Determining SUSY parameters at the ILC

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DESY

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- Why the ILC is great for searching investigating SUSY
- Example benchmark point: STC
- Determining SUSY parameters: tree-level estimates

How do we know it is supersymmetry?

- Must measure spins and couplings of any new particles
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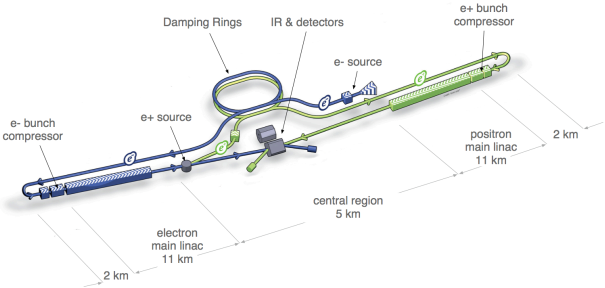
What is the International Linear Collider

- electron-positron collider at $\sqrt{s} = 200 - 500$ GeV, upgradable to 1TeV
- polarisation of electrons 80%, positrons 30-60%
- $250fb^{-1}$ per year



What can the ILC measure?

- Kinematic edges and threshold scans for masses
- Polarised production cross-sections for mixing and couplings
- Angular distributions for spin

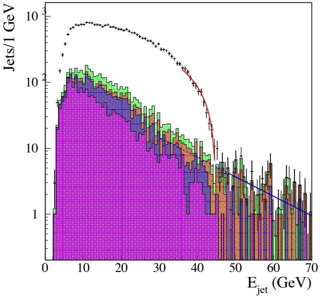


Figure : STC8: Stau1 endpoint at 500GeV, 500fb^{-1} ILC (Mikael Berggren)

Question: Which observables are important for the detector and accelerator design?

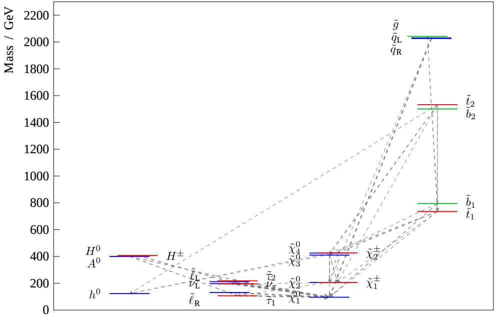
- Want to determine SUSY parameters
- Which measurement uncertainties are allowed?

STC: stau coannihilation scenarios

- Set of benchmark points with 12 independently chosen parameters (arXiv: 1307.0782)
- Satisfy all constraints (LHC8, LEP, low energy, cosmology)
- $\tan\beta = 10$, $\mu = 400\,GeV$, $M_1 = 100\,GeV$, $M_2 = 210\,GeV$, $M_3 = 2000\,GeV$, $m_{A_0} = 400\,GeV$, $M_{\tilde{Q}} = 2000\,GeV$, $M_{\tilde{u}} = 2000\,GeV$, $M_{\tilde{t}} = M_{\tilde{d}} = 800\,GeV$, $M_{\tilde{L}} = 315\,GeV$, $M_{\tilde{e}} = 119\,GeV$ $M_{\tilde{\tau}} = 205\,GeV$, $m_{top} = 173.1\,GeV$
- Small mass difference between $\tilde{\tau}_1$ and $\tilde{\chi}_1^0$

STC8 mass spectrum

- STC8 mass spectrum and decay modes
- All sleptons and light electroweakinos accessible at $\sqrt{s} = 500 GeV$ ILC
- Also many decay modes accessible



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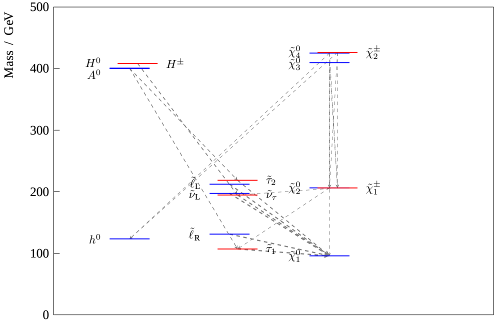
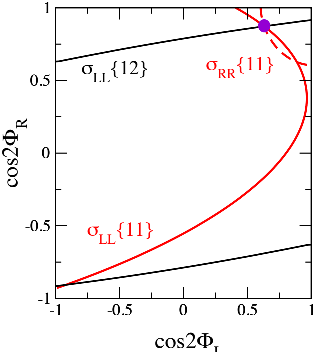


First step: Tree-level estimate of tan β

- Measure chargino 2 and 1 masses and
- Measure LL and RR polarised chargino1 pair production and chargino 1 and 2 mixed production cross section
- $\tan\beta = \left(\frac{1+\Delta(\cos 2\phi_R - \cos 2\phi_L}{1-\Delta(\cos 2\phi_R - \cos 2\phi_L}\right)^{\frac{1}{2}}$ with $\Delta = \Delta(m_{\tilde{\chi}_1^\pm}, m_{\tilde{\chi}_2^\pm})$

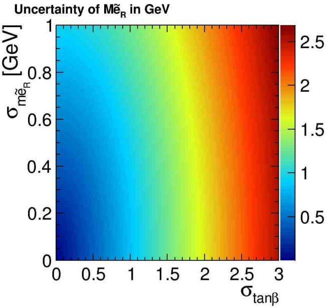


More on tree-level estimates

- $M_{\tilde{e}_R} = \sqrt{m_Z^2 \cos(2\beta)(-\sin^2\theta_W) - m_e^2 + m_{\tilde{e}_R}^2}$
- $M_{\tilde{t}_L} = \sqrt{m_Z^2 \cos(2\beta)(\frac{1}{2} - \sin^2\theta_W) - m_t^2 + m_{\tilde{t}_L}^2}$

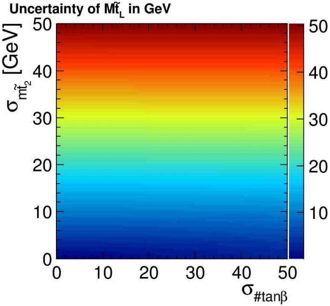
More on tree-level estimates: right-handed selectron mass parameter

- 500 GeV 500 fb^{-1}, ILC would measure right-handed selectron mass with 200MeV precision ($m_{\tilde{e}_R} = 131 GeV$)



More on tree-level estimates: stopL mass parameter

- $M_{\tilde{t}_L} = 1500\,GeV$, $m_{stop2} = 1424\,GeV$ in STC8
- Uncertainty on stop2 mass dominates over tan β

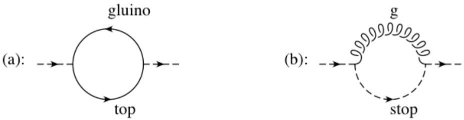


Tree-level estimates of STC8 parameters

TanBeta 21.7857 +- 21.0326
Mu 397.422 +- 39.689
Atau 0 +- 1000
MSelectronR 134.76 +- 13.476
MSelectronL 204.661 +- 20.4661
Atop 0 +- 1000
Abottom 0 +- 1000
MSupL 2028.93 +- 202.893
MStopL 1520.44 +- 152.044
MSupR 2025.01 +- 202.501
MStopR 715.393 +- 71.5393
MSbottomR 1501.39 +- 150.139
M1 96.8487 +- 0.188593
M2 218.818 +- 0.628434
M3 2042.28 +- 21.4188
massA0 400 +- 2.57
massTop 173.1 +- 0.05

Loop corrections to parameters

- Loop diagrams give corrections to sparticle (and particle) masses $\rightarrow$ corrections to parameters
- Not all sparticle masses have to be measured directly



Plan for the future

- Do a full fit with Fittino
- Find out which measurements at the ILC are of crucial importance to SUSY parameter determination