Hollow Cone Sieve for tops

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Outline

Why boosted tops and fat jets?

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- particles in new physics extension of the SM decay to a single top or top-quark pairs
- The LHC is a top factory: about 160,000 top pairs should have been produced with about 1 fb^{-1}.

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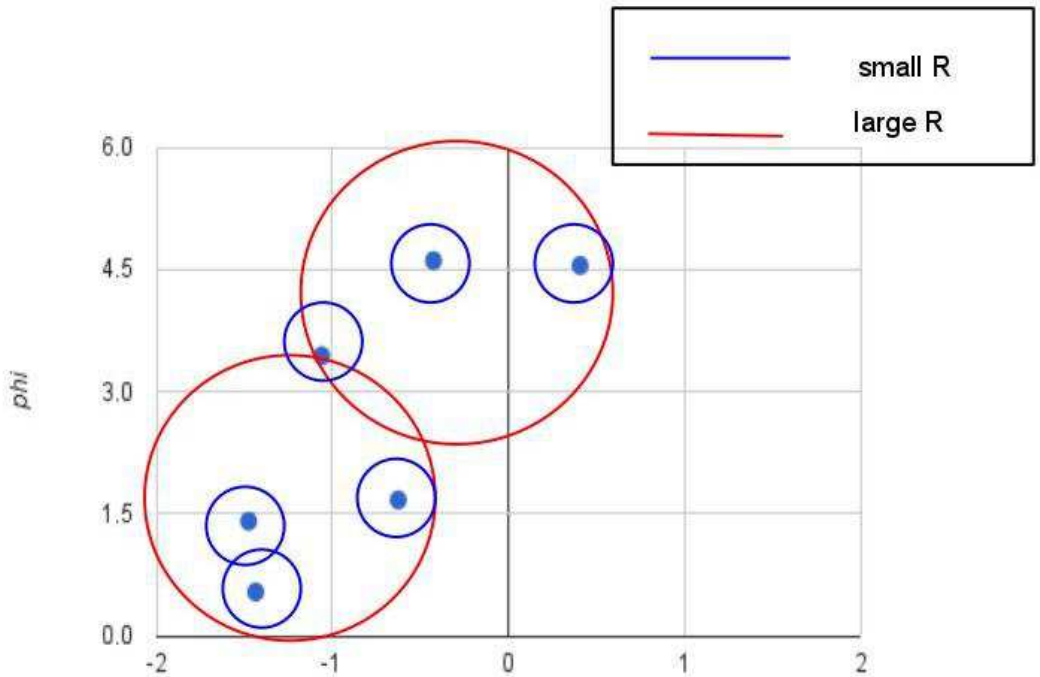

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- what we know about QCD radiation : soft singularity and collinear singularity

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- Hopkins Toptagger Kaplan, Rehermann, Schwartz, Tweedie arXiv: 0806.0848

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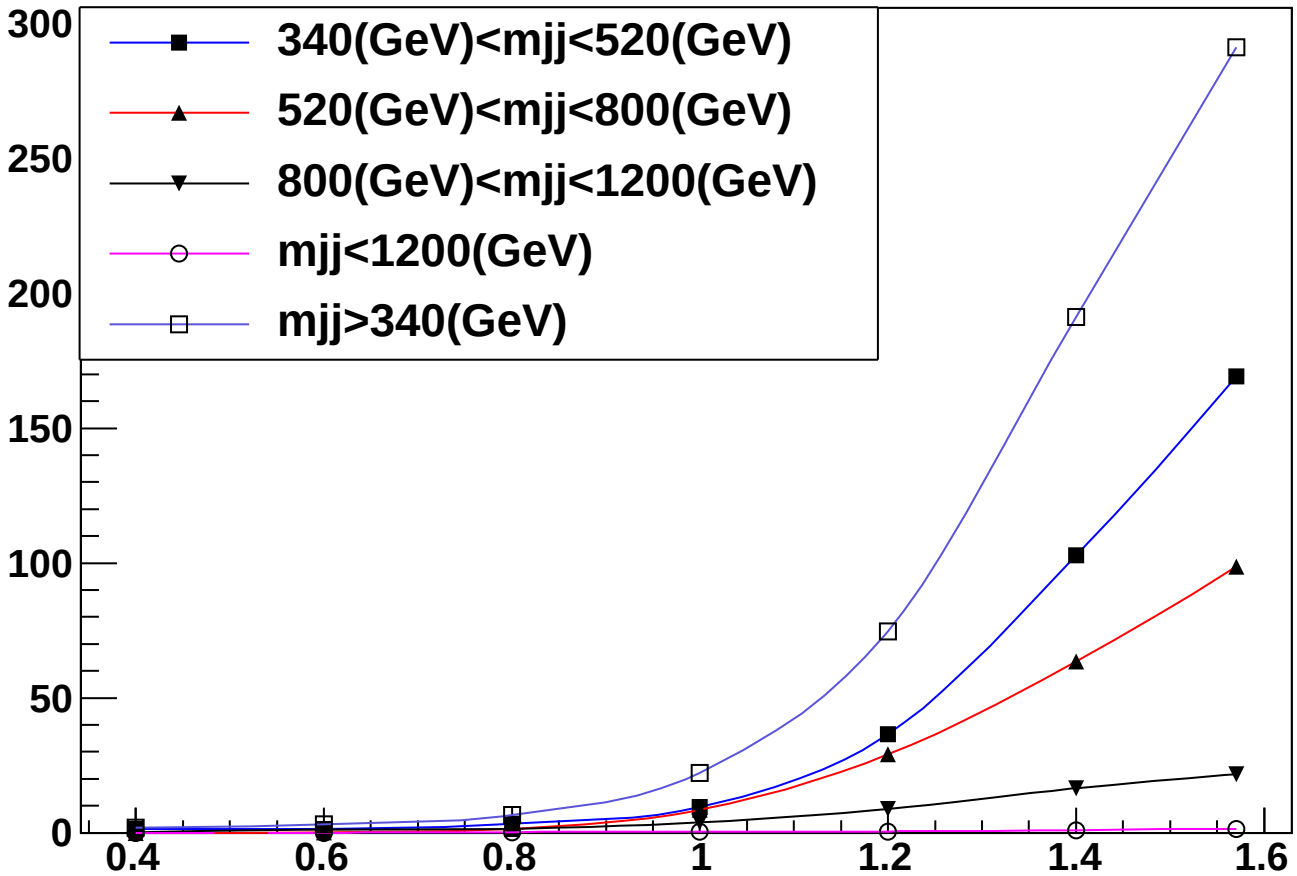
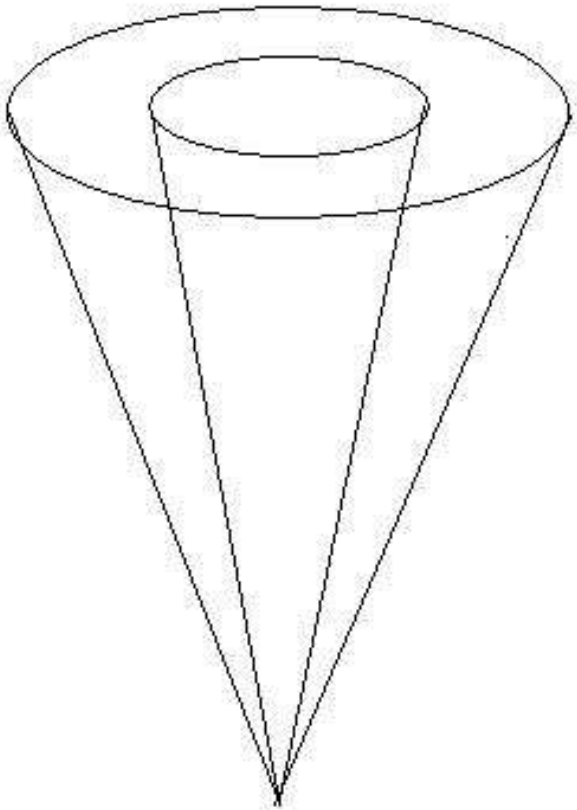
- light jets: number of reconstructed jets doesn't vary with R



- consider anti-kt algorithm as a “ perfect cone ” algorithm
- after subtracting a jet of small cone size in the interior
  - some jets remain in the hollow cone : top
  - no jet in the hollow cone : light quark or gluon



- 1) Reconstruct jets using the anti-kt jet algorithm with R = 1.5 to obtain a set of jets. The number of jets is n_{jets}.
- 2) Redo the jet reconstruction,with R = 0.6 (or R = 0.5), to obtain another set of jets.
- 3) Keep the event as a $t\bar{t}$ candidate if $n_{jets,R=1.5} = 2$ and $n_{R=0.6} > 2$.
- 4) Go into the 2 jets reconstructed in step 1, find all the subjets for each fat jet. For a fat jet of invariant mass of m_j, undo the last step of jet clustering to obtain two jets j_1 and j_2, with invariant masses m_{j1} and m_{j2} ($m_{j1} > m_{j2}$). If $m_{j1} < 0.9\, m_j$, keep both j_1 and j_2, otherwise, keep only j_1 to add to the subjet list and decompose further. Add j_i to the jet substructure list if $m_{ji} < 30$ GeV, otherwise decompose j_i iteratively. If the total number of subjets is less than 4, reject the event.

- 5) See whether there is a W inside either of the 2 fat jets, if not, reject the event. To do this, look into a fat jet and iterate over all of the 2 subjets configurations. After the jet filtering, if the invariant mass of the 2 subjets falls in the window of 65 GeV to 95 GeV, tag that configuration as a W.
- 6) See whether either of the 2 jets has a subjet can be tagged as a b jet.The jet candidates of a W must not be tagged as a b-jet. Keep other b-tagged events.
- 7)Any event that survives the above sequence is tagged as a $t\bar{t}$ event.

backgrounds

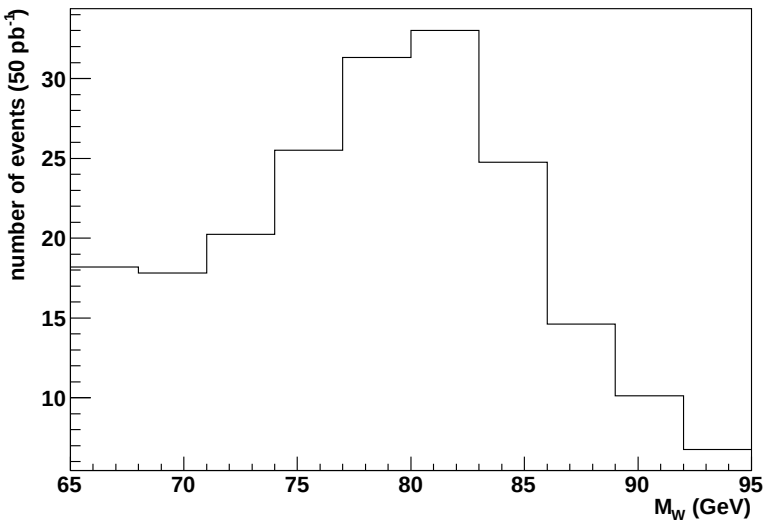
- $wb\bar{b}$, $zb\bar{b}$
- wjj, zjj
- dijet can be reliably removed by hollow cone sieve
- trijet can be eliminated by the number of subjets

cut flow table

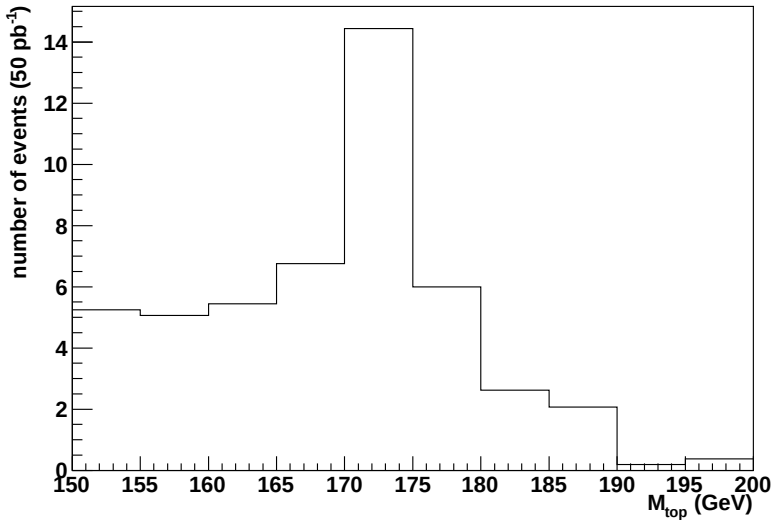
- cut 1 : The "hollow cone" sieve. Require $n_{jets} = 2$ and $n_{veto} > 2$.
- cut 2 : Total number of subjets ≥ 4.
- cut 3 : A hadronic W can be tagged.
- cut 4 : A b jet can be tagged.
- Assume a 0.5 b-tagging efficiency and a light jet rejection of 1/200.

	cross section(pb)	cut 1(pb)	cut 2(pb)	cut 3(pb)	cut 4(pb)
$t\bar{t}$	100.00	12.63	7.59	5.39	4.05
$Wb\bar{b}$	239.52	63.93	1.40	0.20	0.18
$Zb\bar{b}$	124.81	23.55	1.20	0.57	0.43
Wjj	2458	771.4	91.9	8.00	0.08
Zjj	7727.5	478.3	121.3	25.5	0.26

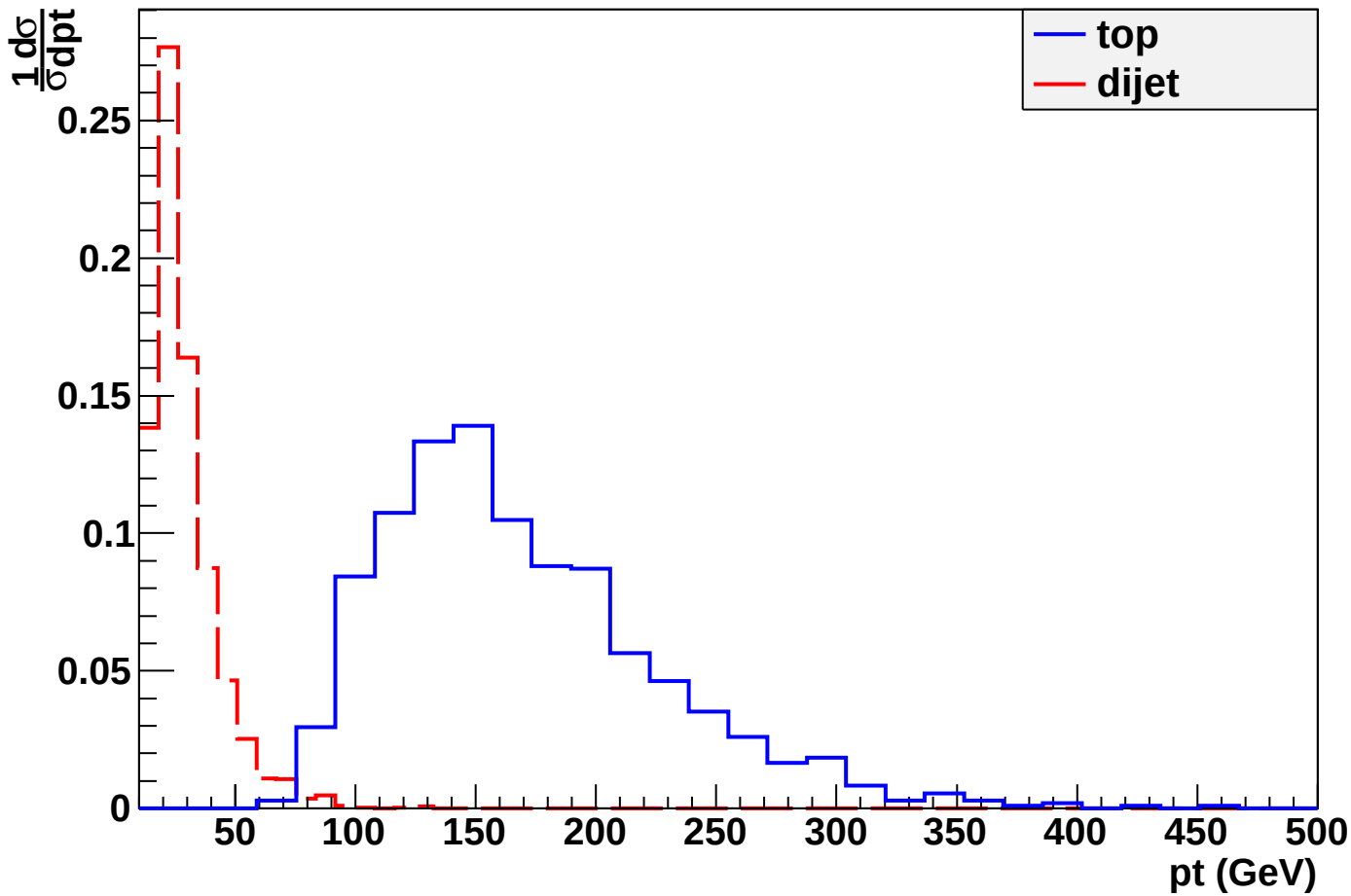
Table: Cut flow table for signal and backgrounds.

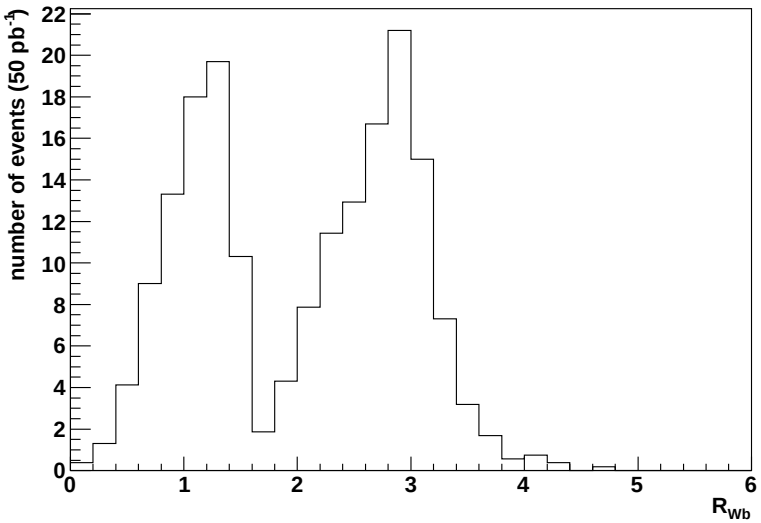


(a) reconstructed W mass

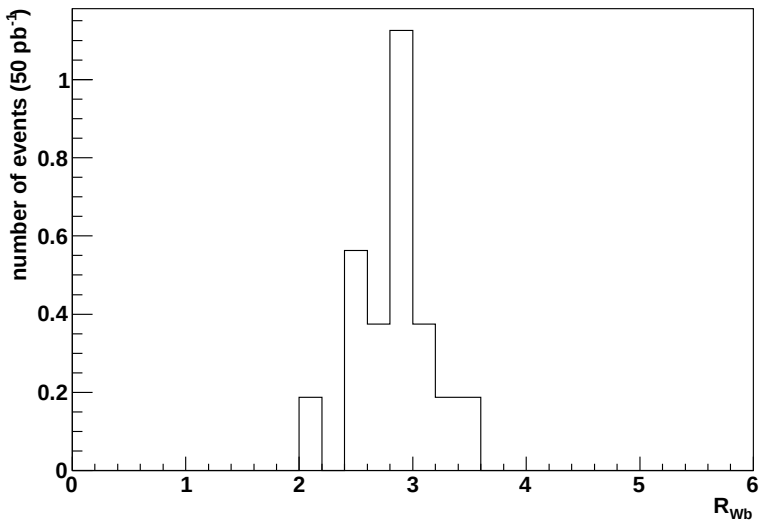


(b) reoncstructed top mass


top
dijet
$\frac{1}{\sigma}\frac{d\sigma}{dpt}$
0.25
0.2
0.15
0.1
0.05
0
50
100
150
200
250
300
350
400
450
500
pt (GeV)



(c) $t\bar{t}$



(d) $Wb\bar{b}$

- hollow cone sieve to tag top pairs
- This method tags 4050 $t\bar{t}$ events at 7 TeV in $1fb^{-1}$.
- The resulting ratio of hadronic tops to semileptonic tops is 2.81, which is consistent with the ratio of decay branching fraction of 3.13
- can be used in identifying new physics that has a top in the final state
- can be used for discovering new, relatively heavy and boosted particles at the LHC.