

Transverse momentum resummation for Higgs boson searches

Pavel Nadolsky

Argonne National Laboratory

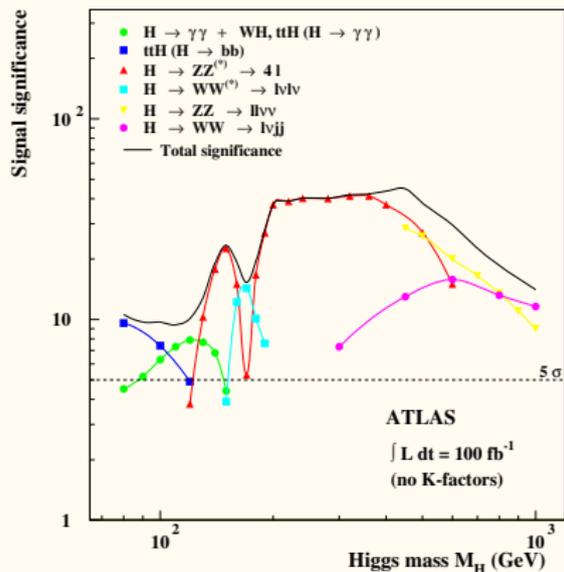
C. Balázs, E. Berger, P. Nadolsky, C.-P. Yuan, hep-ph/0603037

(see also Ed Berger's talk)

Transverse momentum (Q_T) resummation

- an analytical method to compute normalization and shape of differential distributions in hadronic scattering
- is proved to all orders in α_s in Drell-Yan-like processes by a QCD factorization theorem
- evaluates to all orders large QCD corrections $\propto \alpha_s^k \ln^p(Q_T^2/Q^2)$, arising at $Q_T \rightarrow 0$ (Q is the invariant mass of the produced system)
- reduces to the finite-order QCD cross sections at $Q_T \approx Q$
- relates the leading nonperturbative contributions in various processes

SM Higgs boson search at the LHC



$gg \rightarrow H \rightarrow \gamma\gamma$ (via t -quark loop) is the crucial search mode for $115 < M_H < 140 \text{ GeV}$

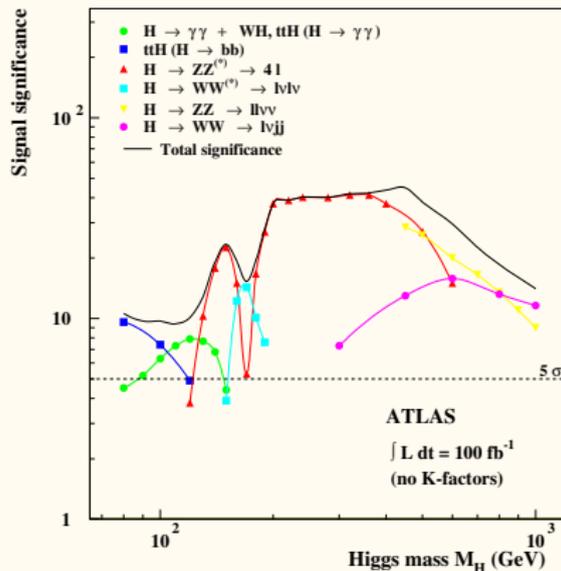
We use Q_T resummation to

- classify & compute QCD radiative corrections
- devise an improved search strategy that employs selection of $\gamma\gamma$ pairs with large Q_T

► Higgs signal has a larger $\langle Q_T \rangle$ than the QCD background



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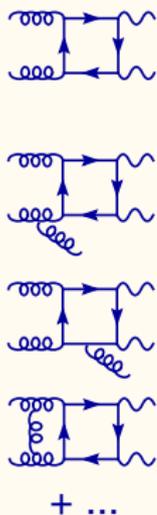
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Q_T resummation for $\gamma\gamma$ production (QCD background)

1. full NNLL accuracy in $q\bar{q}$, qg , and gg direct production channels
 - ▶ resummed $\mathcal{O}(\alpha_s^3)$ contributions in $gg \rightarrow \gamma\gamma X$
 - ▶ NNLO corrections to small- Q_T cross sections in all channels
2. new model for nonperturbative resummed contributions
3. improved treatment of the fragmentation region

$gg \rightarrow \gamma\gamma X$ in the $Q_T \rightarrow 0$ limit



- $\mathcal{O}(\alpha_s^3)$ 1-loop 5-leg (pentagon) diagrams
 - ▶ are computed in the helicity amplitude formalism
 - ▶ numerically checked against the “sector decomposition” calculation (Binoth, Guillet, Mahmoudi)
 - ▶ small- Q_T limit is derived at the matrix-element level using the splitting amplitude method
- 2-loop box diagrams are added at $Q_T = 0$; the full cross section is resummed in the $Q_T \rightarrow 0$ limit

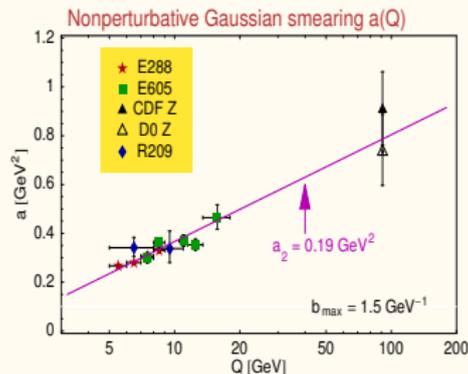
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New model for nonperturbative contributions

A. Konychev, **P. Nadolsky**, *PLB 633, 710 (2006)*

- A small fraction of heavy $\gamma\gamma$ pairs recoils against nonperturbative QCD radiation with $Q_T < a$ few GeV



- Initial-state nonperturbative contributions (\sim “intrinsic” $\langle k_T^2 \rangle \equiv a$) are predicted to follow universal quasi-linear dependence on $\ln Q$; this expectation is confirmed by our global analysis of Drell-Yan and Z boson data

- the observed $\ln Q$ dependence agrees with renormalon/lattice estimates
- the model is employed to predict $\gamma\gamma$ cross sections

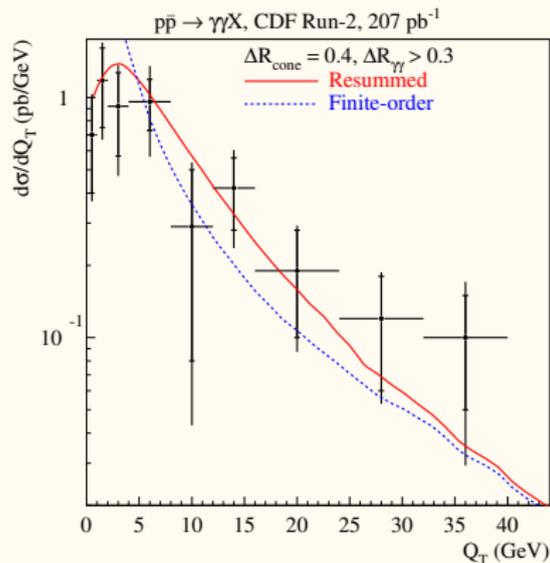
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Strategy to reduce fragmentation contributions at the Tevatron and LHC

Comparison with the CDF Run-2 data



- The NLO prediction (blue) diverges at low Q_T
- The resummed prediction (red) agrees with the data at all Q_T ; matches the NLO prediction at large Q_T
- Similar predictions are made for the LHC (Ed's talk)

Q_T resummation at small x and for heavy flavors

BFKL-like effects at small x at the Tevatron and LHC

S. Berge, P. Nadolsky, F. Olness, C.-P. Yuan, PRD 72, 033015 (2005)

- may affect the measurement of W boson mass and Higgs boson searches
- predicted by utilizing universality of resummed cross sections and HERA data

Q_T resummation for scattering of heavy (c, b) quarks

Berge, Nadolsky, Olness, Yuan, PRD 73, 013002 (2006); Belyaev, Nadolsky, Yuan, hep-ph/0509100 (accepted by JHEP)

- A framework to calculate dependence of resummed cross sections on heavy-quark masses $m_{c,b}$
- Computation of $m_{c,b}$ -dependent terms in W and Z boson production, $b\bar{b} \rightarrow \text{Higgs}$ in MSSM

