Top quark production: Sensitivity to new physics

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The production cross section and distributions of the top quark are sensitive to new physics; e.g., the $t\bar{t}$ system can be a probe of new resonances or gauge bosons that are strongly coupled to the top quark, in analogy with Drell-Yan production. The existence of such new physics is expected in dynamical electroweak symmetry-breaking schemes, and associated with the large mass of the top quark. The total top quark production cross section can be more than doubled, and distributions significantly distorted with a chosen scale of new physics of ~ 1 TeV in the vector color singlet or octet s channel. New resonance physics is most readily discernible in the high-p_T distributions of the single top quark and of the W boson, and the mass distribution of the $t\bar{t}$ pair.

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We also consider a color octet of massive vector bosons B_μ^A also of mass M_B, which we will call "colorons." These are necessarily degenerate because QCD is unbroken. Such objects may be composite, ρ-like objects, with a scale of compositeness of order $\sim M_B$ which serves as a cutoff scale for the B_μ^A effective Lagrangian. It then suffices to consider B_μ^A as a linear representation of QCD (if B_μ^A are fundamental, with effectively infinite cutoff, then consistency requires they are necessarily gauge bosons, as we consider below). We can write a phenomenological coupling as

$$g_3\left[z_1\bar{\psi}\gamma_\mu\frac{\lambda^A}{2}\psi+z_2\bar{t}\gamma_\mu\frac{\lambda^A}{2}t\right]B^{A,\mu}\ . \qquad (13)$$

Here we again use rescaled QCD couplings, $z_1 g_3$ and $z_2 g_3$. The process $\bar{q}+q\to\bar{t}+t$ involves the coherent sum of the gluon and coloron s-channel amplitudes. It is therefore easy to implement the effect of the coloron in QCD production, i.e., we simply make the replacement in the gluon propagator:

$$\frac{g_3^2}{s}\to\frac{g_3^2}{s}+\frac{g_3^2 z_1 z_2}{(s-M_B^2)+iM_B\Gamma_B}\ . \qquad (14)$$

The production amplitude therefore depends upon the product of the new rescaled coupling constants, $z_1 z_2$ (which can be negative), the mass M_B, and the coloron width Γ_B. As we will see below, the relative sign of these terms, determined by the sign of $z_1 z_2$, has a significant effect in shaping the top quark p_T distributions.

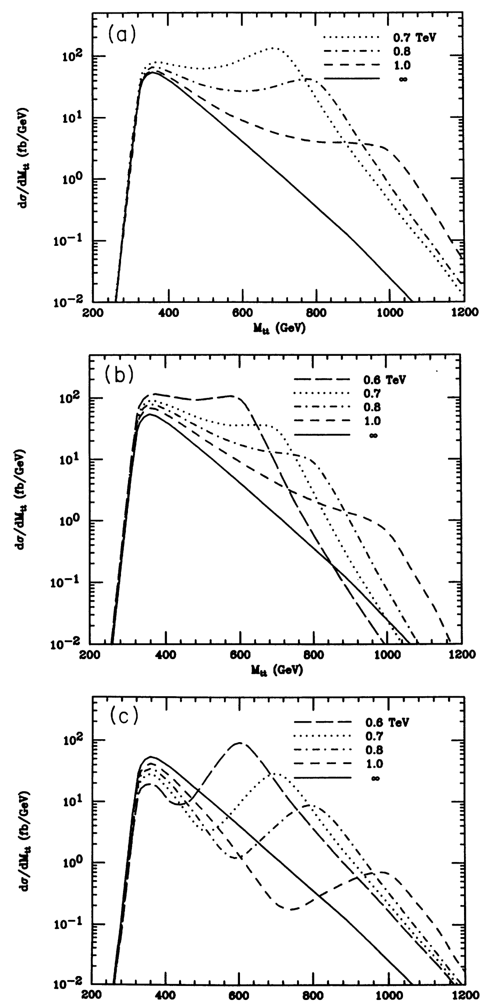

FIG. 6. The differential distribution $d\sigma/dM_{tt}$, where M_{tt} is mass of the $t\bar{t}$ quark pair. Results are presented in sequence as in Fig. 4.

the following sequence: (a) the gauge color-singlet vector resonance model (A); (b) the gauge color-octet vector resonance model (B) (with $z_1 z_2=-1$); (c) the hybrid gauge color-octet vector resonance model (C) (with $z_1 z_2=+1$). Results are given in each case for resonance masses $M_B=(0.6,\ 0.7,\ 0.8,\ 1.0)$ TeV, and $M_B\to\infty$ corresponding to pure QCD.

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