

Combination single top + $t\bar{t}$

$tH \rightarrow 1\ell 3b$ and $tZ \rightarrow 1b 3\ell$

Lorenzo Basso

$$tH \rightarrow 1\ell 3b$$

Optimisation

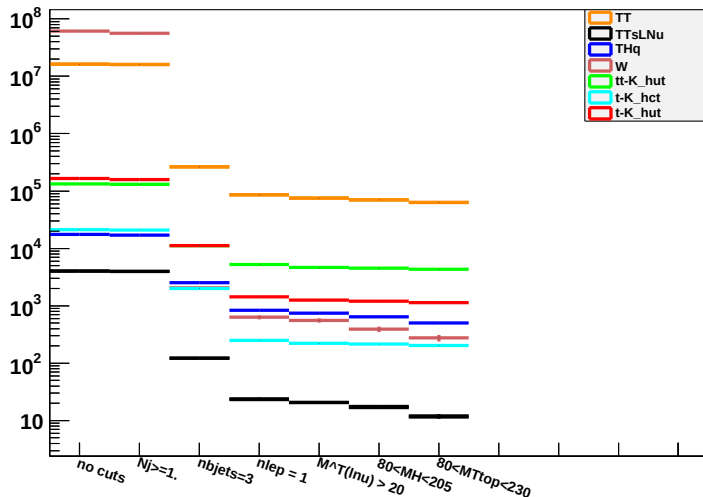
- $p_\ell^T > 30 \text{ GeV}$, $p_j^T > 40 \text{ GeV}$
- isolation: CONE04 with threshold = 0.20
- $N_J \geq 1$ (J = light and b jets)
- $N_\ell \equiv 1$, $N_b \equiv 3$
- ✓ reco of H candidate + t candidate together $\rightarrow$ **weighted**
- $M^T(\ell\nu) > 20 \text{ GeV}$

Here, MVA or Cut&Count with

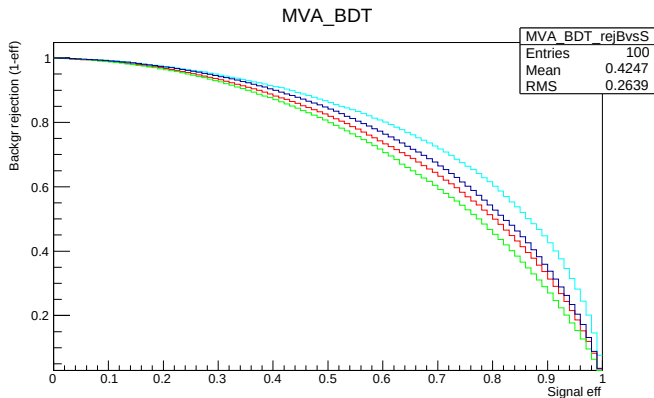
- $80 \text{ GeV} < |M(bb) - M_H| < 205 \text{ GeV}$
- loose top reco: $M^T(b\ell\nu) < 230 \text{ GeV}$

Backgrounds - cutflow

$\sqrt{s} = 13 \text{ TeV}$



Higgs and top reco: MVA



Red: H reco only

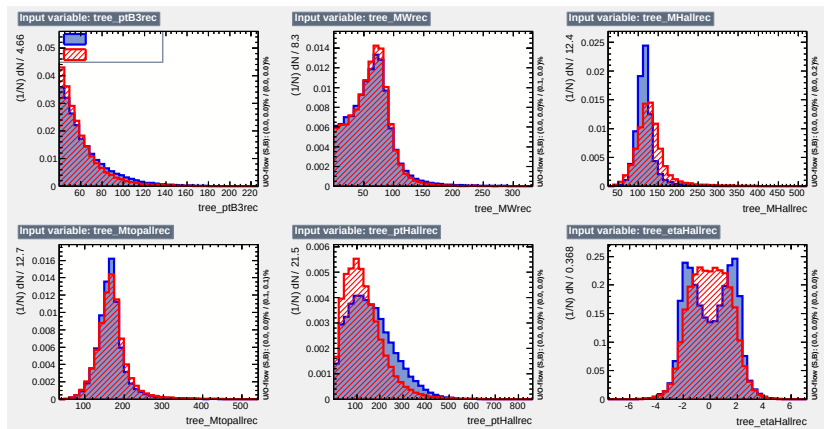
Green: t reco only

Blue: simultaneously

Cyan: weighted: $\Delta_H = 16$ GeV and $\Delta_t = 30$ GeV

MVA: variables

Signal: only single top



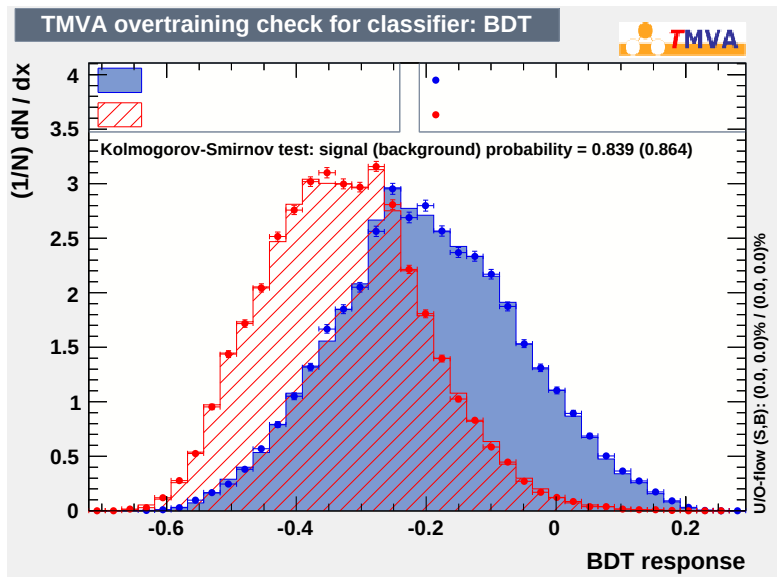
Filled after the $M^T(\ell\nu) > 20$ GeV cut.

8 Variables with relative importance when trained on the single-top sample only:

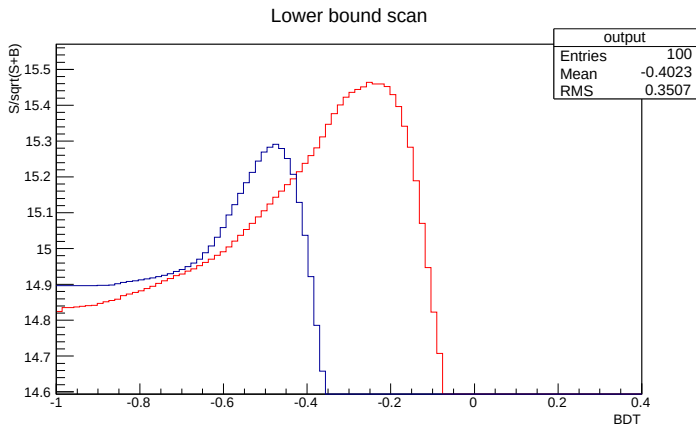
Variable	Importance
$M(H)$	$2.43 \cdot 10^{-1}$
$p^T(H)$	$2.18 \cdot 10^{-1}$
$\eta(H)$	$1.55 \cdot 10^{-1}$
$\Delta R(H, \text{MET})$	$1.10 \cdot 10^{-1}$
$M(\text{top})$	$9.47 \cdot 10^{-2}$
$\Delta R(H, \ell)$	$8.26 \cdot 10^{-2}$
$M^T(\ell\nu)$	$7.56 \cdot 10^{-2}$
$p^T(b_3)$	$2.81 \cdot 10^{-2}$

Discarded ones: $p^T(b_1)$, $p^T(b_2)$, $\Delta R(bb)|_H$: correlated with $p^T(H)$ all other lepton variables: $p^T(\ell)$, $\eta(\ell)$, $\Delta\phi, \Delta\eta, \dots$: no discrimination power

MVA: overtraining



MVA: reading of sum of signals



Training onto

Blue: single top signal only

Red: sum of signals

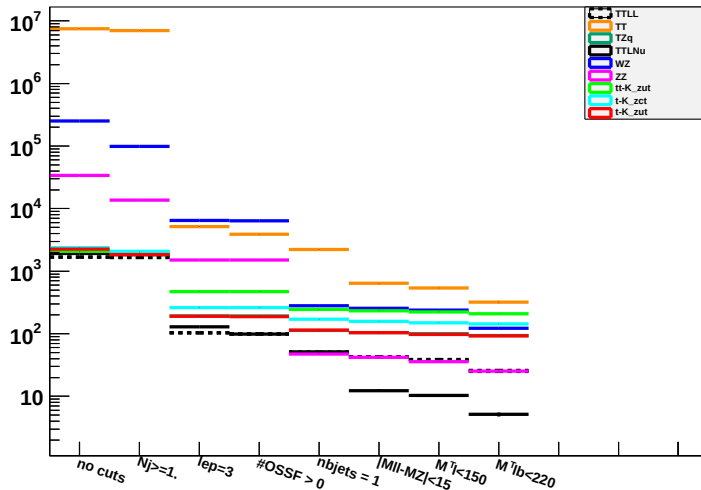
$$tZ \rightarrow 1b3\ell$$

Optimisation - almost matched Isis's

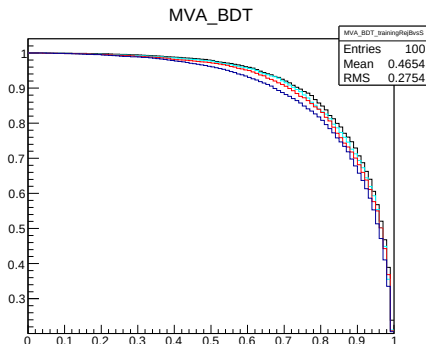
- $p_\ell^T > 20 \text{ GeV}, p_j^T > 40 \text{ GeV}$
- isolation: CONE04 with threshold = 0.20
- $N_J \geq 1$ ($J = \text{light and b jets}$)
dropped $N_J \leq 3$: no real gain
- $N_b \geq 1$ to reduce WZ , $N_b \leq 1$ once WZ is removed $\Rightarrow N_b \equiv 1$
- Z candidate as pair of $e^+e^- (\mu^+\mu^-)$ closest to M_Z
and $|M_{\ell\ell} - M_Z| < 15 \text{ GeV}$
- loose W reco: $10 < M^T(\ell_W)/\text{GeV} < 150$
- loose top reco: $M^T(b\ell_W)/\text{GeV} < 215$

Backgrounds - cutflow

$\sqrt{s} = 13 \text{ TeV}$



Higgs and top reco: MVA



Black: full set of variables (19), all backgrounds

Cyan: 13 variables, all backgrounds

Red: 7 variables, all backgrounds: **smaller set, decorellated**

Blue: 13 variables, no $t\bar{t} \rightarrow$ has to be included

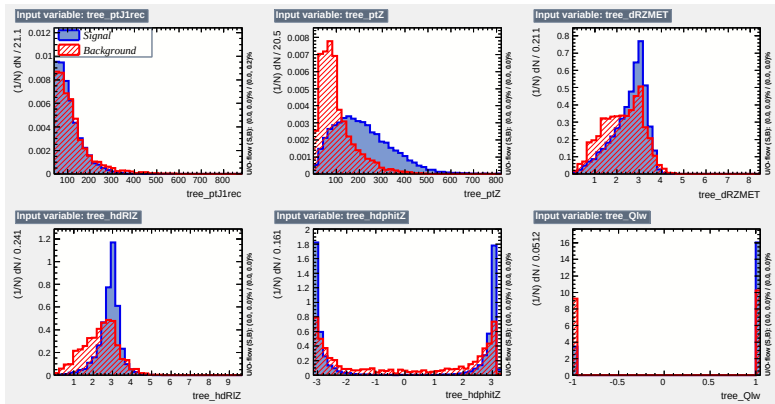
Filled after the $M(\ell^+\ell^-) - M_Z < 15$ GeV cut.

7 Variables with relative importance when trained on the single-top sample only. when considering all backgrounds, including $t\bar{t}$:

Variable	Importance
$p^T(Z)$	$2.25 \cdot 10^{-1}$
$Q(\ell_W)$	$1.94 \cdot 10^{-1}$
$p^T(j_1)$	$1.40 \cdot 10^{-1}$
$\Delta\phi(t, Z)$	$1.24 \cdot 10^{-1}$
$M(\ell b)$	$1.19 \cdot 10^{-1}$
$\Delta R(Z, \text{MET})$	$1.01 \cdot 10^{-1}$
$\Delta R(Z, \ell)$	$9.88 \cdot 10^{-2}$

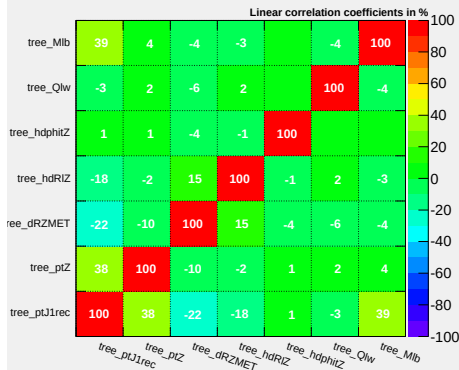
$Q(\ell_W)$, charge of the lepton from top decay, dropped when considering κ_{zct}

MVA: variables + $M(\ell b)$

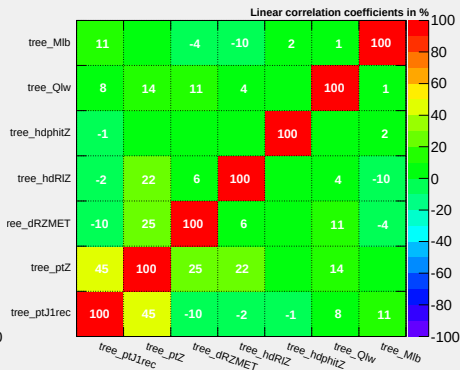


MVA: correlations

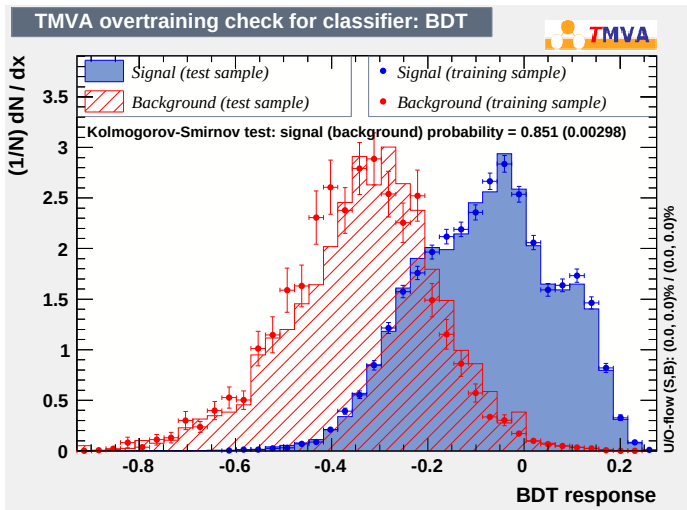
Correlation Matrix (background)



Correlation Matrix (signal)

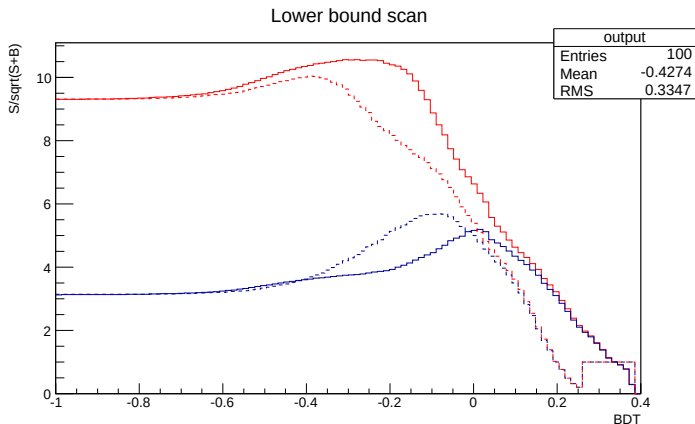


MVA: overtraining (signal is single-top only)



Sort of decent even when $t\bar{t}$ is included

MVA: reading



Training onto: single top signal only (dashed) or sum of signals (solid)

Reading onto single top signal only (Blue) or sum of signals (Red)

C&C: significances

Cut	comb (u)	comb (c)	Cut	comb (u)	comb (c)	Cut	comb (u)	comb (c)
<i>no cuts</i>	0.173	0.094	<i>no cuts</i>	0.173	0.094	<i>no cuts</i>	0.173	0.094
$N_j \geq 1$	0.366	0.212	$N_j \geq 2$	0.463	0.309	$N_j \equiv 1$	0.088	0.029
$N_\ell \equiv 3$	4.437	3.380	$N_\ell \equiv 3$	4.109	3.535	$N_\ell \equiv 3$	1.104	0.540
$nOSSF > 0$	4.525	3.451	$nOSSF > 0$	4.239	3.650	$nOSSF > 0$	1.110	0.543
$N_b = 1$	6.558	4.907	$N_b = 1$	5.793	5.016	$N_b = 1$	1.793	0.692
$ M(\ell\ell) - M_Z < 15$	8.350	6.399	$ M(\ell\ell) - M_Z < 15$	7.345	6.461	$ M(\ell\ell) - M_Z < 15$	2.123	0.842
$10 < M^T(\ell\nu) < 120$	8.378	6.494	$10 < M^T(\ell\nu) < 120$	7.445	6.597	$10 < M^T(\ell\nu) < 120$	2.488	1.022
$M^T(b\ell\nu) < 220$	9.532	7.458	$M^T(b\ell\nu) < 220$	8.635	7.717	$M^T(b\ell\nu) < 220$	2.601	1.048
$M(\ell b) < 150$	9.546	7.463	$M(\ell b) < 150$	8.636	7.718	$M(\ell b) < 150$	2.834	1.144

Table: $S/\sqrt{S+B}$

Highest significance when selecting at least 1 jet, $t\bar{t}$: single top (u) = 2 : 1

$N_j \geq 2$ selects $t\bar{t}$ -type signal: $t\bar{t}$: single top (u) = 4.5 : 1

$N_j \equiv 1$ selects single top - type signal: $t\bar{t}$: single top (u) = 1 : 3.5, but it cuts too much signal