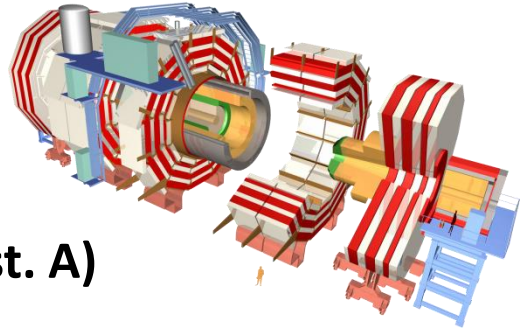
Search for Excited Leptons in CMS



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on behalf of the CMS Collaboration

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References:

- CMS-PAS-EXO-18-013, *JHEP 05 (2020) 052*
- CMS-PAS-EXO-18-004, *JHEP 04 (2019) 015*

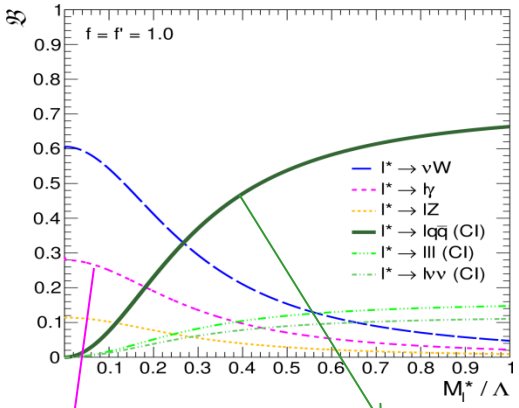
Compositeness and Excited Leptons

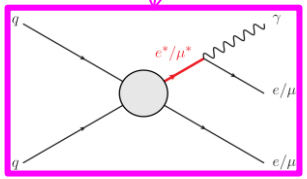
Search for compositeness by looking for excited leptons (e*, μ*)
in several channels: Note: ℓ^* produced in conjuction with SM ℓ

- Decay via gauge interaction (GI)
  - $\ell^* \rightarrow \ell W \rightarrow \ell jj$ ($\ell\ell\nu$ hard to separate)
  - $\ell^* \rightarrow \ell\gamma$ => best channel for high Lambda reach
  - $\ell^* \rightarrow \ell Z \rightarrow \ell jj$ (or $\ell\ell\ell$ very clean but low xsec)
- Decay via contact interaction (CI)
  - $\ell^* \rightarrow \ell jj$ => best channel for high m_{ℓ^*} reach (or $\ell\ell\ell$ but low xsec)

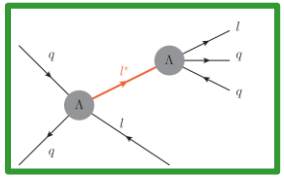
Model parameters:

- Compositeness scale Λ
- Excited lepton mass m_{ℓ^*}
- Fraction of GI and CI governed by parameters f and f'. Usual assumption f = f' = 1 where all channels contribute and branching fractions of above plot apply.
  - $l\gamma$ cannot contribute in scenario f = -f' = 1
  - For |f| < 1 CI channels becomes dominant





Final state:
2 leptons + 1 γ
JHEP 04 (2019) 015



Final state:
2 leptons + 2 separated jets
JHEP 05 (220) 052

CI Search with 2ℓ2j Final State

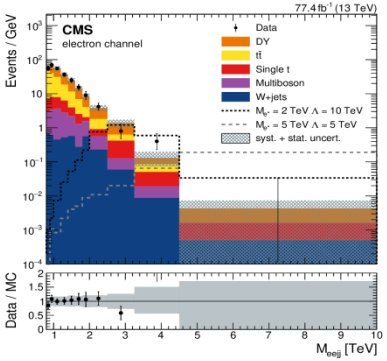
Standard analysis for f = f'= 1

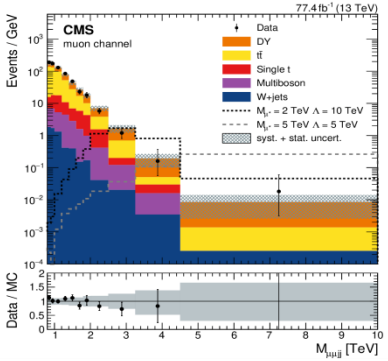
Use 77.4/fb of pp collision data at √s = 13 TeV

Event selection:

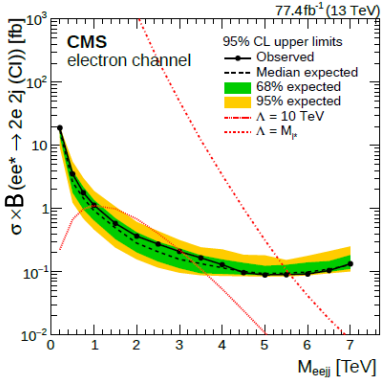
- Leading ele > 230 GeV, leading mu > 53 GeV (trigger!)
- Two same-flavour leptons. p_T>35(e)/25(mu) GeV for 2nd ℓ.
- Jets (Anti-kT with R=0.4) > 50 GeV
- Signal region ($M_{\ell\ell}$ > 500 GeV) to suppress DY and $t\bar{t}$ bkg.

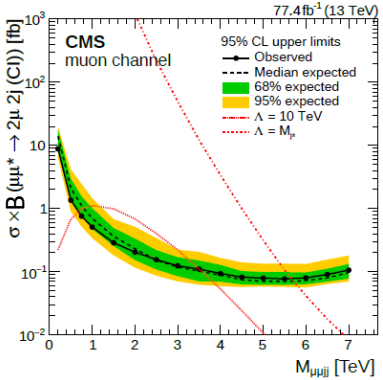
Signal region $M_{\ell\ell}$ > 500 GeV



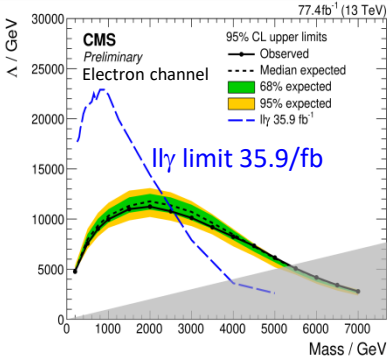


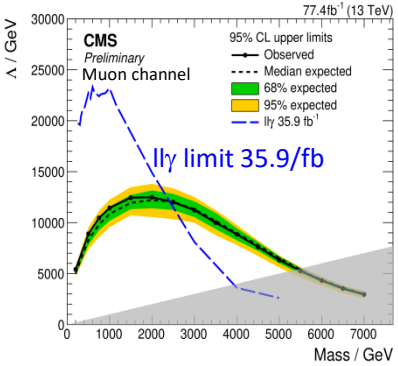
Excited lepton signal **would yield additional** events at **high** $M_{\ell\ell jj}$ depending on Λ and m_{ℓ^*}. No sign of ℓ* seen in data
→ Limit on cross-section





Reinterpretation of CI limit for f = f' = 1
Limits on m_{ℓ^*} > 5.6 TeV
Λ > 11(12) TeV @ m=2 TeV





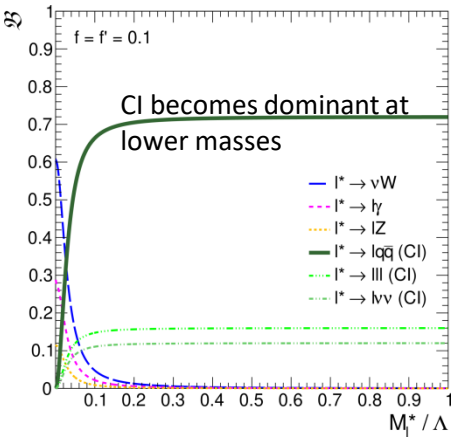
CI Search - If f and f' < 1

Allows to test larger values of Λ

Use 77.4/fb of pp collision data at √s = 13 TeV

Typically |f| = 1 is chosen but |f| could be different from unity. Choice has **significant impact on sensitivity on compositeness scale Λ**. Limit on m_{ℓ^*} is unaffected.

Search channel	Coupling strength	$M_{\ell^*} = \Lambda$, values in TeV $f = f'$	$f = -f'$	Limit on Λ, in TeV Observed (Expected)
$ee^* \to 2e2j$	$f = 1$	5.6 (5.6)	5.6 (5.6)	11 (11) for $M_{\ell^*} \approx 2$ TeV
	$f = 0.1$	5.6 (5.6)	5.6 (5.6)	17 (18) for $M_{\ell^*} \approx 1.5$ TeV
	$f = 0$	5.6 (5.6)	5.6 (5.6)	18 (19) for $M_{\ell^*} \approx 1$ TeV
$\mu\mu^* \to 2\mu2j$	$f = 1$	5.7 (5.7)	5.7 (5.7)	12 (12) for $M_{\ell^*} \approx 2$ TeV
	$f = 0.1$	5.7 (5.7)	5.7 (5.7)	19 (19) for $M_{\ell^*} \approx 1.5$ TeV
	$f = 0$	5.7 (5.7)	5.7 (5.7)	22 (20) for $M_{\ell^*} \approx 1$ TeV



In extreme case GI couplings vanish and only CI channel can be used.