MSTW PDF Studies From ATLAS Jet Data

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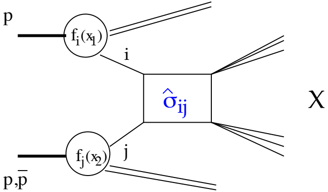
Outline

- Introduction to PDFs
- MSTW method
- Inclusive Jets/Dijets at ATLAS
- Calculational Methods
- Effects of the data on current PDFs

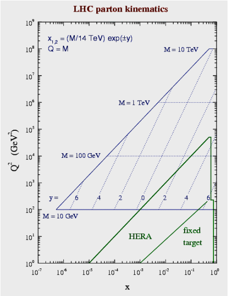
PDFs



- PDFs encode the incalculable non-perturbative physics involved in hadron collisions.

$$\sigma_{AB} = \sum_{a.b=q,g} \hat{\sigma}_{ab} \otimes f_{a/A}(x_1, Q^2) \otimes f_{b/B}(x_2, Q^2)$$

- Kinematic (x, Q^2) range at LHC far greater than previous experiments.



MSTW method

Parameters

$$xu_v(x,Q_0^2) = A_u x^{\eta_1}(1-x)^{\eta_2}(1+\epsilon_u\sqrt{x}+\gamma_u x)$$

$$xd_v(x,Q_0^2) = A_d x^{\eta_3}(1-x)^{\eta_4}(1+\epsilon_d\sqrt{x}+\gamma_d x)$$

$$xS(x,Q_0^2) = A_S x^{\delta_s}(1-x)^{\eta_S}(1+\epsilon_S\sqrt{x}+\gamma_S x)$$

$$x\Delta(x,Q_0^2) = A_\Delta x^{\eta_\Delta}(1-x)^{\eta_{S+2}}(1+\gamma_\Delta x+\delta_\Delta x^2)$$

$$xg(x,Q_0^2) = A_g x^{\delta_g}(1-x)^{\eta_g}(1+\epsilon_g\sqrt{x}+\gamma_g x) + A_{g'} x^{\delta_g'}(1-x)^{\eta_{g'}}$$

$$x(s+\bar{s})(x,Q_0^2) = A_+ x^{\delta_S}(1-x)^{\eta_+}(1+\epsilon_S\sqrt{x}+\gamma_S x)$$

$$x(s-\bar{s})(x,Q_0^2) = A_- x^{\delta_-}(1-x)^{\eta_-}(1-\frac{x}{x_0})$$

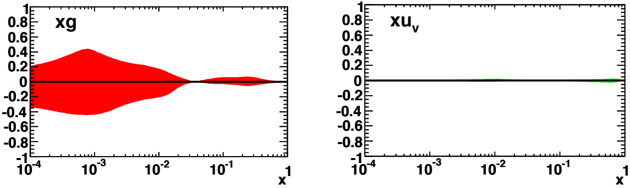
Sum rules constrain

$$A_u, A_d, A_g, x_0$$

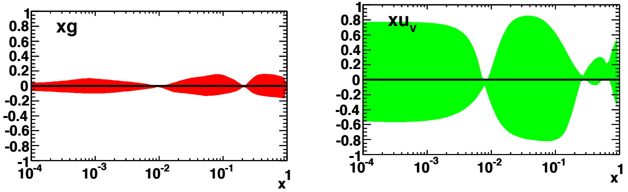
30 free parameters reduce to 20 eigenvector directions.

Eigenvectors

Each eigenvector contributes to the distributions differently. For example:



Eigenvector 1



Eigenvector 18

Dependence of cross-sections on different partonic initial states probed by response to different eigenvectors.

NLO Calculation - NLOjet++ and APPLgrid

- This study: ATLAS inclusive jets and dijets
- **NLOjet++** fully NLO calculation of jet observables. No soft corrections. Very long calculation times.
- **APPLgrid** interface to NLOjet++ allowing a posteriori inclusion of PDFs/scales.
- Predictions generated for scales multiples of pT for inclusive, multiples of pT_{av} for dijet.
- Currently generating multiples of M_{jj} for dijets due to lack of stability using pT_{av}.
- Predictions for all MSTW eigenvalue sets.
- Similar to **FastNLO** method. Results from both methods agree to good level of accuracy.

Treatment of Systematics

χ^2 for determining fit to data must include one nuisance parameter for each systematic.

$$\chi^2 = \sum_{i=1}^{N_{pts}} \left(\frac{D_i - \sum_{k=1}^{N_{corr}} r_k \sigma_{k,i}^{corr} - T_i}{\sigma_i^{uncorr}} \right)^2 + \sum_{k=1}^{N_{corr}} r_k^2$$

$$r_k = \sum_{k'=1}^{N_{corr}} (A^{-1})_{kk'} B_{k'}$$

$$A_{kk'} = \delta_{kk'} + \sum_{i=1}^{N_{pts}} \frac{\sigma_{k,i}^{corr} \sigma_{k',i}^{corr}}{(\sigma_i^{uncorr})^2}, B_k = \sum_{i=1}^{N_{pts}} \frac{\sigma_{k,i}^{corr}(D_i - T_i)}{(\sigma_i^{uncorr})^2}$$

Individual systematics included multiplicatively (multiply percentage uncertainties by **shifted** data values). Large difference in results when using additive (multiply by **unshifted** data)

Effect of Jet Data on MSTW

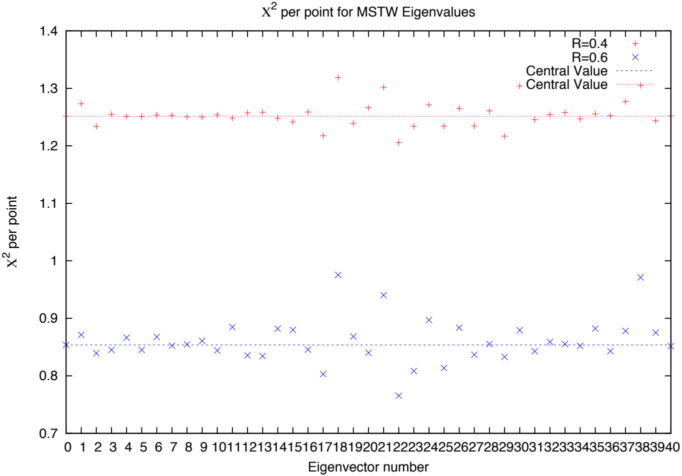
Table 1: χ^2 per point (90 points)

Scale	pT/2	pT	2pT
Inclusive (R=0.4)	0.580	0.548	0.522
Inclusive (R=0.6)	0.630	0.584	0.587
Dijet (R=0.4)	3.12	1.67	1.76
Dijet (R=0.6)	2.78	1.64	1.34

Table 2: Distribution of r_ks (Total 88)

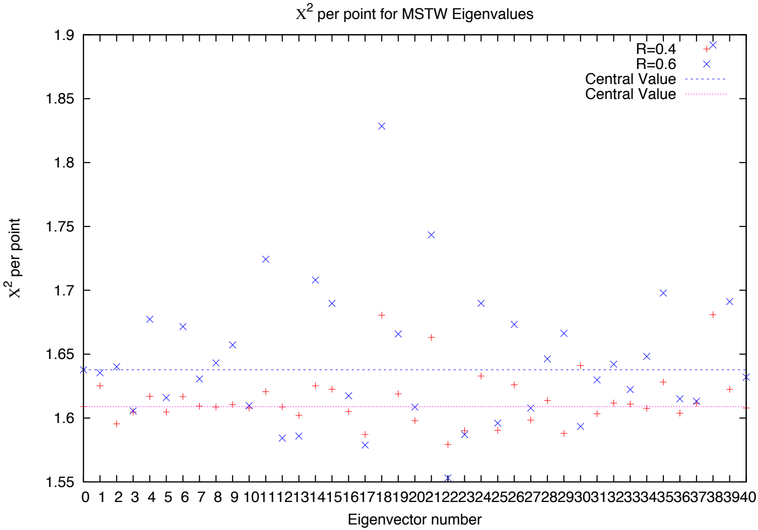
	$\|r_k\| < 1$	$1 < \|r_k\| < 2$	$2 < \|r_k\| < 3$	$3 < \|r_k\| < 4$
Inclusive (R=0.4)	74	13	1	0
Inclusive (R=0.6)	71	16	1	0
Dijet (R=0.4)	60	25	2	0
Dijet (R=0.6)	55	30	2	0

MSTW Eigenvectors - Inclusive Jets



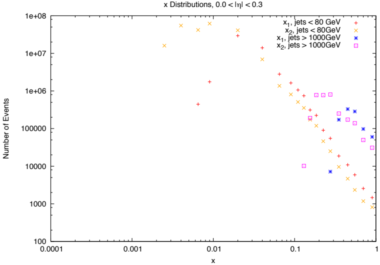
- Main fluctuations from eigenvalues 9, 18: sensitive to low-x gluon and valence quark distributions.

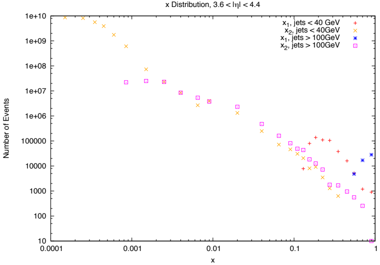
MSTW Eigenvectors - Dijets



- Less dependence on R, higher fluctuations.

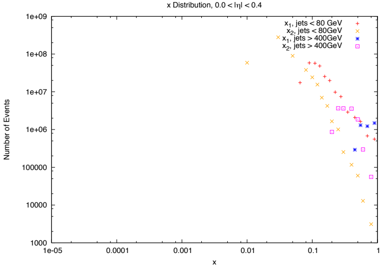
x Reach -LHC

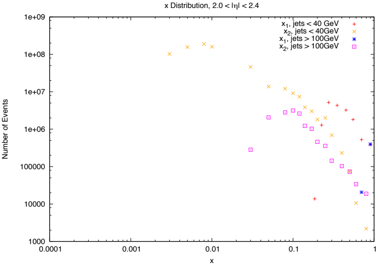




- High eta - lowest x reach.
- Low eta - good percentage of high x at high pT

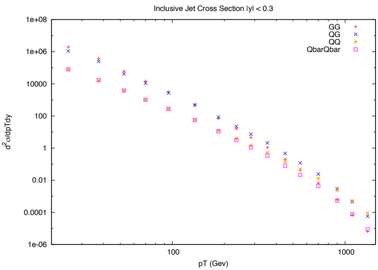
x Reach - Tevatron

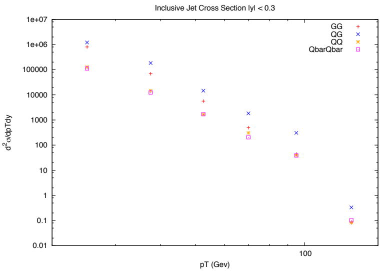




- Tevatron - less x reach
- Similar behaviour for high x

Subprocesses



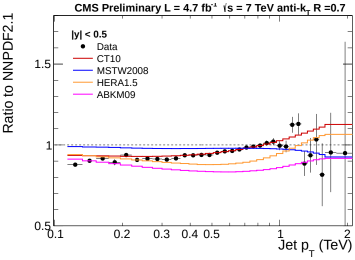


- Central jets - low pT dominated by gg, high pT by qq.
- Forward jets - all regions dominated by qg.

Conclusions and Further Work

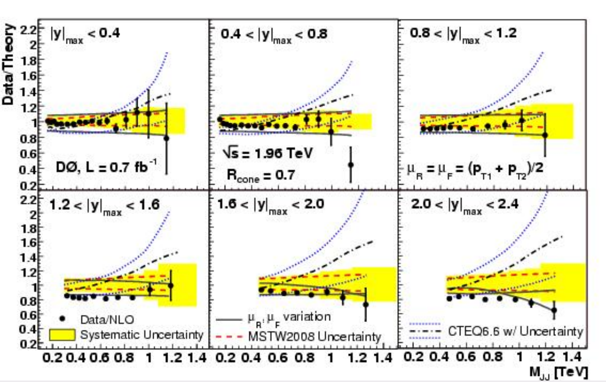
- Inclusive jet data fits well to current NLO PDFs. Not yet hugely discriminating for initial state.
- Dijet data more discriminating but worse fit - scale choice pT_{av} unstable at high eta.
- Currently testing other scale choices for dijets at TVT and LHC.
- Utilitise jet data from HERA, Tevatron and LHC together.

More Data



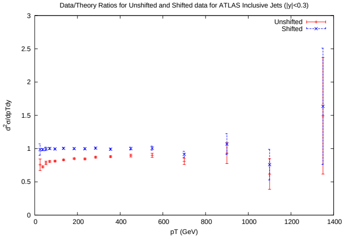
- Inclusive/Dijet data with $4.7 fb^{-1}$ soon to be released.

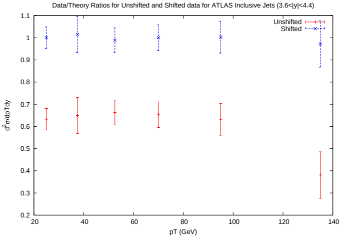
Backup - Dijet scale choice, DZero



- Plot from D0 collaboration
- Scale choice pT_{av}
- At forward rapidities, prediction falls off dramatically

Backup - Ratio Plots (Inclusive)





Backup - Ratio Plots (Dijet)