Transfer matrix for high-x MC
and
Comparison of various PDFs at high-x

Ritu Aggarwal, Allen Caldwell

New in today's talk

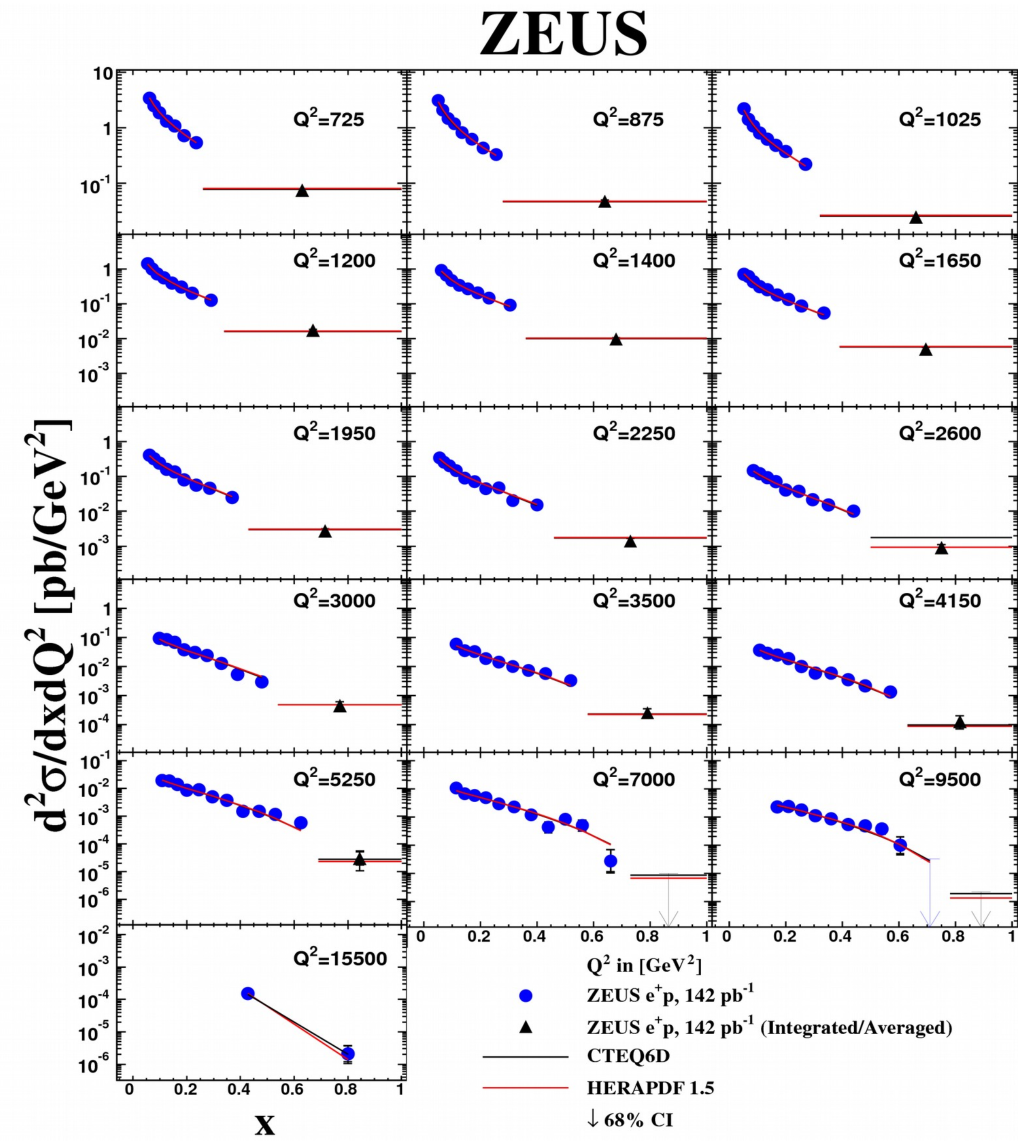
New Since last talk :

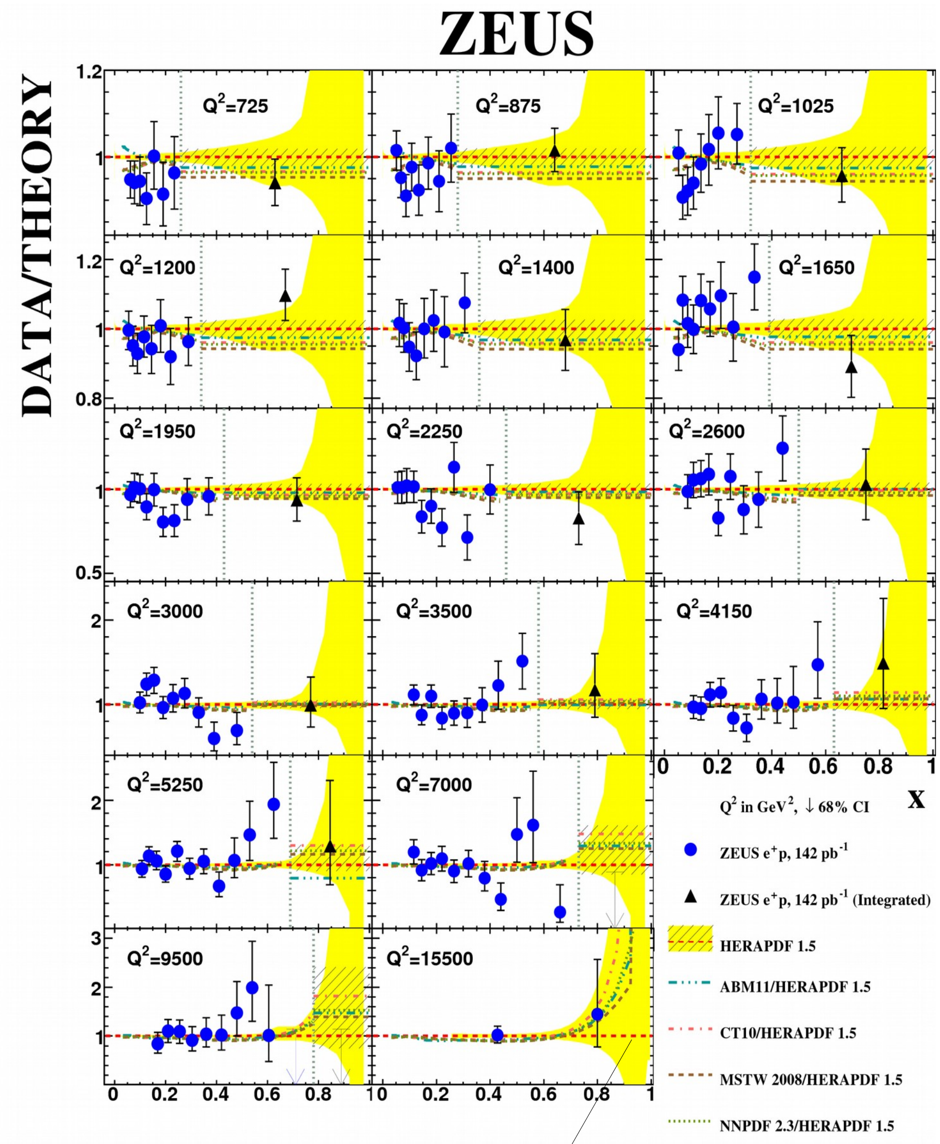
All new suggested PDFs and their latest versions included.

Plots with comparison of generated events via different PDFs updated

P-values and other numbers updated

Motivation of studying published high-x data





At present x upto 0.65 ZEUS data is included in PDF fits

Note the uncertainity bands above x ~ 0.65, can high-x data impact here

ZEUS Collaboration; H. Abramowicz et al. Measurement of Neutral Current $e^{\pm}p$ Cross-Sections at High Bjorken x with the ZEUS Detector Phys. Rev. D 89 (2014) 072007

Current Analysis : Extension of ZEUS high-x paper

Data & MC samples (same as high-x paper)
04-06 e-p data (185 pb -1) & 06/07 e+p data (141.44 pb^{-1})
DJANGOH 1.6, Ariadne 4.12, CTEQ-5D MCs

Using a combination of Ariadne and MEPS MC to get best representation of data.
(same as high-x paper)

Selection Cuts :

Please refer backup for details (same as in high-x paper)

Other Inputs to MC :

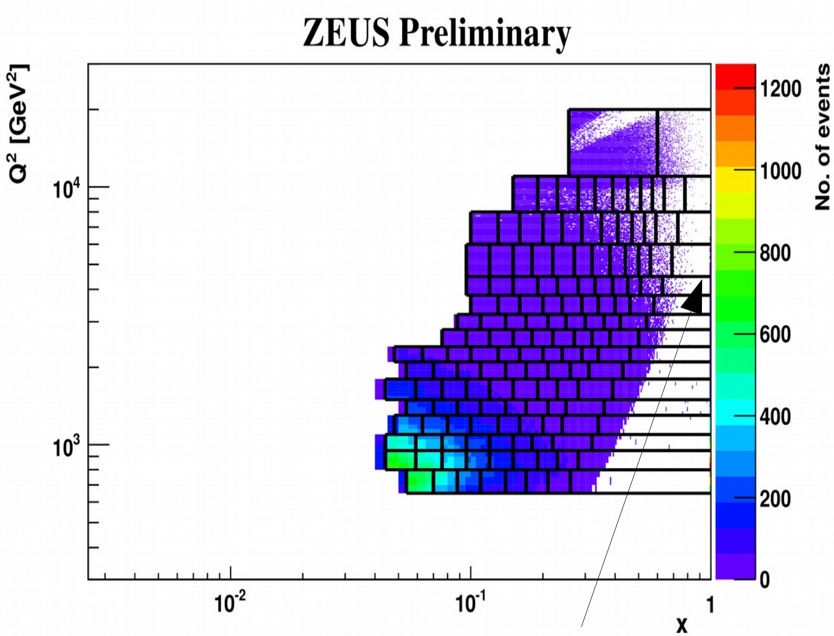
(termed as simulation weights in further presentation : w^{SM}_{MC})

- Calibrations
- Track Matching Efficiency
- Track Veto inefficiency
- Zvtx Reweighting

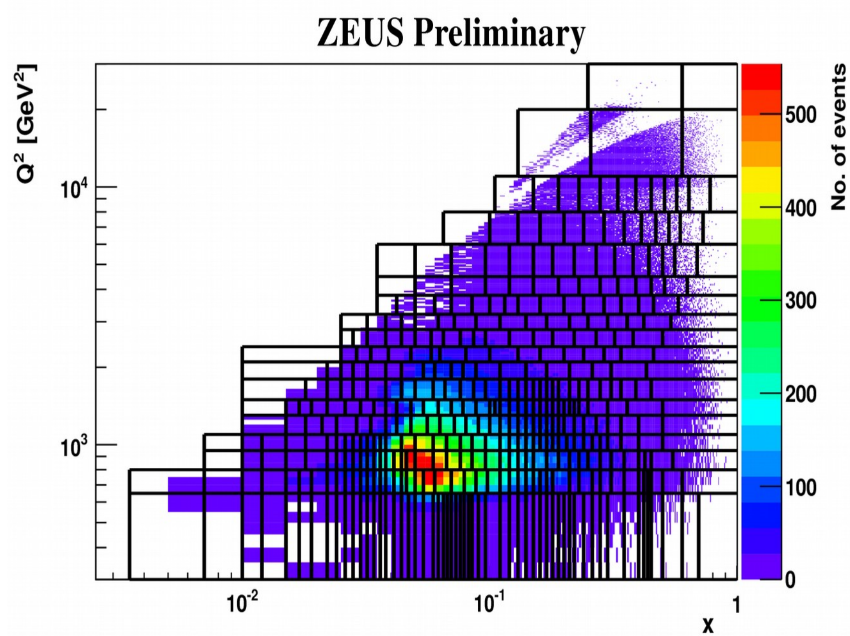
(same as in high-x paper)

Tracing back the path of MC reconstructed events in the generated x-Q^2 phase space

Plots for Preliminary



High-x events with
x > x_edge



Reconstructed MC events in xsection binning 'N' (total 153 bins, i bins)

Generated distribution of these events in extended binning 'M' (total 429 bins, k bins)

These plots will be required for explaining the building of Transfer matrix (to be shown at ICHEP)

Transfer Matrix :

Probability of an event reconstructed in j^{th} bin : $\nu_{j,k}$ to come from i^{th} true bin : $\nu_{i,k}$

$$\nu_{j,k} \approx \mathcal{L} \sum_i t_{ij} \sigma_{i,k}$$

L : data luminosity & $\sigma_{i,k}$: born level cross sections in k^{th} bin

Where $t_{ij} = K_{ii}\, a_{ij}$

Here, K_{ii} = radiative corrections on the Born level Cross-sections

Each element in Transfer Matrix is represented as

$$a_{ij} = \frac{\sum_{k=1}^{M_i} \omega_k I(k \in j)}{\sum_{k=1}^{M_i} \omega_k}$$

a_{ij} = probability of an event reconstructed in j^{th} bin to come from i^{th} bin

ω_k = weight given to k^{th} event in bin i
(contains 2 type of weights : simulation weights and Q^2 weights due to different Q^2 subsamples)

I = 1 if k^{th} event is reconstructed in bin j, else = 0

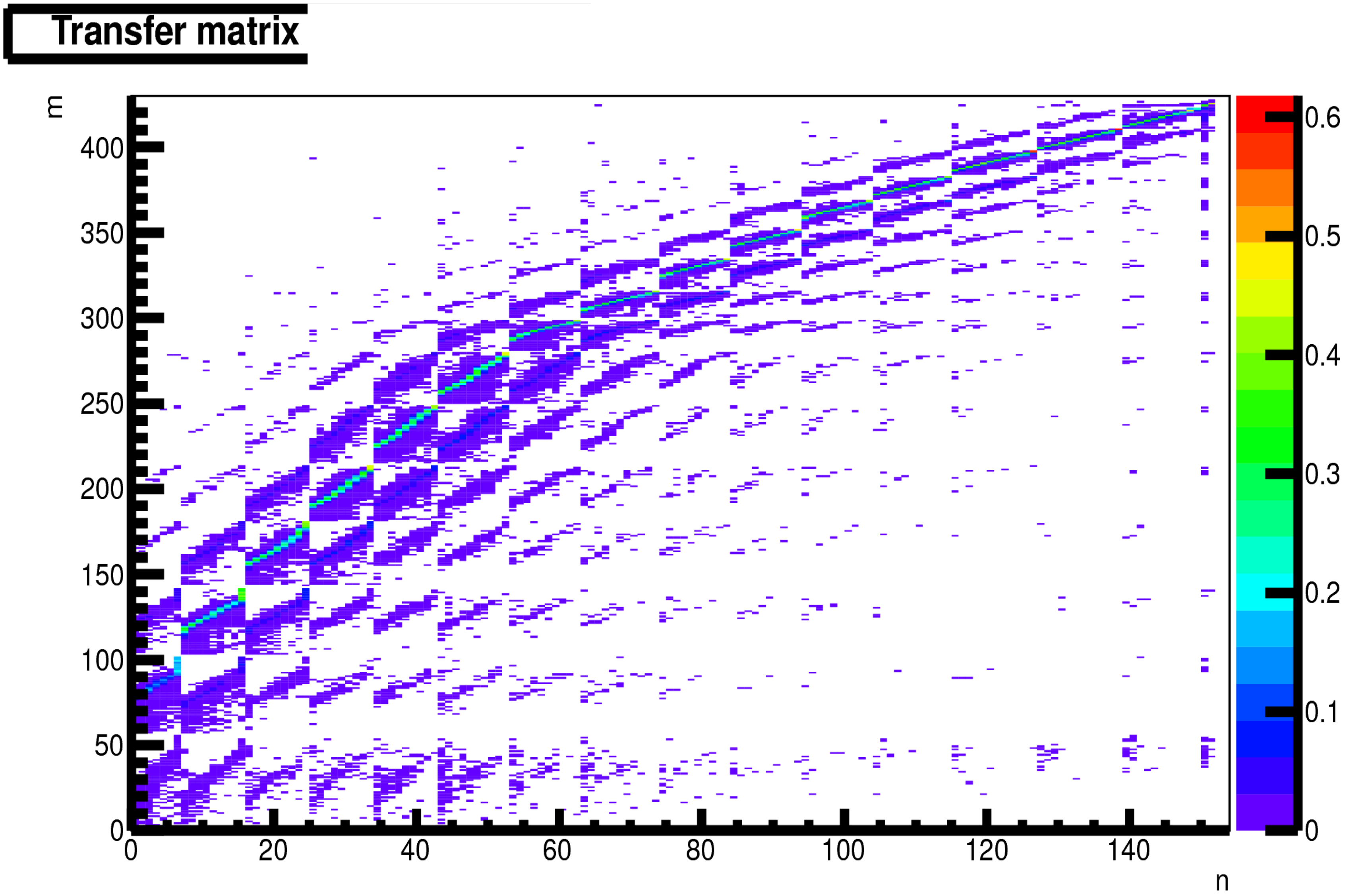
M_i = total events generated in i^{th} bin

a_{ij} has all detector and analysis effects

Also

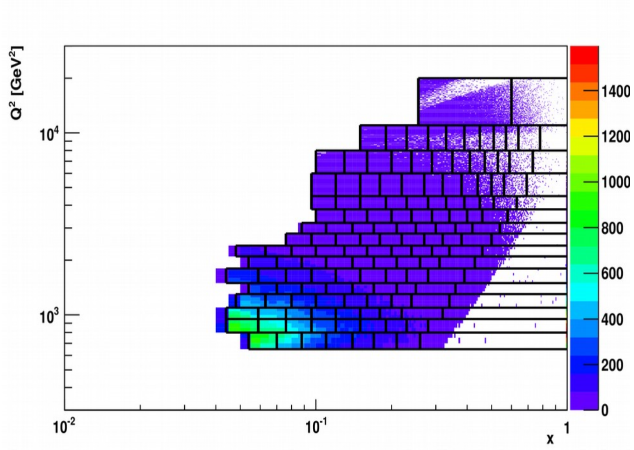
$$\mathbf{K_{ii}} = \frac{\text{Integrated Xsec in (x,Q2) bin with radiative corrections}}{\text{Integrated Xsec in (x,Q2) bin}}$$

Transfer Matrix (T)

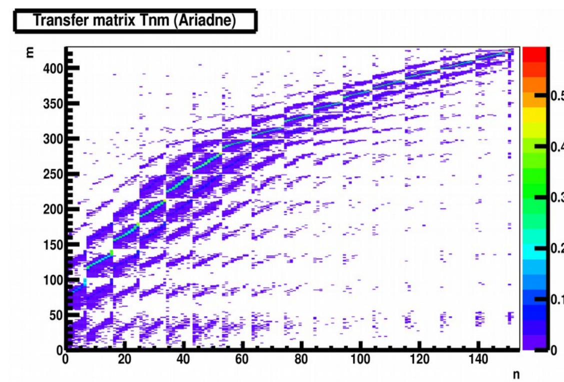


Using Transfer matrix to predict no. of events reconstructed in a given cross section bin

$$N = T\,M$$



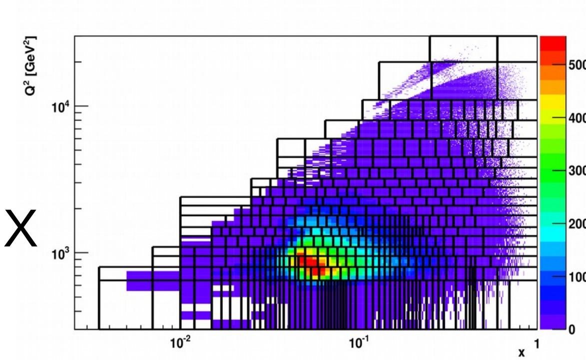
Predicted x-Q2 events in Cross section binning
(153 elements in N Vector = number of cross section bins)



Transfer Matrix

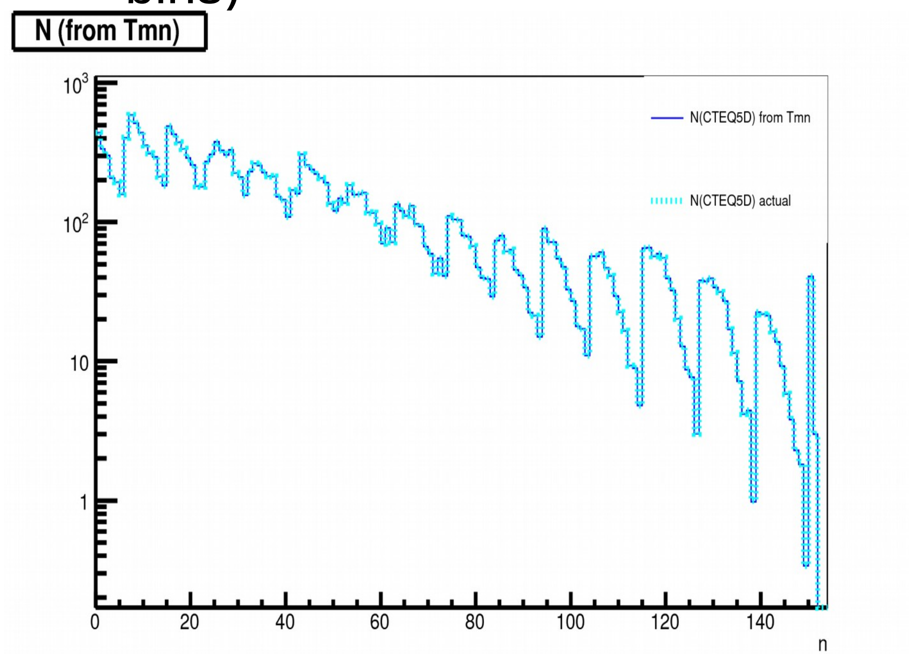
(153 X 429 elements)

X



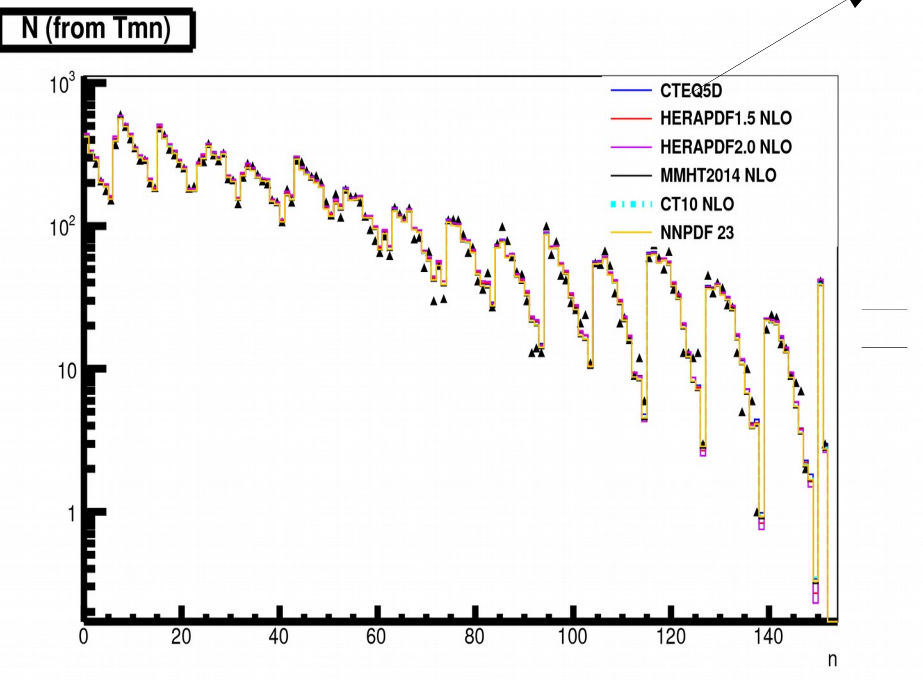
Generated x-Q2 events in Extended binning

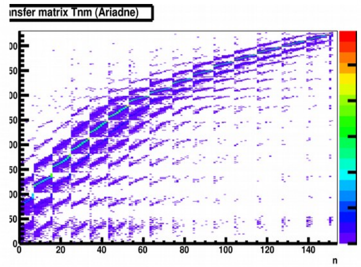
(429 elements in M Vector = number of generated bins)



Using Transfer matrix to predict no. of events reconstructed in a given cross section bin

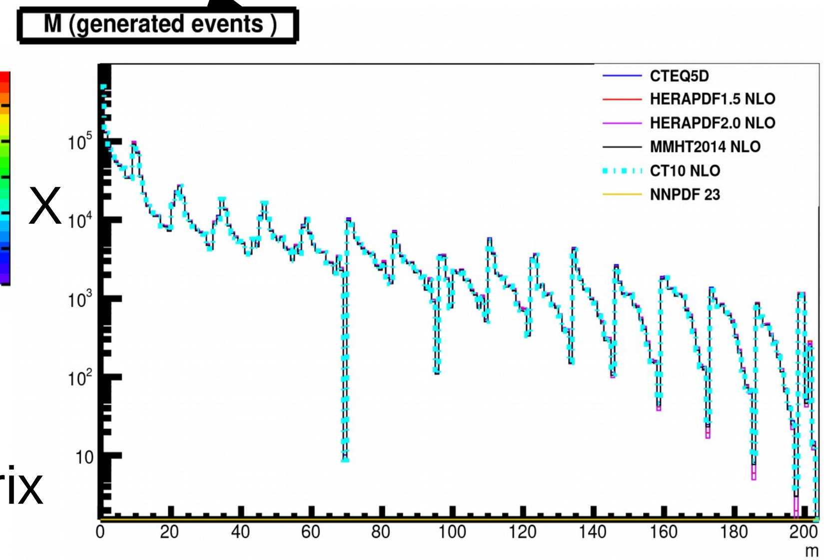
N = AM





Transfer Matrix

X



Predicted x-Q2 events in Cross section binning (for different PDFs)

Generated x-Q2 events in Extended binning (for different PDFs)

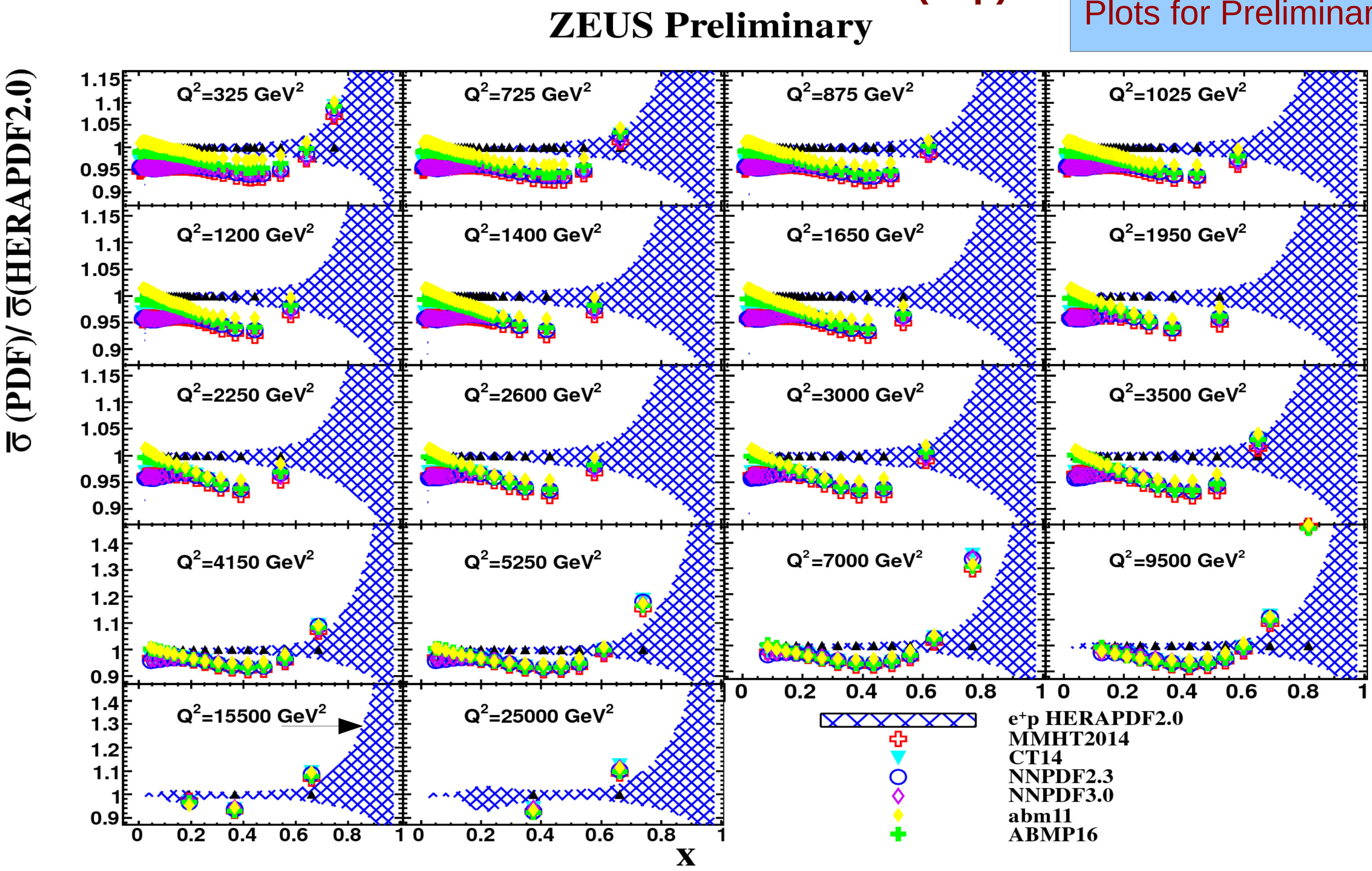
Where for each $(x,Q^2)_i$ true bin

$$\nu_{i,k} = \sum_{m}^{M_i} \frac{d^2\sigma(x,Q^2|M_k)/dxdQ^2}{d^2\sigma(x,Q^2|M_0)/dxdQ^2}\omega_m^{MC}$$

Comparison Shown on next slide

Average ratio of Born level cross sections in different PDFs to HERAPDF2.0NLO for M bins (e+p)

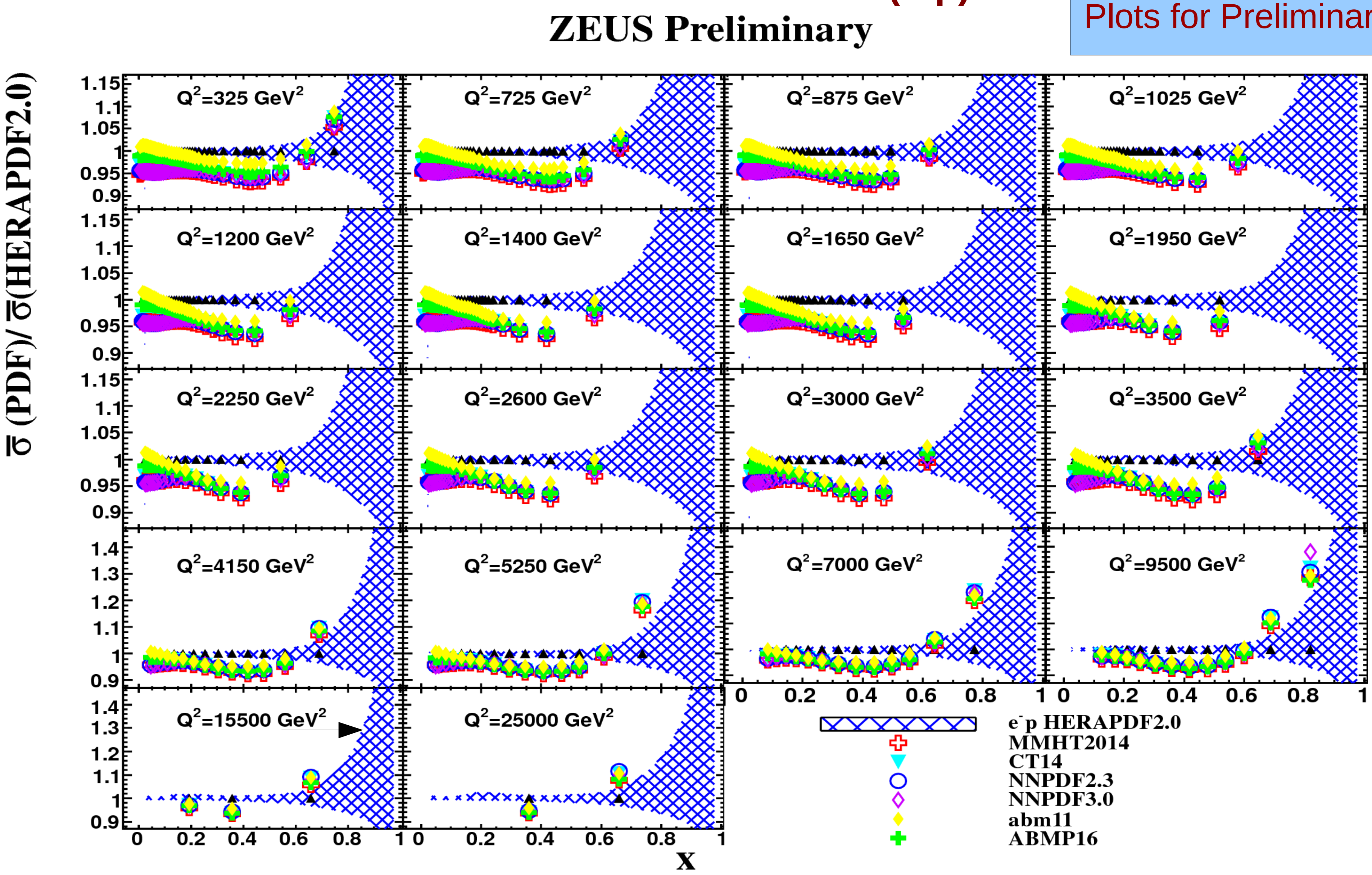
Plots for Preliminary



There is a shape difference between HERAPDF & other PDFs, approaches 10% at x ~ 0.4, well outside PDF uncertainties.

Average ratio of Born level cross sections in different PDFs to HERAPDF2.0NLO for M bins (e-p)

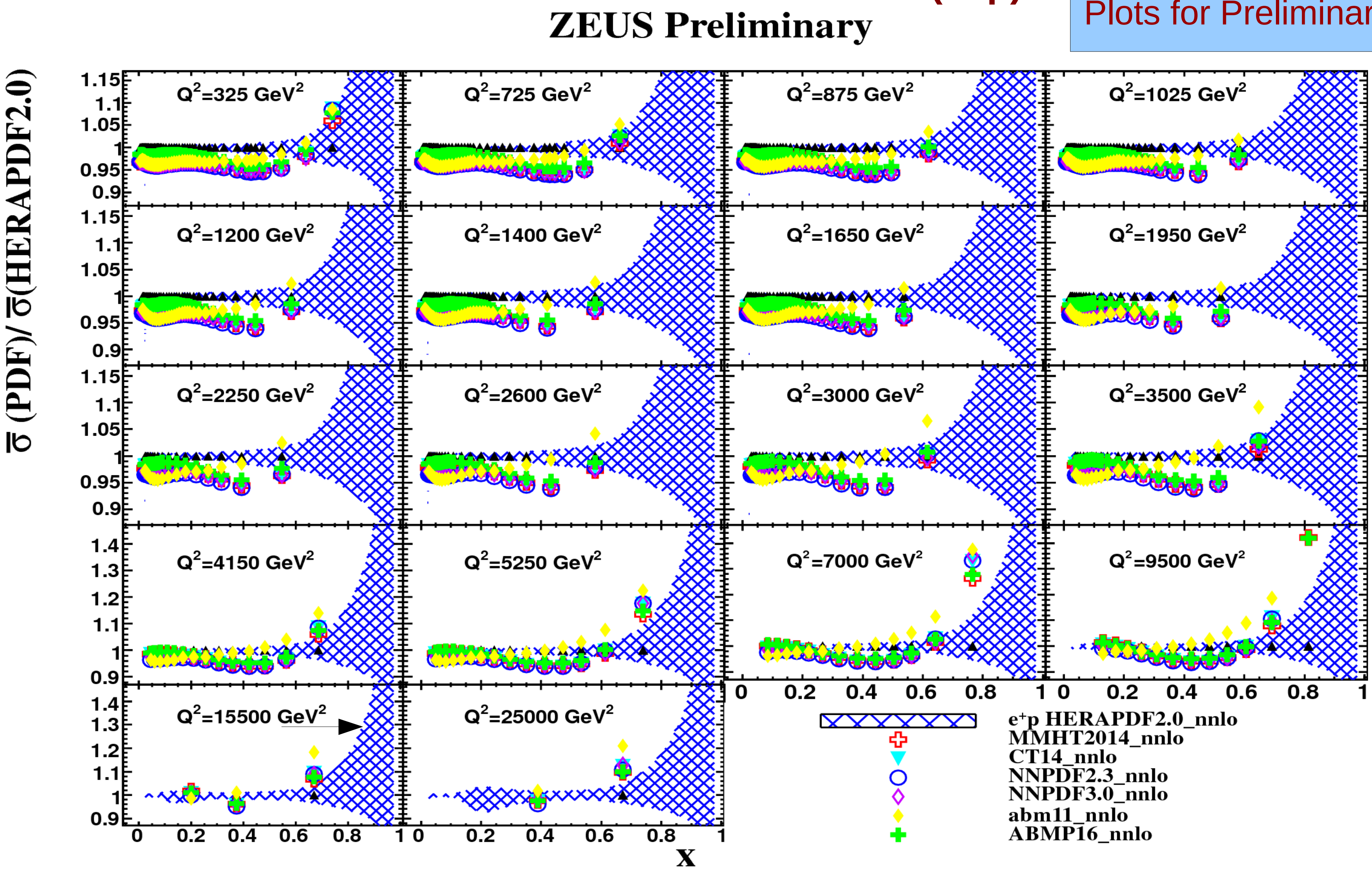
Plots for Preliminary



There is a shape difference between HERAPDF & other PDFs, approaches 10% at x ~ 0.4, well outside PDF uncertainties.

Average ratio of Born level cross sections in different PDFs to HERAPDF2.0NNLO for M bins (e+p)

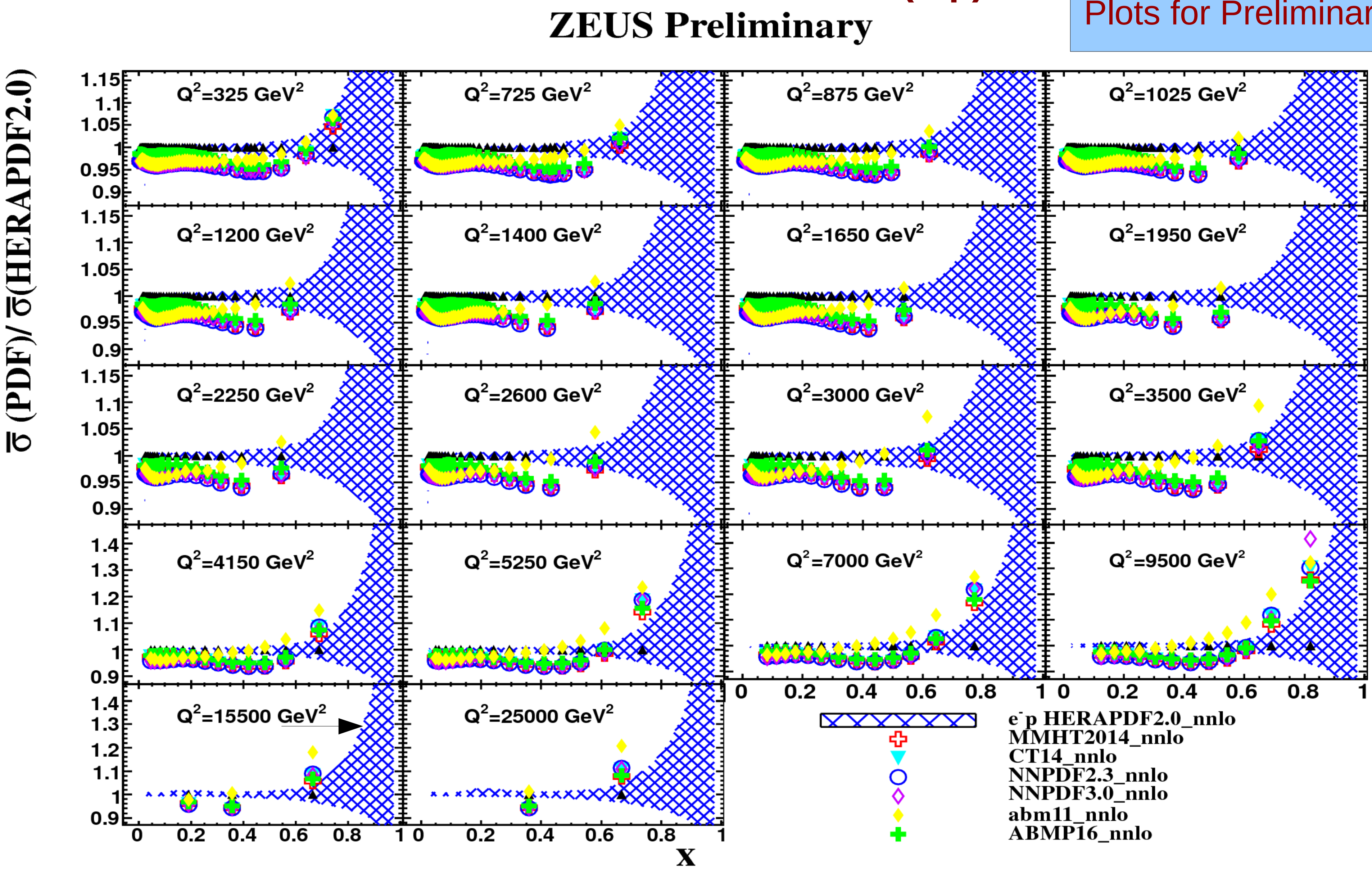
Plots for Preliminary



Differences are smaller with NNLO PDFs than with NLO PDFs!

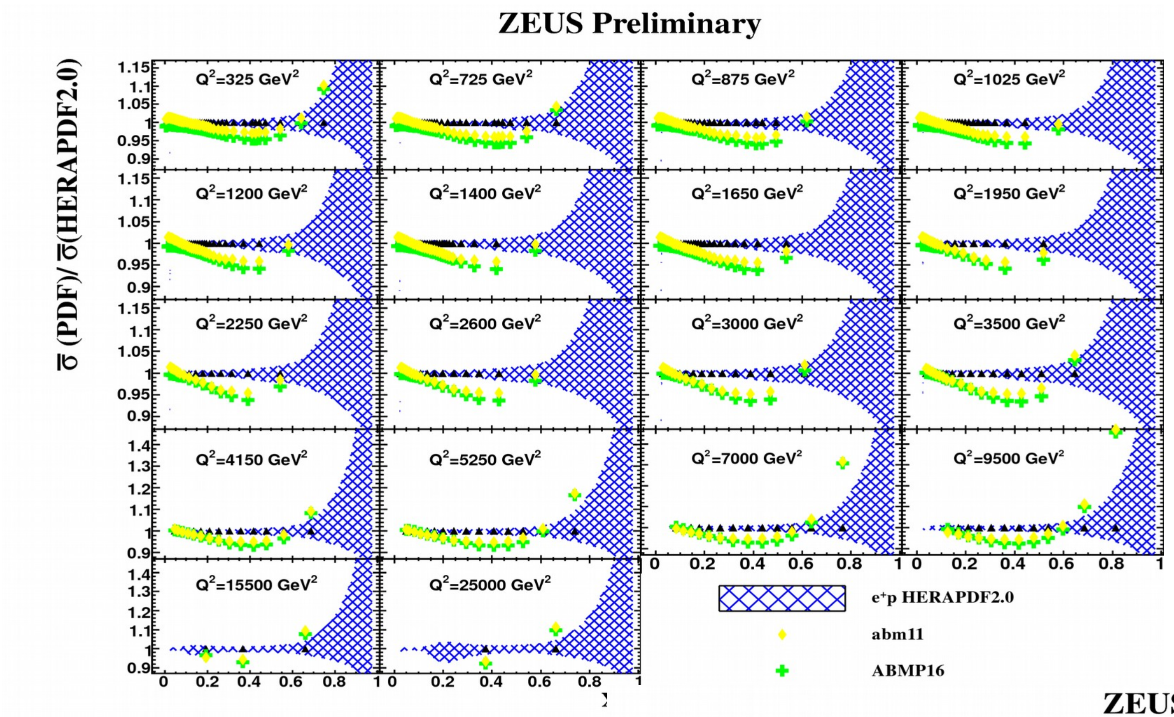
Average ratio of Born level cross sections in different PDFs to HERAPDF2.0NNLO for M bins (e-p)

Plots for Preliminary



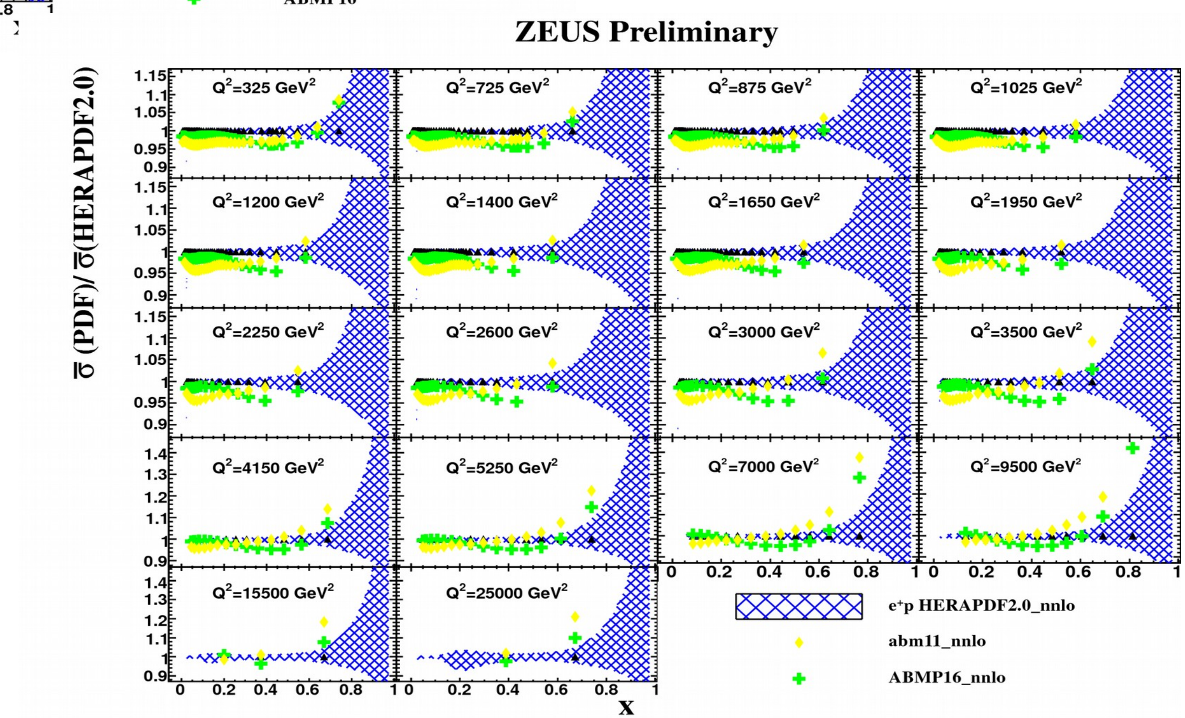
Differences are smaller with NNLO PDFs than with NLO PDFs!

Average ratio of Born level cross sections in ABM PDFs to HERAPDF2.0 for M bins (e+p)

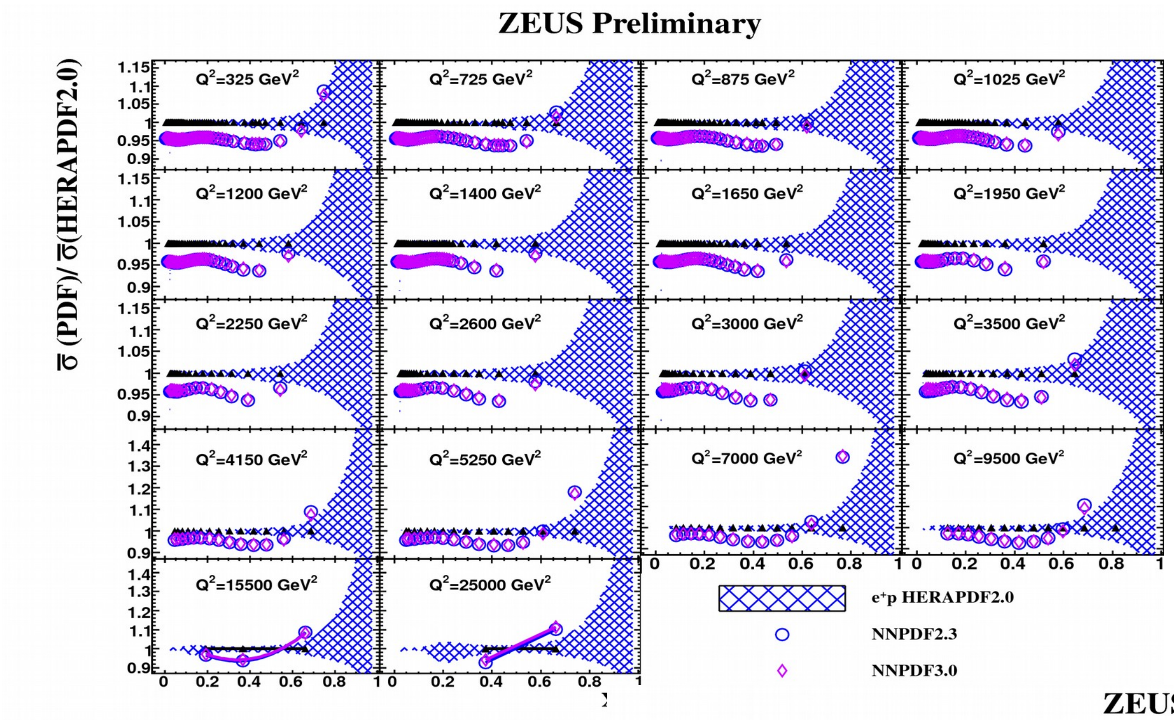


NLO

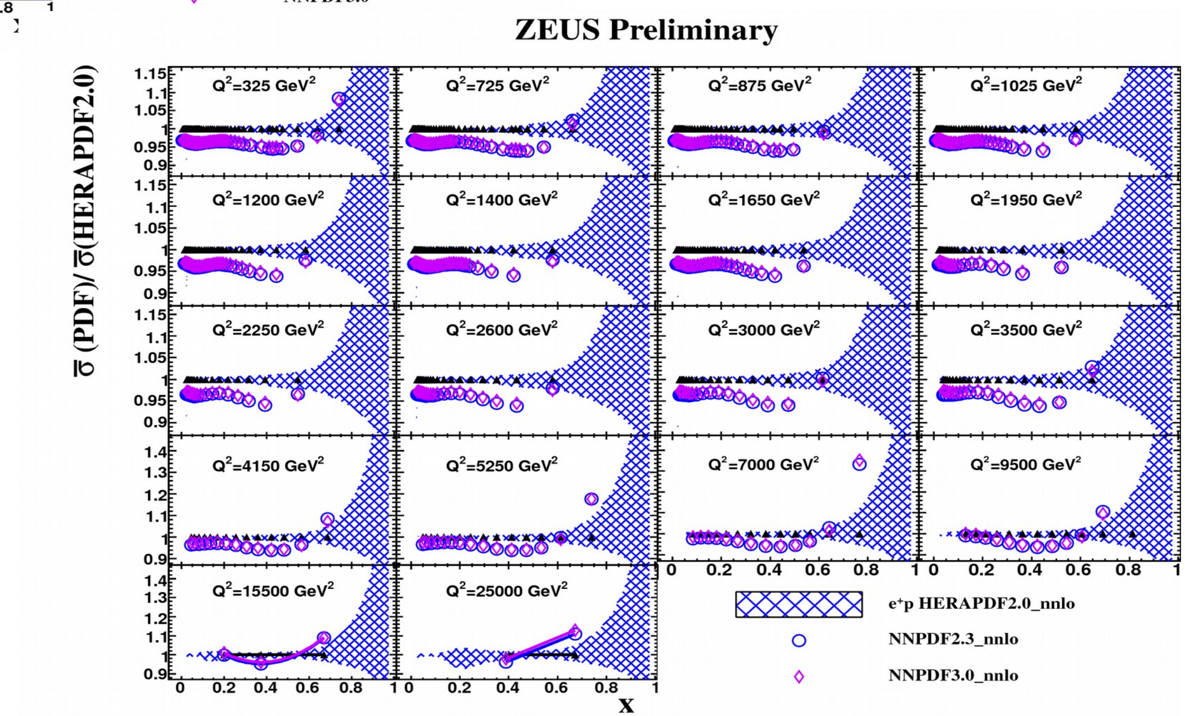
NNLO



Average ratio of Born level cross sections in NNPDF to HERAPDF2.0 for M bins (e+p)



NLO

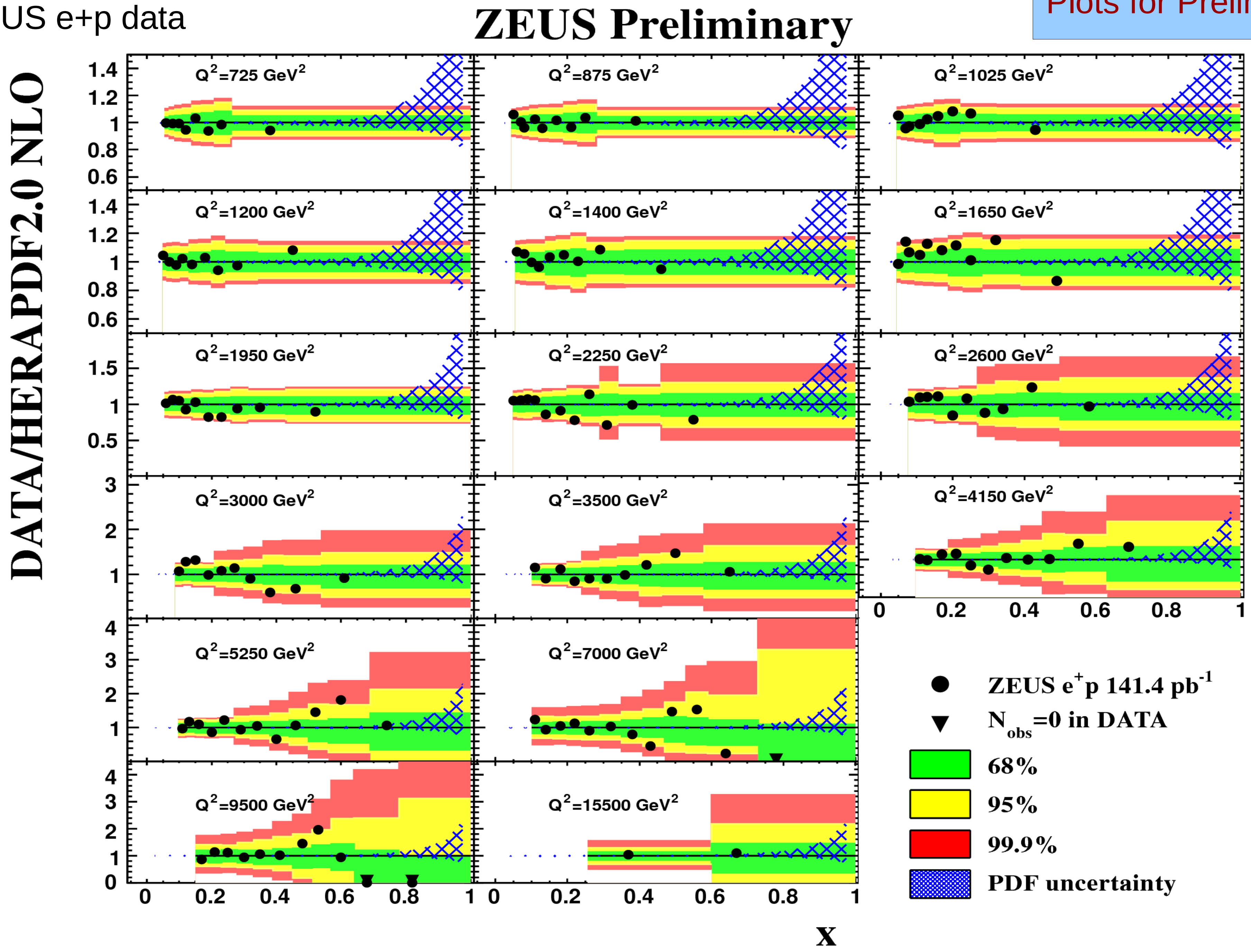


NNLO

Ratio of No. of events in data to HERAPDF2.0 NLO and 1,2,3 sigma bands from Poisson Statistics

Plots for Preliminary

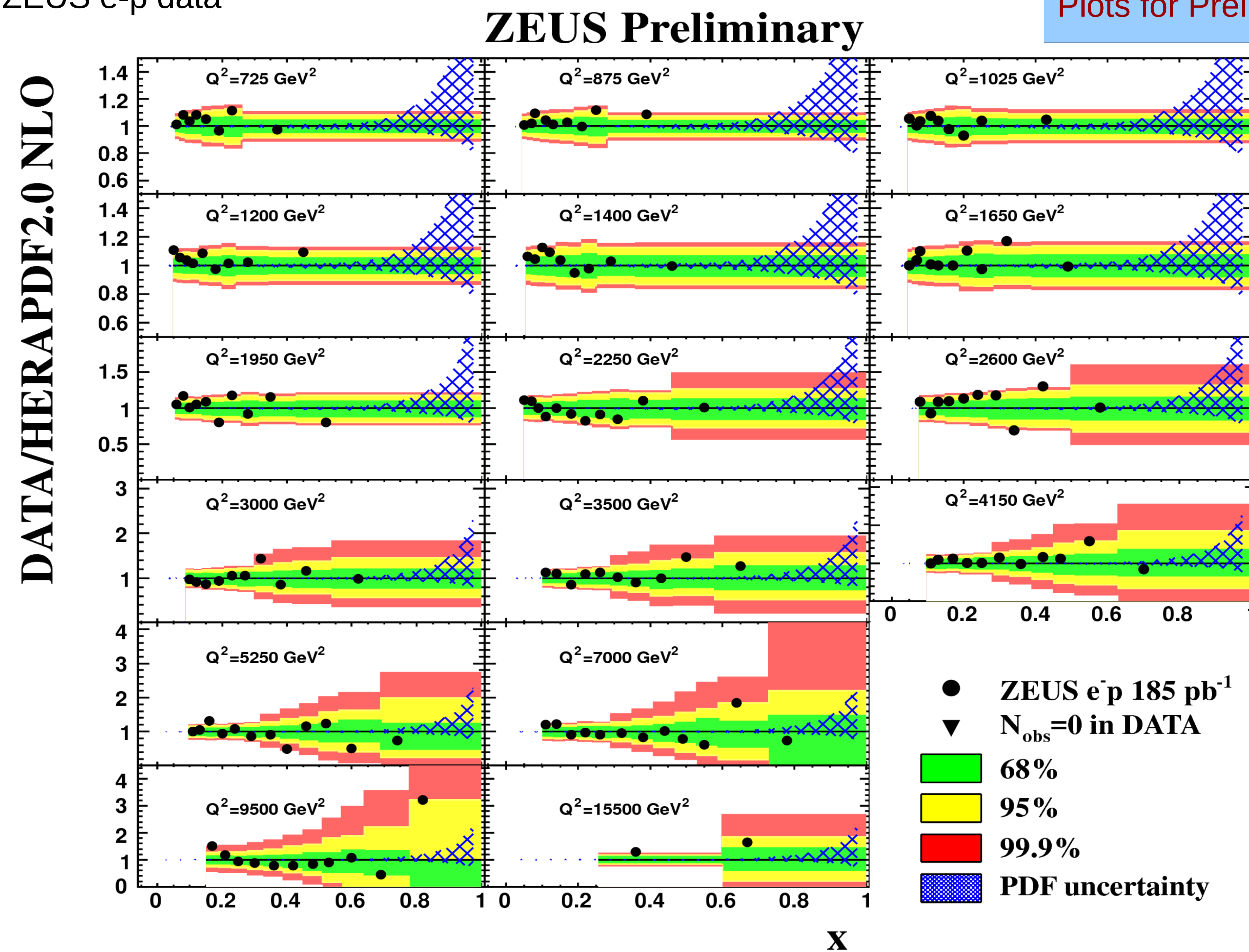
ZEUS e+p data



Ratio of No. of events in data to HERAPDF2.0 NLO and 1,2,3 sigma bands from Poisson Statistics

ZEUS e-p data

Plots for Preliminary



Probability for explaining data from different PDFs

Total probability for each PDF :

$$P(D|M_k) = \prod_j \frac{e^{-\nu_{j,k}} \nu_{j,k}^{n_j}}{n_j!}$$

n_j = events in data in j^{th} bin
k : k^{th} PDF index

Calculating the **relative Probablity wrt. HERAPDF**

Preliminary Request : only p-values from the table

	e^-p			e^+p		
PDF	$\ln P$	p-value	$\Delta\chi^2$	$\ln P$	p-value	$\Delta\chi^2$
CT14	-588.4	$1.6e-03$	19.8	-526	$7.8e-01$	-19.2
HERAPDF2.0	-578.5	$5.5e-02$	0	-535.6	$4.6e-01$	0
MMHT2014	-588.2	$1.9e-03$	19.4	-525.9	$7.9e-01$	-19.4
NNPDF2.3	-598.3	$6.9e-05$	39.6	-528.7	$6.5e-01$	-13.8
NNPDF3.0	-595.4	$2.5e-04$	33.8	-527.7	$7.0e-01$	-15.8
ABMP16	-582.2	$1.5e-02$	7.4	-526.8	$7.8e-01$	-17.6
abm11	-593	$1.0e-03$	29	-532.2	$5.7e-01$	-6.8

TABLE 1. The results from comparisons of predictions (at NLO) using different PDF sets to the observed numbers of events. The log of the probability, the corresponding p-value, and the effective χ^2 difference relative to the HERAPDF2.0 result are given. The results are shown separately for the e^-p and e^+p data sets. The results are for the full Bjorken-x range

Eg. of P-value determination

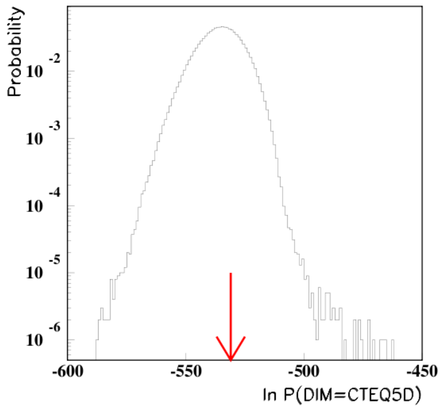


FIGURE 4. Distribution of expected values for $\ln P(D|M = CTEQ)$ for the e^+p data set. The arrow shows the value found in the data.

P-value is calculated by integrating out the probability from the left edge till red for the given PDF

Equivalent Delta chi2 determination

$$\Delta\chi^2_{k,l} = -2\ln\frac{P(D|M_k)}{P(D|M_l)} = -2\left(\sum_j \nu_{j,l} - \nu_{j,k} + n_j \cdot \ln\frac{\nu_{j,k}}{\nu_{j,l}}\right)$$

MMHT2014, CT14nlo, NNPDF2.3, ABM better than HERAPDF2.0 for e^+P, much worse for e^-P.

Comparing Total Probability for different Pdfs in different x range

Preliminary Request : only p-values from the table as below

	e^-p				e^+p			
	$x < 0.6$		$x \geq 0.6$		$x < 0.6$		$x \geq 0.6$	
PDF	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value
CT14	-530.3	$8.2e-04$	-62.02	$1.9e-01$	-471.3	$7.4e-01$	-55.22	$5.8e-01$
HERAPDF2.0	-517.9	$5.9e-02$	-61.37	$2.3e-01$	-477.2	$5.9e-01$	-60.16	$1.1e-01$
MMHT2014	-538.1	$3.0e-05$	-62.81	$1.2e-01$	-472.9	$6.5e-01$	-54.86	$6.0e-01$
NNPDF2.3	-536.3	$6.6e-05$	-61.92	$1.8e-01$	-473.2	$6.4e-01$	-55.28	$5.6e-01$
NNPDF3.0	-536.3	$2.6e-05$	-61.8	$1.9e-01$	-472.9	$6.5e-01$	-55.32	$5.6e-01$
ABMP16	-522	$1.3e-02$	-61.6	$2.1e-01$	-471.1	$7.6e-01$	-55.56	$5.4e-01$
abm11	-519	$3.1e-02$	-60.89	$2.8e-01$	-473.9	$6.8e-01$	-56.69	$4.0e-01$

TABLE 2. The results from comparisons of predictions using different PDF sets (at NLO) to the observed numbers of events. The log of the probability is given for two different x ranges for the e^+p and e^-p data sets.

At high x MMHT, CT, NNPDF ABM better for e+P data. disagreement comes primarily from lower x in e-p

Statistical and systematic uncertainties

Type of Systematic Uncertainties :

1) Affecting the predictions at generator level (M values)
2) Affecting the Transfer Matrix T

Type I :
1) Luminosity uncertainty scaling M values

Type II :
1) MC statitical fluctuations (uncorrelated uncertainty)
2) All correlated and uncorrelated systematic uncertainties as in high-x paper
3) Choice of PDF for building T

Have been studied in detail, but we don’t want the numbers/plots from these (coming in the following slides) as preliminary

Nomalization Error : Vary M by 1.8 % up and down and calculate ln P.

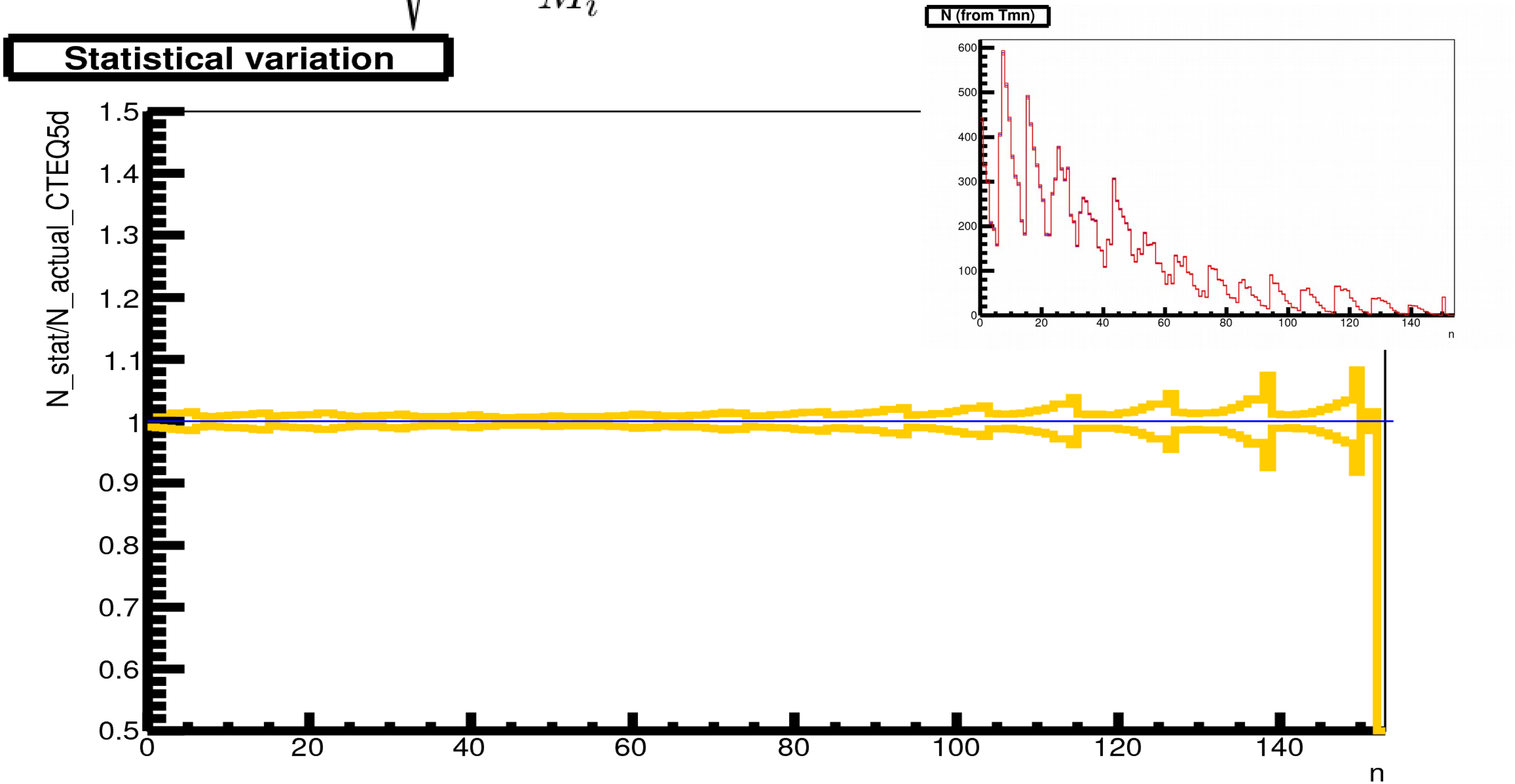
+1.8 %								
	e^-p				e^+p			
	$x < 0.6$		$x \geq 0.6$		$x < 0.6$		$x \geq 0.6$	
PDF	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value
CT14	-520.2	$2.4e-02$	-60.95	$2.9e-01$	-470.8	$8.1e-01$	-56.36	$4.6e-01$
HERAPDF2.0	-523.8	$1.9e-02$	-62.72	$1.4e-01$	-488.2	$1.8e-01$	-63.15	$2.7e-02$
MMHT2014	-524.3	$7.6e-03$	-61.36	$2.3e-01$	-470	$8.2e-01$	-55.72	$5.1e-01$
NNPDF2.3	-523.2	$9.5e-03$	-60.92	$2.8e-01$	-470.4	$8.1e-01$	-56.47	$4.3e-01$
NNPDF3.0	-523.4	$7.8e-03$	-60.83	$3.0e-01$	-470.4	$8.1e-01$	-56.55	$4.3e-01$
ABMP16	-518.3	$4.0e-02$	-60.83	$3.0e-01$	-475.7	$6.1e-01$	-56.94	$3.8e-01$
abm11	-520.4	$3.0e-02$	-60.82	$3.1e-01$	-481.5	$3.6e-01$	-58.58	$2.2e-01$
−1.8 %								
	e^-p				e^+p			
	$x < 0.6$		$x \geq 0.6$		$x < 0.6$		$x \geq 0.6$	
PDF	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value	$\ln P$	p-value
CT14	-548	$0.0e+00$	-63.89	$7.8e-02$	-477.4	$3.9e-01$	-54.68	$6.3e-01$
HERAPDF2.0	-520	$2.8e-02$	-60.85	$2.6e-01$	-472	$7.7e-01$	-57.8	$2.5e-01$
MMHT2014	-559.5	$0.0e+00$	-65.04	$3.7e-02$	-481.2	$2.2e-01$	-54.59	$6.1e-01$
NNPDF2.3	-556.8	$0.0e+00$	-63.72	$7.8e-02$	-481.5	$2.2e-01$	-54.7	$6.1e-01$
NNPDF3.0	-556.9	$0.0e+00$	-63.57	$8.4e-02$	-480.9	$2.3e-01$	-54.71	$6.2e-01$
ABMP16	-533.4	$2.6e-04$	-63.18	$1.0e-01$	-472.1	$6.7e-01$	-54.78	$6.1e-01$
abm11	-525.5	$3.9e-03$	-61.77	$1.9e-01$	-471.9	$7.1e-01$	-55.41	$5.4e-01$

TABLE 5. The results from comparisons of predictions using different PDF sets increased by 1.8 % (top) and decreased by 1.8 % (bottom) to the observed numbers of events. The log of the probability is given for two different x ranges for the e^-p and e^+p data sets.

Statistical Error : Error in element aij of the Transfer Matrix

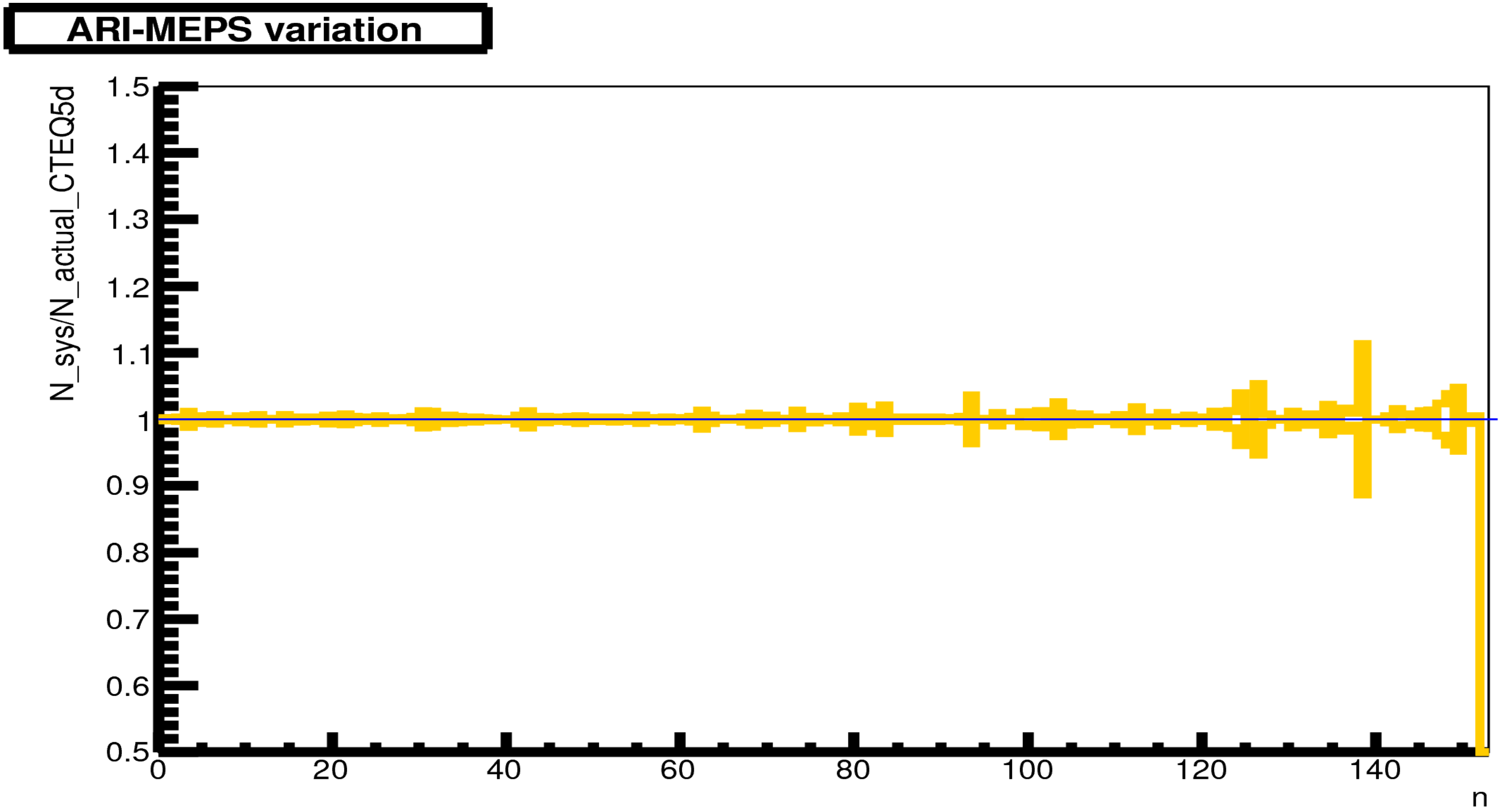
$$\delta a_{ij}^{\text{stat}} = \sqrt{\frac{a_{ij}(1-a_{ij})}{M_i}}$$

Where Mi are the total number of events Generated in MC



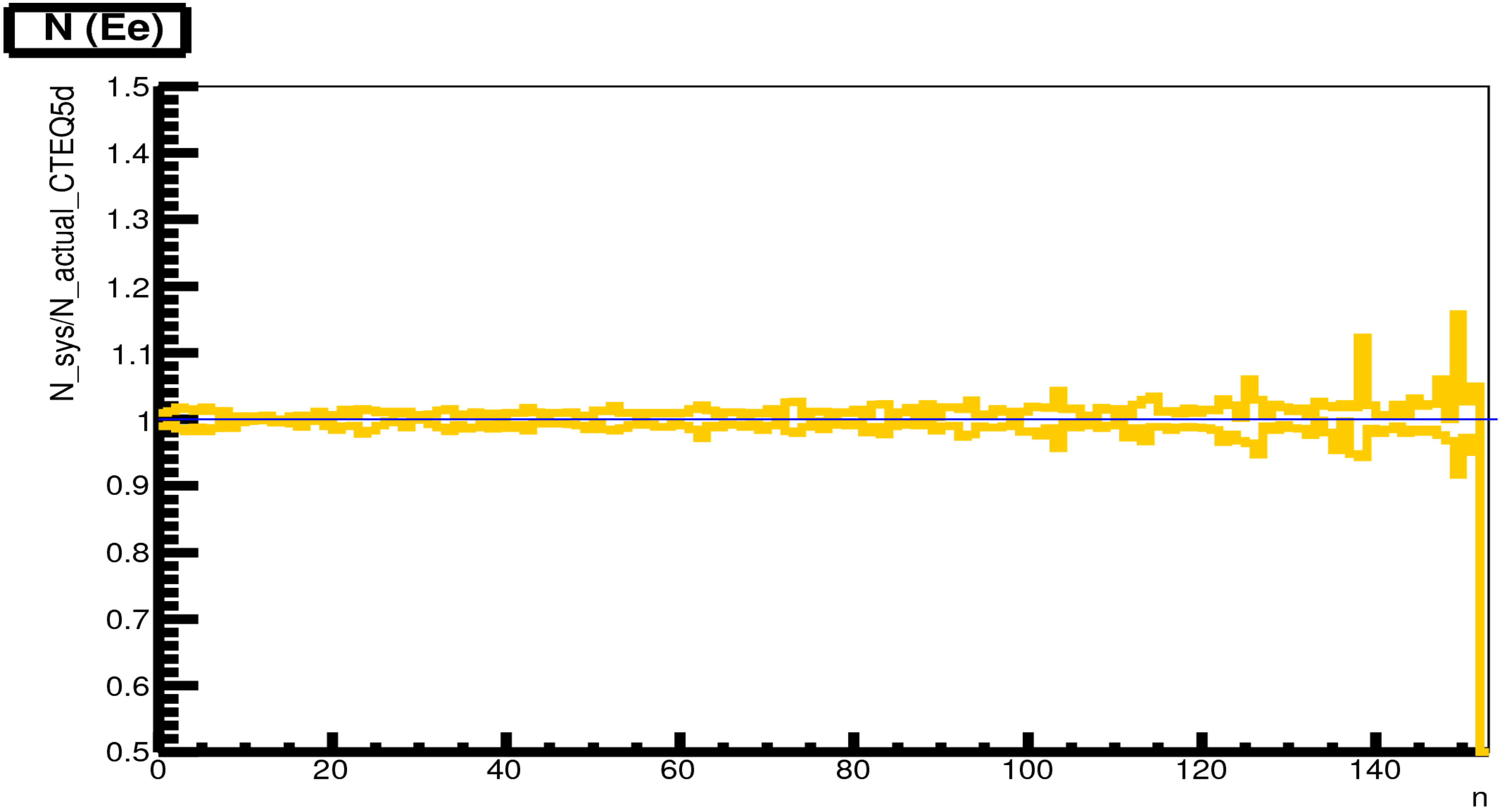
For most of the bins with in 1%, increases to 6-10% in the highest x-bins at high Q2.

Ariadne-MEPS variation: The ARI-MEPS combination is varied in construction of Transfer Matrix.



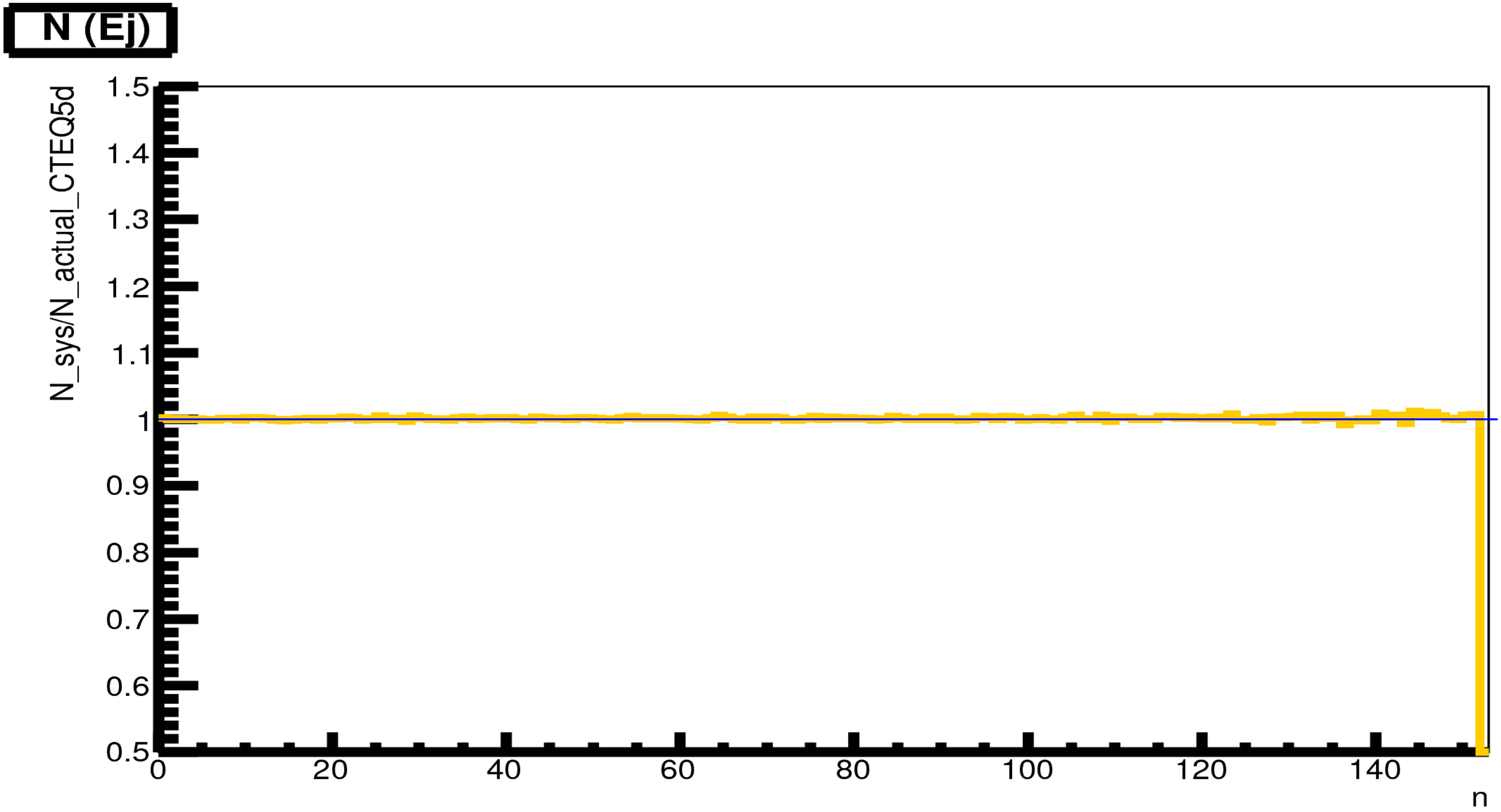
For most of the bins with in 1%, increases to 2-10% in the highest x-bins at high Q2.

Other Systematic Variation : Ee varied up and down and new Transfer Matrix constructed .



For most of the bins with in 1%, increases to 2-12% in the highest x-bins at high Q2.

Other Systematic Variation : Ejet varied up and down and new Transfer Matrix constructed .



Negligible

Major Systematic Errors : New a_ij according to systematic variation up and down.

	e^+p		e^-p	
Systematic	$\ln P$ up : down	p-value up : down	$\ln P$ up : down	p-value up : down
Electron energy scale	$-533.4 : -531.6$	$0.62 : 0.60$	$-576.7 : -579.3$	$0.09 : 0.03$
Electron energy resolution	$-530.5 : -532.7$	$0.68 : 0.65$	$-578.6 : -576.3$	$0.05 : 0.09$
Electron isolation cut	$-532.7 : -528.9$	$0.61 : 0.74$	$-576.5 : -580.7$	$0.08 : 0.02$
Hadronic energy scale	$-531.4 : -531.2$	$0.66 : 0.67$	$-577.3 : -576.8$	$0.068 : 0.072$
FCAL alignment	$-530.8 : -531.5$	$0.69 : 0.66$	$-576.7 : -576.9$	$0.085 : 0.075$
F-BCal Crack cut	$-531.1 : -531.2$	$0.68 : 0.69$	$-575.2 : -578.5$	$0.052 : 0.108$
MEPS/Ariadne reweighting	$-530.8 : -532.0$	$0.69 : 0.64$	$-576.0 : -578.7$	$0.083 : 0.059$

TABLE 5. The log of the probability and the p-value for various systematic checks performed for the e^+p and e^-p data sets.

Nomial value for comparison	e^+p			e^-p		
PDF	$\ln P$	p-value	$\Delta\chi^2$	$\ln P$	p-value	$\Delta\chi^2$
CTEQ5D	-531.2	0.68	0	-577.0	0.079	0

Systematic Errors : Considering various vectors for HERAPDF2.0

	e^-p		e^+p	
Eigen Vector	$\ln P$	p-value	$\ln P$	p-value
0	−580.2	0.04	−538.9	0.34
1	−580.2	0.03	−539.2	0.32
2	−580.2	0.03	−538.6	0.35
3	−580.0	0.04	−538.0	0.37
4	−580.4	0.03	−539.8	0.30
5	−579.8	0.04	−538.0	0.37
6	−580.7	0.03	−539.9	0.30
7	−580.3	0.03	−538.5	0.34
8	−580.2	0.04	−539.4	0.32
9	−580.8	0.03	−540.7	0.28
10	−579.7	0.04	−537.3	0.37
11	−580.6	0.03	−540.0	0.30
12	−579.9	0.03	−537.9	0.36
13	−580.5	0.03	−539.6	0.31
14	−580.0	0.03	−538.3	0.34
15	−580.0	0.04	−538.4	0.36
16	−580.4	0.04	−539.4	0.32
17	−580.0	0.04	−538.7	0.34
18	−580.4	0.03	−539.3	0.31
19	−579.9	0.04	−538.0	0.36
20	−580.5	0.03	−539.8	0.31
21	−580.8	0.04	−540.5	0.28
22	−579.9	0.04	−537.9	0.36
23	−580.2	0.03	−538.6	0.34
24	−580.5	0.03	−539.9	0.29
25	−579.7	0.04	−538.3	0.35
26	−580.4	0.03	−538.8	0.33
27	−579.7	0.03	−536.8	0.39
28	−580.6	0.03	−540.0	0.30

Variance Vector	$\ln P$	p-value	$\ln P$	p-value
1	−580.1	0.03	−538.8	0.33
2	−580.3	0.03	−539.0	0.33
3	−580.1	0.04	−538.8	0.34
4	−580.2	0.04	−539.0	0.33
5	−580.3	0.04	−539.5	0.32
6	−579.9	0.04	−538.0	0.36
7	−580.2	0.03	−539.0	0.32
8	−580.2	0.04	−538.9	0.34
9	−580.1	0.04	−538.8	0.35
10	−580.3	0.03	−539.1	0.31
11	−580.2	0.04	−538.9	0.34
12	−580.2	0.03	−539.1	0.32
13	−579.4	0.04	−537.3	0.38

TABLE 3. The results from the different variants in HERAPDF2.0 NLo. The log of the probability and respective p-values are given for the e^-p and e^+p data sets. The $\mathbf{M}$ values for different variants are calculated at the bin-average and not using ?? Equation given in slide 8

Results

1)Technique of building Transfer Matrix Shown.

2) Transfer Matrix can be used to predict number of events in the given cross section bins in MC.

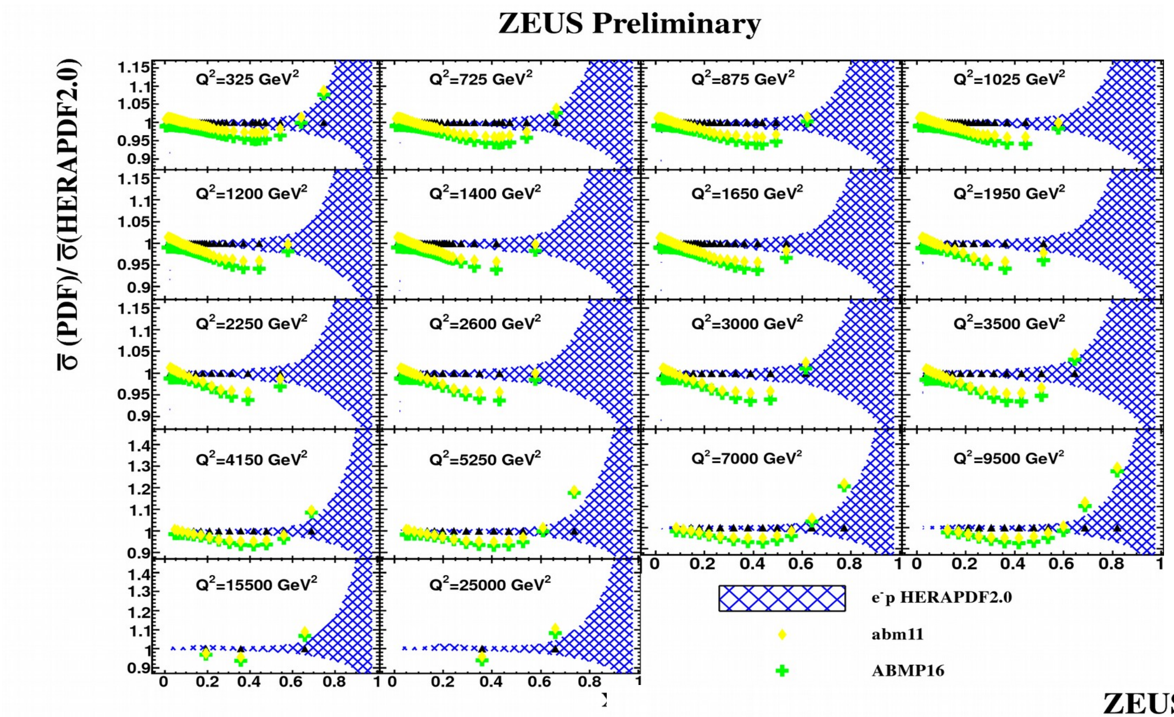
3) Transfer Matrix can be used to compare number of events reconstructed by different PDFs.

4) A comparison of different PDFs can be done on the basis of best explanation to the high-x data using Transfer Matrix.

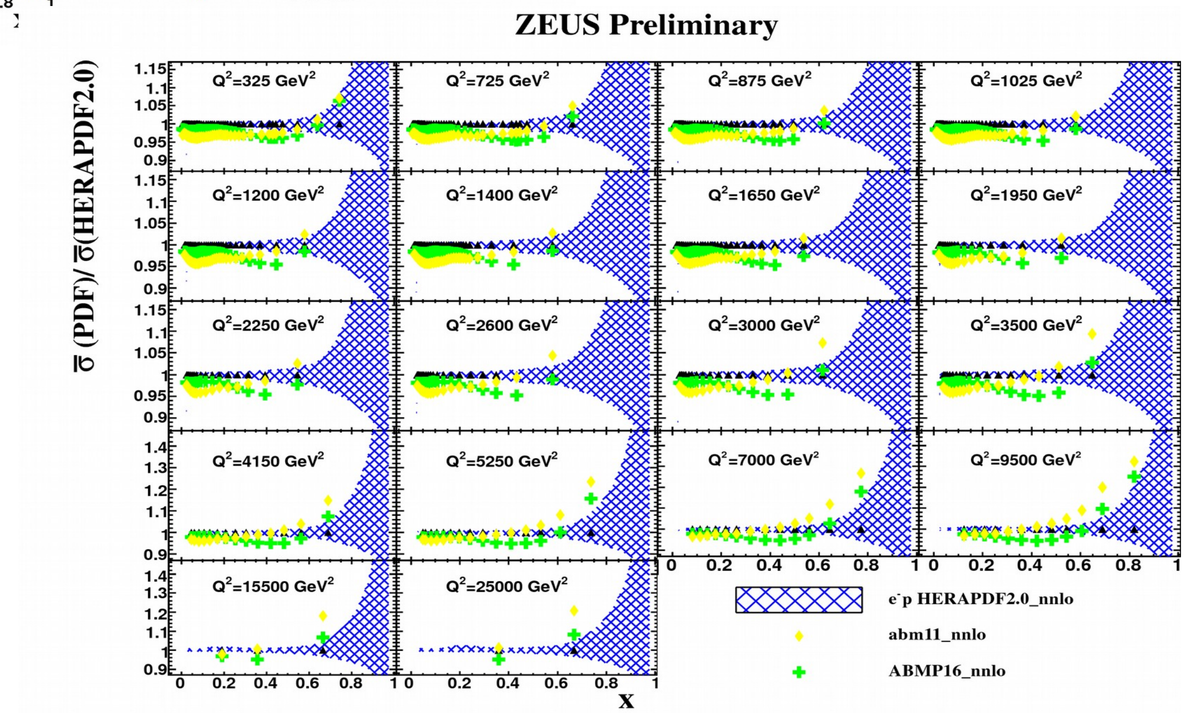
5)Statistical, normalization and systemtic errors in a_ij checked Normalization uncertainty is the dominant one.

Back Up
(some Old slides)

Average ratio of Born level cross sections in ABM PDFs to HERAPDF2.0 for M bins (e-p)



NLO



NNLO

Prescription of model fitting to high-x data

Probability of observing Data with given set of PDF parameters θ and nuisance parameters λ:

$$P(D|\theta,\lambda) = \prod_j P(n_j|\nu_j(\theta,\lambda))$$

Predicted number of events ν_j is given as :

$$\nu_j = \sum_i \nu_i (1 + 0.018\cdot\lambda_0) a_{ij} (1 + \sum_{k=1} \lambda_k \delta_{ij}^k)$$

δ's : one standard deviation due to k correlated systematic sourses
λo : modification in normalization in units of standard deviatiom
λk : shifts in the systematic errors

Where a penalty is added to the loglikelihood function: $\mathcal{L}(\theta,\lambda) = P(n_j|\nu_j(\theta,\lambda))P(\lambda)$

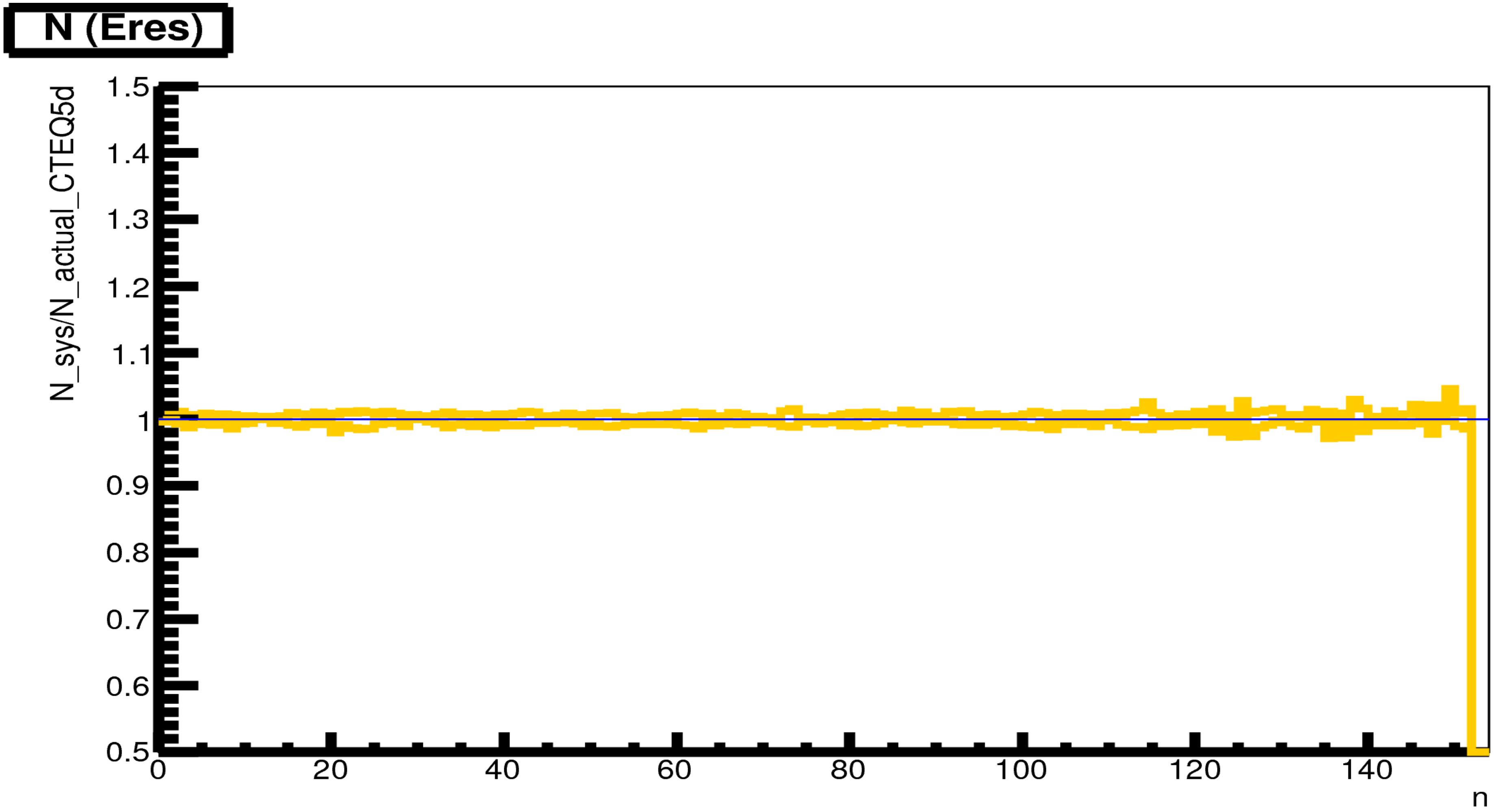
where the $P(\lambda)$ is a product of Gauss distributions:

$$P(\lambda) = \prod_{k=0} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\lambda_k^2}$$

Uncorrelated uncertainties can be taken into account by folding a Gauss distribution for them with the Poisson distribution :

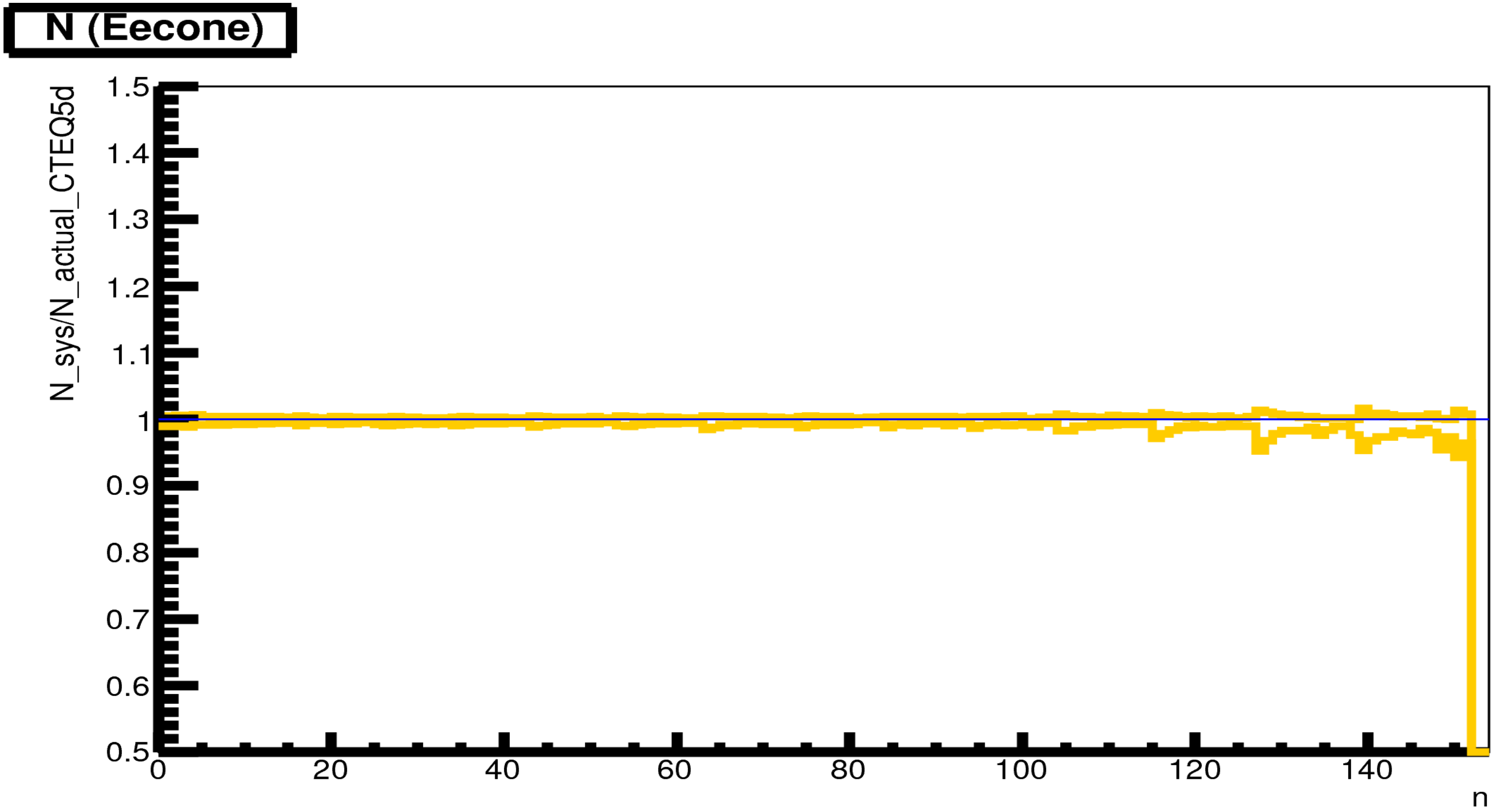
$$P(n_j|\nu_j) = \int \frac{e^{-\nu_j(1+\epsilon_j)}(\nu_j(1+\epsilon_j))^{n_j}}{n_j!} \frac{1}{\sqrt{2\pi}\delta_j} e^{-\frac{1}{2}(\frac{\epsilon_j}{\delta_j})^2} d\epsilon_j$$

Other Uncorr Systematic Variation : Eres varied up and down and new Transfer Matrix constructed .



For most of the bins with in 1%, increases to 2-3% in the bins at high Q2.

Other Uncorr Systematic Variation : Econe varied up and down and new Transfer Matrix constructed .



For most of the bins with in 1%, increases to 2-5% in the bins at high Q2.

Data & MC sample:

04-06 e-p data (185 pb -1) & 06/07 e+p data (141.44 pb^{-1})

DJANGOH 1.6, Ariadne 4.12, CTEQ-5D MCs (Standard Orange)

Selection:

Vertex:

Valid vertex && |Zvtx| < 50. cm

Electron:

EM finder

e- candidate with Ee>15GeV

EmProb >0.001 (θ_e>0.3) else EmProb > 0.01

Econe (w/o e+) < 4.0 GeV

QEDC rejection

Fiducial volume cuts:

BCAL+FCAL e-s

no cracks, no RCAL

|DME| > 1.4 cm && | DCE| > 0.6 cm

In CTD Acceptance

DCA < 10 cm

Superlayers > 4

TrkP > 5. GeV

Not in Acc. Of CTD

Pt elec > 30. GeV

Trigger selection:

DST 14

Kinematics:

40<Empz<65

Pt/SqrtEt < 5 GeV

y_el < 0.80

Jets

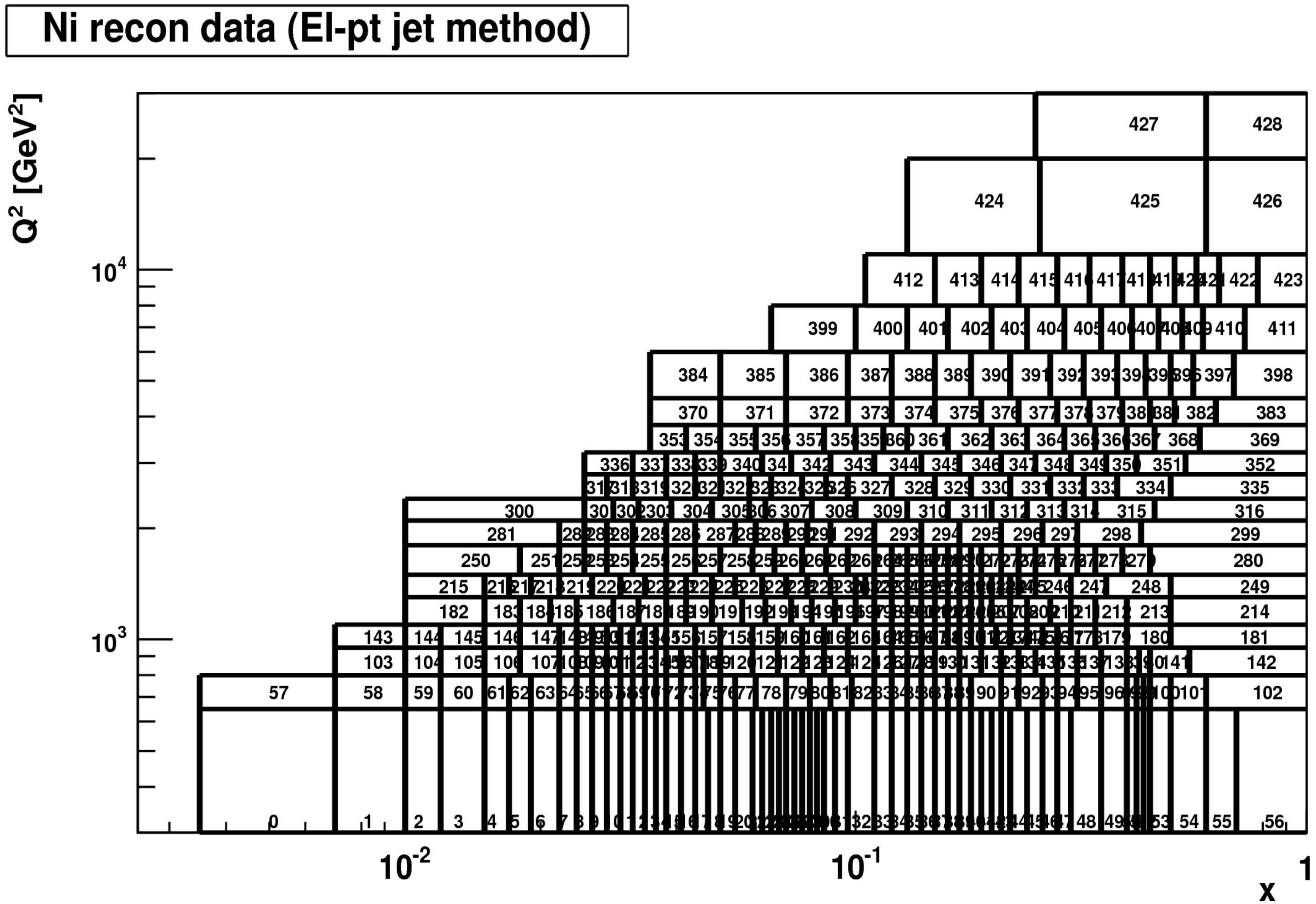
1,2,3(<4) jet events

Box cut (40.40 cm^2)

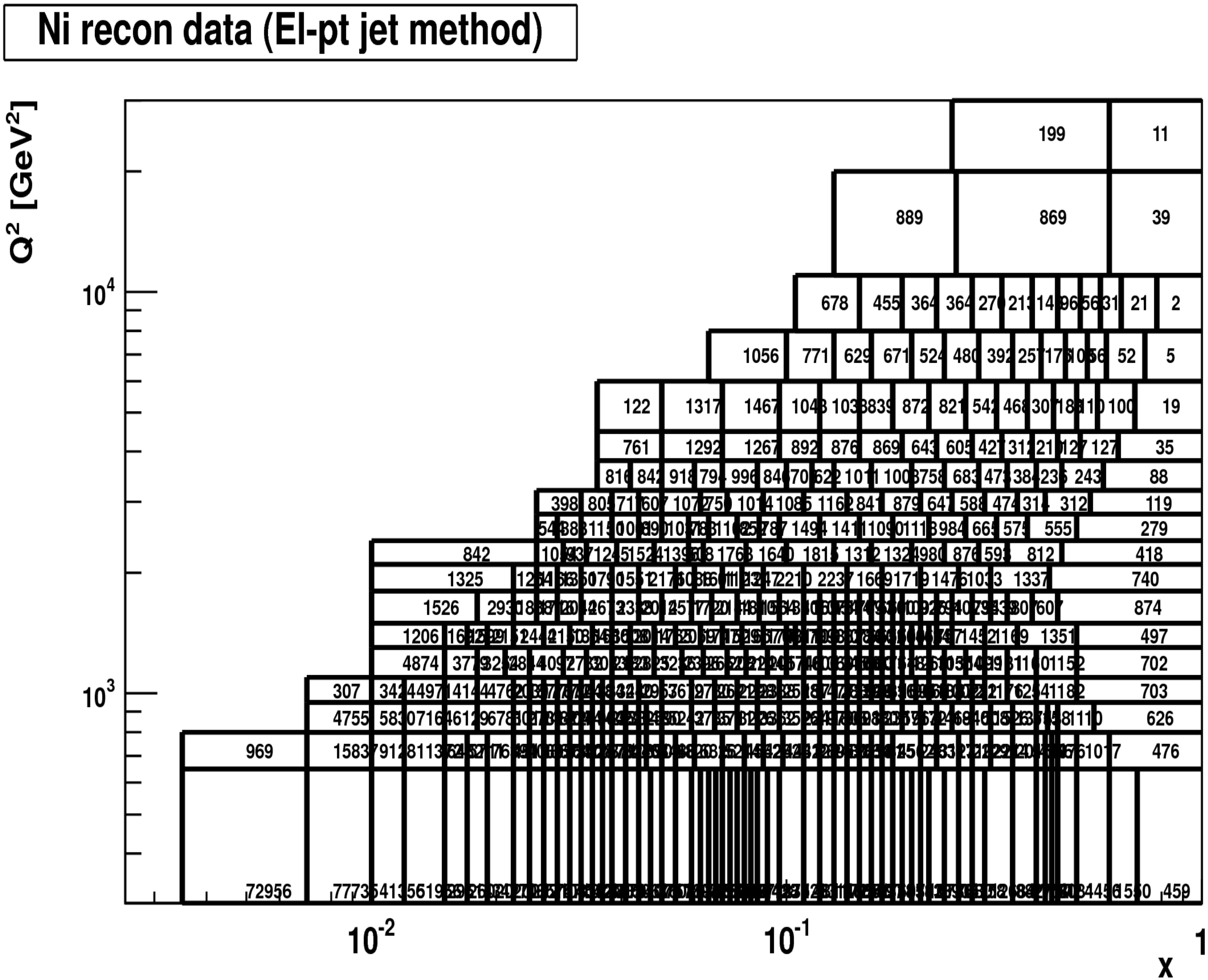
Et (all jets) > 10 GeV

0 jet events (including events rejected in box cut & Et cut) to be assigned to highest x-bin.

extended binning Bin number (total 429 bins)



extended binning generated events (sum of weights)



Why do we study in Probability numbers

What types of probabilities do we expect ?

E.g., imagine you expect 1 event, and measure 1, then the probability is

$$P(n|\nu) = e^{-\nu}\frac{\nu^n}{n!} = e^{-1} \approx 0.37$$

E.g., imagine you expect 10 events, and measure 8, then the probability is

$$P(n|\nu) = e^{-\nu}\frac{\nu^n}{n!} = e^{-10}\frac{10^8}{8!} \approx 0.11$$

E.g., imagine you expect 100 events, and measure 90, then the probability is

$$P(n|\nu) = e^{-\nu}\frac{\nu^n}{n!} = e^{-100}\frac{100^{90}}{90!} \approx 0.02$$

If we have 150 bins with probabilities ranging from a few % to few 10 %, then

$$P(\{n\}|\{\nu\}) = \prod_{i=1}^{150} e^{-\nu_i}\frac{\nu_i^{n_i}}{n_i!} \text{ maybe } 10^{-200} \quad \ln P \approx -500$$

Slide from Allen

Why do we study in Probability numbers

If the likelihood (product of the data probabilities) is a product of Gaussian distributions, then we have

$$\mathcal{L} \propto e^{-\chi^2/2}$$ and $$\ln \mathcal{L}_1 - \ln \mathcal{L}_2 = \frac{1}{2}(\chi_2^2 - \chi_1^2)$$

So we can translate differences in the ln of the probabilities (multiplied by -2) to equivalent chi squared differences

If we look at ratios of probabilities, and again assuming Gaussian distributions, then

$$\frac{P_1}{P_2} = e^{-(\chi_1^2 - \chi_2^2)/2}$$

so taking -2* the natural logarithm of a probability ratio is again equivalent to a chi squared difference

Slide from Allen

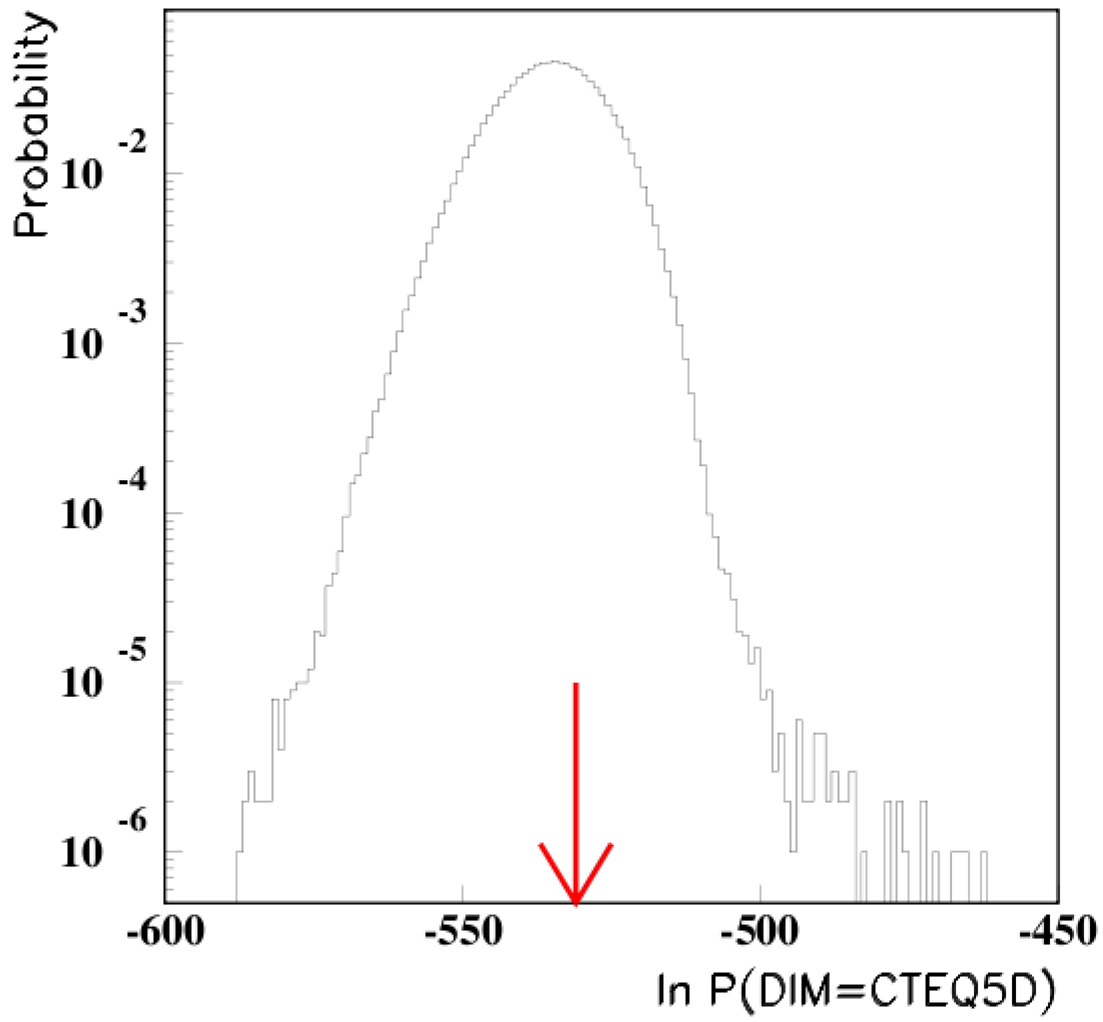
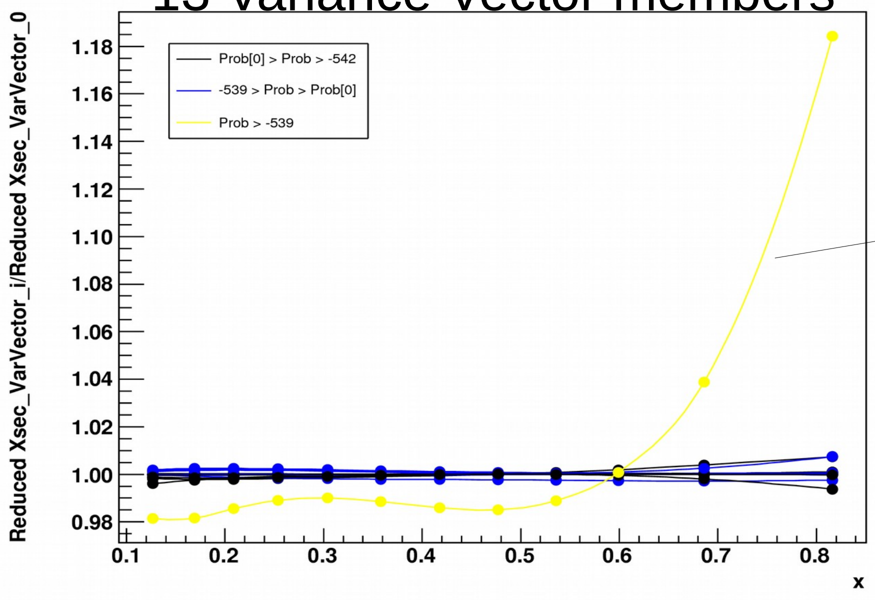


FIGURE 4. Distribution of expected values for $\ln P(D|M = CTEQ)$ for the e^+p data set. The arrow shows the value found in the data.

Study II - Check the Probability for each member in HERAPDF2.0 Error band For Q^2 ~ 9200 GeV2

13 Variance Vector members

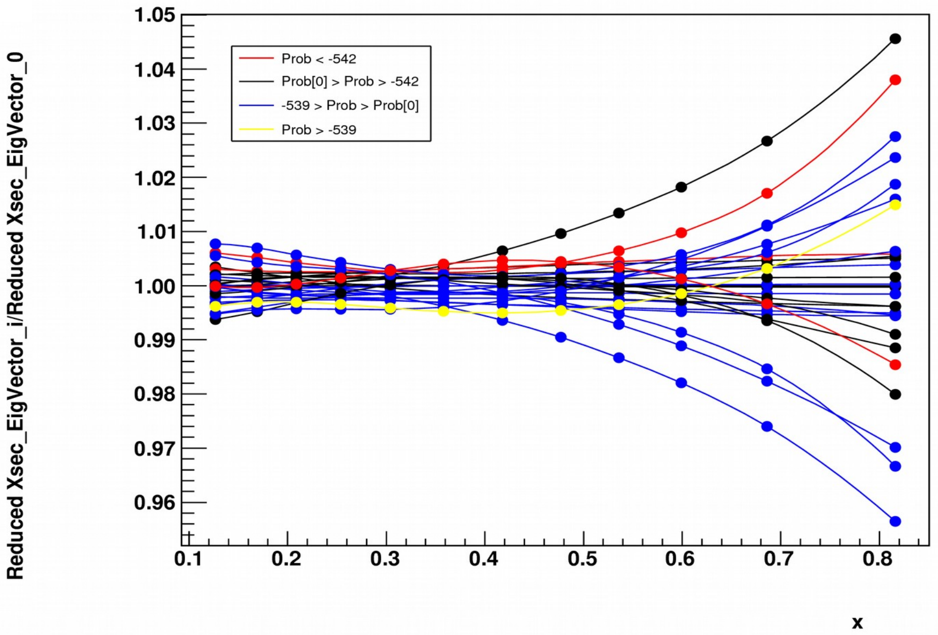


Prob[0] : Central value

13th (last) member in the Vector
Corresponds to u-valence parameter

Variation in the PDFs within HERAPDF2.0 much smaller than the inter PDF variation. Big change comes from #13 which has different normalization!

28 Eigen Vector members



Check 1 : Comparing N (calculated from Transfer Matrix) for different Pdfs
For high-x bins only (~20 bins) e+p

Q2bin	x bin	N_data	CTEQ5D	CT10nlo	HERAPDF1.5	HERAPDF2.0	MMHT2014	NNPDF2.3
650 - 800	0.26 - 1.00	371	405.72	394.06	410.30	423.25	389.24	393.99
800 - 950	0.28 - 1.00	482	489.51	474.57	495.66	511.02	468.23	474.34
950 - 1100	0.32 - 1.00	281	306.00	295.75	309.94	319.02	291.59	295.59
1100 - 1300	0.34 - 1.00	275	263.15	253.57	266.32	273.48	249.89	253.43
1300 - 1500	0.36 - 1.00	146	159.65	153.43	161.38	165.35	151.13	153.32
1500 - 1800	0.39 - 1.00	115	137.63	131.77	138.76	141.57	129.71	131.65
1800 - 2100	0.43 - 1.00	62	71.67	68.33	71.88	72.89	67.21	68.25
2100 - 2400	0.46 - 1.00	31	40.99	38.95	40.84	41.15	38.27	38.89
2400 - 2800	0.50 - 1.00	27	29.22	27.68	28.83	28.79	27.16	27.62
2800 - 3200	0.54 - 1.00	13	15.03	14.20	14.62	14.43	13.90	14.15
3200 - 3800	0.58 - 1.00	11	11.01	10.41	10.53	10.26	10.15	10.35
3800 - 4500	0.63 - 1.00	6	4.82	4.57	4.47	4.26	4.43	4.53
4500 - 6000	0.69 - 1.00	3	3.03	2.92	2.67	2.47	2.79	2.86
6000 - 8000	0.59 - 0.73	1	4.44	4.16	4.18	3.98	4.03	4.11
6000 - 8000	0.73 - 1.00	0	0.98	0.96	0.83	0.75	0.90	0.93
8000 - 11000	0.57 - 0.64	2	2.29	2.13	2.21	2.13	2.07	2.11
8000 - 11000	0.64 - 0.78	0	1.82	1.72	1.63	1.49	1.64	1.68
8000 - 11000	0.78 - 1.00	0	0.34	0.35	0.27	0.23	0.32	0.33
11000 - 20000	0.60 - 1.00	3	2.99	2.82	2.80	2.60	2.70	2.75

Check 1 : Comparing N (calculated from Transfer Matrix) for different Pdfs

For high-x bins only (~20 bins) e-p

Q2bin	x bin	N_data	CTEQ5D	CT10nlo	HERAPDF1.5	HERAPDF2.0	MMHT2014	NNPDF2.3
650 - 800,	0.26 - 1.00,	504,	532.79,	517.39,	537.46,	555.91,	511.00,	517.30
800 - 950,	0.28 - 1.00,	671,	635.27,	615.70,	642.07,	663.36,	607.38,	615.41
950 - 1100,	0.32 - 1.00,	414,	407.28,	393.53,	412.05,	424.52,	388.02,	393.37
1100 - 1300,	0.34 - 1.00,	368,	348.28,	335.45,	352.39,	361.86,	330.60,	335.31
1300 - 1500,	0.36 - 1.00,	202,	210.08,	201.77,	212.44,	217.51,	198.75,	201.66
1500 - 1800,	0.39 - 1.00,	173,	181.26,	173.43,	182.95,	186.35,	170.75,	173.33
1800 - 2100,	0.43 - 1.00,	74,	95.75,	91.18,	96.29,	97.25,	89.70,	91.12
2100 - 2400,	0.46 - 1.00,	51,	53.00,	50.29,	53.01,	53.10,	49.43,	50.25
2400 - 2800,	0.50 - 1.00,	36,	37.61,	35.57,	37.30,	36.94,	34.90,	35.52
2800 - 3200,	0.54 - 1.00,	19,	20.34,	19.21,	19.95,	19.49,	18.80,	19.16
3200 - 3800,	0.58 - 1.00,	17,	14.32,	13.52,	13.81,	13.28,	13.18,	13.47
3800 - 4500,	0.63 - 1.00,	5,	6.32,	6.00,	5.93,	5.55,	5.80,	5.95
4500 - 6000,	0.69 - 1.00,	3,	4.34,	4.18,	3.88,	3.50,	3.98,	4.11
6000 - 8000,	0.59 - 0.73,	10,	5.88,	5.49,	5.53,	5.22,	5.32,	5.46
6000 - 8000,	0.73 - 1.00,	1,	1.47,	1.43,	1.26,	1.11,	1.34,	1.39
8000 - 11000,	0.57 - 0.64,	4,	4.05,	3.75,	3.86,	3.73,	3.64,	3.73
8000 - 11000,	0.64 - 0.78,	1,	2.46,	2.32,	2.21,	2.02,	2.21,	2.28
8000 - 11000,	0.78 - 1.00,	1,	0.32,	0.34,	0.24,	0.19,	0.30,	0.31
11000 - 20000,	0.60 - 1.00,	8,	5.28,	4.94,	4.82,	4.58,	4.75,	4.90