Search for long-lived particles with displaced vertices in multijet events

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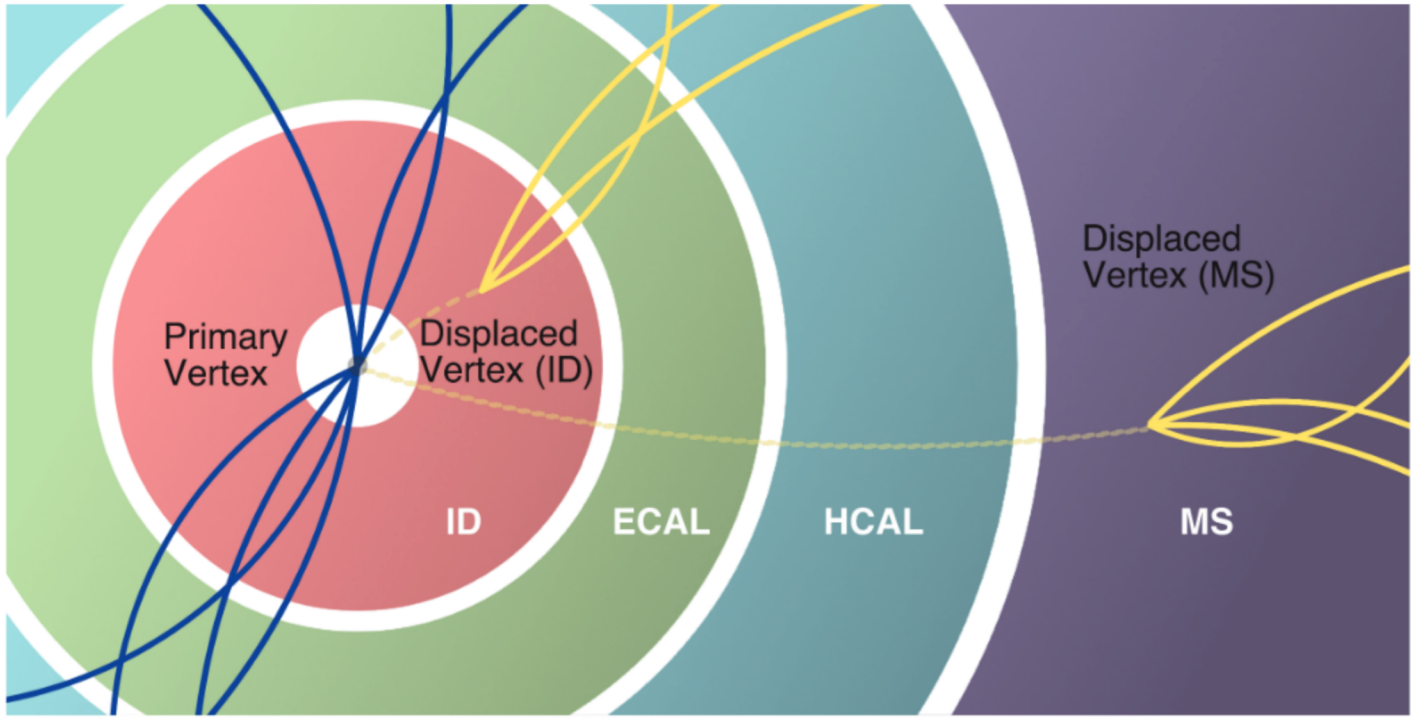
ATLAS EXPERIMENT

Long-lived particles with ATLAS

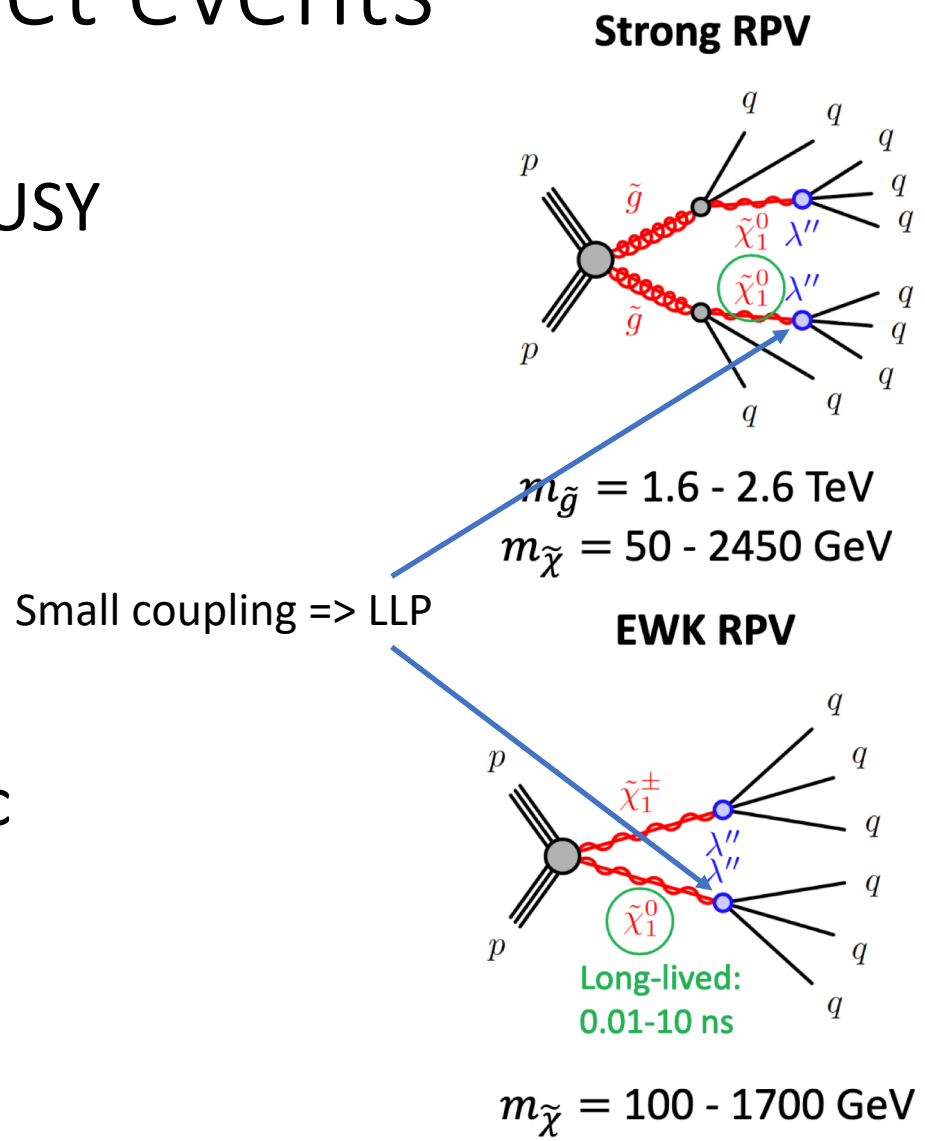
- There are different types of long-lived searches at the ATLAS experiment
  - Direct searches
  - Indirect searches
- Indirect searches look for decay products of the LLPs, and appear as Displaced vertices (DVs)
- Some SM particles which can be seen as DVs decaying inside the Inner Detector (ID) are K_S and Λ



Indirect searches

Displaced vertices in multijet events

- Looking for long-lived particles in RPV SUSY
- Benchmark models: Strong RPV & EWK
- The quarks hadronize => jets
- Two signal regions
  - High-pT: Optimized for Strong RPV
  - Trackless: Optimized for EWK
- There are no SM interactions that mimic the signature

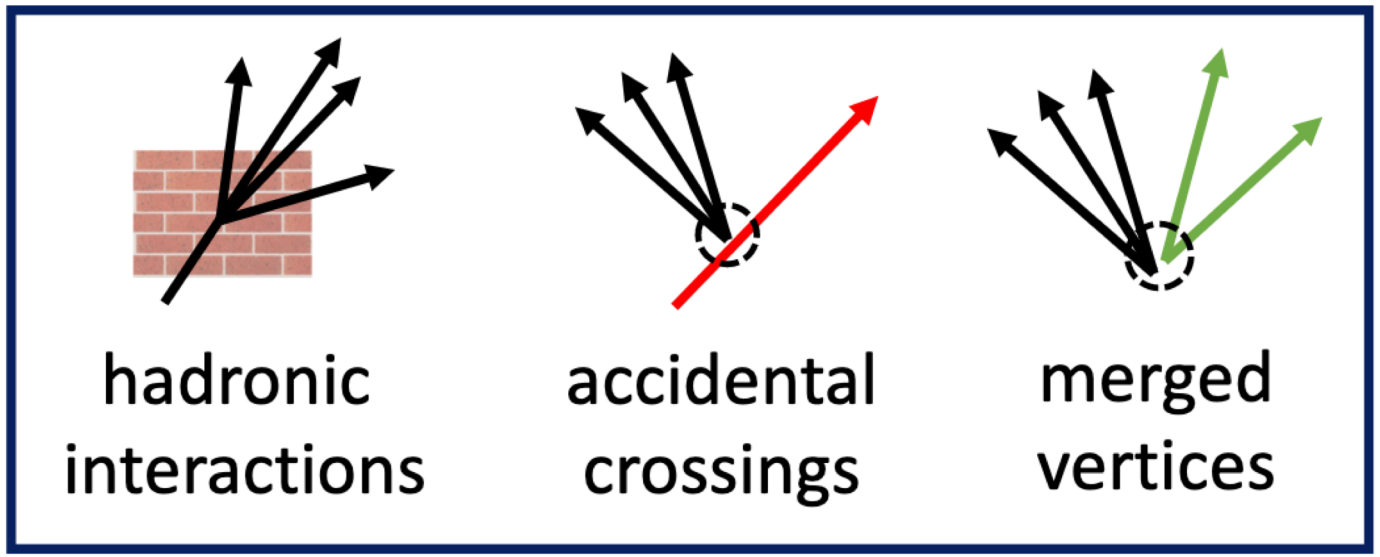


Background estimation

- Three main backgrounds
- Two methods were used
  - An MC control background estimate based on the three separate sources
  - A data-driven inclusive estimate based on jet proximity

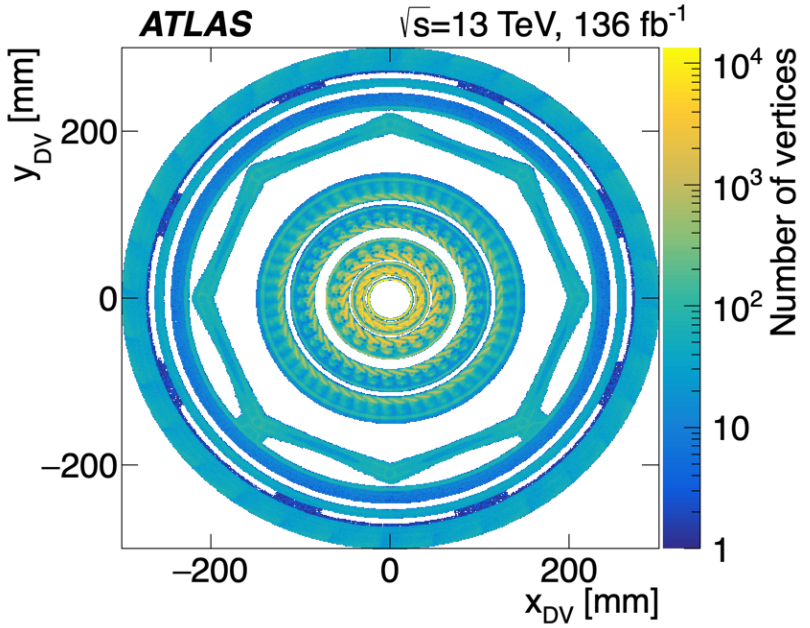
DV Selection
$r_{\mathrm{DV}} < 300$ mm, $\lvert z_{\mathrm{DV}} \rvert < 300$ mm
$r_{\mathrm{DV\text{-}PV}} > 4$ mm
$\chi^2/N_{DoF} < 5$
Pass strict material map veto
$m_{\mathrm{DV}} > 10$ GeV, $N_{\mathrm{trk}} \geq 5$, $N_{\mathrm{trk}}^{\mathrm{sel}} \geq 2$

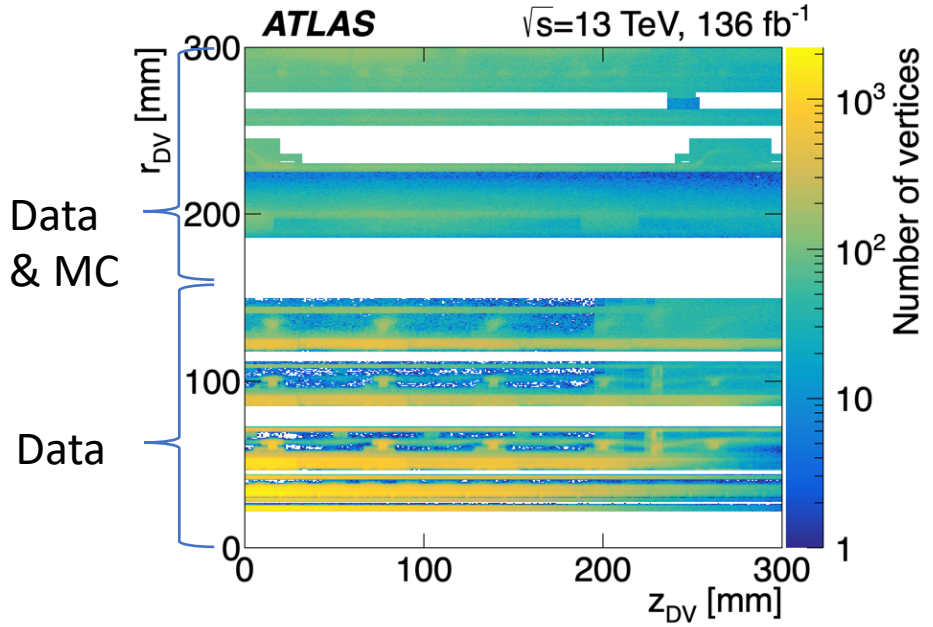
Background sources:



Material veto

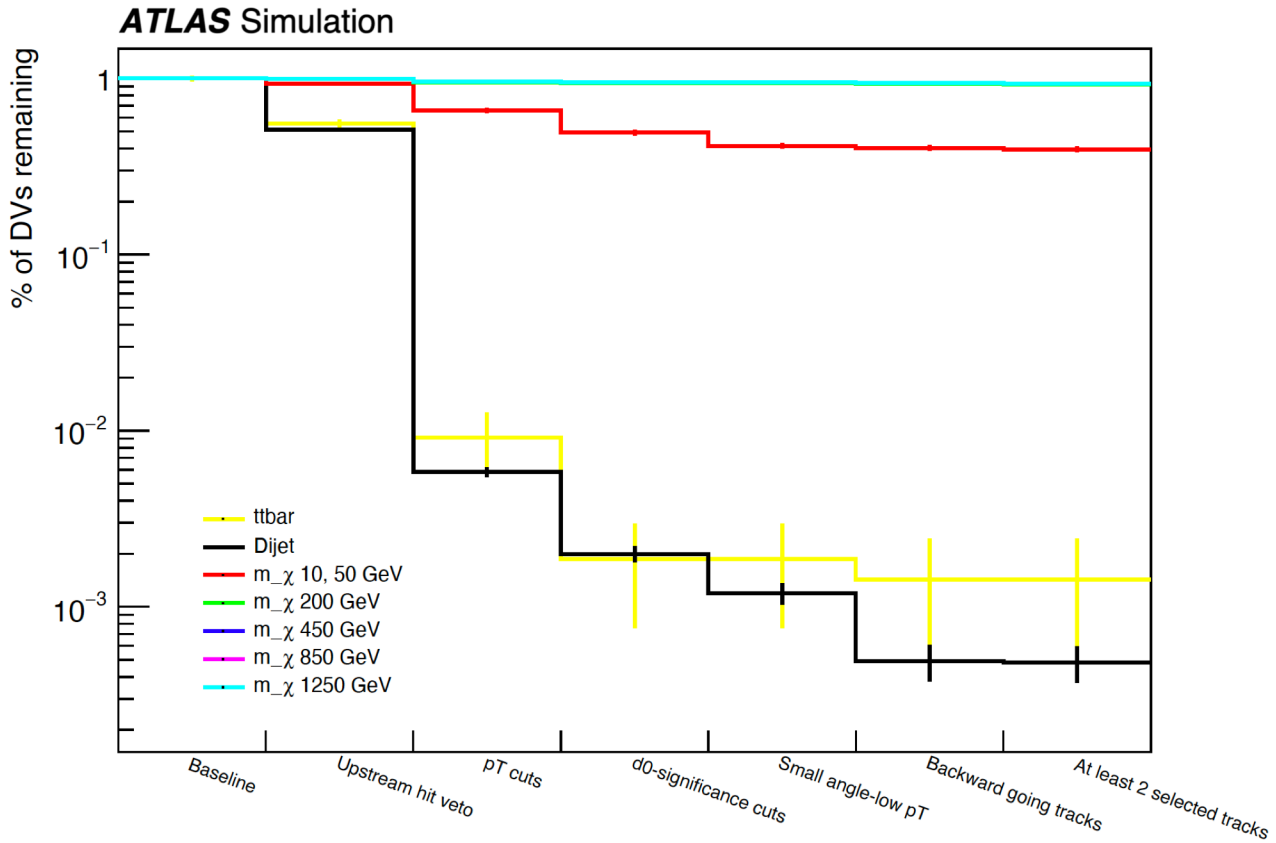
- Data-driven material map based on DVs from all of Run-2
- Two separate maps for inner and outer region (cut-off at 150mm)
  - Inner uses pure data with a finer bin size
  - Outer uses a combination of data and MC
- Removes ~42% of the fiducial volume
- For this analysis it was extended by also vetoing all adjacent bins in the map ~48% of the volume



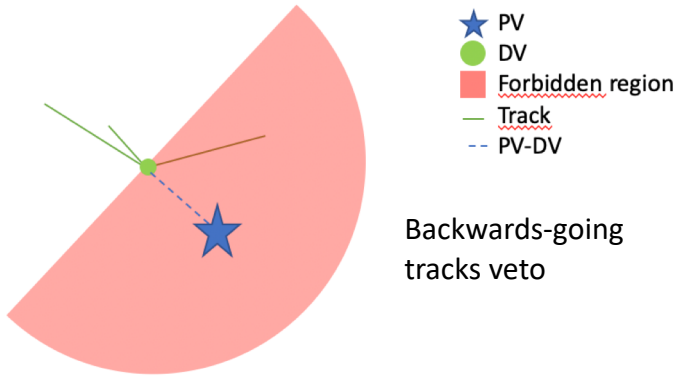


SR optimization

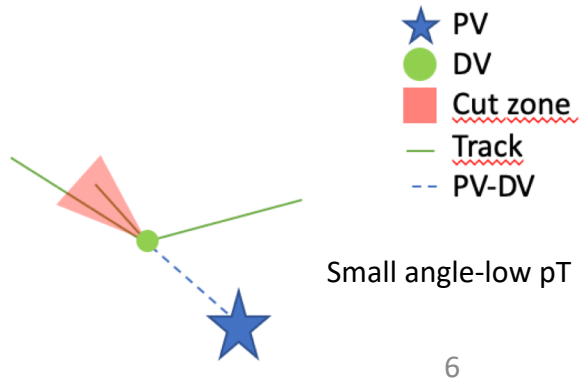
- Aiming for around ~1 background event in the SR
- Study made on MC, optimized for Strong RPV grid
- To optimize SR, we used region-based selections on the DVs to remove background
- Estimated background:
  - High-pT SR: $0.46^{+0.27}_{-0.30}$
  - Trackless SR: : $0.83^{+0.51}_{-0.53}$



d0-significance = $d0/\sigma_{d0}$



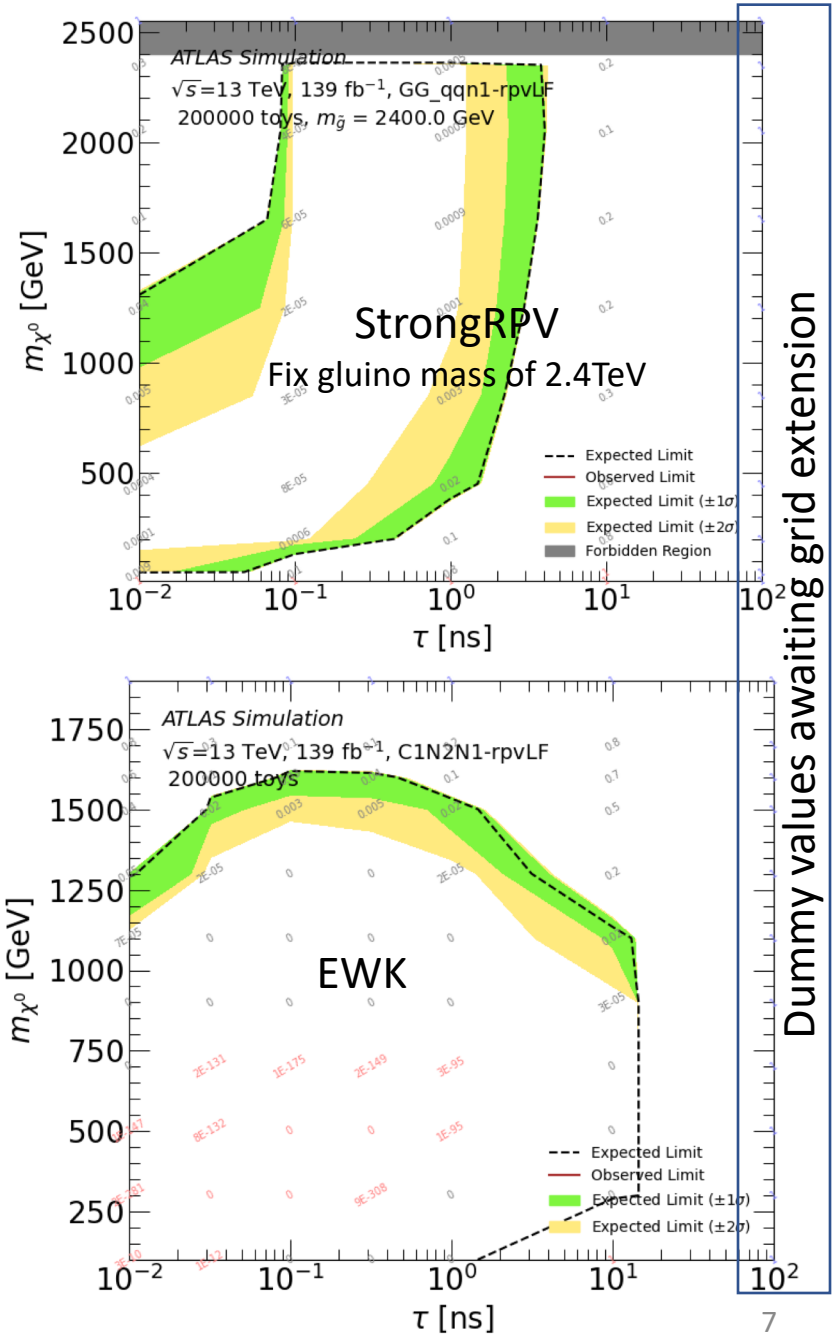
Backwards-going tracks veto



Small angle-low pT

Regions of sensitivity

- Using pyHF to get limits for the search
- Still in progress (requesting more stats)
- Have the best sensitivity at around $\tau = .1\text{ns}$
- Results from unblinding is publically available in [Giulia Ripellino's Doctoral thesis]



Summary

- A search for LLPs which decay inside the ID of ATLAS has been conducted using two benchmark models with 2 and 3 parameters
- A material veto is used to remove the majority of the background
- Achieved ~1 background event in SR
- The making of final limits is currently in progress using pyHF
- Unblinding has been done, but the results are not yet public through ATLAS

Backup

SR definitions

- Trackless jet requirements:
  - Sum(trk_pt)<5 GeV in jet
  - single: 56 GeV
  - Double: 78 GeV
- High-pT jet requirements:
  - 4j137
  - 5j101
  - 6j83
  - 7j55