BDT Analysis Update

Min Zhong, Yanxi Gu 2020.7.14

Introduction

Use "2D" cut to suppress signal overlap



- Separate this phase space into two regions, so as to eliminate the overlap of analysis region.
- - vvHµµqq red region" or "vvHµµqq'"

> Add "2D cut" to the several pre-BDT cuts

μμΗννqq

	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	1000	1140511	801811977	107203890	<u> </u>
	Pre-selection	616	30494	480828	515424	
	Signal or not	211	30282	480828	515424	
	$M_{missing} > M_{dijet}$	107	1608	115062	28811	0.283
Without	N(pfo)	104	908	33480	14161	0.4722
	M_{dimuon}	92	296	24151	1629	0.5714
2D cuts	M_{dimuon}^{rec}	89	256	1642	406	1.8279
	$cos \theta_{visible}$	85	240	388	127	2.9422
	$BDT \ score$	45	6	0	2	6.1727
	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	1000	1140511	801811977	107203890	
	Pre-selection	616	30494	480828	515424	
	$Signal \ or \ not$	211	30282	480828	515424	
With	$M_{missing} > M_{dijet}$	107	1608	115062	28811	0.283
	N(pfo)	104	908	33480	14161	0.4722
2D cuts	M_{dimuon}	92	296	24151	1629	0.5714
	M_{dimuon}^{rec}	89	256	1642	406	1.8279
	$cos heta_{visible}$	85	240	388	127	2.9422
	$2D \ Mass \ Cut \ 1$	85	240	388	127	2.9423
	$2D \ Mass \ Cut \ 2$	77	187	335	121	2.876
	BDT score	57	14	0	6	6.484

μμΗννqq

> Remained backgrounds comparison

	name	scale	final
Without	e2e2h_ww	0.08176	3
	nnh_zz	0.06832	2
2D cuts	zz_sl0mu_down	1.08025726079	1
	zz_sl0tau_up	1.10880522921	1
	name	scale	final
	e2e2h_ww	0.08176	6
With	nnh_zz	0.06832	7
	zz_sl0mu_up	1.09032214858	3
2D cuts	zz_sl0tau_up	1.10880522921	2
	zz_l0taumu	1.0404004004	1

>Explanations

For different BDT models & different BDT score cut points, the number of signals/backgrounds differs a lot

μμΗqqνν

	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	1000	1140511	801811977	107203890	<u> </u>
	Pre-selection	616	30494	480828	515424	
Cut Signal ZH Background 2f Background	480828	515424				
	$M_{missing} < M_{dijet}$	103	28674	365766	486613	0.1102
Without	N(pfo)	100	21686	12184	332136	0.1657
	M_{dimuon}	89	16833	9085	207927	0.186
2D cuts	M_{dimuon}^{rec}	87	16144	321	25675	0.4236
	$cos \theta_{visible}$	82	14667	0	12539	0.4992
	$BDT\ score$	54	806	0	605	1.4262
	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	1000	1140511	801811977	107203890	
	Pre-selection	616	30494	480828	515424	
	$Signal \ or \ not$	211	30282	480828	515424	
X7:4L	$M_{missing} < M_{dijet}$	103	28674	365766	486613	0.1102
VV I LII	N(pfo)	100	21686	12184	332136	0.1657
2D cuts	M_{dimuon}	89	16833	9085	207927	0.186
	M_{dimuon}^{rec}	87	16144	321	25675	0.4236
	$cos heta_{visible}$	82	14667	0	12539	0.4992
	$2D \ Mass \ Cut \ 1$	75	14224	0	11535	0.4712
	$2D \ Mass \ Cut \ 2$	75	14224	0	11533	0.4712
	BDT score	61	988	0	607	1.5079

μμΗqqνν

Remained backgrounds comparison

-							
-	name	scale	final	-	name	scale	final
-	$e2e2h_bb$	0.21896	448		e2e2h_bb	0.21896	571
	$e2e2h_cc$	0.011032	5		$e2e2h_cc$	0.011032	6
	$e2e2h_e3e3$	0.023968	1		$e2e2h_e3e3$	0.023968	3
Without	$e2e2h_gg$	0.0326888819557	1	With	e2e2h_gg	0.0326888819557	1
vv iuioui	e2e2h_ww	0.08176	298	VV I LII	e2e2h_ww	0.08176	371
2D cuts	$e2e2h_zz$	0.010024	5	2D cuts	e2e2h_zz	0.010024	6
	$e3e3h_zz$	0.009968099681	1		e3e3h_zz	0.009968099681	1
	qqh_e3e3	0.4844	11		aah e3e3	0 4844	5
	qqh_ww	1.6464	1		agh zz	0 20216	18
	qqh_zz	0.20216	30		zz slūmu up	1 00032214858	1/3
	zz_sl0mu_up	1.09032214858	127		zz_siomu_up	1.09052214050	140
	zz_sl0mu_down	1.08025726079	455		zz_siomu_down	1.00023720079	442
	zz_sl0tau_down	1.10887174477	5		zz_siotau_down	1.1000/1/44//	4
	ww_sl0muq	1.10890944134	13		ww_sl0muq	1.10890944134	14
	ww_sl0tauq	1.10899434445	3		ww_sl0tauq	1.10899434445	2

Explanations

- **For different BDT models & different BDT score cut points, the number** of signals/backgrounds differs a lot
- > But if the number of signals didn't change a lot, 2D cut could reduce the number of other signal channels that passed selections efficiently

ννΗμμqq

	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	6844	1140511	801811977	107203890	1212
	Pre-selection	238	30494	480828	515424	
	$Signal \ or \ not$	226	30268	480828	515424	
	$M_{dimuon} > M_{dijet}$	125	2832	421952	156993	0.1642
Without	N(pfo)	117	1259	60398	68100	0.325
2D and a	$M_{missing}$	102	147	2152	791	1.8168
2D cuts	$M_{visible}$	101	82	696	325	2.9267
	$cos heta_{visible}$	96	77	124	79	4.9672
	$BDT \ score$	80	12	0	27	7.383
	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	6844	1140511	801811977	107203890	
	Pre-selection	238	30494	480828	515424	
	Signal or not	226	30268	480828	515424	
***	$M_{dimuon} > M_{dijet}$	125	2832	421952	156993	0.1642
With	N(pfo)	117	1259	60398	68100	0.325
2D cuts	$M_{missing}$	102	147	2152	791	1.8168
	$M_{visible}$	101	82	696	325	2.9267
	$cos \theta_{visible}$	96	77	124	79	4.9672
	$2D \ Mass \ Cut \ 1$	87	21	87	69	5.3562
	$2D \ Mass \ Cut \ 2$	87	21	87	67	5.378
	BDT score	81	11	0	17	7.7125

ννΗμμqq

Remained backgrounds comparison

Without **2D cuts**

name	scale	final
e2e2h_ww	0.08176	3
e2e2h_zz	0.010024	4
e3e3h_ww	0.0812	2
zz_sl0tau_up	1.10880522921	4
zz_l0taumu	1.0404004004	3
ww_sl0muq	1.10890944134	9
ww_sl0tauq	1.10899434445	4
zzorww_10mumu	1.10891486372	3
sze_l0mu	1.10916641266	1

Note: Consistent with cut-based results

name	scale	final
e2e2h_ww	0.08176	4
e2e2h_zz	0.010024	4
e3e3h_ww	0.0812	2
zz_sl0tau_down	1.10887174477	1
zz_104tau	0.258421381722	1
zz_l0taumu	1.0404004004	2
ww_sl0muq	1.10890944134	7
ww_sl0tauq	1.10899434445	3
zzorww_10mumu	1.10891486372	1
sze_l0mu	1.10916641266	1

With **2D cuts**

ννΗqqμμ

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $							
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		Expected	6844	1140511	801811977	107203890	
$ \begin{tabular}{ c c c c c c c c c c c c c c c c c c c$		Pre-selection	238	30494	480828	515424	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Signal or not	226	30268	480828	515424	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		$M_{dimuon} < M_{dijet}$	101	27436	58876	358431	0.1521
$\begin{array}{c ccccc} \text{With} & M_{missing} & 79 & 769 & 37 & 2083 & 1.4503 \\ \text{2D cuts} & M_{visible} & 76 & 445 & 0 & 910 & 2.032' \\ \hline & cos\theta_{visible} & 73 & 430 & 0 & 360 & 2.4836 \\ \hline & BDT \ score & 47 & 76 & 0 & 16 & 3.9875 \\ \hline & \hline$	Without	N(pfo)	97	20843	364	231698	0.1939
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		$M_{missing}$	79	769	37	2083	1.4508
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	2D cuts	$M_{visible}$	76	445	0	910	2.0327
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		$cos heta_{visible}$	73	430	0	360	2.4836
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		$BDT \ score$	47	76	0	16	3.9875
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $			-				
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		Expected	6844	1140511	801811977	107203890	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		Pre-selection	238	30494	480828	515424	
With $M_{dimuon} < M_{dijet}$ $N(pfo)$ 10127436588763584310.1522D cuts $N(pfo)$ 97208433642316980.1932D cuts $M_{missing}$ $M_{visible}$ 797693720831.450 $M_{visible}$ $cos \theta_{visible}$ 7644509102.032 $2D$ Mass Cut 17343003602.483		Signal or not	226	30268	480828	515424	
With $N(pfo)$ 97208433642316980.1932D cuts $M_{missing}$ 797693720831.450 $M_{visible}$ 7644509102.032 $cos \theta_{visible}$ 7343003602.4832D Mass Cut 17343003602.483	XX7°41	$M_{dimuon} < M_{dijet}$	101	27436	58876	358431	0.1521
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	WITH	N(pfo)	97	20843	364	231698	0.1939
$\begin{array}{c cccc} M_{visible} & 76 & 445 & 0 & 910 & 2.032 \\ \hline cos \theta_{visible} & 73 & 430 & 0 & 360 & 2.483 \\ 2D \ Mass \ Cut \ 1 & 73 & 430 & 0 & 360 & 2.483 \end{array}$	2D cuts	$M_{missing}$	79	769	37	2083	1.4508
$\begin{array}{c cccc} cos \theta_{visible} & 73 & 430 & 0 & 360 & 2.483 \\ 2D Mass Cut 1 & 73 & 430 & 0 & 360 & 2.483 \end{array}$		$M_{visible}$	76	445	0	910	2.0327
2D Mass Cut 1 73 430 0 360 2.483		$cos \theta_{visible}$	73	430	0	360	2.4836
		$2D \ Mass \ Cut \ 1$	73	430	0	360	2.4839
2D Mass Cut 2 60 240 0 263 2.556		$2D \ Mass \ Cut \ 2$	60	240	0	263	2.5564
BDT score 55 96 0 43 3.971		BDT score	55	96	0	43	3.9717

ννΗqqμμ

> Remained backgrounds comparison

name	scale	final
e2e2h_bb	0.21896	4
e2e2h_ww	0.08176	4
e3e3h_ww	0.0812	3
qqh_e3e3	0.4844	21
qqh_ww	1.6464	29
qqh_zz	0.20216	11
zz_sl0mu_down	1.08025726079	2
zz_sl0tau_up	1.10880522921	1
zz_sl0tau_down	1.10887174477	7
ww_sl0muq	1.10890944134	4
ww_sl0tauq	1.10899434445	1
	-	
name	scale	final
$e2e2h_bb$	0.21896	6
e2e2h_bb e2e2h_ww	$0.21896 \\ 0.08176$	$\frac{6}{6}$
e2e2h_bb e2e2h_ww e3e3h_ww	$0.21896 \\ 0.08176 \\ 0.0812$	6 6 8
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3	$0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww	$0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844 \\ 1.6464$	$ \begin{array}{c} 6 \\ 8 \\ 24 \\ 37 \end{array} $
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz	$\begin{array}{c} 0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844 \\ 1.6464 \\ 0.20216 \end{array}$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz zz_sl0mu_down	$\begin{array}{r} 0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844 \\ 1.6464 \\ \hline 0.20216 \\ 1.08025726079 \end{array}$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz zz_sl0mu_down zz_sl0tau_up	$\begin{array}{c} 0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844 \\ 1.6464 \\ \hline 0.20216 \\ 1.08025726079 \\ 1.10880522921 \end{array}$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz zz_sl0mu_down zz_sl0tau_up zz_sl0tau_down	$\begin{array}{c} 0.21896 \\ 0.08176 \\ 0.0812 \\ 0.4844 \\ 1.6464 \\ \hline 0.20216 \\ 1.08025726079 \\ 1.10880522921 \\ 1.10887174477 \end{array}$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz zz_sl0mu_down zz_sl0tau_up zz_sl0tau_down ww_sl0muq	$\begin{array}{c} 0.21896\\ 0.08176\\ 0.0812\\ 0.4844\\ 1.6464\\ \hline 0.20216\\ 1.08025726079\\ 1.10880522921\\ 1.10887174477\\ 1.10890944134\\ \end{array}$	
e2e2h_bb e2e2h_ww e3e3h_ww qqh_e3e3 qqh_ww qqh_zz zz_sl0mu_down zz_sl0tau_up zz_sl0tau_down ww_sl0muq ww_sl0tauq	$\begin{array}{c} 0.21896\\ 0.08176\\ 0.0812\\ 0.4844\\ 1.6464\\ \hline 0.20216\\ 1.08025726079\\ 1.10880522921\\ 1.10887174477\\ 1.10890944134\\ 1.10899434445\\ \end{array}$	

With 2D cuts

Without

2D cuts

qqHννμμ

	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	20254	1140511	801811977	107203890	
	Pre-selection	826	30494	480828	515424	
	Signal or not	203	30291	480828	515424	
	$M_{missing} > M_{dimuon}$	94	3179	18606	40769	0.3795
Without	N(pfo)	84	2242	1212	12626	0.6659
without	M_{dijet}	75	1532	7	4965	0.9263
2D cuts	M_{dijet}^{rec}	70	1318	0	1381	1.3315
	$cos \theta_{visible}$	67	1259	0	541	1.551
	$BDT\ score$	48	305	0	116	2.2226
	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	20254	1140511	801811977	107203890	T ·
	Pre-selection	826	30494	480828	515424	
	$Signal \ or \ not$	203	30291	480828	515424	
	$M_{missing} > M_{dimuon}$	94	3179	18606	40769	0.3795
With	N(pfo)	84	2242	1212	12626	0.6659
2D cuts	M_{dijet}	75	1532	7	4965	0.9263
	M_{dijet}^{rec}	70	1318	0	1381	1.3315
	$cos heta_{visible}$	67	1259	0	541	1.551
	$2D \ Mass \ Cut \ 1$	66	1252	0	511	1.562
	$2D\ Mass\ Cut\ 2$	53	1062	0	440	1.35
	BDT score	28	95	0	29	2.2701

*qqHνν*μμ

> Remained backgrounds comparison

:	name	scale	final		name	scale	final
	e2e2h_bb	0.21896	6		$e3e3h_bb$	0.21784	1
Without	e2e2h_ww	0.08176	2	With	$e3e3h_ww$	0.0812	2
2D cuts	e3e3h_bb	0.21784	6	2D cuts	nnh_zz	0.06832	4
	e3e3h_ww	0.0812	6		$qqh_{e}3e3$	0.4844	59
	nnh_zz	0.06832	24		qqh_ww	1.6464	26
	qqh_e3e3	0.4844	151		zz_sl0mu_down	1.08025726079	1
	qqh_ww	1.6464	107		zz_sl0tau_up	1.10880522921	15
	zz_sl0mu_down	1.08025726079	1		zz_sl0tau_down	1.10887174477	13
	zz_sl0tau_up	1.10880522921	36	-			
	zz_sl0tau_down	1.10887174477	76				
	sze_l0mu	1.10916641266	2				

qqHμμνν

	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	20254	1140511	801811977	107203890	VUID
	Pre-selection	826	30494	480828	515424	
	Signal or not	203	30291	480828	515424	
	$M_{missing} < M_{dimuon}$	108	27112	462222	474655	0.1104
Without	N(pfo)	103	19806	17185	313602	0.1741
	M_{dijet}	97	4531	44	250527	0.1937
2D cuts	M_{dijet}^{rec}	88	3385	7	33021	0.4622
	$cos \theta_{visible}$	82	3081	0	18293	0.56
	$BDT \ score$	33	161	0	51	2.1536
	Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
	Expected	20254	1140511	801811977	107203890	
	Pre-selection	826	30494	480828	515424	
	$Signal \ or \ not$	203	30291	480828	515424	
XX 7°41.	$M_{missing} < M_{dimuon}$	108	27112	462222	474655	0.1104
with	N(pfo)	103	19806	17185	313602	0.1741
2D cuts	M_{dijet}	97	4531	44	250527	0.1937
	M_{dijet}^{rec}	88	3385	7	33021	0.4622
	$cos \theta_{visible}$	82	3081	0	18293	0.56
	$2D \ Mass \ Cut \ 1$	64	1190	0	17441	0.4681
	$2D \ Mass \ Cut \ 2$	64	1177	0	17441	0.4683
	$BDT \ score$	21	48	0	10	2.3632

qqHμμνν

> Remained backgrounds comparison

	· · · · · · · · · · · · · · · · · · ·						
	name	scale	final		name	scale	final
Without	$e2e2h_bb$	0.21896	24	With	e2e2h_bb	0.21896	10
	$e2e2h_ww$	0.08176	18		$e2e2h_ww$	0.08176	6
2D cuts	e2e2h_zz	0.010024	2	2D cuts	qqh_e3e3	0.4844	25
	$qqh_{e}3e3$	0.4844	81		qqh_ww	1.6464	4
	qqh_ww	1.6464	31		zz_sl0mu_up	1.09032214858	1
	zz_sl0mu_up	1.09032214858	4		zz_sl0mu_down	1.08025726079	8
	zz_{sl0mu_down}	1.08025726079	27		zz_sl0tau_down	1.10887174477	1
	zz_sl0tau_up	1.10880522921	3				
	zz_sl0tau_down	1.10887174477	16				