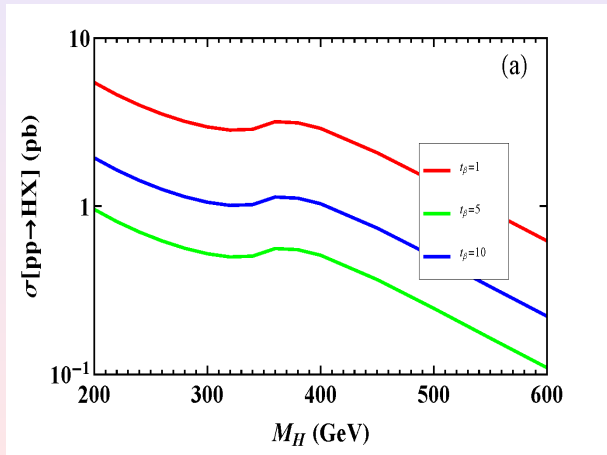
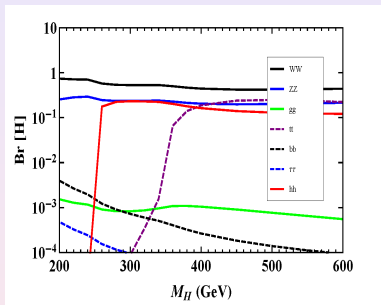


The 2HDM-I heavier CP-even Higgs production

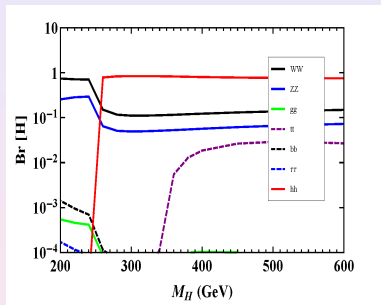
- $\sqrt{s} = 14$ TeV.
- Alinement limit: $\cos(\beta - \alpha) = 0.4$.



The 2HDM-I heavier CP-even Higgs Br



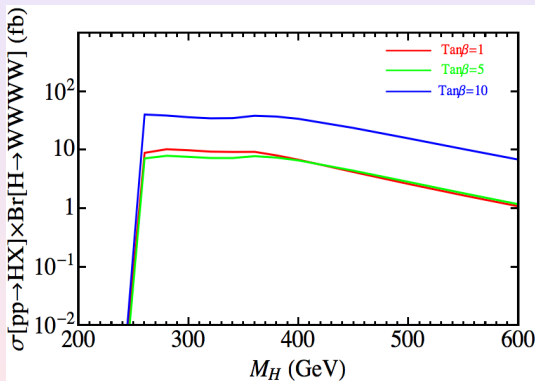
$$\tan \beta = 1$$



$$\tan \beta = 10$$

The 2HDM-I $pp \rightarrow H \rightarrow hh \rightarrow 4W$ channel

$$\sigma[pp \rightarrow HX] \times Br[H \rightarrow hh] \times (Br[h \rightarrow W^+ W^-])^2 :$$



We take Xsection= 50 fb for $M_H = 300$ GeV.

The 2HDM-I $pp \rightarrow H \rightarrow hh \rightarrow 4W$ channel

- $Br [W \rightarrow \ell \nu] \simeq 10.8\%$ ($\ell : e \text{ or } \mu \text{ or } \tau$);
- $Br [W \rightarrow \text{hadrons}] \simeq 67.6\%$.
- Signal cross section with W decay:

- 1 hadronnic decay:

$$67.6\% \times (3 \times 10.8\%)^3 \times 4 \times \text{Xsection} \simeq 0.092 \times \text{Xsection};$$

- all leptonic decay:

$$(3 \times 10.8\%)^4 \times \text{Xsection} \simeq 0.011 \times \text{Xsection}.$$

1 hadronnic decay channel

- Fast-simulation project:

MG5 + pythia + delphes 3.0.10.

- 2HDM Signal: $M_H = 300$ GeV.

- SM irreducible background:

$$p p \rightarrow \ell \nu W W W \rightarrow q q \ell \nu \ell \nu \ell \nu \sim 0.03837[\text{fb}].$$

- SM reducible background:

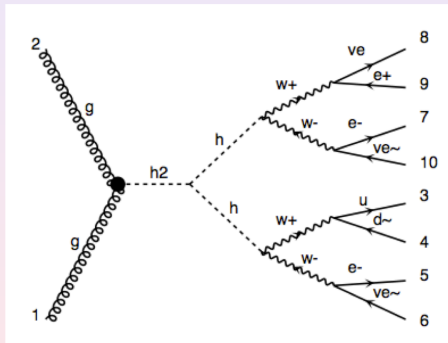
$$\circ p p \rightarrow \ell \nu \ell \nu \ell \nu \sim 3.811[\text{fb}].$$

$$\circ p p \rightarrow \ell \nu \ell \ell W \rightarrow \ell \nu \ell \ell q q \sim 2.197[\text{fb}].$$

$$\circ p p \rightarrow \ell \nu \ell \ell \sim 468.2[\text{fb}].$$

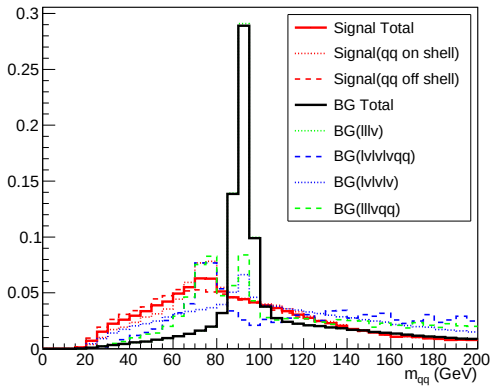
Signal generated by MG5

- Generating $q q$ on shell ($\ell \nu$ off shell) and $q q$ off shell ($\ell \nu$ on shell) separately



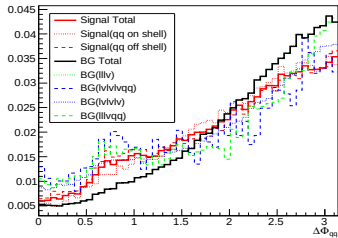
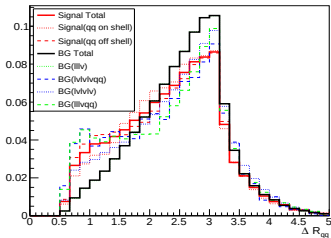
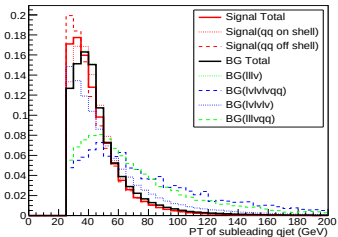
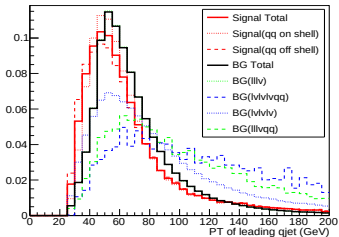
- Overlap remove:
 - Electrons with $\Delta R(e, \gamma) < 0.4$ are removed;
 - Jets(BTag, TauTag = 0) with $\Delta R(\text{jet}, e) < 0.2$ or $\Delta R(\text{jet}, \gamma) < 0.4$ are removed;
 - Muons with $\Delta R(\mu, \text{jet}) < 0.4$ or $\Delta R(\mu, \gamma) < 0.4$ are removed.
- Final state($q \ q \ \ell \ \nu \ \ell \ \nu \ \ell \ \nu$) selection:
 - Number of $q\text{jet} \geq 2$, choosing leading and subleading $q\text{jet}$ pair;
 - Number of electron + Number of muon = 3.
- Basic cuts: $|\eta_{q,\ell}| < 2.5$, $P_{T_q} > 25 \text{ GeV}$, $P_{T_\ell} > 15 \text{ GeV}$.

Distribution of $q_{\text{jet}}(M_H = 300\text{GeV})$

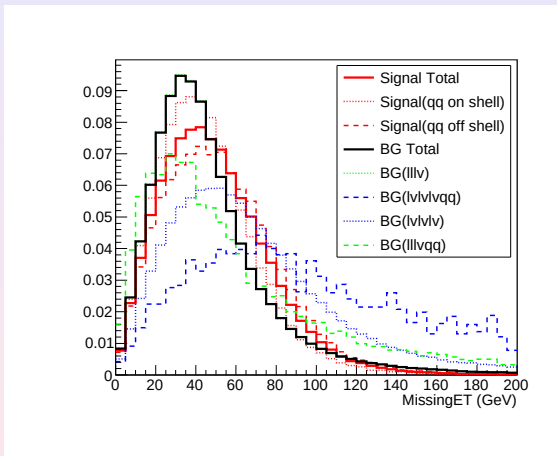


- Cut based: $m_{qq} < 85\text{ GeV}$.

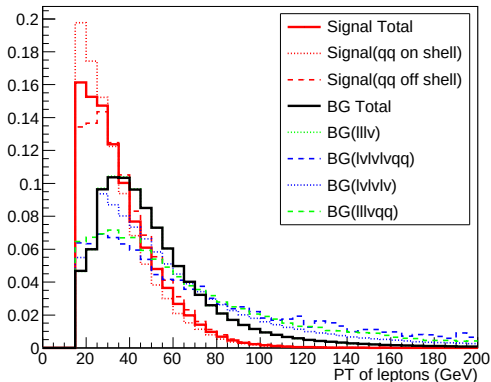
Distribution of $q_{\text{jet}}(M_H = 300\text{GeV})$



Missing ET distribution($M_H = 300\text{GeV}$)

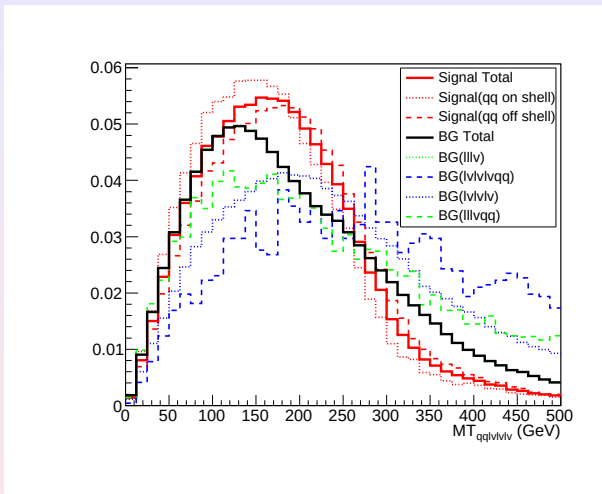


Distribution of leptons ($M_H = 300\text{GeV}$)



- Cut based: $P_{T_\ell} < 40 \text{ GeV}$ to be used.

Transverse mass distribution($M_H = 300\text{GeV}$)



- Cut based: $M_{T_{qqlvllv}} < 280 \text{ GeV}$.

Cut efficiency(1 hadronnic decay, $M_H = 300\text{GeV}$)

Cuts	σ_{total}	Events selection	m_{qq}	$P_{T_\ell}, M_{T_{q\bar{q}\ell\nu\ell\nu\ell\nu}}$
Signal [fb]	4.6	0.22	0.097	0.037
$lll\nu$ [fb]	468.2	47.56	5.46	0.78
$qq\ell\nu\ell\nu\ell\nu$ [fb]	0.03837	0.0048	0.00087	0.00006
$\ell\nu\ell\nu\ell\nu$ [fb]	3.811	0.301	0.072	0.0012
$qq\ell\ell\ell\nu$ [fb]	2.197	0.30	0.065	0.0037
S/B	0.0097	0.0046	0.017	0.047
$S/\sqrt{B}^{[1]}$	6.68	1.02	1.29	1.31
$S/\sqrt{B}^{[2]}$	14.94	2.28	2.89	2.94
Signif-P ^[1]	6.67	1.02	1.29	1.30
Signif-P ^[2]	14.91	2.28	2.88	2.92

Signif-P: $\sqrt{2 \times \left\{ (S+B) \times \ln[(S+B)/B] - S \right\}}$. Integrate luminosity is assumed to be $\int \mathcal{L} dt =$ ^[1] 1000 (^[2] 5000) fb^{-1} .