LOOP INDUCED PROCESSES WITH MADGRAPH

October 7, 2012

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Status report

2. Gluon induced Weak Boson Pair Production

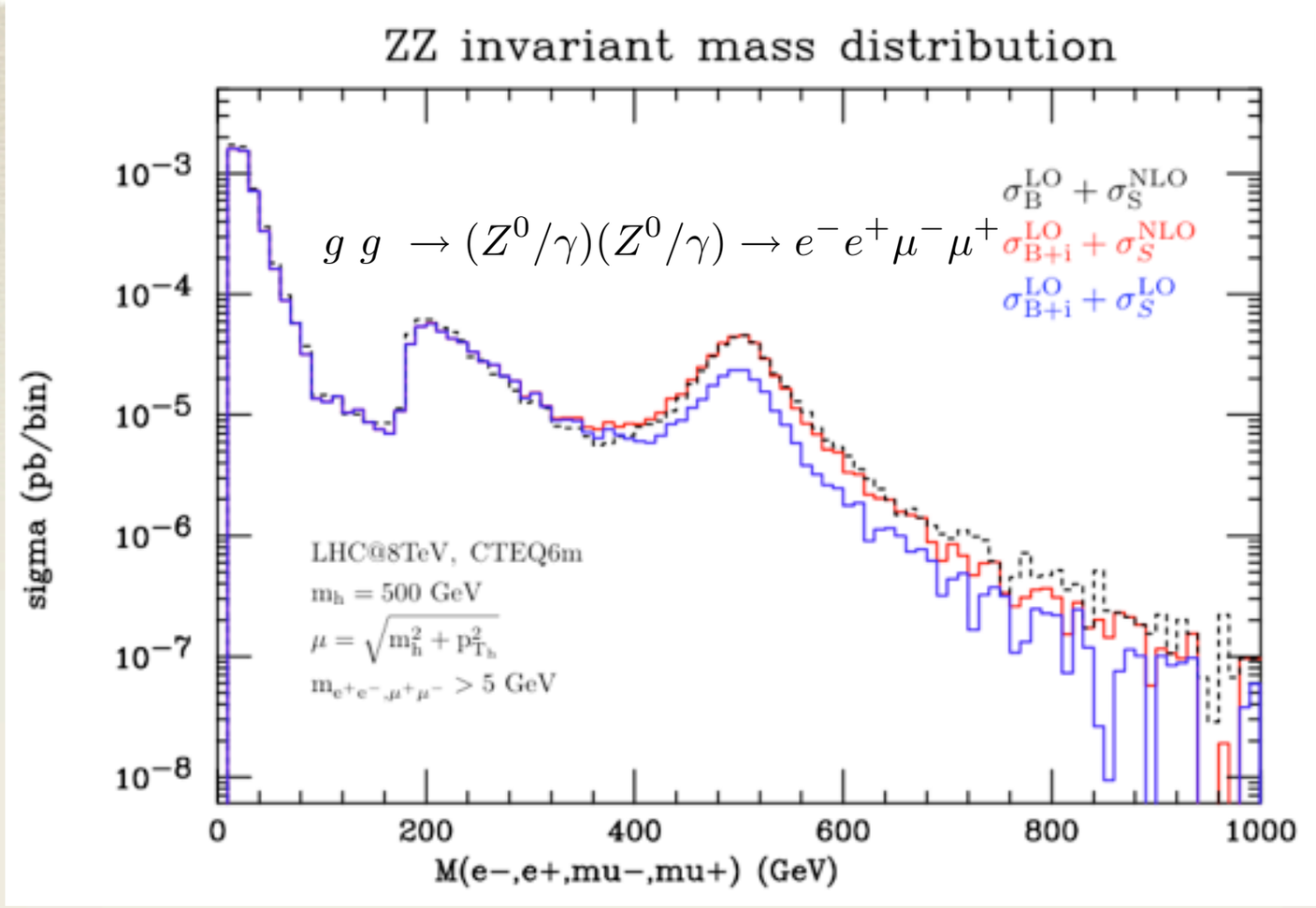
$$g\ g\ \rightarrow W^+W^- \rightarrow \nu_e e^+ \mu^- \overline{\nu}_\mu$$
$$g\ g\ \rightarrow (Z^0/\gamma)(Z^0/\gamma) \rightarrow e^- e^+ \mu^- \mu^+$$
$$g\ g\ \rightarrow (Z^0/\gamma) Z^0 \rightarrow e^- e^+ \nu_e \overline{\nu}_e$$

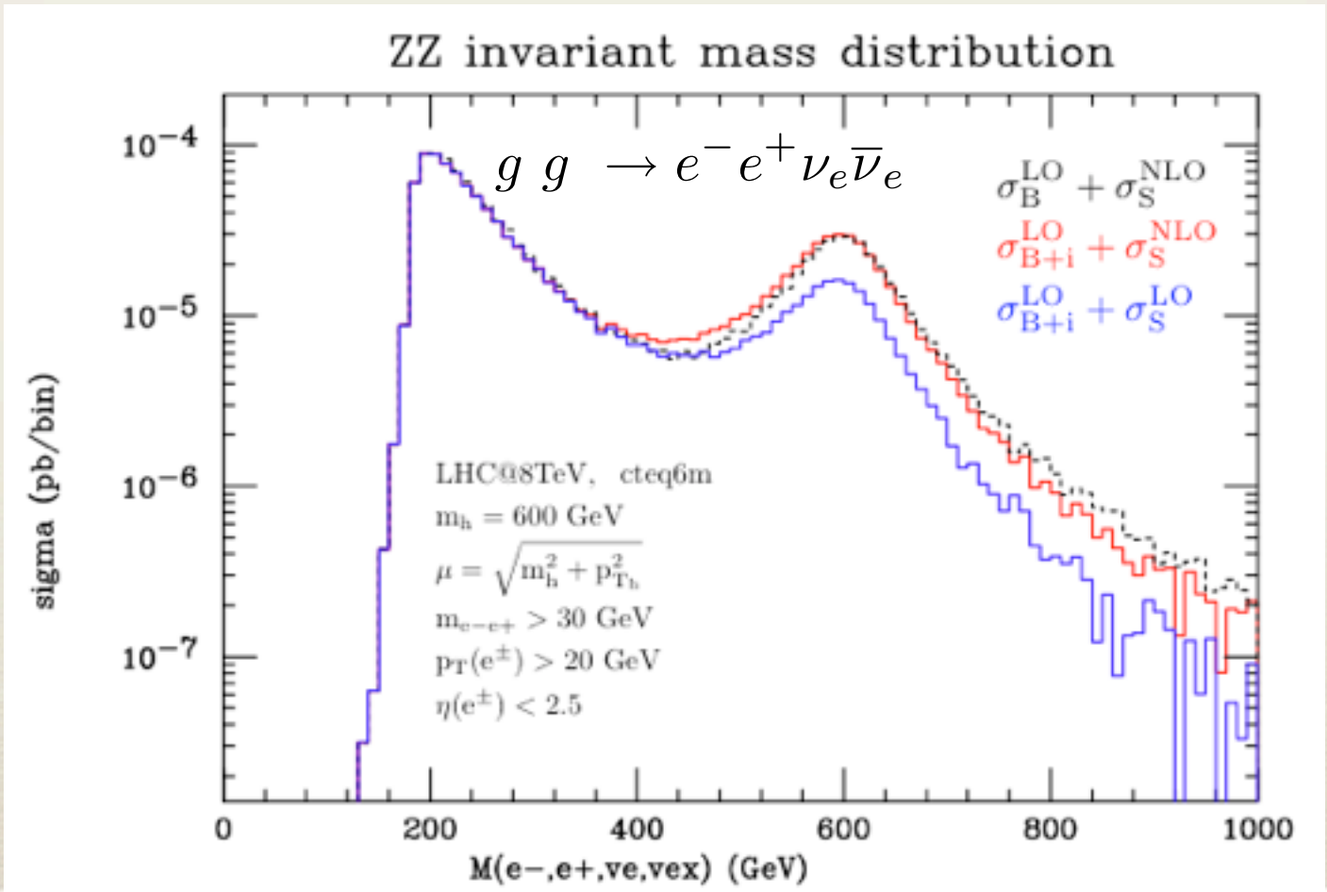
Codes available for :

$$\sigma^{LO}_{B+i+S} = |B|^2 + 2Re(B.S^*) + |S|^2$$
$$\sigma^{LO}_{B+i} = |B|^2 + 2Re(B.S^*)$$
$$\sigma^{NLO}_{S}, \quad \text{MC@NLO v4.09}$$

→ Negative weights = standard

http://cp3.irmp.ucl.ac.be/~alaureys/home.html


ZZ invariant mass distribution
$g\ g\ \to (Z^0/\gamma)(Z^0/\gamma) \to e^-e^+\mu^-\mu^+$
$\sigma_{\rm B}^{\rm LO} + \sigma_{\rm S}^{\rm NLO}$
$\sigma_{\rm B+i}^{\rm LO} + \sigma_{S}^{\rm NLO}$
$\sigma_{\rm B+i}^{\rm LO} + \sigma_{S}^{\rm LO}$
LHC@8TeV, CTEQ6m
$m_h = 500$ GeV
$\mu = \sqrt{m_h^2 + p_{T_h}^2}$
$m_{e^+e^-,\mu^+\mu^-} > 5$ GeV
sigma (pb/bin)
M(e−,e+,mu−,mu+) (GeV)


ZZ invariant mass distribution
$g\ g\ \to e^-e^+\nu_e\overline{\nu}_e$
$\sigma_{\rm B}^{\rm LO} + \sigma_{\rm S}^{\rm NLO}$
$\sigma_{\rm B+i}^{\rm LO} + \sigma_{S}^{\rm NLO}$
$\sigma_{\rm B+i}^{\rm LO} + \sigma_{S}^{\rm LO}$
LHC@8TeV, cteq6m
$m_h = 600$ GeV
$\mu = \sqrt{m_h^2 + p_{T_h}^2}$
$m_{e^-e^+} > 30$ GeV
$p_T(e^\pm) > 20$ GeV
$\eta(e^\pm) < 2.5$
sigma (pb/bin)
M(e−,e+,ve,vex) (GeV)

Prospects

$$g\ g\ \rightarrow W^+W^- \rightarrow \nu_e e^+ \mu^- \overline{\nu}_\mu$$
$$g\ g\ \rightarrow (Z^0/\gamma)(Z^0/\gamma) \rightarrow e^- e^+ \mu^- \mu^+$$
$$g\ g\ \rightarrow (Z^0/\gamma) Z^0 \rightarrow e^- e^+ \nu_e \overline{\nu}_e$$

1. Detailed analysis of W+W- channel
2. Four same flavor lepton production

3. Form facors : H → Z°* γ

Analytic formulae are known :
Nucl. Phys. B259 (1985) , hep-ph/0503172v2

lorentz.py :

```
VVS3 = Lorentz(name = 'VVS3',
               spins = [ 3, 3, 1 ],
               structure = 'GGH*P(1,2)*P(2,1) - GGH*P(-1,1)*P(-1,2)*Metric(1,2)',
               formfactors = [ ForFac.GGH ])

VVS5 = Lorentz(name = 'VVS5',
               spins = [ 3, 3, 1 ],
               structure = 'HZA*P(1,2)*P(2,1) - HZA*P(-1,1)*P(-1,2)*Metric(1,2)',
               formfactors = [ ForFac.HZA ])
```

formfactors.py :

```
GGH = FormFactor(name = 'GGH',
                 type = 'complex',
                 value = '(0.75*(4.*MT*MT/(2.*P(-1,1)*P(-1,2)))*(2.+2.*(1.-4.*MT*M

HZA = FormFactor(name = 'HZA',
                 type = 'complex',
                 value = '2./3.*(3.-8.*SW2)/4./SW/CW*(1./2./((P(-5,3)**2)/4./MT/MT
```

The user is allowed to use a theta function :

$$\theta(x,y,z) \quad = \quad \begin{array}{l} \text{y if x} > 0, \\ \text{z if x} < 0 \end{array}$$

The user can use any other function, but will have to define it himself or link the needed libraires.

1. Two different analytical results cross checked
2. Numerical result cross checked with HDECAY (M. Spira)
3. +-3% difference with *Handbook for LHC Higgs cross sections*