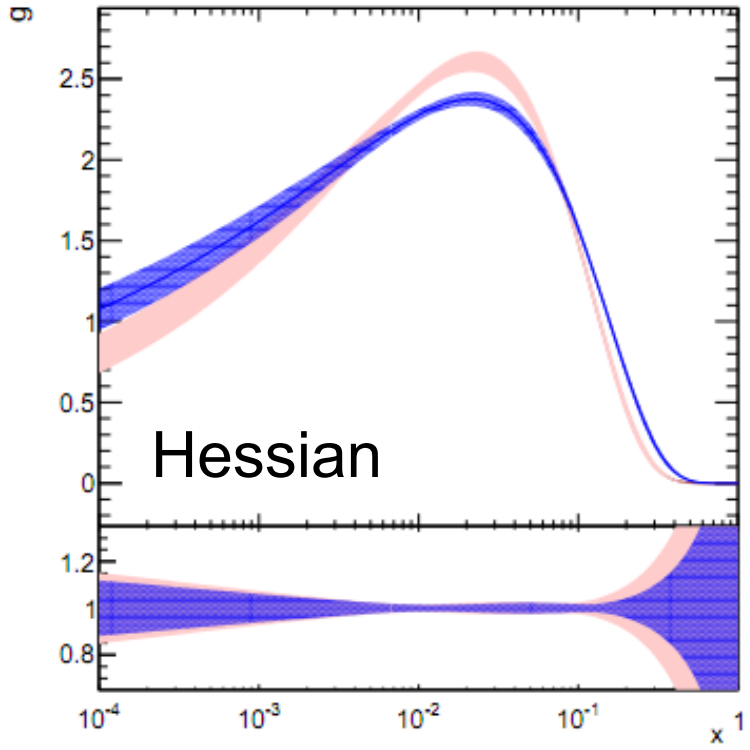
- Beta release contains a minimum set of tools for its use at the LHC experiments
  - It can produce out of the box HERAPDF1.0
  - Sample data file formats for DY and jets usages

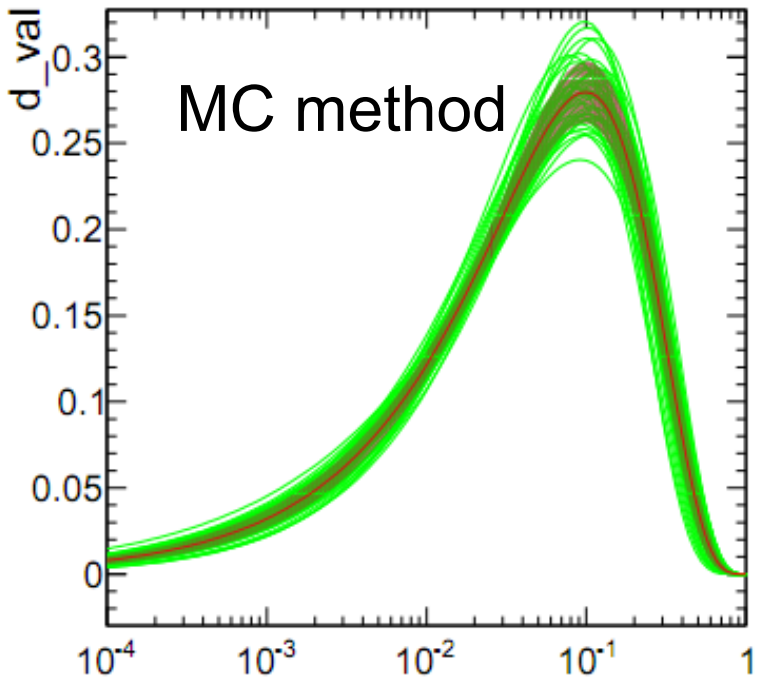
- **DATA:**
  - DIS ep
    - Inclusive
    - jets
  - DY pp and ppbar
    - W, Z, cross sections
    - Zrapidity
    - W asymmetries
    - jets
  - Error treatment:
    - Correlated, Uncorrelated
    - Hessian Method
    - MC method
- **Parametrisation studies:**
  - Standard functional form of PDFs
  - CTEQ
  - Chebyshev

- **Theory (DIS):**
  - ZM-VFNS accessed from QCDNUM
  - GM-VFNS RT from R. Thorne
- **Treatment for jets:**
  - FastNLO:
    - A wraper around NLOJets++
  - Applgrid:
    - A wraper around MCFM, NLOJets++
- **DY cross sections at LO x kfactors**
- **Output:**
  - PDFs at predifined scales
  - LHAPDF grids
  - Theory predictions per data points
  - Pulls per data points

DIS(upol)	✔
DIS(pol)	✔
RT(st)	✔
RT(kfact)	✔
DY	✔
Jets ep	✔
Jets pp,ppbar	✔
Param studies	✔
Error band	✔
MC errors	✔
LHAPDF grids	✔
Drawing Tools	✔

Functionality HERAFitter Beta Release





- MC method

- **Parametrisation studies:**
  - Standard functional form of PDFs
  - CTEQ
  - Chebyshev

- **Output:**
  - PDFs at predifined scales
  - LHAPDF grids
  - Theory predictions per data points
  - Pulls per data points

Drawing Tools ✔

Functionality HERAFitter Beta Release

- Beta release contains a minimum set of tools for its use at the LHC experiments

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- Para
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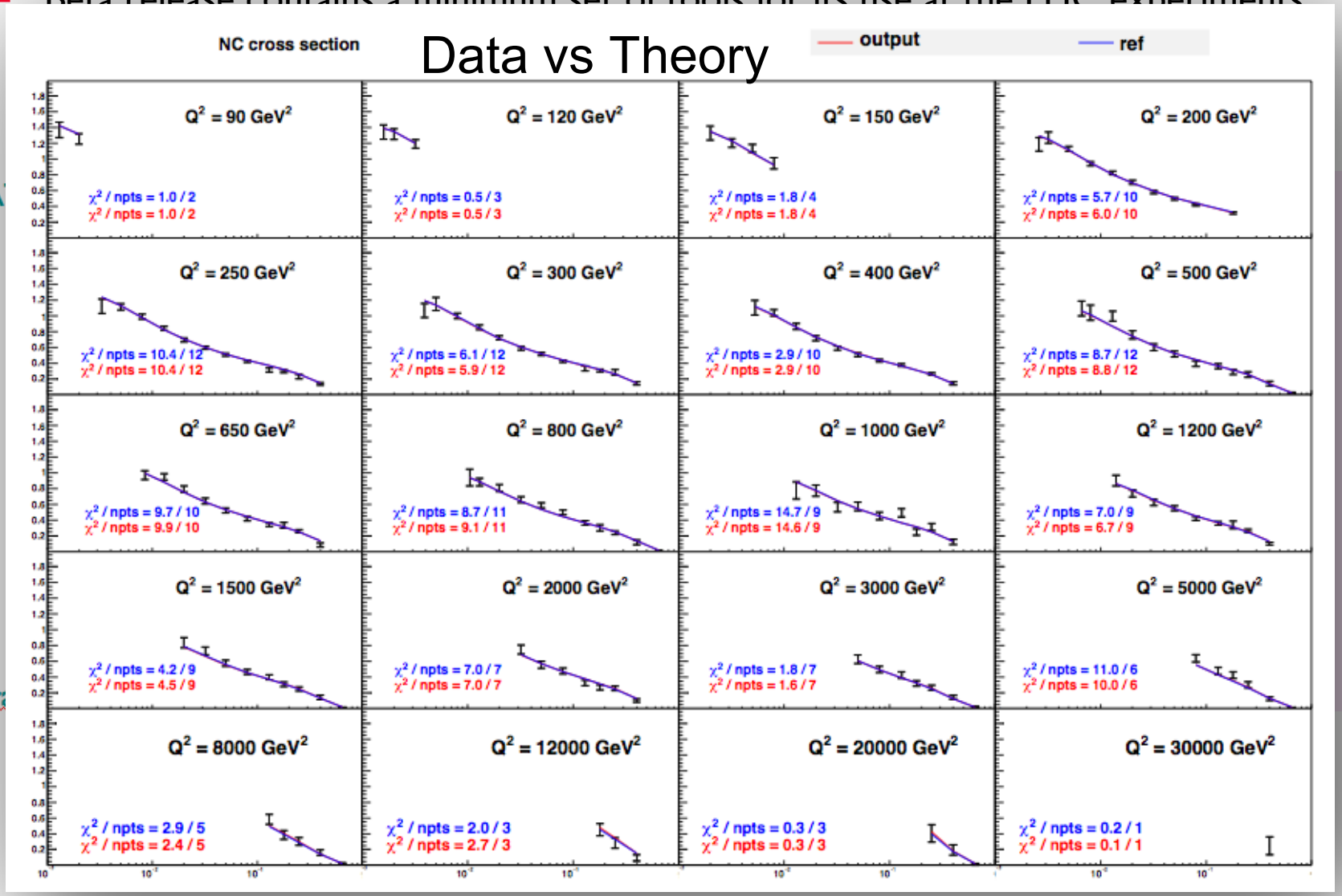

Data vs Theory

HERAFitter After Beta Release

- HERAFitter User's interaction
  - Weekly developer's meeting (https://znwiki3.ifh.de/H1Fitter/H1Fitter/H1FitterInternal/FitForumMeetings)
  - Monthly users's meeting (https://znwiki3.ifh.de/H1Fitter/H1Fitter/HERAFitterMeetings)

- Mailing lists:
  - h1fitter-help -- for immediate help on HERAFitter 0.1.0
  - herafitter-user -- for broad discussion among all users
  - h1fitter-devel -- for developers discussion (also by invitation)

- Timescale:
  - 15.09.2011 Package released (blessed by both H1 and ZEUS collaborations)
  - 21.09.2011 Package presented in ATLAS community (ATLAS-Germany meeting, Goettingen)
  - 12.10.2011 Package presented in CMS community (CMS meeting, CERN)
  - 19.10.2011 First HERAFitter User's Meeting
  - 23.11.2011 Second HERAFitter User's Meeting
  - 28.11.2011 First presentation of the HERAFitter at a workshop (PDF4LHC, Cristi Diaconu)
  - 12.12.2011 Third HERAFitter User's Meeting
  - 13/14.02.2012 External HERAFitter Meeting in Marseille

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- Mailing lists:
  - h1fitter-help
  - herafitter-user
  - h1fitter-devel

For discussions:
- define developers
- define concrete coding rules
- advisable to provide readme for each module
- define timescale and deliverables for stable release

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Organisation since beta-release

- H1fitter codes are stored in the DESY svn repository

https://svnsrv.desy.de/k5viewvc/h1fitter/trunk/

File	Rev.	Age
branches/	175	6 months
releases/	374	3 months
tags/	176	6 months
trunk/	467	6 days

- The development of the code is performed in the trunk
  - Code development model:
    - More external developers with commit rights ⇒ stricter code validation.
    - Modularity to allow simultaneous code development
    - Report developments at the regular weekly/monthly meetings.

- New releases stored under "releases" branch:
  - Together with the bug-fixes releases

File	Rev.	Age
Parent Directory		
h1fitter-0.1.0/	355	4 months
h1fitter-0.1.1/	374	3 months

- Possibility to decouple modules and store them in branches (ex: Dipole models)

New developments since beta-release

- Data file storage (published Tevatron, LHC data) https://znwiki3.ifh.de/H1Fitter/H1Fitter/downloads/datatables
- New heavy flavour schemes:
  - RT optimal as in MSTW (see G. Watt's talk)
  - ACOT as in CTEQ (see F. Olness's talk)
  - FONLL as in NNPDF (see J. Rojo's talk)
  - FFNS and BMSN as in ABM (see R. Placakyte's talk)

- Developments in the top area: ttbar cross section (see S. Naumann's talk)
- Slightly modified code flow from the beta-release (see K. Nowac's and A. Sapronov's talk)
  - Adjusted wrappers around interfaces
  - Removal of redundancy between NC and CC codes
- Possibility to link to LHAPDF

- Additions to HERAFitter package: HERAaverager
  - Used for combining the measurements
- To be included:
  - Addition of the NNPDF reweighting tool (see A. Guffanti's talk)

  - Additions from ZEUS:
    - Offset method in estimating the uncertainties
    - Diffractive fits
    - Photon PDFs
    - C++ wrappers

Summary

- Successful download of beta-release HERAFitter package so far
  - Multi-platform usage of the package: ATLAS, CMS, theory groups
- Successful organisation of the HERAFitter meetings:
  - Developers - weekly meetings
  - Users - monthly meetings
- Further development of the package towards the stable release:
  - Modular addition of the heavy flavour schemes with the support of Theory groups

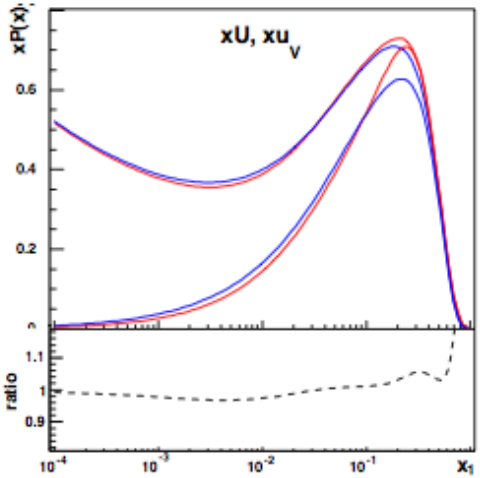
Feedback from the user community is very much appreciated!

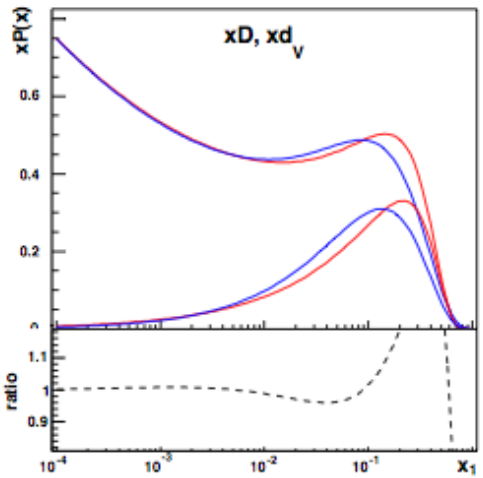
New developments since beta-release

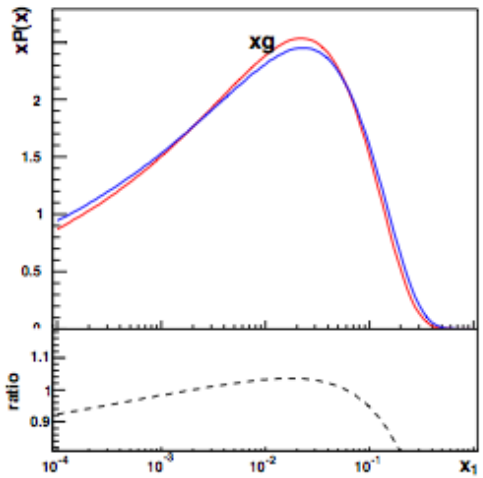
File	Rev.	Age
Parent Directory		
DY/	293	5 months
FastNLO/	308	5 months
HS/	293	5 months
RT/	342	5 months
bin/	293	5 months
datafiles/	351	4 months
include/	324	5 months
input_steering/	318	5 months
minuit/	324	5 months
output/	293	5 months
src/	353	4 months
theoryfiles/	293	5 months
tools/	293	5 months
LICENCE	293	5 months
Makefile.am	298	5 months
README	343	5 months
REFERENCES	355	4 months
acinclude.m4	293	5 months
aminclude.am	293	5 months
configure.ac	299	5 months
doxygen.cfg	293	5 months
ewparam.txt	293	5 months
minuit.in.txt	293	5 months
steering.txt	293	5 months

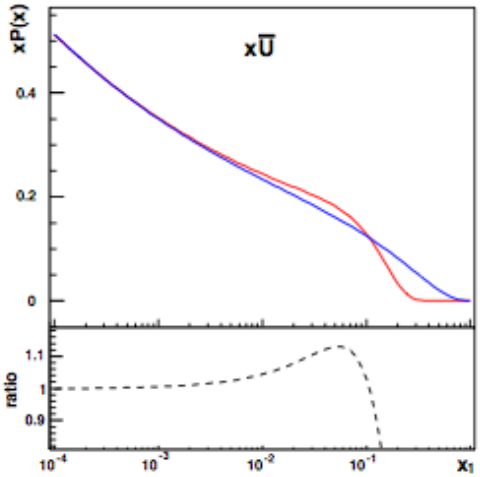
File	Rev.	Age
Parent Directory		
ACOT/	466	6 days
DIPOLE/	463	6 days
DY/	456	11 days
FastNLO/	461	6 days
HS/	396	2 months
Hathor/	434	5 weeks
RT/	422	2 months
bin/	76	7 months
datafiles/	460	6 days
doc/	425	8 weeks
include/	457	11 days
input_steering/	369	4 months
minuit/	464	6 days
output/	71	7 months
src/	467	6 days
theoryfiles/	459	6 days
tools/	441	3 weeks
LICENCE	69	7 months
Makefile.am	430	5 weeks
README	356	4 months
REFERENCES	356	4 months
acinclude.m4	89	6 months
aminclude.am	89	6 months
configure.ac	430	5 weeks
doxygen.cfg	89	6 months
ewparam.txt	226	6 months
minuit.in.txt	381	3 months
steering.txt	431	5 weeks

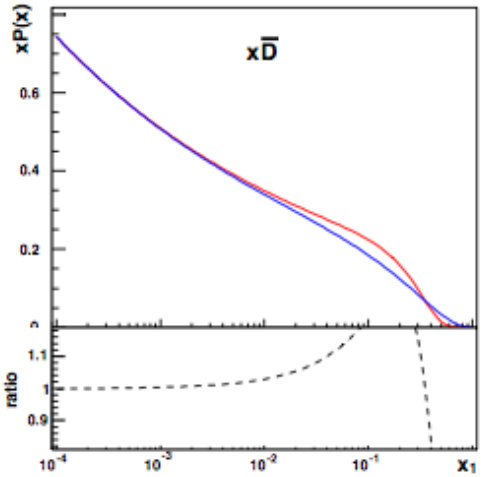
PDF plots











ref

output

Q^2 = 1.90 GeV^2

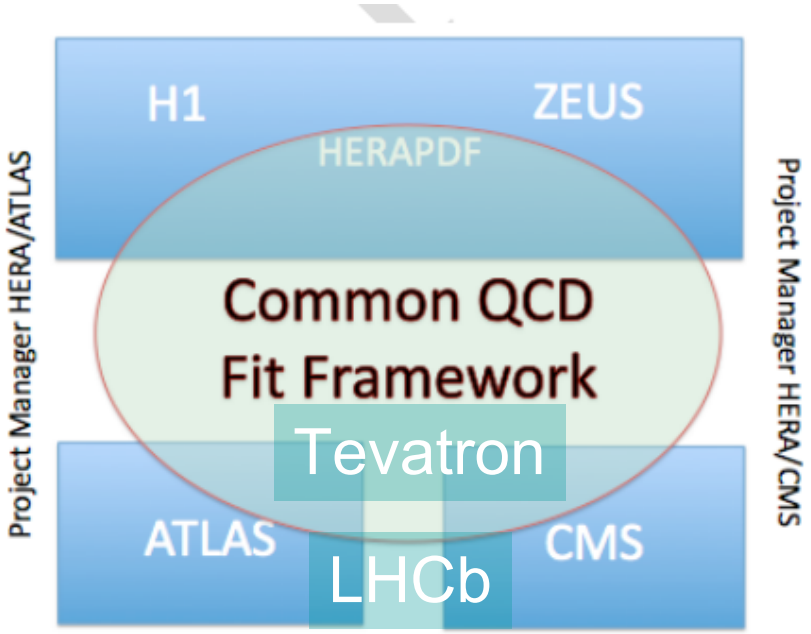
Motivation for HERAFitter

- QCD Fits within experiments proved to be a very useful tool to understand data.
- Ready platform to analyse new data and their impact.
- Feedback PDFs, their uncertainties into data analysis.

- The idea is to benefit from the learned experience and continue developing the HERAfitter

- A common initiative of H1 and ZEUS:
  - HERAFitter is a set of PDF fitting tools jointly developed by the H1 and ZEUS collaborations for determination of the parton density functions.

  (currently the package is just a wrapper around H1fitter, no ZEUSfitter released at this moment)



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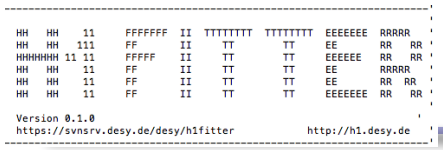


Structure of the h1fitter

- H1fitter codes are stored in the DESY svn repository

svn

File
- Parent Directory
- DY/
- FastNLO/
- HS/
- RT/
- bin/
- datafiles/
- doc/
- include/
- input_steering/
- minuit/
- output/
- src/
- theoryfiles/
- tools/

https://svnsrv.desy.de/k5viewvc/h1fitter/trunk/

Directory revision: 348 (of 348)
Sticky Revision: Set
Query: Query revision history

File	Rev.
branches/	175
releases/	348
tags/	176
trunk/	345

- Minimal coupling to external modules
- Keep essential validated modules (more for later stages)
- Includes documentation

Based on autoconfigure

Functionalities

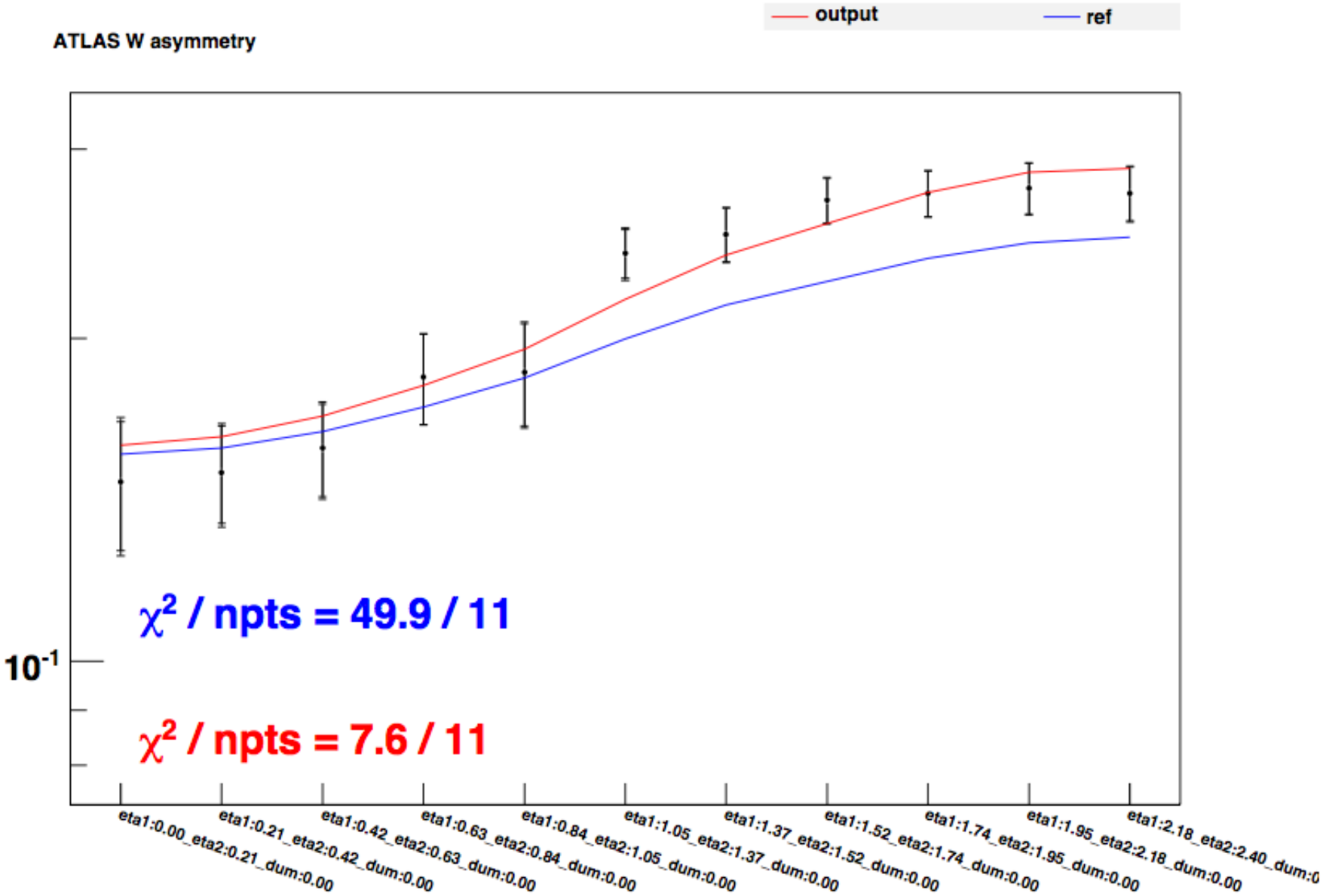
H1fitter	SVN
DIS(upol)	✔
DIS(pol)	✔
RT(st)	✔
RT(kfact)	✔
DY	✔
Jets ep	✔
Jets pp,ppbar	✔
Param studies	✔
Error band	✔
MC errors	✔
LHAPDF grids	✔
Drawing Tools	✔

Out of the box:
- H1fitter produces central fit for HERAPDF1.0
- DY and jet packages can be used to fit pp, ppbar data as well

- DATA:
  - DIS ep
    - Inclusive
    - jets
  - DY pp and ppbar
    - W, Z, cross sections
    - Zrapidity
    - W asymmetries
    - jets
  - Error treatment:
    - Correlated, Uncorrelated
    - Hessian Method
    - MC method
- Parametrisation studies:
  - Standard functional form of PDFs
  - CTEQ
  - Chebyshev

- Theory (DIS):
  - ZM-VFNS accessed from QCDNUM
  - GM-VFNS RT from R. Thorne
- Treatment for jets:
  - FastNLO:
    - A wraper around NLOJets++
  - Applgrid:
    - A wraper around MCFM, NLOJets++
- DY cross sections at LO x kfactors
- Output:
  - PDFs at predifined scales
  - LHAPDF grids
  - Theory predictions per data points
  - Pulls per data points

Example: Data vs Theory (ATLAS)



Package for pp,ppbar data: DY code

[Andrey Sapronov -SanC]

DY integration code:

Simple LO cross section formulae: DY NC: $pp \to Z/\gamma \to e^+e^-$

$$\frac{d\sigma^2_\gamma}{dMdydcos\theta^*} = N_c C^2_{q\bar{q}} \frac{8\alpha^2}{3M^3}\tau \times \sum_q e_q^2 f_q(x_1, M) f_{\bar{q}}(x_2, M) F_{q\bar{q}}(1+\cos^2\theta^*, \cos\theta^*)$$

DY CC: $pp \to W^\pm \to e^\pm \nu$

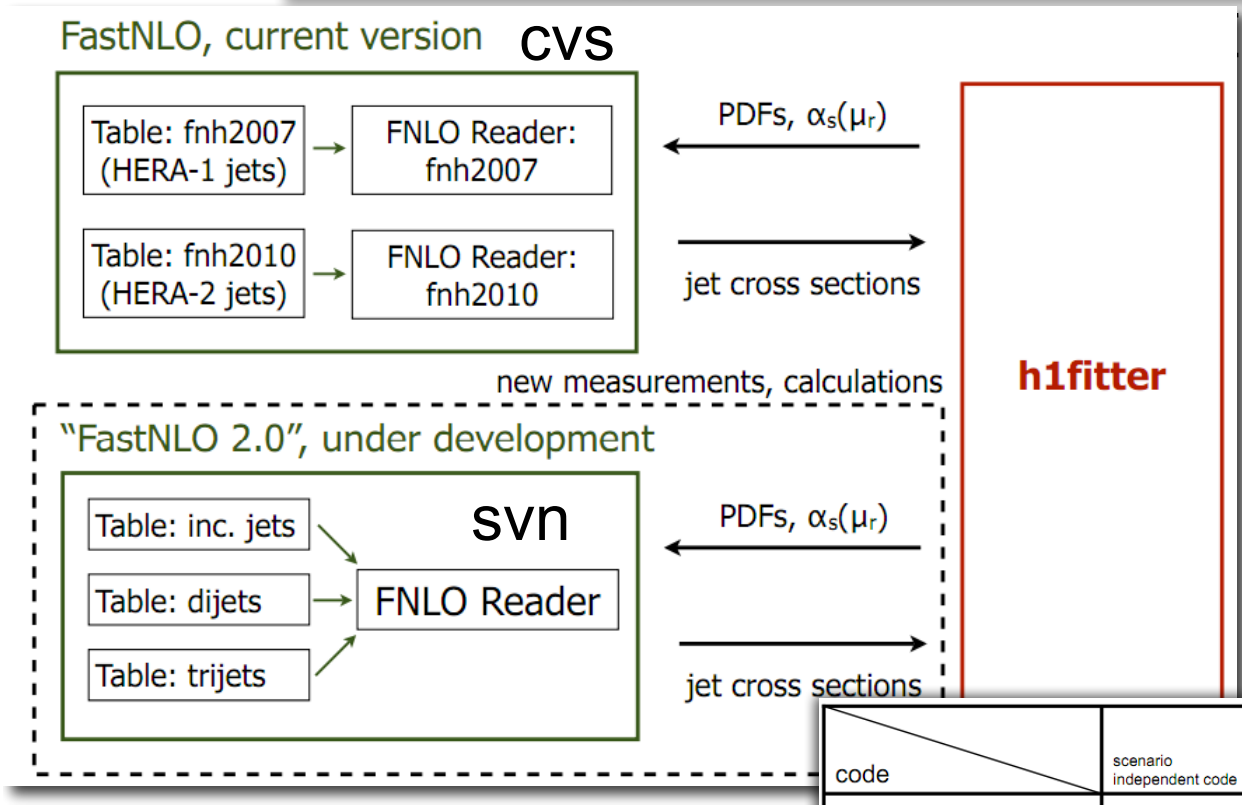
$$\frac{d\sigma^3_{W\pm}}{dMdydcos\theta^*} = \frac{\pi\alpha^2}{48 s_W^4} M\tau \frac{(1-cos\theta^*)^2}{(M^2-M_W^2)^2+\Gamma_W^2 M_W^2} \times \sum_{qq'} V_{qq'} f_q(x_1, M) f_{q'}(x_2, M)$$

where $\tau = \frac{M^2}{S_0}$, S_0 - beam energy.
$F_{q\bar{q}}(1+\cos^2\theta^*, \cos\theta^*)$ is a linear homogenious dependence on $1+\cos^2\theta^*$ and $\cos\theta^*$.

Sapronov Andrey () | DY integrator PDF fitting. | June 28, 2011 | 2 / 5

- Kfactors are determined from MCFM
- Cross checks of results
  - between LO x kfactors and NLO using Applgrid (H1Fitter, ZEUSFitter)
  - between LO x kfactors and DY code from J. Stirling (ZEUSFitter)

Package for jets: FastNLO in h1fitter



[Daniel Britzger, Krzysz Nowak]

- Originally developed FasttNLOReadrer (C++)
- Interfaced to to the H1Fitter, enables DIS jet fits

code	scenario independent code	DIS			pp / ppbar		
		v1.4	v2.0	v2.0+	v1.4	v2.0	v2.0+
FastNLO v1.4 (Fortran)	no	yes	no	no	yes	no	no
FastNLO v2.0 (C++)	yes	no	yes	no	no	buggy	no
FastNLO LHC (Fortran Reader)	only LHC	no	no	no	pp only	no	no
FastNLOReader (C++)	yes	no we don't need it !!!	yes	yes	not yet	not tested to come…	w/o TC to come…
APPL_grid	yes	yes	no	no	yes ? (w/o TC?)	no	no