Search for New Phenomena in Dijet Events with the ATLAS Detector

BENJAMIN ALLEN (OREGON)

ON BEHALF OF THE ATLAS COLLABORATION

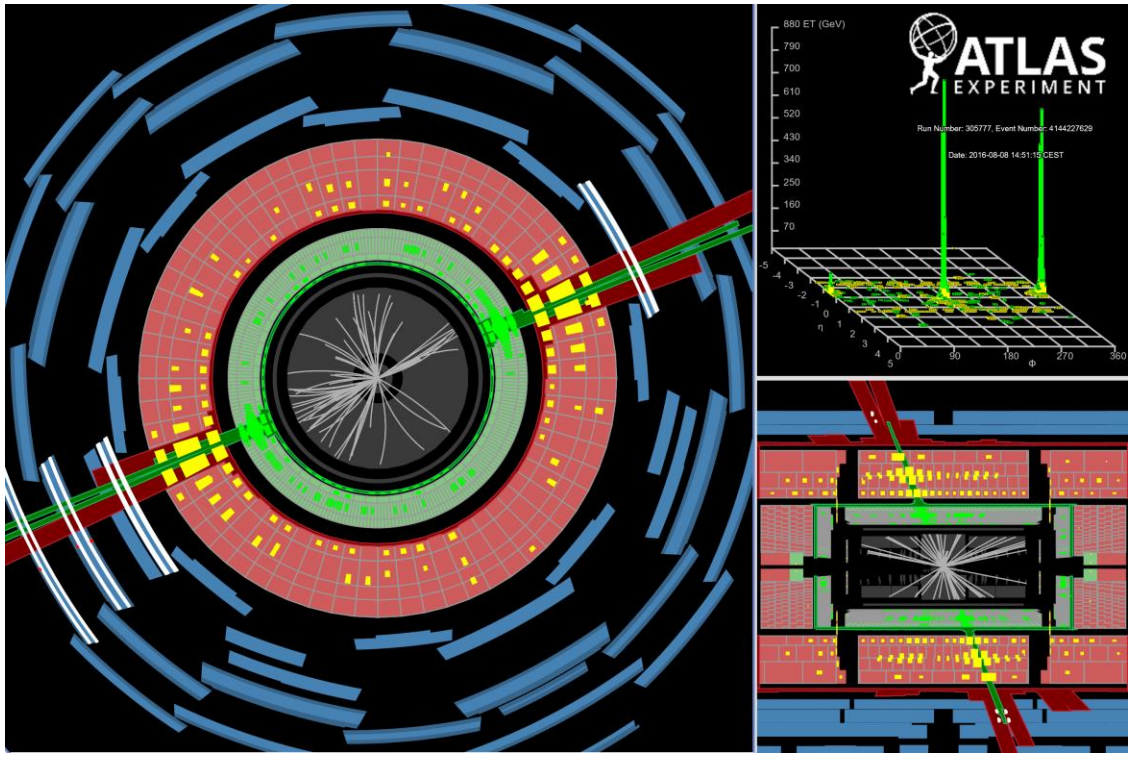
Introduction

- Any new phenomena produced in parton collisions will have a sizeable branching fraction to final states with 2+ partons (jets)
- With the increase in center-of-mass energy from 8 to 13 TeV there has been a huge increase in sensitivity for searches for high-mass resonances
  - 13 TeV dataset is now nearly twice the size of the 8 TeV dataset
- ATLAS has several complementary searches for new resonances decaying to a pair of jets
  - High-mass dijets
  - Low-mass dijets using trigger-level jet information
  - Di-b-jet systems
  - Dijets in association with an ISR photon or jet

arXiv: 1703.09127

Dijet Search

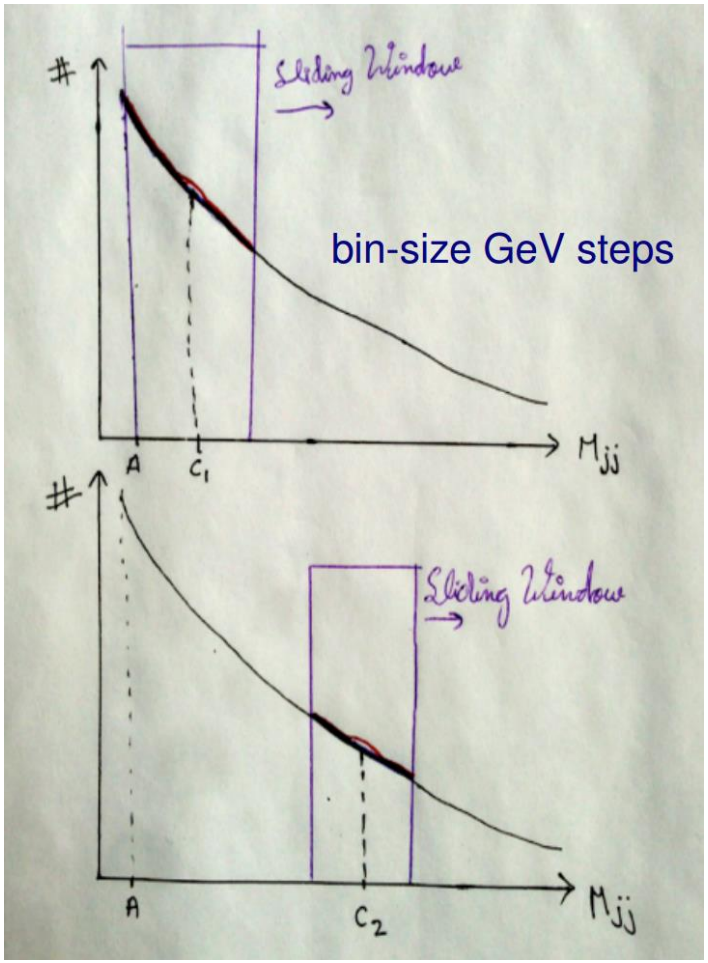
- Analysis Cuts:
  - Using Anti-k_t R=0.4 jets
  - Pass lowest unprescaled single-jet trigger
  - Leading jet p_T > 440 GeV, sub-leading p_T > 60 GeV
    - Cut chosen based on full-efficiency point for the trigger
    - No significant pileup contributions
- Resonance Selection
  - $y^* = (y_1 - y_2)/2 < 0.6$
  - m_{jj} > 1100 GeV



The highest invariant mass dijet event (m_{jj} = 8.12 TeV)

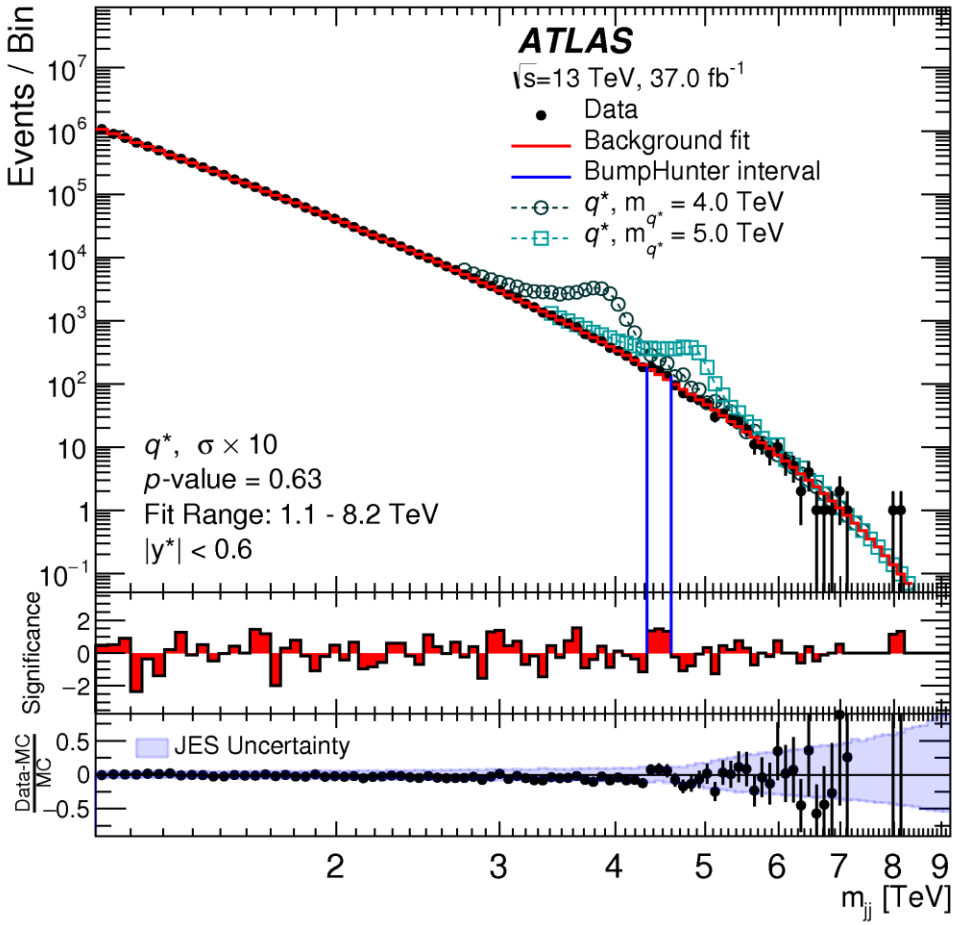
Resonance Fit Function

- Previous iterations fit the complete spectrum using:
  - $f(z) = p_1(1-z)^{p_2} * z^{p3+p_4 \ln(z)+p_5(\ln(z))^2}$
  - $z = \frac{m_{jj}}{\sqrt{s}}$
- 4-parameter version properly describes the current spectrum ($p_5 = 0$), but more parameters needed as lumi increases
- For this analysis, replace global fit with a sliding window fit
  - Much better flexibility, requires fewer parameters as luminosity increases (3-parameter)
- Construct the background bin-by-bin by evaluating the fit value at the center of each window
  - Window width chosen as the widest that provides a good fit for all possible windows
  - Final window is ~half the full spectrum, wider than all considered signal models

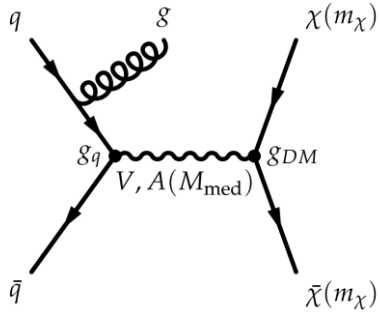


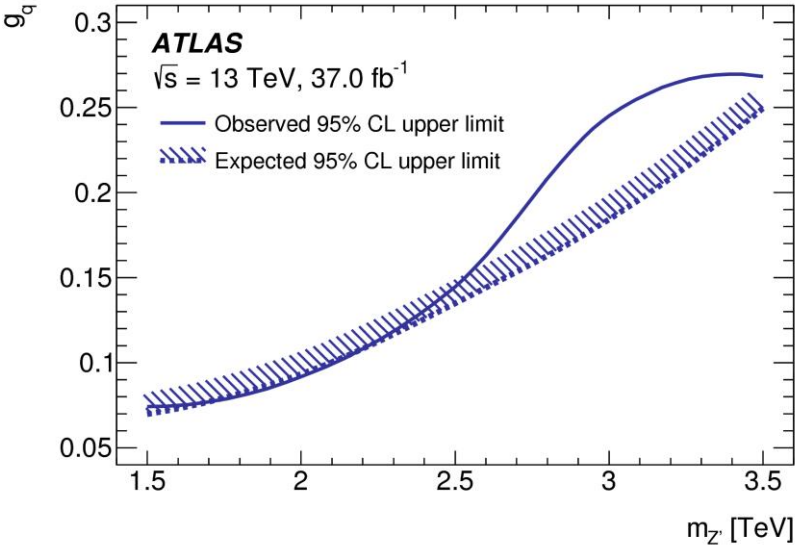
arXiv: 1703.09127

Resonance Search



- Dark matter mediator Z'
- Model A1 from arXiv:1703.05703
- g_{DM}=1, g_l=0



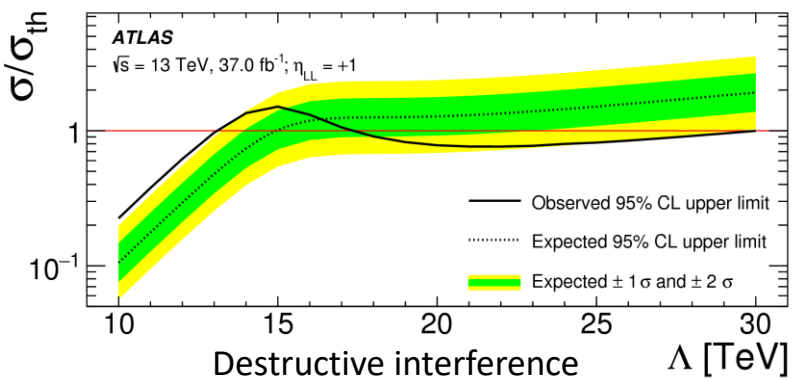


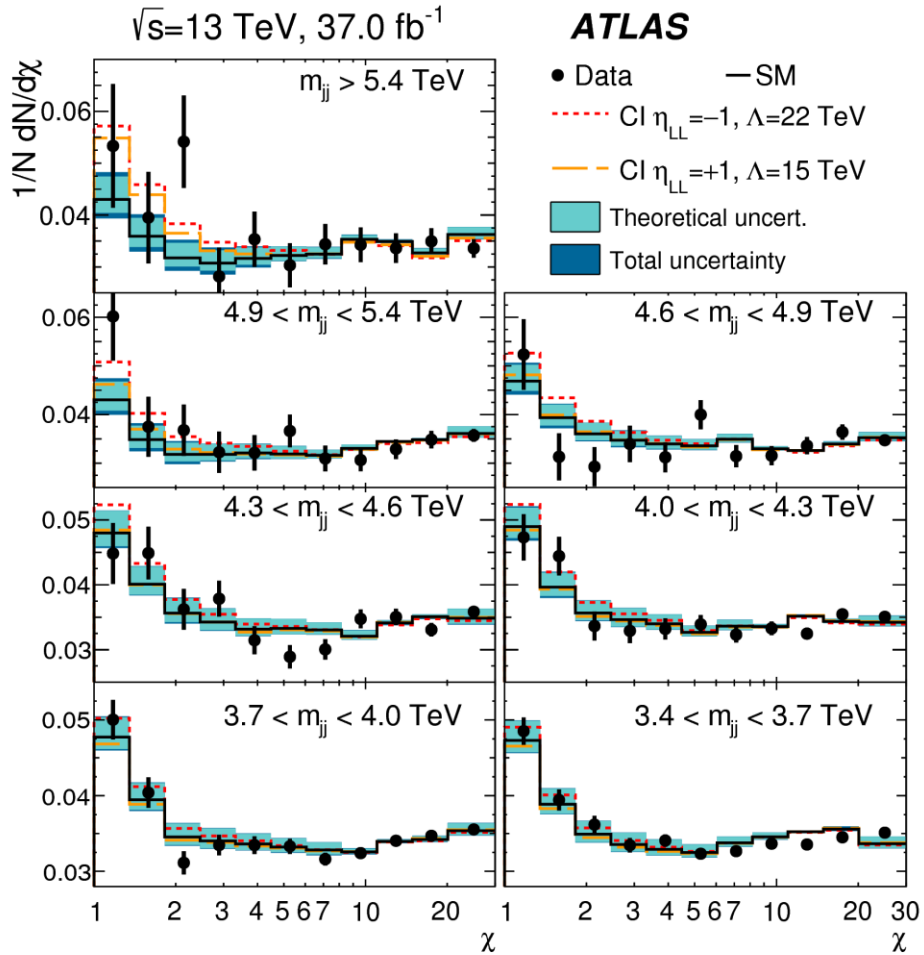
- Also set limits on q*, W*, W', QBH

arXiv: 1703.09127

Angular Analysis

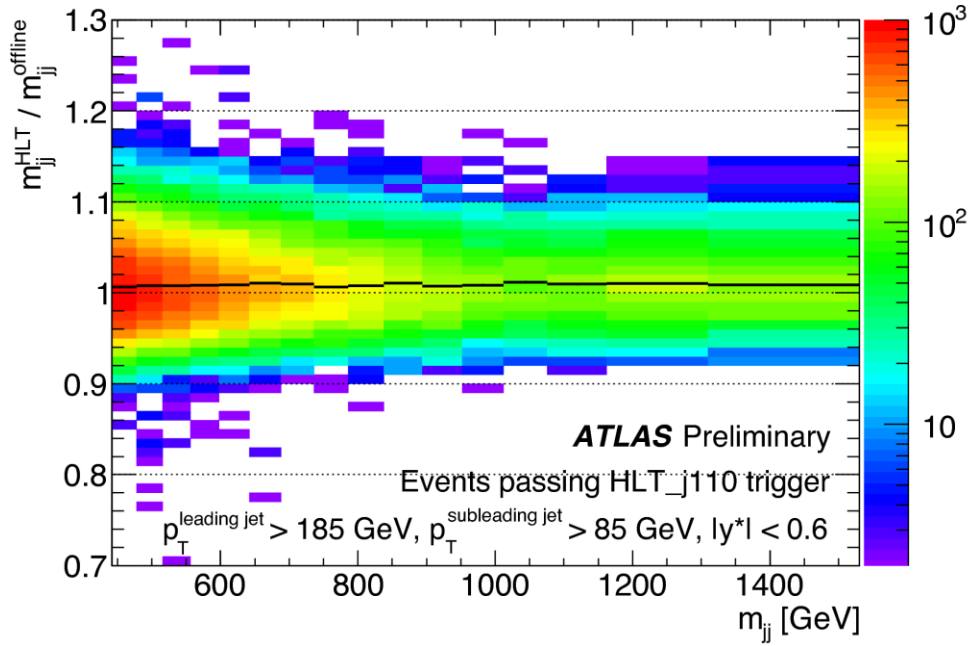
- Bin events in $\chi=e^{2y^*}$ and m_{jj}
- Compare shape of data distribution to simulated data
  - NLO and EW corrections applied
- Angular Selection
  - $y^* < 1.7$ ($\chi<30$)
  - $y_B = (y_1+y_2)/2 < 1.1$
  - $m_{jj} > 2500$ GeV
- Set limits on scale of contact interactions





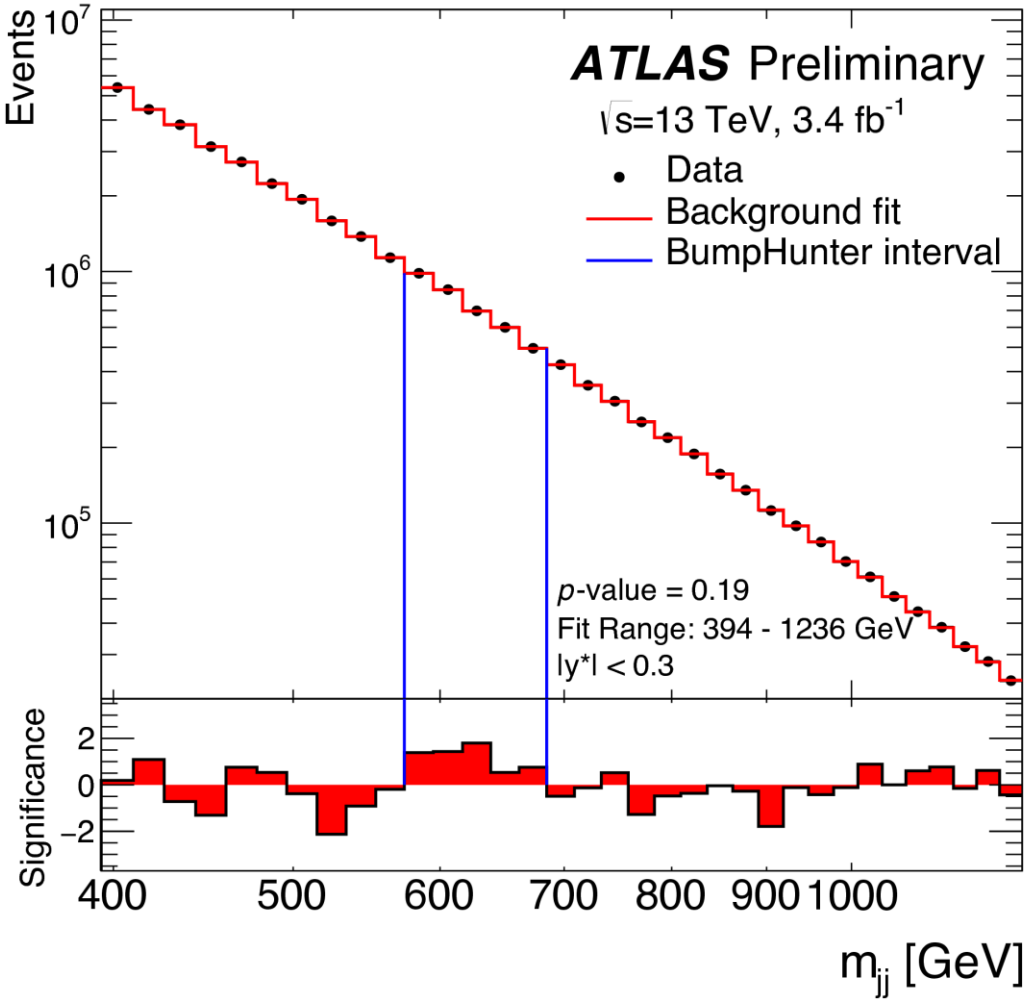
Trigger-Level Analysis (Data Scouting)

- Avoid trigger rate limitations by only saving a limited amount of data in each event
  - Access to trigger-level jets, but not the full offline quantities
- Analysis Cuts:
  - L1 Jet RoI with $p_T > 75$ GeV
  - Leading trigger jet $p_T > 185$ GeV, subleading >85 GeV
  - $y^* < 0.6$ (< 0.3)
  - $m_{jj} > 450$ GeV (400 GeV)
- Global fit using 4-parameter function:
- $f(z) = \frac{p_1}{z^{p_2}} e^{-p_3 z - p_4 z^2}$

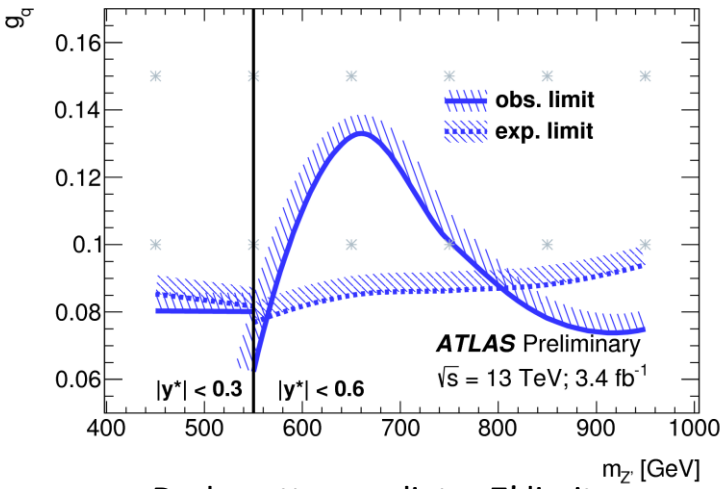


Comparison of invariant mass as measured using trigger jets and using offline jets

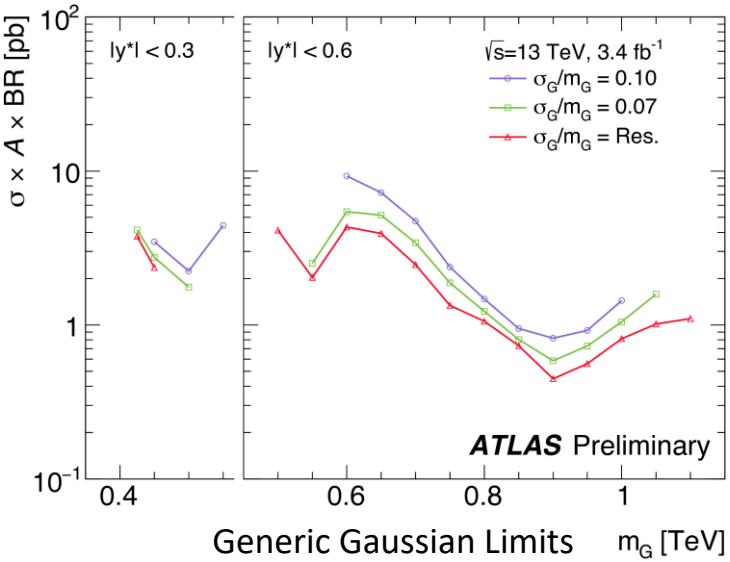
TLA Results



Invariant mass spectrum with most discrepant interval



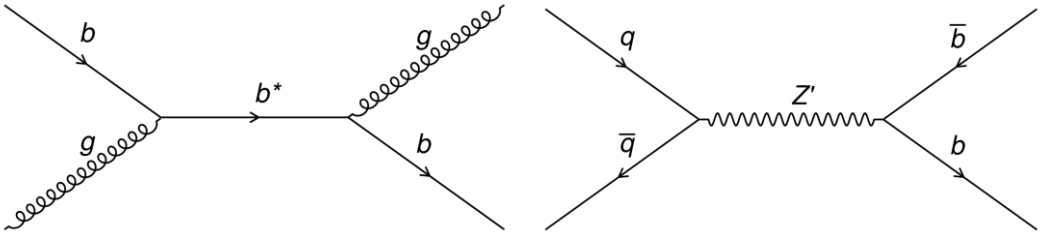
Dark matter mediator Z' limits

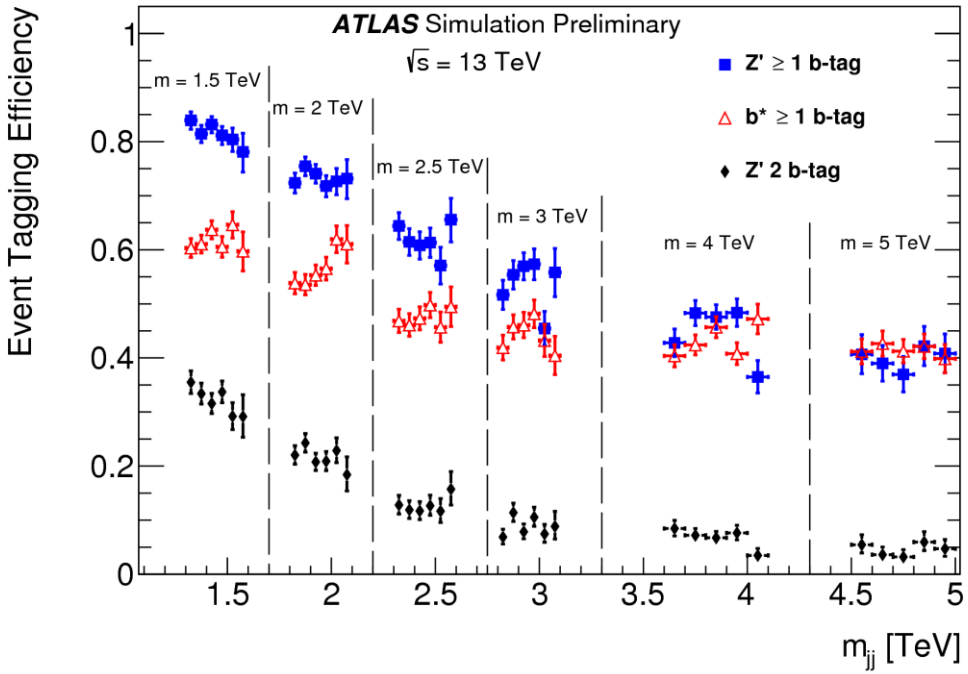


Generic Gaussian Limits

Di-b-jet Search

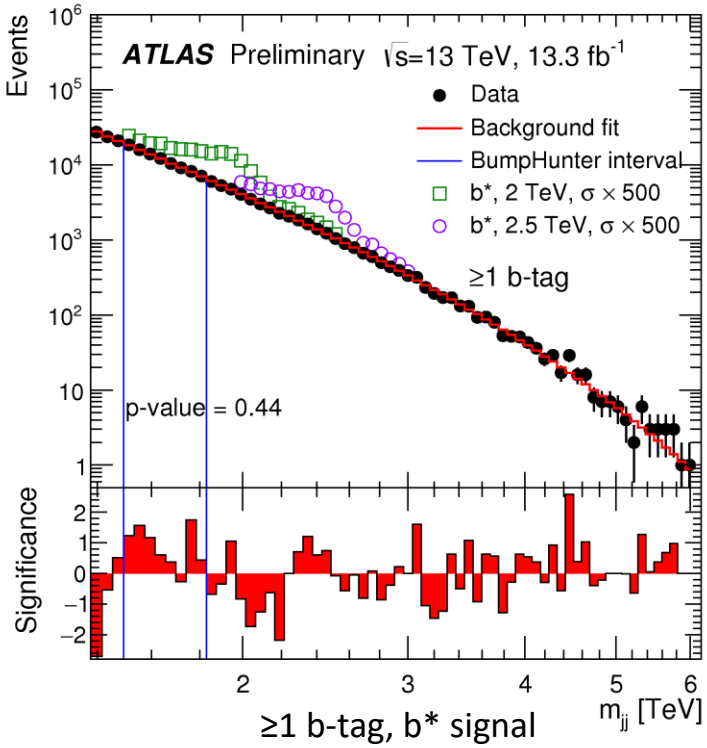
- Search for new resonances decaying to 1 or two b-quarks
- Analysis Cuts:
  - Pass lowest unprescaled single-jet trigger
  - Leading jet $p_T > 430$ GeV, sub-leading $p_T > 60$ GeV
  - Jet $|\eta|<2.4$
  - $y^* < 0.6$
  - $m_{jj} > 1.38$ TeV
  - At least one of the two leading jets b-tagged
- Global fit using 3-parameter dijet function



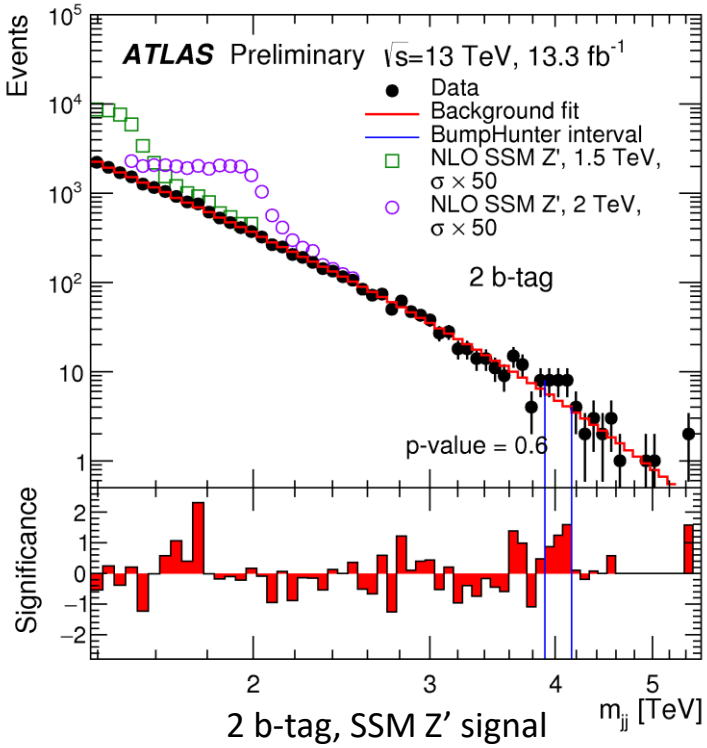


B-tagging efficiencies as a function of invariant mass

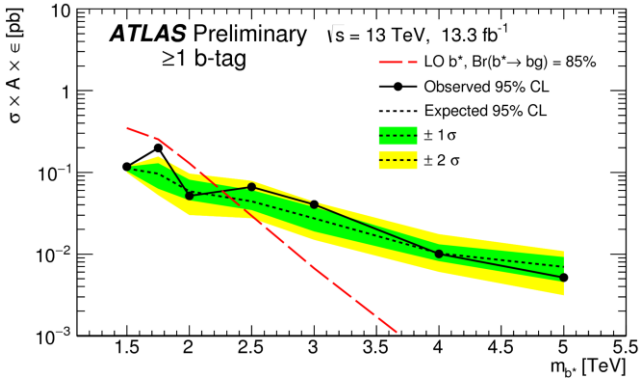
Di-b-jet High-Mass Results

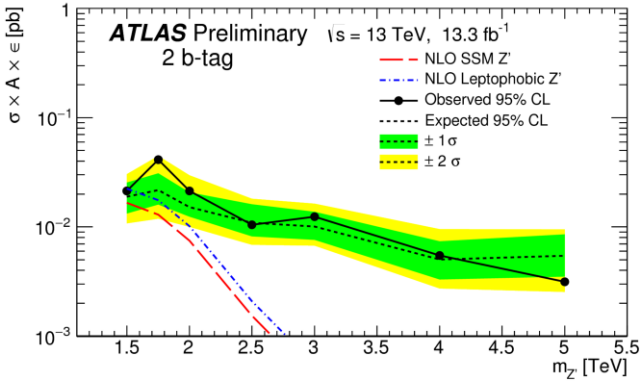


≥1 b-tag, b* signal



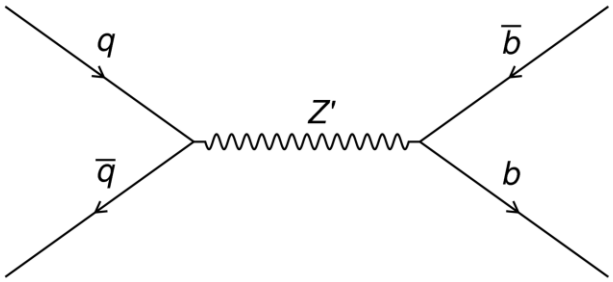
2 b-tag, SSM Z' signal

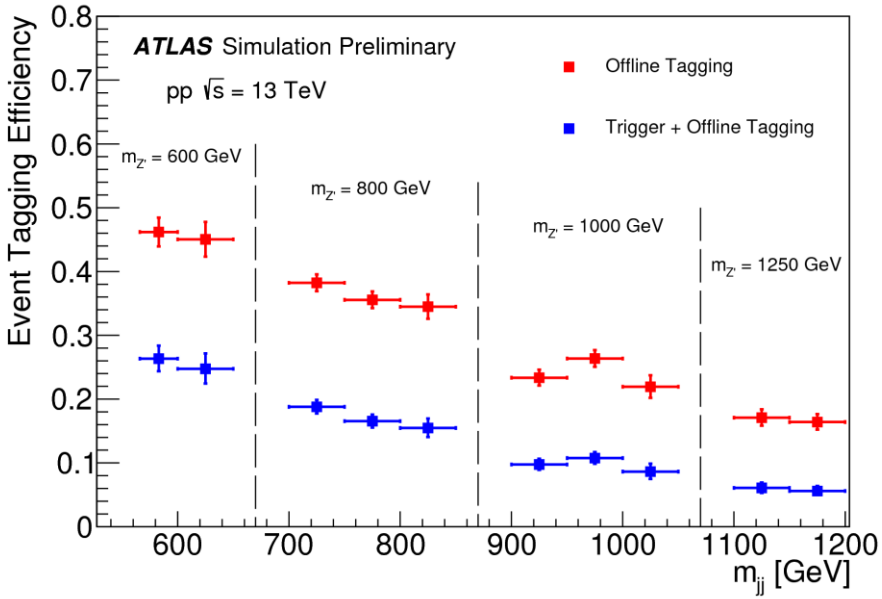




Low Mass Di-b-jet Search

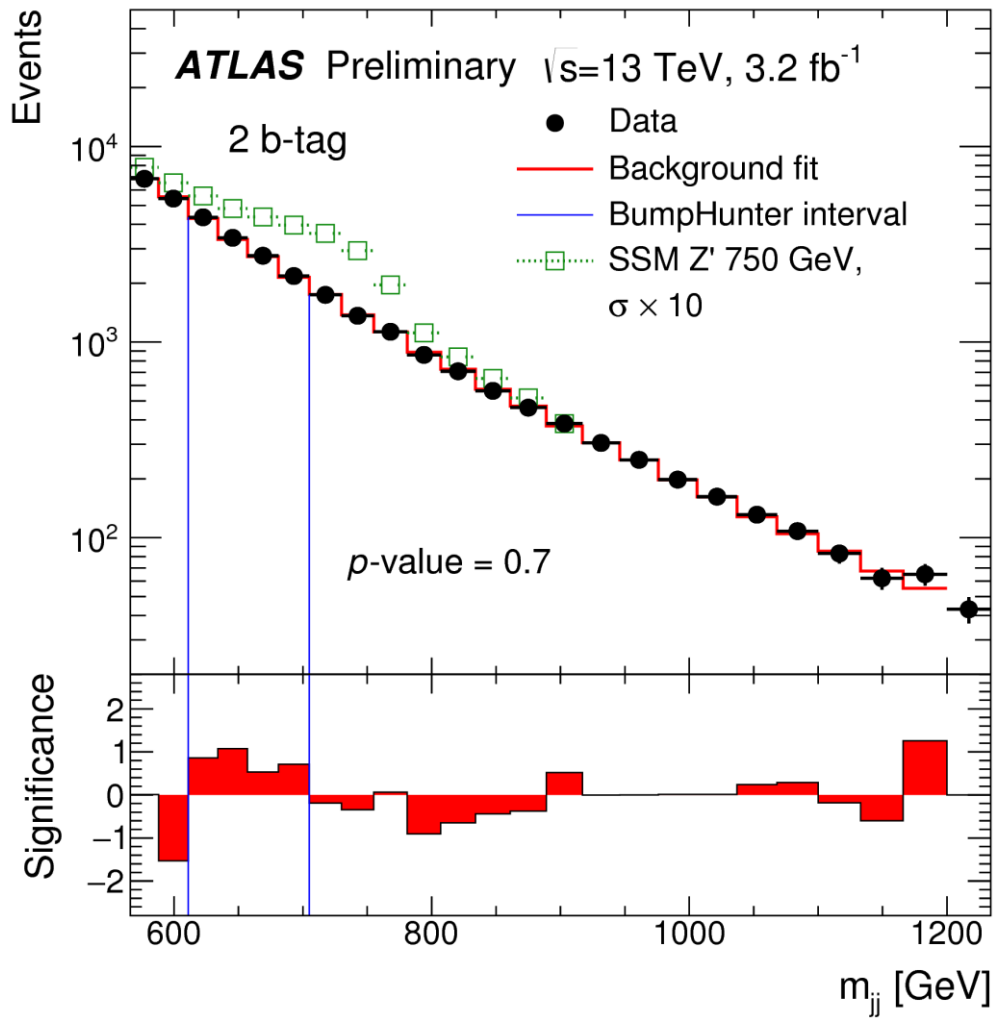
- Analysis Cuts:
  - Trigger requirement of two b-tagged jets
    - p_T > 170 GeV (60 GeV) for (sub)-leading b-jet
  - Leading jet p_T > 230 GeV, sub-leading p_T > 90 GeV
  - Jet $|\eta|<2.4$
  - $y^* < 0.6$
  - 0.57 TeV < m_{jj} < 1.2 TeV
- Global fit using 3-parameter dijet function



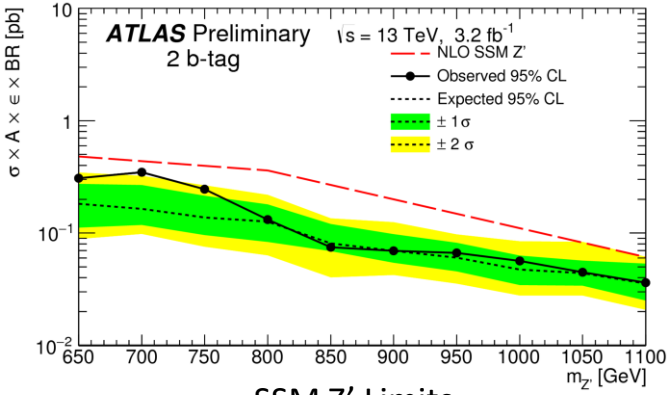


B-tagging efficiencies as a function of invariant mass

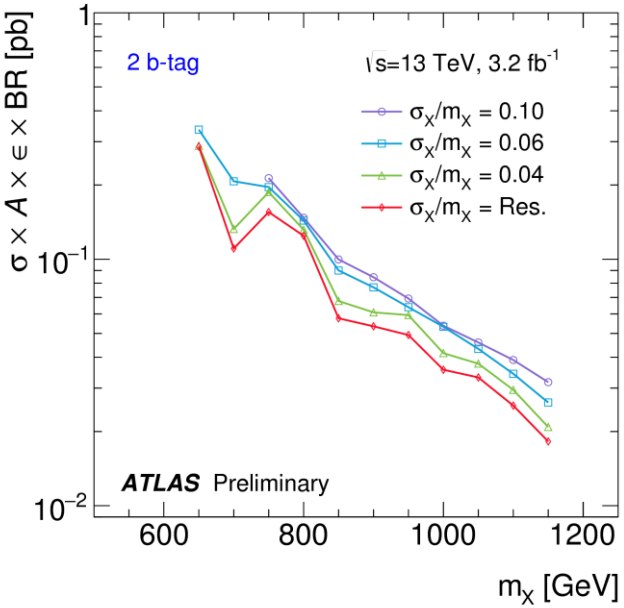
Di-b-jet Low Mass Results



Invariant mass spectrum with overlaid SSM Z' signal



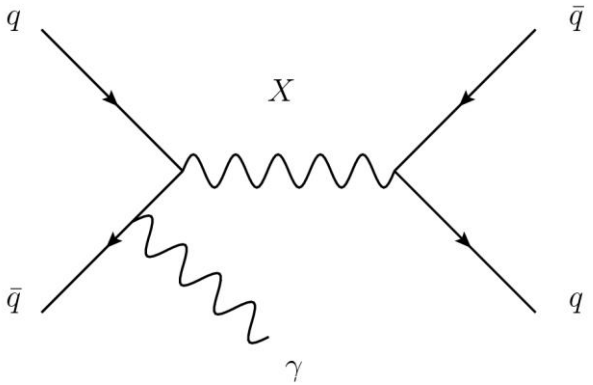
SSM Z' Limits



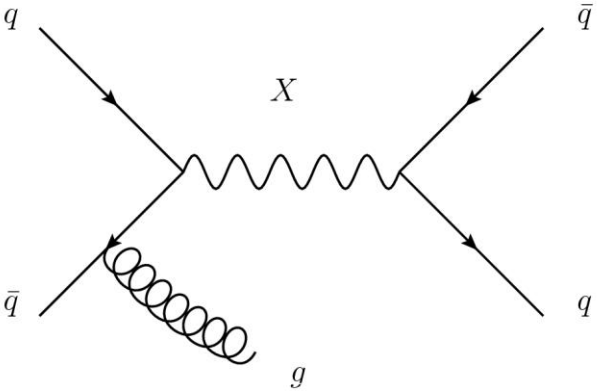
Generic Gaussian Limits

Dijet+ISR

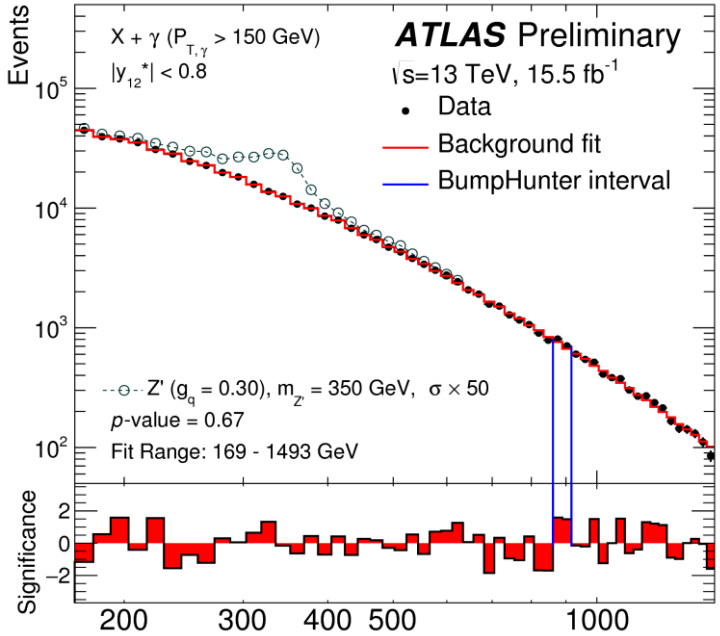
- Probe lower invariant masses by triggering on initial state radiation
- Dijet+Photon
  - Unprescaled single-photon trigger
  - Isolated photon with $p_T > 150$ GeV, $|\eta|<2.37$
  - Jet $p_T > 25$ GeV and $|\eta| < 2.8$
  - $y^* < 0.8$
  - $\Delta R > 0.85$ between jets and photon
  - Global fit using 4-parameter dijet function



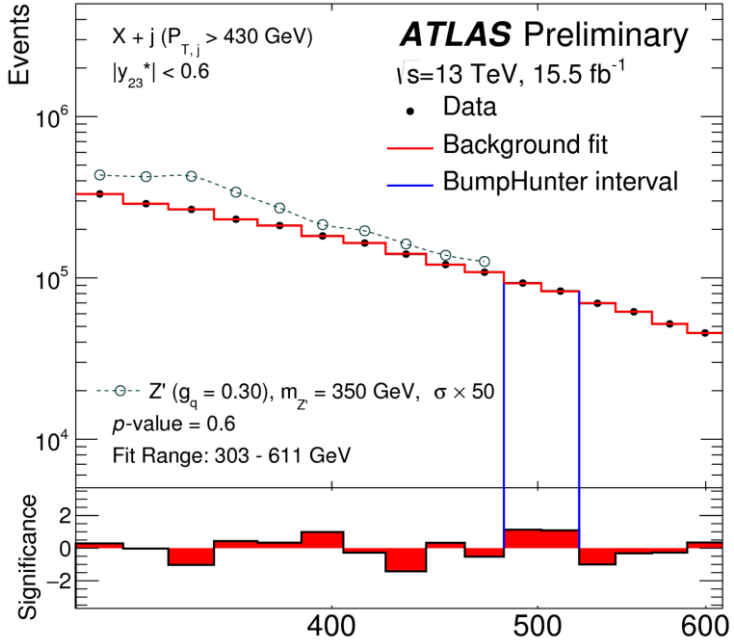
- Dijet+Jet
  - Unprescaled single-jet trigger
  - Leading jet $p_T > 430$ GeV
  - Jet $p_T > 25$ GeV and $|\eta| < 2.8$
  - $y^* < 0.6$
  - Global fit using 3-parameter dijet function



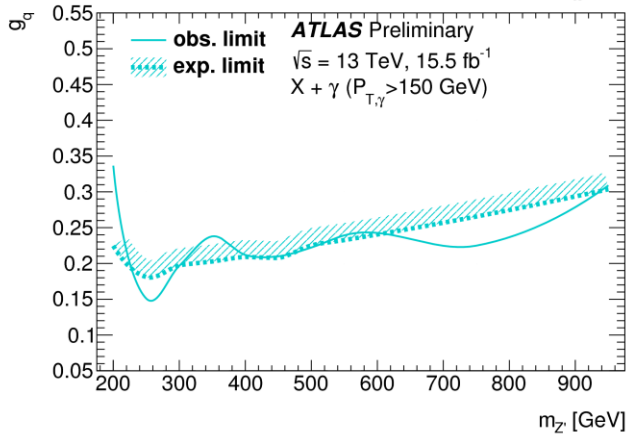
Dijet+ISR Results



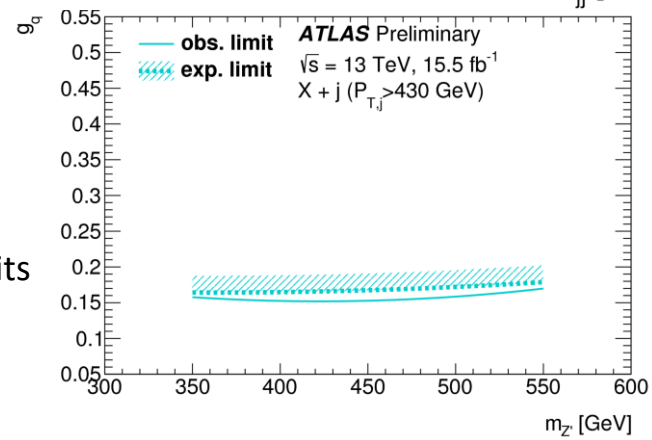
Photon ISR channel



Jet ISR channel

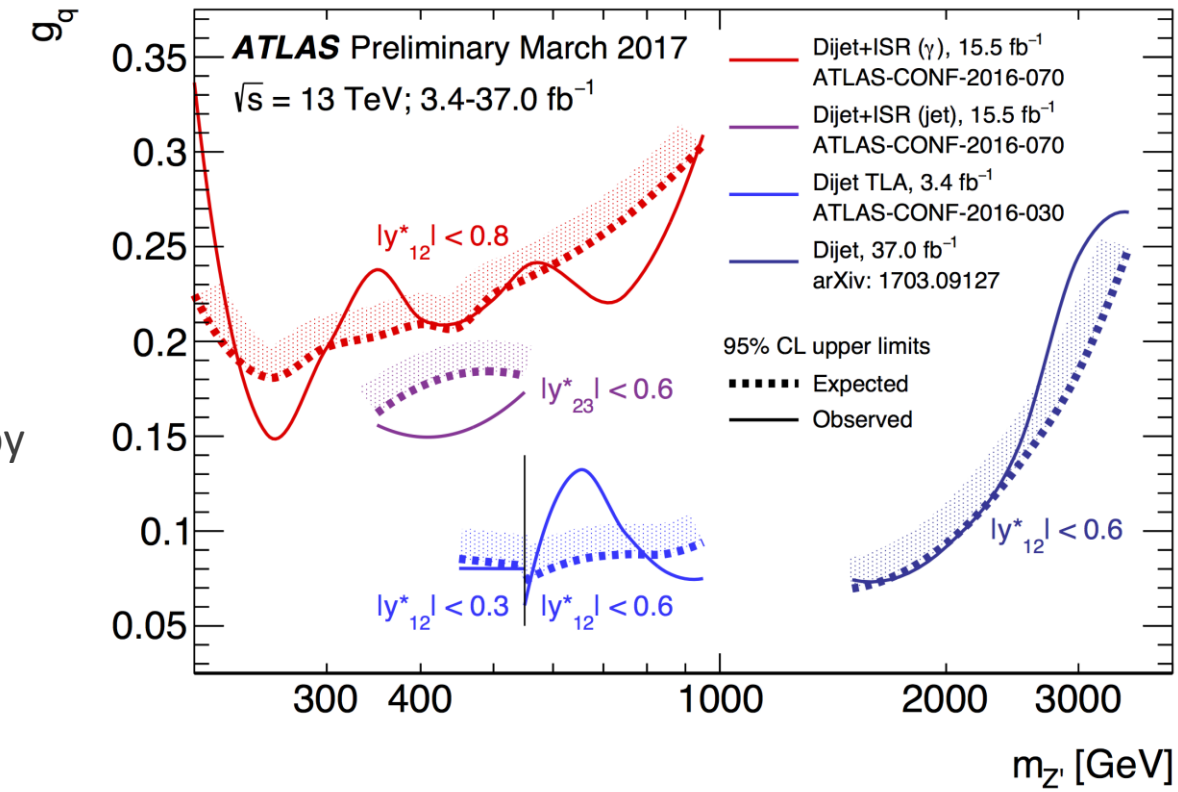


Dark matter mediator Z' limits

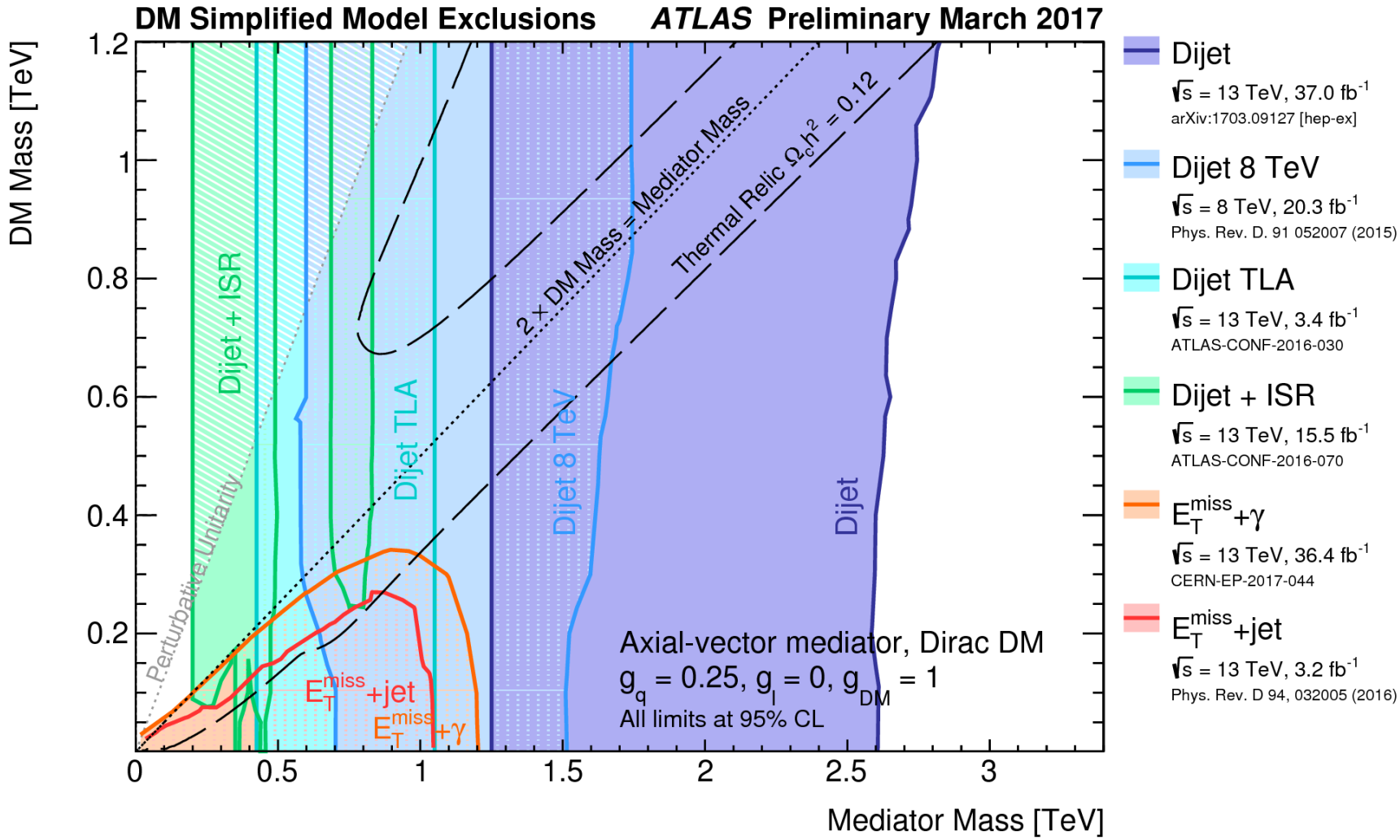


Summary

- ATLAS has a strong collection of complementary dijet searches
  - Sadly, no significant excesses spotted in any regions
- Z' exclusions set from 200 GeV-3.5 TeV
  - 1-1.5 TeV range covered by 8 TeV dijet search
- Updated 36 fb^{-1} results expected in the coming months

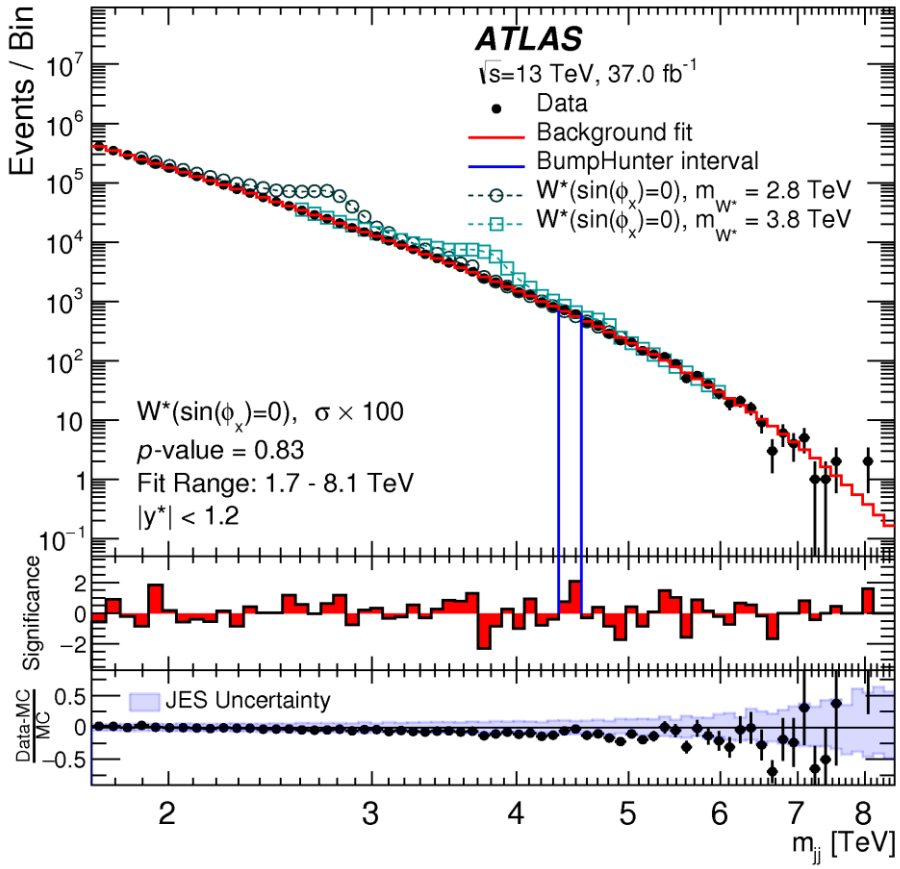


Dark Matter Exclusions (A1 Model)



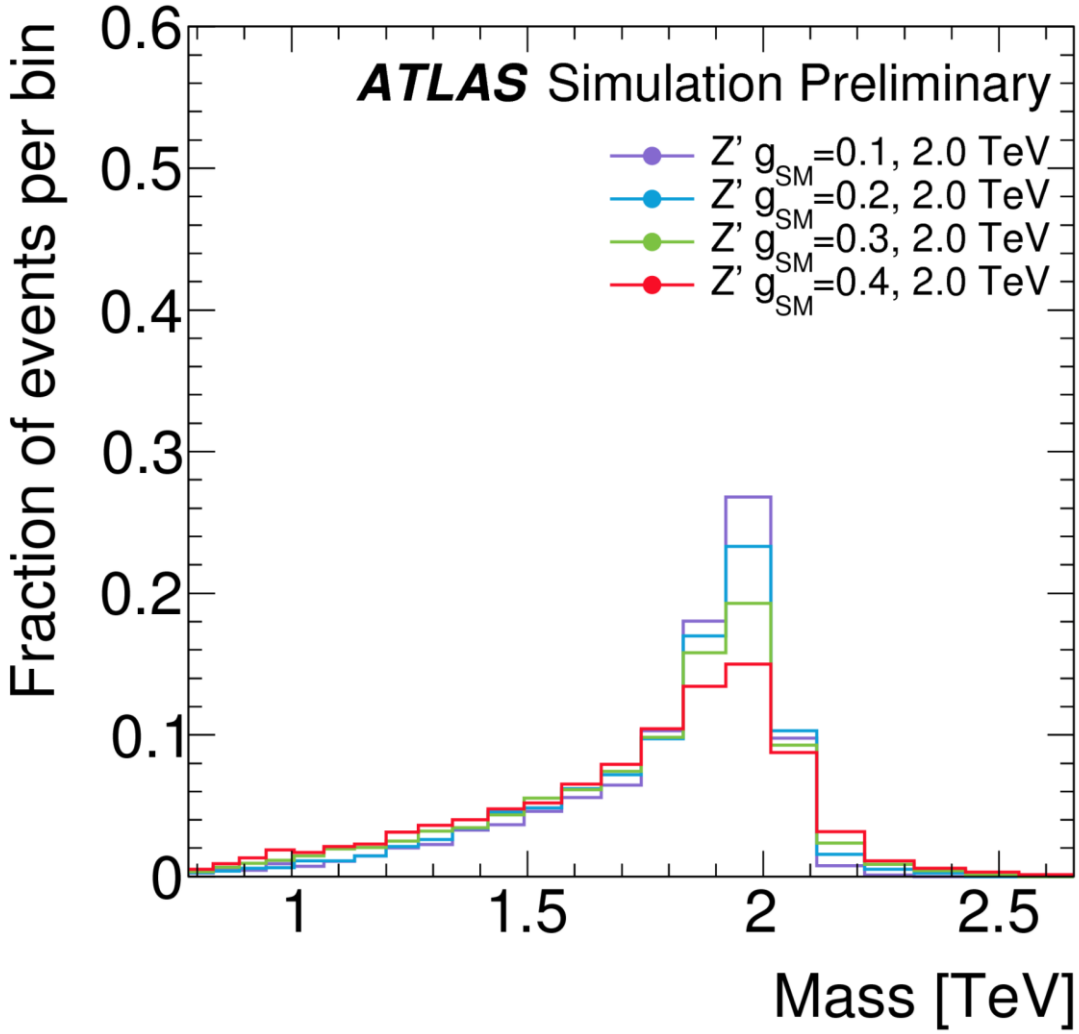
Backup

High-mass Dijet Results



Model	95% CL exclusion limit	
	Observed	Expected
Quantum black hole	8.9 TeV	8.9 TeV
W'	3.6 TeV	3.7 TeV
W^*	3.4 TeV 3.77 TeV – 3.85 TeV	3.6 TeV
Excited quark	6.0 TeV	5.8 TeV
Z' ($g_q = 0.1$)	2.1 TeV	2.1 TeV
Z' ($g_q = 0.2$)	2.9 TeV	3.3 TeV
Contact interaction ($\eta_{\mathrm{LL}} = -1$)	21.8 TeV	28.3 TeV
Contact interaction ($\eta_{\mathrm{LL}} = +1$)	13.1 TeV 17.4 TeV – 29.5 TeV	15.0 TeV

Z’ Widths


ATLAS Simulation Preliminary
Z’ g_{SM}=0.1, 2.0 TeV
Z’ g_{SM}=0.2, 2.0 TeV
Z’ g_{SM}=0.3, 2.0 TeV
Z’ g_{SM}=0.4, 2.0 TeV
Fraction of events per bin
0.6
0.5
0.4
0.3
0.2
0.1
0
1
1.5
2
2.5
Mass [TeV]