Evidence for the associated production of a single top quark and W boson with the CMS detector
Danny Noonan on behalf of the CMS Collaboration
University of Kansas

INTRODUCTION

Production of a single top quark allows for probing electroweak physics with top quarks. This analysis searched for the production of a single top quark in association with a W boson (tW channel).

Leading order Feynman diagrams for tW channel production of a single top quark

Top quarks decay almost exclusively to a b quark and a W boson. In the dilepton final state, both W bosons will further decay into a lepton and a neutrino. The event signature for tW production decaying to the dilepton final state will be two oppositely charged isolated leptons (e and μ, and ee), a jet originating from a b quark, and missing transverse energy (E_{miss}^{T}) from the neutrinos.

Analysis is based on 4.9 fb$^{-1}$ of pp collisions with the CMS detector [1]. At a center of mass energy of 7 TeV, the Standard Model predicts a cross section of $\sigma_{WW}=15.6+0.4\pm0.6$ pb [2].

MULTIVARIATE ANALYSIS

A Boosted Decision Tree (BDT) was trained to discriminate between the tW signal and tt background. Input variables:

- $p_T$, of leading jet
- $P_T$, of the system: Vector sum of transverse momentum of leptons, jet, and missing energy
- $\Delta(1+\phi_{E_{miss}^{T}})$, closest lepton: Difference in $\phi$ between $E_{miss}^{T}$ and closest lepton
- $H_T$: Scalar sum of transverse momentum of leptons, jet, and missing energy

The BDT returns a single discriminant for each event ranging from -1 (background-like) to +1 (signal-like).

EVENT SELECTION

Lepton Selection:
- Transverse momentum $p_T > 20$ GeV
- Pseudorapidity $|\eta| < 2.5$ for muons (electrons)
- Isolated from other particles
- Oppositely Charged

Jet Selection:
- Transverse momentum $p_T > 30$ GeV
- Pseudorapidity $|\eta| < 2.4$
- Tagged as coming from a b quark (b-tagged) based on displaced secondary vertex

Additional Cuts
- Invariant Mass of leptons, $m_{ll} > 20$ GeV
- veto event $81 < m_{ll} < 101$ GeV in $\mu\mu$ and $ee$ channels
- $E_{miss}^{T}$ > 30 GeV in $\mu\mu$ and $ee$ channels

Signal / Control Regions

Signal and control regions based on jet and b-tagged jet multiplicity

- Signal region:
  - One jet, which is b-tagged (one jet – one tag: 1j1t)
  - Control regions:
    - Two jets, one is b-tagged (two jet – one tag: 2j1t)
    - Two jets, both are b-tagged (two jet – two tags: 2j2t)

RESULTS

An excess over the expected background-only hypothesis is observed with a significance of 4.0σ, compatible with the expected value based on simulation of $3.6\pm0.8$ pb [3].

Cross section is measured to be $\sigma = 16.1^{+2.3}_{-2.1}$ pb, in agreement with the standard model prediction of $\sigma = 15.6\pm0.4\pm0.6$ pb [2].

An estimate of the CKM matrix element, $|V_{tb}|$, is extracted under the assumption that $|V_{tb}|$ is much larger than $|V_{ts}|$ and $|V_{td}|$:

$$|V_{tb}| = \frac{1.01^{+0.06}_{-0.05}(\exp.)\times 4.03^{+0.20}_{-0.22}(\text{th.})}{\sqrt{2}}$$

Number of events passing event selection for simulation and data for all three dilepton channels combined. Statistical (first) and systematic (second) uncertainties are quoted for simulation estimates.

STATISTICAL EVALUATION

A binned likelihood fit to the shape of the BDT discriminant is performed. The fit is performed simultaneously across the three channels in all three regions. Templates for the shapes of signal and background are taken from simulation.

Systematic uncertainties are taken into account by applying ±10% systematic shifts to the templates and adding them as nuisance parameters to the fit.

REFERENCES
