Measurement of NC $e^{\pm}p$ cross sections at high Bjorken x with the ZEUS detector

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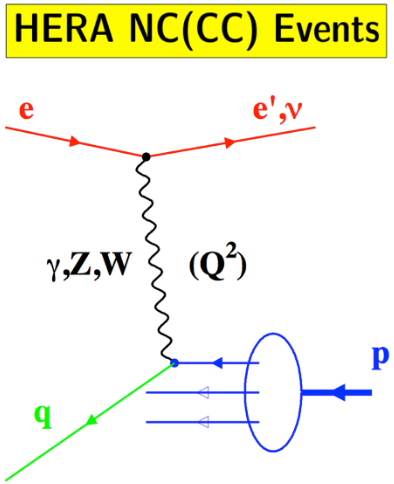
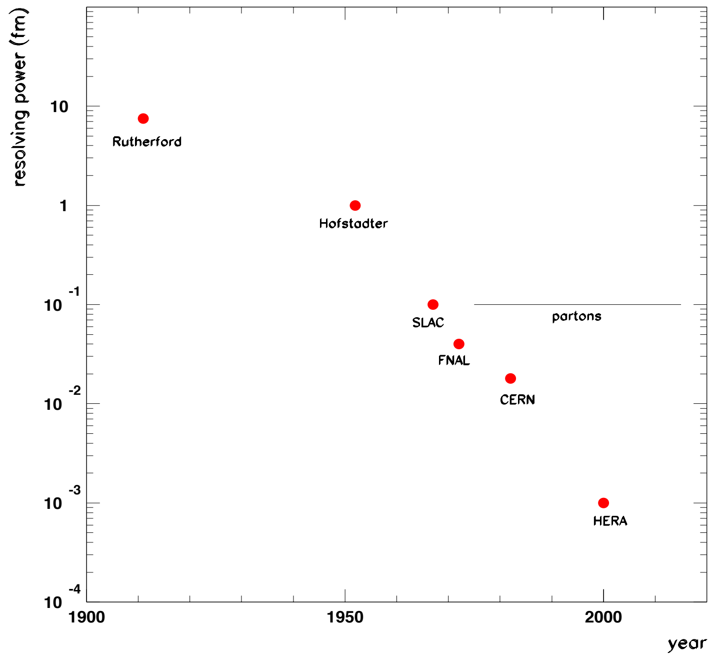
On behalf of the ZEUS collaboration

Resolving Structure of Matter

HERA, e (27.5 GeV) p (920 GeV) collider to study the proton structure with a high resolving power. (~ 10^{-3} fm)



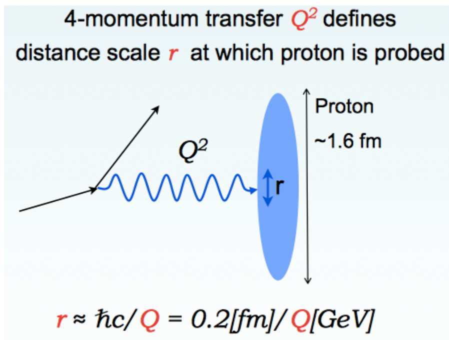


Kinematics:

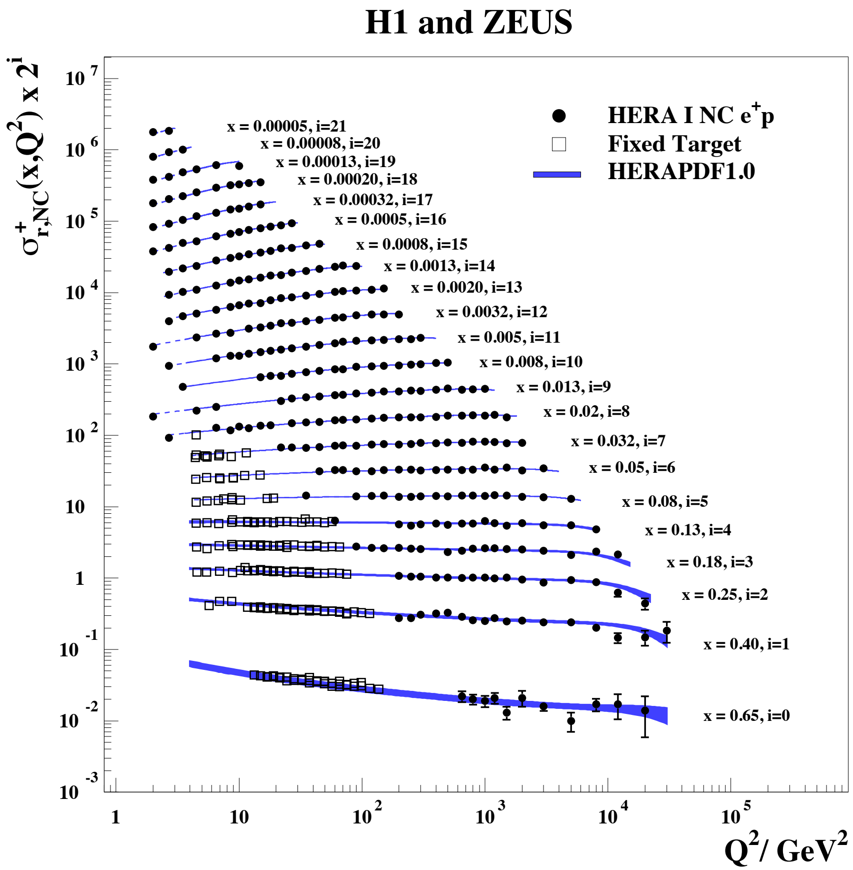
$$Q^2 = -q^2 = -(k - k')^2$$ Boson virtuality

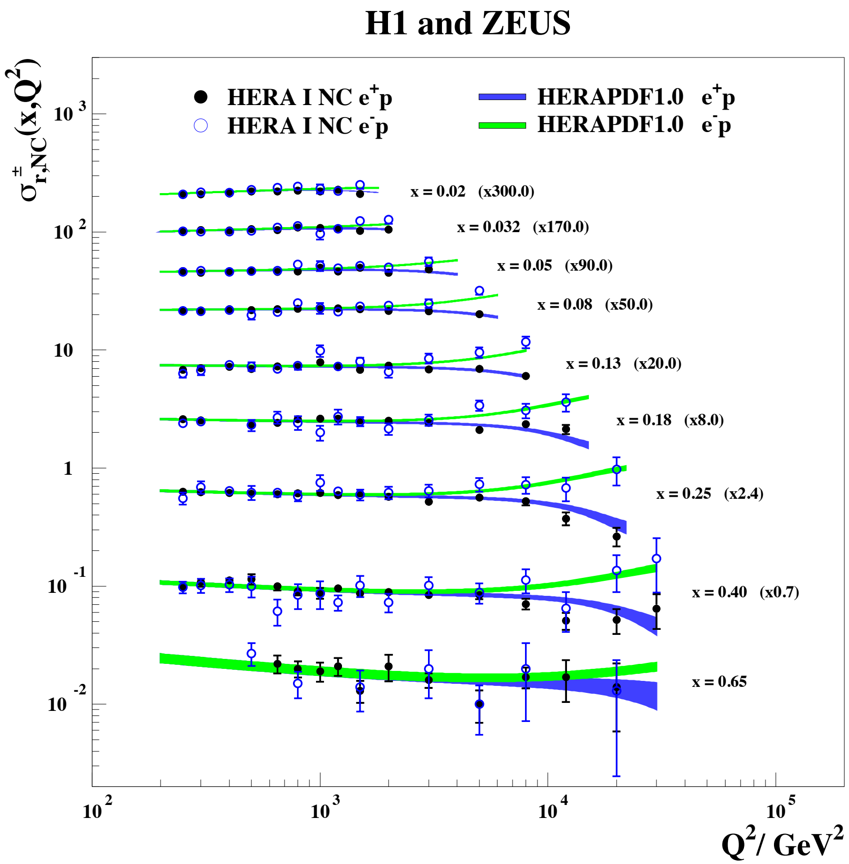
$$x = \frac{Q^2}{2p \cdot q}$$ Bjorken variable

$$y = \frac{p \cdot q}{p \cdot k}$$ Inelasticity



Combined cross sections, H1+ZEUS



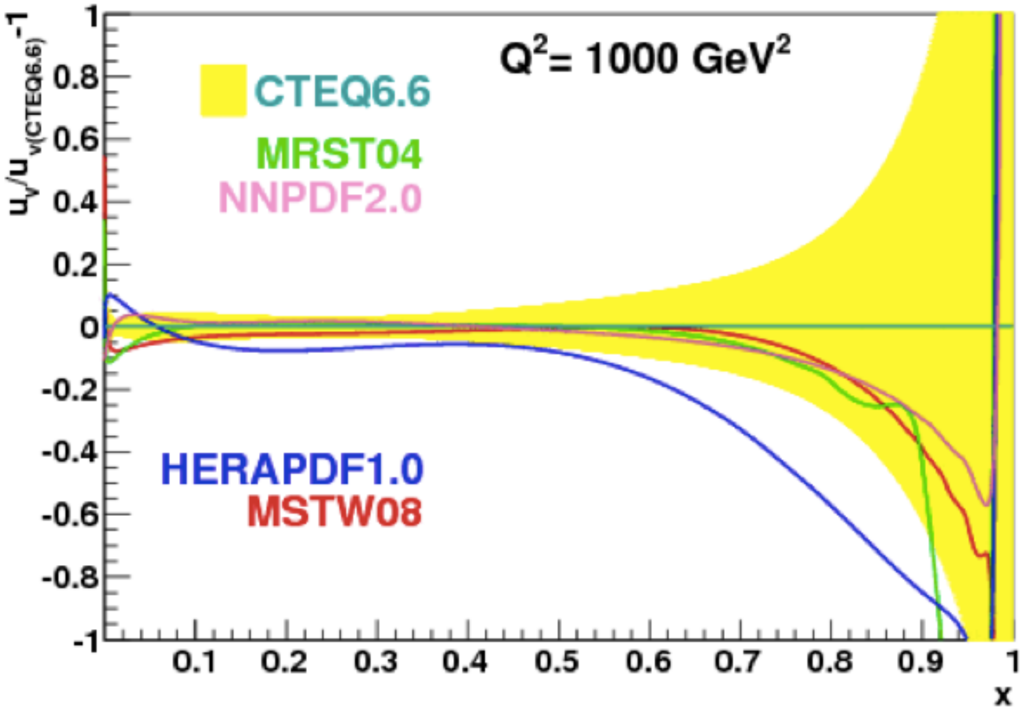


High x - Motivation

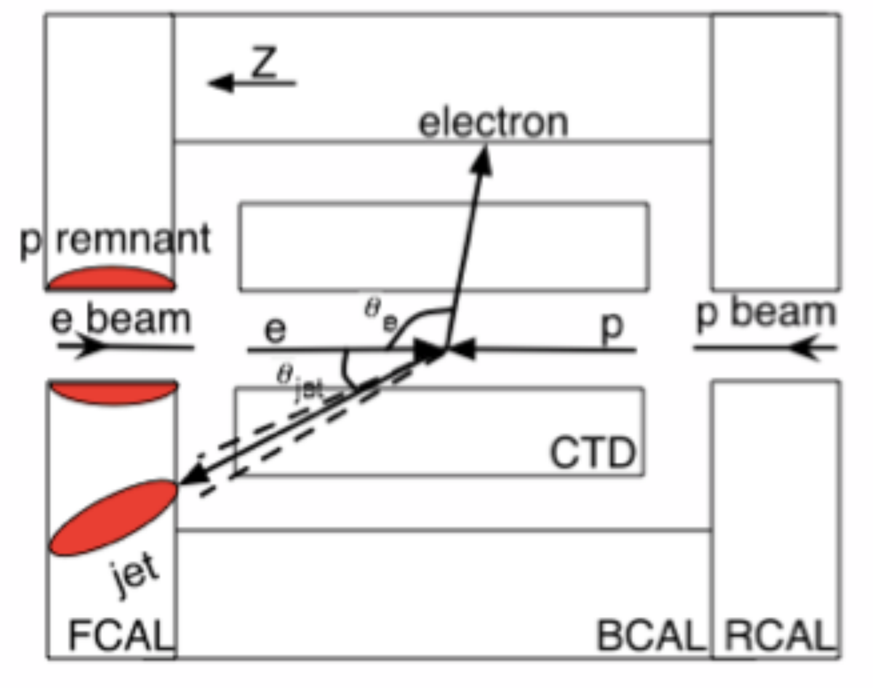
- At very low x, access to Q^2 limited.
- At low x, photon starts fluctuating long before resolving the proton. Study the γ^*p interaction region.
- As x increases, reach of higher Q^2 values is possible. Photon can resolve details of the proton.
- As x and Q^2 increase, probe's fluctuation time is short. Probe 'sees' inside the proton.
- HERA data, used for PDF determination, only up to x=0.65.
- Higher x data exist only from fixed target experiments and at low Q^2.
- Want to measure at HERA at high Q^2 up to x=1 and use these data for constraining PDFs at high x.

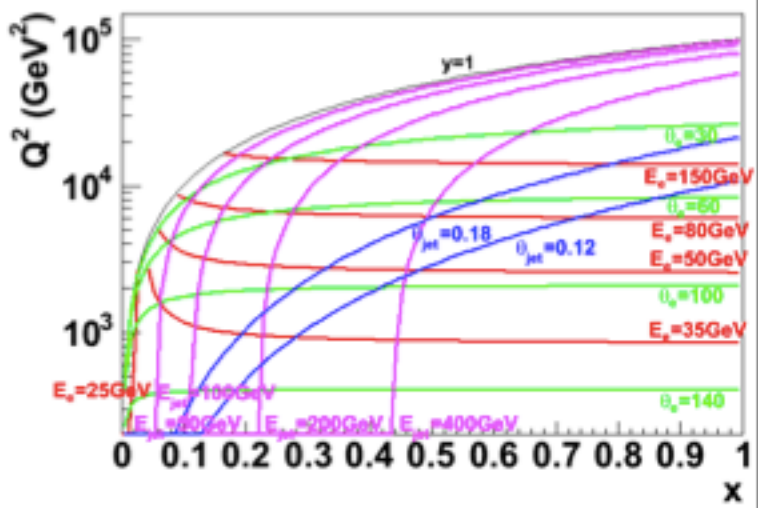
High x - Motivation

The PDF's are poorly determined at high-x. Sizeable differences despite the fact that all fitters use the same parametrization $xq \propto (1-x)^{\eta}$. Is it possible to check this ?



HERA high x high Q^2



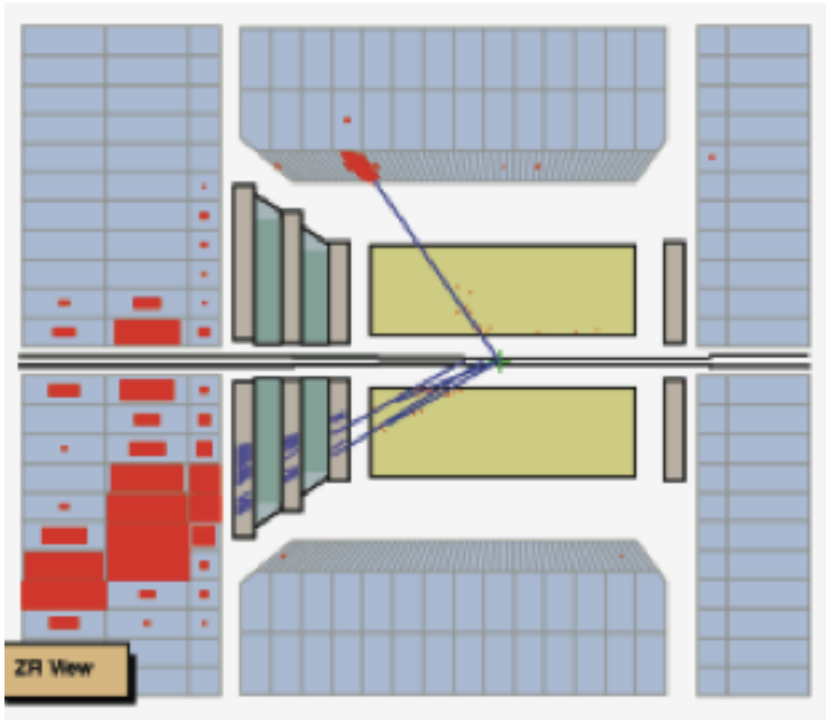


- At high Q^2, scattered electron seen with ≈100% acceptance
- For not too high x, measure x from jet: $\frac{d^2\sigma}{dxdQ^2}$
- For $x>x_{Edge}$, measure $\int_{x_{Edge}}^{1} \frac{d^2\sigma}{dxdQ^2}dx$

1-jet, 0-jet

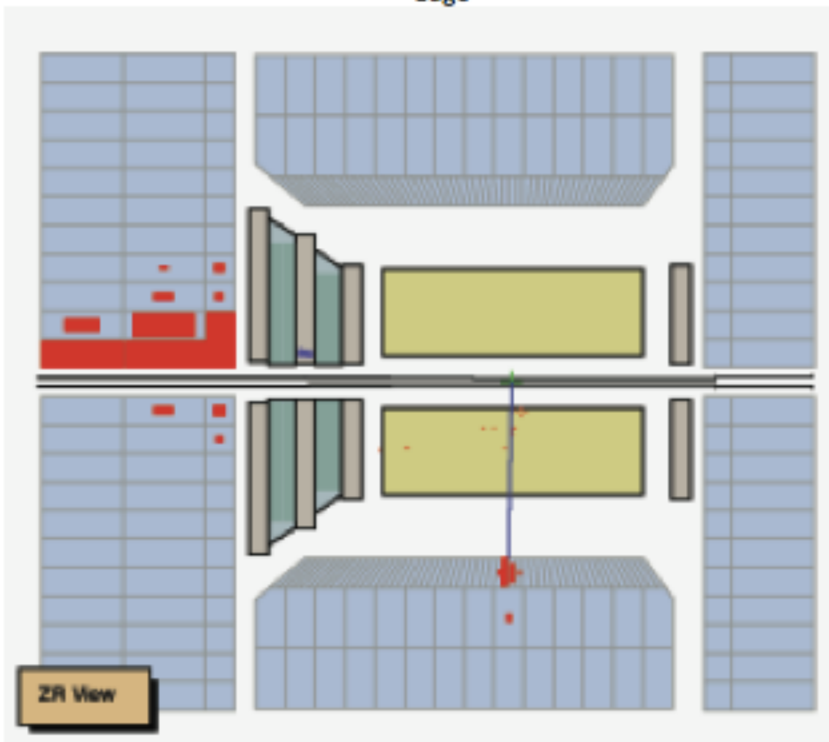
Jet found

$x<x_{Edge}$



No jet found

$x>x_{Edge}$



x and Q^2 reconstruction

Electron Pt jet method is chosen for reconstruction of kinematic variables

$$Q_e^2 = 4E_e E'_e \cos^2\frac{\theta_e}{2},$$

Q^2 by electron method

x for 1 jet events

$$x_{pt_e} = \frac{(p_{t_e}/sin\theta_{jet})(1+cos\theta_{jet})}{2E_p(1-\frac{(p_{t_e}/sin\theta_{jet})(1-cos\theta_{jet})}{2E_e})}$$

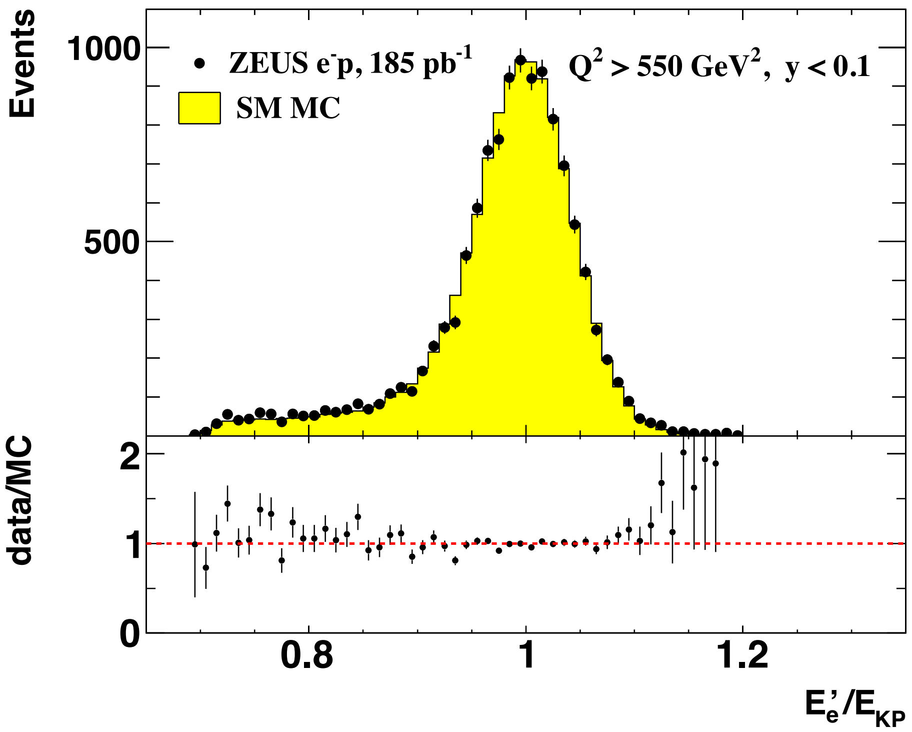
.

$$x = \frac{E_{\rm jet}(1+\cos\theta_{\rm jet})}{2E_p\left(1-\frac{E_{\rm jet}(1-\cos\theta_{\rm jet})}{2E_e}\right)}$$

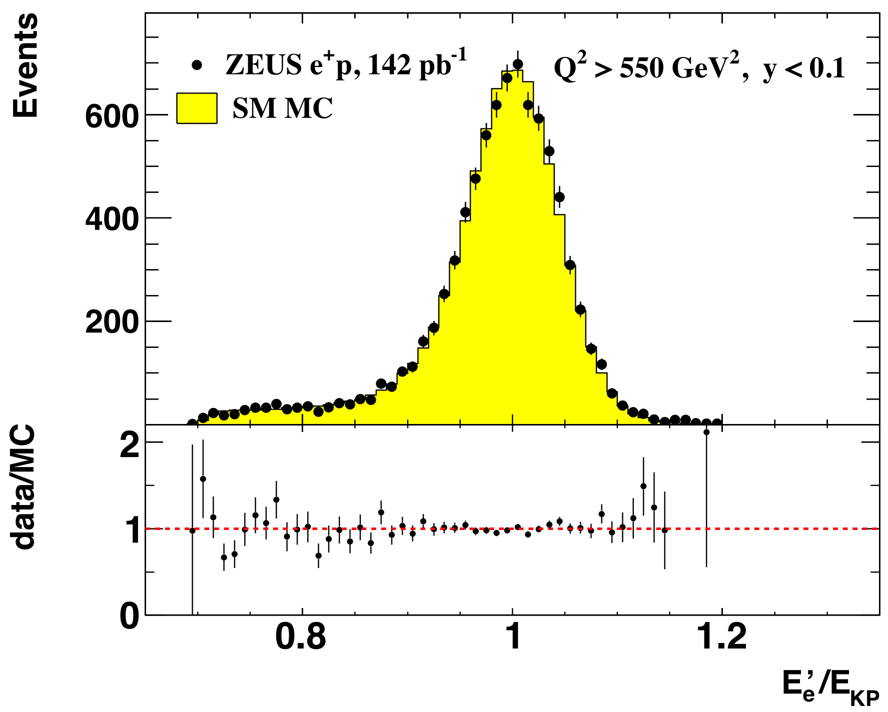
x for multi-jet events

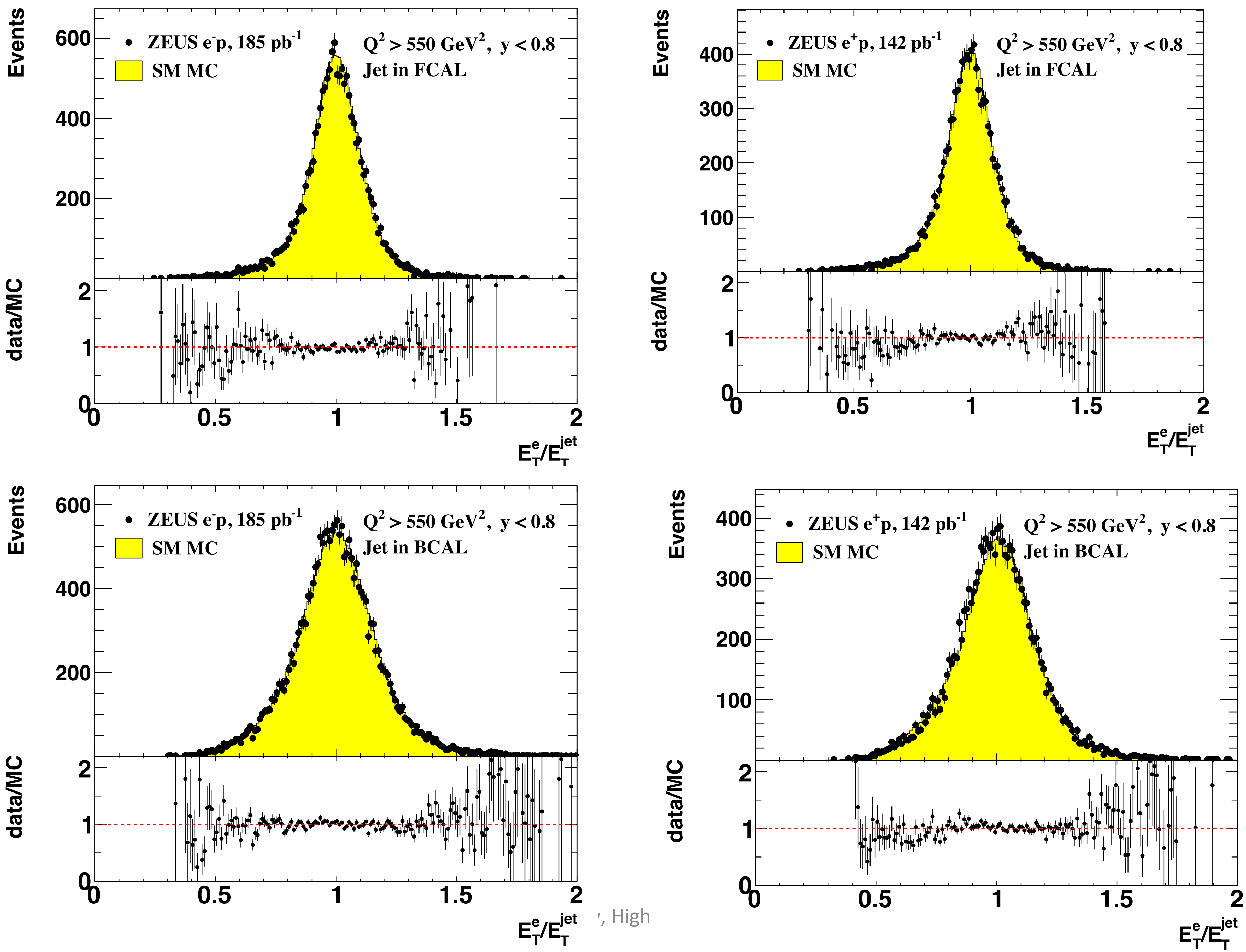
Control plots

e^-p



e^+p

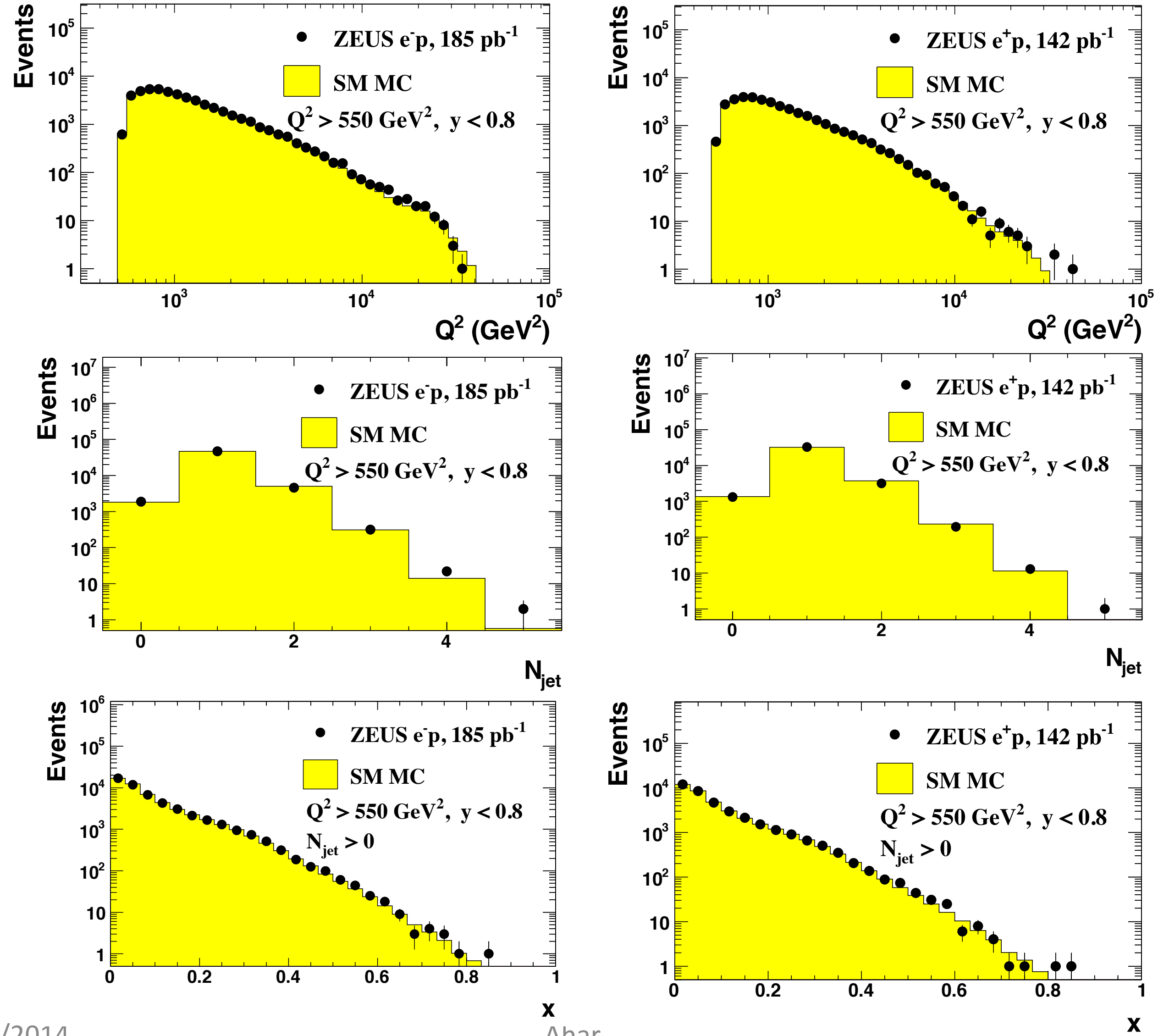




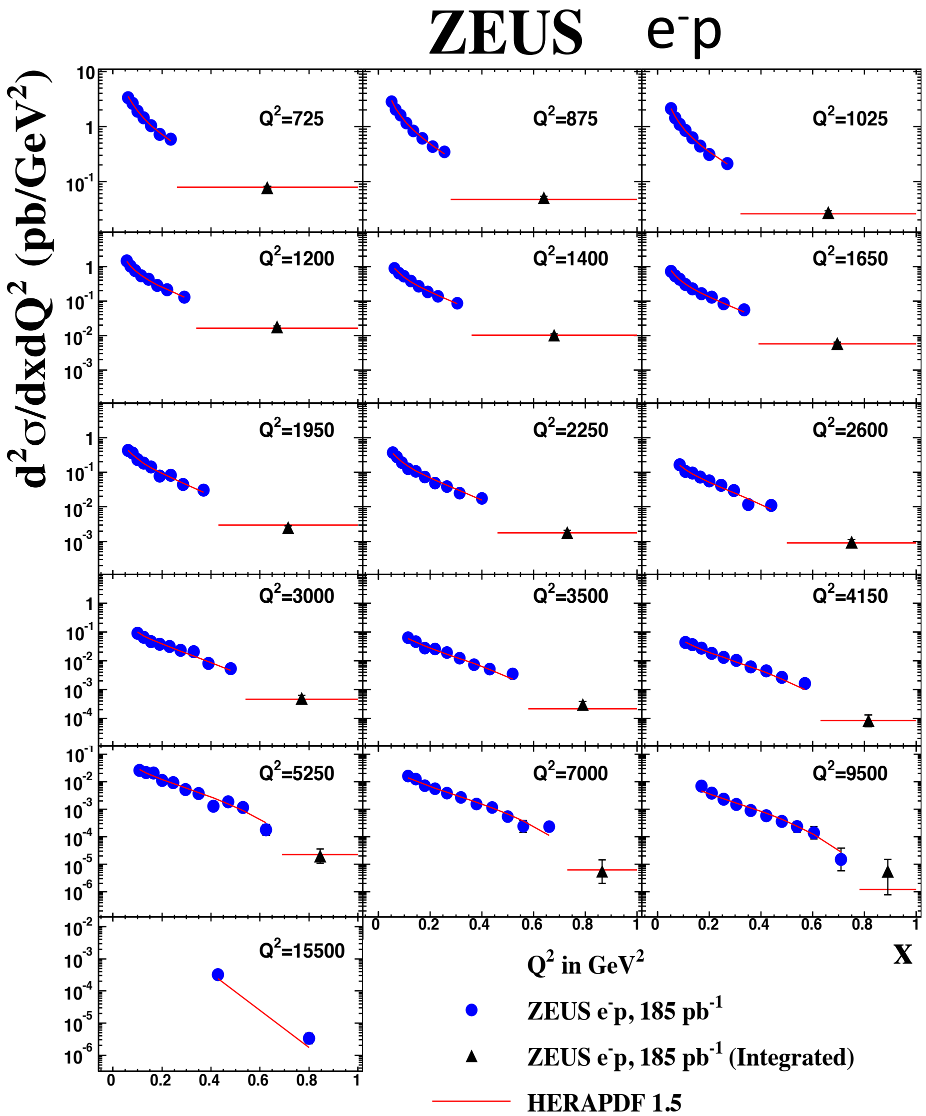
Events
data/MC
ZEUS e⁻p, 185 pb⁻¹
SM MC
Q² > 550 GeV², y < 0.8
Jet in FCAL
Events
data/MC
ZEUS e⁺p, 142 pb⁻¹
SM MC
Q² > 550 GeV², y < 0.8
Jet in FCAL
Events
data/MC
ZEUS e⁻p, 185 pb⁻¹
SM MC
Q² > 550 GeV², y < 0.8
Jet in BCAL
Events
data/MC
ZEUS e⁺p, 142 pb⁻¹
SM MC
Q² > 550 GeV², y < 0.8
Jet in BCAL
E_T^e/E_T^jet

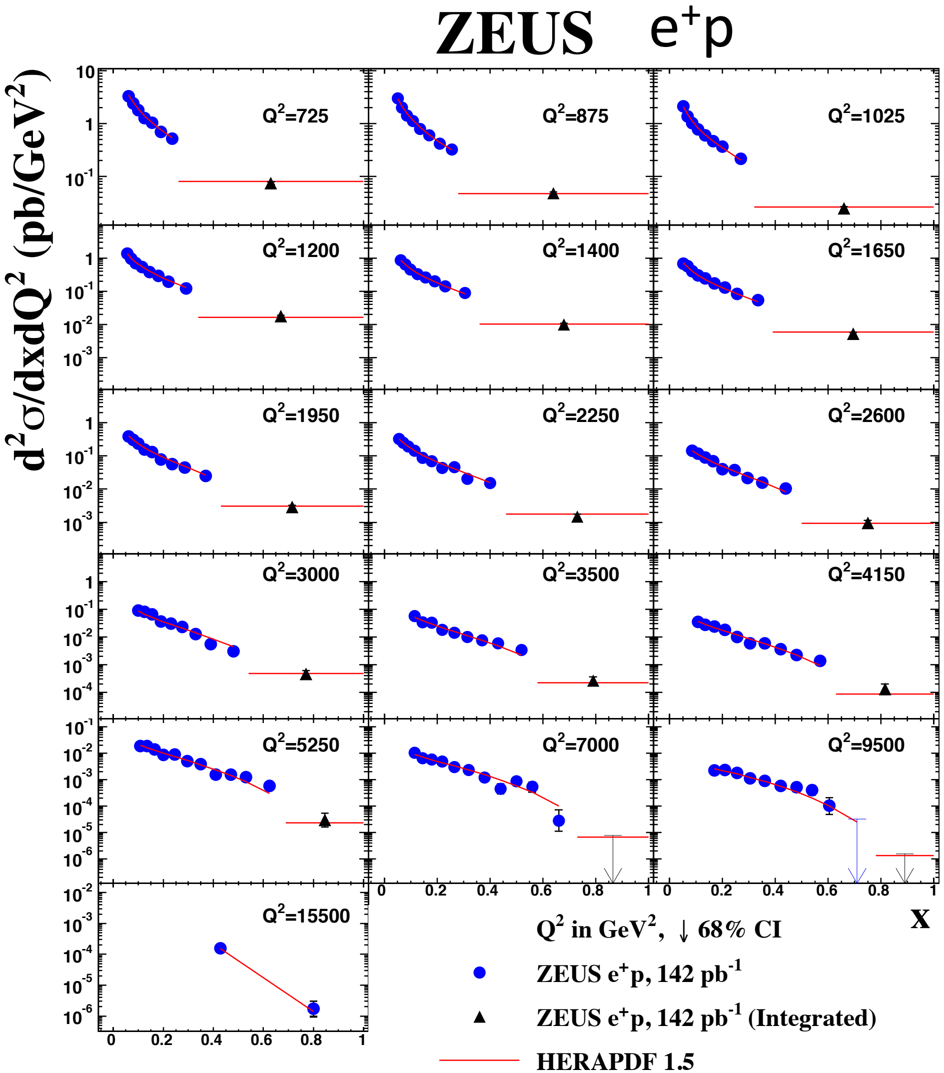
Control plots

e^-p e^+p

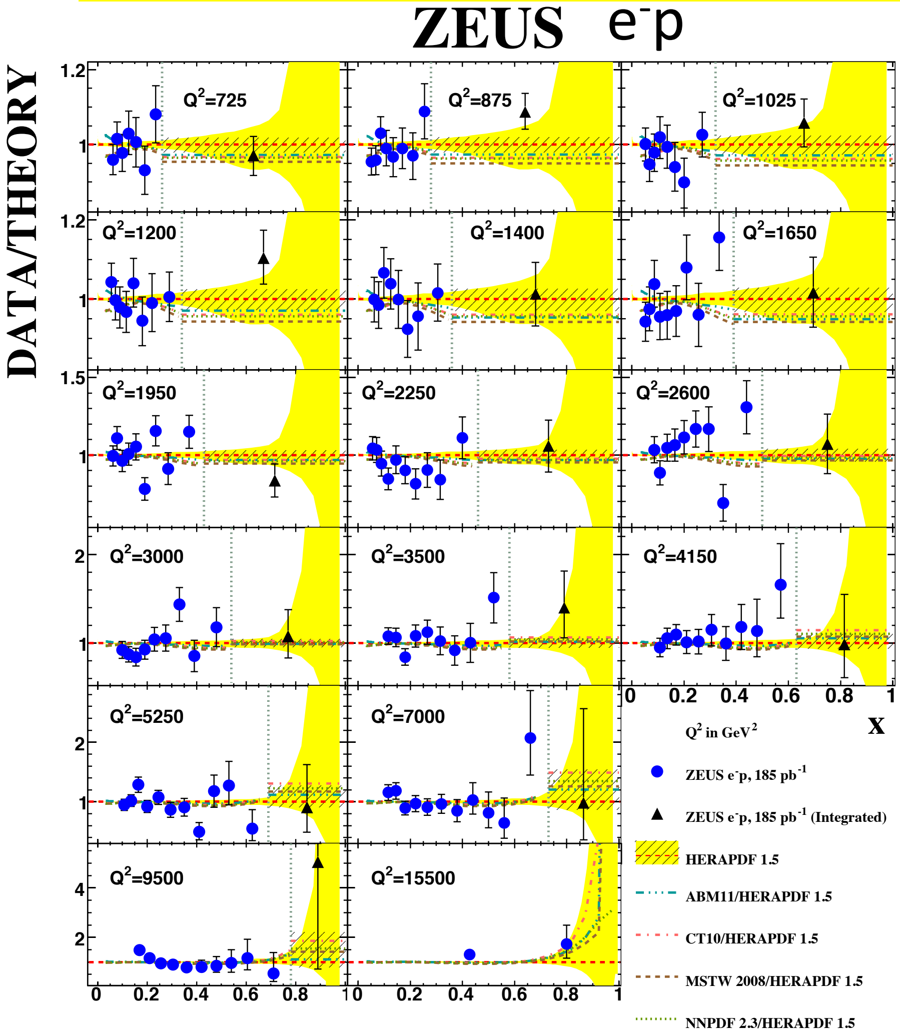


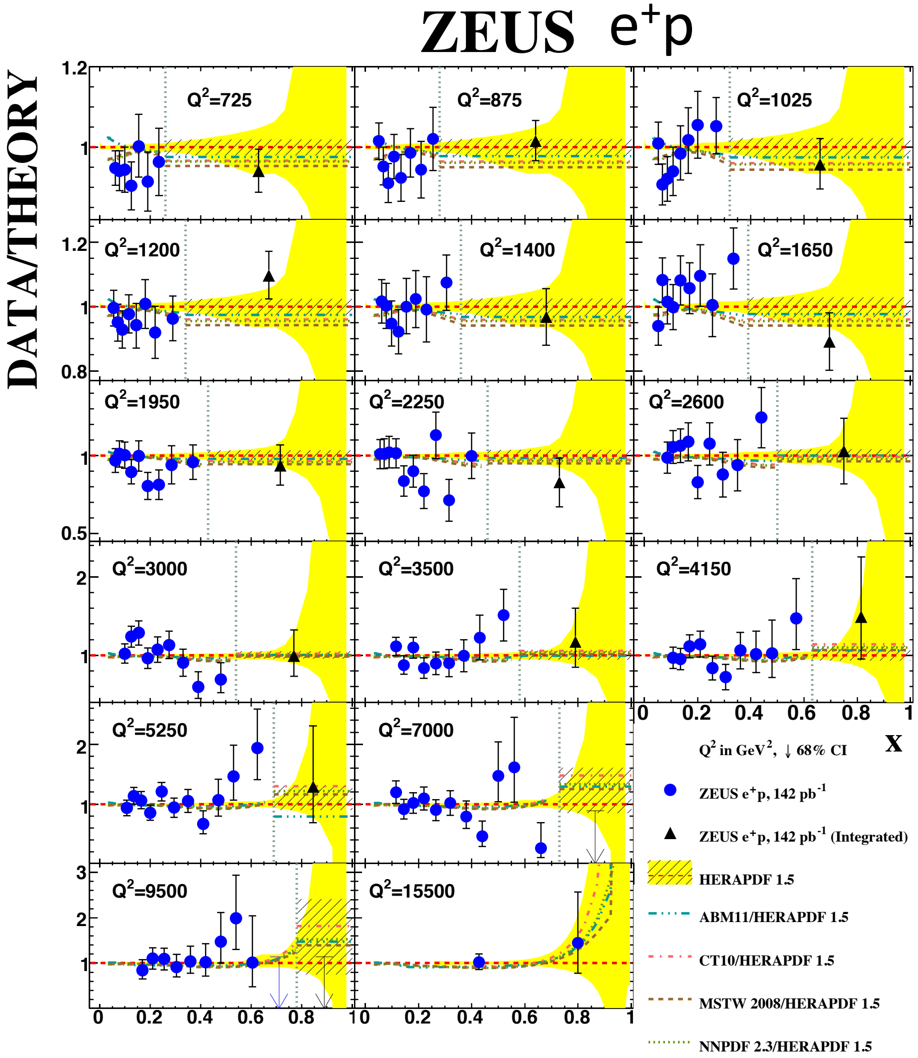
NC cross section e±p





Data/Theory NC $e^{\pm}p$





How to include these data for PDF fits?

Simple chi squared methods are not appropriate for including these data in fits. Many of the bins have only a few or zero events. One should use the number of measured events in the fits. Fitters should provide predictions for the number of events expected in the bins in which event counts are reported, and then use Poisson statistics to calculate the probability for the observed number of events given this expectation (from a Note by Allen Caldwell).

$Q^2(GeV^2)$	x	$N(e^-)$	$N(e^+)$	x_{edge}	$N(e^-)$	$N(e^+)$
3500	0.52	33	24	0.79	17	11
4150	0.57	18	12	0.81	5	6
5250	0.62	5	13	0.85	3	3
7000	0.66	10	1	0.87	1	0
9500	0.71	1	0	0.89	1	0
15500	0.80	8	3			

Conclusions high x

Measured $e^{\pm}p$ NC DIS cross sections at $Q^2>725$ GeV^2 up to $x\cong1$.

Fine binning in x, extension of kinematic coverage up to $x\cong1$ make data important input to fits constraining the PDFs in the valence-quark domain.

More details: Phys. Rev. D89 (2014) 072007 (arXiv:1312.4438 [hep-ex])