Round Table: Anomalies
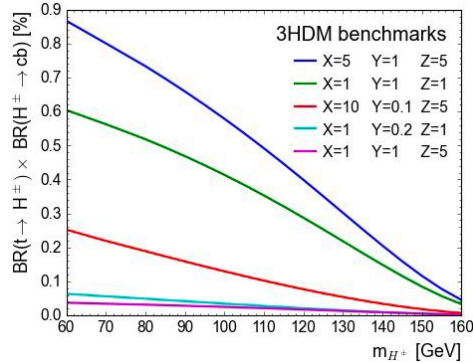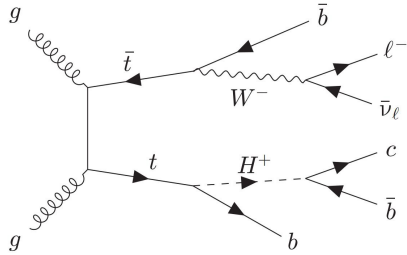
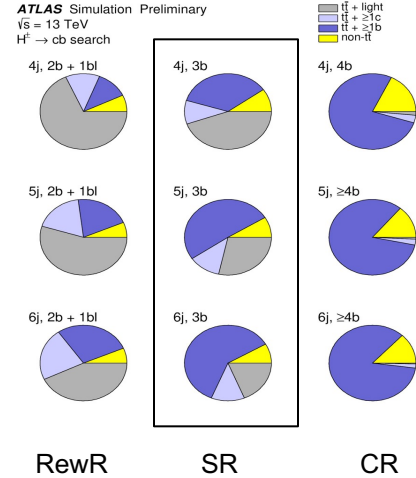# (in BSM searches)

Aurelio Juste
(ICREA / IFAE)

H+→cb
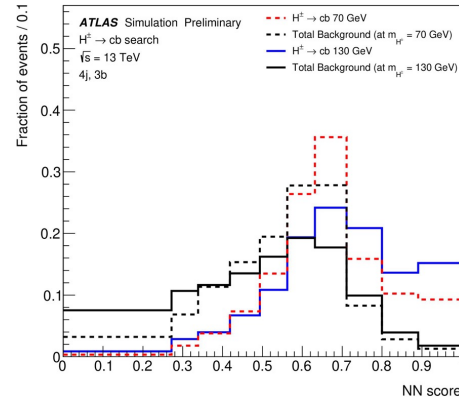

ATLAS-CONF-2021-037

RewR   SR   CR
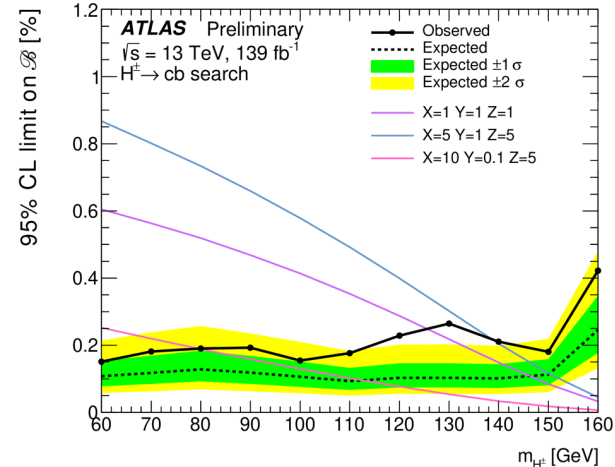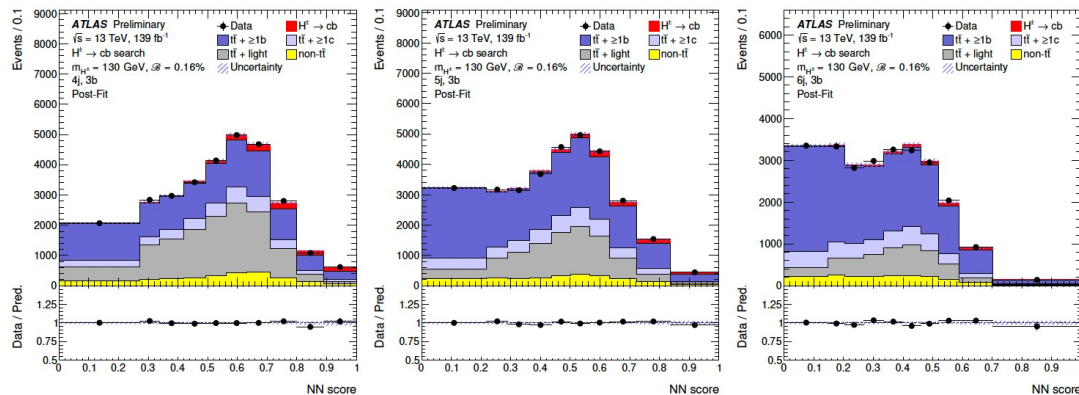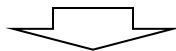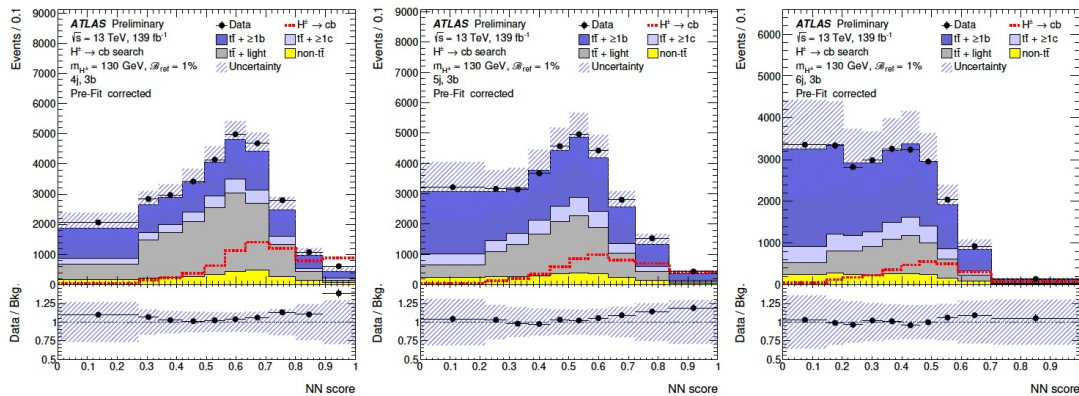
- Search for H+→cb in 60-160 GeV mass range
- Analysis strategy:
  - Select e/μ+≥4-jets events
  - Categorize events according to jet and b-jet multiplicity
  - NN to discriminate signal from background in 3b regions
  - Sophisticated likelihood fit across SRs and CRs.

H⁺→cb

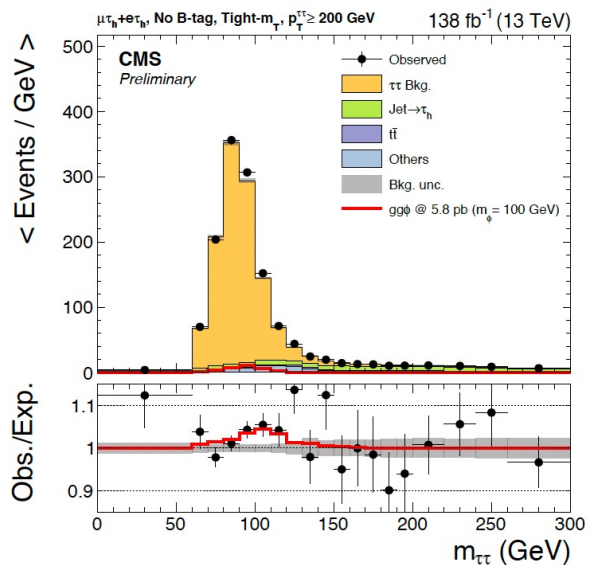3.0σ (local) excess at 130 GeV
Excess vs mass consistent
with limited mass resolution

3

ττ resonances

- Search for resonance in ττ (gluon-fusion and bbφ)
  - "low mass": 60 GeV < m_φ < 250 GeV
  - "high mass": 250 GeV < m_φ < 3.5 TeV
- Combination of eµ, µτ$_h$, eτ$_h$, and τ$_h$τ$_h$ channels
- Sophisticated event categorization

"low mass" categories

4

ττ resonances

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- Combination of eμ, μτ$_h$, eτ$_h$, and τ$_h$τ$_h$ channels
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	No b-tag			b-tag		
$\tau\tau \to e\mu$	Low-D_ζ	Medium-D_ζ	High-D_ζ	Low-D_ζ	Medium-D_ζ	High-D_ζ
$\tau\tau \to e\tau_h$	Loose-m_T	Tight-m_T		Loose-m_T	Tight-m_T	
$\tau\tau \to \mu\tau_h$	Loose-m_T	Tight-m_T		Loose-m_T	Tight-m_T	
$\tau\tau \to \tau_h\tau_h$						
$t\bar{t}(e\mu)$						

Signal region (SR)

Control region

5
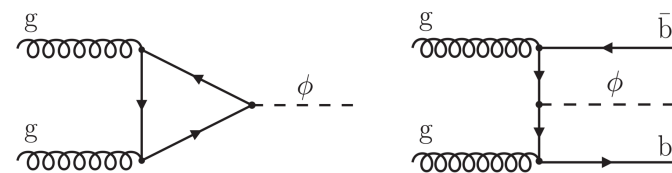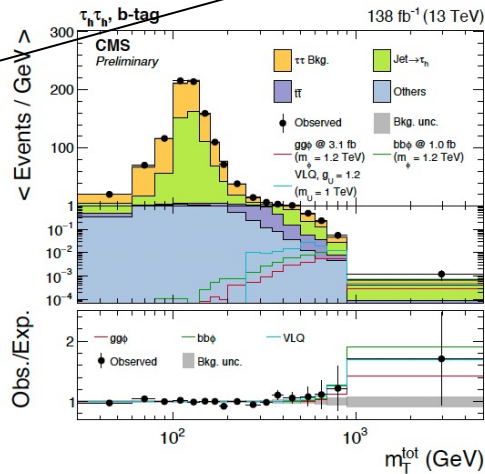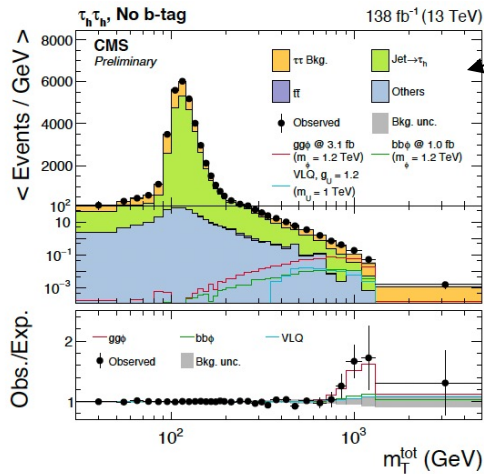
ττ **resonances**

- Two localized excesses:

  At 100 GeV:
  Local (global) significance: 3.1σ (2.7σ)

  At 1.2 TeV (gg→φ regions):
  Local (global) significance: 2.8σ (2.4σ)

- Also non-resonant-ττ vector LQ interpretation
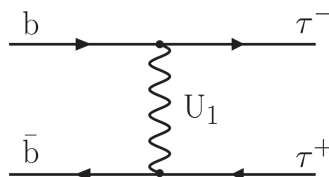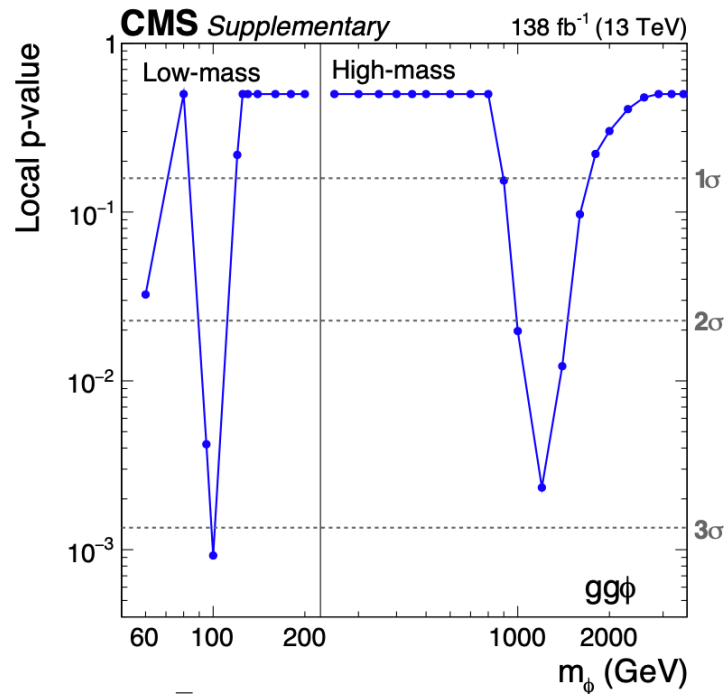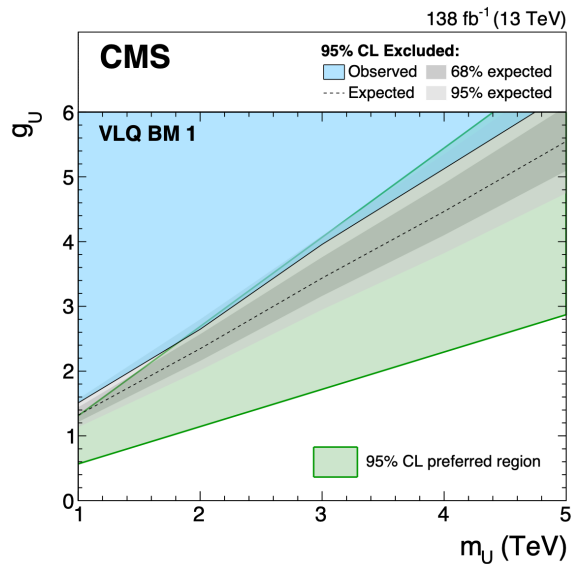
Vector-like leptons in 4321 model

- Search for VLLs in the 4321 model

  - Can accommodate B-physics anomalies (via a vector LQ)

  - Lightest particles in the spectrum are VLLs

    - Produced in pairs via the EW interaction

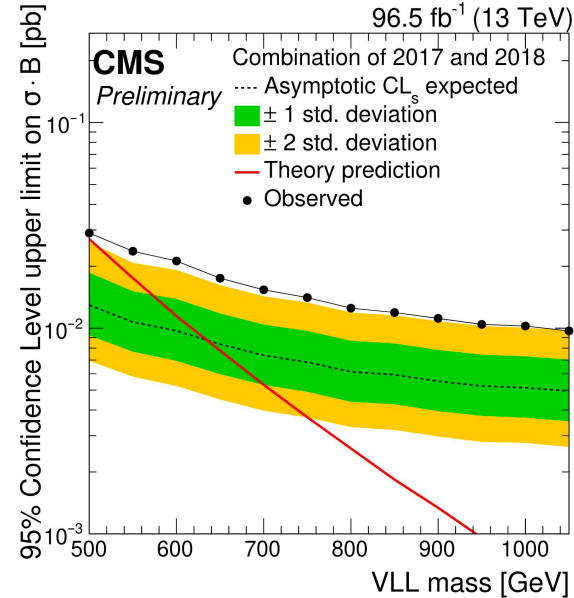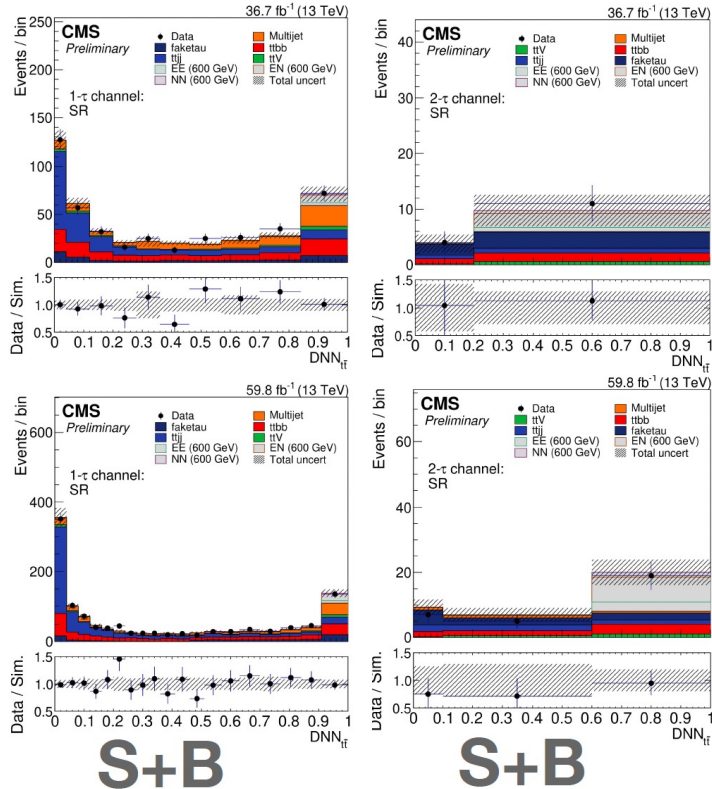   - 3-body decay via off-shell LQ
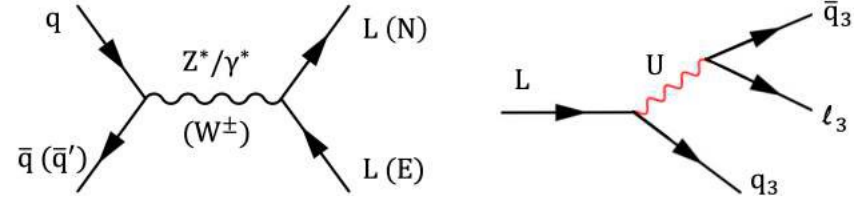
[CMS-PAS-B2G-21-004](CMS-PAS-B2G-21-004)

- Analysis strategy:

  - Focus on events with: ≥ 3 b-jets, 0,1,2 τ_h, and MET

  - Deep NN to discriminate signal from QCD ($0\tau_h$) and ttbar (1, $2\tau_h$)

  - Final discriminat: Njets ($0\tau_h$) and Dttbar (1, $2\tau_h$)

tau multiplicity	production + decay mode	final state
0 τ	EE $\to$ b(tν_τ)b(tν_τ)	4b + 4j + 2ν_τ
	EN $\to$ b(tν_τ)t(tν_τ)	4b + 6j + 2ν_τ
	NN $\to$ t(tν_τ)t(tν_τ)	4b + 8j + 2ν_τ
1 τ	EE $\to$ b(bτ)b(tν_τ)	4b + 2j + τ + ν_τ
	EN $\to$ b(tν_τ)t(bτ)	4b + 4j + τ + ν_τ
	EN $\to$ b(bτ)t(tν_τ)	4b + 4j + τ + ν_τ
	NN $\to$ t(bτ)t(tν_τ)	4b + 6j + τ + ν_τ
2 τ	EE $\to$ b(bτ)b(bτ)	4b + 2τ
	EN $\to$ b(bτ)t(bτ)	4b + 2j + 2τ
	NN $\to$ t(bτ)t(bτ)	4b + 4j + 2τ

Vector-like leptons in 4321 model

Local significance (600 GeV)

	2017	2018	Combination
0-τ	0	0	0
1-τ	1.44	1.65	1.93
2-τ	0.83	2.04	2.26
1+2-τ	1.63	2.55	2.88
0+1+2-τ	1.38	2.57	2.83

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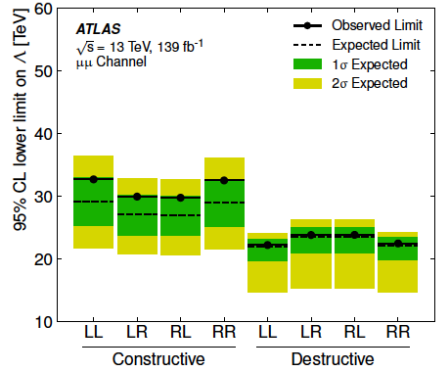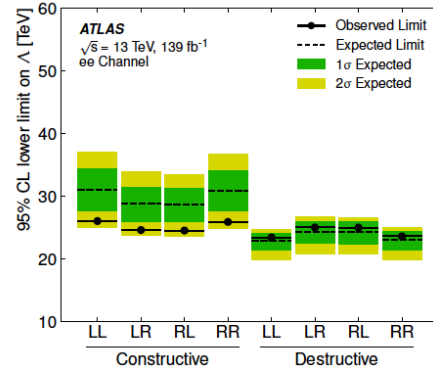# High-mass ee/μμ

- Non-resonant inclusive ee, μμ searches show slight excess in ee channel and deficit in μμ channel, in both ATLAS and CMS.

- Unfolded spectra and LFUV ratio test performed by CMS.
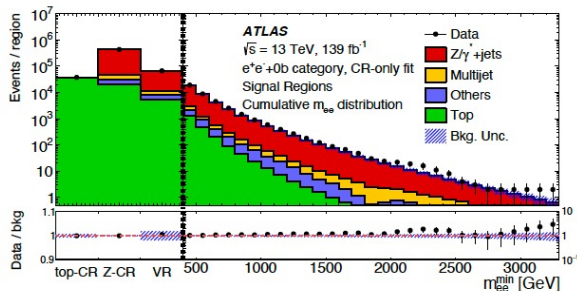
Chi2/dof=17.9/7
P-value=1.2%
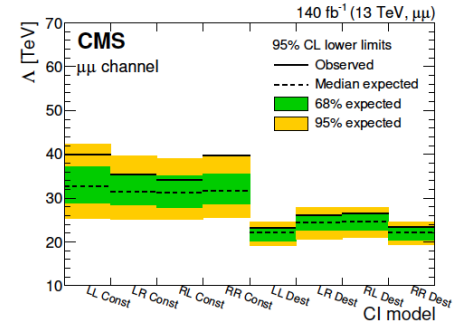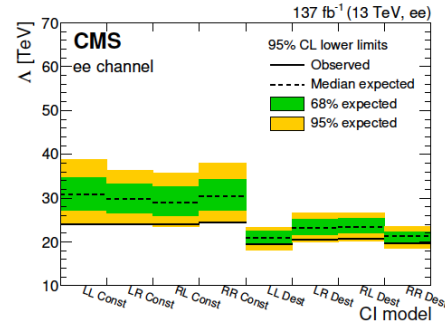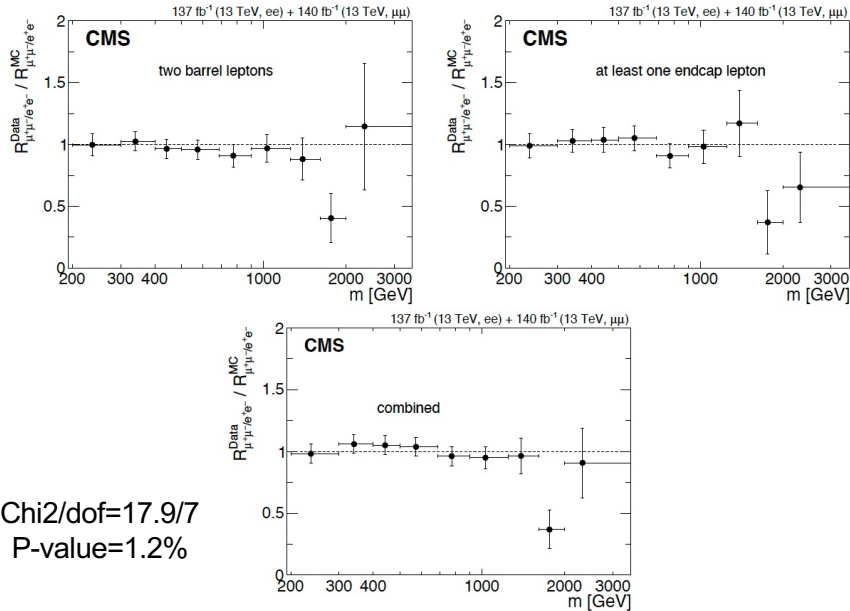
$$\mathcal{L}_{q\ell} = \frac{g_{contact}^2}{\Lambda^2} \left[\eta_{LL}(\overline{q}_L \gamma^\mu q_L)(\overline{\ell}_L \gamma_\mu \ell_L) + \eta_{RR}(\overline{q}_R \gamma^\mu q_R)(\overline{\ell}_R \gamma_\mu \ell_R) \right.$$
$$\left. + \eta_{LR}(\overline{q}_L \gamma^\mu q_L)(\overline{\ell}_R \gamma_\mu \ell_R) + \eta_{RL}(\overline{q}_R \gamma^\mu q_R)(\overline{\ell}_L \gamma_\mu \ell_L) \right]$$

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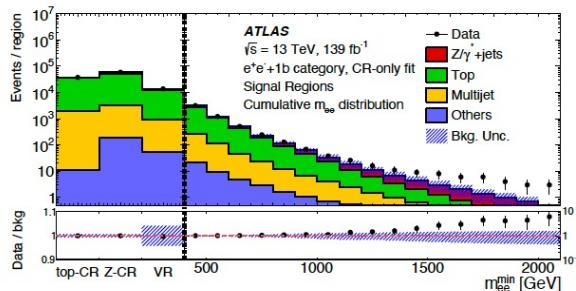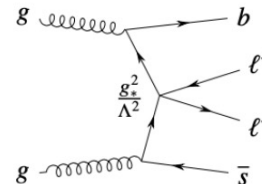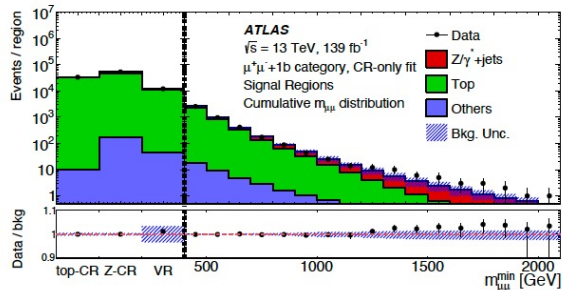# High-mass ee/μμ

- First search for bsll CI performed by ATLAS.

(a)
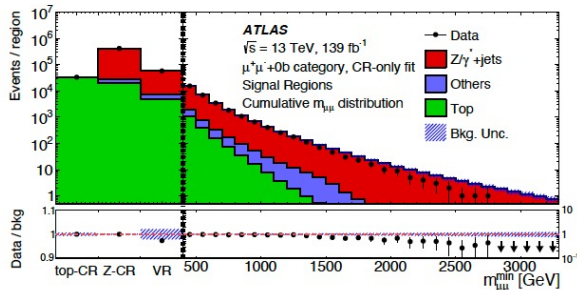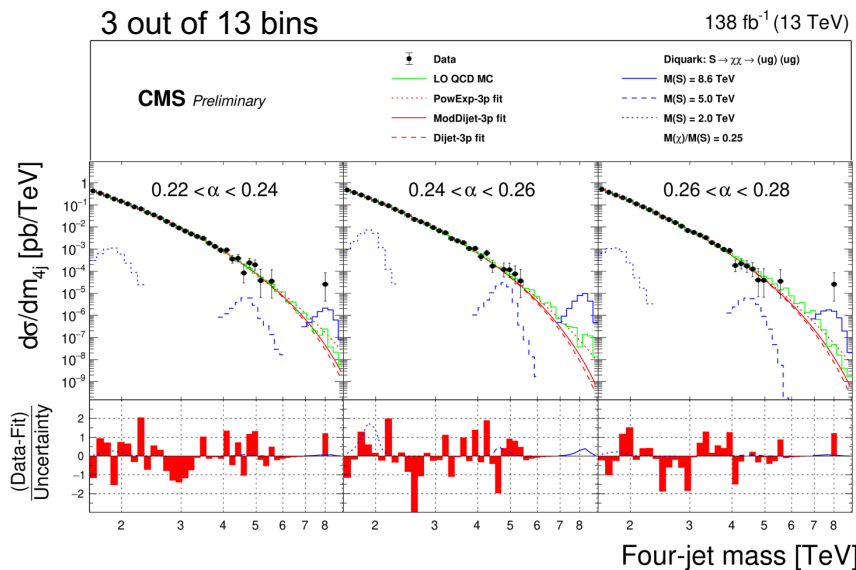

(b)

ee+1b, m_{ll}>1.7 TeV:
Local significance: 2.6σ
Global significance: 1.5σ
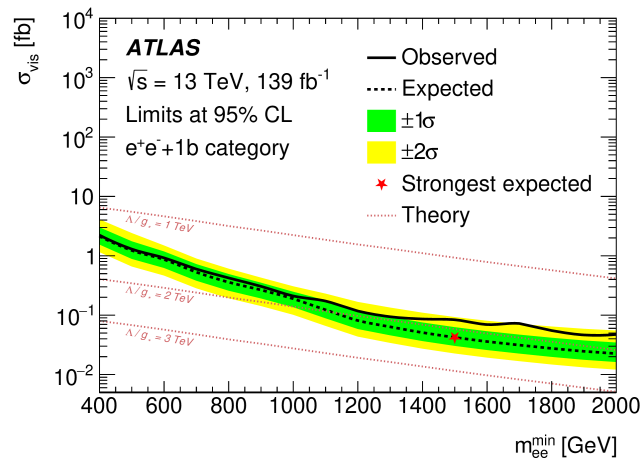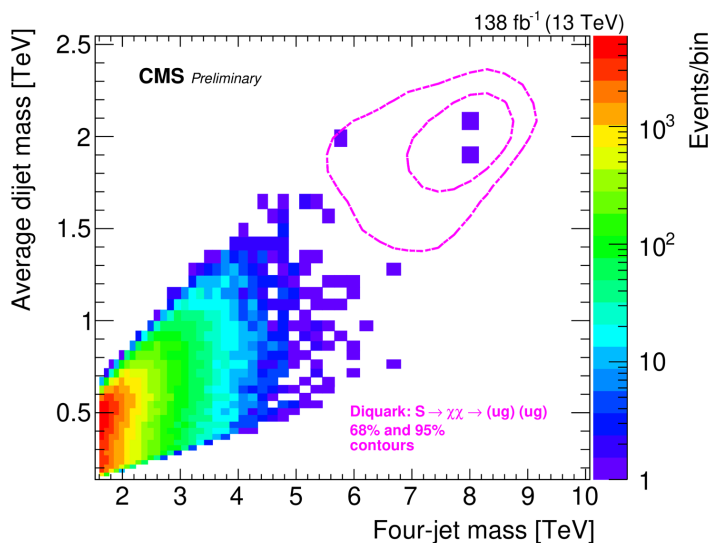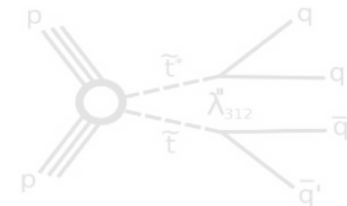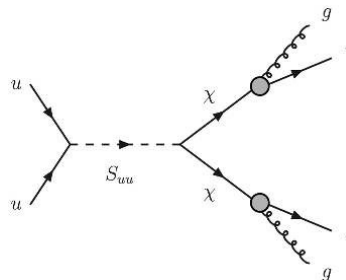
$(Y\rightarrow)XX\rightarrow(jj)(jj)$

- Analysis strategy

  - 4 narrow jets paired to two dijets

  - $\Delta R_{1,2},<2.0$, $\Delta\eta=|\eta_1-\eta_2|<1.1$, $|m_1-m_2|/(m_1+m_2)<0.1$

  - Search over m_{4j} and average m_{2j}

  - Fit 3-parameter function to data in slices of $\alpha=m_{2j}/m_{4j}$

$(Y\rightarrow)XX\rightarrow(jj)(jj)$
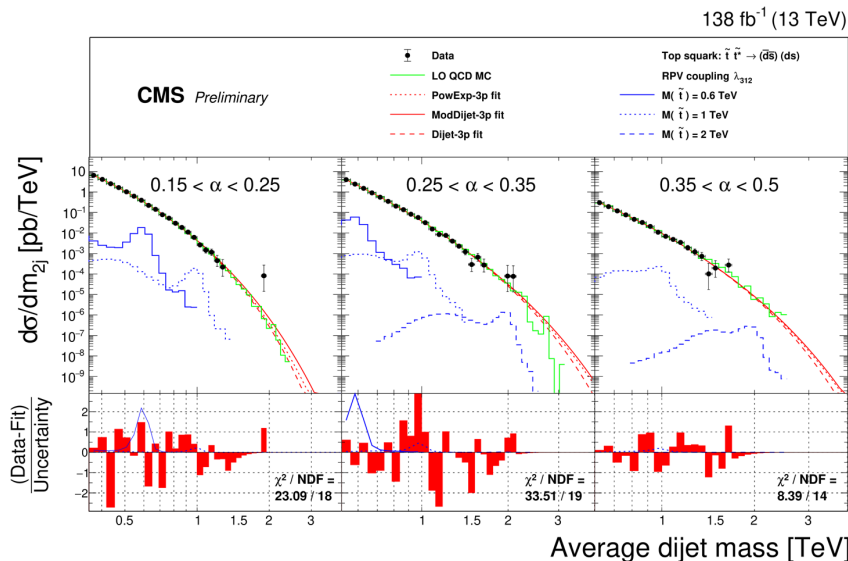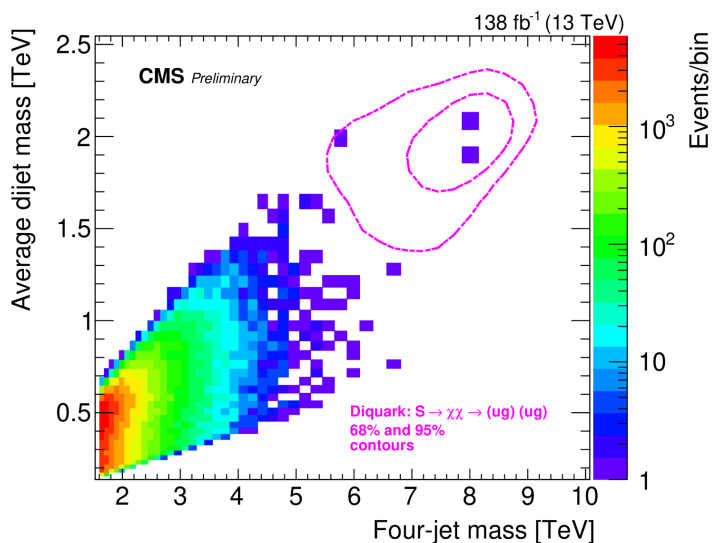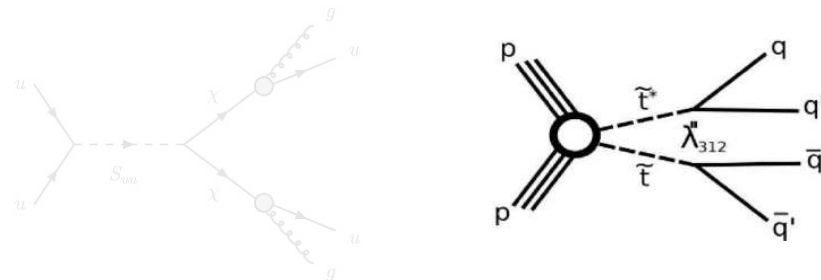
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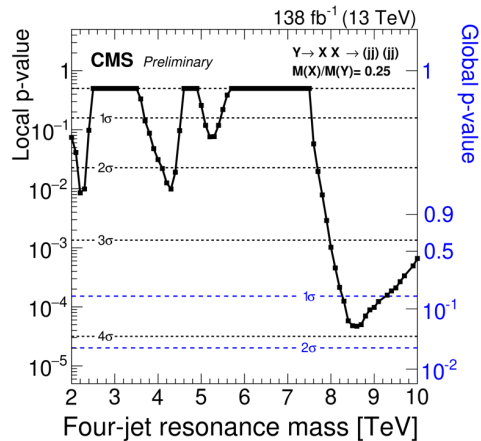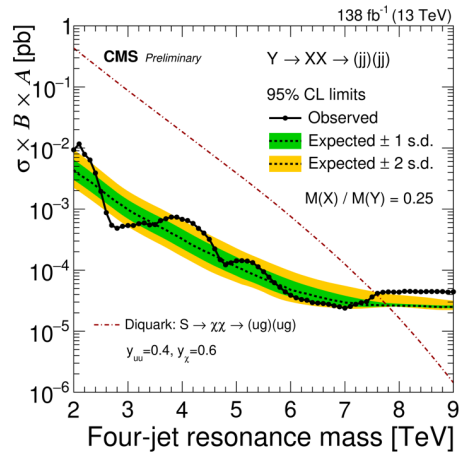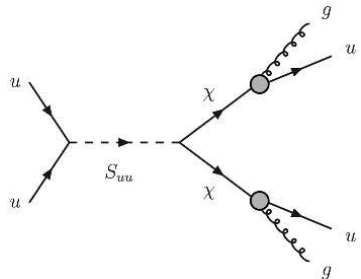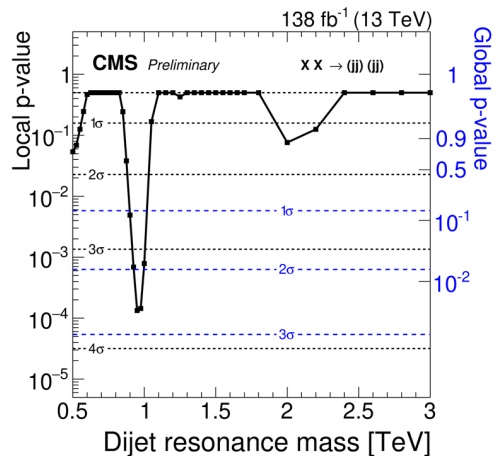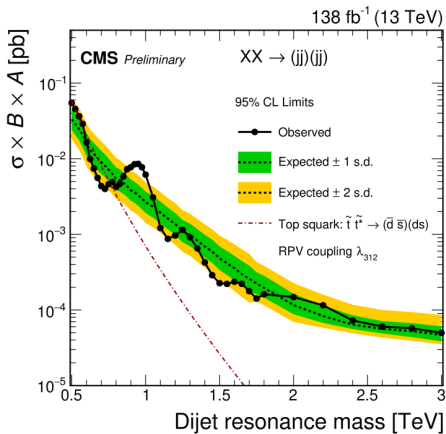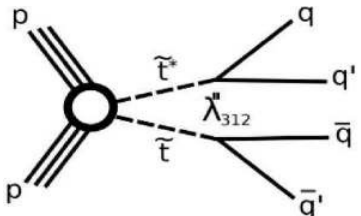
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(Y→)XX→(jj)(jj)

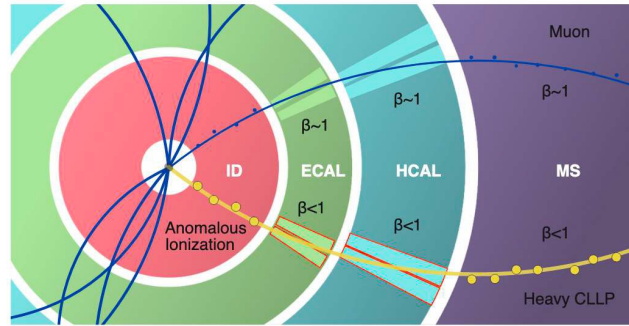Local significance: 3.9σ
Global significance: 1.6σ

Local significance: 3.6σ
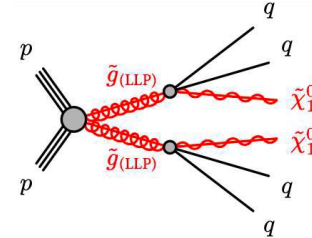Global significance: 2.5σ

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Massive LLPs

- Analysis strategy
  - Events selected with MET trigger
  - Select high-p_T isolated tracks with large specific ionization in pixel detector
  - Reconstruct the mass of these tracks

$$m_{dE/dx} \equiv \frac{p_{reco}}{\beta\gamma(\langle dE/dx \rangle_{corr})}$$

- Data-driven background estimation based on CRs.
  - Good agreement shown in VRs.

- An excess of events is observed in the "Inclusive-High" SR at masses exceeding 1 TeV.

- Local significance: 3.9σ
  Global significance: 1.6σ

- Caution: ToF study of excess events with calorimeter and muon system show a β~1.

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