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STATUS OF A$_{LR}$ MEASUREMENT AT SLD*

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ABSTRACT

The SLD Collaboration is making a precision measurement of the left-right asymmetry (A_{LR}) at the SLAC Linear Collider, exploiting the significantly improved luminosity and the high electron-beam polarization of over 60%. General features of the polarized source and polarimetry are described. The experimental method is briefly presented, together with the preliminary values of the raw asymmetry, which should lead to a precision in the measurement of $\sin^2\theta_W^{eff}$ of $\pm 0.0008 \pm 0.0005$. The collaboration is preparing a proposal for an extended run for one million Z^0s with improved polarimetry to reach an ultimate level of $\delta \sin^2\theta_W^{eff} = \pm 0.00025$.

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Overview

The Left-Right Asymmetry

The left-right asymmetry is a simple function of the production cross section of the Z^0 by a polarized electron beam:

$$A_{LR} = \frac{\sigma_L - \sigma_R}{\sigma_L + \sigma_R}, \qquad (1)$$

where σ_L and σ_R are the e^+e^- production cross sections for Z bosons with left-handed and right-handed electrons, respectively. This is the most sensitive of the electroweak asymmetries to the effective electroweak mixing parameter $\sin^2\theta_W^{eff}$ and does not depend on the final state couplings. The experiment measures A_{LR} by simply counting the number of hadronic and tau decays for the two polarization states to form the measured asymmetry for the known polarization of the beam:

$$A_{LR} = \frac{A_{meas}}{P_e} = \frac{1}{P_e}\left\{\frac{N_L - N_R}{N_L + N_R}\right\}. \qquad (2)$$

Operation of the SLC

Over the past three years the SLC luminosity has dramatically increased, delivering for the SLD pilot run in 1991 about 300 Z^0s, increasing to 11,000 in the 1992 run. For the 1993 run a new machine configuration that delivered 'flat beams' raised the delivered luminosity to over 50,000. This very gratifying progression is shown in Fig. 1.

The polarized electron source, which is essential to the measurement of the left-right asymmetry, was installed in 1992, giving an average longitudinal polarization of about 22%. A new 'strained-lattice' cathode was installed for the 1993 run boosting the polarization value at the interaction point to about 62%.

These two developments, as well as other advances in instrumentation and control that have made possible a truly competitive physics program, are described in recent publications from the 1993 Particle Accelerator Conference.[1]

Experimental Procedure

The experimental procedure outlined briefly here is discussed in detail in the collaboration's first publication of the asymmetry based on the small sample of lower polarization data taken in 1992 [2].

Measured Asymmetry

The events used in the analysis are based on triggers in the SLD liquid argon calorimeter, covering 98% of the solid angle and segmented radially into two electromagnetic and two hadronic sections and transversely into projective towers, including 17,000 in the first electromagnetic section. Cuts based on energy and energy balance have an efficiency of over 90% with an estimated background contamination of less than 0.5%. The measured asymmetry, which is simply the difference in the number of these triggers for the two polarization states divided by their sum, is shown in Fig. 2.

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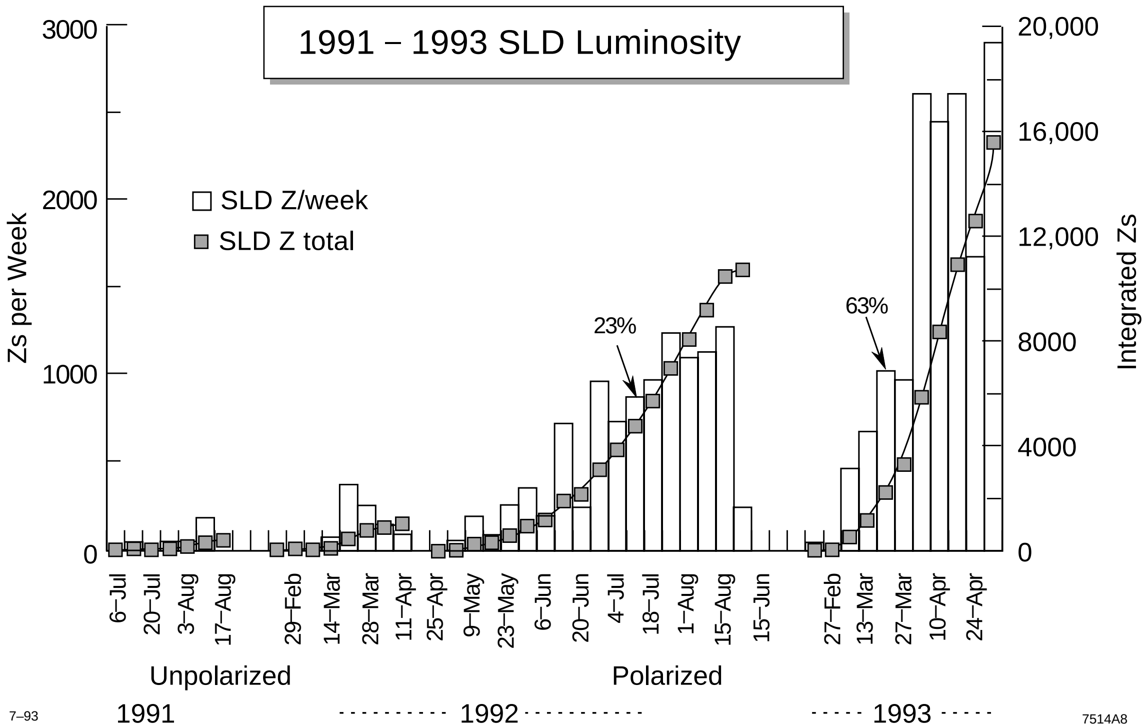

Figure 1: The plot shows both the instantaneous luminosity at SLC in Z^0s per week and the integrated luminosity logged by the SLD it its three runs since 1991. As much luminosity was delivered per day in the 1993 as the entire 1991 run.

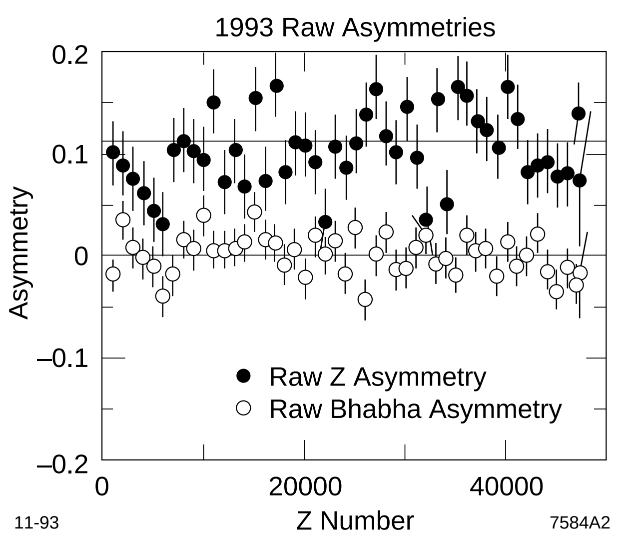

Figure 2: Plot of the measured asymmetry in Z^0 production in one-thousand-event bins for the current SLD run. The asymmetry is large, at about 10%, and the statistical error for data shown is about ±0.59%. Also plotted is the asymmetry in the Bhabhas detected in the luminosity monitor, which should be negligible.

The dominant corrections in the measured asymmetry (expressed as $\delta A_{LR}/A_{LR}$) are from the background fraction (0.6%) and the difference in measured luminosity for the two states (0.2%). The error in the first factor is about 0.3% and negligible in the second. Statistics, then, account for most of the uncertainty in the measured asymmetry at about 4%, relative.

Polarization

The beam electrons Compton scatter on a circularly polarized, laser-produced photon beam downstream of the interaction point and are detected in multichannel Čerenkov and proportional tube chambers. The large asymmetry in counting rates between parallel and anti-parallel combinations of electron and photon helicities is proportional to the product of electron polarization and the separately measured laser beam polarization. The series of three-minute measurements for the past two runs is shown in Fig. 3.

The error in the polarization is dominated by the measurement of the laser polarization, currently estimated at less than 3%, and by detector linearity

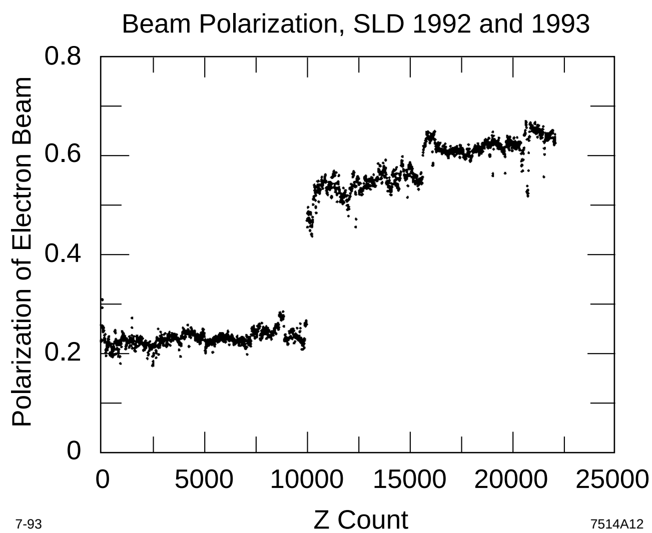

Figure 3: The polarization of the SLC electron beam for the 1992 and 1993 runs shows the increase due to the new 'strained lattice' cathode.

effects of about 0.7%. Since the polarimeter averages over all electrons in the bunch and the luminosity is weighted by the small energy variation in the beam, there is a potential for a small correction from the dependence of longitudinal polarization at the end of the SLC arc on momentum. This chromatic correction is currently estimated at about 1 to 3%.

Status and Plans

The current run finishes in August 1993 and includes time for study of polarization transport; comparison of polarimeters at the beginning and end of the arc; and testing Møller polarimetry near the Compton polarimeter as a cross check and a potential measure of transverse components. The expected result after final analysis is a measure of the mixing angle to a precision of $\delta \sin^2 \theta_W^{meas} = \pm 0.0009(stat) \pm 0.0004(sys)$.

Next year's run will have the benefit of higher luminosity from an improvement in the SLC final focus to reduce further the chromatic aberrations that now limit the smaller spot available using flat beams. New vacuum chambers, which will be installed in the damping ring to reduce microwave instabilities and permit larger currents, will also raise luminosity. Finally, thinner strained-lattice cathodes for the electron gun should give a somewhat higher beam polarization. The combination should give a net improvement by a factor of two in the precision of the mixing angle.

Longer term, the collaboration is preparing a proposal to collect one million Z^0s, together with improved polarimetry that reduces the polarization error to 1% or better. This leads to an ultimate goal for the mixing angle error of ± 0.00025.

References

[1] M. Ross, Recent SLC Developments, *SLAC–PUB–6103*, April 1993, and references therein.

[2] The SLD Collaboration, First Measurement of the Left-Right Cross Section Asymmetry in Z Boson Production by e^+e^- Collisions, *Physical Review Letters* **70**, 2515 (1993).