Status of ttbar → cZ Wb → cll vlb

Isis Van Parijs

Object selection

Object selection:

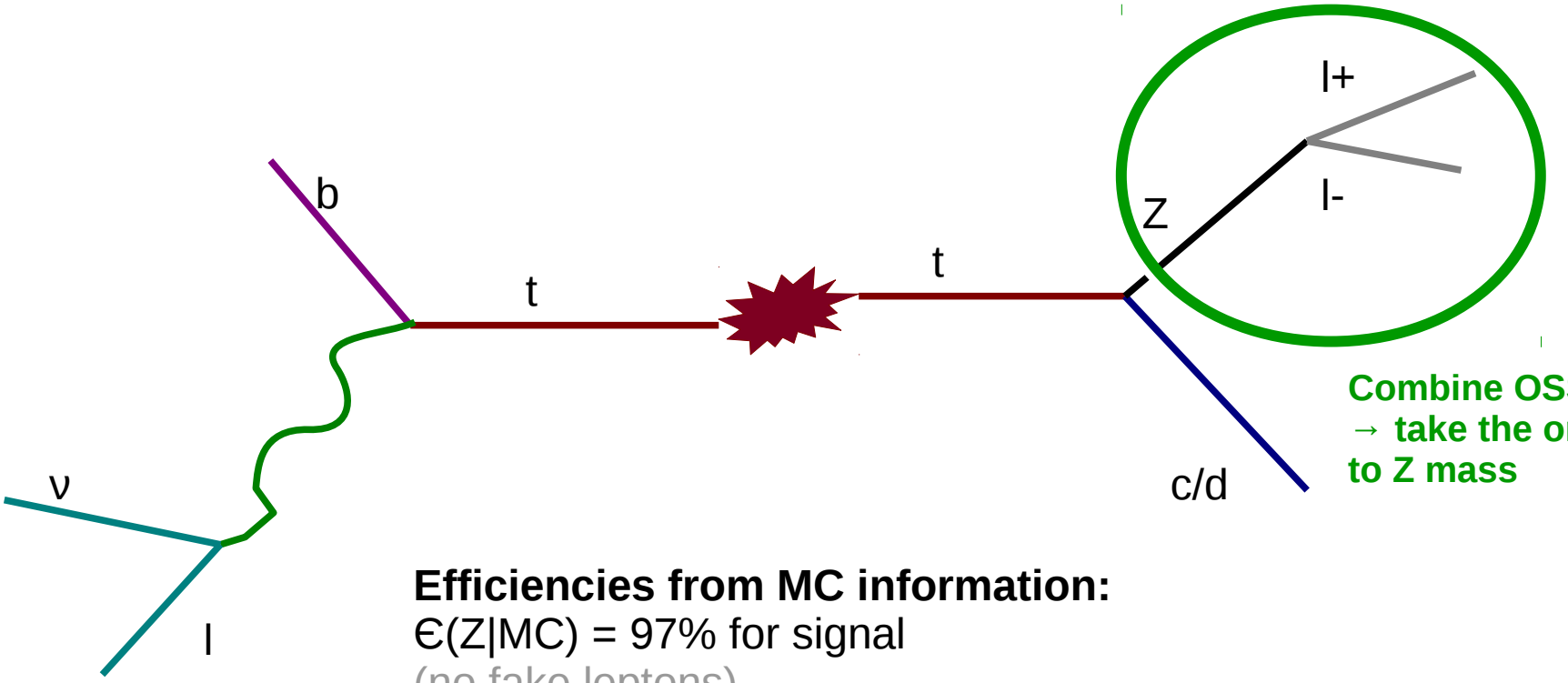
- Lepton pt:
  - Electrons and muons: pt > 20 GeV
  - Electrons |eta|: <2.5 en muons |eta|< 2.4
- Jets: pt > 40 , |eta| < 2.4 , EEoverHE() > 0.3
- Cone 04
- B jet discriminator: CSV loose

Cutflow

- Number of jets ≥ 2
- Number of b-jets ≥ 1
- At least 1 OSSF pair
- Z mass window of 15 GeV
- Top mass window of 35 GeV

Revising the object reconstruction

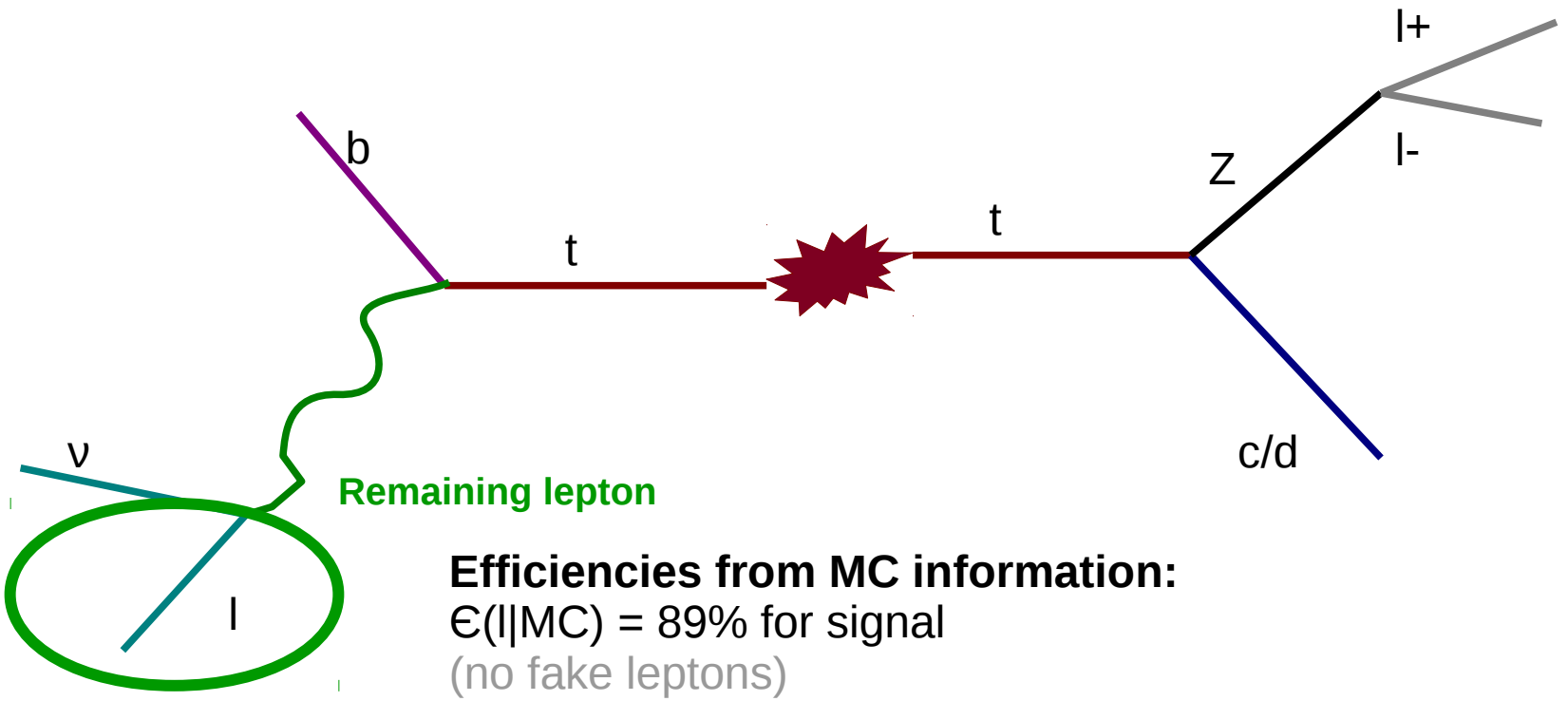
Old Object reconstruction



Combine OSSF pairs → take the one closest to Z mass

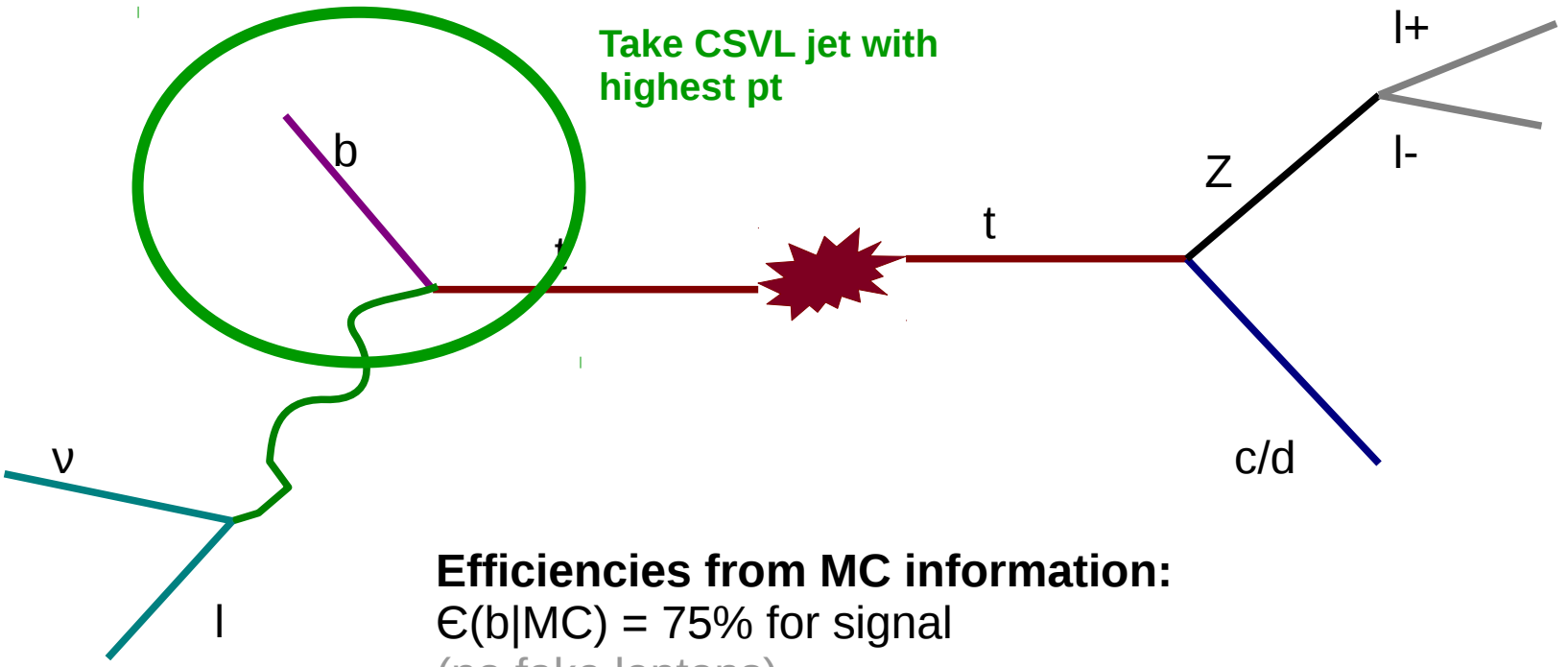
Efficiencies from MC information:
Є(Z|MC) = 97% for signal
(no fake leptons)

Old Object reconstruction



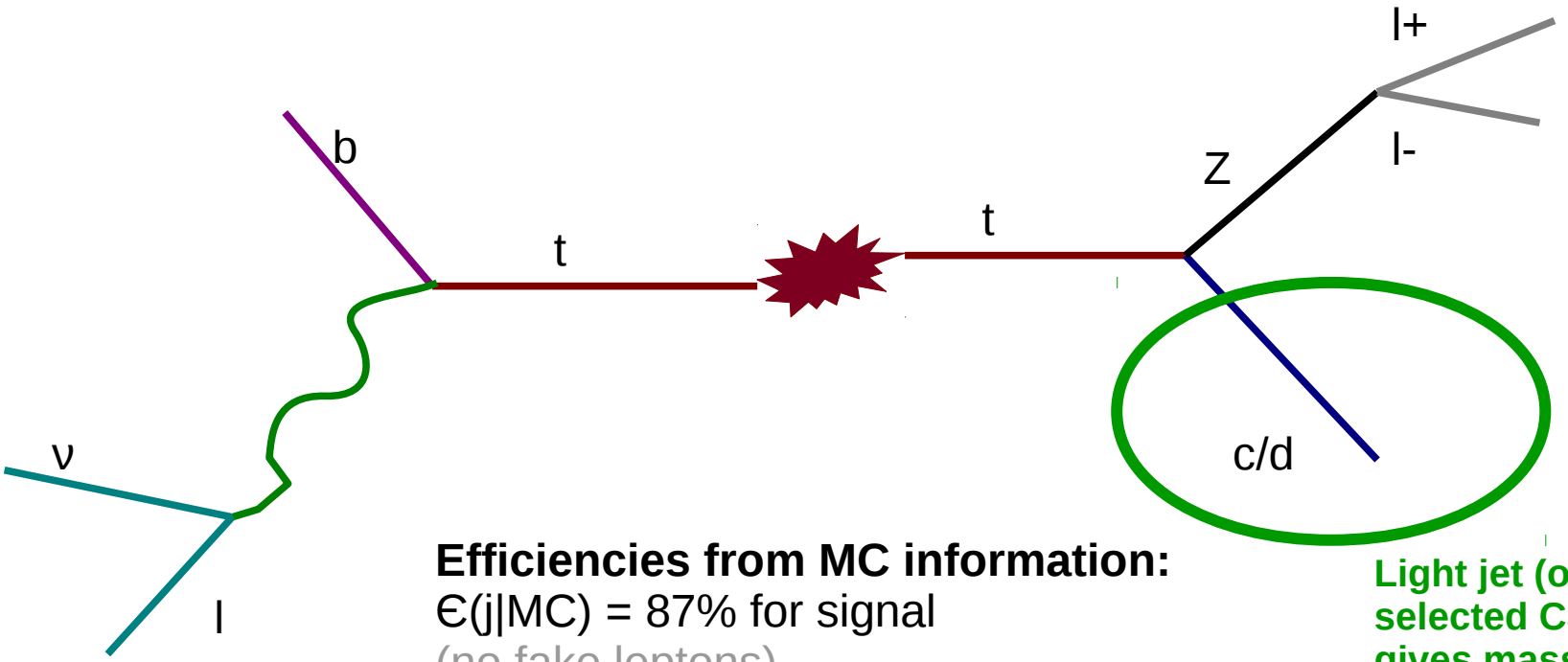
Efficiencies from MC information:
Є(l|MC) = 89% for signal
(no fake leptons)

Old Object reconstruction



Efficiencies from MC information:
Є(b|MC) = 75% for signal
(no fake leptons)

Old Object reconstruction



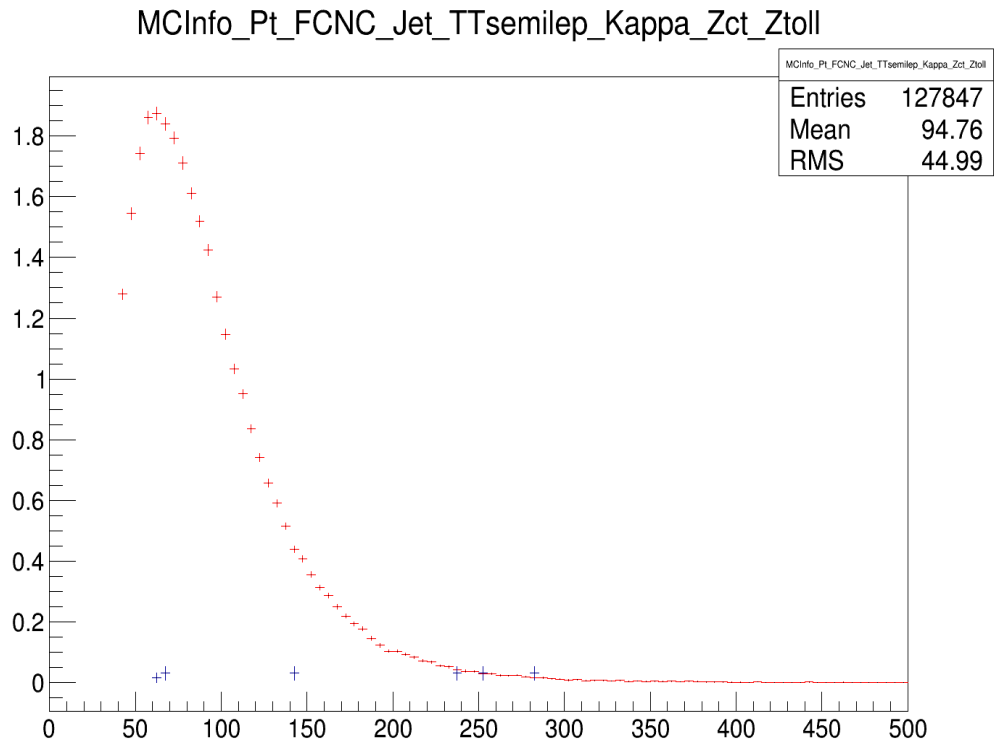
Efficiencies from MC information:
Є(j|MC) = 87% for signal
(no fake leptons)

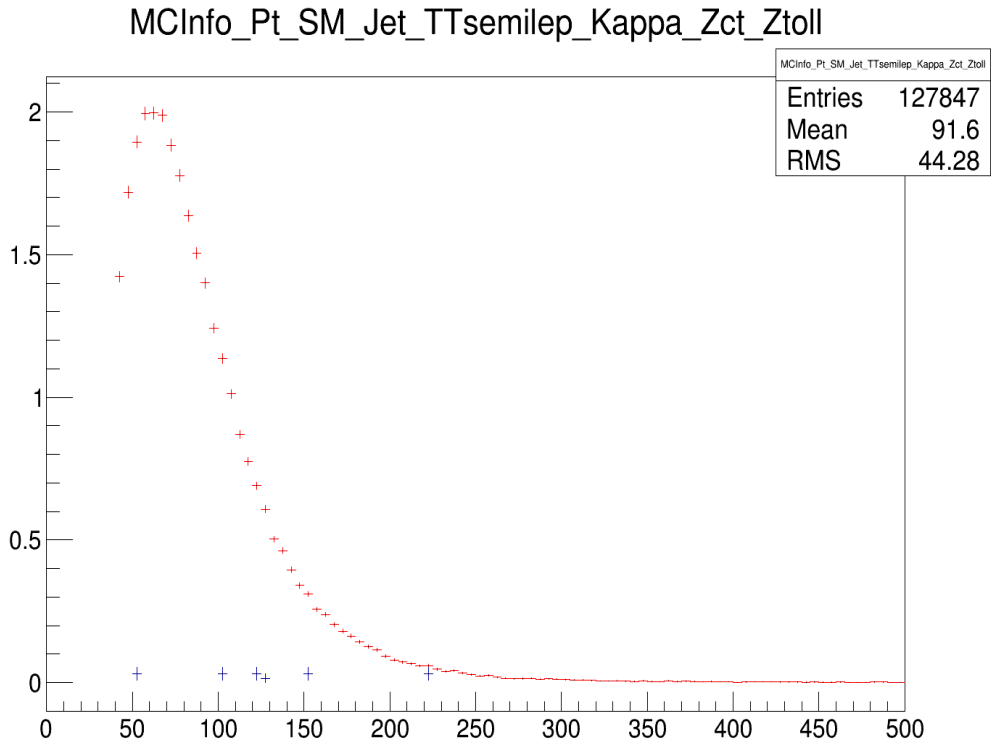
Light jet (or non selected CSVL jet) that gives mass closest to top mass

New object reconstruction

- Z/W boson reconstruction stays the same
- c and b jet: choose the two highest pt jets
  - Avoids using b-tagger
  - Efficiency of selecting the right b and c jet changes from 78% to 87%
  - How to disentangle these two jets?

Transverse momentum jets

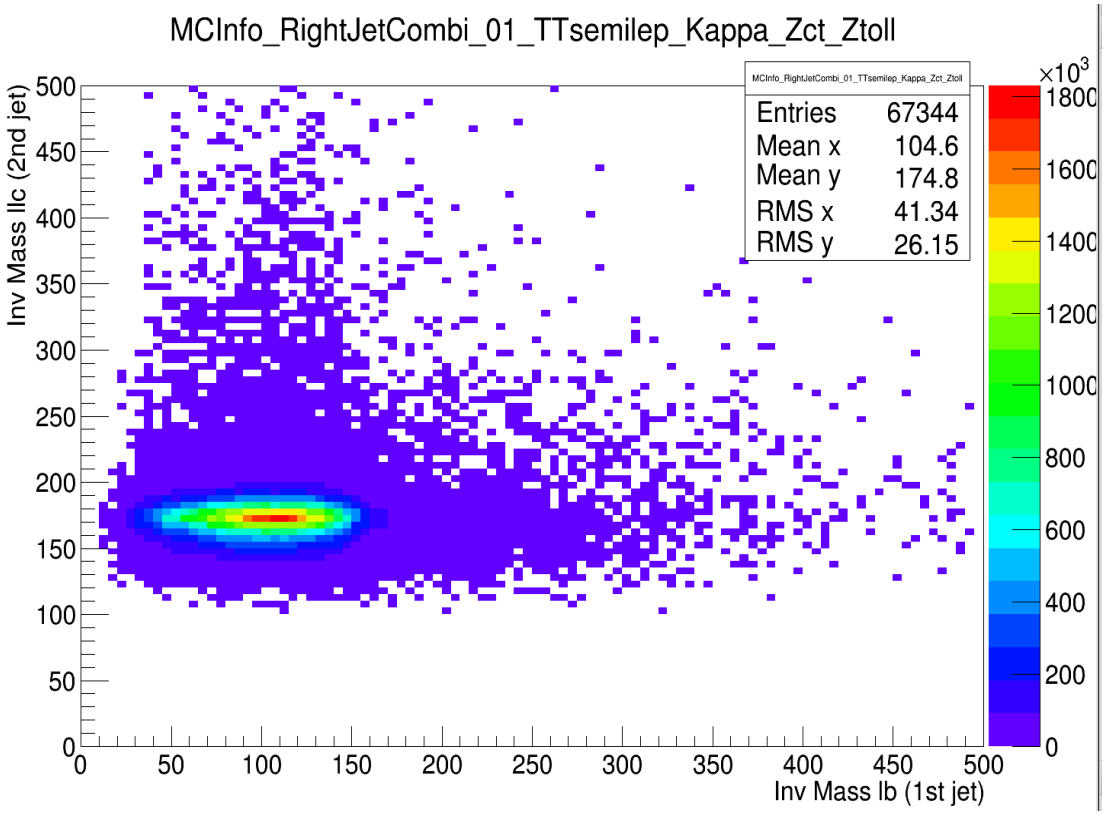




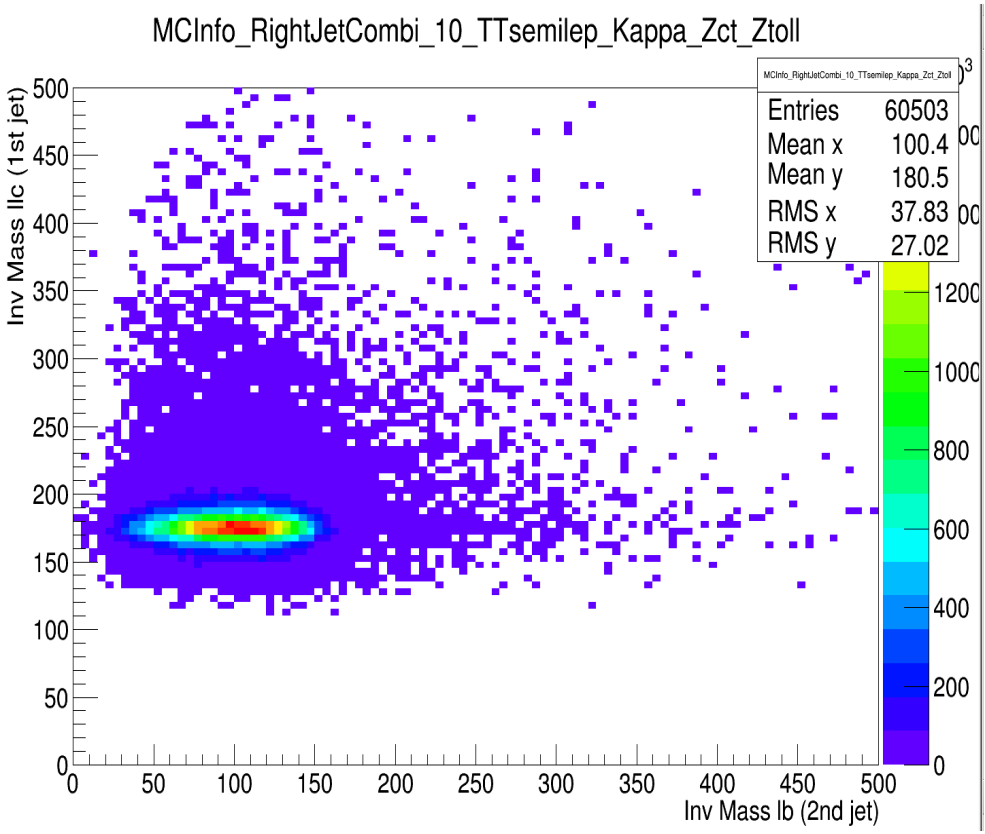
Signal = red
WZ = blue

pT is almost the same

M(l,b) vs M(l,l,c) for Zct right jet combinations

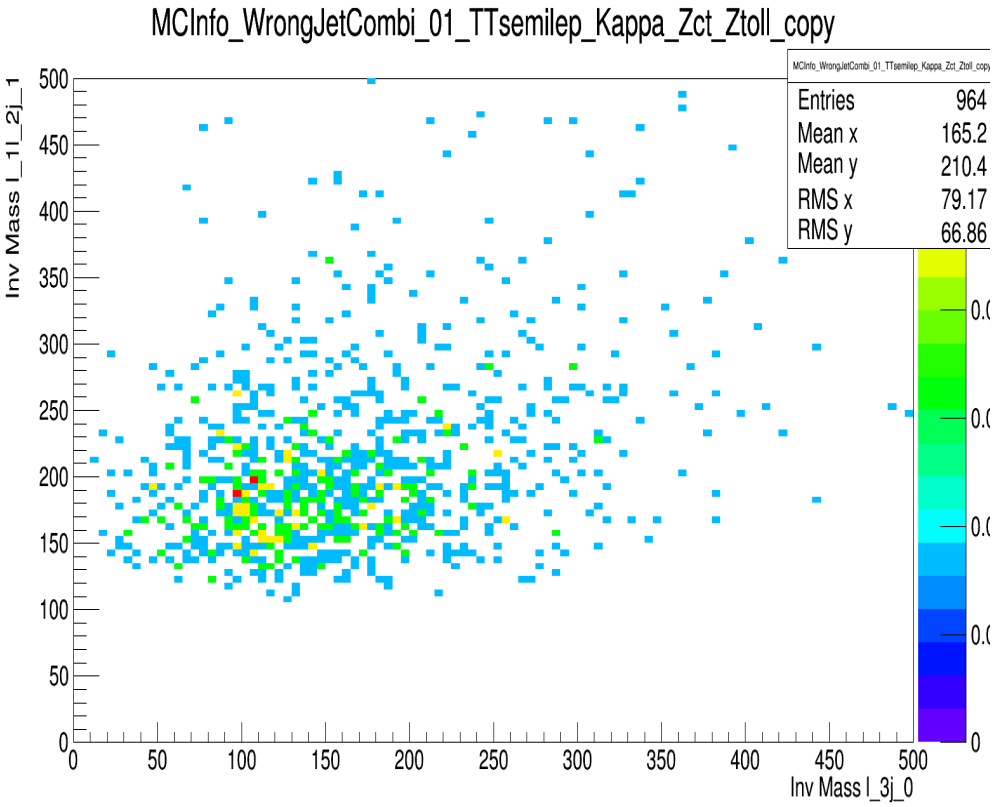


Highest pT jet in M(l,b)

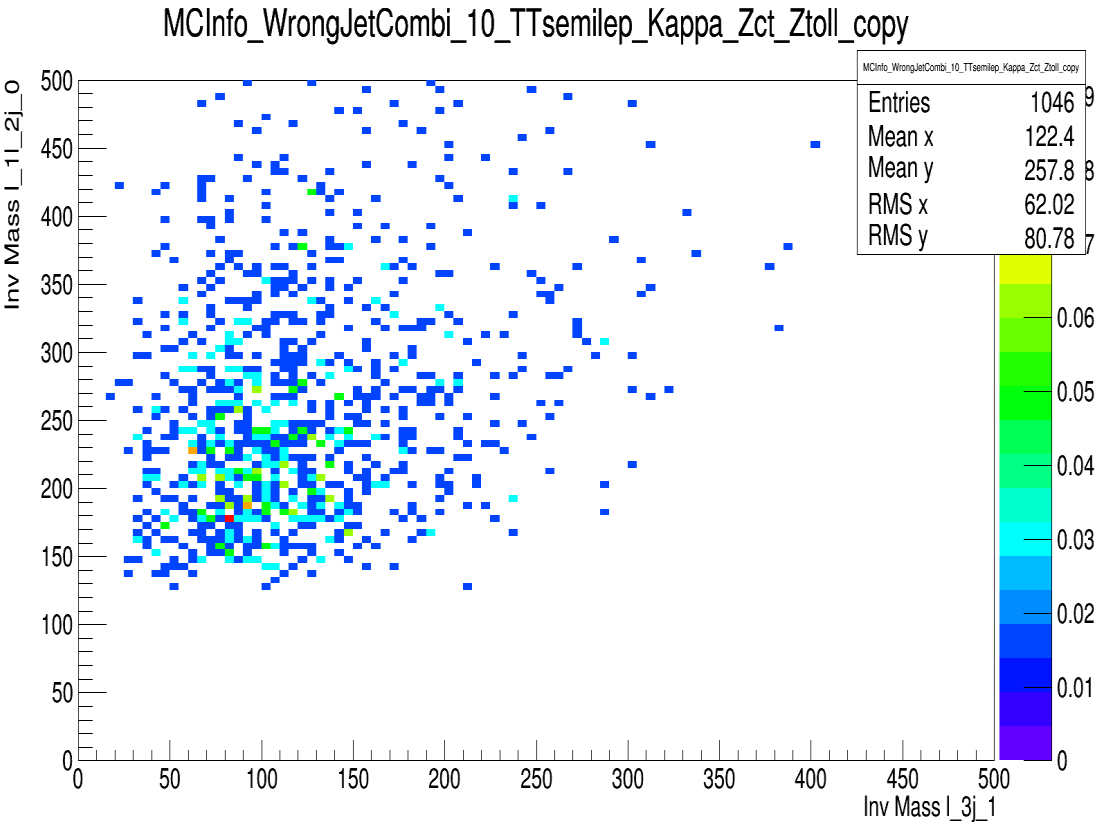


Second highest pT jet in M(l,b)

M(l,b) vs M(l,l,c) for Zct wrong jet combinations



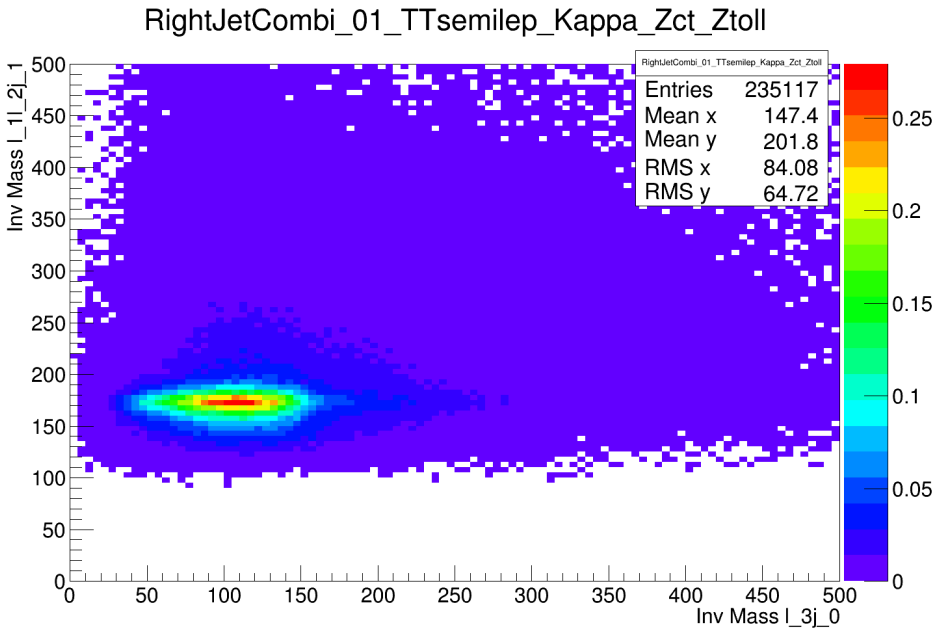
Highest pT jet in M(l,b)



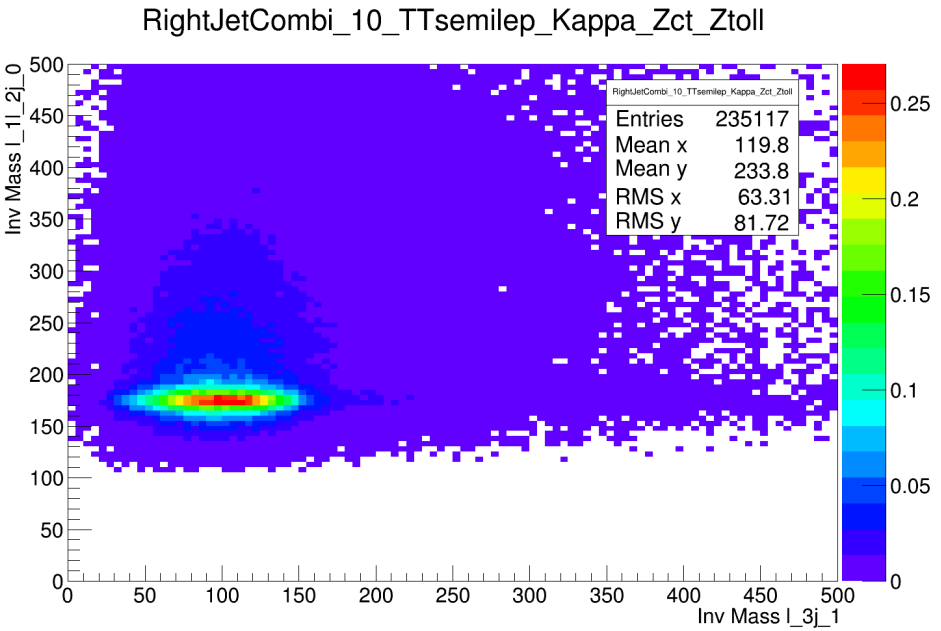
Second highest pT jet in M(l,b)

Maybe use this to do a fit instead of the MVA?

M(l,b) vs M(l,l,c) for Zct all jet combinations

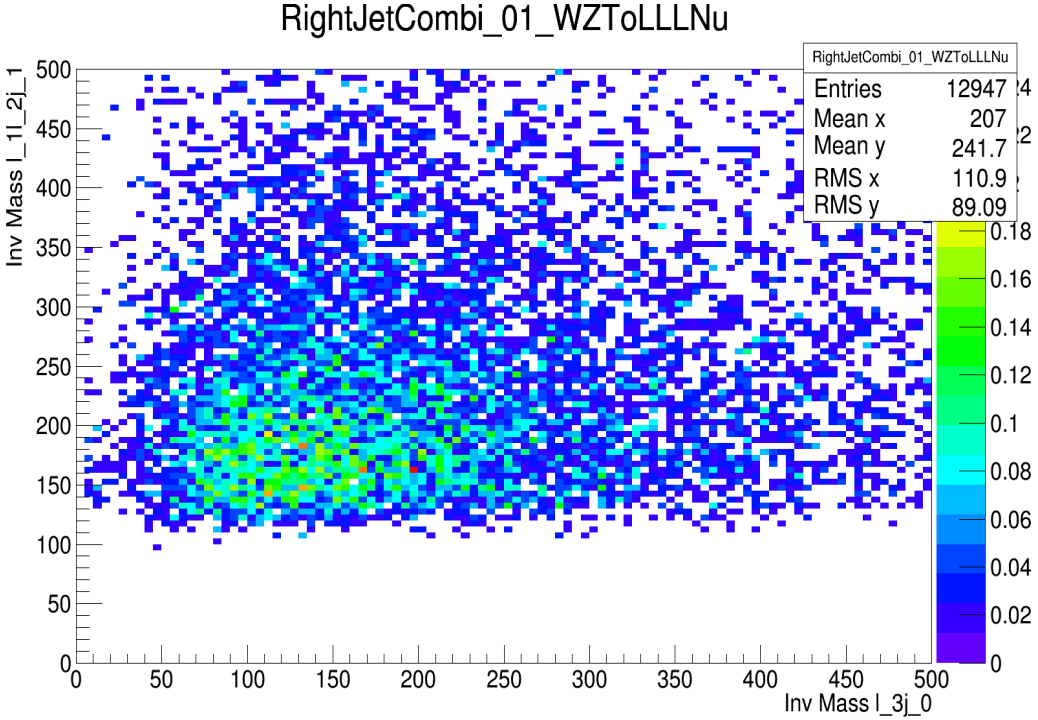


Highest pT jet in M(l,b)

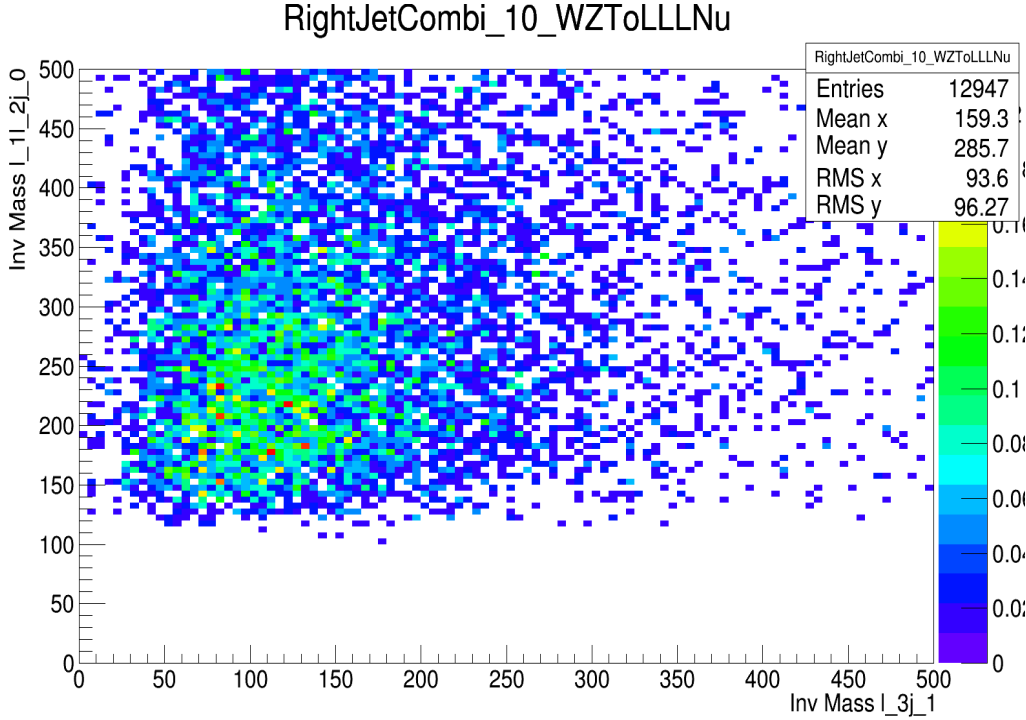


Second highest pT jet in M(l,b)

M(l,b) vs M(l,l,c) for WZ all jet combinations



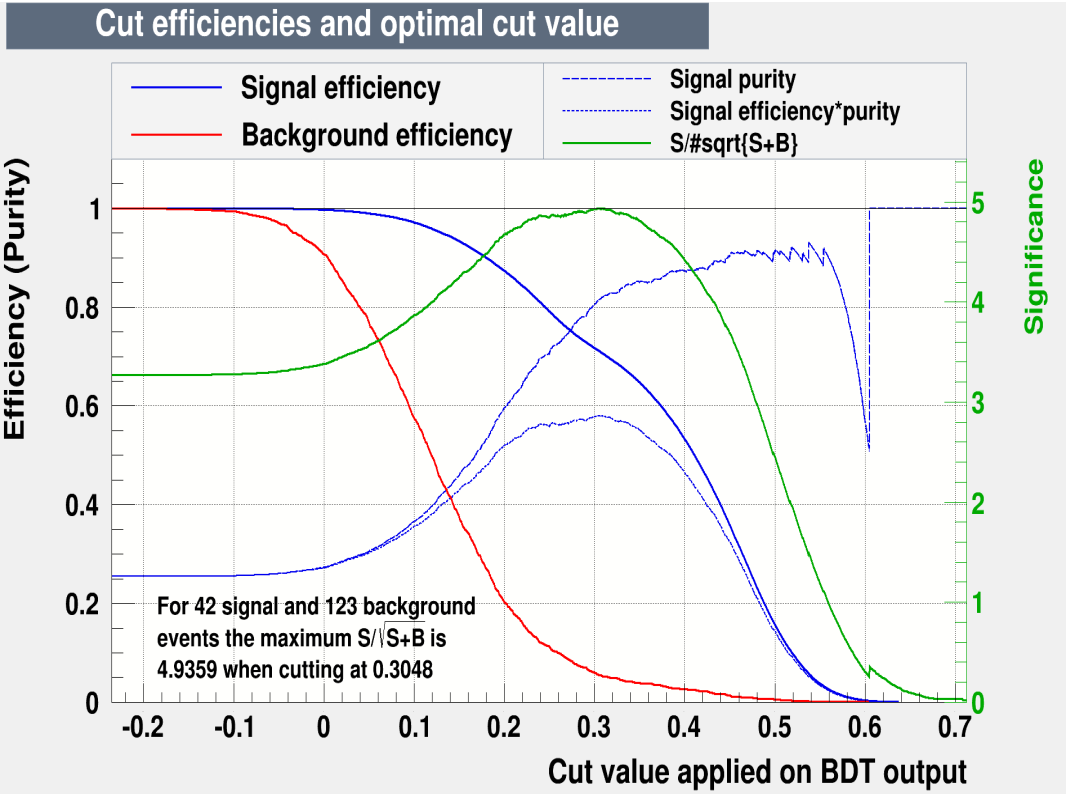
Highest pT jet in M(l,b)



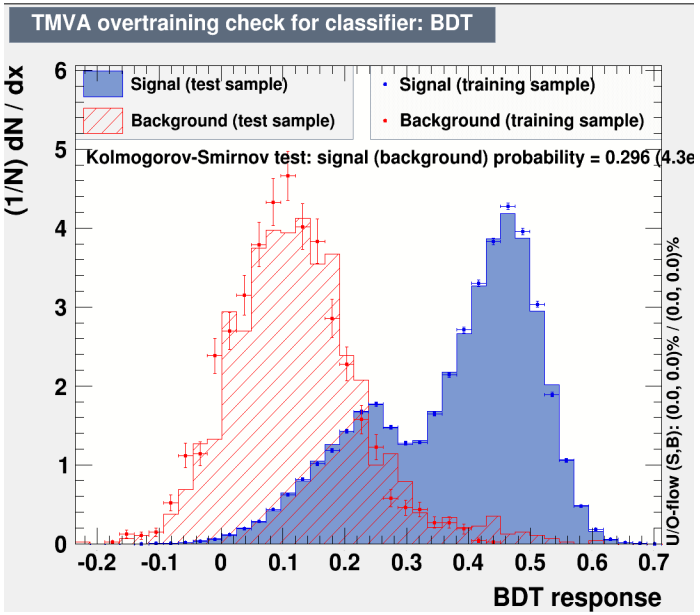
Second highest pT jet in M(l,b)

Checking the MVA

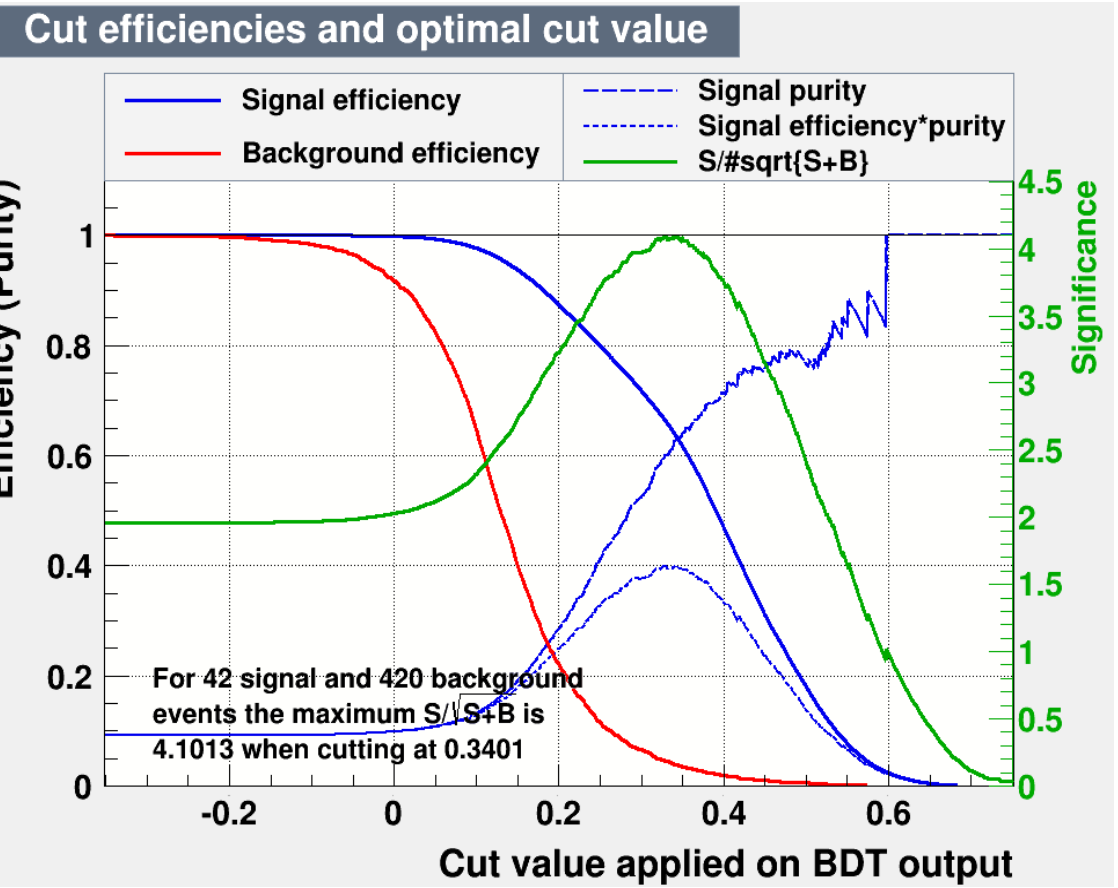
MVA with only WZ for training: overtraining fixed!



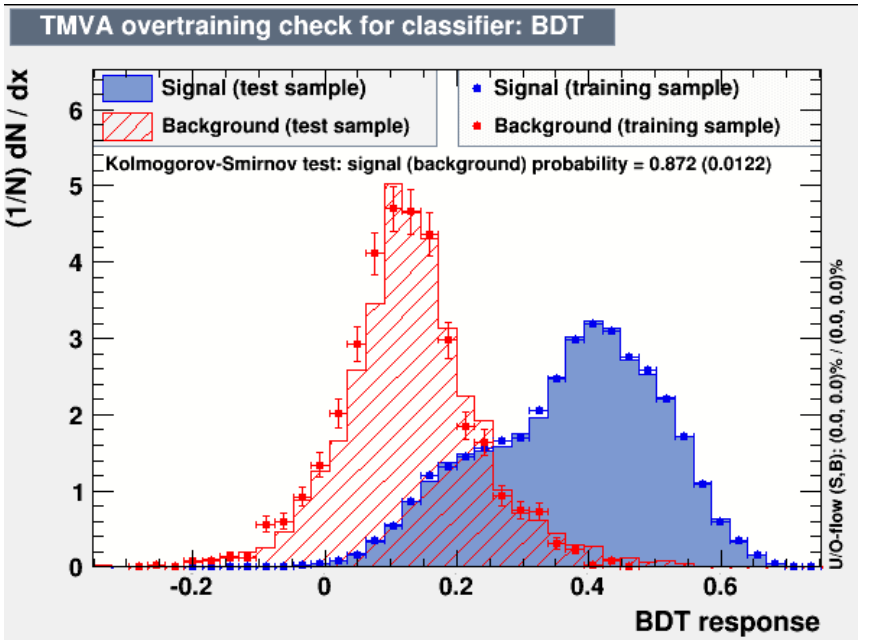

```
Ranking input variables (method specific)...
Ranking result (top variable is best ranked)
------------------------------------------------------------------
Rank : Variable                          : Variable Importance
------------------------------------------------------------------
   1 : MVA_Nb_CSVM_jets                  : 1.605e-01
   2 : MVA_SM_lb                         : 1.540e-01
   3 : MVA_Inv_Mass_FCNCtop              : 9.794e-02
   4 : MVA_Transverse_Mass_Wlep_MET_Bjet : 8.696e-02
   5 : MVA_DeltaEta_Leptons_Zcan         : 8.239e-02
   6 : MVA_DeltaEta_Bjet_Zcan            : 8.040e-02
   7 : MVA_DeltaEta_Wlep_MET             : 7.969e-02
   8 : MVA_Ht                            : 7.682e-02
   9 : MVA_Ratio_top_InvMass             : 6.215e-02
  10 : MVA_MET                           : 6.140e-02
  11 : MVA_DeltaEta_Wlep_Zcan            : 5.781e-02
```



MVA only WZ for training and testing with fake leptons



Rise in significance!




```
Ranking input variables (method specific)...
Ranking result (top variable is best ranked)
-----------------------------------------------------------------
Rank : Variable                          : Variable Importance
-----------------------------------------------------------------
   1 : MVA_Nb_CSVM_jets                  : 1.944e-01
   2 : MVA_Transverse_Mass_Wlep_MET_Bjet : 1.684e-01
   3 : MVA_Inv_Mass_FCNCtop              : 1.214e-01
   4 : MVA_DeltaEta_Wlep_Zcan            : 1.052e-01
   5 : MVA_DeltaEta_Bjet_Zcan            : 1.026e-01
   6 : MVA_DeltaEta_Wlep_MET             : 9.698e-02
   7 : MVA_Ht                            : 8.099e-02
   8 : MVA_DeltaEta_Leptons_Zcan         : 6.898e-02
   9 : MVA_MET                           : 6.098e-02
-----------------------------------------------------------------
```

→ still need to include new variables

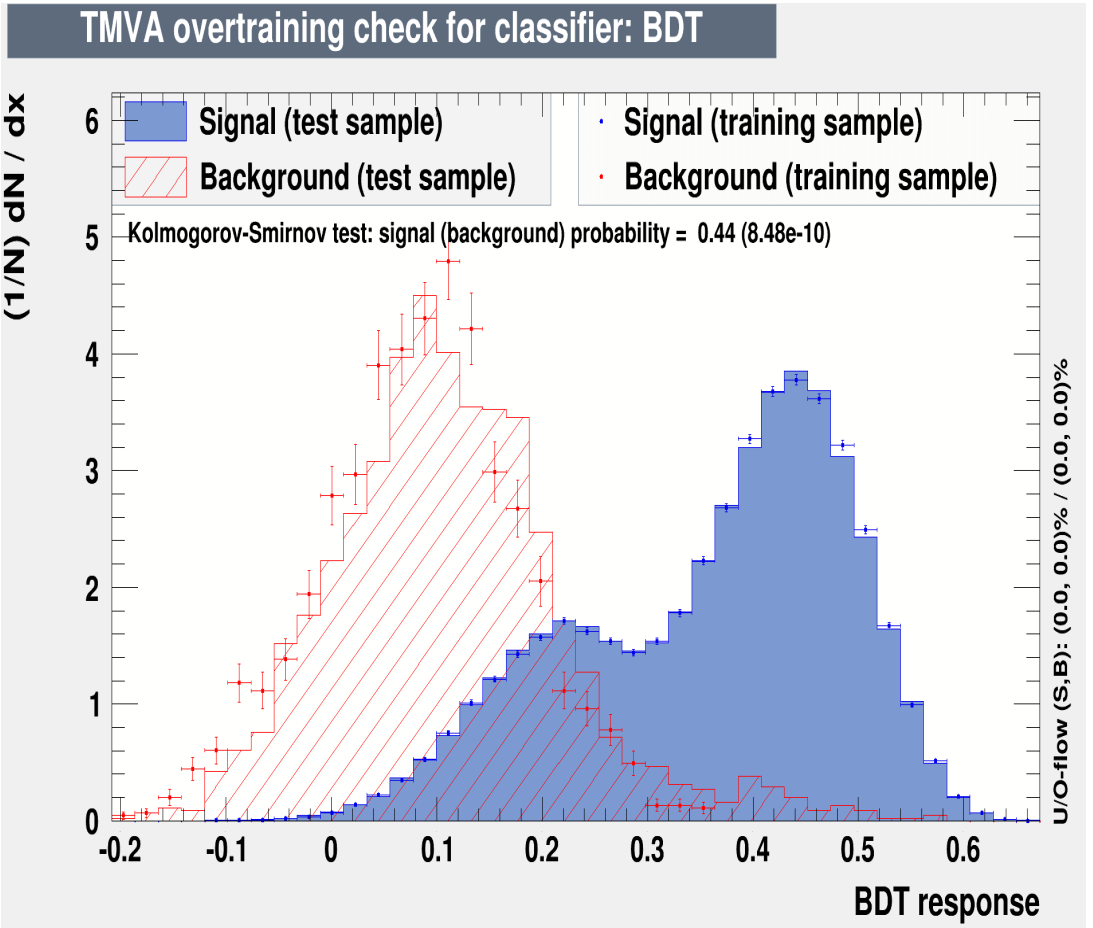
Conclusions

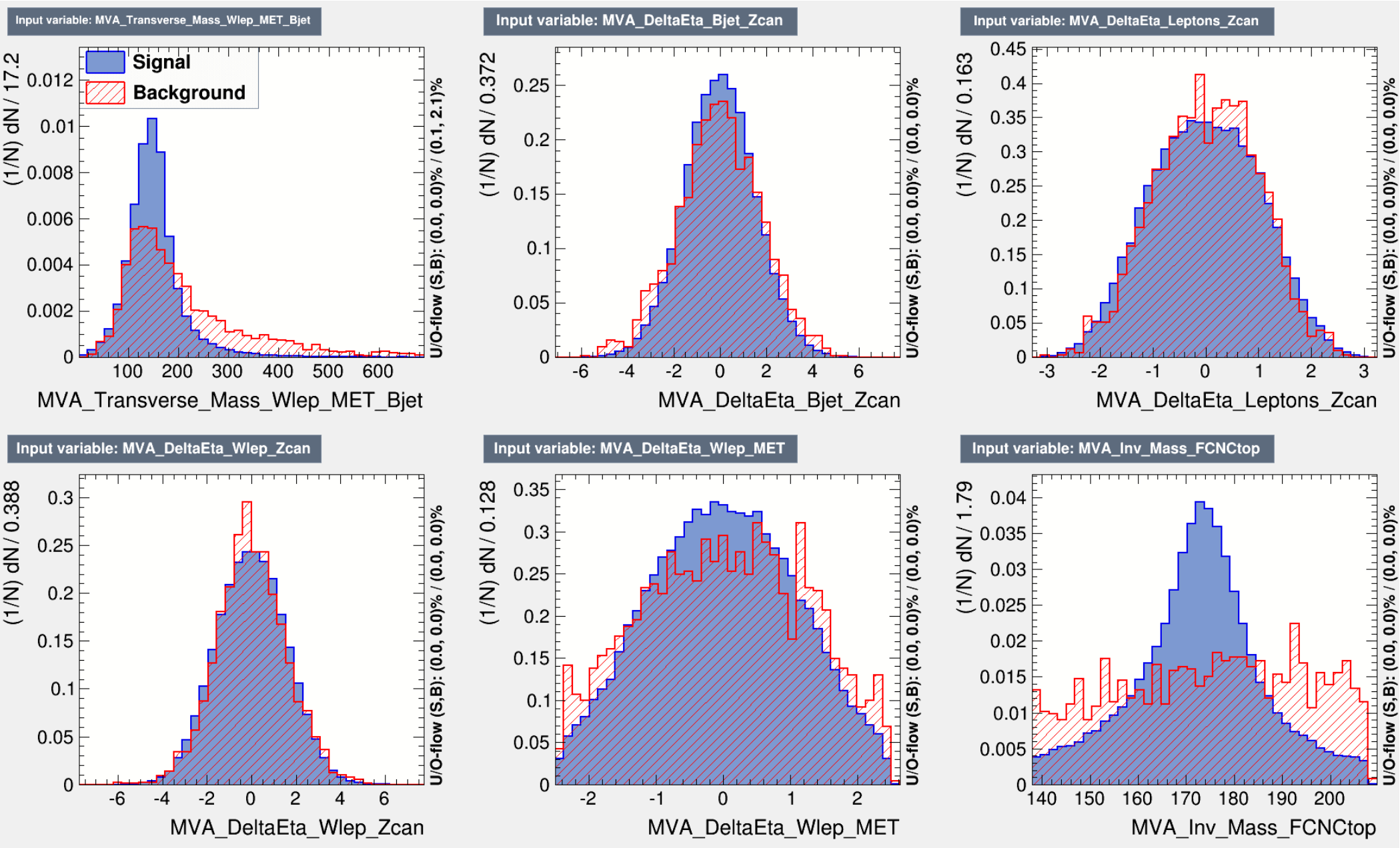
- Looking for a way to disentangle b and c jets
- Found variables to do a template fit instead of the MVA
- Solved the overtraining in the MVA

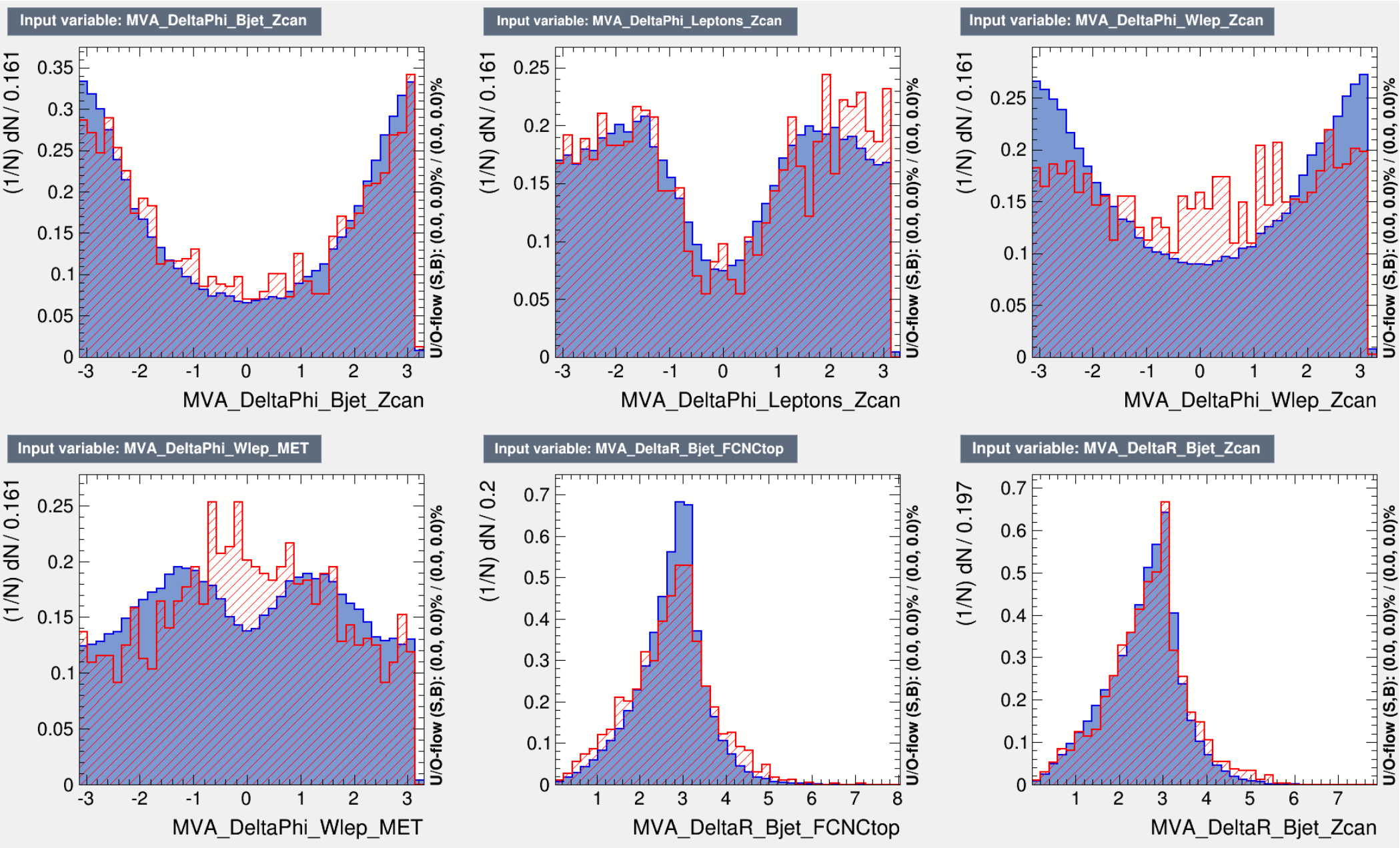
Back up

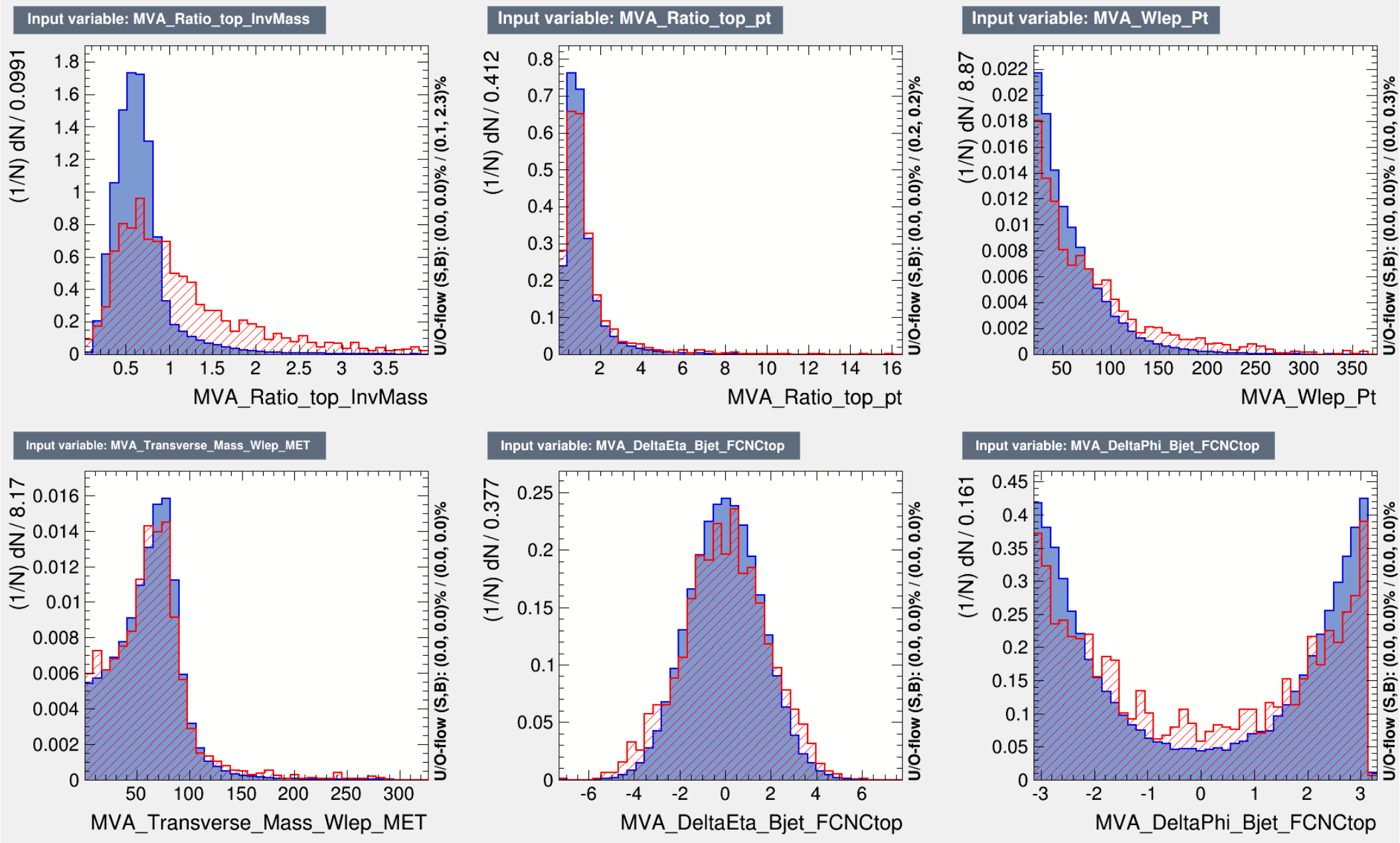
MVA: only WZ for training (no fakes)

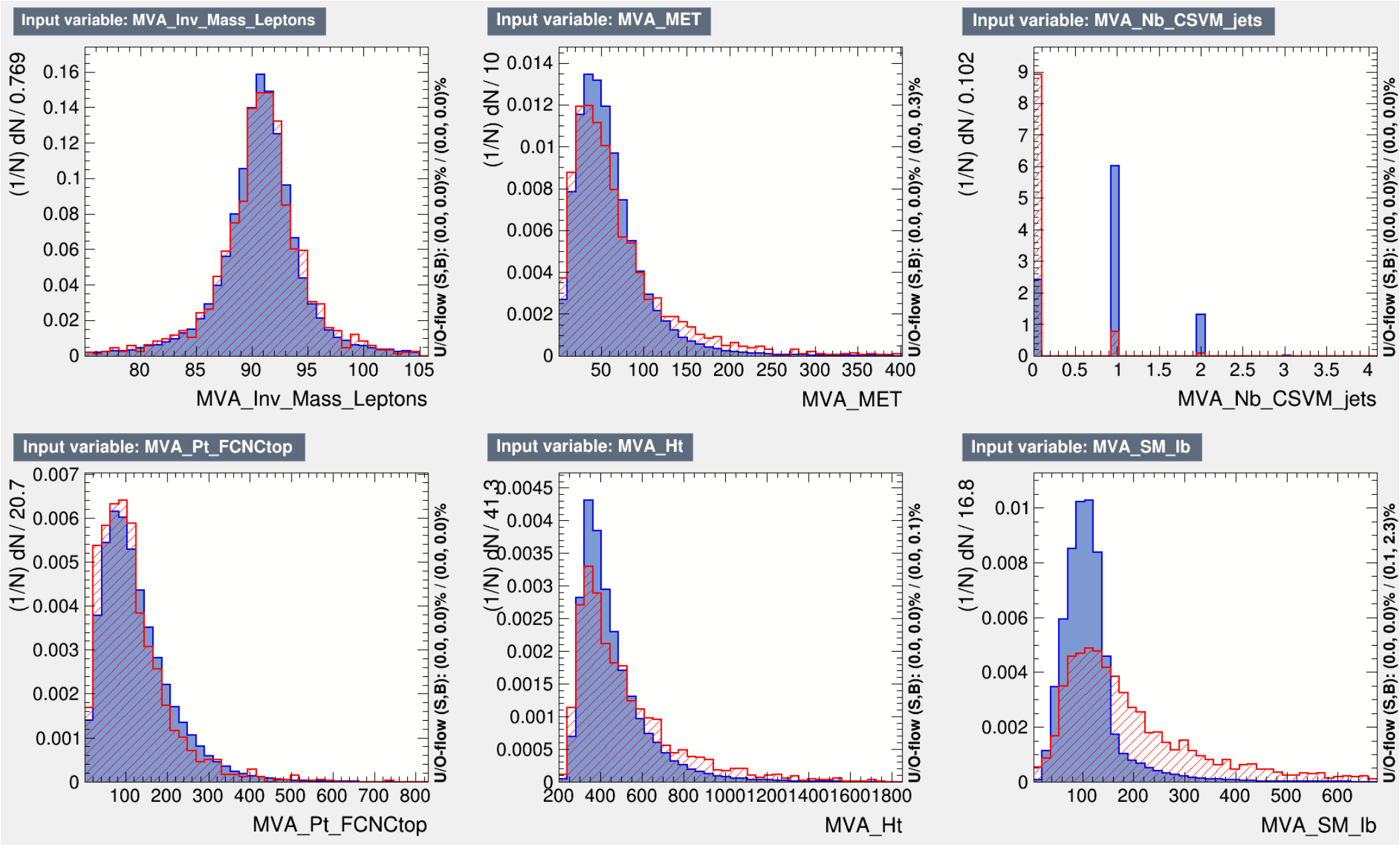
```
Ranking input variables (method specific)...
Ranking result (top variable is best ranked)
------------------------------------------------------------
Rank : Variable                          : Variable Importance
------------------------------------------------------------
   1 : MVA_Nb_CSVM_jets                  : 9.919e-02
   2 : MVA_SM_lb                         : 8.769e-02
   3 : MVA_Inv_Mass_FCNCtop              : 4.808e-02
   4 : MVA_DeltaR_Bjet_Zcan              : 4.767e-02
   5 : MVA_DeltaPhi_Wlep_Zcan            : 4.503e-02
   6 : MVA_DeltaR_Wlep_Zcan              : 3.873e-02
   7 : MVA_Ratio_top_InvMass             : 3.353e-02
   8 : MVA_DeltaR_Bjet_FCNCtop           : 3.329e-02
   9 : MVA_Transverse_Mass_Wlep_MET_Bjet : 3.316e-02
  10 : MVA_DeltaEta_Bjet_Zcan            : 3.184e-02
  11 : MVA_DeltaPhi_Leptons_Zcan         : 3.179e-02
  12 : MVA_Inv_Mass_Leptons              : 3.094e-02
  13 : MVA_DeltaEta_Leptons_Zcan         : 3.080e-02
  14 : MVA_DeltaPhi_Wlep_MET             : 3.057e-02
  15 : MVA_Pt_Zcandidate                 : 3.009e-02
  16 : MVA_Transverse_Mass_Wlep_MET      : 2.875e-02
  17 : MVA_MET                           : 2.846e-02
  18 : MVA_DeltaR_Wlep_MET               : 2.798e-02
  19 : MVA_Nb_jets                       : 2.787e-02
  20 : MVA_DeltaEta_Wlep_MET             : 2.776e-02
  21 : MVA_DeltaPhi_Bjet_FCNCtop         : 2.752e-02
  22 : MVA_Pt_FCNCtop                    : 2.700e-02
  23 : MVA_Ht                            : 2.652e-02
  24 : MVA_Wlep_Pt                       : 2.572e-02
  25 : MVA_DeltaEta_Wlep_Zcan            : 2.360e-02
  26 : MVA_DeltaEta_Bjet_FCNCtop         : 2.334e-02
  27 : MVA_DeltaPhi_Bjet_Zcan            : 2.253e-02
  28 : MVA_DeltaR_Leptons_Zcan           : 2.162e-02
  29 : MVA_Ratio_top_pt                  : 8.929e-03
```



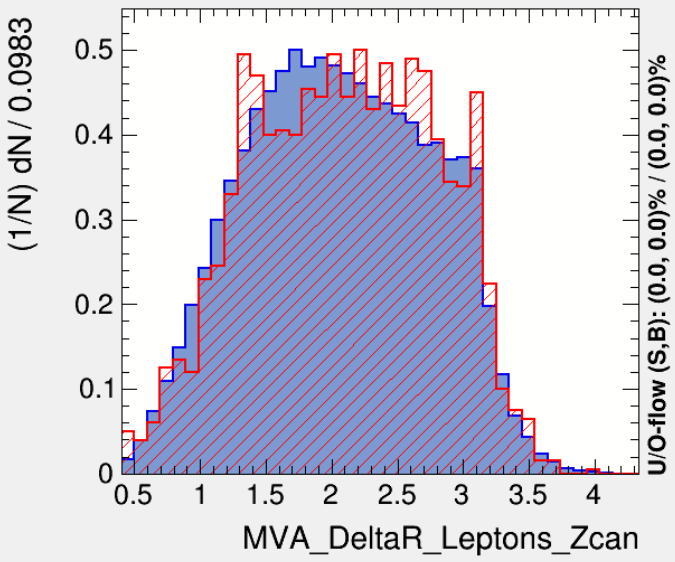

Input variable: MVA_Transverse_Mass_Wlep_MET_Bjet
Signal
Background
(1/N) dN / 17.2
U/O-flow (S,B): (0.0, 0.0)% / (0.1, 2.1)%
MVA_Transverse_Mass_Wlep_MET_Bjet
Input variable: MVA_DeltaEta_Bjet_Zcan
(1/N) dN / 0.372
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
MVA_DeltaEta_Bjet_Zcan
Input variable: MVA_DeltaEta_Leptons_Zcan
(1/N) dN / 0.163
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
MVA_DeltaEta_Leptons_Zcan
Input variable: MVA_DeltaEta_Wlep_Zcan
(1/N) dN / 0.388
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
MVA_DeltaEta_Wlep_Zcan
Input variable: MVA_DeltaEta_Wlep_MET
(1/N) dN / 0.128
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
MVA_DeltaEta_Wlep_MET
Input variable: MVA_Inv_Mass_FCNCtop
(1/N) dN / 1.79
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
MVA_Inv_Mass_FCNCtop


Input variable: MVA_DeltaPhi_Bjet_Zcan
(1/N) dN / 0.161
MVA_DeltaPhi_Bjet_Zcan
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaPhi_Leptons_Zcan
(1/N) dN / 0.161
MVA_DeltaPhi_Leptons_Zcan
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaPhi_Wlep_Zcan
(1/N) dN / 0.161
MVA_DeltaPhi_Wlep_Zcan
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaPhi_Wlep_MET
(1/N) dN / 0.161
MVA_DeltaPhi_Wlep_MET
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaR_Bjet_FCNCtop
(1/N) dN / 0.2
MVA_DeltaR_Bjet_FCNCtop
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaR_Bjet_Zcan
(1/N) dN / 0.197
MVA_DeltaR_Bjet_Zcan
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%

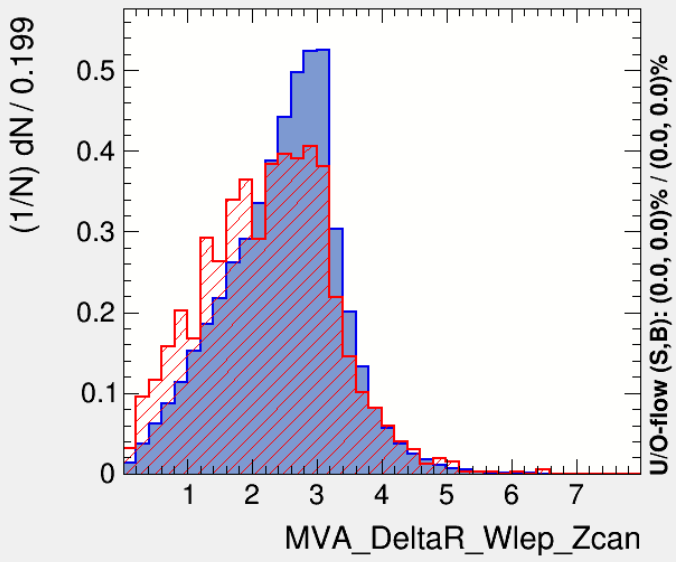

Input variable: MVA_Ratio_top_InvMass
(1/N) dN / 0.0991
MVA_Ratio_top_InvMass
U/O-flow (S,B): (0.0, 0.0)% / (0.1, 2.3)%
Input variable: MVA_Ratio_top_pt
(1/N) dN / 0.412
MVA_Ratio_top_pt
U/O-flow (S,B): (0.0, 0.0)% / (0.2, 0.2)%
Input variable: MVA_Wlep_Pt
(1/N) dN / 8.87
MVA_Wlep_Pt
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.3)%
Input variable: MVA_Transverse_Mass_Wlep_MET
(1/N) dN / 8.17
MVA_Transverse_Mass_Wlep_MET
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaEta_Bjet_FCNCtop
(1/N) dN / 0.377
MVA_DeltaEta_Bjet_FCNCtop
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_DeltaPhi_Bjet_FCNCtop
(1/N) dN / 0.161
MVA_DeltaPhi_Bjet_FCNCtop
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%


Input variable: MVA_Inv_Mass_Leptons
(1/N) dN / 0.769
MVA_Inv_Mass_Leptons
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_MET
(1/N) dN / 10
MVA_MET
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.3)%
Input variable: MVA_Nb_CSVM_jets
(1/N) dN / 0.102
MVA_Nb_CSVM_jets
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_Pt_FCNCtop
(1/N) dN / 20.7
MVA_Pt_FCNCtop
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Input variable: MVA_Ht
(1/N) dN / 41.3
MVA_Ht
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.1)%
Input variable: MVA_SM_lb
(1/N) dN / 16.8
MVA_SM_lb
U/O-flow (S,B): (0.0, 0.0)% / (0.1, 2.3)%

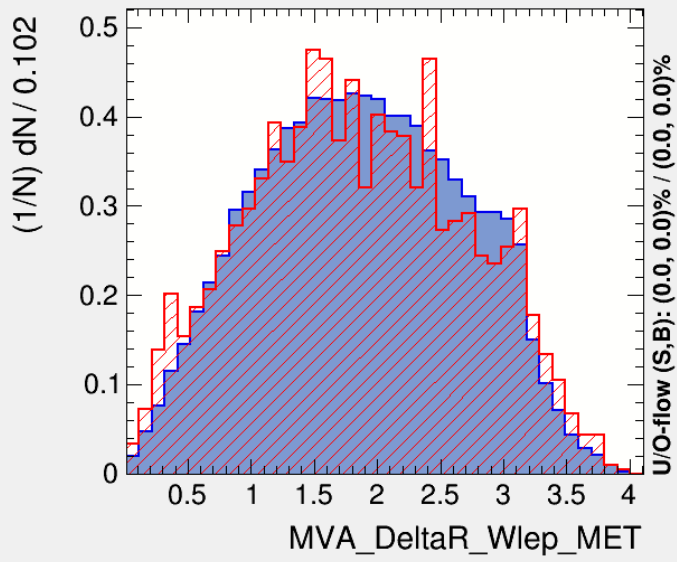
Input variable: MVA_DeltaR_Leptons_Zcan



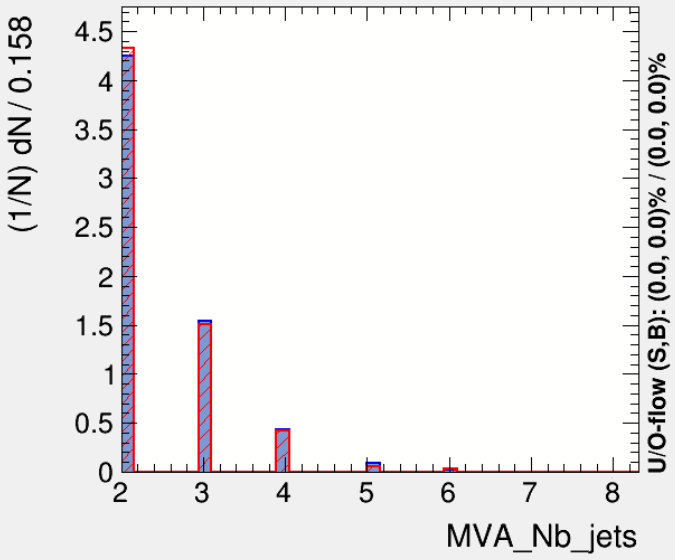
Input variable: MVA_DeltaR_Wlep_Zcan



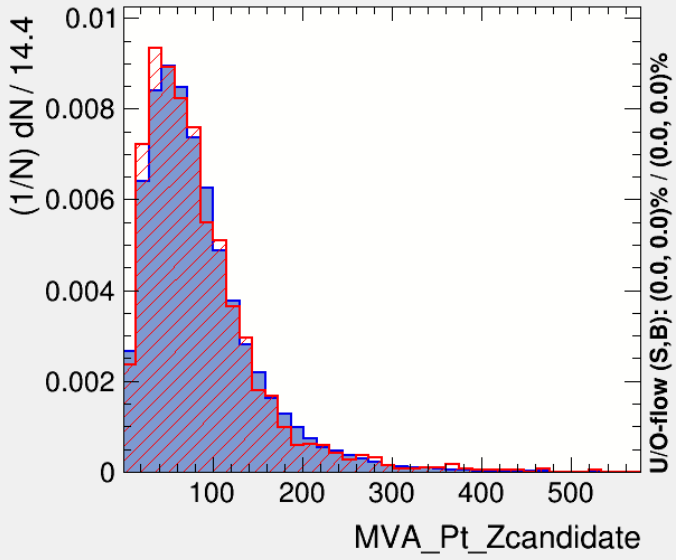
Input variable: MVA_DeltaR_Wlep_MET

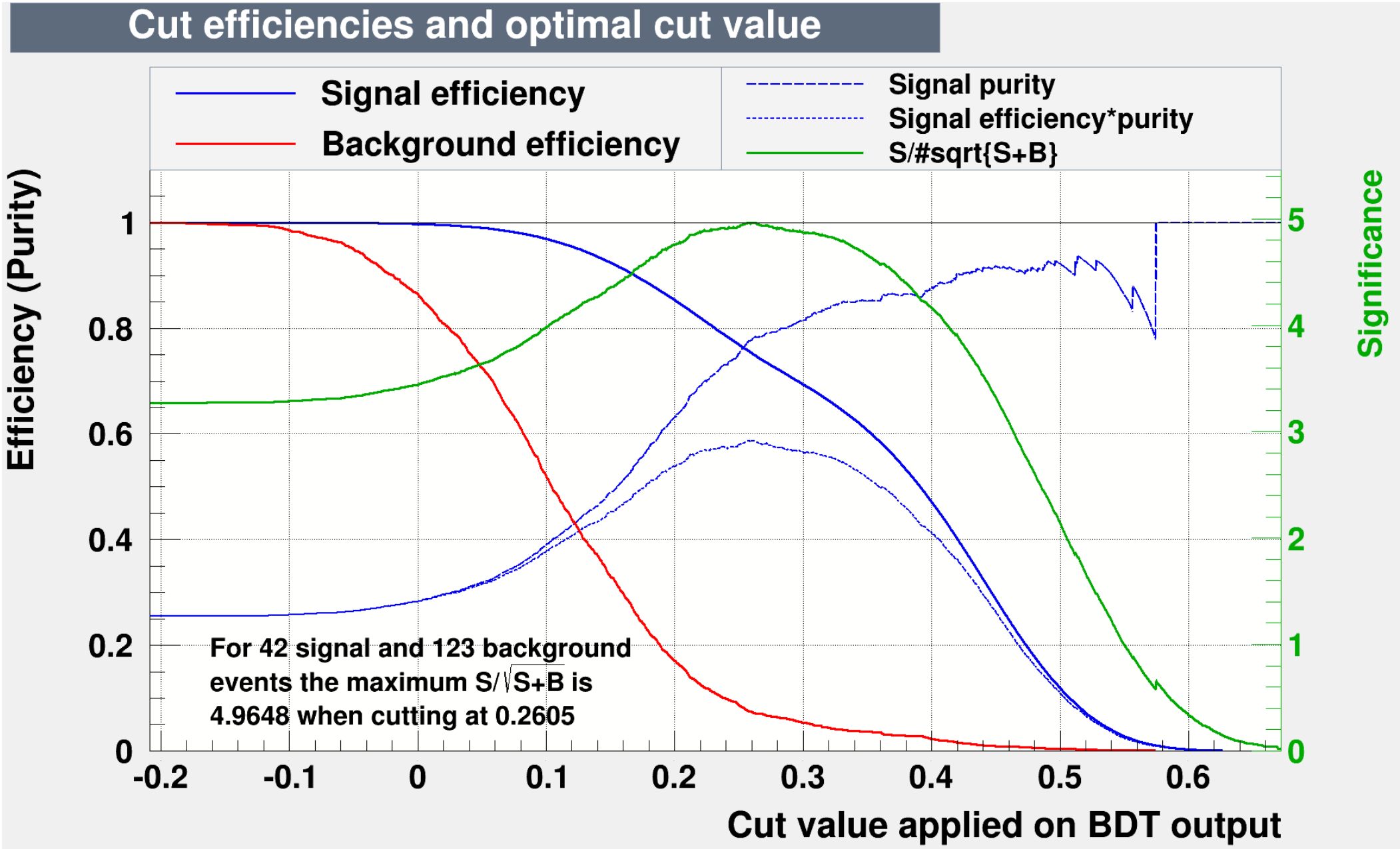


Input variable: MVA_Nb_jets



Input variable: MVA_Pt_Zcandidate




Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/#sqrt{S+B}
Efficiency (Purity)
Significance
1
0.8
0.6
0.4
0.2
0
5
4
3
2
1
0
-0.2
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
Cut value applied on BDT output
For 42 signal and 123 background
events the maximum S/√S+B is
4.9648 when cutting at 0.2605

Nb of events with fake leptons

	Initial	3 leptons	At least 2 jets	At least 1 loose bjet	At least 1 OSSF pair	Invariant Mass Z	Invariant Mass FCNC top
TTsemilep Kappa Zct Ztoll	2.09e+03 ± 0.718	243 ± 0.239	161 ± 0.195	136 ± 0.179	72.2 ± 0.13	55.2 ± 0.114	41.9 ± 0.0989
HToWW	7.02e+05 ± 1.08e+03	15 ± 5	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
HToZZ	8.6e+04 ± 230	51.6 ± 5.62	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
SingleTop W madspin	4.74e+06 ± 2.11e+03	420 ± 19.6	82.4 ± 8.68	58.6 ± 7.32	15.6 ± 3.77	3.66 ± 1.83	0 ± 0
SingleTop s madspin	1.02e+06 ± 2.29e+03	5.12 ± 5.12	5.12 ± 5.12	5.12 ± 5.12	0 ± 0	0 ± 0	0 ± 0
SingleTop t madspin	2.2e+07 ± 2.45e+04	27.4 ± 27.4	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
TTdilep WToLNu madspin	1.93e+03 ± 7.6	150 ± 2.12	87.6 ± 1.62	80.6 ± 1.55	33.6 ± 1	7.95 ± 0.488	4.44 ± 0.365
TTdilep ZToLL madspin	803 ± 2.54	209 ± 1.3	123 ± 0.996	114 ± 0.956	55 ± 0.665	34.7 ± 0.528	13 ± 0.324
TTdilep madspin	6.78e+06 ± 3.44e+03	7.03e+03 ± 108	3.37e+03 ± 75	2.92e+03 ± 69.8	657 ± 33.1	132 ± 14.8	48.4 ± 8.99
TTsemilep HToWW madspin1	2.18e+03 ± 2.21	9.87 ± 0.149	0.00673 ± 0.00388	0.00224 ± 0.00224	0 ± 0	0 ± 0	0 ± 0
TTsemilep HToWW madspin2	2.17e+03 ± 3.49	10.2 ± 0.239	0.0056 ± 0.0056	0 ± 0	0 ± 0	0 ± 0	0 ± 0
TTsemilep HToZZ madspin1	266 ± 0.383	2.7 ± 0.0386	0.0022 ± 0.0011	0.00165 ± 0.000955	0.0011 ± 0.000779	0.000551 ± 0.000551	0 ± 0
TTsemilep HToZZ madspin2	267 ± 0.34	2.71 ± 0.0343	0.00174 ± 0.00087	0.00174 ± 0.00087	0.00087 ± 0.000615	0.00087 ± 0.000615	0.00087 ± 0.000615
TTsemilep ZToLL madspin 1	1.68e+03 ± 5.3	111 ± 1.36	84.4 ± 1.19	74.9 ± 1.12	38.7 ± 0.805	28.1 ± 0.687	11 ± 0.43
TTsemilep ZToLL madspin 2	1.68e+03 ± 5.3	113 ± 1.37	85.6 ± 1.2	75.7 ± 1.13	38.4 ± 0.803	27.7 ± 0.682	10.9 ± 0.428
TTsemilep madspin 1	1.62e+07 ± 5.19e+03	171 ± 17.7	120 ± 14.8	89.3 ± 12.8	0 ± 0	0 ± 0	0 ± 0
TTsemilep madspin 2	1.61e+07 ± 5.26e+03	195 ± 19.1	152 ± 16.9	127 ± 15.5	0 ± 0	0 ± 0	0 ± 0
WToLNu-3Jets sm-no masses	6.21e+07 ± 1.46e+04	165 ± 25.2	42.2 ± 12.7	15.4 ± 7.68	0 ± 0	0 ± 0	0 ± 0
WWToLLNuNu	5.67e+05 ± 2.36e+03	97.9 ± 30.9	19.6 ± 13.8	0 ± 0	0 ± 0	0 ± 0	0 ± 0
WZToLLLNu	2.57e+05 ± 60.5	1.53e+04 ± 15.5	1.98e+03 ± 5.53	586 ± 3.01	272 ± 2.05	201 ± 1.76	61.9 ± 0.978
WZToLNuJJ sm-no masses	9.17e+05 ± 1.07e+03	1.26 ± 1.26	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
ZToLL10-50-3Jets sm-no masses	2.42e+07 ± 1.45e+04	645 ± 75.5	53 ± 21.7	8.84 ± 8.84	0 ± 0	0 ± 0	0 ± 0
ZToLL10-50-4Jets sm-no masses	1.05e+07 ± 1.34e+04	619 ± 103	155 ± 51.6	68.8 ± 34.4	17.2 ± 17.2	0 ± 0	0 ± 0
ZToLL50-3Jets sm-no masses	6.28e+06 ± 3.39e+03	6.14e+03 ± 107	2.12e+03 ± 62.6	720 ± 36.5	298 ± 23.5	281 ± 22.8	118 ± 14.8
ZToLL50-4Jets sm-no masses	2.16e+06 ± 1.49e+03	2.92e+03 ± 54.3	1.93e+03 ± 44.2	719 ± 26.9	374 ± 19.4	348 ± 18.7	138 ± 11.8
ZZToLLJJ sm-no masses	2.12e+05 ± 480	162 ± 13.3	41.3 ± 6.7	23.9 ± 5.1	10.9 ± 3.44	10.9 ± 3.44	5.44 ± 2.43
ZZToLLNuNu	6.54e+04 ± 182	11.7 ± 2.44	1.53 ± 0.881	0.509 ± 0.509	0.509 ± 0.509	0.509 ± 0.509	0 ± 0
ZZToLLLL sm-no masses	3.59e+04 ± 135	2.75e+03 ± 37.4	193 ± 9.9	58.9 ± 5.47	30.5 ± 3.93	23.4 ± 3.44	9.65 ± 2.21

Nb of events without fake leptons

	Initial	3 leptons	At least 2 jets	At least 1 loose bjet	At least 1 OSSF pair	Invariant Mass Z	Invariant Mass FCNC top
TTsemilep Kappa Zct Ztoll	2.09e+03 ± 0.718	241 ± 0.238	160 ± 0.194	135 ± 0.178	72.1 ± 0.13	55.1 ± 0.113	41.9 ± 0.0989
TTdilep WToLNu madspin	1.93e+03 ± 7.6	147 ± 2.1	86 ± 1.61	78.9 ± 1.54	33 ± 0.995	7.89 ± 0.487	4.5 ± 0.367
TTdilep ZToLL madspin	803 ± 2.54	208 ± 1.29	124 ± 0.997	114 ± 0.957	55.3 ± 0.667	35 ± 0.531	13.3 ± 0.326
TTdilep madspin	6.78e+06 ± 3.44e+03	145 ± 15.6	38.4 ± 8	30 ± 7.08	6.67 ± 3.34	1.67 ± 1.67	0 ± 0
TTsemilep HToZZ madspin2	267 ± 0.34	2.64 ± 0.0339	0.00174 ± 0.00087	0.00174 ± 0.00087	0.00087 ± 0.000615	0.00087 ± 0.000615	0.000435 ± 0.000435
TTsemilep ZToLL madspin 1	1.68e+03 ± 5.3	108 ± 1.35	82.3 ± 1.17	73.1 ± 1.11	37.8 ± 0.797	27.4 ± 0.679	10.6 ± 0.421
TTsemilep ZToLL madspin 2	1.68e+03 ± 5.3	110 ± 1.36	83.9 ± 1.19	74.1 ± 1.11	37.3 ± 0.791	26.6 ± 0.668	10.3 ± 0.416
WZToLLLNu	2.57e+05 ± 60.5	1.52e+04 ± 15.4	2.08e+03 ± 5.67	601 ± 3.05	269 ± 2.04	200 ± 1.76	63 ± 0.987
ZToLL50-3Jets sm-no masses	6.28e+06 ± 3.39e+03	33.3 ± 7.85	11.1 ± 4.53	7.4 ± 3.7	1.85 ± 1.85	1.85 ± 1.85	0 ± 0
ZToLL50-4Jets sm-no masses	2.16e+06 ± 1.49e+03	6.05 ± 2.47	6.05 ± 2.47	5.04 ± 2.25	5.04 ± 2.25	4.03 ± 2.02	2.02 ± 1.43
ZZToLLJJ sm-no masses	2.12e+05 ± 480	1.09 ± 1.09	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
ZZToLLLL sm-no masses	3.59e+04 ± 135	2.74e+03 ± 37.3	196 ± 9.97	55.9 ± 5.33	26.9 ± 3.7	19.3 ± 3.13	8.63 ± 2.09