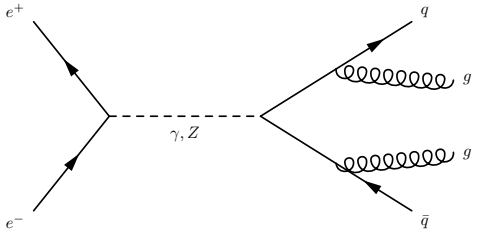
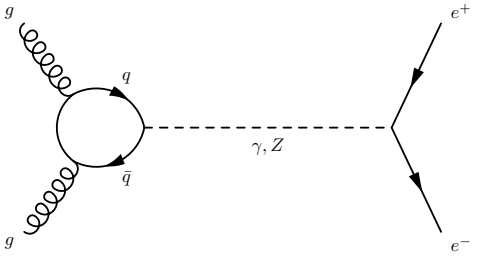
1 SM and beyond: Allowed, forbidden and discovery process

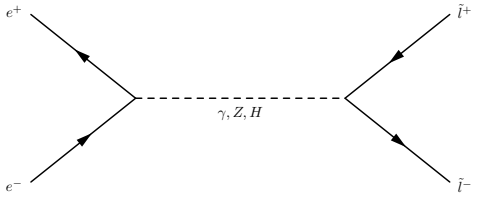
1. 1.
   - Electromagnetic
     - 1, 2, 3, 4, 6, 8, 11, 12, 13, 14, 15, 16, 20
   - Weak
     - 5, 7, 10, 13, 18, 19
   2. Particle decay, lifetime and branching
   3. Conservation laws, suppression, etc.
   4. process 3,4,8,10,11, 14 and 18 more important



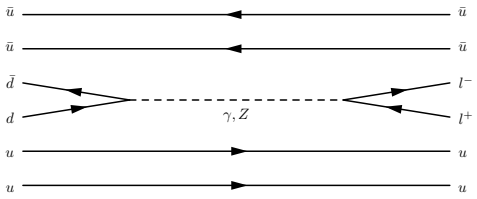
(1) $e^+e^- \to q\bar{q}gg$



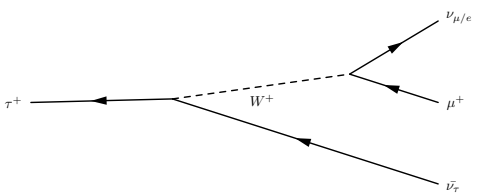
(2) $gg \to e^+e^-$



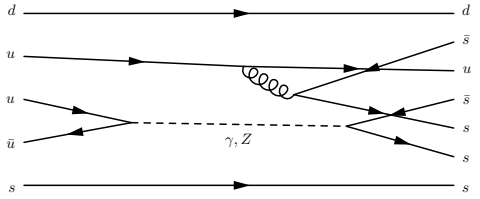
(3) $e^+e^- \to \tilde{l}^+\tilde{l}^-$



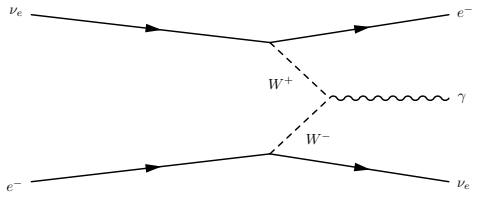
(4) $p\bar{p} \to l^+l^-x$



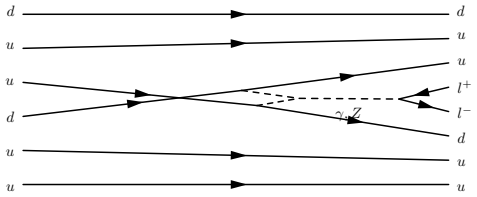
(5) $\tau^+ \to \mu^+\bar{\nu}_\tau\nu_{e/\mu}$



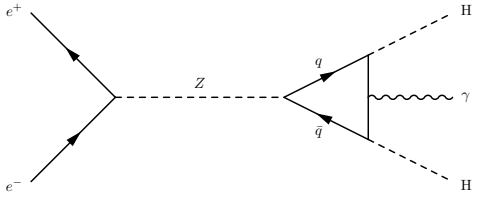
(6) $k^-p \to \omega^-k^+k^0$



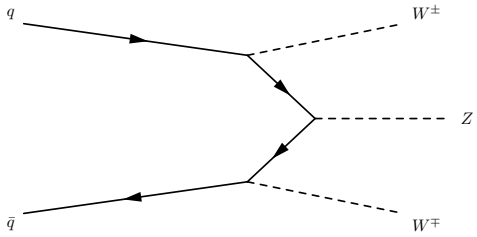
(7) $e^-\nu_e \to \nu_e\gamma e^-$



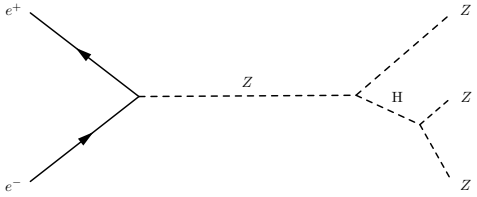
(8) $pp \to ppl^+l^-$



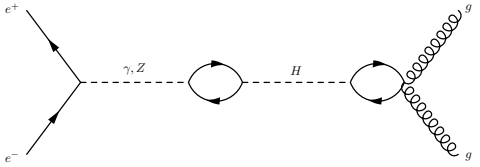
(9) $e^-e^+ \to \gamma HH$



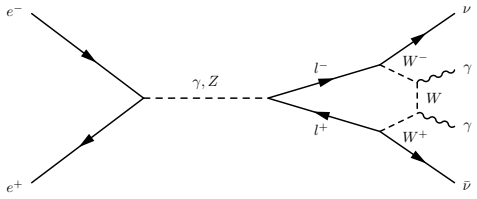
(10) $qq \to W^\pm W^\mp Z$



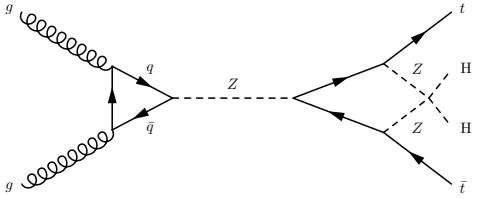
(11) $e^-e^+ \to ZZ$



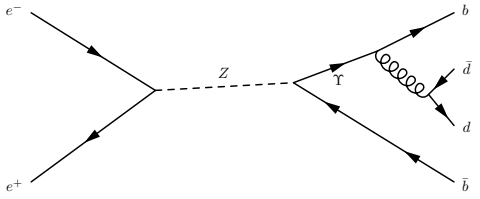
(12) $e^-e^+ \to H \to gg$



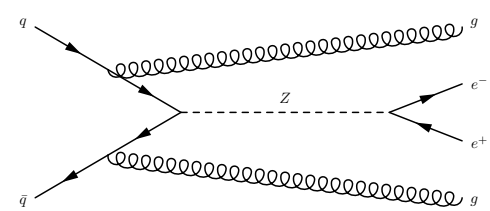
(13) $e^+e^- \to \nu\bar{\nu}\gamma\gamma$



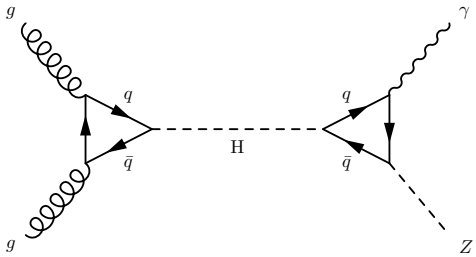
(14) $gg \to t\bar{t}HH$



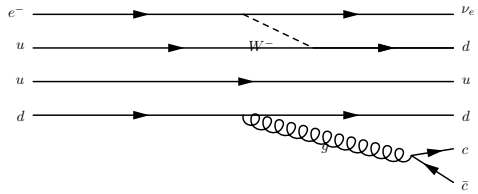
(15) $e^+e^- \to \Upsilon(3s) \to B^0\bar{B}^0$



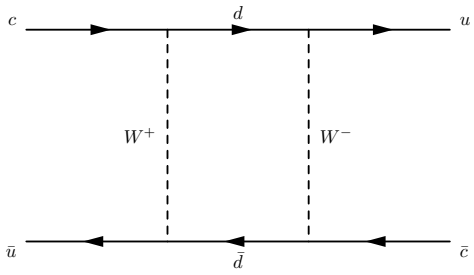
(16) $q\bar{q} \to gge^-e^+$



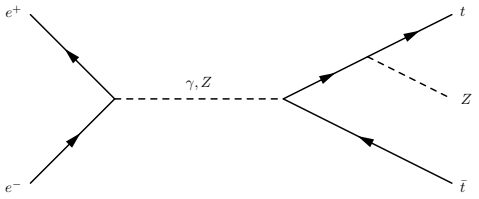
(17) $gg \to Z\gamma$



(18) $gg \to t\bar{t}HH$



(1) $D^0 \longleftrightarrow \bar{D}^0$



(2) $e^+e^- \to t\bar{t}Z$

2 Top quark and W boson

1. The CKM-matrix is a unitary matrix where each element holds information about the strength of the flavour changing weak deacys which happens between quarks. These changes are mediated with the $W^{\pm}$ boson. When four quarks were discovered it was created two sets of equation describing the decay from down and strange into top and charm. Seeing that with CP-violation could not be explained with these four quarks, they added another generation to create the CKM-matrix:

$$\begin{bmatrix} d' \\ s' \\ b' \end{bmatrix} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} \begin{bmatrix} d \\ s \\ b \end{bmatrix} \tag{1}$$

   The W boson is a mediater of the weak force, it has either $+1$ or -1 charge so it can react with charged particles. In regards to the CKM-matrix it is the mediator for decaying quarks between up and down types as well as changing flavours.

   1. V_{ud} can be experimentally shown from the ration between netron decay and μ decay.
      V_{us} is shown in the $K^+ \to \pi^0 e^+ \nu_e$ decay proceAss.
      V_{cs} is experimentally shown in hadronic decays of $W^{\pm}$ and $D \to \bar{K} e^+ \nu_e$ process.

2. 1. For the electron-positron annihilation, the $e^- e^+ \to W^- t\bar{b}$ process requires high energy input because of the large difference in masses from starting to resulting particles. Which is more difficult for linear colliders to achieve. For the proton-proton collision these energies are easier to reach because of the circular colliders. The proton-antiproton collisions provide even more energies due to the annihilation of particles, but experimentally harder to accelerate to high energies.
   2.

3. 1.
   2. 1.
      2.
   3. 1.

4.

3 Gauge theories