Search for higgsino with compressed mass spectra using low pT tracking

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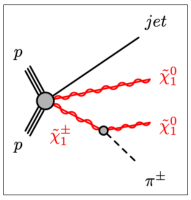
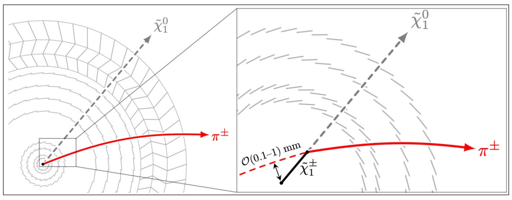
1. Physics motivation and signature

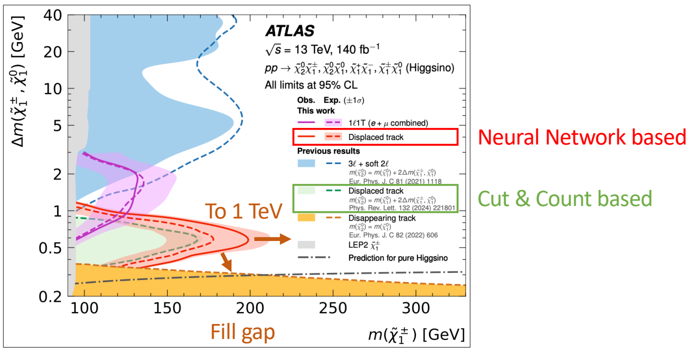
- Target: Higgsino LSP scenario with $\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0) \leq 1$ GeV
  - ➢ Δm becomes small naturally if EW gauginos and higgsino are decoupled.
- Well-motivated by the naturalness argument [1] & qualification as DM candidate.
  - ➢ Higgsino mass close to EW scale.
  - ➢ Small Δm is not excluded yet [2] & difficult to explore with DM direct detection [3].
- $\Delta m \in [0.3, 1.0]$ GeV → Lifetime of $\tilde{\chi}_1^{\pm}$ is relatively long.
  Track has large transvers impact parameter (**Displaced Track**).





2. Previous analysis

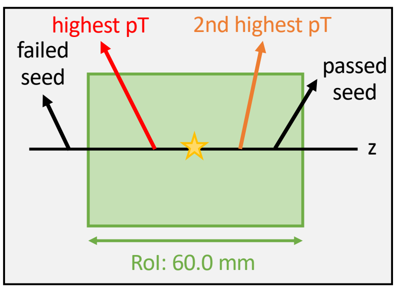
- Cut & Count [4] and Neural Network [5] based analysis with ATLAS RUN2 data (140 fb^{-1}).
  - ➢ High pT Initial State Radiation (ISR) jet to boost the system.
  - ➢ Trigger signal event using missing transverse momentum (E_T^{miss}).
- **C&C analysis**
  Required tight cut:
  - E_T^{miss} > 600 GeV
  - track pT ∈ [2,5] GeV
  to reduce SM BG mainly from Z(→νν)+jets and W(→τν)+jets.
  → Lost signal acceptance.
- **NN analysis**
  Overcome this point by achieving efficient Signal-BG separation using event-level and track-level NN.



3. Analysis strategy

- Gap between Displaced Track analysis (red and green) and Disappearing Track analysis (orange):
  - ➢ Lifetime of $\tilde{\chi}_1^{\pm}$ is too short to leave short track in inner detector.
    → Less sensitivity in Disappearing Track analysis.
  - ➢ Track has typically pT < 0.5 GeV, which is out of range of ATLAS nominal tracking.
    → Less sensitivity in Displaced Track analysis.

- Overcome using special tracking dedicated to pT < 0.5 GeV (**low pT tracking**). [6]



4. Estimated increase of signal tracks

- Monte Carlo sample for RUN2 (140 fb^{-1})
  $\tilde{\chi}_2^0\tilde{\chi}_1^0, \tilde{\chi}_2^0\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp}, \tilde{\chi}_1^0\tilde{\chi}_1^{\pm}$ assuming pure-higgsino like state with $\Delta m(\tilde{\chi}_2^0, \tilde{\chi}_1^0) = 2\Delta m(\tilde{\chi}_1^{\pm}, \tilde{\chi}_1^0), m(\tilde{\chi}_1^0) = 150$ GeV
- Detector simulation data was deleted.
  → Estimated reco. efficiency using leptonic decayed W(→τν)+jets.
- Estimated cut efficiency using signal sample (5%).

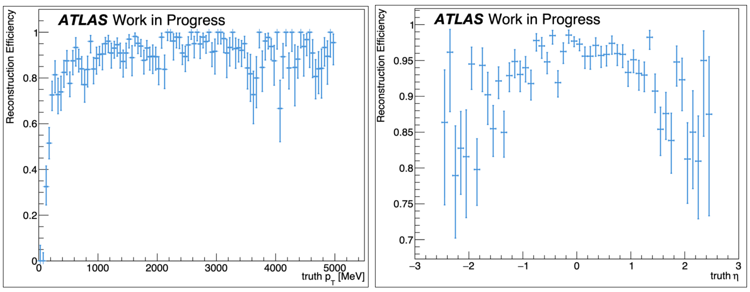
1. Apply event kinematics cut to W(→τν)+jets sample.
2. Retrieve HITS files containing selected events and reconstruct low pT tracks.
3. Apply event & track kinematics selection and calculate efficiency depending on truth pT and η.
4. Apply it and cut efficiency to the signal MC sample.

Event kinematics cut	
Trigger	E_T^{miss} trigger
Leading jet pT	> 250 GeV
Leading jet WP	Tight
Leading jet |η|	< 2.4
E_T^{miss}	> 600 GeV
baseline leptons	= 0
baseline photons	= 0
min(Δϕ(jet, p_T^{miss}))	> 0.4 rad

Track kinematics cut	
Track quality	Tight
IBL Hits	> 0
pT	< 5 GeV
|η|	< 1.5
|d0|	< 10 mm
|Δz0sinθ|	< 3 mm
|Δϕ(track, E_T^{miss})|	< 0.4
track based isolation	no tracks within ΔR<0.4
tracks from secondary vertex	veto

- Signal tracks increase 25 times and 2 times for Δm=0.25, 0.5 GeV, respectively.

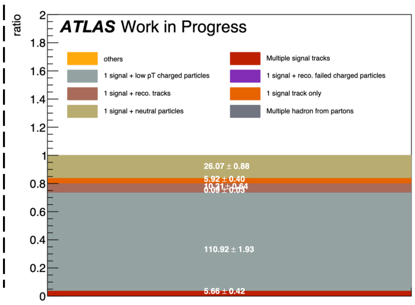
Δm	track pT > 2 GeV	track pT > 0.2 GeV
0.25 GeV	0.37 ± 0.07 tracks	9.23 ± 0.62 tracks
0.5 GeV	17.13 ± 0.75 tracks	36.28 ± 1.3 tracks



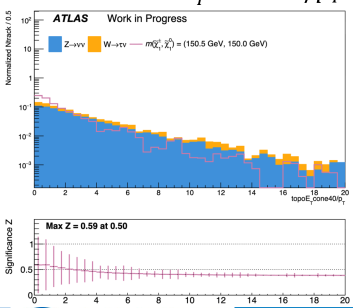
5. Estimated increase of BG tracks

- BGs from underlying event, pileup, and fake increase by factor 23 by lowering pT threshold (2 → 0.5 GeV).
- Newly introduced handles for rejecting these BGs:
  - Secondary Vertex Veto using low pT tracks
    70% of BG tracks accompanies low pT charged particle (gray)
    (e.g. $K_s^0 \to \pi^+\pi^-$ which one π is pT < 0.5 GeV)
  - Calorimeter isolation

Truth composition of Z(→νν)+jets



Distribution of $E_T^{topocone40}/p_T$



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[5] The ATLAS Collaboration, arXiv:2511.20042.
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