

HERAFitter

an open source QCD fit framework



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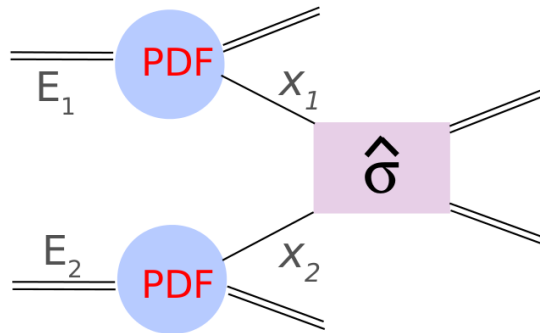
for HERAFitter team

- Motivation
- Project overview
- Progress and plans
- Summary

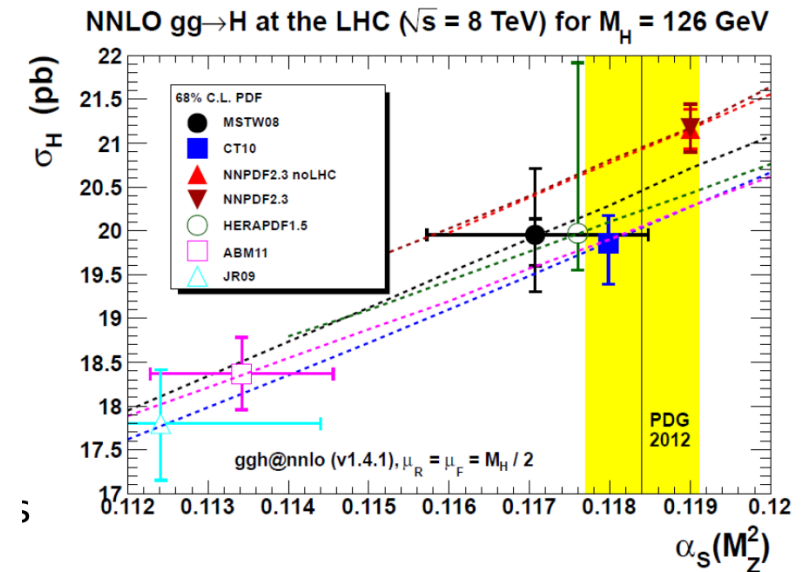
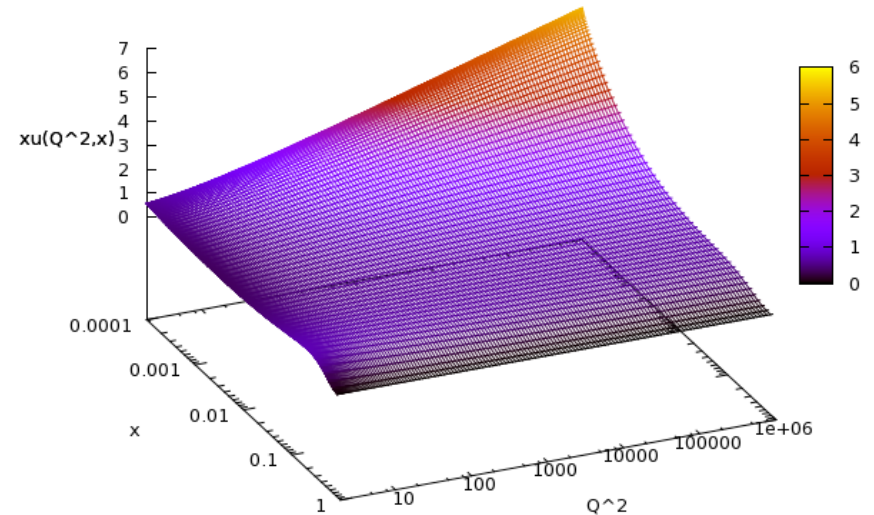


- Nonperturbative nature of PDFs at low $Q^2 \rightarrow$ empirical determination
- Factorization:

$$\sigma \approx \hat{\sigma} \otimes \text{PDF}$$



- Depending on factorization scheme, radiative corrections can be included in PDFs (DIS)
- Main PDF fitting groups: ABM, CTEQ, JR, HERAPDF, MSTW, NNPDF



- Sources of uncertainty in theoretical predictions: estimates for DY at LHC (ATL-COM-PHYS-2010-695)
- Inclusion of additional experimental data reduces uncertainty of sensitive PDFs
- + more constraints from correlated experimental uncertainties.

Uncertainty (%)	NLO	NNLO	Correlated to PDF unc.
PDF errors (90% CL)	3.5	4.5	
α_s (0.110 – 0.130)	2.2	2.6	+
scales ($0.5 \leq \mu_F / \mu_R \leq 2$)	3.	0.6	+
fixed order (QCD)	3.	<0.1	-
EW parameters (M_W, m_t)	~2	~1	+

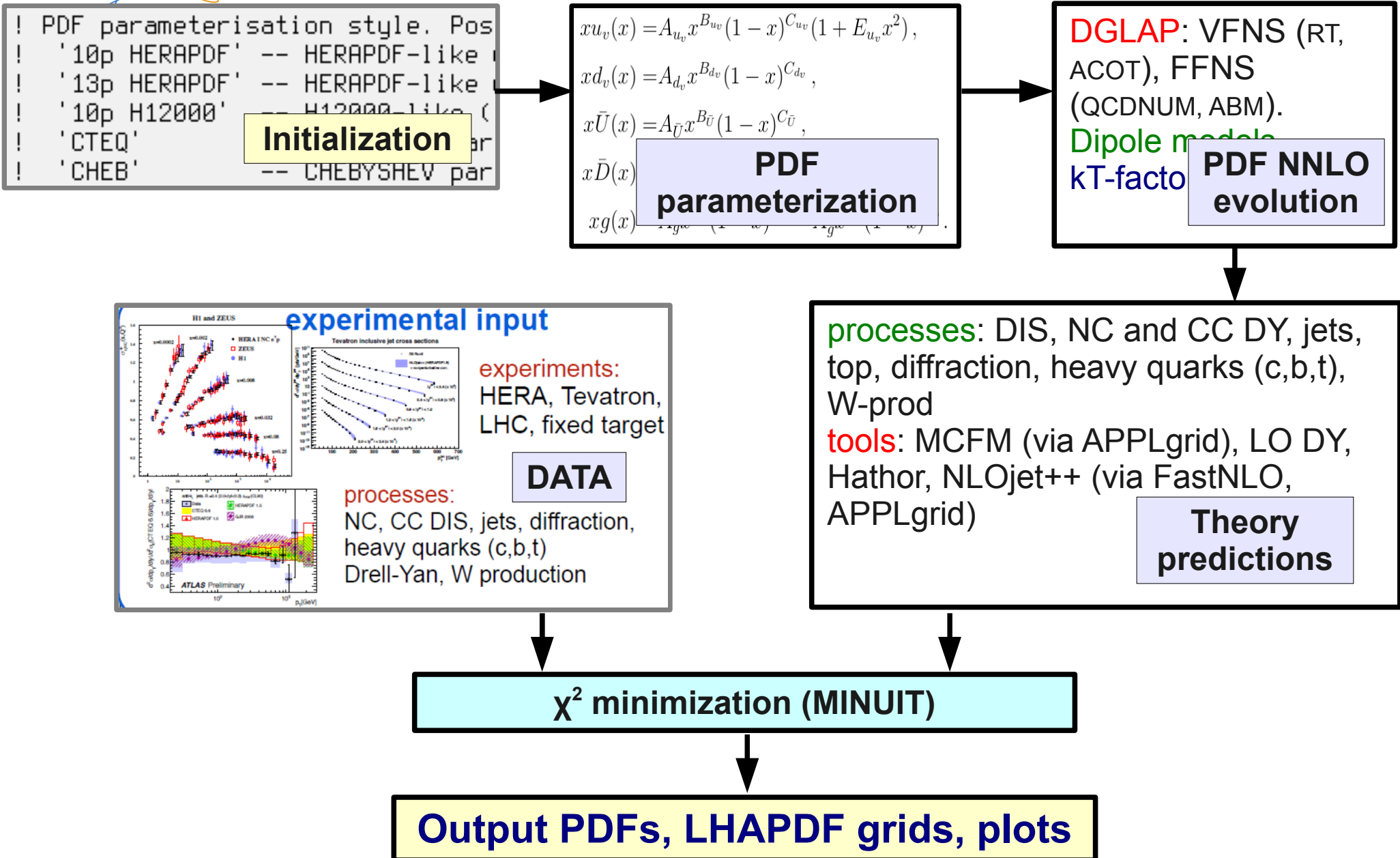
Data impact varies for different experiments and PDFs, therefore

- sensitivity studies
 - representation optimization (binning, cuts, etc)
 - treatment of systematic uncertainties
- are all needed for presenting the data in the best way for QCD interpretation

HERAFitter is an opensource project for QCD analysis of exp data.

- Historically based on H1FITTER and ZEUSFITTER developments
- Provides means for PDF extraction from experimental collider and/or fixed target data:
 - Theoretical predictions for a variety of processes (DIS, DY, top)
 - DGLAP evolution (QCDNUM)
 - LHAPDF-ready output, plots
- Flexible PDF parameterization
- Supports a variety of schemes of heavy flavour treatment in DGLAP formalism for DIS
- Elaborate uncertainty treatment:
 - Uncertainty correlations in the input data
 - Asymmetric errors
 - Different uncertainty treatments (Hessian, MC, regularization)

HERAFitter workflow



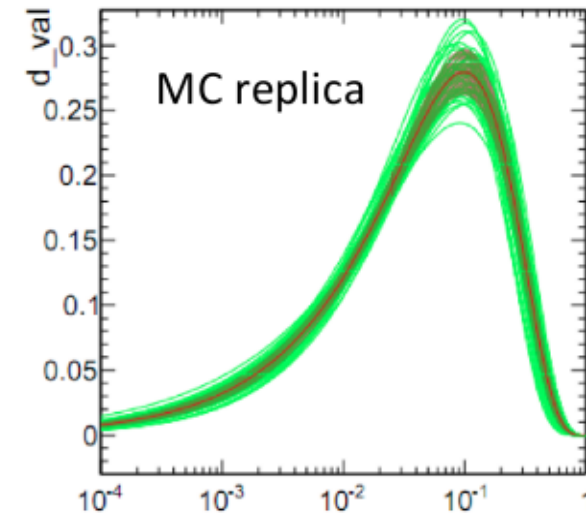
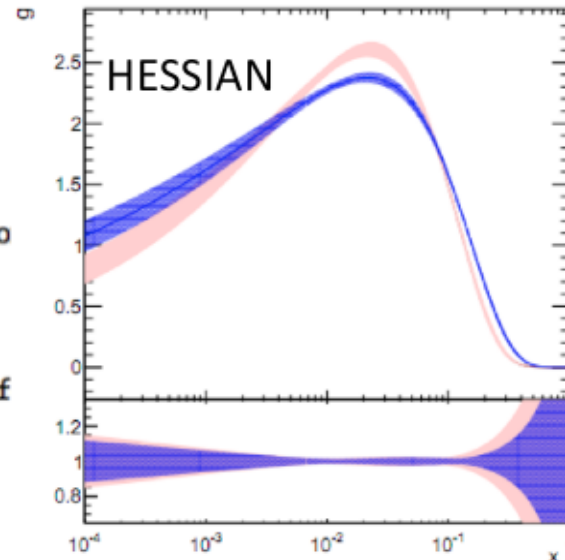
HERAFitter package allows for various types of data uncertainty treatment:

► Hessian and Monte Carlo replica method

&MCErrors

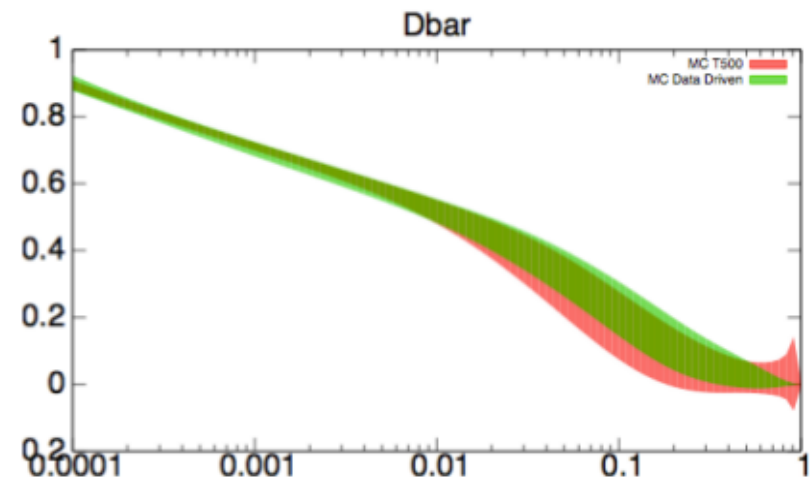
```
lRAND = False
lRANDDATA = True
lSeedMC = 123456
! --- Choose what distribution for the random
! STATYPE (SYS_TYPE) = 1 gauss
! STATYPE (SYS_TYPE) = 2 uniform
! STATYPE (SYS_TYPE) = 3 lognormal
! STATYPE (SYS_TYPE) = 4 poisson (only f
STATYPE = 1
SYSTYPE = 1
```

&End



► Regularisation methods: to constrain PDFs in a flexible parametrisation style:

- Data Driven Regularisation (as used by NNPDF): fit and control samples
- External Regularisation based on a penalty term in χ^2



DY data analysis: combining APPLgrid and K-factor methods:

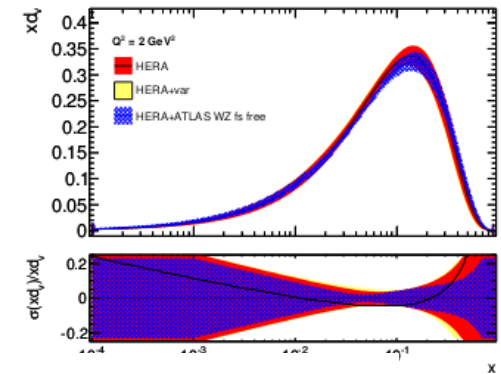
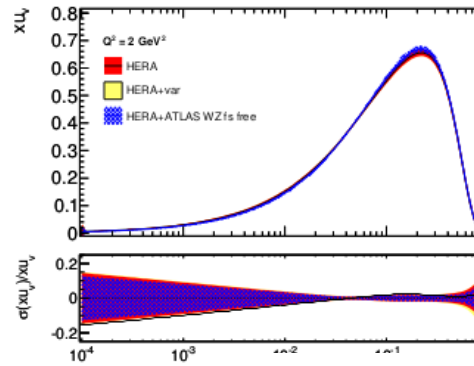
- Generate grids with APPLgrid and calculate corresponding HO QCD and/or EW K-factors in the data-optimized phase space region
- Configure HERAFitter steering files and datafiles

y_{min}	y_{max}	$K_{QCD}(NNLO/NLO)$	$K_{EW}(NLO)$
0.0	0.4	0.99943	0.99313
0.4	0.8	0.99423	0.99307
0.8	1.2	1.00320	0.99306
1.2	1.6	0.99889	0.99299
1.6	2.0	0.99846	0.99286
2.0	2.4	0.99750	0.99271
2.4	2.8	0.98983	0.9925
2.8	3.6	0.97726	0.99242

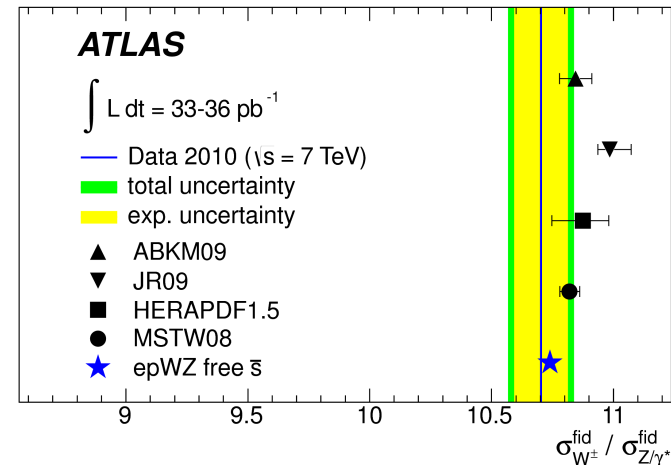
```

Reaction = 'NC pp'
TheoryType = 'applgrid','kfactor'
NKfactor = 2
TheoryInfoFile = 'theoryfiles/atlas/WZ2010/Z0-applgrid.root

PERCENT = F, 32*T
END
0.00 0.40 129.27 1.88 0.59 0.291
0.19 0.069 -0.101 -0.526 0.066 -0.164 0.343 -0.145
0.40 0.80 129.44 1.90 0.50 0.291
    
```



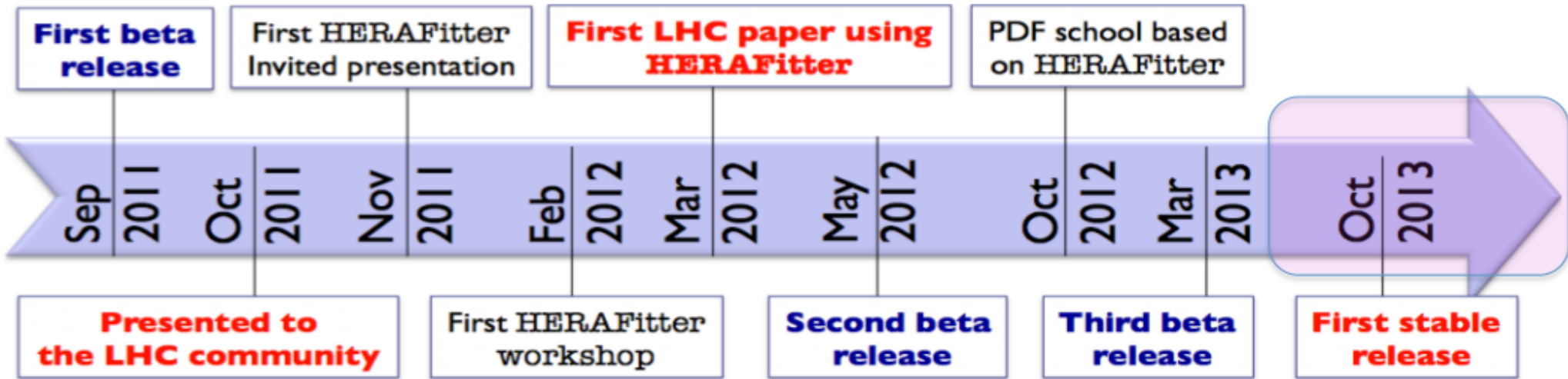
- Perform QCD fit to extract PDF information
- Cross check and validate



HERAFitter QCD Fit platform

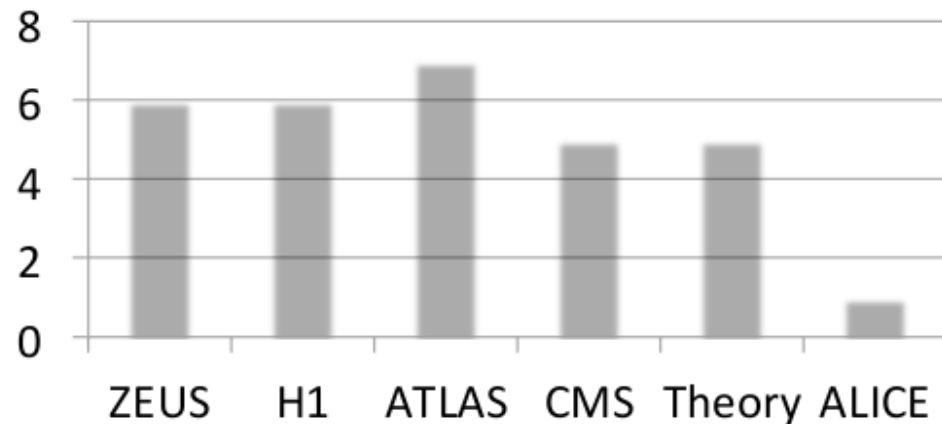


HERAFitter Package is an open source QCD Fit platform ready to analyse new data



◆ Statistics of developers team

~100 downloads



◆ The releases are publicly accessed via <https://www.herafitter.org>

Results using HERAFitter



<https://www.herafitter.org/HERAFitter/HERAFitter/results>



ATLAS results obtained using HERAFitter:

- ▶ Determination of the strange quark density from ATLAS WZ measurements [[Phys.Rev.Lett. 109 \(2012\) 012001](#)]
- ▶ Measurement of the inclusive jet cross section in pp collisions at 2.76 and 7 TeV [[arXiv:1304.4739](#)]
- ▶ Measurement of the high-mass Drell-Yan differential cross-section in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector [[arXiv:1305.4192](#)]



CMS several analyses are using HERAFitter for PDF constraints

- ▶ inclusive jets, s-quark density determination
- ▶ planned for DY and W+charm data



HERA publications:

- ▶ QCD Analysis to final H1 HERA data [[JHEP 09 \(2012\) 061](#)]
- ▶ QCD Analysis of Charm Production Cross Section Measurements [[Eur. Phys. J. C73 \(2013\) 2311](#)]



LHeC impact studies [[J.Phys. G39 \(2012\)](#)]

◆ Theory:

- ▶ updates of ACOT scheme module (with CTEQ group)
- ▶ inclusion of photon PDF in QCDNUM (publication is planned)



Summary

- Successful releases of the HERAFitter package, latest in March 2013
- Monthly users' meetings, weekly developers' meetings
- HERAFitter tool has grown into multifunctional QCD platform:
 - Different treatments for heavy flavours
 - Robust data input
 - Various parameterization techniques
 - Various physics cases
- Ready for tests within experimental data analysis as well as theoretical studies. User-friendly interface, documentation and technical support.
- **Next release scheduled for October 2013**



Extra slides

◆ Steering Group members:

- ▶ **Conveners:** Voica Radescu, Ringaile Placakyte, Amanda Cooper-Sarkar
- ▶ **Code Librarian:** Hayk Pirumov
- ▶ **Release coordinator:** Sasha Glazov
- ▶ **Contact Persons:**
Klaus Rabbertz (CMS), Bogdan Malaescu (ATLAS),
Gavin Salam (theory), Olaf Behnke (ZEUS), Cristi Diaconu (H1, chair),
Ronan McNulty (LHCb) , Bogdan Malaescu (ATLAS)

◆ Communication:

- ▶ **Developers (~30):** HERA, LHC experiments and theory groups
- ▶ Weekly meetings:

<https://herafitter.org/HERAFitter/HERAFitter/HERAFitterInternal/FitForumMeetings>

- ▶ **Users (~100):**
- ▶ Monthly meetings:

<https://herafitter.org/HERAFitter/HERAFitter/HERAFitterMeetings>

New functionality in beta3 release:

- ◆ experimental uncertainties for data:
asymmetric errors, offset method, covariance matrix representation
- ◆ flexible PDF parametrisation and regularisation techniques
- ◆ PDF Bayesian reweighting based on eigenvectors (Hessian method)
- ◆ upgraded interface format to FastNLO
- ◆ newer electro-weak DIS program
- ◆ unintegrated PDFs based on the k_T factorisation (CCFM) evolution
- ◆ addition of dipole and dipole+DGLAP models
- ◆ inclusion of more data sets (LHC, Tevatron)

A list of post beta3 developments:

- ▶ cleaning and restructuring of the codes
- ▶ updates in Drawing tools
- ▶ updates to the chi2 code
- ▶ for LHAPDF added calculation of errors in chi2
- ▶ improvements in the parametrisation style
- ▶ openMP

- ▶ ttbar in HATHOR
- ▶ tool to transform covariance matrix to nuisance parameter representation
- ▶ QED+QCD PDFs
- ▶ ACOT NNLO
- ▶ ACOT in QCDNUM
- ▶ nuclear PDFs
- ▶ intrinsic charm
- ▶ APPLGRID interfaces to DYNNLO
- ▶ LHAPDF in C++
- ▶ fitting photon PDFs
- ▶ different evolution codes, ...

Any wish from you?
(new person power is also welcome)

Releases of the HERAFitter 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: @HERAFitter_release_notes.pdf.

README

Write-up
(description of modules,
methodology, examples)

Date	Version	Files	Remarks
03/2013	0.3.0	@herafitter-0.3.0.tgz	latest release includes @manual-0.3.0.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

Documentation

- From 0.3.0 on a manual is provided together with an example directory.
- The **README** file (accessible via the package) gives an explanation for a quick start.

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 herafitter-user@desy.de account and PDFfits password.

Doxygen Documentation

- The doxygen documentation is located [here](#)

Links to external packages

External packages that could be run with HERAFitter via configuration flags can be accessed for convenience [HERE](#) .

HERAverager data combination package

Information can be accessed here <https://wiki-zeuthen.desy.de/HERAverager>.