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Search for excited leptons in pp collisions at $\sqrt{s} = 7$ TeV

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Shilpi Jain*
Saha Institute of Nuclear Physics,
On behalf of the CMS Collaboration
E-mail: shilpi.jain@cern.ch

In this paper, a search for compositeness in electrons and muons carried out with the CMS detector in pp collision at the LHC at $\sqrt{s}$ = 7 TeV with 5.0 fb^{-1} of data, is presented. The search has been performed for an associated production of a lepton and an oppositely charged excited lepton $pp \to ll^*$ followed by the decay $l^* \to l + \gamma$ resulting in the $ll + \gamma$ final state, where $l = e, \mu$. This search has been done assuming that excited leptons (l^*) are produced via contact interactions. The number of events observed in data is consistent with the expected standard model background. The 95% confidence upper limits are reported for l^* production at this collision energy and the exclusion region in the $\Lambda - \mathrm{M}_l^*$ parameter space. This paper is based on the work done in [2].

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*Speaker.

1. Introduction

With the recent discovery of the Standard Model (SM) like Higgs particle at 125 GeV, the SM in its present form may be complete though more checks are needed to confirm that the new particle is indeed the SM Higgs particle. However it is an effective theory and there are a number of fundamental questions which the SM doesn't answer. SM does not contain any clue about the existence of several generations of quarks and leptons. One possibility which can resolve these questions is that they are composite particles [1]. Excited leptons can be produced singly due to radiative transitions between standard and excited fermions or via novel contact interaction [1].

2. Event selection and Background estimation

Candidate events for the electron (muon) channel are collected with double-electron (single-muon) High Level Trigger (HLT) paths. This corresponded to a transverse momentum (p_{T}) threshold of 33(40) GeV for the electron (muon) channel. For the muon analysis, two high quality muons with $|\eta| < 2.1$ and $p_{\mathrm{T}} > 45(40)$ GeV for the muon with a higher (lower) momentum are required. For the electron analysis, two high quality electrons with $p_{\mathrm{T}} > 35(40)$ GeV in EB(EE) and $|\eta| < 2.5$ are required. Photon is required to be with $|\eta| < 1.4442$ and $p_T > 35$ GeV. Details of the electron, muon and photon reconstruction and identification are given elsewhere [3, 4, 5]. For the electron channel, the dielectron invariant mass and the electron-photon invariant masses are required to be outside a ± 25 GeV window centered at the nominal Z mass. The larger ($M_{\ell\gamma}^{max}$) and the smaller ($M_{\ell\gamma}^{min}$) invariant masses of the photon paired with one of the leptons are used for signal selection. A region in $M_{\ell\gamma}^{min} - M_{\ell\gamma}^{max}$ plane forming an L-shape is used for signal selection, as illustrated in Fig. 1 for $M(\ell^*) = 0.2$.

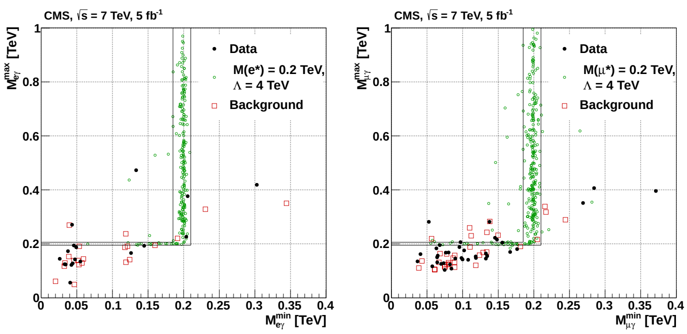

Figure 1: $M_{\ell\gamma}^{max}$ VS $M_{\ell\gamma}^{min}$ for the excited electron analysis (left) and excited muon analysis (right).

The contamination from SM processes with real leptons and photons final state is estimated using Monte Carlo simulation. Backgrounds from processes in which jets are mis-reconstructed as leptons (in e^*, mainly $W(\rightarrow e\nu)+$ jet + γ) or photons (mainly Z + jets) is measured in data samples containing jets.The photon (electron) misidentification rate is measured directly from a data sample dominated by jets, with a photon-like (electron-like) candidate cluster embedded inside, which can potentially be misidentified as a photon (electron). Table 1 compares the predicted and observed number of events passing all selection requirements.

Table 1: Table showing measured signal and expected background event numbers for the electron and muon channels as a function of the mass of the excited lepton.

M_{ℓ^*} (TeV)	$M_{\ell\gamma}^{min}$ (TeV)	$M_{\ell\gamma}^{max}$ (TeV)	Electron channel $\varepsilon_{\text{signal}}$ (%)	N_{bkgd}	N_{data}	Muon channel $\varepsilon_{\text{signal}}$ (%)	N_{bkgd}	N_{data}
0.2	0.19-0.21	0.20-0.21	24.8 ± 1.8	$1.0\,^{+1.1}_{-0.5}$	2	28.2 ± 1.3	$1.2^{+1.7}_{-0.6}$	2
0.4	0.28-0.52	0.38-0.41	32.7 ± 2.4	$0.1\,^{+1.4}_{-0.1}$	1	39.1 ± 1.8	$1.6^{+2.0}_{-0.9}$	3
0.6	0.42-0.78	0.55-0.64	36.6 ± 2.6	$0.0\,^{+1.4}_{-0.0}$	0	45.4 ± 2.0	$0.0^{+1.4}_{-0.0}$	0

3. Results and discussion

As seen in Table 1, for masses above 0.6 TeV, no data events pass the event selection criteria. Hence we provide upper limits on the production cross section of excited electrons and excited muons at the 95% C.L. using a single bin counting method. The observed limits for the electron and the muon channels are shown in Figure 2. Excited leptons (electrons or muons) with masses below 1.9 TeV are excluded for the scale of contact interaction $\Lambda = M_{\ell^*}$.

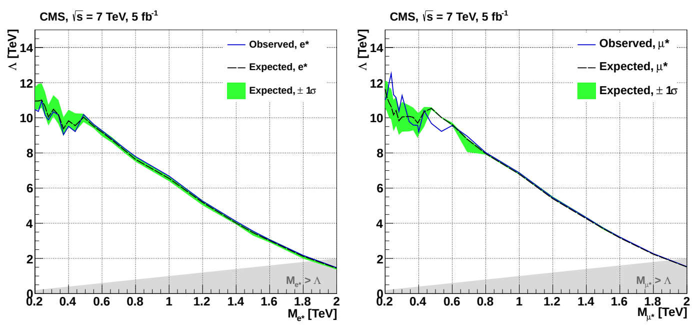

Figure 2: Expected and observed 95% CL lower limits on the Λ scale for the different excited electron (left) and muon (right) mass points. The one standard deviation uncertainty band is shown in green.

References

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