# Impact of new data on the gluon PDF in NNPDF 4.0

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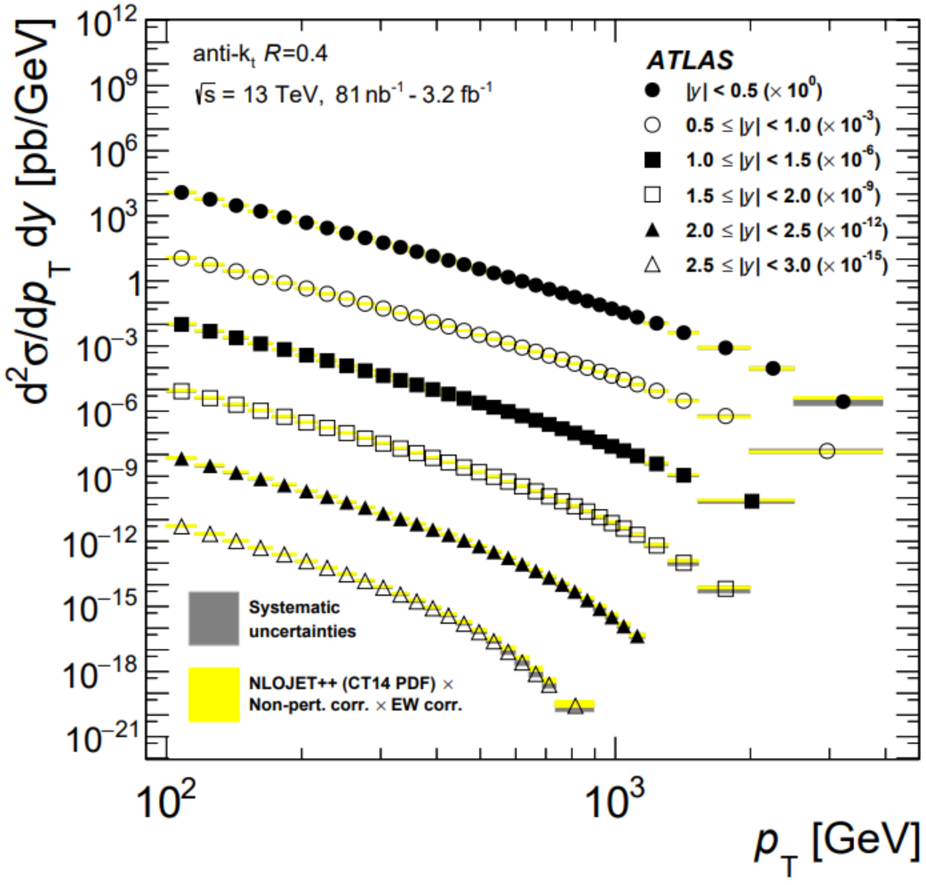
# Introduction

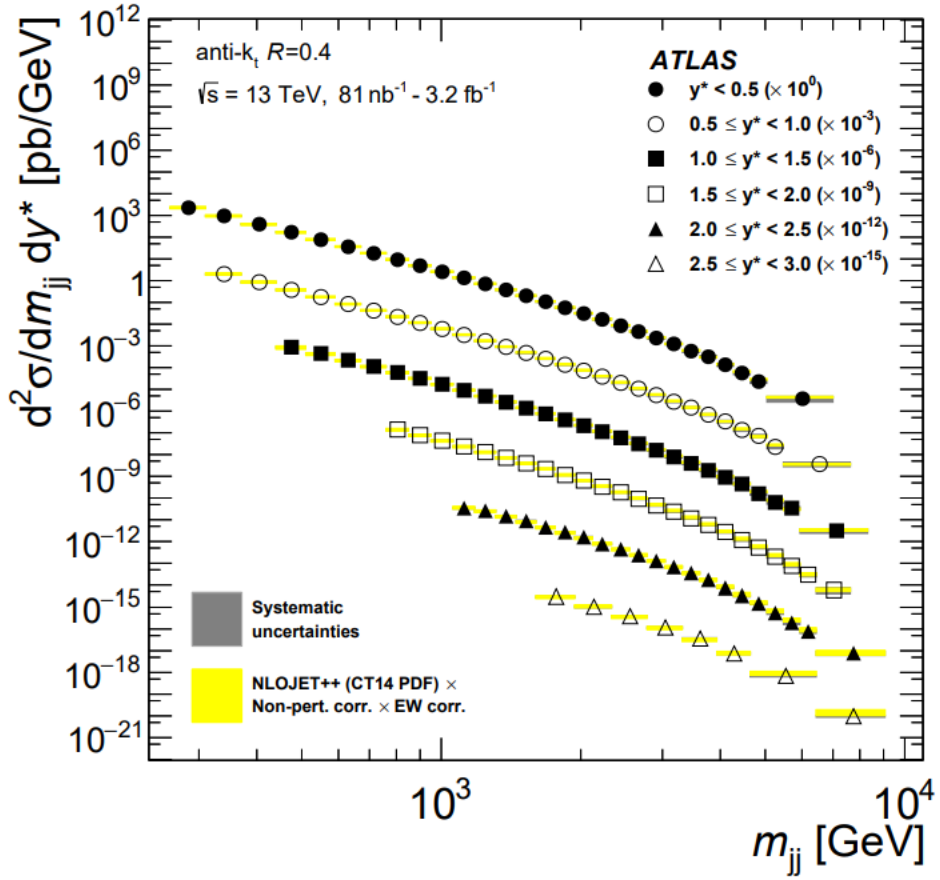
- New datasets include jets, top pair production and DIS + jets
- Reference fit is NNPDF4.0 (with 3 differences)
  - Using new NNPDF software (Yadism, EKO, PineAPPL) [2302.12124]
  - MHOUs used in fitting procedure [2401.10319] (see J. Rojo's talk)
  - Purely NNLO theory predictions (instead of K-factors) for top pair production (using MATRIX)
- Perform a fit with the new datasets
- Choose the datasets that maximize consistency
- Assess the impact of the maximally consistent datasets

# New Datasets: Jets

ATLAS 13 TeV Jets [1711.02692]




CMS 13 TeV Jets [2111.10431]

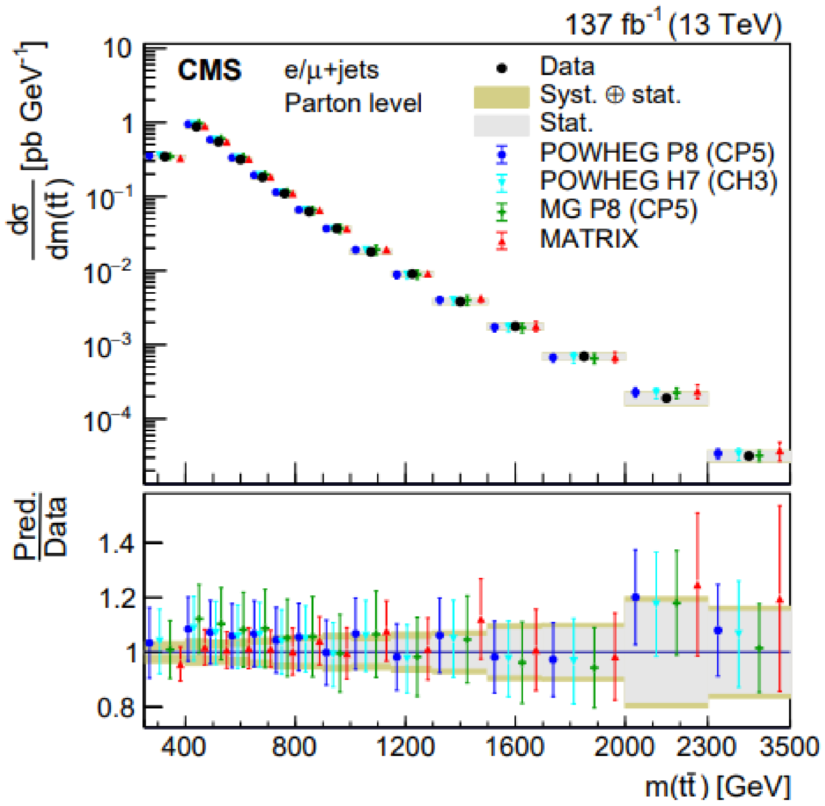


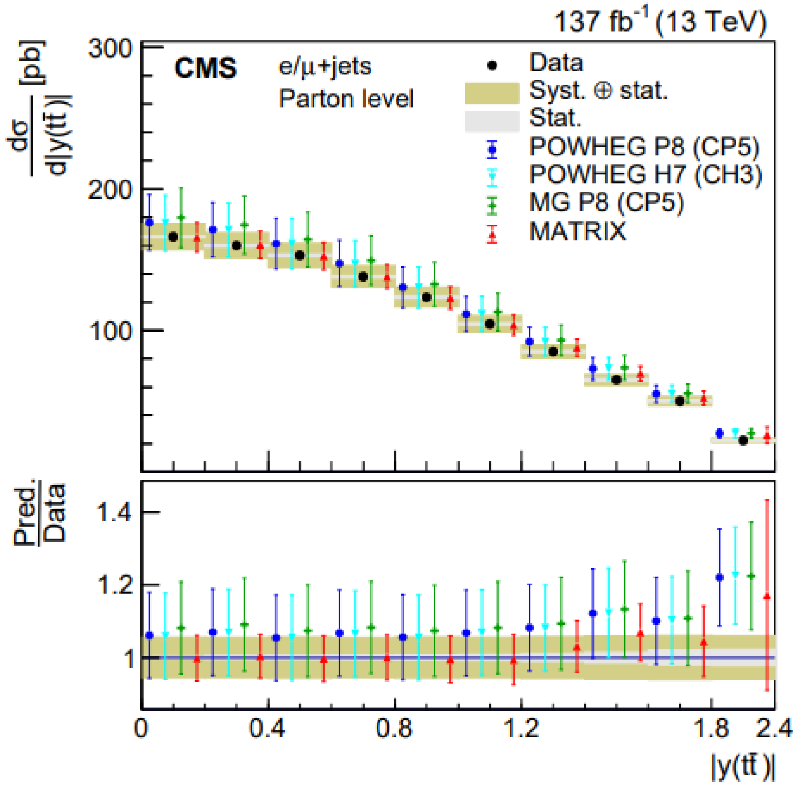
# New Datasets: $t\bar{t}$

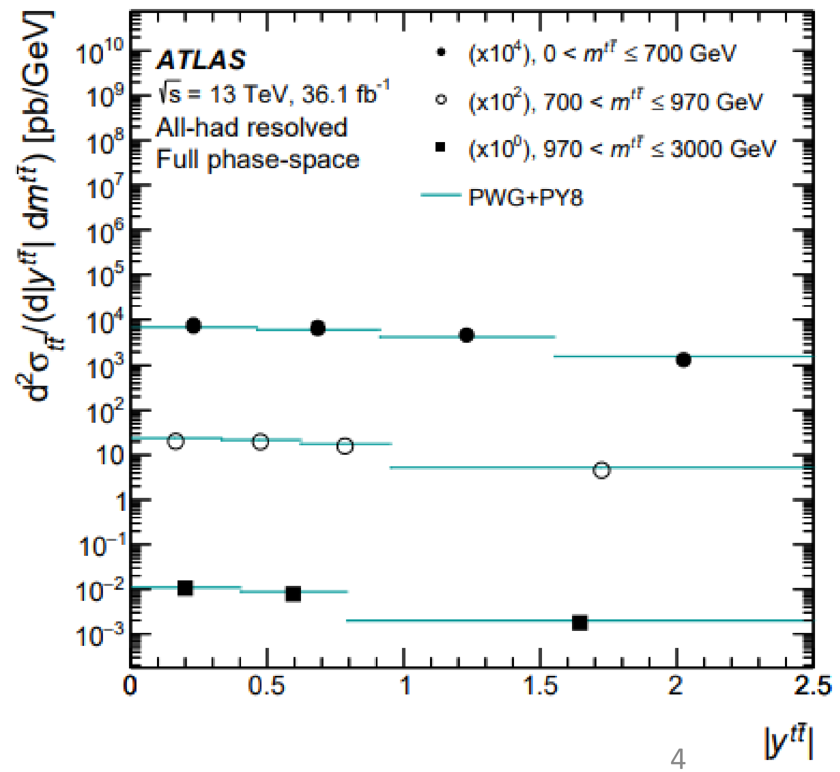
ATLAS 13 TeV $t\bar{t}$ (hadronic channel) [2006.09274]

ATLAS 13 TeV $t\bar{t}$ (l+j channel) [1908.07305]

CMS 13 TeV $t\bar{t}$ (l+j channel)* [2108.02803]



# New Datasets: DIS + jets

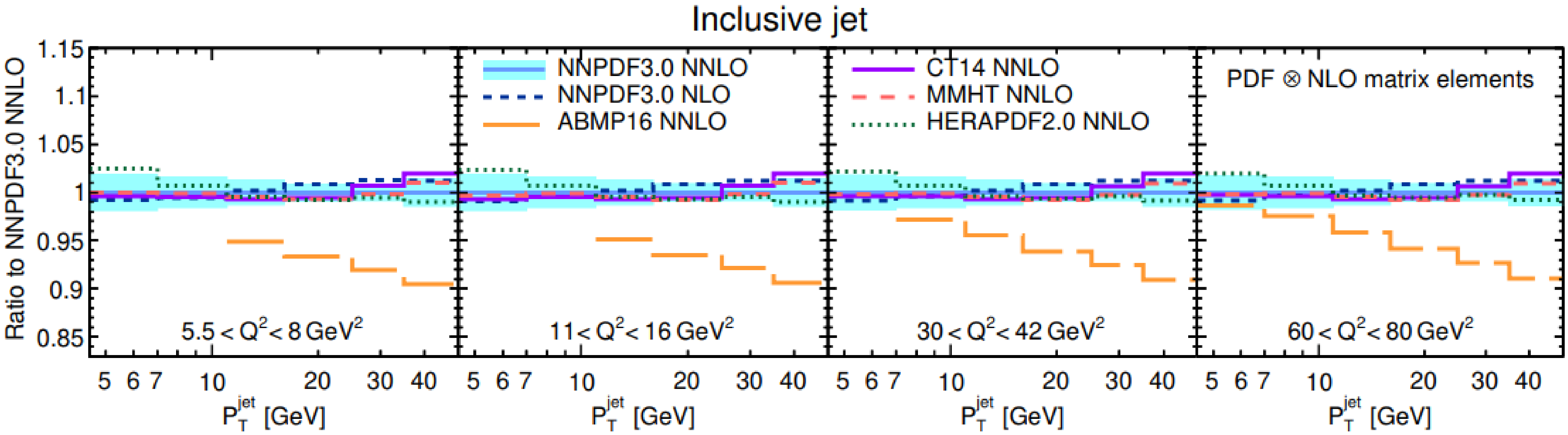
H1 Jets 319 GeV (290 $pb^{-1}$; $low\ q^2$) [1611.03421]

H1 Jets 319 GeV (351 $pb^{-1}$; $high\ q^2$) [1406.4709]

ZEUS Jets 300 GeV (38.6 $pb^{-1}$) [hep-ex/0208037]

ZEUS Jets 319 GeV (82 $pb^{-1}$) [hep-ex/0608048]

ZEUS Jets 319 GeV (374 $pb^{-1}$) [1010.6167]



# Note on Theory Predictions

- Top pair production: NNLO theories from MATRIX with dynamic scale based on [1611.08609]

$$\mu_R = \mu_R = \mu = {H_T}/{4} \, ; \; H_T = \sqrt{{m_t}^2 + (p_T^t)^2} + \sqrt{{m_t}^2 + (p_T^{\bar{t}})^2}$$

- Jets and DIS + Jets: NNLO theories from NNLOJET with dynamic scale based on [2005.11327] (from ploughshare)

$$\mu_R = \mu_R = \mu = H_T \, ; \;\; H_{T,jet} = \sum_{i \in partons} p_{T,i} \, ; \;\; H_{T,dijet} = m_{jj}$$

# Selection of distribution (kinematic variable)

- 3 figures of merit: dataset $\chi^2$, global $\chi^2$ and the z-score
- 1 criterion: choose datasets that minimize $\chi^2$ and have the lowest z-score
- $\chi^2 = (\boldsymbol{d} - \boldsymbol{t})^t C^{-1} (\boldsymbol{d} - \boldsymbol{t})$
- Stability of the exp. Cov. Mat. Given through a metric called the 'z-score' [2207.00690]
- $C = DRD$, $\min\left(eig.val.(R)\right) = \lambda_0$, then $Z = {\lambda_0}^{-\frac{1}{2}}$ whereby the required reduction in the value of correlations should be at most $(\sqrt{2}Z)^{-1}$

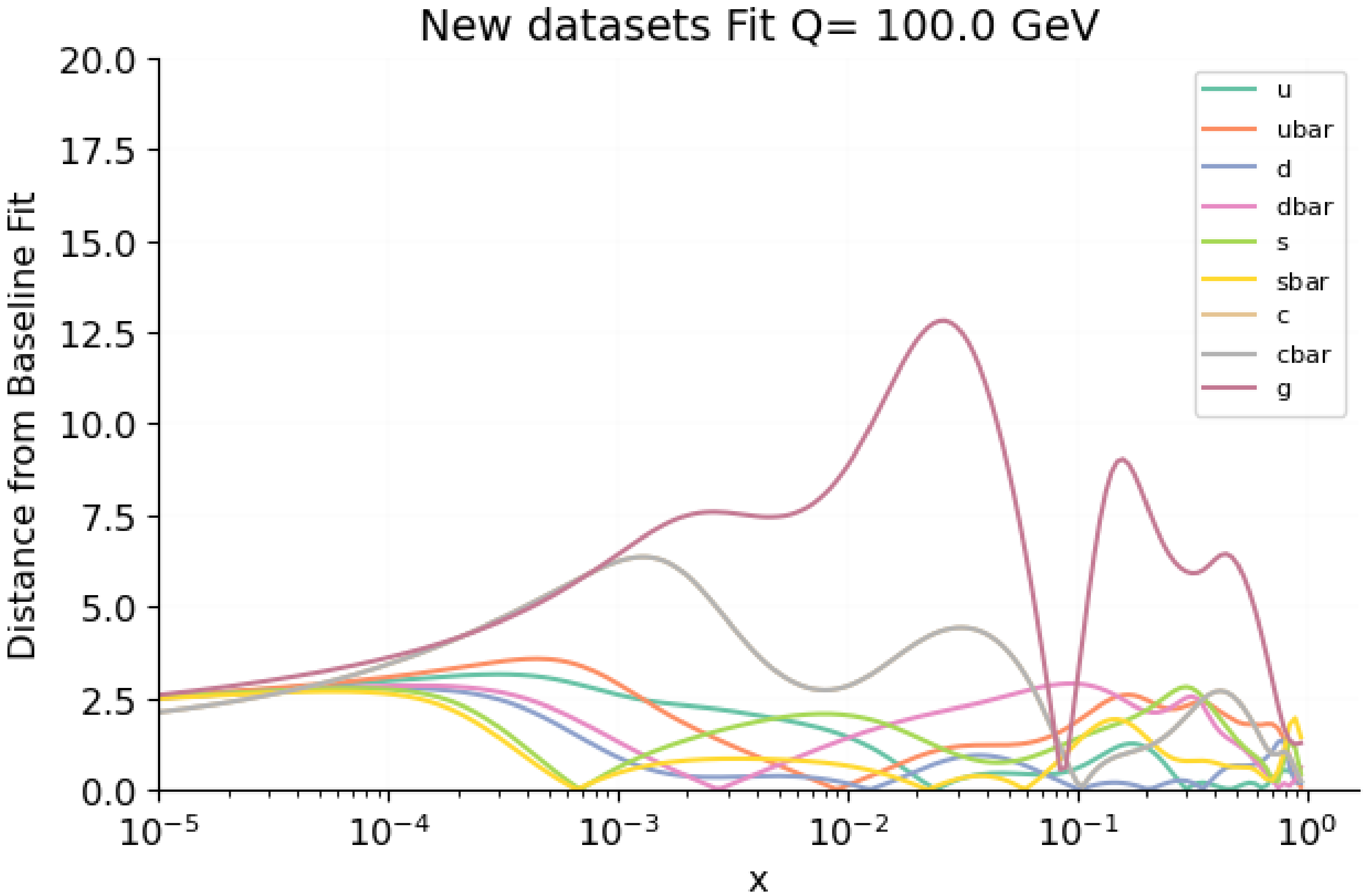
# Selected Datasets

| Dataset | Z-score | Dataset chi2 | Global chi2 |
|---|---|---|---|
| ATLAS_2JET_13TEV_DIF_MJJ-Y | 16.80 | 1.76 | 1.168 |
| ATLAS_TTBAR_13TEV_HADR_DIF_YTTBAR-NORM | 1.769 | 0.711 | 1.127 |
| ATLAS_TTBAR_13TEV_LJ_DIF_YT-NORM | 2.062 | 1.40 | 1.13 |
| CMS_1JET_13TEV_DIF_PT-Y-R07 | 14.81 | 2.25 | 1.153 |
| CMS_TTBAR_13TEV_LJ_DIF_PTT-NORM | 1.781 | 0.799 | 1.13 |
| H1_1JET_319GEV_290PB-1_DIF_PTQ2 | 5.991 | 2.64 | 1.145 |
| H1_1JET_319GEV_351PB-1_DIF_PTQ2 | 1.461 | 1.30 | 1.132 |
| H1_2JET_319GEV_290PB-1_DIF_PTQ2 | 7.668 | 2.84 | 1.148 |
| H1_2JET_319GEV_351PB-1_DIF_PTQ2 | 1.569 | 1.32 | 1.135 |
| ZEUS_1JET_300GEV_38P6PB-1_DIF_ETQ2 | 1.821 | 0.654 | 1.127 |
| ZEUS_1JET_319GEV_82PB-1_DIF_ETQ2 | 2.434 | 0.792 | 1.126 |
| ZEUS_2JET_319GEV_374PB-1_DIF_ETQ2 | 2.720 | 1.00 | 1.129 |

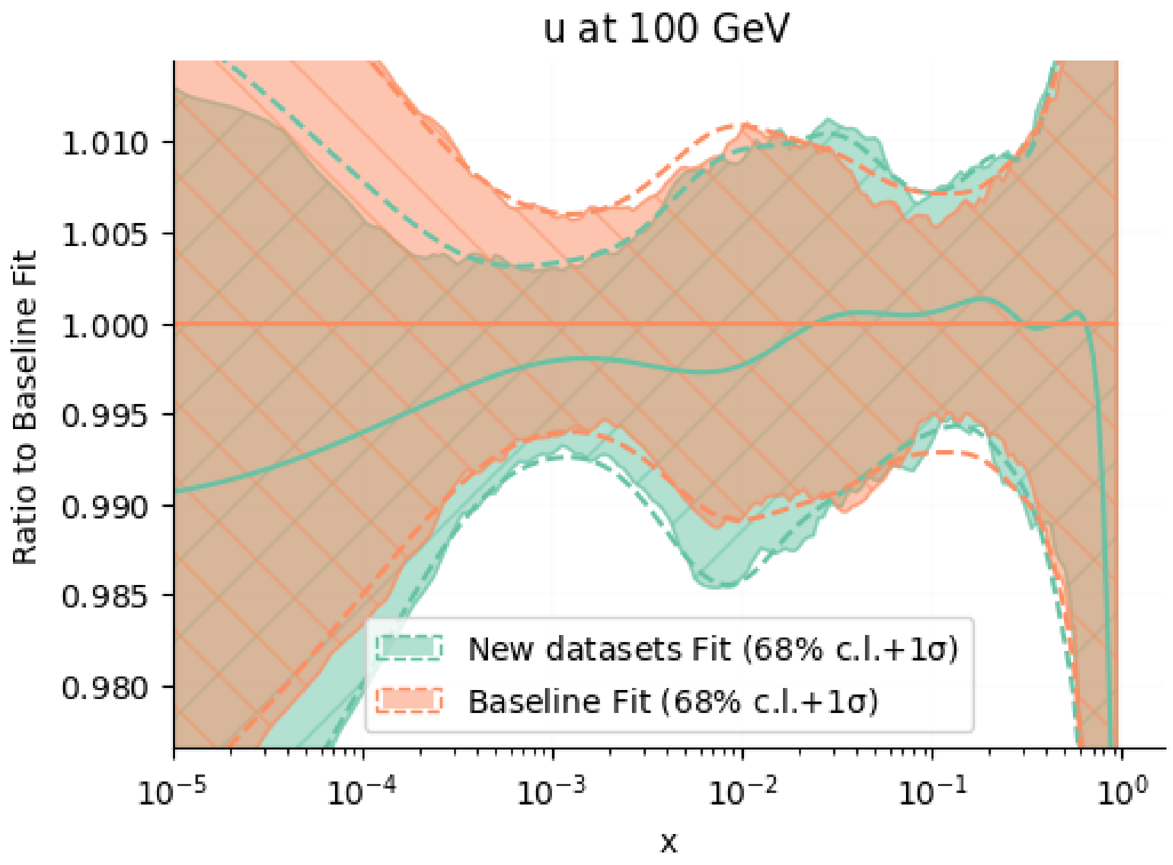
# Results: Global $\chi^2$ & PDF Distances

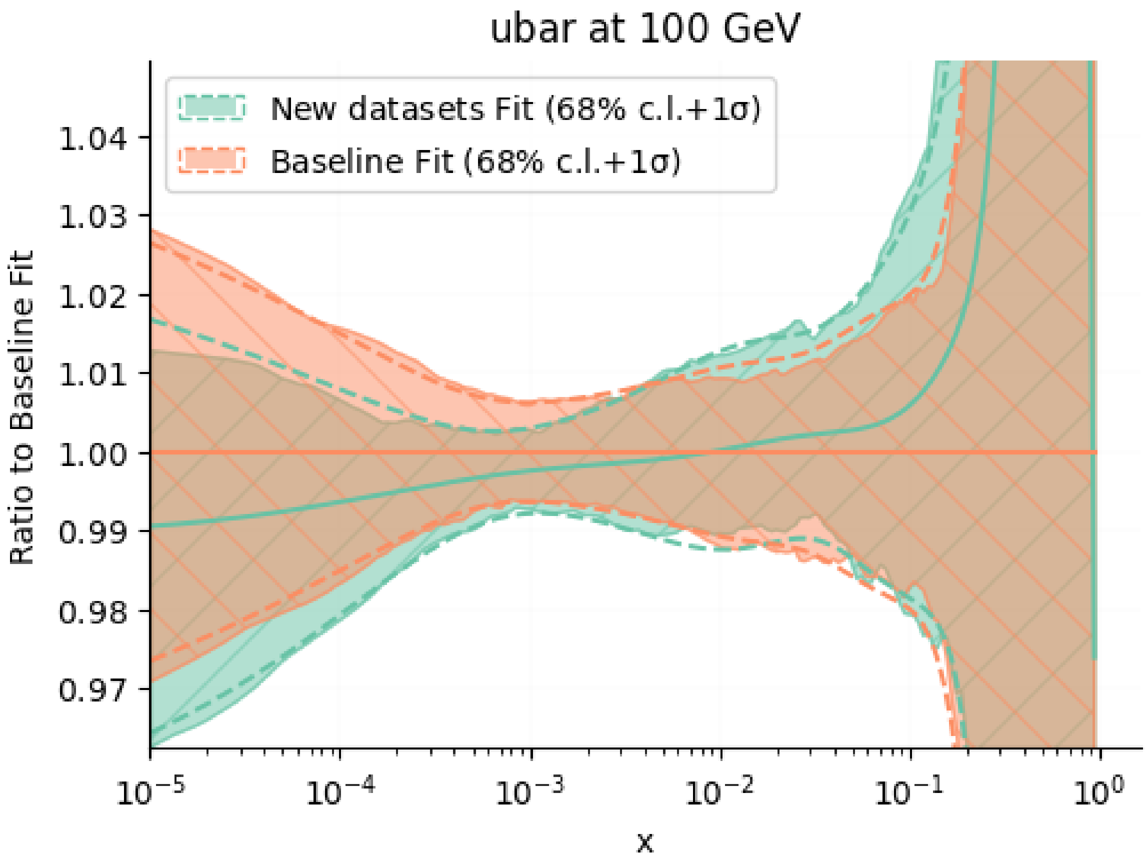
Baseline: 1.128

Fit with new datasets: 1.228

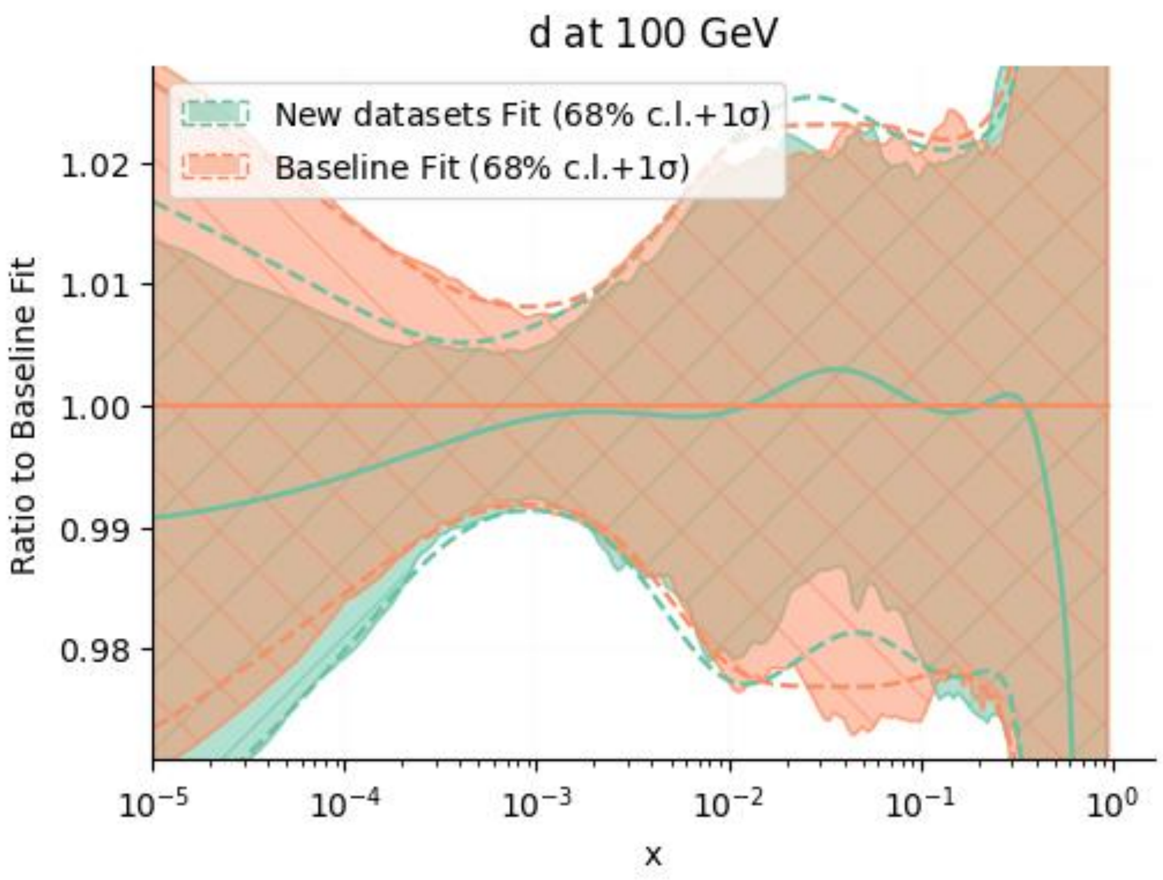


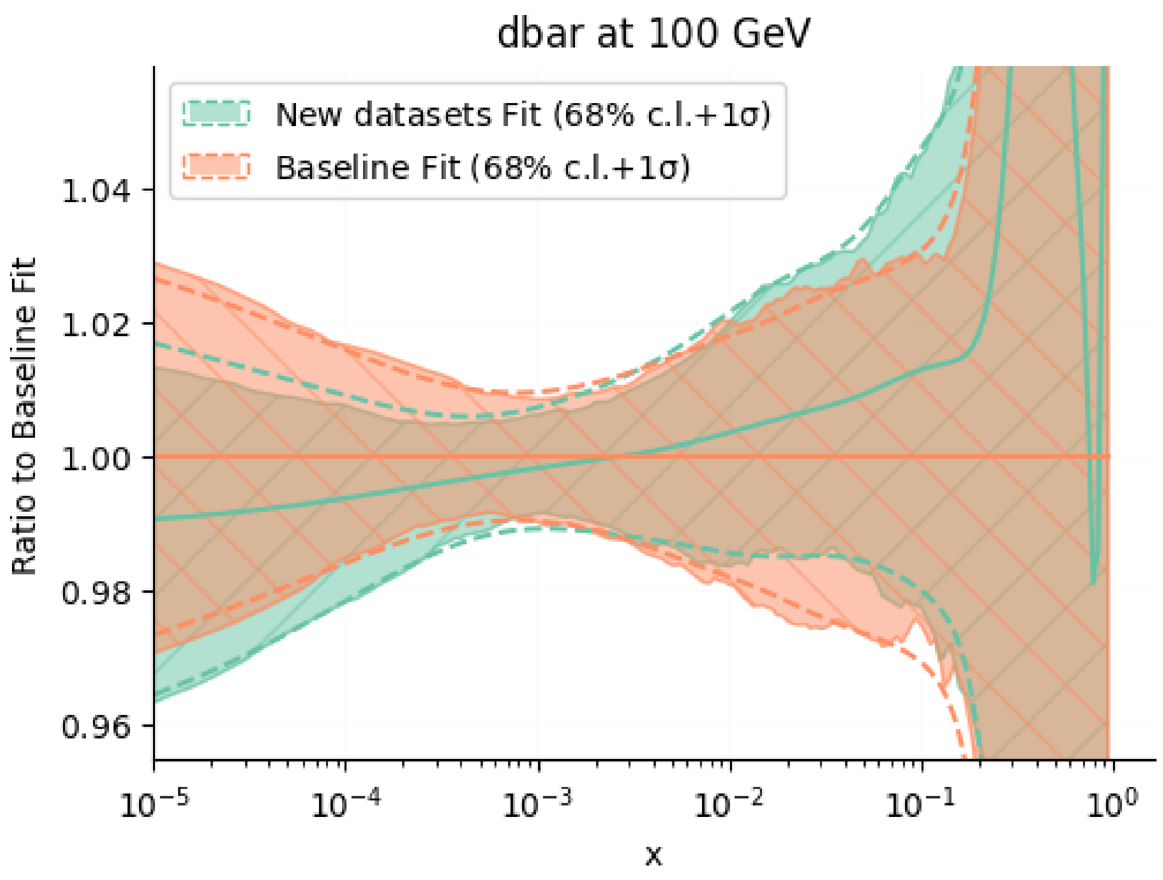
# Results: Quark PDF Plots



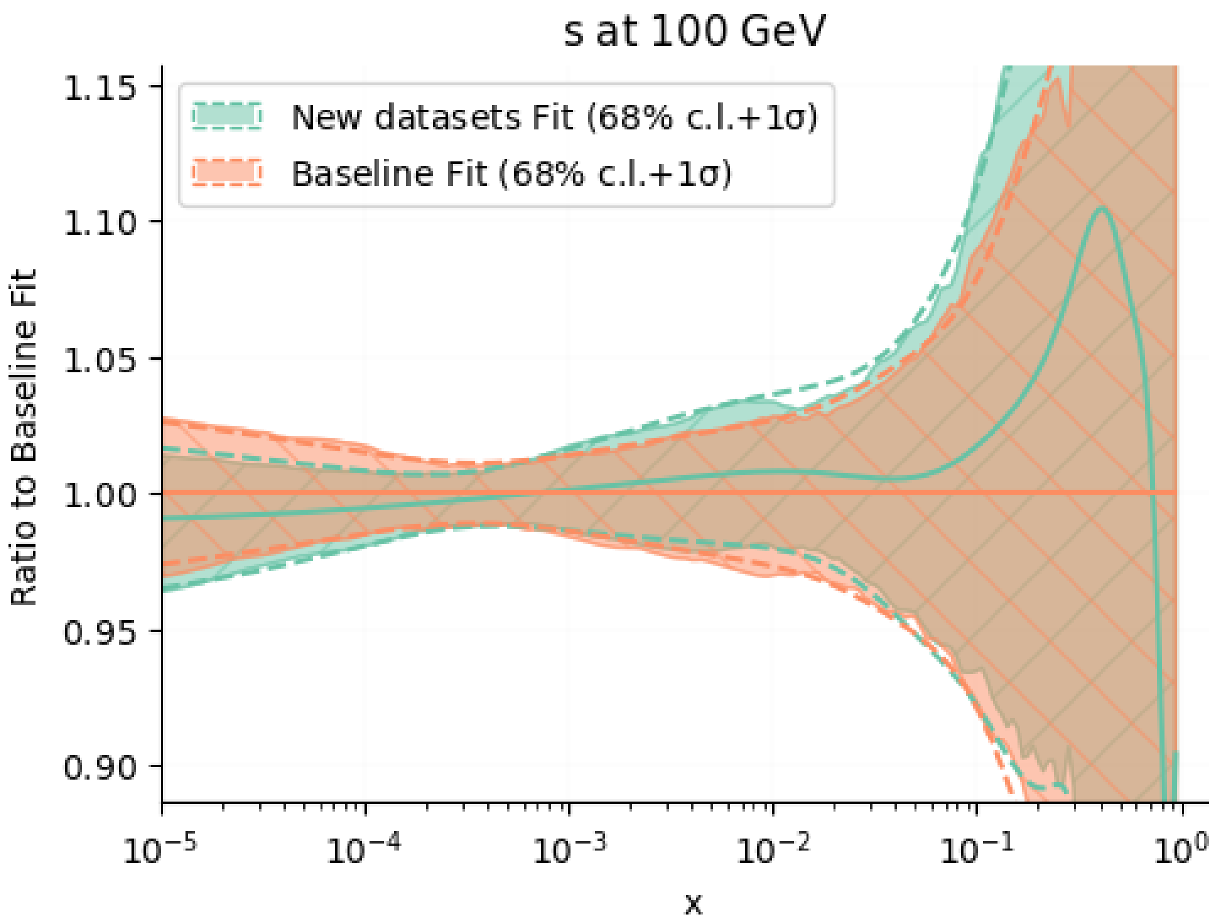



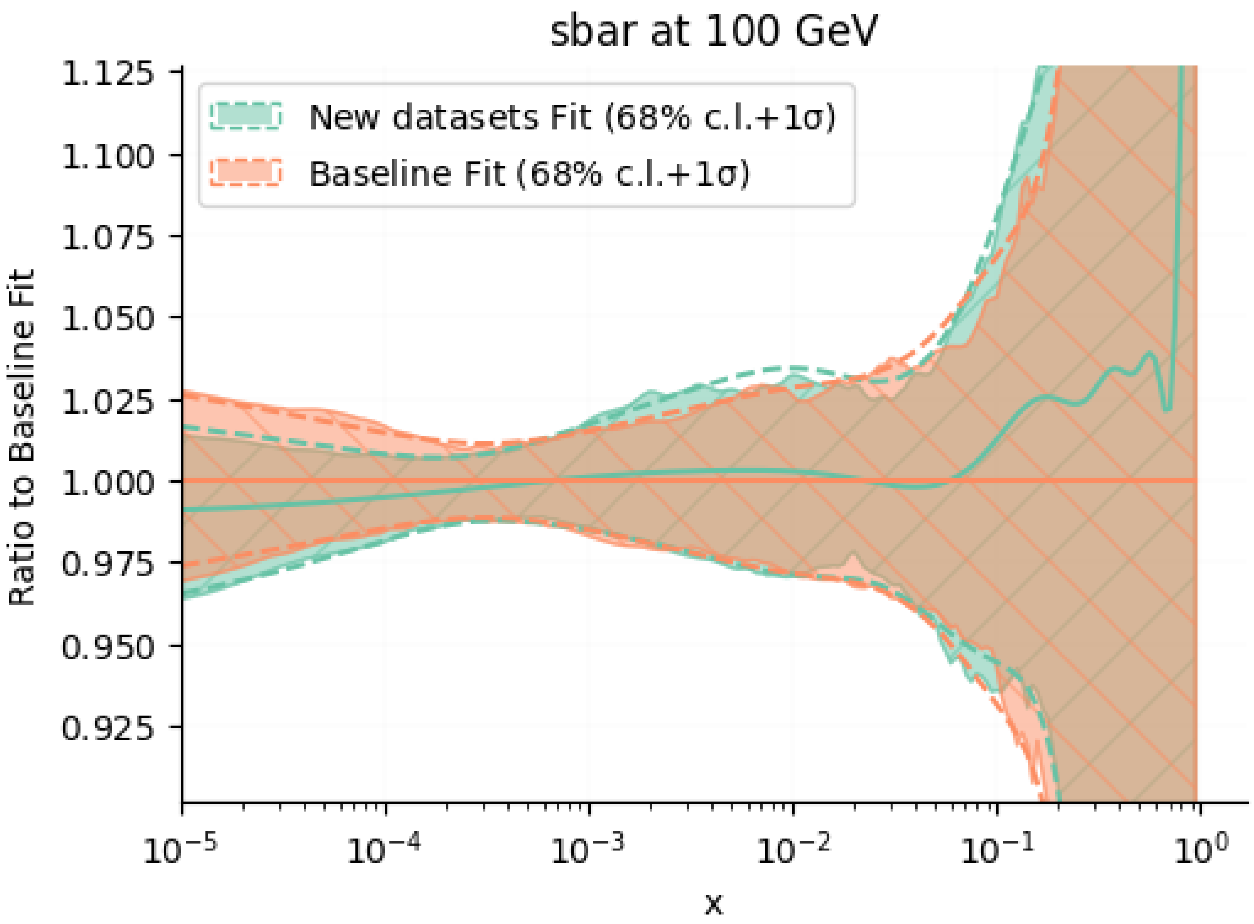
# Results: Quark PDF Plots



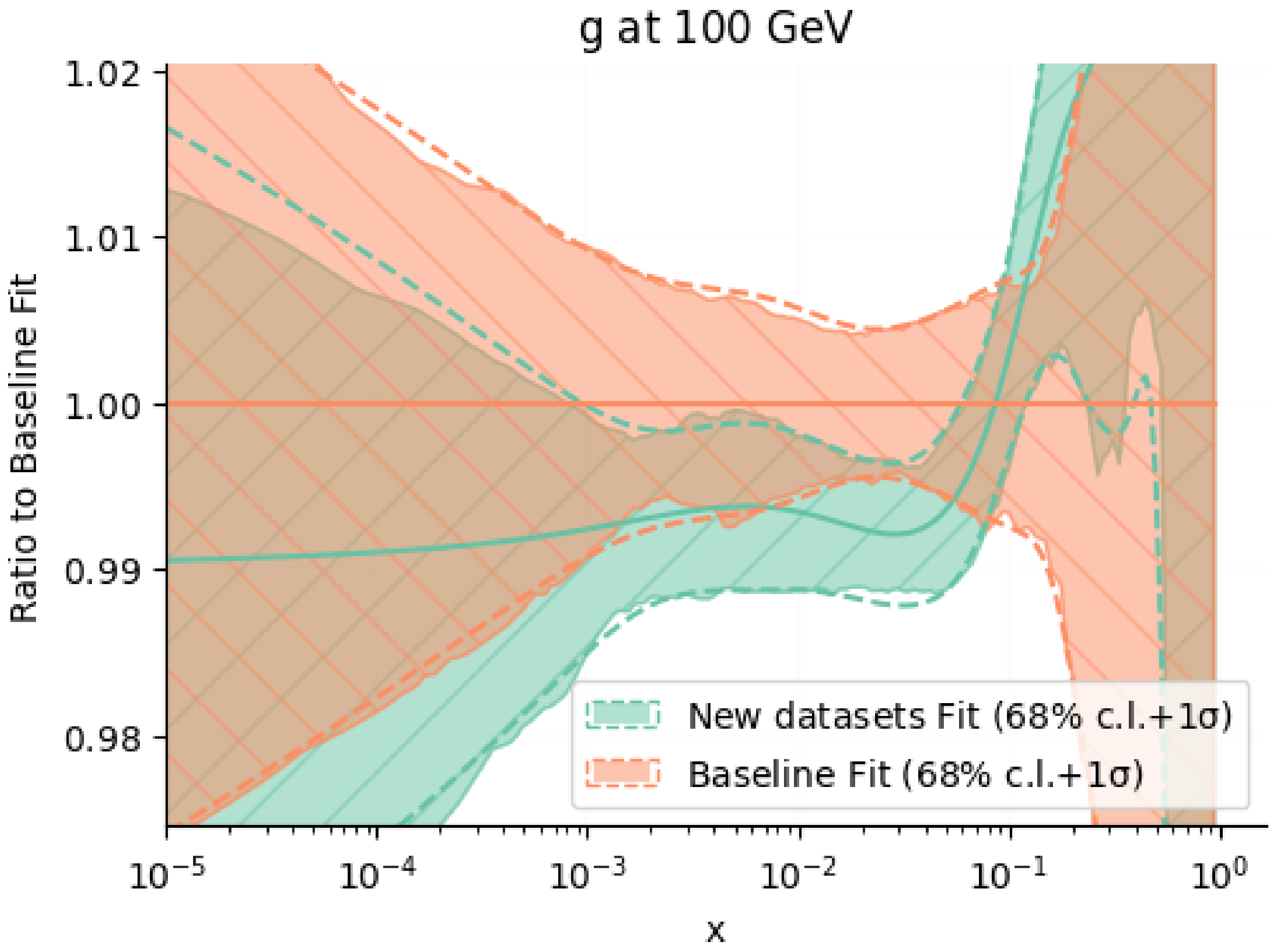



# Results: Quark PDF Plots

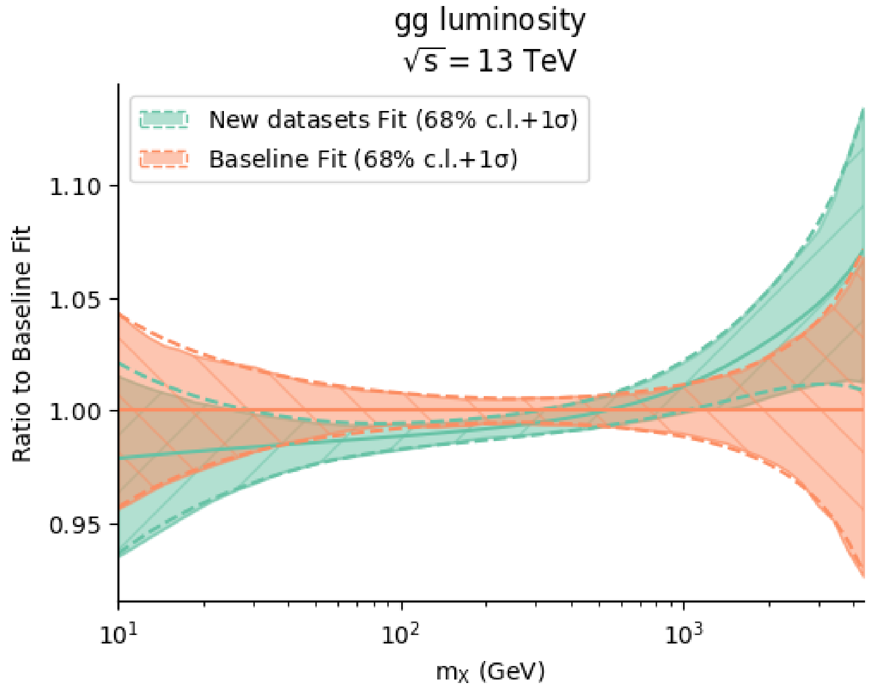


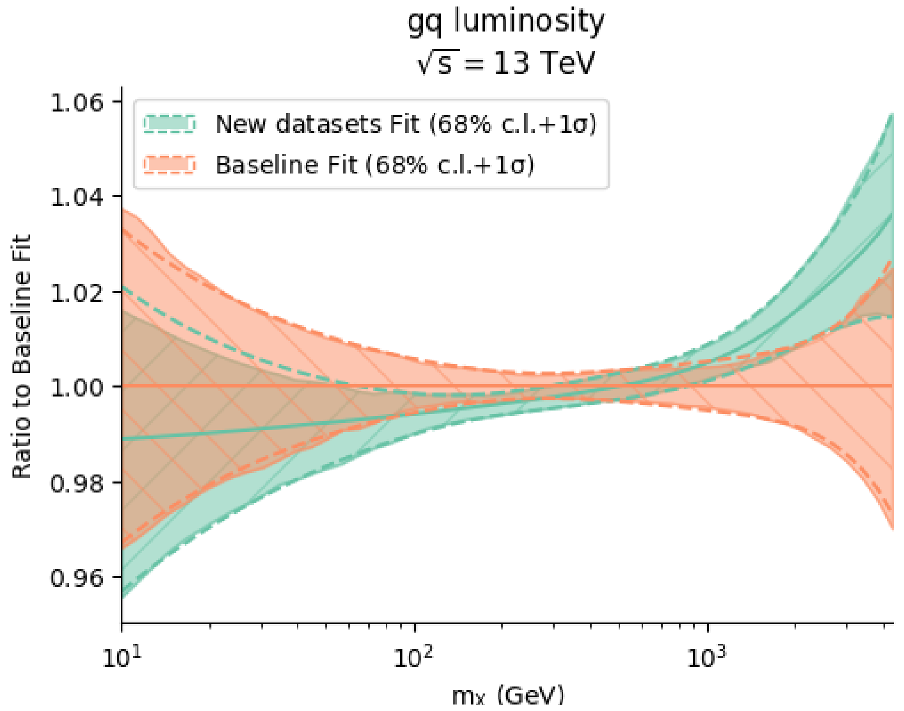



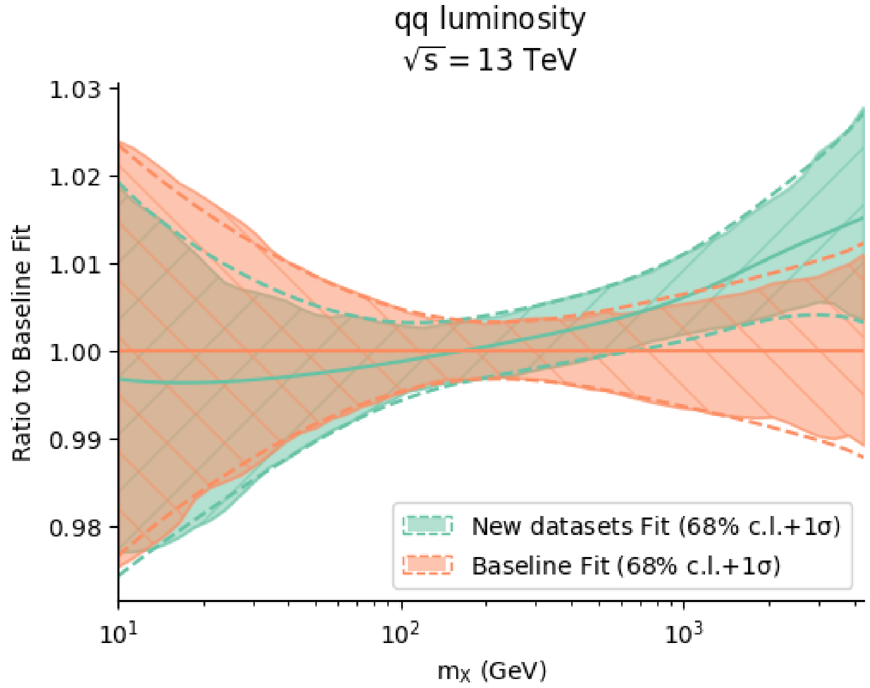
# Results: Gluon PDF

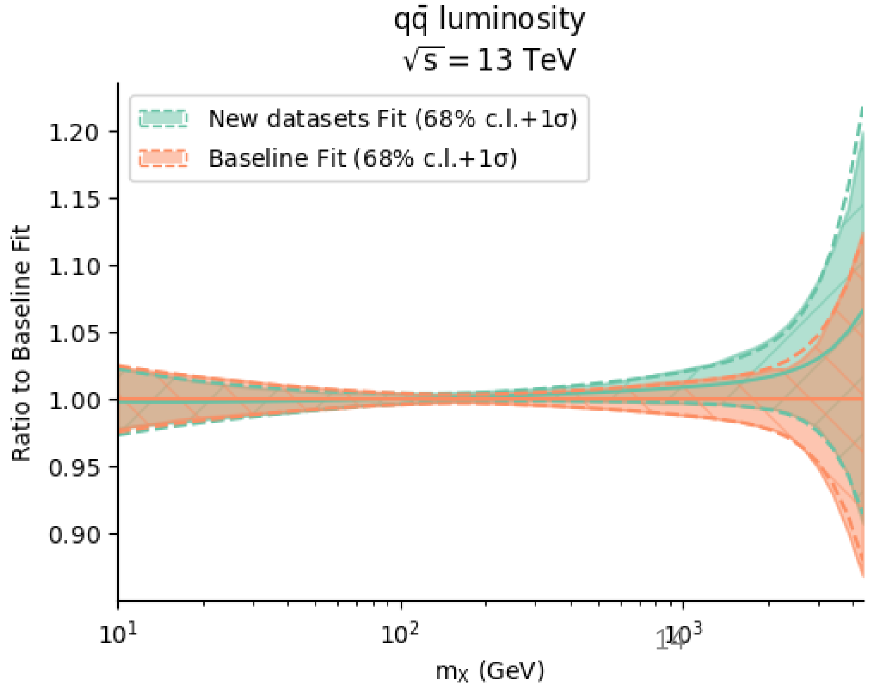


# Results: PDF Luminosities

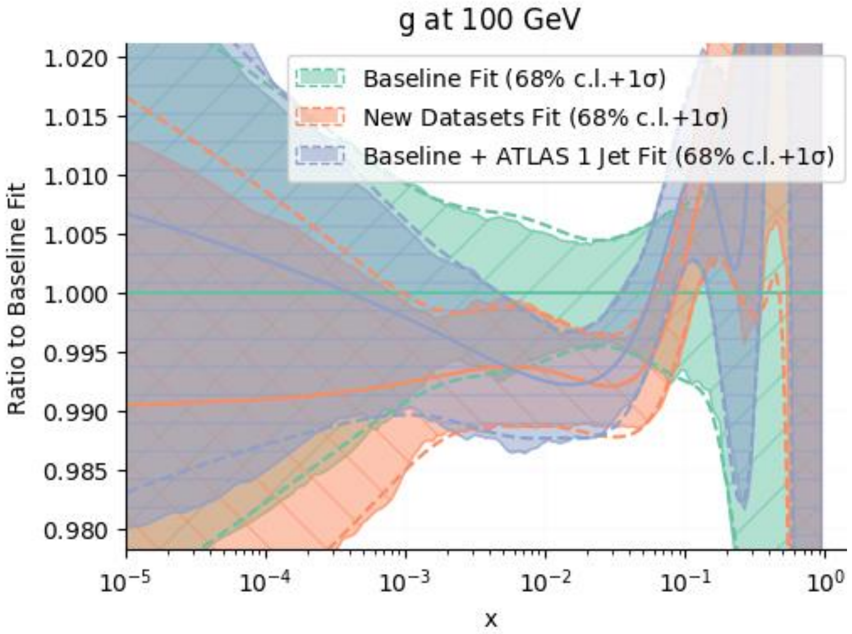


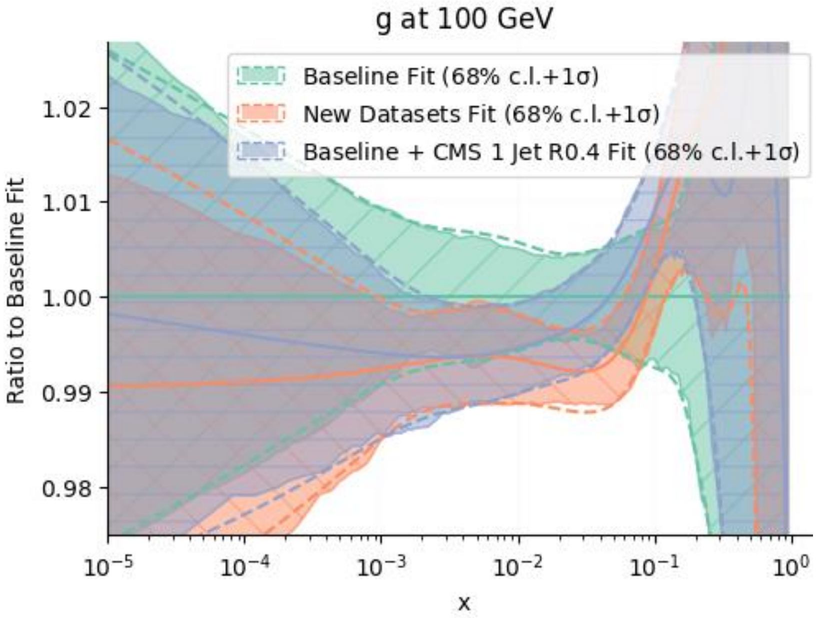



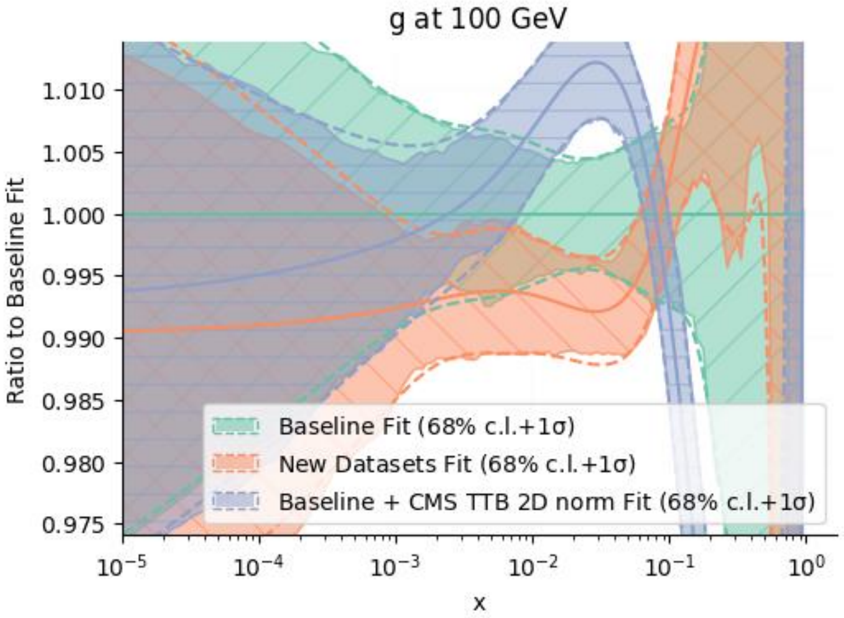



# A look at select excluded datasets



# Summary

- Baseline fit: NNPDF4.0 + MHOUs [2401.10319] + NNLO $t\bar{t}$ theories
- New datasets from LHC 13 TeV Jets and $t\bar{t}$ and HERA Jets
- Dataset selection based on $\chi^2$ and z-score
- Little difference in quark PDFs
- Clear Impact on gluon PDF
- The shifting of gluon PDF within uncertainty bands
- NNPDF4.0 with its uncertainties can accommodate new datasets

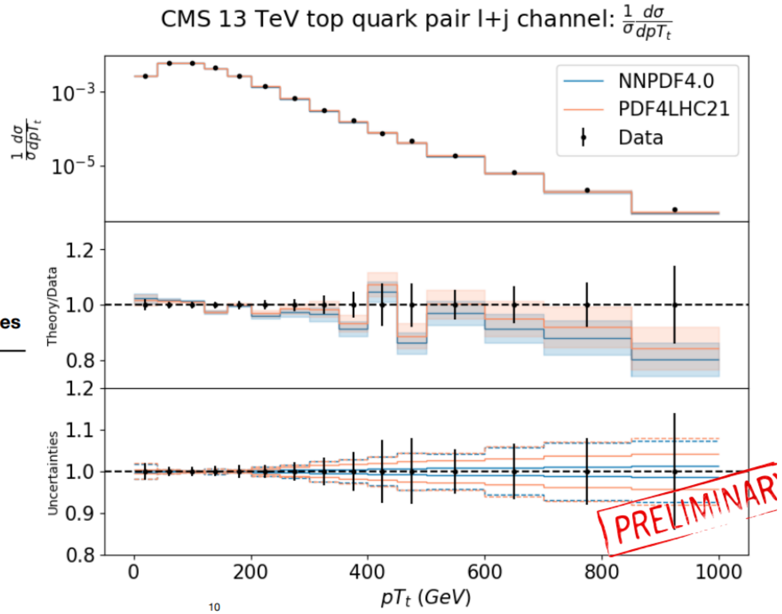
# Backup: JCM's DTCs

## CMS TTB

Differential $t\bar{t}$ production at $\sqrt{s} = 13$ TeV

Predictions: MATRIX
Hepdata: 10.17182/hepdata.102956

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 0.658 | 0.647 |
| NNPDF40 | 0.817 | 0.811 |

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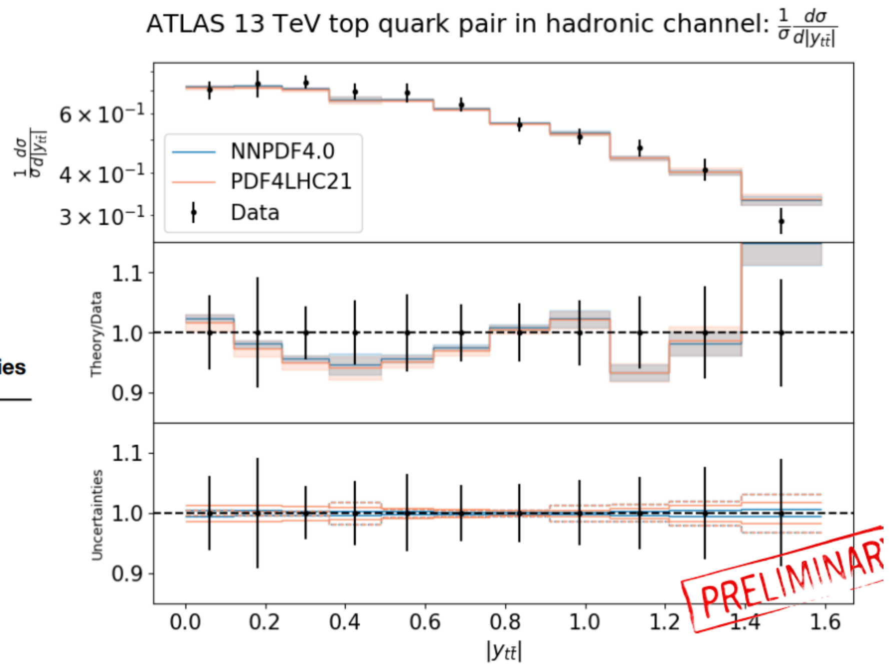
## ATLAS TTB

Differential $t\bar{t}$ production at $\sqrt{s} = 13$ TeV

Predictions: MATRIX
Hepdata: 10.17182/hepdata.95758

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 0.772 | 0.750 |
| NNPDF40 | 0.713 | 0.711 |

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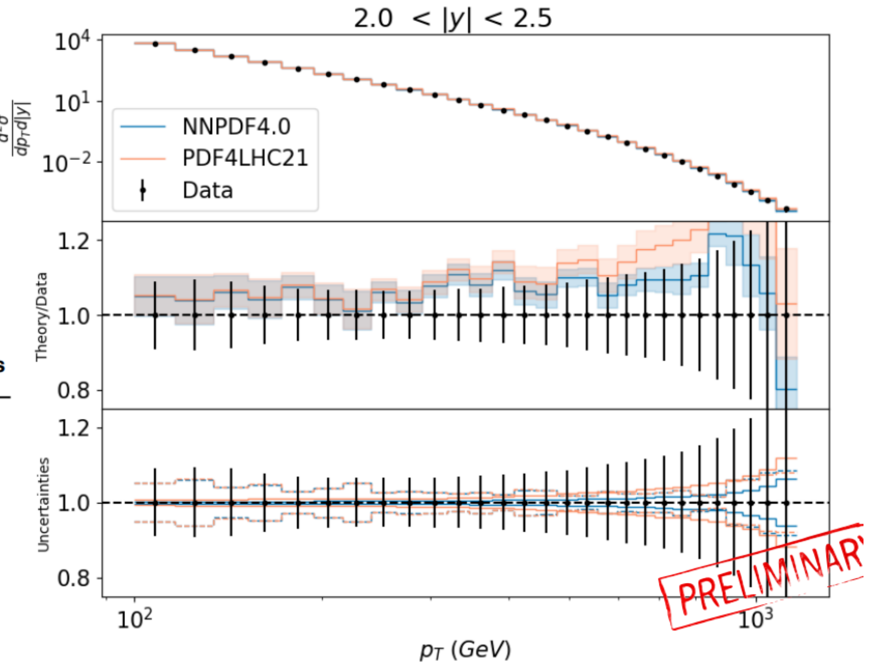
## Atlas 1jet

Inclusive jet cross-sections at $\sqrt{s} = 13$ TeV. Dataset with 3.2fb-1 2015.
Leading color NNLO correction

Predictions: NNLOJET (plougshare)
Hepdata: 10.17182/hepdata.79952

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 4.62 | 3.93 |
| NNPDF40 | 4.78 | 4.59 |

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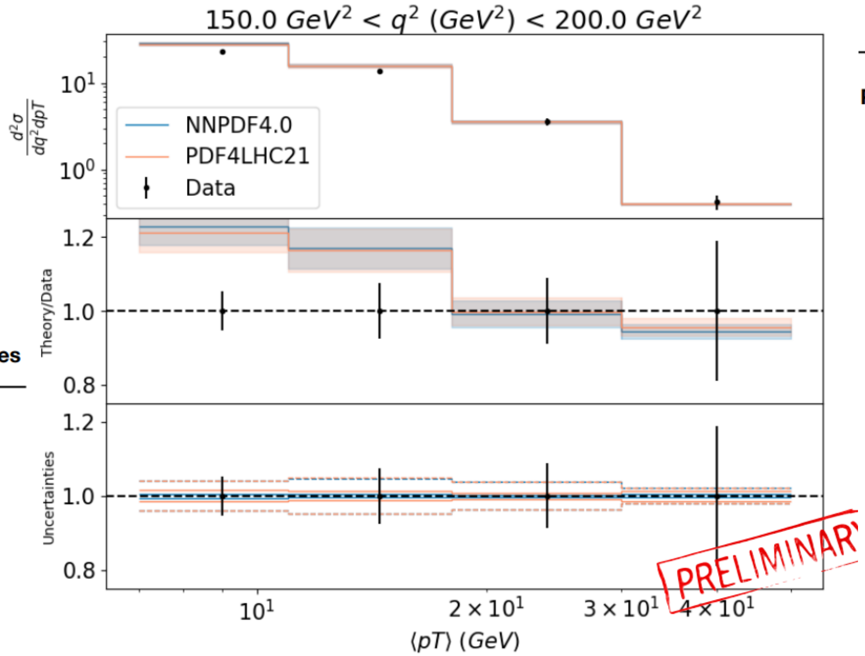
# Backup: JCM's DTCs

## H1 dijet

Data taken from 2003 to 2007, integrated luminosity of 351pb-1

Predictions: NNLOJET (plougshare)
Hepdata: 10.17182/hepdata.64353

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 1.50 | 1.49 |
| NNPDF40 | 1.54 | 1.50 |

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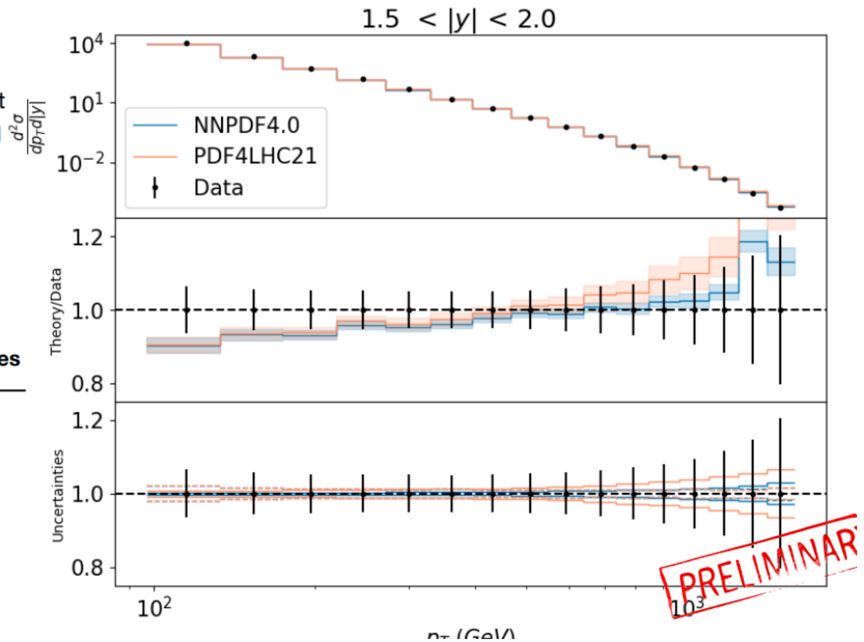
## CMS 1jet

Inclusive jet cross-sections at $\sqrt{s} = 13$ TeV. Dataset with 33.5fb-1 (data for anti-kT radius of 0.7)
Leading color NNLO correction

Predictions: NNLOJET (plougshare)
Hepdata: 10.17182/hepdata.115022.v2

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 4.76 | 2.85 |
| NNPDF40 | 3.81 | 3.23 |

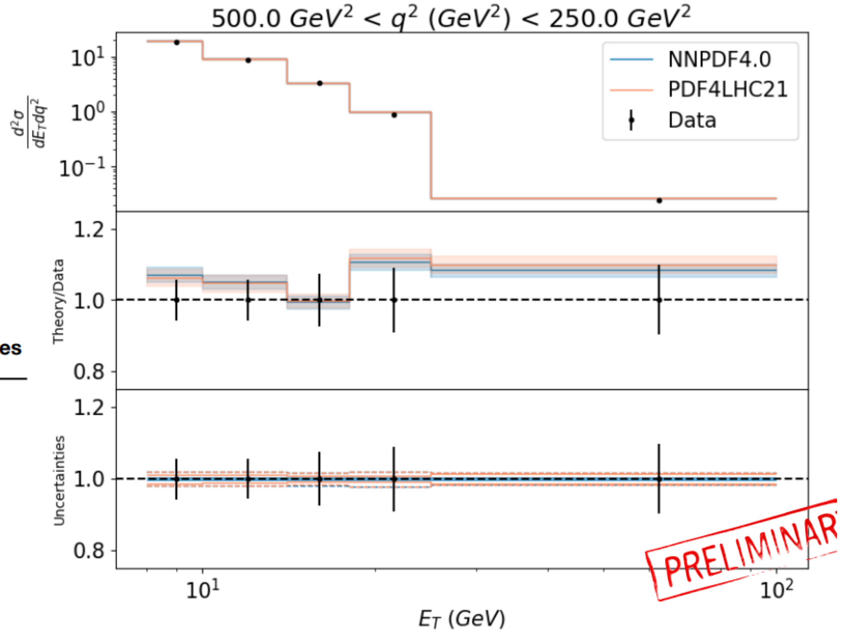



## Zeus 1jet

Inclusive jet differential cross section, integrated luminosity of 82pb-1

Predictions: NNLOJET (plougshare)
Hepdata: 10.17182/hepdata.45641

| $\chi^2/N$ | Only exp. and th. unc. | All uncertainties |
|---|---|---|
| PDF4LHC21 | 0.819 | 0.817 |
| NNPDF40 | 0.813 | 0.813 |

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