# MEASUREMENT OF THE TAU POLARIZATION AND POLARIZATION ASYMMETRY

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With a data sample of 58,000 $Z \to \tau^+\tau^-(\gamma)$ events collected in the L3 detector during 1994, we have performed a preliminary measurement of the polarization of $\tau$-leptons. Combining this measurement with our previous L3 measurement from 1990-1993 data, we obtain $\mathcal{A}_\tau = 0.152 \pm 0.010 \pm 0.009$, and $\mathcal{A}_e = 0.156 \pm 0.016 \pm 0.005$, consistent with the hypothesis of $e - \tau$ universality. Assuming universality of the $e - \tau$ neutral current we determine the effective electroweak mixing angle to be $\sin^2\theta_w^{eff} = 0.2308 \pm 0.0013$.

## 1. Introduction

In the reaction $e^+e^- \to Z^0 \to \tau^+\tau^-$ with unpolarized beams at $\sqrt{s} \approx M_Z$ the final state $\tau$ leptons are polarized. This polarization is due to the different couplings of left and right handed leptons to the $Z^0$ boson. The $\tau$ polarization, $\mathcal{P}_\tau(\cos\theta)$, is defined as the asymmetry in the production cross section of $\tau^-$ leptons with positive helicity and negative helicity, where $\theta$ is the angle between the $e^-$ beam and $\tau^-$ flight direction. In the improved Born approximation, $\mathcal{P}_\tau(\cos\theta)$ at the $Z^0$ pole is given by [1]:

$$\mathcal{P}_\tau(\cos\theta) = -\frac{\mathcal{A}_\tau + 2\mathcal{A}_e\cos\theta/(1+\cos^2\theta)}{1 + 2\mathcal{A}_\tau\mathcal{A}_e\cos\theta/(1+\cos^2\theta)}. \qquad (1)$$

The quantities $\mathcal{A}_\ell$ ($\ell = e, \tau$) are defined as: $\mathcal{A}_\ell \equiv 2{g_V}^\ell {g_A}^\ell/(g_V^{\ell 2} + g_A^{\ell 2})$, where ${g_V}^\ell$ and ${g_A}^\ell$ denote the vector and axial-vector coupling constants. In the Standard Model[2] the lepton couplings are equal and $\mathcal{A}_\ell \simeq 2(1-4\sin^2\theta_w^{eff})$.

In this analysis it is assumed that the decays of the $\tau$ are described by a pure V$-$A weak charged current.

## 2. Event Selection

The following $\tau$ decay channels are used in the analysis: $\tau^- \to e^-\overline{\nu}_e\nu_\tau$, $\tau^- \to \mu^-\overline{\nu}_\mu\nu_\tau$, $\tau^- \to \pi^-(K^-)\nu_\tau$, and $\tau^- \to \rho^-(K^{*-})\nu_\tau$. First, a sample of low multiplicity, back-to-back events is preselected, which consists mainly of leptons from Z decays. Classification of the $\tau$ decay modes is done independently in two hemispheres separated by a plane perpendicular to the thrust axis of the event. Particle identification in each hemisphere is based upon the topological properties of the energy deposition in the electromagnetic and hadron calorimeters with respect to the trajectory of the charged track[a]. Finally, requirements are placed on the hemisphere opposite to the $\tau$ decay candidate to suppress the non-$\tau$ background. This technique is found to be relatively independent of the energy of the $\tau$-decay products, so polarization bias is minimal [4].

## 3. Fitting Procedure

$\mathcal{P}_\tau(\cos\theta)$ is obtained by measuring the polarization in seven regions of $\cos\theta$ separately for every decay channel. The data is fitted as the linear combination of the positive, the negative helicity Monte Carlo and the non-$\tau$ background [4]. In case of $\tau^- \to \mathrm{e}^-\overline{\nu}_\mathrm{e}\nu_\tau$, $\tau^- \to \mu^-\overline{\nu}_\mu\nu_\tau$, $\tau^- \to \pi^-\nu_\tau$, the energy spectra of the decay particles are used as the fitting variable. The decay $\tau^- \to \rho^-\nu_\tau$ is analyzed using angular distrubutions of $\tau^- \to \rho^-\nu_\tau$ and $\rho^- \to \pi^-\pi^0$. $\mathcal{A}_\tau$ and $\mathcal{A}_\mathrm{e}$ are determined by a fit of Eqn. 1 to the $\mathcal{P}_\tau(\cos\theta)$ dependence. Since Eqn. 1 neglects radiative corrections, contributions from $\gamma$-exchange and $\gamma\mathrm{Z}^0$-interference, the measurements of $\mathcal{P}_\tau(\cos\theta)$ must be corrected. The analytical program ZFITTER [5] was used to calculate these corrections.

Finally the measurements of $\mathcal{P}_\tau(\cos\theta)$ for each individual $\tau$ decay mode are combined bin-by-bin in $\cos\theta$, taking into account the statistical correlation occurring when both $\tau$ decays are selected. Our estimate of the systematic errors is consistent with those obtained from the final analysis of 1993 data [4]. We obtained the preliminary measurement of $\mathcal{P}_\tau$ for 1994, using the barrel region of the L3 detector only ($|\cos\theta_{thrust}| < 0.7$).

By fitting Eqn. 1 to the corrected $\mathcal{P}_\tau$ values, we obtain $\mathcal{A}_\tau = 0.156 \pm 0.017 \pm 0.009$ and $\mathcal{A}_\mathrm{e} = 0.155 \pm 0.025 \pm 0.005$. Fitting Eqn. 1 assuming $\mathcal{A}_\tau = \mathcal{A}_\mathrm{e}$, we get $\mathcal{A}_{\mathrm{e}-\tau} = 0.156 \pm 0.014 \pm 0.005$.

The same set of data is analyzed with an independent method based on the analytical description of the energy spectra of $\tau$ decay particles [6]. The result from two methods are in agreement. Also, 38,000 $\mathrm{Z} \to \tau^+\tau^-(\gamma)$ events collected in 1993 are used for an additional polarization measurement using the acollinearity [7] in the pion decay mode [8].

## 4. Conclusion

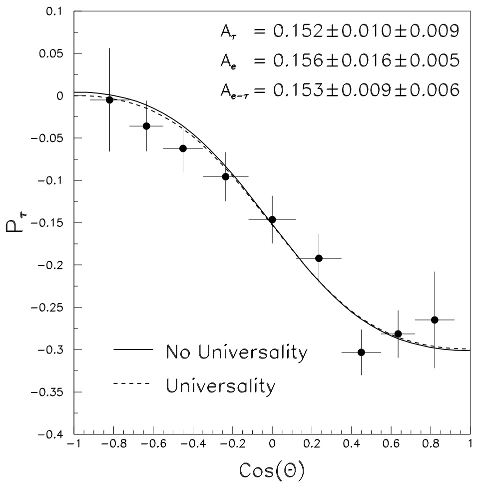
Combining the above measurement with our previous measurement from 1990-1993 data [4], we obtain $\mathcal{A}_\tau = 0.152 \pm 0.010 \pm 0.009$, and $\mathcal{A}_\mathrm{e} = 0.156 \pm$

[a] A detailed description of the L3 detector can be found in reference [3]

$0.016 \pm 0.005$. The ratios of vector to axial-vector weak neutral couplings for electrons and taus are deduced as $g_V^e/g_A^e = 0.0787 \pm 0.0078 \pm 0.0025$ and $g_V^\tau/g_A^\tau = 0.0763 \pm 0.0051 \pm 0.0044$, respectively.

Assuming lepton universality we derive the ratio of vector to axial-vector weak neutral couplings for leptons and the effective electroweak mixing angle:

$$
\begin{aligned}
g_V/g_A &= 0.0770 \pm 0.0043 \\
&\quad \pm 0.0031 \\
\sin^2\theta_w^{\rm eff} &= 0.2308 \pm 0.0013.
\end{aligned}
$$





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