TOP QUARK PRODUCTION IN EXTENDED BESS MODEL

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Abstract

We study top production at Tevatron collider in the extended BESS model, which is an effective lagrangian parametrization of a dynamical symmetry breaking of the electroweak symmetry. The existence of a colored octet of gauge vector bosons can increase top production at a rate still consistent with recent experimental data and lead to distortions in the transverse momentum spectrum of the top.

Key-Words: Top production. Dynamical Symmetry Breaking.

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1. Introduction

Very recently the CDF [1] and D0 [2] collaborations have established the existence of the top by observing a signal consistent with $t\bar{t}$ decay into $W^+W^-b\bar{b}$ with a statistical significance of $4.8\sigma$ and $4.6\sigma$ respectively. The observed topologies rely on the decay modes of the W bosons leading to dilepton events or to events with isolated leptons and more than three jets. To suppress background in the second mode b quark tagging is mandatory. The CDF measurement of the top quark mass is $m_t = 176 \pm 8 \pm 10$ GeV with a cross section of $6.8^{+3.6}_{-2.3}$ pb, whereas D0 collaboration has measured a mass $m_t = 199^{+19}_{-21} \pm 22$ GeV with a production cross section of $6.4 \pm 2.2$ pb. From LEP, which is sensitive to heavy particles through radiative corrections, it has been possible to extract a top mass in the same mass range $F(m_t = 178 \pm 11^{+18}_{-19}$ GeV), reinforcing our confidence that the top is around 180 GeV.

Since the top has a mass of the order of the electroweak symmetry breaking scale, it is not unreasonable to expect that it may be strongly coupled to the symmetry breaking dynamics and therefore the possibility that top production may give an insight on new physics beyond the SM has to be considered.

This sensitivity to new physics has been recently investigated in the context of walking technicolor [4]. The pseudo-goldstone color octet $\eta_T$, characterized by a small decay constant, can significantly increase and even double the top production rate at Tevatron collider if it lies in the mass range $\eta_T \sim 400 - 500$ GeV [5]. The existence of a color octet technirho boson, or contact terms from an effective lagrangian involving dimension six operators, may significantly modify the transverse momentum distribution of the top quark and the distribution of the decay $W$ boson [6]. Concerning the total cross section for top production it will also lead to significant deviations from SM expectations. Since present measurements of top production rate do not indicate a strong deviation from SM expectations, they will put constraints on this type of new physics.

In what follows we will restrict on the consequences of a strong dynamical electroweak symmetry scheme called the BESS model [7], which provides for a general frame avoiding specific dynamical assumptions. More precisely we will consider the extended BESS [8] - based on a chiral structure $SU(8)_L \times SU(8)_R$ - which includes as a special case the low energy phenomenology
of the one family technicolor model. This model leads to the existence of pseudo-goldstone bosons and new vector and axial vector resonances. The colored pseudo-goldstone bosons $\pi^a_s$ and the massive partners of the gluons, denoted as $V^a_s$, might significantly modify top production. The purpose of this work is to perform such a quantitative study.

Our extended-BESS calculations are only aimed at phenomenological studies, in the spirit of an effective lagrangian approach, including spin-1 bosons of the strong electroweak sector. The problem of an underlying field-theoretic dynamics, such as technicolor and extended technicolor models, is beyond the BESS model approach, which aims at being more general though of a more limited role. For the non-extended BESS, specialization to technicolor and extended technicolor was discussed in ref. [9]. Much work by different authors has been devoted during the last years to improve on the original technicolor ideas [10], after the soon appreciated difficulty of flavor changing neutral currents and the related fermion mass problem [11]. We have already referred to the proposal of walking technicolor [4] to induce bigger techni-condensates and allow for large fermion masses with extended technicolor at the needed large scale. The existence of an acceptable model with realistic properties is however still an unanswered question, complicated by the overall uncertainties related to non-perturbative strong dynamics. For the weak isospin-conserving technicolor the large mass difference between the top and the bottom quark would require weak-isospin violation at the extended technicolor level, which immediately raised up some doubts on the possibility of satisfying the experimental limits on the parameter $\rho$, in ordinary or in walking technicolor schemes. This lead in 1989 to consideration of schemes of strong extended technicolor [12], to have large top masses and satisfy the limits on $\rho$, for the values that were accepted at that time. Apart from the theoretical uncertainties typical of non-perturbative strong dynamics, a fine-tuning close to the line of criticality appeared necessary in those models [12], suggesting additional scalars of light mass [13]. For the vertex $Zb\bar{b}$ (see our discussion in Section 5 below) one may also expect smaller corrections in these cases. As we have said, we shall entirely refrain from speculating on particular underlying dynamical models and use BESS as a free effective model, only subject to existing experimental data. In particular this will concern the discussion of the possible direct couplings (called $b_S$ and $b'_S$ in Section 4 below) with would be hints at extended technicolor, when interpreted within such dynamical schemes. We must add that recent inves-
tigations have dealt with models of non-commuting extended technicolor, where the gauge boson of the extended technicolor generating the mass of $t$ has non trivial weak-$SU(2)$ transformation (with implications on $Z\bar{b}b$ [14]). Finally, as a further hint to the richness of dynamical schemes which have been recently proposed, we will also refer to a new class of technicolor models which incorporate a new strong dynamics mostly coupled to $t$ and $b$, and broken by technicolor [15]. Such schemes lead to consequences such as for instance ”top-pions” and new testable phenomenological effects, as described in ref. [15].

The paper is organized as follows. We will first recall in section 2 some basics of the $SU(8)$ BESS model. We study in section 3 the effect of a color octet of technipions on the top production at Tevatron collider. Section 4 is devoted to the consequences of the existence of an octet of massive colored vector bosons. We discuss the numerical results at Tevatron energy in section 5 and we conclude in section 6.

2. The $SU(8)$ BESS model

In a dynamical scheme for electroweak symmetry breaking an initial global invariance symmetry characterized by a group $G$, here $G = SU(8)_L \times SU(8)_R$, is spontaneously broken into a subgroup $H$, here $SU(8)_{L+R}$.

Assuming that the information for the fermion mass mechanism can be embedded into effective Yukawa couplings between ordinary fermions and pseudo-goldstones, their mass spectrum can be derived from the one loop effective potential which includes also the ordinary gauge interactions. One gets for the masses of the colored states [10]:

$$
M^2(\pi_{s}^{\alpha \pm}) = \frac{\Lambda^2}{4\pi^2v^2} \left[ m_t^2 + m_b^2 + \frac{9}{2}v^2g_s^2 \right]
$$

$$
M^2 \left( \frac{\pi_{s}^{\alpha} + \pi_{s}^{\alpha3}}{\sqrt{2}} \right) = \frac{\Lambda^2}{2\pi^2v^2} \left[ m_t^2 + \frac{9}{4}v^2g_s^2 \right]
$$

$$
M^2 \left( \frac{\pi_{s}^{\alpha} - \pi_{s}^{\alpha3}}{\sqrt{2}} \right) = \frac{\Lambda^2}{2\pi^2v^2} \left[ m_b^2 + \frac{9}{4}v^2g_s^2 \right]
$$

where $\Lambda$ is a cut-off, here taken equal to $\Lambda = 2$ TeV, $g_s$ the strong coupling constant and $v = 246$ GeV. For $\Lambda = 2$ TeV, the typical mass scale of the colored technipion is $\sim 1$ TeV.
After performing the $SU(3)_C \times SU(2)_L \times U(1)_Y$ gauging, the strong part of the lagrangian reads:

\[
\mathcal{L}_s = -\frac{v^2}{4} \left\{ b Tr \left( \sqrt{2} g_s G^\alpha_{\mu T} T^\alpha_8 - g'' V^\alpha_{\mu \bar{\nu} T} T^\alpha_8 \right)^2 \\
+ c Tr \left( g'' A^\alpha_{\mu \bar{\nu} T} T^\alpha_8 \right)^2 + d Tr \left( g'' A^\alpha_{\mu \bar{\nu} T} T^\alpha_8 \right)^2 \right\}
\]  

(2)

where $G^\alpha_\mu$ ($\alpha = 1, \ldots, 8$) is the octet of $SU(3)_C$ and $V^\alpha_{\mu \bar{\nu}}$ (resp. $A^\alpha_{\mu \bar{\nu}}$) the new color octet of vector (resp. axial vector) resonances. The $SU(8)$ generators satisfy the algebra:

\[
[T^A, T^B] = i f^{ABC} T^C \quad \text{with} \quad Tr(T^A T^B) = \frac{1}{2} \delta^{AB}
\]  

(3)

The eigenstates are obtained, after diagonalisation of the mass matrix, in the basis $(G^\alpha_{\mu T} T^\alpha_8, V^\alpha_{\mu \bar{\nu} T} T^\alpha_8)$:

\[
\frac{v^2}{4} \begin{pmatrix}
2 b g_s^2 & -\sqrt{2} b g_s g'' & 0 \\
-\sqrt{2} b g_s g'' & b g''^2 & 0 \\
0 & 0 & (c + d) g''^2
\end{pmatrix}
\]  

(4)

leading to the physical states characterized by the masses:

\[
M^2_{G} = 0
\]

\[
M^2_{V_8} = \frac{1}{4} b g''^2 v^2 \left[ 1 + \frac{2 g_s^2}{g''^2} \right]
\]  

(5)

\[
M^2_{A_8} = \frac{1}{4} (c + d) g''^2 v^2
\]

The physical bosons $G_\mu, V_{\mu \bar{\nu}}$ are related to $G^\alpha_\mu$ and $V^\alpha_{\mu \bar{\nu}}$ by:

\[
G_\mu = \cos \xi \cdot G_\mu + \sin \xi \cdot V_{\mu \bar{\nu}} \\
V_{\mu \bar{\nu}} = -\sin \xi \cdot G_\mu + \cos \xi \cdot V_{\mu \bar{\nu}}
\]  

(6)

with

\[
\tan \xi = \frac{\sqrt{2} g_s}{g''}
\]  

(7)
Notice that we get a massless color octet vector boson, the physical gluon, as it should be.

The coupling of the gluon to a quark antiquark pair is given by:

$$g_s \cos \xi \gamma_\mu \frac{\lambda^a}{2}$$  \hspace{1cm} (8)

We must have: $g'_s = g_s \cos \xi = g_{QCD}$.

The coupling to the physical colored massive gauge boson is given by:

$$- g_s \sin \xi \cdot \gamma_\mu \frac{\lambda^a}{2} \quad \text{i.e.} \quad - \frac{\sqrt{2} g'_s}{\sqrt{g''^2 - 2g'_s^2}} \gamma_\mu \frac{\lambda^a}{2}$$  \hspace{1cm} (9)

3. Top pair production through a color-octet pseudo goldstone boson $P_8$

The color octet pseudo goldstone boson is expected to decay predominantly into the heaviest kinematically allowed fermion pair or into $gg$ through the anomaly.

The decay into $t\bar{t}$ is calculated from the lagrangian:

$$\mathcal{L}_y = m_t \bar{t} R e \frac{2i}{\sqrt{2}} (T^\alpha_8 \bar{\pi}^\alpha_8 + T^{a3}_8 \bar{\pi}^{a3}_8) t_L + \text{h.c}$$  \hspace{1cm} (10)

leading to a partial width:

$$\Gamma(P^0_{8} \to t\bar{t}) = \frac{1}{2\pi} \left( \frac{m_t}{v} \right)^2 M_{P_8} \sqrt{1 - \frac{4m_t^2}{M_{P_8}^2}}$$  \hspace{1cm} (11)

where $P^0_8 = \frac{1}{\sqrt{2}} (\pi_8 - \pi^{a3}_8)$. The amplitude for $\pi_8^\alpha \to gg$ is calculated from the Adler-Bell-Jackiw triangle anomaly [17].

One gets

$$\Gamma(\pi_8^\alpha \to gg) = \alpha_s^2 C_g \frac{10}{3} \frac{1}{\pi^3} M_{\pi_8}^3 \left( \frac{1}{v} \right)^2$$  \hspace{1cm} (12)

where $C_g$ is a dimensionless parameter, expected to be not too different from one. It is equal to one for the one family technicolor model with $N_{TC} = 8$. 
It corresponds to a phenomenological parameter in our BESS model. The physical $P_8^0$ is a mixed state of $\pi_8^\alpha$ and $\pi_8^\beta$, and since $\pi_8^\beta$ does not contribute, we get:

$$\Gamma(P_8^0 \to gg) = \alpha_8^2 C g \frac{1}{\pi} M_{P_8^0}^3 \left(\frac{1}{v}\right)^2$$

(13)

For $M_{P_8^0} = 822$ GeV, the dominant contribution to the total width $\Gamma_{\text{tot}}$ is mainly due to top decay since $\Gamma(P_8^0 \to t\bar{t}) = 60.5$ GeV and $\Gamma(P_8^0 \to gg) = 6.9$ GeV (for $C_g = 1$ and $m_t = 176$ GeV).

The colored pseudo goldstone bosons being relatively narrow, the partonic cross section $gg \to P_8^0 \to t\bar{t}$ reads:

$$\frac{d\hat{\sigma}}{d\cos \theta} = \frac{\pi}{4} \frac{\Gamma(P_8^0 \to gg)\Gamma(P_8^0 \to t\bar{t})}{(\hat{s} - M_{P_8^0}^2)^2 + M_{P_8^0}^2 \Gamma_{P_8^0}^2}$$

(14)

The hadronic cross section is obtained after convolution with the gluon structure function $g(x, M^2)$.

The observable we deal with is the transverse momentum of the top:

$$\frac{d\sigma}{dp_{\text{top}}^T dy} = 2 p_{\text{top}}^T \int_{x_{\min}}^{1} dx_1 \frac{x_1 x_2}{x_1 - p_{\text{top}}^T} \chi e^y \frac{d\hat{\sigma}}{dt}$$

$$= \int_{-y_B}^{y_B} dy \int_{x_{\min}}^{1} dx_1 \frac{x_1 x_2}{x_1 - p_{\text{top}}^T} \chi e^y \frac{d\hat{\sigma}}{dt}$$

(15)

where $f_B^H(x, M^2)$ are the partonic structure functions evolved at scale $M^2$.

$$\frac{d\sigma}{dp_{\text{top}}^T} = 2 p_{\text{top}}^T \int_{-y_B}^{y_B} dy \int_{x_{\min}}^{1} dx_1 \frac{x_1 x_2}{x_1 - p_{\text{top}}^T} \chi e^y \frac{d\hat{\sigma}}{dt}$$

$$\frac{\Gamma(P_8^0 \to gg)\Gamma(P_8^0 \to t\bar{t})}{2x_1 x_2 s \beta (\hat{s} - M_{P_8^0}^2)^2 + M_{P_8^0}^2 \Gamma_{P_8^0}^2} + \frac{d\hat{\sigma}}{dt}$$

(16)

where $\hat{t} = -\hat{s} (1 - \beta \cos \theta) / 2$, $y$ is the top rapidity,

$$\beta = \sqrt{1 - \frac{4m_t^2}{s}}$$

$$\chi = \sqrt{1 + \frac{m_t^2}{(p_{\text{top}}^T)^2}}$$

$$x_1 = \frac{p_{\text{top}}^T \chi e^{-y}}{x_1 \sqrt{s - p_{\text{top}}^T \chi e^y}}$$

$$x_2 = \frac{p_{\text{top}}^T \chi e^{-y}}{x_1 \sqrt{s - p_{\text{top}}^T \chi e^y}}$$

$$x_{\min} = \frac{\Gamma_{P_8}}{\sqrt{s - p_{\text{top}}^T \chi e^y}}$$
\( \sigma_{\text{SM}} \) is the QCD cross section \[19\], slightly modified from the SM expectation due to the mixing angle \( \xi \).

At Tevatron energy the differential cross section \( \frac{d\sigma}{dp_T^{\text{top}}} \) is very small in magnitude since gluon gluon subprocess is suppressed compared to quark-antiquark channel. Moreover, the pseudo goldstone \( P_8^0 \) is too massive to produce a clear signal distinguishable from the QCD background.

4. **Top pair production from a color-octet massive vector resonance**

Let us first assume that there is no direct coupling of the massive octet vector resonance to quarks. The total width of the massive gauge boson \( V_8^\alpha \), assuming five massless quarks and taking into account only the top quark mass, reads:

\[
\Gamma(V_8^\alpha) = \frac{1}{12\pi} \frac{g_8'^4}{g''^2 - 2g_8'^2} m_t^2 \left[ 5 \left( 1 - \frac{4m_t^2}{M_V^2} \left( 1 + \frac{2m_t^2}{M_V^2} \right) \right) \right] \tag{17}
\]

with \( g'_s = \frac{g_s g''}{\sqrt{g''^2 + 2g_s'^2}} \).

Top quark production is obtained by coherent sum of the gluon and \( V_8 \) s-channel amplitudes. The differential partonic cross section reads:

\[
\frac{d\hat{\sigma}}{dt} = \frac{| M |^2}{16\pi s^2}
\]

with

\[
| M |^2 = \frac{4}{9} g_8' \left( m_t^2 - \hat{u} \right)^2 + \left( m_t^2 - \hat{t} \right)^2 + 2\hat{s}m_t^2 \left[ 1 + \frac{4g_8'^4}{(g''^2 - 2g_s'^2)^2} \left( \hat{s} - M_{V_8}^2 \right)^2 + \frac{M_{V_8}^2 \Gamma_{V_8}^2}{\hat{t}} \right] \tag{18}
\]

A direct coupling of the colored gauge bosons \( V_8^\alpha \) to quarks can be considered, extending the construction of \[7\] to the extended BESS model. Then the
couplings to $q\bar{q}$ pairs become:

$$g_s' \frac{\lambda^a}{2} \gamma_\mu$$  
for the gluon

$$\frac{\sqrt{2}}{2} \frac{(b_s g_s''^2 - 2 g_s'2 (1 + b_s)) \lambda^a}{2(1 + b_s) \sqrt{g_s''^2 - 2 g_s'^2}}$$  
for the $V_8^a$

In principle we can have two different couplings one for light quarks, parametrized by $b_s$, and one for top and bottom quarks parametrized by $b'_s$.

The presence of parameters $b_s$ and $b'_s$ different from zero will modify the expression of the squared matrix element $|M|^2$ \((q\bar{q} \rightarrow g, V_8 \rightarrow t\bar{t})\) according to:

$$|M|^2 = \frac{4}{9} \frac{(m_t^2 - \hat{t})^2 + (m_t^2 - \hat{t})^2 + 2 \hat{s} m_t^2}{\hat{s}^2} \left[ g_s'^4 \frac{s^2}{(\hat{s} - M_{V_8}^2)^2 + M_{V_8}^2 \Gamma_{V_8}^2} + \frac{2 \hat{s} (\hat{s} - M_{V_8}^2)}{(\hat{s} - M_{V_8}^2)^2 + M_{V_8}^2 \Gamma_{V_8}^2} \times \frac{g_s'^2 \left[ b_s g_s''^2 - 2 g_s'^2 (1 + b_s) \right] \left[ b'_s g_s''^2 - 2 g_s'^2 (1 + b'_s) \right]}{2(1 + b_s) (1 + b'_s) (g_s''^2 - 2 g_s'^2)} \right]$$  
(20)

The above expression corresponds to an initial state with light quarks. For the process involving bottom quarks in the initial state i.e. for the subprocess $b\bar{b} \rightarrow t\bar{t}$ $b_S$ must be replaced by $b'_S$ in the previous relation. We are now ready to study the increase of the total cross section due to the colored massive vector resonance and the modification on the observable $\frac{d\sigma}{dpt_{\text{top}}}$.

In this analysis, for simplicity, we did not include a direct coupling for the axial vector particles.

5. Numerical results

We consider top production at the Tevatron energy $\sqrt{s} = 1.8$ TeV. The BESS contribution depends on two parameters: the mass of the color octet boson...
and the strength of its coupling to quarks. We give, in fig.1, the prediction concerning the transverse momentum spectrum of the top, for $b_S, b'_S = 0$ using two values of the $SU(8)_V$ coupling constants $g'' = 15$ and 20, which are consistent with LEP1 bounds. The top mass has been fixed to 170 GeV and the colored vector boson mass to 600 GeV. We observe a slight excess of events -above the QCD prediction- for $p_{T}^{\text{top}} \geq 200$ GeV. This corresponds to the jacobian peak shifted from $p_{T}^{\text{top}} \approx M_{V_8}/2$ towards lower $p_{T}^{\text{top}}$ values due to the heavy top mass. The deviation from SM expectations is more pronounced for $g'' = 15$, leading to an excess of events around $p_{T}^{\text{top}} \sim 240$ GeV by a factor 2-3. There is no significant increase of the total cross section compared to SM expectation. When the colored gauge boson becomes heavier the effect becomes less and less important. For $M_{V_8} \approx 1$ TeV there is no significant distortion in the transverse momentum spectrum of the top.

When direct couplings, i.e. $b_S, b'_S \neq 0$, are allowed, more drastic deviations appear. This is illustrated in figures 2 and 3 respectively, for $g'' = 20$ with $M_{V_8} = 600$ GeV. In the choice of the parameter $b_S$ and $b'_S$ we restrict ourselves to values which are allowed by the uncertainty in our knowledge of the decay $Z$ widths in hadrons $\Gamma_h$ and $b\bar{b} \Gamma_b$. This is because the new color octet gives vertex corrections to $\Gamma_h$ and $\Gamma_b$ [8], depending on the choice of BESS parameters. For instance for $g'' = 20$, $M_{V_8} = 400$ GeV and $b_S = 0.03$ we have $\delta\Gamma_h/\Gamma_h = 1.6 \times 10^{-4}$, which is one order of magnitude smaller than the experimental value $\delta\Gamma_h/\Gamma_h$.

Two set of values for the direct coupling parameters have been chosen in fig.2: $b_S = 0$, $b'_S = -0.03$ and $b_S = b'_S = -0.03$. In both cases we observe an excess of events around $p_{T}^{\text{top}} \sim 240$ GeV. For $b_S = b'_S$ values large and negative, the presence of the colored vector resonance is clearly manifest since we would get an increase of the differential cross section by a factor of $\sim 40$. For $b'_S = -0.03$ and $b_S = 0$, the existence of a colored massive gauge boson would increase the differential cross section around $p_{T}^{\text{top}} \sim 240$ GeV by roughly a factor of four. If we choose a smaller $g''$ value (like $g'' = 15$) there is a slight increase of the differential cross section around the jacobian peak. Concerning the total cross section its increase depends strongly on the values for the direct couplings. The greatest discrepancy is observed when both $b_S$ and $b'_S$ are large and negative, where we get $\sigma_{\text{tot}} = 8.24$ pb. In any case this value is within 1$\sigma$ from the experimental value. As shown in fig.3 for the sets $b_S = 0$, $b'_S = 0.03$ and $b_S = b'_S = 0.03$ we get an increase of events by roughly one order of magnitude around $p_{T}^{\text{top}} \sim 240$ GeV.
Deviations become more drastic for lighter \( V_s \): for \( M_{V_s} \simeq 400 \text{ GeV} \) the excess of events is displaced around \( p_T^{\text{top}} \sim 100 \text{ GeV} \). This is illustrated in fig.4 for \( b_S = b'_S = -0.005 \) and \( b_S = b'_S = 0.02 \) with \( g'' = 20 \). For \( M_{V_s} = 600 \text{ GeV} \), even for large negative \( b_S = b'_S \) values, the excess of events is within the experimental bounds whereas for \( M_{V_s} = 400 \text{ GeV} \) the range of direct couplings still compatible with CDF and D0 experiments is more restricted for a top mass of 176 GeV. The choice of parameters in fig.4 corresponds to the upper and lower limits. In fact, in this case, for \( b_S = b'_S = -0.005 \) we get \( \sigma_{\text{tot}} = 8.24 \text{ pb} \). The next to leading QCD corrections \cite{19}, not taken into account in this work, are expected to increase this Born cross section by roughly 30% in the same way for the SM contribution and for the BESS contribution.

If we increase the top mass up to 200 GeV, since the Standard Model value of the total cross section is smaller, a larger domain of BESS parameters remains still allowed. As an example the limits on direct couplings are \( b_S = b'_S = -0.02 \) for \( M_{V_s} = 400 \text{ GeV} \).

6. Conclusion

We have studied top production in the extended BESS model. At Tevatron energy, since gluon gluon subprocess is very small compared to quark anti-quark annihilation subprocess, the contribution of a colored pseudo goldstone boson is not expected to modify SM predictions for top production.

The existence of a relatively light massive color-octet vector resonance \( (M_{V_s} > 500 \text{ GeV}) \) leads to an excess of top production still compatible with present data for a very large domain of BESS parameters. Therefore the observation of significant distortions in the transverse momentum spectrum of the top, and certainly also of the transverse momentum distribution of the \( W \) boson, will be the appropriate way to constrain the BESS model parameters in the strong sector and more precisely the direct couplings of the colored vector resonances to quarks.

Predictions at LHC will be different since the gluon gluon subprocess is dominant. Therefore the anomaly-type contribution is not expected to be negligible and top production from decay of pseudo goldstone bosons has also to be taken into account.
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**Figure Captions**

Fig.1 Transverse momentum spectrum of the top at Tevatron Collider. Full curve: SM prediction. Dashed (resp. dotted) curve: BESS prediction for $g'' = 20$ (resp. $g'' = 15$), $M_{\bar{\psi} s} = 600$ GeV and $b_S = b'_S = 0$.

Fig.2 Transverse momentum spectrum of the top at Tevatron Collider. Full curve: SM prediction. Dashed (resp. dotted) curve: BESS prediction for $b_S = 0$ and $b'_S = -0.03$ (resp. $b_S = b'_S = -0.03$), $M_{\bar{\psi} s} = 600$ GeV and $g'' = 20$.

Fig.3 Transverse momentum spectrum of the top at Tevatron Collider. Full curve: SM prediction. Dashed (resp. dotted) curve: BESS prediction for $b_S = 0$ and $b'_S = 0.03$ (resp $b_S = b'_S = 0.03$), $M_{\bar{\psi} s} = 600$ GeV and $g'' = 20$.

Fig.4 Transverse momentum spectrum of the top at Tevatron Collider. Full curve: SM prediction. Dashed (resp. dotted) curve: BESS prediction for $b_S = b'_S = -0.005$ (resp. $b_S = b'_S = 0.02$), $M_{\bar{\psi} s} = 400$ GeV and $g'' = 20$. 
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