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Search for displaced vertices of oppositely charged leptons from decays of long-lived particles in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

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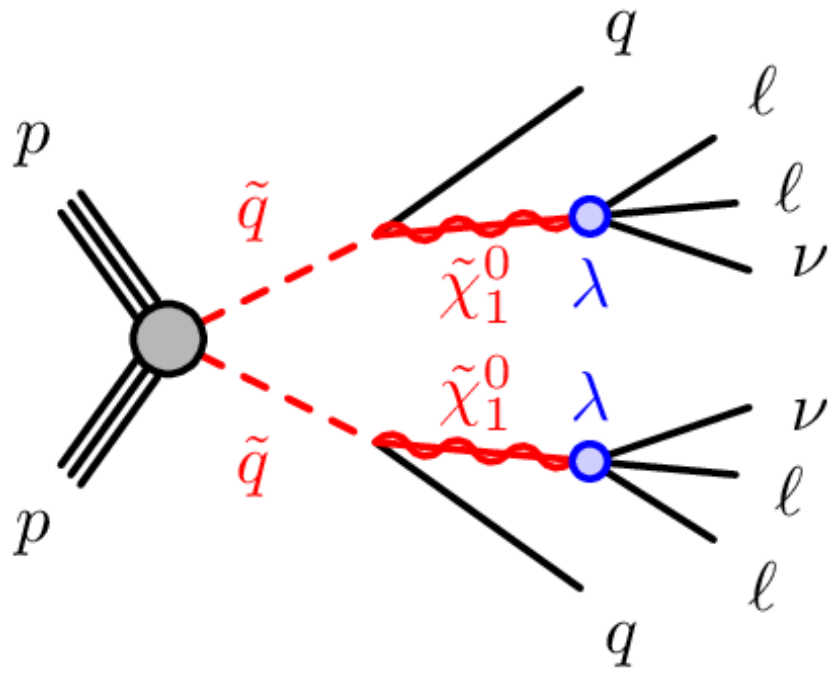
ABSTRACT

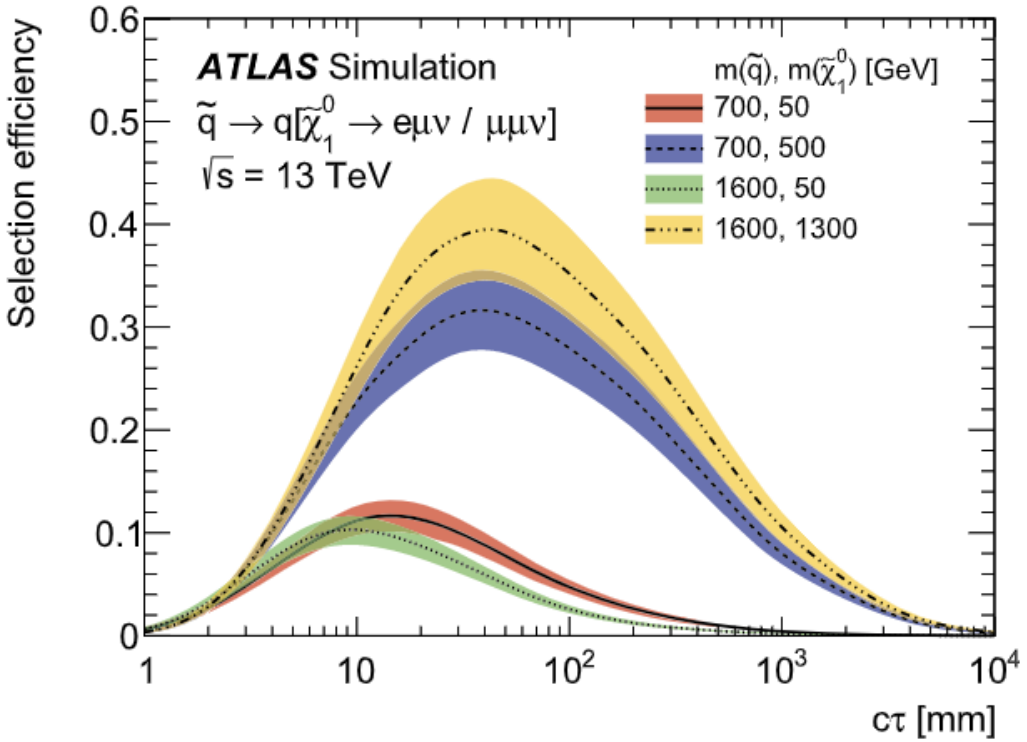
A search for long-lived particles decaying into an oppositely charged lepton pair, $\mu\mu$, ee, or $e\mu$, is presented using 32.8 fb^{-1} of pp collision data collected at $\sqrt{s} = 13$ TeV by the ATLAS detector at the LHC. Candidate leptons are required to form a vertex, within the inner tracking volume of ATLAS, displaced from the primary pp interaction region. No lepton pairs with an invariant mass greater than 12 GeV are observed, consistent with the background expectations derived from data. The detection efficiencies for generic resonances with lifetimes $(c\tau)$ of 100–1000 mm decaying into a dilepton pair with masses between 0.1–1.0 TeV are presented as a function of p_{T} and decay radius of the resonances to allow the extraction of upper limits on the cross sections for theoretical models. The result is also interpreted in a supersymmetric model in which the lightest neutralino, produced via squark–antisquark production, decays into $\ell^+\ell'^-\nu$ $(\ell, \ell' = e, \mu)$ with a finite lifetime due to the presence of R-parity violating couplings. Cross-section limits are presented for specific squark and neutralino masses. For a 700 GeV squark, neutralinos with masses of 50–500 GeV and mean proper lifetimes corresponding to $c\tau$ values between 1 mm to 6 m are excluded. For a 1.6 TeV squark, $c\tau$ values between 3 mm to 1 m are excluded for 1.3 TeV neutralinos.

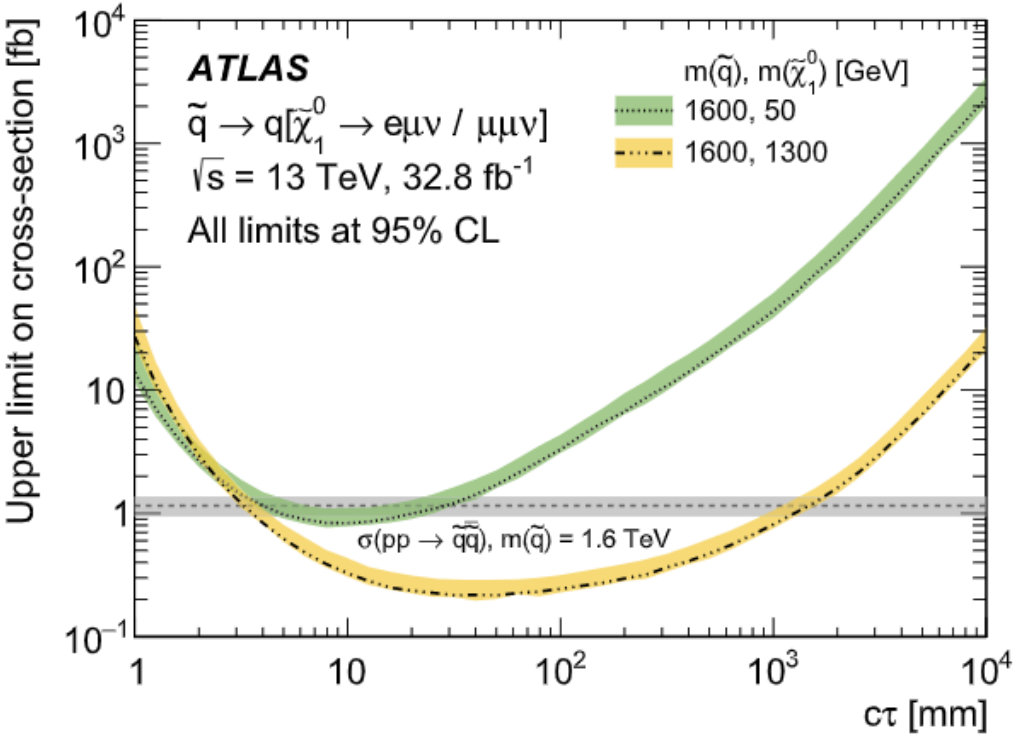
RPV susy : LLP Neutralino



This model was interpreted in two different scenarios, where a single dominant λ_{121} or λ_{122} coupling was assumed. Decays via a pure λ_{121} coupling have branching fractions $\mathcal{B}(\tilde{\chi}_1^0 \to ee\nu) = \mathcal{B}(\tilde{\chi}_1^0 \to e\mu\nu) = 0.5$, while decays via a pure λ_{122} coupling have $\mathcal{B}(\tilde{\chi}_1^0 \to \mu\mu\nu) = \mathcal{B}(\tilde{\chi}_1^0 \to e\mu\nu) = 0.5$.

Result from atlas





Trigger and Preselection

Table 1
Requirements on the muon, photon and electron candidates that pass the triggers used in the preselection. e^* refers to electrons that are required to pass the 'loose' electron identification criteria [49].

Trigger	Candidate 1	p_T [GeV]	$\|\eta\|$	$\|d_0\|$ [mm]	Candidate 2	p_T [GeV]	$\|\eta\|$	$\|d_0\|$ [mm]
μ	μ	> 62	< 1.07	see text				
γ	γ	> 150	< 2.5	–	γ	> 10	< 2.5	–
					e	> 10	< 2.5	> 2.0
					μ	> 10	< 2.5	see text
γ	e	> 150	< 2.5	> 2.0				
$\gamma\gamma$	γ	> 55	< 2.5	–	γ	> 55	< 2.5	–
$\gamma\gamma$	e	> 55	< 2.5	> 2.0	e	> 55	< 2.5	> 2.0
$\gamma\gamma$	e^*	> 55	< 2.5	–	γ	> 55	< 2.5	–
$\gamma\gamma$	e	> 55	< 2.5	> 2.0	γ	> 55	< 2.5	–

Cuts

- The z position of the pp collision satisfy |z| < 200 mm.
- vertex-level requirements :
- The transverse distance between the pp collision and the LLP decay satify : 2mm < |dxy| < 300mm
- *The invariant mass of the charged LLP decay products must be larger than 12 GeV.*
- N(e) + N(μ) > 1. (muons) with pT > 10 GeV and |η| < 2.47 (2.5)
- At least one of the following criteria to be satisfied :
- One mu with pt > 62 GeV and |eta| < 1.07 or
- One e with pt > 150 GeV and |eta| < 2.47
- Two e with pt > 55 GeV and |eta| < 2.47
- From a vertex there should be two oppositely charged lepton.

Cutflow table given by atlas

	$c\tau = 30$ mm			$c\tau = 100$
Cut	N_{weighted} (N_{raw})			N_{weighted}
Channel	ee	$e\mu$	$\mu\mu$	ee
No cuts	21.0 (11 119)	21.2 (11 245)	20.8 (11 079)	21.1 (11 101)
Triggers	20.6 (11 070)	20.5 (11 157)	16.6 (9217)	19.1 (10 221)
Cosmic-ray veto	20.6 (11 068)	20.5 (11 154)	16.6 (9214)	19.0 (10 201)
Primary vertex	20.6 (11 066)	20.5 (11 152)	16.6 (9212)	19.0 (10 200)
$N(\text{DV}) \geq 1$	15.1 (8189)	15.2 (8306)	12.7 (7026)	10.5 (5615)
Vertex fit	15.1 (8186)	15.2 (8302)	12.7 (7023)	10.5 (5609)
d_{xy}	15.1 (8186)	15.2 (8302)	12.7 (7023)	10.5 (5609)
Fiducial volume	14.8 (8003)	14.9 (8124)	12.4 (6902)	9.8 (5274)
Dis. pixel mod. veto	14.4 (7813)	14.6 (7939)	12.2 (6760)	9.3 (5019)
Material veto	10.9 (5897)	11.1 (6060)	12.2 (6760)	4.9 (2652)
$N(\ell) \geq 1$	7.7 (4185)	9.5 (5231)	8.5 (4799)	2.2 (1218)
$N(\ell) \geq 2$	5.4 (2913)	6.3 (3513)	6.8 (3858)	1.3 (721)
Lepton kinematics	5.3 (2862)	6.3 (3486)	6.8 (3843)	1.2 (707)
Lepton identification	4.7 (2587)	5.5 (3057)	6.2 (3550)	1.1 (628)
Overlap removal	4.7 (2563)	5.4 (3018)	6.2 (3550)	1.1 (624)
Trigger matching	4.7 (2559)	5.2 (2880)	5.7 (3262)	1.1 (623)
Presel. matching	4.7 (2553)	5.2 (2855)	5.7 (3254)	1.1 (617)
m_{DV}	4.7 (2553)	5.2 (2854)	5.7 (3253)	1.1 (617)
Opposite charge	4.6 (2504)	5.1 (2810)	5.7 (3238)	1.0 (591)
SR		14.2 (7868)		

Validation progress

We generated HEPMC events using pythia8.2 with the slha file given by atlas coll.

We need to use the MC level muon/electron to find the location of the neutralino decay.

We have finalized the Analysis code but we are still trying to use the vertex information using the MC level information.

```
// mu
Manager()->AddCut("two m");
Manager()->AddCut("mu pT > 62 GeV");
Manager()->AddCut("mu eta < 1.07");
Manager()->AddCut("mu d0 > 1.5 mm");
// * DV selection
Manager()->AddCut("dxy > 2.0 mm");
Manager()->AddCut("rxy < 300 mm"); // rxy=dxy
Manager()->AddCut("|z|_DV < 300 mm");
Manager()->AddCut("opposite charge");
```

Conclusion

- We are validating the RPV displaced vertex study
- For proper validation we need the MC level info.
- We need prod vertex of the leptons inside reco mode which we have to implement in the analysis.
- For that we need to run our analysis code using the recent MA5 and we will dot that.