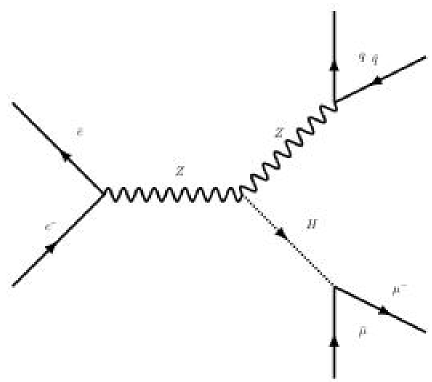
Simulation studies for $e^+e^- \to ZH$ production with $Z \to qq$ and $H \to \mu^+\mu^-$

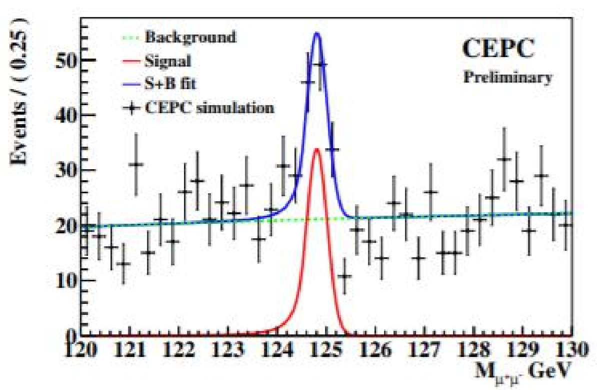
October , 2019

Motivation

- H → μ μ is important for probing the Higgs Yukawa couplings. Also, offers the best opportunity to measure the couplings to the second generation fermions.
- With electron-positron colliders, we can gain much higher significance due to extremely clean background.

Previous Measuerments[05301]gave counted significance at [124, 125] GeV: 10.8σ





next step：

Develop new selection criterial by keeping most signals and suppressing background.

samples

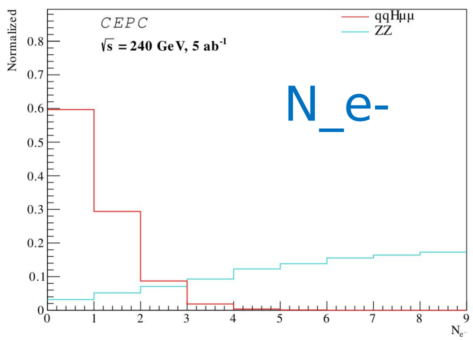
- CEPC : $\sqrt{s}$=240GeV, luminosity:5.6ab^{-1},3.5 Tesla magnetic field
- Sample:
  - —signal :qqh_e2e2, ~100M
  - —background :
    - 2 fermions, ~28 M
    - 4 fermions
      - —Single W, ~18M
      - —Single Z, ~8 M
      - —WW, ~46 M
      - —ZZ, ~6 M
      - —Z or W: ~20 M
- Data set: for qqh_e2e2 ,we generate by ourselves.
  for others,we use dst files in
  path :/cefs/data/DstData/CEPC240/CEPC_v4/.

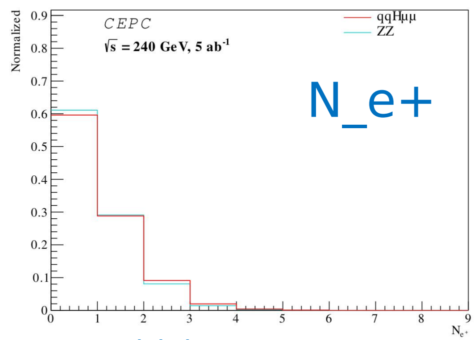
Event selction

Cut	qqh_e2e2 (Yield)	eff	zz_sl0mu_down (Yield)	eff	ww_sl0muq (Yield)	eff
Initial	148.849	1	680700	1	1.21172e+07	1
N_mum > 0, N_mup > 0	147.917	0.99374	328010	0.4818	623044	0.0514183
105 < M_mumu < 130 GeV	122.165	0.82073	7106.62	0.0104	4285.14	0.0003536
25 < N_particle < 115	121.532	0.81648	7032.29	0.0103	4230.69	0.0003491
55 < M_qq < 125 GeV	120.583	0.8101	6766.7	0.00994	2880.19	0.0002376
P_qqmumu < 32 GeV, 195 < E_qqmumu < 265 GeV	119.935	0.80575	6672.55	0.00980	1947.52	0.00016072
35 < E_mum < 100 GeV, 35 < E_mup < 100 GeV	119.508	0.80288	6186.95	0.00908	823.761	6.79831e-05
16 < p_mumu < 72 GeV	118.721	0.79759	6080.91	0.00893	803.959	6.63489e-05
N_em < 6, N_ep < 6, N_e < 9						
E_em < 10 GeV, E_ep < 10 GeV, E_ee < 19 GeV						

Compare two PID methods

- method1: int pID=recPart->getType();
- Then we classify them by if(pID ==11 or -11) statements.
- Nevertheless,we get a non-consistent result in lepton number, we decided to check the reason.

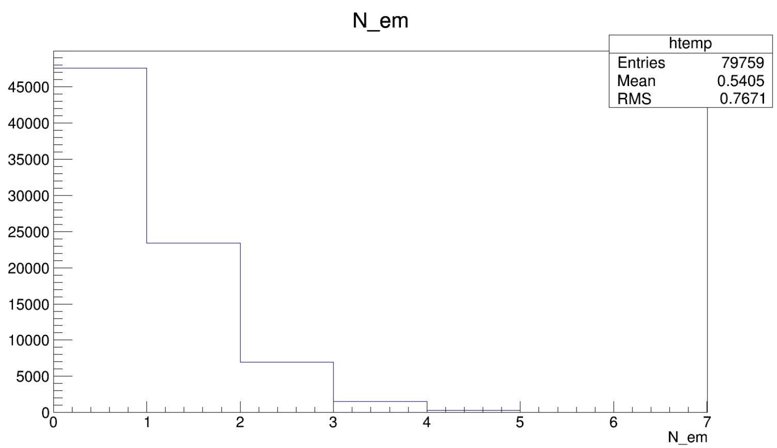


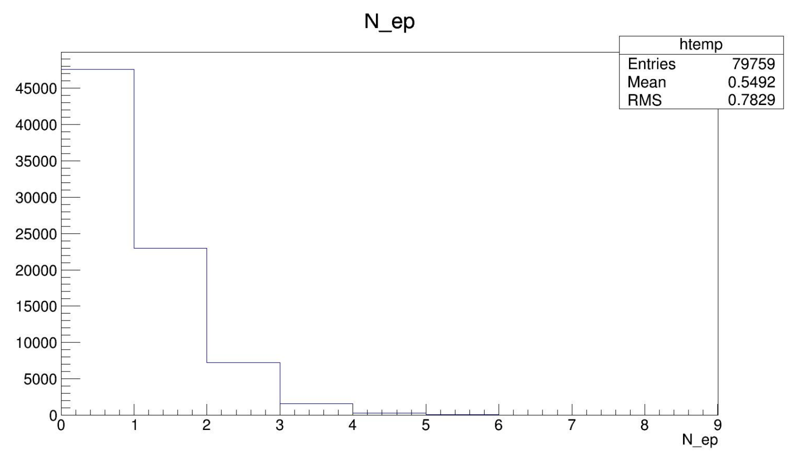


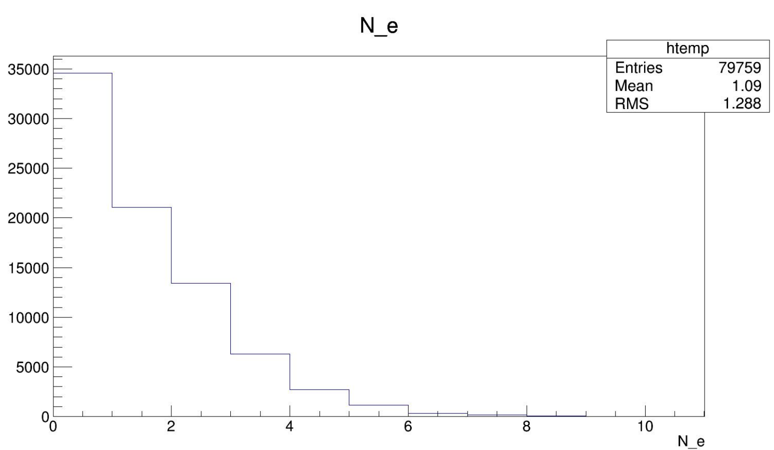
- method2: int pID=abs(recPart->getType()); Double_t charge = recPart->getCharge();
- After a long time, we find out another method. Then we classify them by if(charge) statements. below are comparision.

n_(e- , e+, e)

- for our signal, two methods is consistent.

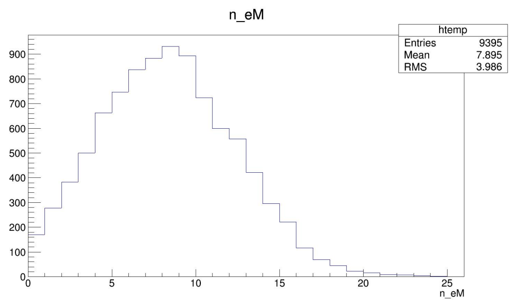


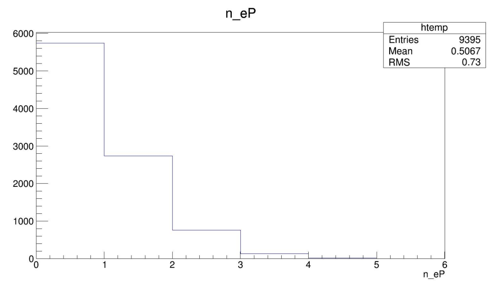


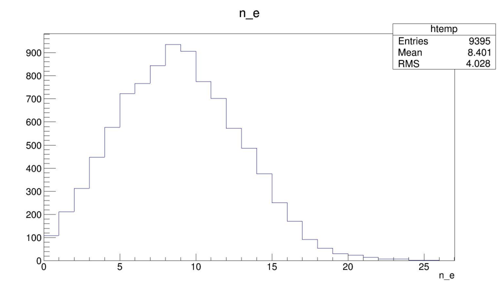


n_(e- , e+, e)

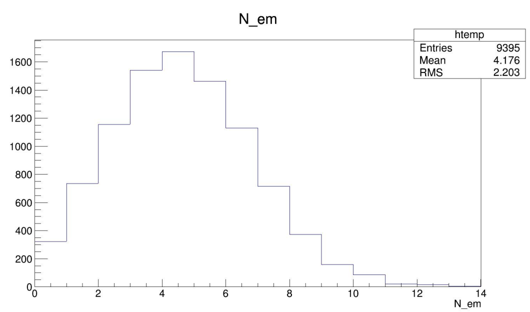
- for our zz bkg, two methods is different.
- method1:

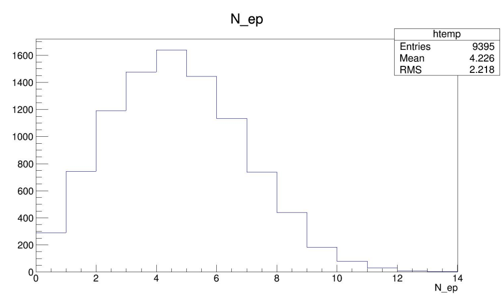


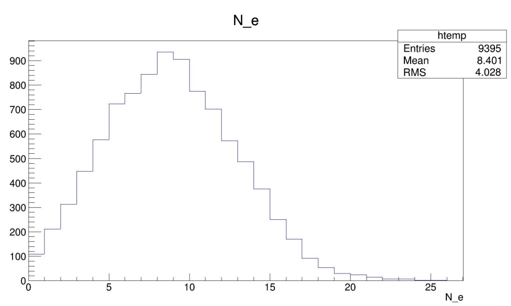




- method2:



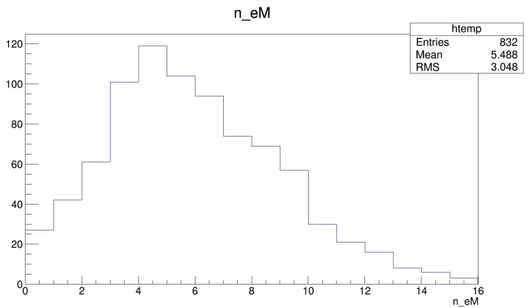


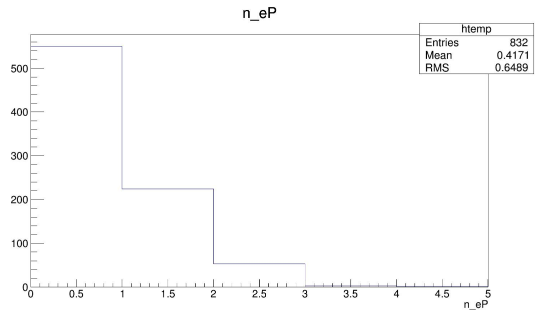


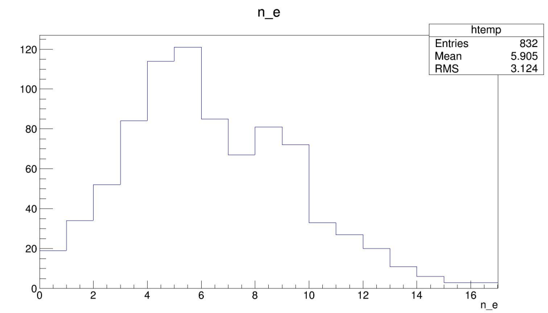
- we conclude that method1 miss the charge identify of electrons and we shuld choose mtehod2. this is the reason why we found e+ and e- behavior bad.

n_(e- , e+, e)

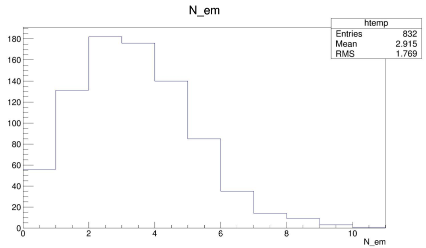
- for our ww bkg, two methods is different.
- method1:

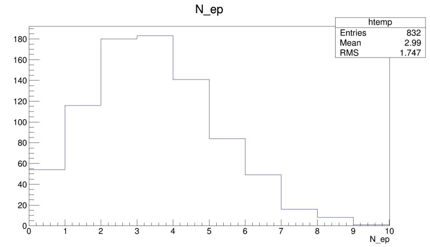


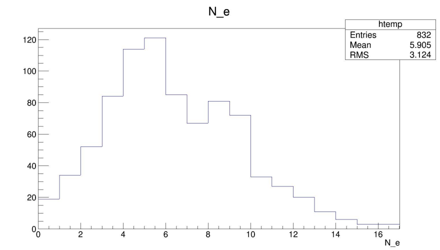




- method2:







- we conclude that method1 miss the charge identify of electrons and we shuld choose mtehod2. this is the reason why we found e+ and e- behavior bad.

n_(e- , e+, e)

- for our zz bkg(9395).

	method1	method2
n_eM	74531	39232
n_eP	4400	39699/4400 miss charge35299/88.9%

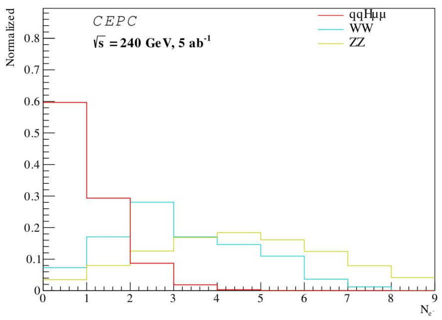
- for our ww bkg(832).

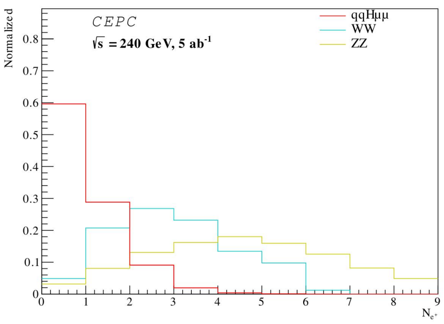
	method1	method2
n_eM	4566	2425
n_eP	347	2488/347 miss charge 2141/86.0%

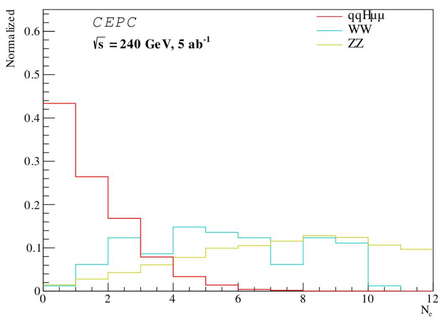
n_e (qqh_e2e2, zz, ww)

- Next, we met another a very hard problem, why signal and background behave differently.

- So, we start to do truth match.

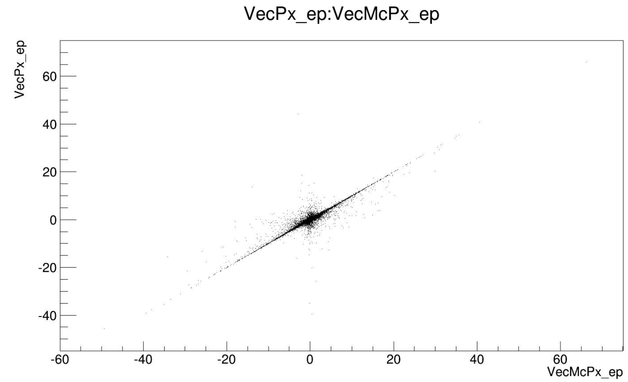


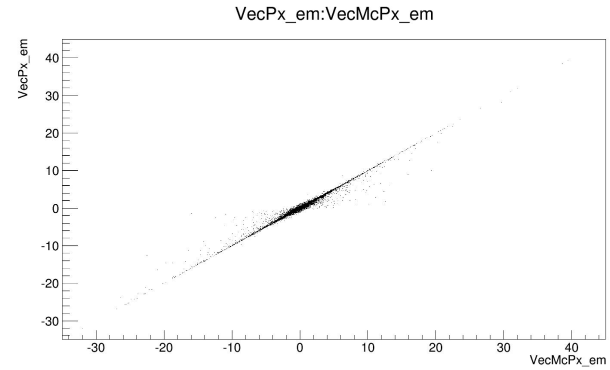


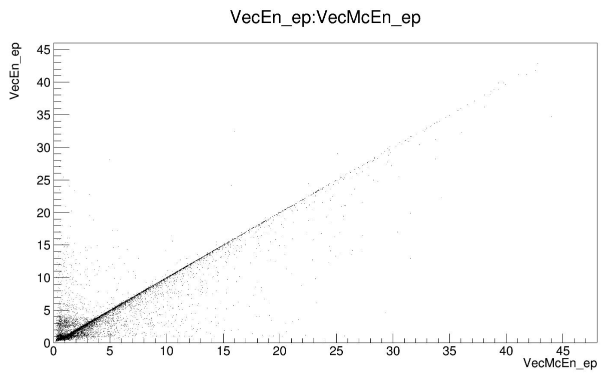


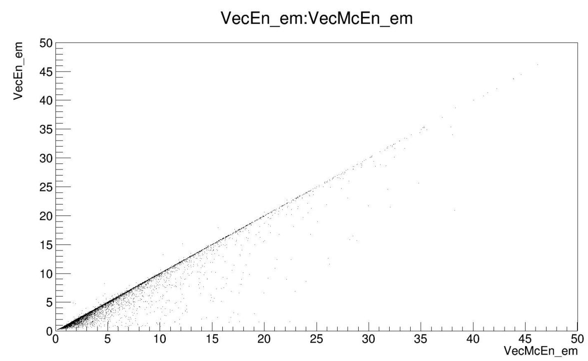
qqh_e2e2(neve=79759)

	reconstruction		truth	diff	match eff
n_eM	43106	truth_n_eM	31691	11415	73.5%
n_eP	43801	truth_n_eP	30962	12839	70.7%



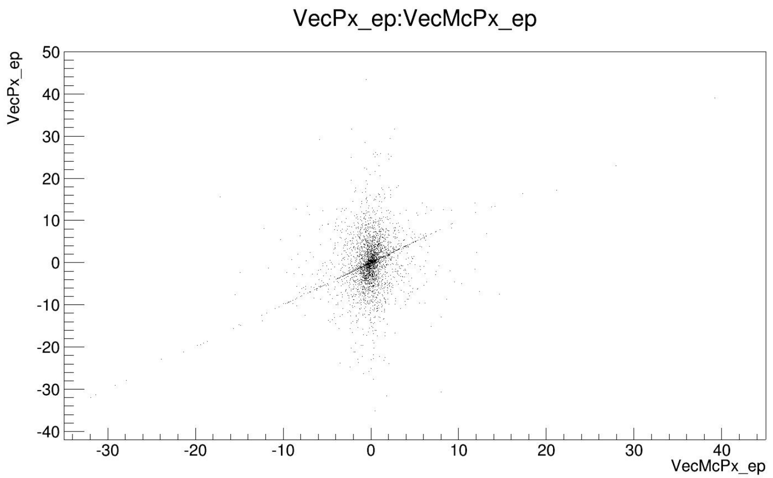


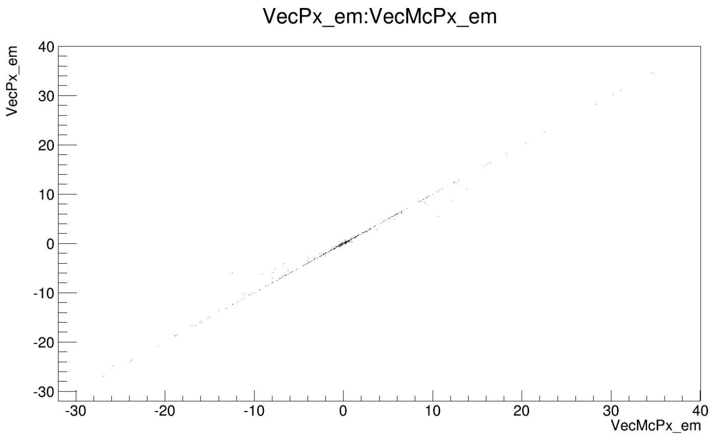




zz(neve=9395)

	reconstruction		truth	diff	match eff
n_eM	39232	truth_n_eM	1599	37633	4.07%
n_eP	39699	truth_n_eP	3207	36492	8.07%





ID

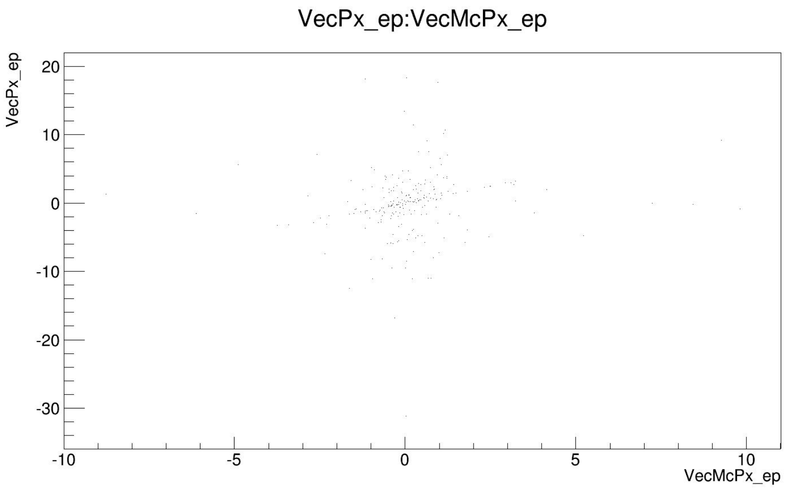
- not macth particles ID(signal, zzbkg).
- mainly for K ,pi,mu,p.

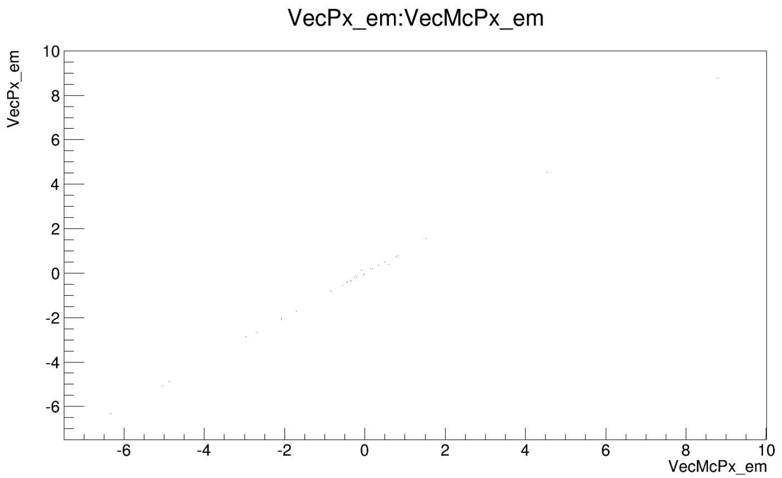
Row	Instance	VecPx_ep	VecPdgid
0	0	-0.865943	321
0	1		-211
3	0	-0.326160	-13
3	1	0.5050494	-211
4	0	-0.197183	-211
4	1		211
9	0	0.6127303	13
9	1		-13
10	0	0.3955472	-13
10	1		13
14	0	-1.761609	-13
14	1		13
15	0	1.8791396	-211
15	1	0.3676467	211
15	2	0.5738330	211
19	0	-0.283491	-211
19	1		-211
22	0	-6.551384	13
22	1		-11
25	0	1.2851487	211
25	1	0.2109682	-211
26	0	0.2689844	-321
26	1		211
29	0	-1.363713	211
29	1	-0.114861	-211

Row	Instance	VecPx_ep	VecPdgid
0	0	-0.723916	-211
0	1	-0.453402	-2212
0	2	0.0484974	-321
1	0	1.1677911	-13
1	1		13
2	0	24.040988	-13
2	1	12.252845	-211
3	0	0.1755324	13
3	1		-13
4	0	16.621028	211
4	1	14.450820	-211
5	0	-8.581720	13
5	1	1.4854545	-13
5	2	3.9532139	-211
6	0	-21.36803	211
6	1		13
7	0	1.5704510	13
7	1		-13
8	0	-2.231853	-211
8	1	-0.411620	-13
9	0	38.72929	-13
9	1		13
10	0	4.7652440	13
10	1	5.0943036	321
10	2	1.4507381	-211

ww(neve=832)

	reconstruction		truth	diff	match eff
n_eM	2425	truth_n_eM	71	2354	2.927%
n_eP	2488	truth_n_eP	228	2260	9.164%

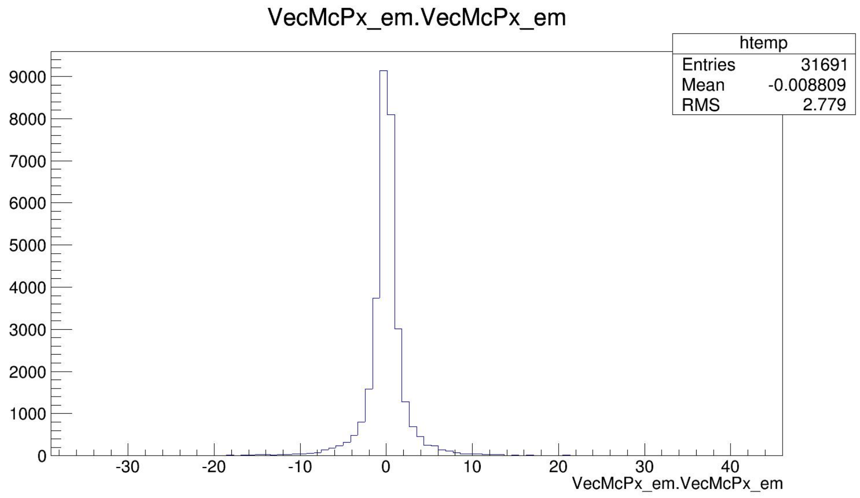


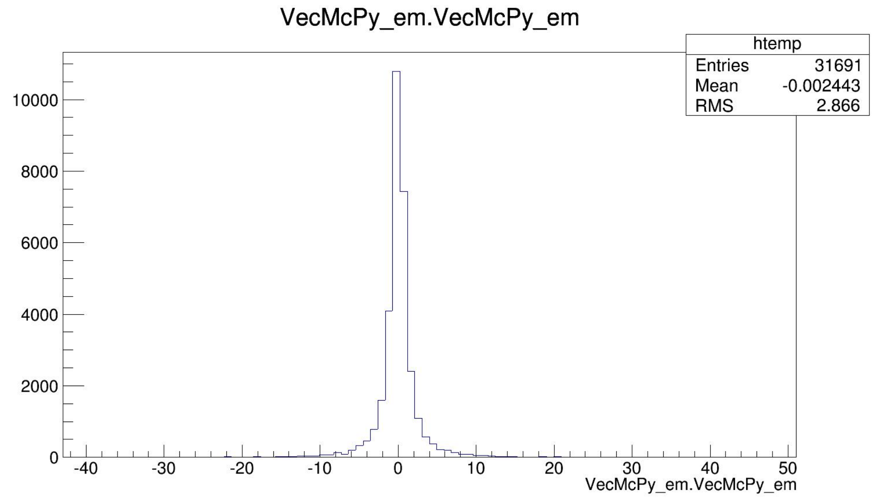


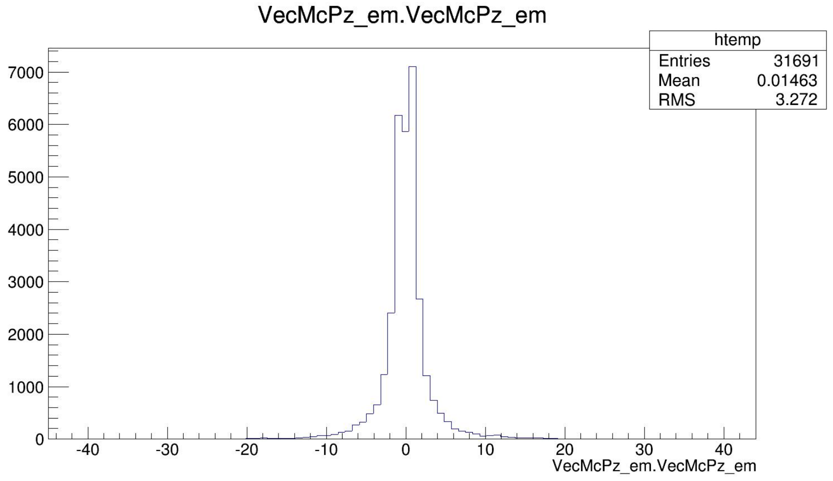
back_up

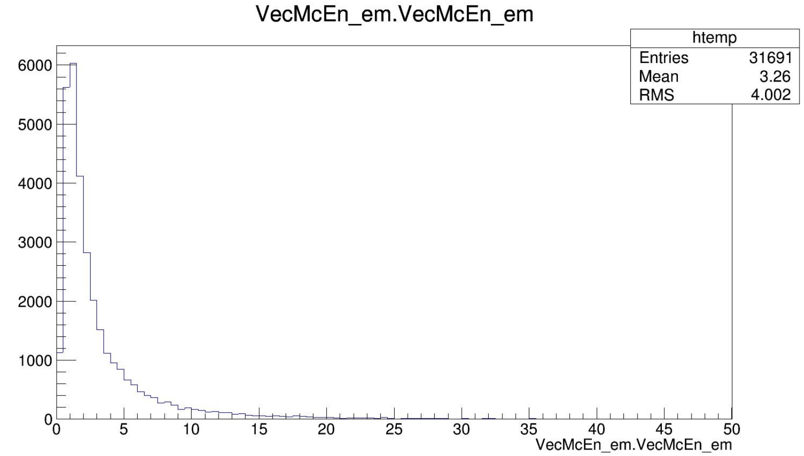
- we see the truth momentum and angle informatation in our signal and zz backgroud as an example.

signal (e- MC four-momentum)

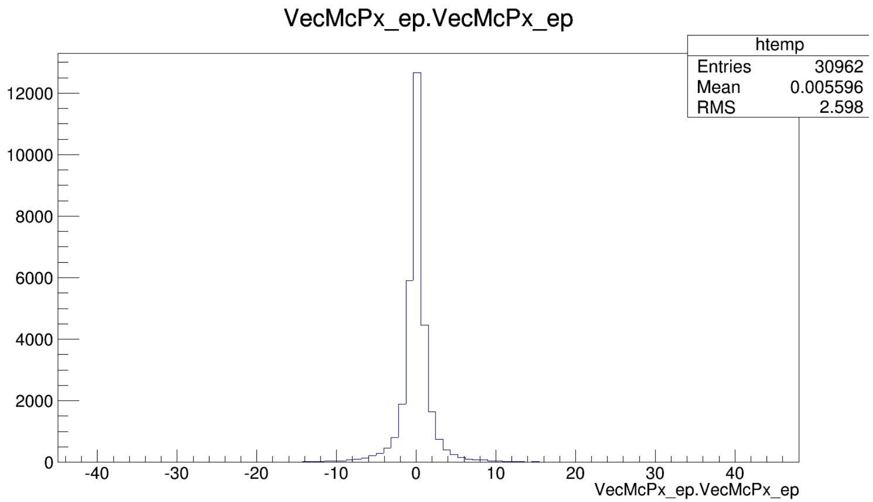


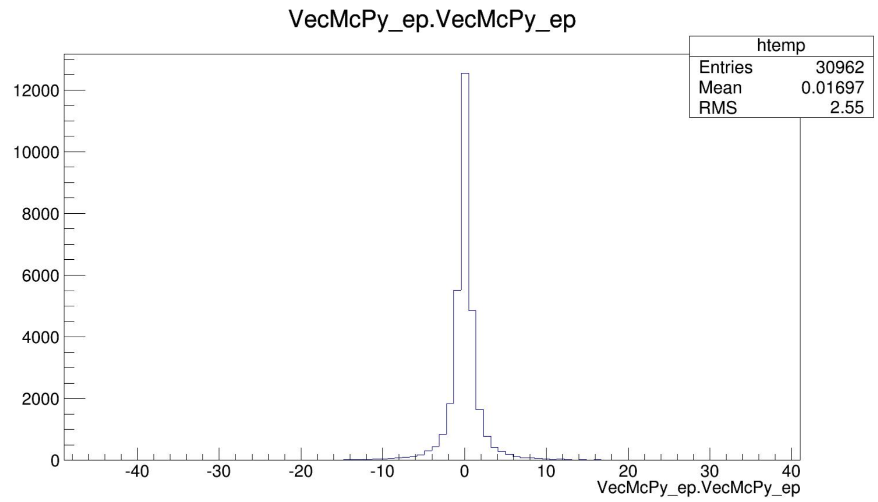


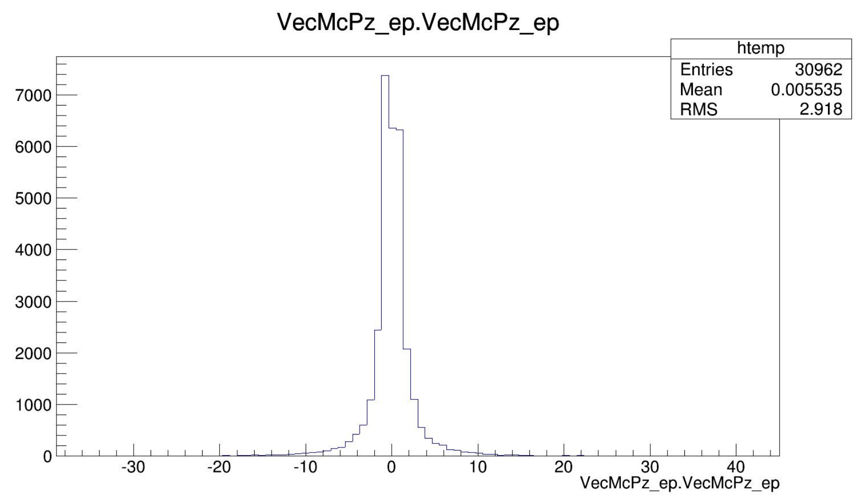


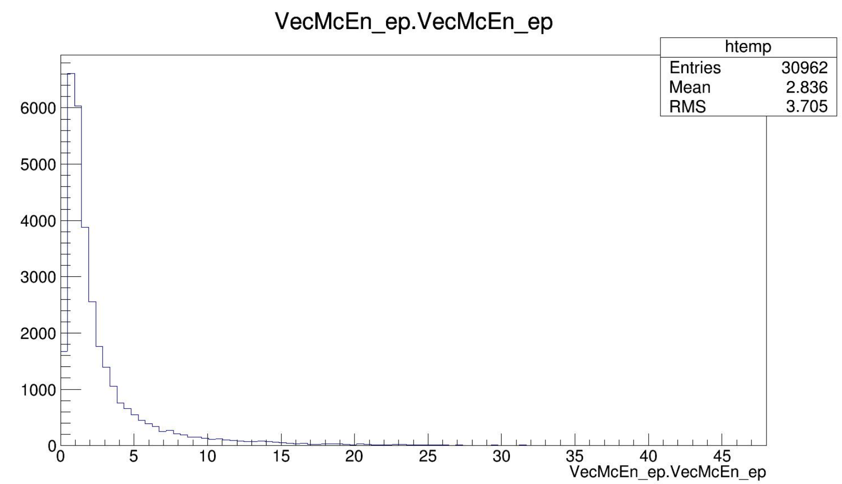


signal (e+ MC four-momentum)

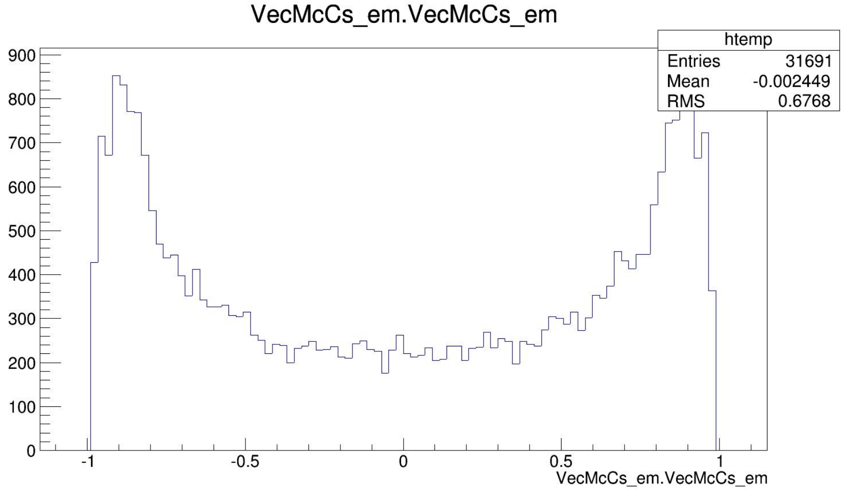


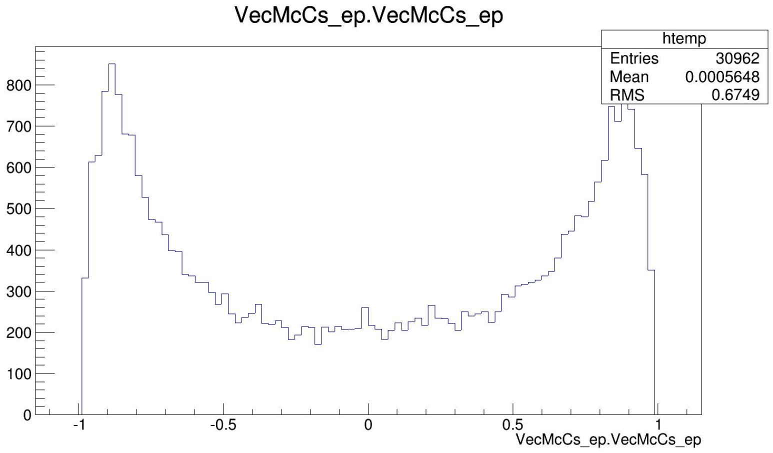




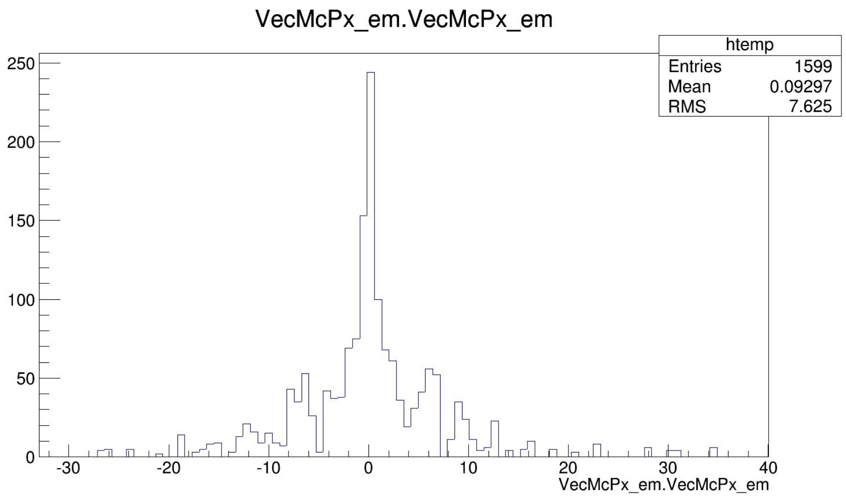


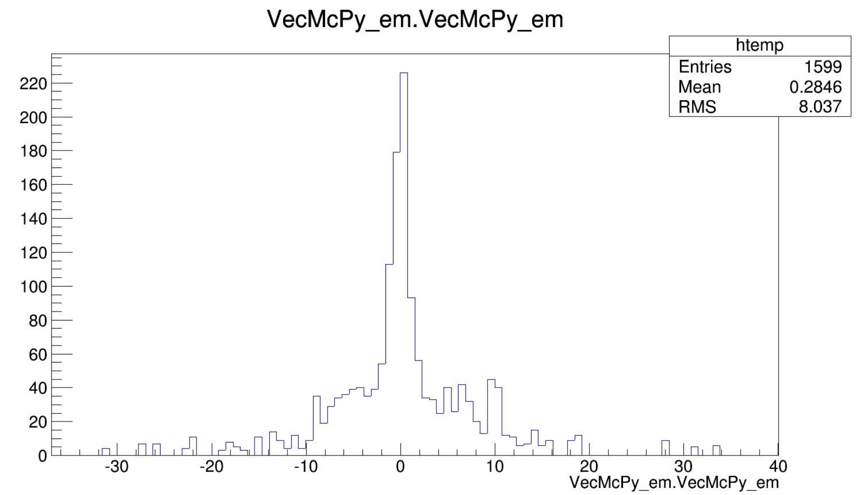
signal (e- and e+ MC CosTheta info)

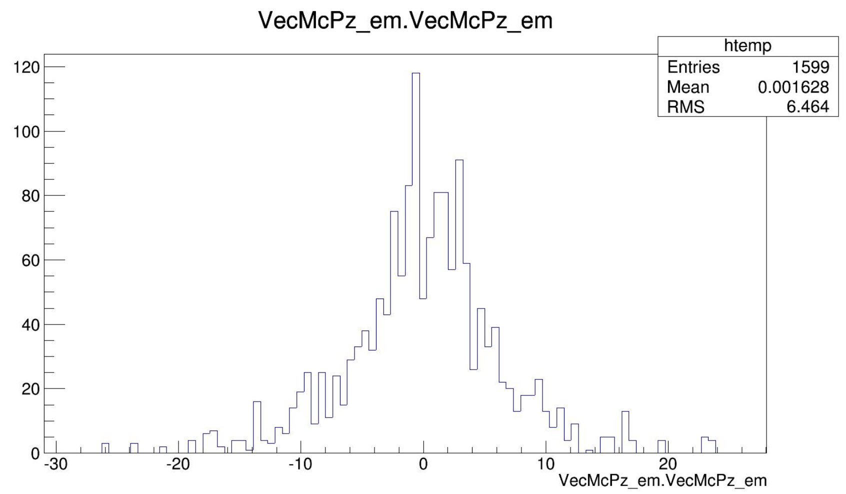


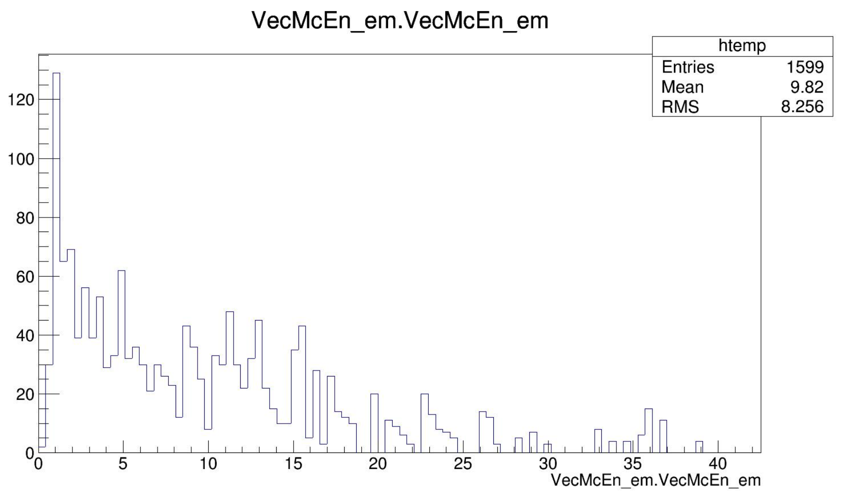


ZZ-bkg (e- MC four-momentum)

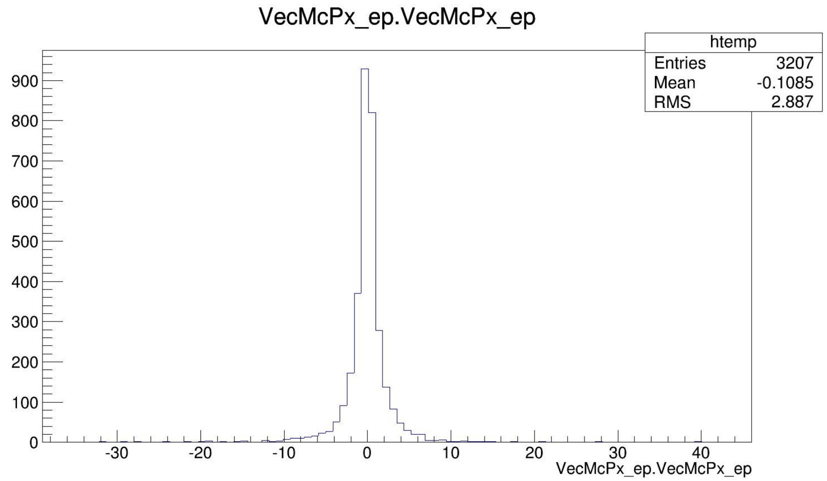


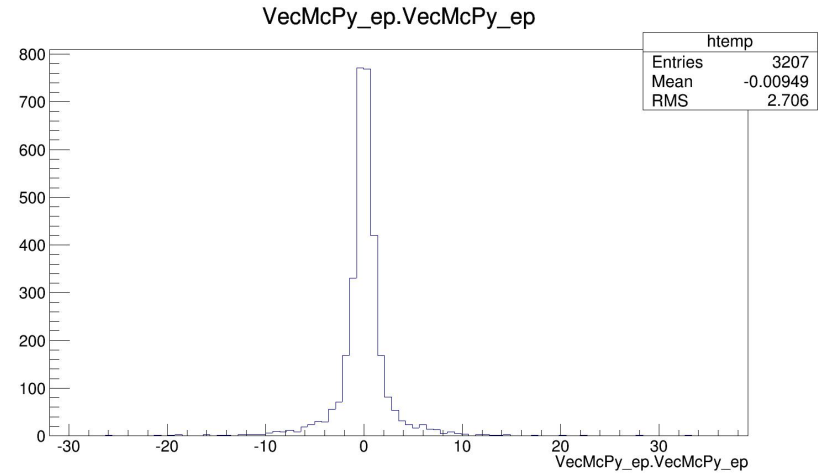


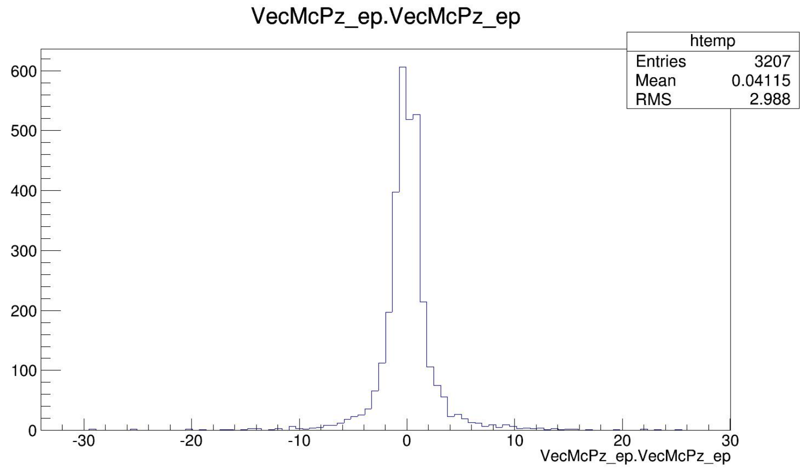


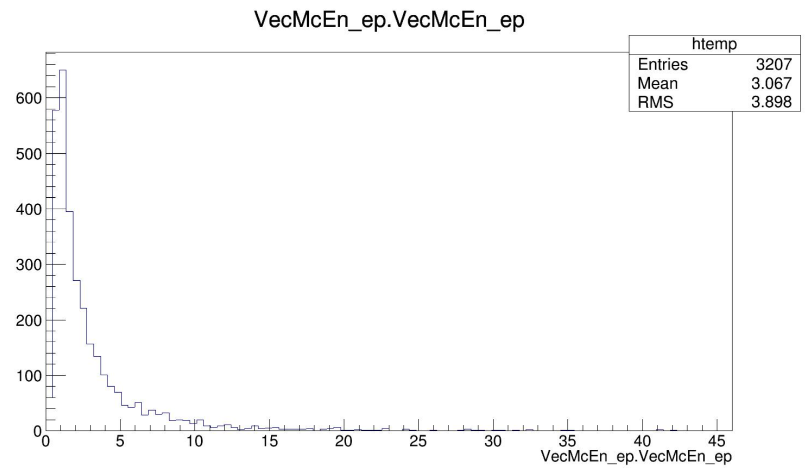


ZZ-bkg (e+ MC four-momentum)









ZZ-bkg (e- and e+ MC CosTheta info)