Direct Slepton Production @ LHC

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on behalf of the ATLAS Collaboration

Outline

- Introduction to sleptons ($\tilde{e}$ and $\tilde{\mu}$) in mSugra
- Reach for low mass sleptons
- SPS 1A example of $\tilde{\ell}_L$ mass
- Conclusions

Sleptons in mSugra

Mass splitting between the left- and right-handed charged sleptons.

Splitting increases with $m_{1/2}$:

m_0 : GUT scalar mass
$m_{1/2}$: GUT fermion mass
tanβ: v2/v1
A_0: trilinear coupling
sign(μ): higgsino mass parameter

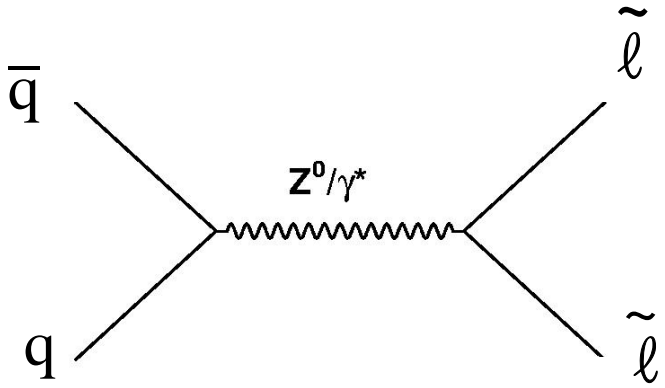
$$m^2_{\tilde{\ell}_R} = m_0^2 + 0.15 m_{1/2}^2 - \sin^2\theta_W M_Z^2 \cos 2\beta$$
$$m^2_{\tilde{\nu}} = m_0^2 + 0.52 m_{1/2}^2 + (1/2) M_Z^2 \cos 2\beta$$
$$m^2_{\tilde{\ell}_L} = m_0^2 + 0.52 m_{1/2}^2 - (1/2 - \sin^2\theta_W) M_Z^2 \cos 2\beta$$

Right-handed production is dominant in most of parameter space

Production

This talk: Direct

$\tilde{\ell}_R \tilde{\ell}_R$, $\tilde{\ell}_L \tilde{\ell}_L$



Indirect from

-Chargino-neutralino decays:

$pp \rightarrow \tilde{\chi}^0_2 \tilde{\chi}^{\pm}_1$ with $\tilde{\chi}^0_2 \rightarrow \tilde{\ell}_R \ell$

-or even more indirect from cascade decays of squarks and gluinos: $\tilde{g} \rightarrow q \tilde{q}_L$

$\tilde{q}_L \rightarrow q \tilde{\chi}^0_2$ / q' $\tilde{\chi}^{\pm}_1 \rightarrow q \tilde{\chi}^0_1 X$

Decay Modes

- Right-handed:

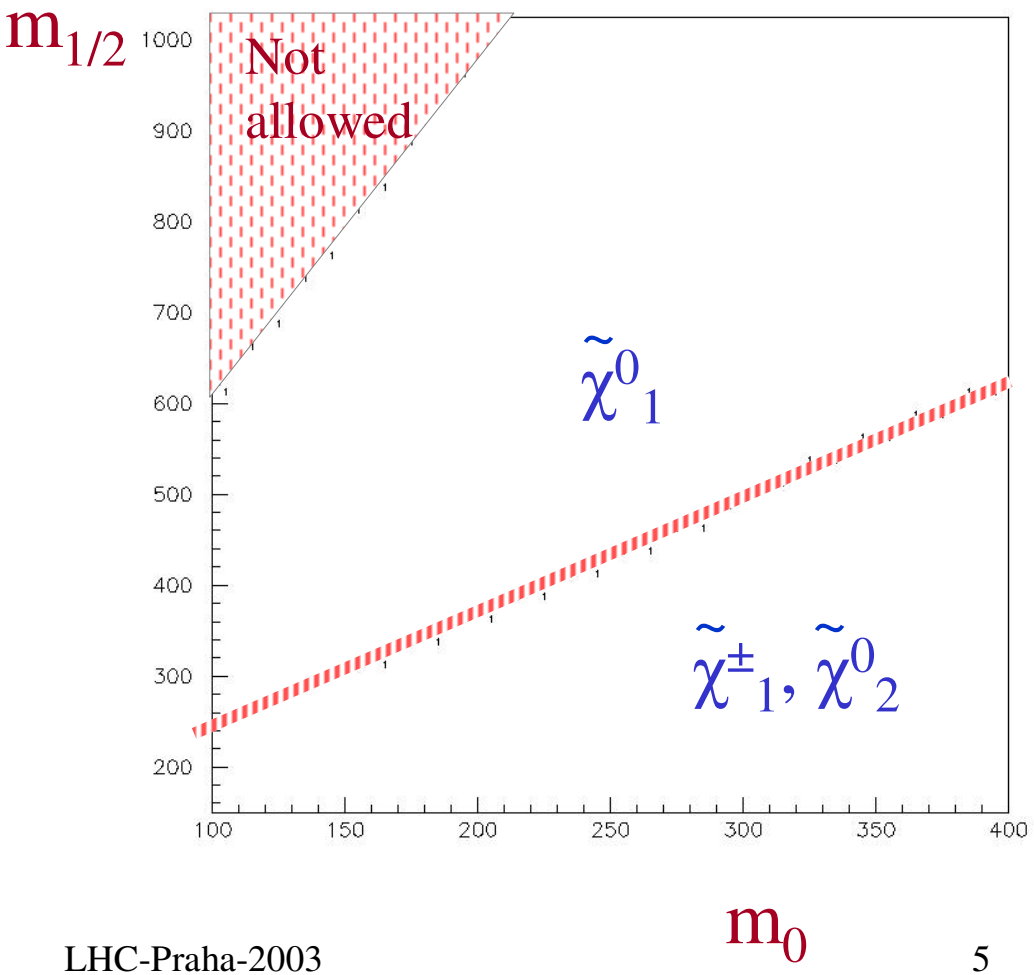
  100% $\tilde{\ell}_R \rightarrow \tilde{\chi}^0_1 \ell$

  (unless $m_{1/2} \ll m_0$)

- Left-handed:

$$\tilde{\ell}_L \rightarrow \begin{cases} \tilde{\chi}^0_1 \ell \\ \tilde{\chi}^\pm_1 \ell \\ \tilde{\chi}^0_2 \ell \end{cases}$$

Dominant mode



Backgrounds

Most promising signature is 2 isolated leptons + $\not{E}_T$
- but huge backgrounds:

Dominant: $WW, t\bar{t}$

Same-flavour: $WZ, \tilde{\chi}^0_2 \tilde{\chi}^{\pm}_1$

Other: $\tilde{\chi}^-_1 \tilde{\chi}^+_1, \tilde{\tau}\tilde{\tau}, \tilde{g}\tilde{g}, \tilde{g}\tilde{q}, \tilde{q}\tilde{q}, \tilde{\upsilon}\tilde{\upsilon}$

SM background alone ≈ 60 pb
Signal:
O(2-200) fb

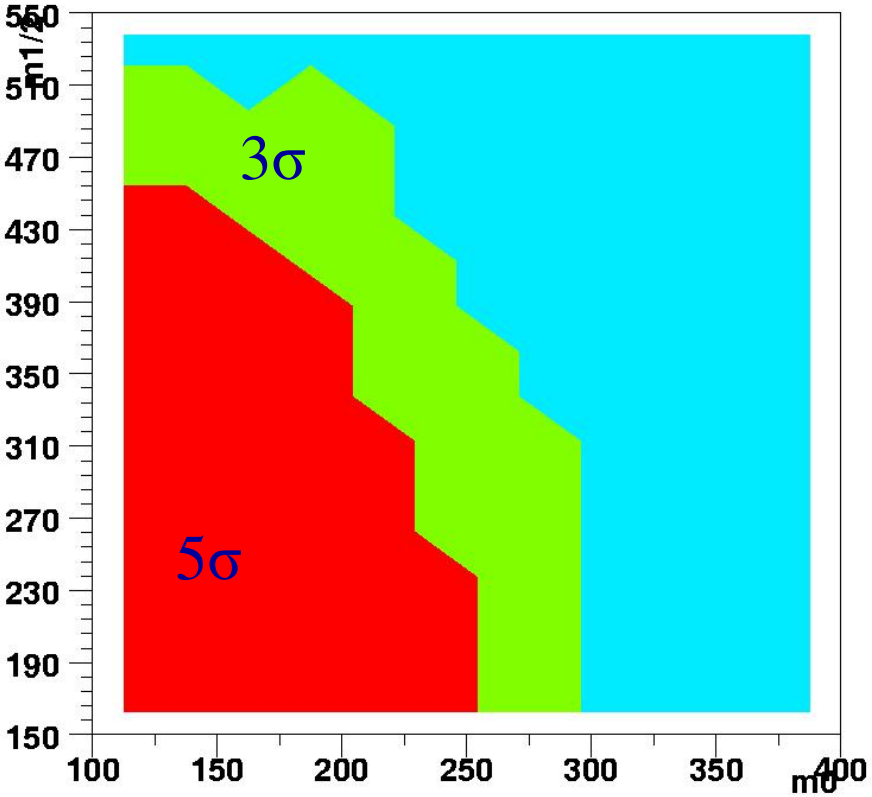
Need hard cuts on p_T, $\not{E}_T$, veto on jets, and require large invariant mass, ...

The simulations in the following slides are all fast simulation and Pythia 6.210

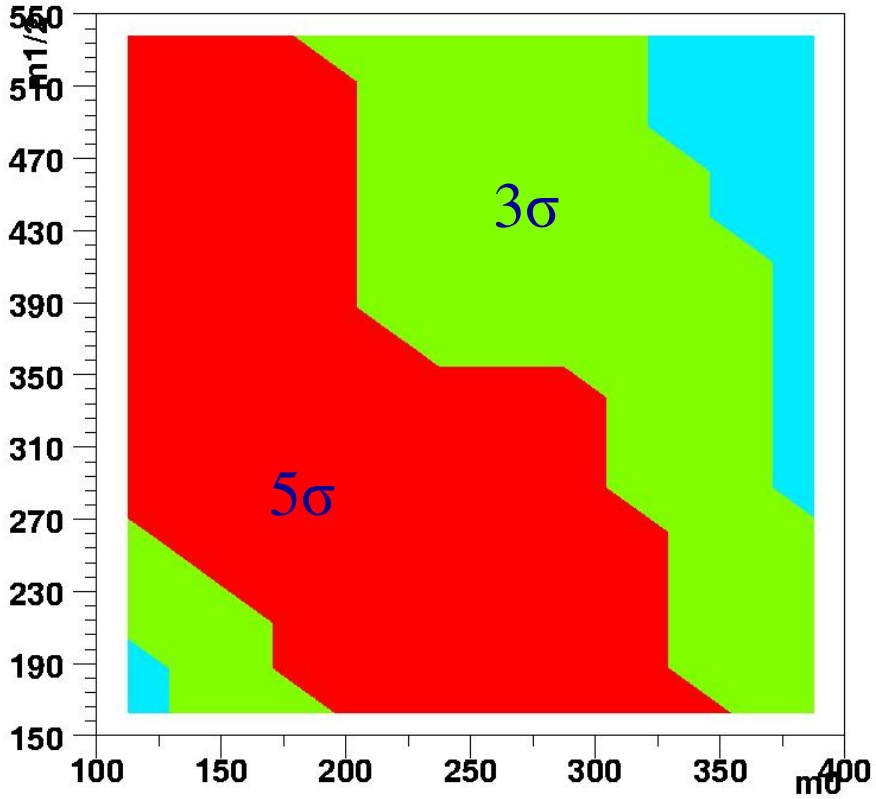
Reach @ 100fb^{-1}

$(\tan\beta, A_0, \mathrm{sign}(\mu)) = (10, 0, +)$

”Soft” cuts:

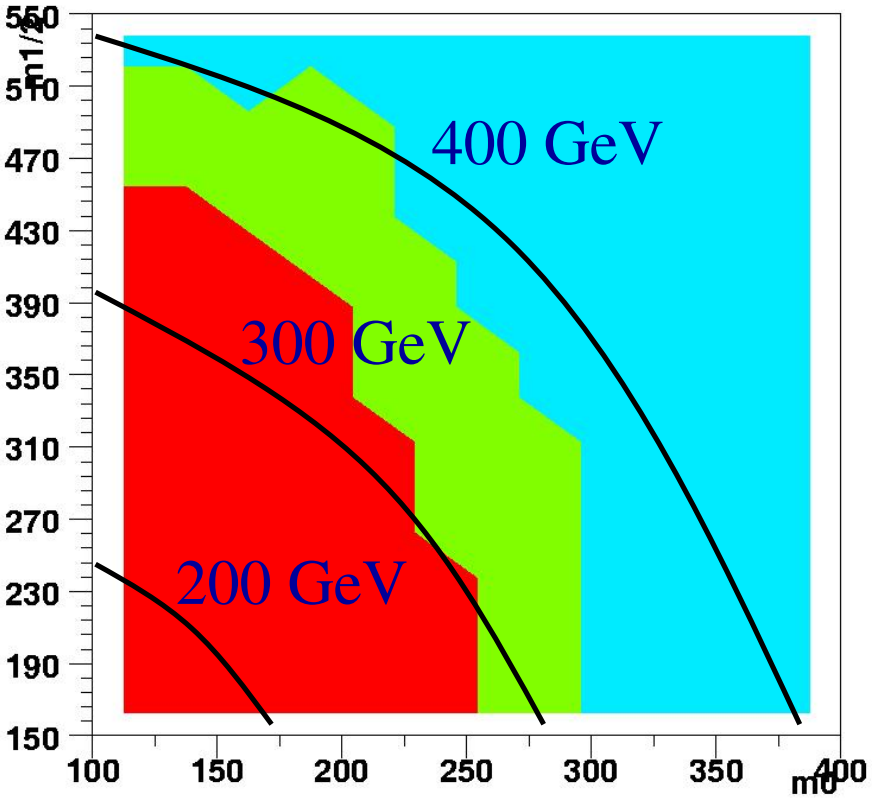


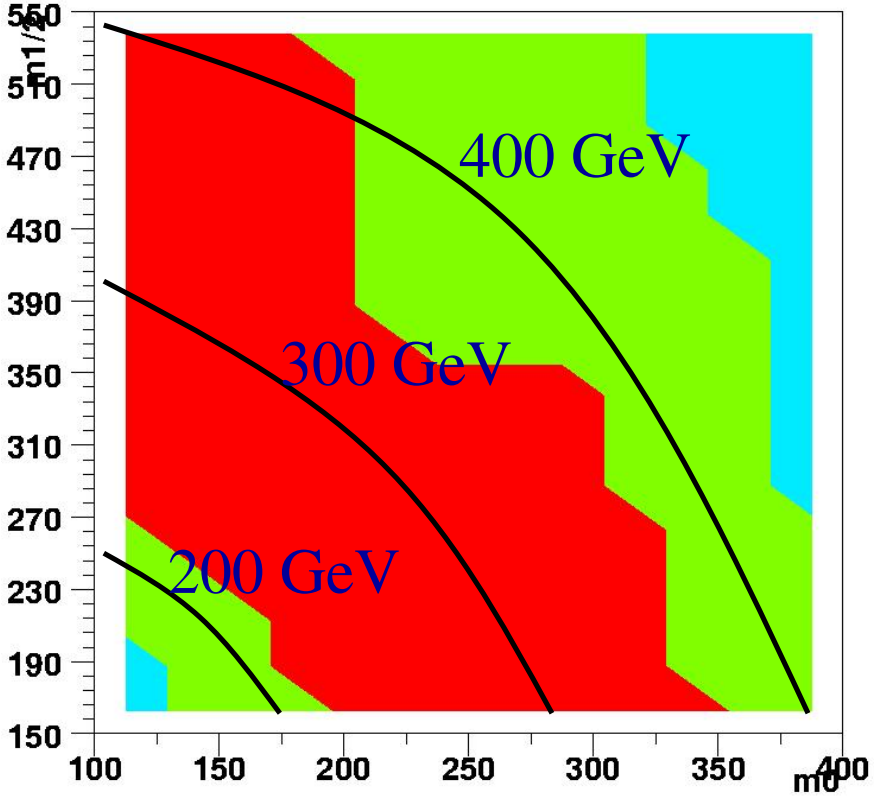
Hard cuts:



Reach @ 100fb^{-1}

$(\tan\beta,\ A_0,\ \mathrm{sign}(\mu)) = (10, 0, +)$

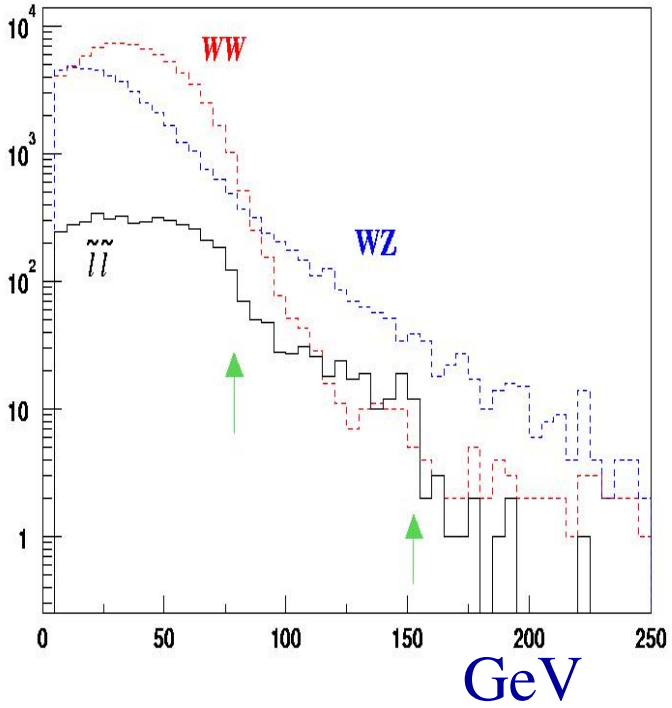




Mass Measurement?

No direct measurement because of neutralinos but the (massless version of) Cambridge M_{T2}:

$$M_{T2}^2 = \min_{\not{p}_1 + \not{p}_2 = \not{p}_T} \left\{ \max\left\{ m_T^2(p_T^{\ell 1}, \not{p}_1), m_T^2(p_T^{\ell 2}, \not{p}_2) \right\} \right\}$$



For A → ℓ + inv, the distribution of M_{T2} has a shoulder at

M_{T2} (max) = func(M_A - M_{inv})

The usual flavour subtraction works here, too, to extract an (almost) clean slepton sample.

SPS 1A Sleptons

$(m_0, m_{1/2}, \tan\beta, A_0, \mathrm{sign}(\mu)) = (100, 250, 10, -100, +)$

Direct:

$\sigma(\tilde{\ell}\tilde{\ell}) = 91$ fb $\mathrm{BR}(\tilde{\ell}_L \rightarrow \tilde{\chi}^0_1 \ell) = 45\ \%$

$m_{LSP} = 96.2$ GeV $m_R = 142.9$ GeV $m_L = 201.9$ GeV

Also indirect production from $\tilde{\chi}^0_2$:

$\mathrm{BR}(\tilde{\chi}^0_2 \rightarrow \tilde{\ell}_R \ell) \sim 15\ \%$

Sleptons are light here => $\geq 5\sigma$ excess @ 100 fb^{-1}

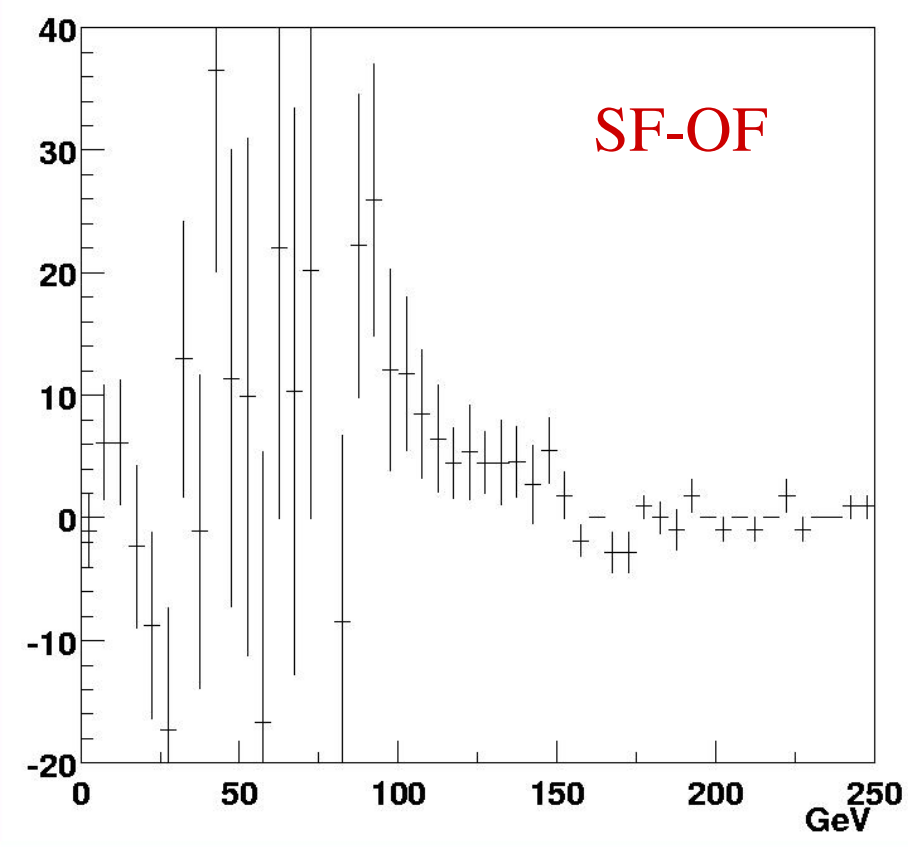
Can we do more than that?

SPS 1A Example

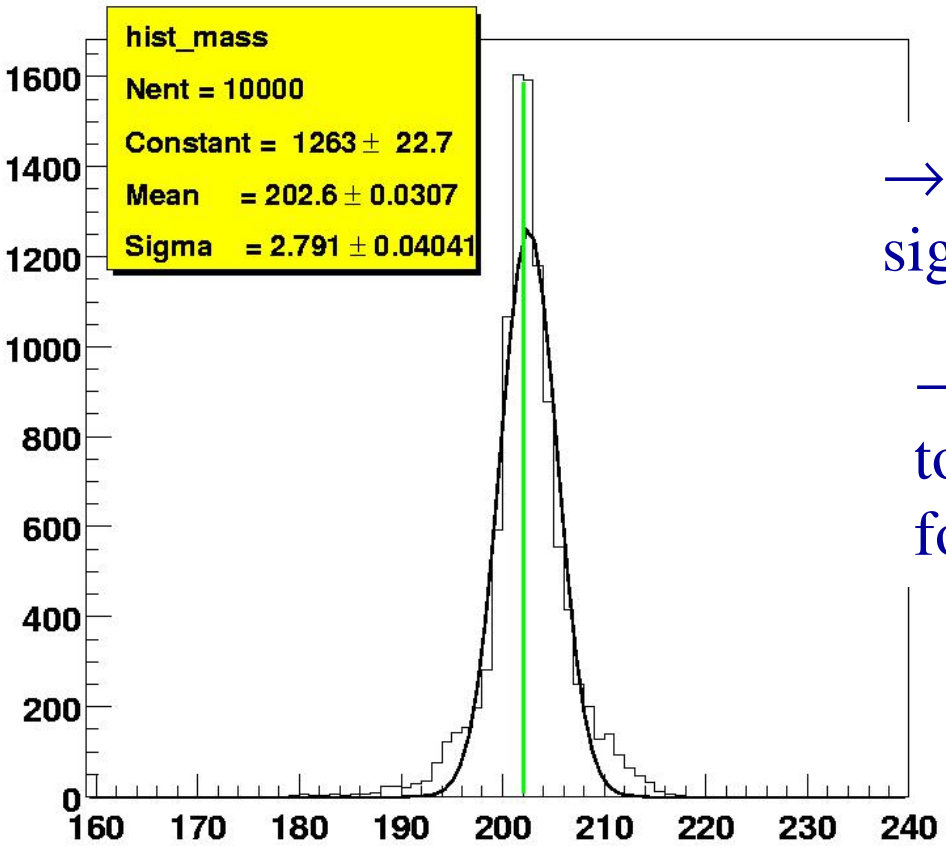
Most important cuts:

- 2 SF OS leptons with

  $p_T^{\ell 1} \geq 50, \quad p_T^{\ell 2} \geq 90$ GeV
- $p_T \geq 70$ GeV
- No jets with $p_T > 40$ GeV
- $m_{\ell\ell} \geq 100$ GeV
- $80^o \leq \Delta\varphi \leq 160^o$



Result of Fit



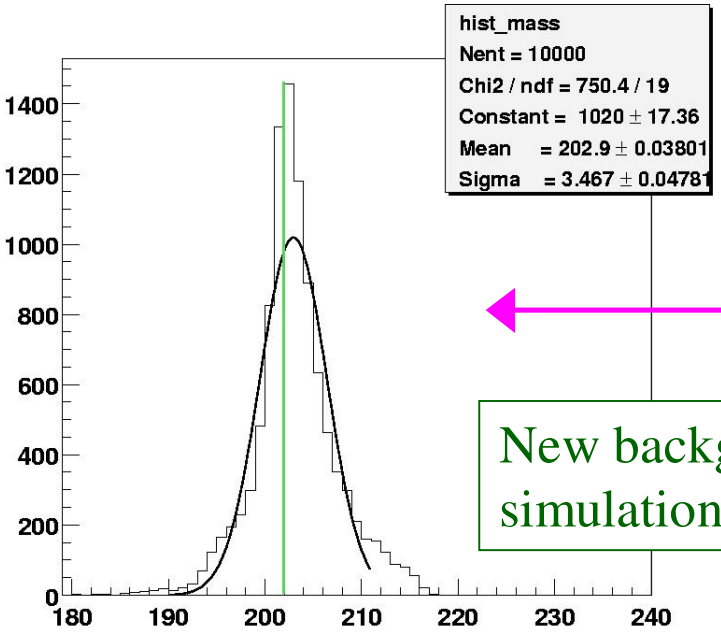
Repeat N times

→Create a ”data” sample from signal and background events

→ Compare shape of result to a set of signal distributions for different ℓ_L masses

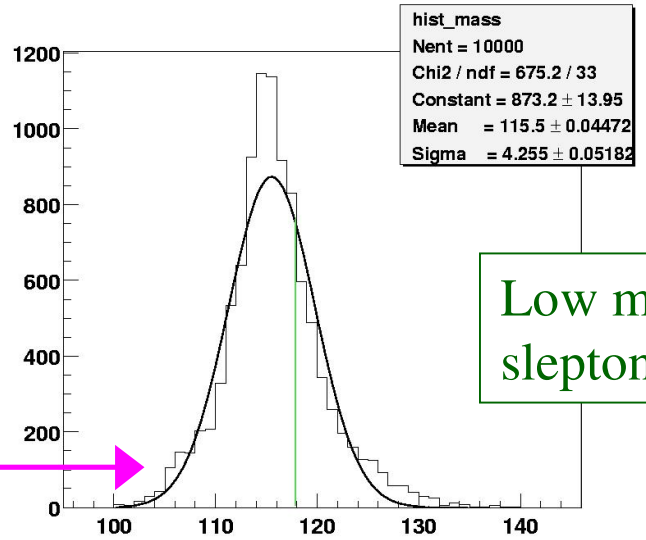
→pick fit with lowest χ^2 as the mass

Importance of Background fluctuations



Since backgrounds are so large try with WW, WZ from Herwig 6.4
Width of gaussian is now 3.5 GeV

New background simulation



Low mass sleptons

With a $\tilde{\ell}_R$ mass of 118 GeV
(*inside* SM shoulders)

Conclusions

- M_{T2} in principle model-independent but no shoulders without hard, specific cuts

At SPS 1A the $\tilde{\ell}_L$ mass can be determined with an error of ☞ 4 GeV

- For intermediate tanβ the direct slepton production would be visible for $\tilde{\ell}_L$ masses

> 300 GeV @100 fb^{-1}

Different strategies for light corner and heavier areas.