HERA, data preservation

PROSA

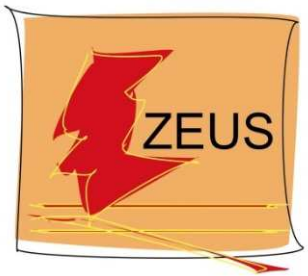
DESY PRC meeting, Hamburg, 11. 05. 15

Achim Geiser, DESY Hamburg

- papers and preliminaries)
- physics highlights) since last PRC
- data preservation status

- papers and physics highlights

HERA results, data preservation



- HERA DESY groups and funding ended 31.12.2014
- Collaborations operating in 'data preservation' mode
- Preserved data managed by DESY IT

Publications since last PRC, october 16

- **Pentaquark Θ^+ search at HERMES,** Phys. Rev. D91 (2015) 5, 057101; DESY-14-245
- **Bose-Einstein correlations in hadron-pairs from lepto-production in nuclei ranging from hydrogen to xenon,** to be submitted to EPJC, DESY-15-074, May 2015

- **Measurement of Dijet Production in Diffractive Deep-Inelastic ep Scattering at HERA** JHEP 1503 (2015) 092; DESY-14-200
- **Diffractive Dijet Production with a Leading Proton in ep Collisions at HERA,** DESY-14-242, Feb. 2015; arXiv:1502.01683
- **Measurement of multijet production in ep collisions at high Q^2 and determination of the strong coupling α_s,** Eur. Phys. J. C75 (2015) 2, 65; DESY-14-089 (already shown last PRC)

- **Production of exclusive dijets in diffractive deep inelastic scattering at HERA,** to be submitted to EPJC, DESY-15-070, May 2015

- **Combination of Differential $D^{*\pm}$ Cross-Section Measurements in Deep-Inelastic ep Scattering at HERA,** submitted to JHEP, DESY-15-037, March 2015; arXiv:1503.06042

- **Combination of Measurements of Inclusive Deep Inelastic $e^{\pm}p$ Scattering Cross Sections and QCD Analysis of HERA Data** to be submitted to EPJC, DESY-15-039

Preliminary results since last PRC, october 16

- **Diffractive single photons,** ZEUS prel-15-001
- **Exclusive ψ' / J/ψ ratio,** ZEUS-prel-15-003

H1-ZEUS combination:

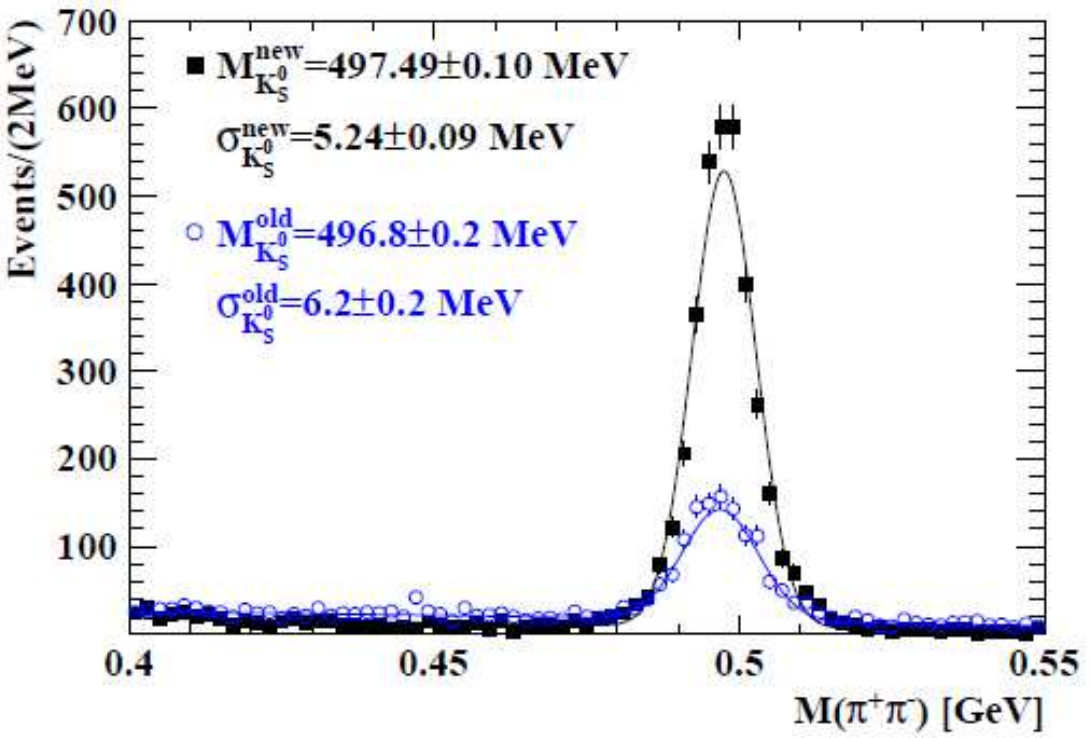
- **update on QCD analysis of combined HERA data,**
  H1prelim-15-041, ZEUS-prel-15-002

+ other results currently at editorial stage

Pentaquark θ^+ search at HERMES

extends earlier search

- With improved HERMES original data set taken in 1998-2000 and also additional 2006-2007 data of deuterium target, K_s^0 obtained with significantly less background and better mass resolution.

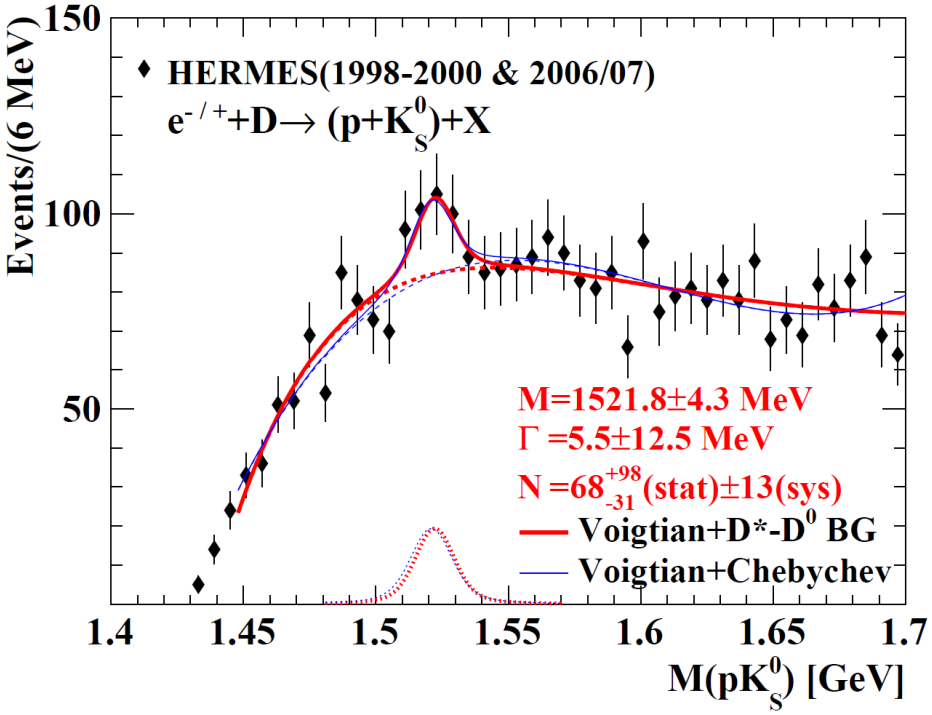


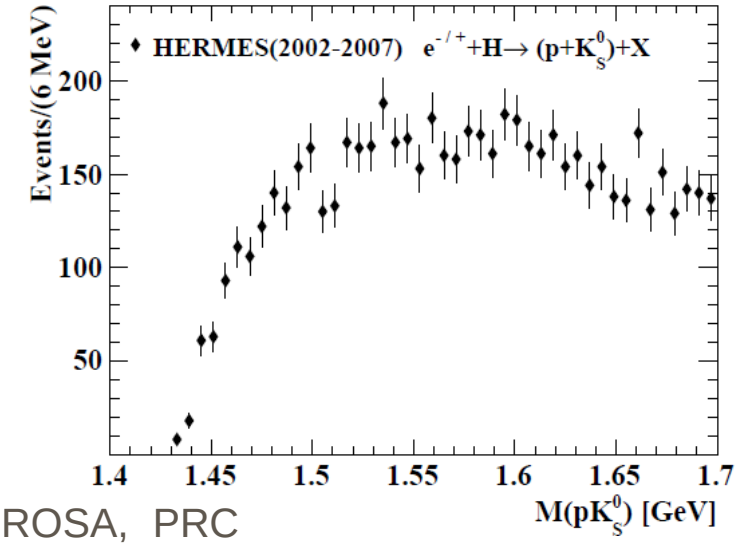
Pentaquark θ^+ search at HERMES

- Potential resonance structure in $M(p,K_s^0)$ spectrum near 1521.8 ± 4.3 MeV has significance ~2 σ while (was 3.7σ at 1528.0 ± 2.6 MeV in old analysis).

- Drop in significance in spite of twice the number of events for the data from a deuterium target does not support presence of a positive θ^+ signal at HERMES

- For hydrogen data, no indication of the existence of an enhancement in region of interest.





Bose-Einstein correlations in hadron-pairs from lepto-production on nuclei ranging from hydrogen to xenon

Bose-Einstein correlations evaluated with 2 different methods

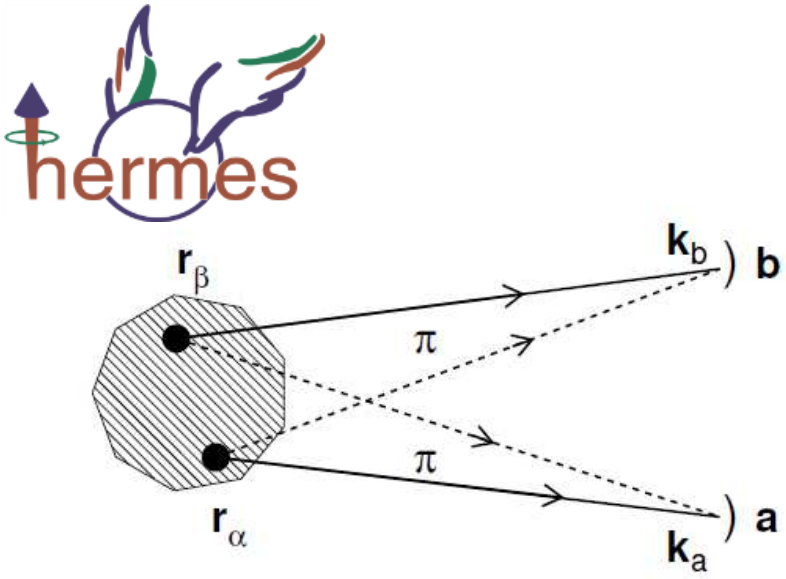
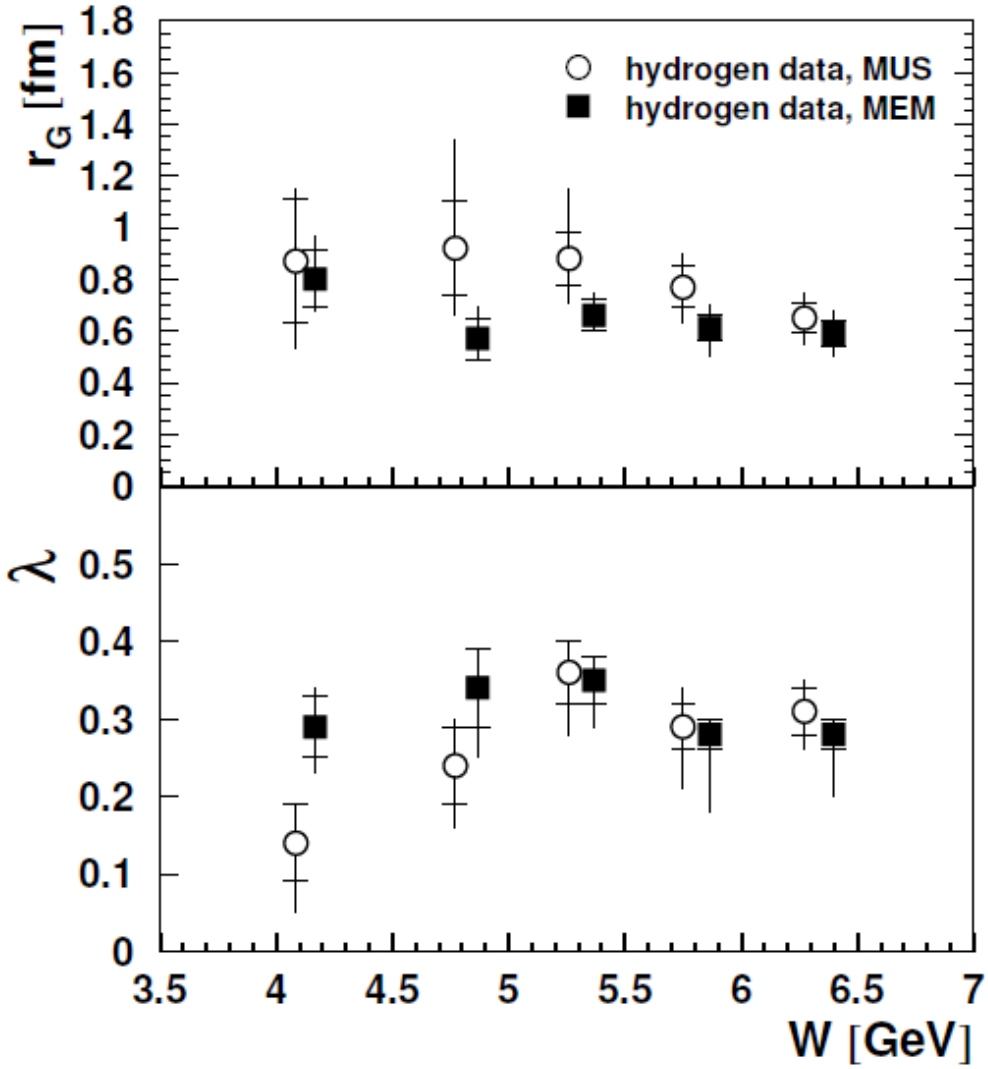


Fig. 1. Schematic illustration of the Bose–Einstein effect.

$$R(p_1, p_2) = D(p_1, p_2)/[D(p_1) \cdot D(p_2)]$$

Method of Unlike Sign pairs (MUS)
Method of Event Mixing (MEM)

$$R(T) = 1 + \lambda \cdot e^{-T^2 r_G^2}$$

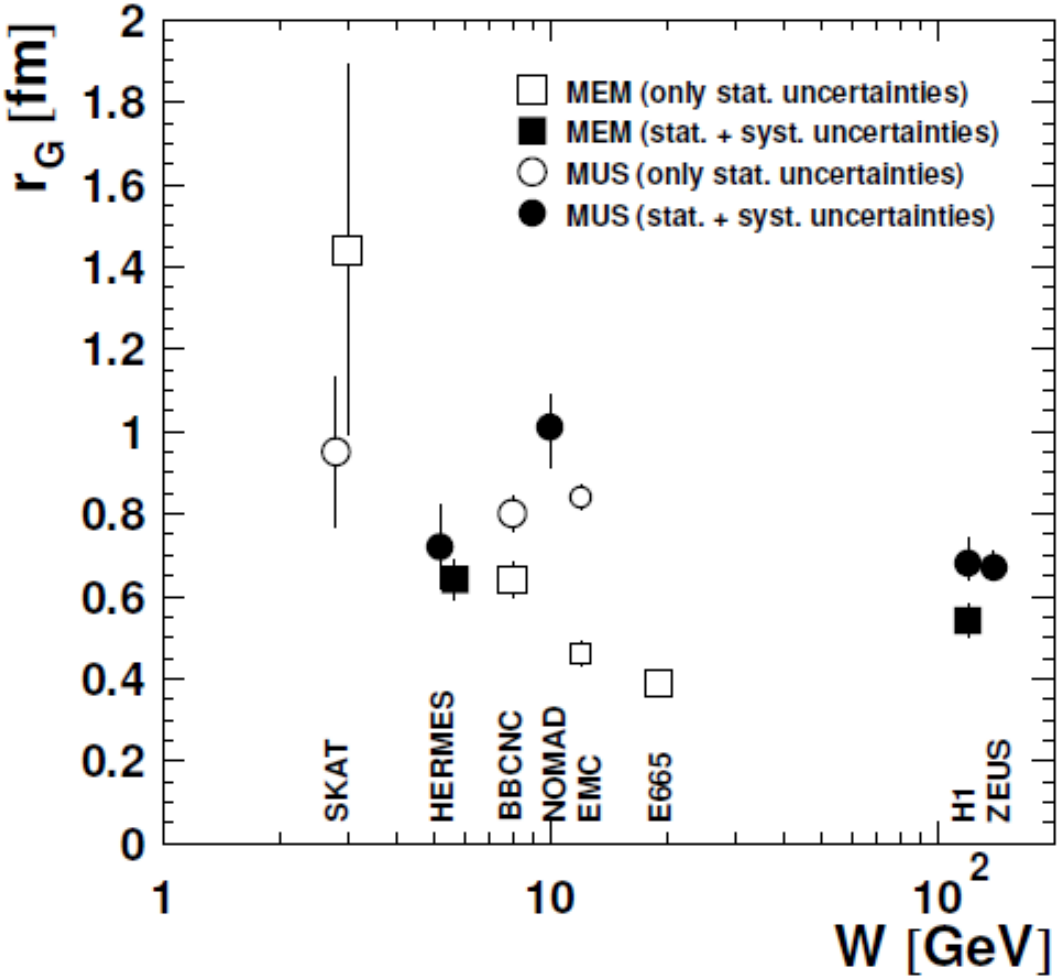


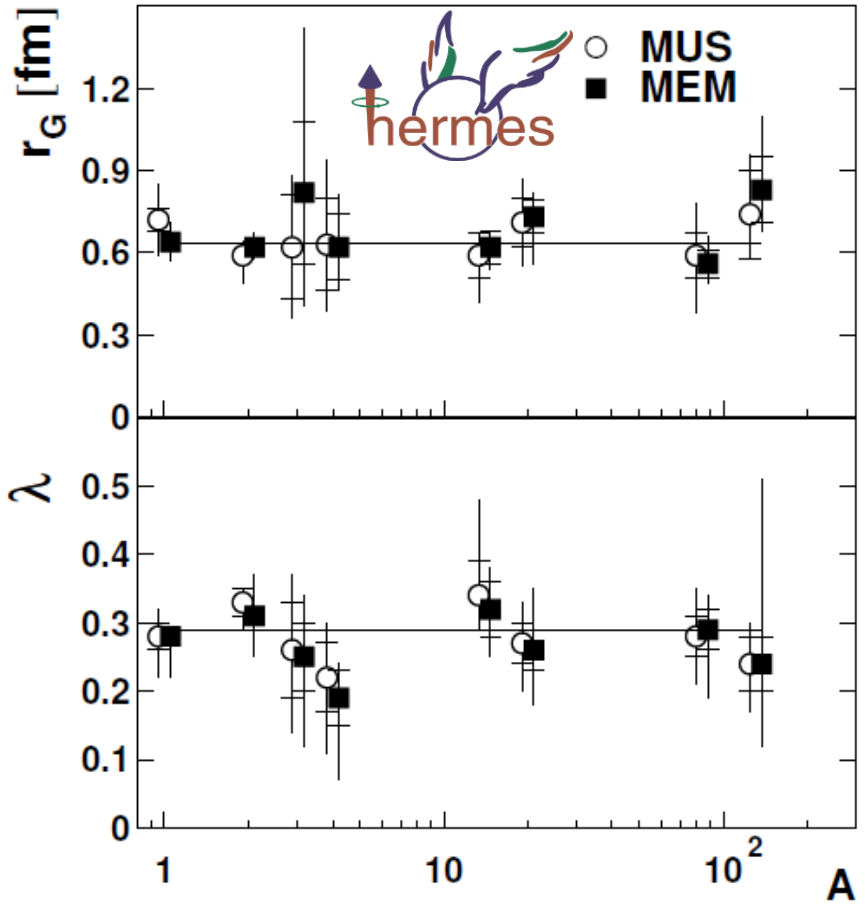
no obvious W dependence

Bose-Einstein correlations in hadron-pairs from lepto-production on nuclei ranging from hydrogen to xenon

comparison with other DIS experiments

A dependence ?





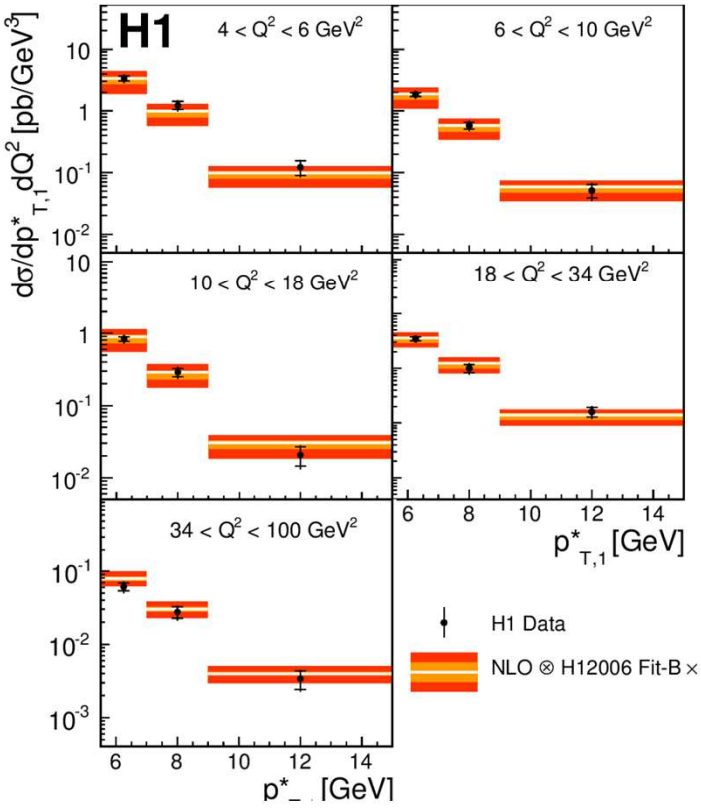
good agreement

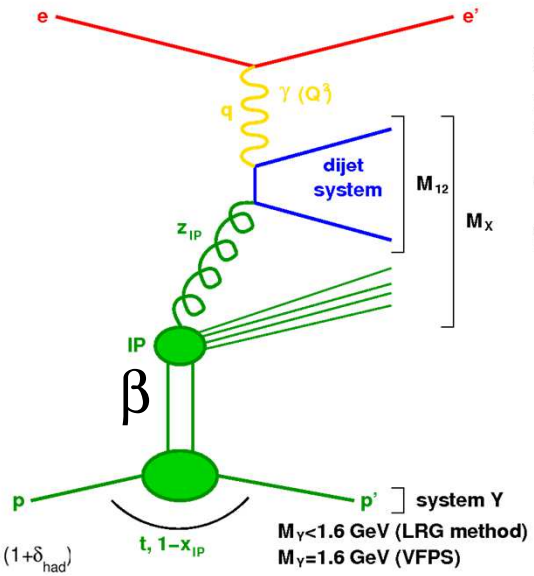
no obvious A dependence

Diffractive dijet production in H1

[arxiv:1412.0928]

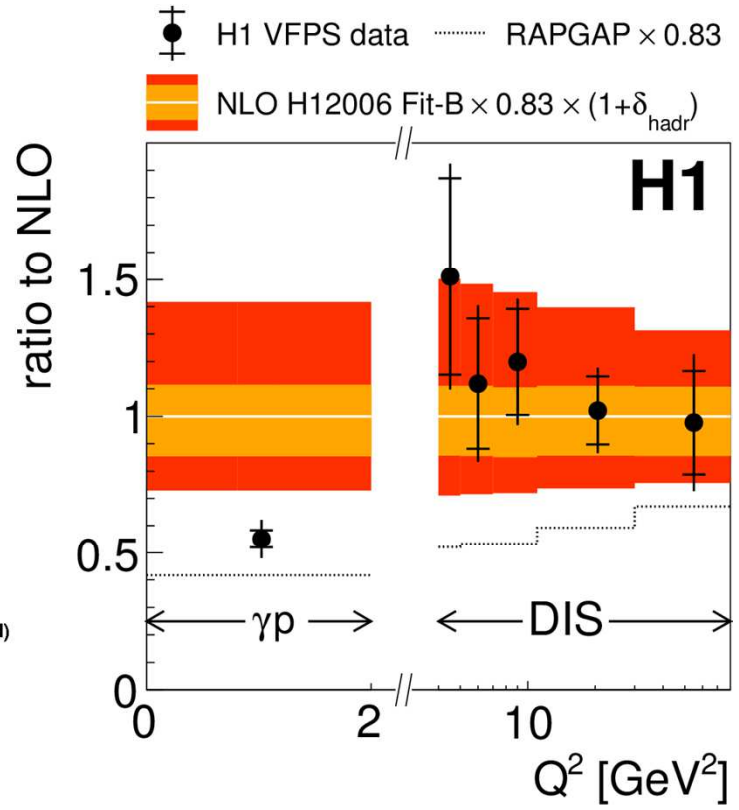
DIS, rapidity gap





[arxiv:1503.06042]

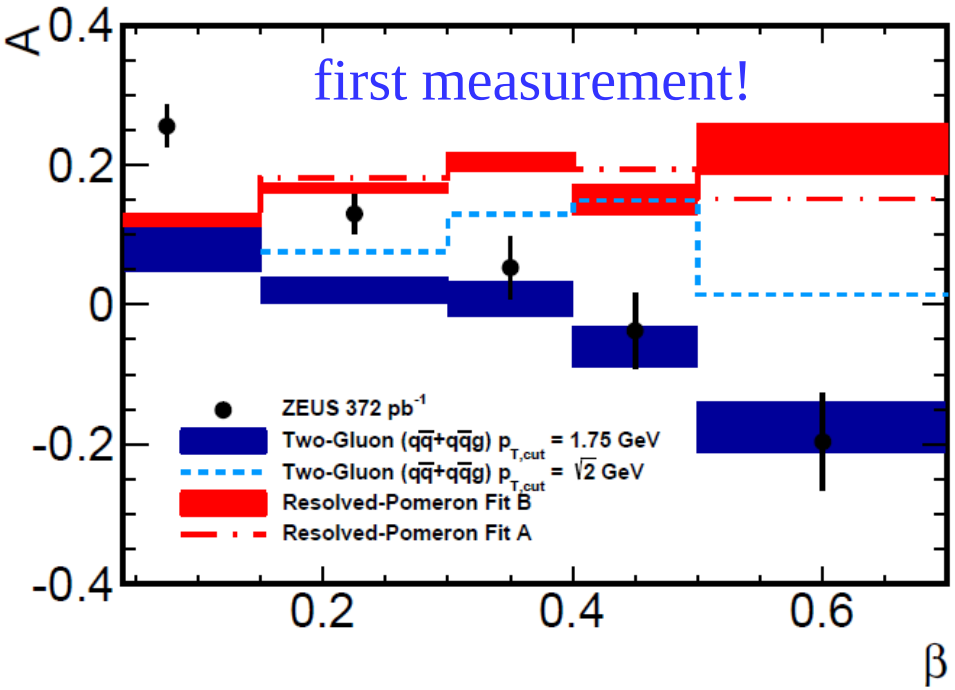
DIS and γp, leading proton



- Data are more precise than DPDF-based predictions
- QCD factorisation works in diffractive DIS
  but not in photoproduction

exclusive diffractive dijets in DIS and diffractive single photon photoproduction in ZEUS

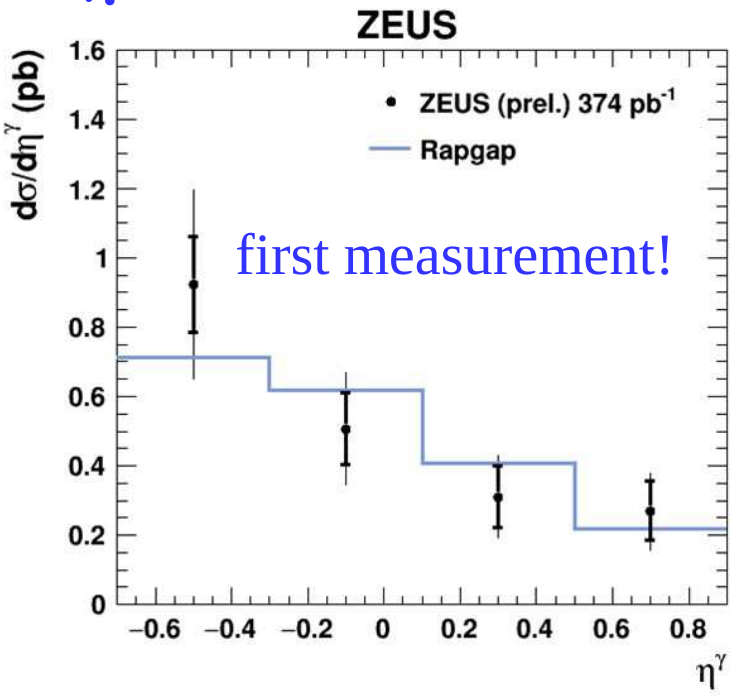
exclusive diffractive dijets in DIS ZEUS



ϕ distribution $\propto 1 + A \cdot \cos 2\phi$

Data - reasonably agree with two-gluon exchange model, but not perfect
- disagree with resolved pomeron model

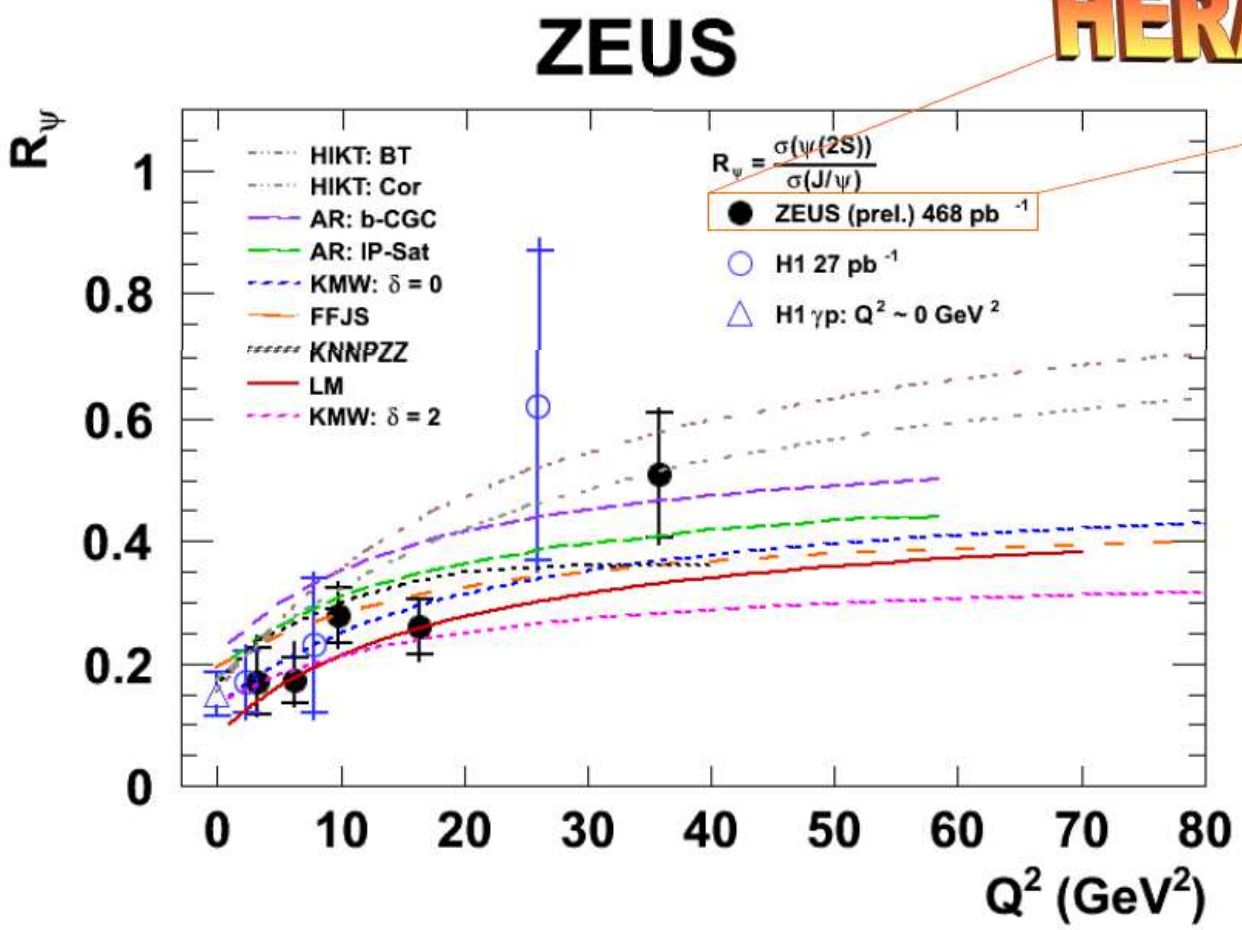
diffractive single photons in γp



well described by RAPGAP

consistent with dominant production via direct photons

exclusive ψ' / J/ψ cross section ratio



HERA I+HERA II

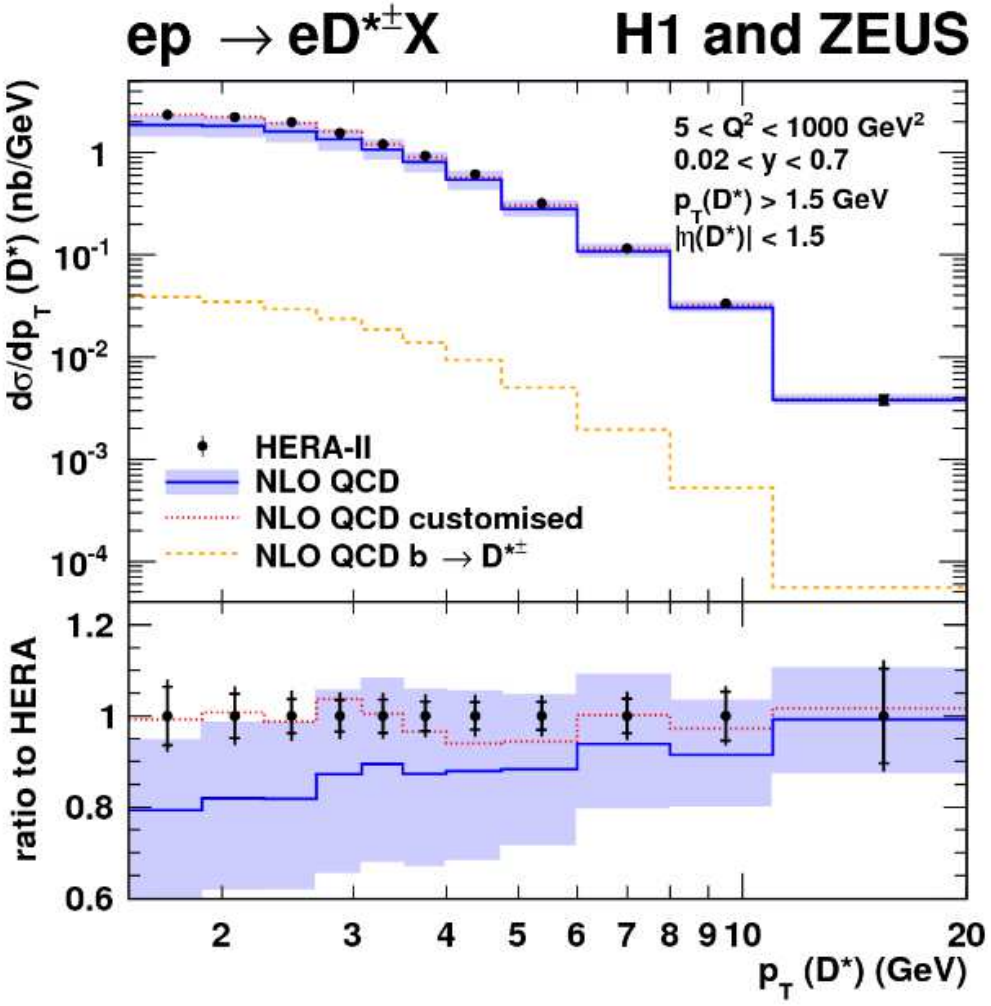
sensitive
to charmonium
wave function

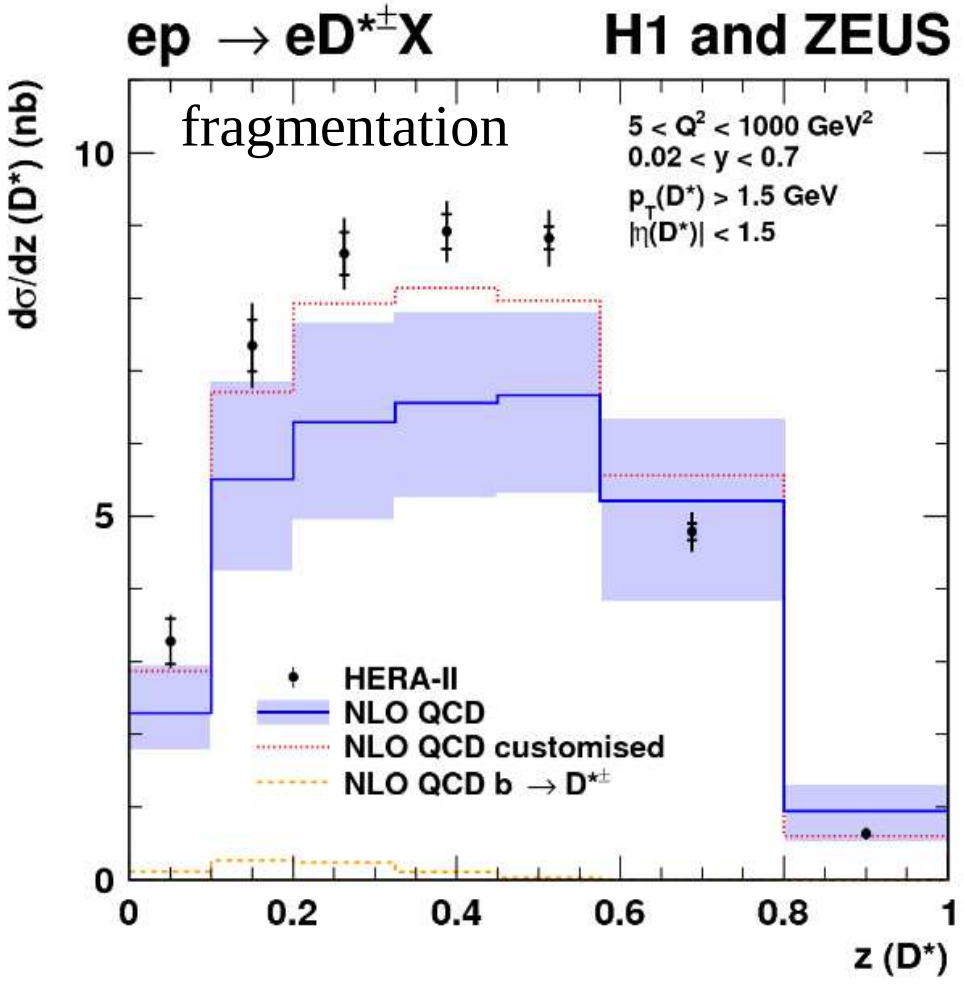
H1 collaboration:
Eur.Phys.J.C10:373-393,1999

Rises with Q^2 as expected
Significantly improved precision

Combination of Differential D*± Cross-Section Measurements in Deep-Inelastic ep Scattering at HERA

combination of final D* measurements





NLO theory describes data, but data much more precise

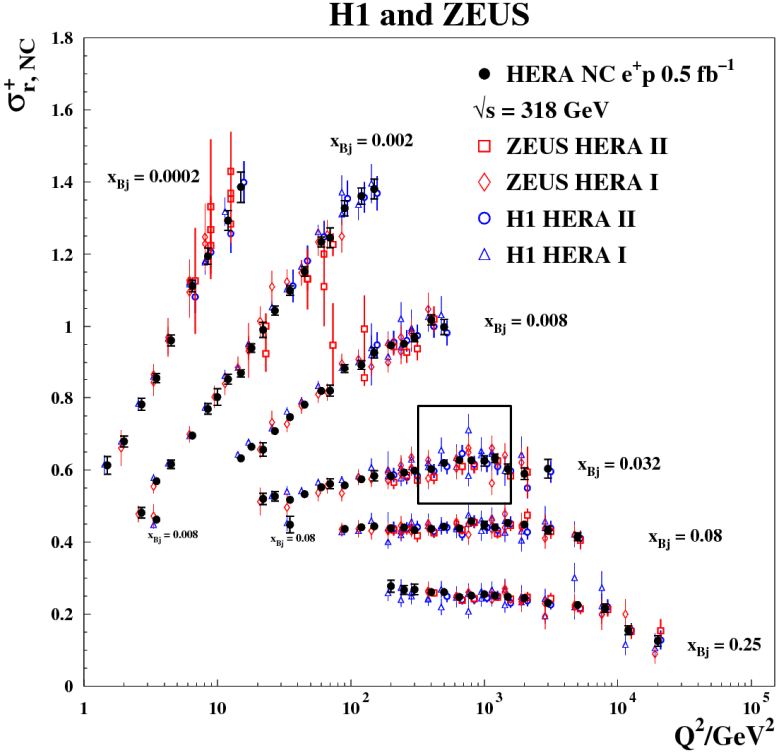
Customised prediction hints towards possible improvements

H1-ZEUS inclusive data combination

HERAPDF1.0

HERAPDF2.0

HERAPDF1.5



Data Set		x_{Bj} Grid from	to	Q^2[GeV^2] Grid from	to	$\mathcal{L}$ pb^{-1}	e^+/e^-	$\sqrt{s}$ GeV
HERA I E_p = 820 GeV and E_p = 920 GeV data sets								
H1 svx-mb	95-00	0.000005	0.02	0.2	12	2.1	e^+p	301, 319
H1 low Q^2	96-00	0.0002	0.1	12	150	22	e^+p	301, 319
H1 NC	94-97	0.0032	0.65	150	30000	35.6	e^+p	301
H1 CC	94-97	0.013	0.40	300	15000	35.6	e^+p	301
H1 NC	98-99	0.0032	0.65	150	30000	16.4	e^-p	319
H1 CC	98-99	0.013	0.40	300	15000	16.4	e^-p	319
H1 NC HY	98-99	0.0013	0.01	100	800	16.4	e^-p	319
H1 NC	99-00	0.0013	0.65	100	30000	65.2	e^+p	319
H1 CC	99-00	0.013	0.40	300	15000	65.2	e^+p	319
ZEUS BPC	95	0.000002	0.00006	0.11	0.65	1.65	e^+p	300
ZEUS BPT	97	0.0000006	0.001	0.045	0.65	3.9	e^+p	300
ZEUS SVX	95	0.000012	0.0019	0.6	17	0.2	e^+p	300
ZEUS NC	96-97						e^+p	300
ZEUS CC	94-97						e^+p	300
ZEUS NC	98-99						e^-p	318
ZEUS CC	98-99						e^-p	318
ZEUS NC	99-00						e^+p	318
ZEUS CC	99-00						e^+p	318
HERA II E_p = 920 GeV data sets								
H1 NC 1.5p	03-07						e^+p	319
H1 CC 1.5p	03-07						e^+p	319
H1 NC 1.5p	03-07						e^-p	319
H1 CC 1.5p	03-07						e^-p	319
H1 NC med Q^2 *y.5	03-07						e^+p	319
H1 NC low Q^2 *y.5	03-07						e^+p	319
ZEUS NC	06-07						e^+p	318
ZEUS CC 1.5p	06-07						e^+p	318
ZEUS NC 1.5	05-06						e^-p	318
ZEUS CC 1.5	04-06						e^-p	318
ZEUS NC nominal *y	06-07						e^+p	318
ZEUS NC satellite *y	06-07	0.000071	0.008343	5	110	44.5	e^+p	318
HERA II E_p = 575 GeV data sets								
H1 NC high Q^2	07	0.00065	0.65	35	800	5.4	e^+p	252
H1 NC low Q^2	07	0.0000279	0.0148	1.5	90	5.9	e^+p	252
ZEUS NC nominal	07	0.000147	0.013349	7	110	7.1	e^+p	251
ZEUS NC satellite	07	0.000125	0.013349	5	110	7.1	e^+p	251
HERA II E_p = 460 GeV data sets								
H1 NC high Q^2	07	0.00081	0.65	35	800	11.8	e^+p	225
H1 NC low Q^2	07	0.0000348	0.0148	1.5	90	12.2	e^+p	225
ZEUS NC nominal	07	0.000184	0.016686	7	110	13.9	e^+p	225
ZEUS NC satellite	07	0.000143	0.016686	5	110	13.9	e^+p	225

Full HERA I data

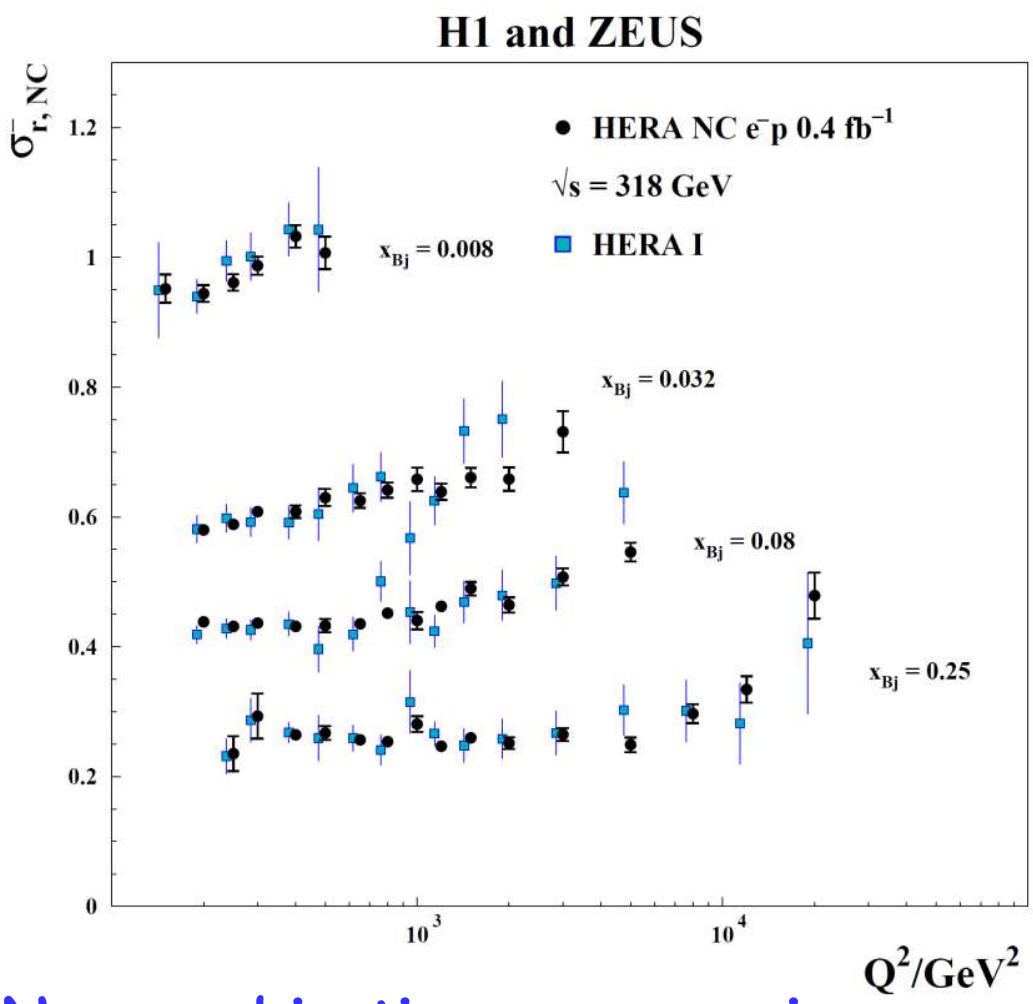
HERA II data HER

HERA II data LER

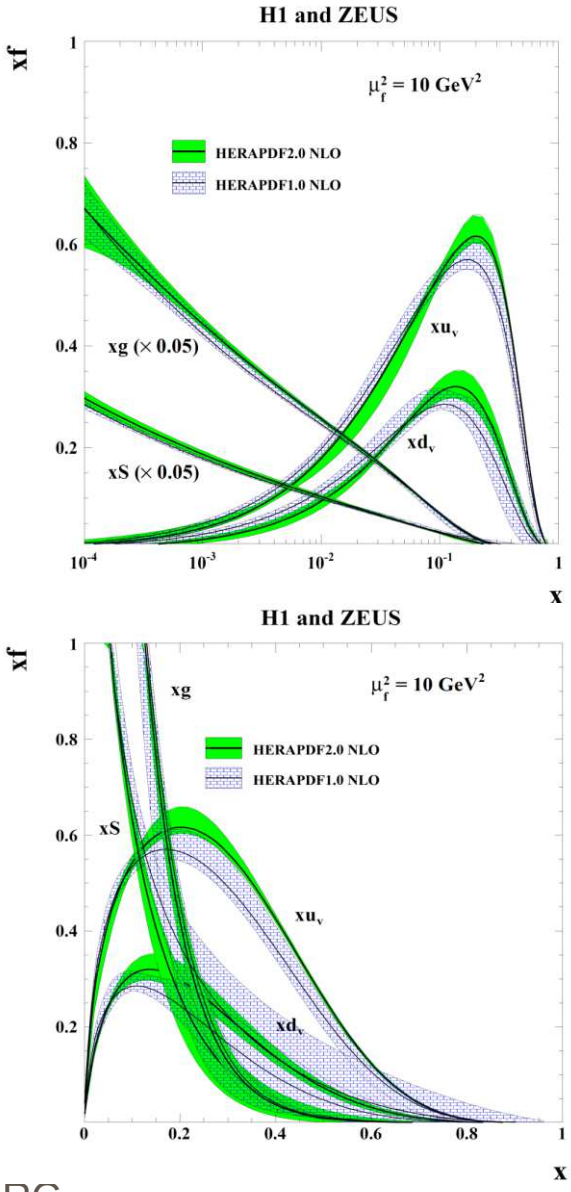
Combination of ~40 data sets with full correlated uncertainty treatment

Data combination and PDF fit

HERA I+II vs. HERA I combination



HERAPDF2.0 vs. 1.0

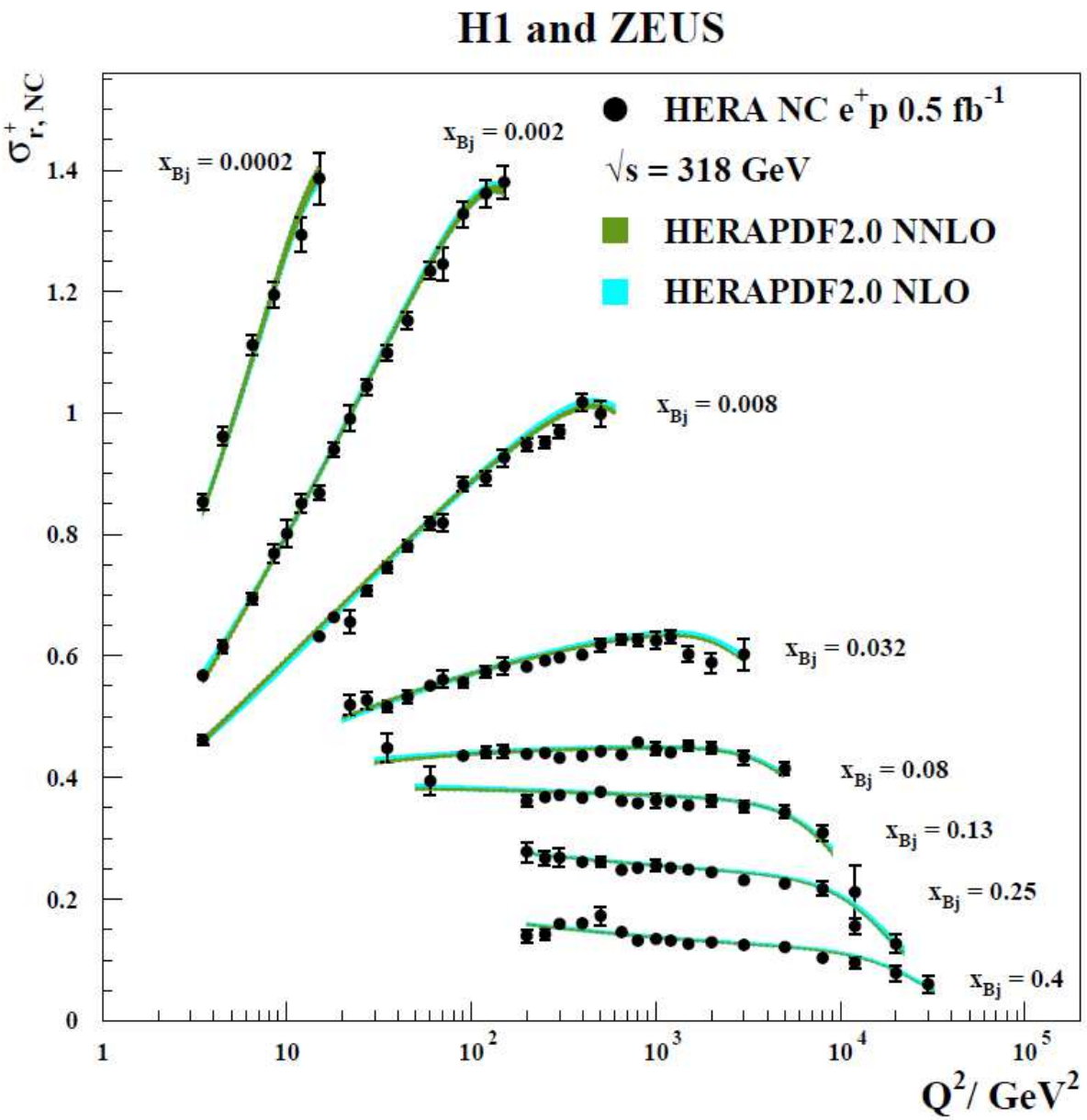


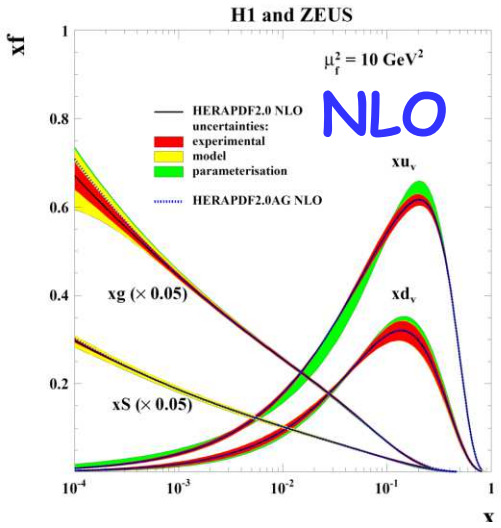
using HERAFitter

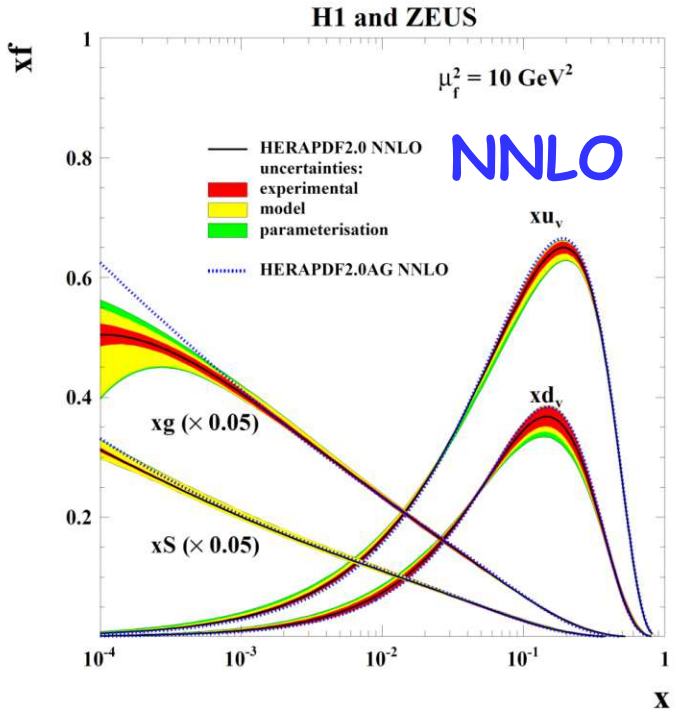
New combination more precise

New HERAPDF fit more precise

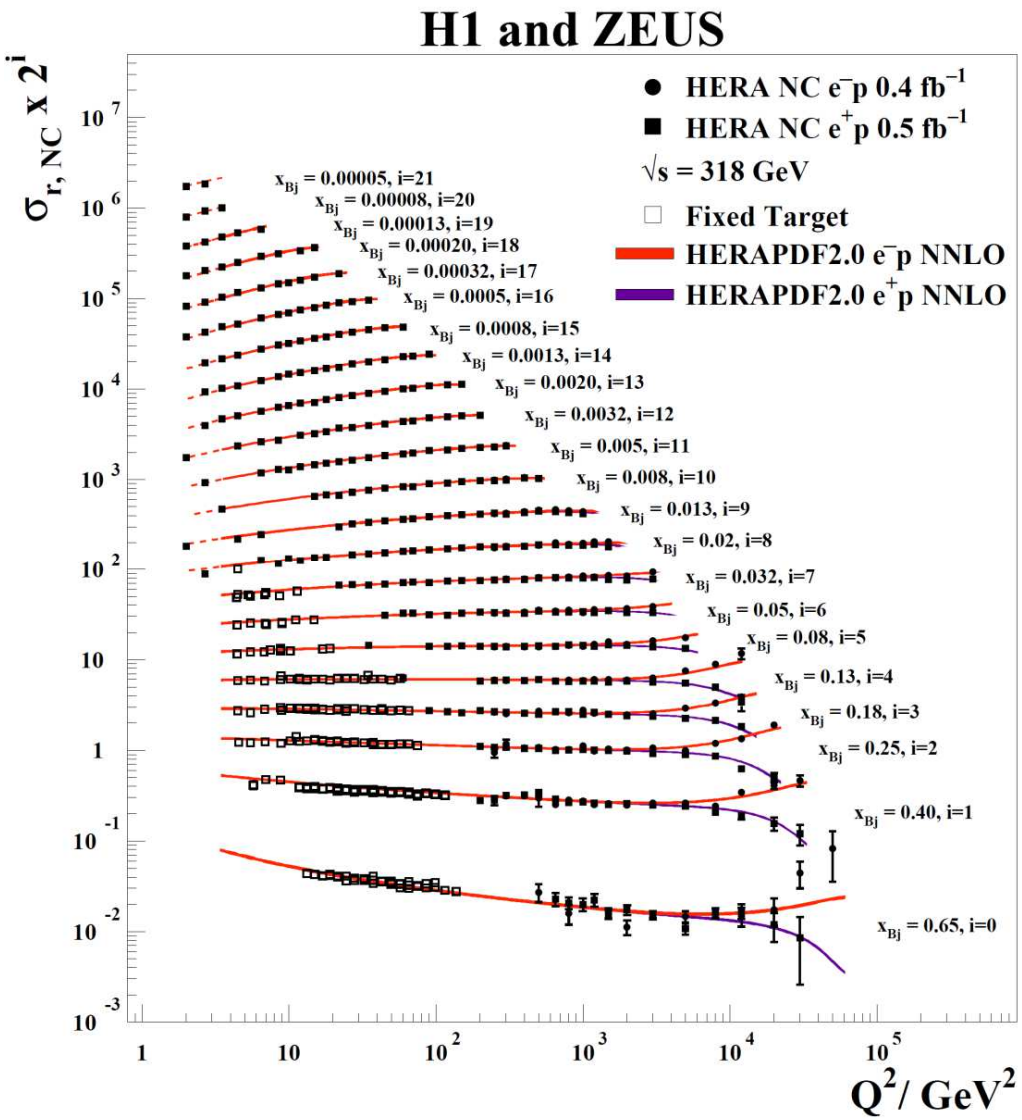
HERAPDF2.0 NLO and NNLO

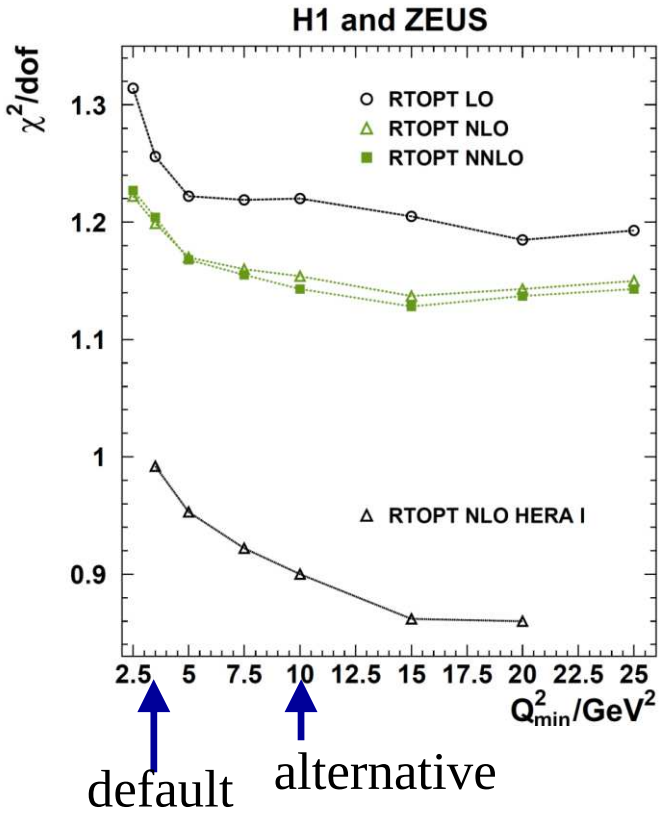






HERAPDF2.0 NLO and NNLO



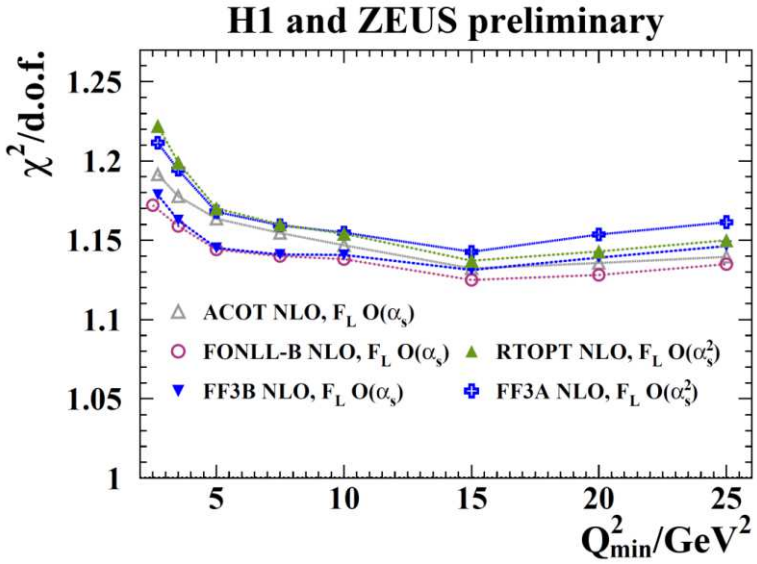


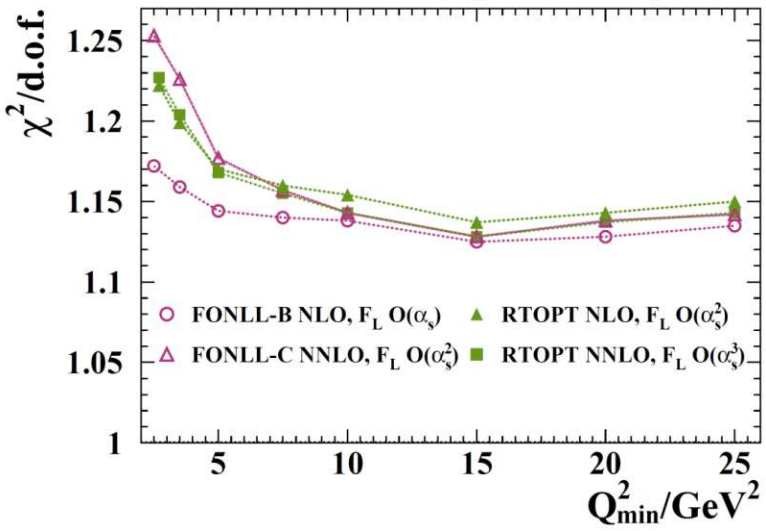
NNLO describes data reasonably, but not better than NLO

special investigation of Q^2_{min} threshold

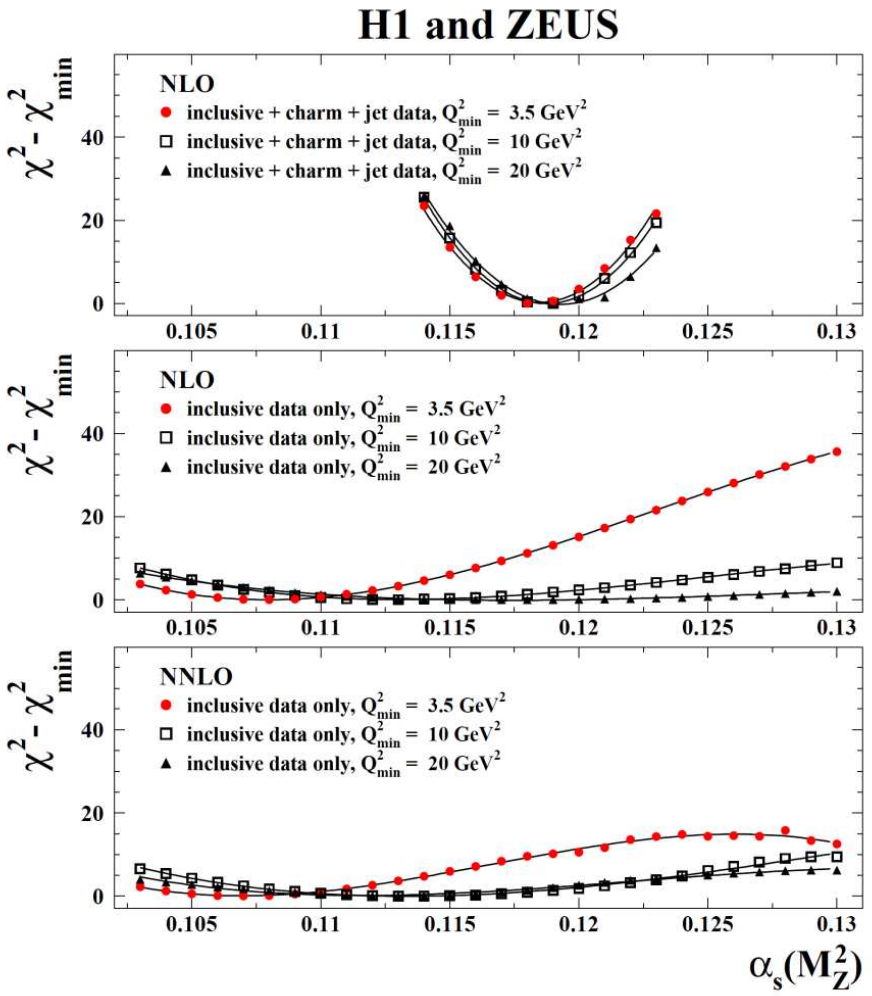
Alternative HERAPDF fits

Different PDF schemes





Include charm and jet data



$$\alpha_S(M_Z) = 0.1183 \pm 0.0009_{(exp)} \pm 0.0005_{(model/param)} \pm 0.0012_{(had)} \; {}^{+0.0037}_{-0.0030}(scale)$$

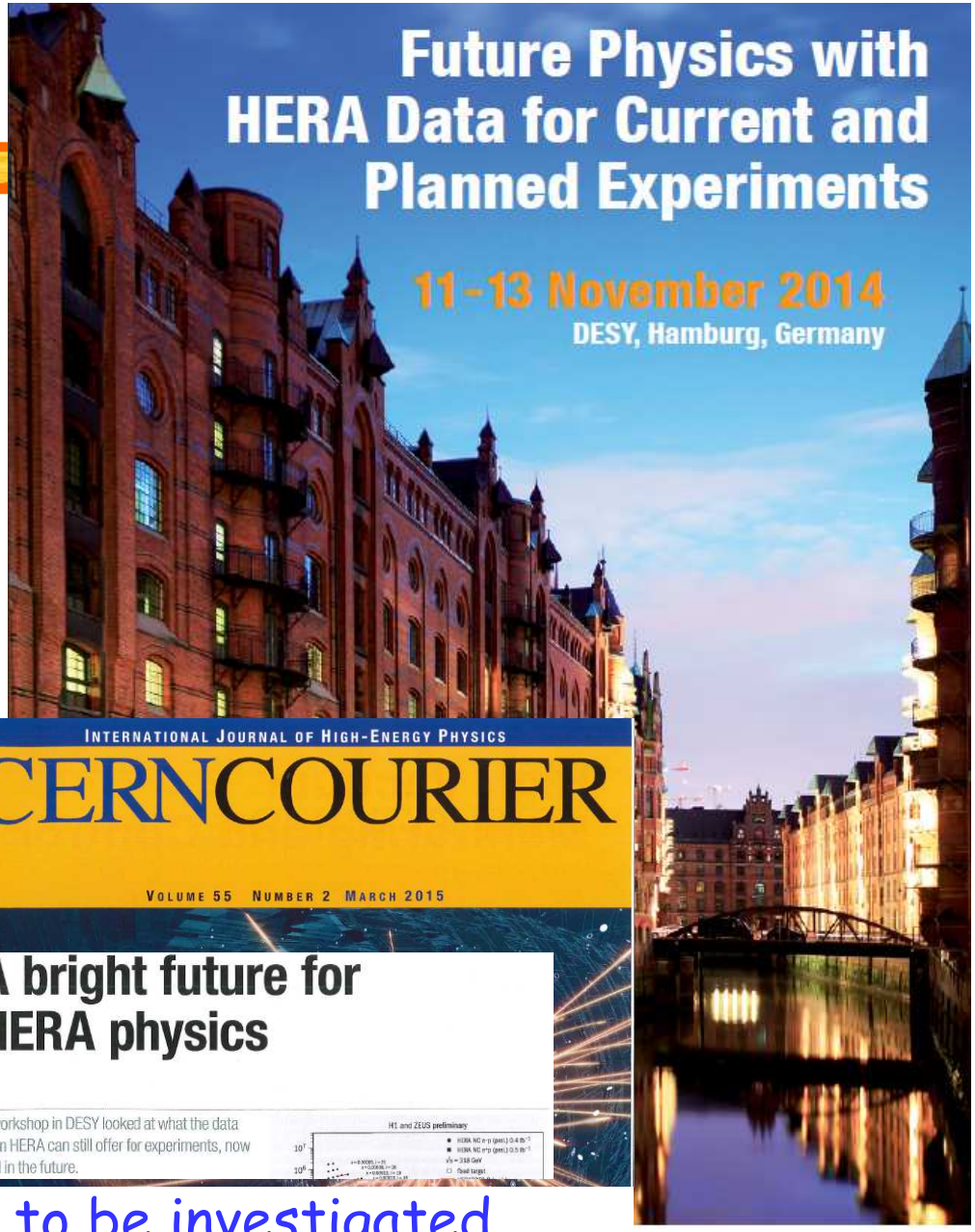
HERA data preservation

- DESY is co-founding member of
  Collaboration Agreement for the DPHEP project
  supported by ICFA (May 2014, already reported last PRC)

- HERA workshop at DESY, future physics topics
  (Nov. 2014) world HEP community

- Status of bit preservation

Workshop:



- What do the HERA data still have to say and how are they relevant to other facilities?

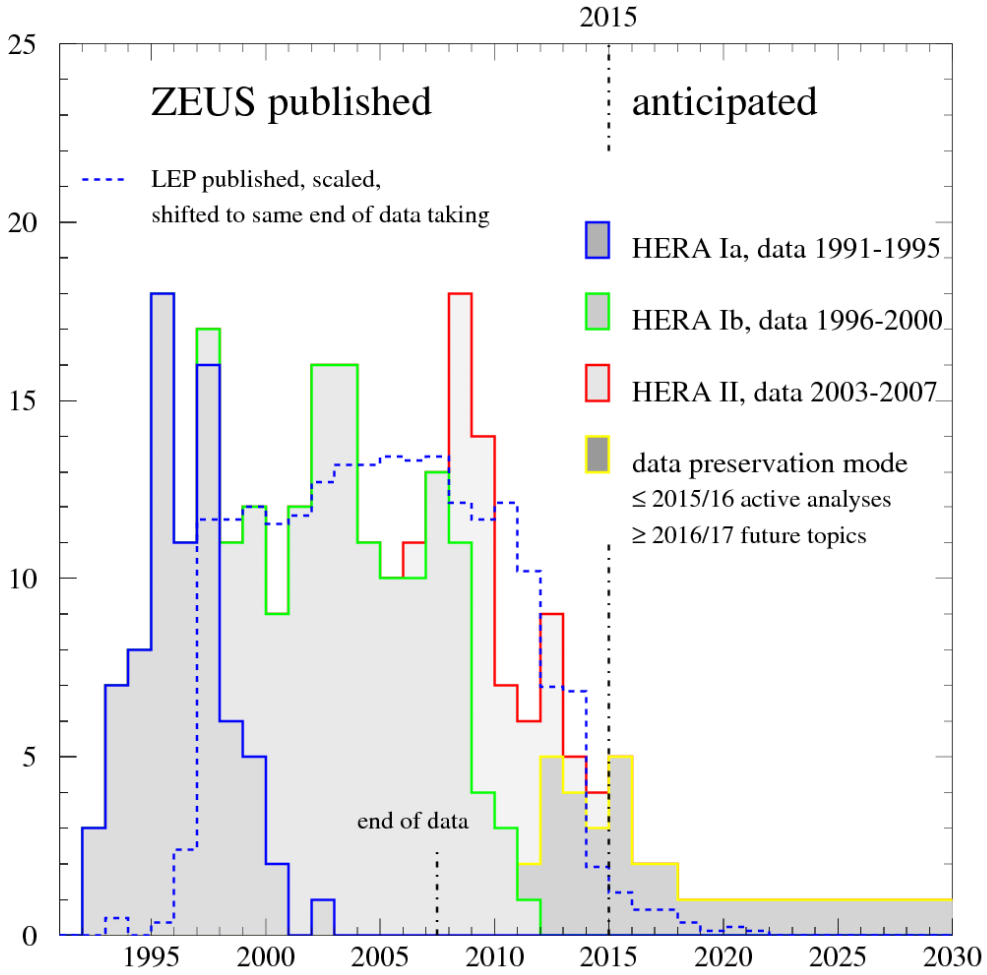
- two days with lively discussions and almost 30 presentations
https://indico.desy.de/event/futurehera

- ~ 70 participants, both experimentalists and theorists from across the globe

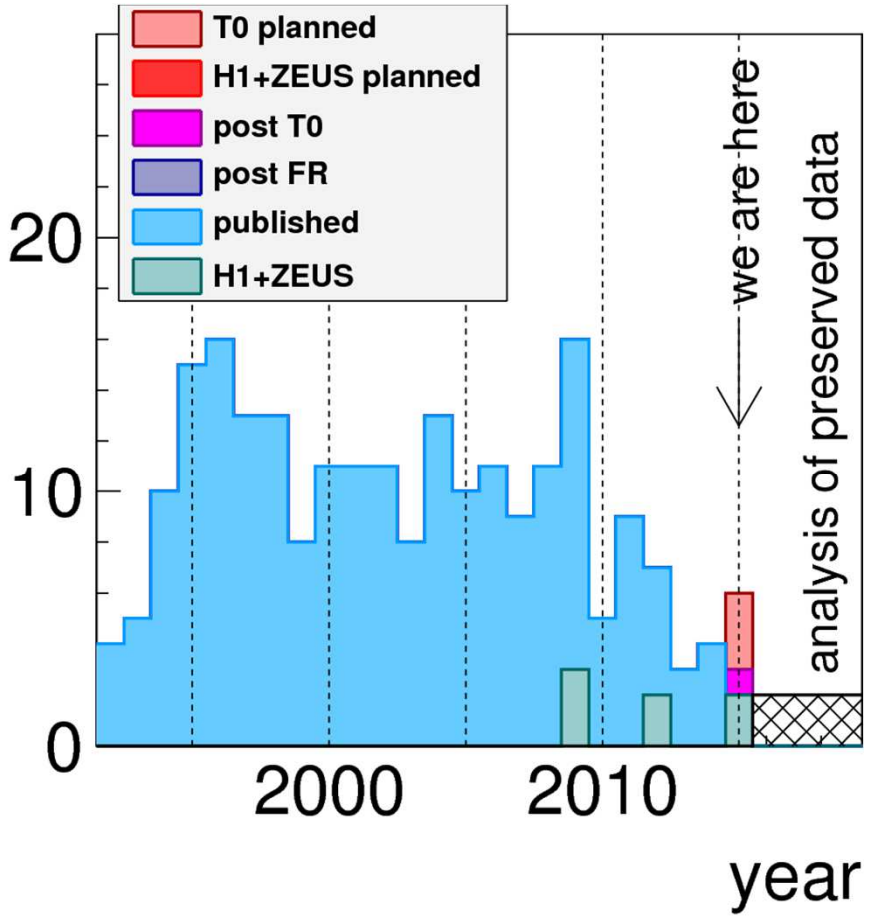
- -> list of subjects that are still to be investigated or exploited fully, using the preserved data sets
(will appear in proceedings)

HERA papers, past and future

ZEUS



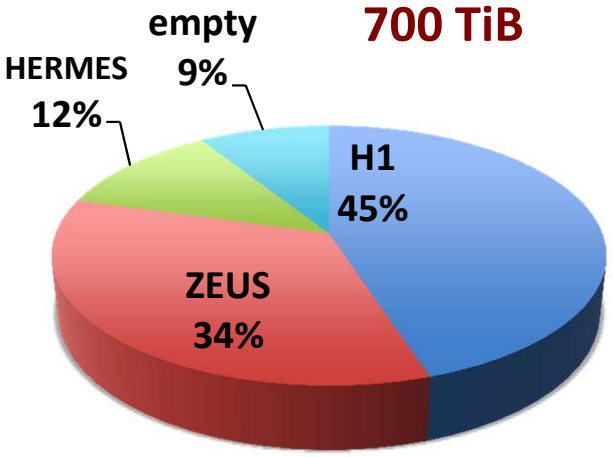
H1



HERA Data Preservation (bit preservation)

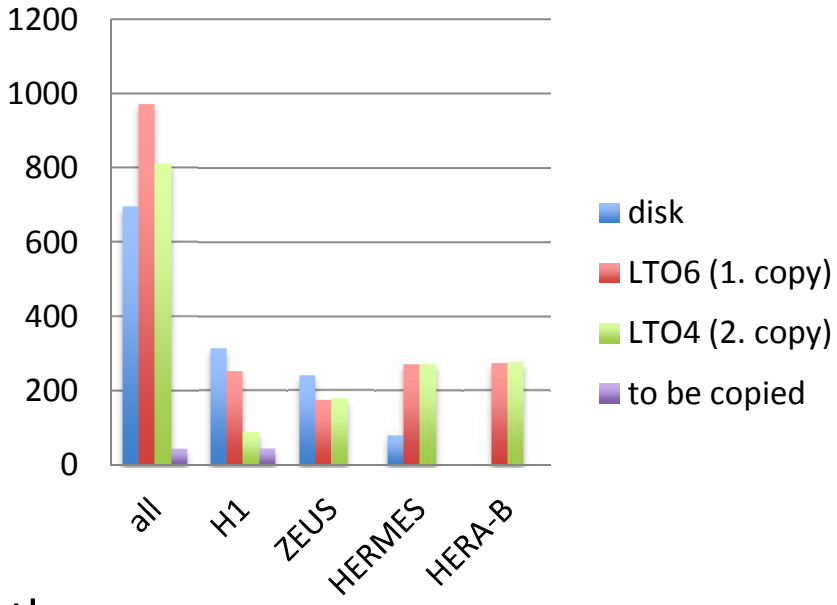
D. Krücker/IT

Present Online Storage
700 TiB



- Defining the legacy dataset and copying data from old HERA store to new DESY store
- DESY-SE provides a DPHEP area
  - **online** store i.e. disk space
  - **archive** i.e. tape with 2 redundant copies

Status Bit-Preservation [TiB]



Major activities

- Old HERA dCache had been set **read only** in Jan 2015
  - a fixed dataset now
- Online store had been extended to **700 TiB**
  - sufficient for the remaining data
  - scratch area 24TiB for ongoing work provided
- ZEUS dataset **finalized** and copied to new store
- HERMES is reorganizing the online store
- H1 data mainly defined but larger datasets for online than expected
- CHEP15 talk "Data preservation of the HERA experiments at DESY using dCache technology"

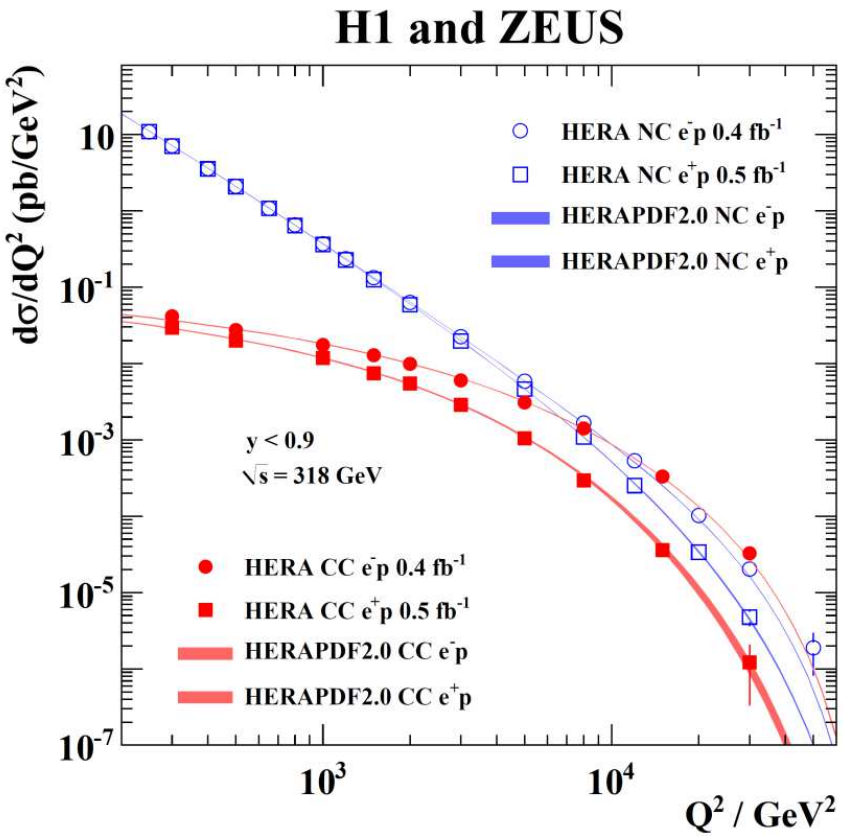
HERA Summary

- 7 (+1) HERA papers
  + 3 new preliminaries

  since last PRC

- Includes

  HERA legacy paper on inclusive DIS data combination and HERAPDF2.0 fit



- Many interesting physics topics still ahead

  (conclusion from Future Physics with HERA workshop)

- Analysis continues in data preservation mode with strongly reduced (wo)manpower

PROton Structure Analyses in Hadronic Collisions

- **International collaboration of experimentalists from different experiments** (mostly, but not only, LHC) **and theorists from different theory groups working together on fundamental physics issues, related directly to proton structure or to fundamental parameters arising from it** (e.g. quark masses, α_s)
- **Working on published data independent of other collaborations, but confidential within PROSA** (+ some work within collaborations, of course following collaboration rules)
- **Focus on theory-experiment interplay and synergy**

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

DESY-15-034, arXiv 1503.04581, submitted to EPJC

PROSA Collaboration

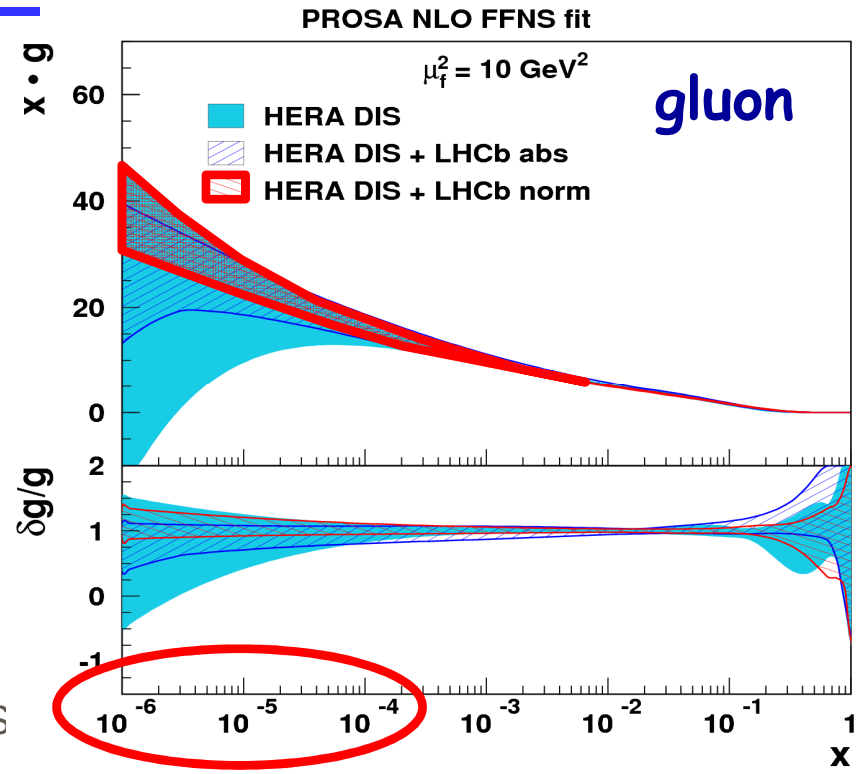
O. Zenaiev[1], A. Geiser[1], K. Lipka[1], J. Blümlein[1], A. Cooper-Sarkar[2], M.-V. Garzelli[3], M. Guzzi[4], O. Kuprash[1], S.-O. Moch[3], P. Nadolsky[5], R. Placakyte[1], K. Rabbertz[6], I. Schienbein[7], P. Starovoitov[1]

[1]DESY Hamburg & Zeuthen, Germany, [2]University of Oxford, UK, [3]Universität Hamburg, Germany, [4]School of Physics and Astronomy, the University of Manchester, UK, [5]Southern Methodist University, Dallas, Texas, USA, [6]Karlsruher Institut für Technologie, Germany, [7]LPSC Grenoble, France.

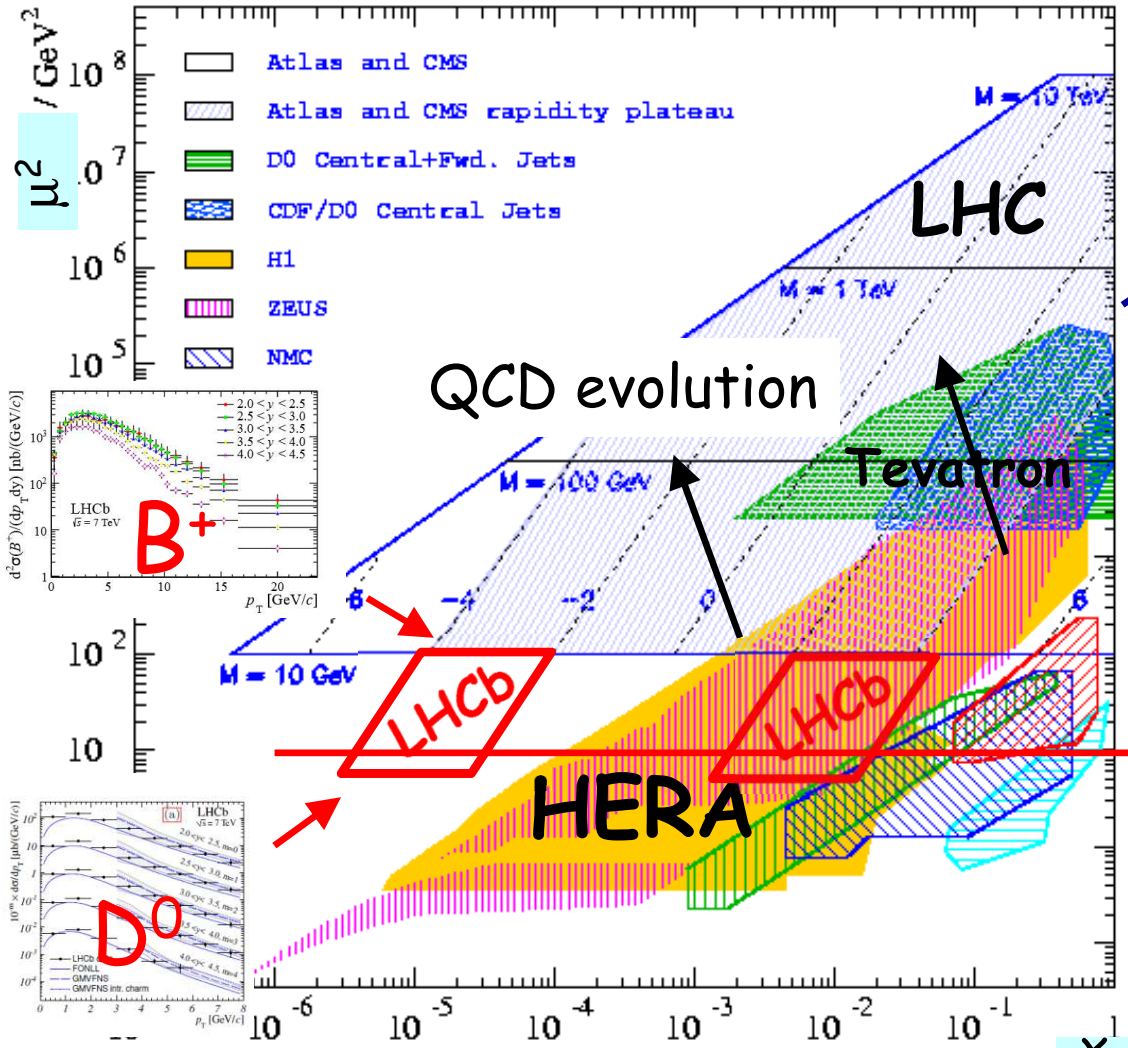
main message:

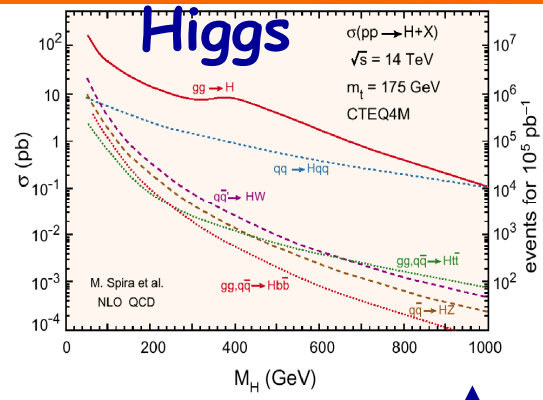
LHCb charm and beauty data (in conjunction with HERA data) can be used to directly constrain gluon PDF down to x ~ 5×10^{-6}

Message already being picked up by NNPDF and ABM groups to improve predictions for cosmic ray physics

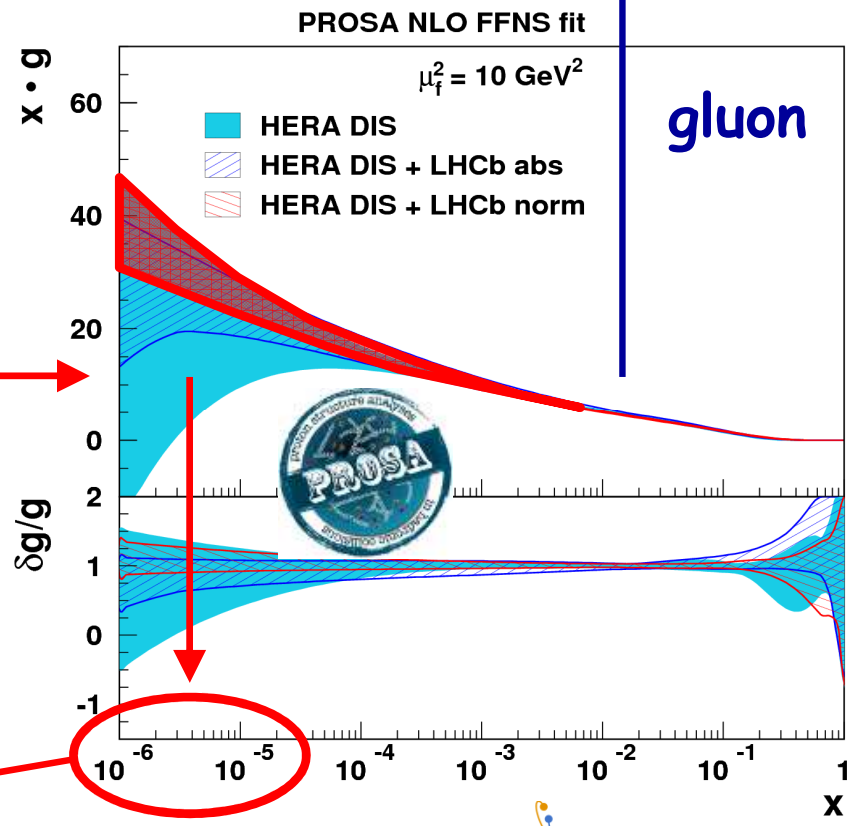


Parton density functions (PDF)





top, jets, ...



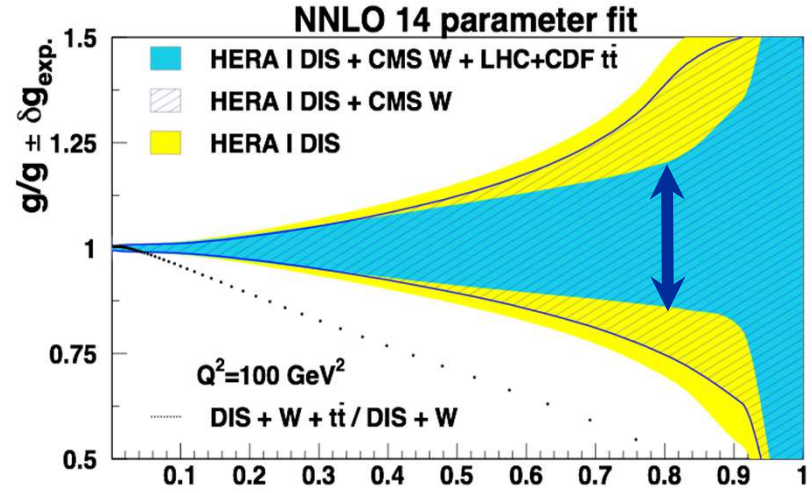
gluon

parton densities from HERA and LHC data
-> cross sections at LHC, cosmic rays, ...

Other results in context of PROSA

- **First use of differential top quark-pair measurements in global QCD analysis**

M. Guzzi et al., JHEP 1501 (2015) 082

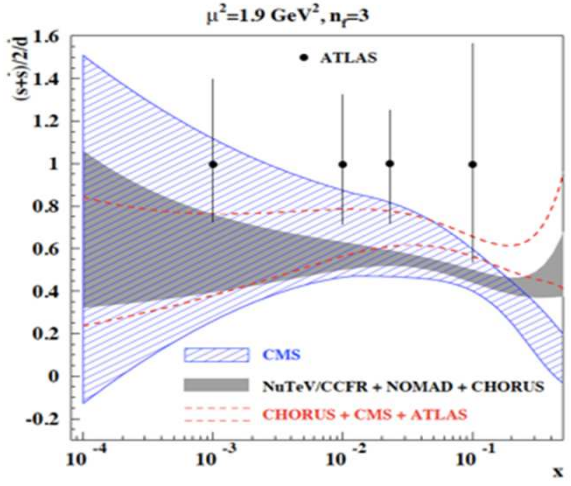


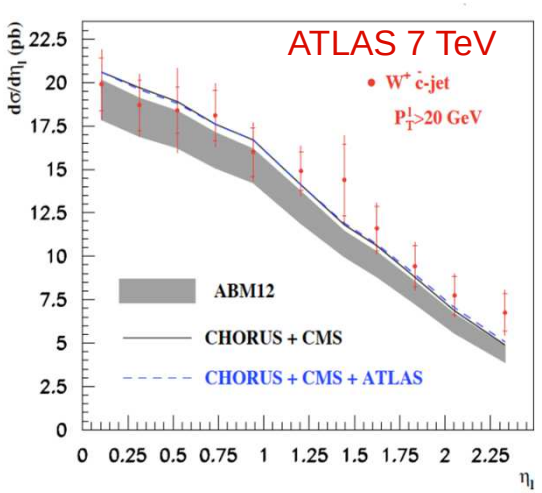
- **NNLO PDF fit using HERAFitter (tool)**
  x Difftop (new theory calculation)
  via fastNLO (tool),
  using published LHC + CDF top data

- **Constrain strangeness using LHC W+c and neutrino CC data**

S. Alekhin et al.,
Phys.Rev. D91 (2015) 9, 094002

- **all data are mutually consistent !**

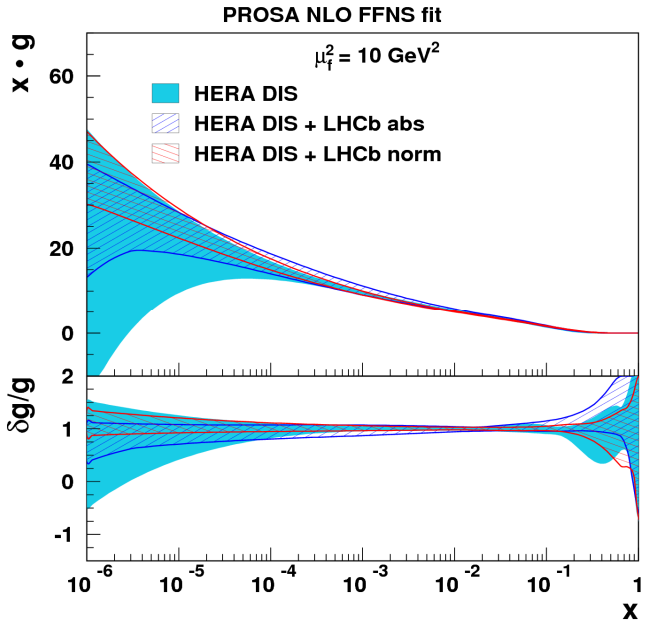




PROSA summary

- PROSA collaboration focuses on added value from direct and intense theorist-experimentalist interaction
- 1 PROSA collaboration paper
  + 2 PROSA-initiated papers

  since last PRC



- Possible next step: simultaneous determination of g(x), α_s and heavy quark masses (m_t, m_b, m_c) in a global QCD analysis

[CMS, arXiv1307.1907]