Search for resonances decaying into top quark pairs with ATLAS

Tadaaki Isobe
on the behalf of ATLAS collaboration
University of Tokyo

SUSY09: the 17th International Conference on Supersymmetry and the Unification of Fundamental Interactions
Contents

- Physics motivation
- Reconstruction of ttbar resonance with standard method
- Reconstruction of boosted top quark
- Summary
BSM through $ttbar$ resonances

- $ttbar$ is one of the key channels for searching for the BSM physics.
- A BSM particle is predicted to be strongly coupled with top quark.
  - $\sigma\{KK\text{gluon}(1\text{TeV})\}=O(10\text{pb})$
  - $\text{Br}\{KK\text{gluon}\to ttbar\}=92\%$
- If there is anomaly in dijet channel, other decay channel is important to understand its characteristics.
- Tevatron experiments exclude part of the mass region for $ttbar$ exotic particles.

$pp \to X \to tt$
Background of ttbar resonances

- Main background of ttbar resonance is QCD multi-jet events.
- and SM ttbar events.

KK gluon invariant mass distribution of bulk RS model in large QCD background.

B. Lillie et. al
JHEP0709:074,2007
1lepton channel to search for resonance

- Golden channel in terms of searching for ttbar resonance.

QCD BG rejection with Missing Et and lepton from W leptonic decay

Reconstruction with 3jet event topology.
Standard reconstruction of ttbar resonances

- Event selection with:
  - One isolated electron or muon
  - At least 4 jets
    - in which 2 jets tagged as b-jets
  - $E_T^{\text{miss}} > 20\text{GeV}$
- Full reconstruction with a semi-leptonic decay top ($\to b\nu$) and a hadronic decay top ($\to bqq$).
  - Use W-mass constraint for W reconstruction
Expected sensitivity for ttbar resonance

- Benchmark based on narrow $Z' \rightarrow t\bar{t}$ resonance.

- Worse sensitivity at higher mass due to the decreasing of reconstruction efficiency of ttbar resonance with $M_{Z'}$.
  - Efficiency: 5% at $M_{Z'} = 700$ GeV, 1% at $M_{Z'} = 1500$ GeV
  - At high-$M_{Z'}$, overlapping jets would be more collimated.

- New techniques to reconstruct boosted high-pT top is necessary to search for high mass BSM particles.

$\sim 7$ pb for $M = 1$ TeV
Difficulty to reconstruct ttbar from BSM resonances

- Due to the large mass of BSM particles, the pT of decay top is quite high.
- Hard to reconstruct such high-pT top with conventional invariant mass method.

pT of top is so high that particles end up reconstructed as one jet. (~75% within dR<0.4 for 1TeV/c top)
Reconstructed as mono-jet.

Top-pT (GeV/c)

\[ dR = \sqrt{(d\phi)^2 + (d\eta)^2} \]
Reconstruction of hadronic decay top jets

- Use of jet inv. mass
- kT algorithm is useful to see the jet substructure
  - \( d_{ij} = \min(p_{T_i}^2, p_{T_j}^2)R_{ij}^2 / R^2 \)
  - get the kT distance (y-scale), where jets merge into \( 2 \to 1 \) (\( 3 \to 2 \)) jet.
- Phys. Rev. D65:096014, 2002
Invariant mass of high-pT top mono-jet

- Useful for rejection of QCD-BG, though much of QCD background is expected to remain.

\[ Z'(m=2\text{TeV}) \rightarrow \text{ttbar} \]

QCD multi-jet
kt splitting parameter of high-pT top mono-jet

- Splitting value of 2jets → 3jets in kt jet reconstruction.

$Z'(m=2 \text{ or } 3 \text{ TeV}) \rightarrow t\bar{t}$

QCD multi-jet
Performance of high-pT hadronic decay top reconstruction

- Cut with invariant mass and kt splitting parameter of jets.
- In the case of pT=1TeV/c, ~50% of top mono-jets and ~5% of QCD jets are identified as originated from top.
b-tagging for high-pT top

- B-tagging for high-pT top reconstruction has been studied.
- Light jet rejection power of ~6 for 60% efficient high-pT top mono-jet identification.
  - $E_T=1$ TeV jet

$Z_H (m=2\text{TeV}) \rightarrow q\bar{q}$
Summary

- ATLAS estimated the expected 95% C.L. limits on signal production cross-section times branching ratio of ttbar resonances.
  - Standard reconstruction in 1lepton ttbar decay channel.
  - With 1fb⁻¹ data, σxBr ~ 7pb for M=1 TeV Z’ boson.
- ATLAS developed kinematic variables and selection criteria in order to reconstruct boosted top quarks with a high efficiency.
  - Jet mass, substructure.
  - b-tagging.