Threshold resummation for Drell-Yan production: theory and phenomenology

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In collaboration with:

Stefano Forte, Giovanni Ridolfi

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N-**space analysis**
and saddle point approximation

Drell-Yan $q\bar{q}$ at NLO in N-space

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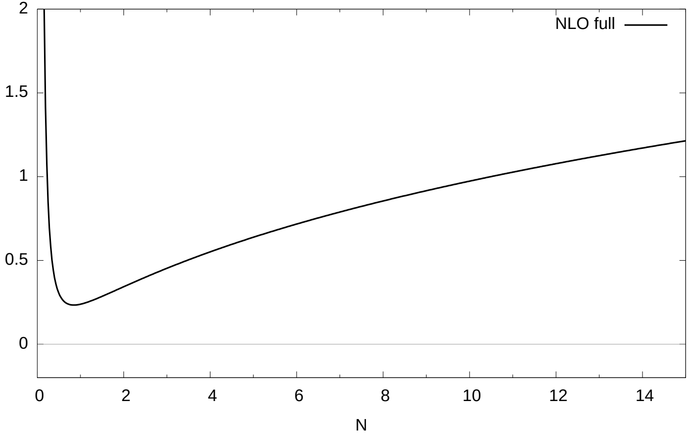

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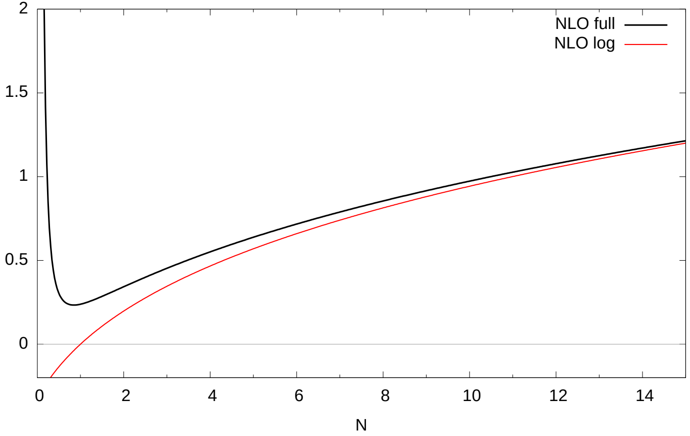

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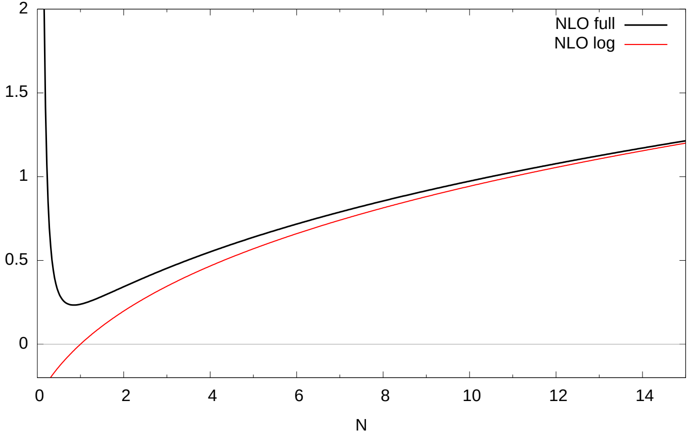

For $N \sim 2$ about 50% of the NLO is given by the log term

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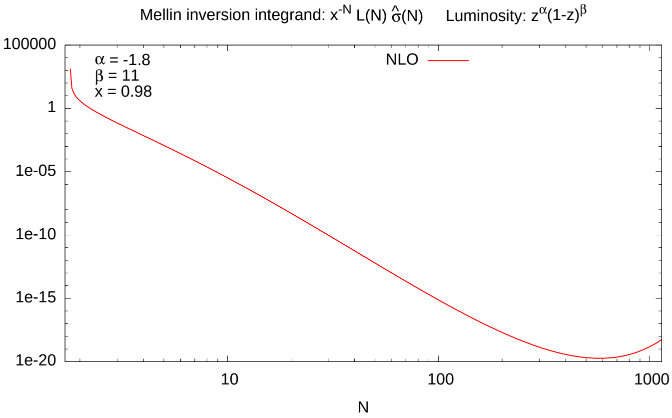

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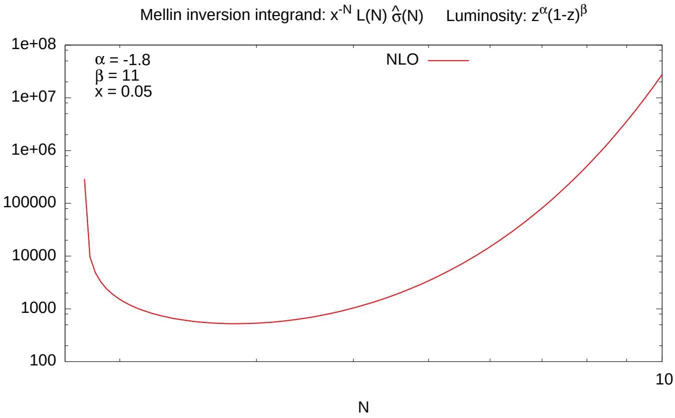

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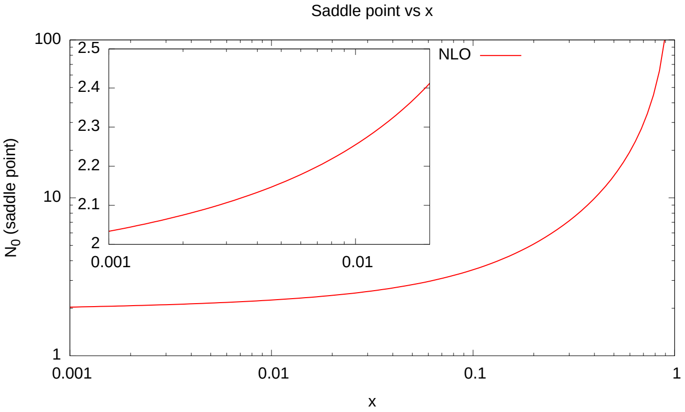

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Resummation can be relevant for values of x as small as 0.002

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* Proposed by R.Abbate, S.Forte, G.Ridolfi, J.Rojo, M.Ubiali

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- proposed solution: cut-off C in the integral

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$$\hat{\sigma}_{\rm BP}(z,C) = \frac{1}{2\pi i}\oint_{\mathcal{C}} \frac{d\xi}{\Gamma(\xi+1)}\,\frac{\left[(1-z)^{\xi-1}\right]_+}{\sqrt{z}^{\xi}}\int_0^C \frac{dw}{\bar{\alpha}}\,e^{-\frac{w}{\bar{\alpha}}}\,\hat{\sigma}^{\rm res}\left(e^{-\frac{w}{\bar{\alpha}\xi}}\right)$$

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- cut-off related to the inclusion of higher-twist terms

$$e^{-\frac{C}{\bar{\alpha}}} \simeq \left(\frac{\Lambda^2}{Q^2}\right)^{C/2}$$

Comparison with fixed order: Drell-Yan $q\bar{q}$ at NLO

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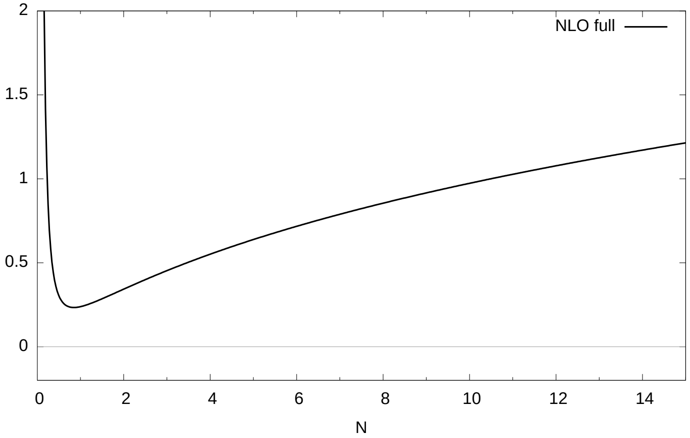

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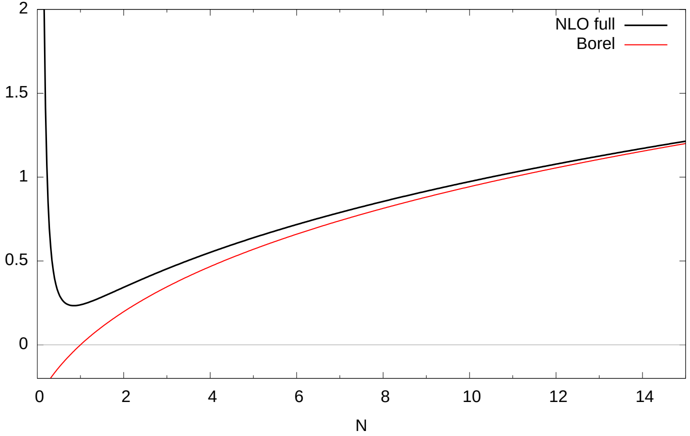

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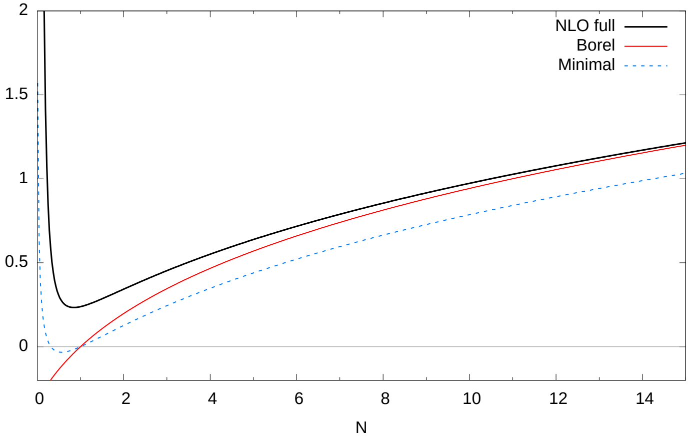

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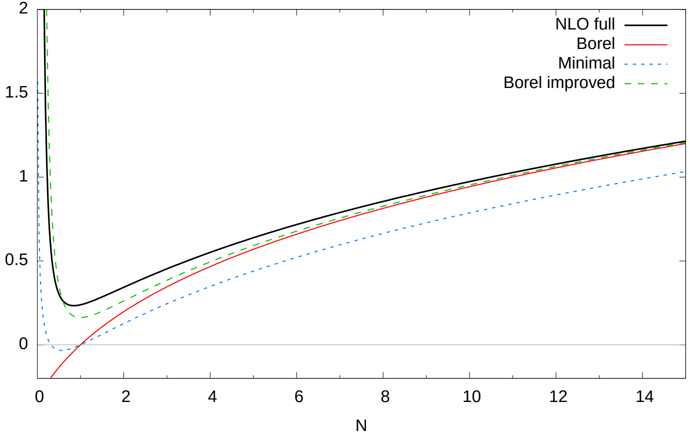

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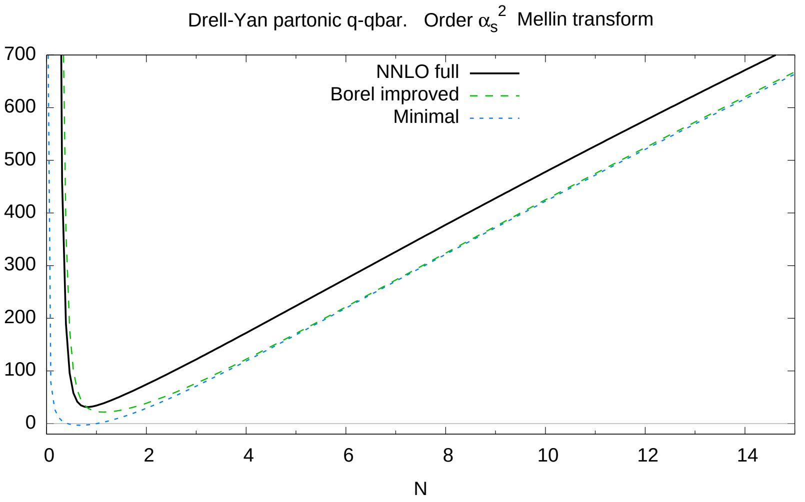

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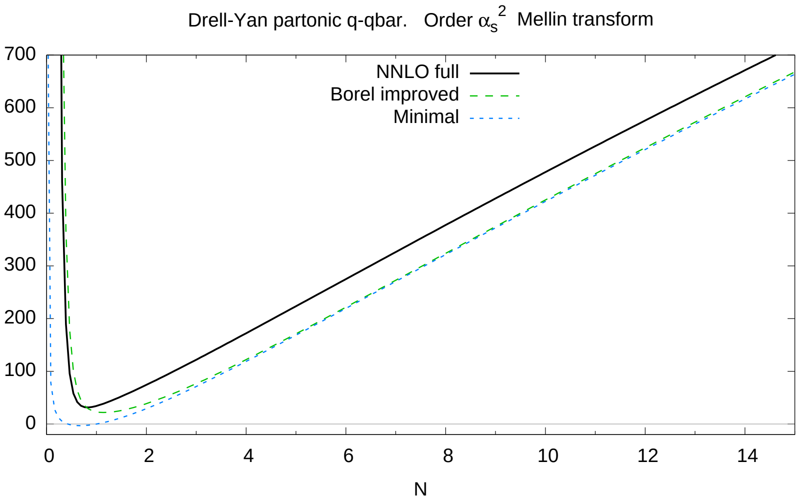

Discrepancy due to terms like $\log^k(1-z) \to \frac{\log^k N}{N}$ $\Rightarrow$ subleading

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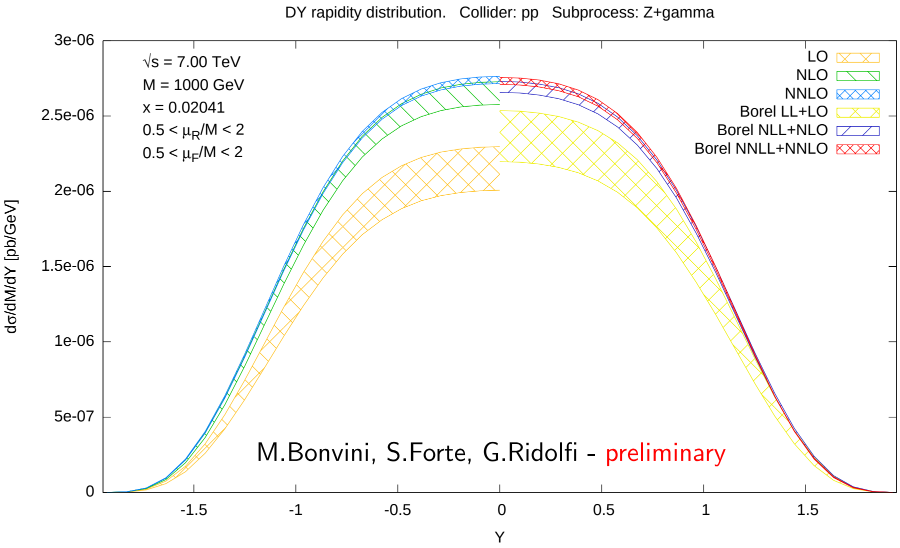
Impact in phenomenology

Rapidity distribution: DY (1 TeV) at LHC (cteq6.6 pdfs used)



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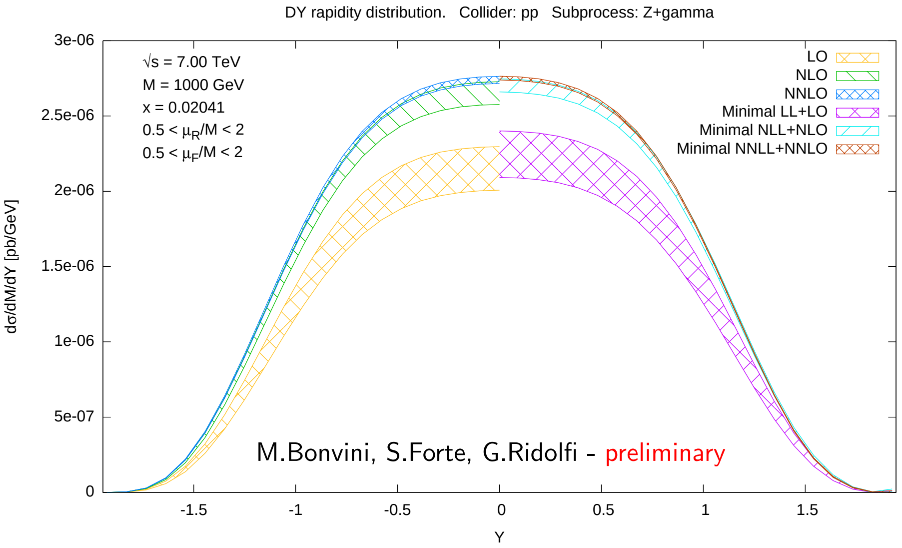

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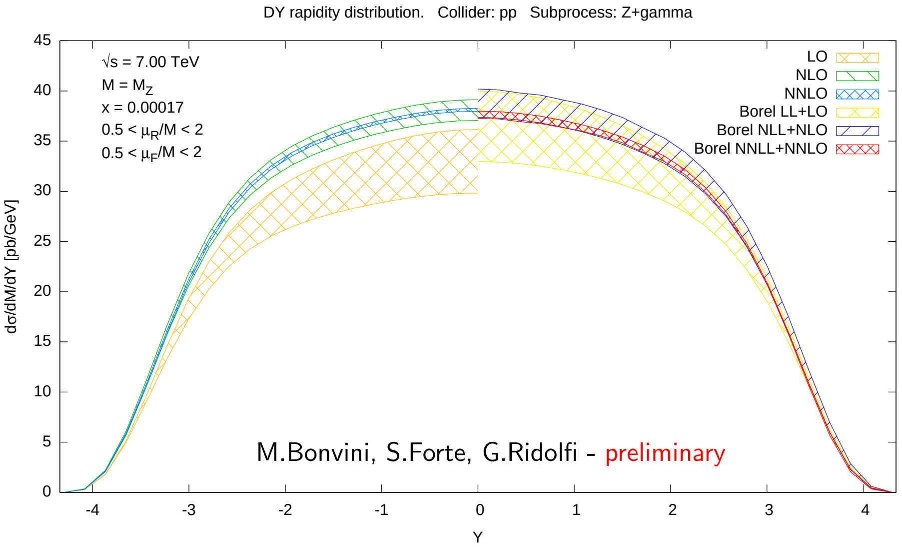

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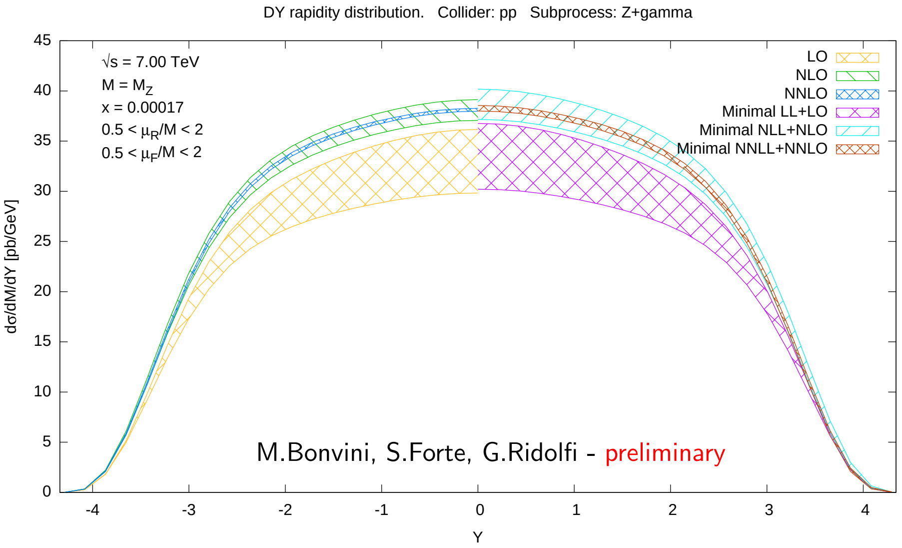

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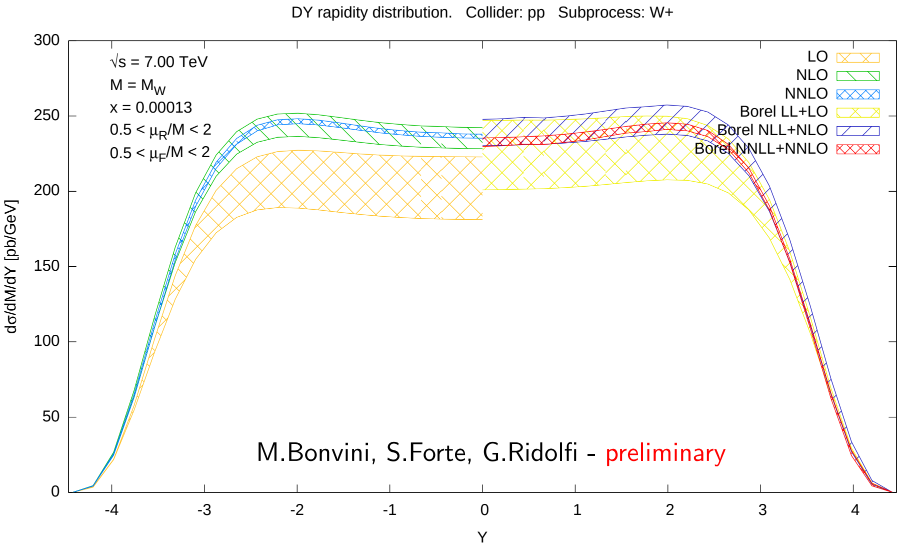

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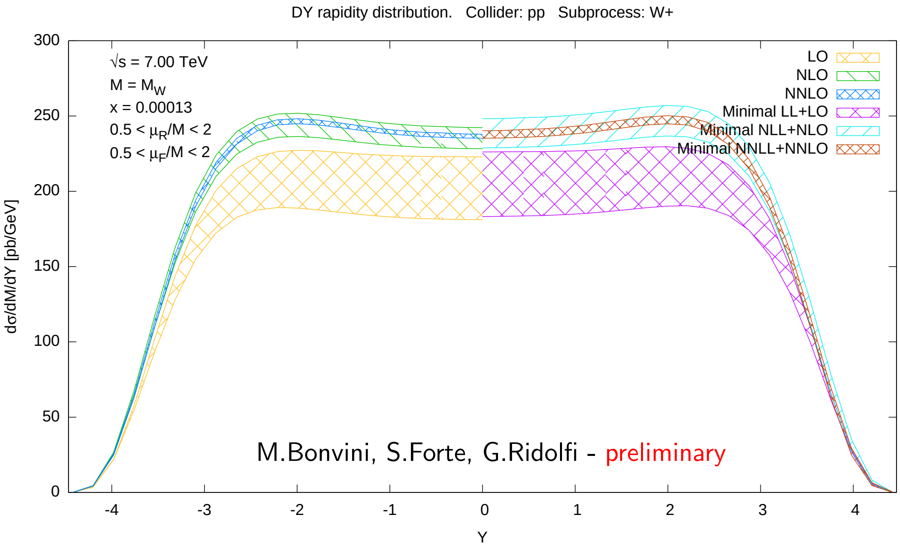
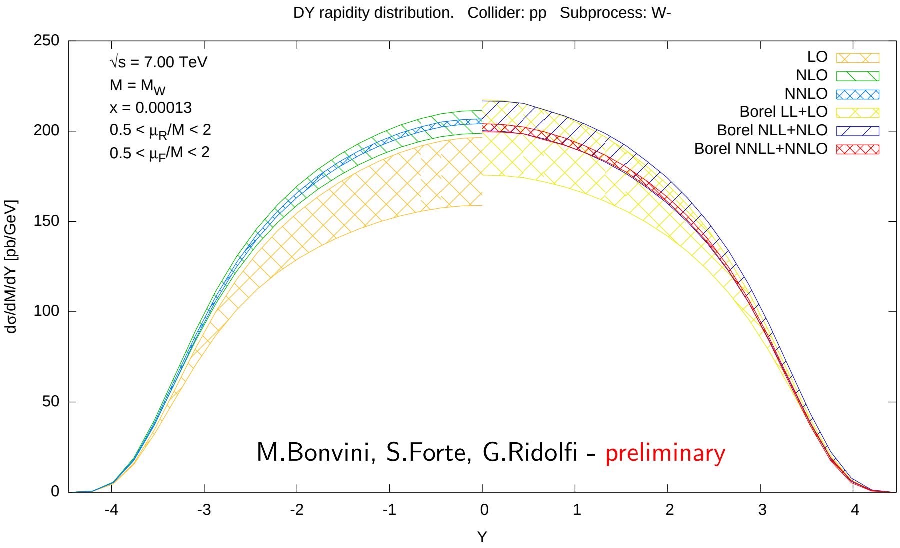


Rapidity distribution: W^- at LHC (cteq6.6 pdfs used)



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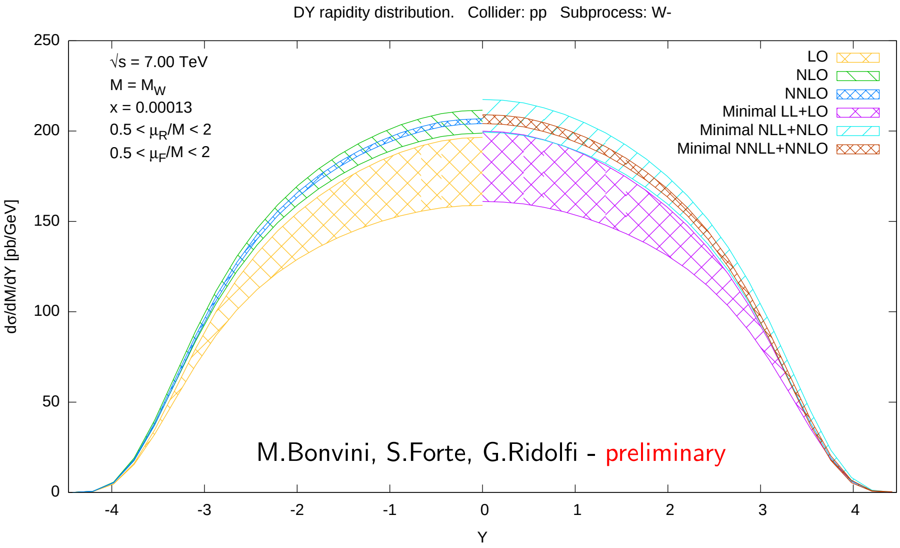

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- Include subdominant (intermediate-z) contributions (next talk)

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Backup slides

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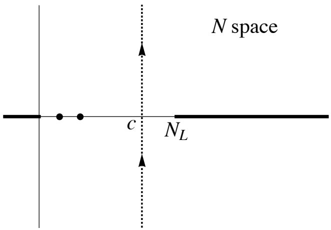
with $c < N_L$, as in the figure.



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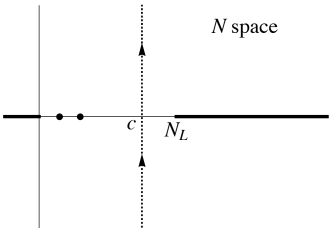

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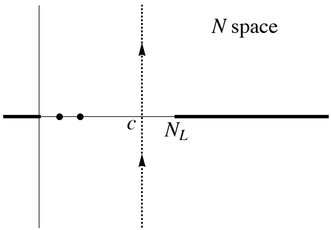


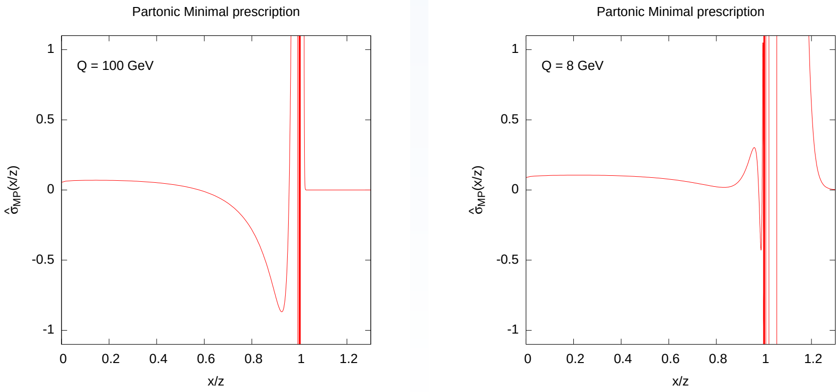
But...

- a non-physical region of the parton cross-section contributes
- difficult numerical implementation

Minimal prescription: non-physical contribution

$$\sigma_{\rm MP}(x) = \int_{\color{red}0}^{1} \frac{dz}{z}\, \mathcal{L}(z)\; \underbrace{\frac{1}{2\pi i}\int_{c-i\infty}^{c+i\infty} dN\, \left(\frac{x}{z}\right)^{-N} \hat\sigma^{\rm res}(N)}_{\hat\sigma_{\rm MP}(x/z)}$$

The integral extends from 0 to 1, not from x to 1!



Mellin transforms

$$\int_0^1 dz\, z^{N-1} \left[\frac{\log^k(1-z)}{1-z}\right]_+ = \frac{1}{k+1}\sum_{j=0}^{k+1}\binom{k+1}{j}\Gamma^{(j)}(1)\Gamma(N)\Delta^{(k+1-j)}(N)$$

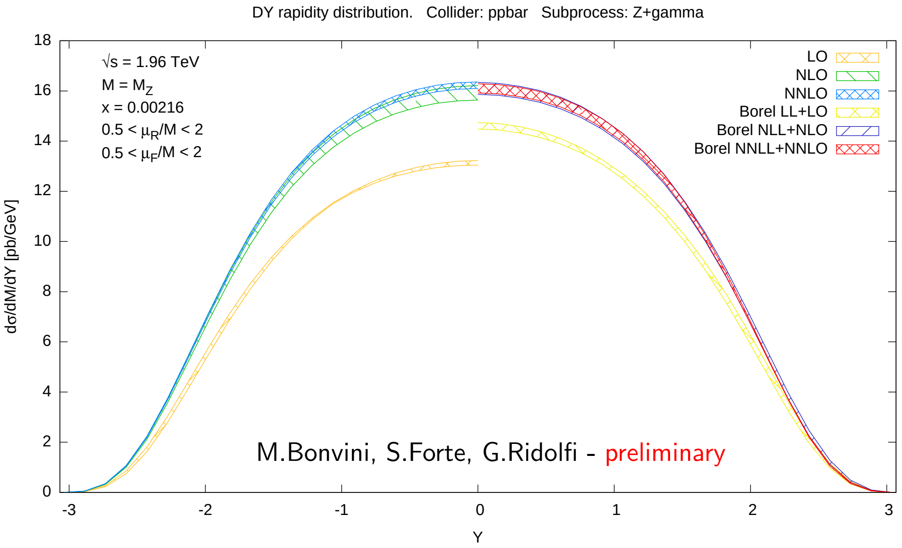
Mellin transforms

$$\int_0^1 dz\, z^{N-1} \left[\frac{\log^k(1-z)}{1-z}\right]_+ = \frac{1}{k+1}\sum_{j=0}^{k+1}\binom{k+1}{j}\Gamma^{(j)}(1)\Gamma(N)\Delta^{(k+1-j)}(N)$$

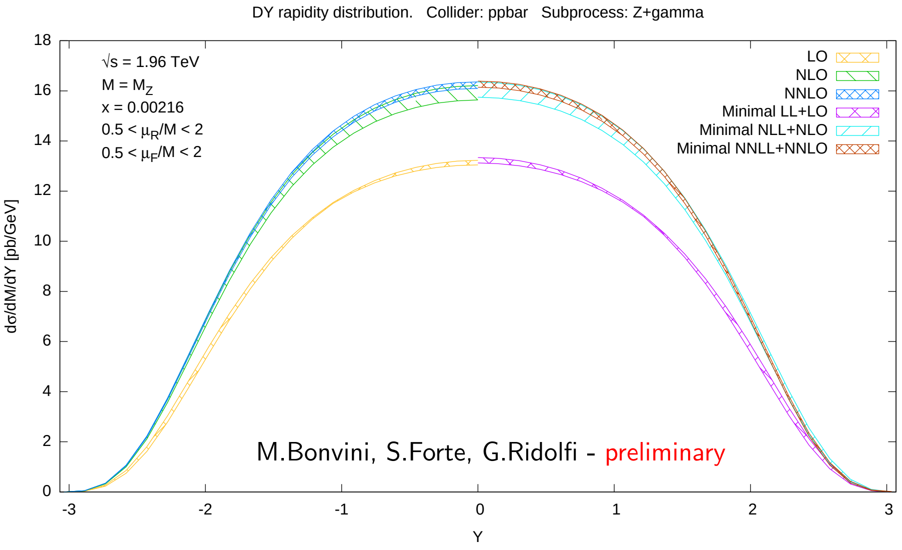
in the large N limit

$$\simeq \frac{1}{k+1}\sum_{j=0}^{k+1}\binom{k+1}{j}\Gamma^{(j)}(1)\log^{k+1-j}\frac{1}{N}$$

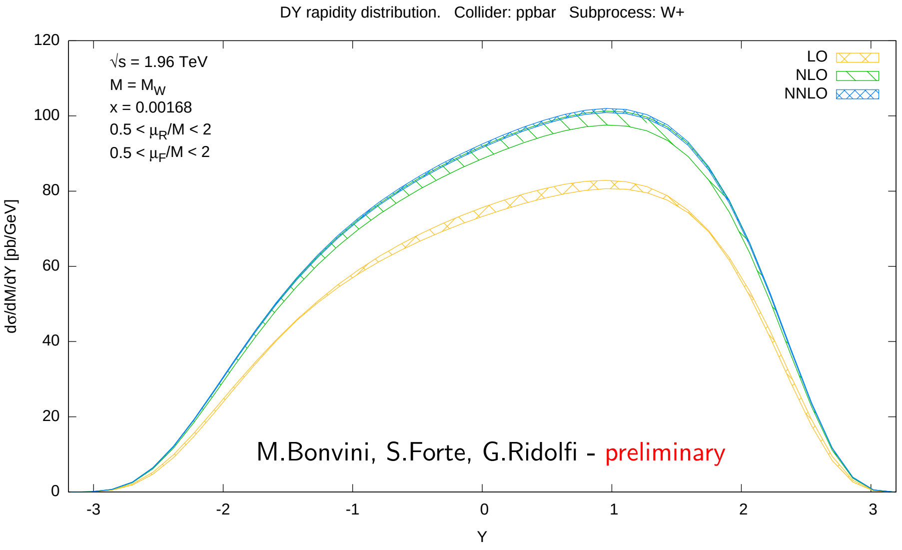
$$= \frac{\Gamma^{(k+1)}(1)}{k+1} + \int_0^1 dz\, z^{N-1}\left[\frac{\log^k \log\frac{1}{z}}{\log\frac{1}{z}}\right]_+$$


DY rapidity distribution. Collider: ppbar Subprocess: Z+gamma
√s = 1.96 TeV
M = M_Z
x = 0.00216
0.5 < μ_R/M < 2
0.5 < μ_F/M < 2
LO
NLO
NNLO
Borel LL+LO
Borel NLL+NLO
Borel NNLL+NNLO
dσ/dM/dY [pb/GeV]
Y
M.Bonvini, S.Forte, G.Ridolfi - preliminary

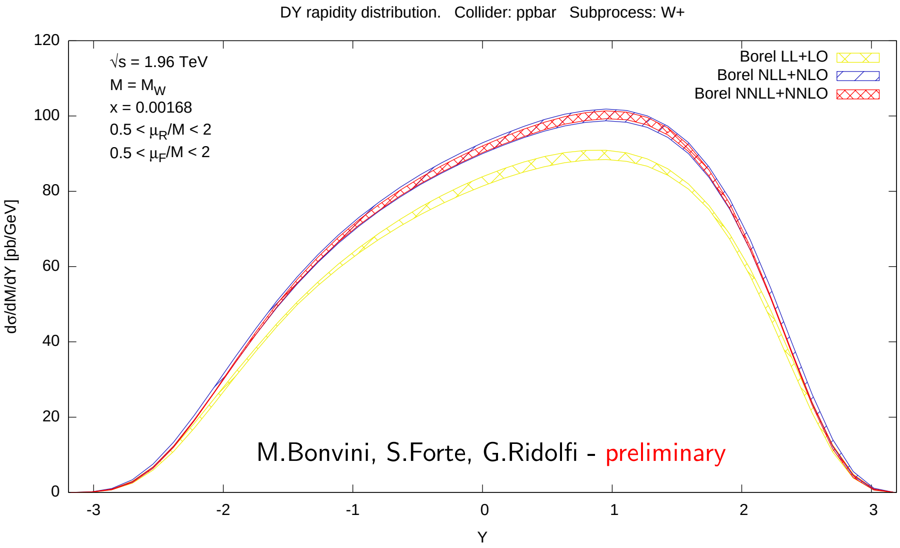
Rapidity distribution: Z at Tevatron (cteq6.6 pdfs used)



Rapidity distribution: W^+ at Tevatron (cteq6.6 pdfs used)



Rapidity distribution: W^+ at Tevatron (cteq6.6 pdfs used)



Rapidity distribution: W^+ at Tevatron (cteq6.6 pdfs used)