

# CEPC HZZ Project

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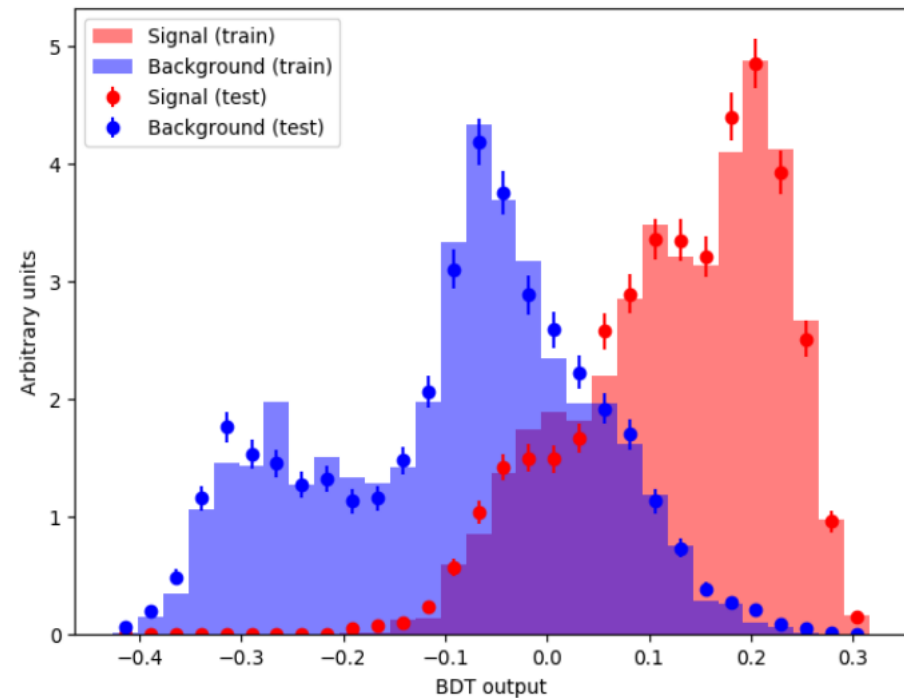
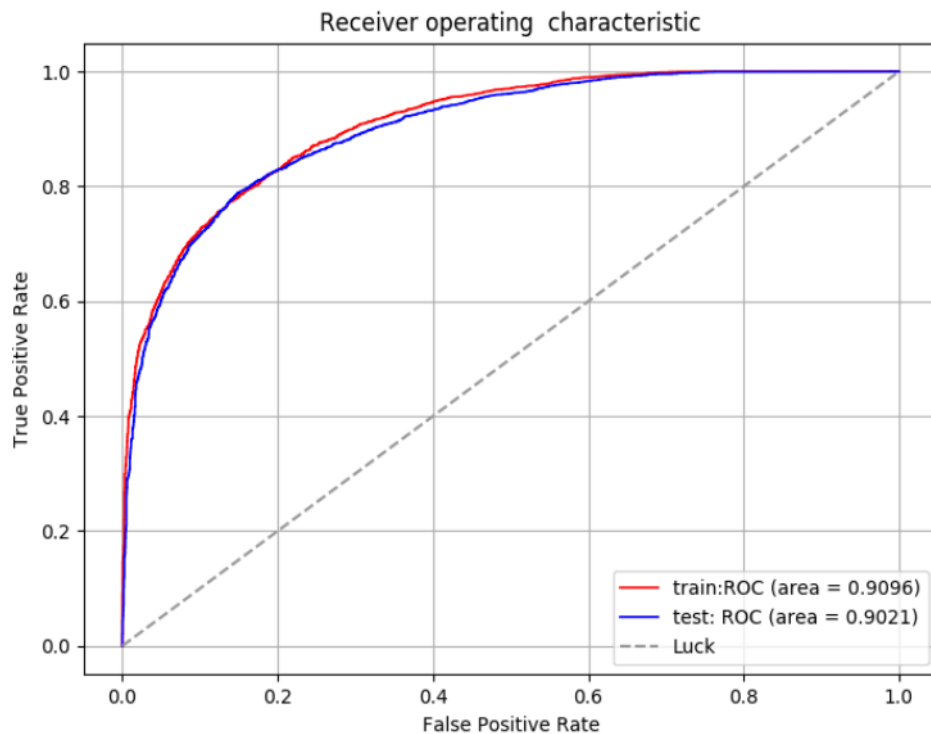
# Project Overview

	mmHZZ	vvHZZ	qqHZZ
Cut-based	Done	Done	Done
Merge into framework	Done	Done	Done
BDT Study	Done	Done	Done
Put BDT code in package	To do	To do	To do
Higgs width fitting in the framework	Done	To do	To do
Dalitz Fitting	To do		

	Status
Table & Plot style	Done
CEPC Memo	To do
EFT	On-going (Ryuta)

# BDT study on $\mu\mu\text{HZZ}$ ( $\nu\nu\text{jj}$ )

- 5 Pre-BDT cuts
- Without higgs mass in training



# BDT study on $\mu\mu H Z Z$ ( $\nu\nu jj$ )

Cut-based

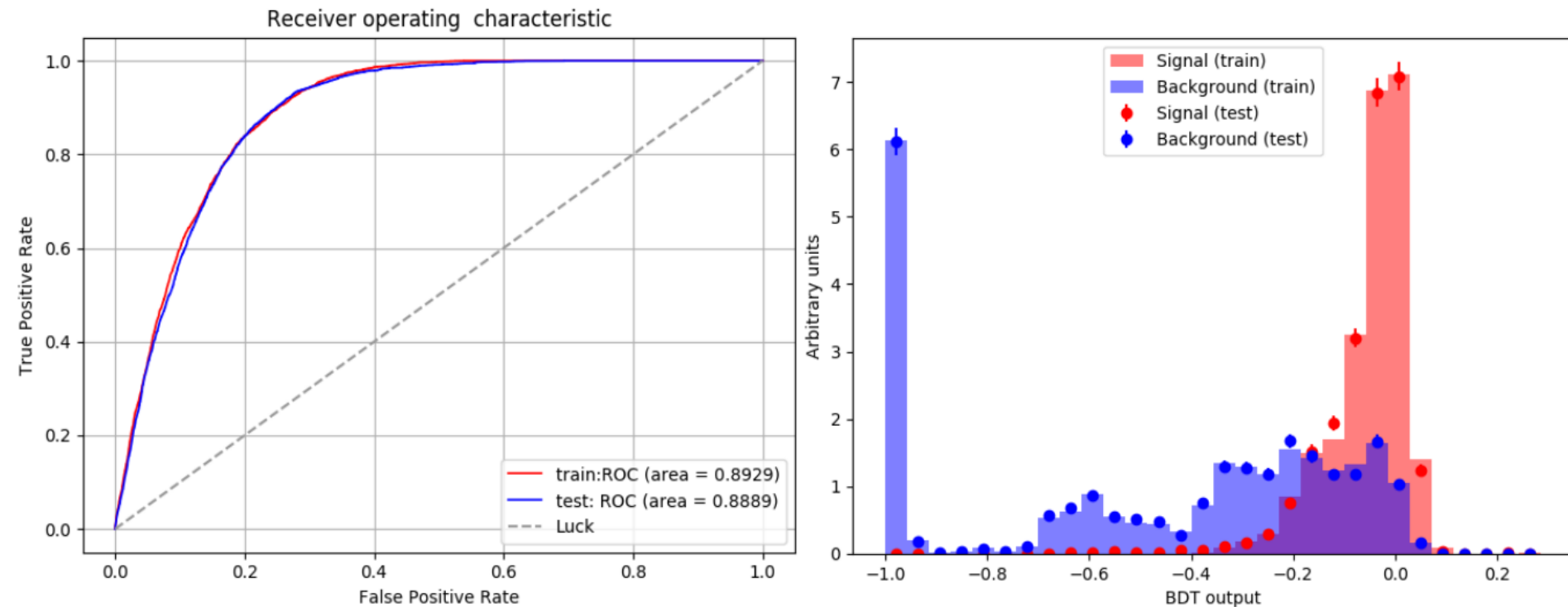
Cut	Signal	ZH background	2f background	4f background
Expected	1000	1140511	801811977	107203890
<i>Pre – selection</i>	616	30524	481301	515955
<i>Signal or not</i>	211	30307	481301	515955
$M_{\text{missing}} > M_{\text{dijet}}$	107	1605	115175	28838
$M_{\text{dimuon}}$	95	726	73813	6836
$M_{\text{dimuon}}^{\text{rec}}$	95	707	7894	1360
$N(\text{pfo})$	94	336	3271	574
$P_{t\text{visible}}$	89	312	342	168
$\text{Angle}_{\text{min}}$	85	298	283	139
$M_{\text{missing}} \text{ and } M_{\text{dijet}}$	62	80	254	46
<i>Single Jet</i>	54	67	0	9

BDT

Cut	Signal	ZH background	2f background	4f background
<i>Expected</i>	1000	1140511	801811977	107203890
<i>Pre – selection</i>	616	30494	480828	515426
<i>Signal or not</i>	211	30282	480828	515426
$M_{\text{missing}} > M_{\text{dijet}}$	107	1608	115062	28811
$M_{\text{dimuon}}$	95	725	73741	6833
$M_{\text{dimuon}}^{\text{rec}}$	95	706	7886	1359
$N(\text{pfo})$	94	336	3268	574
$P_{t\text{visible}}$	89	312	342	168
<i>BDT score</i>	57	22	14	9

# BDT study on $\mu\mu\text{HZZ}$ ( $\text{jj}\nu$ )

- 5 Pre-BDT cuts
- Without higgs mass in training



# BDT study on $\mu\mu H Z Z$ (jjvv)

Cut-based

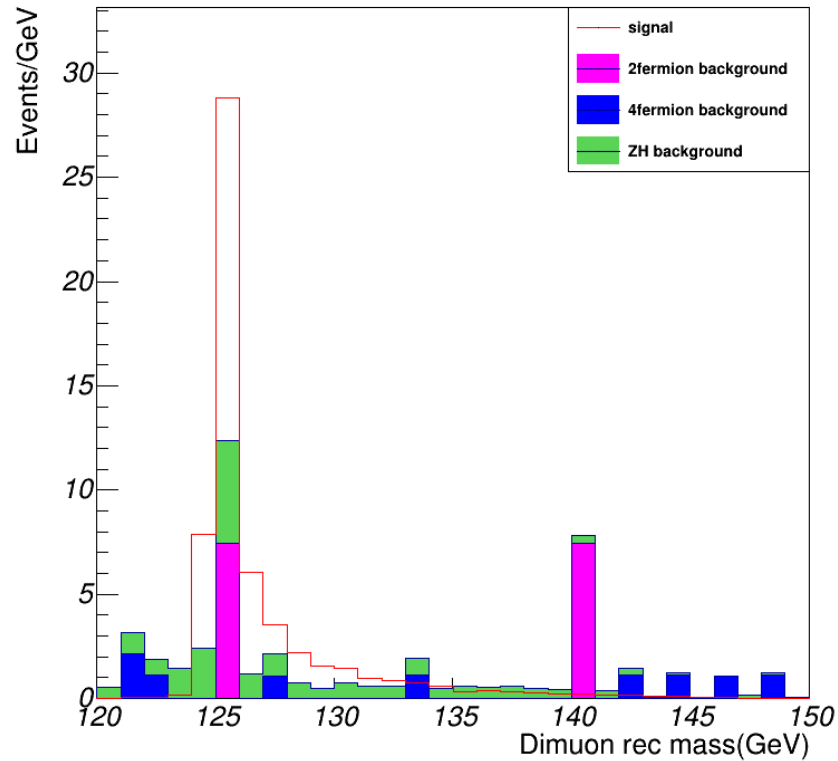
Cut	Signal	ZH background	2f background	4f background
Expected	1000	1140511	801811977	107203890
<i>Pre – selection</i>	616	30524	481301	515955
<i>Signal or not</i>	211	30307	481301	515955
$M_{\text{missing}} > M_{\text{dijet}}$	103	28701	366125	487117
$M_{\text{dimuon}}$	92	22495	215657	239256
$M_{\text{dimuon}}^{\text{rec}}$	92	22401	17380	20630
$N(\text{pfo})$	89	16776	321	16319
$P_{t\text{visible}}$	74	4345	59	1273
$\text{Angle}_{\text{min}}$	71	4186	59	1216
$M_{\text{missing}}$ and $M_{\text{dijet}}$	47	866	0	276
<i>Single Jet</i>	42	716	0	260

BDT

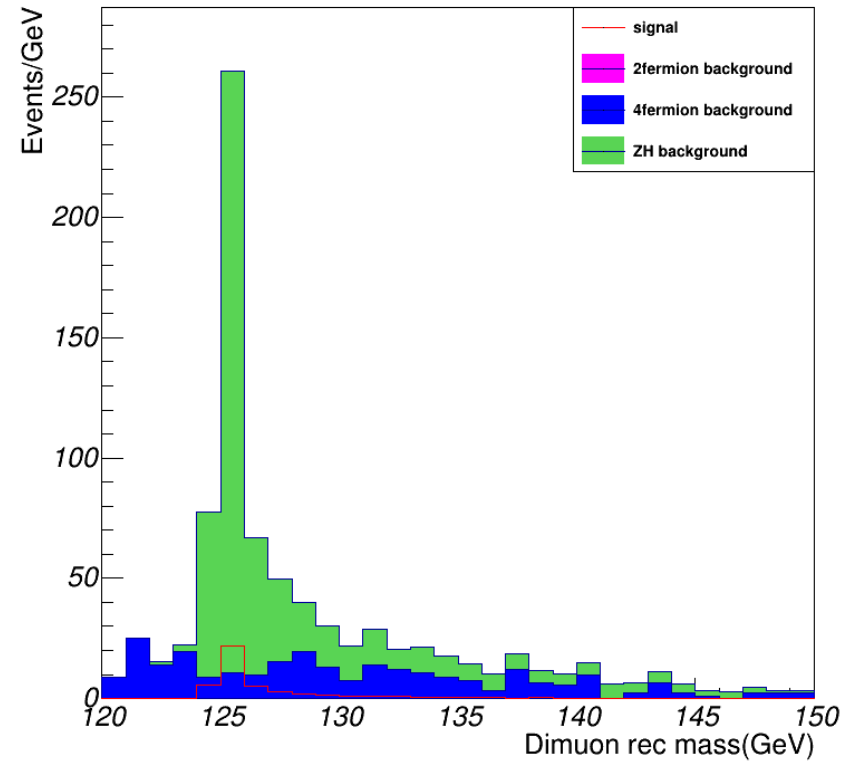
Cut	Signal	ZH background	2f background	4f background
<i>Expected</i>	1000	1140511	801811977	107203890
<i>Pre – selection</i>	616	30494	480828	515426
<i>Signal or not</i>	211	30282	480828	515426
$M_{\text{missing}} > M_{\text{dijet}}$	103	28674	365766	486615
$M_{\text{dimuon}}$	92	22473	215445	239023
$M_{\text{dimuon}}^{\text{rec}}$	92	22379	17363	20611
$N(\text{pfo})$	89	16760	321	16304
$P_{t\text{visible}}$	74	4341	59	1273
<i>BDT score</i>	45	573	0	260

# Higgs mass ( $\mu\mu$ recoil mass)

## ➤ BDT results



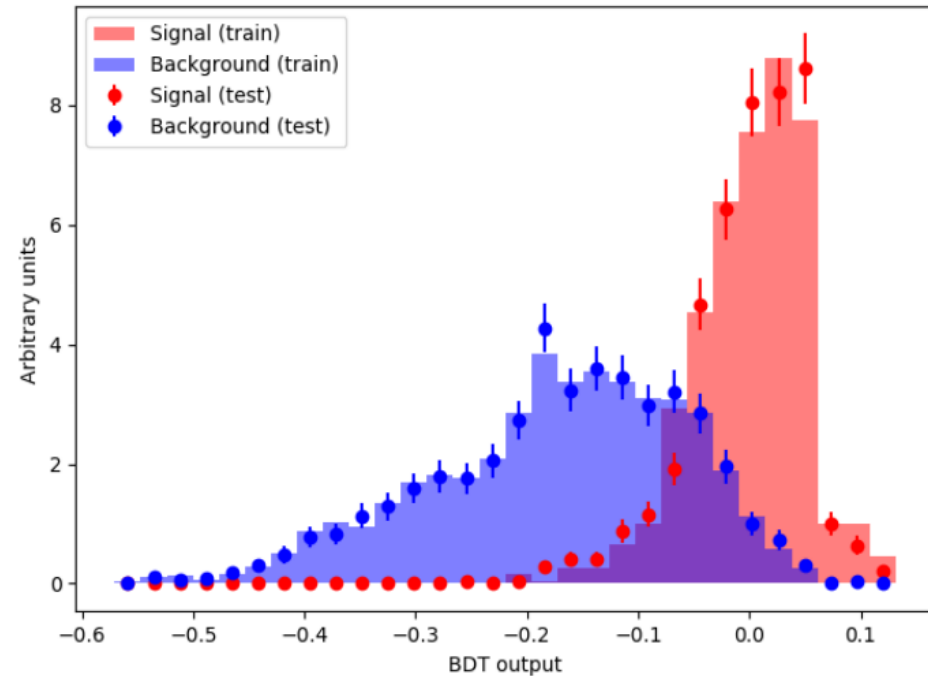
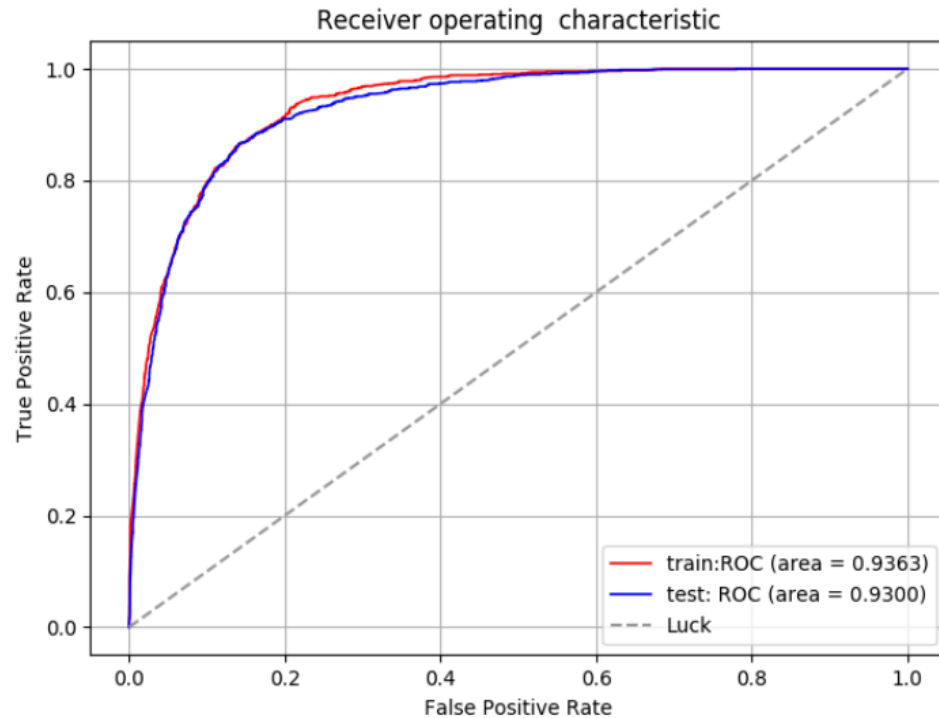
$\nu\nu jj$



$jj\nu\nu$

# BDT study on $\nu\text{HZZ}$

- 3 Pre-BDT cuts
- Without  $\text{iggs}$  mass in training





# BDT study on $\nu\text{HZZ}$

## Cut-based

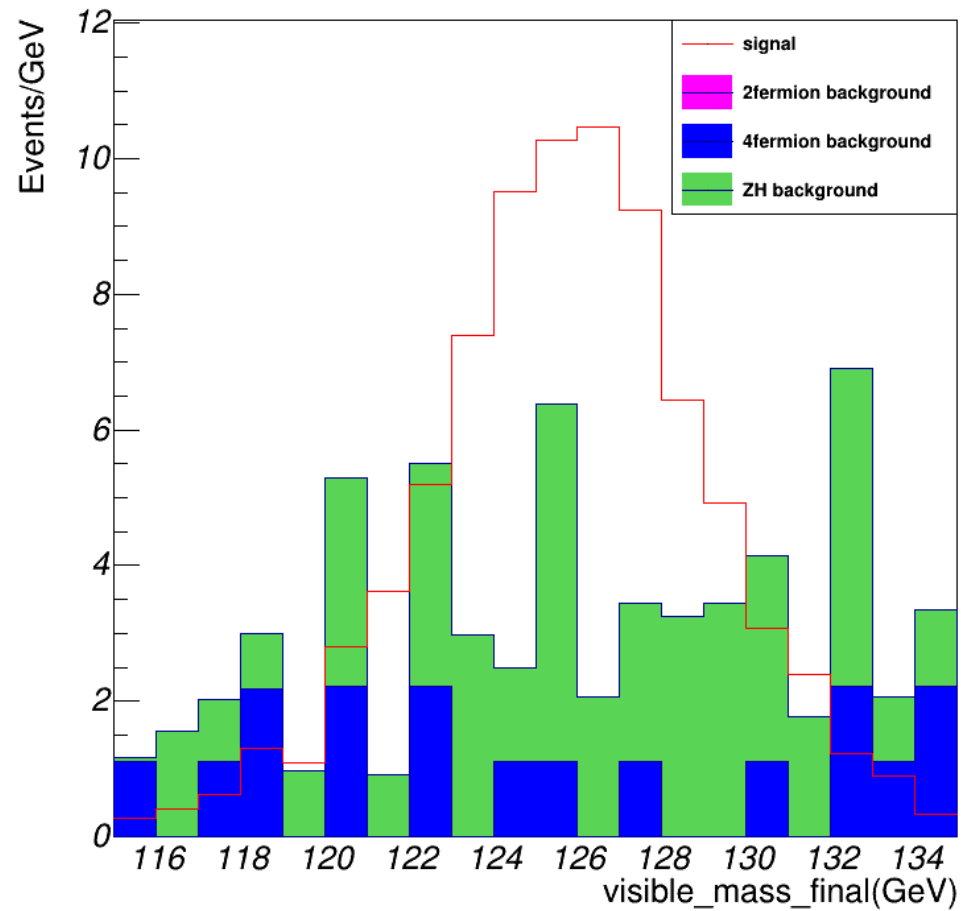
Cut	Signal	ZH background	2f background	4f background
Raw events	6844	1140511	801811977	107203890
<i>Pre – selection</i>	238	30494	480828	515425
<i>Signal or not</i>	226	30268	480828	515425
<i>N(pfo)</i>	198	10580	61902	268709
$115\text{GeV} < M_{\text{visible}} < 135\text{GeV}$	175	450	9694	6533
$ \cos\theta  < 0.9$	126	328	132	414
$130\text{GeV} < M_{\text{dimuon}}^{\text{rec}} < 220\text{GeV}$	123	285	125	366
$43\text{GeV} < P_{\text{visible}} < 60\text{GeV}$	109	157	6	105
$10\text{GeV} < M_{\text{dijet}} < 100\text{GeV}$	106	150	6	100
$E_{\text{leading jet}}$	99	122	0	54
$E_{\text{subleading jet}}$	97	116	0	46
$\text{Angle}_{\mu j}$	92	103	0	34
$13\text{GeV} < M_{\text{dimuon}} < 100\text{GeV}$	92	100	0	33
$\cos \theta_{\text{visible}}$	92	100	0	33
$80\text{GeV} < M_{\text{visible}}^{\text{rec}} < 107\text{GeV}$	87	89	0	30
<i>not</i> $120\text{GeV} < M_{\text{dimuon}}^{\text{rec}} < 130\text{GeV}$	75	65	0	30
<i>not</i> $120\text{GeV} < M_{\text{dijet}}^{\text{rec}} < 130\text{GeV}$	71	46	0	26

## BDT

Cut	Signal	ZH background	2f background	4f background
<i>Expected</i>	6844	1140511	801811977	107203890
<i>Pre – selection</i>	238	30494	480828	515426
<i>Signal or not</i>	226	30268	480828	515426
<i>N(pfo)</i>	226	29861	152634	444220
$M_{\text{visible}}$	201	710	15429	10306
$\cos \theta$	144	510	367	831
<i>BDT score</i>	81	43	0	18

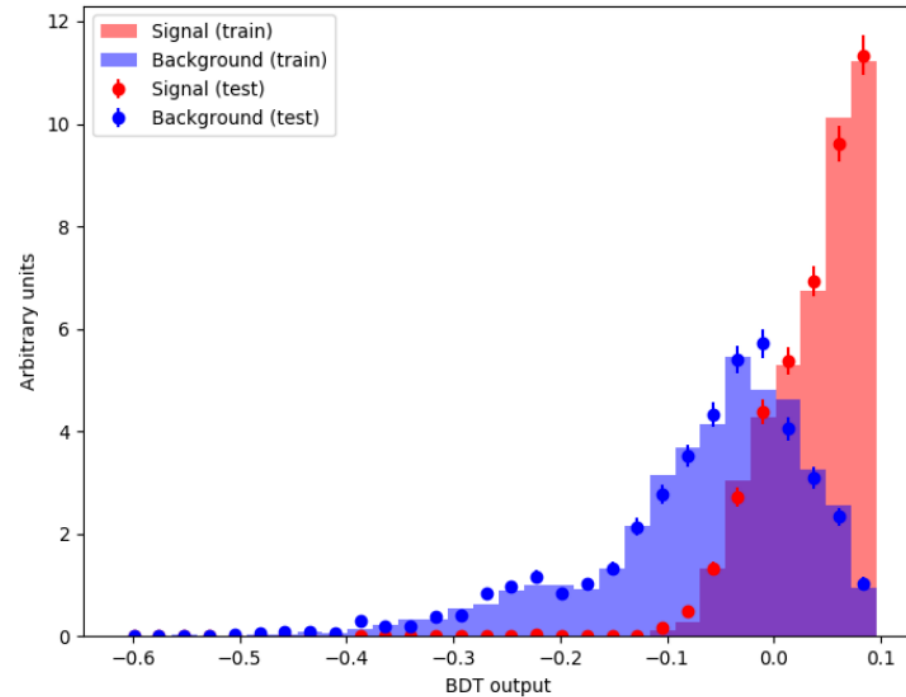
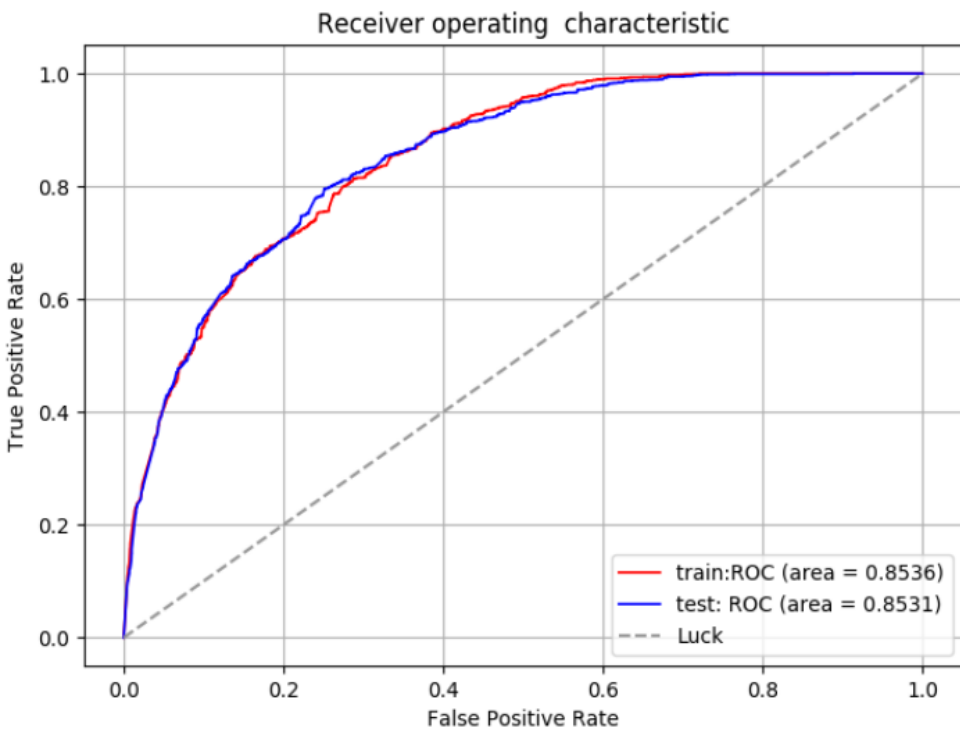
# Higgs mass (visible mass)

## ➤ BDT results



# BDT study on $qqHZZ (\nu\nu\mu\mu)$

- 5 Pre-BDT cuts
- Without higgs mass in training



# BDT study on $qqHZZ$ ( $\nu\nu\mu\mu$ )

## Cut-based

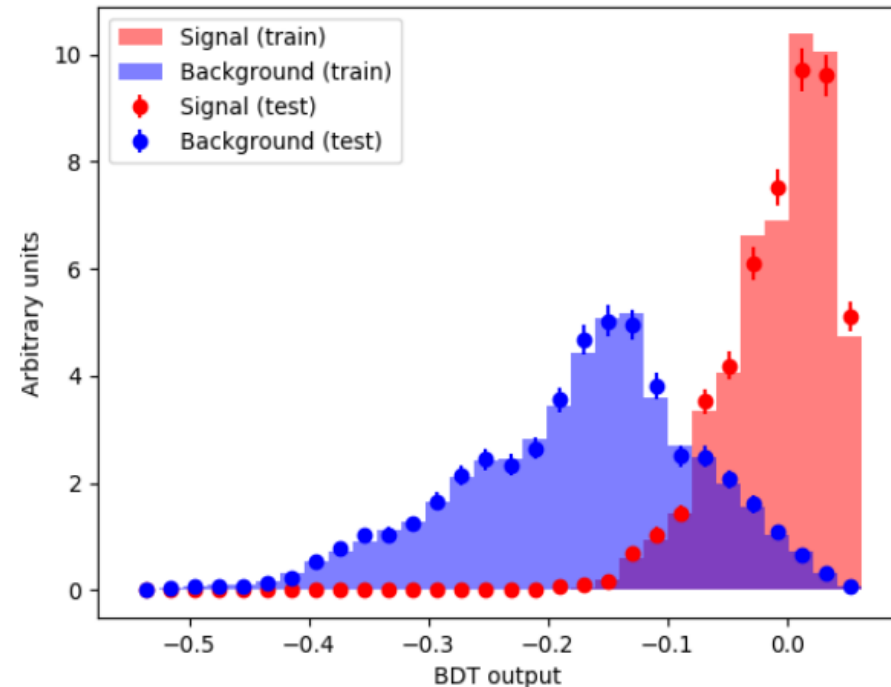
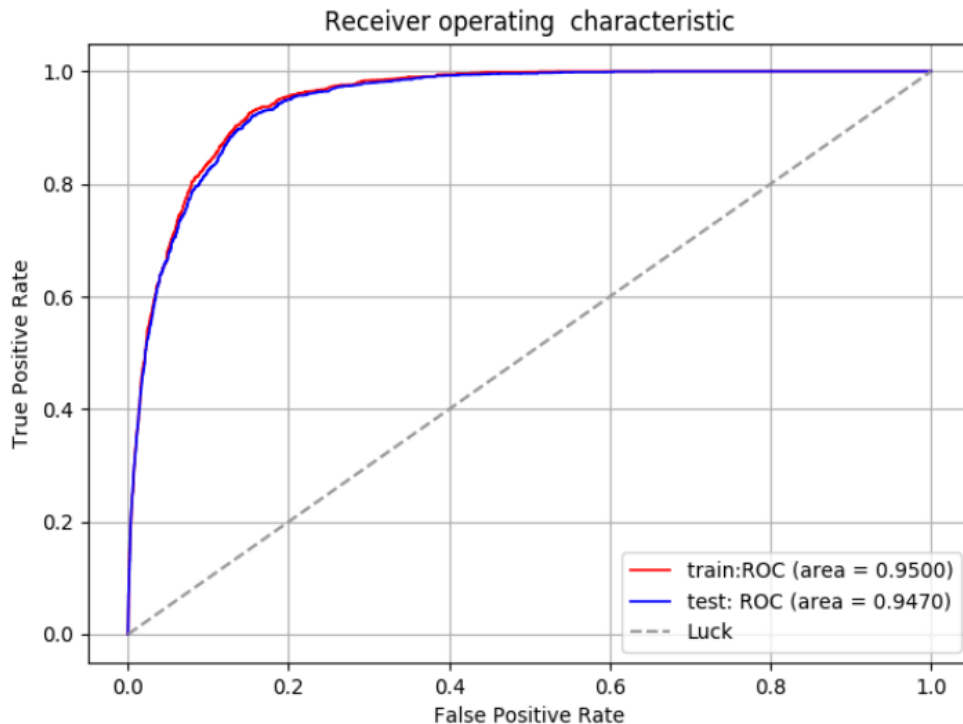
cut	signal	zh background	2f background	4f background
Raw events	20254	1140511	801811977	107203890
<i>Pre – selection</i>	826	30494	480828	515425
<i>Signal or not</i>	203	30271	480828	515425
$M_{missing} > M_{dimuon}$	94	3167	18606	40769
$N(pfo)$	91	2502	2050	15114
$M_{visible}$	90	2220	557	6573
$\cos \theta$	72	1797	59	2156
$M_{dimuon}^{rec}$	70	1506	14	1942
$P_{visible}$	69	1459	14	1843
$M_{dijet}$	67	1207	0	1526
$E_{leading}$	67	1191	0	1203
$E_{subleading}$	67	1186	0	1119
$Angle_{\mu j}$	67	1165	0	1003
$M_{dimuon}$	67	1105	0	970
$\cos \theta_{visible}$	64	1048	0	850
$M_{visible}^{rec}$	64	973	0	817
$P_{t_{visible}}$	63	962	0	775
<i>not <math>\mu^+\mu^-HZZ</math></i>	63	962	0	775
<i>not <math>\nu\nu HZZ</math></i>	56	884	0	744

## BDT

Cut	Signal	ZH background	2f background	4f background
<i>Expected</i>	20254	1140511	801811977	107203890
<i>Pre – selection</i>	826	30494	480828	515426
<i>Signal or not</i>	203	30291	480828	515426
$M_{missing} > M_{dimuon}$	94	3179	18606	40770
$N(pfo)$	91	2502	2050	15115
$M_{dijet}$	85	1793	14	6178
$\cos \theta$	67	1439	0	2175
$M_{visible}$	67	1345	0	1476
<i>BDT score</i>	46	358	0	226

# BDT study on $qqHZZ (\mu\mu\nu)$

- 5 Pre-BDT cuts
- Without higgs mass in training
- Imbalanced learn



# BDT study on qqHZZ

## Cut-based

cut	signal	zh background	2f background	4f background
Expected	20254	1140511	801811977	107203890
<i>Pre – selection</i>	826	30494	480828	515425
<i>Signal or not</i>	203	30271	480828	515425
$M_{dimuon} > M_{missing}$	108	27103	462222	474656
$N(pfo)$	106	21479	27891	332167
$M_{visible}$	102	5496	2277	46449
$\cos\theta$	82	4051	0	13096
$M_{dimuon}^{rec}$	77	3492	0	2617
$P_{visible}$	77	3461	0	2507
$M_{dijet}$	75	2795	0	1841
$E_{leading\ jet}$	74	2584	0	1466
$E_{subleading\ jet}$	73	2544	0	1397
$Angle_{\mu j}$	68	2157	0	963
$M_{dimuon}$	66	1832	0	772
$\cos\theta_{visible}$	64	1734	0	570
$M_{visible}^{rec}$	50	844	0	395
$P_{tvisible}$	49	822	0	369
<i>not <math>\mu^+\mu^-HZZ</math></i>	44	335	0	324
<i>not <math>\nu\nu HZZ</math></i>	44	335	0	324

## BDT

Cut	Signal	ZH background	2f background	4f background
<i>Expected</i>	20254	1140511	801811977	107203890
<i>Pre – selection</i>	826	30494	480828	515426
<i>Signal or not</i>	203	30291	480828	515426
$M_{missing} > M_{dimuon}$	108	27112	462222	474656
$N(pfo)$	106	21480	27891	332167
$M_{dijet}$	103	4833	141	265478
$\cos\theta$	80	3576	7	156098
$M_{visible}$	77	2913	0	8750
<i>BDT score</i>	38	166	0	140

# Higgs mass ( $\mu\mu$ recoil mass)

## ➤ BDT results

