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COMMENT ON LEPTOPHOBIC BOSONS AND νN NEUTRAL CURRENT
SCATTERING DATA

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Abstract

The relevance of existing νN deep inelastic scattering data to the model of an additional leptophobic vector boson presented at this conference is discussed. It is shown that the neutral current data is in good agreement with the Standard Model and disfavors such a leptophobic boson.

A number of different new physics models have been suggested to explain the significant discrepancies between the measured R_b and R_c at LEP and their Standard Model predictions. Generally, these models fall into two classes: those that affect primarily the third generation (not affecting R_c), and those that introduce changes in couplings to all generations of fermions. The latter type of model takes advantage of the observation that the quantity $3\delta\Gamma_b + 2\delta\Gamma_c$ is consistent with zero, where $\delta\Gamma_q$ is the difference between the Standard Model and measured widths of $Z \rightarrow q\bar{q}$. As has been pointed out by a number of authors [1][2][3], this suggests generation-universal shifts in the hadronic couplings to the Z^0 so that

$$\Gamma_{d,s,b} = \Gamma_{d,s,b}^{SM} + \delta\Gamma_b \quad (1)$$

$$\Gamma_{u,c,t} = \Gamma_{u,c,t}^{SM} + \delta\Gamma_c. \quad (2)$$

Such a model not only shifts observables at Z^0 pole away from their Standard Model values, but will also affect lower-energy neutral-current phenomena such as atomic parity violation and νN deep inelastic scattering, both of which measure the interactions of first generation quarks.

A model presented at the XXXI^{ème} Rencontres de Moriond Electroweak session [2][4] introduced a new neutral vector boson, V , with a 1 TeV mass. In order to avoid conflict with very precise leptonic data from SLD and LEP, the coupling of the V to leptons is chosen to be zero: thus the name “leptophobic”. However, such a boson will still affect processes induced by leptons, be they neutrinos scattering from quarks or electrons annihilating to Z^0 s at resonance, as long as it has non-zero mixing with the Standard Model Z^0 . The mixing, parameterized by the angle ξ , will change the couplings of the physical Z^0 to quarks.

$$\epsilon_{L,R} \rightarrow \epsilon_{L,R}^{SM} \cos \xi + \epsilon_{L,R}^V \sin \xi, \quad (3)$$

and will add a tree level shift to the ρ parameter,

$$\rho \rightarrow \rho^{SM} + \xi^2 \left(\frac{M_V}{M_Z} \right)^2. \quad (4)$$

The V^0 couplings in this model are given by $\epsilon_L^{u,d} = x$, $\epsilon_R^u = y_u$ and $\epsilon_R^d = y_d$.

In the presentation at Moriond [4], the couplings x , y_u and the mixing angle, ξ were allowed to float in a fit to 12 observables, Γ_Z , R_l , σ_h , R_b , R_c , M_W/M_Z , \mathcal{A}_l , \mathcal{A}_b , \mathcal{A}_c , \mathcal{A}_{FB}^b , \mathcal{A}_{FB}^c and the weak charge in Cesium, Q_W . M_V was fixed at 1 TeV, and y_d was set to zero. Two of the reported fit results are shown in Table 1. The second set of fit parameters shown are claimed to be in better agreement with the extremely high p_T CDF jet rates than the first [2][4].

	Fit 1	Fit 2		Measured Value	Std. Model	Fit 1	Fit 2
ξ	2.8×10^{-3}	3.8×10^{-3}	g_L^2	0.3017 ± 0.0033	0.303	0.3045	0.3049
x	-1.8	-1.0	g_R^2	0.0326 ± 0.0033	0.030	0.0266	0.0271
y_u	4.7	2.7	χ^2		0.77/2 dof	4.03/2 dof	3.72/2 dof
χ^2	14.3/9 dof	15.9/9 dof	C.L.		68%	13%	15%

Table 1: The reported best fit values for the parameters of the leptophobic boson model are shown in the left table. The χ^2 values do not include the neutrino data. The right table shows the νN constraints on neutral current quark couplings, and the effects of the leptophobic boson models. Only the isoscalar combinations of couplings $g_{L,R}^2 = (\epsilon_{L,R}^u)^2 + (\epsilon_{L,R}^d)^2$ are measured to high-precision in νN scattering.

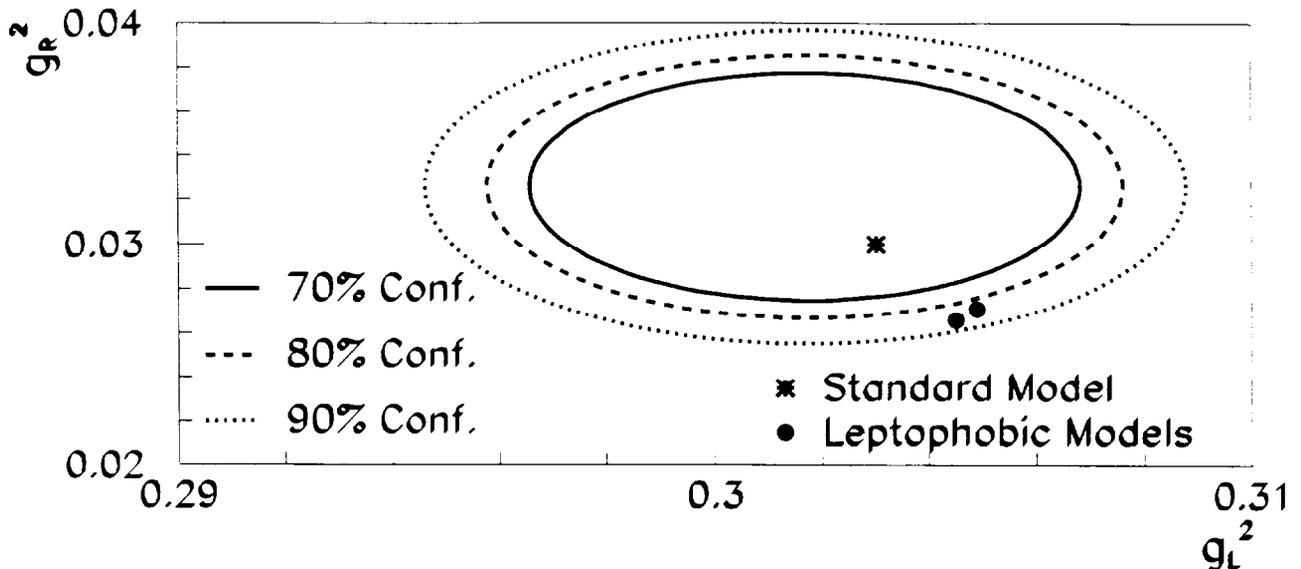


Figure 1: The νN data and leptophobic models in the g_L^2 - g_R^2 plane

Global fits to the neutral-current quark couplings from νN scattering data have been performed [5][6], and recently the CCFR collaboration has reported their results in terms of quark couplings [7][8]. The constraint on the neutral current quark couplings from the νN data used for this analysis is that reported in the Review of Particle Properties [9] which does not reflect the recent update to the CCFR data [8]. Table 1 shows the measured values, Standard Model predictions, and the values predicted from the two fits presented above. The νN data is in agreement with the Standard Model, but excludes the central values of either leptophobic fit at about 85% confidence. This is shown graphically in Figure 1.

In conclusion, models which introduce generation-universal changes to neutral current quark couplings to explain the R_b , R_c at LEP will also induce changes in parameters measured accurately in νN scattering. Although the νN does not rule out models such as the one discussed here, it clearly can place constraints on such models. For example, in the preferred fit (#2) of this leptophobic boson model [4], the χ^2 , including the νN data, is now 19.6/11 dof, which is an improvement over the Standard Model 29.0/14 dof, but is still excluded at more than 95% confidence.

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