HARD DIFFRACTION AT THE LHC

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We use a Monte Carlo implementation of recently developped models of inclusive and exclusive diffractive W, top, Higgs and stop productions to assess the sensitivity of the LHC experiments.

1. Theoretical framework

We distinguish in the following the so called inclusive and exclusive models for diffraction [1]. We call exclusive models the models where almost the full energy available in the center of mass is used to produce the heavy object (dijets, Higgs, diphoton, W...). In other words, we get in the final state the diffractive protons (which can be detected in roman pot detectors) and the heavy state which decays in the main detector. The inclusive diffraction corresponds to events where only part of the available energy is used to produce the heavy object diffractively. For this model, we assume the pomeron is made of quarks and gluons (we take the gluon and quark densities from the HERA measurements in shape and the normalisation from Tevatron data), and a quark or a gluon from the pomeron is used to produce the heavy state. Thus the exclusive model appears to be the limit where the gluon in the pomeron is a δ distribution in this framework or in other words, there is no pomeron remnants in exclusive events.

More details about the theoretical model and its phenomenological applications can be found in Refs. [3] and [2]. In the following, we use the Bialas Landshoff model for exclusive Higgs production recently implemented in a Monte-Carlo generator [3].

2. Results on exclusive diffractive Higgs production

Results are given in Fig. 1 for a Higgs mass of 120 GeV, in terms of the signal to background ratio S/B, as a function of the Higgs boson mass resolution. Let us notice that the background is mainly due the exclusive

$b\bar{b}$ production. However the tail of the inclusive $b\bar{b}$ production can also be a relevant contribution and this is related to the high β gluon density which is badly known as present. It is thus quite important to constrain these distributions using Tevatron and LHC data as suggested in a next section. In order to obtain an S/B of 3 (resp. 1, 0.5), a mass resolution of about 0.3 GeV (resp. 1.2, 2.3 GeV) is needed. The diffractive SUSY Higgs boson production cross section is noticeably enhanced at high values of $\tan\beta$ and since we look for Higgs decaying into $b\bar{b}$, it is possible to benefit directly from the enhancement of the cross section contrary to the non diffractive case. A signal-over-background up to a factor 50 can be reached for 100 fb^{-1} for $\tan\beta \sim 50$ [4].

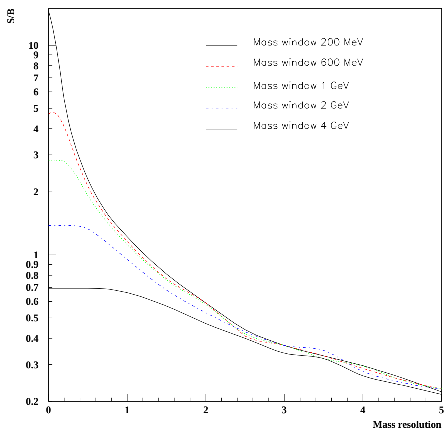

Figure 1. Standard Model Higgs boson signal to background ratio as a function of the resolution on the missing mass, in GeV for a Higgs boson mass of 120 GeV.

3. Threshold scan method: W, top and stop mass measurements

We propose a new method to measure heavy particle properties via double photon and double pomeron exchange (DPE), at the LHC [5]. In this category of events, the heavy objects are produced in pairs.

Pair production of WW bosons and top quarks in QED and double pomeron exchange are described in detail in this section. WW pairs are produced in photon-mediated processes, which are exactly calculable in QED. On the contrary, $t\bar{t}$ events, produced in exclusive double pomeron exchange, suffer from theoretical uncertainties since exclusive diffractive production is still to be observed at the Tevatron, and other models lead to different cross sections, and thus to a different potential for the top quark mass measurement. However, since the exclusive kinematics are simple, the model dependence will be essentially reflected by a factor in the effective luminosity for such events.

One proposed method (the "histogram" method) corresponds to the comparison of the mass distribution in data with some reference distributions following a Monte Carlo simulation of the detector with different input masses corresponding to the data luminosity. For each Monte Carlo sample, a χ^2 value corresponding to the population difference in each bin between data and MC is computed. This method has the advantage of being easy but requires a good simulation of the detector.

The precision of the WW mass measurement (0.3 GeV for 300 fb^{-1}) is not competitive with other methods, but provides a very precise way to check the alignment of the roman pot detectors. The precision of the top mass measurement is however competitive, with an expected precision better than 1 GeV at high luminosity provided the cross section is high enough.

The other application is to use the so-called "threshold-scan method" to measure the stop mass in exclusive events. The idea is straightforward: one measures the turn-on point in the missing mass distribution at about twice the stop mass. After taking into account the stop width, we obtain a resolution on the stop mass of 0.4, 0.7 and 4.3 GeV for a stop mass of 174.3, 210 and 393 GeV for a luminosity (divided by the signal efficiency) of 100 fb^{-1}.

4. Constraining the high β gluon using Tevatron and LHC data?

In this section, we would like to discuss how we can measure the gluon density in the pomeron, especially at high β since the gluon in this kinematical domain shows large uncertainties and this is where the exclusive contributions should show up if they exist. To take into account, the high-β uncertainties of the gluon distribution, we chose to multiply the gluon density in the pomeron measured at HERA by a factor $(1-\beta)^{\nu}$ where ν varies between -1.0 and 1.0.

A possibility to measure precisely the gluon distribution in the pomeron at high β would be at the LHC the measurement of the $t\bar{t}$ cross section in double pomeron exchange in inclusive events. By requiring the production of high mass objects, it is possible to assess directly the tails of the gluon distribution. In Fig.2, we give the total mass reconstructed in roman pot detectors for double tagged events in double pomeron exchanges and the sensitivity to the gluon in the pomeron.

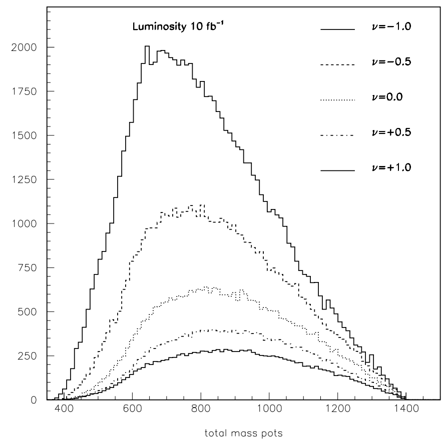

Figure 2. Total diffractive mass reconstructed for $t\bar{t}$ inclusive events in double pomeron exchanges using roman detectors at the LHC. We multiply the gluon distribution by $(1-\beta)^{\nu}$ to show the sensitivity on the gluon density at high β

References

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