Update on predictions for Z boson $p_\perp$ spectrum with MCatNLO

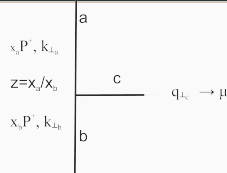Ola Lelek

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Introduction

$p_\perp$-ordering:
$\qquad q_{\perp,c}^2 = 1\mu'^2 \qquad\qquad z_M = \text{fixed} \qquad\qquad \alpha_s\left(1\mu'^2\right)$

virtuality ordering:
$\qquad q_{\perp,c}^2 = (1-z)\mu'^2 \qquad z_M = 1 - \left(\dfrac{q_0}{\mu'}\right)^2 \qquad \alpha_s\left((1-z)\mu'^2\right)$

angular ordering:
$\qquad q_{\perp,c}^2 = \underbrace{(1-z)^2}_{a^2(z)}\mu'^2 \qquad z_M = 1 - \left(\dfrac{q_0}{\mu'}\right) \qquad \alpha_s(\underbrace{(1-z)^2}_{a^2(z)}\mu'^2)$
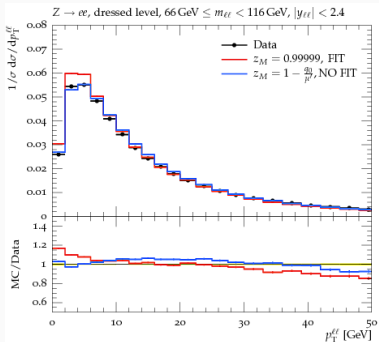
$$k_{\perp,a} = k_{\perp,b} - q_{\perp,c}$$

$$\widetilde{A}_a\left(x, k_\perp, \mu^2\right) = \Delta_a\left(\mu^2\right)\widetilde{A}_a\left(x, k_\perp, \mu_0^2\right) + \sum_b \int \frac{\mathrm{d}^2\mu'_\perp}{\pi\mu'^2}\Theta\left(\mu^2 - \mu'^2\right)\Theta\left(\mu'^2 - \mu_0^2\right)$$

$$\times \quad \frac{\Delta_a\left(\mu^2\right)}{\Delta_a\left(\mu'^2\right)}\int_x^{z_M}\mathrm{d}z P_{ab}^R\left(z, \mu'^2, \alpha_s(a(z)^2\mu'^2)\right)\widetilde{A}_b\left(\frac{x}{z}, k_\perp + a(z)\mu_\perp, \mu'^2\right)$$
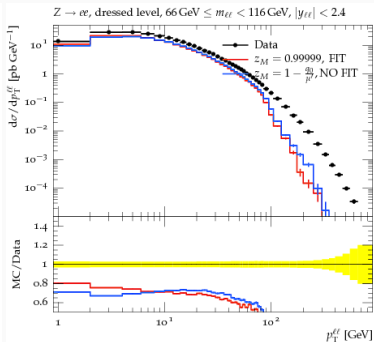
- PB method: effect of every individual part of the ordering definition can be studied separately,
  Up to now: studies mostly with fixed z_M.
  e.g. PBset2: $q_\perp^2 = (1-z)^2\mu'^2$, $\alpha_s\left((1-z)^2\mu'^2\right)$, fixed $z_M = 1 - 10^{-5}$
- Currently: studies on full angular ordering condition, including dynamic $z_M = 1 - \frac{q_0}{\mu'}$
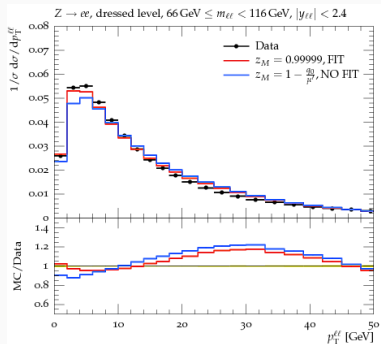
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Reminder:

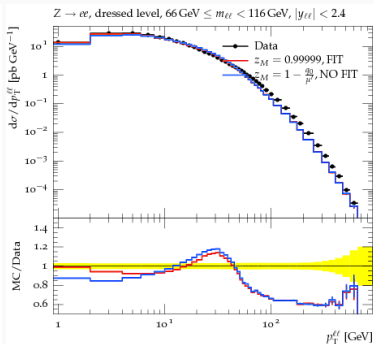PBset2, fitted to HERA data
NO FIT, ct10nlo as a starting distr

Dynamic zmax better!

Z boson $p_\perp$ with MCatNLO ME

PBset2, fitted to HERA data
NO FIT, ct10nlo as a starting distr

Dynamic zmax looks very bad $\rightarrow$ Will the fit improve the situation?

Z boson $p_\perp$ with MCatNLO ME
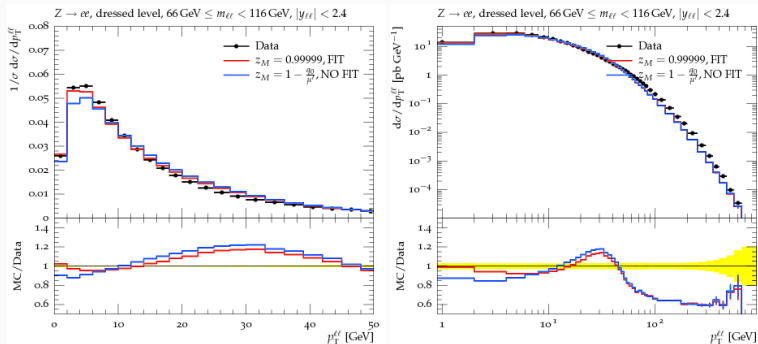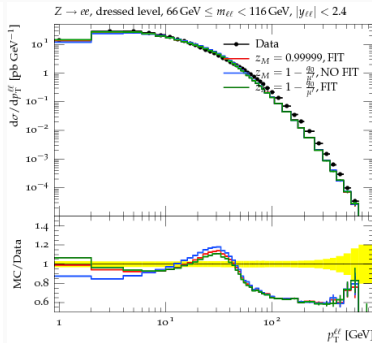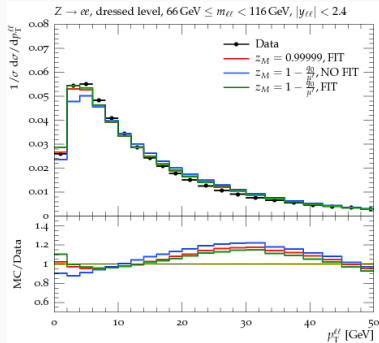

PBset2, fitted to HERA data
NO FIT, ct10nlo as a starting distr

Dynamic zmax looks very bad $\rightarrow$ Will the fit improve the situation?

- Fit for $Q^2 > 3.5\,\mathrm{GeV}^2$: not converging and $\chi^2/dof \approx 35$
- Fit for $Q^2 > 20\,\mathrm{GeV}^2$: converging and $\chi^2/dof \approx 1.3$
  TMD obtained from this fit

Z boson $p_\perp$ with MCatNLO ME

$Z \to ee$, dressed level, $66\,\mathrm{GeV} \le m_{\ell\ell} < 116\,\mathrm{GeV}$, $|y_{\ell\ell}| < 2.4$

$Z \to ee$, dressed level, $66\,\mathrm{GeV} \le m_{\ell\ell} < 116\,\mathrm{GeV}$, $|y_{\ell\ell}| < 2.4$

- Data
- $z_M = 0.99999$, FIT
- $z_M = 1 - \frac{q_0}{p^i}$, NO FIT
- $z_M = 1 - \frac{q_0}{p^i}$, FIT

PBset2, fitted to HERA data
NO FIT, ct10nlo as a starting distr
FIT with dynamic zmax

Dynamic zmax: fit improves the prediction
Fit with dynamic zmax gives better prediction than fit with fixed zmax everywhere except the first bin → this can be still adjusted with intrinsic kt distribution

Summary

- Studies on PB with angular ordering including dynamic z_M ongoing
- very good description of Z boson pt obtained with dynamic z_M and Pythia LO ME
- New result: very good description of Z boson pt obtained with TMD from the fit with dynamic z_M and MCatNLO ME