Search for supersymmetry with displaced dileptons at ATLAS in run 2

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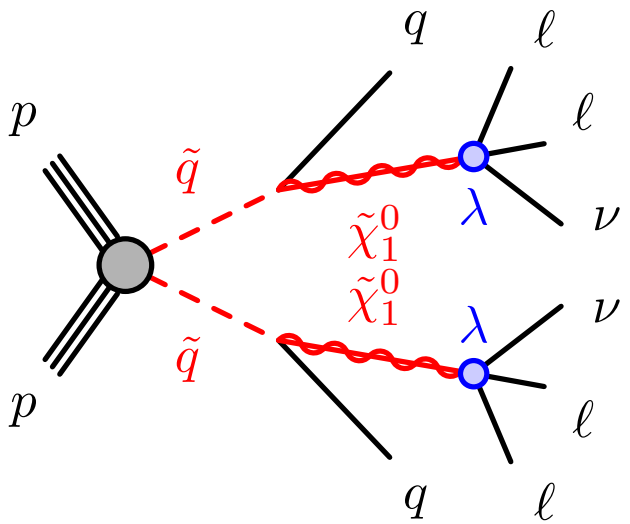
Introduction

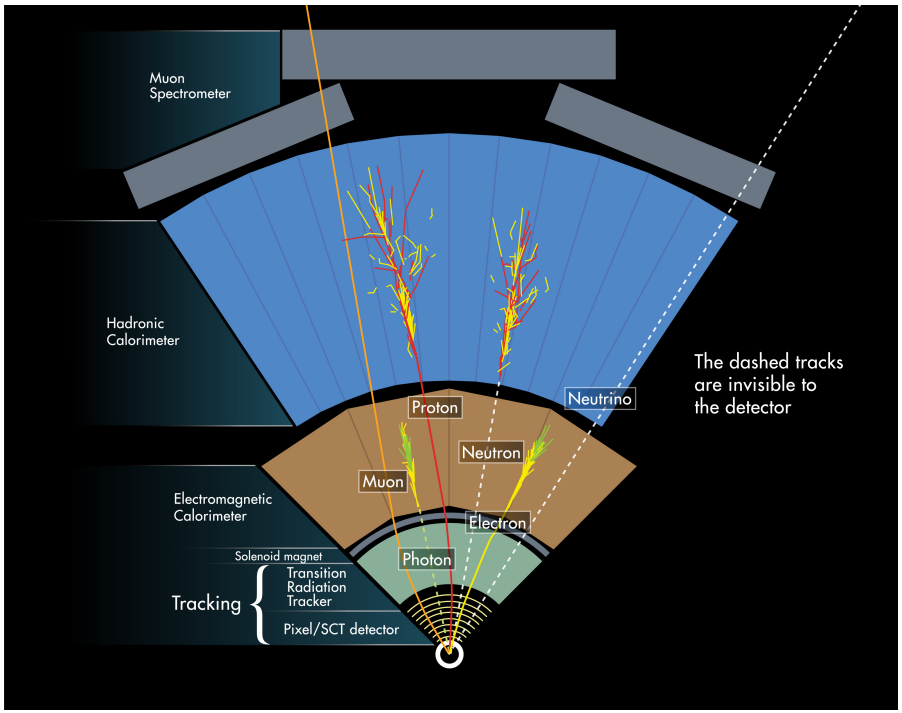
- Search for displaced vertices with two lepton tracks in the inner detector
- Sensitive to particle lifetimes ($c\tau$) of about 1 mm to 1 m
- Example: Supersymmetric model with direct squark production



  - Long-lived R-parity violating $\tilde{\chi}_1^0$ decays to $\ell\ell\nu$
  - Pythia+MadGraph with full detector simulation

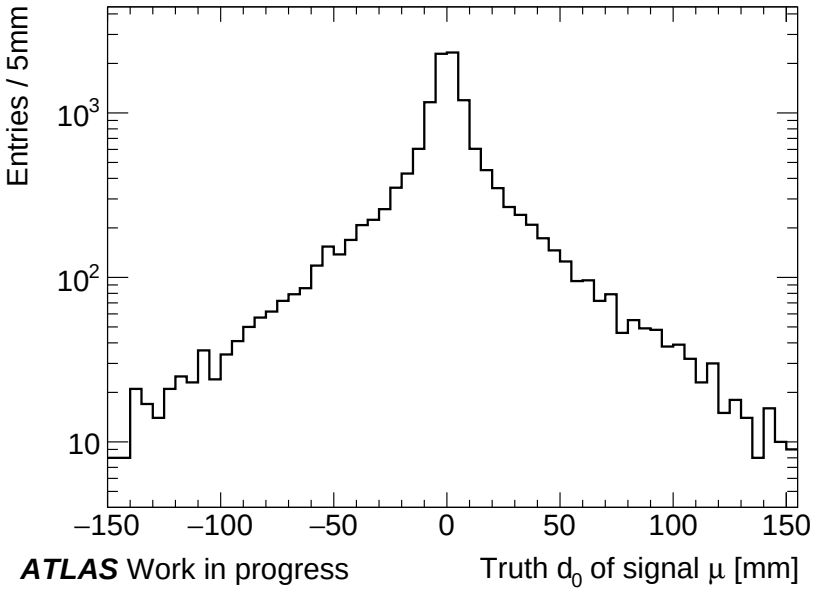
Preselection of data events

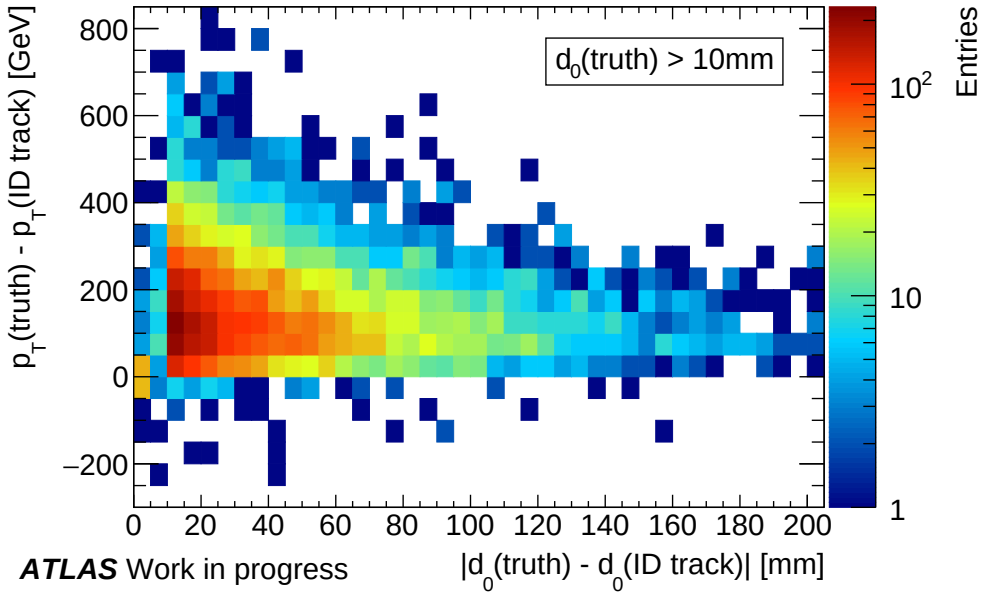
- Standard ATLAS reconstruction not sensitive to such signals
- Redo reconstruction for large d_0 tracks $\rightarrow$ very resource consuming
- Preselection filters required with high signal efficiencies and low rates
  - Limited use of inner detector (ID) information
    $\rightarrow$ Main filter objects: Photons and muon spectrometer (MS) tracks
  - Lepton tracks of standard reconstruction with $d_0 > 2\,\text{mm}$ selected
    $\rightarrow$ Vertices with small displacement



Standard reconstruction of displaced muons

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

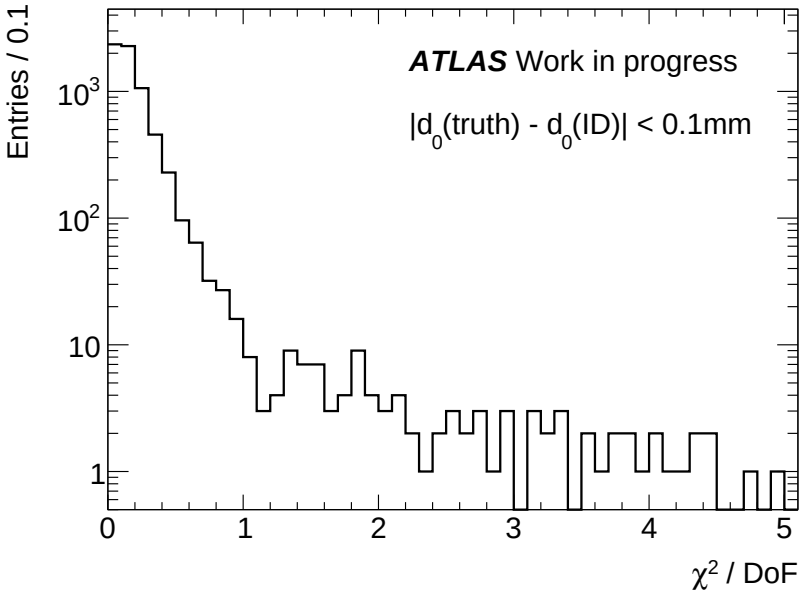


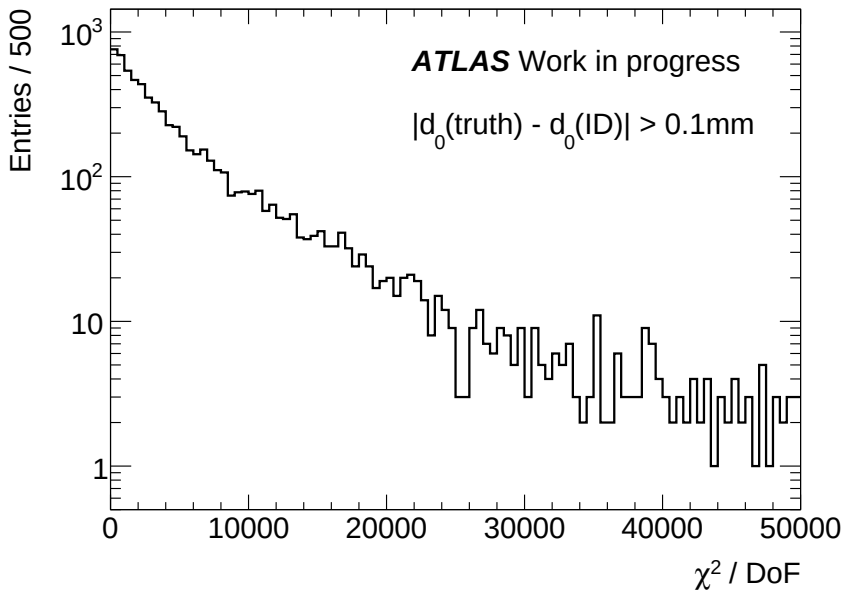


Sample: $m(\tilde{q}) = 700\,\text{GeV}$, $m(\tilde{\chi}_1^0) = 500\,\text{GeV}$ and $c\tau(\tilde{\chi}_1^0) = 100\,\text{mm}$

Identifying mismatches of muon tracks in data

- Use truth information to study well- and badly-reconstructed muons
  $\rightarrow$ 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 filter

- Muon spectrometer trigger with 60 GeV threshold
  - High fake rate in end-caps
  - Trigger restricted to barrel: $|\eta| < 1.07$
- Offline η and p_T cuts = trigger cuts
- Muons are classified into two groups:
  - Muons with ID match ($\chi^2/\text{DoF} < 50$):
    $\rightarrow$ Muon track has to pass kinematic cuts and $|d_0| > 1.5\,\text{mm}$
  - Everything else:
    $\rightarrow$ MS track has to pass kinematic cuts

Electron and photon filters

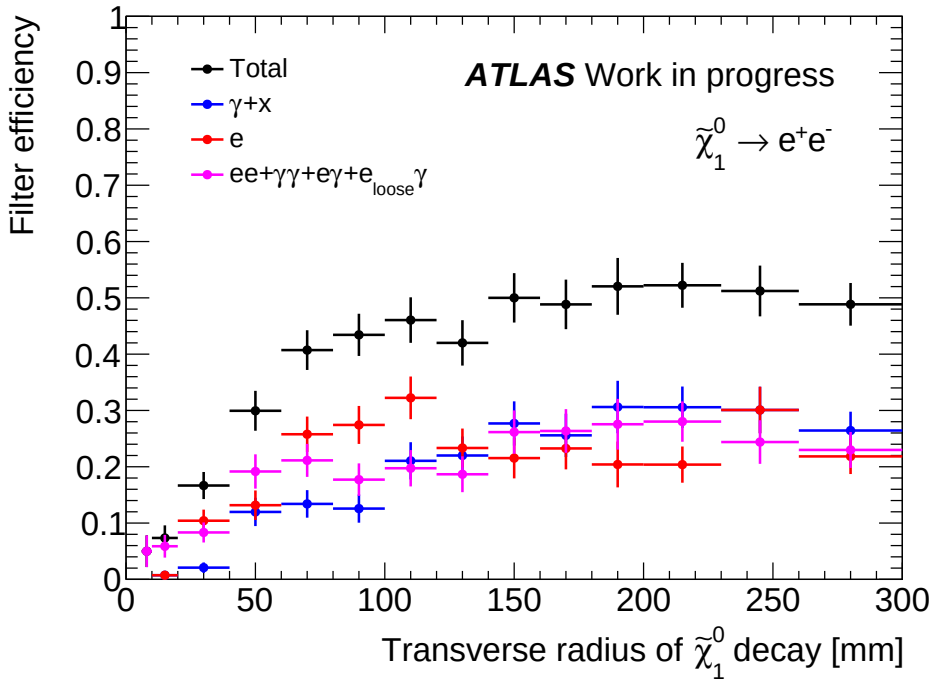
- 6 preselection filters:

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, γ: $|\eta| < 2.5$
  - 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
  $\rightarrow$ γ filter requires now additional low p_T e, γ or μ

Filter efficiency in signal samples

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

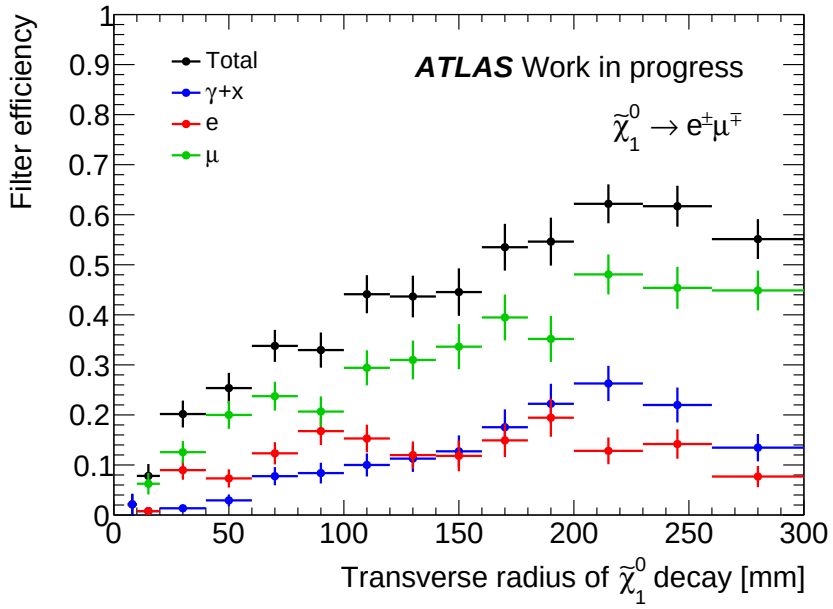


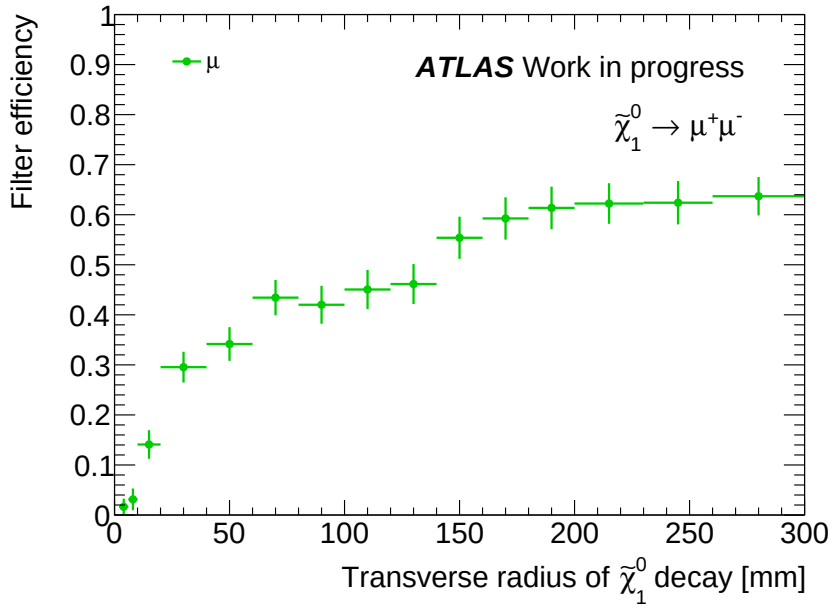
Sample: $m(\tilde{q}) = 700\,\text{GeV}$, $m(\tilde{\chi}_1^0) = 50\,\text{GeV}$ and $c\tau(\tilde{\chi}_1^0) = 100\,\text{mm}$

- 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

Filter efficiency in signal samples

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

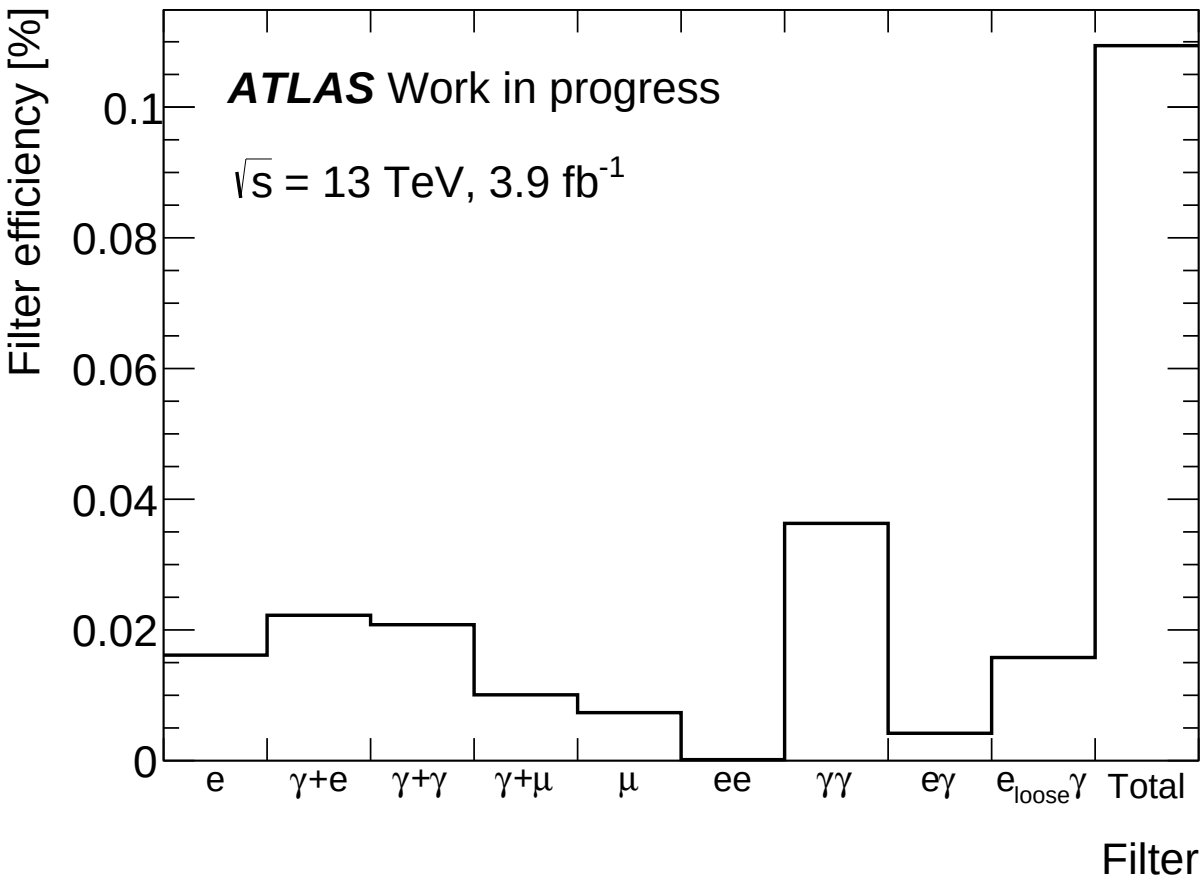




Sample: $m(\tilde{q}) = 700\,\text{GeV}$, $m(\tilde{\chi}_1^0) = 50\,\text{GeV}$ and $c\tau(\tilde{\chi}_1^0) = 100\,\text{mm}$

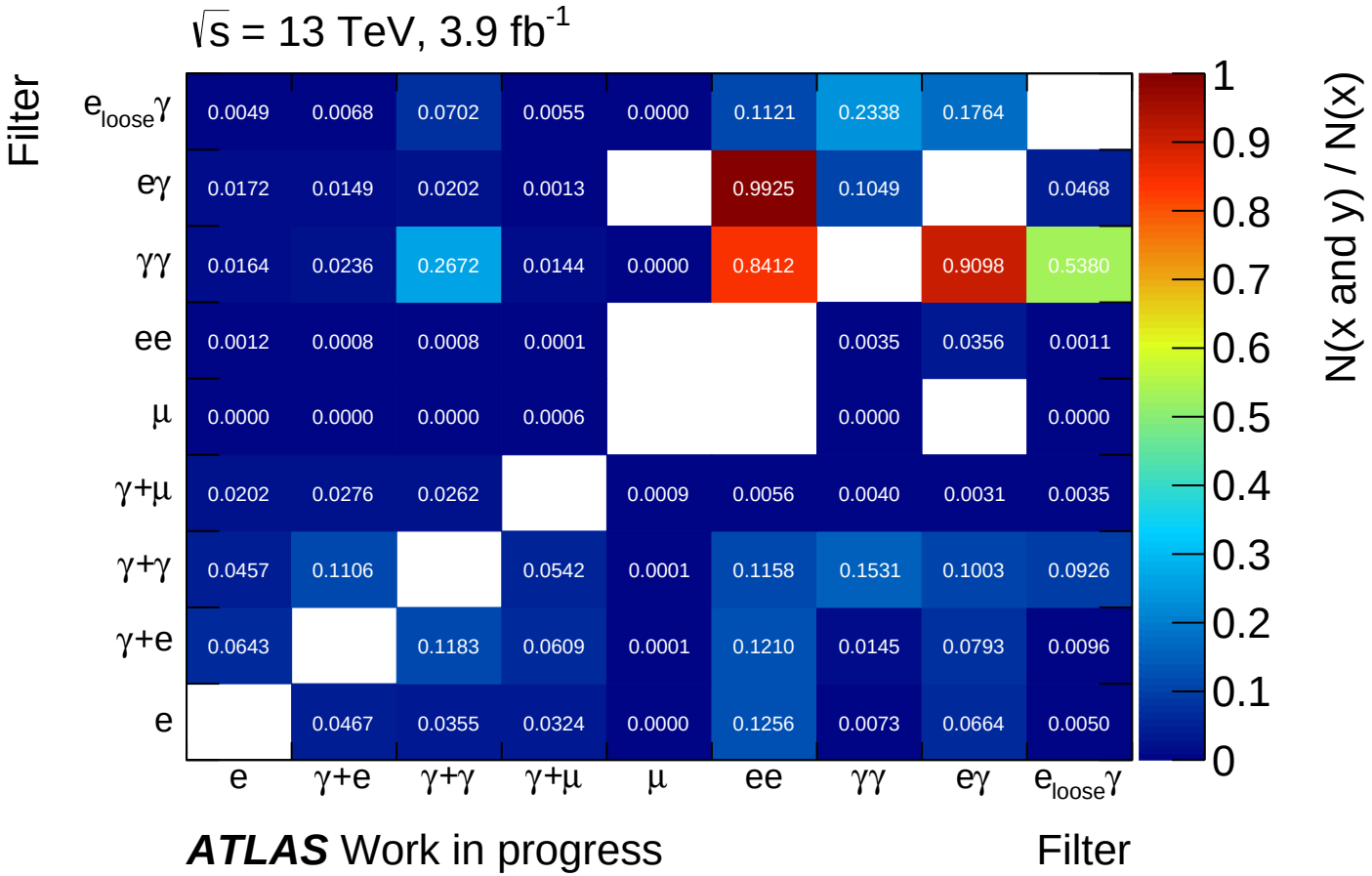
- μ filter most important in both cases
- e and $\gamma + x$ filters less important due to high p_T cuts

Filter efficiency in 2015 data



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

Filter overlap in 2015 data



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

Summary

- Search for displaced vertices with two leptons
- Standard ATLAS reconstruction not sensitive
- Retracking of displaced tracks necessary
- Preselection filters defined and 1.5 million events selected in 2015
- Filters provide good signal efficiencies even for low LSP masses
- Analysis framework updated for run 2
- Targeting publication for 2016