June 27, 2016

Estimate of Limit on the Production of X(750) → γγ from D0

The indication of a new state in 13 TeV pp collisions at the LHC with M = 750 GeV in decays to γγ [1,2] raises the question of the limit on its production in 2 TeV ppbar collisions at the Tevatron. We provide here an estimate of the comparison of a limit based upon a previous study by the D0 experiment [3] using 5.4 fb^{-1} of data to a result obtained by ATLAS at 8 TeV [4].

Owing to the differences in center of mass energy, initial state parton content, kinematic coverage etc. between the Tevatron and LHC, it is preferable to compare limits deduced for a hypothetical new γγ resonance at the two machines, rather than for the underlying cross sections. One such model based on Randall Sundrum (RS) gravitons in a warped fifth dimension [5] has been used both in the D0 study [3] and by ATLAS [4]. The cross section times branching ratio into dielectrons or diphotons can be computed in terms of the mass of the lowest Kaluza Klein graviton state and the dimensionless graviton coupling to the Standard Model fields, and thus cross section limits for a given mass can be used to infer limits on couplings. D0 measured the cross sections for both dielectrons and diphotons as well as their combination. ATLAS measured only diphoton cross sections.

In the RS model, the γγ to ee branching ratios are expected to be in the ratio 2:1. D0 chose to present its results in terms of the branching ratio to dielectrons, so the σB(γγ) limit is two times that for σB(ee). In Table I of the D0 publication [3], only the combined γγ+ee channel upper limit $\sigma(\text{ppbar}\rightarrow G_{RS}X)$ x $B(G_{RS}\rightarrow ee)$ of 0.52 fb was reported. The corresponding limit for the γγ channel only, expressed in terms of the dielectron branching ratio, was 0.64 fb. We thus take the 95% upper limit for diphoton production $\sigma(\text{ppbar}\rightarrow G_{RS}X)$ x $B(G_{RS}\rightarrow\gamma\gamma)$ to be 1.28 fb at M(γγ)=750 GeV. From the equivalent plot to Fig. 2 in Ref. [3] for the γγ channel-only analysis, we infer a 95% upper limit on the dimensionless coupling of a 750 GeV RS graviton of about 0.025. The highest mass D0 diphoton event was at M(γγ)=610 GeV.

The corresponding 8 TeV ATLAS coupling limit, using the γγ channel only, is about 0.005 (reading with limited precision from Fig. 5 of Ref. [4]). Thus, the D0 RS graviton coupling limit is approximately 5 times worse than the ATLAS limit. The corresponding ratio of cross section limits would then be about 25. Even if the full 9.7 fb^{-1} D0 data set were analyzed, the D0 to ATLAS ratio would improve only marginally.

We thus infer that the ratio of the ATLAS to D0 cross section sensitivities for a M=750 GeV diphoton resonance would be approximately 25, although possible differences in the production mechanisms for the RS graviton and the potential new γγ state could alter this ratio. In particular, there is no reason that the mix of gg and qqbar initial states in producing the RS graviton and the 750 GeV resonance should be the same, thus altering the relative sensitivities at the Tevatron and the LHC.

1. ATLAS Collaboration, *Search for resonances in diphoton events at √s = 13 TeV with the ATLAS detector*, arXiv 1606.03833 [hep-ex], submitted to JHEP (2016).
2. CMS Collaboration, *Search for resonant production of high mass diphoton pairss in proton-proton collisions at √s = 8 and 13 TeV,* arXiv:1606.04093 [hep-ex], submitted to Phys. Lett. B (2016).
3. V.M. Abazov *et al*., *Search for Randall-Sundrum gravitons in the dielectron and diphoton final states with 5.4 fb-1 of data from ppbar collisions at √s =1.96 TeV,* Phys. Rev. Lett. **104**, 241802 (2010).
4. ATLAS collaboration, *Search for high-mass diphoton resonances in pp collisions at √s =8 TeV with the ATLAS detector,* Phys. Rev. D **92**, 032004 (2015).
5. L. Randall and R. Sundrum, Phys. Rev. Lett. **83**, 3370 (1999).