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MEASUREMENTS OF GLUON SPIN-SENSITIVE QUANTITIES AT THE Z^0 RESONANCE*

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Abstract

We present preliminary measurements of scaled jet energies and the Ellis-Karliner angle in 3-jet hadronic events from the Z^0 decay. Good agreement is found between the data and the QCD prediction. A scalar gluon model is clearly excluded.

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1. Introduction

Distributions of the scaled jet energies and the Ellis-Karliner angle[1], θ_{EK}, in $Z^0 \longrightarrow q\bar{q}g$ events are sensitive to the spin of the gluon. Several groups[2,3] have used these distributions to determine the gluon spin and to test a scalar gluon model at energies around 30 GeV. We present these distributions at the Z^0 resonance, where the differences between the vector gluon (QCD) predictions and the scalar gluon predictions are larger. Similar analyses were done at OPAL[4] and L3[5].

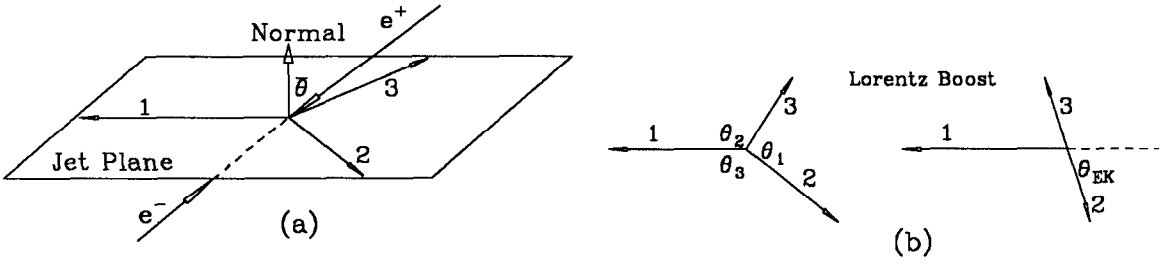

Fig 1. the 3-jet event plane (a), and the Ellis-Karliner Angle (b).

The $\mathcal{O}(\alpha_s)$ cross-section for $q\bar{q}g$ events in e^+e^- annihilation at the Z^0 resonance can be written, assuming massless partons, as[6,7]:

$$\frac{d^2\sigma^V(x_1,x_2)}{dx_1dx_2} \sim \frac{x_1^3+x_2^3+(2-x_1-x_2)^3}{(1-x_1)(1-x_2)(x_1+x_2-1)} \quad (1)$$

$$or \quad \frac{d^2\sigma^S(x_1,x_2)}{dx_1dx_2} \sim \frac{x_1^2(1-x_1)+x_2^2(1-x_2)+(2-x_1-x_2)^2(x_1+x_2-1)}{(1-x_1)(1-x_2)(x_1+x_2-1)} - \frac{10C_a^2}{C_v^2+C_a^2} \quad (2)$$

where $x_i = 2E_i/E_{cm}$, $x_1 > x_2 > x_3$, are the scaled parton energies (Fig. 1a), and C_v and C_a are the vector and axial-vector coupling constants. Eq. (1) is from the vector gluon (the standard QCD) theory, and Eq. (2) is from a scalar gluon model. For massless partons, one has:

$$x_i = \frac{sin\theta_i}{sin\theta_1+sin\theta_2+sin\theta_3} \quad (i=1,2,3) \quad (3)$$

$$cos\theta_{EK} = \frac{(x_2-x_3)}{x_1} \quad (4)$$

where the θ_i are the angles between the two jets opposite to jet i; and θ_{EK}, the Ellis-Karliner angle, is the angle between jets 1 and 2 in the rest frame of jets 2 and 3 (see Fig. 1b). The cross-section can also be written in terms of any single x_i and $cos\theta_{EK}$. Distributions of each individual variable, obtained by integration of the above cross-sections, are clearly different for the two gluon spins.

2. Data Selection

A total of 9,000 hadronic Z^0s measured by the SLD[8] experiment are used in this analysis. We use only the charged tracks measured in the central drift chamber[8].

Details of the track and event selection cuts are described elsewhere[9]. 3-jet events are selected at $y_{cut} = 0.02$ using the JADE jet-finding algorithm[10]. We require $|cos\bar{\theta}| > 0.704$ where $\bar{\theta}$ is the angle between the electron beam direction and the normal to the event plane (Fig. 1a). 1418 events survived these cuts. The background in the three-jet sample from non-hadronic Z^0 decays is negligible.

3. Results and Conclusion

The variables x_i and $cos\theta_{EK}$ are calculated using Eqs. (3) and (4) and the jet axes from the JADE jet-finding algorithm. Using only the angles reduces the effects of not detecting all the energy in each jet. Monte Carlo events are generated using the JETSET 6.3[11] and HERWIG 5.3[12] programs and passed through a detailed SLD detector simulation and the same selection criterion as applied to the real data. The Monte Carlo results and the data agree well within statistical errors. A bin-by-bin correction is applied using the JETSET 6.3 simulation to correct the data to

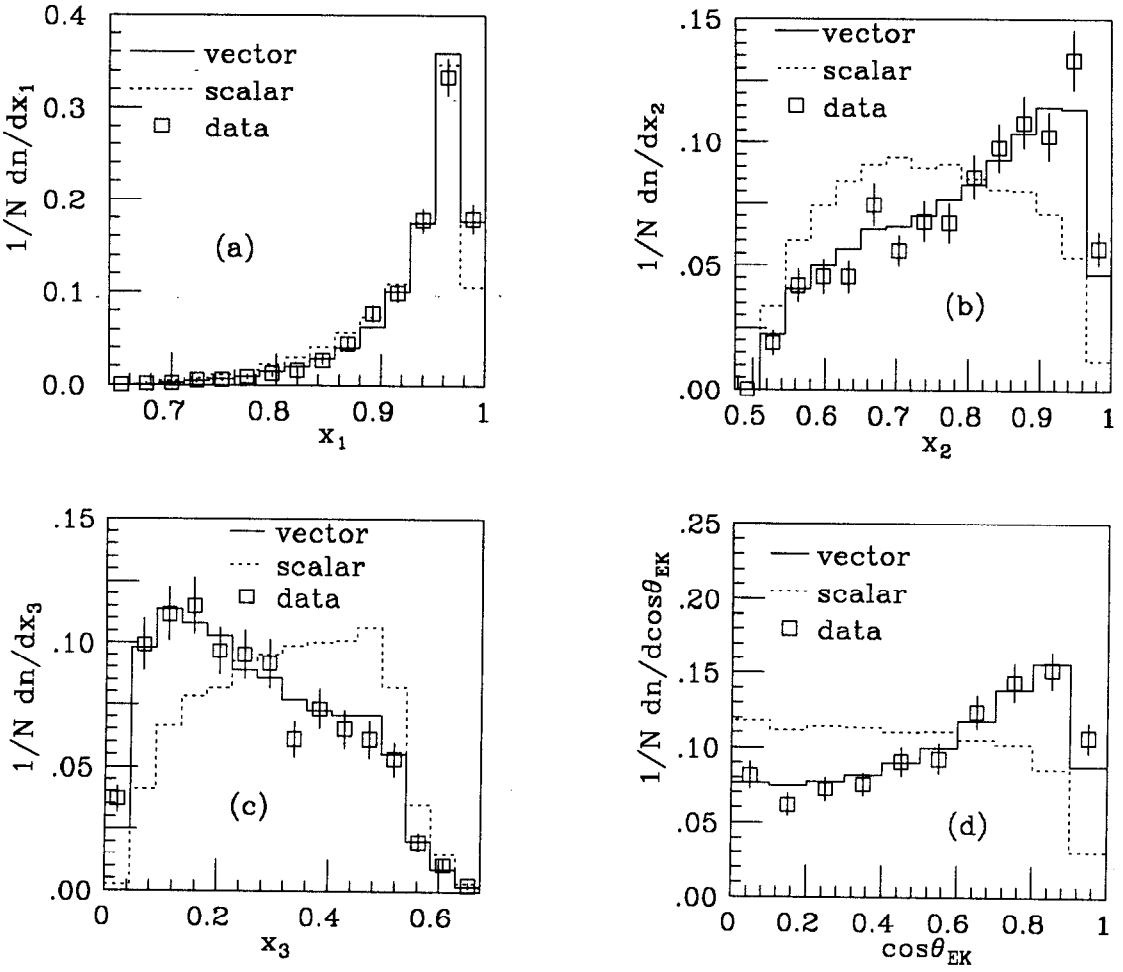

Fig. 2 comparison of the measured distributions with vector(QCD) and scalar gluon predictions at the parton level.

the parton level. Fig. 2 shows the corrected distributions of x_1, x_2, x_3 and $cos\theta_{EK}$, compared with leading order scalar and vector (QCD) gluon calculations. Both equations 1 and 2 are implemented in JETSET 7.3[11] program, by which all the theoretical distributions are generated. The vector gluon calculation agrees with the data. The scalar gluon model does not agree with the data. The following table shows the χ^2 per degree of freedom between the data and calculations.

χ^2/df between data and vector/scalar gluon predictions.

	x_1	x_2	x_3	$cos\theta_{EK}$
Vector Gluon	0.69	1.17	1.01	0.99
Scalar Gluon	7.33	17.1	16.5	22.9

In conclusion, a scalar gluon model is convincingly excluded by the data, which is in good agreement with the predictions of QCD. Similar results were obtained at OPAL[4] and L3[5].

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