SUSY@ILC

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1. Probing SUSY

2. Precision SUSY measurements at the ILC

3. Determining the SUSY Lagrangian

4. Summary

From the physics chapter of the ILC Reference Design Report:

“Physics at the ILC”, August 2007.

1. Introduction: motivations for low–energy SUSY

If SUSY is to solve some of the most severe problems of the SM:

We need light SUSY particles: $M_S \lesssim 1$ TeV.

- **The hierarchy problem: radiative corrections to the Higgs masses**

$$\Delta M_H^2 = \frac{\lambda_f^2 N_f}{4\pi^2}\left[(m_f^2 - M_S^2)\log\left(\frac{\Lambda}{M_S}\right) + 3m_f^2\log\left(\frac{M_S}{m_f}\right)\right] + \mathcal{O}\left(\frac{1}{\Lambda^2}\right)$$

- **The unification problem: the slopes of the α_i SM gauge couplings need to be fixed early enough to meet at $M_{GUT} \sim 2 \times 10^{16}$ GeV.**
- **The dark matter problem: the electrically neutral, weakly interacting, stable LSP should have a mass $\lesssim \mathcal{O}(1$ TeV) for Ωh^2 to match WMAP.**

In this case, sparticles are accessible at future machines.

– We expect great discoveries at the LHC.

– We will have a great deal of exciting physics to do at the ILC.

1. Introduction: SUSY models

Focus mainly on the Minimal Supersymmetric Standard Model (MSSM):

- **minimal gauge group: SU(3)$\times$SU(2)$\times$U(1),**
- **minimal particle content: 3 fermion families and 2 Φ doublets,**
- **R=$(-1)^{(\mathbf{2s+L+3B})}$ parity is conserved,**
- **minimal set of terms (masses, couplings) breaking "softly" SUSY.**

To reduce the number of the (too many in general) free parameters:

– impose phenomenological constraints: $\mathcal{O}$(20) free parameters,

– unified models, O(5) parameters (mSUGRA: $\mathrm{m_0, m_{\frac{1}{2}}, A_0}, \tan\beta, \epsilon_\mu$),

In this talk, I will concentrate on the MSSM with gravity mediated breaking.

But, one should not forget that:

-- other possibilities are models with GMSB/AMSB....

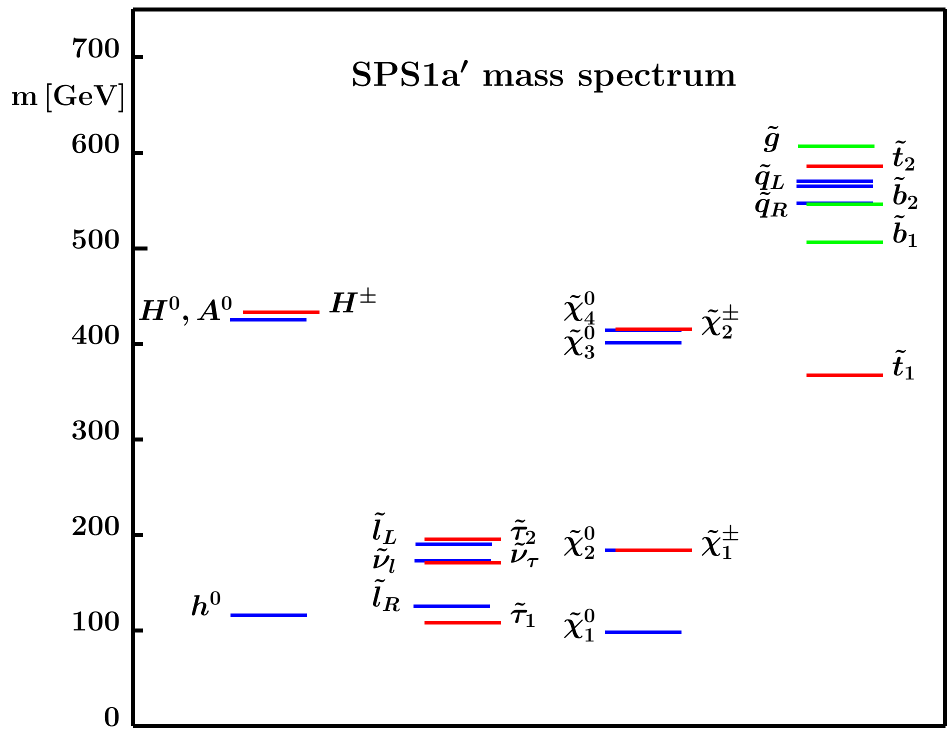
-- the impact of relaxing some MSSM basic assumptions can be large

-- other scenarios are possible (strings, right–handed neutrinos,...)

There is a need for model independent analyses...

1. Introduction: example of SUSY spectrum

SPS1a': $\mathbf{m_{1/2}=250GeV}, \mathbf{m_0=70GeV}, \mathbf{A_0=-300GeV}, \tan\beta=\mathbf{10}, \mu>$



$\tilde{p}$/**mass**	χ^0_1	χ^0_2	$\chi^\pm_1$	$\tilde{e}_1$	$\tilde{e}_2$	$\tilde{\nu}_e$	$\tilde{\tau}_1$	$\tilde{\tau}_2$	$\tilde{\nu}_\tau$	$\tilde{t}_1$	$\tilde{b}_1$
SPS1a$'$	98	184	184	125	190	172	108	195	170	366	506
SPS1a	96	177	176	143	202	186	133	206	185	379	492

1. Introduction: probing SUSY

All these particles will be produced at the LHC (direct/cascades)...

These particles can also be produced directly at the ILC...

But producing these new states is not the whole story! We need to:

- **measure the masses and mixings of the newly produced particles, their decay widths, branching ratios, production cross sections, etc...;**
- **verify that there are indeed superpartners and, thus, determine their spin and parity, gauge quantum numbers and their couplings;**
- **reconstruct the low–energy soft–SUSY breaking parameters with the smallest number of assumptions (model independent way);**
- **ultimately, unravel the fundamental SUSY breaking mechanism and shed light on the physics at the very high energy scale.**
- **make the connection to cosmology and predict the relic density.**

To achieve this goal, a combination of LHC and ILC is mandatory!

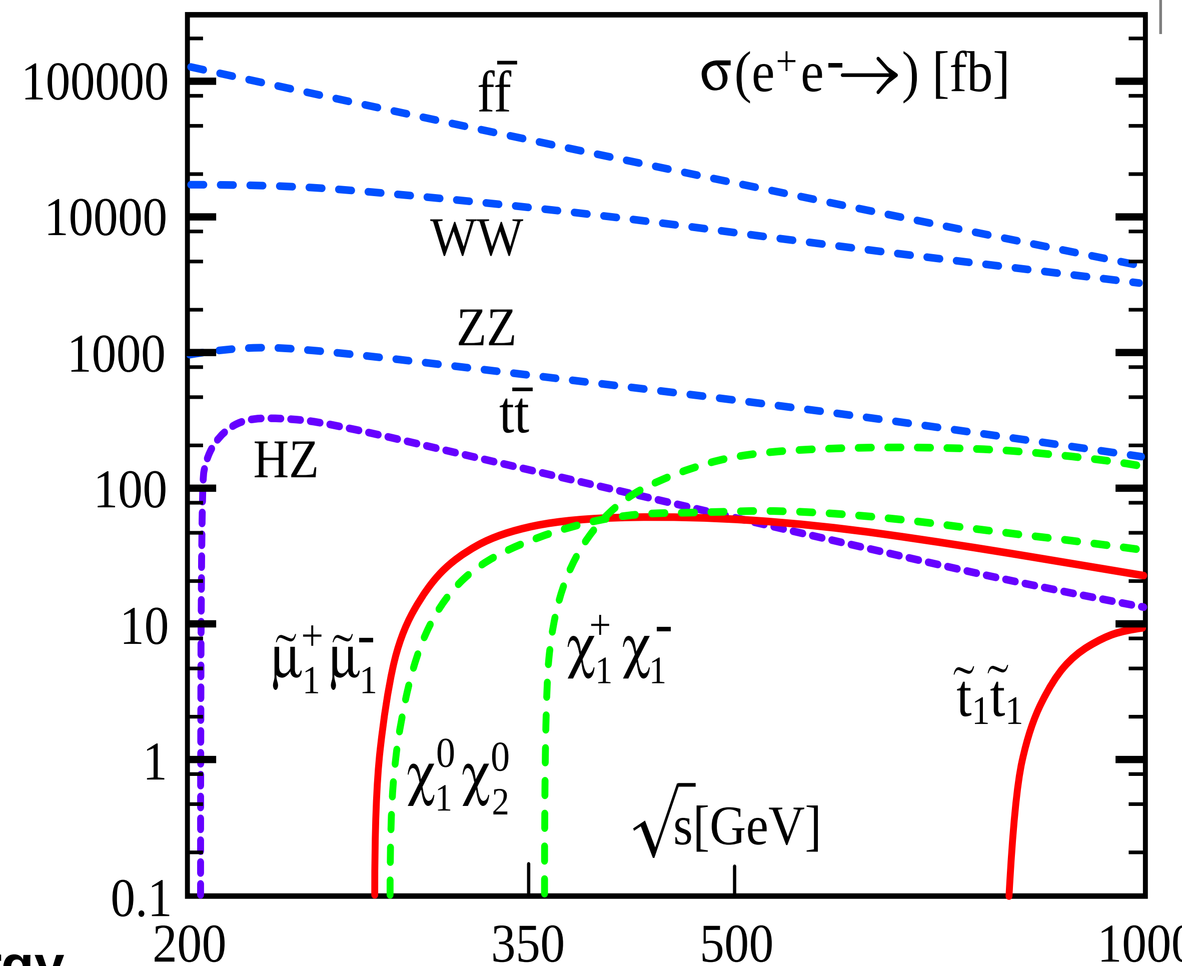
1. Introduction: the role of the ILC

At the LHC:

- **copious $\tilde{q}/\tilde{g}$ production**
- **$\tilde{\ell}/\chi$ from cascades**
- **complicated topologies**
- **very large backgrounds**
- **difficult environment.**

At the ILC:

- **direct $\tilde{\ell}/\chi$ production**
- **large production rates**
- **good signal to bkg ratios**
- **very clean environment**
- **possibility of tuning energy**
- **initial beam polarization**
- **more collider options...**



2. Precision SUSY measurements: the χ sector

- **Charginos:** mixtures of the charged higgsinos and gauginos

$$\tilde{\mathbf{W}}^{\pm}, \tilde{\mathbf{h}}^{\pm}_{\mathbf{2/1}} \longrightarrow \chi^{\pm}_{\mathbf{1}}, \chi^{\pm}_{\mathbf{2}}$$

The general chargino mass matrix, in terms of M_2, μ and $\tan\beta$, is

$$\mathcal{M}_{\mathbf{C}} = \begin{bmatrix} M_2 & \sqrt{2} M_W s_\beta \\ \sqrt{2} M_W c_\beta & \mu \end{bmatrix} , \ \mathbf{s}_\beta \equiv \sin\beta \ \mathbf{etc}$$

- **Neutralinos:** mixtures of the neutral higgsinos and gauginos

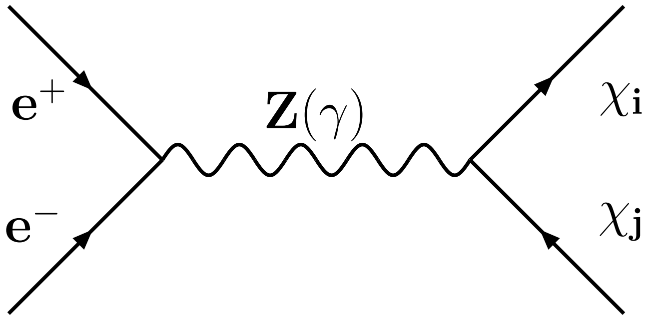
$$\tilde{\mathbf{B}}, \tilde{\mathbf{W}}_{\mathbf{3}}, \tilde{\mathbf{H}}^{\mathbf{0}}_{\mathbf{1}}, \tilde{\mathbf{H}}^{\mathbf{0}}_{\mathbf{2}} \longrightarrow \chi^{\mathbf{0}}_{\mathbf{1,2,3,4}}$$

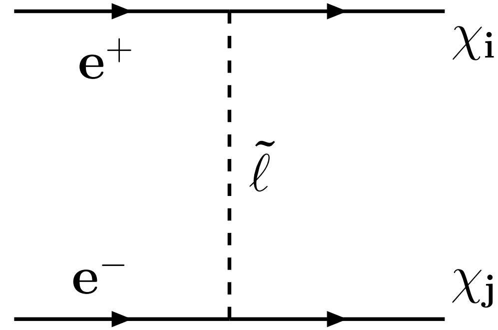
The 4x4 mass matrix depends on $\mu, \mathbf{M_2}, \tan\beta, \mathbf{M_1}$; given by:

$$\mathcal{M}_{\mathbf{N}} = \begin{bmatrix} M_1 & 0 & -M_Z s_W c_\beta & M_Z s_W s_\beta \\ 0 & M_2 & M_Z c_W c_\beta & -M_Z c_W s_\beta \\ -M_Z s_W c_\beta & M_Z c_W c_\beta & 0 & -\mu \\ M_Z s_W s_\beta & -M_Z c_W s_\beta & -\mu & 0 \end{bmatrix}$$

2. Precision SUSY measurements: the χ sector

χ production:





- $e^+e^- \to \chi_i^\pm \chi_j^\pm$: s–channel γ, Z and t–channel $\tilde{\nu}_e$; large σ for i=j
- $e^+e^- \to \chi_i^0 \chi_j^0$: s–channel Z and t–channel $\tilde{e}$; $\sigma = \mathcal{O}(10$ fb).

– $e^\pm$ beam polarization selects various production channels

– cross section for $\chi^\pm$ rises steeply near threshold, $\sigma \propto \beta$

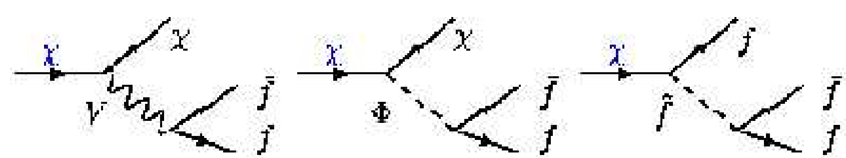
– cross sections for χ^0 rise less steeply in general, $\sigma \propto \beta^3$

χ decays:

- in general $\chi_i \to V\chi_j, \Phi\chi_j, f\tilde{f}$

- possibility of cascade decays

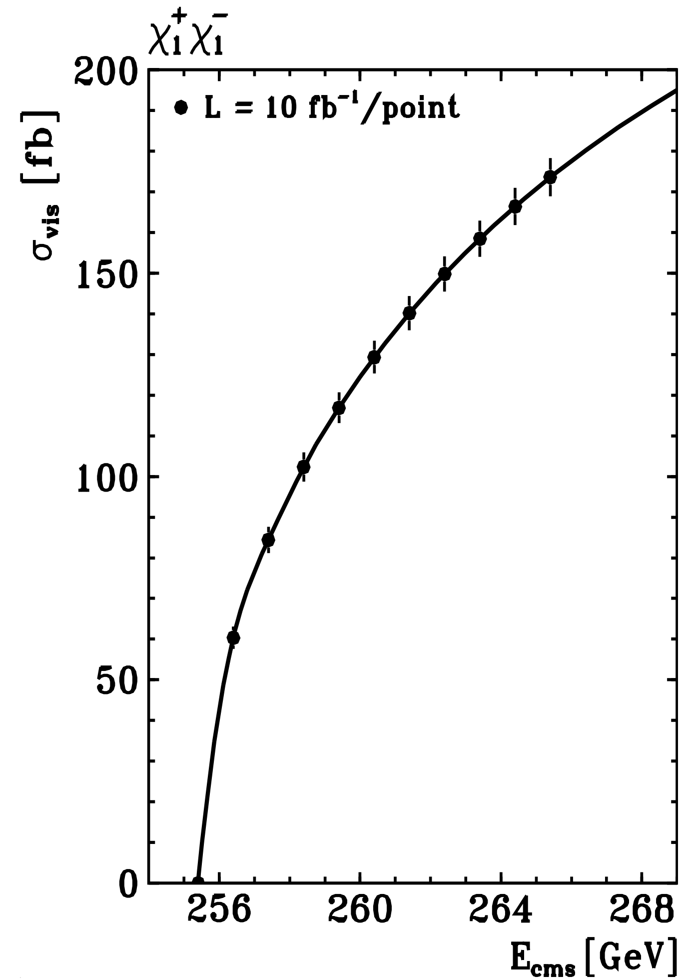
– signature: $\not{E}_T$ from escaping χ_1^0



2. Precision SUSY measurements: the χ sector

Measurement of $\chi^\pm/\chi^0$ masses:

- **from a threshold scan, $\Delta m_{\chi_1^\pm} \sim$ 50 MeV for $m_{\chi_1^\pm} \sim 200$ GeV as steep rise $\sigma \propto \beta$.**
- **$\Delta m_{\chi_1^\pm} \sim 0.1\%$ in continuum from dijet mass in $e^+e^- \to \chi_1^+\chi_1^- \to \ell^\pm \nu q\bar{q}' \chi_1^0\chi_1^0$**
- **from dijet mass, $m_{\chi_1^0}$ determination with precision $\Delta(m_{\chi_1^\pm} - m_{\chi_1^0}) = \mathcal{O}(50)$ MeV.**
- **for small $m_{\chi_1^\pm} - m_{\chi_1^0}$, use $e^+e^- \to \chi_1^+\chi_1^-\gamma$ to measure both $m_{\chi_1^\pm}/m_{\chi_1^0}$ from spectra.**
- **$e^+e^- \to \chi_2^0\chi_1^0 \to \ell^+\ell^-\chi_1^0\chi_1^0$ allows an accuracy $\Delta(m_{\chi_2^0} - m_{\chi_1^0}) = \mathcal{O}(0.1\%)$**



2. Precision SUSY measurements: the χ sector

Determination of spin:

– idea from excitation curve and angular distribution from production,

– sure with angular distributions of polarized χ decays with $\mathrm{e}^{\pm}_{\mathbf{pol}}$.

Determination of Majorana nature of neutralinos:

– guess from β^3 threshold behavior of $\sigma(\mathrm{e^+e^-} \to \chi^0_{\mathbf{i}}\chi^0_{\mathbf{j}})$,

– $\mathrm{e^-e^-} \to \tilde{\mathrm{e}}^-\tilde{\mathrm{e}}^-$ occurs only because Majorana χ^0 exchange.

Verification of the SUSY identity of gauge/Yukawa couplings:

– production cross sections for $\chi^0, \chi^\pm \propto \hat{g}(e\tilde{e}\chi^0), \hat{g}(e\tilde{\nu}\chi^\pm)$,

– combing with $\tilde{\ell}$ production, $\Delta\tilde{g} = 0.7\%$ and $\Delta\tilde{g}' = 0.2\%$

Determination of the chargino/neutralino mixing angles:

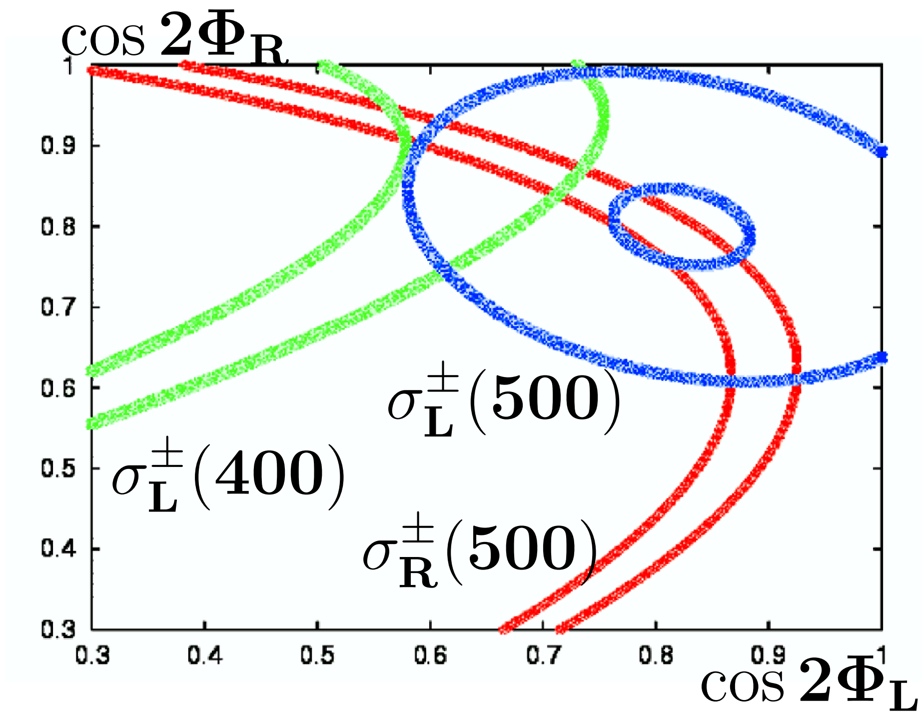
$\sigma(\mathrm{e^+e^-} \to \chi^+_{\mathbf{i}}\chi^-_{\mathbf{j}})$ is binomial in the $\chi^\pm$ mixing angles $\cos 2\phi_{\mathbf{L},\mathbf{R}}$

$\to$ determined in a model independent way using polarized $\mathrm{e}^\pm$ beams

(neutralino mixing from χ^0 production/decay, see Jan Kalinowski).

2. Precision SUSY measurements: the χ sector

SPS1a: $c_{2\phi_L} = [0.62, 0.72], c_{2\phi_R} = [0.87, 0.91]$ **at 95% CL at** $\sqrt{s} = \frac{1}{2}$ **TeV**



– **CPC:** $e^+e^- \to \chi_i^+\chi_j^-$ **alone allows to determine basic parameters;**

– **sneutrinos can be probed up to masses of 10 TeV with polarization.**

– **CPV:** $e^+e^- \to \chi_i^0\chi_j^0$ **would be needed (with direct probe of CPV).**

2. Precision SUSY measurements: the $\tilde{f}$ sector

Sfermion system described by $\tan\beta, \mu$ and 3 param.for each species:

$\mathbf{m_{\tilde{f}_L}, m_{\tilde{f}_R}}$ **and $\mathbf{A_f}$. For 3d generation, mixing $\propto \mathbf{m_f}$ to be included.**

$$\mathcal{M}^2_{\tilde{\mathbf{f}}} = \begin{pmatrix} m_f^2 + m_{\tilde{f}_L}^2 + (I_f^{3L} - e_f s_W^2) M_Z^2 c_{2\beta} & m_f A_f - \mu (\tan\beta)^{-2I_f^{3L}} \\ m_f A_f - \mu (\tan\beta)^{-2I_f^{3L}} & m_f^2 + m_{\tilde{f}_R}^2 + e_f s_W^2 M_Z^2 c_{2\beta} \end{pmatrix}$$

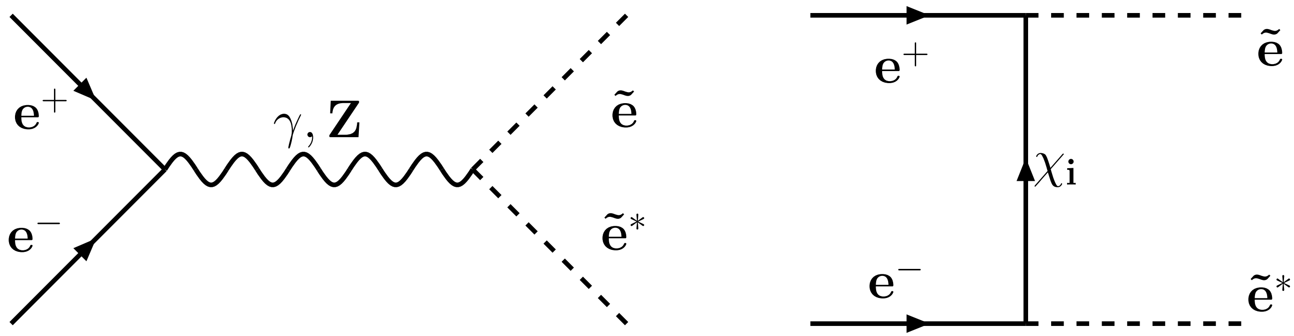
They are diagonalized by 2×2 rotation matrices of angle θ_f, which turn the current eigenstates $\tilde{\mathbf{f}}_\mathbf{L}, \tilde{\mathbf{f}}_\mathbf{R}$ into the mass eigenstates $\tilde{\mathbf{f}}_\mathbf{1}, \tilde{\mathbf{f}}_\mathbf{2}$.

$$\mathbf{m^2_{\tilde{f}_{1,2}} = m_f^2 + \frac{1}{2}\left[m^2_{LL} + m^2_{RR} \mp \sqrt{(m^2_{LL} - m^2_{RR})^2 + 4 m_f^2 X_f^2} \right]}$$

Note: mixing very strong in stop sector, $\mathbf{X_t} = \mathbf{A_t} - \mu \cot\beta$ and generates mass splitting between $\tilde{\mathbf{t}}_\mathbf{1}, \tilde{\mathbf{t}}_\mathbf{2}$, leading to light $\tilde{\mathbf{t}}_\mathbf{1}$; mixing in sbottom/stau sectors also for large $\mathbf{X_{b,\tau}} = \mathbf{A_{b,\tau}} - \mu \tan\beta$.

2. Precision SUSY measurements: the $\tilde{\ell}$ sector

$\tilde{\ell}$ **production:**



- $e^+e^- \to \tilde{\mu}^+\tilde{\mu}^-/\tilde{\tau}^+\tilde{\tau}^-/\tilde{\nu}_{\mu,\tau}\tilde{\nu}_{\mu,\tau}$: **s–channel γ,Z exchange;**
- $e^+e^- \to \tilde{e}^+\tilde{e}^-$: **s–channel γ, Z and t–channel χ^0 exchange;**
- $e^+e^- \to \tilde{\nu}_e\tilde{\nu}_e$: **s–channel Z and t–channel $\chi^\pm$ exchange;**

Again, in this case:

– $e^\pm$ beam polarization selects various channels/chiralities for $\tilde{e}, \tilde{\nu}_e$;

– $\tilde{e}_{L/R}$ production in $e^-_{L/R}e^-_{L/R}$ collisions;

– cross sections for $\tilde{e}, \tilde{\nu}_e$ rise steeply near threshold, $\sigma \propto \beta$,

– cross sections for 2d/3d generation rise less steeply, $\sigma \propto \beta^3$.

Slepton decays: **in general $\tilde{\ell} \to \ell\chi_1^0$ with possible cascades.**

2. Precision SUSY measurements: the $\tilde{\ell}$ sector

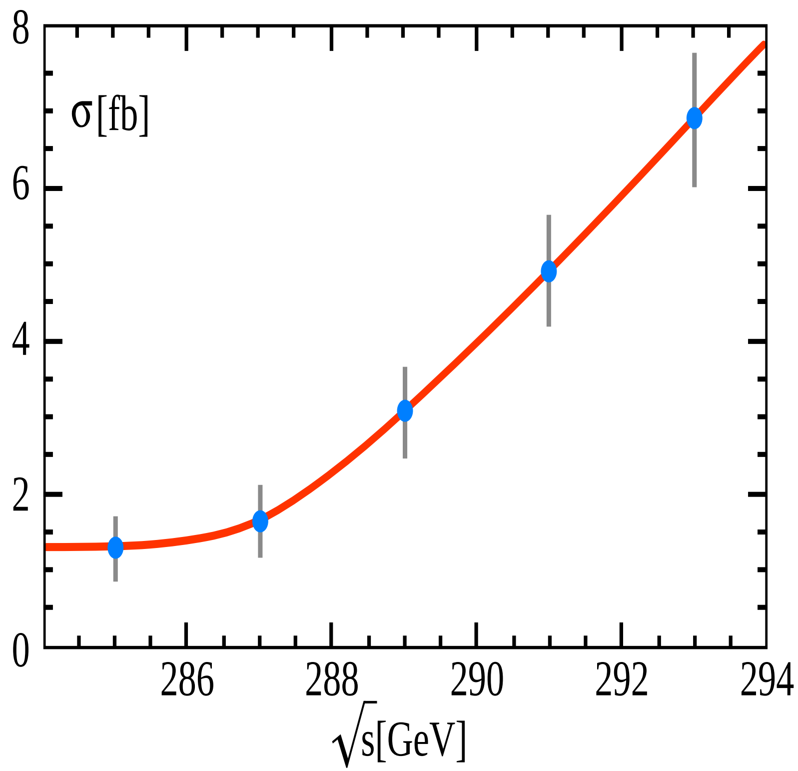
Slepton mass measurement from threshold scan and in continuum:

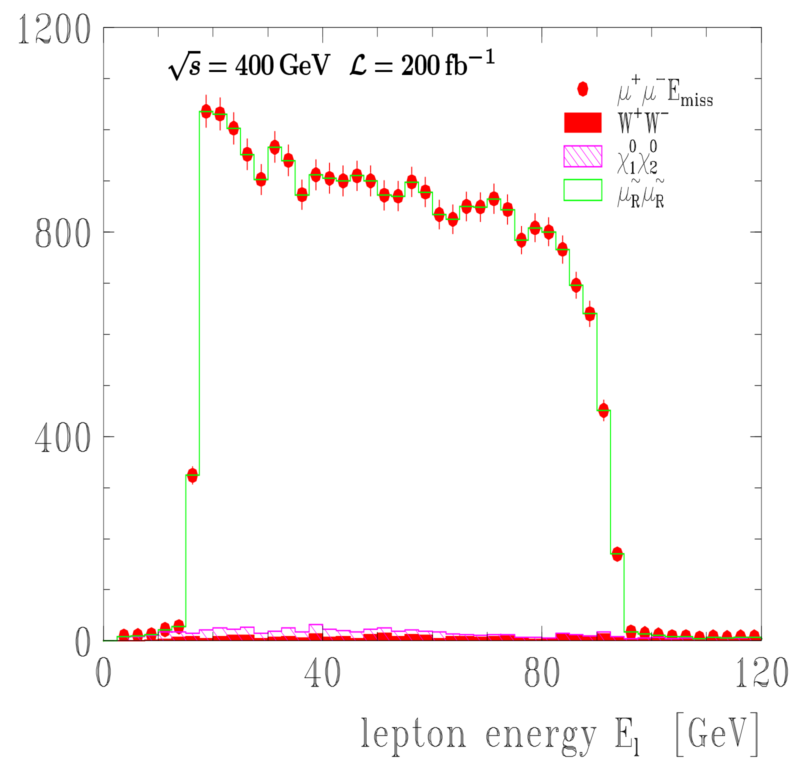
– polarized e^+e^-: $\Delta m_{\tilde{e}_R} = 0.2$ GeV and $\Delta\Gamma_{\tilde{e}_R} = 0.25$ GeV;

– improvement by 4 using e^-e^- but 2 times worse for $\tilde{\mu}$ in e^+e^-;

– from E_ℓ spectra in $\tilde{\ell} \to \ell\chi_1^0$ decays, 0.1% precision for $m_{\tilde{\ell}}$ and $m_{\chi_1^0}$;

– $\tilde{\nu}_e$ more involved, $m_{\tilde{\nu}}$ at 1% from $e^+e^- \to \tilde{\nu}_e\tilde{\nu}_e \to \nu_e\chi_1^0 e^\pm \chi_1^\mp$





2. Precision SUSY measurements: the $\tilde{\ell}$ sector

Slepton spin determination: conceptually very simple in $\mathrm{e^+e^-}$:

– hint from the P–wave onset of the excitation curve (not sufficient),

– the $\sin^2\theta$ behavior of the cross section (for $\tilde{\mathrm{e}}$, near threshold).

Coupling determination: check of the SUSY identity $\mathrm{g_{gauge}} = \tilde{\mathrm{g}}_{\mathrm{Yukawa}}$:

– from $\tilde{\mathrm{e}}$ and $\tilde{\nu}_{\mathrm{e}}$ production cross sections (t–channel contributions),

– also in $\chi^{\pm}$ and χ^0 production (works also for heavy $\tilde{\ell}$).

In the case of $\tilde{\tau}$: $\tilde{\tau}$ mixing and final state τ slightly complicate pattern:

– mass determination as above for $\tilde{\mu}$ but accuracy $\sim$ 3 times worse,

– complication ($\gamma\gamma$ bkg) when $\tilde{\tau}_1$ almost degenerate with the LSP χ_1^0,

– mixing $\theta_{\tilde{\tau}}$ measurable from $\sigma(\mathrm{e^+e^-} \to \tilde{\tau}_1\tilde{\tau}_1)$ with $\neq$ beam polarization,

– polarization of τ-lepton measurable and helps for model discrimination,

– μ, A_τ and $\tan\beta$ can be determined from $\sigma(\tilde{\tau}\tilde{\tau})$ and τ polarization

– $\mathbf{H}, \mathbf{A} \to \tilde{\tau}_1\tilde{\tau}_2$ decays give extra information (A_τ measurement)...

2. Precision SUSY measurements: the $\tilde{Q}$ sector

Third generation $\tilde{Q} = \tilde{t}_1, \tilde{b}_1$: possibly lightest squarks due to mixing.

– In particular, $\tilde{t}_1$ is in general the lightest squark (RGE+mixing).

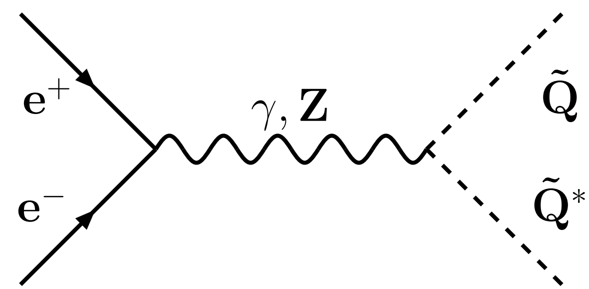
– Light stops needed in models with electroweak baryogenesis.

– Light stops are very difficult to detect at the LHC (large tt bkg).

$\tilde{Q}$ production at ILC:

$e^+e^- \to \tilde{t}_1\tilde{t}_1$ and $\tilde{b}_1\tilde{b}_1$:

via s–channel γ,Z exchange

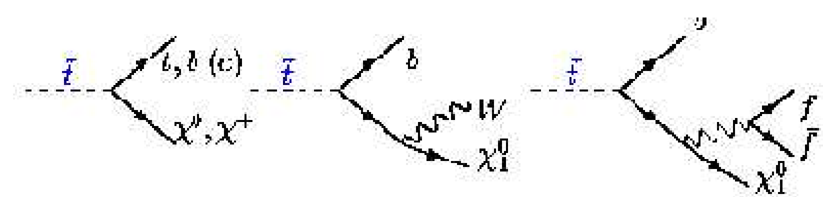


$\tilde{t}_1$ decays:

– if heavy, two–body $\tilde{t}_1 \to t\chi_1^0, b\chi_1^+$,

– otherwise multi–body decays,

– or loop induced $\tilde{t}_1 \to c\chi_1^0$ decays.



2. Precision SUSY measurements: the $\tilde{Q}$ sector

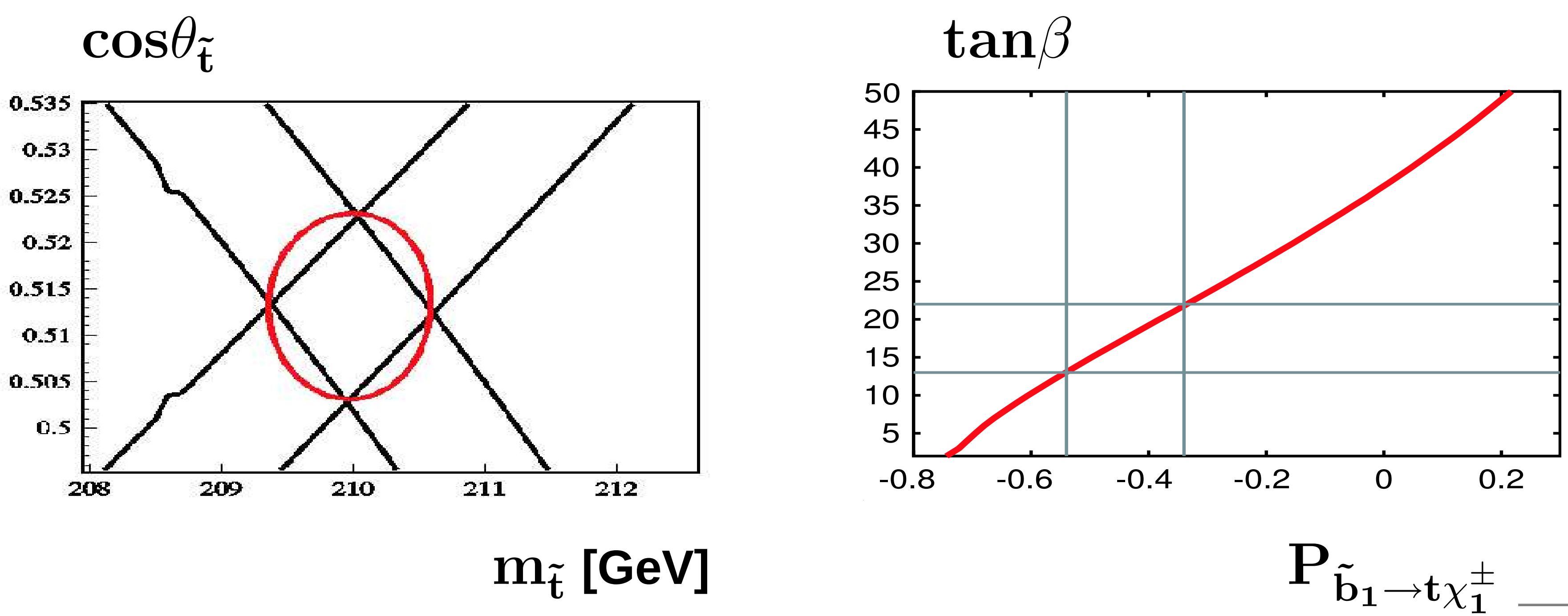
Phenomenology of $\tilde{t}_1$ and $\tilde{b}_1$ at the ILC similar to that of $\tilde{\tau}_1$:

- **Masses and mixing obtained from production with polarized beams,**

ex: study of $\sigma(e^-_R e^+_L, e^-_L e^+_R \to \tilde{t}_1 \tilde{t}_1)$ for $\tilde{t}_1 \to b\chi^\pm_1, c\chi^0_1$ at 500 GeV.

- **Top quark polarization in $\tilde{t}_1, \tilde{b}_1$ decays provides crucial information**

ex: top polarization in $e^+_L e^-_R \to \tilde{b}_1 \tilde{b}_1 \to t\chi^-_1 + \bar{t}\chi^+_1$ at $\sqrt{s} = 1$ TeV.



2. Precision SUSY measurements: summary

From analyses at ILC with $\sqrt{s} = 0.5$–1 TeV and 10–1000 fb^{-1} luminosity:

	m [GeV]	Δm]	**Comments**
$\chi_1^\pm$	**183.7**	**0.55**	**simulation threshold scan, 100 fb^{-1}**
$\chi_2^\pm$	**415.4**	**3**	**estimate $\chi_1^\pm \chi_2^\mp$, spectra $\chi_2^\pm \to Z\chi_1^\pm$, $W\chi_1^0$**
χ_1^0	**97.7**	**0.05**	**combination of all methods**
χ_2^0	**183.9**	**1.2**	**simulation threshold scan $\chi_2^0\chi_2^0$, 100 fb^{-1}**
χ_3^0	**400.5**	**3–5**	**spectra $\chi_3^0 \to Z\chi_{1,2}^0$, $\chi_{2,4}^0\chi_3^0$, 750 GeV, $\gtrsim 1$ ab^{-1}**
χ_4^0	**413.9**	**3–5**	**spectra $\chi_4^0 \to W\chi_1^\pm$, $\chi_{2,3}^0\chi_4^0$, 750 GeV, $\gtrsim 1$ ab^{-1}**
$\tilde{e}_R$	**125.3**	**0.05**	**$\mathrm{e^-e^-}$ threshold scan, 10 fb^{-1}**
$\tilde{e}_L$	**189.9**	**0.18**	**$\mathrm{e^-e^-}$ threshold scan 20 fb^{-1}**
$\tilde{\nu}_e$	**172.5**	**1.2**	**simulation energy spectrum, 500 GeV, 500 fb^{-1}**
$\tilde{\mu}_R$	**125.3**	**0.2**	**simulation energy spectrum, 400 GeV, 200 fb^{-1}**
$\tilde{\mu}_L$	**189.9**	**0.5**	**estimate threshold scan, 100 fb^{-1}**
$\tilde{\tau}_1$	**107.9**	**0.24**	**simulation energy spectra, 400 GeV, 200 fb^{-1}**
$\tilde{\tau}_2$	**194.9**	**1.1**	**estimate threshold scan, 60 fb^{-1}**
$\tilde{t}_1$	**366.5**	**1.9**	**estimate b-jet spectrum, $\mathrm{m_{min}}(\tilde{\mathrm{t}}_1)$, 1TeV, 1 ab^{-1}**

3. Determination of the SUSY parameters:

Once $\mathrm{m_i}, \sigma, \mathrm{P_i}$ are measured, determine the low–energy SUSY parameters from inversion of the mass and cross section formulae:

- **Chargino/neutralino system: see Jan Kalinowski**

$$\mathbf{M_1 = \sqrt{\Sigma_i m^2_{\chi^0_i} - M_2^2 - \mu^2 - 2M_Z^2}, M_2 = M_W \sqrt{\Sigma - \Delta[c_{2\phi_R} + c_{2\phi_L}]}}$$

$$|\mu| = \mathbf{M_W \sqrt{\Sigma + \Delta[c_{2\phi_R} + c_{2\phi_L}]}}, \quad \tan\beta = \sqrt{\mathbf{(1+\Delta')/(1-\Delta')}}$$

with $\mathbf{\Delta = \frac{m^2_{\tilde{\chi}^\pm_2} - m^2_{\tilde{\chi}^\pm_1}}{4M_W^2}, \Delta' = \Delta(c_{2\phi_R} - c_{2\phi_L}, \Sigma = \frac{m^2_{\tilde{\chi}^\pm_2} + m^2_{\tilde{\chi}^\pm_1}}{2M_W^2} - 1.}$

- **Sfermion system: see Barbara Mele**

$$\mathbf{m^2_{\tilde{f}_{L,R}} = M^2_{\tilde{f}_{L,R}} + M_Z^2 \cos 2\beta\, (I^3_{L,R} - Q_f \sin^2\theta_W) + m_f^2}$$

$$\mathbf{A_f - \mu(\tan\beta)^{-2I_3^f} = (m^2_{\tilde{f}_1} - m^2_{\tilde{f}_2})/(2m_f) \cdot \sin 2\theta_{\tilde{f}}}$$

- **Higgs system: see e.g. Marco Battaglia**

Precise $\mathrm{M_h}$ measurement: $\mathbf{M_h^2 = M_Z^2 |\cos 2\beta|^2 + \frac{3g^2}{2\pi^2} \frac{m_t^4}{M_W^2} \log \frac{m_{\tilde{t}}^2}{m_t^2}}$

Also: $\mathbf{e^+e^- \to t\bar{t}\Phi, b\bar{b}\Phi, \chi\chi\Phi, \tau\tau \to \Phi, \Phi \to \tilde{\tau}_1\tilde{\tau}_2, \Phi \to \chi\chi, \ldots}$

3. Determination of SUSY parameters: summary

In reality, life is more complicated than the tree-level results above:

complete analysis with sophisticated programs: Sfittino, Sfitter, ...

	ΔLHC	ΔILC	ΔLHC+ILC	SPS1a	ΔLHC+ILC	SPS1a$'$
$\tan\beta$	$\pm$9.1	$\pm$0.3	$\pm$0.2	10	$\pm$0.3	10
μ	$\pm$7.3	$\pm$2.3	$\pm$1.0	344.3	$\pm$1.1	396
M_A	fixed	$\pm$0.9	$\pm$0.8	399.1	$\pm$0.8	372
A_t	$\pm$91	$\pm$2.7	$\pm$3.3	$-$504.9	$\pm$24.6	$-$565
M_1	$\pm$5.3	$\pm$0.1	$\pm$0.1	102.2	$\pm$0.1	103.3
M_2	$\pm$7.3	$\pm$0.7	$\pm$0.2	191.8	$\pm$0.1	193.2
M_3	$\pm$15	fixed	$\pm$11	589.4	$\pm$7.8	571.7
$M_{\tilde{\tau}_L}$	fixed	$\pm$1.2	$\pm$1.1	197.8	$\pm$1.2	179.3
$M_{\tilde{e}_L}$	$\pm$5.1	$\pm$0.2	$\pm$0.2	198.7	$\pm$0.18	181.0
$M_{\tilde{e}_R}$	$\pm$5.0	$\pm$0.05	$\pm$0.05	138.2	$\pm$0.2	115.7
$M_{\tilde{Q}3_L}$	$\pm$110	$\pm$4.4	$\pm$39	501.3	$\pm$4.9	471.4
$M_{\tilde{Q}1_L}$	$\pm$13	fixed	$\pm$6.5	553.7	$\pm$5.2	525.8
$M_{\tilde{d}_R}$	$\pm$20	fixed	$\pm$15	529.3	$\pm$17.3	505.7

3. Determination of SUSY parameters

Once the low–energy SUSY parameters have been obtained, try to determine the SUSY parameters at the very high scale (M_{GUT}, M_P):

- **pin–down the model/SUSY–breaking (mSUGRA, AMSB, GMSB, ..),**
- **determine the few fundamental unified parameters of the model.**

Example of mSUGRA, using all previous measurements at LHC/ILC:

	SPS1a	LHC	ILC	LHC+ILC	SPS1a$'$	LHC+ILC
m_0	100	±4.0	±0.09	±0.08	70	0.2
$m_{1/2}$	250	±1.8	±0.13	±0.11	250	0.2
$\tan\beta$	10	±1.3	±0.14	±0.14	10	0.3
A_0	-100	±31.8	±4.43	±4.13	-300	13

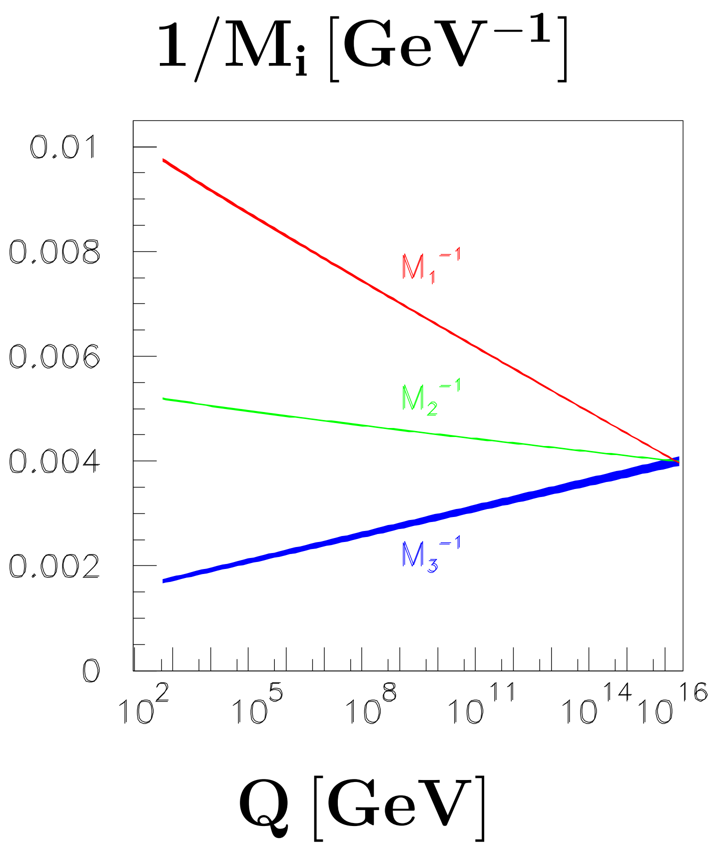
The same type of analysis in other breaking schemes/other models.

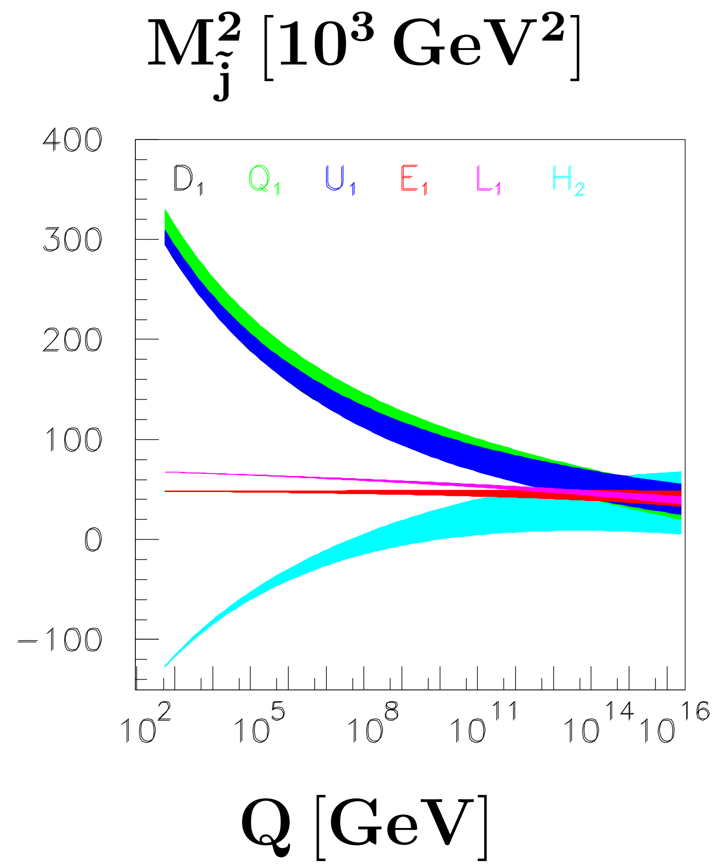
To be absolutely sure: only with model dependent analyses at ILC!

3. Determination of SUSY parameters:

One can check the fundamental assumptions at high (GUT) scale.

For example: gaugino and scalar mass unification in mSUGRA....





Also, check that one is in accord with cosmology (see G. Bélanger):

use precise determinantion of SUSY parameters to predict Ωh^2.

4. Summary

If SUSY is the solution to the SM pbs: SUSY particles should be light.

Colored and non–colored sparticles observable (very?) soon at LHC.

The ILC will be needed as it will provide crucial additional information:

- very clean environment, large production rates with low backgrounds,
- tunable energy to perform threshold scans and increase rates,
- beam polarization which allow to select various channels,
- additional options ($e^-e^-, \gamma\gamma, e\gamma$) for complementary studies,

$\Rightarrow$ high–precision analyses and a true probe of SUSY phenomena.

Only coherent/combined analyses of LHC+ILC data will allow for:

- better/model independent reconstruction of low energy SUSY paramete
- connect weak-scale SUSY with more fundamental physics at GUT scale,
- provide input to predict the LSP density and connection with cosmolog

Here: gave illustration of ILC "performance" in mSUGRA–type MSSM.

Many interesting analyses/physics can also be done in other scenarios!