# Small $x$ Physics and Diffraction

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Measurements of structure functions and parton densities at HERA and the Tevatron have provided much insights into the high energy behavior of cross sections. The structure functions and parton densities increase rapidly with increasing energies, consistent with pQCD calculations. However, this increase with energy is much more rapid than for the total cross sections of $\gamma p$ and $pp$ collisions. Vector meson and diffractive dijet production in $ep$ provide an effective method to measure the energy dependence of the generalized gluon distribution of the proton as well as the impact parameter dependence of the gluon distribution.

At sufficiently small $x$ achievable at LHC new QCD regimes are expected. In particular within the double logarithmic approximation the transverse momenta of radiated partons in the current fragmentation region begin to increase with increasing energy. Besides this, the interpretation of parton distributions as probability distribution becomes in conflict with the probability conservation at the kinematics to be achieved at LHC. Therefore, the challenging question is to quantify the boundaries of this kinematical regime and elucidate properties of the new QCD regime of strong interaction with small coupling constant.

At the high energies of the LHC multjet cross sections will become more and more important. For the detailed calculation of multi-jet cross sections of moderate transverse momentum, integrated single parton density functions are no longer sufficient. Multi-parton densities in impact parameter space are needed.

Whereas in principle the relation between diffraction and multi-parton interaction is given by the AGK rules, the details in terms of QCD are not yet fully understood. The topic of creation of rapidity gaps (diffractive processes) and the influence of absorptive effects, which can destroy the rapidity gap, is currently under detailed investigations, both theoretically and experimentally. These effects are directly related to multi-parton interaction in non-diffractive processes.

The separation of soft and hard processes in impact parameter space will tell whether multi-parton interactions are dominated by the soft - strong coupling regime, or whether significant contributions come also from the weak coupling - perturbative region. Indications, that hard perturbative processes are in the regime of strong interaction with weak running coupling constant come from the diffractive jet (vector meson) production but also from investigations of multiparton interactions with Monte Carlo event generators. To avoid too large particles multiplicities in $pp$ collisions at LHC energies the standard approaches are applicable to the regions of $p_t^2 \gtrsim 6 GeV^2$. Below this value multi-parton interactions probably cannot be considered as independent. The issue of separating soft from hard processes can be also investigated by the transverse momentum distribution of jets close to the rapidity gap and by the standard forward and Mueller-Navelet jets. At LHC energies it becomes practical to separate experimentally peripheral and central collisions. Small $x$ physics of hard processes, new heavy particle production are concentrated at central $pp$ collisions, soft QCD is mostly peripheral. Hard (soft) diffraction are dominated by central(peripheral) collisions

The topics of the session *small $x$ and diffraction* were grouped around these major areas. Much progress has been achieved in the last years, both experimentally and theoretically, which is reflected in the presentations in this session. However, a full understanding of *small $x$ and diffractive* processes is still far ahead. We mention a few of the major open issues:

- how well do we understand PDFs at small x ?
- how well do we understand the properties of new regime of high density QCD in the weak coupling constant limit ?
- what is the relation between diffraction and multiparton interaction in the region of high gluon density in small $x$ QCD where coupling constant is small but the interaction is strong ?
- what is the interplay between soft and hard processes ?
- how can diffraction and saturation be consistently implemented in Monte Carlo event generators ?
- what are the impact parameter distributions of partons and the correlations between partons within the wave functions of the colliding hadron in case of multiparton interactions ?