Fermi National Accelerator Laboratory

FERMILAB-Pub-94/131-E
CDF

$b\bar{b}$ Quark Pair Correlations in $p\bar{p}$ Collisions at $\sqrt{s}$ = 1.8 TeV

F. Abe et. al
The CDF Collaboration

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

September 1994

Submitted to *Physical Review Letters*

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy

Disclaimer

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

CDF/PUB/BOTTOM/PUBLIC/2456

FERMILAB-PUB-94/131-E

$b\bar{b}$ Quark Pair Correlations in $p\bar{p}$ Collisions at $\sqrt{s} = 1.8$ TeV

Abstract

Events with an $e\mu$ pair resulting from the dual semileptonic decay of a $b\bar{b}$ quark pair ($b_1 \to e^{\pm}X, b_2 \to \mu^{\pm}X$) are used to investigate correlations between $b\bar{b}$ quark pairs produced in $p\bar{p}$ collisions at $\sqrt{s} = 1.8$ TeV. Data collected with the CDF detector during the 1988-1989 run of the Fermilab Tevatron Collider are used to extract the cross section for $b\bar{b}$ quark pair production as a function of $P_T(b_1)$ and $P_T(b_2)$. The data are also used to investigate spatial $b\bar{b}$ correlations *via* the $e\mu$ opening angle. The cross section and the distribution of $e\mu$ opening angles are seen to be consistent with the predictions of next-to-leading order QCD.

PACS numbers: 13.85.Ni 13.85.Qk

Submitted to Physical Review Letters August 1, 1994

F. Abe,[12] M. Albrow,[6] D. Amidei,[15] C. Anway-Wiese,[3] G. Apollinari,[23] M. Atac,[6] P. Auchincloss,[22] P. Azzi,[17] N. Bacchetta,[16] A. R. Baden,[8] W. Badgett,[15] M. W. Bailey,[21] A. Bamberger,[6,a] P. de Barbaro,[22] A. Barbaro-Galtieri,[13] V. E. Barnes,[21] B. A. Barnett,[11] P. Bartalini,[20] G. Bauer,[14] T. Baumann,[8] F. Bedeschi,[20] S. Behrends,[2] S. Belforte,[20] G. Bellettini,[20] J. Bellinger,[28] D. Benjamin,[27] J. Benlloch,[14] J. Bensinger,[2] A. Beretvas,[6] J. P. Berge,[6] S. Bertolucci,[7] K. Biery,[10] S. Bhadra,[9] M. Binkley,[6] D. Bisello,[17] R. Blair,[1] C. Blocker,[2] A. Bodek,[22] V. Bolognesi,[20] A. W. Booth,[6] C. Boswell,[11] G. Brandenburg,[8] D. Brown,[8] E. Buckley-Geer,[6] H. S. Budd,[22] G. Busetto,[17] A. Byon-Wagner,[6] K. L. Byrum,[1] C. Campagnari,[6] M. Campbell,[15] A. Caner,[6] R. Carey,[8] W. Carithers,[13] D. Carlsmith,[28] J. T. Carroll,[6] R. Cashmore,[6,a] A. Castro,[17] Y. Cen,[18] F. Cervelli,[20] K. Chadwick,[6] J. Chapman,[15] G. Chiarelli,[7] W. Chinowsky,[13] S. Cihangir,[6] A. G. Clark,[6] M. Cobal,[20] D. Connor,[18] M. Contreras,[4] J. Cooper,[6] M. Cordelli,[7] D. Crane,[6] J. D. Cunningham,[2] C. Day,[6] F. DeJongh,[6] S. Dell'Agnello,[20] M. Dell'Orso,[20] L. Demortier,[23] B. Denby,[6] P. F. Derwent,[15] T. Devlin,[24] M. Dickson,[22] S. Donati,[20] R. B. Drucker,[13] A. Dunn,[15] K. Einsweiler,[13] J. E. Elias,[6] R. Ely,[13] S. Eno,[4] S. Errede,[9] A. Etchegoyen,[6,a] B. Farhat,[14] M. Frautschi,[16] G. J. Feldman,[8] B. Flaugher,[6] G. W. Foster,[6] M. Franklin,[8] J. Freeman,[6] H. Frisch,[4] T. Fuess,[6] Y. Fukui,[12] G. Gagliardi,[20] A. F. Garfinkel,[21] A. Gauthier,[9] S. Geer,[6] D. W. Gerdes,[15] P. Giannetti,[20] N. Giokaris,[23] P. Giromini,[7] L. Gladney,[18] M. Gold,[16] J. Gonzalez,[18] K. Goulianos,[23]

H. Grassmann,[17] G. M. Grieco,[20] R. Grindley,[10] C. Grosso-Pilcher,[4] C. Haber,[13] S. R. Hahn,[6] R. Handler,[28] K. Hara,[26] B. Harral,[18] R. M. Harris,[6] S. A. Hauger,[5] J. Hauser,[3] C. Hawk,[24] T. Hessing,[25] R. Hollebeek,[18] L. Holloway,[9] A. Hölscher,[10] S. Hong,[15] G. Houk,[18] P. Hu,[19] B. Hubbard,[13] B. T. Huffman,[19] R. Hughes,[22] P. Hurst,[8] J. Huth,[6] J. Hylen,[6] M. Incagli,[20] T. Ino,[26] H. Iso,[26] H. Jensen,[6] C. P. Jessop,[8] R. P. Johnson,[6] U. Joshi,[6] R. W. Kadel,[13] T. Kamon,[25] S. Kanda,[26] D. A. Kardelis,[9] I. Karliner,[9] E. Kearns,[8] L. Keeble,[25] R. Kephart,[6] P. Kesten,[2] R. M. Keup,[9] H. Keutelian,[6] D. Kim,[6] S. B. Kim,[15] S. H. Kim,[26] Y. K. Kim,[13] L. Kirsch,[2] K. Kondo,[26] J. Konigsberg,[8] K. Kordas,[10] E. Kovacs,[6] M. Krasberg,[15] S. E. Kuhlmann,[1] E. Kuns,[24] A. T. Laasanen,[21] S. Lammel,[3] J. I. Lamoureux,[28] T. LeCompte,[9] S. Leone,[20] J. D. Lewis,[6] W. Li,[1] P. Limon,[6] M. Lindgren,[3] T. M. Liss,[9] N. Lockyer,[18] M. Loreti,[17] E. H. Low,[18] D. Lucchesi,[20] C. B. Luchini,[9] P. Lukens,[6] P. Maas,[28] K. Maeshima,[6] M. Mangano,[20] J. P. Marriner,[6] M. Mariotti,[20] R. Markeloff,[28] L. A. Markosky,[28] J. A. J. Matthews,[16] R. Mattingly,[2] P. McIntyre,[25] A. Menzione,[20] E. Meschi,[20] T. Meyer,[25] S. Mikamo,[12] M. Miller,[4] T. Mimashi,[26] S. Miscetti,[7] M. Mishina,[12] S. Miyashita,[26] Y. Morita,[26] S. Moulding,[23] J. Mueller,[24] A. Mukherjee,[6] T. Muller,[3] L. F. Nakae,[2] I. Nakano,[26] C. Nelson,[6] D. Neuberger,[3] C. Newman-Holmes,[6] J. S. T. Ng,[8] M. Ninomiya,[26] L. Nodulman,[1] S. Ogawa,[26] C. Pagliarone,[20] R. Paoletti,[20] V. Papadimitriou,[6] A. Para,[6] E. Pare,[8] S. Park,[6] J. Patrick,[6] G. Pauletta,[20] L. Pescara,[17] T. J. Phillips,[5] A. G. Piacentino,[20] R. Plunkett,[6] L. Pondrom,[28] J. Proudfoot,[1] F. Ptohos,[8] G. Punzi,[20] D. Quarrie,[6]

K. Ragan,[10] G. Redlinger,[4] J. Rhoades,[28] M. Roach,[27] F. Rimondi,[6,a] L. Ristori,[20] W. J. Robertson,[5] T. Rodrigo,[6] T. Rohaly,[18] A. Roodman,[4] W. K. Sakumoto,[22] A. Sansoni,[7] R. D. Sard,[9] A. Savoy-Navarro,[6] V. Scarpine,[9] P. Schlabach,[8], E. E. Schmidt,[6] O. Schneider,[13] M. H. Schub,[21] R. Schwitters,[8] G. Sciacca,[20] A. Scribano,[20] S. Segler,[6] S. Seidel,[16] Y. Seiya,[26] G. Sganos,[10] M. Shapiro,[13] N. M. Shaw,[21] M. Sheaff,[28] M. Shochet,[4] J. Siegrist,[13] A. Sill,[22] P. Sinervo,[10] J. Skarha,[11] K. Sliwa,[27] D. A. Smith,[20] F. D. Snider,[11] L. Song,[6] T. Song,[15] M. Spahn,[13] P. Sphicas,[14] A. Spies,[11] R. St. Denis,[8] L. Stanco,[17] A. Stefanini,[20] G. Sullivan,[4] K. Sumorok,[14] R. L. Swartz, Jr.,[9] M. Takano,[26] K. Takikawa,[26] S. Tarem,[2] F. Tartarelli,[20] S. Tether,[14] D. Theriot,[6] M. Timko,[27] P. Tipton,[22] S. Tkaczyk,[6] A. Tollestrup,[6] J. Tonnison,[21] W. Trischuk,[8] Y. Tsay,[4] J. Tseng,[11] N. Turini,[20] F. Ukegawa,[26] D. Underwood,[1] S. Vejcik, III,[15] R. Vidal,[6] R. G. Wagner,[1] R. L. Wagner,[6] N. Wainer,[6] R. C. Walker,[22] J. Walsh,[18] A. Warburton,[10] G. Watts,[22] T. Watts,[24] R. Webb,[25] C. Wendt,[28] H. Wenzel,[20] W. C. Wester, III,[13] T. Westhusing,[9] S. N. White,[23] A. B. Wicklund,[1] E. Wicklund,[6] H. H. Williams,[18] B. L. Winer,[22] J. Wolinski,[25] D. Y. Wu,[15] X. Wu,[20] J. Wyss,[17] A. Yagil,[6] W. Yao,[13] K. Yasuoka,[26] Y. Ye,[10] G. P. Yeh,[6] J. Yoh,[6] M. Yokoyama,[26] J. C. Yun,[6] A. Zanetti,[20] F. Zetti,[20] S. Zhang,[15] W. Zhang,[18] S. Zucchelli,[6,a]

The CDF Collaboration

[1] *Argonne National Laboratory, Argonne, Illinois 60439*

[2] *Brandeis University, Waltham, Massachusetts 02254*

[3] *University of California at Los Angeles, Los Angeles, California 90024*

[4] *University of Chicago, Chicago, Illinois 60637*

[5] *Duke University, Durham, North Carolina 27706*

[6] *Fermi National Accelerator Laboratory, Batavia, Illinois 60510*

[7] *Laboratori Nazionali di Frascati, Istituto Nazionale di Fisica Nucleare, Frascati, Italy*

[8] *Harvard University, Cambridge, Massachusetts 02138*

[9] *University of Illinois, Urbana, Illinois 61801*

[10] *Institute of Particle Physics, McGill University, Montreal, and University of Toronto, Toronto, Canada*

[11] *The Johns Hopkins University, Baltimore, Maryland 21218*

[12] *National Laboratory for High Energy Physics (KEK), Japan*

[13] *Lawrence Berkeley Laboratory, Berkeley, California 94720*

[14] *Massachusetts Institute of Technology, Cambridge, Massachusetts 02139*

[15] *University of Michigan, Ann Arbor, Michigan 48109*

[16] *University of New Mexico, Albuquerque, New Mexico 87131*

[17] *Universita di Padova, Instituto Nazionale di Fisica Nucleare, Sezione di Padova, I-35131 Padova, Italy*

[18] *University of Pennsylvania, Philadelphia, Pennsylvania 19104*

[19] *University of Pittsburgh, Pittsburgh, Pennsylvania 15260*

[20] *Istituto Nazionale di Fisica Nucleare, University and Scuola Normale Superiore of Pisa, I-56100 Pisa, Italy*

[21] *Purdue University, West Lafayette, Indiana 47907*

[22] *University of Rochester, Rochester, New York 15627*

[23] *Rockefeller University, New York, New York 10021*

[24] *Rutgers University, Piscataway, New Jersey 08854*

[25] *Texas A&M University, College Station, Texas 77843*

[26] *University of Tsukuba, Tsukuba, Ibaraki 305, Japan*

[27] *Tufts University, Medford, Massachusetts 02155*

[28] *University of Wisconsin, Madison, Wisconsin 53706*

Studies of b production in $p\bar{p}$ collisions provide quantitative tests of perturbative Quantum Chromodynamics (QCD). For processes involving momentum tranfers on the order of m_b, the strong coupling constant α_s becomes relatively small, and perturbative methods may provide reliable predictions [1]. Measurements of the inclusive cross section for $p\bar{p} \rightarrow bX$ have been made at UA1 [2] and at CDF [3]. The process $p\bar{p} \rightarrow b\bar{b}X$ provides further opportunities for comparison of experiment and NLO QCD through observation of the P_T and spatial correlations between the b and $\bar{b}$ quarks.

The CDF detector has been described in detail elsewhere [4]. The $e\mu$ data sample consists of events collected with a dilepton trigger. The trigger requires an electron with a minimum E_T of 5 GeV and a muon with a minimum P_T of 3 GeV/c. Hardware constraints limit the reconstruction of muons and electrons to the regions $\mid \eta \mid < 0.6$ and $\mid \eta \mid < 1$, respectively [1]. The integrated luminosity for the sample is 2.7 pb^{-1}. The ee and $\mu\mu$ channels are not considered because of the additional background from Drell-Yan production and decays of vector mesons. Lepton selection criteria are

[1] $\eta = -\log\tan\theta/2$ is the pseudo-rapidity. θ is the polar angle defined with respect to the proton beam. ϕ is the azimuthal angle.

applied to the data to reject hadrons. The data, including all the lepton selection criteria, have been used previously in a measurement of the $B^0\overline{B^0}$ mixing parameter χ [5].

The data come from the dual semileptonic decays of $b\bar{b}$ quark pairs and $c\bar{c}$ quark pairs, the cascade decays of single b quarks, and 'fakes', where fakes are misidentified particles. The cascade decays are removed by requiring the invariant mass of the $e\mu$ pair $M_{e\mu}$ be greater than 5.0 GeV/c^2. The contribution from fakes is removed by subtracting the number of events with leptons of like sign (LS) from the number of event with leptons of opposite sign (OS). $b\bar{b}$ production produces mostly OS pairs but also contributes to LS. Leptons may be produced from B meson decays either directly ($B \to \ell X$) or indirectly through a sequential D meson ($B \to DX, D \to \ell X$). In the absence of $B^0\overline{B^0}$ mixing, pairs of direct leptons and pairs of indirect leptons are OS while one direct and one indirect lepton are LS. $B^0\overline{B^0}$ mixing also produces LS pairs. $c\bar{c}$ contributes only to OS as there is negligible mixing. Fake events contribute equally to OS and LS as no sign correlation is expected between fake leptons or between fake and real leptons [5]. An excess of OS $e\mu$ events remains after the subtraction of the LS events. This excess represents the excess OS $b\bar{b}$ events and the $c\bar{c}$ events. The fraction of the excess $e\mu$ events due to $b\bar{b}$ is denoted by $f_{b\bar{b}}$. The total number of $b\bar{b}$ events $N_{b\bar{b}}$ is obtained by correcting the number of excess OS $b\bar{b}$ events for the

fraction lost in the subtraction:

$$N_{b\bar{b}} = \frac{f_{b\bar{b}}(\text{Number OS } e\mu \text{ - Number LS } e\mu\ )}{(1-2\chi^2)\delta} \tag{1}$$

The factor $(1-2\chi)^2$ corrects for the events lost due to mixing. χ is the b mixing parameter and is defined as:

$$\chi \equiv \frac{Prob(b \rightarrow \overline{B^0_{d,s}} \rightarrow B^0_{d,s} \rightarrow \ell^+)}{Prob(b \rightarrow \ell^\pm)}. \tag{2}$$

Here B^0 refers to either B^0_d or B^0_s. The factor δ corrects for a smaller fraction of events lost because of cases in which one or both of the leptons come indirectly from the decay of a B meson, through the semileptonic decay of a sequential D meson $(B \rightarrow DX, D \rightarrow \ell X)$.

The fraction $f_{b\bar{b}}$ of the excess OS $e\mu$ events due to $b\bar{b}$ production is determined by examining the P_T^{rel} distribution. P_T^{rel} is the component of the lepton momentum transverse to the direction of the associated jet. The jet axis is reconstructed by clustering tracks with an algorithm utilizing a fixed cone of radius $R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$. R is chosen to be 1.0 to ensure adequate containment of the B decay products. The tracks associated with the electron and muon are excluded from the clustering.

The expected P_T^{rel} distributions for electrons from semileptonic decays of b and c quarks are shown in the inset of figure 1. The c quark distribution is obtained from the ISAJET Monte Carlo event generator [6]. The b quark distribution is obtained

from a Monte Carlo model incorporating the following.

(1) The shape of the b quark P_T and rapidity spectrum is provided by the NLO calculation [7]. The b quarks are generated with rapidity $\mid y \mid < 1$.

(2) The energy sharing between the quark and the meson is modeled with the Peterson function [8]. The value of the free parameter of the model is chosen to be $\epsilon_P = 0.006 \pm 0.002$ in accordance to experimental results from e^+e^- annihilation [9].

(3) The semileptonic decay of the B mesons is handled by the CLEO Monte Carlo program [11] which employs the model of Isgur *et al.* [10].

(4) The effects of the CDF trigger, detector and event reconstruction code are simulated. The simulated events are then subjected to the same lepton selection criteria as the data.

The P_T^{rel} distributions for electrons in OS and LS events are shown as histograms in figure 1. Also shown is the difference of the two histograms with a fit to the sum of the normalized b and c distributions; the fit indicates $f_{b\bar{b}} = 1.0^{+0.0}_{-0.1}$, where the uncertainty includes both statistical and systematic effects.

The cross section for the inclusive production of two b quarks is:

$$\sigma(p\bar{p} \rightarrow b\bar{b}X) = \frac{N_{b\bar{b}}}{\mathcal{L}\varepsilon_{CUTS}\varepsilon_{TRIG}A(e)A(\mu)2Br(b \rightarrow eX)Br(b \rightarrow \mu X)}.$$

$\mathcal{L}$ is the integrated luminosity represented by the data. The factor of two associated with the branching fractions reflects the two ways in which a $b\bar{b}$ pair may produce an $e\mu$ pair. $A(\ell)$ $(\ell = \mu, e)$ is the acceptance for leptons from b decay. ε_{TRIG} is

the combined efficiency of the electron and muon trigger requirements. ε_{CUTS} is the combined efficiency of the electron and muon quality cuts.

The efficiencies of the lepton selection criteria are calculated from the number of excess OS $e\mu$ events before and after the imposition of the selection criteria. The $b\bar{b}$ content of the excess is in both cases determined from the P_T^{rel} distribution of the electron. The efficiencies of the muon quality cuts are obtained from $J/\psi \rightarrow \mu^+\mu^-$ events.

The electron and muon trigger requirements are uncorrelated and are considered seperately. The efficiency of the muon trigger requirements is obtained from a study of cosmic ray events [12]. The efficiency of the electron requirements is determined from a simulation of the trigger[13].

The electron and muon acceptances are obtained from the Monte Carlo model of b production described above. The structure function parameterizations of Diemoz *et al.*(DFLM) [14] with $\Lambda_{QCD}^{[4]} = 260$ MeV are used. The acceptances are defined as the fraction of accepted b quarks relative to the number of b quarks with $P_T > P_T^{min}$. P_T^{min} is defined as the P_T such that 90% of the accepted quarks have $P_T > P_T^{min}$ [2]. The electron and muon acceptances are treated independently. Justification for this factorization is obtained from the NLO calculation of $b\bar{b}$ production [7]. The calculation predicts that the biasing of the b quark P_T distributions due to interquark correlations is negligible compared to the biasing introduced by the lepton P_T and E_T thresholds.

$P_T(\mu) >$ (GeV/c)	3.0	4.0	5.0
P_T^{min} (GeV/c)	6.5	7.5	8.75
Excess OS $e\mu$	248 ± 33	190 ± 25	115 ± 18
ε_{TRIG}	0.56 ± 0.10	0.61 ± 0.10	0.65 ± 0.10
ε_{CUTS}	0.69 ± 0.27	0.52 ± 0.21	0.41 ± 0.20
$A(\mu)$	0.12 ± 0.02	0.10 ± 0.02	0.09 ± 0.02
δ	0.76 ± 0.03	0.80 ± 0.03	0.81 ± 0.03

Table 1: Table of quantities as a function of the muon P_T threshold.

Table 1 lists some quantities used in calculating the cross section. $A(e)$ is found to be 0.15 ± 0.02 for $E_T(e) > 5$ GeV. The values of χ and the branching fractions are taken to be the world average values: $\chi = 0.16 \pm 0.04$, $Br(b \rightarrow eX) = 0.107 \pm 0.005$, and $Br(b \rightarrow \mu X) = 0.103 \pm 0.005$ [15]. The values for δ are determined from a Monte Carlo calculation.

Figure 2 shows the cross section for $p\bar{p} \rightarrow b\bar{b}X$ and the prediction from NLO QCD. The cross section is plotted versus the P_T^{min} of the second b given the P_T^{min} of the first b. The inner error bars indicate the size of the statistical uncertainty. The outer error bars represent the combined statistical and systematic uncertainty. The systematic uncertainties are highly correlated, tending to change the normalization, but not the shape, of the cross section. The dominant uncertainties are associated with ε_{CUTS} and χ. The theoretical prediction uses the DFLM parton distribution parameterizations. The upper and lower bands represent the theoretical uncertainty corresponding to variation of the bottom-quark mass, the choice of the renormalization scale μ, and the uncertainty in the parton distributions through the parameter $\Lambda_{QCD}^{[4]}$. The theoretical uncertainty is dominated by the μ dependence.

$P_T^{min}(b_2)$ (GeV/c)	$\sigma(b\bar{b}$ X; $P_T^{min}(b_1) = 8.75(GeV/c), \mid y_{b1} \mid < 1, \mid y_{b2} \mid < 1)$ (μb)
6.5	$1.76 \pm (0.23)_{stat} \pm (0.97)_{sys}$
7.5	$1.83 \pm (0.24)_{stat} \pm (1.03)_{sys}$
8.75	$1.39 \pm (0.22)_{stat} \pm (0.89)_{sys}$

Table 2: $\sigma(b\bar{b}$ X) as a function of $P_T^{min}(b_2)$.

Spatial $b\bar{b}$ correlations are investigated by examining the $\Delta\phi_{e\mu}$ distribution, where $\Delta\phi_{e\mu}$ is the opening angle between the electron and muon in the transverse plane. Figure 3 compares the sign subtracted $\Delta\phi_{e\mu}$ distribution for the data with the NLO QCD prediction. The theoretical prediction is shown both with and without the $M_{e\mu} > 5$ GeV/c^2 requirement. The UA1 collaboration has published a measurement of $\Delta\phi_{b\bar{b}}$ which also agrees well with the NLO prediction [16].

The data is seen to be consistent with the $b\bar{b}X$ cross section predicted by NLO QCD to within one standard deviation. Using the theory to convert the $b\bar{b}X$ cross section to the equivalent single inclusive cross section, we obtain $\sigma(bX) = 3.8$ μb for $P_T^{min}(b) = 8.75$GeV/c, $\mid y_b \mid < 1$, which is in good agreement with previous CDF results [3]. The shape of the $\Delta\phi_{e\mu}$ distribution from $b\bar{b}$ production is also seen to be in good agreement with the theory.

The authors wish to thank the technical and support staffs of Fermilab and the participating institutions. This work was supported by the U.S. Department of Energy, the U.S. National Science Foundation, the Italiano Istituto Nazionale di Fisica Nucleare, the Ministry of Science, Culture and Education of Japan, the Natural Sciences and Engineering Research Council of Canada, and the Alfred P. Sloan Foundation.

References

[1] P. Nason, S. Dawson, and R.K. Ellis, Nucl. Phys. **B327** , 49 (1989).

[2] C. Albajar, *et al.*, Phys. Lett. **B256** (1991).

[3] F. Abe, *et al.*, Phys. Rev. Lett. **68**, 3403-3407 (1992); F. Abe, *et al.*, Phys. Rev. Lett. **69**, 3704-3708 (1992); F. Abe, *et al.*, Phys. Rev. Lett. **71**, 500-504 (1993); F. Abe, *et al.*, Phys. Rev. Lett. **71**, 2396-2400 (1993).

[4] F. Abe, *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **271**, 387 (1988).

[5] F. Abe, *et al.*, Phys. Rev. Lett. **67**, 3351-3355 (1991).

[6] F. E. Paige and S. D. Protopopescu, Report No. BNL-38034, 1986 (unpublished).

[7] M. Mangano, P. Nason, and G. Ridolfi, Nucl. Phys. **B373** ,295-345 (1992).

[8] C. Peterson *et al.*, Phys. Rev. **D27**, 105 (1983)

[9] J. Chrin, Z. Phys. C **36**, 165 (1987); D. Decamp *et al.*, Phys. Lett. B **244**, 551 (1990).

[10] N. Isgur, D. Scora, B. Grinstein, and M.B. Wise, Phys. Rev. **D39** (1989).

[11] P. Avery, K. Read, and G. Trahern, Report No. CSN-212, 1985 (unpublished).

[12] R. Hughes, *Reconstruction of B Meson Decays and Measurement of the B Quark and B Meson Production Cross Sections at the Fermilab Tevatron Collider*, Ph.D. Thesis, University of Pennsylvania (1992).

[13] R. Mattingly, *The Cross Section for the Production of $b\bar{b}$ Pairs in Proton-Antiproton Collisions at $\sqrt{s}$ = 1.8 TeV*, Ph. D. Thesis, Brandeis University (1994).

[14] M. Diemoz *et al.*, Z. Phys. **C39**, 21 (1988).

[15] Particle Data Group, *Review of Particle Properties*, Phys. Lett. **B239** (1992).

[16] C. Albajar *et al.*, Z. Phys. **C61**, 41-52 (1994).

Figure Captions

Figure 1: P_T^{rel} for electrons from the data. OS (SS) events are shown in solid (dashed) lines. The difference of the OS and SS distributions is shown with points. The curve is a fit of the sum of the normalized b and c distributions to the subtracted data. The normalized b and c distributions from simulation are shown in the inset. The fit yields a value of $1.0^{+0.0}_{-0.1}$ for $f_{b\bar{b}}$, the fraction of the sign-subtracted events from $b\bar{b}$ production.

Figure 2: The cross section for $p\bar{p} \rightarrow b\bar{b}X$. $M_{e\mu} > 5$ GeV/c^2, $\mid y_{b1,2} \mid < 1$. The cross section is plotted as a function of the P_T^{min} of the second b, given the P_T^{min} of the first b. The theoretical prediction and associated uncertainty are represented by the solid and dotted lines, respectively.

Figure 3: The opening angle between the electron and the muon in the transverse plane. The data is shown as dots. The NLO QCD prediction is shown with (solid) and without (dotted) the $M_{e\mu} > 5$ GeV/c^2 requirement. The theoretical prediction including the mass cut is normalized to the data. The theoretical prediction excluding the mass cut is normalized to the data above 80°.

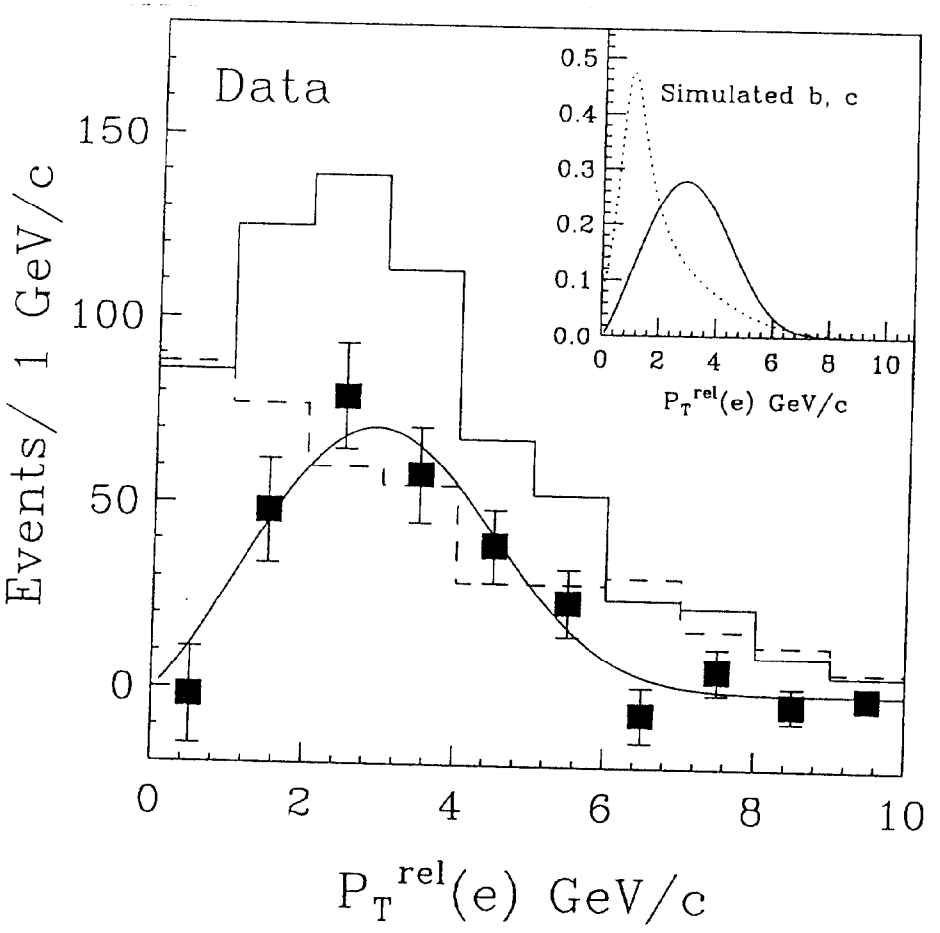

Figure 1:

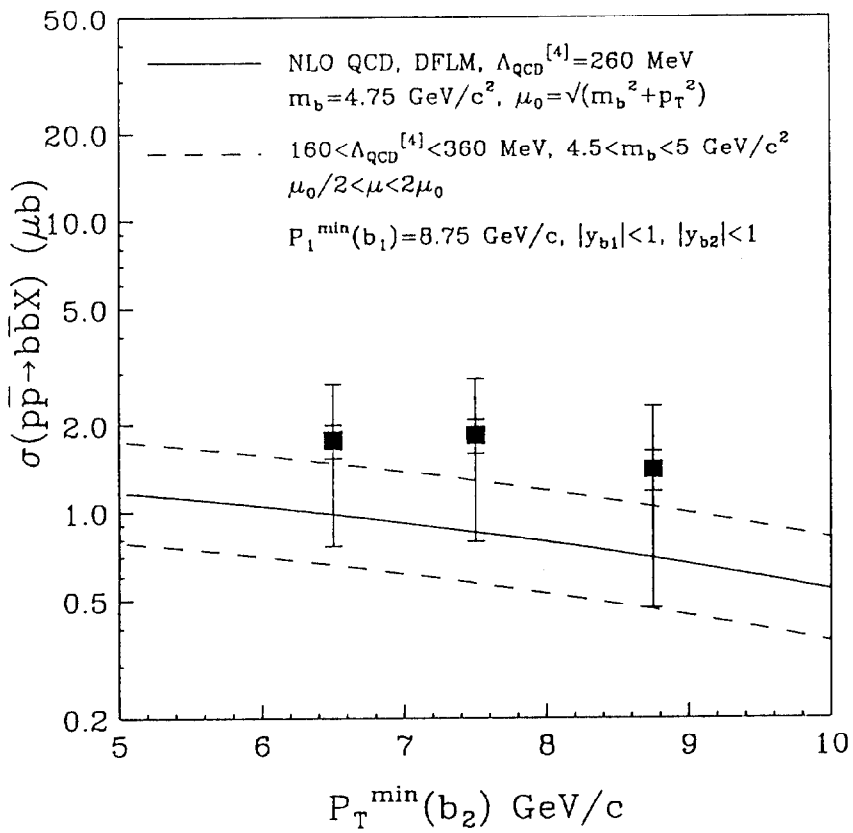
NLO QCD, DFLM, $\Lambda_{QCD}^{[4]}$=260 MeV
m_b=4.75 GeV/c^2, $\mu_0=\sqrt{(m_b^2+p_T^2)}$
160<$\Lambda_{QCD}^{[4]}$<360 MeV, 4.5<m_b<5 GeV/c^2
$\mu_0/2<\mu<2\mu_0$
$P_1^{min}(b_1)$=8.75 GeV/c, $|y_{b1}|<1$, $|y_{b2}|<1$
$\sigma(p\bar{p}\to b\bar{b}X)$ (μb)
50.0
20.0
10.0
5.0
2.0
1.0
0.5
0.2
5
6
7
8
9
10
$P_T^{min}(b_2)$ GeV/c

Figure 2:

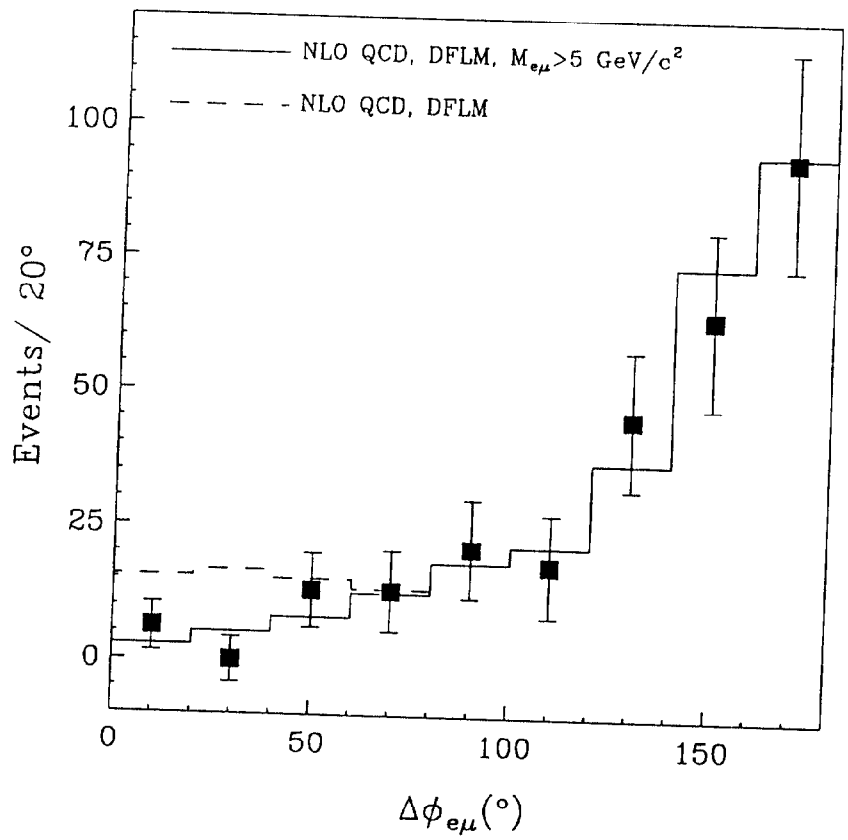
NLO QCD, DFLM, $M_{e\mu}$>5 GeV/c^2
NLO QCD, DFLM
Events/ 20°
100
75
50
25
0
0
50
100
150
$\Delta\phi_{e\mu}(°)$

Figure 3: