

$$e^+e^- \rightarrow ZH \rightarrow \nu\bar{\nu}WW^* \rightarrow \nu\bar{\nu}l\nu l\bar{\nu} (l = e, \nu)$$

Xianke He

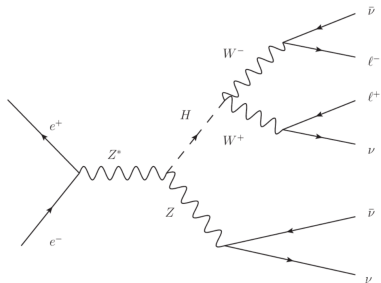
SJTU

2018.4.9

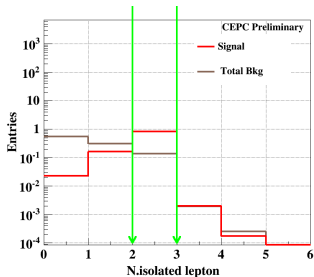
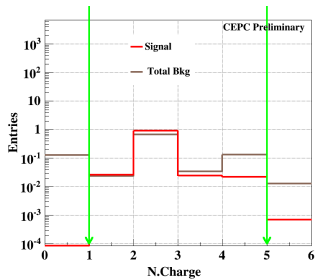
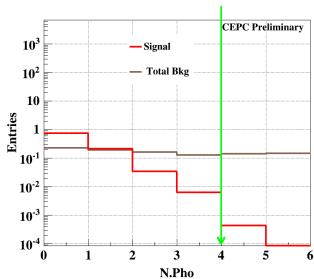


- Precut
- BDT result
- Branch Ratio precision
- Summary

- Measure the branch ratio of $WW \rightarrow \bar{l}\nu l\bar{\nu}$ ($l = e, \nu$) on CEPC

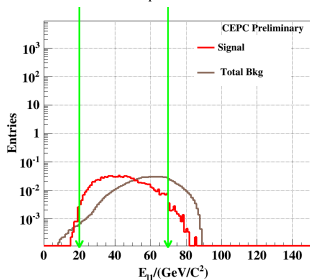
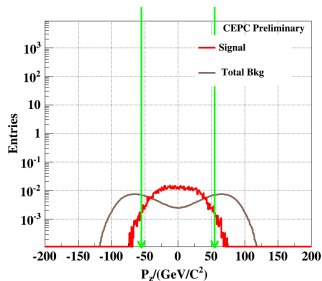
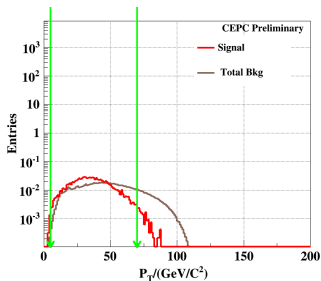


Precut on $WW \rightarrow \bar{e}\nu e\bar{\nu}$



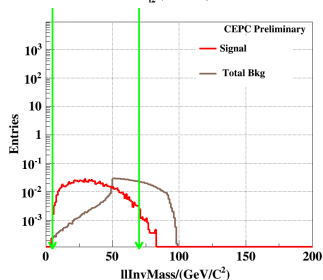
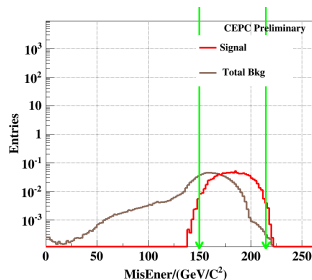
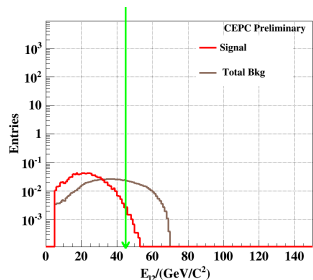
- Number of Photon: $N.Pho < 4$
- Number of Charge:
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- Number of Isolated Lepton:
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Precut on $WW \rightarrow \bar{e}\nu e\bar{\nu}$



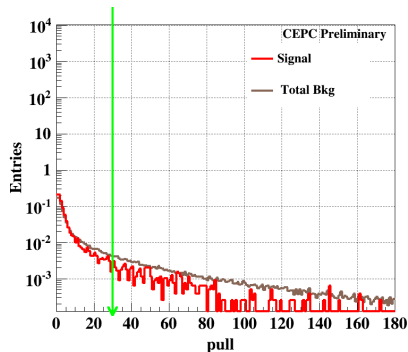
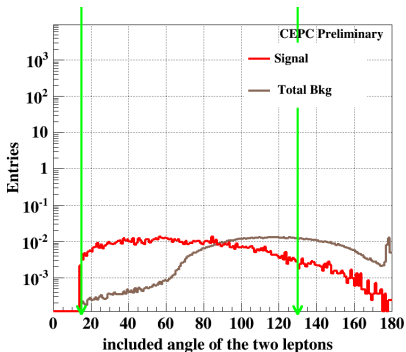
- the Leading Leptons' Transverse Momentum: $5 < P_T < 70$
- the Leading Leptons' Longitudinal Momentum: $-55 < P_Z < 55$
- the Leading Leptons' Energy: $20 < E_{l1} < 70$

Pre-cut on $WW \rightarrow \bar{e}\nu e\bar{\nu}$



- the second Leading Leptons' Energy: $E_{l2} < 45$
- Miss Energy: $150 < MisEner < 215$
- the two leptons' Invariant Mass: $5 < llInvMass < 70$

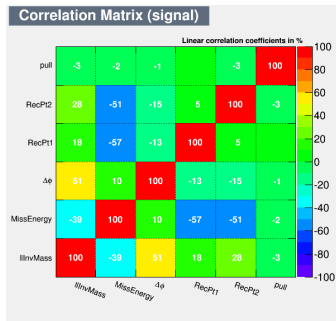
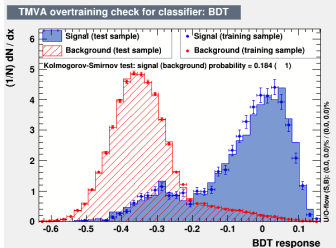
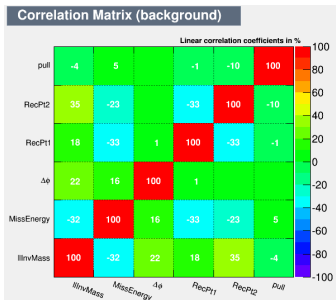
Precut on $WW \rightarrow \bar{e}\nu e\bar{\nu}$



- included angle of the two leptons: $15 < llAngle < 130$

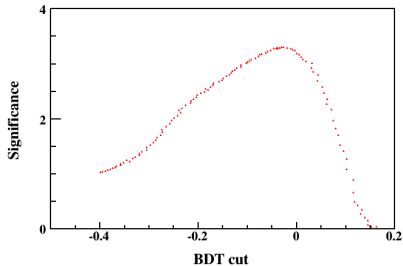
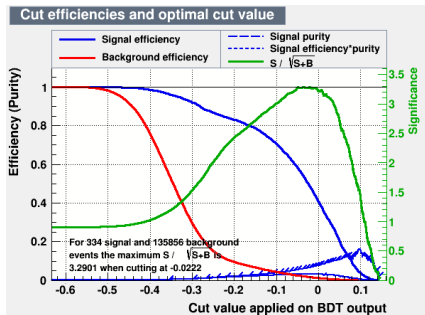
- pull: $\sqrt{\left(\frac{trkD0_0^2}{sigD0_0^2} + \frac{trkZ0_0^2}{sigZ0_0^2}\right) \cdot \left(\frac{trkD0_1^2}{sigD0_1^2} + \frac{trkZ0_1^2}{sigZ0_1^2}\right)} < 30$

BDT result of $WW \rightarrow \bar{e}\nu e\bar{\nu}$



- RecPt1: the Leading Leptons' Transverse Momentum
- RecPt2: the second Leading Leptons' Transverse Momentum
- $\Delta\phi$: azimuth angle between the two leptons

BDT result of $WW \rightarrow \bar{e} \nu e \bar{\nu}$



- left: BDT result
- right: BDT result by hand \Rightarrow consist with left

Cut Chain of $WW \rightarrow \bar{\nu}e\nu\bar{\nu}$

$e^+e^- \rightarrow$	<i>Signal</i>	<i>ZHbkg</i>	<i>SZ</i>	<i>SW</i>	<i>ZorW</i>
Total	11582	948400	871051	3.3278×10^6	520935
$N_\gamma < 4, 1 \leq N_{ch} < 5$	99.8273%	5.69475%	20.4173%	66.6195%	99.5715%
$N_{isoLep} == 2$	81.3849%	1.23872%	13.3392%	36.6292%	81.071%
$5\text{GeV} < P_T < 70\text{GeV}$	79.8826%	1.21552%	10.761%	30.45%	68.669%
$ P_Z < 55\text{GeV}$	77.7845%	1.20034%	4.59698%	14.8287%	35.7068%
$20\text{GeV} < E_{l1} < 70\text{GeV}$	75.9972%	1.01445%	3.4277%	11.4589%	28.0536%
$E_{l2} < 45\text{GeV}$	75.3497%	1.01413%	1.68073%	7.91904%	17.3728%
$150\text{GeV} < E_{Miss} < 215\text{GeV}$	74.0459%	0.940953%	0.584352%	5.80353%	11.8533%
$5\text{GeV} < l\text{InvMass} < 70\text{GeV}$	73.1825%	0.932307%	0.312381%	3.72417%	7.53875%
$15^\circ < \text{Angle} < 130^\circ$	68.192%	0.862505%	0.240399%	2.53053%	6.13627%
$\text{Pull} < 30$	62.6058%	0.570751%	0.183916%	2.08092%	5.60742%
$-0.0222 < \text{BDT}$	33.543%	0.04024%	0.00319%	0.00661%	0.1384%
<i>number(weight considered)</i>	179	176	278	220	721

$e^+e^- \rightarrow$	<i>ZZ</i>	<i>WW</i>	<i>ZZorWW</i>	<i>2f</i>
Total	1.12546×10^6	7.47571×10^6	838472	7.91415×10^6
$N_\gamma < 4, 1 \leq N_{ch} < 5$	6.28792%	16.4381%	80.6651%	12.4574%
$N_{isoLep} == 2$	2.96231%	5.37296%	33.9094%	4.41572%
$5\text{GeV} < P_T < 70\text{GeV}$	2.24088%	4.33506%	28.3377%	3.991%
$ P_Z < 55\text{GeV}$	1.33541%	1.87707%	14.7789%	1.17757%
$20\text{GeV} < E_{l1} < 70\text{GeV}$	0.976011%	1.47582%	11.7299%	1.00275%
$E_{l2} < 45\text{GeV}$	0.635423%	1.22429%	8.33194%	0.789522%
$150\text{GeV} < E_{Miss} < 215\text{GeV}$	0.257931%	0.969928%	6.51232%	0.293803%
$5\text{GeV} < l\text{InvMass} < 70\text{GeV}$	0.222701%	0.646521%	4.25238%	0.175344%
$15^\circ < \text{Angle} < 130^\circ$	0.1469%	0.364822%	2.38851%	0.0321576%
$\text{Pull} < 30$	0.0514906%	0.246157%	1.91885%	0.00751818%
$-0.0222 < \text{BDT}$	0.00956%	0.07028%	0.0701%	0.000594%
<i>number(weight considered)</i>	105	918	588	47

Combined Result of Three Channel Before Fit

- after BDT cut

channel ($WW \rightarrow l\nu l\nu$)	N.sig	N.bkg	$\Delta s/s = \sqrt{s + b}/s$
$e\nu e\nu$	179	3053	31.7265%
$e\nu \mu\nu$	419	3489	14.8996%
$\mu\nu \mu\nu$	223	2801	24.6314%

- combined

$$\Delta s/s = \frac{1}{\sqrt{(1/31.7265\%)^2 + (1/14.8996\%)^2 + (1/24.6314\%)^2}} = 11.8293\%$$

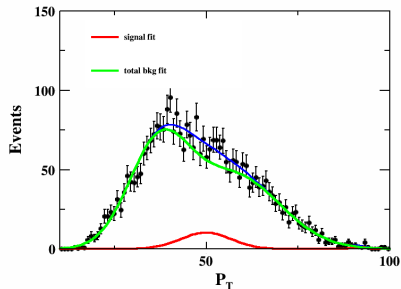
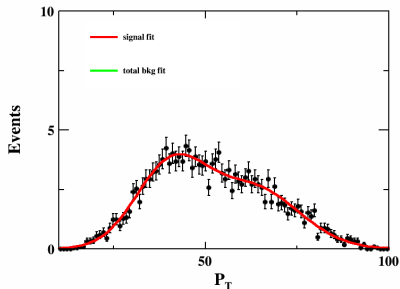
- considering

$$Br = \frac{N}{L \cdot \sigma}$$

$\frac{\Delta\sigma}{\sigma} = 0.5\%$ and ignore the ΔL , so

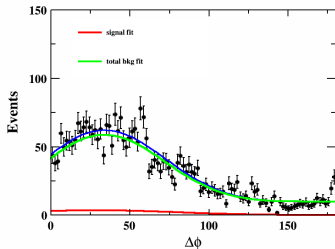
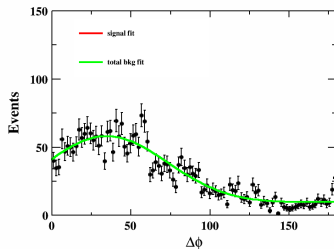
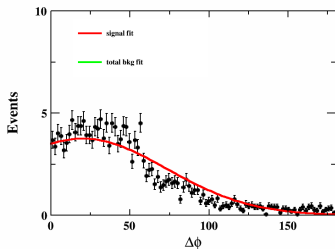
$$\frac{\Delta Br}{Br} = \sqrt{\left(\frac{\Delta s}{s}\right)^2 + \left(\frac{\Delta\sigma}{\sigma}\right)^2} = \sqrt{0.5\%^2 + 11.8293\%^2} \approx 11.84\%$$

the Two Leptons Transverse Momentum Fit



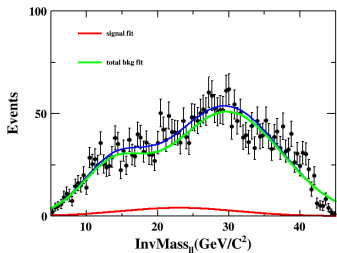
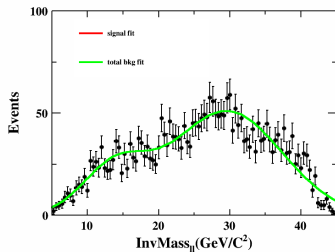
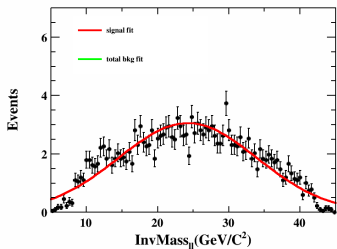
- Not strict but hard to fit the shape successfully, $n_{sig}: 199.99 \pm 199.90$

the Two Leptons $\Delta\phi$ Fit



- Gaussian Fit, $nsig = 176 \pm 2.54$
- Double Gaussian Fit, $nbkg = 3056 \pm 56.91$

the Two Leptons Invariant Mass Fit



- Gaussian Fit,
 $n_{sig} = 200 \pm 29.95$
- Double Gaussian Fit,
 $n_{bkg} = 3021.13 \pm 69.74$

• Writing...

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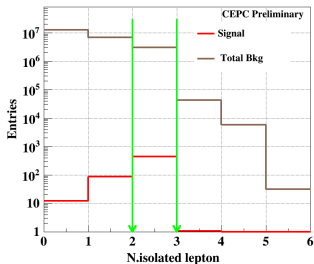
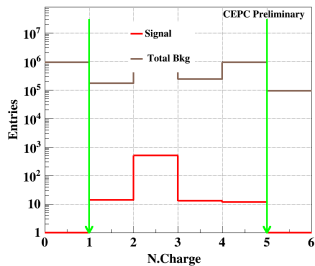
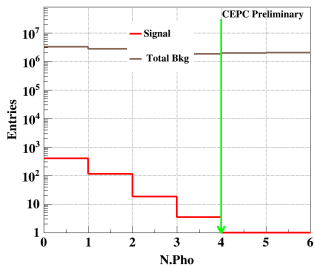
Summary and To do

- $\frac{\Delta Br}{Br}$ of $WW \rightarrow l\nu l\nu$ is 11.84%
- find a meaningful variable to do fit?
- finish the memo as soon as possible!

Thanks !

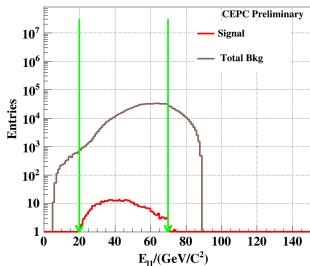
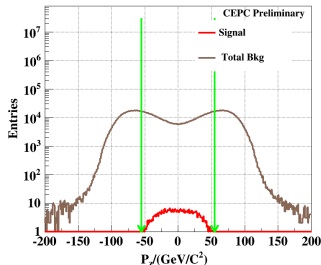
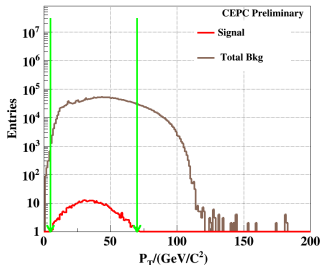
Backup !

Precut on $WW \rightarrow \bar{e}\nu e\bar{\nu}$



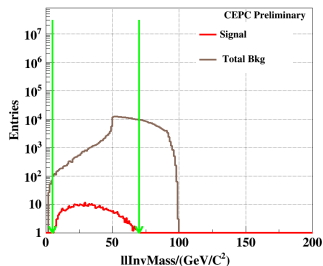
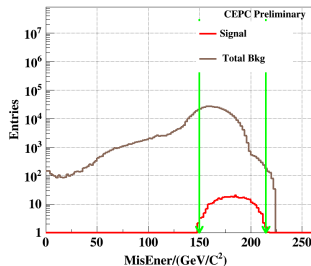
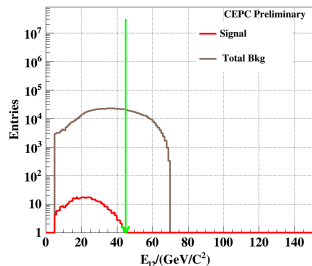
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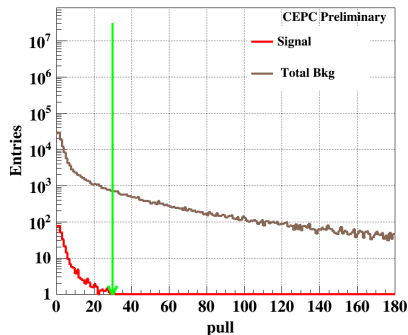
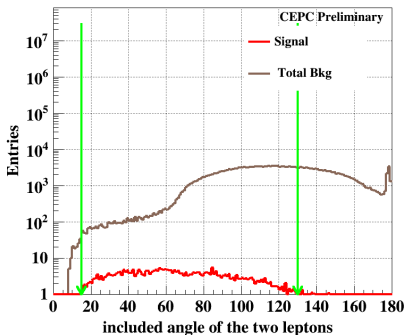
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- pull: $\sqrt{\left(\frac{trkD0_0^2}{sigD0_0^2} + \frac{trkZ0_0^2}{sigZ0_0^2}\right) \cdot \left(\frac{trkD0_1^2}{sigD0_1^2} + \frac{trkZ0_1^2}{sigZ0_1^2}\right)} < 30$