Pair production of heavy charged gauge bosons in Proton-Proton collision at LHC

Ijaz Ahmed$^1$ Taimoor Khurshid$^2$ Fazal Khaliq$^1$

$^1$ Riphah International University, Hajj Complex, I-14 Islamabad
$^2$ International Islamic University, H-10, Islamabad

Abstract: Two opposite charged new heavy gauge boson pair production is studied in this paper at Large Hadron Collider. These bosons are known to be $W'$ boson as it is the heavy version of Standard Model's weak force carrier, the $W$ boson. The production cross section and decay width in proton-proton collision at 14 TeV center of mass energy are calculated for different masses of $W'$ and coupling strengths. Efficiencies for different signal regions and branching ratios for different decay channels are computed. In this study the pair production $(W'^+ W'^-)$ is considered in emerging new physics as a result of proton-proton collision with final state containing two tau leptons and two neutrinos (each $W'$ decay to tau and its neutrino). The event selection efficiency is used that is given in CMS experiment for the mass of $W'$ to set lower limits for different coupling strengths of $W'$ and results are given in this paper. For heavy gauge bosons when coupling strength is similar to that of Standard Model's $W$ boson, the mass of $W'$ at confidence level of 95% below 305 GeV are excluded.

Key words: heavy gauge boson, LHC, tau leptons

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1 Introduction

At the scale of TeV energy a new physics can be observed. This new scenario of physics is the finding of additional new heavy gauge bosons ($W'^\pm, Z'$). Many extension of standard model realize the existence of these additional gauge bosons. These bosons are the heavy version of standard model weak vector gauge bosons. The property of these bosons may be similar or not to that of the standard model weak bosons $W$ this depends upon the underlying theory. The model that predict heavy $W'$ bosons also contains $Z'$ bosons generically, but this is not true in the reverse. The detail of the model gives the difference in mass of $W'$ and $Z'$ bosons, hence the discovery of $W'$ bosons are more probable to discover before the discovery of $W'$ bosons. The property that differentiate standard model W and the new heavy charged gauge bosons is that it may couple to left handed, right handed or mixture of both fermions while standard model weak bosons only couple to left handed fermions. The lagrangian that generally gives mathematical description of fermions interaction of $W'$ bosons is given by

$$L = \frac{V_{ij} f_j \gamma^\mu \left( g_R' \left( 1 + \gamma^5 \right) + g_L' \left( 1 - \gamma^5 \right) \right) W'^\mu f_i + h.c.}{2 \sqrt{2}} \quad (1)$$

where left hand (right hand) coupling constant is given by $g_{L(R)}'$ respectively. For lepton $V_{ij}$ matrix is $3 \times 3$ identity matrix, while CKM matrix for quark. The left and right handed projection operator is given by $(1 \pm \gamma^5)$ operator. In equation (1) if $g_R' = 0$ and $g_L' \neq 0$ both lepton and quark may couple to $W'$ boson (pure left handed), but if $g_R'$ not zero and $g_L'$ is zero then only quark can couple to the $W'$ boson (pure right handed). This implies that the neutrino mass is much higher than $W'$ bosons or we can introduce right handed neutrino.

This paper contains the study where two oppositely charged heavy gauge ($W'$) bosons are produced in proton-proton collision at center of mass energy. Since this energy is easily accessible nowadays in LHC. We consider the case where two tau leptons and its neutrinos are in final state (each $W'$ decays to one Tau and its neutrino). Due to neutrino in the final state $g_{L}'$ can be zero.

CMS experiment [2] efficiencies are used in this paper to compare the wanted signal yields having standard model backgrounds reported in this paper. CMS takes this data from proton-proton collision at LHC. This make us able to set lower limits on $W'$ mass. The integrated luminosity used is 18.1 $fb^{-1}$ and 19.6 $fb^{-1}$ for two different Channels.
2 Search of heavy gauge bosons ($W'$)

Difference searches are used in many experiments for $W'$ bosons signatures. In ATLAS experiment $W'$ bosons are considered to decay into lepton with missing transverse energy from neutrino [3]. At 95% confidence level this paper exclude masses less than 5.1 TeV in standard model conditions. Two main searches can be done for the heavy charged gauge boson a Direct and Indirect searches.

2.1 Direct search

Many experimental analyses propose left or right handed $W'$ in the direct searches for $W'$ bosons done hadrons collider. These bosons decay into leptons in the final state with standard model like couplings. The decay of right handed bosons or left handed, which is to decay into right handed neutrino is restricted kinematically to the conditions on mass of $W'$ that is $m_{W'} > 786$ GeV [4,11]. This decay is forbidden if mass of right handed neutrino is greater than mass of $W'$ bosons. In Dijet data right handed $W'$ boson are directly restricted by peak search only. To the light quarks $W'$ has more large coupling unless to give the limit for mass of 420 GeV [12,14] by QCD background the dijet data is limited.

![Fig. 1. Study of W-prime in quark anti quark annihilation, and decays to lepton and its neutrinos](image1)

W-prime boson can be detected directly at Large Hadrons Collider decaying to lepton and its neutrino or top bottom quark in quark anti quark annihilation. Fig 2 is the schematic diagram. This physics can be achieve at the energy of TeV.

2.2 Indirect search

The second method for the search of $W'$ is indirect method. Standard model $W$ can be replaced by $W'$ in some decay process like muon decay to set a limit on its mass to study. Fig.3 gives a diagrammatic scheme for muon decay. The standard model $W$ can be replaced in this process with heavy charged gauge boson.

![Fig. 2. A muon decay to electron and neutrinos](image2)

3 Simulation and Results

3.1 Cross section and decay width calculation

For the theoretical study of pair production of heavy charged gauge bosons at 14 TeV in proton-proton collision and its decay into Tau and its neutrino in the final state the version 2.6.0 of MADGRAPH [15] is used. It is the extension to madgraph5 [16] which is matrix-element generator.

The events are generated in madgraph first considering only left handed $W'$ by setting the coupling parameter for $W'$ ($g_L = g_{SM}$, $g_R = 0$) the interaction as permitted both to quarks and leptons. The mass of $W'$ bosons are varied from 110 GeV to 500 GeV with increment of 30 GeV selecting the total energy of beam 14 TeV ( 7 TeV for each beam of proton).

The decay width or life time calculated using Madgraph for various masses and compared with the results in [11]. In this case the partial width for $W'$ decays to tb and tbar and the total decay width for $W'$ in leading order and next to leading order precision is calculated. The results are agreed. The decay width is the function of modes of decay, process of decay, coupling constant and depend upon kinematics constraint. Estimation for production cross section are also done by MadGraph event generator. Decay width and production cross section for both quarks and leptons are given in Table. The model does not keep the value of coupling constant fixed.

Then We changed the coupling constant to find its effect on the production cross section and decay width, by increasing and decreasing (multiplying the left hand coupling with 1.5 and 0.5 of the standard model). By increasing or decreasing the coupling constant, cross section is also increasing with factor 5 and decreasing with factor 0.062. The decay width increases or decrease by factor of 2.25 and 0.25 respectively.
Table 1. Wide table.

| Mass (GeV) | $g_R' = 0, g_L' = 0.32$ | $g_R' = 0, g_L' = 0.64$ | $g_R' = 0, g_L' = 0.96$ |
|------------|-------------------------|-------------------------|-------------------------|
|            | $\sigma(pp \to W^+ W^-)$ (fb) | $\Gamma(W \to XY)$ (GeV) | $\sigma(pp \to W^+ W^-)$ (fb) | $\Gamma(W \to XY)$ (GeV) | $\Gamma(pp \to W^+ W^-)$ (fb) | $\Gamma(W \to XY)$ (GeV) |
| 110        | 128.6                   | 0.69                    | 2055.3                  | 2.8                      | 10296.9                  | 6.2                      |
| 140        | 57.3                    | 0.82                    | 923.5                   | 3.5                      | 3950.8                   | 7.9                      |
| 170        | 22.4                    | 1.1                     | 360.1                   | 4.3                      | 1804.5                   | 9.5                      |
| 200        | 10.9                    | 1.3                     | 173.9                   | 5.2                      | 867.2                    | 11.7                     |
| 230        | 5.5                     | 1.6                     | 87.6                    | 6.2                      | 440                      | 14                       |
| 260        | 3.0                     | 1.8                     | 48                      | 7.4                      | 238                      | 16.6                     |
| 290        | 1.7                     | 2.1                     | 28.1                    | 8.5                      | 146.5                    | 19.1                     |
| 320        | 1.1                     | 2.4                     | 17.4                    | 9.6                      | 84.5                     | 21.6                     |
| 350        | 0.7                     | 2.7                     | 11.2                    | 10.7                     | 40.2                     | 24.0                     |
| 380        | 0.5                     | 2.9                     | 7.5                     | 11.7                     | 19.2                     | 24.4                     |
| 410        | 0.3                     | 3.2                     | 5.16                    | 12.82                    | 9.2                      | 28.8                     |
| 440        | 0.2                     | 3.47                    | 3.64                    | 13.88                    | 4.6                      | 31.2                     |
| 470        | 0.2                     | 2.7                     | 2.6                     | 14.9                     | 2.9                      | 33.6                     |
| 500        | 0.12                    | 4.0                     | 1.9                     | 15.9                     | 1.2                      | 35.9                     |

Table 2. Cross section and decay width for different masses and different coupling constants.

Now the left handed and right handed couplings are changed such that the sums of their square are equal to the square of standard model coupling.

$$g_{SM}^2 = (g_L')^2 + (g_R')^2$$

and

$$g' L = g_{SM} \cos \theta$$

where $\theta$ is the mixing angle, from the above equation we can see that changing angle from 00 to 900 W’ goes to purely right handed from purely left handed.

The cross section and decay width with different mixing angles for mass of $W' = 350$ GeV are given in table 3.

3.2 Branching ratios

$W'$ boson decay to different final state in our study we only consider Tau and its neutrino in the final state. TAUOLA package [17] is used for simulation of Tau lepton decay. This package is also used for the leptonic and hadronic decay of Tau to simulate in the final state. It also gives full information of neutrino and mediator particles in the final state. This also contains spin information and can do simulation for angular distribution of decay products. The ratio of decay in one channel divided by the total decay width is referring as branching ratio. This is given by TAUOLA package and listed in table for different masses and different decay channels.

Fig. 3. Branching ratios of $W'$ decays
Mixing angle | Coupling constant | Cross-section (fb) | Decay Width (GeV) | $\tau^+\nu_\tau$
--- | --- | --- | --- | ---
0 | $g_R = 0, g_L = 0.64$ | 11.2 | 10.7 | 0.09
15 | $g_R = 0.16, g_L = 0.62$ | 9.97 | 10.7 | 0.09
30 | $g_R = 0.32, g_L = 0.56$ | 7.3 | 10.9 | 0.09
45 | $g_R = 0.45, g_L = 0.45$ | 5.7 | 10.6 | 0.09
60 | $g_R = 0.56, g_L = 0.32$ | 7.8 | 10.9 | 0.09
90 | $g_R = 0.64, g_L = 0$ | 11.3 | 10.7 | 0

Table 3. The cross section and decay width for $m_{W'} = 350$ GeV for different mixing angle and branching ratio in $\tau\nu_{\tau}$ final state.

| Mass (GeV) | Branching ratios ($W' \rightarrow x + y$) |
| --- | --- | --- | --- | --- | --- | --- | --- |
| $u + d'$ | $c + s'$ | $b + t'$ | $e + e'$ | $\mu + \mu$ | $\tau + \tau'$ | $u + s'$ | $c + d'$ |
| 110 | 0.32 | 0.32 | 0 | 0.11 | 0.11 | 0.11 | 0.02 | 0.02 |
| 140 | 0.32 | 0.32 | 0 | 0.11 | 0.11 | 0.11 | 0.02 | 0.02 |
| 170 | 0.32 | 0.32 | 0 | 0.11 | 0.11 | 0.11 | 0.02 | 0.02 |
| 200 | 0.31 | 0.31 | 0.03 | 0.11 | 0.108 | 0.11 | 0.02 | 0.02 |
| 230 | 0.29 | 0.29 | 0.08 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 |
| 260 | 0.28 | 0.28 | 0.11 | 0.10 | 0.10 | 0.10 | 0.02 | 0.02 |
| 290 | 0.27 | 0.27 | 0.14 | 0.10 | 0.10 | 0.10 | 0.01 | 0.01 |
| 320 | 0.26 | 0.26 | 0.16 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 350 | 0.26 | 0.26 | 0.18 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 380 | 0.26 | 0.26 | 0.19 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 410 | 0.25 | 0.25 | 0.11 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 440 | 0.25 | 0.25 | 0.20 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 470 | 0.25 | 0.25 | 0.21 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |
| 500 | 0.24 | 0.25 | 0.22 | 0.09 | 0.09 | 0.09 | 0.01 | 0.01 |

Table 5. Table 3: gives the Branching ratios of W-prime into different signal.

### 3.3 Selection efficiency

The event generated in MadGraph and tau decay by Tauola package is measured in method section. Now we will obtain the selection efficiency for different masses of $W'$ in different channels. For any given signal region efficiency cuts table of experimental paper [2] is used to find the selection cut for the probability to pass for any given signal region. Efficiency cuts are reported in this paper for events reconstructed properties and these cuts are the function of generator level values for that property. The detectors effects taken into account becomes very easy and accurate due to these properties that are difficult in to the model always. The cuts are all taken independent following that paper. For different signals region and different channels to get full selection efficiency all the efficiency cuts are multiplied.

The efficiency for different channels are found for different masses of $W'$ bosons by running simulation code. The following table gives the efficiency for different channels and different masses in the standard model like scenario, and fig gives its graph.

The efficiencies are calculated for different masses of $W'$ and for different coupling constants (mixing angles). These results are compared with the above table and figure produced in standard model like scenario, and found that the efficiency do not depend upon the coupling strength as expected. The efficiency of the signal region is only the function of kinematics of the event.
generated which changing with mass of $W'$. For any given integrated luminosity ($\mathcal{L}$) the total number of expected events can be estimated in that channel, if one know the production cross section ($\sigma$) of the event and branching ratio (BR) of the signal and for that channel full selection efficiency by the following equation:

$$N = \mathcal{L} \times \sigma(pp \rightarrow W^+W^-) \times BR(W^\rightarrow \tau \nu) \times BR(W^\prime \rightarrow \tau \nu) \times \epsilon_{\text{ch}}$$

where $\epsilon$ is the full selection efficiency. The systematic uncertainty and integrated luminosities are given in the table taken from the experimental paper followed.

The number of expected Events are calculated using above formula for production cross section for the standard model scenario and branching ratios of the signal of our interest ($W'\rightarrow \tau \nu$) using luminosity of the above table taken from experimental paper and the channel efficiencies calculated in Table 5.6 using our simulation codes. The Table has given below summaries calculations.

### Table 6

| Mass (GeV) | SR-1 | SR-2 | $\mu\tau$ | $e\tau$ |
|-----------|------|------|----------|--------|
| 110       | 0.09 | 0.77 | 0.12     | 0.01   |
| 140       | 0.27 | 0.92 | 0.40     | 0.03   |
| 170       | 0.09 | 0.77 | 0.01     | 0.01   |
| 200       | 0.55 | 1.00 | 0.14     | 0.10   |
| 230       | 1.20 | 1.10 | 0.48     | 0.39   |
| 260       | 1.51 | 1.05 | 0.68     | 0.54   |
| 290       | 1.85 | 1.05 | 0.90     | 0.72   |
| 320       | 2.16 | 1.07 | 1.08     | 0.92   |
| 350       | 2.46 | 0.99 | 1.37     | 1.10   |
| 380       | 2.85 | 0.98 | 1.56     | 1.30   |
| 410       | 3.00 | 1.01 | 1.92     | 1.57   |
| 440       | 3.29 | 0.96 | 2.15     | 1.73   |
| 470       | 3.40 | 0.96 | 2.42     | 2.05   |
| 500       | 3.70 | 0.83 | 2.63     | 2.14   |

Table 6. Table 4: gives the efficiency of different channel for different masses in the standard model like scenario.

#### 3.4 Transverse mass

The detector can detect the transverse component indirectly, all though detector cannot directly detect the emerging neutrinos. According to the momentum conservation the final stat should not have any transverse component, because the initial transferable components of momentum are zero. When all transverse component are added and their sum is other than zero, the additional transverse component to make zero as known as missing transverse energy (MET). This energy represents neutrinos that are the only particle in the Standard Model which contribute to the missing energy. The signal missing transverse energy of the event is not because of instrumental MET but relate to the real physical contents. If we do not have the invariant mass the transverse component may be reconstructed for neutrino. This is called transverse mass (MT) rather be calculated as:

$$M_T = \sqrt{2P_T^\tau P_T^{\nu}(1 - \cos\Delta\theta_{\tau\nu})}$$

$$\sqrt{2P_T^\tau MET(1 - \cos\Delta\theta_{\tau\nu})}$$

Represent transverse momentum of tau, the missing transverse energy which is the neutrino transverse component. For the generated event this was done as a cross check, and kinematics are produced. In the final state of our signal contain mixture of hadronic, leptonic and also pure hadronic channels. For different mass of $W'$ the distribution of missing transverse momentum (Pt-miss) and transverse mass MT2 are given in figure for different channels. The distribution of maximum and minimum momentum of the $\ell_1$ lepton and $\ell_1\ell_2$ channels are given in figure while the distribution of transverse momentum are given in figure of the $\ell_1$ lepton in $\ell_1\ell_2$ channels. Looking into the plot of distribution of these variables it shows that with increasing mass of $W'$ bosons , more harder objects are produced. In the figure the transverse gives Jacobean peak characteristics instead of Breit Weigner which in case of invariant...
mass the peak rise up to MT=MW' with transverse mass and then start falling rapidly. For the statistical analysis transverse distribution is very useful.

3.5 Background Events

Background events are additional interactions that are originate in proton-proton collision and mainly studied in two categories. In one class gluon and quarks jets are misidentified as ?h and in second with genuine ?h candidate. In the first class the dominant source are the W+jets and QCD multi jets and in the second case dominated events are Z+jets, Higgs bosons, Dibosons and tbar. Back ground estimation are given in detail below.

3.6 QCD Multi jets

In signal region two hadronic jets misidentified and appear as pair results QCD multi jets production. Isolation variable are used to specify genuine and misidentified ?h candidate. One signals region and three control region are specified for estimation of QCD multi jets selecting threshold on search variable M_{T2} (MET) or such that M_{T2} > 90GeV to 40GeV and > 250GeV to 100GeV. One loose ?h at least are selected with same sign. The non QCD event are subtracted based on expectation of Moto Carlo simulation. The search variable are not related, isolation misidentified candidate where QCD multi jets dominated. In the two signal region SR-1 (M_{T2} > 90GeV) and SR-2 (M_{T2} < 90 GeV) are estimated in the table below.

3.7 W+ jets back ground

From MC (mote carlo) W+ jets are zero for remaining events in channels, while due to statistical errors in simulation sample large statistical uncertainty is there. In channels W+ back ground contribution from simulation are taken by formula

$$N_{SR} = \epsilon_{FS}N_{BFS}$$

(3)

N_{SR} = W+ jets in signal region
N_{BFS} = before final selection (MT2 > 90GeV for SR-1 and > 250GeV for SR-2)
3.8 Drell-Yan backgrounds

This back grounds comes from MC. Different leptons pair (ee, $\tau\tau$, $\mu\mu$) are included in production. Due to misidentified probability $\tau_h$, contribution from $Z \to \tau\tau \to l\ell$ and $Z \to l\ell$ is very small for $l \to \tau_h$. For $\tau_h \to l$ misidentified probability is also very small, the dominant DY contribution to back ground from $Z \to \tau\tau \to \tau_h\tau_h$ and $Z \to \tau\tau \to l\tau_h$, are very dominant. The contribution from $Z \to \tau\tau \to \tau_h\tau_h$ very low in $l\tau_h$ channel. This is suitable in $\mu\tau_h$ control region. Table gives the estimation of DY back ground in $l\tau_h$ is given for genuine

$\epsilon_{FS} =$ Final selection efficiency

The table gives the background with statistical uncertainty in two signal region for $W^+ \text{jets}$.

| Signal region | $W^+ \text{jets}$ |
|---------------|-------------------|
| SR-1          | 0.70±0.21         |
| SR-2          | 4.36±1.05         |

$\begin{align*}
\text{Signal region} & & \text{DY-back ground} \\
\tau_h & & 0.19±0.04 \\
\mu\tau_h & & 0.25±0.06 \\
\tau_h \tau_h \text{SR-1} & & 0.56±0.07 \\
\tau_h \tau_h \text{SR-2} & & 0.81±0.56 \\
\end{align*}$

Table 9: DY back grounds

3.4 Misidentified $\tau_h$ in $l\tau_h$ channels back ground

The misidentified $\tau_h$ contribution in $l\tau_h$ channels is assumed by a method in which probability of genuine isolated misidentified $\tau_h$ passes through tight isolation taken into account. The number of $\tau_h$ loose isolation candidate, when $\tau_h$ pass through loose isolation and signal selection done than

$$N_l = N_g + N_m$$

Where $N_l$ are loose, $N_g$ are genuine and $N_m$ are number of misidentified candidate. The number of tight candidate are if selection are tighten

$$N_l = r_m(N_l - r_g N_l / r_m - r_g)$$
Fig. 7. Transverse momentum distributions in different channels

Here \( r_m(r_g) \) gives the probability for loosely selected misidentified (genuine) \( \tau_h \) that passes through tighten selection. Eliminating \( N_g \) gives

\[
r_m N_m = r_m (N_t - r_g N_t) / r_{m-r}
\]

(6)

Contamination of misidentified \( \tau_h \) is given by the product \( r_m N_m \) in the signal region. The total misidentified events \( l \tau_h \) channel are summarized in table.

| Back grounds  | Signal regions | $e \tau_h$ | $\mu \tau_h$ | $\tau_h \tau_h$ SR-1 | $\tau_h \tau_h$ SR-2 |
|---------------|----------------|-----------|--------------|-----------------------|-----------------------|
| DY           |                | 0.19±0.04 | 0.25±0.06    | 0.56±0.07             | 0.81±0.56             |
| $v_x,v_v,h_x$|                | 0.03±0.03 | 0.19±0.09    | 0.19±0.03             | 0.75±0.35             |
| W+ jets      |                | 3.3±3.35  | 8.15±4.59    | 0.70±0.21             | 4.36±1.05             |
| QCD multi jets|                | 0         | 0            | 0.13±0.06             | 1.15±0.39             |
| Standard model total | 3.52±3.35 | 8.59±4.59 | 1.58±0.23 | 7.07±1.3 |

Table 11: Total backgrounds events.

4 Exclusion

The compatibility of the observed data with expected signals being tested can be quantitatively preformed using statistical analysis. Bayesian and frequentest are the two most famous approaches used for this compatibility test. In this study Bayesianic approach is used to set Limit on mass of \( W' \). This statistic based on Bayes theorem [?].

\[
P(A \vee B) = \frac{P(B|A)P(A)}{P(B)}
\]

(7)

This theorem gives the conditional probability of Event A when given B. this probability may relates to the experiment when A is considered hypothesis test. In this study A is replaced with new heavy gauge boson \( W' \) as a hypothesis test, while B is considered as expected results. For hypothesis (Observed data) to be true P \( (A/B) \) is the probability in this theorem.

To set Limits statistical analysis is done for which it is compulsory to choose the parameter of interest. The back ground events, expectation of signals and data are used to determine the probability density for this parameter. The parameter of interest selected in this study is \( \sigma B \), which is also very commonly chosen parameter in different searches of W‘ that are published. \( \sigma B \) is the product of cross section (\( \sigma \)) of signal (PP \( \rightarrow W'W' \)) and Branching ratio (B) of \( W' \) decay into the required final stat (\( W' \rightarrow \tau \nu \nu \)). Limit for the mass exclusion may be calculated by comparing cross sections predicted upper
Limit by theory.

Constraint on mass of $W'$ can be set to exclude the lower mass at 95% confidence level. The signal strength is given by the ratio $\sigma/\sigma_{pp \rightarrow W' W'}$. This can be done using a method of semi-bayesian ratio that is implemented in root [18] by summing all the the channels. Different results are obtained for different cross section and efficiency to set limit on mass. The standard model like and others limits are given in the table and shown in figure. For standard model type the mass of $W'$ up to 445 GeV are excluded.

This method was repeated for different scenario and founded that limit is proportional to coupling that the limit increasing when $g'_L$ is increased and decreasing when $g'_L$ is decreased. Different observed and expected limits with uncertainty of $+/-1 \sigma$ are given in figure, and table gives the summary of different coupling scenario for observed and expected limits. As seen in table and figure that the observed limit is higher than the expected always, this due to the fact that large expected backgrounds in different signals region than the observed data given in background summary table in the previous article.

We see that compared to direct search the results are lower but any new model can be constraint that having same final state using this model, with no need of real detector response to simulate.

| Mixing scenarios | Observed | expected |
|------------------|----------|----------|
| SM               | 445      | 400      |
| 1/2 SM           | 200      | 160      |
| 3/2 SM           | 645      | 595      |
| Theta 30         | 405      | 365      |
| Theta 45         | 395      | 375      |
| Theta 60         | 380      | 340      |

Table 12: observed and expected mass limits on mass of $W'$. 
5 Conclusion

In the final we are in the positions that summarize the results. The $W'$ pair production is easily accessible as we increase the center of mass energy for proton-proton collision. The production cross section and decay width are calculated for different coupling strength and for different masses. It can be assumed that with the increasing mass of $W'$ the decay width is increasing while the production cross section is decreasing as expected. The signal region efficiencies are found invariant with coupling strength but change with mass. This shows that it only depend upon kinematics of the process which is related to $W'$ mass, that is increasing with $W'$ mass. For transverse parameters (Momentum, missing energy and mass) treatment is done which gives distribution plot of these parameters. The distribution shows that with increasing mass of $W'$ make accessible to get harder objects.

We have used the selection efficiencies provided for same final state by CMS experiment rather to fill in the complex situation of simulation for full response of detectors. For the yield of favorite signals these efficiencies are used. For statistical analysis tools are used to check the observed results with the signal yields that make it easy to set lower limit on $W'$ mass. The lower limits for different scenario are reported when different coupling strength are used. For the coupling constant same that as Standard Model it is reported that the mass below 445 GeV at confidence level of 95% are excluded. This exclusion limit are may be raised up to 645 GeV when different coupling strength are used.

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