Search for resonances in dijet with one or two jets identified as b-jets at ATLAS

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Outline

- Motivation
- Previous searches
- Strategy
- B-tagging WP
- Background estimation
- Results
- Discussion

Draft version 1.2

ATLAS NOTE

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Search for resonances in the di-jet mass distribution with one or two jets identified as b-jets in proton-proton collisions at $\sqrt{s}$=13 TeVwith the ATLAS detector.

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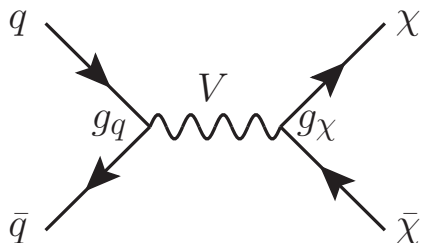
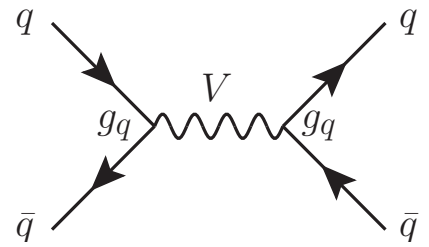
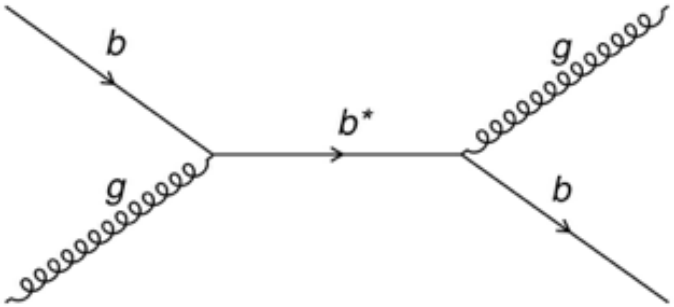
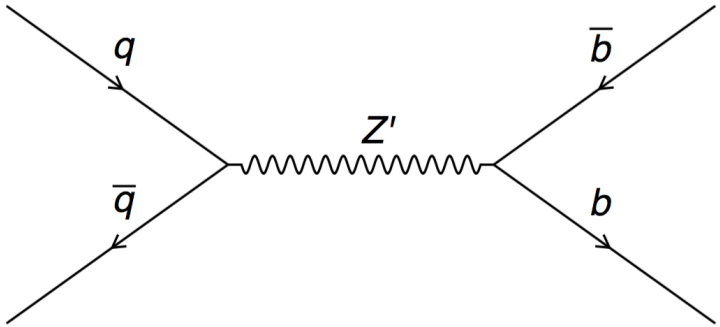
Motivation

- Search for DM-SM mediator
  - Many BSM predict mediators connecting SM and DM
  - The mediator may have heavy quark coupling
    - **Spin-1**: vector Z', axial-vector Z'
    - **Spin-0**: Yukawa coupling
    - **Spin-2**: KK graviton
  - Disturbing the QCD di-jet production
- Signature
  - two jet resonance with one or both b-tagged



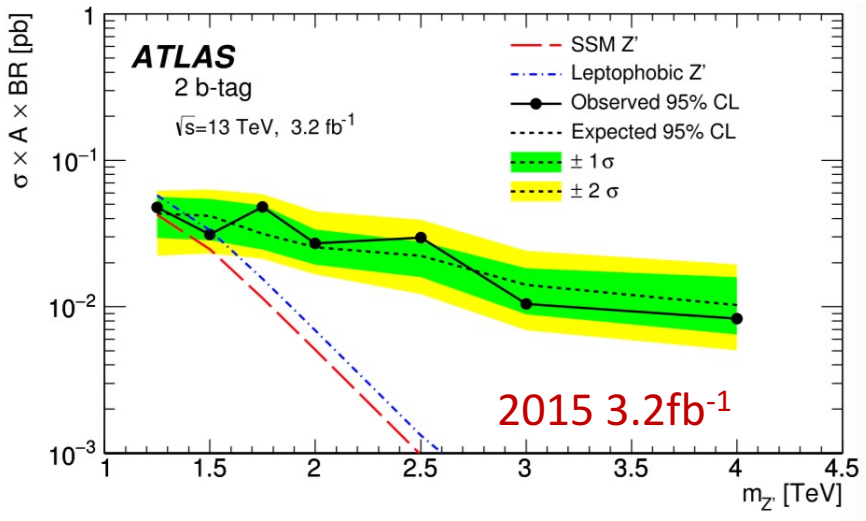


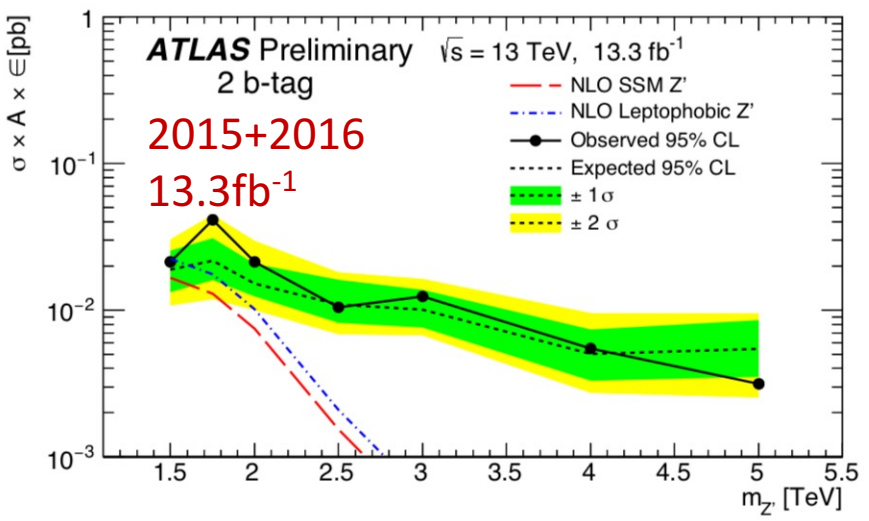




Previous Results

- 2015 data, 3.2 fb^{-1}: **PLB 759 (2016) 229-246** (contact editor) and **ATLAS-CONF-2016-031**
  - single jet trigger (pT threshold 360 GeV in 2015), m_{jj} > 1.1 TeV
  - di-bjet trigger: 600 GeV < m_{jj} < 1.1 TeV
- 2015+2016 data, 13.3 fb^{-1}: **ATLAS-CONF-2016-060**
  - single jet trigger (pT threshold 380 GeV in 2016), m_{jj} > 1.38 TeV
- Sensitivity continues improving with more data statics and better b-tagging performance

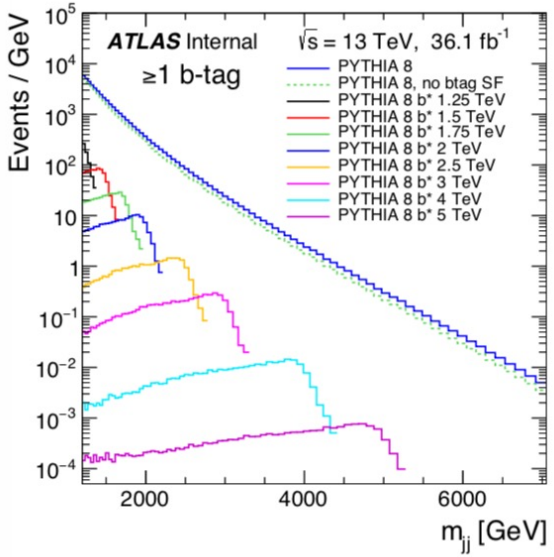




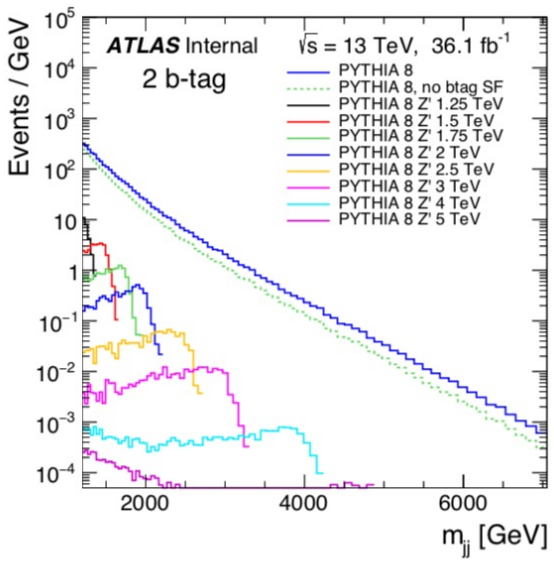
Signal and Search Strategy

- 2015+2016 data: 36 fb^{-1}
- Dijet invariant mass spectrum
- Signal resonance on top of QCD background
- One or two b-tagging to suppress the background

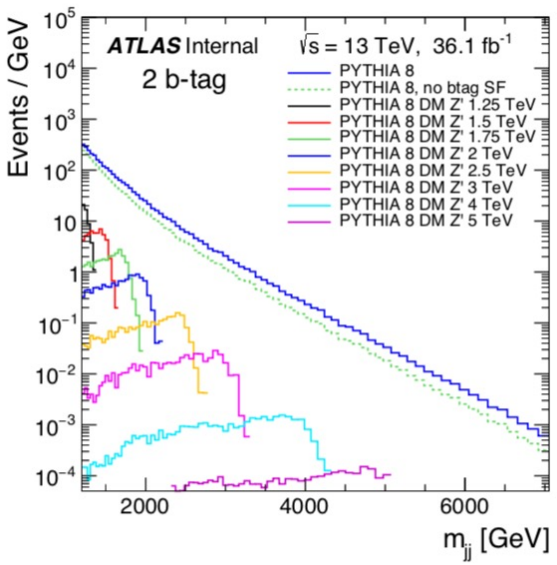
b*	Vector SSM Z' (leptofobic)	Axial-vector, DM-Z'
Pythia8, LO x-sec	Pythia8, NLO x-sec	MadGraph+Pythia8
>= 1 b-tag	2 b-tag	2 b-tag



(a) b^* inclusive one b-tag



(b) Z' two b-tag



(c) DM Z' two b-tag

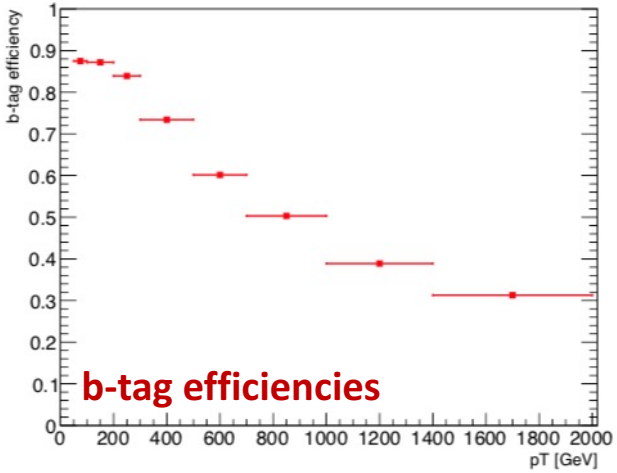
High Mass and Low Mass Regions

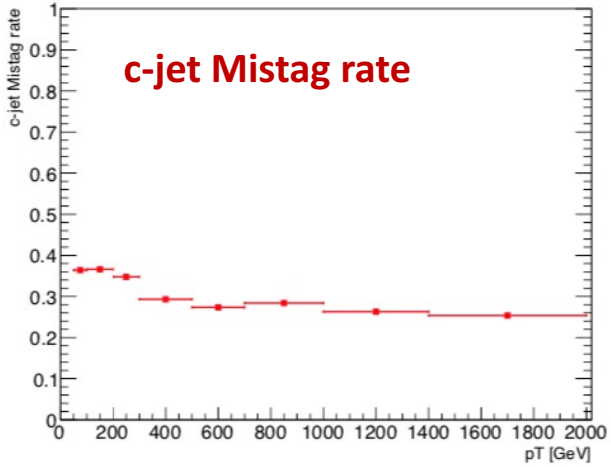
- Selection and mass range are defined
  - Trigger efficiency, signal significance

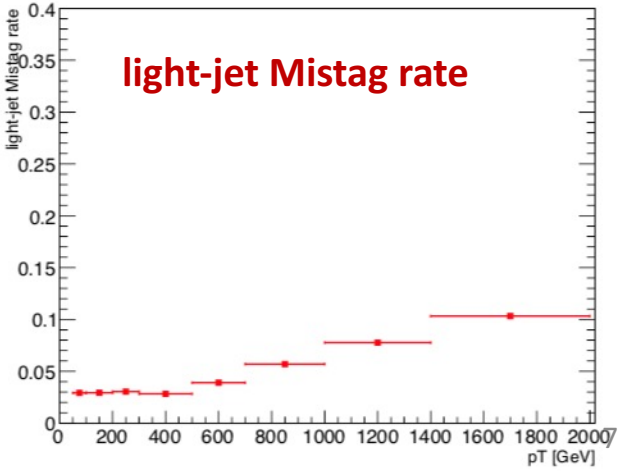
Low Mass	High Mass
Di-bjet trigger j150_j50	Single jet trigger j380
24.3 fb^{-1}	36.1 fb^{-1}
Leading jet pT > 200 GeV	Leading jet pT > 430 GeV
Both jets $\|\eta\|<2.0$, sub-leading jet pT > 80 GeV	
$\|y^*=(y_1-y_2)/2\| < 0.6$	$\|y^*\|<0.8$
566 GeV < m_{jj} < 1.5 TeV	m_{jj} > 1.2 TeV
B-tagging: 70% OP	B-tagging: 85% OP
2 b-tag	>= 1 b-tag and 2 b-tag

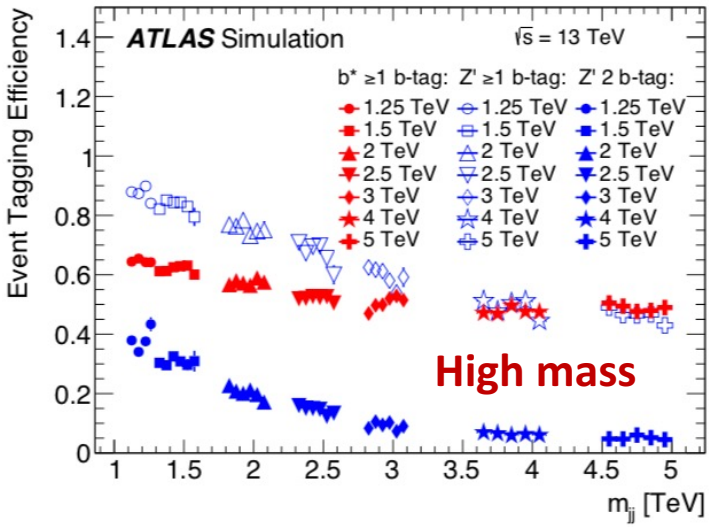
B-tagging Optimization

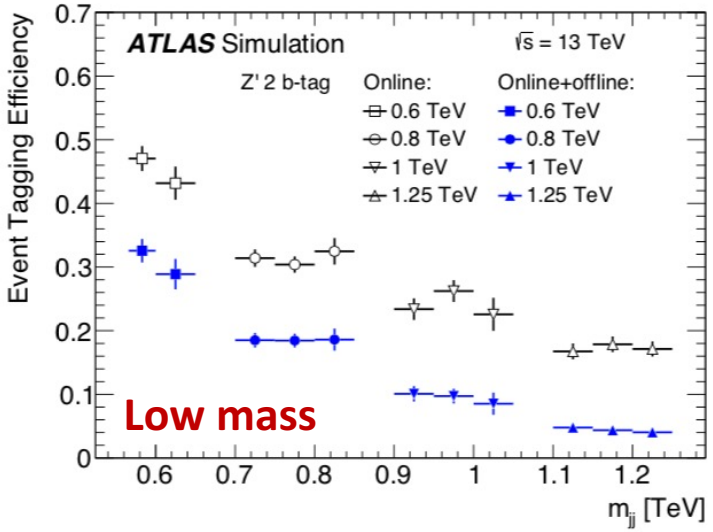
- B-tagging working point
  - Degrading performance with higher pT





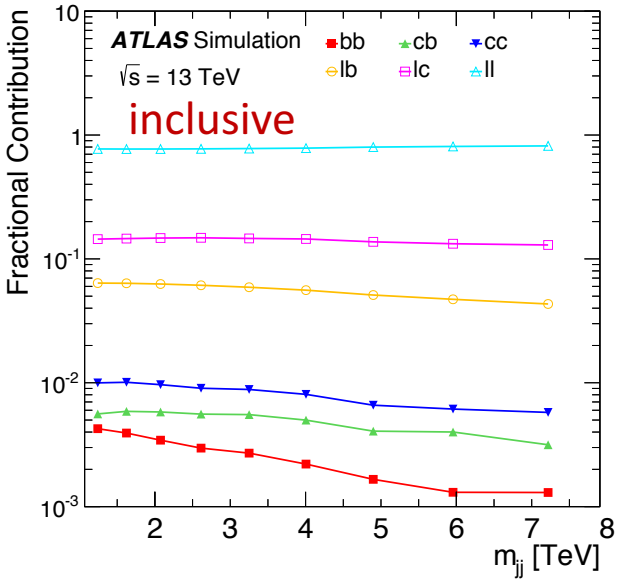


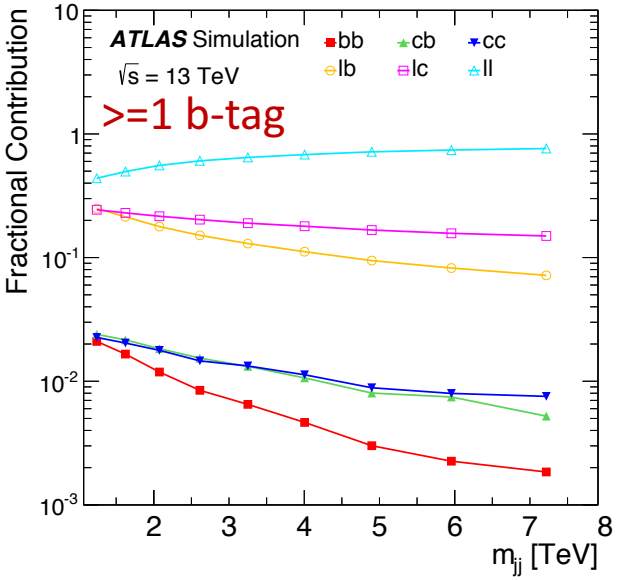


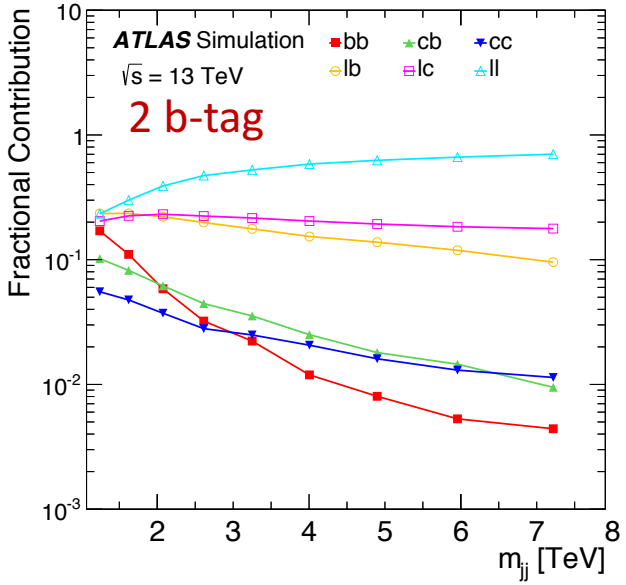


Background Composition

- Background is dominated by mis-tagged light-jet
- Dijet mass spectrum is affected by the non-flat tagging efficiency

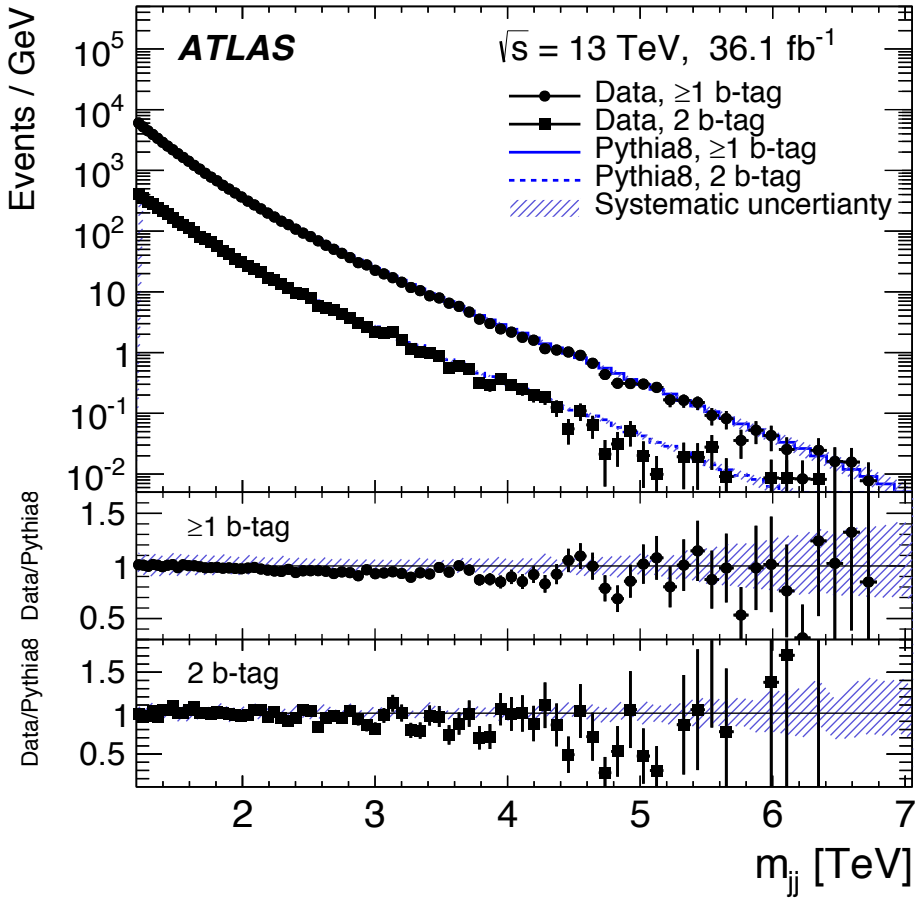






QCD Background

- MC Pythia8 QCD spectra are normalized to the >=1 b-tag and 2 b-tag separately.
- The MC-calculated spectrum shapes agree with the data.



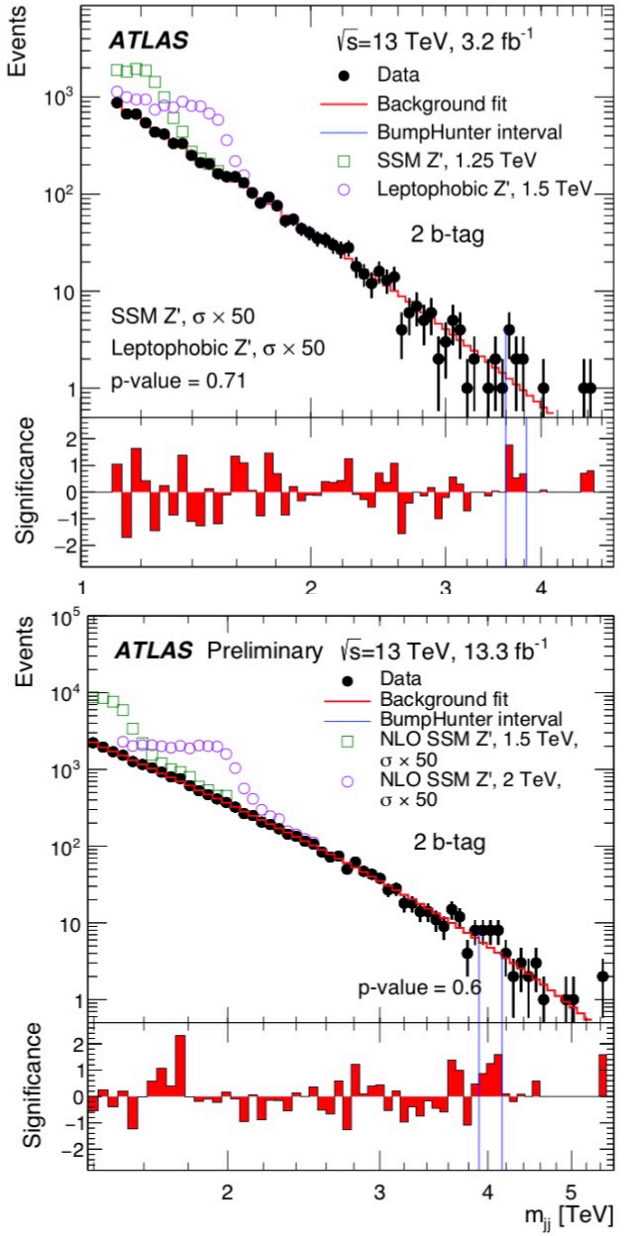
Background Global Fitting

- In the previous searches, the QCD background is estimated by fitting the data spectrum globally

- Fitting function

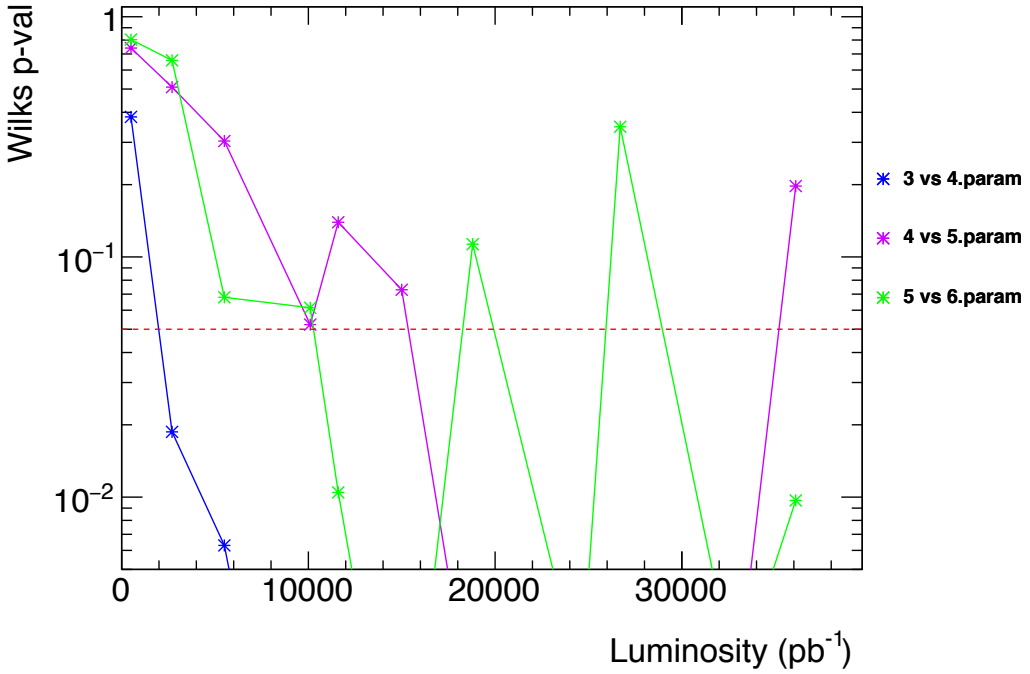
$$f(x) = p_1(1-x)^{p_2}(x)^{p_3+p_4\ln x+p_5(\ln x)^2},$$
$$x = m_{jj}/\sqrt{s}$$

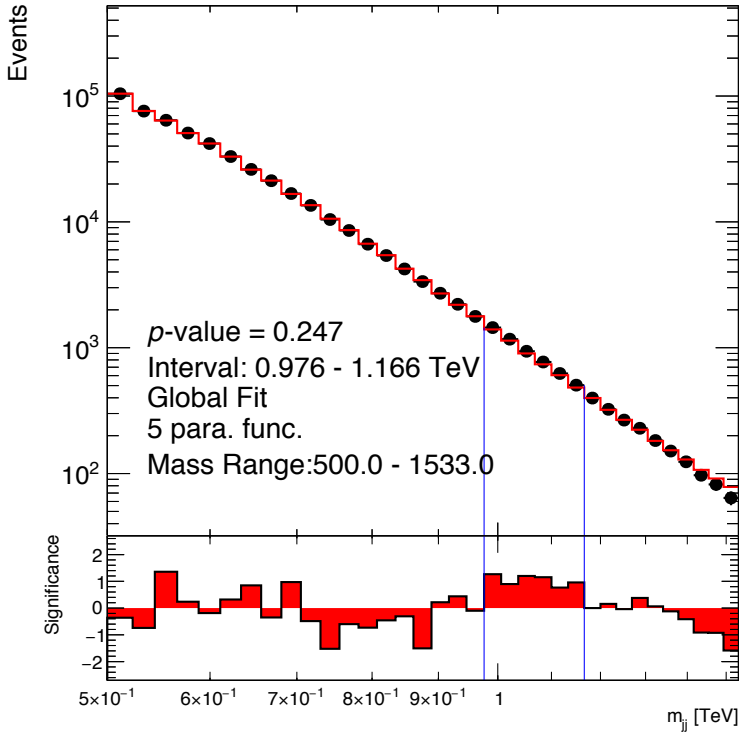
- Up to 13.3 fb^{-1}, the global fitting worked well.



Background Global Fitting

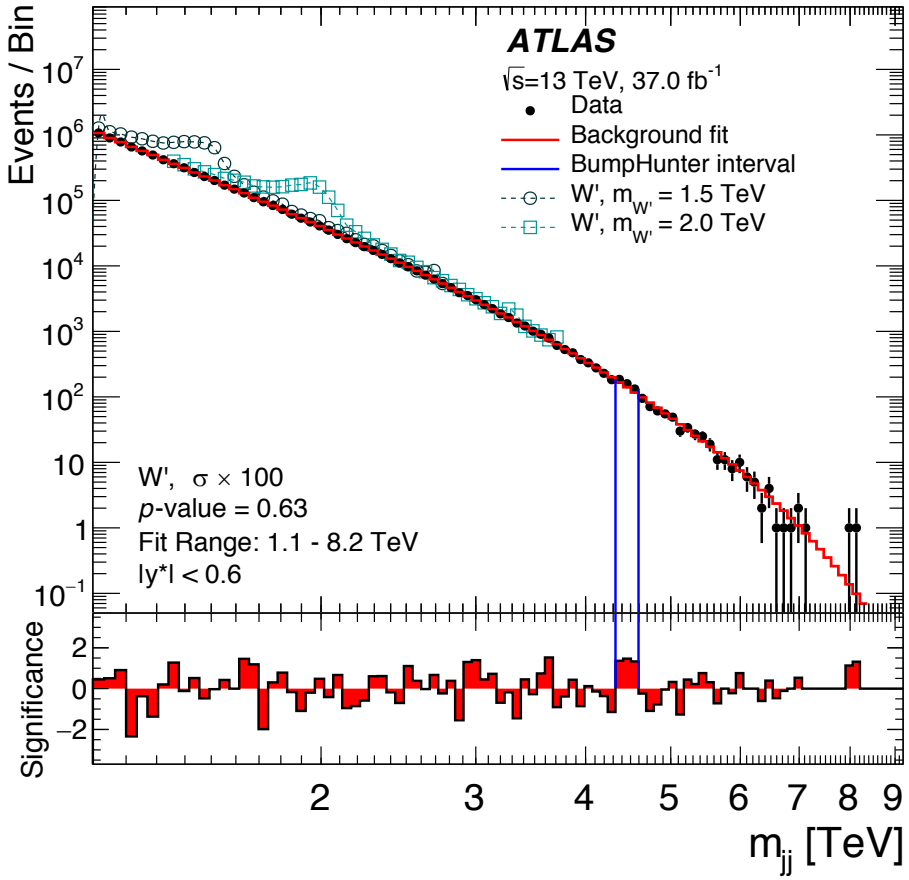
- However, with the growing statistics, the global fitting fails
  - Wilks p-value unstable over increasing luminosity
  - Visible spurious signal in Data/MC comparison





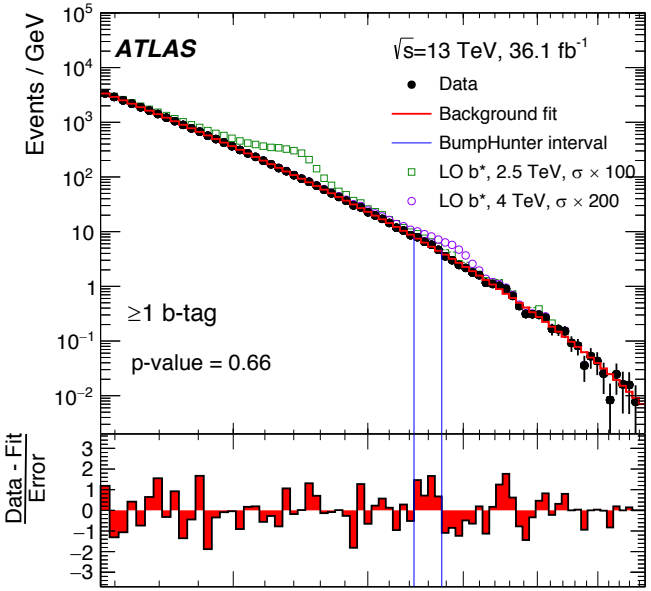
Background Sliding Window Fit

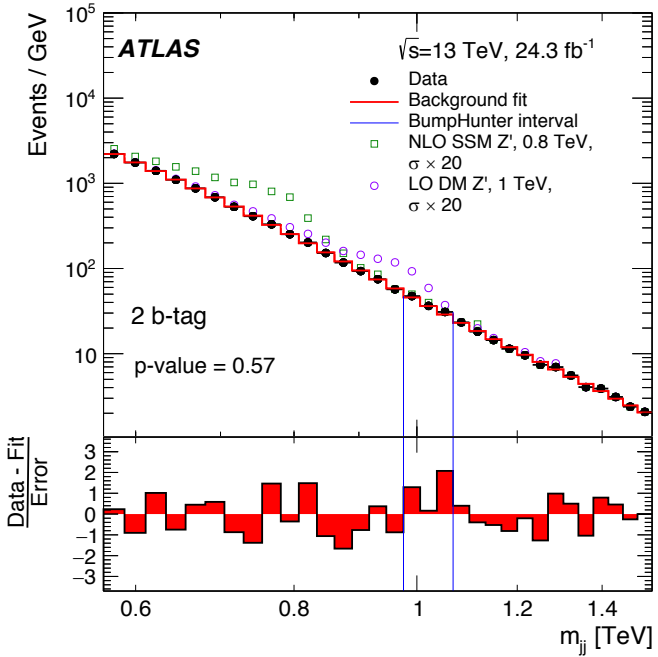
- For the background yield in each bin, local fit within a window
- Iterate window selection to obtain
  - Window width (largest possible window size)
  - Function form (fewest number of parameters)
  - Fit criteria: p-value>0.05
- Passing signal injection tests

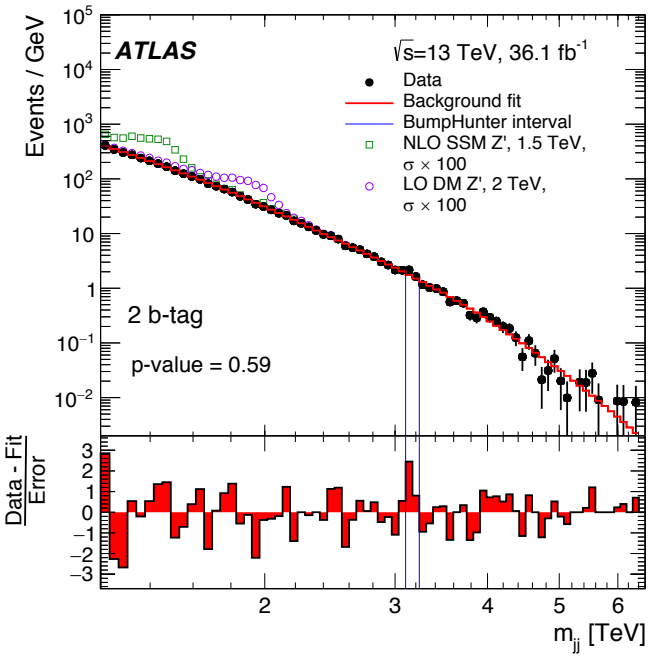


Bump-Hunter Results

- No significant excesses are observed.
- P-values are ~0.6 in three categories.

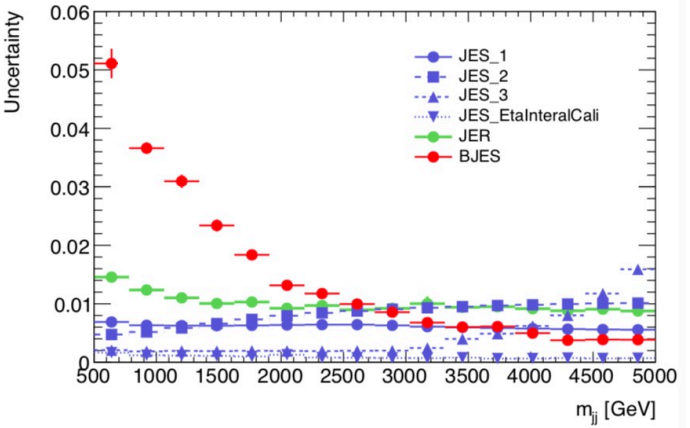


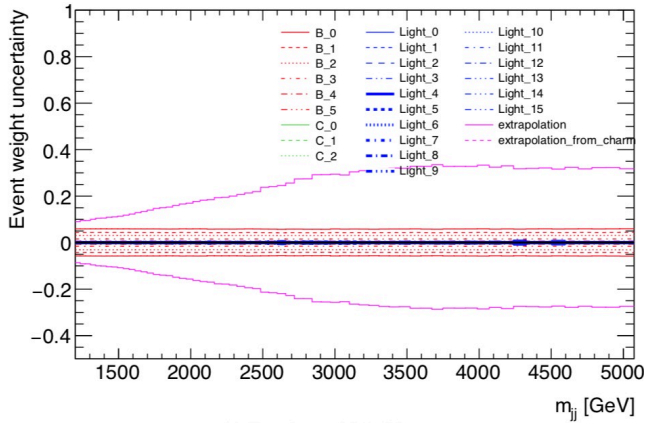




Systematics

- Background modeling
  - Fit function: from alternate function
  - Fit parameter: from 1000 pseudo-experiments
- Signal modeling
  - Luminosity: 2.2% for 2016, 2.1% for 2015+2016
  - JES/bJES/JER: <5%
  - B-tagging: 5%-30%

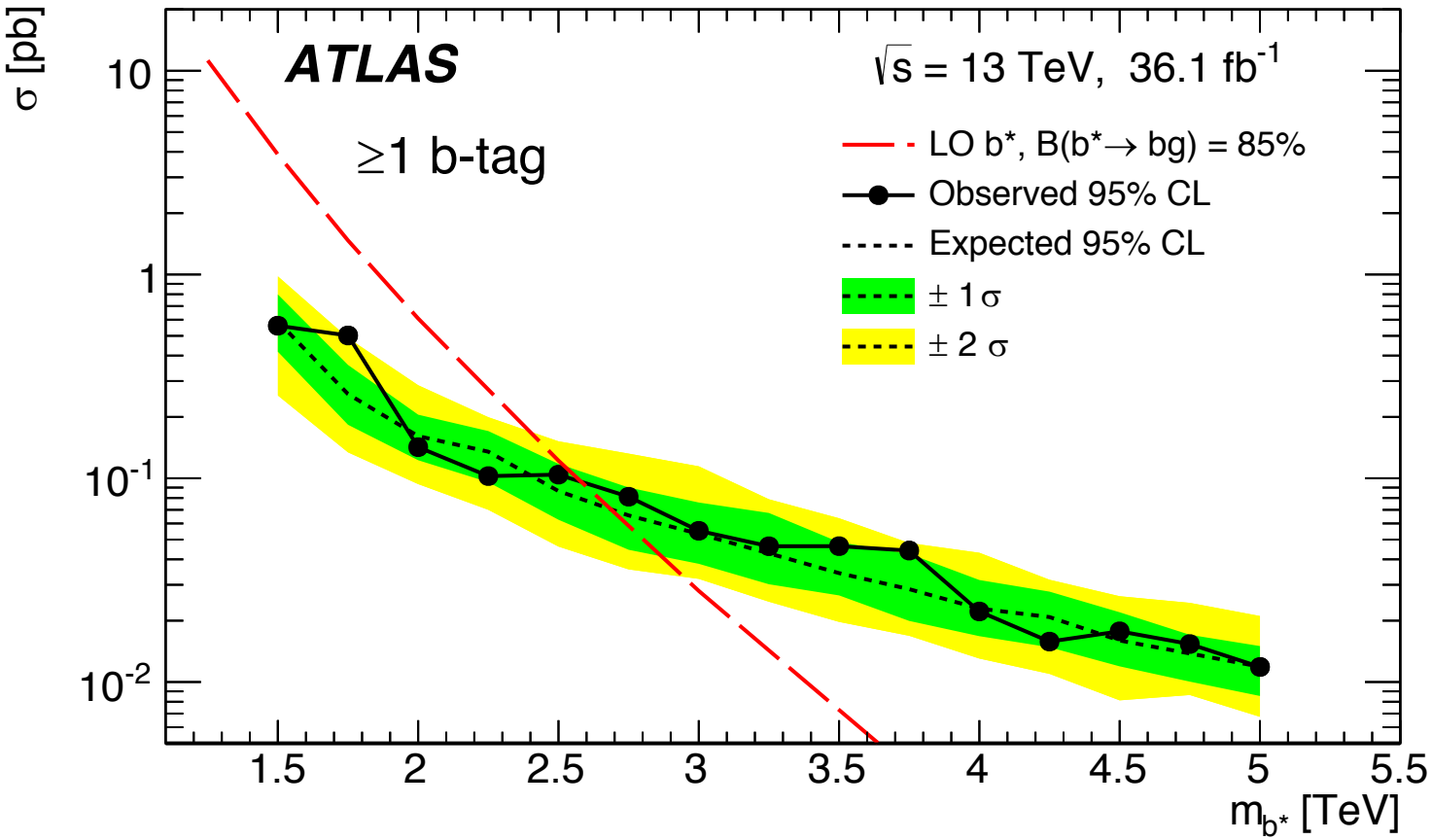




Rec. mass (TeV)	JES (para1 / para2 / para3 / para4)	JER	bJES	b-tagging SF ($\geq 1b$-tag/$2b$-tag)
0.6	0.7% / 0.5% / 0.2% / 0.15%	1.4%	5%	- / 5%
1.0	0.6% / 0.5% / 0.2% / 0.1%	1.2%	3%	- / 7%
1.5	0.6% / 0.7% / 0.2% / 0.1%	1.0%	1.8%	5% / 10%
3	0.6% / 0.9% / 0.2% / 0.05%	0.9%	0.7%	5% / 30%
5	0.6% / 1.0% / 1.6% / 0.05%	0.9%	0.4%	5% / 30%

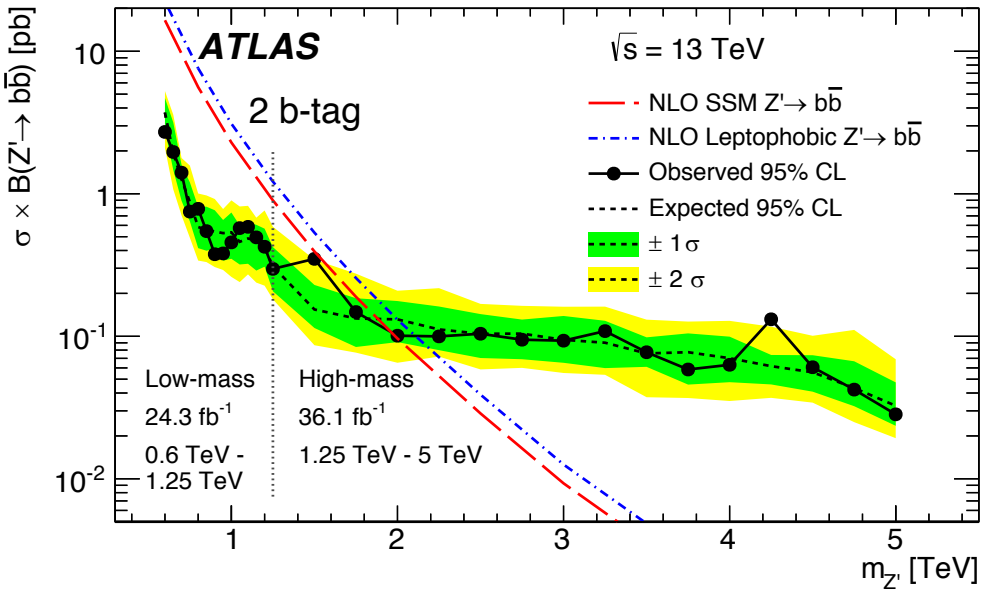
Exclusion Limits on b*

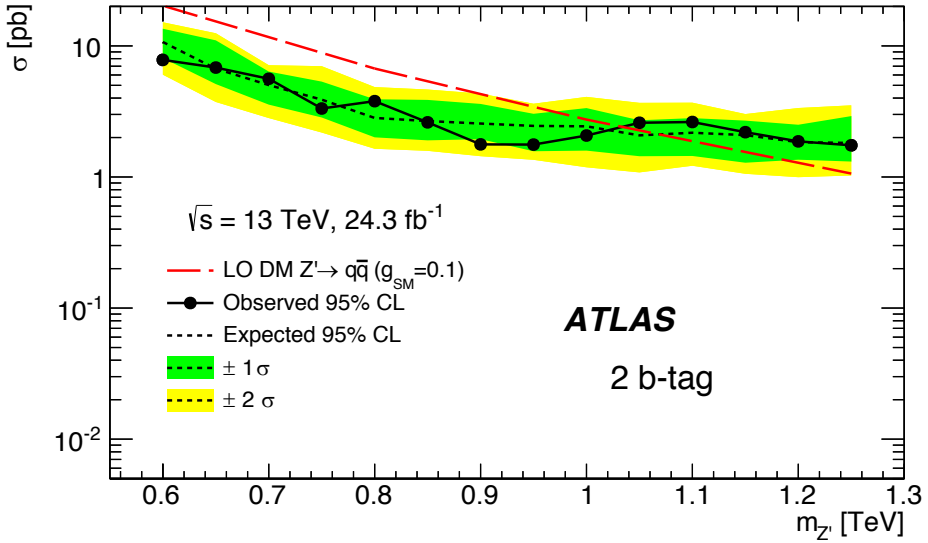
- Bayesian approach to set 95% upper limit on cross section.
- Exclusion on b* mass reaches 2.6 TeV (previously 2.3 TeV)

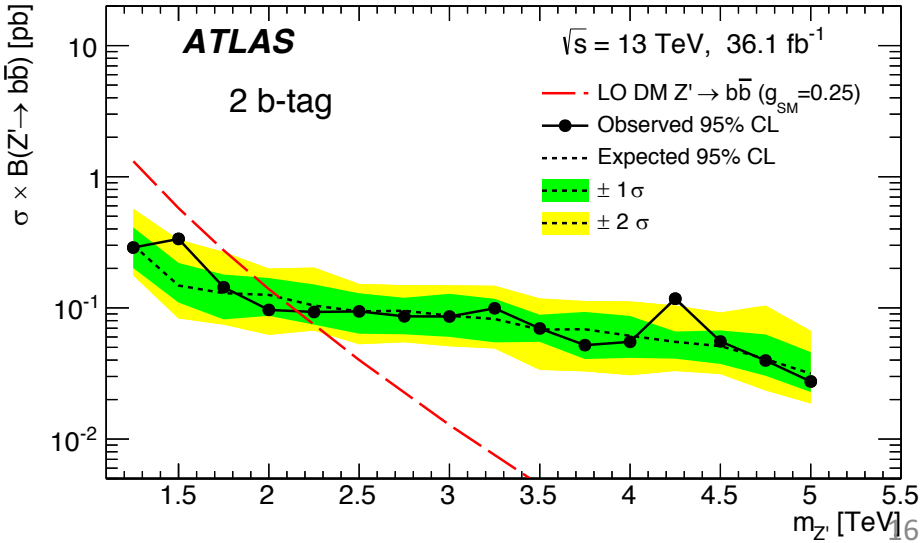


Exclusion Limits on Z’

- Excluded mass @ 95% C.L.
  - SSM Z’: 2.0 TeV
  - Leptophobic Z’: 2.1 TeV
- DM Z’ depends on decay mode and g_SM
  - Z’->bb, g_SM=0.25: 2.1 TeV
  - Z’->udcsb, g_SM=0.1: 1.03 TeV

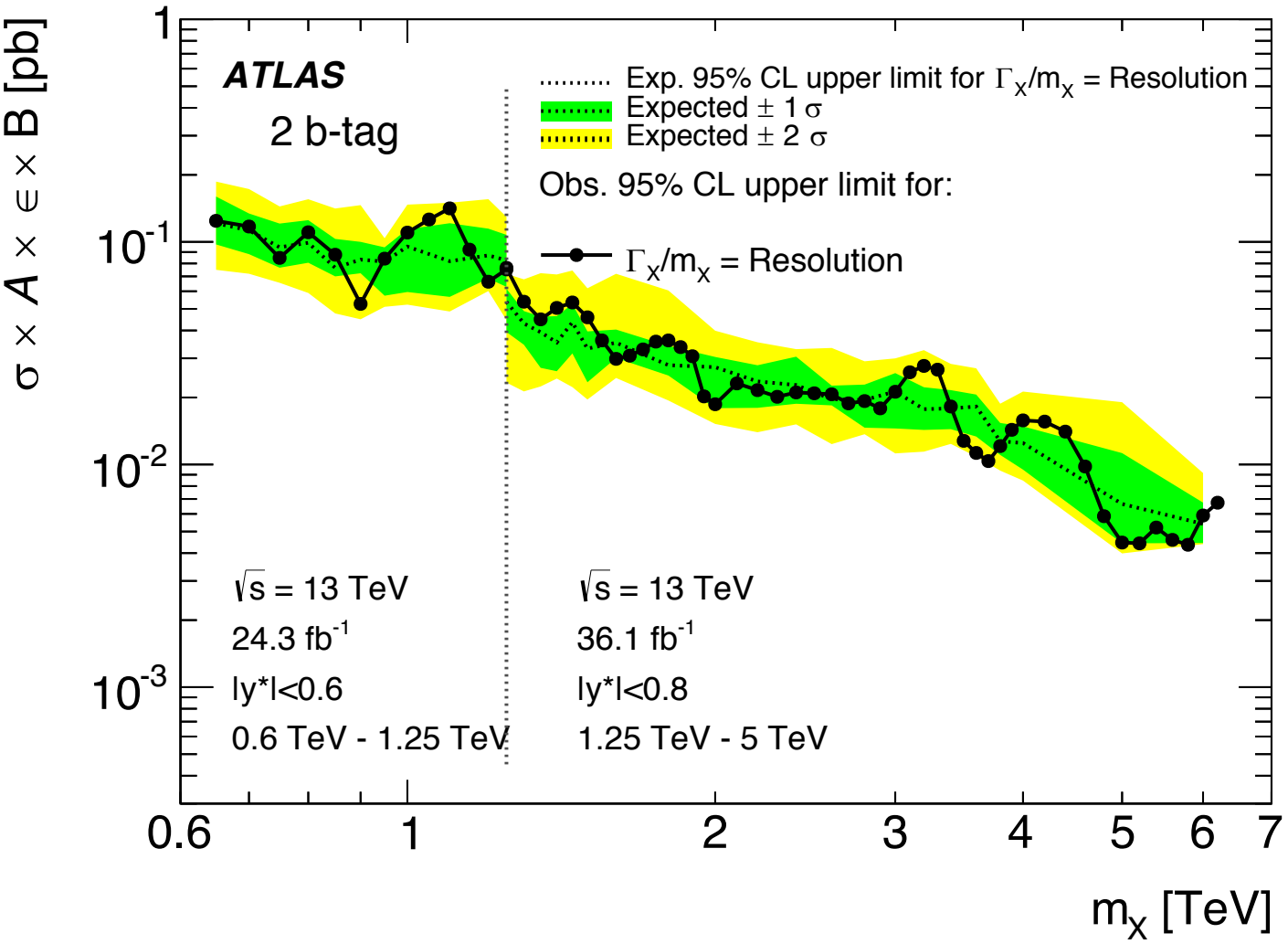






Exclusion Limits on Gaussian Peak

- General limits for narrow Gaussian resonance



Summary

- Search for resonances in the dijet final state with b-tagging has been performed at the ATLAS with 36 fb^{-1}.
  - Single jet trigger for high mass selection
  - Di-bjet trigger to reach low mass region
- B-tagging non-flat efficiency or fake rate introduces complexity in the background estimation.
- No significant excesses in the data.
- Strong constraints on the SSM Z', DM-SM mediator and b* are obtained.
- Next: 2015+2016+2017 data analysis (80 fb^{-1}) is starting.