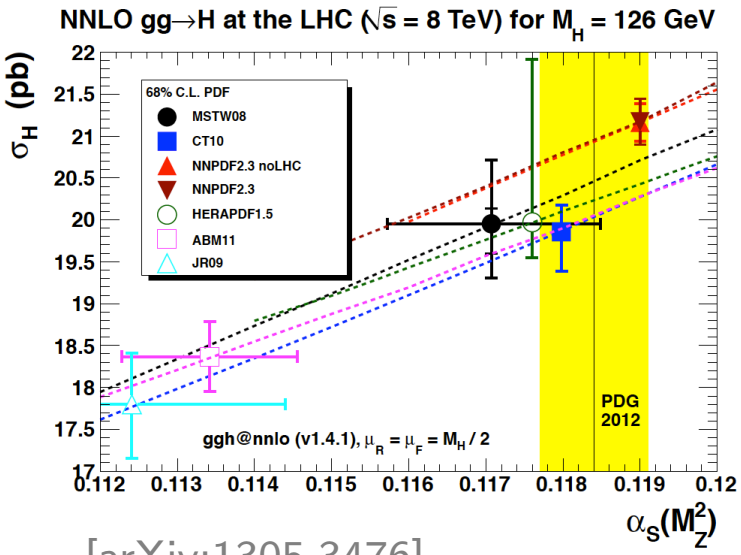
xFitter project

Oleksandr Zenaiev
(DESY)
on behalf of the xFitter team

DIS2016, Hamburg, 13.04.2016

Introduction

- PDFs are an essential input for any hadron collider prediction
- PDFs are measured with increasing precision over the last decades
- Both new precise data and improved theoretical calculations appear
- $\Rightarrow$ constantly need to merge them



[arXiv:1305.3476]

xFitter (former HERAFitter): an open source QCD fit framework

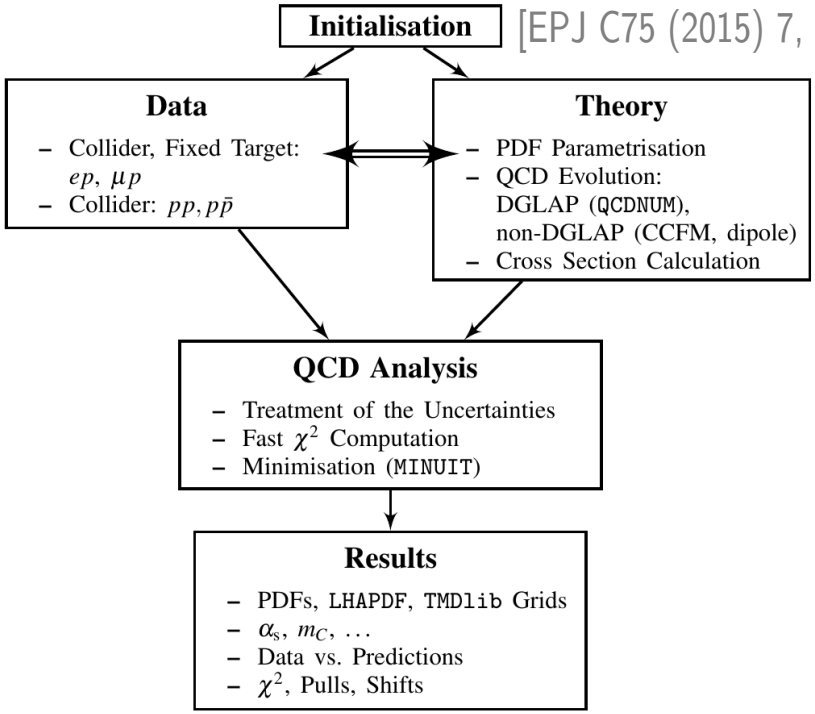
[EPJ C75 (2015) 304]

- on theory side: a unique QCD framework to address theoretical differences
- on experimental side: assess consistency and/or impact of new data
- additional dedicated studies by xFitter developers

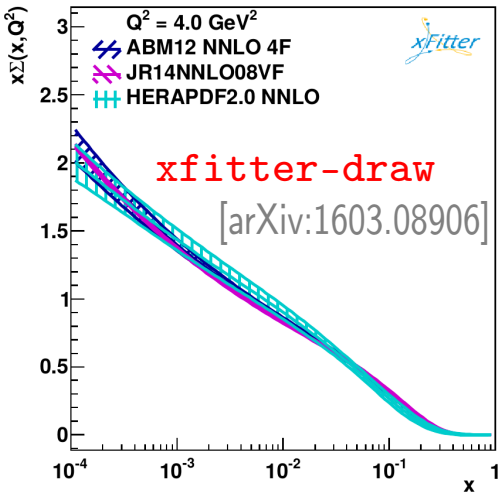
Program workflow

Main ingredients of a QCD analysis:

- Parametrise PDF at initial scale
  - polynomial, Chebyshev etc.
- Evolve to the scale of the process:
  - DGLAP (QCDNUM and APFEL in x-space, MELA in N-space)
  - non-DGLAP (CCFM, dipole)
  - +QED (new!)
- Calculate hard scattering:
  - for DIS: FFNS and many VFNS available
  - fast techniques (FastNLO, ApplGrid) for many other processes
- Calculate χ^2 w.r.t data:
  - account for correlations
  - various treatment of uncertainties
- Analyse/minimise χ^2:
  - MINUIT
  - reweighting/profiling
  - data driven regularisation
- Drawing tools



[EPJ C75 (2015) 7, 304]



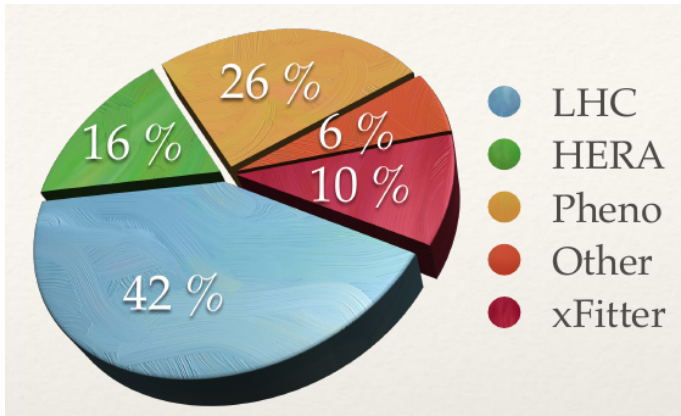
xFitter project and team

Date	Version	Files	Remarks
02/2016	**1.2.0**	xfitter-1.2.0.tgz	release with decoupled data and theory files which can be dowloaded with getter.sh script

- 2011 QCD open source revolution: 1st release

Date	Version	Files	Remarks
02/2015	**1.1.1**	herafitter-1.1.1.tgz	fix release with decoupled theoryfiles-new.tgz
09/2014	1.1.0	herafitter-1.1.0.tgz	release with decoupled theoryfiles-new.tgz
12/2013	1.0.0	herafitter-1.0.0.tgz	stable released with decoupled theoryfiles.tgz
06/2013	0.3.1	herafitter-0.3.1.tgz	fix release includes manual-0.3.1.pdf and decoupled theoryfiles.tgz
03/2013	0.3.0	herafitter-0.3.0.tgz	release includes manual-0.3.1.pdf and decoupled theoryfiles.tgz
07/2012	0.2.1	herafitter-0.2.1.tgz	fix release for 0.2.0
05/2012	0.2.0	herafitter-0.2.0.tgz	added functionality for LHC users
09/2011	0.1.0	herafitter-0.1.0.tgz	first release

- April 2016:
  - > 30 publications used framework
  - additional dedicated studies by xFitter team:
    "Parton distribution functions at LO, NLO and NNLO with correlated uncertainties between orders" [EPJ C74 (2014) 3039]
    "QCD analysis of W- and Z-boson production at Tevatron" [EPJ C 75 (2015) 458]
    "Determination of charm running mass using FONLL" (in preparation, see Valerio Bertone talk)



  - $\approx$ 30 developers:
    - from various experiments and theory
    - regular developer meetings
    - more information at (new!) webpage:
      www.xfitter.org

xFitter new release 1.2.0: technical aspects

Available at:

`https://www.xfitter.org/xFitter/xFitter/DownloadPage`

Main improvements:

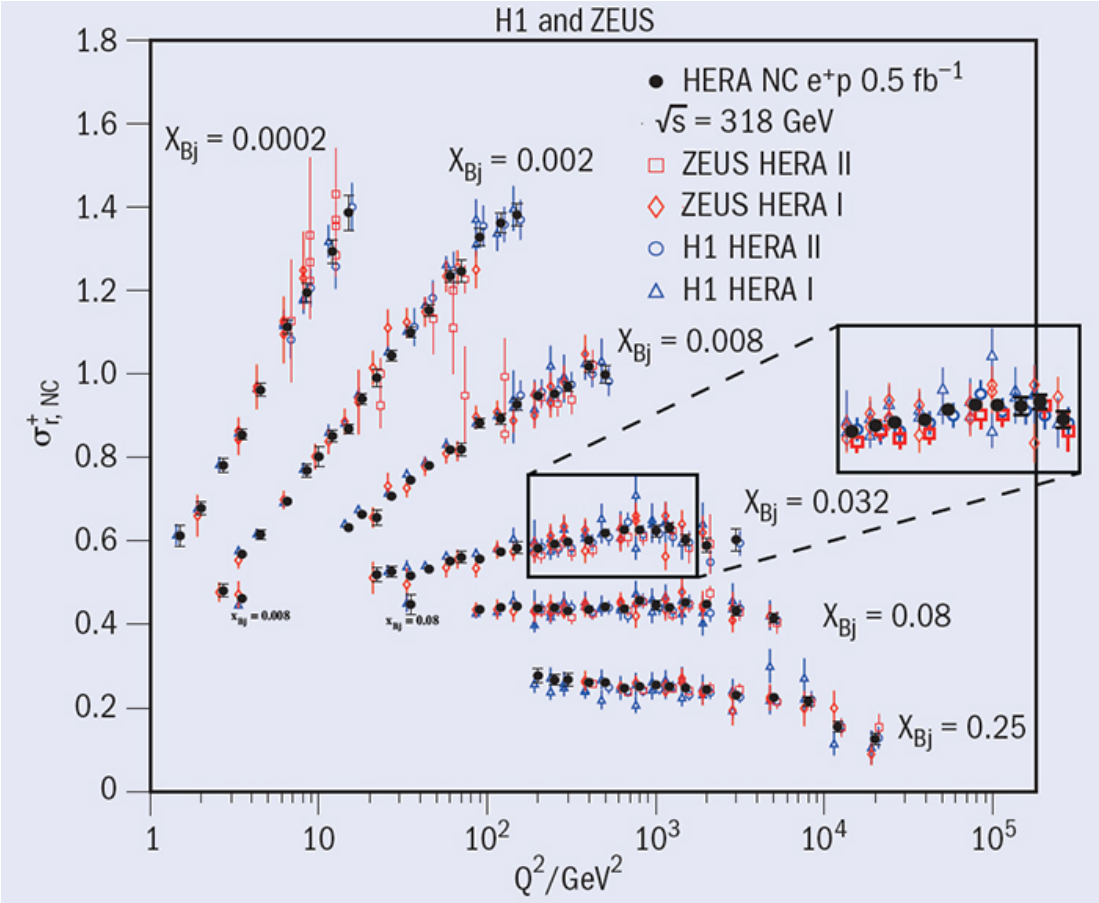
- Full installation script provided
- Standalone script to download data and theory files
- Theory files go to the same location as data
- Names of executables:
  - FitPDF -> xfitter
  - DrawPdfs, DrawResults -> xfitter-draw
  - Postproc -> xfitter-process
- QCDNUM 17.01.11 or higher is needed (QED PDFs, autotools)
- Direct access to LHAPDF avoiding QCDNUM (via LHAPDFNATIVE)
- Unified theory interface for FastNLO and ApplGrid
- New reweighting option using GieleKeller weights available
- More data and processes (next slides)

(see BACKUP for full Release Notes)

xFitter new release 1.2.0: new data sets

New datasets, e.g.:

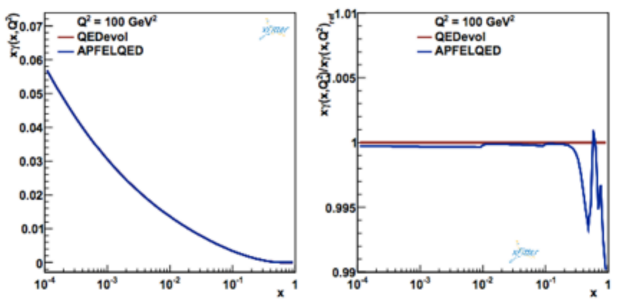
- legacy HERA DIS data (as used for HERAPDF2.0) [EPJ C75 (2015) 580]
- H1 multijets [EPJ C75 (2015) 2]
- LHCb open charm and beauty data as used for PROSA [EPJ C75 (2015) 396]
- updated Tevatron data as used for [EPJ C 75 (2015) 458]



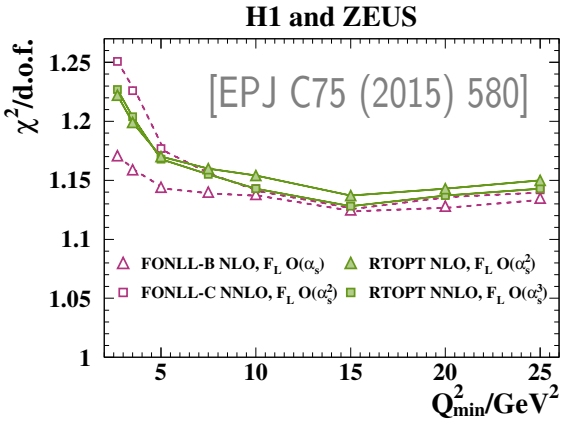
[CERN Courier, September 2015]

New theory techniques:

- QED PDFs up to NNLO QCD + LO QED:
  - via QCDNUM
  - via APFEL



- Updates in HF schemes:
  - new FONLL scheme via interface to APFEL
    [`https://apfel.hepforge.org`]
    as used by NNPDF
  - FFNS scheme updated to `OPENQCDRAD v2.0b4`
    [`http://www-zeuthen.desy.de/~alekhin/OPENQCDRAD`]
    as used by ABM



- MNR (Mangano-Nason-Ridolfi) calculations added:
  - massive NLO calculations (single-particle option)
  - full flexibility retained: scales, heavy-quark masses, NP fragmentation parameters

Latest results using xFitter

List of analyses by xFitter

The link to the list of analyses using former HERAFitter can be accessed here

04.2016	**HERAFitter and APFEL teams**	Preliminary	V.Bertone DIS2016	Material

V. Bertone

List of analyses using xFitter

Number	Date	Group	Reference	Title
	2016			
31	03.2016	Pheno/R.M. Chatterjee at al.	arXiv:1603.09619	A QCD analysis of CMS inclusive differential Z production data at sqrt(s) = 8 TeV
30	03.2016	HERA	arXiv:1603.09628	Combined QCD and electroweak analysis of HERA data
29	03.2016	Pheno/A. Accardi et al.	arXiv:1603.08906	Recommendations for PDF usage in LHC predictions

V. Myronenko

R. Plačakytė

List of analyses using HERAFitter

Number	Date	Group	Reference	Title
	2016			
28	03.2016	LHC/CMS	arXiv:1603.01803 (CMS PAS SMP-14-022)	Measurement of the muon charge asymmetry in inclusive pp->W+X production at 8 TeV
	2015			
27	10.2015	LHC/CMS	CMS PAS SMP-14-001	Measurement of the double-differential inclusive jet cross section at 8 TeV
26	07.2015	REF2014 proceedings	Acta Phys Polon B 46 (2015) 2501, arXiv:1507.05267	Transverse momentum dependent (TMD) parton distribution functions: status and prospects
25	07.2015	PDF4LHC	accepted by Journal of Physics G	The PDF4LHC report on PDFs and LHC data:Results from Run I and preparation for Run II
24	06.2015	HERA/H1 and ZEUS	submitted to EPJC	Combination of Measurements of Inclusive Deep Inelastic e+-p Scattering Cross Sections and QCD Analysis of HERA Data II
23	03.2015	LHC/ATLAS	arXiv:1503.03709	Measurement of the forward-backward asymmetry of e and m pair-production in pp collisions at 7 TeV with the ATLAS detector
22	03.2015	PROSA	arXiv:1503.04581	Impact of the LHCb measurements of forward charm and beauty production on PDFs

E. Eren

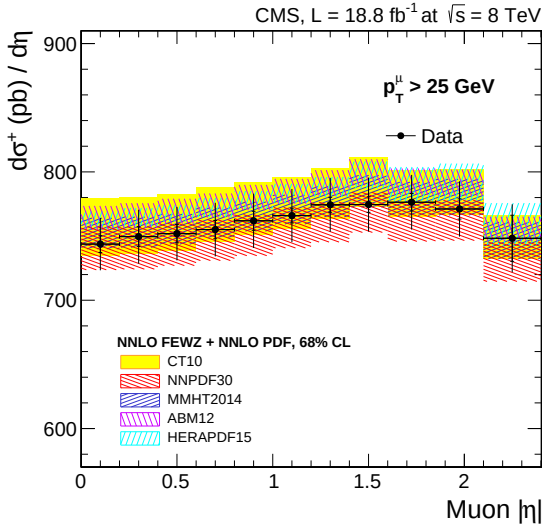
E. Eren

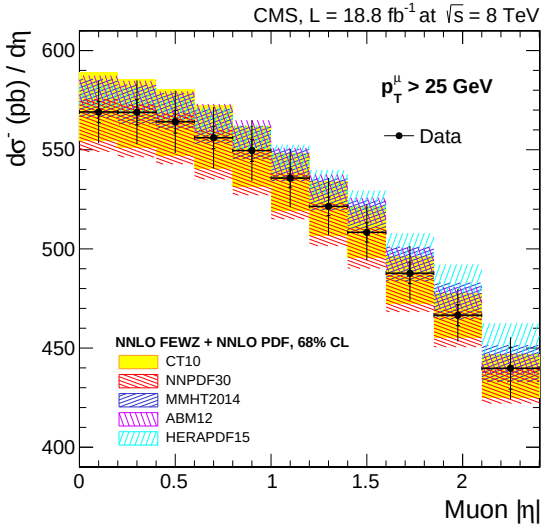
Latest results using xFitter: CMS W asymmetry

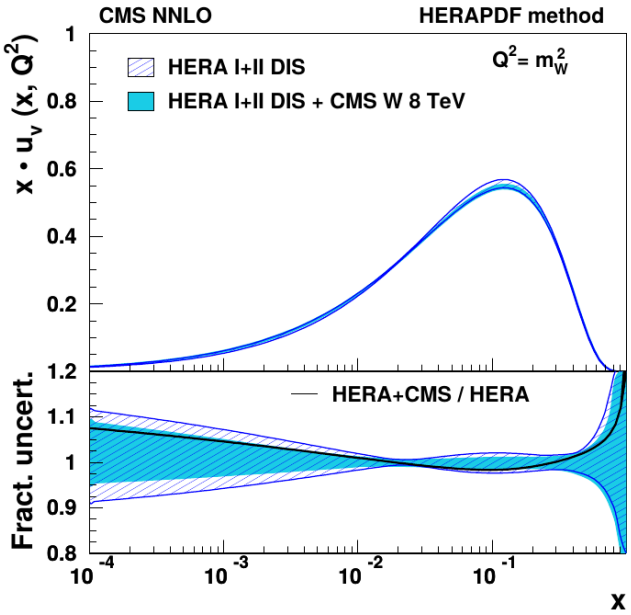
Measurement of the differential cross section and charge asymmetry for inclusive $\mathrm{pp} \to \mathrm{W}^{\pm} + \mathrm{X}$ production at $\sqrt{\mathrm{s}} = 8$TeV

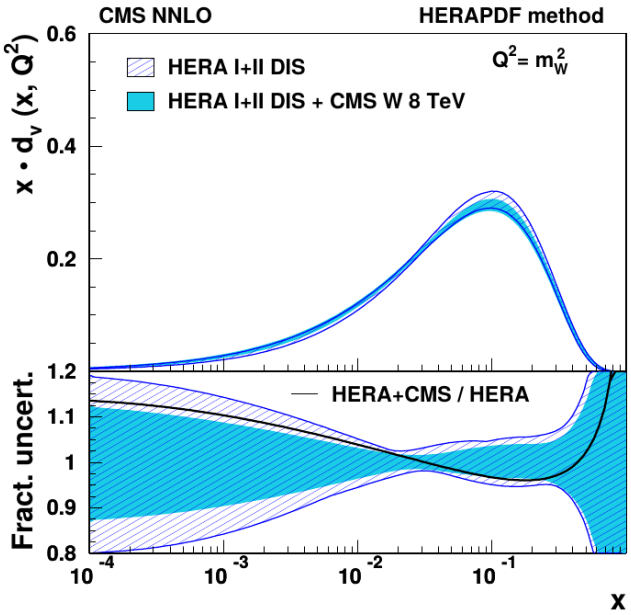
CMS, arXiv:1603.01803, submitted to EPJ C

- NNLO QCD analysis of CMS W asymmetry data
- Improved valence distributions at $10^{-3} < x < 10^{-1}$







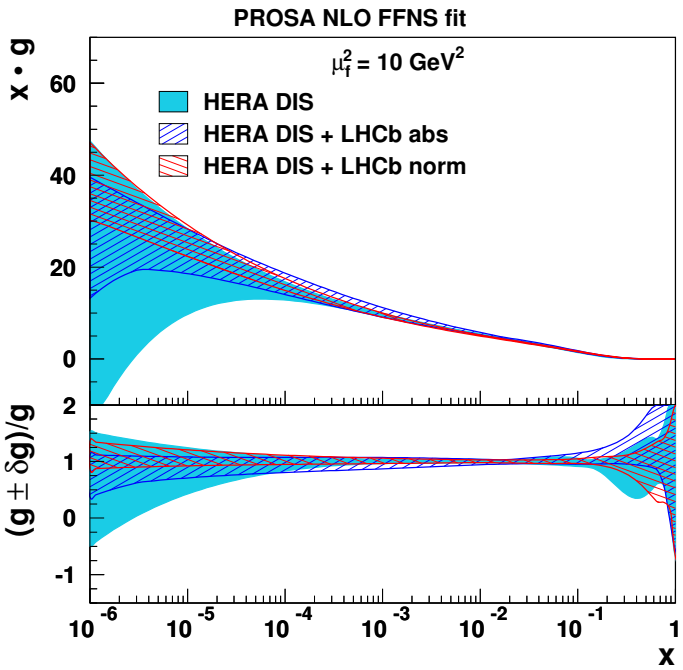


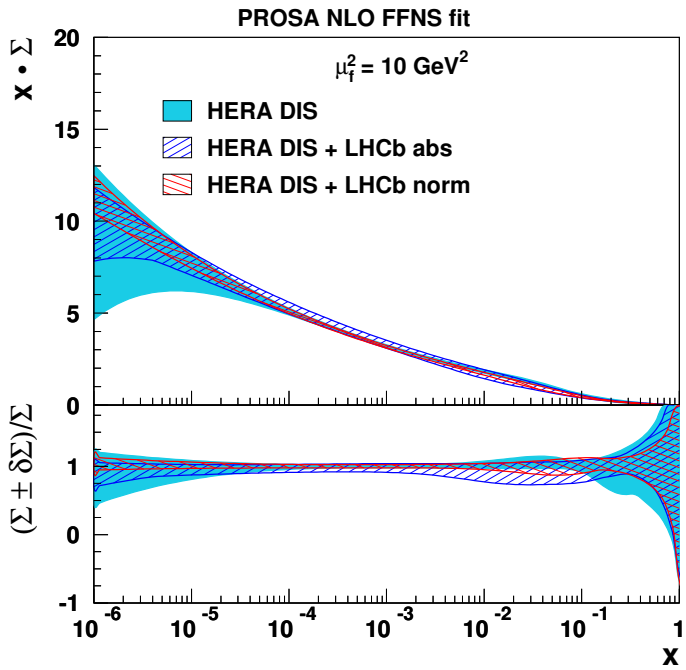
Latest results using xFitter: low x gluons from LHCb data

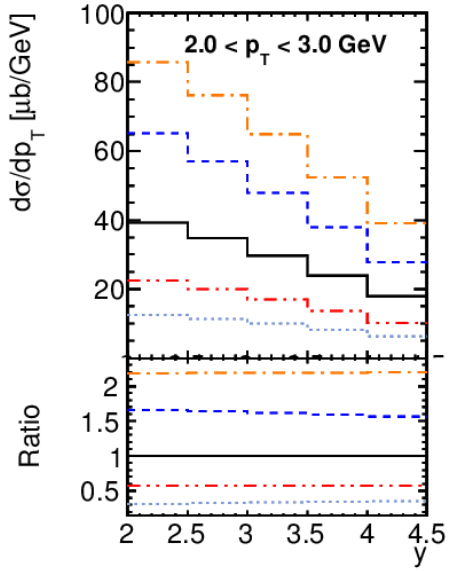
Impact of heavy-flavour production cross sections measured by the LHCb experiment on parton distribution functions at low x

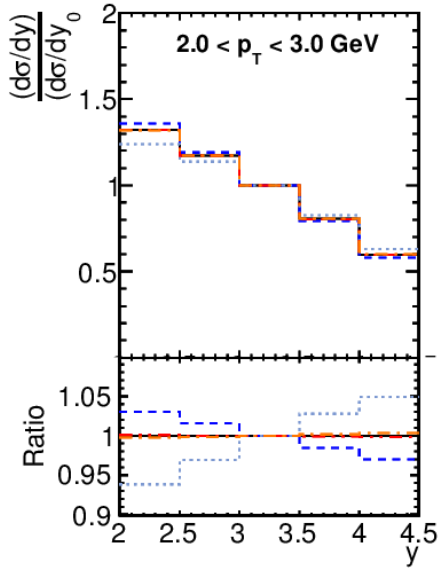
PROSA, EPJ C75 (2015) 396

- NLO QCD analysis of LHCb charm and beauty data
- Reduction of theory uncertainty for y shape
- Improved gluon and sea-quark distributions up to $x \gtrsim 5 \times 10^{-6}$









Summary and outlook

xFitter (former HERAFitter) project is based on open source QCD software that provides a framework for scrupulous interpretations of the QCD analyses with its main application at the LHC program

Give it a try: www.xfitter.org **(latest release 1.2.0)**

Plenty of foreseen developments:

- Improve user interface for various parametrisation
- Simplification of steering file for profiling (no fit)
- Add resummation options
- More on low x phenomenology
- Nuclear PDFs
- Interface to other grids (APFELgrids, TMDgrids)

BACKUP

BACKUP. xFitter 1.2.0 Relese Notes

Date	Version	Files	Remarks
02/2016	**1.2.0**	xfitter-1.2.0.tgz	release with decoupled data and theory files which can be dowloaded with getter.sh script

Documentation

- A list of datasets which can be downloaded with the help of getter script.
- Manual (under continuous improvement) can be accessed here.
- The **README** file (accessible via the package) gives an explanation for a quick start.
- The **INSTALLATION** file (accessible via the package) provides information for package installation and usage instructions.
- The package is licensed under GNU GPL, please see **LICENCE** for mode details (accessible via the package).

Web access to SVN

- For users with a valid DESY account, the SVN repository is accessible on the web at https://svnsrv.desy.de/k5viewvc/h1fitter .
- For users without DESY account, the SVN repository is accessible on the web at https://svnsrv.desy.de/basviewvc/h1fitter/ with xfitter-svn-user@desy.de account and PDFfits password.

- Project renamed from herafitter to xfitter.
- Added stand-alone scripts for downloading data/theory files: `getter` . No need of theory directory anylonger, the theory files are now stored under same location with data files.
- Change in the executable names:
  - FitPDF → xfitter
  - DrawPdfs → xfitter-draw
  - postproc → xfitter-process
- Updated configure.ac to work with latest QCDNUM which is now available with autotools installation (> 17.01.10).
  - new QCDNUM allows possibility to have more than standard PDFs.
- Added QED PDFs via generalised `nxn` convolution engines of QCDNUM.
- Added interface to APFEL which provides access to:
  - evolution code: added DGLAP_APFEL option for standard evolution, or DGLAP_APFEL_QED for QED adjusted evolution.
  - FONLL heavy flavour schemes with multiple options.
- Added interface to n-space code MELA for Mellin Transformation and it is available via configuration flag.
- Added direct access to LHAPDFs avoiding QCDNUM: LHAPDFNATIVE option
- Added more data formatted for xfitter: updated Tevatron data, LHCb, HERA)
- Added `--disable-root` option (root is enabled by default).
- Default steering updated to HERAI+II data.
- Removed DrawResults package, which was redundant, and added and updated drawing options for data files.
- Added fixes to DIS electroweak part of the code.
- Fixed several fortran warning messages.
- Unifying theory interface for expression between FastNLO and APPLGRID usage.
- Updated FastNLO to the latest version
- Installation possible with `--prefix` option, added xfitter-config script.
- Added MNR calculation code as used for the LHCb and HERA data analysis [Eur.Phys.J. C75 (2015) 8, 396]
- Added new options for the reweighting using Giele-Keller weights. Merged common codes between profiling and reweighting.
- Fixing lapack and blas tests to give configure errors and stop
- Updated the ABM calculations in sync with OPENQCDRAD 2.0b4
- Added possibility to get integrated cross sections for DIS.
- Tools/RunJobs and steerings for diffraction adjusted to xFitter.