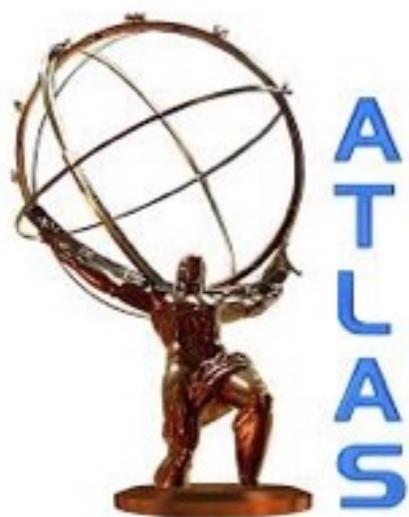


Searches for dijet resonances at high mass and other hadronic final states without MET with 13 TeV data



Yanyan Gao (University of Liverpool)

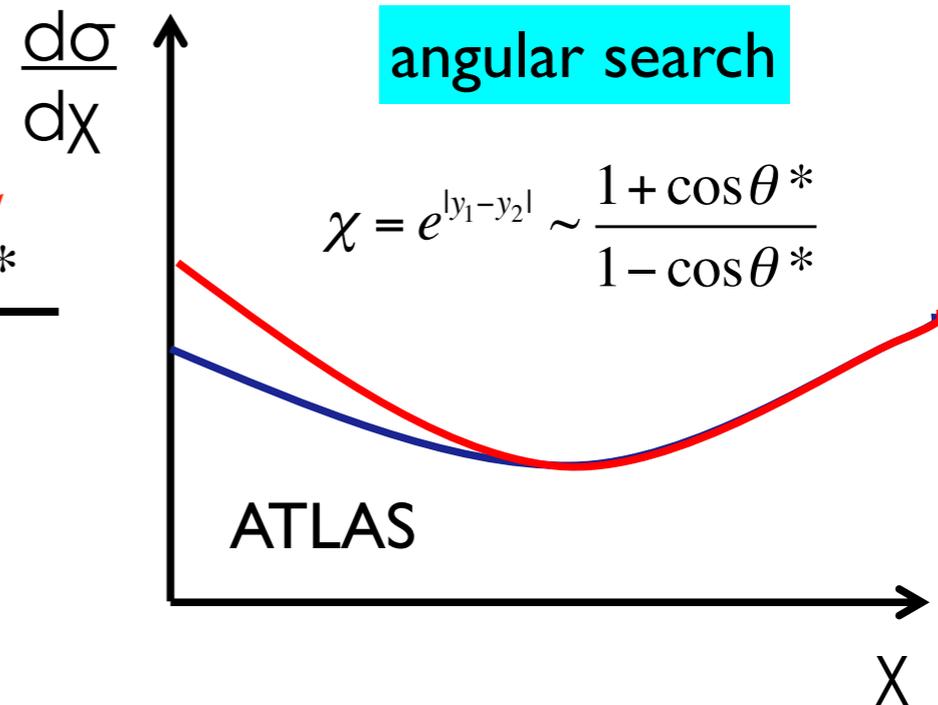
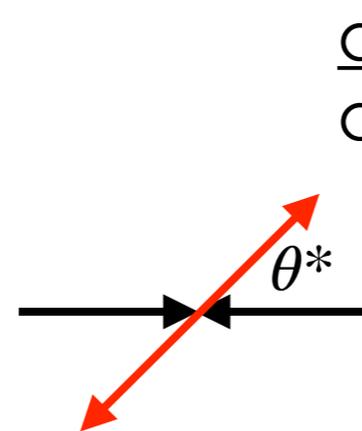
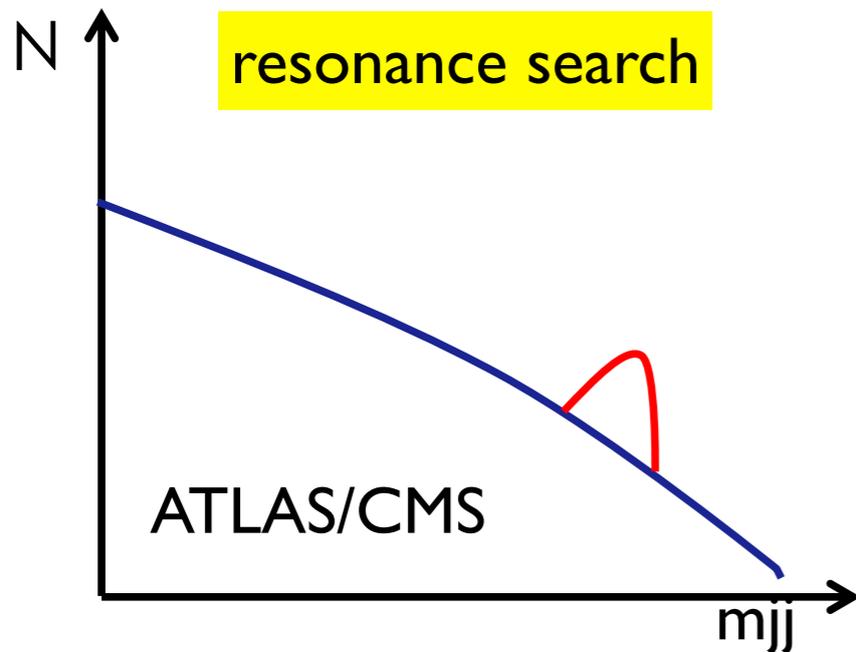
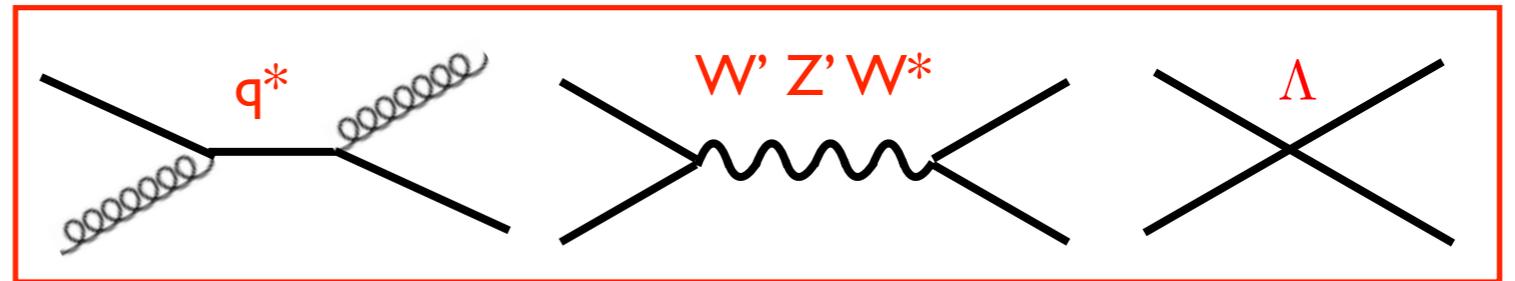
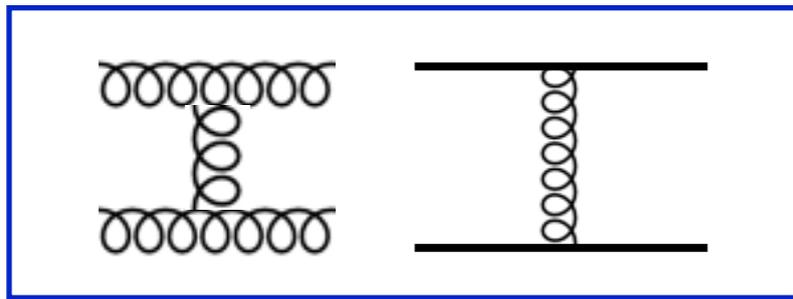
On behalf of ATLAS and CMS Collaboration

Moriond/EW 19 March 2017, La Thuille Italy



Introduction

- Di-jet final states are “classic signatures” to search for NP with strong interactions

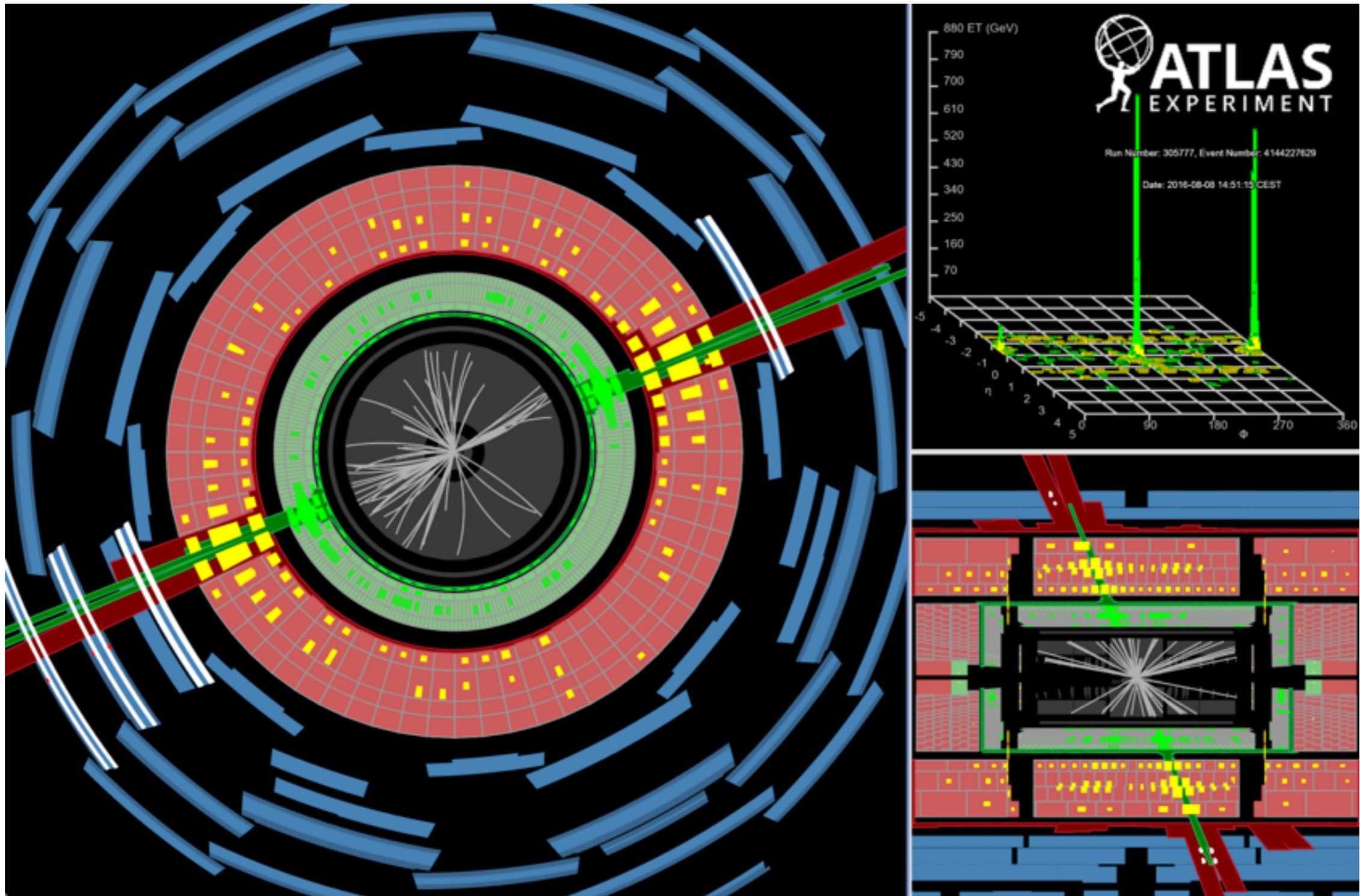


- QCD background: smoothing falling
- **Signal visible as resonance peak**
 - described by fit function
- Sensitive to narrow resonances

- QCD: produced in smaller polar angles
- BSM: more isotropic
- **visible as excess at low χ and high m_{jj}**
- Sensitive to contact interactions

Di-jet events

- Select two energetic jets (anti-Kt R=0.4) with high invariant mass



Each jet $p_t = 3.8$ TeV, Di-jet mass 8.12 TeV

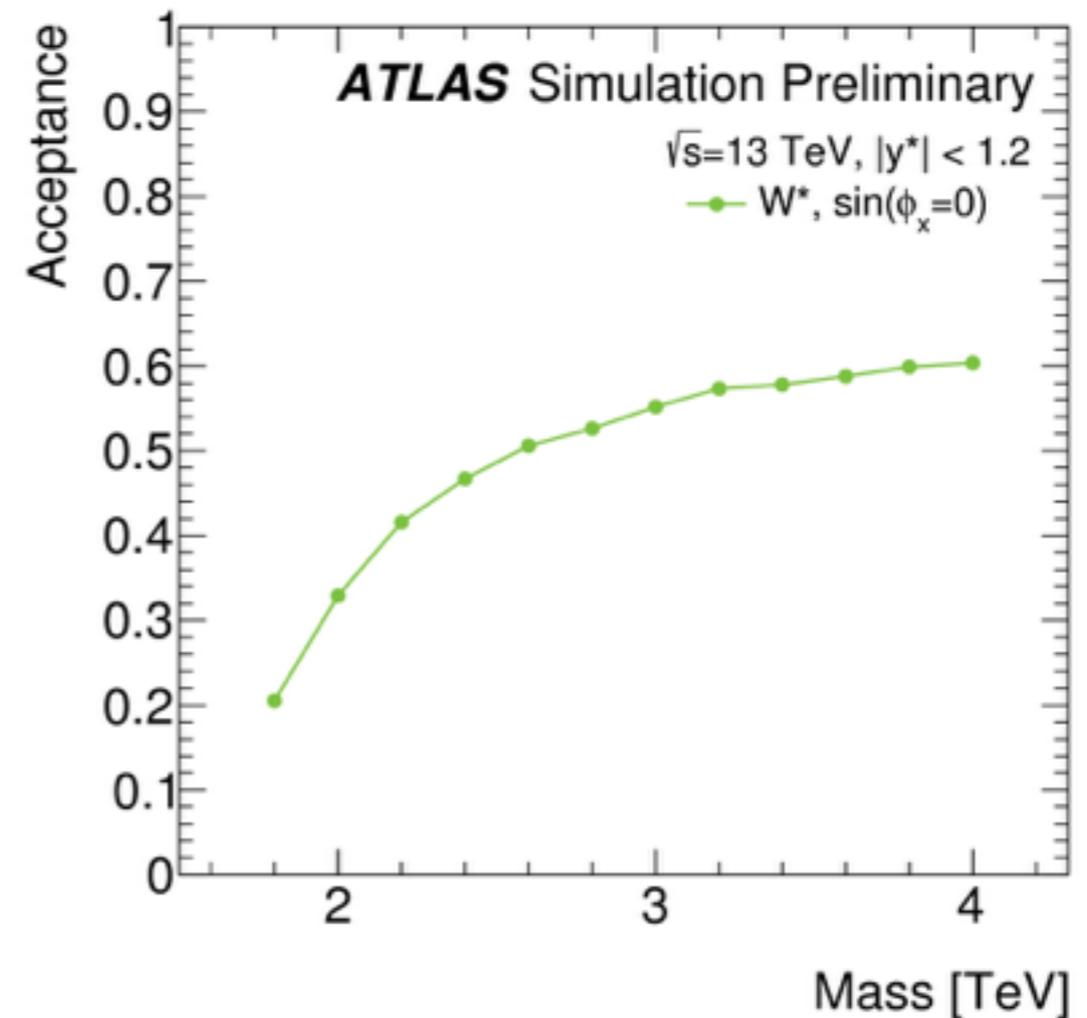
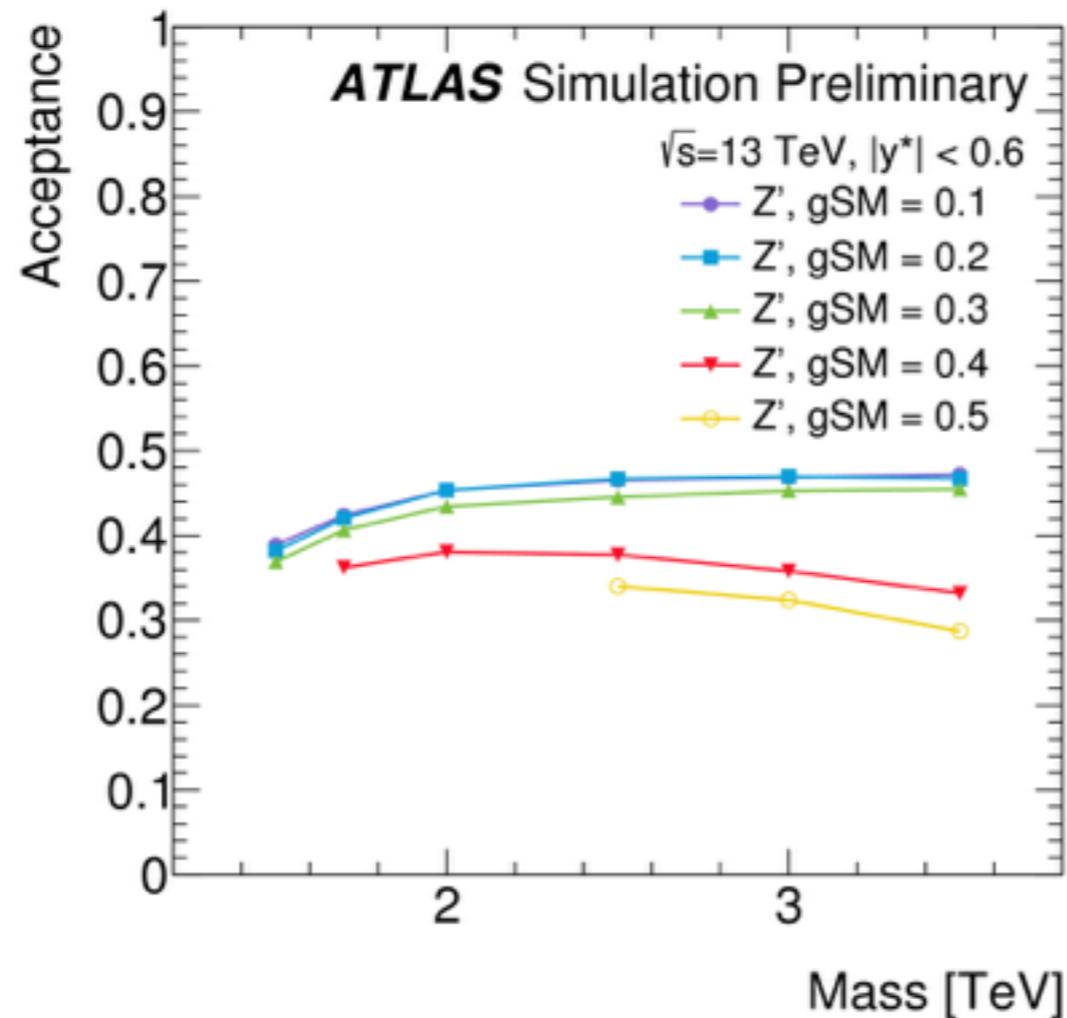
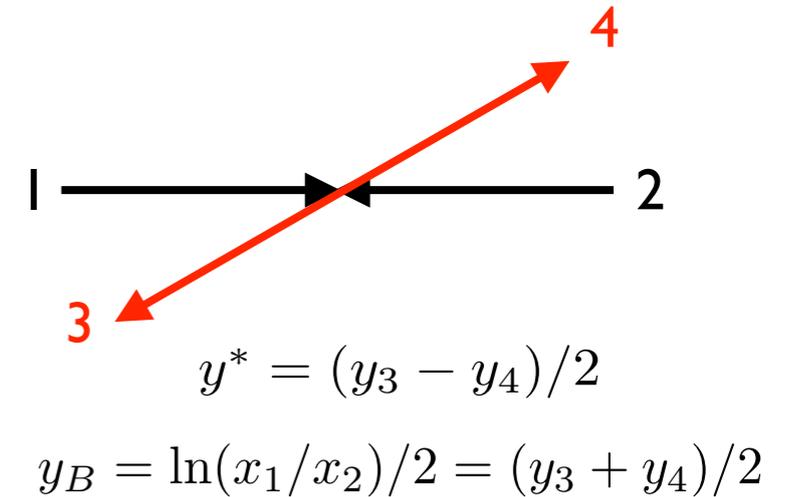
Event selection in ATLAS

- Target both **resonant** (both isotropic and forward decays) and **non-resonant** signals

Trigger $p_T(j_1) > 380$ GeV

Offline $p_T(j_1) > 440$ GeV, $p_T(j_2) > 60$ GeV

	Resonance	W*(chiral)	Angular
Topo	$ y^* < 0.6$	$ y^* < 1.2$	$ y^* < 1.7$ $ y_B < 1.1$
mjj	> 1.1 TeV	> 1.7 TeV	> 2.5 TeV

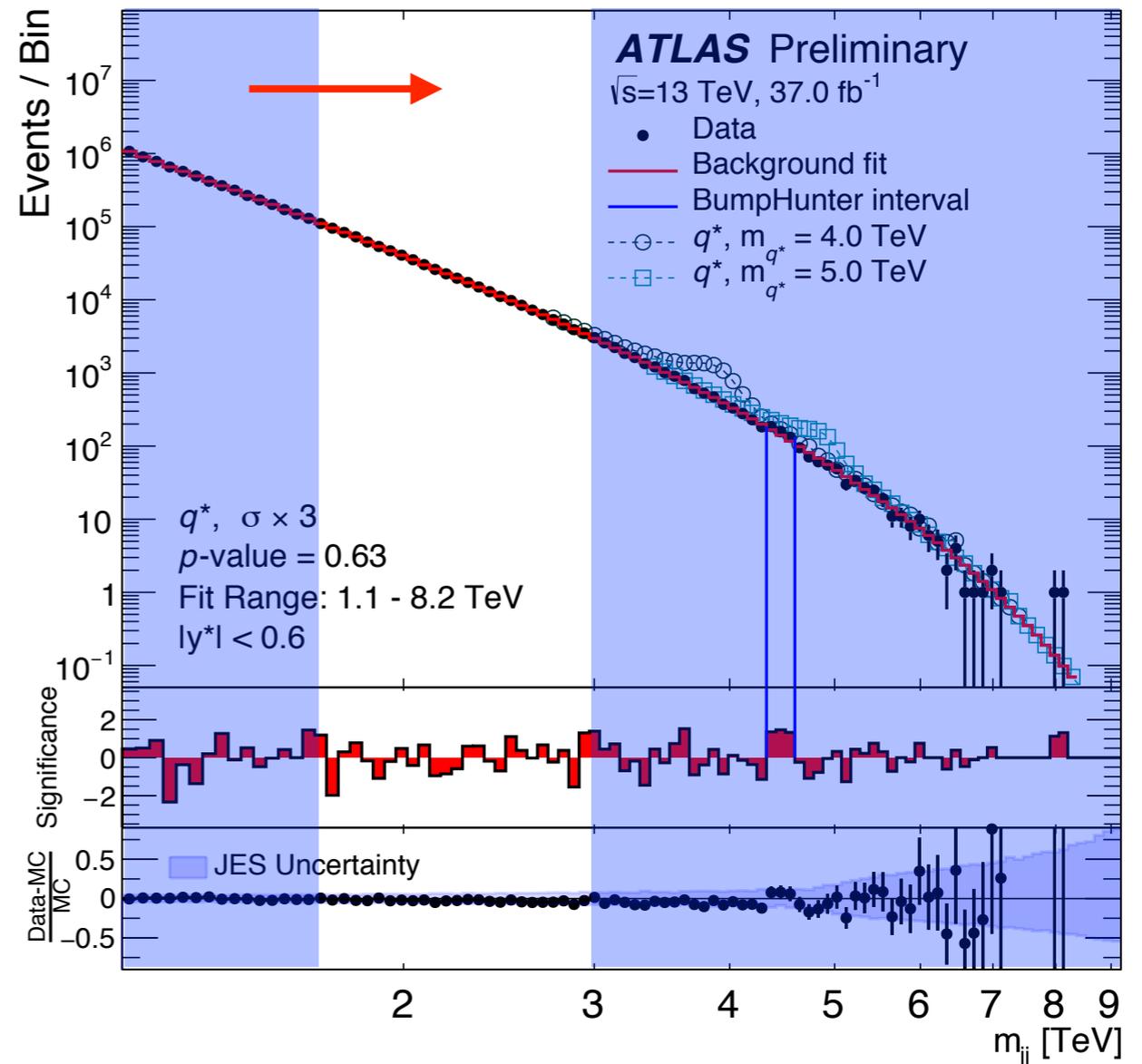


Di-jet spectrum and background fit (ATLAS)

- Previously: fit the full spectrum with a global “dijet” function for QCD bkg
- Fit complexity increase as lumi goes up
- **Sliding window fit (SWVFit)**
 - Fit spectra in restricted regions “window”
 - Window size 50 bins (30 left, 20 right)
 - Sliding the window centre bin by bin
 - Perform background only fit based on 3 parameter dijet function in each window
 - Evaluate fit at window center
 - Stitch background fit value in each bin together for the full range prediction
- New fit give compatible results with the global fit approach in previous results

$$f(z) = p_1(1 - z)^{p_2} z^{p_3} z^{p_4} \log z$$

$$z = m_{jj} / \sqrt{s}$$



PAPER EXOT-2016-21

$|y^*| < 1.2$ spectra in backup slide

Event selection in CMS

- Targeted for narrow resonances at low and high mass regions (CMS PAS EXO-16-056)
- Angular analysis contact interaction results in CMS-PAS-EXO-15-009 with 2.6/fb

	Low mass	High mass
m_{jj}	[0.49 - 2] TeV	> 1.25 TeV
Jets	Calo jets $p_T > 40$ GeV, $ \eta < 2.5$	Particle Flow jets $p_T > 30$ GeV, $ \eta < 2.5$
Trigger H_T	> 250 GeV	> 900 GeV
Topological		$ \eta_{j_1} - \eta_{j_2} < 1.3$
data	first 27 fb ⁻¹	36 fb ⁻¹

- Low mass analysis is achieved by “Data-scouting”
 - Directly use compact-form of di-jet events at HLT level
- Spatially close jets are combined into “wide jets” to calculate the dijet mass
 - Designed to reduce the analysis sensitivity to gluon radiation from final-state partons
 - Use the leading two jets as seed
 - Add all other jets if within $\Delta R < 1.1$ to form two wide-jets

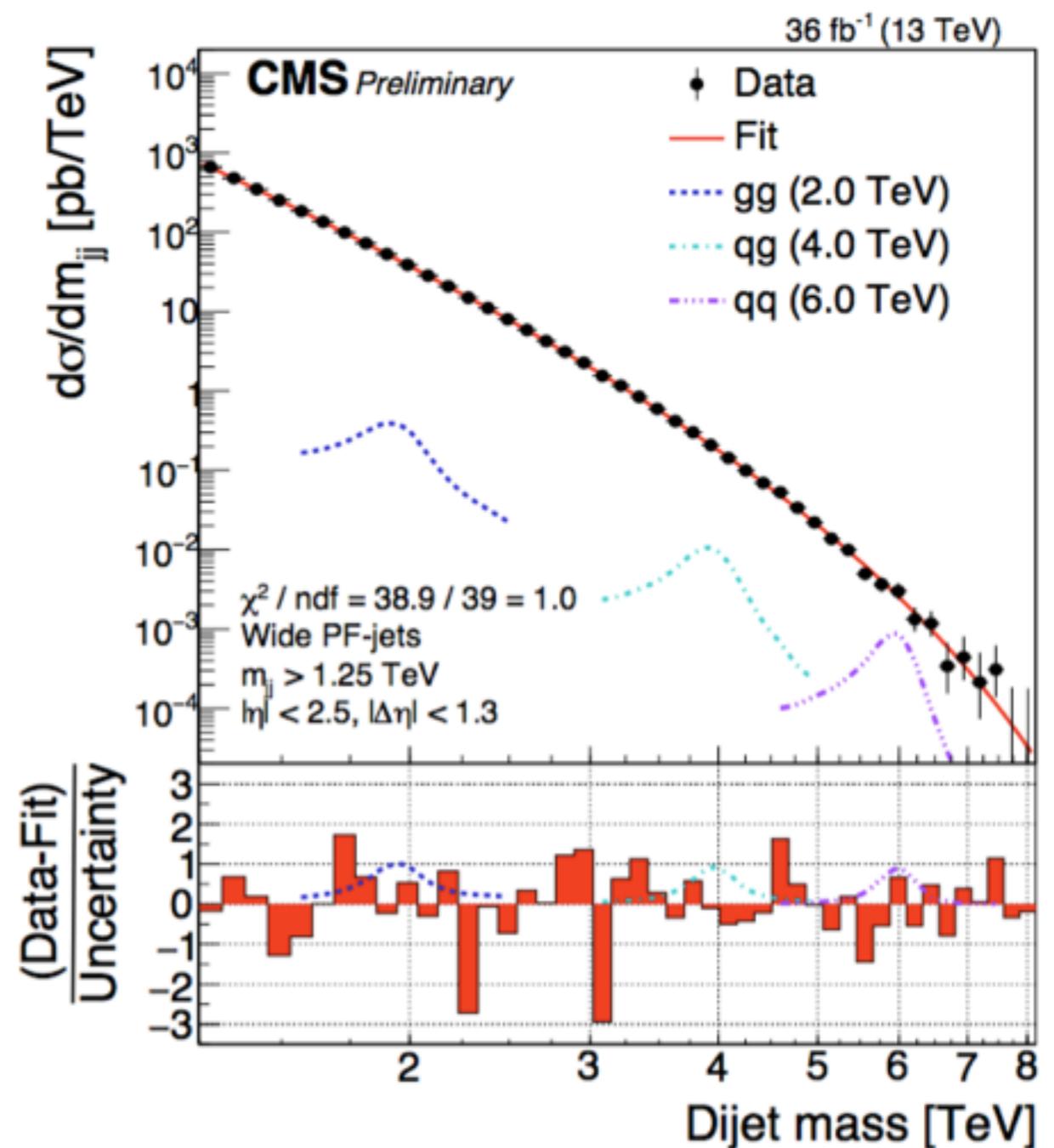
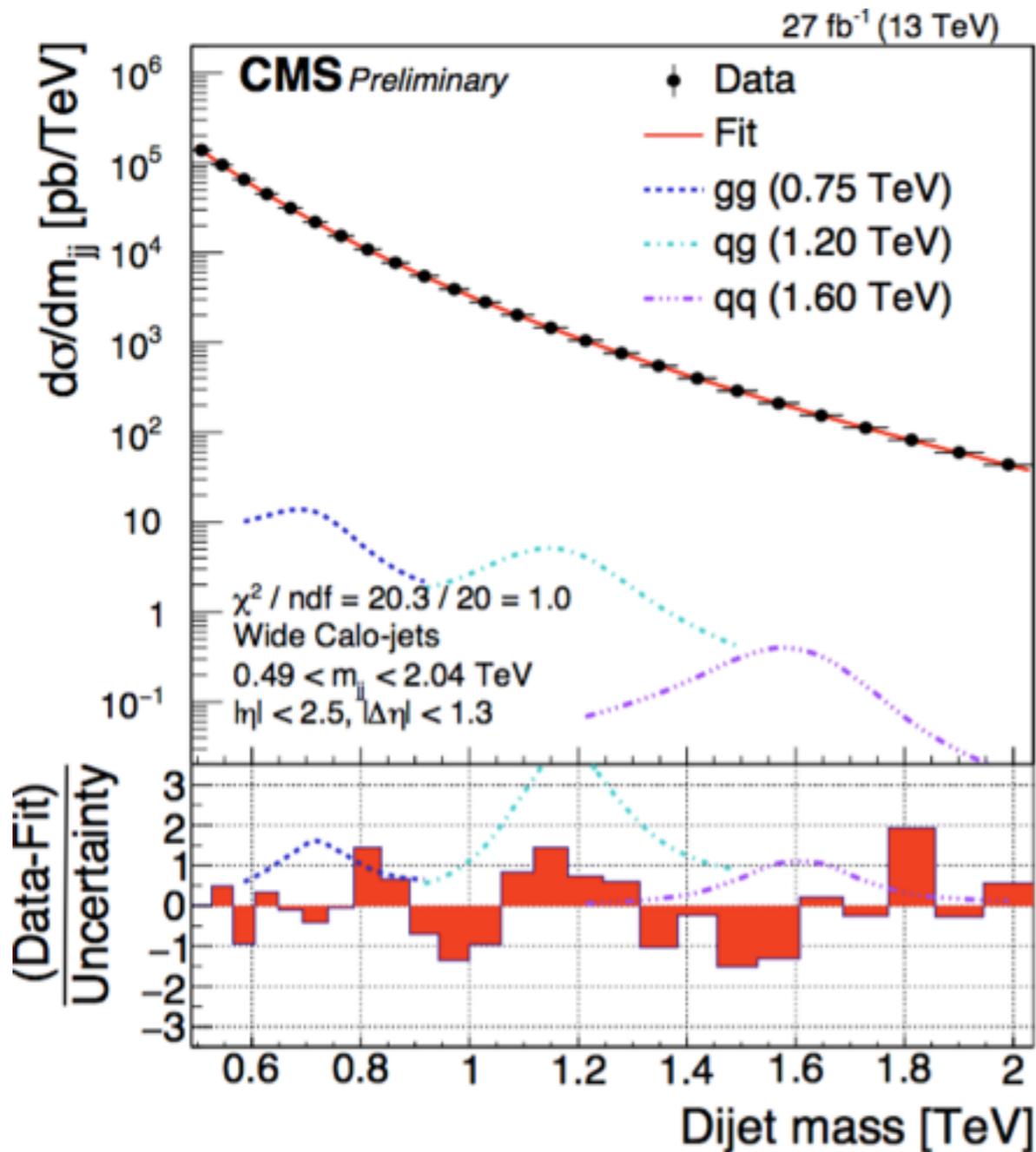
* H_T : scalar sum of all jets p_T satisfying p_T requirements (table) and $|\eta| < 3$

Dijet mass spectra and fits in CMS

- Global background fits used in both regions

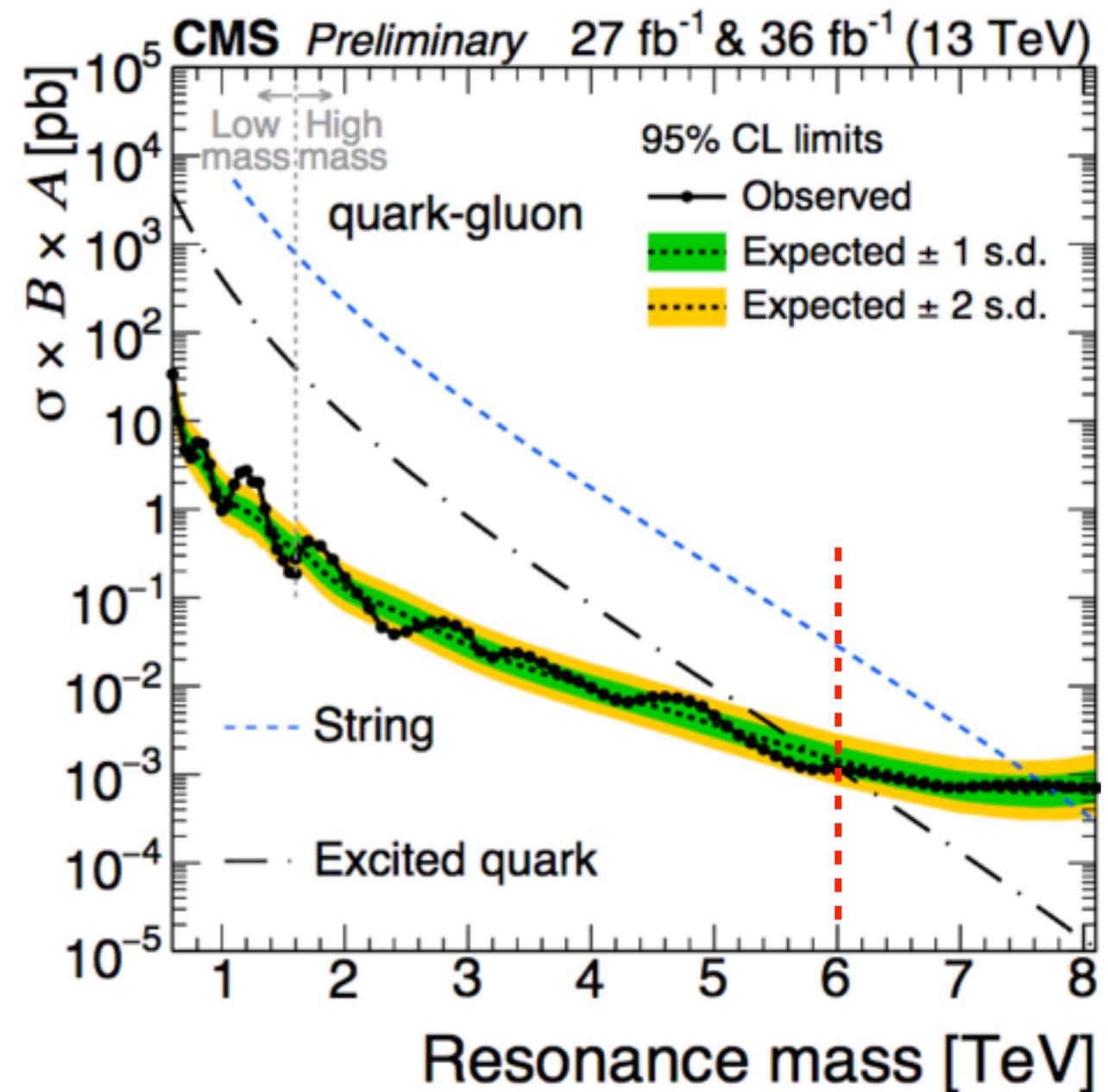
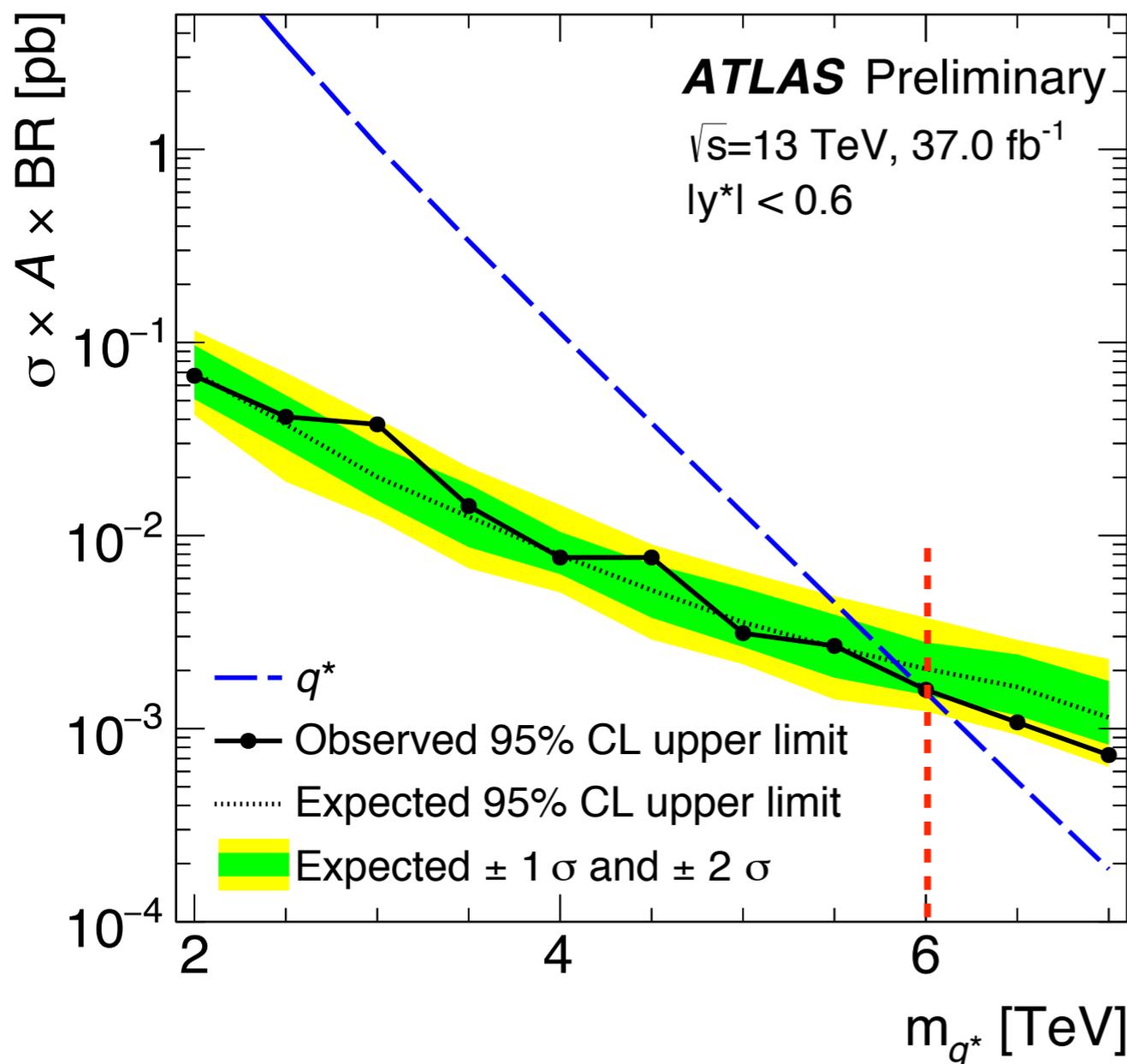
$$\frac{d\sigma}{dm_{jj}} = \frac{P_0(1-x)^{P_1}}{x^{P_2+P_3} \ln(x) + P_4 \ln(x)^2} \quad x = m_{jj}/\sqrt{s}$$

$$\frac{d\sigma}{dm_{jj}} = \frac{P_0(1-x)^{P_1}}{x^{P_2+P_3} \ln(x)}$$



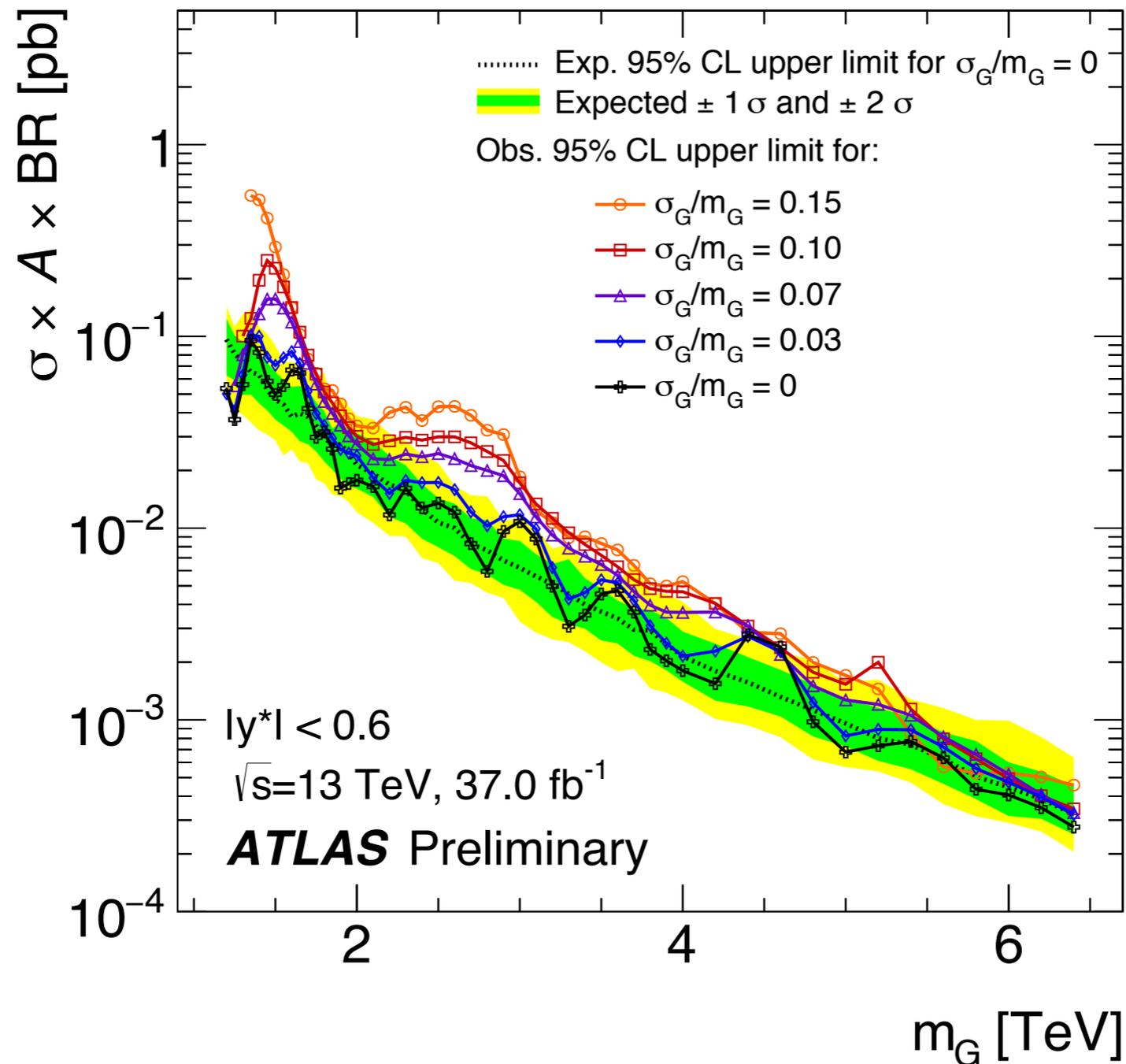
Classic resonance interpretation

- Diverse signal models are explored in both experiments with largely overlapping models
 - Many models explored such as QBH, W' , W^* etc (see backup slide)
 - Consistent results from both experiments

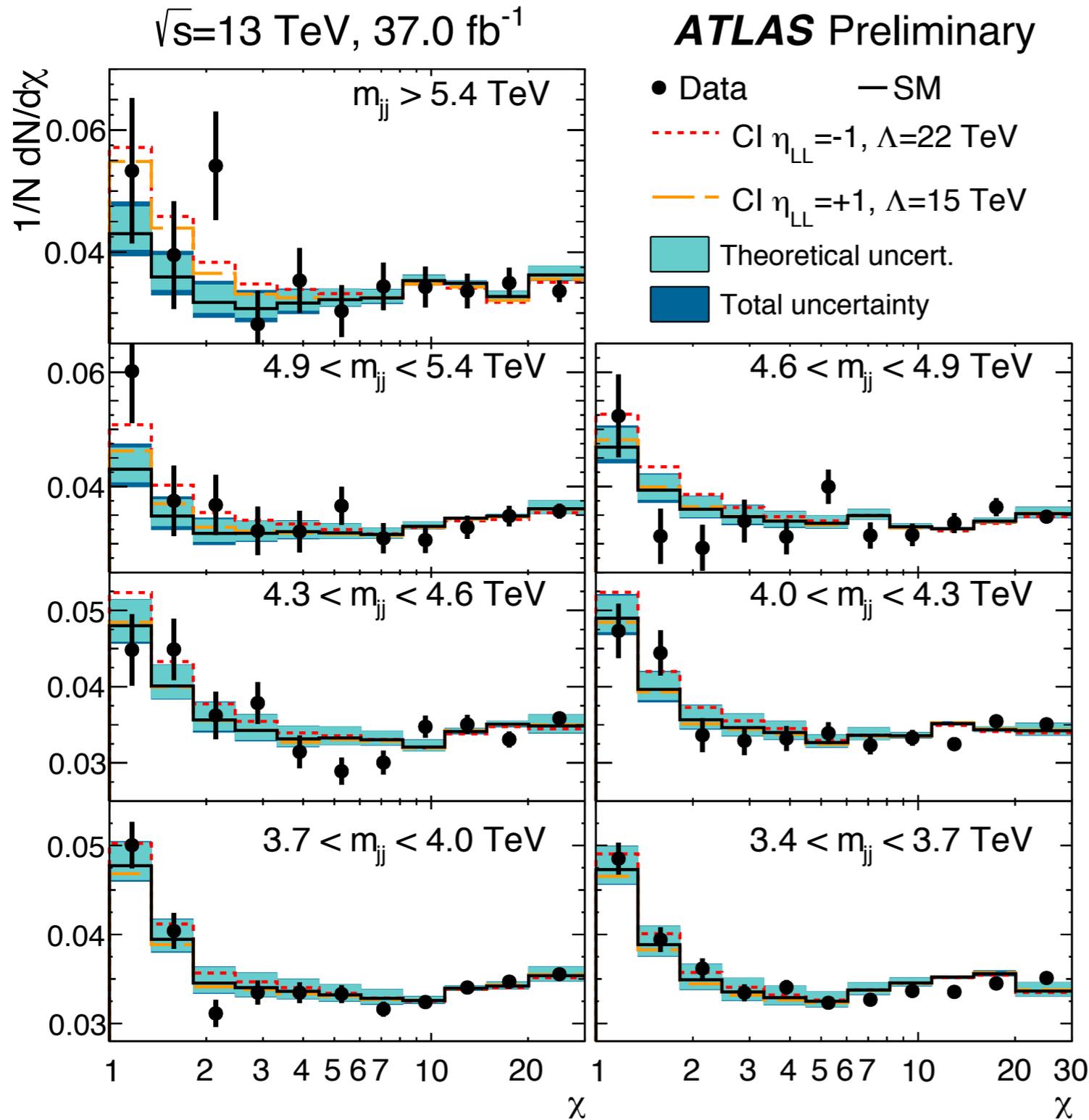


Generic resonance interpretations

- ATLAS set limits on generic Gaussian signal shapes with different width
- Apply jet energy folding to separate out the detector effects from intrinsic width



Angular analysis results from ATLAS

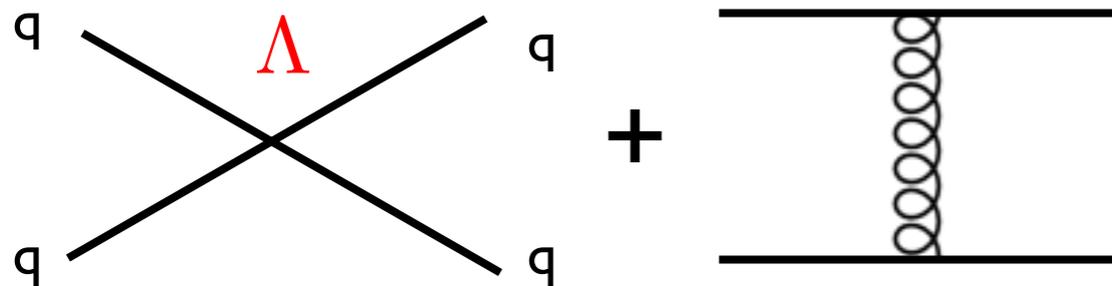


Background:
 Pythia8
 + NLO QCD corrections
 (NLOJET++)
 + LO EW correction

Explored angular distributions
 with $m_{jj} > 5.4$ TeV, no excess seen

Angular analysis limits on contact interactions

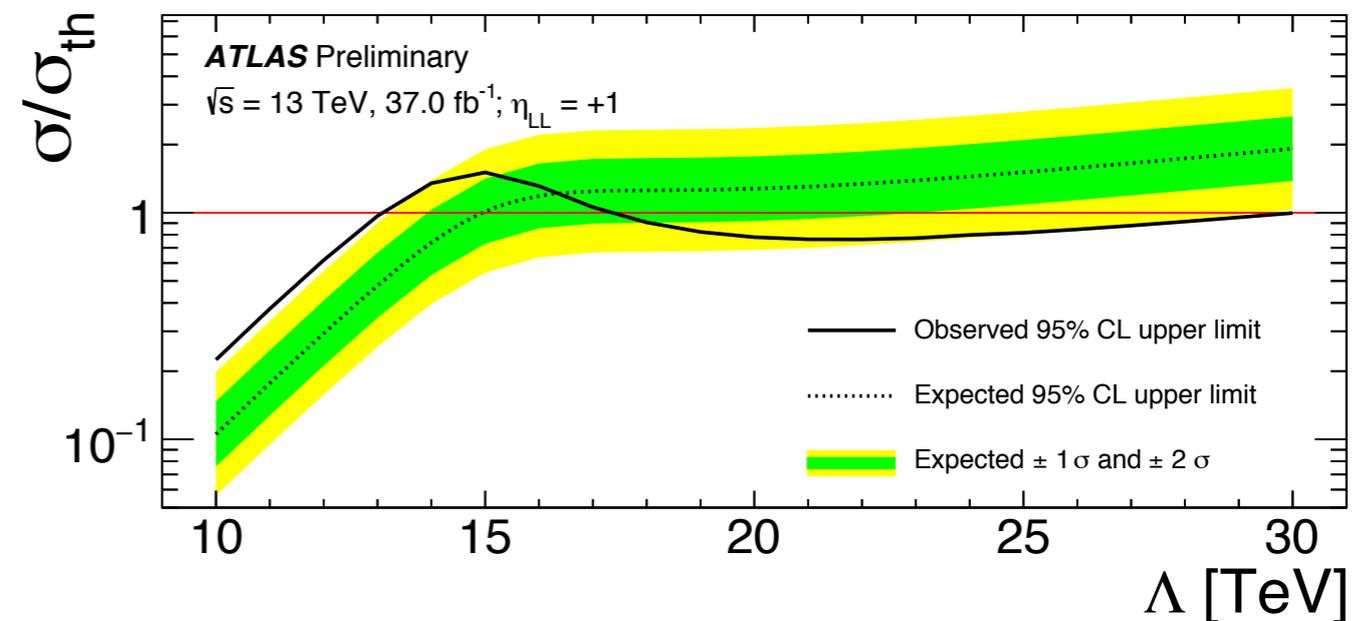
- Set limits on $q\bar{q} \rightarrow q\bar{q}$ contact interactions with constructive/destructive interference with the SM process



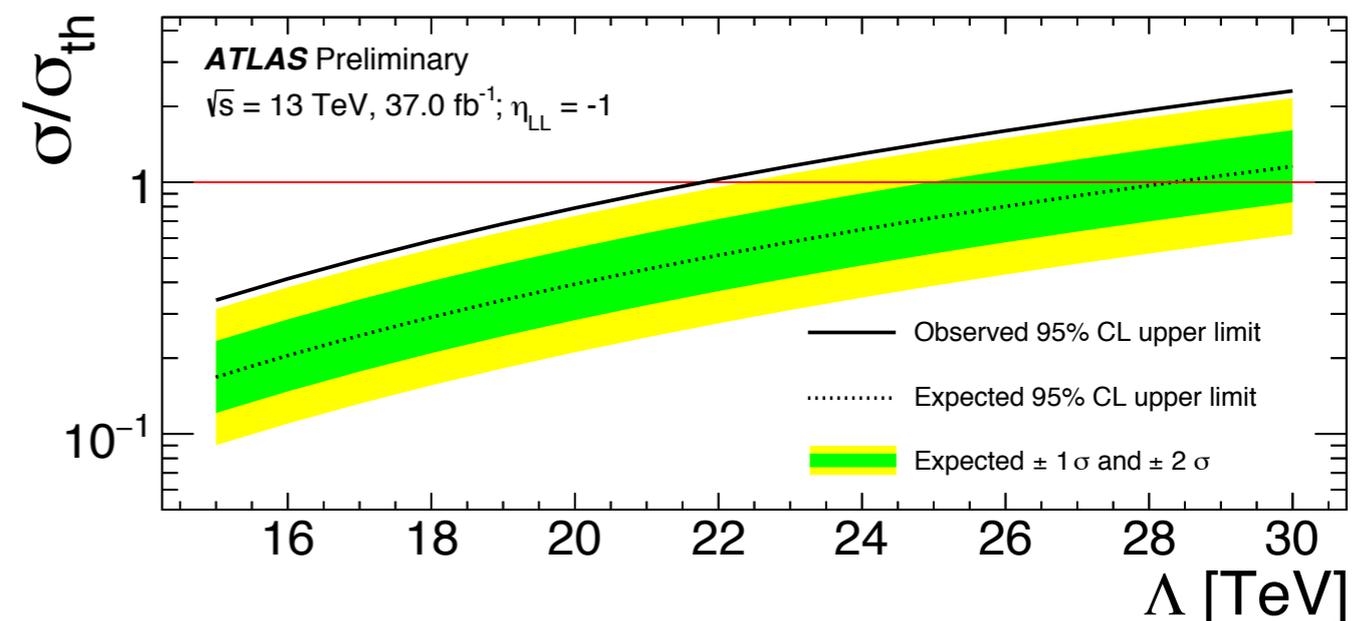
$$L_{qq} = \frac{2\pi}{\Lambda^2} [\eta_{LL} (\bar{q}_L \gamma^\mu q_L) (\bar{q}_L \gamma_\mu q_L) + \eta_{RR} (\bar{q}_R \gamma^\mu q_R) (\bar{q}_R \gamma_\mu q_R) + 2\eta_{RL} (\bar{q}_R \gamma^\mu q_R) (\bar{q}_L \gamma_\mu q_L)]$$

- NP scale probed up to 30 TeV
 - Excluded up to 28 TeV

destructive interference



constructive interference

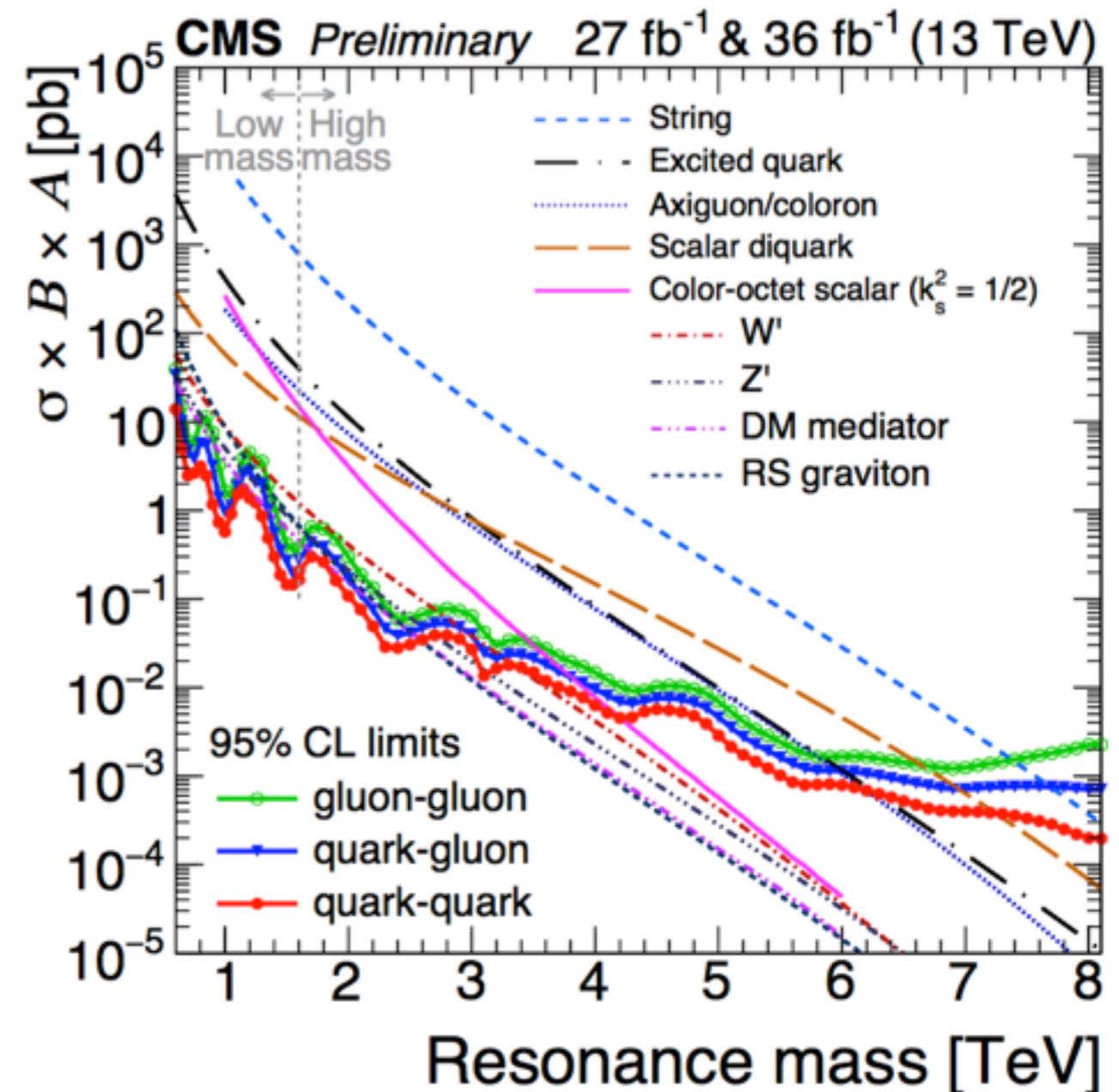


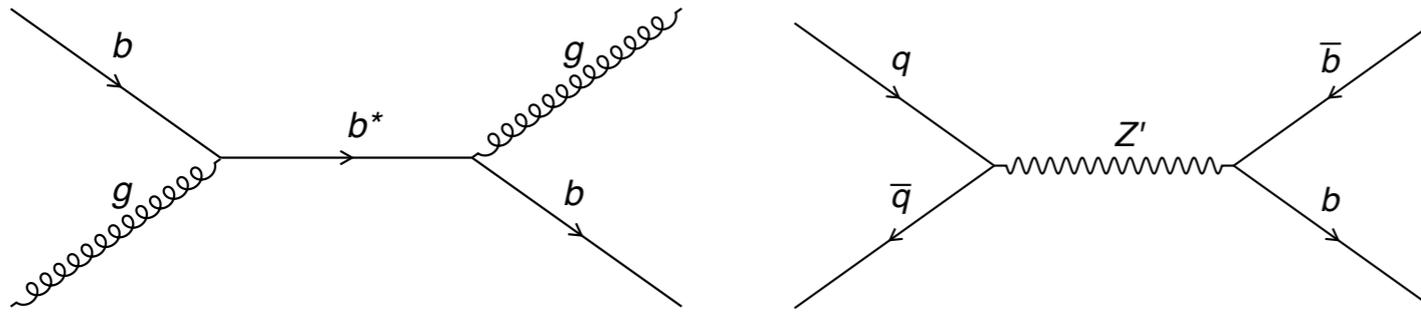
Summary of models explored

- Resonances excluded up to 9 TeV
- Contact interaction NP scale excluded up to 28 TeV

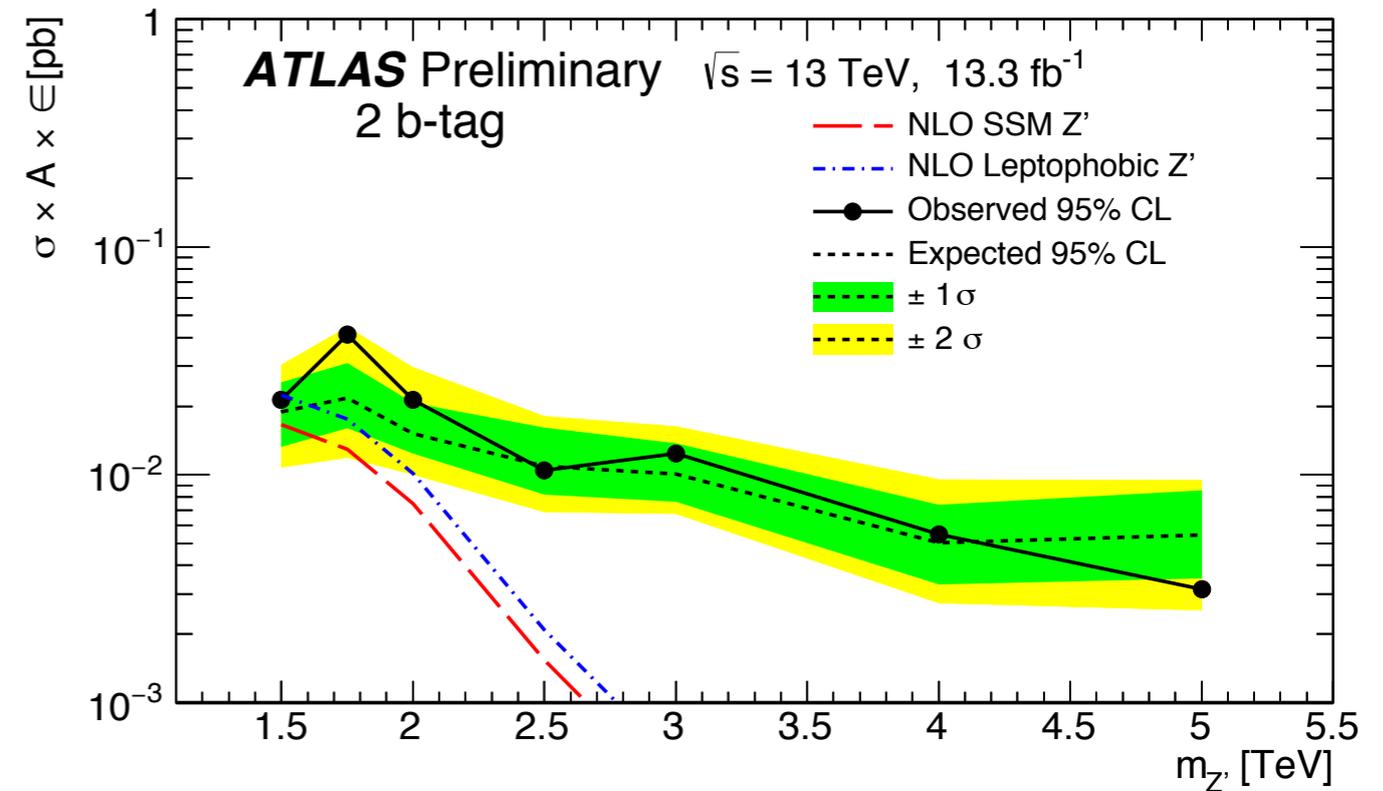
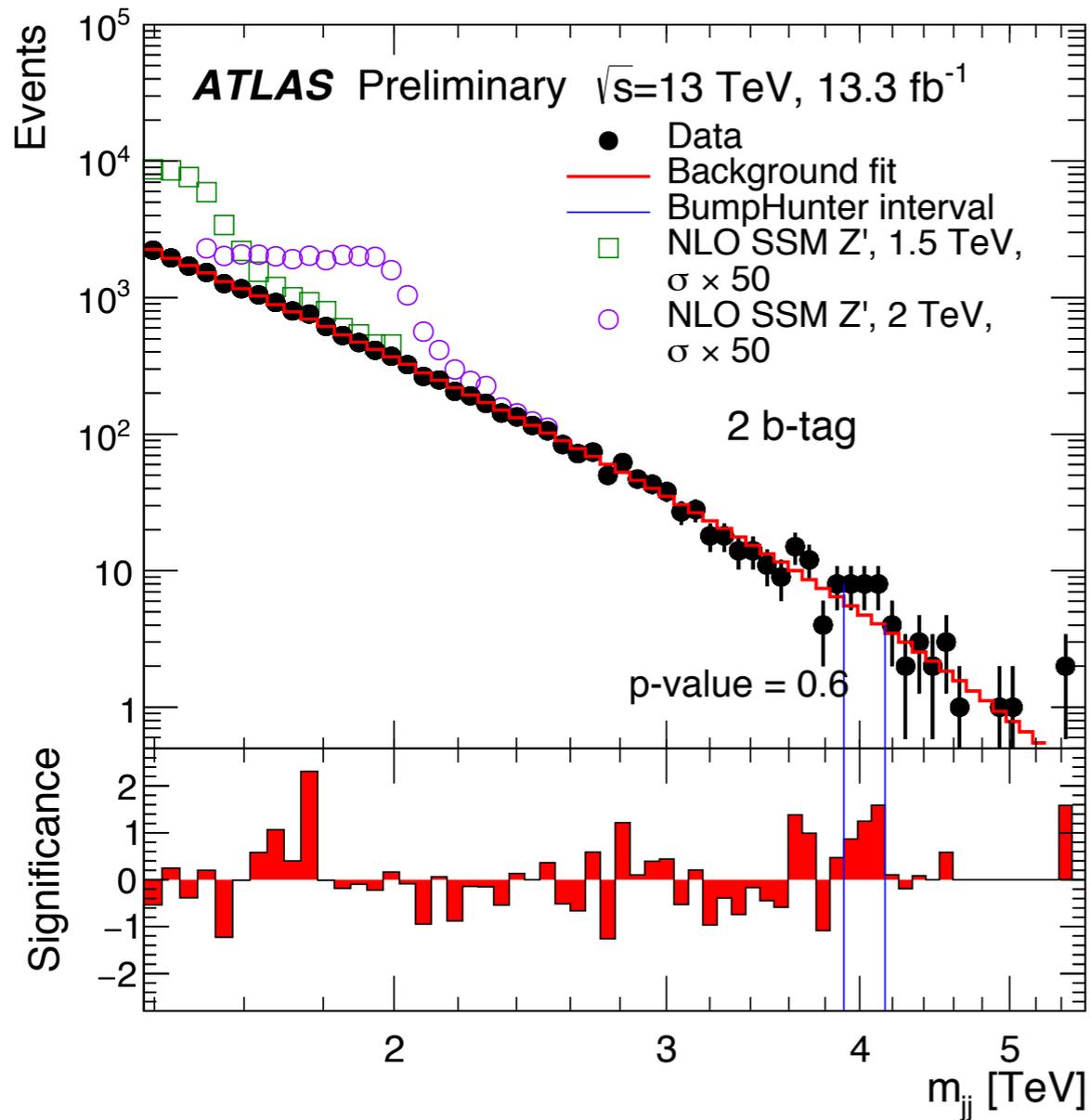
Exclusion limit from ATLAS 37 fb⁻¹

Model	95% CL exclusion limit	
	Observed	Expected
Quantum black hole, ADD	8.9 TeV	8.9 TeV
W'	3.6 TeV	3.7 TeV
W^*	3.4 TeV 3.77–3.85 TeV	3.6 TeV
Excited quark	6.0 TeV	5.8 TeV
Contact interaction ($\eta_{LL} = -1$)	21.8 TeV	28.3 TeV
Contact interaction ($\eta_{LL} = +1$)	13.1 TeV 17.4 TeV- 29.5 TeV	15.0 TeV





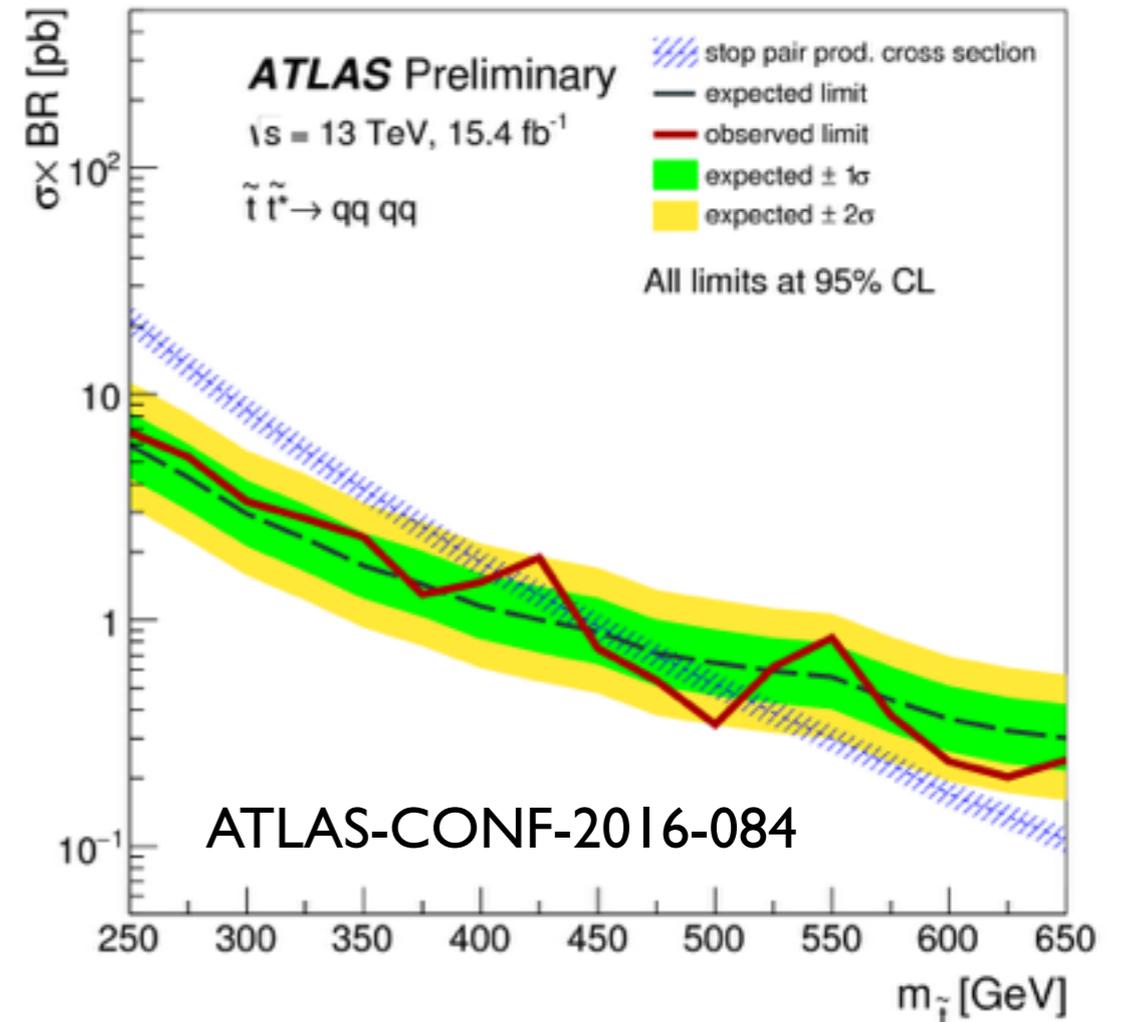
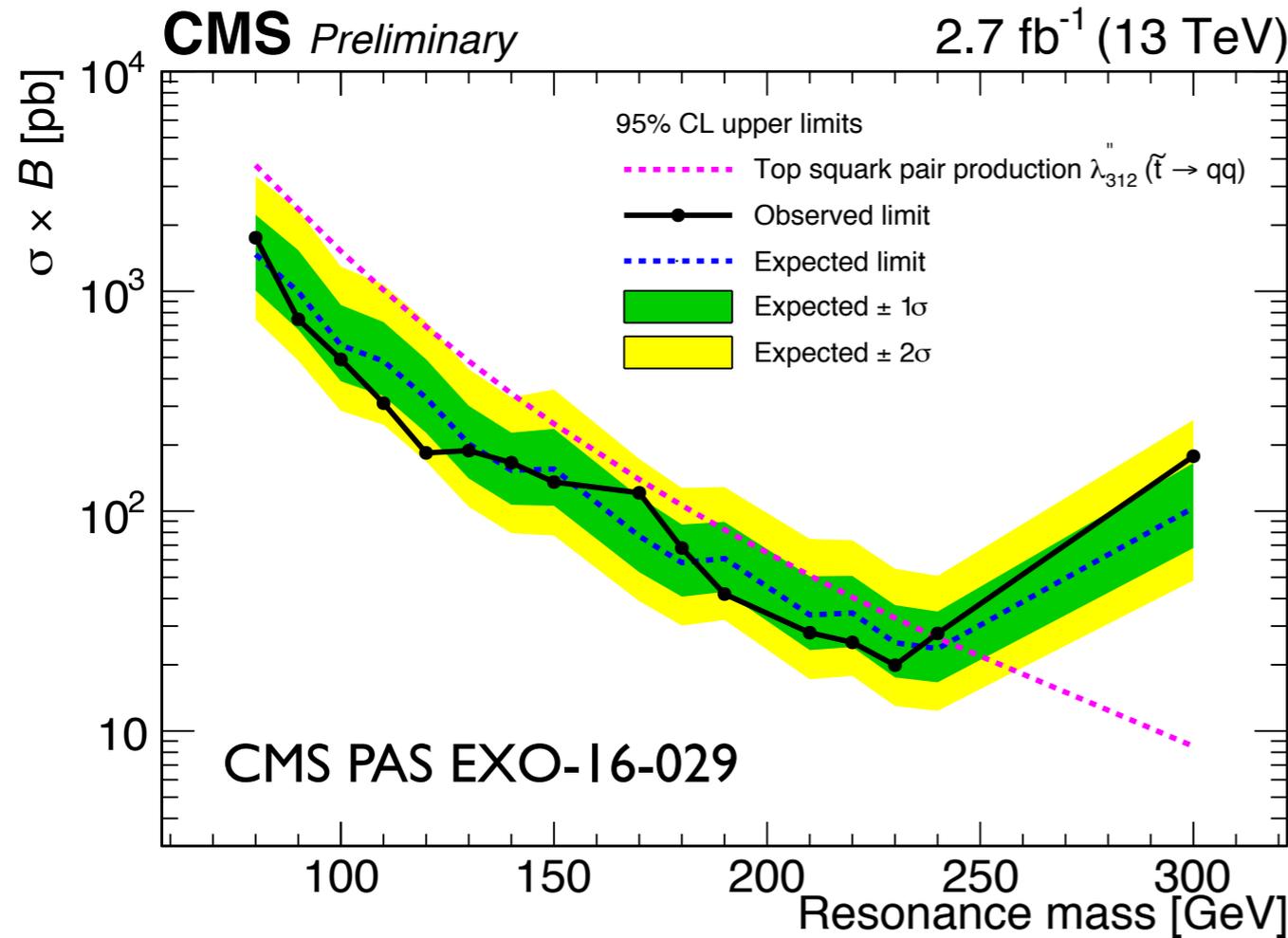
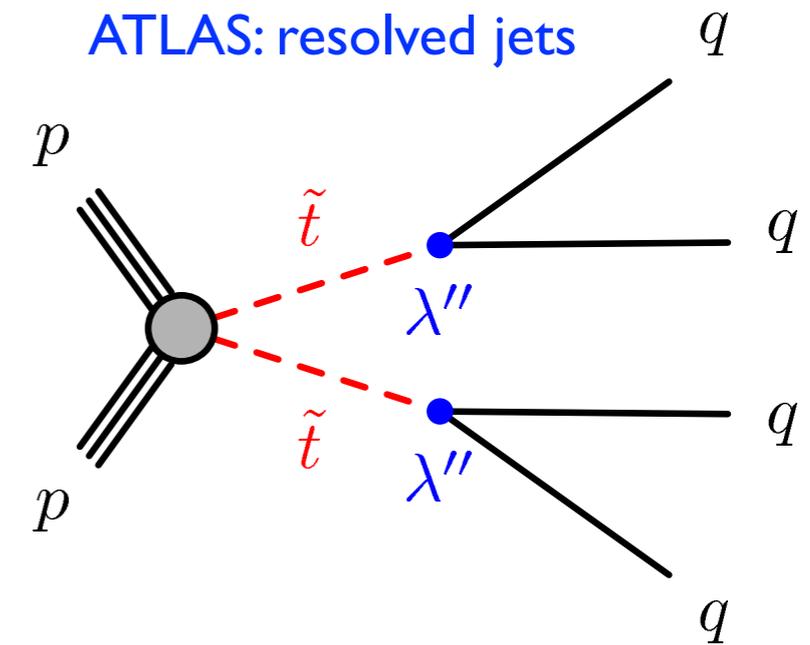
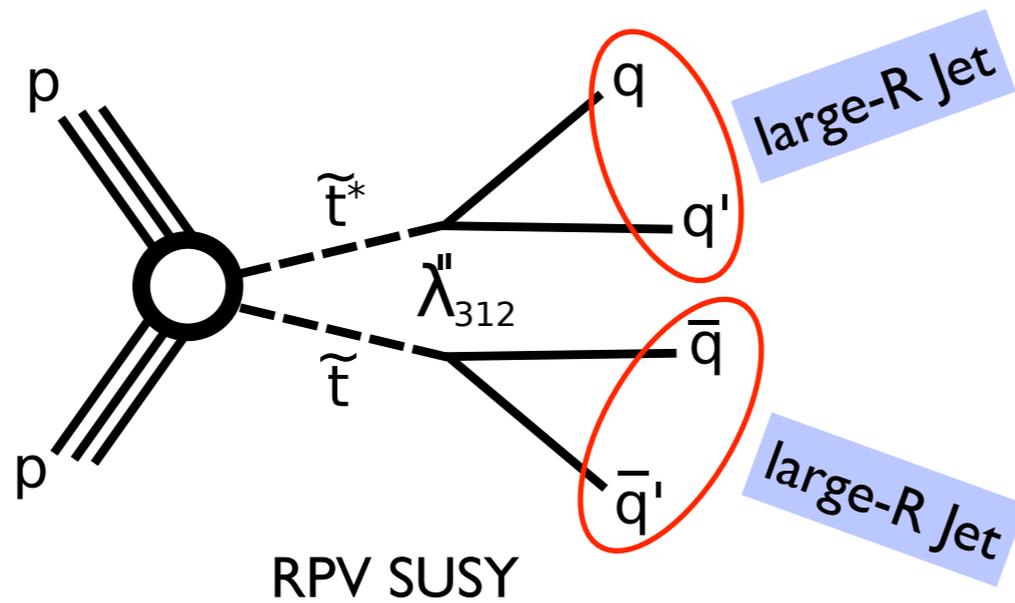
Follows similar strategy as the resonance di-jet analysis



≥ 1 b-jets results in the backup slides
 Provided also limits on generic gaussian shapes

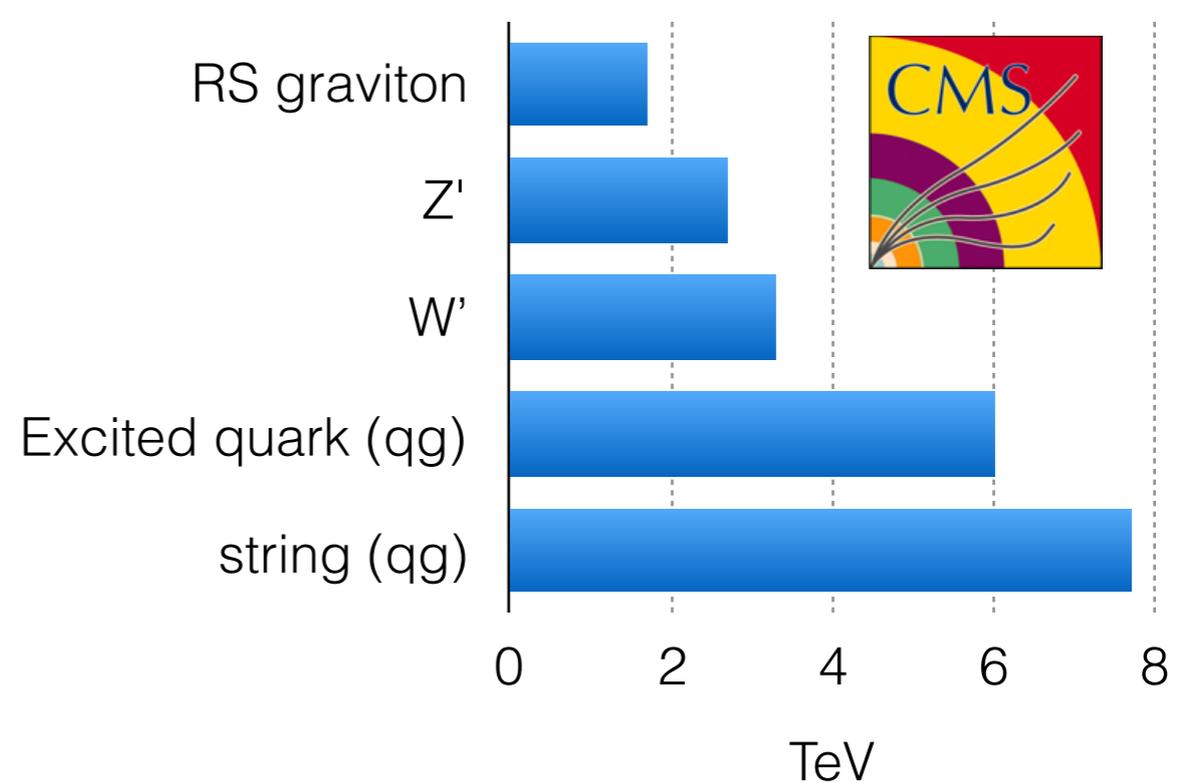
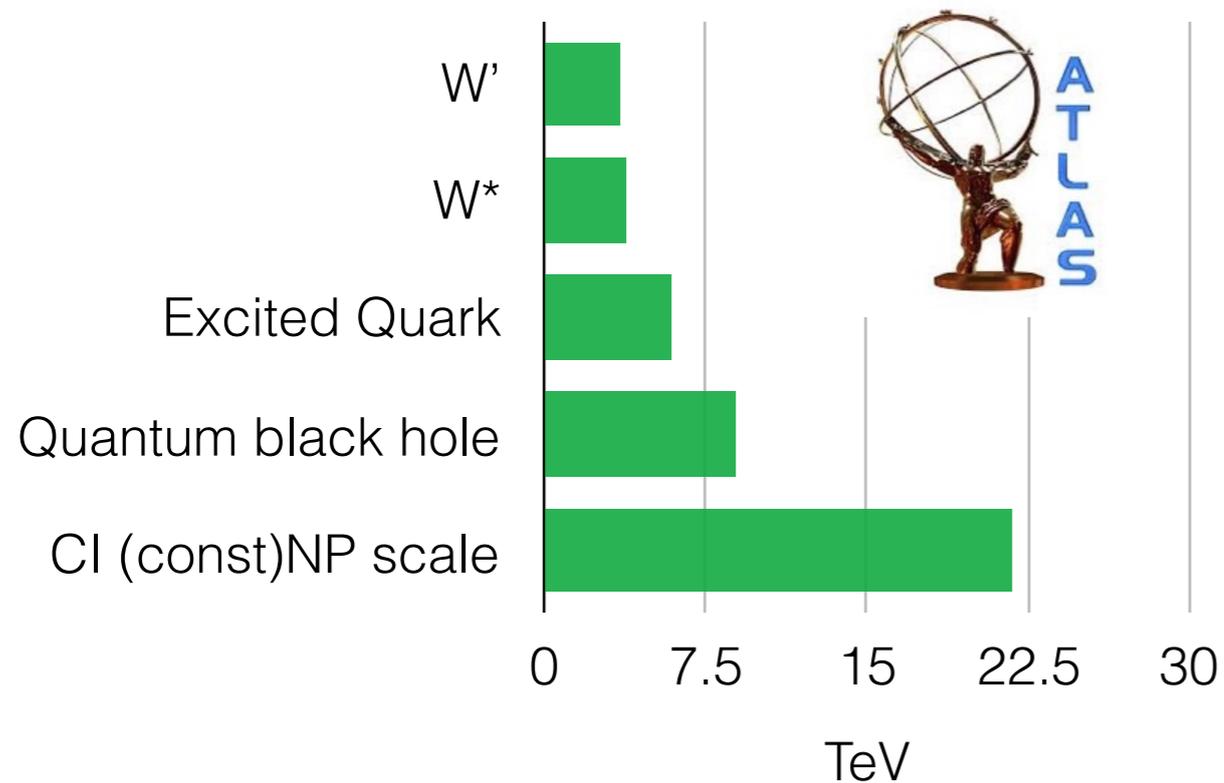
Di-jet pair productions

CMS
 Boosted resonances
 Pruned jet mass
 jet substructure



Summary

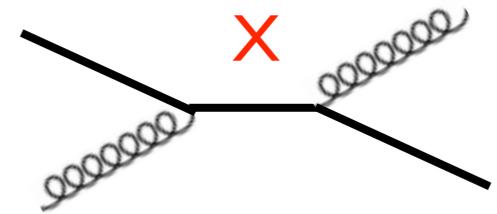
- Di-jet final states remain frontiers to search for new physics at multi-TeV range
- Latest results are reported using up to 37(36) fb-1 at 13 TeV from ATLAS(CMS)
 - Unfortunately no sign of significant excesses
 - Improved limits on many signal scenarios compared to previous results
 - See Raffaele Gerosa's talk on Thursday morning for its implications on dark matter searches
- Di-jet become useful tool to explore more complex signatures



References

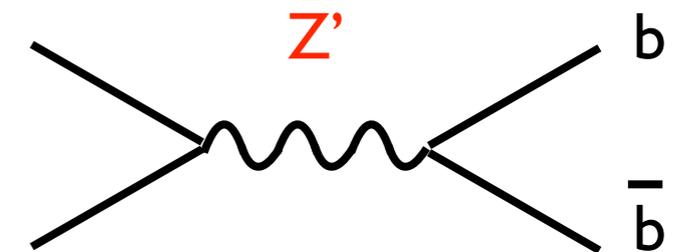
- Di-jet

- ATLAS EXOT-2016-021 37/fb
- CMS PAS EXO-16-056 36/fb
- ATLAS-CONF-2016-030 (Trigger Level Ana) 3.4/fb
- CMS-PAS-EXO-15-009 (CI) 2.6/fb



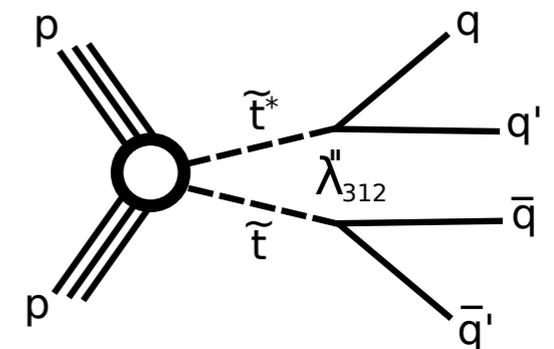
- Di-jet with b-jets

- ATLAS-CONF-2016-060 13.3/fb



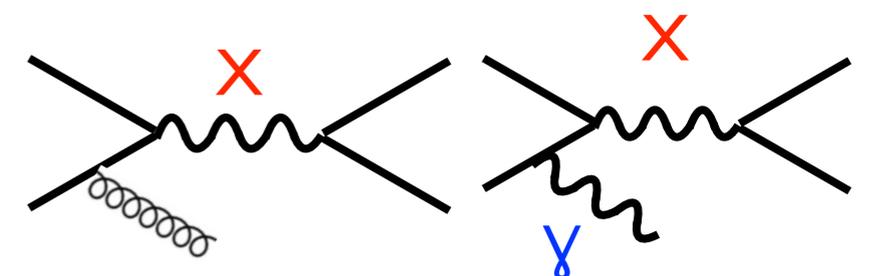
- Di-jet pair productions

- CMS PAS EXO-16-029 2.7/fb
- ATLAS-CONF-2016-084 15.4/fb



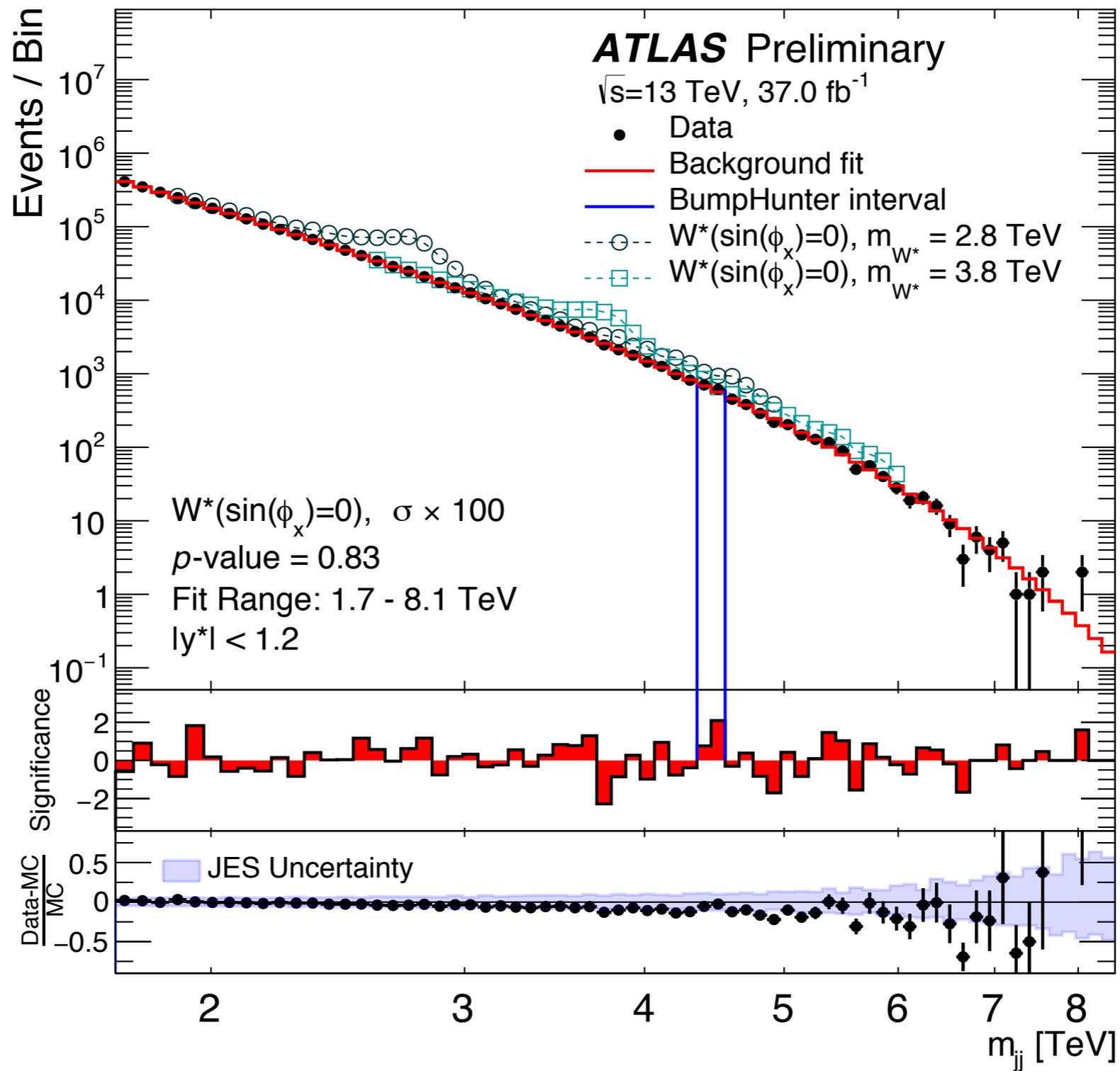
- Di-jet with ISR photon and jet

- CMS PAS EXO-16-030 3.4/fb
- ATLAS-CONF-2016-070 15.5/fb

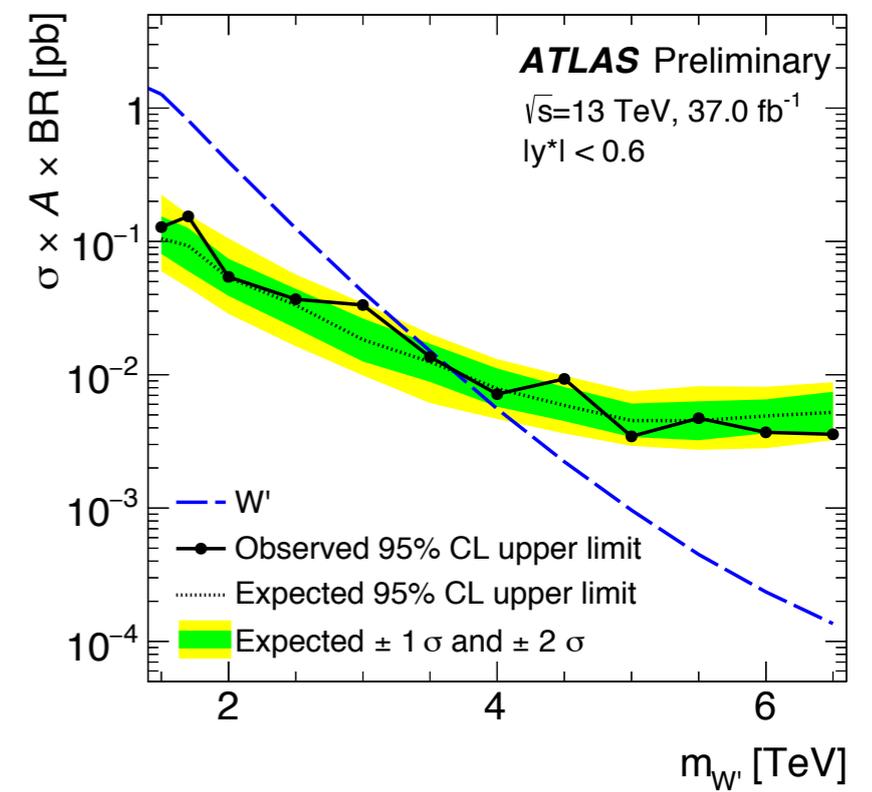
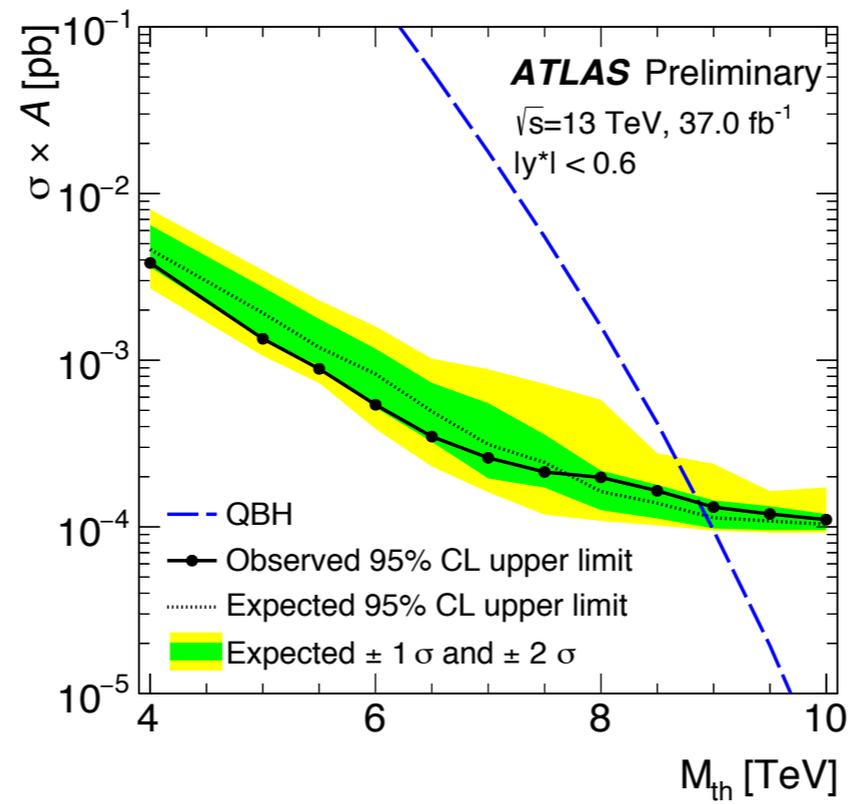
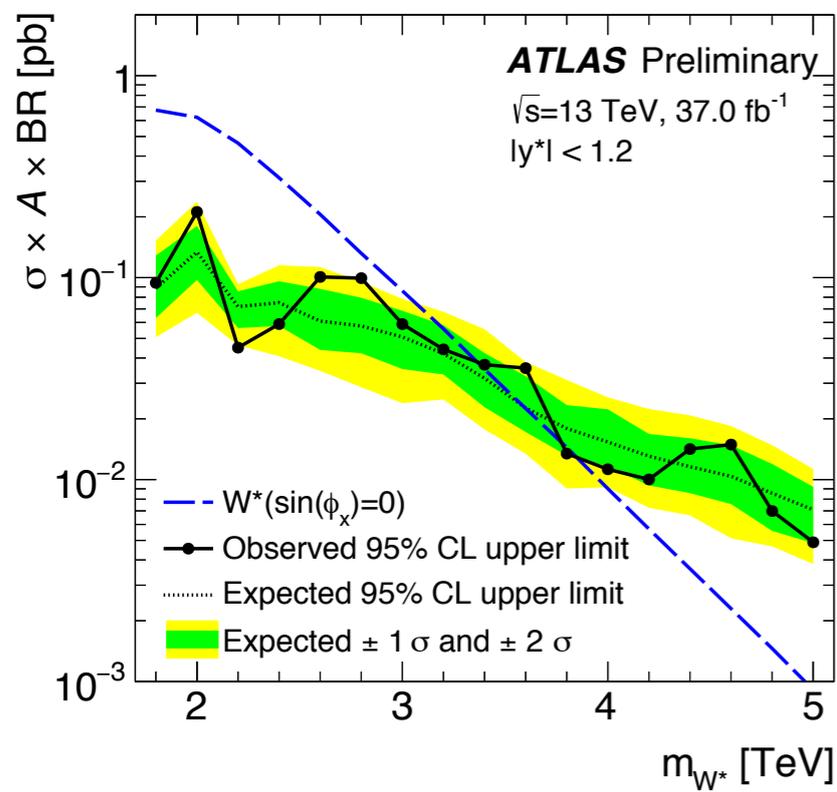


backup slides

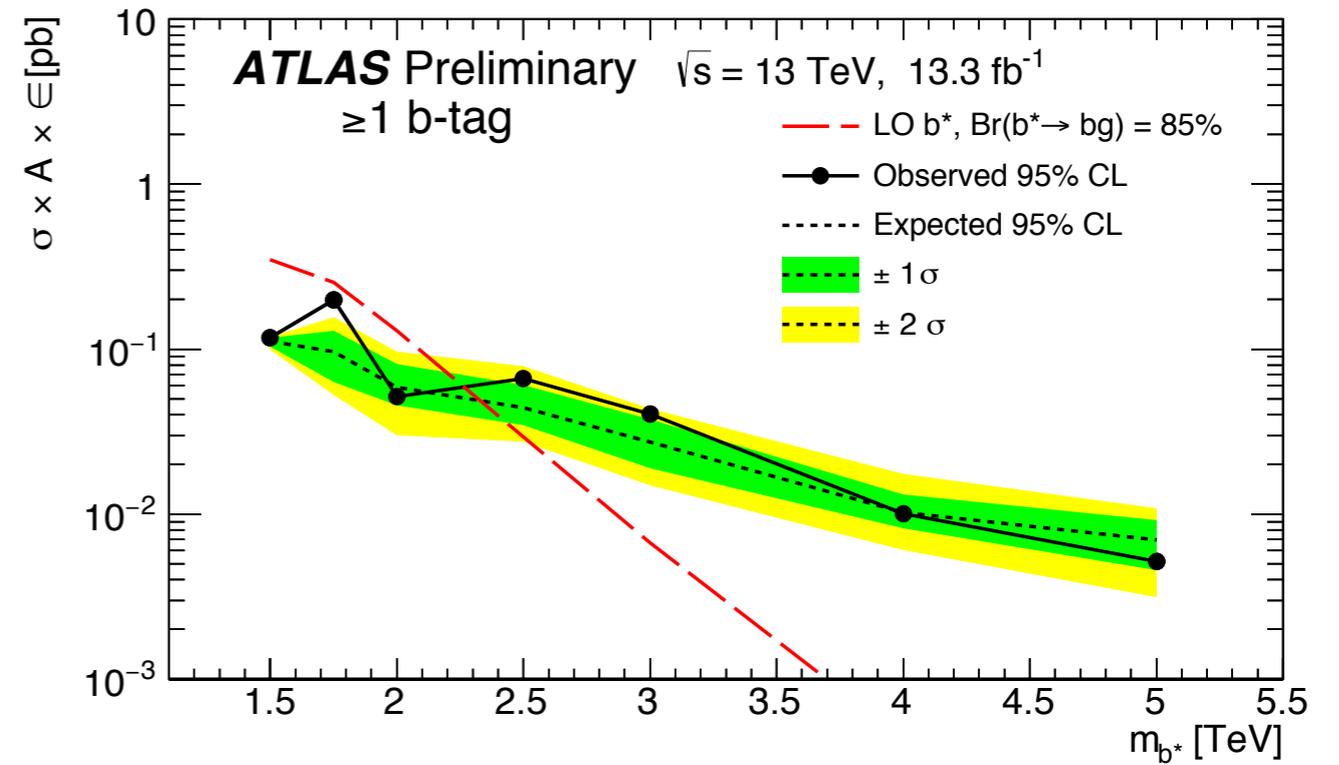
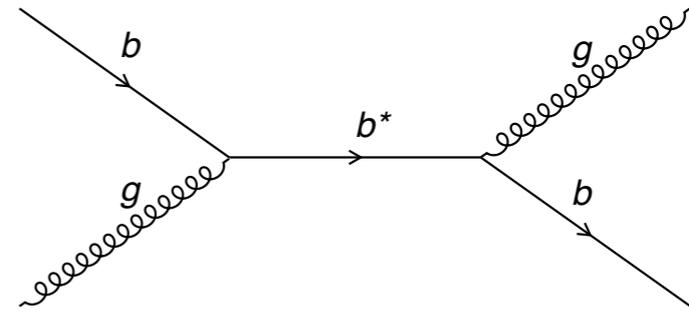
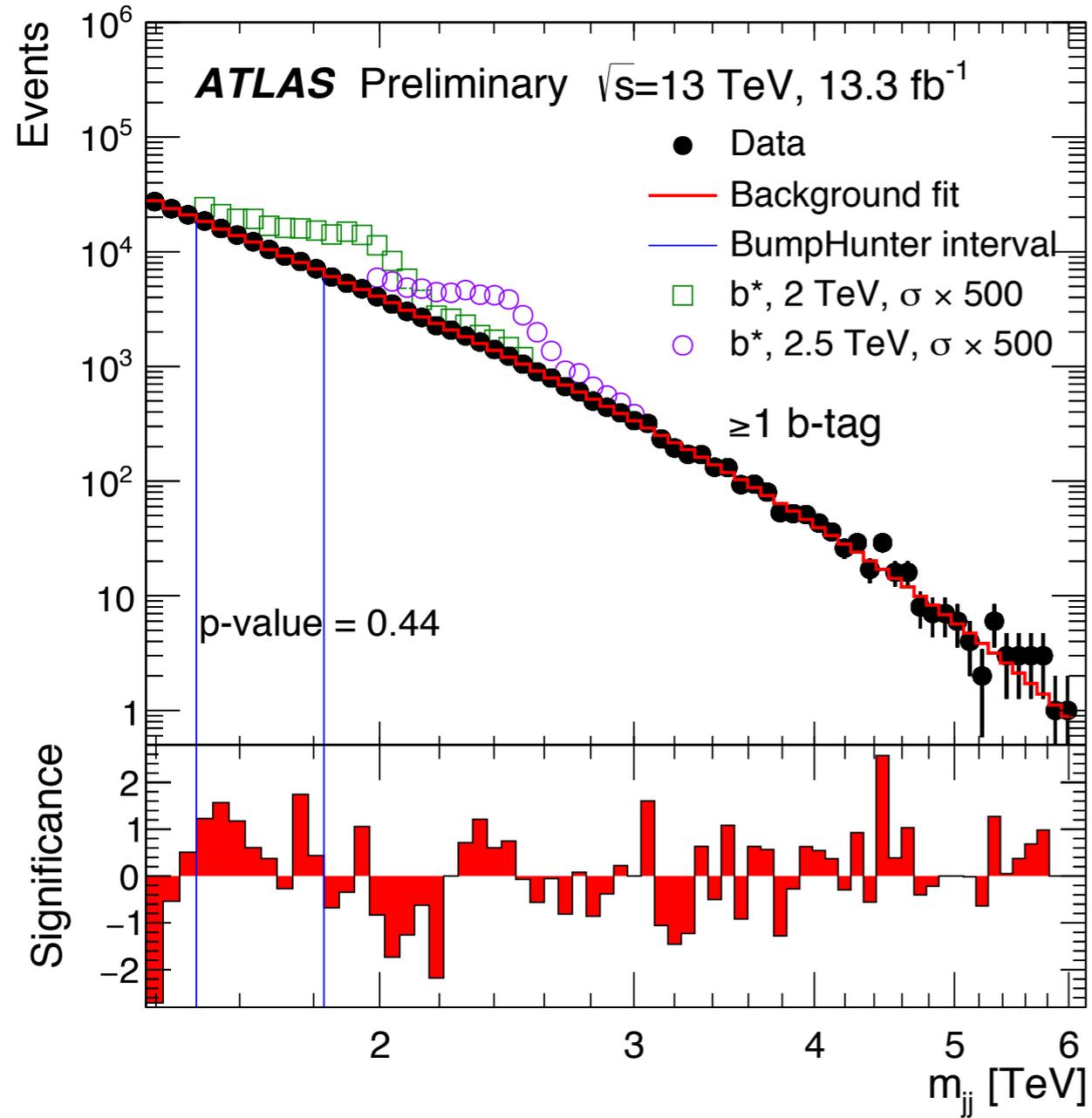
Di-jet mass spectra (ATLAS)



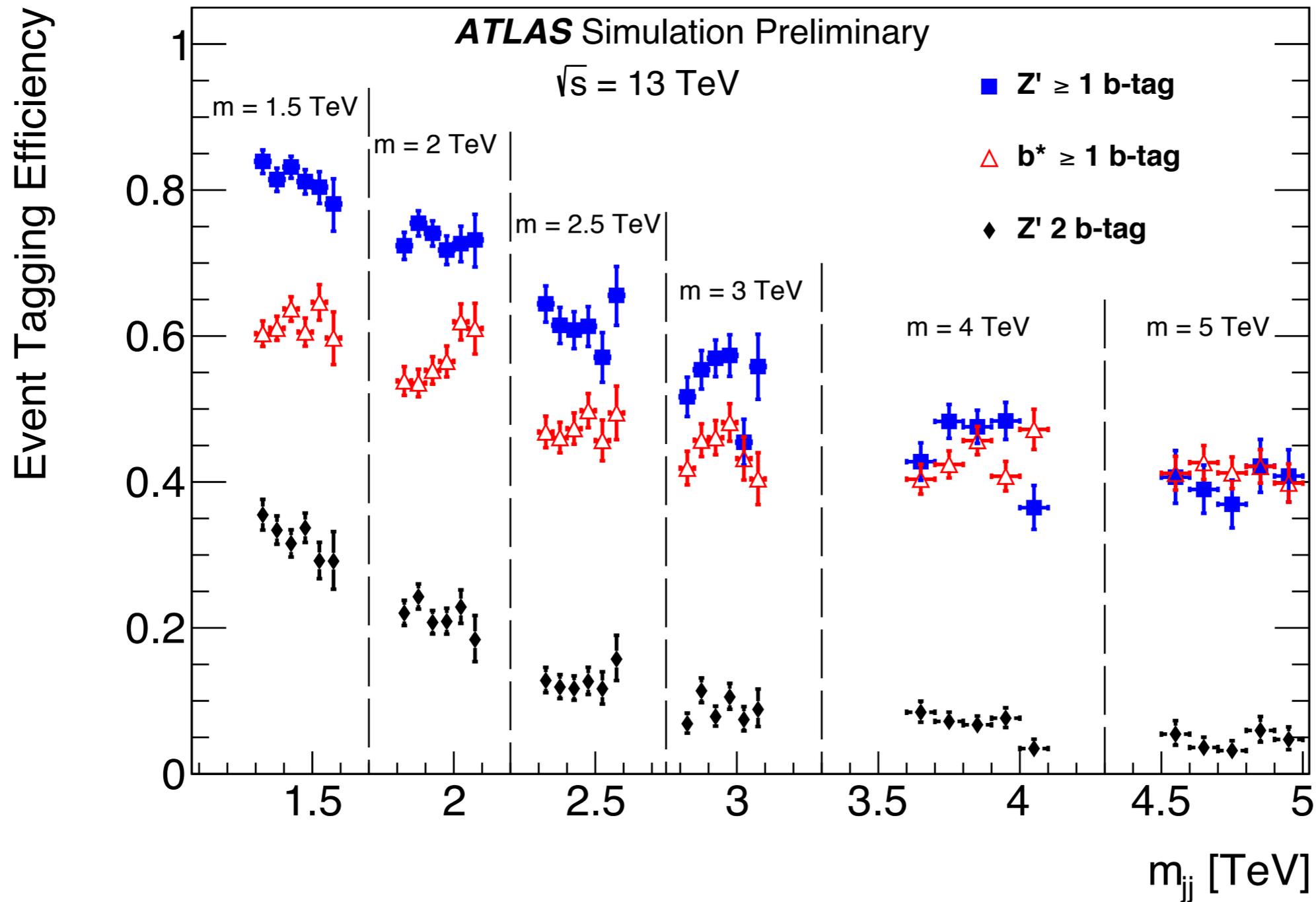
Limits on other signal models (ATLAS)



dijet (≥ 1 b-jets)

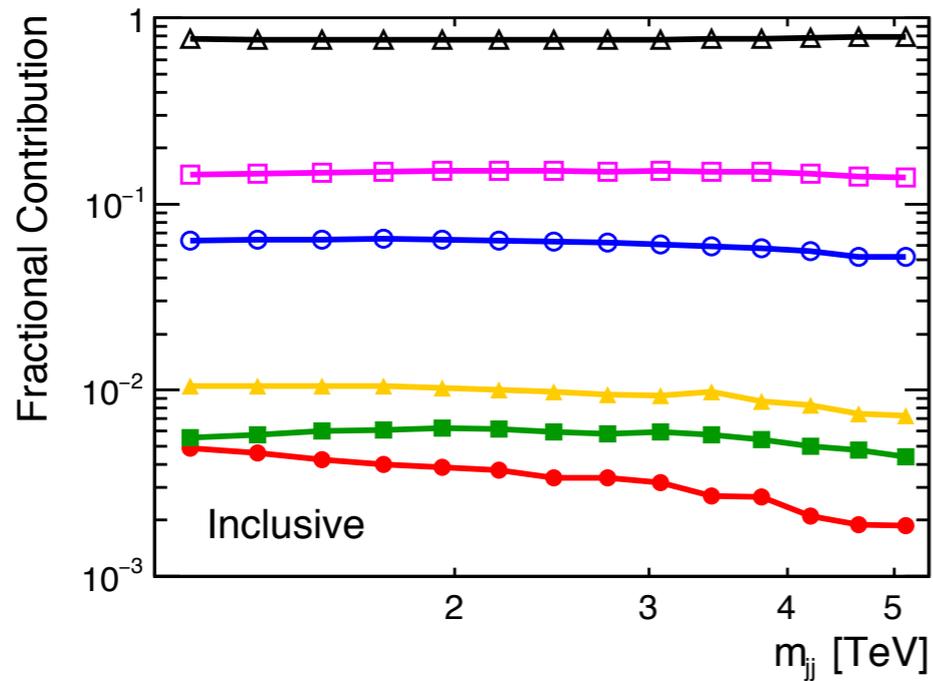


Di-jet (with b-jets) b-tag efficiency

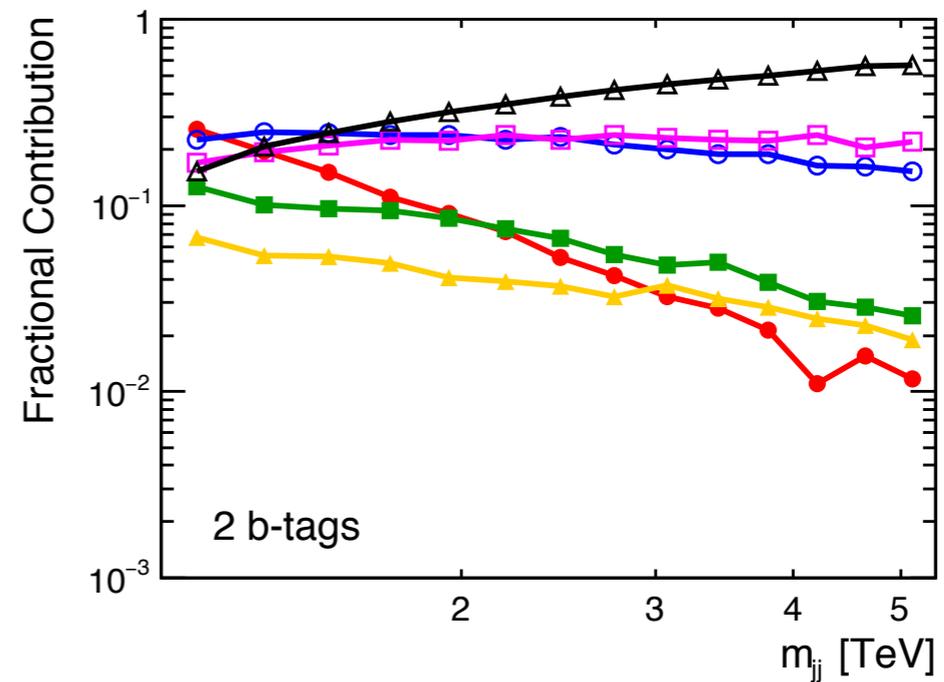
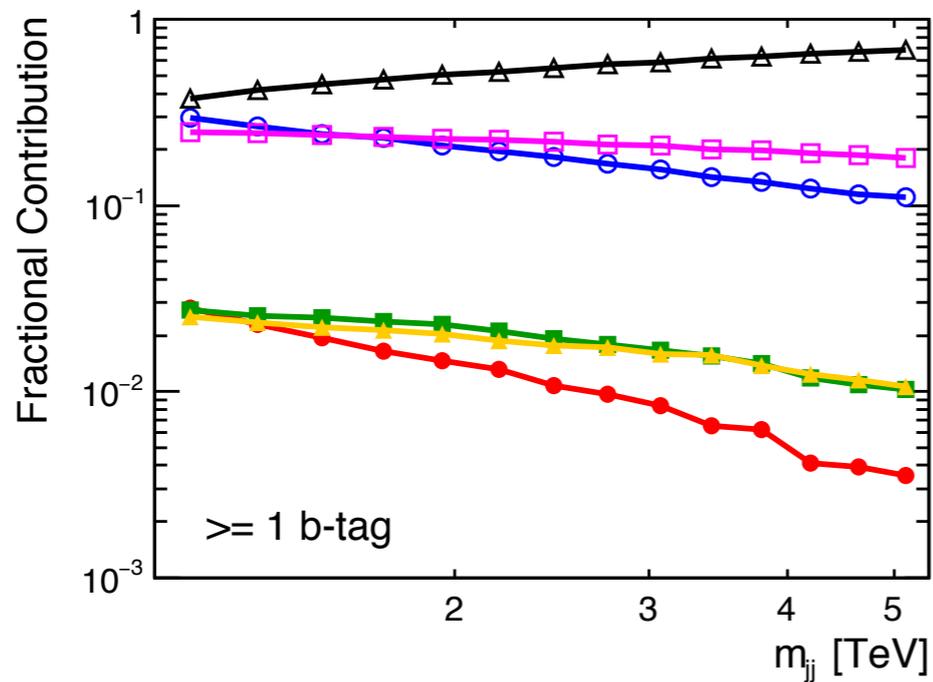
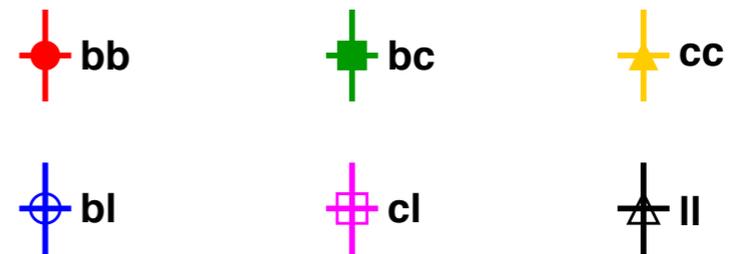


● ATLAS-CONF-2016-060

Di-jet (with b-jets) background composition



ATLAS Simulation Preliminary
 $\sqrt{s} = 13$ TeV



● ATLAS-CONF-2016-060