SLAC-PUB-7278
September 1996

Z^0 Pole Direct Measurements of the Parity Violation Parameters A_b and A_c at SLD*

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Presented at the annual Divisional Meeting (DPF 96) of the Division of Particles and Fields of the American Physical Society, Minneapolis, MN, August 10–15, 1996

* Work supported in part by the Department of Energy, contract DE-AC03-76SF00515.

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This report presents three different techniques used at SLD to measure directly the parity violation parameters of $Zb\bar{b}$ and $Zc\bar{c}$ couplings from the left-right forward-backward asymmetries. The results have been obtained using 150,000 hadronic Z^0 decays accumulated during the 1993-95 runs with high electron beam polarization.

1 Introduction

The parity violation in the $Zf\bar{f}$ coupling can be expressed as the observable $A_f = 2v_f a_f/(v_f^2 + a_f^2)$, where v_f and a_f represent the vector and axial couplings. In particular A_b and A_c are more sensitive to the right handed Zbb and Zcc couplings than R_b and R_c. For $Z^0 \to f\bar{f}$ events with final-state fermion f at polar angle $z = \cos\theta$ with respect to the electron-beam direction, the Born level forward-backward asymmetry is $A^f_{FB}(z) = \frac{\sigma^f(z)-\sigma^f(-z)}{\sigma^f(z)+\sigma^f(-z)} = A_e A_f \frac{2z}{1+z^2}$. In the presence of e^- beam polarization, it's possible to measure the left-right forward-backward asymmetry: $\tilde{A}^f_{FB}(z) = \frac{[\sigma^f_L(z)-\sigma^f_L(-z)]-[\sigma^f_R(z)-\sigma^f_R(-z)]}{[\sigma^f_L(z)+\sigma^f_L(-z)]+[\sigma^f_R(z)+\sigma^f_R(-z)]}$ $= |P_e| A_f \frac{2z}{1+z^2}$, where P_e is the e^- beam longitudinal polarization. In the $\tilde{A}^f_{FB}$ the dependence on the initial state A_e disappears, and the final state A_f can be measured directly. This report reviews preliminary measurements of A_b and A_c obtained from 100,000 hadronic Z^0 decays with average $|P_e| = (77.3 \pm 0.6)\%$ collected in the 1994–95 run, combined with 50,000 Z^0 decays with $|P_e| = (63.0 \pm 1.1)\%$ from the 1993 run at SLC/SLD. The high polarization achieved also brings a large gain of $(P_e/A_e)^2 \sim 25$ in statistics compared to conventional A^f_{FB} on the sensitivity to A_f. $cos\theta$ dependent QCD corrections are included in the measurements described in this report, including mass quark effects at first order in α_s. The lepton measurement described in Section 3 is the only one updated and improved since the 1995 results [1]. The SLD detector components descriptions can be found in the references of the individual analysis papers.

2 A_b measurement using a Momentum-Weighted Track Charge

In this analysis $Z^0 \to b\bar{b}$ events are selected using a lifetime tag. 61% efficiency and 89% purity are achieved. The momentum-weighted track charge sum and difference between the two hemispheres are used to extract the analyzing power from the data: this reduces the MC dependency and many systematic effects. Distributions of the signed thrust axis for the tagged events are shown in Fig. 1.

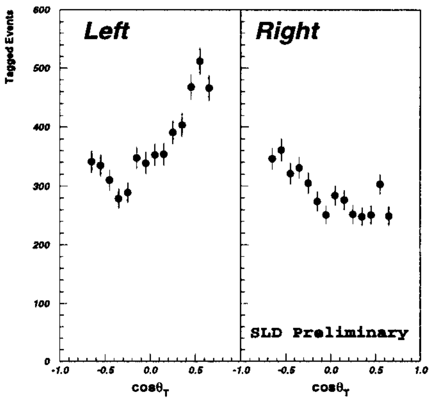

Figure 1: Distributions of the raw signed thrust axis $cos\theta_T$ for 1994–1995 data for left- and right-handed e^- beams using momentum-weighted track charge.

Systematic source	$\delta A_b/A_b$
α_b calibration statistics	3.0%
$P(Q)$ shape	1.0%
cosθ depend. of α_b	1.5%
Hemisph. charge corr.	3.7%
Light flavor subtraction	0.2%
Detector material	0.1%
$c\bar{c}$ analyzing power	0.2%
b-tag flavor composition	2.6%
$A_c = 0.67 \pm 0.07$	1.0%
$A_{bckg} = 0 \pm 0.50$	0.6%
Beam polarization	0.8%
QCD correction	0.9%
Total	6.0%

Table 1: Relative systematic errors on the A_b measurement using momentum weighted track charge.

A maximum likelihood fit is used to measure A_b. The systematics errors are shown in Table 1. The preliminary result for the 1993–1995 data sample is:

$$A_b = 0.843 \pm 0.046\ (stat) \pm 0.051\ (syst).$$

3 A_b using Identified Charged Kaons

In this preliminary asymmetry measurement of A_b using the 1994–1995 data, the decay channel $\bar{B} \to D \to K^-$ is exploited to tag the b charge. The gas-radiator data of the Cherenkov Ring Imaging Detector (CRID) is used to identify charged kaons with high-impact parameter tracks and a momentum of 3–20 GeV. The K:π efficiency ratio results of ~12:1. The MC $\pi \to K$ mis-id rate is corrected for using $Z \to \tau\bar{\tau}$ and $K^0_s \to \pi^+\pi^-$ events. $b\bar{b}$ events are selected with a lifetime tag. The charges of the K candidates are summed in each hemisphere, and the difference between the two hemisphere charges is used to determine the polarity of the thrust axis for the b-quark direction.

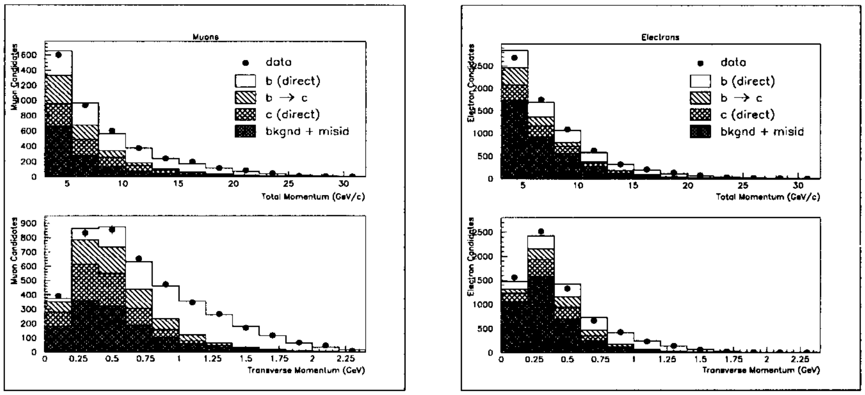

Figure 1: Distributions of momentum and transverse momentum to each lepton in thewith respect to the nearest jet for identified muons and electrons in the data (points), compared to the MC prediction (histograms) for various sources.

A_b is obtained using the MC as a fitting function (after subtracting the *udsc* background). The preliminary result from the 1994–1995 data is:

$$A_b = 0.91 \pm 0.09\ (stat) \pm 0.09\ (syst).$$

4 A_b, A_c using Leptons

This analysis of A_b and A_c uses an improved lepton identification[2] which now includes also information from the CRID. The new electron ID utilizes a Neural Network technique. Electrons and muons are identified in hadronic decays of the Z^0 and used to enrich the $b\bar{b}$ and $c\bar{c}$ event samples. The charge of

Systematic source	δA_b	δA_c	Systematic source	δA_b	δA_c
Lepton mis-ID rate	.009	.017	b-fragmentation	.001	.006
Background asymmetry	.003	.022	c-fragmentation	.006	.014
Jet axis simulation	.029	.022	$\mathrm{Br}(b \to \bar{c} \to \ell)$	.005	.034
MC weights	.016	.017	$\mathrm{Br}(b \to \tau \to \ell)$	.000	.006
Tracking efficiency	.009	.002	$\mathrm{Br}(c \to \ell)$	.004	.023
$R_b = .2216 \pm .0017$	$-.003$	.001	$b \to \ell$ model	.014	.023
$R_c = .16 \pm .01$	.005	$-.030$	$c \to \ell$ model	.011	.007
$\overline{\chi} = .122 \pm .006$	.017	.000	Beam polarization	.009	.005
$\mathrm{Br}(b \to \ell) = 10.75 \pm .23\%$	$-.007$	.010	QCD correction	.005	.012
$\mathrm{Br}(b \to c \to \ell) = 8.10 \pm .37\%$	.005	$-.023$	Total systematic	.047	.076

Table 2: Systematic errors for A_b, A_c measurements using leptons.

the lepton is used to tag the b quark charge, while the jet nearest to the lepton approximates the quark direction. A maximum likelihood analysis of all hadronic Z^0 events containing leptons is used to determine A_b and A_c. Since the lepton source fractions are derived by counting leptons in the MC with similar p and p_t data, MC and data momentum spectra must be in good agreement (see Fig. 2). The preliminary combined muon and electron results for the 1993–1995 data are:

$A_b = 0.88 \pm 0.07\ (stat) \pm 0.05\ (syst)$ $A_c = 0.61 \pm 0.10\ (stat) \pm 0.08\ (syst)$. Most of the systematic errors (see Table 2) have been evaluated following the recommendations from the LEP Electroweak Working Group[3]. The branching ratios used are in much better agreement with the world averages with respect to the 1995 results, especially the $BR(b \to c \to l)$. The background levels have been studied with the MC, but also with a data sample of pure pions from kinematically reconstructed K_s^0 decays.

5 Combined A_b, A_c Results

The measurements covered in this report (together with another SLD measurement of A_c using reconstructed D^{*+} and D^+ [1]) can be combined with a simultaneous fit to A_b and A_c, including correlations, to get the combined SLD results: $A_b = 0.863 \pm 0.049$ and $A_c = 0.625 \pm 0.084$. In Fig. 3 we show the parity violation-like variable ζ_b versus $\delta \sin^2 \theta_W^{eff}$, following the scheme of a full $Zb\bar{b}$ coupling analysis proposed by Takeuchi et al.[4], for various current experimental results. The 68% and 90% C.L. contours for the best fit to all measurements are shown together with the SM predictions.

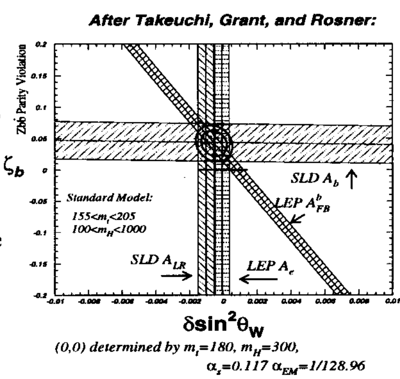

Figure 3: Zbb coupling parity violation versus $\sin^2 \theta_W^{eff}$.

References

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