Search for new phenomena in dijet events with the ATLAS detector at $\sqrt{s} = 13$ TeV

Wei Ding (Tsinghua University)

The 5th China LHC Physics Workshop
Oct 23-27, 2019

ATLAS EXPERIMENT

CERN

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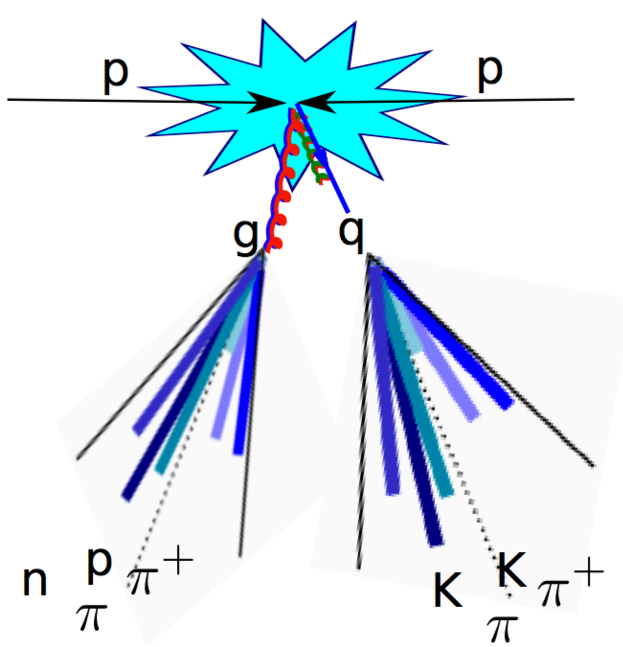
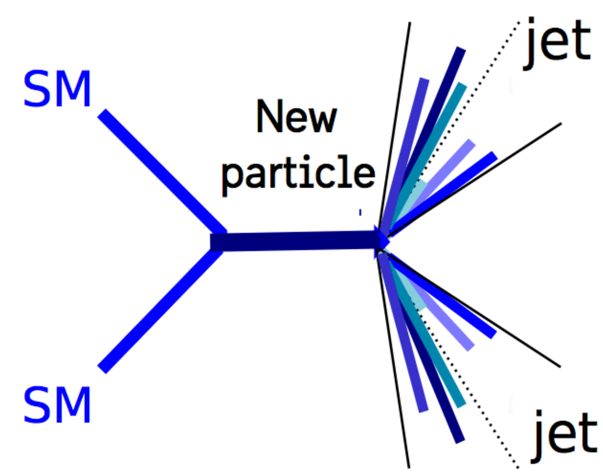
Outline

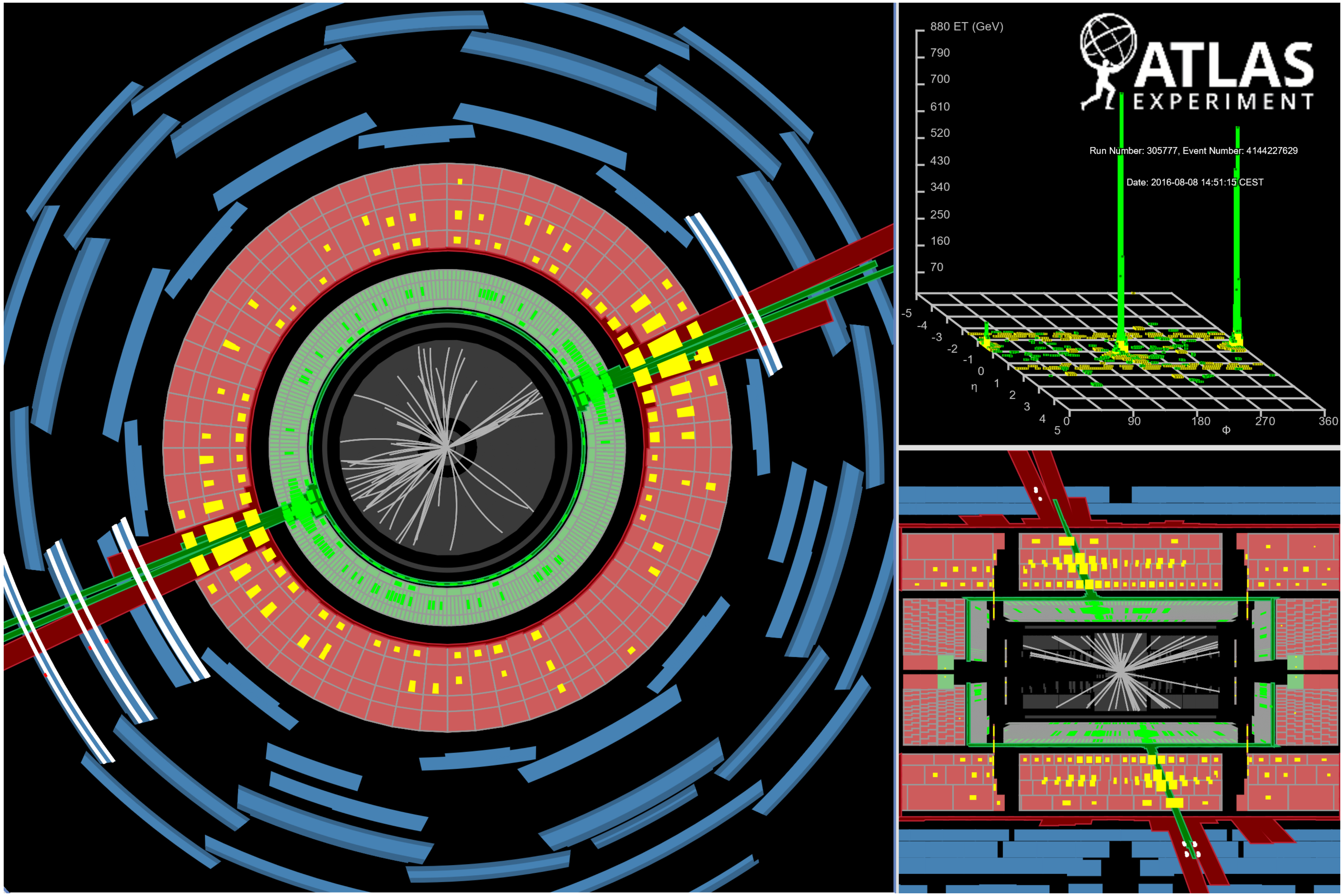
- Introduction to Dijet Analysis
- Dijet Resonance Analysis: three presented results: 15.7 fb^{-1}, 37 fb^{-1} and 139 fb^{-1} in Run 2.
- Summary

- *pp* collisions at $\sqrt{s}$ = 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;
- A complementary analysis: resonance analysis based on m_{jj}



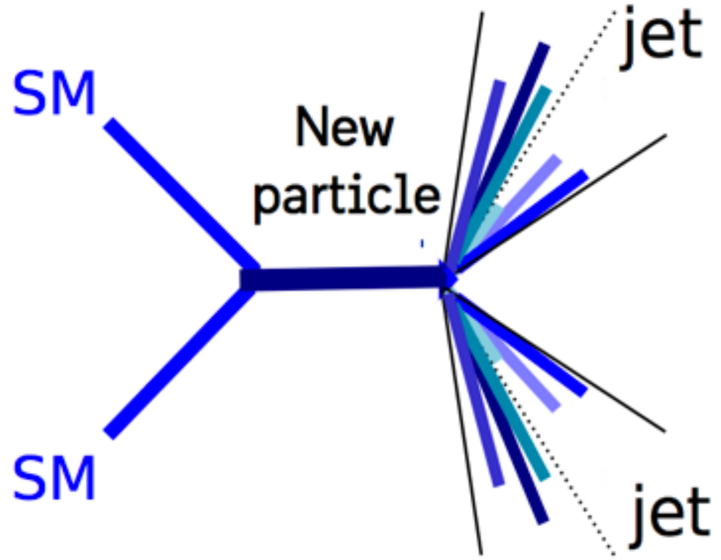


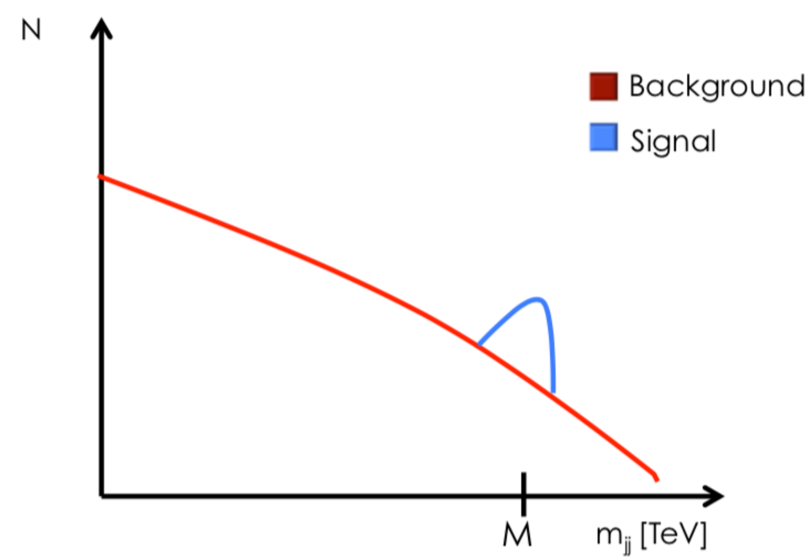
Dijet Event Display



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

- 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.

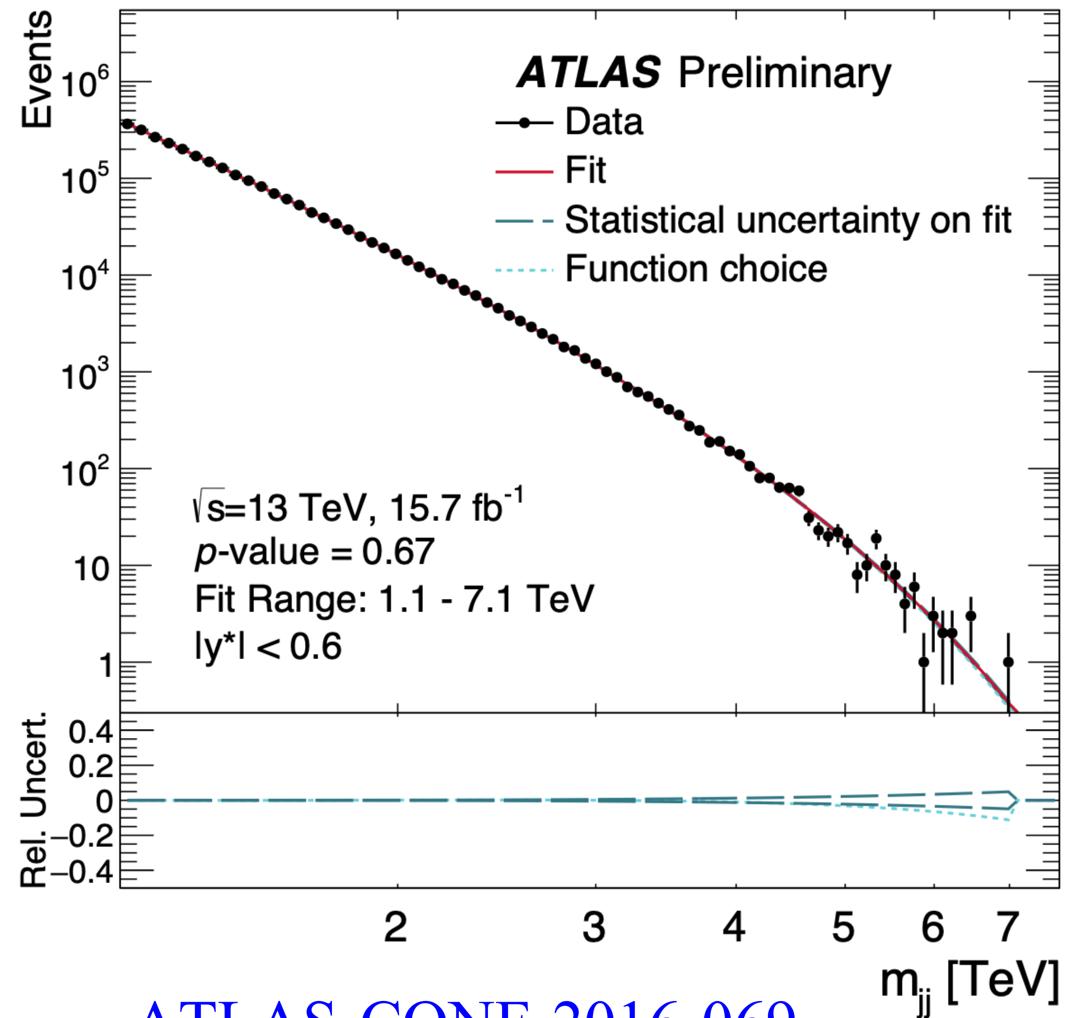




- Sensitive to resonant signals.
- Benchmark Model: q^*, Z′, W′, W*, QBH, etc.
- Three presented results: 15.7 fb^{-1}, 37 fb^{-1} and 139 fb^{-1} in Run 2.

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*)



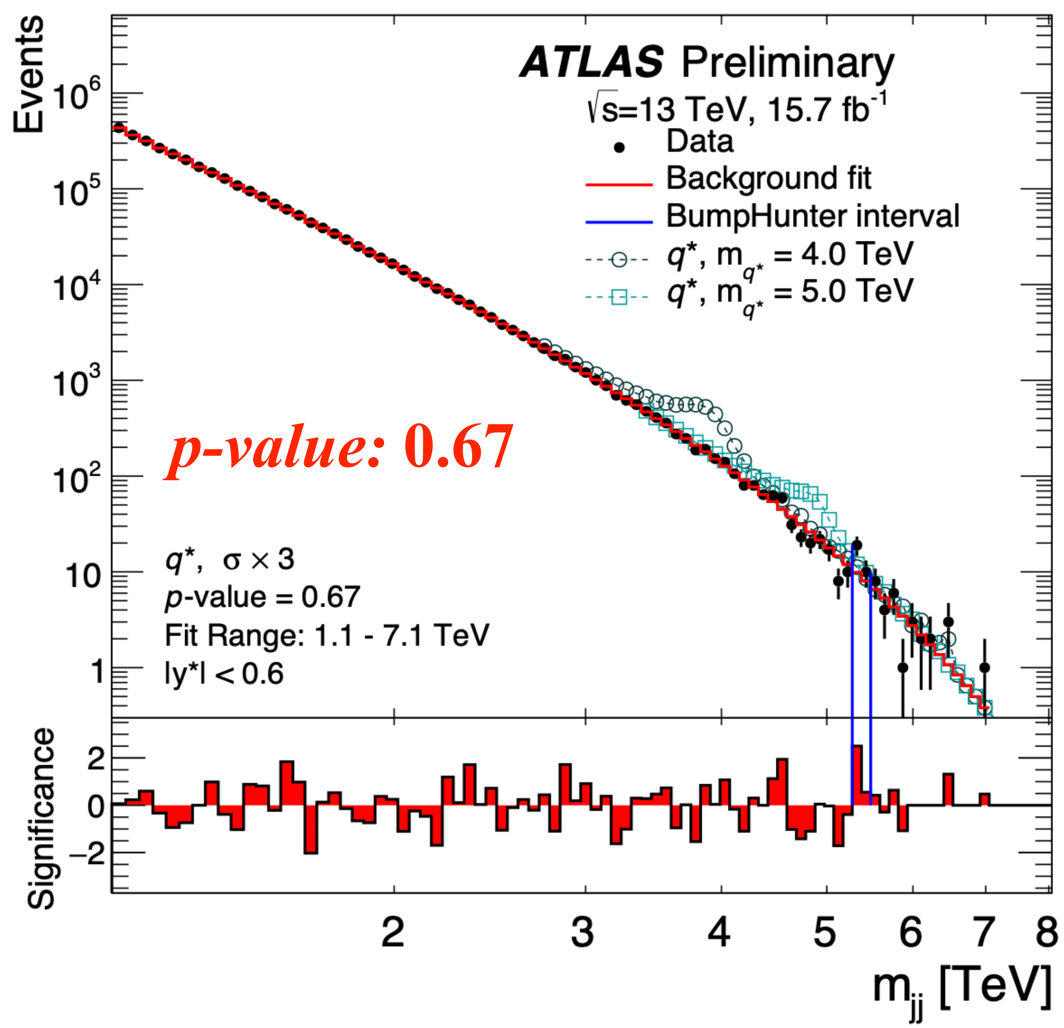
ATLAS-CONF-2016-069

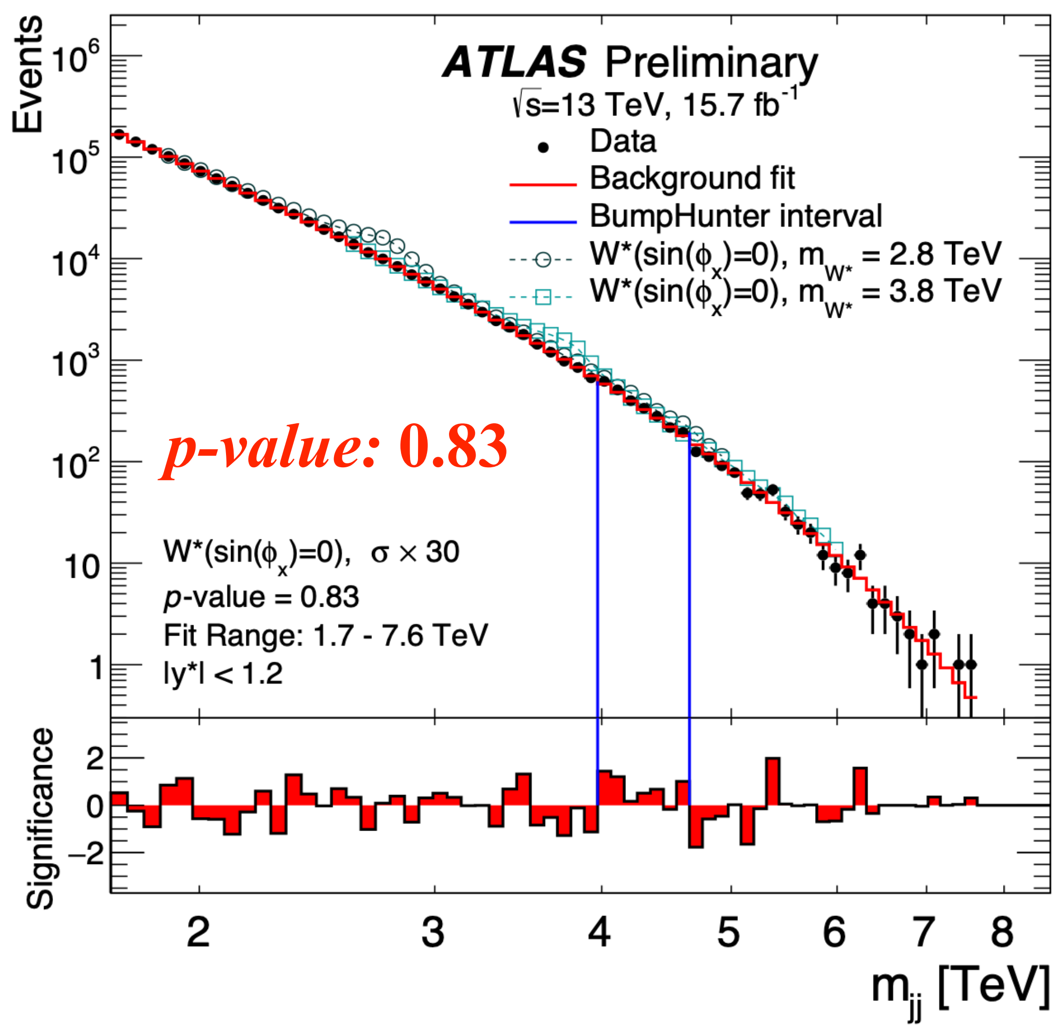
Global fitting with 3-parameters function on the m_{jj} spectrum to estimate the background directly:

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

SearchPhase Results: 15.7 fb^{-1}

- 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}

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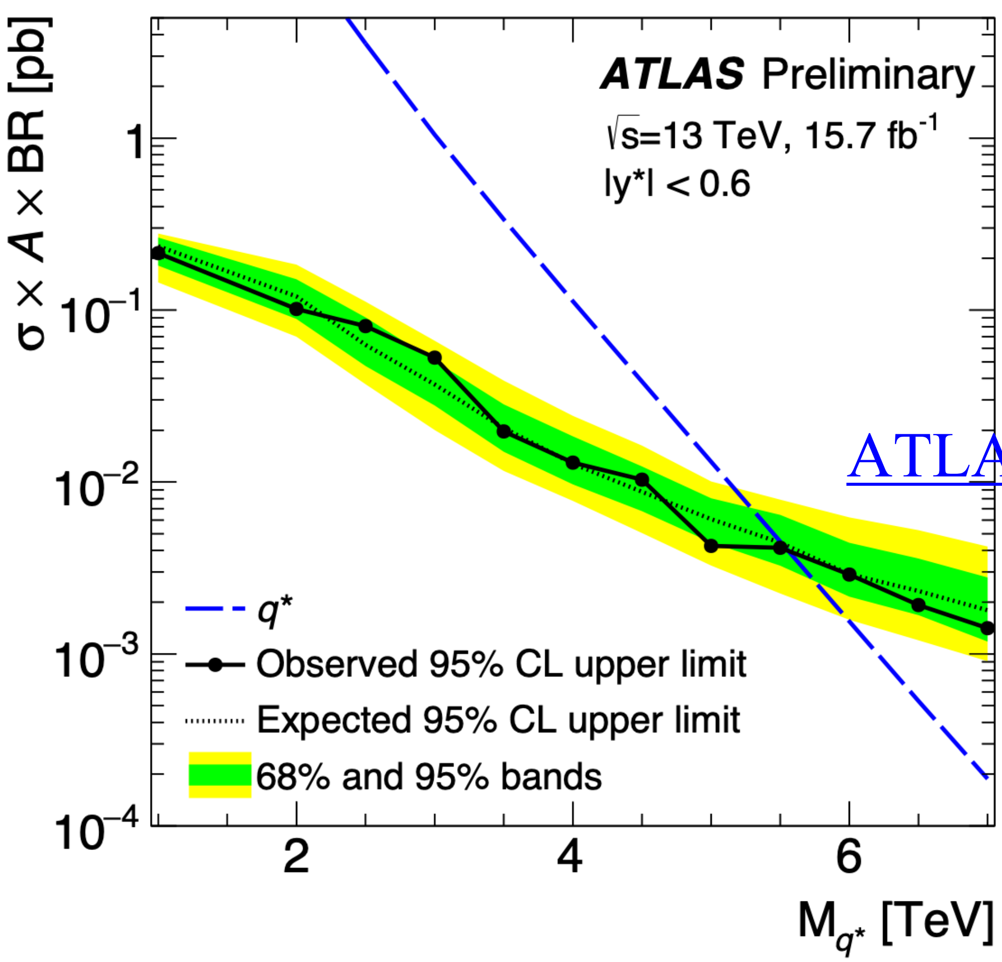
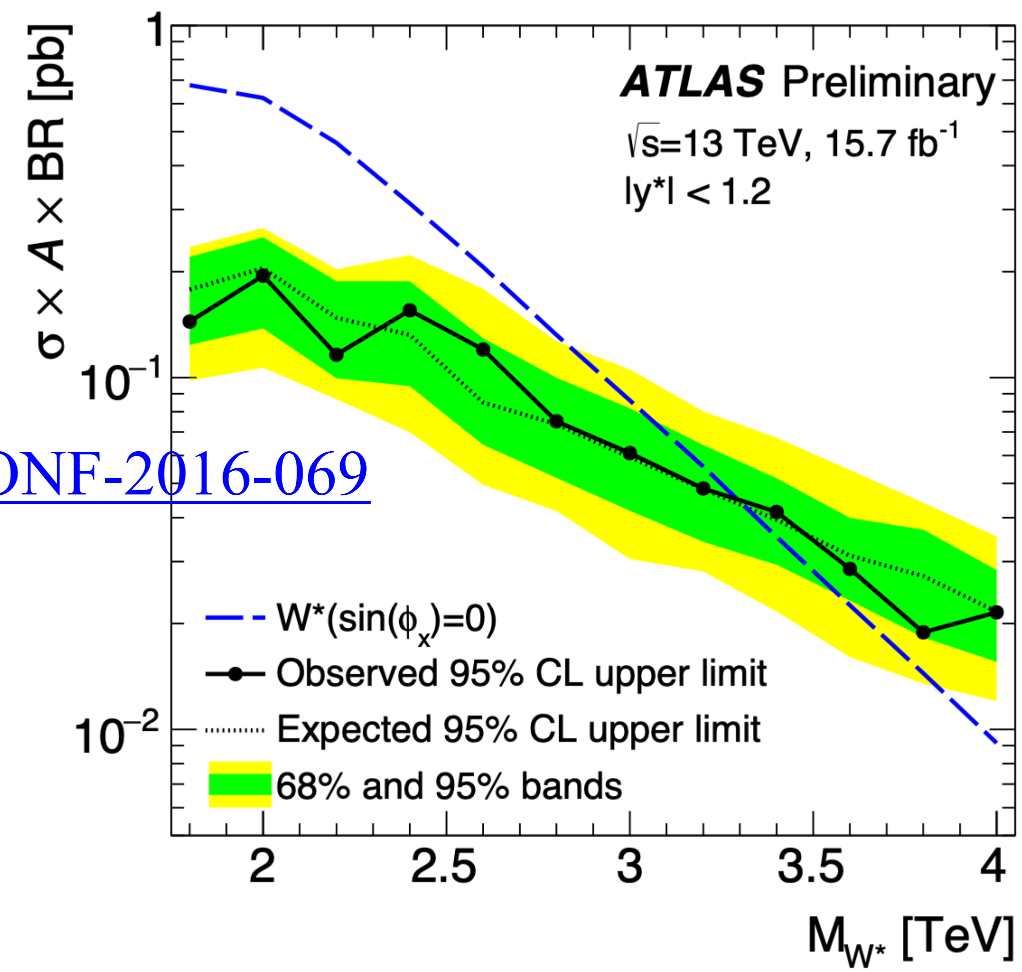
Bayesian method to set upper limits at 95% C.L. on Acceptance*Xs*Br.





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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 and Background Estimation: 37 fb^{-1}

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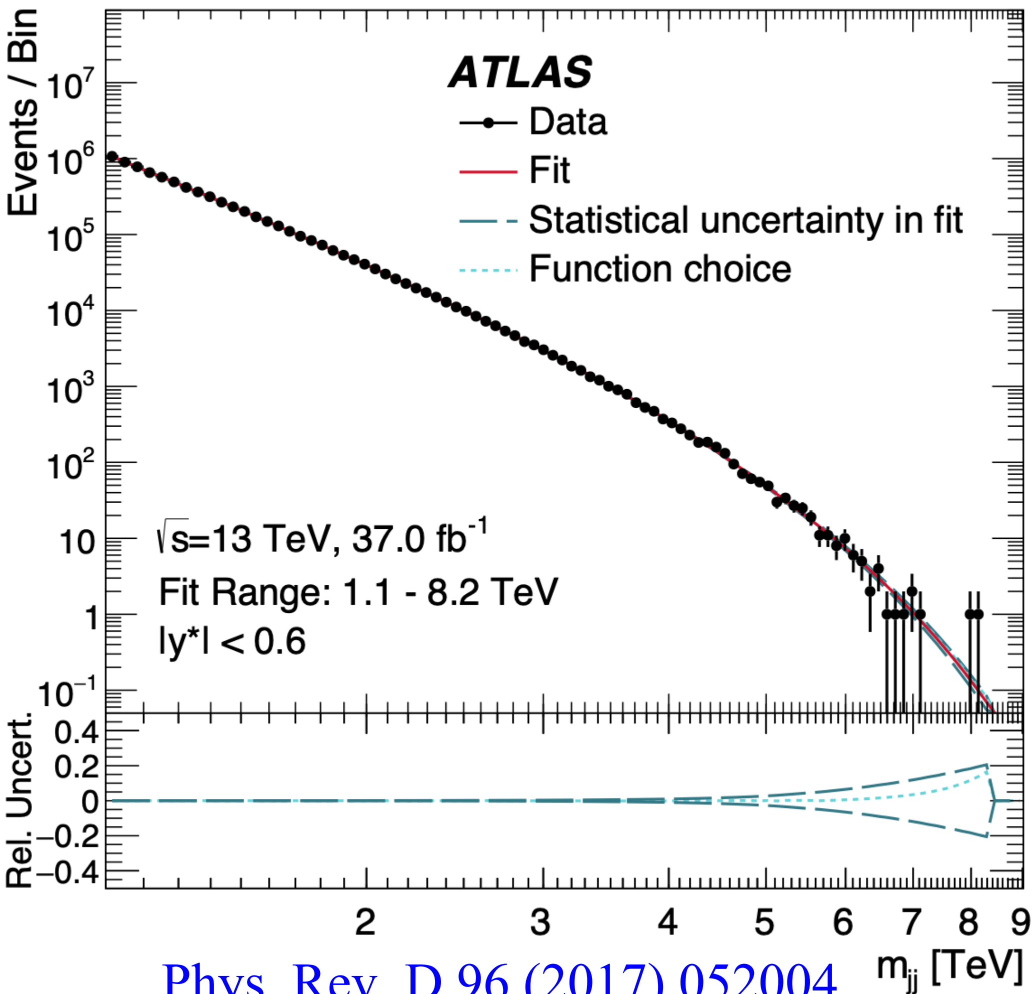
Event Selection: Same with last publication.

- 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 $p_T > 60$GeV
- $|y^*| = |y_1 - y_2|/2 < 0.6$(1.2 for W*)
- $m_{jj} > 1100$ GeV(1717 GeV for W*)



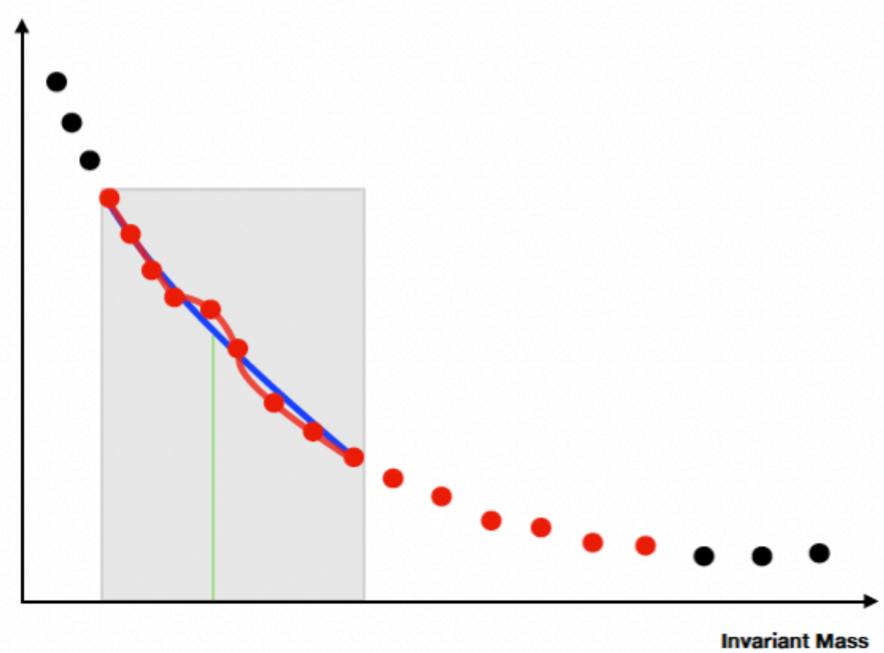
Phys. Rev. D 96 (2017) 052004

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.



SearchPhase Results: 37 fb^{-1}

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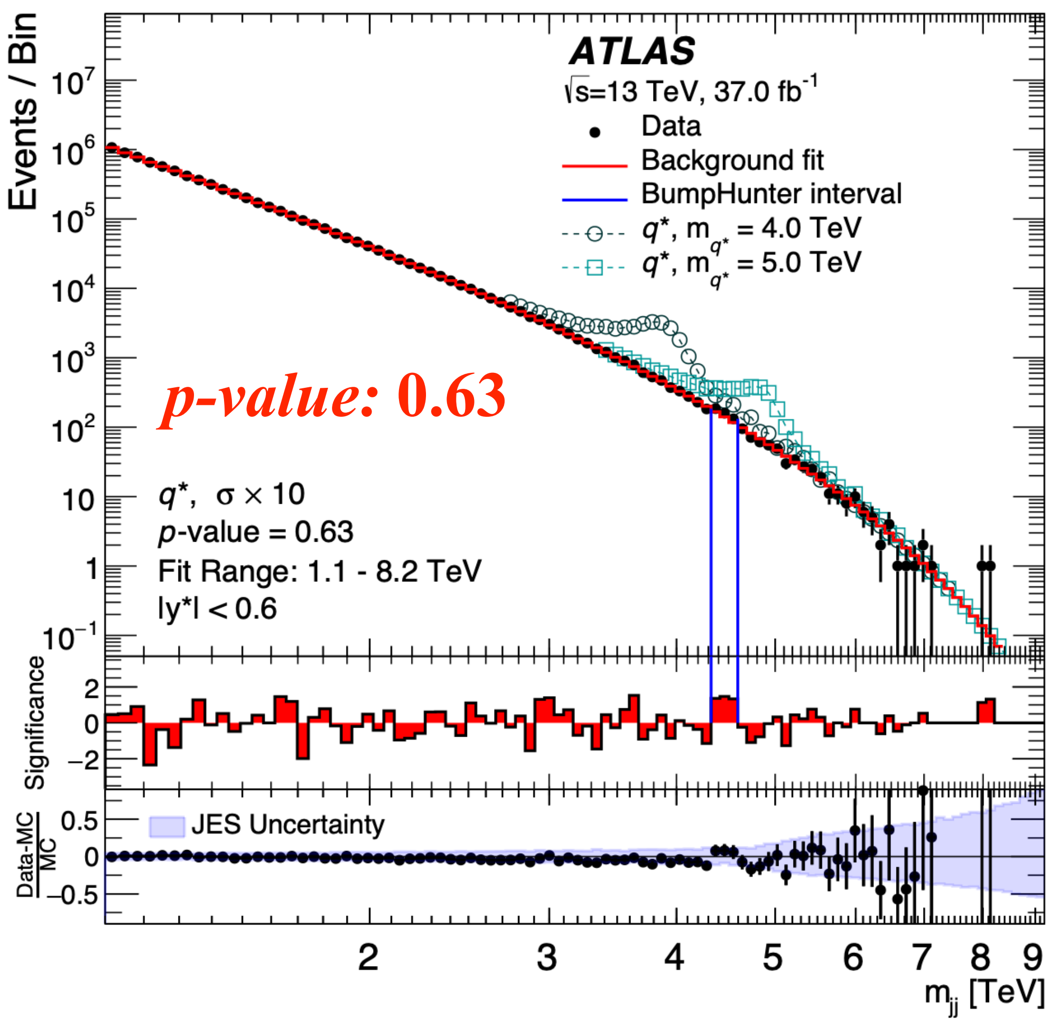
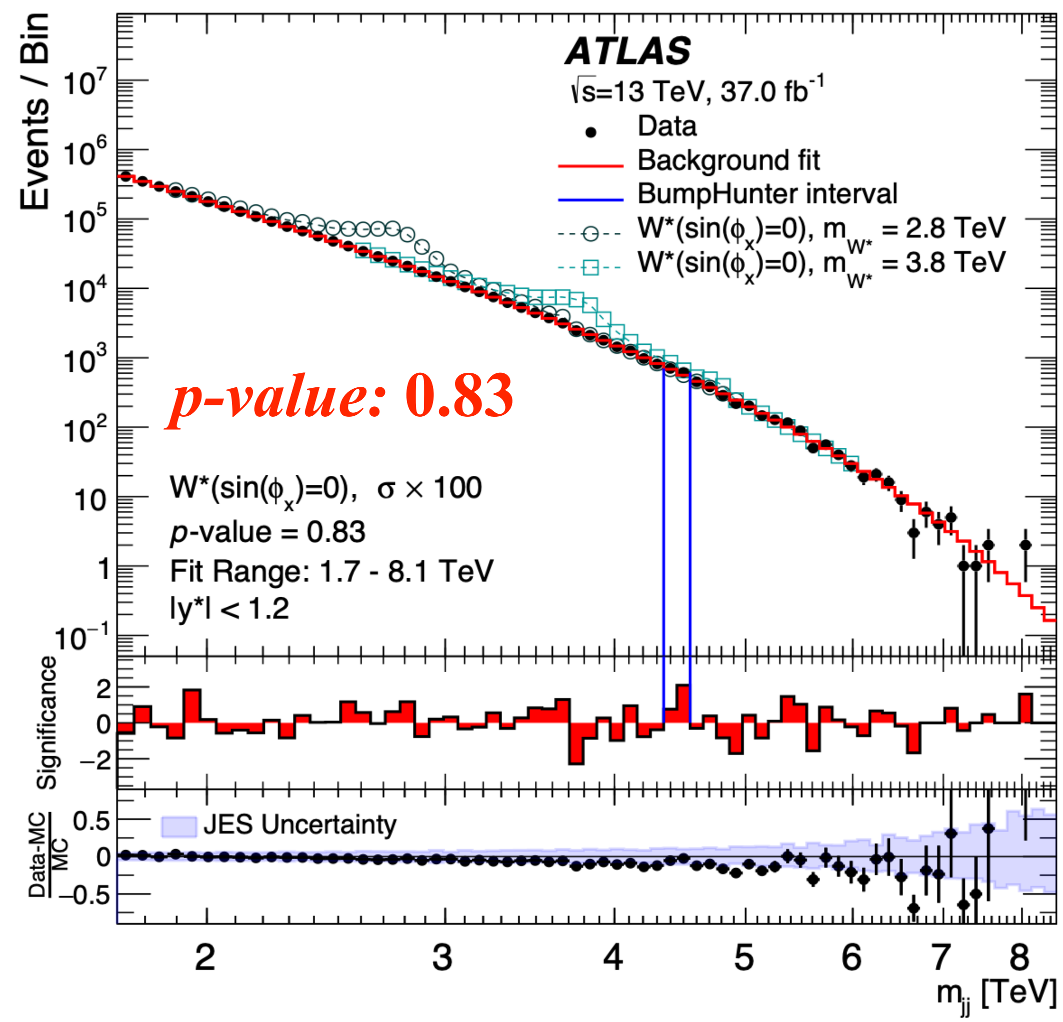
- BumpHunter Algorithm is employed to search for local excess over the background.
- No significant local excess.

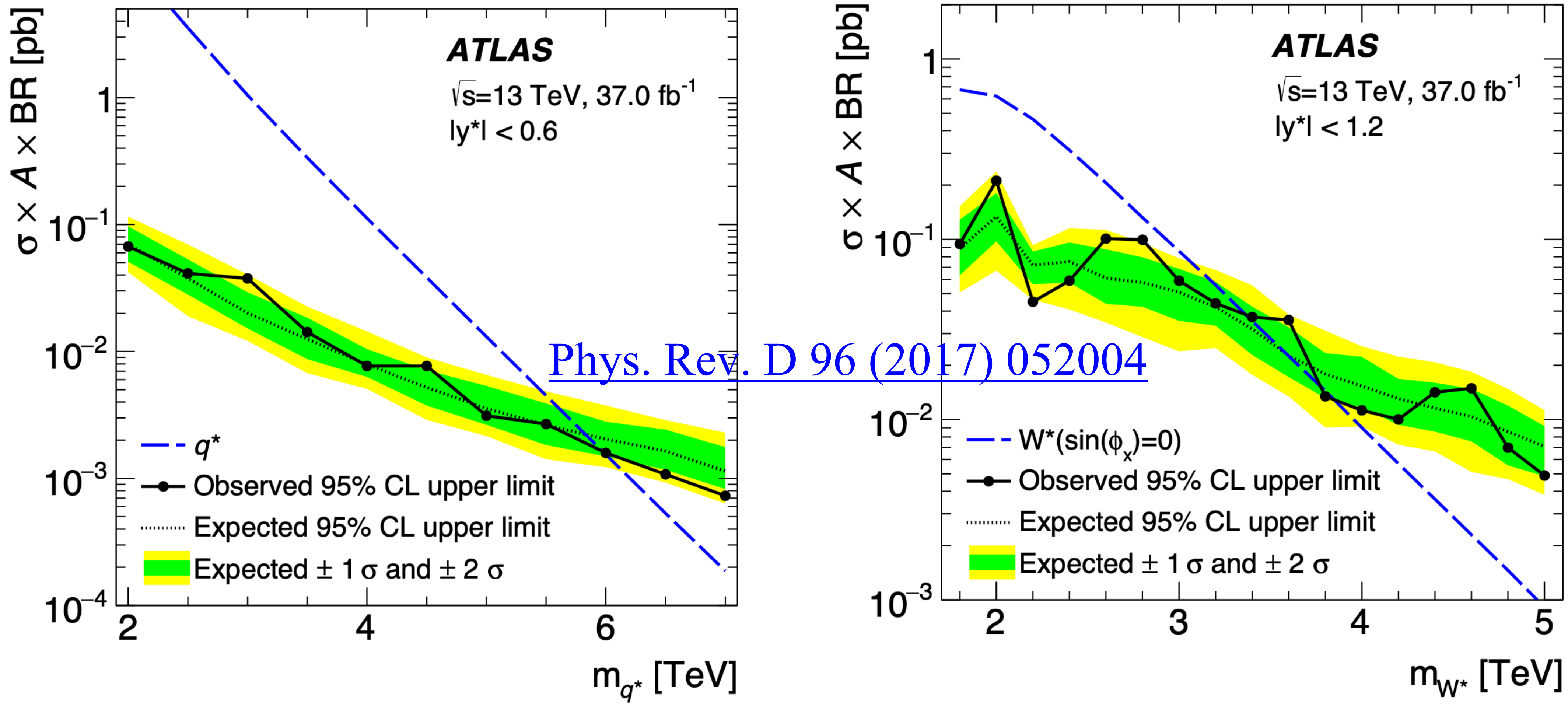




Phys. Rev. D 96 (2017) 052004

Limit Setting: 37 fb^{-1}

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



Phys. Rev. D 96 (2017) 052004

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

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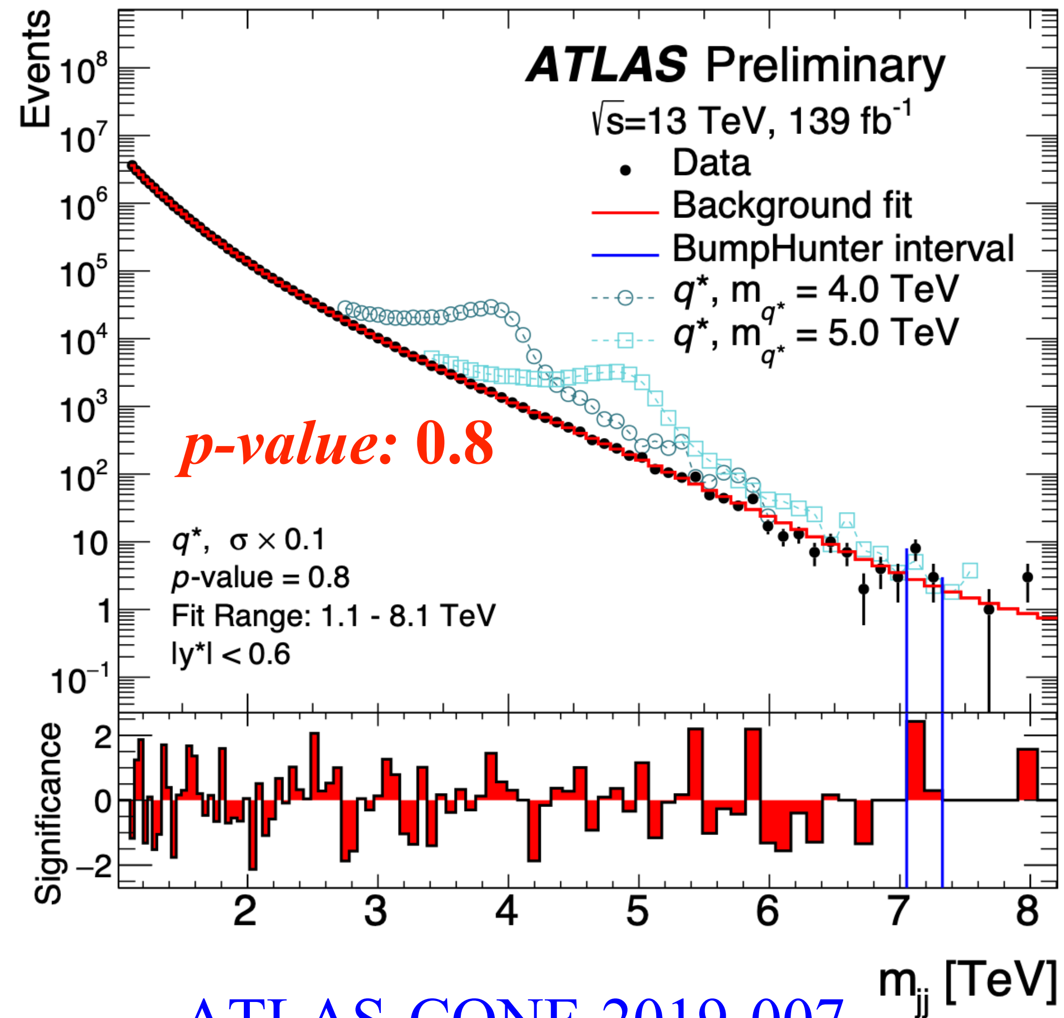
Full Run2 Data

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



ATLAS-CONF-2019-007

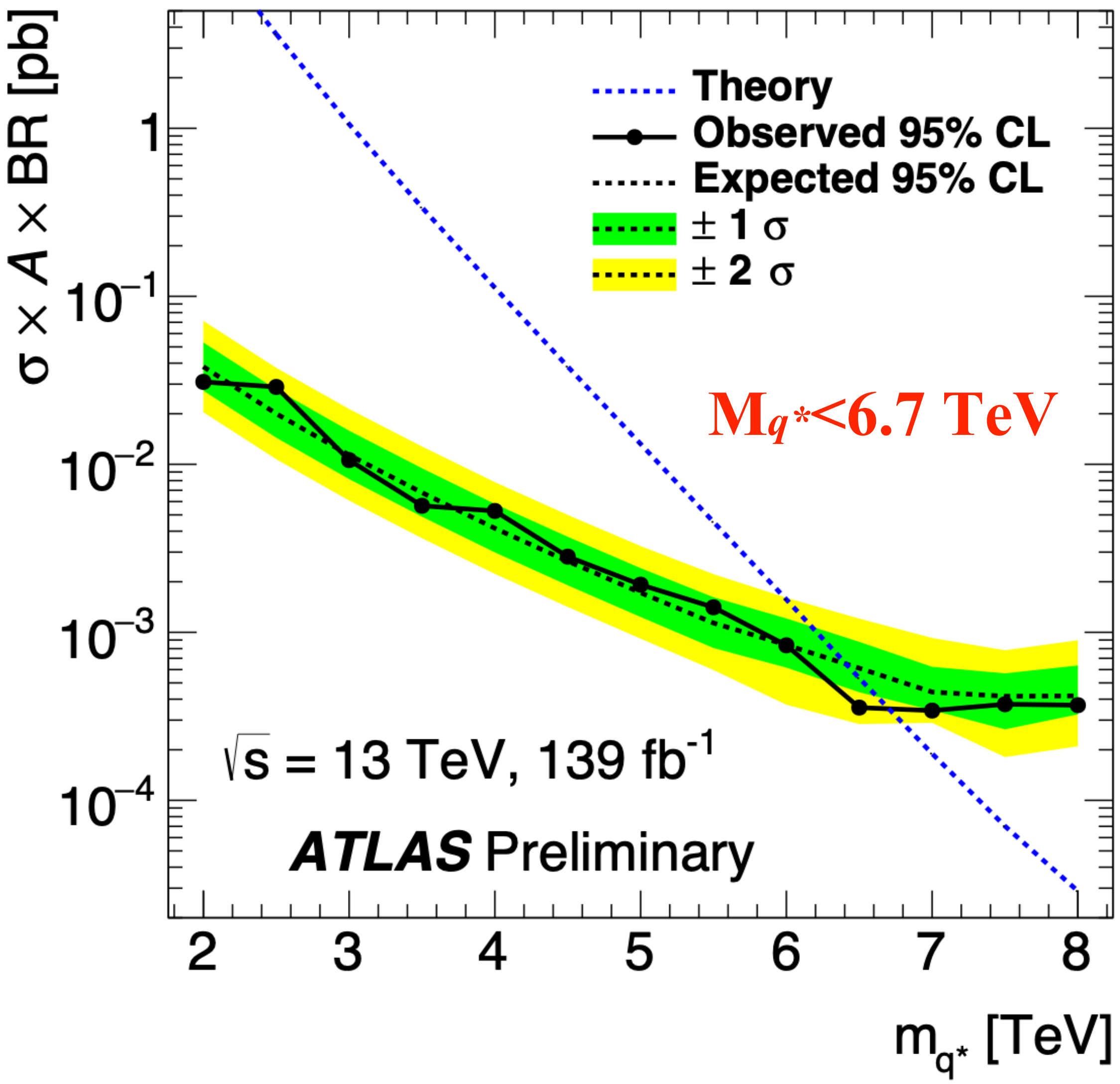
- Sliding Window Fitting Method(SWiFt) is still robust:

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

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

Latest Resonance Analysis: 139 fb^{-1}

- CL_s technique implemented using Frequentist method to set upper limits at *C.L.* of 95%.



ATLAS-CONF-2019-007

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

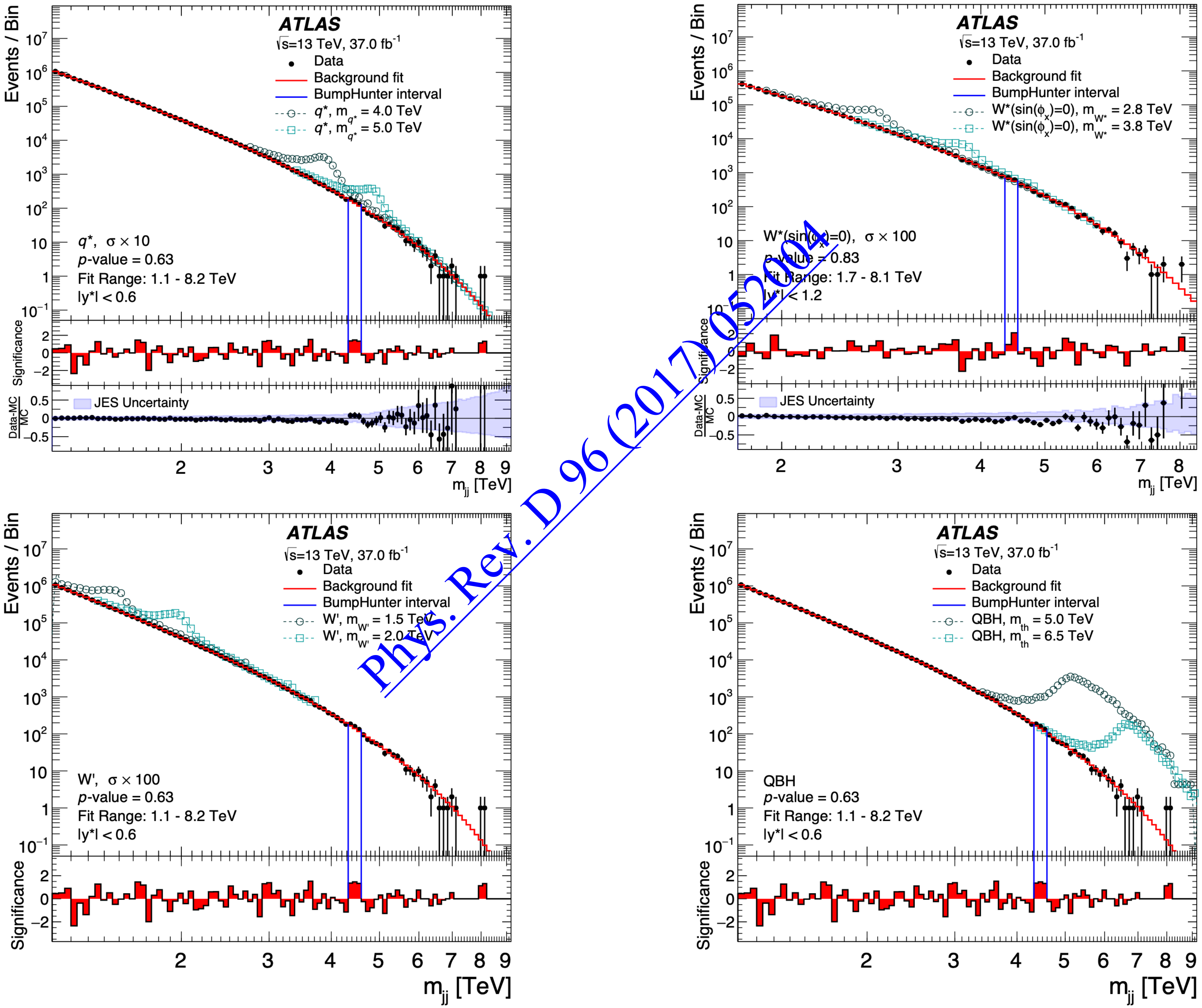
Summary

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

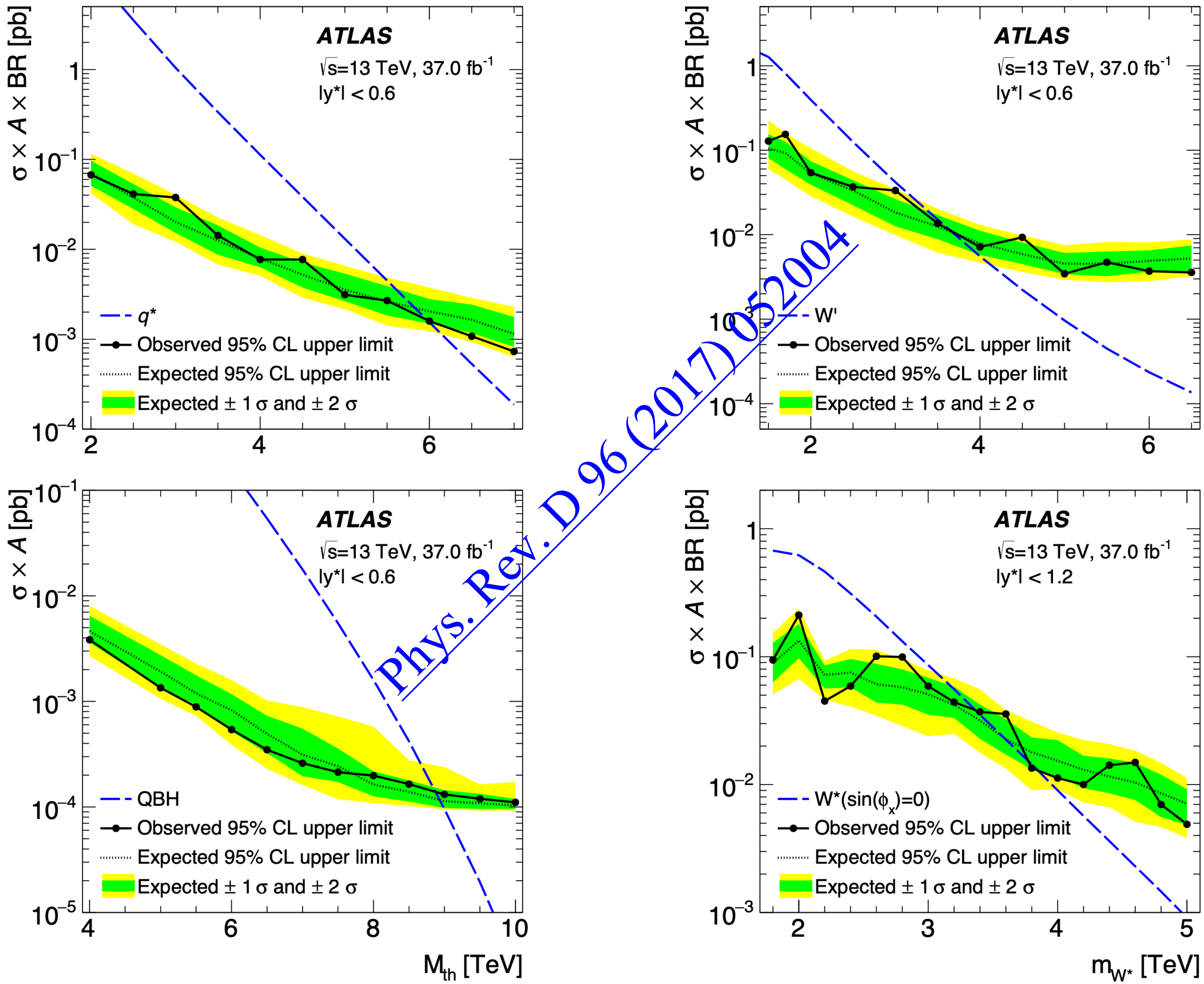
Thanks

Backup

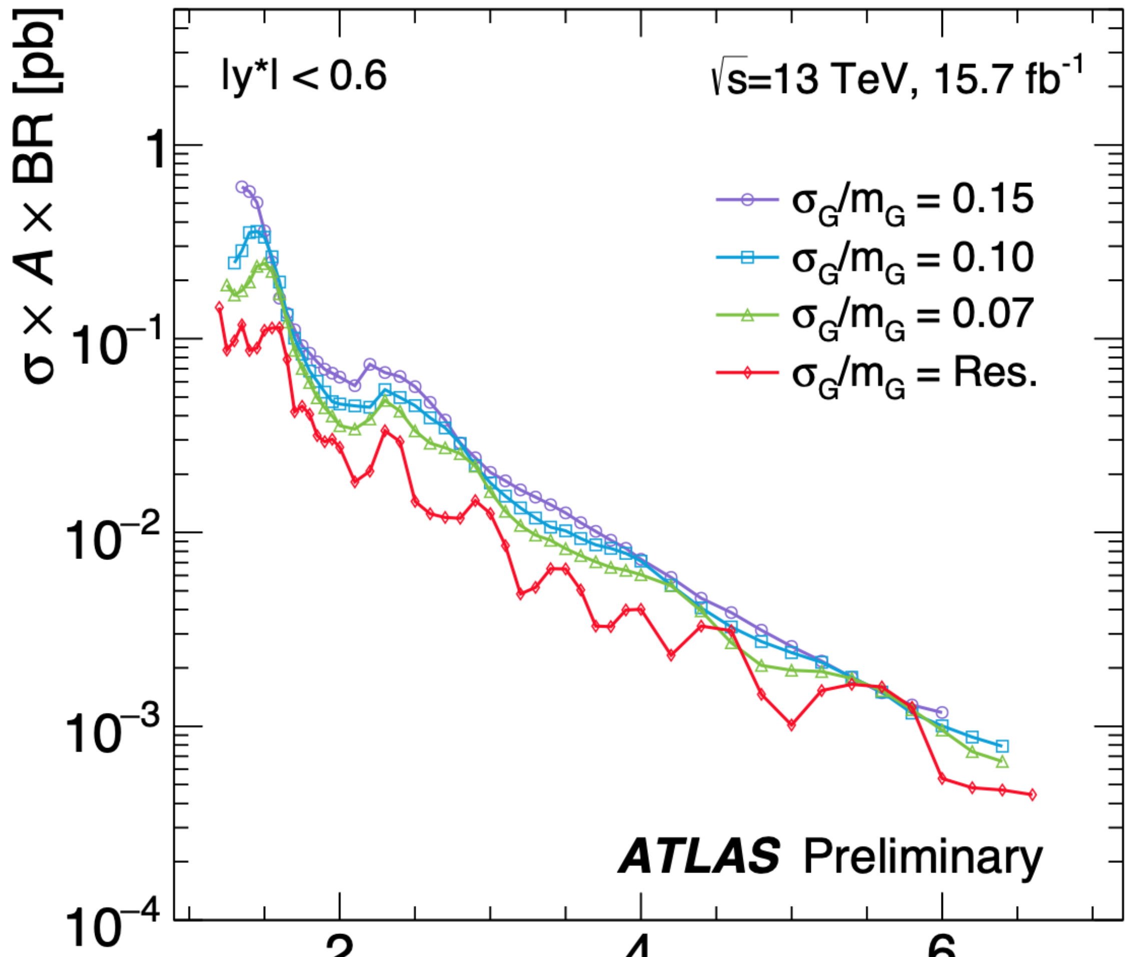
SearchPhase Results



Upper limits on q*,W’,QBH and W*



Upper limits on Gaussian signals



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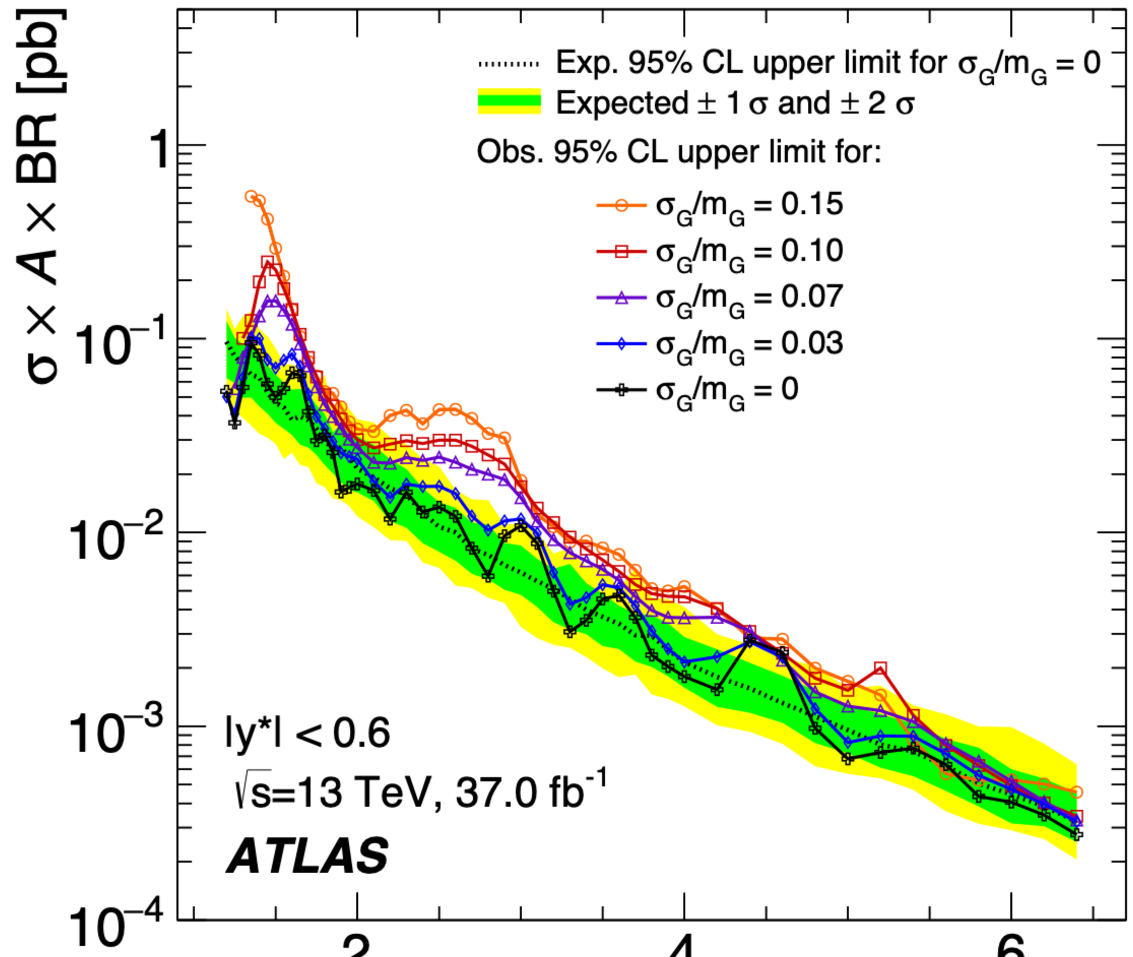

Phys. Rev. D 96 (2017) 052004

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.

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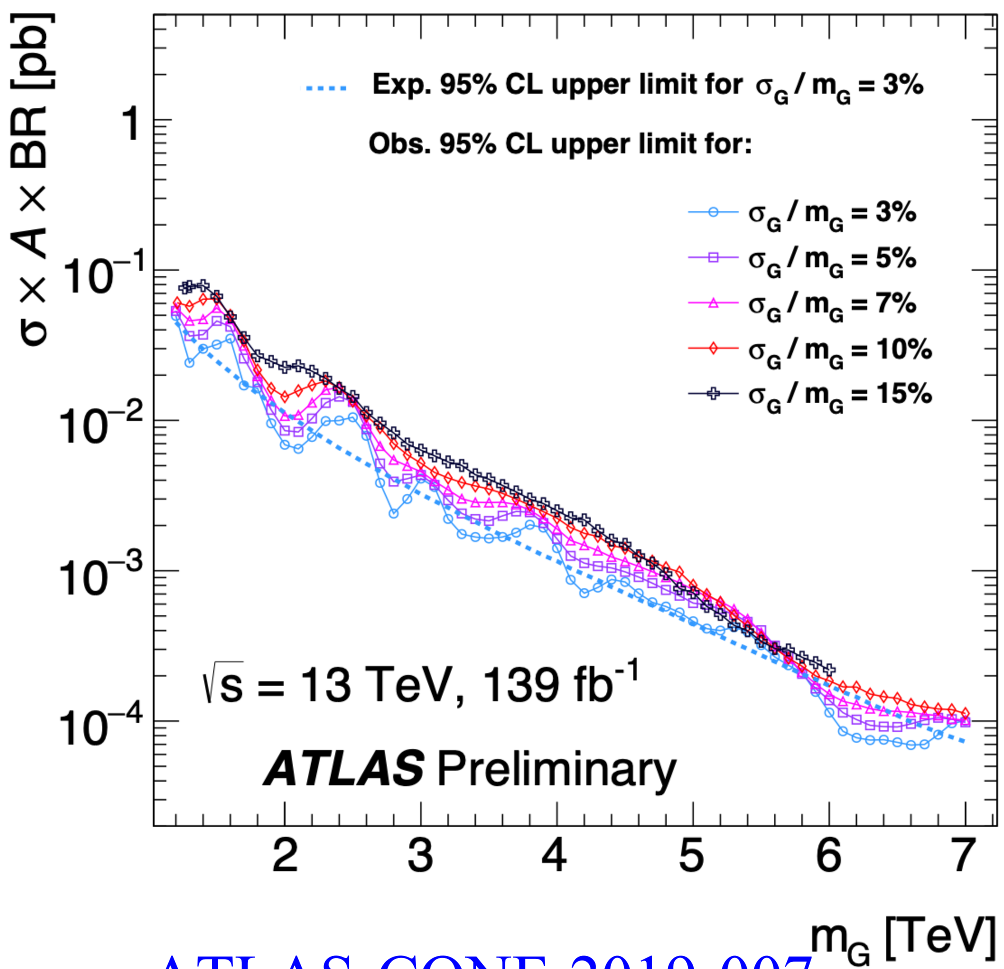

[ATLAS-CONF-2019-007]

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.