# Search for low mass di-jet resonances in association with an ISR object at ATLAS

**Laser Kaplan**

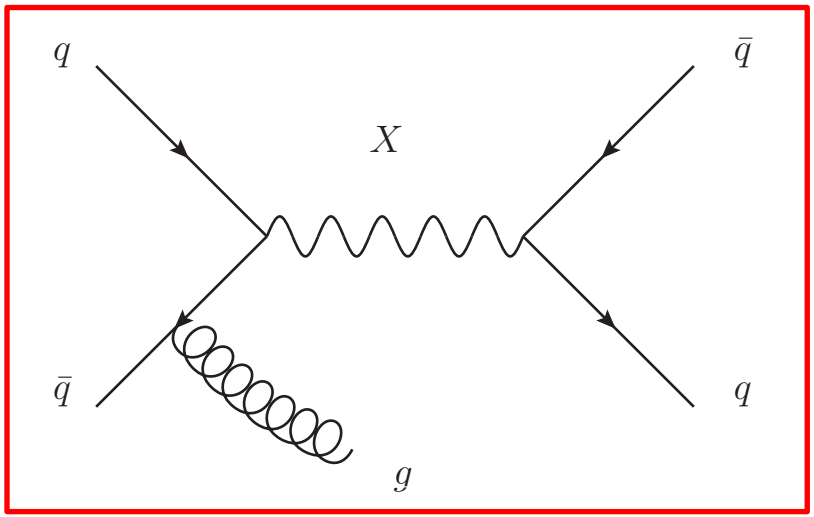
University of Wisconsin-Madison

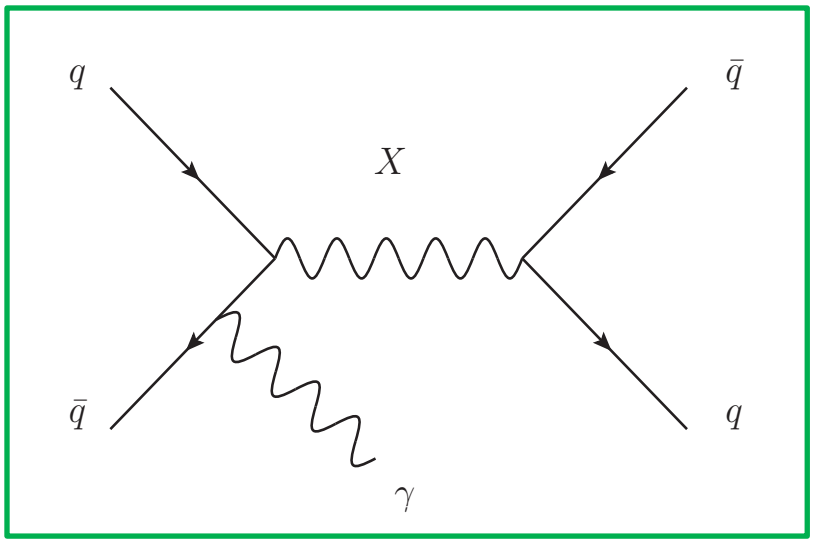
DPF 2017
August 1, 2017


# Introduction

- Overview/Motivation
- Event selection
- DDT technique/Optimization
- Background/Systematics
- W/Z region
- Conclusion

# Overview

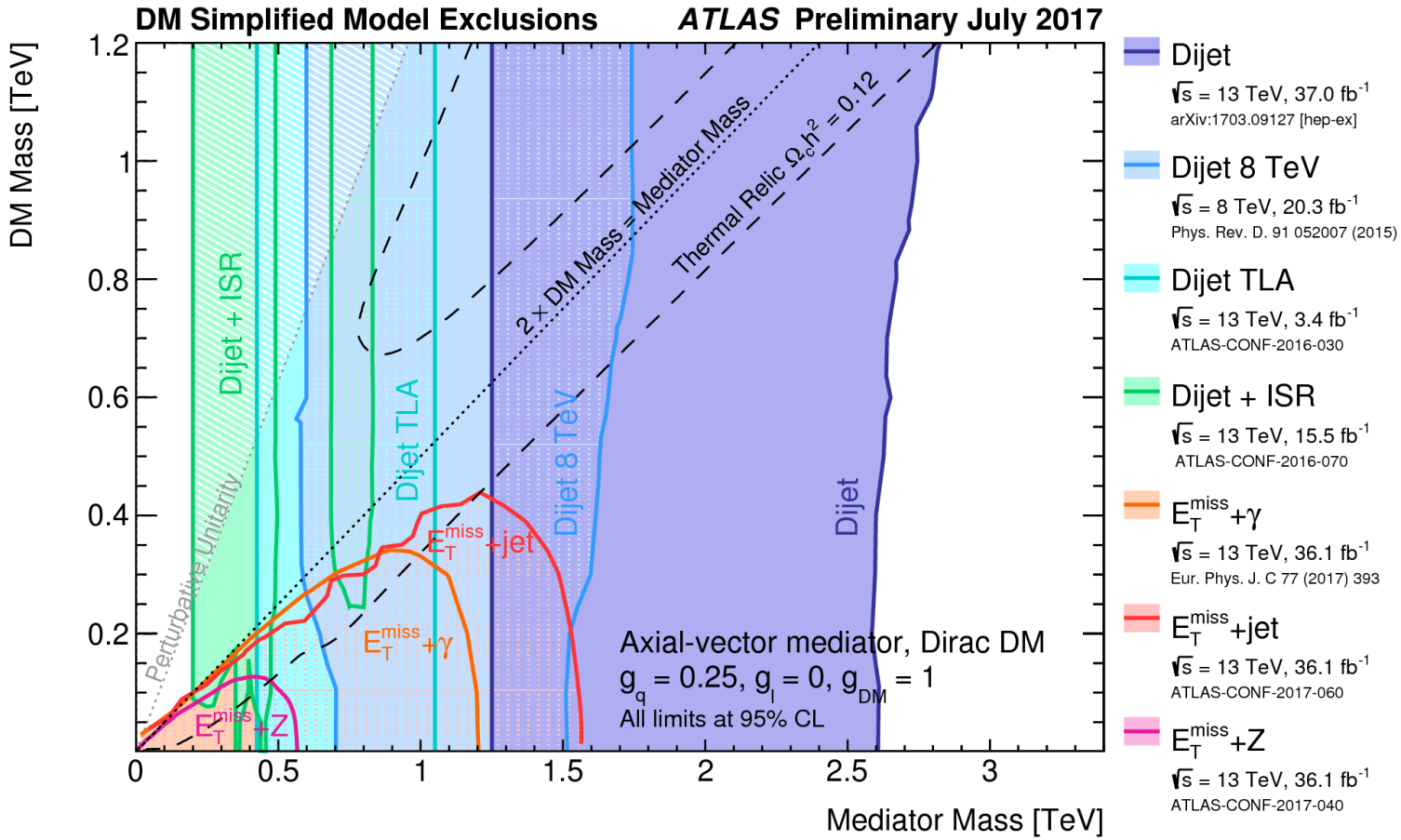



- Search for new low-mass resonances, in particular a lepto-phobic Z′ acting as a dark matter mediator
- ISR object acts as trigger requirement, both ISR jet and photon channels considered
- High $p_T$ requirement for ISR object forces resonance decay into boosted regime, where substructure techniques allow for additional signal/background separation
- Limits set on both production cross section and Z′-SM coupling ($g_{SM}$)

# Motivation

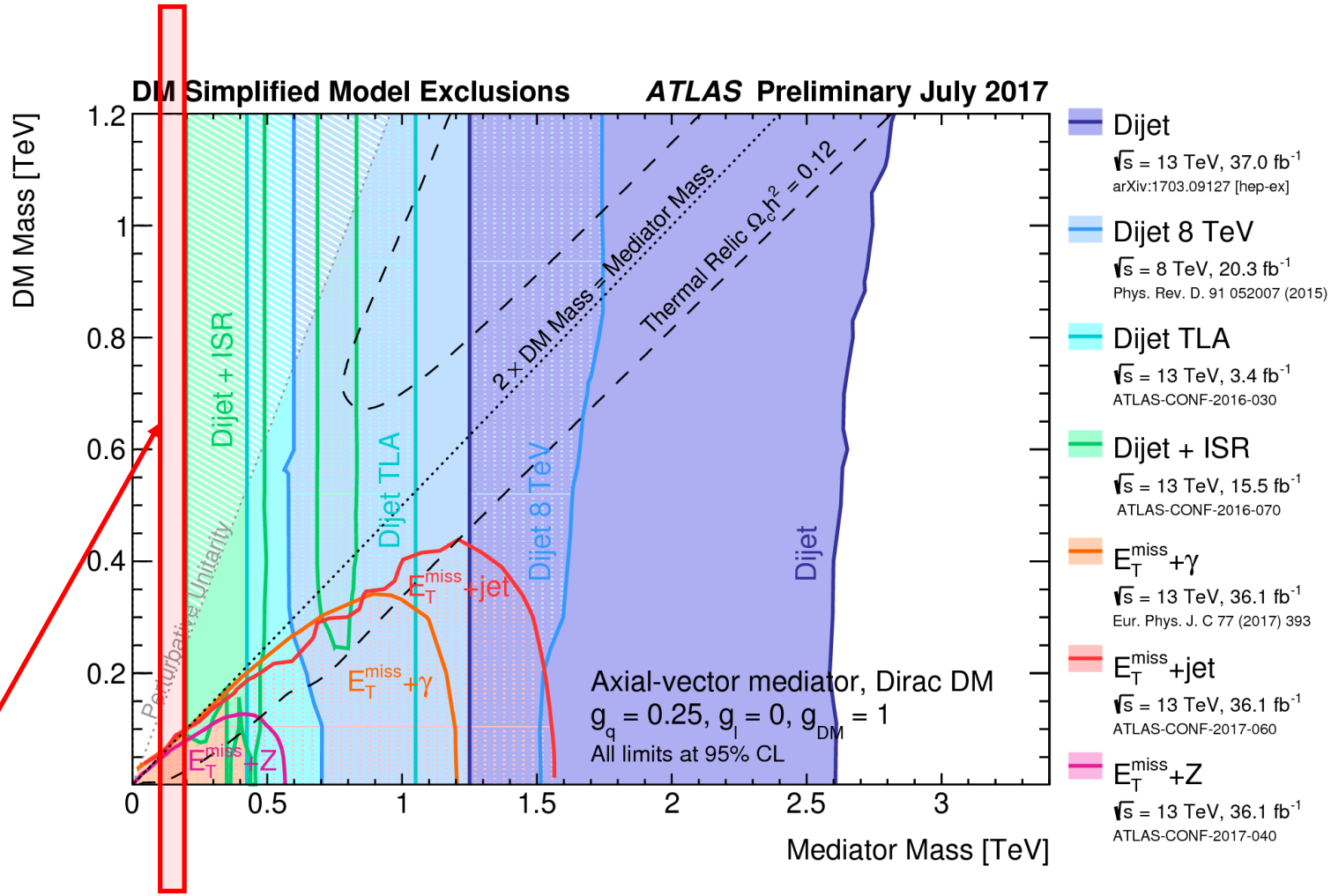
- Current searches already cover wide range of mediator mass, but trigger requirements and resolved mass spectrum fitting leave below 200 GeV to be probed




https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/EXOTICS/

# Motivation

- Current searches already cover wide range of mediator mass, but trigger requirements and resolved mass spectrum fitting leave below 200 GeV to be probed
- Goal of this analysis is to search down to ~100 GeV




https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CombinedSummaryPlots/EXOTICS/

# Event selection

- Final state consists of the resonance jet pair, reconstructed as a single large-radius jet, and one ISR object

- Analysis split into two channels: ISR jet and ISR photon

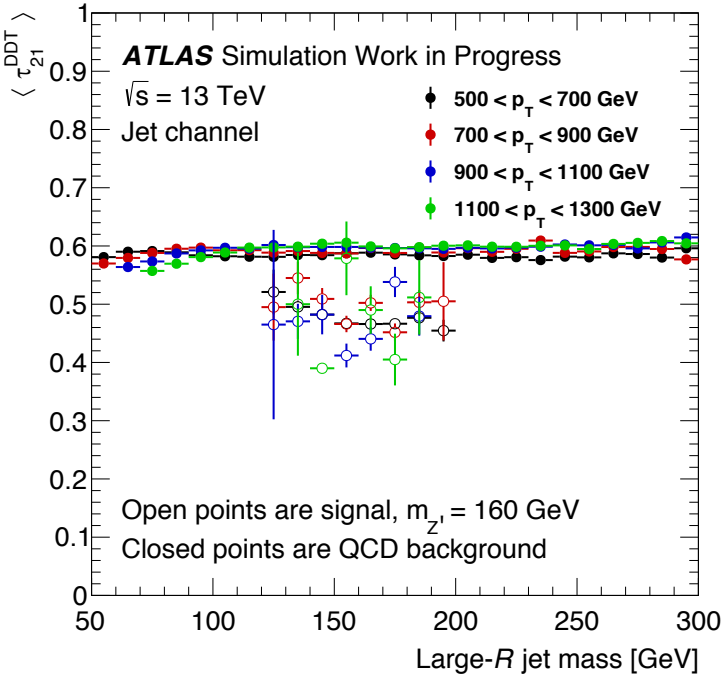
**ISR jet channel**

- One large-radius jet (R=1.0) with trimming and $p_T$ > 450 GeV
- One small-radius jet (R=0.4) with $p_T$ > 420 GeV
- $\Delta R_{J,j}$ > 1.0 (to ensure no overlap)
- $|\Delta\Phi_{J,j}|$ > π/2

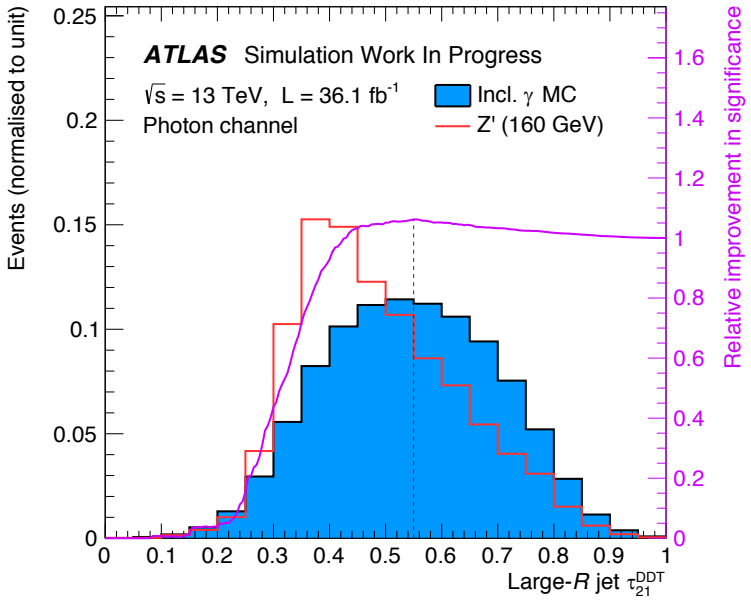
**ISR photon channel**

- One large-radius jet (R=1.0) with trimming and $p_T$ > 200 GeV
- One tight and isolated photon with $p_T$ > 155 GeV
- $|\Delta\Phi_{J,\gamma}|$ > π/2

# Designed Decorrelated Tagger technique



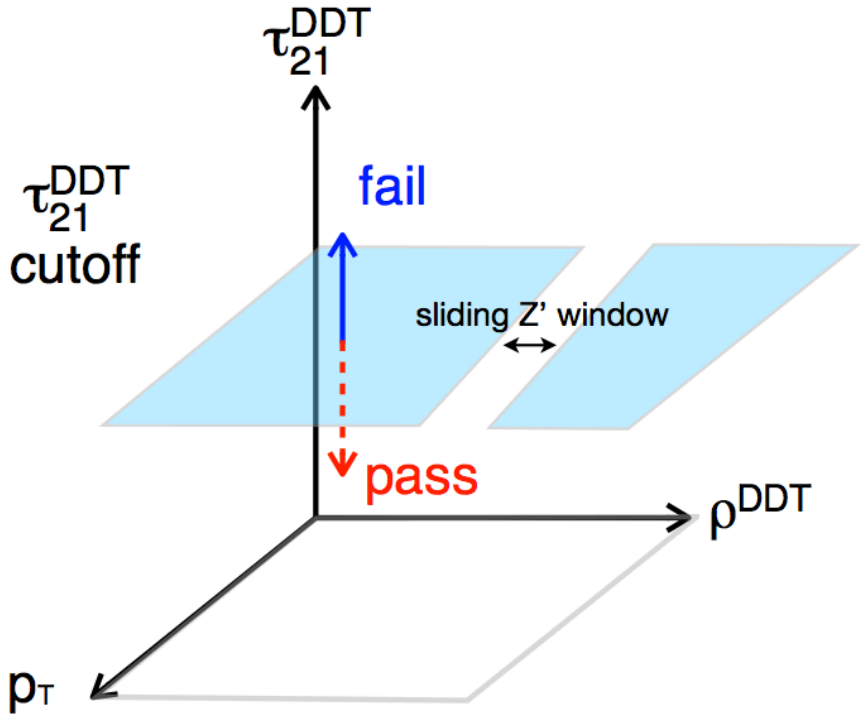

- Detailed in arXiv:1603.00027 (J. Dolen, P. Harris, S. Marzani, S. Rappoccio, N. Tran), first employed in arXiv:1705.10532 (CMS boosted di-jet + ISR result)
- Method for decorrelating jet substructure variables ($\tau_{21}$) from jet mass




- Then can use transformed $\tau_{21}^{DDT}$ to select signal-like events without skewing final background estimation
- Optimal selection value for all mass points is $\tau_{21}^{DDT} < 0.5$

# Background estimation and systematics

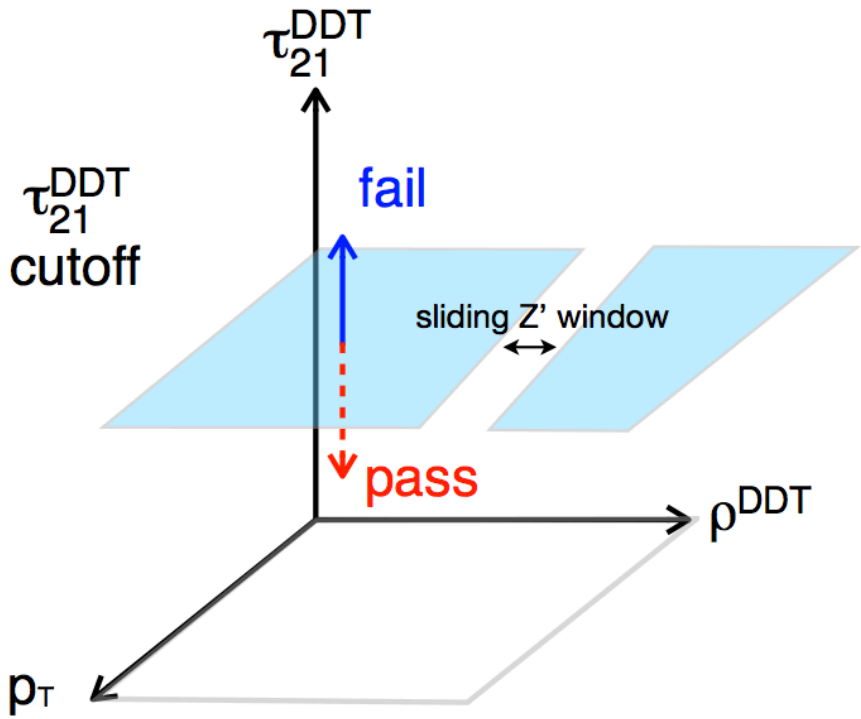
- Residual mismodeling between leading background Monte Carlo and data leads to data-driven background estimate
- Transfer factor (TF) constructed to bring events fail region ($\tau_{21}^{DDT} > 0.5$) to pass region ($\tau_{21}^{DDT} < 0.5$), parametrized in jet $p_T$ and $\rho^{DDT}$
- To avoid fluctuations from signal, 20% stripe around signal mass removed from TF corresponding to roughly twice the jet mass resolution
- Contribution from SM W/Z production subtracted at NLO




arXiv:1603.00027

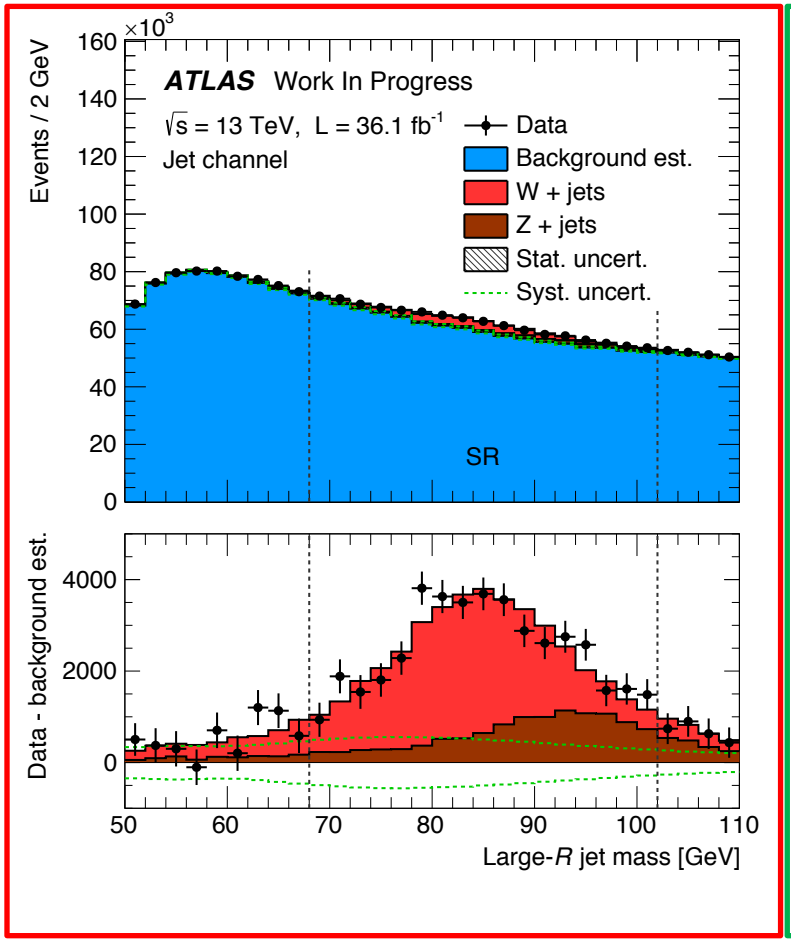
# Background estimation and systematics

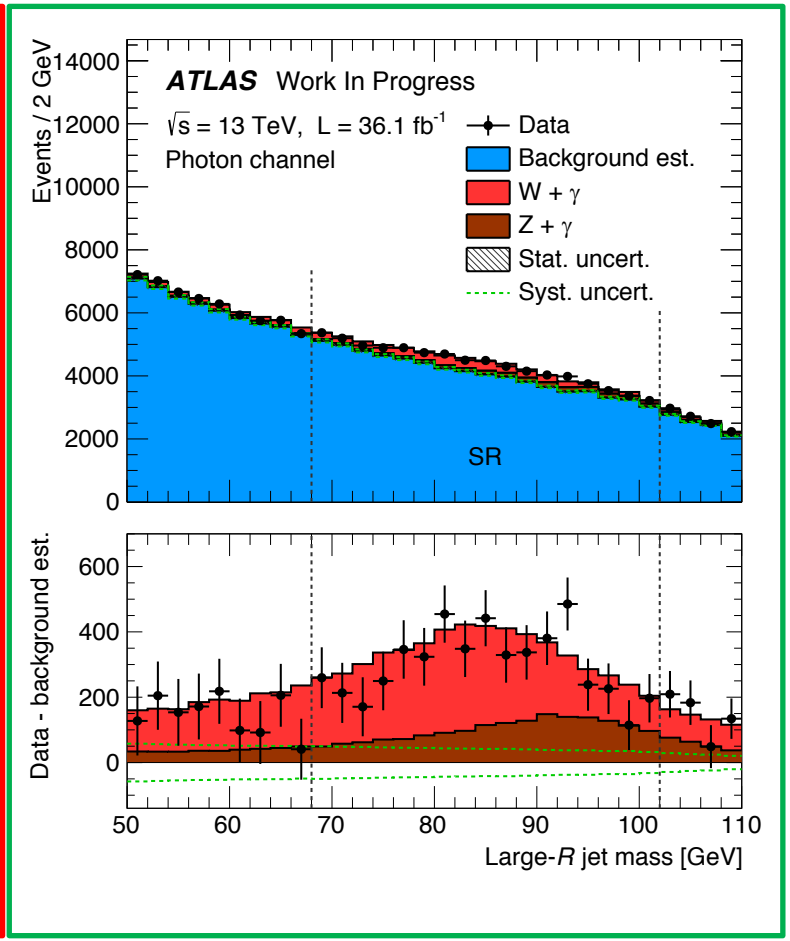
- TF 2D histogram smoothed with Gaussian process regression, providing continuous transformation with well-defined systematic errors
- TF systematic dominant uncertainty on background (~1%)
- W/Z + jet/photon additional backgrounds in final signal region, estimated from MC, XS corrected to NLO
- Other major uncertainties on MC backgrounds and signals: jet mass/$\tau_{21}$ scale, PDF, luminosity




arXiv:1603.00027

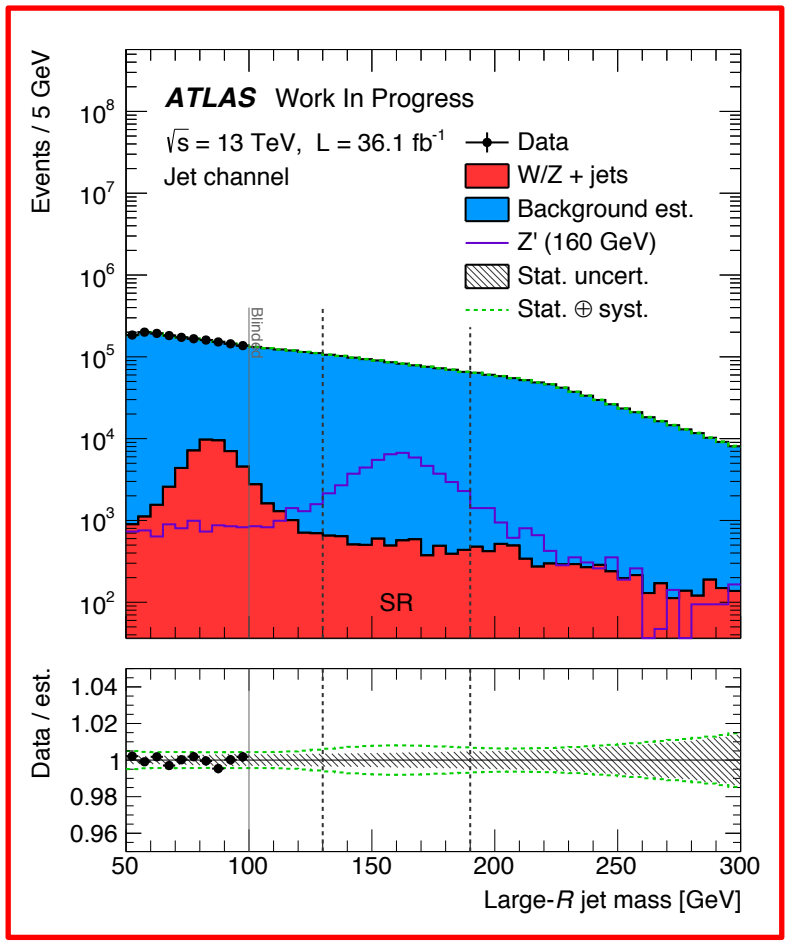
# W/Z region

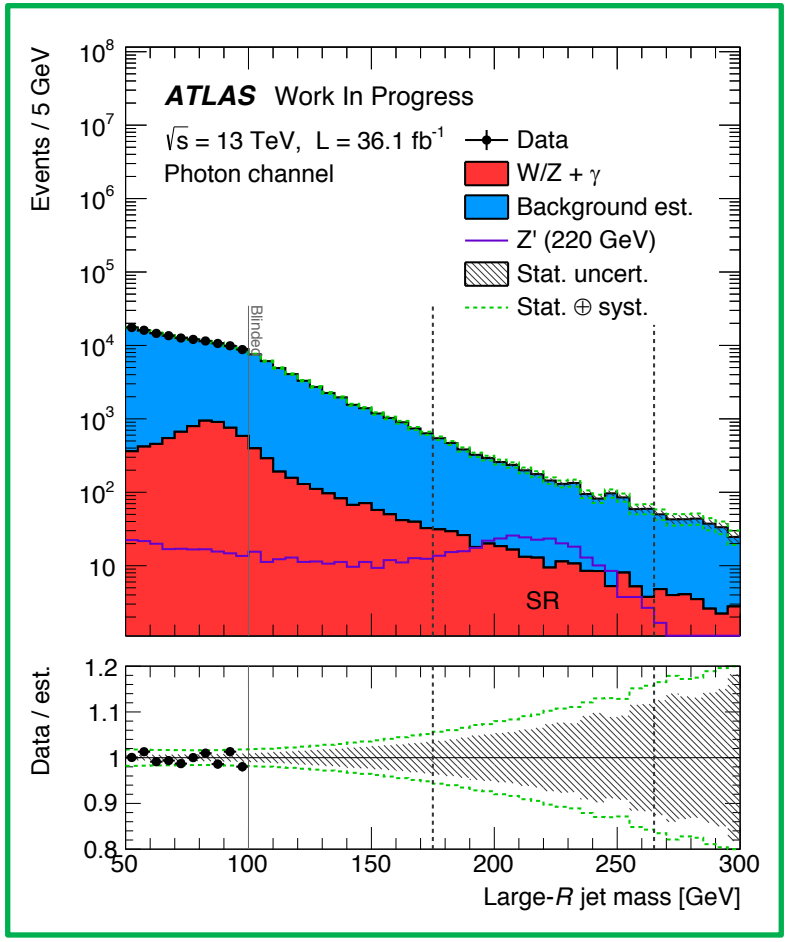



- Test of full analysis chain on known W/Z "signal"
- Best fit signal strengths consistent with 1 for both ISR jet and photon channels

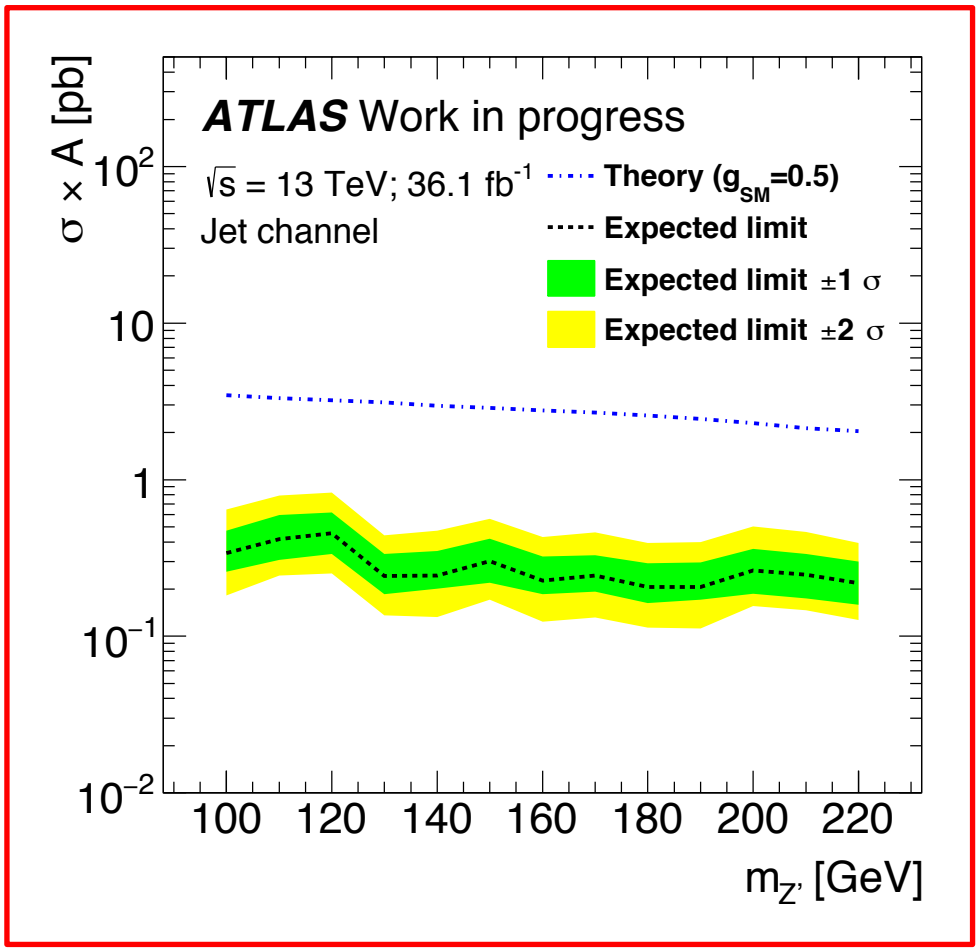
# Results

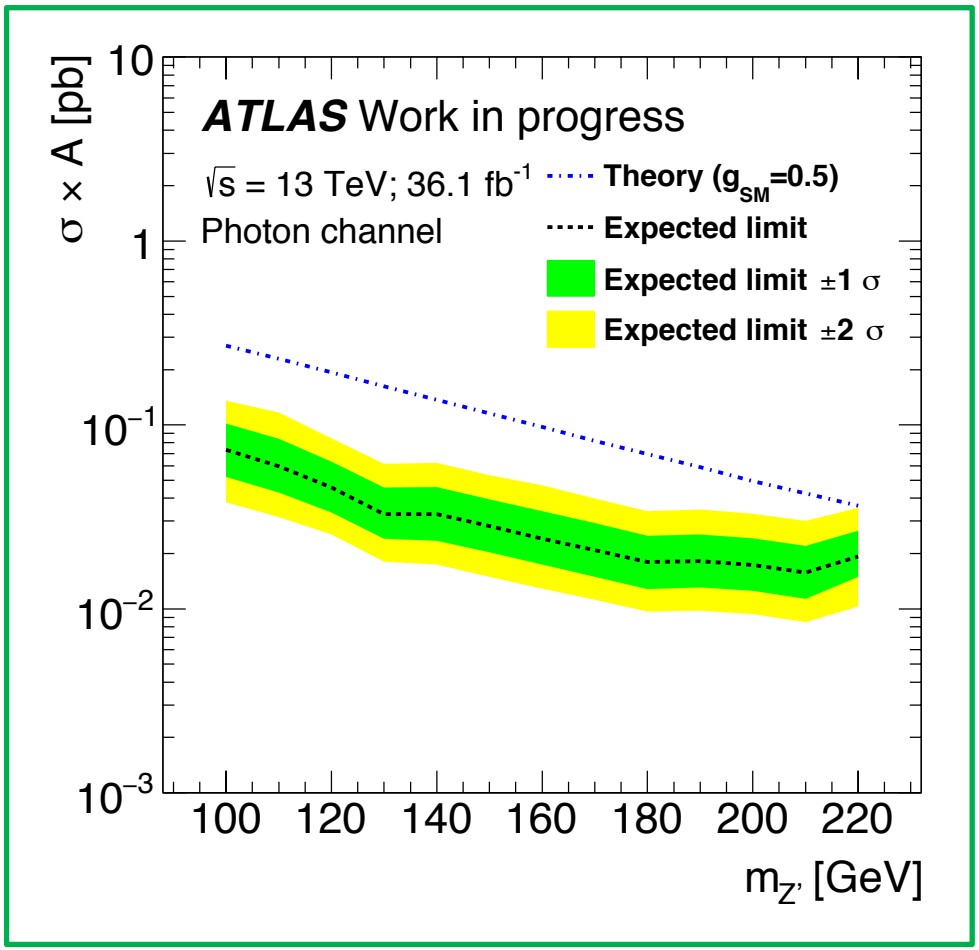



- Blinded jet mass spectra for ISR jet (overlaid signal with mass = 160 GeV) and photon (220 GeV) channels

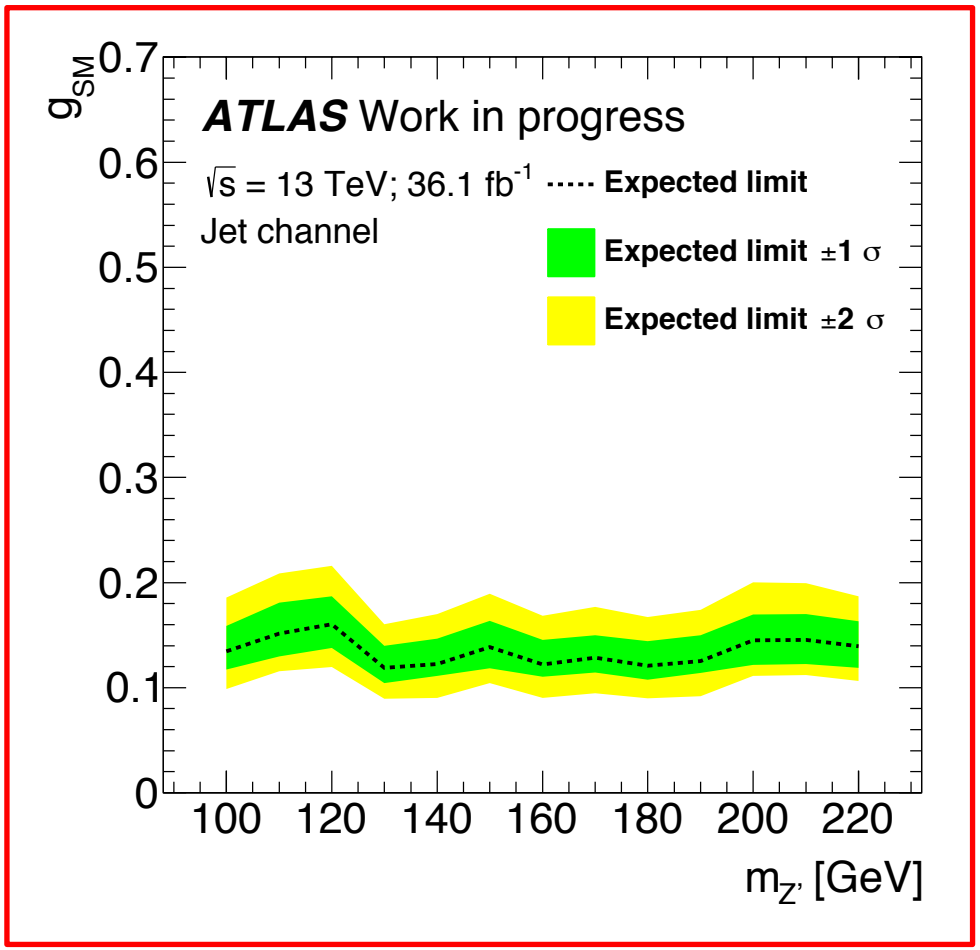
# Results

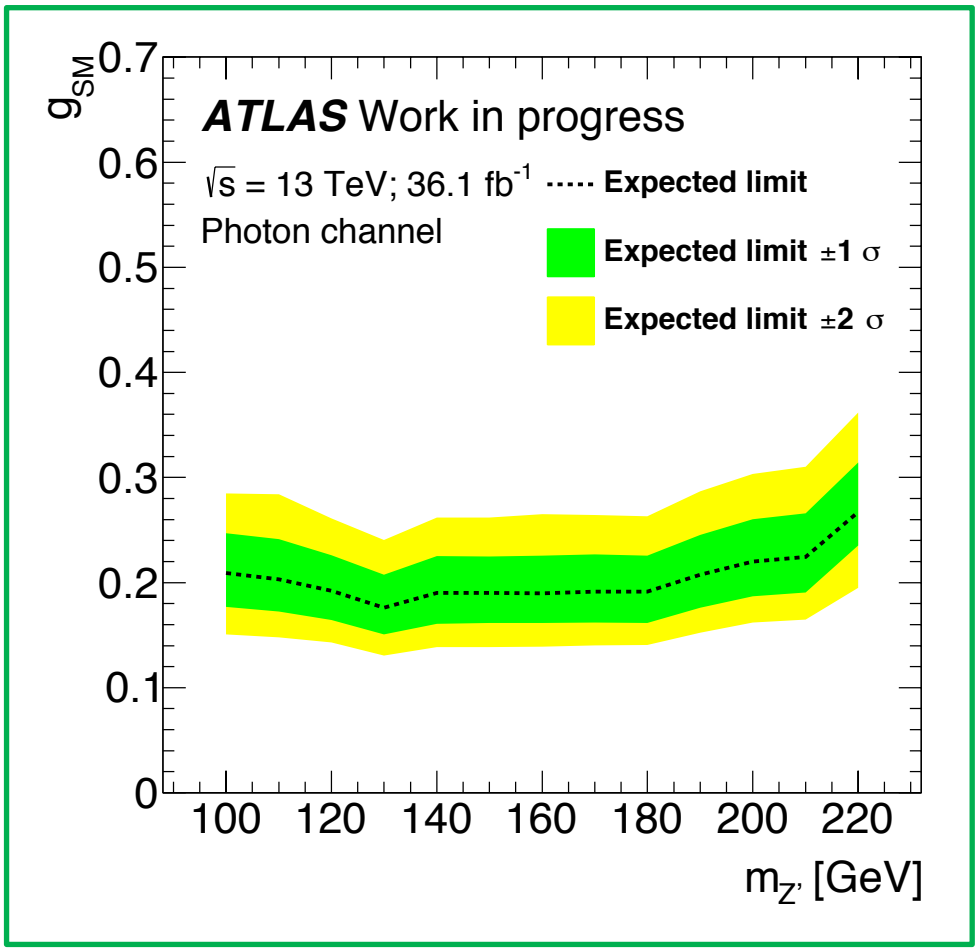



- Expected limits on production cross section for ISR jet and photon channels

# Results




- Expected limits on $g_{SM}$ for ISR jet and photon channels

# Conclusion

- First results from boosted di-jet+ISR analysis presented
- Analysis employs novel substructure techniques to reduce dominant backgrounds in very low-mass region
- W/Z signal found with signal strength consistent with SM prediction
- Limits to be placed on production cross section and $g_{SM}$
- Further iterations of the analysis hope to probe lower in mass and scalar signals

THANKS!