Study of near-degenerate $\tilde{e}$

Mikael Berggren[1]

[1]DESY, Hamburg

ILD physics&analysis phone meeting

Outline

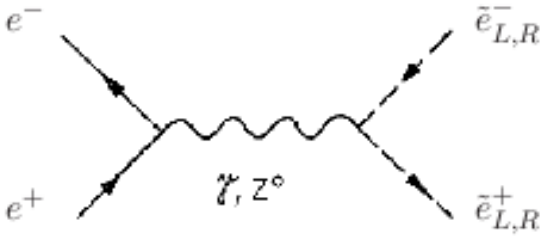
- Introduction. The model.
- Analyis
- Conclusions.

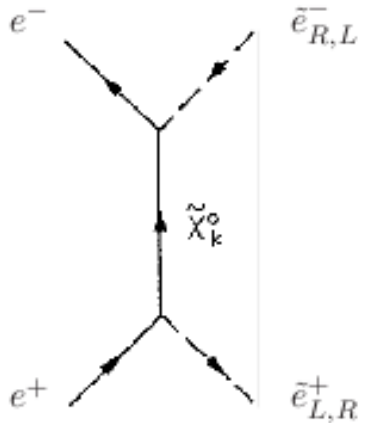
Introduction: What SUSY means ...

(Preliminary work by M.B., G. Moortgat-Pick)

SUSY associates scalars to chiral (anti)fermions

$$e^-_{L,R} \leftrightarrow \tilde{e}^-_{L,R} \quad \text{and} \quad e^+_{L,R} \leftrightarrow \tilde{e}^+_{R,L}. \tag{1}$$





$\tilde{e}$:s with same helicity

Helicity for $\tilde{e}^{\pm}$ same as $e^{\pm}$

What if $M_{\tilde{e}_L} \approx M_{\tilde{e}_R}$, so that thresholds can't separate $e^+e^- \to \tilde{e}_L\tilde{e}_L, \tilde{e}_R\tilde{e}_R$ and $\tilde{e}_R\tilde{e}_L$?

Introduction: Model

Model: SPS1a' like, but:

$M_{\tilde{e}_L} = 200$ GeV and $M_{\tilde{e}_R} = 195$ GeV. Both decay 100 % to $\tilde{\chi}_1^0$ e.

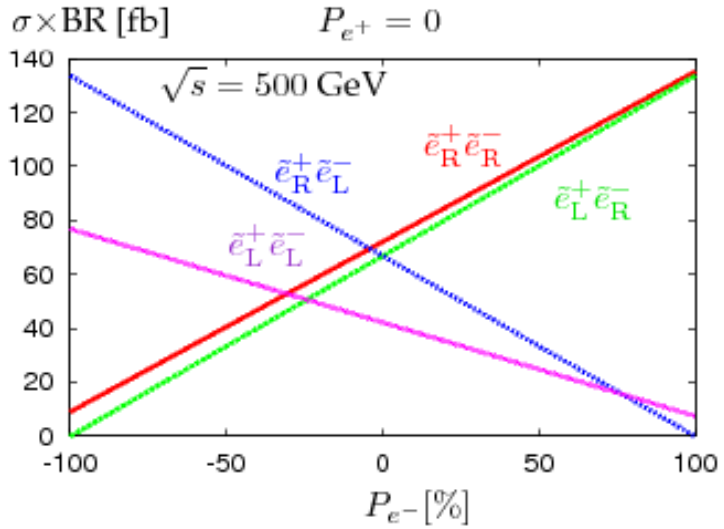
Even with $P_{e^-} \geq +90\%$: No separation of $\tilde{e}_L^+ \tilde{e}_R^-$ and $\tilde{e}_R^+ \tilde{e}_R^-$: Ratio of the cross sections $\approx$ constant.

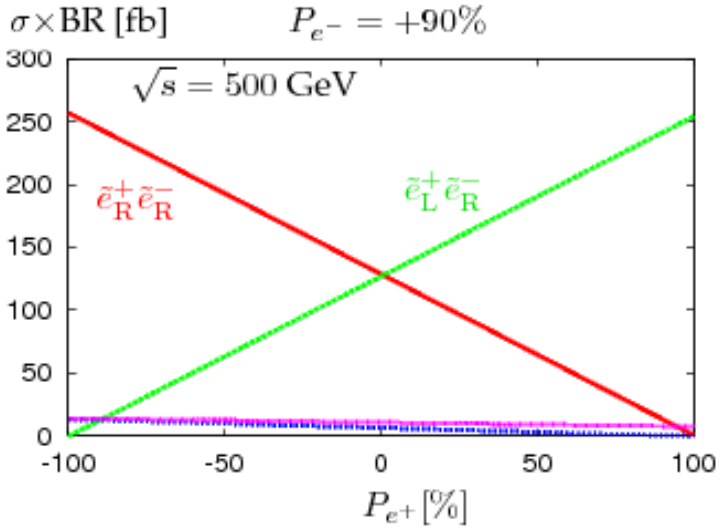
Introduction: Model

Model: SPS1a' like, but:

$M_{\tilde{e}_L} = 200$ GeV and $M_{\tilde{e}_R} = 195$ GeV. Both decay 100 % to $\tilde{\chi}_1^0$ e.

Even with $P_{e^-} \geq +90\%$: No separation of $\tilde{e}_L^+ \tilde{e}_R^-$ and $\tilde{e}_R^+ \tilde{e}_R^-$: Ratio of the cross sections $\approx$ constant.



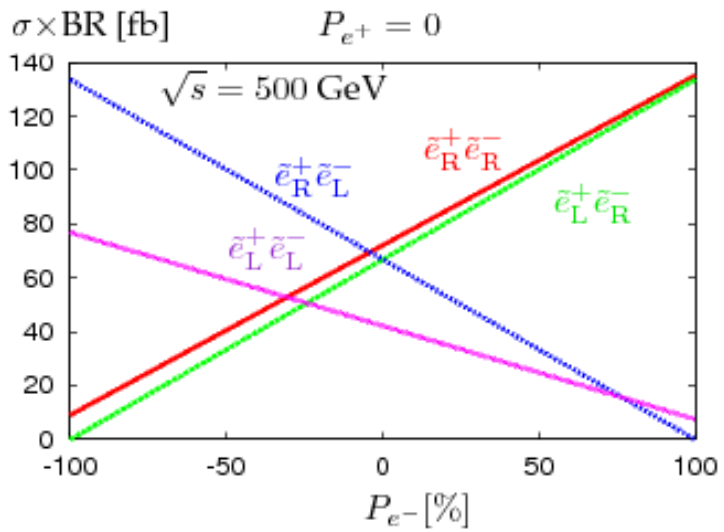


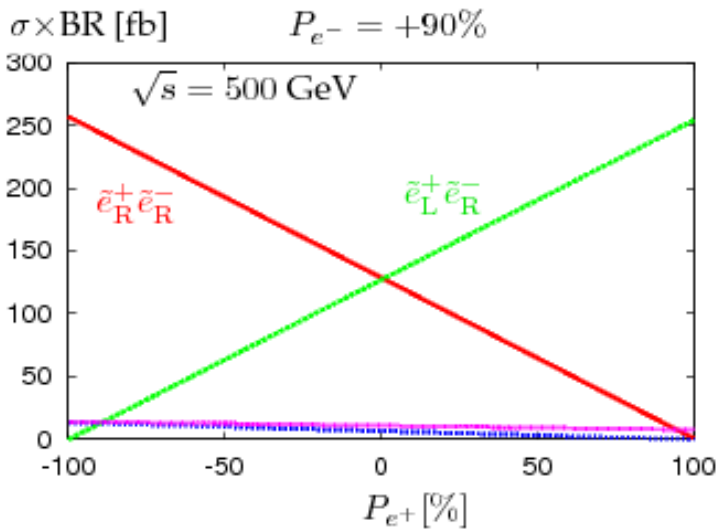
Introduction: Model

Model: SPS1a' like, but:

$M_{\tilde{e}_L} = 200$ GeV and $M_{\tilde{e}_R} = 195$ GeV. Both decay 100 % to $\tilde{\chi}_1^0$ e.

Even with $P_{e^-} \geq +90\%$: No separation of $\tilde{e}_L^+ \tilde{e}_R^-$ and $\tilde{e}_R^+ \tilde{e}_R^-$: Ratio of the cross sections $\approx$ constant.





Polarised positrons a must !

Analysis: samples

Background and efficiency from Full-sim SPS1a' sample, kinematics from Whizard simulation of the model.

Analysis: samples

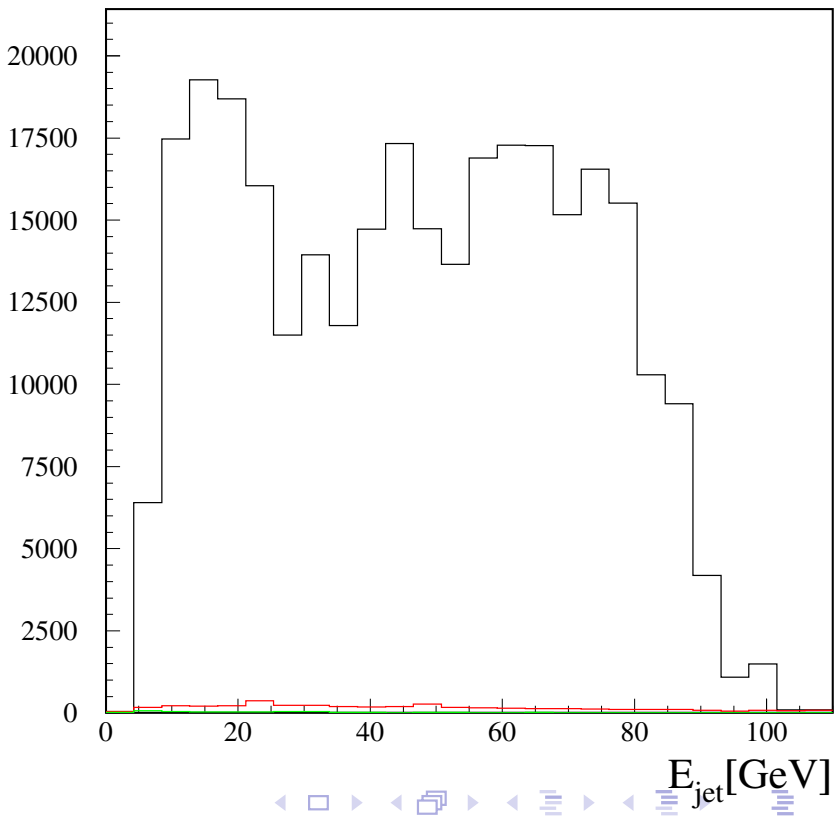
Background and efficiency from Full-sim SPS1a' sample, kinematics from Whizard simulation of the model.

- The $\tilde{e}$ signal was extracted from the same sample as was used for the SPS1a' $\tilde{\tau}$study, using the same cuts except
  - Demand exactly two well identified electrons.
  - Reverse the $\tilde{\tau}$anti-SUSY background cut
  - Some cuts could be loosened
- Almost background-free !

Analysis: samples

Background and efficiency from Full-sim SPS1a' sample, kinematics from Whizard simulation of the model.

- The $\tilde{e}$ signal was extracted from the same sample as was used for the SPS1a' $\tilde{\tau}$study, using the same cuts except
  - Demand exactly two well identified electrons.
  - Reverse the $\tilde{\tau}$anti-SUSY background cut
  - Some cuts could be loosened
- Almost background-free !



Analysis: samples

Background and efficiency from Full-sim SPS1a' sample, kinematics from Whizard simulation of the model.

For the signal:

- Generate (with Whizard 1.95) the modified model.
- Apply the kinematic cuts used for the full simulation analysis.
- Scale down the over-all event-weight so that the efficiency agrees with the full simulation.

Analysis: The handle

The handle:
Opposite polarisation beams produces $\tilde{e}$:s in both s- and t-channel.
Same polarisation produces $\tilde{e}$:s in t-channel only $\Rightarrow$

Modification of Θ distribution with changed positron polarisation

However, the effect is small since t-channel always dominates !
$\tilde{e}$:s are heavy (and are scalars) $\Rightarrow$ t- and s- channel kinematic distributions of the electrons are not very different.

Analysis: The handle

The handle:
Opposite polarisation beams produces $\tilde{e}$:s in both s- and t-channel.
Same polarisation produces $\tilde{e}$:s in t-channel only $\Rightarrow$

Modification of Θ distribution with changed positron polarisation

However, the effect is small since t-channel always dominates !
$\tilde{e}$:s are heavy (and are scalars) $\Rightarrow$ t- and s- channel kinematic distributions of the electrons are not very different.

Analysis: the $\tilde{e}$ direction

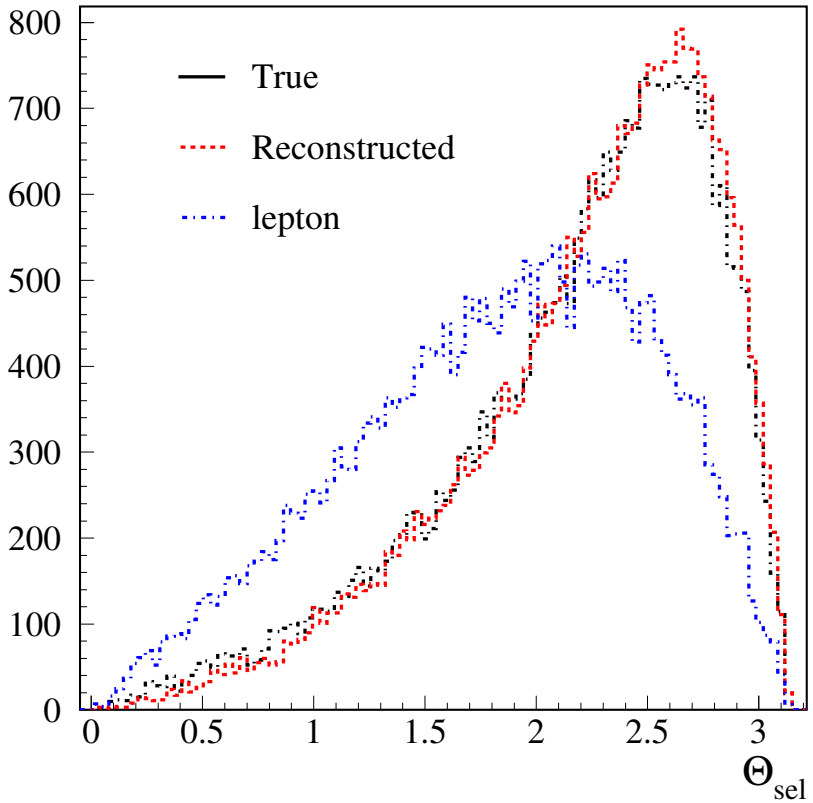
Need to reconstruct the $\tilde{e}$ direction:

- 8 unknown $\tilde{\chi}_1^0$ momentum components
- Assume $M_{\tilde{e}}$ and $M_{\tilde{\chi}_1^0}$ known $\rightarrow$
- 8 constraints (E and p conservation, 4 mass-relations)
- WORKS !

Analysis: the $\tilde{e}$ direction

Need to reconstruct the $\tilde{e}$ direction:

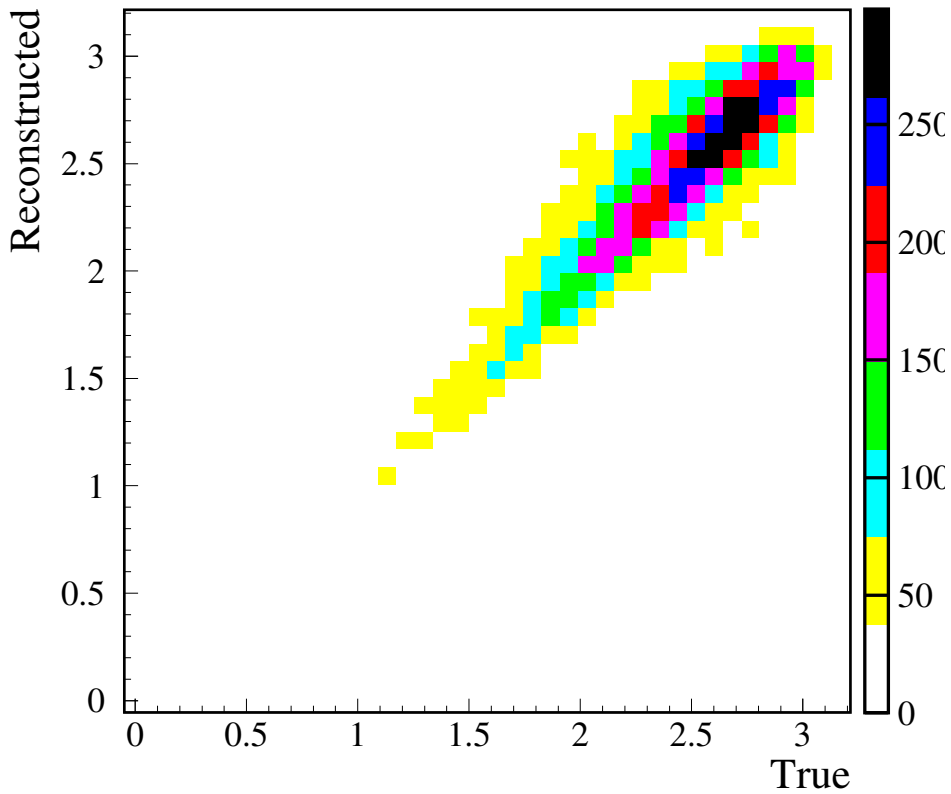
- 8 unknown $\tilde{\chi}_1^0$ momentum components
- Assume $M_{\tilde{e}}$ and $M_{\tilde{\chi}_1^0}$ known $\rightarrow$
- 8 constraints (E and p conservation, 4 mass-relations)
- WORKS !



Analysis: the $\tilde{e}$ direction

Need to reconstruct the $\tilde{e}$ direction:

- 8 unknown $\tilde{\chi}_1^0$ momentum components
- Assume $M_{\tilde{e}}$ and $M_{\tilde{\chi}_1^0}$ known $\rightarrow$
- 8 constraints (E and p conservation, 4 mass-relations)
- WORKS !



Analysis: Observing the shift

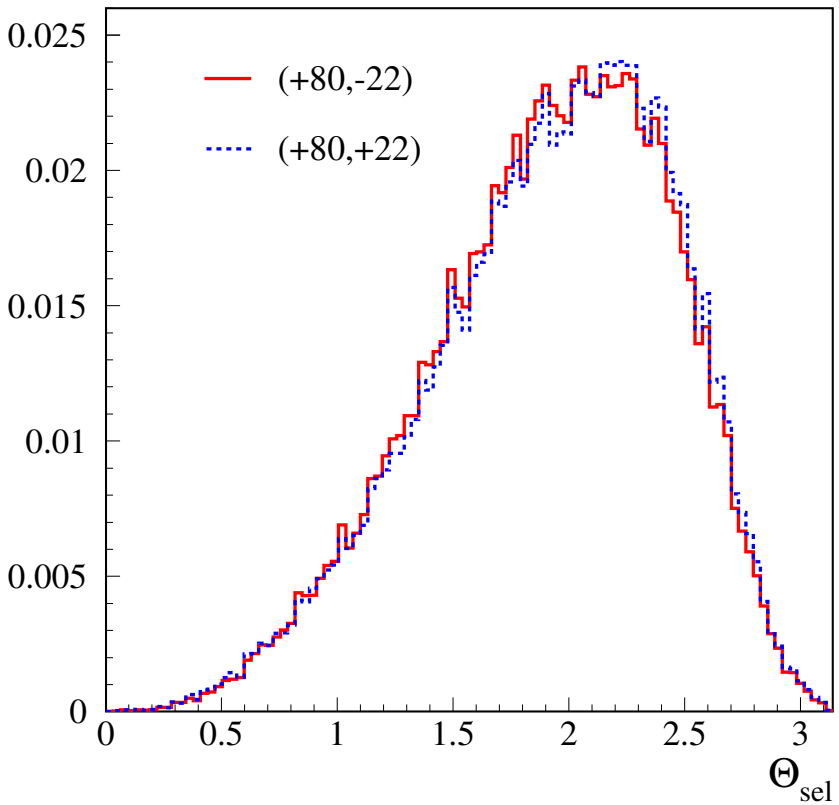
Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

- $P(e^-)$= +80 % and ..
- $P(e^+) = \pm$ 22 % ...
- $P(e^+) = \pm$ 30 % ...
- $P(e^+) = \pm$ 60 % ...
- ... and for $P(e^-) = \pm$ 80 %
  $P(e^+) = 0$

Analysis: Observing the shift

Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

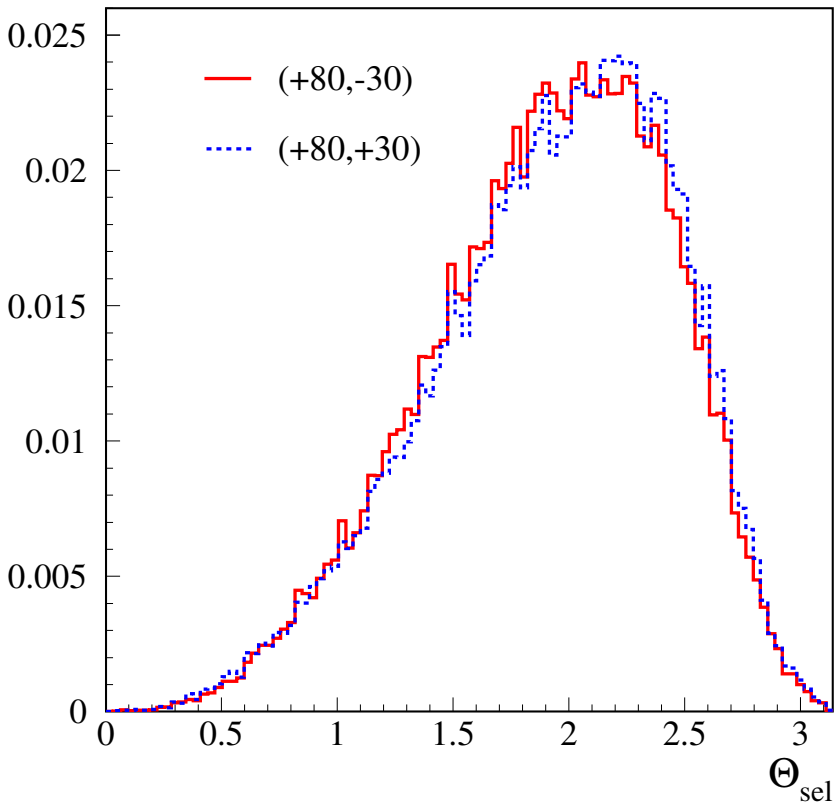
- $P(e^-)$= +80 % and ..
- $P(e^+)$ = $\pm$ 22 % ...
- $P(e^+)$ = $\pm$ 30 % ...
- $P(e^+)$ = $\pm$ 60 % ...
- ... and for $P(e^-)$= $\pm$ 80 % $P(e^+)$ = 0



Analysis: Observing the shift

Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

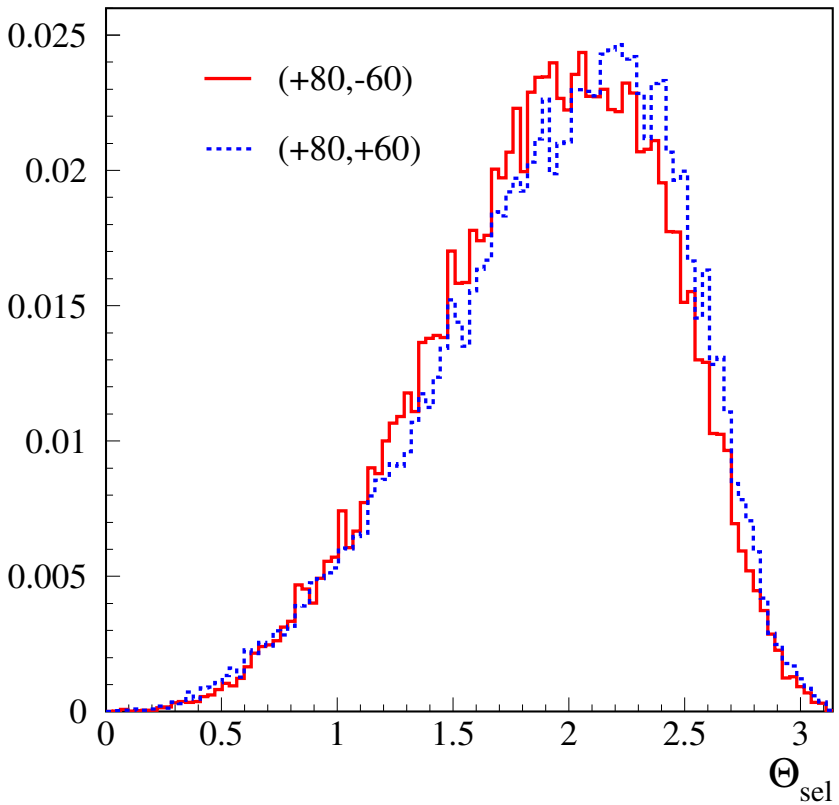
- $P(e^-)$= +80 % and ..
- $P(e^+)$ = $\pm$ 22 % ...
- $P(e^+)$ = $\pm$ 30 % ...
- $P(e^+)$ = $\pm$ 60 % ...
- ... and for $P(e^-)$= $\pm$ 80 % $P(e^+)$ = 0



Analysis: Observing the shift

Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

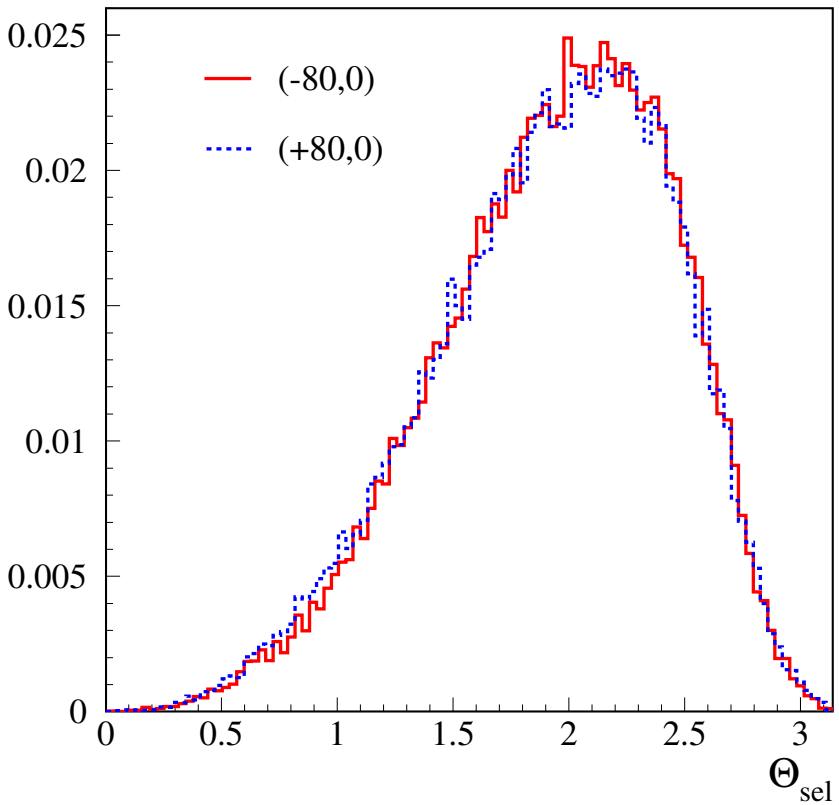
- $P(e^-)$= +80 % and ..
- $P(e^+)$ = $\pm$ 22 % ...
- $P(e^+)$ = $\pm$ 30 % ...
- $P(e^+)$ = $\pm$ 60 % ...
- ... and for $P(e^-)$= $\pm$ 80 % $P(e^+)$ = 0



Analysis: Observing the shift

Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

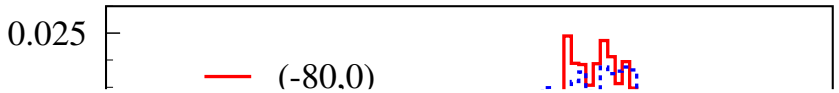
- $P(e^-)$= +80 % and ..
- $P(e^+) = \pm$ 22 % ...
- $P(e^+) = \pm$ 30 % ...
- $P(e^+) = \pm$ 60 % ...
- ... and for $P(e^-) = \pm$ 80 % $P(e^+) = 0$



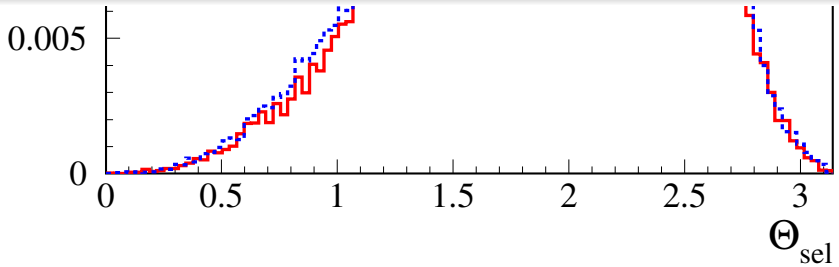
Analysis: Observing the shift

Analyse assuming 100 fb^{-1} for each of the polarisations configurations.

- $P(e^-)$= +80 % and ..
- $P(e^+)$ = $\pm$ 22 % ...



$\lvert P(e^+)\rvert$ (%)	significance of shift (σ)	Title of paper
22	2.4	"Limit on ..."
30	3.5	"Evidence for ..."
60	6.6	"Observation of ..."



Conclusions

- The $\tilde{e}$ cross-section in SPS1a' is huge:
  - Potentially the best M_{LSP} measurement ?
- The preliminary determination of the chiral structure of near-degenerate $\tilde{e}$:s
  - Cannot be done without positron polarisation
  - Profits largely even from a modest increase (22 % to 30 % $\leftrightarrow$ doubling the luminosity)
  - Lack of FullSim statistics for $\tilde{e}$:s in SPS1a'.
  - More work to be done ...

Conclusions

- The $\tilde{e}$ cross-section in SPS1a' is huge:
  - Potentially the best M_{LSP} measurement ?
- The preliminary determination of the chiral structure of near-degenerate $\tilde{e}$:s
  - Cannot be done without positron polarisation
  - Profits largely even from a modest increase (22 % to 30 % $\leftrightarrow$ doubling the luminosity)
  - Lack of FullSim statistics for $\tilde{e}$:s in SPS1a'.
  - More work to be done ...

Conclusions

- The $\tilde{e}$ cross-section in SPS1a' is huge:
  - Potentially the best M_{LSP} measurement ?
- The preliminary determination of the chiral structure of near-degenerate $\tilde{e}$:s
  - Cannot be done without positron polarisation
  - Profits largely even from a modest increase (22 % to 30 % $\leftrightarrow$ doubling the luminosity)
  - Lack of FullSim statistics for $\tilde{e}$:s in SPS1a'.
  - More work to be done ...

Conclusions

- The $\tilde{e}$ cross-section in SPS1a' is huge:
  - Potentially the best M_{LSP} measurement ?
- The preliminary determination of the chiral structure of near-degenerate $\tilde{e}$:s
  - Cannot be done without positron polarisation
  - Profits largely even from a modest increase (22 % to 30 % $\leftrightarrow$ doubling the luminosity)
  - Lack of FullSim statistics for $\tilde{e}$:s in SPS1a'.
  - More work to be done ...