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Addendum to: Search for anomalous top-gluon couplings at LHC revisited

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ABSTRACT

In our latest paper "Search for anomalous top-gluon couplings at LHC revisited" in *Eur. Phys. J.* **C65** (2010), 127–135 (arXiv:0910.3049 [hep-ph]), we studied possible effects of nonstandard top-gluon couplings through the chromoelectric and chromomagnetic moments of the top quark using the total cross section of $p\bar{p}/pp \to t\bar{t}X$ at Tevatron/LHC. There we pointed out that LHC data could give a stronger constraint on those two parameters, which would be hard to obtain from Tevatron data alone. We show here the first CMS measurement of top-pair-production cross section actually makes it possible.

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In our latest paper [1], we studied possible effects of nonstandard top-gluon couplings through the chromoelectric and chromomagnetic moments of the top quark yielded by $SU(3) \times SU(2) \times U(1)$ invariant dimension-6 effective operators [2, 3] (see also [4]) via the total cross section of $p\bar{p}/pp \to t\bar{t}X$ at Tevatron/LHC. There we pointed out that future LHC data could give a stronger constraint on those two parameters, which would be hard to obtain from Tevatron data alone. This note is an addendum to that paper and the aim is to show that the recently reported first CMS measurements [5] actually make it possible.

In our framework the top-gluon interaction Lagrangian including the above operator contribution is given by

$$\begin{aligned}\mathcal{L}_{t\bar{t}g,gg} = -\frac{1}{2} g_s \sum_a \Big[& \bar{\psi}_t(x)\lambda^a\gamma^\mu\psi_t(x)G^a_\mu(x) \\ & - \bar{\psi}_t(x)\lambda^a\frac{\sigma^{\mu\nu}}{m_t}(d_V + id_A\gamma_5)\psi_t(x)G^a_{\mu\nu}(x)\Big], \end{aligned} \tag{1}$$

where g_s is the $SU(3)$ coupling constant, and d_V and d_A correspond to the top chromomagnetic and chromoelectric moments respectively. It is straightforward, though a bit lengthy, to calculate various cross sections and distributions within the parton-model framework, so we do not repeat those works here and leave them to [1]. There we carried out the analysis just after LHC started to operate, and we had only CDF and D0 data from Tevatron available [6]:

$$\sigma_{\rm exp} = 7.02 \pm 0.63 \text{ pb} \quad (\text{CDF}: \; m_t = 175 \text{ GeV}) \tag{2}$$

$$= 8.18 \begin{array}{l}+\,0.98\\-\,0.87\end{array} \text{ pb} \quad (\text{D0}: \; m_t = 170 \text{ GeV}). \tag{3}$$

Comparing them with $\sigma_{\rm tot}(t\bar{t})$ computed in our framework as a function of $d_{V,A}$, we obtained an allowed region on d_V-d_A plane surrounded by two closed curves (see Fig.1 presented below).

It is possible to narrow the region if we get data with smaller errors, but we will not be able to single out the standard model, i.e., the area around $d_V = d_A = 0$, as long as we use $\sigma_{\rm exp}(t\bar{t})$ measured at Tevatron alone even if those $d_{V,A}$ are correct values. However we showed in [1] that it can be very effective to combine data from Tevatron and LHC together (see Fig.6 in [1]). This is because $q\bar{q} \to t\bar{t}$ process dominates at Tevatron, while $gg \to t\bar{t}$ becomes the main process at LHC and therefore different parts in the cross section are enhanced at these two hadron colliders.

Recently CMS collaboration published their first data on $\sigma_{\rm exp}(t\bar{t})$ [5],

$$\sigma_{\rm exp} = 194 \pm 72 \pm 24 \pm 21 \ {\rm pb} \quad (m_t = 172.5\,{\rm GeV}) \tag{4}$$

and we found this new information actually enabled us to realize our analysis. Let us show our main result. As the standard-model total cross section, we take the NLO theoretical cross section

$$\sigma_{\rm QCD} = 157.5^{+23.2}_{-24.4} \ {\rm pb} \tag{5}$$

for a top-quark mass of 172.5 GeV [7, 8], which is used in [5]. We combine this theoretical error with the above experimental errors as

$$\sigma_{\rm exp} = 194 \pm 82 \ {\rm pb} \tag{6}$$

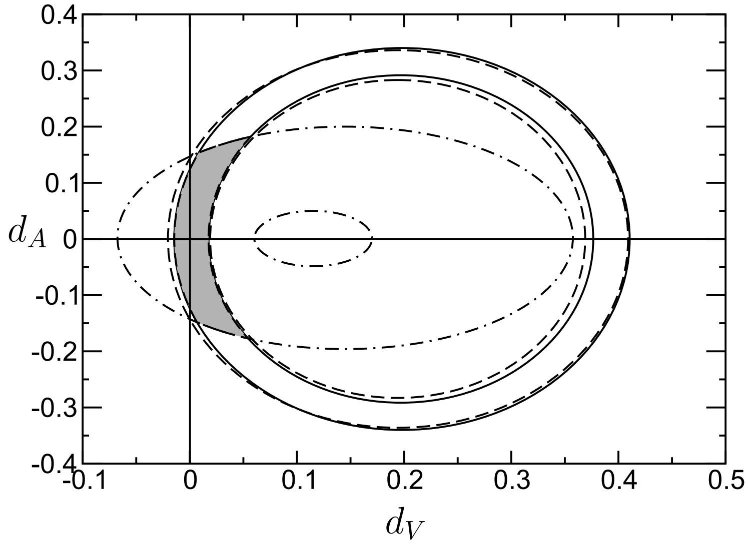

Figure 1: The $d_{V,A}$ region allowed by Tevatron and LHC data (the shaded part). The solid curves are from CDF data, the dashed curves are from D0 data, and the dash-dotted curves are from CMS data.

and use this value as our input that is to be compared with the calculated total cross section. Superposing thus-obtained new result with the constraints from

Tevatron which we already have from [1], we find that only a small region around $d_V = d_A = 0$ survives as in Fig.1. There the solid curves are from CDF data, the dashed curves are from D0 data, and the dash-dotted curves are from CMS data. The shaded part is the new $d_{V,A}$ region allowed by both Tevatron and LHC data. This figure is quite similar to Fig.6 of [1], which however we drew assuming some plausible values for $\sigma(t\bar{t})$ at LHC energy. This is what we expected of LHC experiments in [1].

In conclusion, we have shown here that combing the Tevatron and latest LHC (CMS) data produces a stronger constraint on d_V and d_A based on our previous analysis. This analysis worked because Tevatron is a $p\bar{p}$ collider, where $q\bar{q} \to t\bar{t}$ process dominates, while LHC is a pp collider, where $gg \to t\bar{t}$ process plays a much more important role. Although the precision is not sufficiently high yet, we expect LHC will give us fruitful data and make it possible to perform much more precise analyses in the near future.

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