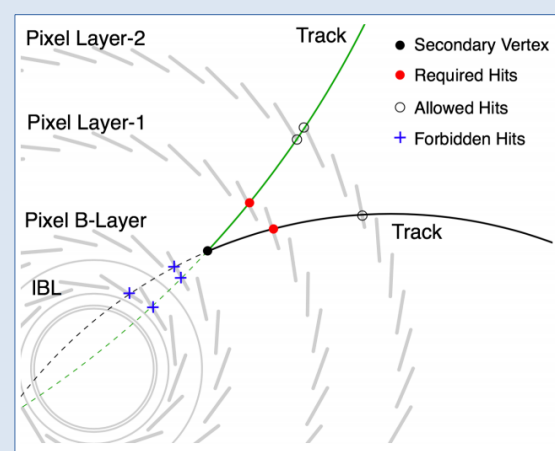
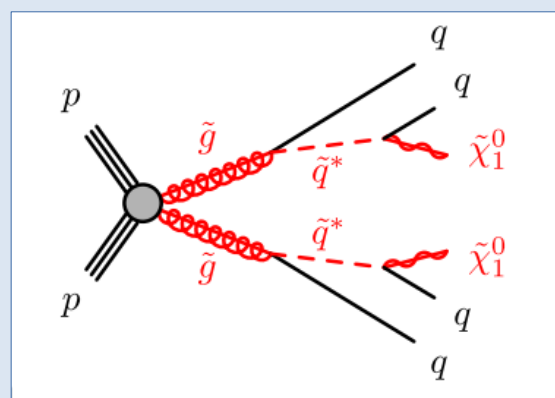




Search for long-lived, massive particles in events with displaced vertices and missing transverse momentum with the ATLAS detector in pp collisions at 13 TeV

Overview

- Long-lived particles in various physics models and wide range of Beyond Standard Model Physics (including SUSY)
- 32.7 fb⁻¹ of data at $\sqrt{s}=13$ TeV in ATLAS LHC run-II
- Pair production of LL gluino, hadronize in R-hadrons: displaced vertices signature.
- Final state: large missing transverse momentum (MET) and at least one high-mass DV with 5+ tracks
- Indirect detection for charged and/or neutral massive LL particle = detection of decay products

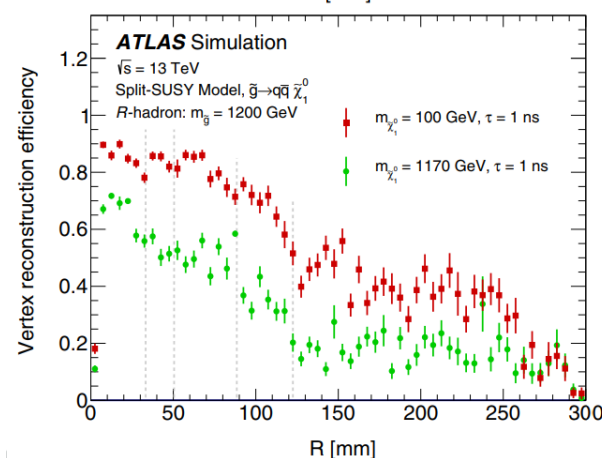
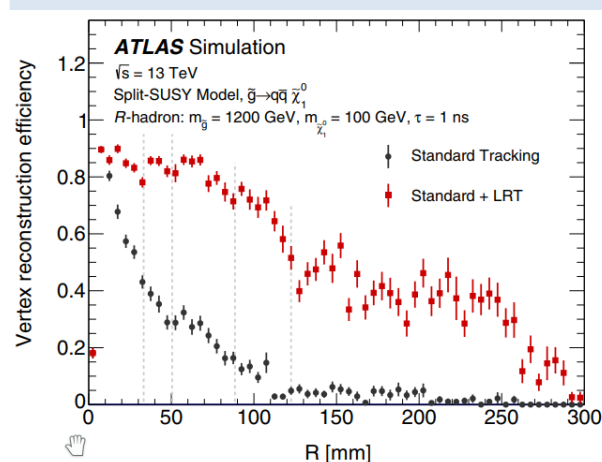


Large radius tracking

Standard tracking not sufficient to reconstruct tracks from DV in large radius.

Large radius tracking specially developed, using only hits non-associated to standardly reconstructed tracks.

Relaxing of impact parameter cuts: $d_0 < 300\text{mm}$ & $z_0 < 1500\text{mm}$ (Standard: 10 & 250 mm)



Signal Region selection

Event selection cuts

- $E_t^{\text{miss}} > 250$ GeV
- Non collision background veto

Vertex selection cuts

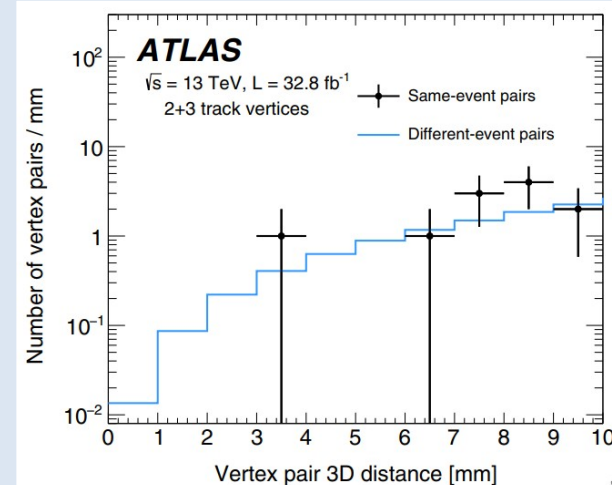
- $R_{\text{DV}} < 300\text{mm}$ and $|z_{\text{DV}}| < 300\text{mm}$
- $\text{Chi}^2/\text{NdF} < 5$
- $|R_{\text{DV}} - R_{\text{PV}}| > 4\text{mm}$
- Veto-material dominated region
- $N_{\text{trk}} > 4$ and $m_{\text{DV}} > 10\text{GeV}$

Selection	Subregion	Category	Yield		
Event preselection $n_{\text{trk}} = 3, m_{\text{DV}} > 10$ GeV		Measured total	3093		
Event preselection $n_{\text{trk}} = 4, m_{\text{DV}} > 10$ GeV	VRLM	(3 + 1)-track	$12.6 \pm 0.3 \pm 1.1$		
		(2 + 2)-track	3.6 ± 3.6		
		Pure 4-track	$0.3^{+0.9}_{-0.3}$		
		Subtotal	16 ± 4		
		Total (after scaling by ϵ_{VRLM})	9 ± 2		
Event preselection $n_{\text{trk}} = 4, m_{\text{DV}} > 10$ GeV	VRM	(3 + 1)-track	$137 \pm 3 \pm 30$		
		Pure 4-track	16^{+47}_{-16}		
		Total	150^{+60}_{-30}		
		Event preselection $n_{\text{trk}} \geq 5, m_{\text{DV}} > 10$ GeV	5-tracks	(4 + 1)-track	$1.30 \pm 0.07 \pm 0.12$
		(2 + 3)-track	0.01 ± 0.01		
Pure 5-track	$0.9^{+2.8}_{-0.9}$				
Total	$2.2^{+2.8}_{-0.9}$				
Event preselection $n_{\text{trk}} \geq 5, m_{\text{DV}} > 10$ GeV	6-tracks	(5 + 1)-track	$0.37 \pm 0.03 \pm 0.04$		
		Pure 6-track	$0.2^{+0.6}_{-0.2}$		
		Total	$0.6^{+0.6}_{-0.2}$		
		≥ 7 -tracks	(n + 1)-track	$0.37 \pm 0.03 \pm 0.04$	
		Pure ≥ 7 -track	1^{+3}_{-1}		
Total	1^{+3}_{-1}				
Full SR selection	Total	(after scaling by $\epsilon_{\text{SR}} \times \kappa$)	$0.02^{+0.02}_{-0.01}$		

Backgrounds

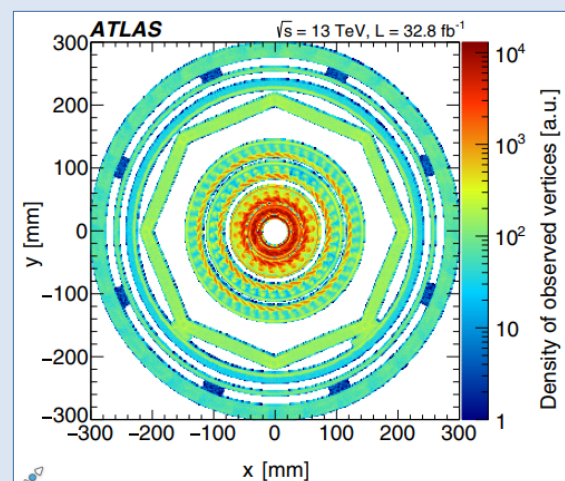
Merged displaced vertices

At small radii, high density of vertices: possible merging of two vertices with low masses and low track multiplicities to a single vertex with higher mass and track multiplicity. To quantify this contribution, vertices from distinct events are randomly merged.



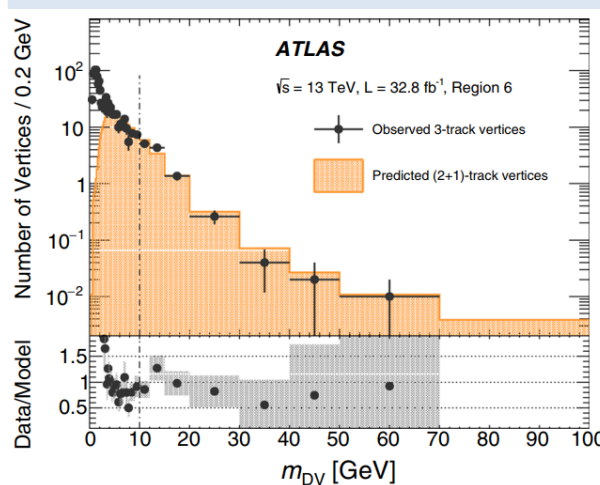
Hadronic Interactions

Hadronic interactions in material-rich regions of the detector are removed with a map constructed by studying observed positions of high vertex-density regions in $\sqrt{s} = 13$ TeV minimum bias data.



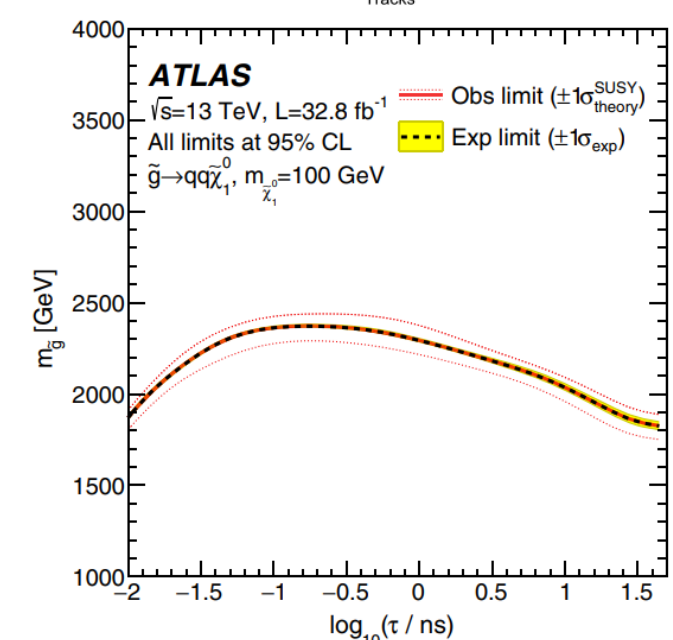
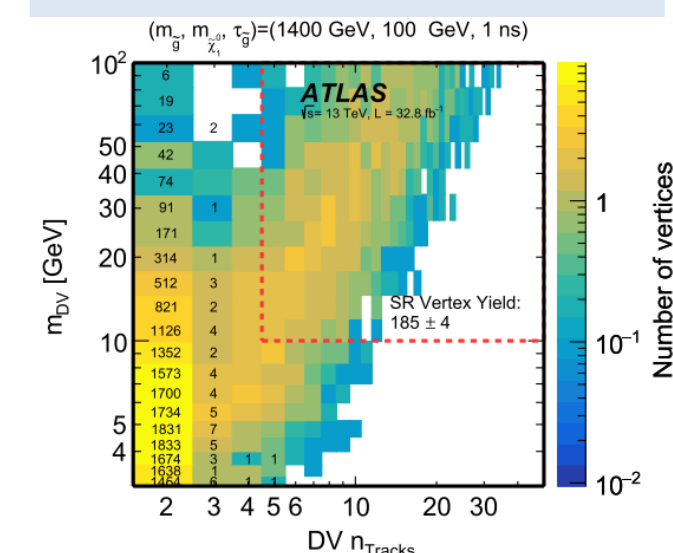
Accidental crossing of vertices and tracks

The dominant source of background is low-mass vertices crossed by an unrelated track in the event, which is estimated by (n+1)-track vertices constructed by adding a *pseudo-track* to n-track vertices from the data.



Results

The final yields for all regions used in this analysis are consistent with the background expectation. In the absence of a statistically significant excess in the data, exclusion limits are placed on R-hadron models. For $\tau = 1$ ns, upper limits on the gluino mass are placed above 2.2 TeV for $m_{\tilde{\chi}_1^0} = 100$ GeV.



Selection	Subregion	Estimated	Observed
Event preselection $n_{\text{trk}} = 3, m_{\text{DV}} > 10$ GeV			3093
Event preselection $n_{\text{trk}} = 4, m_{\text{DV}} > 10$ GeV	VRLM	9 ± 2	9
	VRM	150^{+60}_{-30}	177
Event preselection $n_{\text{trk}} \geq 5, m_{\text{DV}} > 10$ GeV	5-tracks	$2.2^{+2.8}_{-0.9}$	1
	6-tracks	$0.6^{+0.6}_{-0.2}$	1
	≥ 7 -tracks	1^{+3}_{-1}	3
	Total	$4.2^{+4.1}_{-1.4}$	5
Full SR selection	Total	$0.02^{+0.02}_{-0.01}$	0