CEPC HZZ Analysis Update

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Introduction

- **Cut-based only analysis**
- **Will discuss qqHvvmm channel only**
- **Every distribution is drawn after its previous cuts applied,**
  then the cut on this observable is determined based on this distribution

$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **Cut Flow Table**

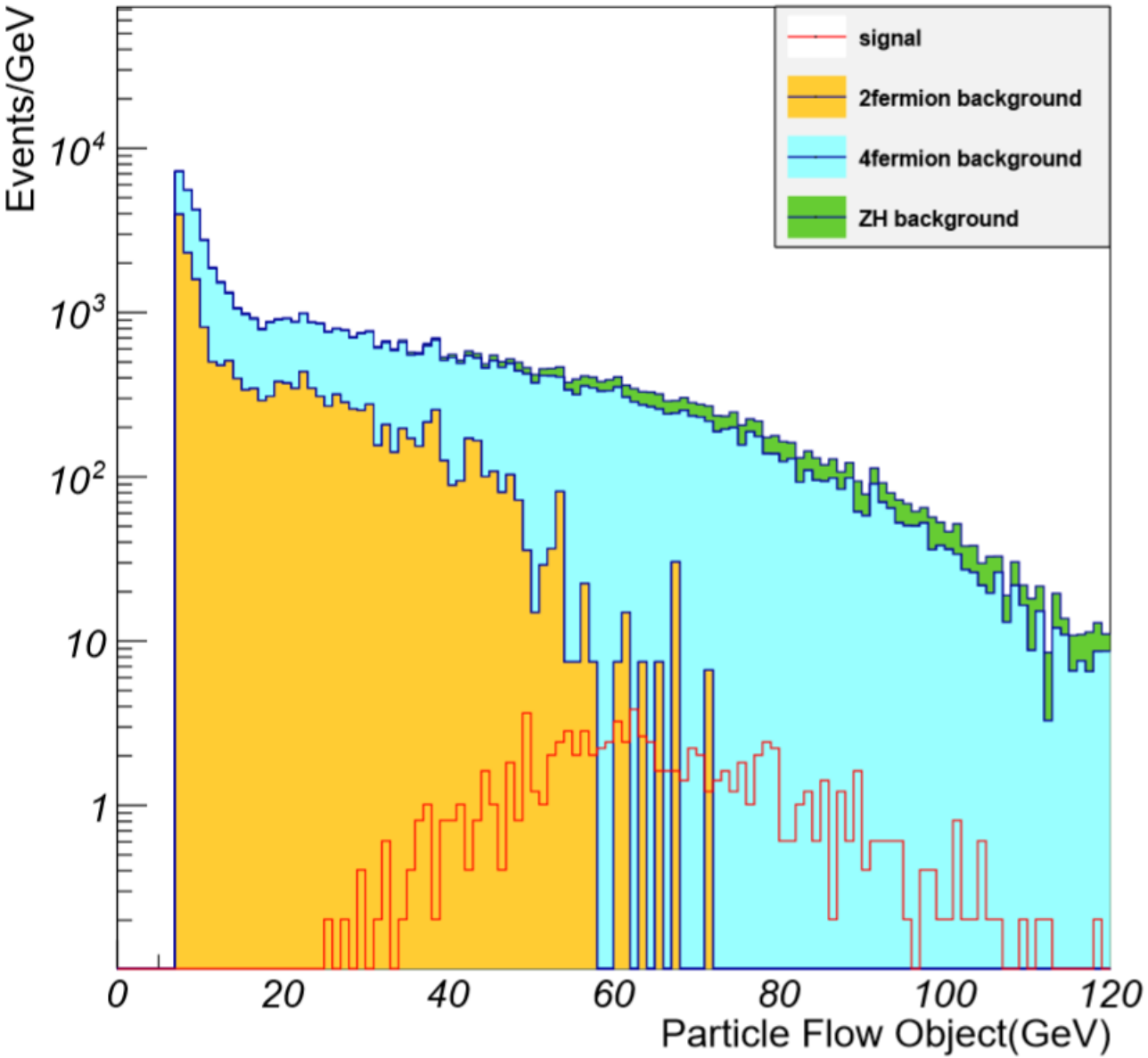
Note: " * " means no cut on this observable

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
$N(pfo)$	84	2242	1212	12626	0.6659
M_{dijet}	75	1532	7	4965	0.9263
M_{dimuon}	68	1231	0	2803	1.0623
$M_{missing}$	57	575	0	572	1.6625
$*cos\ \theta$	57	575	0	572	1.6625
$cos\theta_{visible}$	55	551	0	403	1.7334
$Angle_{\mu j}$	52	495	0	365	1.7354
M^{rec}_{dimuon}	51	438	0	318	1.8032
M^{rec}_{dijet}	49	378	0	220	1.9249
$M_{visible}$	46	340	0	196	1.936
$*P_{visible}$	46	340	0	196	1.936
$Pt_{visible}$	46	327	0	186	1.9512
$*E_{leading\ jet}$	46	327	0	186	1.9512
$*Pt_{leading\ jet}$	46	327	0	186	1.9512
$*E_{subleading\ jet}$	46	327	0	186	1.9512
$*Pt_{subleading\ jet}$	46	327	0	186	1.9512
$not\mu^+\mu^- HZZ$	46	327	0	186	1.9512
$not\nu\nu HZZ$	40	287	0	170	1.8217
$not\nu\nu HZZ$	35	483	0	360	
$not\nu$	30	166	0	110	

- **This time**
- **2020-2-26 result**
- **BDT optimized cuts**

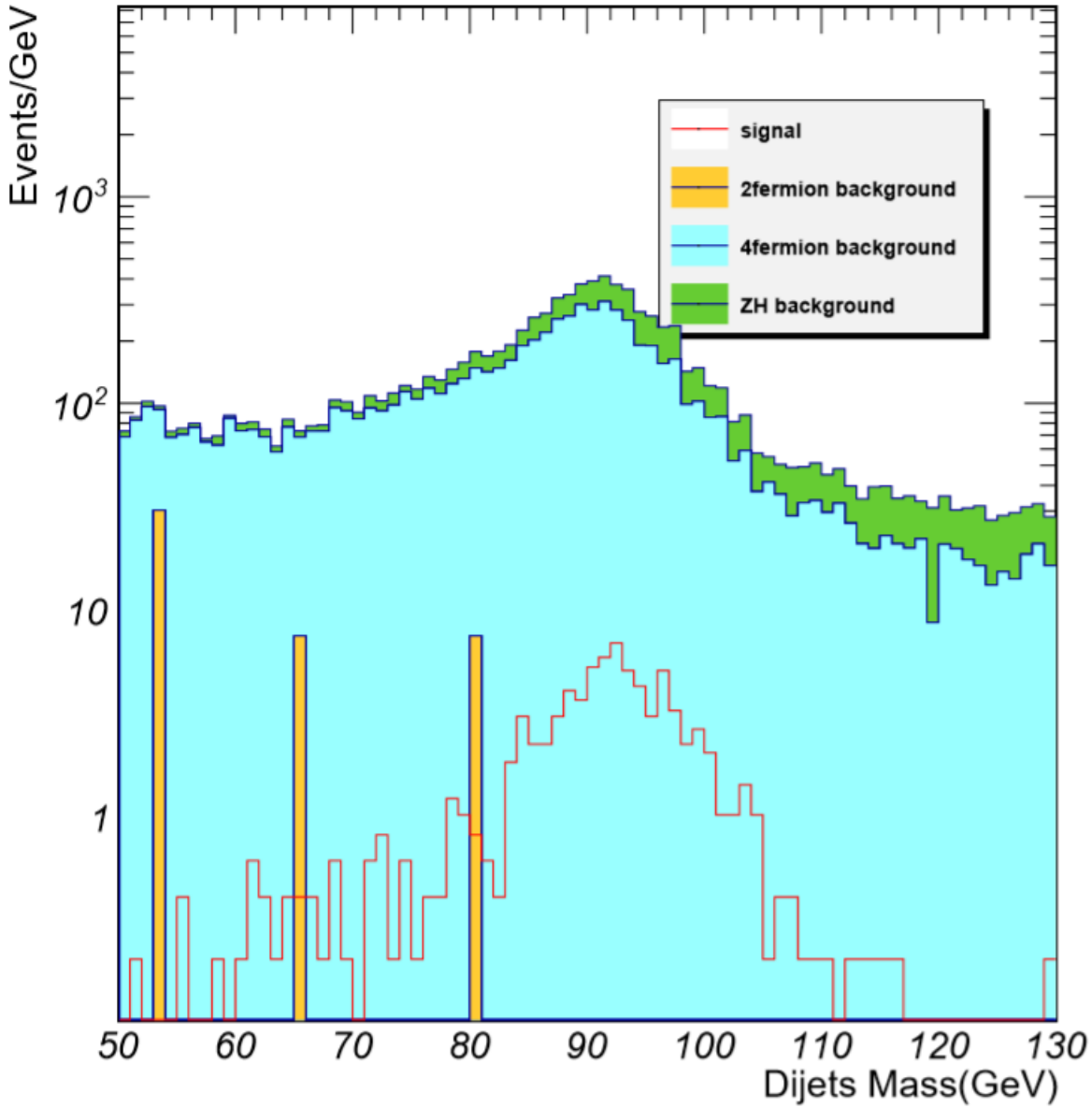
$qqHZZ\ (Z\ \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **$40 < N(pfo) < 95$**



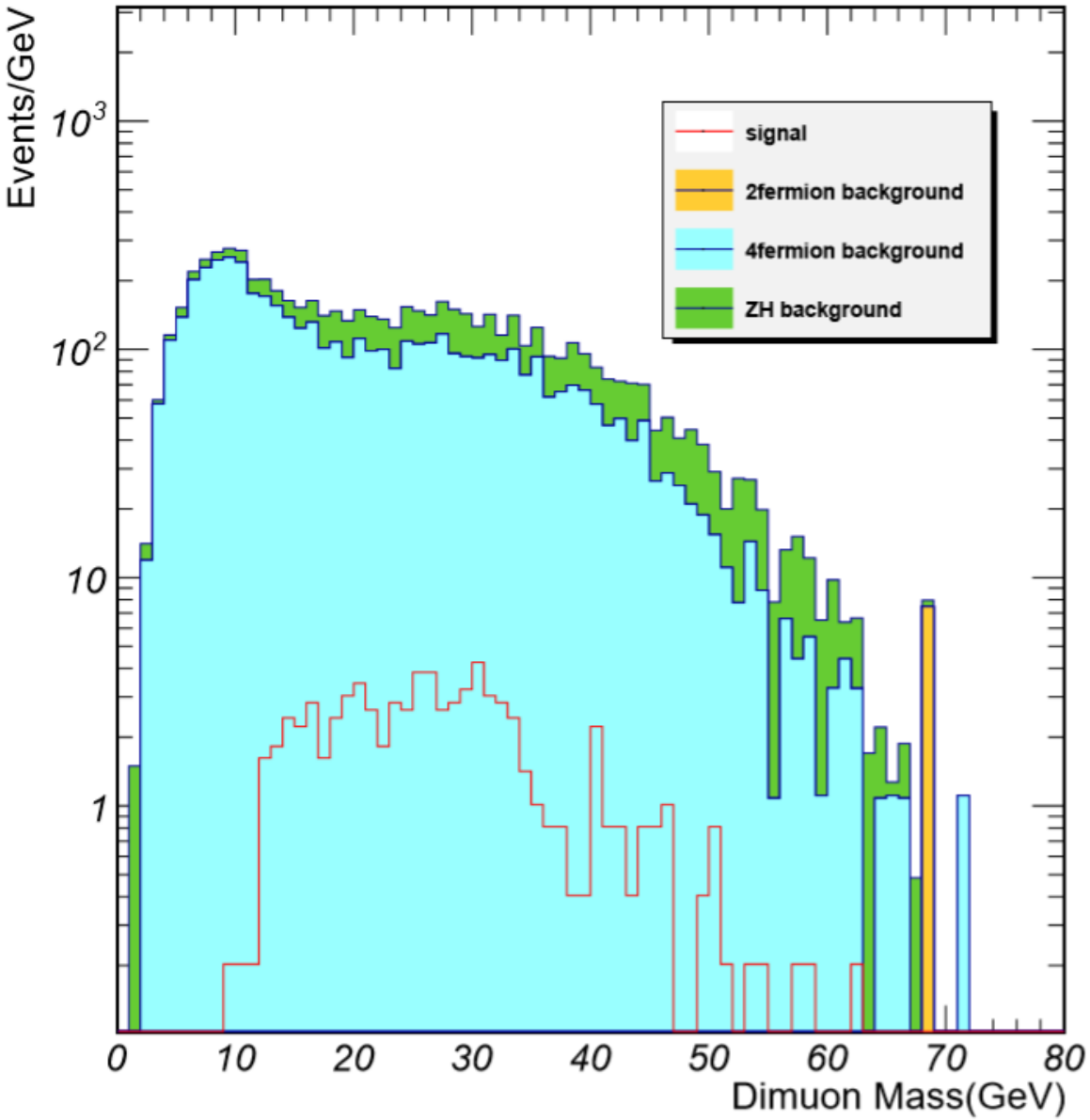
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **75 < Di-jet mass < 105 GeV**



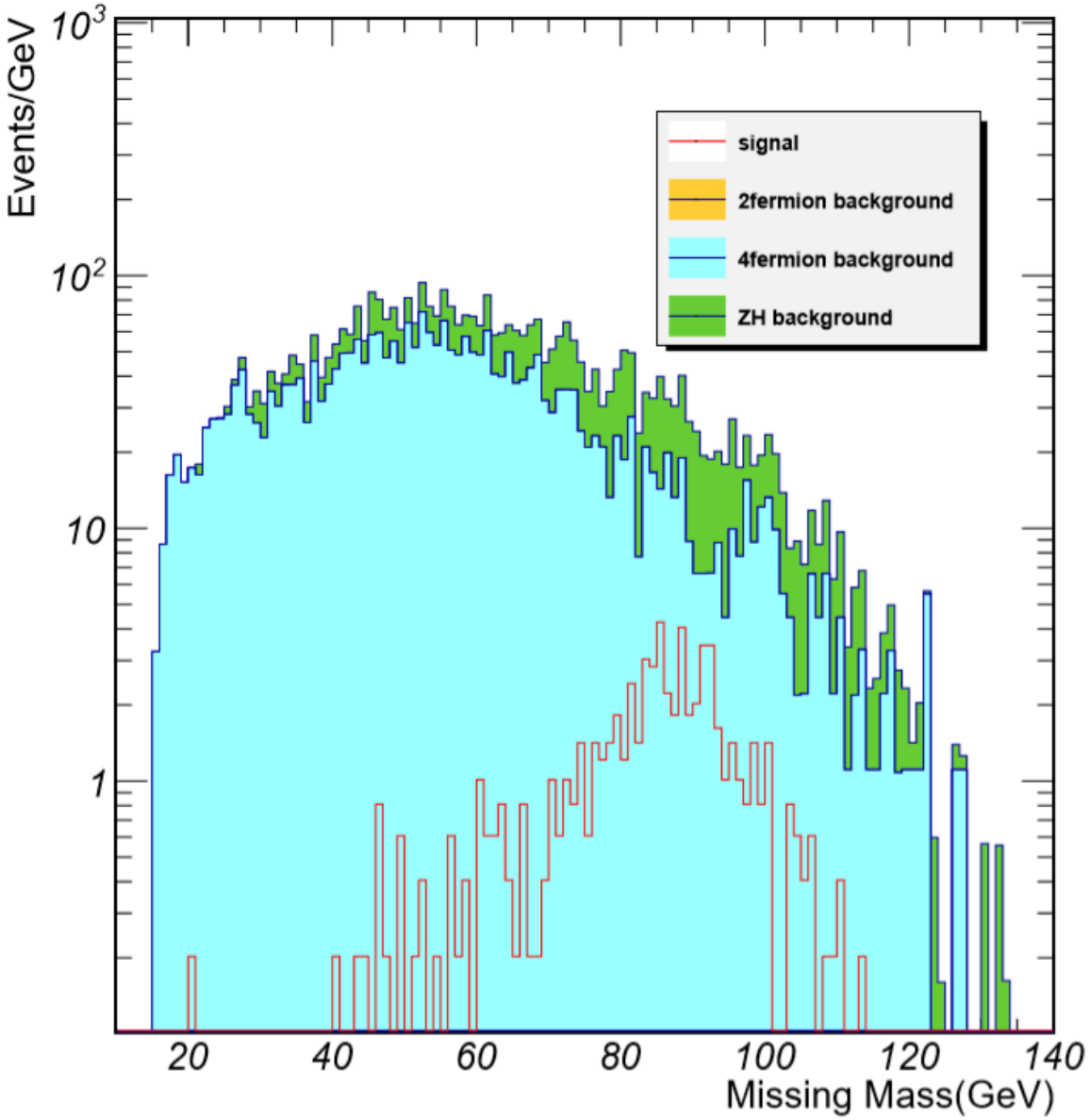
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **15 < Di-muon mass < 55 GeV**



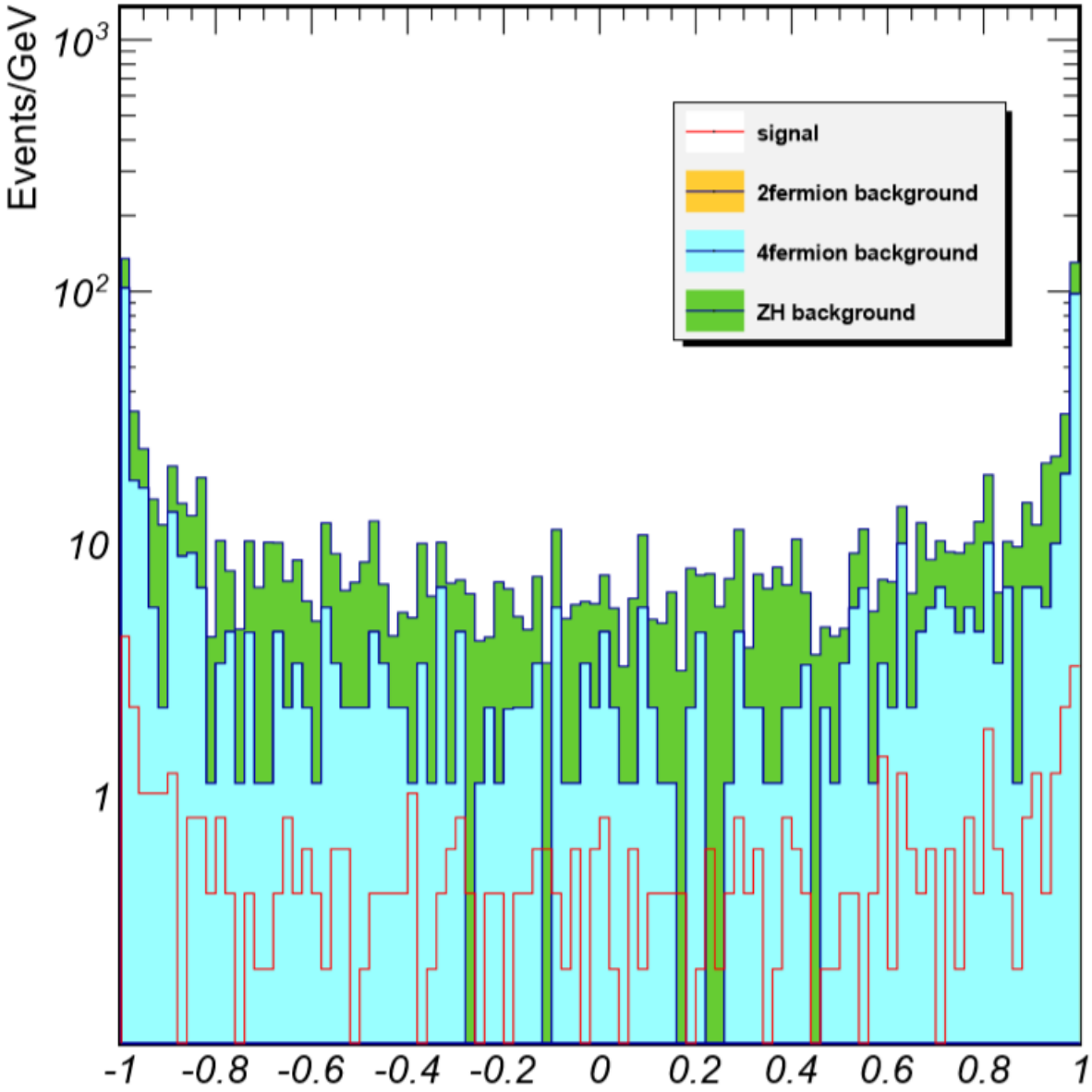
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **70 < Missing mass < 110 GeV**



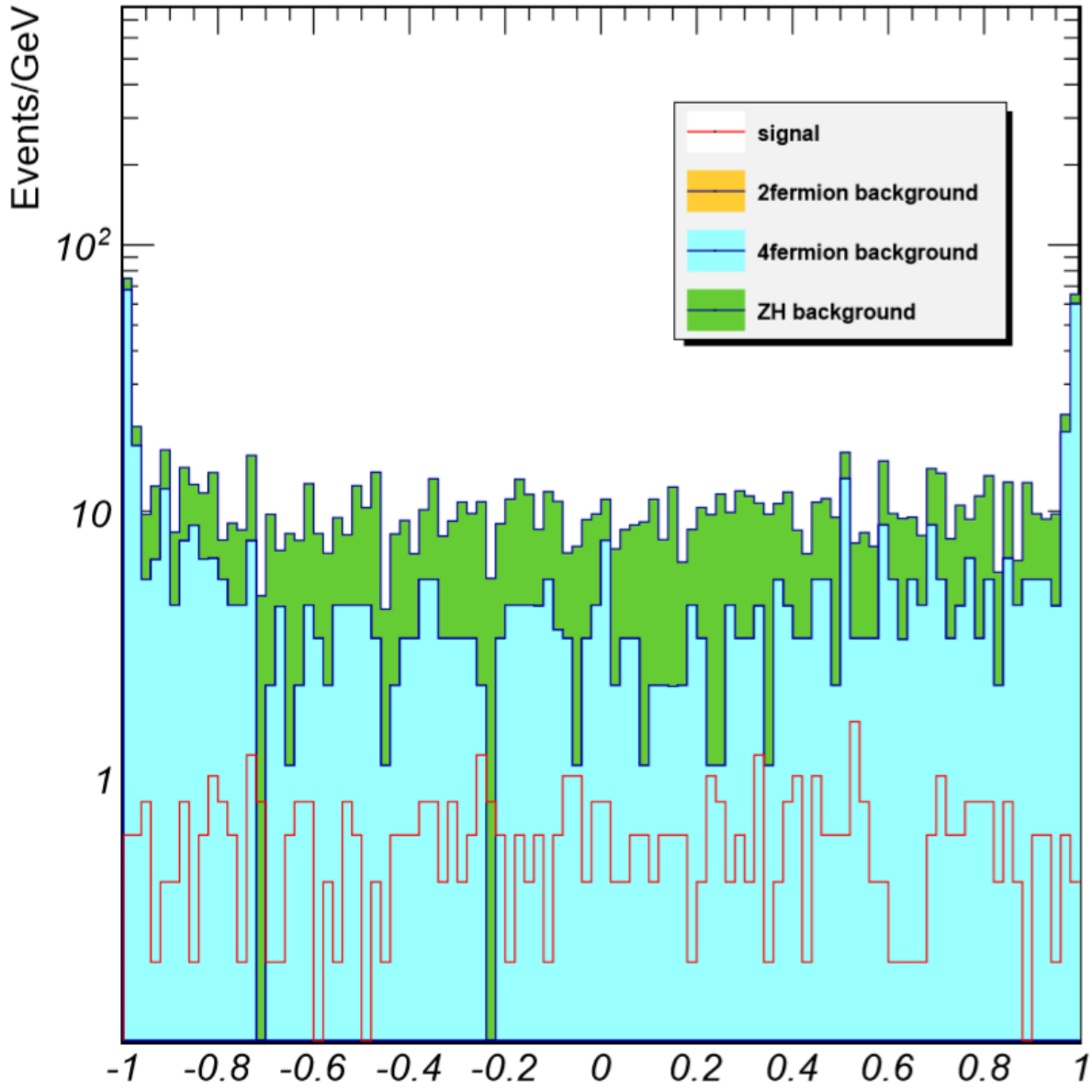
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **cos theta: no cut**



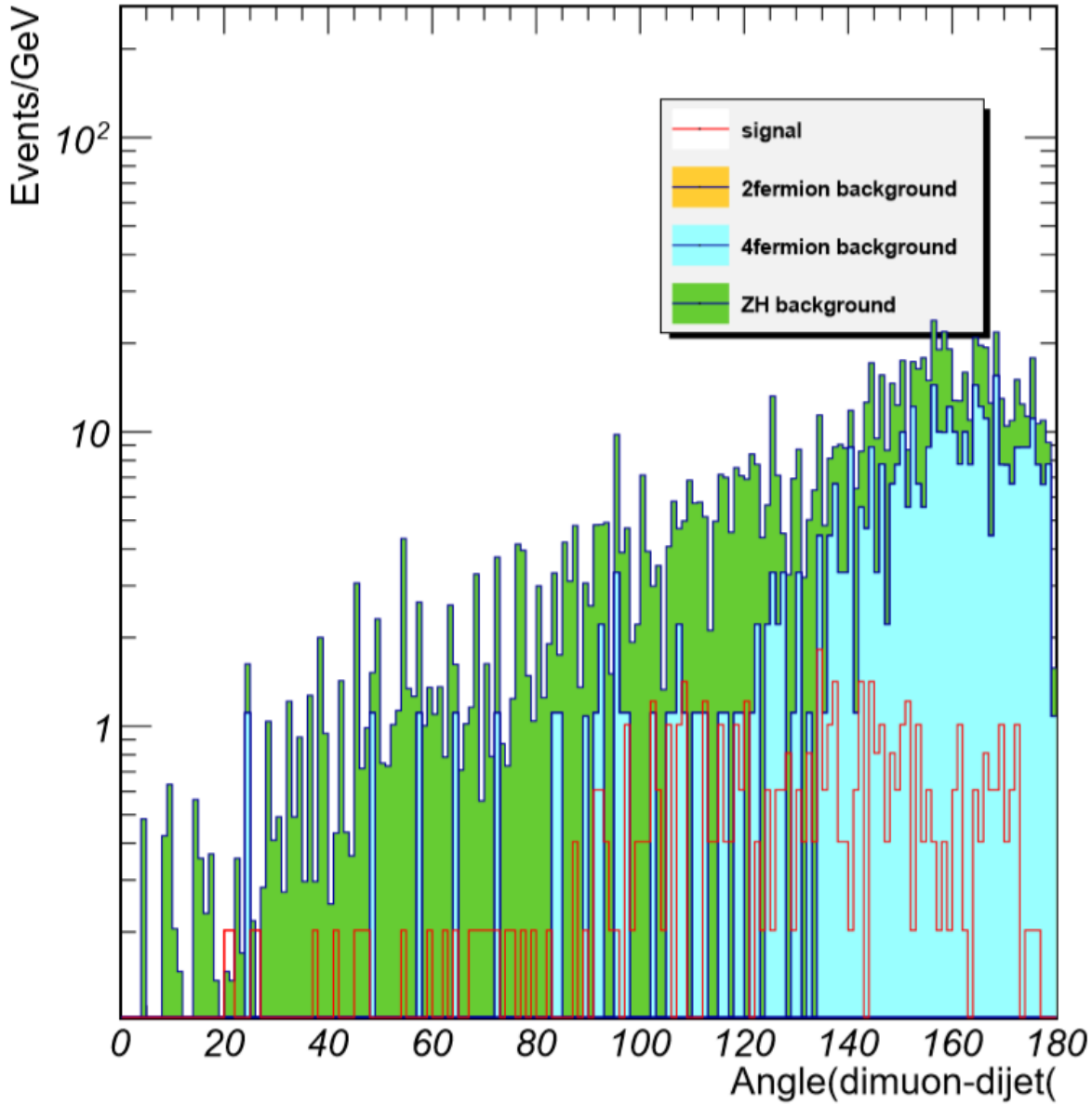
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **-0.95 < cos theta (visible) < 0.95**



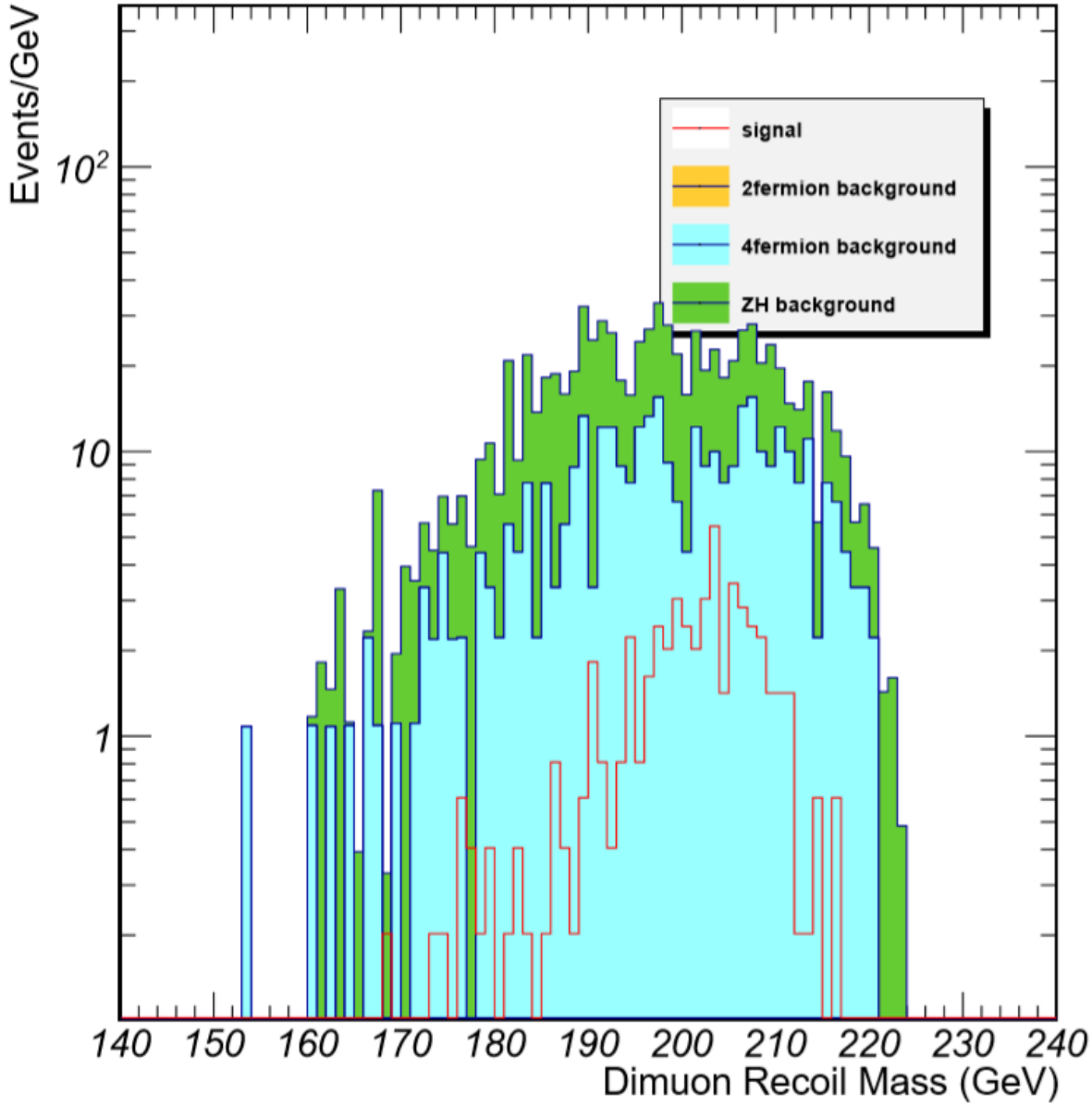
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **60° < Dimuon-dijet angle < 175°**



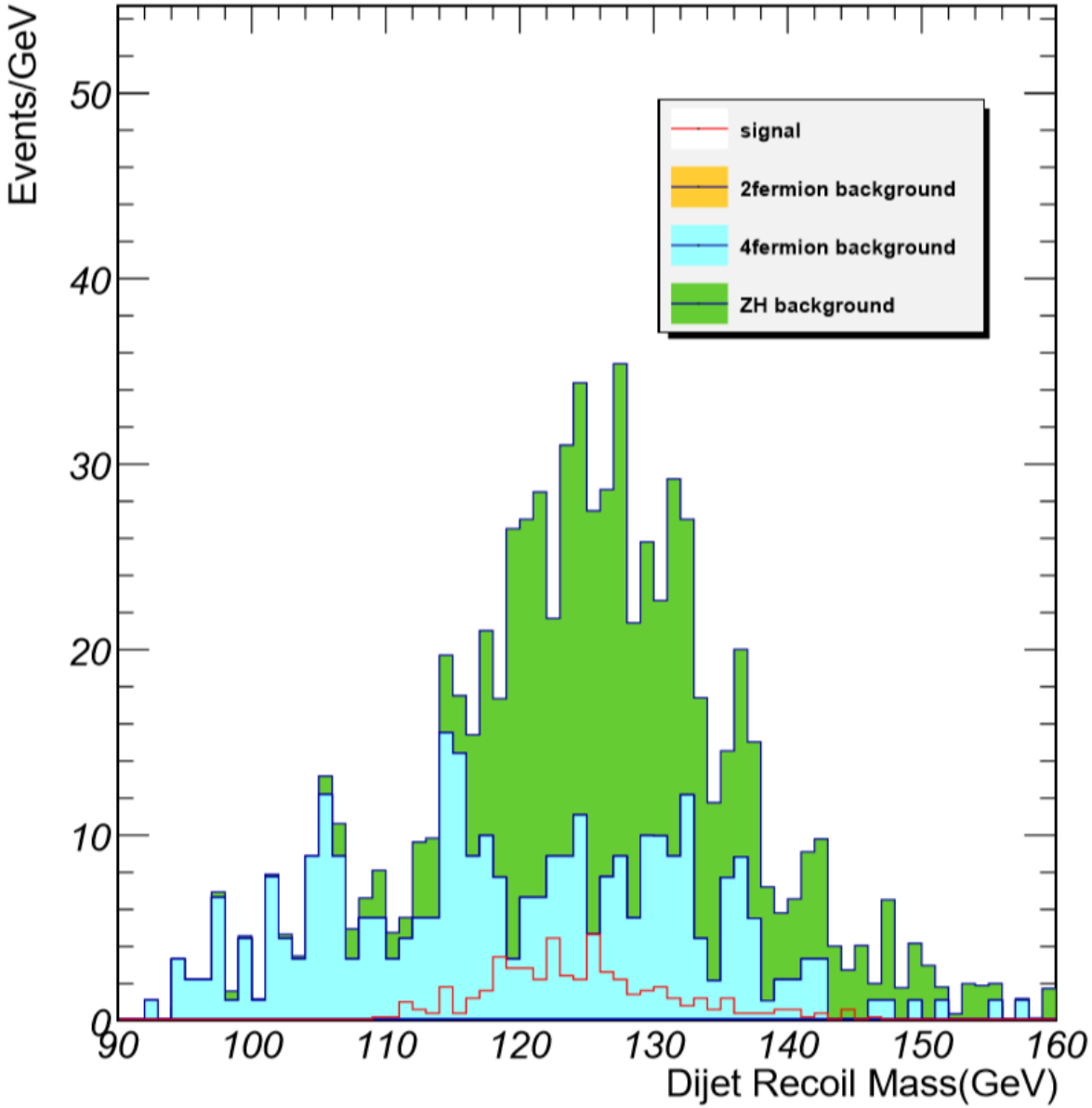
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **175 < Di-muon recoil mass < 215 GeV, and not in [122, 128]**



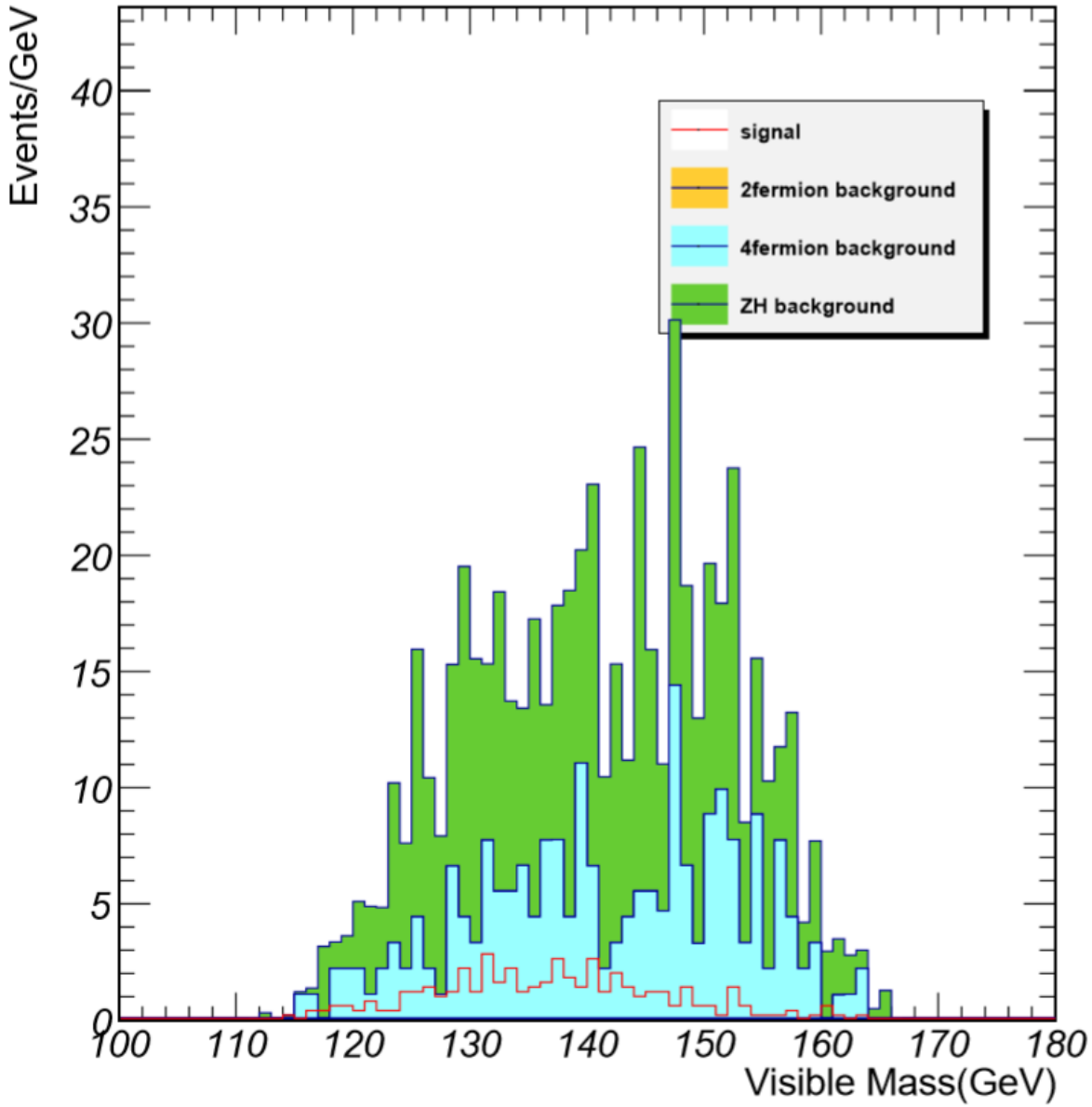
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **110 < Di-jet recoil mass < 140 GeV**



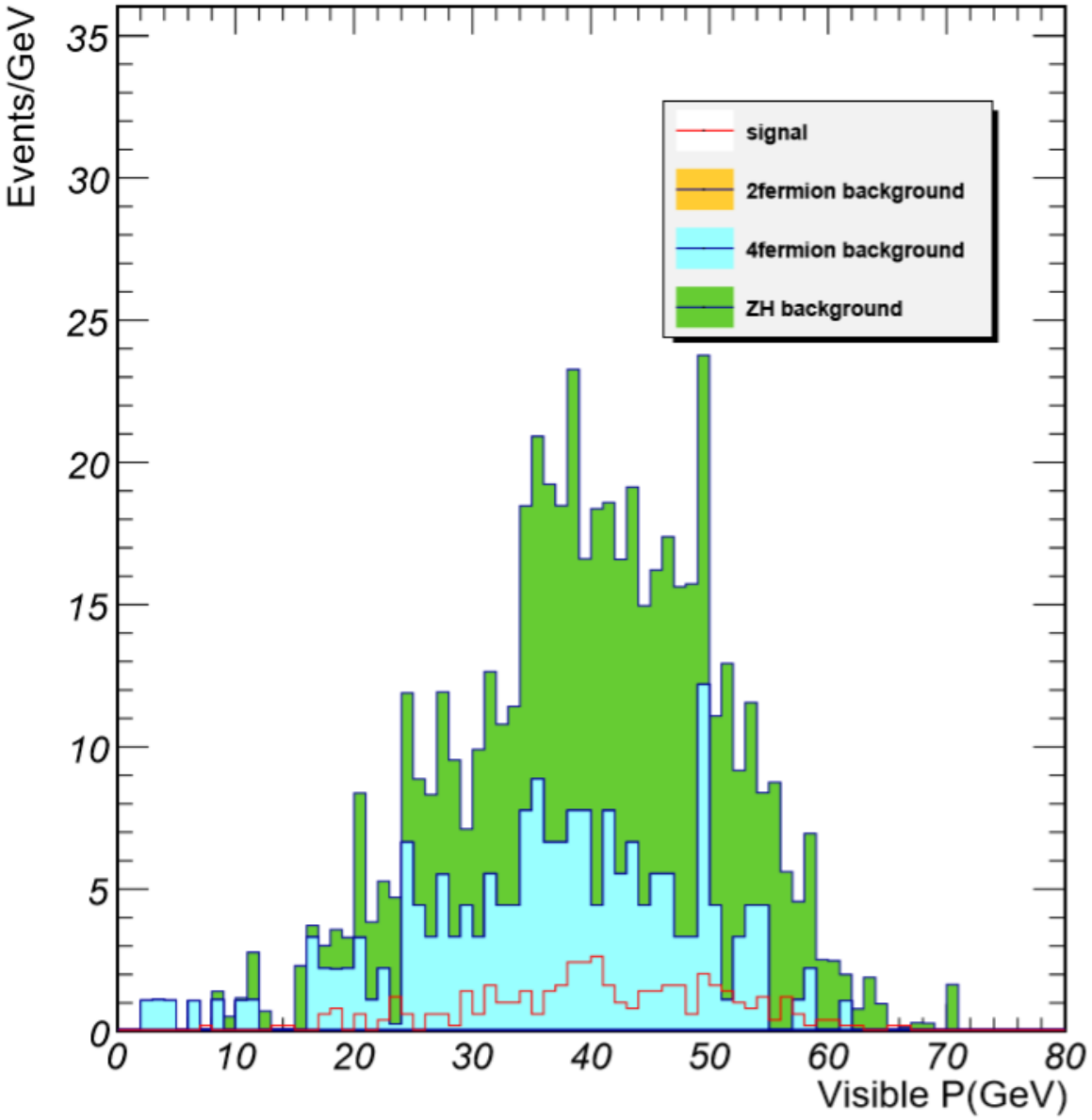
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **115 < Visible mass < 155 GeV**



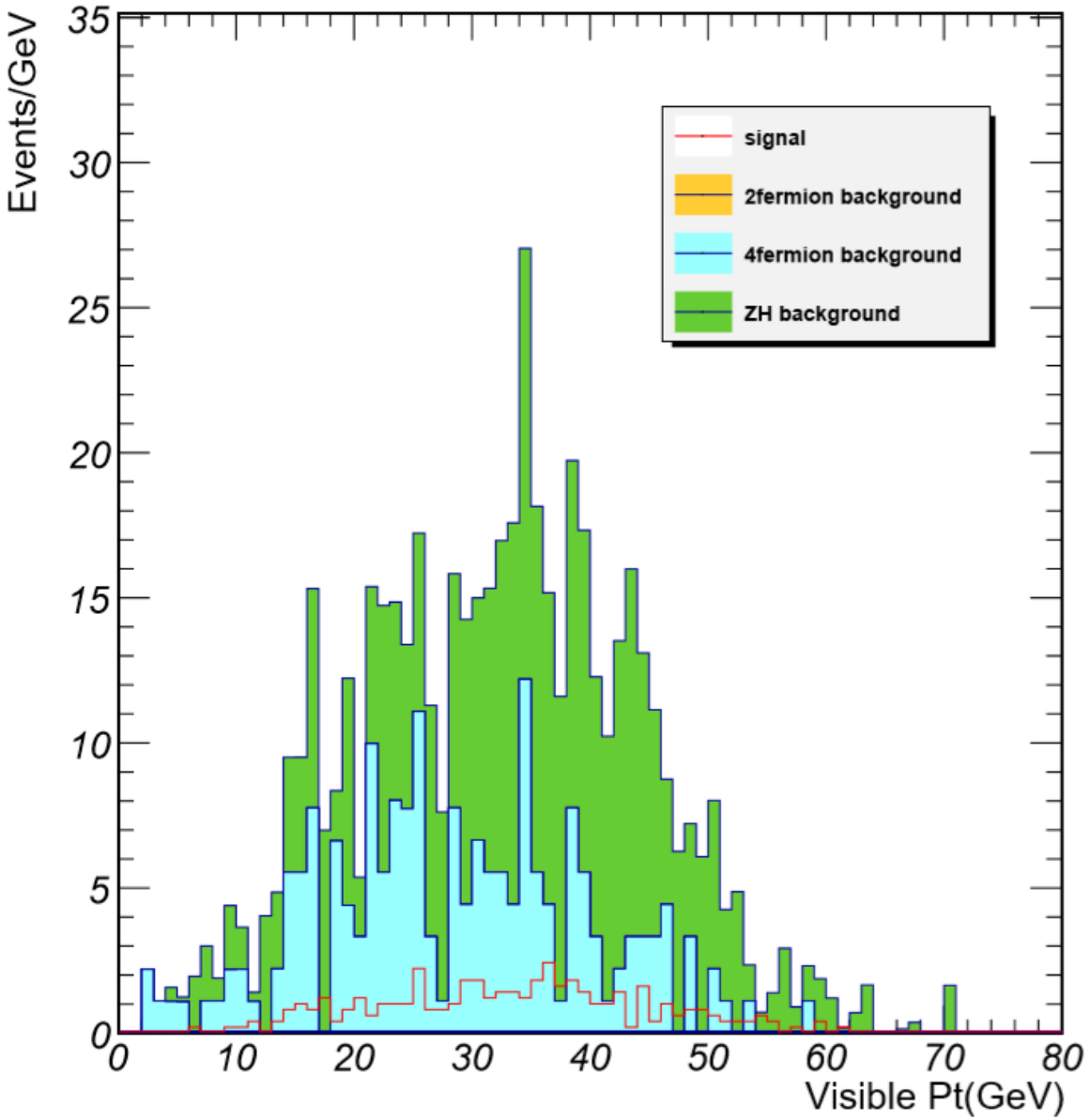
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **P visible: no cut**



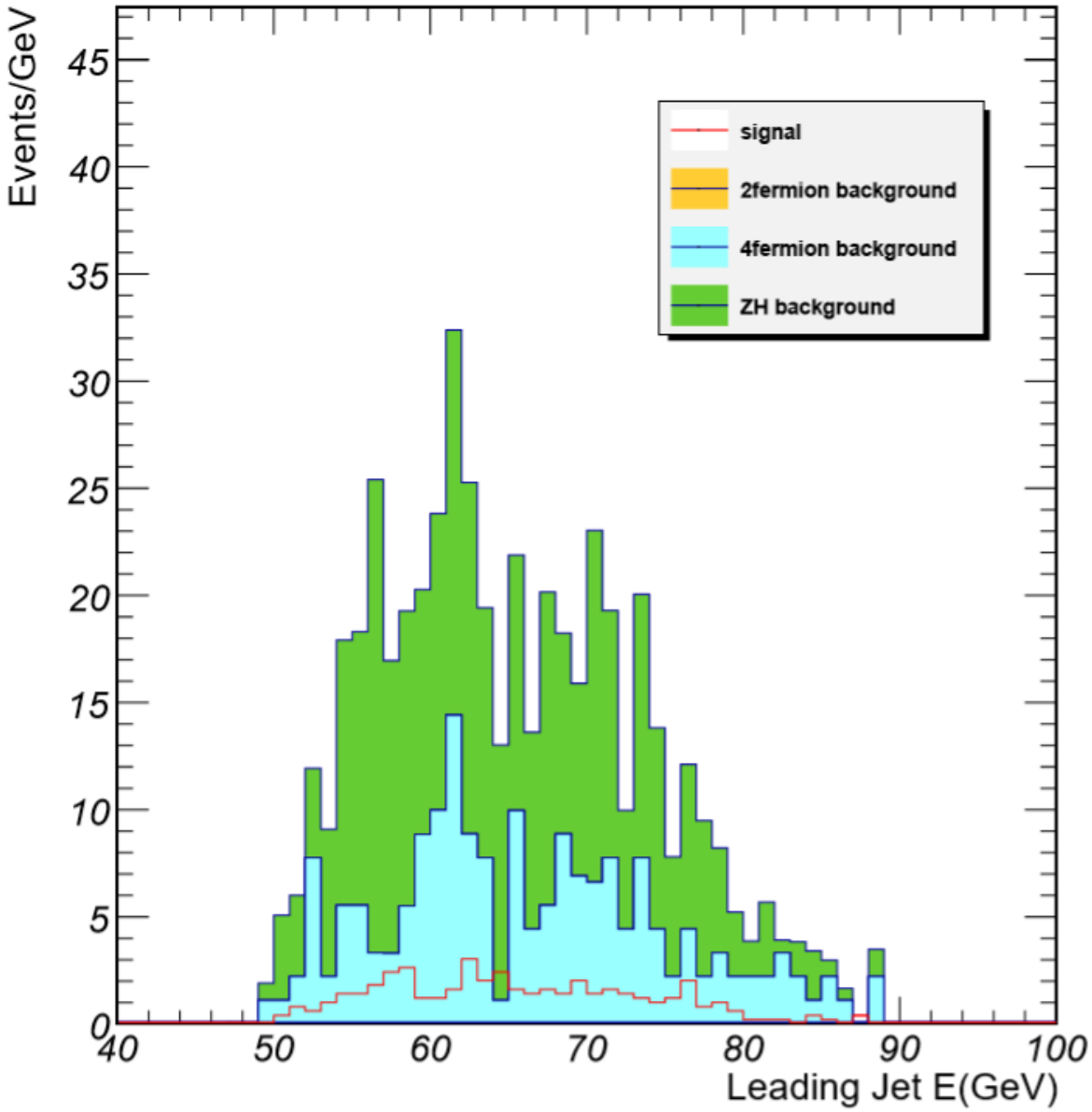
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **10 < Pt visible < 60 GeV**



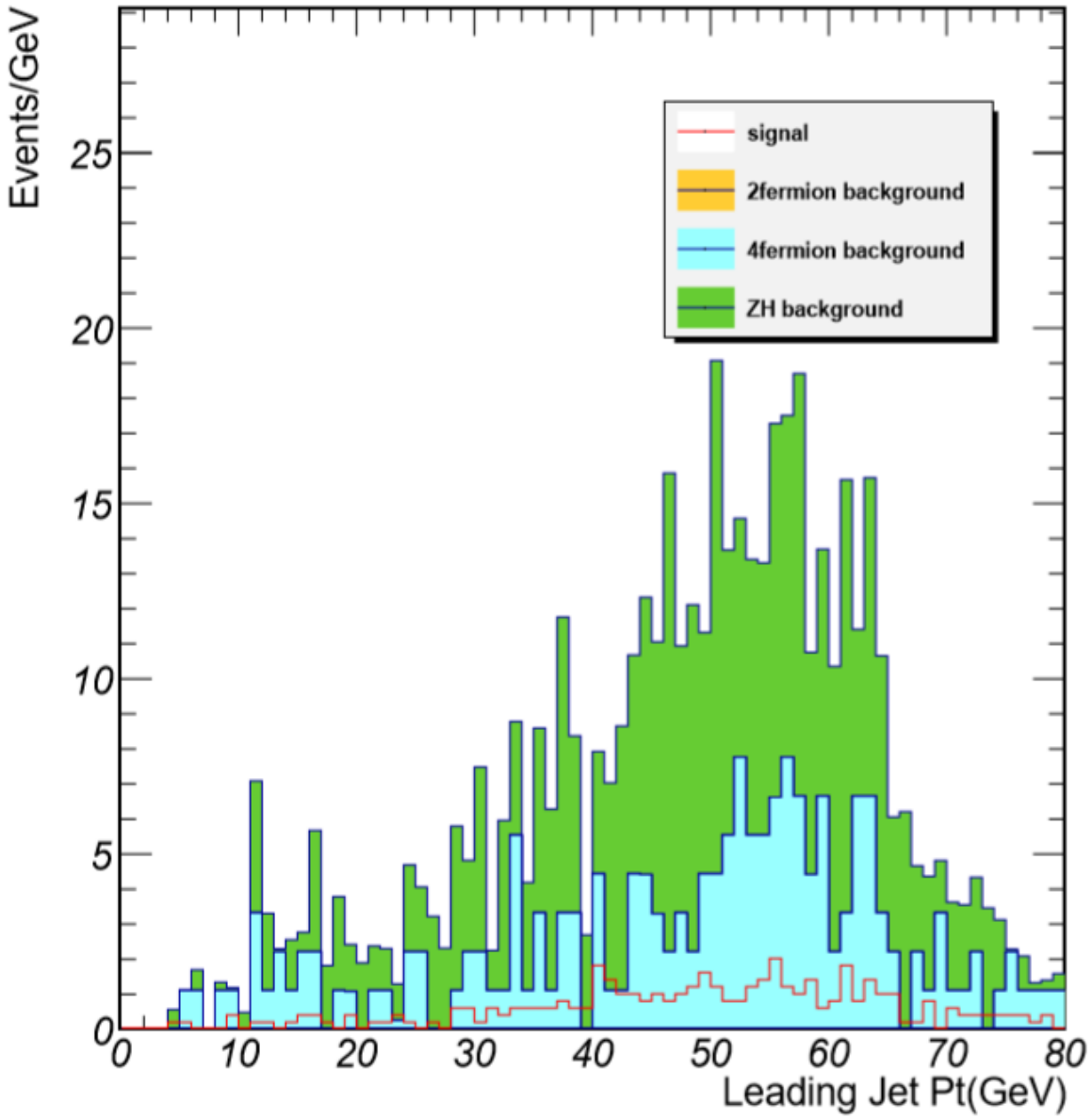
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **Leading jet E: no cut**



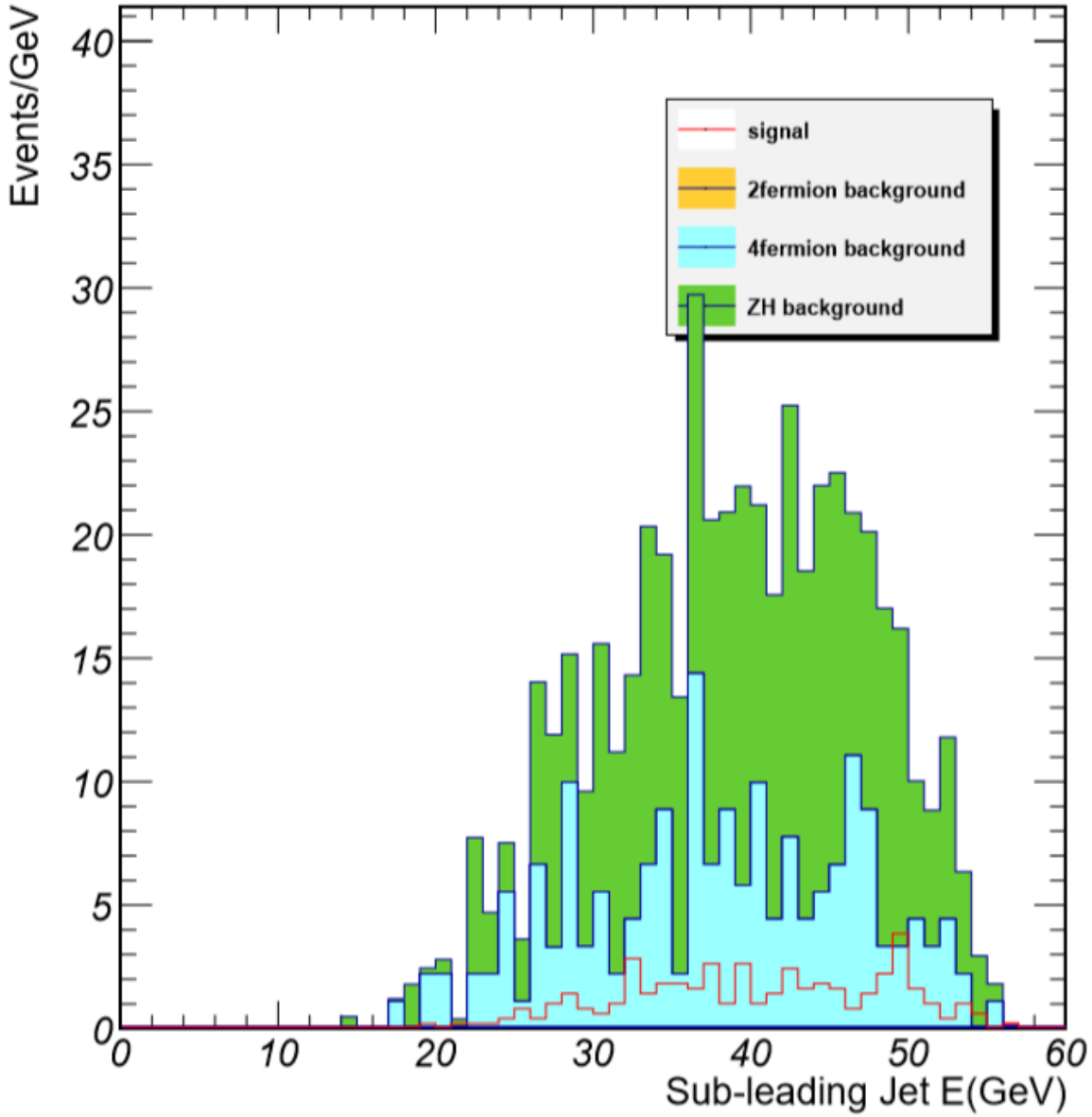
$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **Leading jet Pt: no cut**



$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

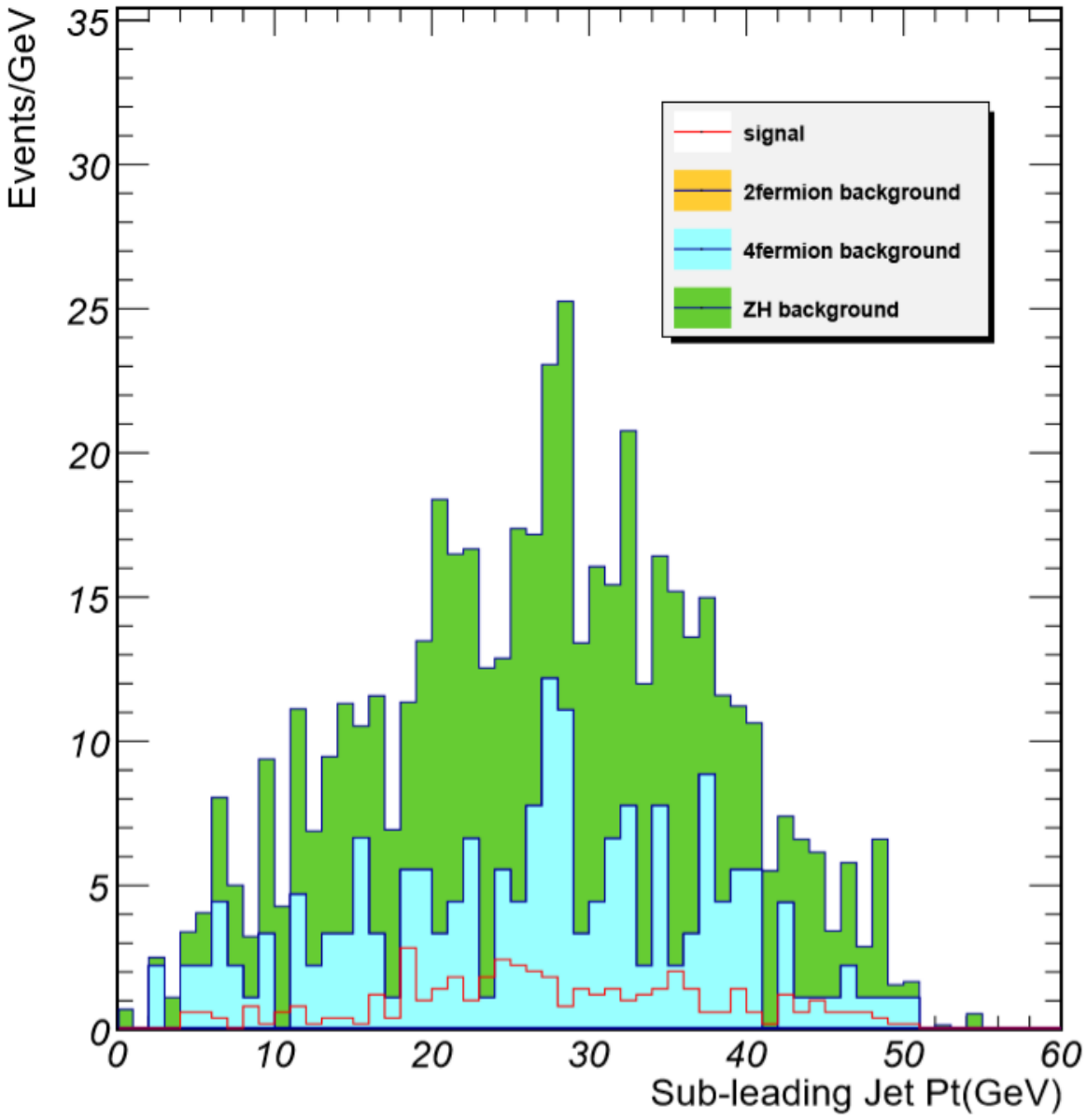
- **Sub-leading jet E: no cut**



$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

- **Sub-leading jet Pt: no cut**

After this, not mmHZZ and not vvHZZ cuts are applied



$qqHZZ\ (Z \rightarrow \nu\nu, Z* \rightarrow \mu\mu)$

➢ Cut Flow Discussion

➢ Which bench mark for selections shall we use?

We have been using: $\frac{S}{\sqrt{S+B}}$

Kaili once suggested: $\sqrt{2(S+B)ln\left(1+\frac{S}{B}\right)-S}$

➢ Reasons for the suggestion

$\frac{S}{\sqrt{S+B}}$ **could be biased when signal is small. Like S smaller than 30.**

Shape fit would give the accurate precision, but since we don't use it during the cuts, $\sqrt{2(S+B)ln\left(1+\frac{S}{B}\right)-S}$ **(from likelihood ratio) might be better.**

Status

- **Finished qqHvvmm channel cut flow**

Next to do

- **Optimize this channel result based on discussion**
- **Do the same procedure for the other 5 channels**