Collecting Efficiency

(Weekly Report)

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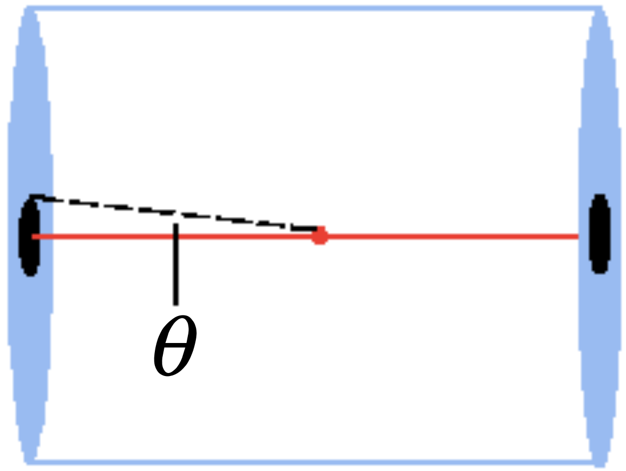
Content

- Motivation
- Event selection
- Collecting efficiency
    - Background
    - Signal
- Summary
- back up

Motivation

- To learn the sensitive of our detector as function of diameter of beam pipe.
- Particle collecting efficiency is defined as number of events wherein all visible particles within detector acceptance divided by number of event.
- Energy collecting efficiency is defined as energy of visible particles within detector acceptance divided by overall visible particles energy.



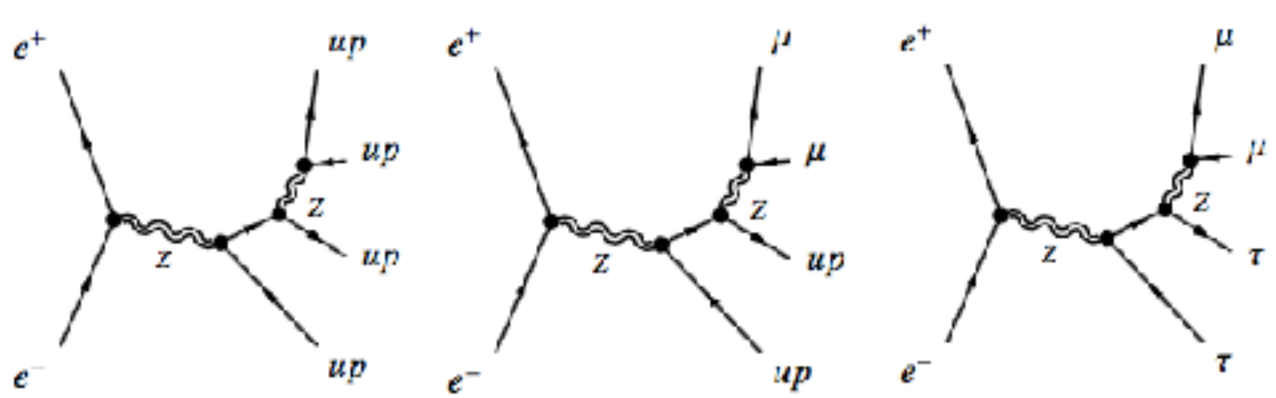
$$Particle\_collecting\_efficiency = \frac{\text{Number of events wherein all visible particles within detector acceptance}}{\text{Number of events}}$$

$$Energy\_collecting\_efficiency = \frac{\text{Energy of visible particles within detector acceptance}}{\text{Overall visible particle energy}}$$

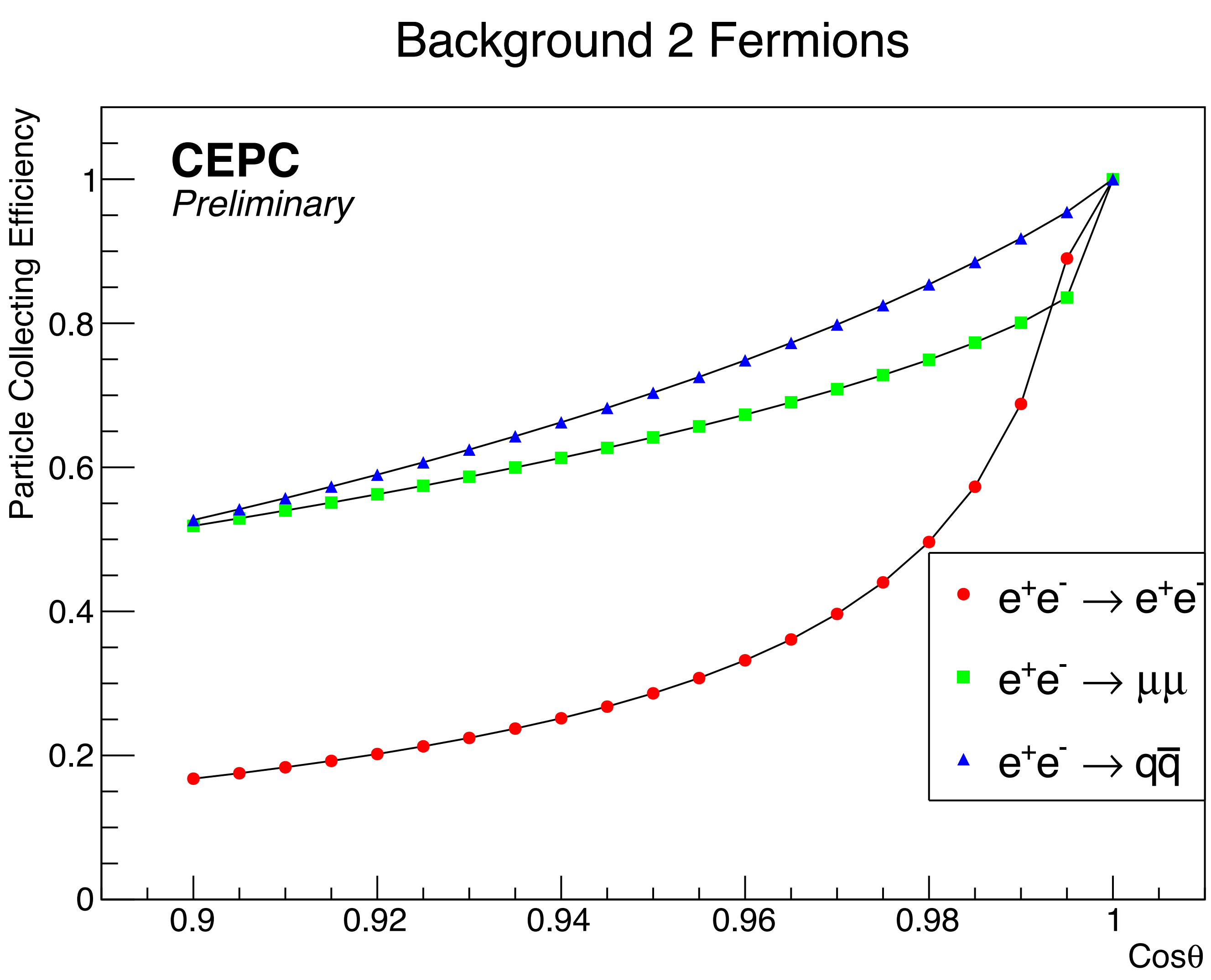
Event Selection

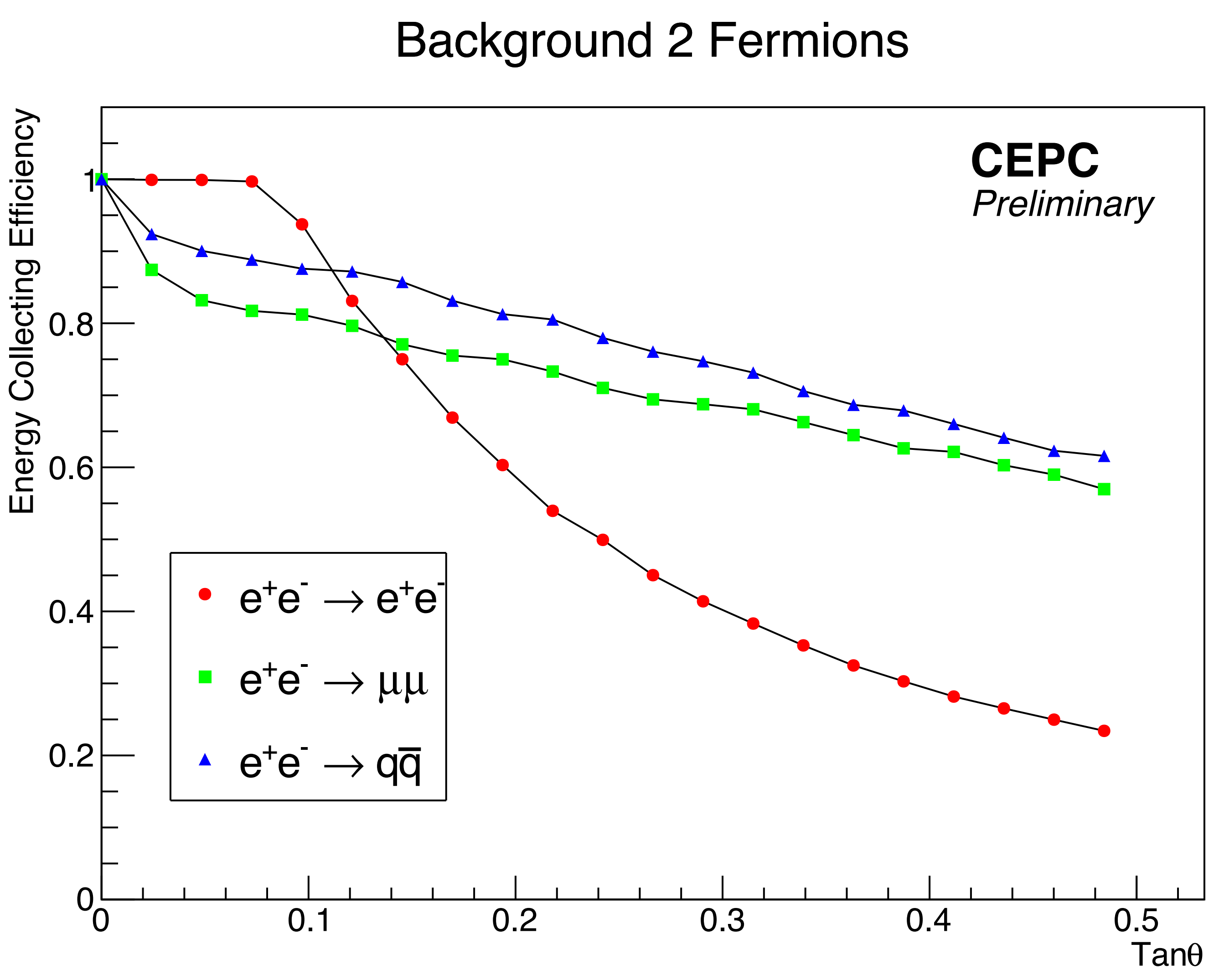
- Particle collecting efficiency :
  - Use MC Trust
  - NParent = 0
    - For electron and positron: skip the photon
    - For parton: PID < 6
    - For lepton: PID = 11, 13, 15
- Energy collecting efficiency:
  - Use MC Trust
  - VTX.Mag() < 10 && EndP.Mag() > 10
  - Visible particle
  - Consider impact of magnetic field

ZZ_h ZZ_sl ZZ_l

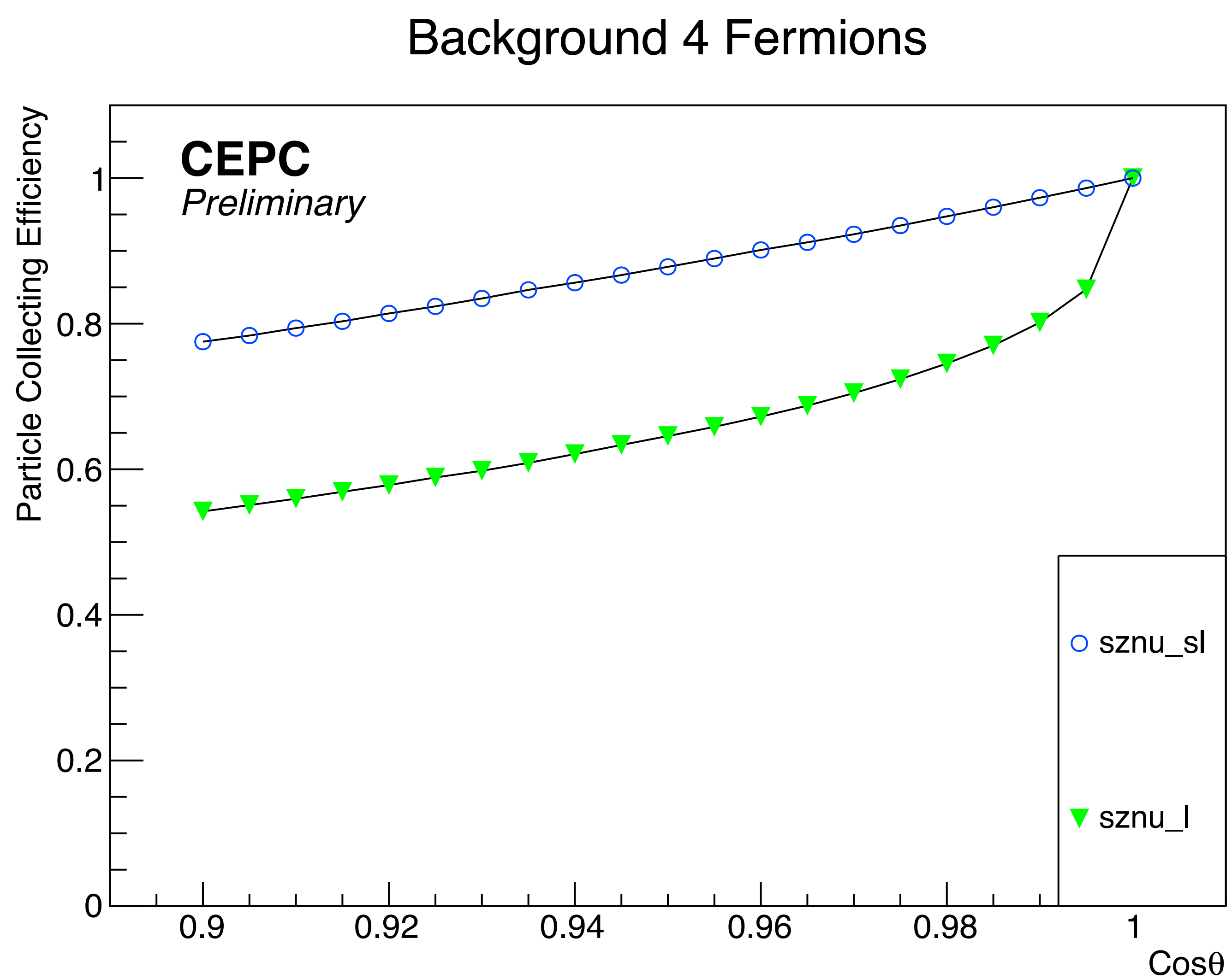


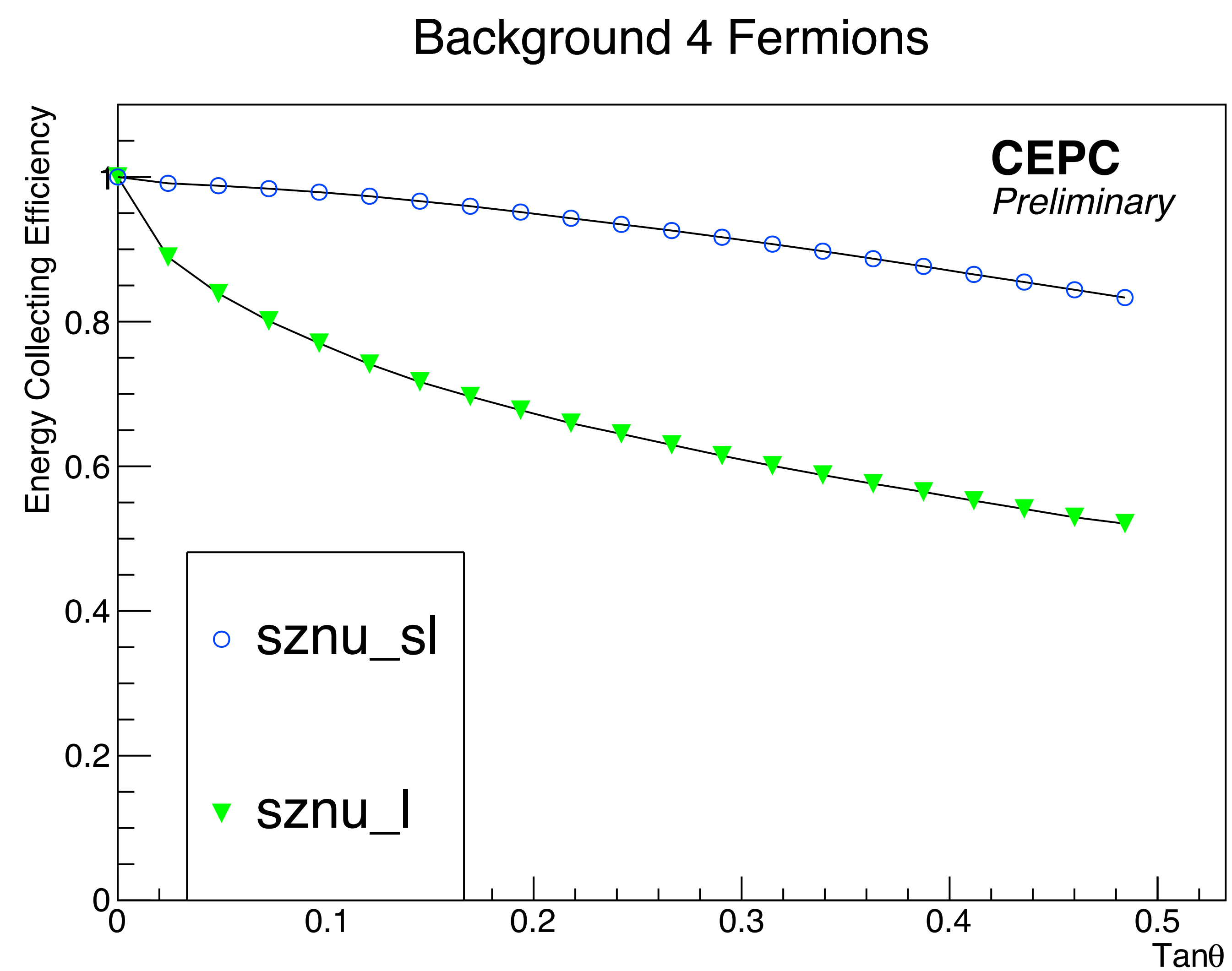
Background 2 Fermions Collecting Efficiency

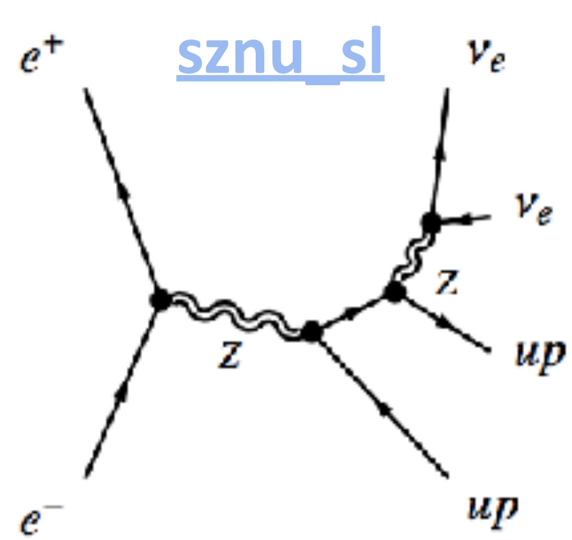


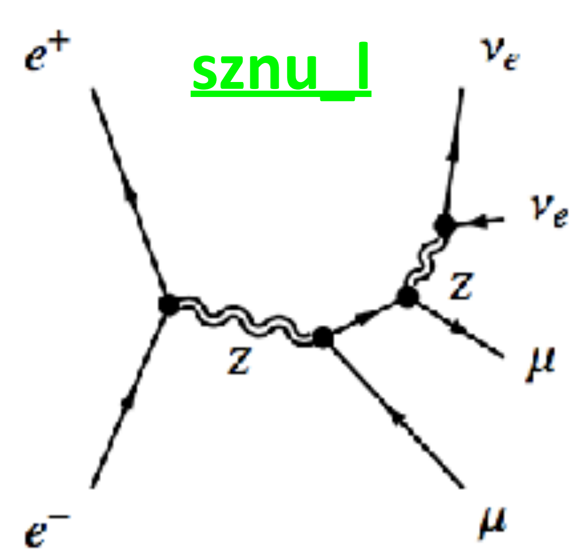


Background 4 Fermions Collecting Efficiency

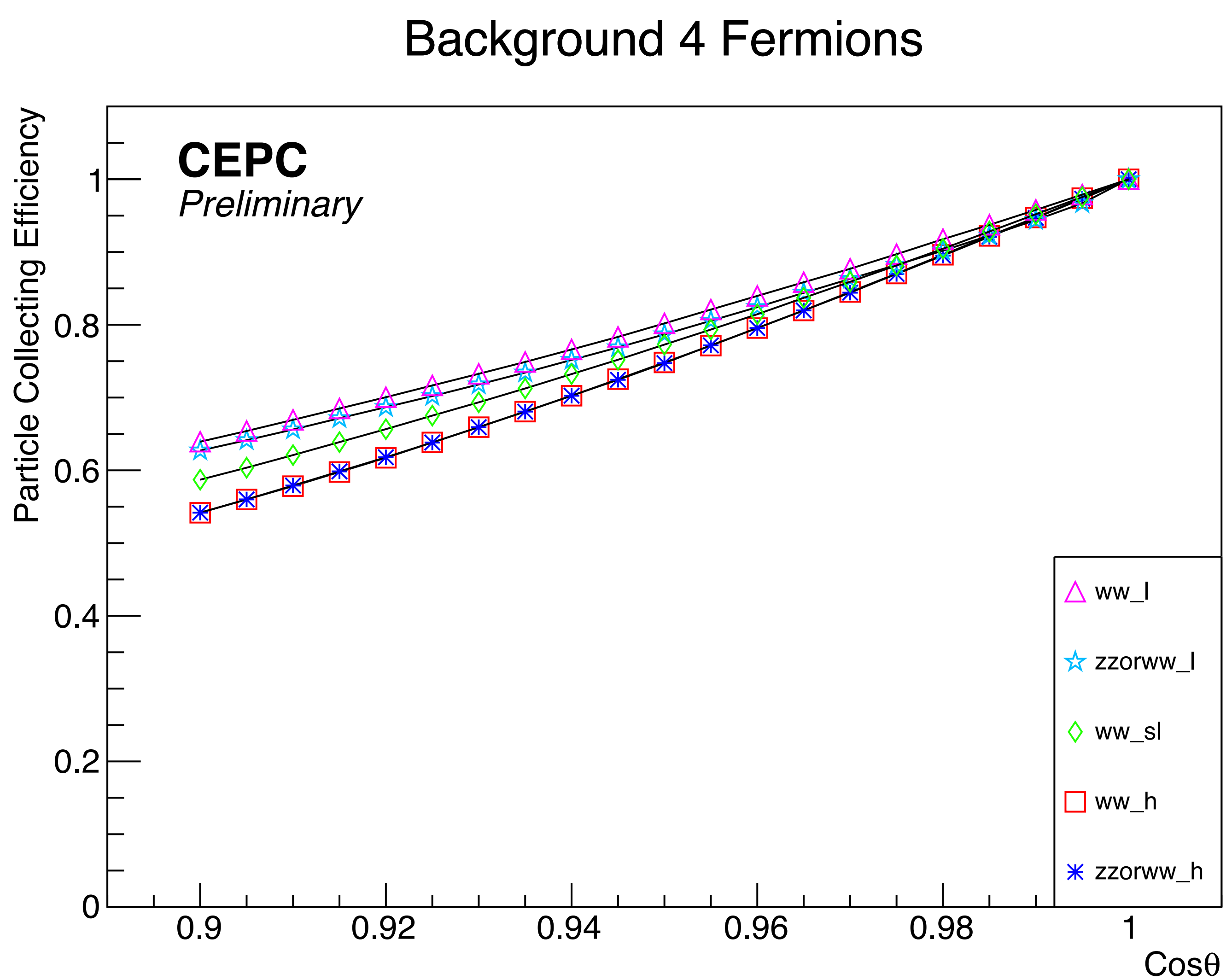


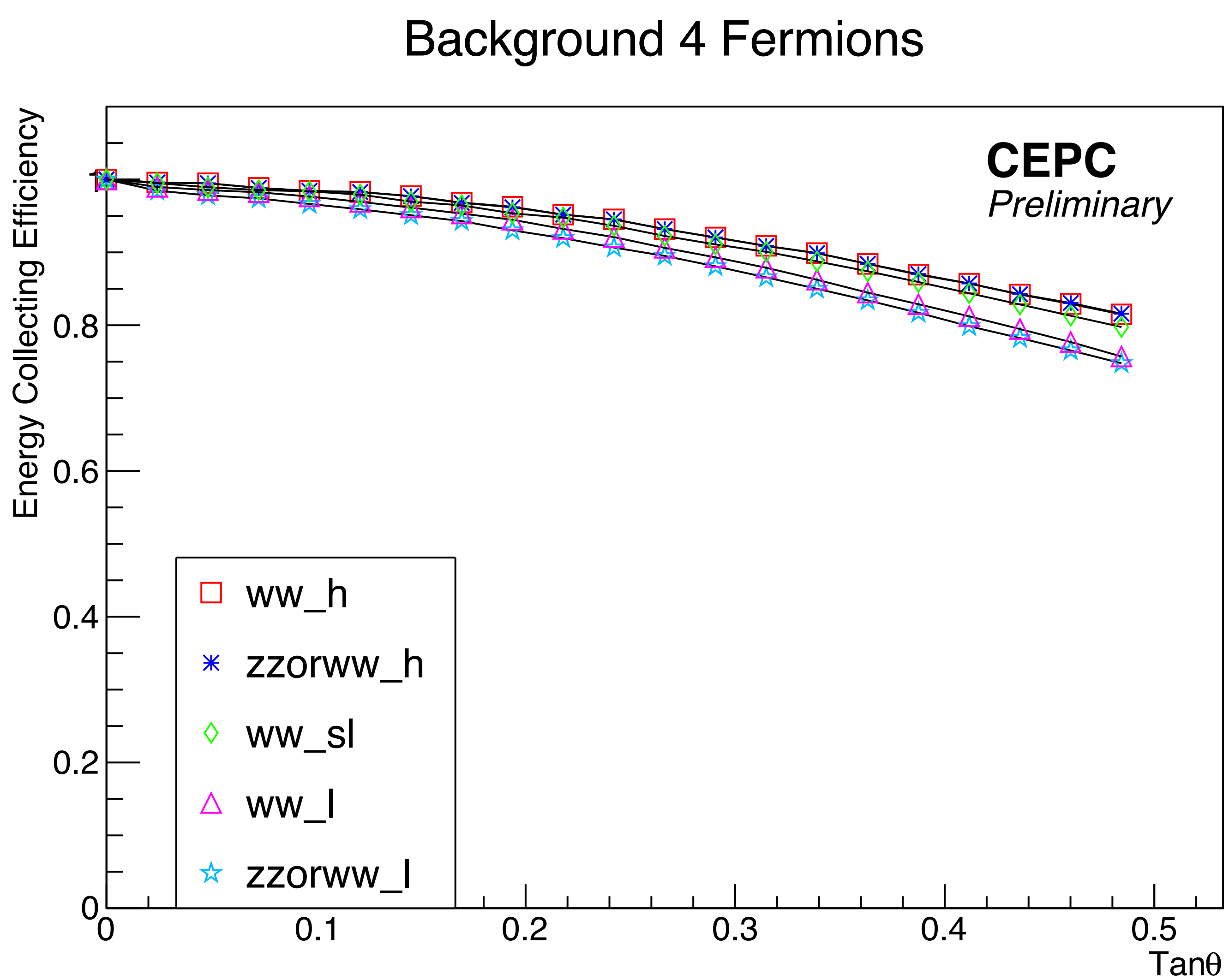


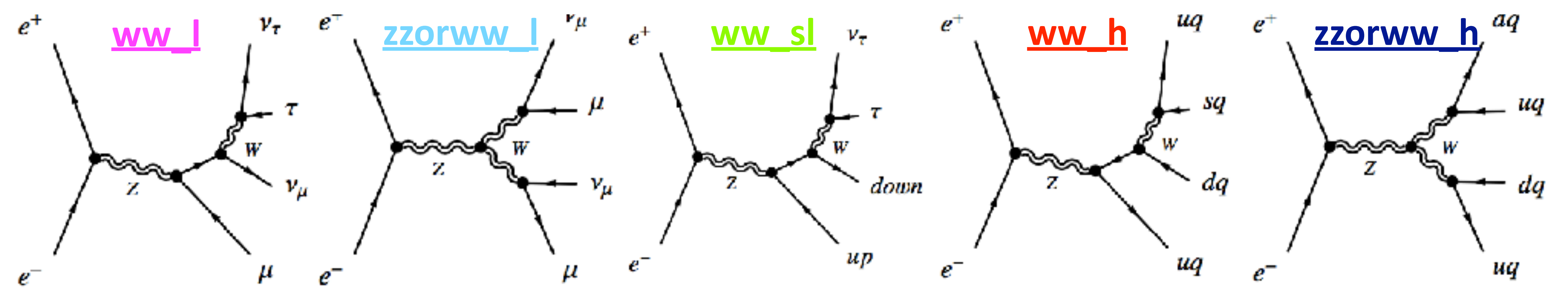




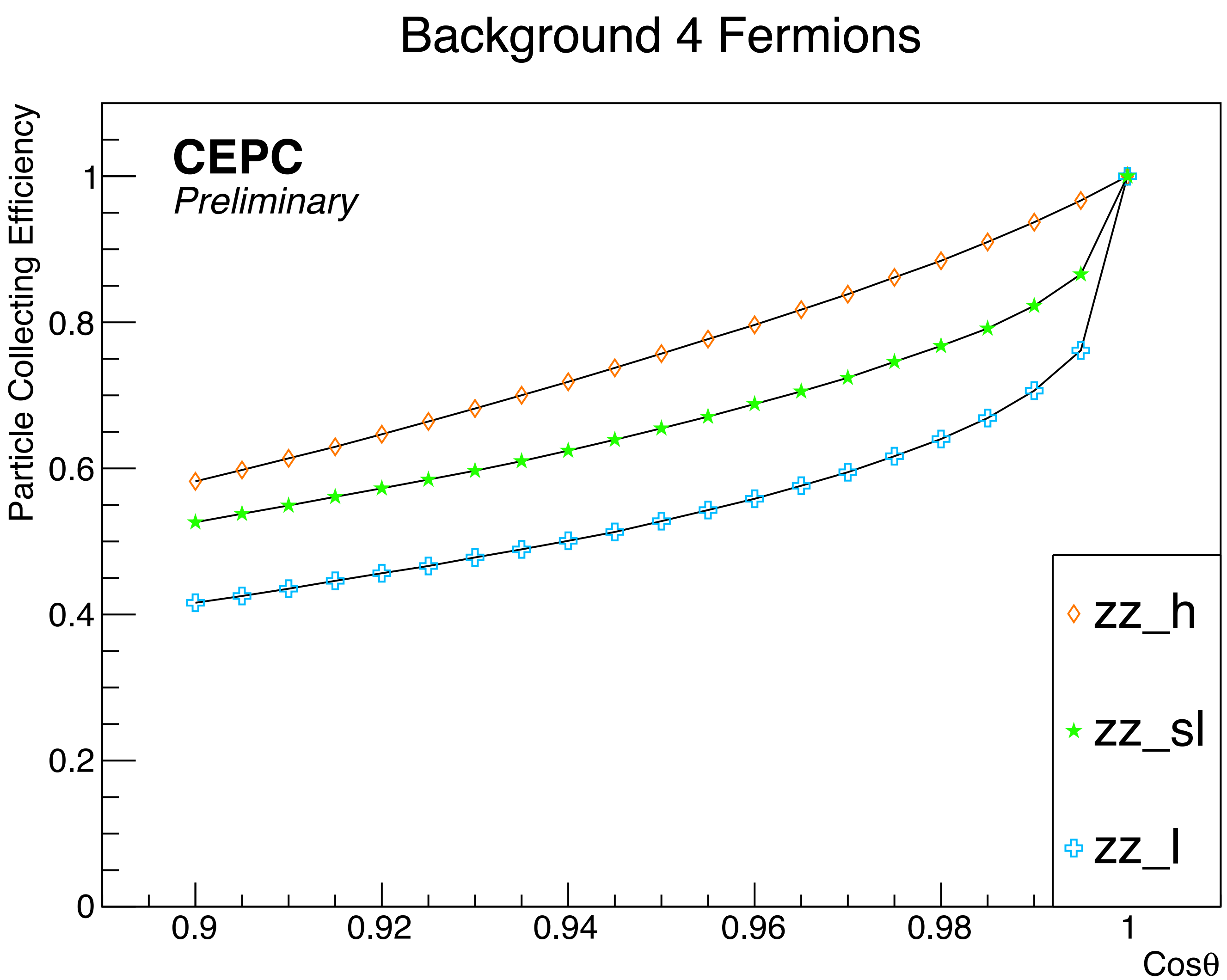
Background 4 Fermions Collecting Efficiency

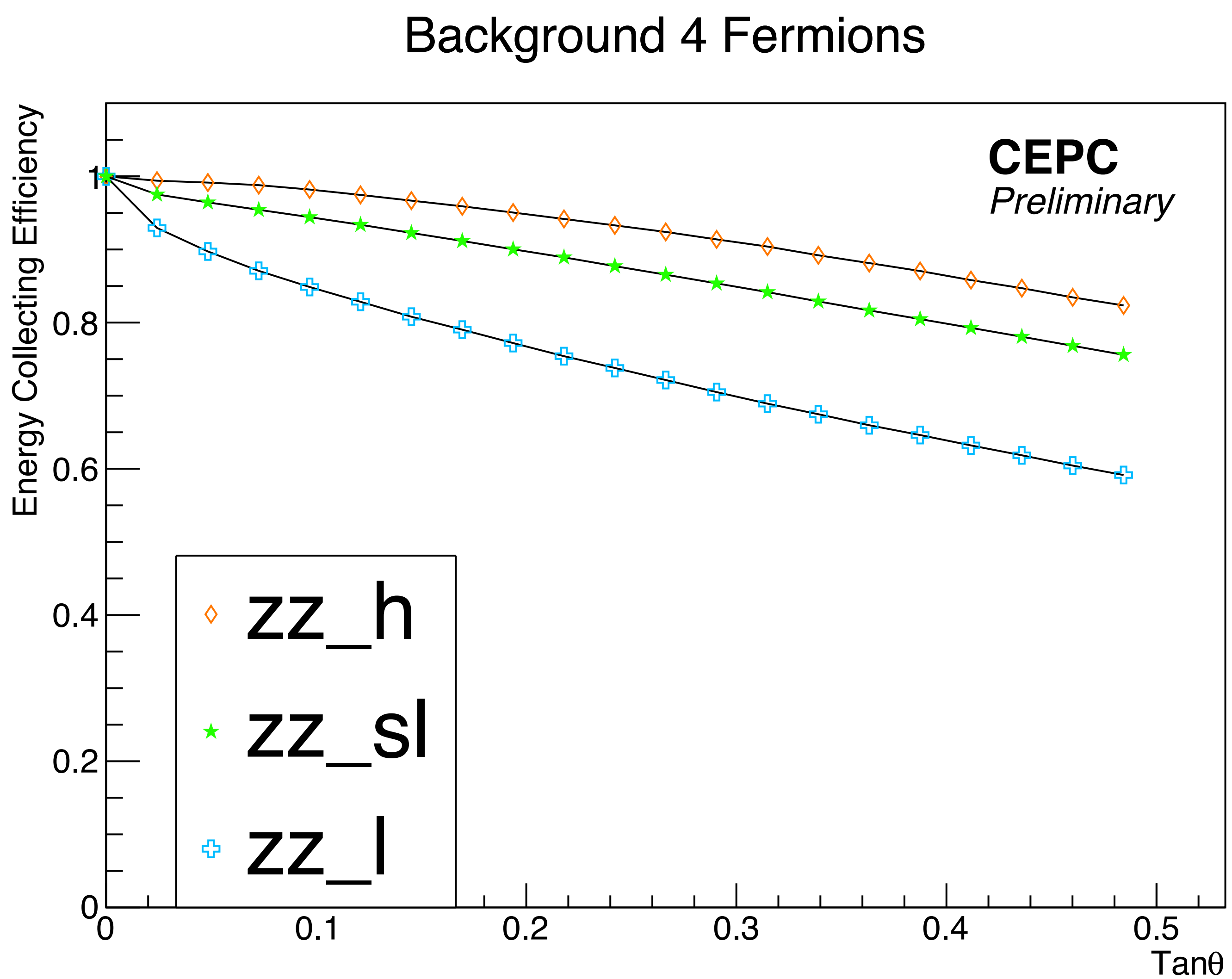


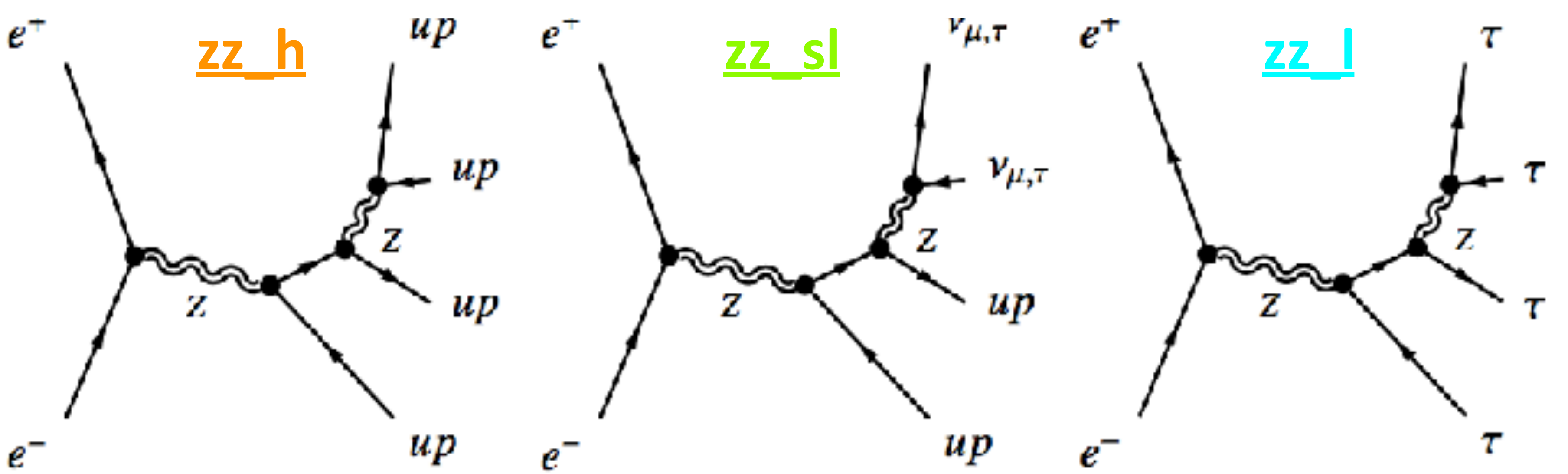




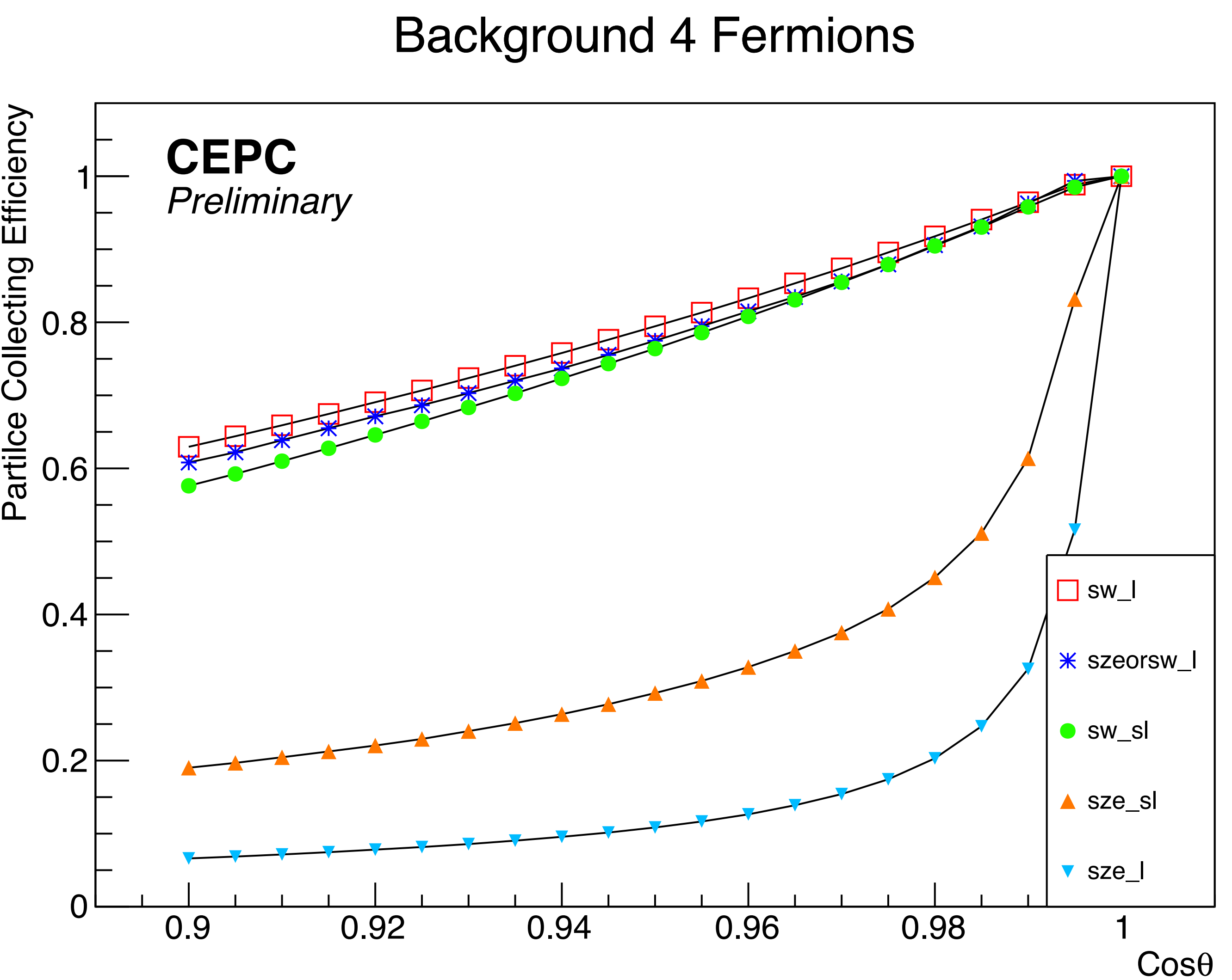
Background 4 Fermions Collecting Efficiency

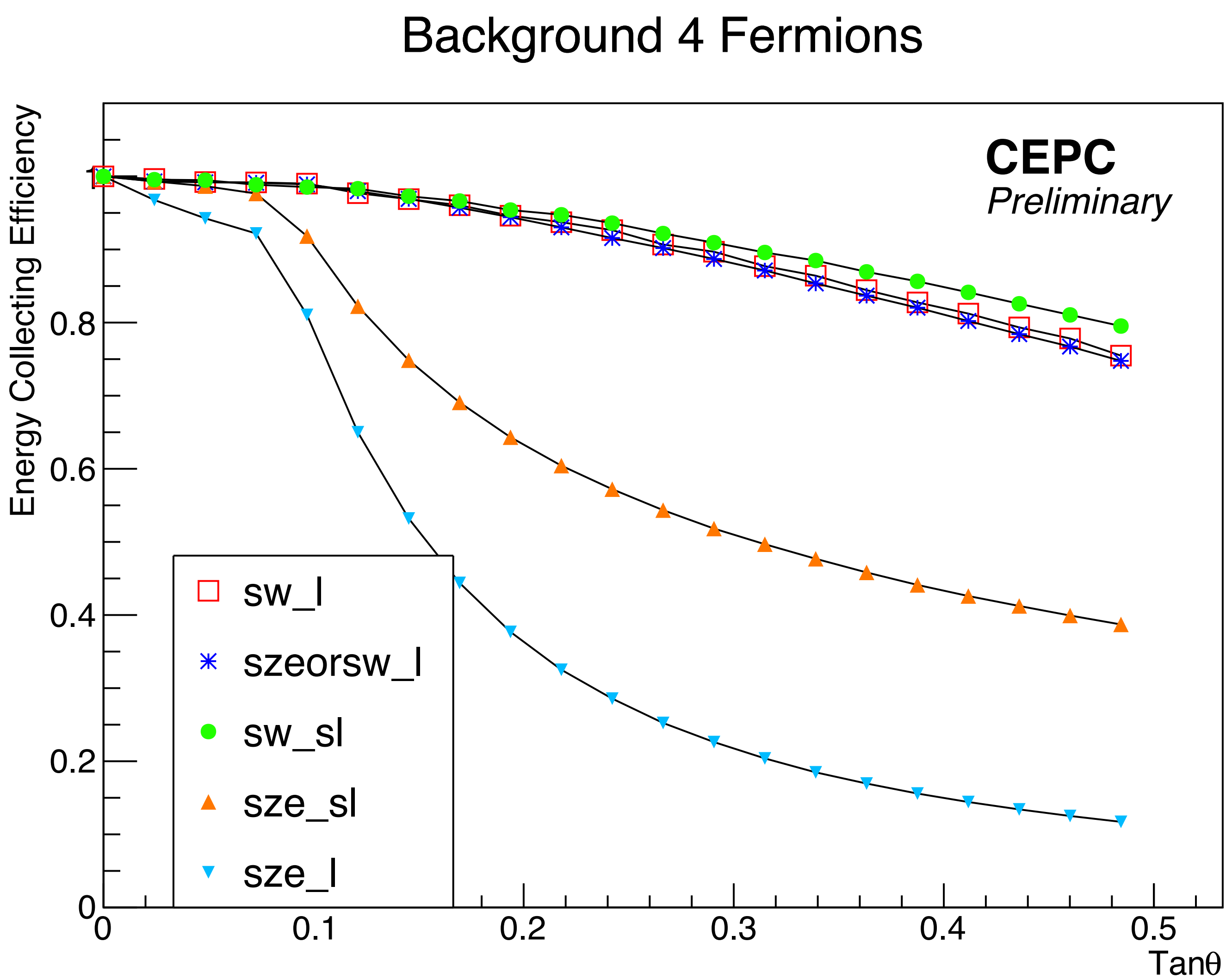


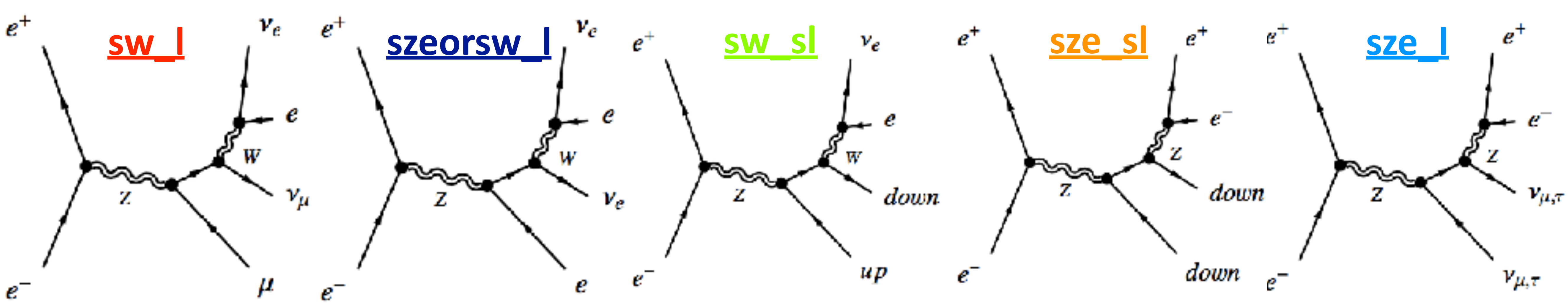




Background 4 Fermions Collecting Efficiency







Higgs Signal Branching Ratio

2P$_v$ $\nu\nu H$

$$H \rightarrow b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow ll\nu\nu, qq\nu\nu$$

5P$_v$ qq/llH

$$H \rightarrow ww \rightarrow l\nu qq$$

3P$_v$ $\nu\nu H$

$$H \rightarrow ww \rightarrow l\nu qq$$

6P$_v$ qq/llH

$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow \begin{matrix} llqq \\ 4q \\ 4l \end{matrix}$$

4P$_v$ qq/llH

$$H \rightarrow b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

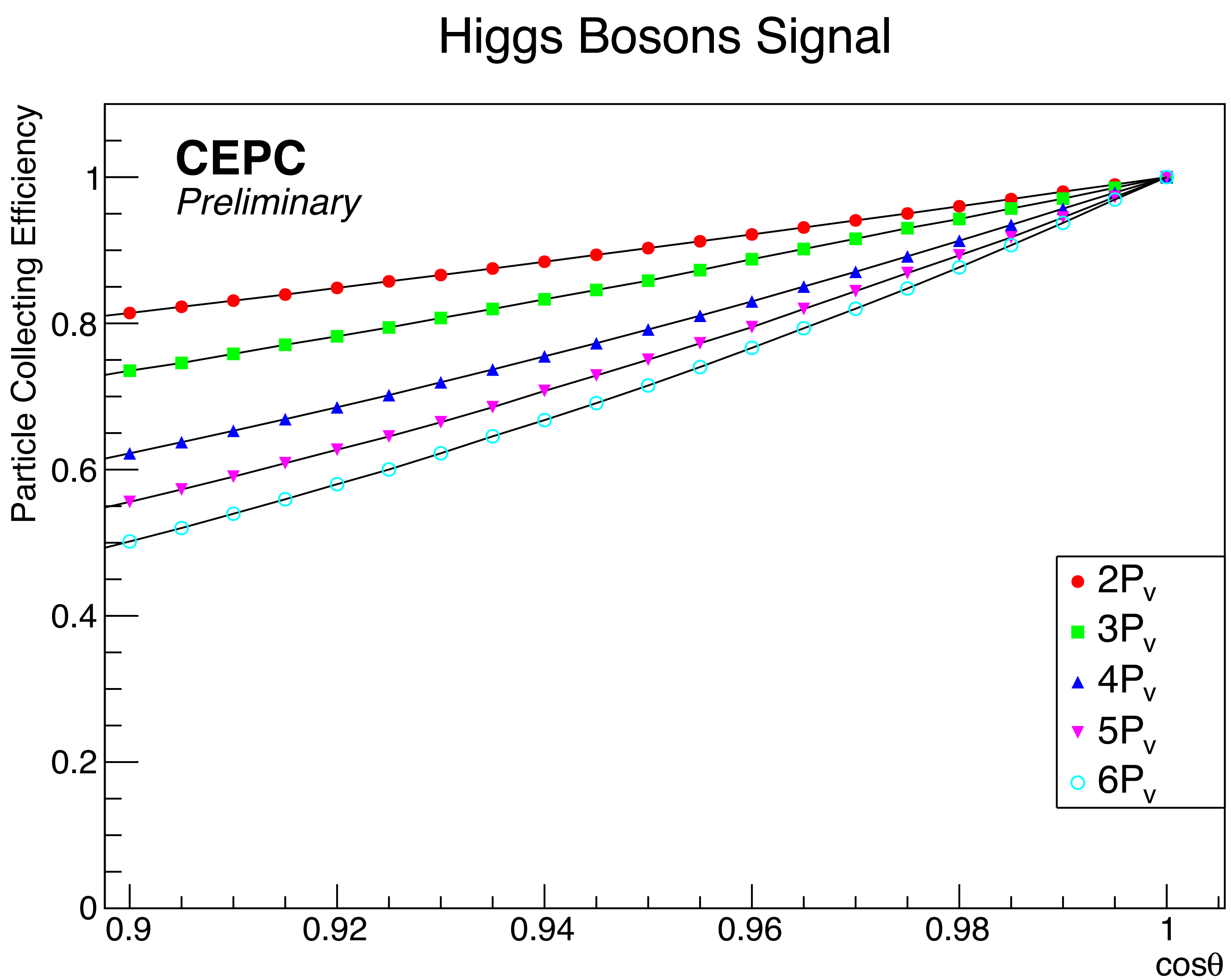
$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow ll\nu\nu, qq\nu\nu$$

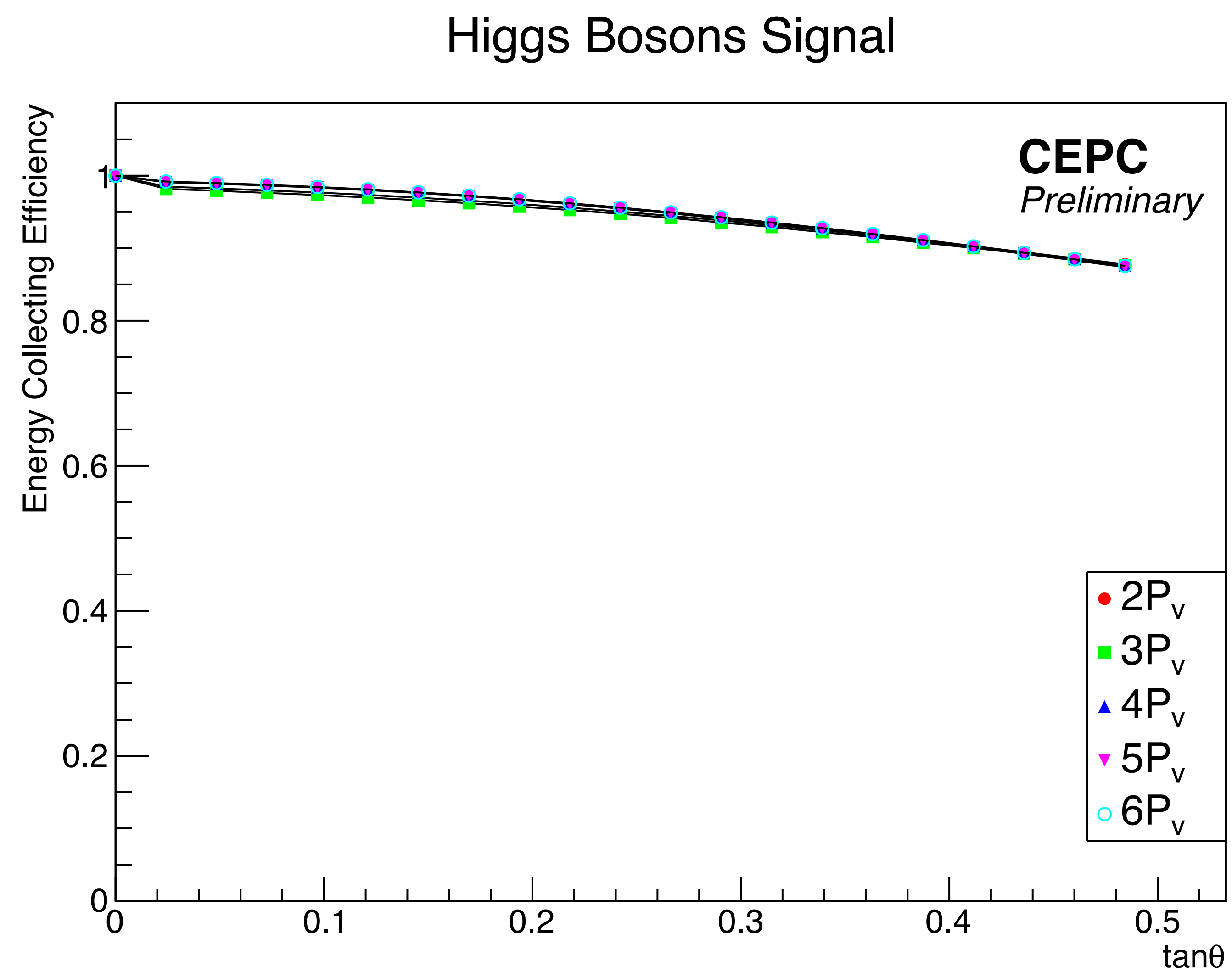
$\nu\nu H$

$$H \rightarrow llqq$$

Category	
2P$_v$	2.3×10^{-1}
3P$_v$	2.8×10^{-2}
4P$_v$	5.8×10^{-1}
5P$_v$	6.6×10^{-2}
6P$_v$	8.0×10^{-2}

Higgs Signal Collecting Efficiency





$2P_v$ vvH

$$H \to b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

$$H \to \begin{matrix} ww \\ zz \end{matrix} \to ll\nu\nu, qq\nu\nu$$

$3P_v$ vvH

$$H \to ww \to l\nu qq$$

$4P_v$ qq/llH

$$H \to b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

$$H \to \begin{matrix} ww \\ zz \end{matrix} \to ll\nu\nu, qq\nu\nu$$

vvH

$$H \to llqq$$

$5P_v$ qq/llH

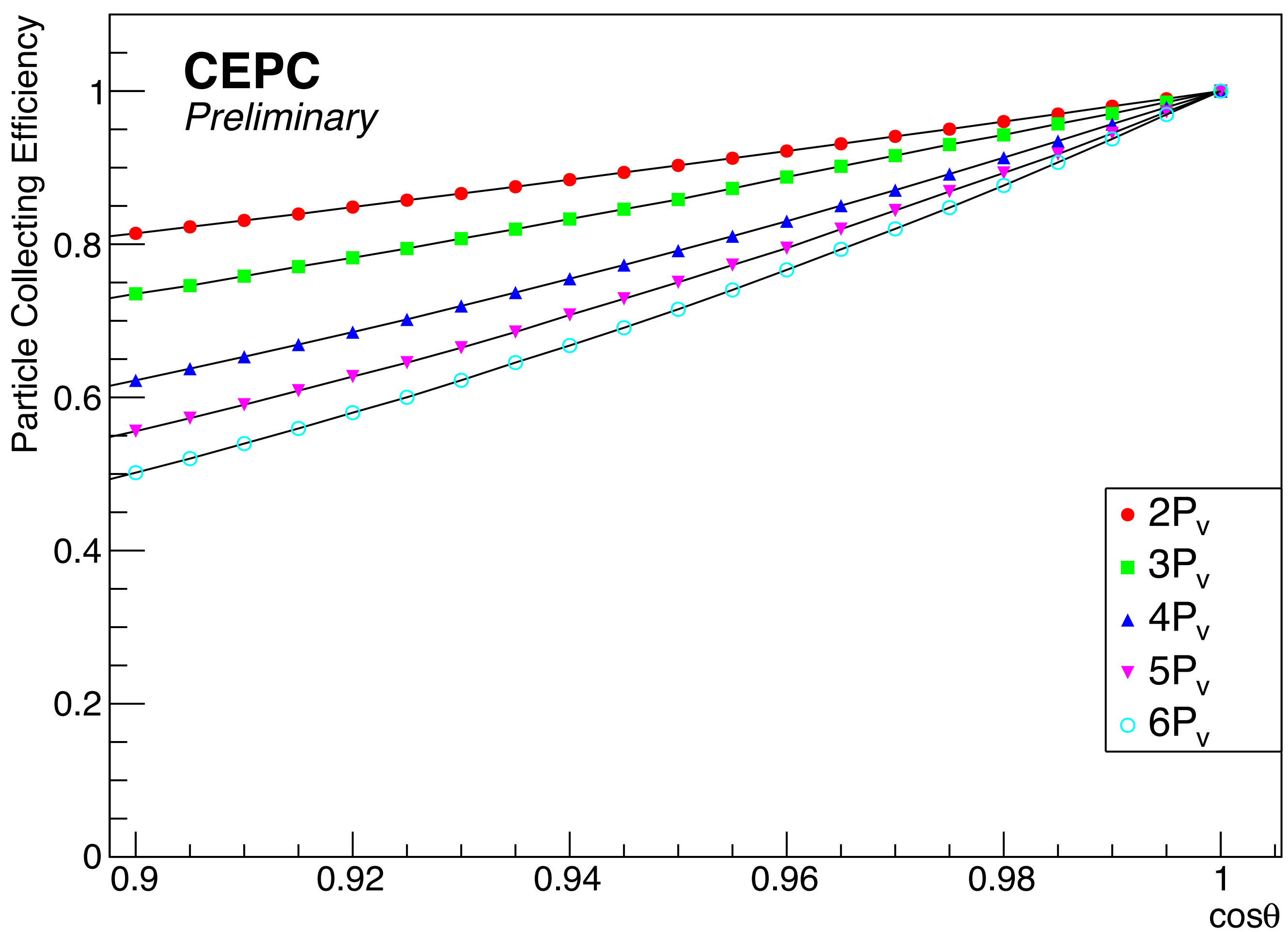
$$H \to ww \to l\nu qq$$

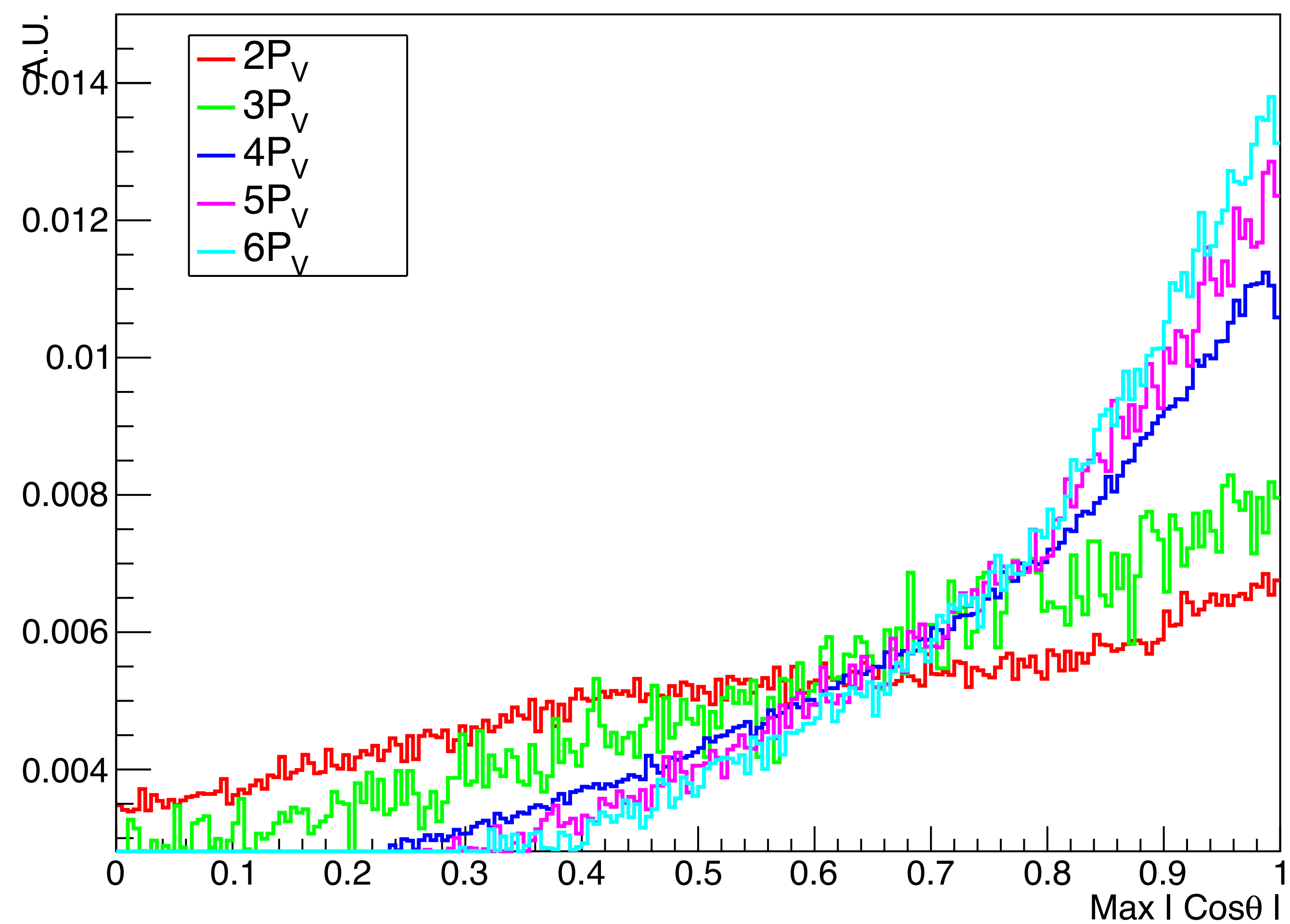
$6P_v$ qq/llH

$$H \to \begin{matrix} ww \\ zz \end{matrix} \to \begin{matrix} llqq \\ 4q \\ 4l \end{matrix}$$

Higgs Signal Collecting Efficiency

Higgs Bosons Signal





2P$_v$ $\nu\nu H$

$$H \rightarrow b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow ll\nu\nu, q q\nu\nu$$

3P$_v$ $\nu\nu H$

$$H \rightarrow ww \rightarrow l\nu qq$$

4P$_v$ $qq\,/\,llH$

$$H \rightarrow b\bar{b}, c\bar{c}, gg, \tau\tau, \gamma\gamma$$

$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow ll\nu\nu, q q\nu\nu$$

$\nu\nu H$

$$H \rightarrow llqq$$

5P$_v$ $qq\,/\,llH$

$$H \rightarrow ww \rightarrow l\nu qq$$

6P$_v$ $qq\,/\,llH$

$$H \rightarrow \begin{matrix} ww \\ zz \end{matrix} \rightarrow \begin{matrix} llqq \\ 4q \\ 4l \end{matrix}$$

Higgs Signal Effective Cross Section

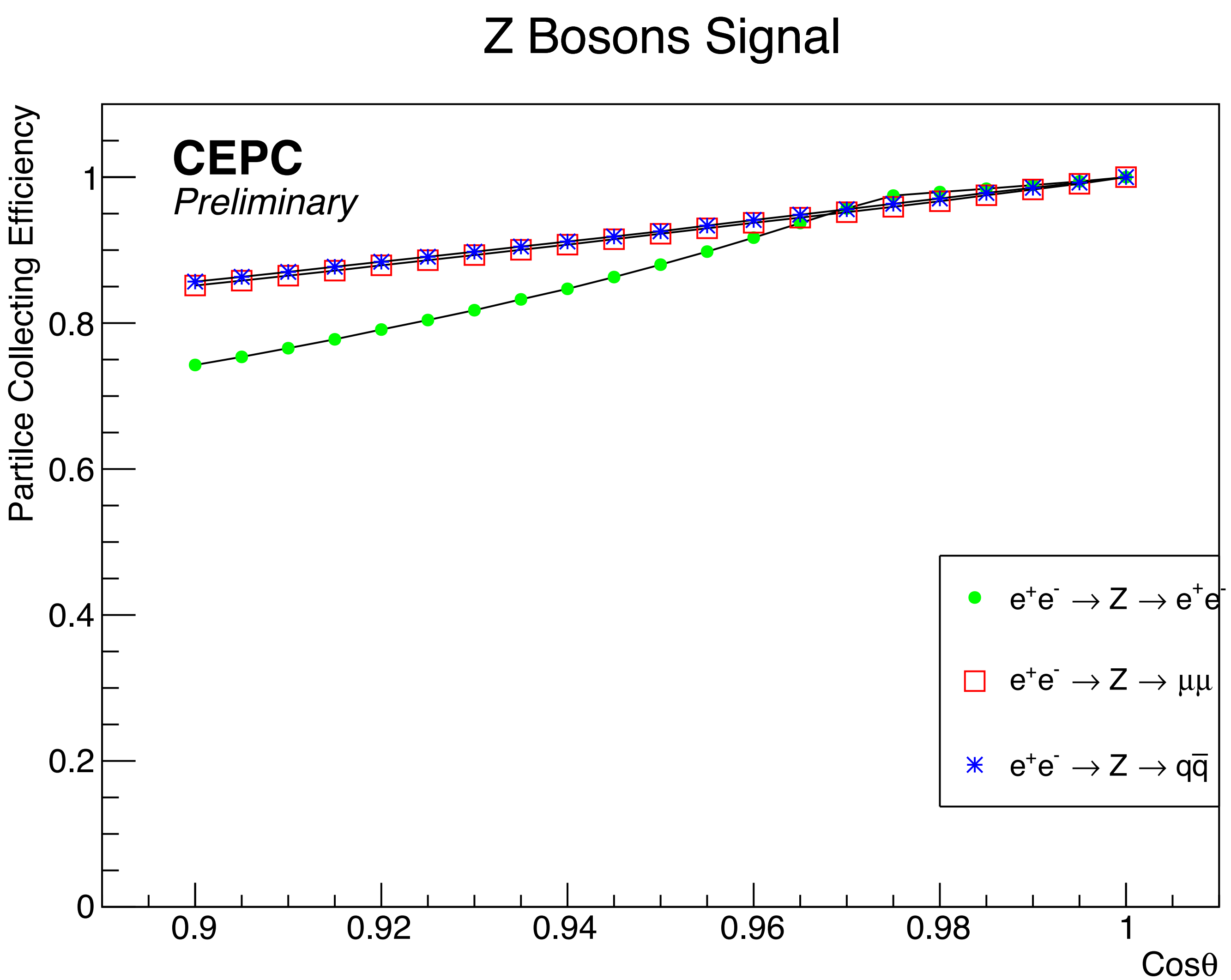
Cos θ	$2P_v$	$3P_v$	$4P_v$	$5P_v$	$6P_v$	Total
0.900	144715	15816	272963	27745	30428	491667
0.905	146230	16044	279661	28595	31541	502071
0.910	147719	16311	286492	29469	32729	512720
0.915	149201	16579	293480	30387	33928	523575
0.920	150819	16827	300600	31308	35178	534732
0.925	152414	17087	307880	32211	36397	545989
0.930	153954	17366	315587	33185	37742	557834
0.935	155536	17631	323261	34210	39149	569787
0.940	157180	17916	331167	35321	40495	582079
0.945	158859	18192	339033	36376	41903	594363
0.950	160495	18464	347272	37452	43366	607049
0.955	162156	18774	355545	38574	44897	619946
0.960	163822	19096	364112	39675	46486	633191
0.965	165508	19397	373040	40915	48113	646973
0.970	167227	19697	381900	42132	49733	660689
0.975	168909	20008	391154	43368	51413	674852
0.980	170663	20278	400535	44577	53167	689220
0.985	172410	20587	410033	45806	55001	703837
0.990	174221	20878	419771	47163	56855	718888
0.995	175953	21197	429373	48560	58789	733872
1.000	177747	21510	438678	49917	60648	748500

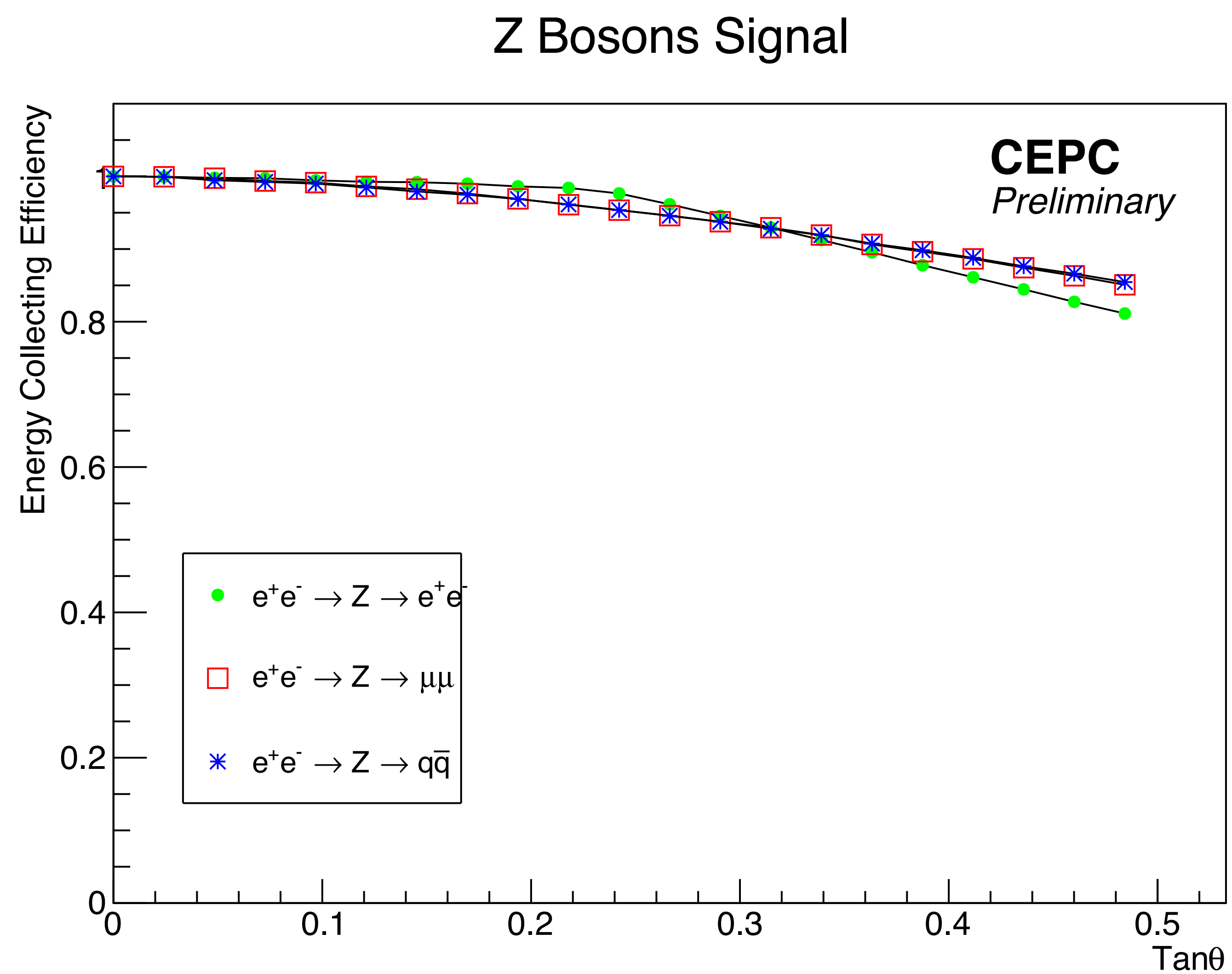
Total events = 748827

Higgs Signal Effective Cross Section

Cos θ	$2P_v$	$3P_v$	$4P_v$	$5P_v$	$6P_v$
0.900	0.814163	0.735286	0.62224	0.555823	0.501715
0.905	0.822686	0.745886	0.637509	0.572851	0.520067
0.910	0.831063	0.758298	0.65308	0.59036	0.539655
0.915	0.839401	0.770758	0.66901	0.608751	0.559425
0.920	0.848504	0.782287	0.685241	0.627201	0.580036
0.925	0.857477	0.794375	0.701836	0.645291	0.600135
0.930	0.866141	0.807345	0.719405	0.664804	0.622312
0.935	0.875041	0.819665	0.736898	0.685338	0.645512
0.940	0.884291	0.832915	0.75492	0.707595	0.667705
0.945	0.893737	0.845746	0.772852	0.72873	0.690921
0.950	0.902941	0.858391	0.791633	0.750285	0.715044
0.955	0.912285	0.872803	0.810492	0.772763	0.740288
0.960	0.921658	0.887773	0.830021	0.794819	0.766489
0.965	0.931144	0.901767	0.850373	0.819661	0.793316
0.970	0.940815	0.915714	0.87057	0.844041	0.820027
0.975	0.950278	0.930172	0.891665	0.868802	0.847728
0.980	0.960146	0.942724	0.91305	0.893022	0.876649
0.985	0.969974	0.95709	0.934702	0.917643	0.906889
0.990	0.980163	0.970618	0.9569	0.944828	0.937459
0.995	0.989907	0.985449	0.978789	0.972815	0.969348
1.000	1	1	1	1	1

Z Bosons Signal Collecting Efficiency





Summary

- **The cosθ from 0.98 to 0.9, particle collecting efficiency decreases by about 20% ~ 30% in the Higgs signal region. The CEPC is designed to run for 10 years. However, due to the decreasing particle collecting efficiency, it needs to run for 2 more years in order to recover the same luminosity used in the beginning. The price of operating CEPC for one full year is similar to the price of the detector itself. Thus, this study is of great significance as it can support the accelerator and detector group vital information on the beam pipe and detector design. Hence, good design can save both time and money.**

To Do

- **Study how many of coverage should the bench mark channel have.**
- **Study the relationship between coverage and S/B ratio**
- **Analysis note**

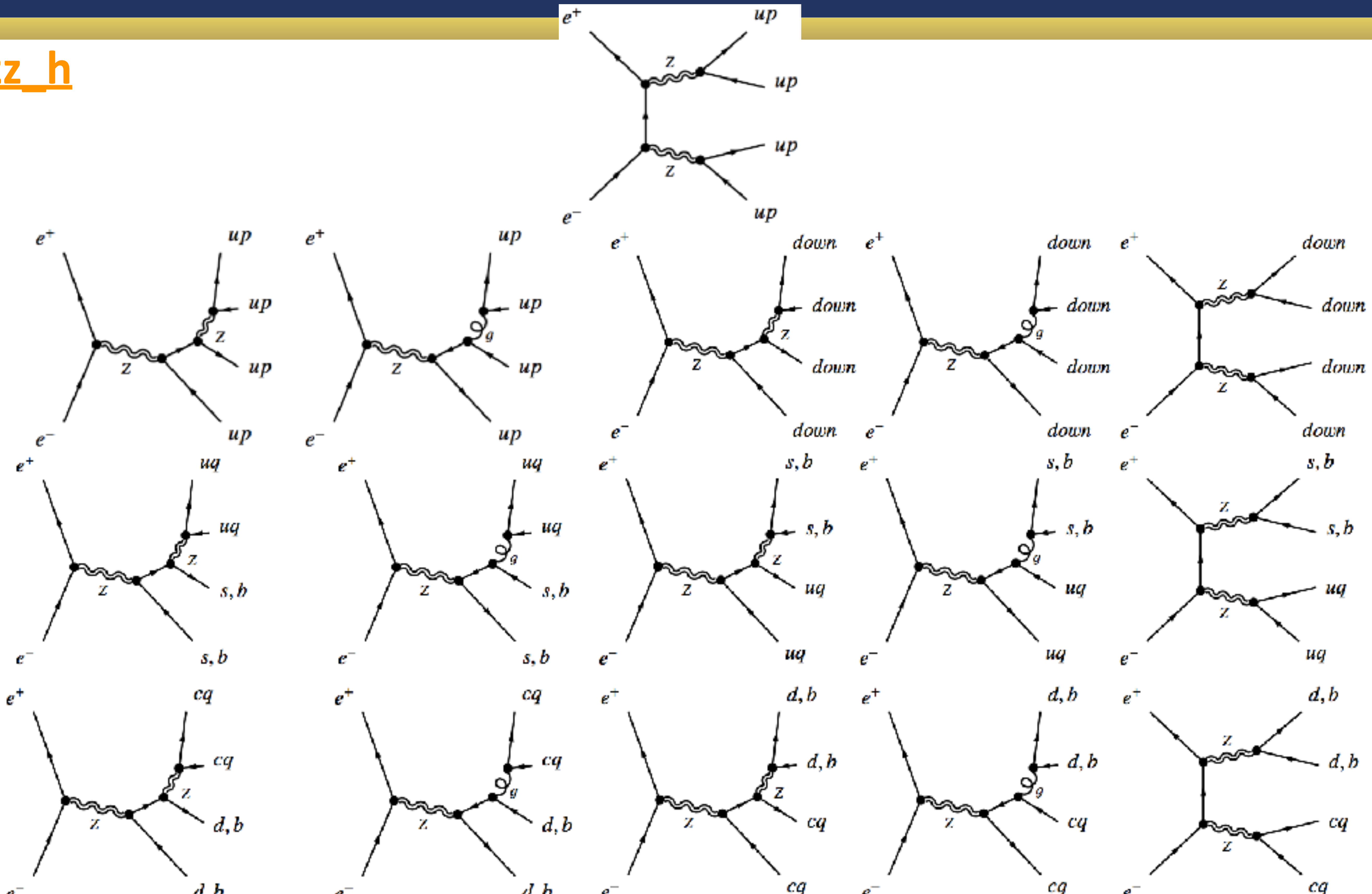
Back up

- **The more precise branching ratio.**
- **Feynman dygram**

The More Precision Branching Ratio

```
Processing event 1 of 100451
Processing event 1 of 99952
Processing event 1 of 224788
Processing event 1 of 323636
 2Pv : 0.237367
 3Pv : 0.0287249
 4Pv : 0.58582
 5Pv : 0.0666603
 6Pv : 0.0809907
 tot: 0.999563
```

zz_h


e+
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e−
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e+
up
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Z
Z
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up
e+
up
up
g
Z
up
e−
up
e+
down
down
Z
Z
down
e−
down
e+
down
down
g
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down
e−
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e−
down
e+
uq
uq
Z
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e+
uq
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e−
s, b
e+
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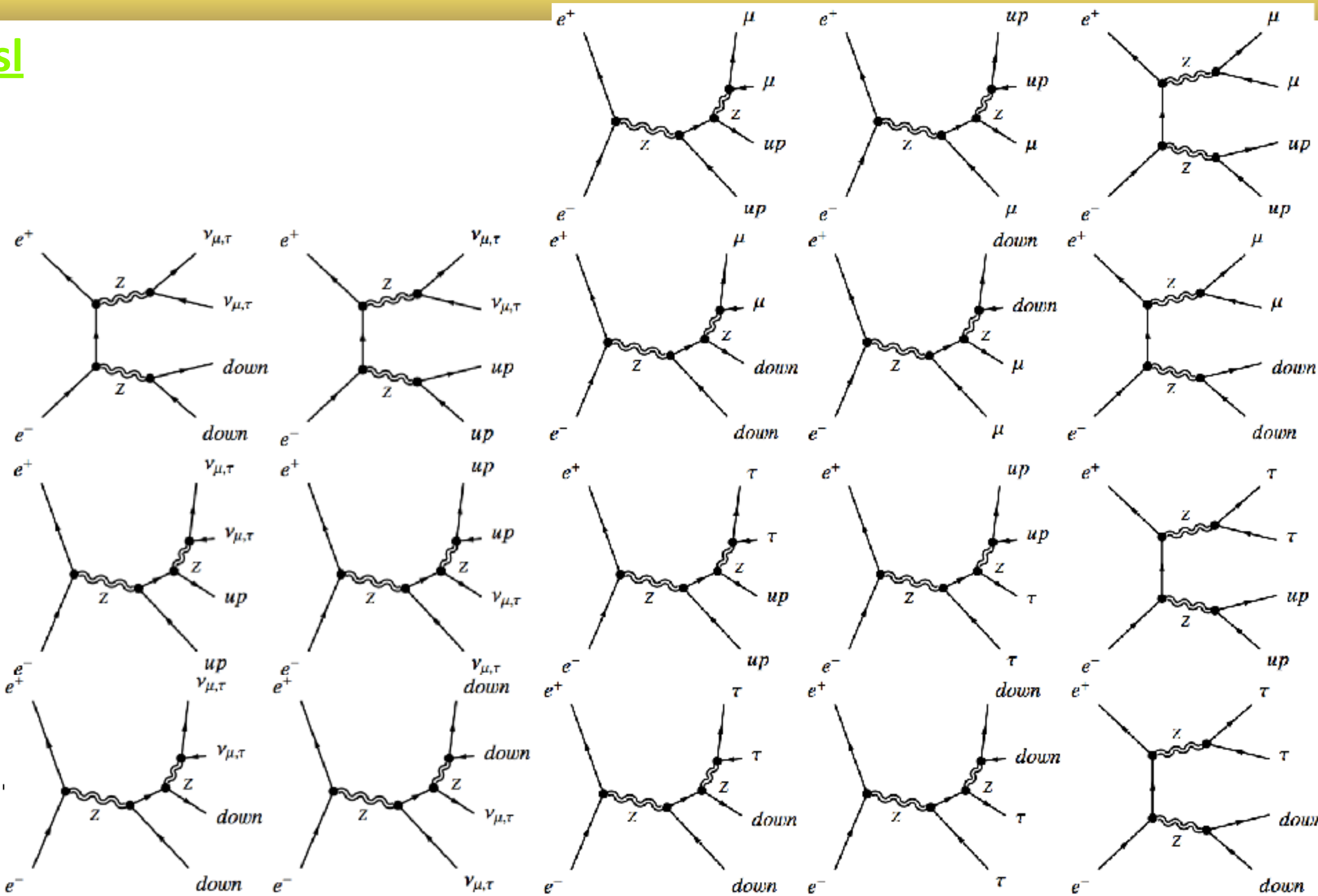
cq

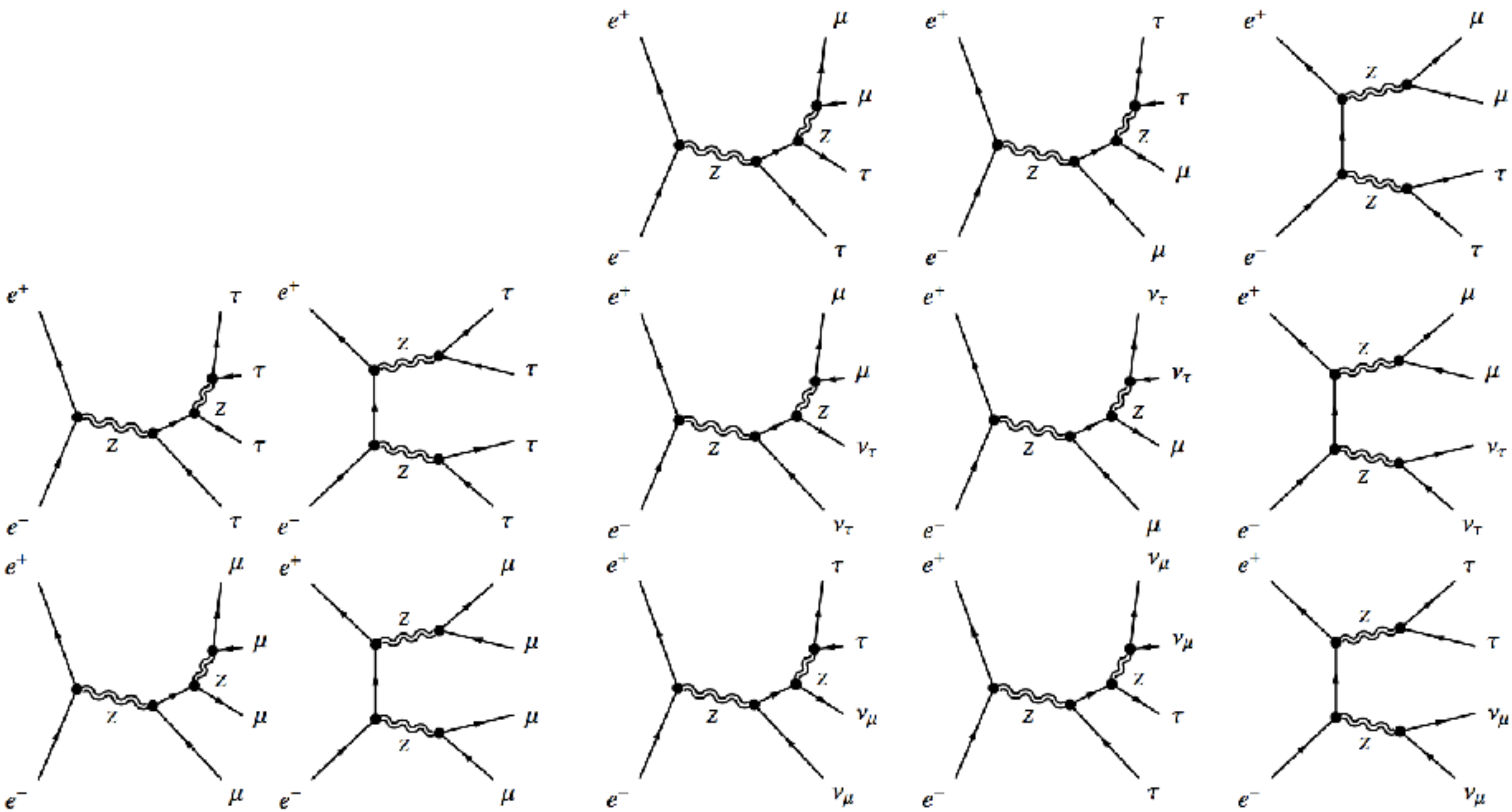
Back up

zz_sl

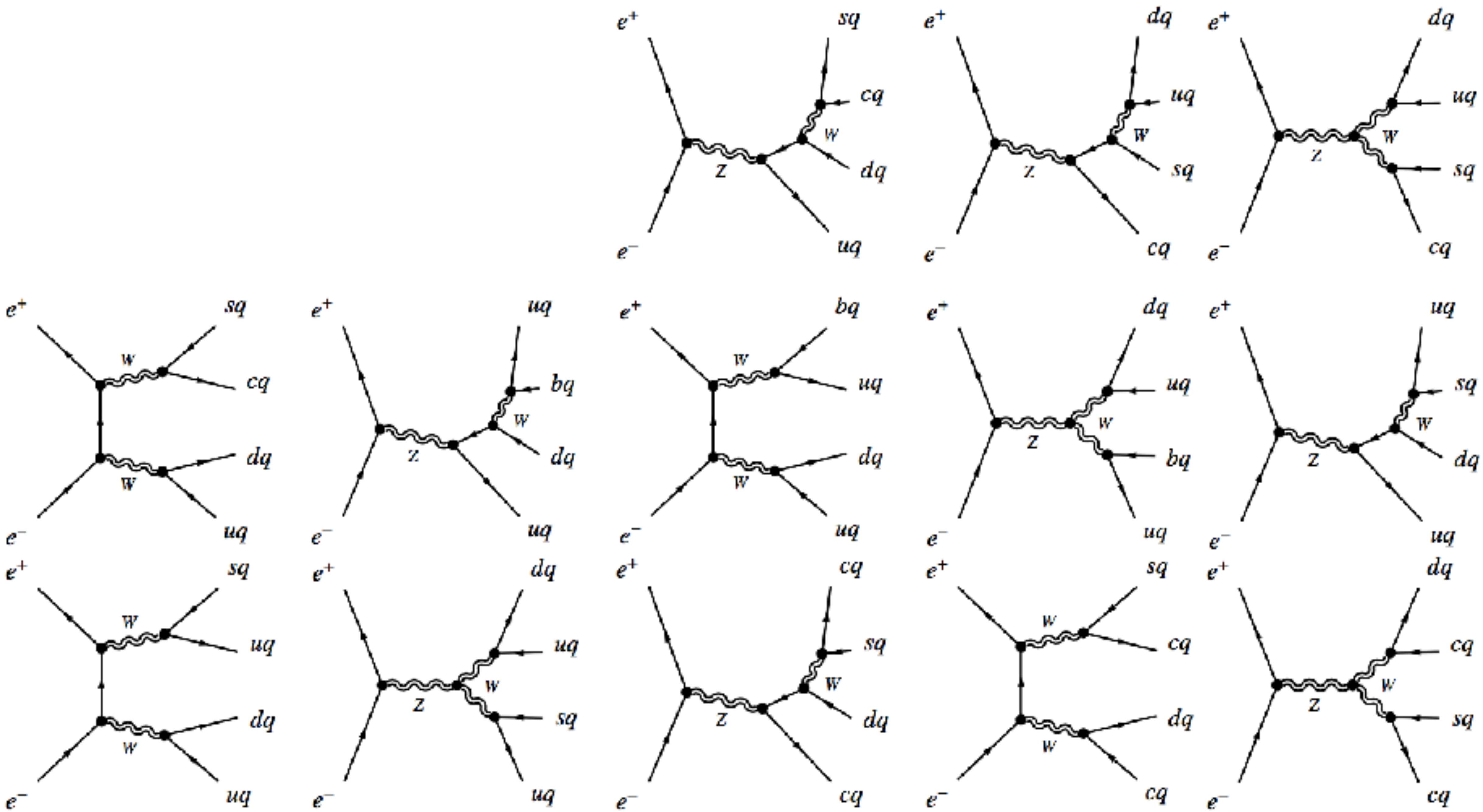


e+ μ μ Z up Z e− up
e+ up up Z μ Z e− μ
e+ μ Z μ up Z e− up
e+ $\nu_{\mu,\tau}$ Z $\nu_{\mu,\tau}$ down Z e− down
e+ $\nu_{\mu,\tau}$ Z $\nu_{\mu,\tau}$ up Z e− up
e+ μ μ Z down Z e− down
e+ down down Z μ Z e− μ
e+ μ Z μ down Z e− down
e+ $\nu_{\mu,\tau}$ $\nu_{\mu,\tau}$ Z up Z e− up
e+ up up Z $\nu_{\mu,\tau}$ Z e− $\nu_{\mu,\tau}$
e+ τ τ Z up Z e− up
e+ up up Z τ Z e− τ
e+ τ Z τ up Z e− up
e+ $\nu_{\mu,\tau}$ $\nu_{\mu,\tau}$ Z down Z e− down
e+ down down Z $\nu_{\mu,\tau}$ Z e− $\nu_{\mu,\tau}$
e+ τ τ Z down Z e− down
e+ down down Z τ Z e− τ
e+ τ Z τ down Z e− down

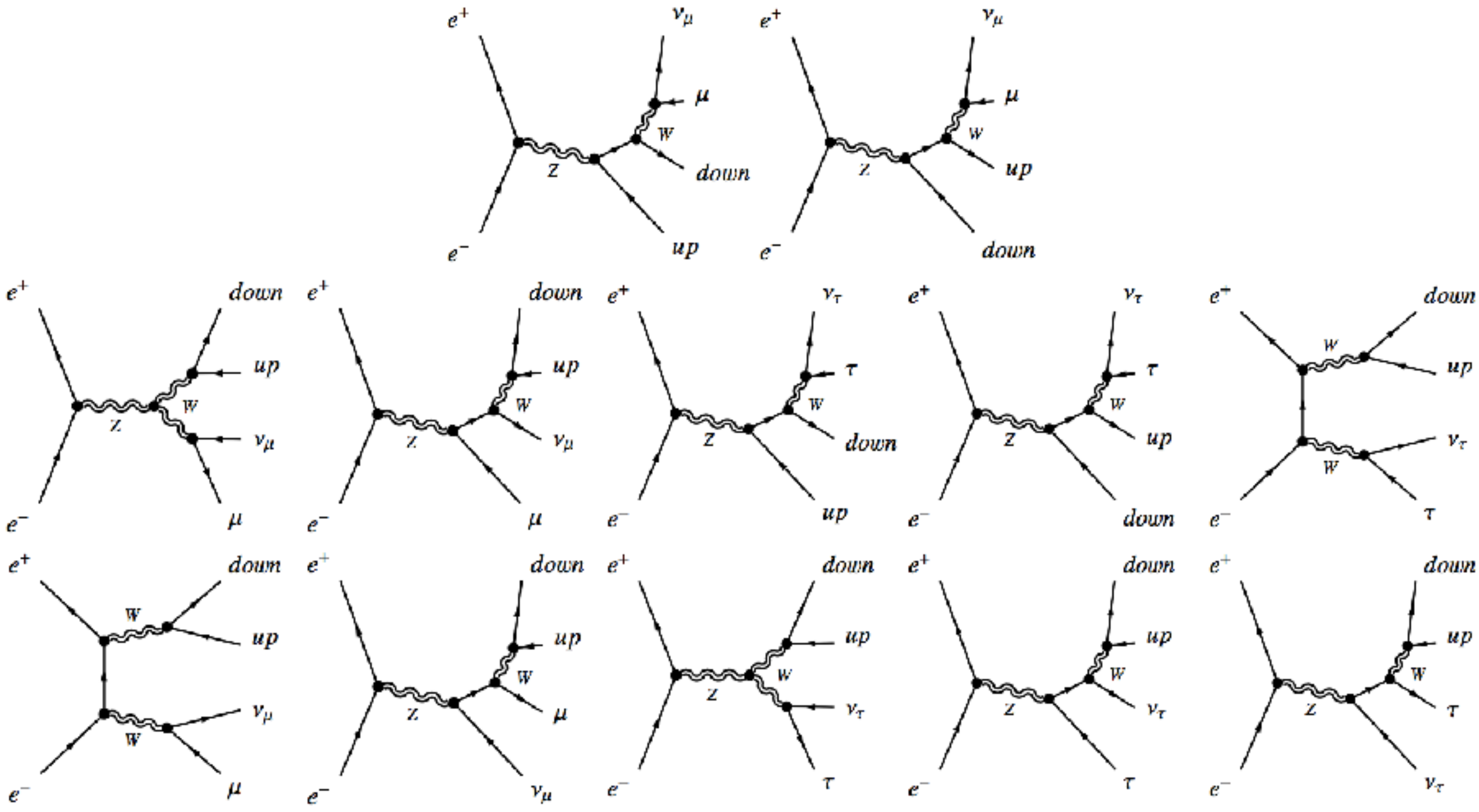
zz_l


e^+ μ μ Z τ Z e^- τ
e^+ τ τ Z μ Z e^- μ
e^+ μ Z μ τ Z e^- τ
e^+ τ τ Z τ Z e^- τ
e^+ τ Z τ τ Z e^- τ
e^+ μ μ Z ν_τ Z e^- ν_τ
e^+ ν_τ ν_τ Z μ Z e^- μ
e^+ μ Z μ ν_τ Z e^- ν_τ
e^+ μ μ Z μ Z e^- μ
e^+ μ Z μ μ Z e^- μ
e^+ τ τ Z ν_μ Z e^- ν_μ
e^+ ν_μ ν_μ Z τ Z e^- τ
e^+ τ Z τ ν_μ Z e^- ν_μ

ww_h

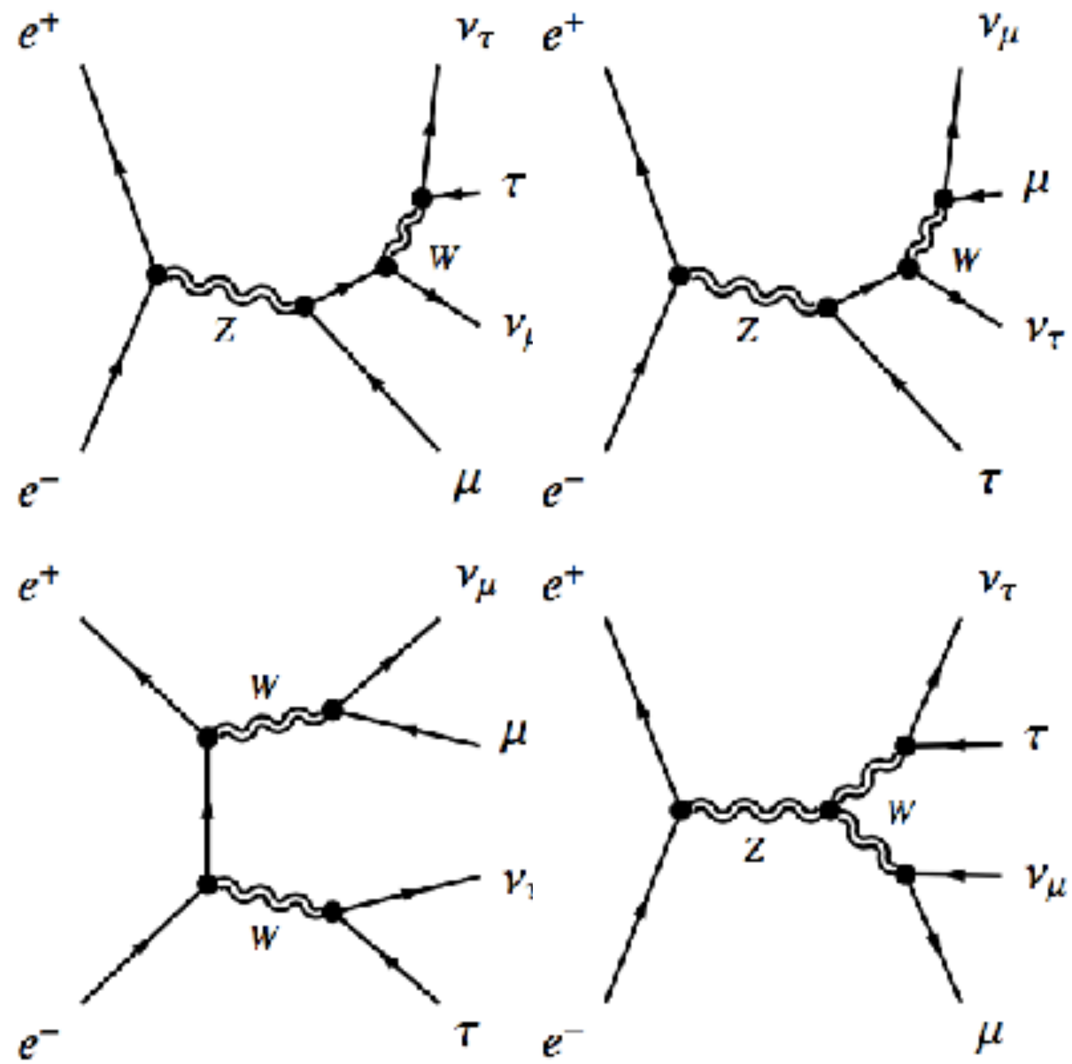

e+ sq cq W Z dq e− uq
e+ dq uq W Z sq e− cq
e+ dq uq W Z sq e− cq
e+ sq W cq dq W e− uq
e+ uq bq W Z dq e− uq
e+ bq W uq dq W e− uq
e+ dq uq W Z bq e− uq
e+ uq sq W Z dq e− uq
e+ sq W uq dq W e− uq
e+ dq uq W Z sq e− uq
e+ cq sq W Z dq e− cq
e+ sq W cq dq W e− cq
e+ dq cq W Z sq e− cq

ww_sl



Back up

ww_l



e^+
ν_τ
τ
W
Z
μ
e^-
e^+
ν_μ
μ
W
ν_τ
Z
τ
e^-
e^+
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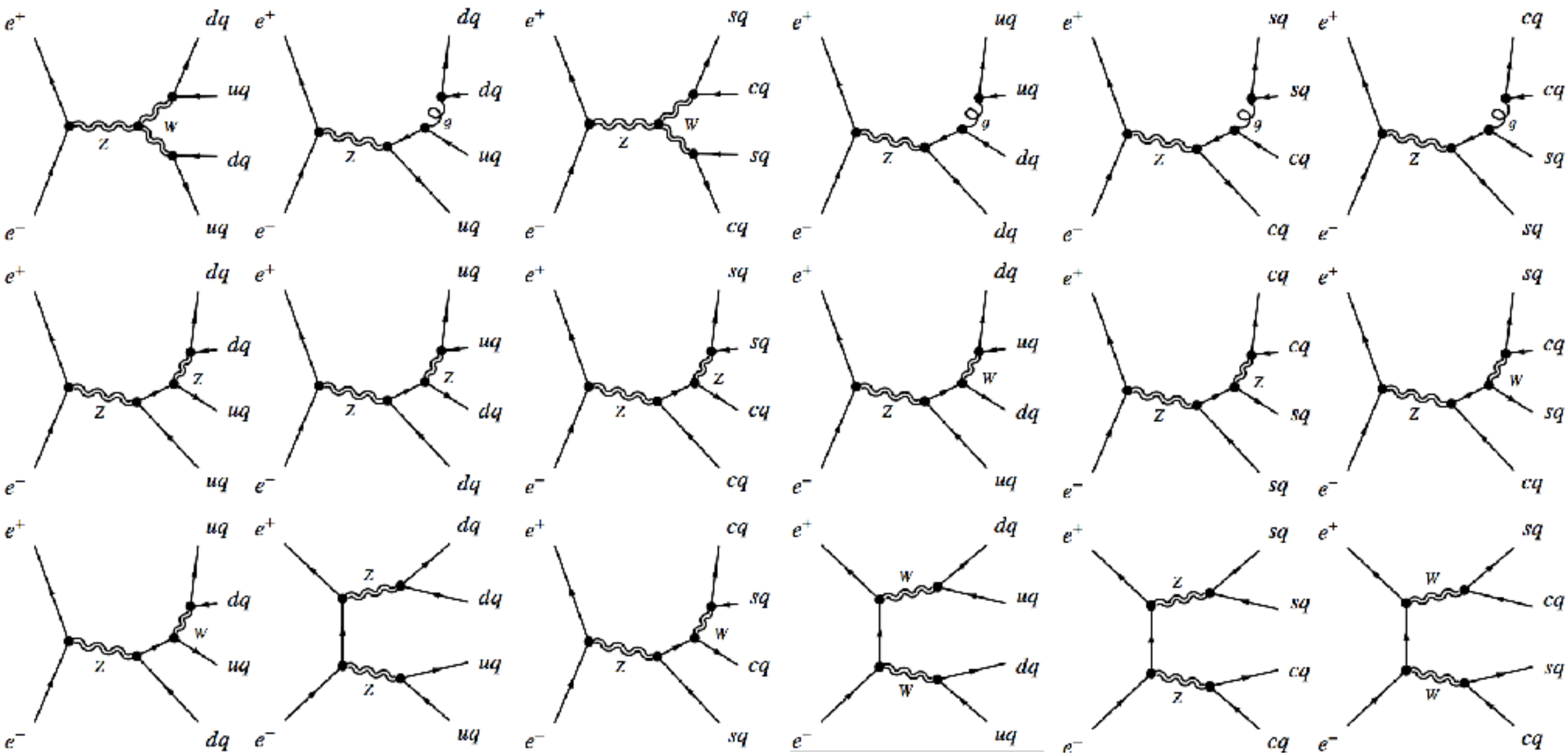
W
μ
W
τ
e^-
e^+
ν_τ
τ
W
Z
ν_μ
μ
e^-

zzorww_h


e+ dq uq W Z dq e− uq
e+ dq dq g uq Z e− uq
e+ sq cq W Z sq e− cq
e+ uq uq g Z dq e− dq
e+ sq sq g Z cq e− cq
e+ cq cq g Z sq e− sq
e+ dq dq Z Z uq e− uq
e+ uq uq Z Z dq e− dq
e+ sq sq Z Z cq e− cq
e+ dq uq W Z dq e− uq
e+ cq cq Z Z sq e− sq
e+ sq cq W Z sq e− cq
e+ uq dq W Z uq e− dq
e+ dq Z dq uq Z e− uq
e+ cq sq W Z cq e− sq
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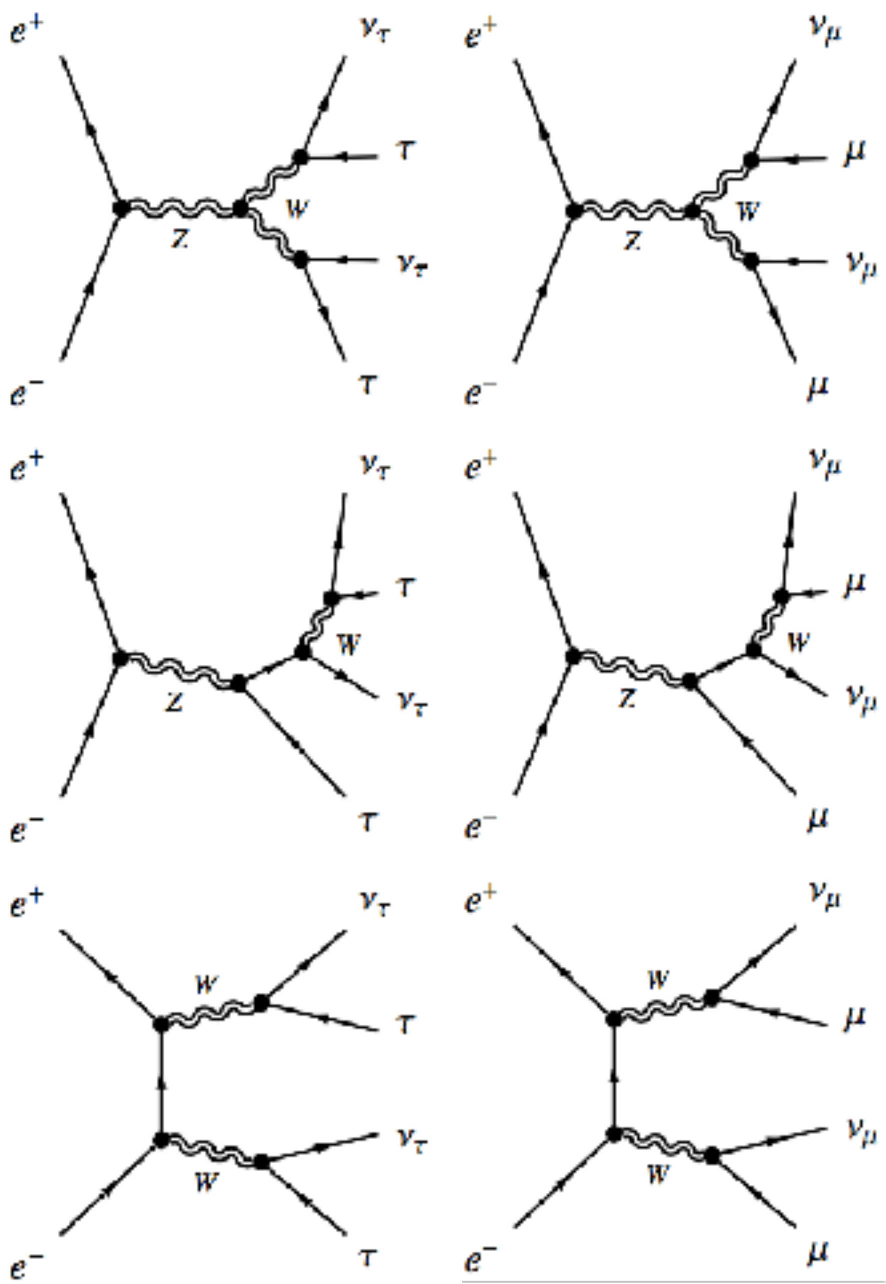
e+ sq W cq sq W e− cq

zzorww_l


e^+
ν_τ
τ
W
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ν_τ
e^-
τ
e^+
ν_μ
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Z
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e^-
μ
e^+
ν_τ
τ
W
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ν_τ
e^-
τ
e^+
ν_μ
μ
W
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ν_μ
e^-
μ
e^+
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ν_μ
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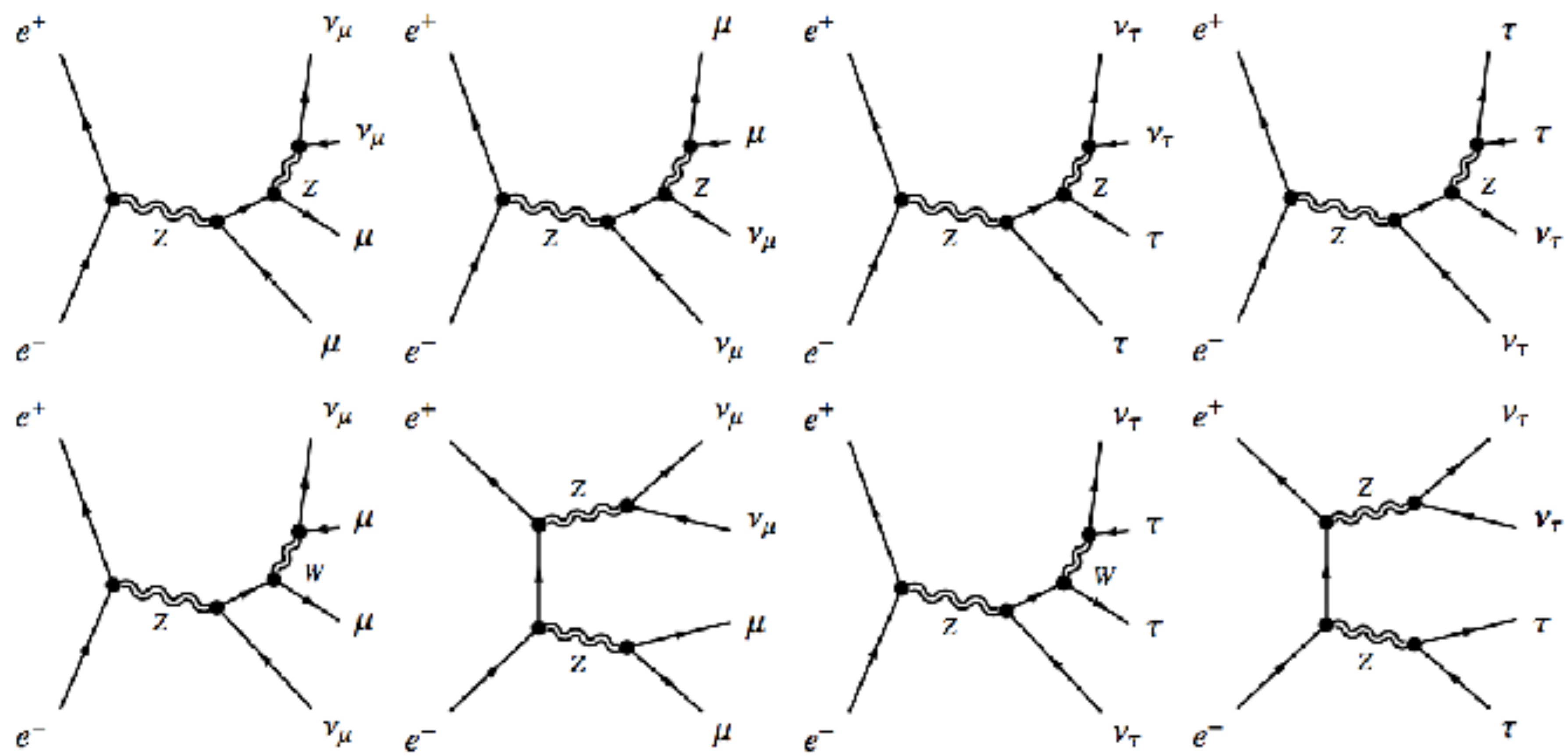
e^-
μ


e^+
ν_μ
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Z
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e^-
μ
e^+
μ
μ
Z
Z
ν_μ
e^-
ν_μ
e^+
ν_τ
ν_τ
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Z
τ
e^-
τ
e^+
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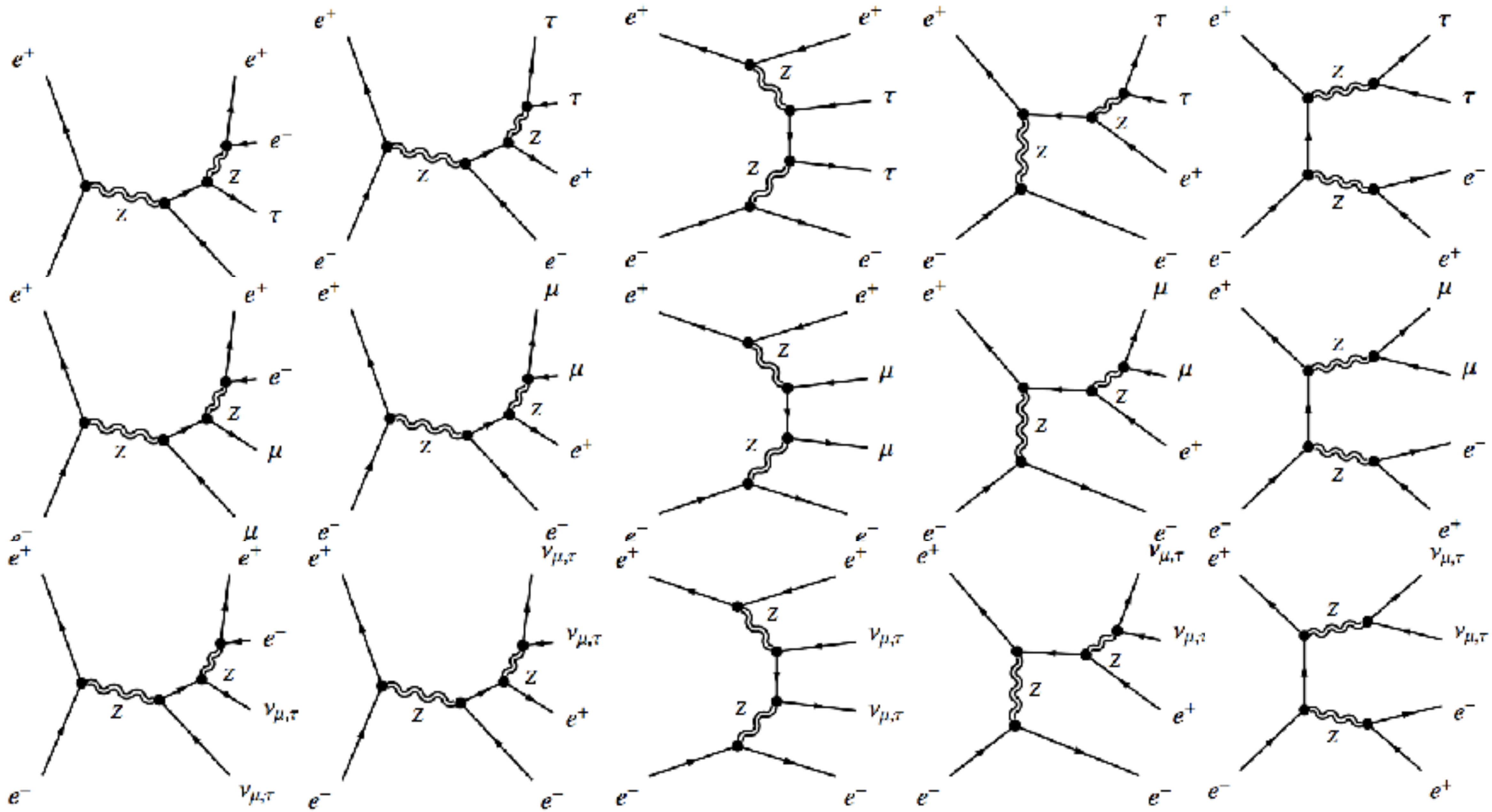
Z
Z
ν_τ
e^-
ν_τ
e^+
ν_μ
μ
W
Z
μ
e^-
ν_μ
e^+
ν_μ
Z
ν_μ
μ
Z
e^-
μ
e^+
ν_τ
τ
W
Z
τ
e^-
ν_τ
e^+
ν_τ
Z
ν_τ
τ
Z
e^-
τ

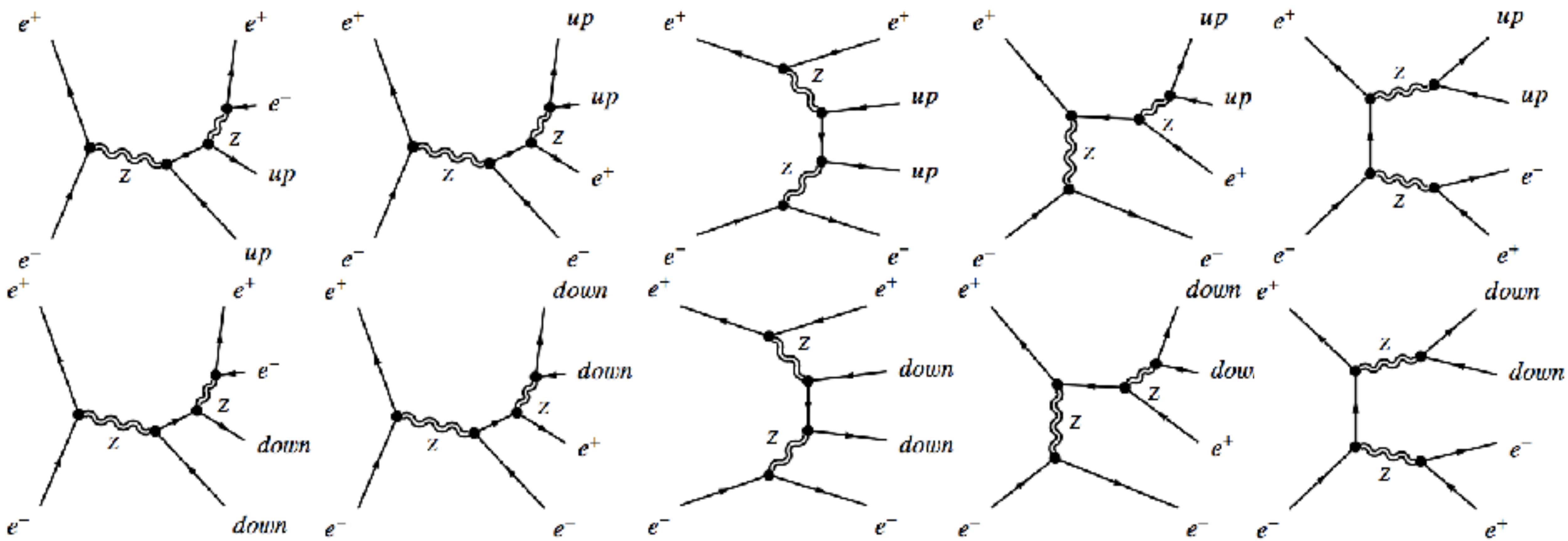
Back up

[sze_l]

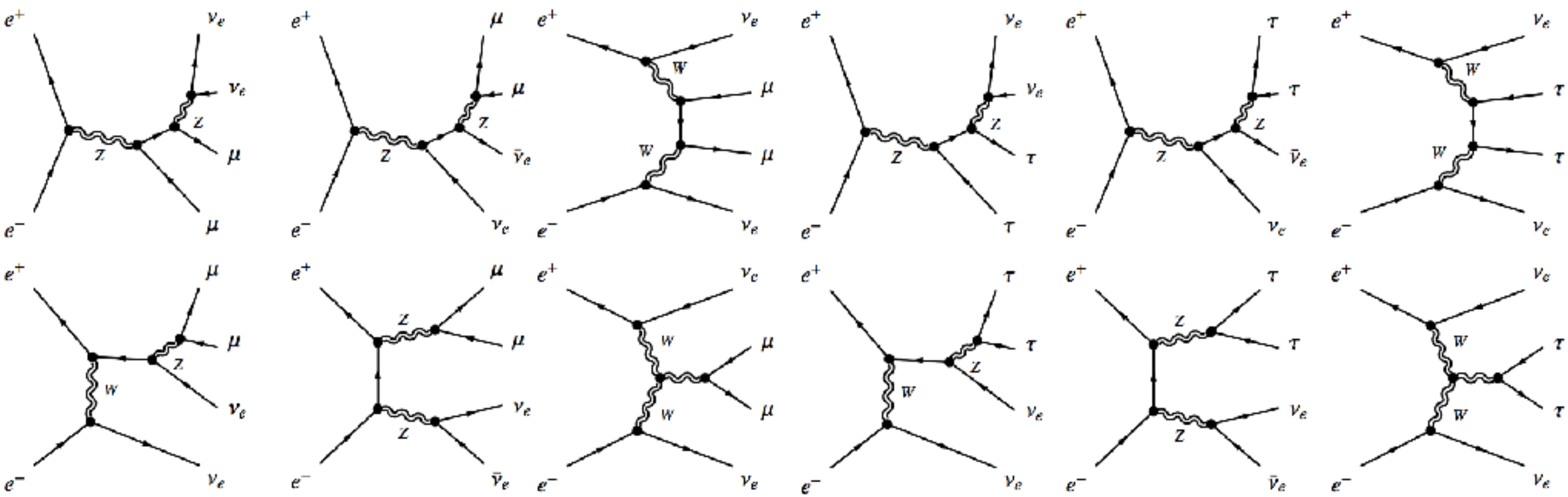


Back up

sze_sl



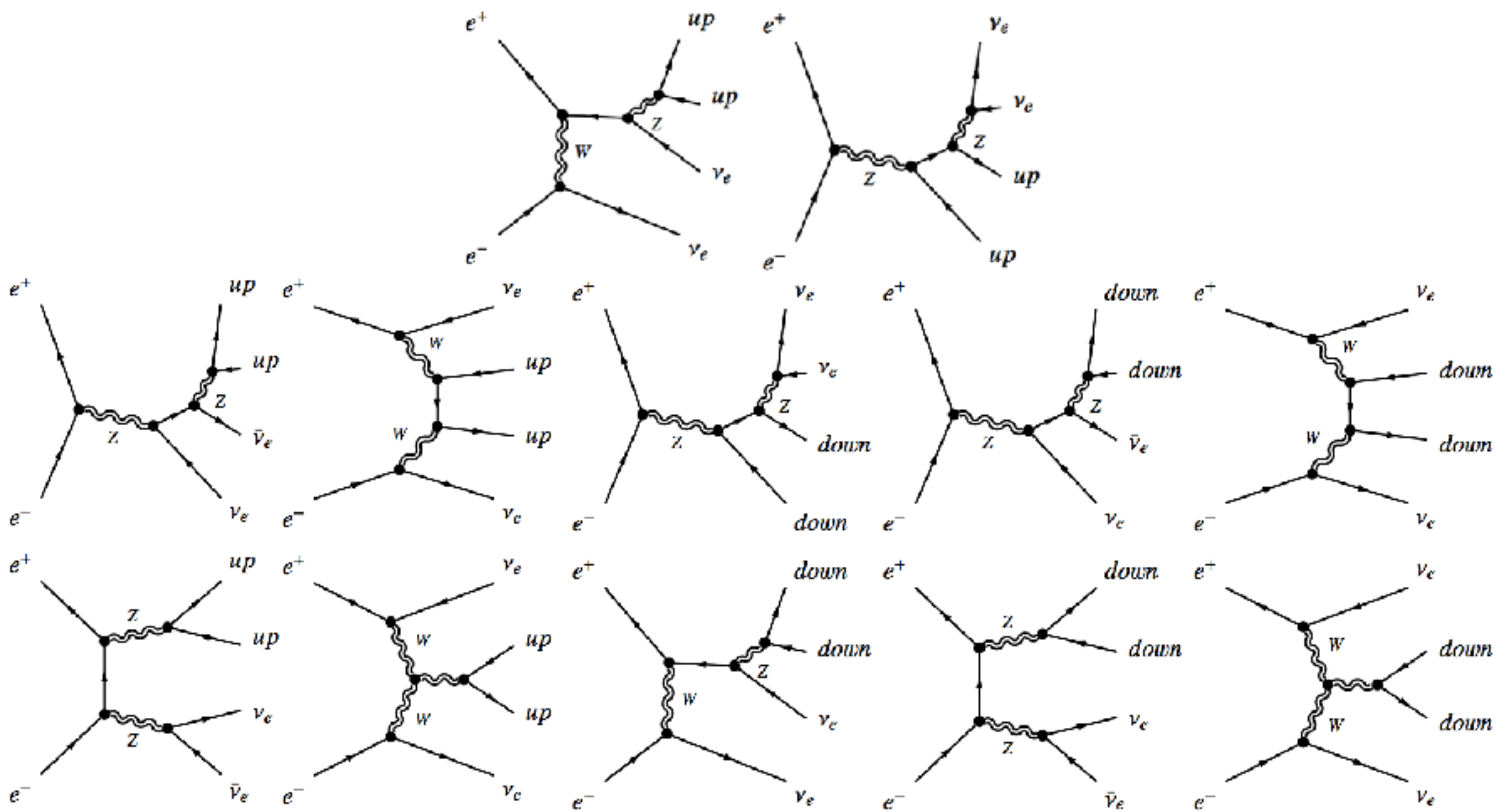
sznu_l



e^+ ν_e ν_e Z μ Z e^- μ
e^+ μ μ Z $\bar{\nu}_e$ Z e^- ν_e
e^+ ν_e W μ W μ e^- ν_e
e^+ ν_e ν_e Z τ Z e^- τ
e^+ τ τ Z $\bar{\nu}_e$ Z e^- ν_e
e^+ ν_e W τ W τ e^- ν_e
e^+ μ μ Z W ν_e e^- ν_e
e^+ μ Z μ ν_e Z e^- $\bar{\nu}_e$
e^+ ν_e W μ W μ e^- ν_e
e^+ τ τ Z W ν_e e^- ν_e
e^+ τ Z τ ν_e Z e^- $\bar{\nu}_e$
e^+ ν_e W τ W τ e^- ν_e

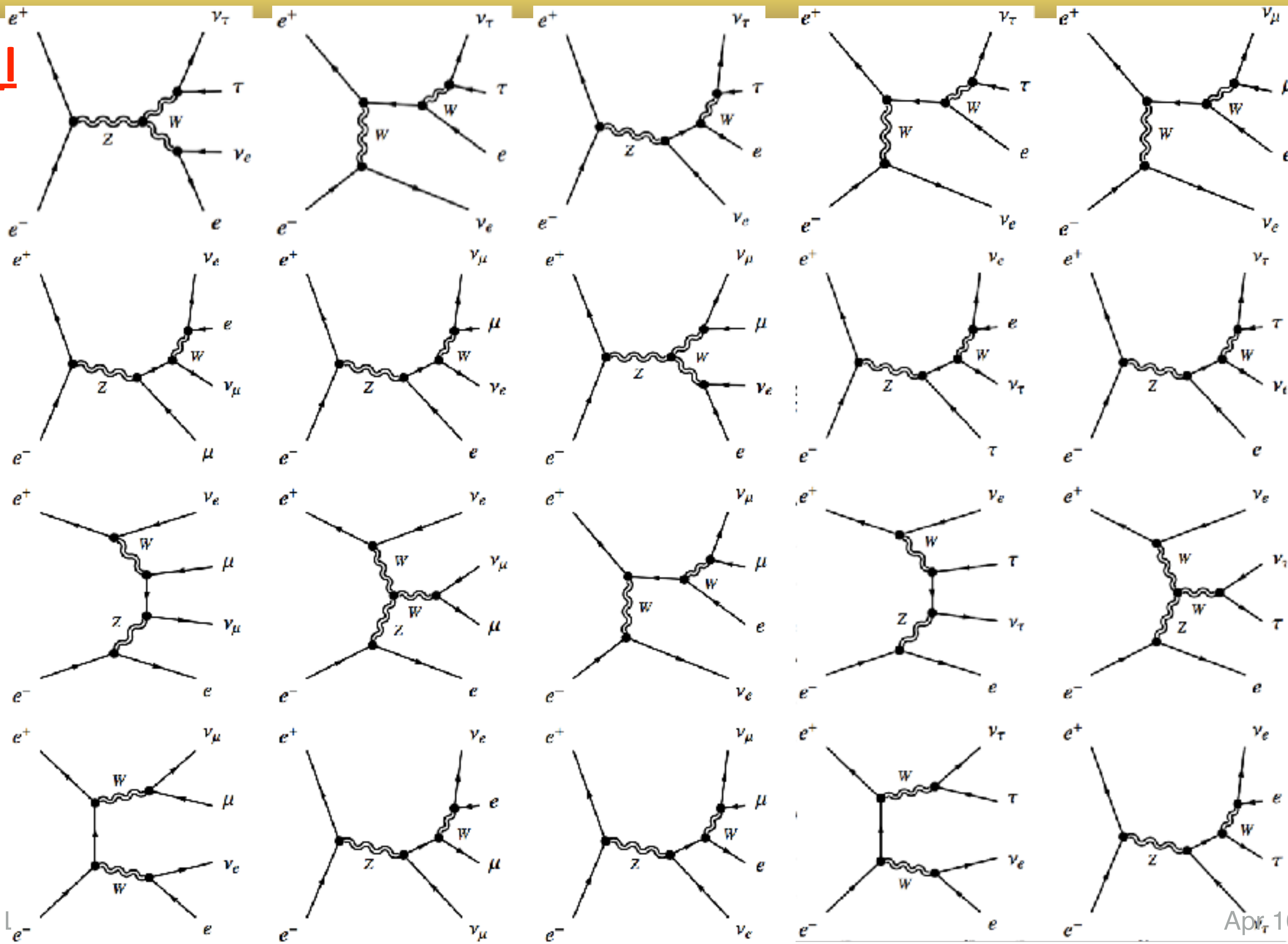
Back up

sznu_sl



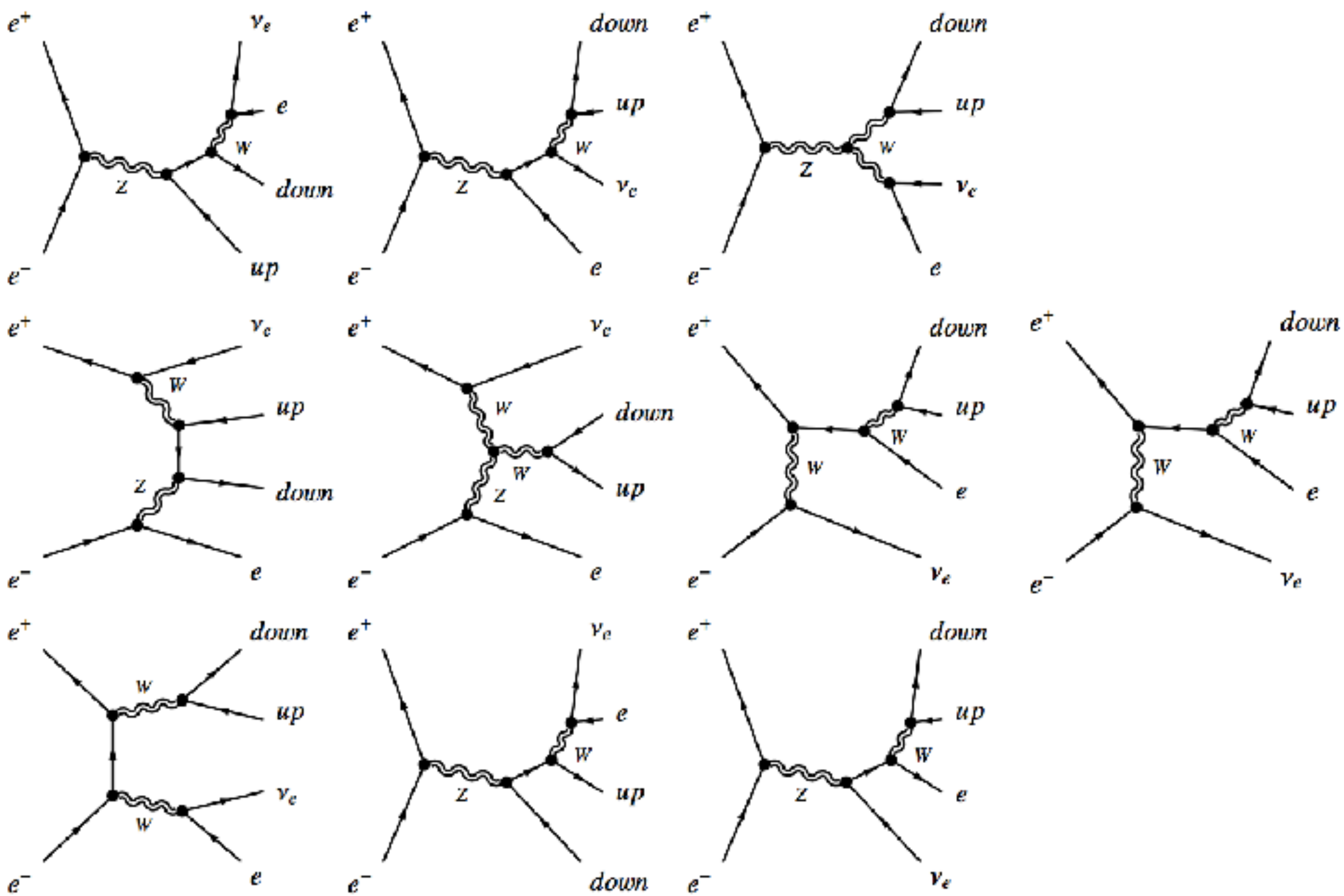
Back up

sw_l



e^+ ν_τ τ W Z ν_e e^- e
e^+ ν_τ τ W W e e^- ν_e
e^+ ν_τ τ W Z e e^- ν_e
e^+ ν_τ τ W W e e^- ν_e
e^+ ν_μ μ W W e e^- ν_e
e^+ ν_e e W Z ν_μ e^- μ
e^+ ν_μ μ W Z ν_e e^- e
e^+ ν_μ μ W Z ν_e e^- e
e^+ ν_e e W Z ν_τ e^- τ
e^+ ν_τ τ W Z ν_t e^- e
e^+ ν_e W μ Z ν_μ e^- e
e^+ ν_e W ν_μ W Z μ e^- e
e^+ ν_μ μ W W e e^- ν_e
e^+ ν_e W τ Z ν_τ e^- e
e^+ ν_e W ν_τ W Z τ e^- e
e^+ ν_μ W μ ν_e W e^- e
e^+ ν_e e W Z μ e^- ν_μ
e^+ ν_μ μ W Z e e^- ν_e
e^+ ν_τ W τ ν_e W e^- e
e^+ ν_e e W Z τ e^- ν_τ

sw_sl


e+
νe
e
W
Z
down
e−
up
e+
down
up
W
Z
νe
e−
e
e+
down
up
Z
W
νe
e−
e
e+
νe
W
up
Z
down
e−
e
e+
νe
W
down
W
Z
up
e−
e
e+
down
up
W
W
e
e−
νe
e+
down
up
W
W
e
e−
νe
e+
down
W
up
νe
W
e−
e
e+
νe
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W
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up
e−
down
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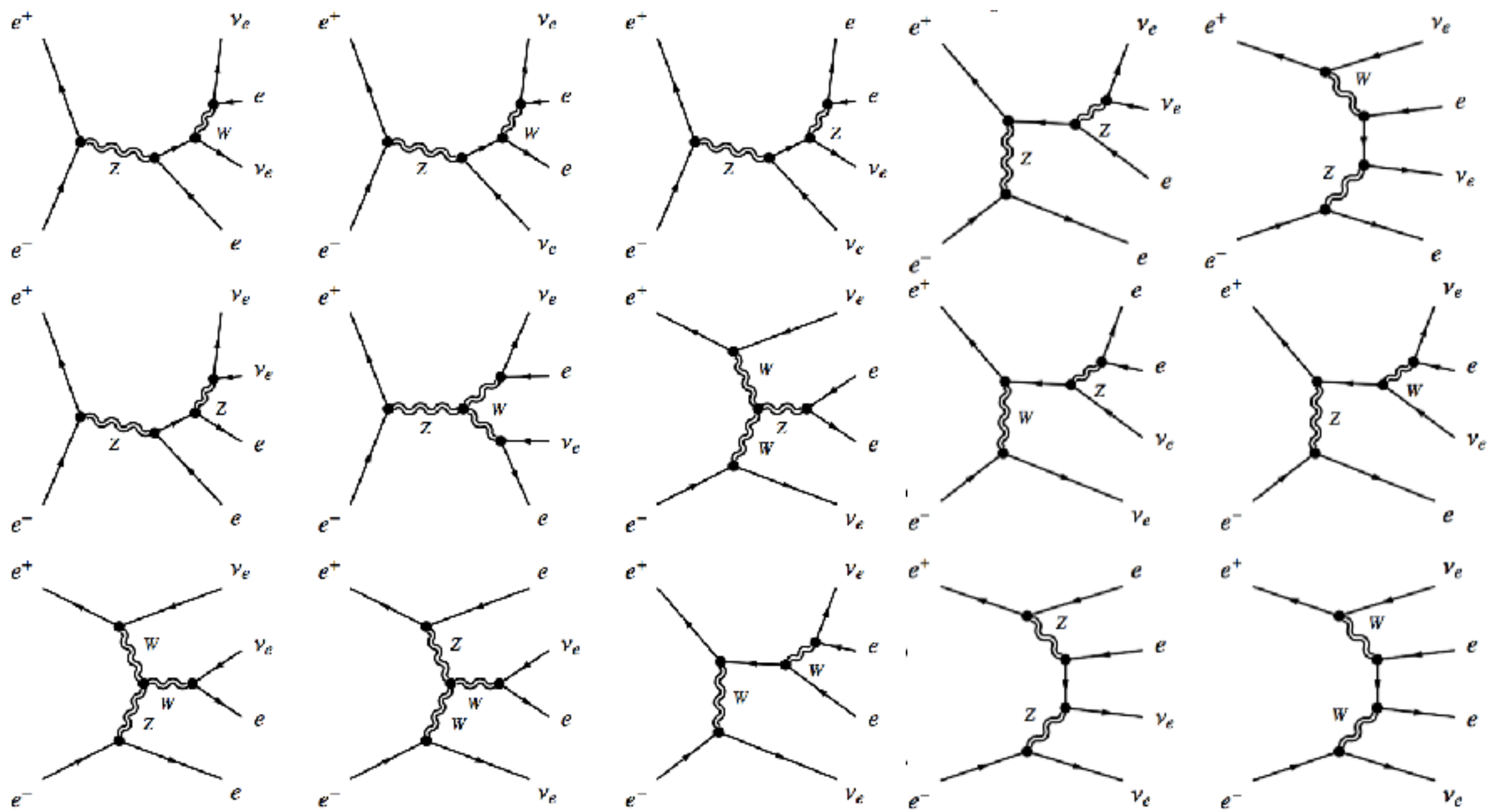
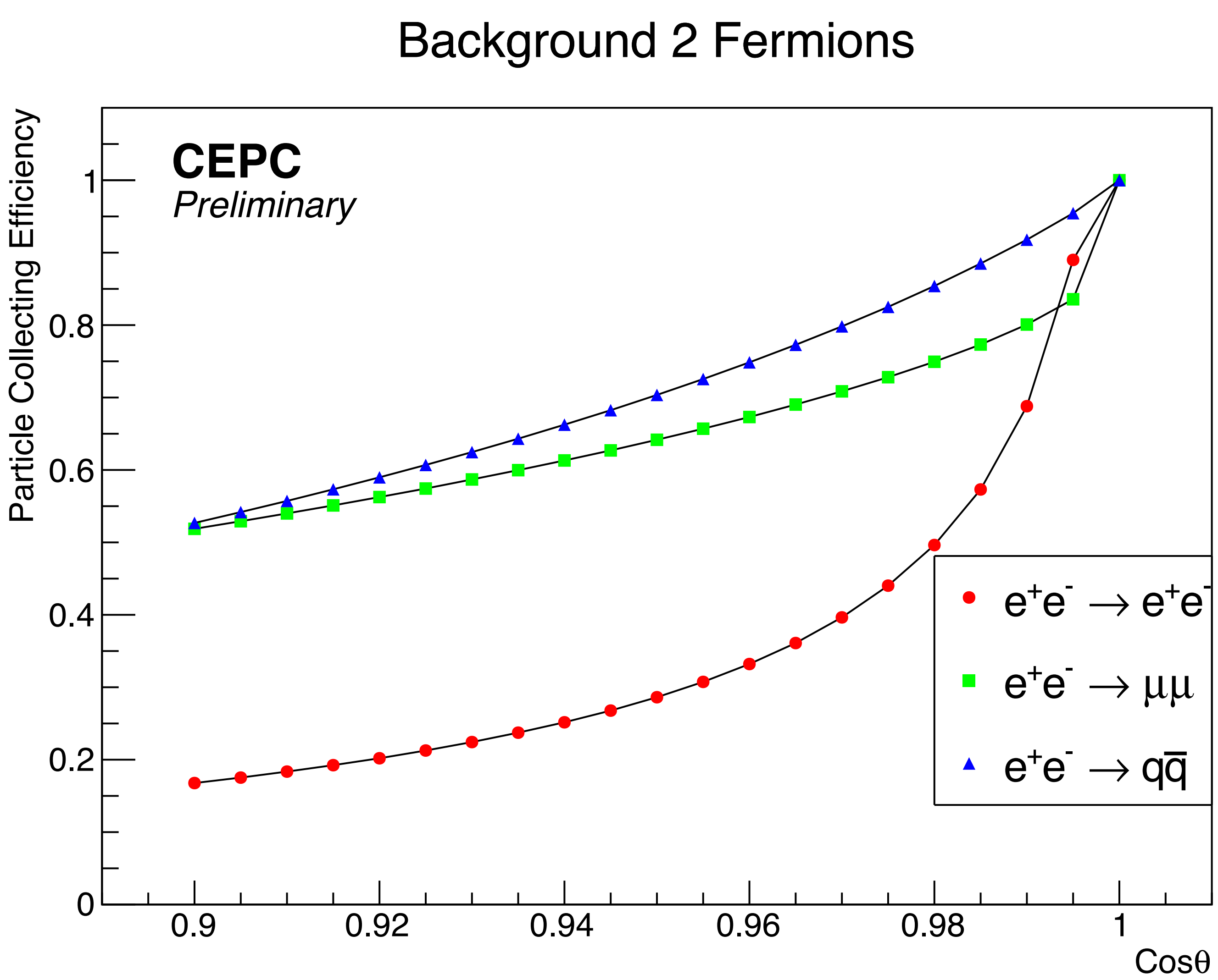
down
up
W
Z
e
e−
νe

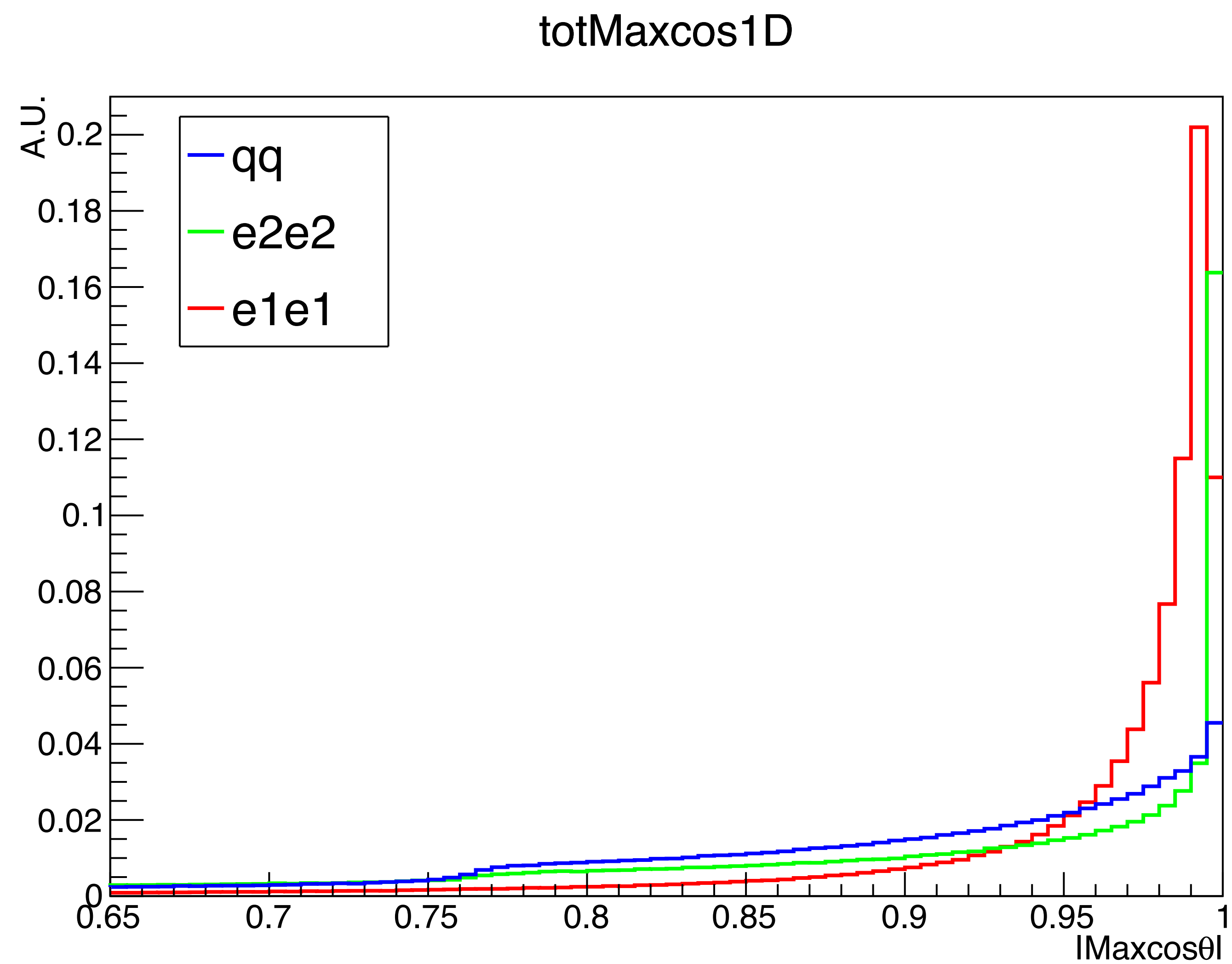
Back up

szeorsw_l

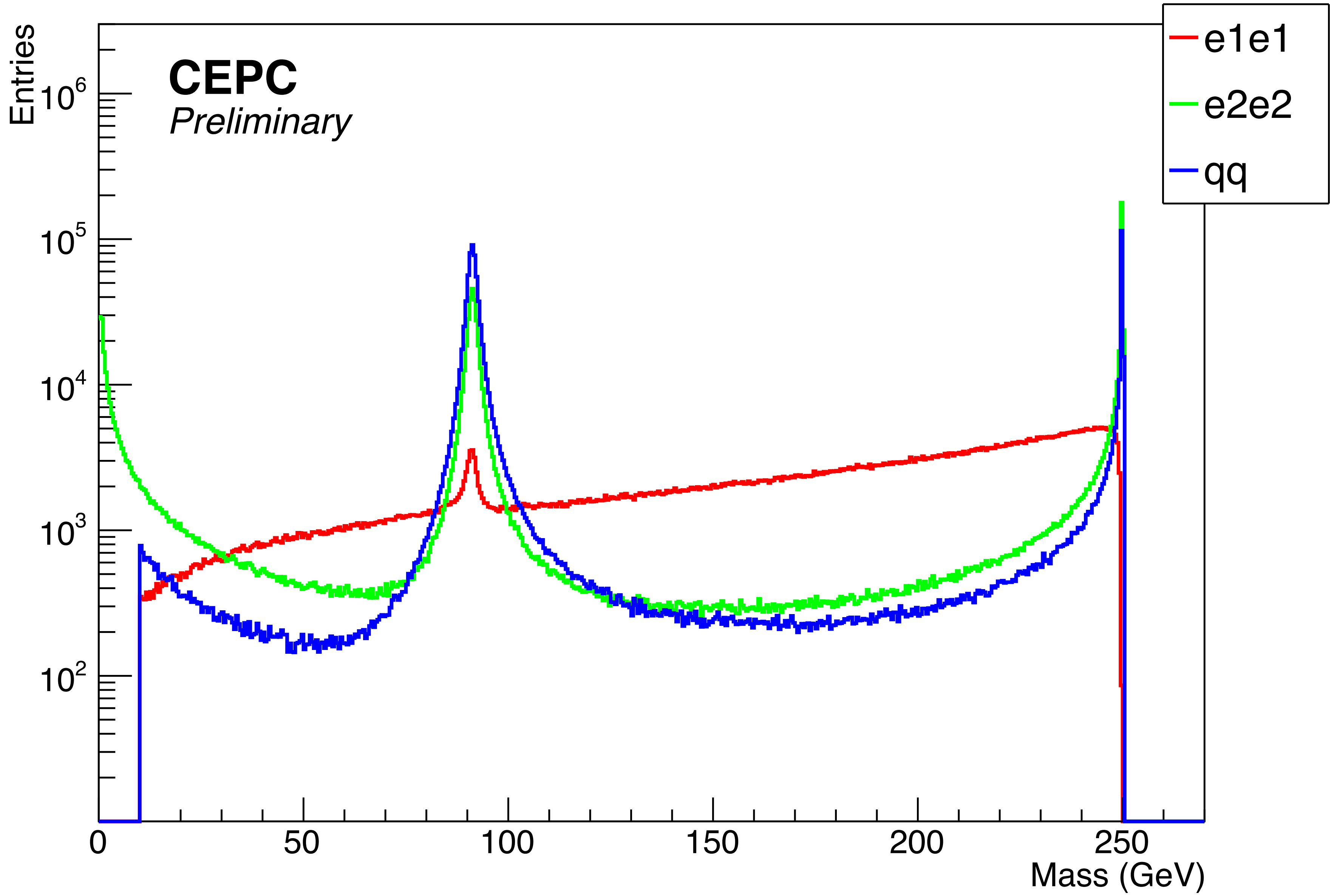


Background 2 Fermions Collecting Efficiency

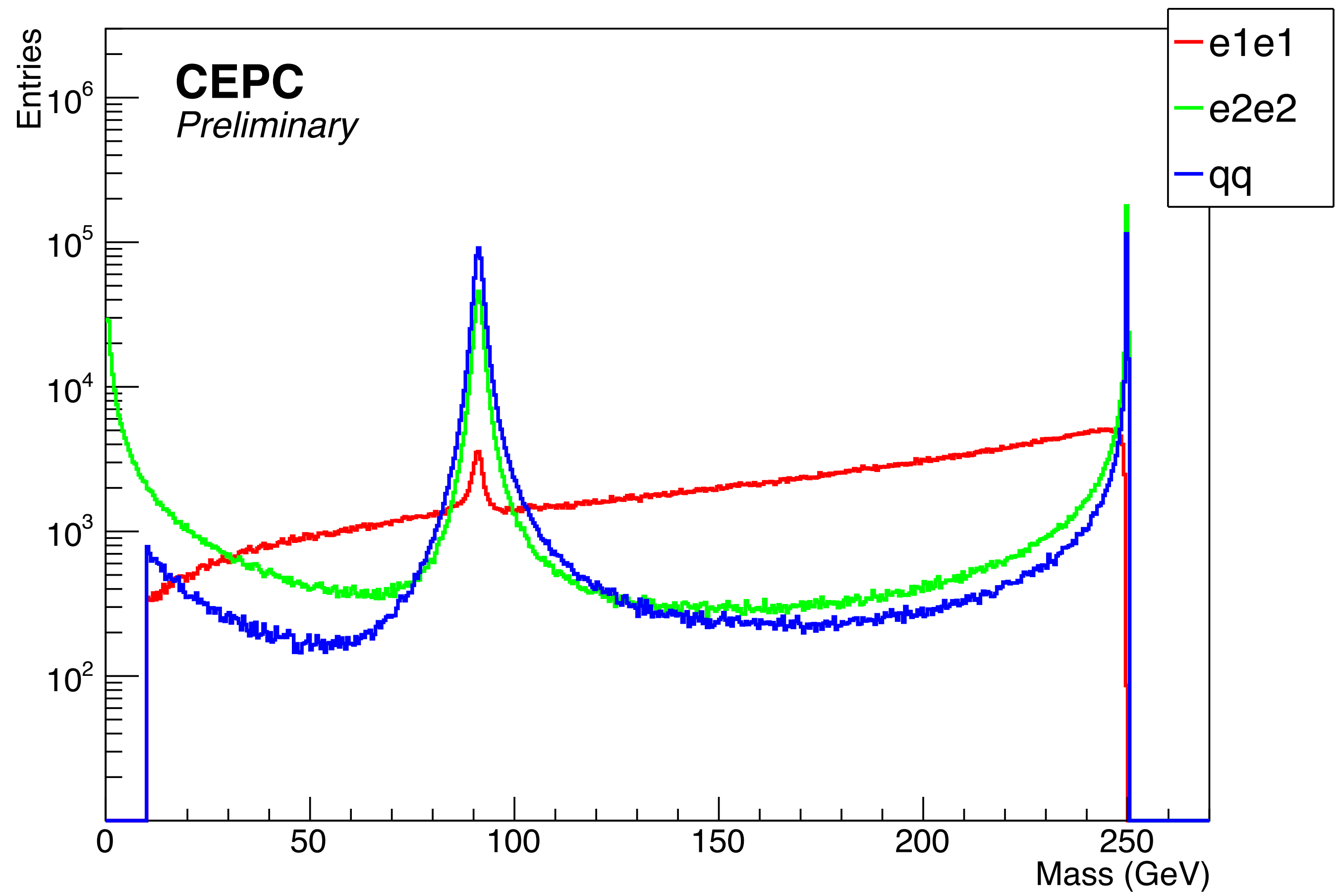




Background 2 Fermions Reconstruction



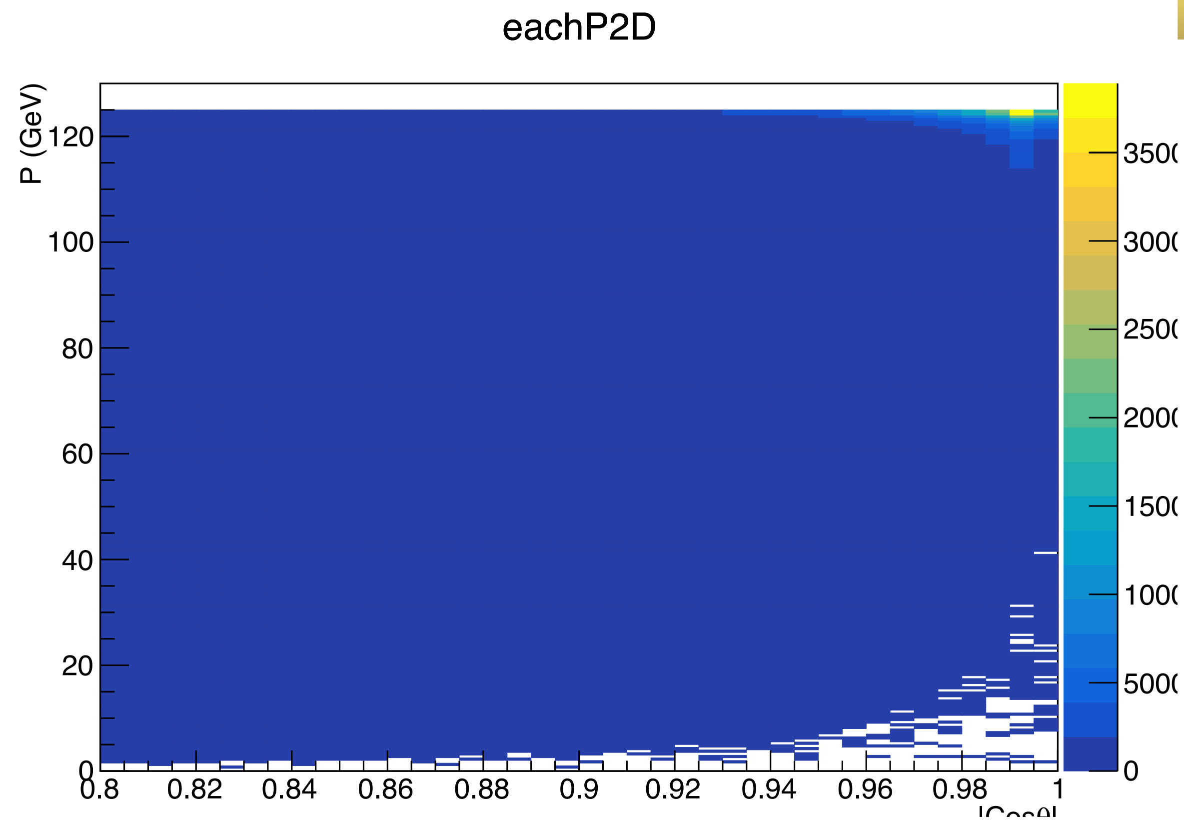
Background 2 Fermions Reconstruction

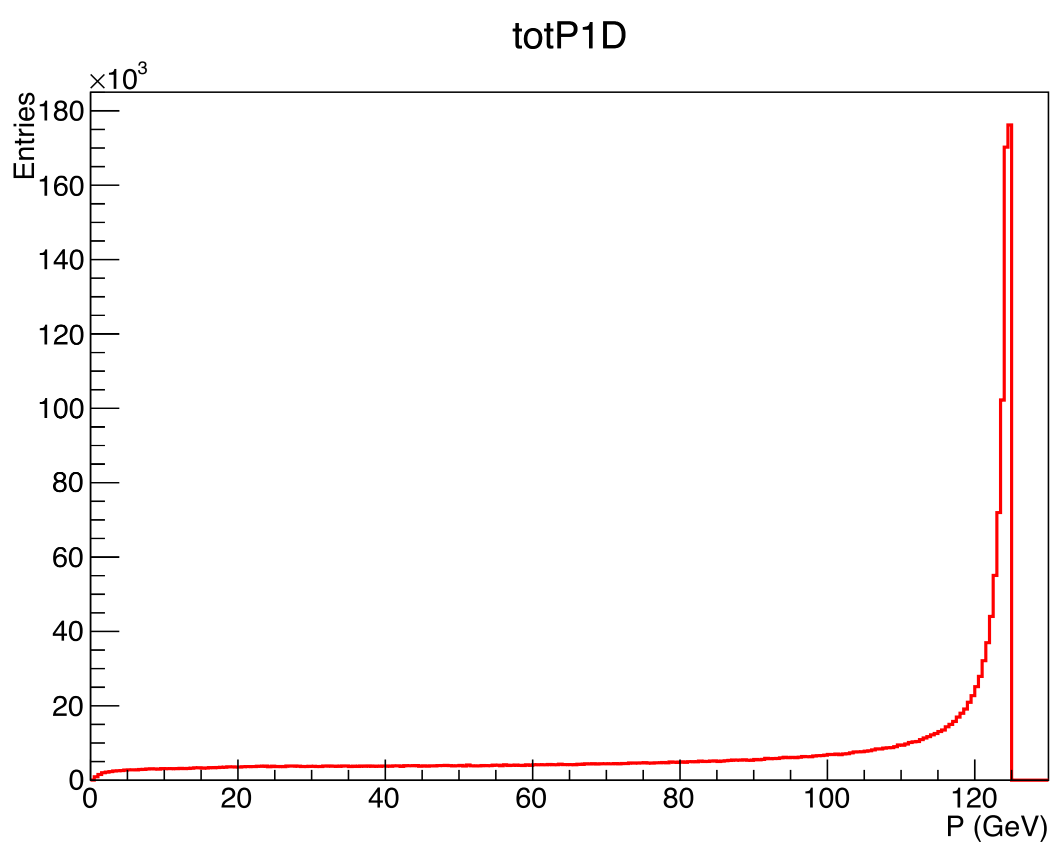


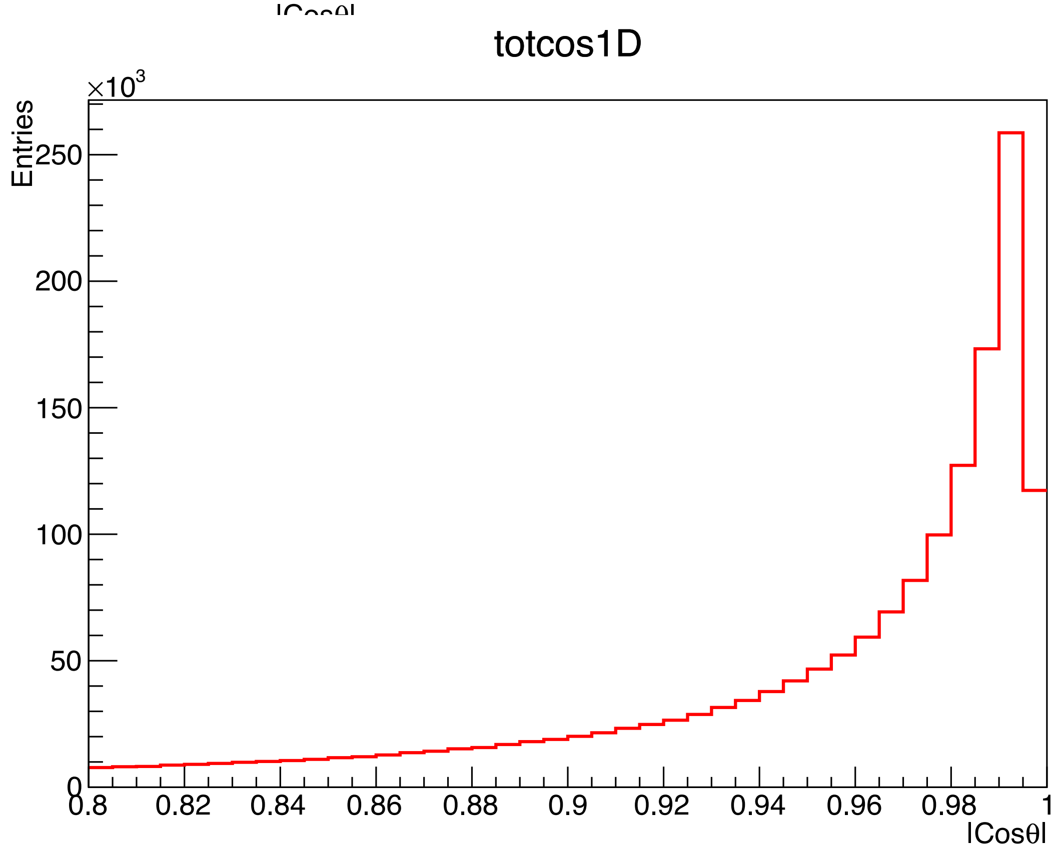

```
! Automatically generated set of cuts
! Process bhabha:
!    e a-e ->    e a-e gamma
!   16   8 ->    1   2     4
process bhabha
cut M of     3       within  1.00000E+01  1.00000E+99
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    17       within -1.00000E+99 -1.00000E+01
cut M of    20       within -1.00000E+99 -1.00000E+01
cut M of    10       within -1.00000E+99 -1.00000E+01
cut M of    12       within -1.00000E+99 -1.00000E+01
```

```
! Automatically generated set of cuts
! Process qq:
!    e a-e ->    u a-u
!    e a-e ->    d a-d
!    e a-e ->    s a-s
!    e a-e ->    c a-c
!    e a-e ->    b a-b
!    8   4 ->    1   2
process qq
cut M of     3       within  1.00000E+01  1.00000E+99
```

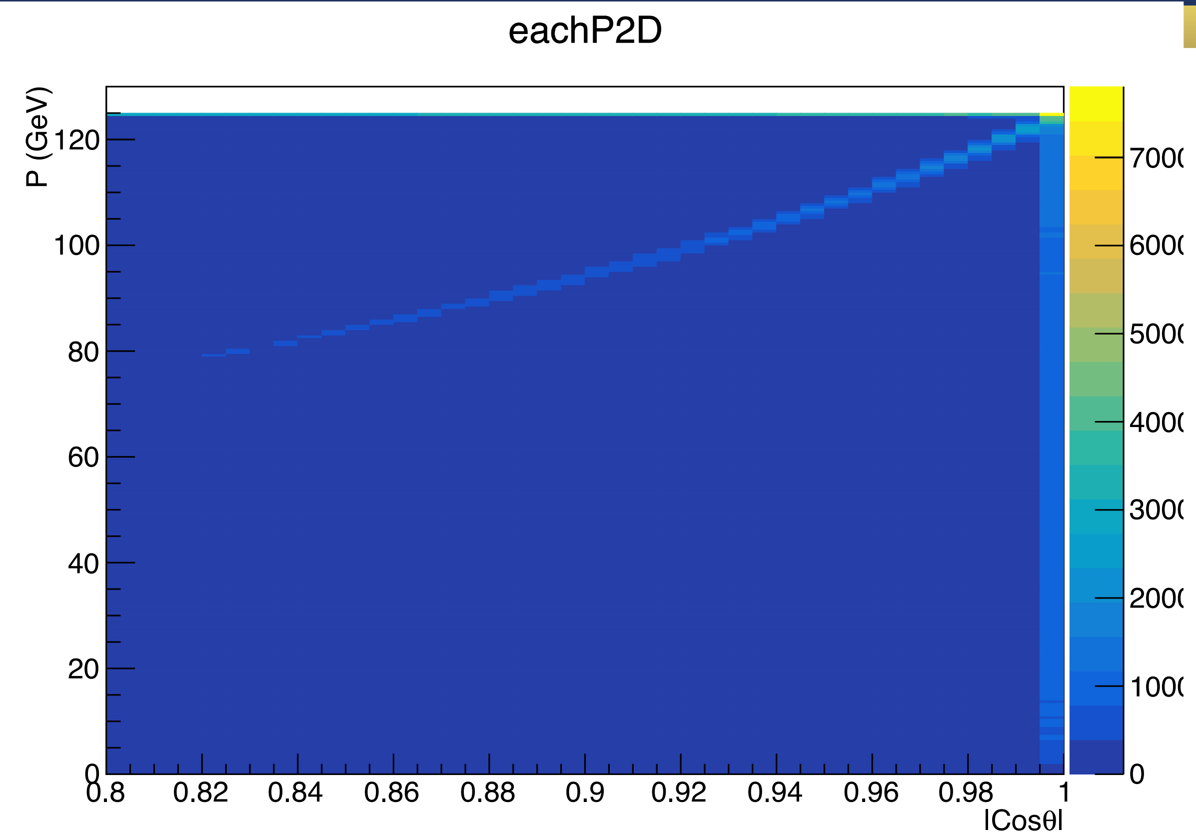
$e^+e^- \rightarrow e^+e^-$ Kinematic Distribution

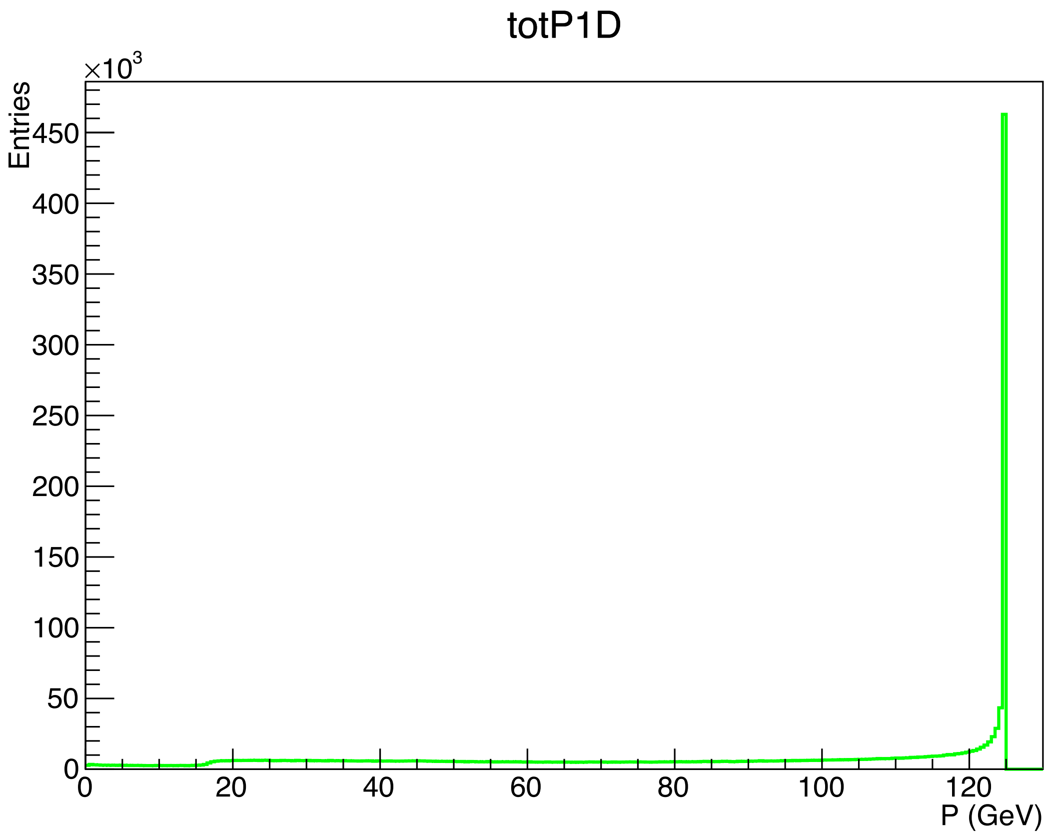


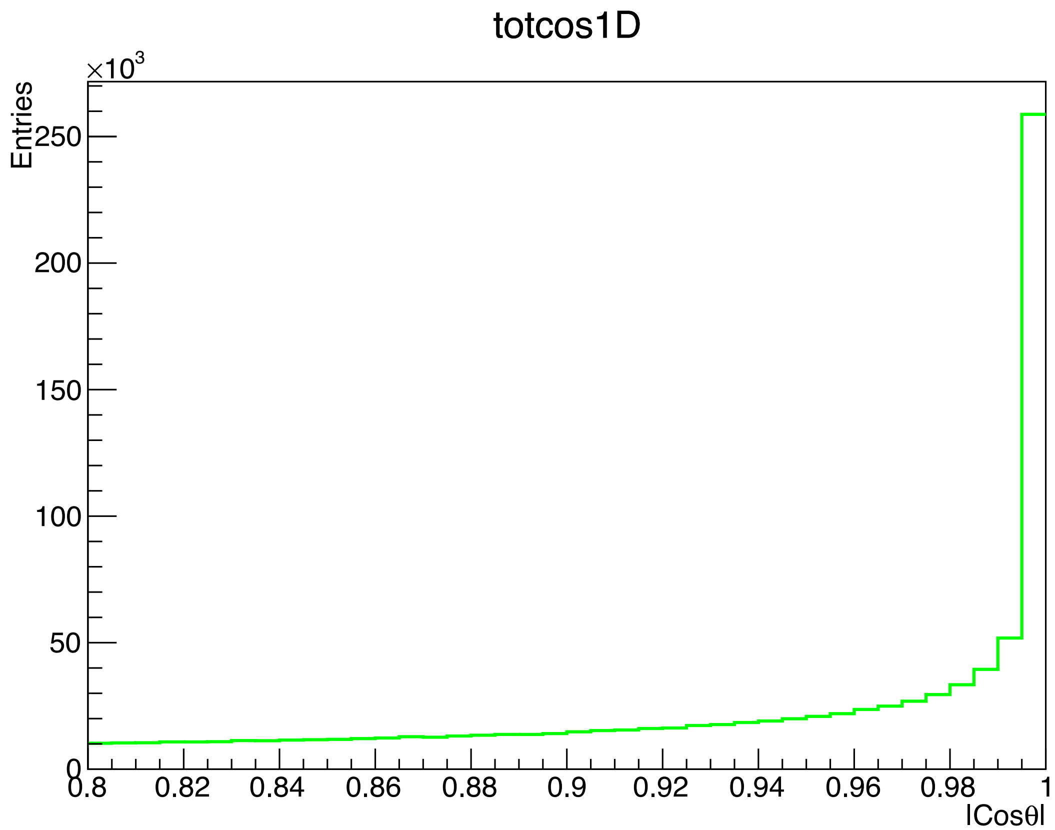




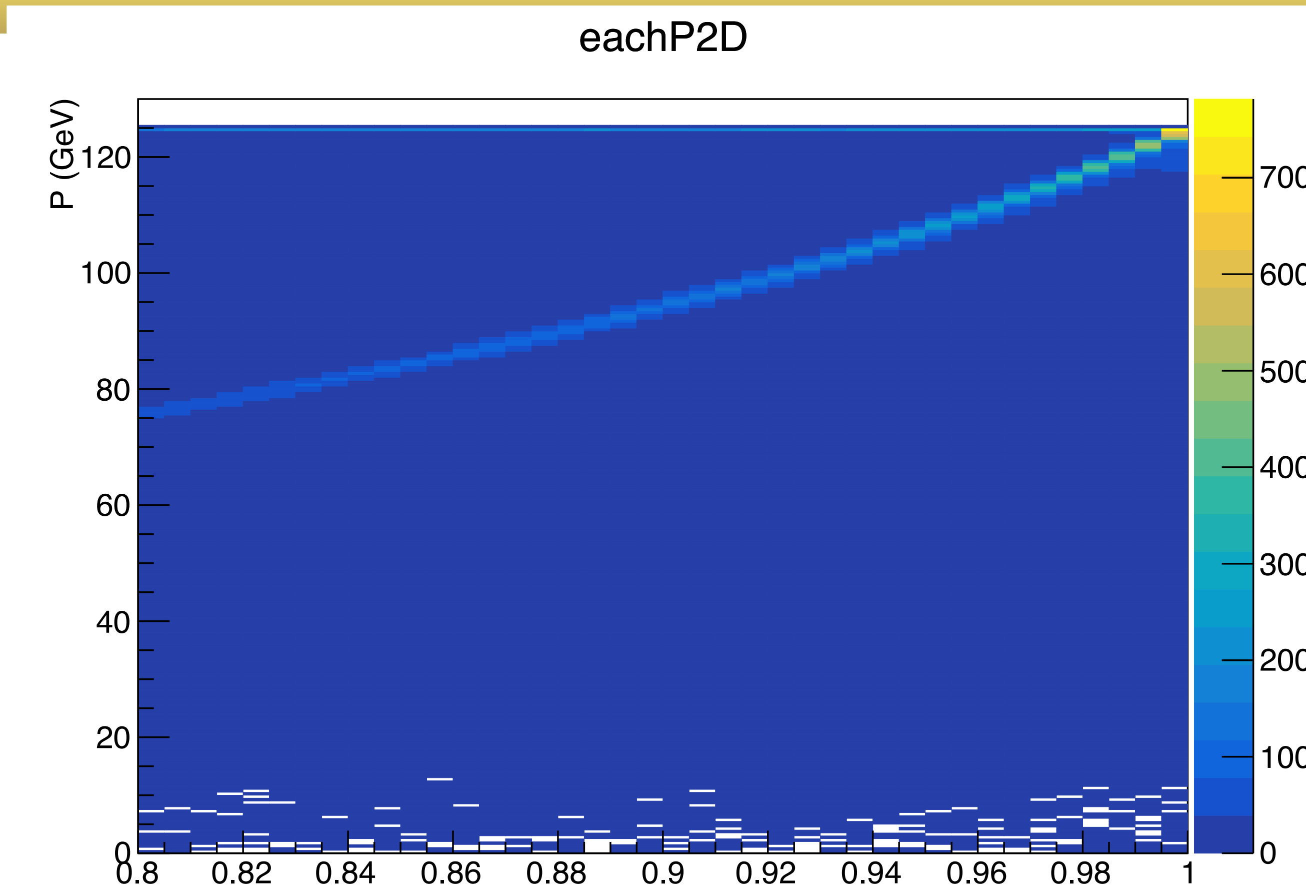
$e^+e^- \rightarrow \mu^+\mu^-$ Kinematic Distribution

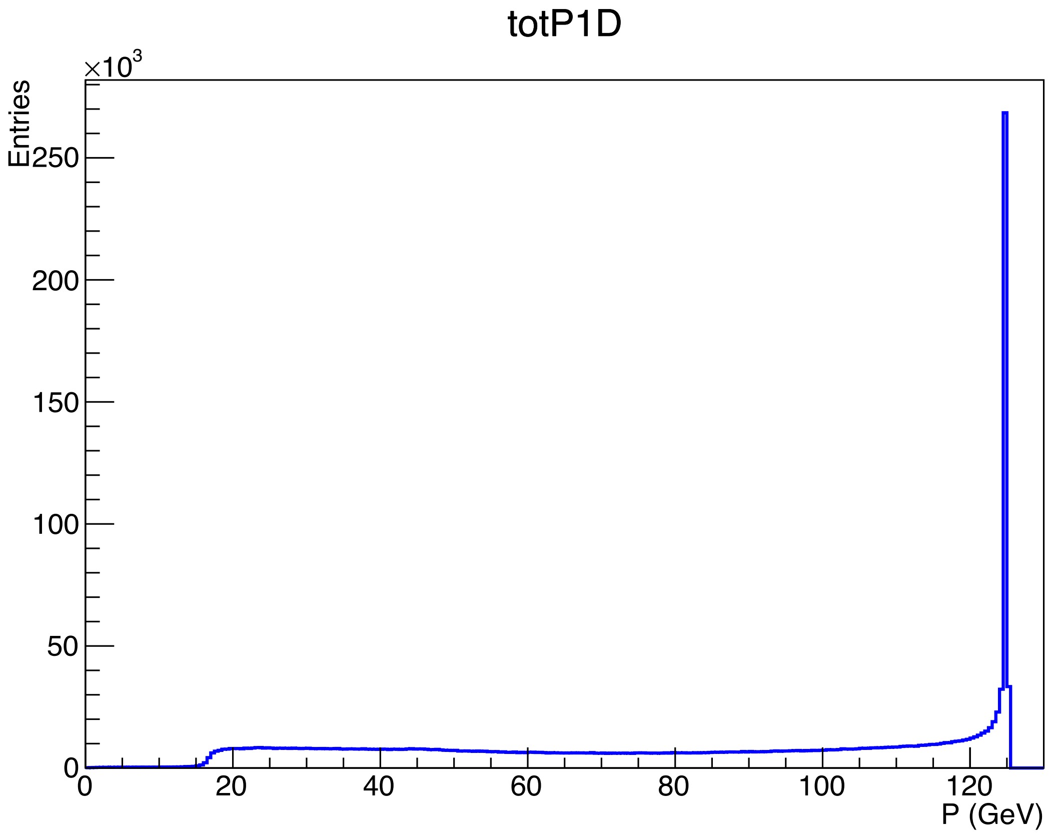


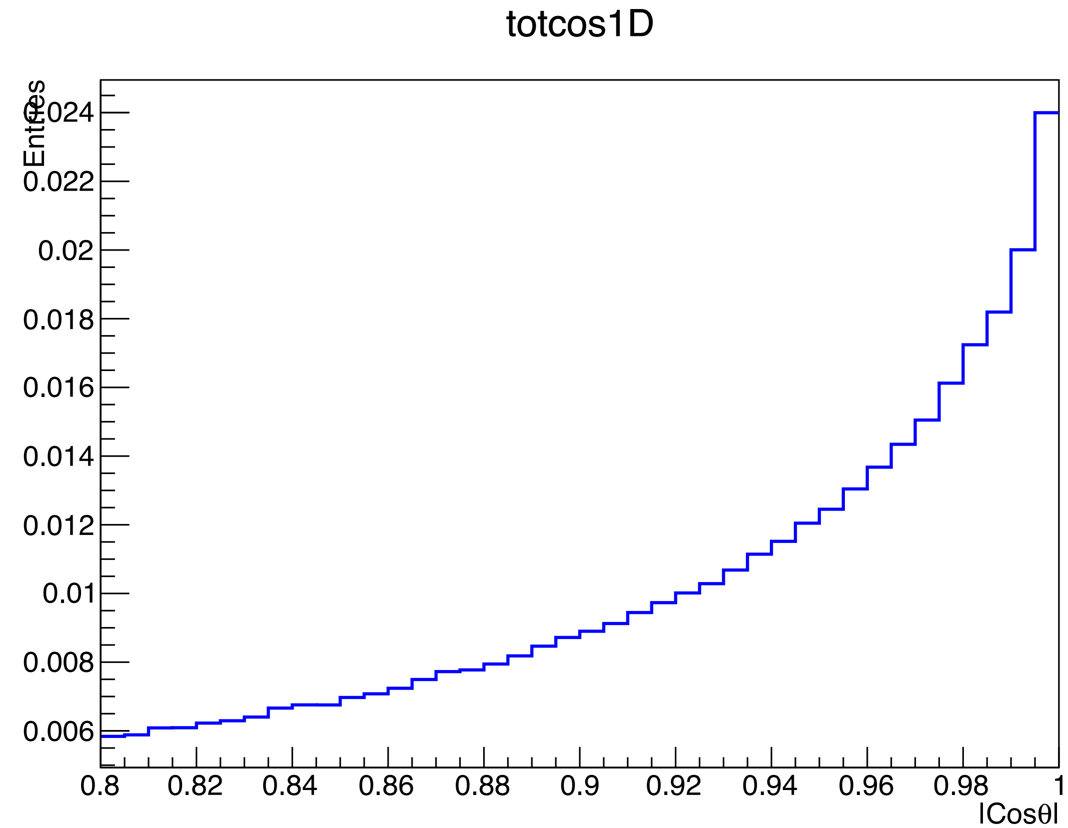




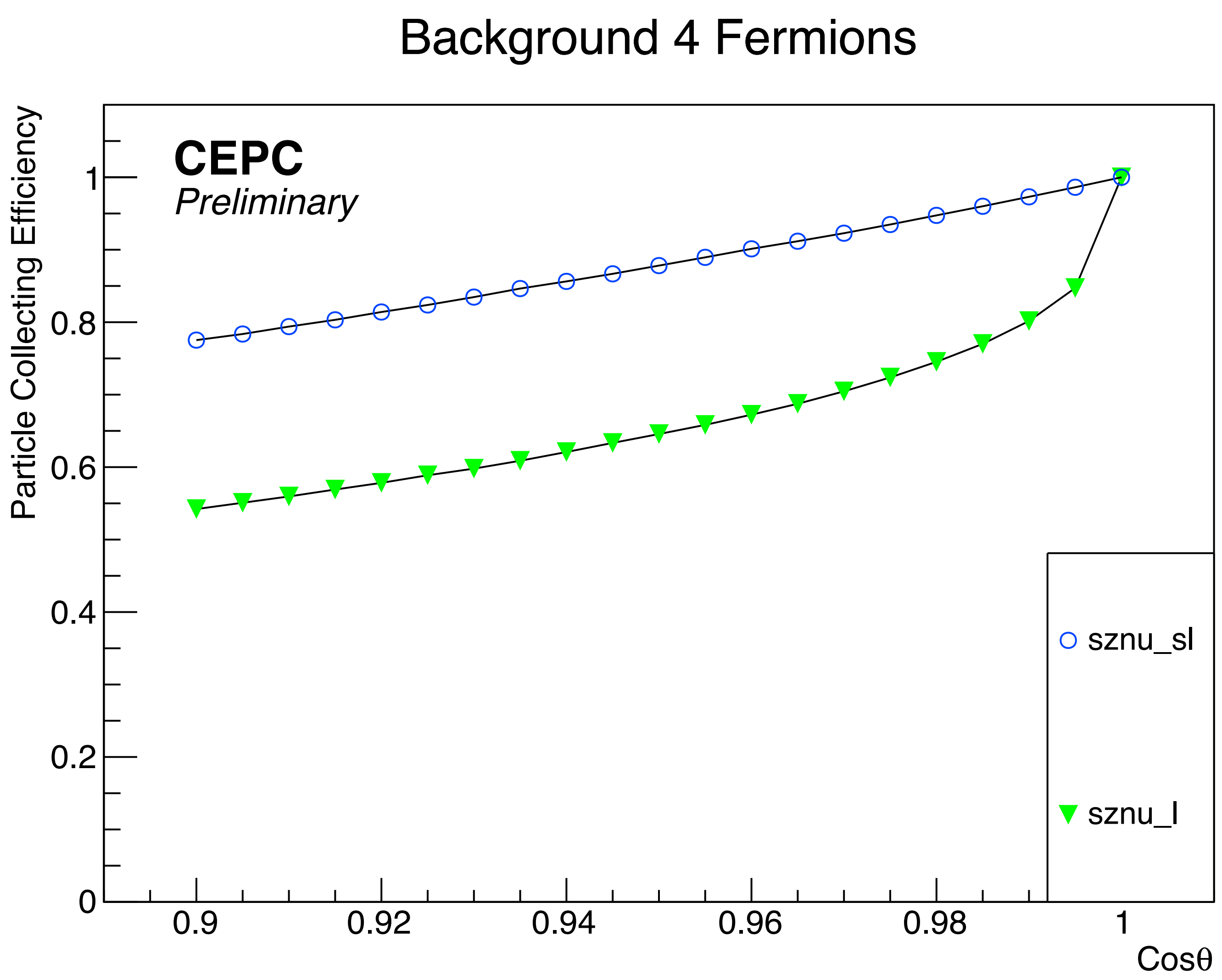
$e^+e^- \to q\bar{q}$ Kinematic Distribution

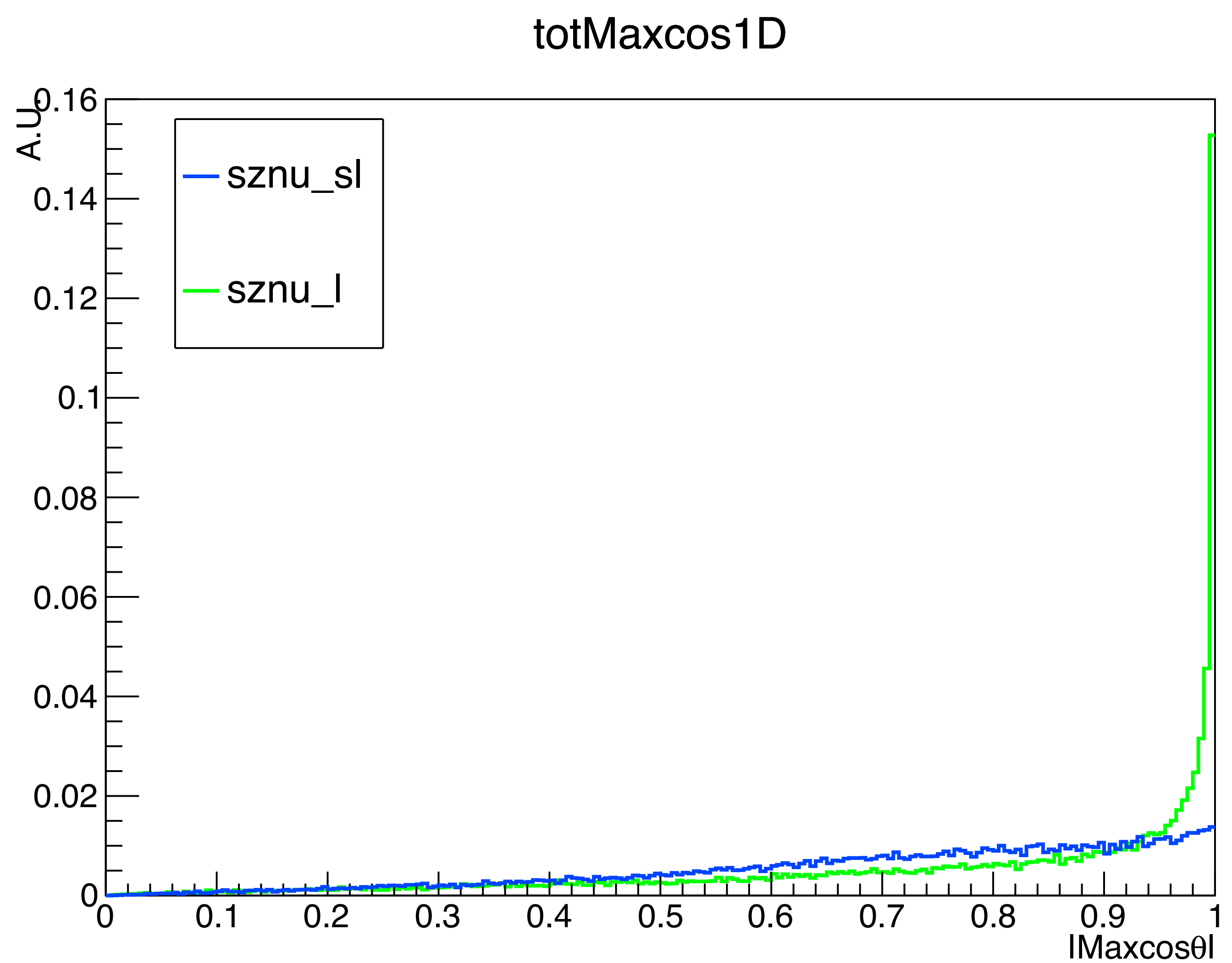


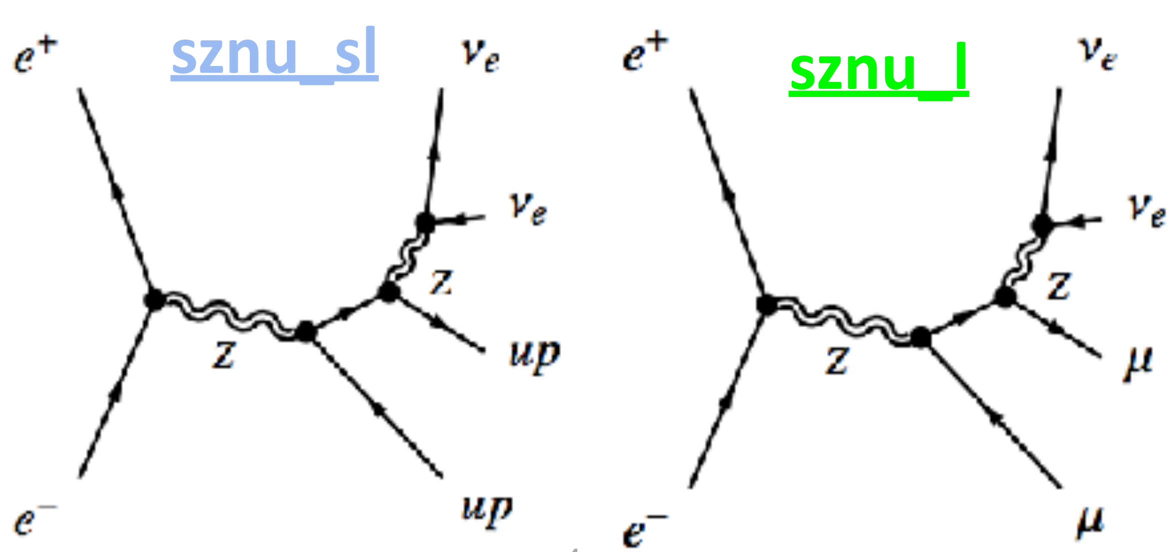




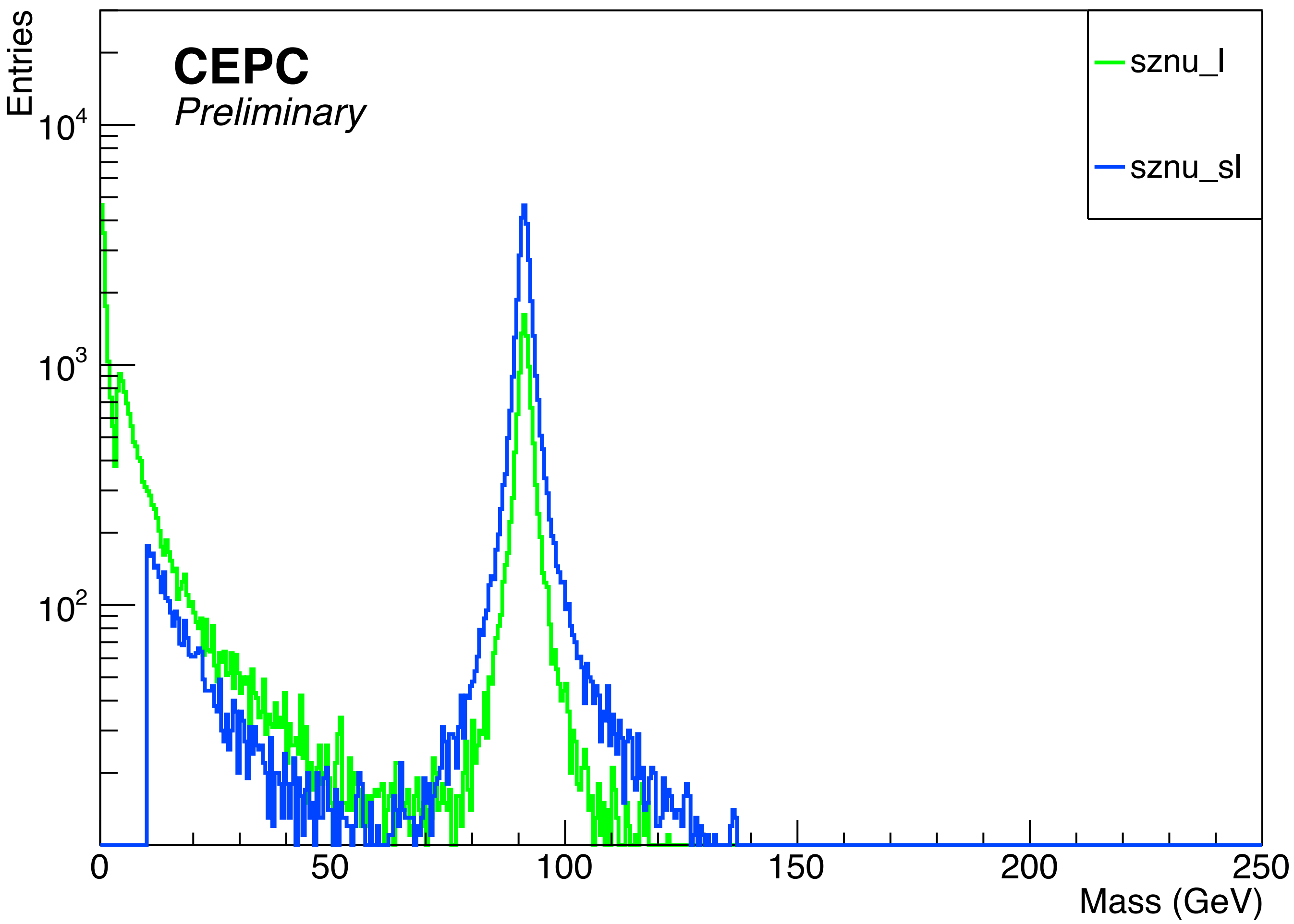
Background 4 Fermions Collecting Efficiency





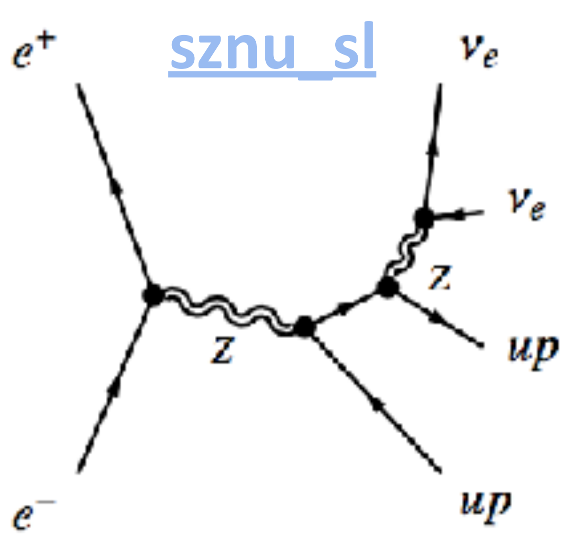


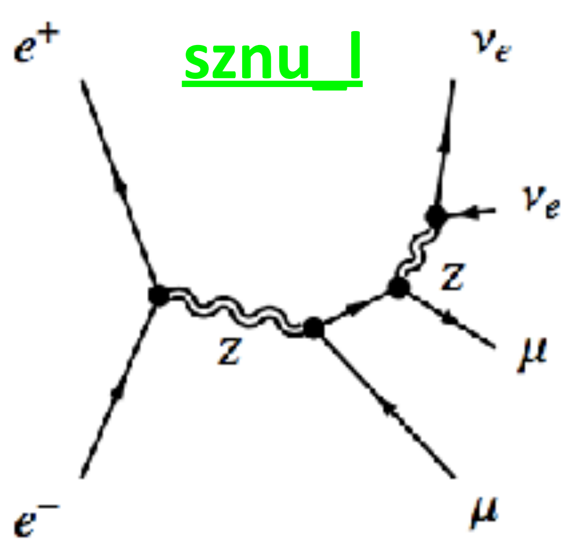
Background 4 Fermions Reconstruction



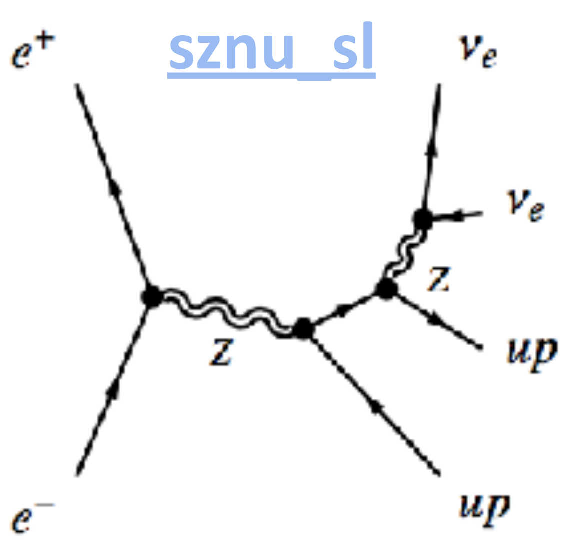

```
! Automatically generated set of cuts
! Process sznu_sl0nu_down:
!    e a-e -> nu_e a-nu_e    d a-d
!    e a-e -> nu_e a-nu_e    d a-s
!    e a-e -> nu_e a-nu_e    d a-b
!    e a-e -> nu_e a-nu_e    s a-d
!    e a-e -> nu_e a-nu_e    s a-s
!    e a-e -> nu_e a-nu_e    s a-b
!    e a-e -> nu_e a-nu_e    b a-d
!    e a-e -> nu_e a-nu_e    b a-s
!    e a-e -> nu_e a-nu_e    b a-b
!   32  16 ->      1      2   4   8
process sznu_sl0nu_down
cut M of    12        within  1.00000E+01  1.00000E+99
```

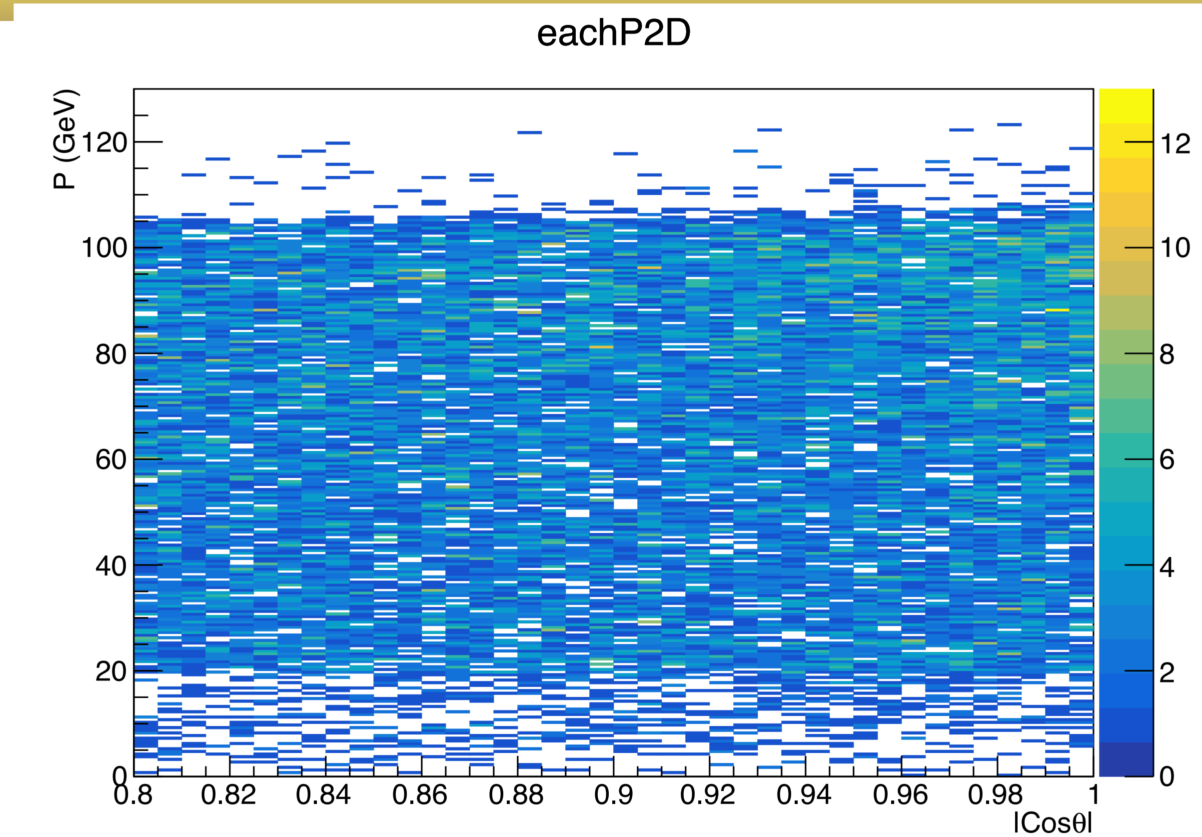
```
! Automatically generated set of cuts
! Process sznu_sl0nu_up:
!    e a-e -> nu_e a-nu_e    u a-u
!    e a-e -> nu_e a-nu_e    u a-c
!    e a-e -> nu_e a-nu_e    c a-u
!    e a-e -> nu_e a-nu_e    c a-c
!   32  16 ->      1      2   4   8
process sznu_sl0nu_up
cut M of    12        within  1.00000E+01  1.00000E+99
```

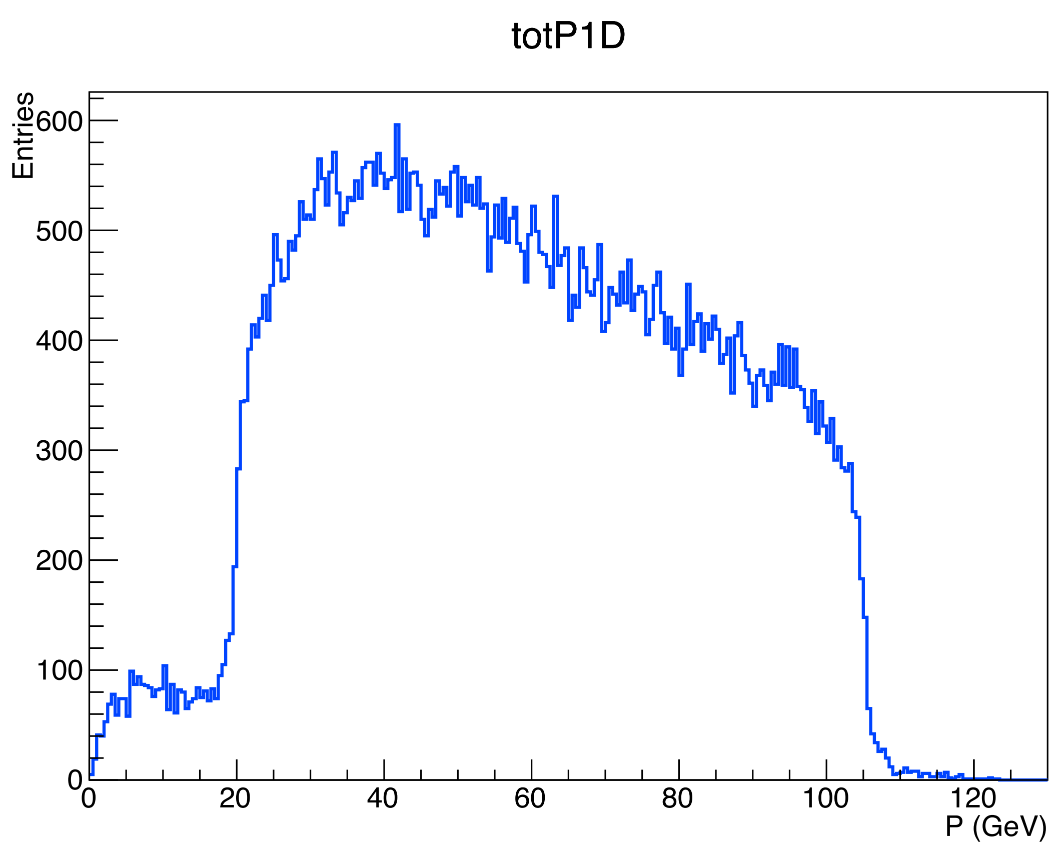


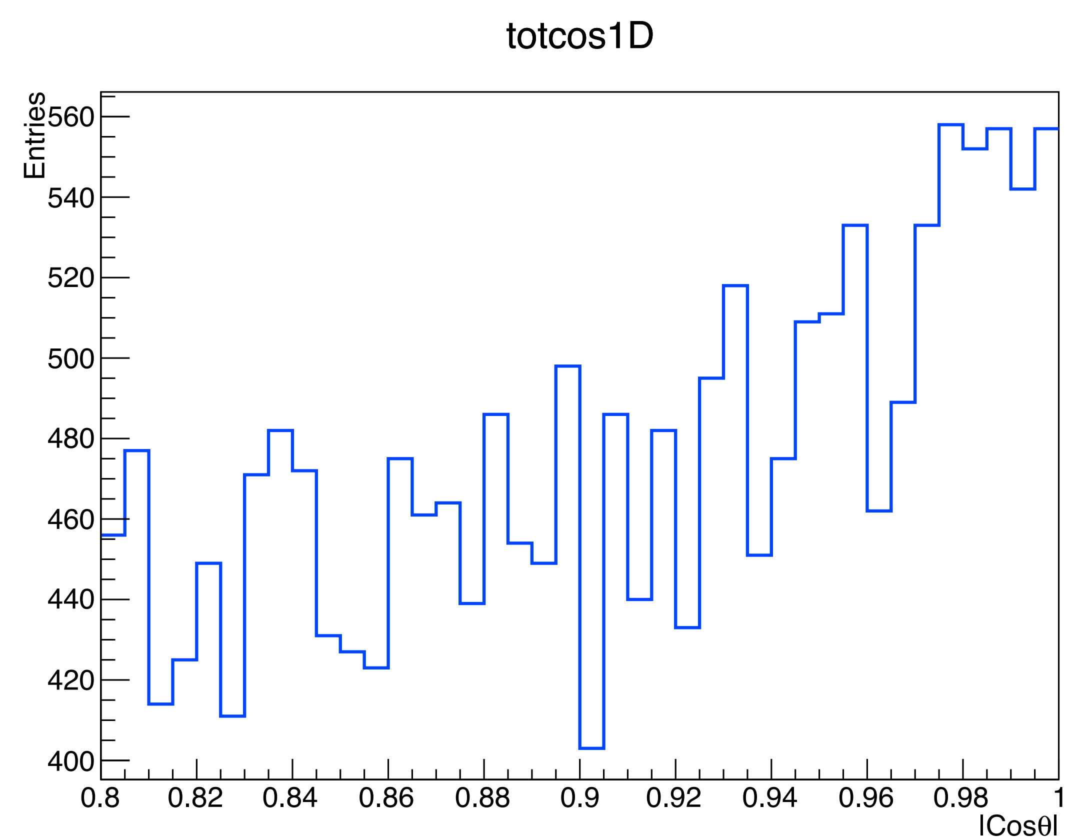


sznu_sl Kinematic Distribution

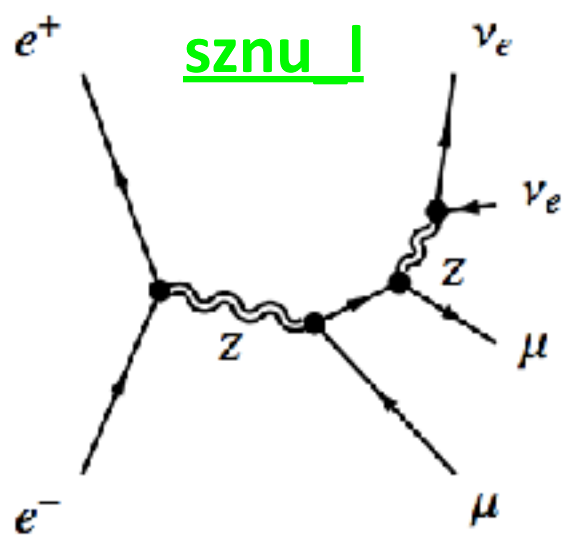


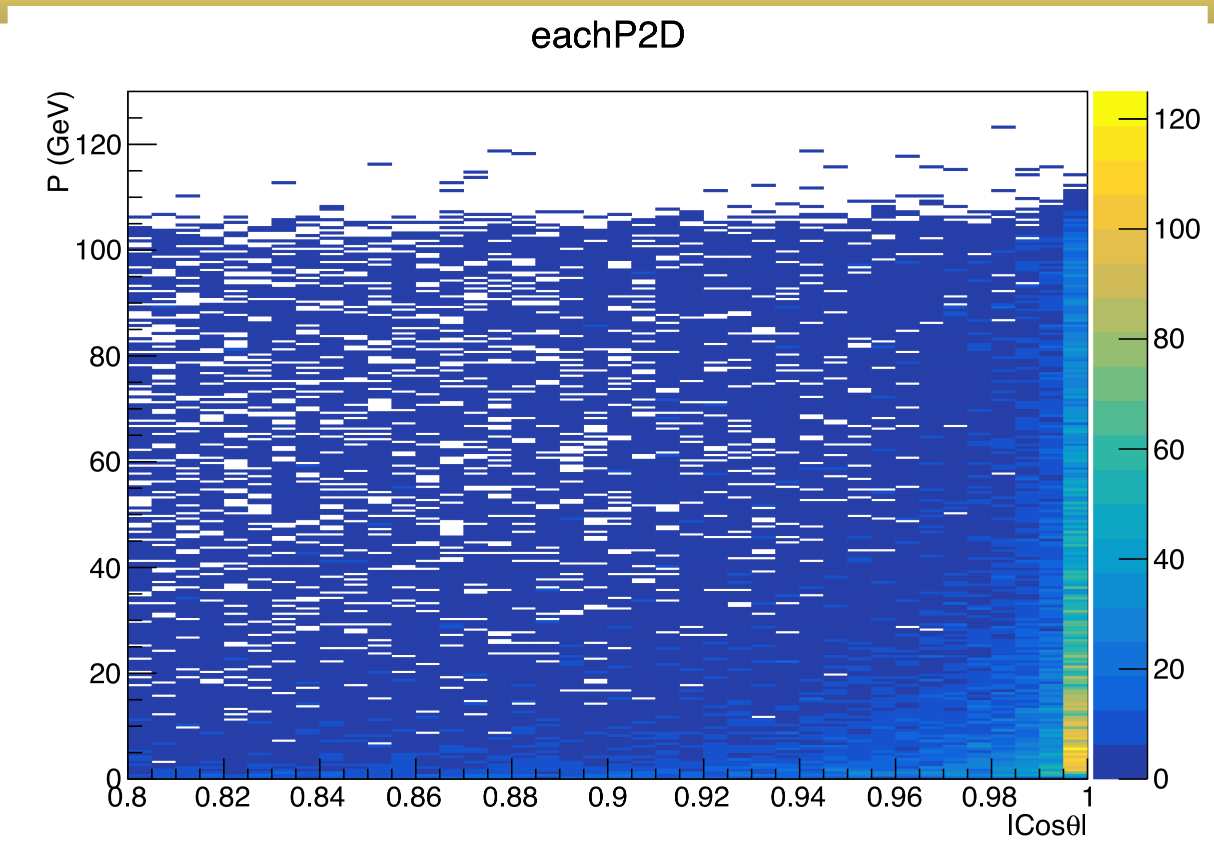


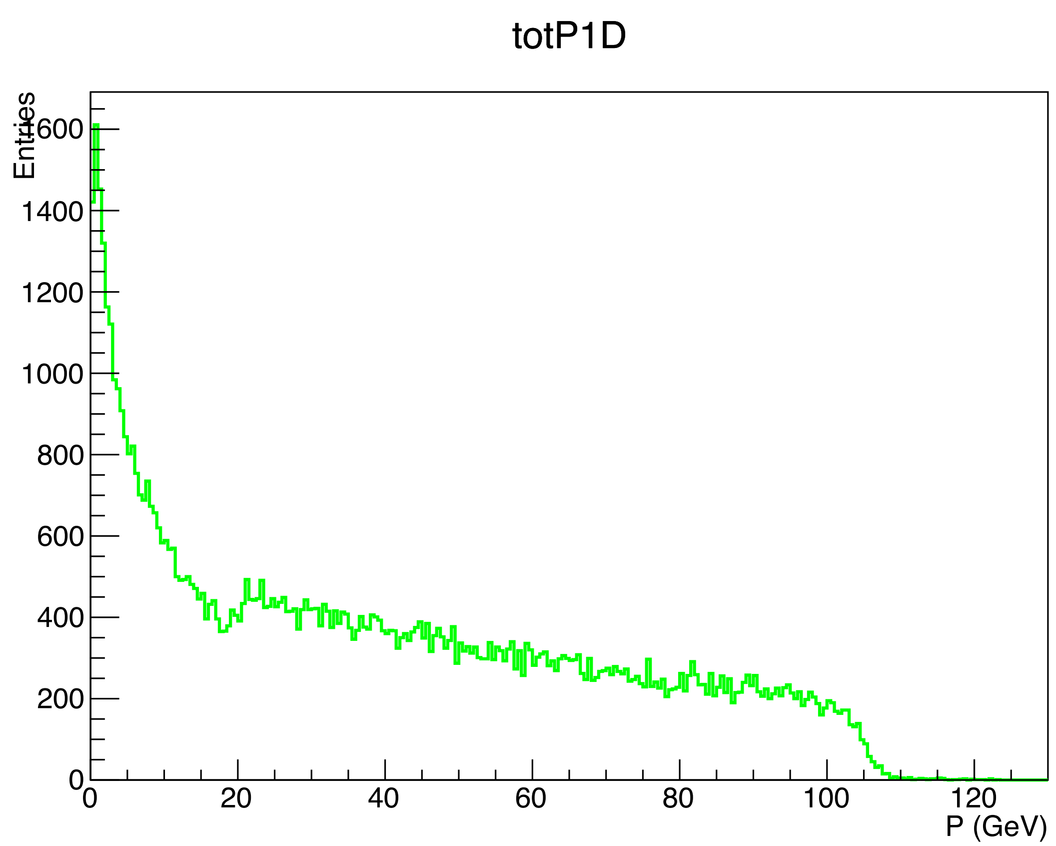


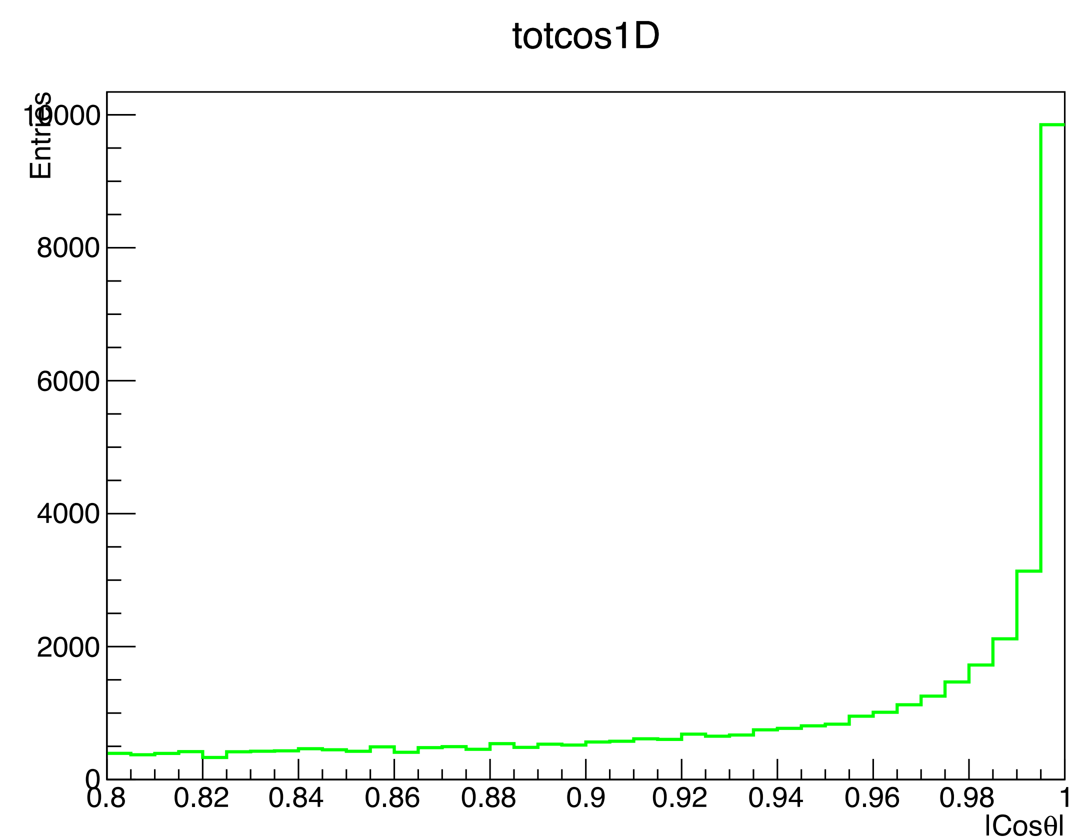


sznu_l Kinematic Distribution

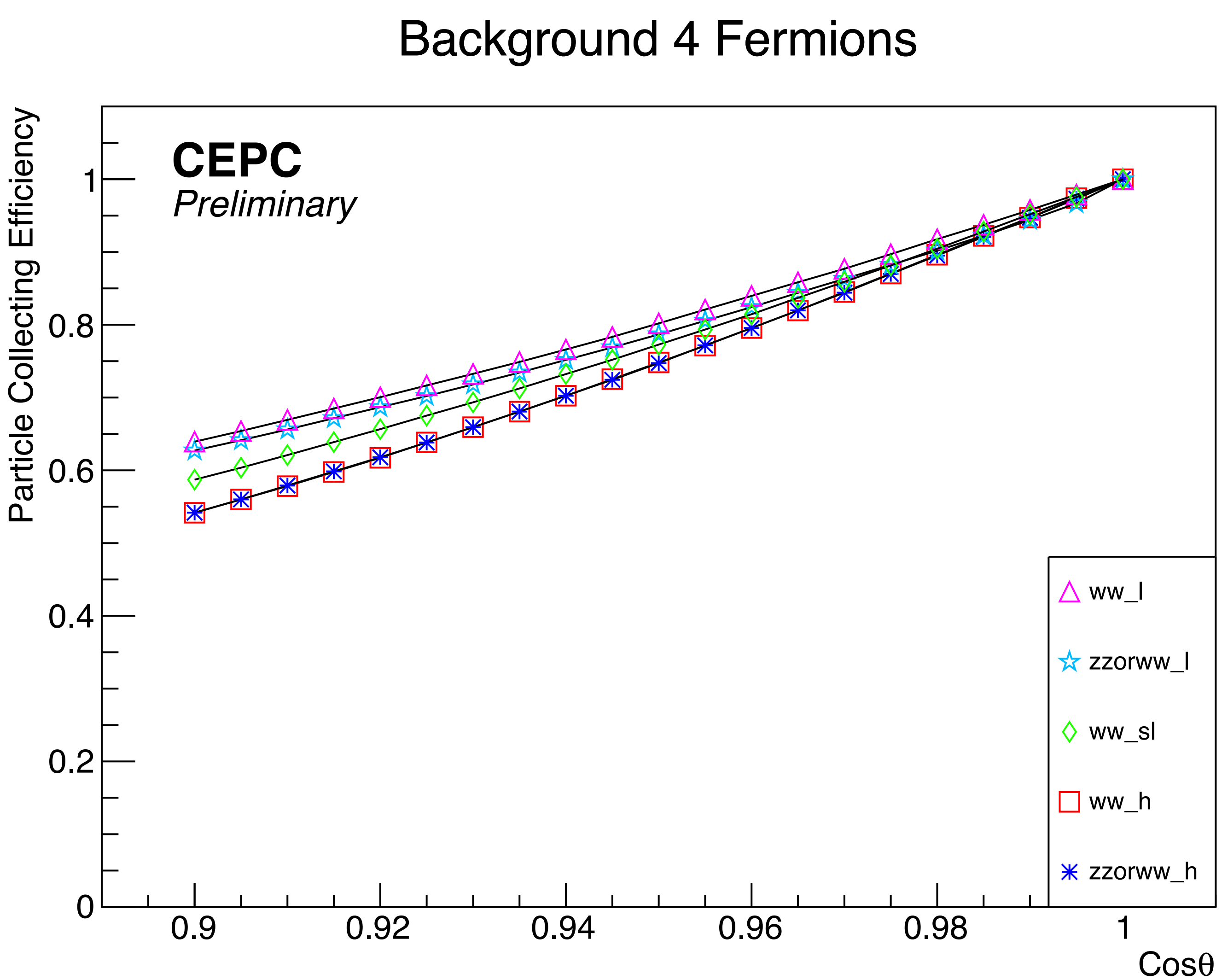


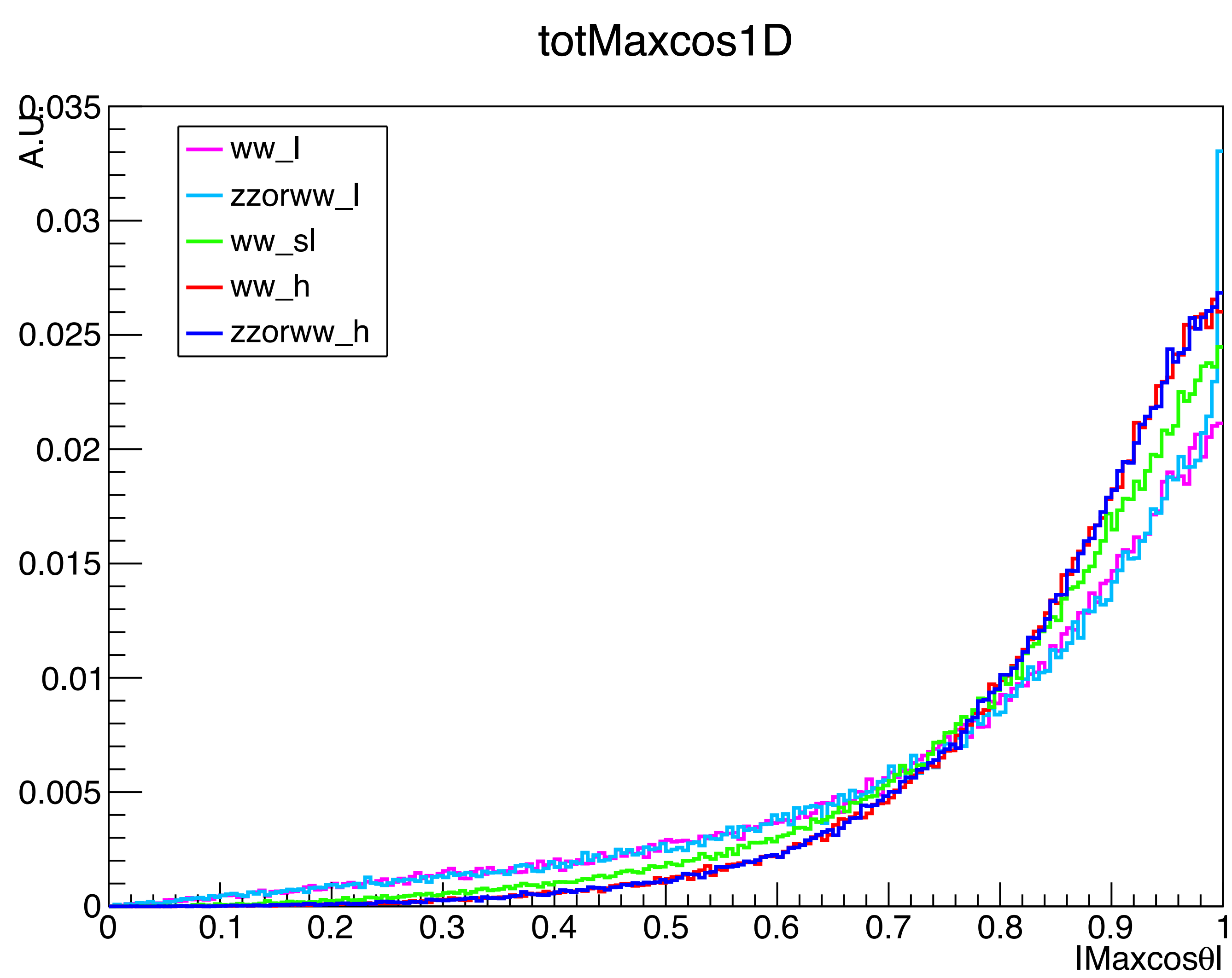


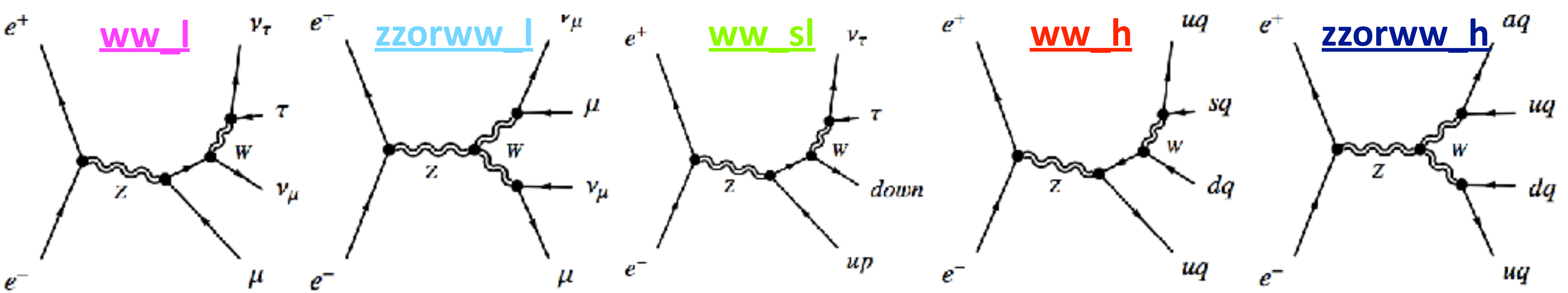




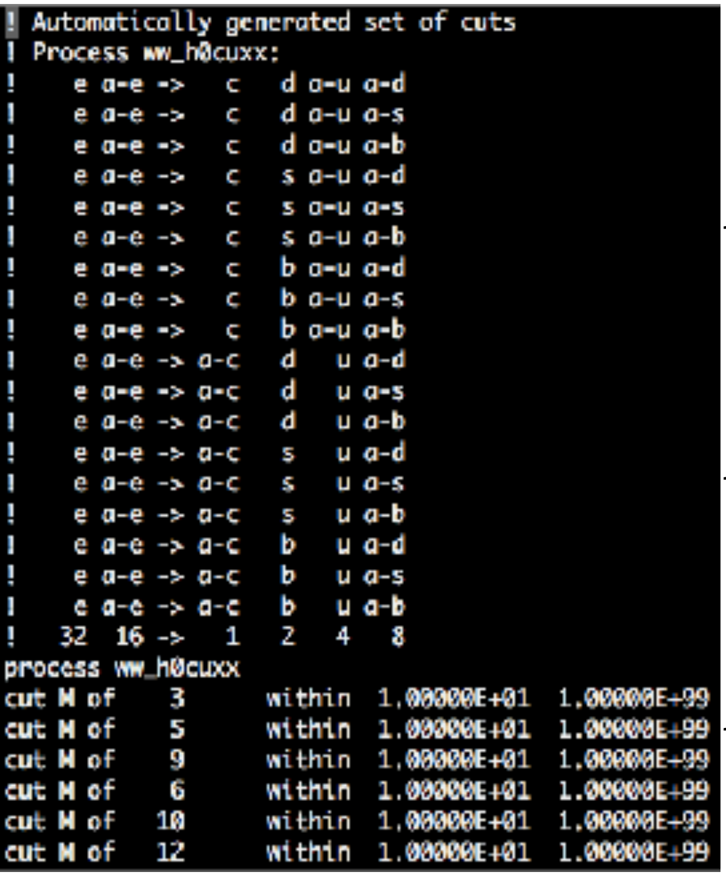
Background 4 Fermions Collecting Efficiency



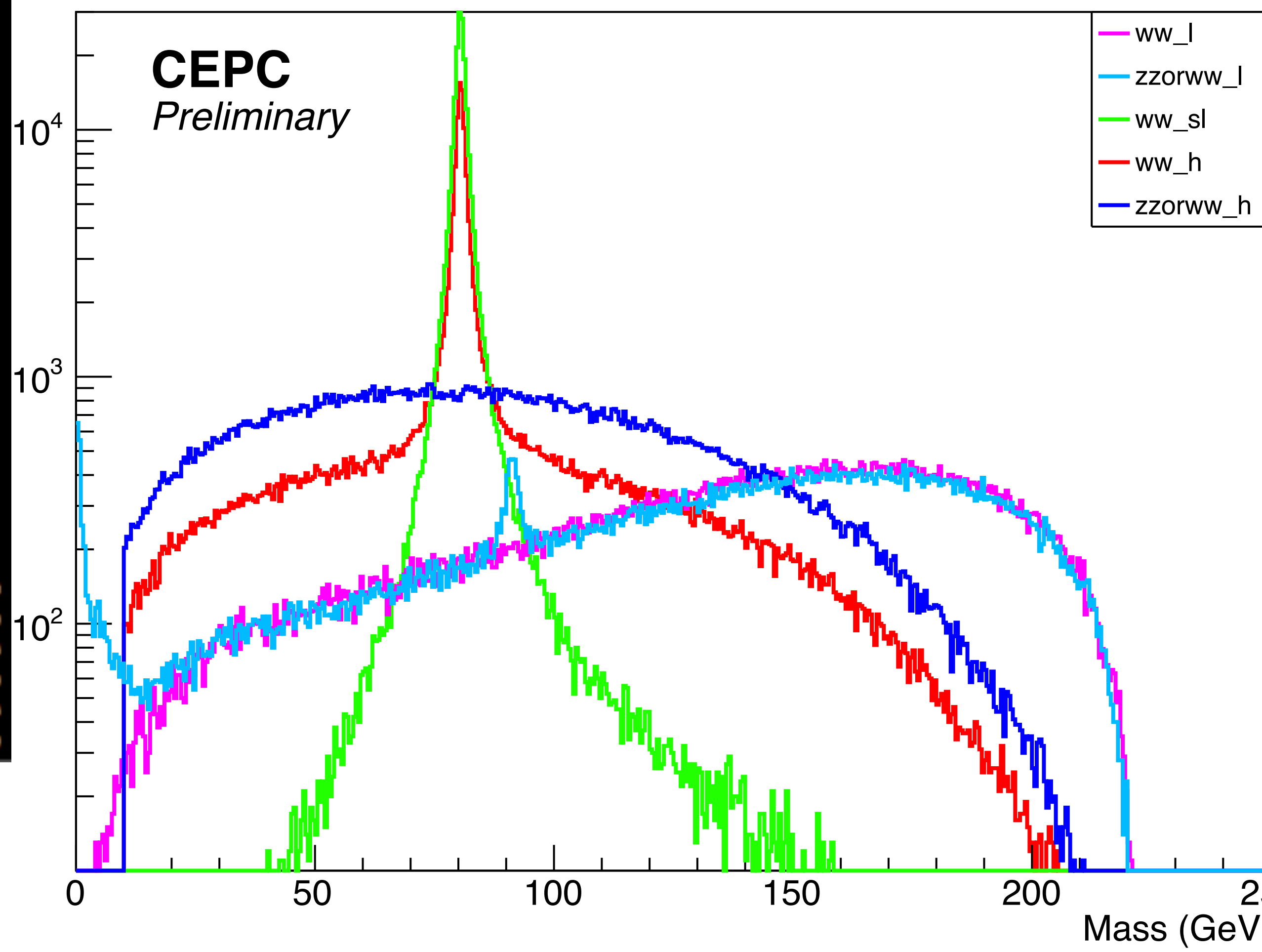


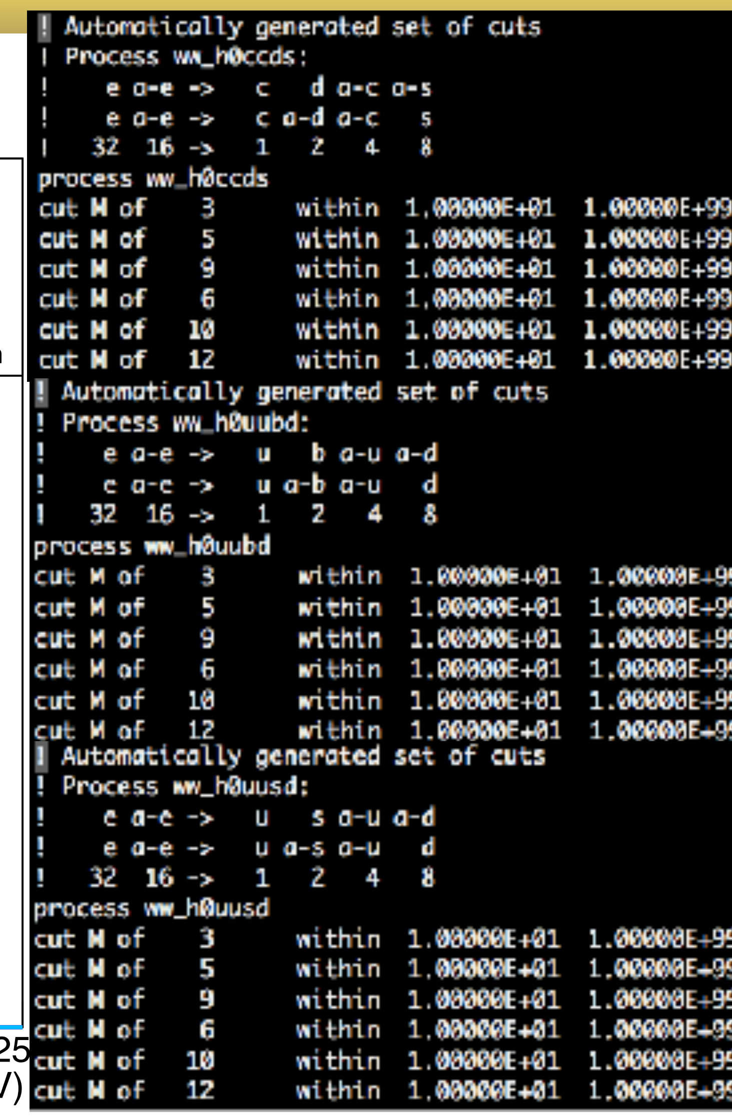


Background 4 Fermions Reconstruction

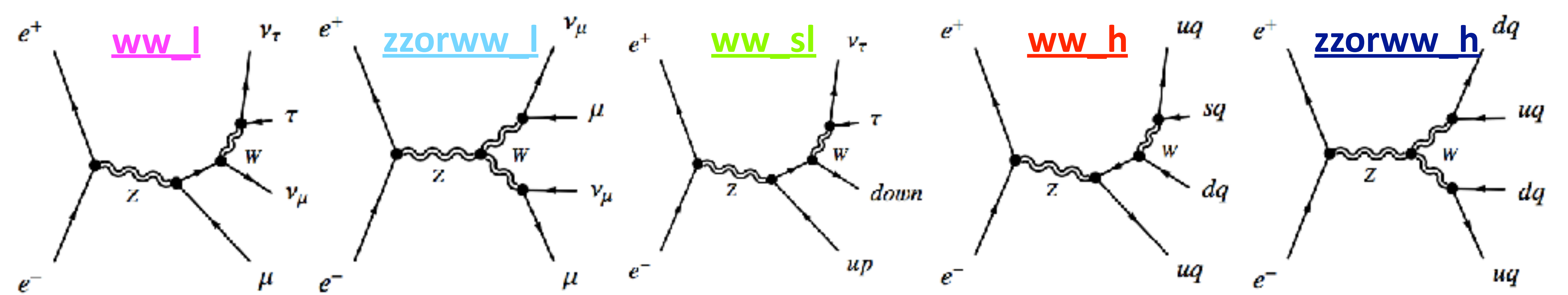


```
! Automatically generated set of cuts
! Process ww_h0cuxx:
!     e a-e ->   c   d a-u a-d
!     e a-e ->   c   d a-u a-s
!     e a-e ->   c   d a-u a-b
!     e a-e ->   c   s a-u a-d
!     e a-e ->   c   s a-u a-s
!     e a-e ->   c   s a-u a-b
!     e a-e ->   c   b a-u a-d
!     e a-e ->   c   b a-u a-s
!     e a-e ->   c   b a-u a-b
!     e a-e -> a-c   d   u a-d
!     e a-e -> a-c   d   u a-s
!     e a-e -> a-c   d   u a-b
!     e a-e -> a-c   s   u a-d
!     e a-e -> a-c   s   u a-s
!     e a-e -> a-c   s   u a-b
!     e a-e -> a-c   b   u a-d
!     e a-e -> a-c   b   u a-s
!     e a-e -> a-c   b   u a-b
!   32  16 ->   1   2   4   8
process ww_h0cuxx
cut M of    3      within  1.00000E+01  1.00000E+99
cut M of    5      within  1.00000E+01  1.00000E+99
cut M of    9      within  1.00000E+01  1.00000E+99
cut M of    6      within  1.00000E+01  1.00000E+99
cut M of   10      within  1.00000E+01  1.00000E+99
cut M of   12      within  1.00000E+01  1.00000E+99
```

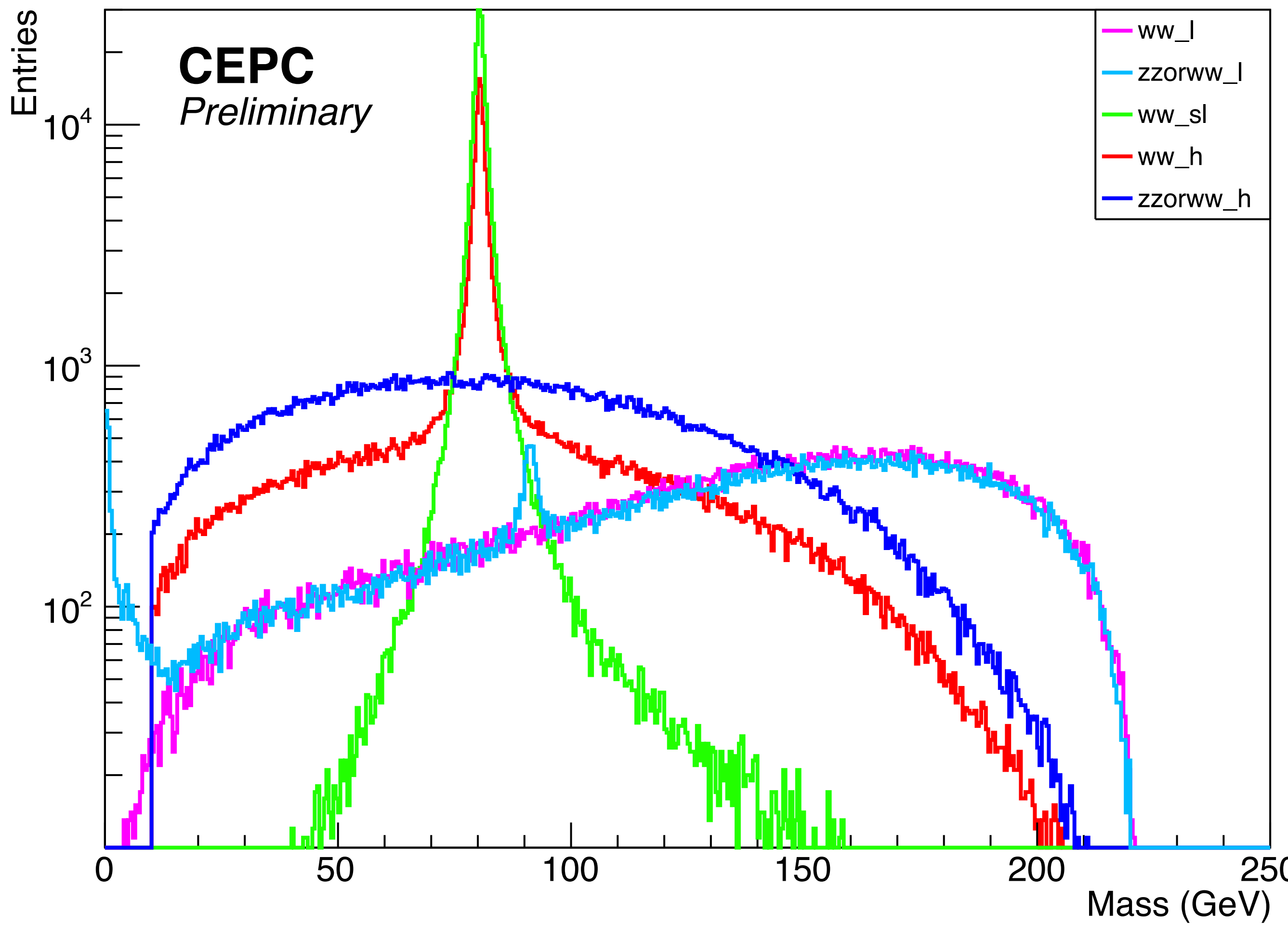




```
! Automatically generated set of cuts
! Process ww_h0ccds:
!     e a-e ->   c   d a-c a-s
!     e a-e ->   c a-d a-c   s
!   32  16 ->   1   2   4   8
process ww_h0ccds
cut M of    3      within  1.00000E+01  1.00000E+99
cut M of    5      within  1.00000E+01  1.00000E+99
cut M of    9      within  1.00000E+01  1.00000E+99
cut M of    6      within  1.00000E+01  1.00000E+99
cut M of   10      within  1.00000E+01  1.00000E+99
cut M of   12      within  1.00000E+01  1.00000E+99
! Automatically generated set of cuts
! Process ww_h0uubd:
!     e a-e ->   u   b a-u a-d
!     e a-e ->   u a-b a-u   d
!   32  16 ->   1   2   4   8
process ww_h0uubd
cut M of    3      within  1.00000E+01  1.00000E+99
cut M of    5      within  1.00000E+01  1.00000E+99
cut M of    9      within  1.00000E+01  1.00000E+99
cut M of    6      within  1.00000E+01  1.00000E+99
cut M of   10      within  1.00000E+01  1.00000E+99
cut M of   12      within  1.00000E+01  1.00000E+99
! Automatically generated set of cuts
! Process ww_h0uusd:
!     e a-e ->   u   s a-u a-d
!     e a-e ->   u a-s a-u   d
!   32  16 ->   1   2   4   8
process ww_h0uusd
cut M of    3      within  1.00000E+01  1.00000E+99
cut M of    5      within  1.00000E+01  1.00000E+99
cut M of    9      within  1.00000E+01  1.00000E+99
cut M of    6      within  1.00000E+01  1.00000E+99
cut M of   10      within  1.00000E+01  1.00000E+99
cut M of   12      within  1.00000E+01  1.00000E+99
```

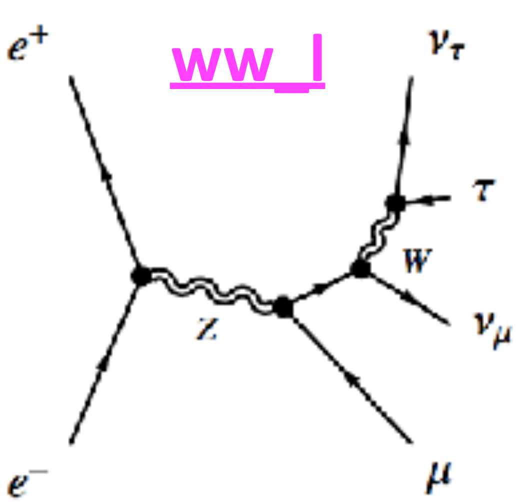


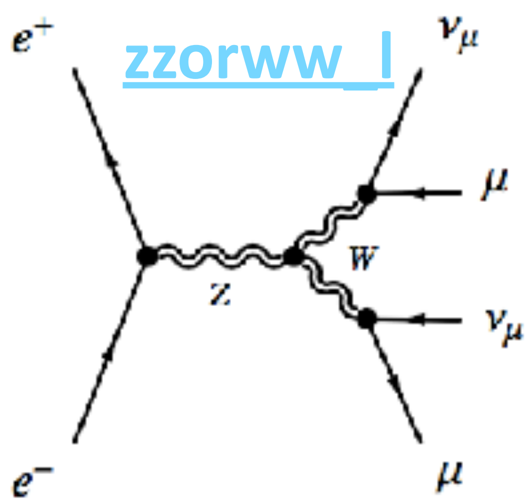
Background 4 Fermions Reconstruction

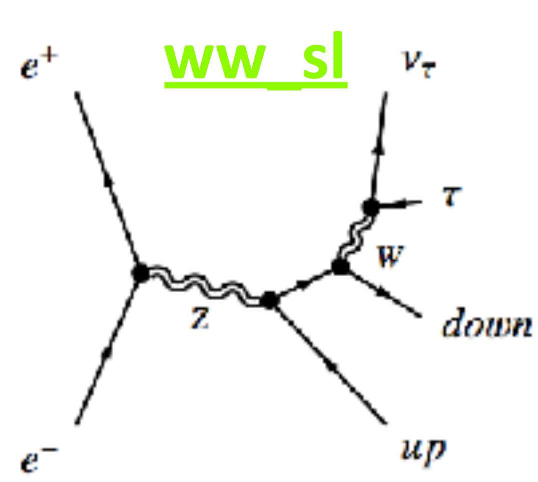


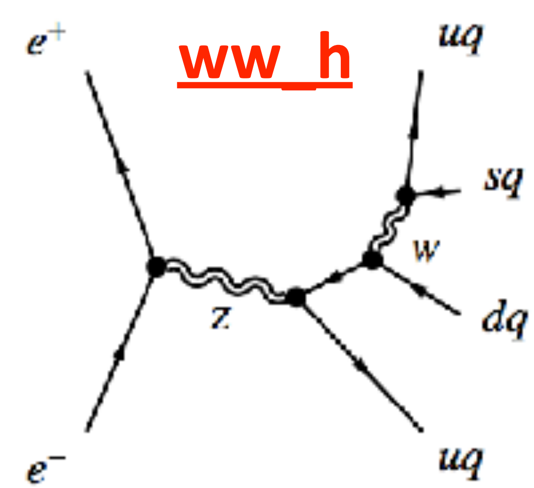

```
! Automatically generated set of cuts
! Process zzorww_h0cscs:
!     e a-e ->   c   s a-s a-c
!    32  16 ->   1   2   4   8
process zzorww_h0cscs
cut M of    3       within  1.00000E+01  1.00000E+99
cut M of    5       within  1.00000E+01  1.00000E+99
cut M of    9       within  1.00000E+01  1.00000E+99
cut M of    6       within  1.00000E+01  1.00000E+99
cut M of   10       within  1.00000E+01  1.00000E+99
cut M of   12       within  1.00000E+01  1.00000E+99
```

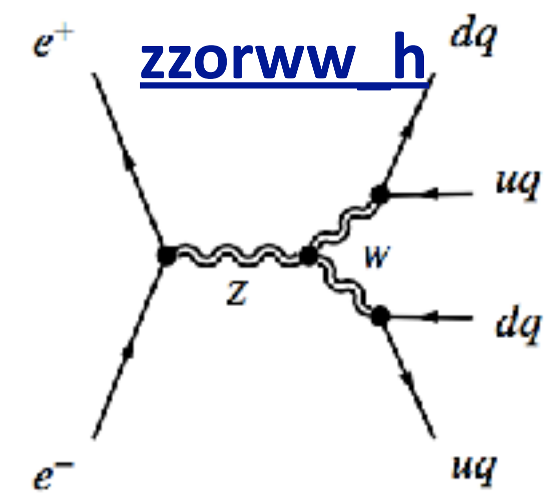
```
! Automatically generated set of cuts
! Process zzorww_h0udud:
!     e a-e ->   u   d a-d a-u
!    32  16 ->   1   2   4   8
process zzorww_h0udud
cut M of    3       within  1.00000E+01  1.00000E+99
cut M of    5       within  1.00000E+01  1.00000E+99
cut M of    9       within  1.00000E+01  1.00000E+99
cut M of    6       within  1.00000E+01  1.00000E+99
cut M of   10       within  1.00000E+01  1.00000E+99
cut M of   12       within  1.00000E+01  1.00000E+99
```



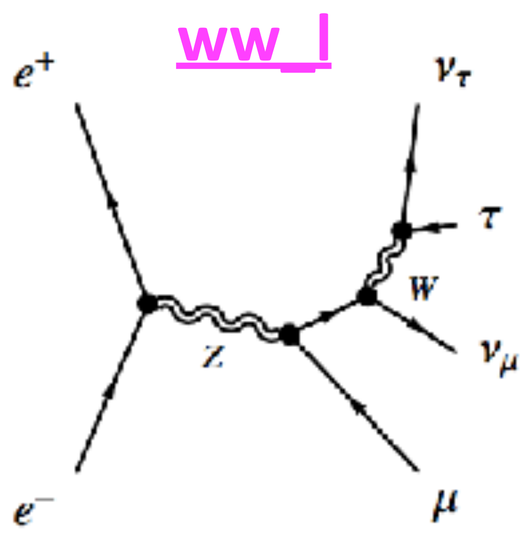


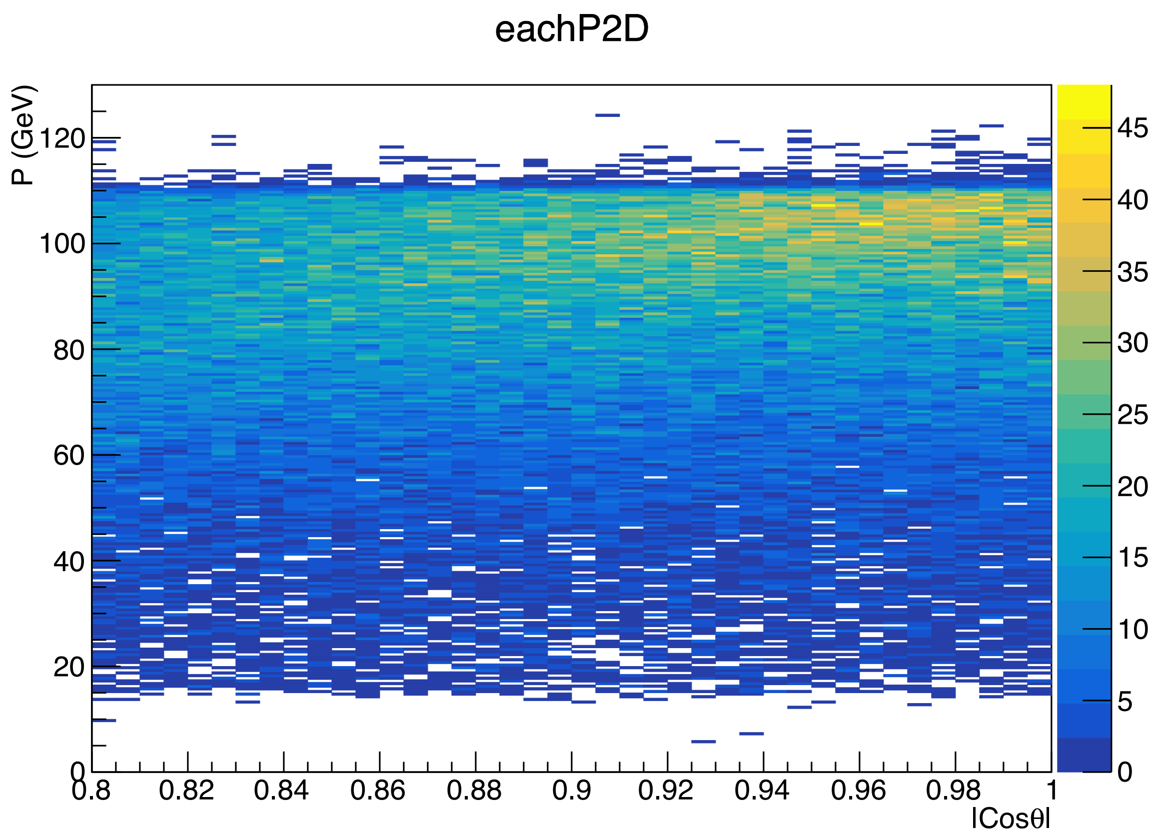


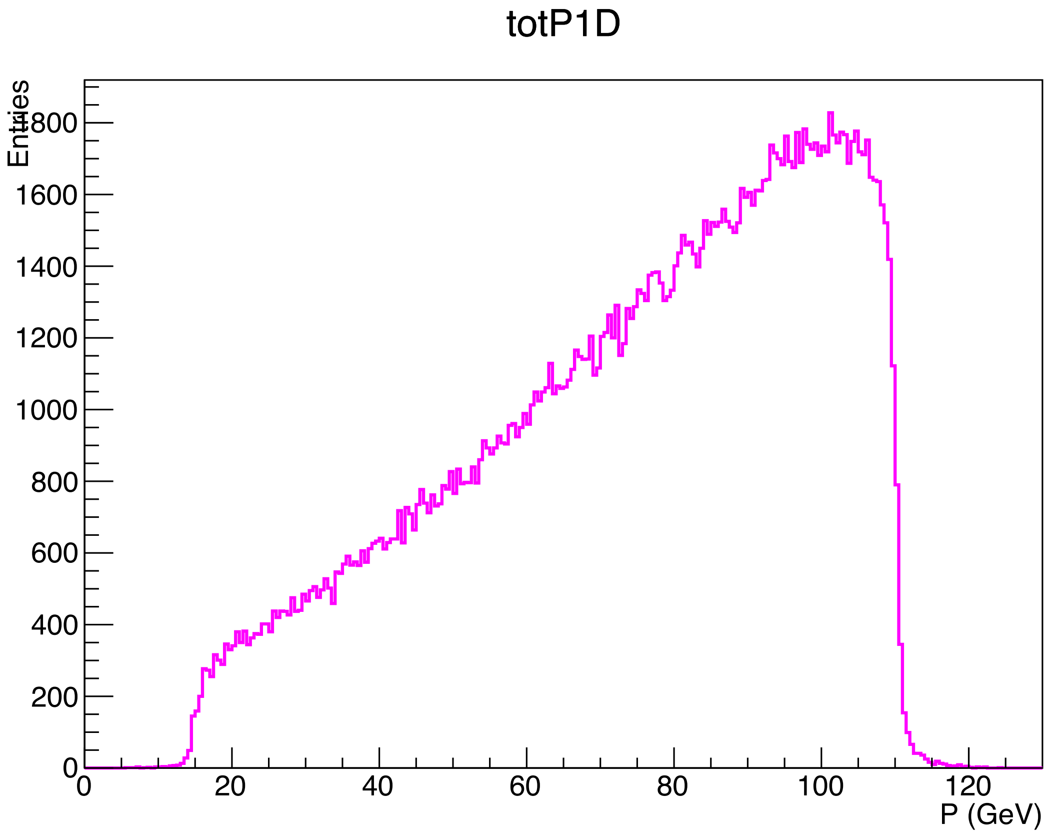


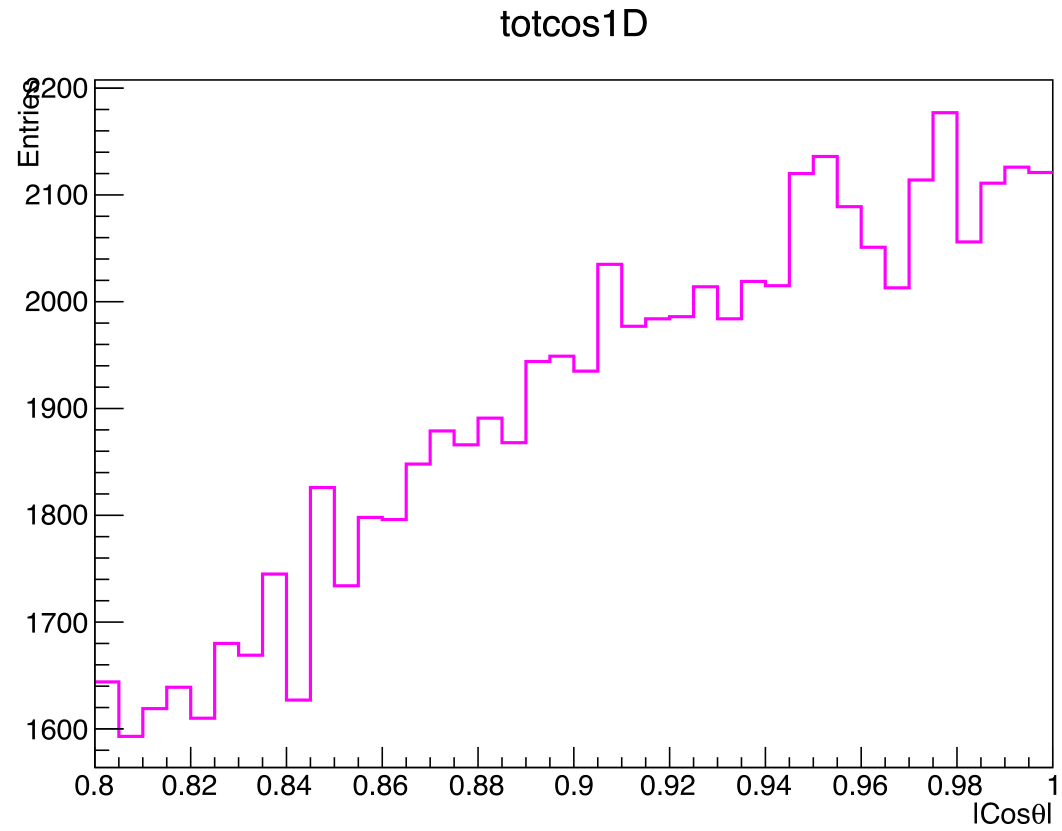


ww_l Kinematic Distribution

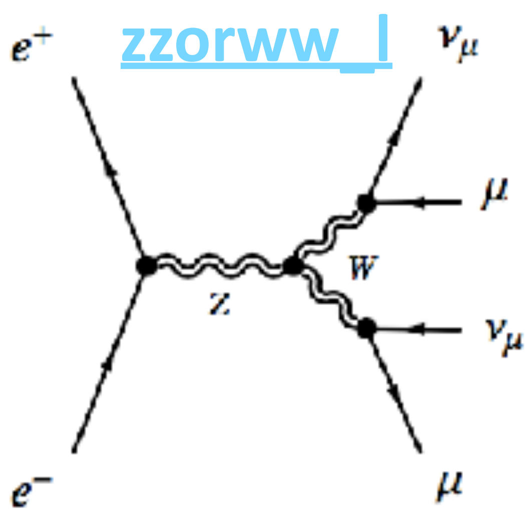


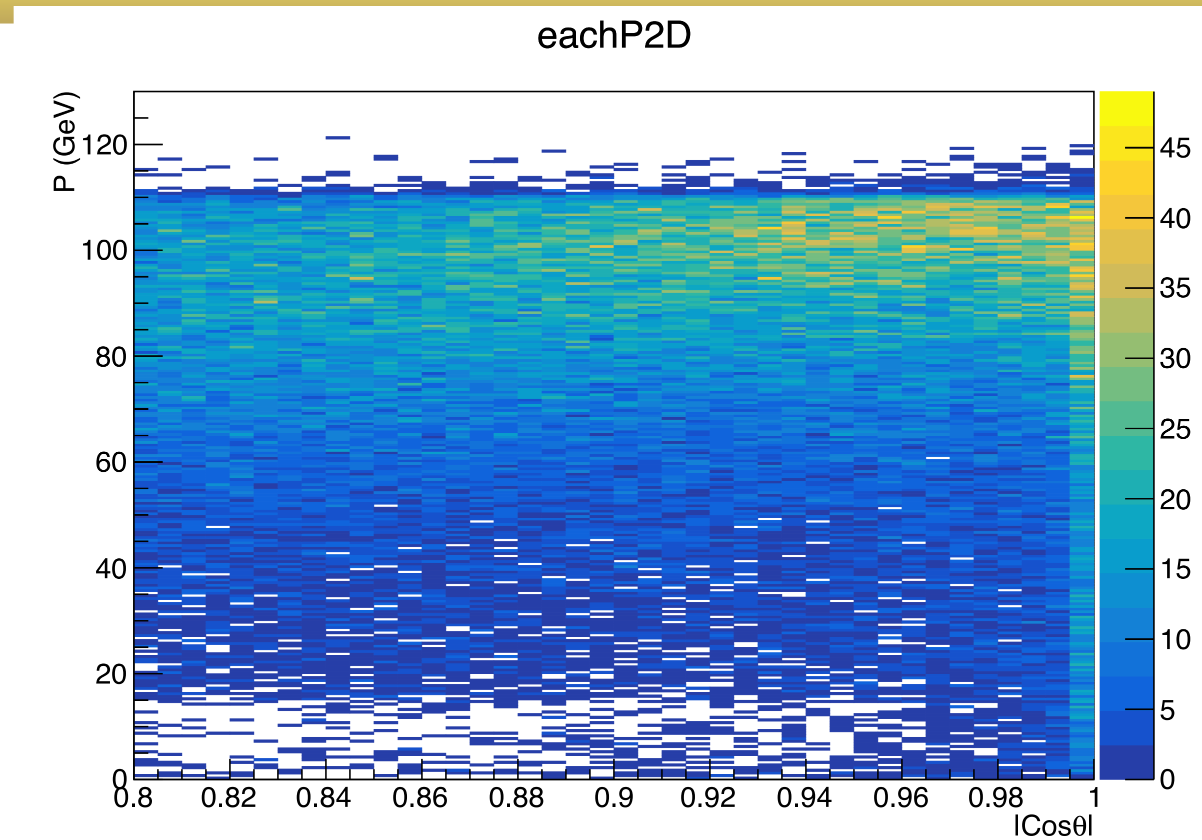


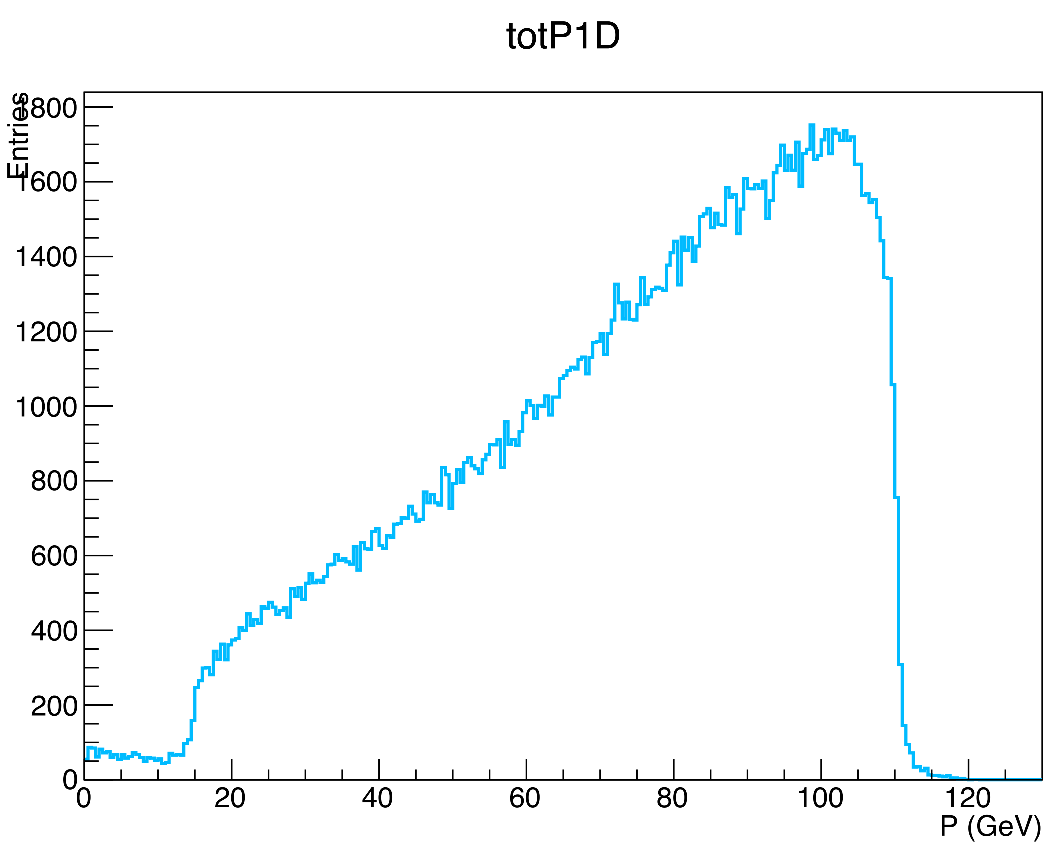


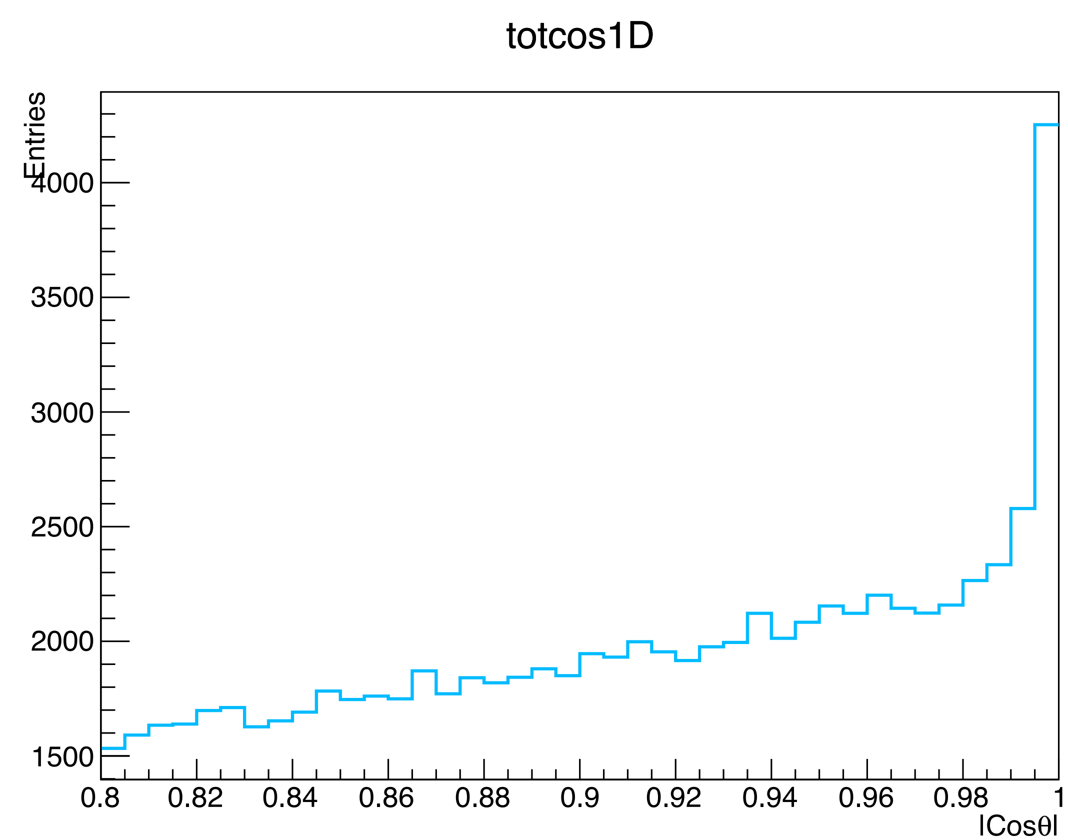


zzorww_l Kinematic Distribution

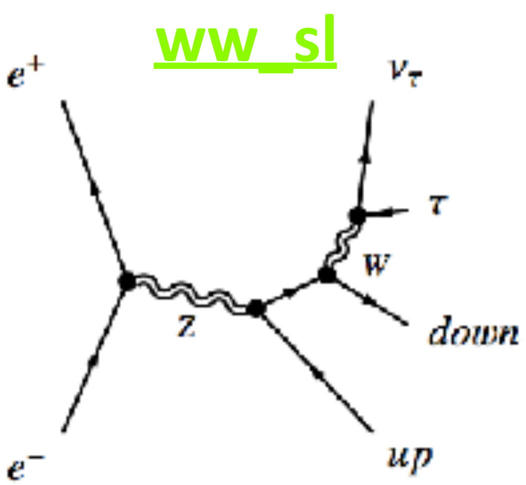


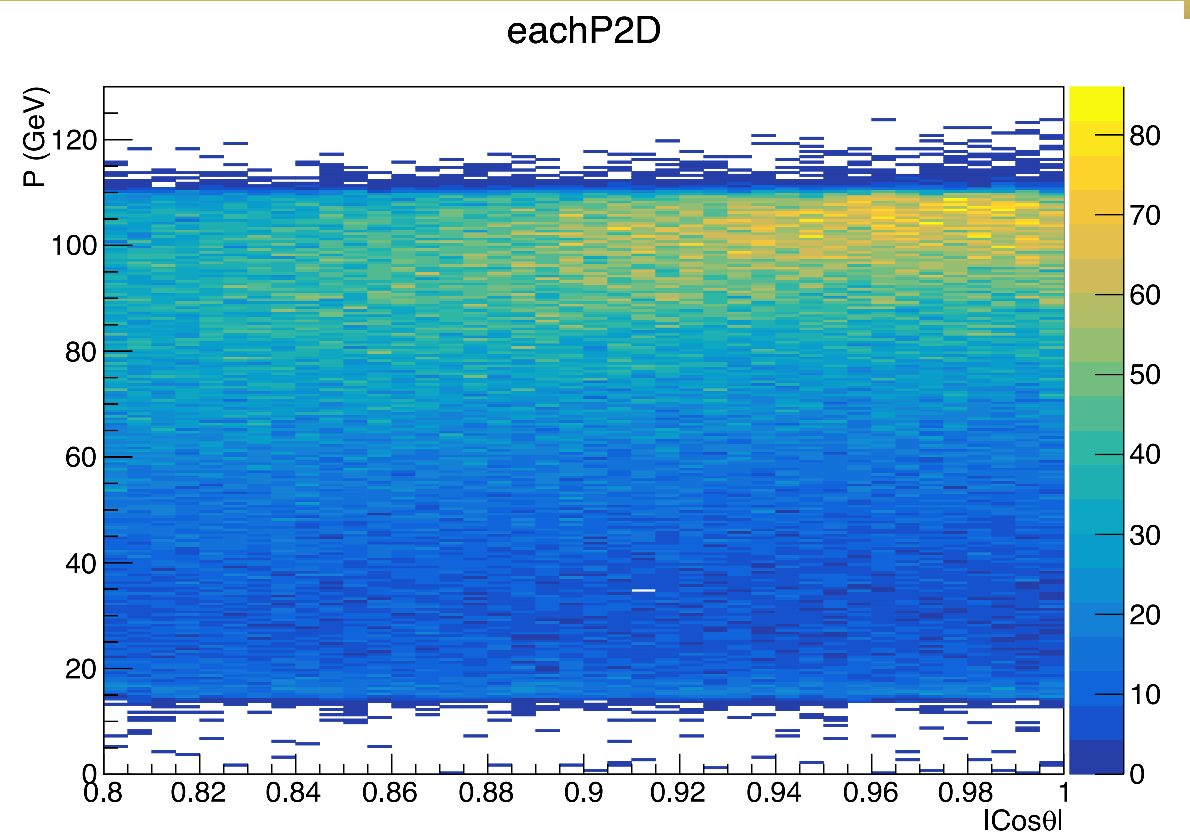


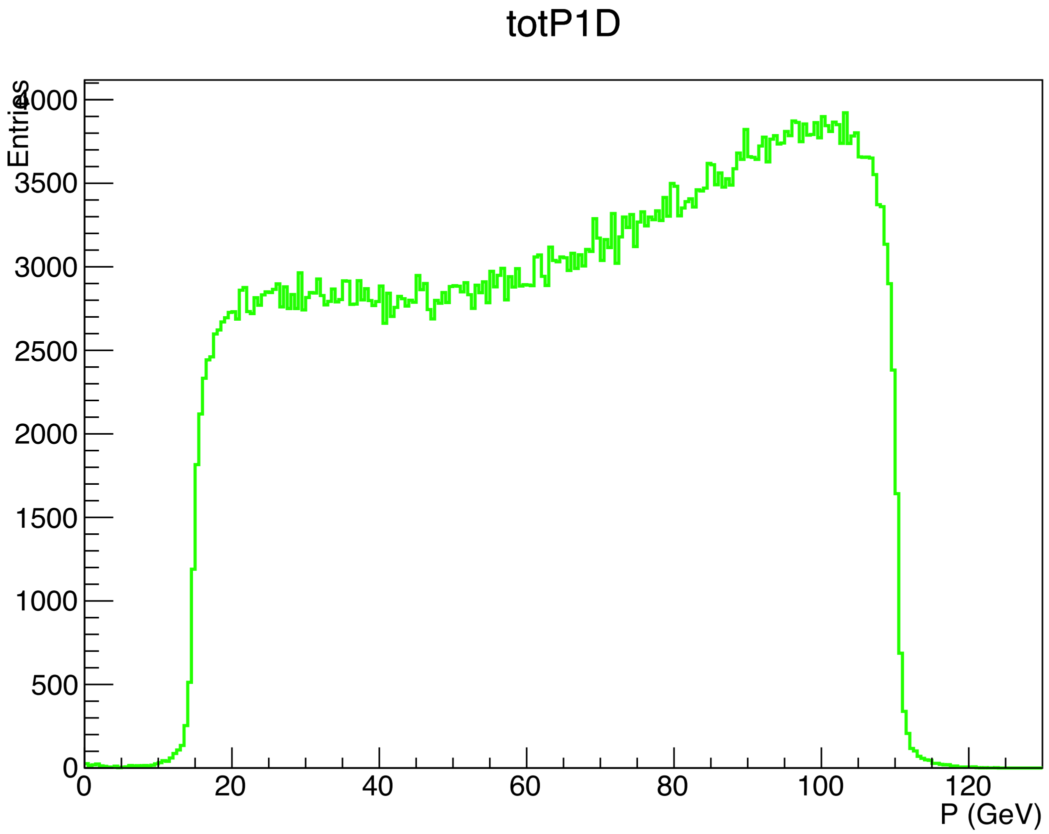


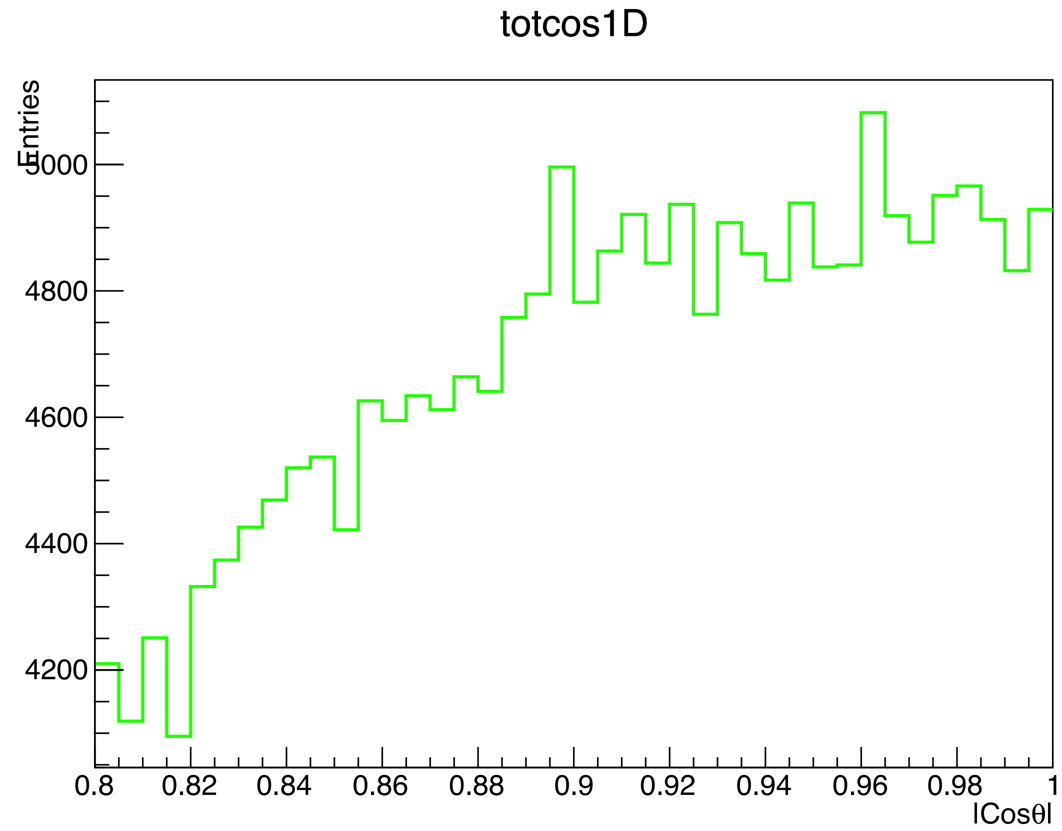


ww_sl Kinematic Distribution

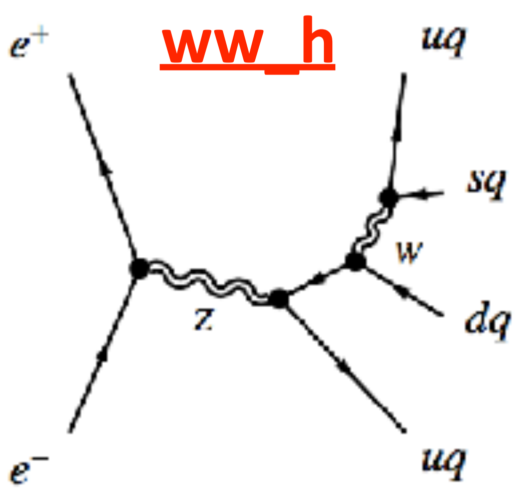


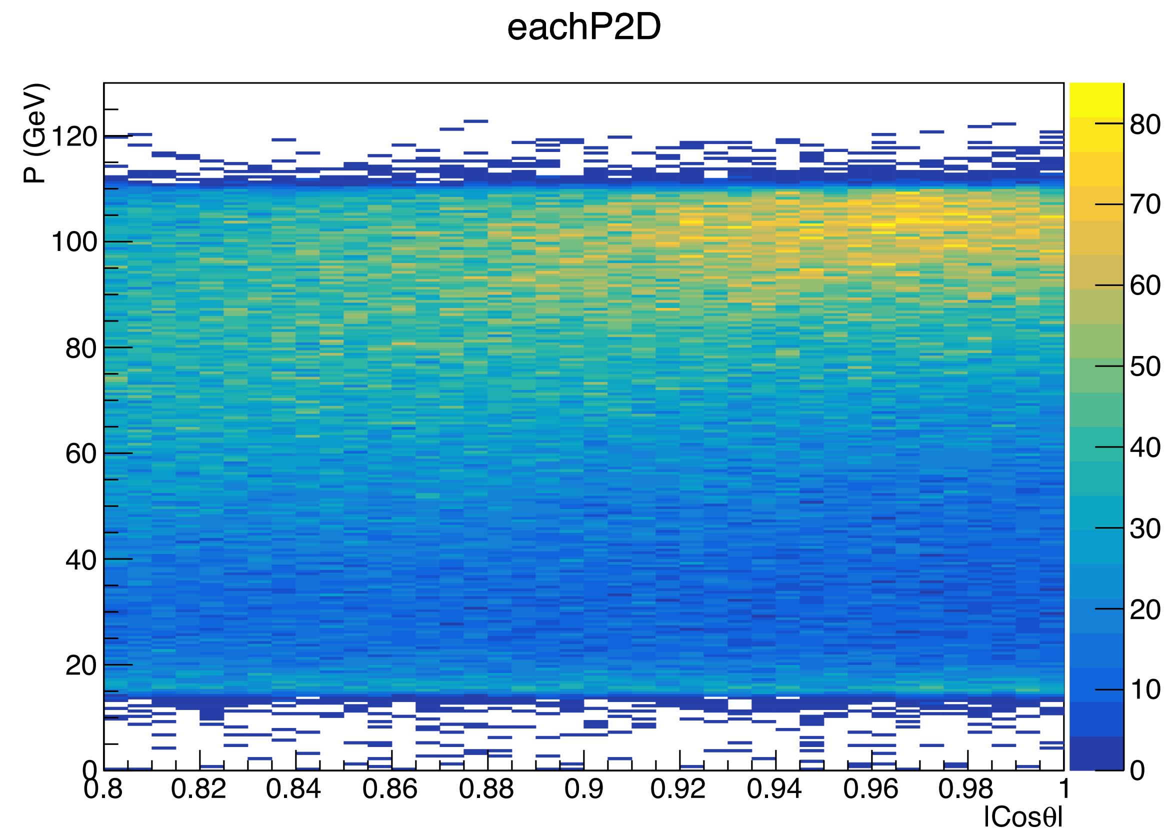


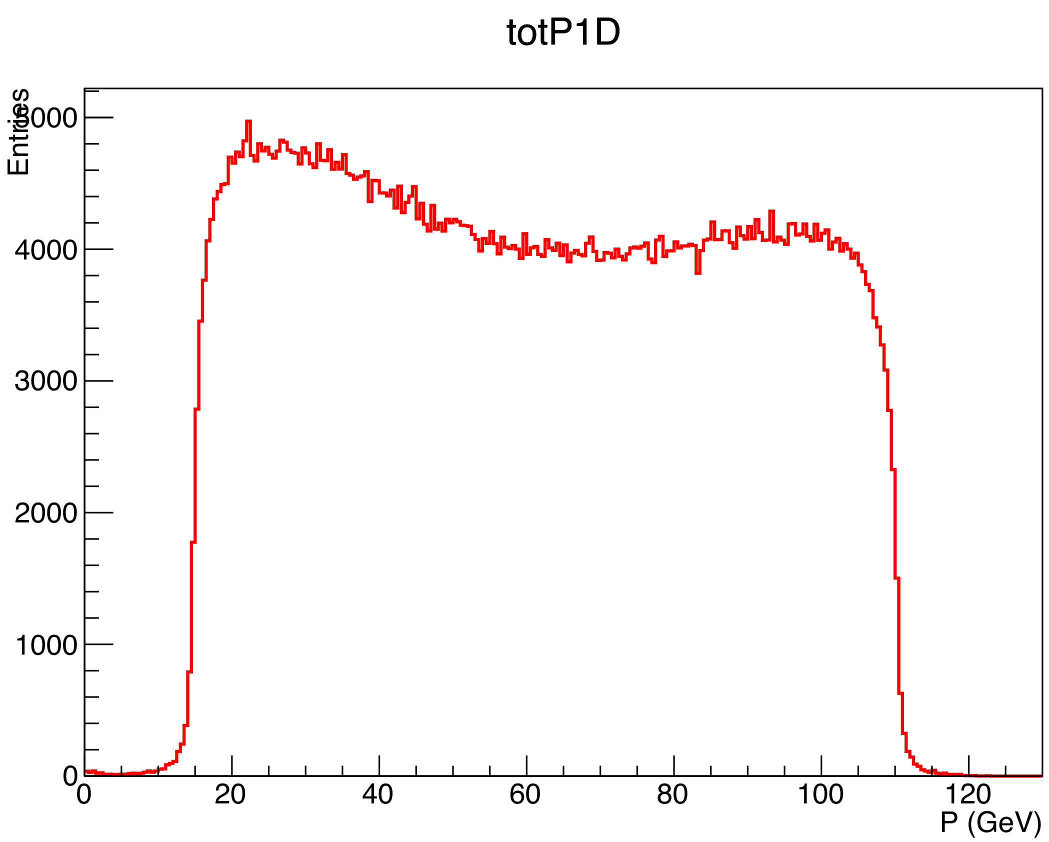


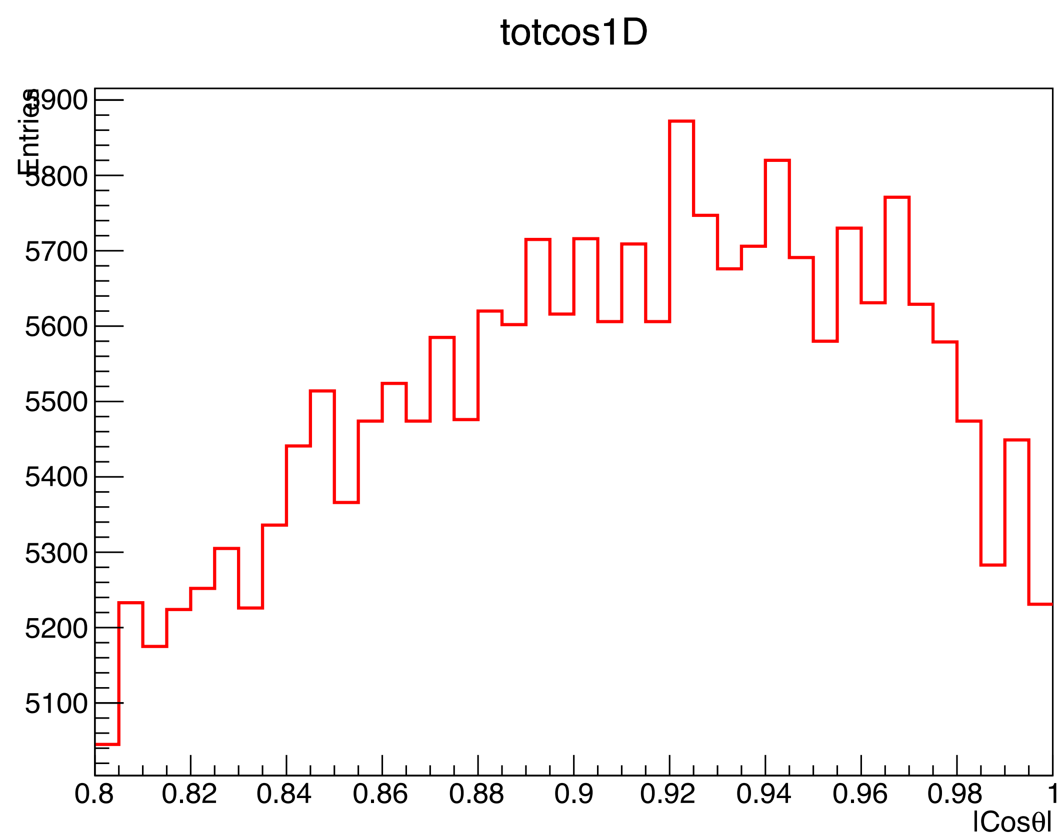


ww_h Kinematic Distribution



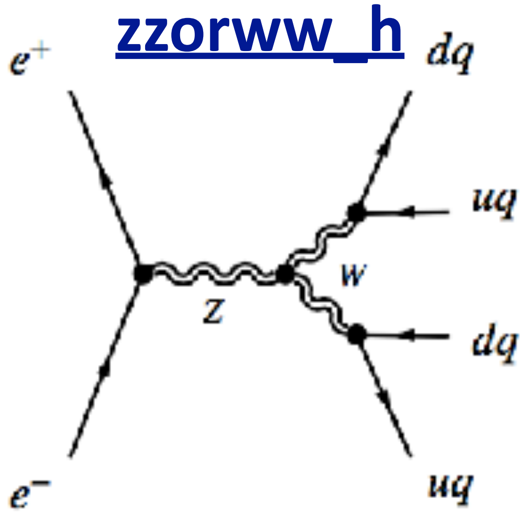


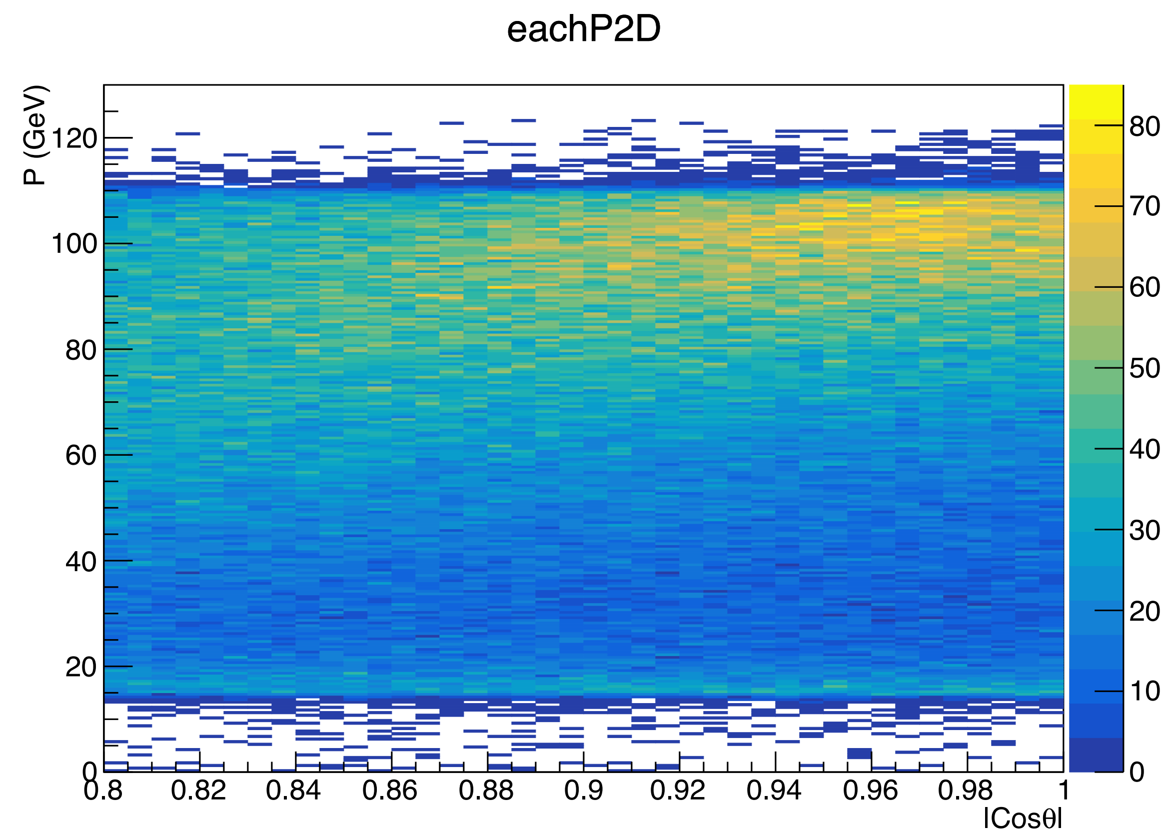


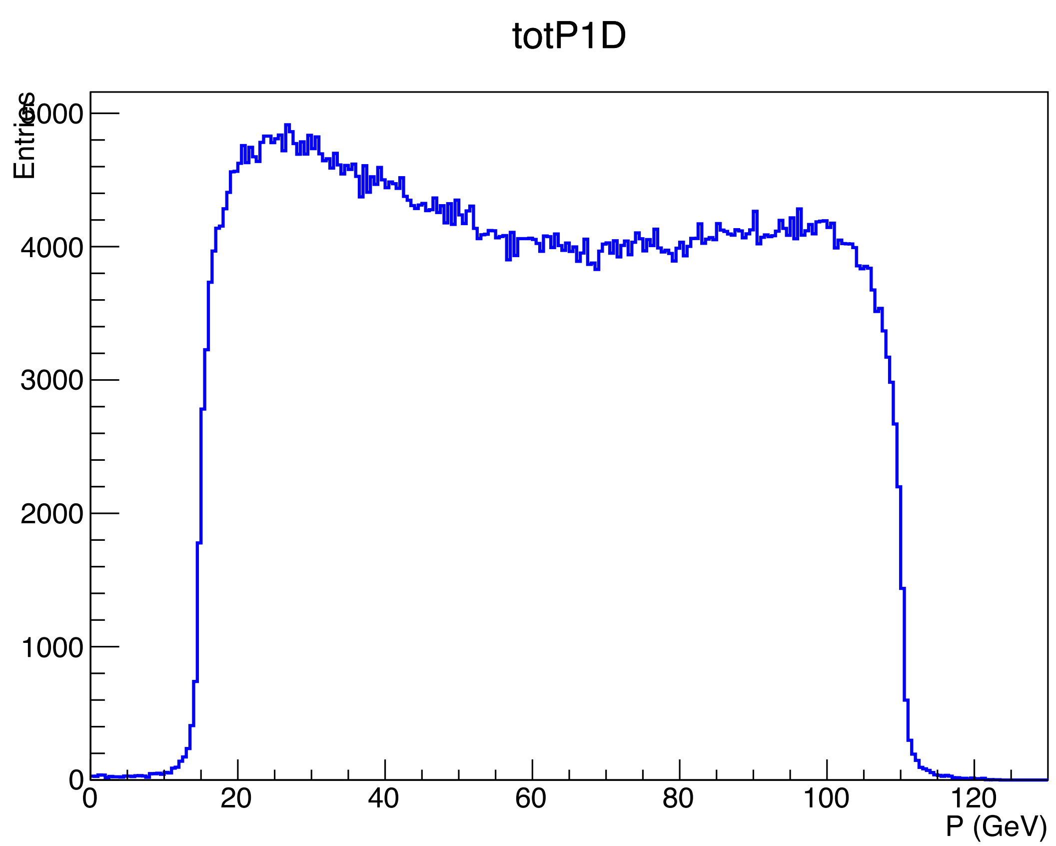


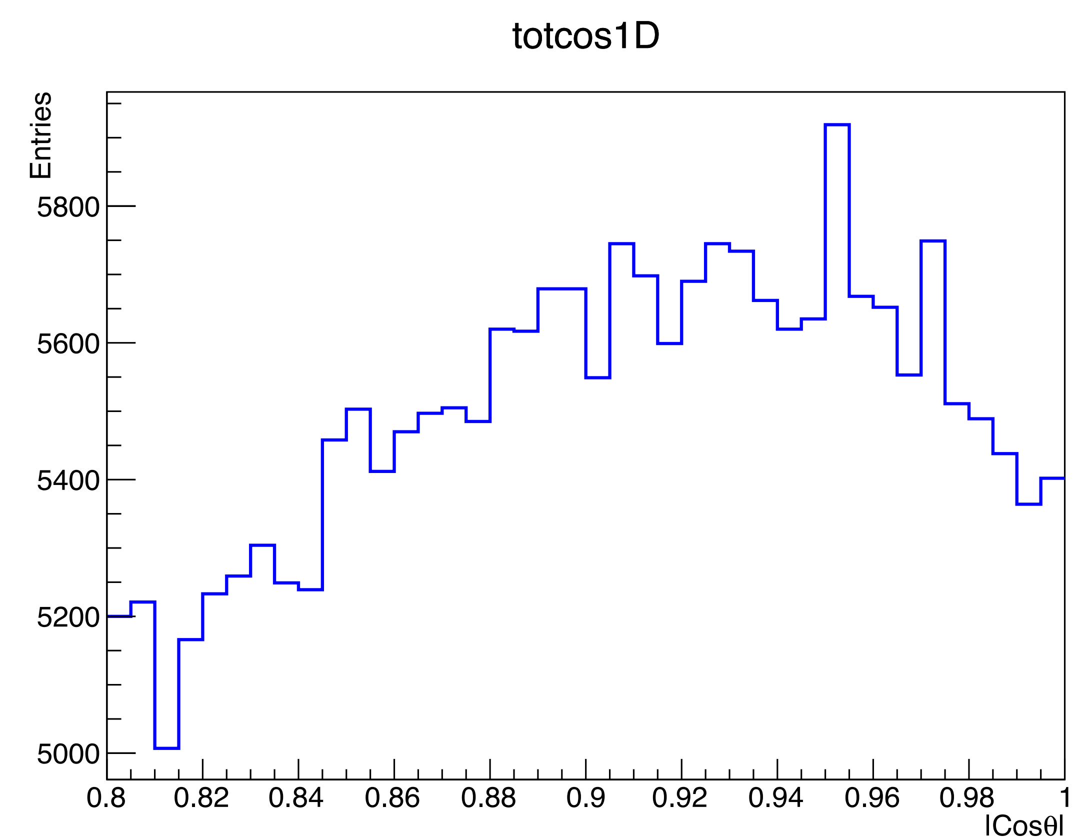
zzorww_h Kinematic Distribution

zzorww_h

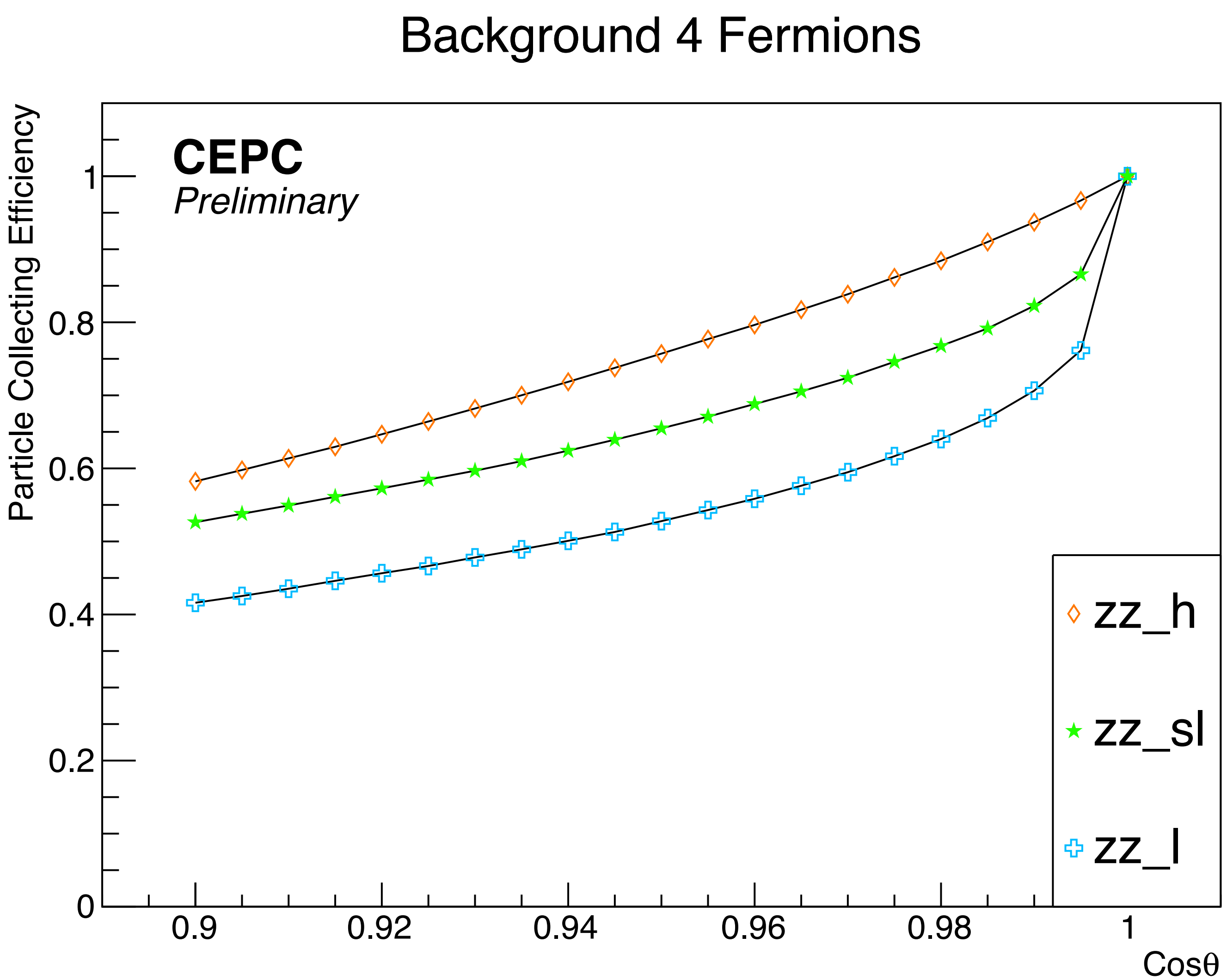


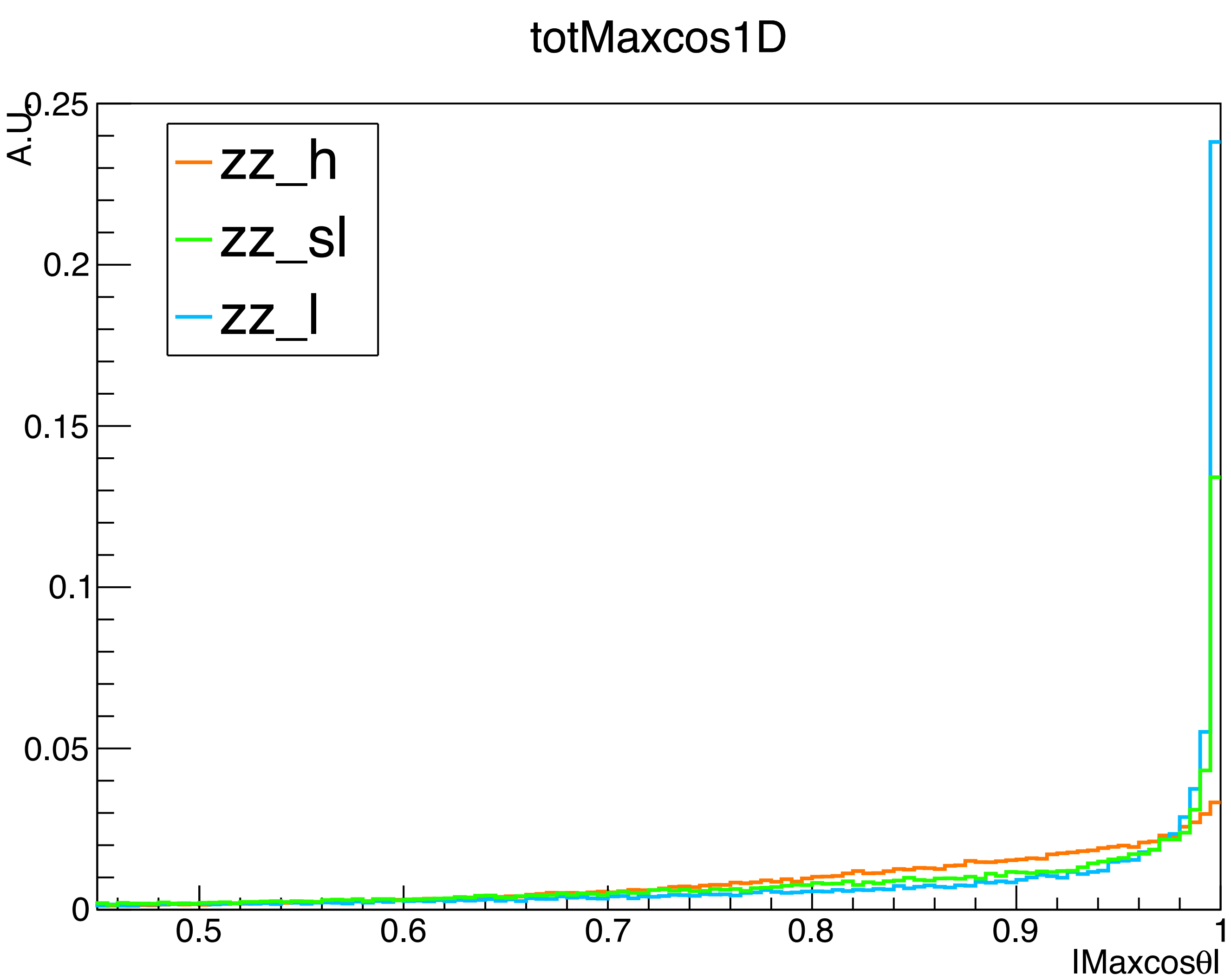


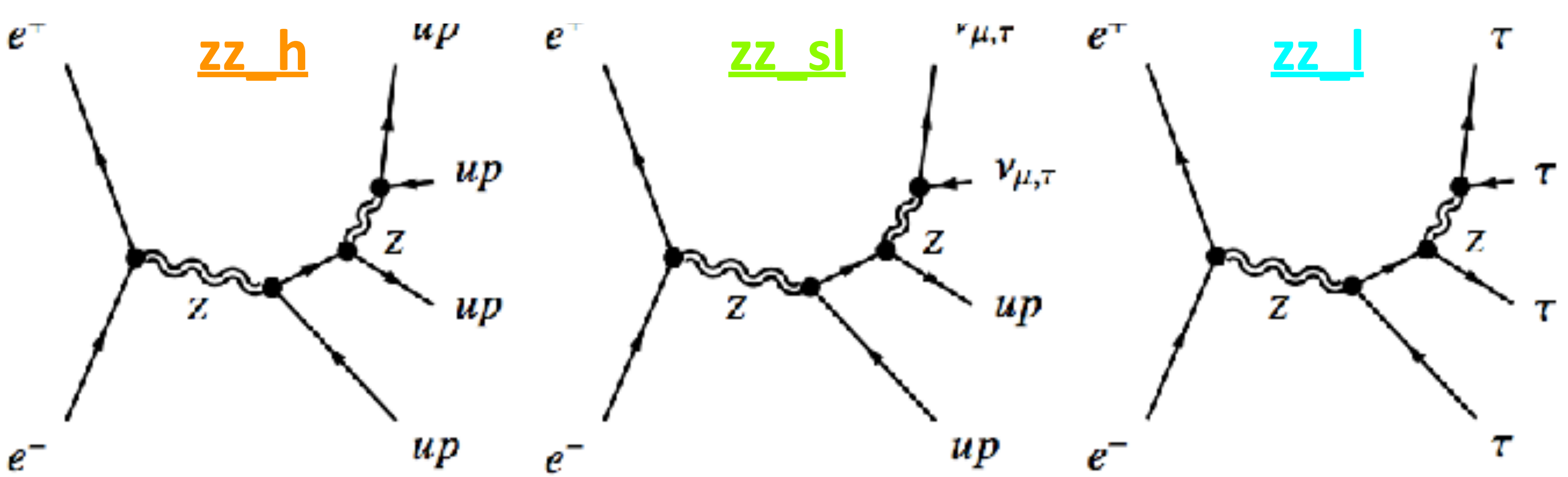




Background 4 Fermions Collecting Efficiency



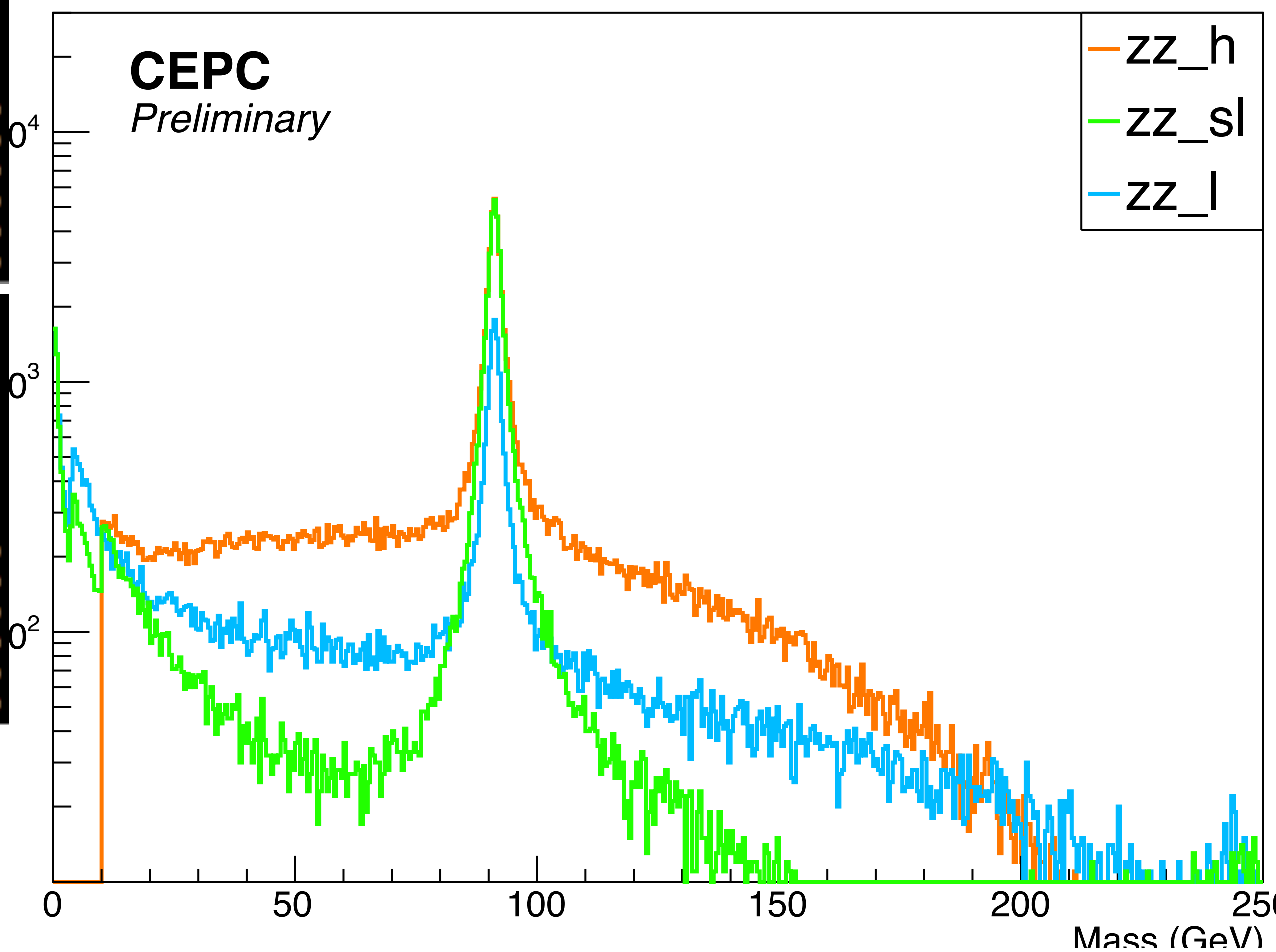




Background 4 Fermions Reconstruction

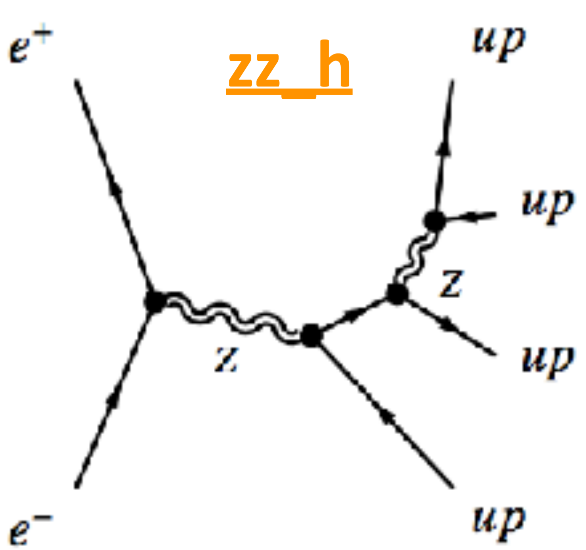
```
! Automatically generated set of cuts
! Process zz_h0utut:
!     e a-e ->   u   u a-u a-u
!     e a-e ->   u   c a-u a-c
!     e a-e ->   c   c a-c a-c
!    32  16 ->   1   2   4   8
process zz_h0utut
cut M of     3       within  1.00000E+01  1.00000E+99
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     9       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    10       within  1.00000E+01  1.00000E+99
cut M of    12       within  1.00000E+01  1.00000E+99
```

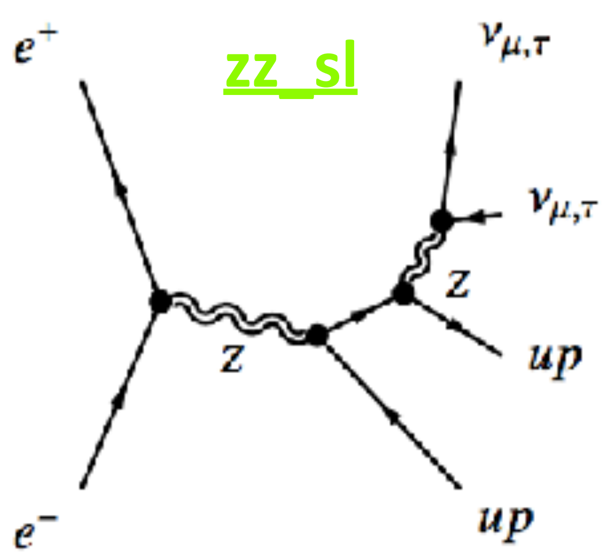
```
! Automatically generated set of cuts
! Process zz_h0uu_notd:
!     e a-e ->   u a-u   s a-s
!     e a-e ->   u a-u   s a-b
!     e a-e ->   u a-u   b a-s
!     e a-e ->   u a-u   b a-b
!    32  16 ->   1   2   4   8
process zz_h0uu_notd
cut M of     3       within  1.00000E+01  1.00000E+99
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     9       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    10       within  1.00000E+01  1.00000E+99
cut M of    12       within  1.00000E+01  1.00000E+99
```

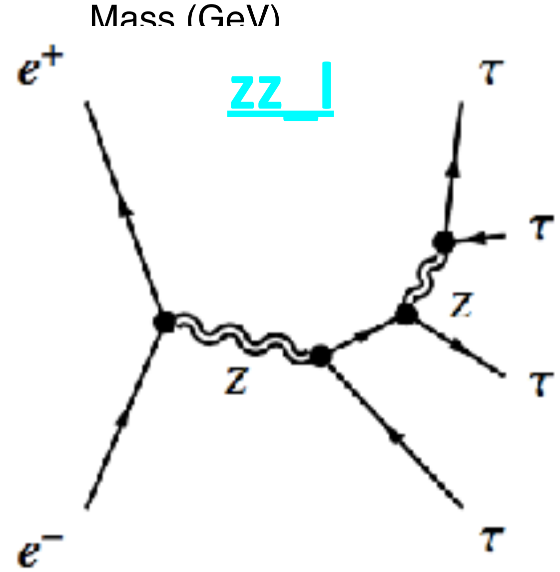



```
! Automatically generated set of cuts
! Process zz_h0cc_nots:
!     e a-e ->   c a-c   d a-d
!     e a-e ->   c a-c   d a-b
!     e a-e ->   c a-c   b a-d
!     e a-e ->   c a-c   b a-b
!    32  16 ->   1   2   4   8
process zz_h0cc_nots
cut M of     3       within  1.00000E+01  1.00000E+99
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     9       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    10       within  1.00000E+01  1.00000E+99
cut M of    12       within  1.00000E+01  1.00000E+99
```

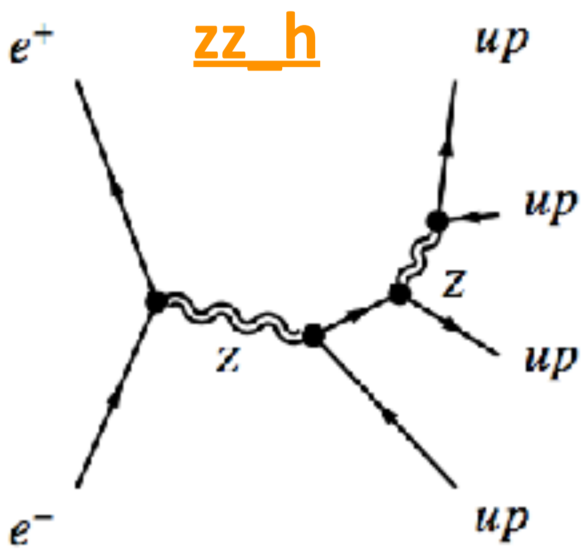
```
! Automatically generated set of cuts
! Process zz_h0dtdt:
!     e a-e ->   d   d a-d a-d
!     e a-e ->   d   s a-d a-s
!     e a-e ->   d   b a-d a-b
!     e a-e ->   s   s a-s a-s
!     e a-e ->   s   b a-s a-b
!     e a-e ->   b   b a-b a-b
!    32  16 ->   1   2   4   8
process zz_h0dtdt
cut M of     3       within  1.00000E+01  1.00000E+99
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     9       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    10       within  1.00000E+01  1.00000E+99
cut M of    12       within  1.00000E+01  1.00000E+99
```

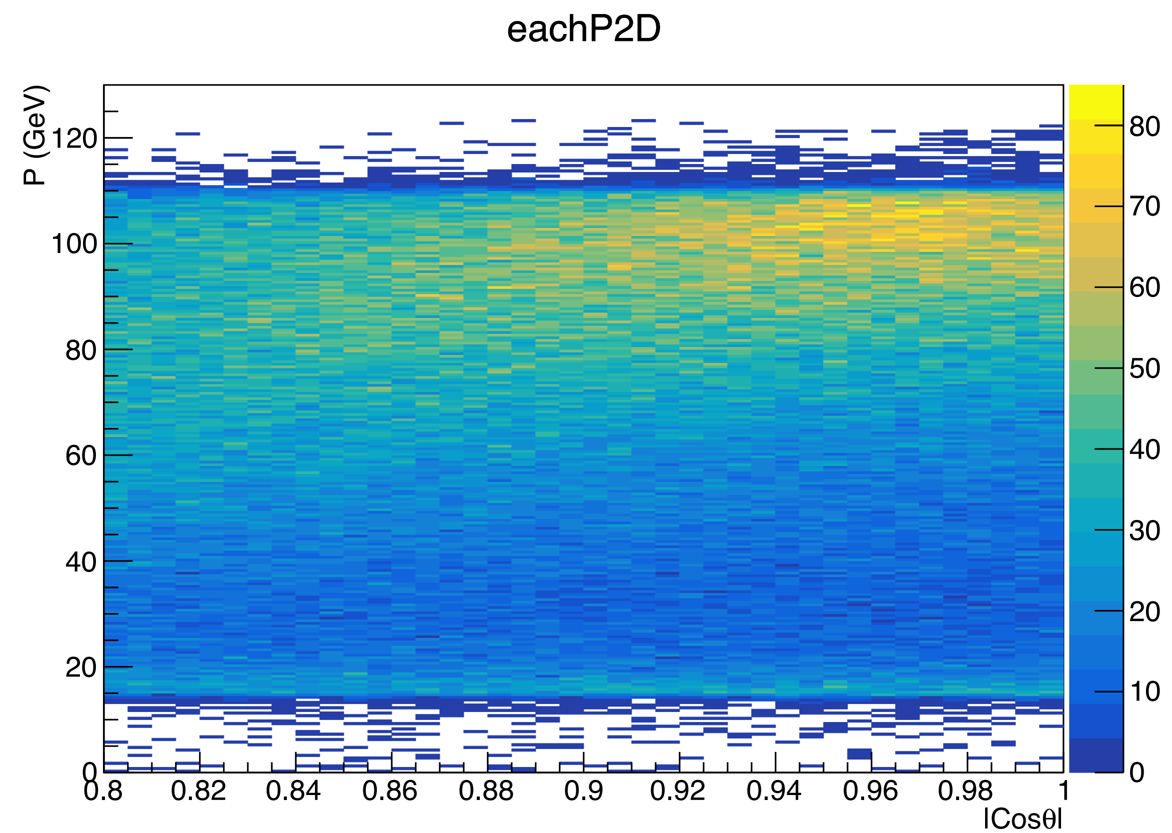


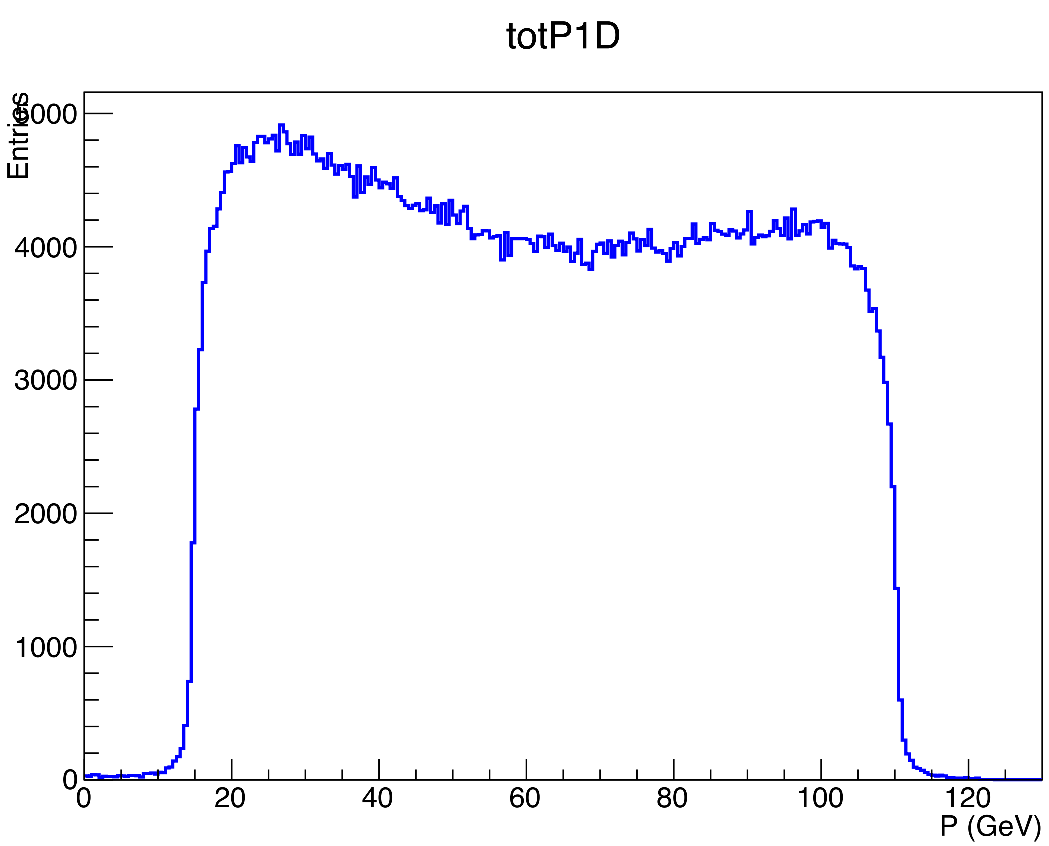


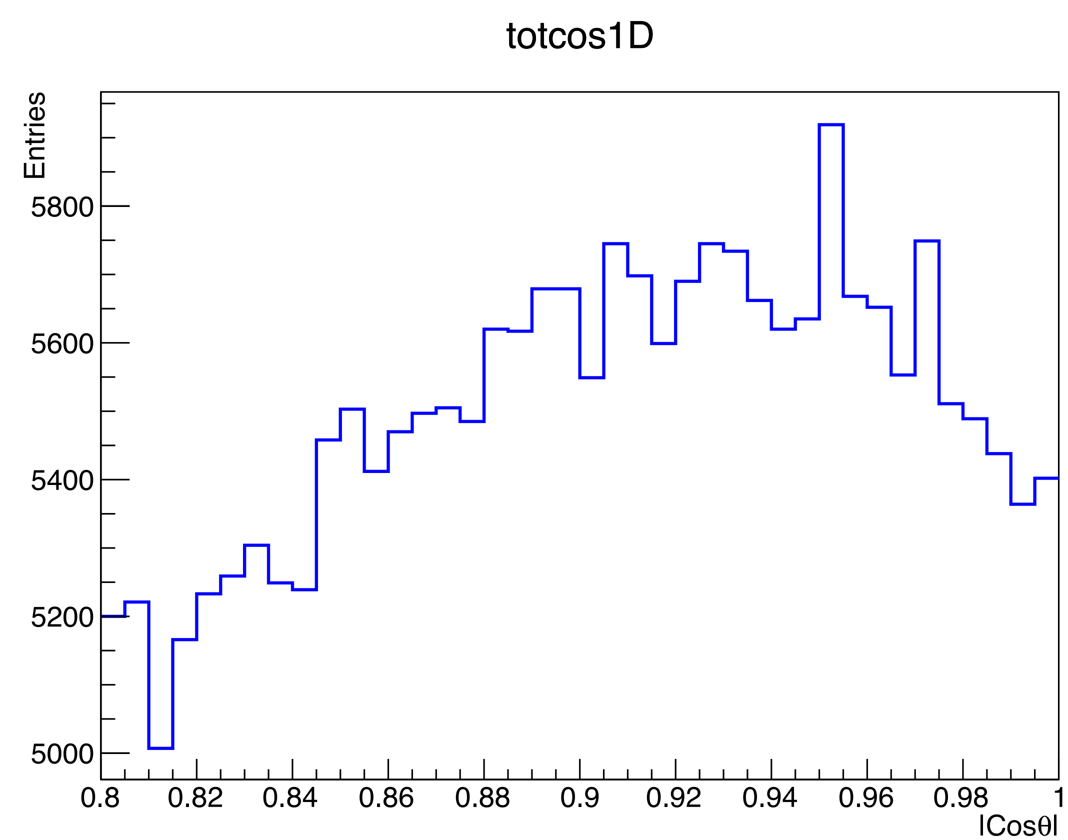


zz_h Kinematic Distribution

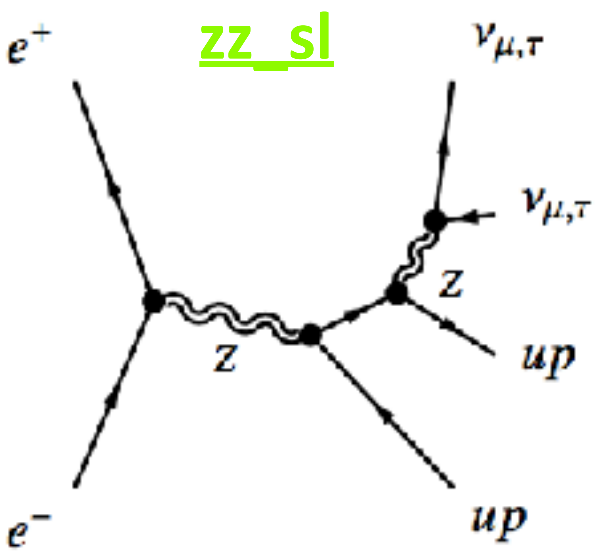


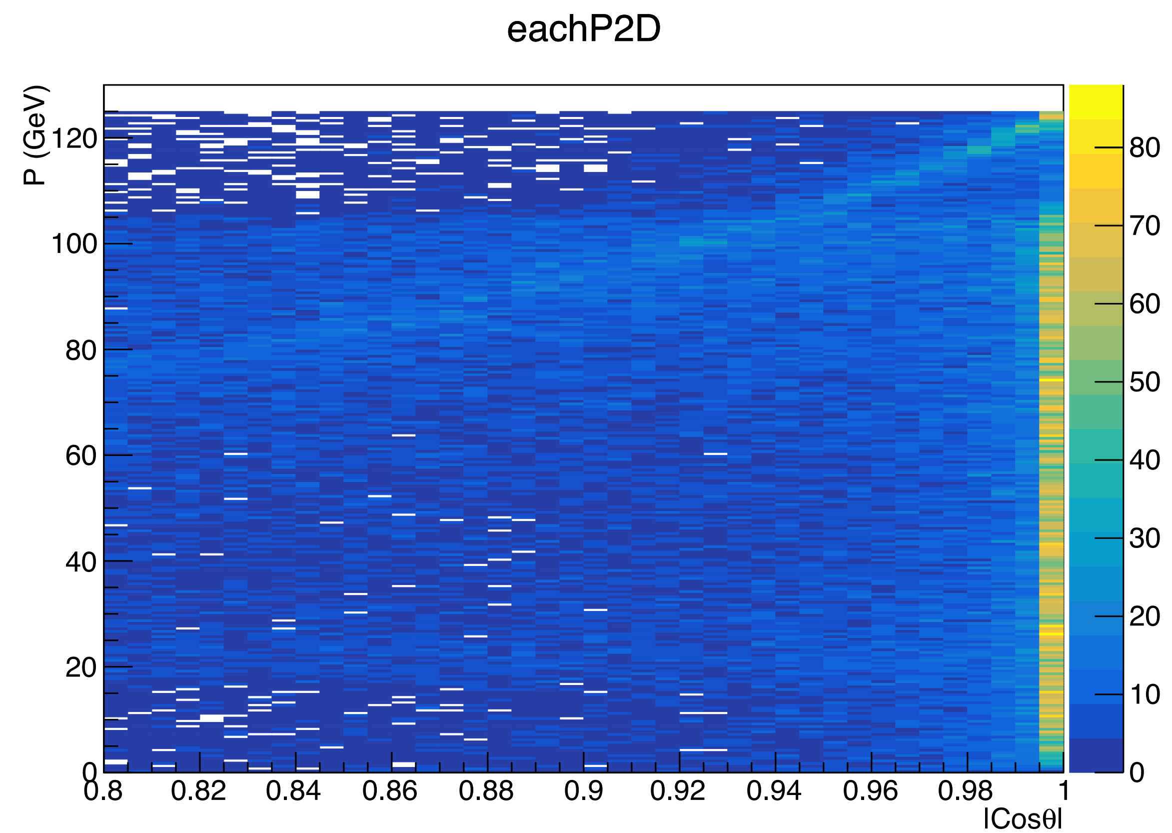


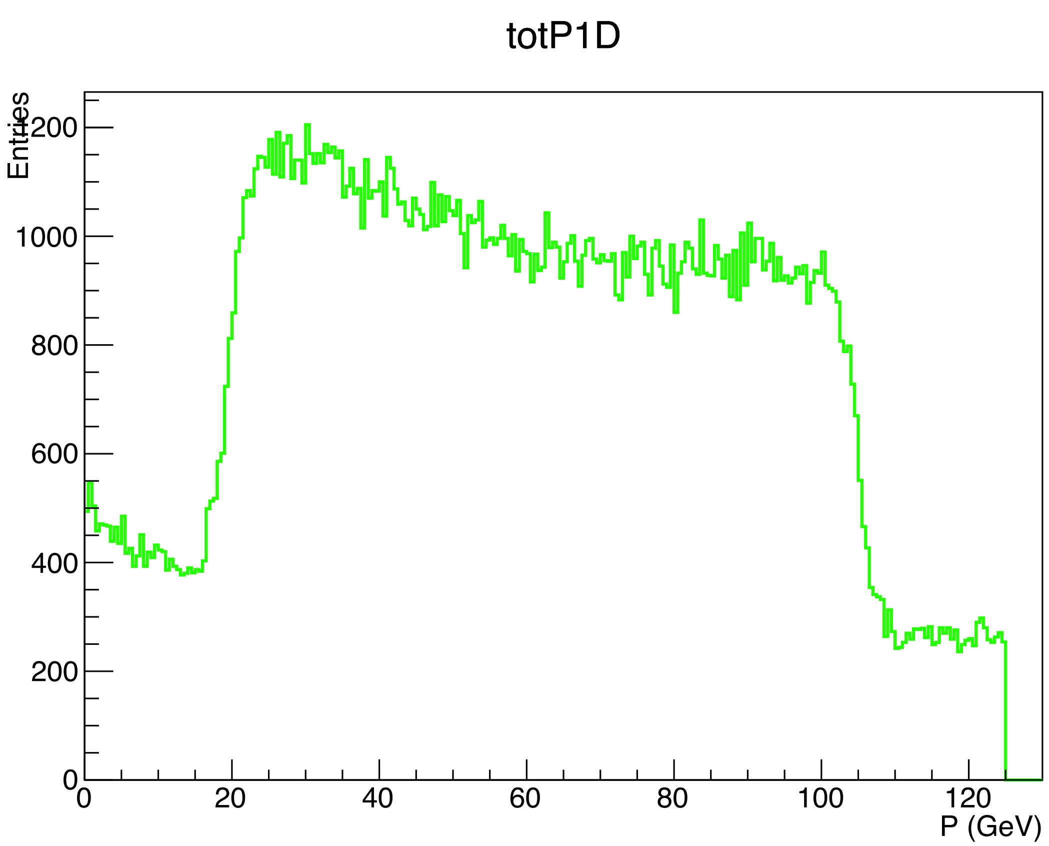


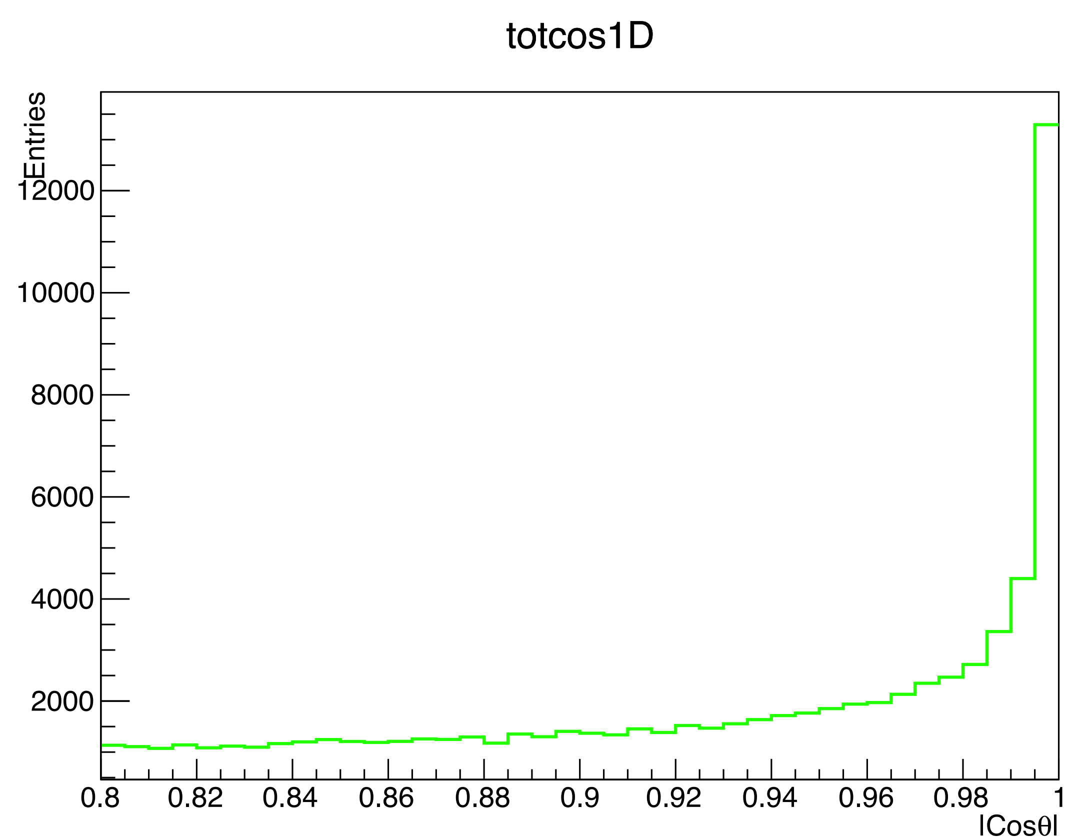


zz_sl Kinematic Distribution

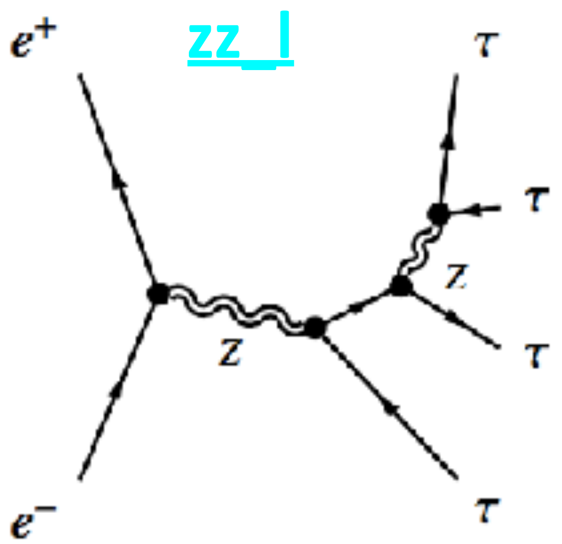


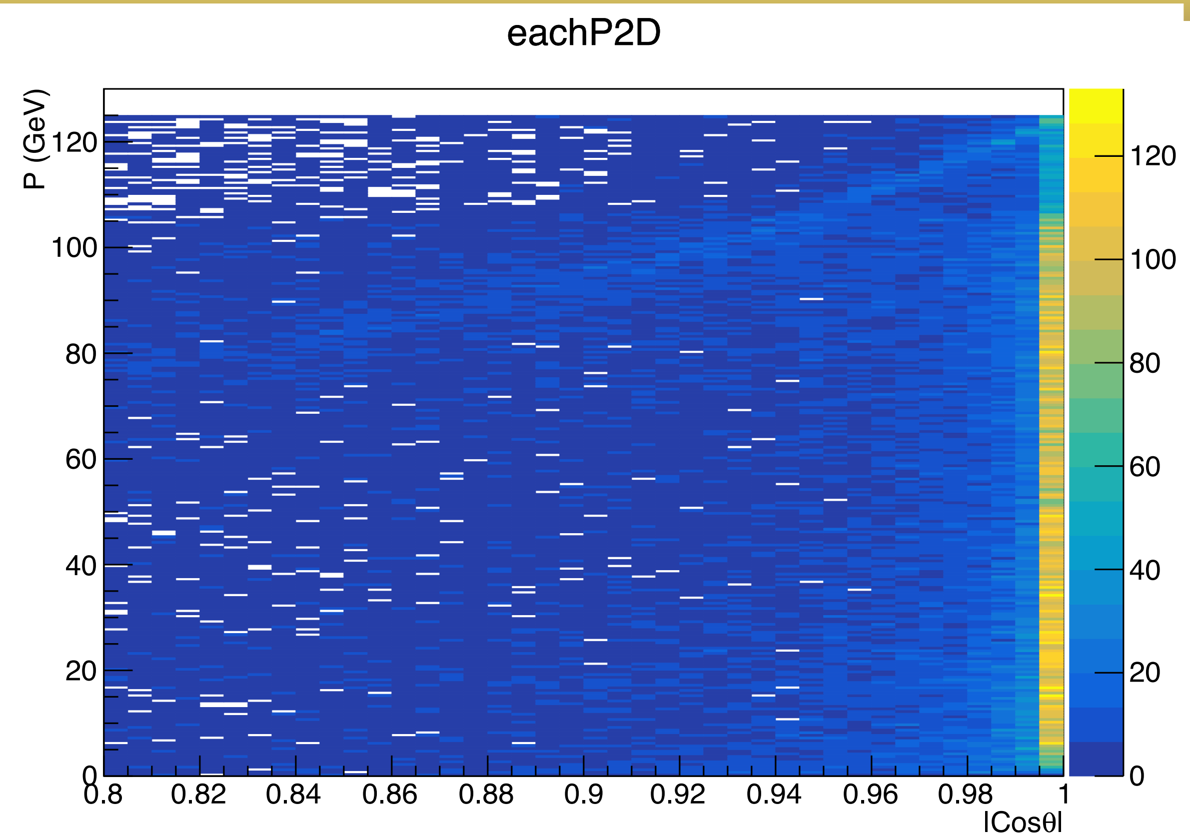


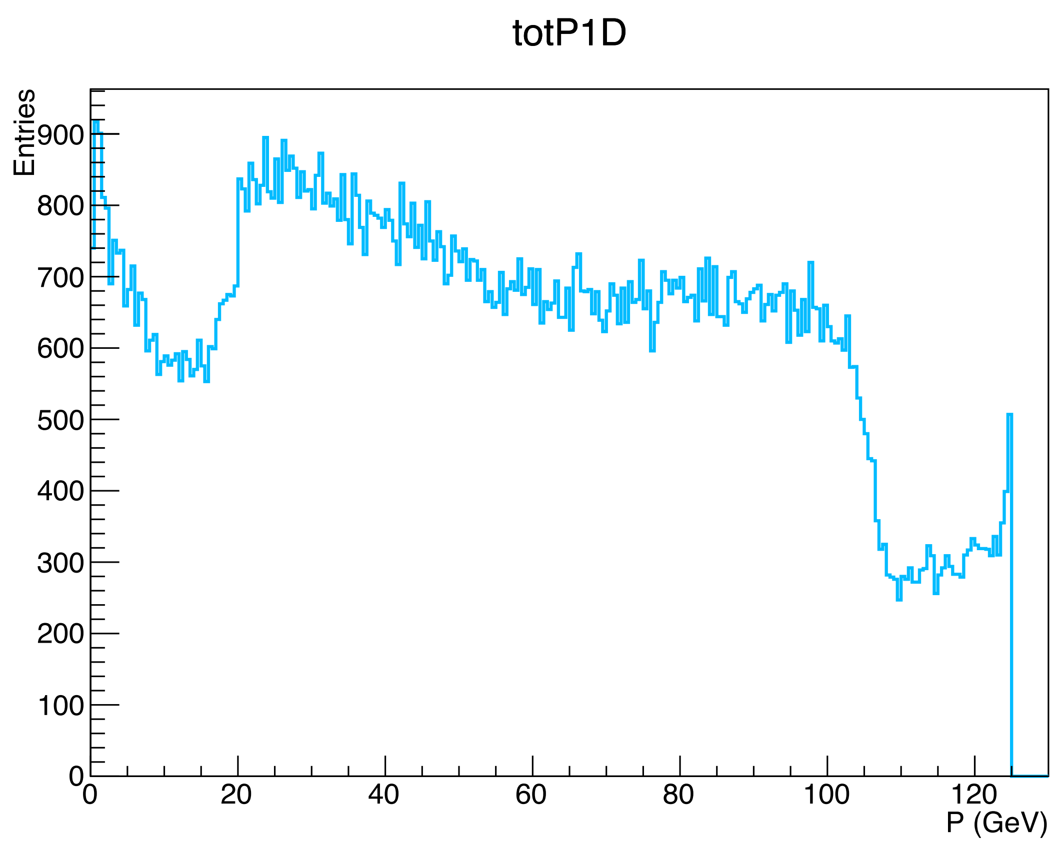


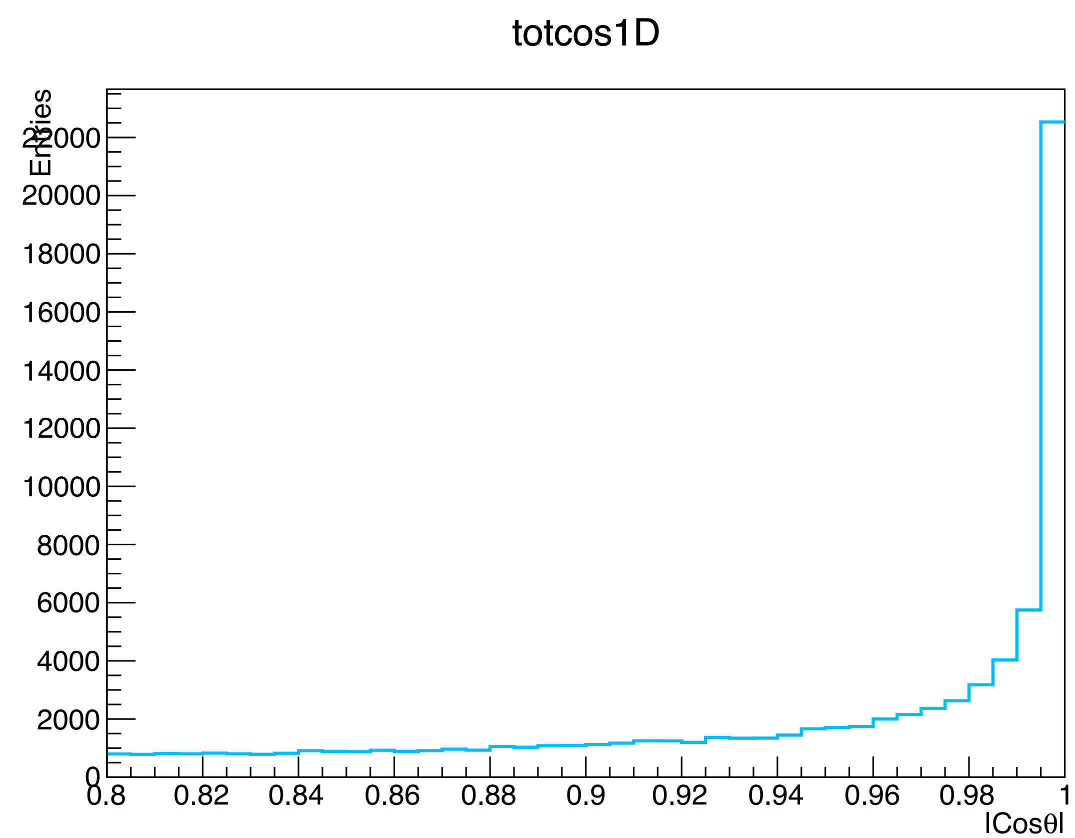


zz_l Kinematic Distribution

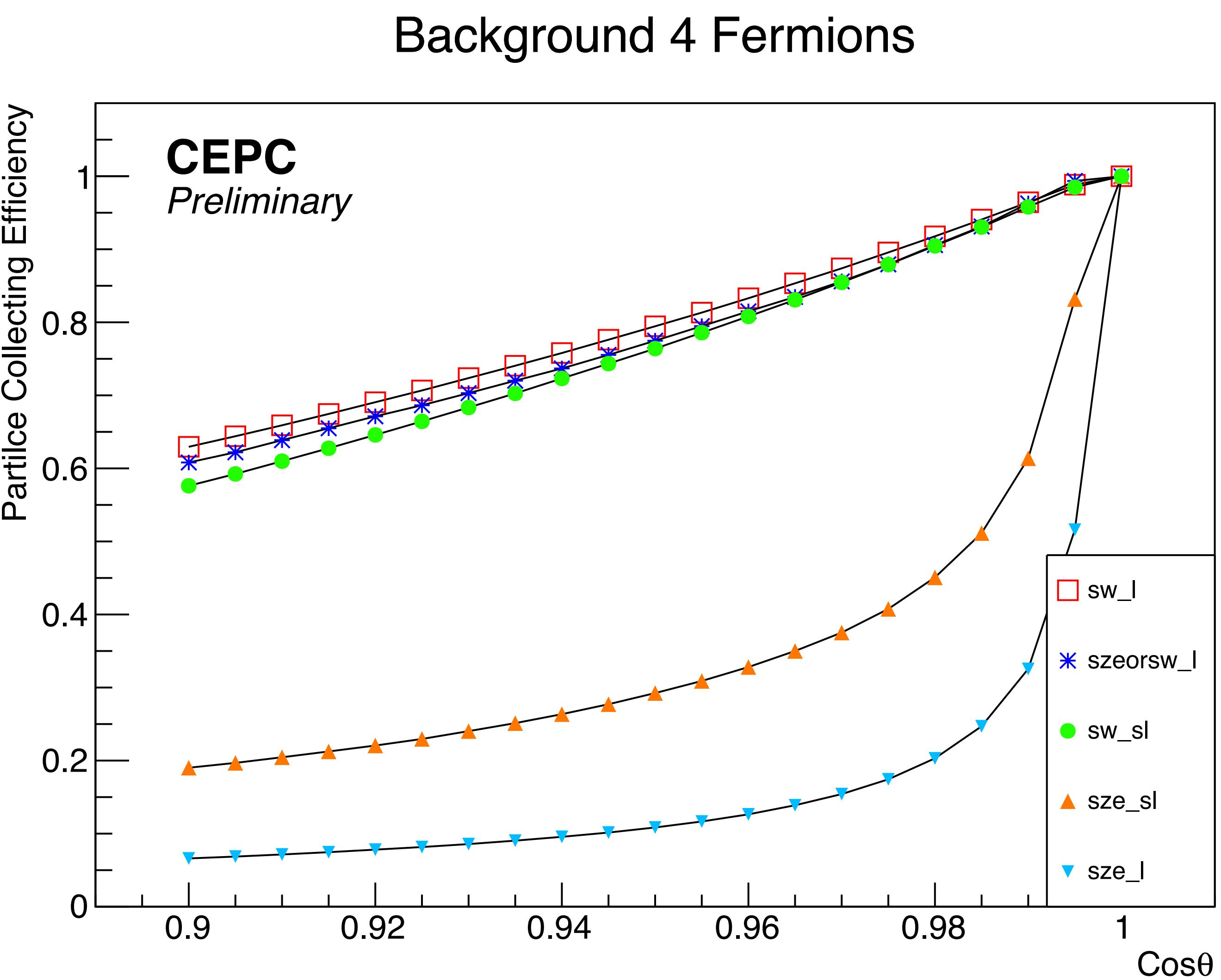


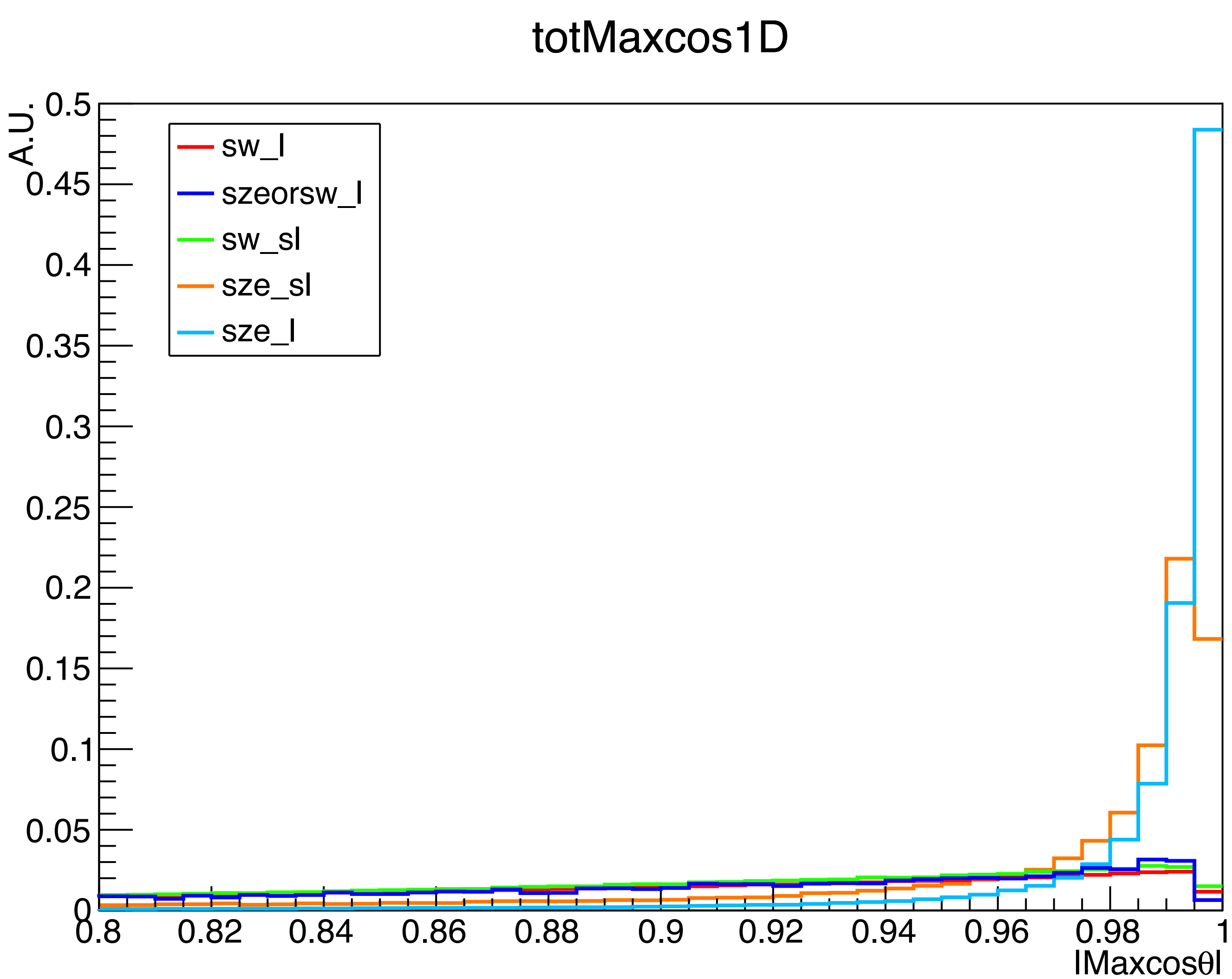


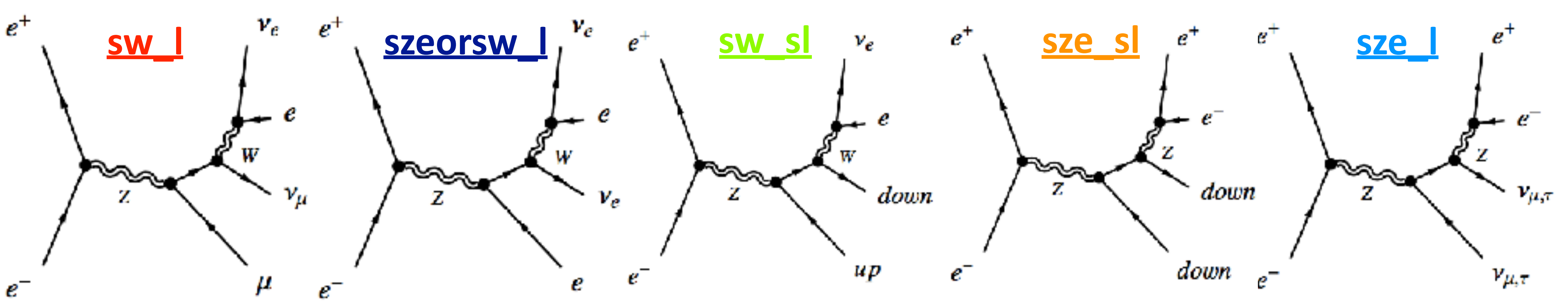




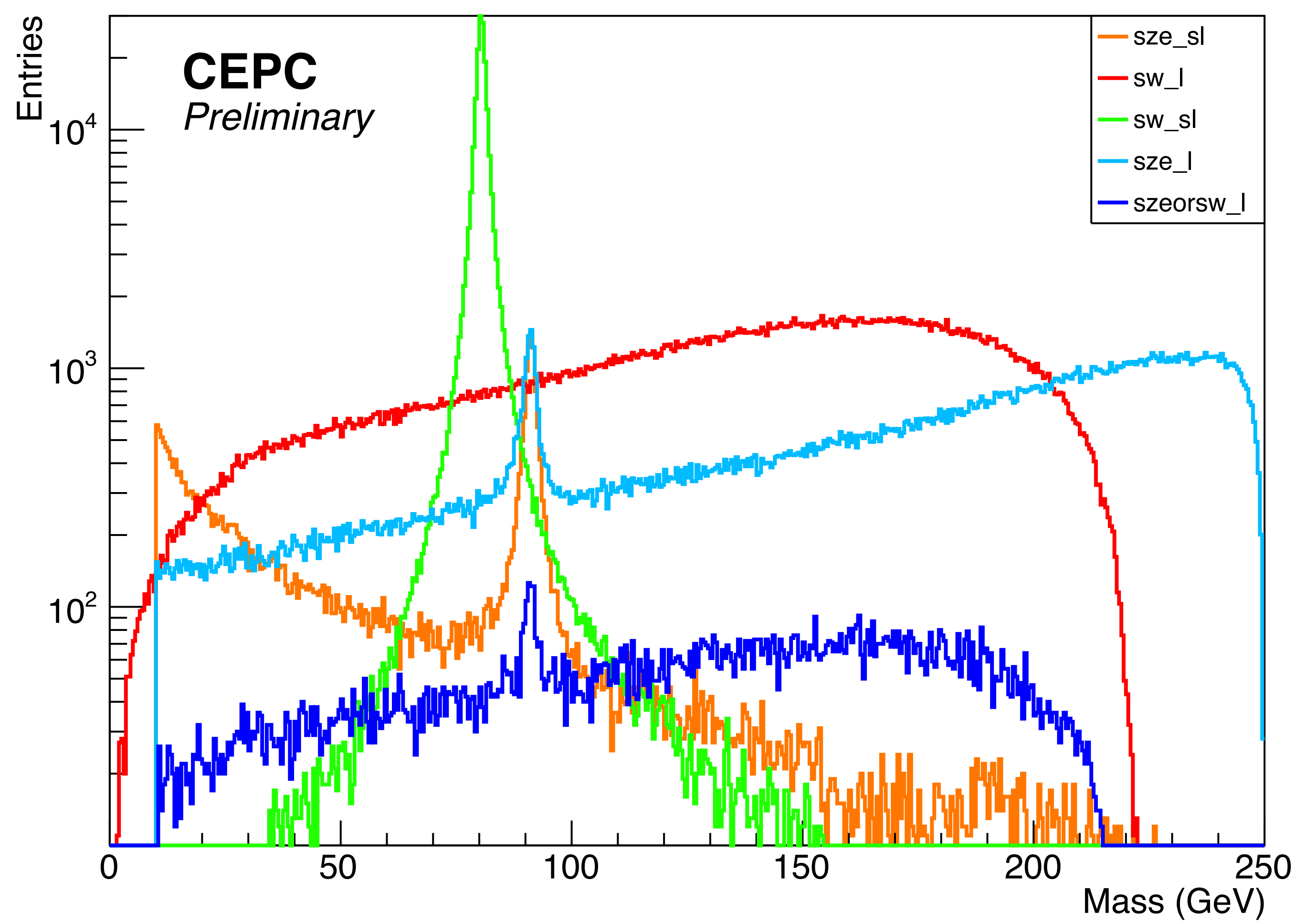
Background 4 Fermions Collecting Efficiency

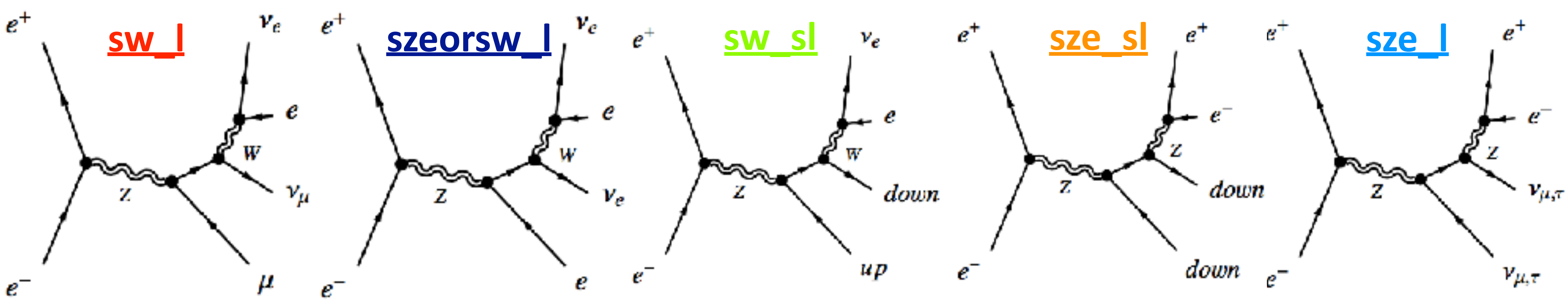




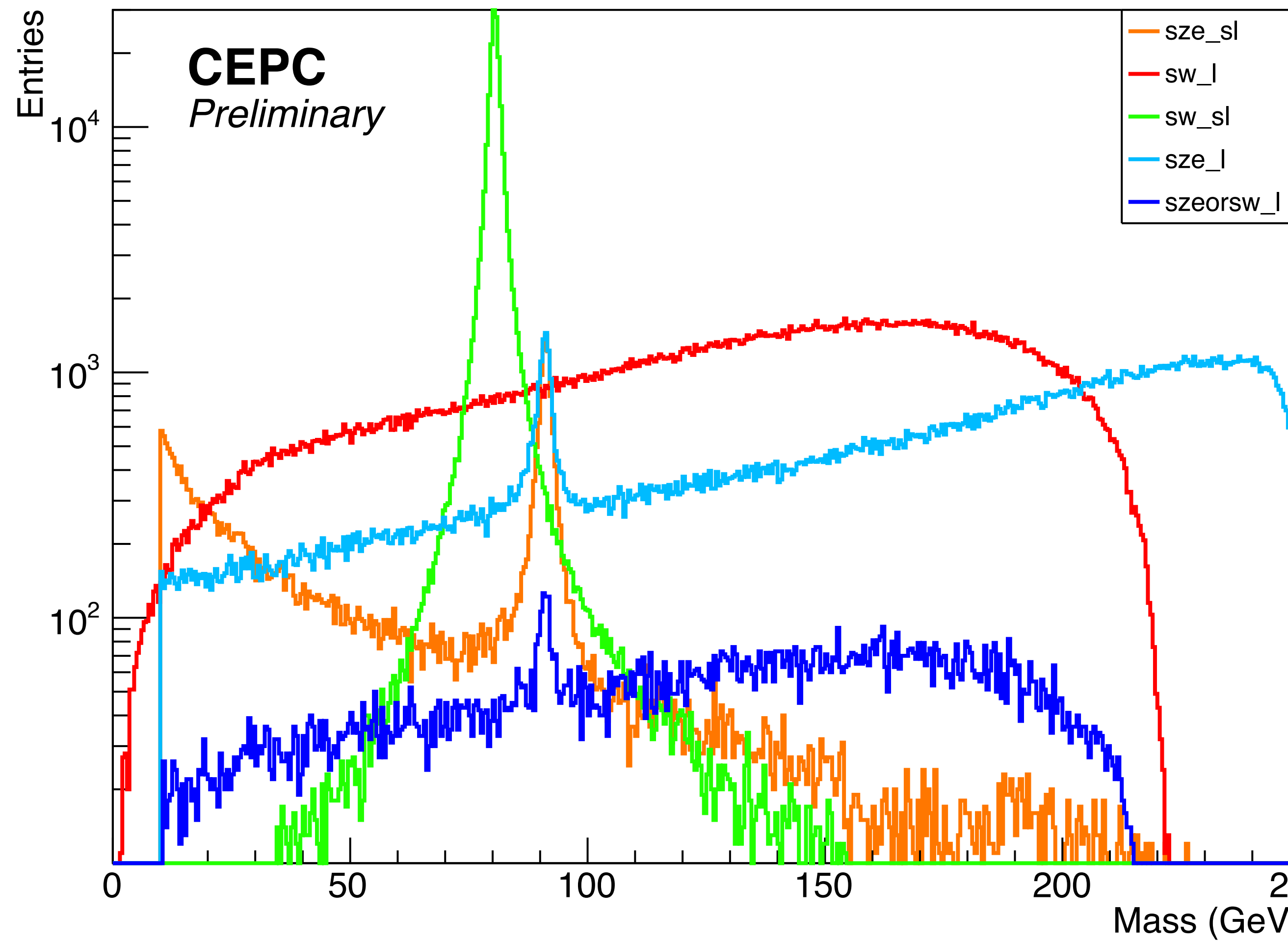


Background 4 Fermions Reconstruction



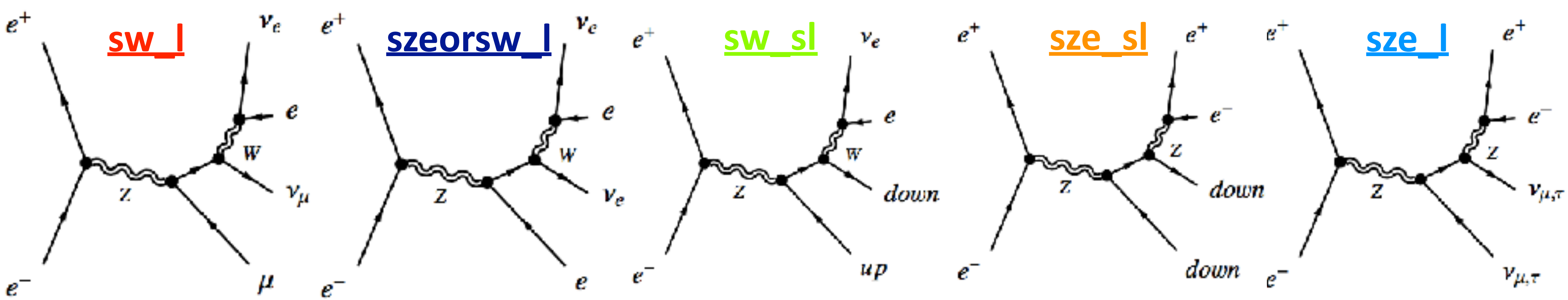


Background 4 Fermions Reconstruction

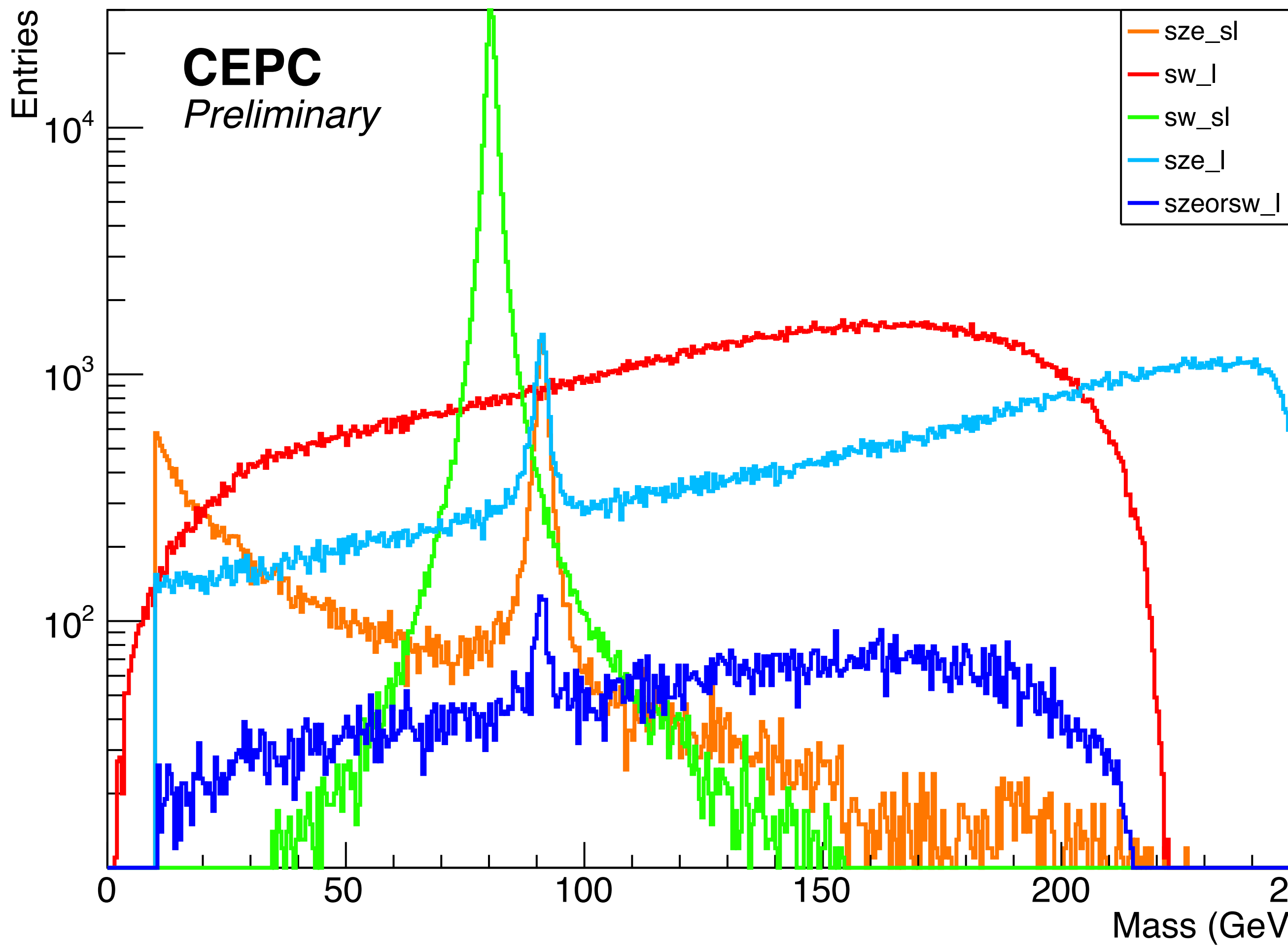



```
! Automatically generated set of cuts
! Process sze_sl0dd:
!     e a-e ->   e a-e   d a-d
!     e a-e ->   e a-e   s a-s
!     e a-e ->   e a-e   b a-b
!    32  16 ->   1   2   4   8
process sze_sl0dd
cut M of    3       within  1.00000E+01  1.00000E+99
cut M of   12       within  1.00000E+01  1.00000E+99
cut M of   33       within -1.00000E+99 -1.00000E+01
cut M of   18       within -1.00000E+99 -1.00000E+01
```

```
! Automatically generated set of cuts
! Process sze_sl0uu:
!     e a-e ->   u a-u   e a-e
!     e a-e ->   c a-c   e a-e
!    32  16 ->   1   2   4   8
process sze_sl0uu
cut N of    3       within  1.00000E+01  1.00000E+99
cut N of   12       within  1.00000E+01  1.00000E+99
cut N of   36       within -1.00000E+99 -1.00000E+01
cut N of   24       within -1.00000E+99 -1.00000E+01
```



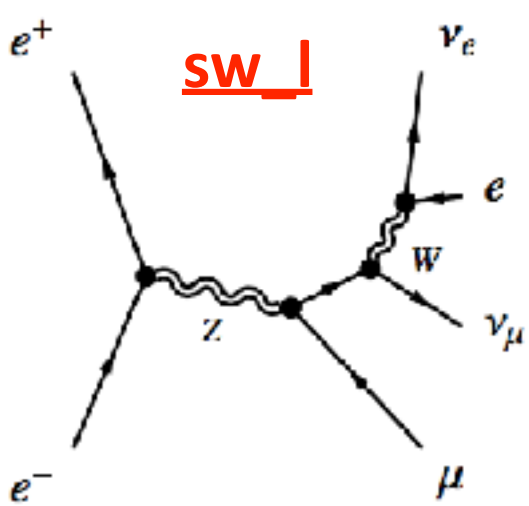
Background 4 Fermions Reconstruction



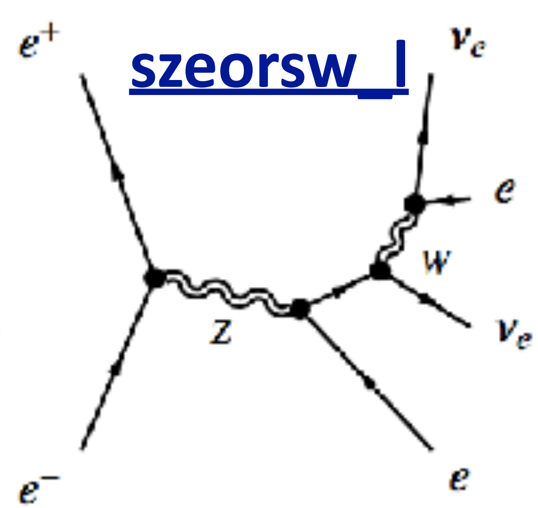

```
! Automatically generated set of cuts
! Process sze_l0e:
!     e a-e ->   e   e a-e a-e
!    32  16 ->   1   2   4   8
process sze_l0e
cut M of     5       within  1.00000E+01  1.00000E+99
cut M of     9       within  1.00000E+01  1.00000E+99
cut M of     6       within  1.00000E+01  1.00000E+99
cut M of    10       within  1.00000E+01  1.00000E+99
cut M of    33       within -1.00000E+99 -1.00000E+01
cut M of    34       within -1.00000E+99 -1.00000E+01
cut M of    20       within -1.00000E+99 -1.00000E+01
cut M of    24       within -1.00000E+99 -1.00000E+01
```

```
! Automatically generated set of cuts
! Process sze_l0nunu:
!     e a-e -> nu_mu a-nu_mu   e a-e
!     e a-e -> nu_tau a-nu_tau   e a-e
!    32  16 ->      1          2   4   8
process sze_l0nunu
cut M of    12       within  1.00000E+01  1.00000E+99
cut M of    36       within -1.00000E+99 -1.00000E+01
cut M of    24       within -1.00000E+99 -1.00000E+01
```

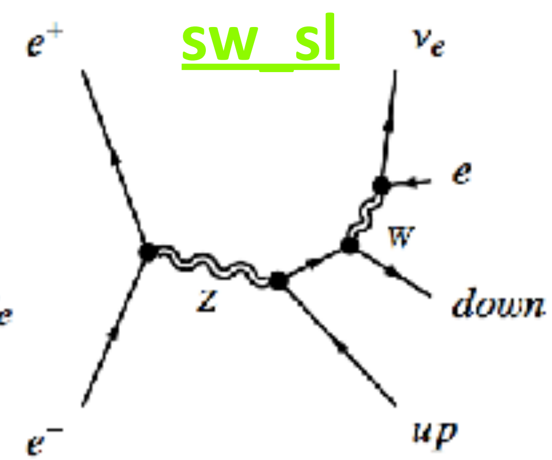
sw_l



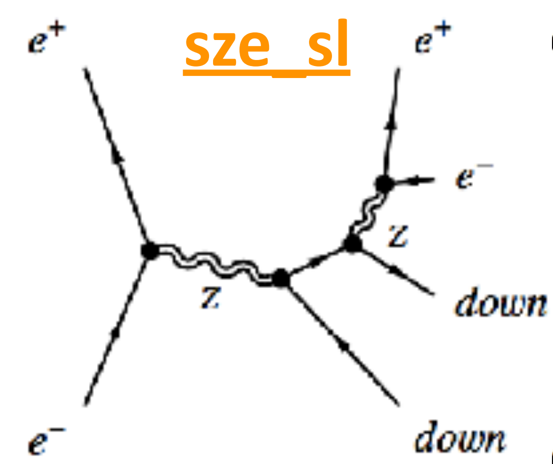
szeorsw_l



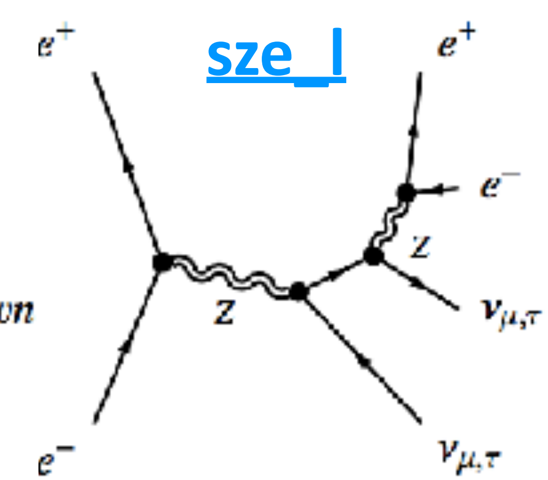
sw_sl



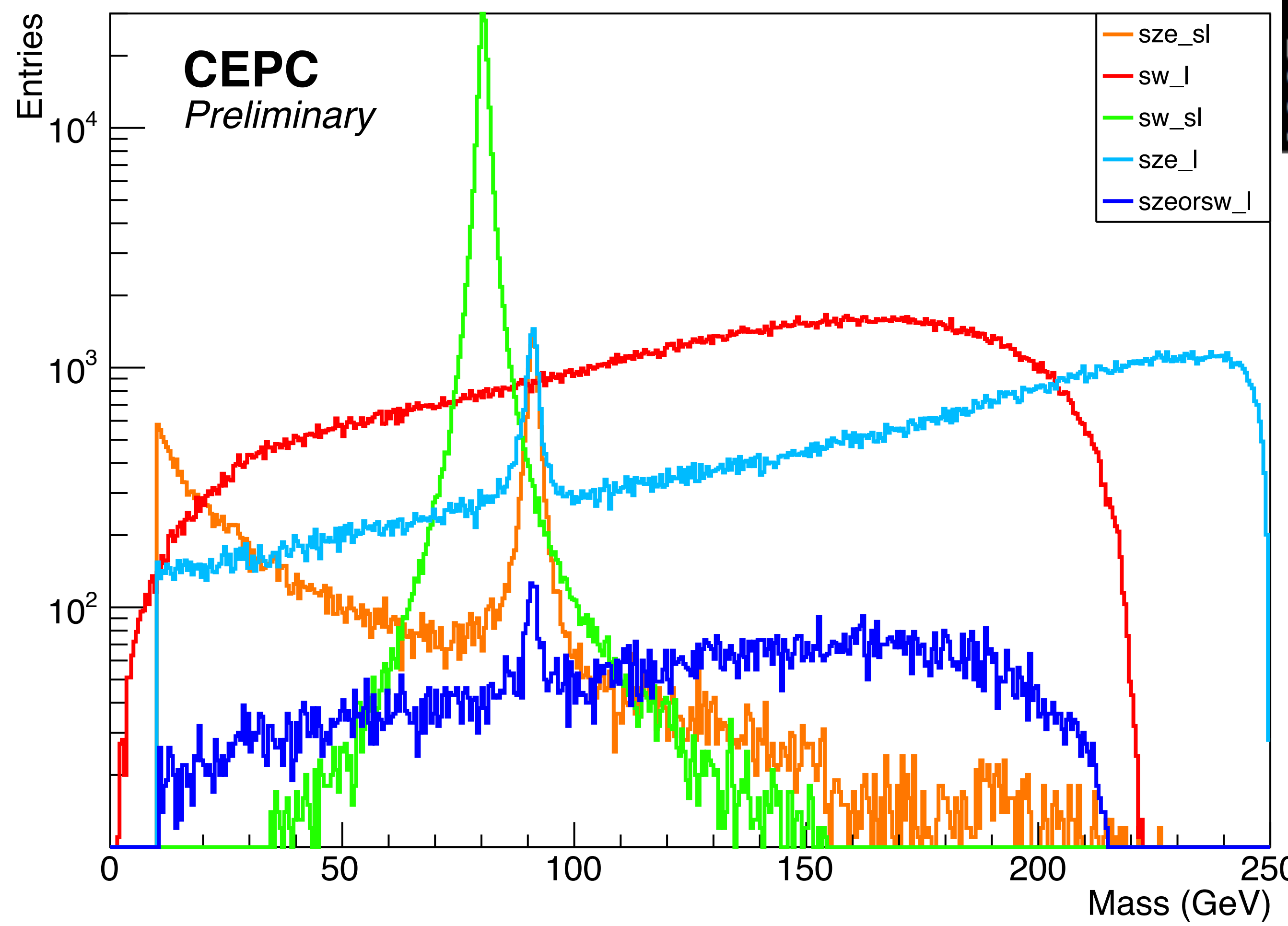
sze_sl



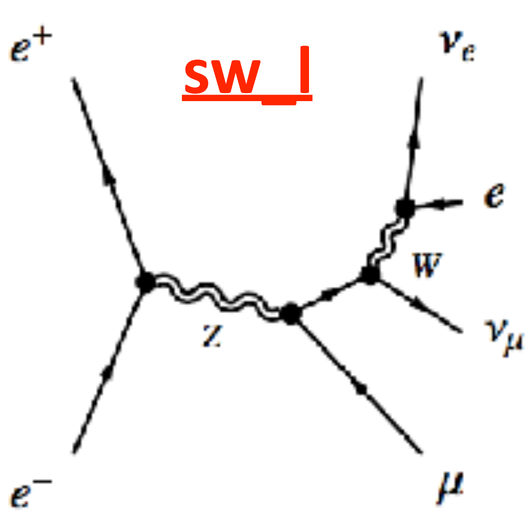
sze_l

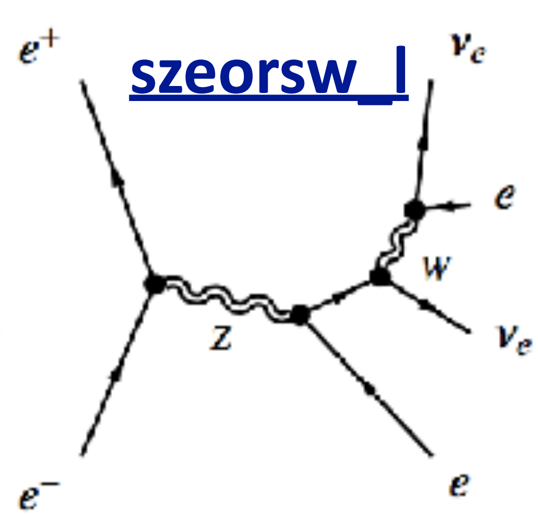


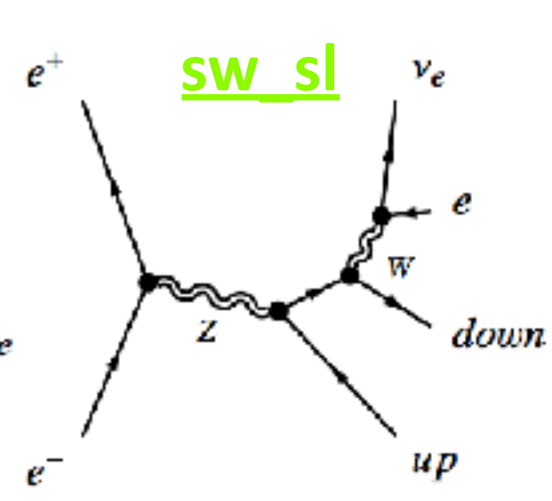
Background 4 Fermions Reconstruction

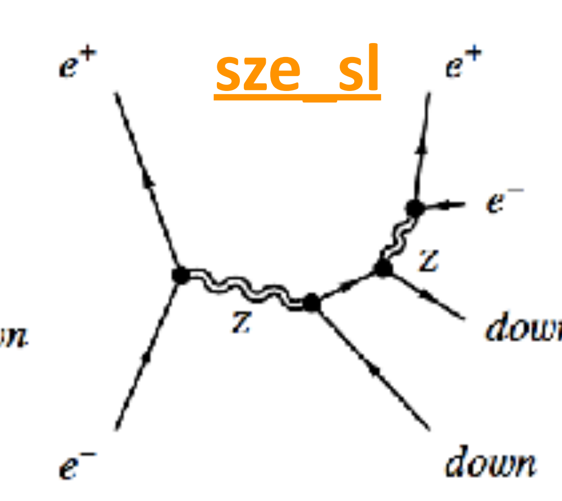


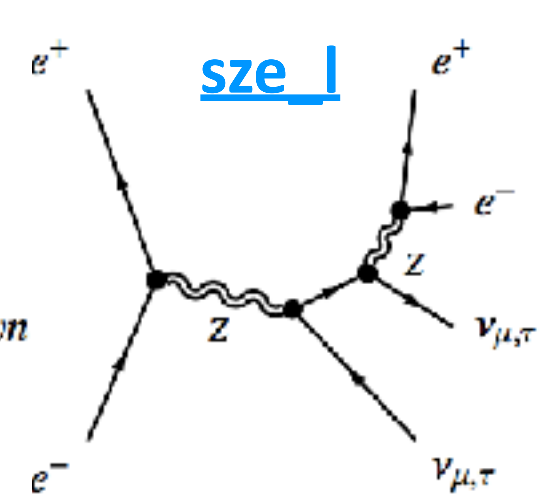

```
| Automatically generated set of cuts
| Process szeorsw_l0l:
!     e a-e -> nu_e    e a-e a-nu_e
!    32  16 ->     1   2   4      8
process szeorsw_l0l
cut M of    6       within  1.00000E+01  1.00000E+99
cut M of   34       within -1.00000E+99 -1.00000E+01
cut M of   20       within -1.00000E+99 -1.00000E+01
```



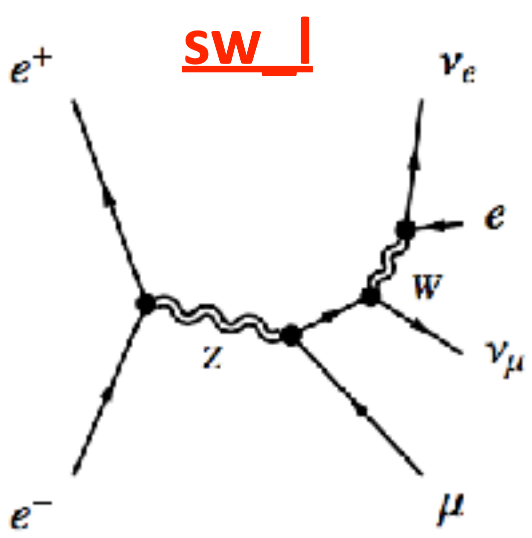


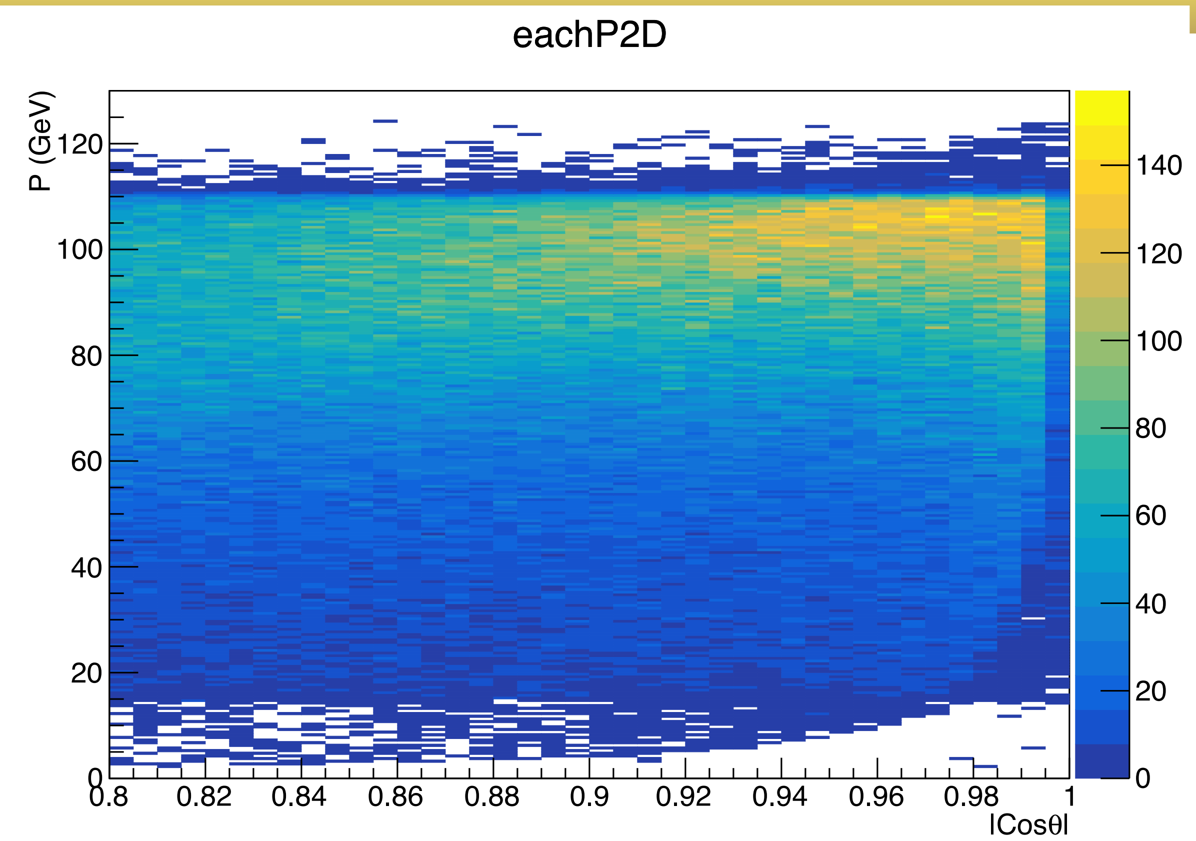






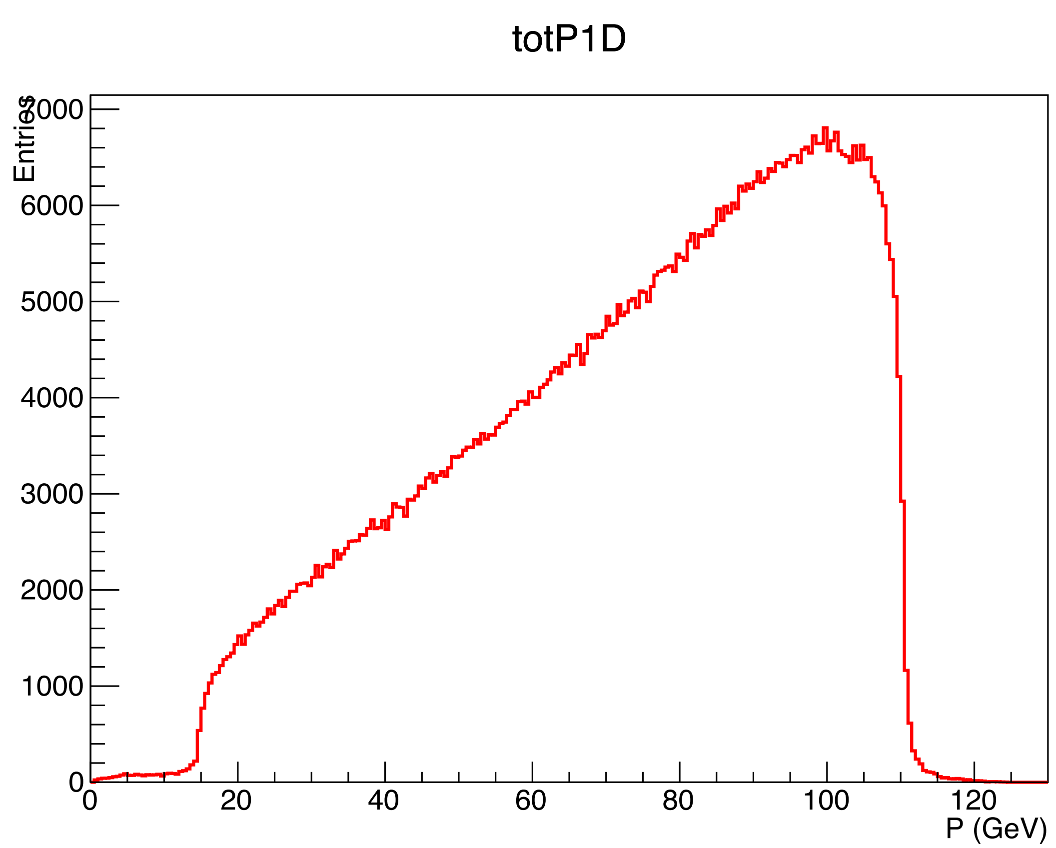
sw_l Kinematic Distribution

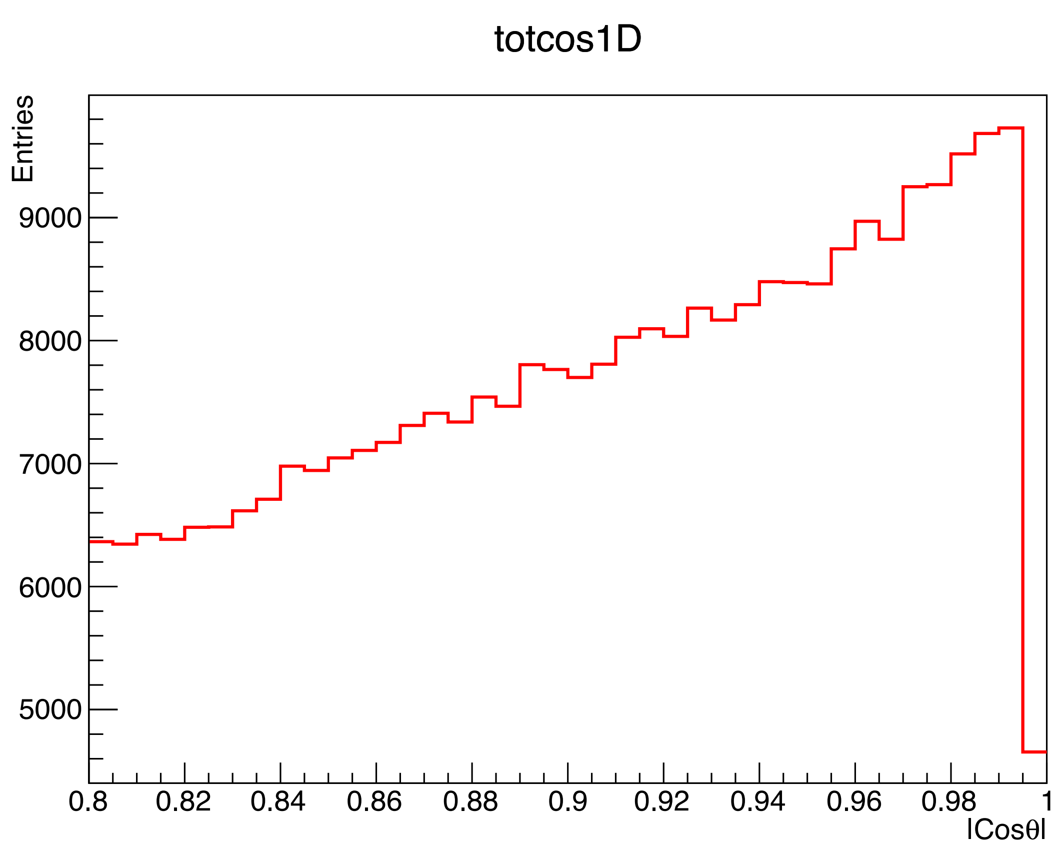




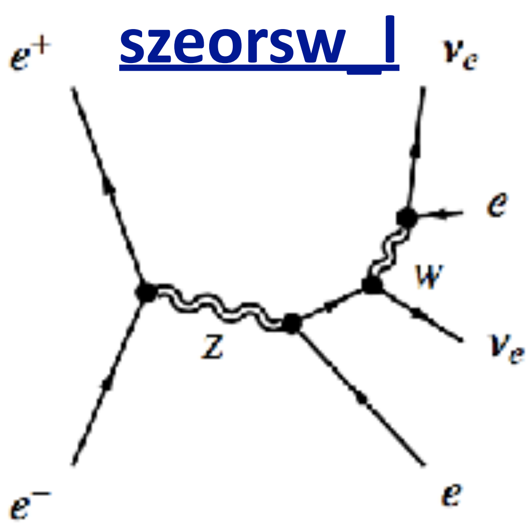

```
! Automatically generated set of cuts
! Process sw_l0mu:
!     e a-e -> nu_mu a-mu    e a-nu_e
!     e a-e -> a-nu_mu  mu a-e nu_e
!    32  16 ->          1   2    4     8
process sw_l0mu
cut M of    36       within -1.00000E+99 -1.00000E+01
cut M of    20       within -1.00000E+99 -1.00000E+01
```

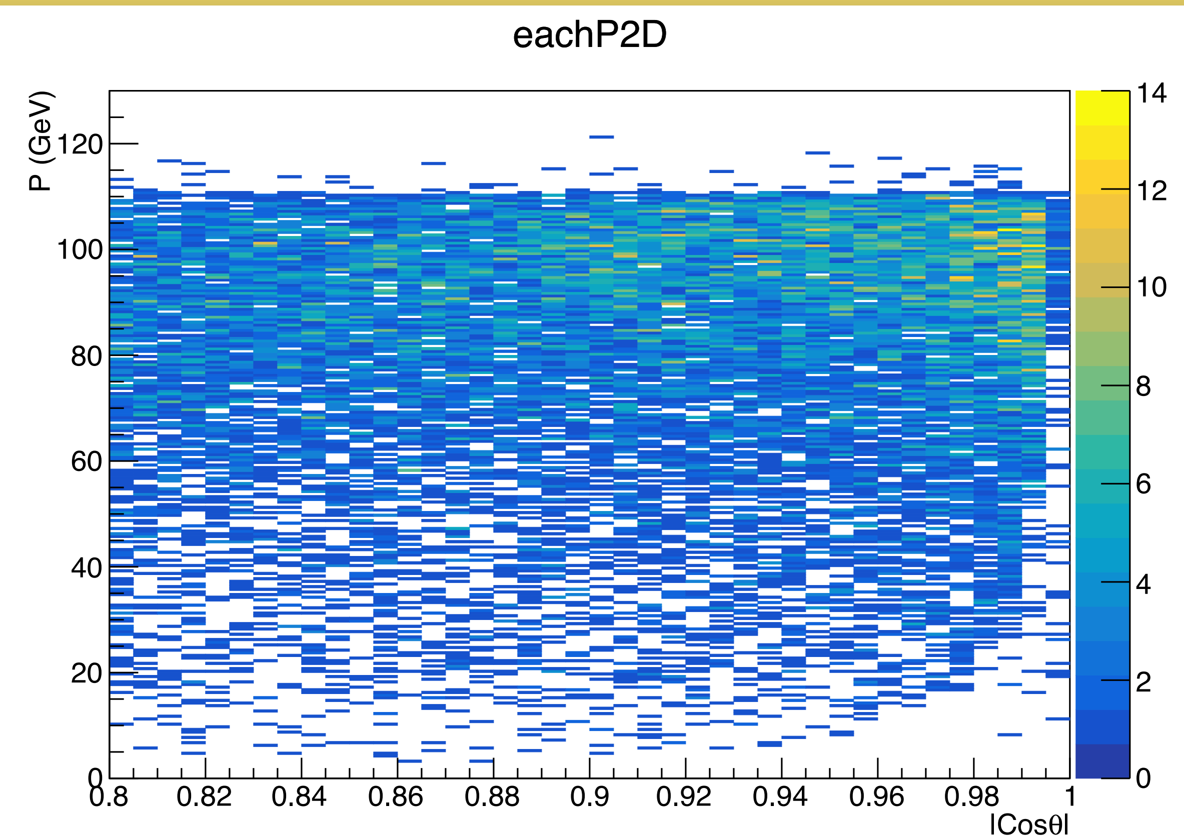
```
! Automatically generated set of cuts
! Process sw_l0tau:
!     e a-e -> nu_tau a-tau    e a-nu_e
!     e a-e -> a-nu_tau tau a-e nu_e
!    32  16 ->          1   2    4     8
process sw_l0tau
cut M of    36       within -1.00000E+99 -1.00000E+01
cut M of    20       within -1.00000E+99 -1.00000E+01
```

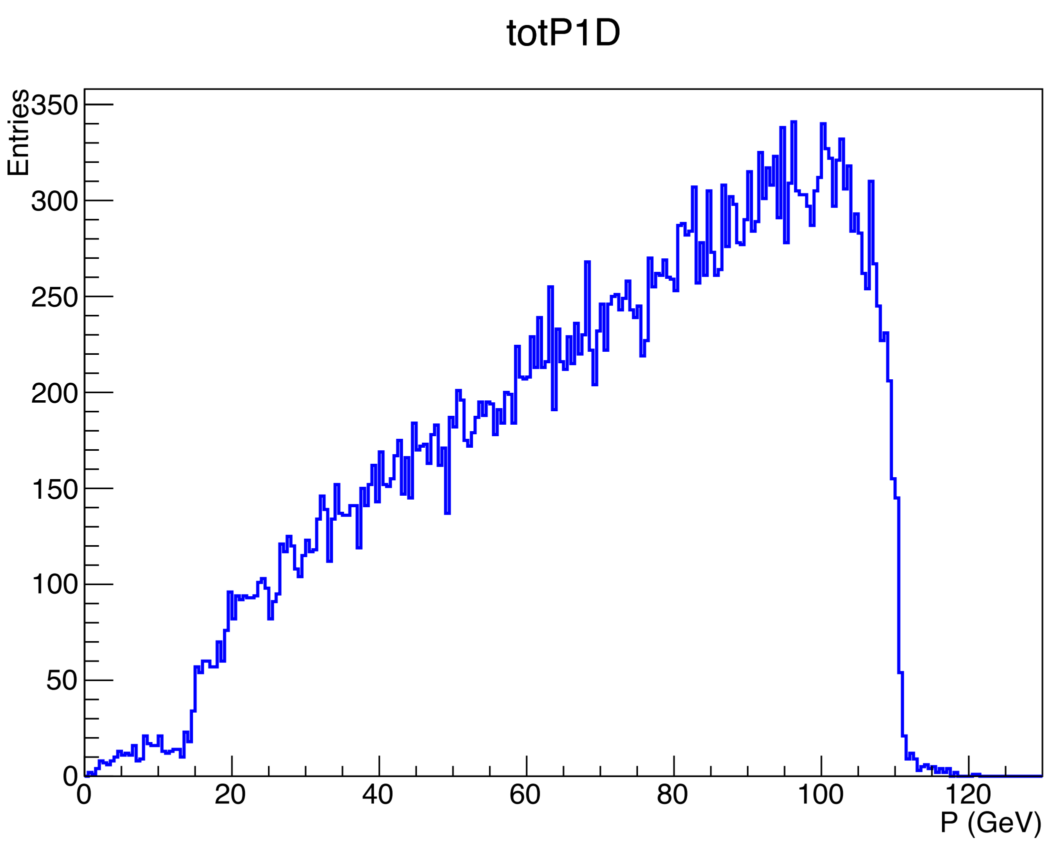


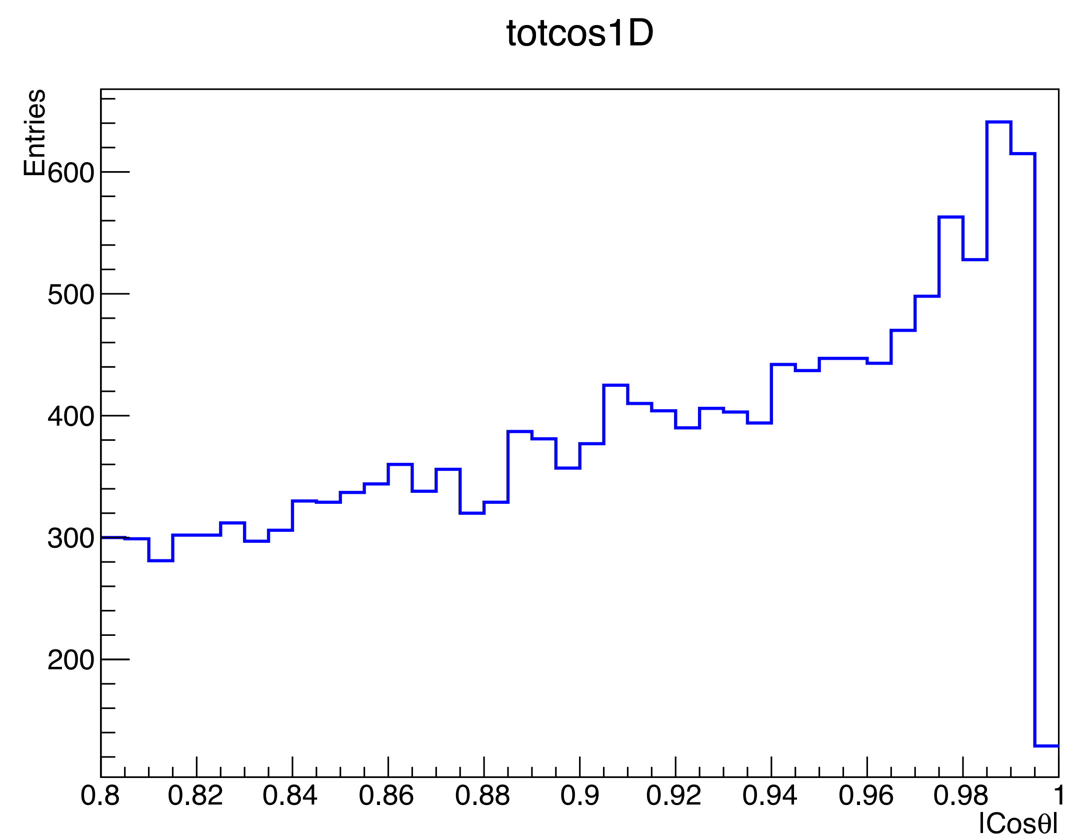


szeorsw_l Kinematic Distribution

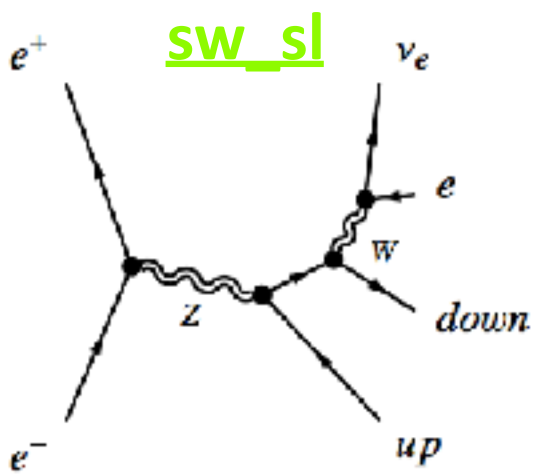


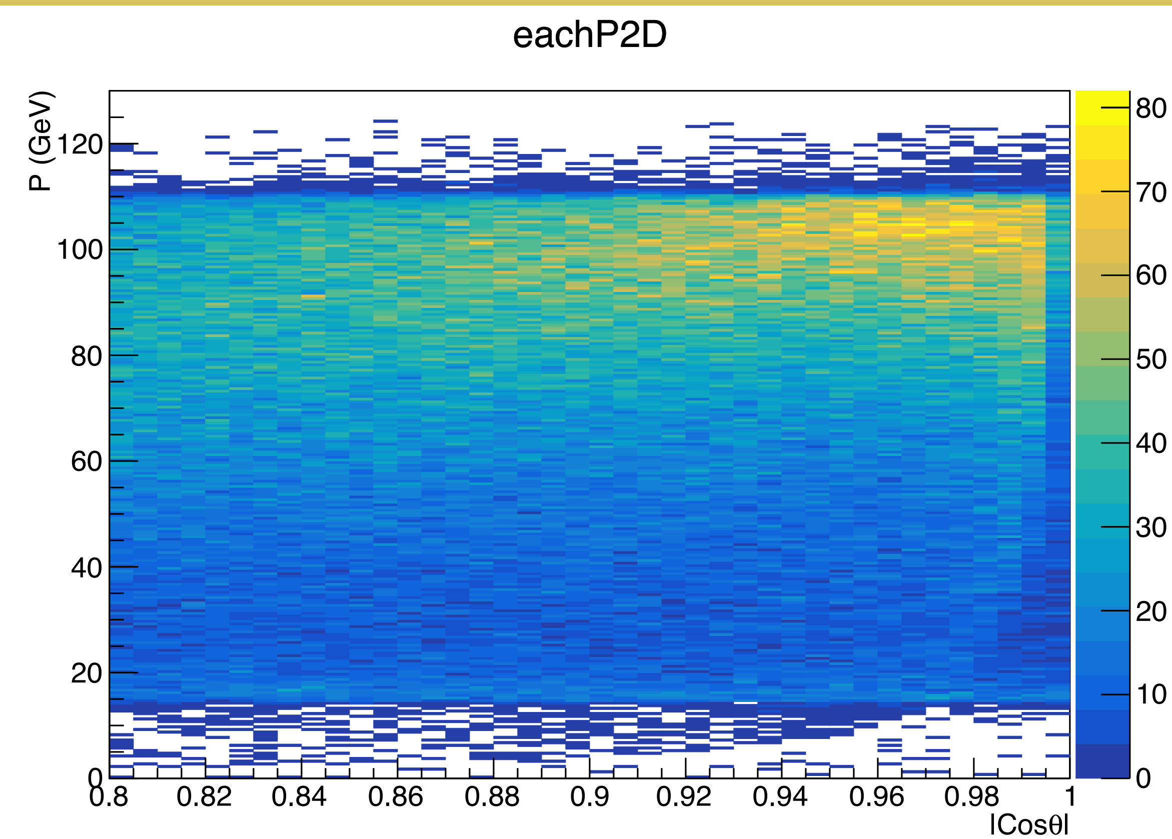




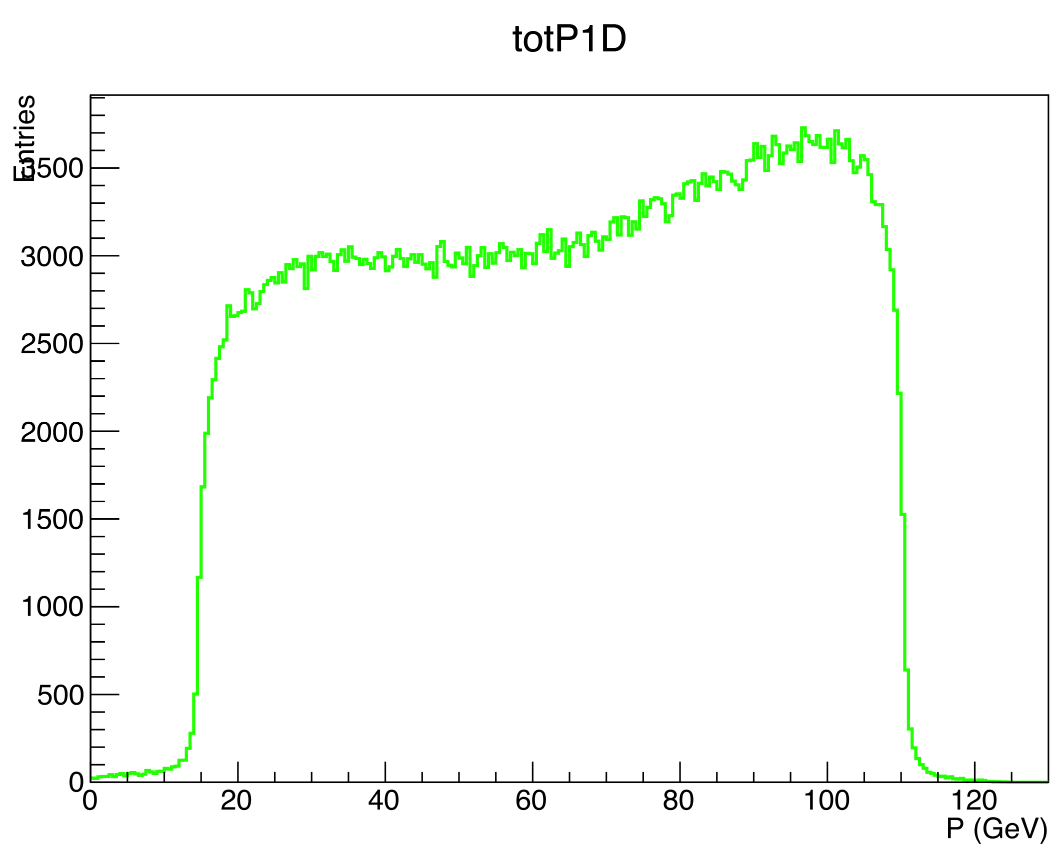


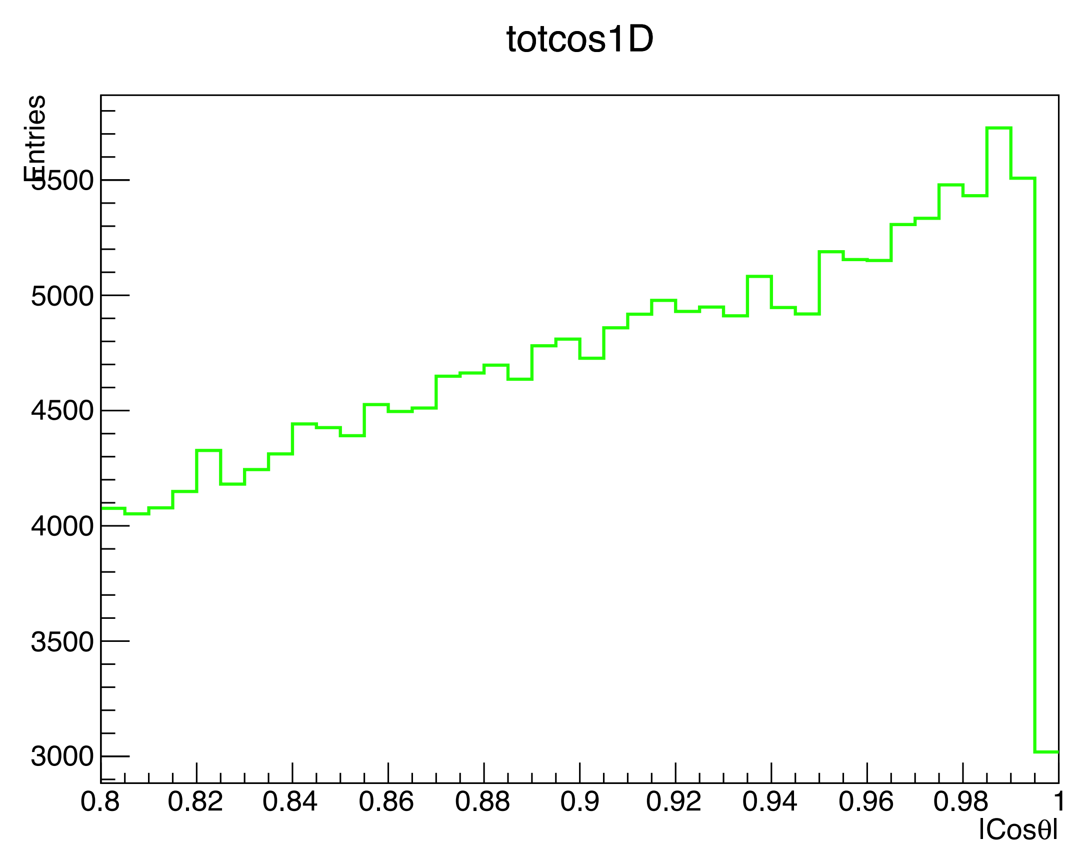
sw_sl Kinematic Distribution



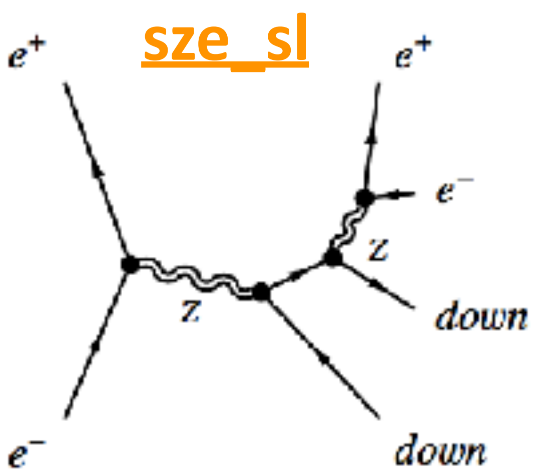


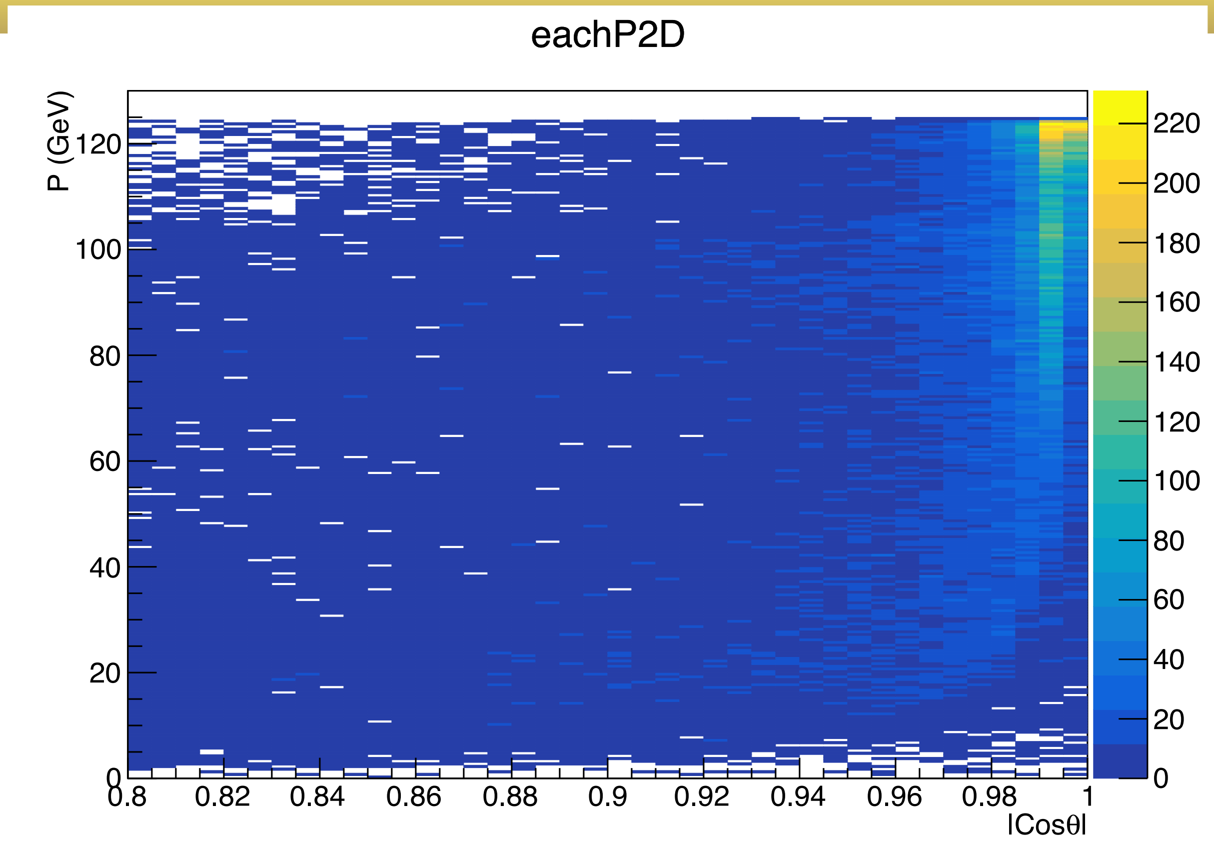

```
! Automatically generated set of cuts
! Process sw_sl0qq:
!     e a-e ->   u a-d   e a-nu_e
!     e a-e ->   u a-s   e a-nu_e
!     e a-e ->   u a-b   e a-nu_e
!     e a-e ->   c a-d   e a-nu_e
!     e a-e ->   c a-s   e a-nu_e
!     e a-e ->   c a-b   e a-nu_e
!     e a-e -> a-u   d a-e nu_e
!     e a-e -> a-u   s a-e nu_e
!     e a-e -> a-u   b a-e nu_e
!     e a-e -> a-c   d a-e nu_e
!     e a-e -> a-c   s a-e nu_e
!     e a-e -> a-c   b a-e nu_e
!   32  16 ->   1   2   4    8
process sw_sl0qq
cut M of    3      within  1.00000E+01  1.00000E+99
cut M of   36      within -1.00000E+99 -1.00000E+01
cut M of   20      within -1.00000E+99 -1.00000E+01
```

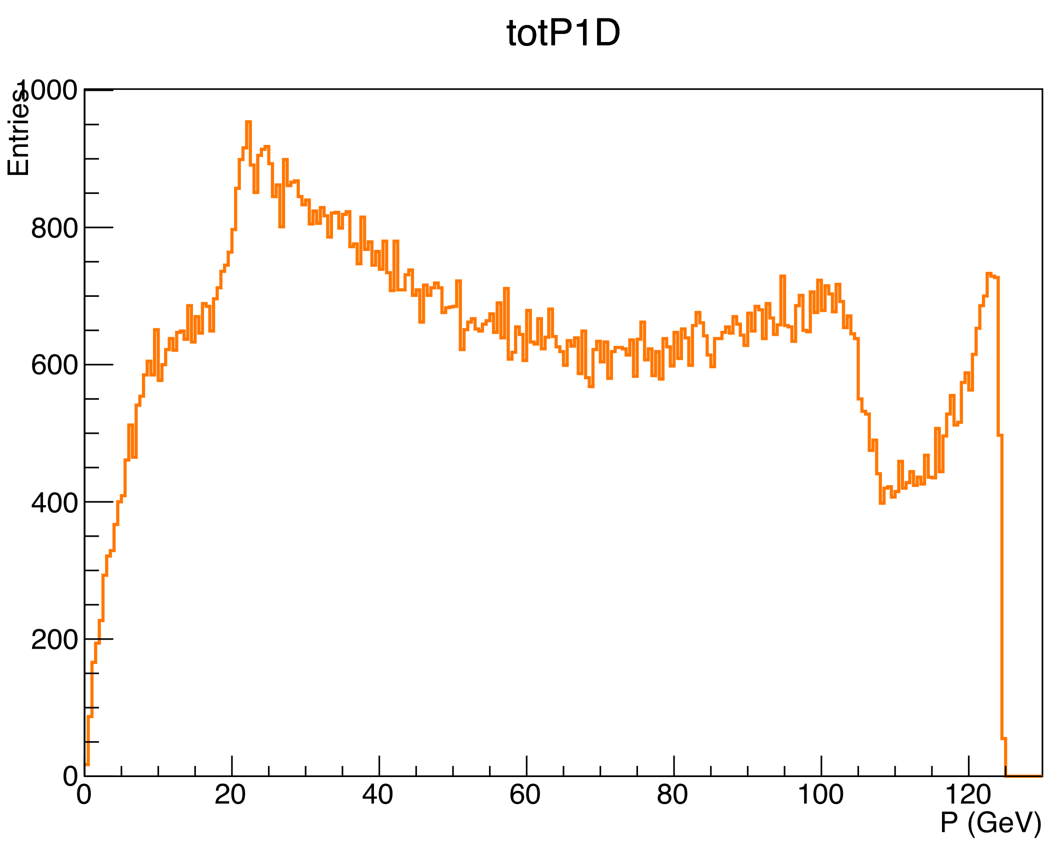


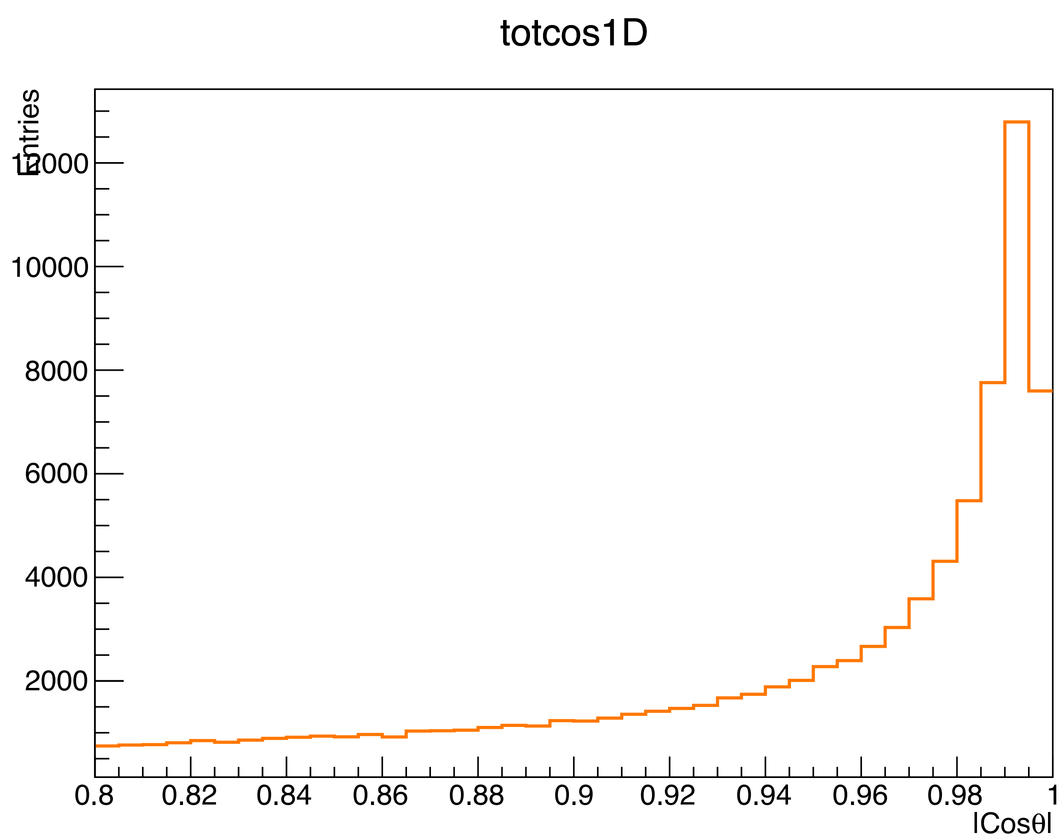


sze_sl Kinematic Distribution



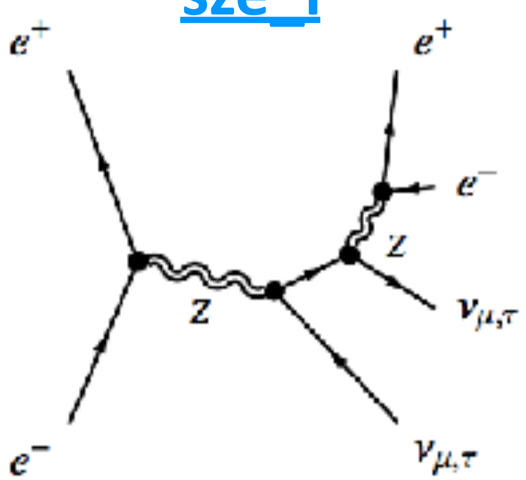


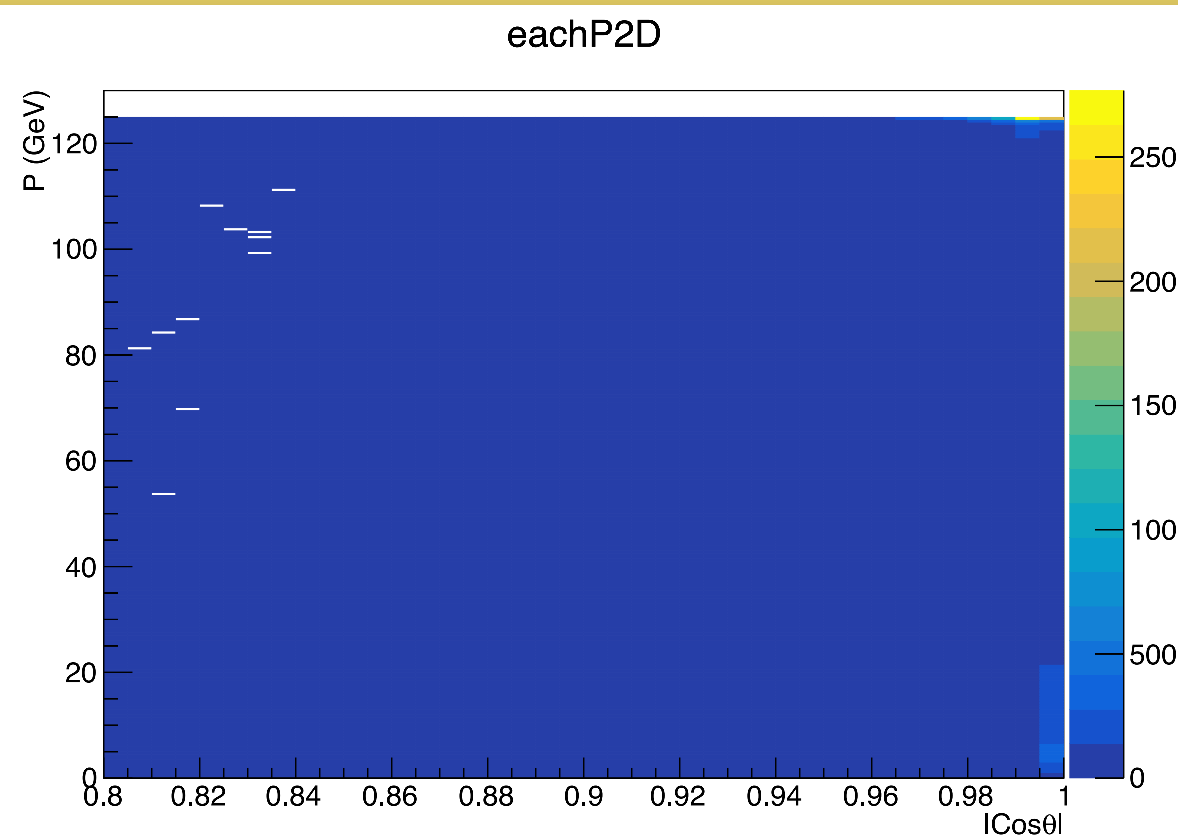


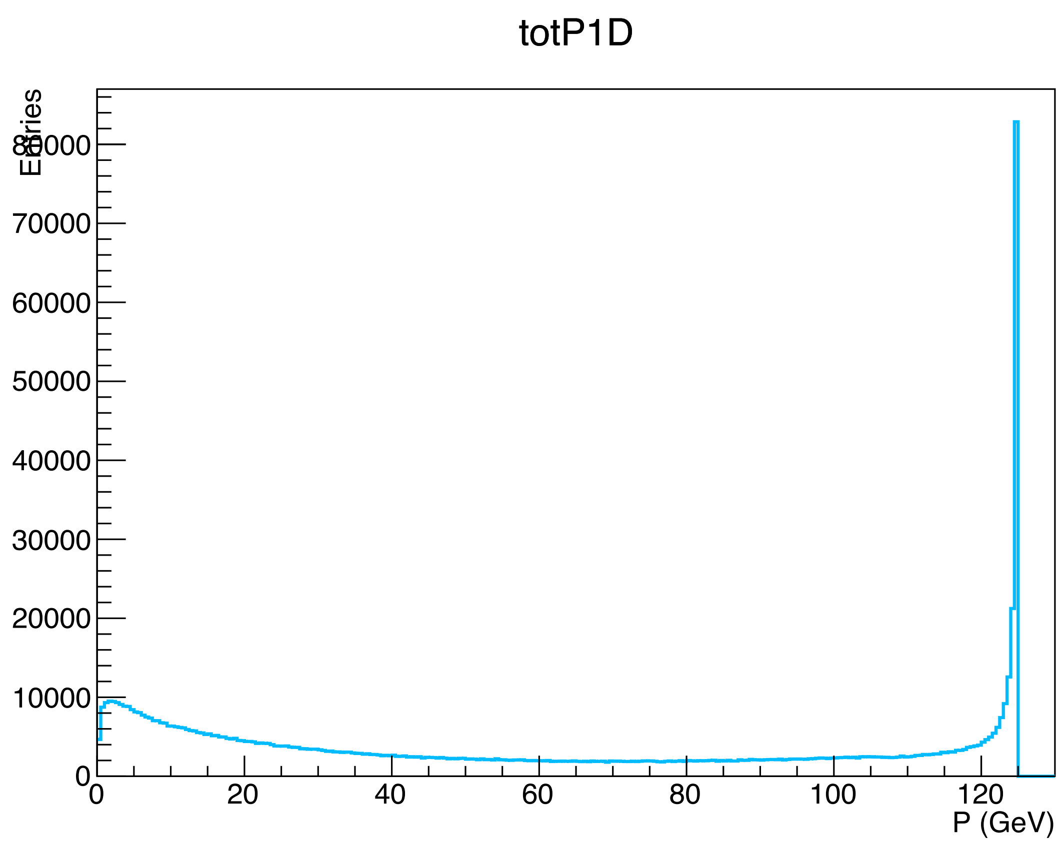


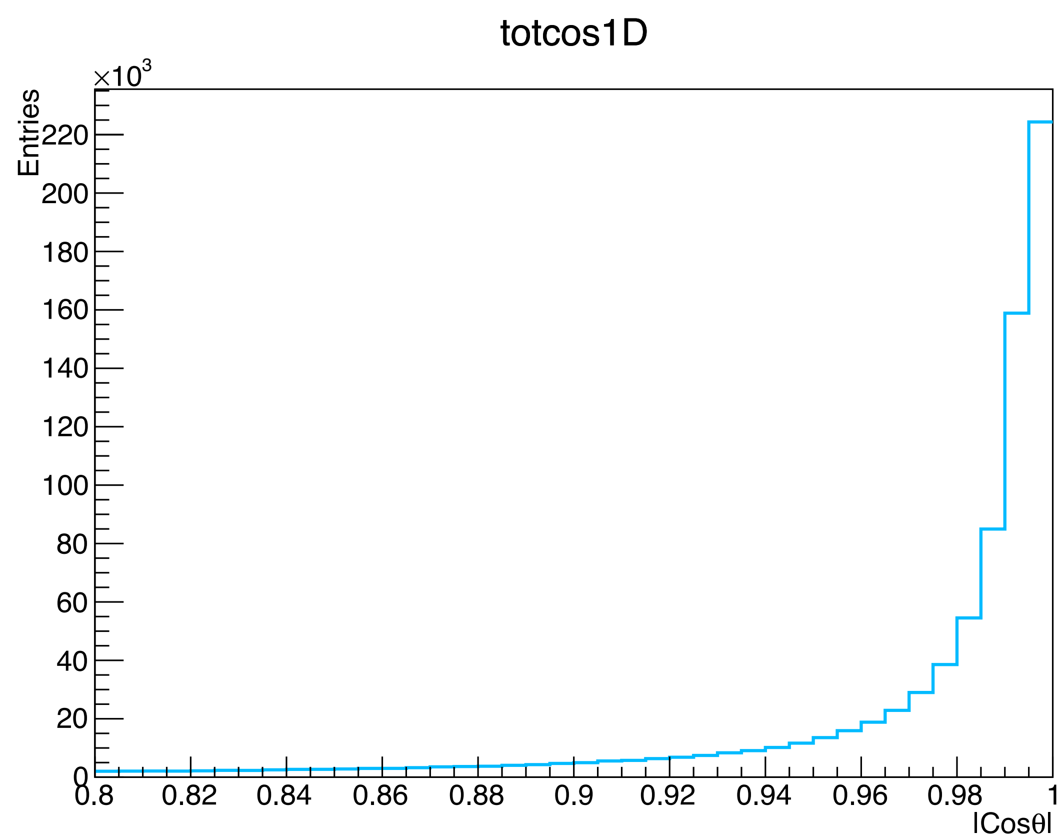
sze_l Kinematic Distribution

sze_l

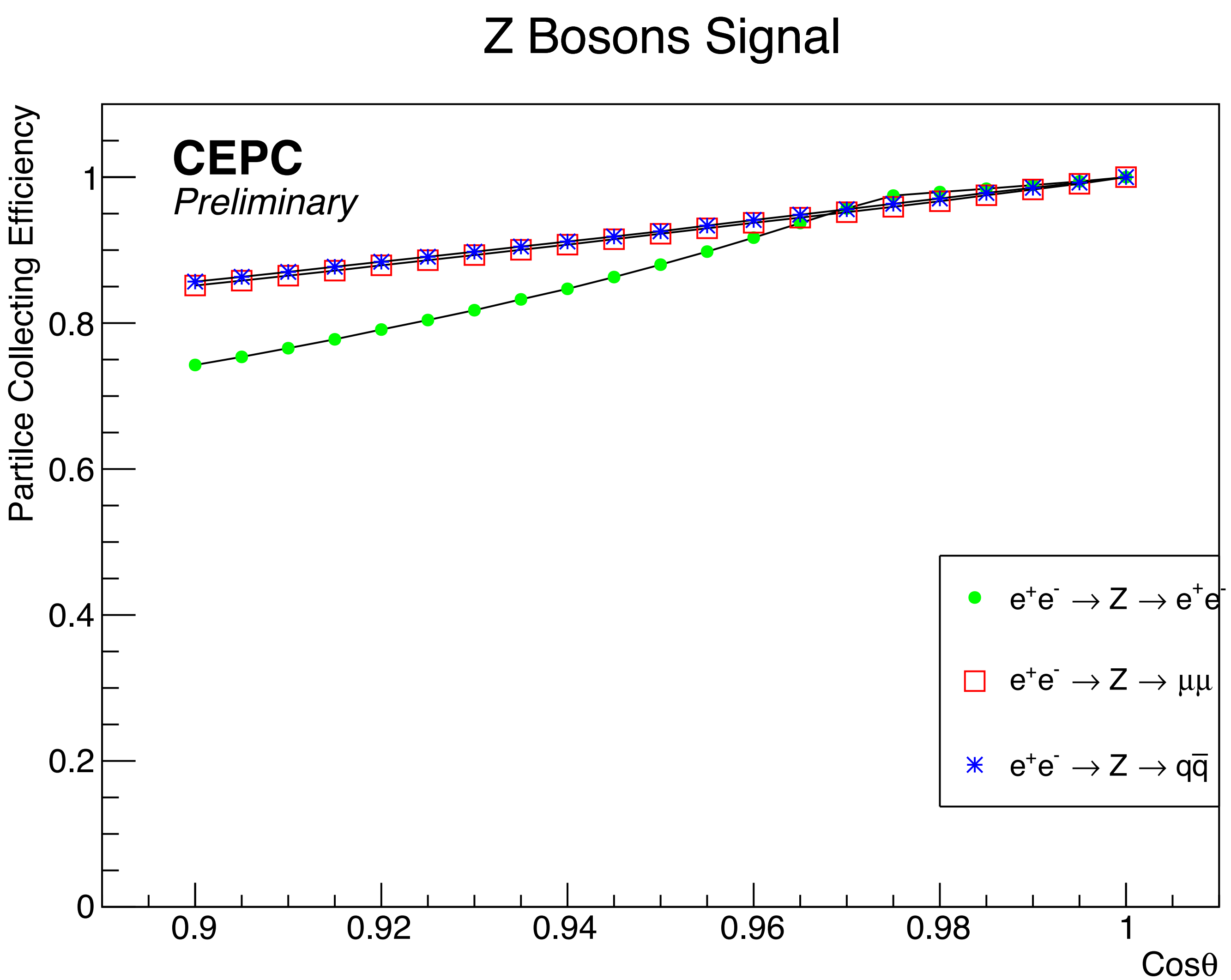


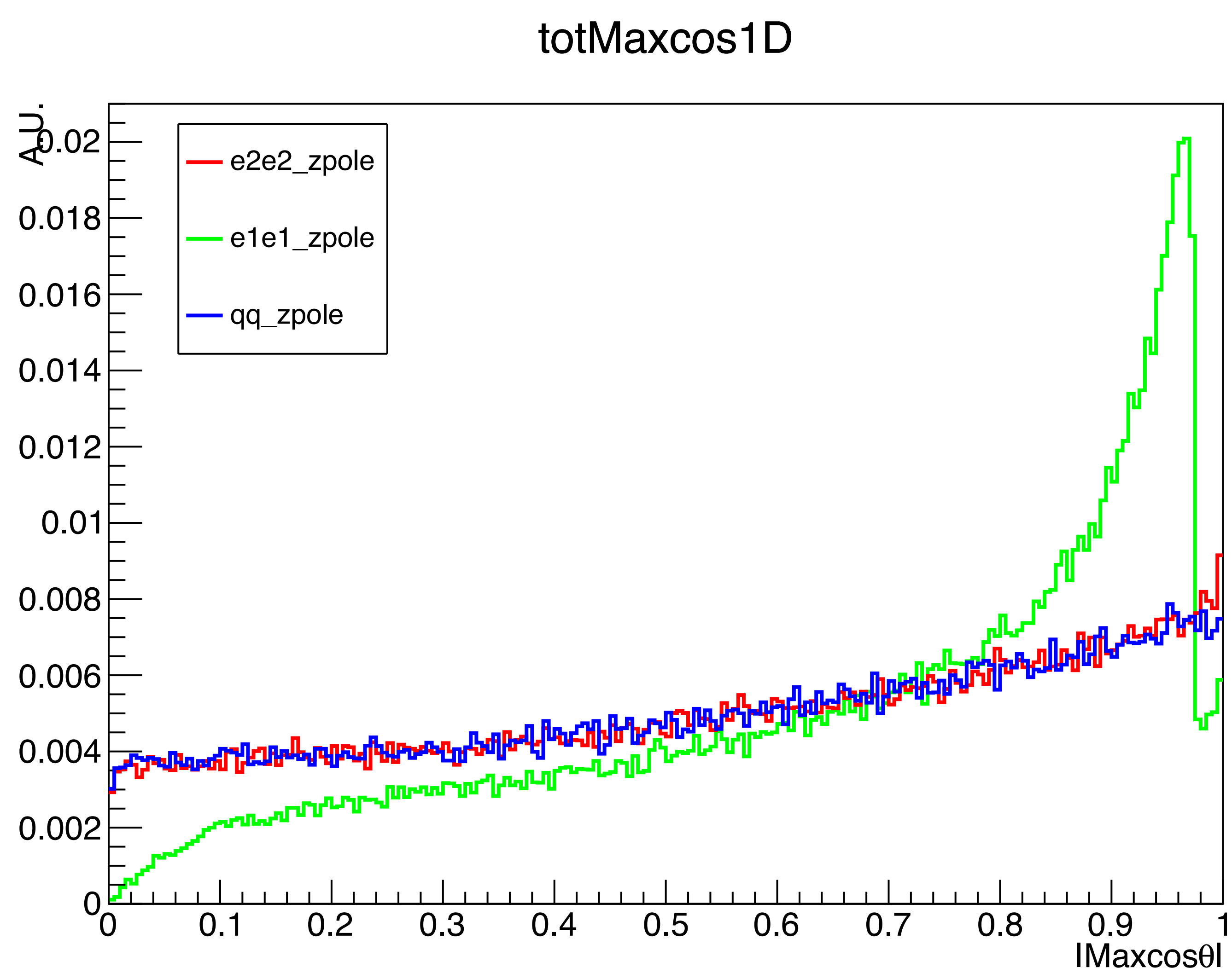






Z Bosons Signal Collecting Efficiency

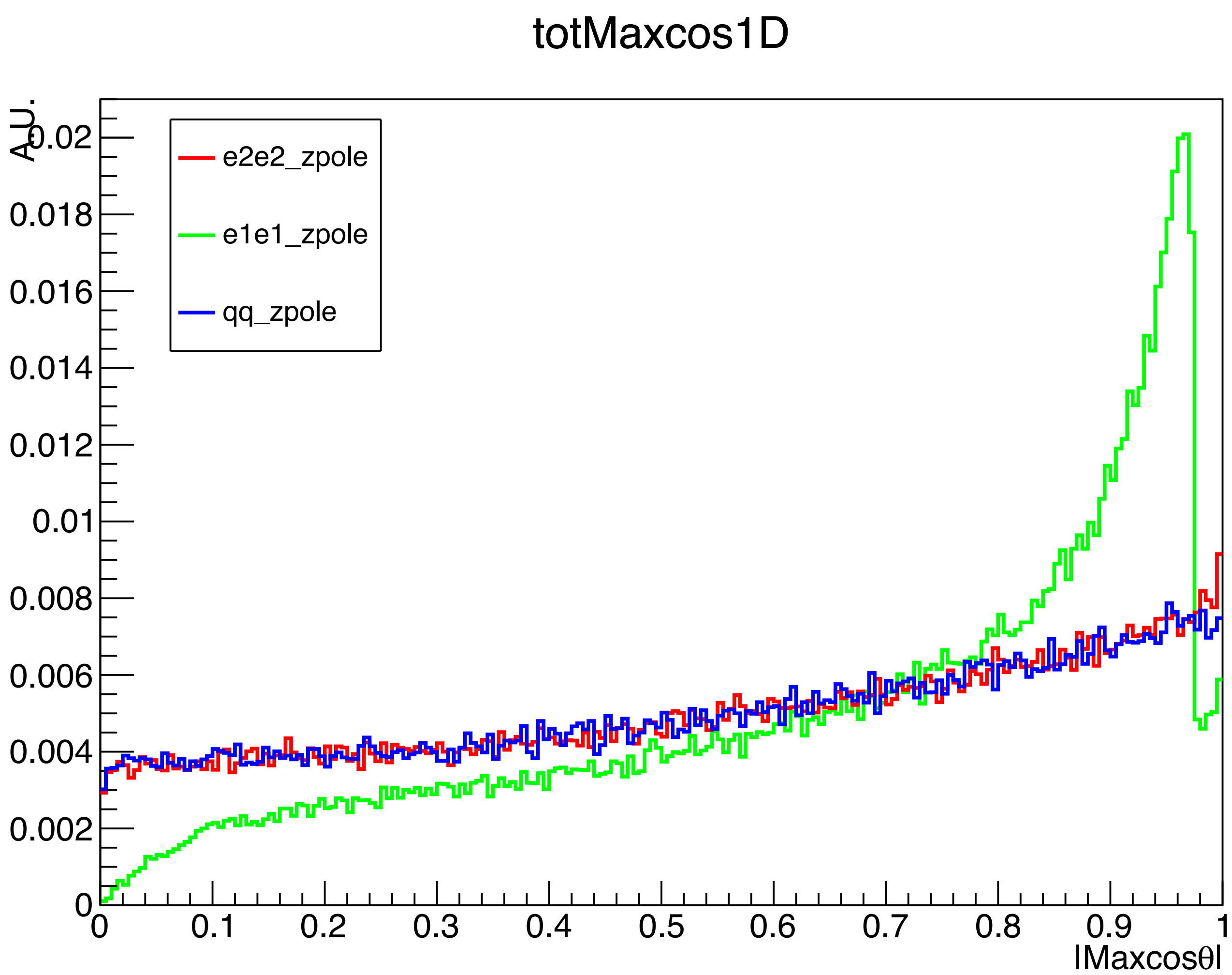


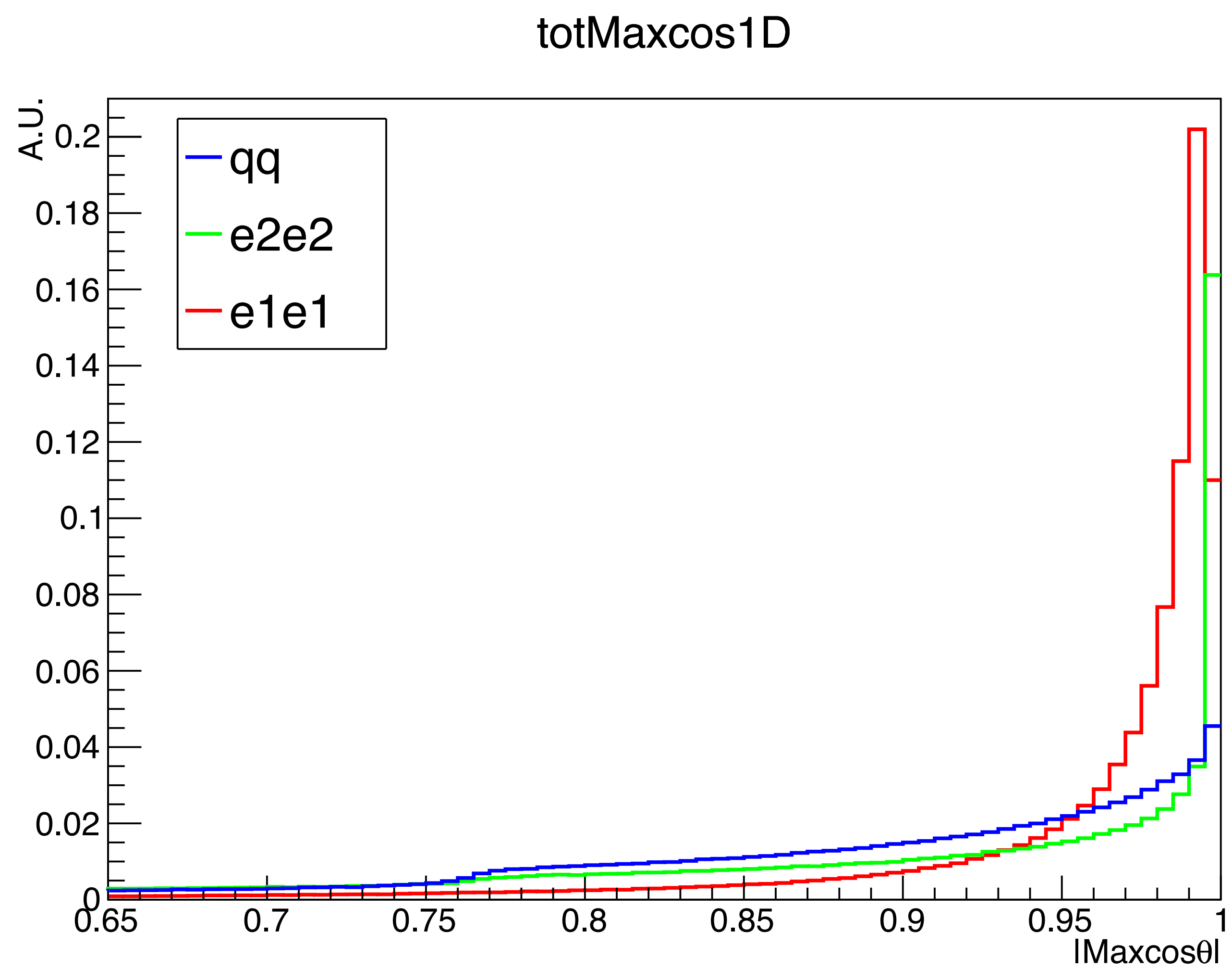



```
! Automatically generated set of cuts
! Process bhabha:
!     e a-e ->    e a-e gamma
!    16   8 ->    1   2     4
process bhabha
cut M of     3      within  1.00000E+01  1.00000E+99
cut M of     5      within  1.00000E+01  1.00000E+99
cut M of     6      within  1.00000E+01  1.00000E+99
cut M of    17      within -1.00000E+99 -1.00000E+01
cut M of    20      within -1.00000E+99 -1.00000E+01
cut M of    10      within -1.00000E+99 -1.00000E+01
cut M of    12      within -1.00000E+99 -1.00000E+01
```

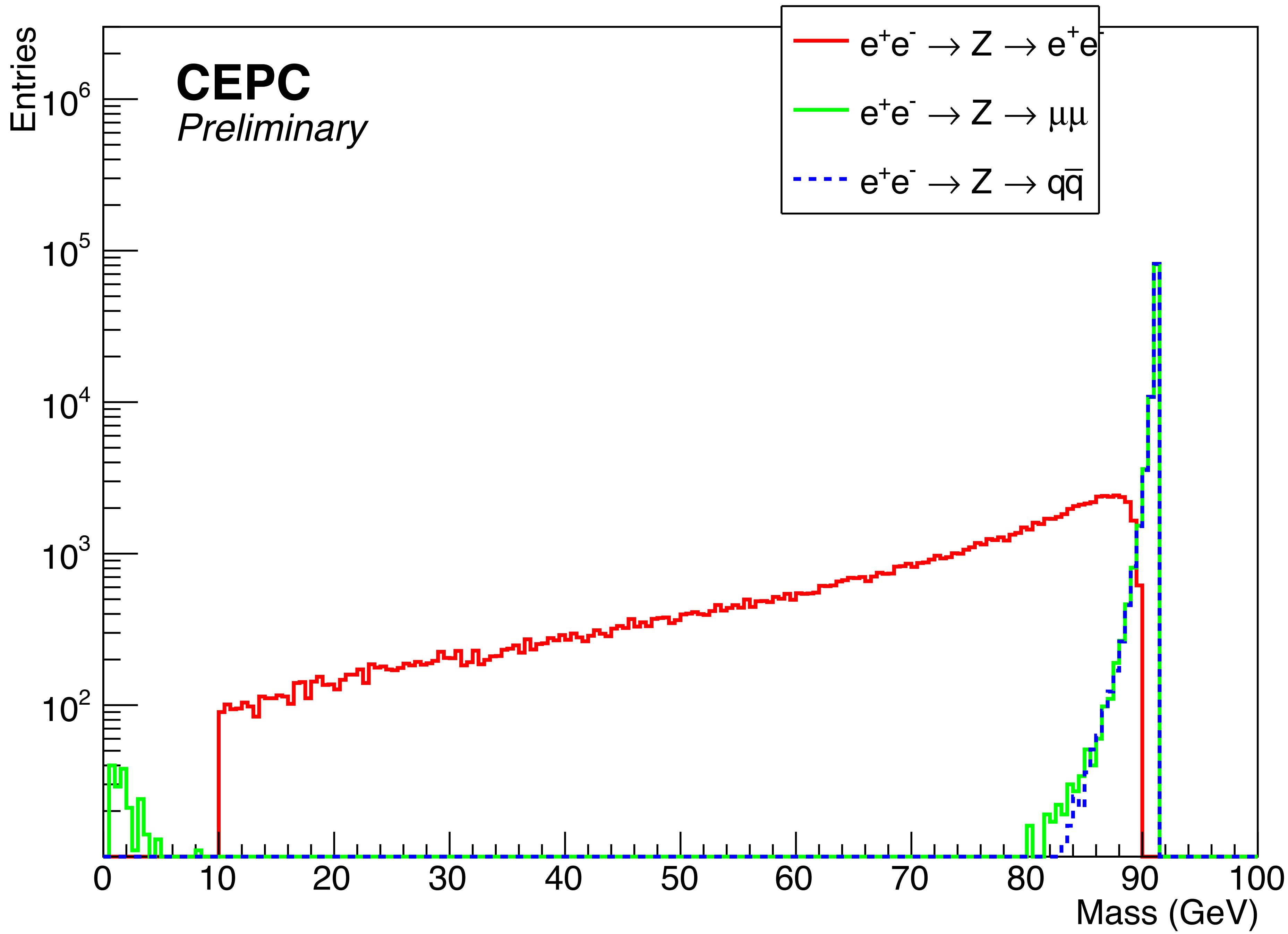
```
! Automatically generated set of cuts
! Process qq:
!     e a-e ->    u a-u
!     e a-e ->    d a-d
!     e a-e ->    s a-s
!     e a-e ->    c a-c
!     e a-e ->    b a-b
!     8   4 ->    1   2
process qq
cut M of     3      within  1.00000E+01  1.00000E+99
```

Background 2 Fermions v.s. Z Signal

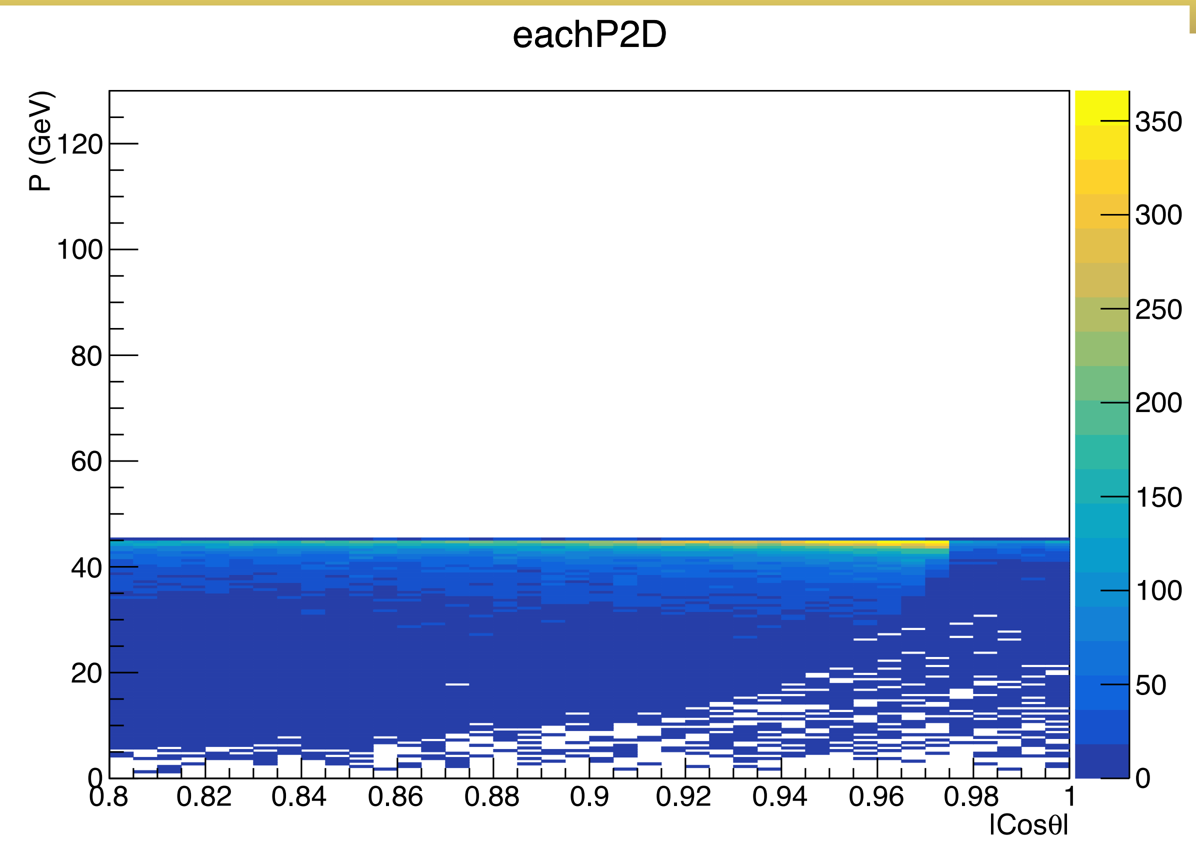


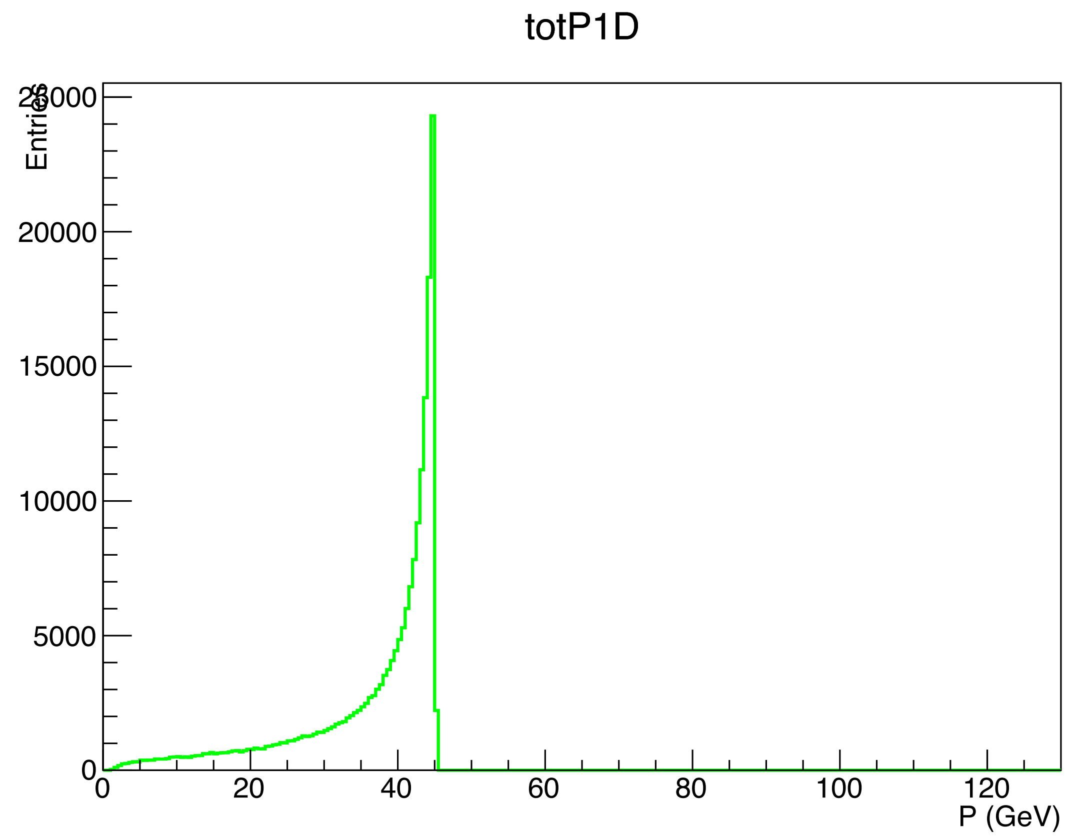


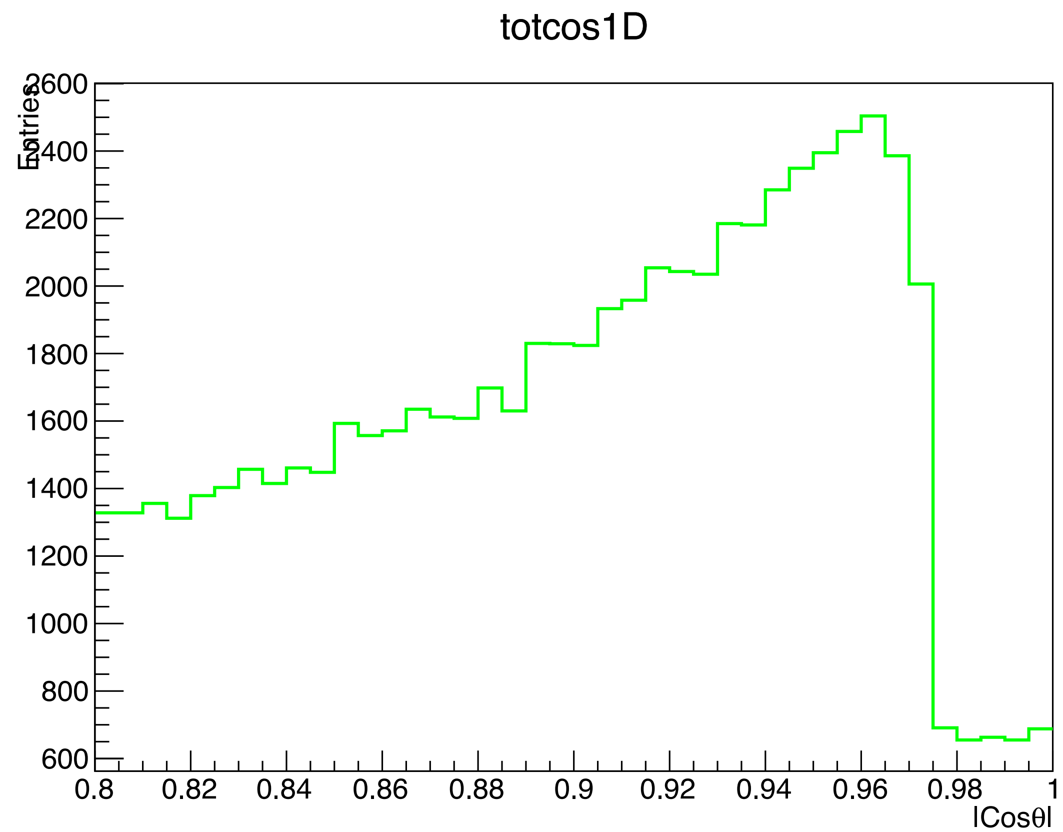
Z Boson Signal Mass Reconstruction



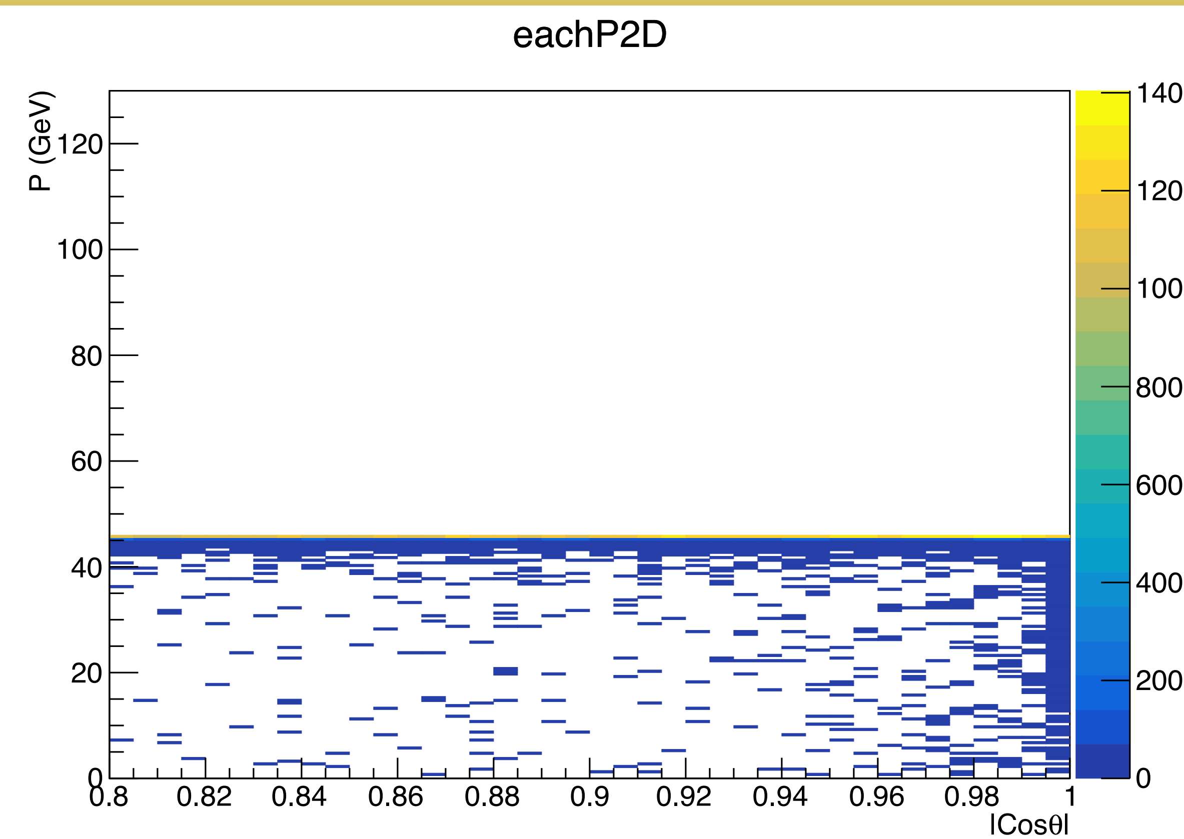
$e^+e^- \to Z \to e^+e^-$ Kinematic Distribution

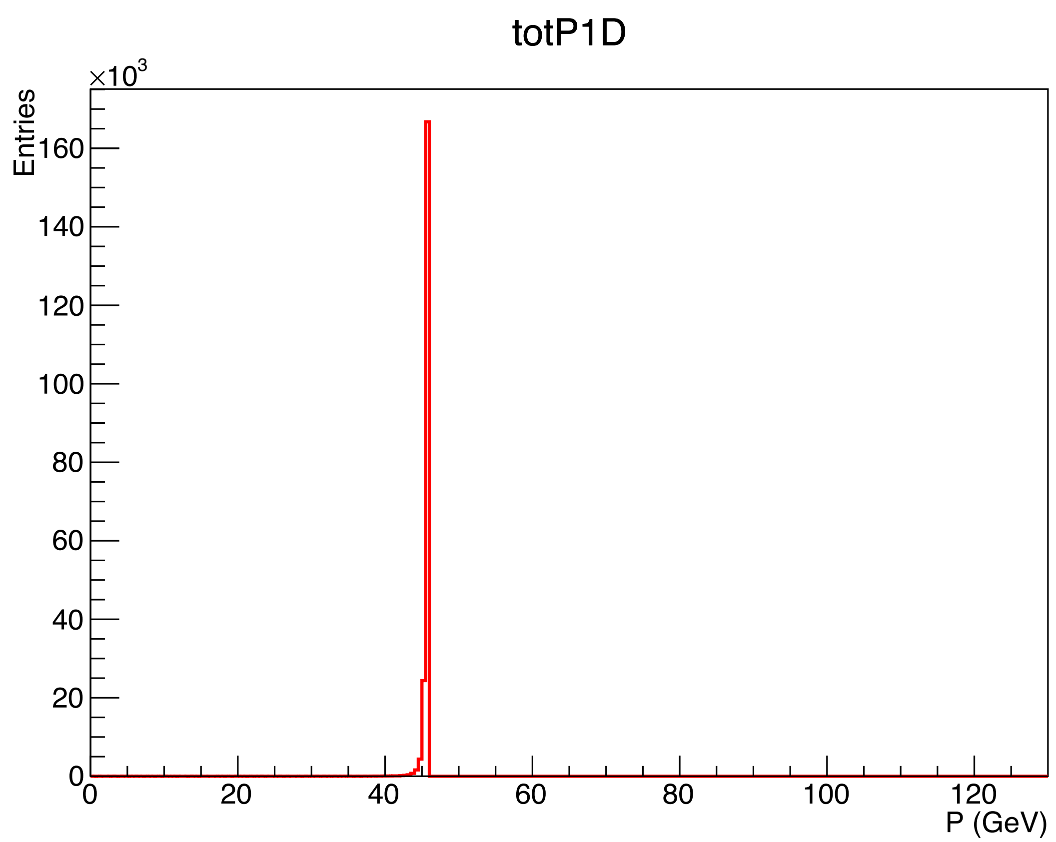


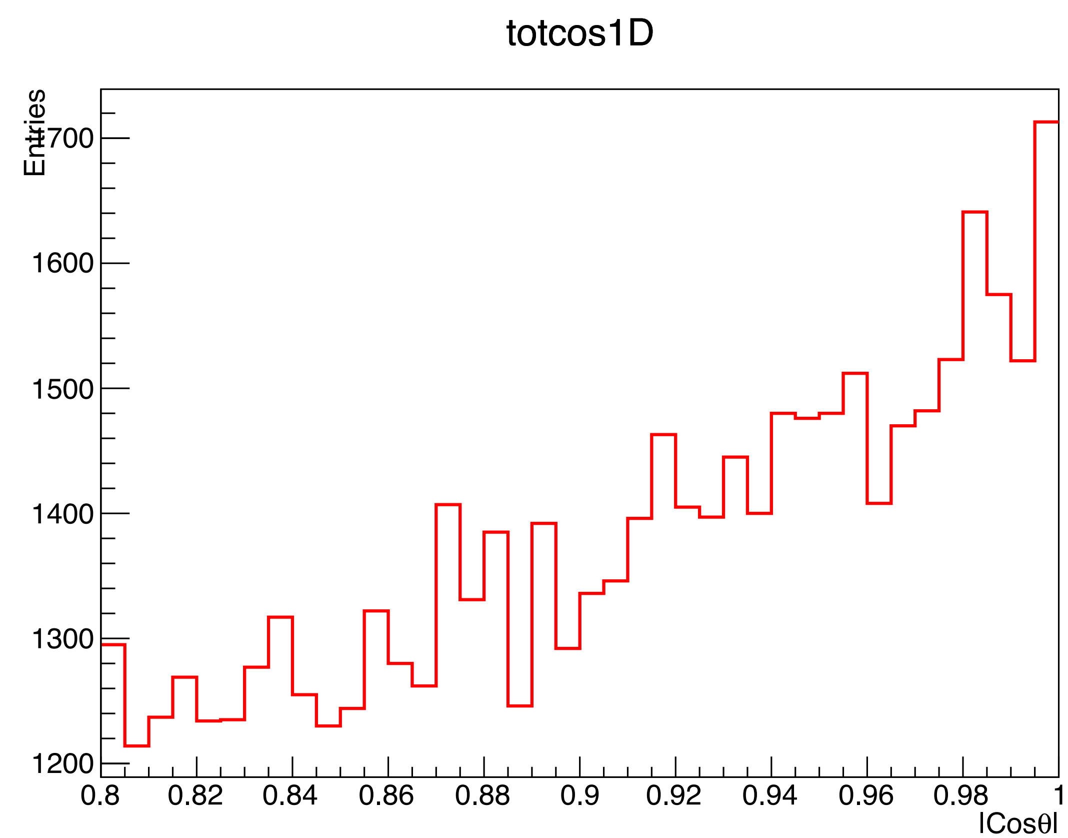




$e^+e^- \rightarrow Z \rightarrow \mu^+\mu^-$ Kinematic Distribution







$e^+e^- \rightarrow Z \rightarrow q\bar{q}$ Kinematic Distribution