

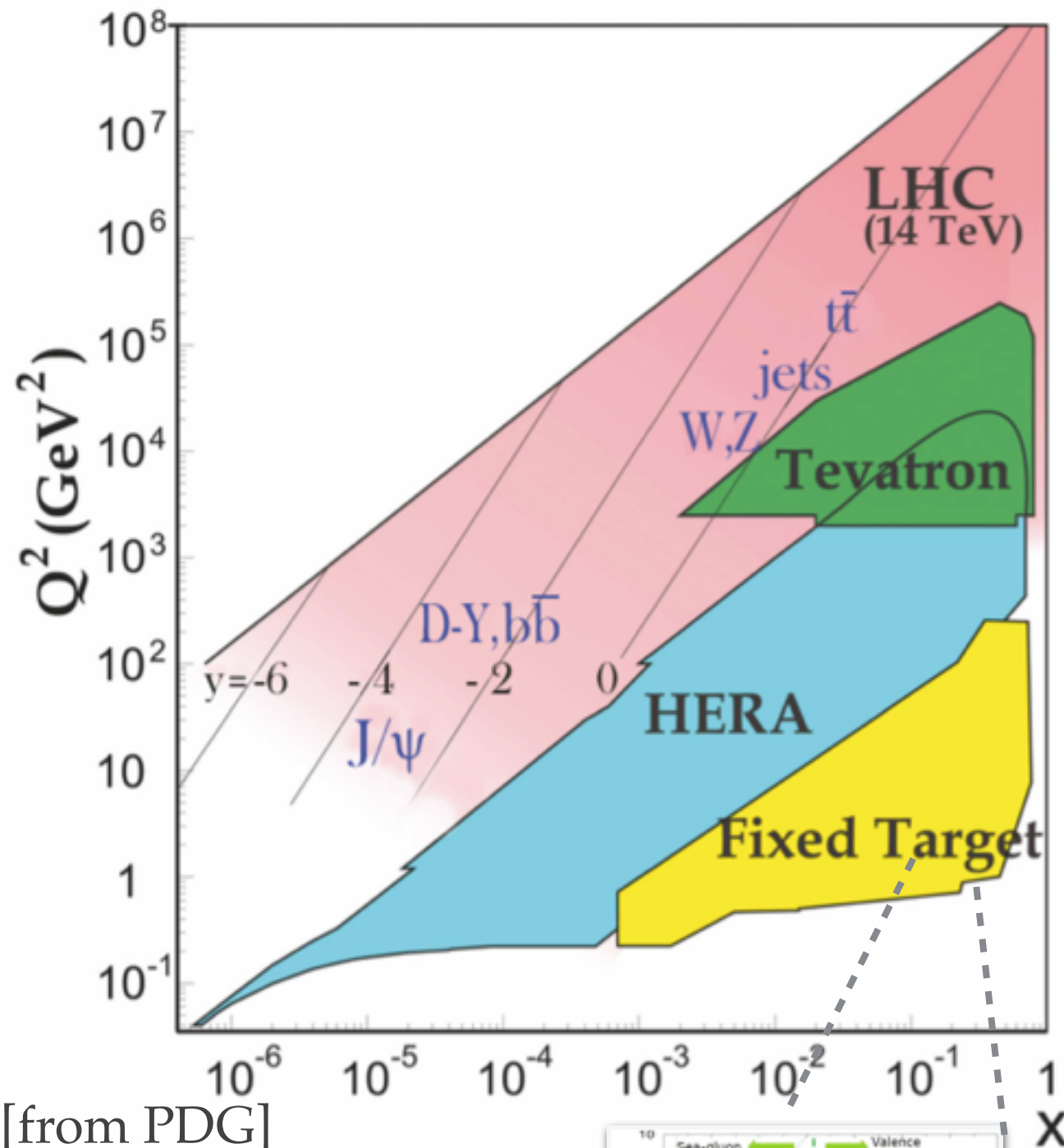
<https://www.xfitter.org/xFitter>

xFitter Project

Open Source QCD Fit framework

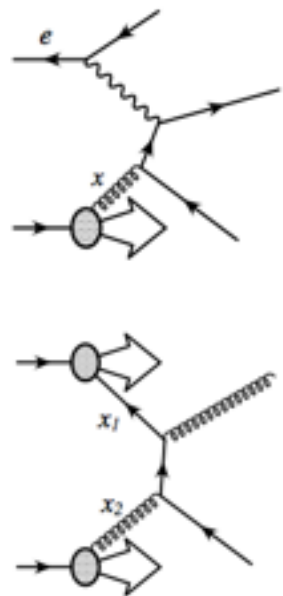
Amanda Cooper-Sarkar
on behalf of the xFitter team

Today's data on proton structure

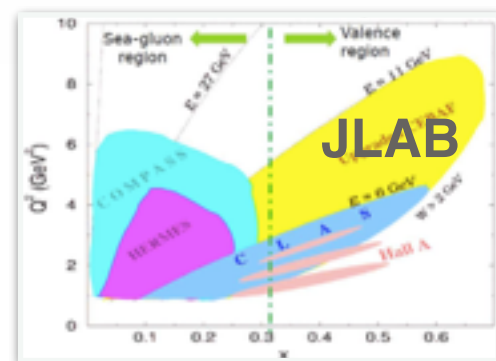


Persistent experimental effort over the last 40 years both by fixed-target and collider experiments around the world supported by the intense theoretical developments

- The cleanest way to probe Proton Structure is via Deep Inelastic Scattering [DIS]:
- Precision of proton structure can be complemented by the Drell Yan [DY] processes at the collider experiments



Different data constrain different parton combinations at different x , evolution with the scale is predicted by pQCD:



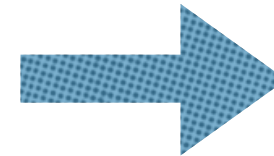
2011 Open Source Revolution:

- Establishing the first open source QCD Fit Platform which started the wave of sharing QCD fit codes

EPJC (2015), 75

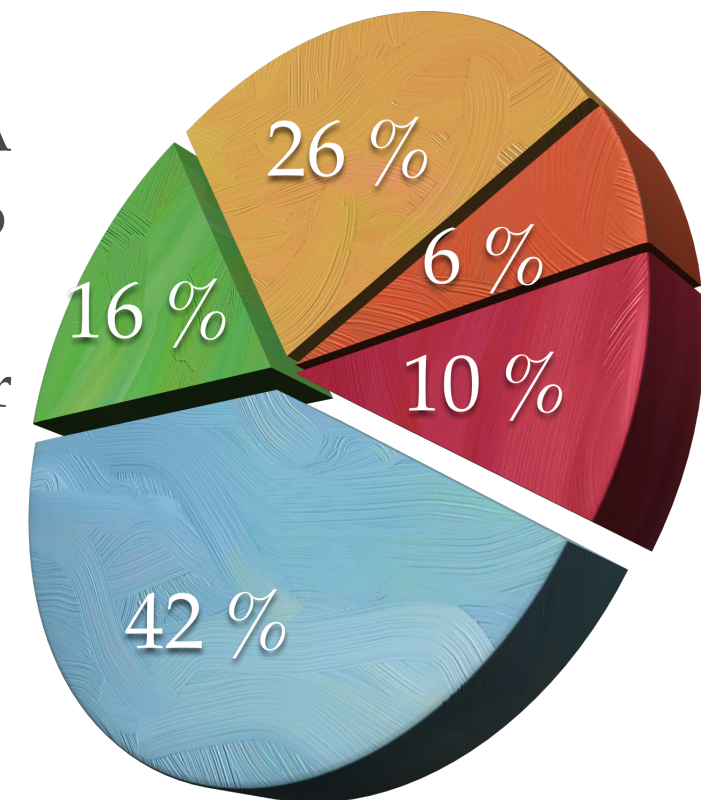
- A team of ~30 developers:

- LHC/HERA/theory/independent
- several releases since 2011
- 31 publications that have used the framework [in total]



- LHC
- HERA
- Pheno
- Other
- xFitter

synergy between experiment and theory groups



- ❖ **provides a unique QCD framework to address theoretical differences:**
—> benchmark exercises / collaborative efforts / topical studies
- ❖ **provides means to the experimentalists to optimise the measurements:**
—> assess impact / consistency of new data

❖ Dedicated studies [xFitter developers]

- ❖ method in preserving correlation between PDFs extracted at different orders in pQCD
- ❖ address consistency of Tevatron measurement and evaluate their collective impact on valence
- ❖ determination of the running mass in \overline{MS} scheme

EPJC (2014) 74

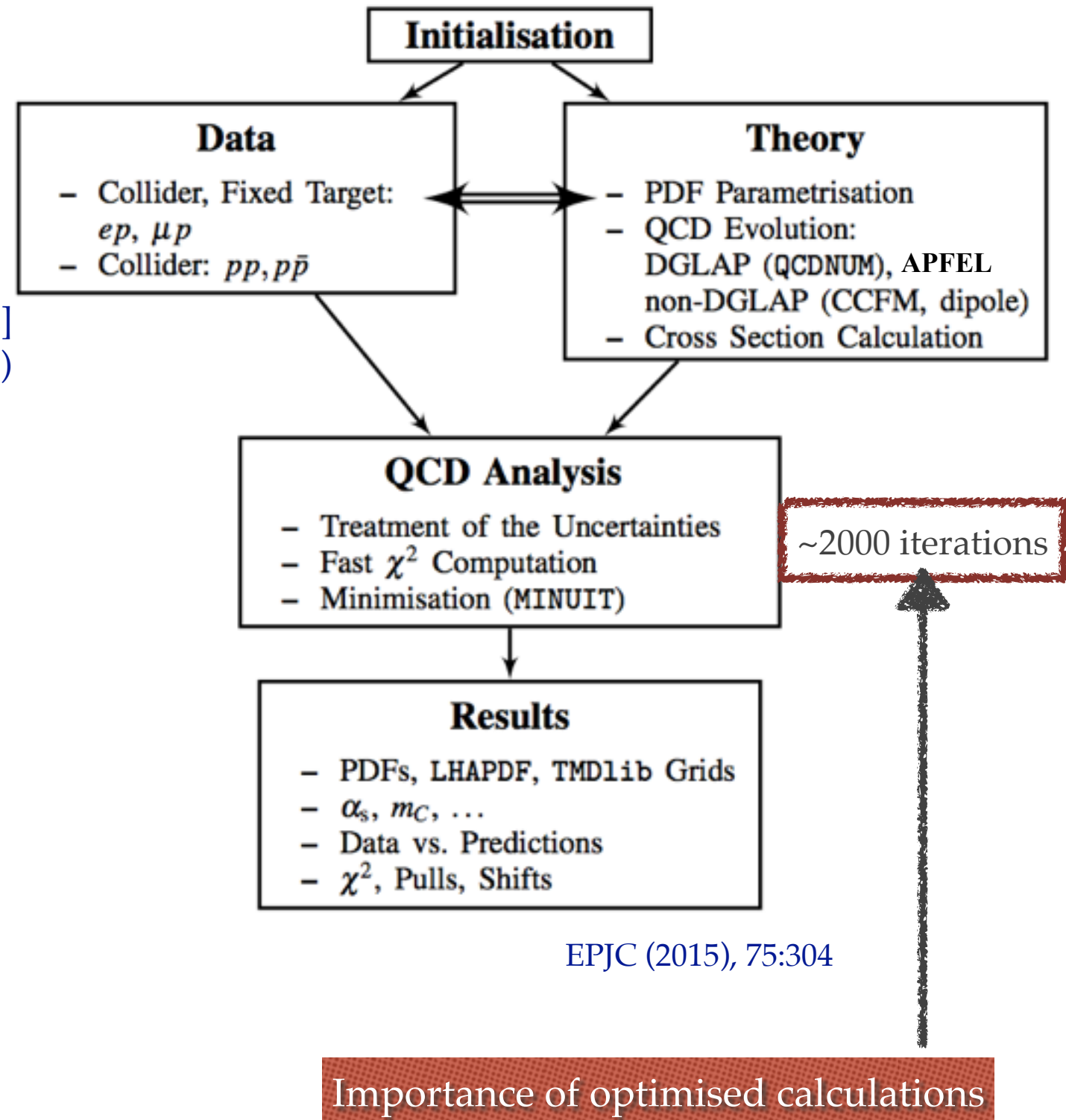
EPJC (2015), 75

submitted to JHEP

xFitter Project at Glance:

Main Steps for a QCD fit:

- Parametrise PDFs at the starting scale
 - multiple options for functional forms
 - Standard Polynomial, Chebyshev, etc
- Evolve to the scale corresponding to data point
 - QCD(DGLAP) evolution codes [QCDNUM, APFEL]
 - kt ordered evolution, Dipole models, QCD(DGLAP)+QED
- Calculate the cross section
 - various heavy flavour schemes:
 - RT, ACOT, FONLL, FFNS(ABM)
 - fast grid techniques interfaced to DY:
 - APPLGRID, FASTNLO
- Compare with data via χ^2 :
 - multiple forms to account for correlations
- Minimize χ^2 with respect to PDF parameters
 - Profiling, reweighting
 - Fit: MINUIT, data driven regularisation



xFitter



Welcome to xFitter (former HERAFitter)

Proton parton distribution functions (PDFs) are essential for precision physics at the LHC and other hadron colliders. The determination of the PDFs is a complex endeavor involving several physics process. The main process is the lepton proton deep-inelastic scattering (DIS), with data collected by the HERA ep collider covering a large kinematic phase space needed to extract PDFs. Further processes (fixed target DIS, ppbar collisions etc.) provide additional constraining powers for flavour separation. In particular, the precise measurements obtained or to come from LHC will continue to improve the knowledge of the PDF.

The xFitter project is an open source QCD fit framework ready to extract PDFs and assess the impact of new data which we would like to present here. The framework includes modules allowing for a various theoretical and methodological options, capable to fit a large number of relevant data sets from HERA, Tevatron and LHC. This framework is already used in many analyses at the LHC.

Downloads of xFitter software package

💡 **xFitter-1.2.1 release is publicly available.**
All the xFitter releases can be accessed [HERE](#).
All the former (HERAFitter) releases can be accessed [HERE](#).
Description: <http://arxiv.org/abs/1410.4412>

xFitter Meetings

- **User's Meetings:** meetings to enhance communication between users and developers (open access)
- **Developer's Meeting:** technical weekly meetings to ensure communication among developers (restricted access)
- **Steering Group's Meeting** (restricted access)

xFitter representation

- [List of results](#)
- [List of collected talks](#)

Developers Info (restricted to developers)

- [Internal Developments](#)

Organisation

Steering Group is composed of:

- **Conveners:** Voica Radescu, Ringaile Placakyte, Amanda Cooper-Sarkar
- **Release coordinator** (revision of the release candidates): Sasha Glazov
- **Librarian** (continuous revision/development of the main code and doxygen): Hayk Pirumov, Andrey Sapronov
- **Contact Persons:** Cristi Diaconu (H1), Klaus Rabbertz (CMS), Bogdan Malaescu (ATLAS), Olaf Behnke (ZEUS), Ronan McNulty (LHCb), Gavin Salam (theory)
- **DESY IT Contact:** Yves Kemp

Getting help

Send email to xfitter-help@desy.de



xFitter new release: 1.2.1

Release xFitter1.2.1.tgz available at:

<https://www.xfitter.org/xFitter/xFitter/DownloadPage>

xFitter / DownloadPage



Releases of the xFitter QCD analysis package

- Versioning convention: **i,j,k** with
 - **i** - stable release
 - **j** - beta release
 - **k** - bug fixes.
- The release notes can be found in this attachment: @xFitter_release_notes.pdf
- Installation script for xFitter together with QCDNUM, APFEL, APPLGRID, LHAPDF @install-xfitter

Date	Version	Files	Remarks
🔦 05/2016	1.2.1	@xfitter-1.2.1.tgz	release with decoupled data and theory files which can be downloaded with @getter.sh script
02/2016	1.2.0	@xfitter-1.2.0.tgz	release with decoupled data and theory files which can be downloaded with @getter.sh script

- ❖ By default only final combined HERA I+II data are distributed
 - ❖ (xfitter-)getter.sh script to download data with corresponding theory files already adjusted for the xfitter format.
- ❖ A complete installation script is also provided (tested under different platforms)
- ❖ A release note to keep track of changes between releases is included
- ❖ A link to the manual

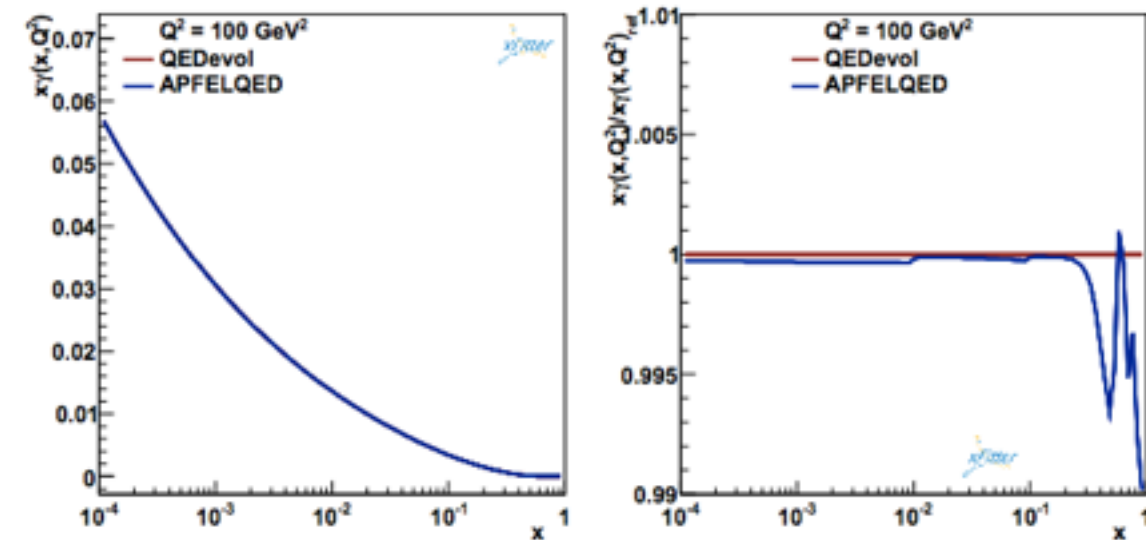
- ❖ **QED PDFs up to NNLO QCD + LO QED in FFNS and VFNS are now available via evolutions in:**

- ❖ QCDNUM adjusted for DGLAP+QED [R. Sadykov]

<http://www.nikhef.nl/~h24/qcdnum>

- ❖ APFEL DGLAP+QED as used by NNPDF2.3 [V. Bertone et al]

<https://apfel.hepforge.org>



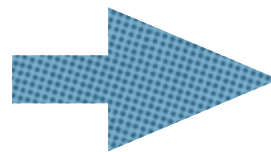
—> plan to add NLO QED, interface APPLGRID to SANC

- ❖ **Mellin Transformation in xfitter via MELA** <https://apfel.hepforge.org/mela.html>

- ❖ Mellin transformations convey convolutions in simple products —> DGLAP has a simple form

- ❖ Motivation:

- ❖ Mellin moments predictions work well:
 - ❖ with fixed order calculations
 - ❖ main stream in extracting PDFs
 - ❖ with all-order resummed predictions
 - ❖ needed for other fundamental parameters



The Mellin moments implementation could allow a broader spectrum of phenomenological applications of xFitter:

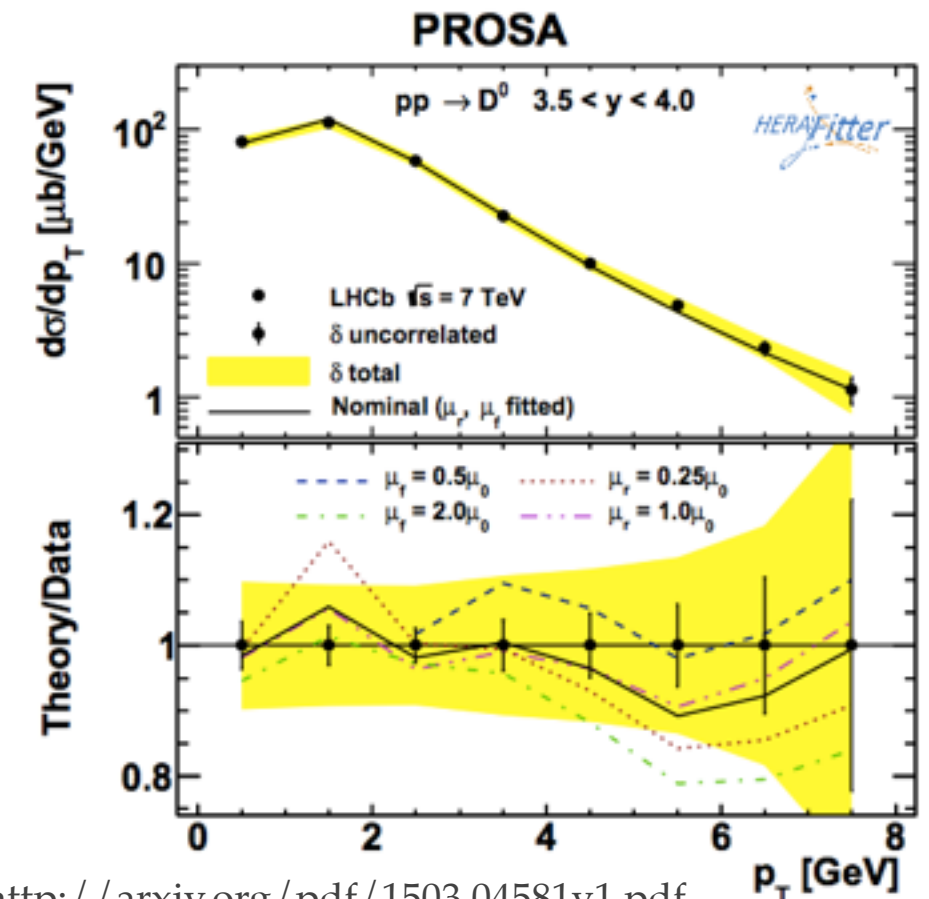
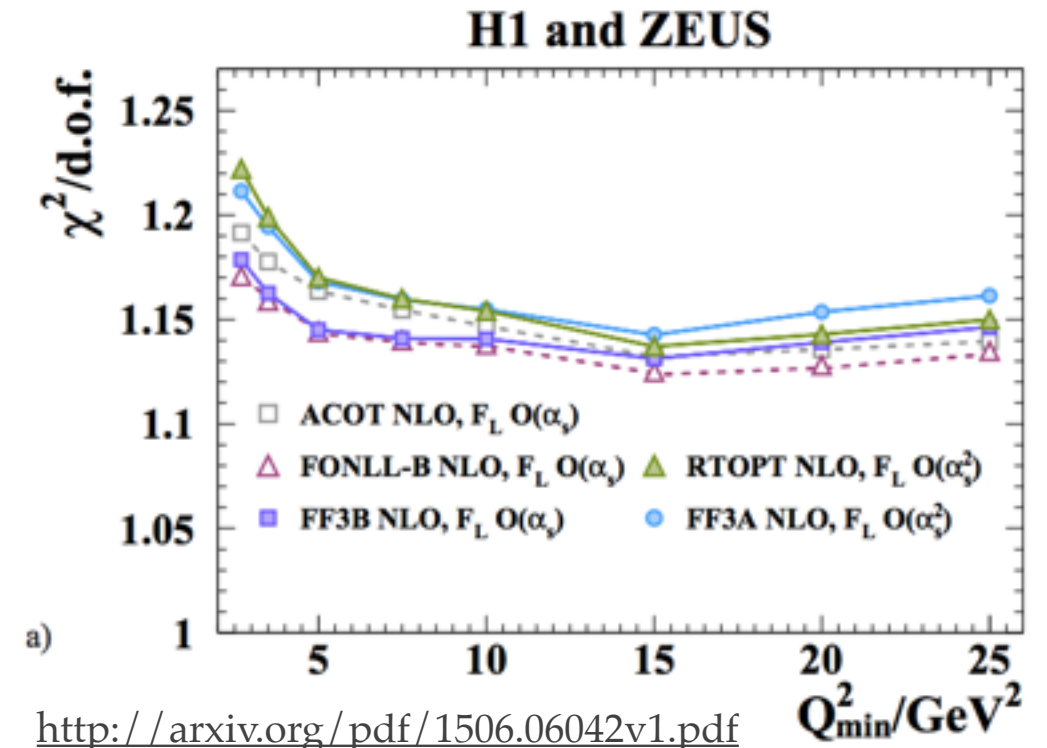
- ❖ Simultaneous fits of PDFs and weak mixing in DY,
- ❖ PDFs and alphas and mt in ttbar

New Physics Cases in xfitter (II)

- ❖ **Addition of new Heavy Flavour Scheme: FONLL**
 - ❖ it is available thanks to collaboration with APFEL
 - ❖ various FONLL options available via interface to APFEL
[<https://apfel.hepforge.org>]
- ❖ ABM scheme was up-to-dated to OPENQCDRAD v 2.0b4
. <http://www-zeuthen.desy.de/~alekhin/OPENQCDRAD>.

Nucl. Phys. B373 (1992) 295

- ❖ **Interface to Mangano-Nason-Ridolfi (MNR) theory code added** in xfitter and it was used for analysing the heavy-flavour production at LHCb and at HERA (via OPENQCDRAD)
 - ❖ use of FFNS for accounting of heavy quark masses at NLO
 - ❖ added also corresponding LHCb data
- ❖ Added extra reweighting options using Giele-Keller weights



Recent Analysis by xFitter developers' team:

arXiv.org > hep-ph > arXiv:1605.01946 Search or Article

High Energy Physics – Phenomenology

A determination of $m_c(m_c)$ from HERA data using a matched heavy-flavor scheme

xFitter Developers' team: Valerio Bertone, Stefano Camarda, Amanda Cooper-Sarkar, Alexandre Glazov, Agnieszka Luszczak, Hayk Pirumov, Ringaile Placakyte, Klaus Rabbertz, Voica Radescu, Juan Rojo, Andrey Sapranov, Oleksandr Zenaiev, Achim Geiser

(Submitted on 6 May 2016)

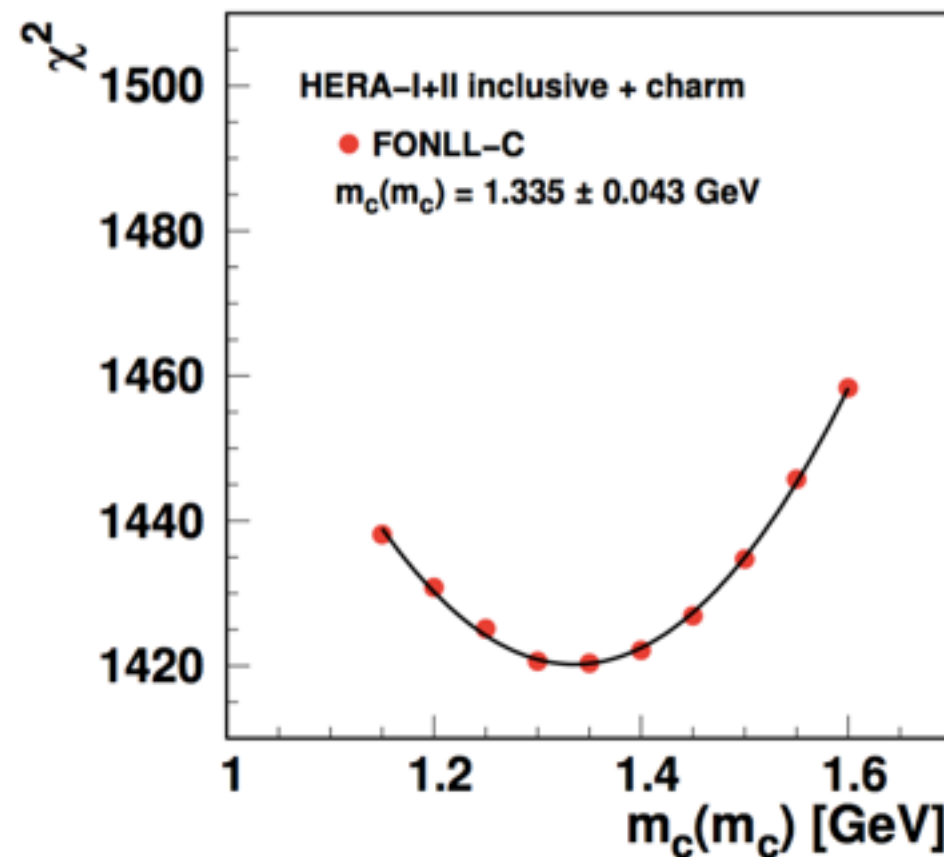
The charm quark mass is one of the fundamental parameters of the Standard Model Lagrangian. In this work we present a determination of the \overline{MS} charm mass from a fit to the inclusive and charm HERA deep-inelastic structure function data. The analysis is performed within the xFitter framework, with structure functions computed in the FONLL general-mass scheme as implemented in APFEL. In the case of the FONLL-C scheme, we obtain $m_c(m_c) = 1.335 \pm 0.043(\text{exp}) + 0.019 - 0.000(\text{param}) + 0.011 - 0.008(\text{mod}) + 0.033 - 0.008(\text{th})$ GeV. We also perform an analogous determination in the fixed-flavor-number scheme at next-to-leading order, finding $m_c(m_c) = 1.318 \pm 0.054(\text{exp}) + 0.011 - 0.010(\text{param}) + 0.015 - 0.019(\text{mod}) + 0.045 - 0.004(\text{th})$ GeV, compatible with the FONLL-C value. Our results are consistent with previous determinations from DIS data as well as with the PDG world average.



- The extraction of $m_c(m_c)$ was performed using FONLL scheme in terms of the \overline{MS} masses —> improves perturbative convergence
 - combined HERA I + II charm production and DIS cross sections
 - FONLL-C scheme used – NLO accuracy in the massive sector
 - Also tested in FFNS (fixed flavor number scheme) at NLO
- The best fit of $m_c(m_c)$ values is determined from parabolic minimum of the global χ^2 variation.

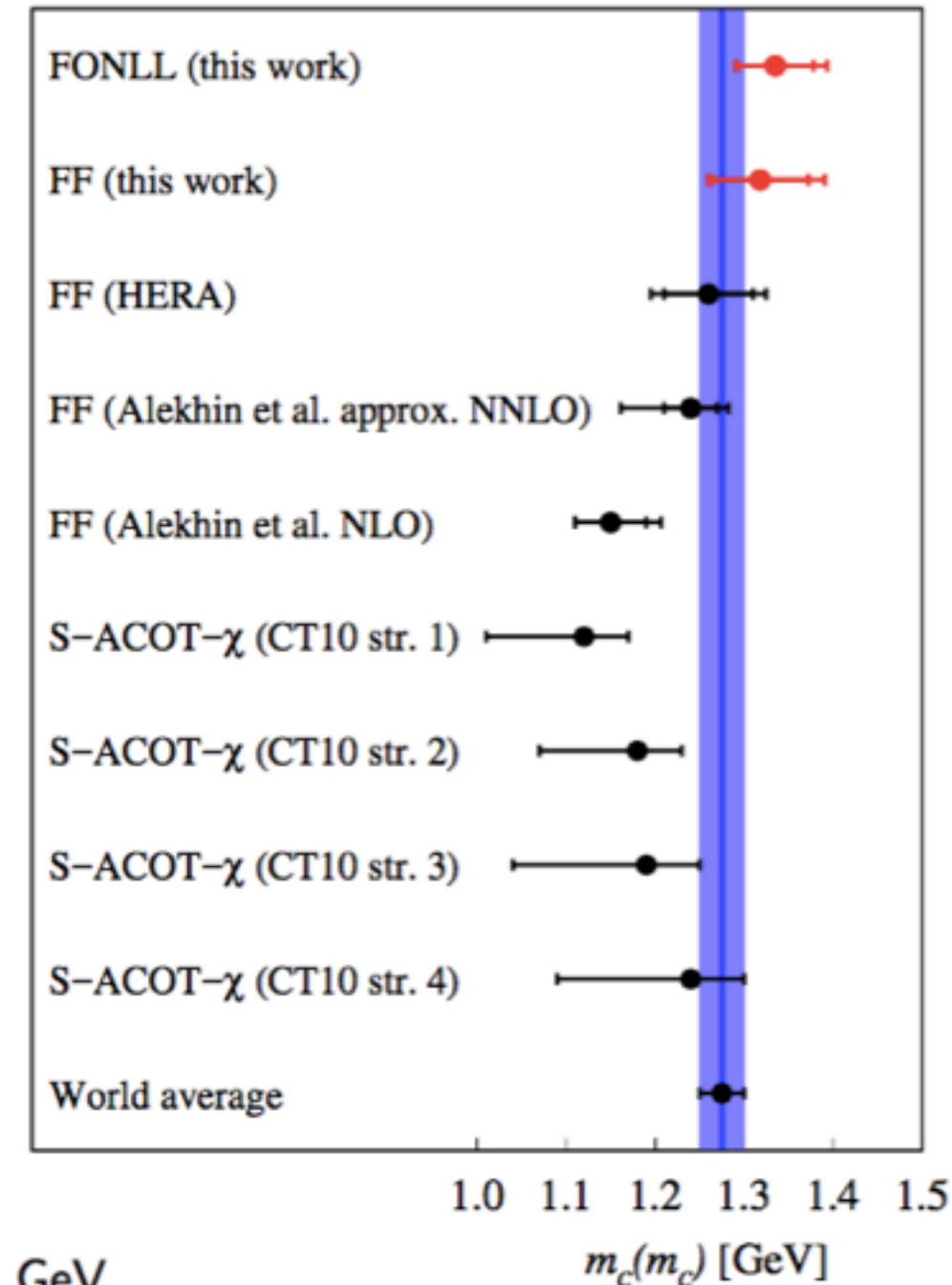
Results of the xFitter charm mass analysis:

- The $m_c(m_c)$ value is determined from a parabolic minimum of the global χ^2 scan vs $m_c(m_c)$ with 1- σ unc. determined from $\Delta\chi^2$ variation.
- The $m_c(m_c)$ measurement is comparable to previous determinations from DIS as well as PDG world average:



FONLL-C:

$$m_c(m_c) = 1.335 \pm 0.043(\text{exp})^{+0.019}_{-0.000}(\text{param})^{+0.011}_{-0.008}(\text{mod})^{+0.033}_{-0.008}(\text{th}) \text{ GeV}$$



Summary

- xFitter (former HERAFitter) project is based on a multi-functional open source QCD software package that provides a framework for scrupulous interpretations of the QCD analyses with its main application at the LHC program
 - www.xfitter.org
 - xfitter-1.2.1 latest release
- New release provides access to new phenomenological studies to follow thanks also to intensive collaboration with theory groups such as APFEL, SANC, CUTE, ABM, CT, NCTEQ, etc...

Outlook: plenty foreseen developments

- Improve user interface for various parametrisation
- Simplification of the steering card for easier access to profiling module [no fit]
- Add resummation options
- More on low x phenomenology: higher twists
- Nuclear PDFs
- Interface to other kind of grids [APFELgrids, TMDgrids]

Organisation

Steering Group is composed of:

- **Conveners:** Voica Radescu, Ringaile Placakyte, Amanda Cooper-Sarkar
- **Release coordinator** (revision of the release candidates): Sasha Glazov
- **Librarian** (continuous revision/development of the main code and doxygen): Hayk Pirumov, Andrey Sapronov
- **Contact Persons:** Cristi Diaconu (H1), Klaus Rabbertz (CMS), Bogdan Malaescu (ATLAS), Olaf Behnke (ZEUS), Ronan McNulty (LHCb), Gavin Salam (theory)
- **DESY IT Contact:** Yves Kemp

Getting help

Send email to  xfitter-help@desy.de

- ❖ **Change of name of executables:**

- ❖ FitPDF —> xfitter
- ❖ DrawPdfs —> xfitter-draw
- ❖ DrawResults —> xfitter-draw
- ❖ Postproc —> xfitter-process

- ❖ Note that in the previous releases there was a theoryfiles directory

- ❖ —> now theoryfiles are stored with datafiles to be in sync

- ❖ **Installation:**

- ❖ xfitter-1.2.0 is compatible with new QCDNUM version > 17.01.10
 - ❖ QCDNUM is available now also with autotools installations
 - ❖ QCDNUM provides now access to more than standard 13 PDFs, e.g. photon PDF can be added
- ❖ Installation of the xfitter-1.2.0 can also be configured via prefix
- ❖ Added the possibility to disable root

- ❖ Theory formats in xfitter (usage/parsing) have been unified between FASTNLO and APPLGRID

- ❖ old format for FASTNLO is still operational

- ❖ Profiling and Reweighing codes now use same general infrastructure

- ❖ Possibility to access directly PDFs as stored in LHAPDF (surpassing QCDNUM)

- ❖ LHAPDFNATIVE option added

Release Notes

xFitter: Releases and Updates

February, 2016

xFitter versions are labeled as **xfitter-i.j.k** where **i** is the stable release number, **j** is beta release number, and **k** is bug fixes.

Release	Date	Description
xfitter-1.2.0	15.02.2016	<ul style="list-style-type: none"> • 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: <ul style="list-style-type: none"> – 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). <ul style="list-style-type: none"> – 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: <ul style="list-style-type: none"> – 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.