artemide at level 2.5
scale variations

LHC EW precision sub-group meeting (pT W/Z benchmarking)

Alexey Vladimirov

Regensburg University

Universität Regensburg

Introduction

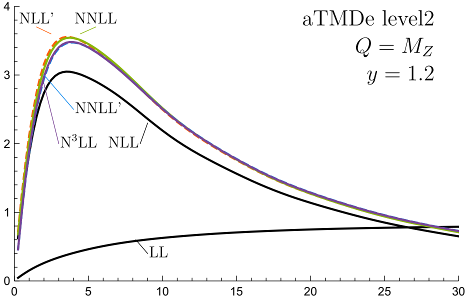
Level 2

~~same as level 1 but with **default evolution settings**~~(see Apr.20 meeting)

same as level 1 but with **default evolution settings and “null” NP parameters**

Default evolution settings in `artemide`

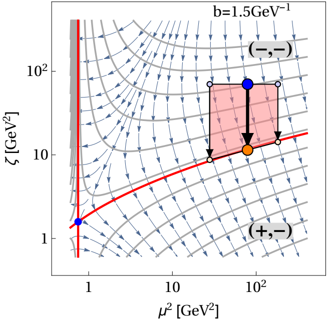
- Fixed μ evolution
- RAD: Resummed ($+b^*$ freezing model)



$$\frac{d\sigma}{dq^4} \sim \int d^2b e^{ibq_T} |C_V(Q, Qc_2)|^2 R^2(Qc_2, Q^2) F_1(x_1, b) F_2(x_2, b) \quad (1)$$

no variation in ζ, since $\zeta_1\zeta_2 = Q^4$ (or $\zeta_1 = \zeta_2 = Q^2$).

There is no other evolution scales in ζ-prescription,
because the TMD is defined non-perturbatively (like in DIS)
This allows a perturbation-theory independent (aka nonperturbative) definition of TMD distributions and CS-kernel



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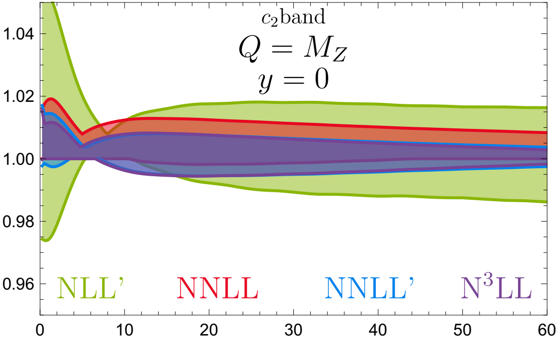
$$c_2 \in [\frac{1}{2}, 2]$$



- c_2 band is y-independent
- The difference between N•LL and N•LL' due to the hard coefficient function.

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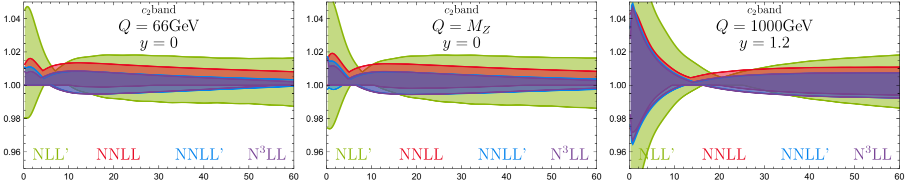
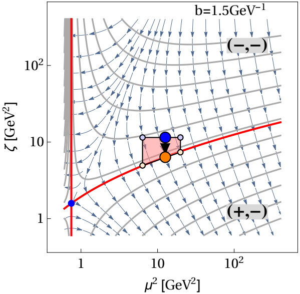
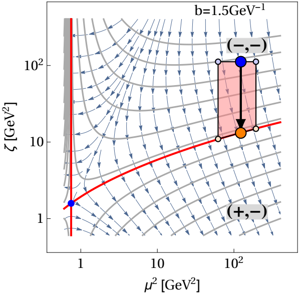
Band increases with the growing of Q





The variation area is bigger



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But there are scales associated with the modeling.

$$F_1(x,b) = \int_x^1 \frac{dy}{y} C\left(y, c_4\mu_{\text{OPE}}\right) f\left(\frac{x}{y}, c_4\mu_{\text{OPE}}\right) \tag{2}$$

- For both TMDs vary simultaneously (separate variation will require deep code modification)

“Missed” scales

- **There is no** scale-variation “c_1” (CSS scale for rapidity logs)
  It is a part of the model CS-kernel (next slide)
- **There is no** scale-variation “c_3” (CSS scale of TMD definition)
  TMD is attached to ζ-line (non-perturbative scale).

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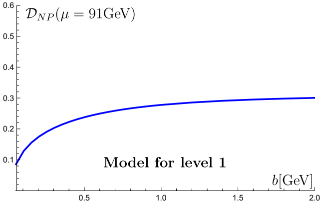
Evolution exponent is an known functional of $\mathcal{D}$

$$R(\mu,\zeta) = \left(\frac{\zeta}{\zeta_\mu[\mathcal{D}(\mathbf{b})]}\right)^{-\mathcal{D}(\mu,\mathbf{b})}. \tag{3}$$

Level 1 Model

$$\mathcal{D}(b,\mu) = \mathcal{D}_{\text{pert}}(\mu, b^*)$$

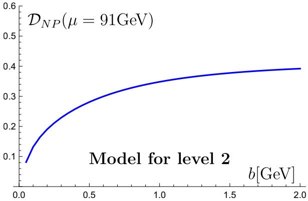
$$B_{NP} = 2e^{-\gamma_E}$$



Level 2 Model

$$\mathcal{D}(b,\mu) = \mathcal{D}_{\text{resum}}(\mu, b^*)$$

$$B_{NP} = 2e^{-\gamma_E}$$



CSS case corresponds to

$$\mathcal{D}(b,\mu) = \mathcal{D}(b^*, c_1\mu_0) + \int_{c_1\mu_0}^{\mu} \frac{d\mu'}{\mu'} \Gamma_{\text{cusp}}(\mu')$$

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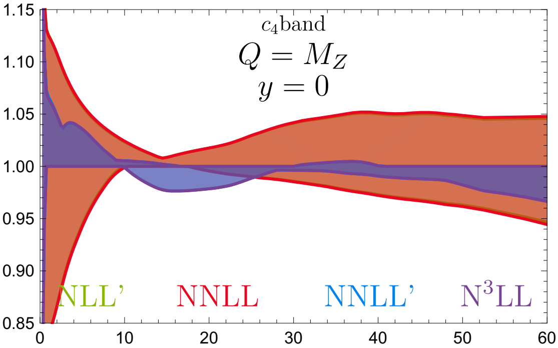
$$c_4 \in [\frac{1}{2}, 2]$$



- 2-3 times larger then c_2 band
- N$^\bullet$LL' =N$^{\bullet-1}$LL

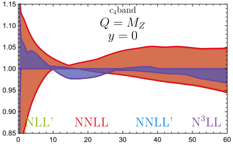
Origin of oscillation

It is combined effect...

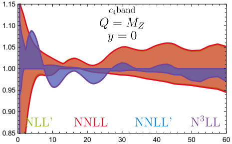
$$F(x,b)=[1+a_s(\mu)(\ln(\mu b)+..)+...]\otimes f_1(x)f_{NP}(x,b)$$

- $\mu=\frac{c_0}{b}\sqrt{1+4\frac{b^2}{c_0^2}}$, then $c_4=1/2$ $\mu\to 1$ at $b>2$ (close to Landau pole)
- b^* in evolution (no suppression at large-b)
- No b^*, so $[...]\to\ln^2(b)$ and Hankel integral diverges
- $f_{NP}\sim\exp(-10^{-3}b^2)$ (by no-NP request)

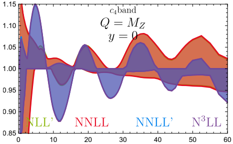
$$\mu=\frac{c_0}{b}\sqrt{1+4\frac{b^2}{c_0^2}}$$



$$\mu=\frac{c_0}{b}\sqrt{1+2\frac{b^2}{c_0^2}}$$

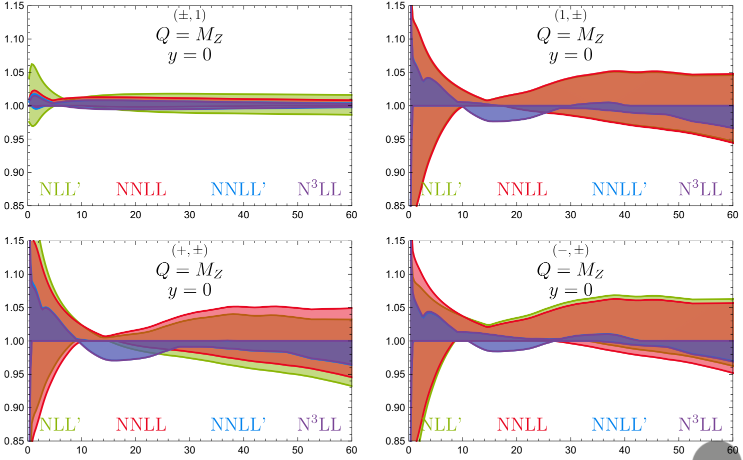


$$\mu=\frac{c_0}{b}\sqrt{1+\frac{b^2}{c_0^2}}$$

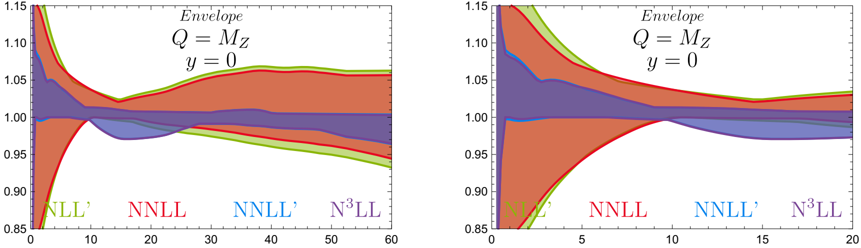


Since the variations are entirely independent the simultaneous variation are direct sum

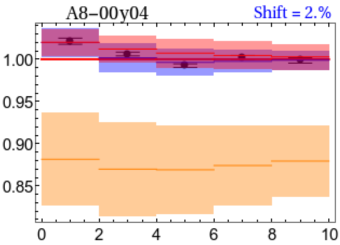
8 variations

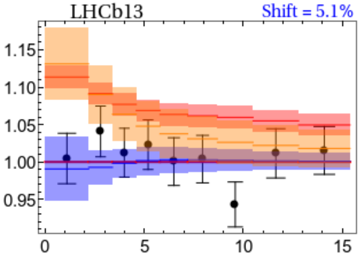


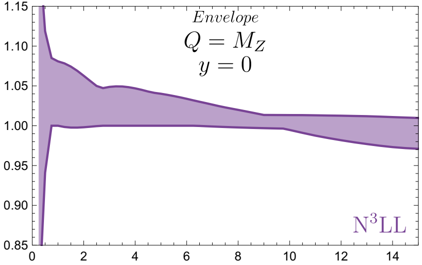
The final band is the maximum deviation (envelope)



- Dominant part comes from PDF-matching (depends on PDF-set), and of the same size as PDF-uncertainty band.
- Band below $q_T < 10$GeV is meaningless because it can be replaced by NP-parameters







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