Search for exotic physics at LEP

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SEARCH FOR EXOCTIC PHYSICS AT LEP

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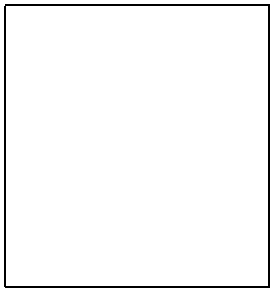

Several extensions of the Standard Model were probed with LEP data. Since no new physics was discovered, limits could be derived on the existence of new particles, such as additional leptons and gauge bosons, excited leptons and leptoquark, techni-particles and on the scale of new physiscs in scenarii with extra compactified dimensions, contact interactions. A selection of results is presented here. All limits are at 95% CL and are preliminary.

1 Introduction

Several extensions of the Standard Model were suggested to answer the questions left opened as the number of families, the masses. These models can be partly probed at LEP, the Large Electron Positron collider at CERN. In the years from 1995 to 2000, LEP delivered an integrated luminosity of 700 pb^{-1} per experiment at centre of mass energies ranging between 130 to 209 GeV. Therefore, the sensitivity for pair produced new particles reaches masses of 104 GeV and extends to 209 GeV for single production at the expense of a dependance with the coupling. Several models can be also constrained indirectly beyond the kinematical limit by looking at deviations from Standard Model expectations of cross-sections, asymmetries and branching ratios. The sensitivity is determined by the experimental precision of the LEP combined measurement (e.g 1% for $e^+e^- \rightarrow q\bar{q}$) and the theoretical error, which was reduced to 1/3 of the LEP combined experimental error for most channels [1].

2 New families of leptons or quarks

New families of leptons, with sequential, vector or mirror quantum numbers were looked for by the L3 collaboration. All limits are at or close to the kinematical limit of 104 GeV [2]. Delphi has searched for an extra heavy quark; a limit on the production cross-section times branching ratio obtained $\sigma(e^+e^- \rightarrow \bar{b'}b')Br(b' \rightarrow Z)^2 < 0.21pb$ for $M_{b'} = 100$ GeV [3].

3 Z'

Additional heavy gauge bosons are predicted in many extension groups : E6(χ, ψ, η), L-R, extra U(1). The LEP combined hadronic and leptonic cross-sections and asymmetries were used to fit indirectly the existence of an additional Z' [4]. Lower limits on the Z' mass are summarised in table .

Table 1: 95% confidence level lower limits on the Z' mass in the χ, ψ, η, L-R and SSM model.

Model	χ	ψ	η	L-R	SSM
GeV	673	478	434	804	1797

4 Excited leptons

The existence of several families may hint to compositeness. Excited leptons were sought for, either directly in pair and single production or indirectly by the exchange of an excited electron in the t-channel in the process $e^+e^- \to \gamma\gamma$. Limits using the combined measurement are shown in the figure 1[5].

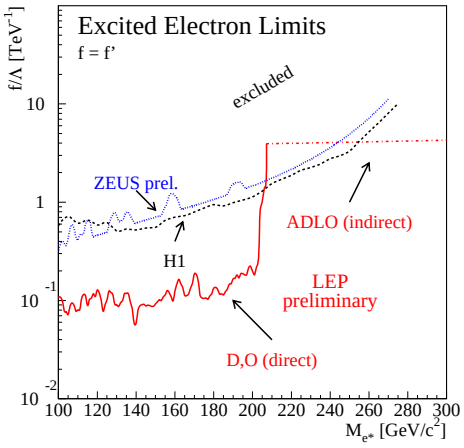

Figure 1: Limits on the mass vs coupling for the excited electron using combined direct and indirect search.

5 Leptoquarks

Leptoquarks would mediate quark-lepton transitions. Within the effective model [6], 14 types are identified, distinguishing coupling to exclusively left or right leptons. At LEP, they could be pair or singely produced or be exchanged in the t/u-channel in $e^+e^- \to q\bar{q}$ with a coupling λ_{lq} depending on the quark flavor in the final state. Lower limits on the mass are traditionally given for a coupling equal to $\sqrt{4\pi\alpha}(\approx 0.3)$. Table 2 presents limits on the mass of leptoquarks coupling to u or d, using the LEP combined hadronic cross-sections, whereas using the LEP combined R_b and A^b_{FB} measurements, the exclusion plots in the mass versus the coupling λ_{13} can be extracted. Some examples are given in the figure 2.

Table 2: 95% CL lower limits on the LQ mass (GeV) assuming a coupling $\lambda(L,R) = \sqrt{4\pi\alpha}$. A - indicates that no limit could be set.

$S_0(L)$	$S_0(R)$	$\tilde{S}_0(R)$	$S_1(L)$	$S_{1/2}(L)$	$S_{1/2}(R)$	$\tilde{S}_{1/2}(L)$
655	520	202	361	178	232	-
$V_0(L)$	$V_0(R)$	$\tilde{V}_0(R)$	$V_1(L)$	$V_{1/2}(L)$	$V_{1/2}(R)$	$\tilde{V}_{1/2}(R)$
917	165	489	659	303	227	176

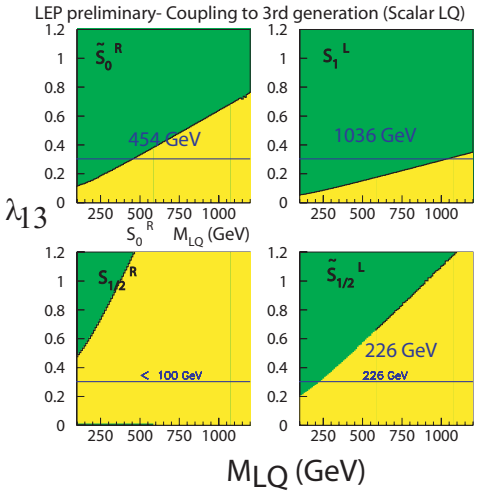

Figure 2: LEP preliminary exclusion plots for scalar LQ coupling to the 3rd generation of quarks.

6 Technicolor

Technicolor models provide an alternative[7] to the Electroweak Symmetry Breaking scenario. Using both indirect constraints from the hadronic and WW cross-sections, and search for a direct production of technipions, limits independent of the model parameters were set by The DELPHI Collaboration on the mass of the Technipion at 79.8 GeV and on the Technirho at 206.7 GeV [8].

7 Single Top

The single top production occurs in the SM model via loop diagrams at a non-measurable level but, because of its large mass, the Electro-Weak Symmetry Breaking scenario could be revealed in the top properties, and the single top production enhanced. As shown in figure 3, LEP [9] improved the exclusion plot in the variables κ_γ and κ_Z parametrising the anomalous transitions $Z/\gamma \rightarrow tq$.

8 Extra-dimensions

Recently, theories of quantum gravity in extra spatial dimensions have suggested a way to go around the hierarchy problem. The graviton would propagate in 4 plus n compactified dimensions whereas SM particles in the usual dimensions[10]. This results in an effective Planck scale M_D which could be as low as the electroweak scale. The graviton could be exchanged in fermions pair production and the most sensitive channel is the di-electron channel. Using the LEP combined measurement [4], limits are obtained on $M_S(= M_D) > 1.20\ TeV$ [11] (resp. $> 1.09\ Tev$) with positive (resp. negative) interference.

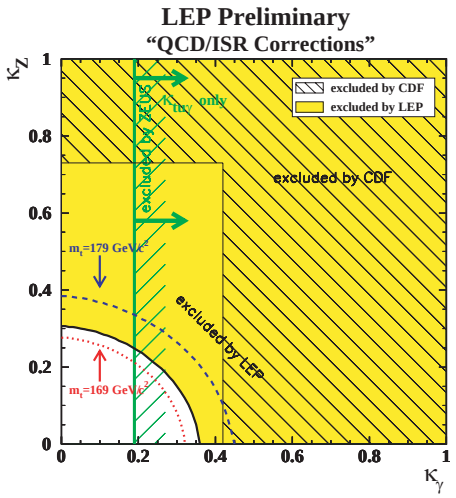

Figure 3: LEP combined limits on anomalous vertices κ_γ and κ_Z.

9 Conclusion

No hint for new physics were found in LEP data. Lots of topologies were searched for directly, and LEP combined measurements of Standard Model processes were interpreted in terms of limits beyond the Standard Model.

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