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The Diphoton Production Rate in $\bar{p}p$ Collisions at $\sqrt{s}$ = 1800 GeV

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THE DIPHOTON PRODUCTION RATE IN $\overline{P}P$ COLLISIONS AT $\sqrt{S} = 1800$ GEV

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ABSTRACT

A measurement of the rate of prompt diphoton production in $\overline{p}p$ collisions at $\sqrt{s} = 1800$ GeV using the CDF detector is presented. The background from non-prompt sources is estimated using a sample of single photon candidate events. The results are compared to a next-to-leading order calculation by Bailey, *et al.* Both background and signal take on particular significance as an indicator of our ability to estimate the backgrounds affecting LHC low mass Higgs to diphoton searches.

1. Introduction

Diphoton production at hadron colliders is a particularly good channel to use for finding new physics. At the LHC the diphoton channel will be used to discover or place limits on the production of an intermediate mass Higgs ($M_Z/2 < M_H < 2M_Z$).[1] The reason this channel is preferred over other channels with much larger branching ratios is twofold; the background is low and the mass resolution is good. For these two reasons measuring the diphoton mass distribution is an excellent way to survey for unexpected physics. We discuss here a measurement of the diphoton mass distribution with particular emphasis on the high mass end, for events produced at the Fermilab Tevatron at $\sqrt{s} = 1800$ GeV.

2. Data Sample and Event Selection

The data sample used for this measurement came from a Fermilab Tevatron run which took place in 1992 and 1993; the total integrated luminosity was 19.3 pb^{-1}. Diphoton candidates were selected using the cuts listed in table 1. These events include cases where one or both of the clusters in the event are from non-prompt sources (e.g. π^0's). The event sample after these cuts consisted of 75 events, of which 44 had a reconstructed diphoton mass greater than 50 GeV/c^2.

Since the isolation cut was applied as a percentage of the candidate E_T, at low E_T it is expected that there will be some mass dependent loss. Using the results of a study of minimum bias events we parameterized the loss for any isolation cut applied to a

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Table 1. Cuts applied to diphoton sample.

CUT	EFF.
$E_T > 18GeV$ for two central electromagnetic clusters ($\eta < 0.9$)	
fiducial cuts for both clusters	0.56
number of 3d tracks < 2 (if one then $P_T < 2GeV$)	0.89
E_T around the clusters ($\sqrt{\Delta\eta^2 + \Delta\phi^2} < 0.7$) less than 10% of cluster E_T	see text
$\lvert Z_{vertex} \rvert < 60cm$	0.96

cluster. Using this parameterization ($\epsilon = (1 - .929e^{-.7142E_{CUT}})$) events were corrected for this loss using the measured E_T and $E_{CUT} = 0.1 \times E_T$ for each of the photons. After this correction the event rate versus diphoton mass is shown in Fig. 1.

Aside from the correction outlined above for the losses due to the isolation cuts no other corrections were applied to the data. None of the other cuts should depend on the candidate E_T so the inefficiencies due to the other cuts were simply included in the theory to yield the curves plotted in Fig. 1.

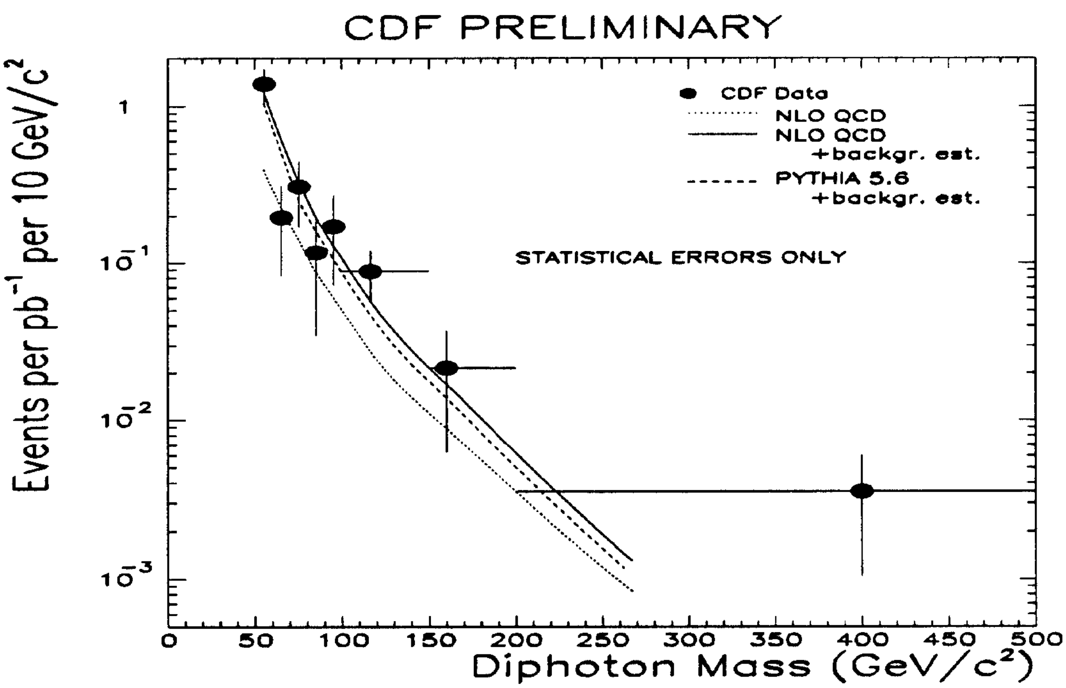

Fig. 1. The event rate for diphoton candidates. For comparison the curves indicate the expected rate for NLO QCD[2] and for the Pythia monte carlo.[3]

3. Estimating the Background

The background contributions come in two categories. Those due to two jets appearing to be isolated photons and those resulting from a single photon event with a jet that appears to be an isolated photon. Both of these can be estimated using the following strategy:

- Evaluate σ_b the cross section for production of non-photon events in the single photon sample for several values of E_T, using the methods detailed in references 4 and 5.

- Use the jet cross sections[6] to turn σ_b into a likelihood, F_b, that a jet will fragment in such a way as to satisfy the cuts applied on each of the diphoton clusters. The value of F_b evaluated this way and used for estimating the background was 8×10^{-4}.

- Apply this likelihood to the leading jet in the events in the photon sample to estimate how often a single photon candidate (both background and true single photons) will show up as a diphoton due to fluctuation of the recoiling jet into a second cluster passing the cuts which is not a true prompt photon.

This approach makes the simplistic assumption that all jets have the same chance of fluctuating into isolated photon candidates. While this may be a slightly naive assumption it provides an adequate estimate at high mass where the backgrounds are small. By using the single photon sample as a resource to estimate the contribution we are able to get good statistics on the jet fluctuation probability. For small event samples the uncertainties resulting from the assumption that the jet fragmentation measured this way is representative of the events in the diphoton sample is smaller or comparable to those resulting from an attempt to use the conversion or profile methods to measure the background directly on an event by event basis. A comparison has been made between the event by event background evaluation published in reference 7 and the one outlined here. They agree well. It should be noted that the measurement of reference 7 used data at much lower E_T than that described here (10 GeV versus 18 GeV). This is probably why there is better agreement between the current measurement and the expected rate.

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