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STATUS OF DIFFRACTIVE PHYSICS AT DØ RUN II

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The Forward Proton Detector (FPD) is a new sub-system of the DØ detector implemented for Run II at the Fermilab Tevatron which gives access to a wide range of diffractive scattering physics processes. This new detector is described and preliminary results from the diffractive program are presented.

1. Introduction

QCD models elastic and diffractive scattering of hadrons as proceeding via the exchange of a color singlet object. Diffractive processes account for about 40% of the total measured $p\bar{p}$ cross-section. One experimental signature of a single diffractive event, ($p\bar{p} \to pX$) where X is a system arising from $\bar{p}$ dissociation, is an area devoid of activity (rapidity gap) in the region of the surviving proton. In addition, the surviving particle travels with a small momentum loss at a small angle with respect to the beam and can be tagged using forward detectors placed far from the interaction region. We present here the first ever search for diffractively produced Z bosons in the muon decay channel (rapidity gap selection) as well as describing the Forward Proton Detector and listing initial studies using tagged protons.

2. Diffractive Z boson production

2.1. *Event selection and data analysis*

Z bosons produced via single diffraction are selected by demanding a rapidity gap near the beampipe in either the outgoing proton or antiproton direction. The data set was collected using the DØ RunII detector at the Fermilab Tevatron which is described in detail elsewhere[1]. The Z boson is selected via its decay into two oppositely charged muons each with $p_T > 15$ GeV.

The rapidity gap events are selected using the Luminosity Monitor (LM) and the end calorimeter. The LM comprises two scintillating detectors, one on each side of the nominal interaction point, in the forward rapidity region. The end calorimeter

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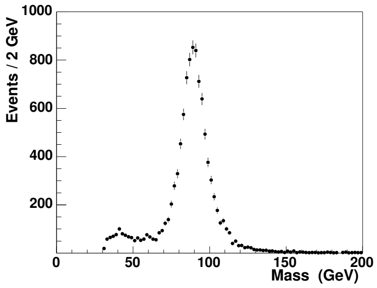
is divided into three layers and subdivided into cells. For this analysis, cells above a low energy threshold are summed separately on each side (in the region of overlap with the LM).

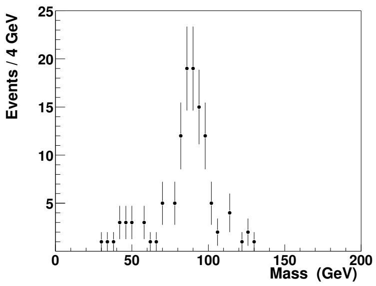
To select single diffractive candidates in the Z boson sample the LM detector is required to be off and the energy sum less than 10 GeV on one side of the interaction region, and the LM detector is required to be on and the energy sum greater than 10 GeV on the opposite side.

2.2. *Results*

Figure 1 shows the di-muon invariant mass distribution for two samples. Fig. 1(a) shows those events that fail the two rapidity gap cuts on both sides. These are strong candidates for non-diffractive production of Z bosons. Fig. 1(b) shows those events that pass both rapidity gap cuts on one side and fail both on the other. These are candidates for single diffractively produced Z bosons.



(a) No rapidity gap



(b) Single rapidity gap

Fig. 1. The di-muon invariant mass distribution for Z boson candidates with (a) no rapidity gap and (b) a single rapidity gap (see text for details).

3. Forward Proton Detector

3.1. *Detector description*

The DØ Forward Proton Detector (FPD)[2] consists of nine momentum spectrometers which make use of accelerator magnets, along with points measured on the track of the scattered proton or antiproton, to reconstruct its momentum and scattering angle. Tracks are reconstructed from hits in scintillating fiber detectors located in vacuum chambers positioned in the Tevatron tunnel 20–60 meters upstream and downstream of the central DØ detector.

Figure 2 shows the layout of the FPD. In the center of the diagram is the central DØ detector (not to scale). The system consists of two types of spectrometers. The dipole spectrometer, located 57 meters upstream of the interaction point on the outgoing $\bar{p}$ side, can select anti-protons that have lost a few percent of the beam momentum and are deflected by the accelerator dipole (D) magnets into the spectrometer. The quadrupole spectrometers are located adjacent to the beam separators (S) on both sides of DØ and use the low beta quadrupole magnets (Q) as the primary analyzing magnets. These spectrometers can be used to detect particles deflected at a sufficient angle.

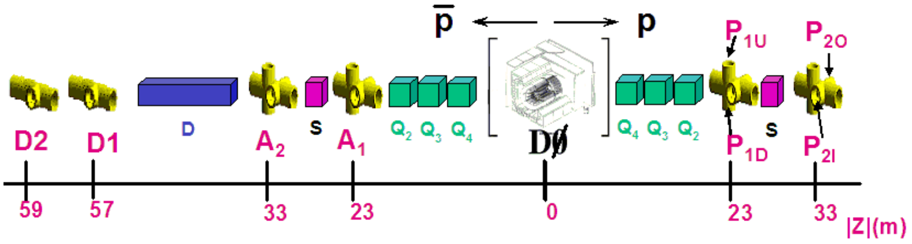


Fig. 2. The layout of the Roman pot stations and Tevatron components comprising the Forward Proton Detector as described in the text (not drawn to scale).

3.2. *Status*

The dipole detectors have been regularly inserted since February 2003 and are currently being used in an analysis. Starting in January 2004, all 18 detectors began regular insertion. Commissioning is currently underway for the quadrupole detectors and most of the detectors are working as expected.

Initial analyses using the FPD include dijets using dipole tags, $Z \to \mu\mu$, B physics with gaps and tags and double Pomeron studies.

Summary

A search for diffractively produced Z bosons in the muon channel using gaps has been presented. The sample is large enough to allow a study of the kinematic properties of the Z bosons for the first time.

The Forward Proton Detector has been presented. It's current status has been discussed and initial analyses using the detector have been listed.

References

1. V. Abazov *et al.* (DØ collaboration), to be submitted to Nucl. Instrum. Methods A; T. LeCompte and H. T. Diehl, Ann. Rev. Nucl. Part. Sci. **50**, 71 (2000).
2. A. Brandt *et al.* (DØ collaboration), FERMILAB-PUB-97-377.