SLAC-PUB-7886
ICHEP–PA01 #179
July, 1997

Measurement of A_b at the Z^0 Resonance using a Jet-Charge Technique.[*]

The SLD Collaboration[**]
Stanford Linear Accelerator Center
Stanford University, Stanford, CA 94309

Abstract

We present a new preliminary measurement of the parity-violation parameter A_b using a self-calibrating jet-charge technique. In the SLD experiment we observe hadronic decays of Z^0 bosons produced in collisions between longitudinally polarized electrons and unpolarized positrons at the SLAC Linear Collider. A sample of $b\bar{b}$ events is selected using the topologically reconstructed mass of B hadrons. From our 1997–1998 data sample of approximately 200,000 hadronic Z^0 decays, we obtain $A_b = 0.824 \pm 0.031(\mathrm{stat}) \pm 0.032(\mathrm{syst})$. Together with our previous 1993–1995 result, it yields a preliminary combined SLD jet-charge measurement of: $A_b = 0.849 \pm 0.026(\mathrm{stat}) \pm 0.031(\mathrm{syst})$.

Paper Contributed to the XXIX International Conference on High Energy Physics, July 23-30, 1998, Vancouver, Canada

---

[*] Work supported in part by the Department of Energy contract DE–AC03–76SF00515.

Measurements of b quark production asymmetries at the Z^0 pole determine the extent of parity violation in the $Zb\bar{b}$ coupling. At Born level, the differential cross section for the process $e^+e^- \to Z^0 \to b\bar{b}$ can be expressed as a function of the polar angle θ of the b quark relative to the electron beam direction,

$$\sigma^b(\xi) \equiv d\sigma_b/d\xi \propto (1 - A_eP_e)(1+\xi^2) + 2A_b(A_e - P_e)\xi, \tag{1}$$

where P_e is the longitudinal polarization of the electron beam, $\xi = \cos\theta$. The parameters $A_f = 2v_fa_f/(v_f^2 + a_f^2)$, ($f = e$ or b) where v_f (a_f) is the vector (axial vector) coupling of the fermion f to the Z^0 boson, express the extent of parity violation in the $Zf\bar{f}$ coupling.

From the conventional forward-backward asymmetries formed with an unpolarized electron beam ($P_e = 0$), such as used by the LEP experiments, only the product of parity-violaton parameters A_eA_b can be measured [1]. For a polarized electron beam, it is possible to measure A_b directly by forming the left-right forward-backward asymmetry [2]

$$\tilde{A}^b_{FB}(\xi) = \frac{[\sigma^b_L(\xi) - \sigma^b_L(-\xi)] - [\sigma^b_R(\xi) - \sigma^b_R(-\xi)]}{\sigma^b_L(\xi) + \sigma^b_L(-\xi) + \sigma^b_R(\xi) + \sigma^b_R(-\xi)} = |P_e|A_b\frac{2\xi}{1+\xi^2}\ , \tag{2}$$

where L, R refers to $Z^0 \to b\bar{b}$ decays produced with a predominantly left-handed (negative helicity) or right-handed (positive helicity) electron beam, respectively. The measurement of the double asymmetry eliminates the dependence on the initial state coupling. The quantity A_b is largely independent of propagator effects that modify the effective weak mixing angle and thus is complementary to other electroweak asymmetry measurements performed at the Z^0 pole.

In this paper we present a preliminary direct measurement of A_b from data collected in the SLC Large Detector (SLD) during its 1997–1998 run. Our previous measurement [3] was done with 1993–95 data and current analysis uses a simular technique. We use an inclusive vertex mass tag to select a sample of $Z^0 \to b\bar{b}$ events, and the net momentum-weighted jet-charge, first suggested by Feynman and Field [4], to identify the sign of the charge of the underlying quark. The analysis presented in this paper uses a jet-charge calibration technique which greatly reduces the model dependence of the result.

A detailed description of the SLD can be found elsewhere [6]. Charged particles are tracked in the Central Drift Chamber (CDC) in a uniform axial magnetic field of 0.6T. In addition, new a pixel-based CCD vertex detector (VXD3), installed in 1996, provides an accurate measure of particle trajectories close to the beam axis. The measured $r\phi$ (rz) track impact parameter resolution approaches 11μm (23μm) for high momentum tracks, while multiple scattering contributions are $40\,\mu$m $/(p\sin^{3/2}\theta)$ in both projections (z is the coordinate parallel to the beam axis and $p_\perp$ is the momentum in GeV/c perpendicular to the beamline). The momentum resolution of the combined SLD tracking systems is $(\delta p_\perp/p_\perp)^2 = (.01)^2 + (.0026p_\perp)^2$. The thrust axis is reconstructed using the liquid argon calorimeter, which covers a range of $|\cos\theta| < 0.98$. The uncertainty in the position of the primary vertex (PV) is 5 μm transverse to the beam axis and 32 μm (for $b\bar{b}$ events) along the beam axis.

Events are classified as hadronic Z^0 decays if they contain: (1) at least seven well-measured tracks (as described in Ref. [6]), (2) a visible charged energy of at least 20 GeV, and (3) have a thrust axis polar angle satisfying $|\cos\theta_{thrust}| < 0.7$. The resulting hadronic sample from the $1997-98$ data consists of 113153 events with a non-hadronic background estimated to be $< 0.1\%$. Events classified as having more than three jets by the JADE jet-finding algorithm with $y_{cut} = 0.02$ [7], using reconstructed charged tracks as input, are discarded.

To increase the $Z^0 \to b\bar{b}$ content of the sample, a tagging procedure based on the invariant mass of 3-dimensional topologically reconstructed secondary decay vertices is applied [8, 9]. The mass of the reconstructed vertex is corrected for missing transverse momentum to account partially for neutral particles. The requirement that the event contain at least one secondary vertex with mass greater than 2.0 GeV/c^2 results in a sample of 18984 candidate $Z^0 \to b\bar{b}$ decays. The purity (97%) and efficiency (76%) are calculated from the data with small correction, based on the Monte Carlo (MC) simulation, applied to account for the *udsc* background.

Using all jet-charge quality tracks, as defined in Ref.[10], we form the signed (Q) and unsigned (Q_+) momentum-weighted charge sums

$$Q = -\sum_{tracks} q_j \cdot \mathrm{sgn}(\vec{p}_j \cdot \hat{T})|(\vec{p}_j \cdot \hat{T})|^{\kappa}, \tag{3}$$

$$Q_+ = \sum_{tracks} q_j |(\vec{p}_j \cdot \hat{T})|^{\kappa}, \tag{4}$$

where q_j and $\vec{p}_j$ are the charge and momentum of track j, respectively, and $\hat{T}$ is a unit vector chosen along the direction of the reconstructed thrust axis so that $Q > 0$. The vector $\hat{T}$ is therefore an estimate of the b-quark direction. We use $\kappa = 0.5$ to maximize the analyzing power of the jet-charge algorithm for $Z^0 \to b\bar{b}$ events.

Fig. 1 shows the $T_z = \cos\theta_{thrust}$ distribution of the b-enriched sample separately for left- and right-handed electron beams. Clear forward-backward asymmetries are observed, with respective signs as expected from the cross section formula in Eq. 1.

The value of A_b is extracted via a fit to a maximum likelihood function based on the differential cross-section (see Eq. 1), which provides a somewhat more efficient estimate of A_b than the simple left-right forward-backward asymmetry of Eq. 2:

$$\begin{aligned}\rho^i(A_b) = {} & (1 - A_e P_e^i)(1 + (T_z^i)^2) + 2(A_e - P_e^i)T_z^i[A_b f_b^i (2p_b^i - 1)(1 - \Delta^i_{QCD,b}) + \\ & A_c f_c^i (2p_c^i - 1)(1 - \Delta^i_{QCD,c}) + A_{bckg}(1 - f_b^i - f_c^i)(2p_{bckg}^i - 1)],\end{aligned} \tag{5}$$

where P_e^i is the signed polarization of the electron beam for event i, $f^i_{b(c)}$ the probability that the event is a $Z^0 \to b\bar{b}(c\bar{c})$ decay, parametrized as a function of the secondary vertex mass, and $\Delta^i_{QCD,b,c}$ are final-state QCD corrections, to be discussed later. A_{bckg} is the estimated asymmetry of residual $u\bar{u}$, $d\bar{d}$, and $s\bar{s}$ final states. The parameters p are estimates of the probability that the sign of Q accurately reflects the charge of the respective underlying quark, and are functions of $|Q|$, as well as the secondary vertex mass and $|T_z|$.

In order to reduce dependance on B decay and fragmentation modeling we use a self-calibrating technique to measure p_b directly from the data [11]. Defining Q_b ($Q_{\bar{b}}$) to be the unsigned momentum-weighted jet-charge sum of the tracks in the thrust hemisphere containing the b ($\bar{b}$) quark, the quantities

$$Q_{sum} = Q_b + Q_{\bar{b}}\ , \quad Q_{dif} = Q_b - Q_{\bar{b}}\ , \tag{6}$$

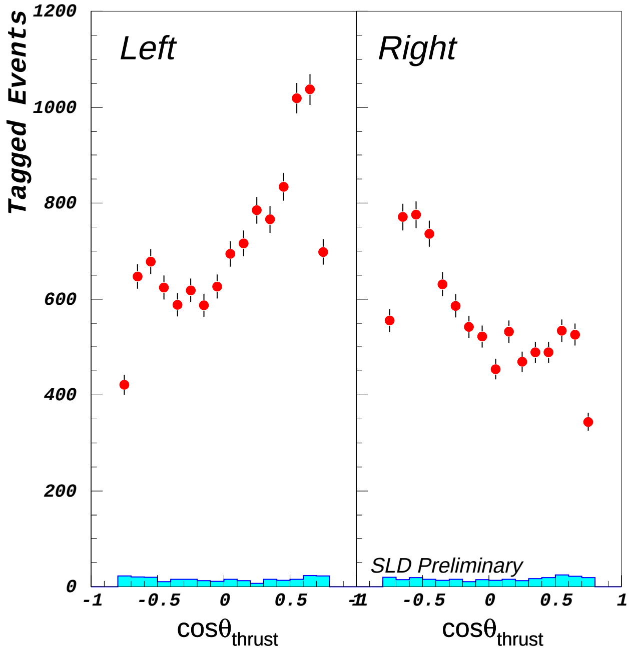

Figure 1: The polar angle distribution of the signed thrust axis for the b tagged sample. The estimated background is shown by the shaded histogram.

may be related to the experimental observables defined in Eqs. 3 and 4 respectively: $|Q_{dif}| = |Q|$ and $Q_{sum} = Q_+$. Our MC simulation indicates that the Q_b and $Q_{\bar{b}}$ distributions are approximately Gaussian. In this limit [11],

$$p_b(|Q|) = \frac{1}{1 + e^{-\alpha_b |Q|}} \ , \tag{7}$$

with

$$\alpha_b = \frac{2q^0_{dif}}{\sigma^2_{dif}} = \frac{2\sqrt{\langle |Q_{dif}|^2 \rangle - \sigma^2_{dif}}}{\sigma^2_{dif}} \ , \tag{8}$$

where q^0_{dif} and σ_{dif} are the mean and width, respectively, of the Gaussian Q_{dif} distribution.

In the absence of a correlation between Q_b and $Q_{\bar{b}}$, $\sigma_{dif} = \sigma_{sum}$, where σ_{sum} is the observed width of the Q_+ distribution. Thus α_b can be derived from experimental observables. In the presence of a correlation, $\sigma_{dif} = (1 + \lambda)\sigma_{sum}$, where λ characterizes the strength of the correlation which can be determined from the MC simulation. For JETSET 7.4 [12] with parton shower evolution, string fragmentation, and full detector simulation, λ is found to be 0.024. The effects of light flavor contamination are taken into account by adjusting the observed widths σ^2_{sum} and $\langle |Q_{dif}|^2 \rangle$, using the magnitude and width of the light-flavor and $c\bar{c}$ contributions estimated from the MC. This correction increases the value of α_b by 0.5%.

Final-state gluon radiation reduces the observed asymmetry from its Born-level value. This effect is incorporated in our analysis by applying a correction $\Delta_{QCD}(|\cos\theta|)$ to the maximum likelihood function (Eq. 5). This correction is based on the $o(\alpha_s)$ calculation for massive final state quarks of Stav and Olsen [13], which ranges from $\Delta^{SO}_{QCD}(|\cos\theta|) \sim 0.05$ at $|\cos\theta| = 0$ to ~ 0.01 at $|\cos\theta| = 1$.

However, QCD radiative effects are mitigated by the use of the thrust axis to estimate the b-quark direction, the $Z^0 \to b\bar{b}$ enrichment algorithm, the self-calibration procedure, and the cut on the number of jets. A MC simulation of the analysis chain indicates that these effects can be represented by a $\cos\theta$-independent suppression factor, $x_{QCD} = 0.25 \pm 0.08$, such that $\Delta_{QCD} = x_{QCD}\Delta^{SO}_{QCD}$. The effects of $o(\alpha_s^2)$ QCD radiation [14], which are dominated by gluon splitting to $b\bar{b}$, lead to an additional correction $\delta A_b/A_b = 0.004 \pm 0.002$.

The dependence of the b-tagging efficiency upon the secondary vertex mass is taken from the simulation, with the overall tagging efficiency derived from the single- and double-tagging rates [8] observed in the data. Tagging efficiencies for charm and uds events are estimated using the MC simulation, as is the charm correct-signing probability p_c. The value of A_c is set to its Standard Model value of 0.67, and the value of A_{bckg} is set to zero. After a small (0.2%) correction [15] for initial state radiation and Z-γ interference, the value of A_b extracted from the fit is $A_b = 0.824 \pm 0.031$ ($stat$). This result is found to be insensitive to the value of the b-tag mass cut. Fig 2 shows the measured value of A_b as a function of mass cut.

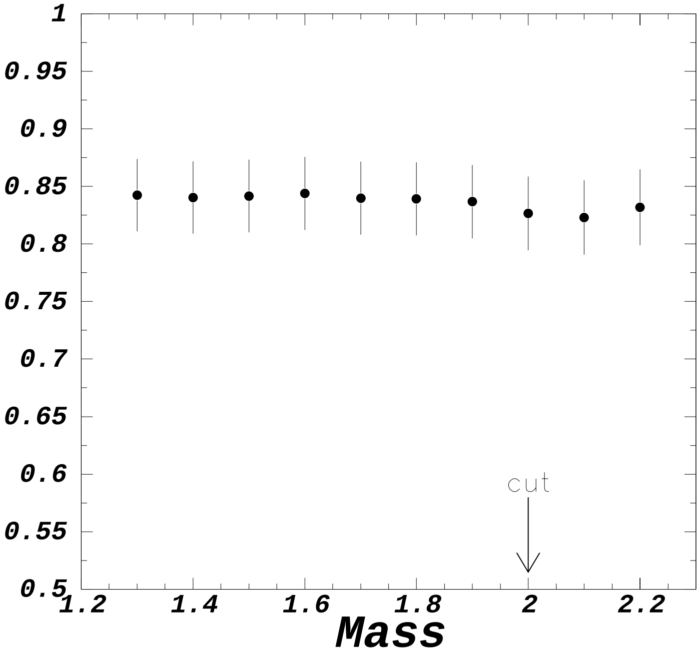

Figure 2: The measured value of A_b as a function of mass cut.

We have investigated a number of systematic effects which can change the measured value of A_b; these are summarized in Table 1. The uncertainty in α_b due to the statistical uncertainties in $\langle|Q_{dif}|^2\rangle$ and σ^2_{sum} corresponds to a 2.4% uncertainty in A_b. The uncertainty in the hemisphere correlation parameter λ is estimated [11] by varying fragmentation parameters within JETSET 7.4, and by comparison with the HERWIG 5.7 [16] fragmentation model at the generator level. The result of this study is summarized in Table 2; the resulting uncertainty in A_b is 1.4%. The sensitivity of the result to the shape of the underlying Q_b distribution is tested by generating various triangular distributions as well as double Gaussian distributions with offset means. The test distributions are constrained to yield a Q_+ distribution consistent with data, and the total uncertainty is found to be 0.8%. The jet-charge distributions in data and Monte Carlo are in good agreement, as shown on Fig. 3, and consistent with Gaussian hypothesis.

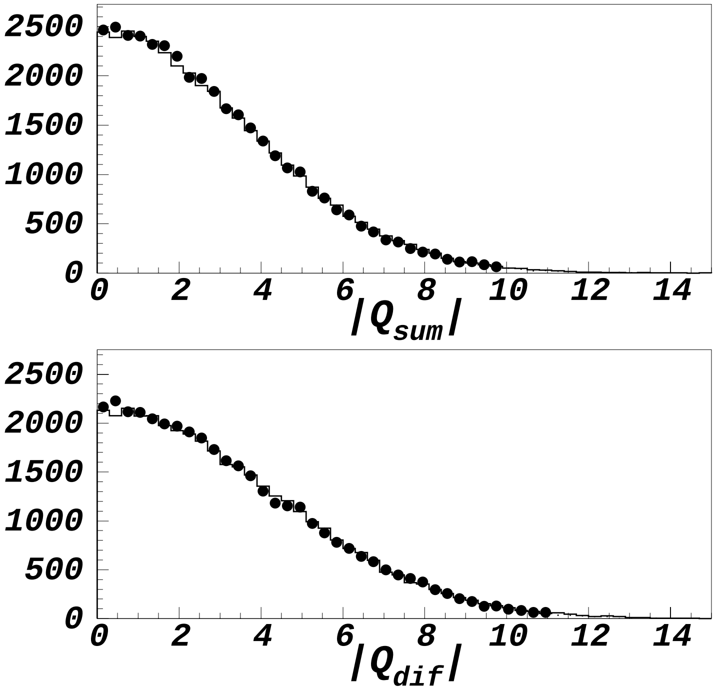

Figure 3: The jet-charge $|Q_{sum}|$ and $|Q_{dif}|$ distributions are shown for the data (bullets) and for the Monte Carlo (histogram).

In addition, while the mean value of the self-calibration parameter α_b is constrained by the data, it has a $\cos\theta$ dependence due to the fall-off of the tracking efficiency at high $\cos\theta$ which must be estimated using the simulation, leading to a 0.4% uncertainty in A_b.

The extracted value of A_b is sensitive to our estimate of the $Z^0 \to c\bar{c}$ background, which tends to reduce the observed asymmetry due to the positive charge of the underlying c quark. The uncertainty in the purity estimate of $97.6 \pm 0.2\%$ is dominated by the uncertainties in the charm tagging efficiency ($\epsilon_c = 0.019 \pm 0.0031$) and charm production fraction ($R_c = 0.1715 \pm 0.0056$) and leads to a 0.3% uncertainty in A_b. Details of the estimate of the light and charmed quark efficiencies can be found in Ref. [8].

In addition, agreement between the data and MC simulation charged track multiplicity distributions is obtained only after the inclusion of additional ad-hoc tracking inefficiency.

This random ineffecicnecy was parametrized as a function of total track momentum, and averages 0.5 charged tracks per event. Removing this additional correction from the MC results in a 1.7% change in A_b, which is also included as a systematic error. Repeating analysis without the "3 jet" cut results in the 1.3% increase in A_b, which is added to the detector systematic error. Combining all systematic uncertainties in quadrature yields a total relative systematic uncertainty of 3.9%.

In conclusion, we have exploited the highly polarized SLC electron beam to perform a direct measurement of

$$A_b = 0.824 \pm 0.031(\mathrm{stat}) \pm 0.032(\mathrm{syst}). \tag{9}$$

Combination with our previous measurement from 1993-95 data ($0.911 \pm 0.045(\mathrm{stat}) \pm 0.045(\mathrm{syst})$) yields combined SLD preliminary jet-charge measurement of

$$A_b = 0.849 \pm 0.026(\mathrm{stat}) \pm 0.031(\mathrm{syst}), \tag{10}$$

This measurement represents a substantial improvement over our previous result [10] due to a larger event sample, higher electron beam polarization, and the use of the Z^0 data to calibrate the b-tagging efficiency as well as the jet-charge algorithm analyzing power.

We thank the personnel of the SLAC accelerator department and the technical staffs of our collaborating institutions for their outstanding efforts on our behalf. This work was supported by the U.S. Department of Energy and National Science Foundation, the UK Particle Physics and Astronomy Research Council, the Istituto Nazionale di Fisica Nucleare of Italy, the Japan-US Cooperative Research Project on High Energy Physics, and the Korea Science and Engineering Foundation.

References

[1] The LEP Collaborations, ALEPH, DELPHI, L3, OPAL, the LEP Electroweak Working Group, and the SLD Heavy Flavor Group, CERN-PPE/97-154.

[2] A. Blondel, B. W. Lynn, F. M. Renard, and C. Verzegnassi, Nucl. Phys. **B304**, 438 (1988).

[3] K. Abe *et al.* (SLD Collaboration), SLAC-PUB-7794 (1998), Submitted to Phys. Rev. Lett.

[4] R. D. Field and R. P. Feynman, Nucl. Phys. **B136**, 1 (1978).

[5] K. Abe *et al.* (SLD Collaboration), Phys. Rev. Lett. **73**, 25 (1994); Phys. Rev. Lett. **78** 2075 (1997).

[6] K. Abe *et al.* (SLD Collaboration), Phys. Rev. **D53**, 1023 (1996).

[7] W. Bartel *et al.* Z. Phys. **C33**, 23 (1986).

[8] K. Abe *et al.* (SLD Collaboration), Phys. Rev. Lett. **80**, 660 (1998).

[9] D. Jackson, Nucl. Instrum. Methods **A388**, 247 (1997).

[10] K. Abe *et al.* (SLD Collaboration), Phys. Rev. Lett. **74**, 2890 (1995).

[11] V. Serbo, SLAC-Report-510 (1997), pp. 58-63; T. Junk, SLAC-Report-476 (1995), pp.182-188.

[12] T. Sjöstrand, Comp. Phys. Comm. **82** 74, (1994)

[13] J.B. Stav and H.A. Olsen, Phys. Rev. **D52**, 1359 (1995); Phys. Rev. **D50**, 6775 (1994).

[14] G. Altarelli, B. Lampe, Nucl. Phys. **B391**, 3, 1993.

[15] D. Bardin *et al.*, European Organization for Particle Physics preprint CERN-TH-6443, 1992.

[16] G. Marchesini *et al.*, Comp. Phys. Comm. **67**, 465 (1992).

[**]List of Authors

K. Abe,(2) K. Abe,(19) T. Abe,(27) I.Adam,(27) T. Akagi,(27) N. J. Allen,(4) A. Arodzero,(20)
W.W. Ash,(27) D. Aston,(27) K.G. Baird,(15) C. Baltay,(37) H.R. Band,(36) M.B. Barakat,(14)
O. Bardon,(17) T.L. Barklow,(27) J.M. Bauer,(16) G. Bellodi,(21) R. Ben-David,(37)
A.C. Benvenuti,(3) G.M. Bilei,(23) D. Bisello,(22) G. Blaylock,(15) J.R. Bogart,(27)
B. Bolen,(16) G.R. Bower,(27) J. E. Brau,(20) M. Breidenbach,(27) W.M. Bugg,(30)
D. Burke,(27) T.H. Burnett,(35) P.N. Burrows,(21) A. Calcaterra,(11) D.O. Caldwell,(32)
D. Calloway,(27) B. Camanzi,(10) M. Carpinelli,(24) R. Cassell,(27) R. Castaldi,(24)
A. Castro,(22) M. Cavalli-Sforza,(33) A. Chou,(27) E. Church,(35) H.O. Cohn,(30)
J.A. Coller,(5) M.R. Convery,(27) V. Cook,(35) R. Cotton,(4) R.F. Cowan,(17) D.G. Coyne,(33)
G. Crawford,(27) C.J.S. Damerell,(25) M. N. Danielson,(7) M. Daoudi,(27) N. de Groot,(27)
R. Dell'Orso,(23) P.J. Dervan,(4) R. de Sangro,(11) M. Dima,(9) A. D'Oliveira,(6)
D.N. Dong,(17) P.Y.C. Du,(30) R. Dubois,(27) B.I. Eisenstein,(12) V. Eschenburg,(16)
E. Etzion,(36) S. Fahey,(7) D. Falciai,(11) C. Fan,(7) J.P. Fernandez,(33) M.J. Fero,(17)
K.Flood,(15) R. Frey,(20) T. Gillman,(25) G. Gladding,(12) S. Gonzalez,(17) E.L. Hart,(30)
J.L. Harton,(9) A. Hasan,(4) K. Hasuko,(31) S. J. Hedges,(5) S.S. Hertzbach,(15)
M.D. Hildreth,(27) J. Huber,(20) M.E. Huffer,(27) E.W. Hughes,(27) X.Huynh,(27)
H. Hwang,(20) M. Iwasaki,(20) D. J. Jackson,(25) P. Jacques,(26) J.A. Jaros,(27) Z.Y. Jiang,(27)
A.S. Johnson,(27) J.R. Johnson,(36) R.A. Johnson,(6) T. Junk,(27) R. Kajikawa,(19)
M. Kalelkar,(26) Y. Kamyshkov,(30) H.J. Kang,(26) I. Karliner,(12) H. Kawahara,(27)
Y. D. Kim,(28) R. King,(27) M.E. King,(27) R.R. Kofler,(15) N.M. Krishna,(7)
R.S. Kroeger,(16) M. Langston,(20) A. Lath,(17) D.W.G. Leith,(27) V. Lia,(17) C.-J. S. Lin,(27)
X. Liu,(33) M.X. Liu,(37) M. Loreti,(22) A. Lu,(32) H.L. Lynch,(27) J. Ma,(35)
G. Mancinelli,(26) S. Manly,(37) G. Mantovani,(23) T.W. Markiewicz,(27) T. Maruyama,(27)
H. Masuda,(27) E. Mazzucato,(10) A.K. McKemey,(4) B.T. Meadows,(6) G. Menegatti,(10)
R. Messner,(27) P.M. Mockett,(35) K.C. Moffeit,(27) T.B. Moore,(37) M.Morii,(27)
D. Muller,(27) V.Murzin,(18) T. Nagamine,(31) S. Narita,(31) U. Nauenberg,(7) H. Neal,(27)
M. Nussbaum,(6) N.Oishi,(19) D. Onoprienko,(30) L.S. Osborne,(17) R.S. Panvini,(34)
H. Park,(20) C. H. Park,(29) T.J. Pavel,(27) I. Peruzzi,(11) M. Piccolo,(11) L. Piemontese,(10)
E. Pieroni,(24) K.T. Pitts,(20) R.J. Plano,(26) R. Prepost,(36) C.Y. Prescott,(27)
G.D. Punkar,(27) J. Quigley,(17) B.N. Ratcliff,(27) T.W. Reeves,(34) J. Reidy,(16)
P.L. Reinertsen,(33) P.E. Rensing,(27) L.S. Rochester,(27) P.C. Rowson,(8) J.J. Russell,(27)
O.H. Saxton,(27) T. Schalk,(33) R.H. Schindler,(27) B.A. Schumm,(33) J. Schwiening,(27)
S. Sen,(37) V.V. Serbo,(36) M.H. Shaevitz,(8) J.T. Shank,(5) G. Shapiro,(13) D.J. Sherden,(27)
K. D. Shmakov,(30) C. Simopoulos,(27) N.B. Sinev,(20) S.R. Smith,(27) M. B. Smy,(9)
J.A. Snyder,(37) H. Staengle,(9) A. Stahl,(27) P. Stamer,(26) R. Steiner,(1) H. Steiner,(13)
M.G. Strauss,(15) D. Su,(27) F. Suekane,(31) A. Sugiyama,(19) S. Suzuki,(19) M. Swartz,(27)
A. Szumilo,(35) T. Takahashi,(27) F.E. Taylor,(17) J. Thom,(27) E. Torrence,(17)
N. K. Toumbas,(27) A.I. Trandafir,(15) J.D. Turk,(37) T. Usher,(27) C. Vannini,(24)
J. Va'vra,(27) E. Vella,(27) J.P. Venuti,(34) R. Verdier,(17) P.G. Verdini,(24) S.R. Wagner,(27)
D. L. Wagner,(7) A.P. Waite,(27) Walston, S.,(20) J.Wang,(27) C. Ward,(4) S.J. Watts,(4)
A.W. Weidemann,(30) E. R. Weiss,(35) J.S. Whitaker,(5) S.L. White,(30) F.J. Wickens,(25)
B. Williams,(7) D.C. Williams,(17) S.H. Williams,(27) S. Willocq,(27) R.J. Wilson,(9)
W.J. Wisniewski,(27) J. L. Wittlin,(15) M. Woods,(27) G.B. Word,(34) T.R. Wright,(36)
J. Wyss,(22) R.K. Yamamoto,(17) J.M. Yamartino,(17) X. Yang,(20) J. Yashima,(31)
S.J. Yellin,(32) C.C. Young,(27) H. Yuta,(2) G. Zapalac,(36) R.W. Zdarko,(27) J. Zhou.(20)

(The SLD Collaboration)

(1)*Adelphi University, South Avenue- Garden City,NY 11530,*
(2)*Aomori University, 2-3-1 Kohata, Aomori City, 030 Japan,*
(3)*INFN Sezione di Bologna, Via Irnerio 46 I-40126 Bologna, Italy,*
(4)*Brunel University, Uxbridge, Middlesex - UB8 3PH United Kingdom,*
(5)*Boston University, 590 Commonwealth Ave. - Boston,MA 02215,*
(6)*University of Cincinnati, Cincinnati,OH 45221,*
(7)*University of Colorado, Campus Box 390 - Boulder,CO 80309,*
(8)*Columbia University, Nevis Laboratories P.O.Box 137 - Irvington,NY 10533,*
(9)*Colorado State University, Ft. Collins,CO 80523,*
(10)*INFN Sezione di Ferrara, Via Paradiso,12 - I-44100 Ferrara, Italy,*
(11)*Lab. Nazionali di Frascati, Casella Postale 13 I-00044 Frascati, Italy,*
(12)*University of Illinois, 1110 West Green St. Urbana,IL 61801,*
(13)*Lawrence Berkeley Laboratory, Dept.of Physics 50B-5211 University of California-Berkeley, CA 94720,*
(14)*Louisiana Technical University, Dept. of Physics, Ruston, LA 71272,*
(15)*University of Massachusetts, Amherst,MA 01003,*
(16)*University of Mississippi, University,MS 38677,*
(17)*Massachusetts Institute of Technology, 77 Massachusetts Avenue Cambridge, MA 02139,*
(18)*Moscow State University, Institute of Nuclear Physics 119899 Moscow, Russia,*
(19)*Nagoya University, Nagoya 464 Japan,*
(20)*University of Oregon, Department of Physics Eugene,OR 97403,*
(21)*Oxford University, Oxford, OX1 3RH, United Kingdom,*
(22)*Universita di Padova, Via F. Marzolo,8 I-35100 Padova, Italy,*
(23)*Universita di Perugia, Sezione INFN, Via A. Pascoli I-06100 Perugia, Italy,*
(24)*INFN, Sezione di Pisa, Via Livornese,582/AS Piero a Grado I-56010 Pisa, Italy,*
(25)*Rutherford Appleton Laboratory, Chiton,Didcot - Oxon OX11 0QX United Kingdom,*
(26)*Rutgers University, Serin Physics Labs Piscataway,NJ 08855-0849,*
(27)*Stanford Linear Accelerator Center, 2575 Sand Hill Road Menlo Park,CA 94025,*
(28)*Sogang University, Ricci Hall Seoul, Korea,*
(29)*Soongsil University, Dongjakgu Sangdo 5 dong 1-1 Seoul, Korea 156-743,*
(30)*University of Tennessee, 401 A.H. Nielsen Physics Blg. - Knoxville, Tennessee 37996-1200,*
(31)*Tohoku University, Bubble Chamber Lab. - Aramaki - Sendai 980, Japan,*
(32)*U.C. Santa Barbara, 3019 Broida Hall Santa Barbara,CA 93106,*
(33)*U.C. Santa Cruz, Santa Cruz,CA 95064,*
(34)*Vanderbilt University, Stevenson Center,Room 5333 P.O.Box 1807,Station B Nashville,TN 37235,*
(35)*University of Washington, Seattle,WA 98105,*
(36)*University of Wisconsin, 1150 University Avenue Madison,WS 53706,*
(37)*Yale University, 5th Floor Gibbs Lab. - P.O.Box 208121 - New Haven,CT 06520-8121.*

Table 1: Relative systematic errors on the 1997-98 measurement of A_b.

Error Source	**Variation**	$\delta A_b/A_b$
Self-Calibration		
α_b statistics	$\pm 1\sigma$	2.4%
λ_b Correlation	JETSET, HERWIG	1.4%
$P(Q_b)$ shape	Different shapes	0.8%
$\cos\theta$ shape of α_b	MC Shape *vs* Flat	0.4%
Light Flavor	50% of correction	0.3%
Analysis		
Tag Composition	Mostly ϵ_c	0.3%
Detector Modeling	Tracking eff. and resolution corrections on/off	2.2%
Beam Polarization	$\pm 0.8\%$	0.8%
QCD	x_{QCD}, $\alpha_s \pm 0.007$, 2^{nd} order terms	0.9%
Gluon Splitting	$\pm 100\%$ of JETSET	0.2%
A_c	0.67 ± 0.08	<0.1%
A_{bckg}	0 ± 0.50	0.2%
Total		**3.9%**

Table 2: Summary of λ_b systematic error analysis. Multiplicative factor 0.61 connects $\lambda_{b,\ gen}$ at the generator level with the λ_b from the full simulation.

Parameter	Nominal	Variation	$\delta\lambda_{b,\ gen}$ (%)
Λ_{QCD}	0.26	0.24 – 0.28	0.06 ± 0.14
Q_0	1.0	0.7 – 1.8	0.17 ± 0.14
σ_q	0.37	0.32 – 0.40	0.20 ± 0.14
γ_s	0.28	0.25 – 0.32	0.19 ± 0.14
$[V/(V+S)]_{u,d}$	0.50	0.30 – 0.75	0.27 ± 0.14
$[V/(V+S)]_s$	0.45	0.45 – 0.60	0.11 ± 0.14
$[V/(V+S)]_{c,b}$	0.53	0.53 – 0.63	0.05 ± 0.14
ϵ_b	0.006	0.006 – 0.0277	0.04 ± 0.14
direct baryon rate	0.08	0.08 – 0.12	0.20 ± 0.14
popcorn parameter	1.	0. – 2.	0.11 ± 0.14
x_d	0.7	0. – 0.7	0.16 ± 0.14
x_s	10.	0. – 100.	0.18 ± 0.14
HERWIG5.7			0.29 ± 0.11
Total			0.6%