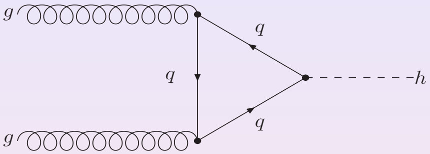
The LHC Searches for The Heavy Higgs via Two B-jets plus Di-photon

Ning Chen, Chun Du, Yaquan Fang, Lan-Chun Lü. [arXiv: 1312.7212].Phys.Rev.D(submitted)

2014.02.25

Higgs productions

- Gluon fusion.



$$\mathcal{R}_{ggF} = \frac{\sigma[\, gg \to h \,]}{\sigma[\, gg \to h \,]_{\rm SM}} = \frac{\left| \sum_q \xi_{hq\bar{q}} \; A^H_{1/2}(\tau_q) \right|^2}{\left| \sum_q A^H_{1/2}(\tau_q) \right|^2},$$

where $\tau_q \equiv M_h^2/(4m_q^2)$. $\mathcal{R}$ is production cross section ratio, ξ is Higgs coupling ratio, A is loop-level form factor.

$$A^H_{1/2}(\tau) \;=\; 2[\tau + (\tau - 1)f(\tau)]\tau^{-2}\,,$$

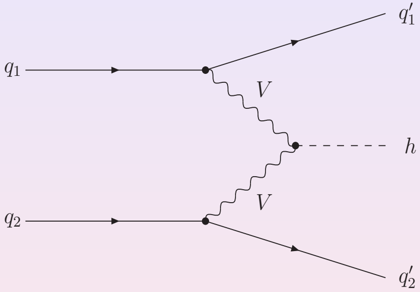
$$f(\tau) = \begin{cases} \arcsin^2\sqrt{\tau}\,, & \tau \leqq 1\,, \\ -\frac{1}{4}\left[\ln\frac{1+\sqrt{1-\tau^{-1}}}{1-\sqrt{1-\tau^{-1}}} - i\pi\right]^2. & \tau > 1\,, \end{cases}$$

when $M_h^2 \ll 4m_q^2$, $A^H_{1/2}(\tau) \to 4/3$ and $M_h^2 \gg 4m_q^2$, $A^H_{1/2}(\tau) \to 0$.

In our case, heavy Higgs(500 GeV) production:

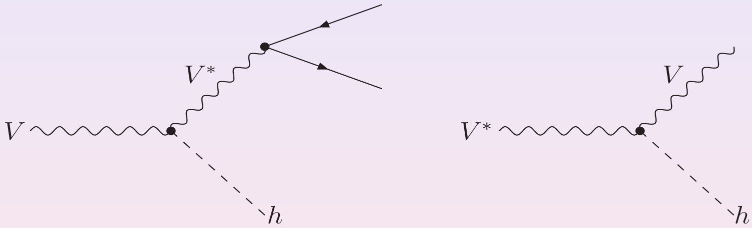
$$\mathcal{R}_{ggF} = \frac{\sigma[\,gg \to H]}{\sigma[\,gg \to H]_{\text{SM}}} \approx (\xi_{Ht\bar{t}})^2\,.$$

- Vector boson fusion.



$$\mathcal{R}_{VBF} = \frac{\sigma[\, q_1 q_2 \to h q_1' q_2' \,]}{\sigma[\, q_1 q_2 \to h q_1' q_2' \,]_{\rm SM}} = \xi_{hVV}^2 .$$

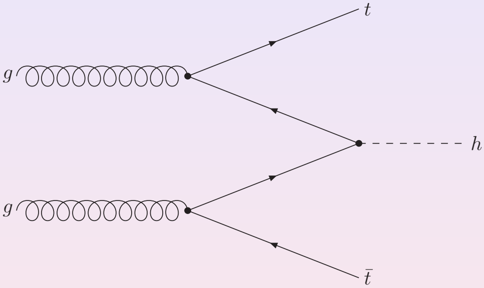
- Associated with vector boson.



$$\mathcal{R}_{VH} = \frac{\sigma[\, q_1 \bar{q}_2 \to \ Vh]}{\sigma[\, q_1 \bar{q}_2 \to \ Vh]_{\text{SM}}} = \xi_{hVV}^2 .$$

Higgs productions

- Associated with heavy quarks.



$$\mathcal{R}_{ttH} = \frac{\sigma[\, gg \to t\bar{t}h\,]}{\sigma[\, gg \to t\bar{t}h\,]_{\rm SM}} = \xi^2_{ht\bar{t}}\,.$$

Higgs productions

- Inclusive production of heavy Higgs.

$$
\begin{aligned}
\sigma[\,pp \to XH] \;&=\; \mathcal{R}_{ggF} \times \sigma[\,gg \to H]_{\rm SM} \\
&\quad + \mathcal{R}_{VBF} \times \sigma[\,q_1 q_2 \to H q_1' q_2'\,]_{\rm SM} \\
&\quad + \mathcal{R}_{VH} \times \sigma[\,q_1 \bar{q}_2 \to VH]_{\rm SM} \\
&\quad + \mathcal{R}_{ttH} \times \;\sigma[\,gg \to t\bar{t}H]_{\rm SM} \\
&\approx\; (\xi_{Ht\bar{t}})^2 \times \sigma[\,gg \to H]_{\rm SM}\,,
\end{aligned}
$$

we just consider the dominant gluon fusion process.

Signal corss section ratio between different energy

$$\frac{\sigma[\,pp \to H \to hh \to XXX'X'(8\text{TeV})\,]}{\sigma[\,pp \to H \to hh \to XXX'X'(14\text{TeV})\,]}$$

$$= \frac{2 \times \sigma[\,pp \to H(8\text{TeV})\,] \times \text{Br}[\,H \to hh] \times \text{Br}[\,h \to XX] \times \text{Br}[\,h \to X'X'\,]}{2 \times \sigma[\,pp \to H(14\text{TeV})\,] \times \text{Br}[\,H \to hh] \times \text{Br}[\,h \to XX] \times \text{Br}[\,h \to X'X'\,]}$$

$$\approx \frac{\sigma[\,gg \to H(8\text{TeV})\,]}{\sigma[\,gg \to H(14\text{TeV})\,]}$$

$$= \frac{(\xi_{Ht\bar{t}})^2 \times \sigma[\,gg \to H(8\text{TeV})\,]_{\text{SM}}}{(\xi_{Ht\bar{t}})^2 \times \sigma[\,gg \to H(14\text{TeV})\,]_{\text{SM}}}$$

$$= \frac{\sigma[\,gg \to H(8\text{TeV})\,]_{\text{SM}}}{\sigma[\,gg \to H(14\text{TeV})\,]_{\text{SM}}} = 0.244\,,$$

for all parameter space in Type-I and Type-II.