IC/88/144
PM/88-29

INTERNATIONAL CENTRE FOR THEORETICAL PHYSICS

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INTERNATIONAL ATOMIC ENERGY AGENCY

UNITED NATIONS EDUCATIONAL, SCIENTIFIC AND CULTURAL ORGANIZATION

1988 MIRAMARE-TRIESTE

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ABSTRACT

We compare the effects of non-standard weak bosons (NSB) expected from E_6-Superstrings (Z'), strong Higgs (V_0) and composite (spin 0,1,2) models by using the classical inclusive $e^{\pm}p \rightarrow e^{\pm}$ + "Hadrons" processes at HERA energies. By assuming a 30% uncertainty for the measurement of the differential cross-sections for unpolarized $e^{\pm}$ beams and a deviation $|\Delta A| = 0.1$ from the longitudinal asymmetry of the Standard Model (SM), we derive significant bounds on the masses of composite NSB with the exception of the excited Z^*. The V_0 of the strong Higgs model is unobservable. Useful bounds on the Z' of the E_6 and the Z^* can only be obtained by increasing the precision measurements ($|\Delta A| \leq 0.05$) of the longitudinal asymmetry. Therefore, we give bounds on these NSB for $|\Delta A| = 0.02$ after selecting the combination of longitudinal asymmetries where their effects are optimal.

MIRAMARE - TRIESTE
July 1988

* Submitted for publication.
This work is prepared for the HERA study group.

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1.Introduction:

There are at present a large amount of efforts and suggestions for providing tests of the true nature of physics beyond the standard model (SM).These tests are decisive and crucial for a clear guidance towards the exact direction of high-energy physics, which at present, is quite confusing and even very speculative. One of the "almost unavoidable consequences" of non-standard models (NSM) is the existence of one or more non-standard weak bosons (NSB) which might (at least expected to) show up in the next generations of lepton and hadron colliders. One can classify these bosons into three specific NSM :

a)E_6-Super (inspired) strings models[1,2]:

The new bosons Z' are associated to the extra U(1) or SU(2) gauge group which arises after E_6-breaking. The Z' parameters and interactions with fermion pairs are characterized by the E_6-mixing angles θ_2 and β (Hereafter we shall follow the notations in Ref 3) and the parametrization in Ref 2)). No-scale rank five model[1] (S_1) corresponds to $\theta_2=0$ where the couplings are β-independent. Rank six intermediate scale models[2] correspond to $\cos(\theta_2)=(3/8)^{1/2}$ and $\sin(\theta_2)=(5/8)^{1/2}$ where for $\beta=0$ and $\pi/2$, we have respectively S_2 and S_3 models. We shall neglect the small Z-Z' mixing in our analysis.

b) Strong Higgs-type model:

This model corresponds to a formulation by a $SU(2)_V$ local hidden symmetry of the $SU(2)_L \times SU(2)_R$ non-linear realization of the scalar sector of SM in the large Higgs mass limit[4].The associated dynamical boson V_0 has the parameters summarized in Table 1.

c) Composite weak bosons:

These bosons are expected "natural" partners of the composite(?) Z-boson. Spin zero bosons are constrained to have a Higgs-type[5] ($\tilde{\pi}$) or chiral[6] ($\tilde{\eta}$) coupling to fermion pairs in order to preserve light fermion masses. We shall be concerned here with the $\tilde{\eta}$ while the $\tilde{\pi}$ will certainly induce unobservable effects in the chiral limit $m_e=0$. We shall also study the possibility that the preon constituents of the scalar (denoted here after as $\tilde{\sigma}$) are coloured, i.e the $\tilde{\sigma}$ can also be produced via gluon fusion.

Spin one bosons are best represented by the excited Z^* and the iso-scalar[7] Y-boson. We also study the effects of a possible spin two tensor boson[3,8] T which can have Z-like (T_Z), chiral ($T_{R,L}$), tensor (T_V) and pseudo-tensor (T_A) couplings to fermion pairs.
Like the case of spinless bosons, we have also investigated the one of coloured constituents.However,with the choice of scale in the Tables 1 and 2, we shall see that the effects of gluons are much smaller than the quark ones.In previous works we have compared the effects of these NSB at polarized e^+e^-[9] and $(\bar{p})p$[3,8] colliders.We persue this comparison at $e^\pm$ p collider for HERA energies. We shall be concerned for unpolarized $e^\pm$ beams with the differential cross-section :

$$d\sigma^\pm \equiv \frac{d\sigma^\pm}{dx\ dQ^2} = \sum_i f_i(x,Q^2)\frac{d\sigma}{dx\ dQ^2}(e^\pm+\text{parton}(i) \longrightarrow e^\pm+\text{parton}(i)) \quad (1)$$

where $f_i(x,Q^2)$ is the quark or gluon structure function, x is the quark or gluon momentum fraction from the proton and $Q^2=-\bar{t}$ is the energy momentum transfer squared of the parton. We use in our numerical analysis the Duke-Owens set 1 parametrization of the structure functions[10].
For longitudinally polarized $e^\pm$ beams,we shall deal with the combinations of asymmetry:

$$A_{-+}^{LR(RL)} = \frac{d\sigma(e^-_{L(R)}) - d\sigma(e^+_{R(L)})}{d\sigma(e^-_{L(R)}) + d\sigma(e^+_{R(L)})}$$

$$\begin{aligned} A_{-+}^{LL} &= A_{-+}^{LR}\ (R \longrightarrow L) \\ A_{-+}^{RR} &= A_{-+}^{LR}\ (L \longrightarrow R) \\ A_{--} &= A_{-+}^{LR}\ (+ \longrightarrow -) \\ A_{++} &= A_{-+}^{RL}\ (- \longrightarrow +) \end{aligned} \quad (2)$$

where $R(L)=\frac{1}{2}(1 \pm \gamma_5)$ is the usual chirality notation.
In Table 1,we summarize the Feynman rules used.In Table 2,

we present the parameters of the models discussed previously. The expressions of the amplitude squared are given in Tables 3 and 4 where the kinematics are shown in Fig 1.

2.Unpolarized $e^\pm$ beams:

Our analysis is summarized in Figs 2 and 3 respectively for the electron and the positron beams. Fig 2a , 3a are the behaviour of the differential cross-section $d\sigma$ versus Q^2 for x = 0.5, whilst Fig 2b, 3b give the variation of $d\sigma$ versus the weak boson mass,for x = 0.5 and $Q^2=2.10^4\,GeV^2$. Our choosen values of x and Q^2 are standard values used in the literature[11]. One can notice in Fig 2a,3a that the behaviour of $d\sigma$ remains very identical for e^+ and e^- beams at large Q^2, where in this region the deviation from the SM curve can become important. One can notice that spin zero ($\tilde{\sigma}$) and spin two (T) composite NSB can have spectacular deviations from the SM predictions depending on their couplings to gluon or (and) fermion pairs. For definiteness, we have normalized such couplings by the weak breaking scale F_π = 260 GeV by analogy with the value of f_π which con: ols the non-linear σ-model of QCD. However, the scale might be larger or smaller. The effects of $\tilde{\sigma}$ is strongly controlled by the $\tilde{\sigma}gg$ coupling. For the range of values given in Table 1, the $\tilde{\sigma}$ effects move from the $\tilde{\eta}$-ones to a very net deviation from the SM prediction. However,in this latter case, the $\tilde{\sigma}$ could have induced too many anomalous W^+W^- events at the $\bar{p}$ p collider[12]. The large effects of the spin two NSB are mainly due to the derivative couplings at the fermion vertices, which induce a $\bar{s}^4$ and $\bar{u}^4$ behaviours of the cross- section and then dominate for moderate values of $\bar{t}$. For large $\bar{t}$, propagator effects compensate such behaviour in such a way that the tensor NSB cross section tends to the SM one.
Let's now fix (Q^2,x) and study the behaviour of the $d\sigma$ versus the NSB masses (Fig 2b,3b). By assuming a 30% experimental accuracy for the measurement of the SM predictions, one can deduce the lower bounds given in the first two columns given in Table5. One can read that there is no bound on V_0, excited Z^* and Z' of the super (inspired) strings models. This is due to the fact that these NSB couple very weakly to fermion pairs. Our results for the Z' agree with the previous ones in Ref 13).

At the 30% level of experimental accuracy, one can only derive significant bounds for composite NSB. The strongest bounds are: 230 (850) GeV for scalar composed by (un)colored preons, 610 GeV for the isoscalar vector Y, 1.9 TeV for a spin two boson. The strongest bound of 1.9 TeV applies to the T_V composite spin two NSB having a parity conserving coupling with fermion pairs. One should also note that the Y is strongly constrained compared to other spin one NSB, due to the nature of its coupling to fermion pairs. The other NSB (Z',Z^* and V_0) are unobservable for the assumed 30% deviation from the SM prediction.

3.Longitudinally polarized $e^{\pm}$ beams:

The behaviour of different combinations of the asymmetries versus Q^2 at given values of the NSB masses and at x=0.6 is shown in Fig 4a-f.Notice that the results are not sensitive to the choice of x-values . This can be understood as the asymmetry involves ratio of structure functions.In Fig 5a-f,we give the behaviour of the asymmetry versus the masses of the NSB fixing (Q^2,x). By assuming a deviation of about ± 0.1 from the SM asymmetry, we obtain the bounds in the remaining columns of Table 5. Like in the case of the unpolarized beams,the important deviations from the SM asymmetry come from the composite T, $\tilde{\sigma}$ and the isoscalar vector Y. The effects of the V_0, $Z^*$and Z' remain again unobservable for $|\Delta A| = 0.1$ .Then,we study the bounds obtained versus the choices of $|\Delta A|$. The bound on Z^* and V_0 starts to be interesting for $|\Delta A| \leq 0.02$.We show in Fig 6a, the bound on Z^* versus Q^2 at x=0.5 for the A^{LR}_{-+} and A^{RL}_{++} asymmetries where the Z^* effects are maximal. We deduce:

$$M_{Z^*} \geq 200 \text{ GeV}. \qquad (3)$$

In Fig 6b, we give the strongest bound on V_0 versus Q^2 . As one can see, it would be difficult to sign the V_0 from the process discussed here or vice-versa the bound on V_0 is very weak:

$$M_{V_0} \geq 90 \text{ GeV}. \qquad (4)$$

We do the same analysis for the Z' of the superstrings models, where we always neglect the Z-Z' mixing effects which are small[13]. We select for each type of superstring models the asymmetry where the effects of the corresponding Z' are maximal.The Z' of S_1 is best seen from the measurements of A^{RL}_{-+}. The Z' of S_2 manifests maximally in the A^{LR}_{-+} while

the one of S_3 shows up equally for A^{LL}_{-+} and A^{LR}_{-+}.The bounds for $|\Delta A| \leq 0.02$ at $Q^2=2\ 10^4\ \text{GeV}^2$ and for x=0.6 are (see Fig.7) :

$$\begin{aligned} M_{Z'}(S_1) &\geq 380 \text{ GeV} \\ M_{Z'}(S_2) &\geq 360 \text{ GeV} \qquad (5) \\ M_{Z'}(S_3) &\geq 170 \text{ GeV} \end{aligned}$$

These bounds though weaker than the ones from composite bosons are interesting compared to other available bounds derived from some other processes[14].Bounds coming from longitudinally asymmetry are in most cases stronger than from the unpolarized cross-section. This is again a good motivation for having polarized beams.

4.Conclusion:

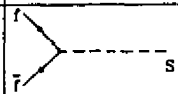
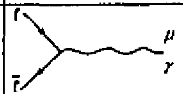
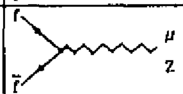
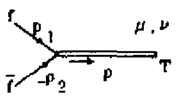
We might expect that HERA and a fortiori an e-p TeV collider with (un)polarized $e^{\pm}$ beams reveals the NSB or at least provide significant bounds on their parameters. In this paper, we have bounded the masses of NSB for given couplings but one might also do the inverse problem. One should note that the effects of the composite bosons might compete with the contact interactions discussed in the literature[11]. The two effects are difficult to be disentangled due to the t-channel exchange of the NSB bosons. However, if what we know from the hadrons of QCD is true here, we might expect that the resonance effects dominate over the contact interactions ones. The later being as usual included into the QHD continuum .

ACKNOWLEDGMENTS

The authors would like to thank R. Rückl for informative discussions. One of the authors (S.N.) would like to thank Professor Abdus Salam, the International Atomic Energy Agency and UNESCO for hospitality at the International Centre for Theoretical Physics, Trieste. He would also like to thank Professor G. Furlan for invitation at the ICTP.

Table 1 : Feynman Rules 1

1. Propagators and boson-fermion-anti-fermion:

Spin	Particles		Propagators	Vertices
0	S Scalar		p ; $iD_s(p)$; $D_s(p)=(p^2-M_s^2)^{-1}$	 $ig_f(v_s^f+a_s^f\gamma_5)$
1	SM	γ Photon	μ p ν ; $-ig_{\mu\nu}D_\gamma(p)$; $D_\gamma(p)=(p^2)^{-1}$	 $iQ_f e\gamma_\mu$
		Z Gauge boson	μ p ν ; $-ig_{\mu\nu}D_Z(p)$; $D_Z(p)=(p^2-M_Z^2)^{-1}$	 $ig_Z\gamma_\mu(v_Z^f+a_Z^f\gamma_5)$
	V Vector		μ p ν ; $-ig_{\mu\nu}D_V(p)$; $D_V(p)=(p^2-M_V^2)^{-1}$	 $ig_V\gamma_\mu(\bar{v}_V^f+a_V^f\gamma_5)$
2	T Tensor		μ,ν p ρ,σ ; $-iT_{\mu\nu\rho\sigma}D_T(p)$; $T_{\mu\nu\rho\sigma}=\frac{1}{2}(\eta_{\mu\rho}\eta_{\nu\sigma}+\eta_{\mu\sigma}\eta_{\nu\rho}-\frac{2}{3}\eta_{\mu\nu}\eta_{\rho\sigma})$; $\eta_{\mu\nu}=-g_{\mu\nu}+p_\mu p_\nu/p^2$; $D_T(p)=(p^2-M_t^2)^{-1}$	 $ig_t T_{\mu\nu}(v_t^f+a_t^f\gamma_5)$; $T=\frac{2}{F_\pi}(\gamma_\mu k_\nu+\gamma_\nu k_\mu-\frac{2}{3}\eta_{\mu\nu}\bar{k})$; $\eta_{\mu\nu}=-g_{\mu\nu}+p_\mu p_\nu/p^2$; $k=(p_1-p_2)$; $\bar{k}=\gamma_\mu k^\mu$

2. Boson-gluon-gluon vertices :

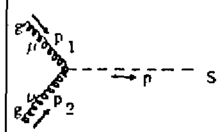
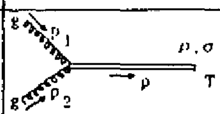
Spin	Particles	Coupling strength	Vertices
0	S Scalar	$G_{ggs}=\frac{4\sqrt{2}\alpha_s}{3F_\pi}\approx\frac{8\sqrt{2}\sin(\theta_w)\alpha_s}{3\alpha M_Z}$ to be compared to the technipion coupling : $G_{ggs}=\frac{2\sqrt{6}\alpha_s}{F_\pi}$	 $iG_{ggs}\epsilon^{\mu\nu\rho\sigma}p_{1\rho}p_{2\sigma}$
2	T	$g_1=\frac{\sqrt{4\pi}\alpha_s}{F_\pi^3}$; $g_2=\frac{\alpha_s}{F_\pi}\sqrt{\frac{4\pi M_T}{F_\pi}}$	 $i(g_1F^1_{\mu\nu}F_2^{\mu\nu}p_1^\rho p_2^\sigma+g_2F^\rho_{1\eta}F_2^{\sigma\eta})$

Table 2 : Coupling strengths in different models

Spin	Particles X		Overall Coupling	Vectorial (v)	Axial (a)
0	Composite $\tilde{\eta}$				
	$\tilde{\eta}_{P(S)}$		$g_f=\frac{e}{\sin\theta_w}$	1 (0)	0 (1)
	$\tilde{\eta}_{L(R)}$		"	$1/\sqrt{2}$	$-(+)\ 1/\sqrt{2}$
1	Standard model (SM)				
	γ		e	Q_f	0
	Z		$g_Z=\frac{g_f}{\cos\theta_w}$	$\frac{1}{2}T_3-Q_f\sin^2(\theta_w)$	$-\frac{1}{2}T_3$
	E_6-Superstrings Inspired Z'		g_Z	$V_{Z'}^u=0$; $V_{Z'}^d=-S_w(C_\theta+\sqrt{5/3}S_\theta C_{2\beta})/4$; $V_{Z'}^e=-(2V_{Z'}^u+V_{Z'}^d)$; $S_w=\sin(\theta_w)$; $S_\theta=\sin(\theta_2)$; $C_\theta=\cos(\theta_2)$; $C_{2\beta}=\cos(2\beta)$	$A_{Z'}^u=S_wC_\theta/3$; $A_{Z'}^d=S_w(C_\theta/3-\sqrt{5/3}S_\theta C_{2\beta})/4$; $A_{Z'}^e=A_{Z'}^d$
	Strong Higgs V_0		g_Z	$S_\psi(T_3C-4Q_fS_w^2(1+C_\psi S_\phi g/(S_\psi g')))/4$; $\psi=-(g^2-g'^2)/(g'(g^2+g'^2)^{1/2})$; $\phi=2g'g/(g'(g^2+g'^2)^{1/2})$; $C=(1+b(1+C_\psi g/(S_\psi S_\phi g'))g'^2/(g^2+g'^2))/(1+b)$; $g=e/S_w$; $g'=e/C_w$; $b_{1,2}=0(-.05)$ if $(g/g')<.22(.1)$; $S_\alpha=\sin(\alpha)$; $C_\alpha=\cos(\alpha)$	$S_\psi CT_3/4$
	Composite	Excited Z^*	$g_{Z^*}=\frac{M_Zg_Z}{M_{Z^*}}$	v_Z^f	a_Z^f
		Iso-scalar Y	g_Z	$\frac{1}{2}(Y_R+Y_L)+Q_f\sinh^2(\theta_Y)$	$\frac{1}{2}(Y_R-Y_L)$
2	Composite				
	T_Z		g_Z	v_Z^f	a_Z^f
	$T_{V(A)}$		g_f	1 (0)	0 (1)
	$T_{L(R)}$		"	$1/\sqrt{2}$	$-(+)\ 1/\sqrt{2}$

Table 3 : Quark subprocess amplitudes

1.Standard model:

$$|M|^2_{SM} = 2\left[(\hat{S}^2+\hat{U}^2)H_0+Q\eta(\hat{S}^2-\hat{U}^2)H_1\right]$$

$$H_0= \frac{e_\ell^2 e_q^2}{D_\gamma^2} + g_z^4\frac{((a_z^{\ell 2}+v_z^{\ell 2})+\zeta\eta 2a_z^\ell v_z^\ell)(a_z^{q2}+v_z^{q2})}{D_z^2} + g_z^2\frac{2e_\ell e_q(v_z^\ell+\zeta\eta a_z^\ell)v_z^q}{D_\gamma D_z}$$

$$H_1= g_z^4\frac{(2a_z^\ell v_z^\ell+\zeta\eta(a_z^{\ell 2}+v_z^{\ell 2}))2a_z^q v_z^q}{D_z^2} + g_z^2\frac{2e_\ell e_q(a_z^\ell+\zeta\eta v_z^\ell)a_z^q}{D_\gamma D_z}$$

2.Spinless boson S:

$$|M_0|^2= (\hat{S}+\hat{U})^2 H_2$$

$$H_2= g_f^4\frac{((a_s^{\ell 2}+v_s^{\ell 2})+\zeta\eta 2a_s^\ell v_s^\ell)(a_s^{q2}+v_s^{q2})}{D_s^2}$$

No interference with the standard model

3.Exotic vector boson V:

$$|m_1|^2= 2\left[(\hat{S}^2+\hat{U}^2)H_3+Q\eta(\hat{S}^2-\hat{U}^2)H_4\right]$$

$$H_3= g_v^4\frac{((a_v^{\ell 2}+v_v^{\ell 2})+\zeta\eta 2a_v^\ell v_v^\ell)(a_v^{q2}+v_v^{q2})}{D_v^2} + g_v^2\frac{2e_\ell e_q(v_v^\ell+\zeta\eta a_v^\ell)v_v^q}{D_\gamma D_v}$$

$$+ g_z^2 g_v^2\frac{2((a_z^\ell a_v^\ell+v_z^\ell v_v^\ell)+\zeta\eta(a_z^\ell v_v^\ell+a_v^\ell v_z^\ell))(a_z^q a_v^q+v_z^q v_v^q)}{D_z D_v}$$

$$H_4= g_v^4\frac{(2a_v^\ell v_v^\ell+\zeta\eta(a_v^{\ell 2}+v_v^{\ell 2}))2a_v^q v_v^q}{D_v^2} + g_v^2\frac{2e_\ell e_q(a_v^\ell+\zeta\eta v_v^\ell)a_v^q}{D_\gamma D_v}$$

$$+ g_z^2 g_v^2\frac{2((a_z^\ell v_v^\ell+a_v^\ell v_z^\ell)+\zeta\eta(a_z^\ell a_v^\ell+v_z^\ell v_v^\ell))(a_z^q v_v^q+a_v^q v_z^q)}{D_z D_v}$$

4.Spin two tensor boson T:

$$|m_2|^2= (H_5T_1+H_7T_3)+Q\eta(H_6T_2+H_8T_4)$$

$$H_5= g_t^4\frac{((a_t^{\ell 2}+v_t^{\ell 2})+\zeta\eta 2a_t^\ell v_t^\ell)(a_t^{q2}+v_t^{q2})}{D_T^2}$$

$$H_6= g_t^4\frac{(2a_t^\ell v_t^\ell+\zeta\eta(a_t^{\ell 2}+v_t^{\ell 2}))2a_t^q v_t^q}{D_T^2}$$

$$H_7= g_t^2\frac{2e_\ell e_q(a_t^\ell+\zeta\eta v_t^\ell)a_t^q}{D_\gamma D_T} + g_z^2 g_t^2\frac{2((a_z^\ell v_t^\ell+a_t^\ell v_z^\ell)+\zeta\eta(a_z^\ell a_t^\ell+v_z^\ell v_t^\ell))(a_z^q v_t^q+a_t^q v_z^q)}{D_z D_T}$$

$$H_8= g_t^2\frac{2e_\ell e_q(v_t^\ell+\zeta\eta a_t^\ell)v_t^q}{D_\gamma D_T} + g_z^2 g_t^2\frac{2((a_z^\ell a_t^\ell+v_z^\ell v_t^\ell)+\zeta\eta(a_z^\ell v_t^\ell+a_t^\ell v_z^\ell))(a_z^q a_t^q+v_z^q v_t^q)}{D_z D_T}$$

$$T_1= \frac{8}{F_\pi^4}(\hat{S}^4-6\hat{S}^3\hat{U}+18\hat{S}^2\hat{U}^2-6\hat{S}\hat{U}^3+\hat{U}^4)$$

$$T_2= \frac{8}{F_\pi^4}(\hat{S}+\hat{U})(\hat{S}-\hat{U})(\hat{S}^2-6\hat{S}\hat{U}+\hat{U}^2)$$

$$T_3= \frac{4}{F_\pi^2}(\hat{S}+\hat{U})(\hat{S}^2-4\hat{S}\hat{U}+\hat{U}^2)$$

$$T_4= \frac{4}{F_\pi^2}(\hat{S}-\hat{U})^3$$

With :

$D_X=\hat{t}-M_X^2$

$Q=(-)+$ for (anti)quarks
$\eta=(-)+$ for (positron)electron
$\zeta=(-)+$ for (left)right handed lepton beam and
$\zeta=0$ for unpolarized beam.

4.Spin two tensor boson T:

$$|m_2|^2 = (H_5T_1+H_7T_3)+Q\eta(H_6T_2+H_8T_4)$$

$$H_5 = g_t^4\frac{((a_t^{\ell 2}+v_t^{\ell 2})+\zeta\eta 2a_t^\ell v_t^\ell)(a_t^{q2}+v_t^{q2})}{D_T^2}$$

$$H_6 = g_t^4\frac{(2a_t^\ell v_t^\ell+\zeta\eta(a_t^{\ell 2}+v_t^{\ell 2}))2a_t^q v_t^q}{D_T^2}$$

$$H_7 = g_t^2\frac{2e_\ell e_q(a_t^\ell+\zeta\eta v_t^\ell)a_t^q}{D_\gamma D_T} + g_Z^2g_t^2\frac{2((a_Z^\ell v_t^\ell+a_t^\ell v_Z^\ell)+\zeta\eta(a_Z^\ell a_t^\ell+v_Z^\ell v_t^\ell))(a_Z^q v_t^q+a_t^q v_Z^q)}{D_Z D_T}$$

$$H_8 = g_t^2\frac{2e_\ell e_q(v_t^\ell+\zeta\eta a_t^\ell)v_t^q}{D_\gamma D_T} + g_Z^2g_t^2\frac{2((a_Z^\ell a_t^\ell+v_Z^\ell v_t^\ell)+\zeta\eta(a_Z^\ell v_t^\ell+a_t^\ell v_Z^\ell))(a_Z^q a_t^q+v_Z^q v_t^q)}{D_Z D_T}$$

$$T_1 = \frac{8}{F_\pi^4}(\hat S^4-6\hat S^3\hat U+18\hat S^2\hat U^2-6\hat S\hat U^3+\hat U^4)$$

$$T_2 = \frac{8}{F_\pi^4}(\hat S+\hat U)(\hat S-\hat U)(\hat S^2-6\hat S\hat U+\hat U^2)$$

$$T_3 = \frac{4}{F_\pi^2}(\hat S+\hat U)(\hat S^2-4\hat S\hat U+\hat U^2)$$

$$T_4 = \frac{4}{F_\pi^2}(\hat S-\hat U)^3$$

With :

$D_x = \hat t - M_x^2$

$Q=(-)+$ for (anti)quarks
$\eta=(-)+$ for (positron)electron
$\zeta=(-)+$ for (left)right handed lepton beam and
$\zeta=0$ for unpolarized beam.

Table 6 :Lower mass limits in GeV for given couplings by assuming the deviations $\Delta(d\sigma)\simeq 30\%$ and $|\Delta A|=0.1$ from the SM predictions

Particles			Unpolarized		Polarized					
			e^-	e^+	A_{--}^{LR}	A_{++}^{RL}	A_{-+}^{LR}	A_{-+}^{RL}	A_{-+}^{LL}	A_{-+}^{RR}
E_6 Based Z'		S_1	/	/	/	/	/	/	/	/
		S_2	/	/	/	/	/	/	/	/
		S_3	/	/	/	/	/	/	/	/
Strong Higgs		V_0	/	/	/	/	/	/	/	/
Composite	Spin 0	$\tilde\eta_{S(P)}$	/	230	/	200	/	200	220	/
		$\tilde\eta_L$	/	"	220	270	200	/	/	280
		$\tilde\eta_R$	/	"	280	360	/	260	320	290
		$\tilde\sigma_{S(P)}$	710	860	650	780	630	770	820	/
		$\tilde\sigma_L$	"	"	820	960	750	/	730	1000
		$\tilde\sigma_R$	"	"	1000	1190	/	930	1100	1010
	Spin 1	Z^*	/	/	/	/	/	/	/	/
		Y	550	610	860	650	420	/	690	740
	Spin 2	T_Z	460	250	440	620	720	340	/	660
		T_V	1220+	1910	1060+	1450	2440	3190	2610	2760
		T_A	680	1080	740	990	1320	1630	1330	1550+
		T_L	670	1480	1930+	1820	2670	/	1590+	1920
		T_R	710	1400	2400+	2410	/	3480	2110	2610+

+) We have taken the strongest bound on these masses.However,due to the M-behaviour of these observables,there also exist a range of lower mass values where these NSB may also be missed (see the Figures).

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Figure Captions :

Fig.1: Kinematics for the reaction $e^{\pm} + p \longrightarrow e^{\pm}$ + Hadrons .

Fig.2: Differential cross section for unpolarized electron beam for
$x = 0.5$: a) versus Q^2 at fixed $M_{NSB} = 300$ GeV ;
b) versus the NSB mass at fixed $Q^2 = 2\ 10^4$ GeV^2

Fig.3: The same as Fig.2 but for positron beam.

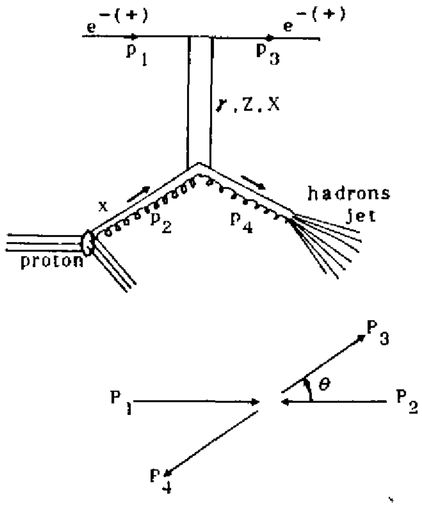
Fig.4 a-f: Behaviour of the longitudinal asymmetries defined in
Eq.(2) versus Q^2 at given values of $x = 0.5$ and $M_{NSB} = 300$ GeV

Fig.5 a-f: Behaviour of the longitudinal asymmetries versus M_{NSB}
at fixed $Q^2 = 2\ 10^4$ and for $x = 0.5$

Fig.6a: Bound on Z^* from A^{RL}_{++} and A^{LL}_{-+} versus Q^2 for $|\Delta A| = 0.02$
and $x = 0.5$

Fig.6b: Bound on V_0 from A^{LR}_{--} versus Q^2 for $|\Delta A| = 0.02$ and $x = 0.5$

Fig.7: Optimal bounds for the three superstring type models from
the longitudinal asymmetries:
a) A^{RL}_{-+} for S_1 , b) A^{LR}_{-+} for S_2 and c) A^{LL}_{-+} for S_3 .



$\hat{S}=(p_1+p_2)^2$: $\hat{S}=xS$

$\hat{t}=(p_1-p_3)^2=-\frac{\hat{S}}{2}(1-\cos(\theta))=-Q^2$

$\hat{U}=(p_1-p_4)^2$

$\sqrt{S}$ = Center of mass energy of $e^{-(+)}p$

= 314 GeV at HERA

We work with :

$x=0.5$ $Q^2=2\ 10^4\ \mathrm{GeV}^2$

Fig 1

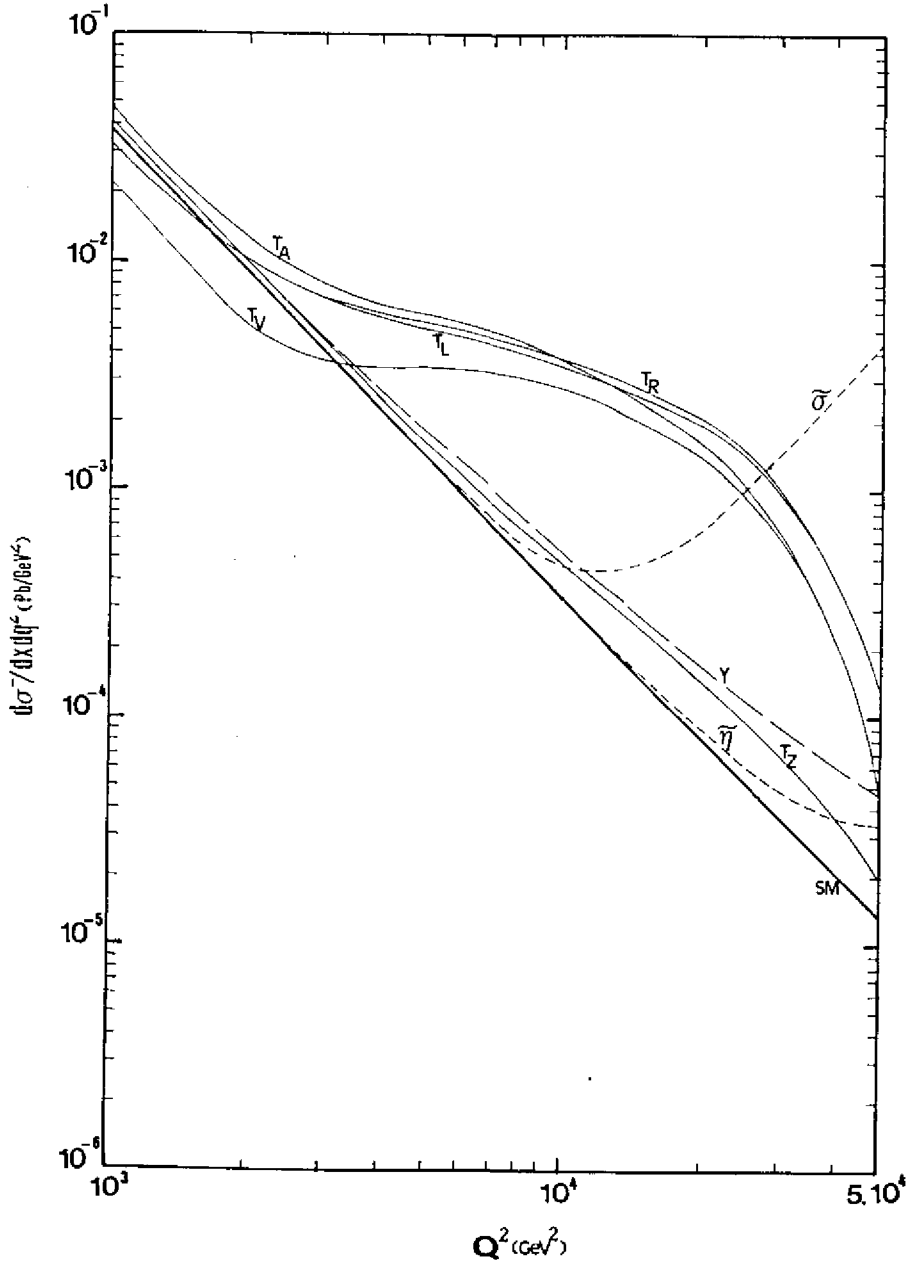
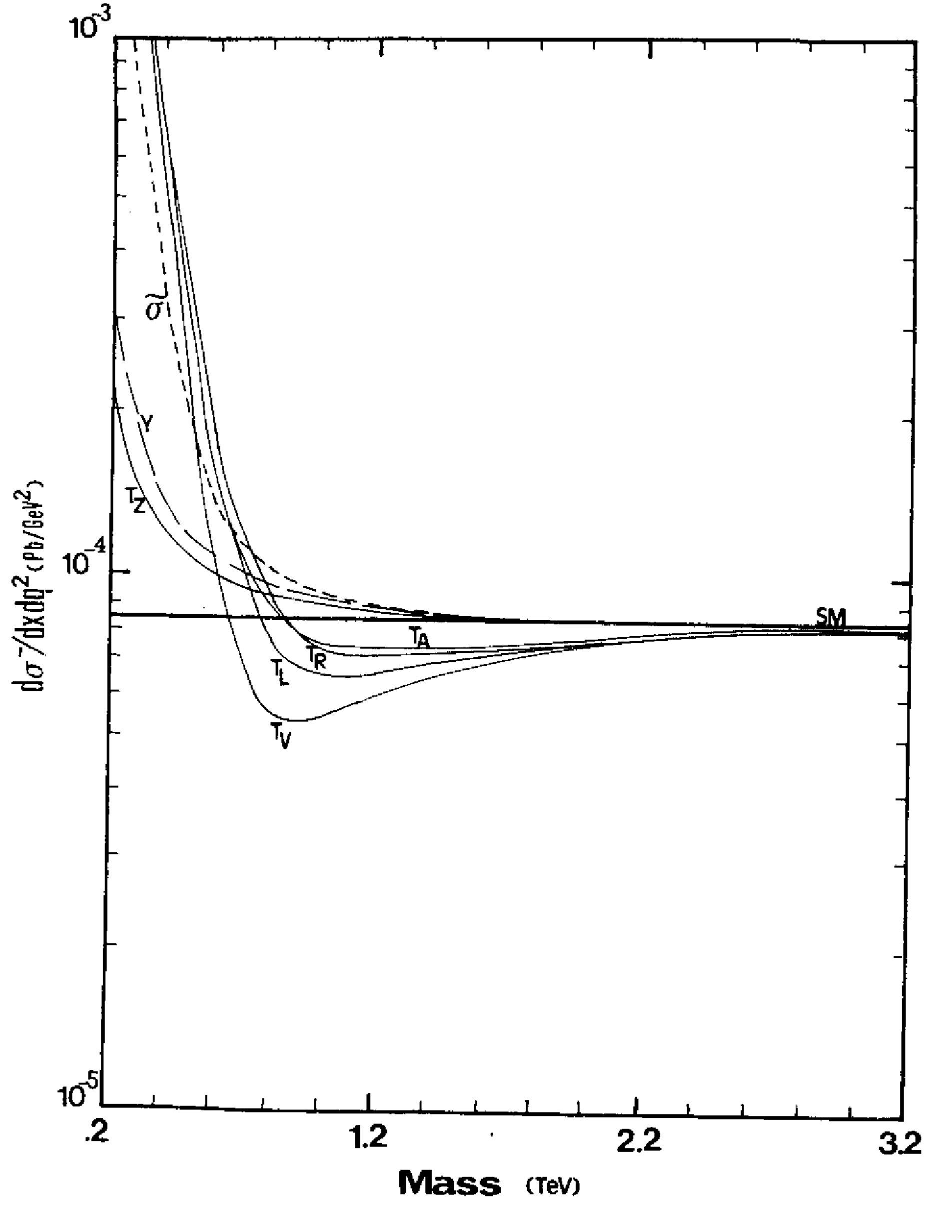
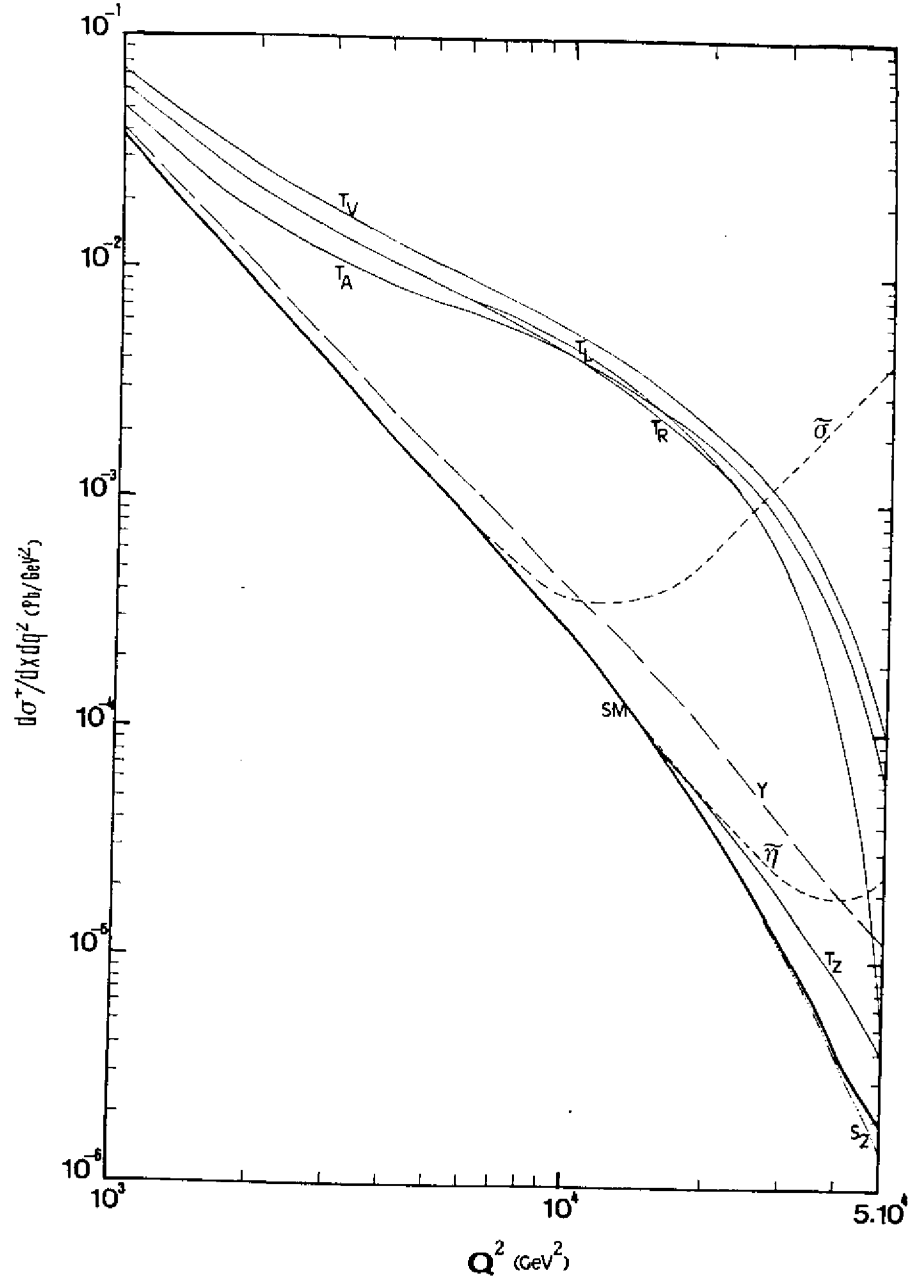


fig 2A



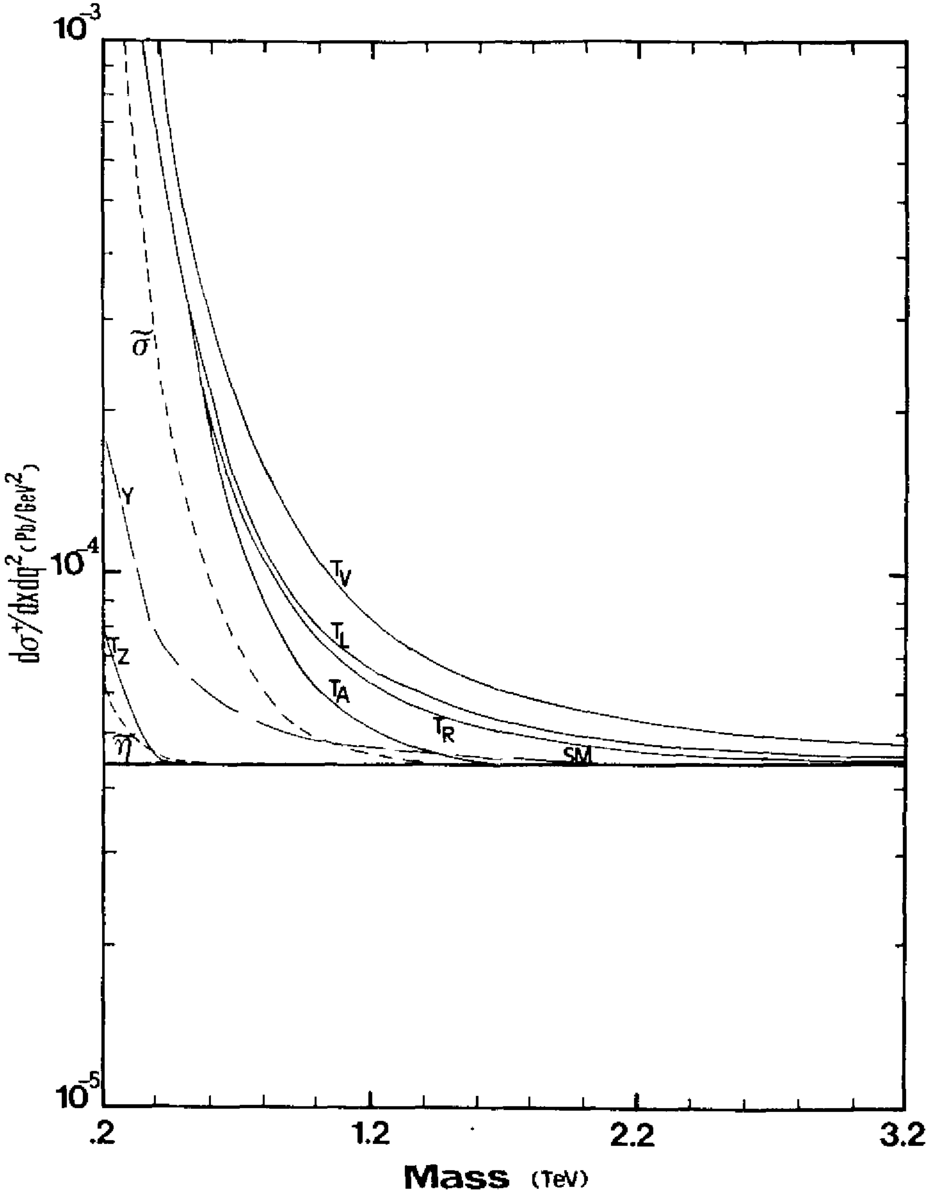
10^-3
10^-4
10^-5
.2
1.2
2.2
3.2
Mass (TeV)
SM
T_A
T_R
T_L
T_V
T_Z
Y

fig 2B



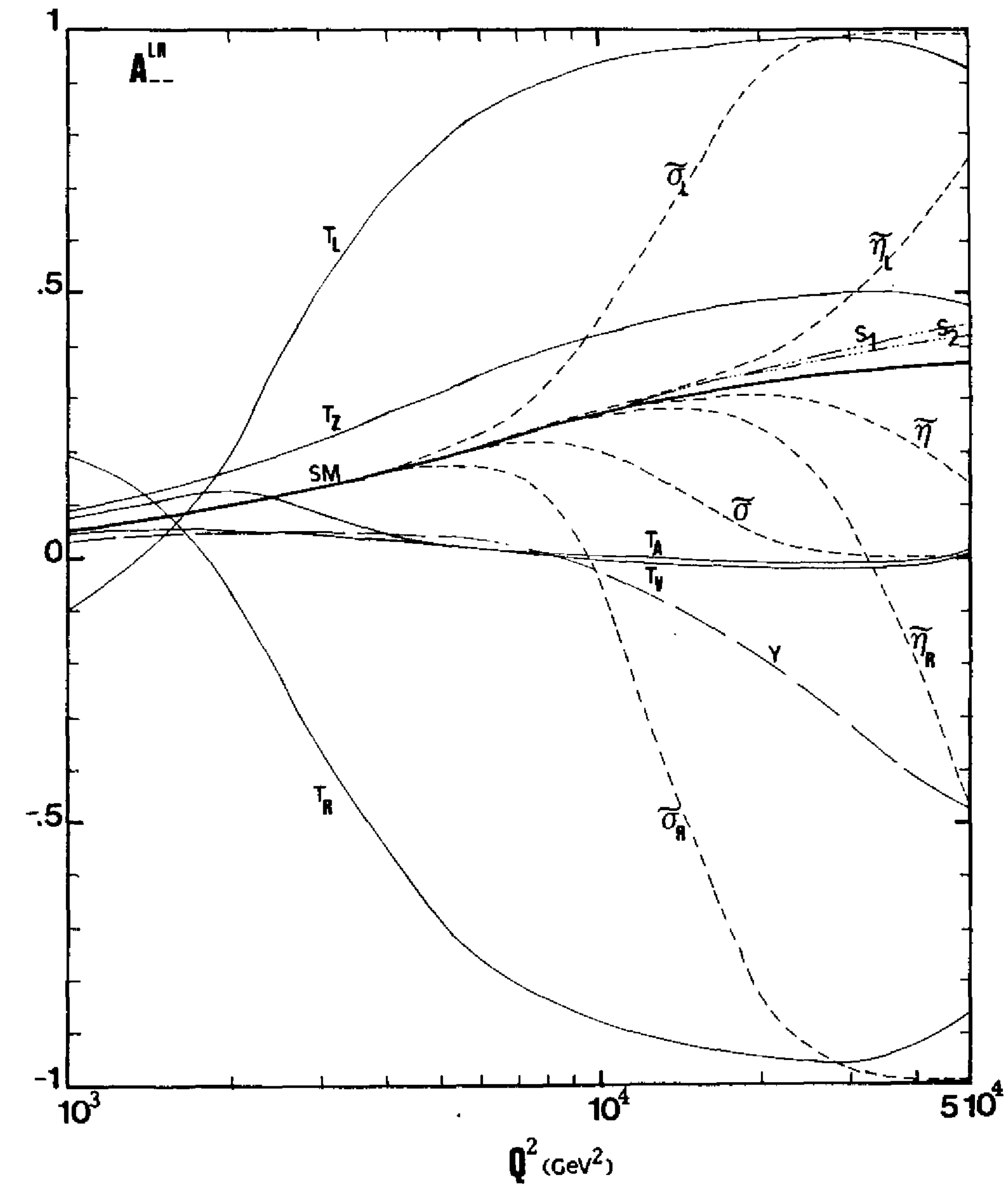
10^-1
10^-2
10^-3
10^-5
10^-6
10^3
10^4
5.10^4
Q^2 (GeV^2)
T_V
T_A
T_L
T_R
SM
Y
T_Z

fig 3A



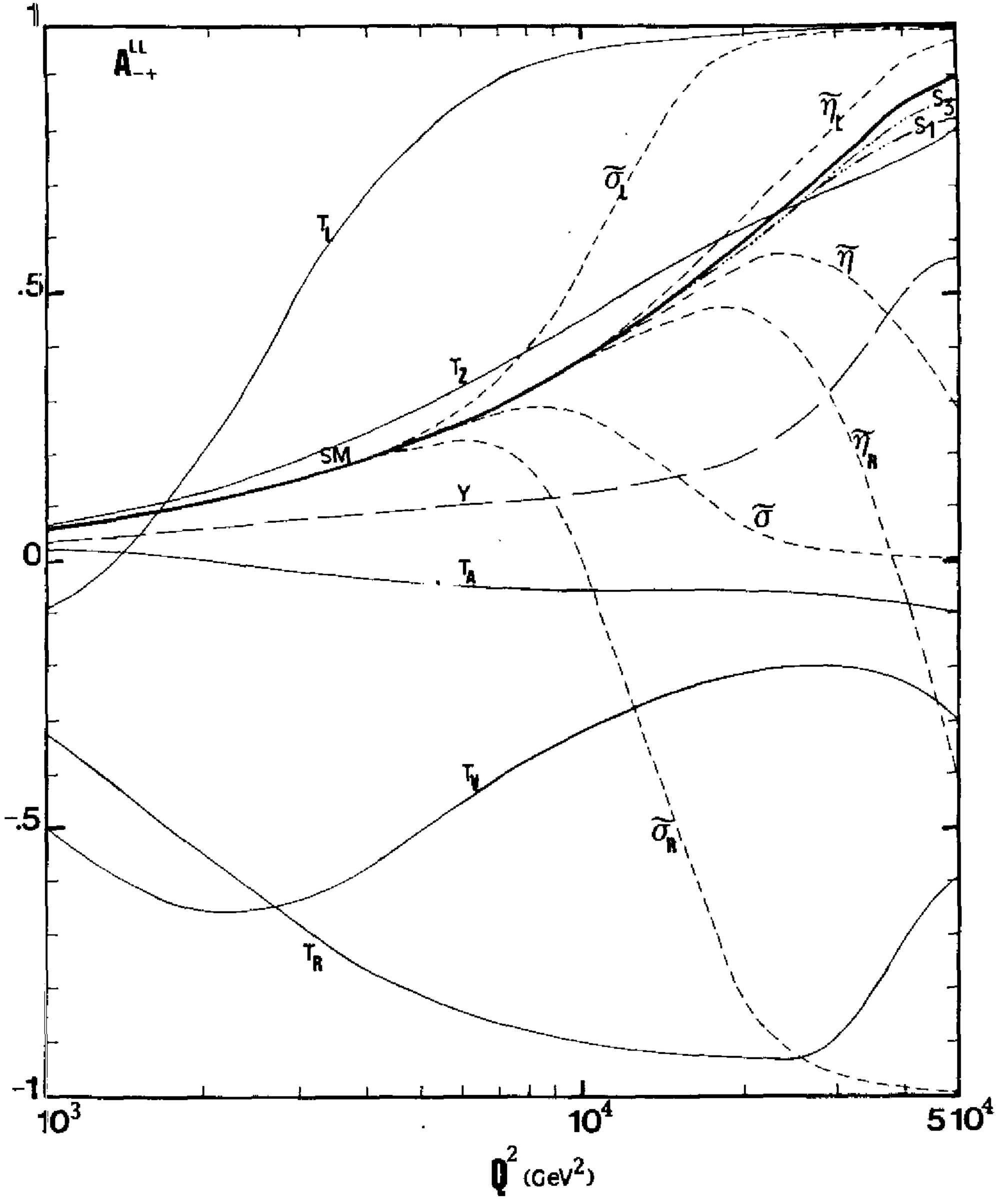
10^-3
10^-4
10^-5
dσ+/dxdq² (Pb/GeV²)
.2
1.2
2.2
3.2
Mass (TeV)
T_V
T_L
T_A
T_R
SM
Y
T_Z
σ̃
η̃

fig 3B



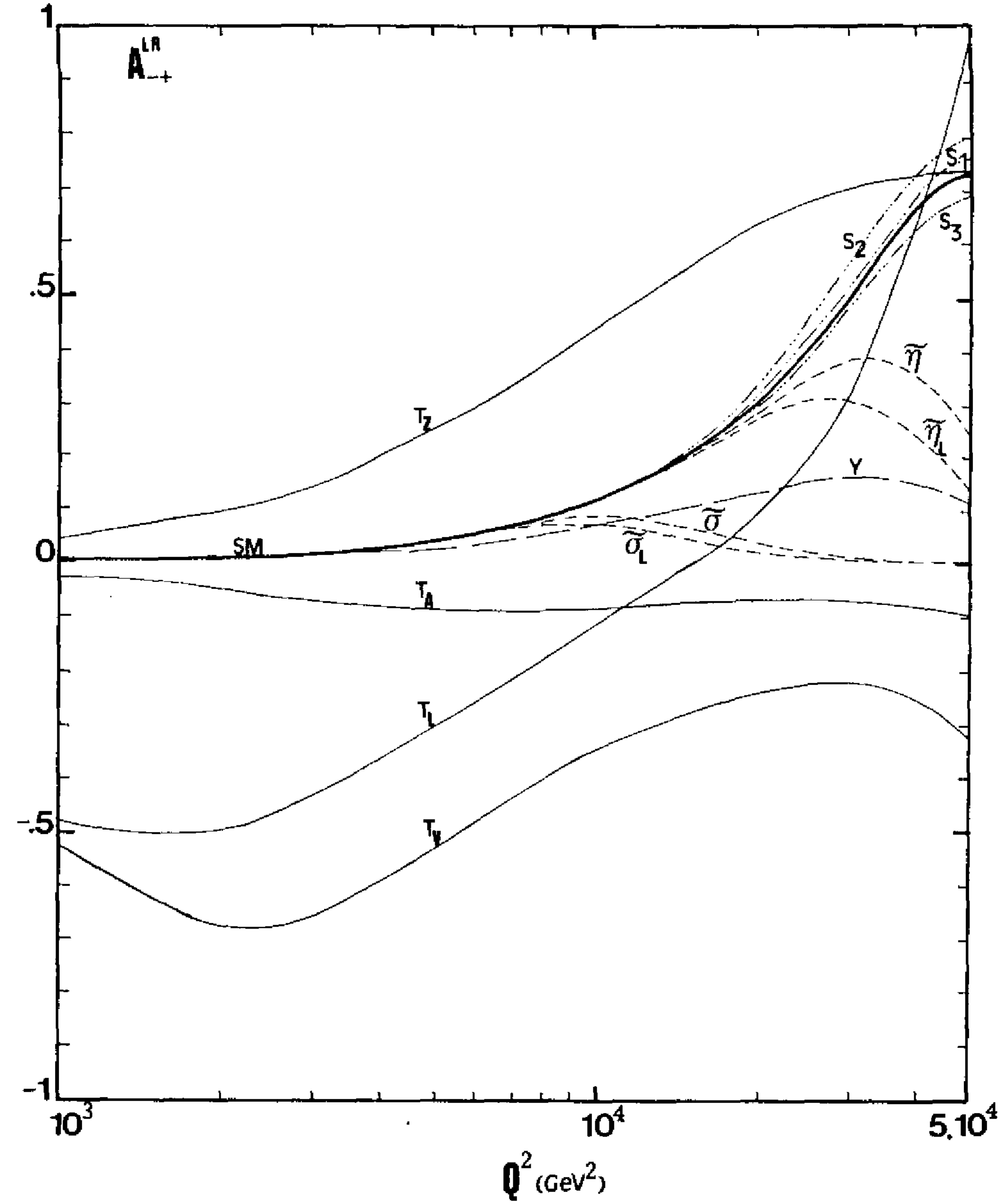
A^LR_--
1
.5
0
-.5
-1
10^3
10^4
5 10^4
Q² (GeV²)
T_L
T_Z
SM
T_A
T_V
T_R
Y
σ̃_L
η̃_L
S_1
S_2
η̃
σ̃
η̃_R
σ̃_R

FIG 4A



A^{LL}_{-+}
1
.5
0
-.5
-1
T_L
$\tilde{\sigma}_L$
$\tilde{\eta}_L$
S_3
S_1
T_Z
$\tilde{\eta}$
SM
$\tilde{\eta}_R$
Y
$\tilde{\sigma}$
T_A
T_V
$\tilde{\sigma}_R$
T_R
10^3
10^4
$5\,10^4$
Q^2 (GeV^2)

FIG 4B



A^{LR}_{-+}
1
.5
0
-.5
-1
S_1
S_2
S_3
T_Z
$\tilde{\eta}$
$\tilde{\eta}_L$
Y
SM
$\tilde{\sigma}$
$\tilde{\sigma}_L$
T_A
T_L
T_V
10^3
10^4
5.10^4
Q^2 (GeV^2)

FIG 4C

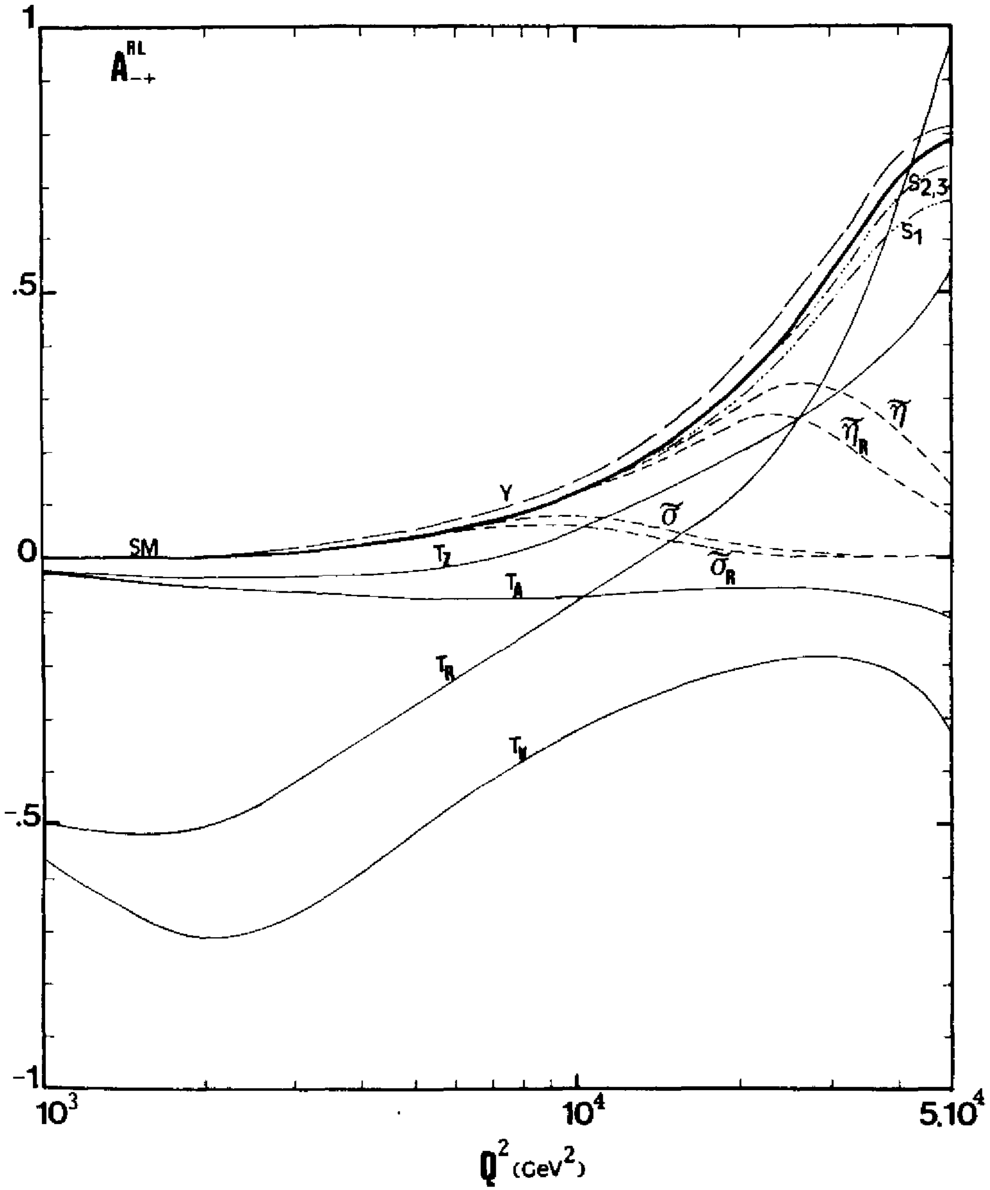

A^{RL}_{-+}
1
.5
0
-.5
-1
SM
Y
T_Z
T_A
T_R
T_N
$\tilde{\sigma}$
$\tilde{\sigma}_R$
$\tilde{\eta}$
$\tilde{\eta}_R$
$S_{2,3}$
S_1
10^3
10^4
5.10^4
Q^2 (GeV^2)

FIG 4D

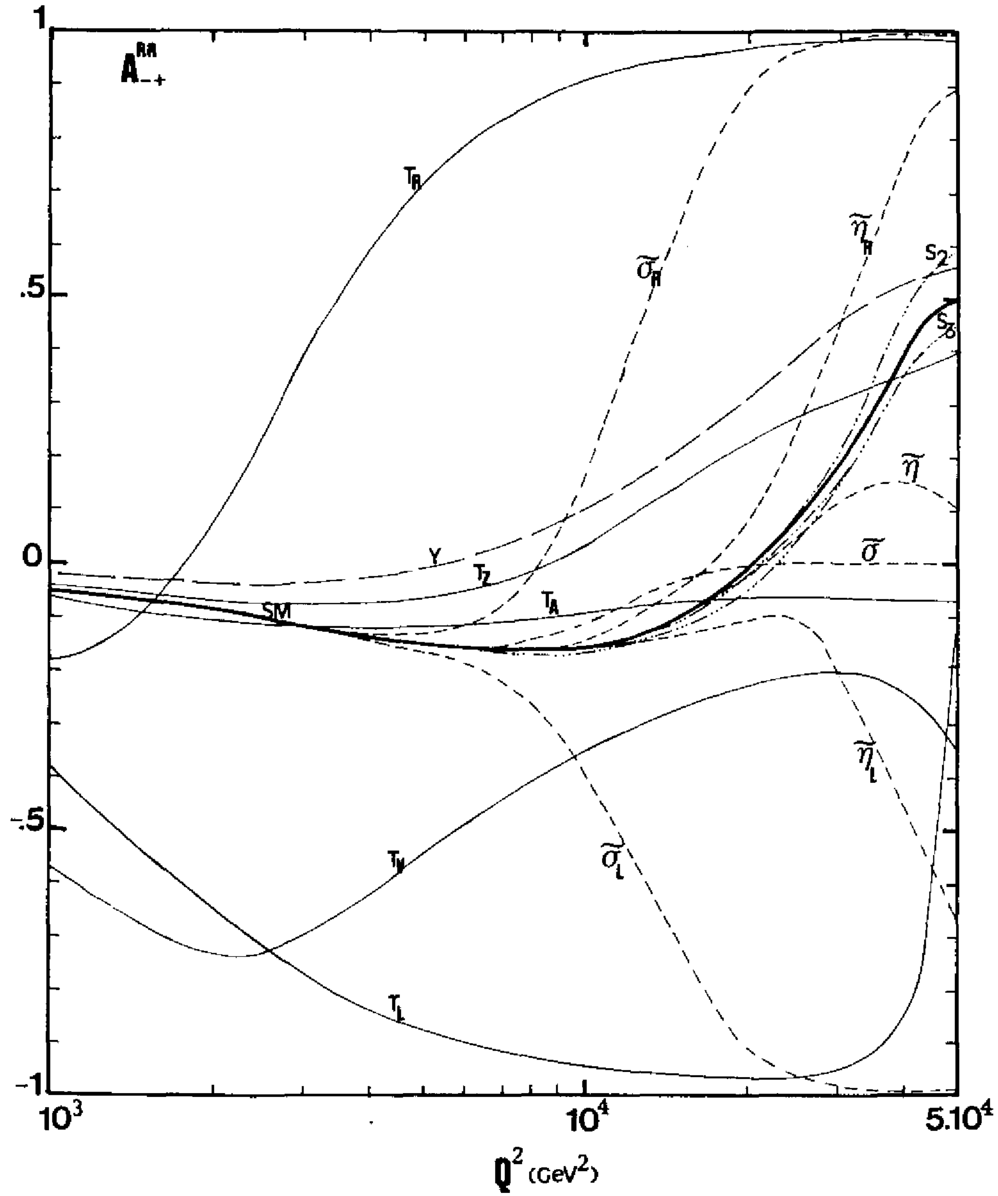
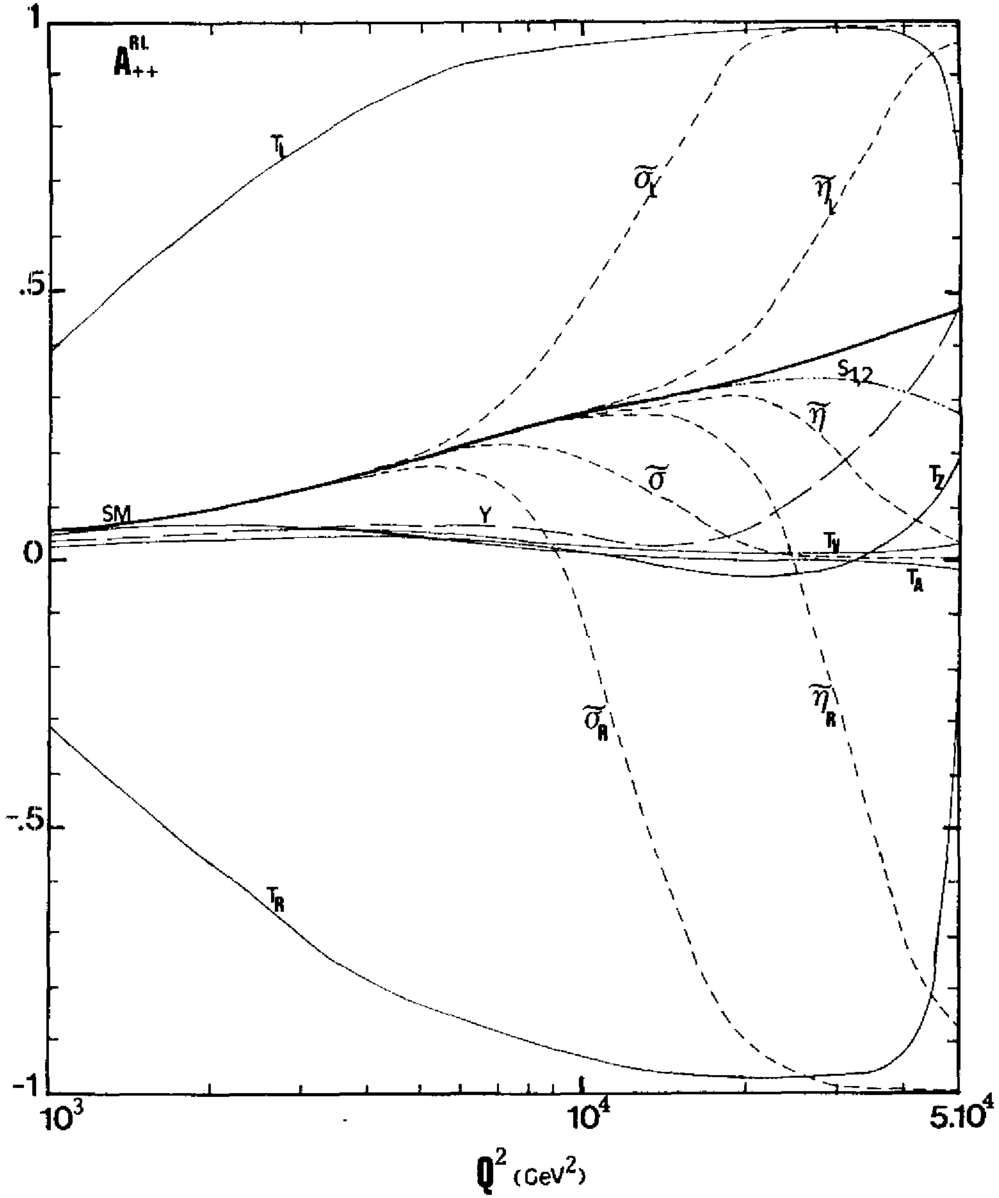
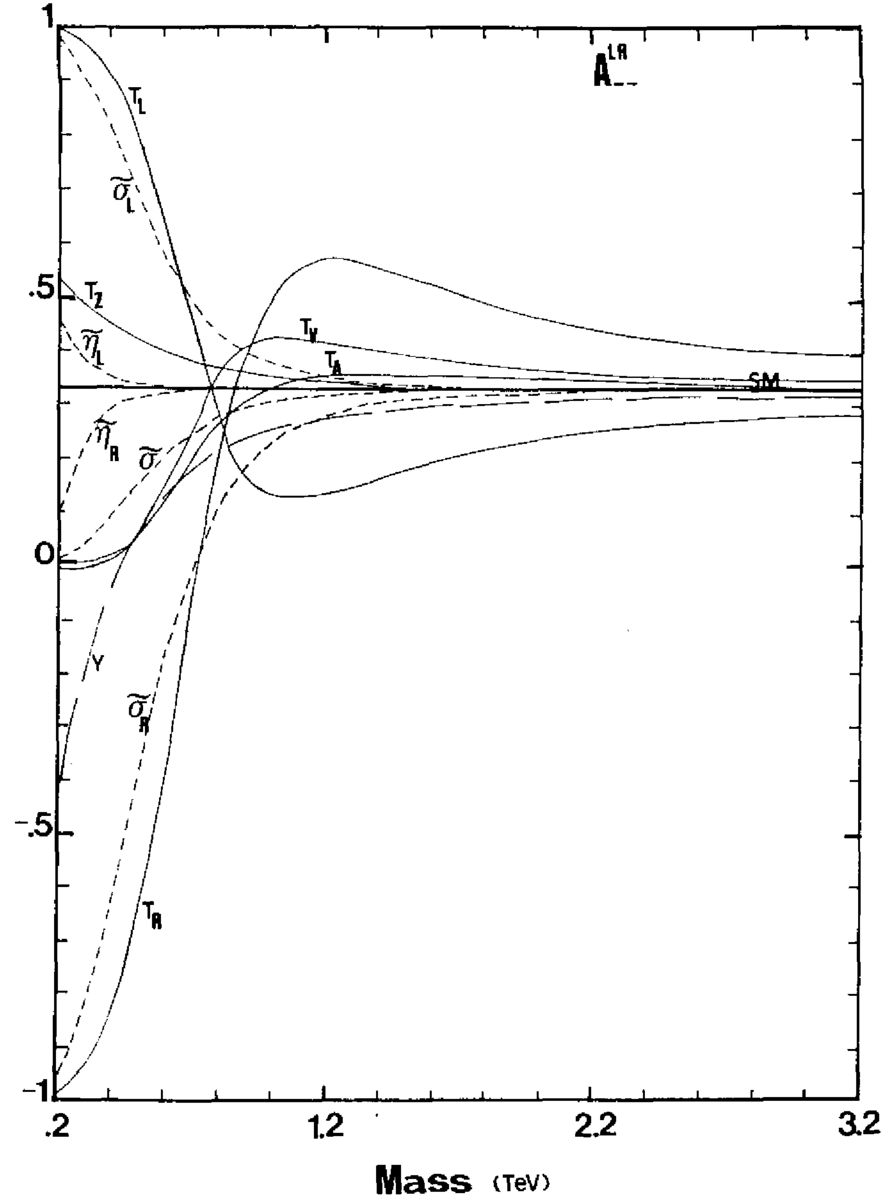

A^{RR}_{-+}
1
.5
0
-.5
-1
SM
Y
T_Z
T_A
T_R
T_N
T_L
$\tilde{\sigma}$
$\tilde{\sigma}_R$
$\tilde{\sigma}_L$
$\tilde{\eta}$
$\tilde{\eta}_R$
$\tilde{\eta}_L$
S_2
S_3
10^3
10^4
5.10^4
Q^2 (GeV^2)

FIG 4E



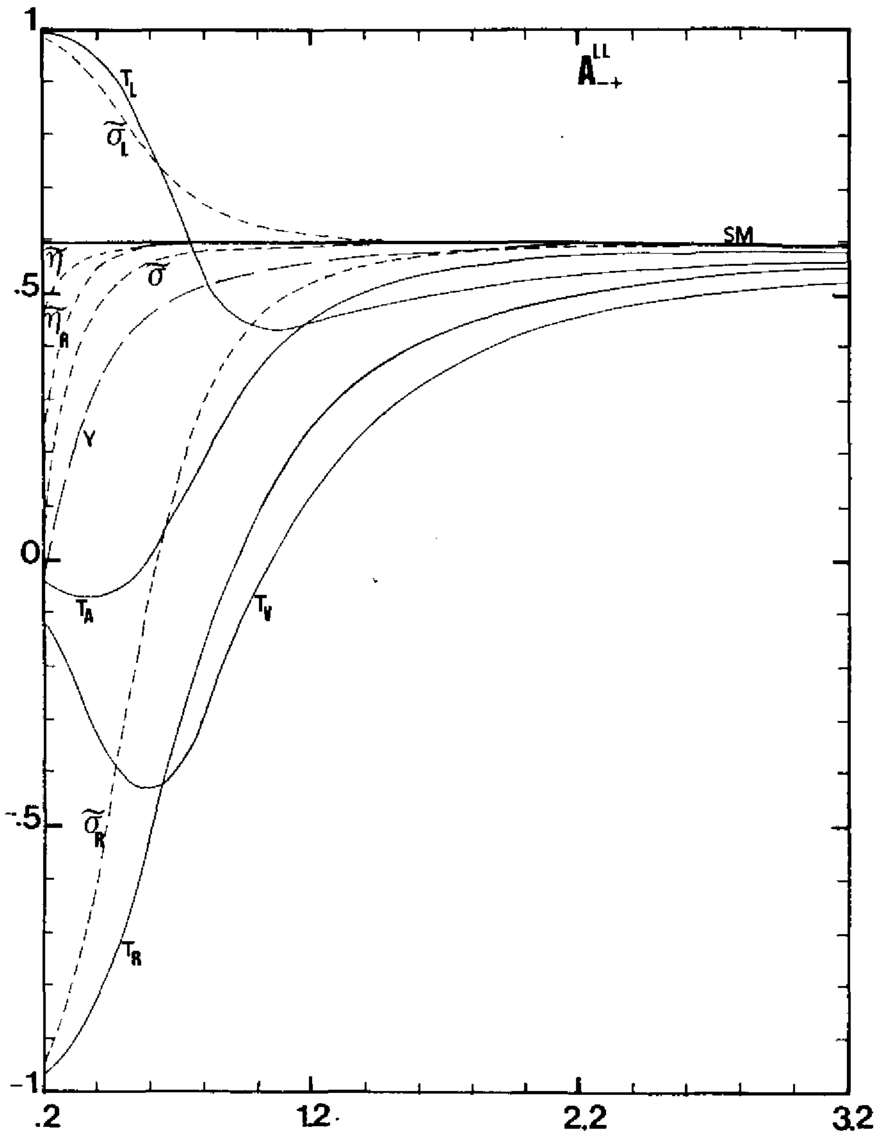
1
.5
0
-.5
-1
A^{RL}_{++}
T_L
$\tilde{\sigma}_L$
$\tilde{\eta}_L$
S_{12}
$\tilde{\eta}$
$\tilde{\sigma}$
T_Z
SM
Y
T_V
T_A
$\tilde{\sigma}_R$
$\tilde{\eta}_R$
T_R
10^3
10^4
5.10^4
Q^2 (GeV^2)

FIG 4F



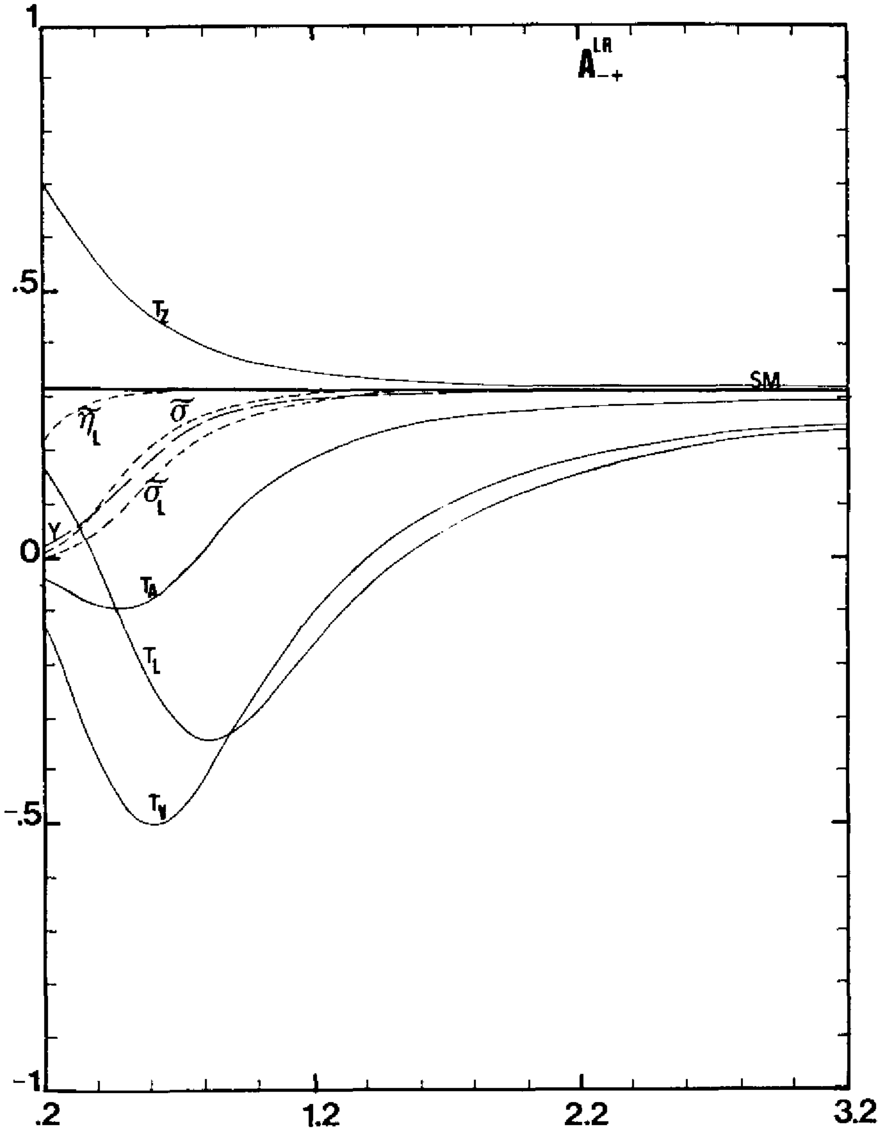
1
.5
0
-.5
-1
A^{LR}_{--}
T_L
$\tilde{\sigma}_L$
T_Z
$\tilde{\eta}_L$
T_V
T_A
SM
$\tilde{\eta}_R$
$\tilde{\sigma}$
Y
$\tilde{\sigma}_R$
T_R
.2
1.2
2.2
3.2
Mass (TeV)

FIG 5A



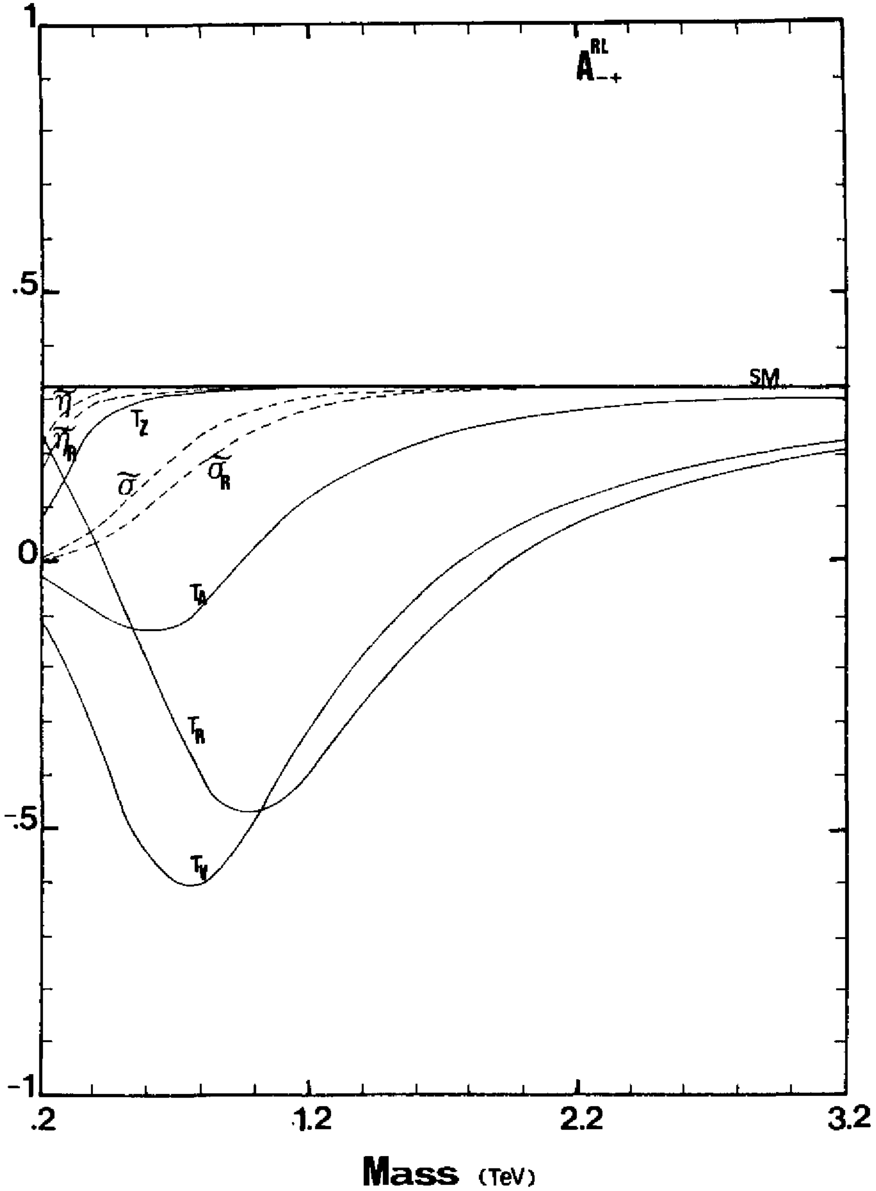
A^{LL}_{-+}
T_L
$\tilde{\sigma}_L$
SM
$\tilde{\eta}$
$\tilde{\sigma}$
$\tilde{\eta}_R$
Y
T_A
T_V
$\tilde{\sigma}_R$
T_R
1
.5
0
-.5
-1
.2
1.2
2.2
3.2
Mass (TeV)

FIG 5B



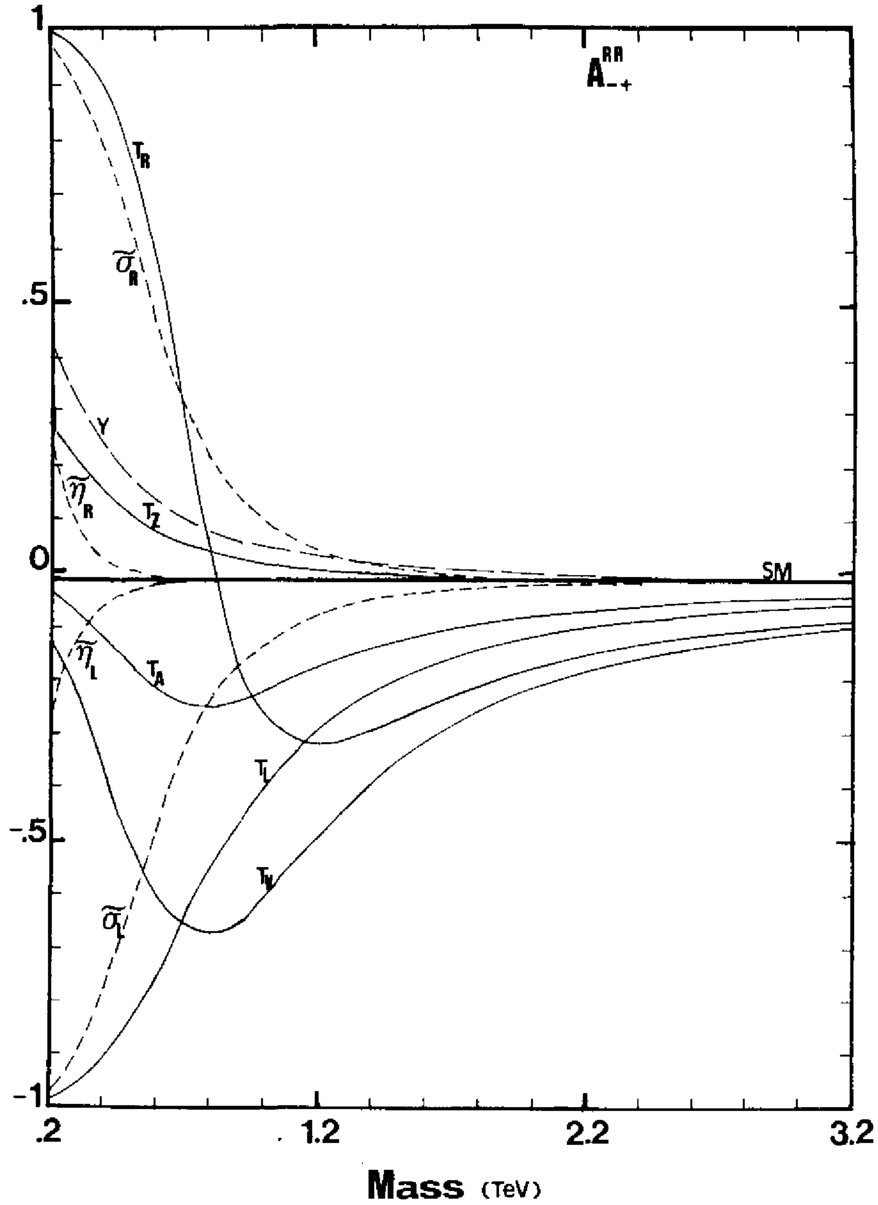
A^{LR}_{-+}
T_Z
SM
$\tilde{\eta}_L$
$\tilde{\sigma}$
$\tilde{\sigma}_L$
Y
T_A
T_L
T_V
1
.5
0
-.5
-1
.2
1.2
2.2
3.2
Mass (TeV)

FIG 5C



A^{RL}_{-+}
1
.5
0
-.5
-1
SM
$\tilde{\eta}$
$\tilde{\eta}_R$
T_Z
$\tilde{\sigma}$
$\tilde{\sigma}_R$
T_A
T_R
T_V
.2
1.2
2.2
3.2
Mass (TeV)

FIG 5D



A^{RR}_{-+}
1
.5
0
-.5
-1
T_R
$\tilde{\sigma}_R$
Y
$\tilde{\eta}_R$
T_Z
SM
$\tilde{\eta}_L$
T_A
T_L
T_V
$\tilde{\sigma}_L$
.2
1.2
2.2
3.2
Mass (TeV)

FIG 5E

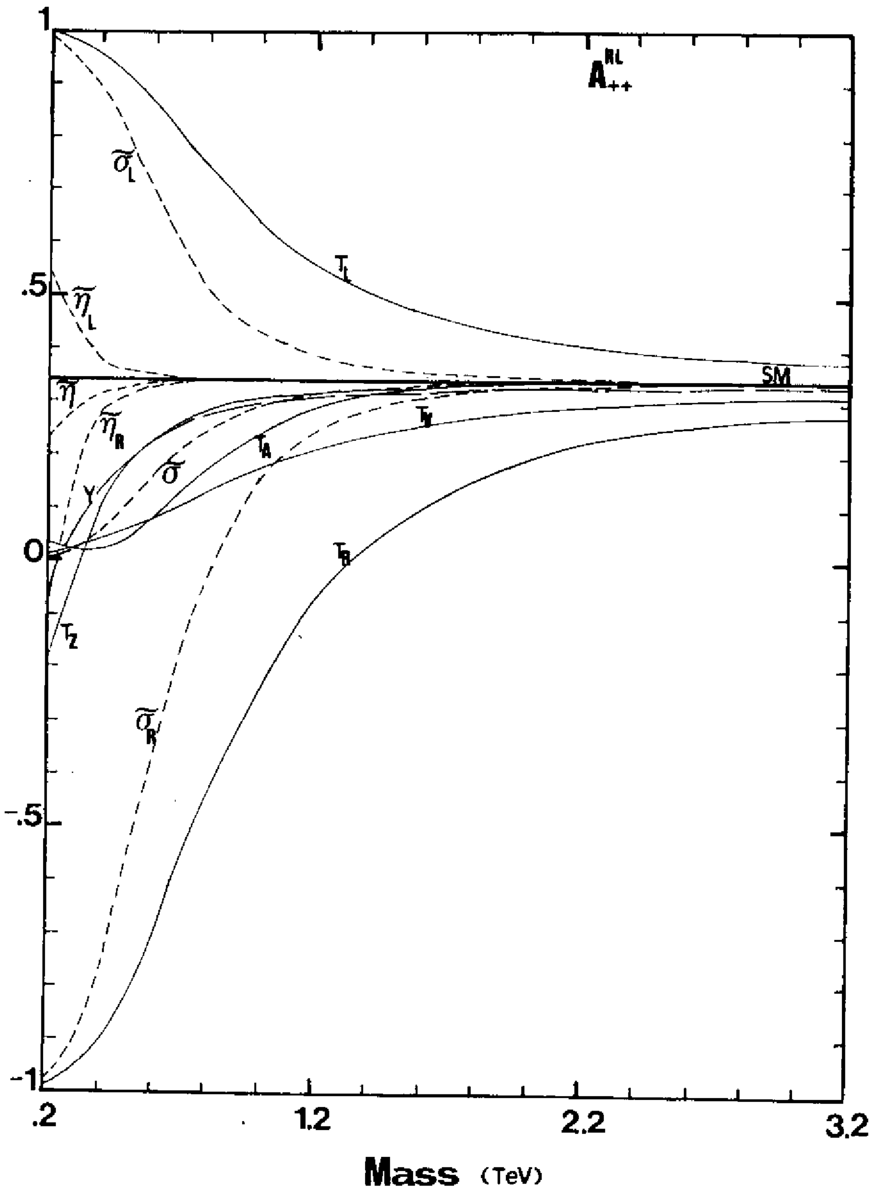


FIG 5F

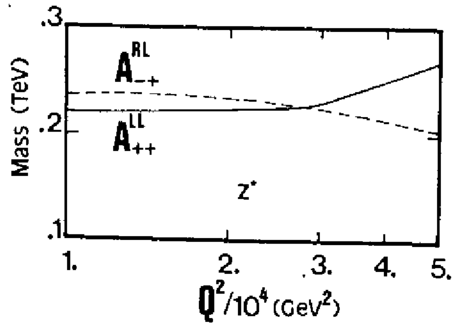


FIG 6A

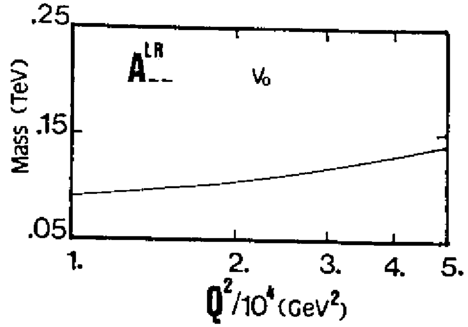


FIG 6B

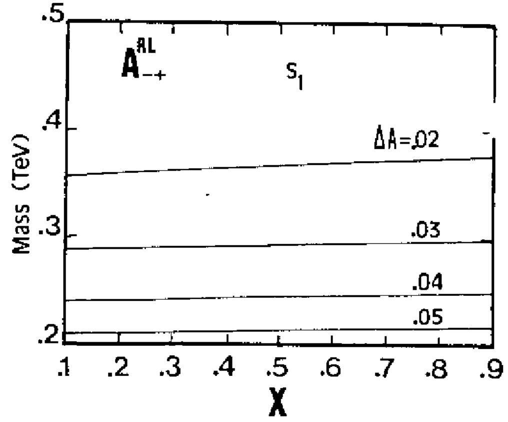


FIG 7A

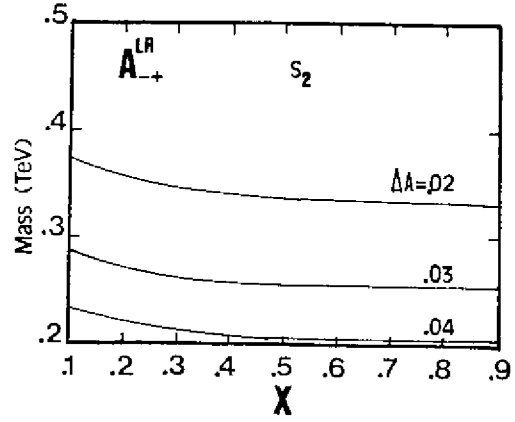


FIG 7B

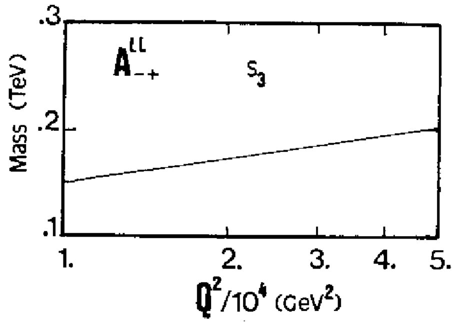


FIG 7C

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