Reinterpretation of the results of this analysis in the context of other signal models is possible through the simplified objects and the search regions described here. We often refer here to the tables, figures, and electronic materials available as auxillary materials on the public web page [1] corresponding to this analysis, and also to the publicly available reconstruction efficiencies and responses for CMS objects [2].

Reinterpretation

The simplification of the BDT-based top and W objects is necessary to avoid the use of the b tagging discriminant value which requires full CMS reconstruction tools. We present no simplification of, and do not make use of, the soft b-tagging. The necessary requirements for the reinterpretation, readily available to the public, are: a signal generator such as MadGraph or Pythia, a jet clustering tool such as FastJet, and the Soft Drop jet algorithm tools.

Jets, such as our primary and large-R jet collections, can be clustered from generator-level particles. Leptons, b-tagged jets, $E_{\mathrm{T}}^{\mathrm{miss}}$ can be constructed from generator-level particles and translated to reconstruction-level using reconstruction efficiencies and responses. From these one can construct the remaining kinematic quantities used by the analysis such as $m_{\mathrm{T}}(\mathrm{b}_{1,2}, E_{\mathrm{T}}^{\mathrm{miss}})$ and $\Delta\phi_{1234}$. The final statistical interpretation of reinterpretation results in terms of exclusion limits may be performed using the simplified likelihood method [3]. A small number of "super" search regions (SSR) are defined by combining groups of the full set of search regions to simplify the statistical interpretation.

In the auxiliary materials we provide in electronic format top and W BDT efficiencies to be used with the simplified object candidates defined below. These efficiencies are: tagging efficiencies, as a function of generator-level p_{T}, of truth-matched candidates (the matching will be defined); and misidentification efficiencies, as a function of reconstruction-level p_{T}, of candidates which could not be truth-matched. Plots of them may be found in the auxillary materials. They will be shown below to reproduce to reasonable accuracy the performance of the top and W objects for two benchmark signal points. One possible method, which is used with the benchmark points and included with example code alongside this document, to approximate event yields in search regions involving top and W objects is to randomly tag the simplified object candidates according to the value of the BDT efficiencies.

Simplified merged top and W

Simplified merged top and W objects are constructed in a similar way as in the analysis, with the exception that the BDT tagging is performed with BDT efficiencies parameterized in p_{T}. From the large-R jet collection, to which the soft drop algorithm has been applied at generator level, we identify merged top (W) candidates using the preselections $p_{\mathrm{T}} \geq 400$ GeV, (200 GeV) $|\eta| \leq 2.4$, soft drop mass $\mathrm{M}_{\mathrm{SD}} \geq 110$ GeV ($50 < M_{\mathrm{SD}} < 110$). In addition, the two hard subjets identified by the soft drop algorithm are required to have $p_{\mathrm{T}} \geq 20$ GeV. The selection in M_{SD} serves to classify a large-R jet as either a merged top or a merged W candidate, but not both.

These selections are identical to those used in the analysis and yield the merged top and W candidates to which the parameterized BDT efficiencies should be applied. However, these candidates, and hence the efficiencies of the BDT on them, are different than in the analysis since the selections on M_{SD} must here be applied before the BDT tagging rather than after. The truth-matched status of each candidate is determined as: A merged top candidate is (is not) truth-matched if there exists (does not exist) a generator-level hadronically decaying top quark within $\Delta R < 0.8$ of the large-R jet; similarly, a merged W candidate is (is not) truth-matched if there exists (does not exist) a generator-level hadronically decaying W-boson within $\Delta R < 0.8$ of the large-R jet.

Simplified resolved top

Simplified resolved top objects are also defined in a similar way to the analysis but require several substitutions. Three-jet candidates are constructed starting from a version of the primary jet collection which has been cleaned of overlaps with the simplified merged top and W objects by requiring $\Delta R(\text{jet}, \text{merged}) > 0.8$. At most two "b constituent jet" candidates are defined as those jets from the cleaned collection closest in ΔR to any generator-level b quarks, as substitutes for the jets leading in b tagging discriminant value used in the analysis. For each of these b constituent jet candidates, combinations with two other "W constituent" jets are identified from the cleaned collection by requiring the invariant mass of the W constituent system to be within 40 GeV of the W boson mass and that of the three-jet system to be within 80 GeV of the top quark mass. Cross-cleaning of the three-jet candidates is then performed using a χ^2 metric as a substitute for the BDT discriminator metric used in the analysis:

$$\chi^2 = (M_{\text{top}} - 173)^2/20^2 + (M_{\text{W}} - 80)^2/20^2 \\ + (p_{\text{T}}(\text{top})\Delta R(\text{top}) - 250)^2/50^2 + (p_{\text{T}}(\text{W})\Delta R(\text{W}) - 150)^2/50^2 + (\text{sd} - 0)^2/1^2$$

where M_{top} and $p_{\text{T}}(\text{top})\Delta R(\text{top})$ are the mass and p_{T} times decay angle $\Delta R(\text{b}, \text{W})$ of the three-jet system; M_{W} and $p_{\text{T}}(\text{W})\Delta R(\text{W})$ are the mass and p_{T} times decay angle $\Delta R(\text{W jet 1}, \text{W jet 2})$ of the W constituent system; and the "sd" variable, calculated using the two W constituent jets and used by the BDT, is inspired by the 'Soft Drop Condition' used by the soft drop algorithm:

$$\text{sd} = \frac{\min(p_{\text{T1}}, p_{\text{T2}})}{p_{\text{T1}} + p_{\text{T2}}} \Delta R(\text{W jet 1}, \text{W jet 2})^{-2}$$

The centers and widths of these variables were estimated in simulation using resolved tops with more stringent truth-matching. Three-jet candidates sharing any constituent jets are cleaned by keeping only the candidate having lower χ^2 value. These are the simplified resolved top candidates to which the parameterized BDT efficiencies may be applied. The truth-matched status of each candidate is determined as: A resolved top candidate is (is not) truth-matched if there exists (does not exist) a generator-level hadronically decaying top quark with at least two of its three decay product quarks (b, W jet 1, W jet 2) matching distinct constituent jets of the candidate according to $\Delta R(\text{jet}, \text{quark}) < 0.4$.

Reinterpreting benchmark signal points

Reinterpretation was attempted using two of the interpreted signal models, T2tt(850,100) and T2ttC(350,330), to test the performance of the reinterpreted top and W objects near the high and low Δm baselines of the SSR, respectively. Reasonable agreement is found and is summarized in a table in the auxillary materials in the form of acceptance times efficiency in the SSR.

Super search regions

We also define a set of super search regions (SSR) by combining groups of the full set of search regions. These SSR represent a simplified version of the analysis and provide sensitivity to different signal topologies. The auxillary materials contain figures, tables, and electronic materials relevant to the SSR. Two tables describe the definitions of the SSR, which are still orthogonal to each other and can be statistically combined. Two figures shows the observed events and the predicted background yields for each of these SSR based on the same background estimation methods as used in the analysis. The background prediction and data yields are also tabulated. The correlation and covariance matrices of the background estimates between different regions are shown in two figures and are also available in electronic format.

References

[1] CMS, "Public Web Page for SUS-16-049", technical report, CERN, 2017. http://cms-results.web.cern.ch/cms-results/public-results/publications/SUS-16-049/index.html.

[2] CMS, "CMS SUSY Results: Objects Efficiency", technical report, CERN, 2017. https://twiki.cern.ch/twiki/bin/view/CMSPublic/SUSMoriond2017ObjectsEfficiency.

[3] CMS Collaboration, "Simplified likelihood for the re-interpretation of public CMS results", Technical Report CMS-NOTE-2017-001. CERN-CMS-NOTE-2017-001, CERN, Jan, 2017. http://cds.cern.ch/record/2242860.