Resummation of High Order Corrections in Higgs Boson Plus Jets Production at the LHC

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Ref: Peng Sun, Joshua Isaacson, C.-P. Yuan, Feng Yuan, PRL 113, 232001 (2014); arXiv:1602.08133.

Outline

- QCD transverse momentum resummation
- Soft gluon resummation in Higgs plus jets production at the LHC
- Summary

QCD k_T resummation

- Consider the production process $h_1 h_2 \rightarrow H(Z)+X$

$$\frac{d\sigma}{dQ_T^2} \sim \frac{1}{Q_T^2}\{\ \alpha_S(L+1) \quad +\alpha_S^2(L^3+L^2) \quad +\alpha_S^3(L^5+L^4)+\alpha_S^4(L^7+L^6)+\ldots$$
$$+\alpha_S^2(\ L+\ \ 1) \quad +\alpha_S^3(L^3+L^2)+\alpha_S^4(L^5+L^4)+\ldots$$
$$+\alpha_S^3(\ L+\ \ 1)+\alpha_S^4(L^3+L^2)+\ldots\ \}$$

Where Q_T is the transverse momentum, and Q is the mass of H(Z), and $L = \mathrm{Log}[Q^2 / Q_T^2]$.

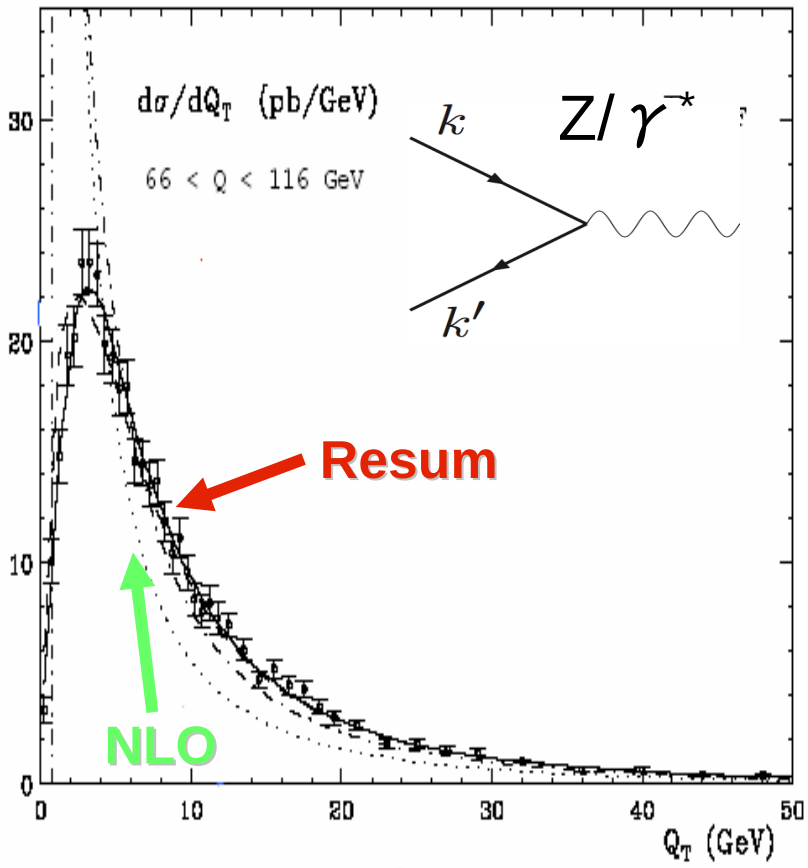
- We have to resum these large logs to make reliable predictions

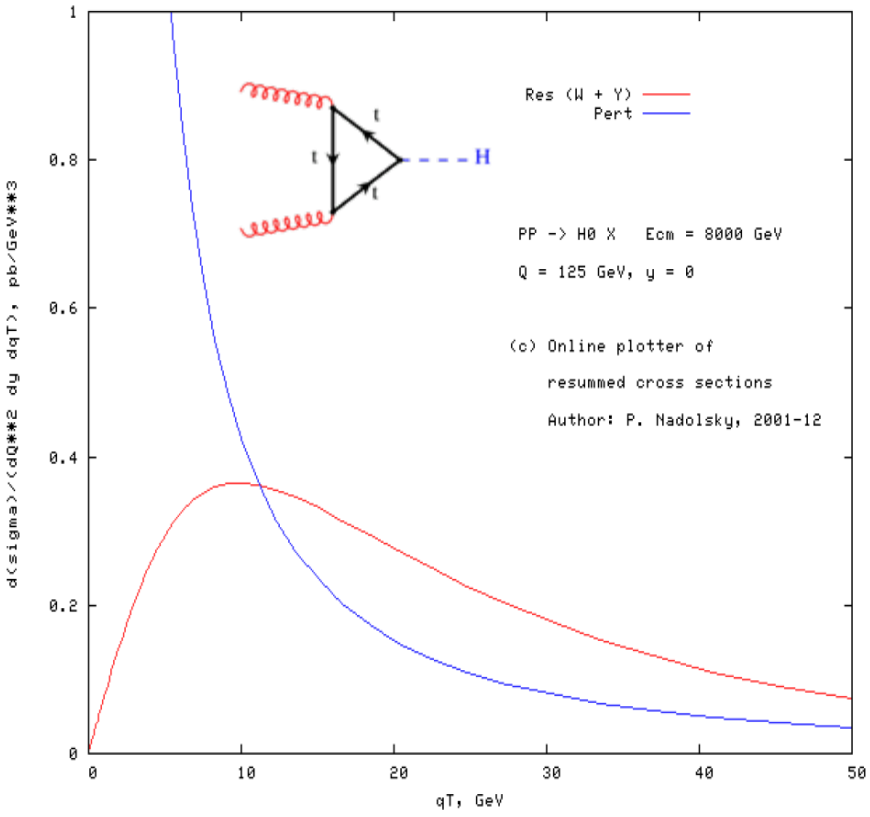
$$W(Q,b) = e^{-\int_{1/b}^{Q}\frac{d\mu}{\mu}\left(\ln\frac{Q}{\mu}A+B\right)}\left[C\otimes f_1\right]\left[C\otimes f_2\right]$$

For g g → H + X $\quad A^{(1)}=C_A\, a_s/\pi \quad B^{(1)}=-2C_A\, \beta_0\, a_s/\pi$

For q q → Z + X $\quad A^{(1)}=C_F\, a_s/\pi \quad B^{(1)}=-2C_F/3\, a_s/\pi$

How large are the resummation effects?

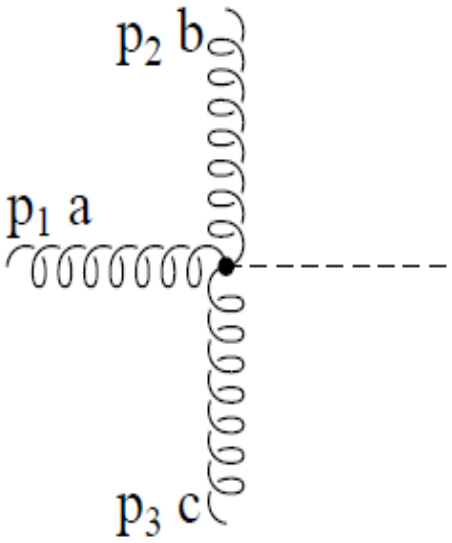


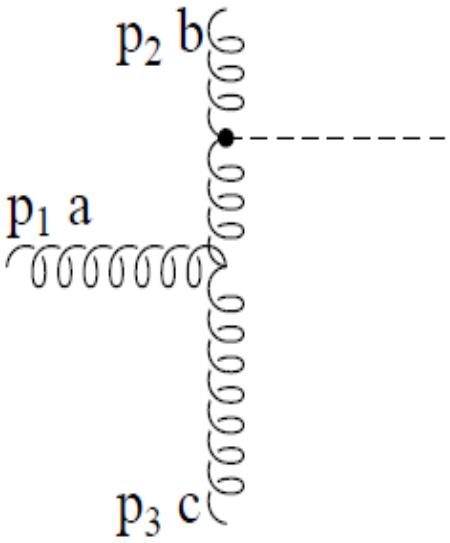


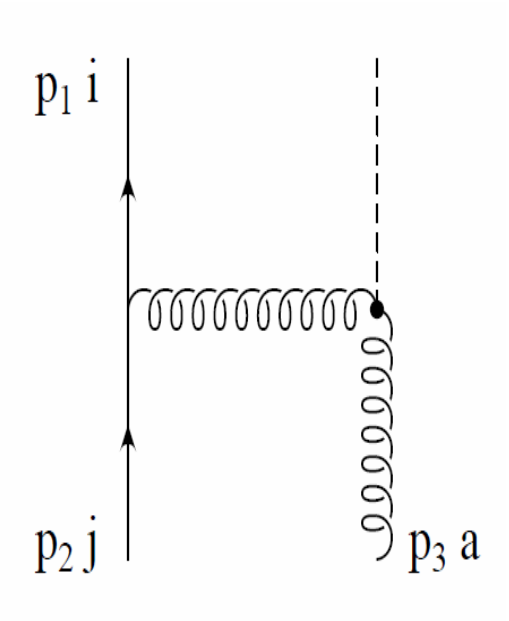
- The Sudakov factor knows about the color structure of the initial states

Higgs plus one jet productions in pp collision

- the leading order feynman diagrams







Sudakov factor in Higgs plus one jet process

$$S_{\mathrm{Sud}}(Q^2, b_\perp) = \int_{b_0^2/b_\perp^2}^{Q^2} \frac{d\mu^2}{\mu^2} \left[\ln\left(\frac{Q^2}{\mu^2}\right) A + B + D \ln \frac{1}{R^2} \right]$$

- for g g → H g

$$A = C_A \frac{\alpha_s}{\pi}, \; B = -2 C_A \beta_0 \frac{\alpha_s}{\pi}$$

- Additional term in Higgs plus jet:

$$D = C_A \frac{\alpha_s}{2\pi}$$

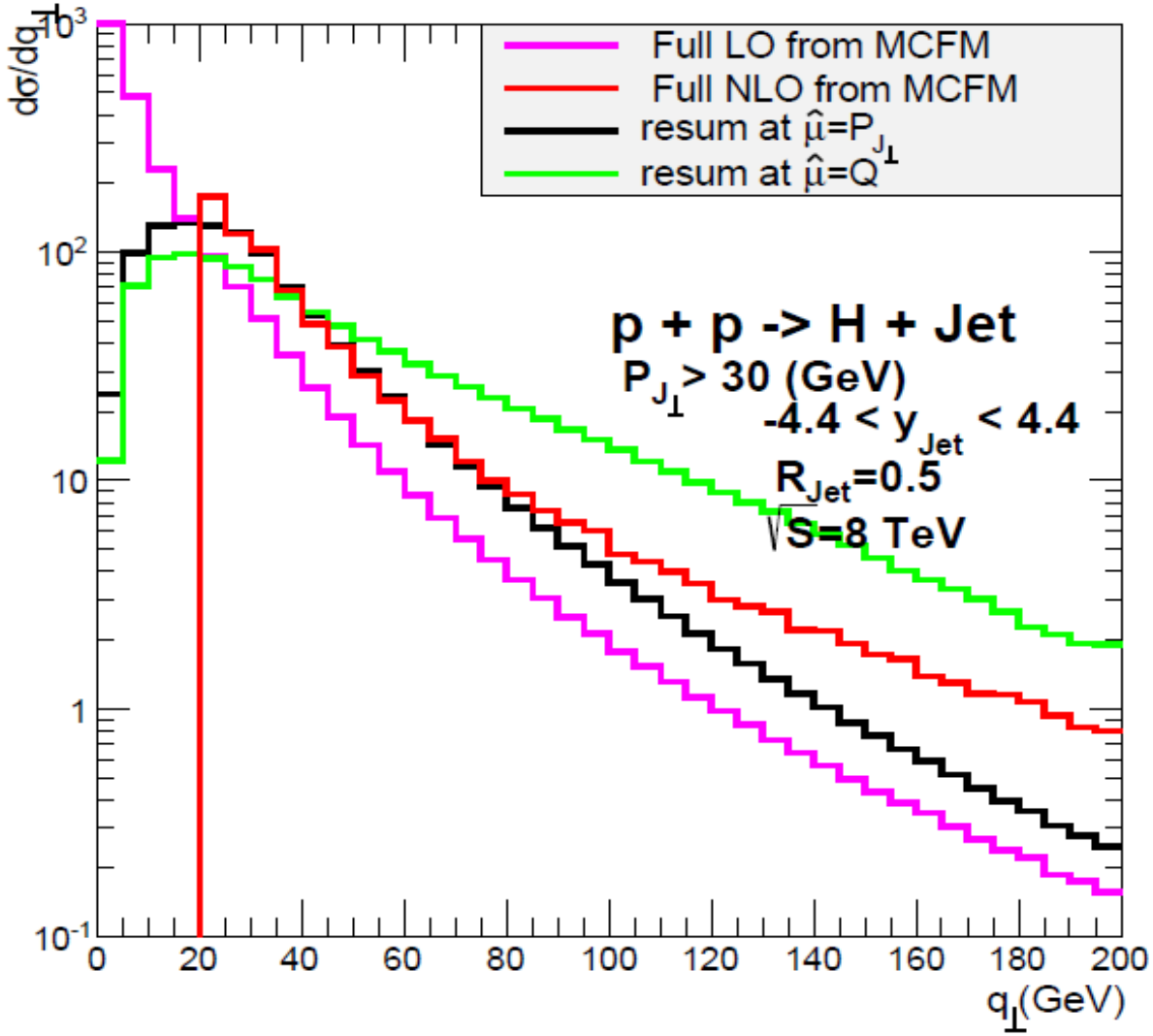
- for g q $\rightarrow$ H q

$$A = (C_F/2 + C_A/2)\frac{\alpha_s}{\pi}$$

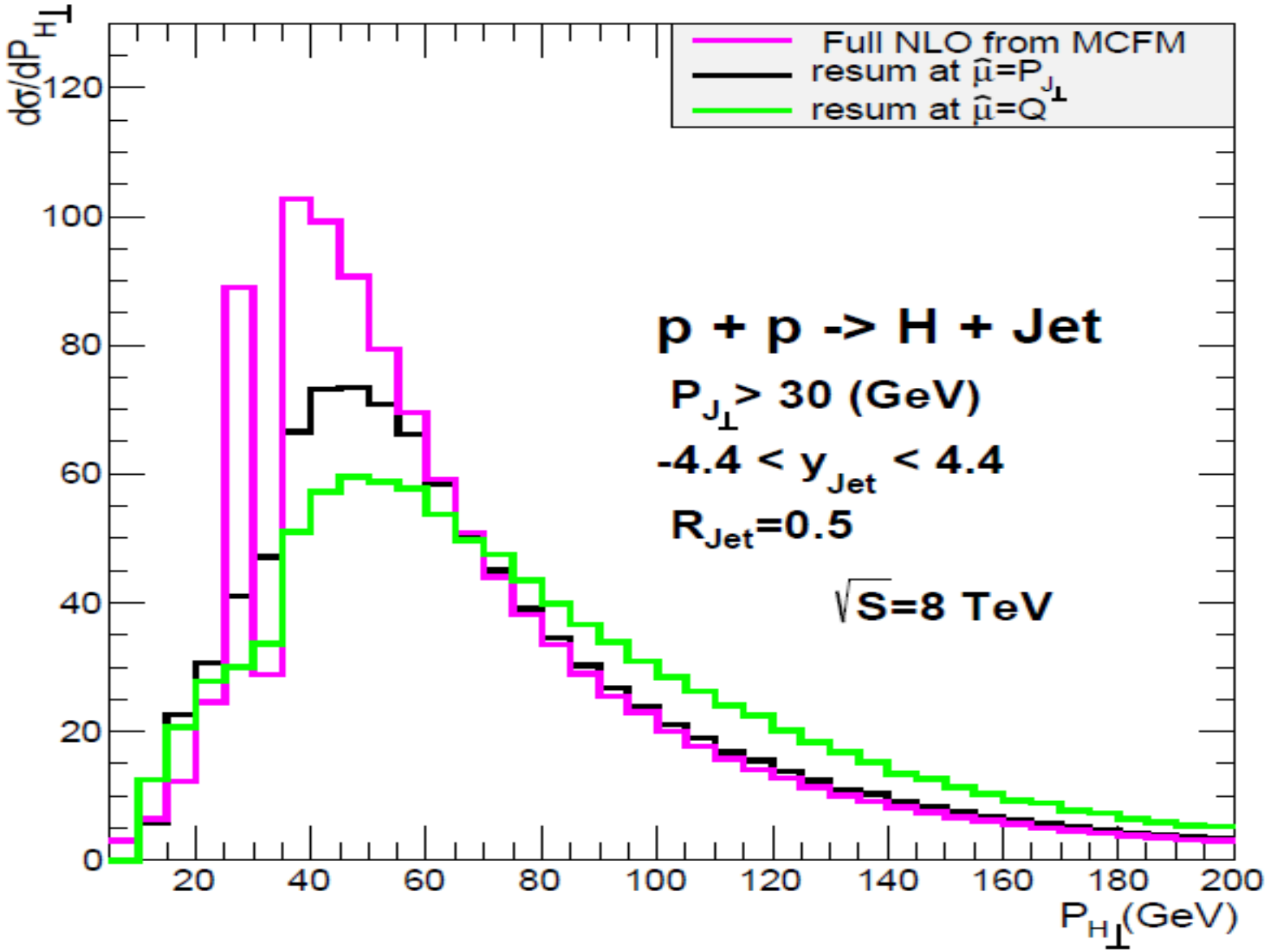
$$B = (-C_A\beta_0 - 3/4C_F - (1/2)C_A \ln u/t + (1/2)C_F \ln u/t)\frac{\alpha_s}{\pi}$$

$$D = C_F\frac{\alpha_s}{2\pi}$$

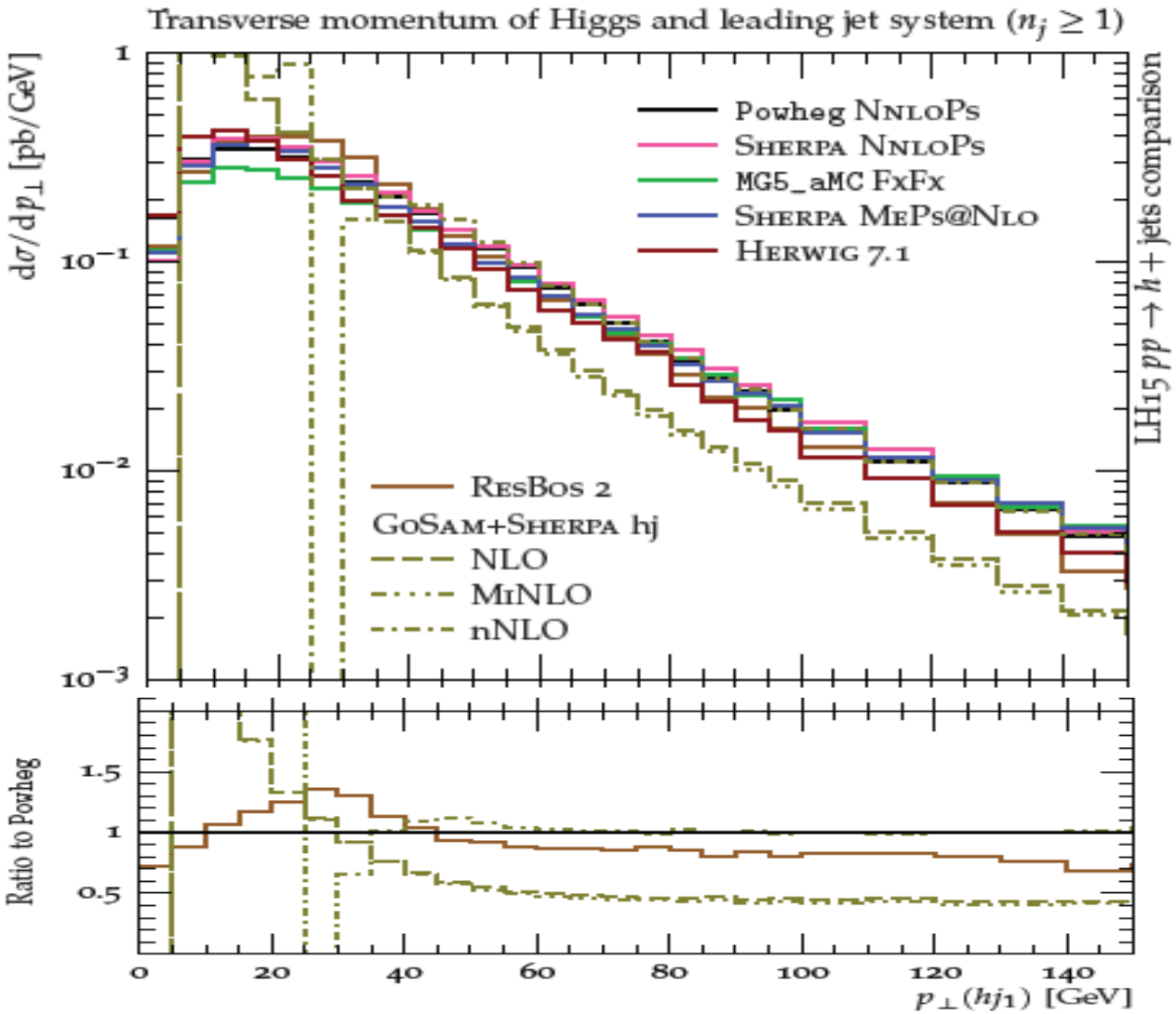
$q_\perp$ distribution of Higgs plus leading jet system



Higgs $P_\perp$ distribution

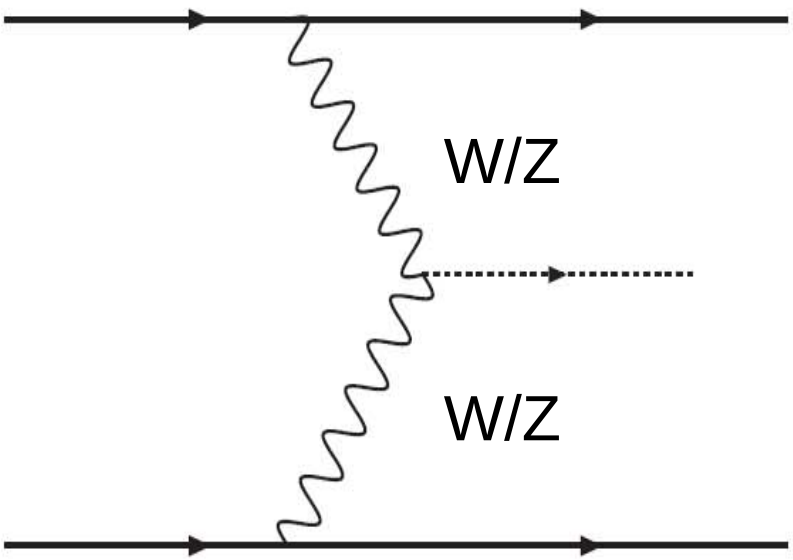


Comparison to MC generators and Fixed Order

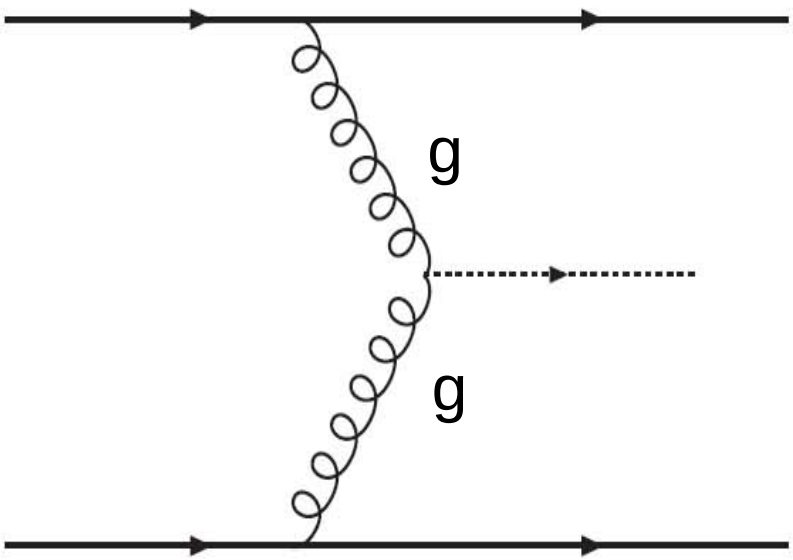


Higgs plus two jets production in pp collisions at large Δy_{jj} region

- The dominant contributions at tree level



(a)



(b)

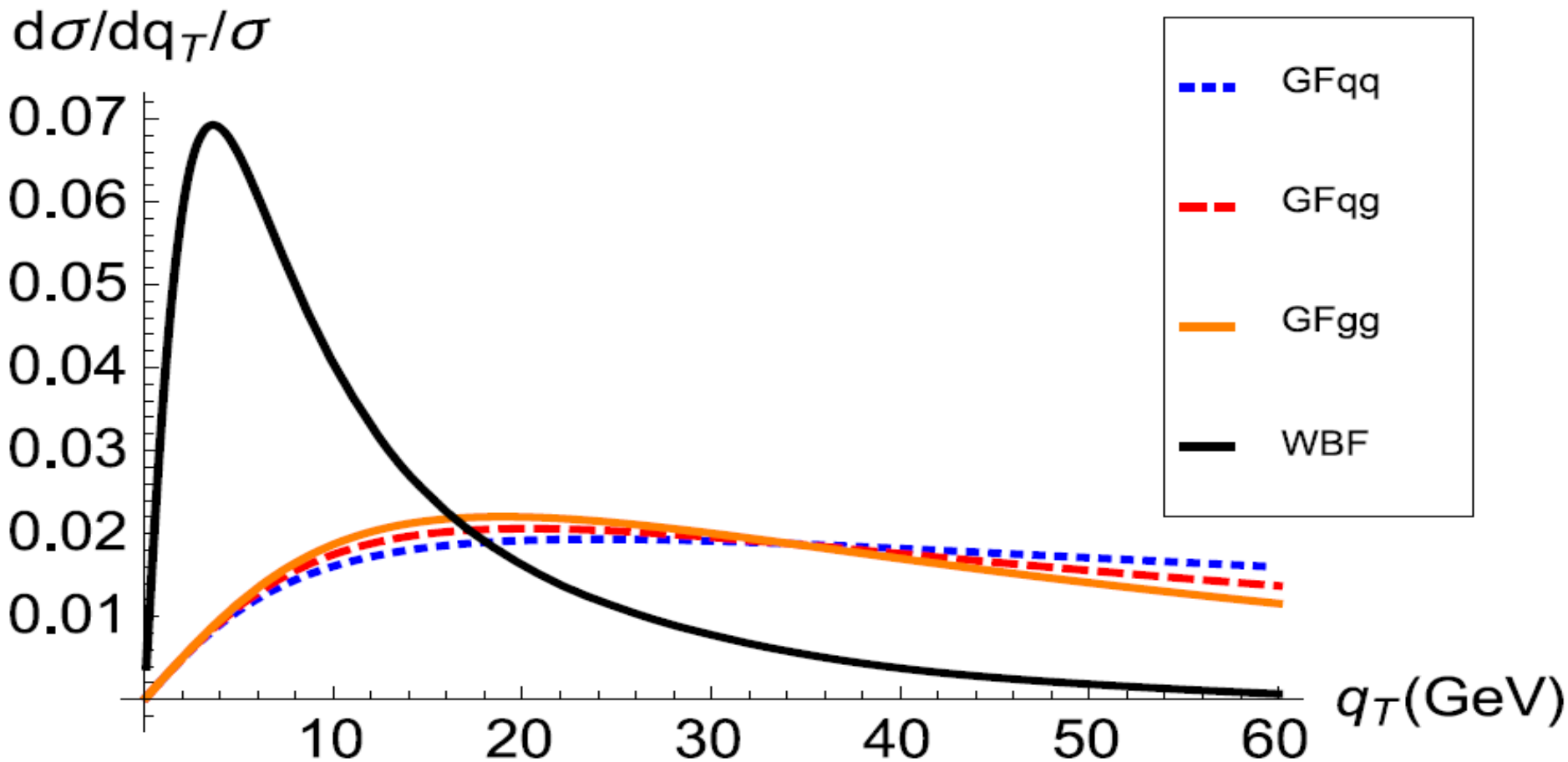
Sudakov factors

$$S_a(\hat{\mu}, b_\perp) = \int_{\mu_b^2}^{\hat{\mu}^2} \frac{d\mu^2}{\mu^2} \left[\ln\left(\frac{s}{\mu^2}\right) A_a + B_a + D_a \ln \frac{1}{R^2} + \gamma_a'^s \right]$$

- Where A and B coefficients are the same as Drell-Yan or Higgs plus 0 jet production.
- The coefficient D is decided by color structure of jet.

$$\gamma_{qWBF}'^s = -C_F \ln \frac{u_1}{t_1}, \quad \gamma_{qGF}'^s = (C_A - C_F) \ln \frac{u_1}{t_1}, \quad \gamma_{gGF}'^s = 0$$

- In the large Δy_{jj} region, $u_1 >> t_1$



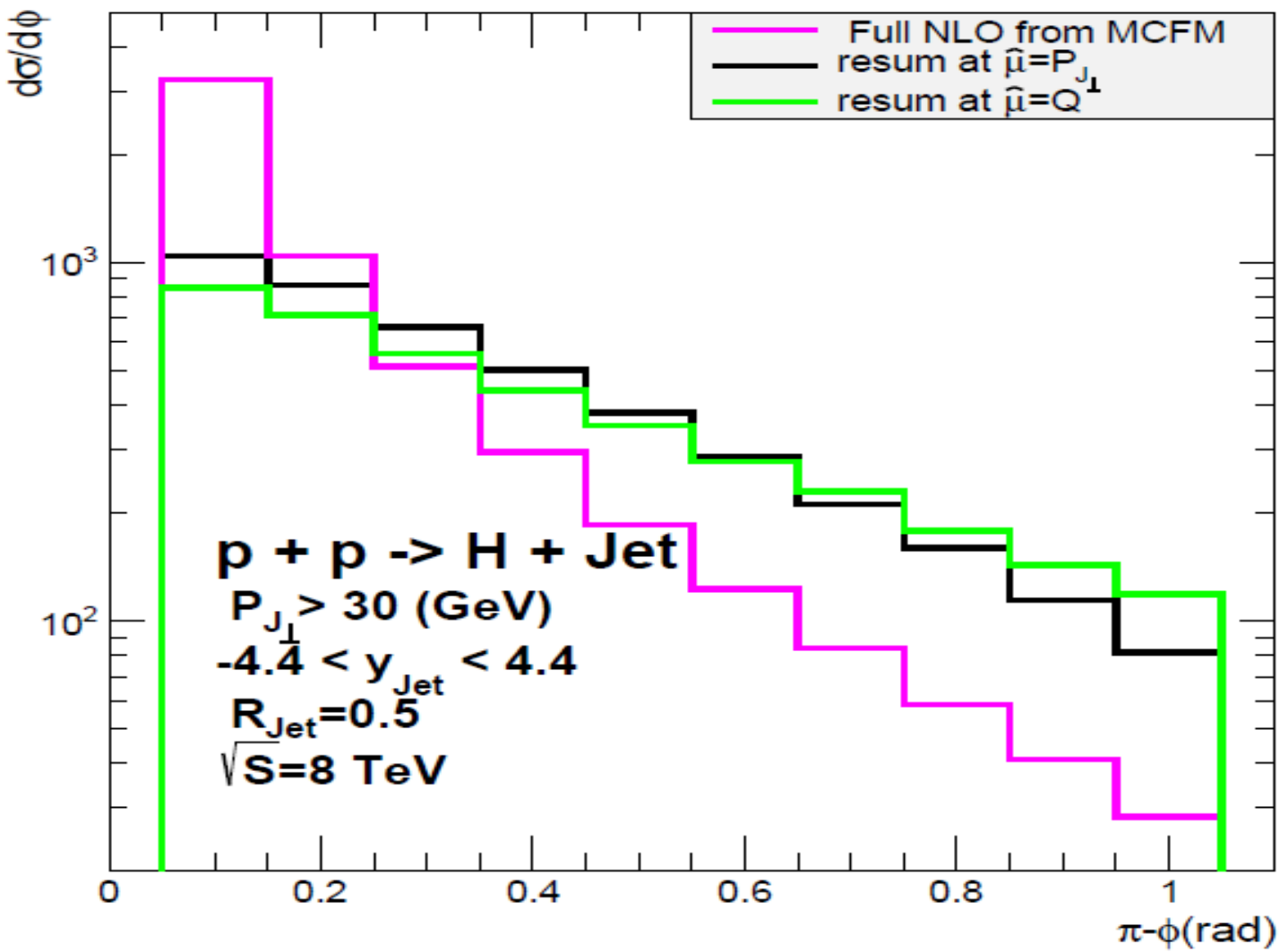
- q_T is the total transverse momentum of Higgs plus two leading jets
- In this plot: $y_{J1} = -y_{J2} = 2$ and $y_h = 0$, $\sqrt{S} = 13$TeV

Summary

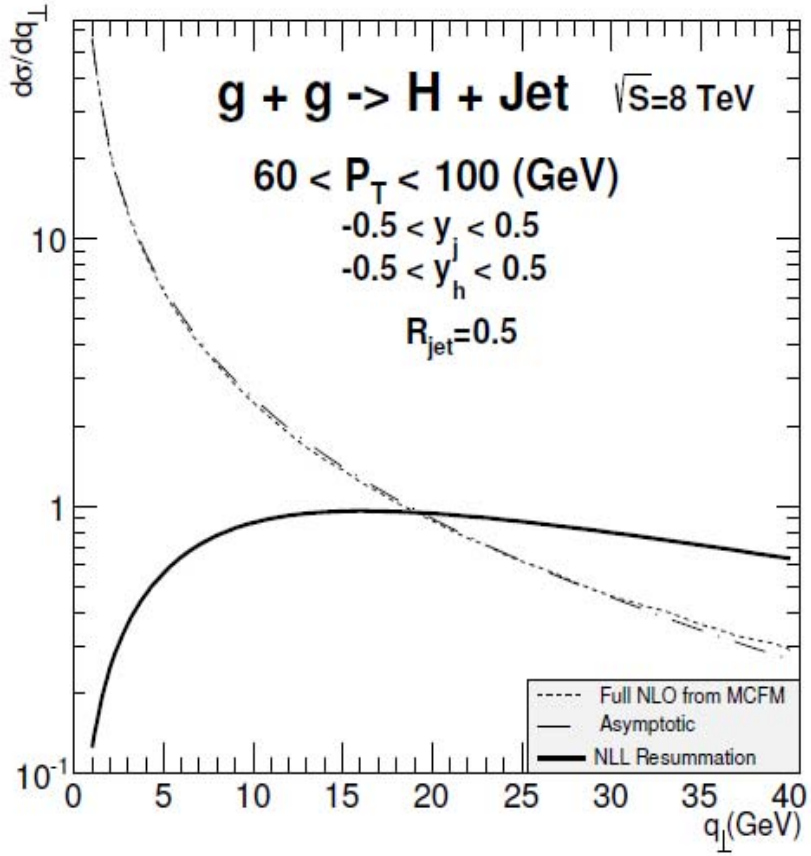
- The QCD resummation can give us a precise prediction of the SM
- The Sudakov factor knows about color structure and kinematics information of initial and final state particles.
- Such properties can help us to search for new physics signal

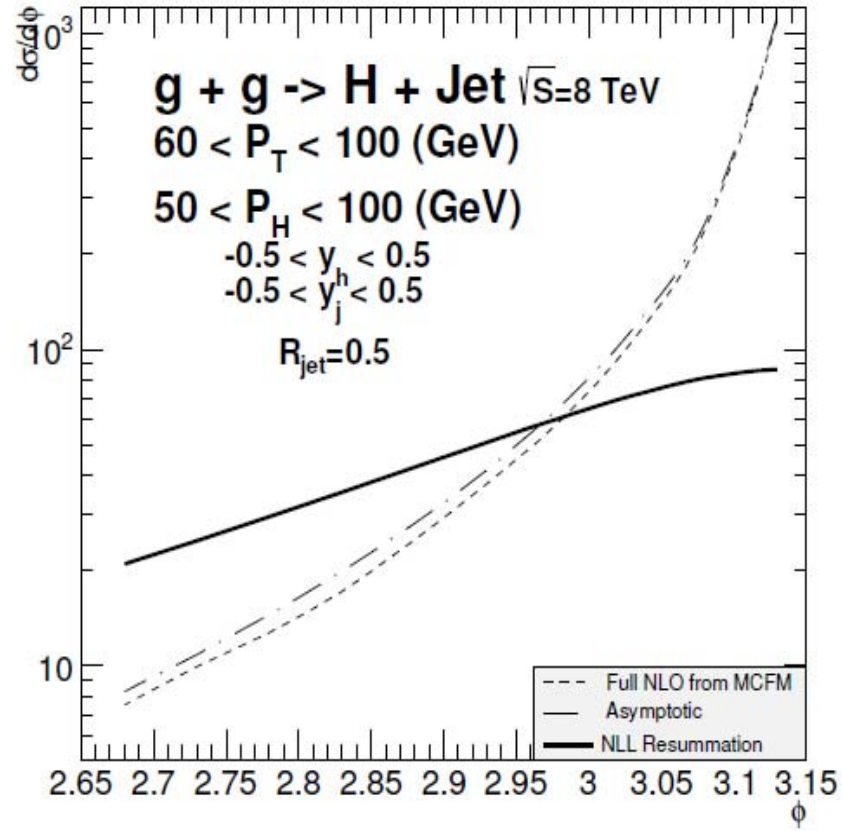
Thank you very much!

distribution of the azimuthal angle between Higgs and leading jet



Higgs + jet production in pp collision





- Higgs+Jet, Sun, C.-P. Yuan, F. Yuan, Phys.Rev.Lett. 114 (2015) 202001

Sudakov knows about cone size