SLAC-PUB-5976
NOVEMBER 1992
(E)

A TEST OF THE FLAVOR INDEPENDENCE OF α_s AT THE Z^0 RESONANCE*

The SLD Collaboration
Stanford Linear Acclelerator Center
Stanford, CA 94309

Represented by

THOMAS R. JUNK
Department of Physics, Stanford University
Stanford, CA 94305

ABSTRACT

We compare the ratio of the strong coupling α_s measured in $Z^0 \to b\bar{b}$ events to that measured in $Z^0 \to q\bar{q}$ (q=u,d,s,c) in the SLD experiment at SLAC. $Z^0 \to b\bar{b}$ events are identified with the aid of a precision silicon vertex detector by requiring that at least three charged tracks pass more than 3.0σ from the Z^0 decay vertex. This method has an estimated efficiency of 54% with a purity of 71%. Jets are identified and counted by clustering charged tracks according to the JADE algorithm. By comparing the 3-jet fraction in tagged events to that in all hadronic events, we extract a preliminary result of $\alpha_s(b)/\alpha_s(udsc) = 1.18 \pm 0.11(stat) \pm 0.05(sys)$.

1. Detector and Data Sample

The SLAC Large Detector[1] (SLD) analyzes the decays of Z^0 bosons produced in e^+e^- collisions at the SLC. The analysis presented here takes advantage of two tracking components, the Central Drift Chamber (CDC) and the Silicon Vertex Detector (VXD)[2]. The CDC consists of 80 layers of sense wires, 48 of which are stereo layers, in an axial magnetic field of 0.6 T. Tracks with polar angle $|cos(\theta)| < 0.71$ traverse all 80 layers, with good reconstruction extending to $|cos(\theta)| < 0.80$. The VXD consists of 480 silicon CCD chips with a total of 120 million 22x22 μm pixels. Charge division between neighboring pixels affords an intrinsic position resolution of 6 μm. The CCD chips are arranged in four layers, ranging from 29.5 mm to 41.5 mm in radius. Track acceptance for the VXD extends to $|cos(\theta)| < 0.75$. The VXD is described in more detail in these proceedings.[3,4]

Well-measured tracks are required to pass within a cylinder of radius 5 cm and half-length 10 cm along the beam axis, centered on the interaction point. In addition, they must be contained within $|cos(\theta)| < 0.8$ and have a momentum transverse to the beam axis of at least 150 MeV/c.

For a Z^0 decay to be selected for use in this analysis, it must have at least 5 well-measured tracks, at least 20% of the total center-of-mass energy must be visible in well-measured tracks, and $|cos(\theta_{thrust})| < 0.71$. These requirements ensure good containment in the barrel of the detector. Of 11659 Z^0 candidates, 5602 satisfy these criteria and are used in this analysis.

* Work Supported by the U.S. Department of Energy under Contract DE-AC03-76SF00515.

Presented at Particles & Fields 92: 7th Meeting of the Division of Particles and Fields of the APS (DPF 92), Batavia, Il, November 10-14, 1992

2. Tagging $Z^0 \to b\bar{b}$ Events

Events with B hadron decays are tagged using the x-y distance of closest approach (DOCA) of charged tracks to the interaction point (IP). In addition to the normal track selection cuts, further restrictions on tracks contributing to the tag are imposed to ensure good measurements of their DOCAs. Tracks must have at least 2 clusters of hits in different CCDs of the VXD, they must have at least 40 out of a possible 80 hits in the CDC, and they must have $\chi^2/DOF < 5.0$ in a track fit to the CDC hits. They must not pair with other charged tracks to form K^0, Λ^0, or photon conversion candidates. The error on the DOCA measurement arises from the intrinsic resolution of the VXD and multiple scattering terms which become dominant at low momentum. The average error on the DOCA of a track is given by $<\sigma_{DOCA}>= 13\mu m \oplus 70\mu m/(P\sqrt{sin^3(\theta)})$, where P is the track momentum in GeV. Tracks with $\sigma_{DOCA} > 250\mu m$ are not used in the tag.

The interaction point (IP) is found by combining tracks from several events and fitting for a common origin. The SLC IP measures 2 μm in x and y, and 650 μm in z. The location of the IP is stable within 20 μm over periods of more than 200 hours. As only the x-y position of the IP is necessary for this analysis, the errors in its measured location may be neglected.

For each event, tracks passing the above selection criteria are extrapolated past the IP and their DOCA to the IP is measured. A sign is applied to the DOCA by comparing the track to the nearest jet axis. Jets used for the purpose of signing the DOCA are found using the JADE algorithm[5] with $y_{cut} = 0.02$. If the x-y projection of a track intersects the projection of the jet axis on the opposite side of the IP in which the track travels, the DOCA is negative.

The normalized DOCA is formed by dividing the DOCA by its measurement error. To identify an event as a $Z^0 \to b\bar{b}$ event, at least N_{trk} charged tracks must have normalized DOCAs exceeding N_{sig}. Fig. 1 illustrates the estimated efficiency and purity of the b tag for various values of N_{trk} and N_{sig}, using JETSET 6.3 with the SLD heavy quark decay package,[7] along with full GEANT detector simulation and SLD event reconstruction. The values of $N_{trk} = 3$ and $N_{sig} = 3.0$ are used in this analysis. Using this identification procedure, we estimate an efficiency of $54.0\% \pm 1.6\%$ with a purity of $71.0\% \pm 2.5\%$.[3] Of the 5602 hadronic events used in this analysis, 919 are tagged as $Z^0 \to b\bar{b}$ decays.

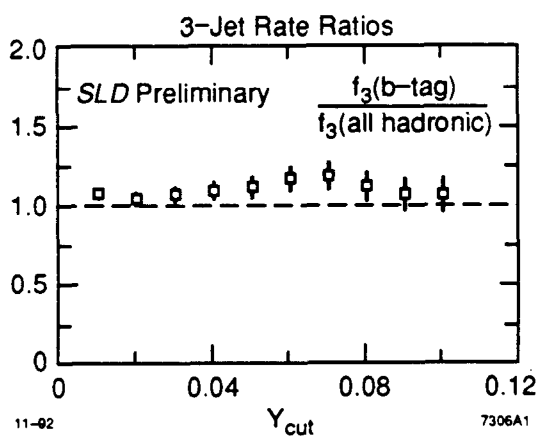
3. Measuring $\alpha_s(b)/\alpha_s(udsc)$

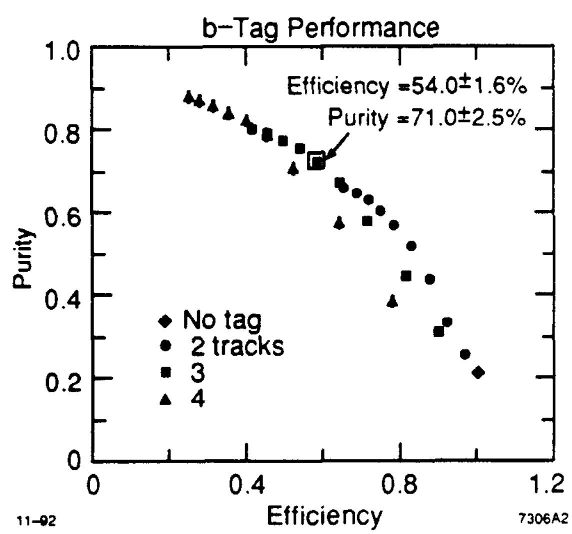
A jet rates analysis[6] was performed on the b tagged sample and on the hadronic dataset using the JADE algorithm. The ratio of the 3-jet rates in these samples, $R_{meas} = f_3(b{-}tag)/f_3(hadr)$, is shown as a function of y_{cut} in fig. 2. Because each event in the sample contributes to each point, the values of R_{meas} at different y_{cut} are correlated. To quote a result with proper errors, one point on fig. 2 is selected. We adopt the convention[8] of the L3 collaboration and quote our results at $y_{cut} = 0.05$, at which the measured ratio is $R_{meas} = 1.11 \pm 0.07(stat)$.

If the purity of the $Z^0 \to b\bar{b}$ tag is $\mathcal{P}$ and the $b\bar{b}$ fraction of the hadronic sample is R_b, then the ratio of the three-jet rate of b decays to that in udsc decays, $f_3(b)/f_3(udsc) = (R_{meas}(1-R_b)+\mathcal{P}-1)/(\mathcal{P}-R_bR_{meas})$. The weak decay of the B hadrons produces many tracks with large p_t and increases the expected 3-jet rate. A correction to the observed 3-jet rate ratio is estimated from Monte Carlo to be 0.99 ± 0.02. The correction to the 3-jet rates owing to detector acceptance cancels in the ratio R_{meas}. Another correction arises from the nonuniformity of the tag efficiency as a function of y_{cut} and amounts to 0.99 ± 0.04 at $y_{cut} = 0.05$. Bhabha and tau contamination contribute $< 1\%$ to the systematic error. The corrected 3-jet ratio, using the Standard Model value of $R_b = 22.1\%$, is $f_3(b)/f_3(udsc) = 1.16 \pm 0.11(stat) \pm .05(syst)$.

The QCD prediction for $f_3(y_{cut})$ has been calculated[9] up to second order in perturbation theory. For $y_{cut} = 0.05$ the second order corrections amount to 0.5% and are neglected here. With this approximation we write $\alpha_s(b)/\alpha_s(udsc) = f_3(b)/f_3(udsc)$. The high mass of the b quark reduces the available phase space for high momentum gluon emission, which amounts to a 2% decrease[10,11] in the expected 3-jet rate. After all corrections, the SLD preliminary measurement for the ratio of the strong couplings is

$$\alpha_s(b)/\alpha_s(udsc) = 1.18 \pm .11(stat) \pm .05(sys).$$





References

1. *SLD Design Report*, SLAC Pub. 273 (1984)
2. G.D. Agnew et. al, *Proceedings of the XXVI International Conference on High Energy Physics, Dallas* (1992).
3. SLD Collaboration, represented by D. Su, *Proceedings of the APS DPF Conference, Fermilab* (1992).
4. SLD Collaboration, represented by M. Strauss, *Proceedings of the APS DPF Conference, Fermilab* (1992).
5. JADE Collaboration, *Z. Phys.* **C33** (1986) p. 23.
6. SLD Collaboration, represented by J. Lauber, *Proceedings of the APS DPF Conference, Fermilab* (1992).
7. *Proceedings of the SLD Physics Week*, SLAC Pub. 354 (1989) p. 175-185.
8. L3 Collaboration, *Phys. Lett.* **B271** (1991) 461-467.
9. Kunszt and Nason, *Z Physics at LEP I*, Vol. 1, CERN-89-08 (1989) p. 373.
10. B.L. Ioffe, *Phys. Lett.* **B78** (1978) p. 277-280.
11. A. Ballestrero, E. Maina, and S. Moretti, DFTT 32/92 (1992).