HARD SCATTERING AND A DIFFRACTIVE TRIGGER

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It has often been suggested that a good way to search for heavy flavors is to look in diffractively produced systems. The data on charm production [1] at the ISR seem to support this idea. In thinking about the SSC, one must therefore examine how useful it would be to use a diffractive trigger. In particular one must ask how important it is to design a special purpose detector. For our purposes, a diffractive event is one in which one of the initial hadrons is scattered through a small angle and in which there is a large rapidity gap between this hadron and the other hadrons in the final state.

We have recently investigated the properties of hard scattering in diffractively produced systems, and in this note we wish to summarize our conclusions. They are presented in detail in ref. 2. There we show how perturbative QCD applies to such processes and present the results of some numerical calculations for heavy flavor production. It should be emphasized, however, that our methods apply to diffractive hard scattering in general, and not only to heavy flavor production. Heavy flavor production is not a particularly special case, except that it is predominantly a gluon-initiated process.

Our investigation of diffractive hard scattering was partly inspired by our demonstration [3] that the totally inclusive cross-section for heavy flavor production can be correctly calculated from the standard factorization theorem of perturbative QCD. We explicitly showed that diffractive production is included as a component of this cross-section. The cross-section for diffractive heavy flavor production is therefore not an extra piece to be added on to the result of the usual perturbative calculation.

There are two particular motivations for studying diffractive hard scattering. The first is to investigate the interface between Regge theory and (perturbative) QCD. This area is not yet very well explored, but there is great potential both at the current generation of hadron colliders (the Sp$\bar{p}$S and the Tevatron) and at the SSC for substantial improvements in our experimental understanding. The second motivation is to see whether diffractive triggering can result in an improvement in the signal-to-background ratio of measurements of production of very heavy quarks, like the top.

Other groups [4,5] have also investigated diffractive hard scattering. In common with them we find that the cross-section is given in terms of what we may term the distribution of partons in a Pomeron. The improvements in our work consist of an evaluation of whether a factorization formula is indeed valid, a computation of the rapidity distribution for individual heavy quarks, and a detailed investigation of the constraints that must be placed on the functional form of the distribution of partons in a Pomeron, even in the absence of an experimental measurement.

The main results that we present in Ref. [2] are as follows:

1. A factorization formula is valid for diffractive hard scattering, <u>but only to the extent that Regge factorization is valid for</u>

ordinary high-mass diffraction.

2. The momentum sum-rule probably applies to the parton distributions in a Pomeron, $f_{i/P}(x)$.
3. Triple Regge theory predicts the value of $f_{i/P}(x)$ at small fractional momentum x.
4. There is a parton-counting rule result that gives the power law for $f_{i/P}(x)$ as $x \longrightarrow 1$.
5. As a consequence of points 2 to 4, the gluon distribution in a Pomeron is predominantly valence-like rather than sea-like. We find that the following gluon distribution satisfies all our constraints: $xf_{g/P}(x) = (0.18 + 5.46\, x)\,(1-x)$. It is normalized so that it carries all the momentum of the Pomeron: $\int dx\, xf_{g/P}(x) = 1$.
6. We calculate the cross-sections for diffractive production of heavy quarks of various masses, corresponding to c, b and t quarks.
7. At $\sqrt{s} = 540$ GeV, the fraction of charm production ($M_Q/\sqrt{s} \sim 1.87/540$) that is diffractive is computed to be above 50%. (However, we probably should not trust a perturbative calculation of charm production.) For bottom, the fraction is about 30%, while for a top quark of 40 GeV, the fraction is less than 1%. The diffractive mechanism is at its most effective if the heavy quark mass is much less than $\sqrt{s}$.
8. We can illustrate the importance of diffractive hard scattering at the SSC by scaling our results for the current colliders. At $\sqrt{s} = 40$ TeV, a quark of mass 400 GeV has approximately the same $M_Q/\sqrt{s}$ as a b quark at the $Sp\bar{p}S$ or at the Tevatron. Therefore we estimate the fraction of diffractive production of such a quark to be around 30%. Evidently, for detailed studies of the properties of quarks and other systems with masses in the region of hundreds of GeV, it would be valuable and interesting to look at diffractive production.

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