1 Introduction

In the standard model (SM) which is completed by the discovery of the Higgs boson, a top quark is the heavist particle. The fact that the Higgs boson is responsible for giving a mass to the fundamental particles in the SM leads us to study the top quark in more details. At the LHC, for Run II period, the top quark candidates are expected to be produced enough to search for rare processes such as flavor changing neutral current (FCNC) which is suppressed in the SM. Searching for FCNC would bring us a hint for the new physics that can explain what the standard model can not. In this analysis, the search for FCNC is performed in the top quark pair production where one of top quarks decays to a Higgs boson and a up type quark (u-, c-quark) and the Higgs boson decays to two photons. The result with simulated data corresponding to an integrated luminosity of 100 fb^{-1} is presented.

2 Samples

The data samples are generated with the MC@NLO package and simulated using the default configuration available in public for the CMS detector. Following samples are considered with NLO cross sections at 13 TeV.

Table 1: Cross sections at LO. The branching ratio of W boson decaying to a lepton $B(W \to l\nu)$ is 10.80%. The branching ratio of Higgs decaying to $\gamma\gamma$ $B(H \to \gamma\gamma)$ is 0.228 %. The best limit of $t \to cH$ coupling is 0.56%.

Selection	Cross sections at 13 TeV (pb)	Number of events	Effective luminosity (fb^{-1})
$t \to cH(\gamma\gamma)$	2*674*0.0056*$B(H \to \gamma\gamma)$	9.078573e+06	527478.574
$t\bar{t}$ dilepton	674*$B(W \to l\nu)$*3*$B(W \to l\nu)$*3	4.24e+06	59.926
$t\bar{t}$ semilepton	674*$B(W \to l\nu)$*3*(1-$B(W \to l\nu)$*3)*2	1.5979886e+07	54.124
W($l\nu$)+1 jet	177300*$B(W \to l\nu)$*3*0.12155	2.8231215e+07	4.043
W($l\nu$)+2 jets	177300*$B(W \to l\nu)$*3*0.03358	1.7403439e+07	9.021
W($l\nu$)+3 jets	177300*$B(W \to l\nu)$*3*0.0861	1.4436939e+07	2.918
$\gamma\gamma$+1 jet	203*0.25410	1.384272e+07	268.361
$\gamma\gamma$+2 jets	203*0.12885	4.379504e+06	167.434
$\gamma\gamma$+3 jets	203*0.06170	6.33577e+06	505.845

3 Event Selection

- Two photons with $p_{\mathrm{T}}^{1} > 60$ GeV and $p_{\mathrm{T}}^{2} > 30$ GeV and both photons $|\eta| < 2.5$ The asymmetry threshold is motivated by the fact that the Higgs is boosted, which leads to the broader invariant mass distribution of the signal with two very asymmetry $\mathrm{p_T}$ of two photons. Photon isolation using combined isolation ¡ 0.1 which is corresponding to around 90% efficiency is applied.
- One lepton with $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.5$.
- The lepton should be isolated. The relative combined isolation of calorimeter energy and track momentum around the pivotal lepton is required to be less than 0.1.
- Jets that overlap with the selected leptons or photons are removed for further consideration.
- At least 2 jets with $p_{\mathrm{T}} > 20$ GeV and $|\eta| < 2.5$ and HEoverEE > 0.15
- Only one b-tagged jet with tight working point
- $163 < m_{j\gamma\gamma} < 183$ GeV

4 Result

5 Conclusion

The significance of $S/\sqrt{S+B}$ as a figure of merit is 4.1 with the data corresponding to 100 fb^{-1}. The remaining background is mosstly $t\bar{t}$ process. Taking the systematic uncertainty for $t\bar{t}$ process based on the Run I measurement of 5% from the dilepton and 15% from the lepton+jets for the inclusive $t\bar{t}$ process, the significance goes down to 3.8. Assuming there is no excess, the exclusion limit for $Br(tcH)$ is set to be 0.24% at the 95% confidence level. This is the significant improvement with respect to the current best limit for this channel: $Br(tcH) < 0.69\%$ for CMS and $Br(tqH) < 0.79\%$ for ATLAS.

Table 2: Expected number of events in the leptonic decay mode for each selection step.

Selection	S1 ($\gamma\gamma$)	S2 ($N_l \geq 1$)	S3 ($N_j \geq 2$)	S4 ($N_b = 1$)	S5 ($m_{j\gamma\gamma}$)
$t \to cH(\gamma\gamma)$	1008 (44%)	263 (13%)	221 (8.9 %)	97.1 (3.9%)	46.5 (1.6%)
$t \to cH(\gamma\gamma)$ in lepton+jets	240 (43%)	104 (19%)	78.1 (14 %)	31.7 (5.7%)	15.4 (2.8%)
$t \to uH(\gamma\gamma)$ in lepton+jets	240 (43%)	105 (19%)	78.0 (14 %)	31.1 (5.6%)	15.0 (2.7%)
$\gamma\gamma$+jets	889517	6.4	0.4	0	0
$t\bar{t}$ dilepton	2583	532	424	209	31.7
$t\bar{t}$ semilepton	1957	225	214	105	16.8
Single top	533	64.9	21.1	9.2	2.8
Z+jets	72761	6649	1908	37.3	1.4
W+jets	32860	2156	523	0	0
$S/\sqrt{S+B}$ ($t \to cH(\gamma\gamma)$)	1.0	2.6	3.8	4.5	4.7
$S/\sqrt{S+B}$ ($t \to cH(\gamma\gamma)$ in lepton+jets)	0.2	1.1	1.4	1.6	1.9
$S/\sqrt{S+B}$ ($t \to uH(\gamma\gamma)$ in lepton+jets)	0.2	1.1	1.4	1.6	1.8