W CHARGE ASYMMETRIES

Reweighting NNPDF

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in collaboration with:

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Outline

- Reweighting @ NNPDF
- The W lepton charge asymmetry data
- NNPDF2.0 predictions
- Reweighting the D0 lepton charge asymmetry data
- Conclusions and outlook

Motivation

- Reweighting:

Idea inspired by Giele-Keller [hep-ph/9803393]

- Conventional fits:

Whenever add new data, need to do full refitting:
Time consuming, impractical, can only be done by fitting group themselves.

- NNPDF:

Provides statistical ensemble:
can add new data simply by reweighting the ensemble.

- Advantage:

Can be done quickly and easily by anybody: all you need to do is to compute the chi2 to the new data for each NNPDF replica.
Can determine consistency, effect on PDF precision and shapes, re-compute standard candle predictions.

Reweighting NNPDFs

- The ensemble of fitted PDFs provides the representation of the probability density

$$\langle \mathcal{O} \rangle = \int \mathcal{O}[f]\, \mathcal{P}(f)\, Df = \frac{1}{N} \sum_{k=1}^{N} \mathcal{O}[f^{(k)}]$$

NNPDF2.0

- Can we update the probability density upon the addition of new data without performing a new fit?

$$y = \{y_1, y_2, \cdots, y_n\}$$

- Statistical inference

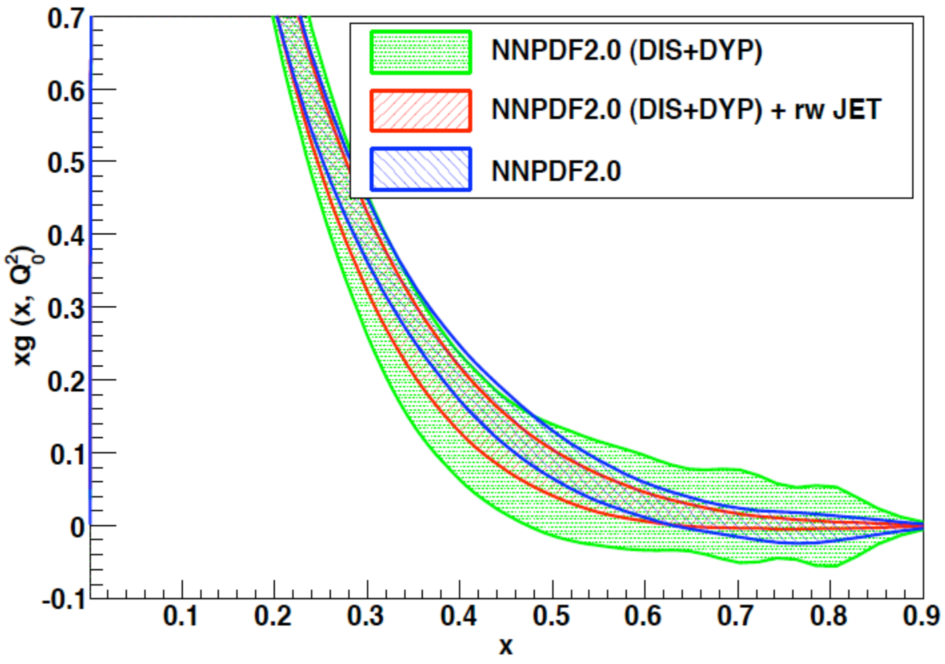
$$\langle \mathcal{O} \rangle_{\mathrm{new}} = \int \mathcal{O}[f] \mathcal{P}_{\mathrm{new}}(f) \mathcal{D}f = \frac{1}{N} \sum_{k=1}^{N} w_k \mathcal{O}[f^{(k)}]$$

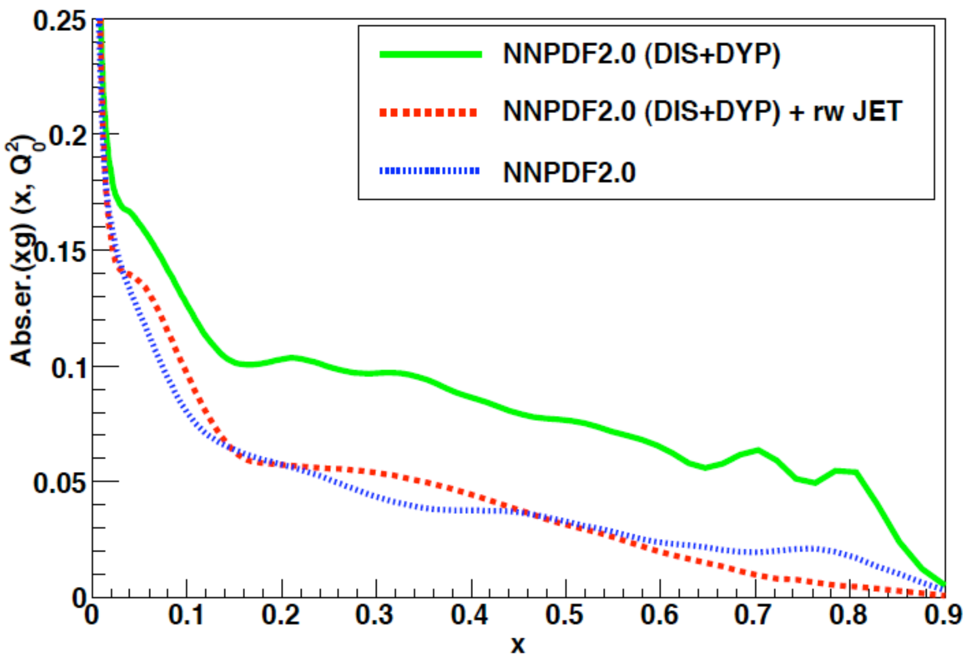
weights

$$\mathcal{N}_\chi \, (\chi^2_k)^{n/2-1} \, e^{-\frac{1}{2}\chi^2_k}$$

- The reweighted ensemble forms a representation of the probability density of PDFs conditional on both old and new data

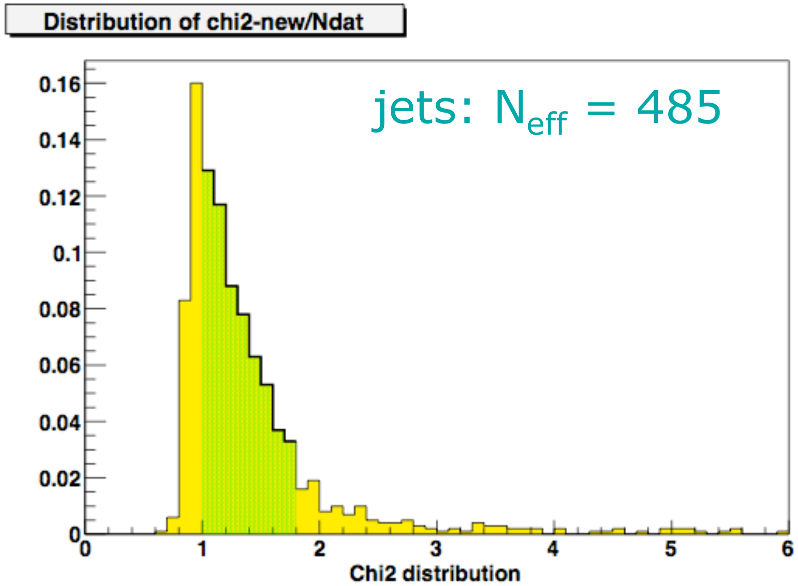
Validation of the method





- Start from DIS+DY fit (NNPDF20_DIS+DYP.LHgrid).
- Add CDF and D0 inclusive jet production data through reweighting
- Compare to refitting (NNPDF20.LHgrid)
- Results are the same within statistical fluctuations.

Features of the method



$$
\begin{aligned}
\chi^2_\alpha &= \chi^2/\alpha \\
w_k(\alpha) &= \left(\chi^2_\alpha\right)^{n/2-1} \mathrm{e}^{-\chi^2_\alpha/2} \\
P(\alpha) &= \frac{\mathcal{N}}{\alpha} \sum_{k=1}^{N} w_k(1) \cdot w_k(\alpha)
\end{aligned}
$$

$$
\ln(N_{\text{eff}}) = \frac{1}{N} \sum_{k=1}^{N} w_k \ln\left(\frac{N}{w_k}\right)
$$

effective # of replicas

If N_{eff} small, two possibilities:

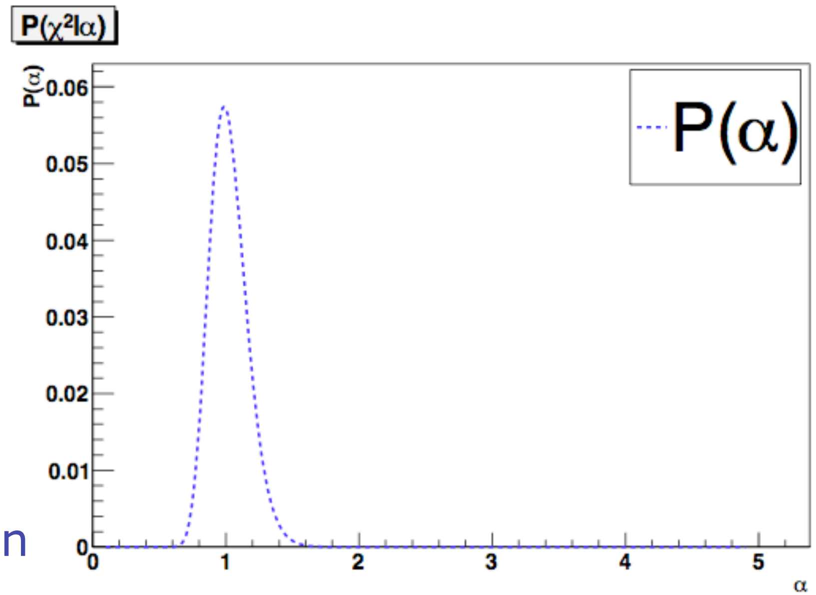
a) new data are very constraining

b) new data are inconsistent

* Rescale covariance matrix by a factor α.

* Compute probability for the rescaling parameter α.

* w_α proportional to the probability of f_k given the new data with rescaled errors.



The W lepton charge asymmetry

✓ CDF W charge asymmetry: [arXiv:0901.2169]

$\chi^2_{NNPDF2.0} = 1.85$

fitted in NNPDF2.0

$$A_W = \frac{d\sigma(W^+)/dy_{W^+} - d\sigma(W^-)/dy_{W^-}}{d\sigma(W^+)/dy_{W^+} + d\sigma(W^-)/dy_{W^-}}$$

$$\frac{u(x_1)d(x_2) - d(x_1)u(x_2)}{u(x_1)d(x_2) + d(x_1)u(x_2)}$$

d/u: $0.01 < x < 0.7$

× CDF electron charge asymmetry [hep-ex/0501023]

➔ D0 muon charge asymmetry in single p_T^μ bin [arXiv:0709.4254]

➔ D0 electron charge asymmetry combined and separated p_T^e bins : [arXiv: 0807.3367]

× D0 muon charge asymmetry combined and separated p_T^μ bins: [D0 Note 5976-conf]

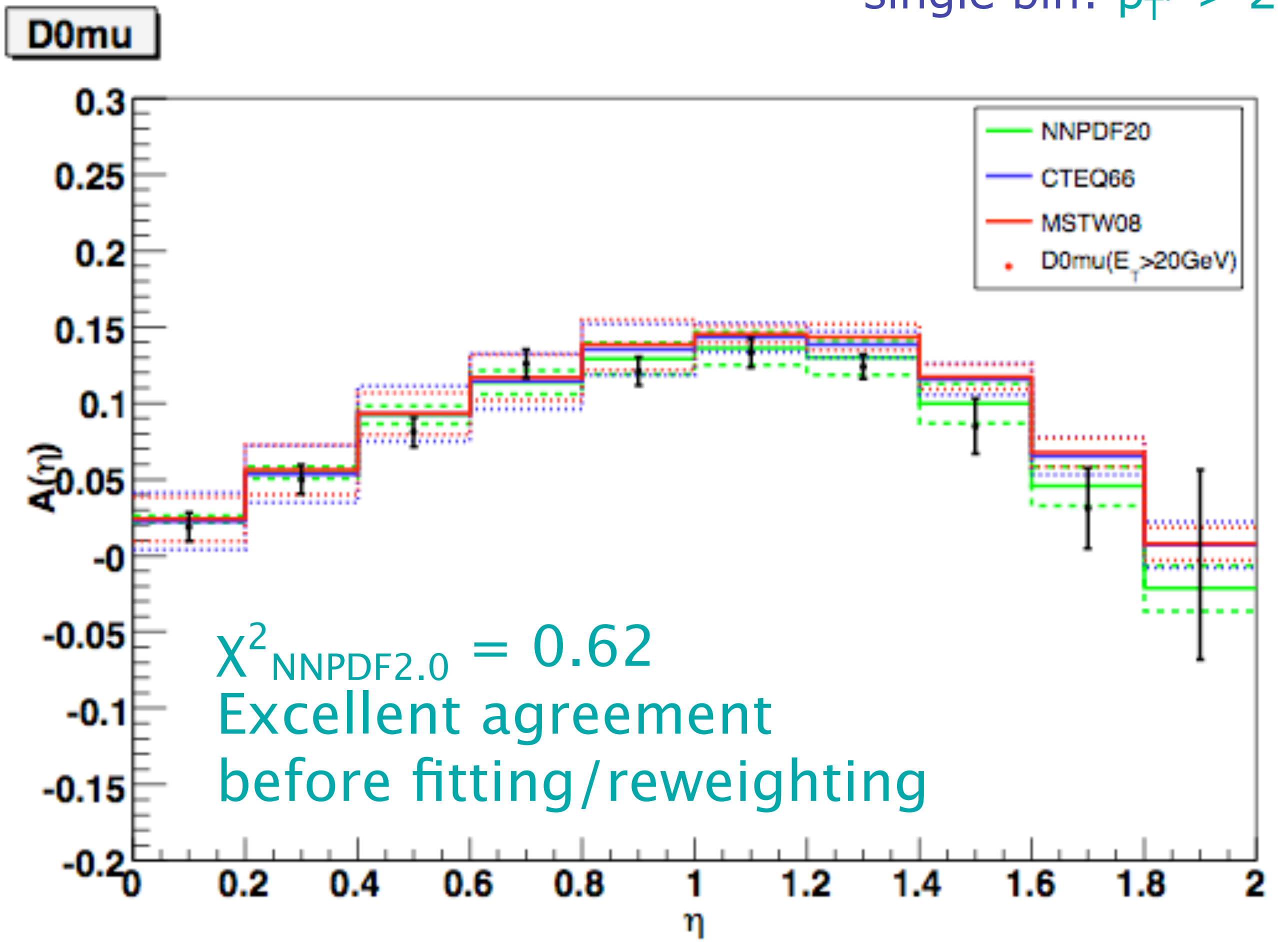
$$A_l = \frac{d\sigma(l^+)/dy(l^+) - d\sigma(l^-)/dy(l^-)}{d\sigma(l^+)/dy(l^+) + d\sigma(l^-)/dy(l^-)}$$

$$\eta_l = y_W + \frac{1}{2}\ln\left(\frac{1+\cos\theta_R}{1-\cos\theta_R}\right)$$

D0 muon charge asymmetry

- D0 muon charge asymmetry data are given for a single bin in p_T^μ:

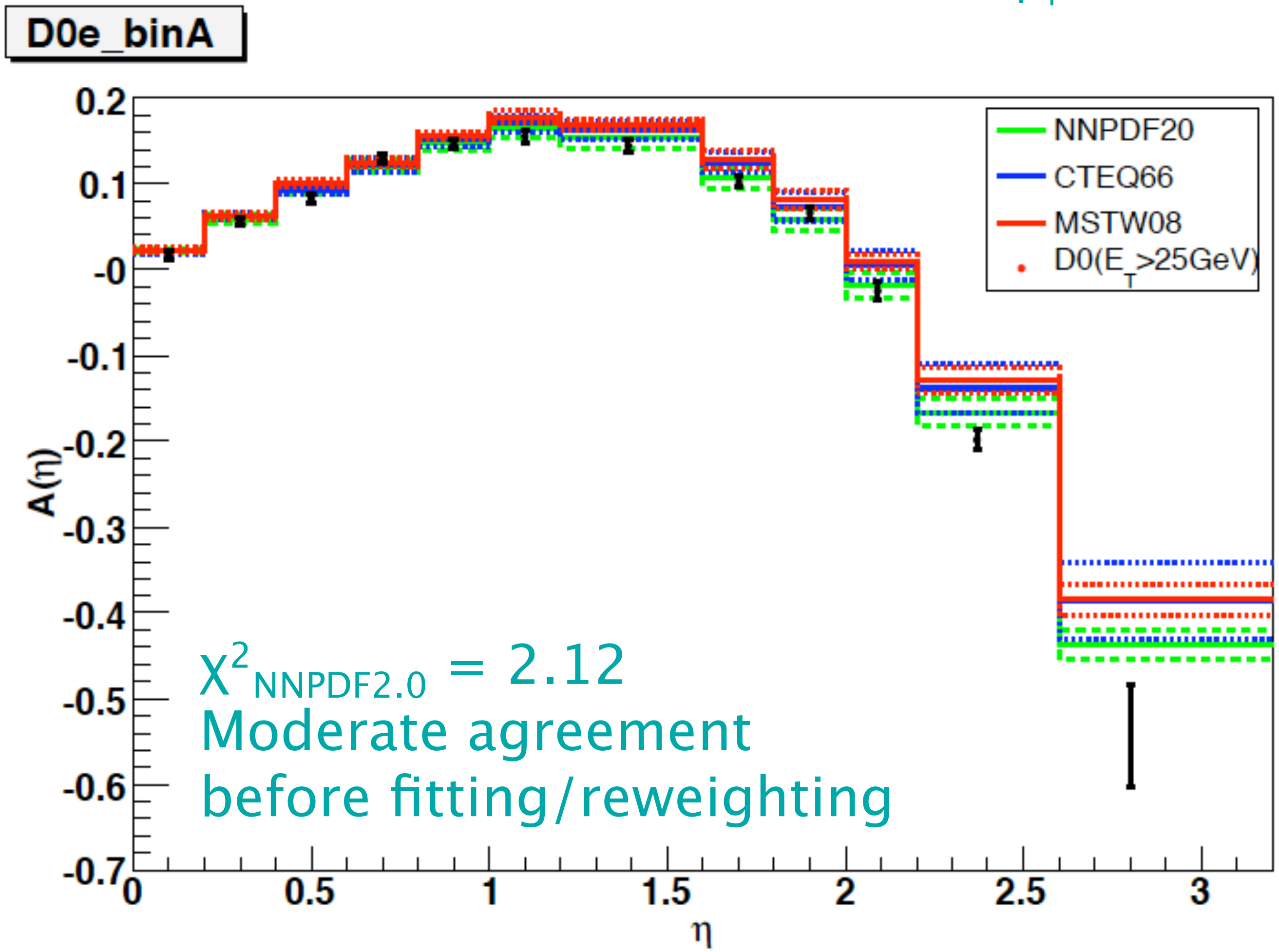
single bin: $p_T^\mu > 20$ GeV



- NLO predictions obtained with DYNNLO [ArXiv: 0903.2120]

D0 electron charge asymmetry

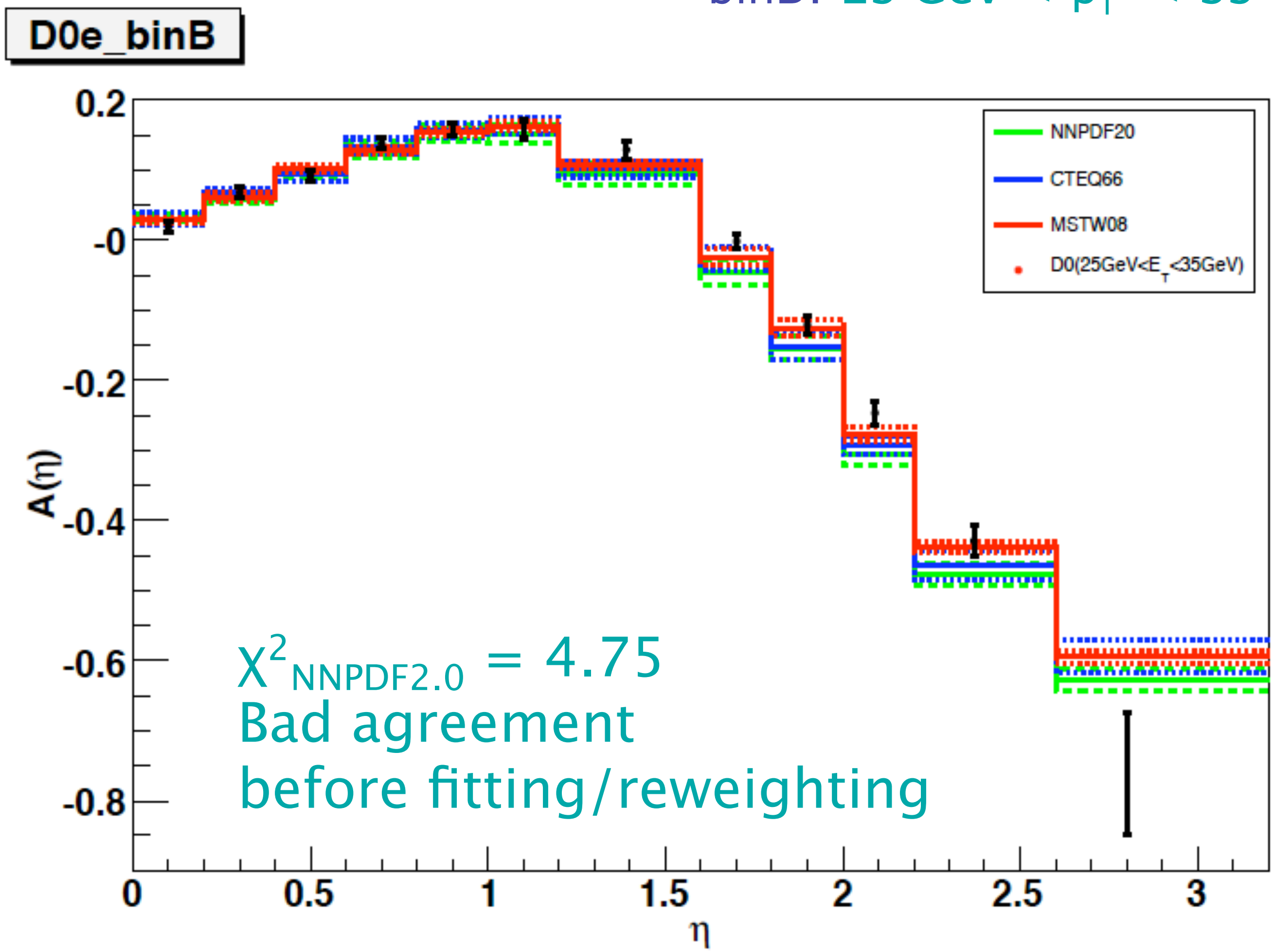
- D0 electron charge asymmetry data are divided in 3 bins in p_T:
  binA: $p_T^e > 25$ GeV



- NLO predictions obtained with DYNNLO [ArXiv: 0903.2120]

D0 electron charge asymmetry

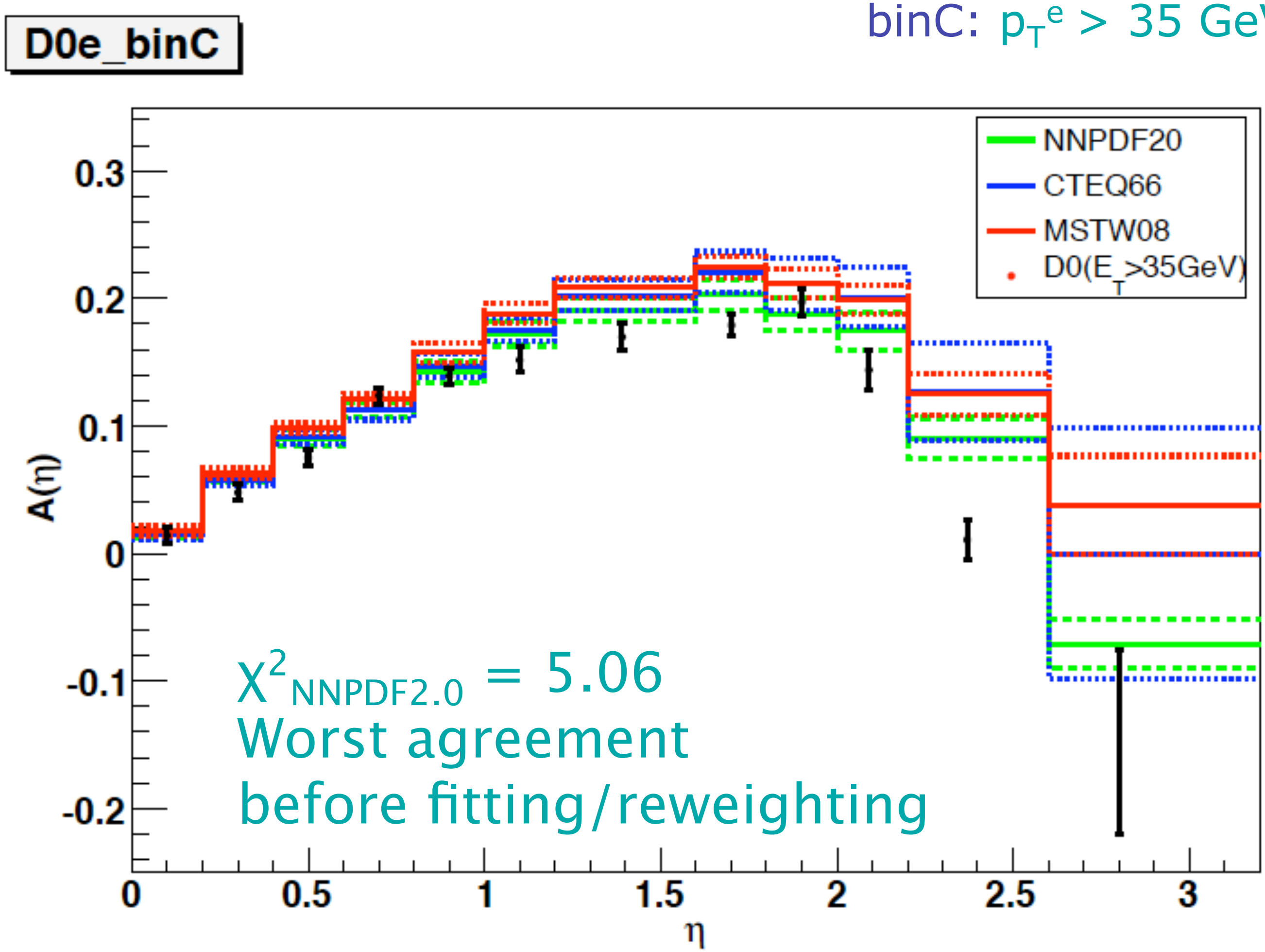
- D0 electron charge asymmetry data are divided in 3 bins in p_T:
  binB: 25 GeV < p_T^e < 35 GeV



- NLO predictions obtained with DYNNLO [ArXiv: 0903.2120]

D0 electron charge asymmetry

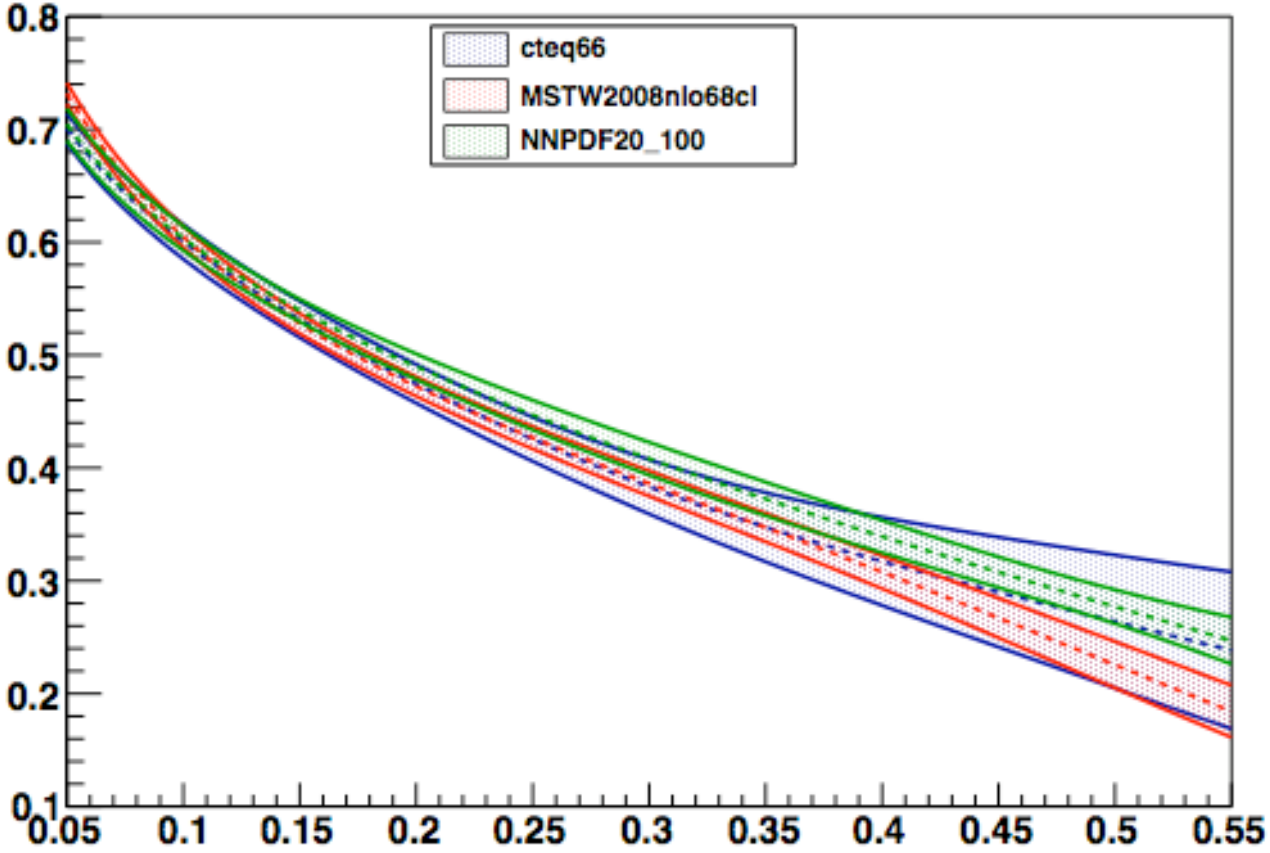
- D0 electron charge asymmetry data are divided in 3 bins in p_T:
  binC: $p_T^e > 35$ GeV



- NLO predictions obtained with DYNNLO [ArXiv: 0903.2120]

d/u ratio

- NNPDF2.0: Constrain on d/u given by the W charge asymmetry and deuteron data.
- D0 muon charge asymmetry data are well-described.
- D0 electron charge asymmetry data are reasonably described for single bin in p_T^e but poorly described for separate high and low p_T regions.
- Overall better description than MSWT2008/CTEQ66.



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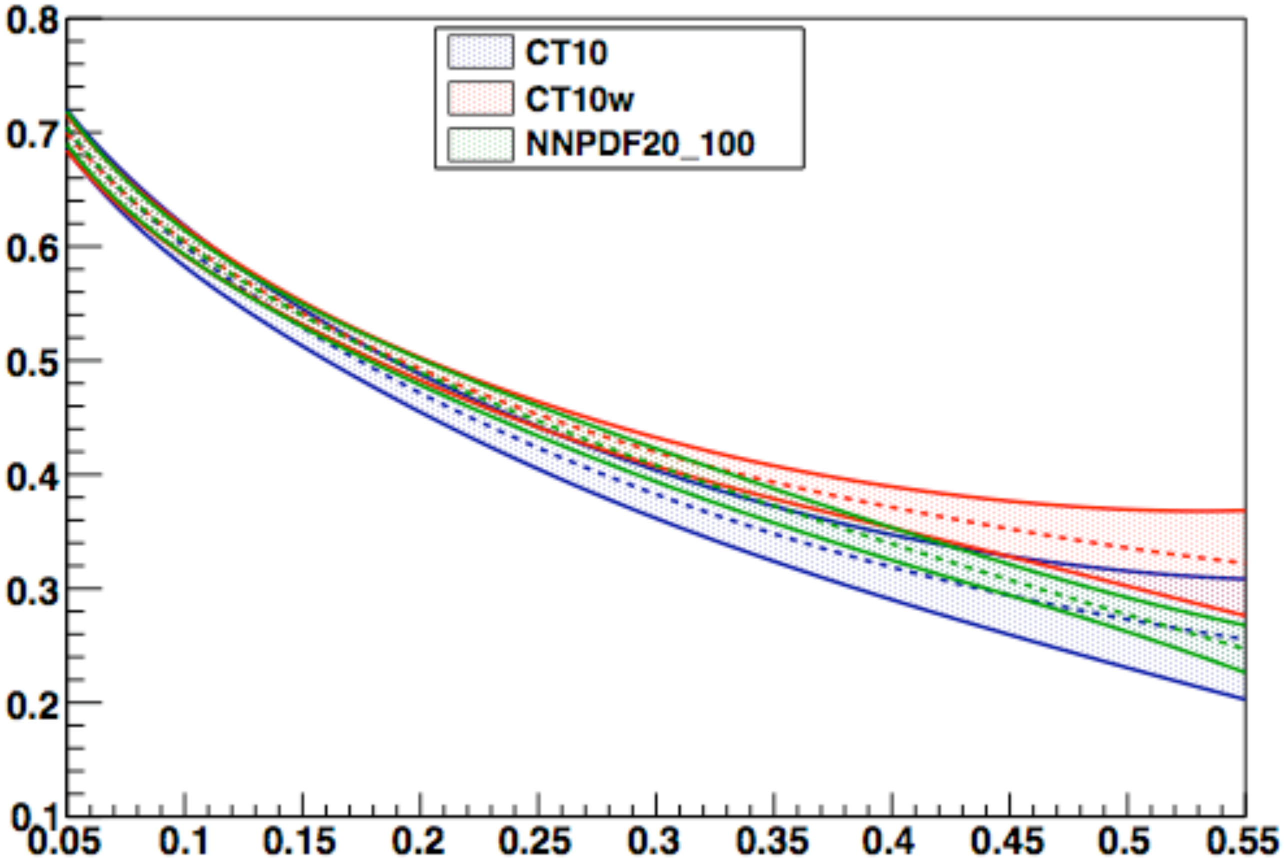
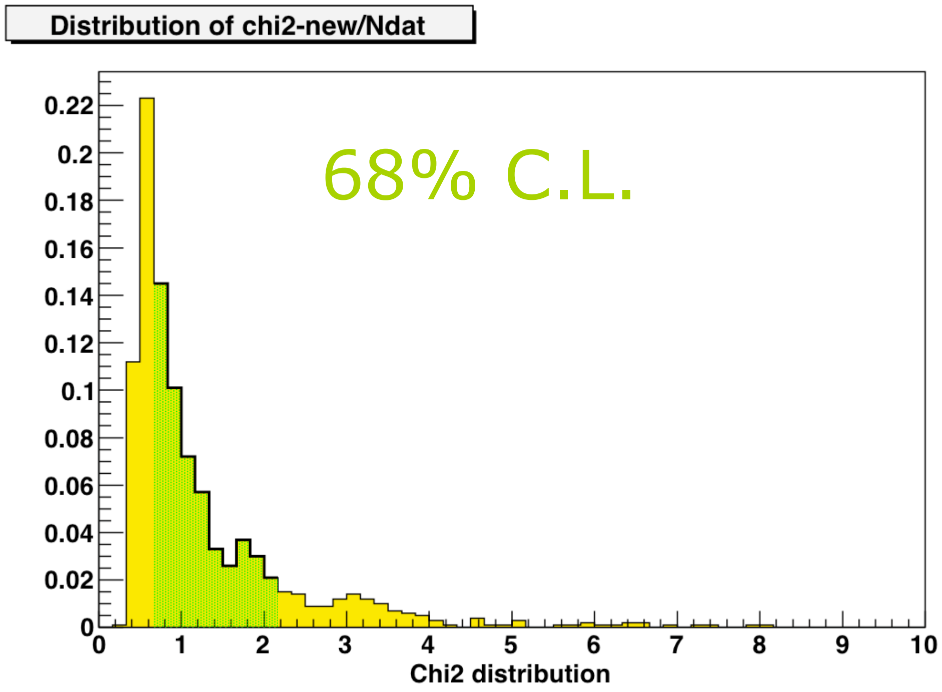
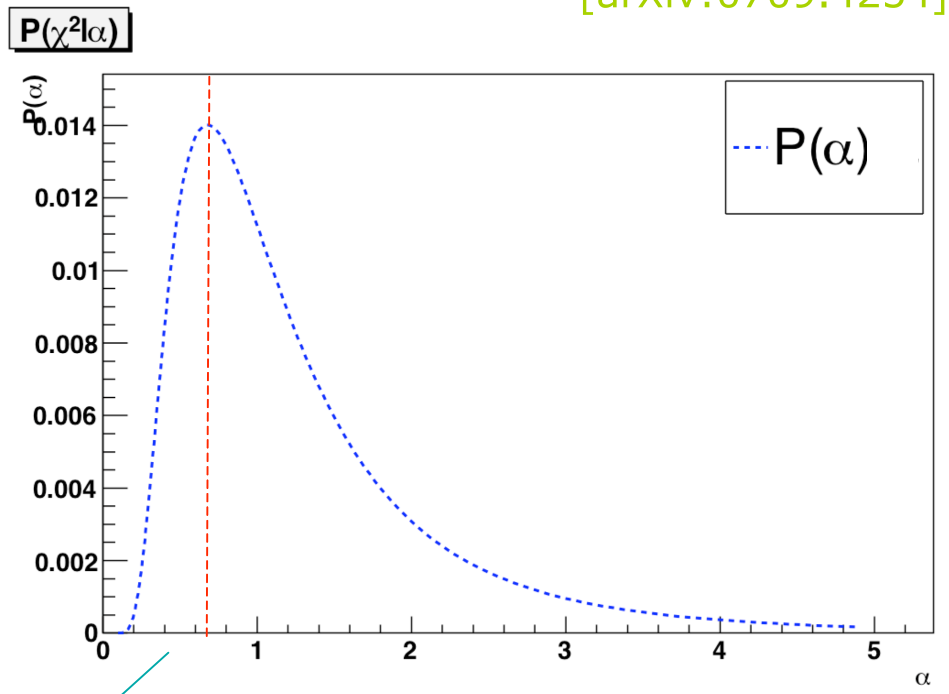


Reweighting analysis: D0 muon

[arXiv:0709.4254]



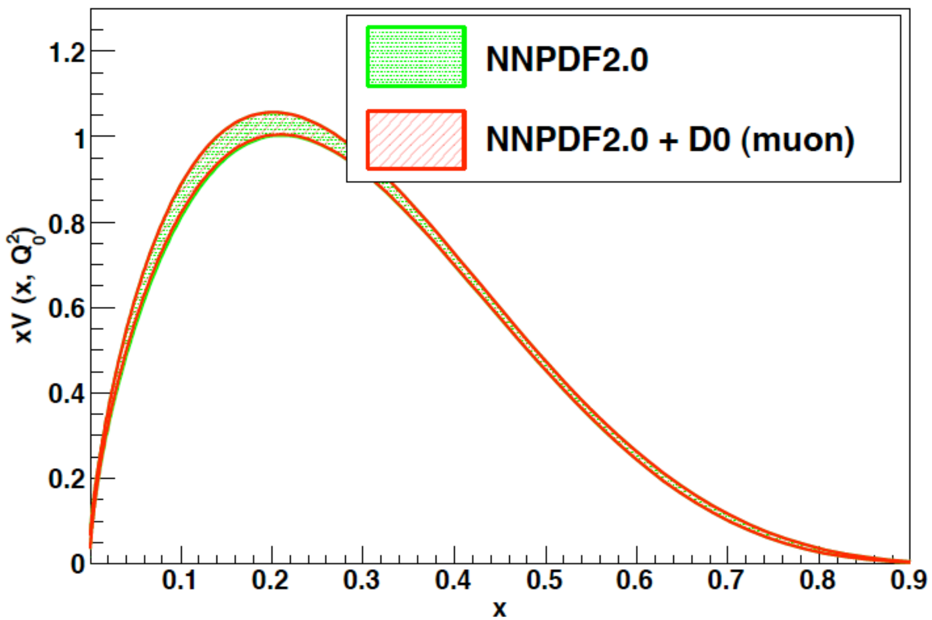


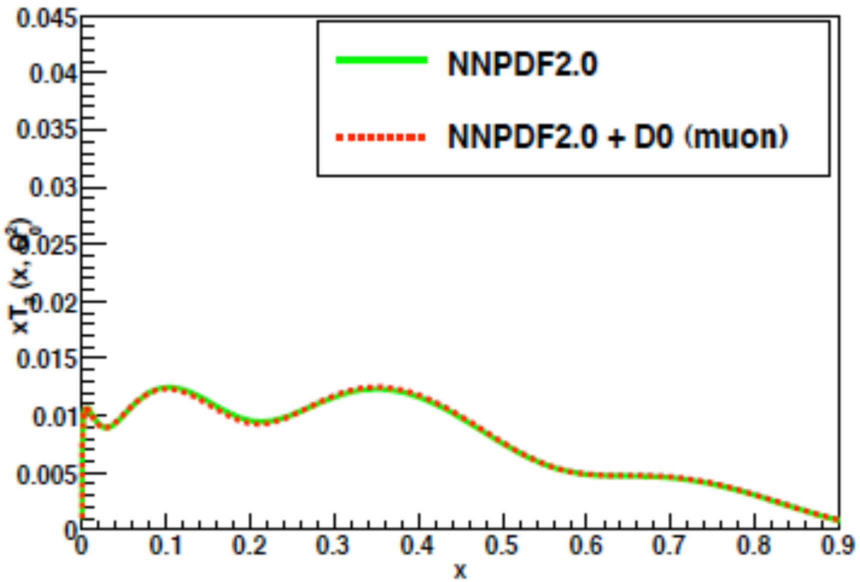
consistent data

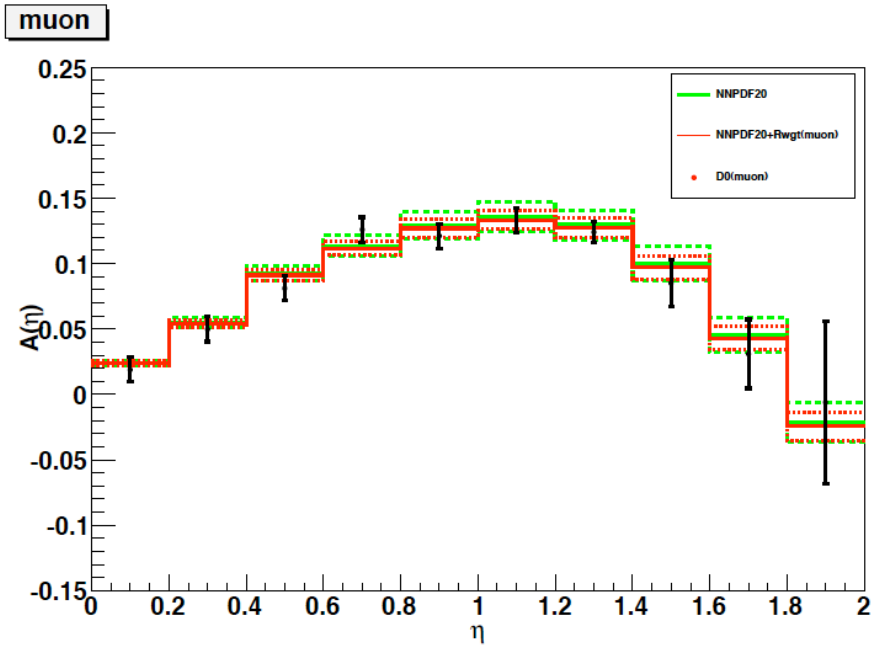
SINGLE BIN

$\sqrt{s}$ = 1.96 GeV
0.3fb^{-1} luminosity
p_T^μ > 20 GeV
M_T^μ > 40 GeV
$\not{E}_T$ > 20 GeV

Reweighting analysis: D0 muon



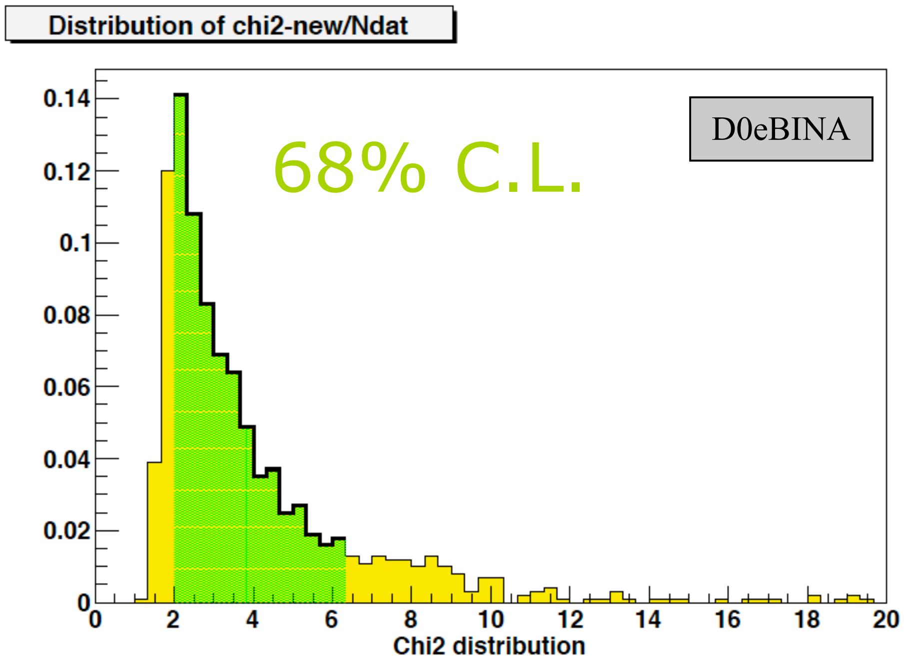


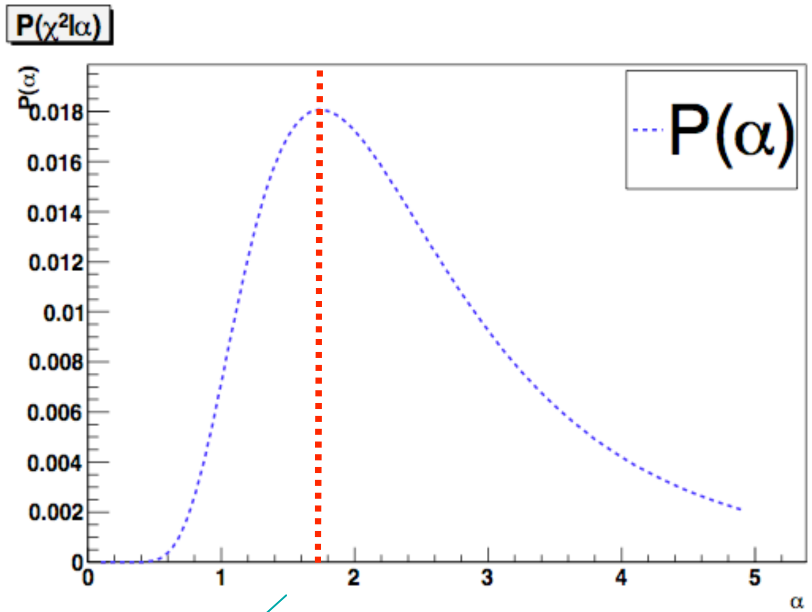


✓ D0 muon data are well described by NNPDF2.0.
✓ D0 muon data do not add info on PDFs.
✓ No relevant improvement in description of the observable after reweighting.

$\chi^2_{\mathrm{NNPDF2.0}} = 0.62 \rightarrow 0.52$

Reweighting analysis: D0 electron





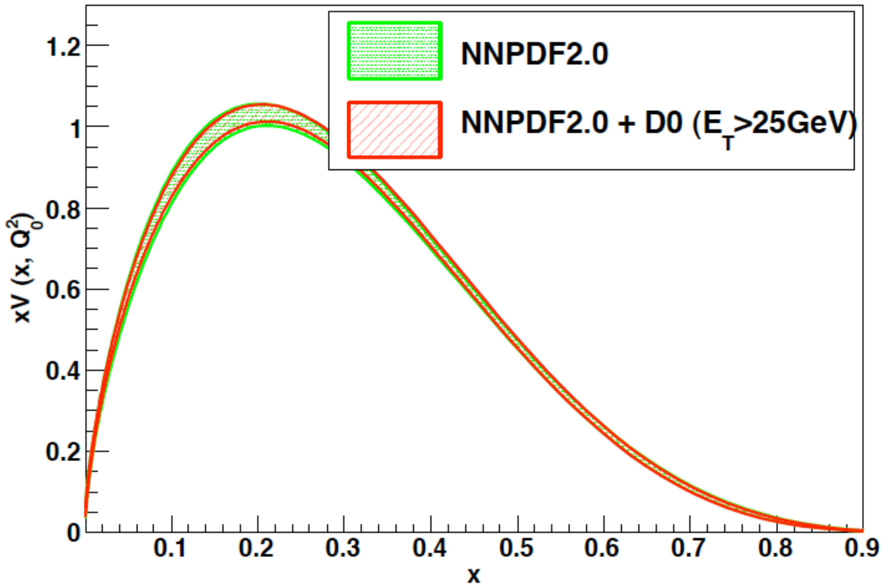
Effective reps #: 262

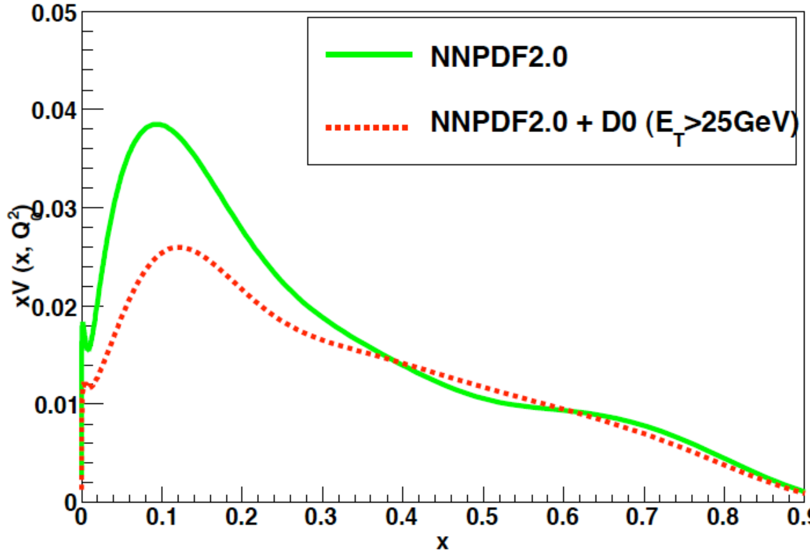
Marginal compatibility.
These data would require a tolerance of ~1.4.

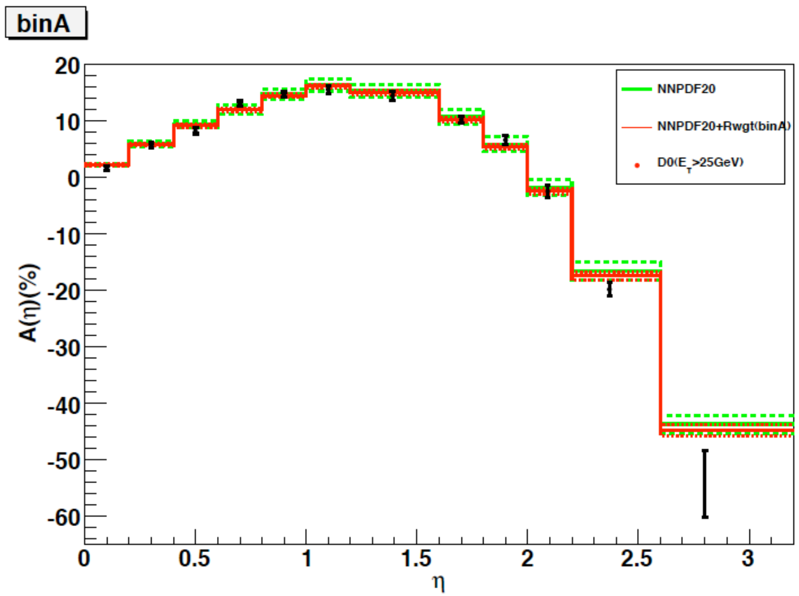
COMBINED BIN

$\sqrt{s}$ = 1.96 GeV
0.75fb^{-1} luminosity
p_T^e > 25 GeV
M_T^e > 50 GeV
$\not{E}_T$ > 25 GeV

Reweighting analysis: D0 electron







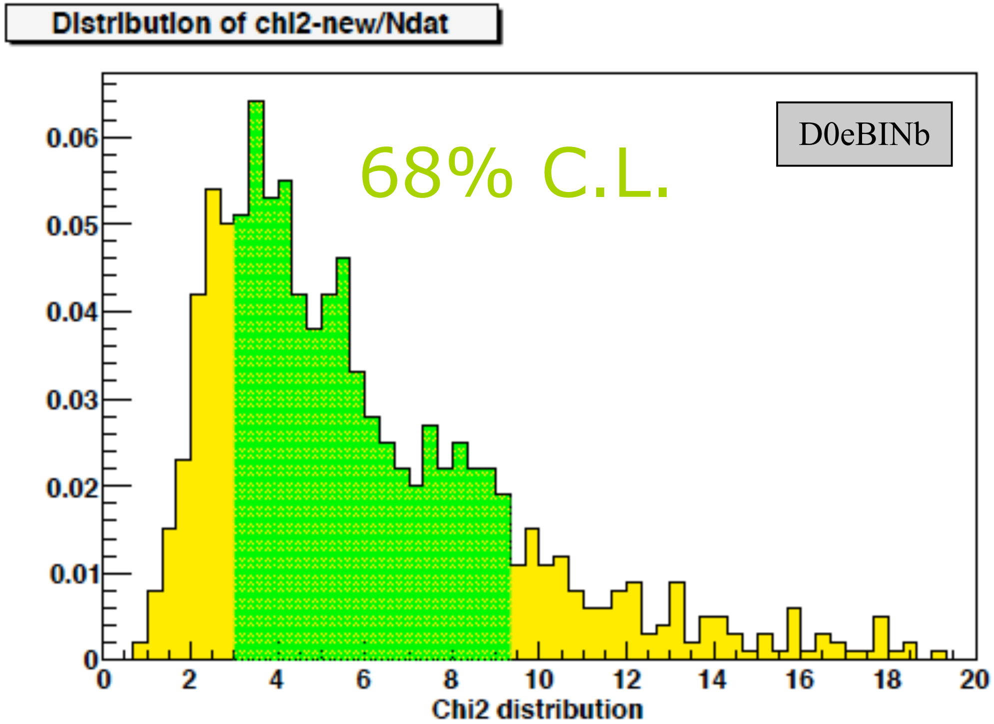
✓ D0 electron data (p_T^e > 25 GeV) are compatible to other data included in NNPDF2.0

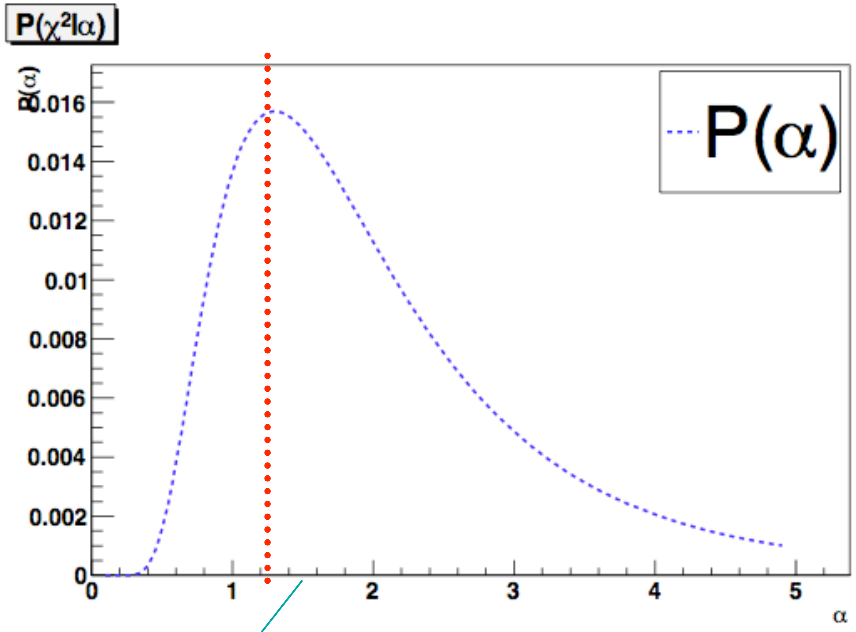
✓ They mainly help in reducing total Valence uncertainty.

✓ Significant improvement in description of the observable.

$$\chi^2_{\mathrm{NNPDF2.0}} = 2.12 \rightarrow 1.55$$

Reweighting analysis: D0 electron





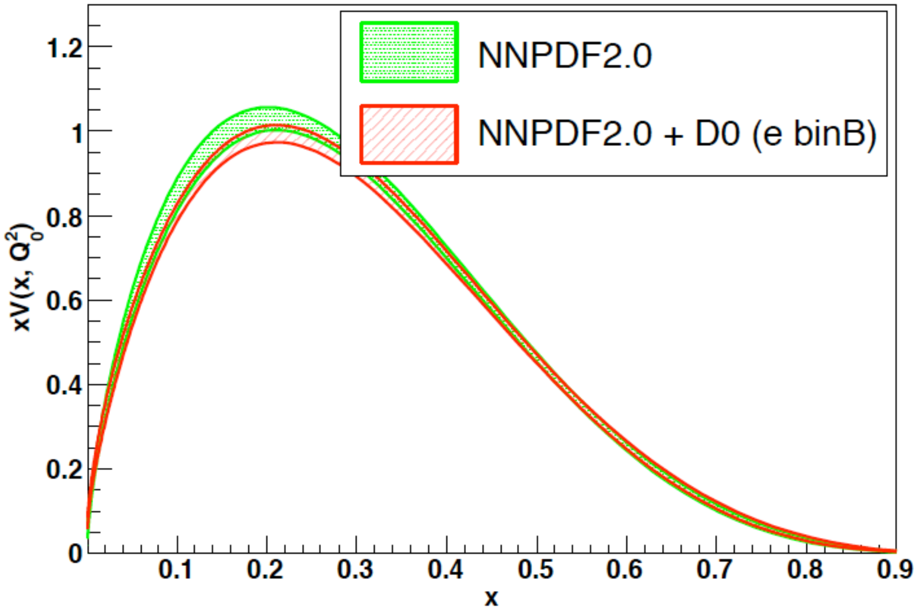
Effective reps #: 61

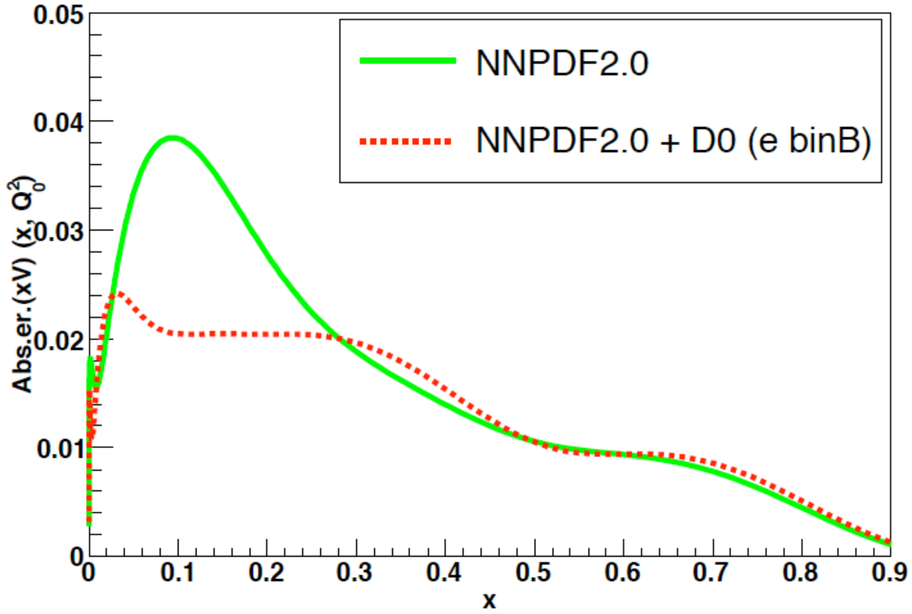
Good compatibility.
These data would require a tolerance of ~1.1.

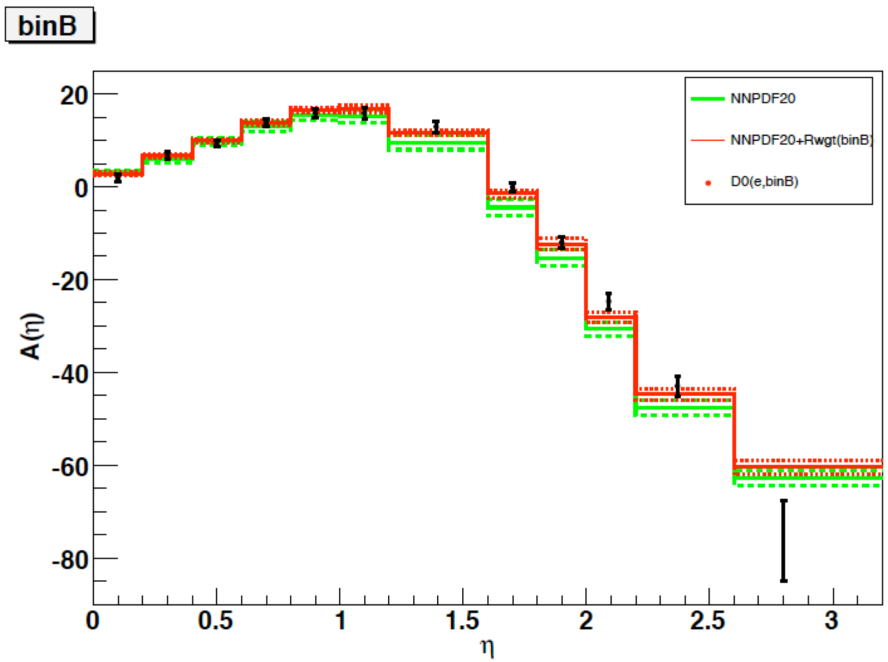
LOW p_T BIN

$\sqrt{s}$ = 1.96 GeV
0.75fb^{-1} luminosity
25 < p_T^e < 35 GeV
low p_T bins
M_T^e > 50 GeV
$\not{E}_T$ > 25 GeV

Reweighting analysis: D0 electron



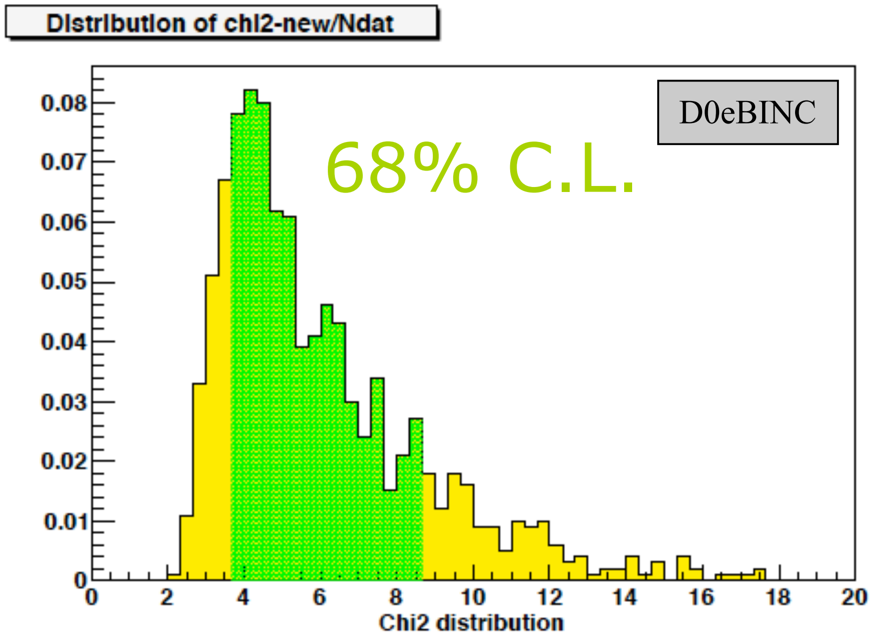


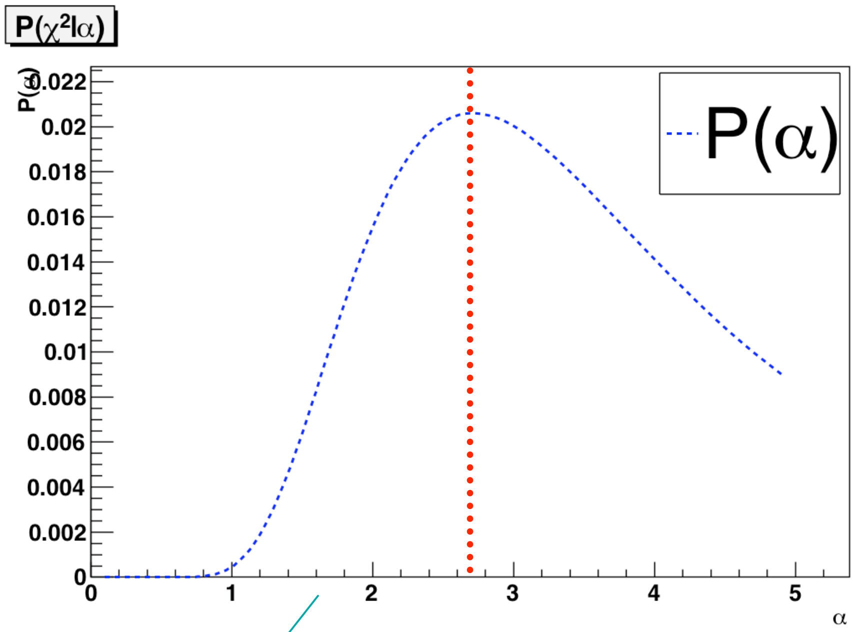


- ✓ D0 electron data (low p_T^e) are compatible to other data included in NNPDF2.0.
- ✓ They mainly help in reducing total Valence uncertainty.
- ✓ Significant improvement in description of the observable.

$$\chi^2_{\mathrm{NNPDF2.0}} = 4.75 \rightarrow 1.12$$

Reweighting analysis: D0 electron





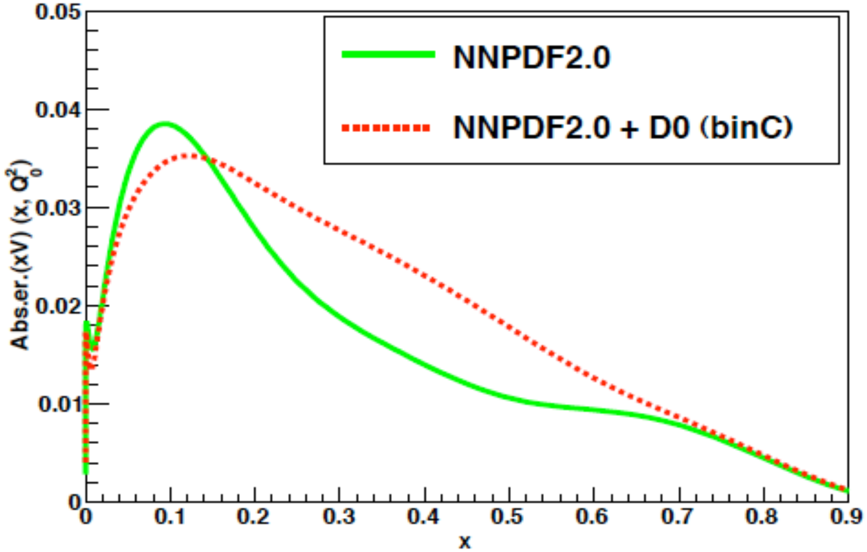
Effective reps # : 65

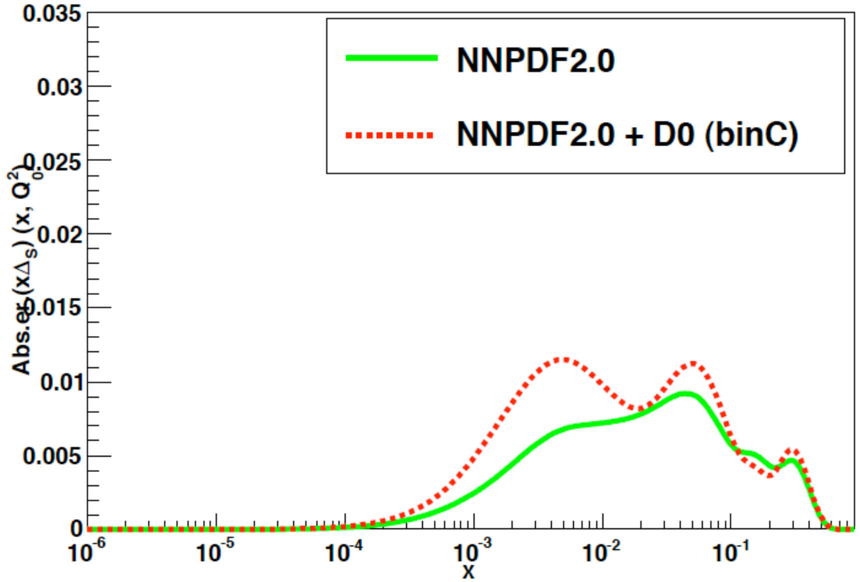
Poor compatibility.
These data would require a tolerance of ~2.

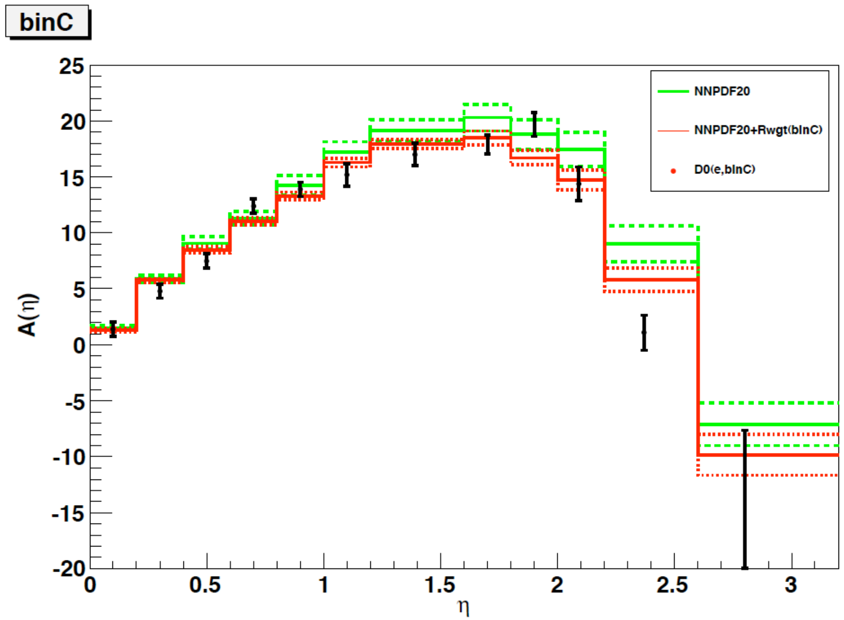
HIGH p_T BIN

$\sqrt{s}$ = 1.96 GeV
0.75fb^{-1} luminosity
p_T^e > 35 GeV
high p_T bins
M_T^e > 50 GeV
E > 25 GeV

Reweighting analysis: D0 electron







✓ D0 electron data (p_T^e > 35 GeV) are incompatible to other data included in NNPDF2.0
✓ With incompatible data uncertainty does not decrease.
✓ Less significant improvement in description of the observable.

$\chi^2_{NNPDF2.0}$ = 5.06 → 2.51

Standard candles

$$\langle \mathcal{O} \rangle_{\text{new}} = \int \mathcal{O}[f] \mathcal{P}_{\text{new}}(f) \mathcal{D}f = \frac{1}{N} \sum_{k=1}^{N} w_k \mathcal{O}[f^{(k)}]$$

standard candle xsec

weights evaluated by including {y} data in PDF analysis

evaluate standard candle xsec with any code for each NNPDF replica

	$\sigma(Z \to ll^-)$	$\sigma(W^- \to l\nu)$	$\sigma(W^+ \to l\nu)$
NNPDF2.0	911 ± 16 pb	3.98 ± 0.08 nb	5.80 ± 0.12 nb
NNPDF2.0 + D0(e bin A)	914 ± 15 pb	4.00 ± 0.07 nb	5.81 ± 0.11 nb
NNPDF2.0 + D0(e bin C)	913 ± 22 pb	4.01 ± 0.10 nb	5.78 ± 0.17 nb
NNPDF2.0 + D0(μ)	911 ± 16 pb	3.98 ± 0.08 nb	5.80 ± 0.12 nb

Evaluate how prediction for standard candles change when they are evaluated with the updated PDF ensemble

Conclusions and outlook

✓ NNPDF offers a method for checking the impact of data without need of performing a new fit.
✓ Method is method quick and easy - all you have to do is compute a chi2.
✓Method can be used by experimentalists to check compatibility of a new measurement with old data.

✓ D0 muon data already fitted by W asymmetry/deuteron data.
✓ D0 in separate bins: low p_T bin is perfectly fine, something funny going on with high p_T.
✓ Marginal compatibility for combination of bins.
✓ D0 new muon charge asymmetry data: analysis in progress shows similar inverted pattern.

Backup slides

Reweighting theory

$$y = \{y_1, y_2, \cdots, y_n\}$$ Experimental points

$$\sigma_{ij}$$ Experimental covariance matrix

Assume new data have Gaussian errors:
➔ relative probabilities for the new data for different {f} are proportional to the probability density of the chi2 to the new data conditional on {f}

$$\boxed{\mathcal{P}(\chi^2|f) \propto (\chi^2(y,f))^{n/2-1} e^{-\frac{1}{2}\chi^2(y,f)}}$$

$$\chi^2(y,f) = \sum_{i,j=1}^{n} (y_i - y_i[f])\sigma_{ij}^{-1}(y_j - y_j[f])$$

Chi2 depends on the predicted value of y given {f}

➔ $\mathcal{P}_{\mathrm{new}}(f) = \mathcal{N}_\chi \mathcal{P}(\chi^2|f)\, \mathcal{P}_{\mathrm{old}}(f)$

Chi2 probability distribution

Reweighting theory

$$y = \{y_1, y_2, \cdots, y_n\}$$ Experimental points

$$\sigma_{ij}$$ Experimental covariance matrix

The idea was initially suggested by Giele-Keller [hep-ph/9803393]

☒ Bayesian reweighting.

☒ Ensemble generated in the parameter space.

☒ Probability was evaluated as a conditional probability in the space of the new data by ignoring the volume element.

$$w_k = e^{-\frac{1}{2}\chi_k^2}$$

Works only for n=1

Gaussian probability distribution

Reweighting theory

$y = \{y_1, y_2, \cdots, y_n\}$ Experimental points

σ_{ij} Experimental covariance matrix

Assume new data have Gaussian errors:
➔ relative probabilities for the new data for different {f} are proportional to the probability density of the chi2 to the new data conditional on {f}

Inclusive jets