ZZTO version 0.0

1 Description.

ZZTO is a newly created code for computing σ_{ZZ} which, at the moment, has has universal Initial State QED, Final State QED, Final State QCD, is fully massive with b and c quarks running masses. Fermion-Loop is also implemented.

ZZTO is missing non-universal QED ISR and purely weak effects (in DPA); however, it is under construction with the final goal of including those effects.

The code sums over all ZZ decay modes, even $\nu\nu\nu\nu$. However, single channels are available, i.e. $qqqq$, $qq\nu\nu$, qqll, ll$\nu\nu$, llll, $\nu\nu\nu\nu$. The main subroutine is

```
subroutine zzto(rs,zm,wm,zg,tqm,hm,alsz,ipm,irm,sig,esig)
```

where the I/O parameters are as follows:

rs $\sqrt{s}$ in GeV,

zm M_Z in GeV,

wm M_Z in GeV,

zg Γ_Z in GeV,

tqm m_t in GeV,

hm M_H in GeV,

alsz $\alpha_S(M_Z^2)$,

ipm number of points for the integration,

irm number of iterations for the integration,

sig cross-section in pb,

esig integration error on the cross-section.

2 Flags

ofl] [y/n , Default = 'n', Fermion-Loop scheme.

otop [f/d], Default = 'd'. Active when `ofl= 'y'`.

1. `otop = 'f'`, fixed top mass to be entered;
2. `otop = 'd'`, top mass derived from a consistency relation by the code.

`oqed` [y/n], Default = 'y'. ISR QED.

`oqedf` [y/n], Default = 'y'. FS QED.

`oqcdf` [y/n], Default = 'y'. FS QCD.

`oscheme` [g/a], Default = 'g'.

`oscheme = 'g'` , G_F scheme;

`oscheme = 'a'` , α scheme.

`ochan` Default = 'tota'.

1. `ochan = 'qqqq'` the $qqqq$ channel;
2. `ochan = 'qqnn'` the $qq\nu\nu$ channel;
3. `ochan = 'qqll'` the qqll channel;
4. `ochan = 'llnn'` the ll$\nu\nu$ channel;
5. `ochan = 'llll'` the llll channel;
6. `ochan = 'nnnn'` the $\nu\nu\nu\nu$ channel;
7. `ochan = 'tota'` the total.

`out` [y/n] Default = 'y'. I/O informations are printed.

Flags can be changed by calling

```
subroutine zztocflag(oflag,oval)
```

eg, `call zztocflag('ochan','qqqq')`. In the following we show the output create by running `ZZTODCK00`.

```
On exit IFAIL = 0


This run is with:

NPTS         =  4 (number of points)
NRAND        =  4 (random starts)



INPUT & derived parameters -------------------



E_cm (GeV) =          0.18000E+03
```

```
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
G_Z (GeV)  =          0.24974E+01


Running Z width

QED SF

FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included

number of calls      80044

LK failures           4060


sigma (pb)    =       0.1256801E+00   +-          0.1377670E-04

Rel. error of      0.011 %
```

```
On exit IFAIL = 0


This run is with:

NPTS        =  4 (number of points)
```

```
NRAND        =  4 (random starts)


INPUT & derived parameters --------------------


E_cm (GeV) =          0.18600E+03
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
G_Z (GeV)  =          0.24974E+01


Running Z width

QED SF

FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included

number of calls      80044

LK failures           4049


sigma (pb)    =       0.4993581E+00   +-          0.3812008E-05

Rel. error of      0.001 %


---------------------------------
```

```
On exit IFAIL = 0


This run is with:

NPTS         =  4 (number of points)
NRAND        =  4 (random starts)



INPUT & derived parameters -------------------



E_cm (GeV) =          0.19200E+03
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
G_Z (GeV)  =          0.24974E+01




Running Z width

QED SF

FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included

number of calls      80044

LK failures           4012


sigma (pb)    =       0.7979400E+00   +-          0.1037744E-04
```

```
Rel. error of      0.001 %



---------------------------------



On exit IFAIL = 0


This run is with:

NPTS         =  4 (number of points)
NRAND        =  4 (random starts)



INPUT & derived parameters -------------------



E_cm (GeV) =          0.19800E+03
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
G_Z (GeV)  =          0.24974E+01



Running Z width

QED SF

FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included
```

```
number of calls      80044

LK failures           3986


sigma (pb)    =       0.9583015E+00   +-          0.9829834E-05

Rel. error of      0.001 %
```

```
On exit IFAIL = 0


This run is with:

NPTS         =  4 (number of points)
NRAND        =  4 (random starts)


INPUT & derived parameters -------------------


E_cm (GeV) =          0.20400E+03
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
G_Z (GeV)  =          0.24974E+01


Running Z width

QED SF
```

```
FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included

number of calls      80044

LK failures           3938


sigma (pb)    =       0.1044809E+01   +-          0.6147278E-05

Rel. error of      0.001 %
```

```
On exit IFAIL = 0


This run is with:

NPTS         =  4 (number of points)
NRAND        =  4 (random starts)


INPUT & derived parameters -------------------


E_cm (GeV) =          0.21000E+03
M_W  (GeV) =          0.80350E+02 M_Z (GeV) =          0.91189E+02
```

```
G_Z (GeV)  =          0.24974E+01


Running Z width

QED SF

FS QED included

FS QCD included

G_F scheme

Total ZZ

nnnn included

number of calls      80044

LK failures           3897


sigma (pb)    =       0.1088875E+01   +-          0.1646176E-04

Rel. error of      0.002 %



--------------------------------


2266.64u 0.01s 37:47 99% 0+3k 0+12io 0pf+0w
```