

# Feynmf examples

September 20, 2013

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## 1 Saving code


Click on the paperclip  to save a piece of code.

## 2 Compiling

You must have the preamble:


```
\usepackage{feynmp}  
\DeclareGraphicsRule{.1}{mps}{*}{}{}
```

You must run `pdflatex` or `latex`, then `mpost` on the intermediate `*.mp`

files, then `pdflatex` or `latex`. To make this document:  `make.sh`

```
pdflatex Example.tex  
for f in *.mp;  
do  
    if [ "$f" = "feynmp.mp" ] ; then continue; fi  
    mpost $f  
done  
pdflatex Example.tex  
pdflatex Example.tex
```

## 3 Macros

I use the following macros in my figure labels:  `Macros.tex`

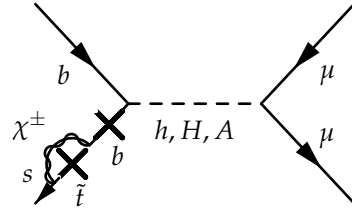
```
\makeatletter  
\newcommand{\s}[1]{%  
\@ifnextchar [{\s@i{#1}}{\s@i{#1}[]}]%  
}  
\def\s@i#1[#2]{%  
\@ifnextchar [{\s@ii{#1}[]}]{\s@ii{#1}[]}]%  
}  
\def\s@ii#1[#2][#3]{%  
\ensuremath{\tilde{#1}_{#2}^{#3}}%  
}  
\makeatother  
\newcommand{\neut}[1][\ensuremath{\chi_{#1}^0}]  
\newcommand{\charg}[1][\ensuremath{\chi_{#1}^{\pm}}]  
\newcommand{\gluino}{\s{g}}  
\newcommand{\bsb}{\ensuremath{\oversymb{B}_s}}  
\newcommand{\bs}{\ensuremath{B_s}}  
\newcommand{\damu}{\ensuremath{\delta a_\mu}}  
\newcommand{\bsg}{\ensuremath{b\to s \gamma}}  
\newcommand{\bsmumu}{\ensuremath{\bs\to\mu^+\mu^-}}  
\newcommand{\bbmix}{\ensuremath{\bsb\text{\emdash}\bs}}  
\newcommand{\butaunu}{\ensuremath{B_u\to\tau\nu}}  
\newcommand{\dmb}{\ensuremath{\Delta M_{\bs}}}
```

## 4 $B_s \rightarrow \mu^+ \mu^-$



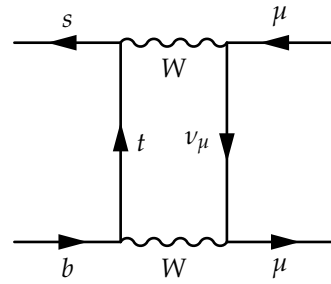
BToMuMu\_MSSM.tex

```
\begin{fmffile}{BToMuMu_MSSM}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2,i3}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v1,v6,o2}
\fmffreeze
\fmf{fermion, label=$b$}{i3,v1}
\fmf{fermion, label=$s$}{v2,i1}
\fmf{fermion, label=$\mu$, label.pos=right,
label.dist=-14}{v6,o1}
\fmf{fermion, label=$\mu$, label.pos=right
}{o3,v6}
\fmf{gaugino, label=$\chi^\pm$, label.dist=3,
left, tension=0.05}{v2,v3}
\fmf{dashes, label=$s\{t\}$, label.pos=right
}{v2,v4}
\fmf{dashes}{v4,v3}
\fmfct{v4}
\fmf{plain, label=$b$, label.pos=right}{v3,
v5}
\fmf{plain}{v5,v1}
\fmfct{v5}
\fmf{dashes, label=$h,,H,,A$, tension=0.5}{
v1,v6}
\end{fmfgraph*}
\end{fmffile}
```



BToMuMu\_SM\_Box.tex

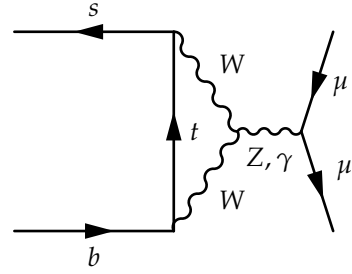
```
\begin{fmffile}{BToMuMu_SM_Box}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,v3,o1}
\fmffreeze
\fmf{phantom}{i2,v2,v4,o2}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{fermion, label=$s$}{v2,i2}
\fmf{fermion, label=$\mu$}{v3,o1}
\fmf{fermion, label=$\mu$}{o2,v4}
\fmf{fermion, label=$t$}{v1,v2}
\fmf{fermion, label=$\nu_\mu$}{v4,v3}
\fmf{boson, label=$W$}{v1,v3}
\fmf{boson, label=$W$}{v2,v4}
\end{fmfgraph*}
\end{fmffile}
```





BToMuMu\_SM\_Penguin.tex

```
\begin{fmffile}{BToMuMu_SM_Penguin}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o2}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{fermion, label=$s$}{v2,i2}
\fmf{fermion, label=$\mu$, label.pos=right,
label.dist=-14}{v4,o1}
\fmf{fermion, label=$\mu$, label.pos=right
}{o2,v4}
\fmf{fermion, label=$t$, label.pos=right}{v
1,v2}
\fmf{boson, label=$W$, tension=0.5}{v1,v3,v
2}
\fmf{boson, label=$Z$,,\gamma}{v3,v4}
\end{fmfgraph*}
\end{fmffile}
```

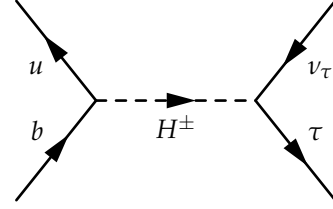


## 5 $B_u \rightarrow \tau \nu$



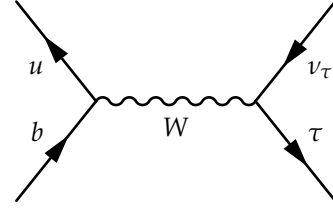
BToTauNu\_Hpm.tex

```
\begin{fmffile}{BToTauNu_Hpm}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{fermion,label=$b$,label.side=left}{i1,v1}
\fmf{fermion,label=$u$,label.side=left}{v1,i2}
\fmf{scalar,label=$H^{\pm}$}{v1,v2}
\fmf{fermion,label=$\nu_{\tau}$,label.side=left}{o1,v2}
\fmf{fermion,label=$\tau$,label.side=left}{v2,o2}
\end{fmfgraph*}
\end{fmffile}
```



BToTauNu\_W.tex

```
\begin{fmffile}{BToTauNu_W}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{fermion,label=$b$,label.side=left}{i1,v1}
\fmf{fermion,label=$u$,label.side=left}{v1,i2}
\fmf{boson,label=$W$}{v1,v2}
\fmf{fermion,label=$\nu_{\tau}$,label.side=left}{o1,v2}
\fmf{fermion,label=$\tau$,label.side=left}{v2,o2}
\end{fmfgraph*}
\end{fmffile}
```

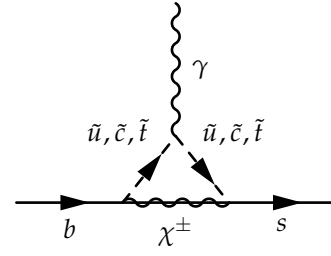


## 6 $b \rightarrow s\gamma$



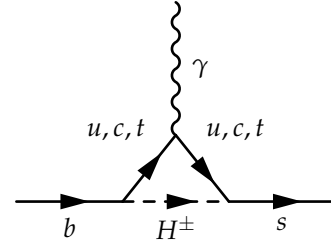
BToXsGamma\_MSSM\_Chargino.tex

```
\begin{fmffile}{BToXsGamma_MSSM_Chargino}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{gaugino, label=$\text{\charc}$}{v1,v2}
\fmf{fermion, label=$s$}{v2,o1}
\fmf{scalar, label=$\text{\s{u}},,\text{\s{c}},,\text{\s{t}}$,
label.dist=-30.0, label.pos=right}{v1,v
3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```



BToXsGamma\_MSSM\_H.tex

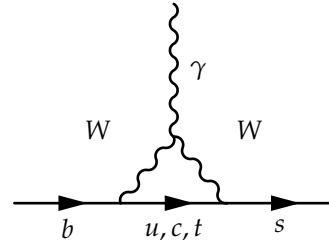
```
\begin{fmffile}{BToXsGamma_MSSM_H}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{scalar, label=$H^{\pm}$}{v1,v2}
\fmf{fermion, label=$s$}{v2,o1}
\fmf{fermion, label=$u,c,t$, label.dist
=-30.0, label.pos=right}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```





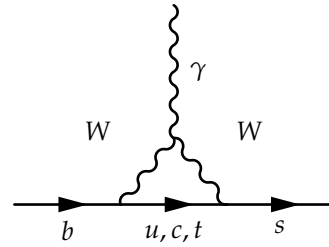
BToXsGamma\_SM\_WLoop.tex

```
\begin{fmffile}{BToXsGamma_SM_WLoop}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{fermion, label=$u,,c,,t$}{v1,v2}
\fmf{fermion, label=$s$}{v2,o1}
\fmf{boson, label=$W$, label.dist=-30.0,
    label.pos=right}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```



BToXsGamma\_SM\_W.tex

```
\begin{fmffile}{BToXsGamma_SM_W}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$b$}{i1,v1}
\fmf{fermion, label=$u,,c,,t$}{v1,v2}
\fmf{fermion, label=$s$}{v2,o1}
\fmf{boson, label=$W$, label.dist=-30.0,
    label.pos=right}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```

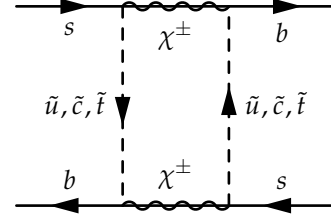


## 7 $\Delta M_{B_s}$



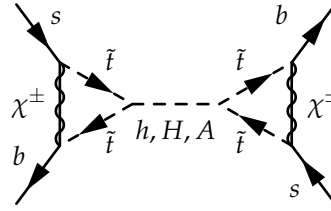
DMBs\_Box\_Chargino.tex

```
\begin{fmffile}{DMBs_Box_Chargino}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,v3,o1}
\fmffreeze
\fmf{phantom}{i2,v2,v4,o2}
\fmffreeze
\fmf{fermion, label=$b$}{v1,i1}
\fmf{fermion, label=$s$}{i2,v2}
\fmf{gaugino, label=\charg}{v3,v1}
\fmf{gaugino, label=\charg}{v2,v4}
\fmf{scalar, label=$\s{u},\s{c},\s{t}$}{v2,v1}
\fmf{scalar, label=$\s{u},\s{c},\s{t}$}{v3,v4}
\fmf{fermion, label=$s$}{o1,v3}
\fmf{fermion, label=$b$}{v4,o2}
\end{fmfgraph*}
\end{fmffile}
```



DMBs\_Box\_DoublePenguin.tex

```
\begin{fmffile}{DMBs_Box_DoublePenguin}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{fermion, label=$b$}{v1,i1}
\fmf{fermion, label=$s$}{i2,v2}
\fmf{gaugino, label=$\charg$, tension=0.4,
label.dist=-18}{v1,v2}
\fmf{scalar, label=$\s{t}$, tension=0.6,
label.dist=-15}{v2,v3,v1}
\fmf{dashes, label=$h,H,A$}{v3,v4}
\fmf{scalar, label=$\s{t}$, tension=0.6,
label.dist=-15}{v5,v4,v6}
\fmf{gaugino, label=$\charg$, tension=0.4,
label.dist=6}{v5,v6}
\fmf{fermion, label=$s$,label.dist=6}{o1,v5}
\fmf{fermion, label=$b$,label.dist=-18}{v6,o2}
\end{fmfgraph*}
\end{fmffile}
```

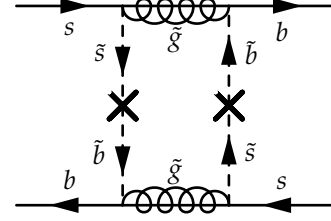






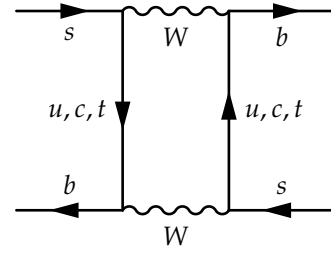
DMBs\_Box\_Gluino.tex

```
\begin{fmffile}{DMBs_Box_Gluino}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,v3,o1}
\fmffreeze
\fmf{phantom}{i2,v2,v4,o2}
\fmffreeze
\fmf{fermion, label=$b$}{v1,i1}
\fmf{fermion, label=$s$}{i2,v2}
\fmf{gluino, label=$\tilde{g}$, label.dist=8,
label.side=right}{v3,v1}
\fmf{gluino, label=$\tilde{g}$, label.dist=8,
label.side=right}{v2,v4}
\fmf{scalar, label=$\tilde{s}$}{v2,v5}
\fmf{scalar, label=$\tilde{b}$}{v5,v1}
\fmfct{v5}
\fmf{scalar, label=$\tilde{s}$}{v3,v6}
\fmf{scalar, label=$\tilde{b}$}{v6,v4}
\fmfct{v6}
\fmf{fermion, label=$s$}{o1,v3}
\fmf{fermion, label=$b$}{v4,o2}
\end{fmfgraph*}
\end{fmffile}
```



DMBs\_Box\_WbyW.tex

```
\begin{fmffile}{DMBs_Box_WbyW}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,v3,o1}
\fmffreeze
\fmf{phantom}{i2,v2,v4,o2}
\fmffreeze
\fmf{fermion, label=$b$}{v1,i1}
\fmf{fermion, label=$s$}{i2,v2}
\fmf{fermion, label=$u, c, t$}{v2,v1}
\fmf{boson, label=$W$}{v1,v3}
\fmf{boson, label=$W$}{v2,v4}
\fmf{fermion, label=$u, c, t$}{v3,v4}
\fmf{fermion, label=$s$}{o1,v3}
\fmf{fermion, label=$b$}{v4,o2}
\end{fmfgraph*}
\end{fmffile}
```



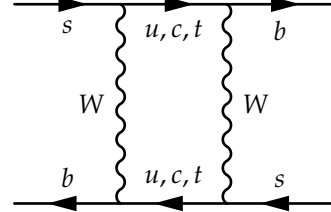


DMBs\_Box\_W.tex

```

\begin{fmffile}{DMBs_Box_W}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,v3,o1}
\fmffreeze
\fmf{phantom}{i2,v2,v4,o2}
\fmffreeze
\fmf{fermion, label=$b$}{v1,i1}
\fmf{fermion, label=$s$}{i2,v2}
\fmf{fermion, label=$u,c,t$}{v3,v1}
\fmf{fermion, label=$u,c,t$}{v2,v4}
\fmf{boson, label=$W$}{v2,v1}
\fmf{boson, label=$W$}{v3,v4}
\fmf{fermion, label=$s$}{o1,v3}
\fmf{fermion, label=$b$}{v4,o2}
\end{fmfgraph*}
\end{fmffile}

```



## 8 Golden decay

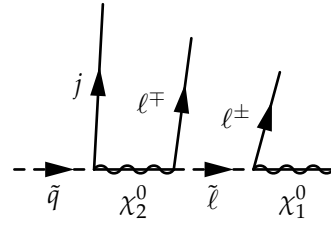


GoldenDecay.tex

```

\begin{fmffile}{GoldenDecay}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2,i3,i4}
\fmfright{o1,o2,o3,o4}
\fmf{phantom}{i1,v1,v2,v3,o1}
\fmffreeze
\fmf{phantom}{i4,v4,v5,v6,o2}
\fmffreeze
\fmf{scalar, label=$s_q$}{i1,v1}
\fmf{fermion, label=$j$}{v1,v4}
\fmf{phantom}{v4,o4}
\fmf{gaugino, label=$\neut[2]$}{v1,v2}
\fmf{fermion, label=$\ell^{\mp}$, label.side=left}{v2,v5}
\fmf{phantom}{v5,o3}
\fmf{scalar, label=$s_{\ell}$}{v2,v3}
\fmf{fermion, label=$\ell^{\pm}$, label.side=left}{v3,v6}
\fmf{phantom}{v6,o2}
\fmf{gaugino, label=$\neut[1]$}{v3,o1}
\end{fmfgraph*}
\end{fmffile}

```

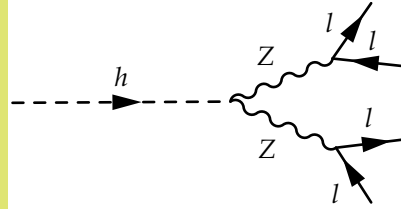


## 9 Higgs decay



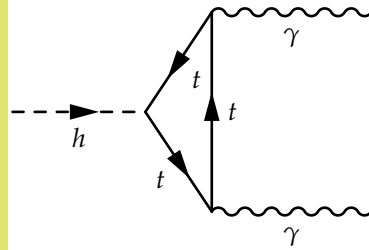
HiggsDecay\_FourL.tex

```
\begin{fmffile}{HiggsDecay_FourL}
\begin{fmfgraph*}(150,75)
\fmfleft{i1}
\fmfright{o1,o2,o3,o4}
\fmf{scalar, label=$h$}{i1,v2}
\fmf{boson, label=$Z$}{v1,v2,v3}
\fmf{phantom, tension=0.1}{v2,v3}
\fmfstraight
\fmf{phantom, tension=0.1}{o1,o2,o3,o4}
\fmf{fermion, label=$l$}{o1,v1,o2}
\fmf{fermion, label=$l$, label.dist=-12.0}{o3,v3,o4}
\end{fmfgraph*}
\end{fmffile}
```



HiggsDecay\_TwoGamma.tex

```
\begin{fmffile}{HiggsDecay_TwoGamma}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2,i3}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i3,v2,o2}
\fmffreeze
\fmf{scalar, label=$h$}{i2,v3}
\fmf{fermion, label=$t$}{v1,v2,v3,v1}
\fmf{boson, label=$\gamma$}{v1,o1}
\fmf{boson, label=$\gamma$}{v2,o2}
\end{fmfgraph*}
\end{fmffile}
```

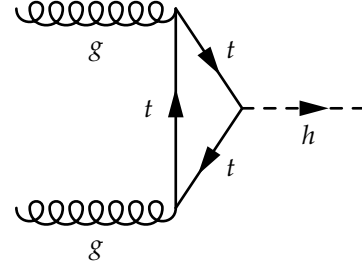


## 10 Higgs production



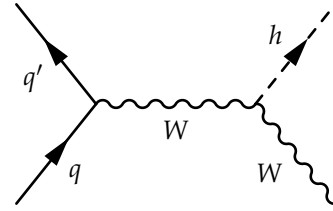
HiggsProduction\_GluonFusion.tex

```
\begin{fmffile}{HiggsProduction_GluonFusion}
\begin{fmfgraph*}(150,75)
\fmflleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o3}
\fmffreeze
\fmf{gluon, label=$g$, label.dist=+12.0}{i1,v1}
\fmf{gluon, label=$g$, label.dist=+12.0}{i2,v2}
\fmf{fermion, label=$t$, label.dist=-12.0}{v1,v2,v3,v1}
\fmf{scalar, label=$h$}{v3,o2}
\end{fmfgraph*}
\end{fmffile}
```



HiggsProduction\_HiggsStrahlung.tex

```
\begin{fmffile}{HiggsProduction_
HiggsStrahlung}
\begin{fmfgraph*}(150,75)
\fmflleft{i1,i2}
\fmfright{o1,o2}
\fmf{fermion, label=$q$}{i1,v1}
\fmf{fermion, label=$q'$}{v1,i2}
\fmf{boson, label=$W$}{v1,v2,o1}
\fmf{scalar, label=$h$}{v2,o2}
\end{fmfgraph*}
\end{fmffile}
```



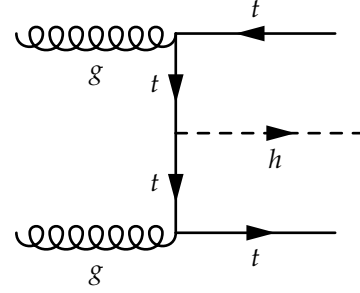


### HiggsProduction\_ttbar.tex

```

\begin{fmffile}{HiggsProduction_ttbar}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o3}
\fmffreeze
\fmfstraight
\fmf{phantom}{v1,v3,v2}
\fmffreeze
\fmf{gluon, label=$g$, label.dist=+12.0}{i1,v1}
\fmf{gluon, label=$g$, label.dist=+12.0}{i2,v2}
\fmf{fermion, label=$t$, o3,v2,v3,v1,o1}
\fmf{scalar, label=$h$, v3,o2}
\end{fmfgraph*}
\end{fmffile}

```

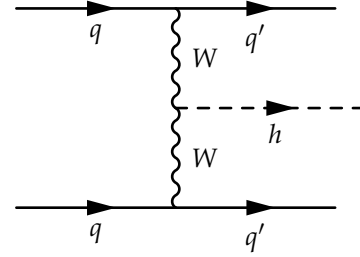


### HiggsProduction\_VBF.tex

```

\begin{fmffile}{HiggsProduction_VBF}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o3}
\fmffreeze
\fmfstraight
\fmf{phantom}{v1,v3,v2}
\fmffreeze
\fmf{fermion, label=$q$, i1,v1}
\fmf{fermion, label=$q$, i2,v2}
\fmf{fermion, label=$q^{\prime}$, v1,o1}
\fmf{fermion, label=$q^{\prime}$, v2,o3}
\fmf{boson, label=$W$, v1,v3,v2}
\fmffreeze
\fmf{scalar, label=$h$, v3,o2}
\end{fmfgraph*}
\end{fmffile}

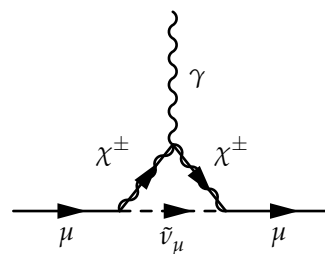
```



11  $\delta a_\mu$ 

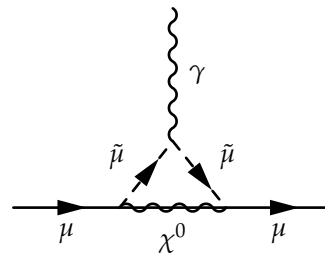
Muon\_Chargino.tex

```
\begin{fmffile}{Muon_Chargino}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$\mu$}{i1,v1}
\fmf{scalar, label=$s_{\nu}[\mu]$}{v1,v2}
\fmf{fermion, label=$\mu$}{v2,o1}
\fmf{boson, tension=0.5}{v1,v3,v2}
\fmf{fermion, label=$\chi$charg$, label.dist
=-24.0, label.side=right, tension=0.5}{v
1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```



Muon\_Neutralino.tex

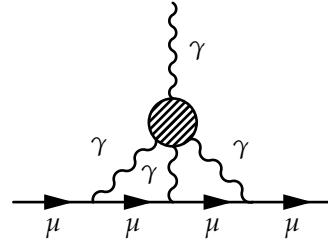
```
\begin{fmffile}{Muon_Neutralino}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$\mu$}{i1,v1}
\fmf{gaugino, label=$\text{neut}$}{v1,v2}
\fmf{fermion, label=$\mu$}{v2,o1}
\fmf{scalar, label=$s(\mu)$, label.dist=-18.0}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```





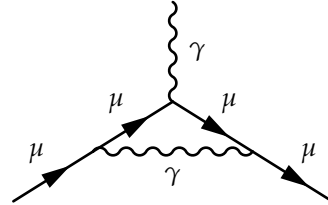
Muon\_SMHadronic.tex

```
\begin{fmffile}{Muon_SMHadronic}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i2,v5,o2}
\fmffreeze
\fmf{phantom}{i1,v1,v2,v3,o1}
\fmffreeze
\fmf{phantom}{v4,v5}
\fmf{fermion,label=$\mu$}{i1,v1,v2,v3,o1}
\fmf{boson,label=$\gamma$,label.dist
=-18}{v1,v4}
\fmf{boson,label=$\gamma$,label.dist
=-12}{v2,v4}
\fmf{boson,label=$\gamma$}{v3,v4}
\fmfblob{.12w}{v4}
\fmf{boson,label=$\gamma$}{v4,v5}
\end{fmfgraph*}
\end{fmffile}
```



Muon\_SMSchwinger.tex

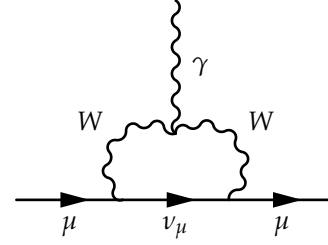
```
\begin{fmffile}{Muon_SMSchwinger}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i2,v4,o2}
\fmffreeze
\fmf{phantom}{i2,v1,o1}
\fmffreeze
\fmf{phantom}{i1,v1,o2}
\fmffreeze
\fmf{phantom}{i1,v2,v1}
\fmffreeze
\fmf{phantom}{v1,v3,o1}
\fmffreeze
\fmf{fermion,label=$\mu$,label.side=left
}{i1,v2,v1,v3,o1}
\fmf{photon,label=$\gamma$}{v2,v3}
\fmf{photon,label=$\gamma$}{v1,v4}
\end{fmfgraph*}
\end{fmffile}
```





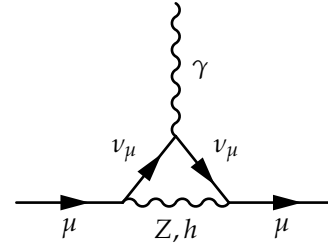
Muon\_SMWBoson.tex

```
\begin{fmffile}{Muon_SMWBoson}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$\mu$}{i1,v1}
\fmf{fermion, label=$\nu_\mu$}{v1,v2}
\fmf{fermion, label=$\mu$}{v2,o1}
\fmf{boson, label=$W$, left}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```



Muon\_SMZBoson\_MSSMHigg.tex

```
\begin{fmffile}{Muon_SMZBoson_MSSMHiggs}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3}
\fmf{phantom}{i2,v4,v5,o3}
\fmffreeze
\fmf{phantom, right}{v4,v6,v5}
\fmffreeze
\fmf{phantom}{i1,v1,v2,o1}
\fmffreeze
\fmf{fermion, label=$\mu$}{i1,v1}
\fmf{boson, label=$Z, h$}{v1,v2}
\fmf{fermion, label=$\mu$}{v2,o1}
\fmf{fermion, label=$\nu_\mu$, label.dist=-18.0}{v1,v3,v2}
\fmf{photon, label=$\gamma$}{v3,v6}
\end{fmfgraph*}
\end{fmffile}
```



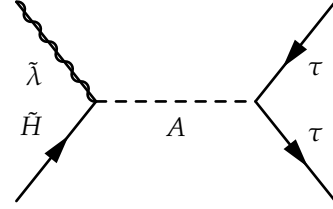


## 12 Relic density



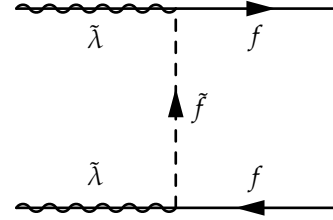
RelicDensity\_AF.tex

```
\begin{fmffile}{RelicDensity_AF}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{fermion, label=$\mathrm{s}\{H\}$, label.side=
left}{i1,v1}
\fmf{gaugino, label=$\mathrm{s}\{\lambda\}$, label.
side=left}{v1,i2}
\fmf{dashes, label=$A$}{v1,v2}
\fmf{fermion, label=$\tau$, label.side=left
}{v2,o1}
\fmf{fermion, label=$\tau$, label.side=left
}{o2,v2}
\end{fmfgraph*}
\end{fmffile}
```



RelicDensity\_Bulk.tex

```
\begin{fmffile}{RelicDensity_Bulk}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o2}
\fmffreeze
\fmf{gaugino, label=$\mathrm{s}\{\lambda\}$, label.
side=left}{i1,v1}
\fmf{gaugino, label=$\mathrm{s}\{\lambda\}$, label.
side=left}{v2,i2}
\fmf{scalar, label=$\mathrm{s}\{f\}$}{v1,v2}
\fmf{fermion, label=$f$, label.side=right}{
o1,v1}
\fmf{fermion, label=$f$, label.side=right}{
v2,o2}
\end{fmfgraph*}
\end{fmffile}
```



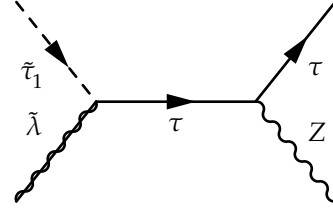


### RelicDensity\_CA.tex

```

\begin{fmffile}{RelicDensity_CA}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{gaugino, label=$\s{\lambda}$, label.
side=left}{i1,v1}
\fmf{scalar, label=$\s{\tau}[1]$, label.side=
right}{i2,v1}
\fmf{fermion, label=$\s{\tau}$}{v1,v2}
\fmf{boson, label=$Z$, label.side=left}{v2,
o1}
\fmf{fermion, label=$\s{\tau}$, label.side=
right}{v2,o2}
\end{fmfgraph*}
\end{fmffile}

```

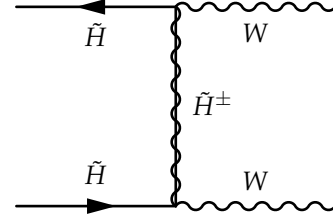


### RelicDensity\_FP.tex

```

\begin{fmffile}{RelicDensity_FP}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmf{phantom}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o2}
\fmffreeze
\fmf{fermion, label=$\s{H}$, label.side=
left}{i1,v1}
\fmf{fermion, label=$\s{H}$, label.side=
left}{v2,i2}
\fmf{gaugino, label=$\s{H}[\pm]$, label.side=
left}{v1,v2}
\fmf{boson, label=$W$, label.side=left}{v1,
o1}
\fmf{boson, label=$W$, label.side=right}{v
2,o2}
\end{fmfgraph*}
\end{fmffile}

```

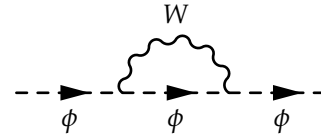


### ScalarLoops\_Boson.tex

```

\begin{fmffile}{ScalarLoops_Boson}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmfstraight
\fmf{scalar, label=$\phi$}{i1,v1,v2,o1}
\fmffreeze
\fmf{boson, label=$W$, left}{v1,v2}
\end{fmfgraph*}
\end{fmffile}

```



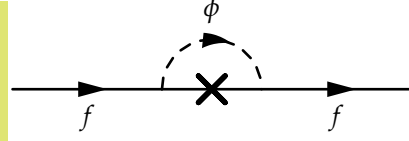


### ScalarLoops\_FermionMass.tex

```

\begin{fmffile}{ScalarLoops_FermionMass}
\begin{fmfgraph*}(150,75)
\fmfleft{i1}
\fmfright{o1}
\fmf{fermion, label=$f$}{i1,v1}
\fmf{plain}{v1,v2,v3}
\fmf{fermion, label=$f$}{v3,o1}
\fmf{scalar, label=$\phi$, left}{v1,v3}
\fmfct{v2}
\end{fmfgraph*}
\end{fmffile}

```

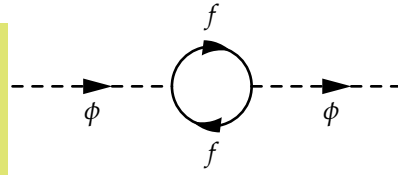


### ScalarLoops\_Fermion.tex

```

\begin{fmffile}{ScalarLoops_Fermion}
\begin{fmfgraph*}(150,75)
\fmfleft{i1}
\fmfright{o1}
\fmf{scalar, label=$\phi$}{i1,v1}
\fmf{fermion, label=$f$, left}{v1,v2,v1}
\fmf{scalar, label=$\phi$}{v2,o1}
\end{fmfgraph*}
\end{fmffile}

```

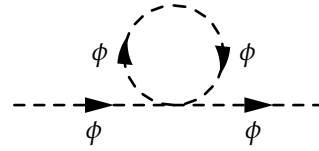


### ScalarLoops\_Quartic.tex

```

\begin{fmffile}{ScalarLoops_Quartic}
\begin{fmfgraph*}(150,75)
\fmfleft{i1,i2}
\fmfright{o1,o2}
\fmfstraight
\fmf{scalar, label=$\phi$}{i1,v1,o1}
\fmffreeze
\fmf{phantom}{i2,v2,o2}
\fmf{scalar, label=$\phi$}{v1,v2,v1}
\end{fmfgraph*}
\end{fmffile}

```



## 13 Trilepton



Trilepton.tex

```
\begin{fmffile}{Trilepton}
\begin{fmfgraph*}(150,150)
\fmfleft{i1,i2}
\fmfright{o1,o2,o3,o4,o5,o6}
\fmf{fermion, label=$u$, tension=5, label.
side=left}{i1,v1}
\fmf{fermion, label=$d$, tension=5, label.
side=left}{v1,i2}
\fmf{boson, label=$W$, tension=5}{v1,v2}
\fmf{gaugino, label=$\chi_1^\pm$, label.side=
left, tension=5}{v2,v3}
\fmf{gaugino, label=$\tilde{\chi}_1^0$, label.side=
right, tension=5}{v2,v4}
\fmf{scalar, label=$\tilde{\nu}_e$, label.side=
right}{v3,v6}
\fmf{fermion, label=$e$, label.side=left,
tension=5}{v3,o6}
\fmf{fermion, label=$\nu_e$, label.side=
left}{v6,o5}
\fmf{gaugino, label=$\tilde{\chi}_1^0$, label.side=
right}{v6,o4}
\fmf{scalar, label=$\tilde{\mu}$, label.side=
left}{v4,v5}
\fmf{fermion, label=$\mu$, label.side=right,
tension=5}{v4,o1}
\fmf{fermion, label=$\mu$, label.side=right
}{v5,o2}
\fmf{gaugino, label=$\tilde{\chi}_1^0$, label.side=
left}{v5,o3}
\end{fmfgraph*}
\end{fmffile}
```

