The Dijet+ISR Analysis in ATLAS: SEARCHING FOR LOW-MASS DARK MATTER MEDIATOR

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Abstract

The WIMP model in the simplified form used as a benchmark by LHC experiments predicts dark matter mediator particles, Z'. Z' would interact as Z, providing a historical basis for Z'→ jj searches.

With a larger number of high energy proton-proton collision events than ever in history, ATLAS is now able to probe decay channels that could not previously be studied. By requiring initial state radiation (ISR) in the standard Z'→ jj dijet channel, we are able to go beyond previous experimental trigger constraints and push the searchable Z' mass limit down to 100GeV. This poster displays the latest dijet+ISR photon and dijet+ ISR jet analysis results for resolved jets topology in 2016 data. A newly studied experiment technique using a machine learning method to estimate the background shape will also be discussed.

Why Dark Matter?

Standard model of particle physics failed to explain various **astronomical observation** in the last couple of decades.

Red: Ordinary matter collides and heats up to emit light

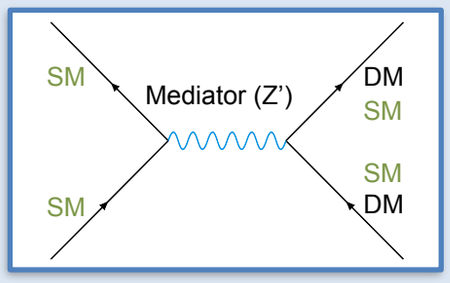
Blue: Dark matter passes through the other cluster of galaxies with no visible interaction

1. Bullet clusters collisions
2. Cosmic microwave background matter composition
3. Rotational velocity curves of galaxies

Dark matter, a particle that has mass but does not interact with light is hypothesized to explain all of these phenomena.

DM Mediator Search

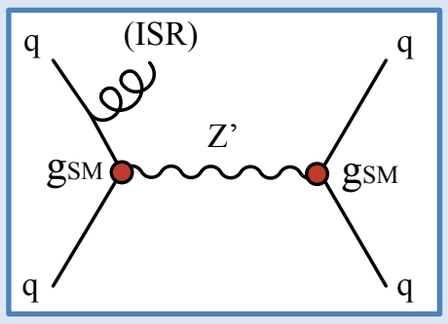
Theoretical calculation of the **thermal freeze out** of a particle with a **mass near the weak scale** could lead to the **observed relic abundance** of dark matter if it is weakly interacting



The simplified WIMP model considered here predicts Z' DM mediator.

The Z' decay to DM can lead to a "Mono-X" final state if produced along ISR; the Z' could also decay to standard model dijet or dilepton final states.

Why Di-jet ISR?



Dijet ISR Final State

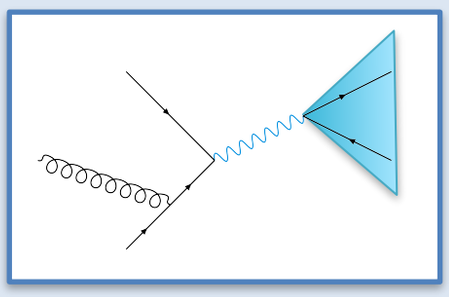
— **SM Z' production** allows for Z' to decay back into SM particles

— The search for dijet resonances is limited at low mass by the high trigger thresholds.
—-Using an ISR jet or photon to trigger.
—-Lower mass Z' search than the dijet channel is possible (100-1000 GeV)

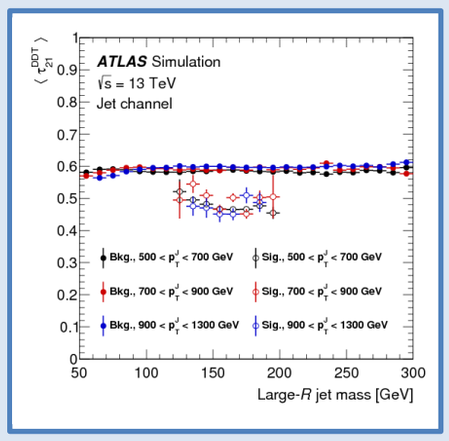
— Dijet + photon / Dijet +jet also serves as an effective **model independent** beyond-SM-anomaly-search

Boosted Di-jet ISR

Mass100-220GeV

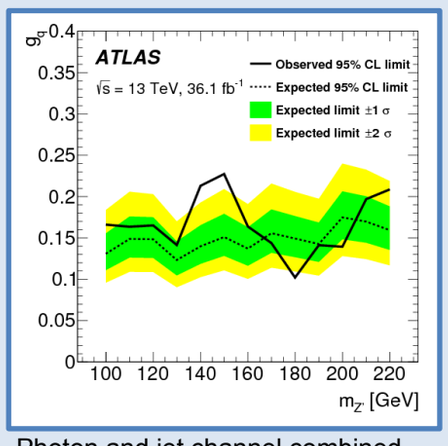


Boosted: The resonance jets fall into 1 jet cone of ΔR=1.0



Mass decorrelated jet tagging substructure as a selector to increase sensitivity for the trijet channel.

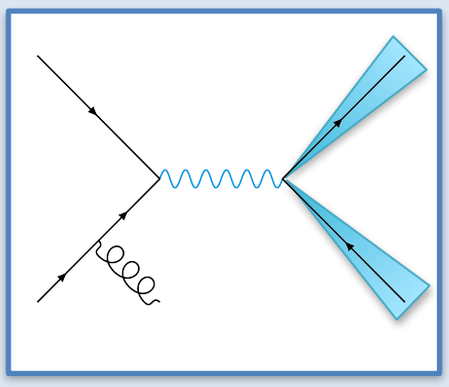
Event Selection:
Large R jet: (2 resonance jet): R=1.0 , $|\eta| < 2.0$, $\tau_{21}^{DDT} < 0.50$ and $\varrho^{DDT} > 1.5$
Channel specific:
ISR jet: 25 GeV < p_T < 60 GeV, R=0.4, from primary vertex
ISR photon: $|\eta| < 2.37$, $E_T > 150$ GeV



Photon and jet channel combined result [1]

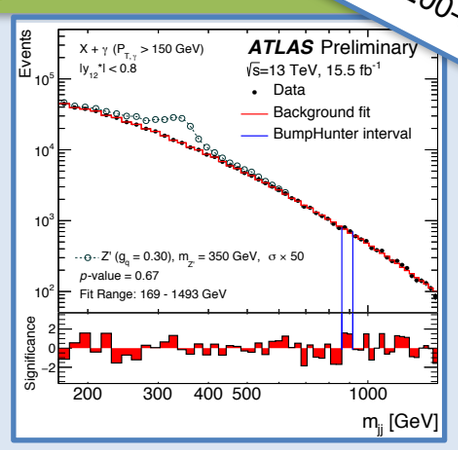
Resolved Di-jet ISR

Mass200-920GeV

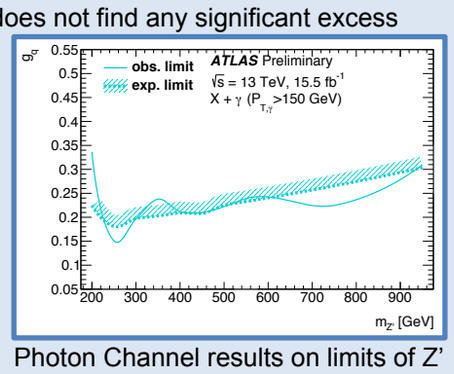


Resolved: The resonance jets fall into 2 jets of cone of ΔR=0.4

Event Selection
At least two jets with $p_T > 25$ GeV and $|\eta| < 2.8$, after p_T ordering, the second and third highest p_T jets are required to be separated by $|y^*| < 0.6$ (jet channel) $|y^*| < 0.8$ (photon channel)
Channel specific:
ISR jet: $p_T > 430$ GeV
ISR photon: $p_T > 150$GeV

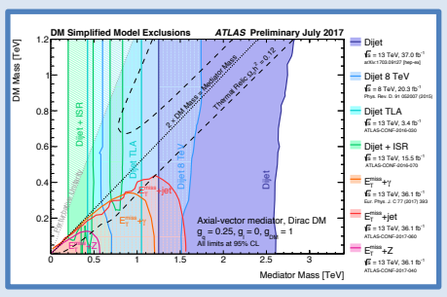


Model-independent check for discrepancies from SM does not find any significant excess

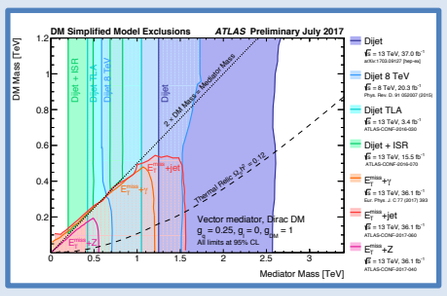


Photon Channel results on limits of Z' [2]

Reinterpretation

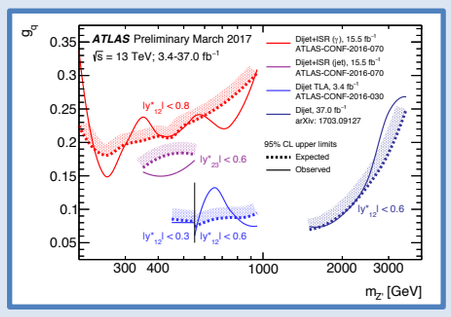


Z' reinterpreted limit for axial-vector-mediated DM



Z' reinterpreted limit for vector-mediated DM

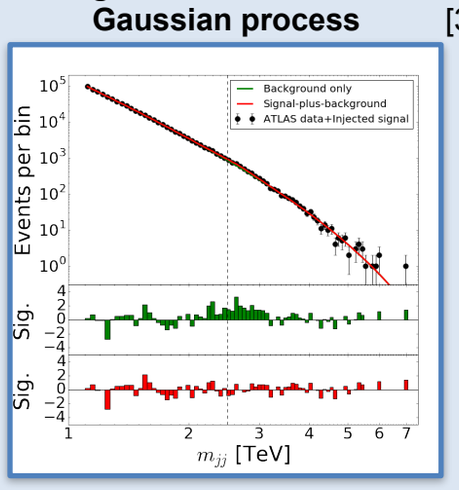
Result comparison



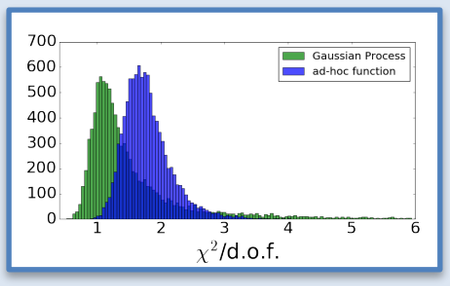
Dijet ISR is able to push Z' mass limit to 100-920GeV

Possible Improvements

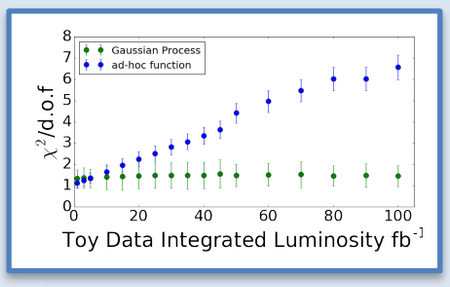
Background estimation with Gaussian process [3]



—High stats in the LHC will take us to **an unexplored region** for the traditional global fit function.
—A data driven method using **Gaussian process** is proposed.



Pseudo Toy data show good fitting result.



G.P shows better performance in high luminosity

References

[1]: ATLAS Collaboration: https://arxiv.org/abs/1801.08769

[2]: ATLAS Collaboration: https://cds.cern.ch/record/2157673/files/ATL-COM-PHYS-2016-671.pdf

[3]: M. Frate et. al: https://arxiv.org/pdf/1709.05681.pdf

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