Direct Slepton Production @ LHC

Advanced Studies Institute – Physics at LHC
Prague, July 6-12 2003

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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

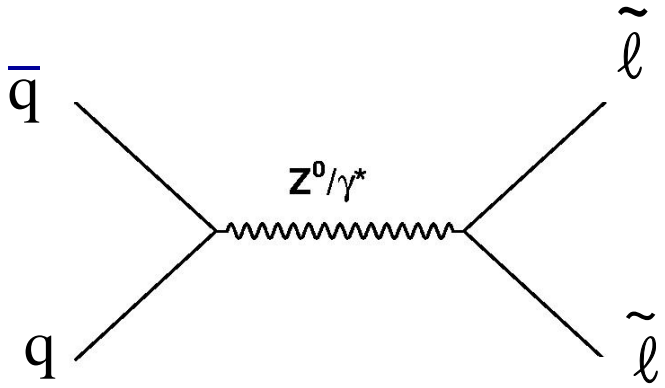
$$m^2_{\tilde{\ell}_R} = m_0^2 + 0.15 m_{1/2}^2 - \sin^2\theta_W M_Z^2 \cos 2\beta$$
$$m^2_{\tilde{\nu}} = m_0^2 + 0.52 m_{1/2}^2 + (1/2) M_Z^2 \cos 2\beta$$
$$m^2_{\tilde{\ell}_L} = m_0^2 + 0.52 m_{1/2}^2 - (1/2 - \sin^2\theta_W) M_Z^2 \cos 2\beta$$

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:

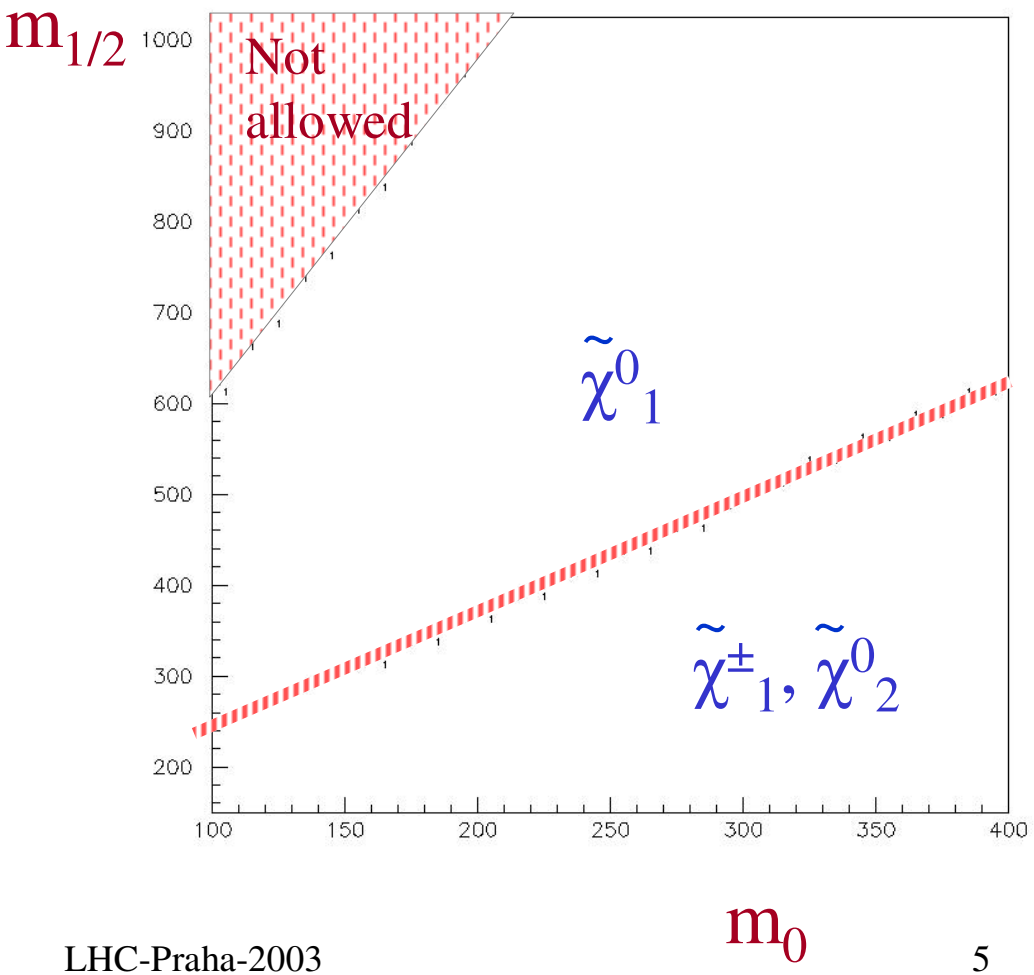
  100% $\tilde{\ell}_R \rightarrow \tilde{\chi}^0_1 \ell$

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

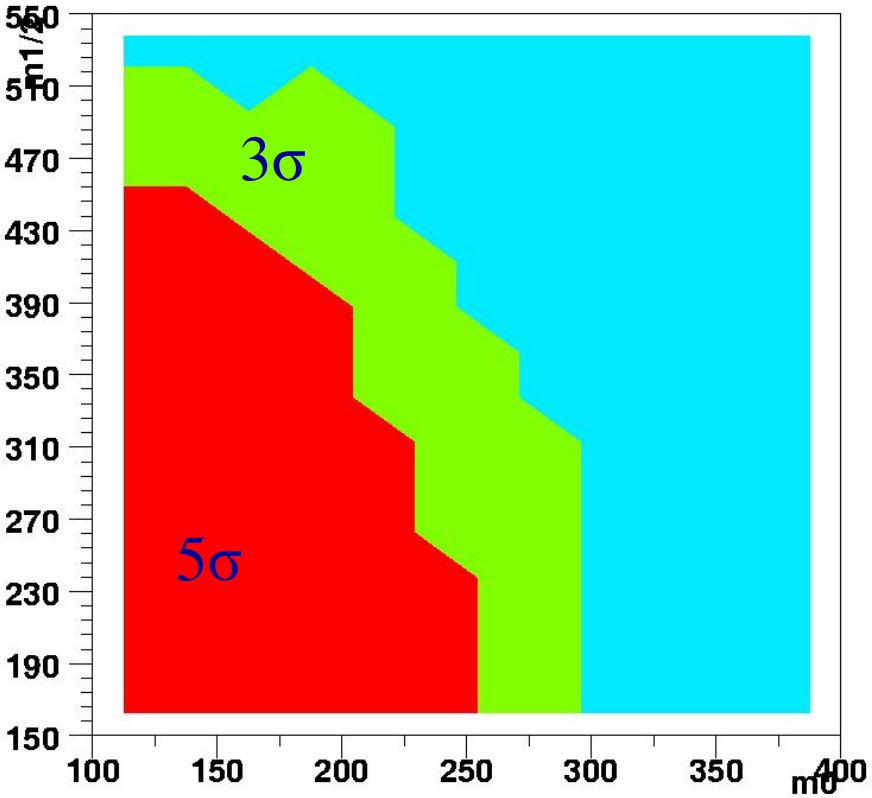
SM background alone ≈ 60 pb
Signal:
O(2-200) fb

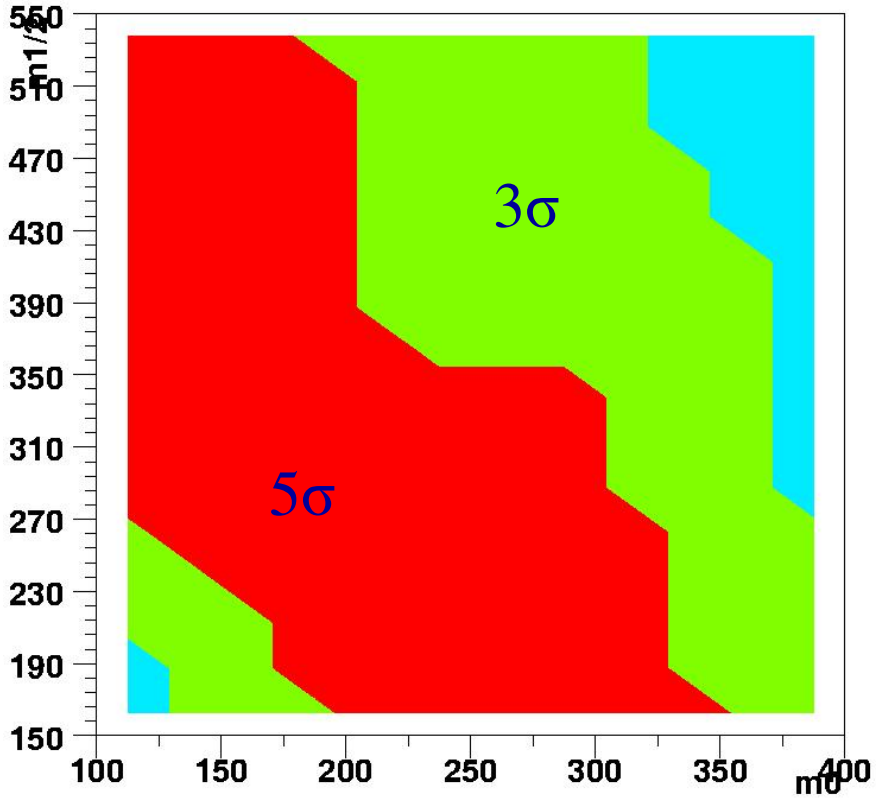
Need hard cuts on p_T, $\not{E}_T$, veto on jets, and require large invariant mass, ...

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

Reach @ 100fb^{-1}

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





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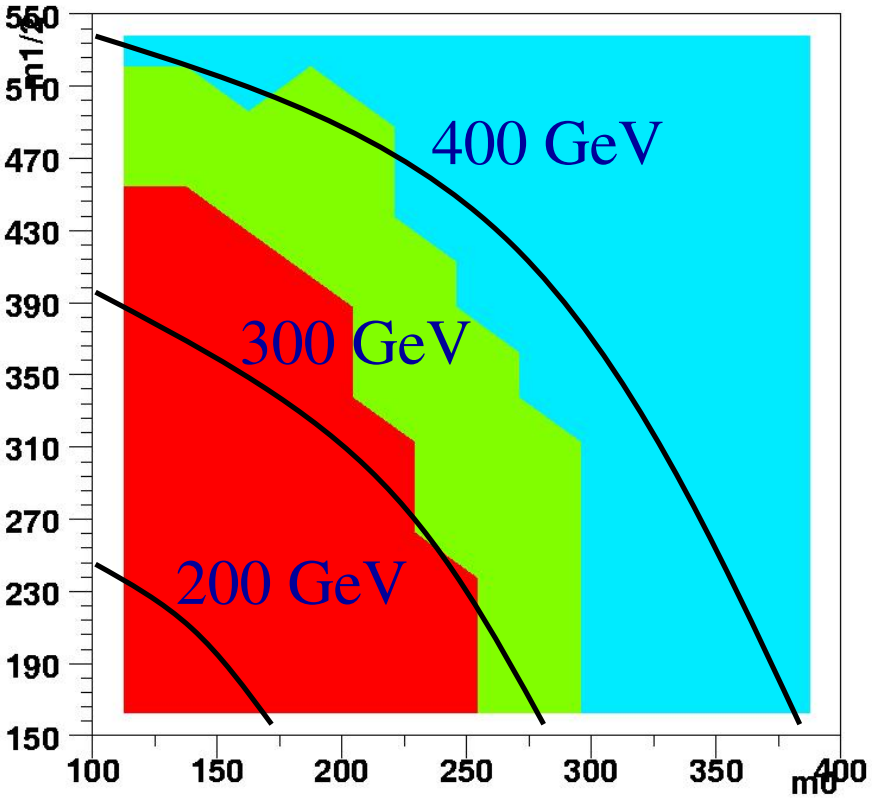
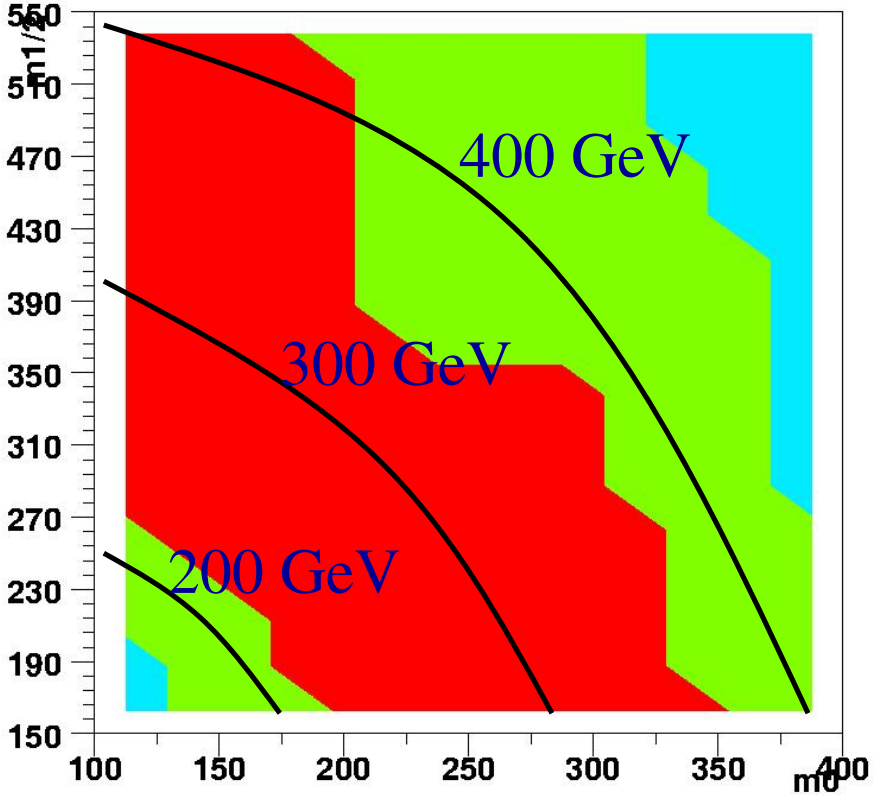
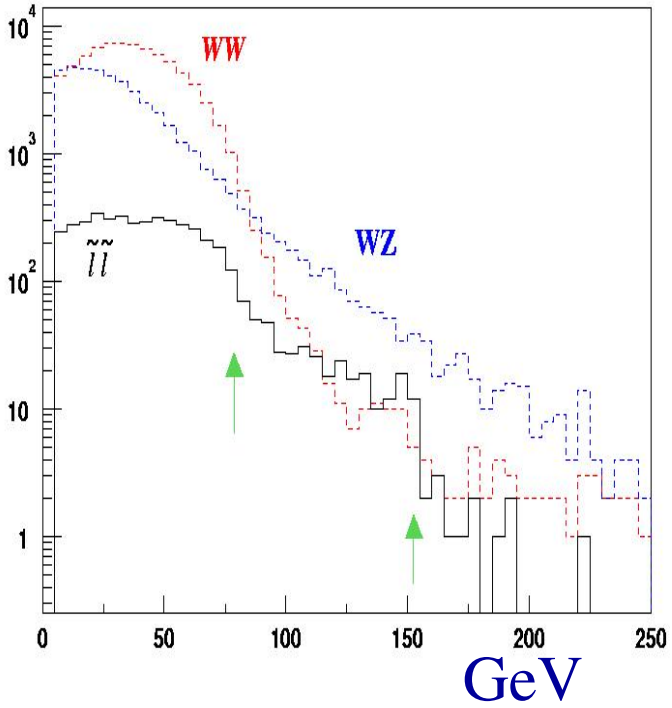




Mass Measurement?

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}

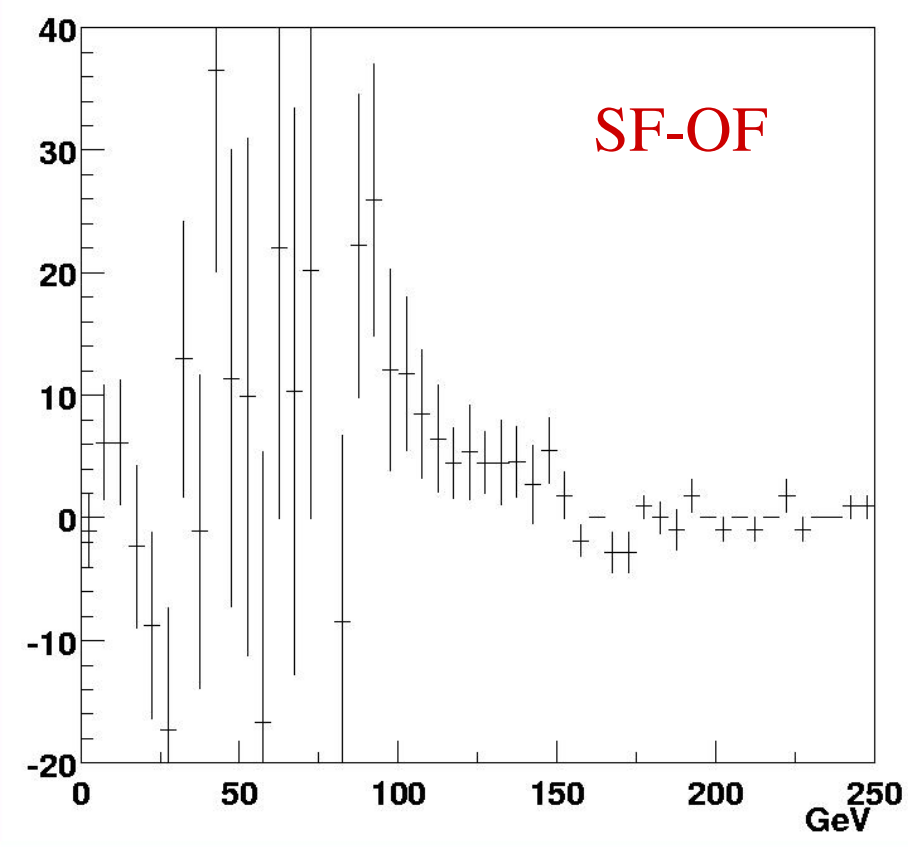
Can we do more than that?

SPS 1A Example

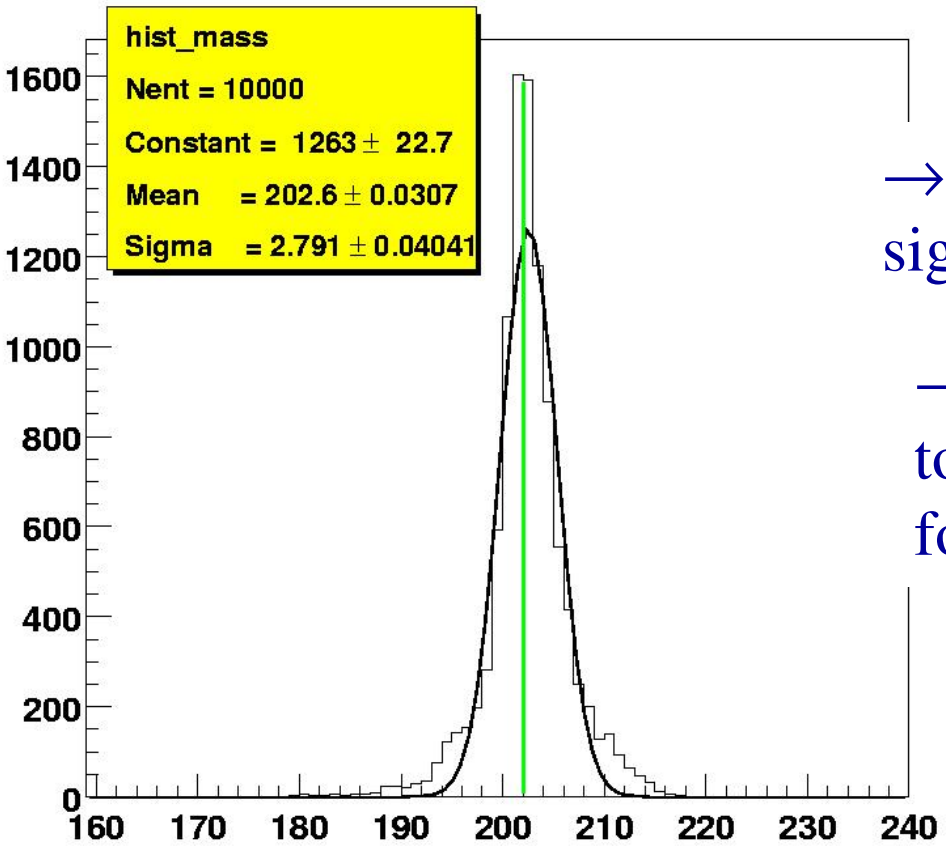
Most important cuts:

- 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



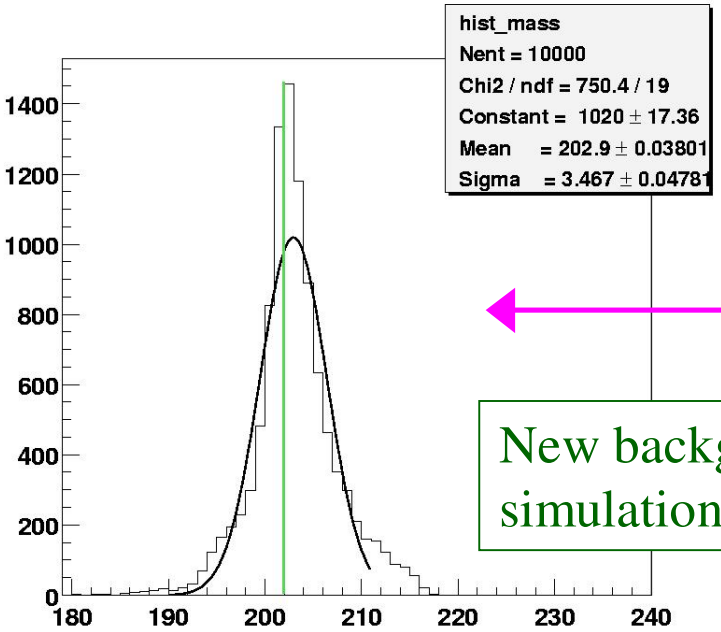
Repeat N times

→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

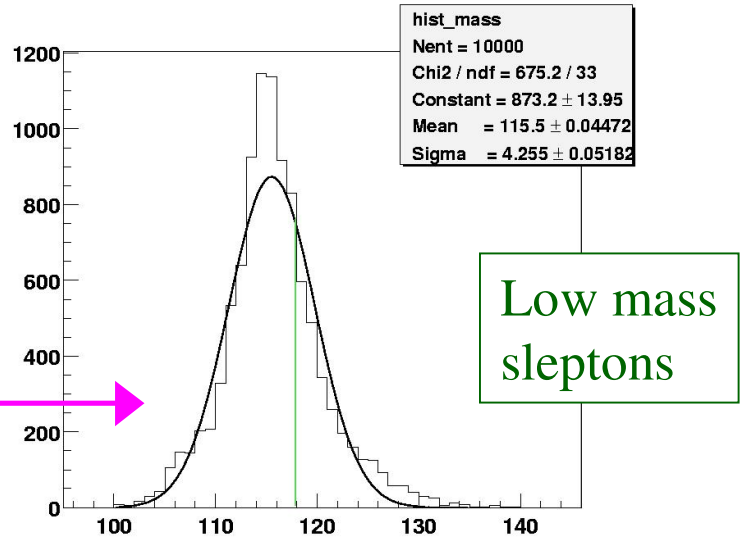
Some Tests



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

New background simulation

With a $\tilde{\ell}_R$ mass of 118 GeV



Low mass sleptons

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.