Measurement of Neutral B Meson Mixing in Electron-Muon Events in 1.8-TeV Proton-Antiproton Collisions

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Abstract

The $B^0\bar{B}^0$ mixing parameter, χ, has been measured in $e\mu$ events in proton-antiproton collisions at a center of mass energy of 1800 GeV. The experiment has been performed at the Fermi National Accelerator Laboratory in the United States using the Tevatron accelerator. The data were collected with the Collider Detector at Fermilab (CDF) during the 1992-1993 Tevatron collider run. The corresponding integrated luminosity is 20 pb^{-1}.

The $B^0\bar{B}^0$ mixing is a process by which neutral B-mesons oscillate into their anti-particles ($B^0 \leftrightarrow \bar{B}^0$). In the absence of mixing, the direct semileptonic decay of a $b\bar{b}$ pair produced in $p\bar{p}$ collisions results in a pair of leptons with opposite charge. The B^0 or $\bar{B}^0$ may undergo mixing, resulting in a like-sign (LS) lepton pair. The magnitude of mixing is determined from the ratio of like-sign dilepton pairs to opposite-sign (OS) dilepton pairs. In this thesis, electron-muon pairs were used as the dilepton pairs.

The CDF detector is a general purpose detector built to explore $p\bar{p}$ collisions. It covers almost the full solid angle around the $p\bar{p}$ interaction point. The CDF detector consists of tracking detectors and calorimeters for measurements of the particle momentum and energy. In order to identify muons, muon detectors are installed at the outside of the detector. Electrons, photons, muons, neutrinos, hadrons and jets are identified using these detector components.

We describe identification of muons and electrons, and then event selection of $b\bar{b}$ events. To remove events in which both leptons are produced by one B meson, it is required that an opening angle of the electron and muon is large enough. We apply the requirement that the transverse momentum of leptons to jet axis, P_T^{rel}, is large enough for $b\bar{b}$ events. This requirement significantly reduces background and systematic uncertainty. 1710 opposite-sign and 861 like-sign $e\mu$ events are found after the event selection.

Then the estimation of the background is described. We estimate the fraction of fake $e\mu$ events using J/ψ, K_s and ϕ samples, minimum bias data and Monte Carlo simulation. Most of the background for $e\mu$ events are pairs of real-electron and fake-muon. The main source of the fake muons is decay-in-flight of hadrons. The systematic uncertainty in estimating the fake muon fraction is substantially reduced by using a newly installed muon detector.

Like-sign lepton pairs are also produced by semileptonic sequential decays of B^0 or $\bar{B}^0$ mesons. The fraction of sequential decays is estimated from Monte Carlo $b\bar{b}$ events by taking into consideration the uncertainties in the structure functions and fragmentation functions. The fraction of direct $c\bar{c}$ production is estimated directly from data by fitting the Monte Carlo P_T^{rel} distribution of leptons from direct and sequential decays as well as from $c\bar{c}$ production to the observed spectra.

From the above analysis, we obtain

$$\chi = 0.130 \pm 0.010(stat.) \pm 0.010(syst.).$$

This result improves the previous CDF result by a factor of 3 and is one of the most accurate measurements of χ at the present time. It is consistent with other measurements and also with the expectations from the standard model.

Since both neutral B mesons, B_d^0 and B_s^0, are produced in $p\bar{p}$ collisions, the mixing parameter for B_s, χ_s, is estimated by using the mixing parameter for B_d measured by the ARGUS and the CLEO groups in e^+e^- collisions and by assuming the fractions of B_d^0 and B_s^0 mesons produced in $b\bar{b}$ events.