Cut Optimisation for $t\bar{t}$ at 10TeV

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Motivation:

Have been using the same selection cuts in top group for years. These are not optimised for 10TeV and can certainly be improved for 14TeV as well. In the future, will be desirable to have different sets of cuts for different purposes - depending on whether we wish to maximise S/B, purity, etc.

Aim:

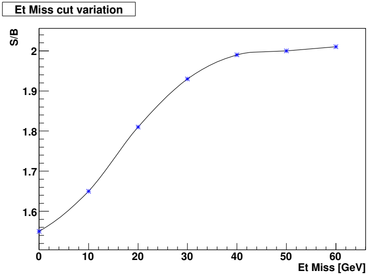
Investigate effects of varying the cuts using the FullSim data at 10TeV, including the currently available backgrounds: recently reproduced unbiased Z+jets and W+jets samples and t-, Wt- channel single top. At the moment, the diboson backgrounds (WW, WZ, ZZ), and s-channel single top are not available.
We're primarily interested in the variation of S/B with the choice of cuts, as well as the total event yields and signal purity.

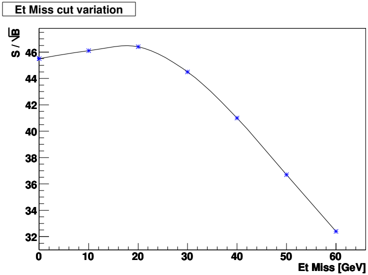
Reminder of the current state of affairs. In CSC note used

- Require event to pass triggers L1EM20, L2e25, EFe25i or muon triggers mu20.
- lepton $P_T > 20$GeV.
- Require 4 jets with $P_T > 20$GeV, and 3 jets with $P_T > 40$GeV.
- $\not{E}_T > 20$GeV.

The most interesting cuts to vary are the jet cuts and the $\not{E}_T$ cut.

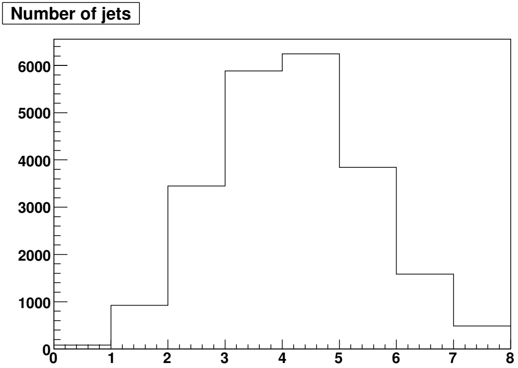
EtMiss cut For a start, we fix the cuts to be the standard Selection A and vary the Et Miss cut.





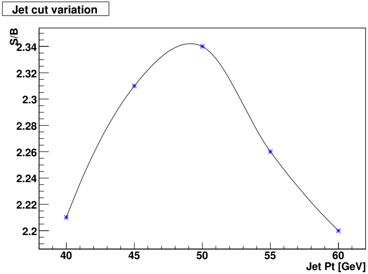
Optimal EtMiss appears to be around 40GeV.

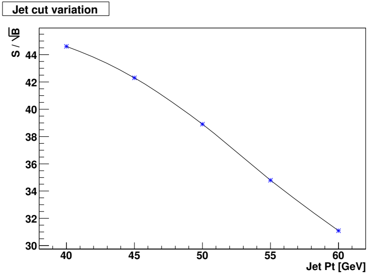
The number of jets required is 4 in the standard selection cuts - this is because the median number of jets with $P_T \geq 20$ is at 4 as expected from event topology.



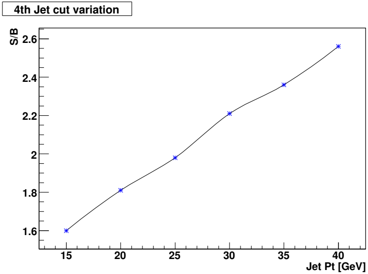
Requiring 5 instead of 4 good jets in Selection A gives $S = 643, B = 236, S/B = 2.73.$

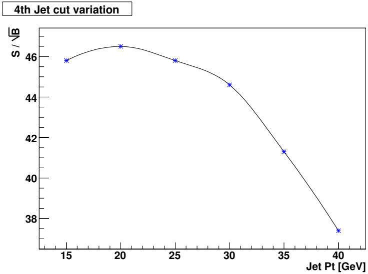
Varying Jet Cuts - I We now fix the 4th jet P_T to be $\geq$ 30GeV and vary the minimum P_T of the first three jets.



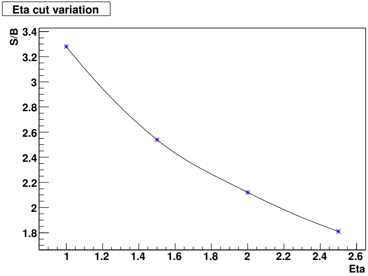


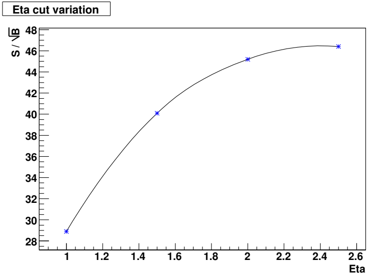
Varying Jet Cuts - II Next the hardest three jets are required to have $P_T \geq 40\text{GeV}$ and the P_T of the fourth jet is varied.





Varying $|\eta|$ cut of Good Jets We return to Selection A cuts but define a good jet to have $|\eta| < x$ rather than $|\eta| < 2.5$ and vary x.





EtMiss variation

Et Miss (GeV)	0	10	20	30	40	50	60
S	1329	1292	1192	1029	844	672	523
B	855	784	658	534	423	335	260
S/B	1.55	1.65	1.81	1.93	1.99	2.00	2.01
$S/\sqrt{B}$	45.5	46.1	46.5	44.5	41.0	36.7	32.4

3 jets $P_T \geq$40 GeV, 4th jet P_T varied

Jet P_T (GeV)	15	20	25	30	35	40
S	1307	1192	1056	898	724	547
B	816	658	532	406	307	214
S/B	1.60	1.81	1.98	2.21	2.36	2.56
$S/\sqrt{B}$	45.8	46.5	45.8	44.6	41.3	37.4

4th jet $P_T \geq 30$ GeV, P_T of first three varied

Jet P_T (GeV)	40	45	50	55	60
S	898	774	648	534	437
B	406	335	277	236	198
S/B	2.21	2.31	2.34	2.26	2.20
$S/\sqrt{B}$	44.6	42.3	38.9	34.8	31.1

Varying $\|\eta\|$ cut of good jets

$\|\eta\|$ cut at	2.5	2.0	1.5	1.0
S	1189	961	633	254
B	658	453	249	77
S/B	1.81	2.12	2.54	3.28
$S/\sqrt{B}$	46.4	45.2	40.1	28.9

We wish now to compare different methods of constructing the top candidate in terms of achieved purity. Purity here is defined as fraction of top candidates which can be matched with $\Delta R < 0.2$ to a real top quark. Methods compared:

1. standard CSC note (top candidate is the 3-jet combination with highest P_T)
2. requiring exactly 4 jets and reconstructing leptonic *b*-jet as jet closest in ΔR to lepton, and thus the hadronic top as the combination of the remaining 3 jets
3. kinematic fit: reconstructing the neutrino and then minimising

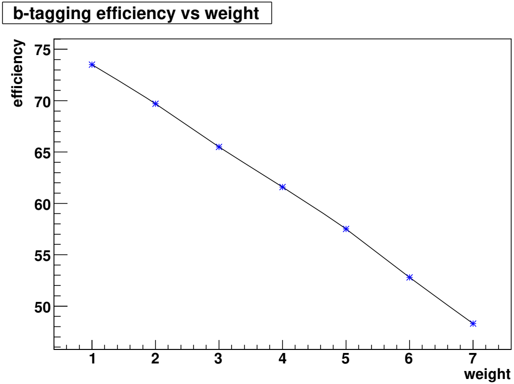
$$\chi^2 = (m_{jjj} - m_t)^2 + (m_{jj} - m_W)^2 + (m_{j\nu l} - m_t)^2 \qquad (1)$$

Purities

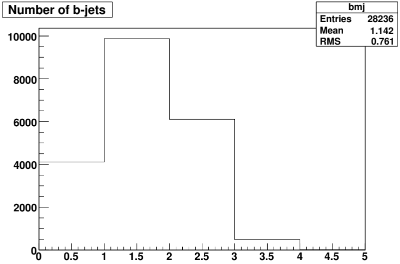
Purity	CSC method	CSC with 4 jets	method 2	method 3
sel A	23	27	30	32
m_T cut	49	53	34	48
m_W cut	33	38	35	42
$\|\eta\| < 1$	37	40	38	41
$\|\eta\| < 1+m_W$	45	44	47	49

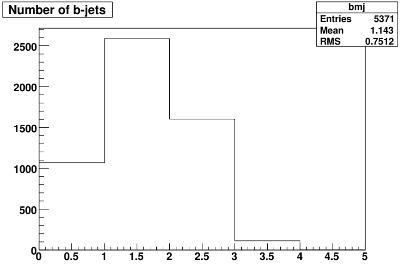
b-tagging efficiency and rejection rate

Weight	1.0	2.0	3.0	4.0	5.0	6.0	7.0
Efficiency (%)	73.5	69.7	65.6	61.6	57.5	52.8	48.3
Rejection (%)	8.34	5.93	4.29	3.42	2.68	2.09	1.50



A fit gives the weight 4.30 for the efficiency 60% after selection A. The corresponding rejection rate is 0.0313. Indeed, with this choice, the results are in very good agreement with 14TeV (where the weight was at 7.05):





Conclusions:

- Raising the $\not\!\!E_T$ cut to about 40GeV helps get rid of the Z+jets background (and presumably a lot of the QCD). Beyond that not much effect on S/B.
- Centrality ($|\eta|$) cut has a large effect on S/B and can be exploited to get a very pure sample, but with little signal left.
- All 'naive' methods for top reconstruction that we tested have a similar performance in terms of purity. Try to improve on this!

Technical aside

- Analysis is done by first producing ntuples on the grid from the AODs. Both PANDA and GANGA are used for this, although recently - more PANDA (sandbox issue with GANGA which put me off...).
- The ttbar used is the one with the HEC quadrant off (mc08.105200.T1_McAtNlo_Jimmy.recon.AOD.e357_s462_r541).
- Z+jets and W+jets are the unbiased samples 7650-7705. Single top in s-channel has not been produced and has not been used in this analysis.