CEPC HZZ Project

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Current Status and Results

Finished

- **Reproduced** $Z(\mu^+\mu^-)H(Z \to \nu\nu, Z^* \to jj)/Z(\mu^+\mu^-)H(Z \to jj, Z^* \to \nu\nu)$ **channel using Ryuta's framework (cut-based)**

  mmHZZ

- **Implemented** $Z(\nu\nu)H(Z \to \mu^+\mu^-, Z^* \to jj)/Z(\nu\nu)H(Z \to jj, Z^*\mu^+\mu^-)$ **channel (Alex's) (cut-based optimized by BDT results)**

  vvHZZ

- **Studied** $Z(jj)H(Z \to \mu^+\mu^-, Z^* \to \nu\nu)/Z(jj)H(Z \to \nu\nu, Z^*\mu^+\mu^-)$ **channel (cut−based)**

  qqHZZ

Ongoing

- **Updating current results using one certain object selection criteria**
- **Merging the two/three channels into one framework**
- **Fitting for Higgs width**

Results for Reference ($Z(\mu^+\mu^-)H(Z \to \nu\nu, Z^* \to jj)$)

➢ Cutflow

cut	llhzz	zh	2f	4f
Raw events	1000	12557950	8828594187	1180400980
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

Lingteng's (right normalization)

Background	Number of events
$nnHZZ$	~ 55
$\mu^+\mu^-HWW$	~ 10

Results for Reference ($Z(\mu^+\mu^-)H(Z \to jj, Z^* \to \nu\nu)$)

➢ Cutflow

cut	llhzz	zh	2f	4f
Raw events	1000	12557950	8828594187	1180400980
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

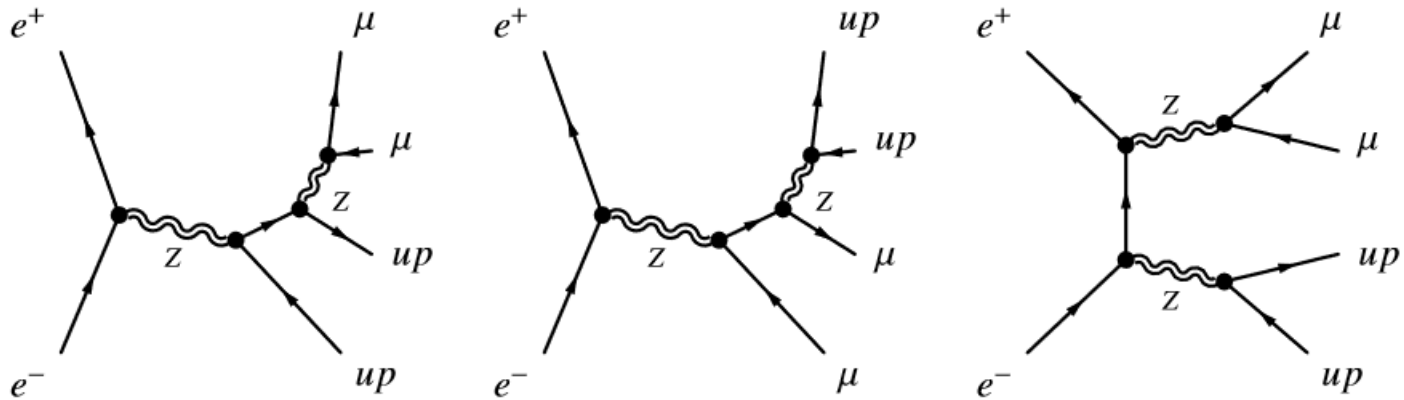
Background	Number of events
$\mu^+\mu^- Hbb\ (ZH)$	~440
$\mu^+\mu^- HWW\ (ZH)$	~200
$zz_sl0mu_up\ (4\ fermion)$	~60
$zz_sl0mu_down\ (4\ fermion)$	~200

Lingteng's (right normalization)

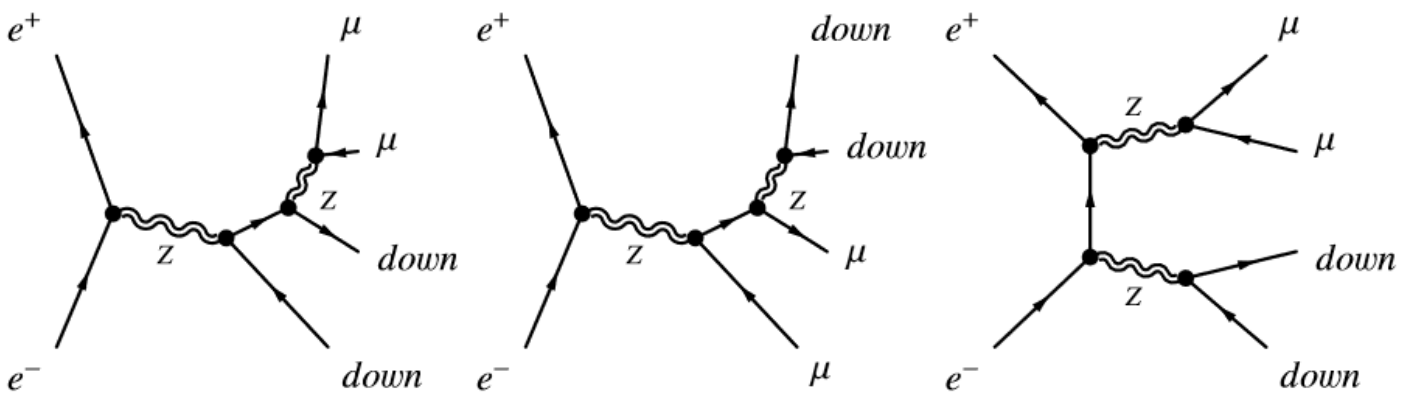
Results for Reference ($Z(\mu^+\mu^-)H(Z \to jj, Z^* \to \nu\nu)$)

➢ Feynman Diagrams

zz_sl0mu_up

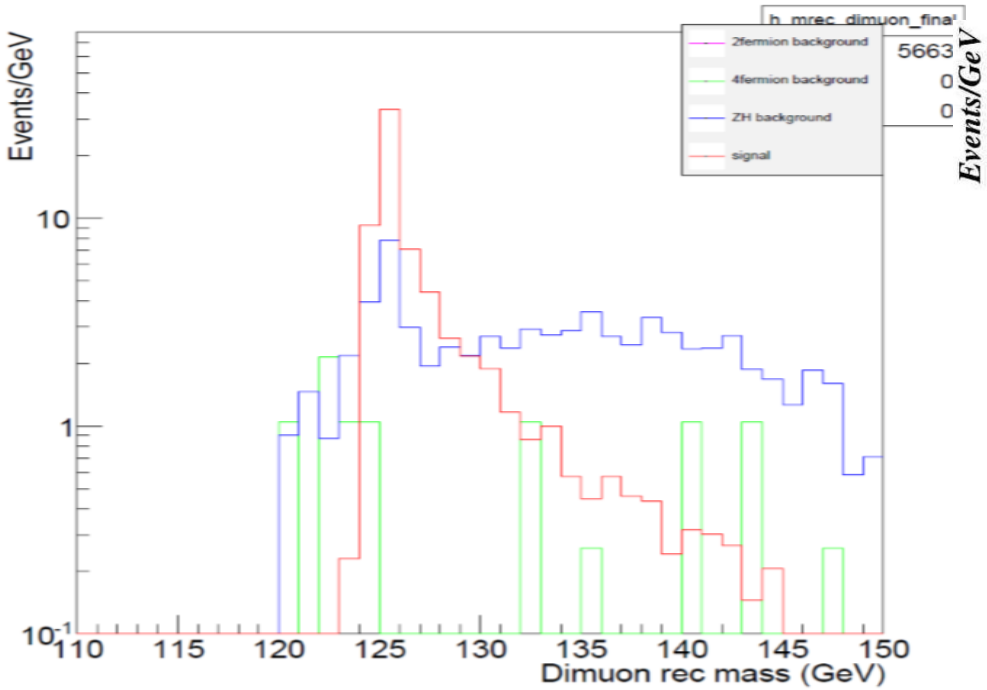


zz_sl0mu_down

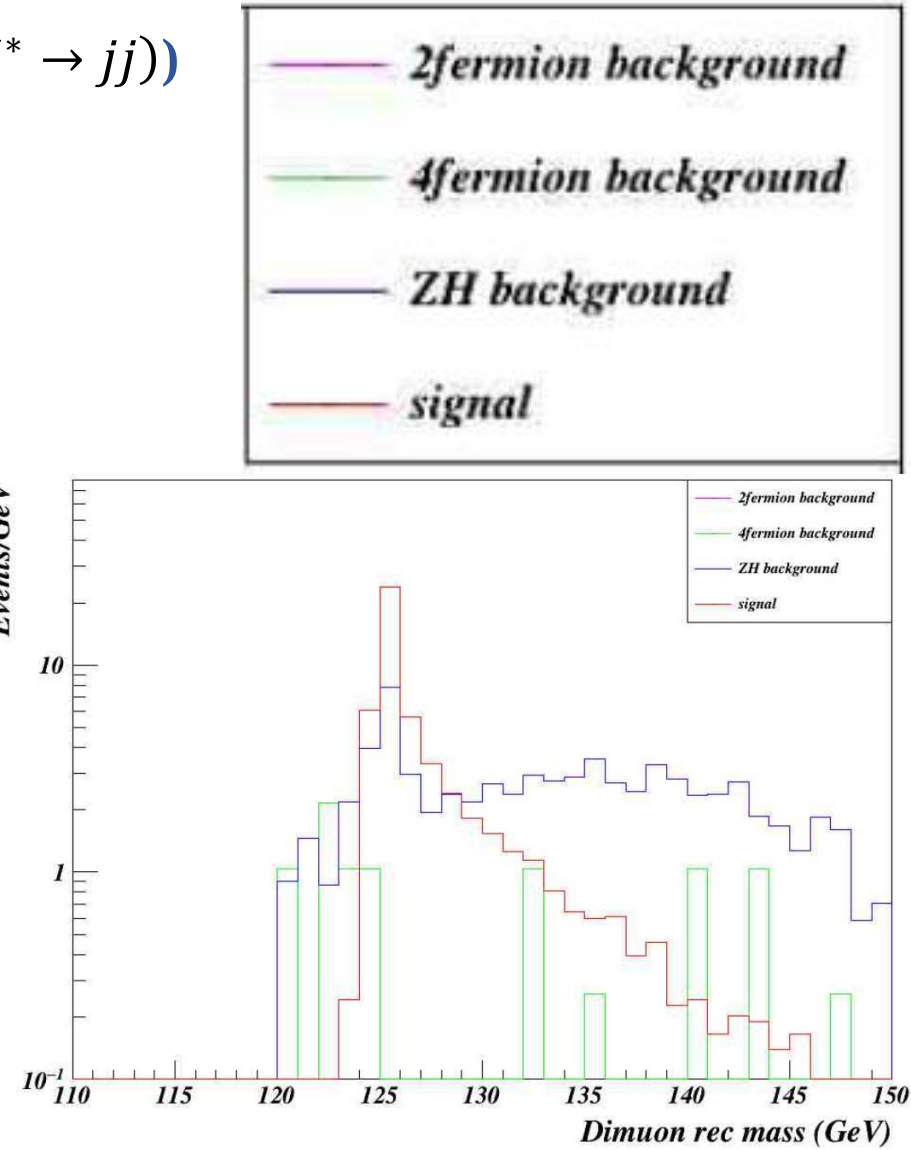


Results for reference $(Z(\mu^+\mu^-)H(Z \to \nu\nu, Z^* \to jj))$

- **Higgs mass distribution (after all the selections)**



Lingteng's



Reproducted

Results ($qqHZZ$)

- $mmvv + vvmm$

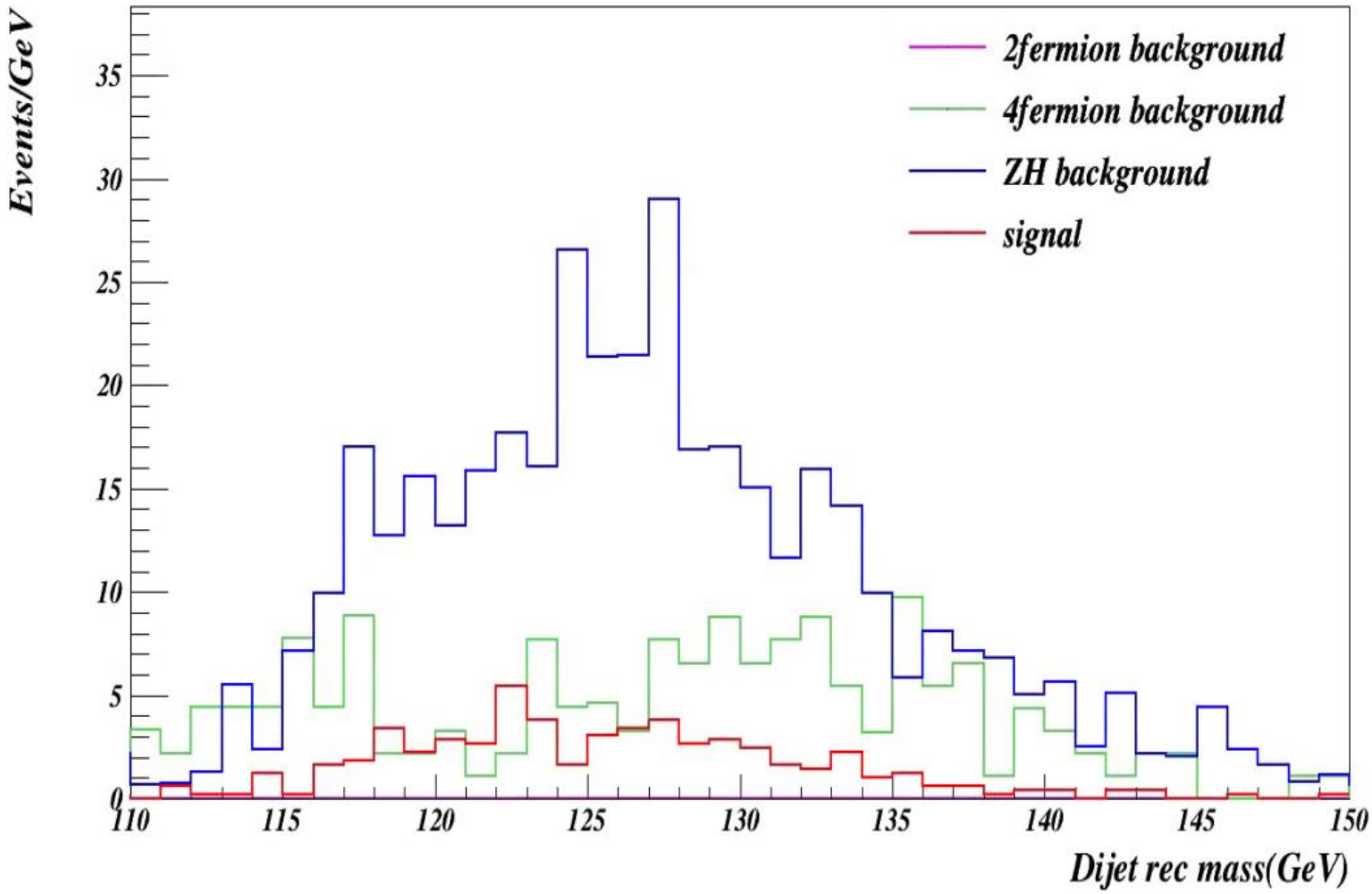
cut	qqhzz	zh	2f	4f
Expected	20254	1140511	801811977	107203890
pre-selection	826	30494	480828	515425
2m + 2v	203	30271	480828	515425
38 < Npfo < 90	180	18036	14766	298938
M(visible)~[115,154]&[164,210]	149	4638	3836	30476
-0.94 < cos_theta < 0.95	120	3594	0	7271
RecM(dimuon)~[117,154]&[185,211]	102	2559	0	2530
11 < vis_all_p < 60	96	2244	0	1897
79 < M(dijet) < 109	88	1587	0	1028
48 < E(leading_jet) < 80	85	1467	0	733
25 < E(subleading_jet) < 55	84	1435	0	628
91 < Angle(mj) < 170	78	1240	0	475
M(dimuon)~[13,46]&[77,94]	74	1045	0	369
-0.84 < vis_all_cos < 0.86	71	994	0	289
RecM(visible)~[15,45]&[51,101]	62	657	0	249
9 < Pt(visible) < 57	61	651	0	242
not mmhzz (M(dimuon)!~[124,128])	60	418	0	227
not nnhzz (M(visible)!~[123,128])	57	406	0	224

Dominant background: qqHww, qqHττ

Results ($qqHZZ$)

- $mmvv + vvmm$

Higgs mass Plot



Results ($qqHZZ$)

- $mmvv$ ($Z \to mm, Z^* \to vv$)

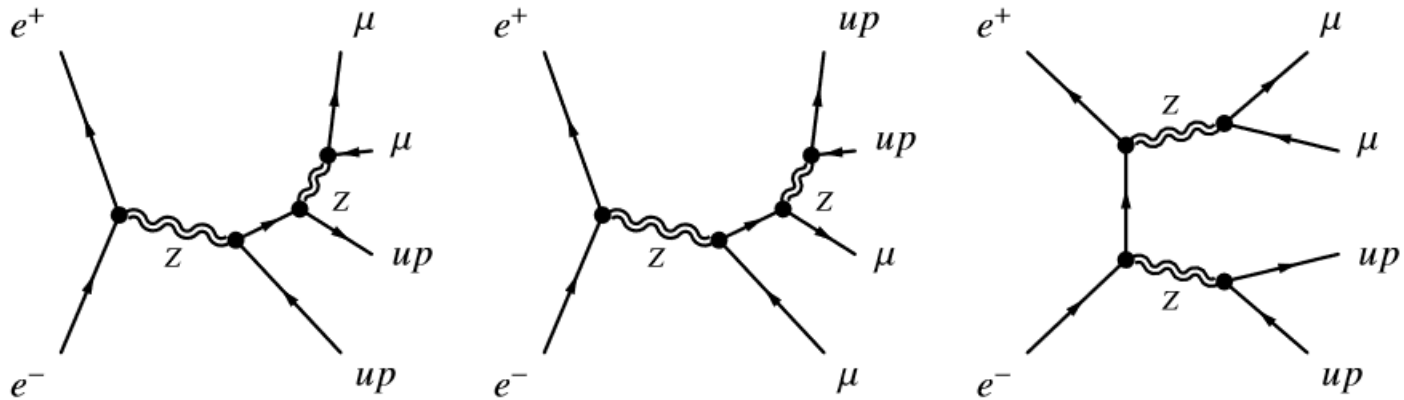
cut	qqhzz	zh	2f	4f
Raw events	20254	1140511	801811977	107203890
pre-selection	826	30494	480828	515425
2m+2v	203	30271	480828	515425
M(dimuon)>M(missing)	108	27103	462222	474656
Npfo	106	21479	27891	332167
Vis_mass	102	5496	2277	46449
cos_theta	82	4051	0	13096
RecM(dimuon)	77	3492	0	2617
vis_all_p	77	3461	0	2507
M(dijet)	75	2795	0	1841
jet_lead_e	74	2584	0	1466
jet_sub_e	73	2544	0	1397
angle_mj	68	2157	0	963
M(dimuon)	66	1832	0	772
vis_all_cos	64	1734	0	570
RecM(vis_all)	50	844	0	395
vis_all_pt	49	822	0	369
not mmhzz	44	335	0	324
not nnhzz	44	335	0	324

Background	Number of events
$\mu^+\mu^- Hbb\ (ZH)$	157
$\mu^+\mu^- HWW\ (ZH)$	73
$qqH\tau\tau\ (ZH)$	46
$qqHWW\ (ZH)$	34
$zz_sl0mu_up\ (4\ fermion)$	56
$zz_sl0mu_down\ (4\ fermion)$	211

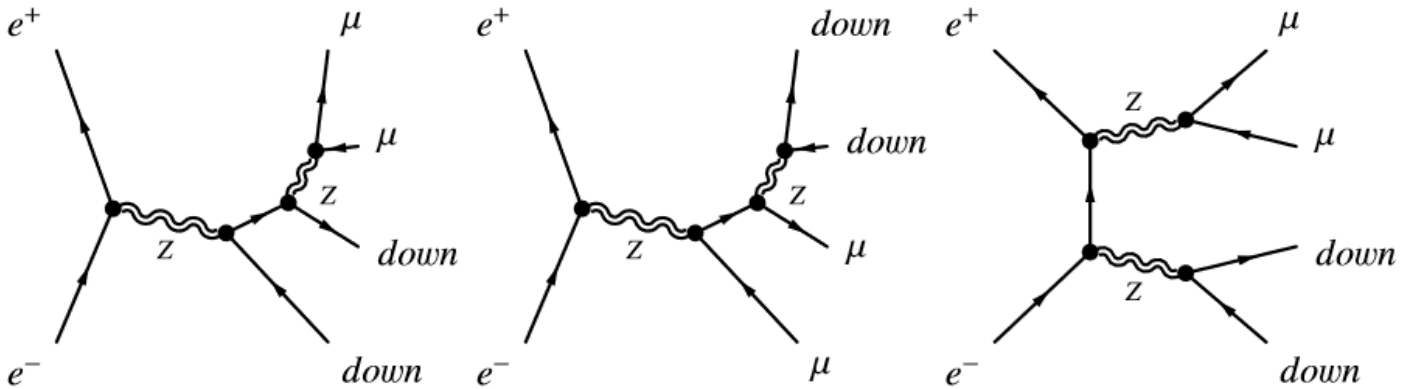
Results ($qqHZZ$)

➢ Feynman Diagrams

zz_sl0mu_up

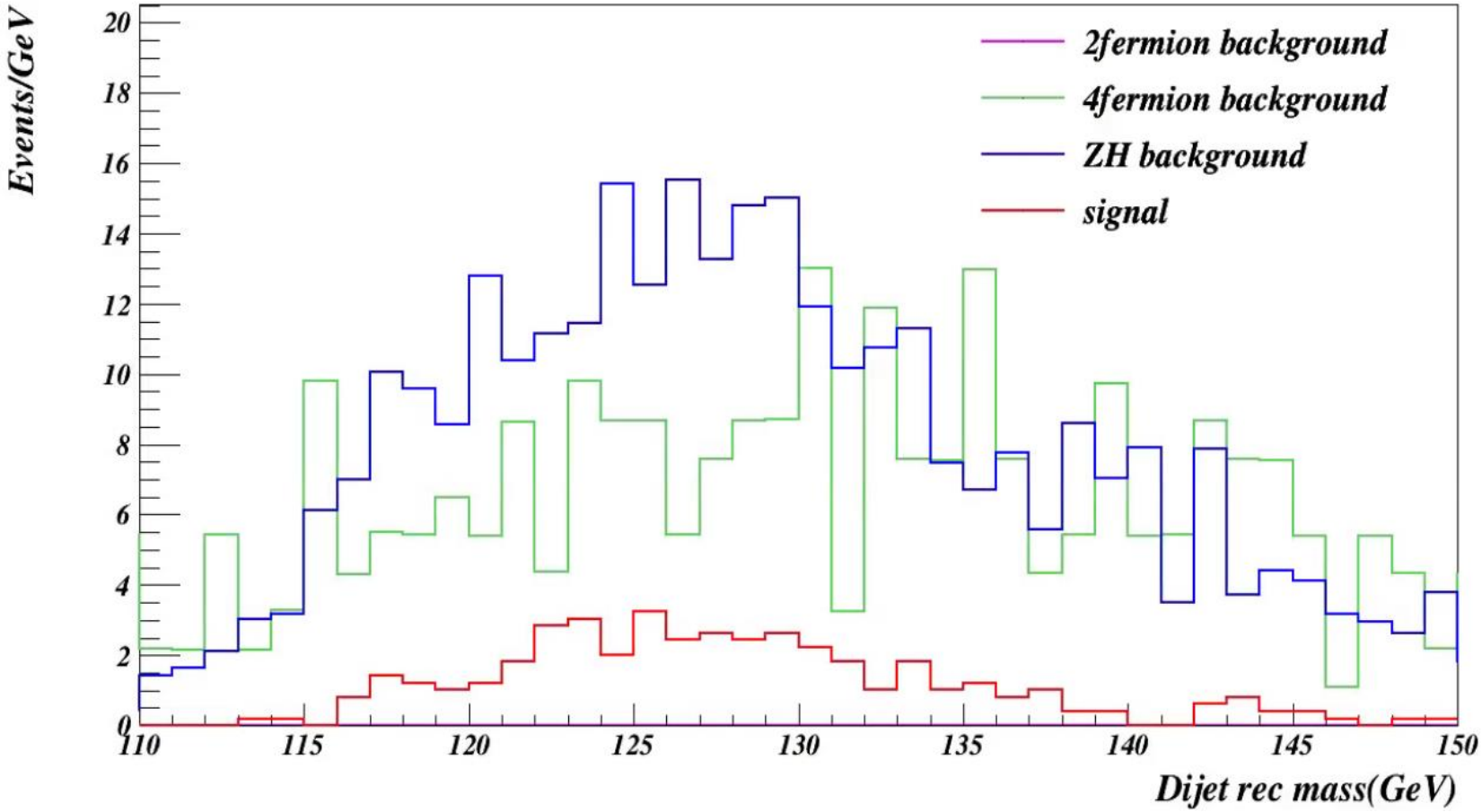


zz_sl0mu_down



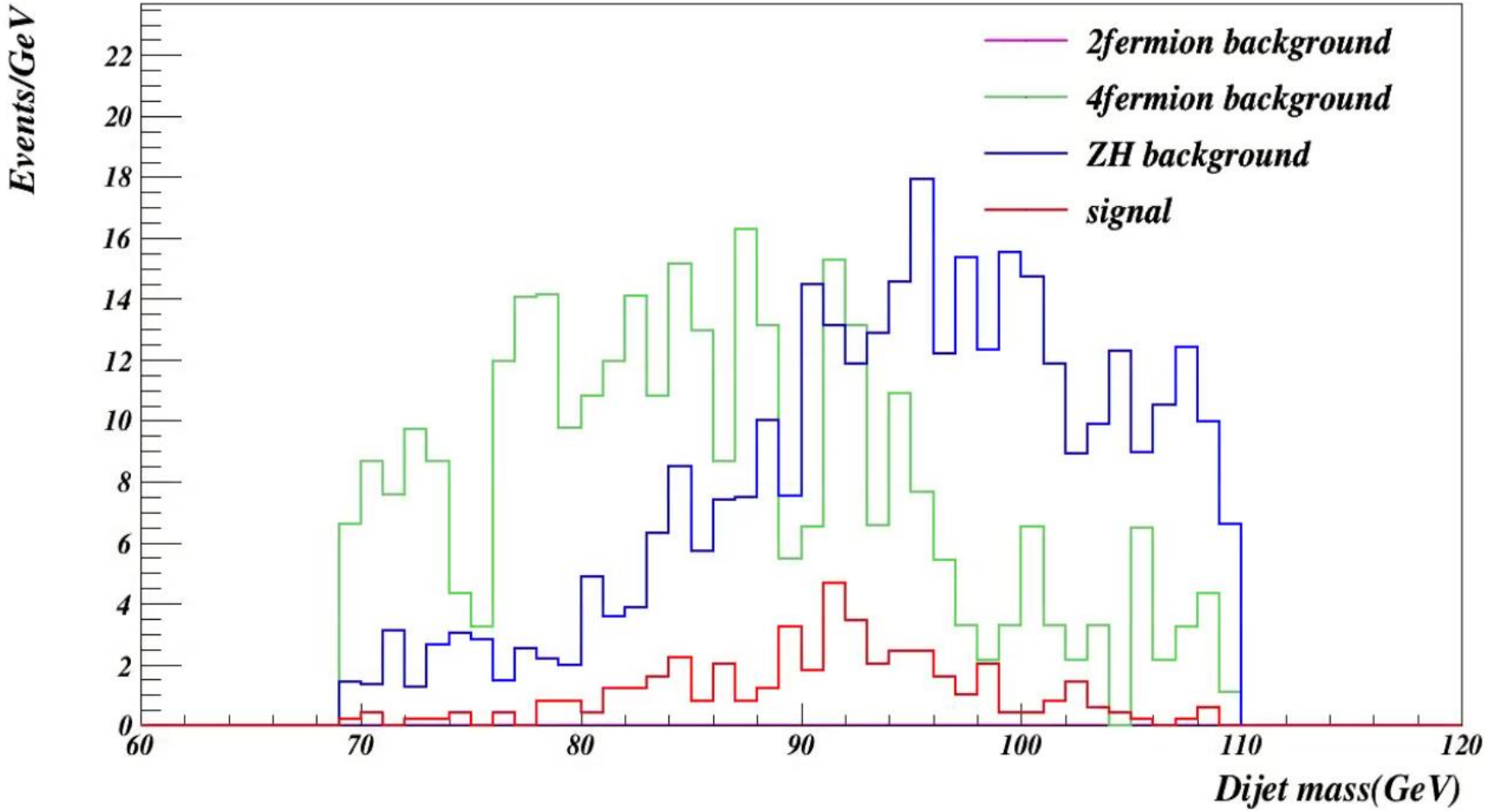
Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Higgs mass



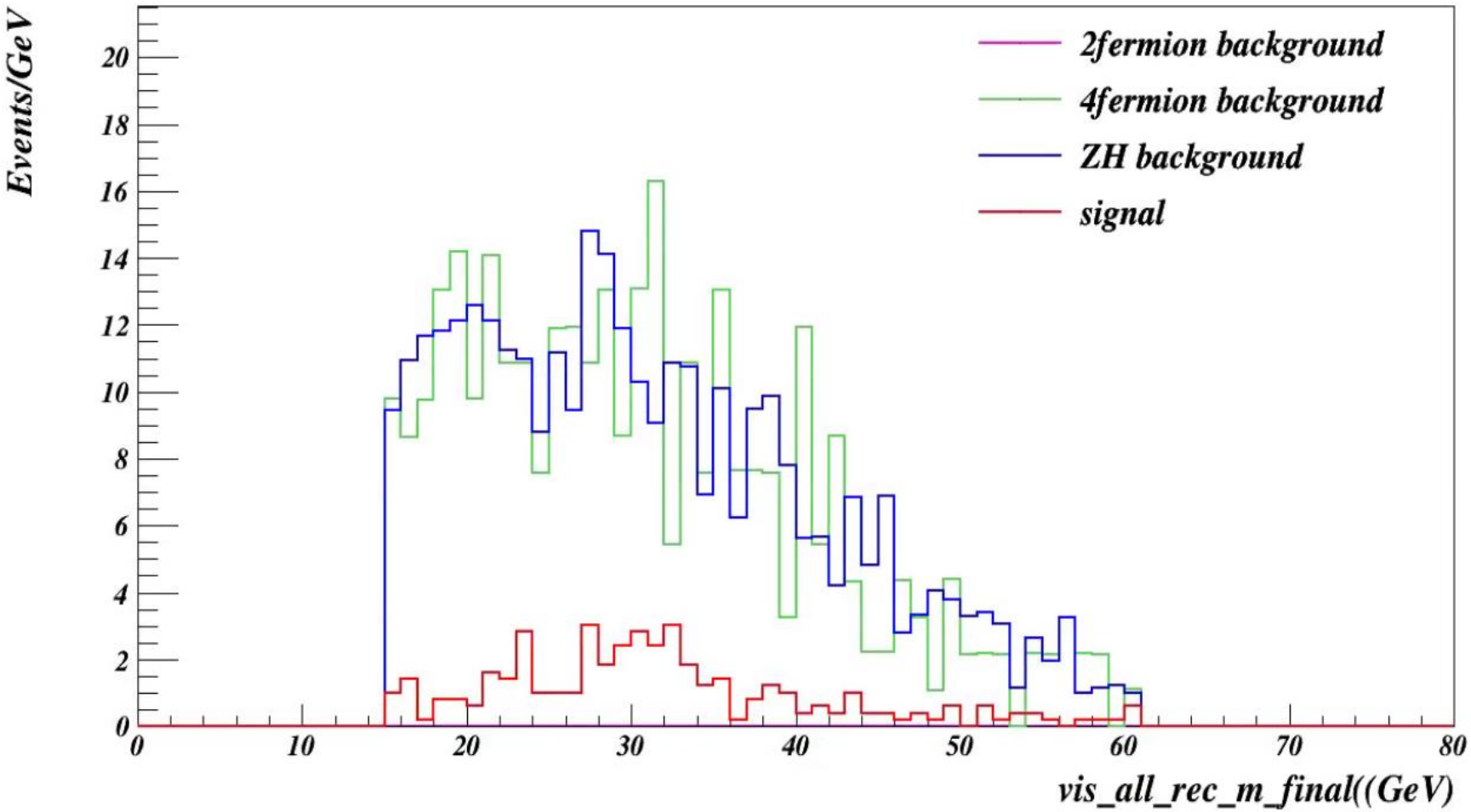
Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Di-jet mass



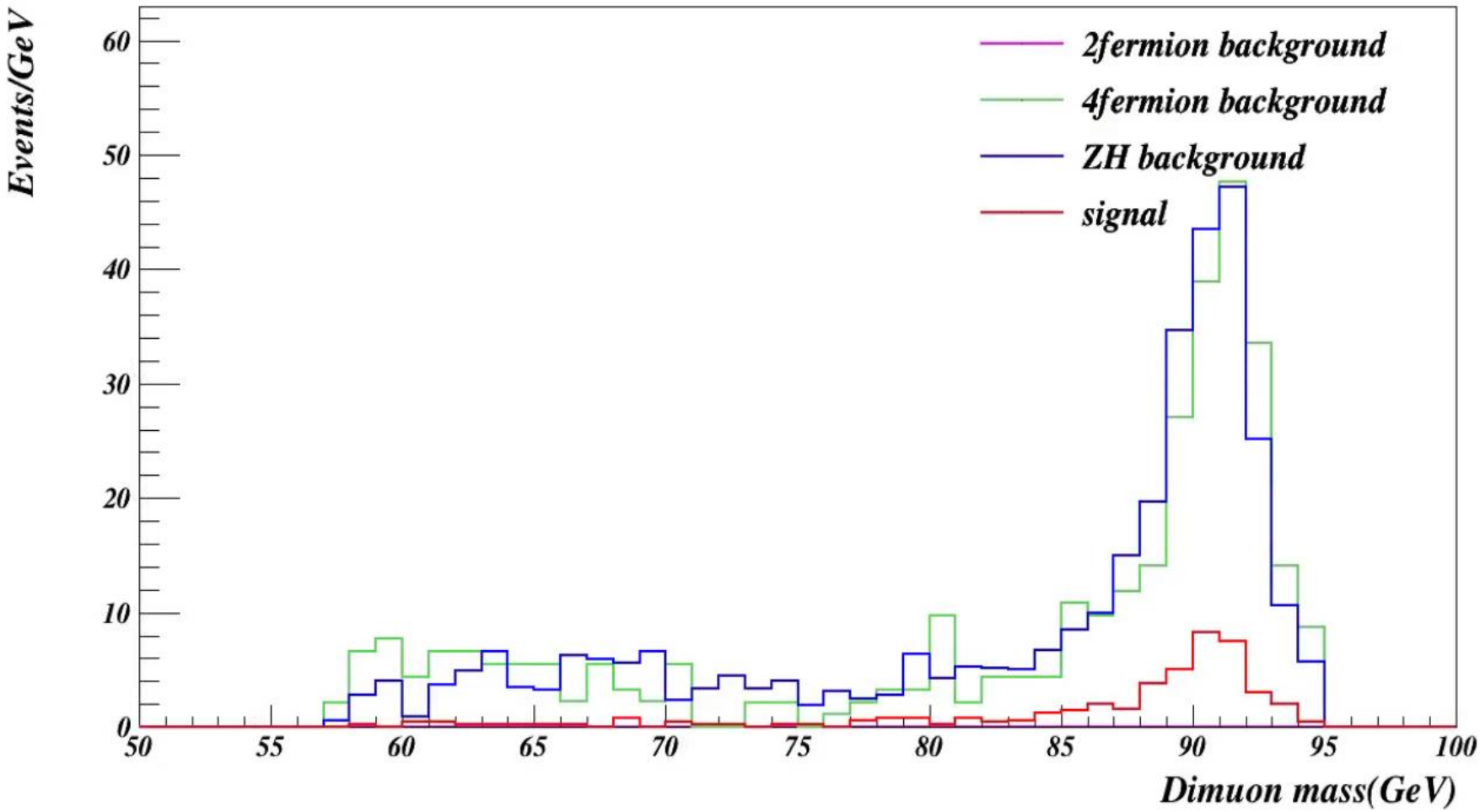
Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Missing mass



Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Dimuon mass



Results ($qqHZZ$)

- $vvmm$ ($Z \rightarrow vv, Z^* \rightarrow mm$)

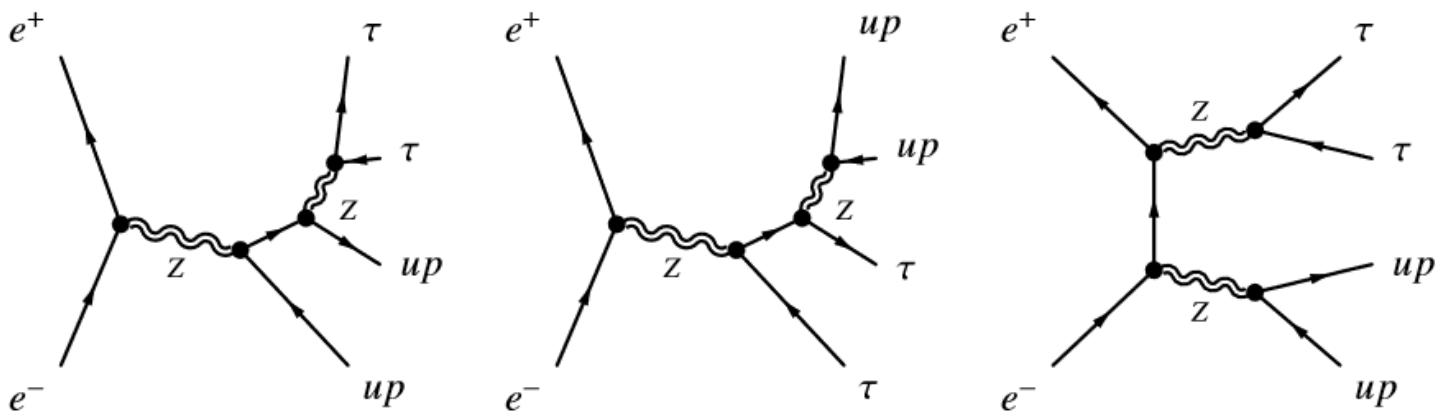
cut	qqhzz	zh	2f	4f
Raw events	20254	1140511	801811977	107203890
pre-selection	826	30494	480828	515425
2m+2v	203	30271	480828	515425
M(dimuon)>M(missing)	94	3167	18606	40769
Npfo	91	2502	2050	15114
Vis_mass	90	2220	557	6573
cos_theta	72	1797	59	2156
RecM(dimuon)	70	1506	14	1942
vis_all_p	69	1459	14	1843
M(dijet)	67	1207	0	1526
jet_lead_e	67	1191	0	1203
jet_sub_e	67	1186	0	1119
angle_mj	67	1165	0	1003
M(dimuon)	67	1105	0	970
vis_all_cos	64	1048	0	850
RecM(vis_all)	64	973	0	817
vis_all_pt	63	962	0	775
not mmhzz	63	962	0	775
not nnhzz	56	884	0	744

Background	Number of events
$qqH\tau\tau$ (ZH)	301
$qqHWW$ (ZH)	400
zz_sl0tau_up (4 $fermion$)	265
zz_sl0tau_down (4 $fermion$)	416

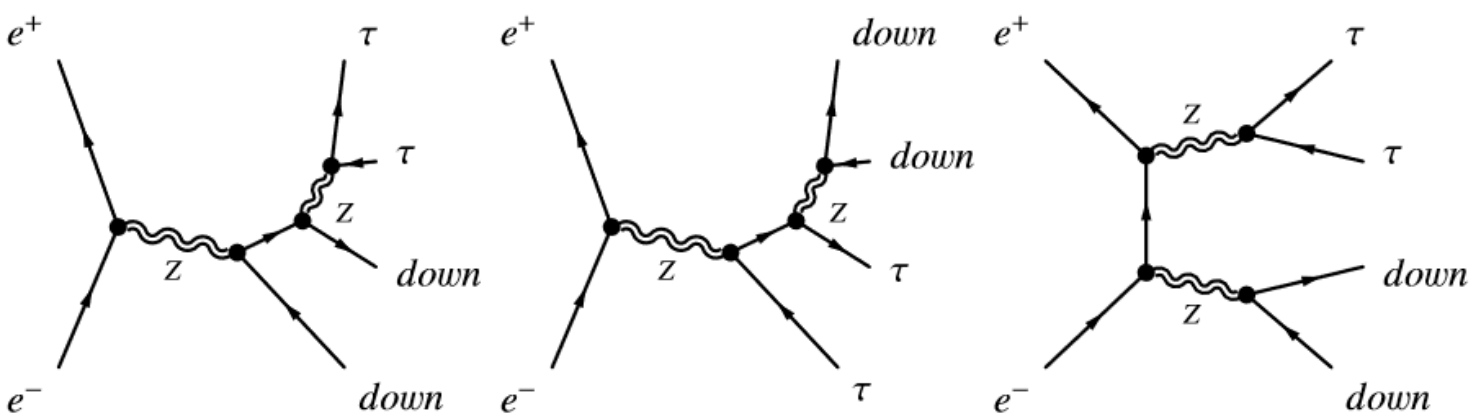
Results ($qqHZZ$)

➢ Feynman Diagrams

zz_sl0tau_up

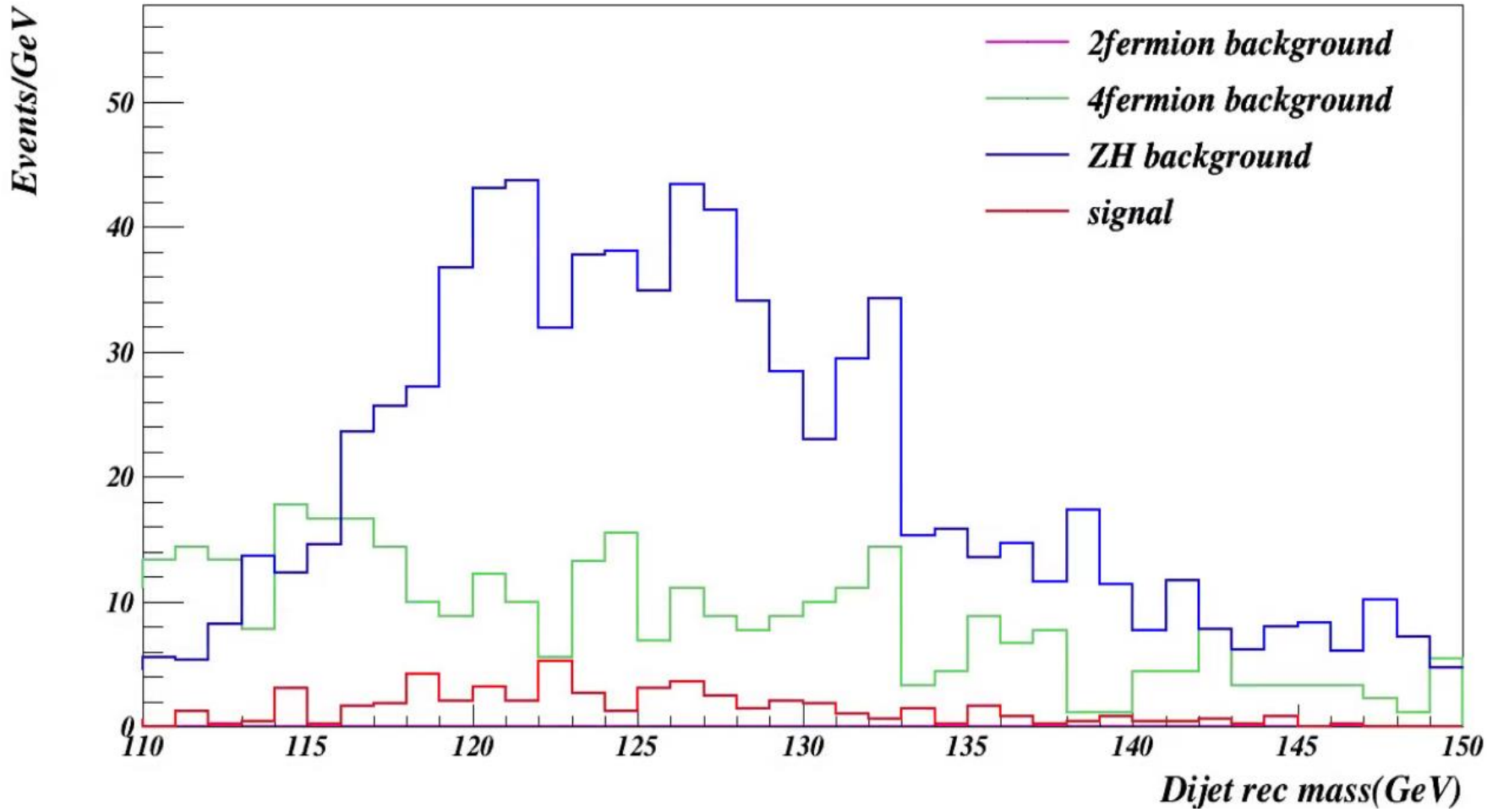


zz_sl0tau_down



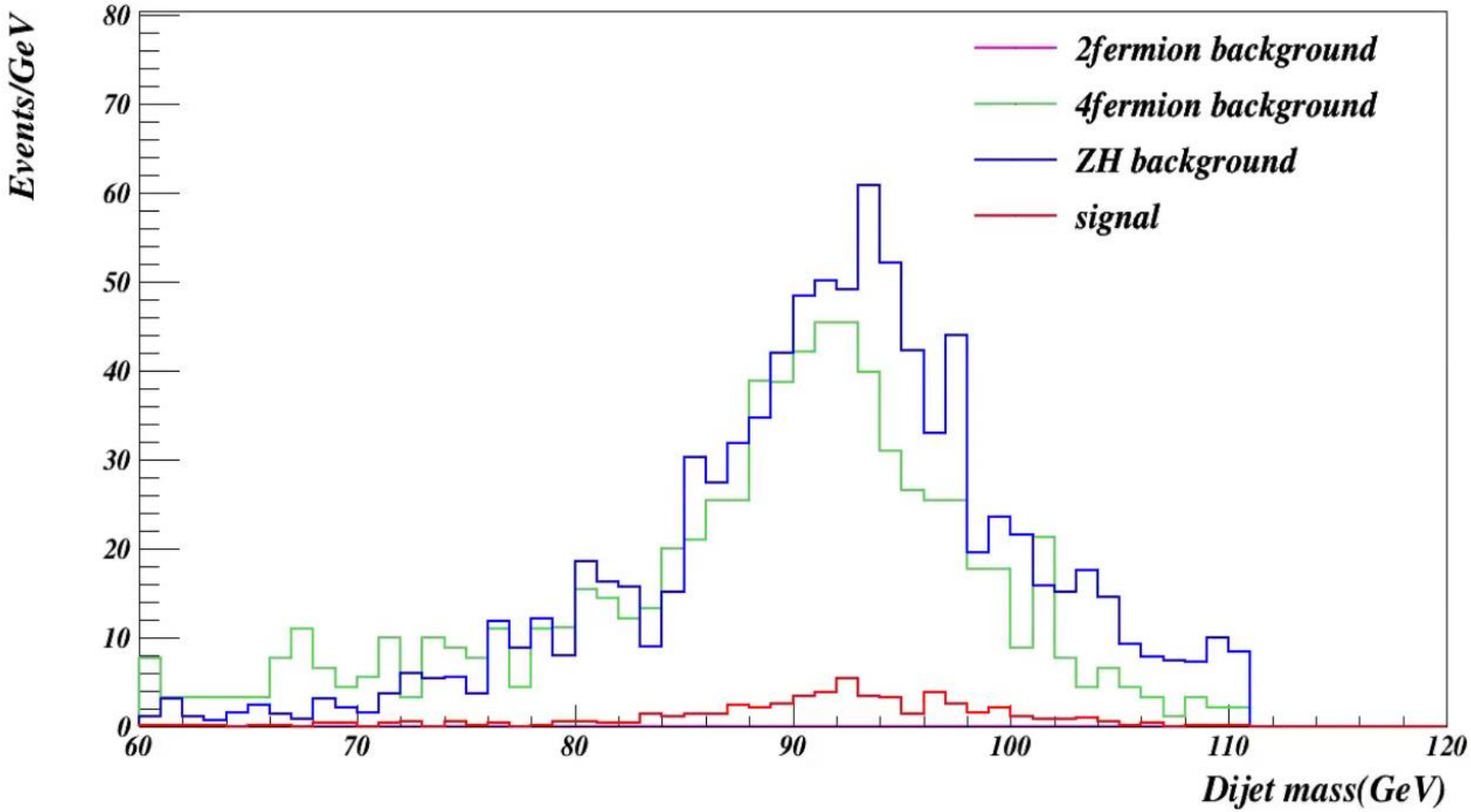
Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Higgs mass



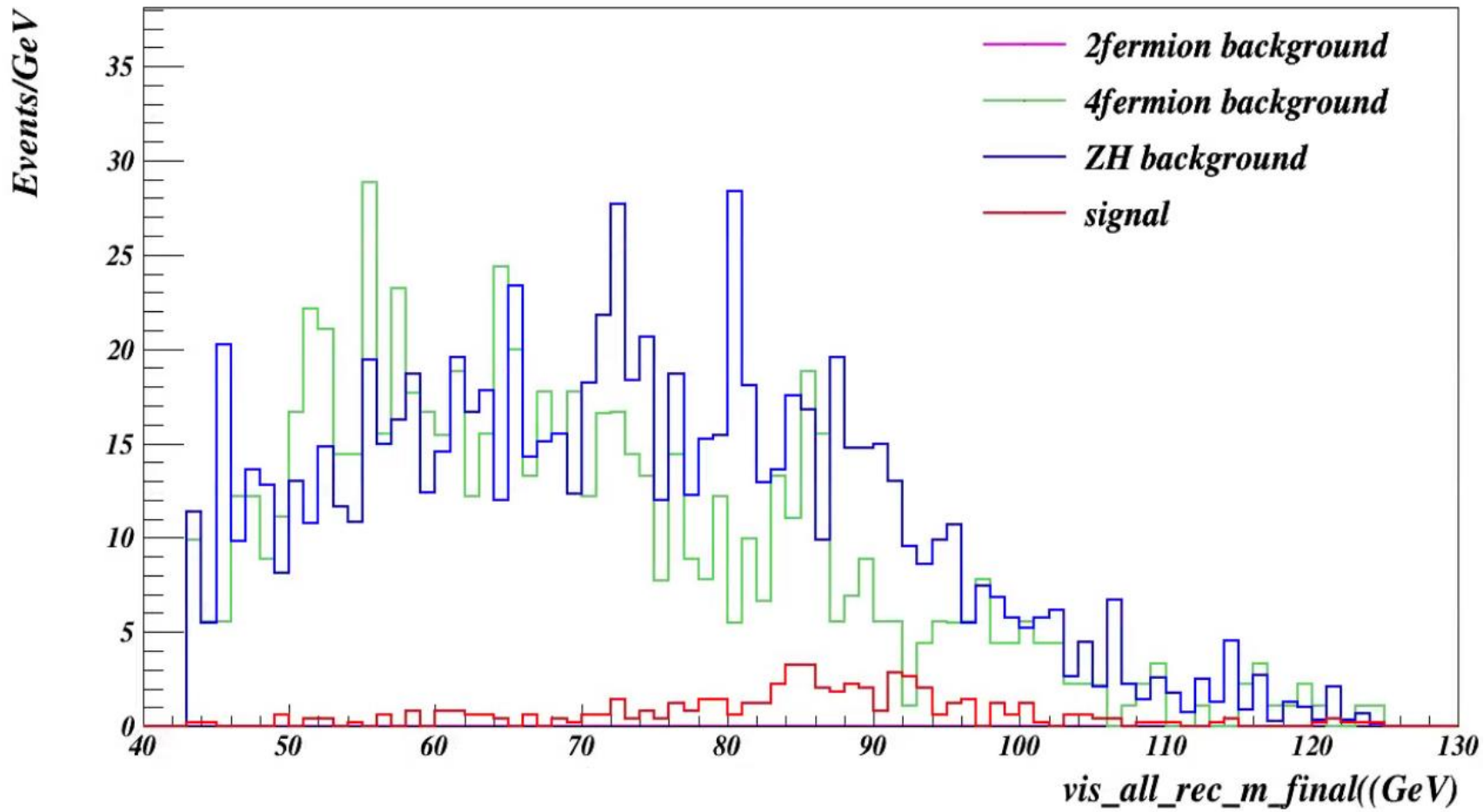
Results ($qqHZZ$)

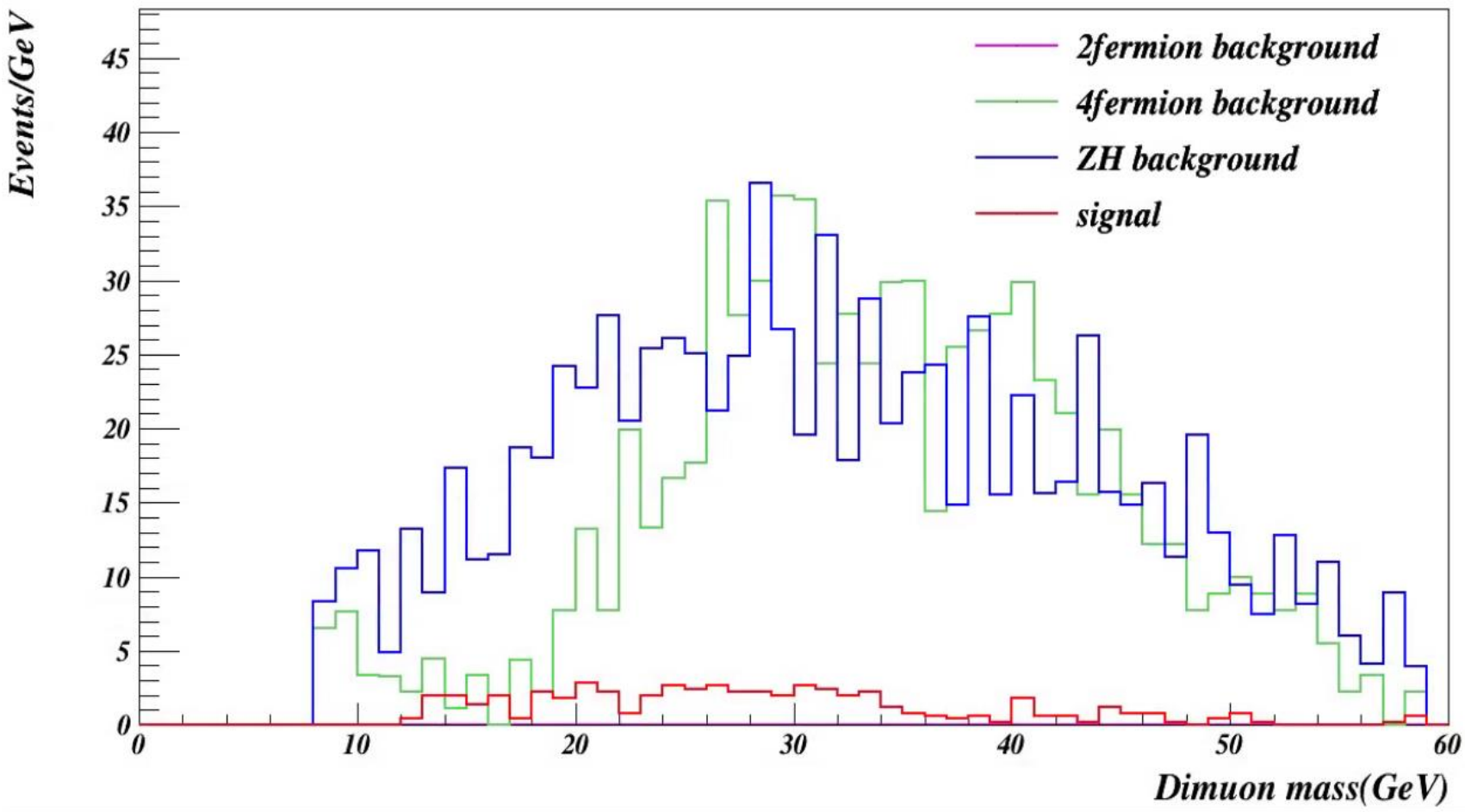
- $mmvv$ ($after\ all\ cuts$)
  - Di-jet mass



Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Missing mass



Results ($qqHZZ$)

- $mmvv$ ($after\ all\ cuts$)
  - Dimuon mass