Search for SUSY Particles at Future e^+e^- Colliders

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- **Supersymmetric Particles – MSSM**
- **Collider and Detector Aspects**
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  - Study of $e^+e^- \to \tilde{\mu}_R \, \tilde{\mu}_R$
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  - Study of $e^+e^- \to \chi_1^+ \, \chi_1^-$
- **Scalar Top Quark**
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- **Conclusions**

'Conceptual Design Report of a 500 GeV e^+e^- Linear Collider',
DESY 1997-048, ECFA 1997-182 and http://www.desy.de/HEP/desy-hep.html

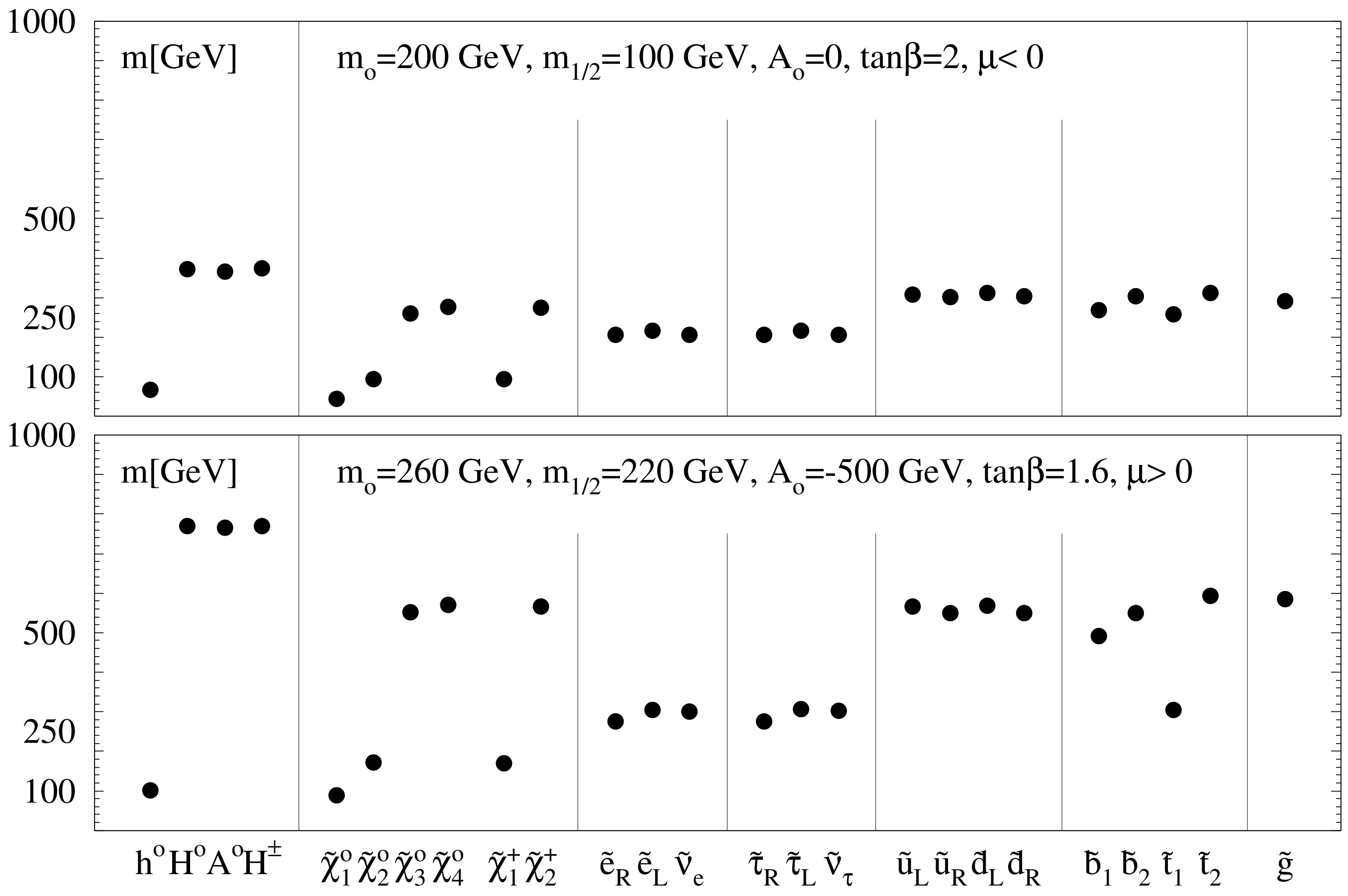
Supersymmetric Particles – MSSM

particle		spin	SUSY partner		spin	mixed states
leptons	ℓ	1/2	sleptons	$\tilde{\ell}$	0	
quarks	q	1/2	squarks	$\tilde{q}$	0	
gluon	g	1	gluino	$\tilde{g}$	1/2	
bosons	γ, Z, W	1	gauginos	$\tilde{\gamma}, \tilde{Z}, \tilde{W}$	1/2	$\chi_1^0, \chi_2^0, \chi_3^0, \chi_4^0$
Higgs	H	0	higgsino	$\tilde{H}$	1/2	$\chi_1^\pm, \chi_2^\pm$

- **GUT scenario – 5 parameters specify particle sector**

  $m_0, \; m_{1/2}, \; A_0, \; \tan\beta = v_2/v_1, \;$ **sign** μ

  in general LSP $= \chi_1^0$



Collider & Detector Aspects

- **Machine parameters**

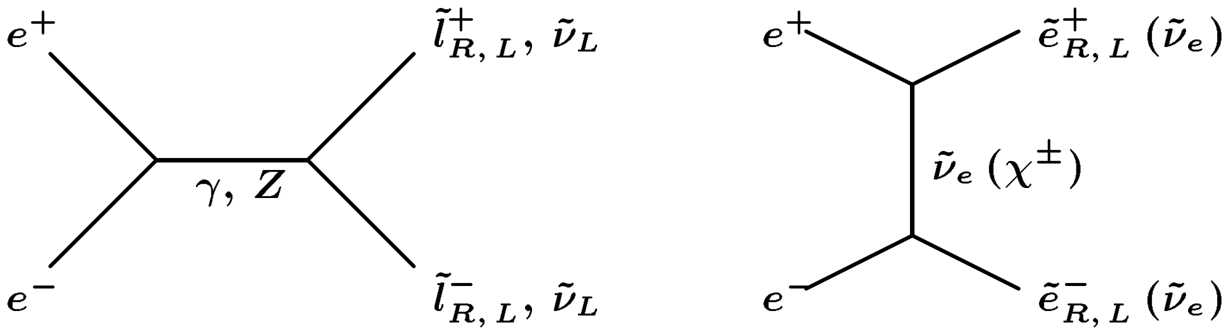
cms energy	350 – 500 GeV	800 GeV	1.6 TeV
$\int \mathcal{L}\, dt$	50 fb^{-1}	125 fb^{-1}	500 fb^{-1}
ISR $\langle \Delta E \rangle$ / rms	0.4 / 6 GeV	0.7 / 11 GeV	
BS $\langle \Delta E \rangle$ / rms	8 / 10 GeV	12 / 19 GeV	
polarisation	$P_{\parallel}(e^-) \sim 90\,\%$	$P_{\parallel}(e^+) \sim 60\,\%$	

- **Detector concept no extraordinary performance required for SUSY searches/studies**

	resolution	coverage
e, γ, μ ID		$\mid \cos\theta \mid < 0.95$
tracking	$\delta p_\perp / p_\perp^2 \simeq 1 \cdot 10^{-4}$ GeV^{-1}	$\mid \cos\theta \mid < 0.95$
em calorimeter	$\delta E/E \simeq 0.10/\sqrt{E} \oplus 0.01$	$\mid \cos\theta \mid < 0.99$
hadr. calorimeter	$\delta E/E \simeq 0.50/\sqrt{E} \oplus 0.04$	$\mid \cos\theta \mid < 0.99$
energy flow	$\delta E/E \simeq 0.30/\sqrt{E}$	

- **MC generator PYTHIA 5.7 + MSSM extension**

Scalar Leptons



Scalar lepton production

$$
\begin{aligned}
e^+ e^- &\to \tilde{e}_R\,\tilde{e}_R,\ \tilde{e}_L\,\tilde{e}_L,\ \tilde{e}_R\,\tilde{e}_L \\
e^+ e^- &\to \tilde{\mu}_R\,\tilde{\mu}_R,\ \tilde{\mu}_L\,\tilde{\mu}_L \\
e^+ e^- &\to \tilde{\tau}_R\,\tilde{\tau}_R,\ \tilde{\tau}_L\,\tilde{\tau}_L \\
e^+ e^- &\to \tilde{\nu}_L\,\tilde{\nu}_L
\end{aligned}
$$

s channel exchange

$$
\frac{d\sigma(e^+ e^- \to \tilde{l}^+\,\tilde{l}^-)}{d\Omega} = \frac{\alpha^2}{8\,s}\,\beta^3\,\sin^2\theta\,|\mathcal{M}_\gamma + \mathcal{M}_Z|^2
$$

Scalar lepton decays

$$
\begin{aligned}
\tilde{l}^\pm_{L,\,R} &\to l^\pm\,\chi^0_{1,\,2,\,3,\,4} \qquad\qquad \chi^0_1 = \mathrm{LSP} \\
\tilde{l}^\pm_L &\to \nu\,\chi^\pm_{1,\,2} \\
\tilde{\nu}_L &\to l^\mp\,\chi^\pm_{1,\,2}
\end{aligned}
$$

Scalar Lepton Searches

- Charged scalar leptons $\tilde{l}^{\pm}$ are easy to detect
- Detecting $\tilde{\mu}_R$ at $\sqrt{s} = 500$ GeV

$$\begin{aligned} e^+ e^- &\rightarrow \tilde{\mu}_R^+ \tilde{\mu}_R^- \\ \tilde{\mu}_R &\rightarrow \mu \, \chi_1^0 \end{aligned}$$

$\Rightarrow$ signature: acoplanar $l^+ l^-$ pair + missing energy

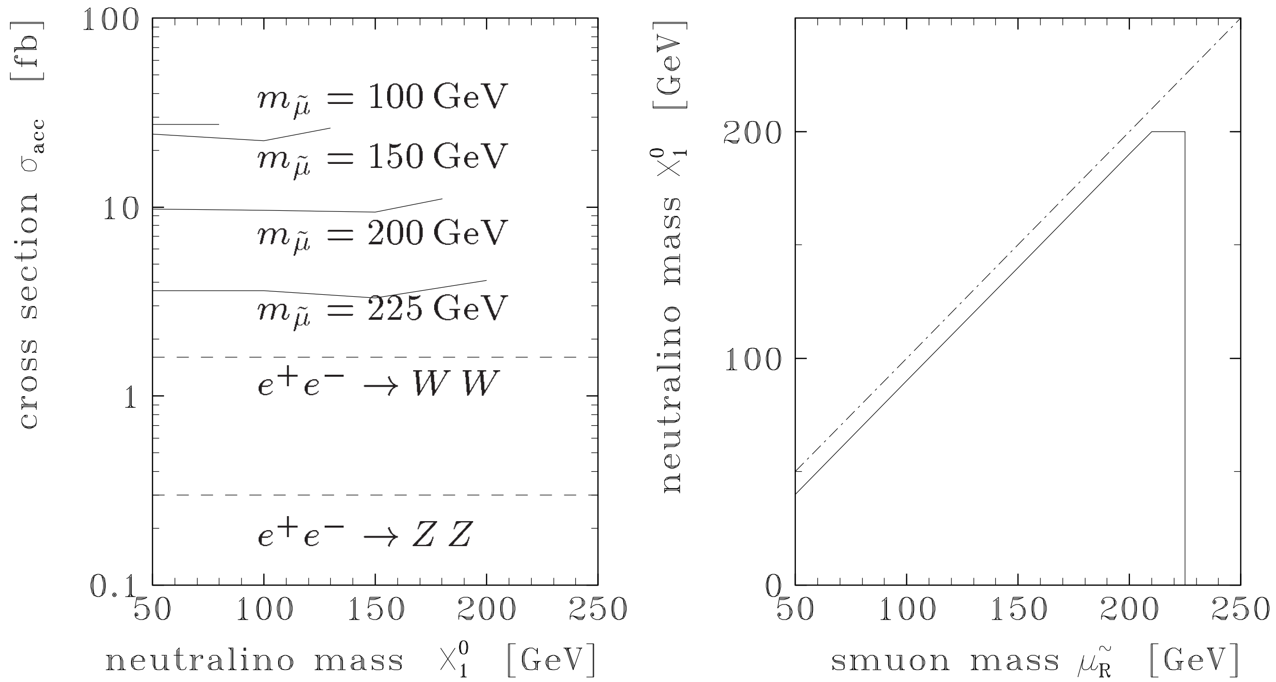
high efficiency, $\epsilon_{\mu^+\mu^-} \simeq 0.35 - 0.5$, low SM background

$\Rightarrow$ $\tilde{l}^{\pm}$ masses accessible up to the kinematic limit

$$m_{\tilde{l}^\pm} \lesssim E_{beam} - 25 \text{ GeV} \quad \text{for} \quad m_{\tilde{l}^\pm} - m_{\chi_1^0} \gtrsim 20 \text{ GeV}$$

$\Rightarrow$ integrated luminosity of $\int \mathcal{L}\, dt \sim \mathcal{O}(10 \text{ fb}^{-1})$ sufficient to establish scalar lepton production

$$e^+ e^- \rightarrow \tilde{\mu}_R^+ \tilde{\mu}_R^- \rightarrow \mu^+ \chi_1^0 \, \mu^- \chi_1^0$$



Slepton & Neutralino Masses

- **Determination of $m_{\tilde{\mu}_R}$ and $m_{\chi^0_1}$ at $\sqrt{s} = 800$ GeV**

SUSY masses: $m_{\tilde{\mu}_R} = 275.1$ GeV $\quad m_{\chi^0_1} = 88.1$ GeV

$$e^+ e^- \rightarrow \tilde{\mu}^+_R \, \tilde{\mu}^-_R$$

$$\tilde{\mu}_R \rightarrow \mu \, \chi^0_1 \qquad \mathcal{BR} = 99.5\,\%$$

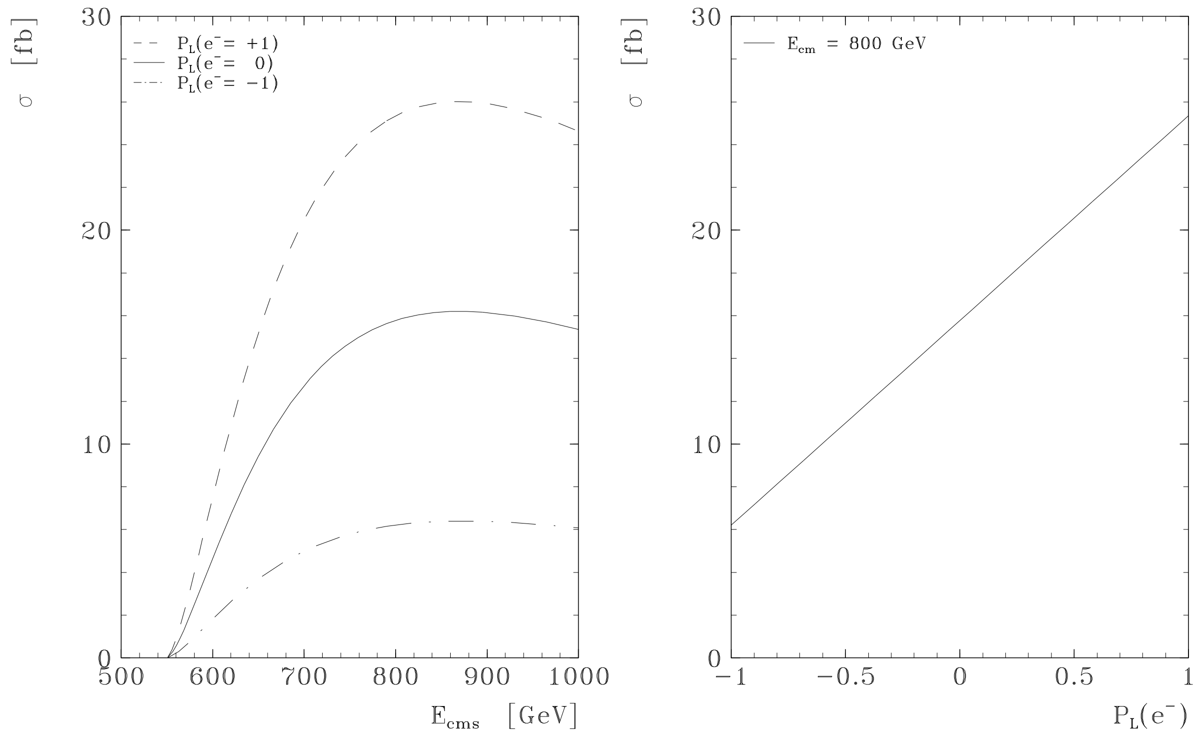
- **Two parameter fit to μ energy spectrum** $\quad (\beta = 0.73)$

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

$\Rightarrow$ **Advantage of polarized e^-_R beam** $\quad P_{\|}(e^-) = +0.90$

- $\star$ enhance $\sigma(e^+ e^-_R \rightarrow \tilde{\mu}^+_R \, \tilde{\mu}^-_R)$ by factor ~ 1.6
- $\star$ suppress $\sigma(e^+ e^-_R \rightarrow W\, W)$ by factor ~ 0.1
- $\star$ essentially background free event sample

$$e^+ e^-_{P_{\|}} \rightarrow \tilde{\mu}^+_R \, \tilde{\mu}^-_R$$



Event selection criteria

topology	$\mu^+ \mu^-$ pair + nothing else in detector
radiative γ veto	$E_\gamma < 1$ GeV $\quad \mid \cos\theta_\gamma \mid < 0.985$
lepton	$E_l < 375$ GeV $\quad \mid \cos\theta_l \mid < 0.95$
at least one lepton	$Q_l \cos\theta_l < 0.75 \quad (0.95)$
acoplanarity	$\mid \phi_{l^+} - \phi_{l^-} \mid < 145^\circ \quad (160^\circ)$
missing momentum	$\mid \cos\theta_{\vec{p}_{miss}} \mid < 0.90$
di-lepton mass	$\mid m_{l^+l^-} - m_Z \mid > 10$ GeV
recoil mass	$\mid m_{recoil} - m_Z \mid > 15$ GeV

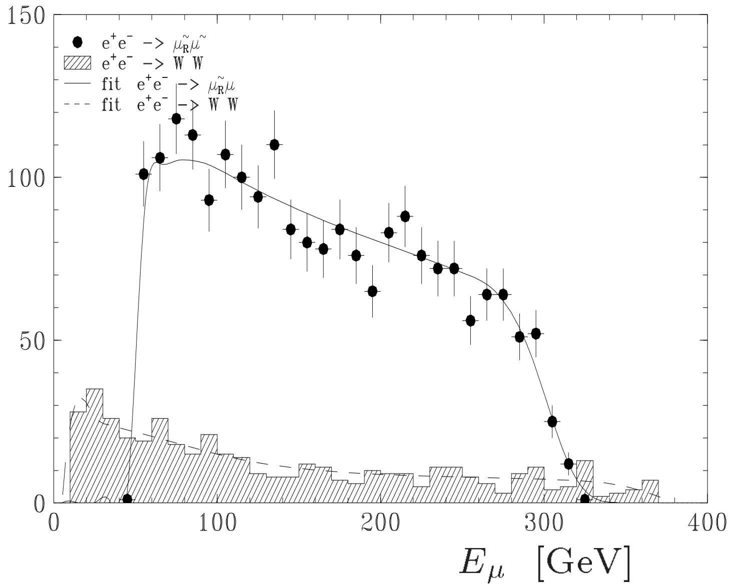
Acceptance	σ [fb]	$\epsilon_{\mu^+\mu^-}$	σ_{acc} [fb]
$e^+ e^- \to \tilde{\mu}_R^+ \tilde{\mu}_R^- \to \mu^+ \mu^- \chi_1^0 \chi_1^0$	15.2	0.50	7.6
$e^+ e_R^- \to \tilde{\mu}_R^+ \tilde{\mu}_R^- \to \mu^+ \mu^- \chi_1^0 \chi_1^0$	24.0	0.60	14.4
$e^+ e^- \to \gamma/Z \to \mu^+ \mu^- (\gamma)$	850	$< 3 \cdot 10^{-5}$	< 0.03
$e^+ e^- \to Z Z \to \mu^+ \mu^- \nu \nu$	5.9	$1.3 \cdot 10^{-2}$	0.08
$e^+ e^- \to W W \to \mu^+ \mu^- \nu \nu$	210	$3.8 \cdot 10^{-3}$	0.8
$e^+ e_R^- \to W W \to \mu^+ \mu^- \nu \nu$	20	$3.8 \cdot 10^{-3}$	< 0.1
(decays $\tau \to \mu \nu$ included)			

- **Lepton energy spectra & results of mass fit**

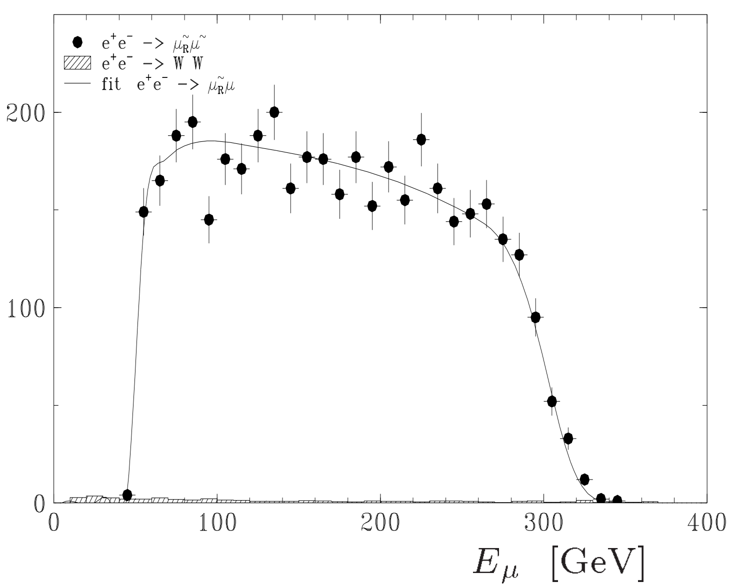
  $49.1\ (\sigma_{E_\mu} = 0.5)\ \text{GeV} \leq E_\mu \leq 309.8\ (\sigma_{E_\mu} = 15)\ \text{GeV}$

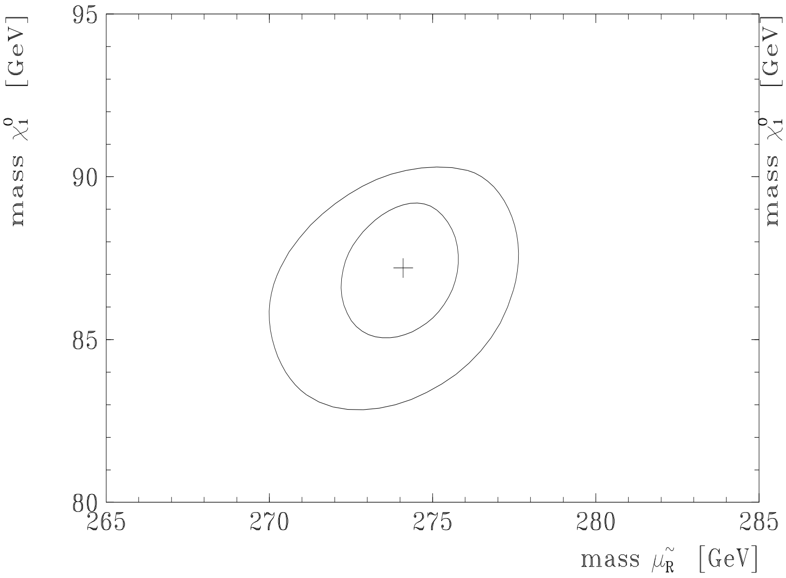
  mass determination limited by resolution, ISR and beamstrahlung

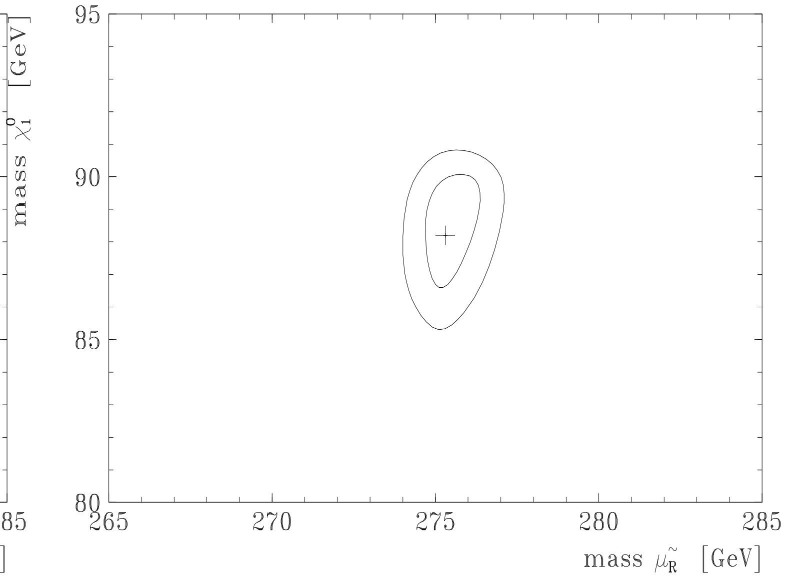
$e^+ e^- \rightarrow \mu^+ \chi^0_1 \mu^- \chi^0_1$



$e^+ e^-_R \rightarrow \mu^+ \chi^0_1 \mu^- \chi^0_1$





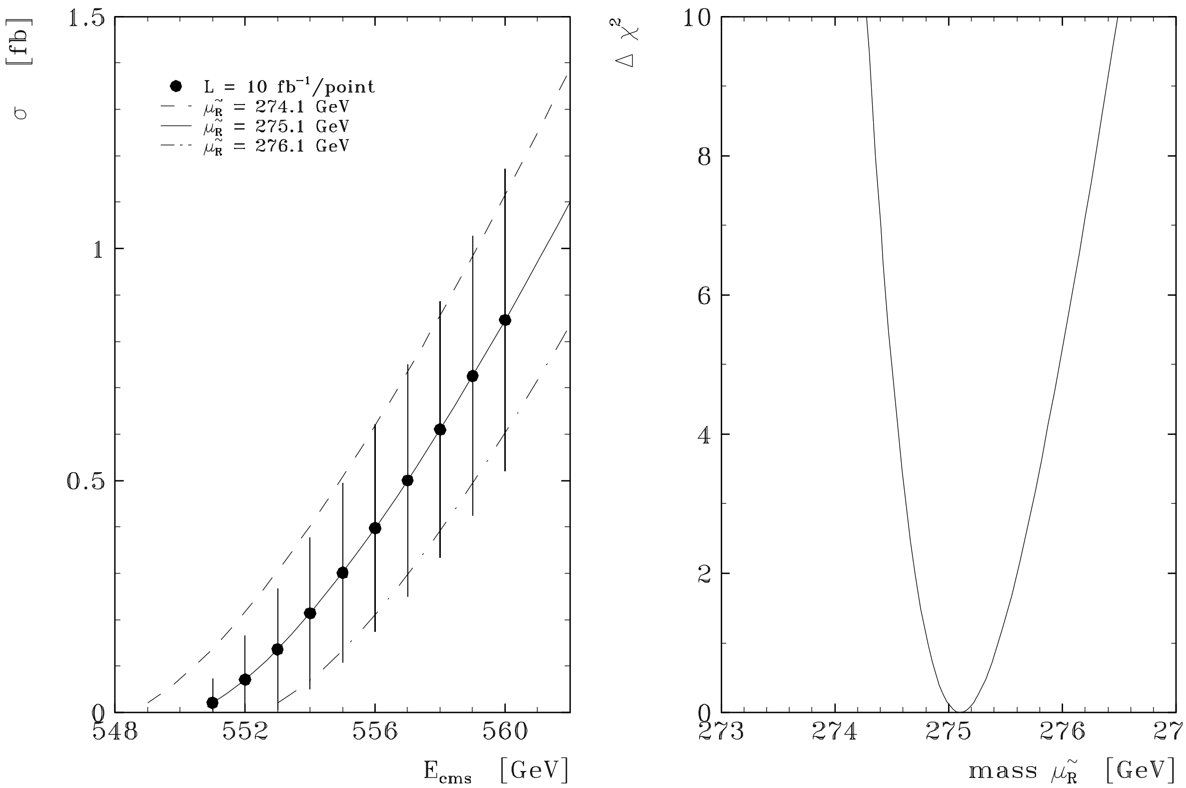


unpolarized e^-	**polarized e^-_R**
$m_{\tilde{\mu}_R}\,(\text{fit}) = \mathbf{274.1}\ ^{+1.7}_{-1.9}$ **GeV**	$m_{\tilde{\mu}_R}\,(\text{fit}) = \mathbf{275.3}\ ^{+0.9}_{-0.7}$ **GeV**
$m_{\chi^0_1}\,(\text{fit}) = \mathbf{87.2}\ ^{+2.1}_{-2.4}$ **GeV**	$m_{\chi^0_1}\,(\text{fit}) = \mathbf{88.2}\ ^{+1.8}_{-1.6}$ **GeV**

Threshold Scan $e^+e^-_R \to \tilde{\mu}_R\,\tilde{\mu}_R$

- $e^+e^-_R \to \tilde{\mu}^+_R\,\tilde{\mu}^-_R$ production at kinematic threshold
- signature: almost monochromatic lepton
  not spoiled by cascade decays
- scan of 10 points à 10 fb^{-1}at $\sqrt{s} = 550 - 560$ GeV
  mass resolution limited by ISR and beamstrahlung

$$e^+e^-_R \to \tilde{\mu}^+_R\,\tilde{\mu}^-_R \qquad (m_{\tilde{\mu}^\pm_R} = 275.1 \pm 1.0 \text{ GeV})$$

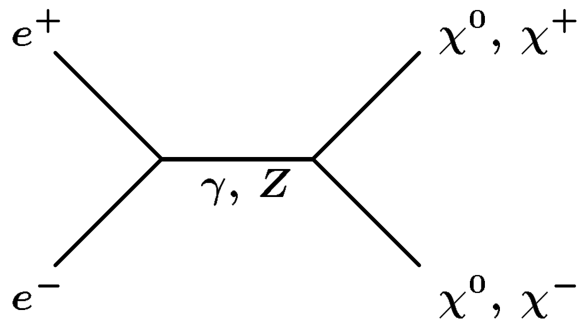


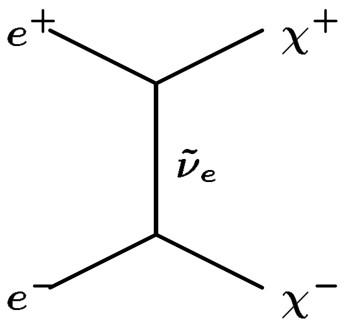
$\Rightarrow$ scalar muon mass

$$m_{\tilde{\mu}_R}(\text{scan}, e^-_R) \quad = \quad 275.1\,^{+0.35}_{-0.30} \text{ GeV}$$

$\Rightarrow$ test of $\tilde{\mu}_R$ spin 0 $\quad \sigma \propto \beta^3$

Charginos and Neutralinos





Chargino and neutralino production

$$e^+ e^- \rightarrow \chi_i^+ \chi_j^- \qquad [i, j = 1, 2]$$

$$e^+ e^- \rightarrow \chi_i^0 \chi_j^0 \qquad [i, j = 1, \ldots, 4]$$

Chargino and neutralino decays

$$\chi_k \rightarrow Z/W\,\chi_1$$

$$\chi_1^\pm \rightarrow W\,\chi_1^0 \qquad \chi_1^0 = \mathrm{LSP}$$

$$\chi^\pm \rightarrow l^\pm\,\tilde{\nu} \qquad \text{if } m_{\tilde{\nu}} < m_{\chi^\pm}$$

Chargino coupling to gaugino and higgsino

$$\chi_1^\pm = \alpha\,\tilde{W}^\pm + \beta\,\tilde{H}^\pm$$

Polarised electrons allow to disentangle s and $t\,(\tilde{\nu}_e)$ channel and to determine the chargino mixing parameters

At high energy γ and Z decouple to B^0/W^3 bosons

$\rightarrow$ only higgsino couples to right-handed electrons

	s channel		t channel
e_L^-	$\tilde{H}^\pm$	$\tilde{W}^\pm$	$\tilde{W}^\pm$
e_R^-	$\tilde{H}^\pm$	—	—

Chargino & Neutralino Searches

- **Neutralino search**

$$e^+ e^- \;\to\; \chi_1^0 \chi_1^0 (\gamma) \qquad \nu \text{ counting type expt}$$
$$\to\; \chi_1^0 \chi_2^0$$

- **Chargino search** gives also handle on neutralino

$$e^+ e^- \;\to\; \chi_1^+ \chi_1^-$$
$$\chi_1^\pm \;\to\; W^\pm \chi_1^0$$

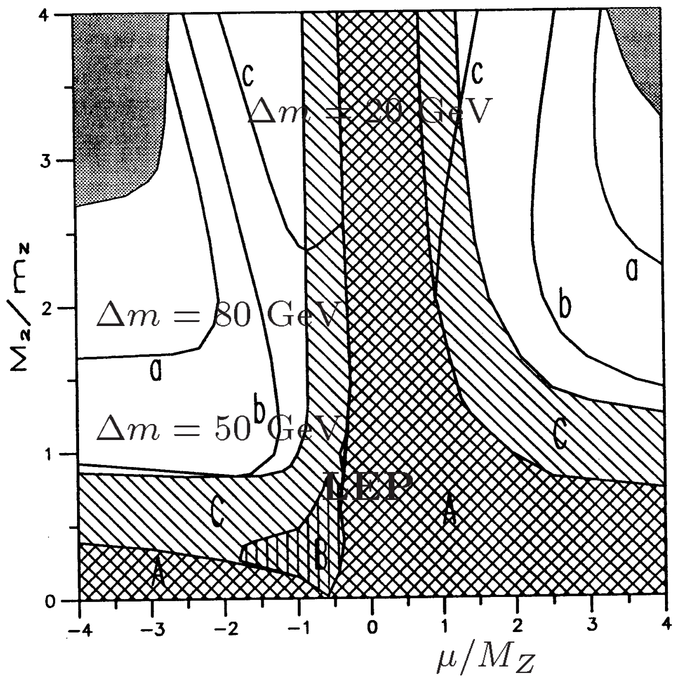
$\Rightarrow$ **4 jets +** E_{miss}**, 2 jets +** l **+** E_{miss}**, 2** l **+** E_{miss}

charginos easy to detect up to kinematic limit

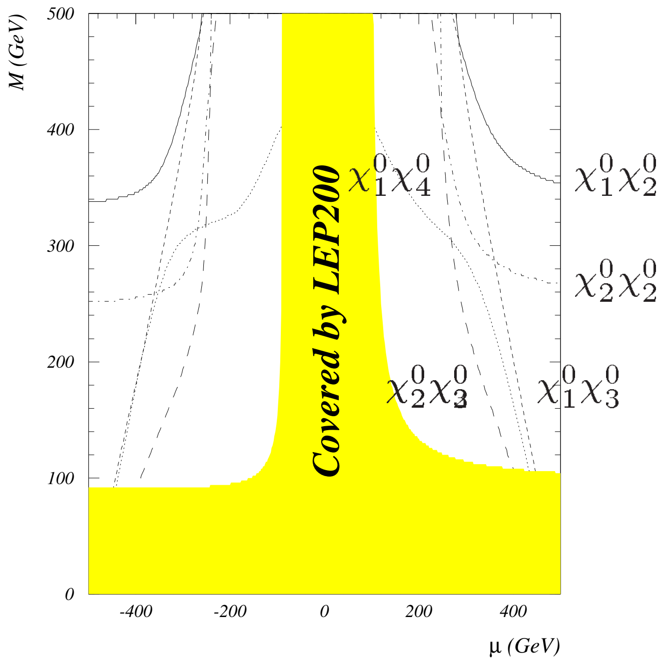
if $\mathrm{m}_{\chi_1^\pm} - \mathrm{m}_{\chi_1^0} \gtrsim$ **20 GeV**

- **Accessible** $\mu - M_2$ **region of MSSM at** $\sqrt{s} = 500$ **GeV**

chargino $\chi_1^\pm$ $(\tan\beta = 2)$



neutralino $(\tan\beta = 4)$



Chargino & Neutralino Masses

- Determination of $m_{\chi_1^\pm}$ and $m_{\chi_1^0}$ at $\sqrt{s} = 500$ GeV

  SUSY masses: $m_{\chi_1^\pm} = 168.2$ GeV $\quad m_{\chi_1^0} = 88.1$ GeV

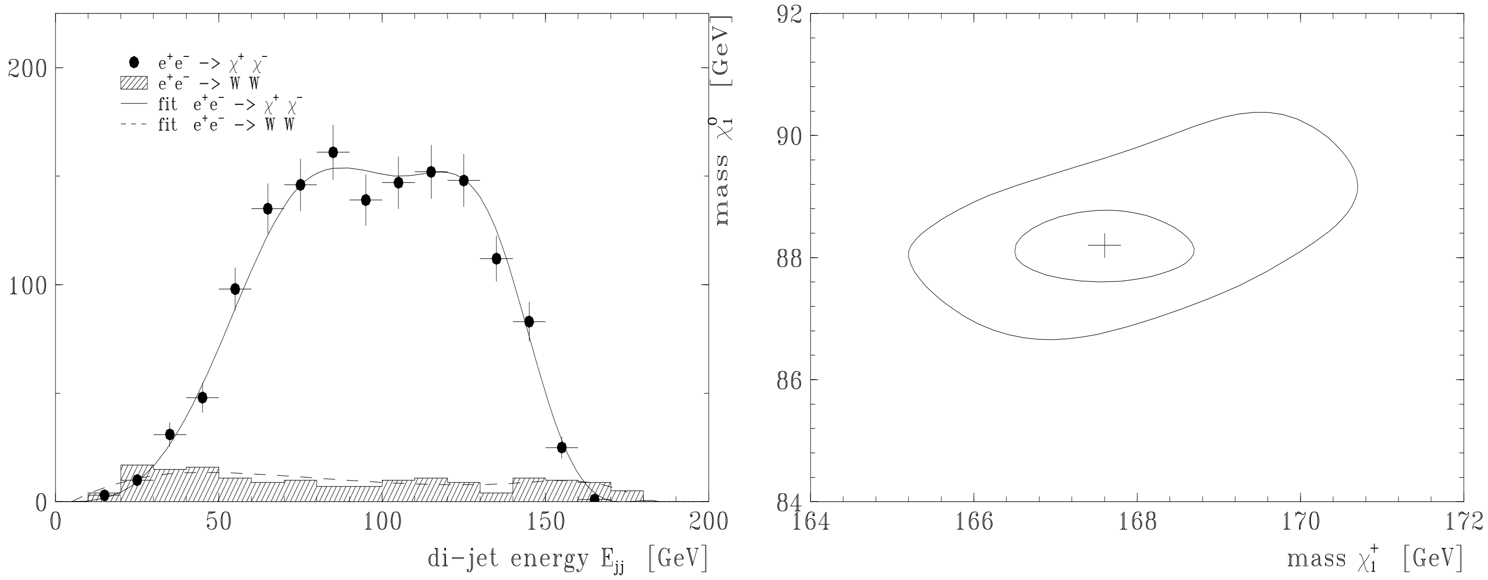
  $m_{\tilde{\nu}_e} = 304.0$ GeV

$$\begin{aligned} e^+ e^- &\to \chi_1^+ \chi_1^- \\ \chi_1^\pm &\to \ell^\pm \nu \chi_1^0 \qquad \mathcal{BR} = 34.5\,\% \quad \ell = e,\ \mu,\ \tau \\ &\to q \bar{q}' \chi_1^0 \qquad \mathcal{BR} = 65.5\,\% \end{aligned}$$

$\Rightarrow$ Signature: 2 jets + isolated e or μ + E_{miss}

- Polarisation no profit wrt $W\,W$ rejection
- Mass determination from two parameter fit to di–jet energy spectrum

$$e^+ e^- \to \chi_1^+ \chi_1^- \to \ell \nu \chi_1^0 \, q \bar{q}' \chi_1^0$$



$$m_{\chi_1^\pm}(\text{fit}, E_{jj}) = 167.6 \pm 1.1 \text{ GeV}$$

$$m_{\chi_1^0}(\text{fit}, E_{jj}) = 88.2 \pm 0.6 \text{ GeV}$$

Event selection criteria

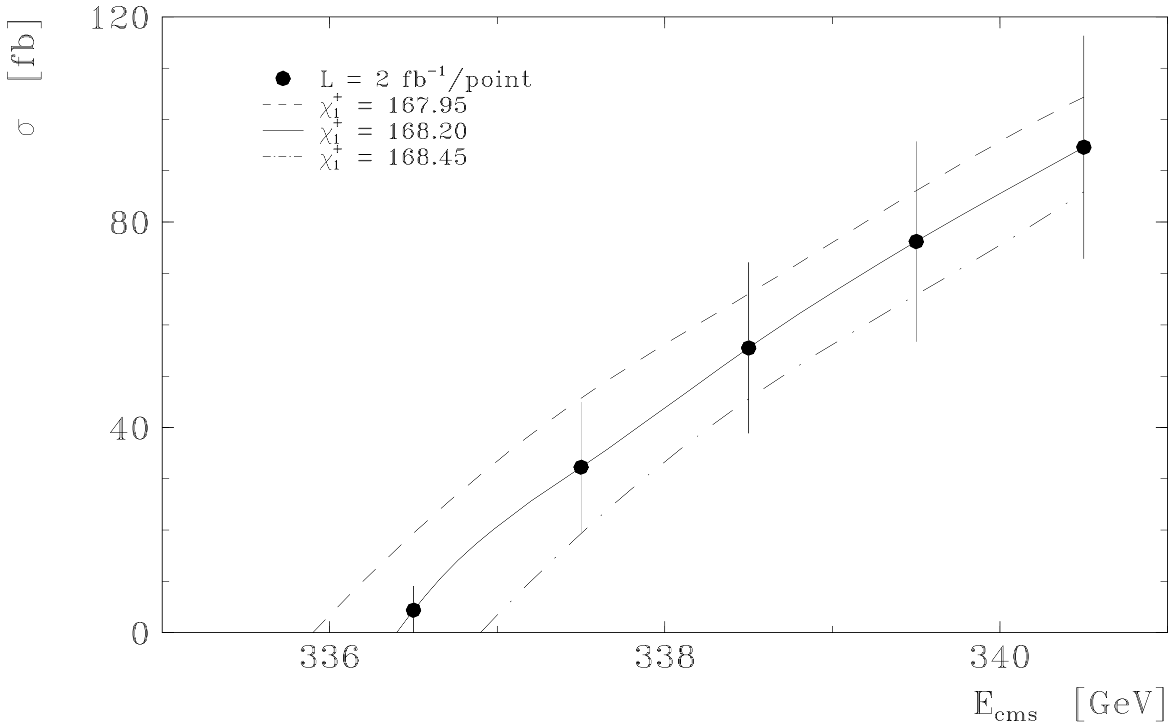
topology	one isolated lepton + two hadron jets
lepton $\ell = e$ or μ	$5\ \mathrm{GeV} < E_\ell < 150\ \mathrm{GeV}$
	$-0.90 < Q_\ell \cos\theta_\ell < 0.50$
hadron jets	$5\ \mathrm{GeV} < E_j < 150\ \mathrm{GeV}$
	$\mid \cos\theta_j \mid < 0.90$
di-jet system	$10\ \mathrm{GeV} < E_{j\,j} < 175\ \mathrm{GeV}$
	$-0.90 < -Q_\ell \cos\theta_{j\,j} < 0.50$
	$m_{j\,j} < m_W - 10\ \mathrm{GeV}$
recoil against di-jet system	$\mid m_{recoil-j\,j} - m_W \mid > 10\ \mathrm{GeV}$
missing momentum	$\mid \cos\theta_{\vec{p}_{miss}} \mid < 0.90$

Acceptance ($\ell = e,\ \mu$)	σ [fb]	$Br(\ell\,\nu\ q\,\bar{q}')$	$\epsilon_{\ell\,j\,j}$	σ_{acc} [fb]
$e^+\,e^- \to \chi_1^+\,\chi_1^- \to \chi_1^0\,\ell\,\nu\ \chi_1^0\,q\,\bar{q}'$	245	0.293	0.117	28.7
$e^+\,e^- \to W\,W \to \ell\,\nu\ q\,\bar{q}'$	8000	0.292	$4 \cdot 10^{-4}$	3.2
(decays $\tau \to e\,\nu,\ \mu\,\nu$ included)				

Threshold Scan $e^+e^- \to \chi_1^+ \chi_1^-$

- $e^+e^- \to \chi_1^+ \chi_1^-$ **production at kinematic threshold**
- **scan of 5 points à 2 fb^{-1}at $\sqrt{s} = 336 - 341$ GeV**
  mass resolution limited by ISR and beamstrahlung

$$e^+e^- \to \chi_1^+ \chi_1^- \qquad (m_{\chi_1^\pm} = 168.2 \pm 0.25 \text{ GeV})$$



⇒ **chargino mass**

$$m_{\chi_1^\pm}\,(\text{scan}) \quad = \quad 168.2 \pm 0.10 \text{ GeV}$$

⇒ **test of $\chi_1^\pm$ spin 1/2** $\qquad \sigma \propto \beta\,(3 - \beta^2)/2$

Scalar Top Quark

The scalar top $\tilde{t}$ may be the lightest squark

large top Yukawa coupling

off-diagonal elements of mass matrix can be large,
leading to strong $\tilde{t}_R - \tilde{t}_L$ mixing

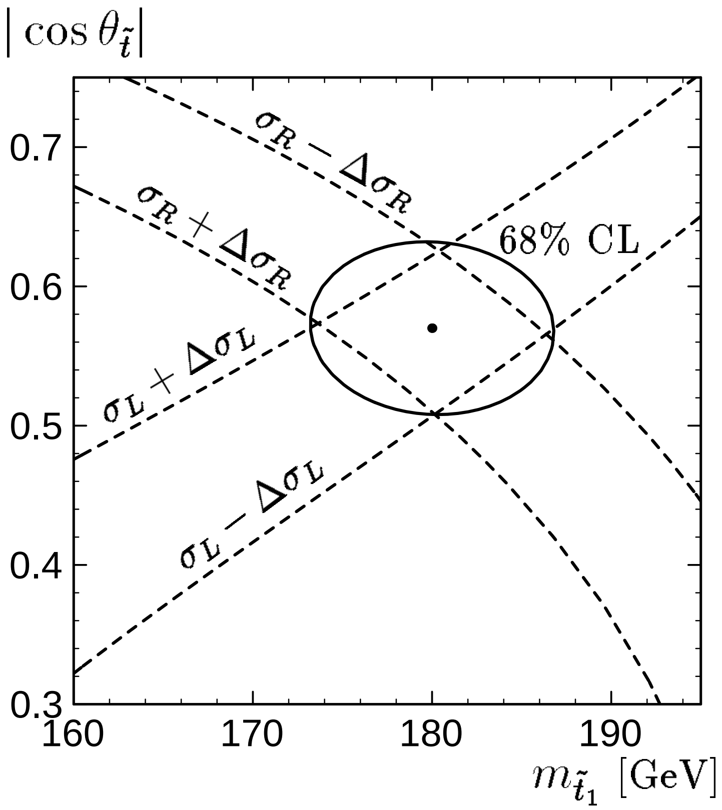
$$\begin{aligned} \tilde{t}_1 &= \cos\theta_{\tilde{t}}\, \tilde{t}_R + \sin\theta_{\tilde{t}}\, \tilde{t}_L \\ \tilde{t}_2 &= -\sin\theta_{\tilde{t}}\, \tilde{t}_R + \cos\theta_{\tilde{t}}\, \tilde{t}_L \end{aligned}$$

Scalar top production at $\sqrt{s} = 500$ GeV, $|\cos\theta_{\tilde{t}}| = 0.57$

$$\begin{aligned} e^+ e^- &\to \tilde{t}_1\, \tilde{t}_1 & m_{\tilde{t}_1} &= 180 \text{ GeV} \\ \tilde{t}_1 &\to b\, \chi_1^\pm & m_{\chi_1^\pm} &= 150 \text{ GeV} \\ &\to c\, \chi_1^0 & m_{\chi_1^0} &= 100 \text{ GeV} \end{aligned}$$

Determination of scalar top mass and mixing angle

via polarised electron cross section measurements
$e^+ e^-_L \to \tilde{t}_1\, \tilde{t}_1$ and $e^+ e^-_R \to \tilde{t}_1\, \tilde{t}_1$



$\sigma_L(\tilde{t}_1\, \tilde{t}_1) = 48.6 \pm 6.0$ fb

$\sigma_R(\tilde{t}_1\, \tilde{t}_1) = 46.1 \pm 4.9$ fb

$m_{\tilde{t}_1} = 180 \pm 7$ GeV

$|\cos\theta_{\tilde{t}}| = 0.57 \pm 0.06$

Testing SUSY – GUT

A e^+e^- collider provides high precision measurements of masses, cross sections, couplings and mixing parameters

Overconstrained set of observables allows to check the basic GUT parameters

Masses	:	$m(\tilde{l}_L)$	$\Leftarrow$	m_0		$M_{1/2}$		$\tan\beta$
		$m(\tilde{l}_R)$	$\Leftarrow$	m_0		$M_{1/2}$		$\tan\beta$
		$m(\tilde{\chi}_1^\pm)$	$\Leftarrow$			M_2	μ	$\tan\beta$
		$m(\tilde{\chi}_{1,2}^0)$	$\Leftarrow$		M_1	M_2	μ	$\tan\beta$
Cross Sections	:	$\sigma(e_L^- e^+ \to \tilde{e}_L^- \tilde{e}_L^+)$	$\Leftarrow$	m_0	M_1	M_2	μ	$\tan\beta$
		$\sigma(e_R^- e^+ \to \tilde{e}_R^- \tilde{e}_R^+)$	$\Leftarrow$	m_0	M_1	M_2	μ	$\tan\beta$
		$\sigma(e_L^- e^+ \to \tilde{\chi}_1^- \tilde{\chi}_1^+)$	$\Leftarrow$	m_0		M_2	μ	$\tan\beta$
		$\sigma(e_R^- e^+ \to \tilde{\chi}_1^- \tilde{\chi}_1^+)$	$\Leftarrow$			M_2	μ	$\tan\beta$

- Gaugino masses at the scale of $SU(2) \times U(1)$ symmetry breaking are related to the common gaugino mass $m_{1/2}$ at the GUT scale by the running couplings

$$M_i = \frac{\alpha_i}{\alpha_{\mathrm{GUT}}} m_{1/2} \qquad i = 1,\ 2,\ 3$$

$\Rightarrow$ Test of gaugino mass relation (to $\sim 0.5\,\%$)

$$\frac{M_1}{M_2} = \frac{5}{3} \tan^2\theta_W \simeq 0.5$$

using masses and cross sections of $\chi^\pm$, χ^0, $\tilde{l}$

- **Slepton masses** can be expressed in terms of the common scalar mass parameter m_0 and the common gaugino mass parameter $m_{1/2}$ at the GUT scale

$$
\begin{aligned}
m^2_{\tilde{l}_R} &= m_0^2 + \kappa_R\, m^2_{1/2} - M_Z^2 \sin^2\theta_W \cos 2\beta \\
m^2_{\tilde{l}_L} &= m_0^2 + \kappa_L\, m^2_{1/2} - 0.5\, M_Z^2 \,(1 - 2 \sin^2\theta_W)\, \cos 2\beta \\
m^2_{\tilde{\nu}_L} &= m_0^2 + \kappa_L\, m^2_{1/2} - 0.5\, M_Z^2 \cos 2\beta
\end{aligned}
$$

evolution to low energies $\quad \kappa_R = 0.15,\ \kappa_L = 0.52$

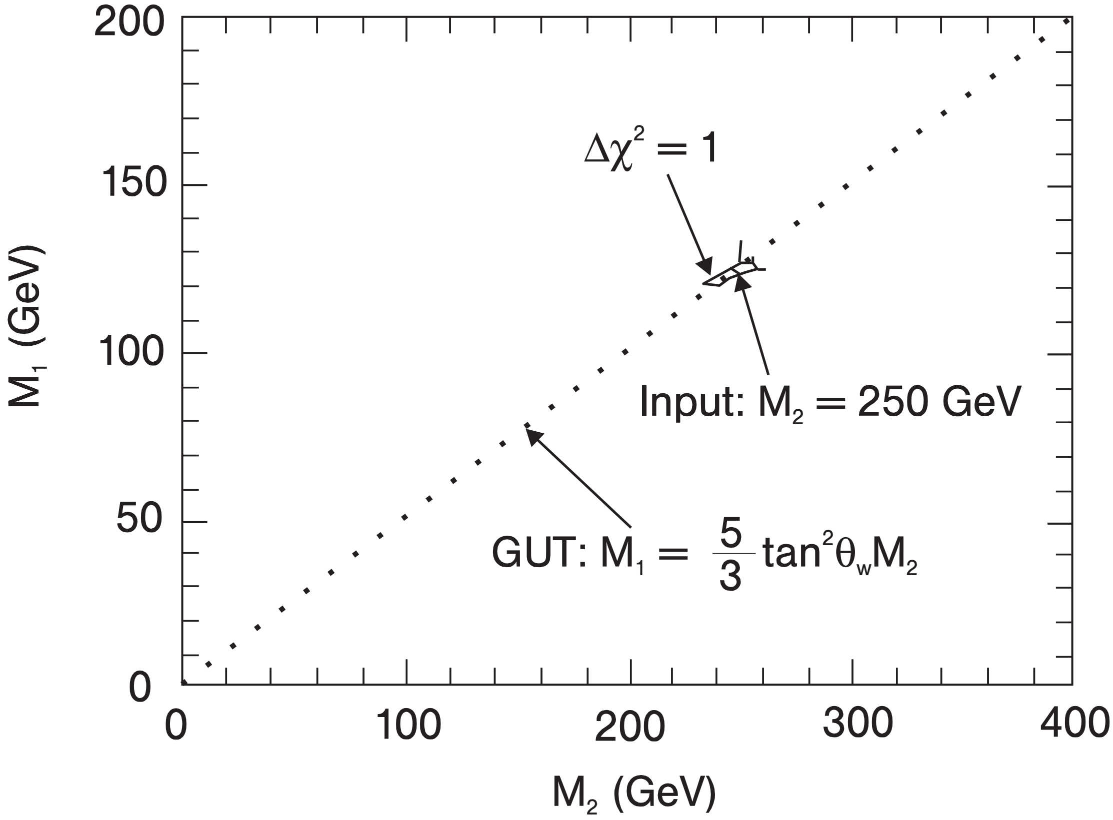
⇒ Test of slepton mass differences

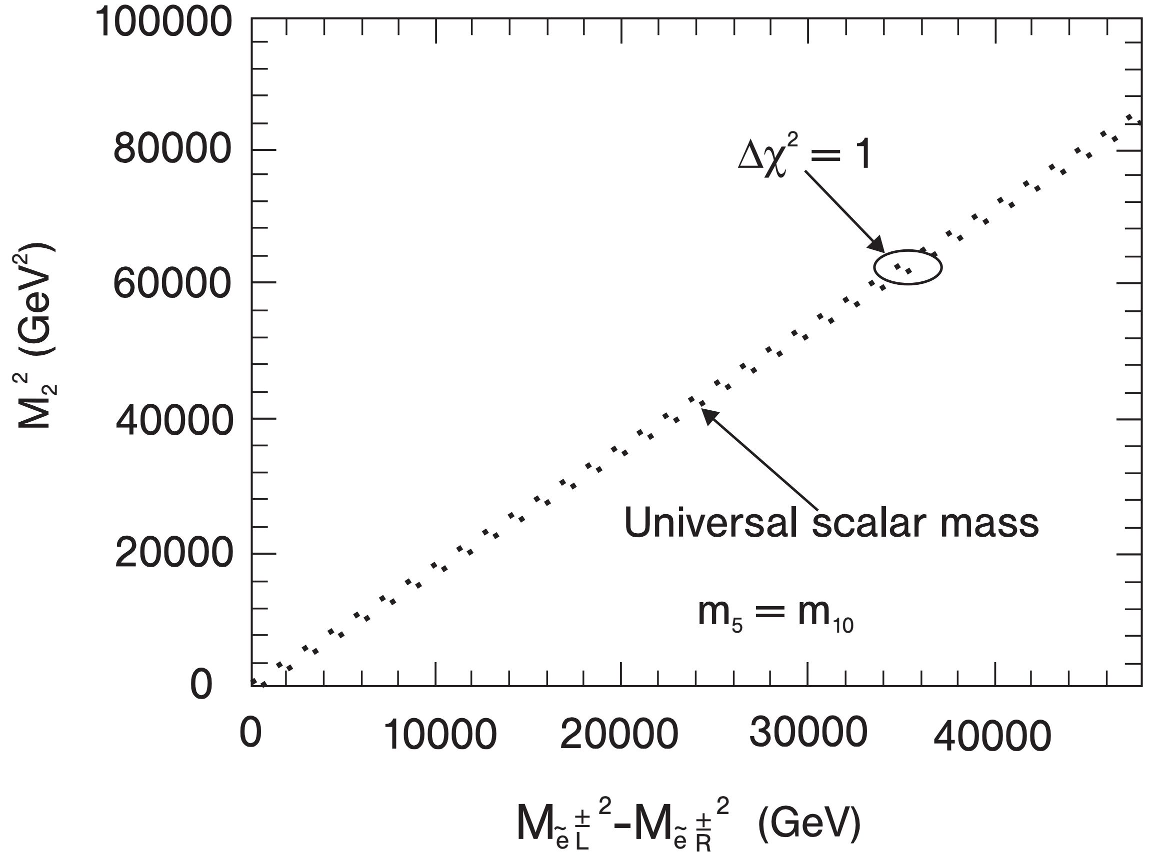
assuming universal $m_0 \quad m_0(5^*) = m_0(10)$ within $SU(5)$

$$
\begin{aligned}
m^2_{\tilde{l}_L} - m^2_{\tilde{\nu}_L} &= -M_Z^2 \cos^2\theta_W \cos 2\beta \\
m^2_{\tilde{l}_L} - m^2_{\tilde{l}_R} &= (\kappa_L - \kappa_R)\, m^2_{1/2} \\
&\quad -0.5\, M_Z^2\,(1 - 4 \sin^2\theta_W)\, \cos 2\beta
\end{aligned}
$$

$\tilde{\nu}_L$ and $\tilde{l}_L$ mass difference $\quad m_{\tilde{\nu}_L} - m_{\tilde{l}_L} < M_Z$

$\tilde{l}_L$ and $\tilde{l}_R$ mass difference related to the $SU(2)$ gaugino mass $m_{1/2}$, resp. M_2


200
150
100
50
0
0
100
200
300
400
M_1 (GeV)
M_2 (GeV)
$\Delta\chi^2 = 1$
Input: $M_2 = 250$ GeV
GUT: $M_1 = \frac{5}{3}\tan^2\theta_w M_2$


100000
80000
60000
40000
20000
0
0
10000
20000
30000
40000
M_2^2 (GeV^2)
$M_{\tilde{e}_L^\pm}^2 - M_{\tilde{e}_R^\pm}^2$ (GeV)
$\Delta\chi^2 = 1$
Universal scalar mass
$m_5 = m_{10}$

Conclusions

- The physics programme of an e^+e^- linear collider extends the searches at LEP and is in many aspects complementary to LHC
- The great advantage of e^+e^- colliders is the high precision of experimental analyses covering the kinematically accessible domain in a conclusive manner
- Studies to determine SUSY masses

	E spectrum	threshold scan
$\tilde{\mu}_R\,\tilde{\mu}_R$	$m_{\tilde{\mu}_R} = 275.1 \pm 0.8$ GeV	$m_{\tilde{\mu}_R} = 275.1 \pm 0.35$ GeV
	$m_{\chi_1^0} = 88.1 \pm 1.7$ GeV	
$\chi_1^+\,\chi_1^-$	$m_{\chi_1^\pm} = 168.2 \pm 1.1$ GeV	$m_{\chi_1^\pm} = 168.2 \pm 0.10$ GeV
	$m_{\chi_1^0} = 88.1 \pm 0.6$ GeV	

  - ⋆ no extraordinary experimental requirements on detector to discover/study SUSY particles
  - ⋆ polarisation is extremely helpful/vital
  - ⋆ beamstrahlung effects have to be kept small

- Overconstrained set of observables allows to check basic GUT parameters
- Potential of future e^+e^- colliders to explore the SUSY particle spectrum

LC 500	light higgsino/profile, light $\tilde{\chi}$, $\tilde{\ell}$	
LC 1000	heavy higgsino, $\tilde{\chi}$, $\tilde{\ell}$, light $\tilde{t}$, $\tilde{b}$	
LC 2000	spectrum *in toto*	$\tilde{H}$, $\tilde{\chi}$, $\tilde{\ell}$, $\tilde{q}$, $\tilde{g}$