SUSY & Cosmology Summary

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Outline:

- SUSY
- Cosmology
- Parameter Group's Questions:
  - Analyses in this context
  - Status of the answers
- Conclusions

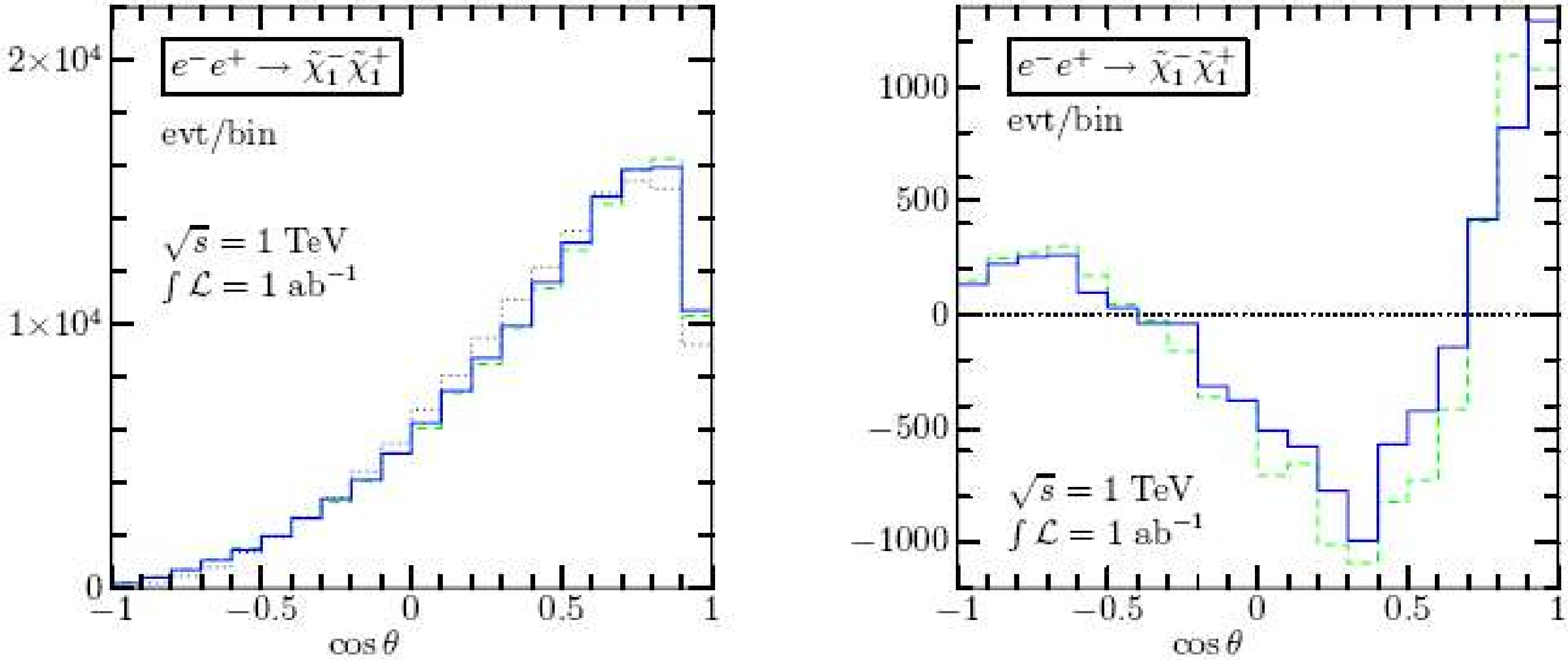
SUSY (non-Cosmology) talks

- Theory:
  - NLO event generation for chargino production at the ILC (T.Robens)
  - How light is the lightest Neutralino? (O.Kittel)
  - Neutralinos in U(1) extended SUSY (J. Kalinowski)
  - Higgs decays into sfermions (K. Kovarik)
  - Neutrino oscillations in split supersymmetry (M. Diaz)
  - Combined LHC/ILC analysis of a SUSY scenario with heavy sfermions (K. Rolbiecki)

- Experiment:
  -

NLO Event Generation for Chargino Production (T.Robens)

simulation results: angular distributions



Born, fixed order, resummation

!! more than 1 σ deviation !! $\sqrt{n_{\mathrm{max}}} \approx \mathcal{O}(10^2)$; nbins = 20

How light is the lightest Neutralino? (O.Kittel)

- What happens if the GUT relation is dropped?

- For $\tilde{\chi}_1^0 =$ bino, the $Z\tilde{\chi}_1^0\tilde{\chi}_1^0$ coupling vanishes at tree-level.
  $\Rightarrow$ No significant contribution to the Z-width!!

Radiative production of neutralinos $e^+e^- \to \tilde{\chi}_1^0\tilde{\chi}_1^0\gamma$

- LEP: due to small luminosity (order 100 pb^{-1}) significance $S < 0.1$

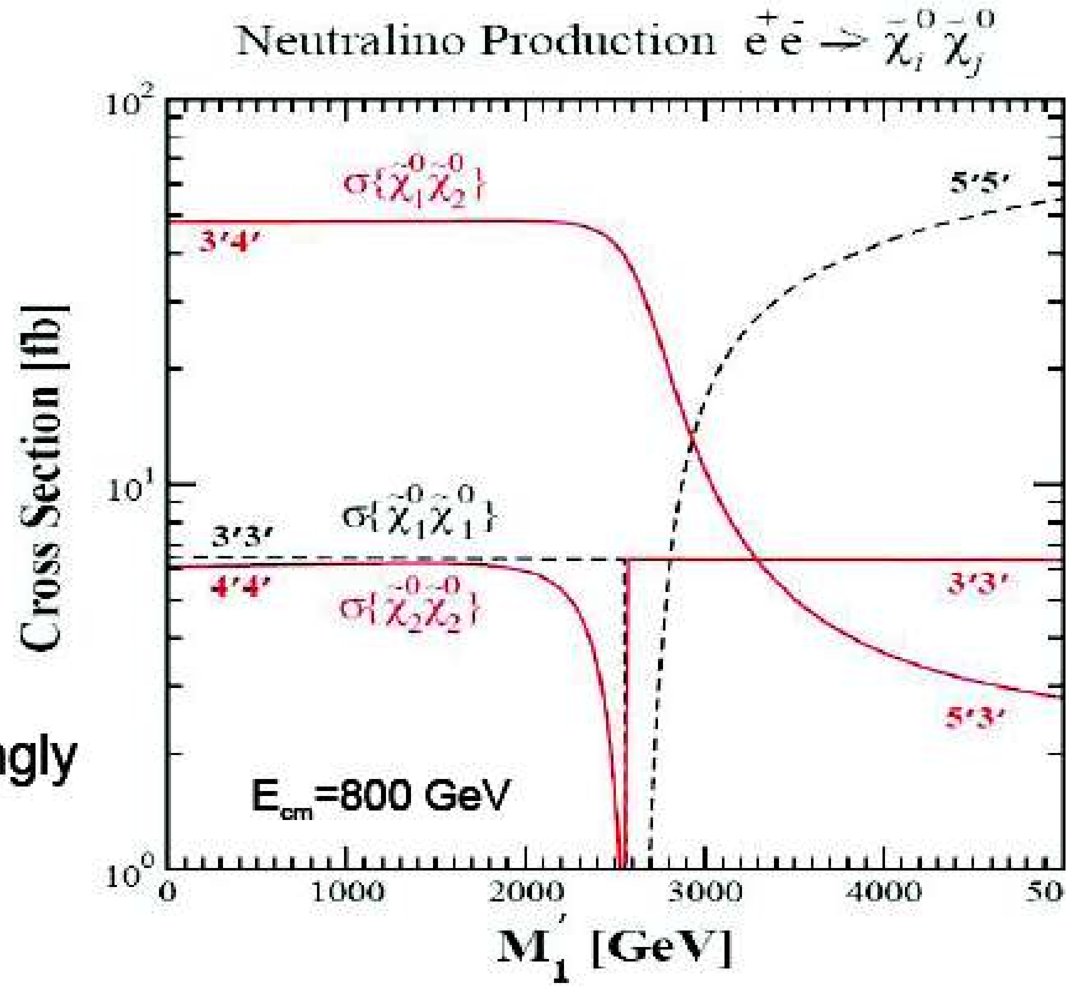
- ILC:
  - $\mathcal{L} = 500$ fb^{-1} $\longrightarrow$ significance $S = 80$ for SPS 1a
  - polarized beams enhance signal and reduce background
    $\longrightarrow$ talk in polarization session
  - $\chi_1^0\tilde{\chi}_1^0\gamma$ could be the lightest SUSY state to be observed!

Neutralinos in U(1) extended SUSY (J.Kalinowski)

- new states: scalar Higgs, Z' and two neutralinos

in our scenario

$$M_{Z_2} = 949 \text{ GeV}$$
$$\theta_{ZZ'} = 3.3 \times 10^{-3}$$
$$m_{\tilde{e}_{R,L}} = 701 \; GeV$$



The presence of ~1 TeV Z_2 strongly affects cross sections e.g. for M_1'=0

Cross Section [fb]	$\sigma\{\tilde{\chi}_1^0\tilde{\chi}_1^0\}$	$\sigma\{\tilde{\chi}_1^0\tilde{\chi}_2^0\}$	$\sigma\{\tilde{\chi}_2^0\tilde{\chi}_2^0\}$
USSM	6.5	48.0	6.1
MSSM	1.7×10^{-3}	67.1	8.5×10^{-3}

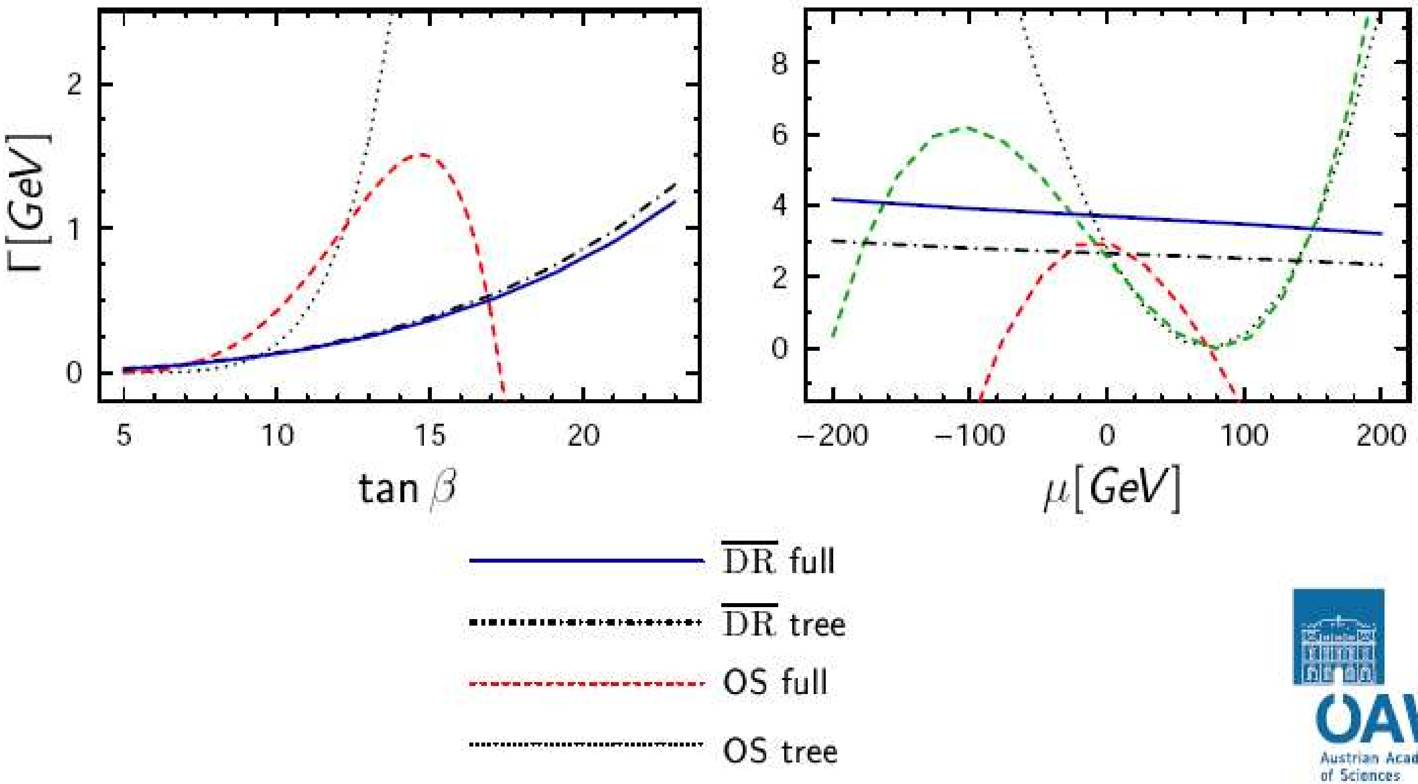
although masses of $\tilde{\chi}_1^0\tilde{\chi}_2^0$ are as in MSSM

Higgs decays into Sfermions (K.Kovarik)

- All Higgs decays into sfermions (or crossed-channels) calculated to one-loop
- Pure on-shell scheme not appropriate - A_f, m_f taken running
- SPA analysis for decays possible for on-shell renormalization scheme using SPheno & DRbar2OS

$A^0 \to \tilde{b}_1 \tilde{b}_2$

SPS1a' parameter shift - $m_{D_3} \to 150\ GeV$ $\quad m_{A^0} \to 1000\ GeV$



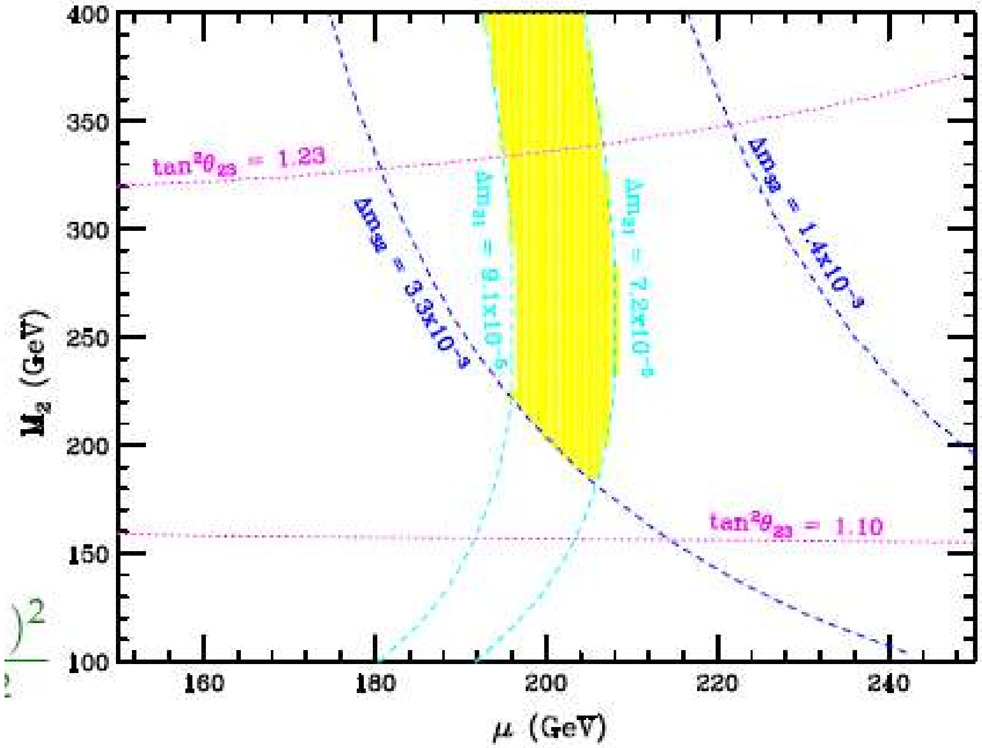
ÖAW
Austrian Academy of Sciences

Neutrino Oscillations in split SUSY (M.A. Diaz)

- Supersymmetry with Bilinear R-Parity Violation provides a framework for neutrino masses and mixing angles compatible with experiments.

- In Split Supersymmetry with BRpV the Higgs boson forms the only and crucial loop, and trilinear RpV couplings are essentially irrelevant.

- Neutrino parameters can be extracted from collider physics, specially from neutralino decays.



Cosmology (non SUSY) talks

- Theory:
  - microMEGAS 2: Calculation of relic density in generic model (A.Pukhov)

- Experiment:
  - Model-independent WIMP searches at the ILC (C. Bartels)

micrOMEGAS 2:
Calculation of Relic Density in Generic Model (A. Pukhov)

The models implemented and in progress.

First of all there are different extensions of MSSM.

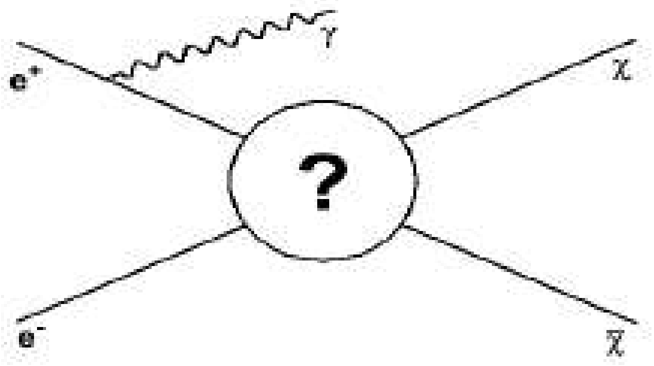
- NMSSM - a model with addition neutralino (singlino) which has super-partners in extended Higgs sector. Relic density for this model was studied in $\mu\Omega$, C.Hugonie , hep-ph/0505142
- MSSM with CP-violation $\mu\Omega$, S.Kraml, Phys.Rev.D73:115007,2006

Also there models motivated by Extra-Dimensions physics

- UED private version by C.Balazs
- Warped X-dim in progress, with G.Servant
- Little Higgs A. Belyaev el al, in progress

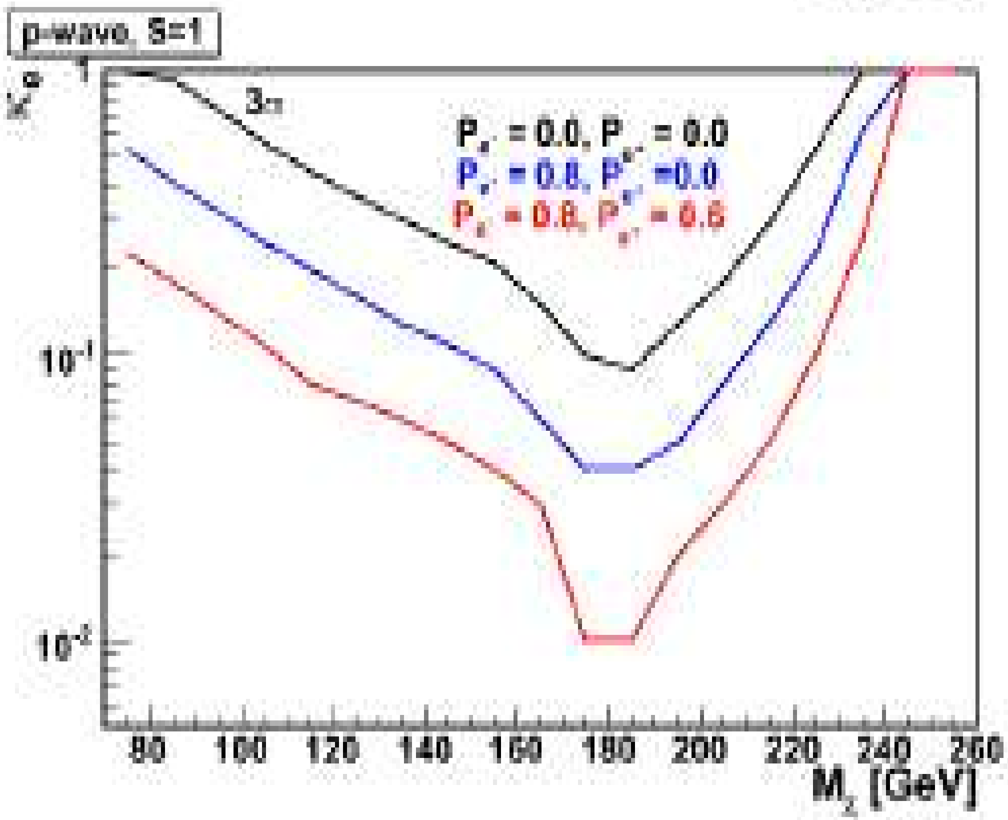
Generation of new models for CalcHEP is done by the LanHEP package
A. Semenov. Nucl.Inst.&Meth. A393 (1997) p. 293.
It gives a possibility to fill automatically long list of model vertices.

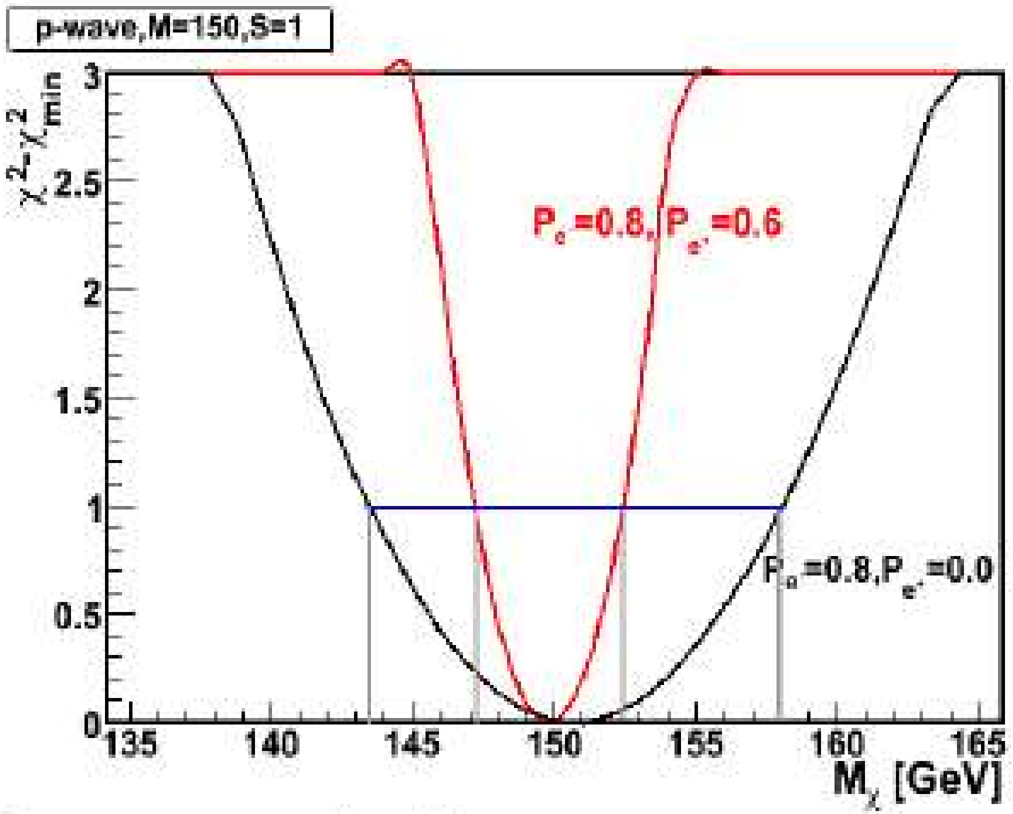
Model-independent WIMP searches at the ILC (C. Bartels)



Cross section parameters

- Free:
  - κ_e: Fraction of WIMP pair annihilations into e^+e-
  - M_χ: WIMP mass
  - S_χ: WIMP spin
  - J: Angular momentum of dominant partial wave
- From cosmological observation: σ_{an}





Parameter Group's Questions

two cases:

- stau co-annihilation with small stau-LSP mass difference ~ 5 GeV
  - Study of $\gamma\gamma$->qq background to SUSY point D' (M. Berggren)
  - Confronting different methods in measuring SUSY DM in co-annihilation scenarios at the ILC (Z.Zhang)
- neutralino pair production
  - Combined LHC/ILC analysis of a SUSY scenario with heavy sfermions (K. Rolbiecki, G. Moortgat-Pick)

Combined LHC/ILC analysis of a SUSY scenario with heavy sfermions (K. Rolbiecki, G. Moortgat-Pick)

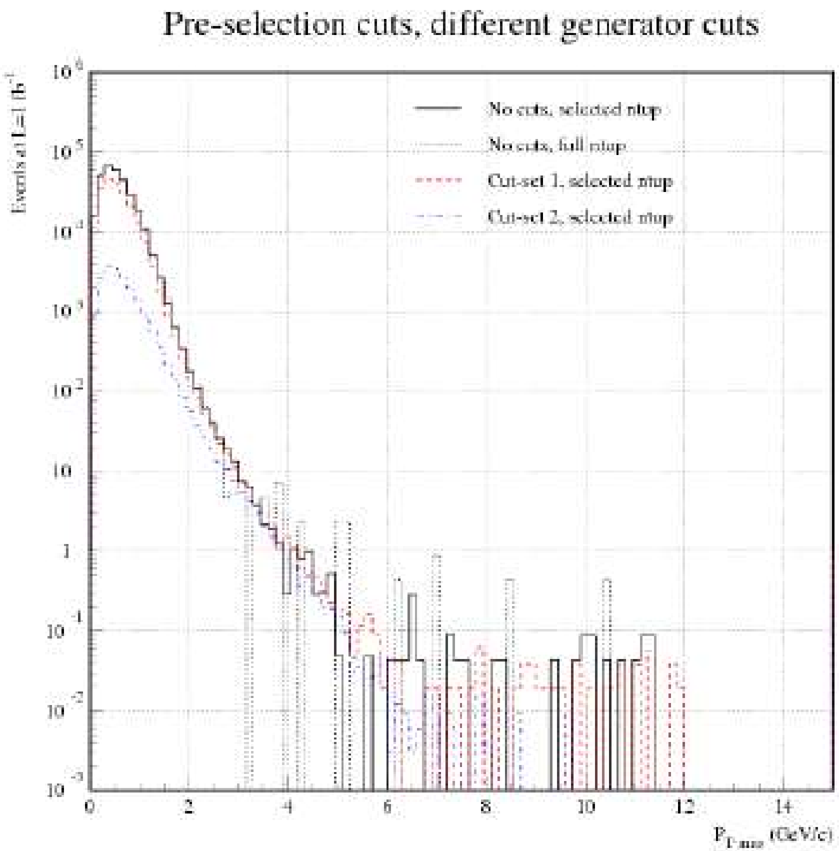
- Tricky case of SUSY: multi-TeV sleptons and squarks
  - only few particles kinematically accessible at the ILC with 500 GeV
- Study done even without assuming a specific SUSY breaking scheme!
- Forward-backward asymmetries of the final leptons/quarks: sensitivity to heavy virtual particles
  - get tight constraints even for masses in the multi-TeV range!
- Also rather accurate parameter determination possible with A_{fb}
  - allows to predict masses of heavier charginos/neutralinos
  - important input to outline needed energy scale for the 2^{nd} stage of the ILC .... !

- LHC / ILC(500): neither of these colliders alone can provide sufficient information to solve such a challenging scenario with multi-TeV squarks and sleptons --> LHC / ILC(500) interplay crucial !

Study of γγ->qq background to SUSY point D' (M. Berggren)

Conclusions

- One must be able to reduce the needed number of simulated $\gamma\gamma$ events by two orders of magnitude.
- By iteratively adjusting PYTHIA's generator-level cuts on x_B and W in such a way that the part of the phase-space that passes the preselection cuts of the analysis remains unchanged, this is doable.
- The adjustment needs to be done separately for each classes.
- Even so, sizable computer resources are needed, eve



Confronting different methods in measuring SUSY DM in co-annihilation scenarios at the ILC (Z.Zhang)

Results on the Stau Mass & Relic DM Density

Method one: ($L=500 fb^{-1}$)

Scenario	A	C	D	G	J
ΔM (GeV)	7	9	5	9	3
Ecm (GeV)	505	337	442	316	700
σ (fb)	0.216	0.226	0.456	0.139	3.77
Efficiency (%)	10.4	14.3	5.7	14.4	<1.0
δm_{stau} (GeV)	0.49	0.16	0.54	0.13	>1.0
$\delta\Omega h^2$ (%)	3.4	1.8	6.9	1.6	>14*

Method two: ($L=$ $200 fb^{-1}$ / $300 fb^{-1}$)

Scenario	Modified SPS 1a			D			
ΔM (GeV)	8	5	3	5			
Ecm (GeV)		400		600			500
Pol 0.8(e-)/0.6(e+)	yes	yes	yes	yes		no	yes
σ (fb)		140		50		20	25
Efficiency (%)		18.5		7.6		7.7	6.4
δm_{stau} (GeV)	0.14	0.22	0.28	0.15	0.11-0.13	0.14-0.17	0.13-0.20
$\delta\Omega h^2$ (%)	1.7*	4.1*	6.7*	1.9	1.4-1.7	1.8-2.2	1.7-2.6
	Uli				This analysis		

*: $\Omega h^2 < 0.094$ (WMAP lower limit)

microMegas

Status of Answers

- before Valencia:
  collection of existing results, some (apparent) contradictions
- ~2 sessions dedicated to discussions and new results
  => many things got clarified
- here: very crude summary, for details:
- new version of draft will come soon
- still many caveats!

Neutralino Production

- At what amount of integrated luminosity are systematic effects becoming dominant?
  low cross sections -> clearly stat. limited for at least 500 fb^{-1}

- Is there any impact of decreasing (increasing) beamstrahlung by a factor of two relative to the standard parameters, i.e. trading off luminosity vs background?
  the more lumi the better, additional background not critical

- Is there any benefit from electron plus positron polarisation (80 and 60%) or from increased electron polarisation in the absence of positron polarisation?
  increased cross sections, positron polarisation crucial for
  - distinguishing higgsino / gaugino nature
  - extracting U(1), SU(2) SUSY couplings
  - accessing SUSY parameters in case of heavy sfermions

- Are there other accelerator parameters strongly influencing this measurement?
  ?

Stau Co-Annihilation

- How much luminosity is needed to reach a precision comparable to the one expected from the measurements with the Planck satellite?
  300 - 800 fb-1 @ 500 GeV, depending on scenario (D', SPS 1a mod)
- At what amount of integrated luminosity are systematic effects becoming dominant?
  stat. limited for at least 500 fb^{-1}
- Is there any impact of decreasing (increasing) beamstrahlung by a factor of two relative to the standard parameters, i.e. trading off luminosity vs background?
  amount of γγ background & forward veto capability critical
  => more beamstrahlung is not desirable
- Is there any benefit from electron plus positron polarisation (80 and 60%) or from increased electron polarisation in the absence of positron polarisation?
  increased cross sections (~ factor 2), not recoverable by P(e-) only
- Are there other accelerator parameters strongly influencing this measurement?
  - crossing angle > 2 mrad worsens forward tagging capabilities
  - anti-DID essential, but still uninstrumented wedge = loss of efficiency
  - stronger focussing of beam very problematic

Conclusions

- made good use of time, although only 10 talks
  => lot of time for discussions
- more combined sessions with closely related topics
  cosmology, maybe even Higgs?
- majority of talks from theory side
  => strengthen experimental effort!
  Parameter group's questions triggered some....
- had one analysis using full simulation
  => usefull for improving reconstruction,
  but also physics output!