Search for Dark Matter in association with a hadronically decaying Z’ vector boson with the ATLAS detector in pp collisions at 13 TeV

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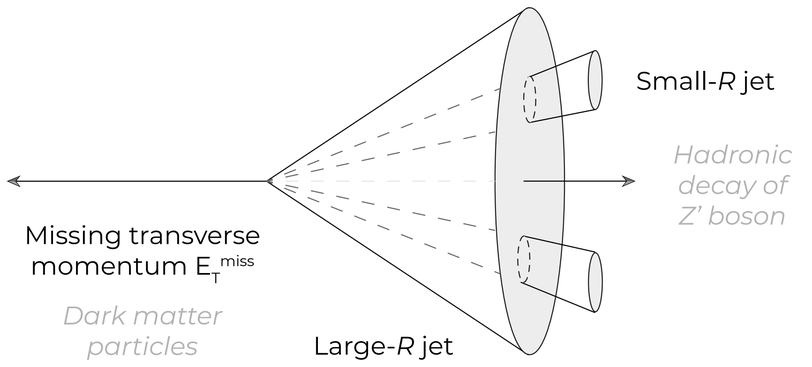
A search for dark matter considering the yet unexplored hypothesis of associated production with a hadronically decaying new vector boson Z’ is performed with 36.1/fb of *pp* collision data at a centre-of-mass energy of √s = 13 TeV recorded by the ATLAS detector at the Large Hadron Collider.



The final state is characterized by **large missing transverse momentum E_T^{miss}** associated with a pair of dark matter particles recoiling against standard model particles compatible with a **hypothetical new *Z’* boson** decay. The decay products are reconstructed as a **pair of small-*R* jets** or in case of topologies with a highly boosted *Z’* boson in which the small-*R* jets start to merge as a **large-*R* jet**.

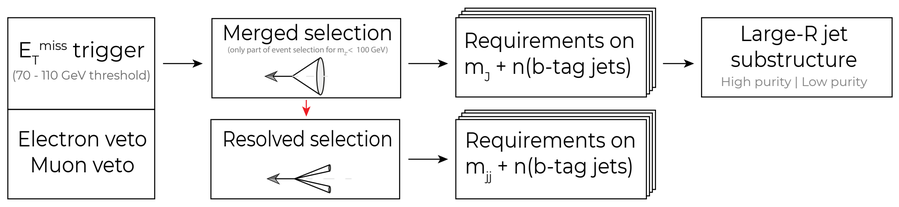
The **results of the search** are in agreement with the standard model predictions and are translated into **exclusion limits** on the production cross-sections and coupling values of a **dark-fermion** model and a **dark-Higgs** model.

Analysis strategy

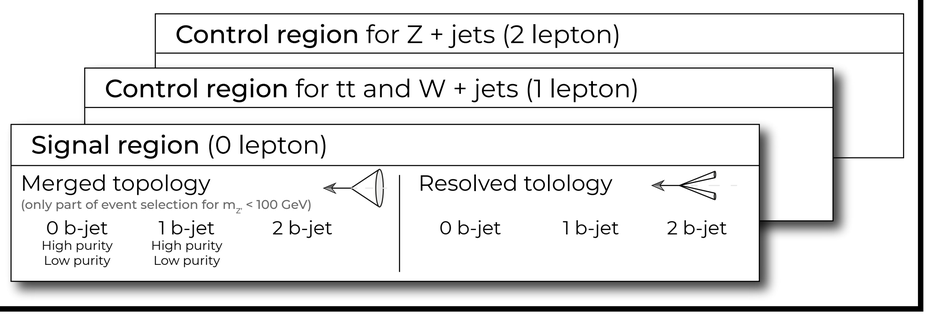
A **general resonance search for a Z’ boson** mass between 80 and 500 GeV is performed.

The **event selection** targeted at the merged (resolved) topology requires E_T^{miss} > 250 GeV (150 GeV) and a large-*R* jet (dijet system) as Z’ boson candidate, imposing a sliding mass window requirement.

Events are classified according to the **number of b-tagged jets** to improve the sensitivity of the search. The merged selection further takes into account the **jet substructure** variable $D_2^{\beta=1}$ to distinguish high and low purity signal regions.



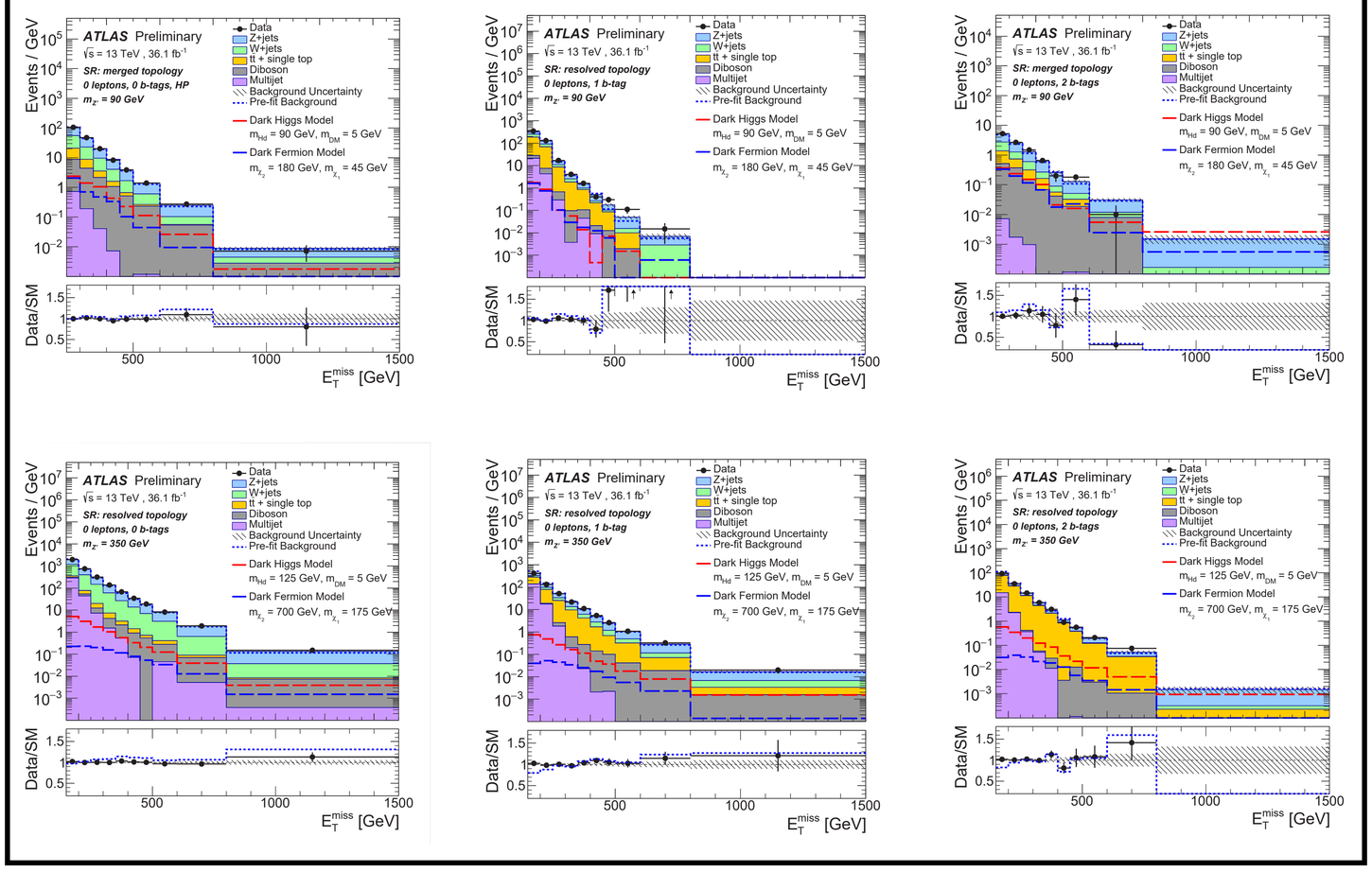
In addition to the **signal region**, two background-enriched **control regions** are defined to constrain both normalisation and E_T^{miss} shape of the dominant background processes in the profile likelihood fit.



Results

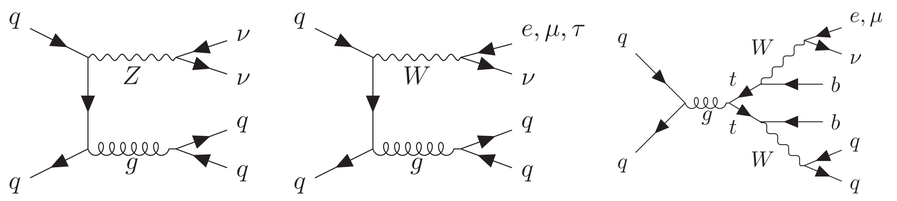
Distributions of E_T^{miss}, the final discriminant for the statistical evaluation, are shown for selections targeted at a vector boson mass of 90 GeV (top) and 350 GeV (bottom) with 0, 1, and 2 b-tagged jets in merged and resolved topologies.
No significant deviation from the standard model prediction is observed.

The largest excess of the data above the expectation, corresponding to a local (global) significance of 3σ (2.2σ), is observed for a hypothesized signal at $m_{Z'}$= 350 GeV within the dark fermion model in the heavy dark-sector scenario.



Background estimation

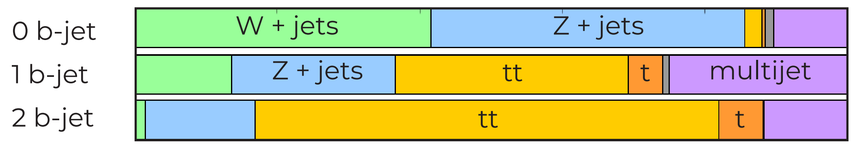
The **dominant background processes** are
Z(→νν, ττ) + jets, W(→lν) + jets, and tt production.



They are estimated using monte-carlo (MC) simulation constrained by dedicated control regions.

Other background processes:
single-top quark + diboson (MC), multijet (data-driven)

Signal region ($m_{Z'}$ = 350 GeV) background composition



Interpretation and exclusion limits

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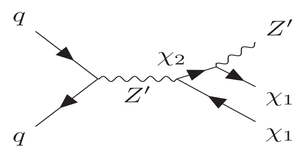
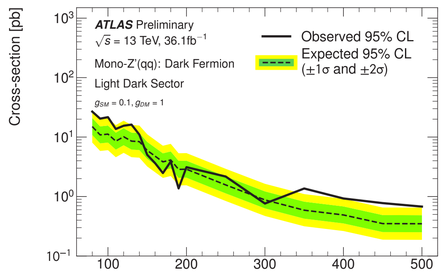
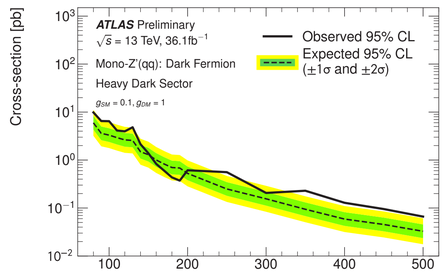
Dark-fermion model



Model parameters:
- Z’ boson mass $m_{Z'}$
- Dark matter masses $m_{\chi 1}$, $m_{\chi 2}$
- Coupling parameters
  g_{SM} = 0.1 , g_{DM} = 1.0

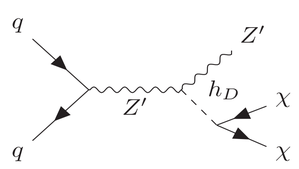


Light Dark Sector scenario
Set $m_{\chi 1}$ = 5 GeV,
$m_{\chi 2}$ = $m_{\chi 1}$ + $m_{Z'}$ + 25 GeV

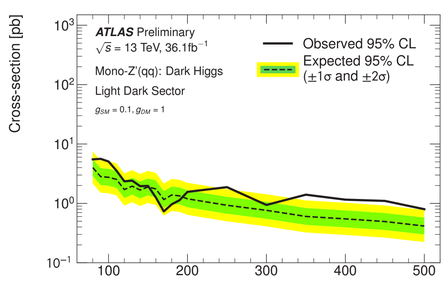


Heavy Dark Sector scenario
Set $m_{\chi 1}$ = $m_{Z'}$ / 2,
$m_{\chi 2}$ = 2$m_{Z'}$

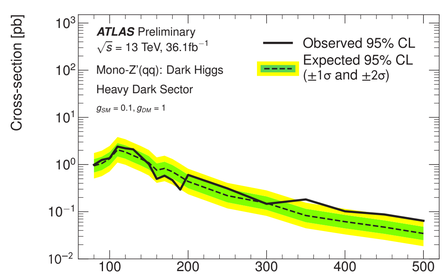
Dark-Higgs model



Model parameters:
- Z’ boson mass $m_{Z'}$
- Dark Higgs mass m_{hD}
- Dark matter mass m_χ = 5 GeV
- Coupling parameters
  g_{SM} = 0.1 , g_{DM} = 1.0



Light Dark Sector scenario
Set m_{hD} = $m_{Z'}$ for $m_{Z'}$ < 125 GeV,
m_{hD} = 125 GeV otherwise



Heavy Dark Sector scenario
Set m_{hD} = 125 GeV for $m_{Z'}$ < 125 GeV,
m_{hD} = $m_{Z'}$ otherwise