A material for further discussions related to the comments on the draft v1.1

Content List

- List of number of remaining events after all of cuts applied (p3-5)

  -- current slide includes numbers from the “cut-based” analysis

From the comments on the draft v1.1

- Topic of B-tagging for veto the H->bb background (p6-7)
- Topic of signal contamination (p8-9)
- plots of BDT score distribution (p10-11)

Number of survived event (1/3)

① Z(→μμ)H(Z→νν, Z*→qq)

Category	channel	N_{event}
Signal		
	$\mu\mu H\nu\nu qq$	50
ZH		
HZZ		
	nnh_zz	10
Others		
	e2e2h_ww	22
	e2e2h_e3e3	2
total		36
4-Fermion Bg.		
	zz_l0taumu	2
	...	
total		4
2-Fermion Bg.		0

There exists more channels but omitted here

② Z(→νν)H(Z→μμ, Z*→qq)

Category	channel	N_{event}
Signal		
	$\nu\nu H\mu\mu qq$	73
ZH		
HZZ		
	e2e2h_zz	9
Others		
	e2e2h_ww	4
	e3e3h_ww	2
total		17
4-Fermion Bg.		
	ww_sl0muq	3
	...	
total		9
2-Fermion Bg.		0

All the numbers are from the cut-based analysis. Discrepancy of a few events in above list between the total number of events and summation of all channels in a category, is due to rounding numbers as well as omitting contributions which have less than one event. (Actual calculation is properly done in our analysis)

Number of survived event (2/3)

③ Z(→νν)H(Z→qq, Z*→μμ)

Category	channel	N_{event}
Signal		
	$\nu\nu$H$qq\mu\mu$	52
ZH		
HZZ		
	qqh_zz	18
Others		
	qqh_e3e3	50
	qqh_ww	55
	e3e3h_ww	11
	e2e2h_bb	8
	e2e2h_ww	7
	...	
total		159
4-Fermion Bg.		
	zz_sl0tau_up	9
	zz_sl0tau_down	25
	sze_l0mu	6
	...	
total		52
2-Fermion Bg.		0

④ Z(→qq)H(Z→νν, Z*→μμ)

Category	channel	N_{event}
Signal		
	qqH$\nu\nu\mu\mu$	42
ZH		
HZZ		
	nnh_zz	18
Others		
	qqh_e3e3	182
	qqh_ww	87
	e2e2h_bb	12
	e3e3h_ww	10
	e3e3h_bb	8
	...	
total		326
4-Fermion Bg.		
	zz_sl0tau_up	58
	zz_sl0tau_down	115
	sze_l0mu	6
	...	
total		190
2-Fermion Bg.		0

Number of survived event (3/3)

⑤ Z(→qq)H(Z→μμ, Z*→νν)

Category	channel	N_{event}
Signal		
	$qq\mathrm{H}\mu\mu\nu\nu$	35
ZH		
HZZ		
	e2e2h_zz	8
Others		
	e2e2h_bb	120
	e2e2h_ww	55
	qqh_e3e3	15
	...	
total		206
4-Fermion Bg.		
	zz_sl0mu_up	85
	zz_sl0mu_down	217
	...	
total		305
2-Fermion Bg.		0

⑥ Z(→μμ)H(Z→qq, Z*→νν)

Category	channel	N_{event}
Signal		
	$\mu\mu\mathrm{H}qq\nu\nu$	48
ZH		
HZZ		
	qqh_zz	21
	e2e2h_zz	6
Others		
	e2e2h_bb	419
	e2e2h_ww	303
	qqh_e3e3	7
	...	
total		774
4-Fermion Bg.		
	zz_sl0mu_up	159
	zz_sl0mu_down	488
	...	
total		659
2-Fermion Bg.		0

About B-tagging to veto the H->bb background events

・ H->bb background, namely “e2e2h_bb” (Z(→μμ)H(→bb)), is a dominant background in following channels

-- Z(→qq)H(Z→νν, Z*→μμ)
-- Z(→μμ)H(Z→νν, Z*→qq)

・A rough estimation about how much improvement could be achieved

<u>Assuming following scenario for a comparison</u>

-- Z(→μμ)H(→bb) event is completely cut by using the b-tagging information

-- Since, the signal and the dominant channels in remaining four-fermion bg. (“zz_sl0mu_up/down) include a decay of Z->bb, it is assumed that their yield becomes 80% by b-tagging.

- Comparison of the numbers between the original & w. b-tagging

Case for the channel $Z(\rightarrow qq)H(Z\rightarrow \nu\nu, Z^{*}\rightarrow \mu\mu)$

method	N_{event}(signal)	N_{event}(zh)	N_{event}(4F)	$\sqrt{}$(S+B)/S
Original	35	206	305	0.667
w B-tagging	28	86	245	0.677

Case for the channel $Z(\rightarrow \mu\mu)H(Z\rightarrow \nu\nu, Z^{*}\rightarrow qq)$

method	N_{event}(signal)	N_{event}(zh)	N_{event}(4F)	$\sqrt{}$(S+B)/S
Original	48	774	659	0.802
w B-tagging	38	355	530	0.799

-- From this “coarse” comparison, the improvement might not be so huge.

-- But of course, estimation is very rough. (not consider b-tagging eff. , as well as the reduction on HWW bg. events)

About the signal cross talks

・ The signal channel, taking Z(→μμ)H(Z→νν, Z*→qq) channel as an example, the signal channel is chosen from “e2e2h_zz” MC samples,
with additional selection of H(Z→νν, Z*→qq) by using the MC truth information.

so, the analysis proceeds as if there exists Z(→μμ)H(Z→νν, Z*→qq) MC samples.
(but H(Z→νν, Z*→qq) & H(Z→qq, Z*→νν) is not distinguished by MC truth,
and is done by an analysis cut, such as , $M_{Z(\nu\nu)} > M_{Z^*(qq)}$

・All the other HZZ data samples, including “e2e2h_zz” but zz is not decaying into 2q+2v, and other Higgs decay samples, are merged into “ZH” background.

Mis-identification of other signals into the signal under consideration, does not happen. Concern might be how much the other signals are included in the “ZH” background.

Contamination of HZZ signals

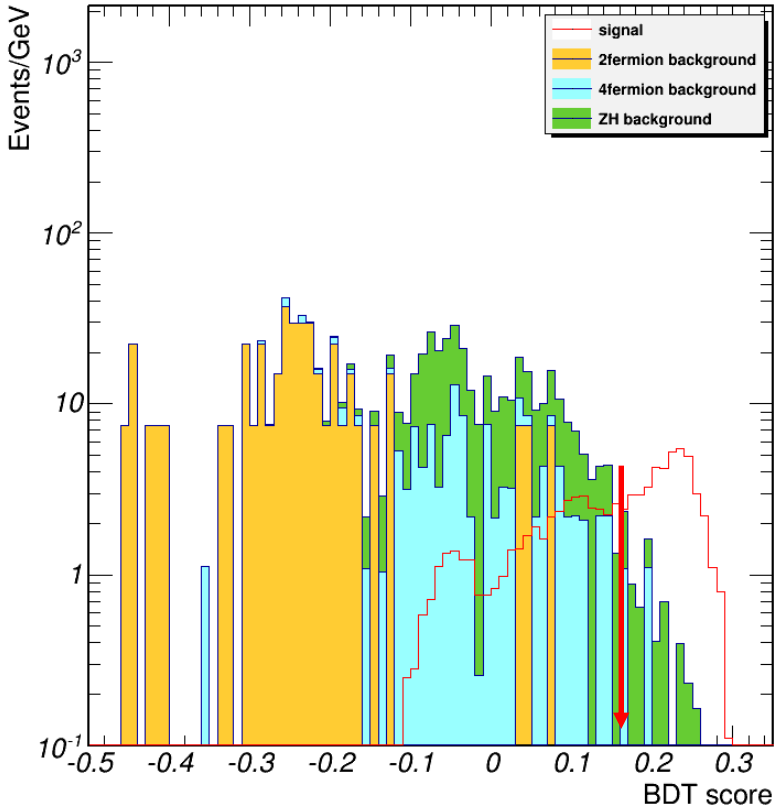
"ZH" bg.

	N_{event}(signal)	N_{event}(HZZ cross talk in ZH bg.)	N_{event}(ZH bg. except the cross talk)	N_{event}(4F bg.)
$Z(\to\mu\mu)H(Z\to\nu\nu, Z^*\to qq)$	50	10 (nnh_zz)	26	4
$Z(\to\nu\nu)H(Z\to\mu\mu, Z^*\to qq)$	73	9 (e2e2_zz)	8	9
$Z(\to\nu\nu)H(Z\to qq, Z^*\to\mu\mu)$	52	18 (qqh_zz)	141	52
$Z(\to qq)H(Z\to\nu\nu, Z^*\to\mu\mu)$	42	18 (nnh_zz)	308	190
$Z(\to qq)H(Z\to\mu\mu, Z^*\to\nu\nu)$	35	8 (e2e2h_zz)	198	305
$Z(\to\mu\mu)H(Z\to qq, Z^*\to\nu\nu)$	48	21 (qqh_zz) 6 (e2e2h_zz)	747	659

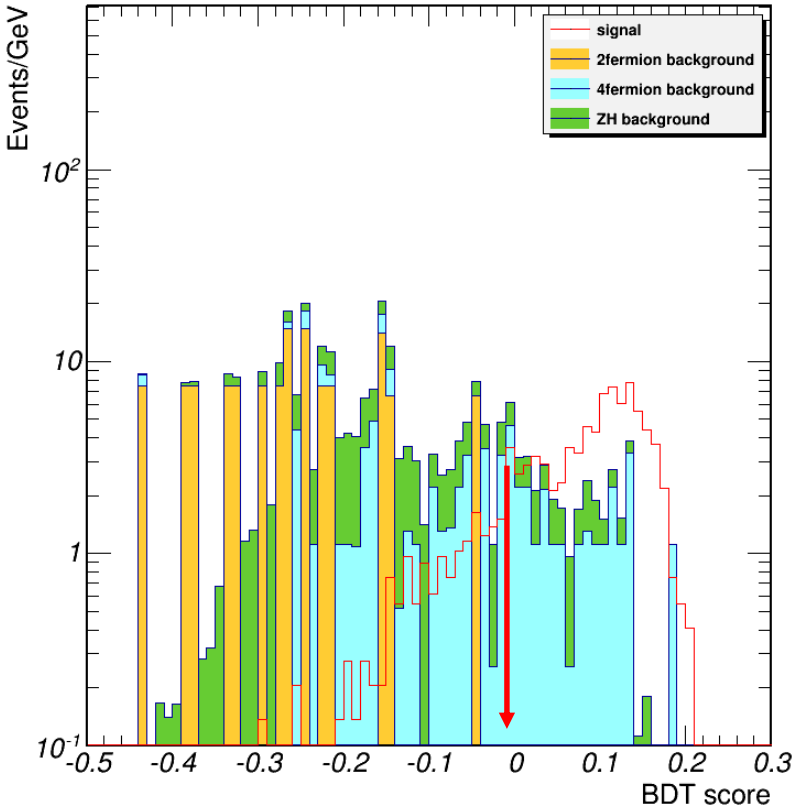
・ Remaining channel, for example, "nnh_zz" in the first row, represents $Z(\to\nu\nu)H(\to ZZ^*)$ and is not identical to $Z(\to\nu\nu)H(Z\to\mu\mu, Z^*\to qq)$, but it is very close to $Z(\to\nu\nu)H(Z\to\mu\mu, Z^*\to qq)$.

Channels whose number of events are less than 1, are not included in the list (in the memo) and those contributions are omitted in above list as well.

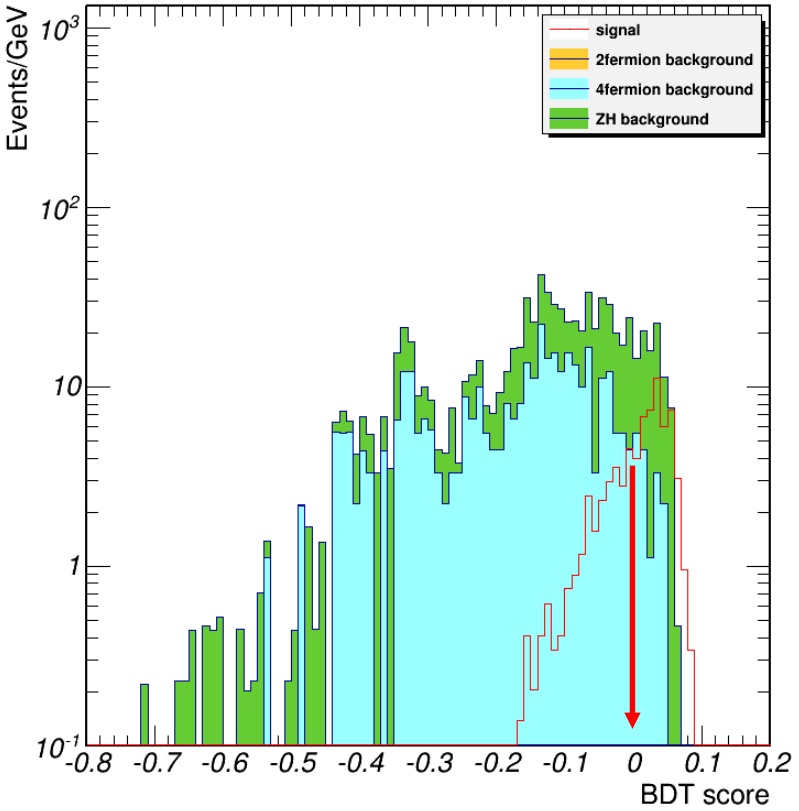
Distribution of the BDT score – I.



① Z(→μμ)H(Z→νν, Z*→qq)



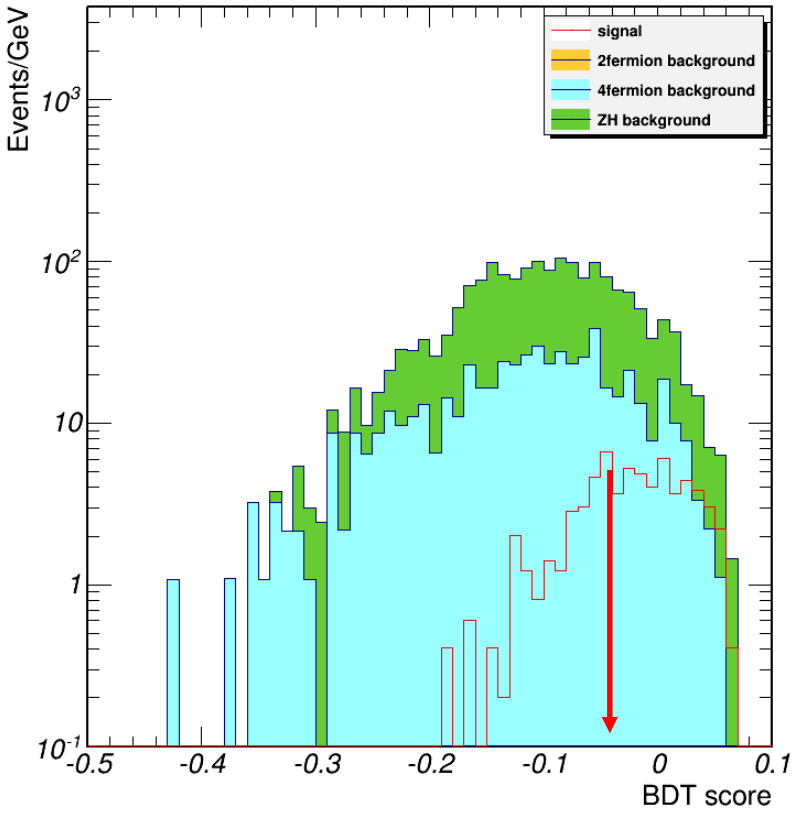
② Z(→νν)H(Z→μμ, Z*→qq)



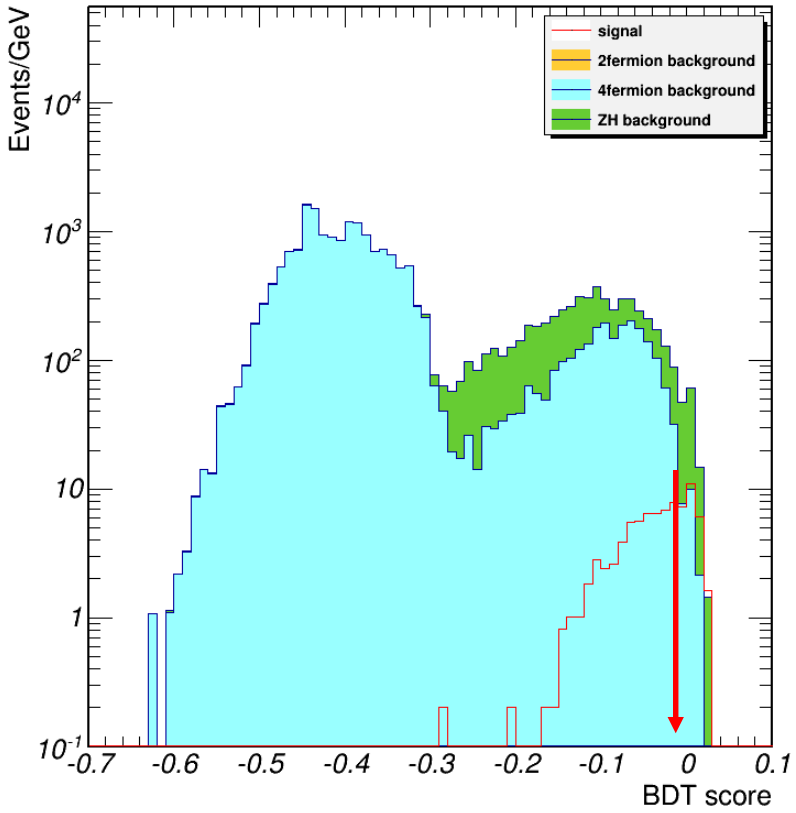
③ Z(→νν)H(Z→qq, Z*→μμ)

Red Arrow indicates cut position on the BDT score

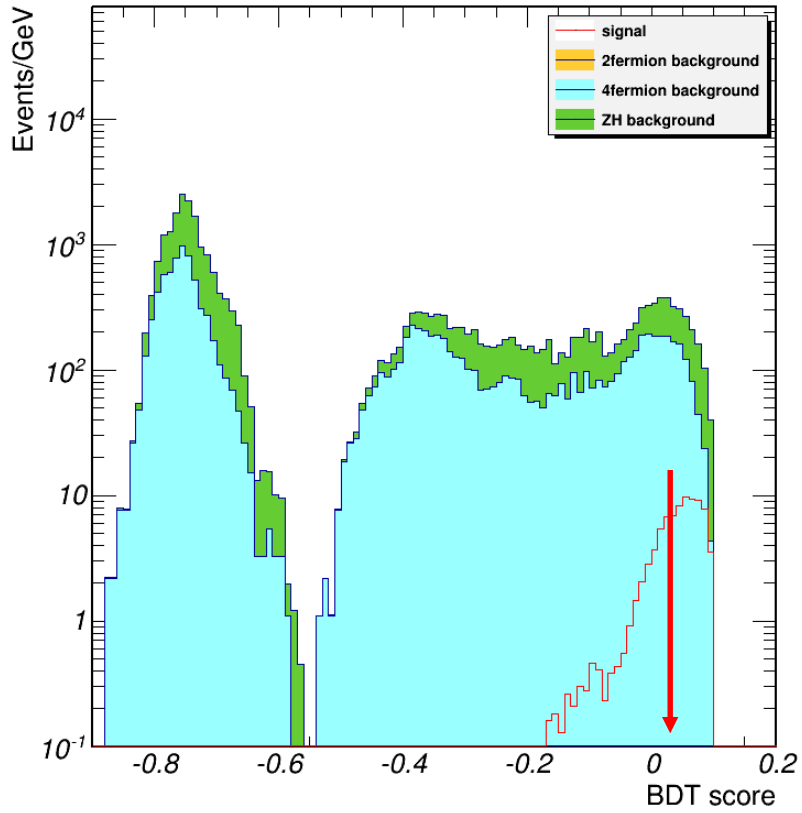
Distribution of the BDT score – II.



④ Z(→qq)H(Z→νν, Z*→μμ)



⑤ Z(→qq)H(Z→μμ, Z*→νν)



⑥ Z(→μμ)H(Z→qq, Z*→νν)