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ASYMMETRY VERSUS MASS FOR A 4 TEV Z'

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ABSTRACT

The measurement of leptonic asymmetry versus mass of the l^+l^- pair for a new 4 TeV neutral gauge boson, Z', by the SDC detector is discussed.

The search for new, heavy vector bosons similar to the W and Z (generically called W' and Z') is an important physics topic at the SSC. The detection of a Z' in the SDC detector has been discussed in Ref. 1. The width of a Z' is expected to be 1-3% of its mass, and its decay into l^+l^- pairs should have virtually no background. The Z' couplings to quarks and leptons are model dependent. The purpose of this note is to discuss the measurement of the forward-backward leptonic asymmetry which can yield detailed information on the Z' couplings.

The leptonic asymmetry arises because the Z' is expected to be produced with a preferred helicity and the subsequent parity violating decay will attempt to conserve this helicity. The size of this effect increases with increasing magnitude of rapidity of

the Z'. The asymmetry, A_{fb}, is defined as:

$$A_{fb} = \frac{\sigma(\theta < \pi/2) - \sigma(\theta > \pi/2)}{\sigma(\theta < \pi/2) + \sigma(\theta > \pi/2)} \tag{1}$$

where θ is the angle between the CM momentum of the Z' and the momentum of the negatively charged lepton in the Z' rest frame. A_{fb} is expected to be an even function of the rapidity of the Z'.

We have studied the dependence of A_{fb} on the dilepton mass for a 4 TeV Z' using the Lund Monte Carlo program, Pythia (version 5.4). Three models for the couplings were considered:

a) Standard Model couplings

b) Left-Right symmetric model (LR) similar to that discussed in Ref. 2

c) Alternative Left-Right symmetric model (ALR) of Ref. 3.

The width of the Z' in the three models is shown in Table 1, together with the time it would take to produce 1000 events in the interval $M(Z') \pm \Gamma(Z')$. The time is shown in SSC years (an integrated luminosity of $10^{40}/cm^2$ per year). The matrix elements used by PYTHIA include the full Z, Z', γ^* structure with interference. We have used a top quark mass 150 GeV, and a K-factor 1.3 in our calculations.

Fig. 1 shows the generated invariant mass distribution of the l^+l^- pair in the range 2.0-6.0 TeV for a 4 TeV Z' with standard model couplings. The normalization is for 1000 events in the interval $M(Z') \pm \Gamma(Z')$, i.e. for 8.5 SSC years. Fig. 2 shows the same distribution for e^+e^- and $\mu^+\mu^-$ pairs as seen in the SDC detector. The detector parameters are taken from Ref. 4. For example, $\Delta E/E = 0.010$ for a 2 TeV transverse electron and $\Delta P_t/P_t = 0.18$ for a 2 TeV transverse muon. The acceptance for $|Y| < 2.5$ is 89%. The efficiency for detecting lepton pairs was taken to be 81%.

The asymmetry, A_{fb}, depends on the rapidity of the Z' and on the dilepton mass. A_{fb} is typically quite small for $\mid Y \mid < 0.3$, and we have therefore restricted ourselves to the region $\mid Y \mid > 0.3$. This is essentially equivalent to a cut on longitudinal momentum, $P_L > 1000$ GeV.

Fig. 3 shows A_{fb} versus dilepton mass for the generated events, with standard model couplings for the Z'. Interference effects between the Z' and Z/γ^* produce a very interesting structure for the asymmetry, and account for the large values of A_{fb} off the resonance peak. Figs. 4 and 5 show the same asymmetry as observed in the SDC detector for the e^+e^- and $\mu^+\mu^-$ final states, respectively. The errors are for 1000 events in the peak, i.e. for 8.5 SSC years. The underlying structure is (marginally) discernible in the electron channel, but is largely washed out in the muon channel due to resolution effects. Figs. 6-9 show the generated asymmetry and the observed asymmetry in the electron channel for the LR (Figs. 6, 7) and the ALR (Figs. 8, 9) models. The errors for observed events correspond to 8.5 SSC years, for ease of comparison with earlier figures. Again, it will be difficult to deduce the underlying structure, even though the two models can be distinguished from each other by the sign of the asymmetry at the resonance peak.

In the future, we plan to study off peak asymmetries associated with a lighter Z'. The higher cross-section should make it easier to discern the nature of a lighter Z'.

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FIGURE CAPTIONS

Figure 1. Invariant mass distribution of the l^+l^- pair for a 4 TeV Z' with standard model couplings. The normalization is such that there are 1000 events in the interval $M(Z') \pm \Gamma(Z')$, which corresponds to 8.5 SSC years.

Figure 2. Invariant mass distributions of the e^+e^- (solid histogram) and $\mu^+\mu^-$ (dashed histogram) pairs for a 4 TeV Z' with standard model couplings as detected by the SDC detector. The normalization and the errors are for 8.5 SSC years.

Figure 3. Asymmetry, A_{fb}, versus dilepton mass for a 4 TeV Z' with standard model couplings.

Figure 4. A_{fb} versus e^+e^- mass for a 4 TeV Z' with standard model couplings as detected in the SDC detector. The errors are for 8.5 SSC years.

Figure 5. Same as Fig. 4, but for $\mu^+\mu^-$ final state.

Figure 6. A_{fb} versus dilepton mass for a 4 TeV Z' with LR couplings.

Figure 7. Same as Fig. 4, but with LR couplings.

Figure 8. A_{fb} versus dilepton mass for a 4 TeV Z' with ALR couplings.

Figure 9. Same as Fig. 4, but with ALR couplings.

figure 1

Z', Z, γ* → l+ l- standard model couplings

MASS Z' = 4 TeV events in 8.5 SSC years

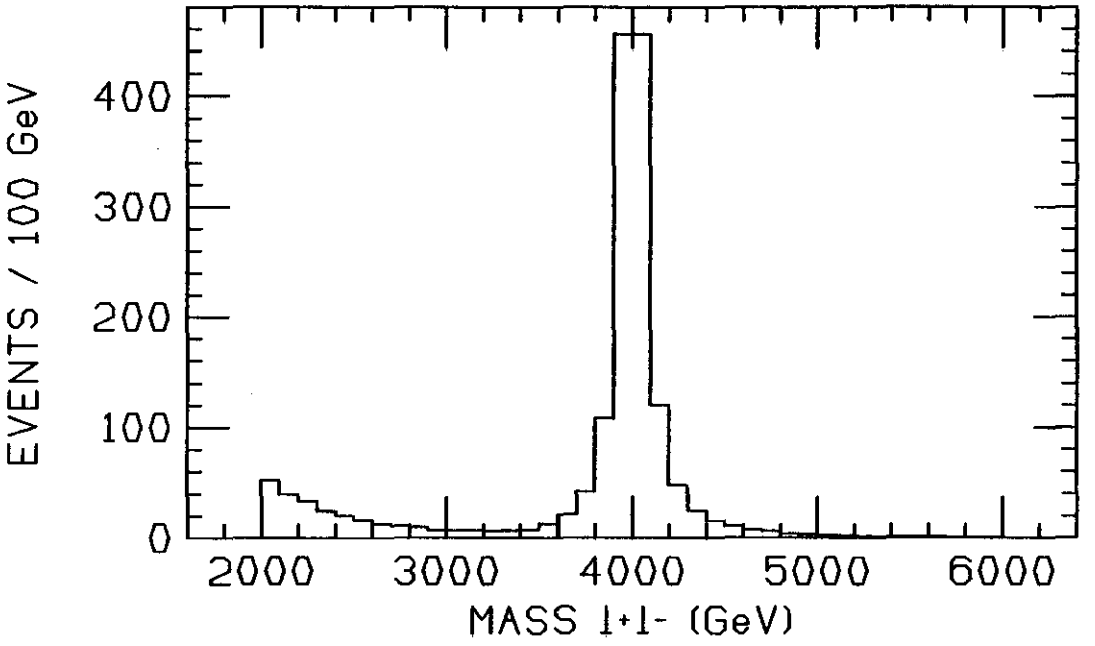

figure 2

Z', Z, γ* → e+e- solid, μ+μ- dashed standard model couplings

MASS Z' = 4 TeV events detected by SDC in 8.5 SSC years

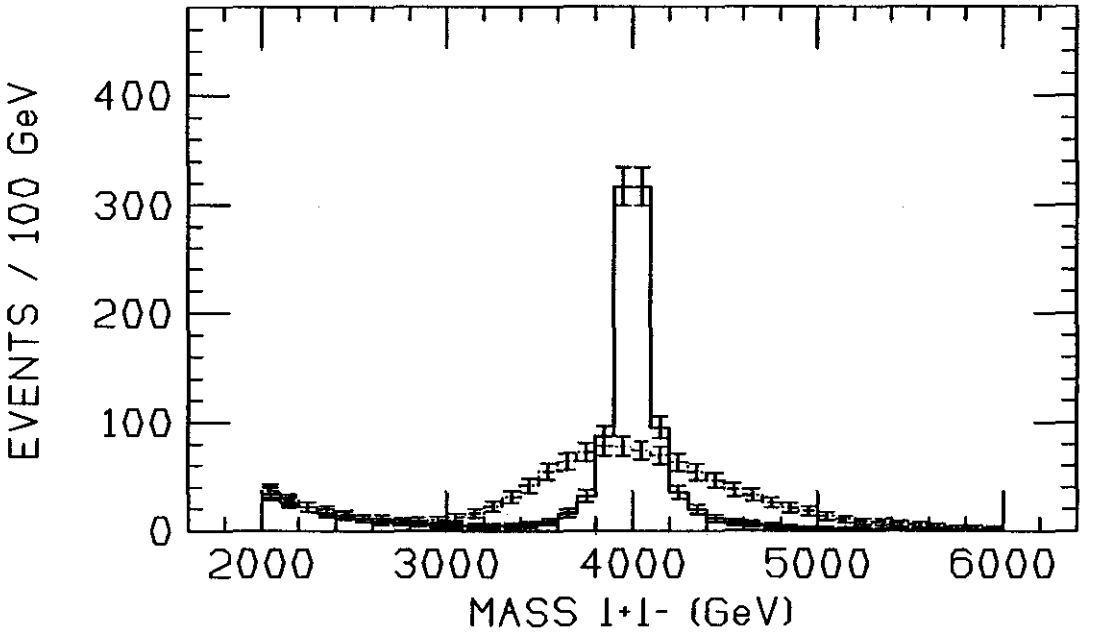

Table 1

Model	Γ (GeV)	SSC Years for 1000 Events in $M(Z') \pm \Gamma(Z')$
Standard Model	127	8.5
LR	48.6	23.8
ALR	34.0	11.2

Figure 3

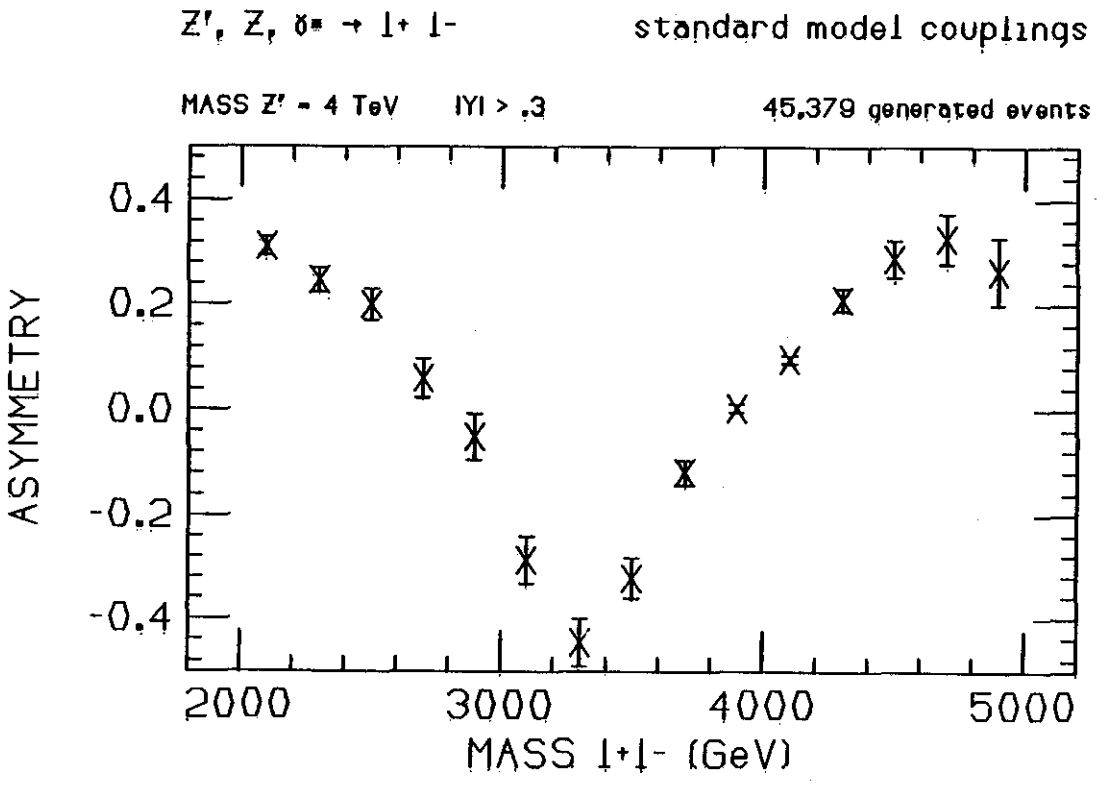

Figure 4

$Z', Z, \gamma^* \rightarrow e^+ e^-$ standard model couplings

MASS Z' = 4 TeV |Y| > .3 events detected by SDC in 8.5 SSC years

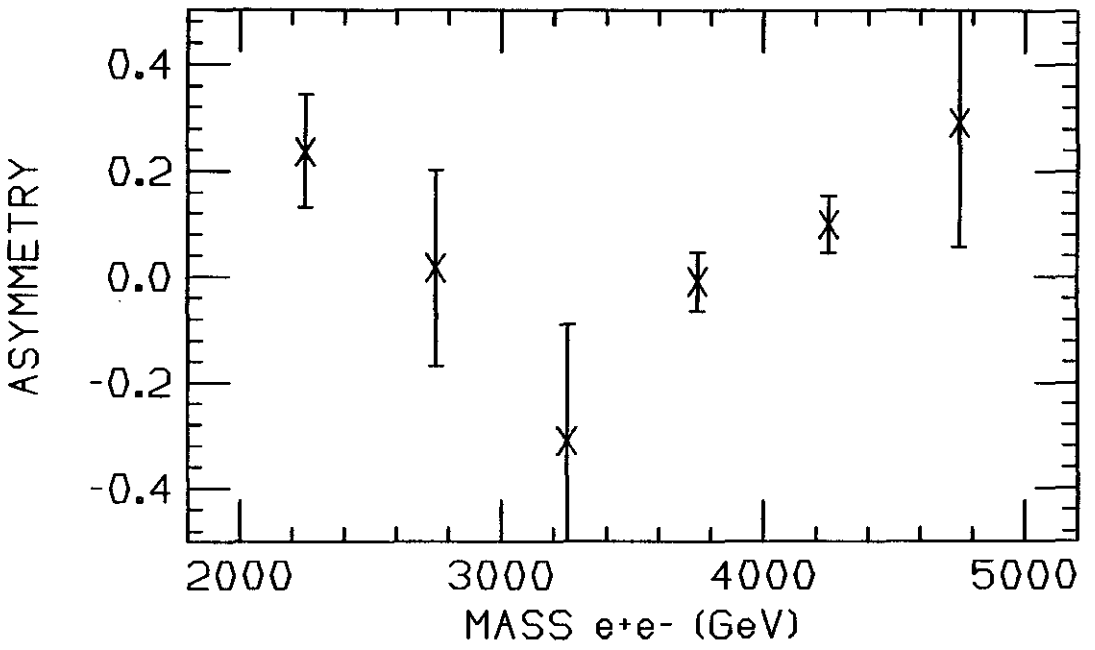

Figure 5

$Z', Z, \gamma^* \rightarrow \mu^+ \mu^-$ standard model couplings

MASS Z' = 4 TeV |Y| > .3 events detected by SDC in 8.5 SSC years

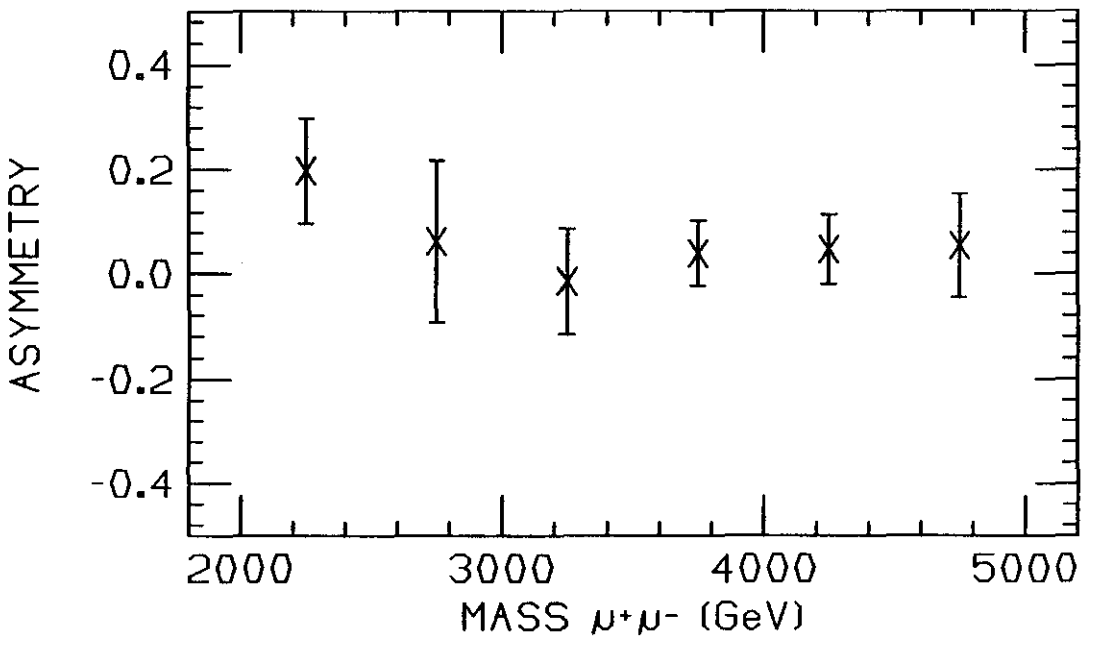

Figure 6

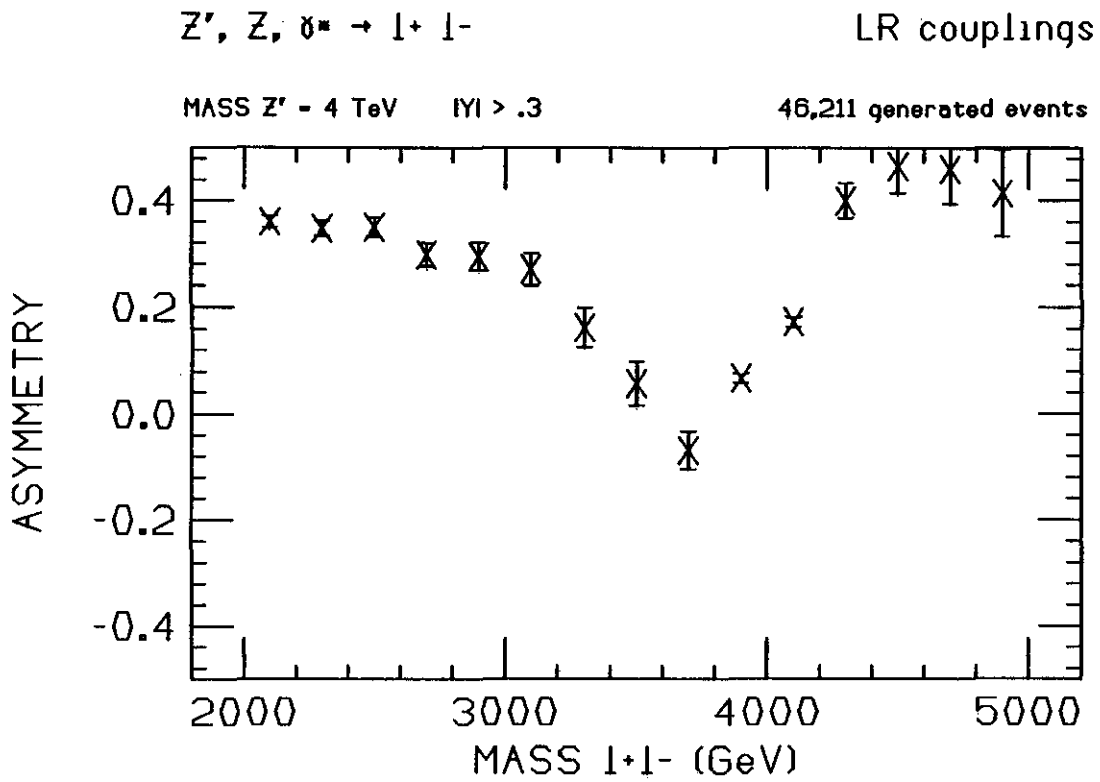

Figure 7

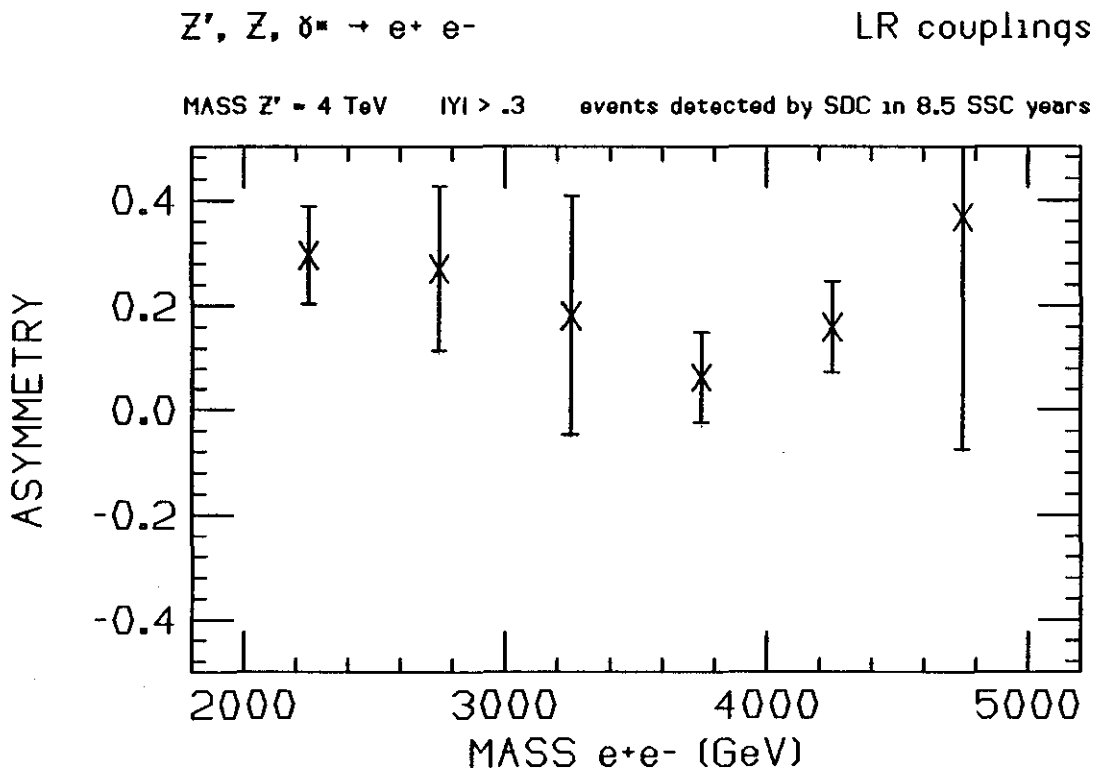

Figure 8

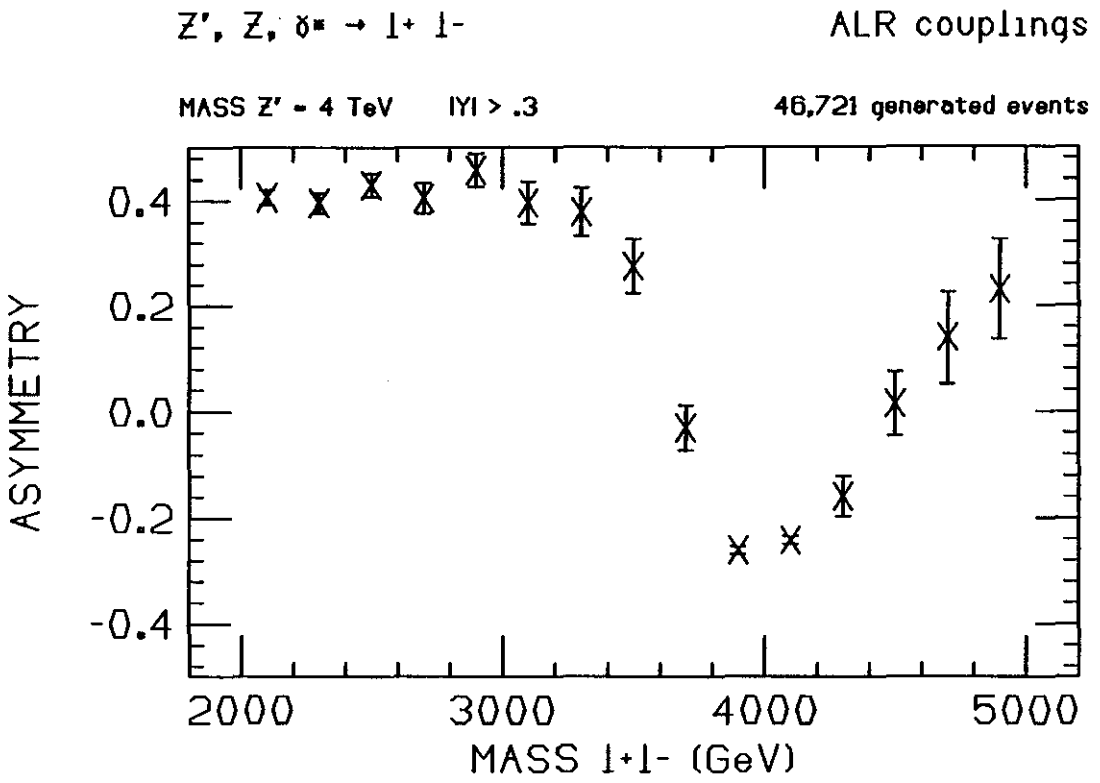
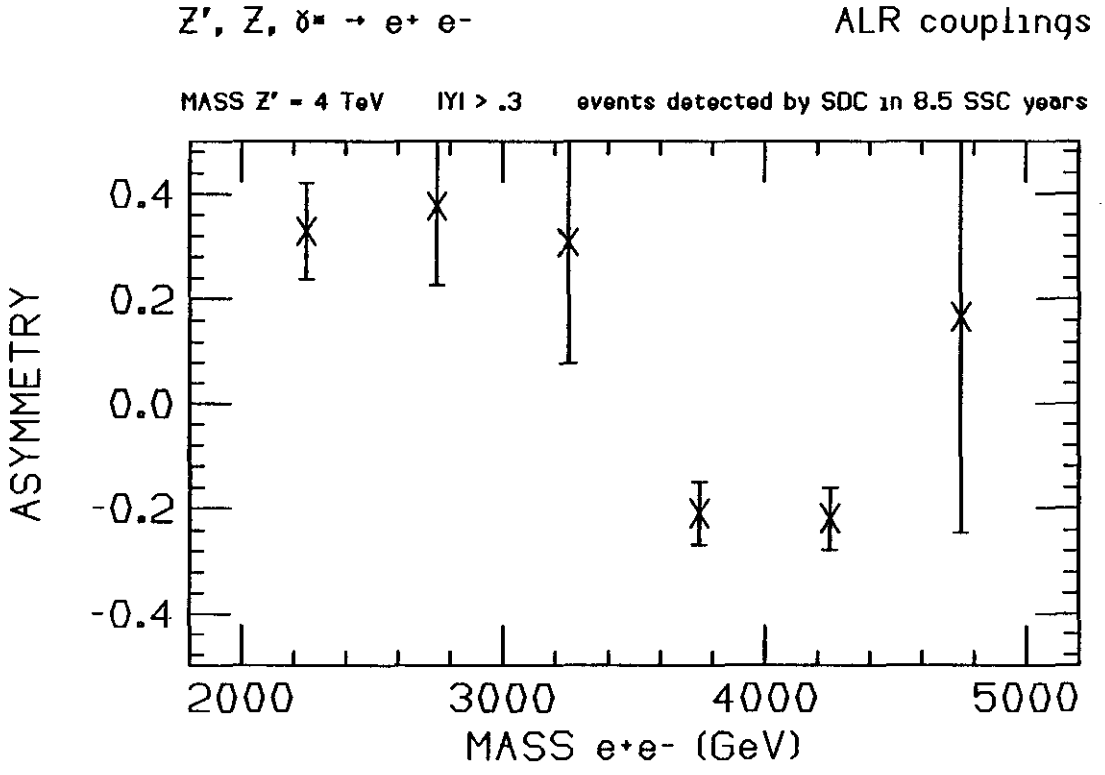
Figure 9