Squeezing (higgsino) disappearing tracks

Rakhi Mahbubani, University of Hertfordshire
(with Can Kilic, Matthew Gignac, Taewook Youn)

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Snowmass EF10 DM@COLLIDERS

Improve sensitivity of hadron collider searches to ‘pure higgsinos’*

*Pseudo-Dirac weak-doublet fermion with hypercharge -1/2.

Simplified model

$$\mathcal{L} = \mathcal{L}_{\rm SM} + i\bar{\chi}\left(\not{\partial} - ig\not{W}^i\tau^i - ig'\frac{1}{2}Y\not{B}\right)\chi + \mu\bar{\chi}\chi\,, \qquad \chi = \begin{pmatrix} \chi^+ \\ \chi^0 \end{pmatrix}$$

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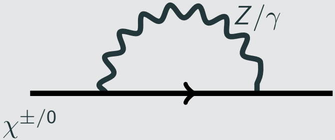
IR contribution



$\Delta m \sim \frac{\alpha}{2} m_Z = \mathcal{O}(300 \text{ MeV})$

Compressed spectrum

Thomas and Wells, hep-ph/9804359

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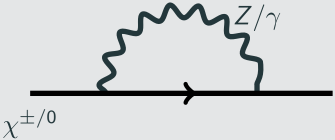

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Decays

Chargino decay kinematically suppressed.

Dominant mode $\chi^+ \to \pi^+ \chi^0$

$$c\tau \sim 7\,\text{mm} \times \left(\frac{340 \text{ MeV}}{\Delta m}\right)^3 \left(1 - \frac{m_{\pi^+}^2}{\Delta m^2}\right)^{-\frac{1}{2}}$$

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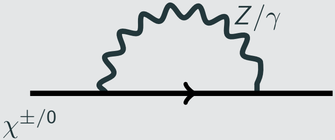

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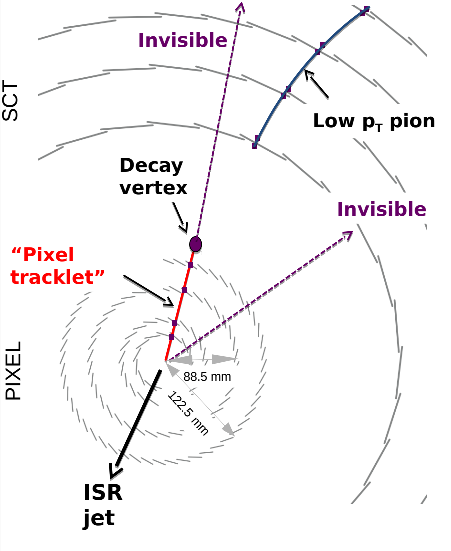
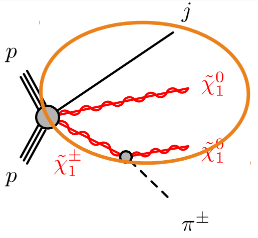
Can also have UV contributions to splittings (incl. neutral splittings c.f. direct detection)

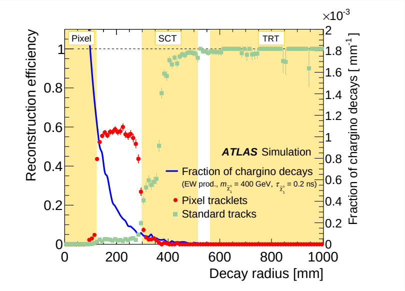
We will consider $\mu = (\mathcal{O}(100\mathrm{GeV}), 1.1\mathrm{TeV})$, with varying $c\tau$

Disappearing charged track(let)

Slide: Matthew Gignac







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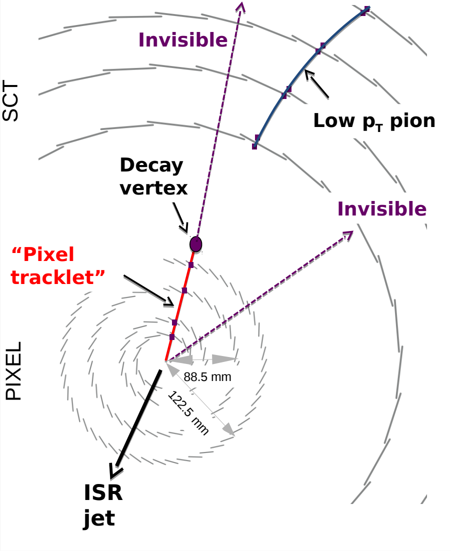
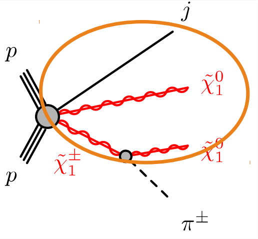
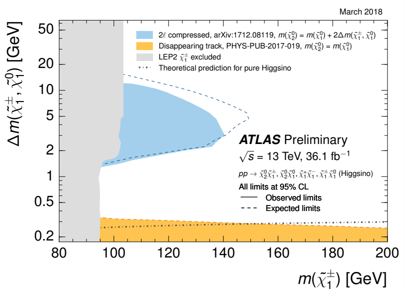
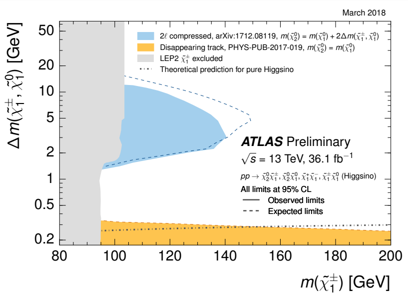




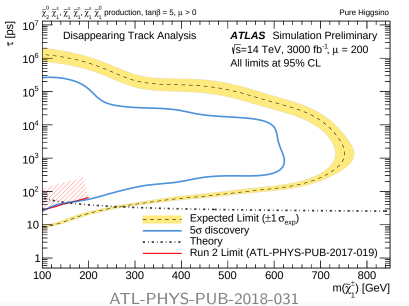


ATLAS 1712.02118

Disappearing charged tracklet: status



LHC Run 2



ATL-PHYS-PUB-2018-031

HL-LHC

HL-LHC has same discovery sensitivity in lifetime as Run 2 exclusion.

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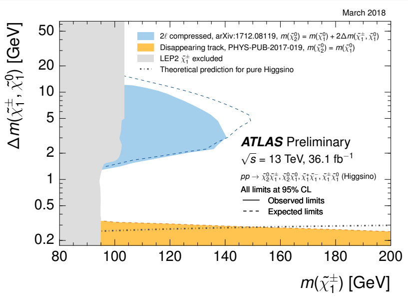

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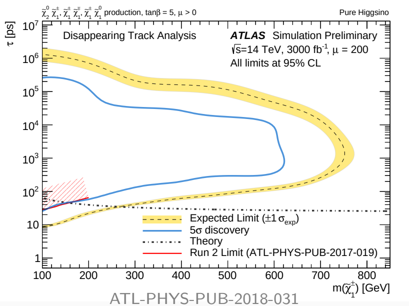

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High pileup environment, fake backgrounds increase by a factor of 200!

BIG CHALLENGE

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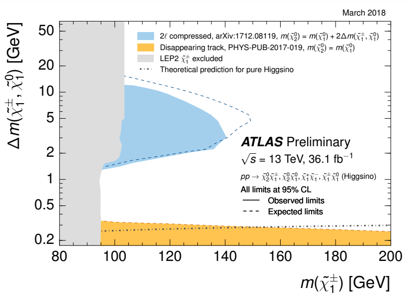

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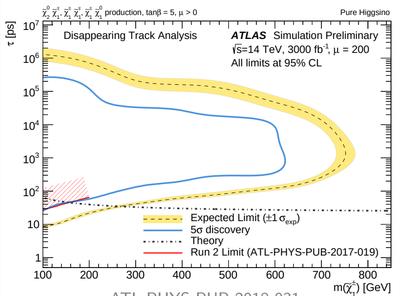

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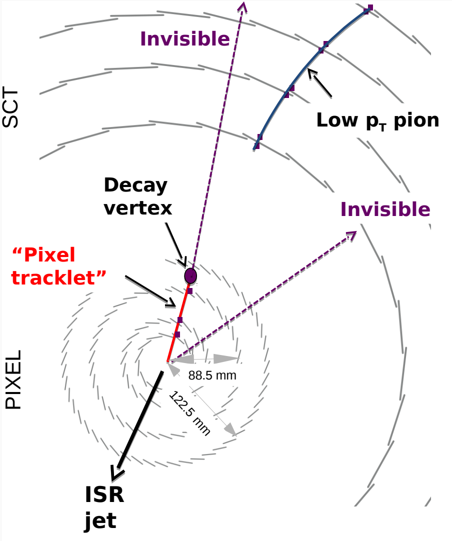
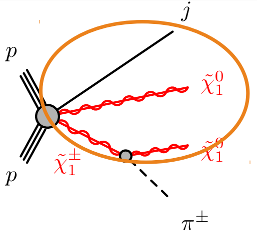
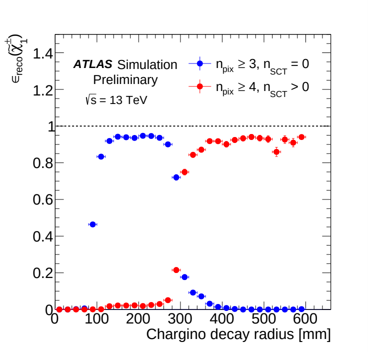
BIG CHALLENGE → BIG OPPORTUNITY

State-of-the-art: 3-hit tracklet

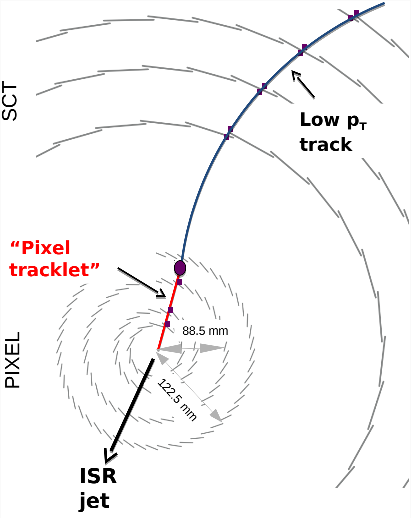


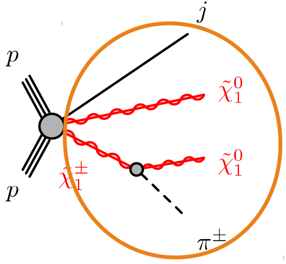




State-of-the-art: 3-hit tracklet + soft pion

Use contiguous soft-pion track to beat down backgrounds.





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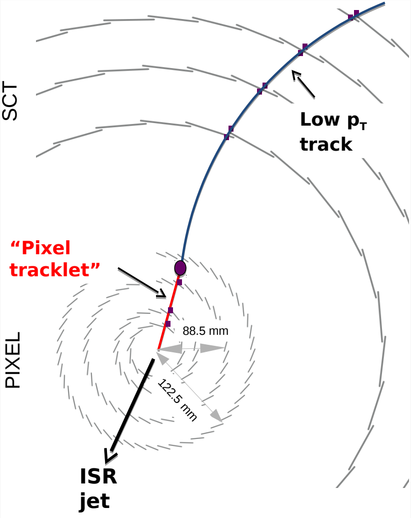

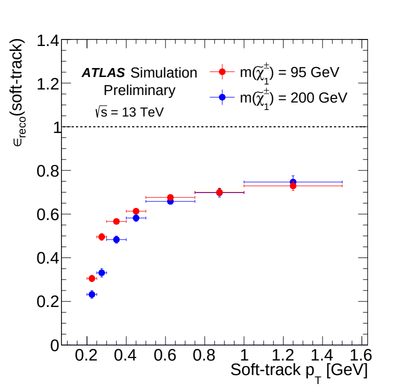

ATL-PHYS-PUB-2019-011

Efficiency 50-60% for $p_T > 300$ MeV

Ideas

Run 3/HL-LHC

Reduce tracklet length and decrease MET cut) to increase signal efficiency.

Scaling of dominant backgrounds crucial (fake, data-driven in ATLAS analysis)

- Use bootstrapping method to extrapolate measured backgrounds to lower MET from ATLAS published data
- Additional handles: two tracklets with different # of hits? soft track? dE/dx? tracklet momentum?

FCC-hh

"Carte blanche" ?

Explore parameter space to maximize sensitivity
(c.f. R.M, Schwaller, Zurita 1703.05327)

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Your comments/ideas welcome

Backup slides

Pure higgsinos

Split Dirac Supersymmetry

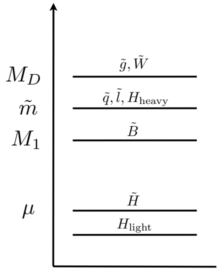
Tuning to get EW vev

Arkani-Hamed and Dimopoulos, hep-th/0405159

+

Dirac masses for gluino and wino

Fox, Kribs, Martin, 1405.3692

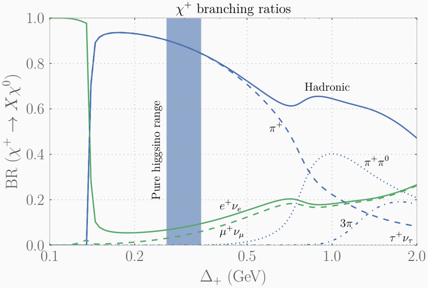


Hypercharge Impure

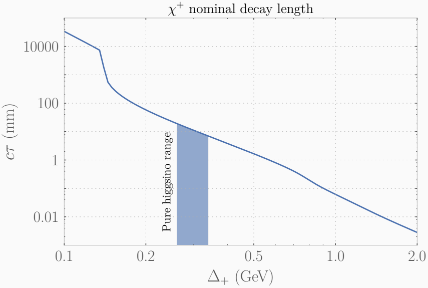
Gauge coupling unification

Weak-scale higgsinos, splitting ∼200 - 900 keV

Decays



χ^+ branching ratios
BR ($\chi^+ \to X\chi^0$)
Δ_+ (GeV)
Pure higgsino range
Hadronic
π^+
$\pi^+\pi^0$
$e^+\nu_e$
$\mu^+\nu_\mu$
3π
$\tau^+\nu_\tau$



χ^+ nominal decay length
$c\tau$ (mm)
Δ_+ (GeV)
Pure higgsino range

Direct detection