PROCEEDINGS OF SCIENCE

Search for $t\bar{t}$ resonances below 1 TeV in the semileptonic final state with the CMS detector at LHC

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Numerous extensions to the standard model (SM) predict gauge interactions with enhanced couplings to the top quark. In this analysis, we present a search for $t\bar{t}$ resonances using the CMS detector, with a selection optimized for non-boosted top pairs.
We do not observe any excess of events above the expected yield from the SM processes. We set the following limits on the production of non-SM particles: topcolor Z' bosons with a width of 1.2 (10) % of the Z' mass are excluded at 95% C.L. for masses below 1.4 TeV (up to 1.5 TeV). In addition, Kaluza-Klein excitations of a gluon with masses below 1.7 TeV in the Randall-Sundrum model are excluded.
To improve the sensitivity over the whole mass range, this analysis is combined with another, optimized for boosted top pairs reconstruction. With this combination, we exclude topcolor Z' bosons with a width of 1.2 (10) % of the Z' mass for masses below 2.1 (2.7) TeV. Kaluza-Klein gluons with masses below 2.5 TeV are excluded.

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1. Event selection

We analyze data samples corresponding to 19.7 fb^{-1} of integrated luminosity of pp collisions at $\sqrt{s} = 8$ TeV collected by the CMS experiment in 2012. The CMS detector, a general-purpose apparatus operating at the CERN LHC, is described in detail elsewhere [1].

In this analysis, we study the inclusive mass range of 0.5 - 2 TeV in $\mathrm{M_{t\bar{t}}}$, using a selection optimized to identify top quarks produced with a small boost in the detector frame (0.5 - 1 TeV). The data analyzed are recorded with a trigger requiring a single isolated lepton in combination with three central jets. Events with two isolated lepton candidates are vetoed to reduce background from Drell-Yan production. Moreover, we require events to contain at least four central jets. Events are classified into four categories, according to the lepton flavor (muon or electron) and the number of b-tagged jets ("exactly 1 b-tagged jet" or "at least 2 b-tagged jets")

2. $\mathrm{t\bar{t}}$ mass reconstruction

The reconstruction of $\mathrm{t\bar{t}}$ candidates begins by assigning the final-state objects in each event either to the leptonic side or the hadronic side of the $\mathrm{t\bar{t}}$ topology. We first assign the charged lepton and $\mathrm{E_T^{miss}}$ ($\equiv$ missing transverse energy) to the leptonic side of the event, where $\mathrm{E_T^{miss}}$ is taken to be the transverse component of the neutrino's momentum. We then form a quadratic equation for the longitudinal component of the neutrino's momentum using the invariant mass of the lepton and neutrino, which is constrained to the W boson mass (80.4 GeV).

Up to 8 central jets are considered. We iterate over all possible associations of the selected jets to the partons in the final state and perform the event reconstruction accordingly. The combination giving the best value for the reconstructed hadronic and leptonic top mass, the hadronic W mass and the transverse momentum of the $\mathrm{t\bar{t}}$ system is choosen.

The lepton, $\mathrm{E_T^{miss}}$ and the four selected jets are used to compute the $\mathrm{t\bar{t}}$ invariant mass of the event.

3. Background and signal parametrizations

We consider two particular models for the signal: a generic spin 1 resonance Z' boson [2], and the Kaluza-Klein (KK) partner of the gluon in the Randall-Sundrum model [3]. For the Z' boson, we generate resonances with a width of 1.2% (narrow resonances) and 10% (wide resonance) of the Z' mass. For the KK gluons, the width is fixed by the cross section.

The signal contribution is extracted from a maximum likelihood fit to the data, using simultaneously the four categories of events described above. The signal PDF (Probability Density Function) in the fit is parametrized from the simulation, using a superposition of Gaussian kernels to model the distribution. From studies on simulated events and data, the background PDF functional form is choosen in order to reproduce the falling shape of the SM $\mathrm{M_{t\bar{t}}}$ distribution. Its parameters are extracted directly from the fit on data.

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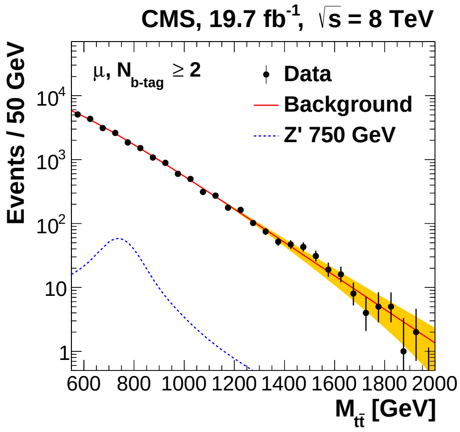

Figure 1: Likelihood fit projection on data, including a signal with a mass hypothesis of 750 GeV, for the muon, at least two b-tagged jets category. The expected shape of the Z' signal is overlaid, normalized to 1 pb.

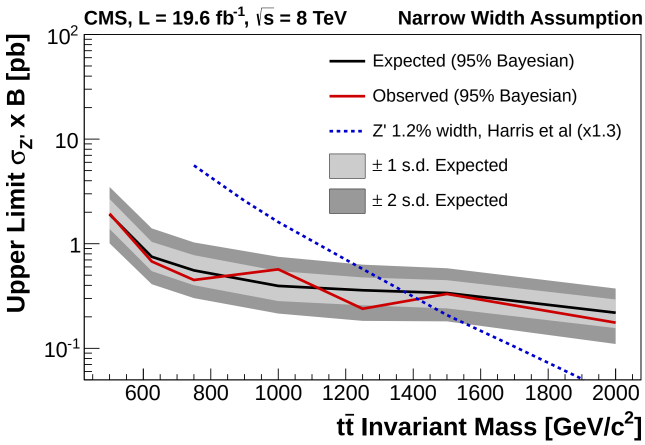

Figure 2: Exclusion limits for a narrow width Z' hypothesis

4. Results

The likelihood fit shows no evidence of signal, we can proceed to set limits. A Bayesian statistical method is used to extract the 95% C.L. upper limits on $\sigma_{Z'} \times B(Z' \to t\bar{t})$.

We exclude masses below 1.4 TeV for the narrow width Z' hypothesis (figure 2), up to 1.5 TeV for the wide width Z' hypothesis, and masses below 1.7 TeV for the Kaluza-Klein gluons.

In order to improve sensitivity over the full mass range, this analysis is combined with another, optimized for boosted top pairs reconstruction [4], as well as with the fully leptonic final state analysis [5]. With these combinations, we exclude masses below 2.1 (2.7) TeV for narrow (wide) width hypothesis, and masses below 2.5 TeV for the Kaluza-Klein gluons.

References

[1] **CMS** Collaboration, *The CMS experiment at the CERN LHC*, *Journal of Instrumentation* **3** no.~08, (2008) S08004.

[2] R. M. Harris and S. Jain, *Cross Sections for Leptophobic Topcolor Z' Decaying to Top-Antitop*, *Eur.Phys.J.* **C72** (2012) 2072, `arXiv:1112.4928 [hep-ph]`.

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[4] **CMS** Collaboration, *Search for $t\bar{t}$ resonances in semileptonic final state*, Tech. Rep. CMS-PAS-B2G-12-006, CERN, Geneva, 2013.

[5] **CMS** Collaboration, *Searches for anomalous ttbar production in pp collisions at $\sqrt{s}$=8 TeV*, `arXiv:1309.2030 [hep-ex]`.