

Updates on $t\bar{t}$ @ 500 GeV

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Updates

For the $t\bar{t}h \rightarrow l n 6\text{jets}$ and $2l 2n 4\text{jets}$ channel

- Isolated lepton energy is included in a candidate of input variables of BDTG.
- optimize a set of input variables

Multivariate Analysis

TMVA BDTG method

- training and test samples
 - signal: $t\bar{t}h \rightarrow 8\text{jets}$ (1n+6jets, 2l2n+4jets)
 - backgrounds: ttZ, ttbb, 6f_ttbar

- pre-cuts

b likelihood

Y values

number of isolated leptons

all jets in $|\cos\theta| < 0.99$

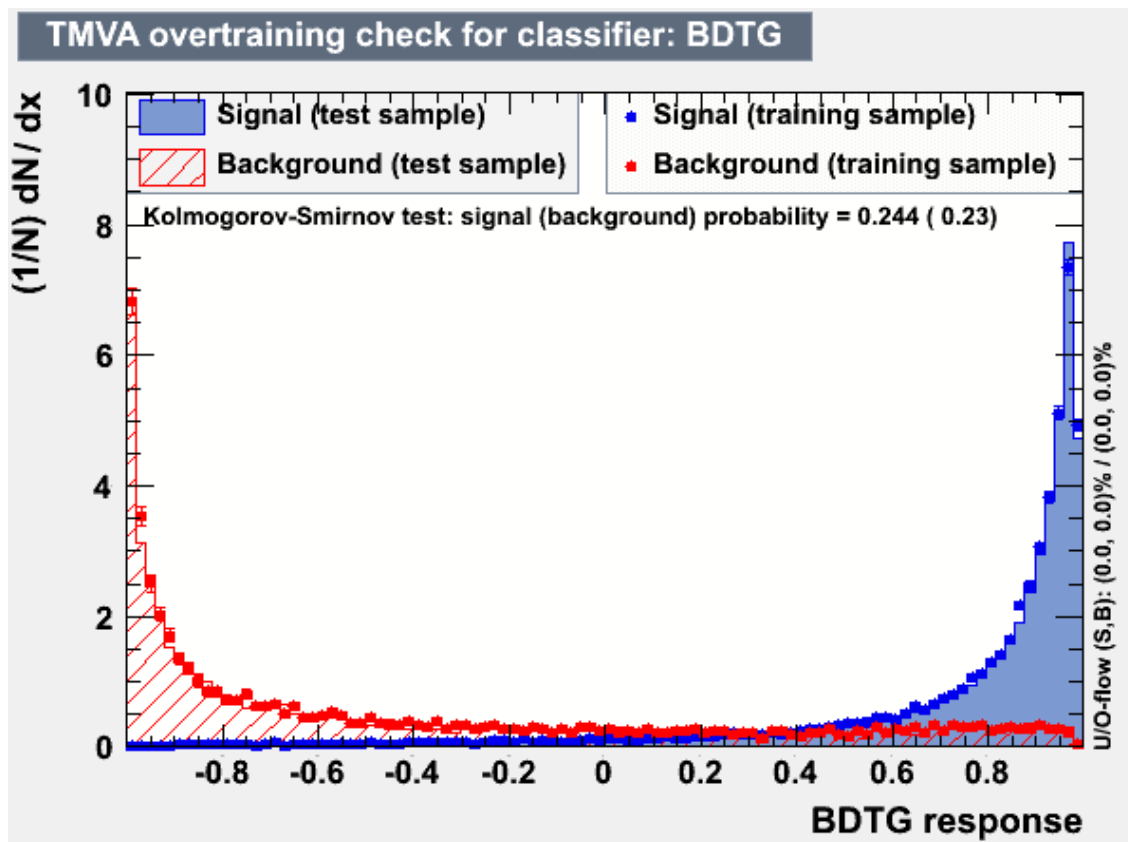
LLH value of jet pairing

Input variables and training result

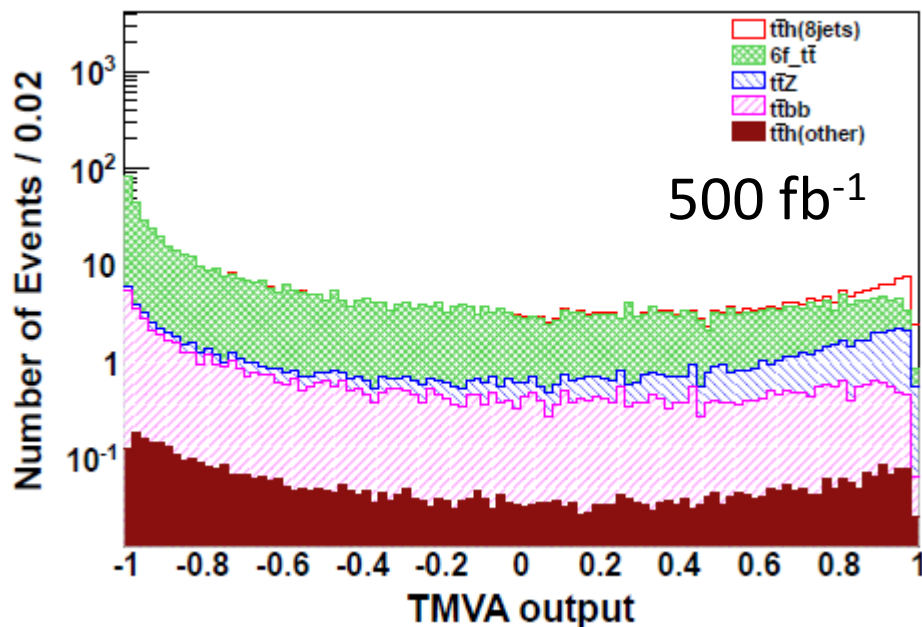
($t\bar{t}h \rightarrow 8\text{jets}$, tight b)

pre cuts: 4 b tagged (b likeliness $> 0.94, 0.82, 0.73, 0.15$), no isolated lepton,
Y value of Durham jet clustering: $Y_{87} > 0.00043, Y_{76} > 0.0021$ && $Y_{87} \leq 0.00043$
detector acceptance $\text{Cos}\theta_{\text{jet}} > 0.99$
jet pairing by maximum likelihood method : llh value > -25

- TMVA inputs
- log likelihood value for jet pairing
highest 2 jets energy sum.
number of PFOs
Mjj of higgs candidate
Missing energy
Missing momentum
Missing transverse momentum
lowest 3 jets energy sum.
Principal thrust
Y87 value
Minor thrust
Y65 value
Major thrust



Result of $t\bar{t}h \rightarrow 8\text{jets}$ (tight b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
tth→8jets	16.65	7.50
tth (other)	0.58	0.25
ttZ	11.53	4.17
ttbb	3.74	2.05
6f	18.79	8.14
bkgd total	34.08	14.37
Signal	17.23	7.75
TMVA thre.	0.82	0.84

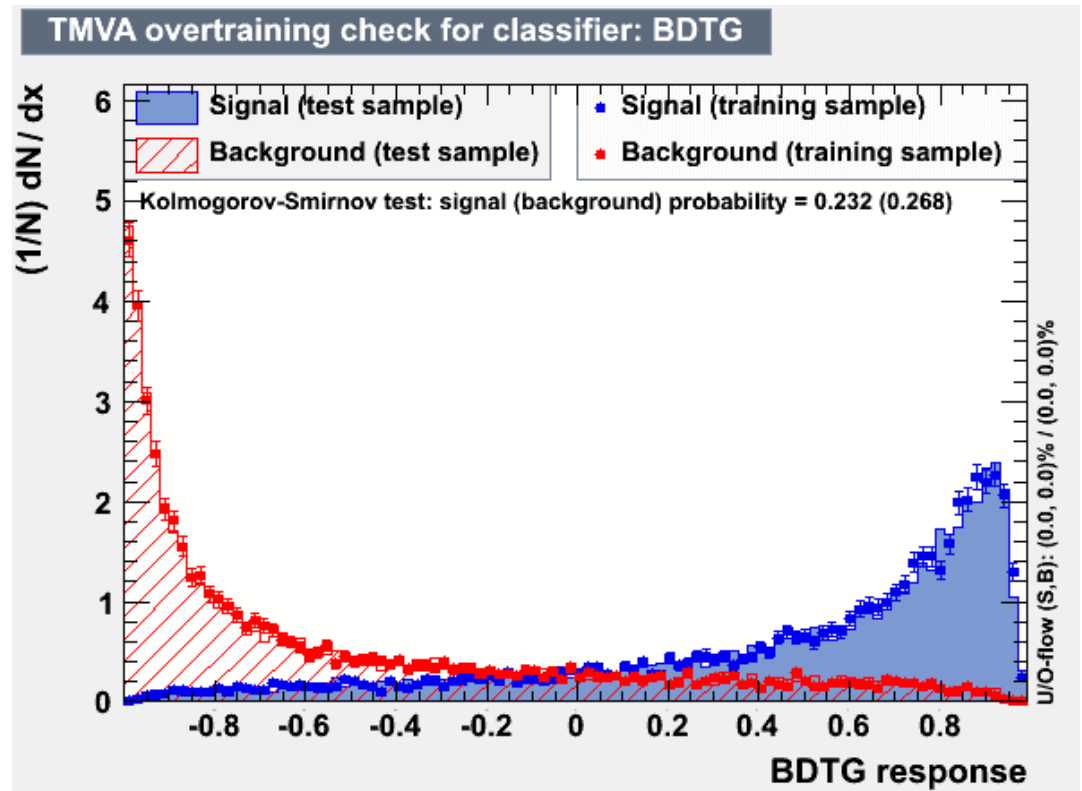
Significance: $S/\sqrt{S+B}$

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	2.40	1.64
200	1.52	1.04
1400	4.02	2.75
TMVA thre.	0.82	0.84

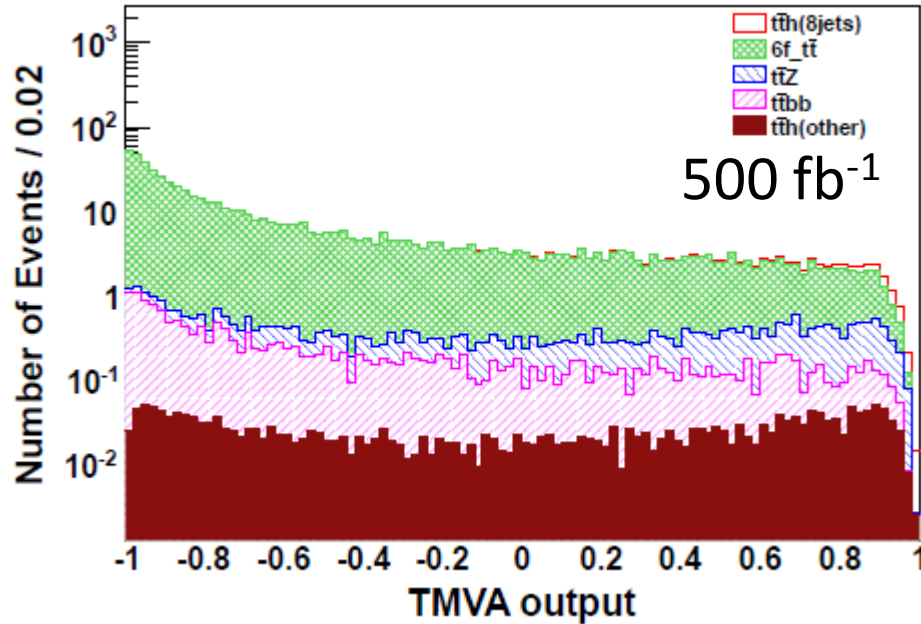
Input variables and training result ($t\bar{t}h \rightarrow 8\text{jets}$, loose b)

pre cuts: 4 b tagged (b likeliness $> 0.75, 0.69, 0.36, 0.06$, not tight b), no isolated lepton,
Y value of Durham jet clustering: $Y_{87} > 0.00098, Y_{76} > 0.0066$ && $Y_{87} \leq 0.00098$
detector acceptance $\text{Cos}\theta_{\text{jet}} > 0.99$
jet pairing by maximum likelihood method : llh value > -25

- TMVA inputs
- log likelihood value for jet pairing
highest 2 jets energy sum.
number of PFOs
Missing momentum
Missing transverse momentum
Missing energy
Mjj of higgs candidate
Y87 value
Principal thrust
lowest 3 jets energy sum.
Major thrust
Y76 value



Result of $t\bar{t} \rightarrow 8\text{jets}$ (loose b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
tth → 8jets	3.97	1.55
tth (other)	0.59	0.20
ttZ	4.66	1.33
ttbb	1.26	0.47
6f	21.82	7.33
bkgd total	27.74	9.14
Signal	4.56	1.75
TMVA thre.	0.66	0.74

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

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	0.80	0.53
200	0.50	0.33
1400	1.34	0.89
TMVA thre.	0.66	0.74

Input variables and training result

($t\bar{t}h \rightarrow l n + 6\text{jets}$, tight b)

pre cuts: 4 b tagged (b likeliness $> 0.91, 0.82, 0.54, 0.15$), one isolated lepton

Y value of Durham jet clustering: $Y_{65} > 0.00086, Y_{54} > 0.032$ && $Y_{65} \leq 0.00086$

detector acceptance $\text{Cos}\theta_{\text{jet}} > 0.99$

jet pairing by maximum likelihood method : llh value > -28.0

- TMVA inputs

log likelihood value for jet pairing

lowest 2 jets energy sum.

highest 2 jets energy sum.

Missing momentum

Isolated lepton energy

number of PFOs

Mjj of higgs candidate

Y76 value

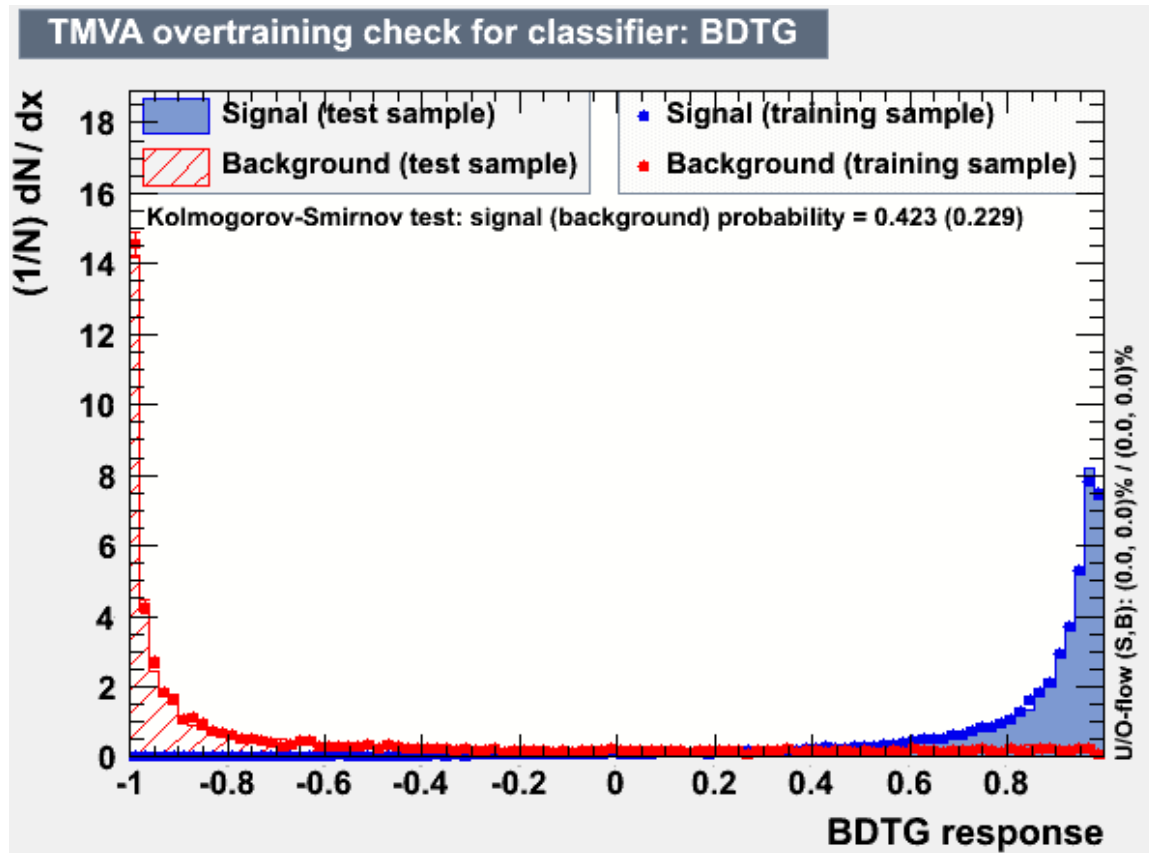
Missing energy

Missing transverse momentum

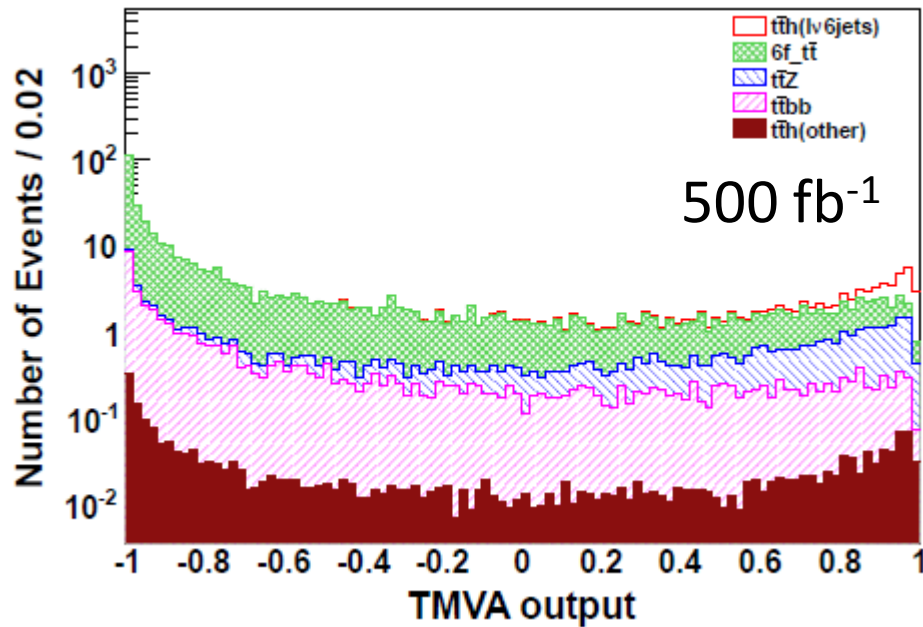
Minor thrust

Y87 value

Y54 value



Result of $t\bar{t} \rightarrow l\nu + 6\text{jets}$ (tight b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
$t\bar{t} \rightarrow l\nu + 6\text{jets}$	11.88	5.59
ttH (other)	0.33	0.15
ttZ	6.32	2.36
ttbb	1.38	0.66
6f	6.73	2.61
bkgd total	14.44	5.65
Signal	12.21	5.74
TMVA thre.	0.86	0.86

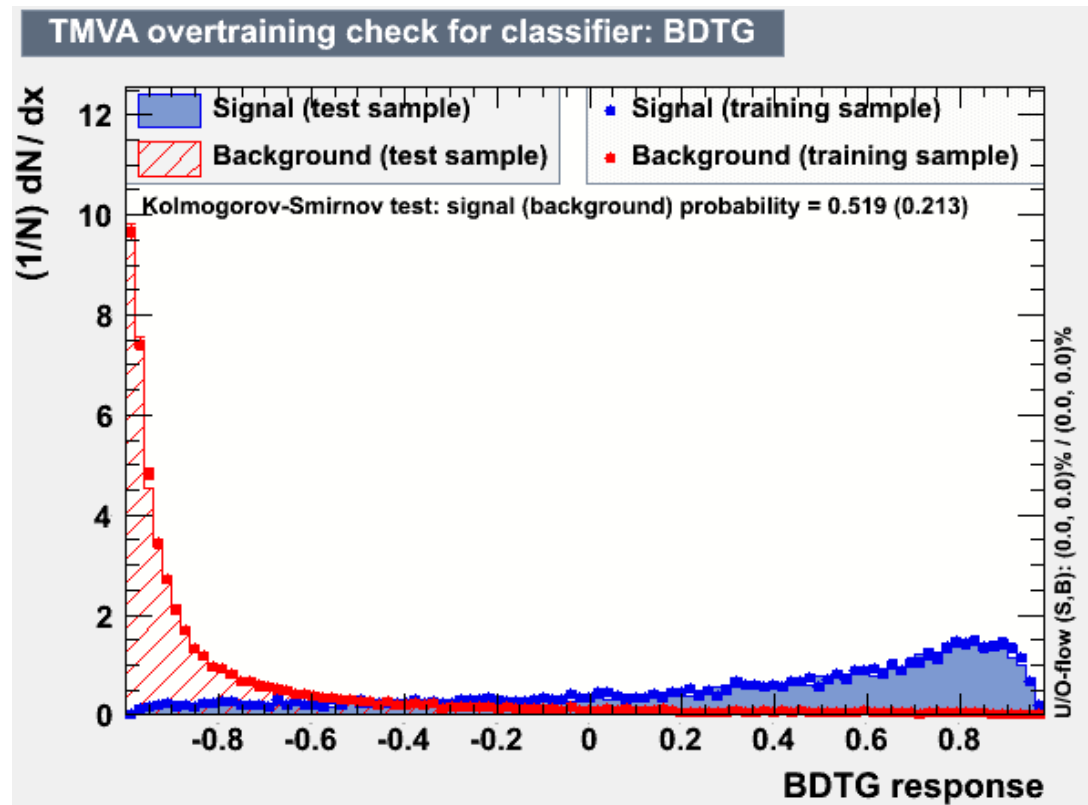
Significance: $S/\sqrt{S+B}$

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	2.36	1.70
200	1.49	1.07
1400	3.95	2.84
TMVA thre.	0.86	0.86

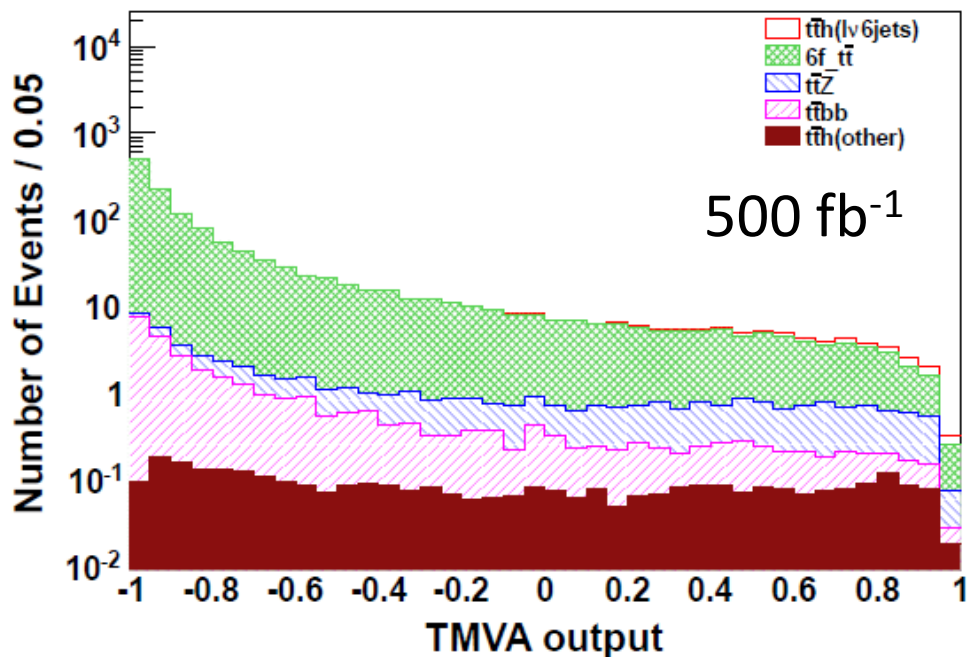
Input variables and training result ($t\bar{t}h \rightarrow l n + 6 \text{jets}$, loose b)

pre cuts: 4 b tagged (b likeliness $> 0.80, 0.56, 0.28, 0.05$), one isolated lepton
Y value of Durham jet clustering: $Y_{65} > 0.00086, Y_{54} > 0.032$ && $Y_{65} \leq 0.00086$
detector acceptance $\text{Cos}\theta_{\text{jet}} > 0.99$
jet pairing by maximum likelihood method : llh value > -28.0

- TMVA inputs
- lowest 2 jets energy sum.
- highest 2 jets energy sum.
- number of PFOs
- log likelihood value for jet pairing
- Missing momentum
- Isolated lepton energy
- Missing energy
- Y76 value
- Missing transverse momentum
- Mjj of higgs candidate
- Y54 value



Result of $t\bar{t}h \rightarrow l\nu + 6\text{jets}$ (loose b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
$t\bar{t}h \rightarrow l\nu + 6\text{jets}$	4.01	1.13
ttH (other)	0.73	0.23
ttZ	4.97	0.84
ttbb	1.21	0.26
6f	28.39	4.13
bkgd total	34.58	5.24
Signal	4.84	1.36
TMVA thre.	0.45	0.70

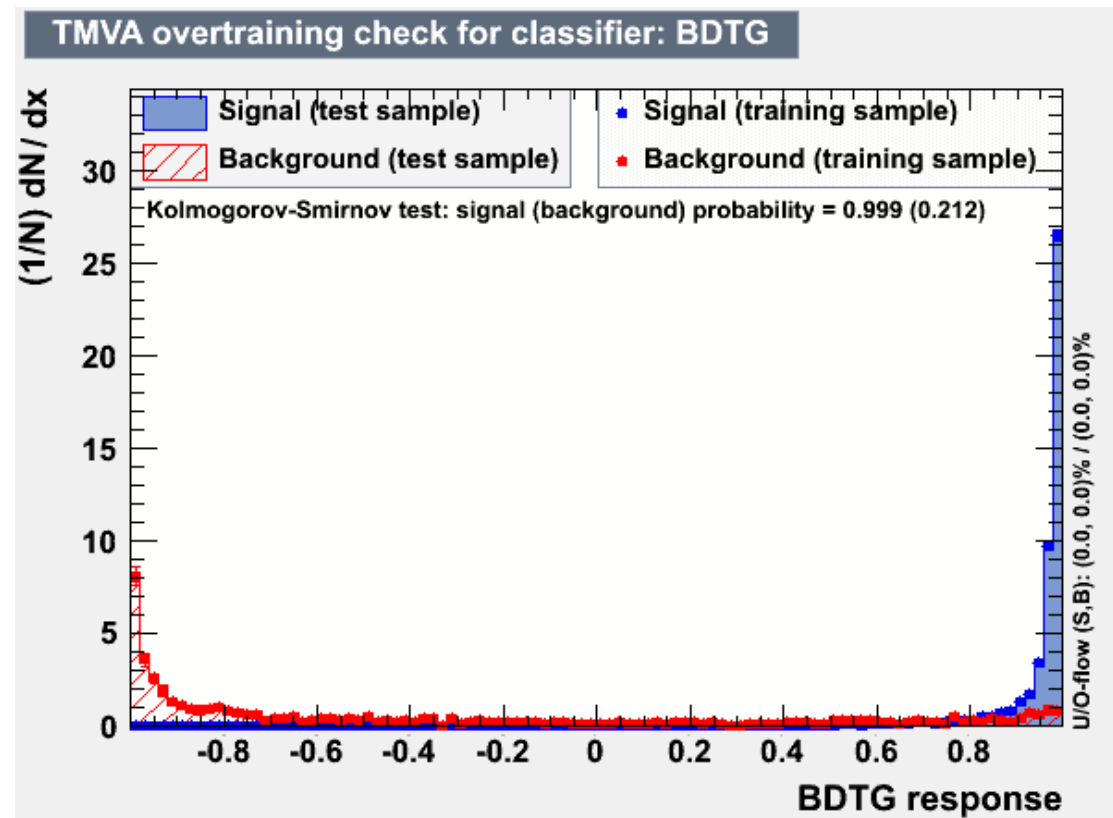
Significance: $S/\sqrt{S+B}$

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	0.77	0.53
200	0.48	0.33
1400	1.29	0.88
TMVA thre.	0.45	0.70

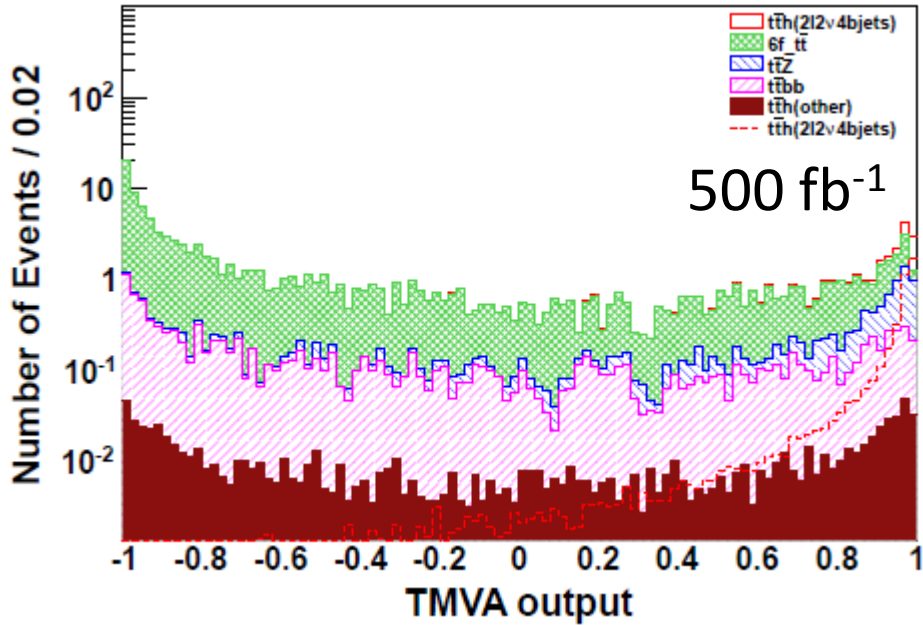
Input variables and training result ($t\bar{t}h \rightarrow 2l2n+4\text{jets}$, tight b)

pre cuts: 4 b tagged (b likeliness > 0.87, 0.8, 0.47, 0.1), two isolated leptons
Y value of Durham jet clustering: $Y_{43} > 0.0064$,
jet pairing by maximum likelihood method : llh value > -18.0

- TMVA inputs
- lowest jet energy
 - highest jet energy
 - log likelihood value for jet pairing
 - lowest Isolated lepton energy
 - Missing energy
 - number of PFOs
 - Y65 value
 - highest Isolated lepton energy
 - Y43 value
 - Y32 value
 - Minor thrust
 - Principal thrust
 - Mjj of higgs candidate



Result of $t\bar{t}H \rightarrow 2l2n+4\text{jets}$ (tight b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
$t\bar{t}H \rightarrow l\nu+6\text{jets}$	2.82	1.32
ttH (other)	0.08	0.04
ttZ	1.86	0.64
ttbb	0.42	0.28
6f	1.90	0.50
bkgd total	4.19	1.42
Signal	2.90	1.36
TMVA thre.	0.96	0.96

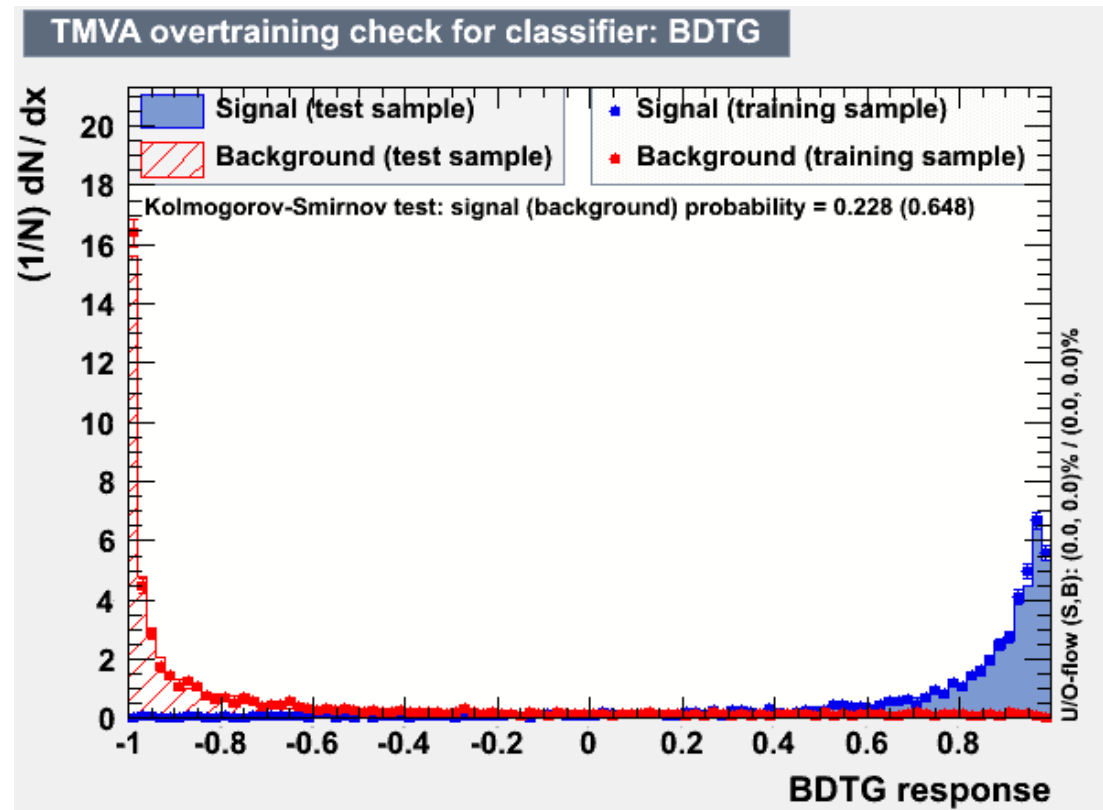
Significance: $S/\sqrt{S+B}$

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	1.09	0.81
200	0.68	0.51
1400	1.82	1.36
TMVA thre.	0.96	0.96

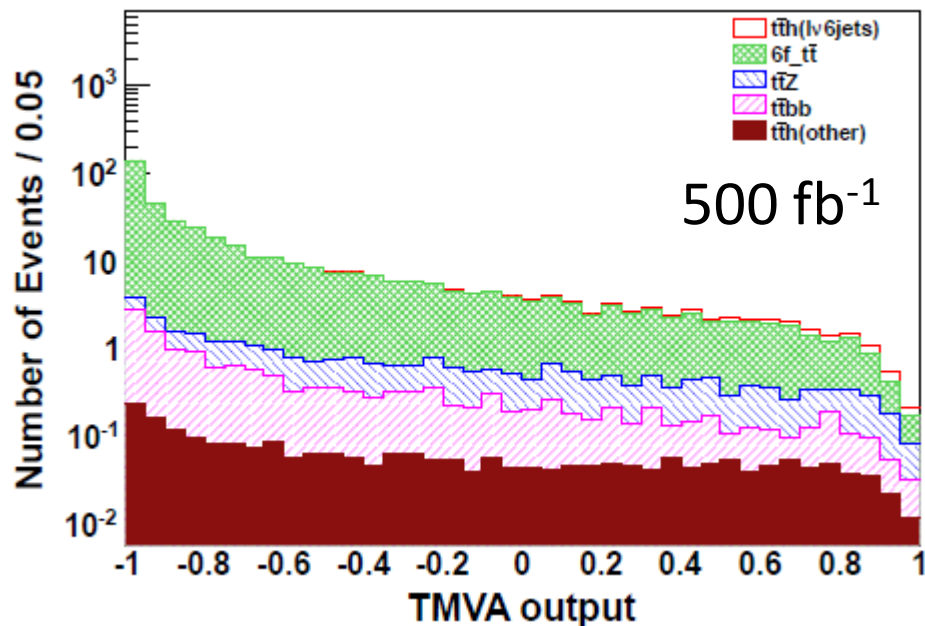
Input variables and training result ($t\bar{t}h \rightarrow 2l2n+4\text{jets}$, loose b)

pre cuts: 4 b tagged (b likeliness > 0.60, 0.43, 0.21, 0.04), two isolated leptons
Y value of Durham jet clustering: $Y_{43} > 0.0072$,
jet pairing by maximum likelihood method : llh value > -18.0

- TMVA inputs
- highest jet energy
lowest jet energy
log likelihood value for jet pairing
lowest Isolated lepton energy
Y32 value
Missing energy
number of PFOs
highest Isolated lepton energy
Y43 value
Mjj of higgs candidate



Result of $t\bar{t}h \rightarrow 2l2n+4jets$ (loose b)



Integrated luminosity	500 fb ⁻¹	500 fb ⁻¹
(Pe ⁻ ,Pe ⁺)	(-0.8,+0.3)	(+0.8,-0.3)
tth \rightarrow lv+6jets	0.40	0.23
ttH (other)	0.07	0.06
ttZ	0.50	0.25
ttbb	0.05	0.11
6f	1.13	0.95
bkgd total	1.69	1.32
Signal	0.47	0.29
TMVA thre.	0.94	0.92

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

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)	(+0.8,-0.3)
500	0.32	0.22
200	0.2	0.14
1400	0.53	0.38
TMVA thre.	0.94	0.92

Summary of improvements comparing with cut based analysis

(500 fb⁻¹)

(Pe-,Pe+)=(-0.8,+0.3)	improvement (%)	(S/√S + B)
8jets tight b	~11	2.16→2.4
8jets loose b	~40	0.57→0.8
ln+6jets tight b	~12	2.11→2.36
ln+6jets loose b	~27	0.6→0.76
2l2n+4jets tight b	~5	1.04→1.09
2l2n+4jets loose b	~10	0.29→0.32

(Pe-,Pe+)=(+0.8,-0.3)	improvement (%)	(S/√S + B)
8jets tight b	~11	1.47→1.64
8jets loose b	~40	0.37→0.53
ln+6jets tight b	~12	1.43→1.70
ln+6jets loose b	~30	0.4→0.52
2l2n+4jets tight b	~15	0.71→0.81
2l2n+4jets loose b	~15	0.19→0.22

Summary of Results with MVA

Integrated Lumi. (fb ⁻¹)	(-0.8,+0.3)		(+0.8,-0.3)		combined (-0.8,+0.3)& (+0.8,-0.3)
	tight b	loose b	tight b	loose b	
500	3.53	1.15	2.50	0.78	4.54
H20 200	2.24	0.72	1.57	0.49	2.87
1400	5.92	1.92	4.17	1.30	7.60
200&1400	6.32	2.05	4.45	1.39	8.11

all combined result of H20 scenario

$$S/\sqrt{S+B} = 8.11, |\Delta g_t/g_t| = 6.41\%$$

% improvement

$$(S/\sqrt{S+B} = 7.14, |\Delta g_t/g_t| = 7.27\% \text{ (cut based analysis)})$$