The Origin of the Production Cross Section of Top Quark Pairs in Association with Two Bottom-Quark Jets

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Abstract: The measured production cross sections of top quark pairs in association with two b jets in proton-proton collisions at sqrt(s) = 13 TeV by the CMS detector at the LHC are found to be larger than theoretical productions by a factor of 1.5-2.4, corresponding to 1-2 standard deviations. Here we show that this discrepancy is due to the omission of the real baryon structure described in the Scale-Symmetric Theory. The properties of the scalar condensate in the centre of baryons and the spacetime mass of gluons are the keys to understanding the observed discrepancy.

1. Introduction and calculations

The production cross sections of top quark pairs in association with two b jets are determined for the total phase space to be [1]

$$\sigma_{Total} = 5.5 \pm 0.3 \text{ (stat) } {}^{+1.6}{}_{-1.3} \text{ (syst) pb} , \qquad (1)$$

where pb (picobarn) = 10^{-40} m^2.

According to the Scale-Symmetric Theory (SST), photons in the nuclear strong fields (they have internal helicity) behave as gluons [2]. In paper [3], we showed that there are three basic quantities defining a photon/gluon: the mass of the carrier of the energy of photon/gluon, its rotational energy resulting from the rotation of the spin of the carrier, and the mass of the additional neutrino-antineutrino pairs around the photon/gluon (the spacetime mass of photon/gluon). For a local observer, the spacetime mass of gluon (STMG) is the part of the zero-energy field so it is not observed by the local observer [3]. According to SST, the wavelength of the STMG, $\lambda_{STMG} = 2\pi R_{STMG}$, is [3]

$$\lambda_{STMG} = h / (M_{STMG}\, c) , \qquad (2)$$

where h is the Planck constant, M_{STMG} is the spacetime mass of gluon, and c is the speed of light in “vacuum”.

On the other hand, the cross section of STMG is defined as follows

$$\sigma_{Total} = \pi\, R_{STMG}^2 = \lambda_{STMG}^2 / (4\, \pi) =$$

$$= \pi \, [\hbar \, / \, (M_{STMG} \, c)]^2 \, . \qquad (3)$$

According to SST, the maximum STMG can be 40,363 times higher than the mass of the central scalar condensate of baryons, i.e. it is $M_{STMG,max} = 17.119$ TeV $= 3.0518 \cdot 10^{-23}$ kg. Such mass leads to the lower limit for the production cross section (see formula (3))

$$\sigma_{Total,lower} = \pi \, [\hbar \, / \, (M_{STMG,max} \, c)]^2 = 4.174 \text{ pb} \, . \qquad (4)$$

On the other hand, the sqrt(s) = 13 TeV = $M_{STMG,min} = 2.3175 \cdot 10^{-23}$ kg leads to the upper limit for the production cross section (see formula (3))

$$\sigma_{Total,upper} = \pi \, [\hbar \, / \, (M_{STMG,min} \, c)]^2 = 7.238 \text{ pb} \, . \qquad (5)$$

In fact, we are dealing with a mixture of states (4) and (5) at any time, so the final result can be written as follows

$$4.2 \text{ pb} \leq \sigma_{Total,SST} \leq 7.2 \text{ pb} \, . \qquad (6)$$

The central value is 5.7 pb so we have

$$\sigma_{Total,SST} = 5.7 \pm 1.5 \text{ pb}. \qquad (7)$$

We can see that the SST results are consistent with the experimental results (see formula (1)).

The results calculated using equation (3) and condition (4) are summarized in Figure 1. We can see that for sqrt(s) $\geq$ 17.1 TeV there appears an asymptote $\sigma_{Total,SST} = 4.2$ pb.

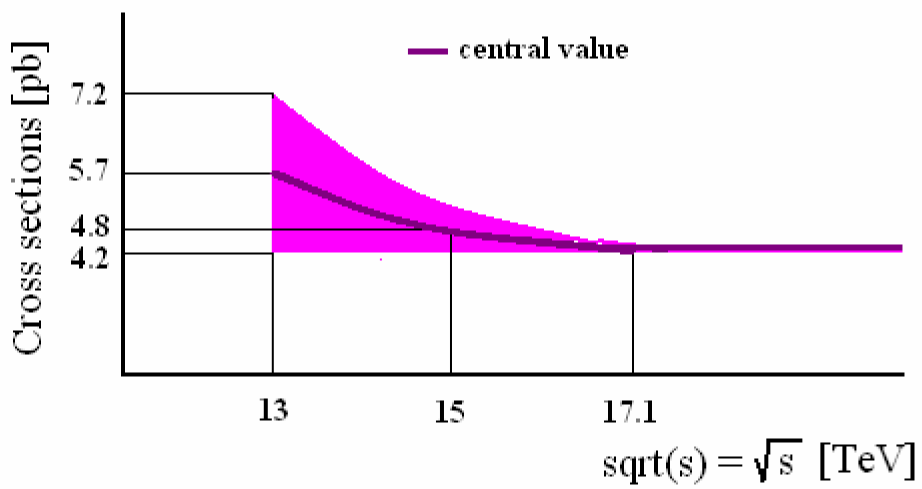

Fig.1
Production cross sections versus sqrt(s).

2. Summary

We showed here that the measured production cross sections of top quark pairs in association with two b jets in proton-proton collisions at sqrt(s) = 13 TeV by the CMS detector at the LHC [1], $\sigma_{Total} = 5.5^{+1.9}_{-1.6}$ pb, is not directly associated with properties of the t and b quarks.

Scientists assume that due to high density of neutron-star cores they are quark-gluon plasma. But recent studies show that even at the highest densities neutrons and protons keep their identity [4]. On the other hand, the Scale-Symmetric Theory shows that the core of baryons is indestructible [2]. The considerations in this work lead to the same conclusions because we have shown that cross sections do not depend on the properties of quarks.

References

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