Search for $t\bar{t}$ resonances in semileptonic final states at $\sqrt{s} = 13$ TeV with the CMS detector

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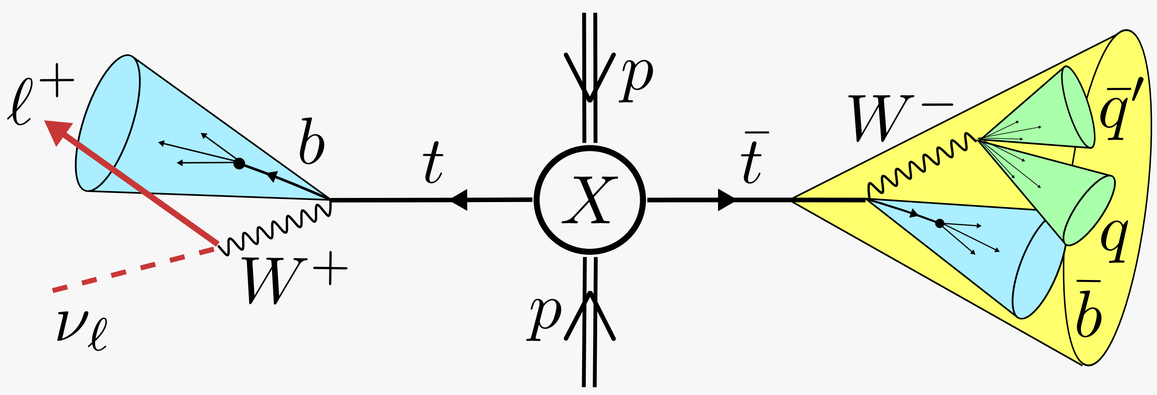
Introduction

- several theories beyond the Standard Model (SM) predict new particles which preferentially decay to a top-antitop pair
- **search for $t\bar{t}$ resonances in $\ell(e,\mu)$+jets final states** with the CMS detector in pp collisions at $\sqrt{s} = 13$ TeV with 2.6 fb^{-1} [1] using the invariant mass spectrum of the $t\bar{t}$ system

Object reconstruction

- **high-p_T lepton**
  without isolation requirement
- **missing transverse energy**
  from the $W \to \ell\nu$ decay
- **jet b-tagging**
  used to identify b quark decays
- **jet t-tagging** [2]
  used to identify top quarks reconstructed as a single jet with substructure properties



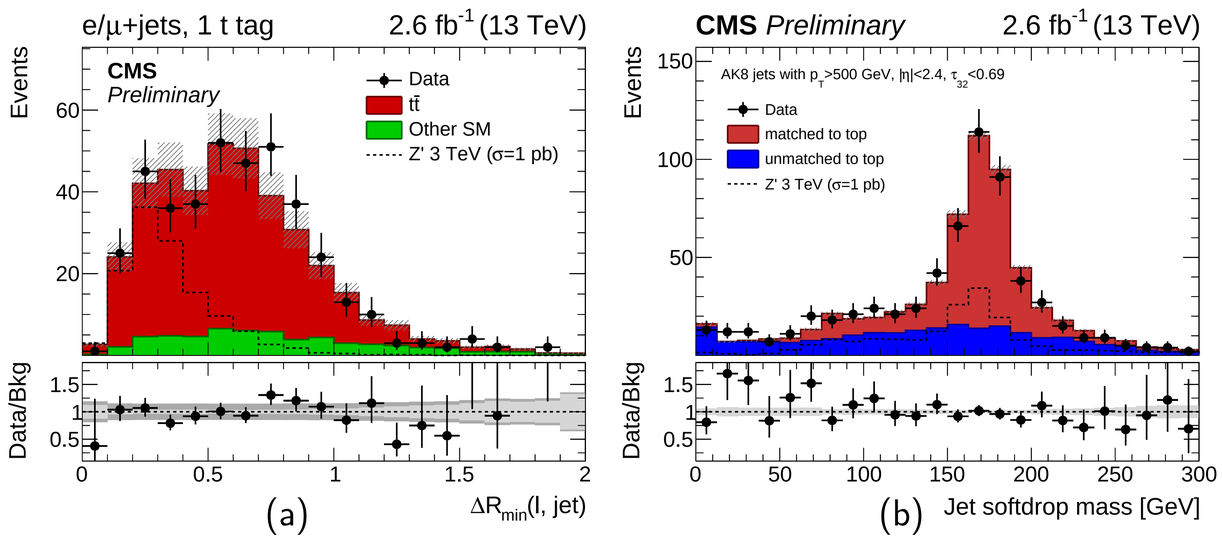


Fig. 1: (a) ΔR-distance between the lepton and its closest jet. (b) Mass of large-radius jets [1].

Event selection in the μ+jets (e+jets) channel

- single-muon trigger (electron+2 jets trigger)
- exactly 1 lepton with $p_T > 50$ GeV and $|\eta| < 2.1(2.5)$
- at least 2 jets with $p_T > 50(70)$ GeV, $p_T^{\text{jet-1}} > 150(250)$ GeV
- missing $E_T > 50(120)$ GeV
- cut on $p_{T,\text{rel}}(\ell, \text{jets})$ used in place of standard lepton isolation
- final ℓ+jets sample split in categories based on the number of b-tagged and t-tagged jets

Kinematical reconstruction of the $t\bar{t}$ system:

- χ^2 discriminator designed to choose the best $t\bar{t}$ hypothesis
- in events with 1 t-tag, hadronic top identified with t-tagged jet

$$\chi^2 = \left[\frac{M_{\text{top}}^{\text{lep}} - \bar{m}_{\text{top}}^{\text{lep}}}{\sigma_M^{\text{lep}}}\right]^2 + \left[\frac{M_{\text{top}}^{\text{had}} - \bar{m}_{\text{top}}^{\text{had}}}{\sigma_M^{\text{had}}}\right]^2$$

- $\chi^2_{\text{min}} < 30$ applied to reduce non-$t\bar{t}$ bkgs, defines the ℓ+jets SR

Background estimation and systematic uncertainties

- main background given by SM $t\bar{t}$ production
- W+jets contribution for events without b/t-tagged jets
- SM backgrounds modeled using MC simulation
- normalization for $t\bar{t}$ and V+jets determined using data in CRs
- main systematic uncertainties:
  - efficiency and mistag rate for jet b-tagging and t-tagging
  - SM cross sections, Q^2-scale and PDF choice in MC simulation

Results

- $M_{t\bar{t}}$ distributions measured in 3 exclusive samples:

  $1\ t$-tag | $0\ t$-tag $+ 1\ b$-tag | $0\ t$-tag $+ 0\ b$-tag

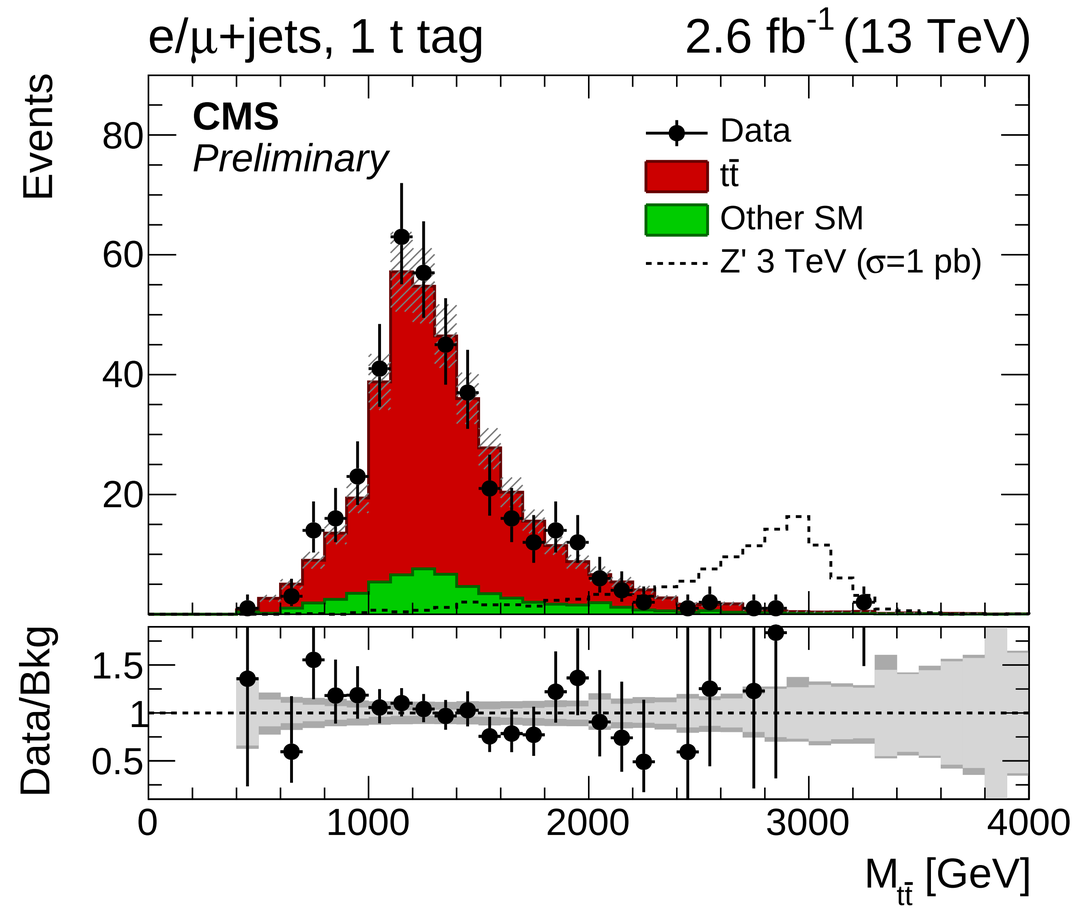


Fig. 2: Invariant mass of the reconstructed $t\bar{t}$ system for events with a t-tagged jet [1].

Statistical analysis and exclusion limits

- no excess observed in data compared to SM backgrounds
- $M_{t\bar{t}}$ spectra used to set limits on the cross section of $t\bar{t}$ resonances
  - $\sigma(X \to t\bar{t})_{\text{obs}} < 97$ fb at 95% CL for a narrow-width Z' with a mass of 3 TeV
  - Z' boson with relative width of 30% excluded for 0.5 TeV $< M_{Z'} < 4$ TeV

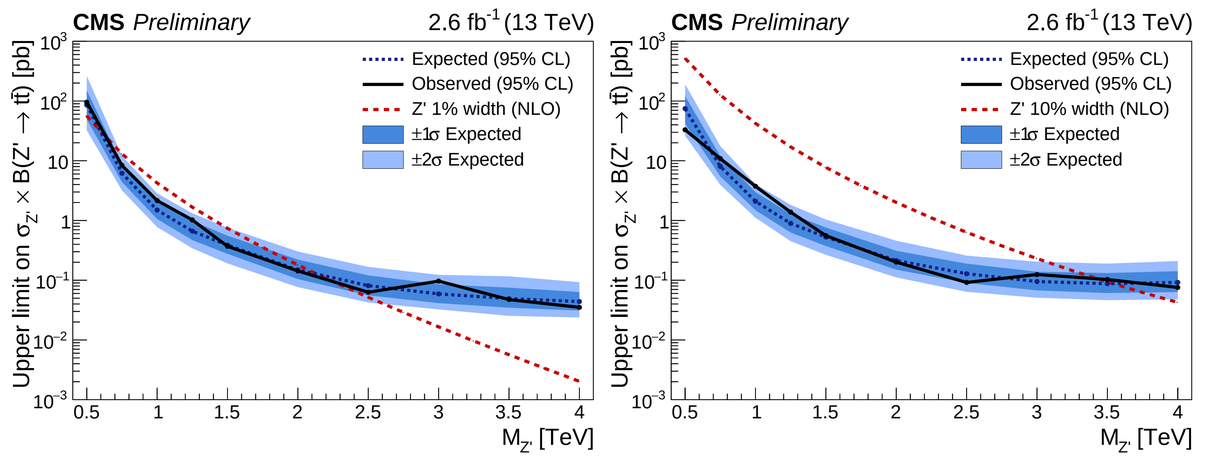


Fig. 3: 95% CL upper limits on the production cross section times branching ratio for a resonance decaying to $t\bar{t}$, as a function of the resonance's mass. Exclusion limits are shown for a Z' boson with relative width (Γ/M) of 1% and 10% [3].

References

[1] CMS Collaboration, Search for $t\bar{t}$ resonances in boosted semileptonic final states in pp collisions at $\sqrt{s} = 13$ TeV, CMS-PAS-B2G-15-002 (2016).

[2] CMS Collaboration, Top Tagging with New Approaches, CMS-PAS-JME-15-002 (2016).

[3] R. Bonciani et al., Electroweak top-quark pair production at the LHC with Z' bosons to NLO QCD in POWHEG, JHEP 02 (2016) 141, [arXiv:hep-ph/1511.08185].