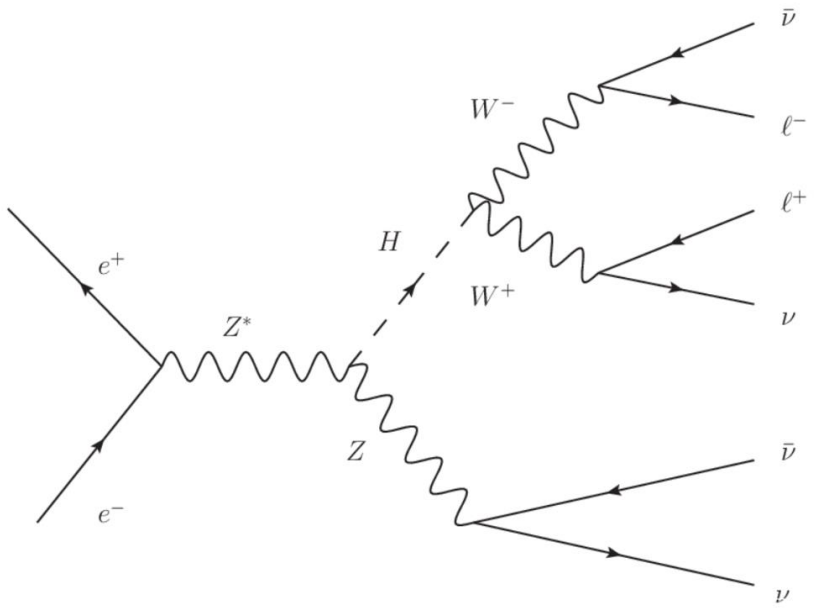


$$e^+e^- \to ZH \to \nu\nu WW^* \to \nu\nu l^+\nu l^-\nu (l = e, \mu)$$

Xianke He

2018-03-19

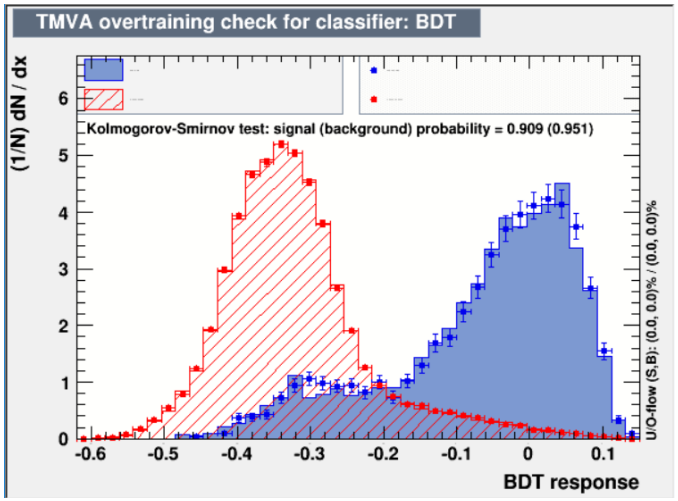
ee channel

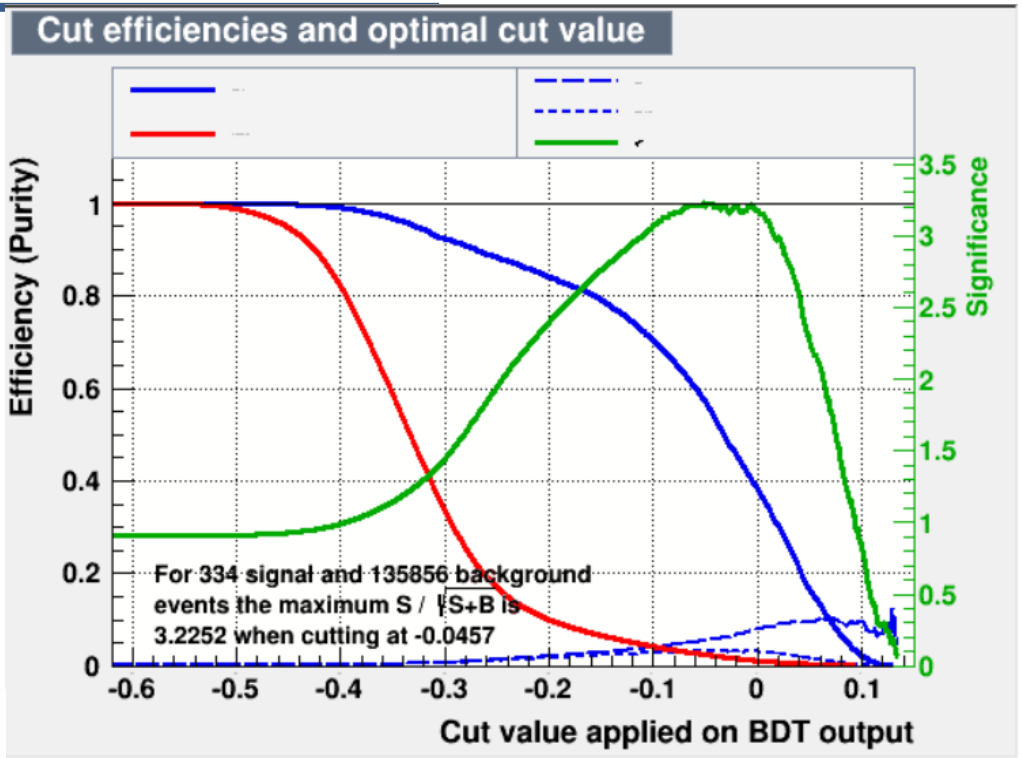
$e^+e^- \rightarrow$	$Signal$	$ZHbkg$	SZ	SW	$ZorW$
Total	11582	982836	871051	3.3278×10^6	520935
$N_\gamma < 4, 1 < N_{ch} < 5$	99.8273%	8.99489%	20.4173%	66.6195%	99.5715%
$1 < N_{iso\_lep} < 3$	81.3849%	4.28739%	13.3392%	36.6292%	81.071%
$P_T < 75GeV$	80.7892%	4.25605%	11.5029%	32.3109%	72.7615%
$\|P_Z\| < 50GeV$	78.6911%	4.14891%	5.2028%	16.2815%	39.1997%
$20GeV < E_{l1} < 85GeV$	78.1126%	3.94664%	4.7414%	14.9759%	36.4003%
$E_{l2} < 45GeV$	75.5828%	3.83329%	1.64571%	7.62765%	15.2998%
$140GeV < E_{Miss}$	74.4345%	3.77194%	0.510533%	5.56731%	10.462%
$InvMass_{ll} < 75GeV$	73.6315%	3.72117%	0.321336%	3.82207%	7.22969%
$Included\_Angle_{ll} < 75GeV$	68.5201%	3.43577%	0.246369%	2.49318%	5.81973%
$Pull$	63.0202%	3.06857%	0.189656%	2.02716%	5.31103%
$BDTcut$	51.7959%	0.02588%	0.000685%	0.000839%	0.00536%

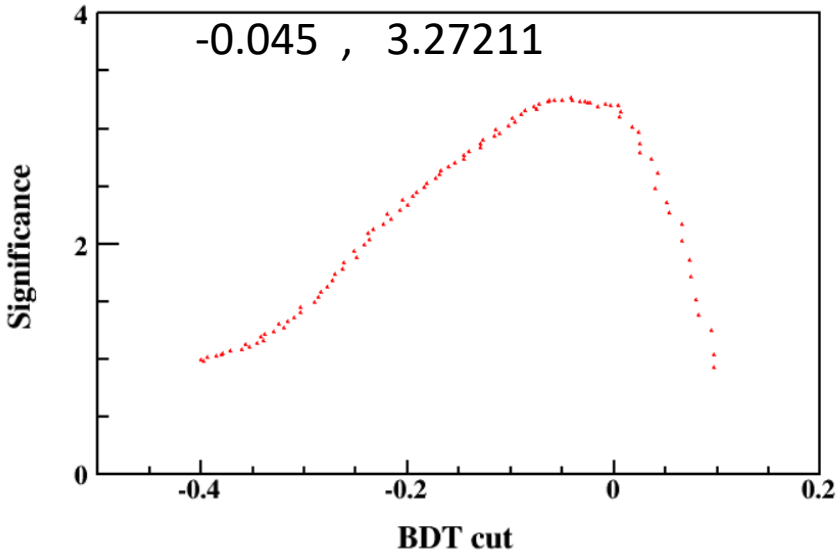
ee channel

$e^+e^- \rightarrow$	ZZ	WW	$ZZorWW$	$2f$
Total	1.12546×10^6	7.47571×10^6	838472	7.91415×10^6
$N_\gamma < 4, 1 < N_{ch} < 5$	6.28792%	16.4381%	80.6651%	12.4574%
$1 < N_{iso\_lep} < 3$	2.96231%	5.37296%	33.9094%	4.41572%
$P_T < 75GeV$	2.44764%	4.61156%	30.0963%	4.0884%
$\|P_Z\| < 50GeV$	1.50184%	2.04539%	16.2226%	1.2439%
$P_T < 75GeV$	1.2832%	1.88382%	14.9442%	1.15446%
$20GeV < E_{l1} < 85GeV$	0.65814%	1.34156%	7.77092%	0.719521%
$E_{l2} < 45GeV$	0.254584%	1.02856%	6.07259%	0.288117%
$140GeV < E_{Miss}$	0.228041%	0.719009%	4.24808%	0.186274%
$InvMass_{ll} < 75GeV$	0.149371%	0.385168%	2.33926%	0.0329536%
$Included\_Angle_{ll} < 75GeV$	0.052208%	0.258972%	1.85886%	0.00756872%
$BDTcut$	0.000243%	0.000367%	0.01%	0.002%

ee channel


TMVA overtraining check for classifier: BDT
Kolmogorov-Smirnov test: signal (background) probability = 0.909 (0.951)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDT response


Cut efficiencies and optimal cut value
Efficiency (Purity)
Significance
For 334 signal and 135856 background events the maximum S / √S+B is 3.2252 when cutting at -0.0457
Cut value applied on BDT output


-0.045 , 3.27211
Significance
BDT cut

Result before fit

channel	cut	significance	s	b
ee	-0.05	3.25326	191.289	3266.04
	-0.045	3.27211	185.753	3036.92
	-0.04	3.25222	178.742	2841.86
emu	0.015	7.00501	364.588	2344.97
	0.02	7.0261	379.764	2541.68
	0.025	7.00411	393.325	2759.39
mumu	0	4.22342	213.706	2346.69
	0.005	4.22686	205.45	2157.07
	0.01	4.226	196.732	1970.42

Backup

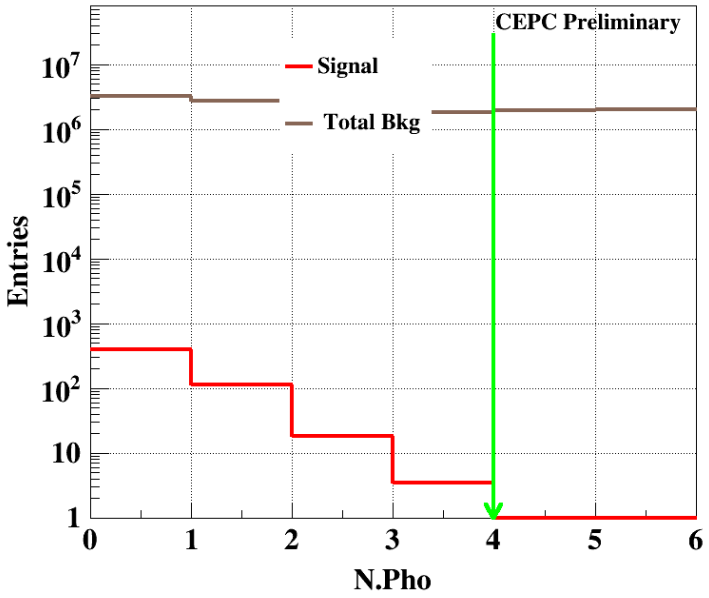
Take lvlv == evev channel for example

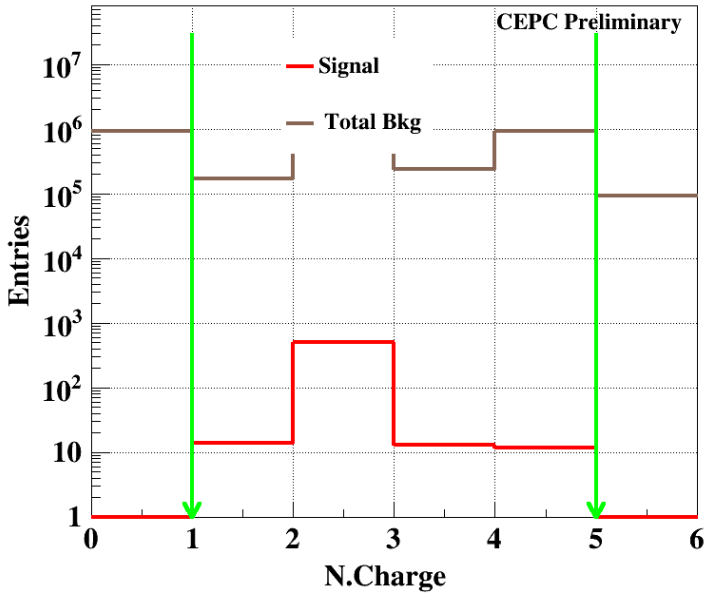
cut variables	what it means
NPi	the number of reconstructed π mesons
$NPin$	the number of reconstructed π^0
$NPie$	the number of reconstructed π^+
NPi	the number of reconstructed π^0 or π^+
$NPho$	the number of reconstructed photons
NMu	the number of reconstructed muons
$NEle$	the number of reconstructed electrons
$NLep$	the number of reconstructed leptons
$NIsL$	the number of reconstructed isolated leptons from $Higgs$'s decay
$NIsL\_ep$	the number of reconstructed isolated e^+ from $Higgs$'s decay
$NIsL\_em$	the number of reconstructed isolated e^- from $Higgs$'s decay
$NIsL\_mup$	the number of reconstructed isolated μ^+ from $Higgs$'s decay
$NIsL\_mum$	the number of reconstructed isolated μ^- from $Higgs$'s decay
nch	the number of reconstructed charged particles
$MisEner$	the missed energy that is not reconstructed: 250-all visible energy
$MisMass$	the missed mass that is not reconstructed
$MisMass2$	the missed mass's squared value
$MisPx$	the missed mass's x momentum
$MisPy$	the missed mass's y momentum
$MisPz$	the missed mass's z momentum
$llInvMass$	the invariant mass of isolated lepton when NIsL=2
$MCllInvMass$	the Monte Carlo invariant mass of isolated lepton when NIsL=2
$ZDPID$	tee particle ID from Z boson's decay
$HDPID$[2]	tee particle ID from $Higgs$ boson's decay
$HGDPID$[2][2]	tee particle ID from "$Higgs$ daughter"'s decay

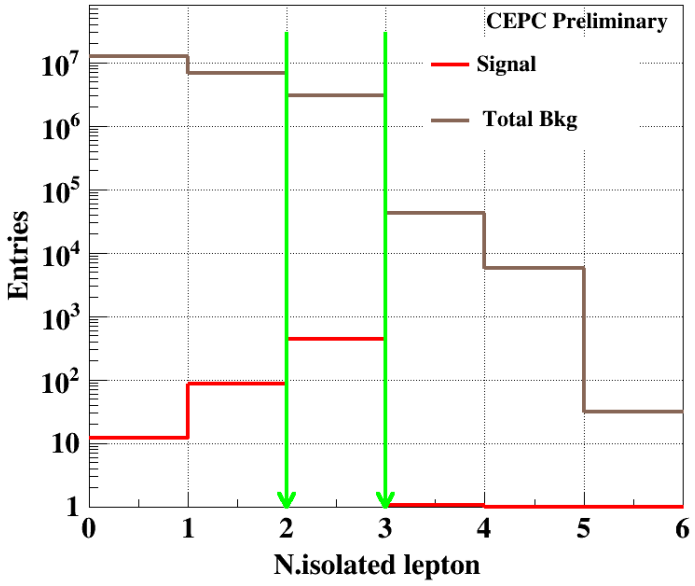
Take lvlv == evev channel for example

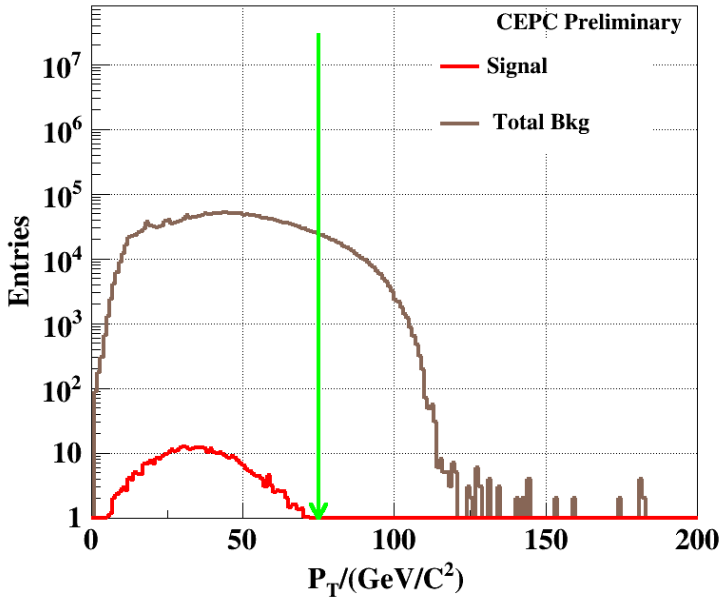
cut variables	what it means
$MCPx[2]$	Monte Carlo leptons's momentum corresponding with $RecPx$
$MCPy[2]$	Monte Carlo leptons's momentum corresponding with $RecPy$
$MCPz[2]$	Monte Carlo leptons's momentum corresponding with $RecPz$
$MCE[2]$	Monte Carlo leptons's momentum corresponding with $RecE$
$MCID[2]$	Monte Carlo leptons's ID corresponding with $RecID$
$MCMID[2]$	Monte Carlo leptons mother's ID
$MCGMID[2]$	Monte Carlo leptons grandmother ID
$MCZdau[2]$	Monte Carlo Z bosons daughters' ID
$l1p[4]$	the highest leptons' 4-momentum
$l2p[4]$	the second highest leptons' 4-momentum
$nRem$	the number of all final state particles except isolated leptons
E_dilep	the sum of dual highest leptons' energy
$P\_Lepton1$	the highest leptons' 4-vector momentum
$P\_Lepton2$	the second highest leptons' 4-vector momentum
P_Lepton	the sum of two highest leptons' 4-vector momentum
$LLAngle$	the DeltaR of two isolated leptons from Higgs decay
$llAngle$	the angle of two isolated leptons from Higgs decay
D_phi	the angle of ϕ of two isolated leptons from $Higgs$ decay see figure 11
$IsoLepRecID$	the ID of the two isolated lepton : e(11 or -11) $\mu(13or-13)$

Take lvlv == evev channel for example

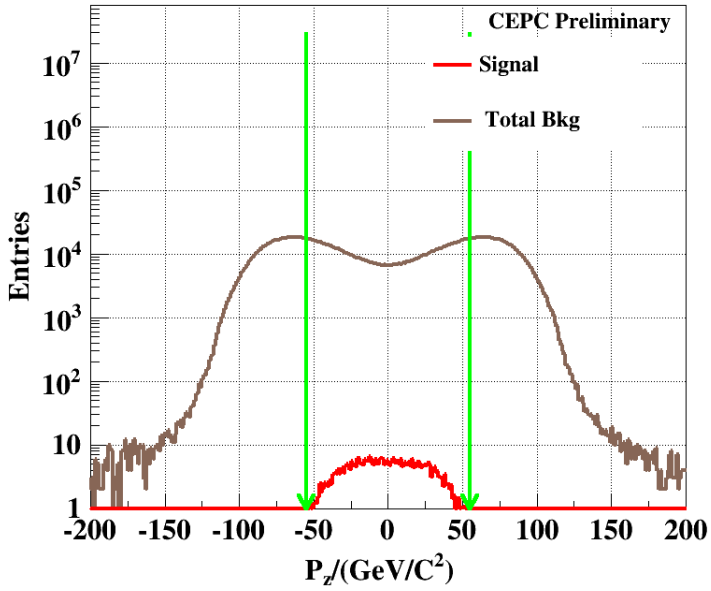


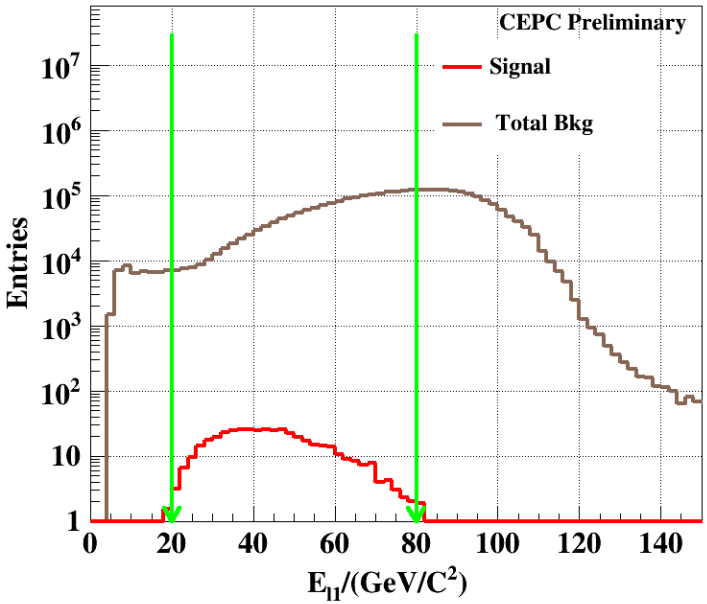


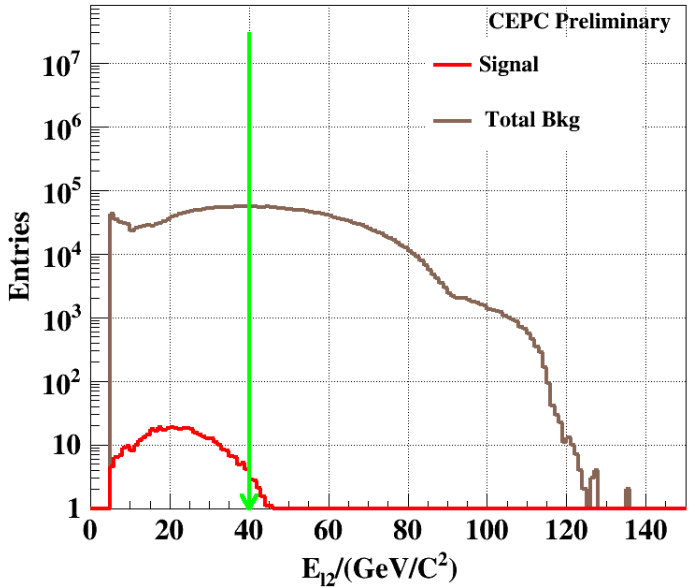


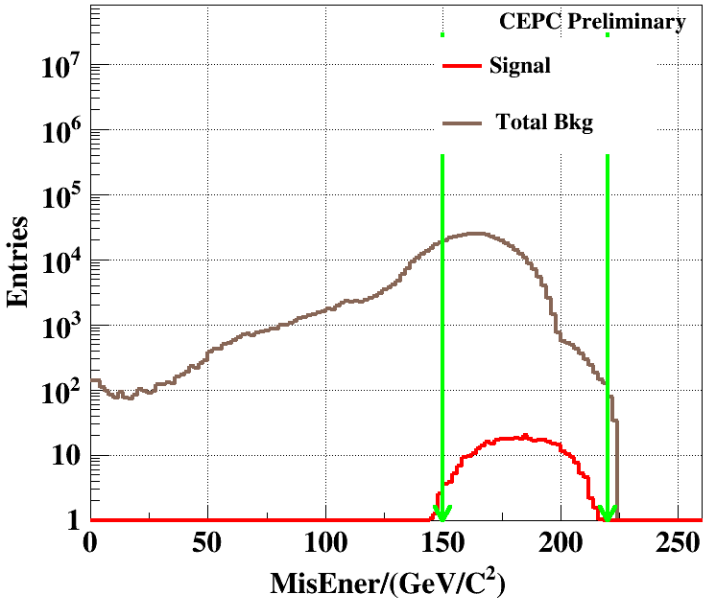


ee channel

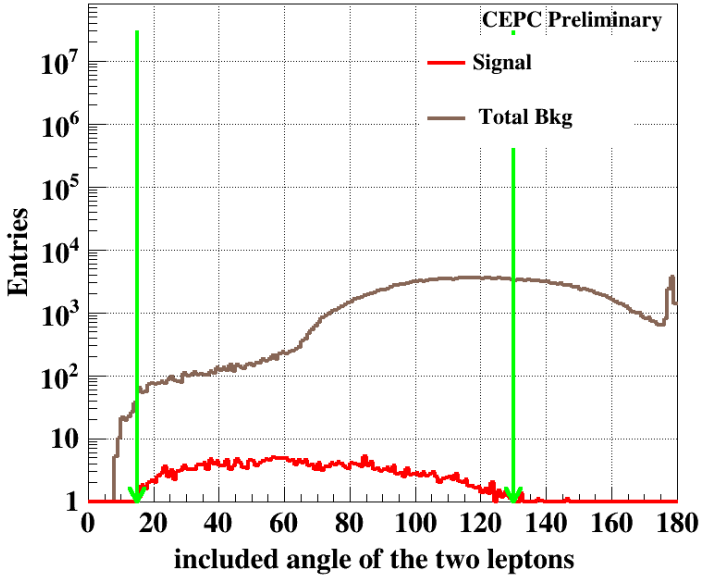

CEPC Preliminary
Signal
Total Bkg
Entries
$P_z/(GeV/C^2)$

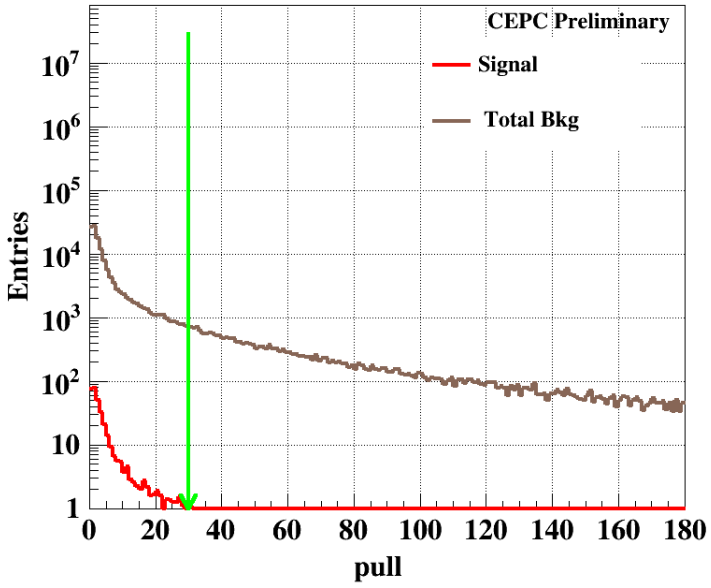

CEPC Preliminary
Signal
Total Bkg
Entries
$E_{l1}/(GeV/C^2)$

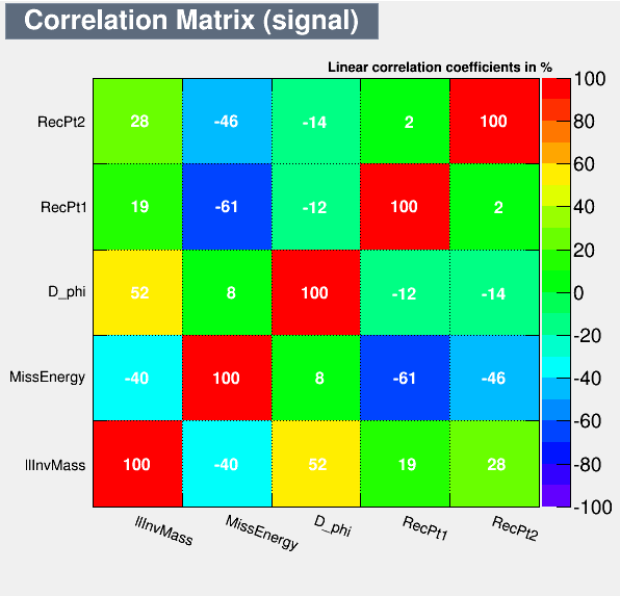

CEPC Preliminary
Signal
Total Bkg
Entries
$E_{l2}/(GeV/C^2)$

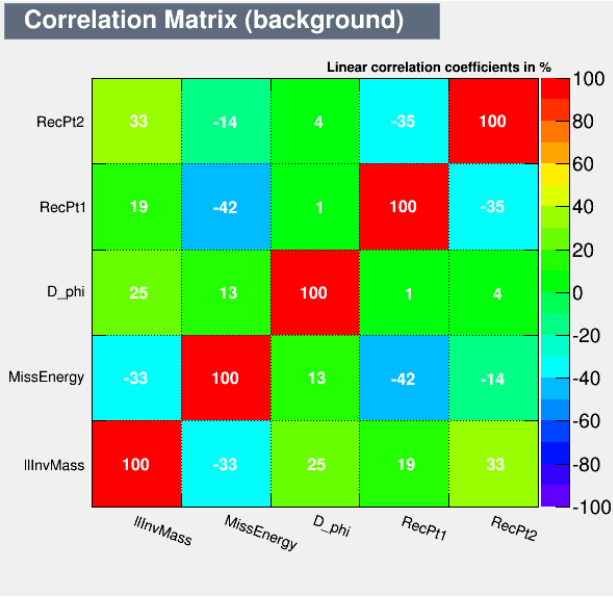

CEPC Preliminary
Signal
Total Bkg
Entries
MisEner/(GeV/C^2)

ee channel

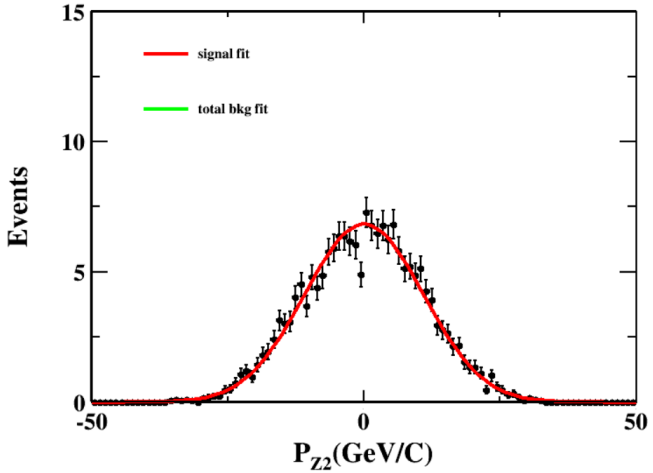

CEPC Preliminary
Signal
Total Bkg
Entries
included angle of the two leptons

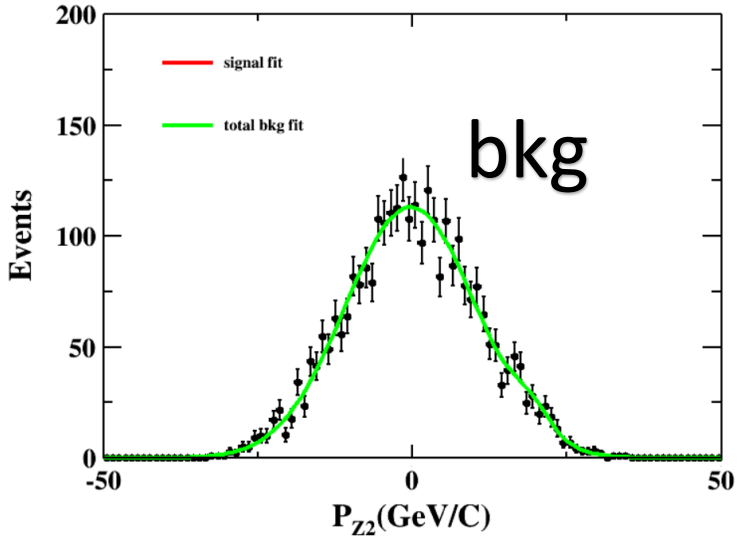

CEPC Preliminary
Signal
Total Bkg
Entries
pull


Correlation Matrix (signal)
Linear correlation coefficients in %
RecPt2 28 -46 -14 2 100
RecPt1 19 -61 -12 100 2
D_phi 52 8 100 -12 -14
MissEnergy -40 100 8 -61 -46
llInvMass 100 -40 52 19 28
llInvMass MissEnergy D_phi RecPt1 RecPt2
100 80 60 40 20 0 -20 -40 -60 -80 -100

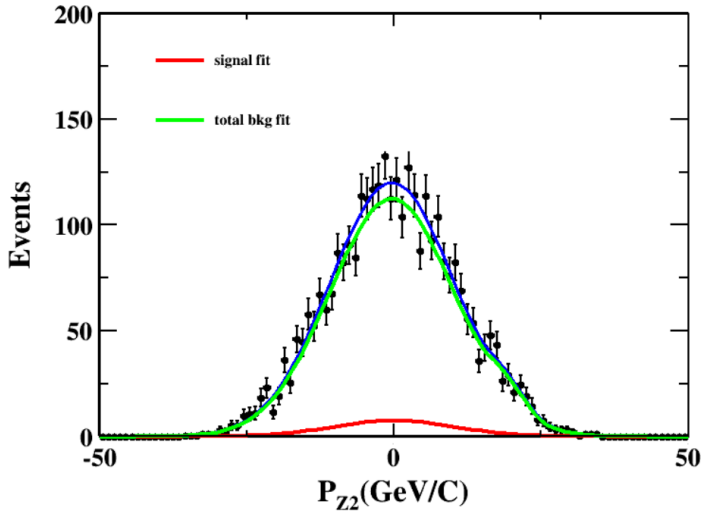

Correlation Matrix (background)
Linear correlation coefficients in %
RecPt2 33 -14 4 -35 100
RecPt1 19 -42 1 100 -35
D_phi 25 13 100 1 4
MissEnergy -33 100 13 -42 -14
llInvMass 100 -33 25 19 33
llInvMass MissEnergy D_phi RecPt1 RecPt2
100 80 60 40 20 0 -20 -40 -60 -80 -100

ee channel





Signal: sigma: 10.89



bkgfrac	9.78165e-01
mean1	-3.46622e-01
mean2	1.93359e+01
nbkg	3.06239e+03
sigma1	1.05567e+01
sigma2	2.99828e+00

Prob =2.6E-302
Signif =37.14