Study of $\tilde{\mu}_R$ mass at TESLA

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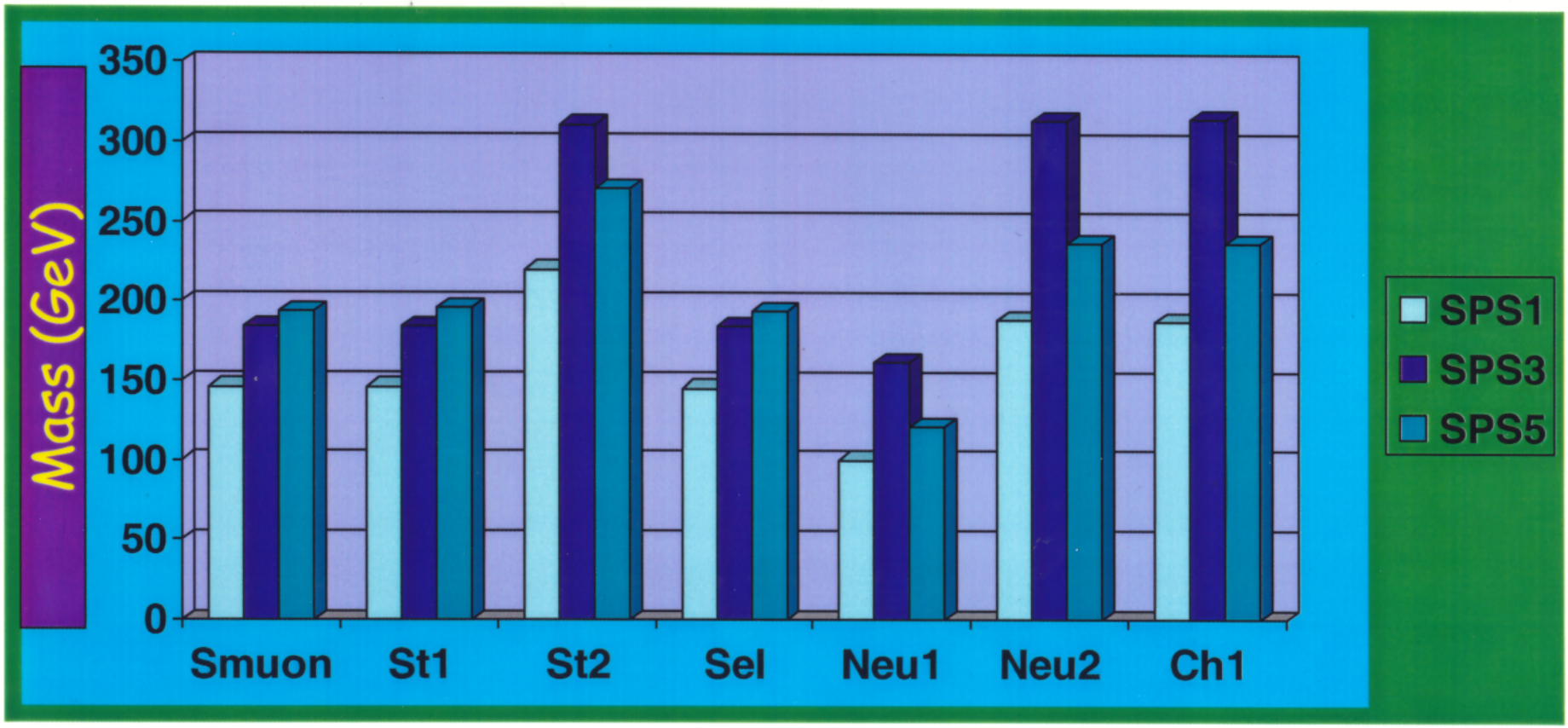
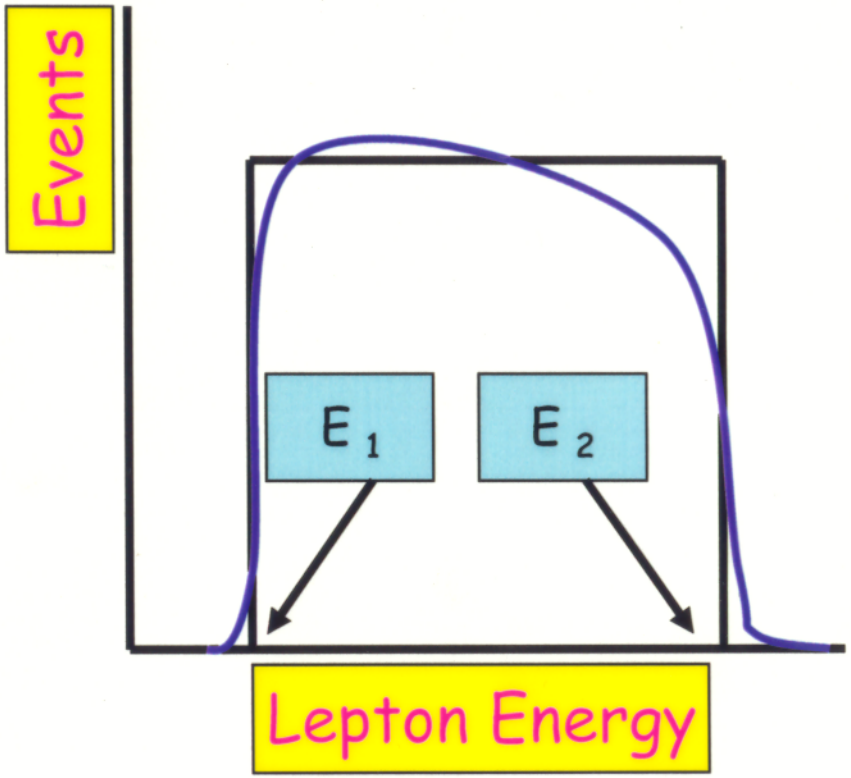
Benchmark Models



The End Point Method



Because smuon decay isotropically, muon spectrum is FLAT
Radiation effects change the shape of the spectrum substantially
Only from kinematic considerations:

$$\frac{m_{\tilde{\mu}}}{2}\left(1-\frac{m^2_{\tilde{\chi}^0_1}}{m^2_{\tilde{\mu}}}\right)\gamma(1-\beta) \leq E_{\tilde{\mu}} \leq \frac{m_{\tilde{\mu}}}{2}\left(1-\frac{m^2_{\tilde{\chi}^0_1}}{m^2_{\tilde{\mu}}}\right)\gamma(1+\beta)$$

$$M_{\tilde{\mu}} = \frac{\sqrt{s}\sqrt{E_1 \bullet E_2}}{E_1 + E_2} \qquad M_{\tilde{\chi}} = M_{\tilde{\mu}}\sqrt{1-\frac{2(E_1+E_2)}{\sqrt{s}}} \qquad \gamma = \frac{\sqrt{s}}{2m_{\tilde{\mu}}}, \quad \beta = \sqrt{1-\frac{4m^2_{\tilde{\mu}}}{s}}$$

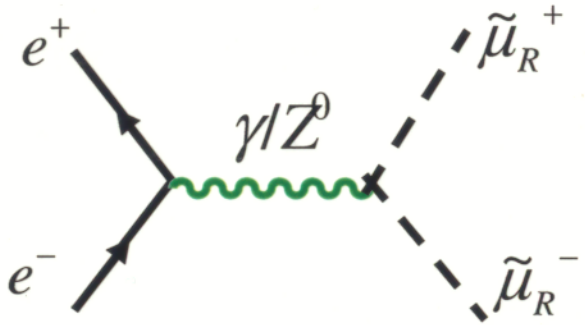
Conclusions

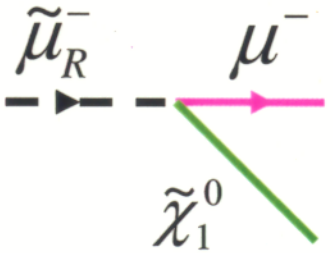
- I have demostrated the capacity of TESLA to measure SUSY particles with very high precision at 0.5 TeV
- Smuon mass error: 0.15(0.001) GeV
- Neutralino : 0.09(0.0009) GeV

  (H.U.Martyn Smuon: 0.18 GeV, Neutral 0.18 GeV)
- Signal: efficiency of 67% and purity: 92%
- The result achieved shows us that SUSY properties could be measured with very good accuracy
- Polarization improves the signal
- Radiative effects are important
- Next study: $\gamma\gamma \rightarrow \tilde{\mu}_R^+ \tilde{\mu}_R^-$

Introduction

- I study the production of smuons at TESLA
- Goal : mass measurement
- Simulation is based in mSUGRA (SPS1) with free parameters of model $\tan(\beta)=10$, $m_{1/2}=250$, $m_0=100$, $A_0=-100$ and sig(u) > 0
- Center of mass energy = 500 GeV, accesible at TESLA
- Polarization is included:
- $e^- = +0.8$, $e^+ = -0.6$
- Beamstrahlung effect is included CIRCE (T. Ohl)
- ISR and FSR as inherent effect is also included
- Signal: σ = 124 fb, Luminosity = 400 fb^{-1}, N events = 49600
- I use Pythia 6.2 (T. Sjostrand) as generator
- The detector is simulated with a fast simulation

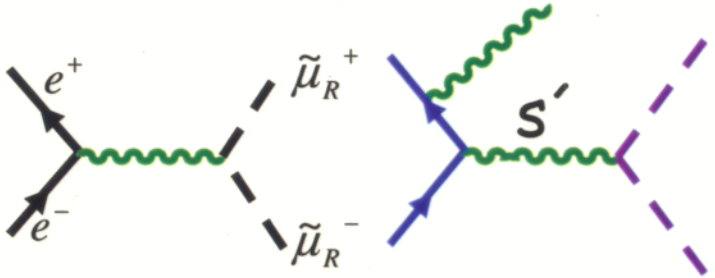


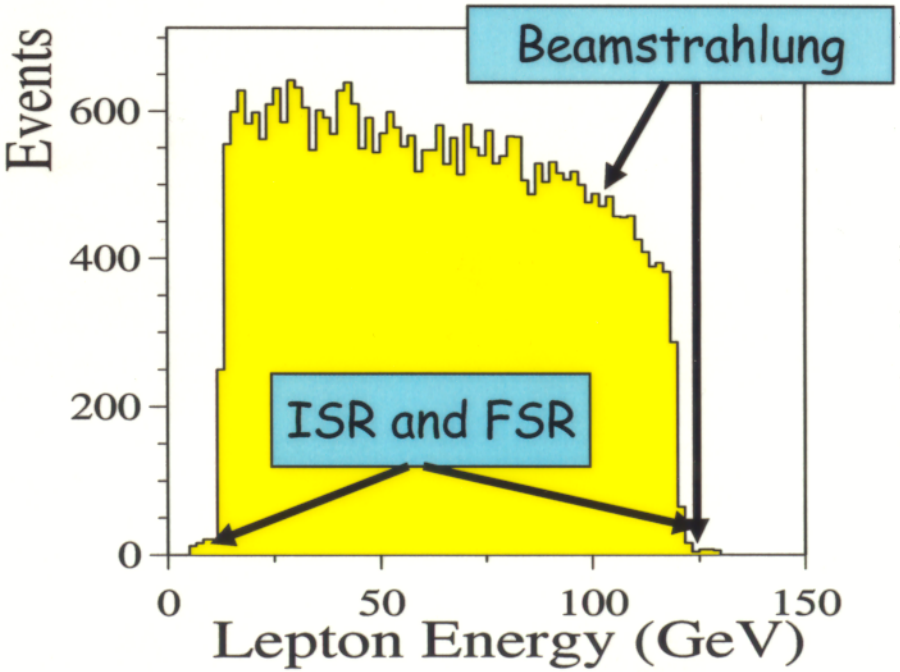


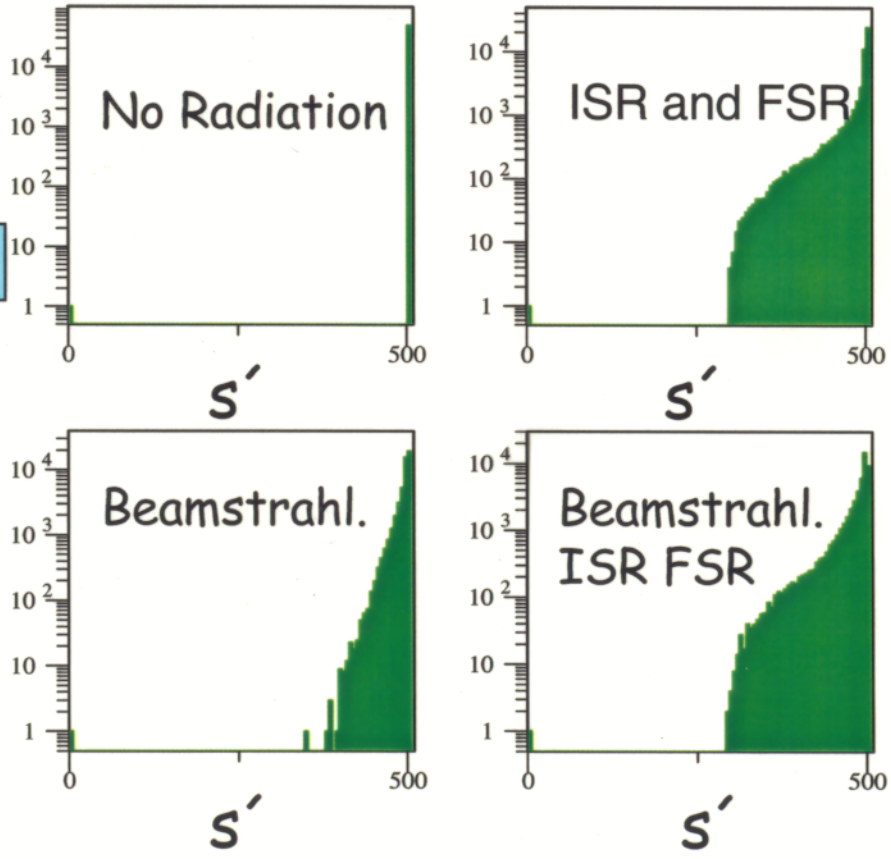
Branching Ratio = 1

LSP: $\tilde{\chi}_1^0$

Signal and Radiation

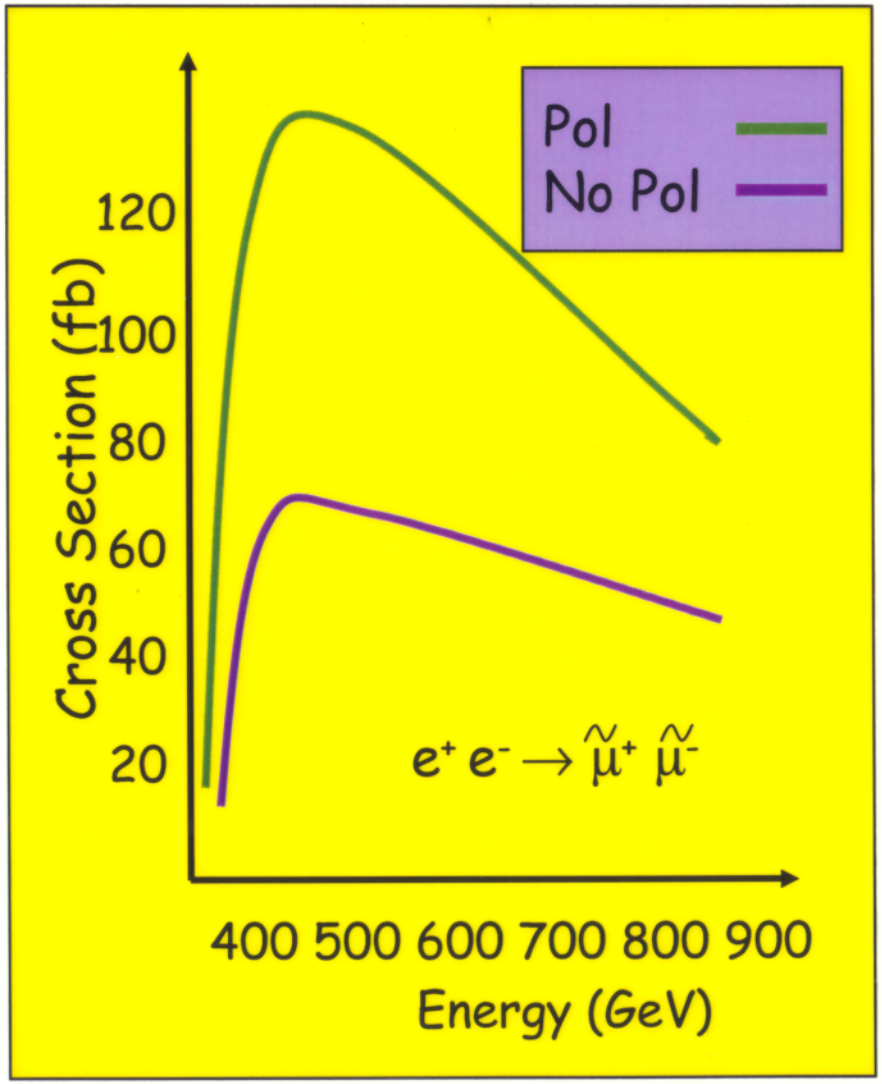


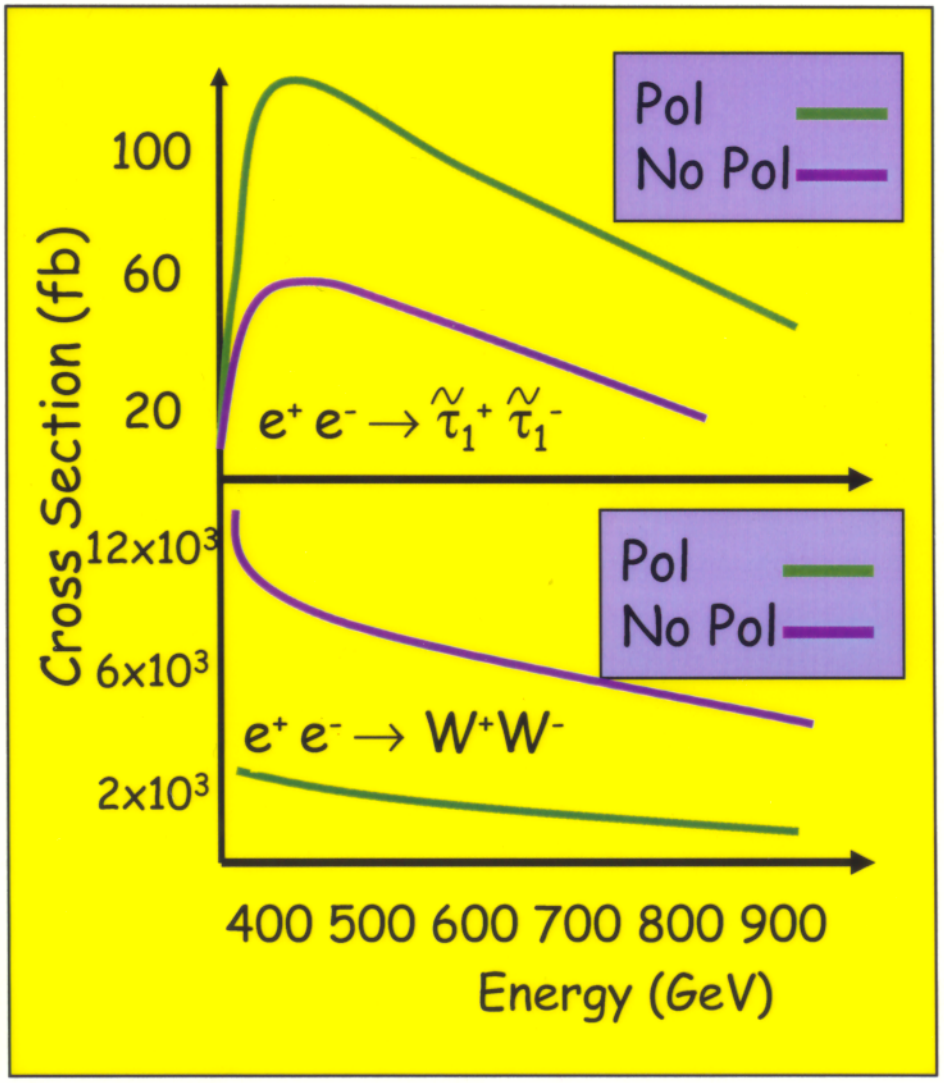




Radiation affecting mass of event

Polarization





Background

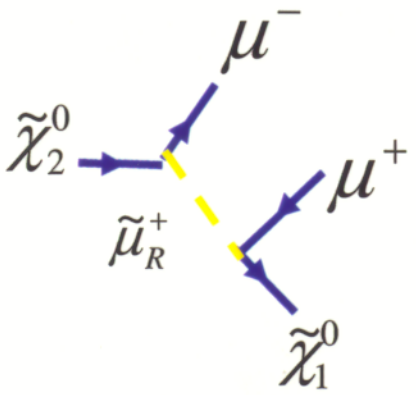
Process	$\sigma \cdot Br$(fb)
• $e^+e^- \to Z \to \mu^+\mu^-$	1032
• $e^+e^- \to Z \to \tau^+\tau^- \to \mu^+\mu^-\ \nu\nu\nu\nu$	31
• $e^+e^- \to ZZ \to \tau^+\tau^-\ \nu\nu \to \mu^+\mu^-\ \nu\nu\nu\nu\nu\nu$	6.0
• $e^+e^- \to ZZ \to \mu^+\mu^-\ \nu\nu$	5.9
• $e^+e^- \to \gamma^*\gamma^* \to \mu^+\mu^-\ e^+e^-$	6991
• $e^+e^- \to \gamma^*\gamma^* \to \tau^+\tau^-\ e^+e^- \to \mu^+\mu^-\ e^+e^-\ \nu\nu\nu\nu$	215
• $e^+e^- \to W^+W^- \to \tau^+\tau^-\ \nu\nu \to \mu^+\mu^-\ \nu\nu\nu\nu\nu\nu$	0.28
• $e^+e^- \to W^+W^- \to \mu^+\mu^-\ \nu\nu$	9.39
• $e^+e^- \to W^+W^- \to \tau^+\mu^-\ \nu\nu \to \mu^+\mu^-\ \nu\nu\nu\nu$	1.62

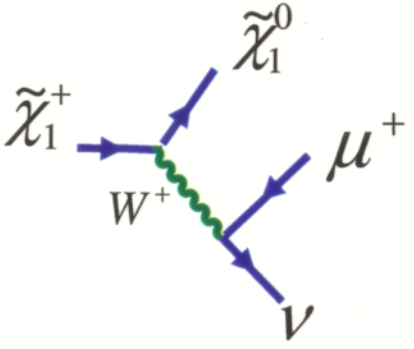
SIGNAL σ = 124 fb

SUSY background

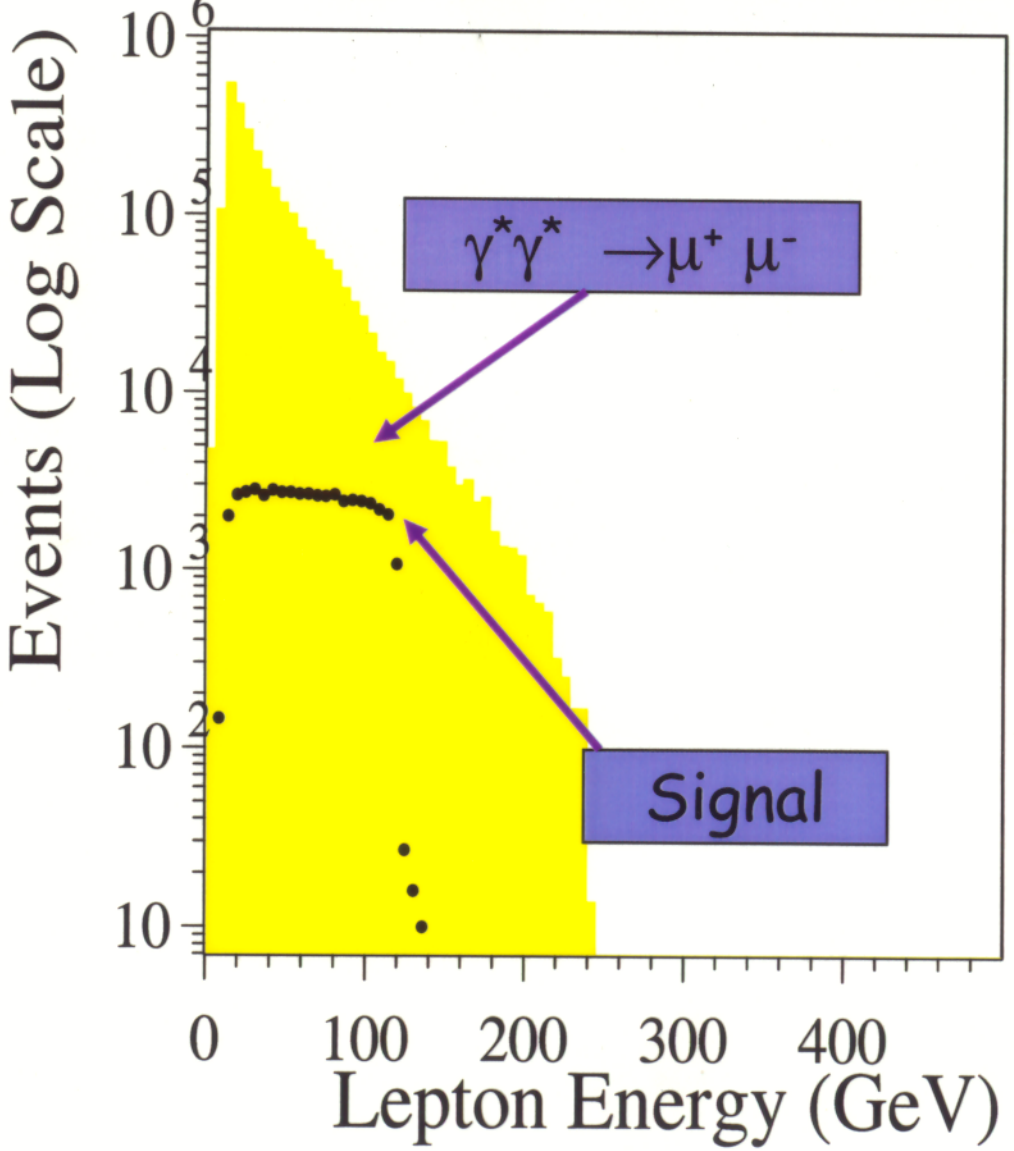
I take account processes of the form $e^+ e^- \to \mu^+ \mu^- \not{E}$

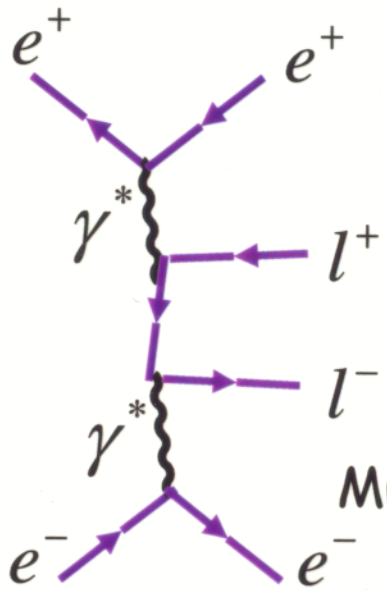
Processes	$\sigma \bullet Br$(fb)
$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \mu^+\mu^-$	0.22
$e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_2^0 \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \tau^+\tau^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \nu\ \nu\ \nu\ \nu\ \mu^+\mu^-$	0.23
$e^+e^- \to \tilde{\tau}_1^+ \tilde{\tau}_1^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \tau^+\tau^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \nu\ \mu^+\ \nu\ \nu\ \mu^-\ \nu$	3.72
$e^+e^- \to \tilde{\tau}_2^+ \tilde{\tau}_2^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \tau^+\tau^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ \nu\ \mu^+\ \nu\ \nu\ \mu^-\ \nu$	0.06
$e^+e^- \to \tilde{\chi}_1^+ \tilde{\chi}_1^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \ W^+ W^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0 \mu^-\ \nu\ \mu^+\ \nu$	4×10^{-4}





Two photon veto





C. Section•Br

Taus = 215 fb

Muons = 6991 fb

e^+e^- pairs: highly energetic
Small transverse momentum
Forward detector: very good hermeticity
Reject events with e^+e^-

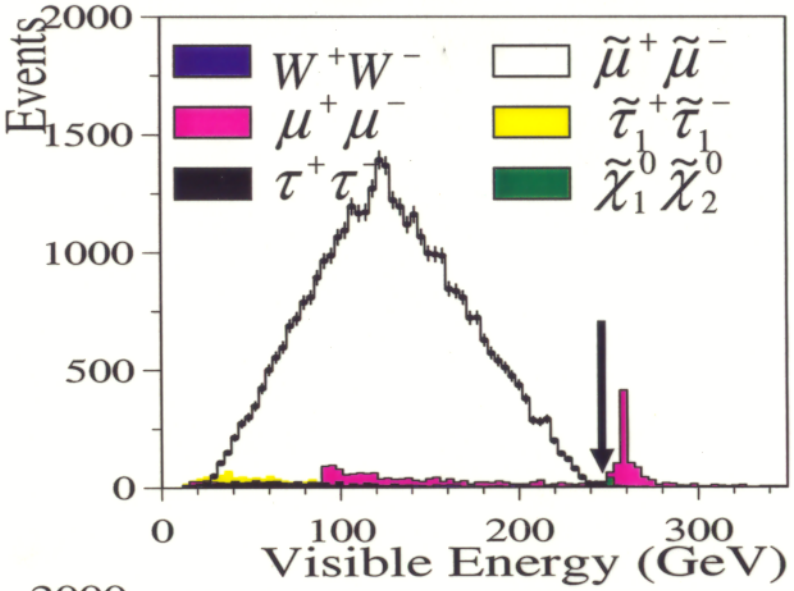
Preselection and Selection

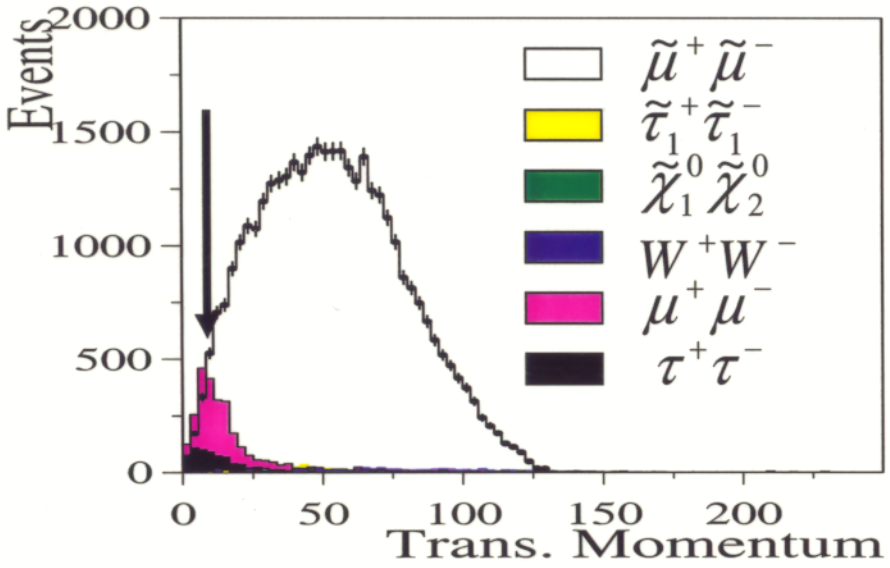
- $2 \leq$ number of energy flow objects ≤ 6
- number of charged particles = 2
- reject particles with $e^+ e^-$ in the final state ($\gamma\gamma$ veto)
- 5 GeV < muon energy (both charges) < 130 GeV
- 0.3 rad. < collinearity < 3.1 rad.
- coplanarity < 3.05 Rad.
- Σ muon energy > 0.56 visible energy
- 27 GeV < visible energy < 250 GeV
- Σ transversal momentum > 15 GeV
- trans. Mom μ- + Trans. Mom μ+ > 0.7 (Total Momentum)

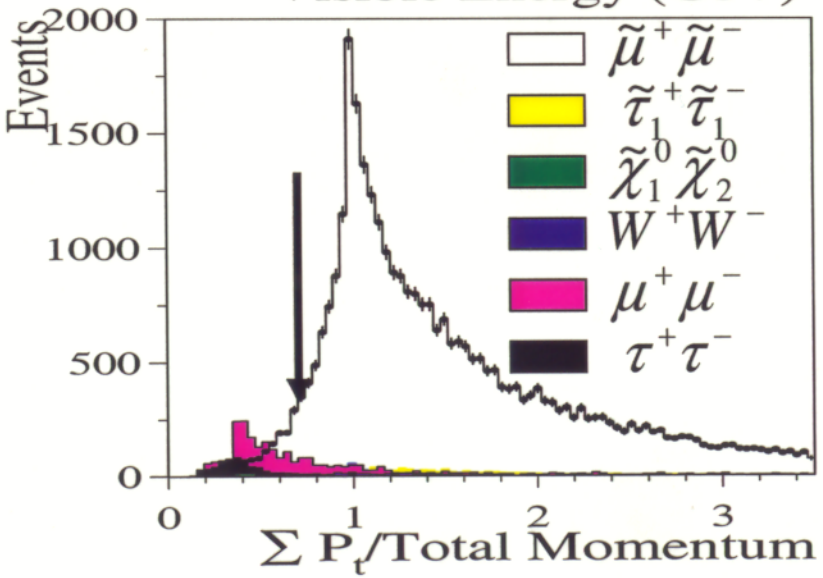
Efficiency : 67% Purity: 92%

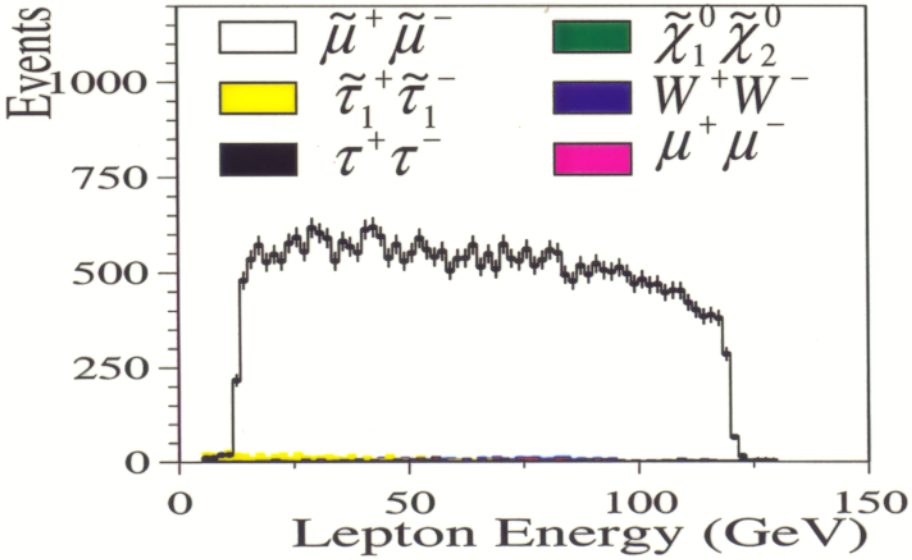
Use of forward detector permits us to lower the cut on P_t momentum (canonical cut estimate ~ 30 GeV)

CUTS


Events
2000
1500
1000
500
0
0
100
200
300
Visible Energy (GeV)
W^+W^-
$\mu^+\mu^-$
$\tau^+\tau^-$
$\tilde{\mu}^+\tilde{\mu}^-$
$\tilde{\tau}_1^+\tilde{\tau}_1^-$
$\tilde{\chi}_1^0\tilde{\chi}_2^0$

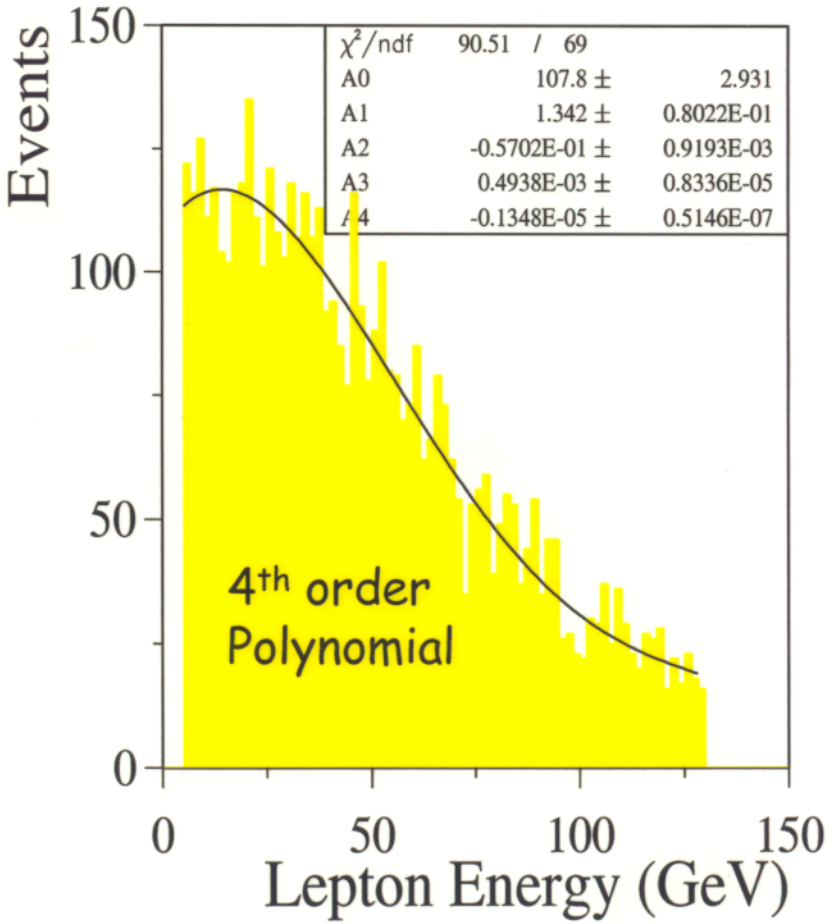

Events
2000
1500
1000
500
0
0
50
100
150
200
Trans. Momentum
$\tilde{\mu}^+\tilde{\mu}^-$
$\tilde{\tau}_1^+\tilde{\tau}_1^-$
$\tilde{\chi}_1^0\tilde{\chi}_2^0$
W^+W^-
$\mu^+\mu^-$
$\tau^+\tau^-$

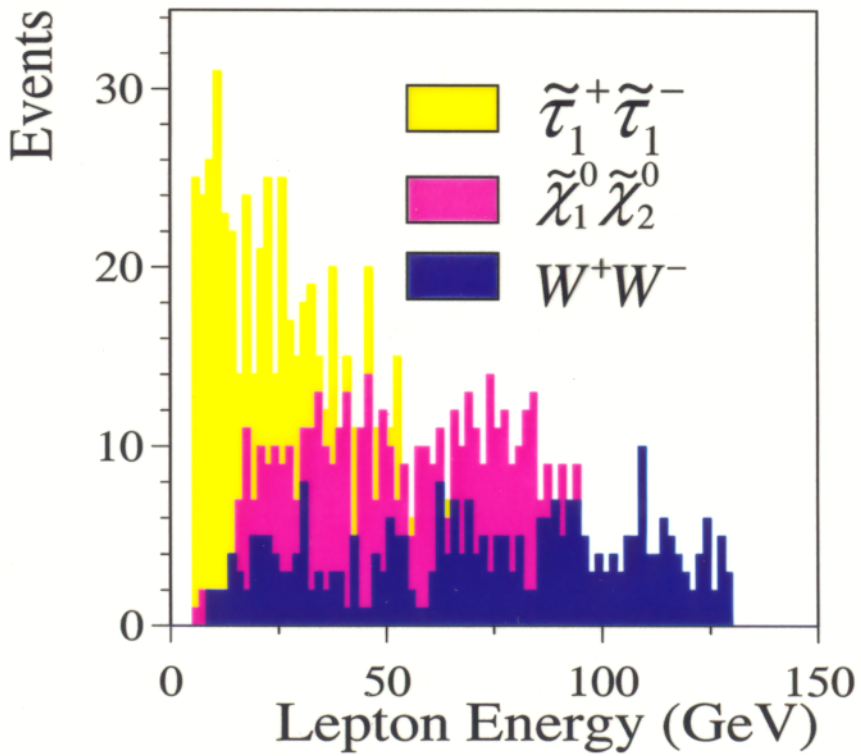

Events
2000
1500
1000
500
0
0
1
2
3
Σ P_t/Total Momentum
$\tilde{\mu}^+\tilde{\mu}^-$
$\tilde{\tau}_1^+\tilde{\tau}_1^-$
$\tilde{\chi}_1^0\tilde{\chi}_2^0$
W^+W^-
$\mu^+\mu^-$
$\tau^+\tau^-$


Events
1000
750
500
250
0
0
50
100
150
Lepton Energy (GeV)
$\tilde{\mu}^+\tilde{\mu}^-$
$\tilde{\tau}_1^+\tilde{\tau}_1^-$
$\tau^+\tau^-$
$\tilde{\chi}_1^0\tilde{\chi}_2^0$
W^+W^-
$\mu^+\mu^-$

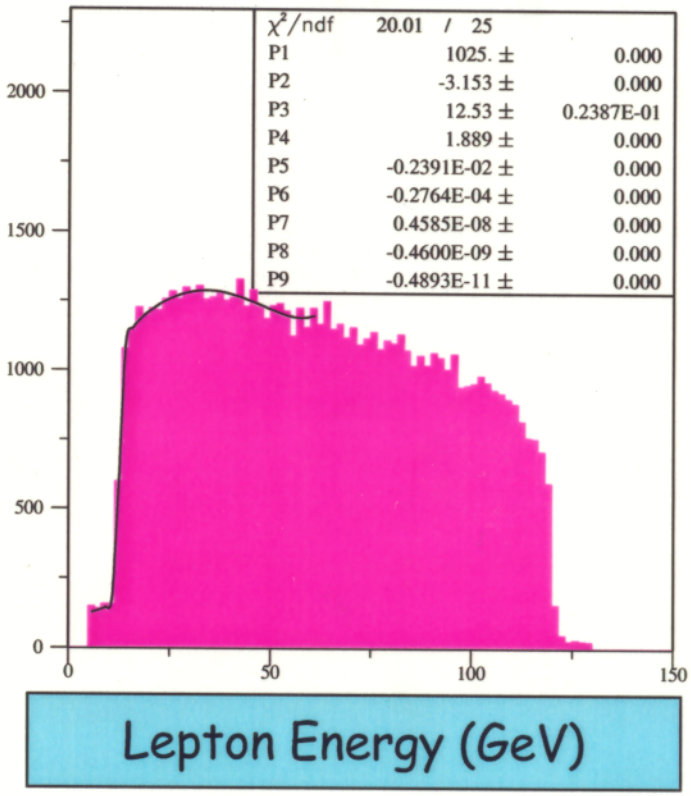
Fitting : Background

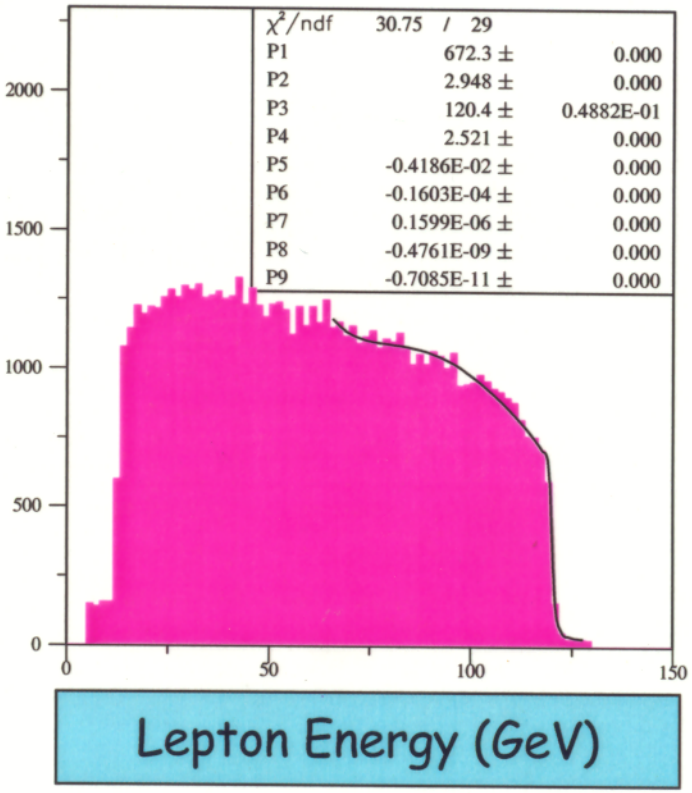
Polynomial function is employed
Contamination at low momentum
Main background $W^+ W^-$, $\chi^0_1 \chi^0_2$ and $\tilde{\tau}_1^+ \tilde{\tau}_1^-$
Stau1 enhanced by polarization





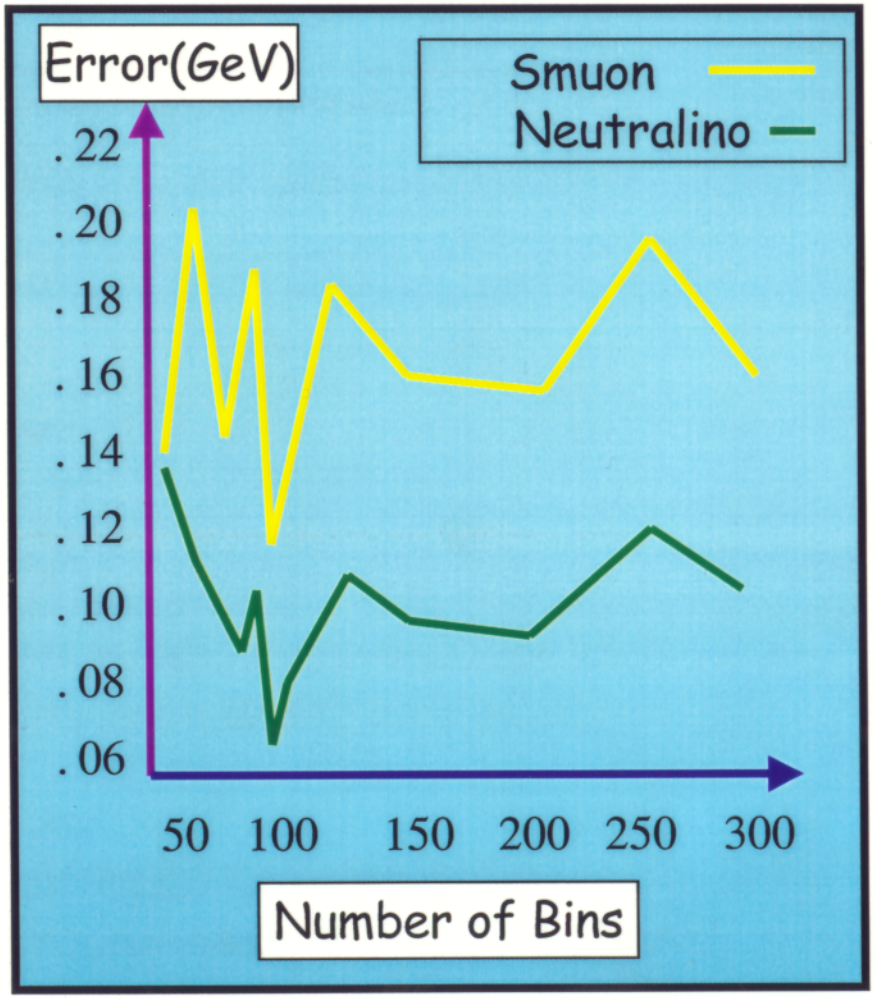
Fitting : Signal





Fitfunction: FIT = Stepfunction x Poly + Background
Different values of end points for different binning
Many fits with reasonable chi²

Fitting



Bins	Smuon	Error	Neutr	Error
80	145.63	0.174	99.73	0.112
90	146.10	0.113	99.77	0.074
100	146.73	0.130	100.39	0.084
110	147.26	0.177	100.73	0.111

Average on fit:

Smuon mass = 146.25 ±0.15

Neutralino mass = 99.98 ±0.09

Input values:

Smuon mass = 145.9 GeV

Neutralino mass = 100.0 GeV