

CEPC HZZ Project

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Current Status

- **Submitted Merge Request of nnHZZ channel**
- **BDT study using Dalitz Variables**

Object selection Final Version

$\frac{E(\text{cone})}{E(\text{track})}$	0.1
<i>Lepton Emin /Gev</i>	3
<i>Lepton Emax /Gev</i>	<i>none</i>
<i>Isolation Minimum Track Energy/Gev</i>	3
<i>Use PID</i>	<i>true</i>
<i>Minimum Jet Energy/Gev</i>	1
<i>Total Npfo of two jets</i>	5

- **Already Produced Ntuples with this criteria, able for all the three channels**

mumuHZZ Comparison (vvjj)

Using
Before-merge
Code

cut	llhzz	zh	2f	4f
Raw events	1000	1141631	802599471	107309180
Pre-selection	616	30524	481301	515955
Signal or not	211	30307	481301	515955
missing mass > dijet	107	1605	115175	28838
M(dimuon)	95	726	73813	6836
RecM(dimuon)	95	707	7894	1360
N(pfo)	94	336	3271	574
Pt(total visible)	89	312	342	168
Min angle	85	298	283	139
Missing Mass & M(dijets)	62	80	254	46
Single jet	54	67	0	9
N(lepton)	54	67	0	9

Using
Merged Code

cut	llhzz	zh	2f	4f
Raw events	1000	1140511	801811977	107203890
Pre-selection	616	30494	480828	515450
Signal or not	211	30282	480828	515450
missing mass > dijet	107	1608	115062	28809
M(dimuon)	95	725	73741	6830
RecM(dimuon)	95	706	7886	1359
N(pfo)	94	336	3268	574
Pt(total visible)	89	312	342	168
Min angle	85	298	283	139
Missing Mass & M(dijets)	62	80	253	46
Single jet	54	67	0	9
N(lepton)	54	67	0	9

mumuHZZ Comparison(jjvv)

Using
Before-merge
Code

cut	llhzz	zh	2f	4f
Raw events	1000	1141631	802599471	107309180
Pre-selection	616	30524	481301	515955
Signal or not	211	30307	481301	515955
missing mass > dijet	103	28701	366125	487117
M(dimuon)	92	22495	215657	239256
RecM(dimuon)	92	22401	17380	20630
N(pfo)	89	16776	321	16319
Pt(total visible)	74	4345	59	1273
Min angle	71	4186	59	1216
Missing Mass & M(dijets)	47	866	0	276
Single jet	42	716	0	260
N(lepton)	42	716	0	260

Using
Merged Code

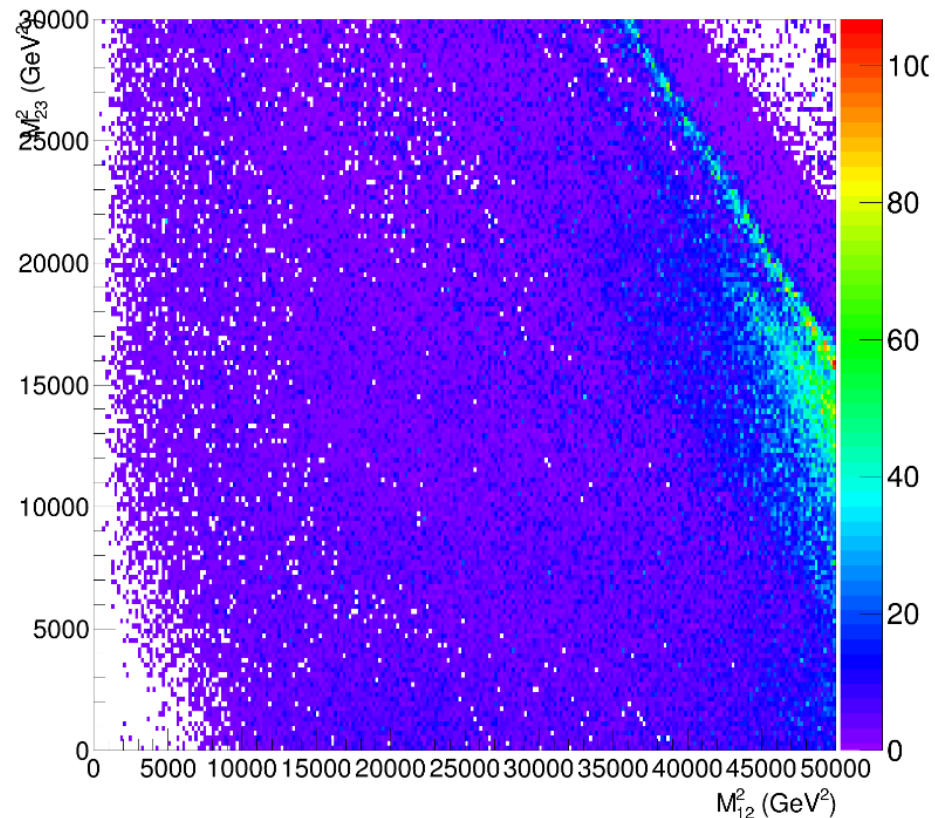
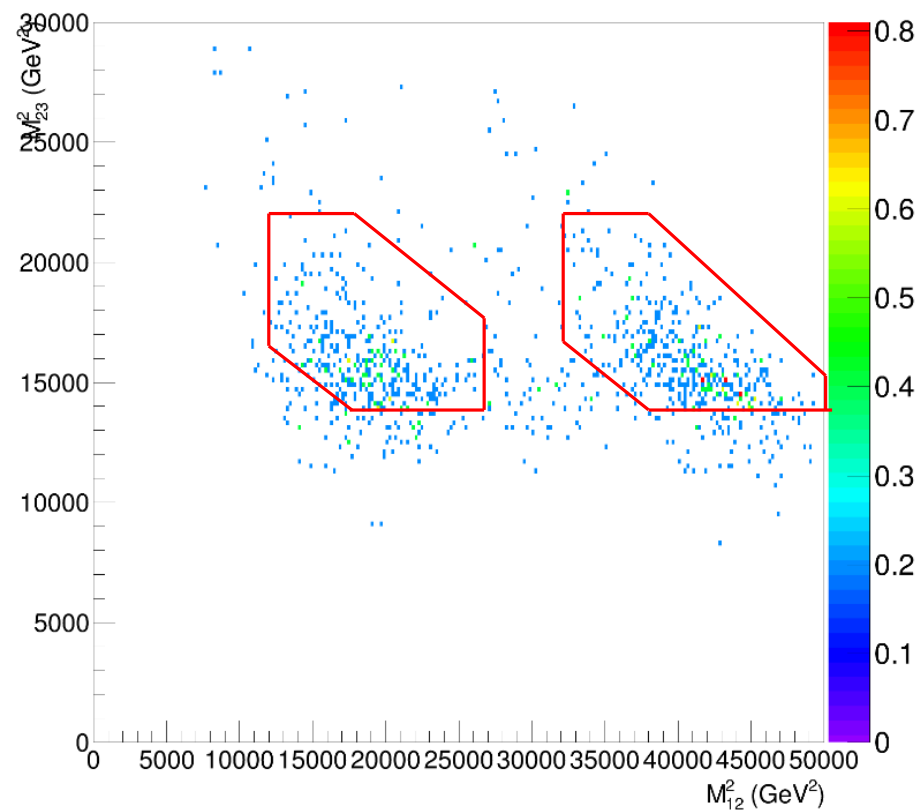
cut	llhzz	zh	2f	4f
Raw events	1000	1140511	801811977	107203890
Pre-selection	616	30494	480828	515450
Signal or not	211	30282	480828	515450
missing mass > dijet	103	28674	365766	486640
M(dimuon)	92	22473	215445	239022
RecM(dimuon)	92	22379	17363	20610
N(pfo)	89	16760	321	16303
Pt(total visible)	74	4341	59	1272
Min angle	71	4181	59	1214
Missing Mass & M(dijets)	47	866	0	276
Single jet	42	716	0	260
N(lepton)	42	716	0	260

Dalitz Plot Preliminary Study (qqHZZ*)

➤ Apply simple 2D cut

➤ X axis: $M_{Di-jet + Di-muon}^2$

➤ Y axis: $M_{Di-muon+Missing}^2$

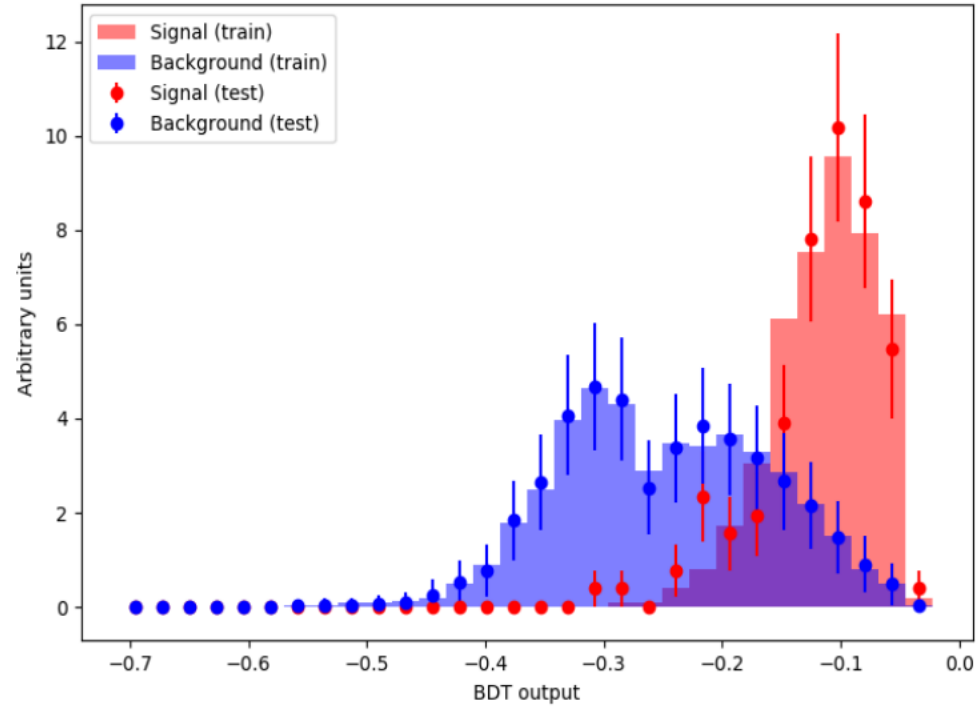
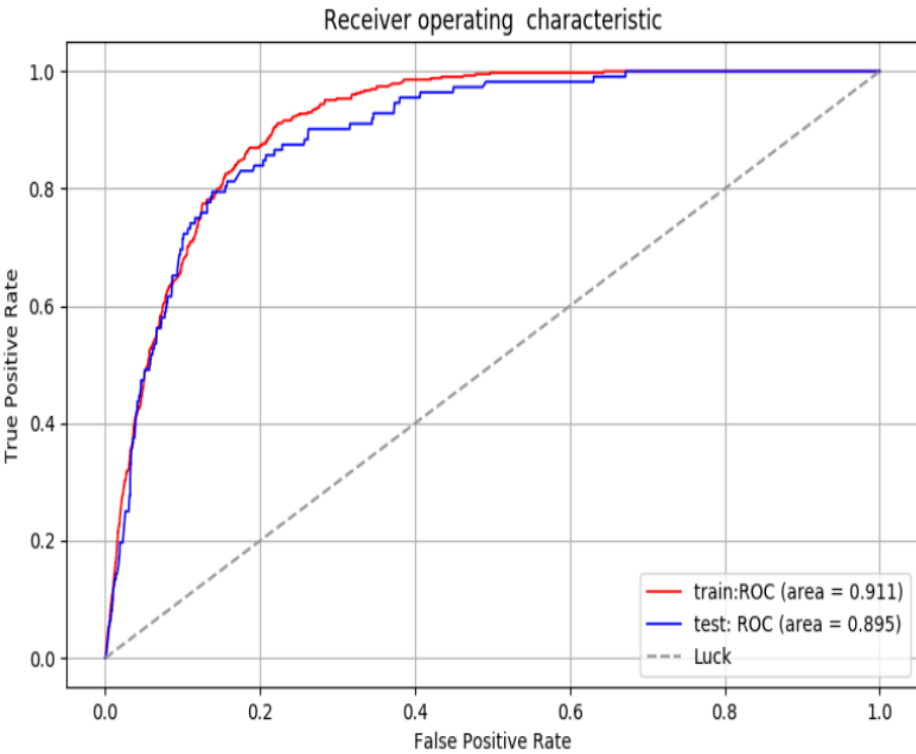


Dalitz Plot Preliminary Study (qqHZZ*)

➤ Applied simple 2D cut

cut	qqhzz	zh	2f	4f
Raw events	20254	1140511	801811977	107203890
pre-selection	826	30494	480828	515425
2m+2j	203	30271	480828	515425
Npfo	180	18036	14766	298938
Vis_mass	149	4638	3836	30476
cos_theta	120	3594	0	7271
RecM(dimuon)	102	2559	0	2530
vis_all_p	96	2244	0	1897
M(dijet)	88	1587	0	1028
jet_lead_e	85	1467	0	733
jet_sub_e	84	1435	0	628
angle_mj	78	1240	0	475
M(dimuon)	74	1045	0	369
vis_all_cos	71	994	0	289
RecM(vis_all)	62	657	0	249
vis_all_pt	61	651	0	242
not mmhzz	60	418	0	227
not nnhzz	57	406	0	224
Dalitz Cut	52	259	0	120

BDT Study Using Dalitz Variables (qqHZZ*)



BDT Study Using Dalitz Variables (qqHZZ*)

<i>Feature</i>	<i>Importance</i>
<i>Di – muon Recoil Mass</i>	0.218
<i>Di – jet Mass</i>	0.050
<i>Leading Jet Energy</i>	0.035
<i>Di – Muon Mass</i>	0.070
<i>Missing Mass</i>	0.142
<i>Dalitz Mzz</i>	0.139
<i>Dalitz Mzz *</i>	0.347

BDT Study Using Dalitz Variables (qqHZZ*)

Add A Simple cut
after all the cuts

cut	qqhzz	zh	2f	4f
Raw events	20254	1140511	801811977	107203890
pre-selection	826	30494	480828	515425
2m+2j	203	30271	480828	515425
Npfo	180	18036	14766	298938
Vis_mass	149	4638	3836	30476
cos_theta	120	3594	0	7271
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Dalitz Cut	52	259	0	120

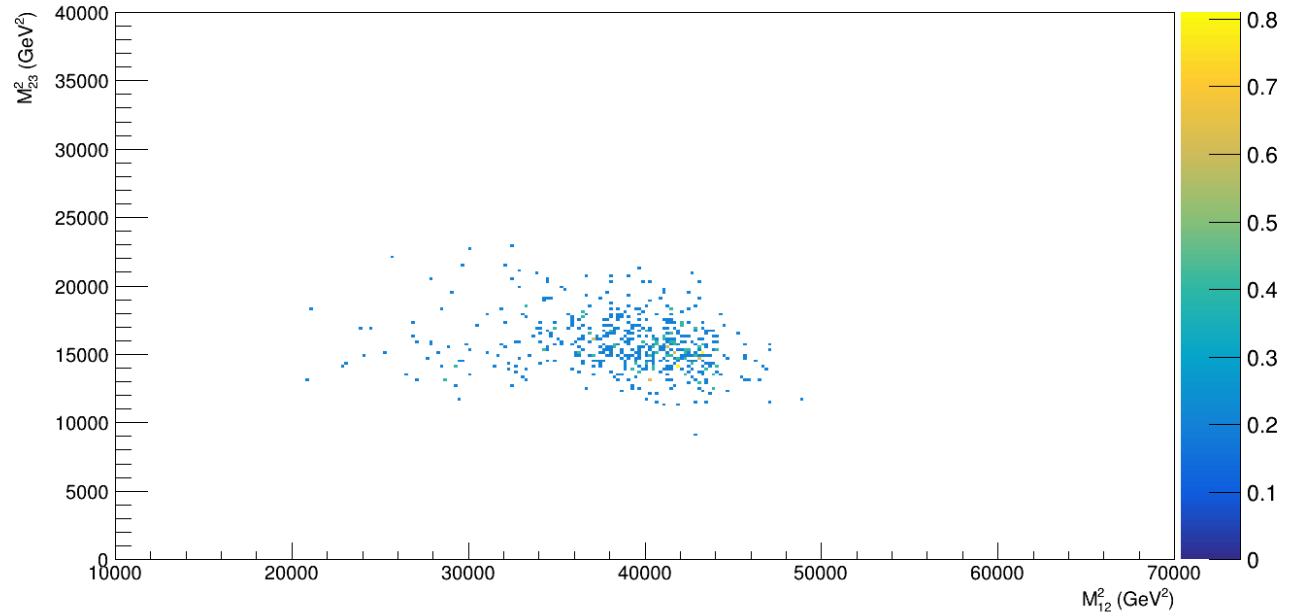
BDT Results

cut	qqhzz	zh	2f	4f
Expected	20254	1140511	801811977	107203890
Pre-selection	826	30494	480828	515426
Is signal	203	30291	480828	515426
38 < Npfo < 90	180	18036	14766	298938
80 < Dijet Mass < 110	161	5452	29	225456
Cos theta < 0.95	130	4238	7	137929
Visible Mass~[115,154]&[164,210]	109	2441	0	2618
BDT Score > -0.016	47	237	0	155

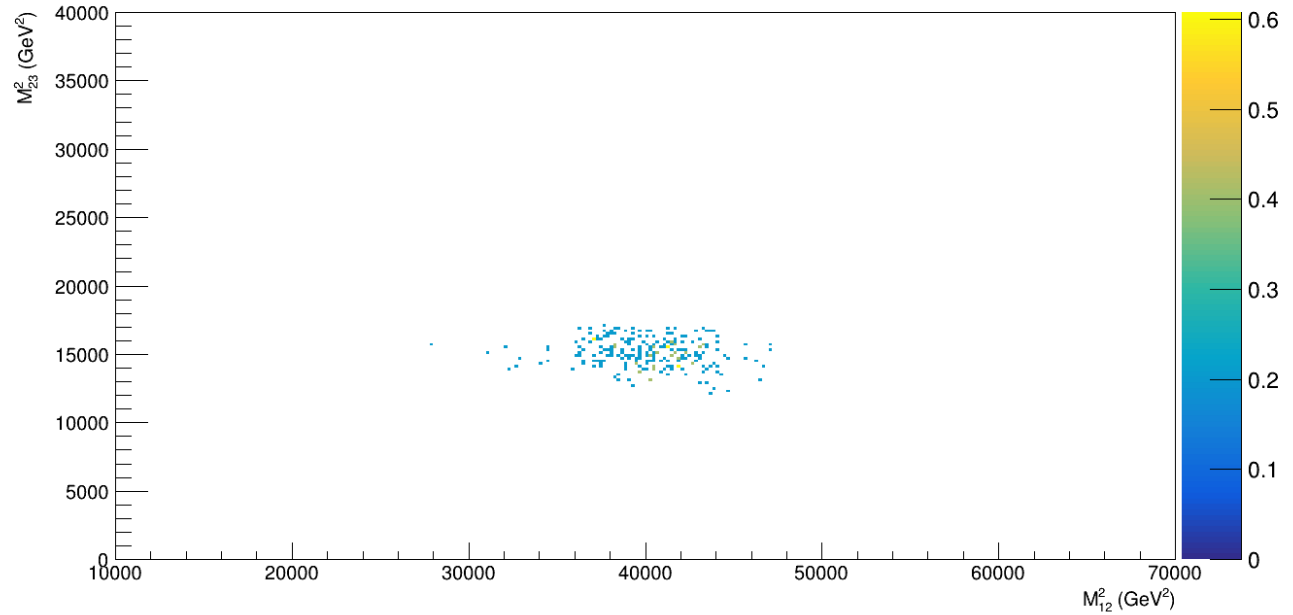
BDT Study Using Dalitz Variables ($qqHZZ^*$)

➤ Signal Dalitz Plot

Before BDT



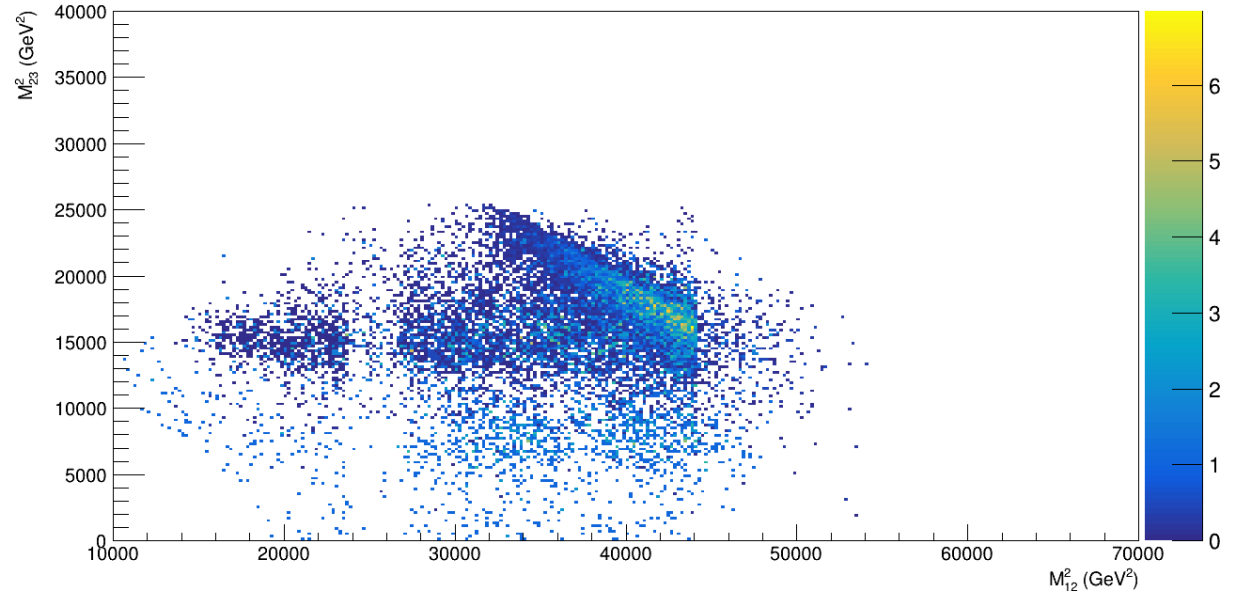
After BDT



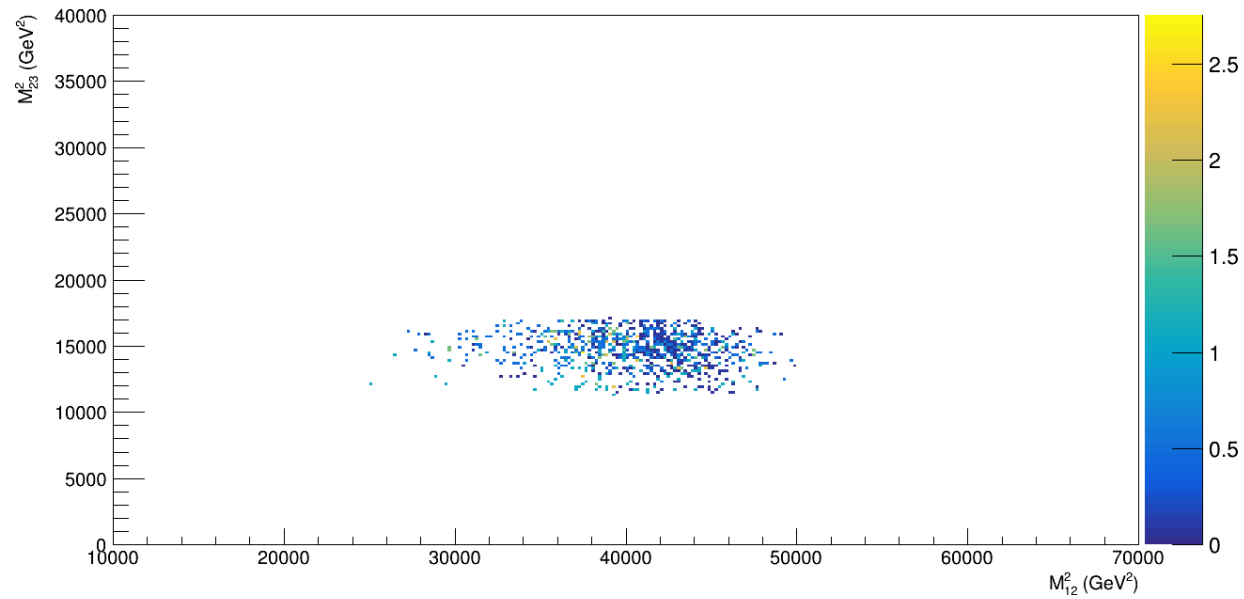
BDT Study Using Dalitz Variables ($qqHZZ^*$)

➤ Background Dalitz Plot

Before BDT



After BDT



Next to do

- **Solve Conflicts**
- **Merge qqHZZ channel into the framework**
- **Put BDT codes on github**
- **Further study on Dalitz plot**