HERAFitter Open source QCD Fit Framework

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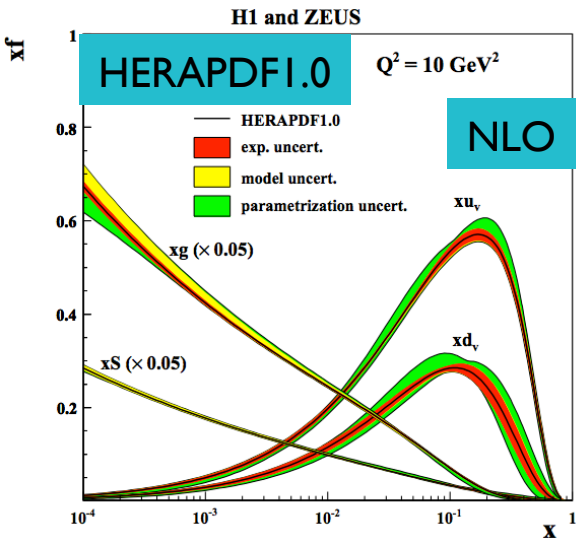
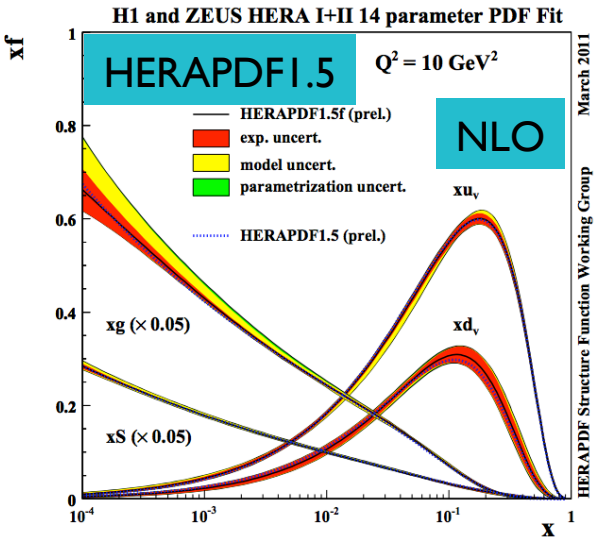
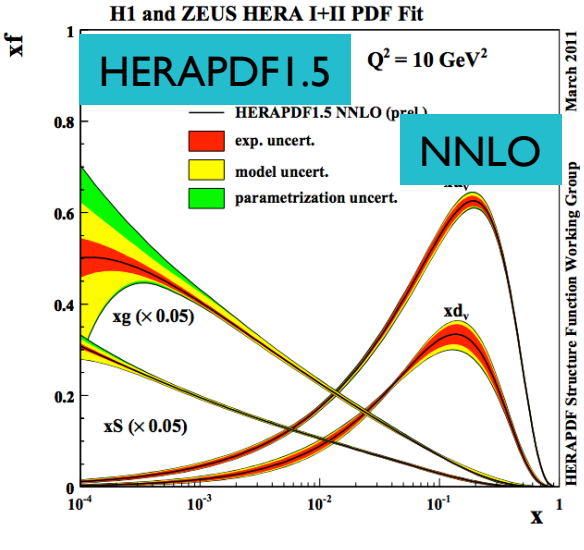
Motivation for a QCD Fit Platform (1)

- There is valuable expertise in the data combination and treatment of the experimental uncertainties as well as in the QCD fits:







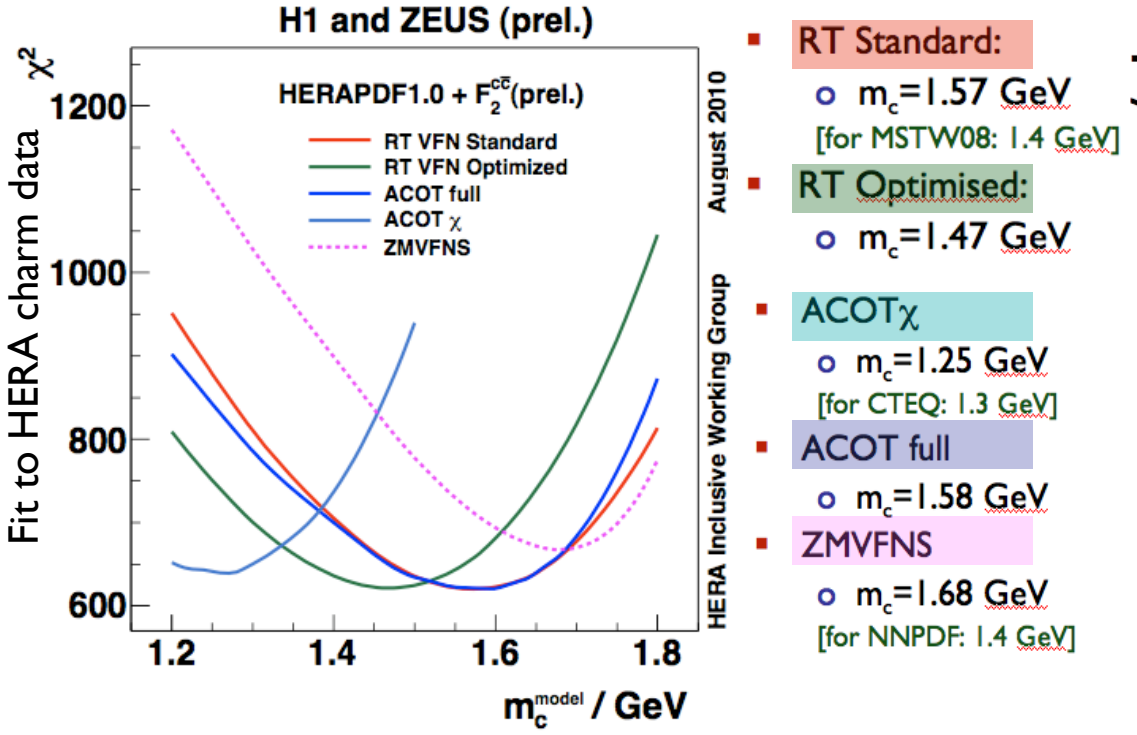
  - Ultimate precision is obtained by combining measurements
    - Improvement on Statistical precision
    - Improvement of Systematic precision

  ➔ Data averaging tool was used for H1 and ZEUS data combination [JHEP01 (2010) 109]

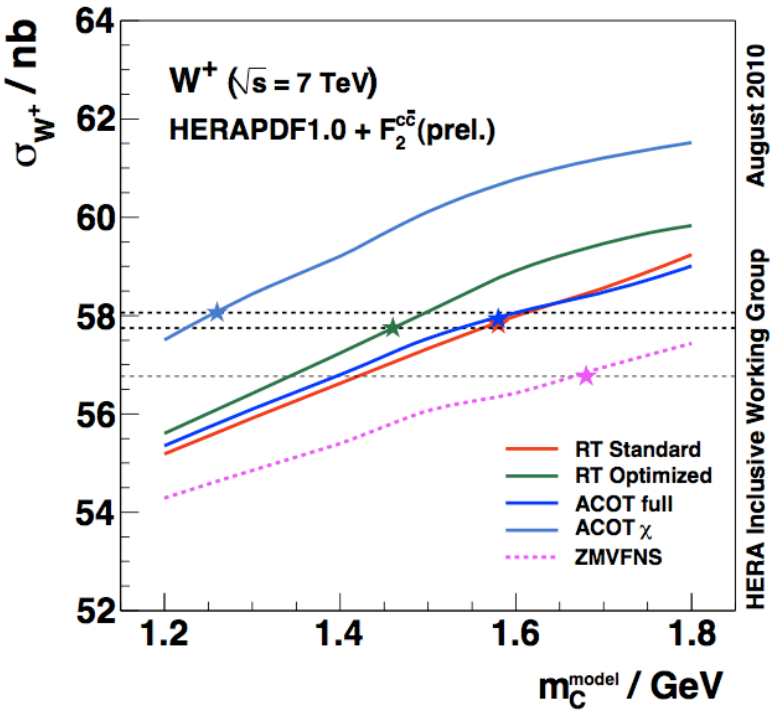
- QCD Fits within experiments proved to be a very useful tool to interpret data!

Motivation for a QCD Fit Platform (II)

- There is a need for an open platform to benchmark various theory predictions under the same conditions.



- RT Standard:
  - m_c=1.57 GeV
  - [for MSTW08: 1.4 GeV]
- RT Optimised:
  - m_c=1.47 GeV
- ACOTχ
  - m_c=1.25 GeV
  - [for CTEQ: 1.3 GeV]
- ACOT full
  - m_c=1.58 GeV
- ZMVFNS
  - m_c=1.68 GeV
  - [for NNPDF: 1.4 GeV]



Very different predictions from various HF schemes -- need to be benchmarked with respect to each other

➔HERAFitter is an open source platform which provides a tool for PDF analyses

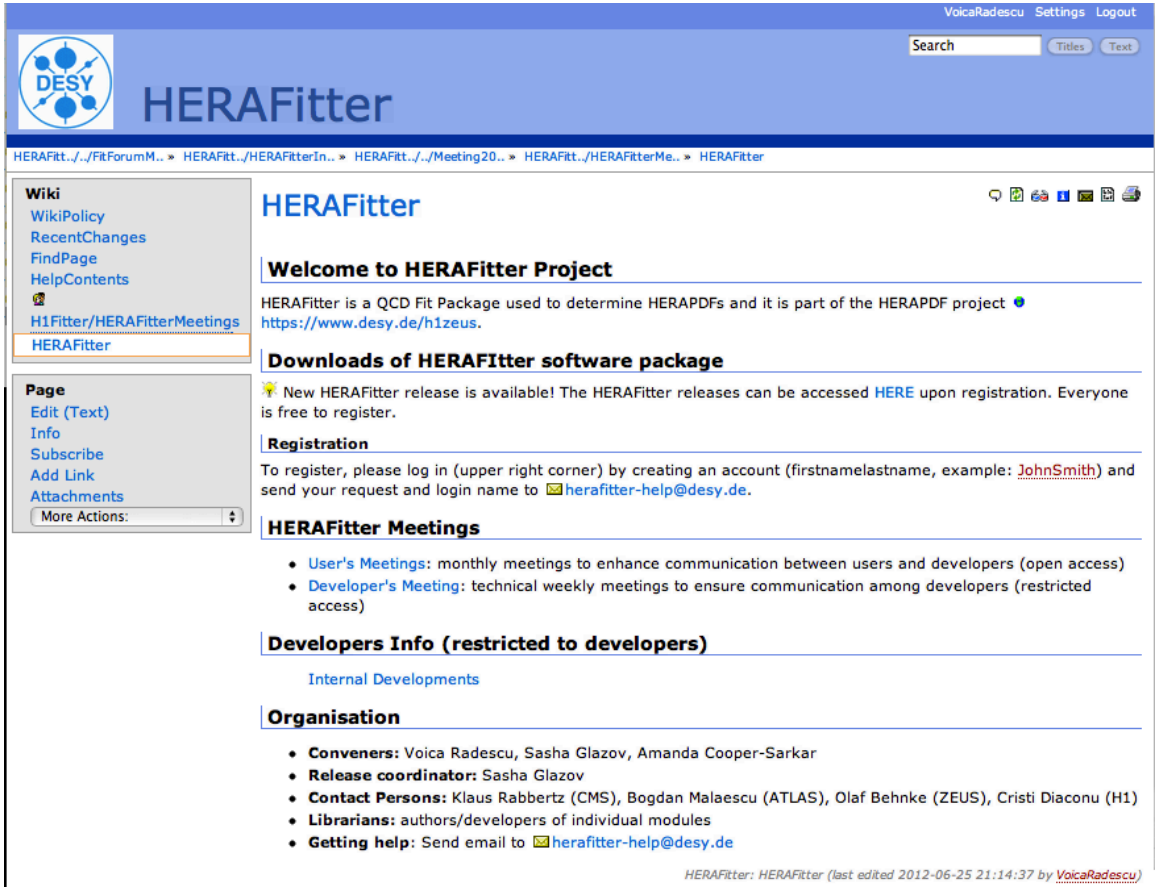
HERAFitter Package

- A ready platform to analyse new data and their impact.
- The beta releases can be accessed through the HEPFORGE site:

  http://projects.hepforge.org/herafitter

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

  - Accessible to anyone for download via registration to feedback users
  - References should follow citations provided with the package



HERAFitter organisation

- Timescale:
  - September 2011 — First Beta Release
  - Septemeber and October — Package presented to the LHC community (ATLAS and CMS)
  - October 2011 — First HERAFitter User's Meeting
  - November 2011 — First presentation of the HERAFitter at a workshop
  - February 2012 — HERAFitter Workshop in Marseille
  - May 2012 — Second Beta Release
  - Winter 2012 — Next release

- Package is supported by a group of developers originally from H1 and ZEUS collaborations and extended to LHC experiments and theory groups:
  - Independent developers can also add their contribution to the package

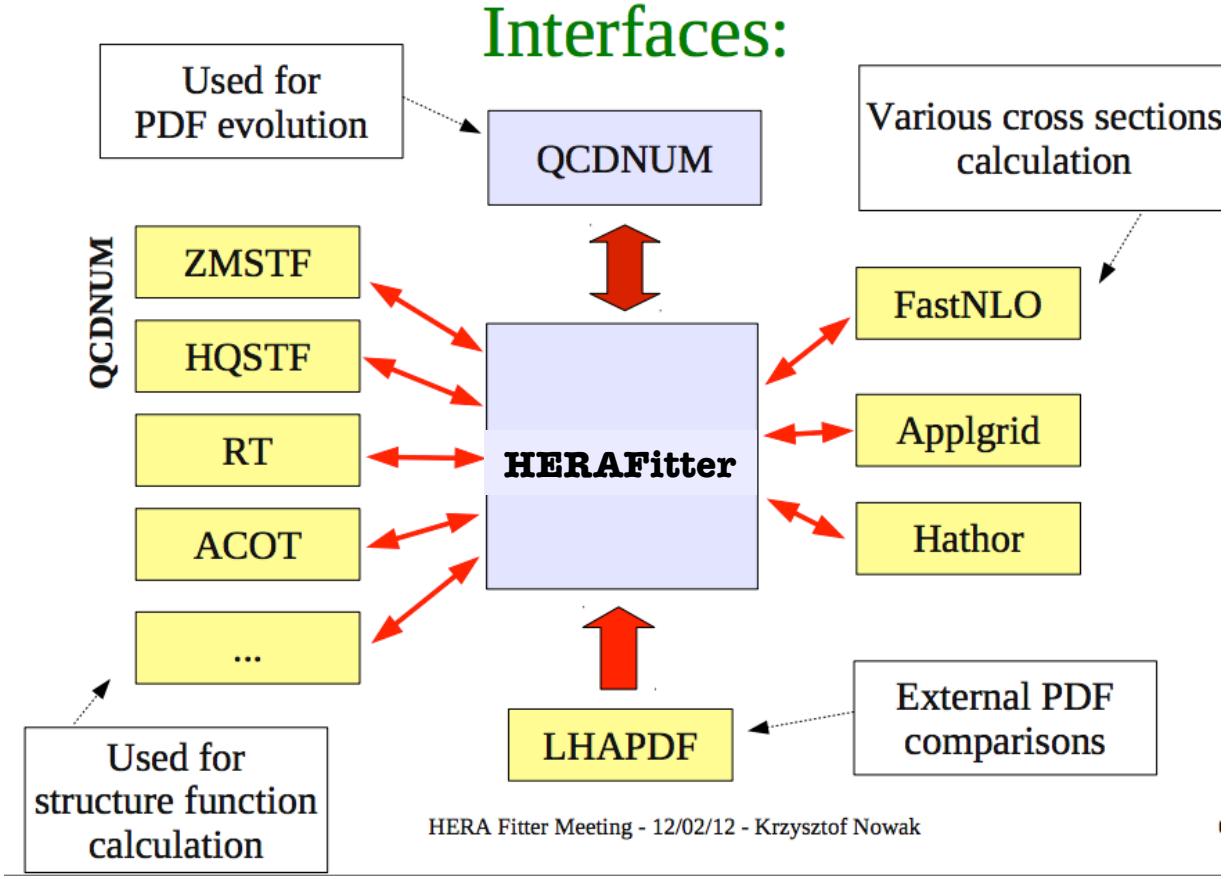
- HERAFitter User's interaction
  - Weekly developer's meeting https://znwiki3.ifh.de/HERAFitter/HERAFitter/HERAFitterInternal/FitForumMeetings
  - Monthly users's meeting (https://znwiki3.ifh.de/HERAFitter/HERAFitter/HERAFitterMeetings)

TODAY at 14:30 - 15:30

HERAFitter Structure

Modular Structure with reduced external dependencies:

- new developments can be added in a modular way



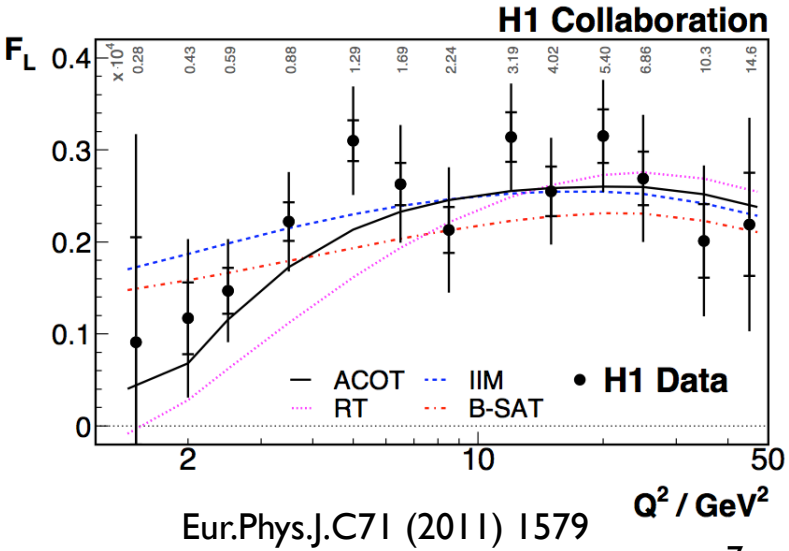
- Beta release contains a minimum set of tools for its use at the LHC experiments
  - It can produce out of the box HERAPDF1.0
  - Sample data file formats for DY and jets usages

Functionality

- Interfaces to DIS, DY, Applgrids and FASTNLO modules
- Heavy flavour schemes:
  - RT standard and optimal as in MSTW
  - ACOT as in CTEQ
  - FFNS and BMSN as in ABM
  - Developments in the top area: ttbar cross section using HATHOR
- Possibility to link to LHAPDF and draw/compare various predictions
- Access to the NNPDF reweighting tool
- Diffractive fits

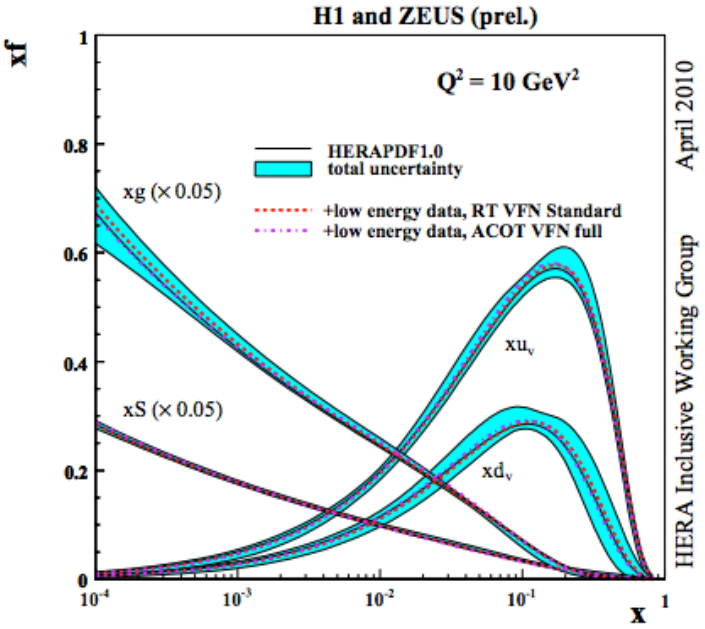
- Additions to HERAFitter package: HERAaverager
  - Used for combining the measurements

- Others developments for cross model benchmarking:
  - DIPOLE Models
  - Various evolutions
  - Kt-evolution for unintegrated PDFs



Eur.Phys.J.C71 (2011) 1579

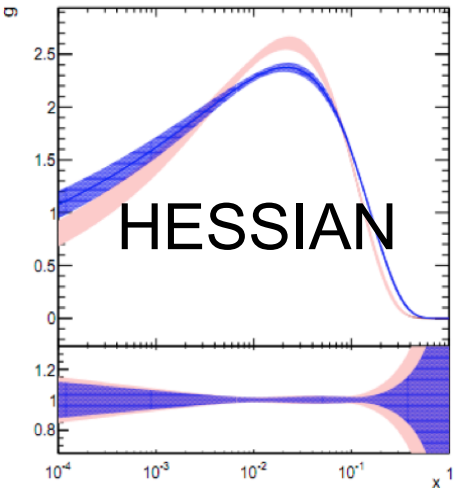
HERAFitter Outputs

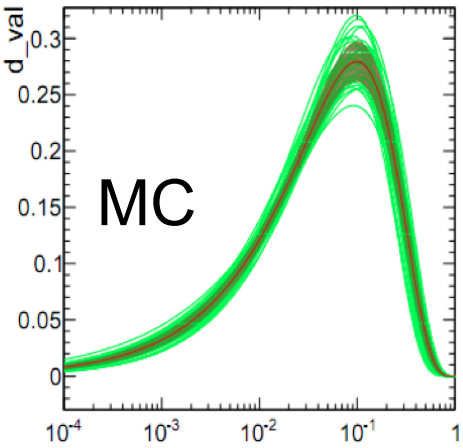


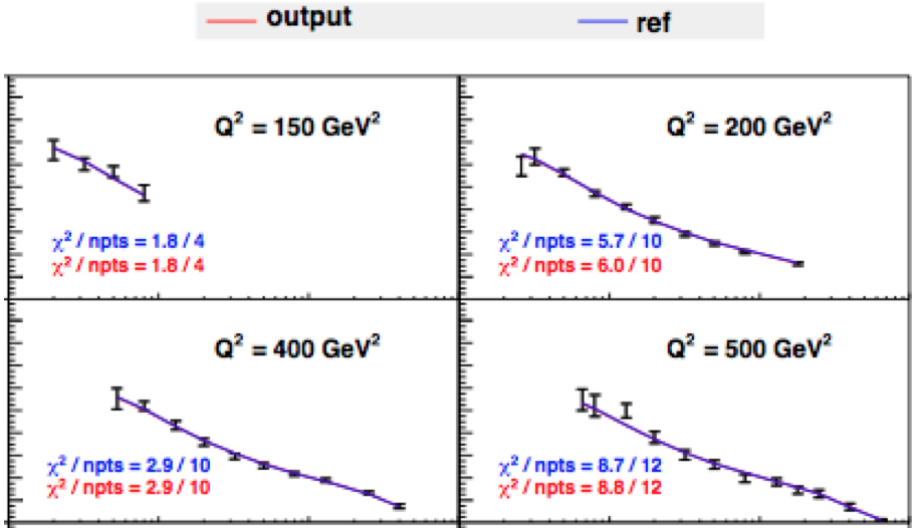
Output contains basic text (and graphic) information on:

- Error logging controlling consistency between input data/fit parameters
- Quality of the fit (chisquares, pulls)
- Resulting PDFs:
  - text and HERALHGRID LHAPDF format grids ready to plug into the MC generators
- Hessian vs MC replicas error estimation

[Phys.Rev.D65:014011,2001 and arXiv:1101:0536]

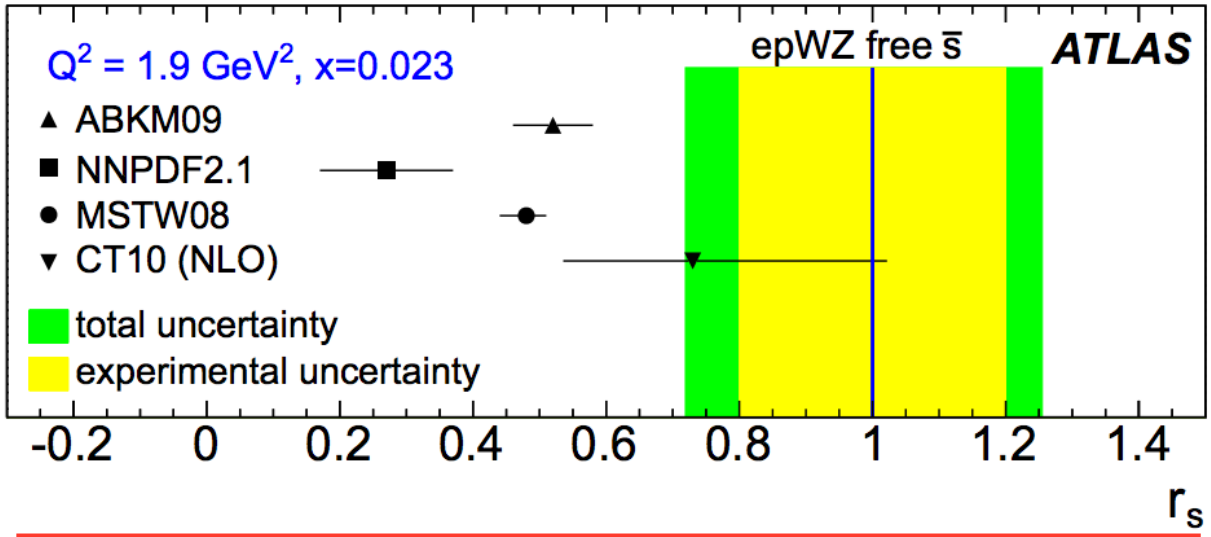






ATLAS determination of the s/d

- The differential $W^{\pm}$, Z cross section data of ATLAS (2010, 35/pb) were jointly analysed with $e^{\pm}p$ cross sections from HERA using the HERAFitter framework



$$r_s = 1.00 \pm 0.20_{\text{exp}} \pm 0.07_{\text{mod}}{}^{+0.10}_{-0.15}{}_{\text{par}}{}^{+0.06}_{-0.07}\alpha_S \pm 0.08_{\text{th.}}$$

http://arxiv.org/pdf/1203.4051v1.pdf

At LHC, ratio of W/Z cross sections together with yZ shape provide a constraint on **s**-quark density.

See M. Karnevsky's talk

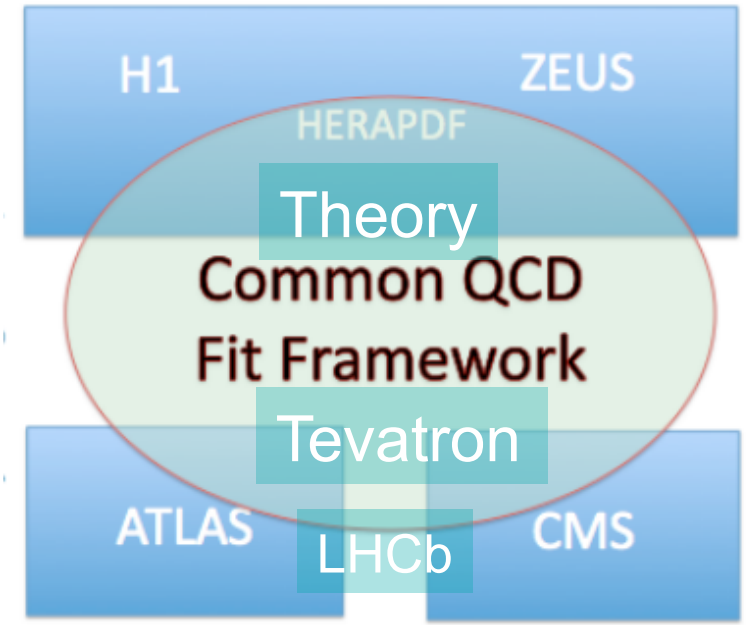
HERAFitter Physics Cases

- Determination of proton PDFs from HERA data
  - Inclusive NC and CC processes
    - involving low Q2 phenomenology (DIPOLE vs DGLAP models)
  - DIS charm data
  - Inclusive DIS jets * (PDF + alphas)
- Production of W, Z at LHC: additional lever arm to constrain PDFs
  - Inclusive Differential W, Z cross sections
  - Drell Yan at low and higher masses
  - Jet production * (PDF + alphas)
  - W+charm
- Studies concerning different treatment of correlations (Hessian vs MC vs Offset):
- Top production at LHC:
  - ttbar cross sections
  - Ratio of top/antitop cross sections
- Further developments:
  - Benchmarking of theories
  - Fits using kt evolution
  - Nuclear PDFs
  - Mixed DGLAP-Dipole fits
  - Diffractive PDF fits

Summary

- Successful beta-releases of the HERAFitter package so far
  - Multi-platform usage of the package: ATLAS, CMS, theory groups
- Further development of the package towards the stable release:
  - Modular addition of the heavy flavour schemes with the support of Theory groups

- HERAFitter infrastructure has the potential to increase the scientific output of the LHC data and to provide a flexible environment for theory benchmarking



License and References

- LICENSE: under GNU GPL v3
- REFERENCES: Citation depending on the usage

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If you use the HERAFITTER 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 HERAFITTER program. In addition, some citations are required depending
on the modules, data and theory tables used in the program.

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  Main citations
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HERAFitter
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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]

QCDNUM  ( evolution code )
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"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]
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