Chapter 8

Conclusions

In this thesis, we have studied the renormalization group approach to resummation for all inclusive deep-inelastic and Drell-Yan processes. The advantage of this approach is that it does not rely on factorization of the physical cross section, and in fact it simply follows from general kinematic properties of the phase space. Then we have analyzed some of its generalizations. In particular, we have presented a generalization to prompt photon production of the approach to Sudakov resummation which has been described in Chapter 3 for deep-inelastic scattering and Drell-Yan production. It is interesting to see that also with the more intricate two-scale kinematics that characterizes prompt photon production in the soft limit, it remains true that resummation simply follows from general kinematic properties of the phase space. Also, this approach does not require a separate treatment of individual colour structures when more than one colour structure contributes to fixed order results. The resummation formulae obtained here turn out to be less predictive than previous results: a higher fixed-order computation is required in order to determine the resummed result. This depends on the fact that here neither specific factorization properties of the cross section in the soft limit is assumed, nor that soft emission satisfies eikonal-like relations which allow one to determine some of the resummation coefficients in terms of universal properties of collinear radiation. Currently, fixed-order results are only available up to $O(\alpha_s^2)$ for prompt photon production. An order α_s^3 computation is required to check nontrivial properties of the structure of resummation: for example, factorization, whose effects only appear at the next-to-leading log level, can only be tested at $O(\alpha_s^3)$. The greater flexibility of the approach presented here would turn out to be necessary if the prediction obtained using the more restrictive resummation were to fail at order α_s^3. We have also proved a resumation formula for the Drell-Yan rapidity distributions to all logarithmic accuracy and valid for all values of rapidity. Isolating a universal dimensionless coefficient function, which is exactly that ones of the Drell-Yan rapidity-integrated, we have shown a general procedure to obtain resummed results to NLL for the rapidity distributions of a virtual photon γ^* or of a real vector boson $W^\pm, Z^0$. Furthermore, we have outlined a general method to calculate numerical predictions and analyzed the impact of resummation for the fixed-target experiment E866/NuSea. This shows that NLL resummation has an important effects on predictions of differential rapidity cross sections giving an agreement with data that is better than NNLO full calculations. We have found a suppression of the cross section for not large values of hadronic rapidity instead of enhancing it. This suppression arises due to the shift in the complex plane of the dominant contribution of resummed exponent. These leaves open questions for future studies about possible suppression of the rapidity integrated cross sections at small x. The study of the renormalization group resummation applied to the case of small transverse momentum distribution of Drell-Yan pairs has opened further interestingly aspects about the relation between factorization properties of the cross section and the final structure of the resummed results which has been not yet well understood. Furthermore, because of its generality, renormalization group resummation lends itself naturally to some important future applications. They are the factorization of resummation of rare meson decay processes (like $B \to X_s \gamma$) and the resummation of generalized parton densities in deeply virtual proton Compton scattering.