

CEPC HZZ Analysis Update

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Introduction

- **Cut-based only analysis**
- **qqHvvmm: discussed on March 3rd**
qqHmvmv, mmHvvqq and mmHqqvv: discussed on March 11th
vvHmqq, vvHqqmm: will discuss this time
- **Every distribution is drawn after its previous cuts applied**

$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

Note: “*” means no cut on this observable

➤ Cut Flow Table

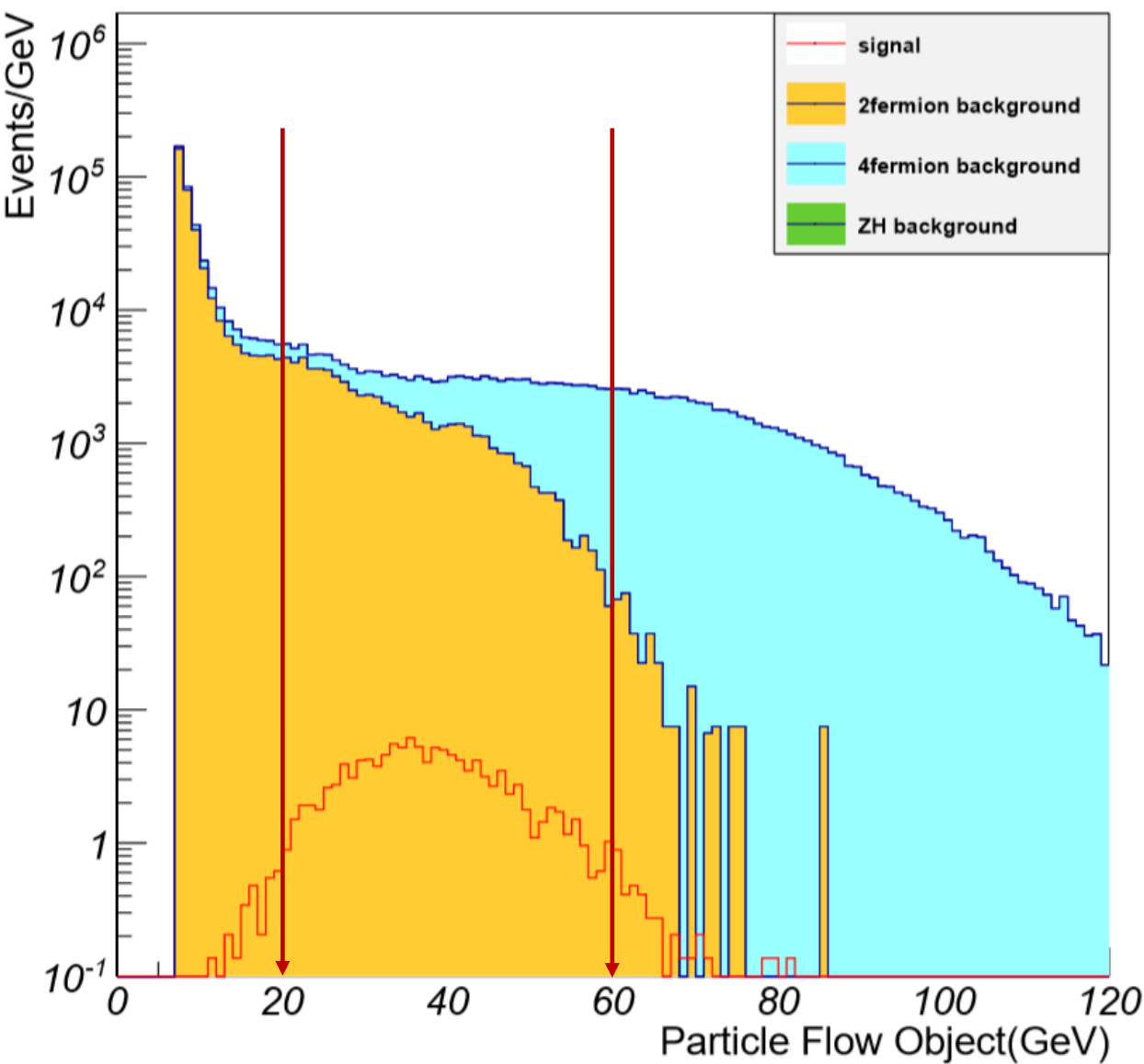
Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
<i>Expected</i>	6844	1140511	801811977	107203890	
<i>Pre – selection</i>	238	30494	480828	515424	
<i>Signal or not</i>	226	30268	480828	515424	
$M_{dimuon} > M_{dijet}$	125	2832	421952	156993	0.1642
$N(pfo)$	117	1259	60398	68100	0.325
$M_{missing}$	102	147	2152	791	1.8168
M_{dimuon}	95	136	1762	258	2.007
M_{dijet}	94	131	258	204	3.5888
$*\cos\theta$	94	131	258	204	3.5888
$\cos\theta_{visible}$	89	125	37	57	5.0842
$Angle_{\mu j}$	83	72	0	16	6.3751
$*M_{dimuon}^{rec}$	83	72	0	16	6.3751
$*M_{dijet}^{rec}$	83	72	0	16	6.3751
$M_{visible}$	83	56	0	11	6.7871
$*P_{visible}$	83	56	0	11	6.7871
$*P_{T_{visible}}$	83	56	0	11	6.7871
$*E_{leading\ jet}$	83	56	0	11	6.7871
$*P_{T_{leading\ jet}}$	83	56	0	11	6.7871
$*E_{sub-leading\ jet}$	83	56	0	11	6.7871
$*P_{T_{sub-leading\ jet}}$	83	56	0	11	6.7871
<i>not $\mu^+\mu^- HZZ$</i>	72	17	0	9	7.2837
<i>not $qqHZZ$</i>	72	17	0	9	7.2837
<i>not $qqHZZ$</i>	77	21	0	8	7.4789

➤ This time

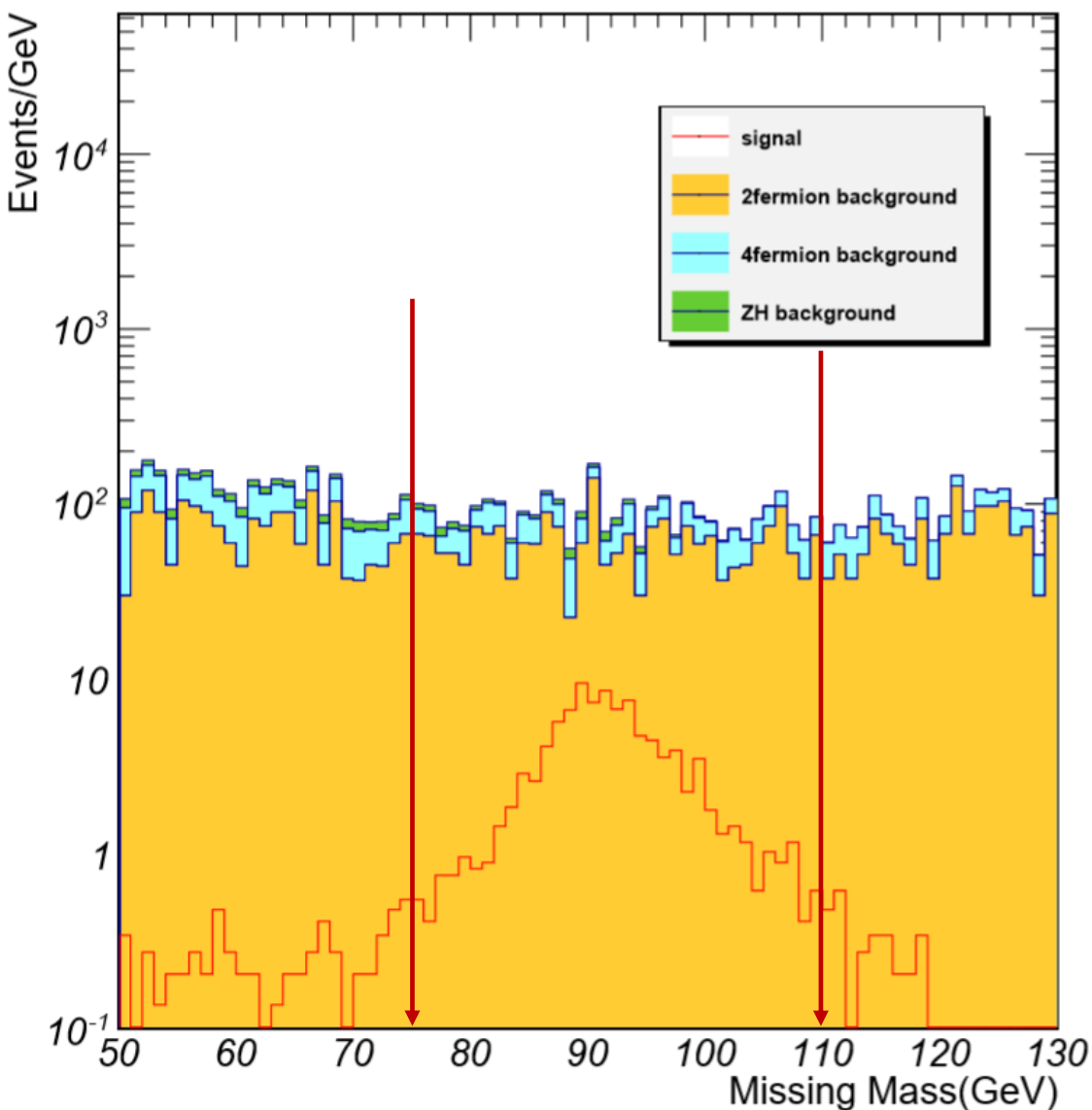
➤ BDT optimized cuts
 $\nu\nu HZZ$, before splitting

$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ $20 < N(pfo) < 60$

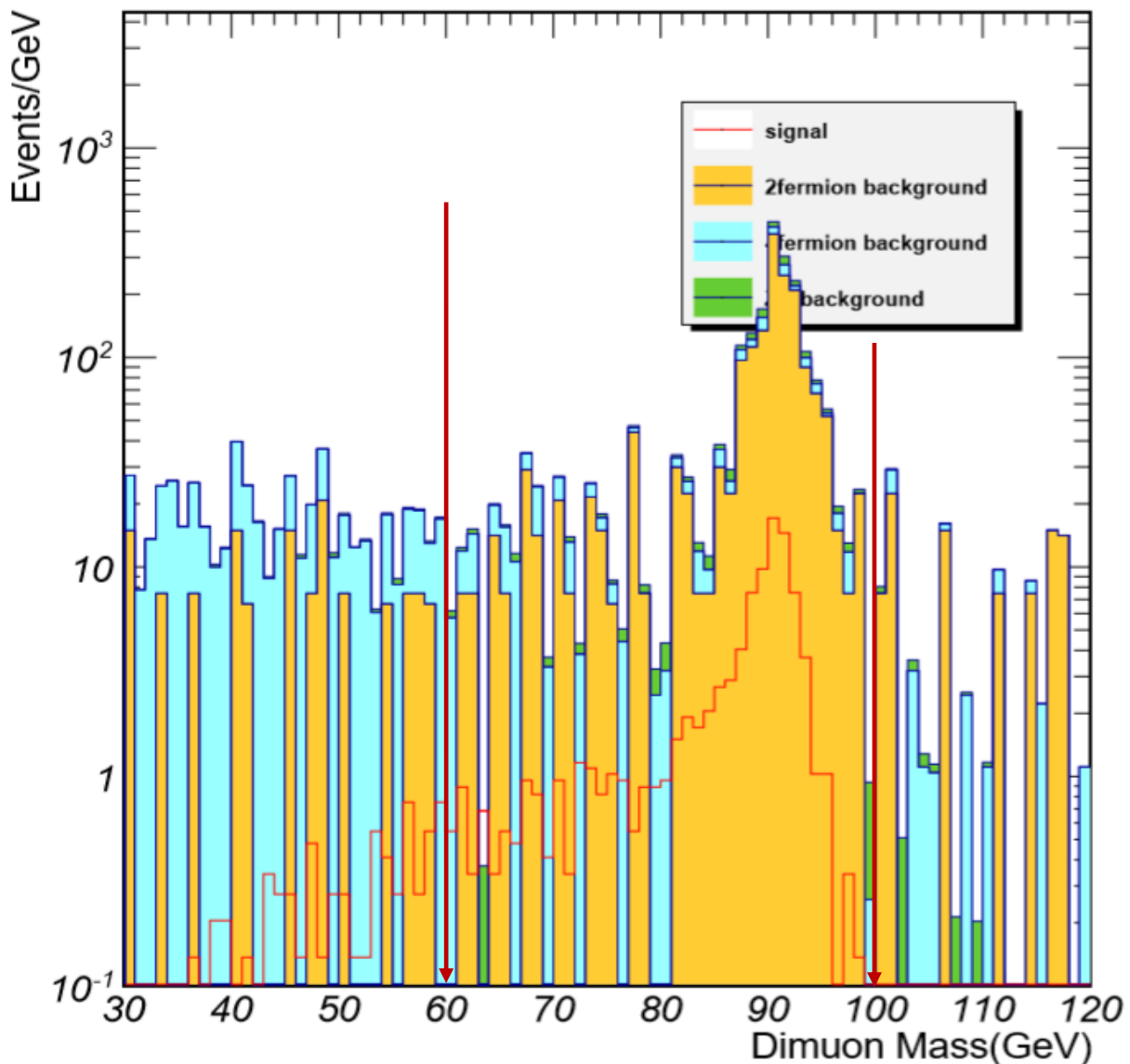


➤ $75 < \text{Missing mass} < 110 \text{ GeV}$

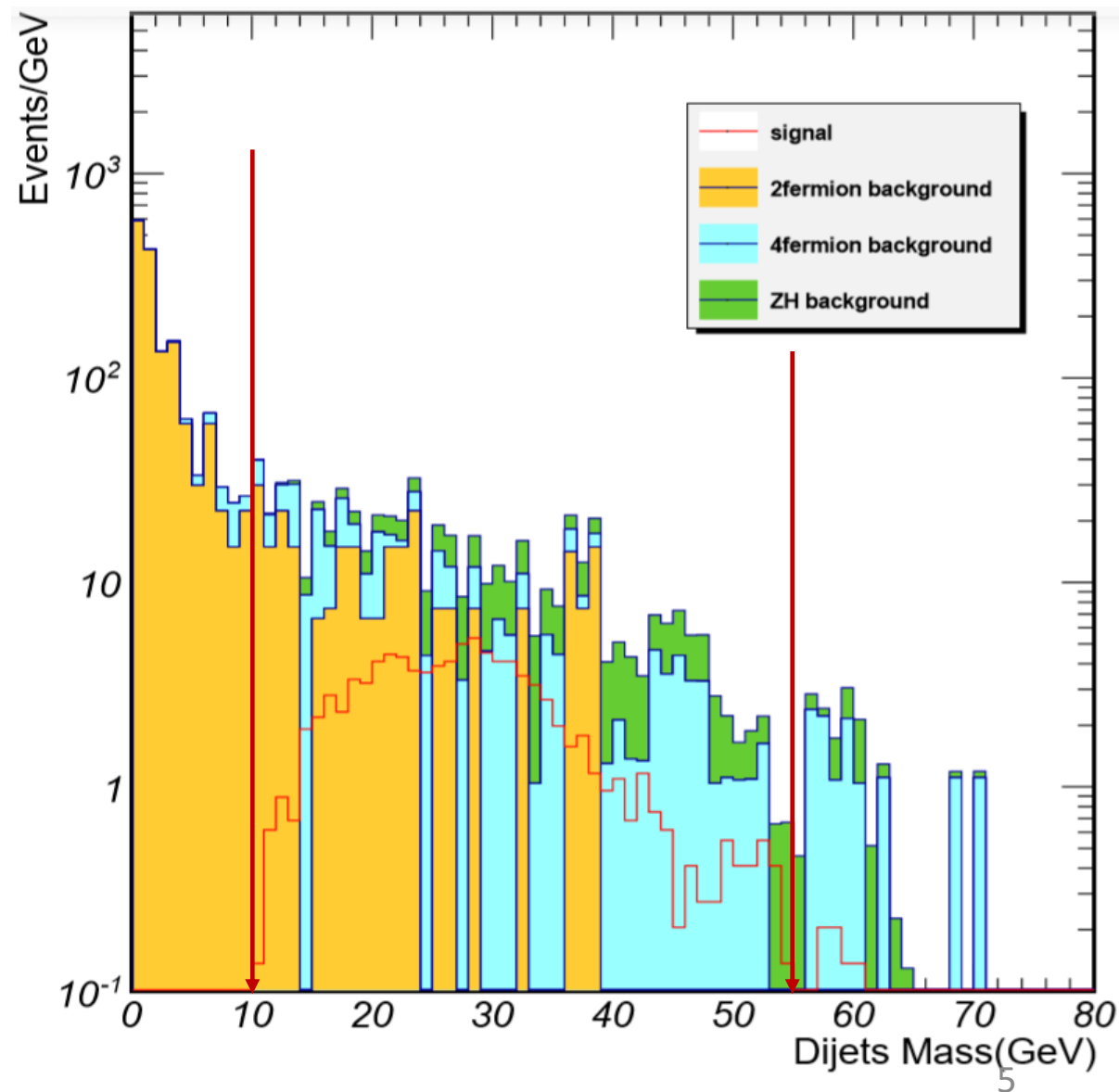


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ $60 < \text{Di-muon mass} < 100 \text{ GeV}$

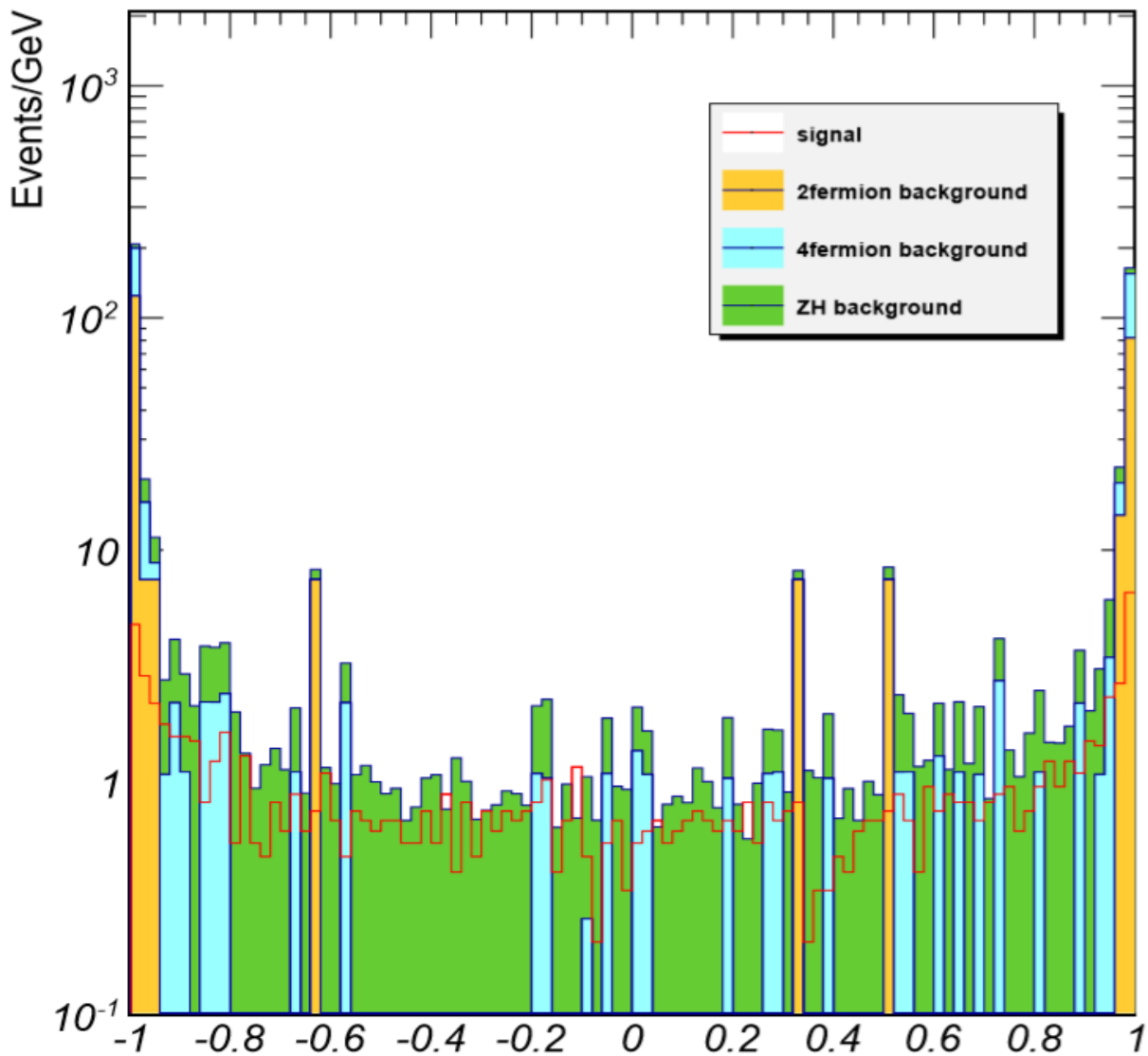


➤ $10 < \text{Di-jet mass} < 55 \text{ GeV}$

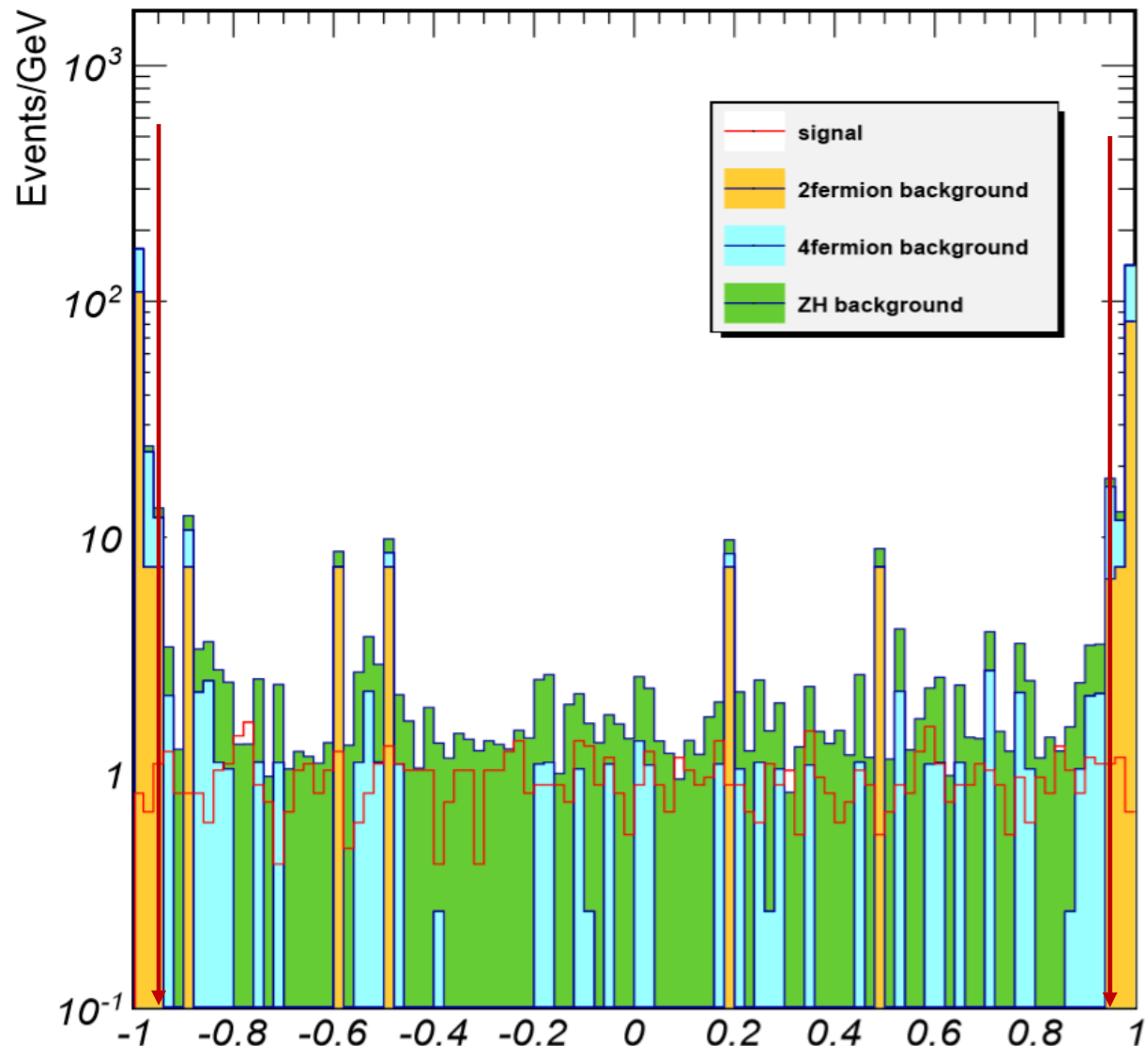


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ $\cos \theta$: no cut

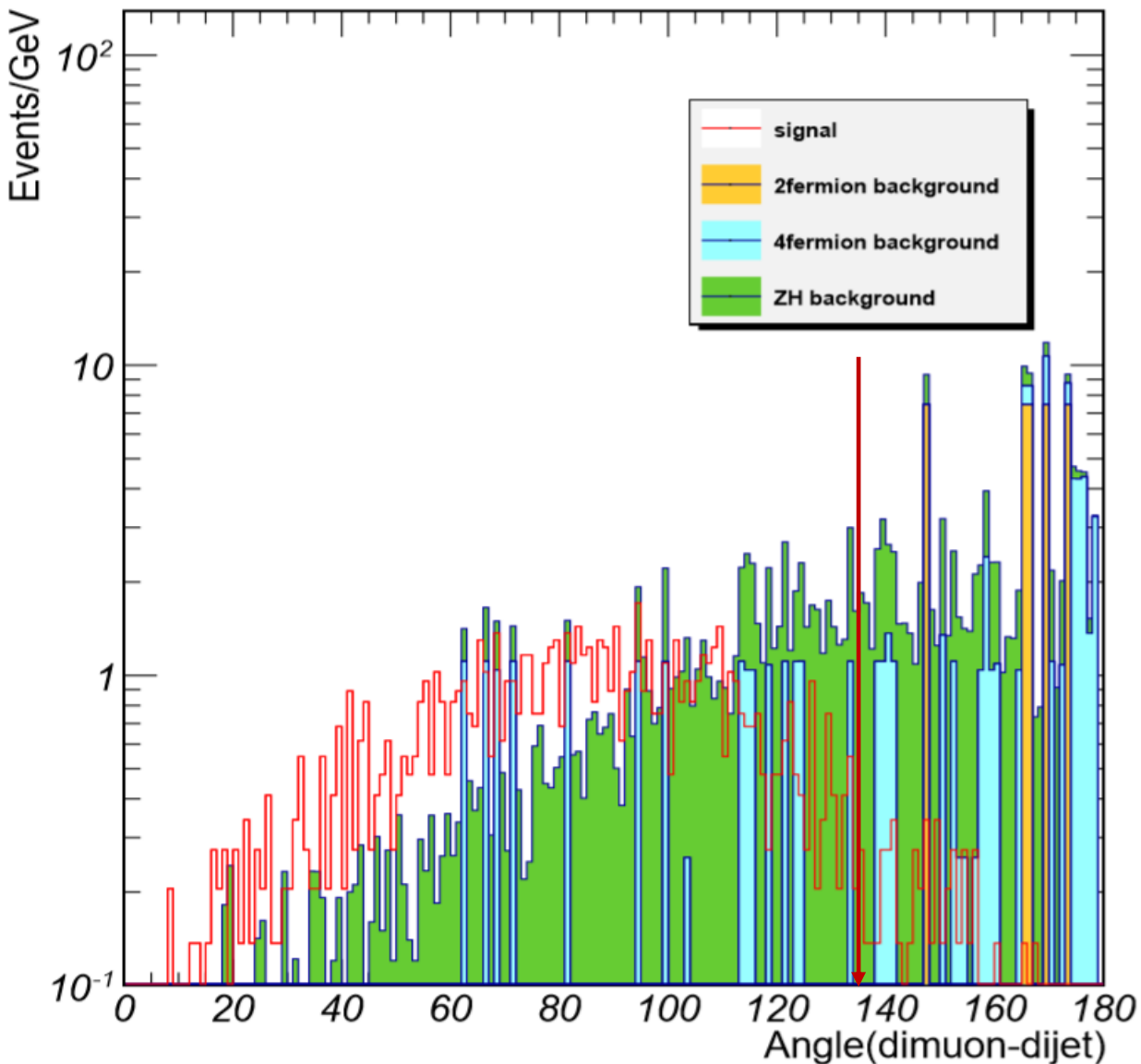


➤ $-0.95 < \cos \theta (\text{visible}) < 0.95$

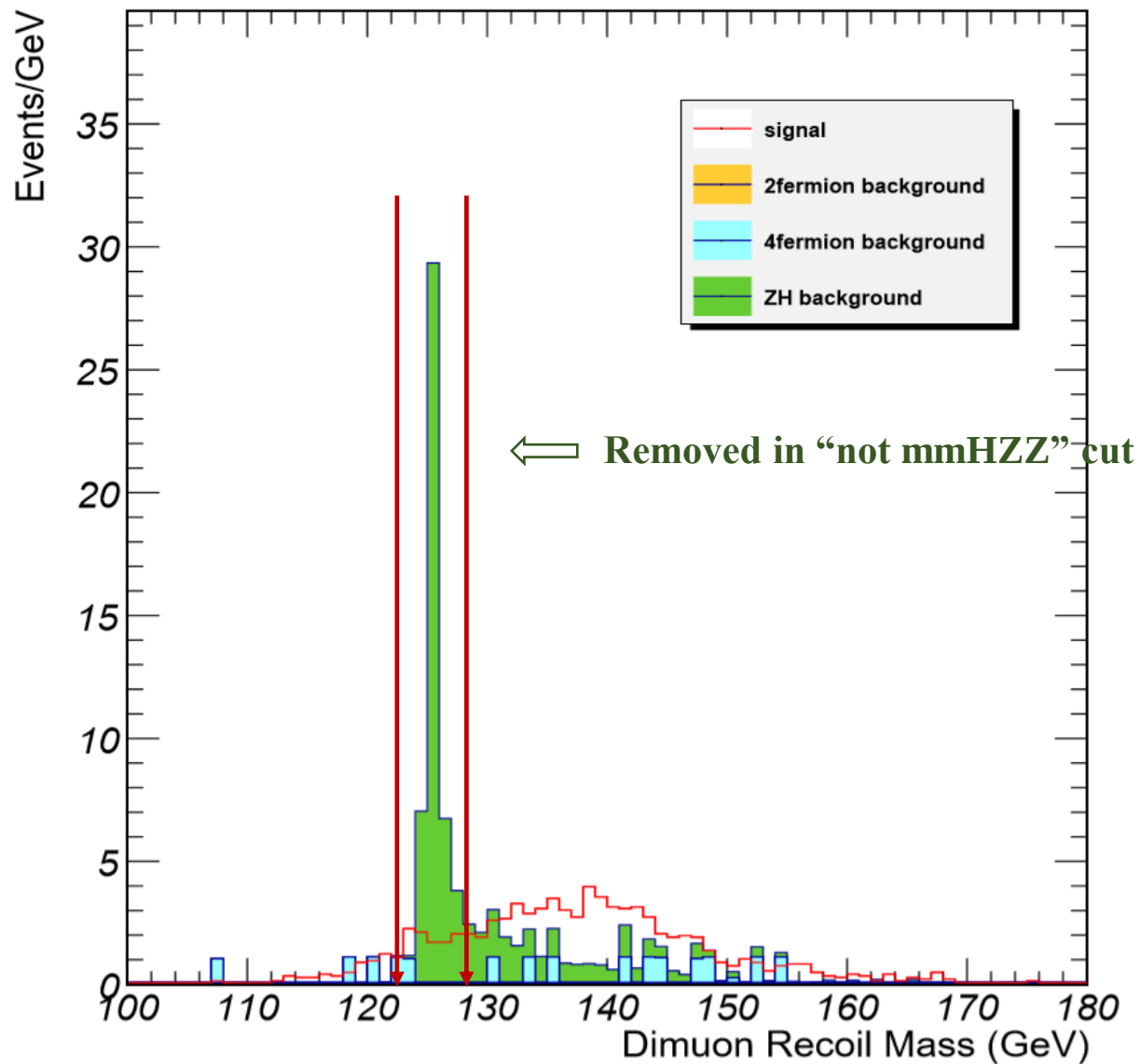


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ Dimuon-dijet angle $< 135^\circ$

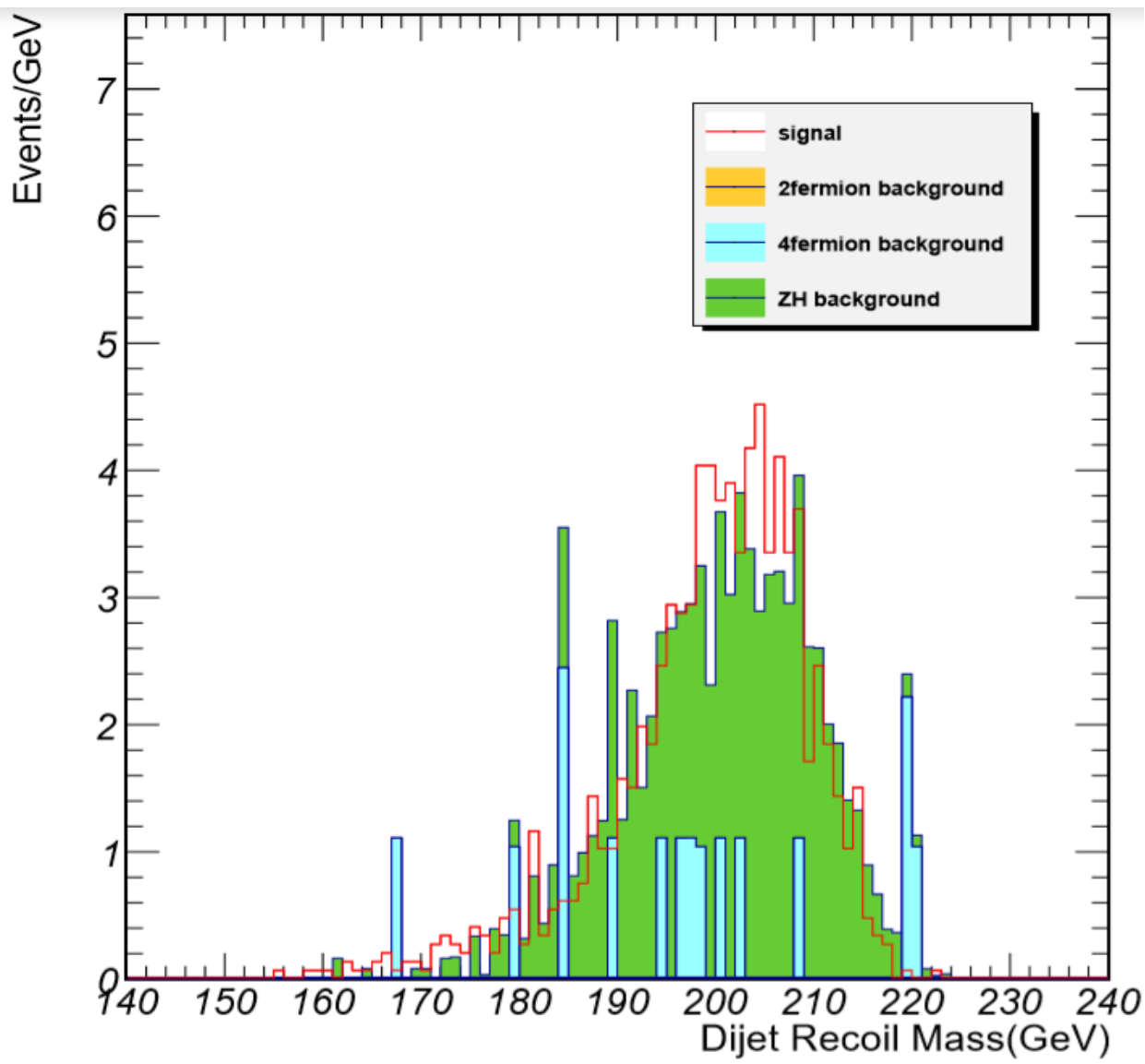


➤ Di-muon recoil mass: no cut

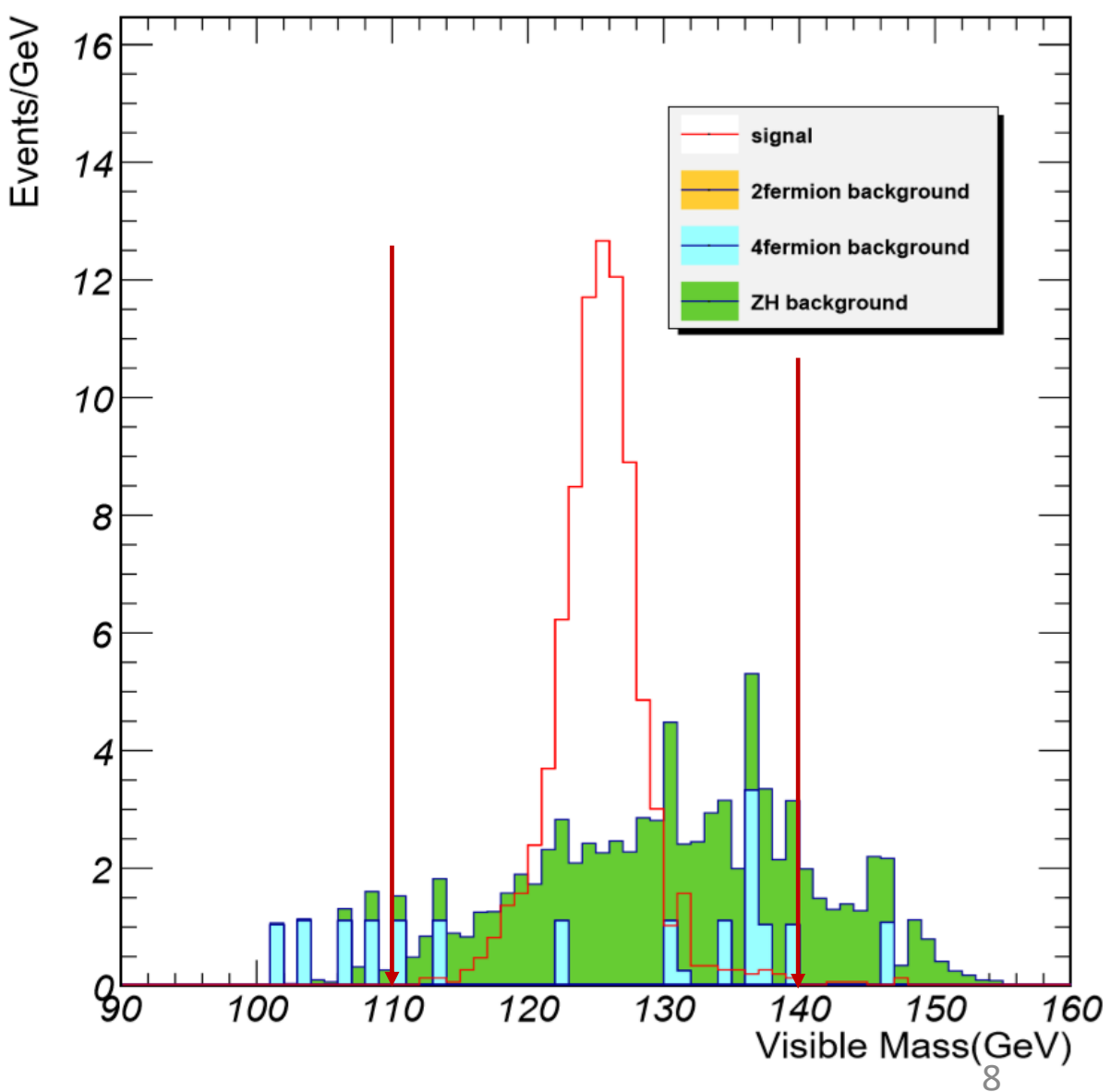


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ Di-jet recoil mass: no cut

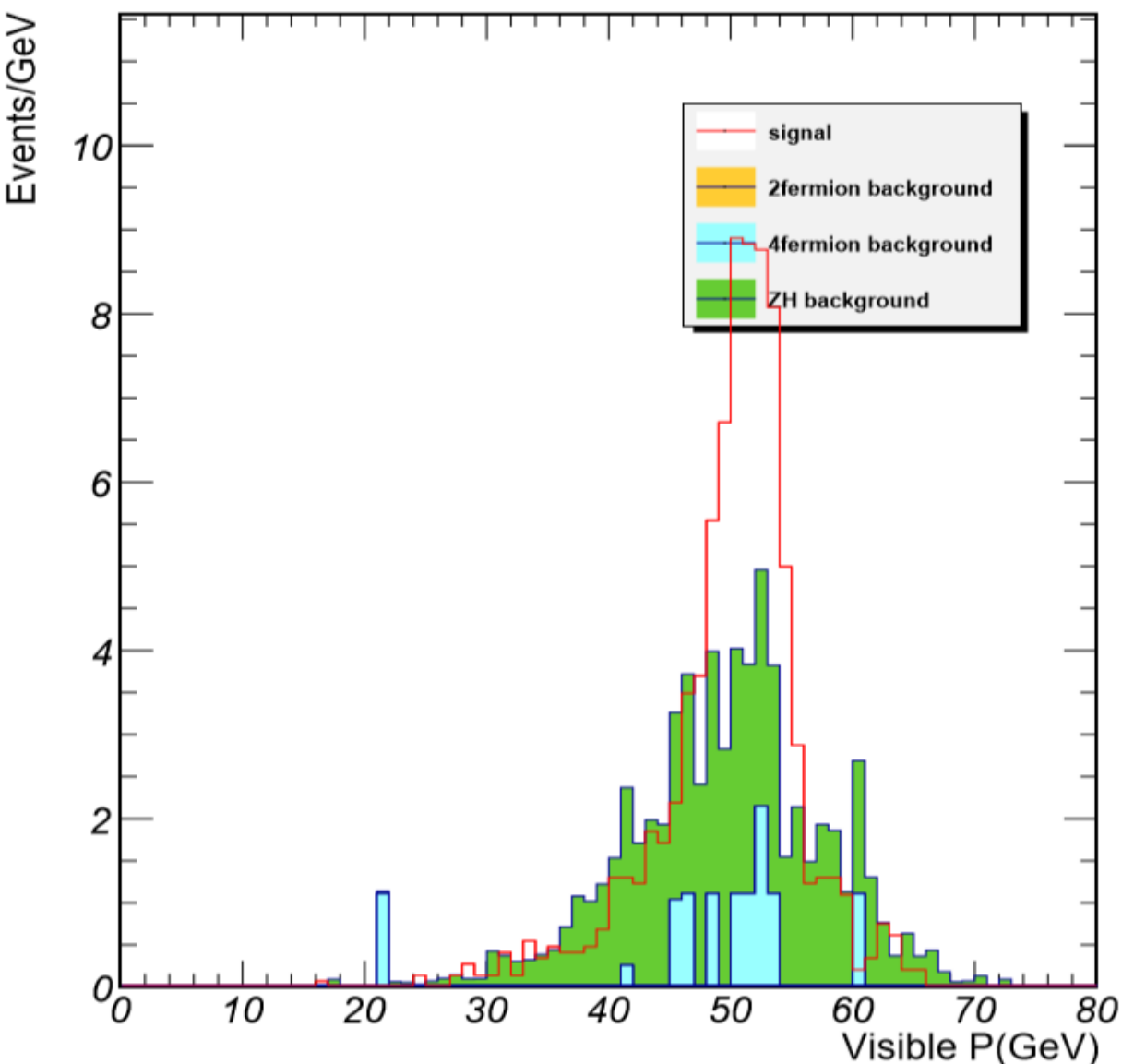


➤ $110 < \text{Visible mass} < 140 \text{ GeV}$

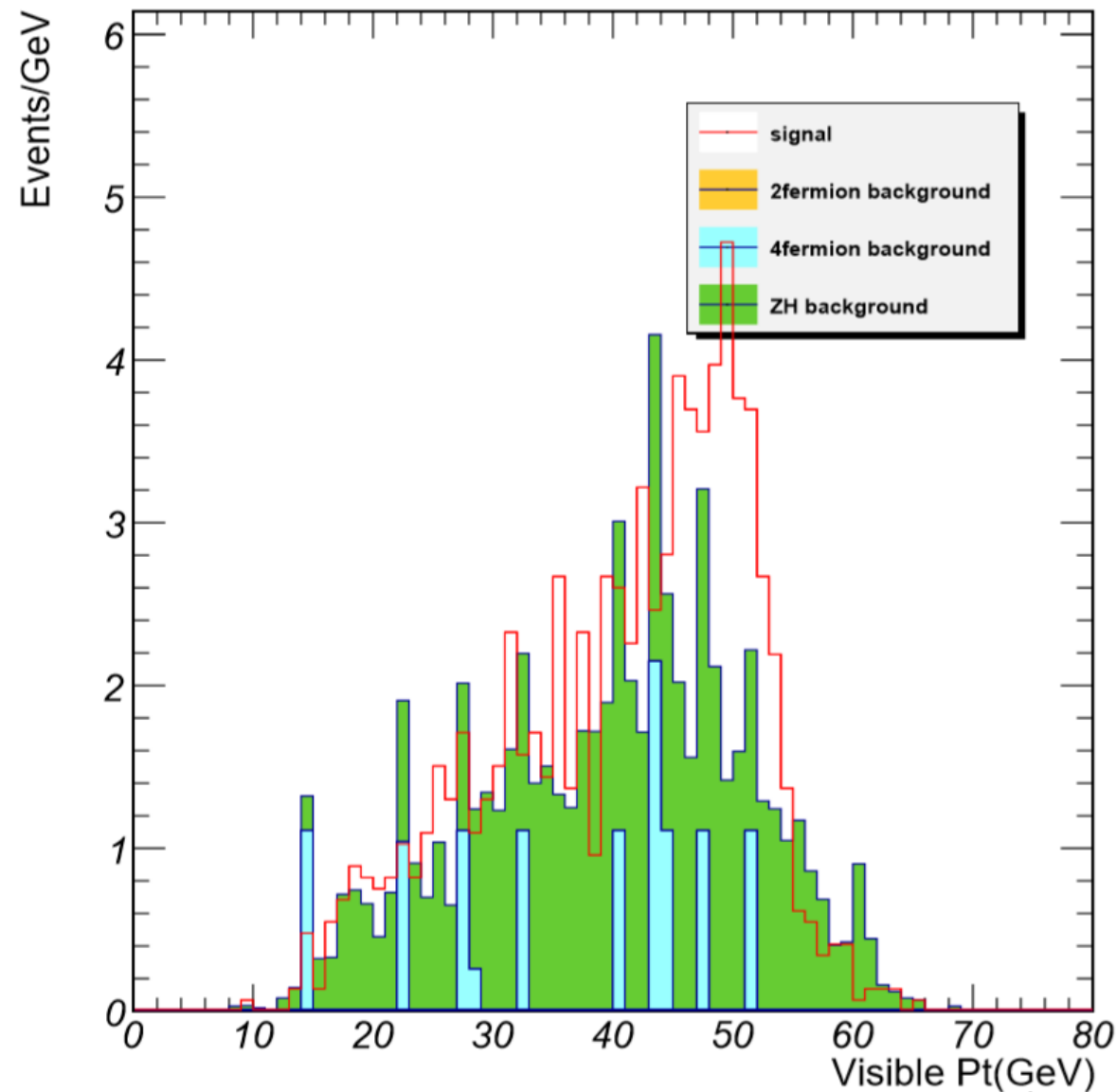


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ **P visible: no cut**

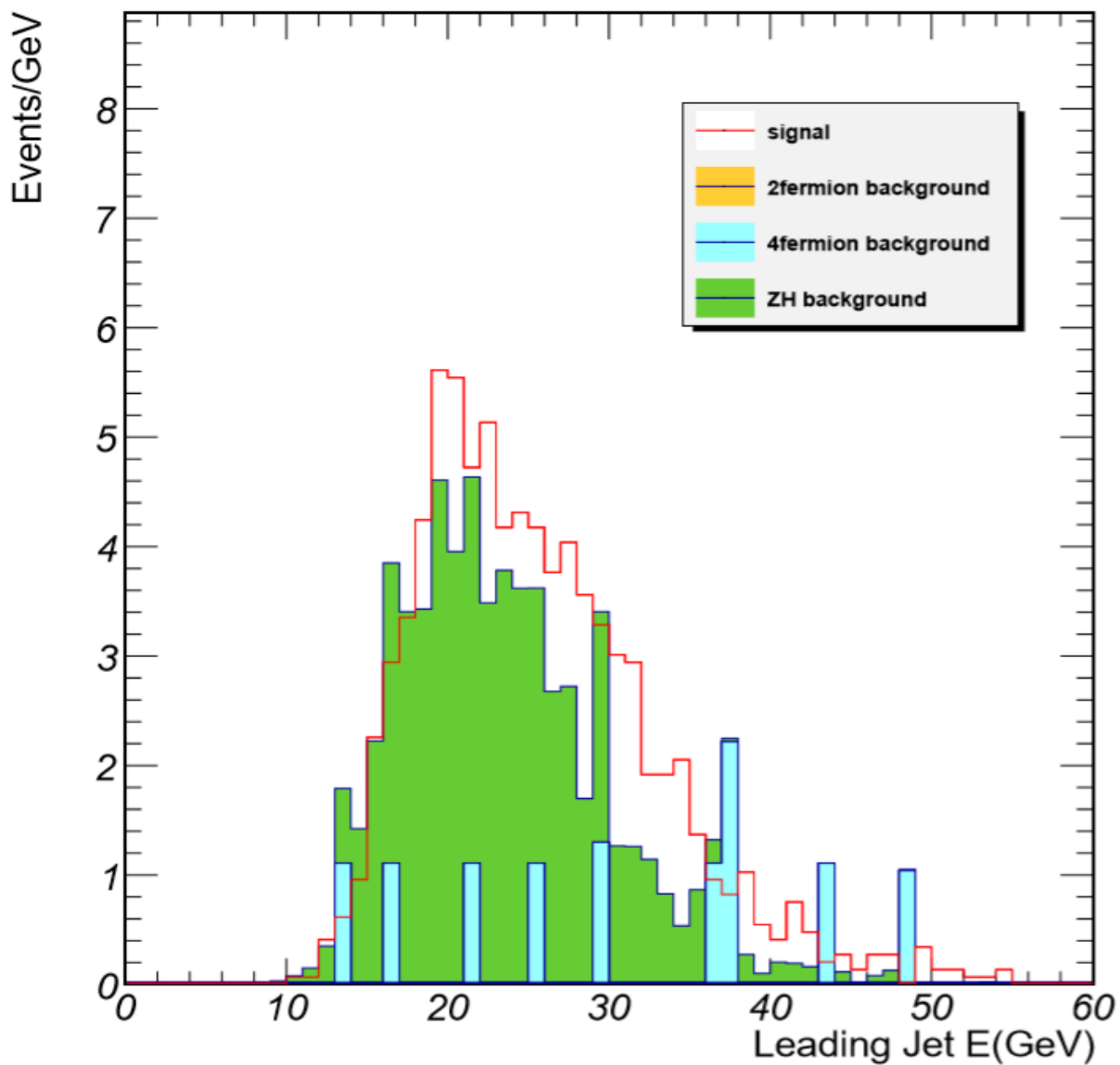


➤ **P_T visible: no cuts**

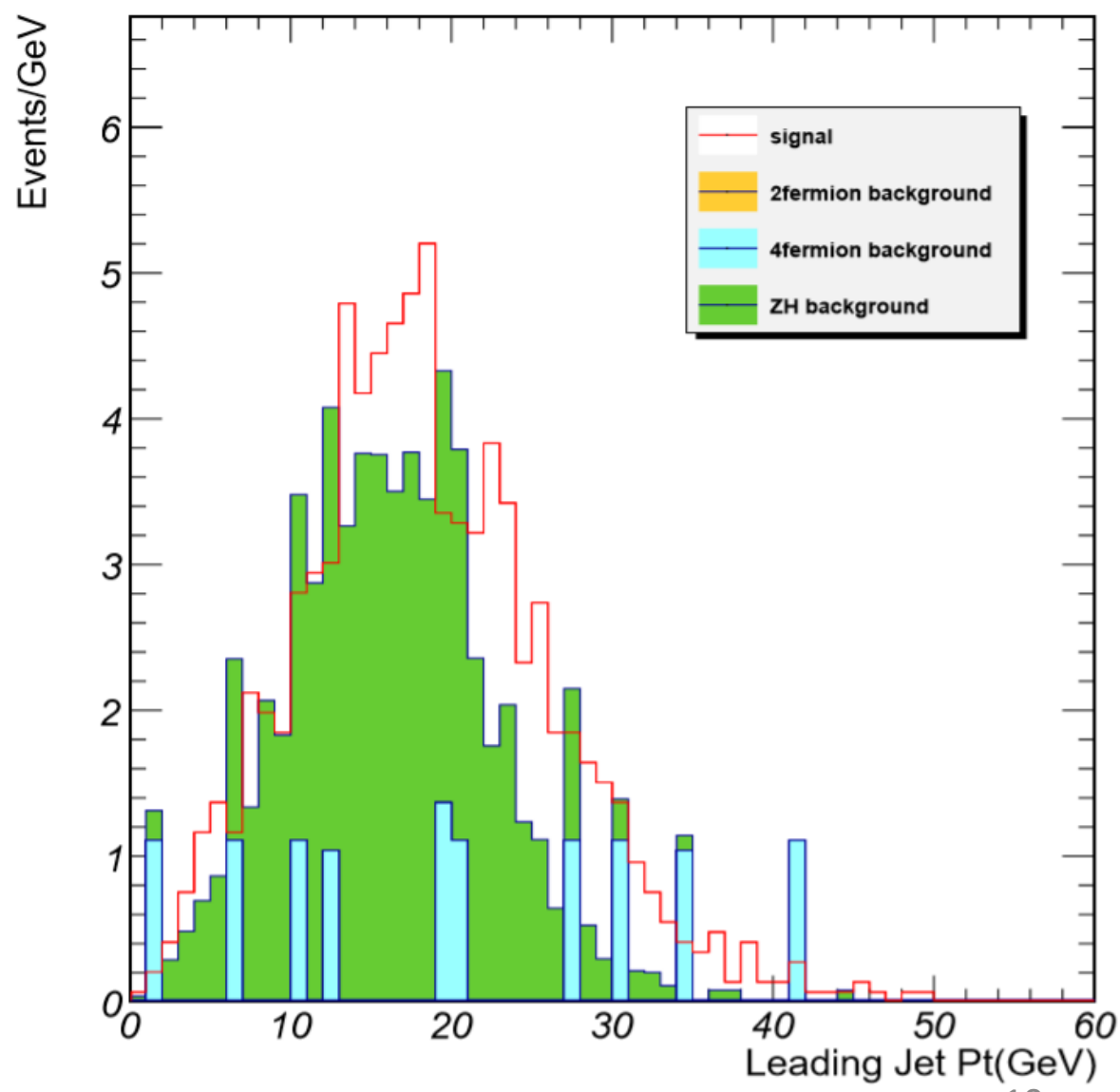


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ **Leading jet E: no cut**

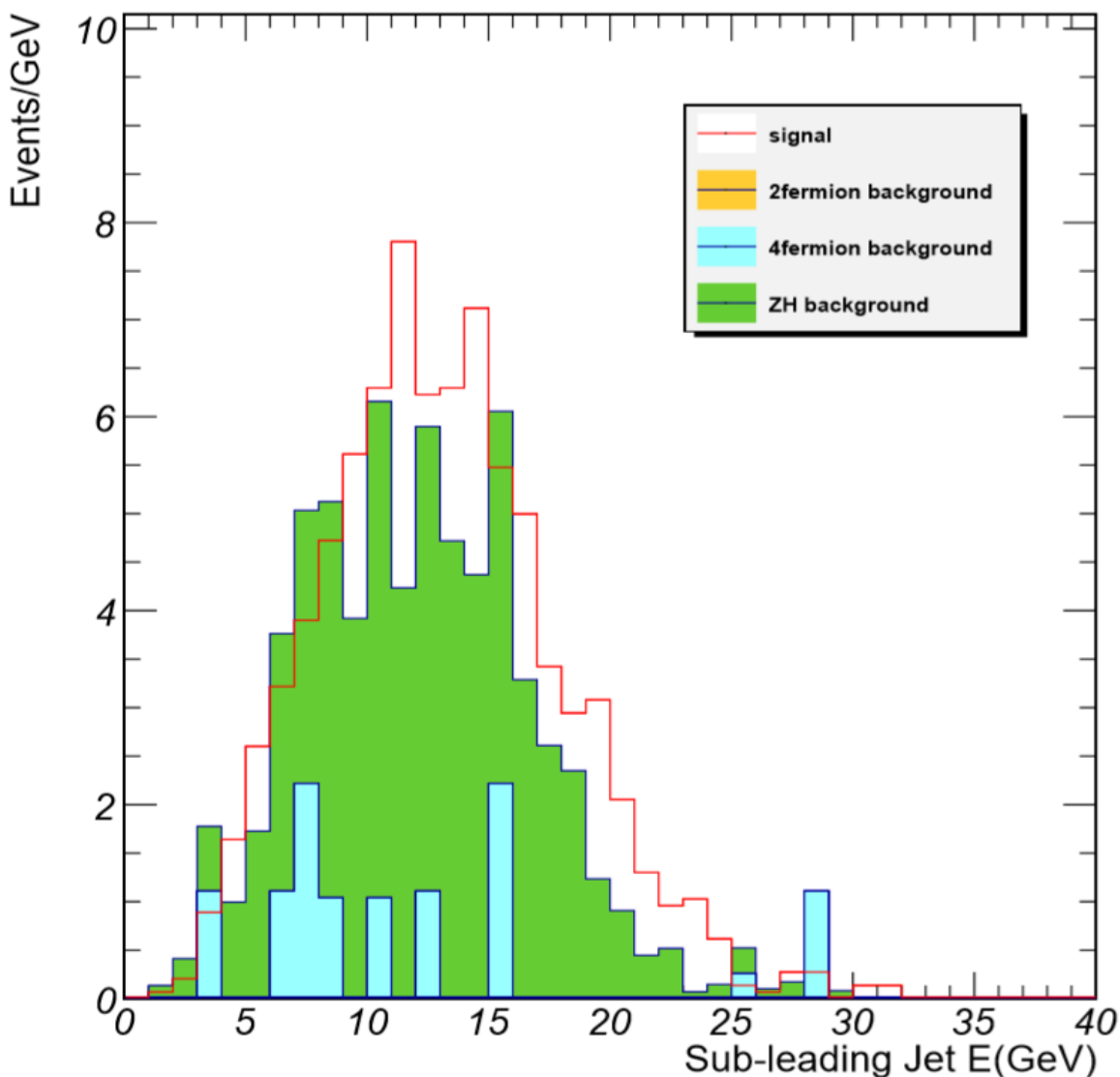


➤ **Leading jet P_T : no cut**

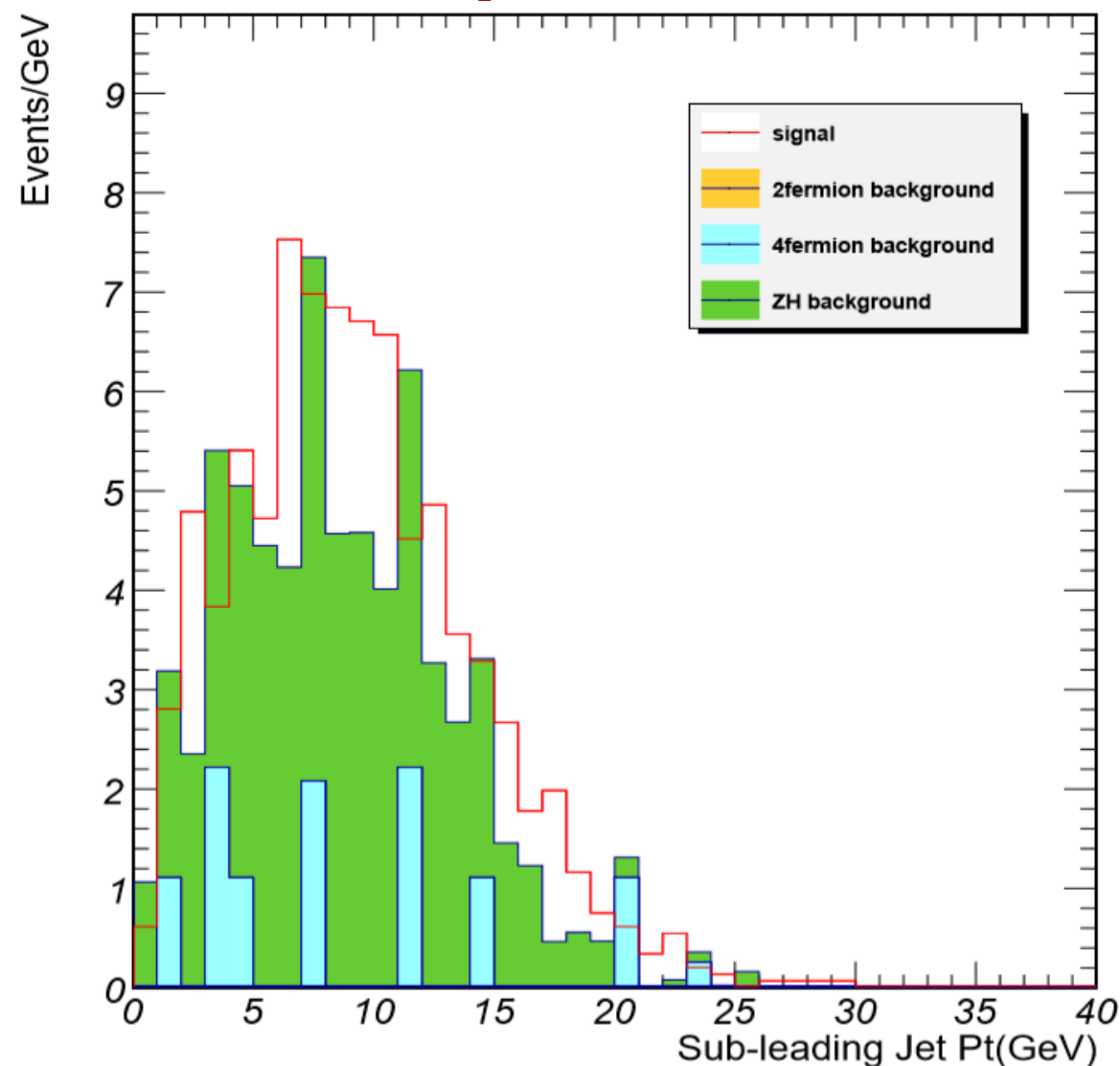


$\nu\nu HZZ$ ($Z \rightarrow \mu\mu, Z^* \rightarrow qq$)

➤ Sub-leading jet E: no cut



➤ Sub-leading jet P_T : no cut



Finally, not mmHZZ and not qqHZZ cuts are applied

$\nu\nu HZZ (Z \rightarrow qq, Z^* \rightarrow \mu\mu)$

Note: “*” means no cut on this observable

➤ Cut Flow Table

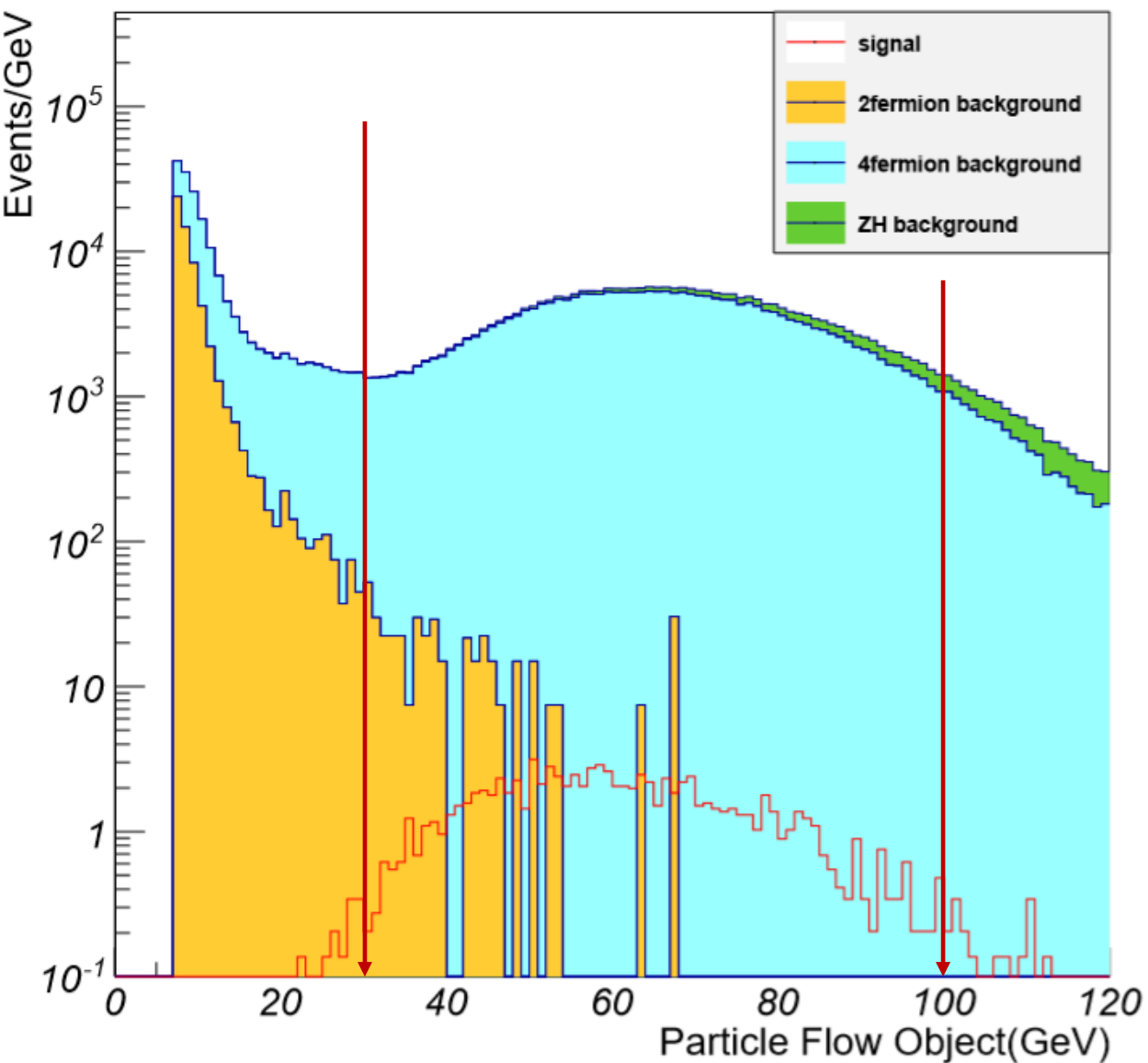
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<i>Expected</i>	6844	1140511	801811977	107203890	
<i>Pre – selection</i>	238	30494	480828	515424	
<i>Signal or not</i>	226	30268	480828	515424	
$M_{dimuon} < M_{dijet}$	101	27436	58876	358431	0.1521
$N(pfo)$	97	20843	364	231698	0.1939
$M_{missing}$	79	769	37	2083	1.4508
M_{dimuon}	78	707	7	1732	1.5596
M_{dijet}	68	576	0	830	1.7719
$*cos \theta$	68	576	0	830	1.7719
$cos\theta_{visible}$	64	552	0	452	1.9743
$Angle_{\mu j}$	59	239	0	70	3.1041
M_{dimuon}^{rec}	58	214	0	65	3.184
$*M_{dijet}^{rec}$	58	214	0	65	3.184
$M_{visible}$	57	175	0	54	3.4122
$*P_{visible}$	57	175	0	54	3.4122
$*P_{T_{visible}}$	57	175	0	54	3.4122
$*E_{leading\ jet}$	57	175	0	54	3.4122
$*P_{T_{leading\ jet}}$	57	175	0	54	3.4122
$*E_{sub-leading\ jet}$	57	175	0	54	3.4122
$*P_{T_{sub-leading\ jet}}$	57	175	0	54	3.4122
$not\ \mu^+\mu^- HZZ$	57	175	0	54	3.4122
$not\ qqHZZ$	50	130	0	43	3.3773
$not\ qqHZZ$	77	21	0	8	7.4789

➤ This time

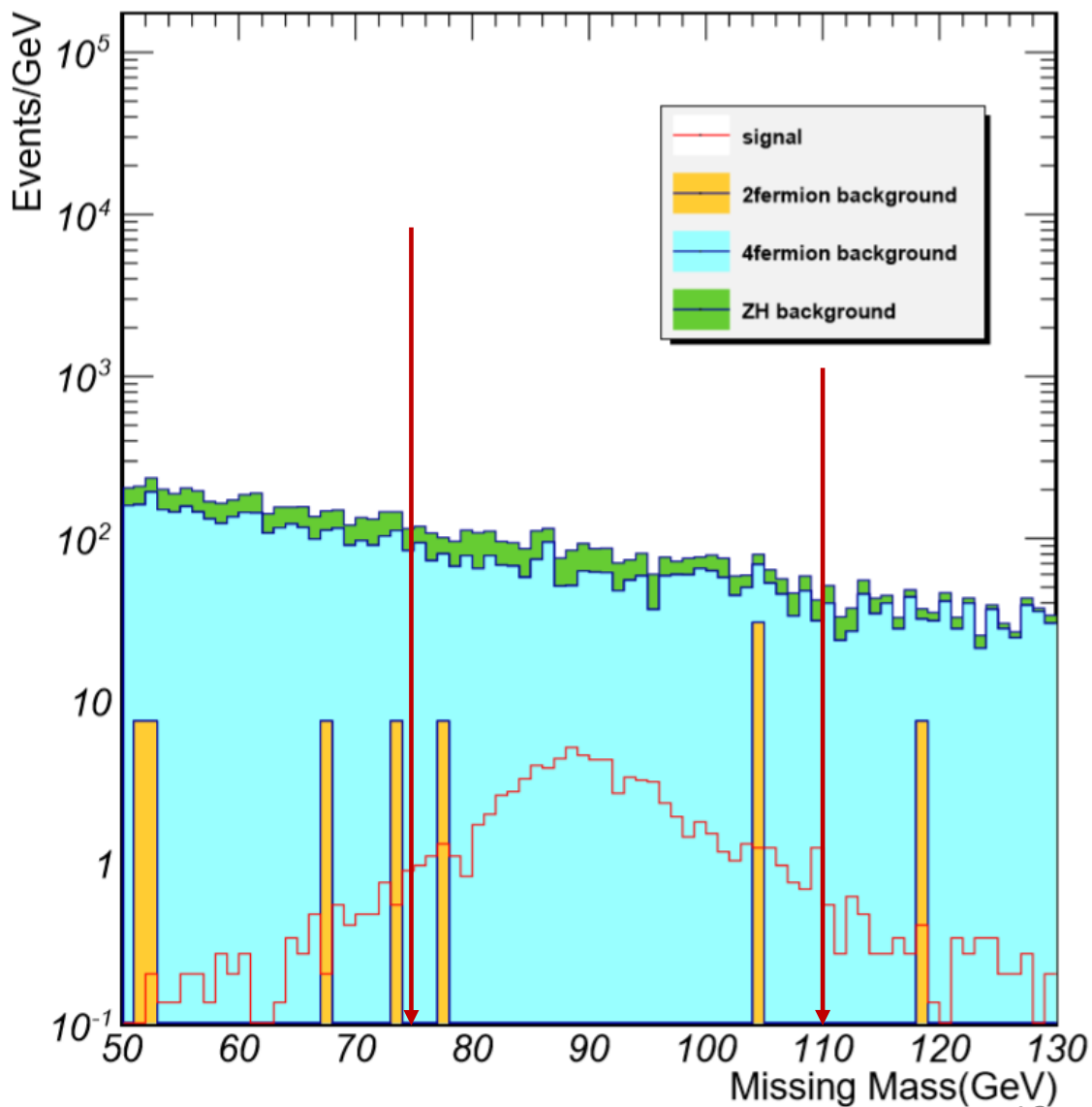
➤ BDT optimized cuts
 $\nu\nu HZZ$, before splitting

$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ $30 < N(pfo) < 100$

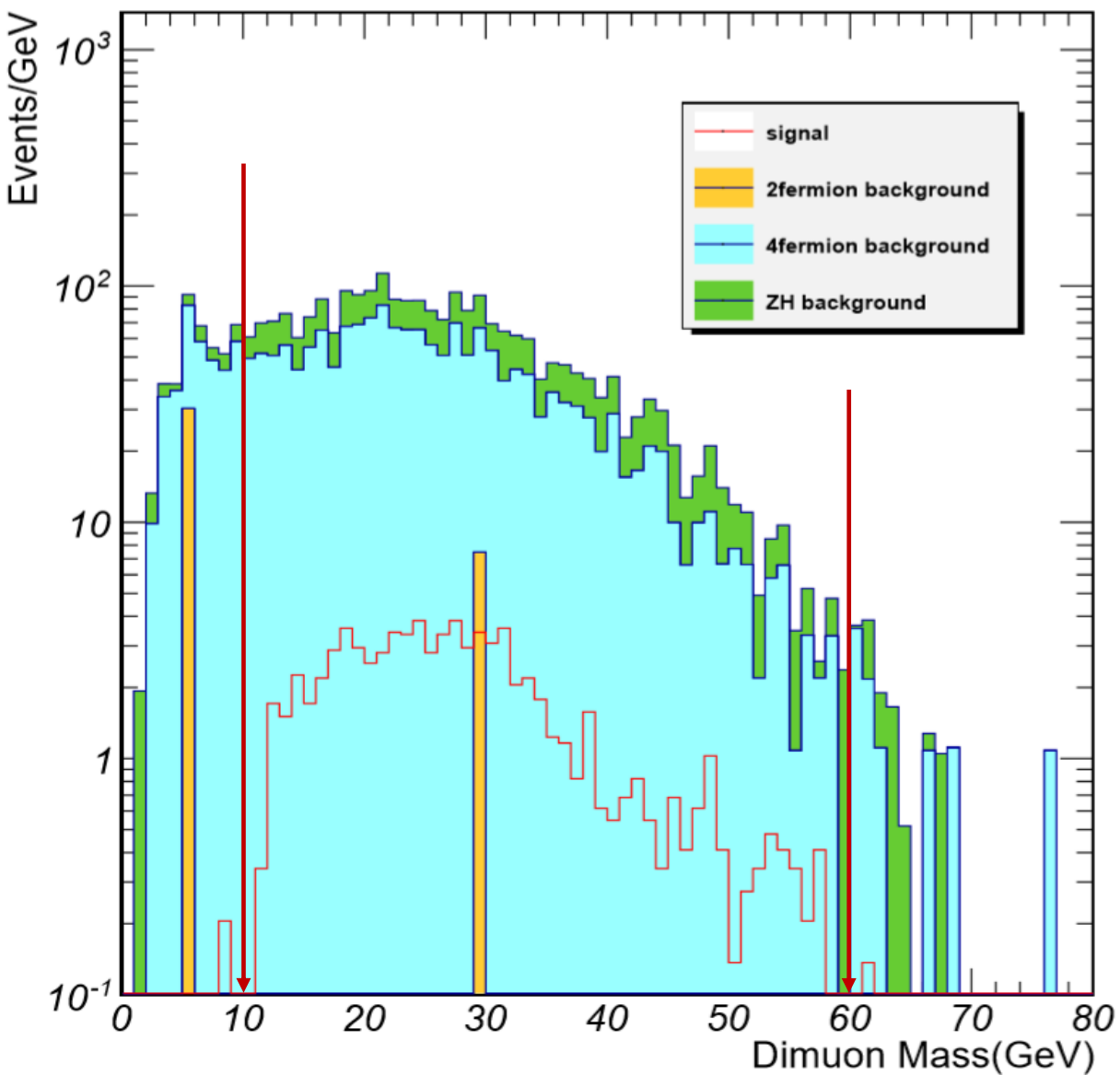


➤ $75 < \text{Missing mass} < 110 \text{ GeV}$

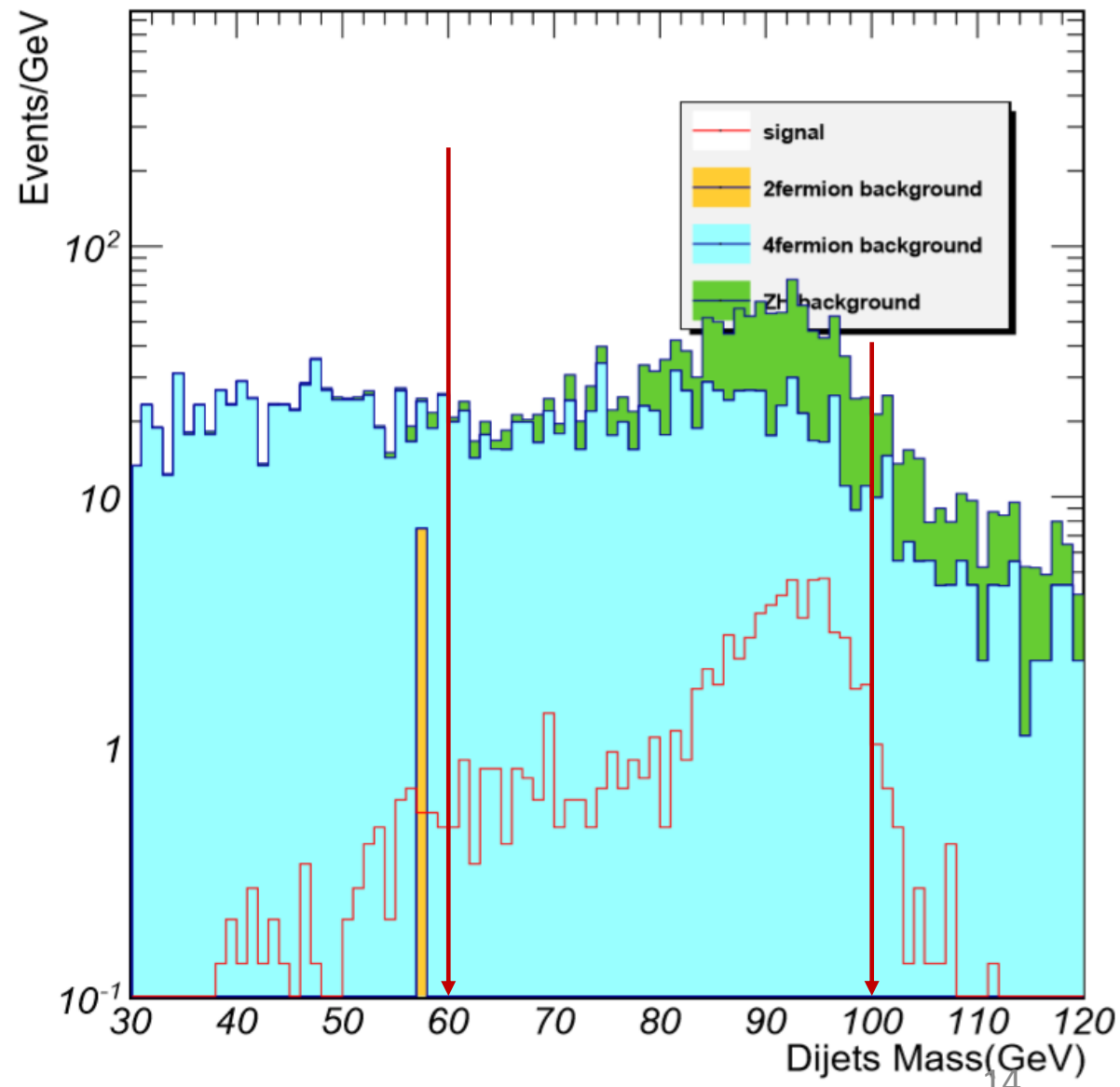


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ $10 < \text{Di-muon mass} < 60 \text{ GeV}$

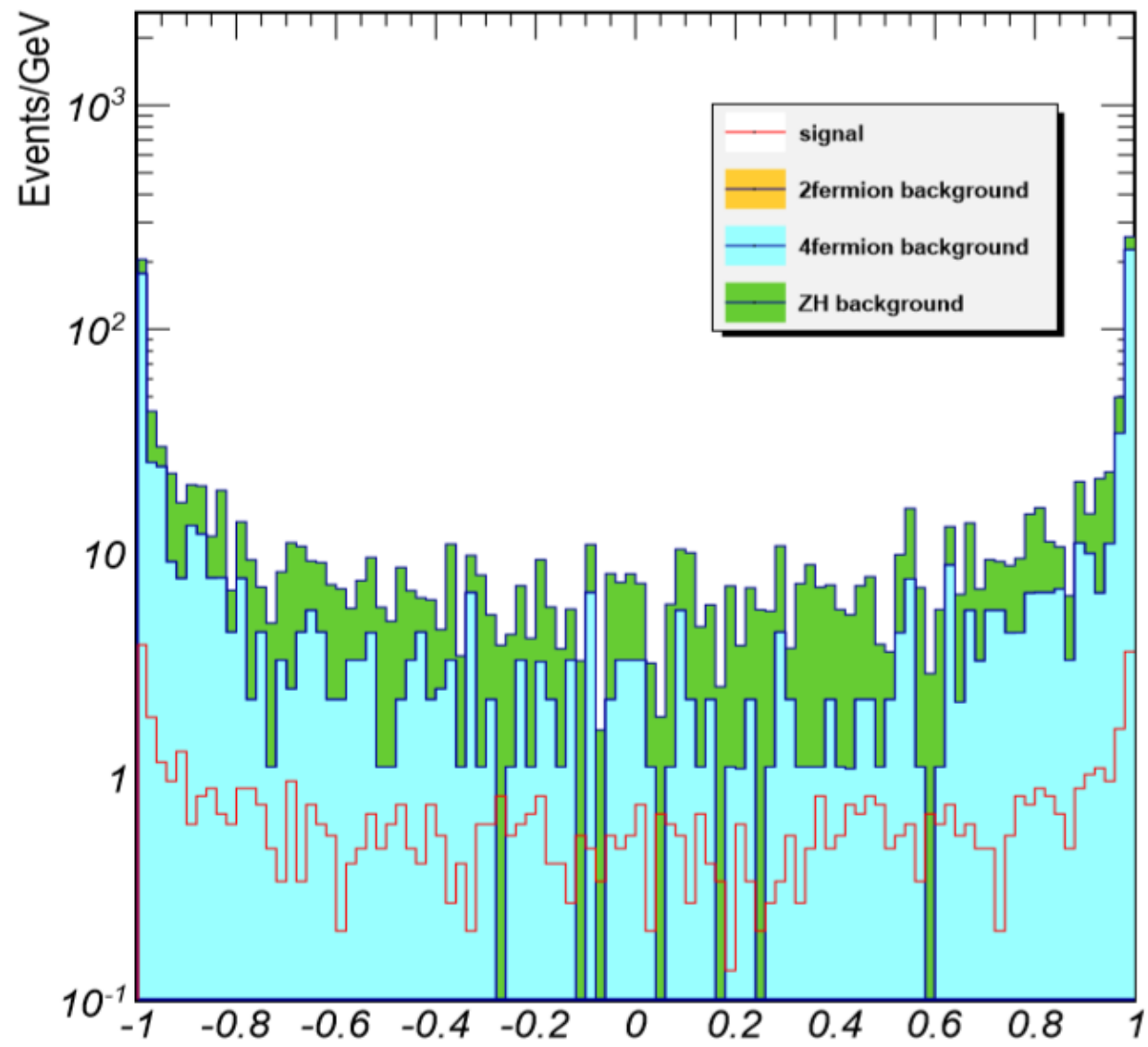


➤ $60 < \text{Di-jet mass} < 100 \text{ GeV}$

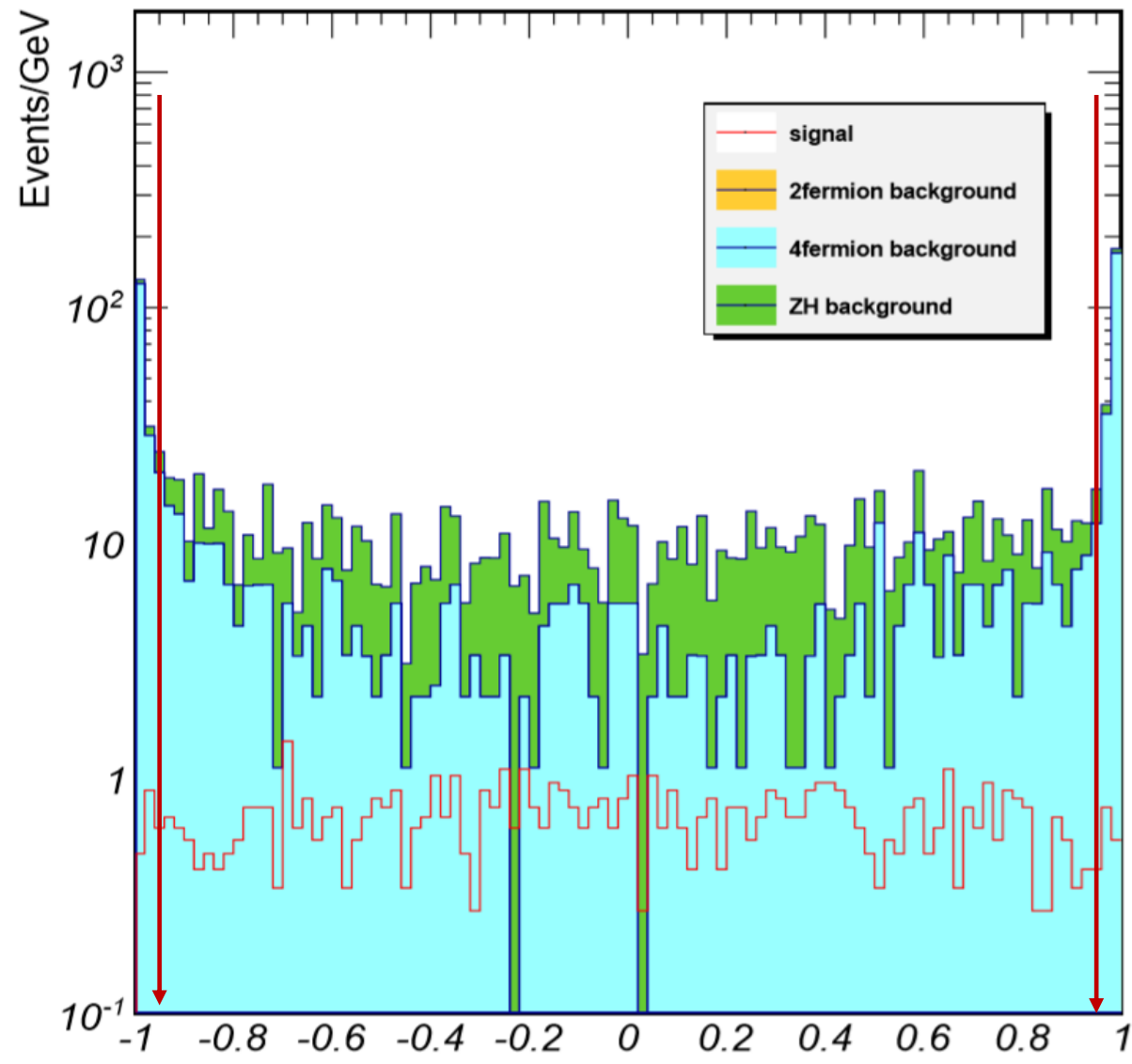


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ $\cos \theta$: no cut

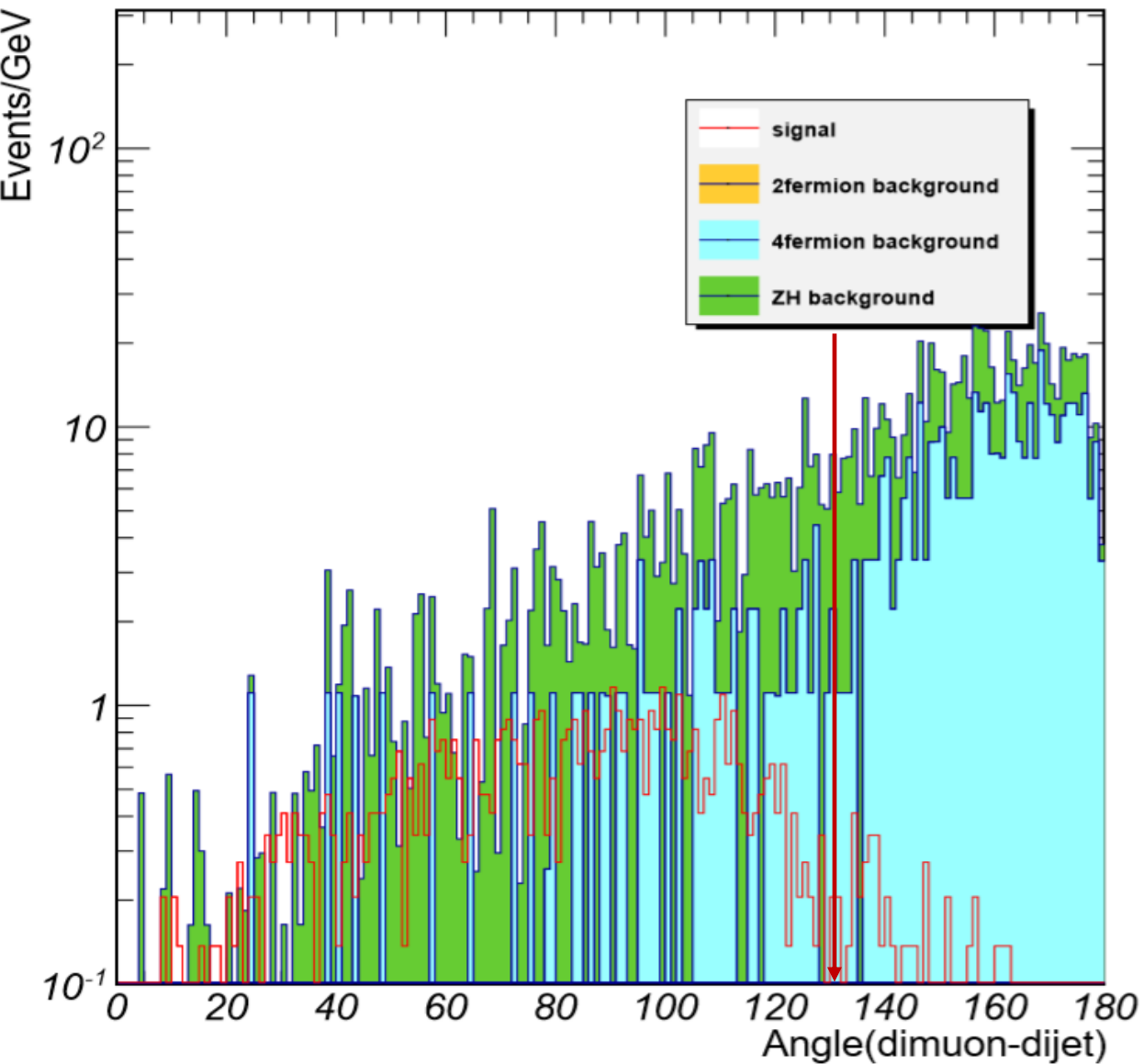


➤ $-0.95 < \cos \theta \text{ (visible)} < 0.95$

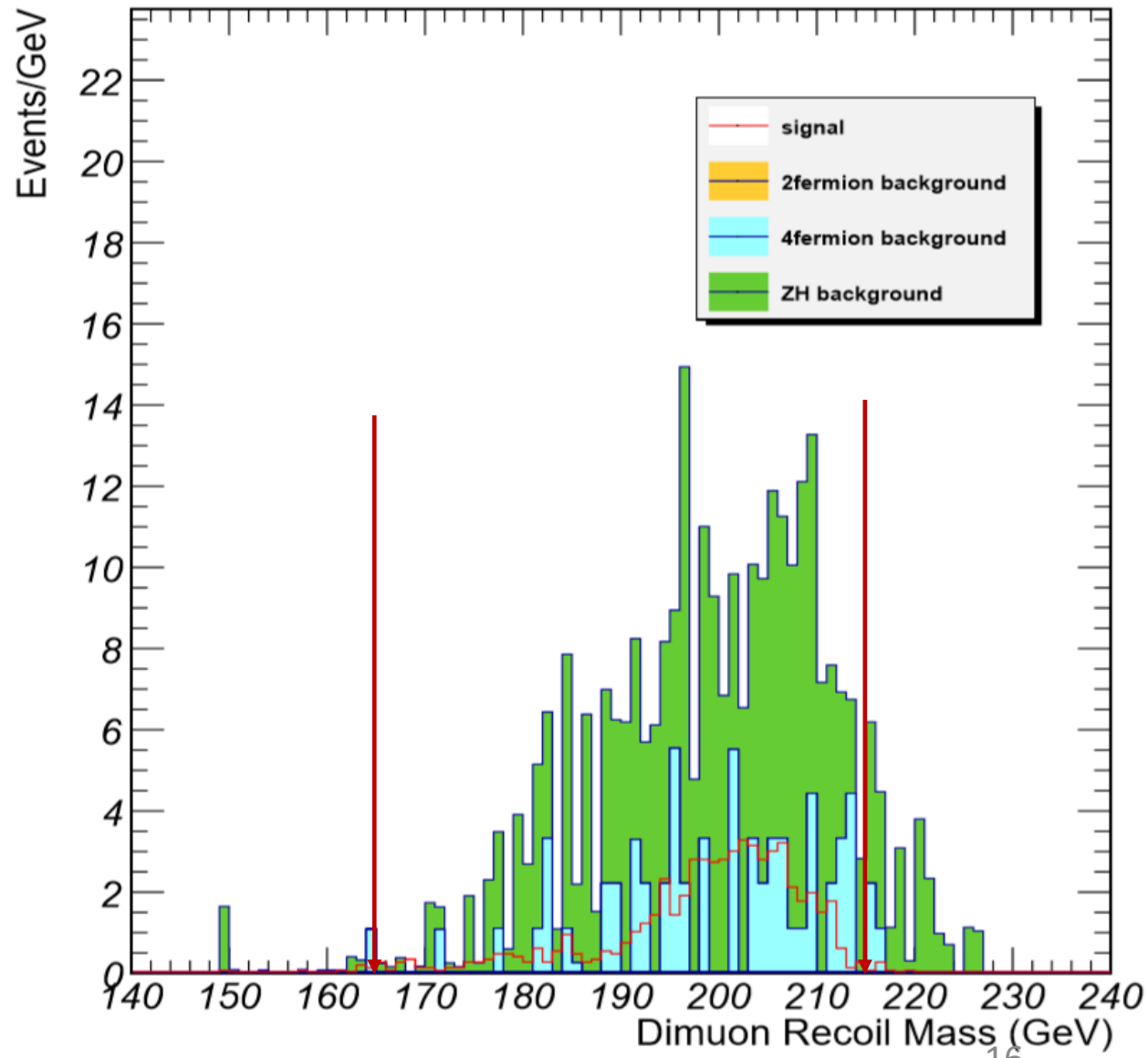


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ Dimuon-dijet angle $< 130^\circ$

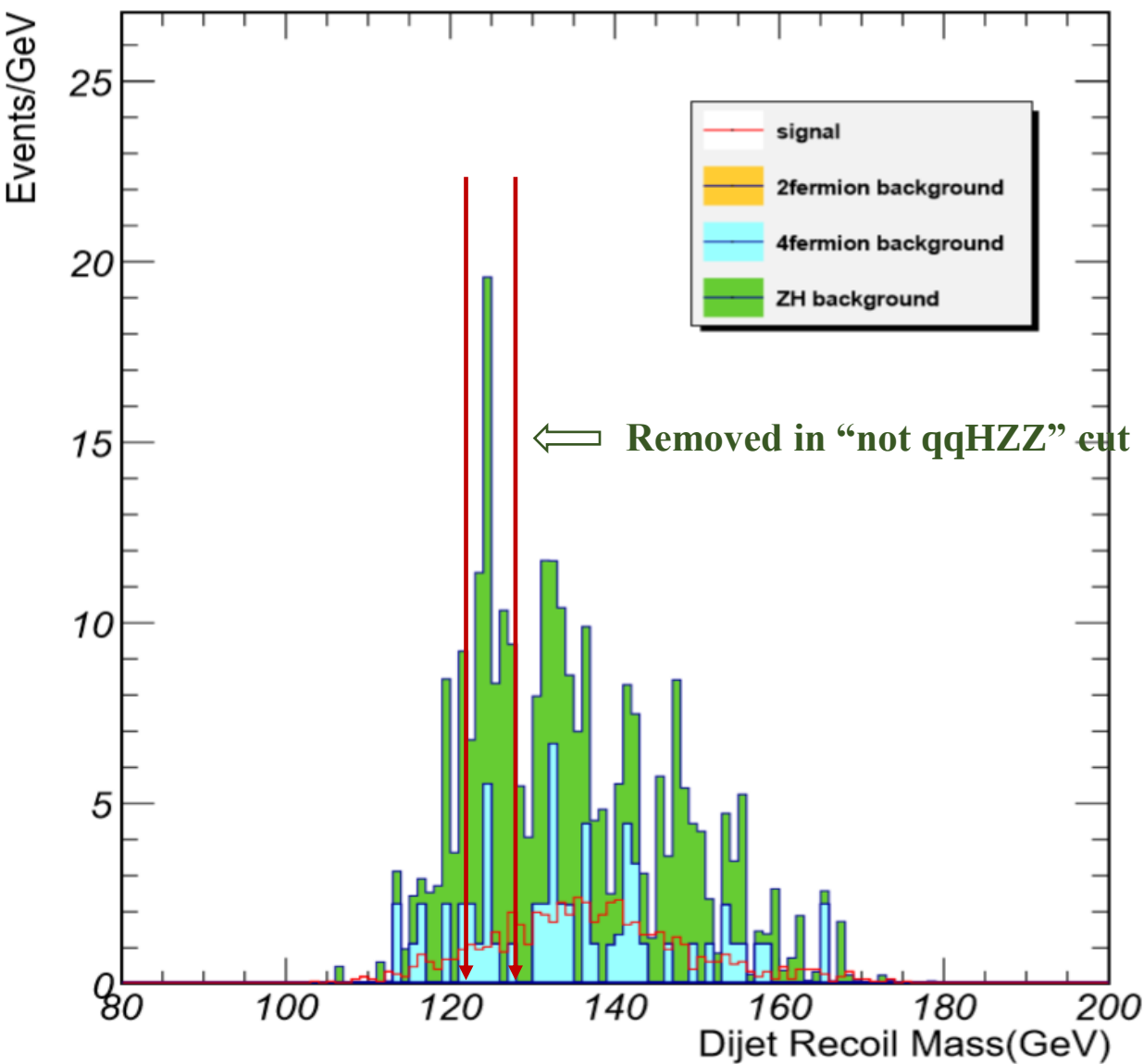


➤ $165 < \text{Di-muon recoil mass} < 215 \text{ GeV}$

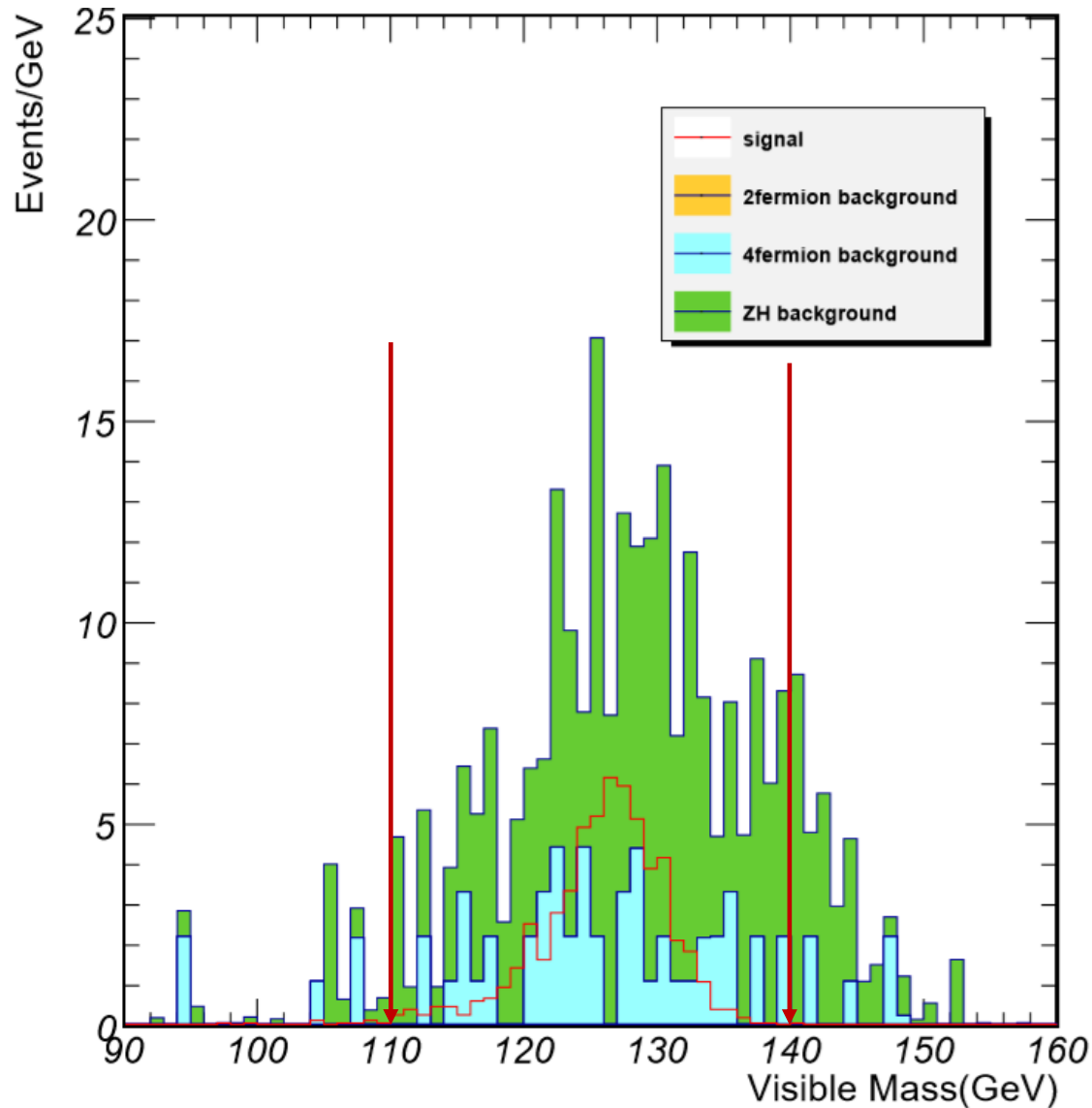


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ **Di-jet recoil mass: no cut**

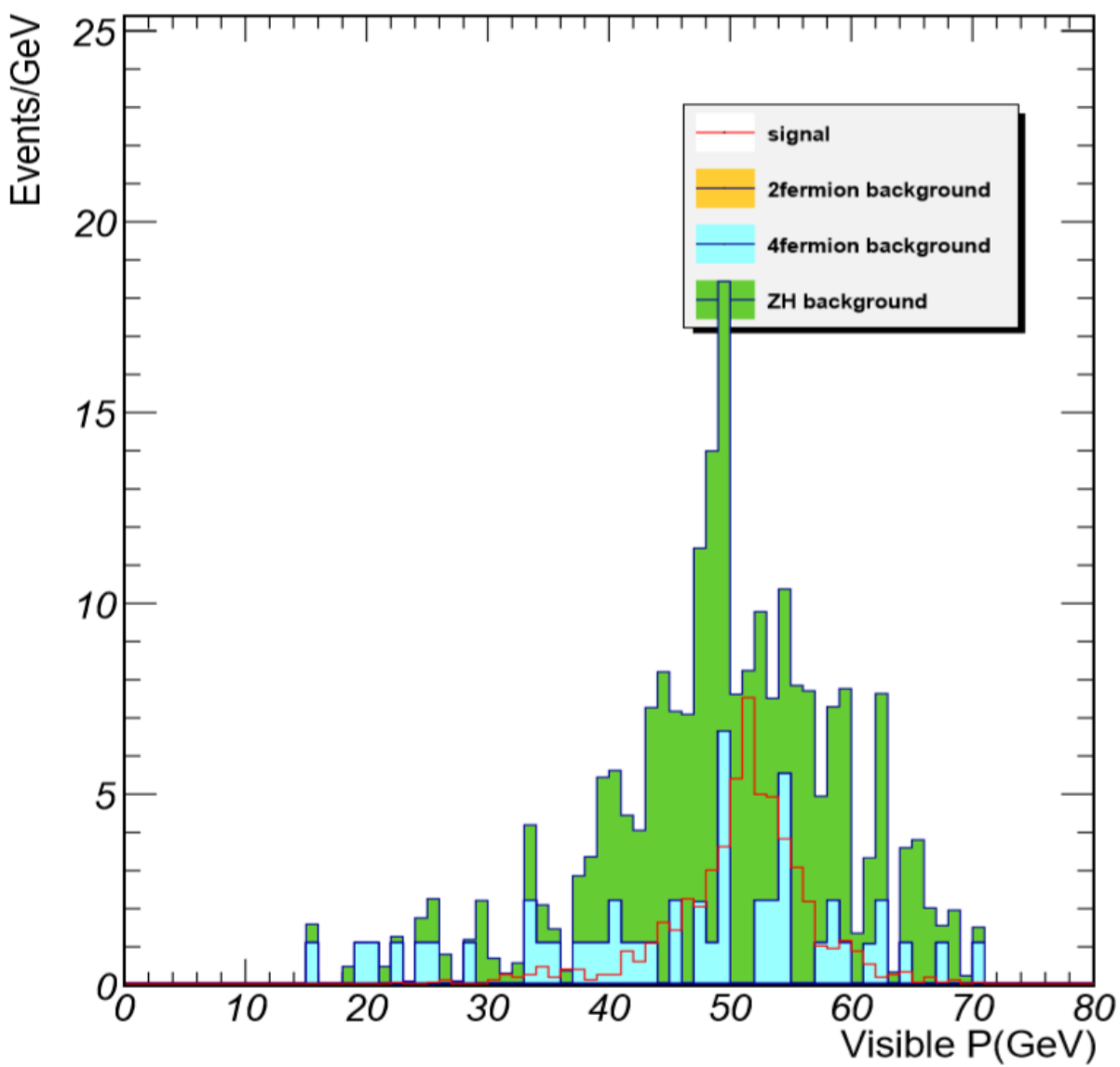


➤ **110 < Visible mass < 140 GeV**

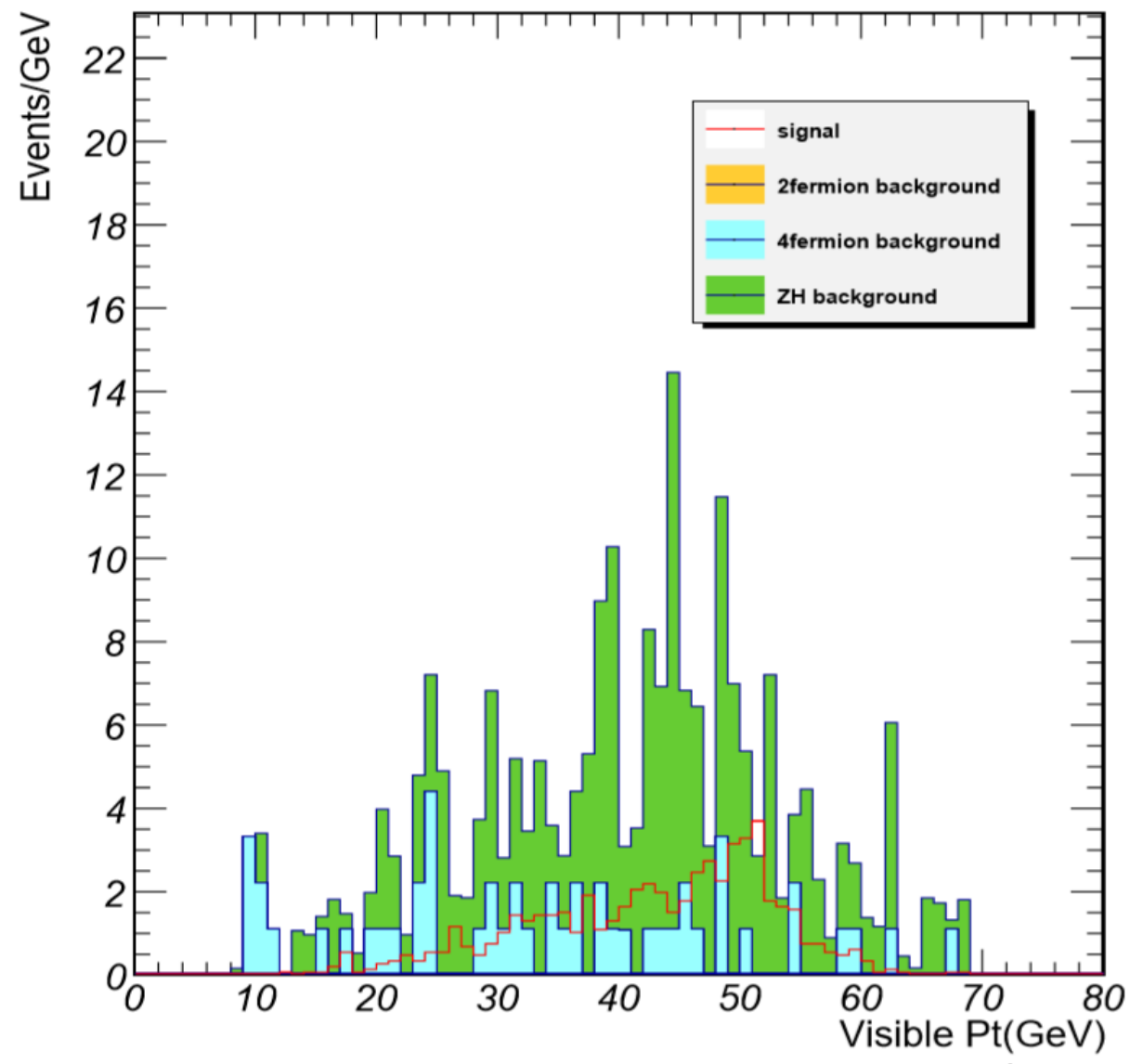


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ **P visible: no cut**

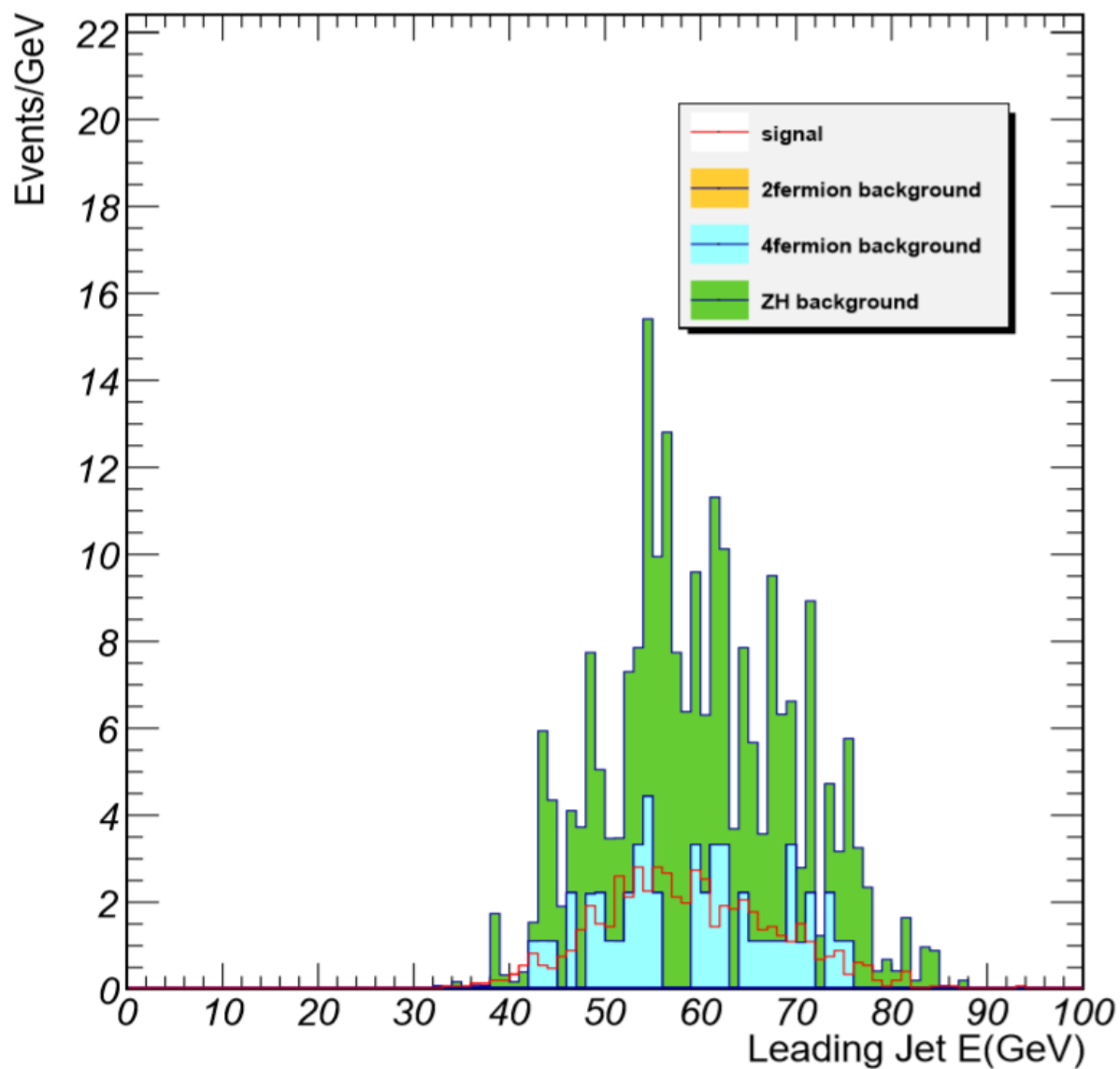


➤ **P_T visible: no cuts**

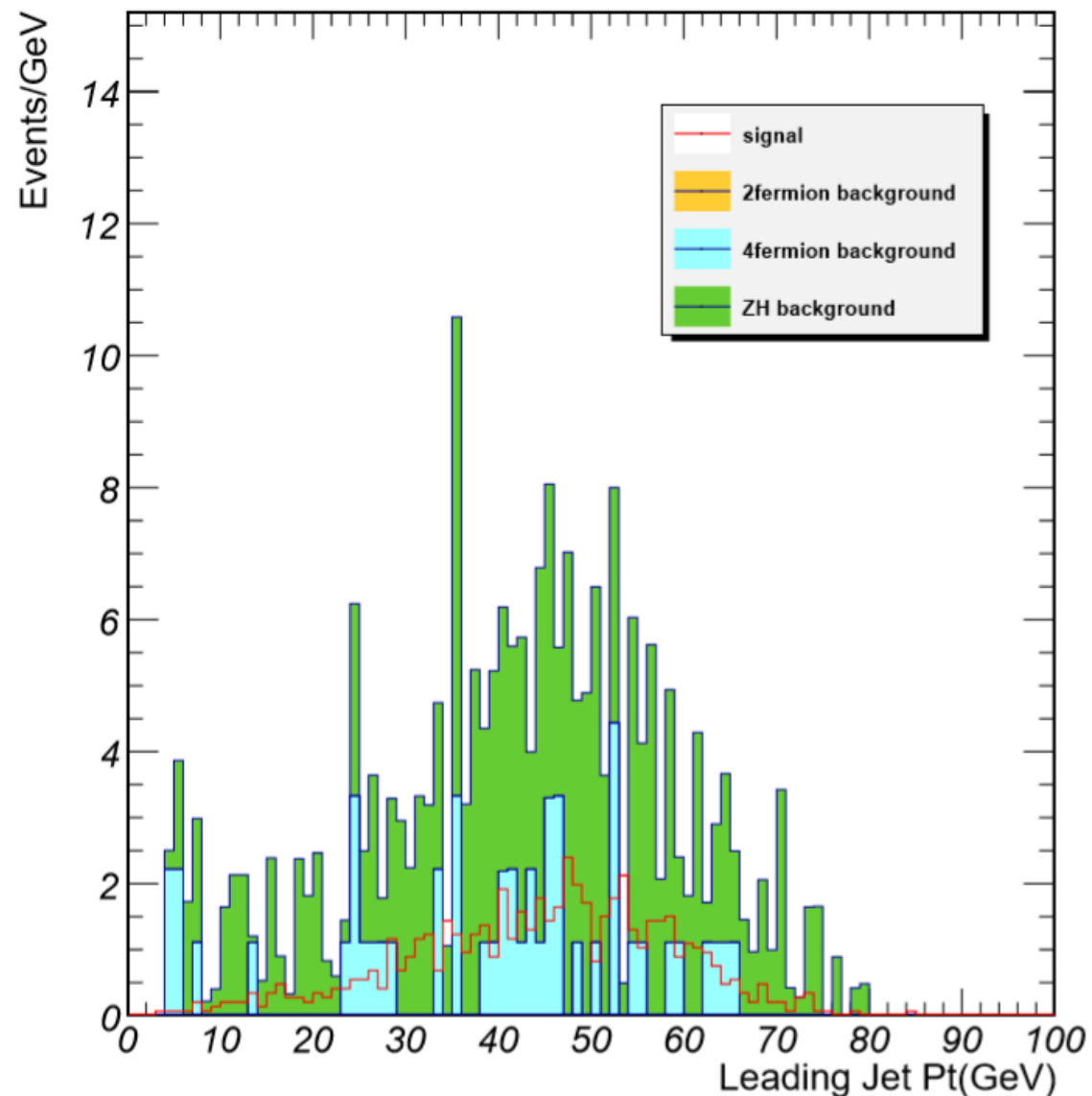


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ **Leading jet E: no cut**

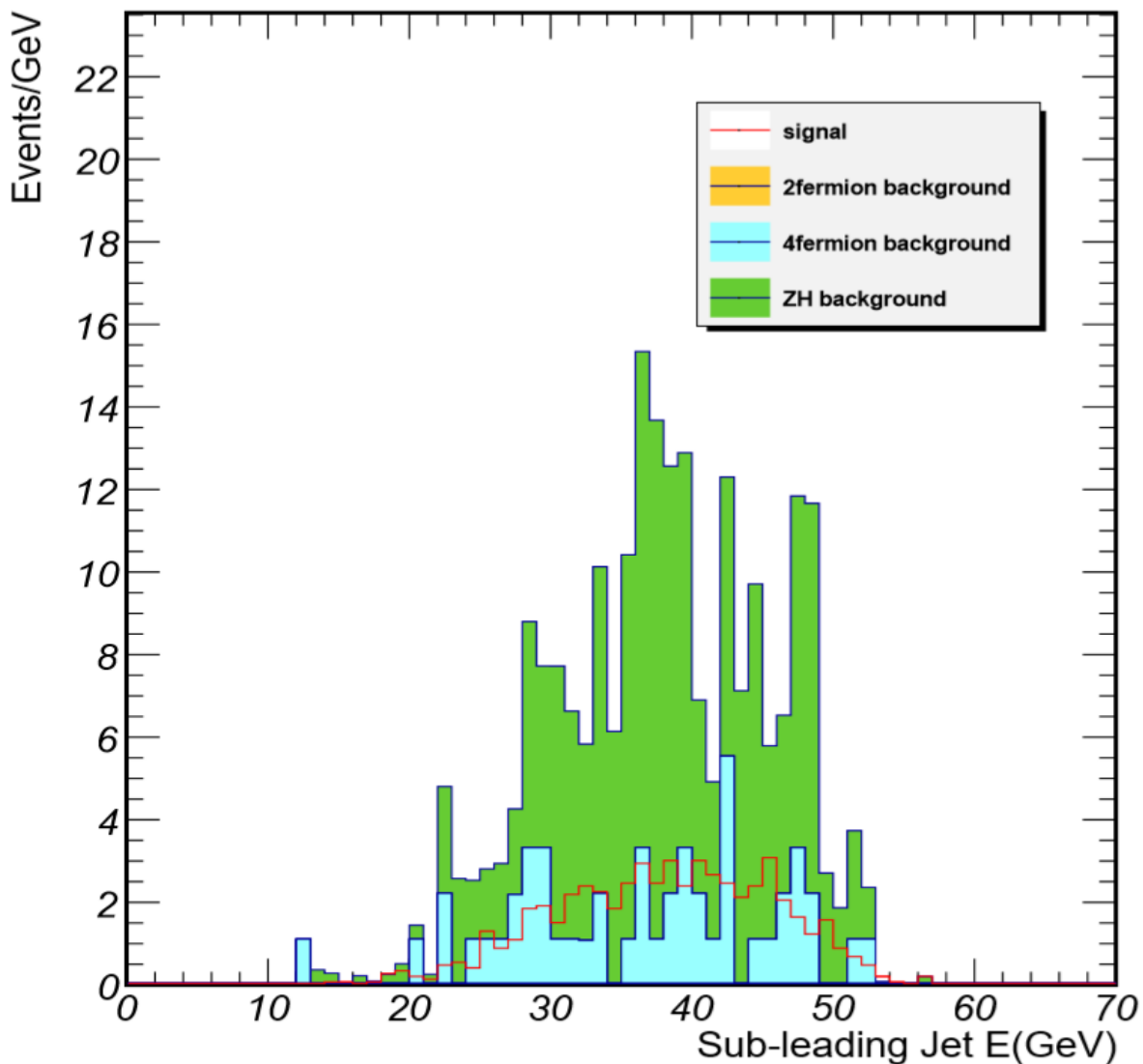


➤ **Leading jet P_T : no cut**

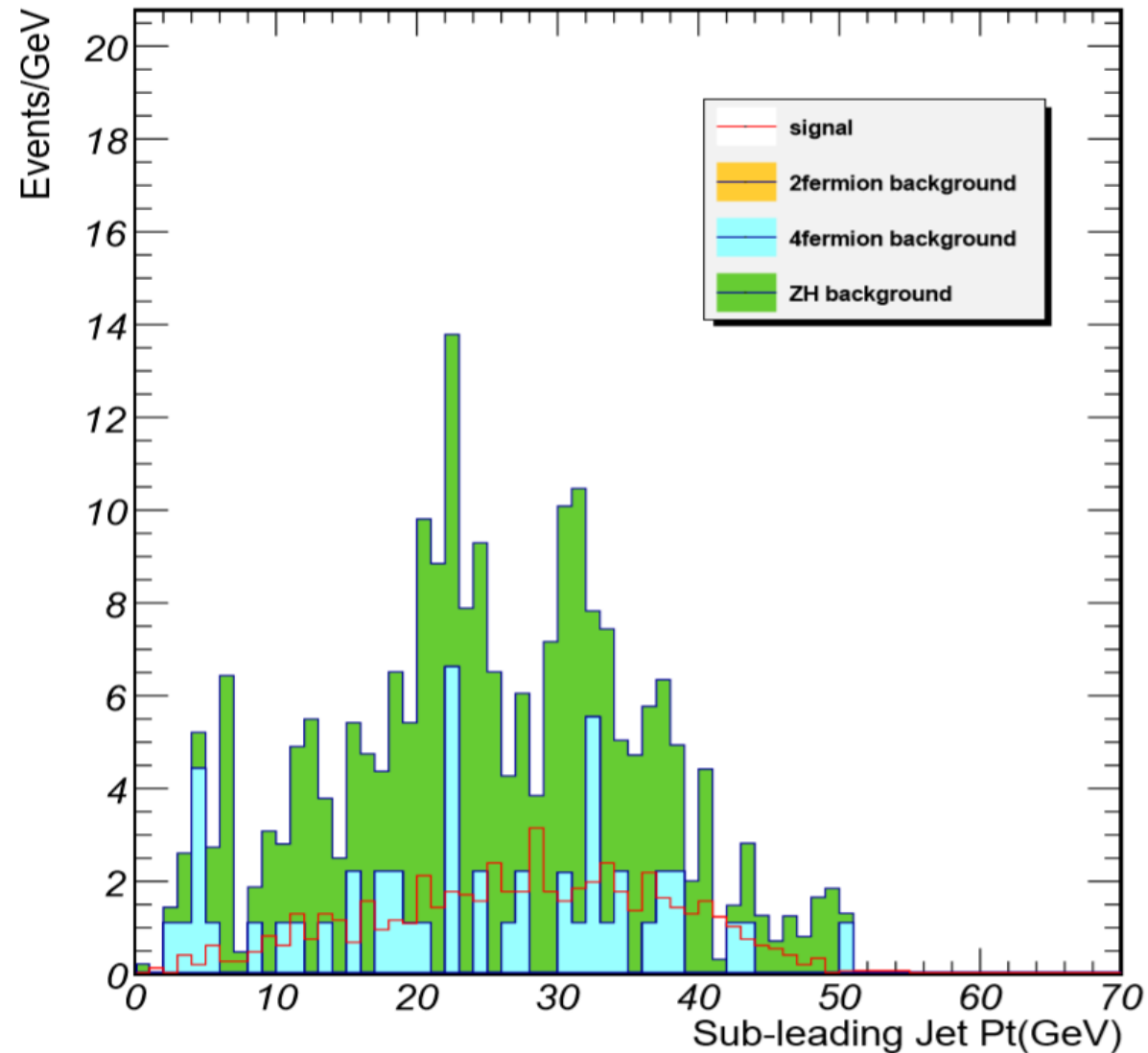


$\nu\nu HZZ$ ($Z \rightarrow qq, Z^* \rightarrow \mu\mu$)

➤ Sub-leading jet E: no cut



➤ Sub-leading jet P_T : no cut



Finally, not mmHZZ and not qqHZZ cuts are applied

Status

- **Finished six channels' cut flows**
- **Updating CEPC memo**

Next to do

- **Finish CEPC memo with new plots/tables**
- **Update analysis code on github**