DYRes and DYqT comparison for Vector Boson production

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- Intrduction: DYRes and DYqT programs;
- p_T distributions for W and Z bosons;
- The role of renormalization, factorization and resummation scaling;
- Parton Distributions impact on p_T spectra;
- Conclusions and future achievements.

- DYRes computes the transverse momentum (p_T) distribution of Drell-Yan lepton pairs of high invariant mass;
- We include leptonic decay of vector bosons with spin correlations, finite width effects and dependence on lepton variables;
- Computation can be performed up to NNLO+NNLL (current QCD best accuracy).

- The DYqT calculation combines the fixed-order result at high values of p_T up to $\mathcal{O}(\alpha_S^2)$ with the resummation of the logarithmically enhanced contributions at small values of p_T up to NNLL;
- The program can be used at LO+NLL and NLO+NNLL;
- At NLO+NNLL (LO+NLL) the result reproduces the NNLO (NLO) after integration upon p_T.

Theoretical scaling provides a good estimation for p_T distributions uncertainties

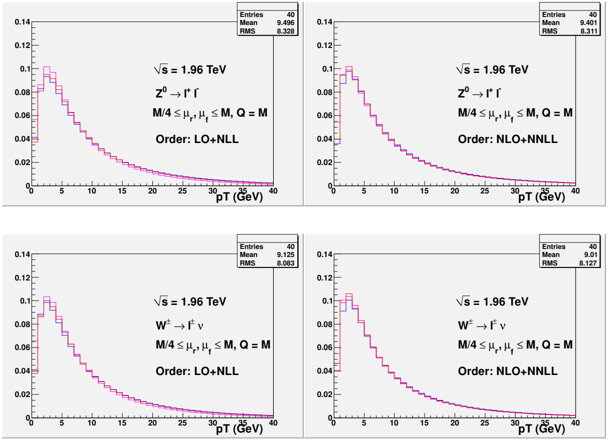
- Non Dependent scaling:
  $(\mu_R, \mu_F, Q) = (M/2, M/4, M)$,
  $(\mu_R, \mu_F, Q) = (M/4, M/2, M)$
- Dependent scaling:
  $(\mu_R, \mu_F, Q) = (M/4, M/4, M)$,
  $(\mu_R, \mu_F, Q) = (M/2, M/2, M)$
- Non-Perturbative smearing scaling
  $g_{NP} = (0, 0.5, 1)$. Model $\exp(-g_{NP} b^2)$, b = impact parameter.

Changing PDFs set allows accurate kinematical test in perturbation theory

- `MSTW2008` : MSTW2008nlo68cl (nnlo);
- `MSTW2004`: MSTW2004nlo (nnlo);
- `NNPDF3.0`: NNPDF30nloAs0118 (nnlo);
- `NNPDF2.3`: NNPDF23nloAs0118 (nnlo).

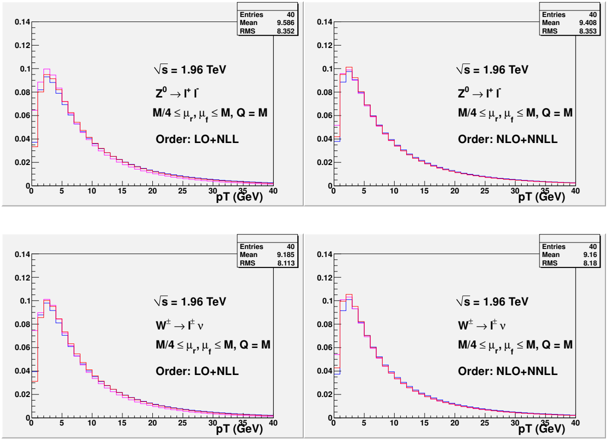
Keep the same order in calculation as well as PDF set.

- p_T distributions: results for MSTW2008



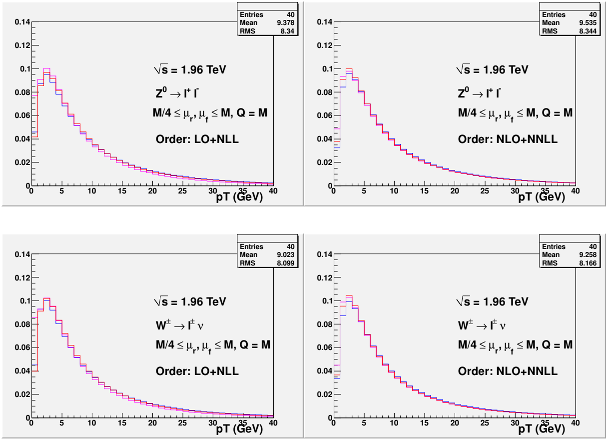
- ■ un-scaled μ_R and μ_F, ■ for $\mu_R, \mu_F = M_b/4$ and ■ for $\mu_R, \mu_F = M_b/2$.

- p_T distributions: results for MSTW2004



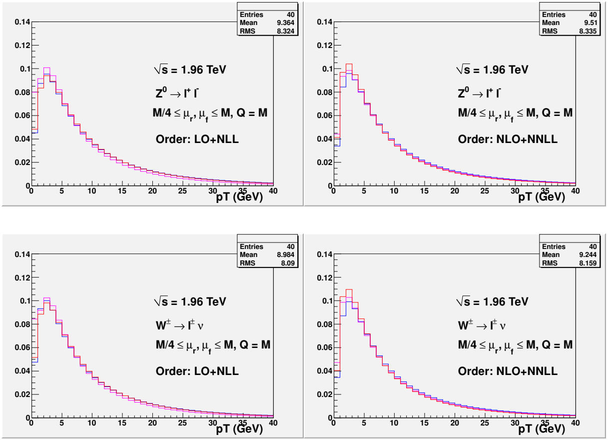
- ■ un-scaled μ_R and μ_F, ■ for $\mu_R, \mu_F = M_b/4$ and ■ for $\mu_R, \mu_F = M_b/2$.

- p_T distributions: results for NNPDF3.0



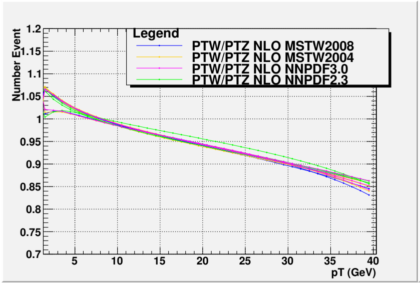
- ■ un-scaled μ_R and μ_F, ■ for $\mu_R, \mu_F = M_b/4$ and ■ for $\mu_R, \mu_F = M_b/2$.

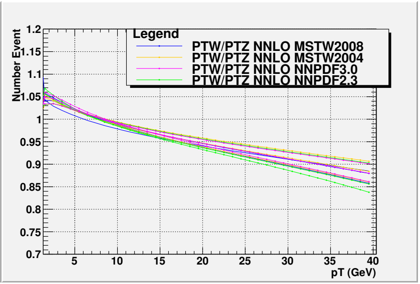
- p_T distributions: results for NNPDF2.3



- ■ un-scaled μ_R and μ_F, ■ for $\mu_R, \mu_F = M_b/4$ and ■ for $\mu_R, \mu_F = M_b/2$.

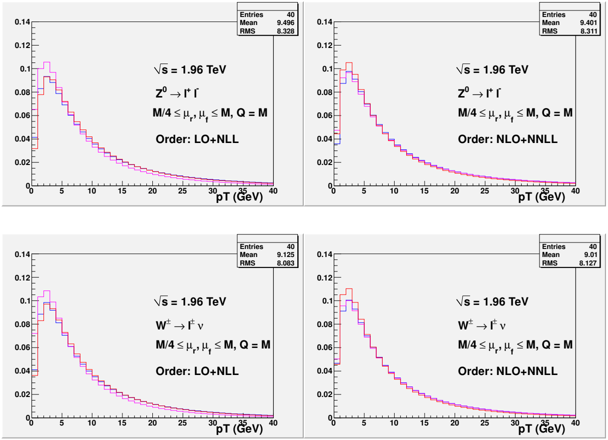
- p_T^W/p_T^Z distributions: MSTW2008, MSTW2004, NNPDF3.0 and NNPDF2.3





- LO+NLL $1-5\%$ spread. NLO+NNLL $2-6\%$ spread.

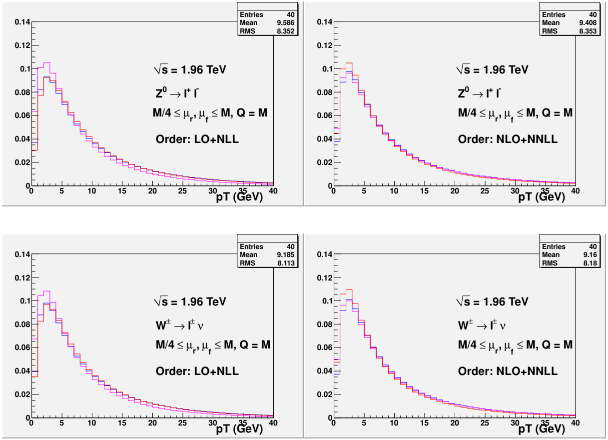
- p_T distributions: results for MSTW2008



- ■ $\mu_R, \mu_F = M_b$, ■ for $(\mu_R, \mu_F) = (M_b/2, M_b/4)$, ■ for $(\mu_R, \mu_F) = (M_b/4, M_b/2)$.

DYqT numerical analysis: Non-Dependent Scaling

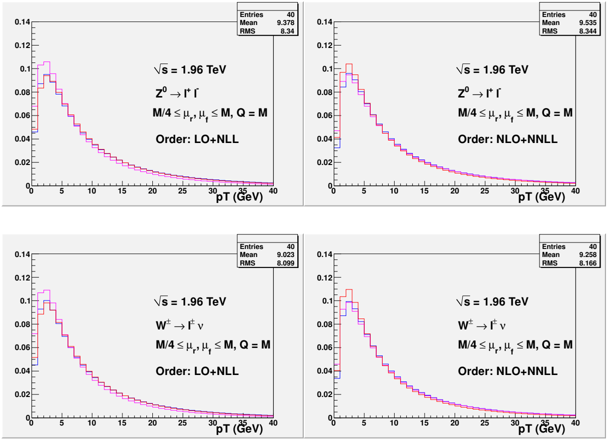
- p_T distributions: results for `MSTW2004`



- Blue: $\mu_R, \mu_F = M_b$, magenta: for $(\mu_R, \mu_F) = (M_b/2, M_b/4)$, red: for $(\mu_R, \mu_F) = (M_b/4, M_b/2)$.

DYqT numerical analysis: Non-Dependent Scaling

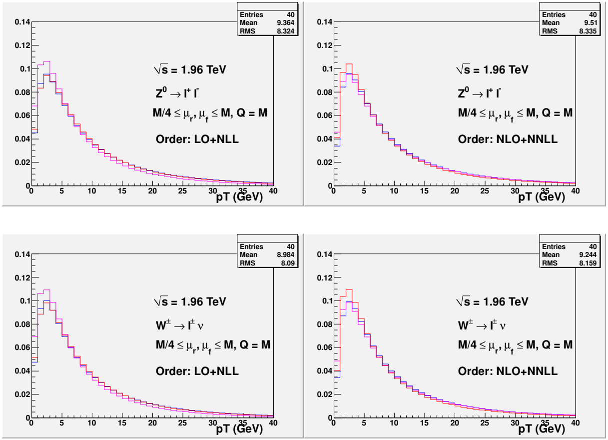
- p_T distributions: results for NNPDF3.0



- ■ $\mu_R, \mu_F = M_b$, ■ for $(\mu_R, \mu_F) = (M_b/2, M_b/4)$, ■ for $(\mu_R, \mu_F) = (M_b/4, M_b/2)$.

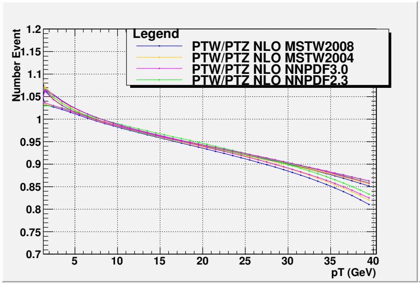
DYqT numerical analysis: Non-Dependent Scaling

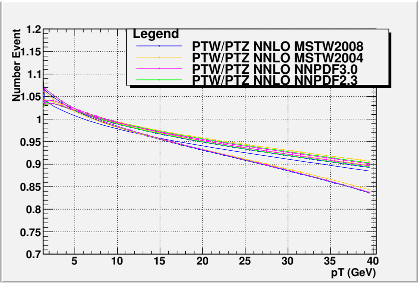
- p_T distributions: results for NNPDF2.3



- ■ $\mu_R, \mu_F = M_b$, ■ for $(\mu_R, \mu_F) = (M_b/2, M_b/4)$, ■ for $(\mu_R, \mu_F) = (M_b/4, M_b/2)$.

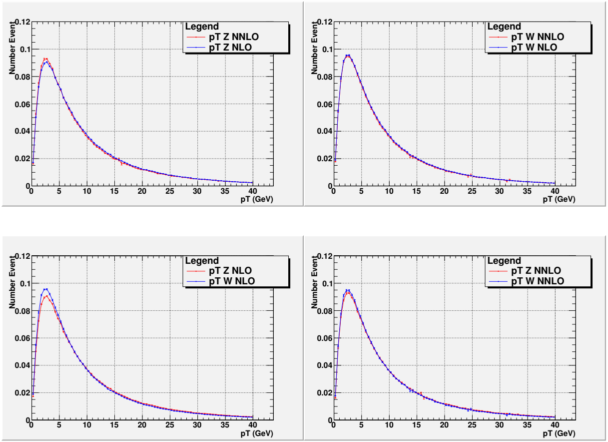
- p_T^W/p_T^Z distributions: `MSTW2008`, `MSTW2004`, `NNPDF3.0` and `NNPDF2.3`





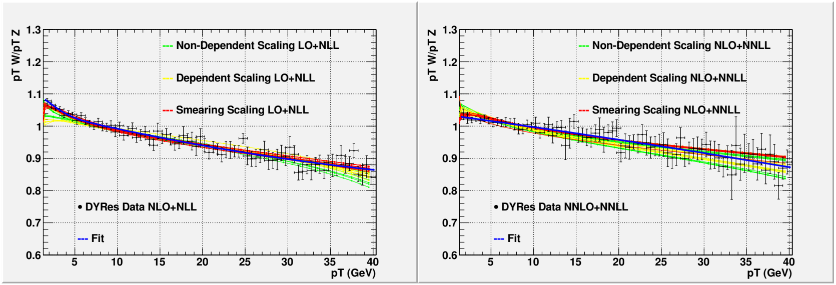
- No band changing at LO+NLL. Good agreement at NLO+NNLL.

- p_T distributions: MSTW2008



- Left-lower panel: 2% spread near peaks at NLO+NLL.

- DYRes data: MSTW2008 results



- Data in good agreement at each order (NLO+NLL and NNLO+NNLL).
- NLO+NLL data slight overestimation (1.5%) in $p_T \leq 5$ GeV. NNLO+NNLL data slight underestimation (1%) in $p_T \leq 5$ GeV.

- LO+NLL $\longrightarrow$ both for W and Z more affected by scales variations;
- NLO+NNLL $\longrightarrow$ both W and Z less affected by scales variations;
- At each order, scaling+PDF set variation $\longrightarrow$ $1-6\%$ band in $p_T \in [0, 40]$ GeV;
- g_{NP} scaling $\longrightarrow$ $2-3\%$ spread, good agreement with MC data at low-p_T.

- Understanding data over/under estimation at low-p_T;
- `DYRes` scaling and changing PDFs set $\longrightarrow$ comparison between `DYRes` and `DYqT` bands;
- Possible way: development of theoretical models for non perturbative smearing at low-p_T.