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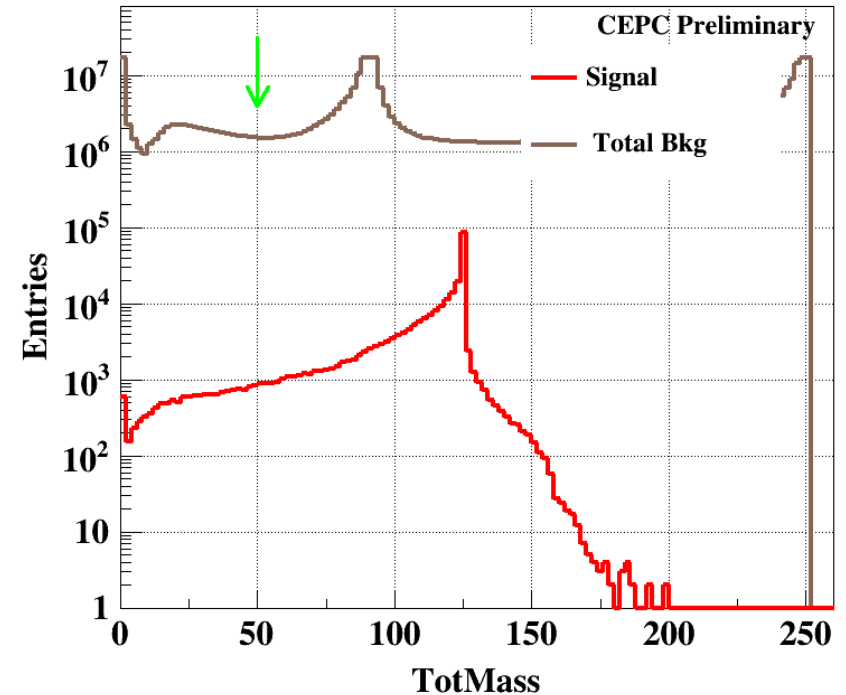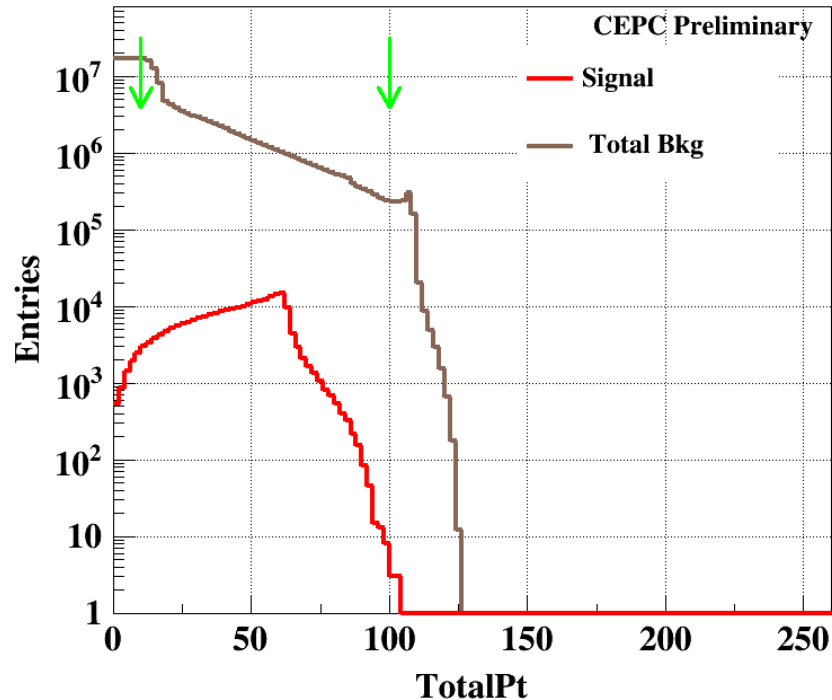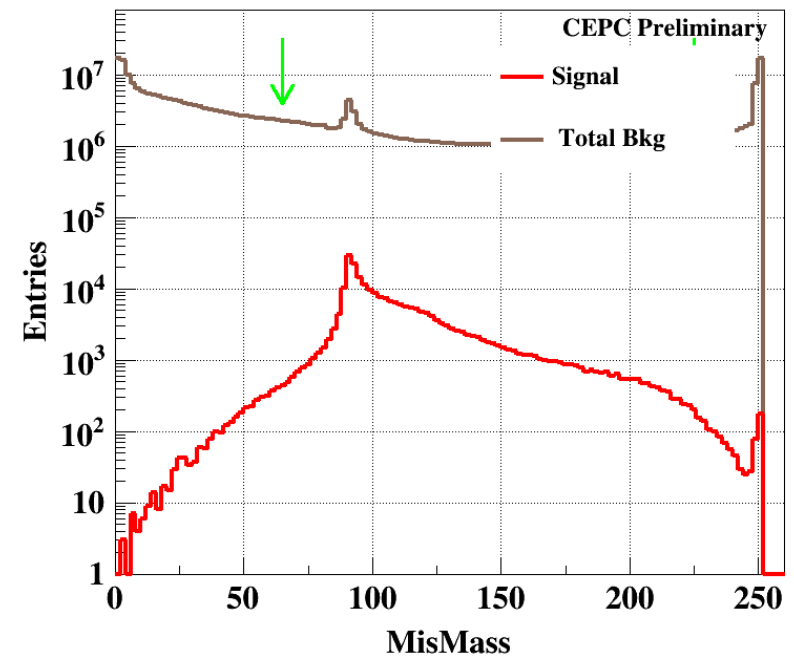
Xianke He

2017-10-16

Pre-selection

TotalPt:
Total transverse momentum
(a+b+c).Pt not (a.Pt+b.Pt+c.Pt)

Data path
/cefs/data/stdhep/

Pre-selection

2 fermion background pre-selection

$e^+e^- \rightarrow$	uu	dd	cc	ss	bb
Total	5.04765×10^7	4.9534×10^7	4.96359×10^7	4.95172×10^7	4.56408×10^7
$65GeV < M_{miss} < 225GeV$	7.86485×10^6	8.63006×10^6	1.02388×10^7	8.59×10^6	1.51951×10^7
$50GeV < M_{Total}$	5.58536×10^6	6.74143×10^6	7.95451×10^6	6.68579×10^6	1.34447×10^7
$10GeV < P_T < 100GeV$	271623	317522	1.1014×10^6	317297	3.1276×10^6

$e^+e^- \rightarrow$	n2n2 $\nu_\mu, \bar{\nu}_\mu$	n3n3 $\nu_\tau, \bar{\nu}_\tau$	e2e2 μ^-, μ^+	e3e3 τ^-, τ^+	bhabha e^-, e^+
Total	2.02983×10^7	2.03354×10^7	2.50863×10^7	2.20934×10^7	1.26211×10^8
$65GeV < M_{miss} < 225GeV$	3.81628×10^6	3.81934×10^6	1.45001×10^6	1.45266×10^7	1.20075×10^7
$50GeV < M_{Total}$	86173	86562	868243	9.24767×10^6	2.10963×10^6
$10GeV < P_T < 100GeV$	83658	83971	30784	6.00104×10^6	1.07712×10^6

Signal and 4 fermion background pre-selection

$e^+e^- \rightarrow$	signal $\nu\nu H$	szeorsw_l0l $e^+, e^-, \nu_e, \bar{\nu}_e$	sw_sl0qq $e, \nu_e, up, down$	sw_l0tau $e, \nu_e, \tau, \nu_{\mu,\tau}$	sw_l0mu $e, \nu_e, \mu, \nu_{\mu,\tau}$
Total	247167	1.25916×10^6	1.30255×10^7	2.16856×10^6	2.16745×10^6
$65GeV < M_{miss} < 225GeV$	242411	745257	1.06088×10^6	1.9542×10^6	1.20012×10^6
$50GeV < M_{Total}$	229693	596727	1.04544×10^6	1.47066×10^6	976257
$10GeV < P_T < 100GeV$	224264	551646	1.01346×10^6	1.41658×10^6	897759

Pre-selection

$e^+e^- \rightarrow$	$zzorww\_h0udud$ uq, uq, dq, dq	ww_l0ll $\mu.\tau, \nu_\mu, \mu_\tau$	$ww\_sl0tauq$ $\tau, \nu, up, down$	ww_sl0muq $\mu, \nu, up, down$
Total	7.93051×10^6	1.98444×10^6	1.18775×10^7	1.19114×10^7
$65GeV < M_{miss} < 225GeV$	37665	1.78001×10^6	5.46159×10^6	1.02968×10^6
$50GeV < M_{Total}$	37513	1.37139×10^6	5.42768×10^6	1.01942×10^6
$10GeV < P_T < 100GeV$	2316	1.32268×10^6	5.13601×10^6	991255

$e^+e^- \rightarrow$	ww_h0ccds $cq.cq, dq, sq$	ww_h0ccbs cq, cq, dq, sq	ww_h0uusd uq, uq, sq, bq	ww_h0uubd $uq.uq, dq, bq$
Total	836128	100000	838010	100000
$65GeV < M_{miss} < 225GeV$	4919	1038	3802	797
$50GeV < M_{Total}$	4911	1038	3799	797
$10GeV < P_T < 100GeV$	937	359	234	247

Analysis

cut variables	what it means
$NIsL$	the number of reconstructed isolated leptons 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
$MisPx$	the missed mass's x momentum
$RecPx$	the isolated lepton's x momentum
$llInvMass$	the invariant mass of isolated lepton when NIsL=2
$l1p[4]$	the highest leptons' 4-momentum
$l2p[4]$	the second highest leptons' 4-momentum
$nRem$	the number of all final state particles except isolated leptons
$LLAngle$	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

Analysis

Data path:
/cefs/tmp_storage/liaolb/Arbor_3.
3/nnH_filter/background/RecData
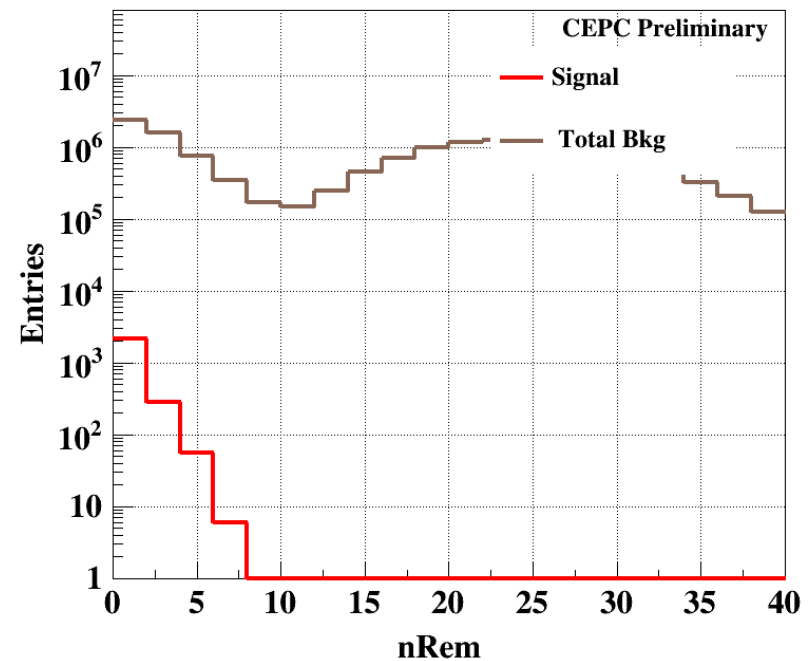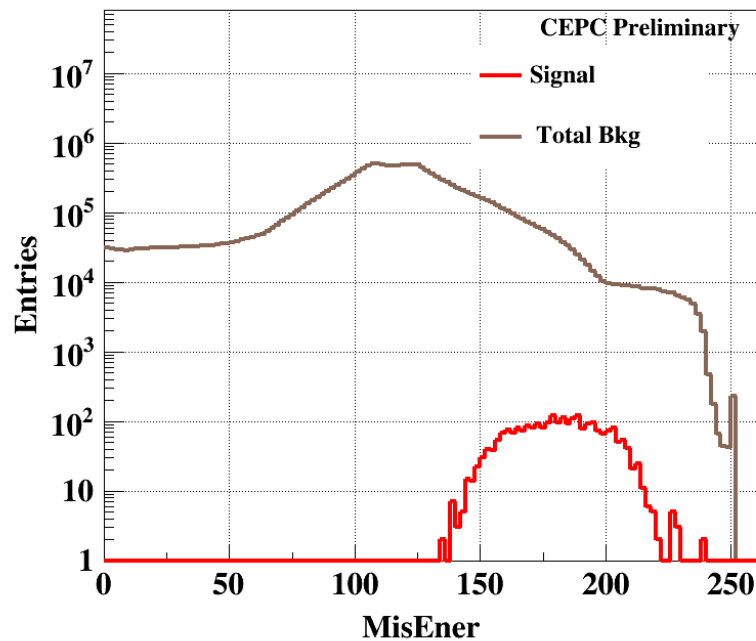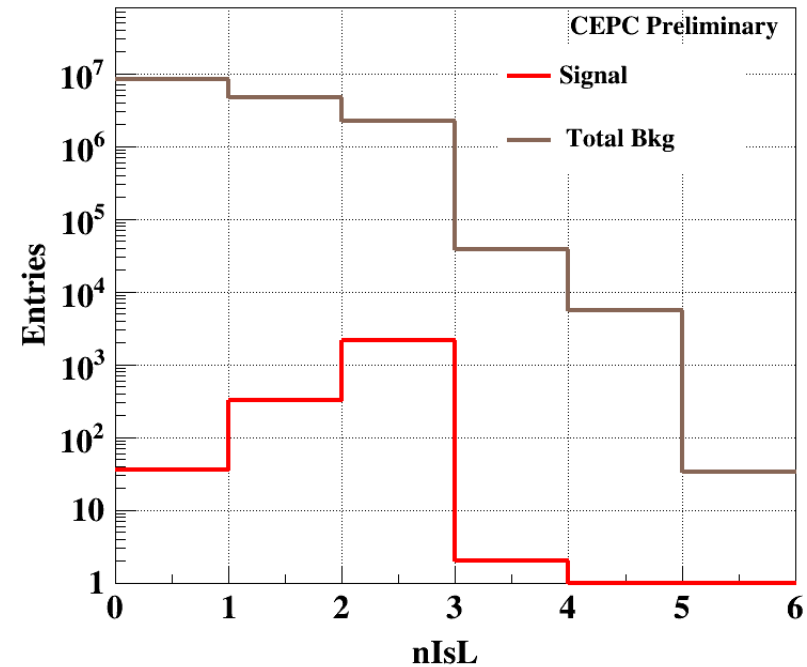
Analysis

Analysis

$$\Delta R \equiv \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$
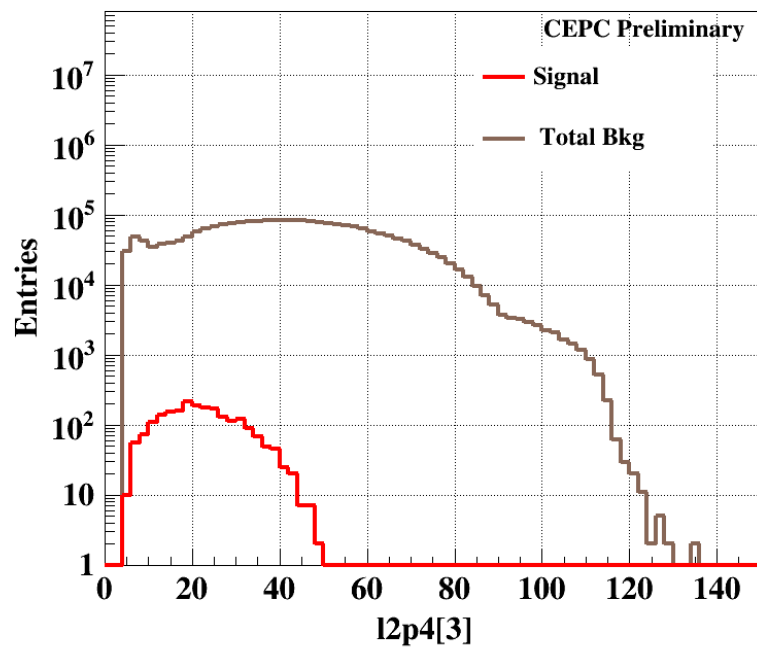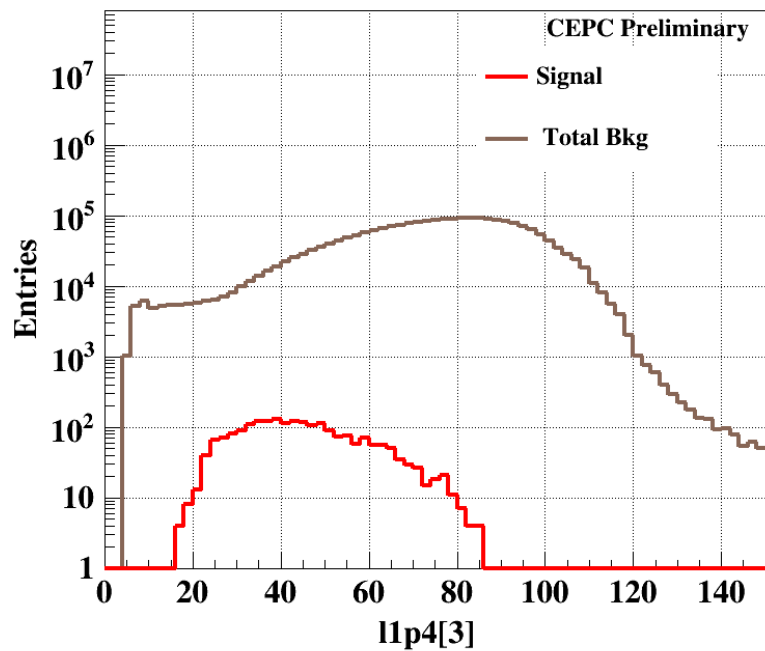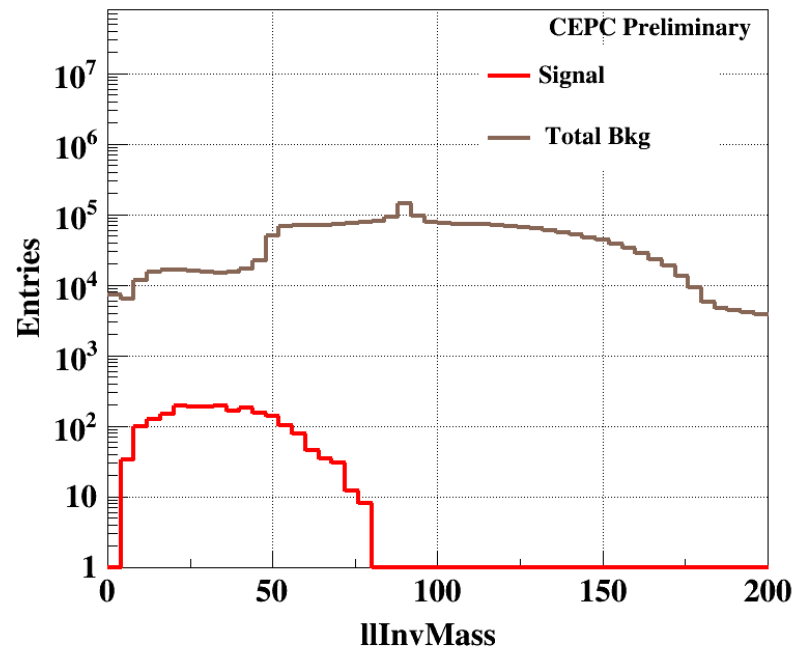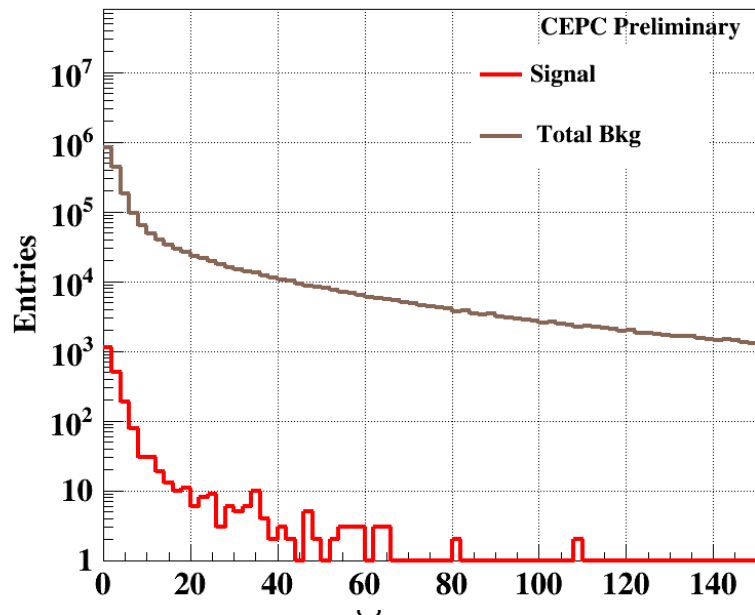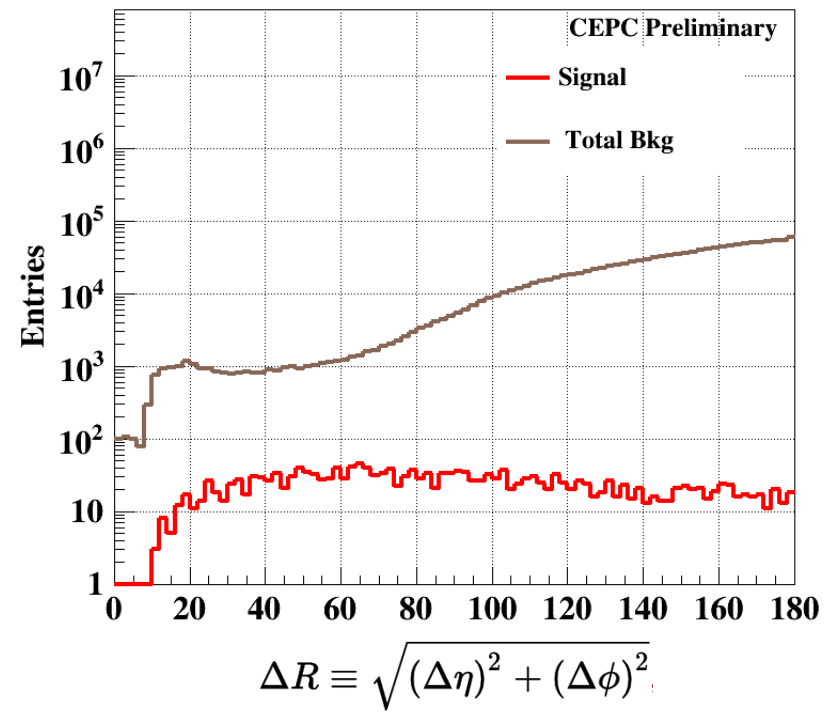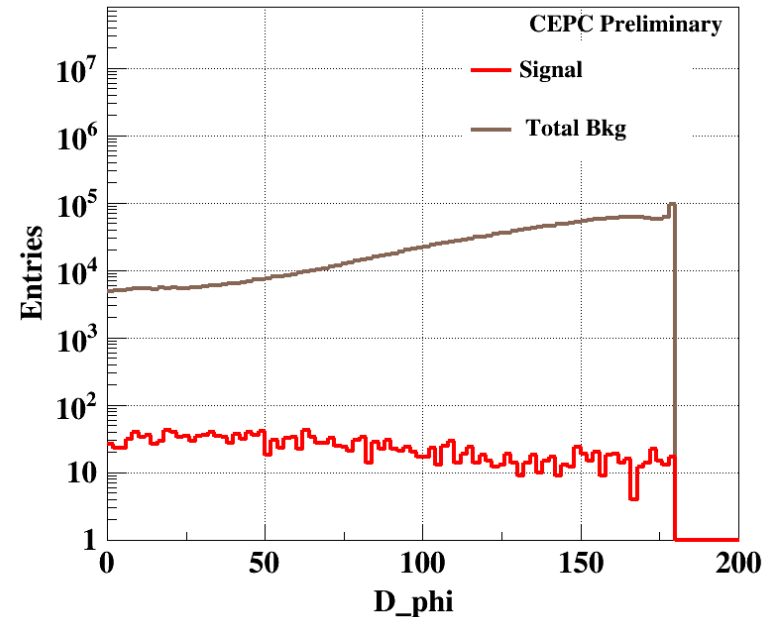

$$\text{pull} = \sqrt{\left(\frac{trkD0^2}{sigD0^2} + \frac{trcZ0^2}{sigZ0^2}\right) \cdot \left(\frac{trkD1^2}{sigD1^2} + \frac{trcD0^2}{sigZ1^2}\right)}$$

Total : the events pass through pre-selection

$e^+e^- \rightarrow$	signal	sznu_l	sze_sl	zz_h	bhabha	ww_h
Total	2480	58852	12599	10109	350286	42303
$nIsL == 2$	1042	578	144	91	3	36
$140\mathrm{GeV} < MisEner < 225\mathrm{GeV}$	1038	484	0	0	0	0
$nRem < 4$	1037	463	0	0	0	0
$5\mathrm{GeV} < llInvMass < 70\mathrm{GeV}$	1037	461	0	0	0	0
$20\mathrm{GeV} < l1p4[3] < 80\mathrm{GeV}$	1024	433	0	0	0	0
$10\mathrm{GeV} < l2p4[3] < 40\mathrm{GeV}$	929	390	0	0	0	0
$\triangle R < 100$	538	17	0	0	0	0
$pull < 70$	535	9	0	0	0	0
$\triangle\phi < 80$	495	6	0	0	0	0

$e^+e^- \rightarrow$	zz_sl	zzorww_h	zzorww_l	sw_l	e3e3
Total	733013	35594	650454	1.53246×10^6	425110
$nIsL == 2$	6618	32	17231	702537	23576
$140\mathrm{GeV} < MisEner < 225\mathrm{GeV}$	325	0	13652	198794	12685
$nRem < 4$	0	0	13392	198446	12483
$5\mathrm{GeV} < llInvMass < 70\mathrm{GeV}$	0	0	13384	198445	12477
$20\mathrm{GeV} < l1p4[3] < 80\mathrm{GeV}$	0	0	12819	183474	11109
$10\mathrm{GeV} < l2p4[3] < 40\mathrm{GeV}$	0	0	11024	138118	9544
$\triangle R < 100$	0	0	92	8804	10
$pull < 70$	0	0	33	8619	1
$\triangle\phi < 80$	0	0	21	5944	1

```
[#0] ERROR:InputArguments -- RooAddPdf::RooAddPdf(tot) number of pdfs and coefficients inconsistent, must have Npdf=
Ncoef or Npdf=Ncoef+1
root.exe: /afs/ihep.ac.cn/soft/common/gcc/v01-17-05/root/root/roofit/roofitcore/src/RooAddPdf.cxx:181: RooAddPdf::Ro
oAddPdf(const char*, const char*, const RooArgList&, const RooArgList&, Bool_t): Assertion `0' failed.
```
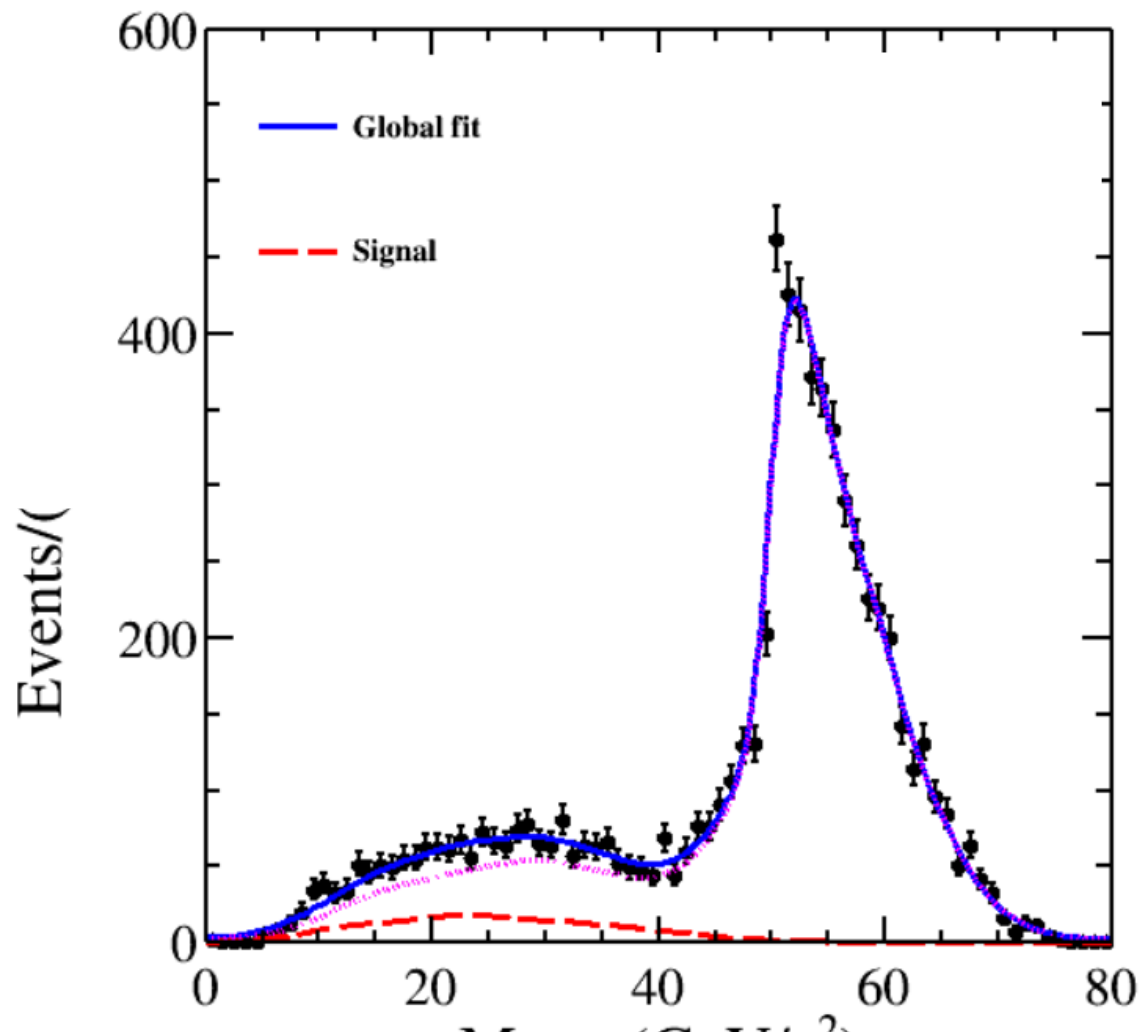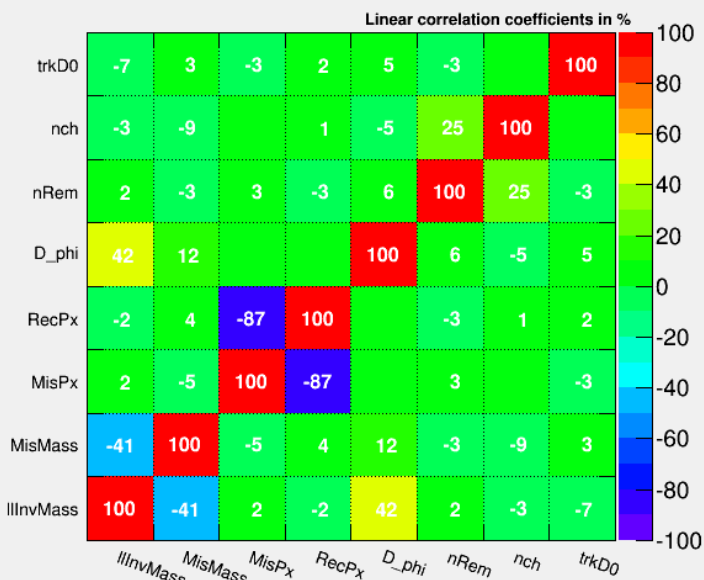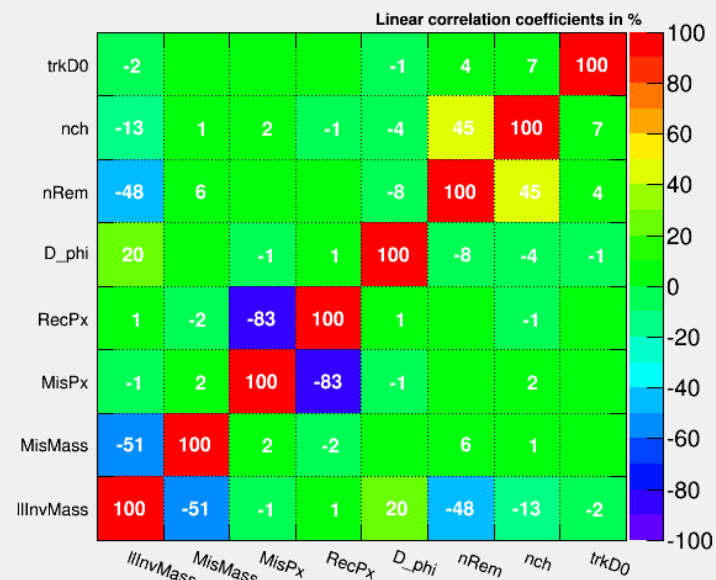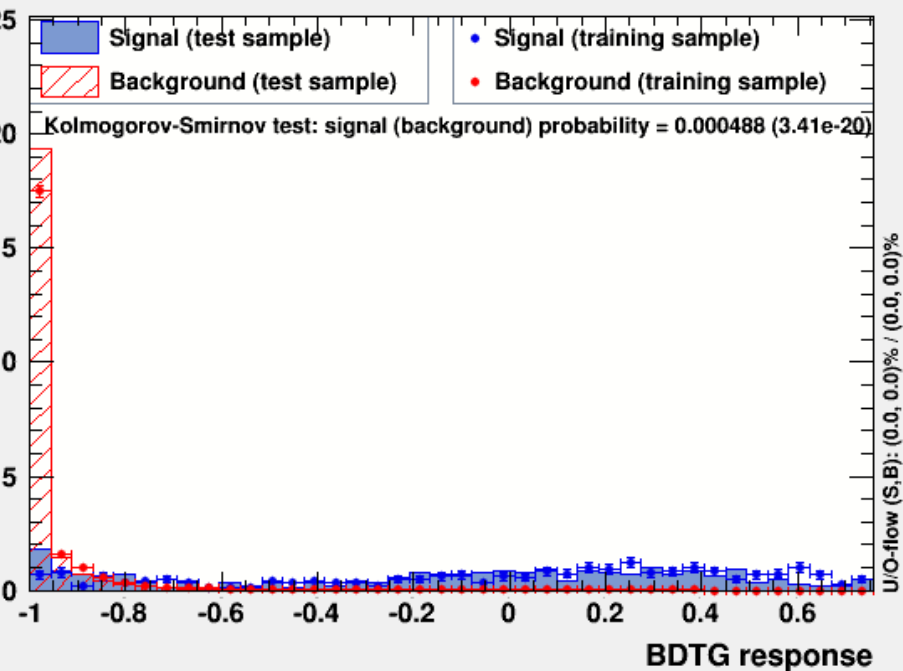

RooKeysPdf

Thanks !

Backup

Correlation Matrix (signal)

Linear correlation coefficients in %

	IIInvMass	MisMass	MisPx	RecPx	D_phi	nRem	nch	trkD0
trkD0	-7	3	-3	2	5	-3		100
nch	-3	-9		1	-5	25	100	
nRem	2	-3	3	-3	6	100	25	-3
D_phi	42	12			100	6	-5	5
RecPx	-2	4	-87	100		-3	1	2
MisPx	2	-5	100	-87				-3
MisMass	-41	100	-5	4	12	-3	-9	3
IIInvMass	100	-41	2	-2	42	2	-3	-7

Correlation Matrix (background)

Linear correlation coefficients in %

	IIInvMass	MisMass	MisPx	RecPx	D_phi	nRem	nch	trkD0
trkD0	-2				-1	4	7	100
nch	-13	1	2	-1	-4	45	100	7
nRem	-48	6			-8	100	45	4
D_phi	20		-1	1	100	-8	-4	-1
RecPx	1	-2	-83	100	1			-1
MisPx	-1	2	100	-83	-1			2
MisMass	-51	100	2	-2		6	1	
IIInvMass	100	-51	-1	1	20	-48	-13	-2

VA overtraining check for classifier: BDTG

Kolmogorov-Smirnov test: signal (background) probability = 0.000488 (3.41e-20)

- Signal (test sample)
- Background (test sample)
- Signal (training sample)
- Background (training sample)

BDTG response

Cut efficiencies and optimal cut value

- Signal efficiency
- Background efficiency
- Signal purity
- Signal efficiency*purity
- $S / \#sqrt\{S+B\}$

For 495 signal and 6850 background events the maximum $S / \sqrt{S+B}$ is 18.5492 when cutting at -0.5105

Cut value applied on BDTG output

Cut efficiencies and optimal cut value

For 1909 signal and 209552 background events the maximum S / √S+B is 4.9534 when cutting at -0.9838

TMVA response for classifier: BDTG

Total : the events pass through pre-selection

$e^+e^- \rightarrow$	signal	sznu_l	sze_sl	zz_h	bhabha	ww_h
Total	2480	58852	12599	10109	350286	42303
$nIsL == 2$	1042	578	144	91	3	36
$140\text{GeV} < MisEner < 225\text{GeV}$	1038	484	0	0	0	0
$nRem < 4$	1037	463	0	0	0	0
$5\text{GeV} < llInvMass < 70\text{GeV}$	1037	461	0	0	0	0
$20\text{GeV} < l1p4[3] < 80\text{GeV}$	1024	433	0	0	0	0
$10\text{GeV} < l2p4[3] < 40\text{GeV}$	929	390	0	0	0	0
$\triangle R < 100$	538	17	0	0	0	0
$pull < 70$	535	9	0	0	0	0
$\triangle \phi < 80$	495	6	0	0	0	0

$e^+e^- \rightarrow$	ww_l	szeorsw_l	sze_l	e2e2	zz_l
Total	886210	420854	118574	42939	113442
$nIsL == 2$	138900	1	2894	42105	7856
$140\text{GeV} < MisEner < 225\text{GeV}$	54848	0	87	35147	3094
$nRem < 4$	54249	0	39	33803	1214
$5\text{GeV} < llInvMass < 70\text{GeV}$	54245	0	38	33785	1200
$20\text{GeV} < l1p4[3] < 80\text{GeV}$	54298	0	27	30954	1042
$10\text{GeV} < l2p4[3] < 40\text{GeV}$	35119	0	17	27425	827
$\triangle R < 100$	908	0	1	853	56
$pull < 70$	808	0	1	327	24
$\triangle \phi < 80$	590	0	1	268	19

$e^+e^- \to$	zz_sl	zzorww_h	zzorww_l	sw_l	e3e3
Total	733013	35594	650454	1.53246×10^6	425110
$nIsL == 2$	6618	32	17231	702537	23576
$140\text{GeV} < MisEner < 225\text{GeV}$	325	0	13652	198794	12685
$nRem < 4$	0	0	13392	198446	12483
$5\text{GeV} < llInvMass < 70\text{GeV}$	0	0	13384	198445	12477
$20\text{GeV} < l1p4[3] < 80\text{GeV}$	0	0	12819	183474	11109
$10\text{GeV} < l2p4[3] < 40\text{GeV}$	0	0	11024	138118	9544
$\triangle R < 100$	0	0	92	8804	10
$pull < 70$	0	0	33	8619	1
$\triangle\phi < 80$	0	0	21	5944	1

$e^+e^- \to$	nn	qq	sznu_sl	ww_sl	sw_sl
Total	649303	3.84418×10^6	541380	3.94811×10^{10}	652741
$nIsL == 2$	0	5245	403	22713	7647
$140\text{GeV} < MisEner < 225\text{GeV}$	0	1440	229	666	190
$nRem < 4$	0	0	1	0	0
$5\text{GeV} < llInvMass < 70\text{GeV}$	0	0	1	0	0
$20\text{GeV} < l1p4[3] < 80\text{GeV}$	0	0	1	0	0
$10\text{GeV} < l2p4[3] < 40\text{GeV}$	0	0	0	0	0
$\triangle R < 100$	0	0	0	0	0
$pull < 70$	0	0	0	0	0
$\triangle\phi < 80$	0	0	0	0	0

D_phi