Hard diffraction at the LHC and the Tevatron using double pomeron exchange

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We use a Monte Carlo implementation of recently developed models of inclusive and exclusive diffractive $W$, top, Higgs and stop productions to assess the sensitivity of the LHC experiments. We also discuss how the Tevatron experiments could test the models and measure the gluon density in the pomeron, which is needed to make precise predictions at the LHC.

Hard diffraction at the LHC has brought much interest recently related to diffractive Higgs and SUSY production. It is thus important that the different models available can be tested at the Tevatron before the start of the LHC. In this contribution, we will consider only one model based on the Bialas-Landshoff approach \( I \), and more details about other models and their implications can be found in \( II \) and the references therein.

I. THEORETICAL FRAMEWORK

We distinguish in the following the so called inclusive and exclusive models for diffraction. 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 shape and the normalisation from Tevatron data), and a quark or a gluon from the pomeron is used to produce the

A. Exclusive model

Let us first introduce the model \( III \) we shall use for describing exclusive production. In \( III \), the diffractive mechanism is based on two-gluon exchange between the two incoming protons. The soft pomeron is seen as a pair of gluons non-perturbatively coupled to the proton. One of the gluons is then coupled perturbatively to the hard process while the other one plays the rôle of a soft screening of colour, allowing for diffraction to occur. We will give here the formulae for either the SUSY Higgs boson, or the $\tilde{t}\tilde{t}$ pairs production and other formulae for standard model Higgs bosons, $t\bar{t}$, diphoton or dijet production can be found in \( III \). The corresponding cross-sections for Higgs bosons and $t\bar{t}$ production read:

\[
d\sigma_{\text{exc}}(s) = C_h \left( \frac{s}{M_h^2} \right) 2^{2e} \delta \left( \xi_1 \xi_2 - \frac{M_h^2}{s} \right) \prod_{i=1,2} \left\{ d^2 v_i \frac{d\xi_i}{\xi_i} \xi_i^{2v_i^2} \exp(-2\lambda_h v_i^2) \right\} \sigma(gg \to h)
\]

\[
d\sigma_{\tilde{t}\tilde{t}}(s) = C_{\tilde{t}\tilde{t}} \left( \frac{s}{M_{\tilde{t}\tilde{t}}^2} \right) 2^{2e} \delta \left( \sum_{i=1,2} (v_i + k_i) \right) \prod_{i=1,2} \left\{ d^2 v_i d^2 k_i d\xi_i d\eta_i \xi_i^{2\eta_i^2} \exp(-2\lambda_{\tilde{t}\tilde{t}} \eta_i^2) \right\} \sigma(gg \to \tilde{t}\tilde{t})
\]

where, in both equations, the variables $v_i$ and $\xi_i$ denote respectively the transverse momenta and fractional momentum losses of the outgoing protons. In the second equation, $k_i$ and $\eta_i$ are respectively the squark transverse momenta and rapidities. $\sigma(gg \to H), \sigma(gg \to \tilde{t}\tilde{t})$ are the hard production cross-sections which are given later on. The model normalisation constants $C_h, C_{\tilde{t}\tilde{t}}$ are fixed from the fit to dijet diffractive production \( III \), while the ratio is fixed theoretically \( III \).

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In the model, the soft pomeron trajectory is taken from the standard Donnachie-Landshoff parametrisation $^3$, namely $\alpha(t) = 1 + \epsilon + \alpha' t$, with $\epsilon \approx 0.08$ and $\alpha' \approx 0.25 \text{GeV}^{-2}$. $\lambda_h, \lambda_{\bar{p}p}$ are kept as in the original paper $^3$ for the SM Higgs and $q\bar{q}$ pairs. Note that, in this model, the strong (non perturbative) coupling constant is fixed to a reference value $G^2/4\pi$, which will be taken from the fit to the observed centrally produced diffractive dijets.

In order to select exclusive diffractive states, it is required to take into account the corrections from soft hadronic scattering. Indeed, the soft scattering between incident particles tends to mask the genuine hard diffractive interactions at hadronic colliders. The formulation of this correction $^5$ to the scattering amplitudes consists in considering a gap survival probability. The correction factor is commonly evaluated to be of order 0.03 for the QCD exclusive diffractive processes at the LHC.

More details about the theoretical model and its phenomenological applications can be found in Refs. $^6$ and $^7$. In the following, we use the Bialas Landshoff model for exclusive Higgs production recently implemented in a Monte-Carlo generator $^8$.

### B. Inclusive model

Let us now discuss the inclusive models. We first notice that both models are related, since they are both based on the Bialas Landshoff formalism. The main difference, as we already mentioned, is that the exclusive model is a limit of the inclusive model where the full energy available is used in the interaction. The inclusive models implies the knowledge of the gluon and quark densities in the pomeron. Whereas exclusive events are still to be observed, inclusive diffraction has been studied already in detail at UA8 and then at HERA and Tevatron.

The inclusive mechanism is based on the idea that a Pomeron is a composite system, made itself from quarks and gluons. In our model, we thus apply the concept of Pomeron structure functions to compute the inclusive diffractive Higgs boson cross-section. The H1 measurement of the diffractive structure function $^7$ and the corresponding quark flux factors in the normalisation between the HERA and hadron colliders $^9$.

Indeed, recent results from a QCD fit to the diffractive structure function in H1 $^9$ show that the discrepancy between the gluonic content of the Pomeron at HERA and Tevatron appears mainly in normalisation.

Regge factorisation is known to be violated between HERA and the Tevatron. Moreover, we want to use the same physical idea as in the exclusive model $^2$, namely that a non perturbative gluon exchange describes the soft interaction between the incident particles. In practice, the Regge factorisation breaking appears in three ways in our model:

i) We keep as in the original model of Ref $^3$ the soft Pomeron trajectory with an intercept value of 1.08.

ii) We normalize our predictions to the CDF Run I measurements, allowing for factorisation breaking of the Pomeron flux factors in the normalisation between the HERA and hadron colliders $^1$.

iii) The color factor derives from the non-factorizable character of the model, since it stems from the gluon exchange between the incident hadrons. We will see later the difference between this and the factorizable case.

The formulae for the inclusive production processes considered here follow. We have, for dijet production$^2$, considering only the dominant gluon-initiated hard processes:

$$d\sigma^{incl}_{JJ} = C_{JJ} \left( \frac{x_1^g x_2^g}{M_{JJ}^2} \right)^{2\epsilon} \sum_{i=1,2} v_i + k_i \prod_{i=1,2} \left\{ d\xi_i d\eta_i d^2v_i d^2k_i \xi_i^{2\alpha'v^2} \exp \left( -2v_i^2 \lambda_{JJ} \right) \right\} \times \left\{ G_{\pi} (x_1^\pi, \mu) G_{\pi} (x_2^\pi, \mu) \right\} ; \quad (1)$$

and for Higgs boson production:

$$d\sigma^{incl}_H = C_H \left( \frac{x_1^g x_2^g}{M_H^2} \right)^{2\epsilon} \delta (\xi_1 \xi_2 - \frac{M_H^2}{x_1^g x_2^g}) \prod_{i=1,2} G_{\pi} (x_i^\pi, \mu) d\xi_i d^2v_i \frac{d\xi_i}{1 - \xi_i} \xi_i^{2\alpha'v^2} \exp \left( -2v_i^2 \lambda_H \right) ; \quad (2)$$

$^1$ Indeed, recent results from a QCD fit to the diffractive structure function in H1 $^3$ show that the discrepancy between the gluonic content of the Pomeron at HERA and Tevatron appears mainly in normalisation.

$^2$ We call “dijets” the produced quark and gluon pairs.
In the above, \( G_P \) (resp. \( Q_P \)) are the Pomeron gluon (resp. quark) densities, and \( x^q \) (resp. \( x^g \)) are the Pomeron’s momentum fractions carried by the gluons (resp. quarks) involved in the hard process. We use as parametrizations of the Pomeron structure functions the fits to the diffractive HERA data performed in Refs.\[8, 9\]. Additional formulae concerning for instance inclusive diffractive production of dileptons or diphotons are given in Ref.\[1\].

Both the inclusive and exclusive productions have been implemented in a generator called DPEMC, which has been interfaced with a fast simulation of the DØ, CDF, ATLAS and CMS detectors.

II. EXPERIMENTAL CONTEXT

In this section, we discuss mainly the parameters which we use to simulate the detectors at the LHC. The simulation will be valid for both CMS and ATLAS detectors. The analysis is based on a fast simulation of the CMS detector at the LHC. The calorimetric coverage of the CMS experiment ranges up to a pseudorapidity of \( |\eta| \approx 5 \). The region devoted to precision measurements lies within \( |\eta| \leq 3 \), with a typical resolution on jet energy measurement of \( \sim 50%/\sqrt{E} \), where \( E \) is in GeV, and a granularity in pseudorapidity and azimuth of \( \Delta \eta \times \Delta \Phi \sim 0.1 \times 0.1 \).

In addition to the central CMS detector, the existence of roman pot detectors allowing to tag diffractively produced protons, located on both \( p \) sides, is assumed.\[10\]. The \( \xi \) acceptance and resolution have been derived for each device using a complete simulation of the LHC beam parameters. The combined \( \xi \) acceptance is \( \sim 100\% \) for \( \xi \) ranging from 0.002 to 0.1, where \( \xi \) is the proton fractional momentum loss. The acceptance limit of the device closest to the interaction point is \( \xi > \xi_{min} =0.02 \).

In inclusive double Pomeron exchange, the mass of the central heavy object is given by \( M^2 = \xi_1 \xi_2 s \), where \( \xi_1 \) and \( \xi_2 \) are the proton fractional momentum losses measured in the roman pot detectors. At this level, we already see the advantages of the exclusive events. Since, there is no energy loss due to additional radiation or pomeron remnants, we can reconstruct the total diffractive mass, which means the mass of the diffractively produced object (the Higgs, dijets, \( t\bar{t}, \bar{t}t, \) events, \( W \) pairs...), very precisely using the kinematical measurements from the roman pot detectors. The mass resolution is thus coming directly from the \( \xi \) resolution which is expected to be of the order of 1%. For inclusive events, the mass resolution will not be so good since part of the energy is lost in radiation, which means that we measure the mass of the heavy object produced diffractively and the pomeron remnants together very precisely. To get a good mass resolution using inclusive events requires a good measurement of the pomeron remnants and soft radiation and being able to veto on it.

III. EXISTENCE OF EXCLUSIVE EVENTS

While inclusive diffraction has already been observed at many colliders, the question arises whether exclusive events exist or not since they have never been observed so far. This is definitely an area where the Tevatron experiments can help to test the models and show evidence for the existence of exclusive events if any. It is crucial to be able to test the different models before the start of the LHC. The DØ and CDF experiments at the Tevatron (and the LHC experiments) are ideal places to look for exclusive events in dijet or \( \chi_C \) channels for instance where exclusive events are expected to occur at high dijet mass fraction. So far, no evidence of the existence of exclusive events has been found. The best way to show evidence of the existence of exclusive events would be the measurement of the ratio of the diphoton to the dilepton cross sections as a function of the diphoton/dilepton mass ratio (the diphoton-dilepton mass ratio being defined as the diphoton-dilepton mass divided by the total diffractive mass). The reason is quite simple: it is possible to produce exclusively diphoton but not dilepton directly since \( (gg \rightarrow \gamma \gamma) \) is possible but not \( (gg \rightarrow t\bar{t}l^+l^-) \) directly at leading order. The ratio of the diphoton to the dilepton cross section should show a bump or a change of slope towards high diphoton-dilepton masses if exclusive events exist. Unfortunately, the production cross section of such events is small and it will probably not be possible to perform this study before the start of the LHC.

Another easier way to show the existence of such events would be to study the correlation between the gap size measured in both \( p \) and \( \bar{p} \) directions and the value of \( \log 1/\xi \) measured using roman pot detectors, which can be performed in the DØ experiment. The gap size between the pomeron remnant and the protons detected in roman pot detector is of the order of \( \log 1/\xi \) for usual diffractive events (the measurement giving a slightly smaller value to be in the acceptance of the forward detectors) while exclusive events show a much higher value for the rapidity gap since the gap occurs between the jets (or the \( \chi_C \)) and the proton detected in roman pot detectors (in other words,
there is no pomeron remnant) \textsuperscript{3}. Another observable leading to the same conclusion would be the correlation between \( \xi \) computed using roman pot detectors and using only the central detector.

Another way to access the existence of exclusive events would be via QCD evolution. If one assumes that the DGLAP evolution equations work for parton densities in the pomeron, it is natural to compare the predictions of perturbative QCD with for instance dijet production in double pomeron exchange as a function of the dijet mass fraction (defined as the ratio of the dijet mass divided by the total diffractive mass) for different domains in diffractive mass. It has been shown that the dependence of the exclusive production cross section as a function of the dijet mass is much larger than the one of the inclusive processes. In other words, if exclusive events exist, it is expected that the evolution of the dijet cross section in double pomeron exchanges as a function of dijet mass fraction in bins of dijet masses will be incompatible with standard QCD DGLAP evolution, and will require an additional contribution, namely the exclusive ones \textsuperscript{4}. It will be quite interesting to perform such an analysis at the Tevatron if statistics allows.

### IV. RESULTS ON 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 \( \beta \) gluon density which is badly known as present. It is thus quite important to constrain these distributions using Tevatron 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 forward detector design of \cite{10} claims a resolution of about 2.-2.5 GeV, which leads to a S/B of about 0.4-0.6. Improvements in this design would increase the S/B ratio as indicated on the figure. As usual, this number is enhanced by a large factor if one considers supersymmetric Higgs boson production with favorable Higgs or squark field mixing parameters.

The cross sections obtained after applying the survival probability of 3\% at the LHC as well as the S/B ratios are given in Table I if one assumes a resolution on the missing mass of about 1 GeV (which is the most optimistic scenario). The acceptances of the roman pot detectors as well as the simulation of the CMS detectors have been taken into account in these results.

Let us also notice that the missing mass method will allow to perform a \( W \) mass measurement using exclusive (or quasi-exclusive) \( WW \) events in double Pomeron exchanges, and QED processes \cite{11}. The advantage of the QED processes is that their cross section is perfectly known and that this measurement only depends on the mass resolution and the roman pot acceptance. In the same way, it is possible to measure the mass of the top quark in \( t \bar{t} \) events in double Pomeron exchanges \cite{11} as we will see in the following.

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 \( \tan \beta \sim 50 \) \cite{12}. We give in Figure 2 the signal-over-background ratio for different values of \( \tan \beta \) for a Higgs boson mass of 120 GeV.

### TABLE I: Exclusive Higgs production cross section for different Higgs masses, number of signal and background events for 100 fb\(^{-1} \), ratio, and number of standard deviations (\( \sigma \)).

| \( M_{\text{Higgs}} \) (GeV) | Cross section | Signal | Background | S/B | \( \sigma \) |
|-------------------------------|---------------|--------|------------|-----|-------|
| 120                           | 3.9           | 27.1   | 28.5       | 0.95| 5.1   |
| 130                           | 3.1           | 20.6   | 18.8       | 1.10| 4.8   |
| 140                           | 2.0           | 12.6   | 11.7       | 1.08| 3.7   |

\textsuperscript{3} To distinguish between pure exclusive and quasi-exclusive events (defined as inclusive diffractive events where little energy is taken away by the pomeron remnants, or in other words, events where the mass of the heavy object produced diffractively is almost equal to the total diffractive mass), other observables such as the ratio of the cross sections of double diffractive production of diphoton and dilepton, or the \( b \)-jets to all jets are needed \cite{1}.

\textsuperscript{4} Let us note that one should also distinguish this effect from higher order corrections, and also from higher twist effects, which needs further studies.
FIG. 1: Standard Model Higgs boson signal to background ratio as a function of the resolution on the missing mass, in GeV. This figure assumes a Higgs boson mass of 120 GeV.

V. 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 [11]. In this category of events, the heavy objects are produced in pairs, whereas the beam particles often leave the interaction region intact, and can be measured using very forward detectors.

Pair production of $W W$ bosons and top quarks in QED and double pomeron exchange are described in detail in this section. $W W$ pairs are produced in photon-mediated processes, which are exactly calculable in QED. There is basically no uncertainty concerning the possibility of measuring these processes at the LHC. 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.

A. Explanation of the methods

We study two different methods to reconstruct the mass of heavy objects double diffractively produced at the LHC. The method is based on a fit to the turn-on point of the missing mass distribution at threshold.

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. As an example, we can produce a data sample for 100 fb$^{-1}$ with a top mass of 174 GeV, and a few MC samples corresponding to top masses between 150 and 200 GeV by steps of. For each Monte Carlo sample, a $\chi^2$ value corresponding to the population difference in each bin between data and MC is computed. The mass point where the $\chi^2$ is minimum corresponds to the mass of the produced object in data. This method has
the advantage of being easy but requires a good simulation of the detector.

The other proposed method (the “turn-on fit” method) is less sensitive to the MC simulation of the detectors. As mentioned earlier, the threshold scan is directly sensitive to the mass of the diffractively produced object (in the $WW$ case for instance, it is sensitive to twice the $WW$ mass). The idea is thus to fit the turn-on point of the missing mass distribution which leads directly to the mass of the produced object, the $WW$ boson. Due to its robustness, this method is considered as the “default” one in the following.

B. Results

To illustrate the principle of these methods and their achievements, we apply them to the $WW$ boson and the top quark mass measurements in the following, and obtain the reaches at the LHC. They can be applied to other threshold scans as well. 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 calibration 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. The resolution on the top mass is given in Fig. 3 as a function of luminosity for different resolutions of the roman pot detectors.

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$^{-1}$. We notice that one can expect to reach typical mass resolutions which can be obtained at a linear collider. The process is thus similar to those at linear colliders (all final states are detected) without the initial state radiation problem.

The caveat is of course that production via diffractive exclusive processes is model dependent, and definitely needs the Tevatron data to test the models. It will allow to determine more precisely the production cross section by

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FIG. 2: SUSY Higgs boson signal to background ratio as a function of the resolution on the missing mass, in GeV. This figure assumes a Higgs boson mass of 120 GeV.
testing and measuring at the Tevatron the jet and photon production for high masses and high dijet or diphoton mass fraction.

VI. HOW TO CONSTRAIN THE HIGH $\beta$ 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 $\beta$ 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-$\beta$ 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 $\nu$ varies between -1.0 and 1.0. If $\nu$ is negative, we enhance the gluon density at high $\beta$ by definition, especially at low $Q^2$.

The measurement of the dijet mass fraction at the Tevatron for two jets with a $p_T$ greater than 25 GeV for instance in double pomeron exchange is indeed sensitive to these variations in the gluon distribution. The dijet mass fraction is given in Fig 3 and 4 which shows how the Tevatron data can effectively constrain the gluon density in the pomeron. Another possibility to measure precisely the gluon distribution in the pomeron at high $\beta$ would be at the LHC the measurement of the $tt$ 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.5, 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.

![Dijet mass fraction at the Tevatron at generator level when the gluon density measured in the H1 experiment is used and multiplied by $(1 - \beta)^\nu$. We notice the sensitivity of this measurement on the gluon density.](image)

FIG. 3: Dijet mass fraction at the Tevatron at generator level when the gluon density measured in the H1 experiment is used and multiplied by $(1 - \beta)^\nu$. We notice the sensitivity of this measurement on the gluon density.
FIG. 4: Dijet mass fraction at the Tevatron at generator level when the gluon density measured in the H1 or the ZEUS experiment is used \cite{8, 9} and one tag is asked in the roman pot acceptance of the DØ or the CDF collaboration in the $p$ direction. We notice the sensitivity of this measurement on the gluon density.

VII. NEW POSSIBLE MEASUREMENT OF SURVIVAL PROBABILITIES IN THE DØ EXPERIMENT

We propose a new measurement to be performed at the Tevatron, in the DØ experiment \cite{5}, which can be decisive to distinguish between Pomeron-based and soft colour interaction models of hard diffractive scattering. This measurement allows to test directly the survival probability parameters as well which is fundamental to predict correctly the exclusive diffractive Higgs production at the LHC. The discriminative potential of our proposal takes its origin in the factorization breaking properties which were already observed at the Tevatron. The explanation given to this factorization breaking in Pomeron-based models is the occurrence of large corrections from the survival probabilities, which is the probability to keep a diffractive event signed either by tagging the proton in the final state or by requiring the existence of a rapidity gap in the event. By contrast with Pomeron models, the soft color interaction models are by nature, non factorizable. The initial hard interaction is the generic standard dijet production, accompanied by the full radiative partons. Then, a phenomenological soft color interaction is assumed to modify the overall color content, allowing for a probability of color singlet exchange and thus diffraction.

The forward detector apparatus in the DØ experiment at the Tevatron, Fermilab, has the potential to discriminate between the predictions of the two approaches in hard “double” diffractive production, e.g. of centrally produced dijets, by looking to the azimuthal distributions of the outgoing proton and antiproton with respect to the beam direction. This measurement relies on tagging both outgoing particles in roman pot detectors installed by the DØ experiment.

The FPD consists of eight quadrupole spectrometers, four being located on the outgoing proton side, the other four on the antiproton side. On each side, the quadrupole spectrometers are placed both in the inner (Q-IN), and outer (Q-OUT) sides of the accelerator ring, as well as in the upper (Q-UP) and lower (Q-DOWN) directions. They provide almost full coverage in azimuthal angle $\Phi$. The dipole spectrometer, marked as D-IN, is placed in the inner side of the ring, in the direction of outgoing antiprotons.
FIG. 5: Total diffractive mass reconstructed for $t\bar{t}$ inclusive events in double pomeron exchanges using roman detectors at the LHC. We use the gluon density in the pomeron measured in the H1 experiment \cite{8,9} and we multiply it by $(1-\beta)^\nu$ to show the sensitivity on the gluon density at high $\beta$.

Each spectrometer allows to reconstruct the trajectories of outgoing protons and antiprotons near the beam pipe and thus to measure their energies and scattering angles. Spectrometers provide high precision measurement in $t = -p_{T}^2$ and $\xi = 1 - p'/p$ variables, where $p'$ and $p_T$ are the total and transverse momenta of the outgoing proton or antiproton, and $p$ is the beam energy. The dipole detectors show a good acceptance down to $t = 0$ for $\xi > 3.10^{-2}$ and the quadrupole detectors are sensitive to outgoing particles down to $|t| = 0.6$ GeV$^2$ for $\xi < 3.10^{-2}$, which allows to get a good acceptance for high mass objects produced diffractively in the DØ main detector. For our analysis, we use a full simulation of the FPD acceptance in $\xi$ and $t$ \cite{15}.

We suggest to count the number of events with tagged $p$ and $\bar{p}$ for different combinations of FPD spectrometers. For this purpose, we define the following configurations for dipole-quadrupole tags (see Fig. 2): same side (corresponding to D-IN on $\bar{p}$ side and Q-IN on $p$ side and thus to $\Delta \Phi < 45$ degrees), opposite side (corresponding to D-IN on $\bar{p}$ side and Q-OUT on $p$ side, and thus to $\Delta \Phi > 135$ degrees), and middle side (corresponding to D-IN on $\bar{p}$ side and Q-UP or Q-DOWN on $p$ side and thus to $45 < \Delta \Phi < 135$ degrees). We define the same kinds of configurations for quadrupole-quadrupole tags (for instance, the same side configuration corresponds to sum of the four possibilities: both protons and antiprotons tagged in Q-UP, Q-DOWN, Q-IN or Q-OUT).

In Table 2, we give the ratios middle/(2 x same) and opposite/same (note that we divide middle by 2 to get the same domain size in $\Phi$) for the different models. In order to obtain these predictions, we used the full acceptance in $t$ and $\xi$ of the FPD detector \cite{15}. Moreover we computed the ratios for two different tagging configurations namely for $\bar{p}$ tagged in dipole detectors, and $p$ in quadrupoles, or for both $p$ and $\bar{p}$ tagged in quadrupole detectors.

In Table 2, we notice that the $\Phi$ dependence of the event rate ratio for the SCI \cite{14} model is weak, whereas for the POMWIG \cite{14} models the result show important differences specially when both $p$ and $\bar{p}$ are tagged in quadrupole detectors. This measurement can be performed even at low luminosity (1 week of data) if two jets with a transverse momentum greater than 5 GeV are required.

With more luminosity, we also propose to measure directly the $\Delta \Phi$ dependence between the outgoing protons and
TABLE II: Predictions for a proposed measurement of diffractive cross section ratios in different regions of $\Delta \Phi$ at the Tevatron (see text for the definition of middle, same and opposite). The first (resp. second) measurement involves the quadrupole and dipole detectors (resp. quadrupole detectors only) leading to asymmetric (resp. symmetric) cuts on $t$. We notice that the SCI models do not predict any significant dependence on $\Delta \Phi$ whereas the Pomeron-based models show large variations.

antiprotons using the good coverage of the quadrupole detectors in $\Phi$ which will allow to perform a more precise test of the models.

FIG. 6: Expected statistical precision of the top mass as a function of the integrated luminosity for various resolutions of the roman pot detectors (full line: resolution of 1 GeV, dashed line: 2 GeV, dotted line: 3 GeV).

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