

Search for supersymmetry with displaced dileptons at ATLAS in run 2

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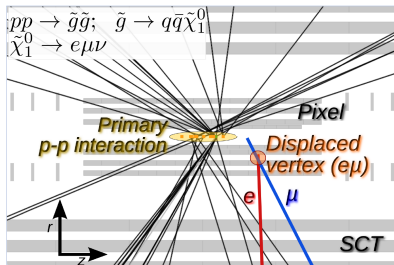
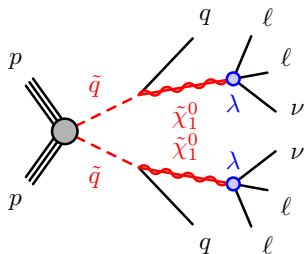
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(Werner-Heisenberg-Institut)

- Symmetry between fermions and bosons
- Every Standard Model particle gets superpartner
- Spin differs by 1/2
- Minimal supersymmetric Standard Model:

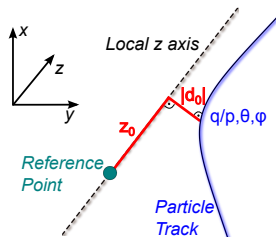
Quarks	Gauge Bosons	Higgs Bosons
u c t	γ	h^0
d s b	Z^0	H^0
Leptons	W^\pm	H^\pm
e^\pm μ^\pm τ^\pm	g	A^0
ν_e ν_μ ν_τ		

Gauginos	Squarks
$\tilde{\chi}_1^0$ $\tilde{\chi}_1^\pm$	\tilde{u} \tilde{c} \tilde{t}
$\tilde{\chi}_2^0$ $\tilde{\chi}_2^\pm$	\tilde{d} \tilde{s} \tilde{b}
$\tilde{\chi}_3^0$	Sleptons
$\tilde{\chi}_4^0$ \tilde{g}	\tilde{e}^\pm $\tilde{\mu}^\pm$ $\tilde{\tau}^\pm$
	$\tilde{\nu}_e$ $\tilde{\nu}_\mu$ $\tilde{\nu}_\tau$

- Search for long-lived heavy particles decaying to two leptons (e^\pm, μ^\pm)
- Lifetimes of order ps to ns \rightarrow displaced vertex in the inner detector
- Example: R-parity violating decays of a long-lived neutralino

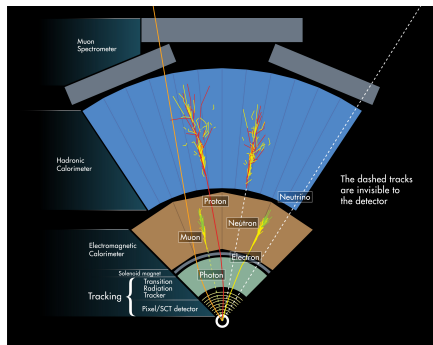


- Standard reconstruction: Tracks up to $|d_0| = 10$ mm

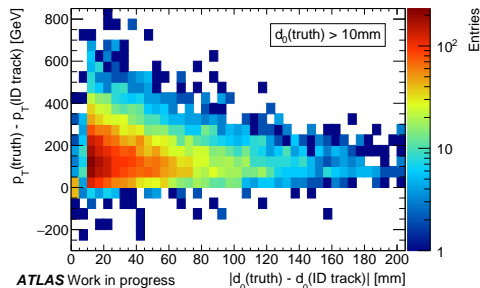
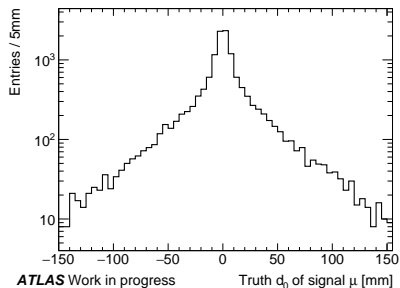


- Searches for displaced vertices require a much larger value
- Redo **entire** detector reconstruction allowing for large d_0 tracks
- Only possible for small fraction ($\approx 1\%$) of data due to resource constraints
- This fraction is defined by filters

- Filters should select events with displaced leptons
- Main challenge: Most displaced tracks not reconstructed yet
- Two types of filters:
 - Lepton tracks of standard reconstruction with $|d_0| > 2$ mm
→ Vertices with small displacement
 - No inner detector (ID) information
→ Photons and muon spectrometer (MS) tracks

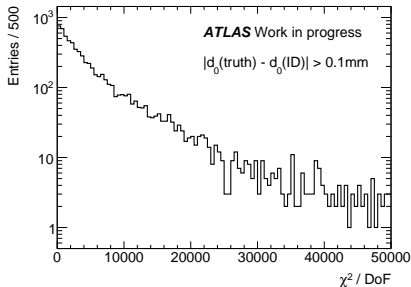
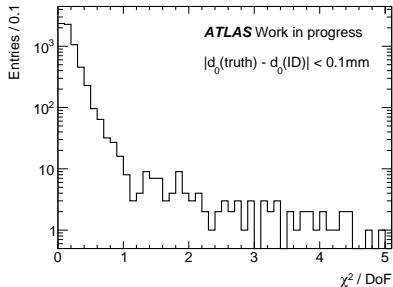


- Performance of standard reconstruction for displaced muons?
- Expectation for $|d_0(\text{truth})| > 10$ mm:
ID track not reconstructed \rightarrow Unmatched MS track
- Observation: MS tracks still matched to unrelated ID tracks



Sample: $m(\tilde{q}) = 700$ GeV, $m(\tilde{\chi}_1^0) = 500$ GeV and $c\tau(\tilde{\chi}_1^0) = 100$ mm

- Use truth information to study well- and badly-reconstructed muons
→ Based on $|d_0(\text{truth}) - d_0(\text{ID})|$
- Fit quality for ID/MS matching effectively discriminates the two cases:



Sample: $m(\tilde{q}) = 700\text{ GeV}$, $m(\tilde{\chi}_1^0) = 500\text{ GeV}$ and $c\tau(\tilde{\chi}_1^0) = 100\text{ mm}$

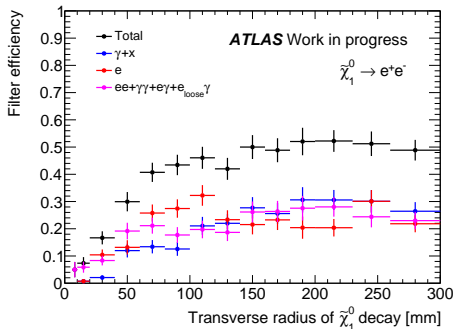
- Muon spectrometer trigger
- Kinematic cuts: $p_T > 60 \text{ GeV}$, $|\eta| < 1.07$
- All muons are classified into two groups:
 - Muons with ID match ($\chi^2/\text{DoF} < 5$):
 - Muon track has to pass kinematic cuts and $|d_0| > 1.5 \text{ mm}$
 - Everything else:
 - MS track has to pass kinematic cuts

- 6 preselection filters:

Filter	e	$\gamma + e/\gamma/\mu$	ee	$e\gamma$	$e_{\text{loose}}\gamma$	$\gamma\gamma$
Trigger [GeV]		$\gamma(140)$				$\gamma\gamma(50)$
Offline p_T [GeV] >	140	150 + 10				50

- $e, \gamma: |\eta| < 2.5$
 - $e: |d_0| > 2 \text{ mm}$ except for e_{loose}
 - e_{loose}, γ : Loose identification required
- γ trigger rates significantly increased with respect to run 1
 $\rightarrow \gamma$ filter requires now additional low p_T e, γ or μ

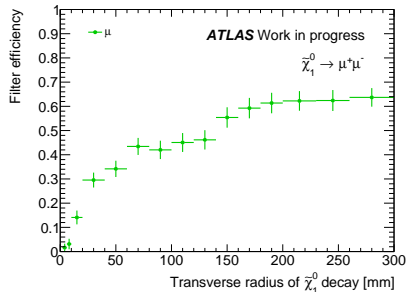
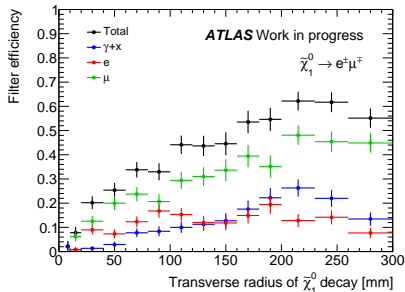
- Plot shows filter efficiencies **per vertex** for e^+e^- vertices:



Sample: $m(\tilde{q}) = 700$ GeV, $m(\tilde{\chi}_1^0) = 50$ GeV and $c\tau(\tilde{\chi}_1^0) = 100$ mm

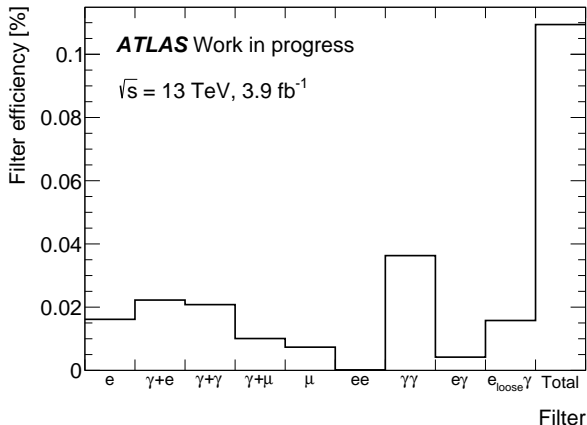
- Reconstructed particles matched to truth vertices
- Good efficiencies even for low LSP mass of 50 GeV
- LSP decays with transverse radii below 50 mm barely selected

- Plots show filter efficiencies **per vertex** for $e^\pm\mu^\mp$ and $\mu^+\mu^-$ vertices:

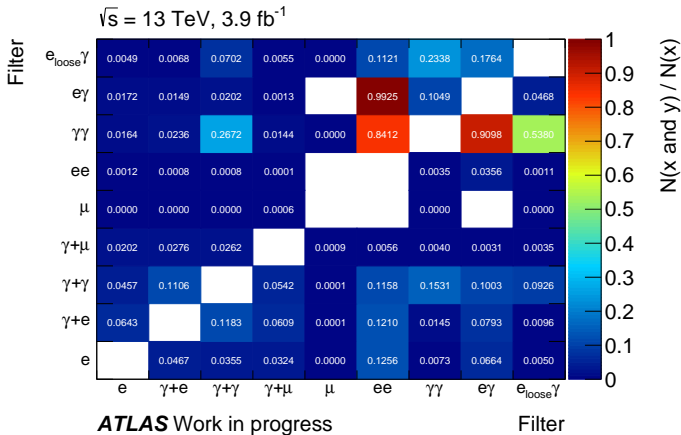


Sample: $m(\tilde{q}) = 700$ GeV, $m(\tilde{\chi}_1^0) = 50$ GeV and $c\tau(\tilde{\chi}_1^0) = 100$ mm

- μ filter most important in both cases
- e and $\gamma + x$ filters less important due to high p_T cuts



- About 1.5 million events selected in 2015
- $\gamma + x$ filter contributes nearly 50% to total rate
- $\gamma\gamma$ filter with second largest rate



- Small overlap of e , $\gamma + x$ and μ filters with other filters
- Large overlap between diparticle filters

- Search for displaced vertices with two leptons
- Standard ATLAS reconstruction not sensitive
- Retracking of displaced tracks necessary
- Only possible for small fraction of data
- Preselection filters defined and 1.5 million events selected in 2015
- Filters provide good signal efficiencies even for low LSP masses
- Targeting publication for full 2015 + 2016 data set