Search for Large Extra Dimensions and Compositeness in $\mu^+\mu^-$ and e^+e^- channels in proton-proton collisions at sqrt(s)=13 TeV in CMS

Prakash Thapa on behalf of CMS Collaboration, Wayne State University

Large Extra Dimensions (LED):

In LED, space-time is extended by an additional number (n) of compactified dimensions of radius R. In this model, gravity propagates to all (n+3) +1 dimensions (the bulk). However, all standard model particles are constrained in a (3+1) space-time dimensions (the brane). The new reduced (n+3) + 1 dimensional Plank scale M_D and (3 + 1) dimensional Plank scale M_{pl} are related as

$$M_{Pl}^2 = (2\pi R)^n M_D^{n+2}$$

The propagation of gravity in extra dimensions give rise to Kaluza-Klein (KK) modes of the graviton. The spacing of KK modes for each dimension n is 1/R. The small spacing of KK modes leads to an almost continuous spectrum of KK graviton states, and a non-resonant excess in dilepton mass spectra at high mass compared to SM background.

Compositeness:

In Compositeness, quarks and leptons are composite structures, bound states of more fundamental constituents called “preons”.The “preons” interact through a new strong gauge interaction called “metacolor”. Below the interaction energy scale Λ, the strength of binding of constituents is very strong and binds “preons” to a composite state. At this energy scale, the effect of compositeness would be a **contact interaction (CI)** enhancing the spectrum at large mass compared to expectation from SM production.

Interferences and helicities:

Constructive (η = -1) and Destructive (η = +1)

Left-Left, Left-Right and Right-Right

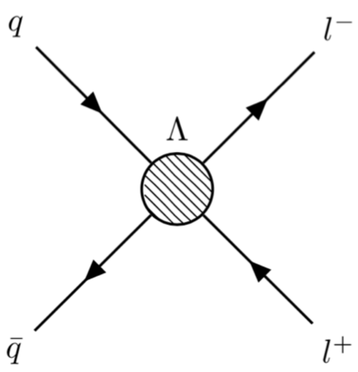


Fig. 3 Contact Interaction

$$\mathcal{L}_{q\ell} = \frac{g^2_{\text{contact}}}{\Lambda^2}\left[\eta_{LL}(\bar{q}_L\gamma^\mu q_L)(\bar{\ell}_L\gamma_\mu\ell_L) + \eta_{RR}(\bar{q}_R\gamma^\mu q_R)(\bar{\ell}_R\gamma_\mu\ell_R) + \eta_{LR}(\bar{q}_L\gamma^\mu q_L)(\bar{\ell}_R\gamma_\mu\ell_R) + \eta_{RL}(\bar{q}_R\gamma^\mu q_R)(\bar{\ell}_L\gamma_\mu\ell_L)\right]$$

$$\frac{d\sigma(\Lambda)}{dM_{l^+l^-}} = \frac{d\sigma(DY)}{dM_{l^+l^-}} - \eta_l\frac{I}{\Lambda^2} + \eta_l^2\frac{C}{\Lambda^4}$$

References:

[1] CMS Collaboration, “Search for physics beyond the standard model in dilepton mass spectra in proton-proton collisions at sqrt (s) = 8 TeV”, JHEP 04 (2015) 025.
[2] ATLAS Collaboration, “Search for contact interactions and large extra dimensions in the dilepton channel using proton-proton collisions at sqrt (s) = 8 TeV with the ATLAS detector”, Eur. Phys. J. C74 (2014), no. 12, 3134.
[3]CMS Collaboration, 'The CMS experiment at the CERN LHC', JINST 3:S08004, 2008

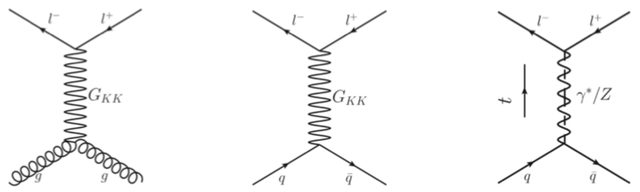


Fig. 2 virtual graviton exchange via gluon and quark initiated processes and Drell-Yan background

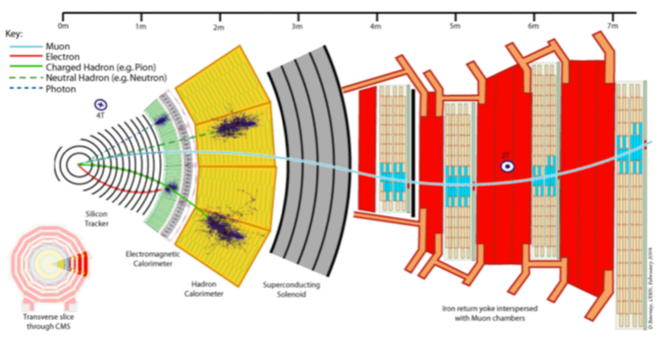
Arkani-Hamed, Dimopoulos and Davli (ADD)

ADD Formalisms: $\sigma_{ADD} \sim \frac{1}{\Lambda_T^8}$

Guidice-Rattazzi-Wells (GRW)

Hewett and Han-Lykken-Zhang (HLZ)

Compact Muon Solenoid



Trigger Selections:

Muons and electrons:

Single muon with threshold of 50 GeV at HLT

Double ElectronGamma with threshold of 33 GeV at HLT

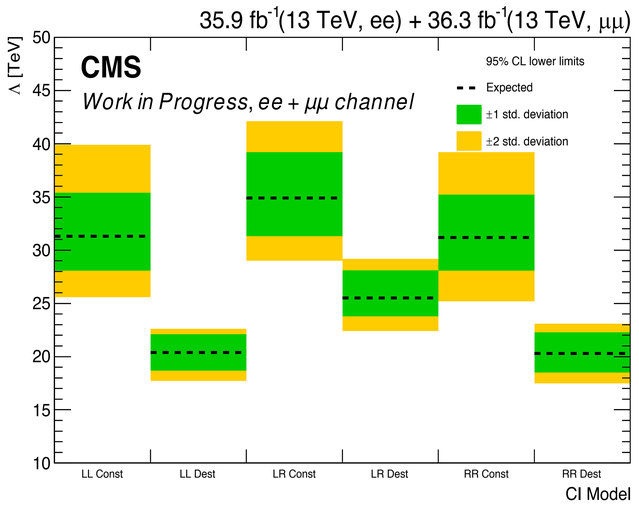


Fig. 7 Summary of 95% CL expected limits for the combination of the dielectron and dimuon channels in Contact Interactions

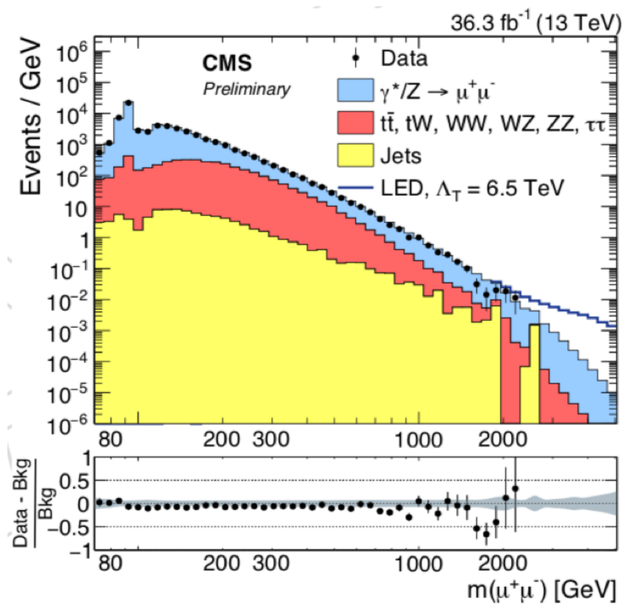


Fig. 5 Dimuon mass distribution for Λ_T = 6.5 TeV LED signal compared to SM background and data collected by CMS

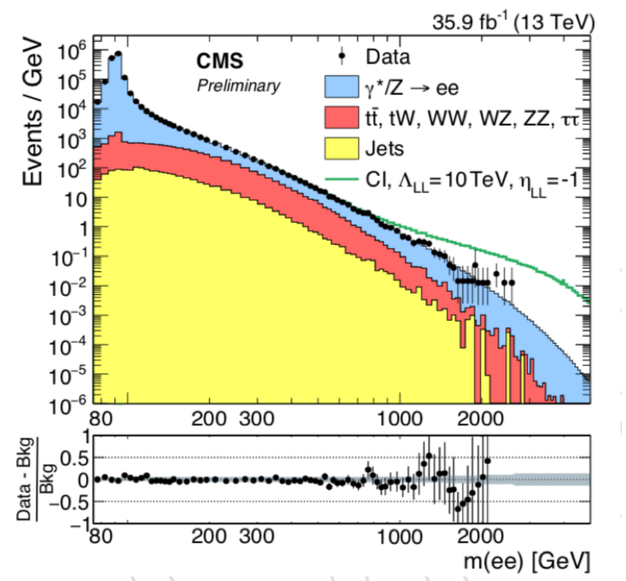


Fig. 6 Dielectron mass distribution for LL constructive, Λ = 10 TeV CI signal compared to SM background and data collected by CMS

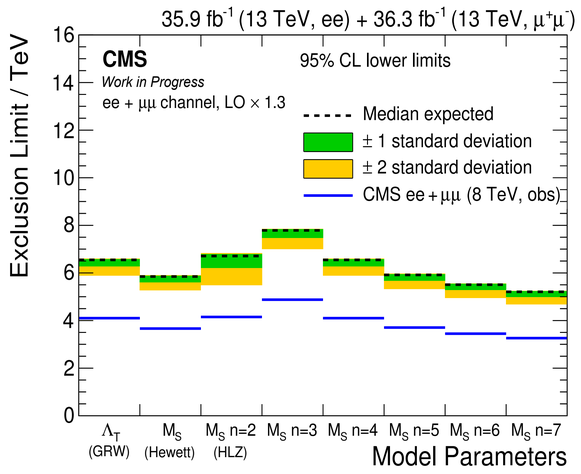


Fig. 8 Summary of 95% CL expected limits for three LED parameter conventions