

# Searches for new physics in dijet, multijet, and lepton+jets final states at CMS

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on behalf of the CMS collaboration

SUSY 2017



Universität Hamburg  
DER FORSCHUNG | DER LEHRE | DER BILDUNG

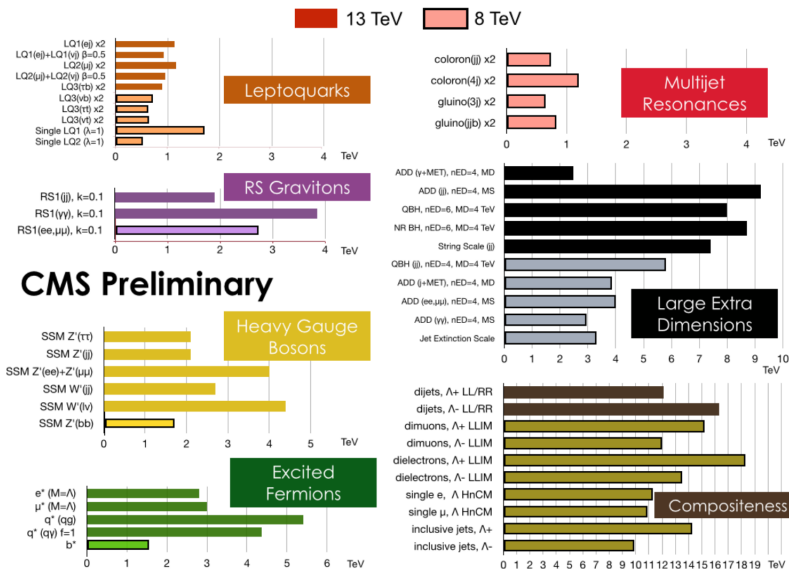


GEFÖRDERT VOM

Bundesministerium  
für Bildung  
und Forschung

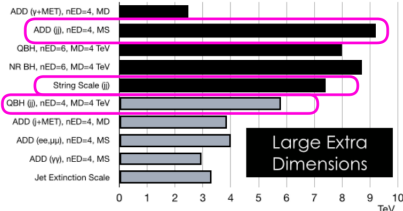
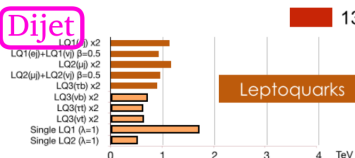


# Extensive CMS Exotica Program

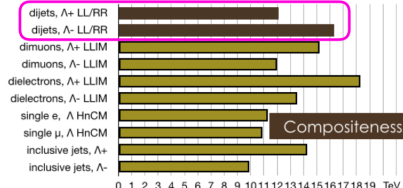
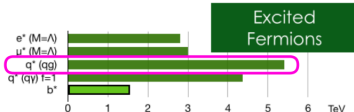


# Extensive CMS Exotica Program

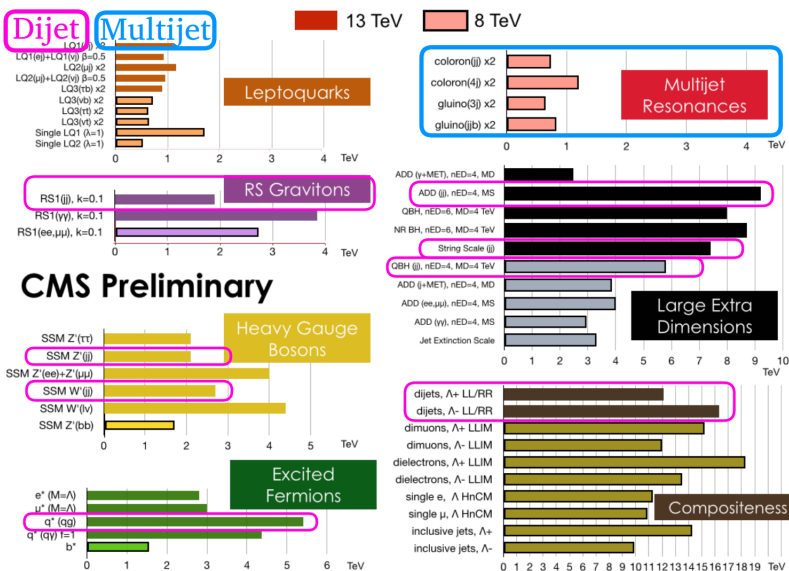
## Dijet



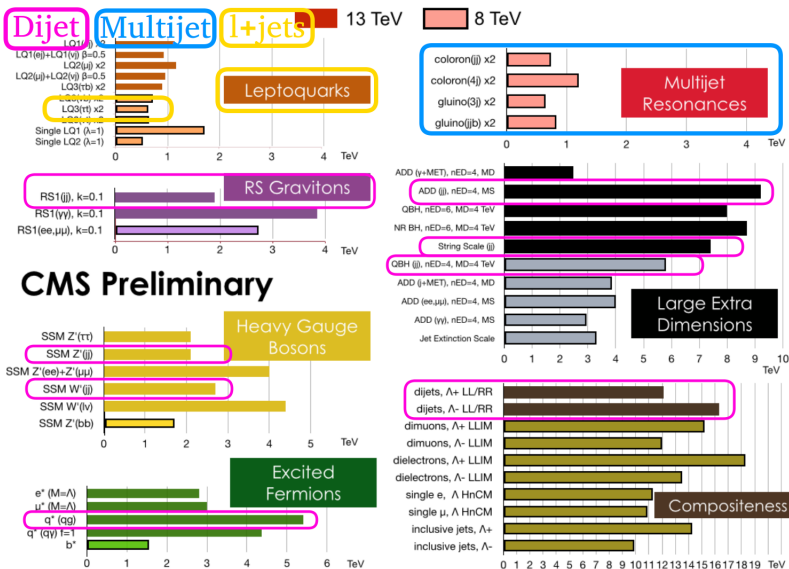
## CMS Preliminary



# Extensive CMS Exotica Program

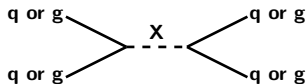


# Extensive CMS Exotica Program



# Search for dijet resonances

CMS-EXO-16-056



Reconstruction of two leading jets with wide-jet-algorithm:

- adds neighboring jets to nearest leading jet if within  $\Delta R < 1.1$   
→ two wide jets
- Wide jets  $|\Delta\eta| < 1.3$  (reduce BG from t-channel dijet events)

Low-mass search:

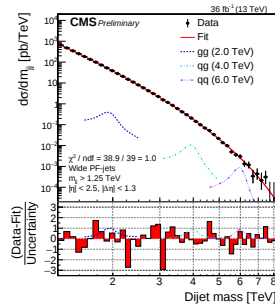
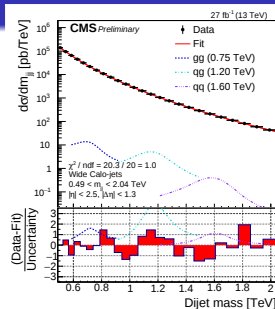
- $H_T^{\text{jets}} > 250\text{GeV}$ ,  $m_{jj} > 0.50\text{TeV}$

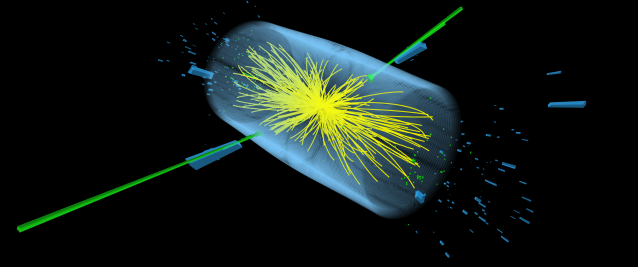
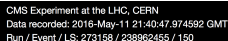
High-mass search:

- $H_T^{\text{jets}} > 900\text{GeV}$ ,  $m_{jj} > 1.25\text{TeV}$

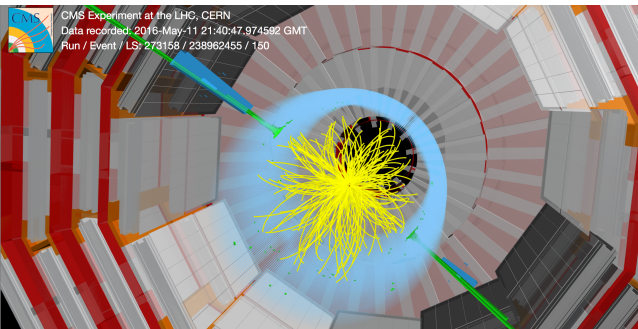
Dijet mass spectrum is fit with a parameterization

No excess observed





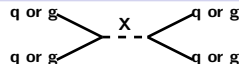
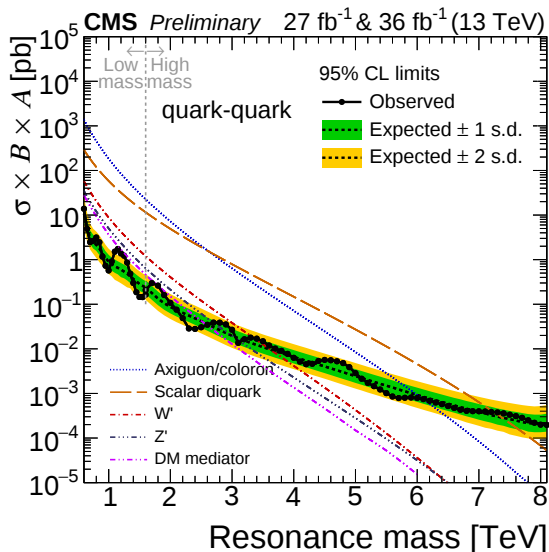
Large mass dijet event  
recorded by CMS:  
 $m_{jj} = 7.7\text{TeV}$



Both jets reconstructed  
in barrel region and with  
 $p_T > 3\text{TeV}$

# Search for dijet resonances – Limits

CMS-EXO-16-056



quark-quark

- axiguons
- colorons
- W', Z', ...

quark-gluon

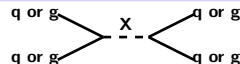
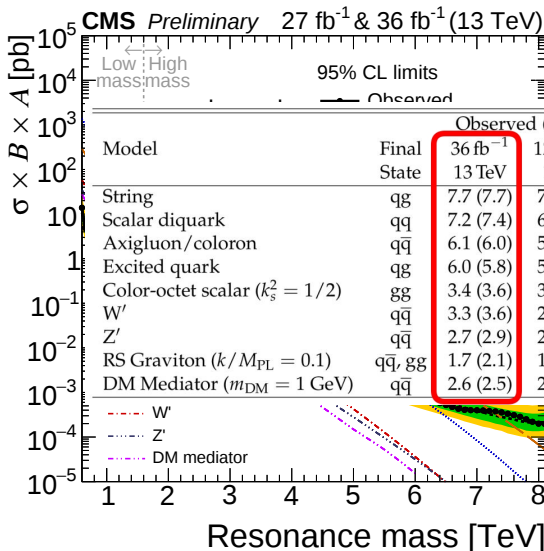
- excited quarks
- string resonances

gluon-gluon

- RS graviton
- Color octet scalar resonances

# Search for dijet resonances – Limits

CMS-EXO-16-056



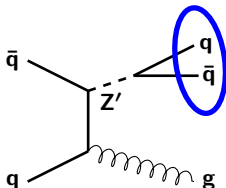
quark-quark

● axigluons

● RS graviton

● Color octet scalar resonances

# Search for light dijet resonances



Dijet topology:

- 1 jet with substructure + 1 jet

Complementary approach to 'resolved' analysis

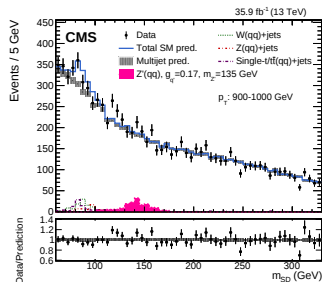
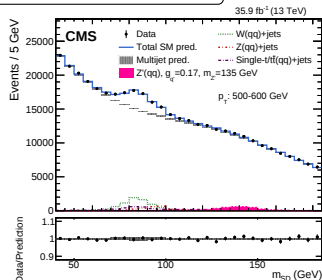
- allows to probe mass region  $< 300\text{ GeV}$

Selection

- large radius jet with  $p_T > 500\text{ GeV}$  with softdrop criterion
- substructure requirement: two (one) prong structure in jets of signal (BG) events
- data driven BG estimation

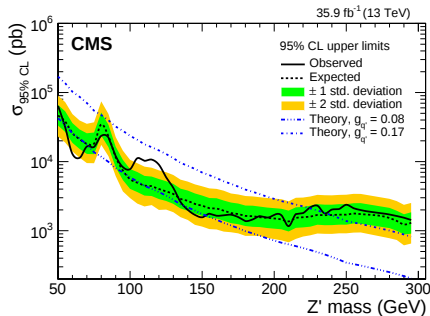
No excess observed

arXiv: 1710.00159



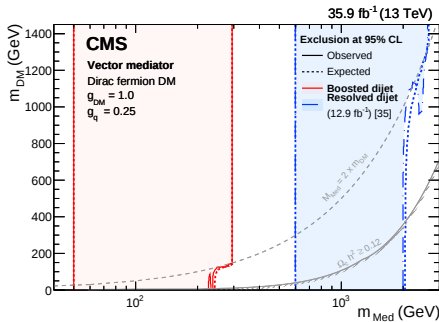
# Search for light dijet resonances

arXiv: 1710.00159



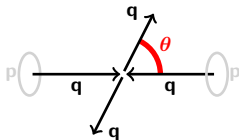
- strong constraint for masses less than 300 GeV
- first results for 50-100 GeV range

- interpretation for DM search
- combination of boosted and resolved analyses



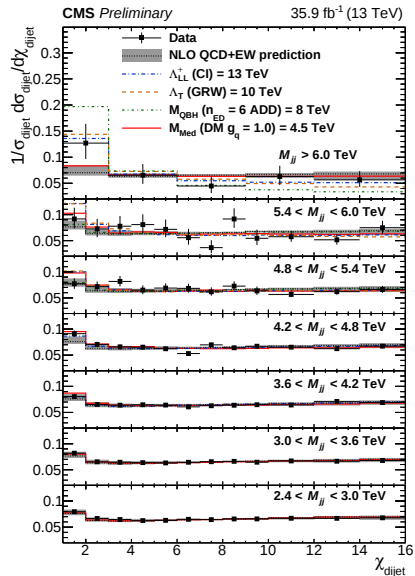
# Search for new physics with dijet angular distributions

CMS-EXO-16-046



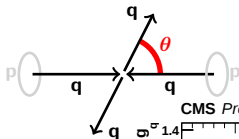
- Angular variable:  

$$\chi_{\text{dijet}} = \exp(|y_1 - y_2|) \sim \frac{1 + |\cos \theta|}{1 - |\cos \theta|}$$
- relatively flat for leading QCD processes  $\rightarrow$  NP will change  $\chi_{\text{dijet}}$  at low values
- two leading jets used to measure  $\chi_{\text{dijet}}$  in bins of  $M_{jj}$
- data unfolding  $\rightarrow$  unfold measured distribution to particle level

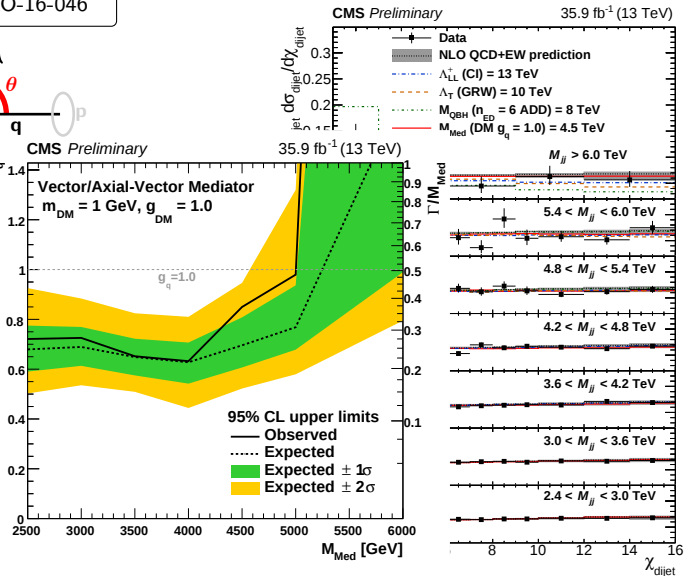


# Search for new physics with dijet angular distributions

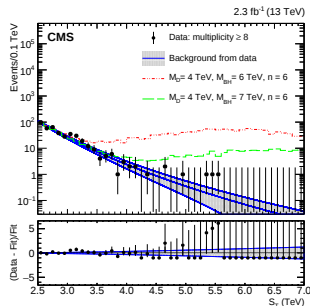
CMS-EXO-16-046



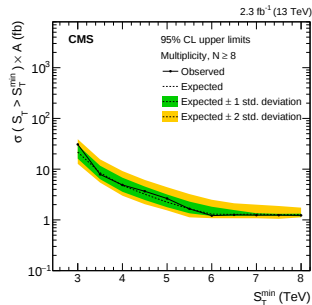
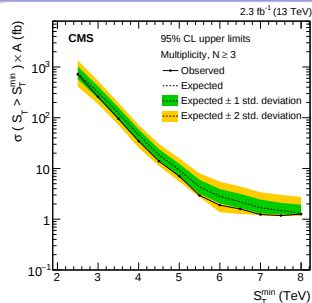
- Angular variable  $\chi_{\text{dijet}} = \exp(|\cos\theta|)$
- relatively flat in  $\chi_{\text{dijet}}$  for SM processes  $\rightarrow$  flat at low values
- two leading jets  $\rightarrow$   $\chi_{\text{dijet}}$  in bins
- data unfolding distribution to



Phys. Lett. B774  
P.279-307 (2017)

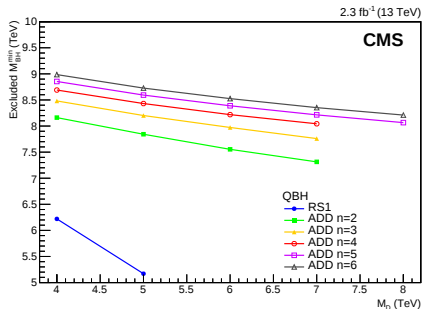


# Search for new physics in multijet final states



Phys. Lett. B774  
P.279-307 (2017)

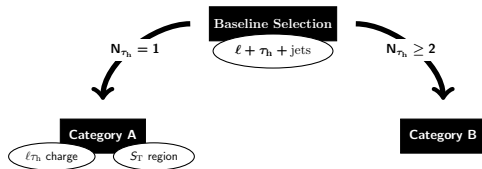
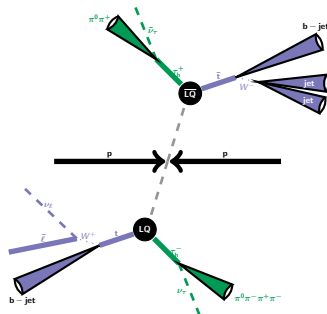
- model independent limits can be applied to various NP models



# Search for $LQLQ \rightarrow t\tau t\tau$

CMS-B2G-16-028

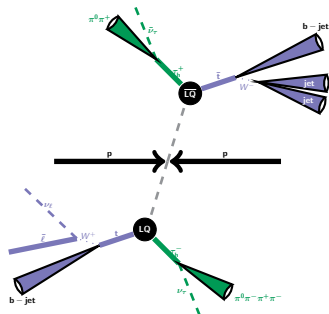
- recent anomalies observed in B-meson decays point to  $LQ_3$



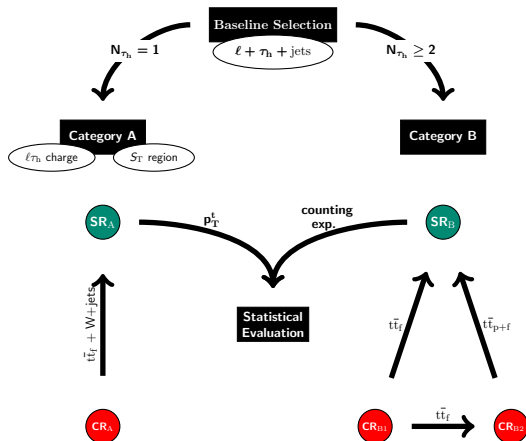
# Search for $LQLQ \rightarrow t\tau t\tau$

CMS-B2G-16-028

- recent anomalies observed in B-meson decays point to  $LQ_3$

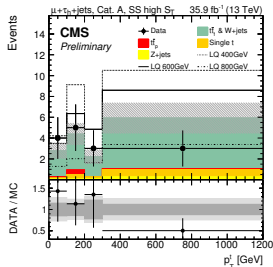
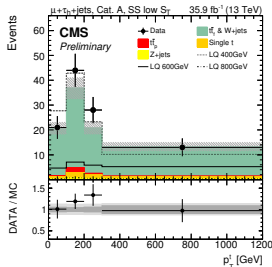
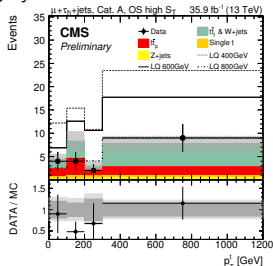
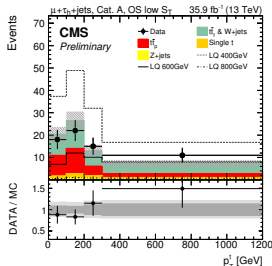


- main BGs with misidentified  $\tau_h$  from CRs (inverted  $\tau_h$  isolation)



# Search for $LQLQ \rightarrow t\tau t\tau$

Category A



CMS-B2G-16-028

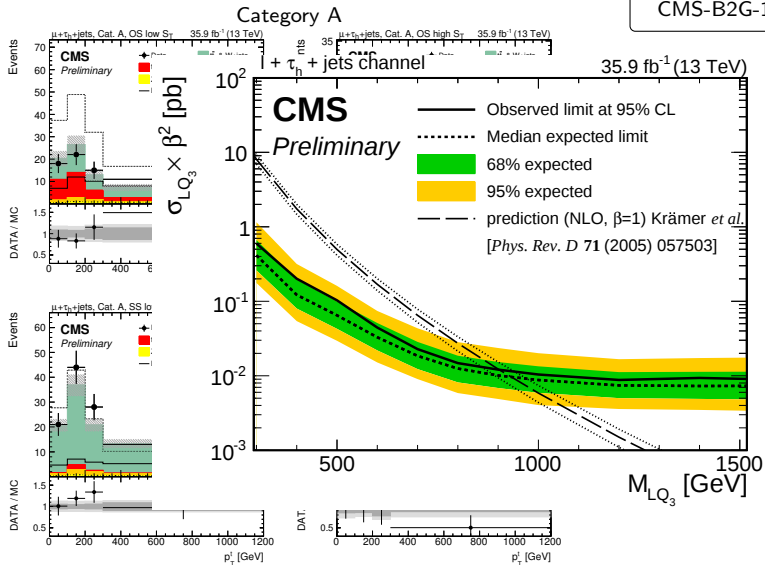
Category B:

|             |                      |
|-------------|----------------------|
| LQ (400GeV) | $101^{+19}_{-18}$    |
| LQ (600GeV) | $22.1^{+4.3}_{-4.0}$ |
| LQ (800GeV) | $4.5^{+1.0}_{-0.9}$  |
| Total BG    | $8.4^{+2.6}_{-2.4}$  |
| DATA        | 11                   |

- different categories cover a wide range of LQ masses
- no excess observed

# Search for $LQLQ \rightarrow t\tau t\tau$

CMS-B2G-16-028

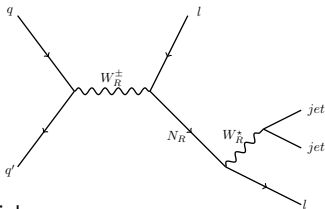


$$\begin{array}{r}
 101^{+19}_{-18} \\
 22.1^{+4.3}_{-4.0} \\
 4.5^{+1.0}_{-0.9} \\
 \hline
 8.4^{+2.6}_{-2.4} \\
 \hline
 11
 \end{array}$$

egories  
range of  
served

# Heavy neutrinos and $W_R$ in $\ell\ell jj$ final state

CMS-EXO-17-011



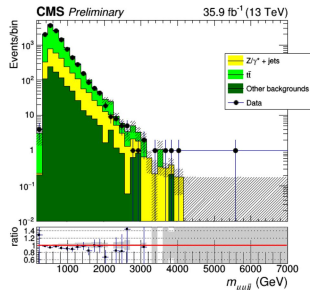
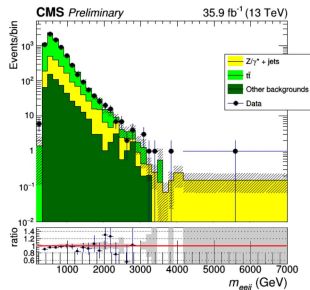
## Selection

- $2\ell$  at high  $p_T$
- 2jets at high  $p_T$
- requirements on  $M_{\ell\ell}$  ( $> 200\text{GeV}$ ) and  $M_{\ell\ell jj}$  ( $> 600\text{GeV}$ )

## BG estimation

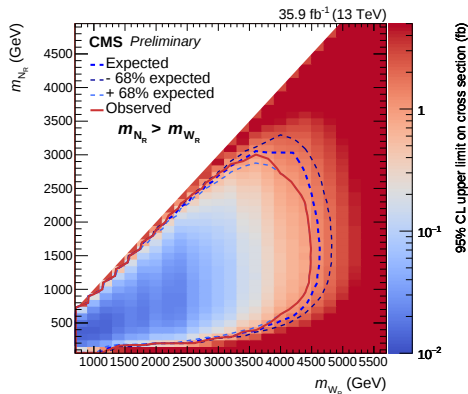
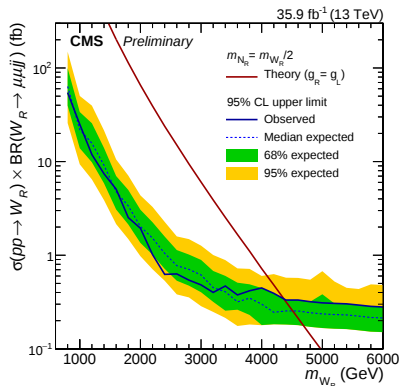
- $t\bar{t}$ : from data in  $e\mu$  CR extrapolated to SR
- $Z$  + jets: estimated from simulation, normalization from data in Z-peak region

No excess observed



# Heavy neutrinos and $W_R$ in $\ell\ell jj$ final state

CMS-EXO-17-011



- results from muon channel
- $W_R > 4.5$  TeV for  $M(\nu) = 0.5M(W_R)$

# Summary

- CMS covers wide program of searches in dijet, multijet, and  $\ell$  + jets final states
- Today: Dijet resonances, dijet angular distribution,  $LQ_3$  and  $W_R$  searches, high-multiplicity final states
- No significant excess found above SM predictions
- Limits are set on benchmark models

