Search for new phenomena in dijet events with the ATLAS detector at √s = 13 TeV

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EXPERIMENT

Outline

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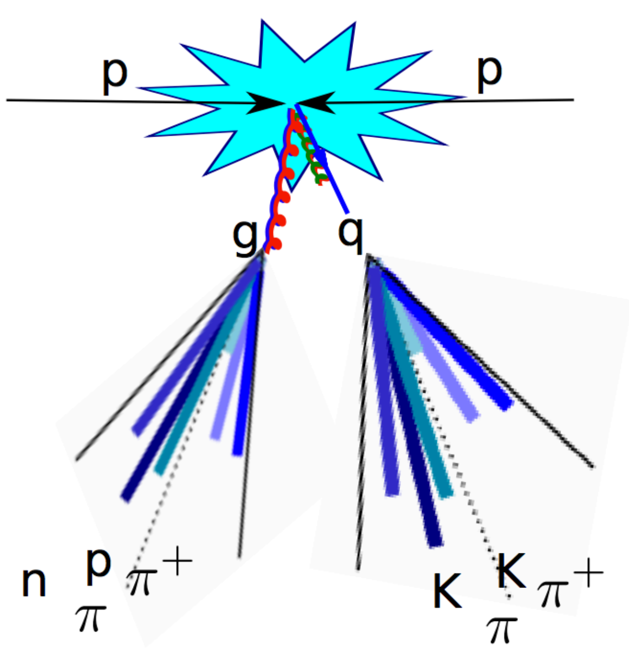
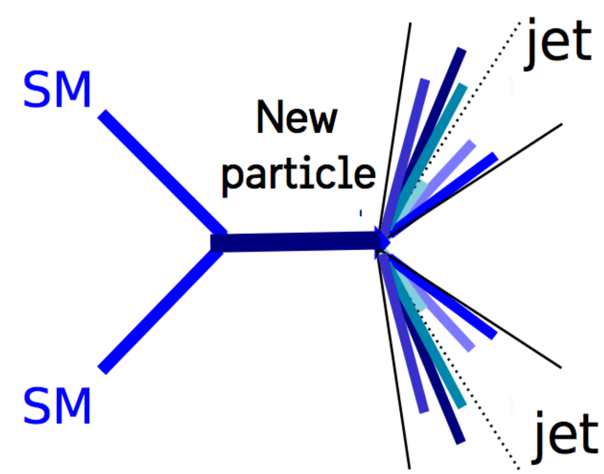
- Introduction to Dijet Analysis
- Dijet Resonance Analysis
- Dijet Angular Analysis
- Summary

- *pp* collisions at √s = 13 TeV, providing a wide scope to search for new phenomena at ATLAS;
- Final states including partons dominate in some BSM models;
- Total dijet production rates for BSM signals can be large;
- Two complementary analysis: resonance analysis based on m_{jj} and angular analysis base on χ.

$$\chi = e^{2|y^*|},\ y^* = (y_1 - y_2)/2$$





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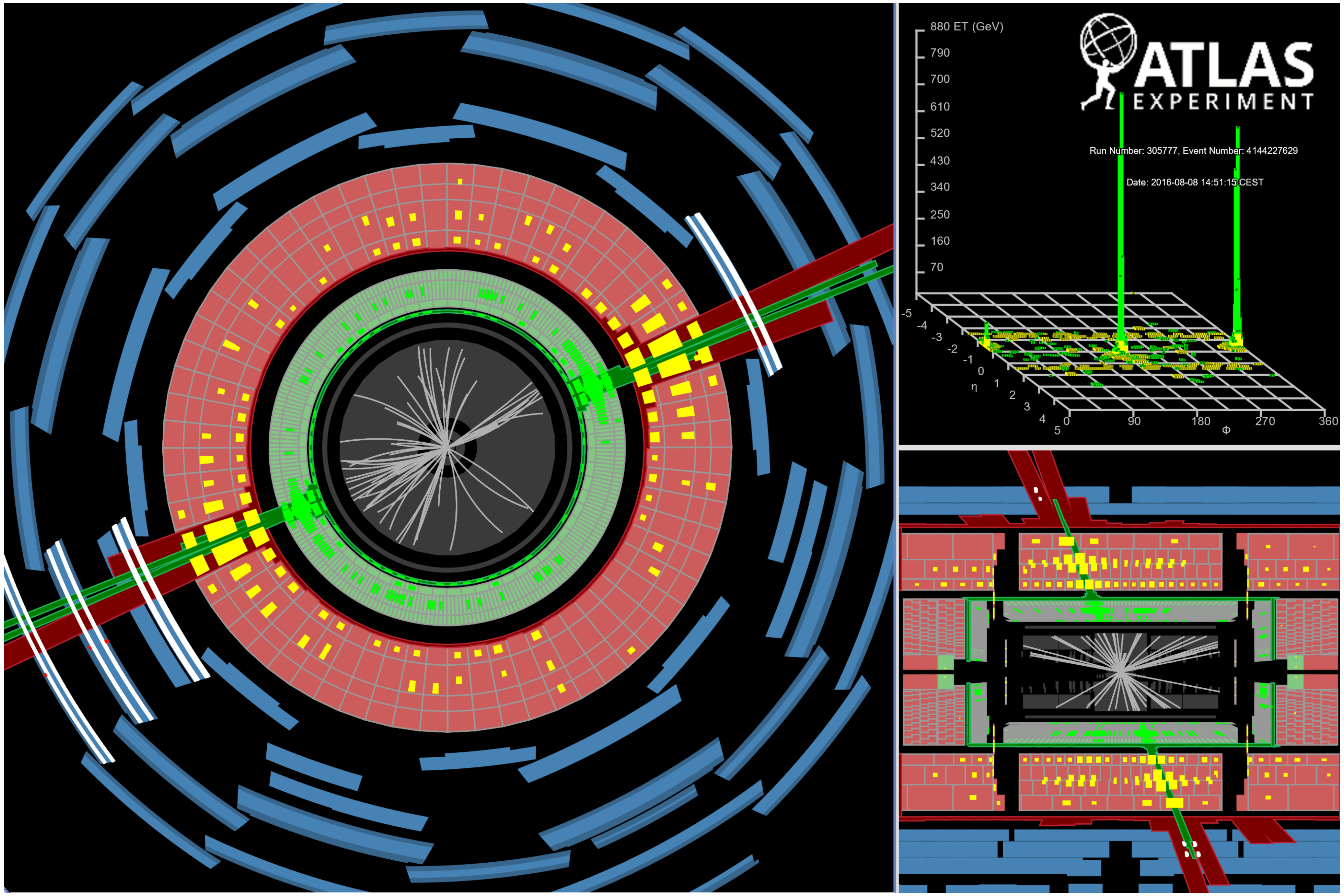
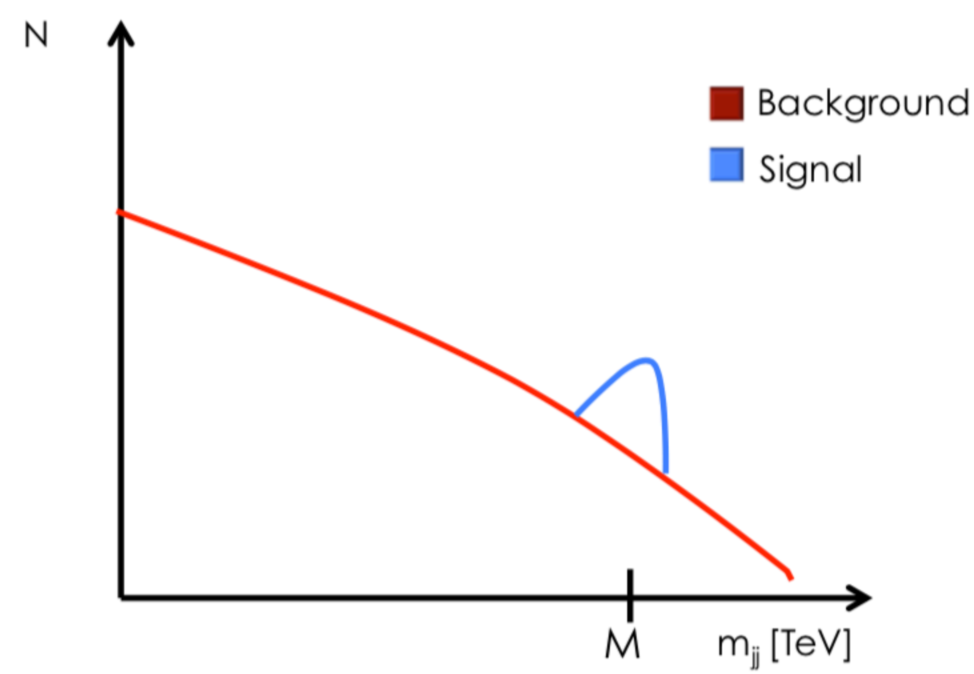
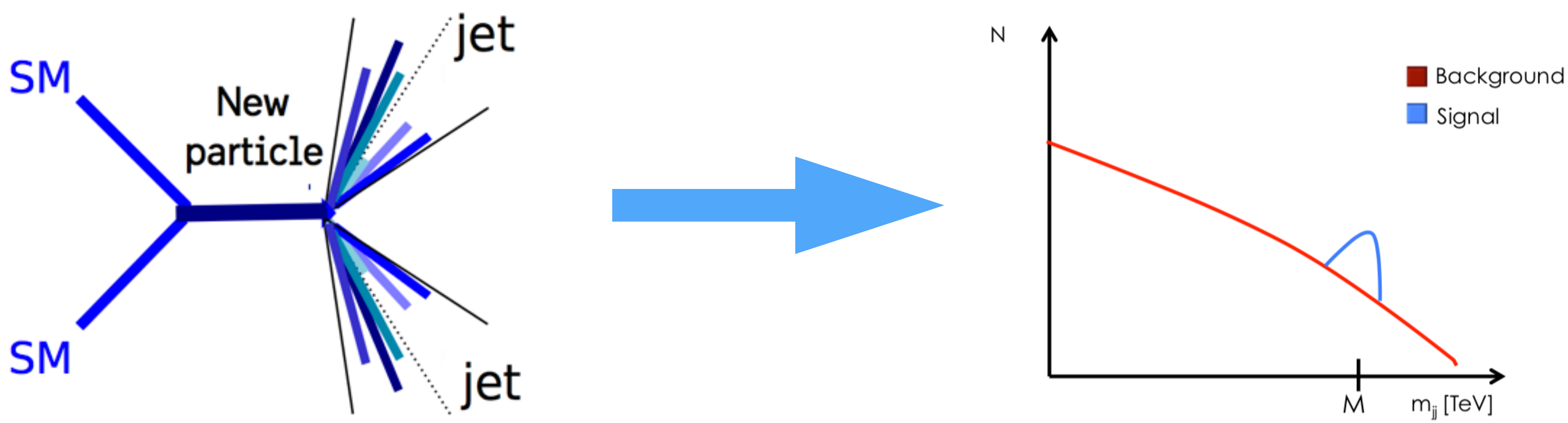


Recorded highest mass dijet event: leading/sub-leading jet p_T=3.74 TeV, $|y^*|$=0.38, m_{jj}=8.02 TeV.

Resonance Analysis



- In SM, hadron collisions produce jet pairs primarily via $2 \rightarrow 2$ parton scattering processes governed by QCD;
- QCD predicts a smoothly falling dijet invariant mass distribution;
- New particles decaying to two jets may introduce local excesses.



- Sensitive to resonant signals.
- Benchmark Model: q^*, Z', W', W^*, QBH, etc.
- Three presented results: 15.7 fb^{-1}, 37 fb^{-1} and 139 fb^{-1} in Run 2.

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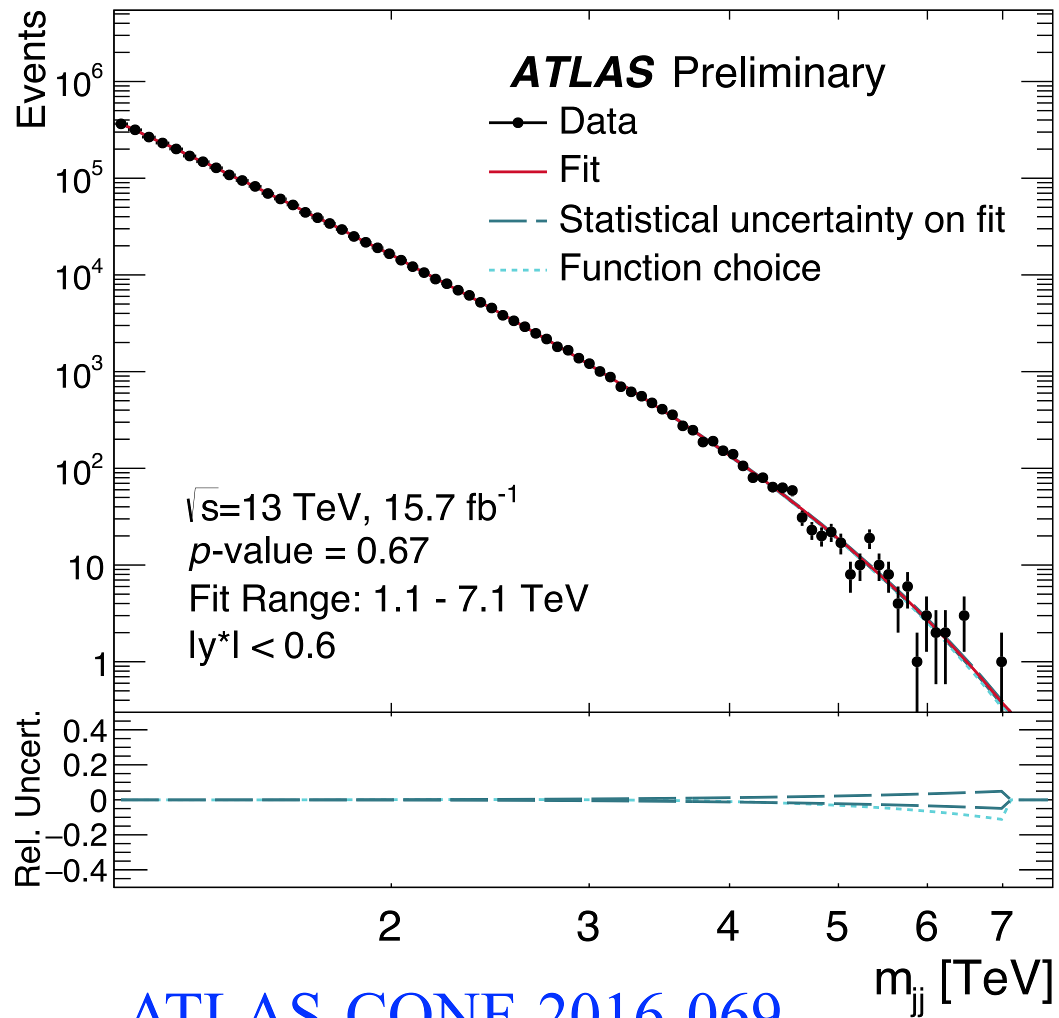
Event Selection:

- GRL
- LAr, Tile, SCT error rejected
- Core: Incomplete event rejected
- PV has at least two tracks
- Pass HLT_j380
- ≥2 clean jets, Leading jet p_T > 440 GeV Sub-leading jet p_T>60GeV
- $|y^*| = |y_1 - y_2|/2 < 0.6$(1.2 for W*)
- m_{jj} > 1100 GeV(1717 GeV for W*)



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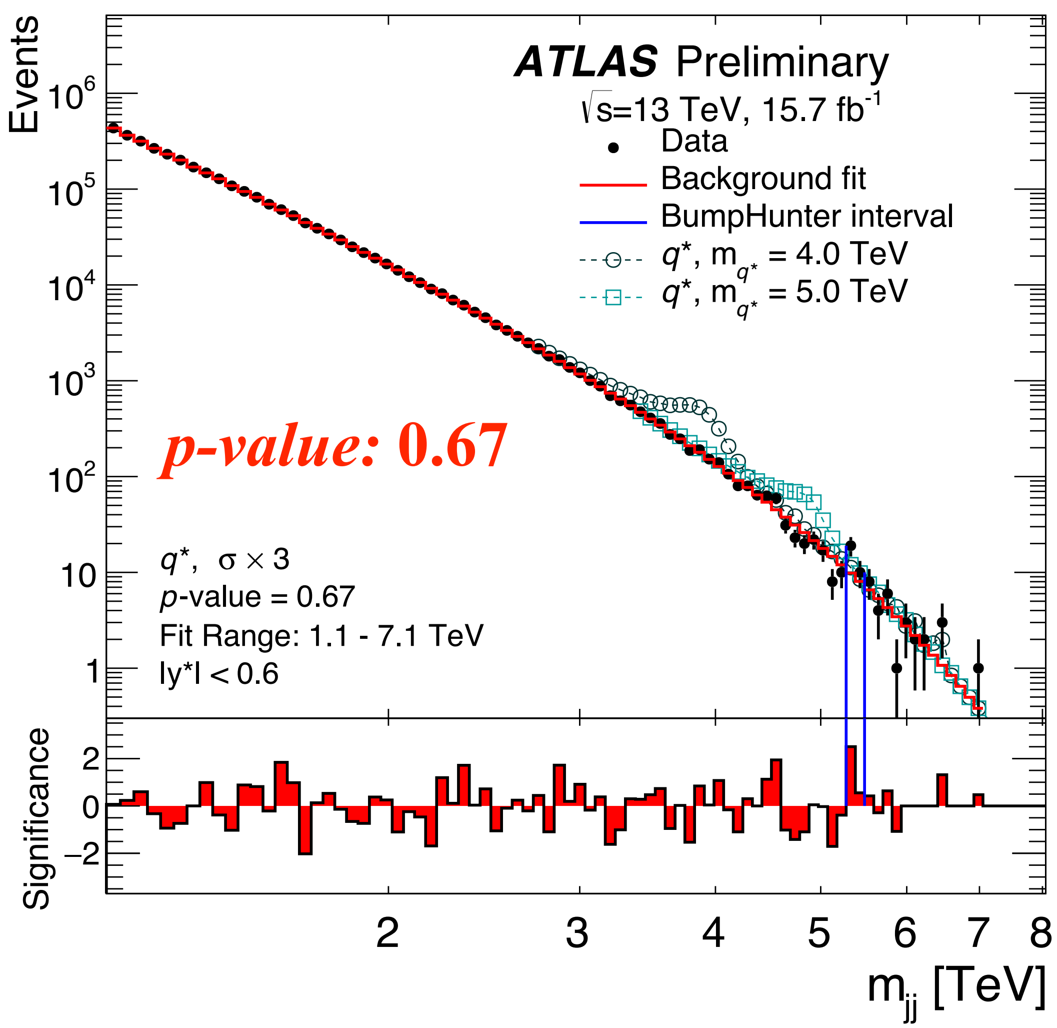
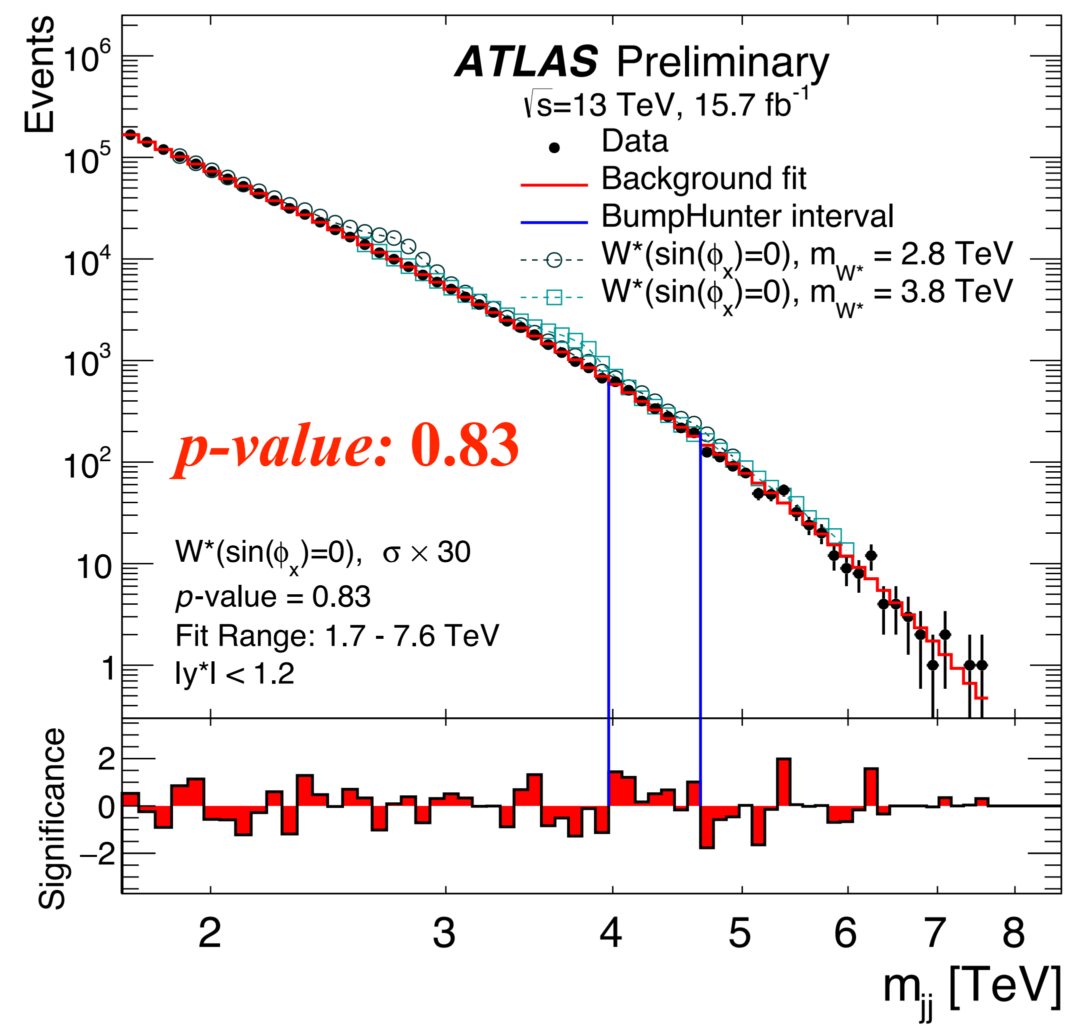
Global fitting with 3-parameters function on the m_{jj} spectrum to estimate the background directly:

$$f(x) = p_1(1-x)^{p_2}x^{p_3}$$
$$x = m_{jj}/\sqrt{s}$$

- BumpHunter Algorithm is employed to search for local excess over the background.
- No significant local excess.





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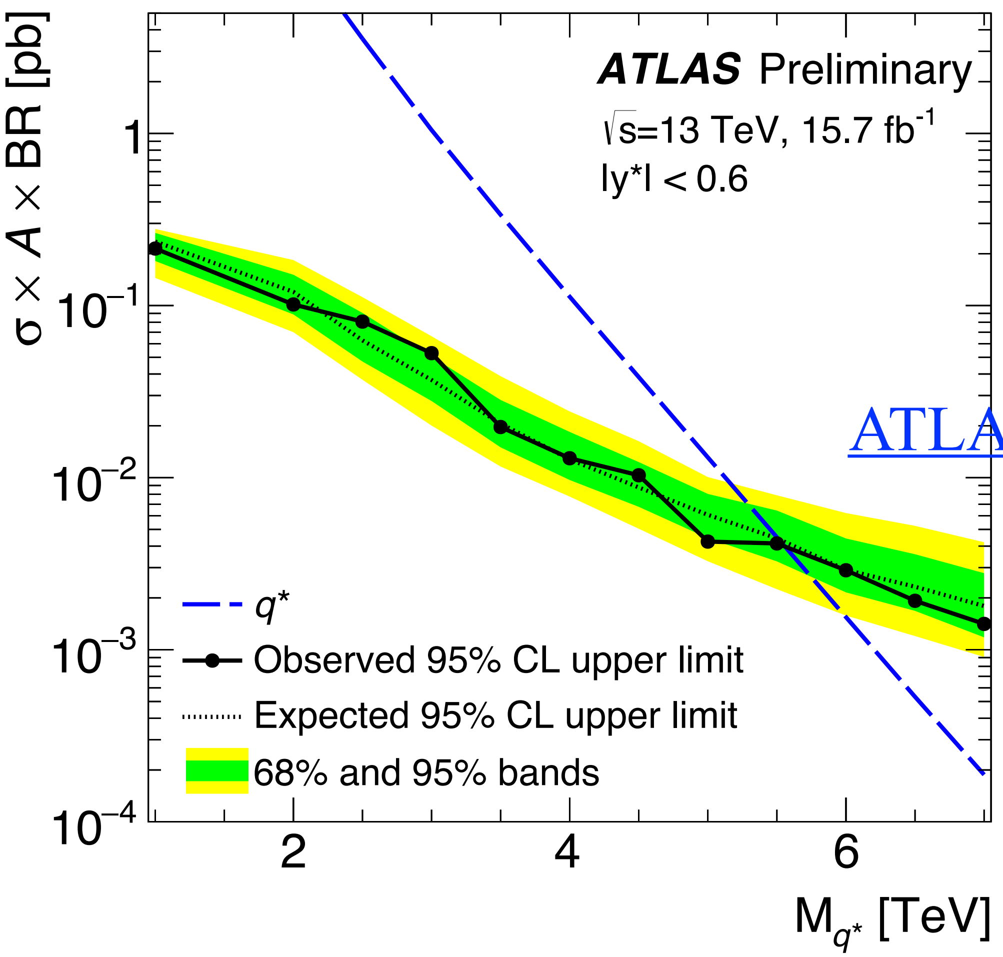
Limit Setting: 15.7 fb^{-1}

Bayesian method to set upper limits at 95% C.L. on Acceptance*Xs*Br.



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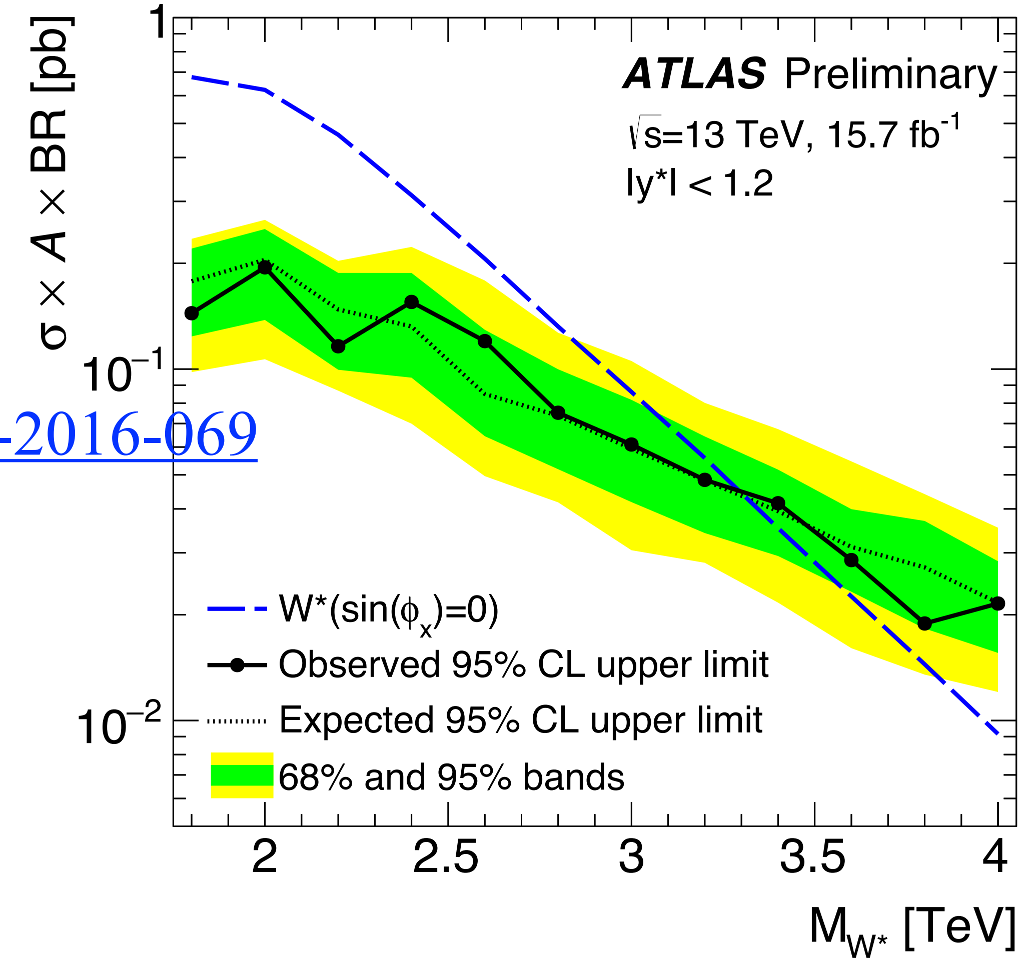
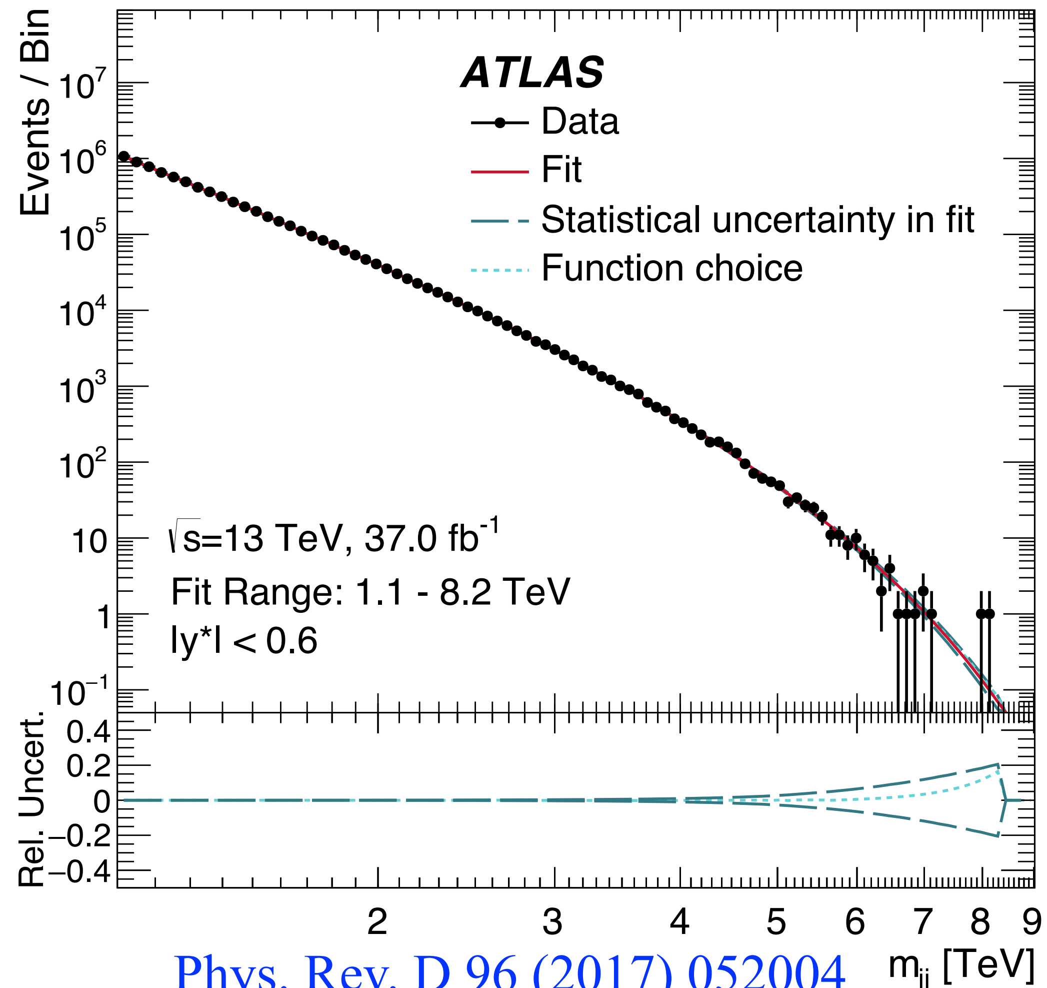


Model	95% CL exclusion limit		2012@8 TeV	
	Observed	Expected	Observed	Expected
Quantum Black Hole	**8.7 TeV**	**8.7 TeV**	5.66 TeV	5.66 TeV
Excited quark	**5.6 TeV**	**5.5 TeV**	4.06 TeV	3.98 TeV
W'	**2.9 TeV**	**3.3 TeV**	2.45 TeV	2.51 TeV
W^*	**3.3 TeV**	**3.3 TeV**	1.75 TeV	1.95 TeV

Event Selection:

Same with last publication.

- GRL
- LAr, Tile, SCT error rejected
- Core: Incomplete event rejected
- PV has at least two tracks
- Pass HLT_j380
- ≥2 clean jets, Leading jet p_T > 440 GeV Sub-leading jet p_T>60GeV
- $|y^*| = |y_1 - y_2|/2 < 0.6$(1.2 for W*)
- m_{jj} > 1100 GeV(1717 GeV for W*)



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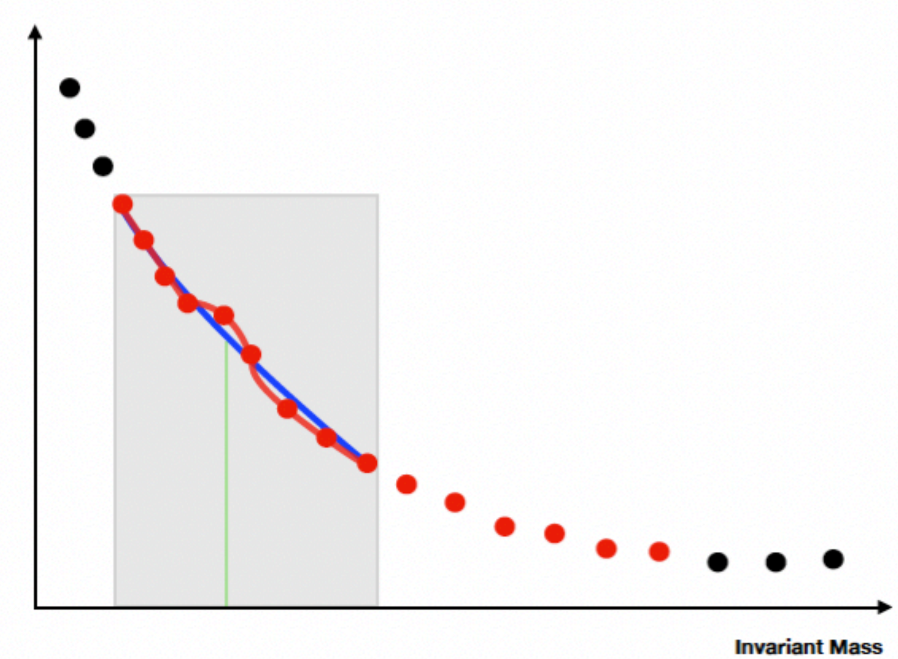
Sliding Window Fitting Method(SWiFt):

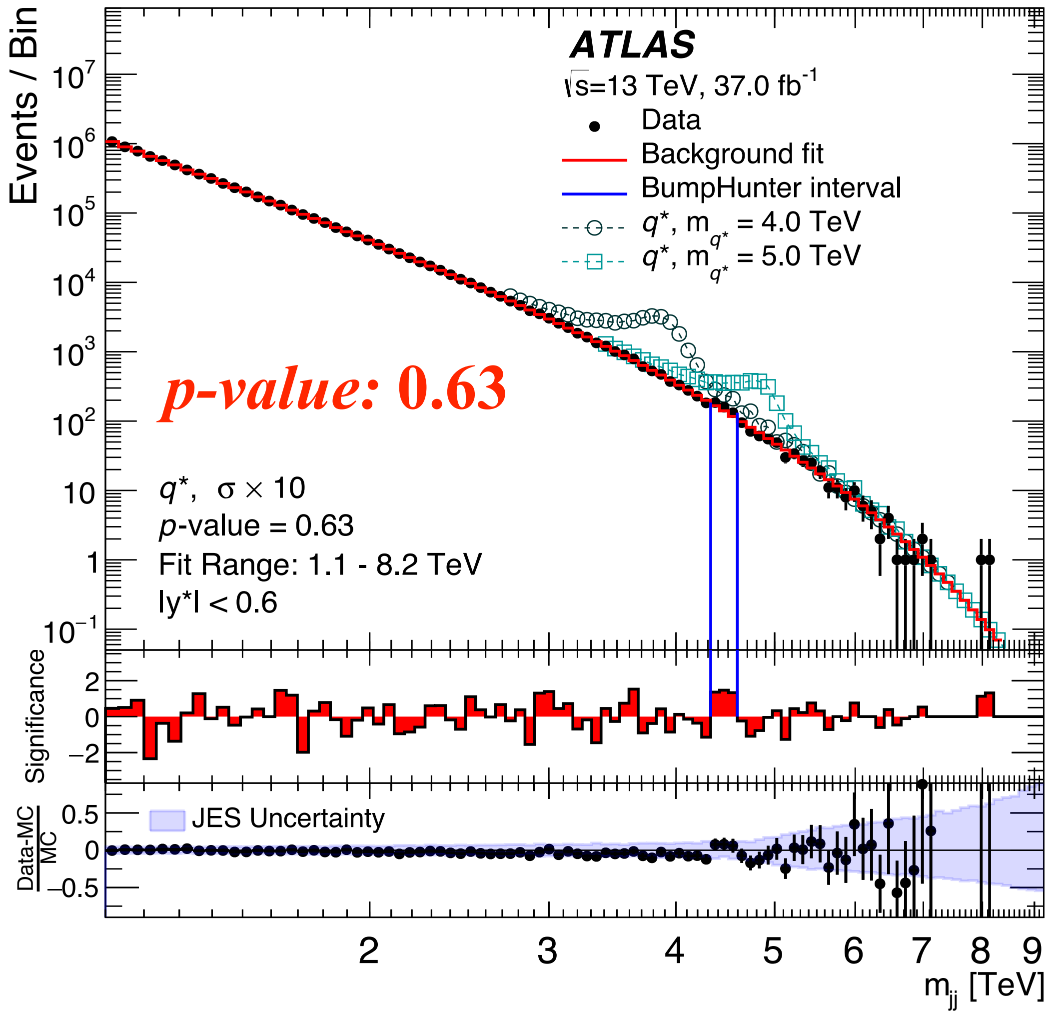
- Slide over mass spectrum into smaller windows;
- Perform fitting in each window;

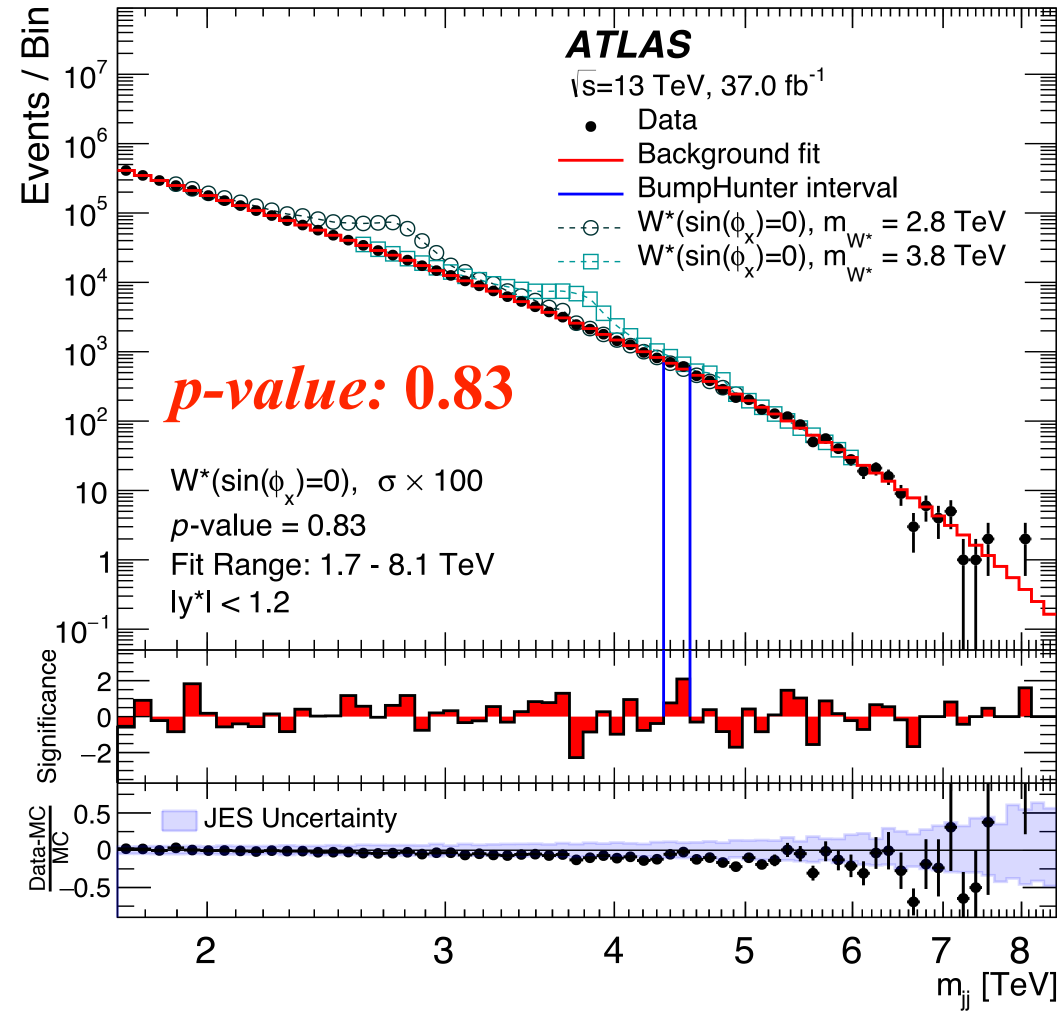
$$f(x) = p_1(1-x)^{p_2}x^{p_3}, x = m_{jj}/\sqrt{s}$$

- Stitch background fit value in each bin together for the full range prediction.



- BumpHunter Algorithm is employed to search for local excess over the background.
- No significant local excess.





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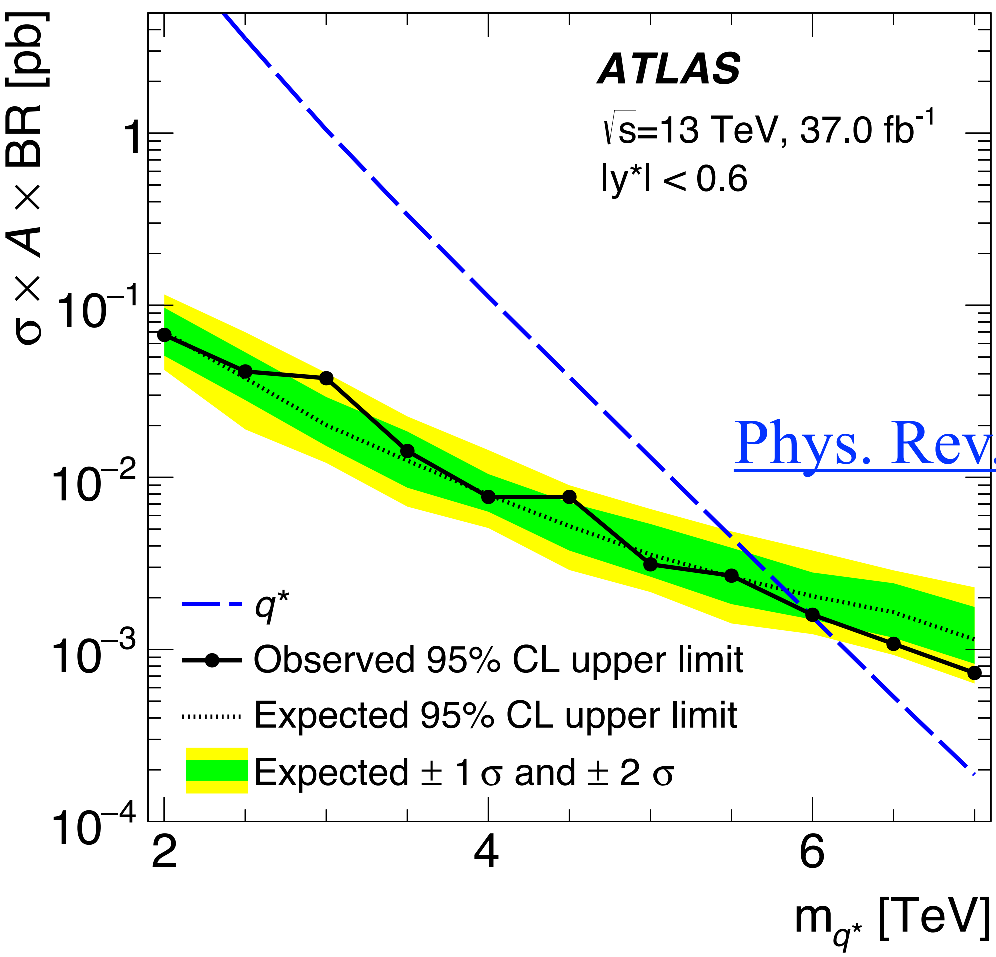
SearchPhase Results: 37 fb^{-1}

Bayesian method to set upper limits at 95% C.L. on Acceptance*Xs*Br.



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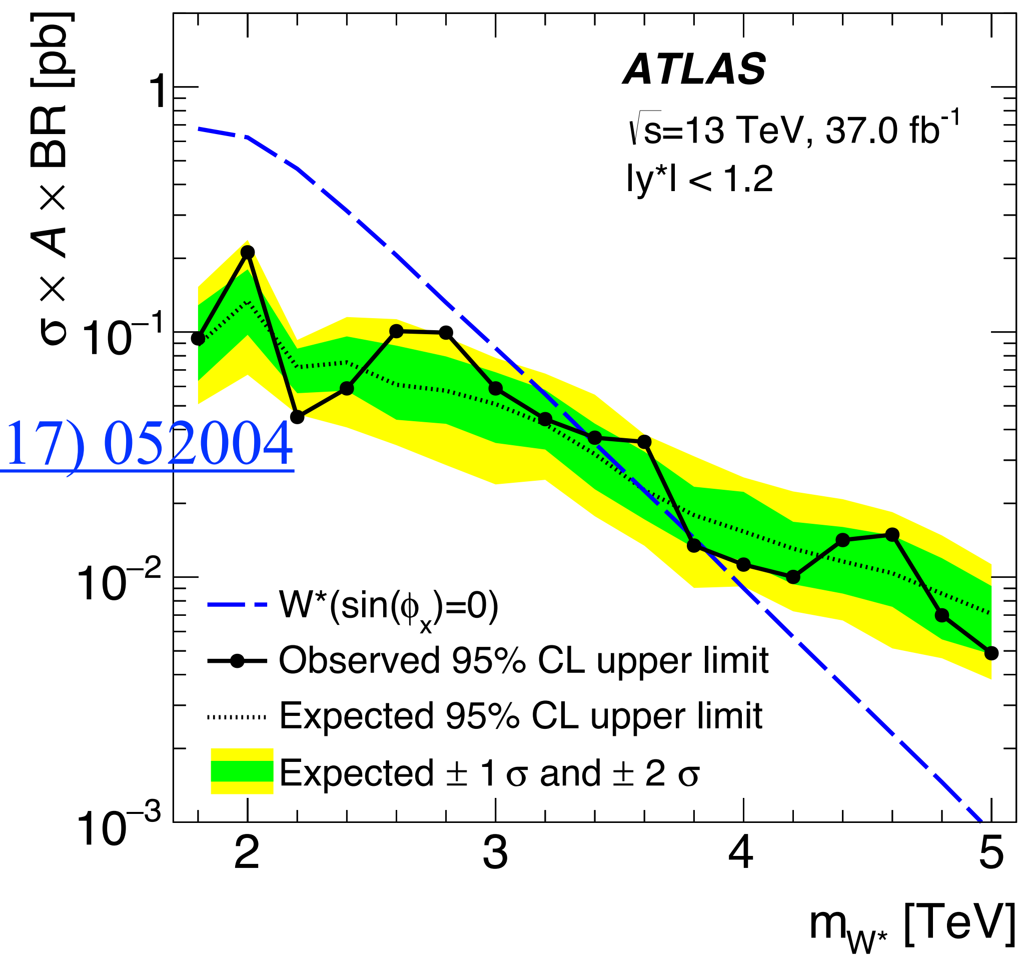
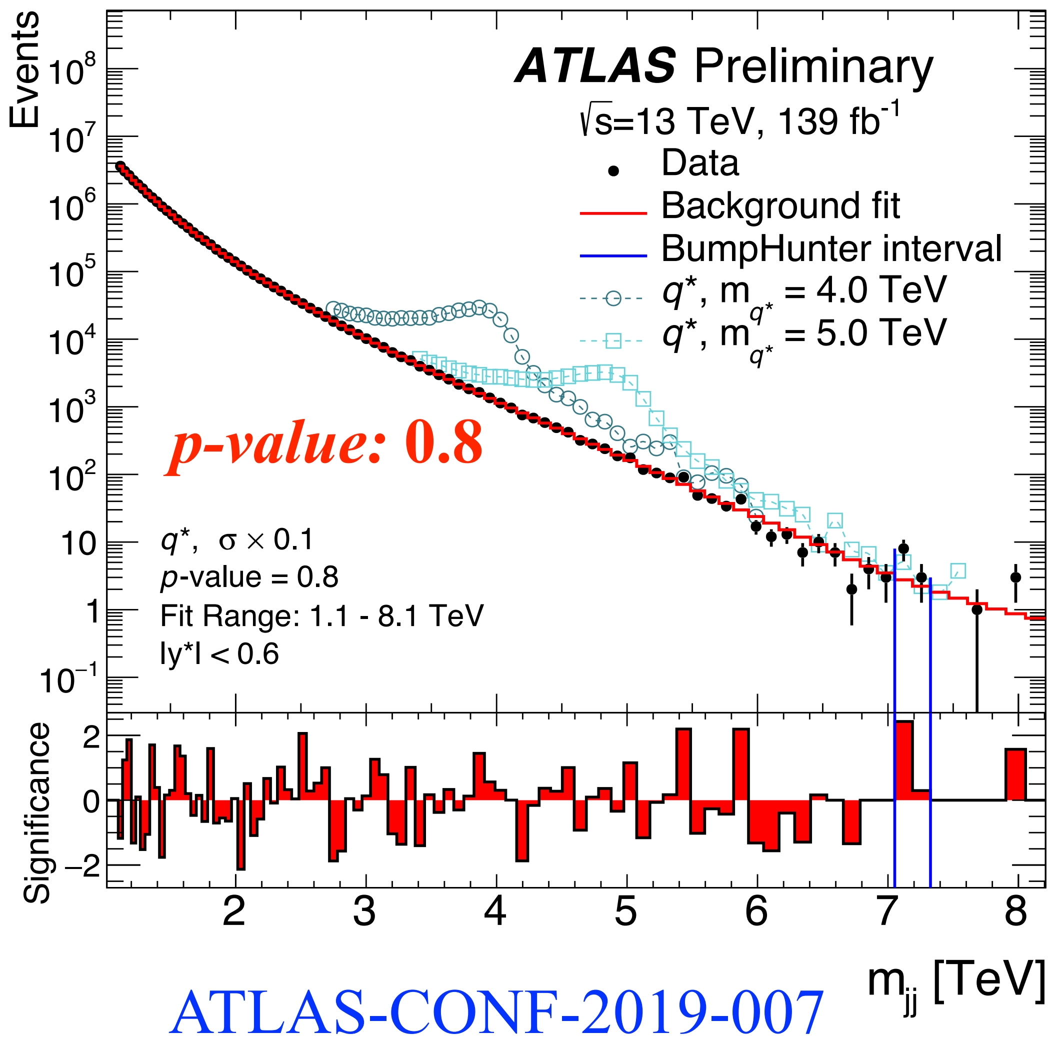


Model	95% CL exclusion limit		2016	
	Observed	Expected	Observed	Expected
Quantum Black Hole	**8.9 TeV**	**8.9 TeV**	8.7 TeV	8.7 TeV
Excited quark	**6.0 TeV**	**5.8 TeV**	5.6 TeV	5.5 TeV
W′	**3.6 TeV**	**3.7 TeV**	2.9 TeV	3.3 TeV
W*	**3.4 TeV**	**3.6 TeV**	3.3 TeV	3.3 TeV

Full Run2 Data

Event Selection:

- Good Run List (GRL)
- LAr, Tile, SCT error rejected,
- Core: Incomplete event rejected,
- PV has at least two tracks,
- Pass HLT_j420,
- ≥2 clean jets, Leading jet p_T > 420 GeV, Sub-leading jet p_T > 150 GeV,
- $|y^*|=|y_1-y_2|/2<0.6$
- $|m_{jj}|>1100$ GeV



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- Sliding Window Fitting Method(SWiFt) is still robust:

$$f(x) = p_1(1-x)^{p_2}x^{p_3+p_4 lnx}, x = m_{jj}/\sqrt{s}$$

- BumpHunter Algorithm is used to search for local excess over the background.
- No significant local excess.

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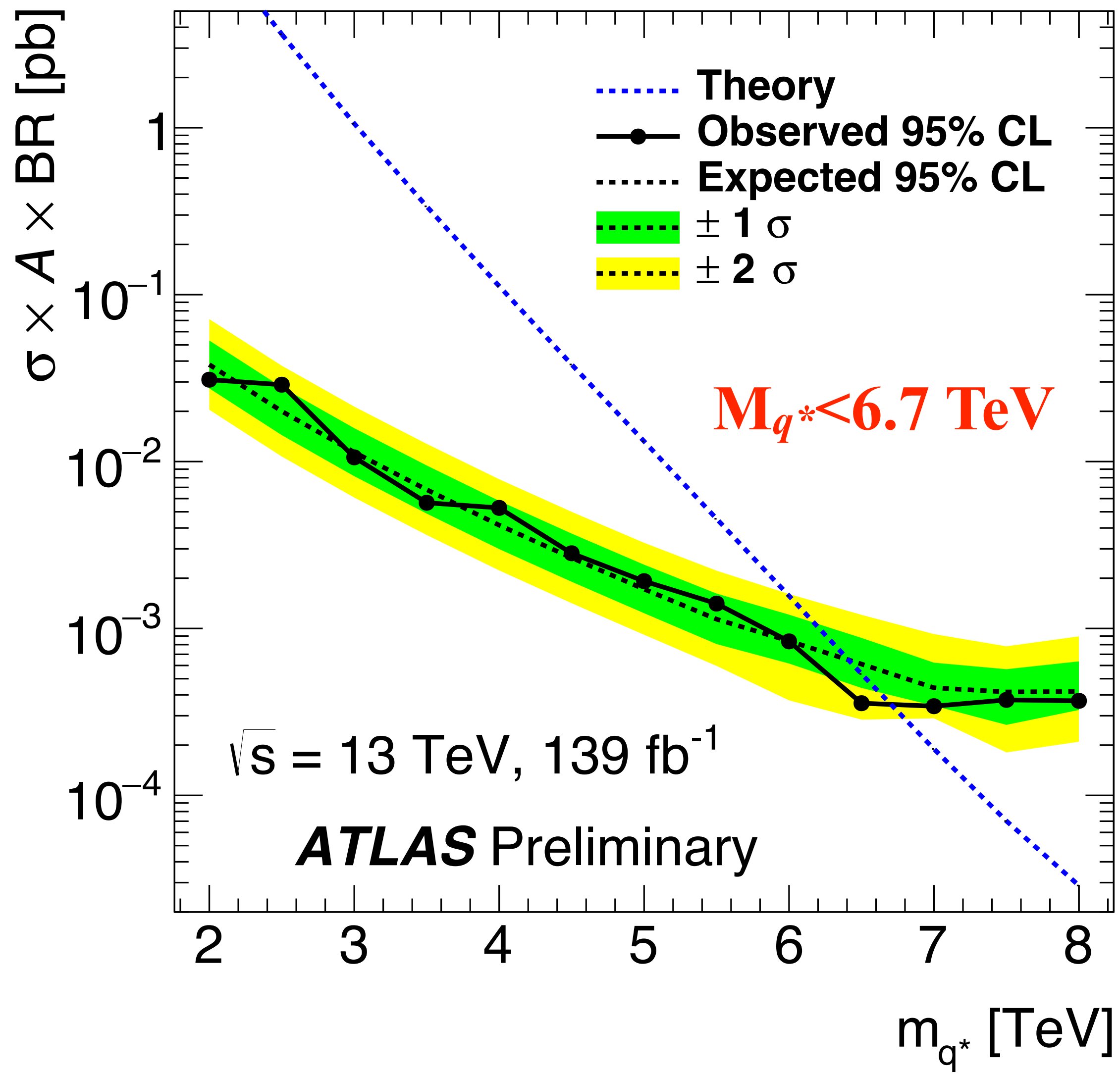
- CL_s technique implemented in HistFitter framework to set upper limits at *C.L.* of 95%.



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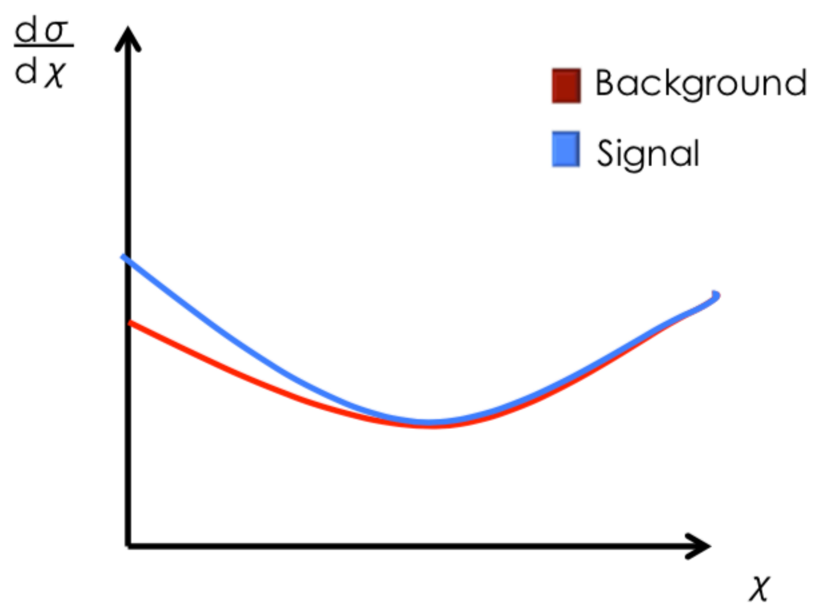
More results of other channels and Dib-jet analysis are coming soon for one paper.

Angular Analysis

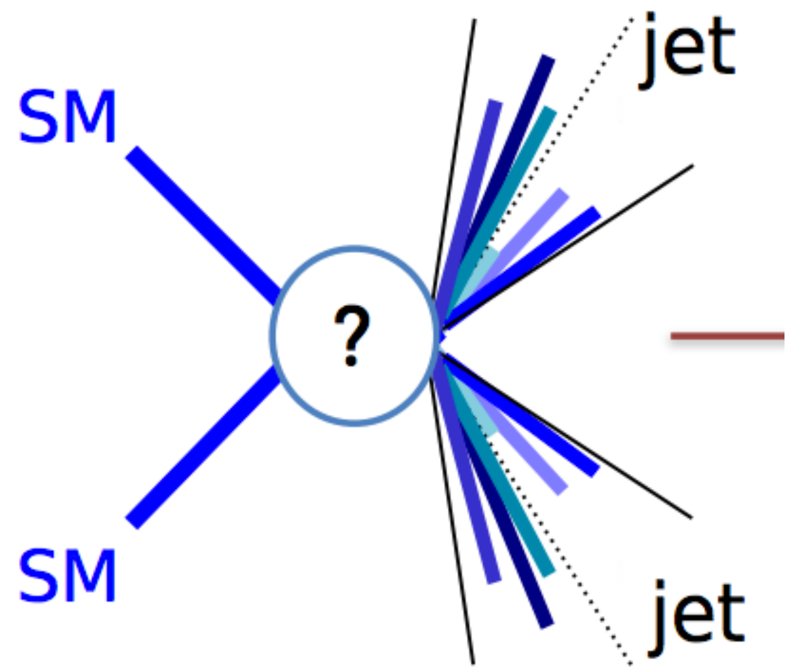


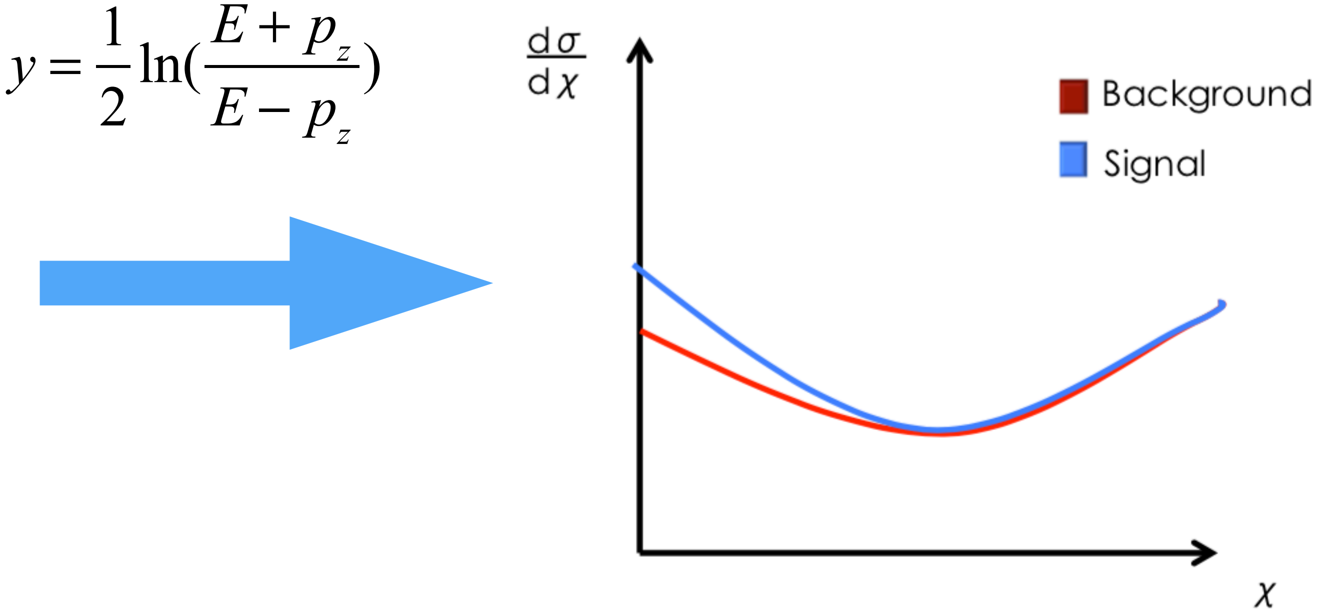
Overview of Angular Analysis

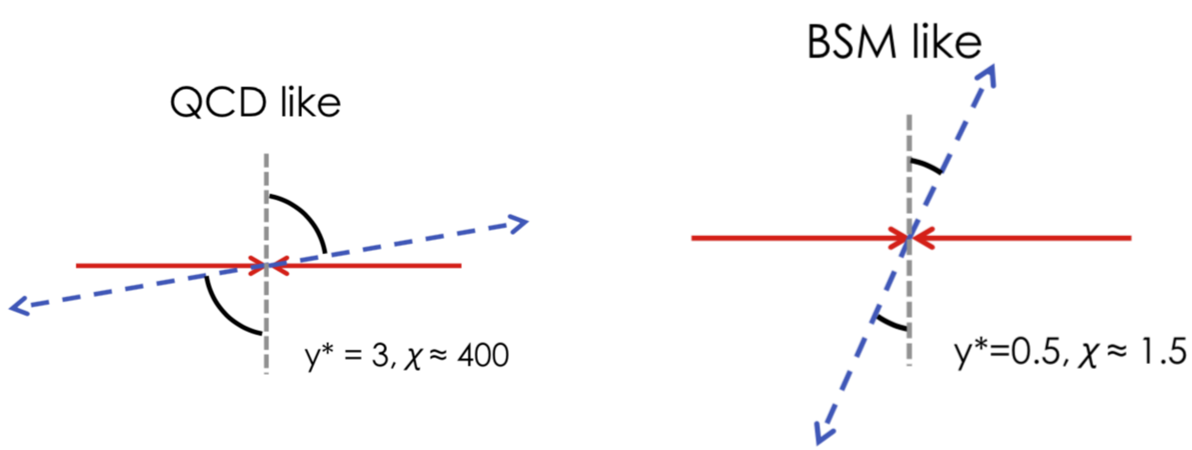
- In SM, t-channel dominates the parton scattering process, most dijet productions occur at small angles, differential cross section tends to be flat;
- BSM predicts additional dijet production at large angles.

$$\chi = e^{2|y^*|}, y^* = (y_1 - y_2)/2$$

$$y = \frac{1}{2}\ln\left(\frac{E + p_z}{E - p_z}\right)$$







- Sensitive to resonant/non-resonant signals;
- Benchmark Models: CI, QBH, etc.
- Two published results: 15.7 fb^{-1}, 37 fb^{-1}.

Same in two released analysis: 15.7 fb^{-1} and 37 fb^{-1}

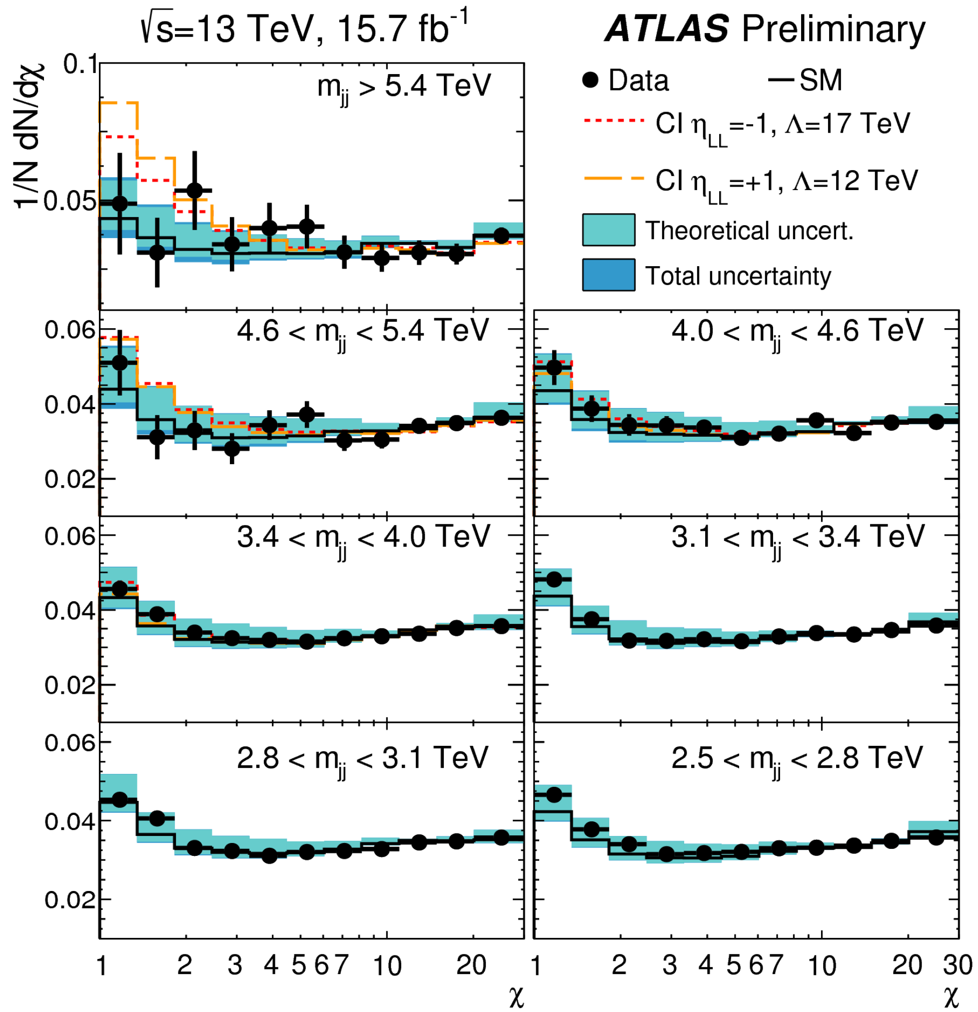
Event Selection:

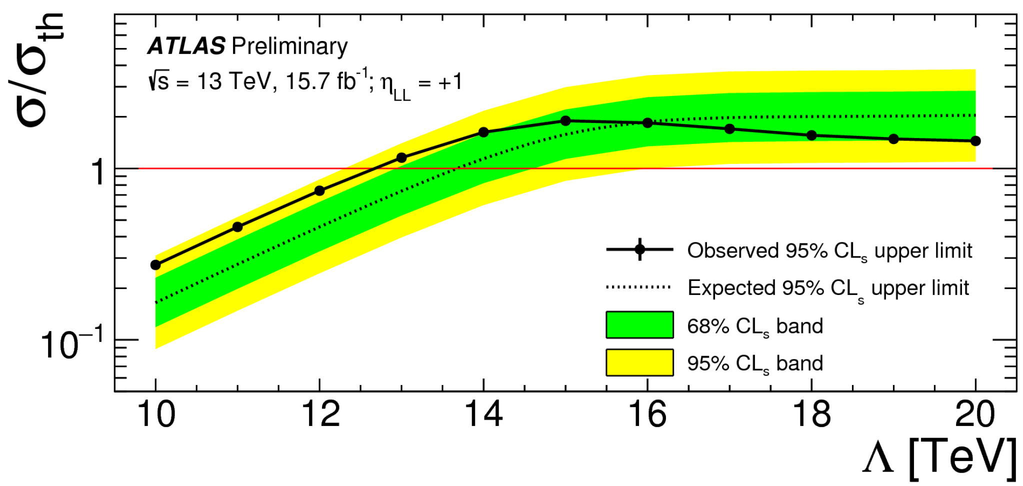
- GRL
- Quality cuts
- HLT_j380
- ≥2 clean jets, Leading jet p_T > 440 GeV Sub-leading jet p_T>60GeV
- $|y^*| = |y_1 - y_2|/2 < 1.7$
- $|y_B| = |y_1 + y_2|/2 < 1.1$
- $m_{jj} > 2500$ GeV

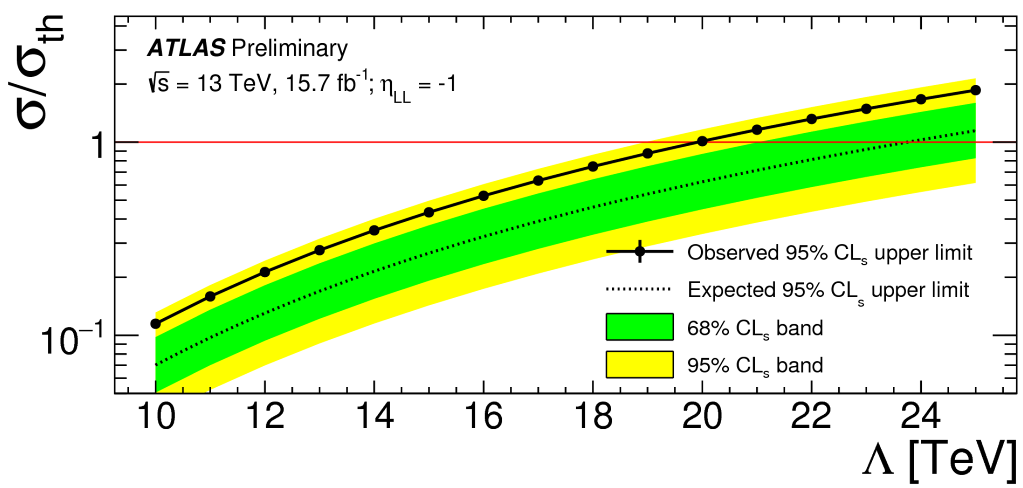
Background Estimation:

- QCD background modeled from MC simulation,
- EW corrections applied as a function of (m_{jj} ,χ),
- QCD NLO corrections applied as a function of (m_{jj} ,χ),
- Normalize QCD background to data.

Angular Analysis Results: 15.7 fb^{-1}







***CL_b p value*: 0.07**

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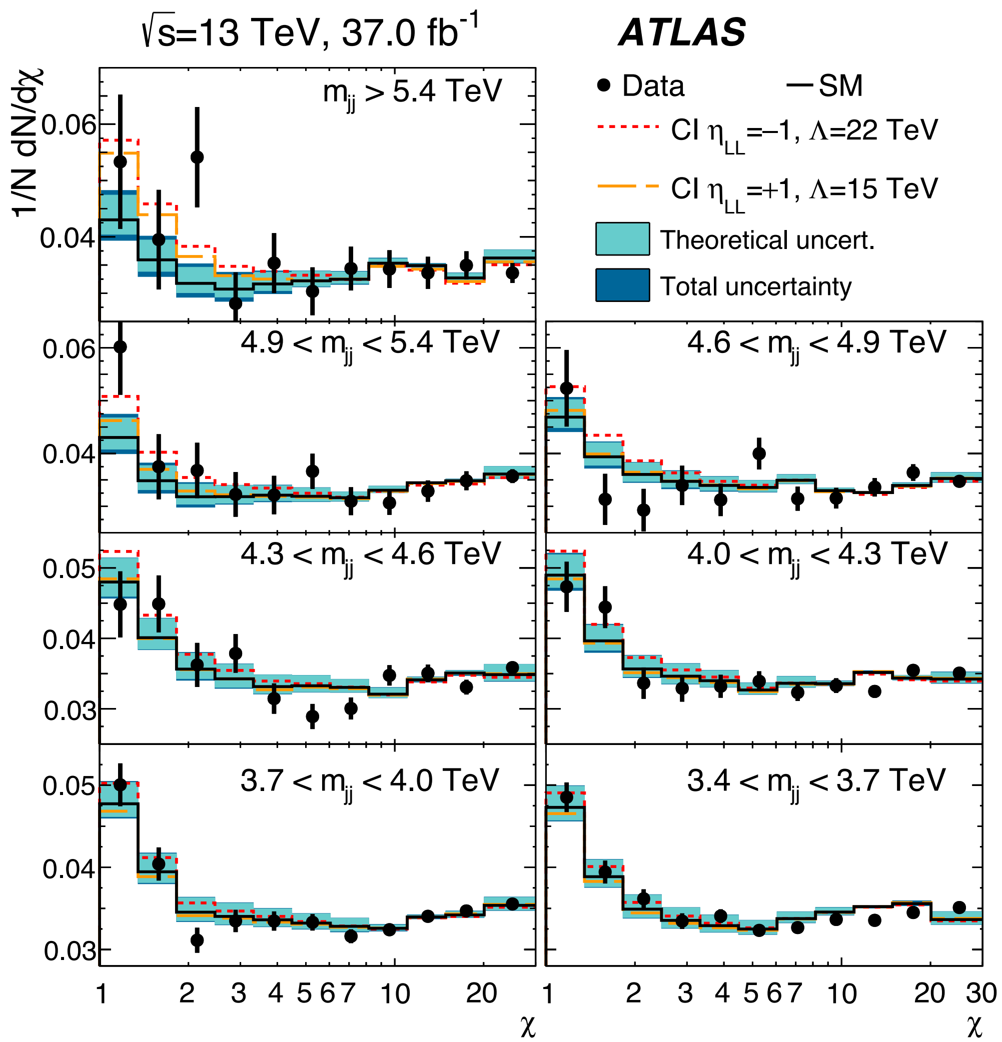
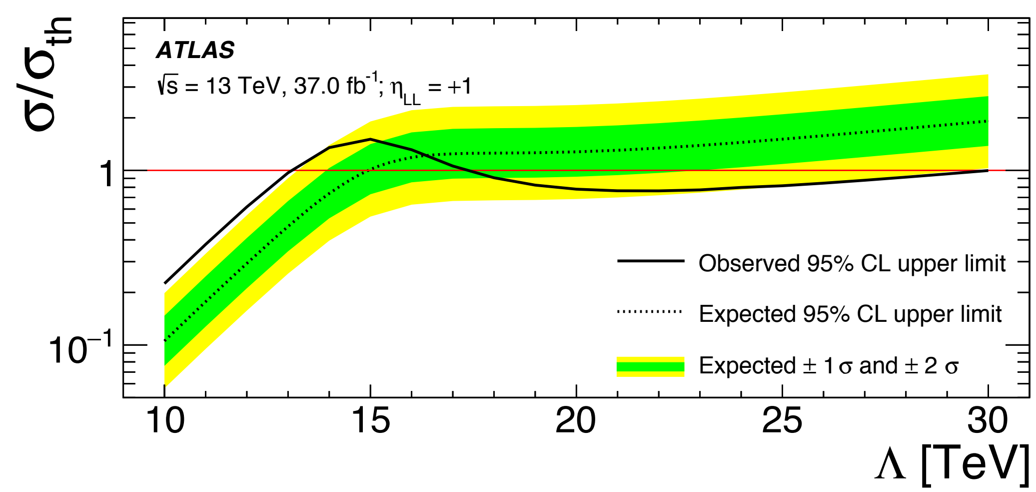
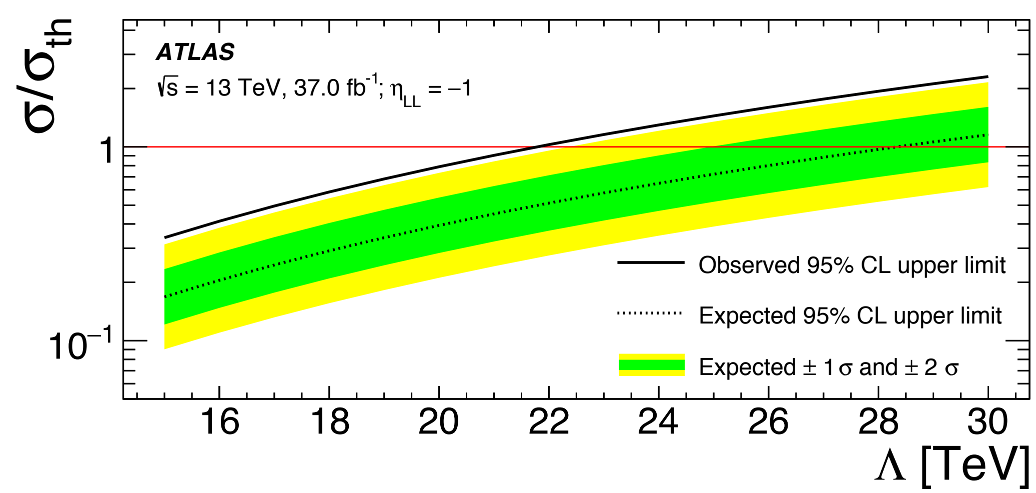
Model	95% CL exclusion limit Observed	Expected
Contact interactions (η_{LL} =+1)	12.6 TeV	13.7 TeV
Contact interactions (η_{LL} =-1)	19.9 TeV	23.7 TeV

Angular Analysis Results: 37 fb^{-1}







***CL_b p value*: 0.06**

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Model	95% CL exclusion limit Observed	Expected
Contact interactions (η_{LL} =+1)	13.1 TeV 17.4-29.5 TeV	15.0 TeV
Contact interactions (η_{LL} =-1)	21.8 TeV	28.3 TeV

Summary

- Performed new physics search in dijet events in resonance and angular analysis using the full Run2 data collected by ATLAS;
- No significant deviation from the background is observed;
- Improved upper limits set on several benchmark models;
- In Dijet Resonance Analysis, results of other channels and Dib-jet analysis are coming soon for one paper.

Thanks

Backup

SearchPhase Results

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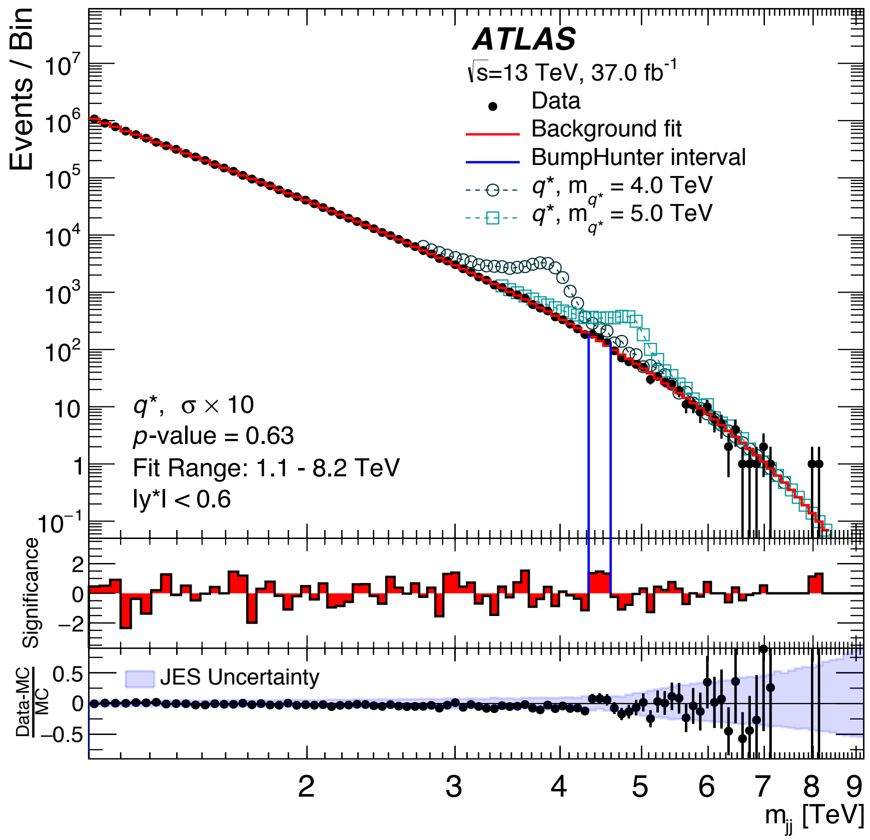

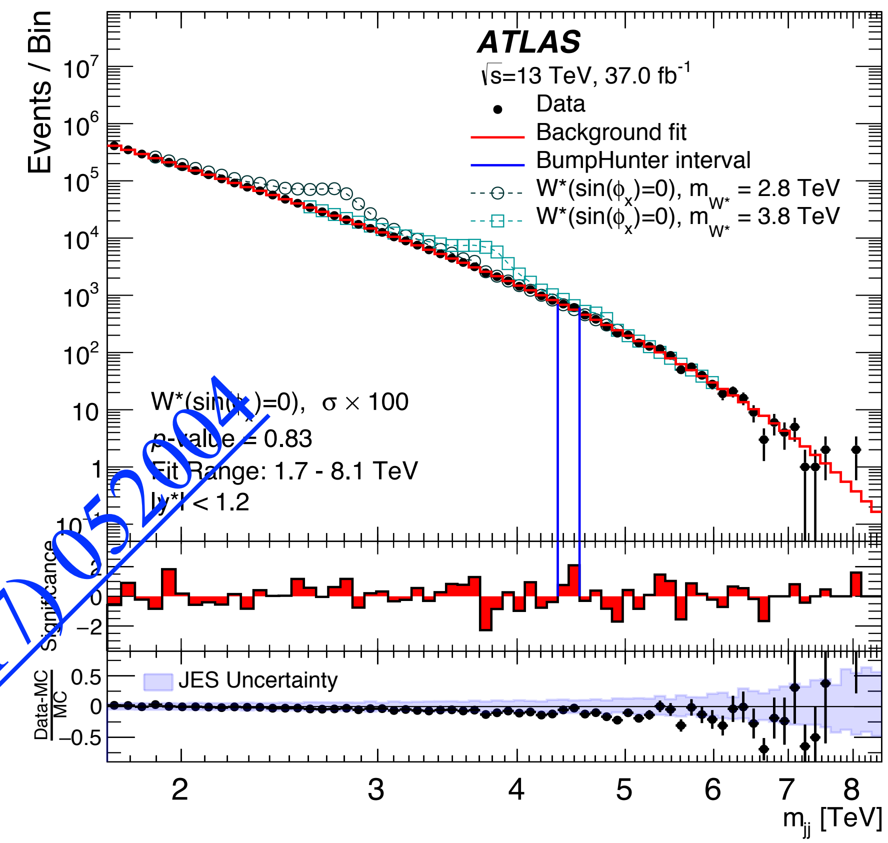

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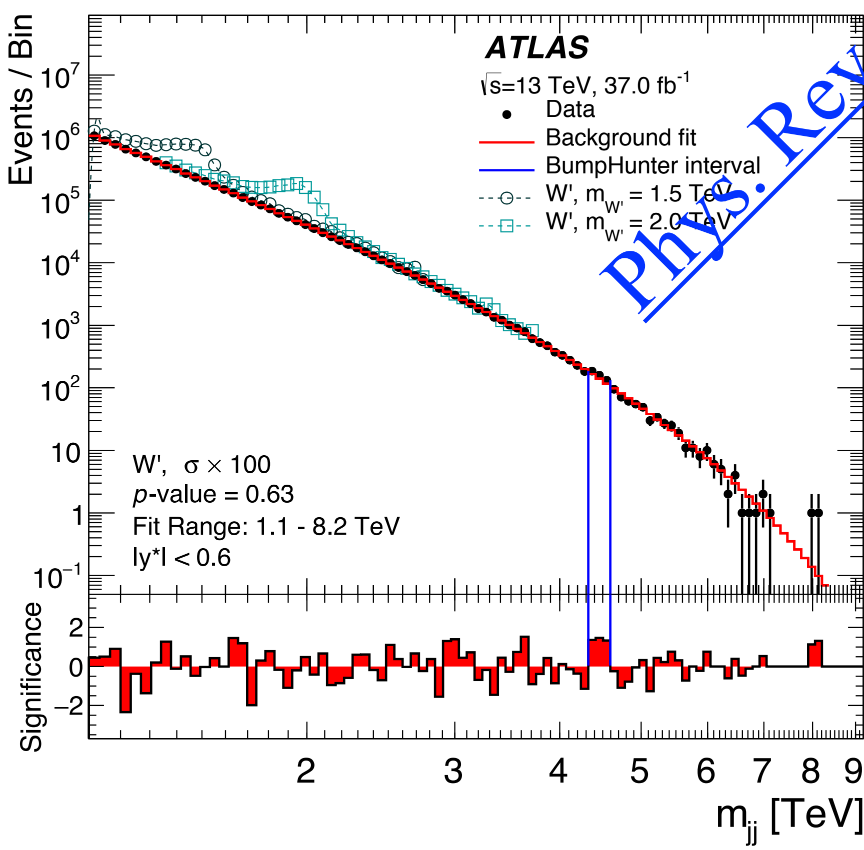

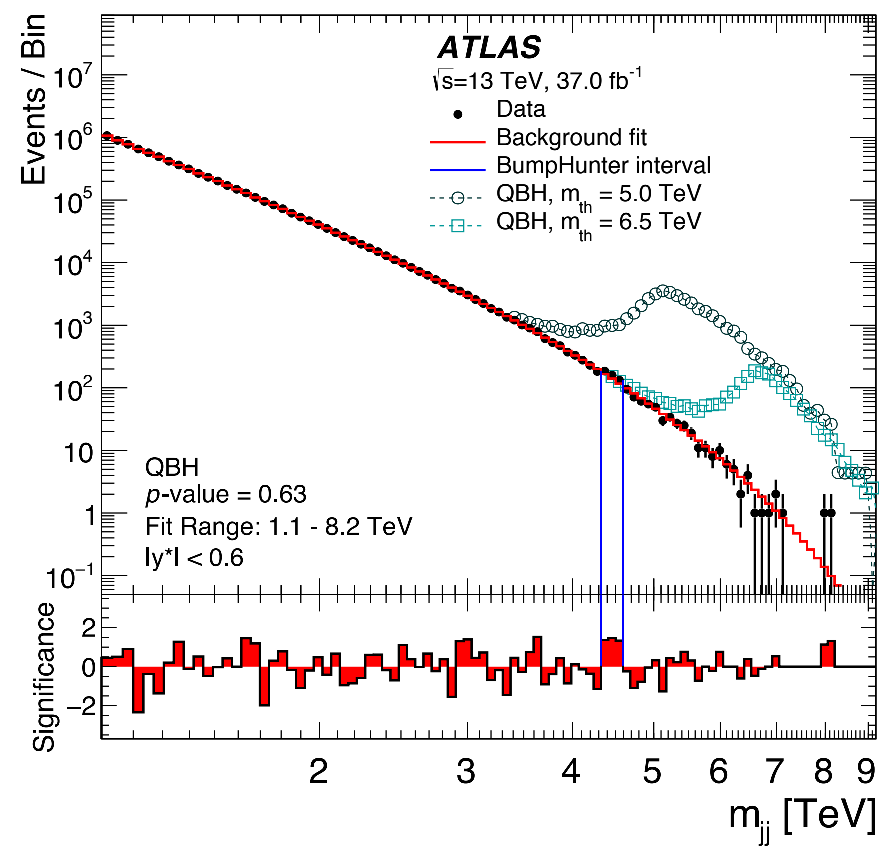

Upper limits on q*,W’,QBH and W*

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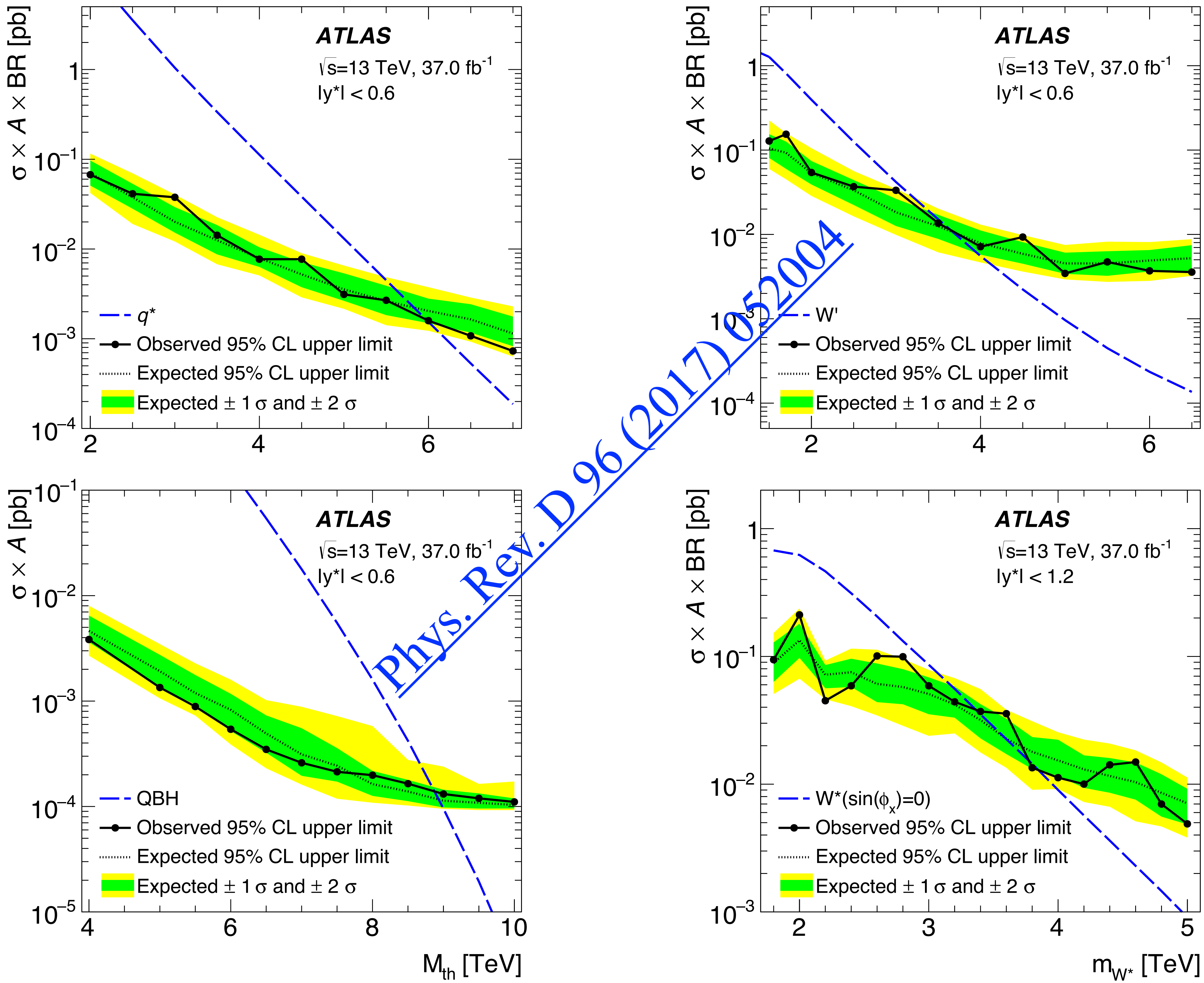

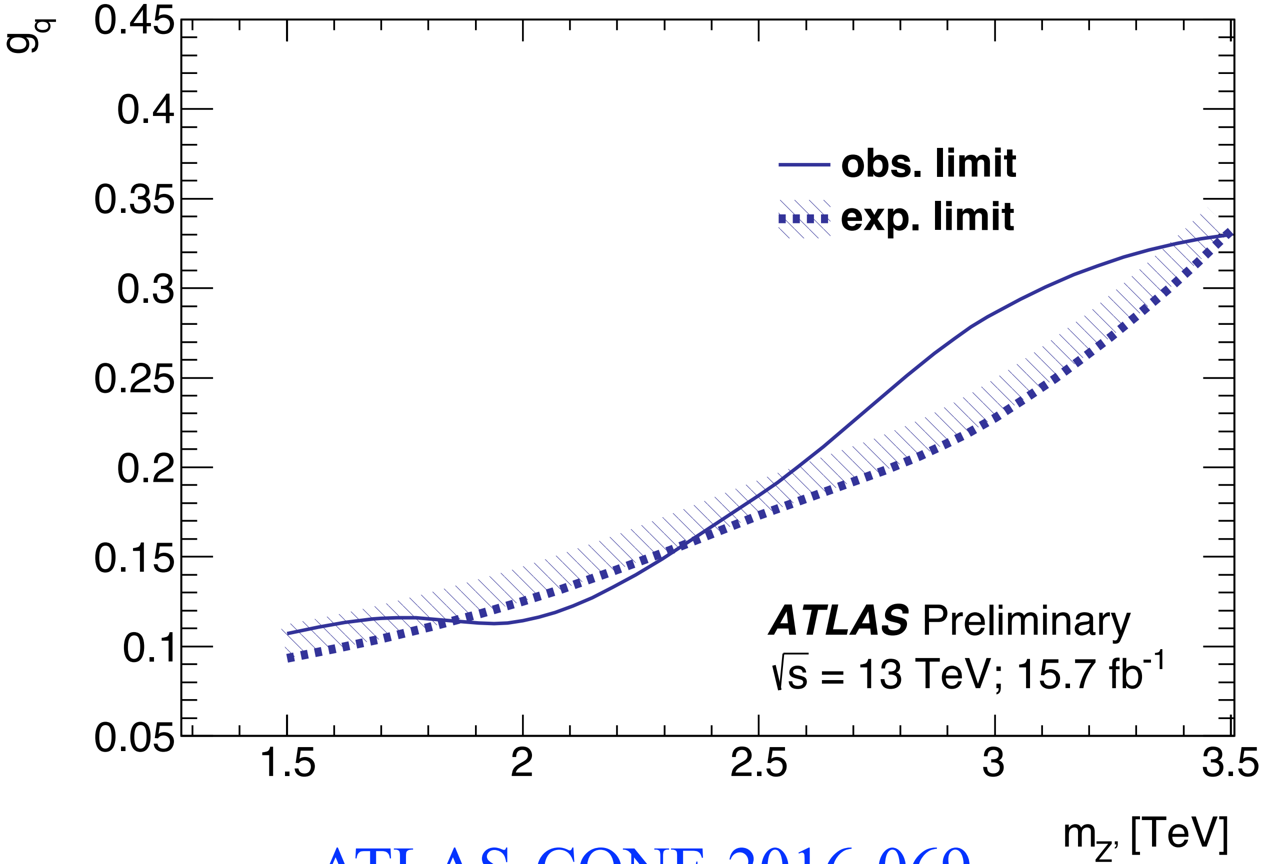

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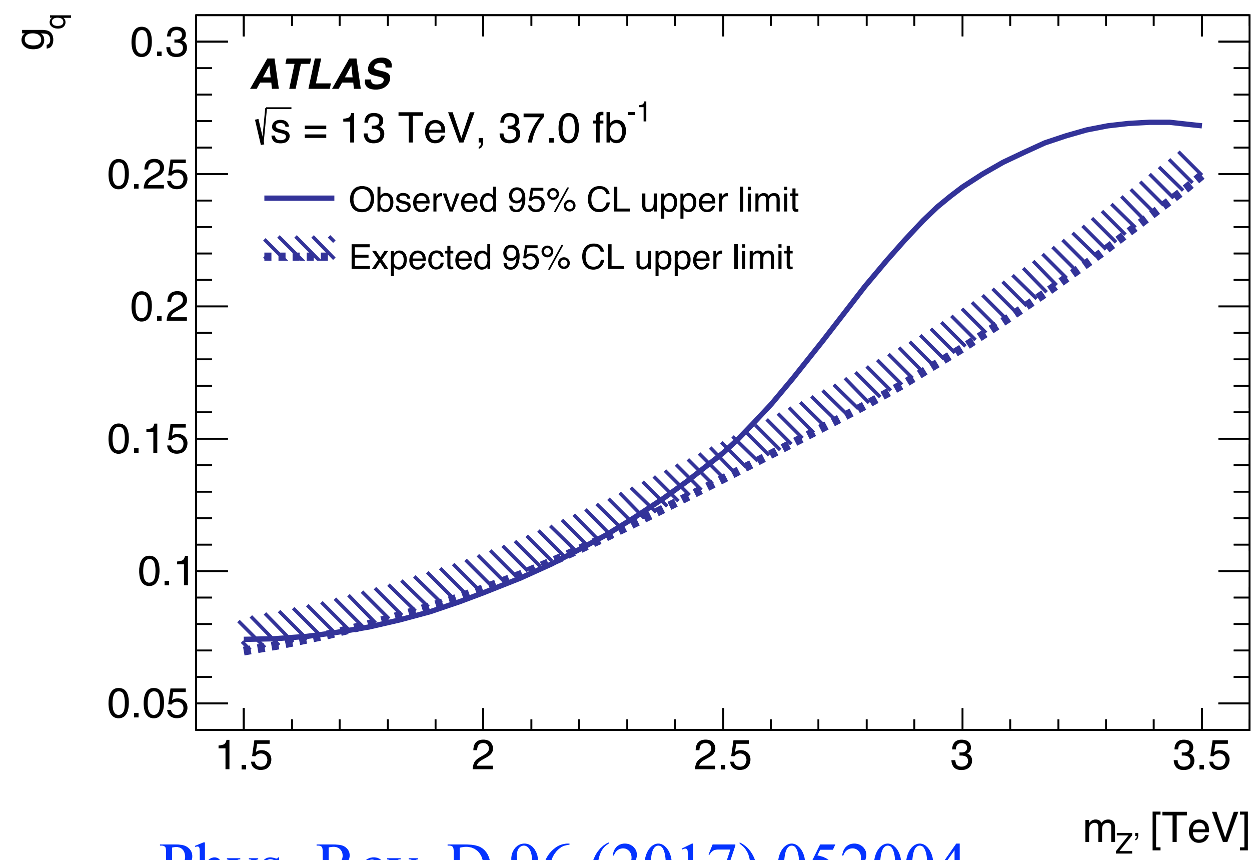
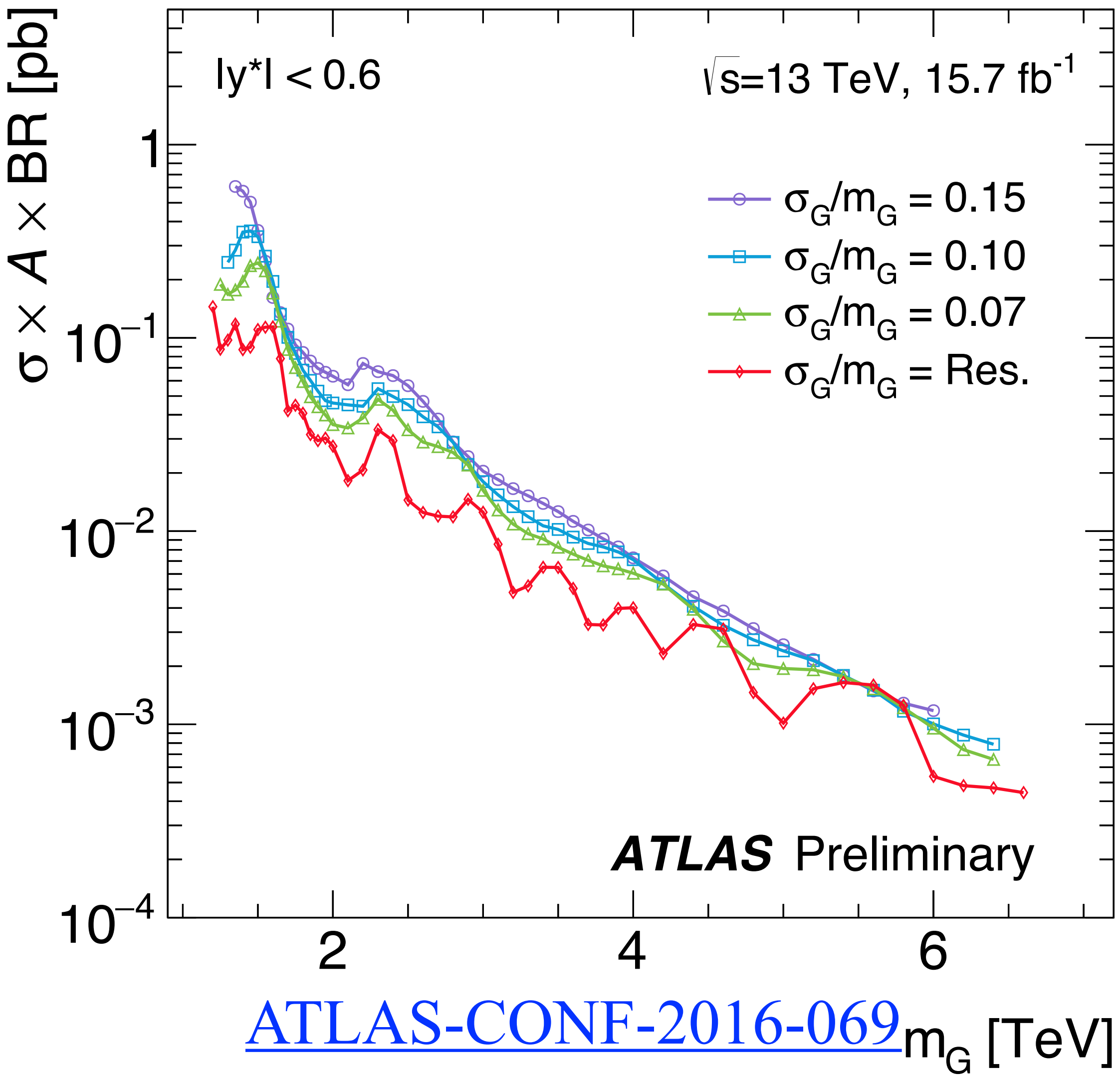


Phys. Rev. D 96 (2017) 052004

The 95% CL exclusion limits for the Z' model described in the text, as a function of the coupling to quarks, g_q, and the mass, $m_{Z'}$, obtained from the dijet invariant mass m_{jj} distribution. For a given mass, the cross-sections rise with g_q, and thus the upper left unfilled area is excluded, as indicated by the direction of the hatched band. The exclusion applies up to g_q=0.5, in the sensitivity range of the method as explained in the text. Points were simulated with 0.5 TeV spacing in mass and spacing as fine as 0.05 in g_q, A smooth curve is drawn between points by interpolating in g_q followed by an interpolation in $m_{Z'}$.

Upper limits on Gaussian signals



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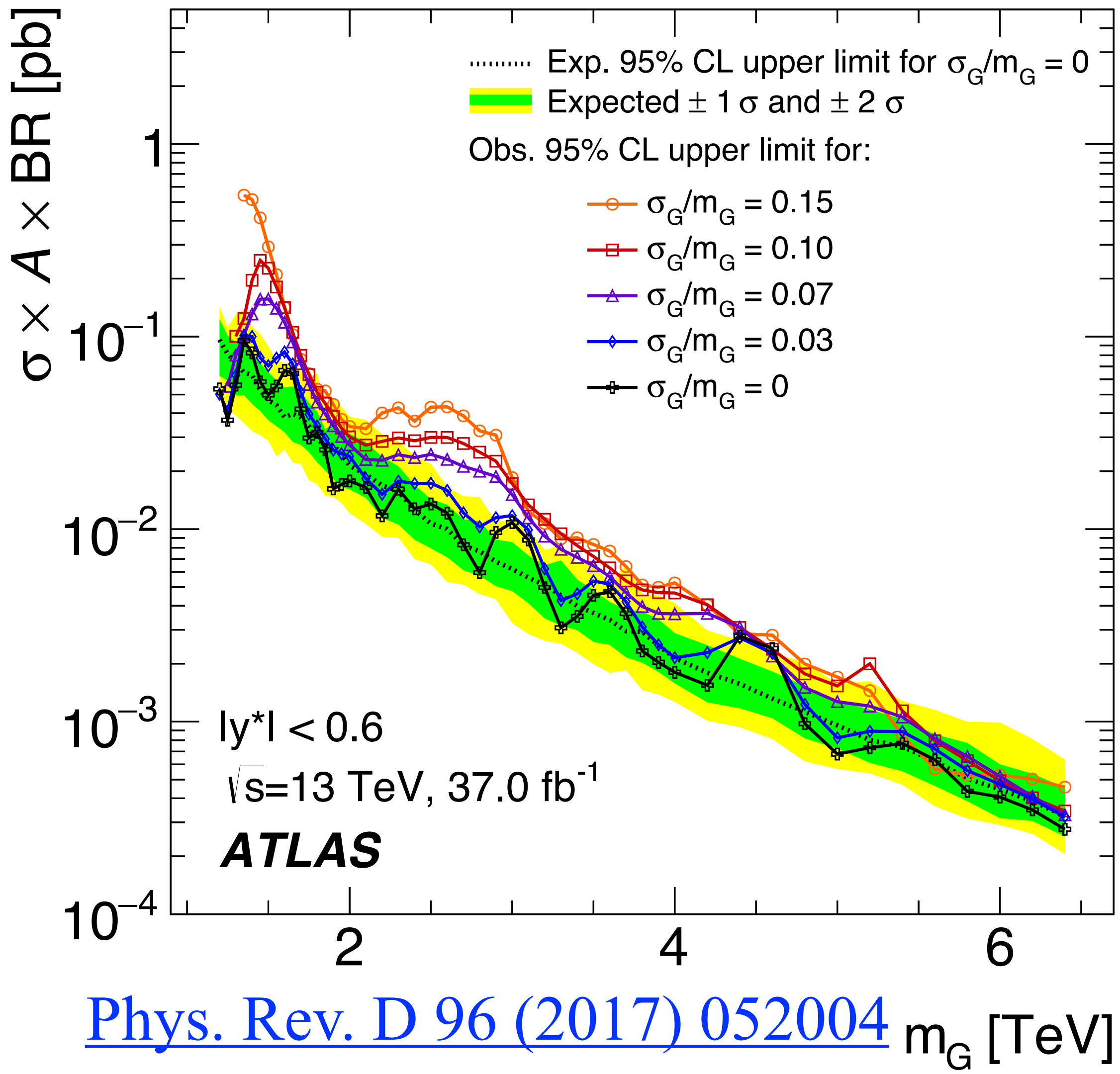

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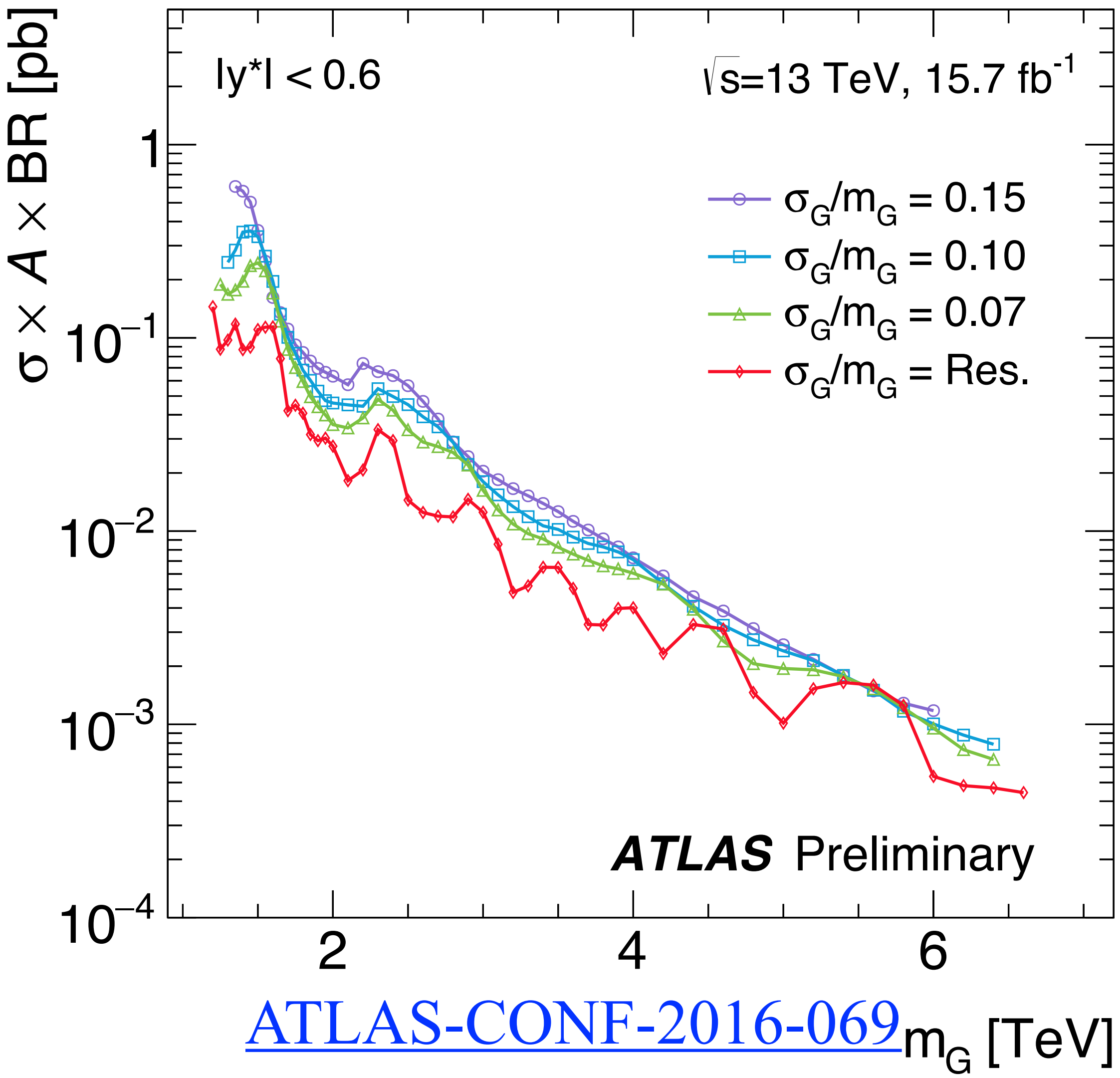
The 95% CL upper limits obtained from the dijet invariant mass m_{jj} distribution on cross-section times acceptance times branching ratio to two jets, σ×A×BR, for a hypothetical signal with a cross-section σ_G that produces a Gaussian contribution to the particle-level m_{jj} distribution, as a function of the mean of the Gaussian mass distribution m_{jj}. Observed limits are obtained for different widths, from a narrow width to 15% of m_{jj}. The expected limit and the corresponding ± 1σ and ± 2σ bands are also indicated for a narrow-width resonance.

Upper limits on Gaussian signals



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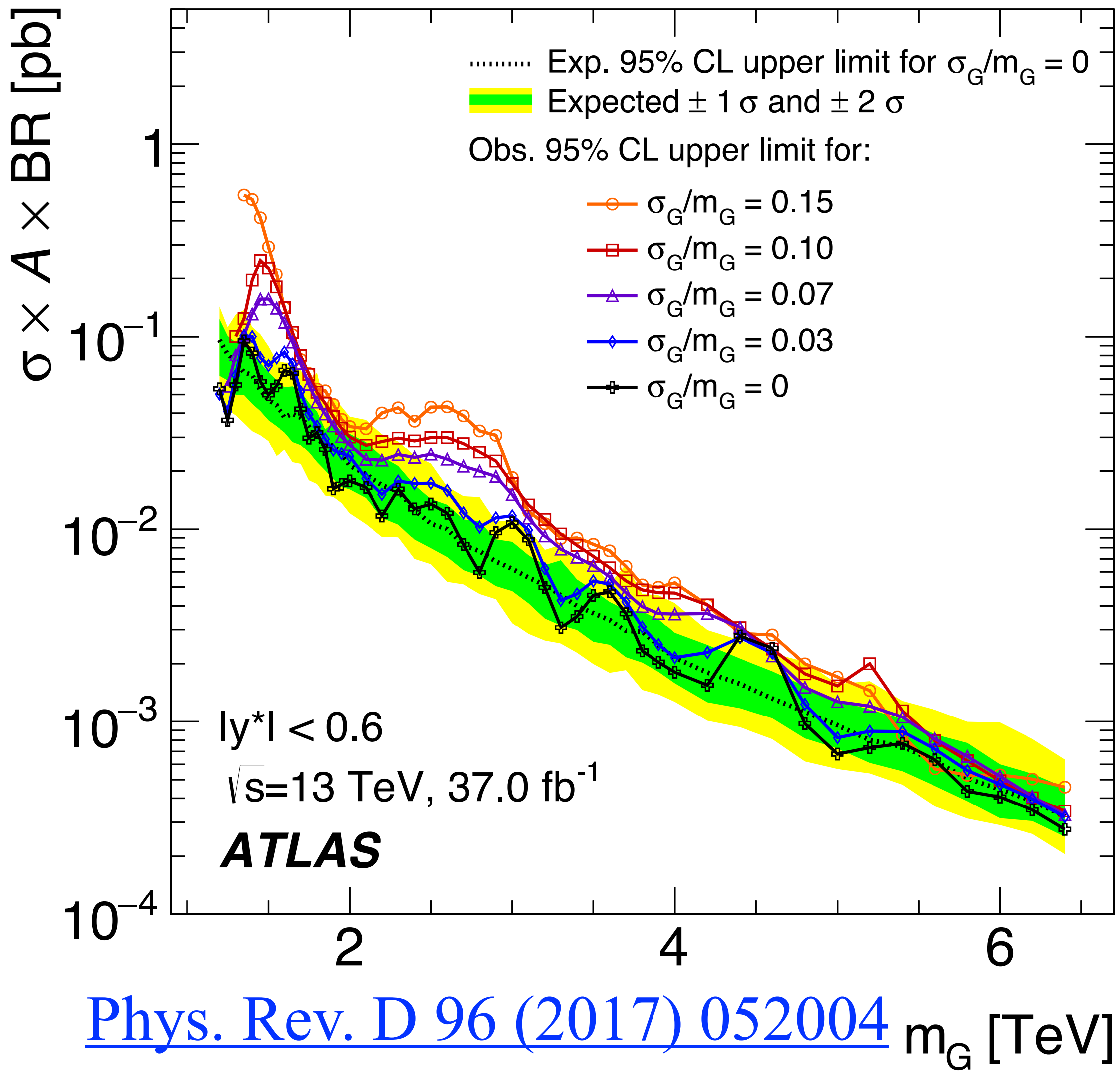
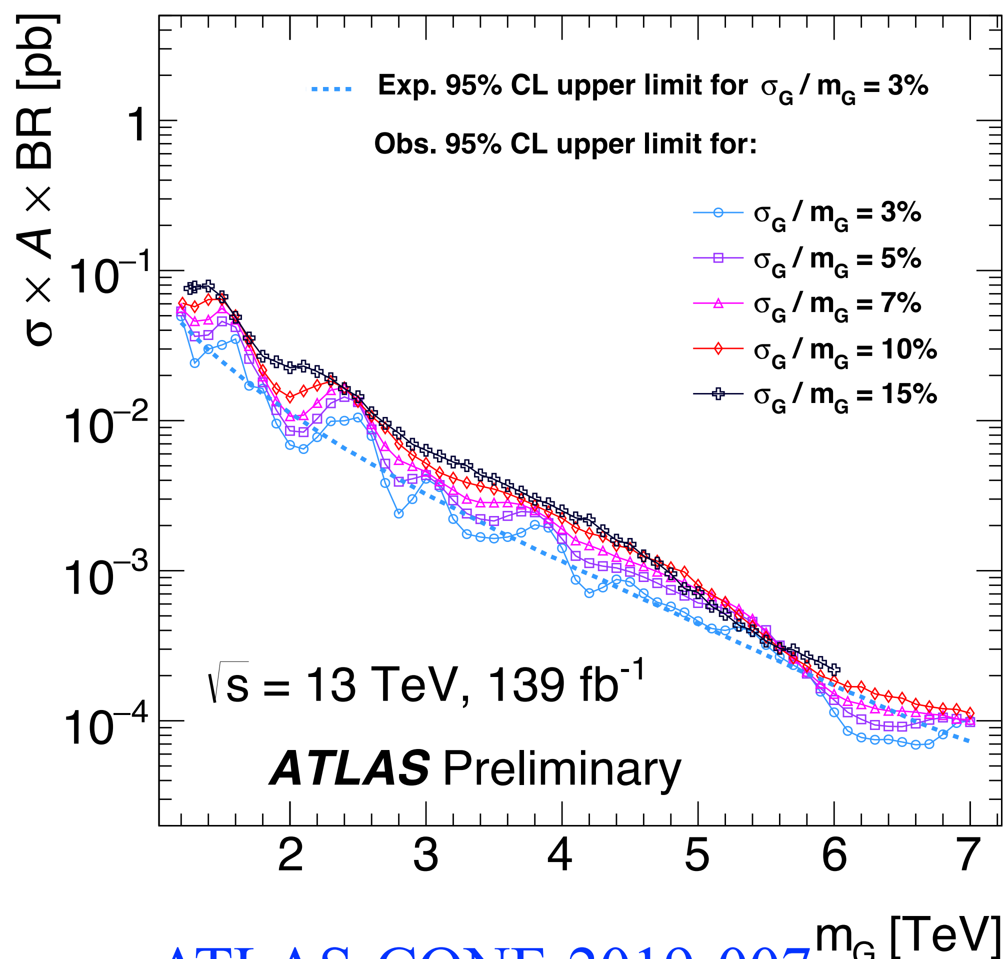


Phys. Rev. D 96 (2017) 052004

The 95% CL upper limits obtained from the dijet invariant mass m_{jj} distribution on cross-section times acceptance times branching ratio to two jets, σ×A×BR, for a hypothetical signal with a cross-section σ_G that produces a Gaussian contribution to the particle-level m_{jj} distribution, as a function of the mean of the Gaussian mass distribution m_{jj}. Observed limits are obtained for different widths, from a narrow width to 15% of m_{jj}. The expected limit and the corresponding ± 1σ and ± 2σ bands are also indicated for a narrow-width resonance.

Upper limits on Gaussian signals



[ATLAS-CONF-2019-007]

The 95% CL upper limits obtained from the dijet invariant mass m_{jj} distribution on cross-section times acceptance times branching ratio to two jets, σ×A×BR, for a hypothetical signal with a cross-section σ_G that produces a Gaussian contribution to the particle-level m_{jj} distribution, as a function of the mean of the Gaussian mass distribution m_{jj}. Observed limits are obtained for different widths, from a narrow width to 15% of m_{jj}. The expected limit and the corresponding ± 1σ and ± 2σ bands are also indicated for a narrow-width resonance.