Search for s-channel single top-quark production in pp collisions with the CMS experiment at the LHC

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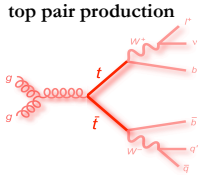
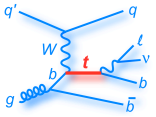
A search for single top-quark production in the s channel in proton-proton collisions at a centre-of-mass energy of $\sqrt{s}$ = 8 TeV by the CMS detector at the LHC is presented [1]. Leptonic decay modes of the top quark with an electron or muon in the final state are considered. The signal is extracted by performing a maximum-likelihood fit to the distribution of a multivariate discriminant defined using Boosted Decision Trees to separate the expected signal contribution from the background processes. Data collected in 2012, corresponding to an integrated luminosity of 19.3/fb, leads to an upper limit on the cross section times branching ratio of 11.5 pb at 95% confidence level.

Backgrounds

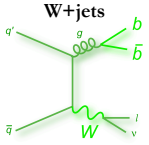
top pair production



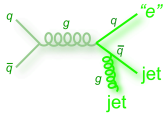
t-channel single top



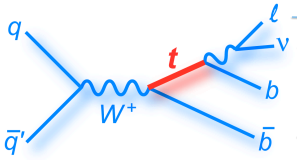
W+jets



QCD multijet



s-channel: topology and selection



- lepton: e, μ high p_T and isolated
- missing energy (E_T^{miss})
- b-jet from top decay, BR(t->Wb) ~ 1
- 2nd b-jet: recoil against top

Selection

- Exactly one muon or electron
- Event categories defined as n jets m b-tags:
  - 2 jets 2 b-tags (signal enriched region)
  - 3 jets 2 b-tags (tt̄ enriched region)
  - 2 jets 0 b-tags (W+jets enriched region)

Physics objects

Leptons:
- p_T^{μ} > 26 GeV,
- p_T^{e} > 30 GeV
- $|\eta^{\mu}| < 2.1$, $|\eta^{e}| < 2.5$
- Isolation and quality requirements

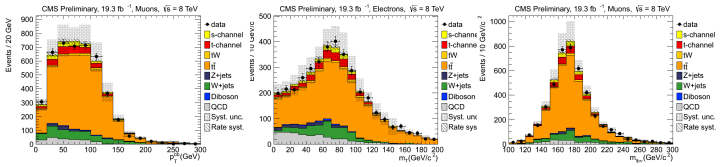
Jets:
- two leading jets p_T > 40 GeV
- other jets p_T > 30 GeV
- $|\eta| < 4.5$, ID criteria and energy resolution corrections applied on simulation
- b-tagging: Track Counting High Purity algorithm, scale factors applied on simulation

Multivariate analysis

Small signal over background ratio (~ 1:27)

Exploit the different topology of the signal and backgrounds using a multivariate classification approach

Build **Boosted Decision Trees (BDT)** in 2 jets 2 b-tags and 3 jets 2 b-tags categories (TMVA package [2]).

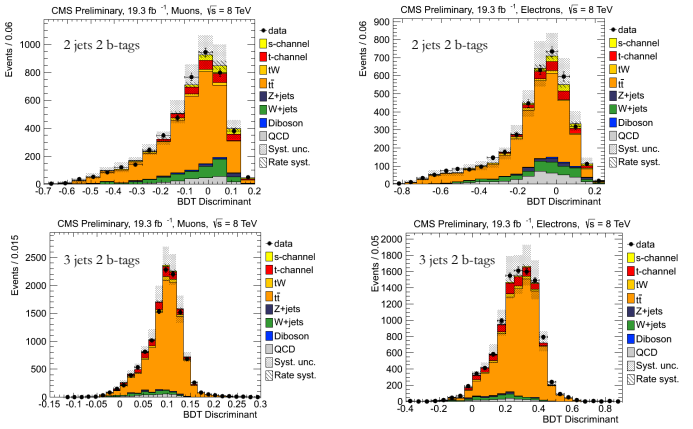


Most discriminating variables:

p_T^{bb}: vector sum of p_T of the two b-tagged jets
m_T: transverse W boson mass
$m_{lb\nu}$: top quark mass (reconstructed choosing the closest to the PDG mass between the two reconstructed with the two b-jets)

Signal extraction and systematic uncertainties

Maximum likelihood fit to the BDT distributions on data simultaneously in 2 jets 2 b-tags and 3 jets 2 b-tags categories. tt̄ and W+jets backgrounds are constrained in the fit as well.



Systematic uncertainty sources

- **Background rates:** tt̄, W+jets, QCD, t-channel, Z+jets, etc.
- **Instrumental uncertainties:** jet energy scale/resolution (JES/JER), b-tagging efficiencies, pile-up, E_T^{miss} modelling, etc.
- **Theoretical uncertainties**: Q^2 of the interaction, matching threshold, top mass, PDFs

Impact on the measurement

Evaluated removing one uncertainty at a time from the likelihood model and measuring the corresponding variation in the profile likelihood

Determined performing two fits to the pseudodatasets generated with the up/down variations of the systematic source of interest (with other sources fixed to zero). The differences with respect to the nominal fit are taken as the corresponding uncertainties

QCD estimation

QCD shape taken from a control sample on data obtained inverting the lepton relative isolation requirement

QCD normalization taken from a fit to m_T/E_t^{miss} in muon/electron channel

Results

Upper limit: $\sigma_{s\text{-chan}}$ < 11.5 (17.0, 9.0) pb @ 95% CL, observed (expected with SM signal, expected with bkg only)

$\sigma_{s\text{-chan}} = 6.2^{+8.0}_{-5.1}$ pb (68% FC interval [3])

$\sigma_{s\text{-channel}}$= 5.55 ±0.08±0.21 pb [4], SM expectation

Most relevant uncertainties: Q^2 (83%), JES (53%), matching (32%), E_t^{miss} modeling (30%)

Outlook: use NLO tt̄ generators (reduce Q^2 uncertainty) and exploit both 7 and 8 TeV datasets; at 13 TeV unfavorable S/B ratio due to the much higher increase of tt̄ cross section w.r.t. s-channel

References
[1] CMS PAS-TOP-13-009; [2] A. Hoecker et al., PoS **ACAT (2007)** 040, arXiv:physics/0703039.
[3] G. J. Feldman and R. D. Cousins, Phys. Rev. D **57 (1998) 3873,** arXiv:physics/9711021
[4] N. Kidonakis, arXiv:1205.3453