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Anomalous single production of the fourth generation neutrino at future *ep* colliders

A.K. Çiftçi [a], R. Çiftçi [b,*], S. Sultansoy [c]

Burada $ep \to \nu_4 X \to \mu W X$ **ve** $ep \to \nu_4 X \to e W X$

süreçlerine bakılmıştır.

4. SM Ailesi nötrinosunun SM ve anomal yüklü akım etkileşmeleri :

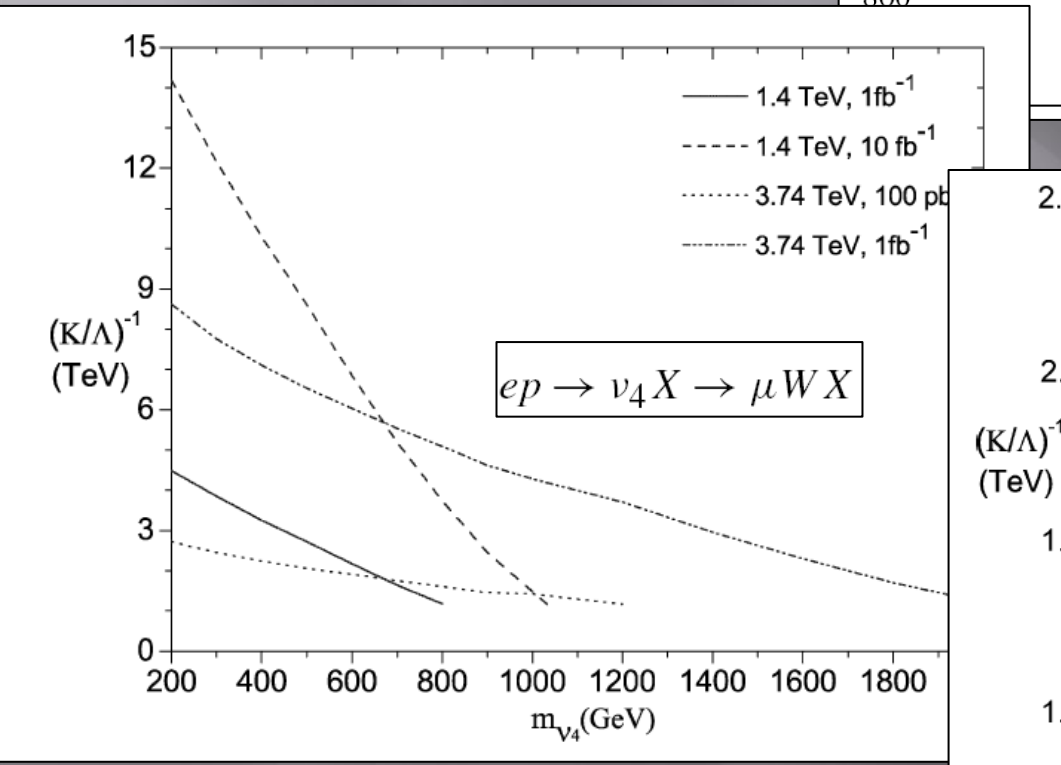
$$L_{cc} = \left(\frac{g_W}{\sqrt{2}}\right)\bar{l}_i\left[|V_{\nu_4 l_i}|\gamma_\mu + \frac{i}{2\Lambda}\kappa_W^{\nu_4 l_i}\sigma_{\mu\nu}q^\nu\right]P_L\nu_4 W^\mu + \text{h.c.}$$
$$(i = 1, 2, 3). \qquad (1)$$

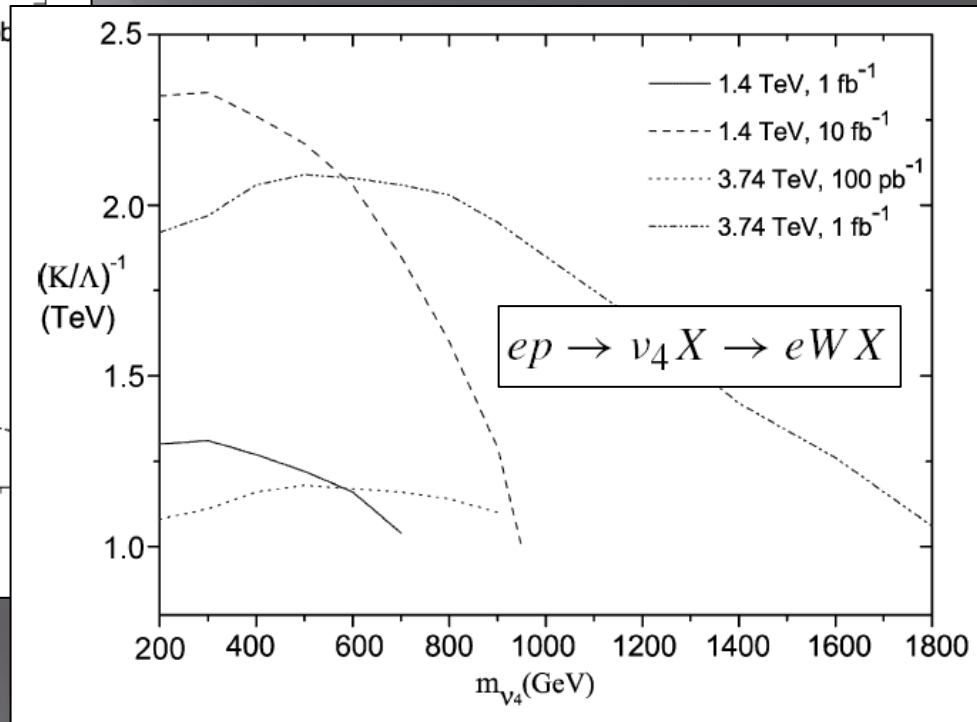
Event numbers of $ep \to \nu_4 X \to \mu W X$ for $\sqrt{s} = 1.4$ TeV, $(\kappa/\Lambda) = 1$ TeV^{-1}

m_{ν_4} (GeV)	N_S	
	$L_{\text{int}} = 1$ fb^{-1}	$L_{\text{int}} =$
200	201	2010
300	148	1480
400	106	1060
500	74	740
600	47	470
700	27	270
800	14	140
900	6	60
1000	2	22

The cross section of signal and background of $ep \to \nu_4 X \to eWX$ for $\sqrt{s} = 1.4$ TeV, $(\kappa/\Lambda) = 1$ TeV^{-1}

m_{ν_4} (GeV)	σ_S (pb)	σ_B (pb)	SS	
			$L_{\text{int}} = 1$ fb^{-1}	$L_{\text{int}} = 10$ fb^{-1}
200	0.201	0.560	8.49	26.86
300	0.148	0.293	8.64	27.34
400	0.106	0.172	8.08	25.56
500	0.074	0.086	7.98	25.23
600	0.047	0.049	6.71	21.23
700	0.027	0.025	5.40	17.07
800	0.014	0.012	4.04	12.78
	0.006	0.005	2.64	8.34
	0.002	0.004	1.10	3.48





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ANOMALOUS SINGLE PRODUCTION OF THE FOURTH GENERATION CHARGED LEPTONS AT FUTURE *ep* COLLIDERS

A. K. Çiftçi et al.

4. SM Ailesi yüklü leptonunun anomal etkileşmeleri :

$$L = \left(\frac{K_\gamma^{l_i}}{\Lambda}\right) e_l g_e \overline{l_4} \sigma_{\mu\nu} l_i F^{\mu\nu} + \left(\frac{K_Z^{l_i}}{2\Lambda}\right) g_Z \overline{l_4} \sigma_{\mu\nu} l_i Z^{\mu\nu} + \text{h.c.}\,, \qquad i = 1, 2, 3$$

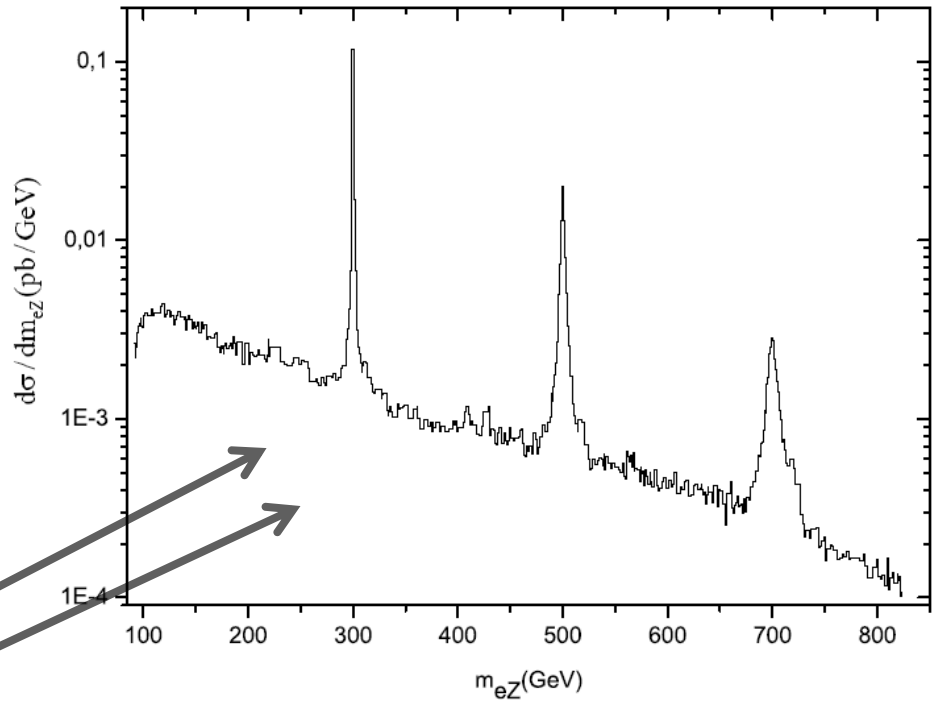
Bu çalışmada $ep \to l_4 X \to \gamma \mu X$ **ve** $ep \to l_4 X \to Z e X$

süreçleri incelenmiştir.

and $ep \to l_4 X \to ZeX$ processes. In the former process anomalous decay of l_4 can be detected easily at ep colliders due to no background. Number of events for $m_{l_4} = 300\,(700)$ GeV at $\sqrt{s} = 1.4$ TeV and $\sqrt{s} = 3.74$ TeV with 1 fb^{-1} integrated luminosity are 240 (30) and 1170 (460), respectively. However, the latter process

Table 2. Total cross-section of signal and background for $\sqrt{s} = 1.4$ TeV and $(K/\Lambda) = 1$ TeV^{-1}.

m_{l_4} (GeV)	σ_{S+B} (pb)	σ_B (pb)	SS
200	0.49	0.09	42.16
300	0.33	0.05	39.60
400	0.21	0.03	32.86
500	0.13	0.02	24.59
600	0.075	0.015	15.49
700	0.039	0.009	10.00
800	0.019	0.005	6.26
900	0.0076	0.002	3.96
1000	0.0028	0.0011	1.62



$$ep \to l_4 X \to ZeX$$

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Anomalous single production of the fourth generation quarks at the CERN LHC

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Possible anomalous single productions of the fourth standard model generation up and down type quarks at CERN Large Hadron Collider are studied. Namely, $pp \to u_4(d_4)X$ with subsequent $u_4 \to bW^+$ process followed by the leptonic decay of the W boson and $d_4 \to b\gamma$ (and its H.c.) decay channel are considered. Signatures of these processes and corresponding standard model backgrounds are discussed in detail. Discovery limits for the quark mass and achievable values of the anomalous coupling strength are determined.

Lagrangian for the FCNC interactions of u_4 and d_4 quarks

$$\mathcal{L} = \left(\frac{\kappa_\gamma^{q_i}}{\Lambda}\right) e_q g_e \bar{q}_4 \sigma_{\mu\nu} q_i F^{\mu\nu} + \left(\frac{\kappa_Z^{q_i}}{2\Lambda}\right) g_Z \bar{q}_4 \sigma_{\mu\nu} q_i Z^{\mu\nu} + \left(\frac{\kappa_g^{q_i}}{\Lambda}\right) g_s \bar{q}_4 \sigma_{\mu\nu} T^a q_i G_a^{\mu\nu} + \text{H.c.}, \quad (1)$$

TABLE IV. SS for anomalous interactions of the fourth generation up and down type quarks at the LHC with integrated luminosity of 100 fb^{-1}.

m_4 (GeV)	SS for $pp \to d_4X \to b\gamma X$	SS for $pp \to u_4X \to b\nu\ell^+X$ $6 \cdot \lvert V^{\text{init}}_{u_4b}\rvert$	$10 \cdot \lvert V^{\text{init}}_{u_4b}\rvert$	$20 \cdot \lvert V^{\text{init}}_{u_4b}\rvert$
300	960	82.3	230	920
400	677	41.0	114	456
500	477	24.4	68	272
600	343	17.6	49	196
700	253	9.7	27	108
800	190	6.2	17	69

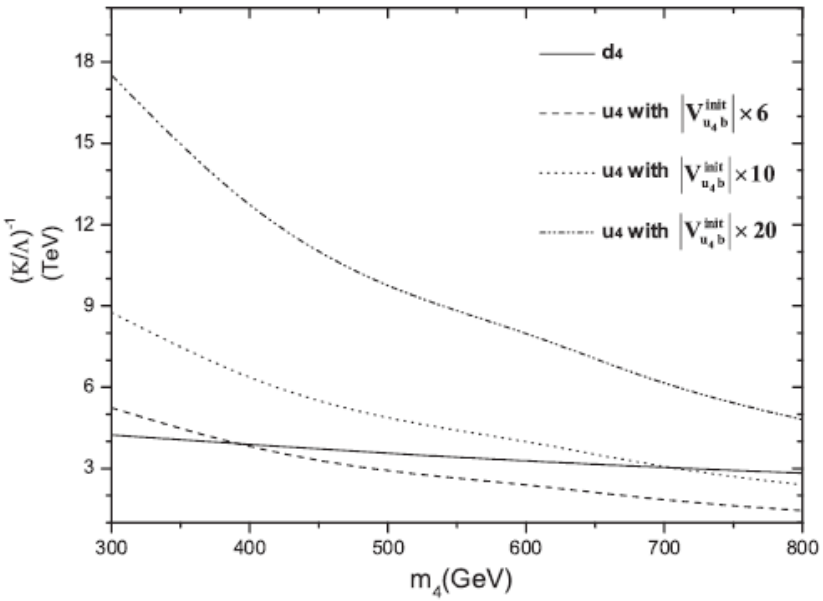
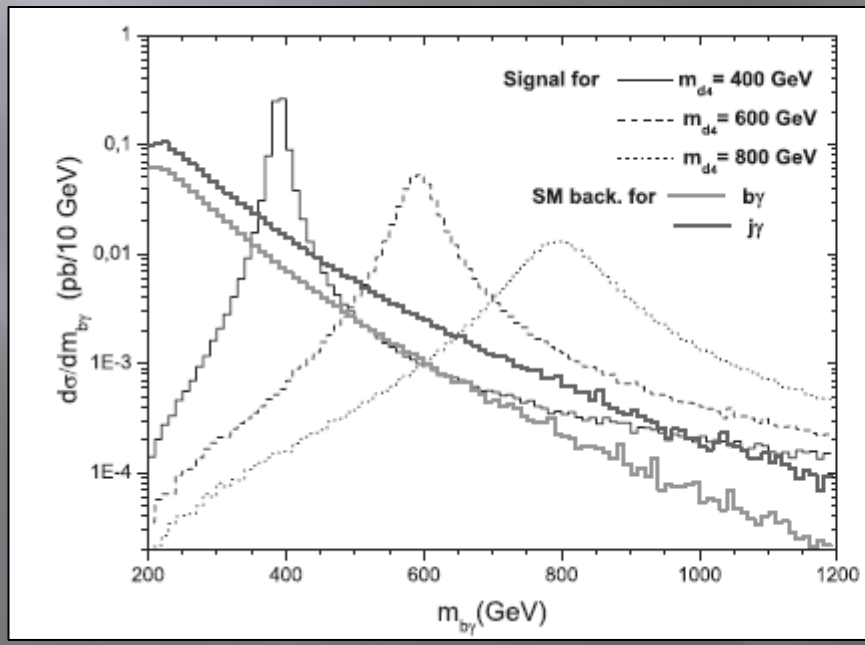
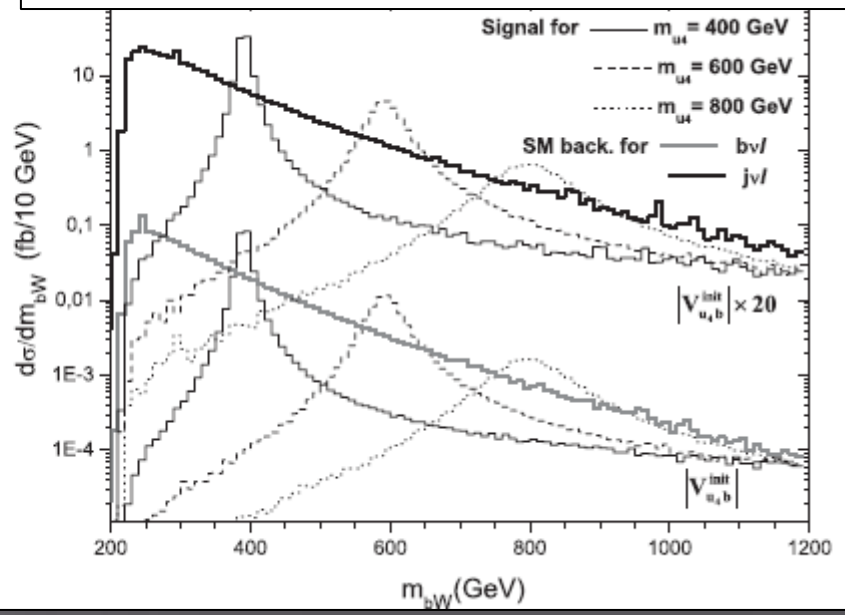


FIG. 6. Observation reach at 3σ for the anomalous coupling strength as a function of the fourth generation quark mass for $pp \to u_4X \to b\nu\ell^+X$ and $pp \to d_4X \to b\gamma X$ processes at the LHC.





Possible Single Resonant Production of the Fourth Generation Charged Leptons at γe Colliders

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Physics Dep

Ankara University

Physics Sectio

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Single resonant productions of the fo
lous interactions at γe colliders based
center of mass energies are studied. Si
processes followed by the hadronic and
model backgrounds are discussed in d
processes and the achievable values of t

PACS numbers: 12.60.-i, 14.60.Hi, 14.80.-j

Keywords: Anomalous interactions; linear

A Comperative Study of the Anomalous Single Production of the Fourth Generation Quarks at ep and γp Colliders

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Abstract

We propose some channels for the possible observation of anomalous interactions of the fourth standard model generation quarks at the Large Hadron Collider based ep and γp colliders. Namely, $u_4(d_4) \to q\gamma$ and $u_4(d_4) \to qZ \to q\ell^+\ell^-$ decay processes are considered. Signatures for signals and corresponding standard model backgrounds are investigated at both colliders comperatively. The lowest necessary luminosities to observe these processes and the achievable values of the anomalous coupling strengths are determined. It is shown that the γp collider is advantageous compare to the ep collider.

PACS numbers: 12.60.-i, 14.65.-q, 13.38.Be

Keywords: Anomalous interactions; colliders; fourth generation quarks.

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Single production of fourth-family quarks at the LHC

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Abstract We study the single production of fourth-family quarks through the process $pp \to Q' jX$ at the Large Hadron Collider (LHC). We have calculated the decay widths and branching ratios of the fourth-family quarks (b' and t') in the mass range 300–800 GeV. The cross sections for the signal and background processes have been calculated in a Monte Carlo framework. It is shown that the LHC can discover single t' and b' quarks if the CKM matrix elements $|V_{tq'}|, |V_{qb'}| \gtrsim 0.01$.

1 Introduction

The standard model (SM) of the electroweak and color interactions does not predict the number of fermion families. However, due to the limits coming from strong coupling in QCD, the number of quark flavors should be less than eighteen. The electroweak precision measurements done by LEP experiments imply that the number of light neutrinos is equal to three [1]. The replications of three quark and lep-

searches. The upcoming
Collider (LHC) are able t
ier mass range, accessib
the pair production sign
with a mass range simila
of the uncertainties on th
remains a door open for
mixings with the other t
precision analysis of the
the idea of the existence

A prediction for the fo
as the CKM mixings hav
duction of the fourth SM
the LHC [11, 12]. Recen
analysis of the signal and
of fourth-family quarks

In this paper, we stud
ied compared to pair proc
through the process pp -
the LHC. We have calcu

Single Production of Fourth Family t' Quarks at LHeC

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Abstract

We study the single production of fourth-family t' quarks via the process $ep \to t'\nu$ at Large Hadron electron Collider (LHeC). We calculate the background and signal cross sections for the mass range 300-800 GeV. It is shown that the LHeC can discover single t' quark up to the mass of 800 GeV for the optimized mixing parameters.

Possible Discovery Channel for New Charged Leptons at the LHC

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April 6, 2009

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Abstract

We propose a channel for the possible discovery of new charged lepto
The proposed final state contains three same-sign leptons, making thi
groundless. The method is illustrated for two different cases: the four
Grand Unified Theory based on the E6 gauge group. An example study
lepton mass shows that in both models, about 20 signal events can be ex
energy with 1 fb^{-1} of integrated luminosity. Although the event yield
tailed measurements of the charged lepton properties, it would be suffici
counting experiment.

1 Introduction

In search of what comes after the Standard Model (SM), a number of th
as Supersymmetry, Extra-dimensions and Grand Unification have been
experiments at the LHC will test the validity of such ideas by searching
particles (bosons or fermions) predicted by these models. Among the m
predicting new fermions one can cite the 4-family Standard Model (S
gauge group (E6GUT) and Little Higgs models [4, 5, 6].

The quark sector of the predicted fermions has received a lot of at
at the LHC, large due to copious QCD production, was extensively di
E6GUT and SM4 also predict new heavy leptons. Some early studies
the heavy leptons mediated by $\gamma/Z/Z'$, as a means of discovery [10]. T
cross-section, compared to the quark sector, and its dependency on the
integrated luminosities corresponding to many years of LHC operation.
for the new heavy leptons would benefit from the clean environment

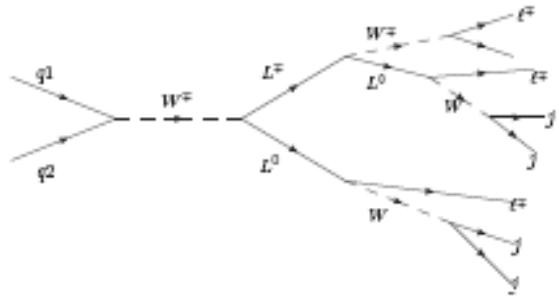
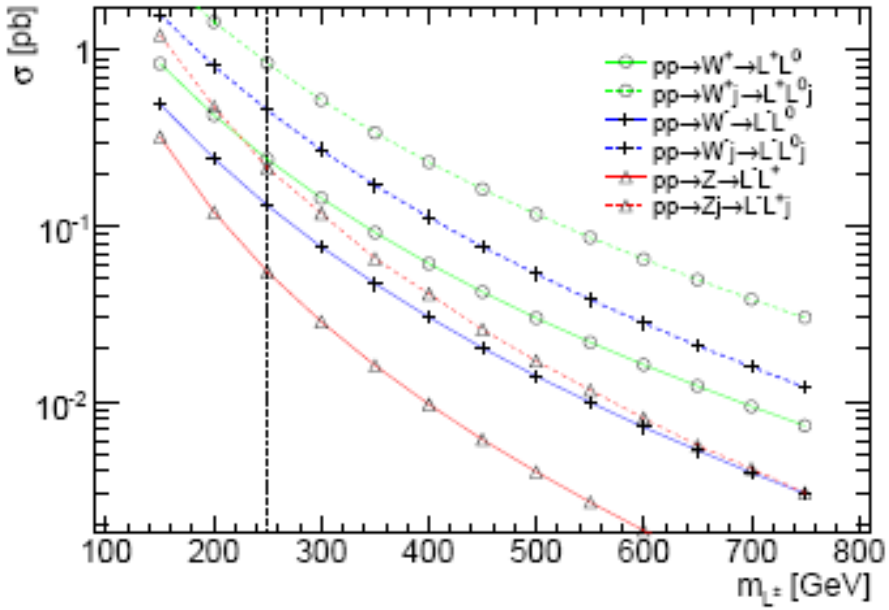


Figure 1: The proposed production and decay of new charged leptons at the LHC



3.1 Expectations for e_4, ν_4

In this section, we use a parameterization of the 4×4 PMNS matrix in agreement with the current neutrino oscillation data. In Ref. [25], the four-dimensional CKM matrix has been parameterized as a modification of 4×4 unit matrix, and the values for the three degrees of freedom in this parameterization have been extracted from the available experimental data on the fermion masses. The parameterization is common between the quark and lepton sectors and predicts $Br(e_4 \to W\nu_4) \simeq 1$, $Br(\nu_4 \to W\mu) = 0.68$ for different values of the assumed unified Yukawa coupling coefficient and the corresponding values of the aforementioned parameters.

$pp \to W\nu_4\nu_4 \to WW\mu\, W\mu$ has been studied as the particular final state where the considered decays are leptonic for the first and hadronic for the remaining two W bosons. As mentioned previously, the two muons in the final state will be of the same sign fifty-percent of the time due to Majorana nature of the ν_4. The branching fraction of these three same-sign lepton final states is $0.68^2 \times 0.22 \times 0.68^2 \times 0.5^2 \simeq 1.2\%$. The effective cross-section for this particular state is 4.44 fb for $m_{e_4} = 250$ GeV when no additional jets are taken into account. The same final state with an additional jet would enhance the cross-section by roughly a factor of four, yielding about 18 "backgroundless" events per fb^{-1}.

4 Application to E6 Leptons

In the GUT (Grand Unified Theory) models, the SM gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y$ is embedded into a larger symmetry group, which is recovered at a higher scale. Such models predict new gauge bosons (e.g. W', Z') which are sought at the current accelerators and new fermions which may also be at the reach of the LHC. Among the most frequently studied ones, the super-string inspired, E6GUT model can be cited. It has a 27-plet per family which contains, among other fields, two fermion fields, denoted as N, and $E^{\mp}$ that could have the quantum numbers of a heavy neutral and charged lepton, respectively. We