Combination single top + $t\bar{t}$
$tH \rightarrow 1\ell 3b$

New $t\bar{t}$-signal samples

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Optimisation

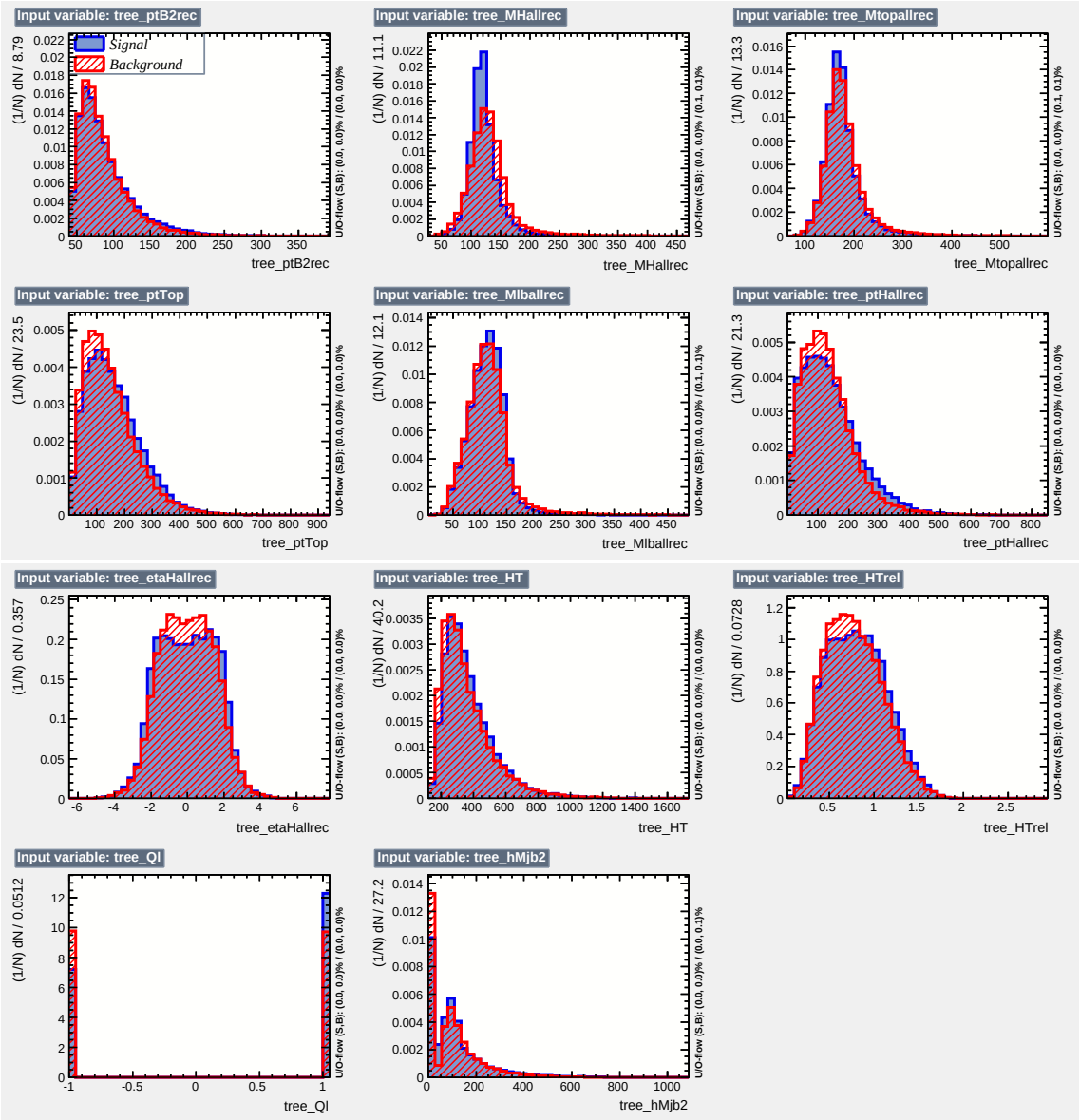
- LEPTONS: $|\eta| < 2.5(2.4)$ for e/μ, then:
  - Tight: $p_\ell^T > 30$ GeV, ISO: `CONE04`, $I_{rel} < 0.10(0.12)$ e/μ
  - Loose: $10 < p_\ell^T < 30$ GeV, ISO: `CONE04`, $I_{rel} < 0.20$
- JETS: $p_j^T > 40$ GeV, $|\eta| < 2.4$, $1/$`EEoverHE` > 0.15
- Selections:
  1. $N_\ell^{tight} \equiv 1, \qquad N_\ell^{loose} \equiv 0$
  2. $M^T(\ell\nu) > 50$ GeV
  3. $N_J \geq 3$ ($J =$ light and b jets)
  4. $N_b \equiv 3$ (CSVM)

  Here, MVA or Cut&Count with
- 80 GeV $< |M(bb) - M_H| < 205$ GeV
- loose top reco: $M^T(b\,\ell\nu) < 230$ GeV

MVA – BDT

- training on sum of signals (naive combination)
- one training each for κ_{hut} and κ_{hct}
- compare κ_{hut} vs. κ_{hct} training by applying reader on sum of signals
- tried various asymmetry variables: Q_ℓ, $Q_\ell \times p_\ell^T$, $Q_\ell \times |\eta_\ell|$: no difference

Variables for κ_{hut}



Variables for κ_{hut}

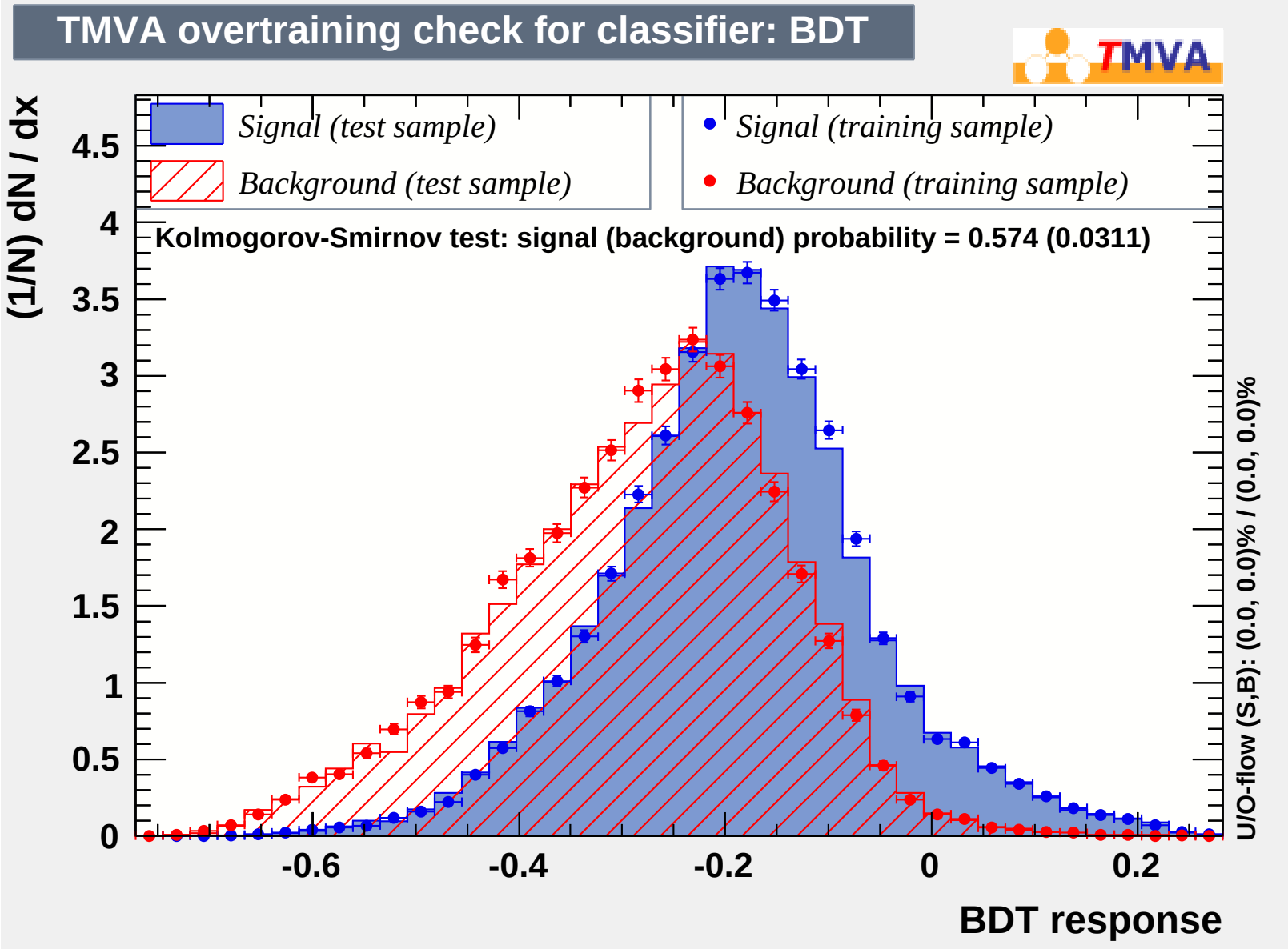
Filled after the $\#b \equiv 3$ cut.

11 Variables with relative importance:

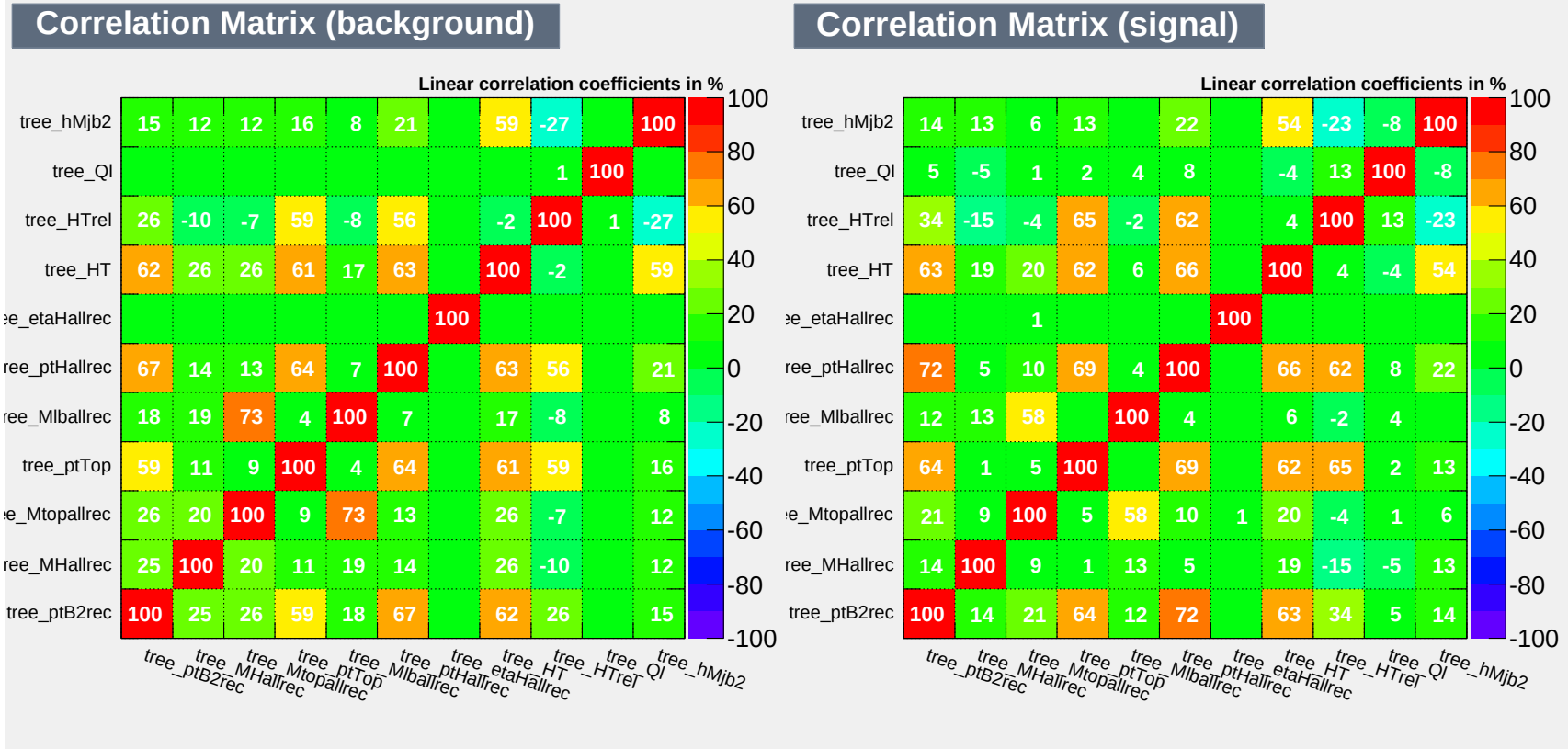
Variable	Importance
$M(H)$	$1.91\,10^{-1}$
Q_ℓ	$1.47\,10^{-1}$
$M(jb_2)$	$1.25\,10^{-1}$
H_T	$9.10\,10^{-2}$
$M(\ell b)$	$9.05\,10^{-2}$
$\eta(H)$	$8.41\,10^{-2}$
$p^T(H)$	$7.78\,10^{-2}$
$p^T(top)$	$7.61\,10^{-2}$
$M(top)$	$5.70\,10^{-2}$
H_T^{rel}	$3.78\,10^{-2}$
$p^T(b_2)$	$2.27\,10^{-2}$

where $H_T^{rel} \equiv (p^T(H) + p^T(top))/H_T$

κ_{hut}: overtraining

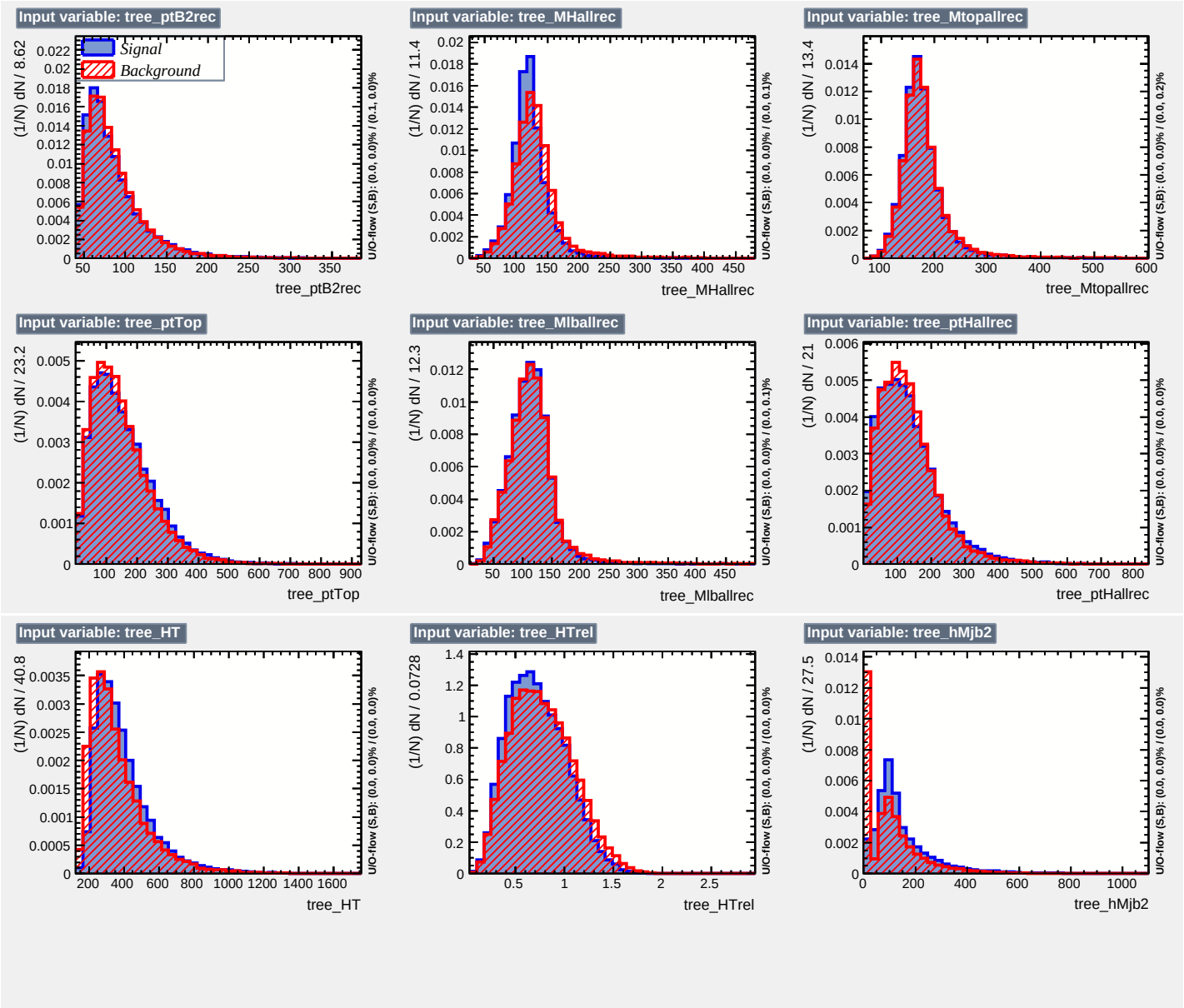


κ_{hut}: correlations



Some large correlations, but if removed BDT loses discriminating power

Variables for κ_{hct}



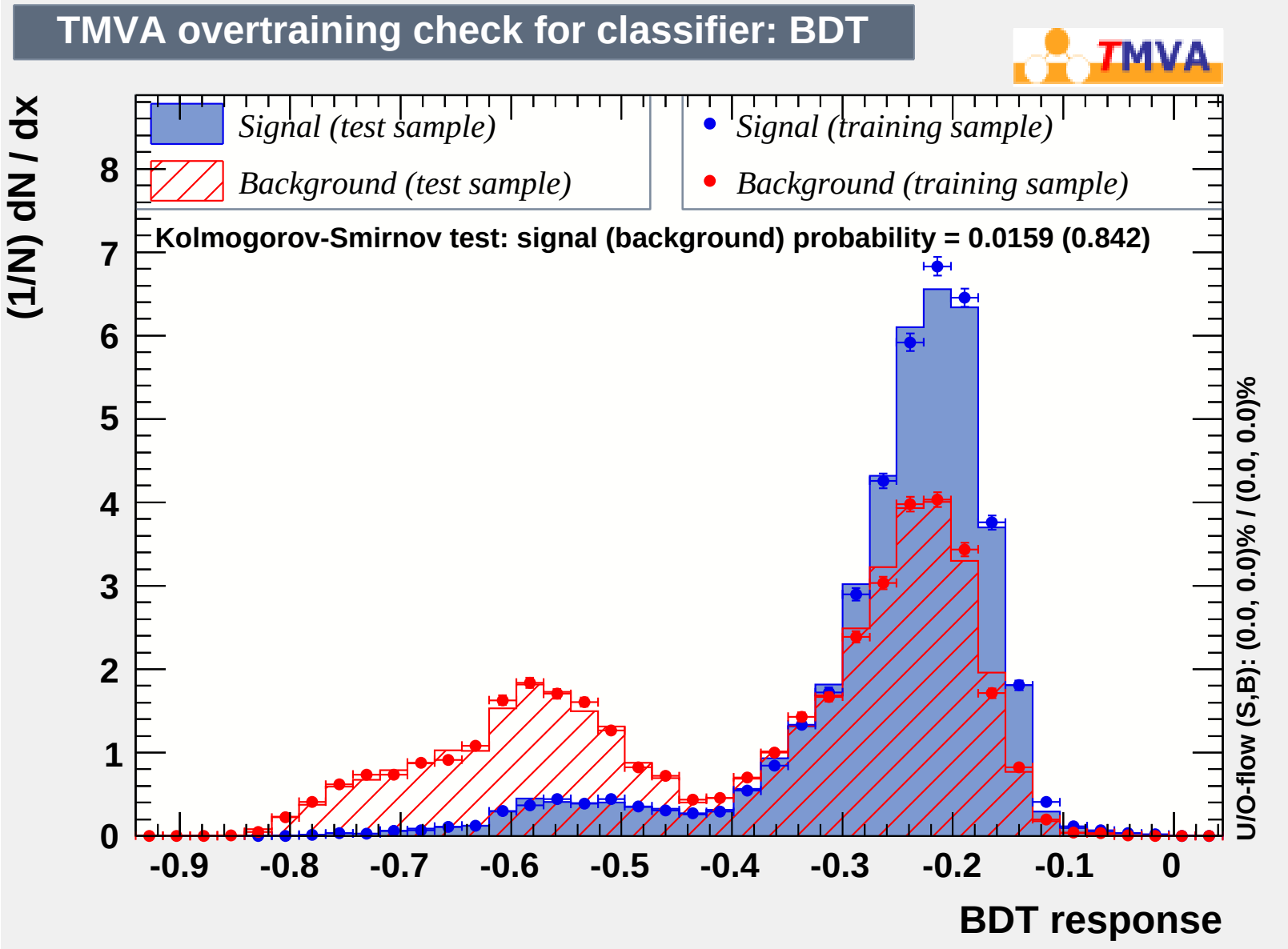
Variables for κ_{hct}

Filled after the $\#b \equiv 3$ cut.

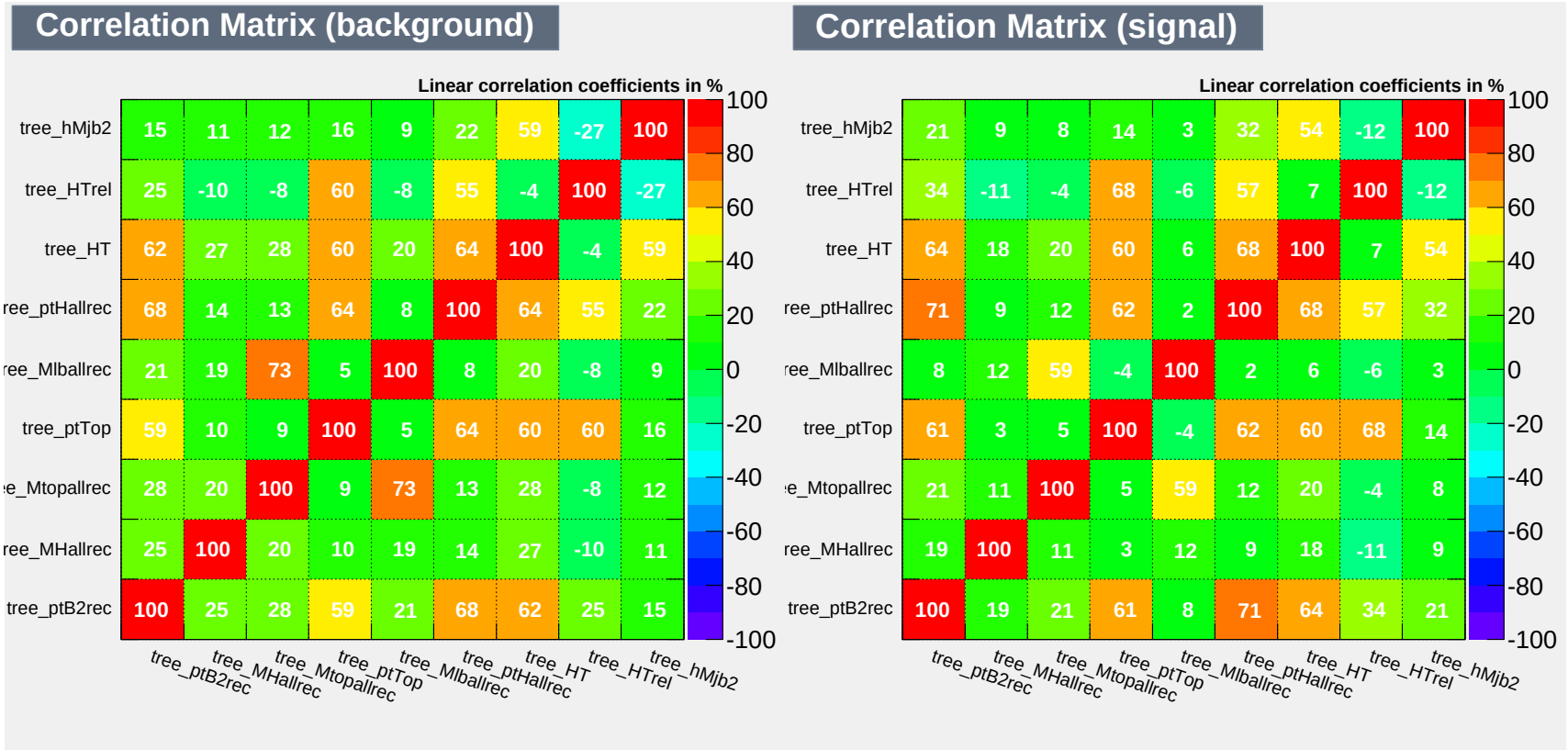
9 Variables with relative importance:

Variable	Importance
$M(jb_2)$	$3.19\,10^{-1}$
$M(H)$	$1.98\,10^{-1}$
H_T	$1.50\,10^{-1}$
$M(\ell b)$	$8.58\,10^{-2}$
H_T^{rel}	$7.19\,10^{-2}$
$p^T(H)$	$5.39\,10^{-2}$
$p^T(b_2)$	$4.99\,10^{-2}$
$p^T(top)$	$3.84\,10^{-2}$
$M(top)$	$3.29\,10^{-2}$

κ_{hct}: overtraining



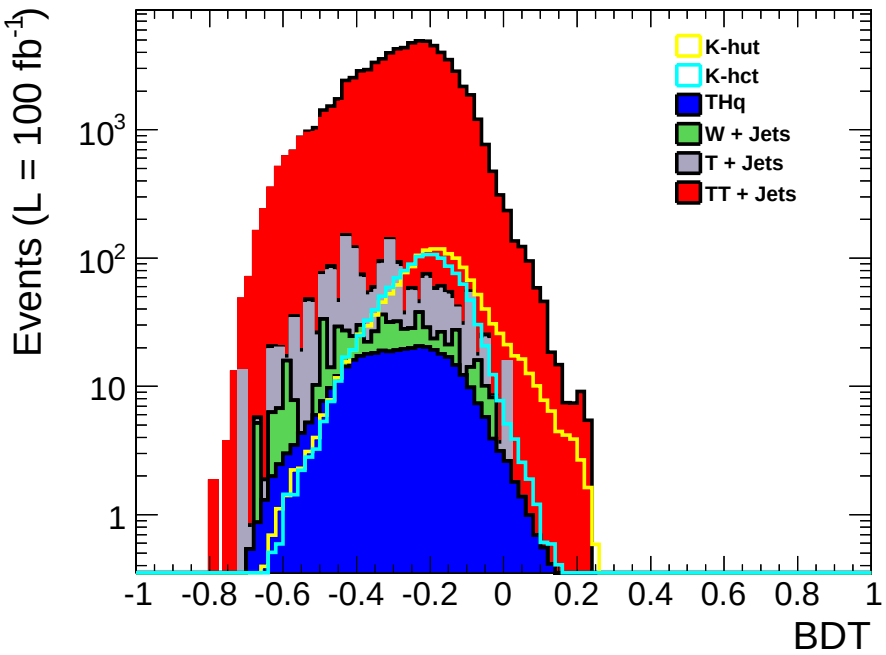
κ_{hct}: correlations



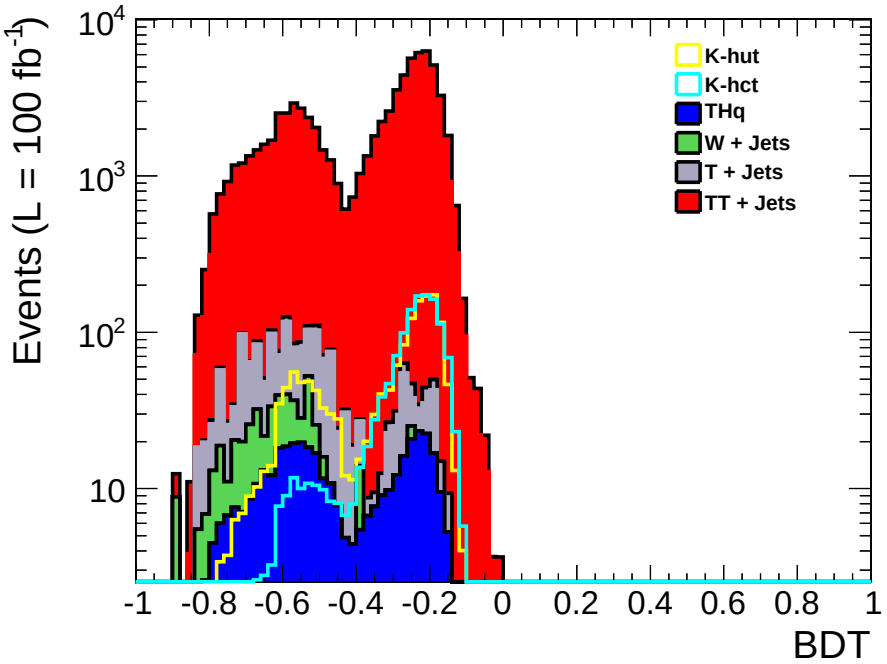
Some large correlations, but if removed BDT loses all discriminating power

BDT output

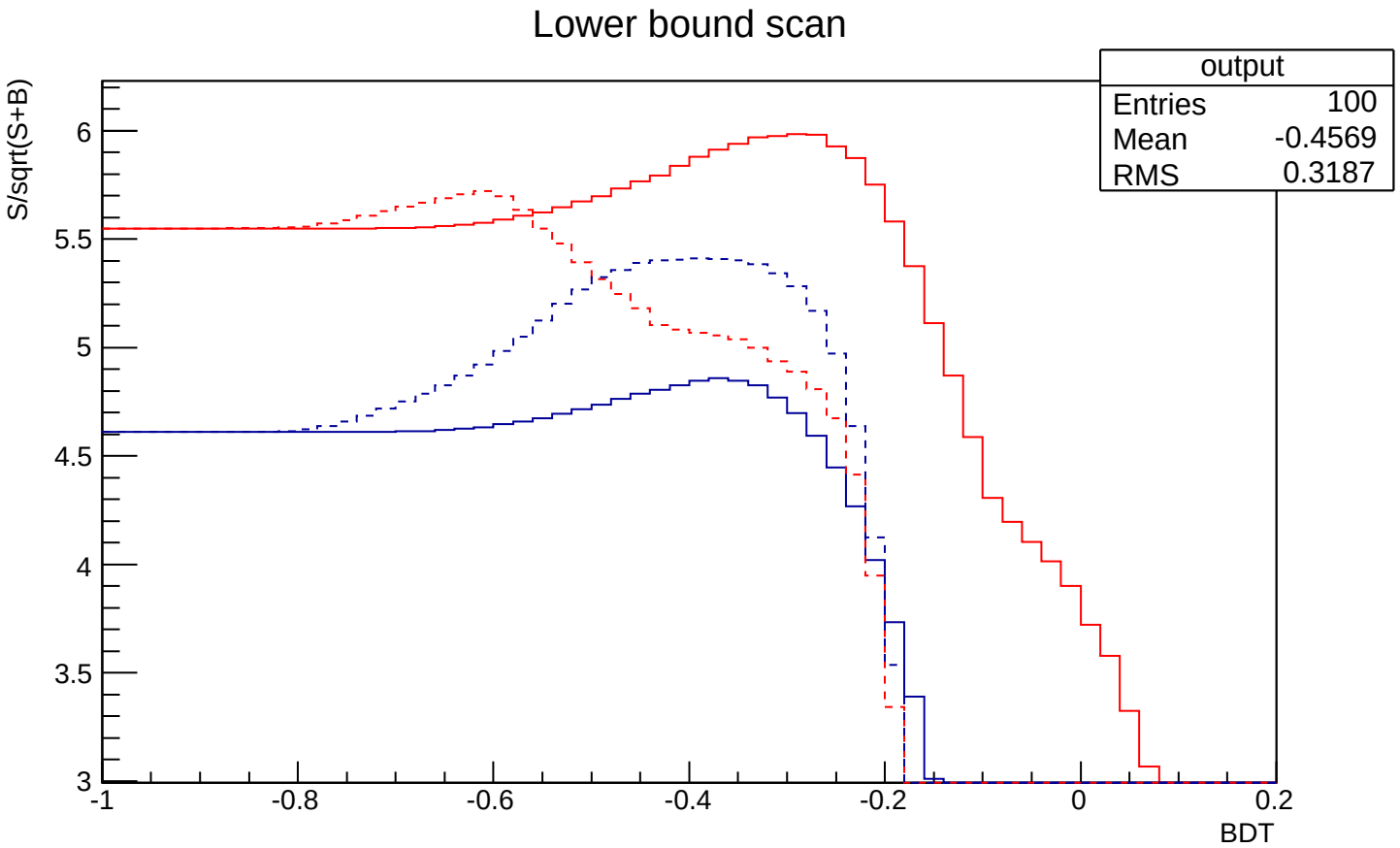
κ_{hut}



κ_{hct}



MVA: reading of sum of signals



Reading onto: Red- κ_{hut} Blue- κ_{hct}

Training onto Solid- κ_{hut} Dashed- κ_{hct}

Cut-and-count

Cut	Sum Bg	κ_{hct}	κ_{hut}	ttbar κ_{hct}	ttbar κ_{hut}
no cuts	$(18.62 \pm 0.03)\,10^9$	21261 ± 21	164242 ± 57	136150 ± 65	136201 ± 65
$\#\ell \equiv 1$, 0 loose	$(5858 \pm 1)\,10^6$	2763 ± 8	21995 ± 20	42995 ± 36	42950 ± 36
$M^T(\ell\nu) > 50$	$(5573 \pm 1)\,10^6$	1832 ± 6	14434 ± 16	27645 ± 29	27421 ± 29
$\#j \geq 3$	$(5262 \pm 7)\,10^3$	575 ± 4	3610 ± 8	7675 ± 15	7579 ± 15
$\#b \equiv 3$	77688 ± 389	112 ± 2	628 ± 3	1184 ± 6	934 ± 5
$80 < M(bb) < 205$	70581 ± 368	109 ± 2	601 ± 3	1096 ± 6	897 ± 5
$80 < M^T(b\ell\nu) < 230$	64942 ± 352	103 ± 1	560 ± 3	1016 ± 6	843 ± 5

Table: Signal

Cut	Sum Bg	T+jets	THq	TT+jets	W+jets
no cuts	$(18622 \pm 0.03)\,10^6$	$(28.11 \pm 0.02)\,10^6$	17526 ± 6	$(32322 \pm 7)\,10^3$	$(18562 \pm 3)\,10^6$
$\#\ell \equiv 1$, 0 loose	$(5858 \pm 1)\,10^6$	$(3162 \pm 5.2)\,10^3$	6074 ± 3	$(9245 \pm 4)\,10^3$	$(5845 \pm 1)\,10^6$
$M^T(\ell\nu) > 50$	$(5573 \pm 1)\,10^6$	$(2225 \pm 4)\,10^3$	4043 ± 3	$(5966 \pm 3)\,10^3$	$(5565 \pm 1)\,10^6$
$\#j \geq 3$	$(5262 \pm 7)\,10^3$	$(255 \pm 1)\,10^3$	1664 ± 2	$(3256 \pm 2)\,10^3$	$(1749 \pm 7)\,10^3$
$\#b \equiv 3$	77688 ± 389	1138 ± 113	401 ± 1	75883 ± 371	266 ± 34
$80 < M(bb) < 205$	70581 ± 368	802 ± 93	337 ± 1	69231 ± 355	210 ± 30
$80 < M^T(b\ell\nu) < 230$	64942 ± 352	651 ± 84	270 ± 1	63866 ± 341	154 ± 26

Table: Background

Significance

Cut	κ_{hct}	κ_{hut}	ttbar κ_{hct}	ttbar κ_{hut}	comb κ_{hct}	comb κ_{hut}
no cuts	0.156	1.204	0.998	0.998	1.154	2.202
$\#\ell \equiv 1$	0.036	0.287	0.562	0.561	0.598	0.849
$M^T(\ell\nu) > 50$	0.025	0.193	0.370	0.367	0.395	0.561
$\#j \geq 3$	0.251	1.573	3.344	3.301	3.594	4.872
$\#b \equiv 3$	0.402	2.246	4.215	3.331	4.611	5.550
$80 < M(bb) < 205$	0.408	2.254	4.094	3.354	4.496	5.580
$80 < M^T(b\ell\nu) < 230$	0.403	2.188	3.956	3.286	4.353	5.447

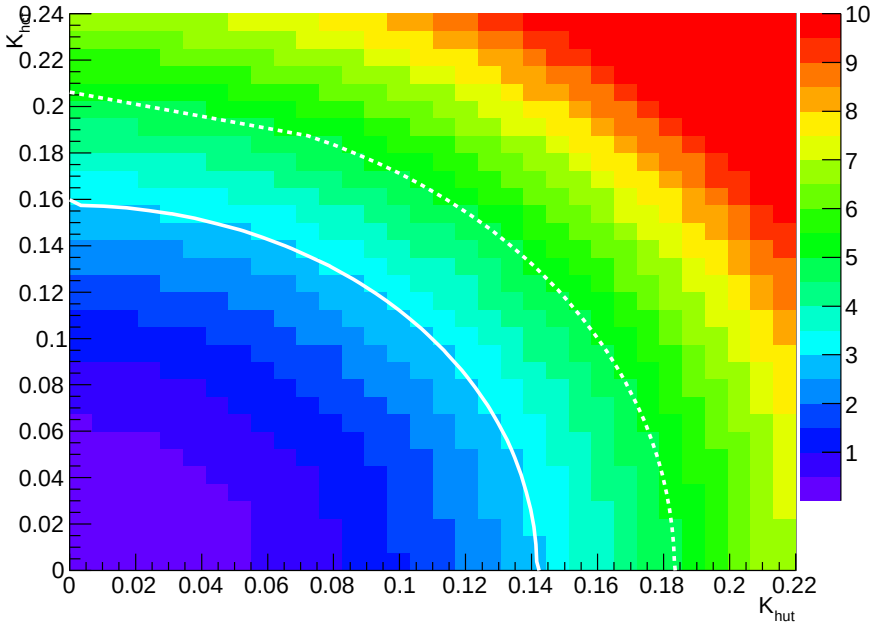
($t\bar{t}h$-background still missing: $\mathcal{O}(1\%)$)

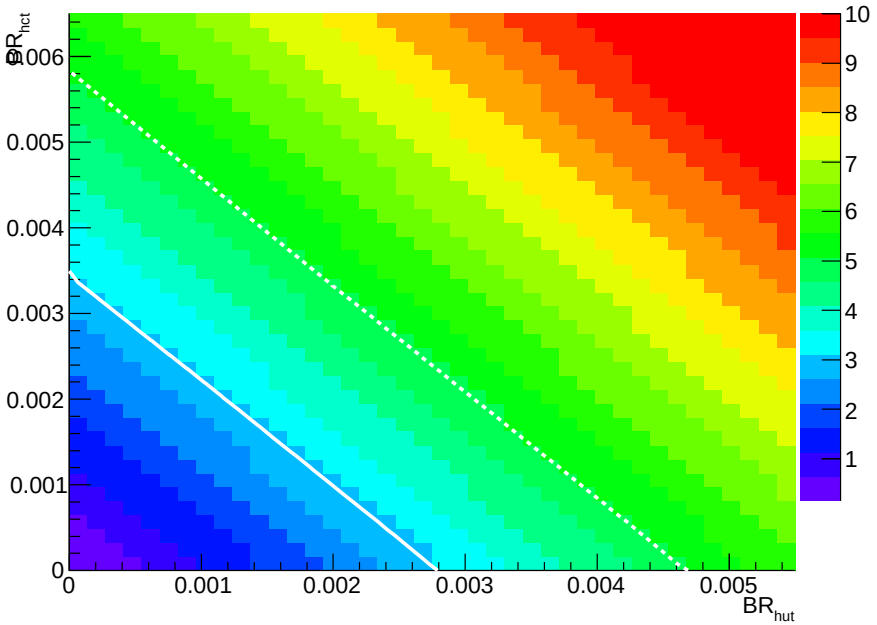
MVA highest signficances when each signal is trained against itself:

$\kappa_{hut} = 5.98\sigma$, $S = 1297.6$, $B = 45712.6$,

$\kappa_{hct} = 5.41\sigma$, $S = 1180.5$, $B = 46393.7$

MVA: 2D limits



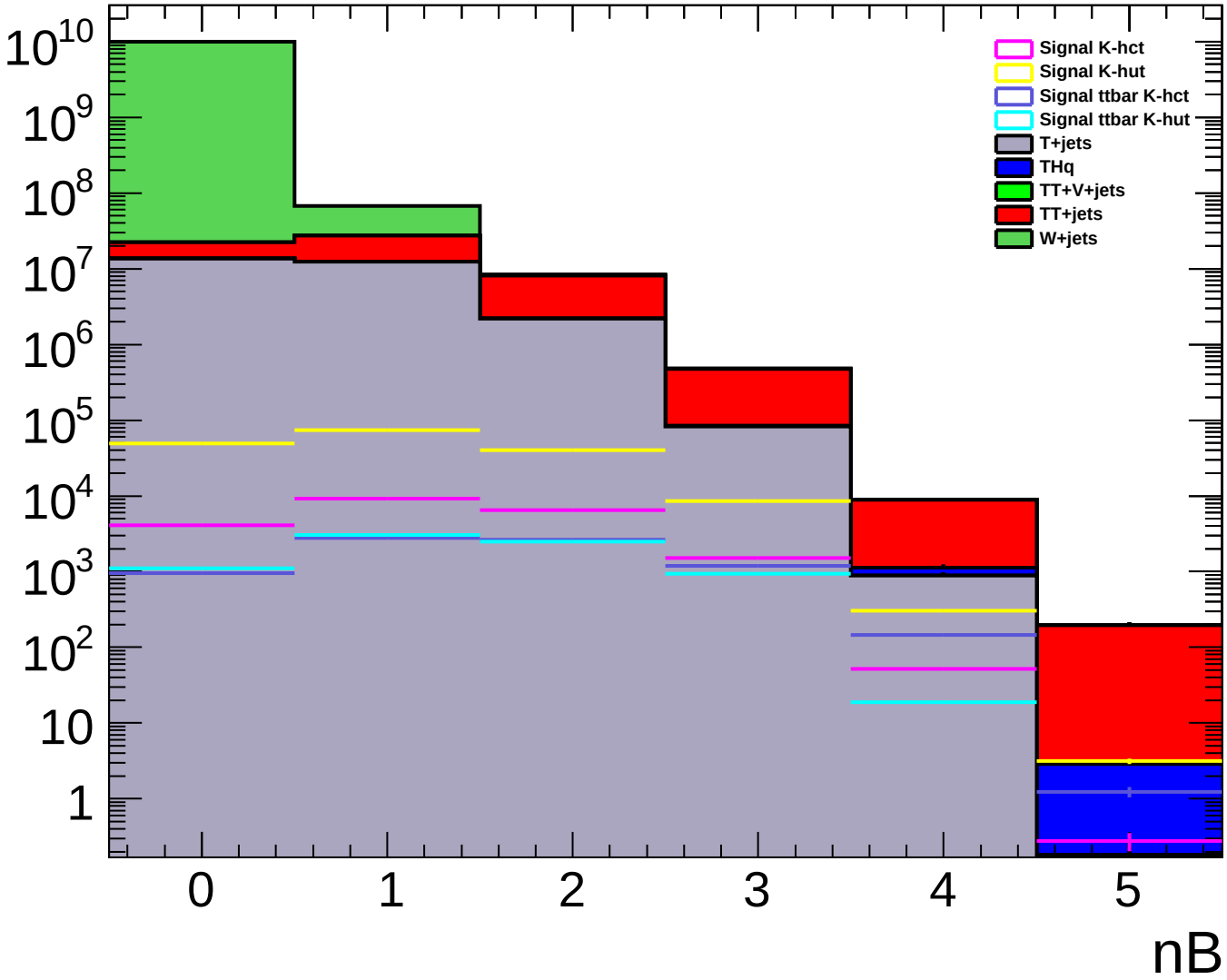


Summary

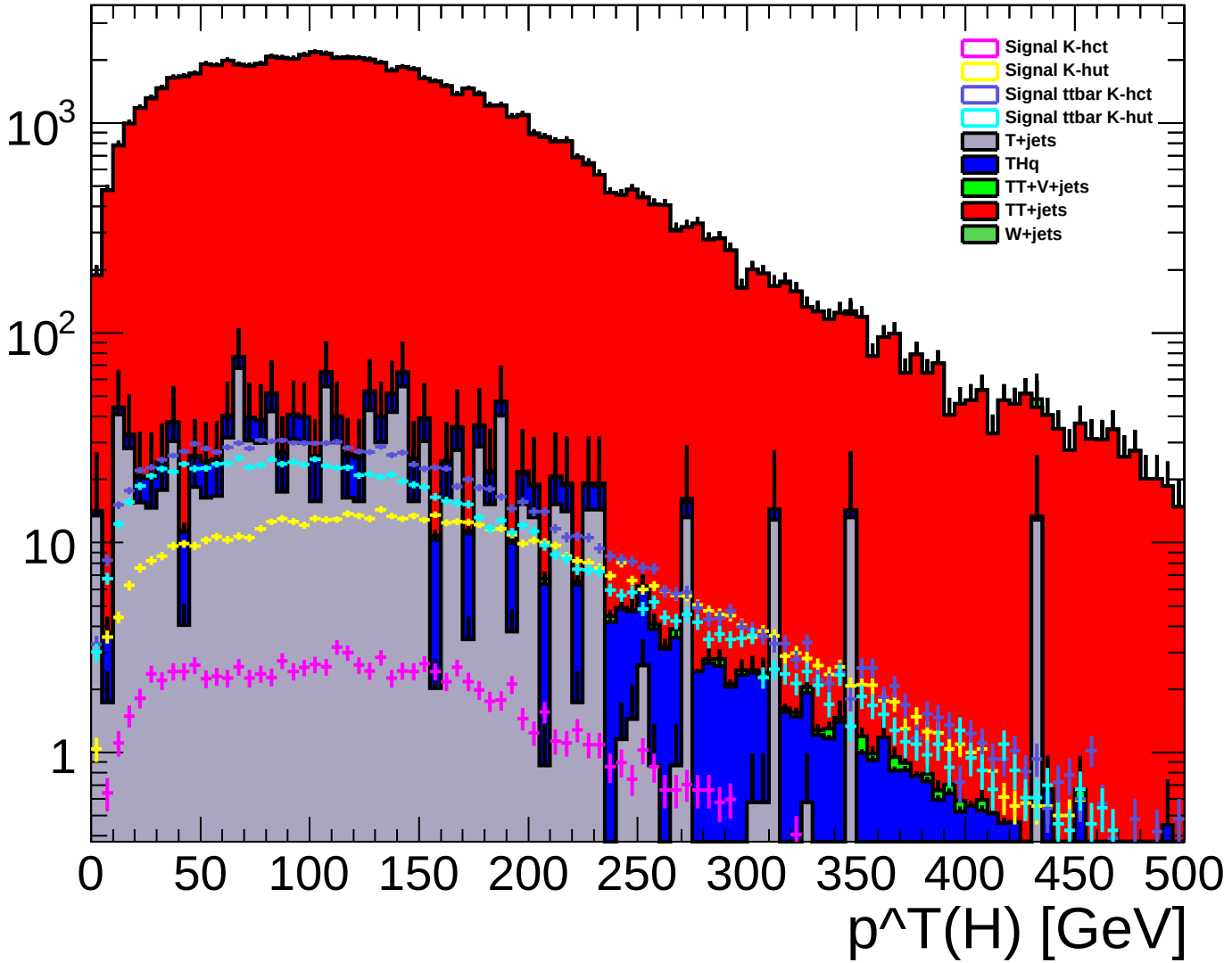
- NEW: OK separate training for different couplings
- tiny improvement with BDT for inclusive sample (a bit better for hct)

Backup slides

Number of b-jets



PT of Higgs


Signal K-hct
Signal K-hut
Signal ttbar K-hct
Signal ttbar K-hut
T+jets
THq
TT+V+jets
TT+jets
W+jets
10^3
10^2
10
1
0
50
100
150
200
250
300
350
400
450
500
p^T(H) [GeV]