Search for supersymmetry with displaced dileptons at the ATLAS experiment

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GEFÖRDERT VOM

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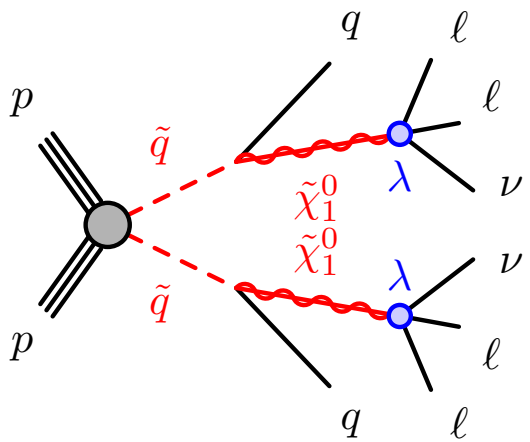
Search for displaced dileptons

- Search for massive long-lived particles decaying to two charged leptons (e or μ)
- Sensitive to lifetimes of about 1 ps to 1 ns
- Model independent search interpreted in supersymmetric models, eg:

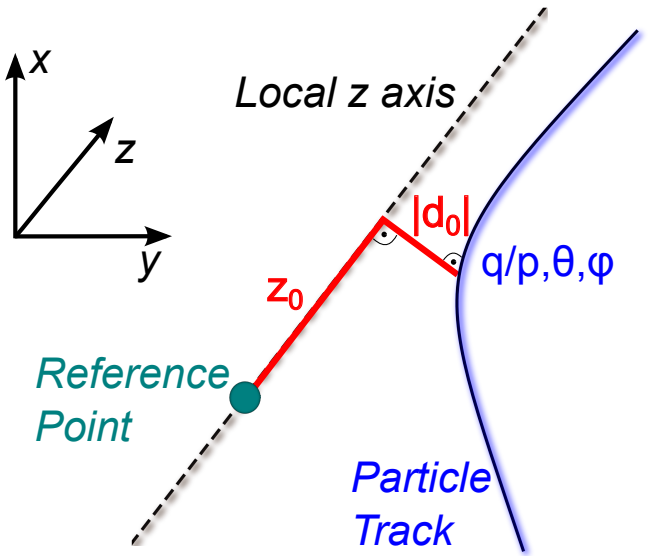


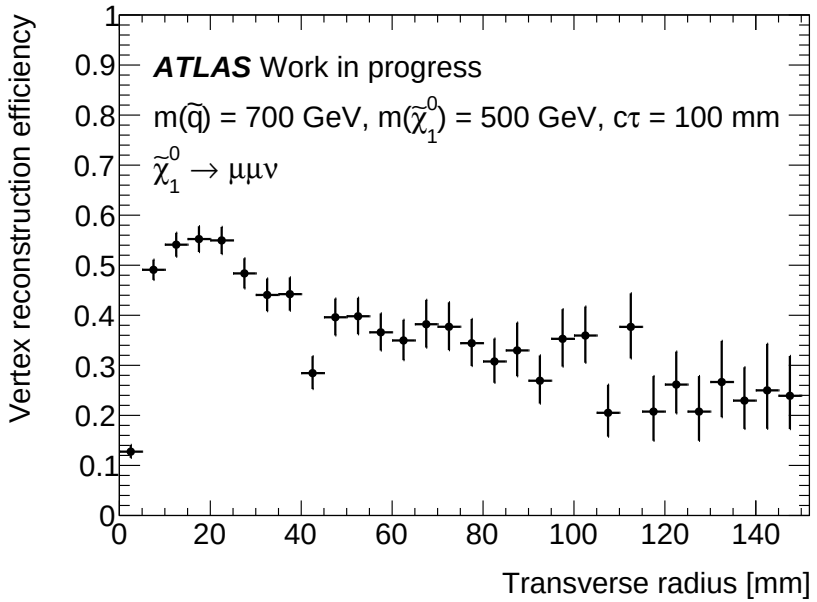
- Experimental signature: Displaced vertices with two lepton tracks

Reconstruction of displaced vertices

- Standard tracking reconstructs tracks up to $|d_0| = 10\,\text{mm}$
- Additional tracking optimised for tracks up to $|d_0| = 300\,\text{mm}$
- Secondary vertices reconstructed by standard ATLAS vertexer
- Tracking and vertexing very resource-intensive

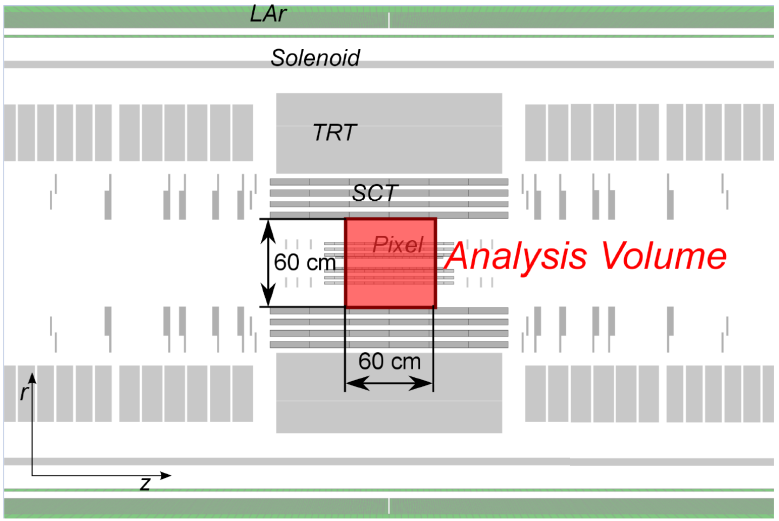
  $\rightarrow$ Event preselection based on photon and muon spectrometer triggers





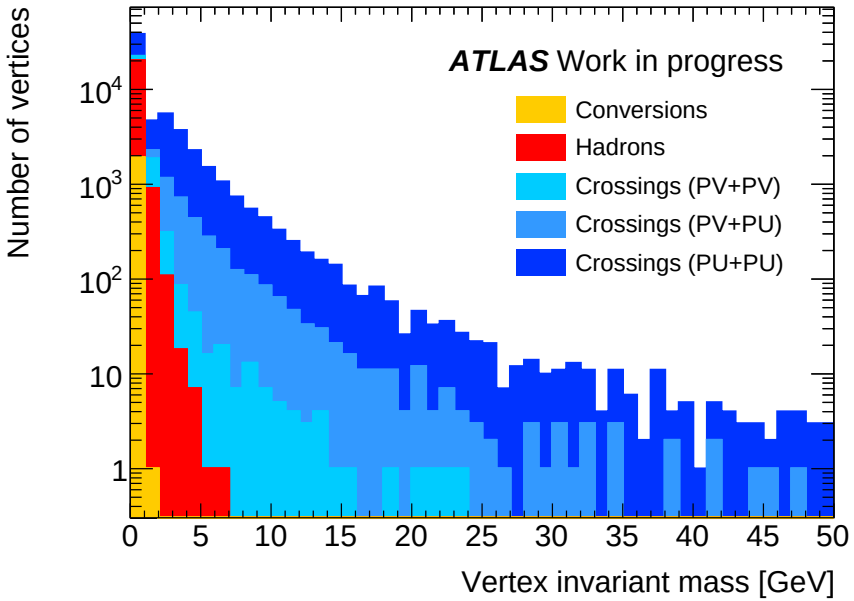
Displaced vertex selection

- Displaced vertex with at least two oppositely charged leptons
  - Lepton tracks: $p_T > 10\,\text{GeV}$ and $|d_0| > 2\,\text{mm}$
  - Displacement: 4 mm in transverse plane to all PVs
  - Fiducial volume:



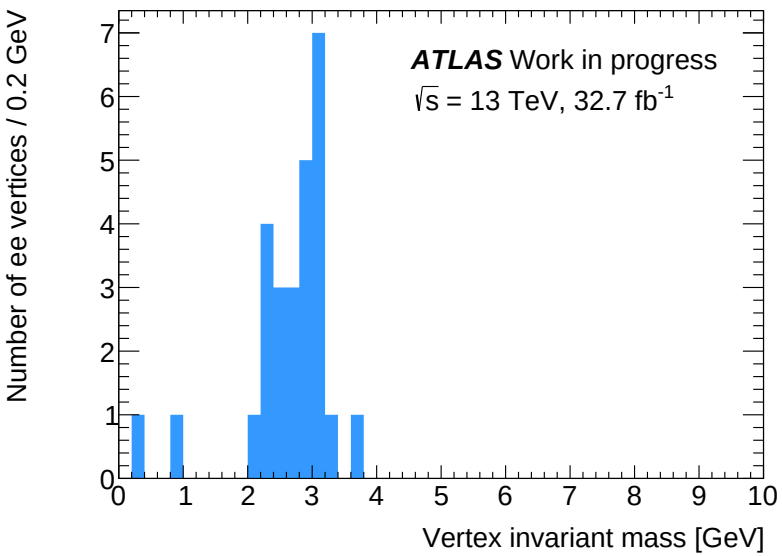
  - Vertices inside detector material are vetoed
  - $m_{\text{DV}} > 10\,\text{GeV}$
  - Vertex has to pass at least one criterion used to preselect data events

Background sources of displaced vertices

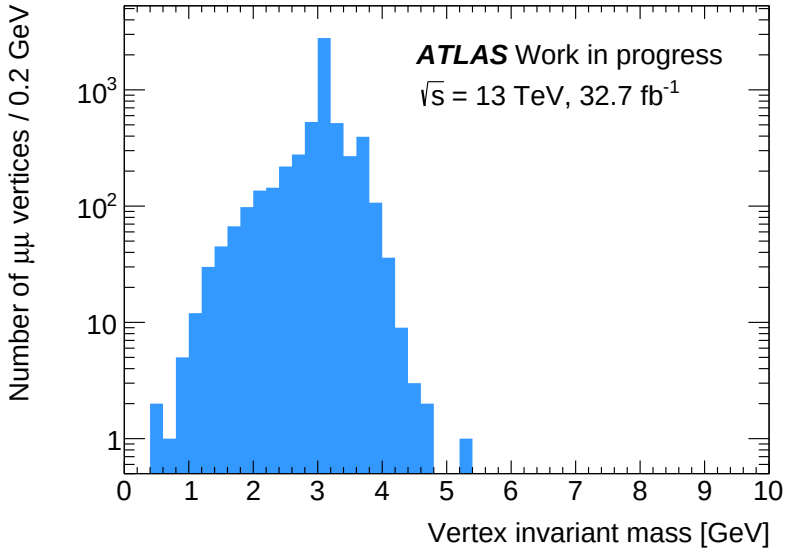


- Plot shows origin of displaced vertices with two tracks in a $t\bar{t}$ Monte Carlo sample
- No leptons required and p_{T} cut on tracks lowered to 1 GeV
- Random crossing of tracks dominant background for $m_{\mathrm{DV}} > 10\,\mathrm{GeV}$

Hadron decays



ee vertices



$\mu\mu$ vertices

- Validation region on data with inverted mass cut and loosened vertex selection
- Most vertices originate from displaced J/ψ particles of B-hadron decays
- No dilepton vertex with $m_{\mathrm{DV}} > 5.5\,\mathrm{GeV}$ observed

  $\rightarrow$ Background from hadron decays negligible

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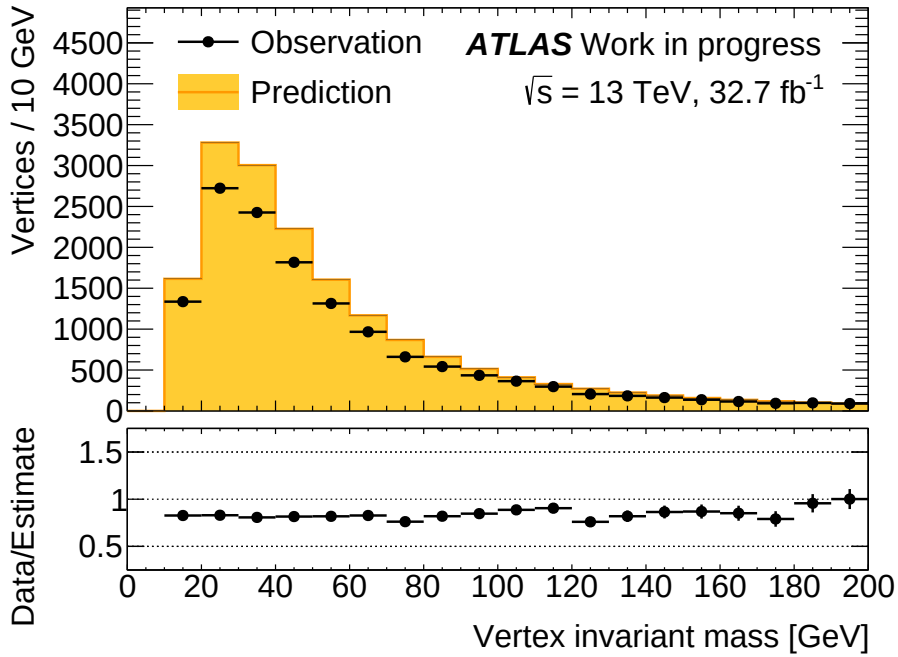
  - Estimate: Number of lepton pairs in data $\times$ p_{xing}

Validation of random crossing estimation

- Validation region: Vertices with two tracks that fail lepton identification
- Enlarge statistics: No trigger and opposite charge requirements
- All other vertex selection criteria applied

	VR
Number of pairs	1.1×10^{8}
Avg. crossing prob.	1.6×10^{-4}
Predicted vertices	17947
Observed vertices	14775



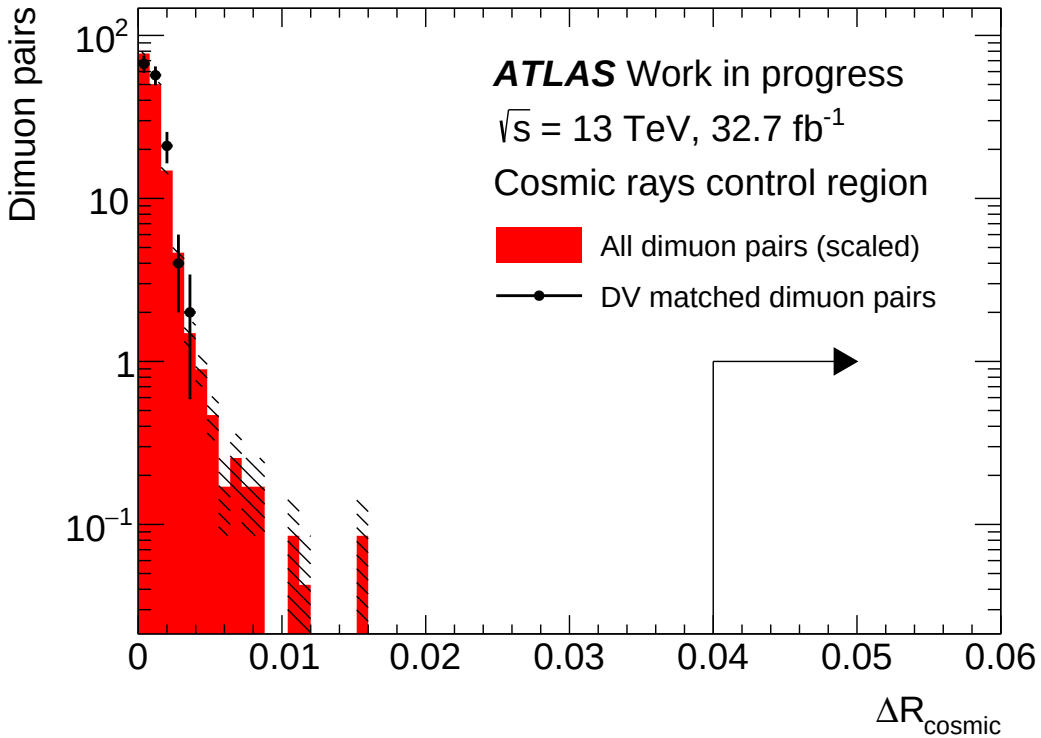
Background estimate for signal regions

SR	$N_{\ell\ell}$	$p_{\text{xing}}/10^{-5}$	$N_{vx}^{est}/10^{-4}$
ee	$22\ ^{+0.6}_{-8.9}$ (syst.)	0.52 ± 0.05 (stat.) ± 0.13 (syst.)	1.2 ± 0.1 (stat.) $^{+0.3}_{-0.6}$ (syst.)
$e\mu$	$11\ ^{+0}_{-2.7}$ (syst.)	6.2 ± 0.2 (stat.) ± 1.4 (syst.)	6.9 ± 0.2 (stat.) $^{+1.6}_{-2.3}$ (syst.)
$\mu\mu$	$5\ ^{+0}_{-2.6}$ (syst.)	9.7 ± 0.3 (stat.) ± 2.2 (syst.)	4.9 ± 0.1 (stat.) $^{+1.1}_{-2.8}$ (syst.)

- Random crossing background is of the order 10^{-4} for all SRs
- p_{xing} larger in VR due to missing trigger requirement
- p_{xing} smaller for ee than for $\mu\mu$ (also observed on MC)
- Total uncertainties on the estimates not larger than 60%

Cosmic muons

- Cosmic muons sometimes reconstructed as a back-to-back muon pair
- Back-to-backness: $\Delta R_{\text{cosmic}} = \sqrt{(\eta_1 + \eta_2)^2 + (|\Delta\phi| - \pi)^2}$
- Veto cosmic muons in signal regions by requiring: $\Delta R_{\text{cosmic}} > 0.04$
- Invert cosmic veto to study back-to-backness of cosmic muons:



Summary

- Search for displaced vertices with at least two lepton tracks
- Interpreted in supersymmetric models
- Dominant background from random crossings of leptons
- Data-driven estimate of random crossings
- Background is of the order 10^{-4} for all SRs
- Potential signal could be identified very clearly in data