Search for a light Dark Matter mediator in the dijet mass spectrum from pp collisions at √s = 13 TeV with the ATLAS detector

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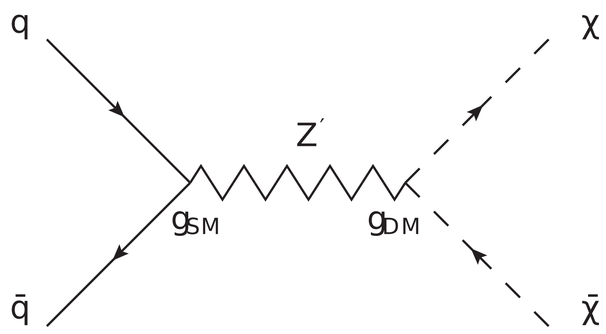
Outline

The ATLAS search for a light axial mediator from the simplified Dark Matter model[1] is presented. To reach mediator masses down to 200 GeV, an initial state radiation (ISR) object is required to trigger the event.

Benchmark Model

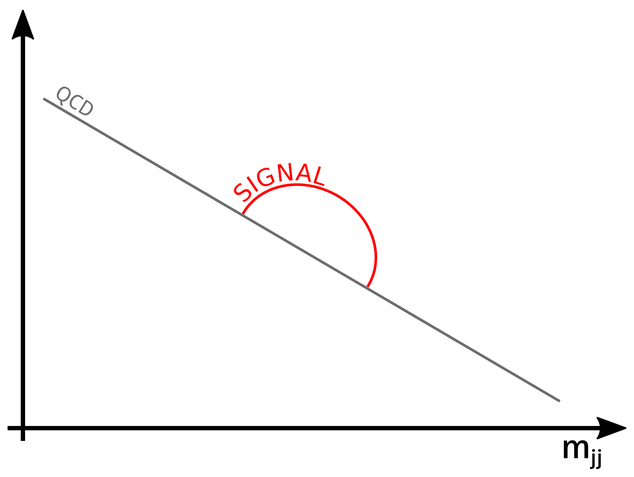
A simplified axial mediator model is used, following the recommendations of the Dark Matter Forum[2]. It adds

- ▶ axial mediator (Z') of mass m_R and a Dark Matter particle (χ) of mass m_{DM}
- ▶ universal mediator-quark coupling g_{SM} and mediator-DM coupling g_{DM}

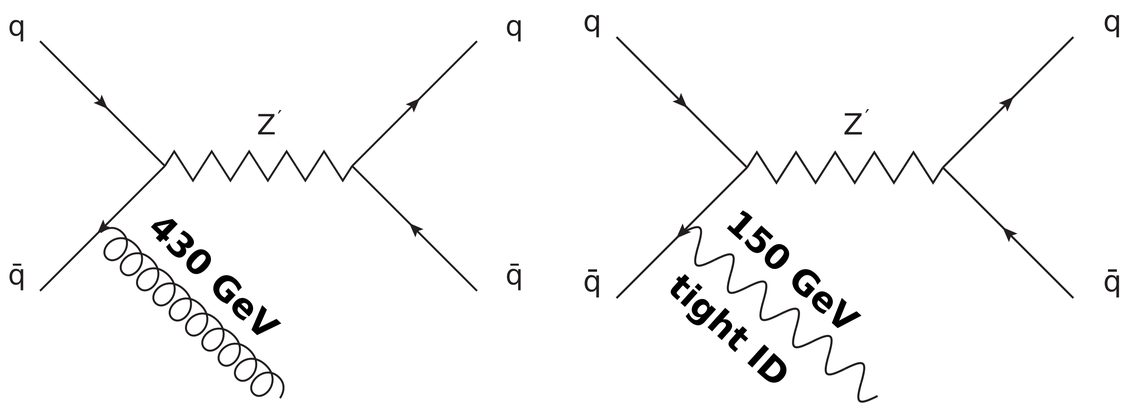


Analysis Method

When the mediator decays back into two quarks, it will show as a bump in the smooth dijet invariant mass spectrum. The background is modelled by a continuous function traditionally used in dijet analyses.



The high mass dijet analysis[3] is limited to m_R>1 TeV, due to the high treshhold of the lowest unprescaled single jet trigger. To reach lower masses, this analysis requires the presence of an ISR object. Both jet (>410 GeV online) and photon (>140 GeV online, loose ID), are used.



Event Selection

The analysis uses data collected with the ATLAS detector during Run 2, with the LHC running at √s=13 TeV. It corresponds to 15.5 fb^{-1} of data gathered in 2015 and 2016. Only events when the full detector was operating wihtout problems were used. For 2016 data, 0.7 fb^{-1} was gathered with the toroid magnet off.

Dijet+γ Selection

- ▶ photon trigger
  - ▹ online p_T>140 GeV, loose ID
- ▶ one photon p_T>150 GeV
  - ▹ tight ID, isolated
  - ▹ converted and unconverted
- ▶ two jets p_T > 25 GeV
  - ▹ form m_{jj}
- ▶ |y*| < 0.8
- ▶ $\Delta R_{\gamma,\text{close jet}}$ >0.85

Dijet+jet Selection

- ▶ jet trigger (HLT_j380)
  - ▹ online jet p_T>380 GeV
- ▶ leading jet p_T>430 GeV
- ▶ two additional jets p_T > 25 GeV
  - ▹ form m_{jj}
- ▶ |y*| < 0.6

$$y^*_{jj} = \frac{|y_{j0} - y_{j1}|}{2}$$

Fit Function Choice

The folowing fit function is used, with colours indicating extra parameters.

$$c_0(1-x)^{c_1} x^{c_2 + c_3 \ln x + c_4 \ln x^2}, x = \frac{m_{jj}}{\sqrt{s}}$$

- ▶ For dijet+γ, the fit is done over 170 GeV to 1500 GeV.
- ▶ For dijet+jet, the fit is done over 300 GeV to 600 GeV.
  - ▹ Above 600 GeV, jets 2/3 are no longer the resonance jets.

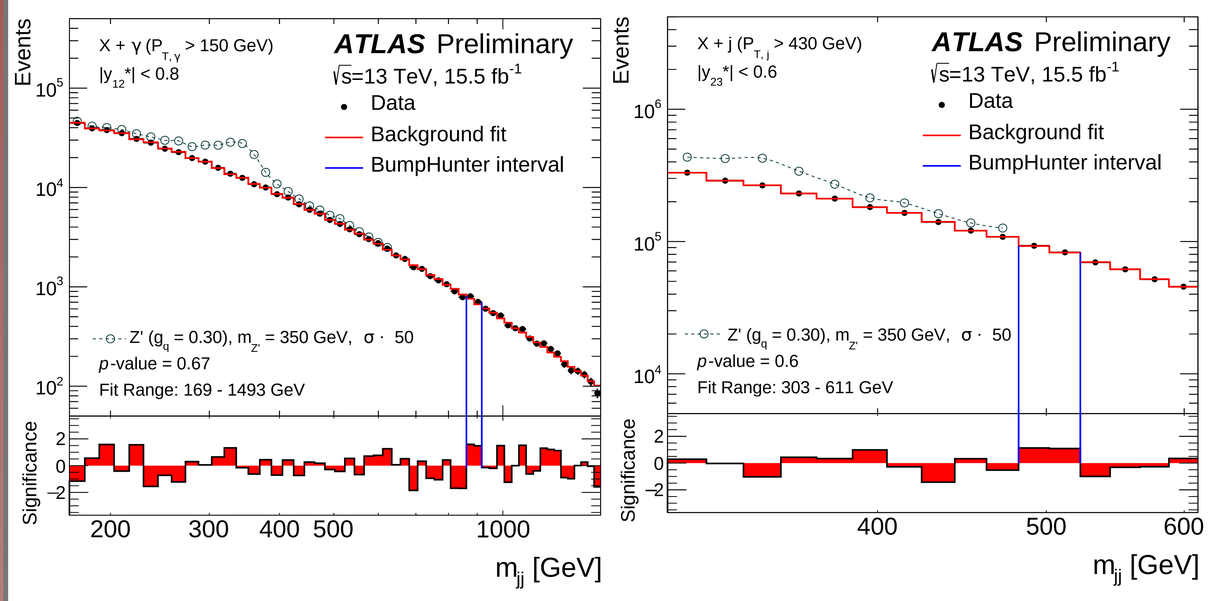
The likelihood ratio test between the n and n+1 parameter functions is used to decide the number of parameters necessary for the fit. If the probability of the ratio falls below 5%, the n+1 function is chosen.

- ▶ For dijet+γ, 4 parameters are needed.
- ▶ For dijet+jet, 3 parameters are needed.

Search Phase

The m_{jj} distribution is searched for using the BumpHunter algorithm[4].

1. Data are fit using the smooth function identified by the likelihood ratio test.
2. The most discrepant interval is identified.
3. The significance of the discrepancy is identified by running pseudo-experiments generated using the fitted function.

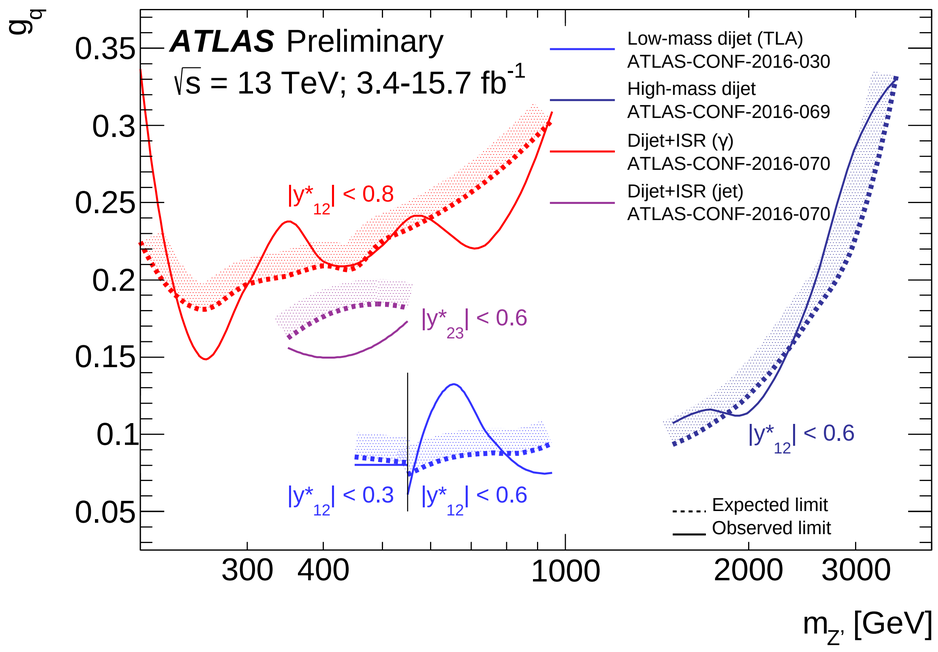


No significant excess is seen in the data.

Limit Setting

Baysian statistics with a flat prior are used for the limit setting.

The limit for a single g_{SM} coupling is calculated. The theoretical cross-section is then scaled by g_{SM}^2 until the excluded value is found.



References:

[1] ATLAS Colloboration, ATLAS-CONF-2016-070, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2016-070/

[2] D. Abercrombie et al., "Dark Matter Benchmark Models for Early LHC Run-2 Searches: Report of the ATLAS/CMS Dark Matter Forum", arXiv:1507.00966

[3] ATLAS Colloboration, “Search for new phenomena in dijet events collected in 2015 and 2016 pp collisions with the ATLAS detector at √s=13 TeV”, ATLAS-CONF-2016-069, https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/ATLAS-CONF-2016-069/

[4] G. Choudalakis, “On hypothesis testing, trials factor, hypertests and the BumpHunter”, arXiv:/1101.0390