Intrinsic kt and low mass DY production

With Parton Branching method

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City, Date

Heading Agenda

- Introduction
- PB-TMDs and Drell-Yan production at NLO
- Low mass Drell-Yan production
- Conclusion

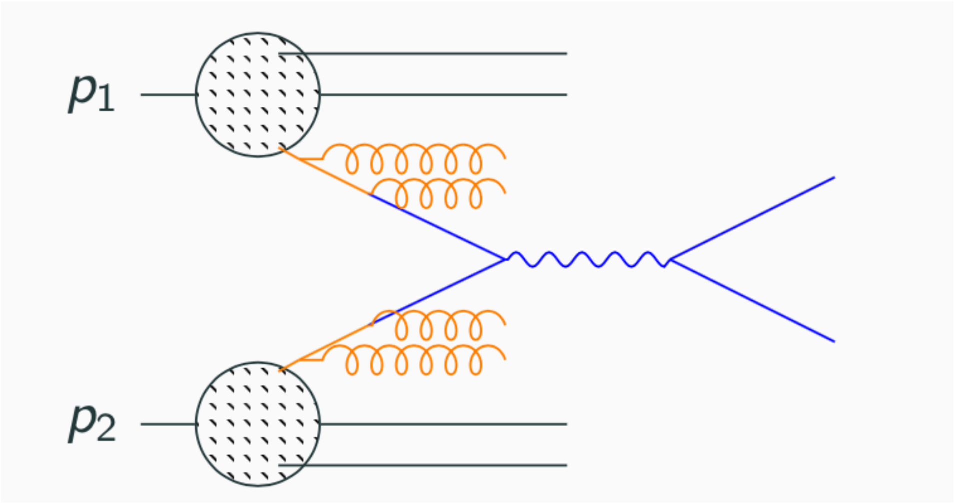
Introduction

Low mass DY issues

- For *proton-proton* collisions the collinear factorization theorem is commonly used

$$\sigma_h \sim \int f_1 \otimes f_2 \otimes \sigma_{partonic}$$

Transverse momentum of the intial parton is neglected



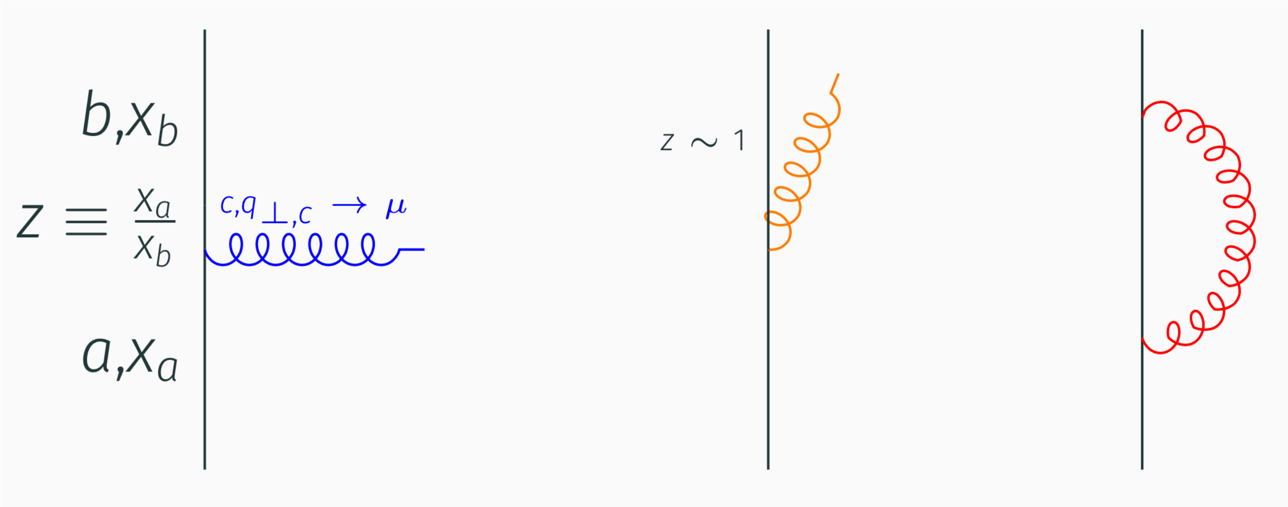
- Many observables are described using colinear factorization

- However, to describe the Z boson p_T spectrum at $p_T < O(m_Z)$ soft gluon resummation to all orders is needed

PB-TMDs and DY production at NLO

PB-TMDs and DY production at NLO

Parton Branching formalism



EVOLTION → Real resolvave splittings + Non resolvable splittings + Virtual correction

DGALP — Splitting functions — Sudakov

$$f_a(x,\mu^2) = f(x,\mu_0^2)\Delta_a(\mu^2) + \int_{\ln\mu_0^2}^{\ln\mu^2} d\ln\mu_1^2 \frac{\Delta_a(\mu^2)}{\Delta_a(\mu_1^2)} \sum_b \int_x^{z_m} d\,z_1 P_{ab}^R(\mu_1^2, z_1) f_b\left(\frac{x}{z_1}, \mu_0^2\right)\Delta_b(\mu_1^2) + \cdots$$: f is the collinear PDF

- TMD evolution, where A is the TMD:

$$A_a(x,\mu^2,k_\perp) = A(x,\mu_0^2,k_\perp)\Delta_a(\mu^2) + \int \frac{d^2\mu_1}{\pi\mu_1^2}\Theta(\mu^2-\mu_1^2)\Theta(\mu_1^2-\mu_0^2)\frac{\Delta_a(\mu^2)}{\Delta_a(\mu_1^2)} \times \sum_b \int_x^1 dz_1 \Theta(z_m(\mu_1)-1) P_{ab}^R(\mu_1^2,z_1) A_b\left(\frac{x}{z_1},\mu_0^2,k_\perp\right)\Delta_b(\mu_1^2) + \cdots$$

PB-TMDs and DY production at NLO

Angular ordering

- The evolution in PB formalism applies angular ordering

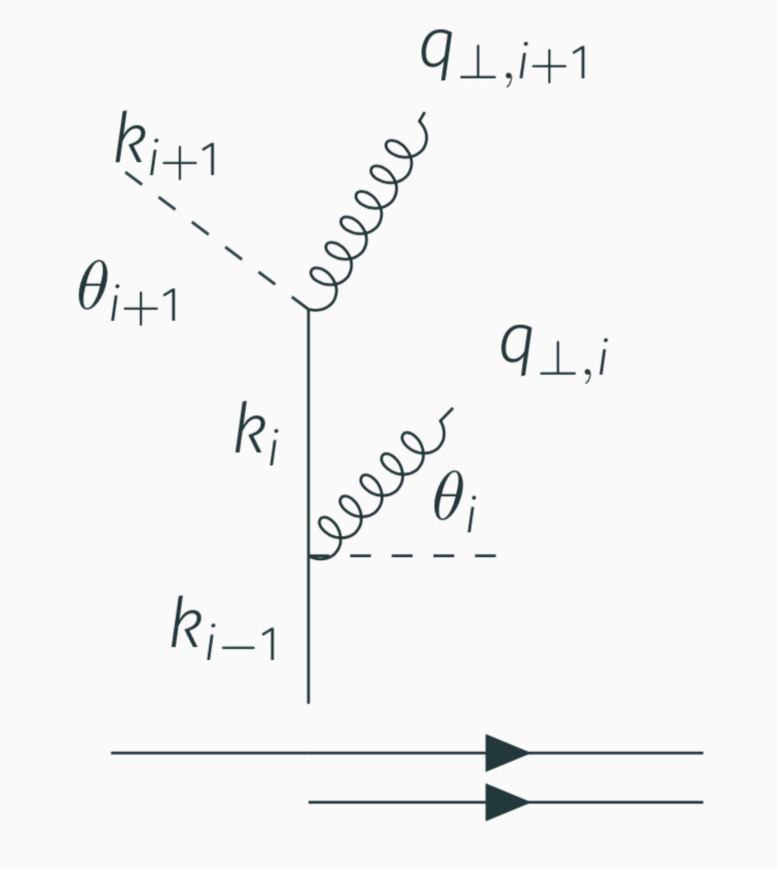
- It enters the evolution as:

$$q_{\perp,c}^2 = (1-z)^2\mu'^2 \qquad z_m = 1 - \left(\frac{q_0}{\mu'}\right) \qquad \alpha_s\left((1-z)^2\mu'\right)$$

- The radiation scale is proportional to the angle of the momentum of the radiated particle respect ot the particle beam

$$\frac{q_{\perp,i}}{1-z_i} = |k_{i-1}|\sin\theta_i = \mu'$$

- The first radiation is the one with smallest angle



q_0: minimum transverse momentum of the emitted parton

PB-TMDs and DY production at NLO

Soft gluon resumation effects

- As mentioned before collinear factorization needs soft gluon resumantion

- The matrix elemt is computed using MC@NLO

- DY lepton-pair transverse momentum:
  - MC@NLO at a partonic level using Herwig6 substraction terms
  - MC@NLO + PB-TMDs

- At LHC energies soft gluon resummation impacts the low p_T region

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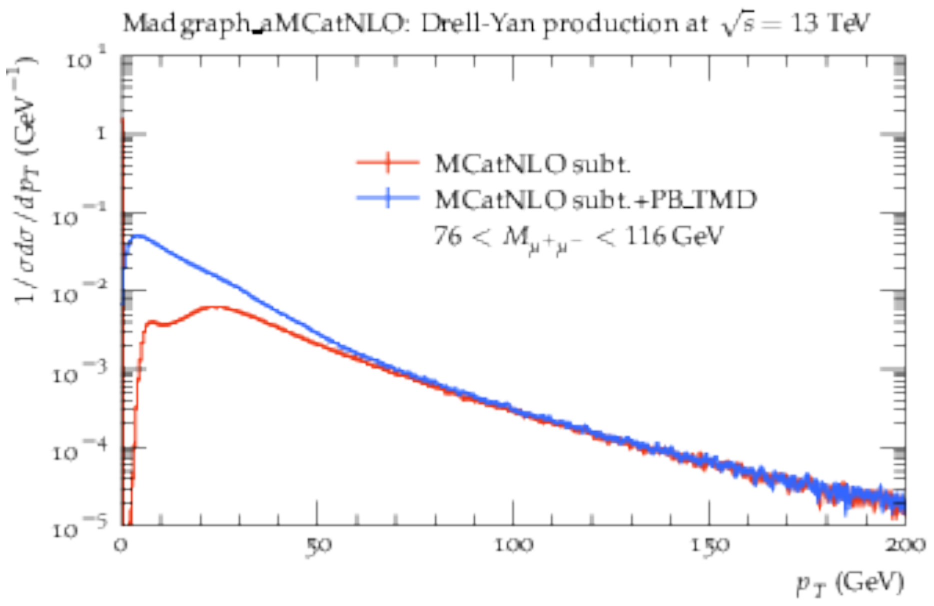


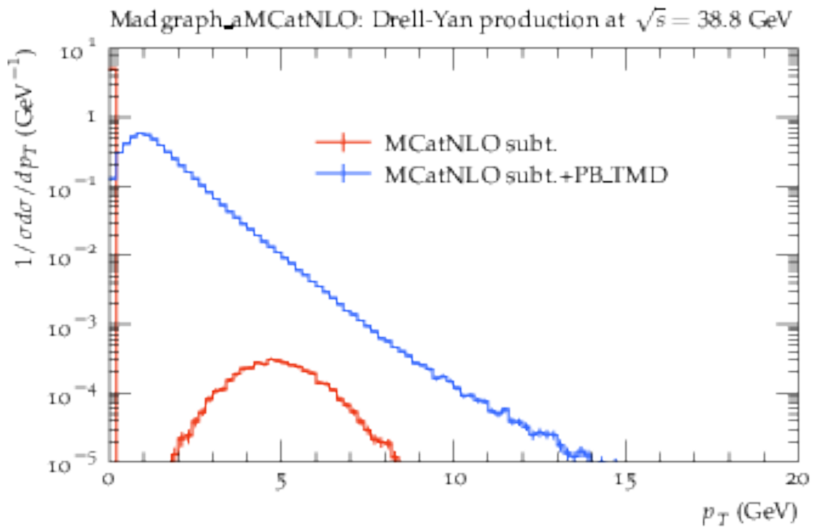
PB-TMDs and DY production at NLO

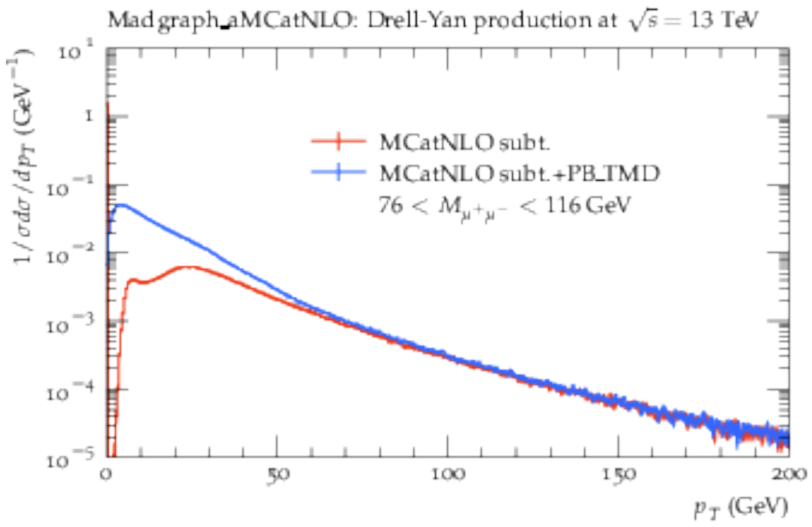
Soft gluon resumation effects at low mass DY

- To see the effect of soft gluon resumation at low mass DY we follow the same procedure

- At low mass DY the largest contribution comes from the soft gluon resumation, both at large and low p_T

- This effect allows studies of contribution from soft gluon emission





Intrinsic k_T of initial state partons

In PB formalism

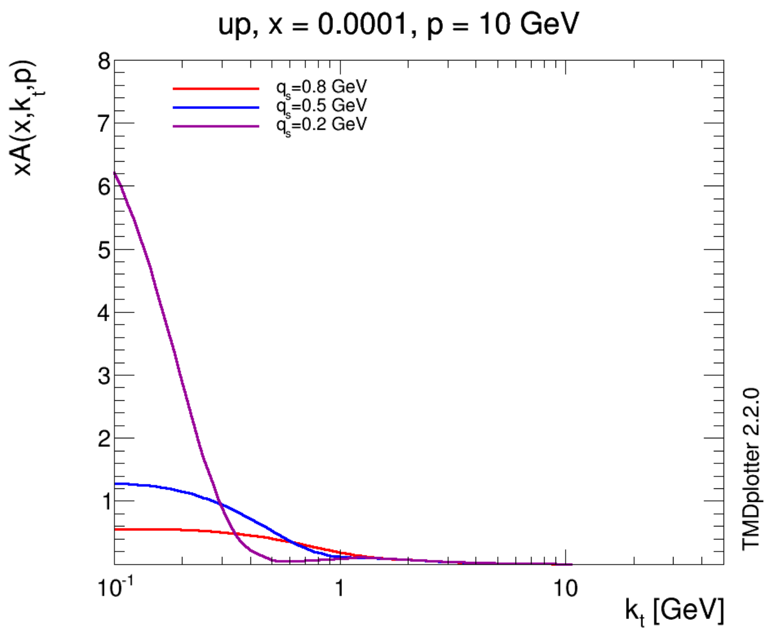
- The intrinsic k_T of the intial state parton is generated from a gaussian distribution

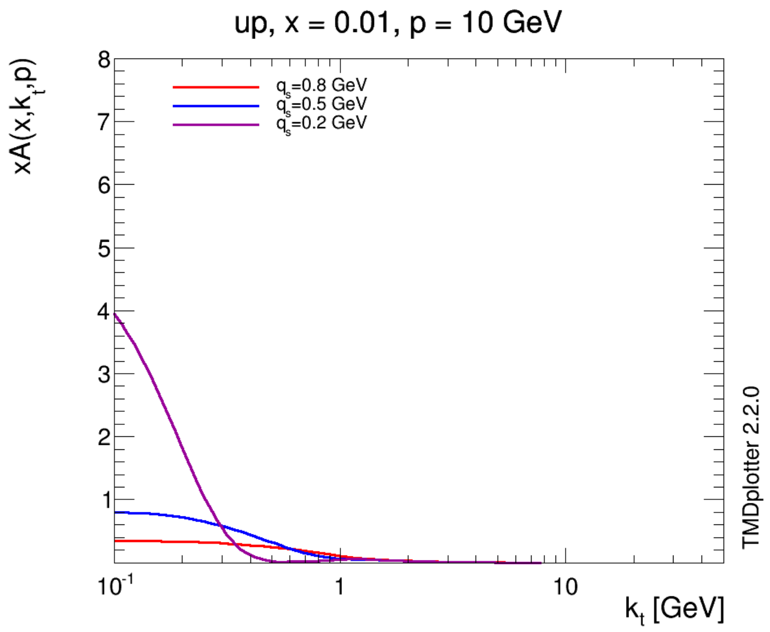
$$A_{0,a}(x, k_{T_0}, \mu_0) = f_{0,a}(x, \mu_0) e^{-\frac{k_{T_0}^2}{\sigma^2}}$$

- The parameter to study is q_s, the width of the distribution:

$$\sigma = \frac{q_s}{\sqrt{2}}$$

- Small values of q_s makes larger TMDs at low k_T region





Low mass DY production

Low mass DY production

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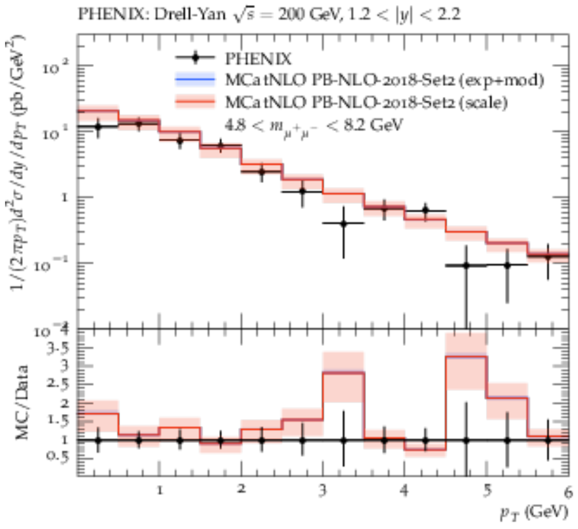
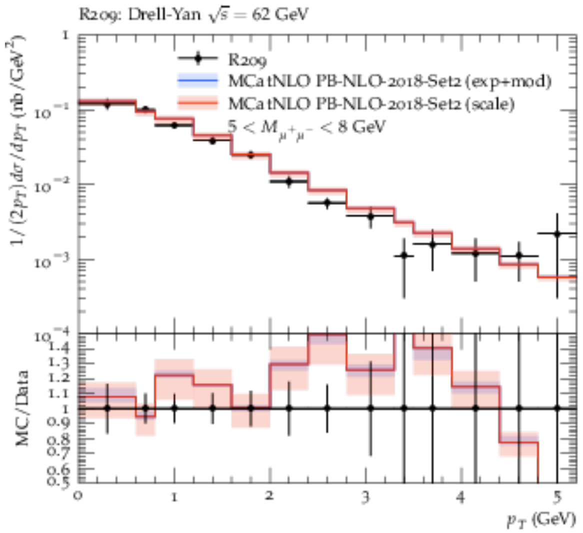
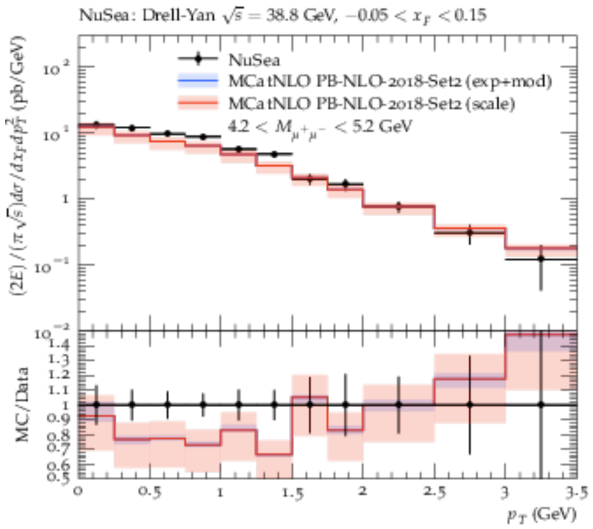
- Theoretical predictons from PB-TMDs and NLO matrix elements with MC@NLO matching are compared to measurements for different center of mass energies:







- The description of the data is good, with a $\frac{\chi^2}{ndf} = 1.04(PHENIX), 1.27(R209), 1.07(NuSea)$

- For this set-up (Set2) $q_s = 0.5$ GeV

Low mass DY production

How sensitive is PB-TMDs to intrinsic k_T ?

- We plot $\frac{\chi^2}{ndf}$ as a function of q_s for different center of mass energies
- Lower mass DY measurements show a larger sensitivity to the choice of the q_s
- An overal minumim is observed for $q_s \in (0.3 - 0.4)$GeV
- For Set2 $q_s = 0.5$GeV

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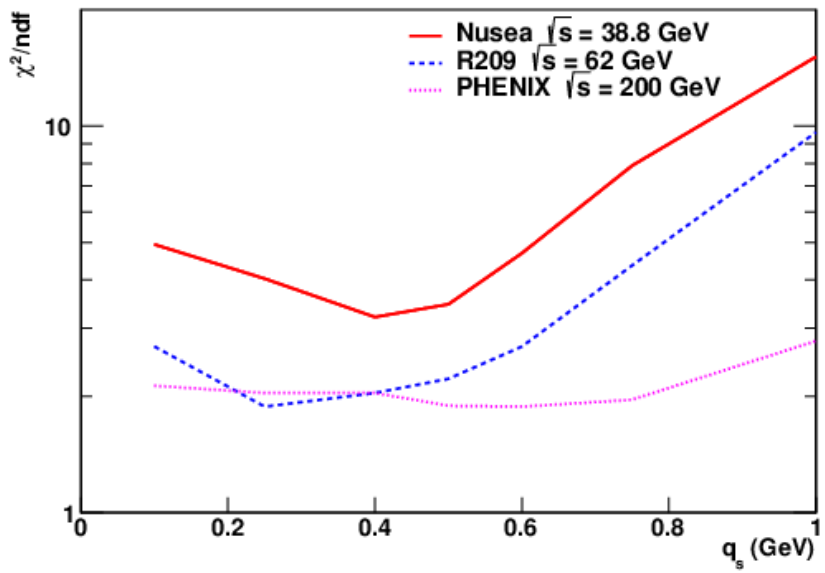


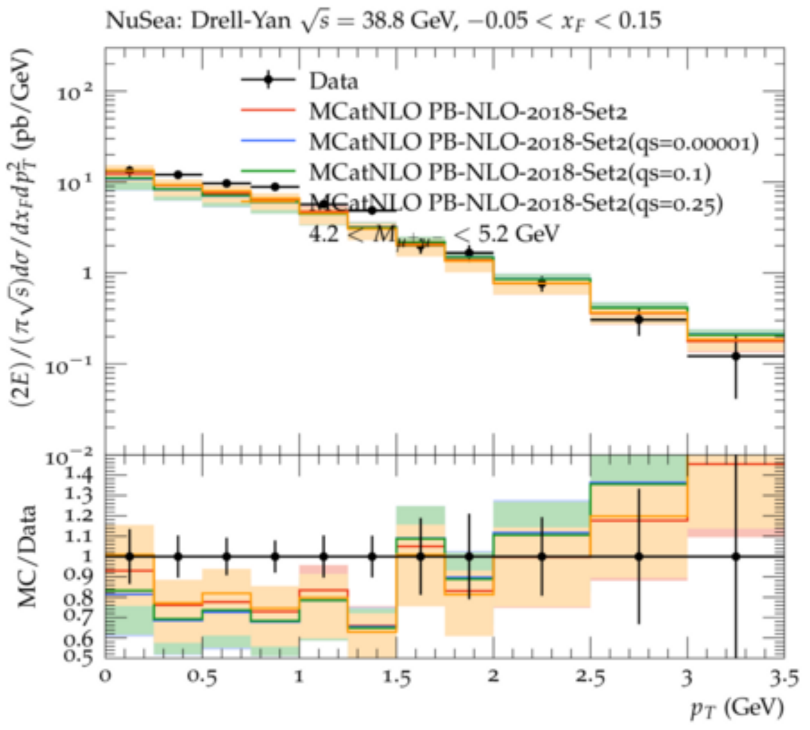
Low mass DY production

Are we really sensitive to intrinsic KT?

- Predictions for different values of q_s for NuSea measurements
  - MCatNLO PB-NLO-2018-Set2 with $q_s = 0.5$ GeV
  - MCatNLO PB-NLO-2018-Set2 with $q_s = 0.25$ GeV
  - MCatNLO PB-NLO-2018-Set2 with $q_s = 0.00001$ GeV

- The set-up shows a small sensitivity for different values of q_s

- The low sensitivity comes from the TMD evolution (next slide)



Low mass DY production

Why are we not as sensitive as expected?

z_m: resolvabe/non-resolvable splittings

- Reminder: Angular ordering enters the evolution as

$$q_{\perp,c}^2 = (1-z)^2 \mu'^2 \qquad z_m = 1 - \left(\frac{q_0}{\mu'}\right) \qquad \alpha_s\left((1-z)^2 \mu'\right)$$

- In our current set-up $q_0 = 0.01$ is fixed → $z_m \sim 1$. At large z_m values: *PB-TMD ev. converges to DGLAP ev.*

- In this way non-perturvative emissions are treated in a similar way as perturvative ones, simulating non-perturvative effects

Summary and outlook

Summary

- We investigated the p_T spectra of DY lepton-pair production at small DY masses and low center of mass energies

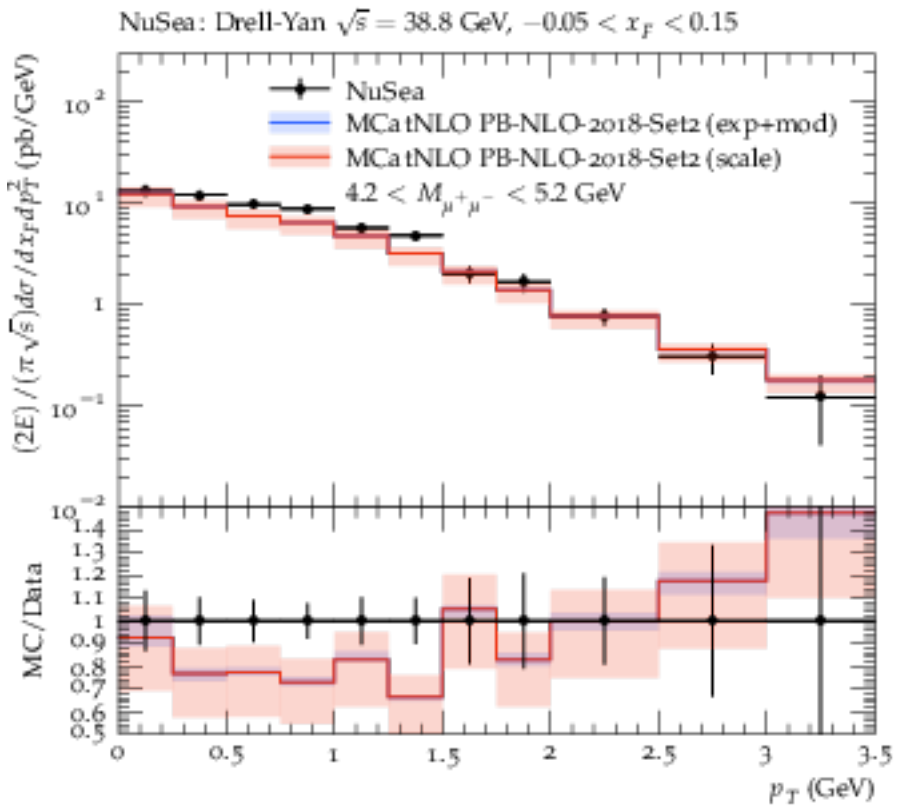
- Measurements at low center of mass energies are well described within PB formalism, with $\frac{\chi^2}{ndf} \sim 1$

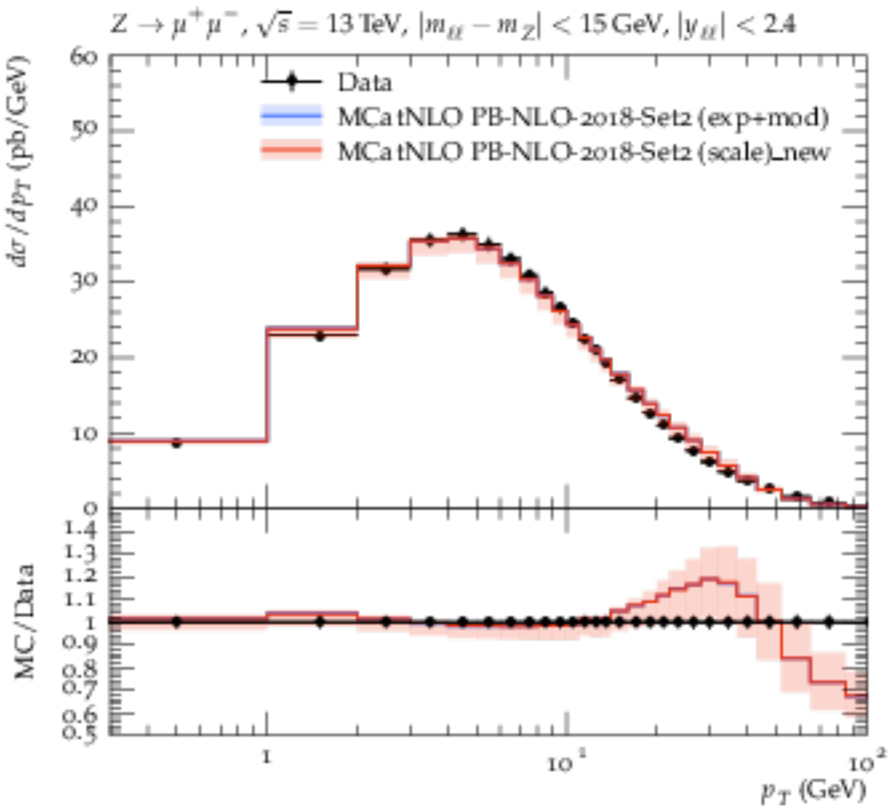
- We determined an optimal value for $q_s \in (0.3 - 0.4)$GeV

- However, a lack of sensitivity is observed to the intrinsic k_T, due to the large value of z_m

Summary and outlook

- A large value of $z_m \sim 1$ reduces the contributions from non-perturvative effects. Making PB formalism safe to use at different center of mass energies with the same configuration





Thank you