Requirements for Charginos and Neutralinos searches at CLIC

Outline

- Physics motivation
- Signal and background cross sections
- Jet and W Boson energy resolution
- W, Z° and H° mass resolution
- Jet energy resolution
- Requirements

Requirements, work done at generator level

For the physics performances it will be done with full simulation

Physics motivation

In the framework of the CMSSM the $\tilde{\chi}_1^{\pm}$ and $\tilde{\chi}^{\pm}_2$ are the mass eigenstates formed by the mixing of the $\tilde{w}$ (winos) fermionic partners of the charged gauge bosons and of the $\tilde{h}$ (higgsinos) partner of the charged Higss bosons .

M $\tilde{\chi}_1^{\pm}$ and M $\tilde{\chi}^{\pm}_2$ ~ f(m1/2,mu, tanβ), with:

m1/2: the common gaugino mass at GUT scale.

tanβ : the ratio of Higss doublet vacuum expectation values at Mz.

mu : the scale of the the Higgsino mass

Measuring $\tilde{\chi}_1$, $\tilde{\chi}_2$ masses allows to constrain m1/2, mu and tanβ.

The present study was done for the K' SUSY parameter space, (heavy masses) another study will be done for another point where the masses are lower.

Signal and Background Cross Sections

Signal:

$e^+ + e^- \rightarrow \tilde{\chi}^+_1 + \tilde{\chi}^-_1 \rightarrow \tilde{\chi}^0_1 + W^+ + \tilde{\chi}^0_1 + W^- \rightarrow$ Lepton + 2Jets

M $\tilde{\chi}_1\pm$ = 1064 GeV, M χ^0 = 554 GeV, σ x B.R = 4.4 x 0.3 fb

$e^+ + e^- \rightarrow \tilde{\chi}^+_2 + \tilde{\chi}^-_2 \rightarrow \tilde{\chi}^+_1 + Z^0 + \tilde{\chi}^-_1 + Z^0 \rightarrow$ kLepton + 2Jets (k>1)

$e^+ + e^- \rightarrow \tilde{\chi}^+_2 + \tilde{\chi}^-_2 \rightarrow \tilde{\chi}^+_1 + h^0 + \tilde{\chi}^-_1 + h^0 \rightarrow$ kL + 2J

$e^+ + e^- \rightarrow \tilde{\chi}^+_2 + \tilde{\chi}^-_2 \rightarrow \tilde{\chi}^0_2 + W^+ + \tilde{\chi}^0_2 + W^- \rightarrow$ kL + 2J

M $\tilde{\chi}_2\pm$= 1435 GeV, M $\tilde{\chi}_1$ = 1064 GeV, σ x B.R = 2.9 x 0.2 fb

The topology xL + 2J; k>1 reduces significantly the S.M background.

Can one tell apart $\tilde{\chi}_2\pm \rightarrow \tilde{\chi}_1\pm$ + h/Z and $\tilde{\chi}_2\pm \rightarrow \tilde{\chi}^0_2$ + W ?

Background:

$e^+ + e^- \rightarrow W^+ + W^-$

$e^+ + e^- \rightarrow Z^0 + Z^0$

$e^+ + e^- \rightarrow$ SUSY

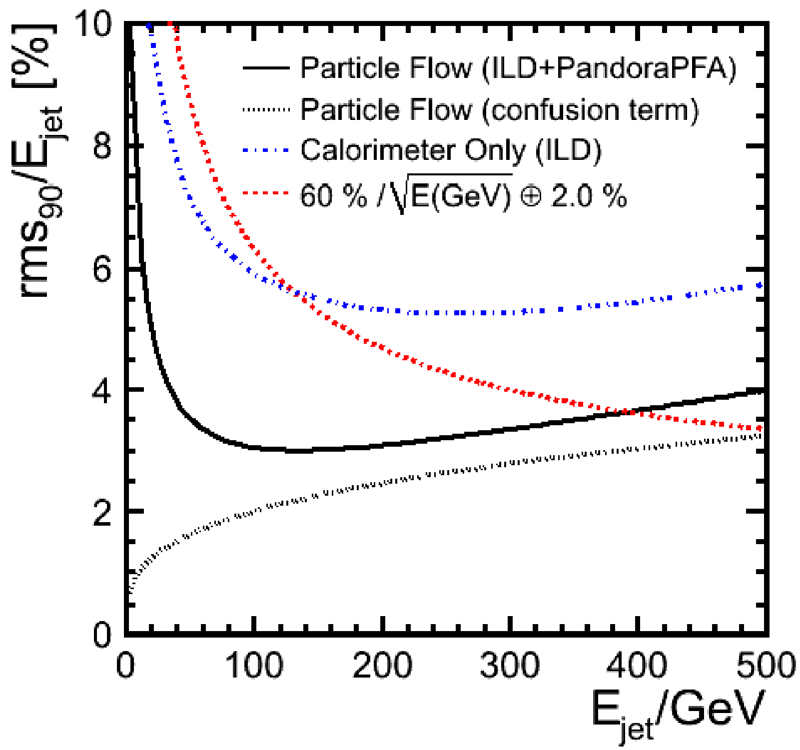
PFA extrapolation to high energy

★ ILD Particle Flow Performance well described by:

$$\frac{\sigma_E}{E} = \frac{21}{\sqrt{E}} \oplus 0.7 \oplus 0.004E \oplus 2.1\left(\frac{E}{100}\right)^{+0.3} \%$$

Resolution Tracking Leakage Confusion

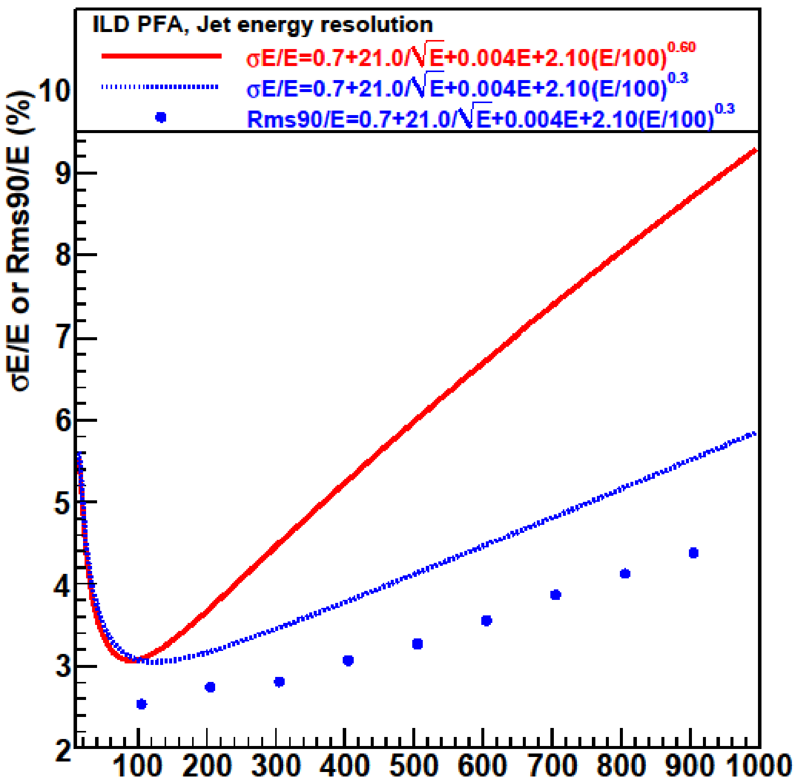
★ Compare PFA/ LEP-like/ILD-pure calorimetric

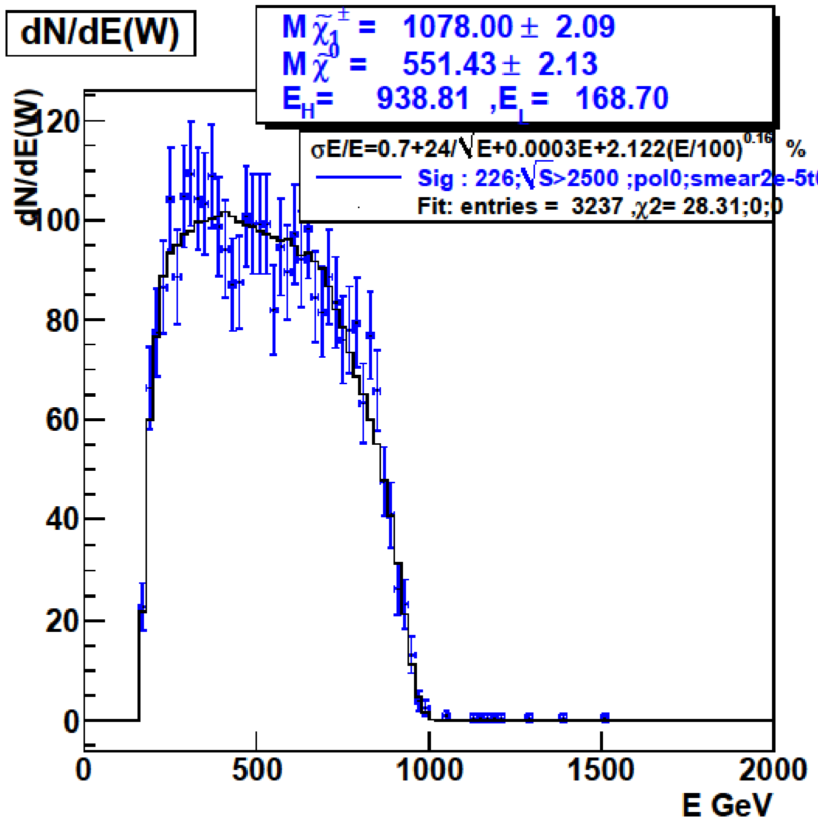


- PFA "wins" for jets energies < 400 GeV (for LEP-like no account of leakage)
- Even at highest energies PFA works in sense that significant improvements c.f. energy sum

M.Thomson

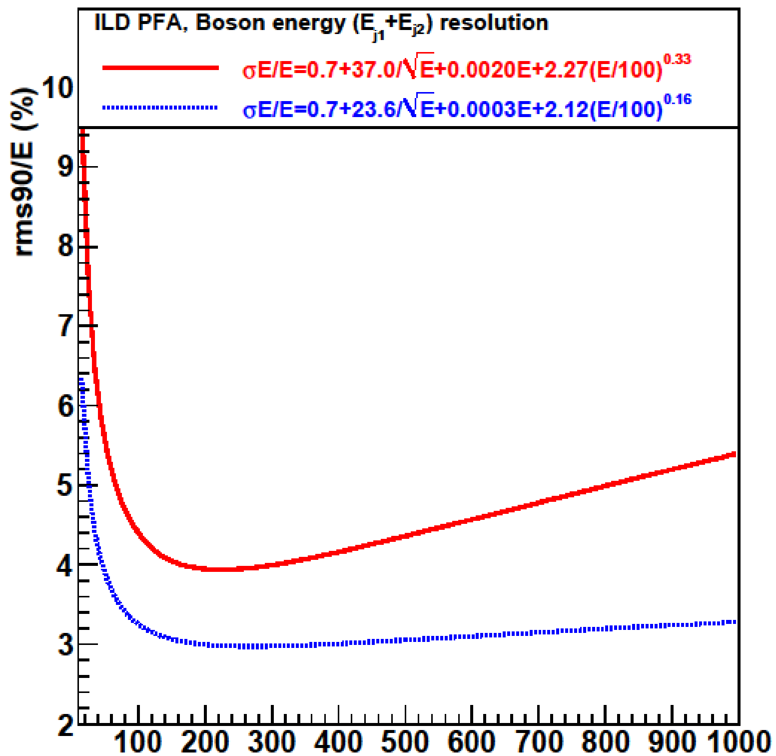
Jet energy resolution and $\tilde{\chi}_1^\pm$ mass fit

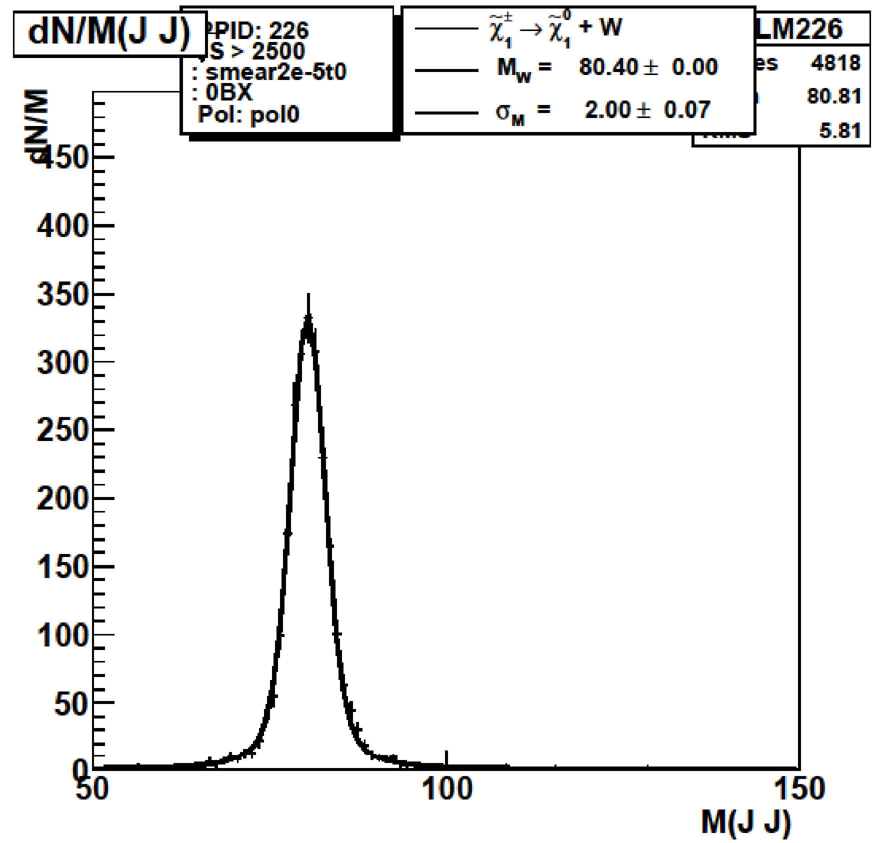




σEj/Ej (left) for jets smeared with two different values of the confusion term (0.3 blue, 0.6 red). $\tilde{\chi}_1^\pm$ mass fit (right), the mass and the boson energy resolution parameters are fitted.

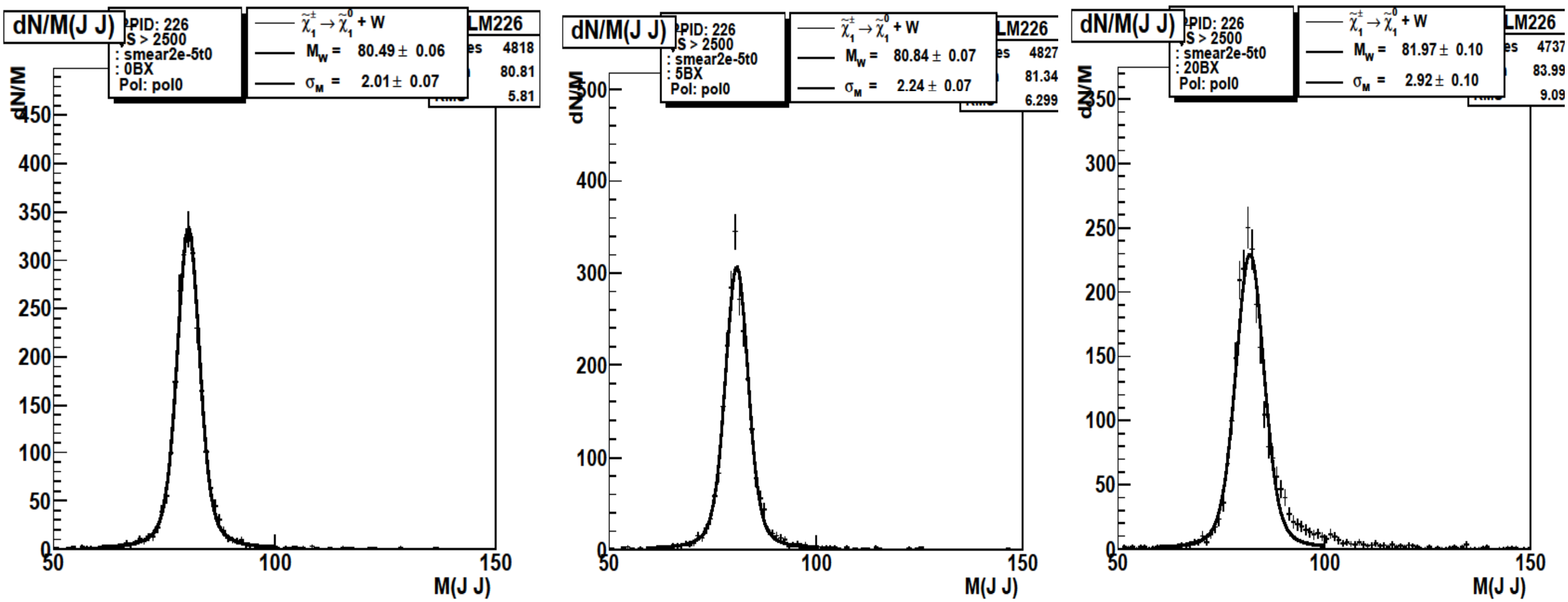
$\tilde{\chi}_1^{\pm} \to \tilde{\chi}_1^{o}$ +W
W energy and mass resolution





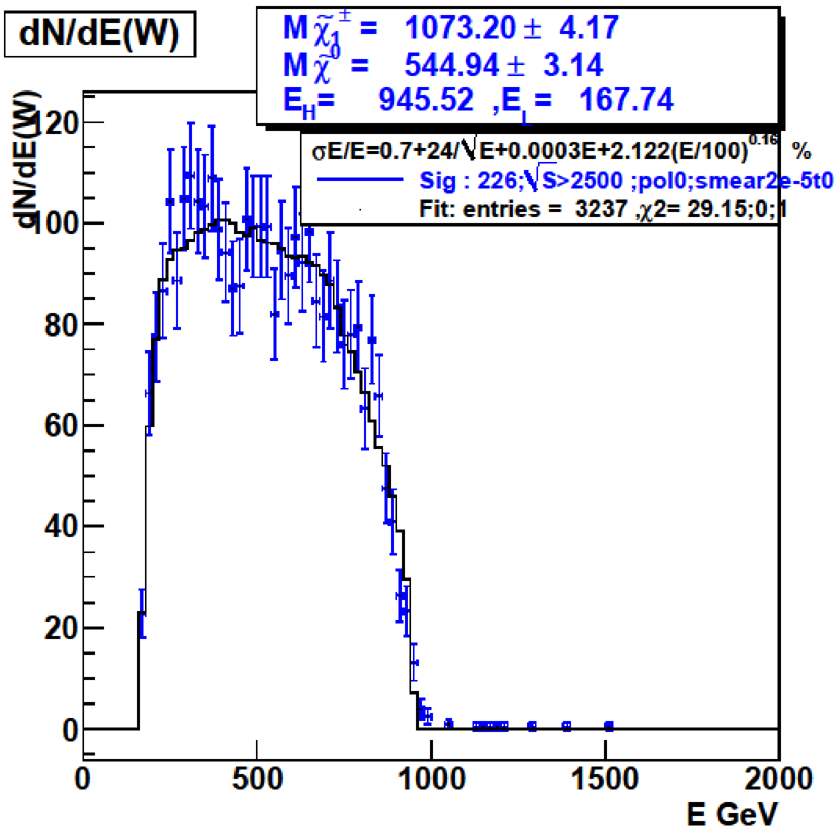
For a confusion term value=0.3, the W energy resolution(left) has a mild energy dependence; σE/E ~ 3.0% (blue curve), for 0.6 σE/E ~4.% (red curve). The corresponding W mass resolution is σM/M ~ 2.5 % for the blue curve and 3.2% for the red curve; M is fixed; and σ=σ(W)xσM ; σ(W)=2.14 GeV (W width).

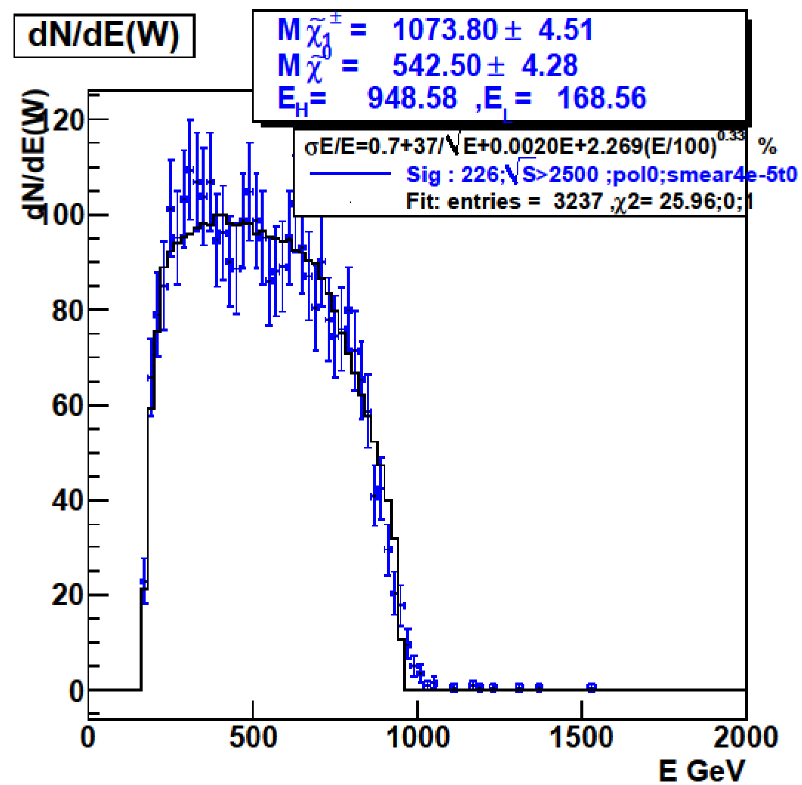
$\tilde{\chi}_1^{\pm}$ -> $\tilde{\chi}_1^{o}$ +W
W mass resolution



W energy resolution, M and σ parameters kept free in the fit:
0Bx (left), 5BX(middle) and 20Bx (right); for 5Bx, σM/M ~ 2.8%; for 20BX (right) it increases to 3.7 % and the central mass value is significantly shifted.

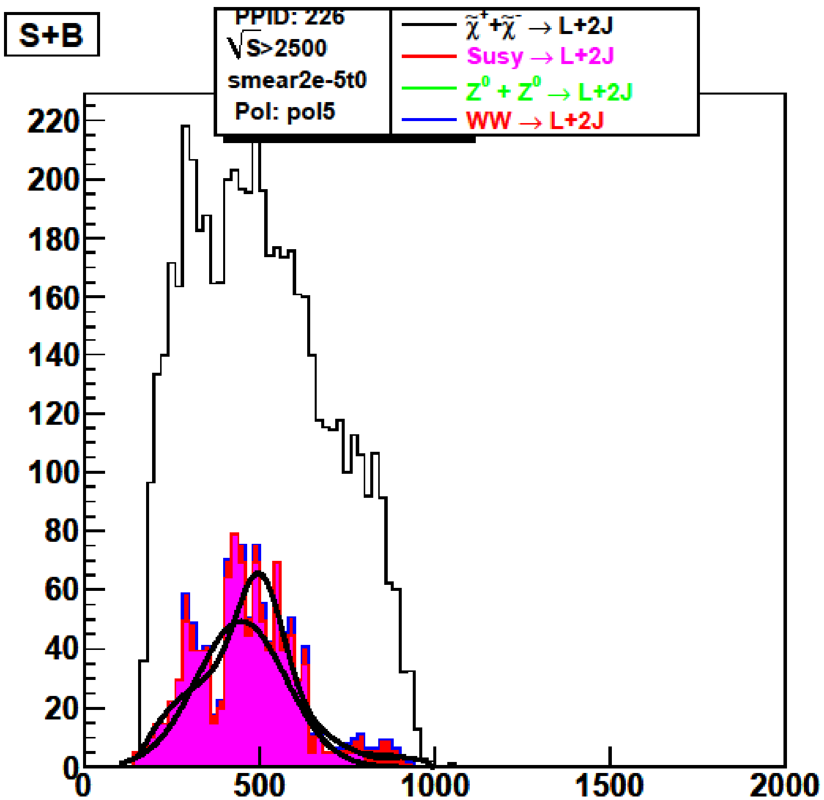
$\tilde{\chi}_1\pm$-> $\tilde{\chi}_1^{o}$ + W (dN/dE fit)

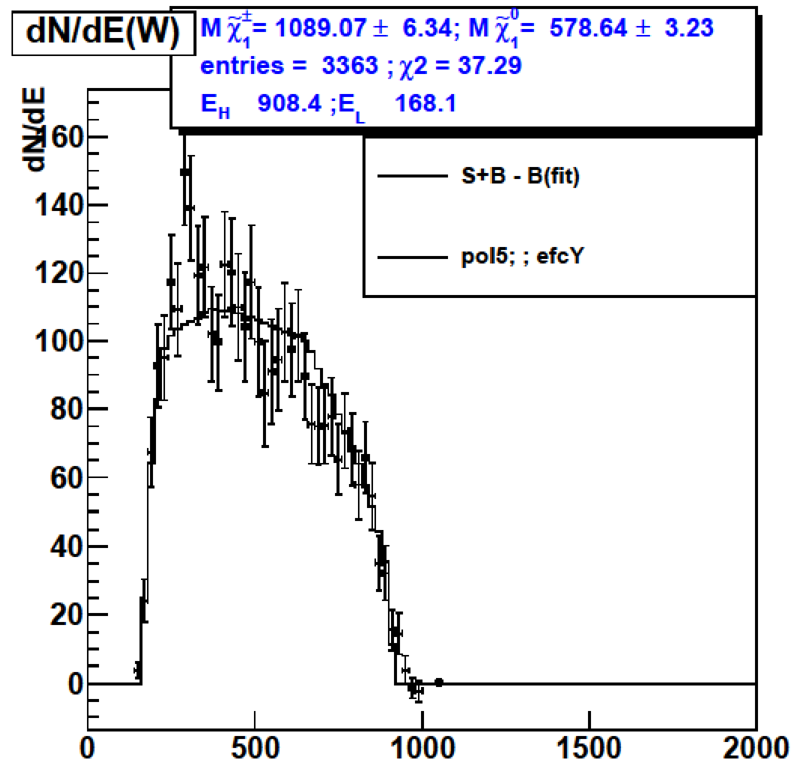




For σE/E ~ 3.0% the mass resolution is σM($\tilde{\chi}_1\pm$) = 4.2 GeV and σM($\tilde{\chi}_1^{o}$)=3.1GeV
For σE/E ~ 4.0% the mass resolution is σM($\tilde{\chi}_1\pm$) = 4.5 GeV and σM($\tilde{\chi}_1^{o}$)=4.3 GeV

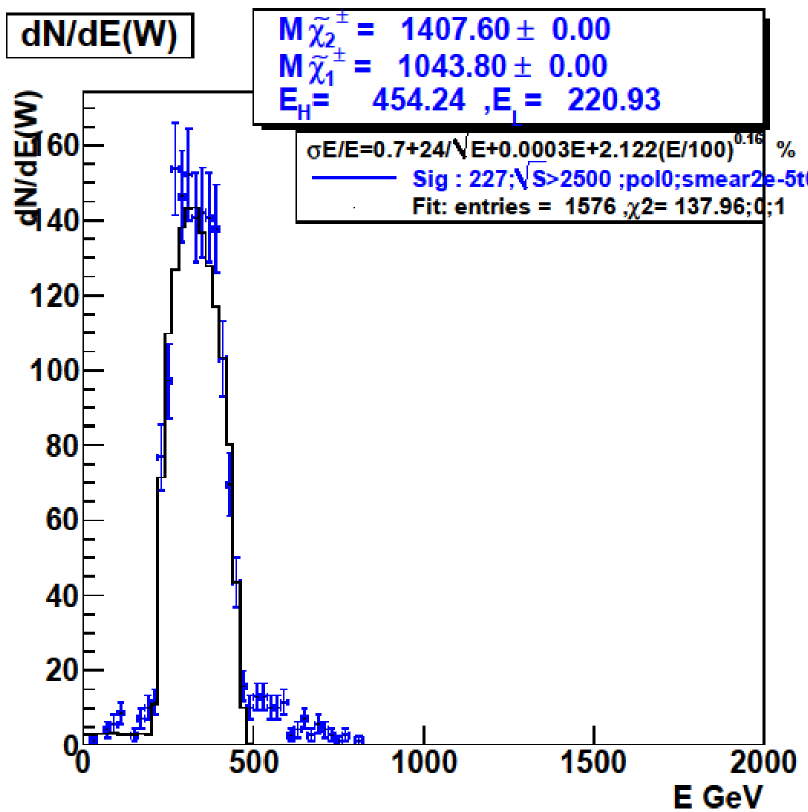
$\tilde{\chi}_1 \pm \text{->} \tilde{\chi}_1^{o}$ + W (S+B fit)

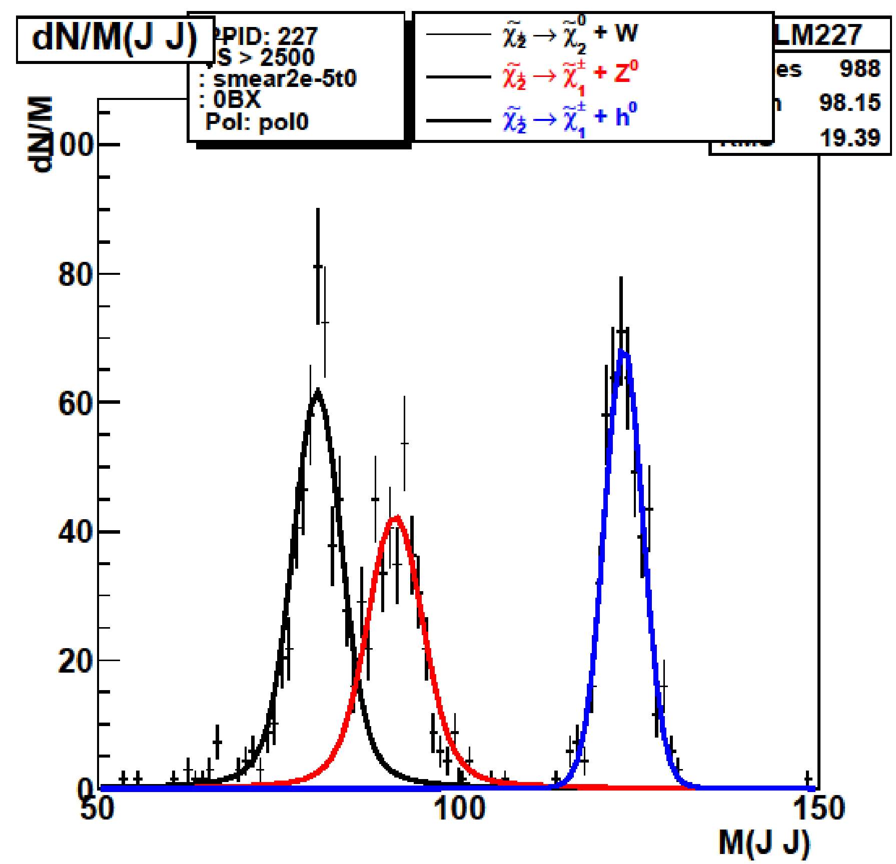




The main background is coming from $\tilde{\mu}$, $\tilde{e}$, or $\tilde{\nu}$ →$\tilde{\chi}_1\pm$ + μ, e, ν with a smaller contribution from WW and ZZ. With polarization (80,0):
For σE/E ~ 3.0% the mass resolution are σM($\tilde{\chi}_1\pm$) = 6.3 GeV and σM($\tilde{\chi}_1^{0}$)=3.3 GeV

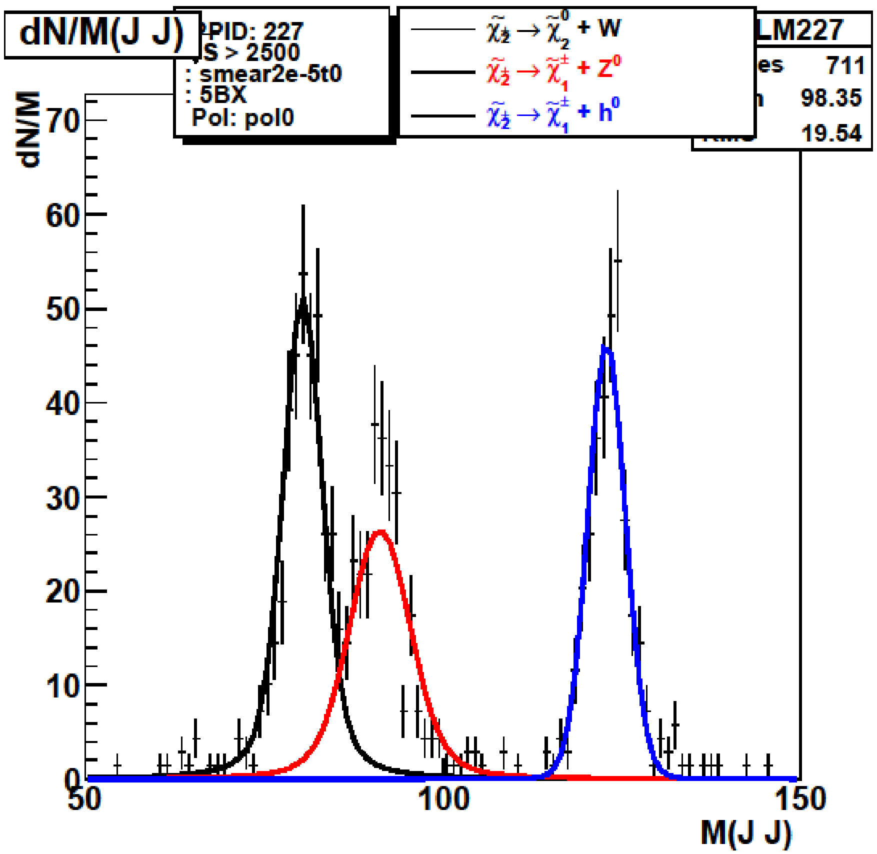
$\tilde{\chi}_2^\pm \to \tilde{\chi}_1^\pm$ or $\tilde{\chi}_2^0 + W/Z^0/h^0$ Boson energy and mass resolution

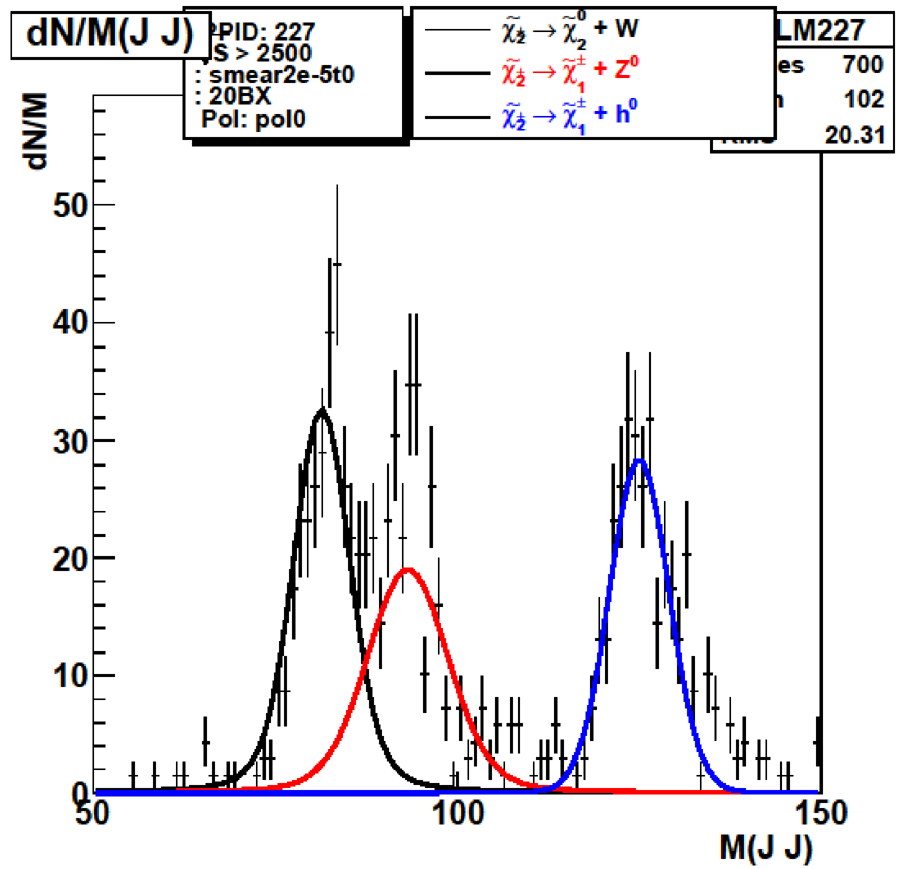




Boson ($W\pm$, Z^0, h^0) energy distribution(left) and fit; to tell apart $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_2^0$ requires to identify W and Z decays, with a mass resolution ~2.5% the W, Z statistical separation is reasonable; issue with error matrix to address, bad convergence.

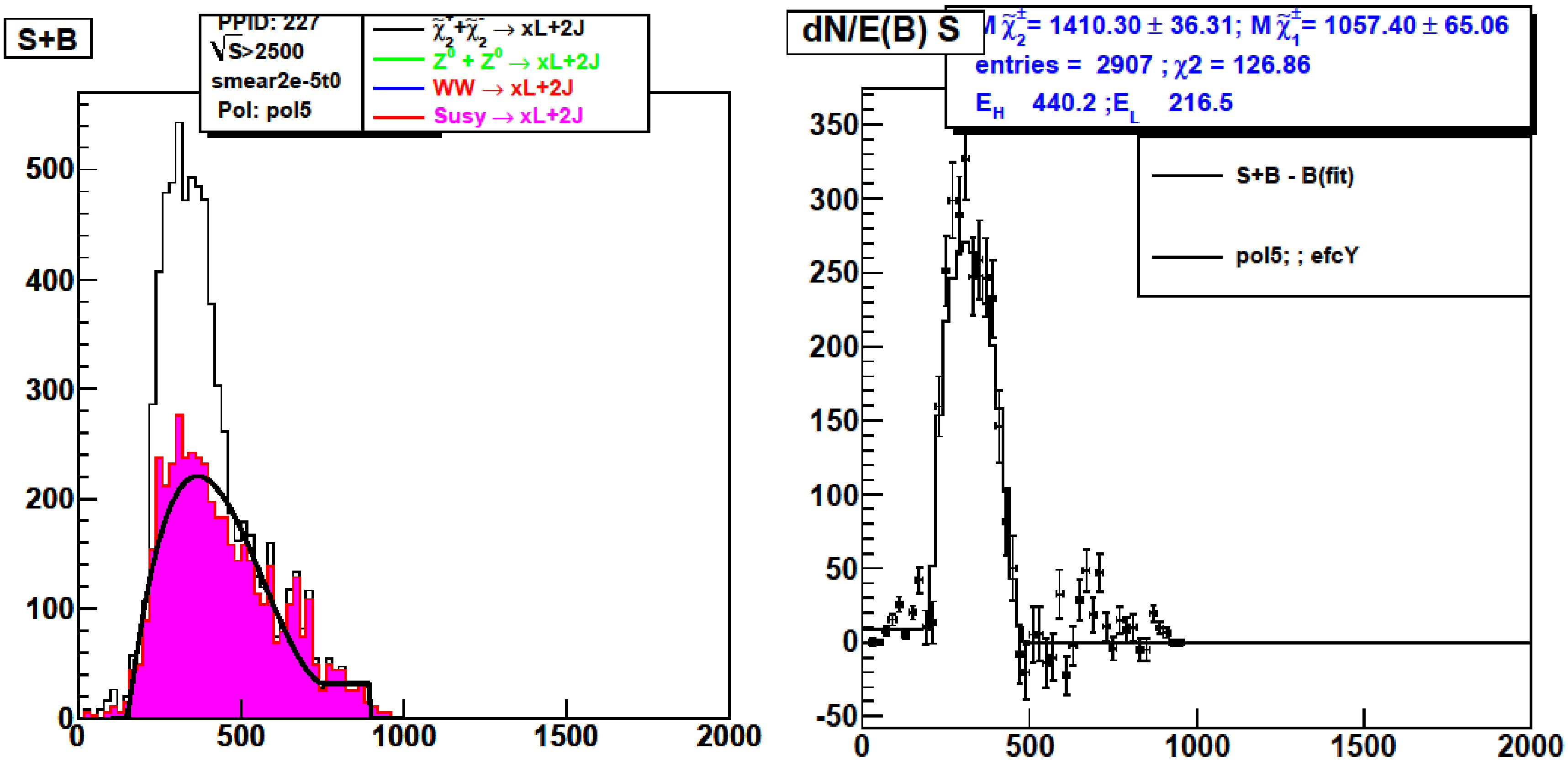
$\tilde{\chi}_2^{\pm}$ -> $\tilde{\chi}_1^{\pm}$ or $\tilde{\chi}_2^{0}$ + $W/Z^0/h^0$
Boson mass resolution





W, Z and h0 mass distributions and fits; 5BX (left) and 20 BX (right)
For 20BX the W, Z separation becomes marginal, b tagging needed.

$\tilde{\chi}_2\pm$-> $\tilde{\chi}_1\pm$ or $\tilde{\chi}_2^{o}$ + W/Z/h



W or Z or H energy distribution for $\tilde{\chi}_2\pm$ -> $\chi_1\pm$ or $\tilde{\chi}_2$ (left) the background is coming from SUSY processes (signal). dN/dE fit after background subtraction (right). Problems with fit, to address

Jet Energy resolution

Objects of mass 91,200,500, 1000, … Gev were produced at 91,200,500,1000, … Gev decay at rest into uds jets. The events are simulated with Mokka, Marlin.

The jet energy is obtained using Durham jet finder, forcing the event into two jets

Two histograms are produced

H1JER which is filled for each jet value je1 and je2

H1TER which is filled with je1+je2

Two different resolutions are computed

from H1JER: jerd=Rms90j/Mean

from H1TER: jert=Rms90t/(sqrt(2)*0.5*Meant) (ILD PFA definition)

	meanj	Rms90j	jerd	Meant	Rms90t	jert	Paper
|cos(theta)|<0.7							
√s= 90 GeV	45.43	2.61	0.057	90.79	2.51	0.039	0.037
√s=200 GeV	100.29	4.32	0.043	200.62	4.58	0.034	0.029
√s=500 GeV	249.89	14.16	0.053	499.74	13.27	0.038	0.028
without theta cut							
			0.063			0.046	
			0.047			0.039	
			0.056			0.043	

1, 2, 3 Tev data under production.

Summary

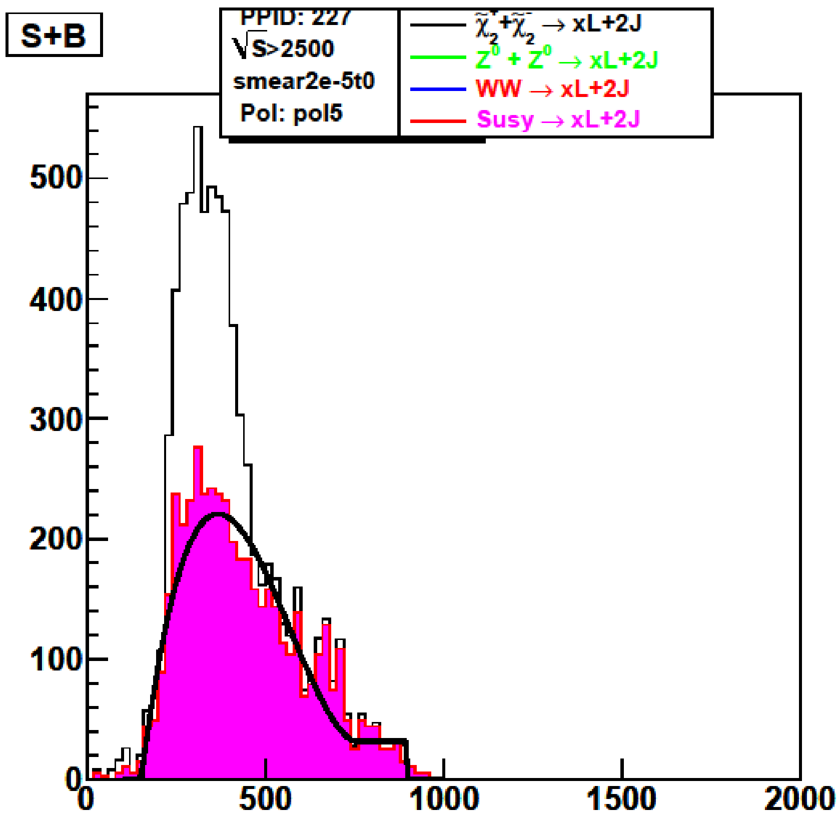
The chargino2, 1 and neutralino masses can be extracted from a fit to the W, Z, h energy distributions. At 3 TeV, the main sources to the errors on the charginos and neutralino masses are:

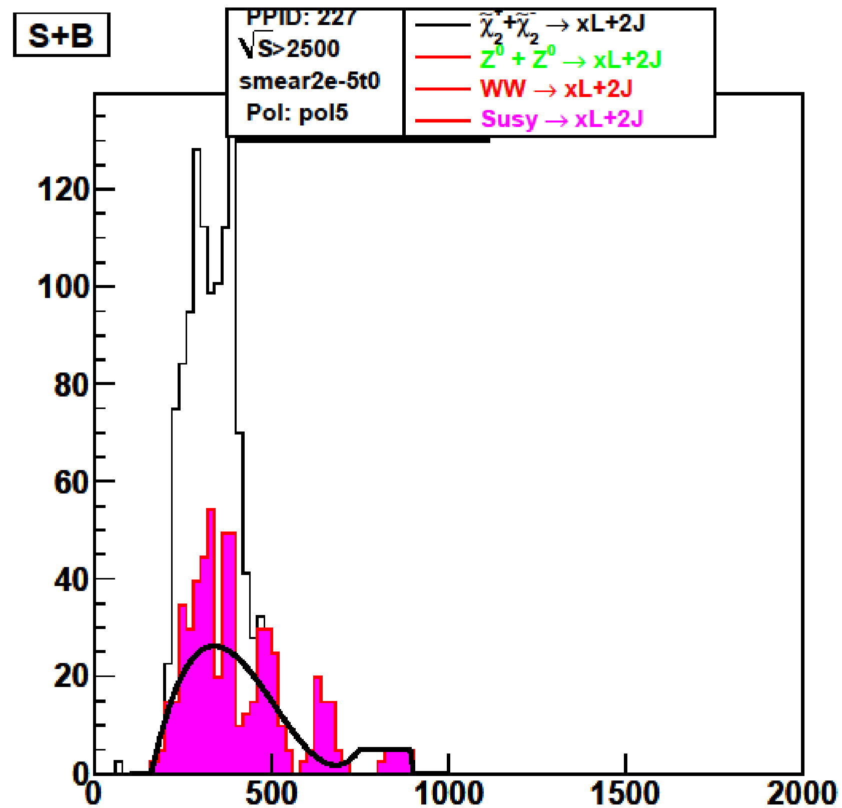
- The background estimation and subtraction.
- The luminosity spectrum modeling.
- The jet energy resolution.

To reach a statistical accuracy of ~ 1 % , on the masses requires:

- 2 ab^{-1} of integrated luminosity
- Excellent jet energy resolution and b tagging to identify W ,Z^0 and H° decays.
- Electron and positron beam polarization to increase the S/B ratio
- Good control of the luminosity spectrum, ISR and beamstrahlung.
- Good lepton ID (e, mu, tau) to identify the right event topology
- Bunch tagging capability <= 5BX to minimize the energy resolution degradation coming from the $\gamma\gamma \rightarrow h$ pile up.
- Jet energy resolution worse then the one quoted; rather ~5,6 % => redo the work.

$\tilde{\chi}_2^{\pm} \to \tilde{\chi}_1^{\pm}$ or $\tilde{\chi}_2^{0}$ + W/Z/h





W, Z or H energy distribution For $\tilde{\chi}_2^{\pm} \to \tilde{\chi}_1^{\pm}$ or $\tilde{\chi}^0_2$ (left)

For $\tilde{\chi}_2^{\pm} \to \tilde{\chi}_1^{\pm}$ Z (right), the background is $\tilde{\chi}_4^0 \to \tilde{\chi}_1^0$, $\tilde{\chi}_3^0 \to \tilde{\chi}_1^0$, $\tilde{\chi}_3^0 \to \tilde{\chi}_2^0$ (half with pol5) and $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0$