Search for Single Top tW Associated Production in the Dilepton Channel

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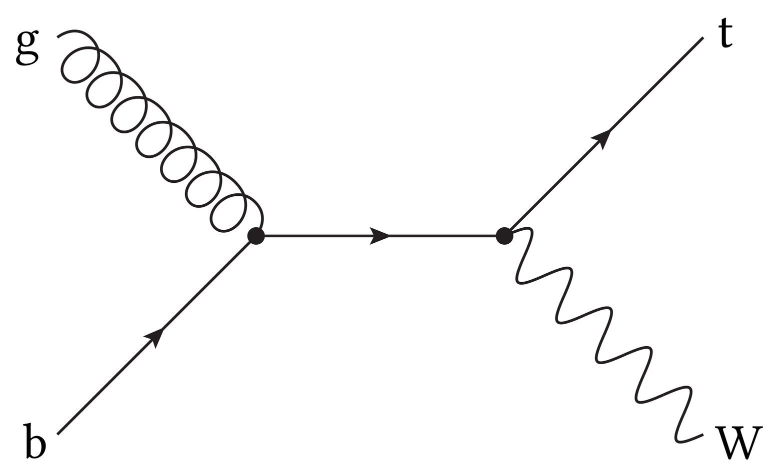
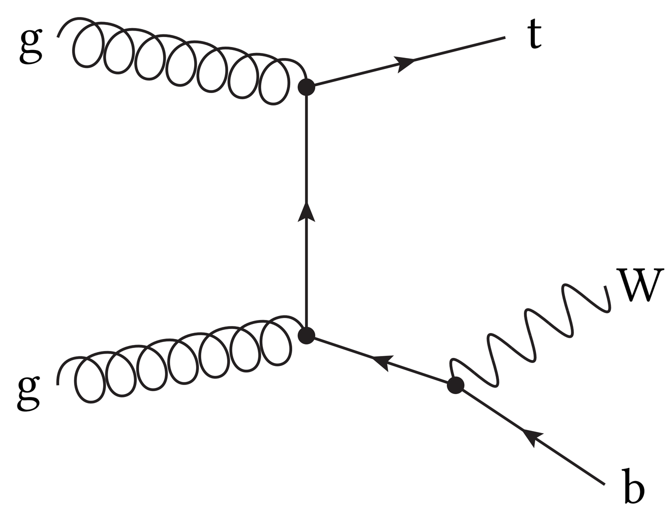
1. Single Top tW Production

Single top tW is characterized by the production of a top quark and a W boson. The approximate NNLO cross section for the LHC at 7 TeV is 15.6 ± 1.2 pb [1].
At next-to-leading order (left diagram), real contributions with a bottom quark in the final state lead to ambiguities in the conceptual distinction between tW and top pair production (right diagram, [2]).





To resolve this ambiguity, diagrams with top pairs are not considered, a method known as *diagram removal*. An alternative method, *diagram subtraction*, which locally subtracts the resonant contribution, is considered as systematic uncertainty.

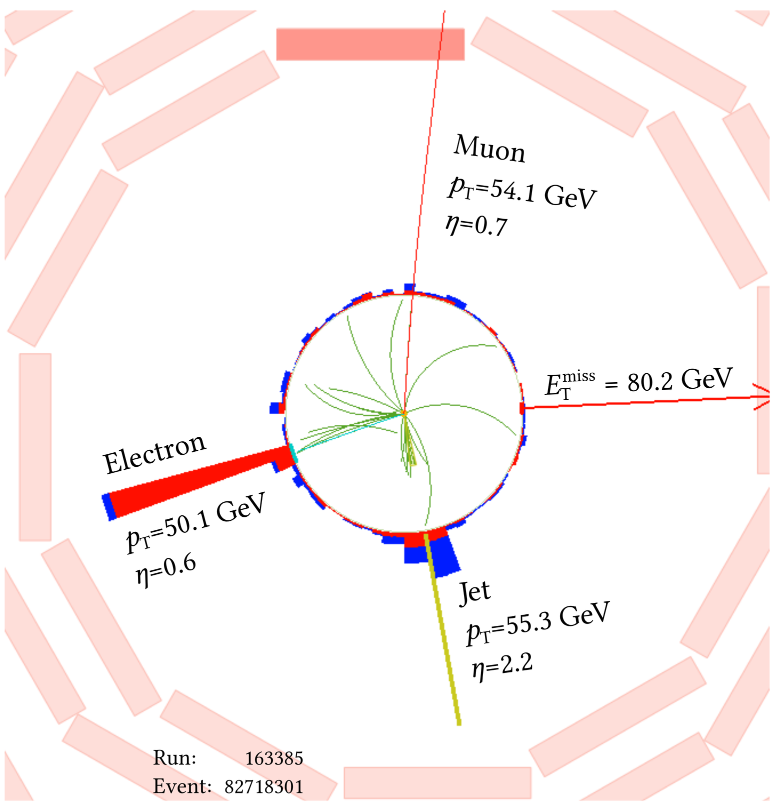
2. Event Selection

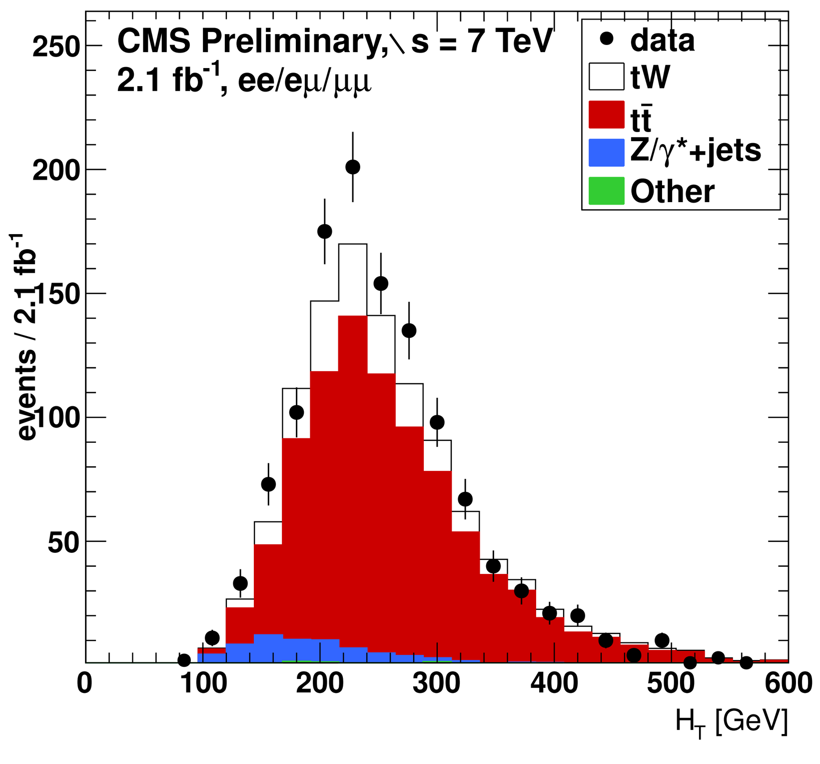
Consider the dilepton channel in which the final state W boson and the W boson from the top quark decay both decay into a lepton (e/μ) and a neutrino. The event signature is: 2 oppositely charged leptons, missing transverse energy from the neutrinos and 1 b-jet from the top quark decay.
Event Selection:

- Dilepton trigger (ee/eμ/μμ)
- Exactly two isolated, oppositely charged leptons ($p_T > 20$ GeV)
- For ee/μμ: reject events with $m_{\ell\ell}$ in the Z mass window, cut on $E_T^{miss} > 30$ GeV
- $p_T^{system} < 60$ GeV, calculated with all leptons, jets, and E_T^{miss}
- For eμ: $H_T > 160$ GeV, calculated with all leptons, jets, and E_T^{miss}

The remaining events are divided into three channels according to jet multiplicity ($p_T > 30$ GeV, $|\eta| < 2.4$) and b-tag multiplicity using a secondary vertex tagger: most tW signal is expected in the 1 jet 1 tag channel, the 2 jet 1 tag and 2 jet 2 tag channels are enriched in top pair background.

Background processes: $t\bar{t}$, Z+jets, Other (W+jets, diboson)





3. Background estimation

For $t\bar{t}$, W+jets, and diboson backgrounds, use simulation scaled to NLO or approximate NNLO cross sections [3,4].
For Z/γ*, use a data-driven technique: Use the ratio of events inside/outside of the vetoed $m_{\ell\ell}$ Z mass window from MC and the observed number of events in this mass window, correcting for non-Z/γ*-dilepton background:

$$N_{\mathrm{DY}}^{\mathrm{est}} = \frac{N_{\ell\ell,\mathrm{out}}^{\mathrm{MC}}}{N_{\ell\ell,\mathrm{in}}^{\mathrm{MC}}} \cdot \left(N_{\ell\ell,\mathrm{in}}^{\mathrm{obs}} - \tfrac{1}{2} k N_{e\mu}\right)$$

where k corrects for differences in e/μ reconstruction efficiency and the factor ½ corrects for the branching ratio BR(ee)/BR(eμ).

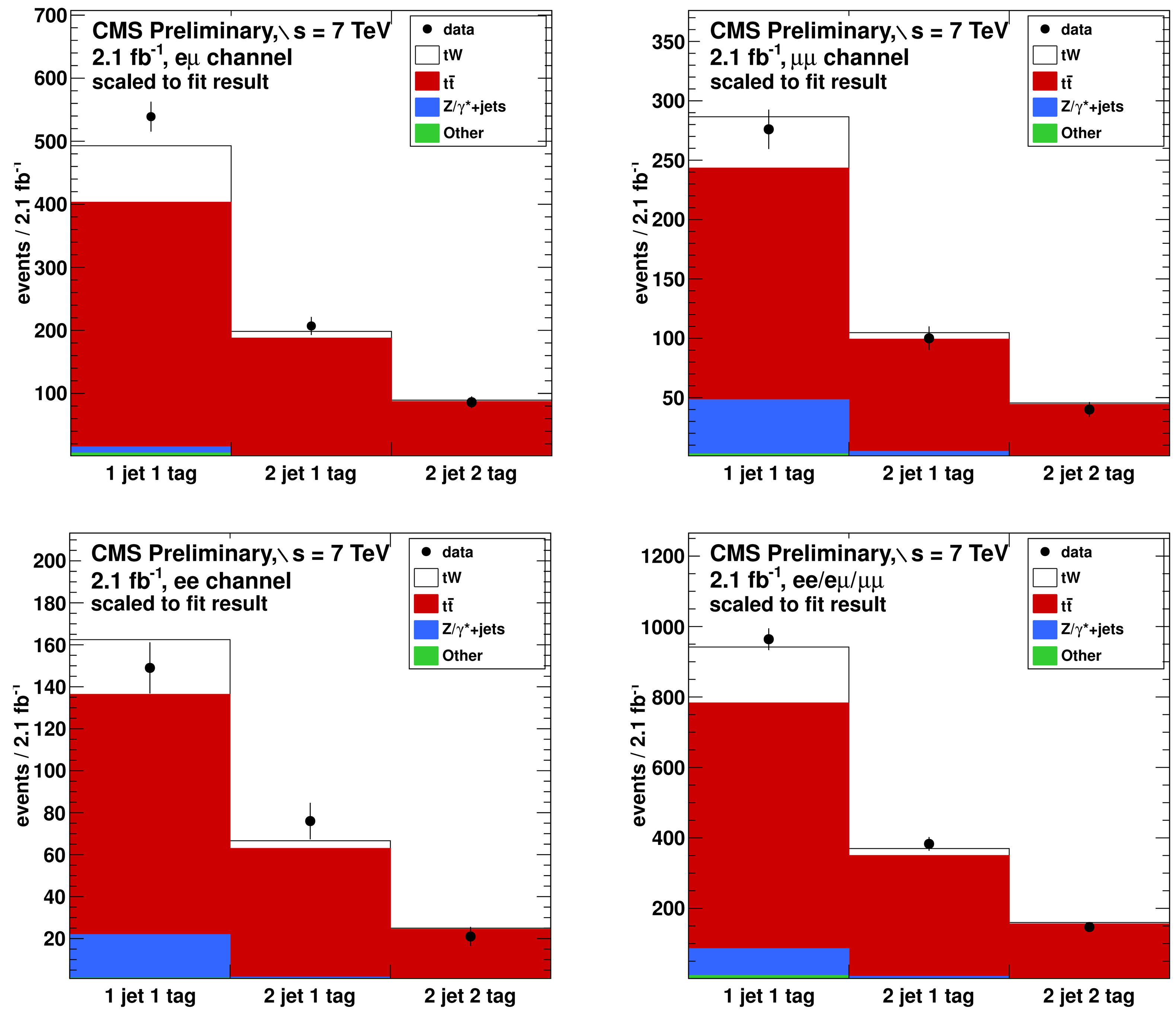
4. Systematic Uncertainties

Considered uncertainties include

- experimental: jet energy scale and resolution, b-tagging efficiency and fake rates, luminosity, lepton id and trigger efficiencies, pileup,
- background modeling: top pair cross section and simulation parameters, uncertainty of the data-driven Z+jets estimate,
- signal modeling: pdf, difference between diagram removal/subtraction.

5. Statistical Analysis

Use a statistical model of Poisson counts in 9 channels: 3 lepton final states (ee/eμ/μμ), each with 3 jet / b-tagging multiplicities.



Systematic uncertainties are modeled by log-normal factors changing the prediction (correlated across all channels) which are allowed to vary in the fit.
Allowing these parameters to vary in the fit helps to constrain some uncertainties on calibrations, such as the jet energy scale calibration and the b-tagging efficiency.
The cross section is extracted using a profile likelihood technique, the significance is calculated using the distribution of a profile likelihood ratio for toy experiments using background only.

6. Results

The measured single top tW cross section is

$$\sigma_{tW} = 22^{+9}_{-7}\ \mathrm{pb}$$

which is consistent with the Standard Model prediction of 15.6 ± 1.2 pb.
The observed significance is

$$2.7\sigma$$

References

This analysis is publicly available as CMS PAS TOP-11-022.

http://cdsweb.cern.ch/record/1385552

[1] Kidonakis, *Phys. Rev.* **D82** (2010) 054018, arXiv:1005.4451
[2] Frixione, Laenen, Motylinski et al., *JHEP* **07** (2008) 029, arXiv:0805.3067
[3] Kidonakis, *Phys. Rev.* **D82** (2010) 114030, arXiv:1009.4935
[4] Gavin et al., *Comput. Phys. Commun.* **182** (2011) 2388ff, arXiv:1011.3540

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