FERMILAB-Conf-95/373-T
hep-ph/9511468
November 29, 1995

TOP QUARK PAIR PRODUCTION: SENSITIVITY TO NEW PHYSICS *

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ABSTRACT

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 to 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 production cross–section can be more than doubled, and distributions significantly distorted with a chosen scale of new physics of $\sim$ 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, of the W boson and the mass distribution of the $t\bar{t}$ pair.

1. Summary

Top quark production at the Fermilab Tevatron probes very high mass scales, $\mathcal{O}(500\ GeV)$, and therefore is sensitive to new physics at this scale. Hence, it is important that we studied this process with high precision and compare the results with the Standard Model predictions.

The dominant mode of top quark production at hadron colliders is via quark-antiquark annihilation or gluon-gluon fusion,

$$\begin{aligned} q\,\bar{q} &\rightarrow t\,\bar{t} \\ g\,g &\rightarrow t\,\bar{t}. \end{aligned}$$

Fig. 1 is the QCD cross section for $m_t = 175\,GeV$ verses $\sqrt{s}$ for both proton-proton colliders and for proton-antiproton colliders. At $\sqrt{s} = 1.8\ TeV$ the gluon-gluon fusion is only 10% of the cross section for a proton-antiproton collider, the Tevatron, whereas at a 14 TeV proton-proton collider, the LHC, gluon-gluon fusion is 90% of the cross section.

Hill and Parke [1] have studied the effects of new physics on top quark production in a general operator formalism as well as in topcolor models. In these models the distortions in top quark production and shape are due to new physics in the $q\bar{q}$

*Invited talk at the International Symposium on Heavy Flavor and Electroweak Theory, Beijing, China, August 17-19, 1995.

†Fermilab is operated by the Universities Research Association under contract with the United States Department of Energy.

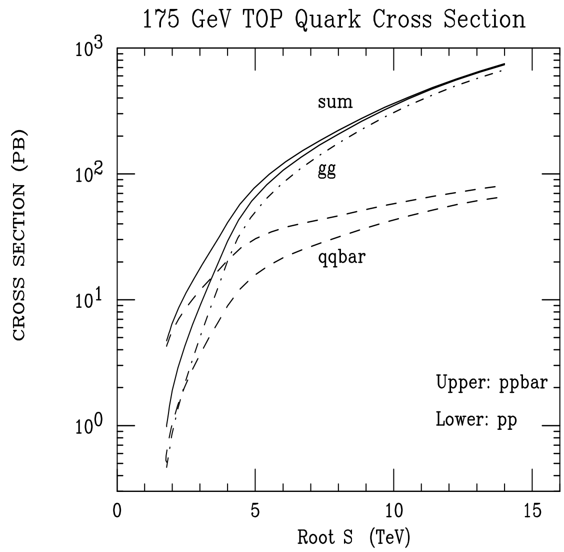

Figure 1: QCD Top quark Production cross section as a function of $\sqrt{s}$, for quark-antiquark annihilation (dashes), gluon-gluon fusion (dot-dash) and the sum (solid) for both proton-antiproton (upper) and proton-proton (lower) colliders.

subprocess. The effects of a coloron which couples weakly to the light generations but strongly to the heavy generation is given in Fig. 2.

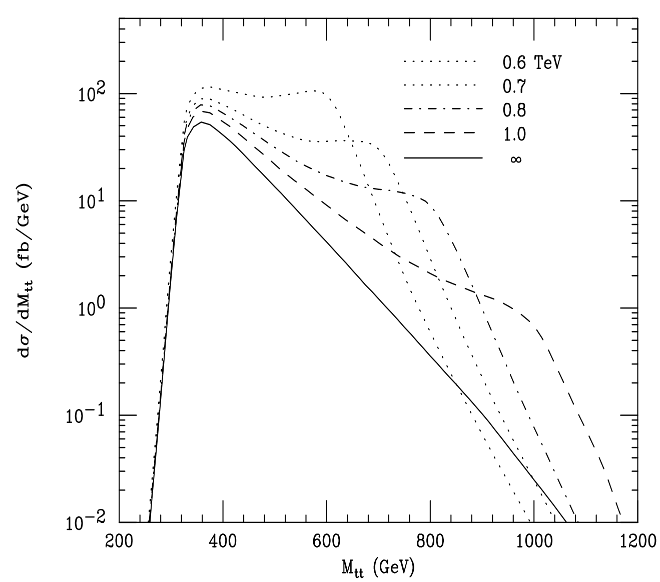

Figure 2: The invariant mass of the $t\bar{t}$ pair for the topcolor octet model.

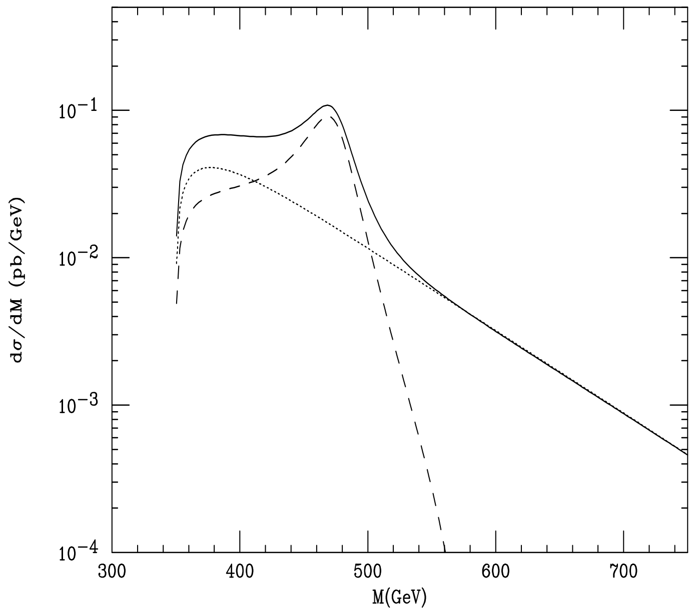

Figure 3: The invariant mass of the $t\bar{t}$ pair for the two scale technicolor model.

Similarly Eichten and Lane [2] have studied the effects of multi-scale technicolor on top production through the production of a techni-eta resonance, see Fig. 3. Here the coupling of the techni-eta is to gg, therefore only this subprocess is different than the standard model. At the Fermilab Tevatron top production is dominated by $q\bar{q}$ annihilation while at the LHC it is the gg fusion subprocess that dominates. Therefore these models predict very different consequences for top production at the LHC.

Therefore the top quark is an exciting new window on very high mass scale physics. While exploring the vista from this window we should be on the lookout for any deviation from the Standard Model which will provide us with information about that elusive beast, the mechanism of electro-weak symmetry breaking. Because the mass of the top quark is very heavy, this quark is the particle most strongly coupled to the electro-weak symmetry breaking sector. Therefore the deviations could be seen at zeroth order or may require more subtle measurements. What is needed is hundreds of top-antitop pairs as soon as possible. Then, watch out for surprises!

2. Acknowledgements

I would like to thank E. Eichten, K. Lane and especially my collaborator C. Hill for many discussions on this topic.

3. References

1. C. Hill and S. Parke, Phys. Rev. **D49** 4454, (1994).
2. E. Eichten and K. Lane, Phys. Lett. **B327** 129, (1994).