Heavy resonance search using b-tagged di-jet in Run 2 at ATLAS

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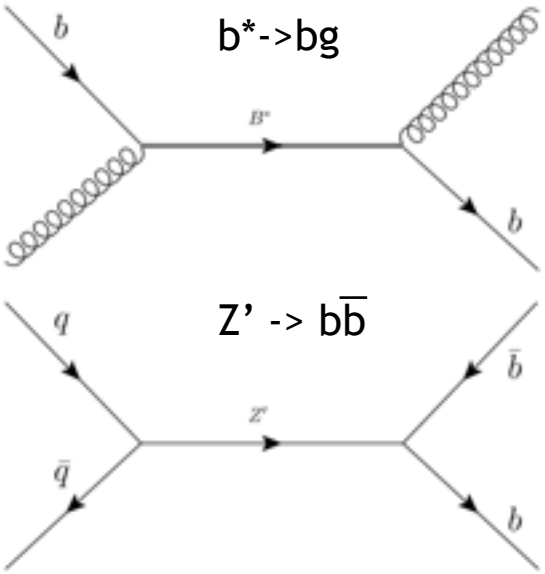
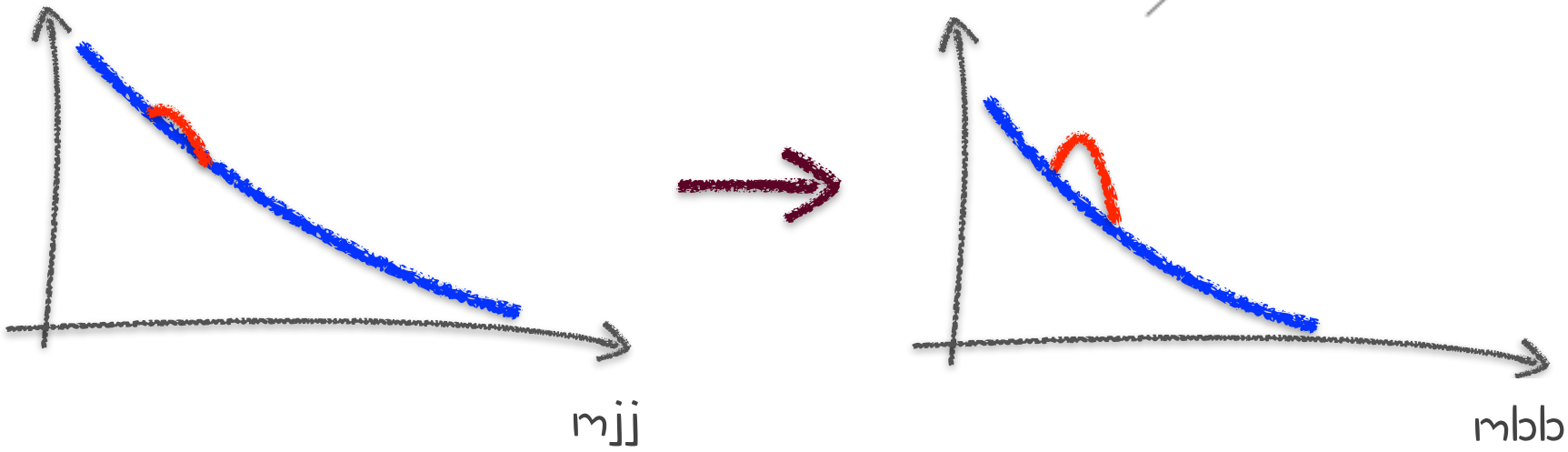
Motivation

- Many theoretical models predict narrow resonance in di-jet mass spectrum
- Some predicted particles prefer to decay into $b\bar{b}$ or bj rather than the light quarks
  - Tag these jets -> increase the sensitivity!

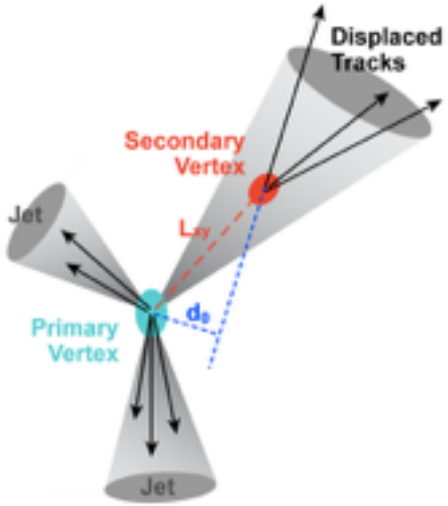




b tagged dijet resonance search

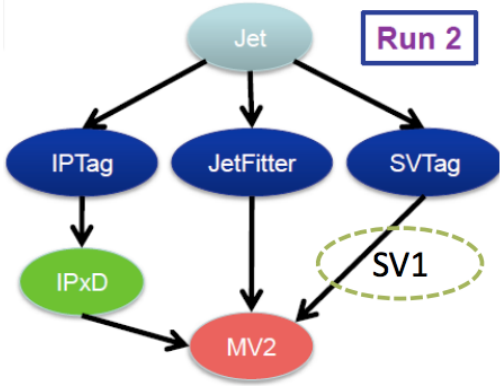
Generic search for resonance in the di-jet mass spectrum with b-tagging

- High mass search looking for resonance @ TeV
  - Collect event using signal jet trigger (high threshold on pT)
- Low mass search looking for resonance @ hundreds GeV
  - Using double b-jets trigger to push down the mass threshold



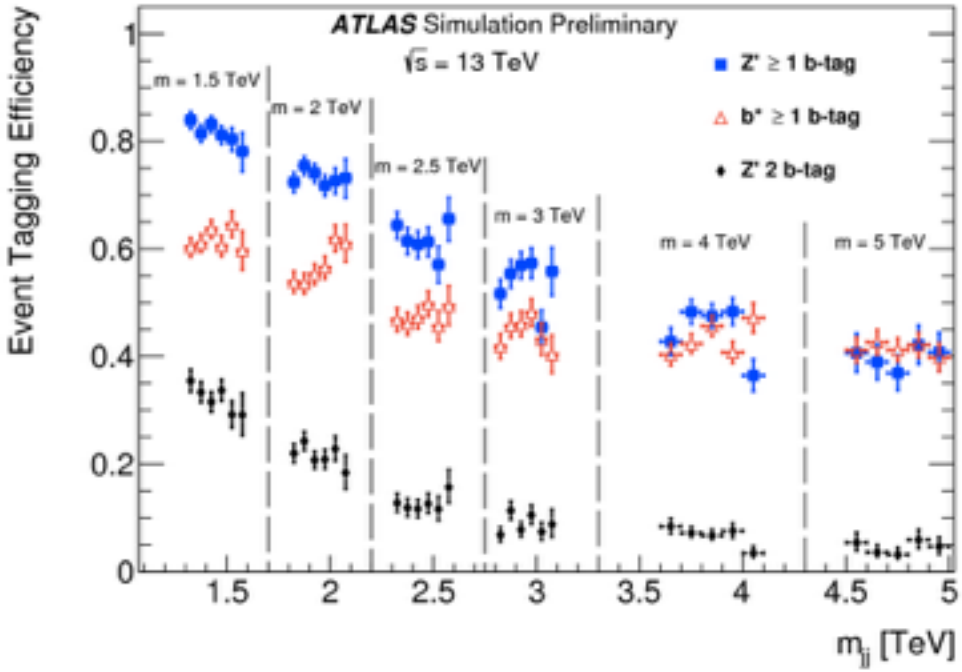
Two categories: tag 1 b-jet inclusively & tag 2 b-jets

- BDT multi-variable algorithm (MV2) to identify the b-jet
  - IPTag: tracks with a large impact parameter with respect to the primary vertex
  - SVTag: displaced secondary vertices
  - JetFitter: reconstructed flight paths of b/c-hadrons associated with the jet
- Operating points are defined to give a global b-jet efficiency
  - The actual efficiency decreases as the jet pT grows (>100 GeV)

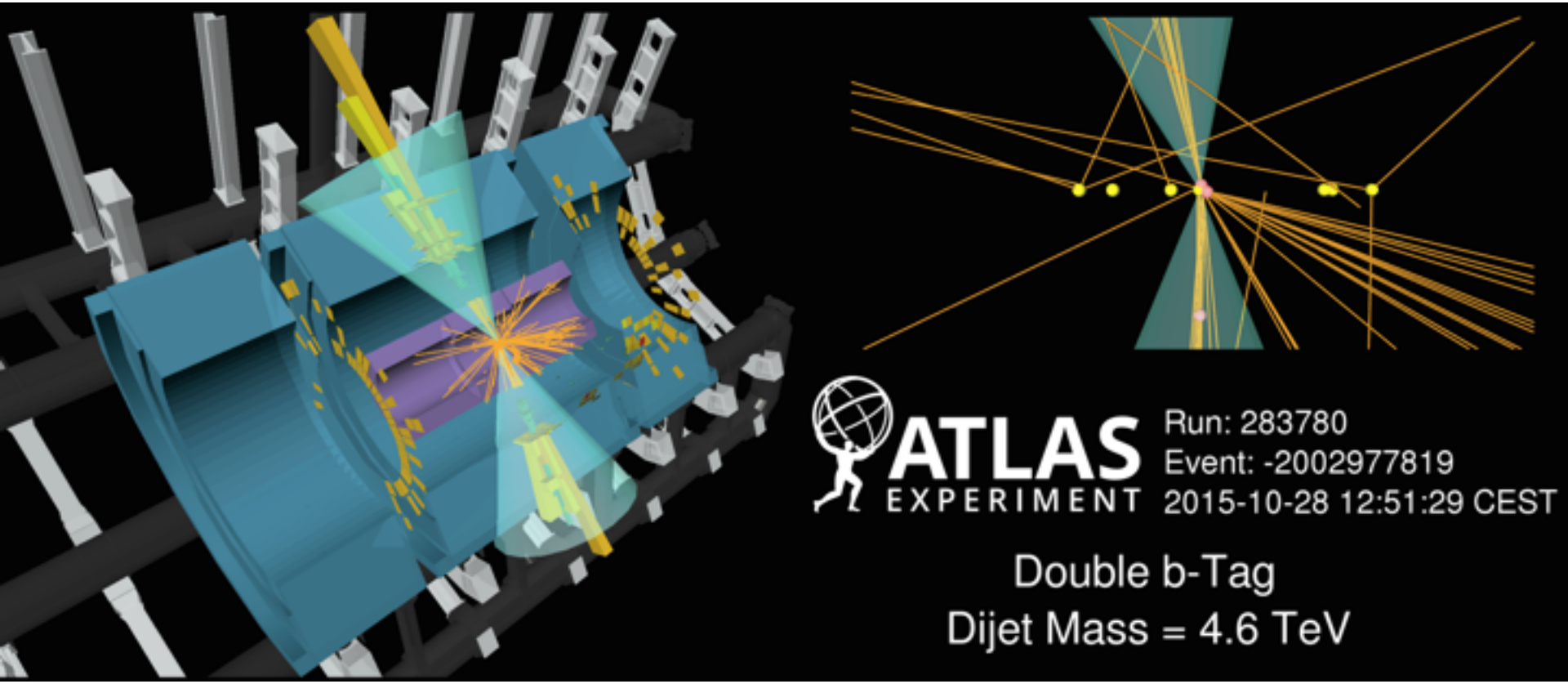


B-tagging

- Per event tagging efficiency highly depends on the kinematics of the samples
  - Higher mis-tagging rate for light/c-jets at high pT
  - More than 1 b-jet can be produced from b* decay because of the gluon splitting
  - The per event tagging efficiency improves at high mass due to the higher off-shell Z' production rate which produce more lower pT b-jets

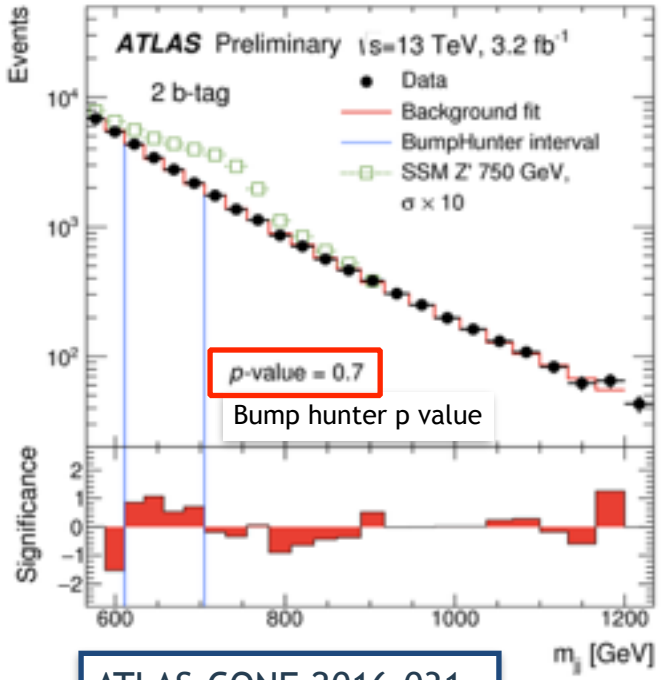


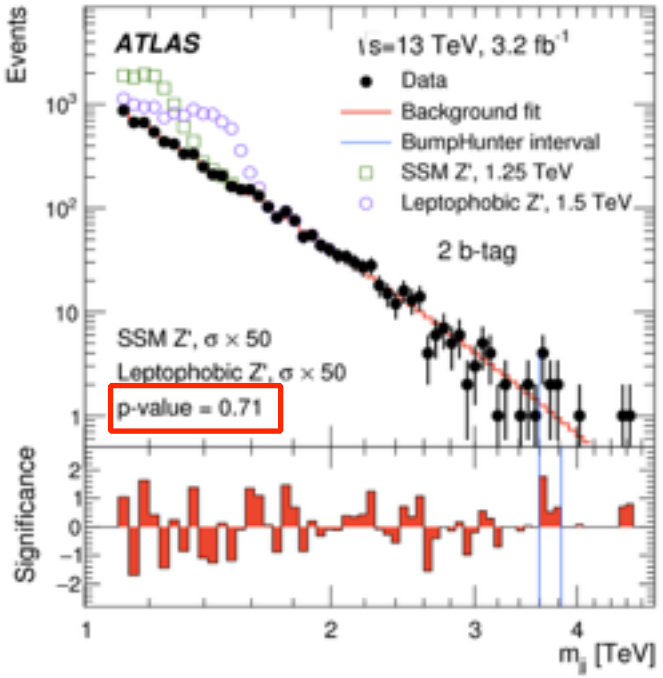
Initial search at ATLAS using 2015 data



Fit the mass spectra

- Using 3 parameter fit: $f(x) = p_1(1-x)^{p_2}(x)^{p_3}$, $x = m_{jj}/\sqrt{s}$
- Using ***Bump hunter*** to search for possible excess
  - Looking for the most significant deviation from the background spectrum
  - Bump hunter p value reflects the bins that have the smallest probability of arising from a background fluctuation (assuming poisson statistics)





ATLAS-CONF-2016-031, PLB 759 (2016) 229-246

No significant (> 3sigma) excess found…

Gaussian limit

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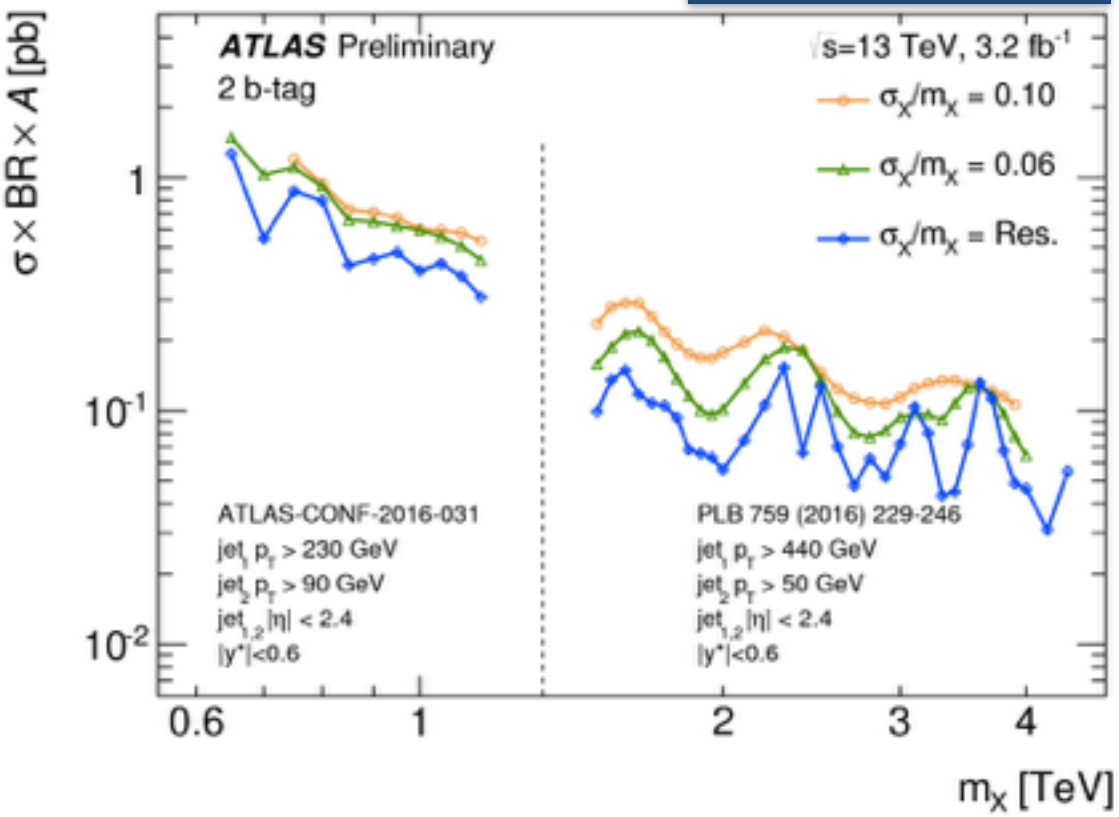

Combined Gaussian limit with trigger and b-tagging efficiency corrected

Benchmark model limits

- 10.1fb^{-1} data collected by 2016 summer has been added to the high mass search
- MC limit set on the b* and Z' models

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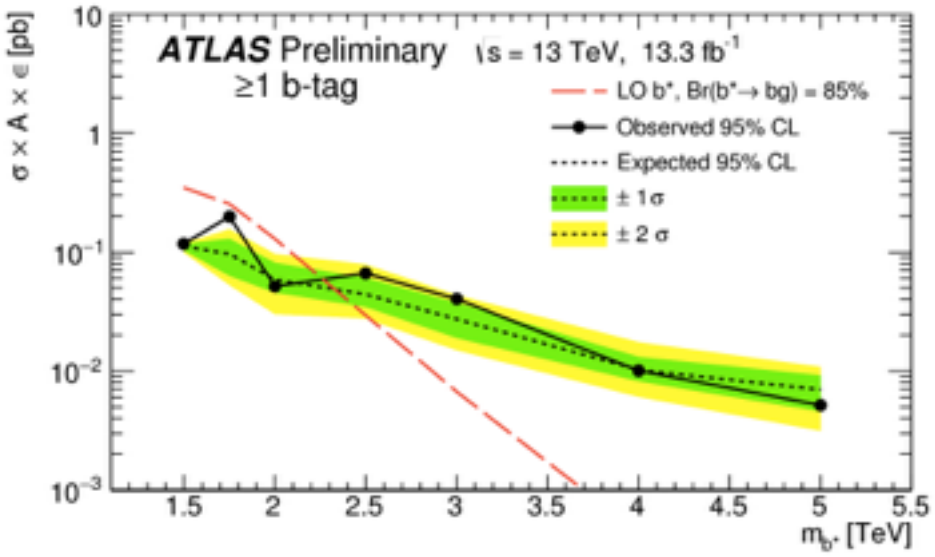
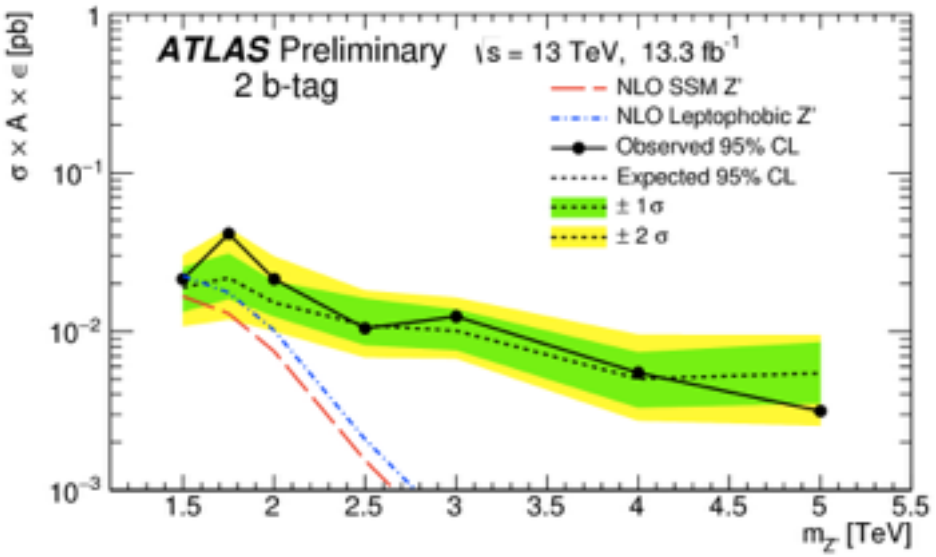




b* excluded at 2.3 TeV, leptophobic Z' excluded at 1.5 TeV

Summary

- b-tagging provides better sensitivity on searches for resonances which prefer to decay to heavy flavour

- ATLAS start exploring the di-jet mass spectra with b-tagging using Run 2 data
  - High mass search looking for TeV resonance
  - Using b-jet trigger to access the hundreds GeV region

- Limits has been set using both Gaussian shape and benchmark models
  - No excess found
  - 13.3 fb^{-1} data excluded b* at 2.3 TeV and leptophobic Z' at 1.5 TeV

Full 2016 data (3 times more luminosity) search in progress!

backup

Event selection

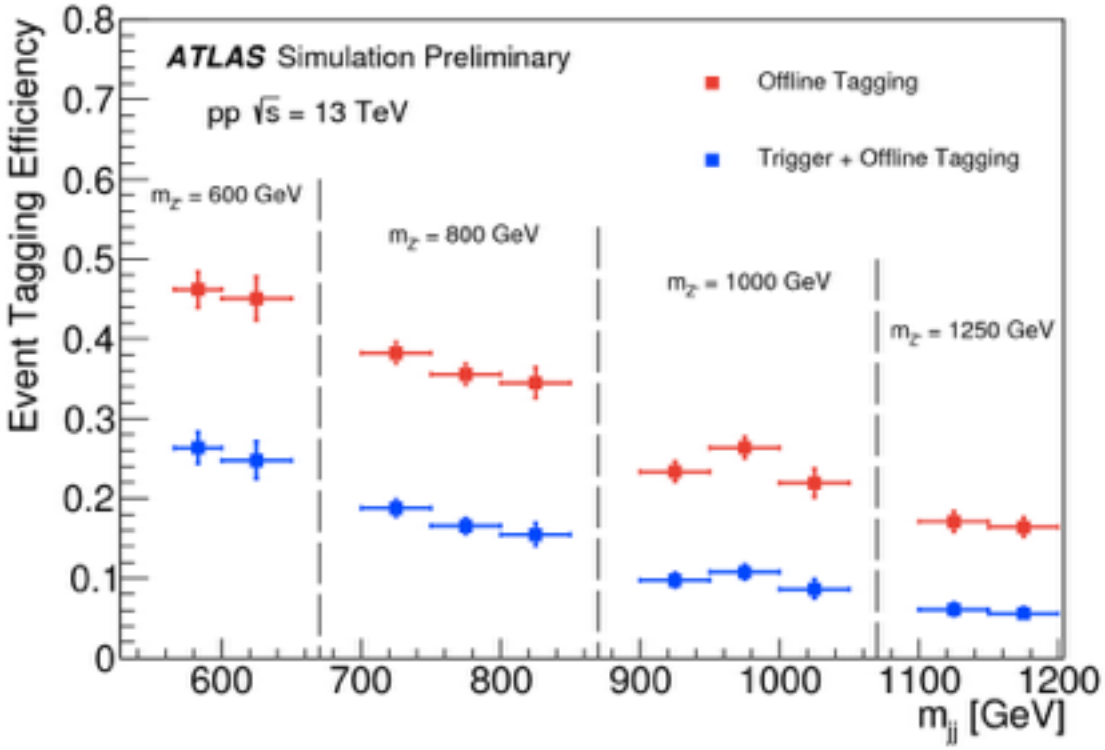
High mass search @ TeV

- Trigger
  - Signal jet trigger with jet pT > 360GeV in HLT (HLT_j360)
- Jet selection
  - $pT_{\text{Leading jet}} > 440$ GeV
  - $pT_{\text{sub-leading jet}} > 50$ GeV
  - Jet $|\eta| < 2.4$
  - $|y^*| < 0.6$ (suppress the QCD backgrounds)

Low mass search @ hundreds GeV

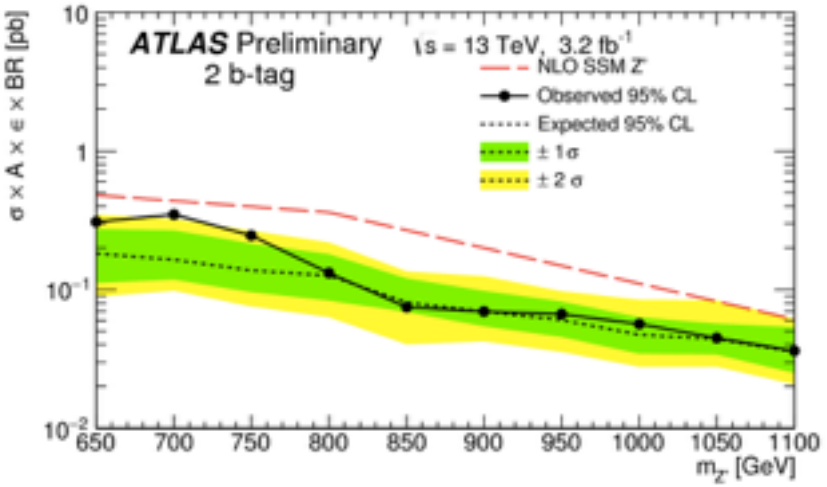
- Trigger
  - Using b-jet trigger to push the mjj threshold lower
  - Lowest unprescaled trigger ***HLT_j175_bmedium_j60_bmedium***
  - Online b-tagging algorithm
  - Orthogonal to the offline algorithm
- Jet selection
  - $pT_{\text{Leading jet}} > 230$ GeV
  - $pT_{\text{sub-leading jet}} > 90$ GeV
  - Jet $|\eta| < 2.4$
  - $|y^*| < 0.6$

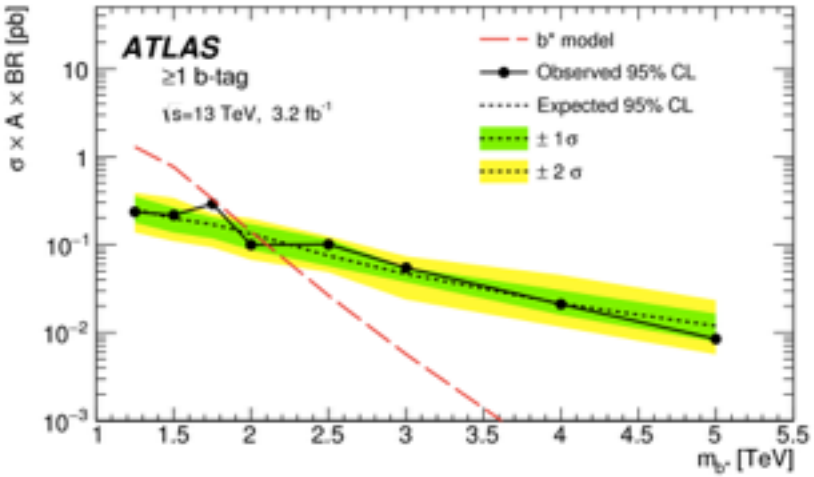
Per event tagging efficiency for low mass search

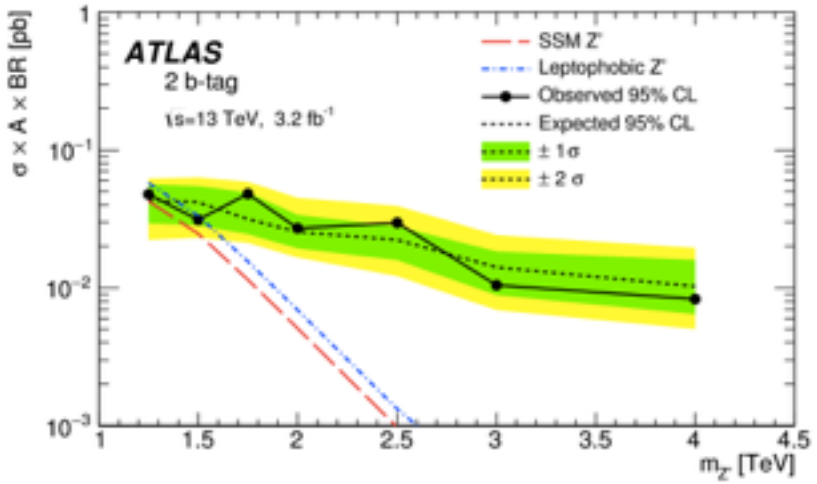


Limits — 2015 high mass

ATLAS-CONF-2016-031,
PLB 759 (2016) 229-246





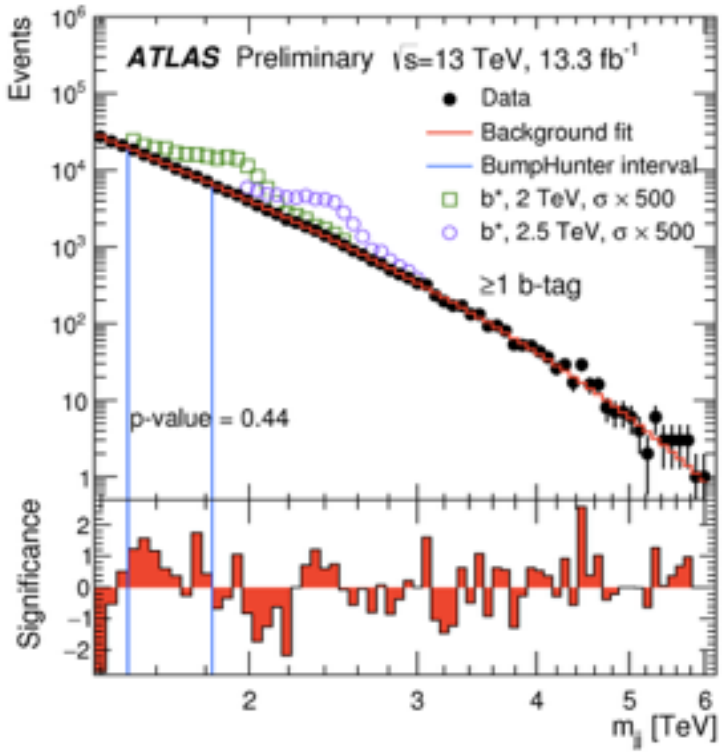


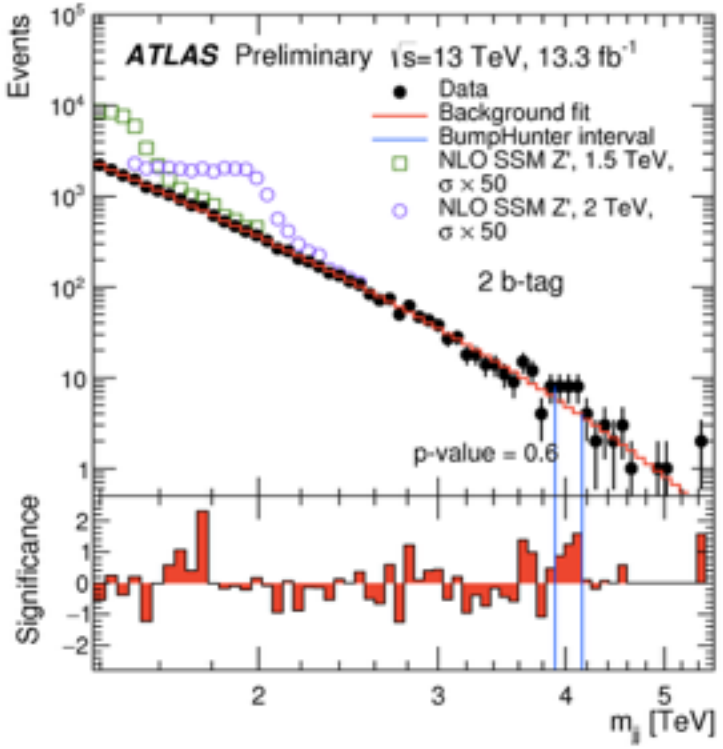
b* excluded at 2.3 TeV, leptophobic Z' excluded at 1.5 TeV

With more luminosity

ATLAS-CONF-2016-060

- By summer 2016, 10.1 fb^{-1} more data has been collected





Trigger: HLT_j380, $pT_{Leading\ jet}$ > 430 GeV, $pT_{sub\text{-}leading\ jet}$ > 60 GeV

With more luminosity

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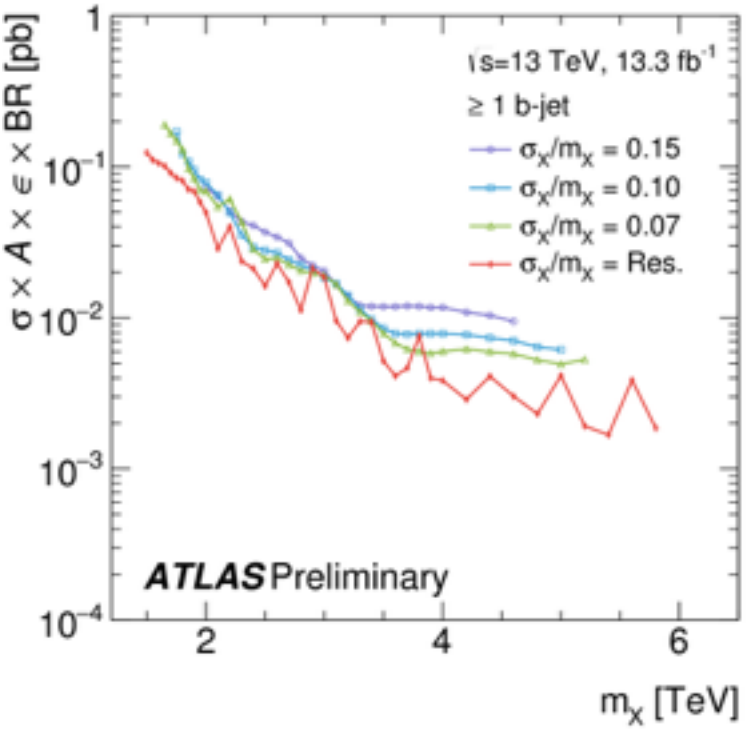

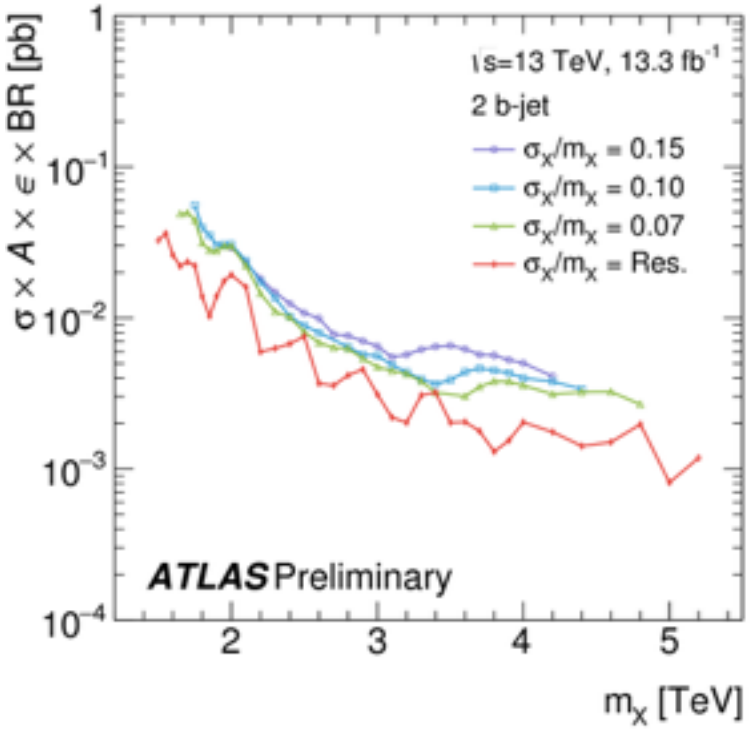

- Gaussian limit for >= 1 b-tag and 2 b-tag
  - Wider resonance width (up to 15% of the mass) has been scanned as well
  - No efficiency correction has been applied