Searches for resonances in hadronic final states with ATLAS detector

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On behalf of the ATLAS Collaboration

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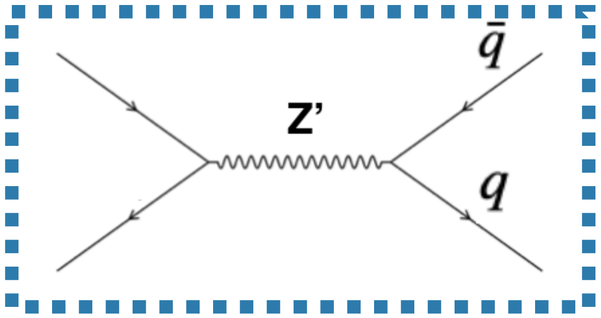
Outline

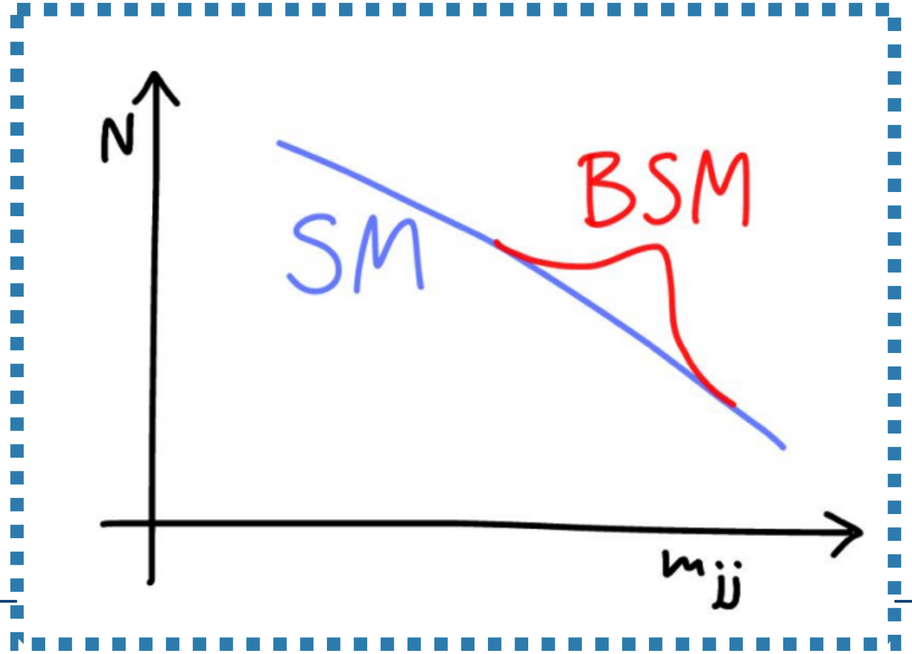
- **Focus on Full Run-2 results.**
  - **Search for new phenomena in dijet events (EXOT-2019-03)**
  - **Search for dijet resonances in events with an isolated charged lepton (EXOT-2018-32)**
  - **Search for heavy particles decaying into a top-quark pair in the fully hadronic final state (EXOT-2018-48)**

Introduction



Make invariant mass distribution from leading and subleading jets

- Analytic function used to fit smoothly falling background
- BumpHunter used to search for the excess of events above background
  - most significant interval defined by bins have smallest probability of arising from fluctuation



Set 95% CL limits on the BSM model if no significant deviation found

High-mass dijet resonances

- Search for high-mass resonances X-> jj
  - Inclusive dijet search and dedicated di-b-jet signature
- Trigger requires 1 jet with pT >= 440 GeV

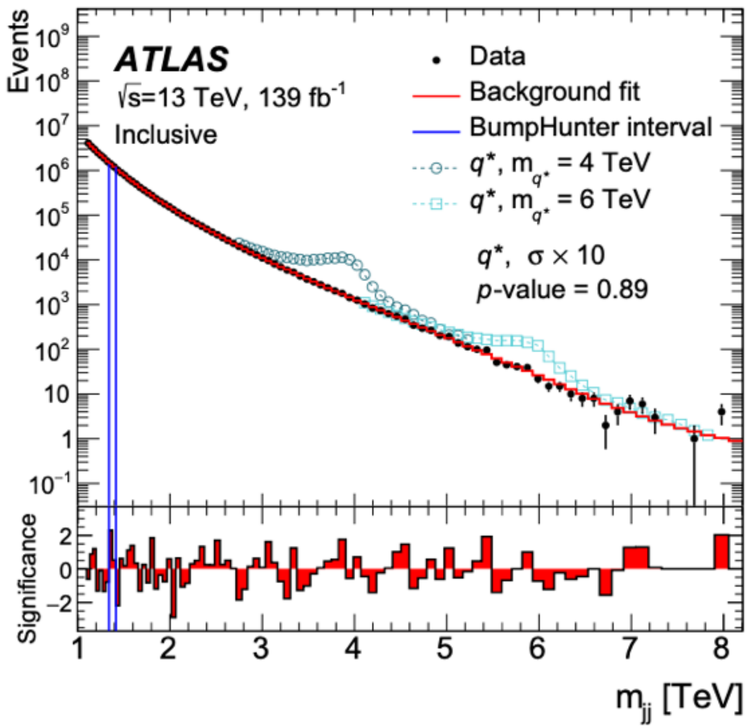
Category	Inclusive		1b	2b
$\|y^*\|$	< 0.6	< 1.2	< 0.8	
m_{jj}	> 1100 GeV	> 1717 GeV	> 1133 GeV	
b-tagging	no requirement		$\geqslant$ 1 b-tagged jet	2 b-tagged jets

- For all categories, background dominated by QCD multijet processes.

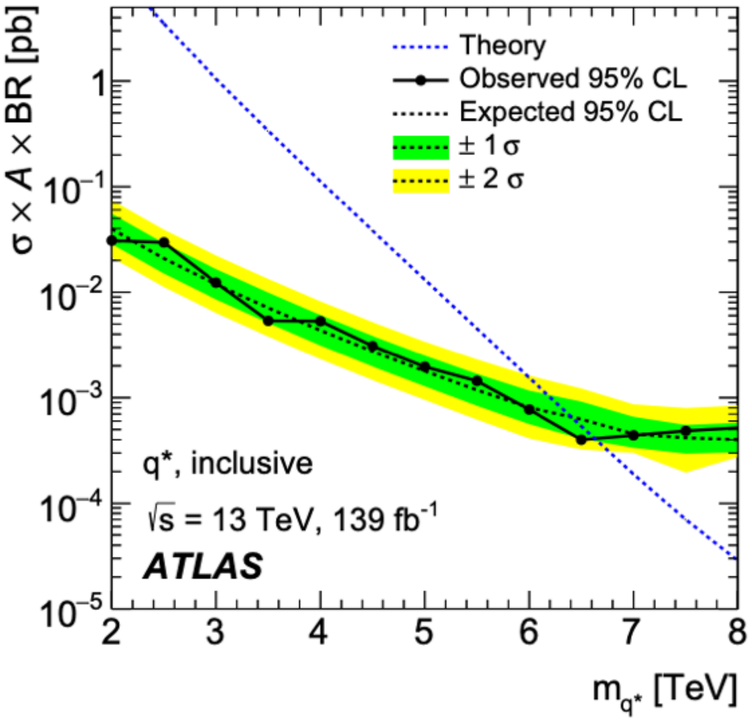
  Estimated through a sliding window fit to data with 4 parameter function:

$$f(x) = p_1(1-x)^{p_2} x^{p_3 + p_4 \ln x}$$

High-mass dijet resonances



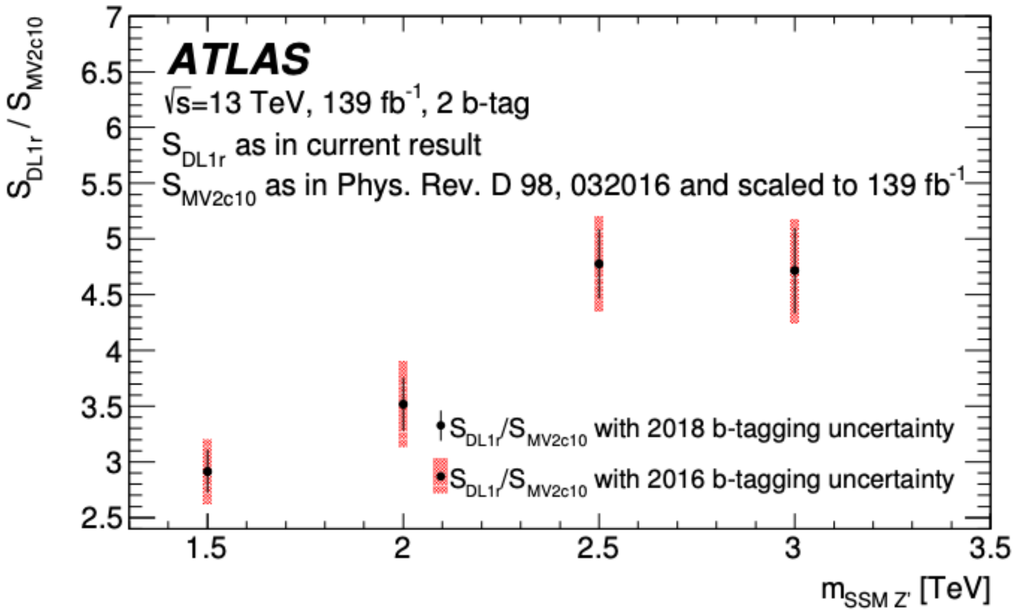
- No significant deviation found
- Frequentist CLs method used to calculate upper limits
- 95% CL upper limits set on σ*A*BR

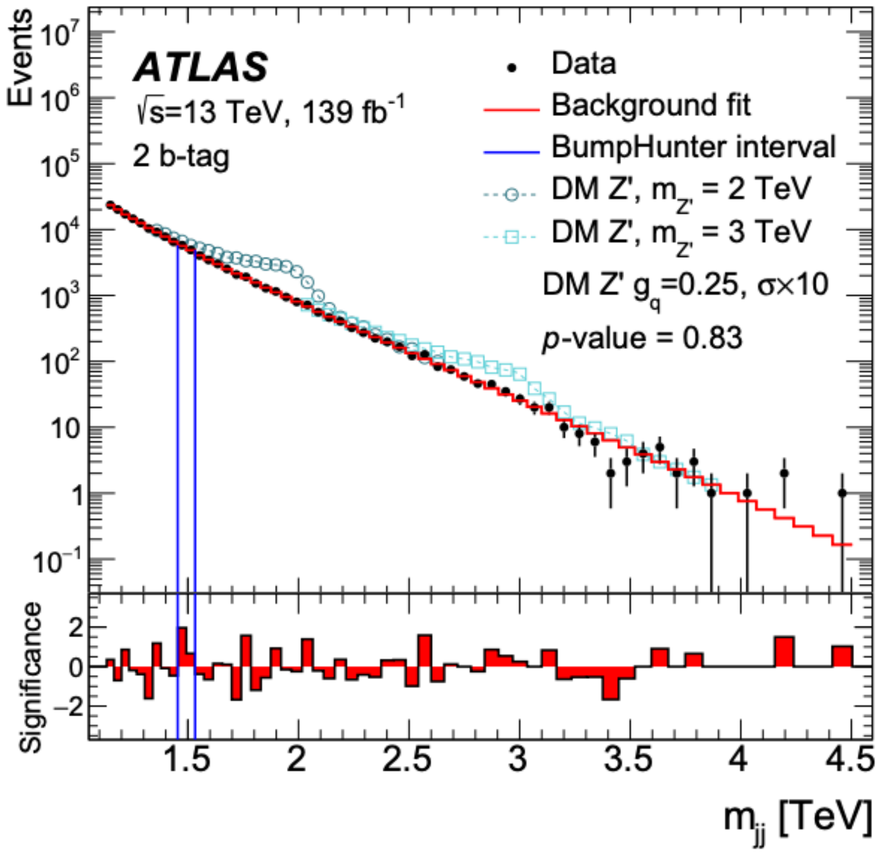


Model	Lower limit on signal mass at 95% CL	
	Observed	Expected
q^*	6.7 TeV	6.4 TeV
QBH	9.4 TeV	9.4 TeV
W'	4.0 TeV	4.2 TeV
W^*	3.9 TeV	4.1 TeV
DM mediator Z', $g_q = 0.20$	3.8 TeV	3.8 TeV
DM mediator Z', $g_q = 0.50$	4.6 TeV	4.9 TeV

High-mass dijet resonances

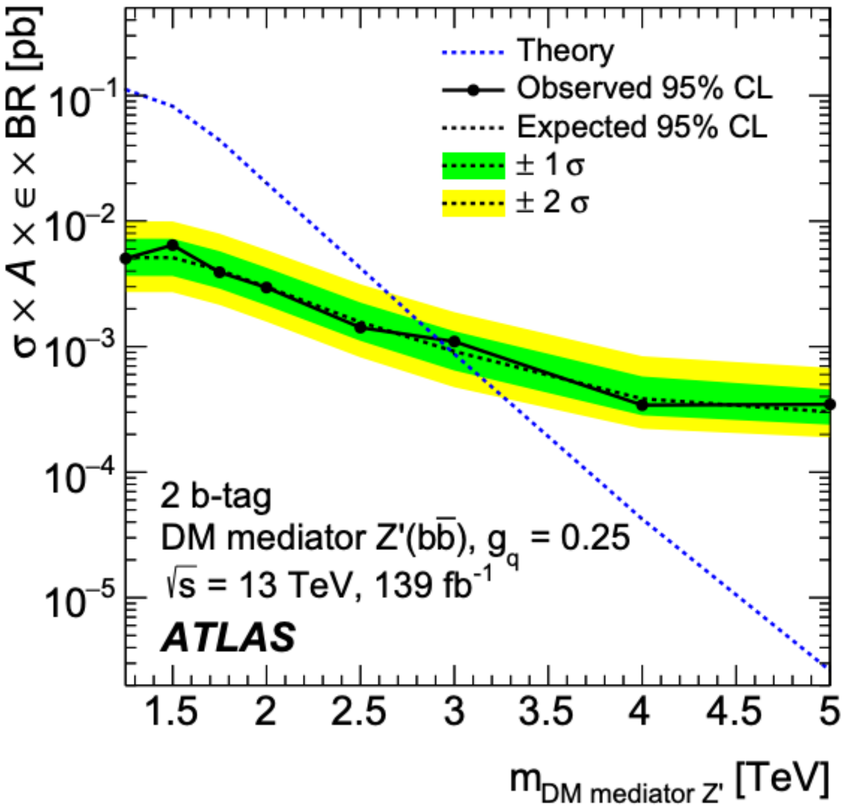
- DL1r tagger
  - DL1r uses a deep learning neural network
  - Improve the performance of jets with high p_T compared to MV2c10 tagger used in previous analysis which use BDT algorithm



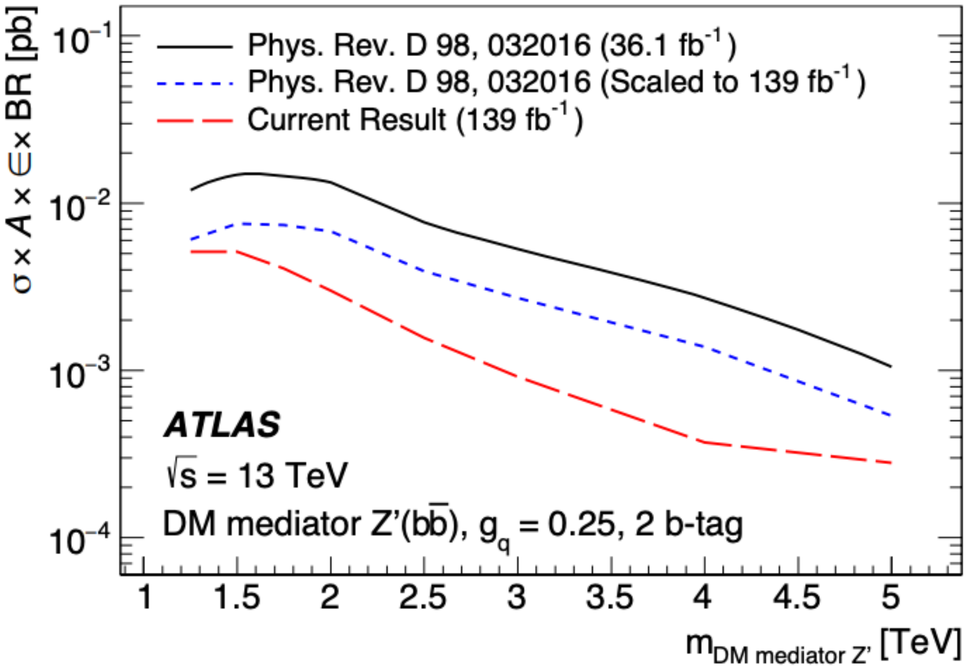


- No significant deviation found

High-mass dijet resonances

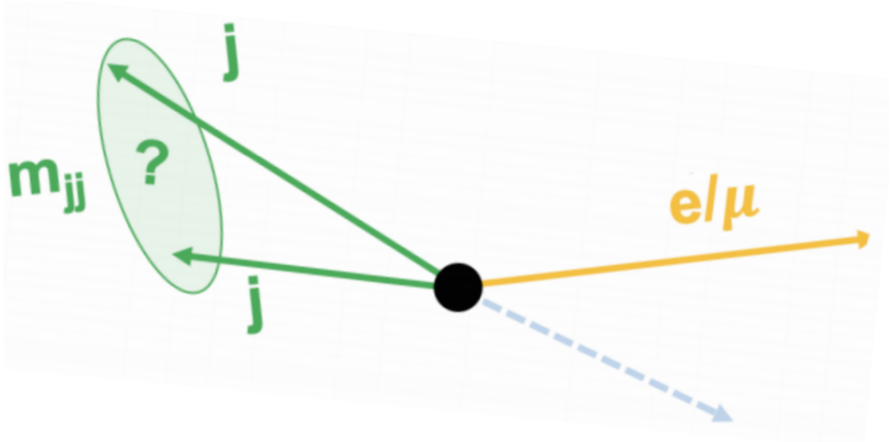


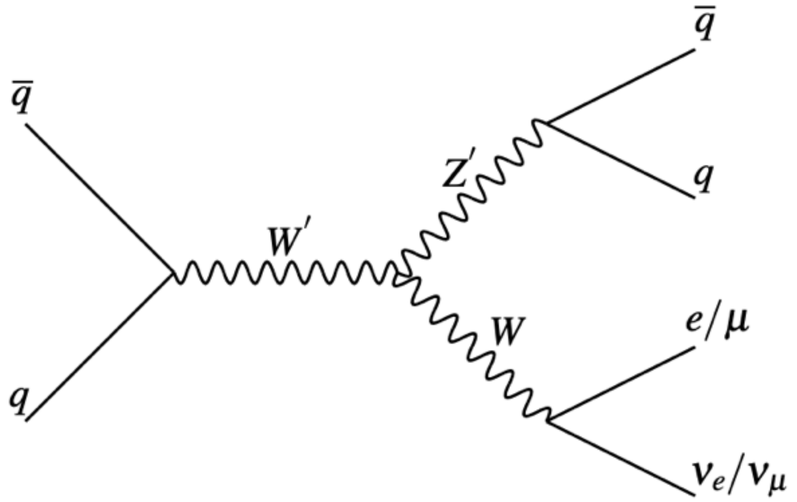
- 95% CL upper limits set on σ*A*BR*ε
- Improvement compared to previous publication:
  - Benefits from substantial improvement in the b-jet tagging algorithm and associated systematic uncertainties.
  - The improvement is a factor within 1.2 and 3.5, maximum improvement at 4 TeV.



Dijet + lepton

- Search for resonances decaying to a pair of jets in events with leptons





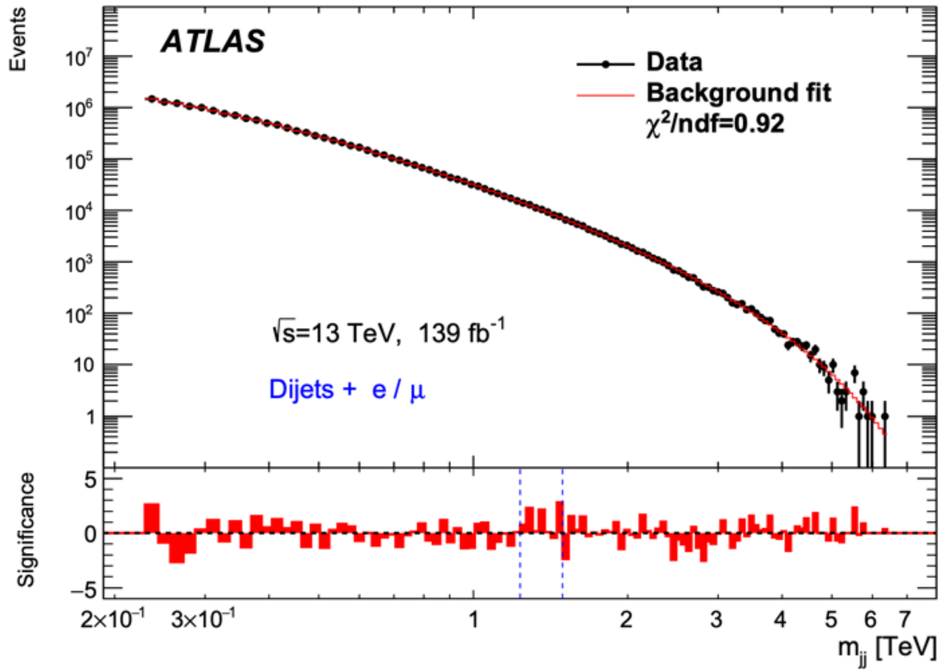
Final-state lepton (e/μ)

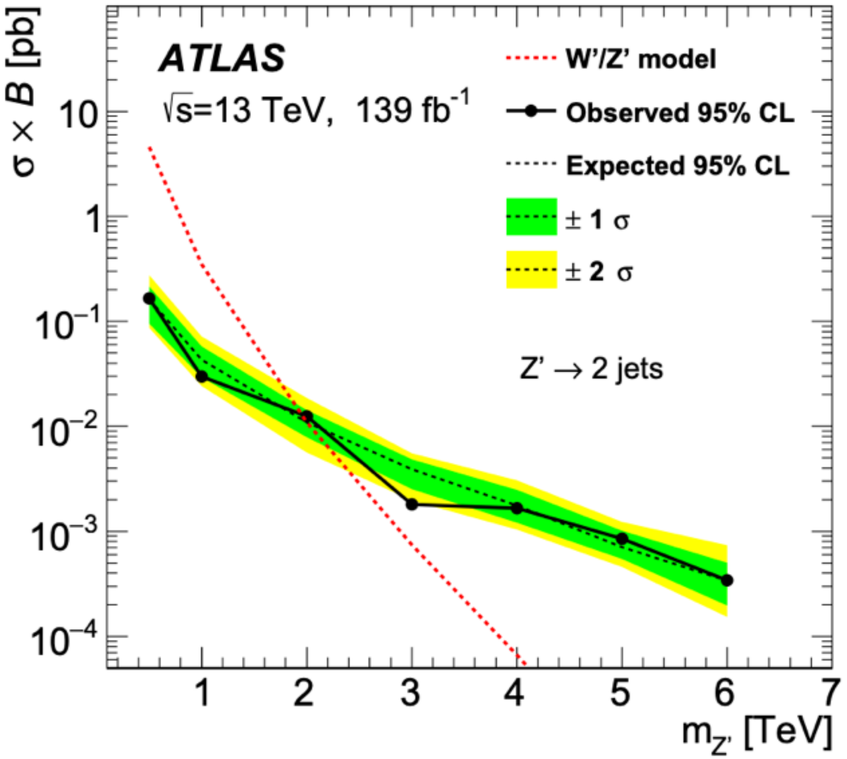
- Trigger based on the presence of electron or muon
  - Wide dijet invariant mass range: $0.22 < m_{jj} < 6.3$ TeV
- Inherently reduces dominate QCD multijet background
- Increased sensitivity to vector bosons, top quark processes

Dijet + lepton

- The following fit function is used to model th shape of the estimated background:

$$f(x) = p_1(1-x)^{p_2} x^{p_3 + p_4 \ln x + p_5 \ln^2 x}$$





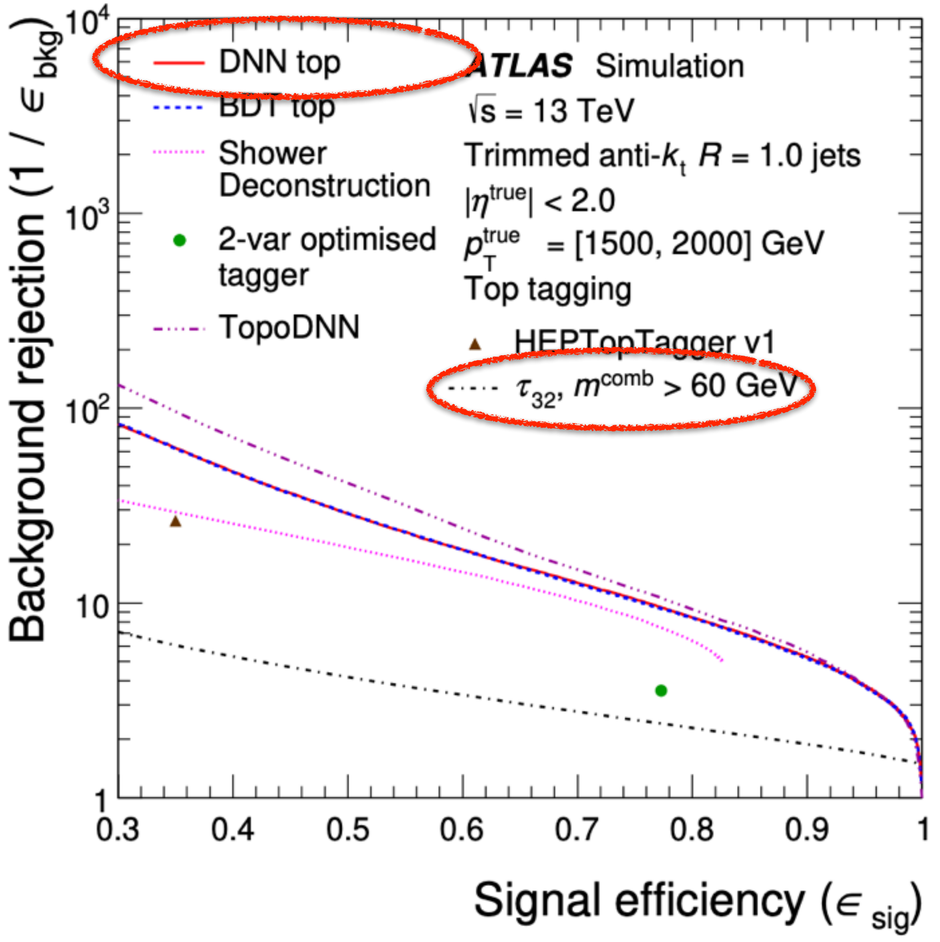
- No significant deviation found
- 95% CL upper limits set on various model
- SSM (W' → WZ' model):
  - Excluded for Z' masses up to 2 TeV

ttbar resonances in fully hadronic final states

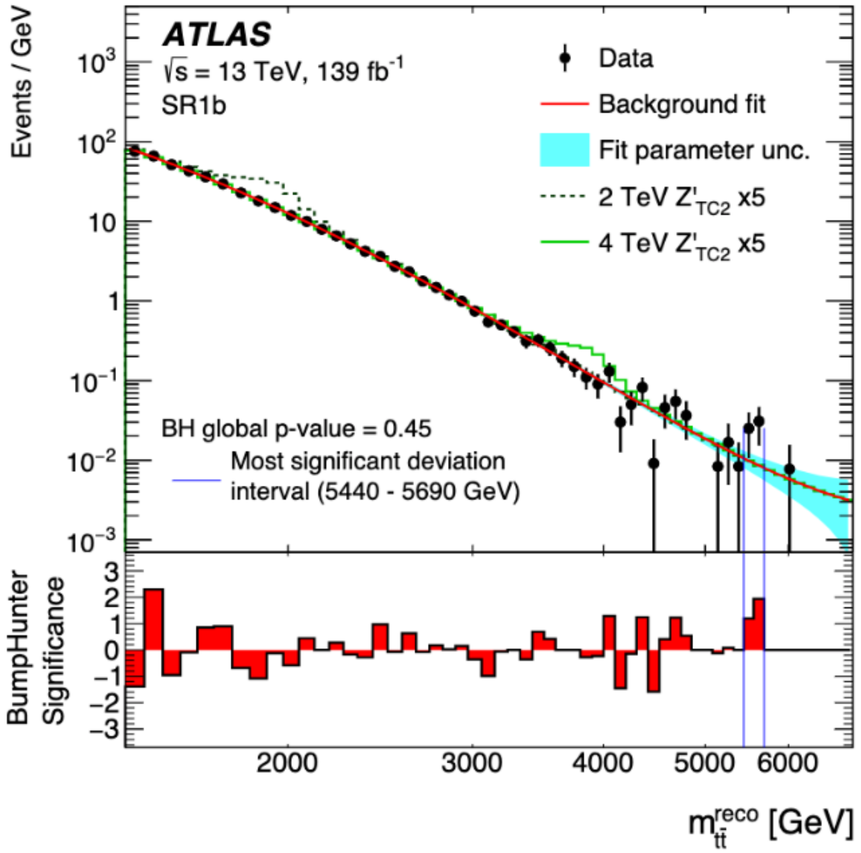
- Search for resonance decaying to ttbar in fully hadronic final states $t\bar{t} \to W^+bW^-\bar{b}$ with $W \to q\bar{q}'$

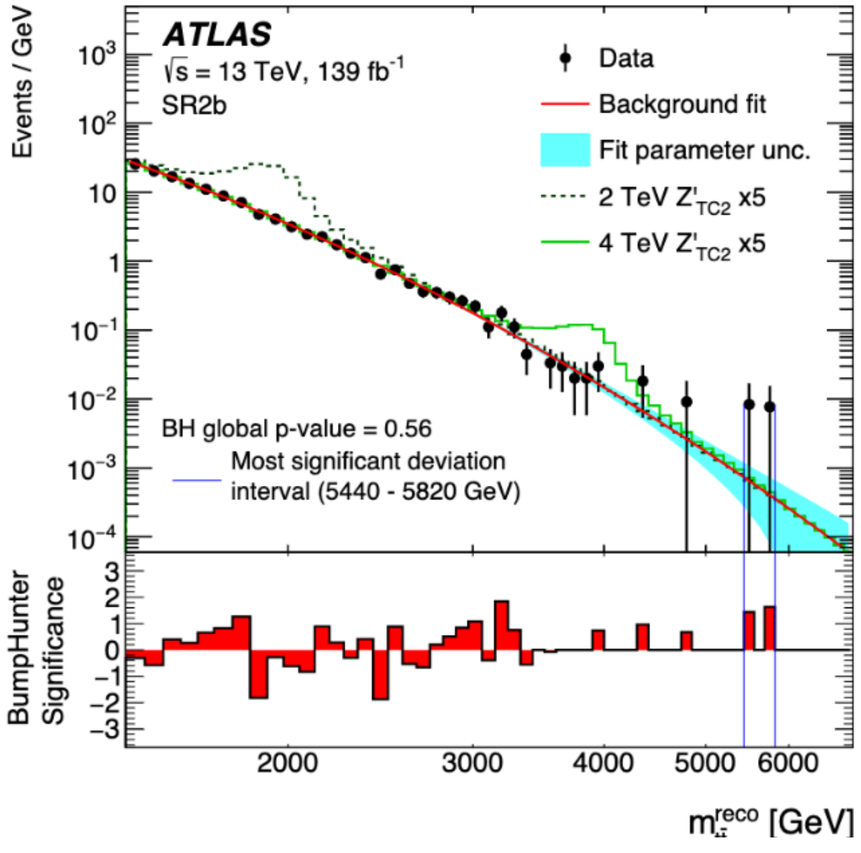
- Event selection:
  - Large-R jet trigger used, $m_{jj} > 1.4$ TeV
  - Leading and subleading large-R jets are top-tagged using deep neural network (DNN) top tagger at fixed 80% efficiency working point
  - One or both top jets should be matched to a variable radius (VR) track jets. The VR track-jets containing b-hadrons are identified using DL1 algorithm, 77% working point chosen

- Events are categorized into 2 channels based on number of b-tagged large-R jets: SR2b and SR1b



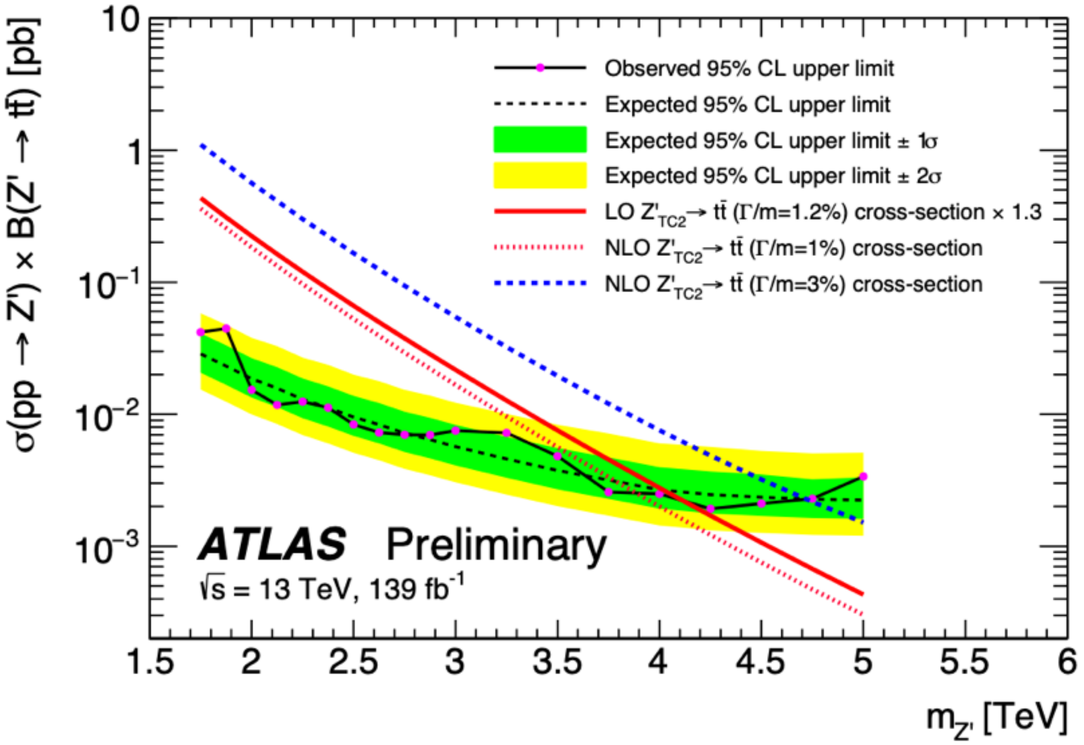
ttbar resonances in fully hadronic final states

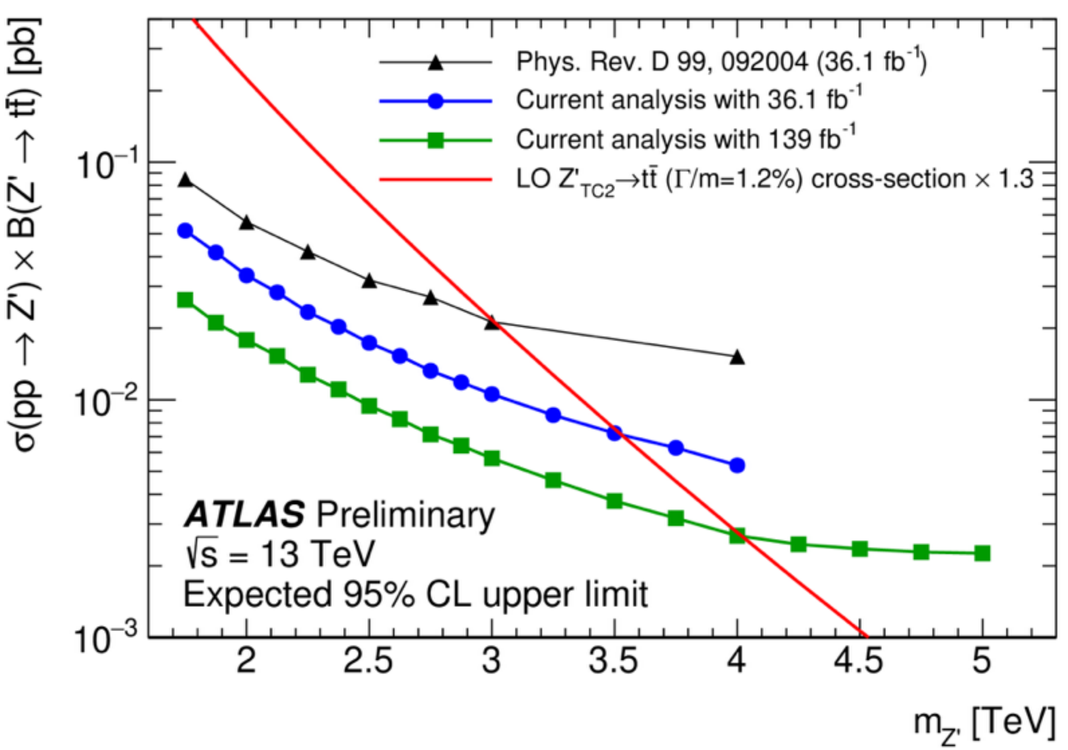




- Estimate background from data using a global fit: $F(x) = p_0(1-x)^{p_1} x^{p_2+p_3\log(x)+p_4\log(x)^2}$
- Function validated on MC ttbar + dijet MC + data driven dijet templates
- No significant discrepancy observed in data

ttbar resonances in fully hadronic final states





- Z'_{TC2} signal is excluded at m<~4 TeV (1.2% width) and m<~4.8 TeV (3% width)
- Great sensitivity gain exceeding increase of statistics:
  - 65% improvement in the expected cross section limit at 4 TeV comparing previous and current publication scaled to 36.1 fb^{-1}

Summary

- Discussed three recent updates based on the full Run-2 dataset:
  - dijet resonance search
  - dijet in events with an isolated charged lepton
  - ttbar high-mass resonance search in all-hadronic final states
- No evidence for new physics observed yet, 95% CL limits are set.
- Searches benefit from performance (b-tagging, top-tagging, etc) improvement!

THANK YOU!

Back-up

ttbar resonances in fully hadronic final states

- VR track jet b-tagging performance