SUSY Point5

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ILD / SiD comparison:

- ILD results
- SiD results
- Discussion

ILD

- Detailed Documentation:

http://arxiv.org/pdf/1006.3396.pdf (ILD LoI)

http://ilcild.org/documents/ild-letter-of-intent/ild-loi-material/point5_090319_2.pdf

- Method:
  - fit function to reconstructed energy spectrum of W/Z boson candidates
  - Z-candidates: determine M(LSP) and M(neutralino-2)
  - W-candiates: determine M(chargino-1), taking M(LSP) from above (incl uncertainty!)
  - errors on masses: from toy MC
- Results:
  500 fb^{-1} at 500GeV with
  $P(e^+,e^-) = (+30\%,-80\%)$

  ("kin fit / no kin fit" refers to whether the boson energies are taken from a 1C kinematic fit or directly from the measured jet energies

Observable	Method	stat. Error
$M_{\tilde{\chi}_1^\pm}$	no kin. fit	3.3 GeV
$M_{\tilde{\chi}_2^0}$	no kin. fit	2.0 GeV
$M_{\tilde{\chi}_1^0}$	no kin. fit	1.3 GeV
$M_{\tilde{\chi}_1^\pm}$	kin. fit	2.9 GeV
$M_{\tilde{\chi}_2^0}$	kin. fit	1.7 GeV
$M_{\tilde{\chi}_1^0}$	kin. fit	1.0 GeV

2C kinfit + further optimisation of the selection indicate possible improvements towards 2.4 GeV, 0.9 GeV and 0.8 GeV for the three mass resolutions.

SiD

- Detailed Documentation:

http://arxiv.org/pdf/0911.0006v1.pdf (SiD LoI)

https://confluence.slac.stanford.edu/download/attachments/46170132/SiD_Answers_to_IDAG_final.pdf?version=1&modificationDate=1244924150000

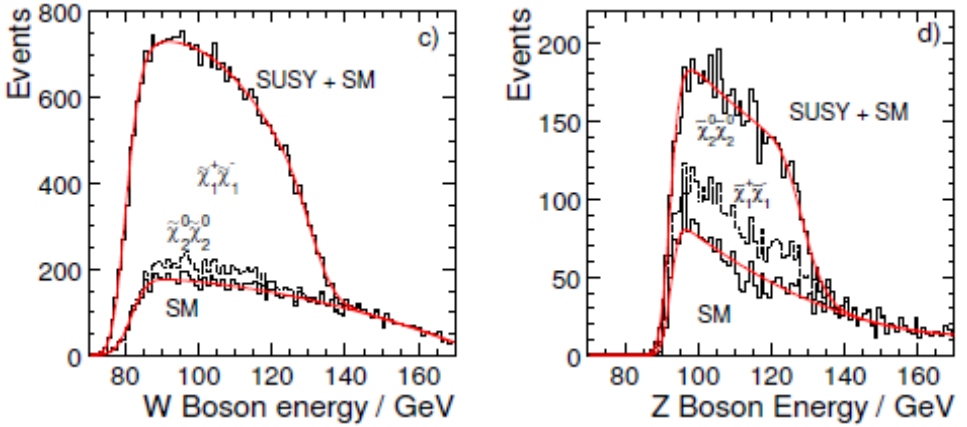
- Method:
  - template fits with varying 1 mass at the time by ±0.5 GeV
  - Z-candidates: determine M(LSP) and M(neutralino-2) (two 1D parabolas!)
  - W-candiates: determine M(LSP) and M(chargino-1) (two 1D parabolas!)
  - errors on masses: from width of chi2 parabola
- Results:
  500 fb^{-1} at 500GeV with $P(e^+,e^-) = (+30\%,-80\%)$

  W-candidates: $\delta M(\text{chargino-1}) = 450$ MeV , $\delta M(\text{LSP}) = 160$ MeV

  Z-candidates: $\delta M(\text{neutralino-2}) = 490$ MeV , $\delta M(\text{LSP}) = 280$ MeV

Discussion (I)

- Observation: SiD's resolutions are factor 3-6 (!) better ..... ?!
- Q: Is this due to the fact that the templates take into account the whole boson energy spectrum instead of just the edges?
- A: No. Due to beam spectrum and W/Z natural width there is no sharp "edges" even for perfect detector resolution. Also ILD fits the whole distributions, convoluting the "box" expected e.g. for smuon decays with voigt functions for width/resolution effects and a heuristic shape for the shape of the "bulk" of the distribution:

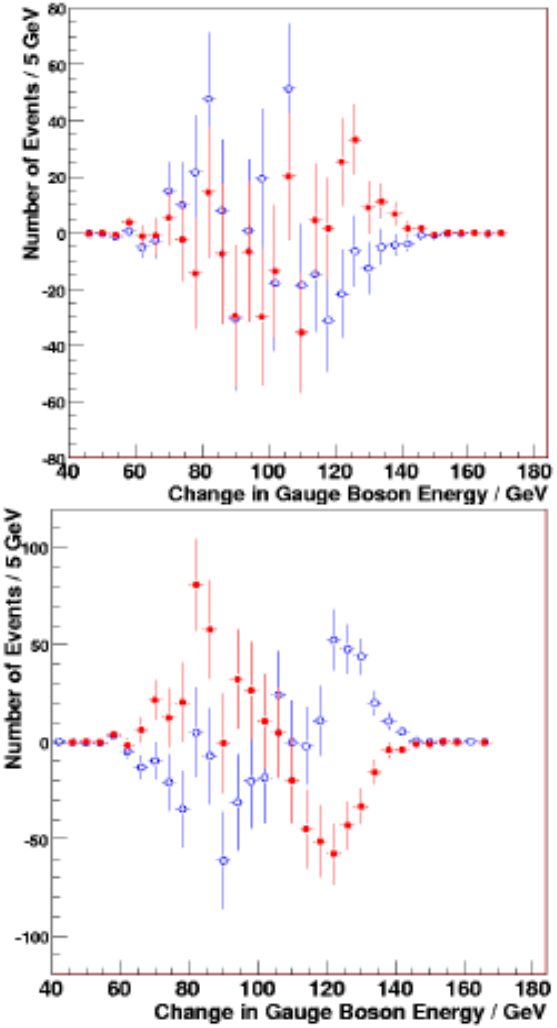


Discussion (II)

- Q: What is it then?
- A: The correlations between the effects on the spectra when changing the different masses.

  SiD templates show clear difference near high energy edge (~130 GeV) when varying *only* the LSP mass (lower figure, fromanswers to IDAG). Thus the tremendous sensitivity to the LSP mass (160 MeV!)

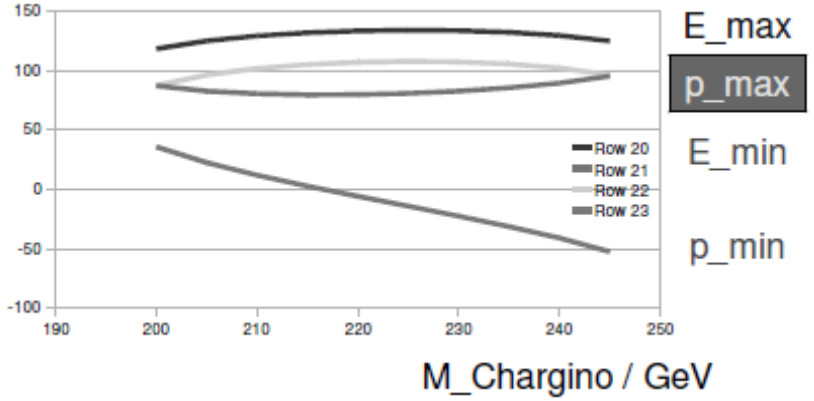
  Note that when changing (*only*!) the chargino-1 mass instead (upper fig), the same region is changing, albeit less and in the "opposite" direction.

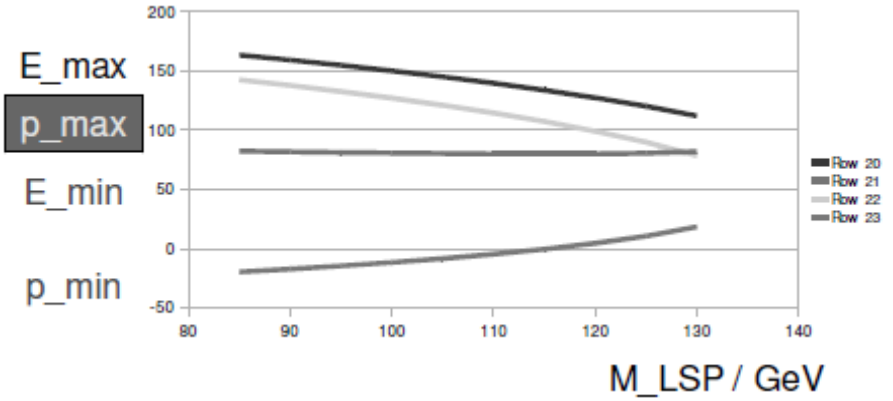


a (top) Difference of templates with corresponding chargino masses different by 0.5 GeV; 4.8 b(Bottom) Difference of templates with corresponding first neutralino masses different by 0.5 GeV.

Discussion (III)

- Q: Do the edges (used in ILD) contain the same information?
- A: Yes. Let's look at the edge positions as function of the chargino-1and LSP masses:
  - lower edge (Emin): at point-5 value (216.5 GeV) no dependency on M(chargino-1), and no dependency on M(LSP)
  - high edge (Emax): useful dependency on M(LSP), but at the nominal values for Point5 (M(LSP) = 115.7 GeV, M(chargino-1) = 216.5 GeV) , still some dependency on M(chargino-1)





=> this is fully consistent with the differences in the templates on the previous page!

Conclusions

- The energy spectrum of the W candidates contains effectively only *one* observable (high edge), since the lower edge does not depend on either of the two masses in the game
- By varying only one mass at the time, SiD exploits the same observable twice to measure two different masses, which works only by neglecting the correlations
- In reality, the LSP mass has to come from another measurement. Depending on the SUSY scenario, this could be slepton decays. But to stay within the benchmark sector, ILD used the neutralino-2 events, and propagates the resulting uncertainties
- The energy spectrum of the Z candidates indeed contains two observables, but they are still highly correlated, which ILD takes into account by fitting both masses simultaneously.
- SiD again only varies one mass at the time, neglecting the sizable correlations.