AMSB Phenomenology

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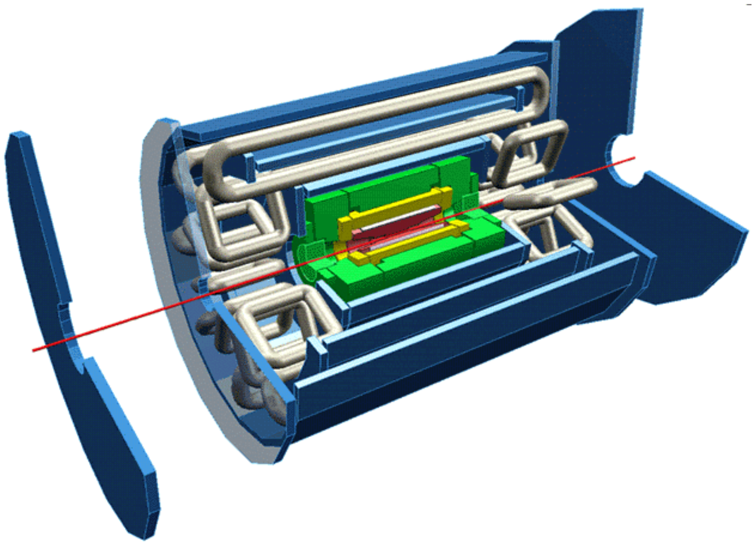
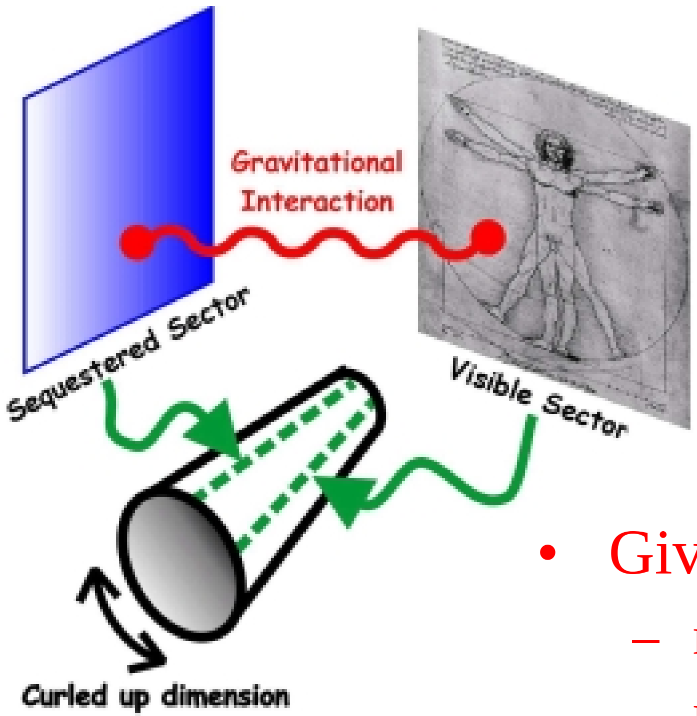
Working Group



- Analysis of a test AMSB model
- Find $\pi^{\pm}$ from $\chi_1^{\pm} \rightarrow \chi_1^0 \pi^{\pm}$
- Calculation of $m(\chi_1^{+}) - m(\chi_1^0)$

AMSB Model

- Characteristic near-degeneracy of χ_1^0 (LSP) and χ_1^+ masses
- $\Delta m < m(\pi)$
  - Long lived χ_1^+
  - ‘cannonball’
- $\Delta m > 1$ GeV
  - multi-hadron decay

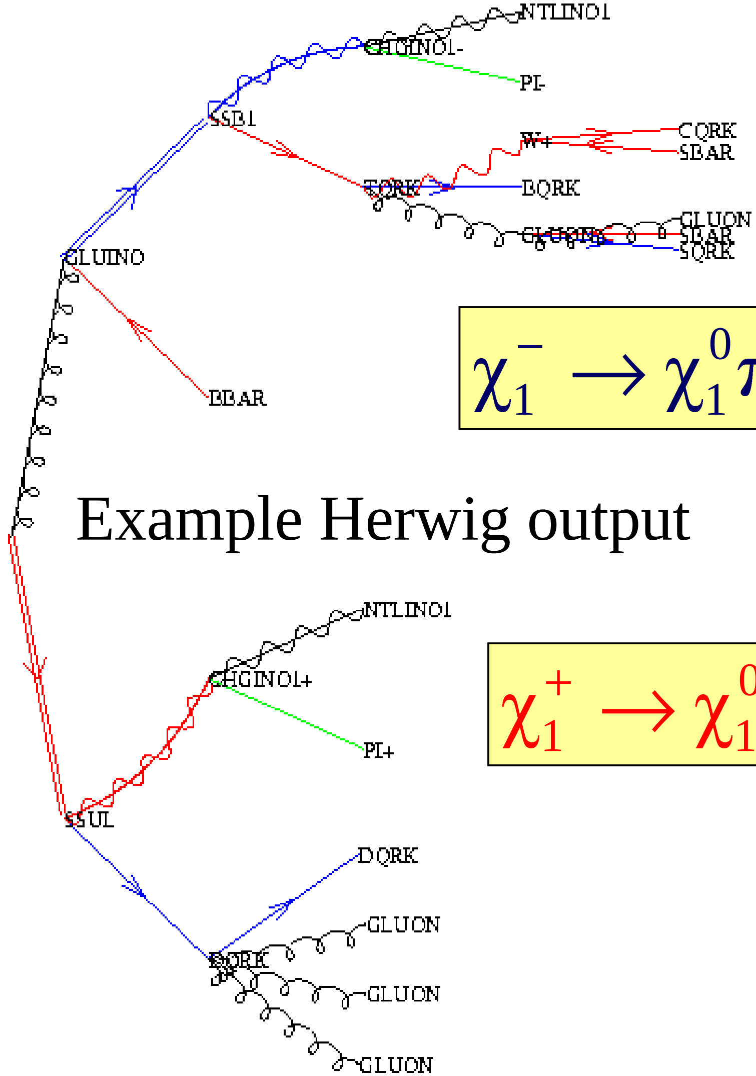


- Our Model:
  - RPC
  - $\tan\beta = 10$
  - $m_{3/2}$= 36 TeV
  - m_0 = 500 GeV
  - μ +ve
- Giving:
  - $m(\chi^+)$ = 99.0 GeV
  - $m(\chi^0)$ = 98.4 GeV
  - Δm = 631 MeV
  - $c\tau$ = 360 μm

Examine model with $c\tau \Rightarrow$ vertexing

MC Simulation

- HERWIG6.1
  - 2 parton $\rightarrow$ 2 sparticle
    - min p_T of 300 GeV
    - 130,000 events @ 4.5 pb = 29 fb^{-1} $\approx$ 3 years low luminosity
    - Underlying event simulation
  - SM background
    - QCD $\rightarrow$ t t-bar
    - min p_T of 300 GeV
    - 580,000 @ 21 pb = 27 fb^{-1}
  - Total time for generation: ~ 6 hours on HPCF

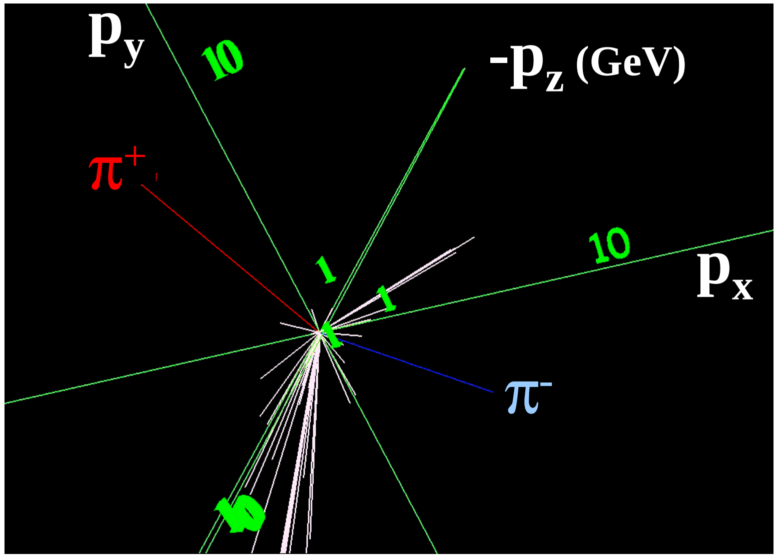


$$\chi_1^- \rightarrow \chi_1^0 \pi^-$$

Example Herwig output

$$\chi_1^+ \rightarrow \chi_1^0 \pi^+$$

Detector Simulation

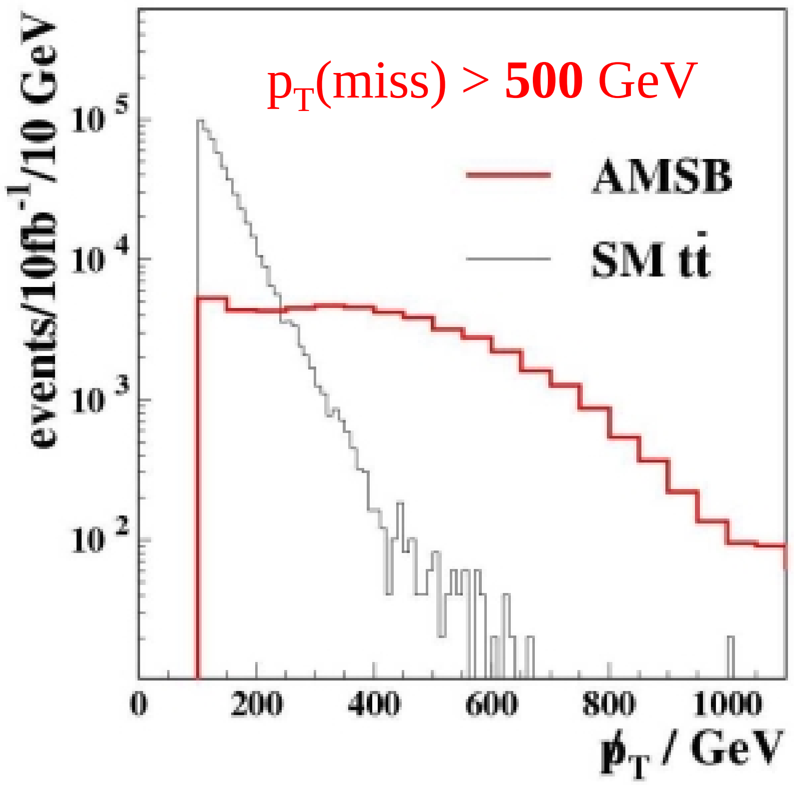


Sample Event (signal π's coloured)

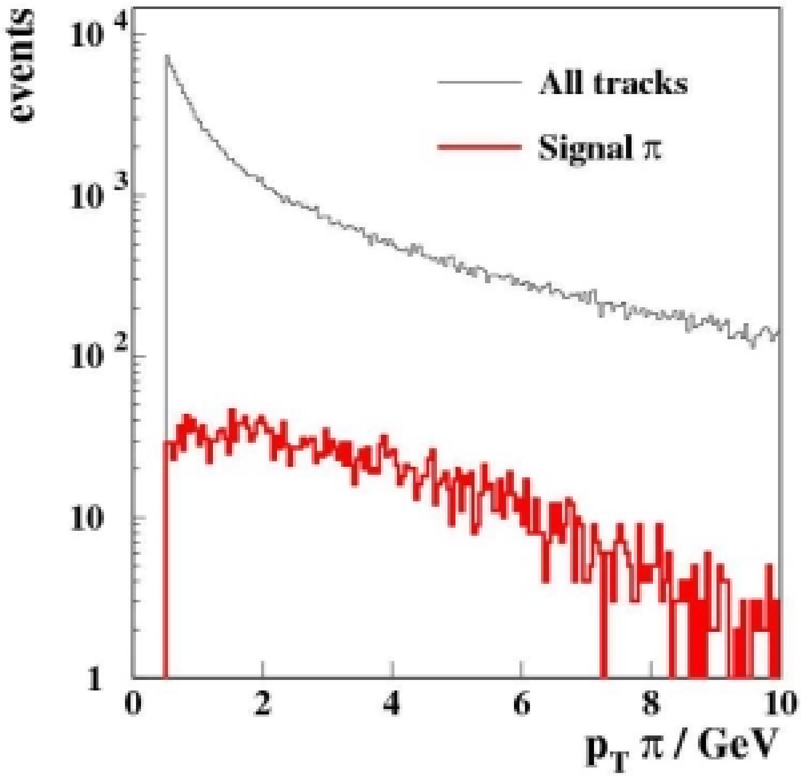
- ATLFAST2.21
  - Detector resolutions:
    - p_T
    - Impact parameters, d_0 z_0
    - calorimeter
    - multiple scattering
  - B-Field
  - Missing E_T

Signature: low p_T pions, in events with large missing p_T

Dynamics

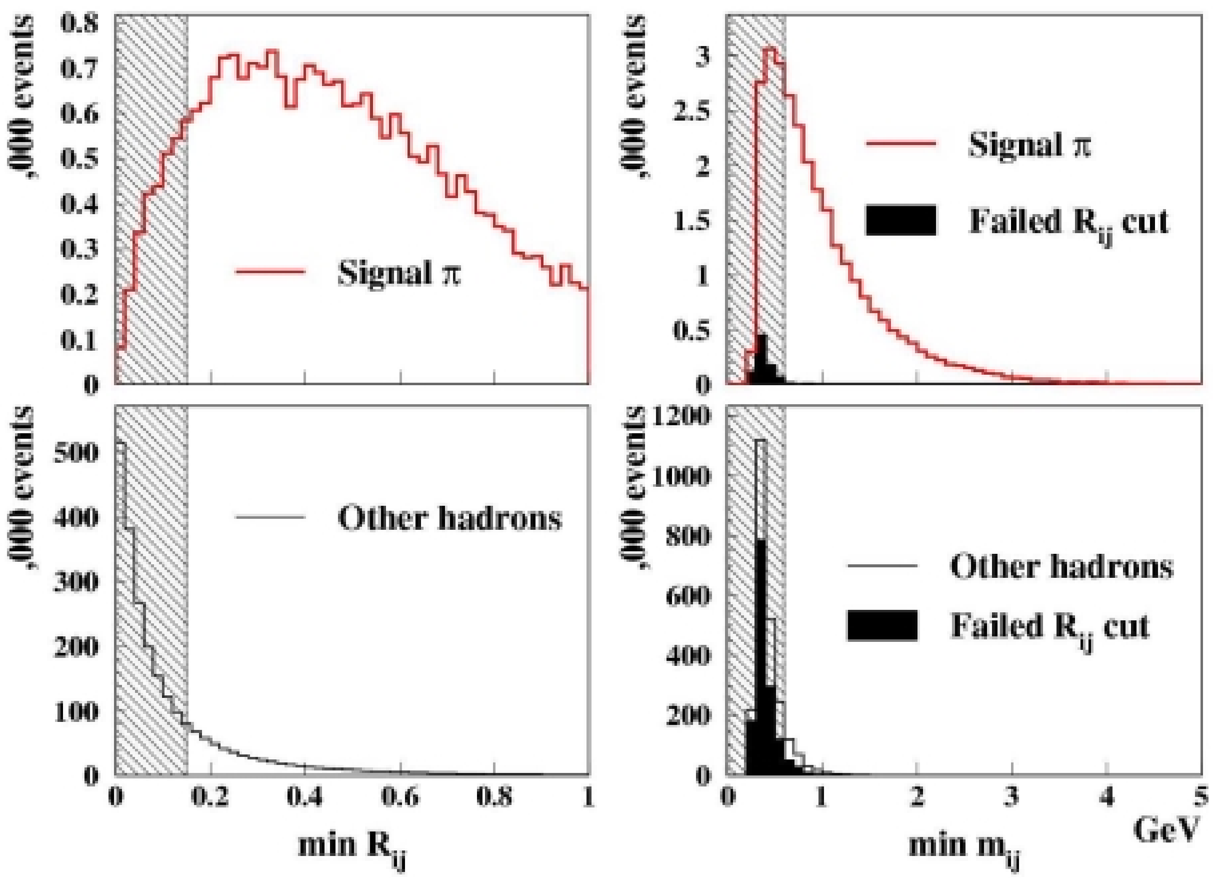


Large missing transverse energy reduces SM background



Require pion momentum p_T > 0.7 GeV, removing softest background

Catching the π's...



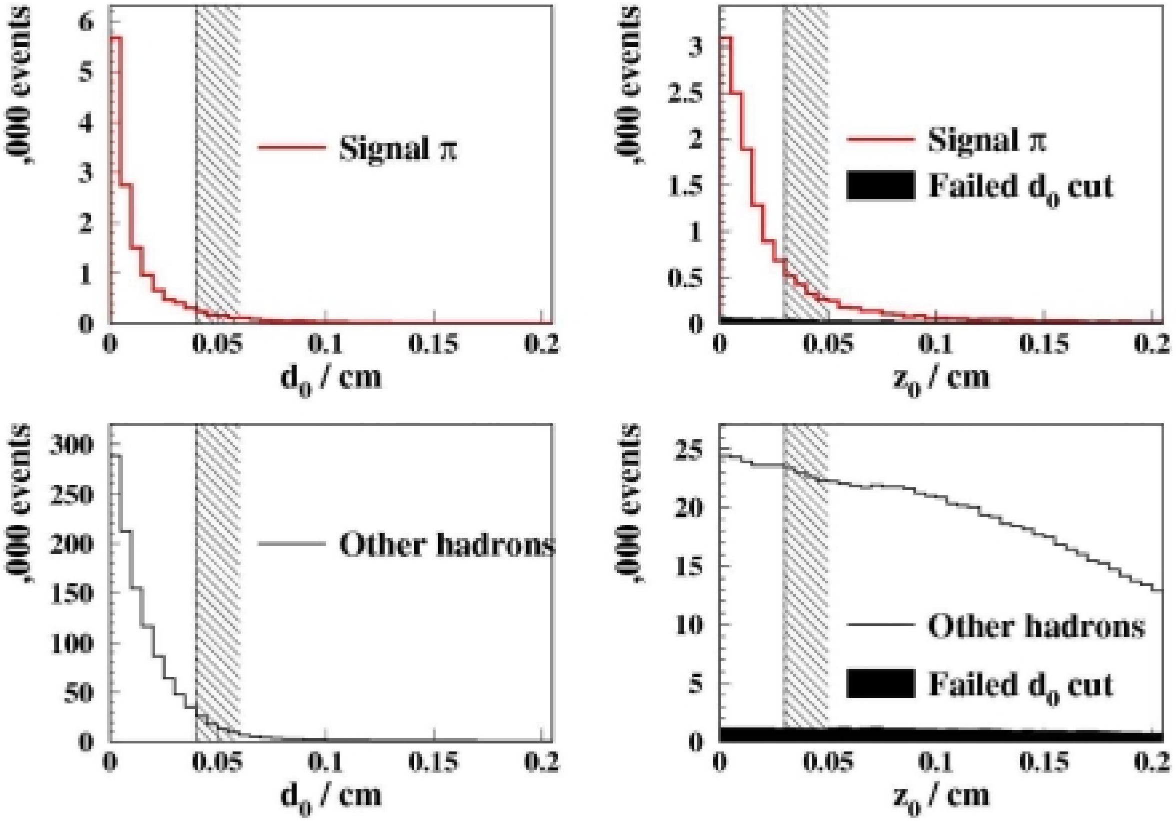
- Isolation in η-ϕ
  - 0 or 1 $R_{ij} < 0.15$
  - remove jets
- No other charged track consistent with $m_{ij} < 0.7$ GeV
  - remove K_S & resonances

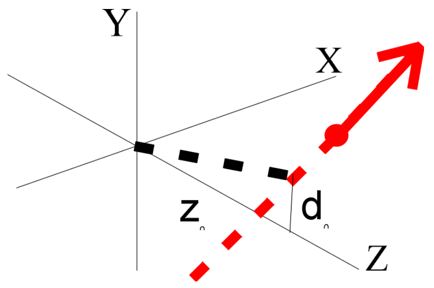
$$R_{ij} \equiv \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2}$$

m_{ij}= invariant mass assuming $m_i=m_j=m(\pi)$

Vertexing

Enforcing **maximum** impact parameter (despite chargino lifetime)





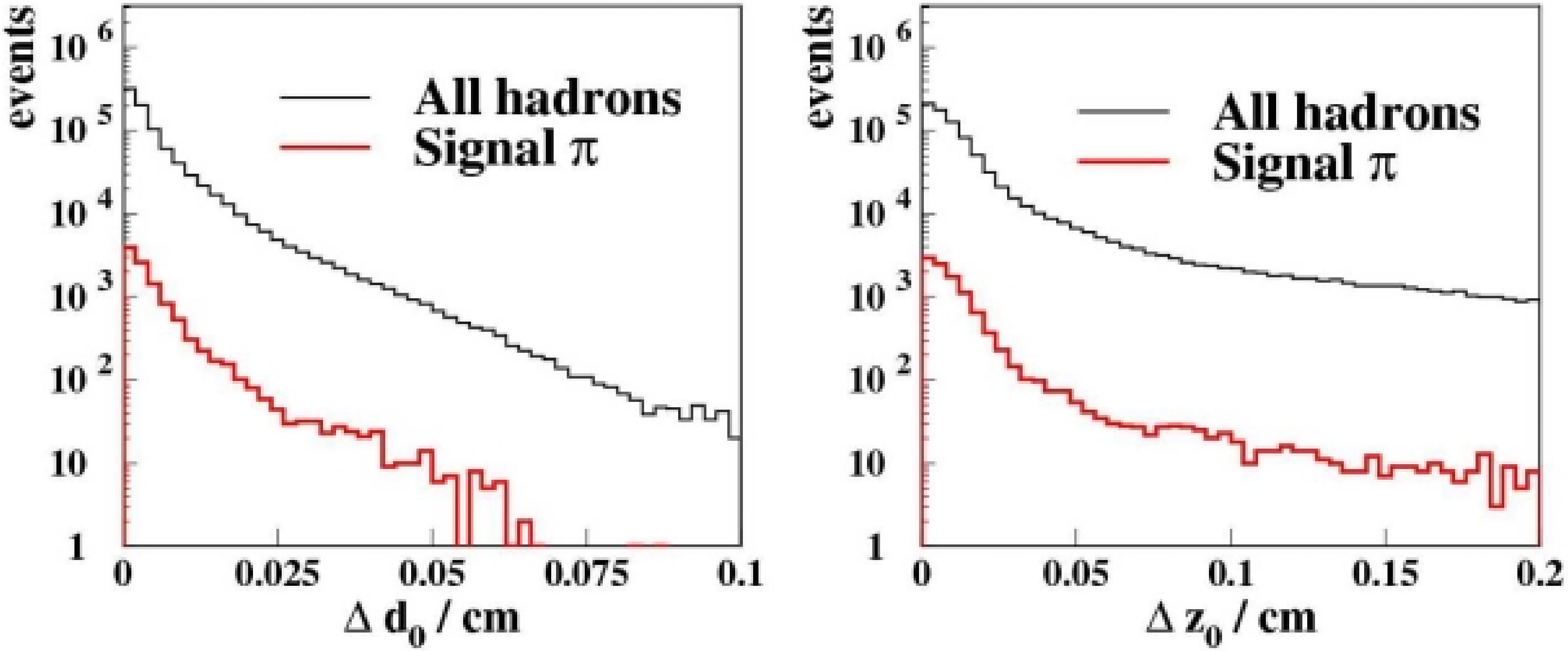
d_0 = transverse impact parameter

z_0 = longitudinal impact parameter

$c\tau = 0.036$ cm

$$\text{Large } \not{E}_T \rightarrow \text{small } \left|\eta(\chi_1^{\pm})\right| \rightarrow d_0(\pi^{\pm}) \approx z_0(\pi^{\pm})$$

Impact Parameter Resolution



- ATLFAST models impact parameter error as sum of:
  - narrow gaussian (tracker resolution)
  - wide gaussian (multiple scattering)

Cuts Summary

- E_T(miss) > 500 GeV
- Exactly 2 pions with
  - $p_T(\pi) > 0.7$ GeV
  - $|\eta(\pi)| < 2.0$
  - 0 or 1 other track within η-ϕ of 0.15
  - no other track with combined invariant mass < 0.6 GeV
  - $d_0(\pi) < 0.04$ cm
  - $z_0(\pi) < 0.03$ cm

- Uses trigger objects:
  - E_T (miss)
  - Jets
  - Isolated e / μ / γ
- But E_T(miss) > 500 GeV
  - Jets/leptons from previous decays ⇒ trigger for all of ~2k events which passed cuts
- Overall Efficiency (Cuts + Trigger) 2k / 130k

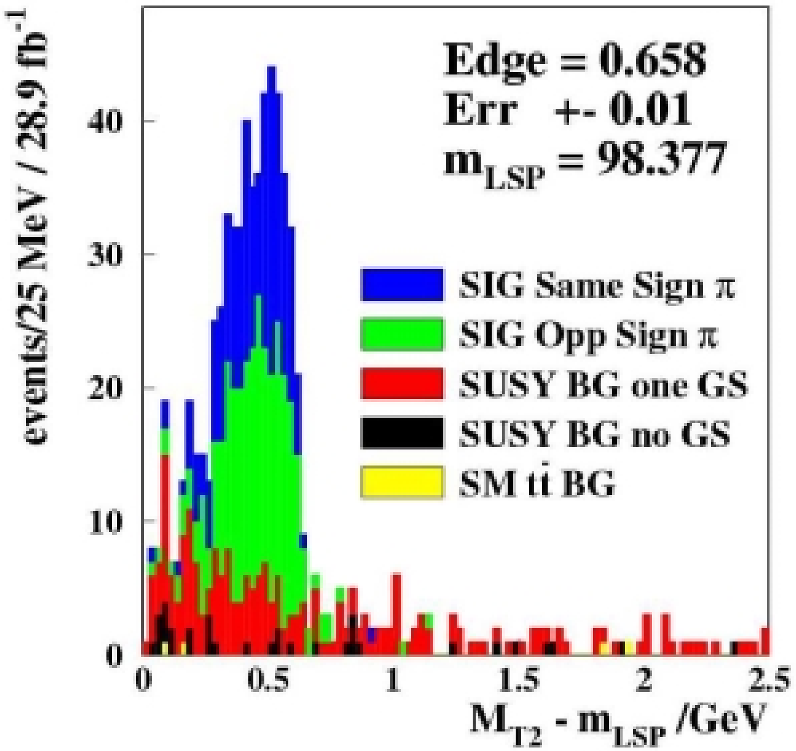
$\varepsilon \approx$ **1.5 %**

Mass Reconstruction

$$M_{T2} \equiv \underset{\not{\mathbf{p}}^{(1)}+\not{\mathbf{p}}^{(2)}=\not{\mathbf{p}}_T}{\mathrm{Min}} \left[\max\left\{m_T\left(\mathbf{p}_T^{\pi(1)}, \not{\mathbf{p}}^{(1)}\right), m_T\left(\mathbf{p}_T^{\pi(1)}, \not{\mathbf{p}}^{(1)}\right)\right\}\right]$$

(Lester, Summers)

$$m_T^2\left(\mathbf{p}_T^{\pi(1)}, \mathbf{p}_T^{\tilde{\chi}(1)}\right) \equiv m(\pi)^2 + m(\tilde{\chi}_1^0)^2 + 2\left(E_T^{\pi} E_T^{\tilde{\chi}} - \mathbf{p}_T^{\pi}.\mathbf{p}_T^{\tilde{\chi}}\right)$$

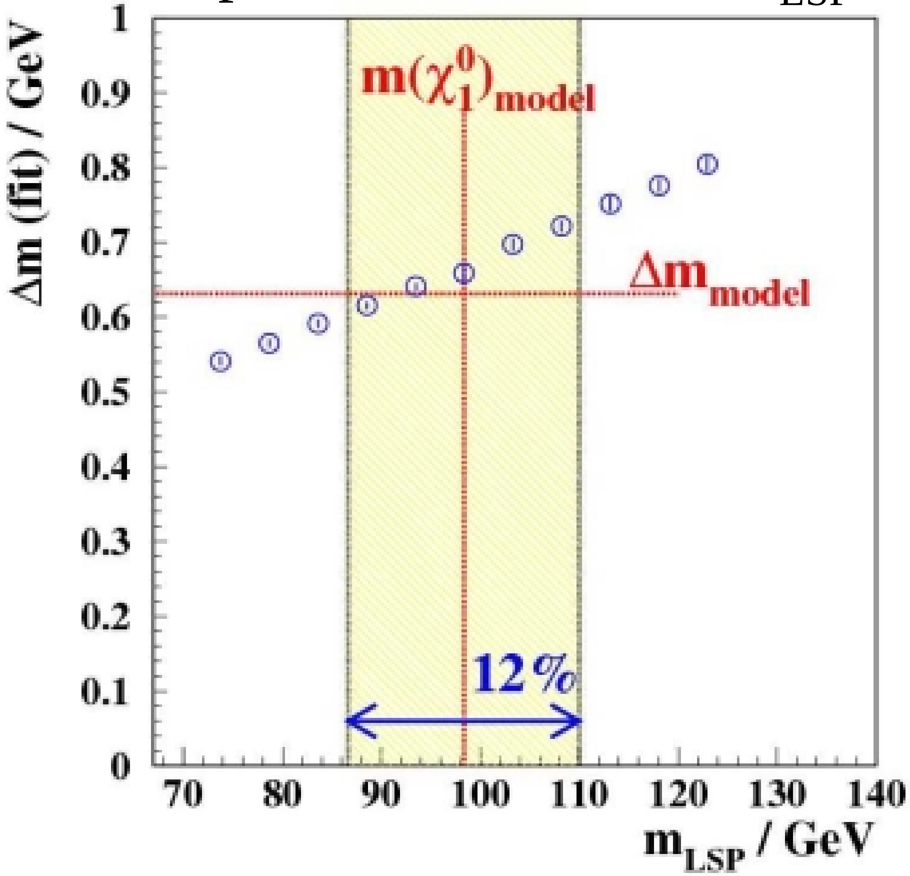


- Upper edge of M_{T2}-m_{LSP} measures $m(\chi_1^+) - m(\chi_1^0)$
- Little $t\bar{t}$ background
- Insensitive to calorimeter resolution

Error ≈ 10 MeV

Absolute mass

Dependence of Δm on m_{LSP}



- LSP mass measurable to 12% by measuring other kinematic endpoints (Paige et. al.) e.g.
  - M_{ll} from $\tilde{\chi}_2^0 \to \tilde{l} \to \tilde{\chi}_1^0$
  - M_{bb} from $\tilde{g} \to \tilde{b} \to \tilde{\chi}_1^0$
- May be able to improve m_{LSP} measurement

Summary

- So Far:
  - Chargino decay may be observable at ATLAS
  - Variable M_{T2} useful for measuring $m(\chi_1^+) - m(\chi_1^0)$
- Future:
  - More realistic underlying event
  - Other SUSY particles (sleptons etc)
  - Better measurement of overall mass scale
  - Other SM background?
- Suggestions:
  - ?