

Right handed Scalar Muon Production in ILC

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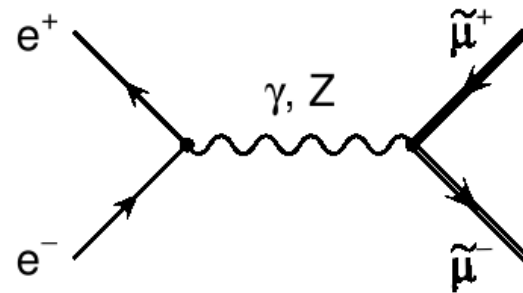
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- Introduction
- Event Generation
- Simulation & Reconstruction
- Analysis
- Results
- Summary & Outlook

Introduction

- MSSM. mSUGRA. SPS1a. 500GeV
- Right handed smuon production

$$e_L^+ e_R^- \rightarrow \tilde{\mu}_R \tilde{\mu}_R \rightarrow \mu^+ \mu^- \tilde{\chi}_1^0 \tilde{\chi}_1^0$$



- Backgrounds:

- ▶ Standard Model: $W^+W^- \rightarrow l^+ \nu_l \bar{l} \nu$ (81fb), $Z^0 Z^0 \rightarrow l^+ l^- \nu \nu$ (57fb)
- ▶ SUSY: $\tilde{\chi}_1^0 \tilde{\chi}_2^0$ (20fb), $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ (12fb)...

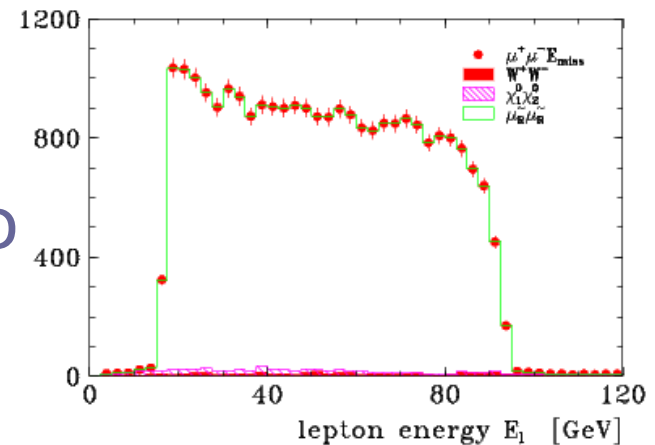
Introduction (cont.)

- we expect:
 - ▶ flat energy spectrum
 - ▶ high signal/backgrounds ratio

$$E_{+/-} = \frac{\sqrt{s}}{4} \left(1 - \frac{m_{\tilde{\chi}}^2}{m_{\tilde{\ell}}^2} \right) (1 \pm \beta)$$

$$m_{\tilde{\ell}} = \frac{\sqrt{s}}{E_- + E_+} \sqrt{E_- E_+}$$

$$m_{\tilde{\chi}} = m_{\tilde{\ell}} \sqrt{1 - \frac{E_- + E_+}{\sqrt{s}/2}}$$



Hans-Ulrich Martyn, LC-PHSM-2003-071
sqrt(s) = 400 GeV

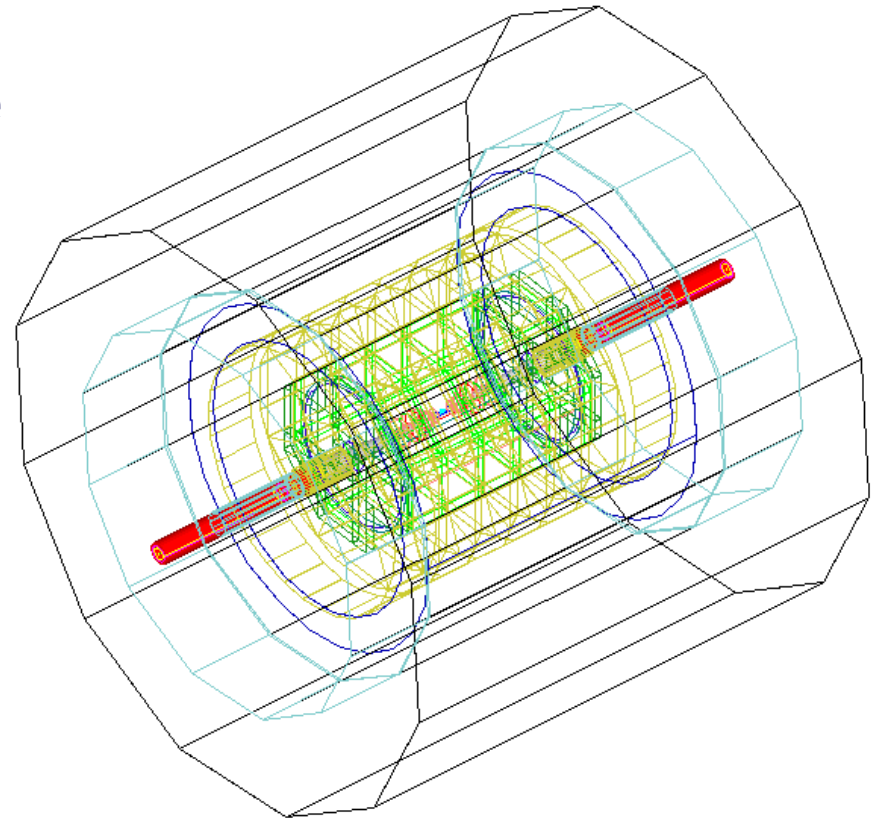
Events Generation

- **PYTHIA 6.410 + ISAJET 7.75**
- Beam polarization: $P(e^-)=80\%$, $P(e^+)=-60\%$
- Initial state beamstrahlung radiation: CIRCE
- Luminosity: 100 fb^{-1} .
- Typical values(mSUGRA SPS1a):
 - ▶ $\sigma = 135 \text{ fb}$.
 - ▶ $m(\tilde{\mu}_R) = 142.52 \text{ GeV}$
 - ▶ $m(\tilde{\chi}_1^0) = 97.36 \text{ GeV}$

Simulation and Reconstruction

- Simulation was done with Mokka LDCSc01
- Reconstruction was done with Marlin&MarlinReco

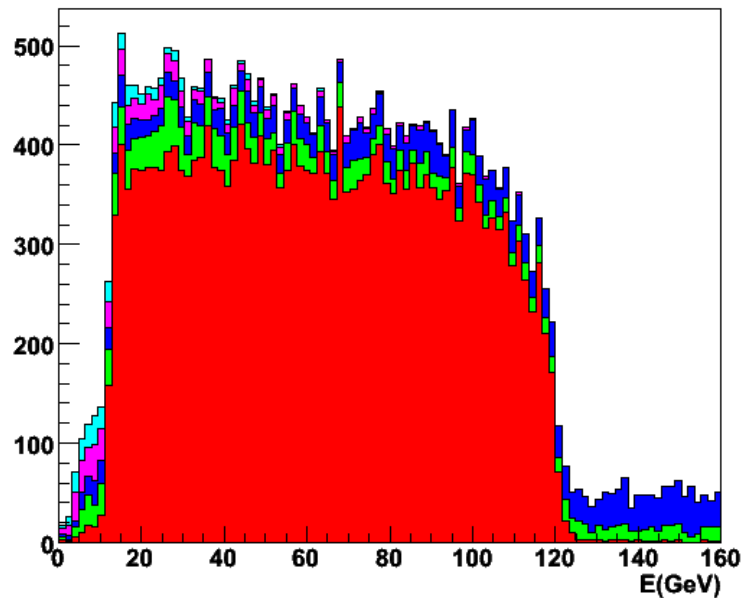
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- Particle information are stored in root file.

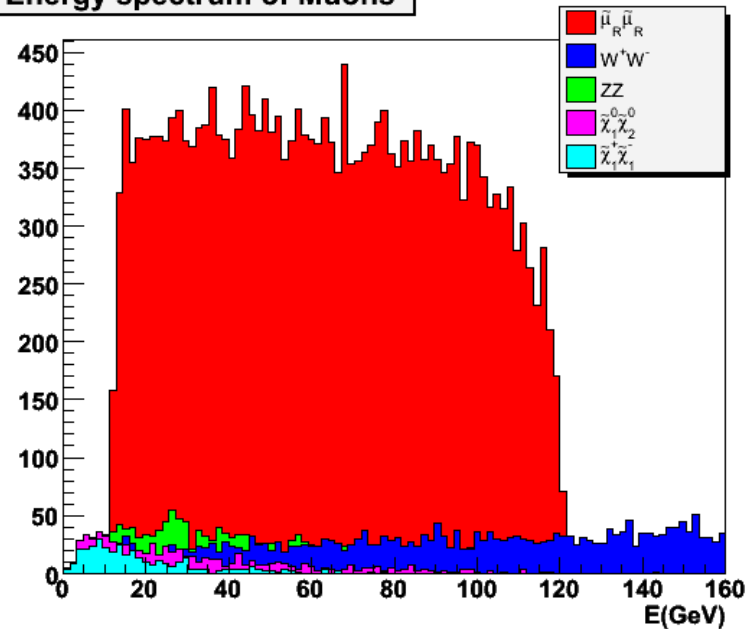
Energy Spectrum after Reconstruction (before cut)

Energy spectrum of Muons



Stack View

Energy spectrum of Muons



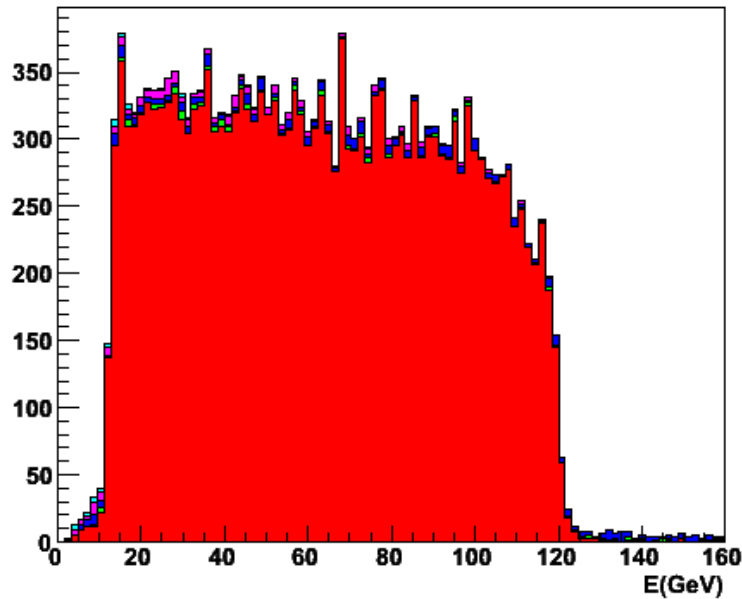
No Stack View

Analysis

- Safe cuts:
 - ▶ Select events with only 2 muons and at most 3 charged particles.
 - ▶ Reject soft muons.
 - ▶ Angular separation of two muons.
 - ▶ Reject missing momentum in forward/backward region from particles lost in the beam pipe.
- Unsafe cuts(depends on the mass of smuons and neutralinos):
 - ▶ Missing Energy (Suppress backgrounds from W pairs)
 - ▶ Recoil Mass (Suppress backgrounds from Z pairs)

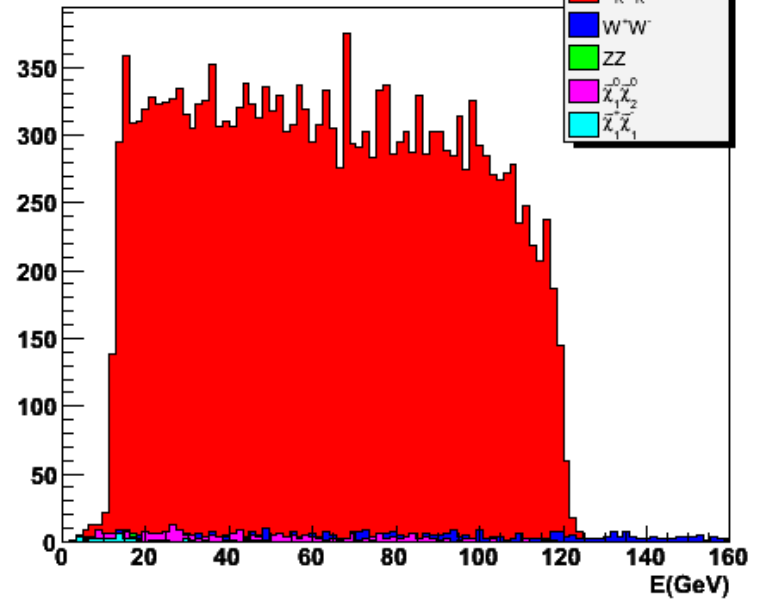
Spectrum After Cuts

Energy spectrum of Muons



Stack View

Energy spectrum of Muons



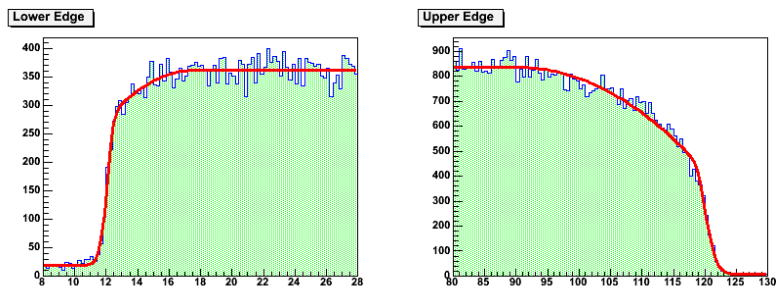
No Stack View

Number of muons from different process:

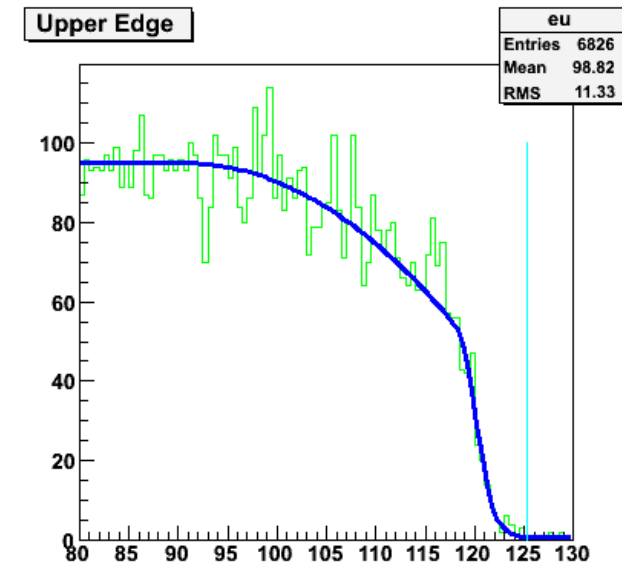
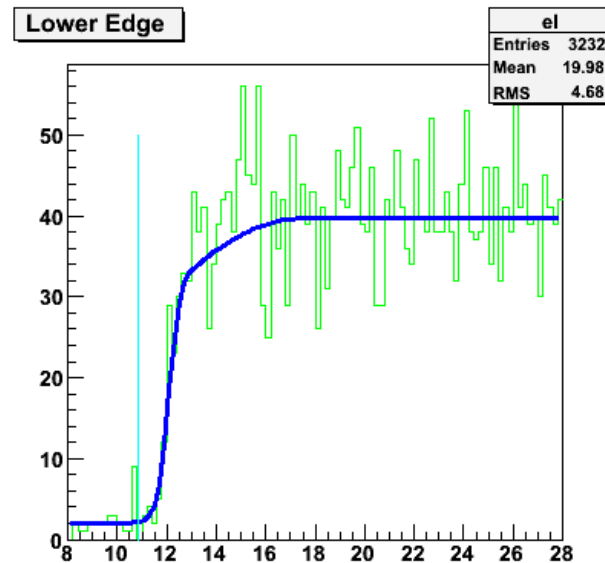
	Singal	W pairs	Z pairs	Neutrinos	Charginos
Before Cut	24411	2712	2161	696	343
After Cut	20364	418	140	253	42

Endpoint Energy

- End point energy is got by fitting the edge of the spectrum.
- High statistic data(900fb⁻¹) is used to get some of the the fitting parameters. (Caution: Background is not considered now.)



$$f(E) = \begin{cases} \frac{a_2}{1 + e^{\frac{a_0 - E}{a_1}}} + a_3, & E < E_1 \\ b(E - a_4)^2 + a_5, & E_1 \leq E \leq E_2 \\ a_5, & E_2 < E \end{cases}$$



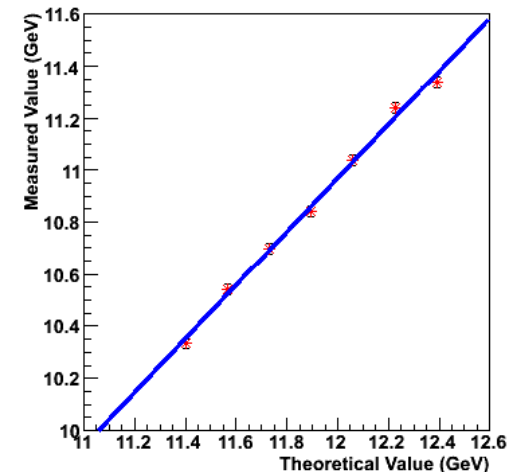
$$E_- = 10.86 \pm 0.06 \text{ GeV}$$

$$E_+ = 125.32 \pm 0.13 \text{ GeV}$$

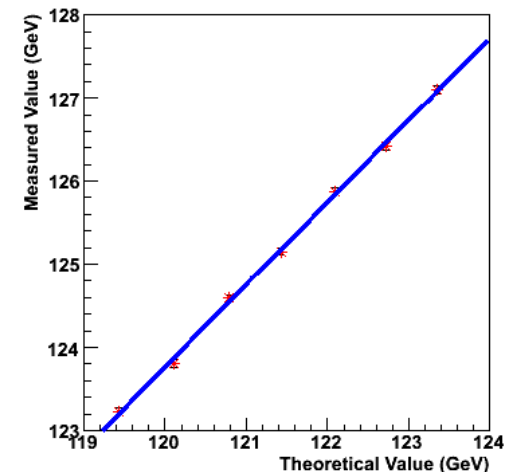
Calibration

- End point energy is smeared by the resolution => It's necessary for calibration.
 - ▶ High statistic events of smuon pairs with different mass.
 - ▶ Same cuts are applied.
 - ▶ Using the same shape of function to fit the edge.
 - ▶ Relation between predicted value and measured value.

Calibration of Lower Edge Energy

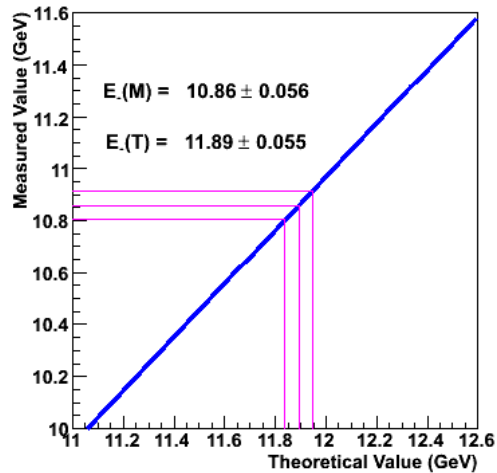


Calibration of Upper Edge Energy

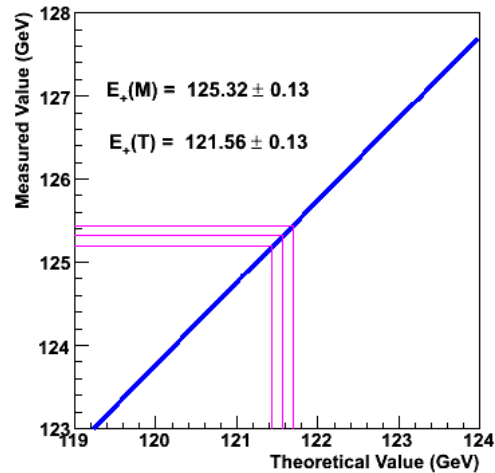


Results

Calibration of Lower Edge Energy



Calibration of Upper Edge Energy



$$E_- = 11.89 \pm 0.05 \text{ GeV}$$

$$E_+ = 121.56 \pm 0.13 \text{ GeV}$$

Input: $m_{\tilde{\mu}_R} = 142.52 \text{ GeV}$

$m_{\tilde{\chi}_1^0} = 97.36 \text{ GeV}$

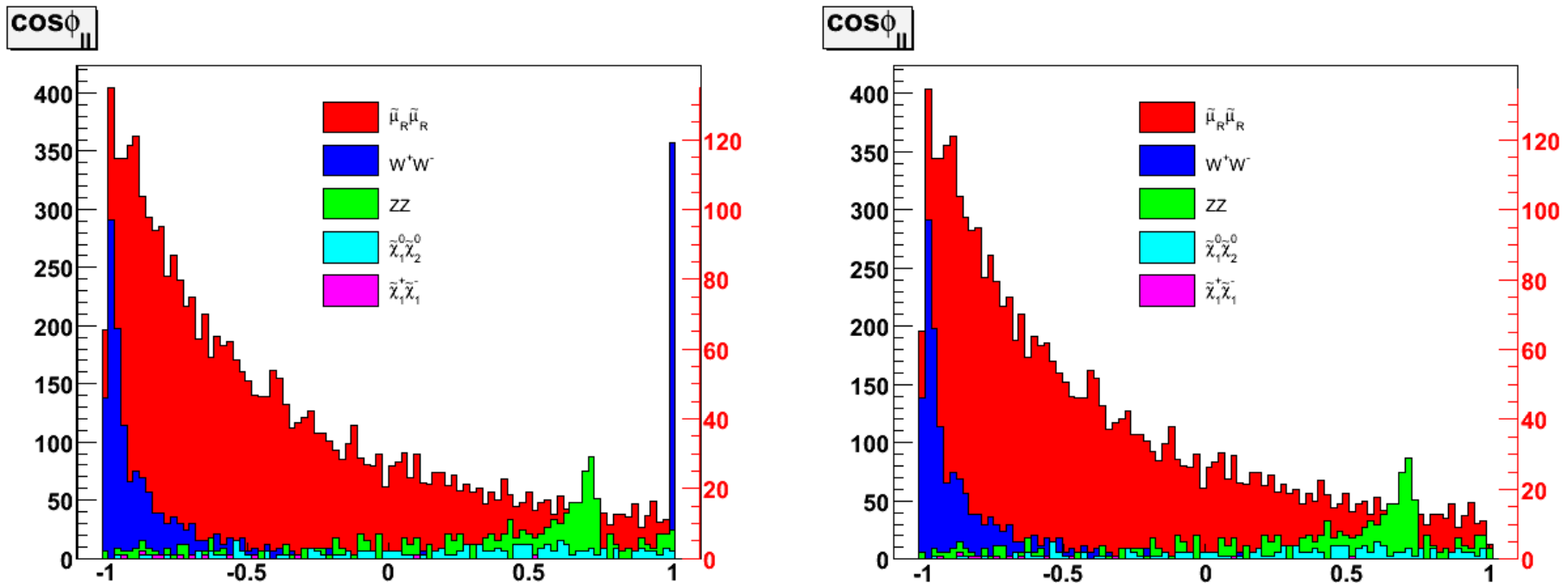
Calculated: $m_{\tilde{\mu}_R} = 142.45 \pm 0.28 \text{ GeV}$

$m_{\tilde{\chi}_1^0} = 97.26 \pm 0.19 \text{ GeV}$

Summary & Outlook

- Production of right handed scalar muons in ILC was studied with existing tools.
- Cuts are efficient to suppress SM backgrounds.
- Calibration based on signal is done.
- Preliminary result about the masses of smuon and neutrino base on signal is given.
- To do:
 - ▶ Take backgrounds into account.
 - ▶ More aggressive cut?
 - ▶ Other properties of scalar muons.

Backup Slides: Study of Cut(1)

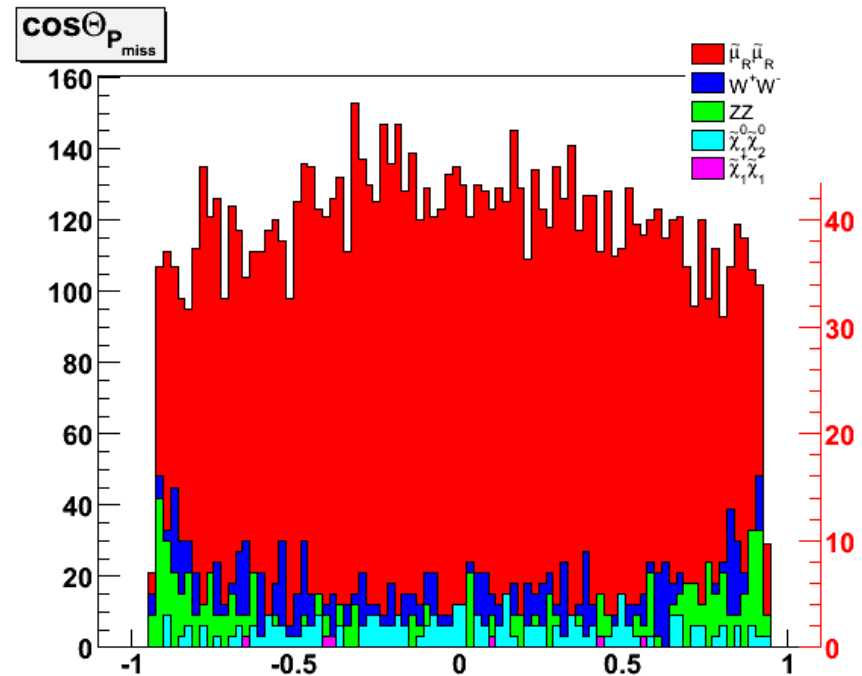
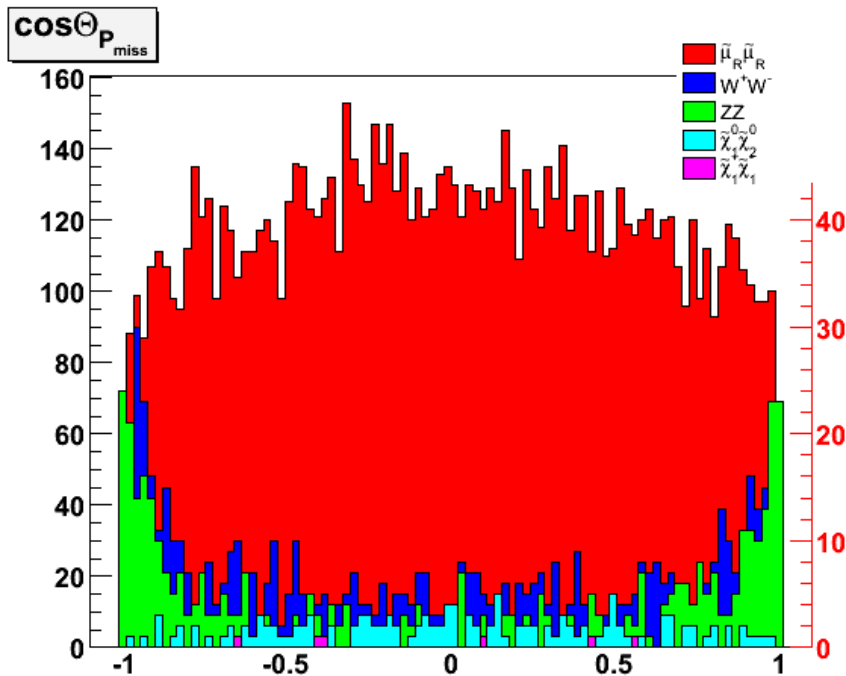


$\cos(\phi_{||}) < 0.998$

Number of events from different process:

	Singal	W pairs	Z pairs	Neutrinos	Charginos
Before Cut	10816	637	434	133	21
After Cut	10807	518	429	131	21

Backup Slides: Study of Cut(2)



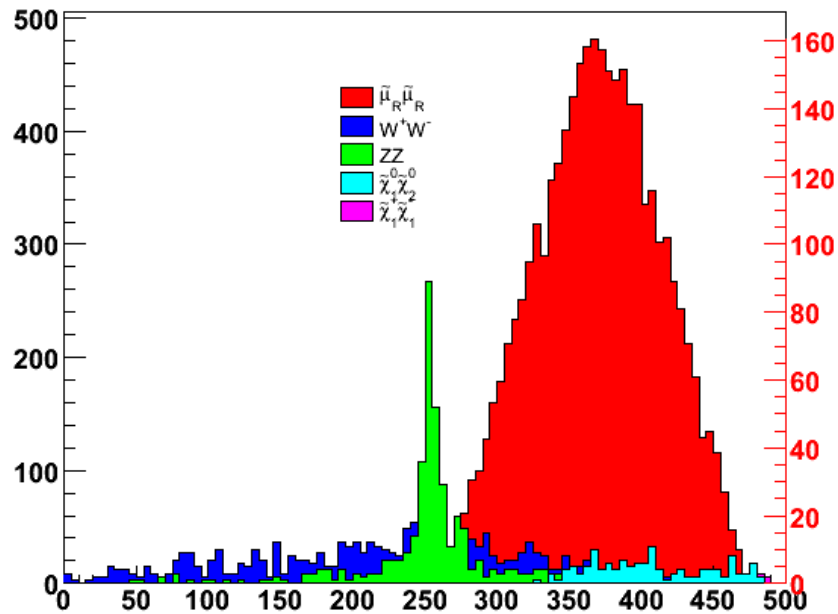
$|\cos(\theta_{pmiss})| < 0.93$

Number of events from different process:

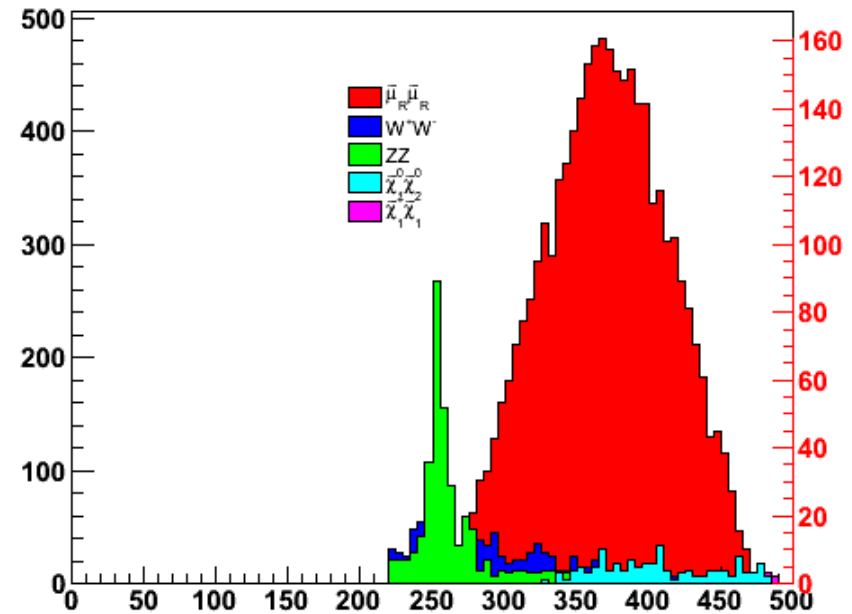
	Singal	W pairs	Z pairs	Neutrinos	Charginos
Before Cut	10816	637	434	133	21
After Cut	10204	518	296	129	21

Backup Slides: Study of Cut(3)

Missing Energy



Missing Energy



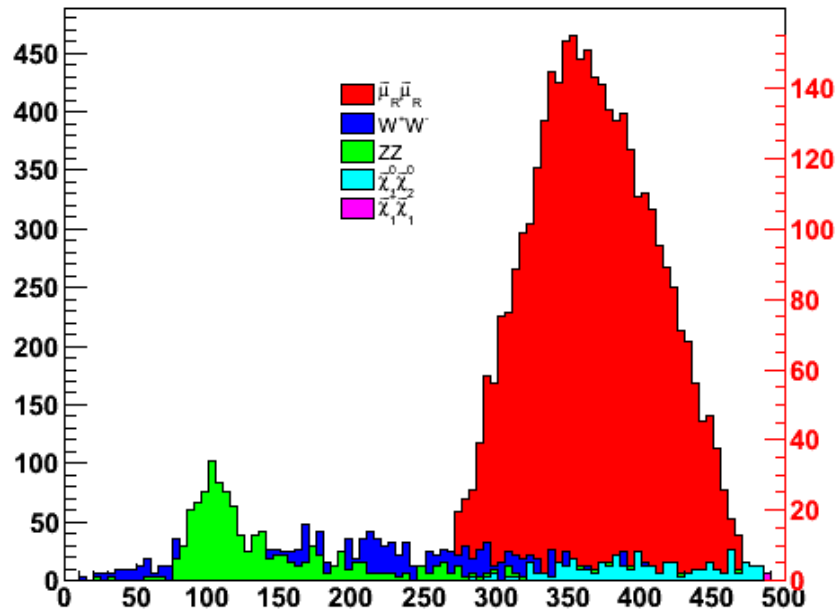
$E_{\text{miss}} > 220 \text{ GeV}$

Number of events from different process:

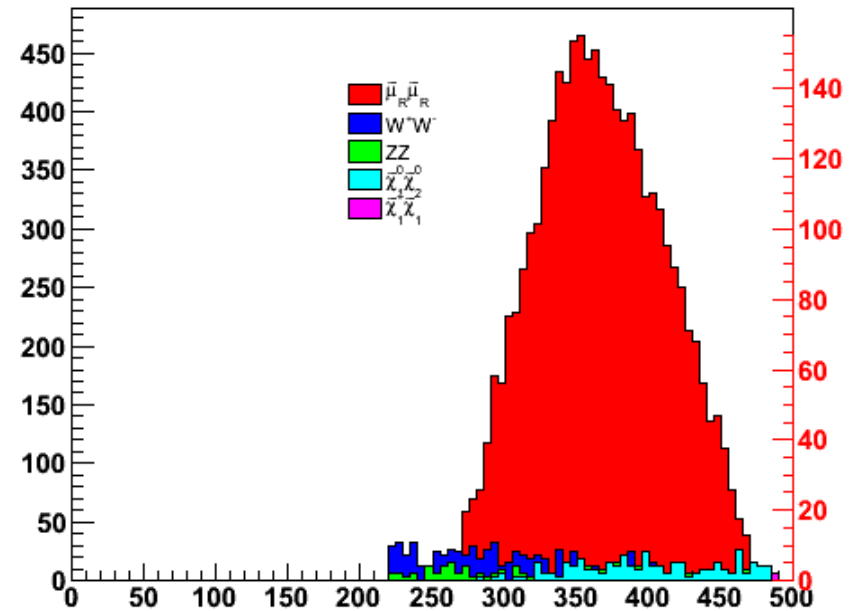
	Singal	W pairs	Z pairs	Neutrinos	Charginos
Before Cut	10816	637	434	133	21
After Cut	10804	316	385	133	21

Backup Slides: Study of Cut(4)

Recoil Mass



Recoil Mass

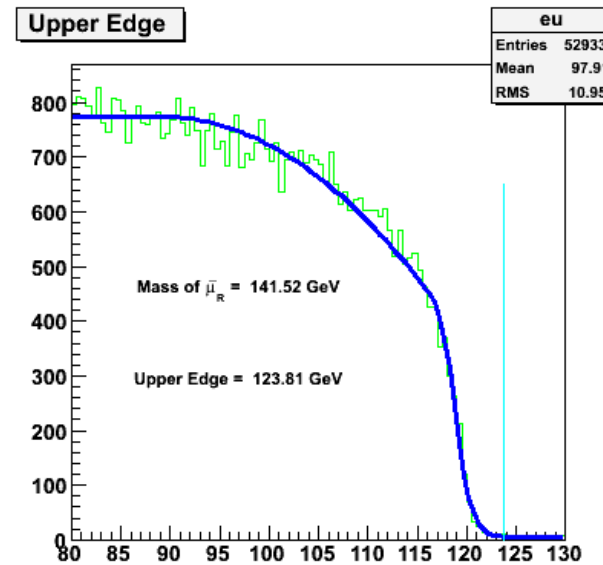
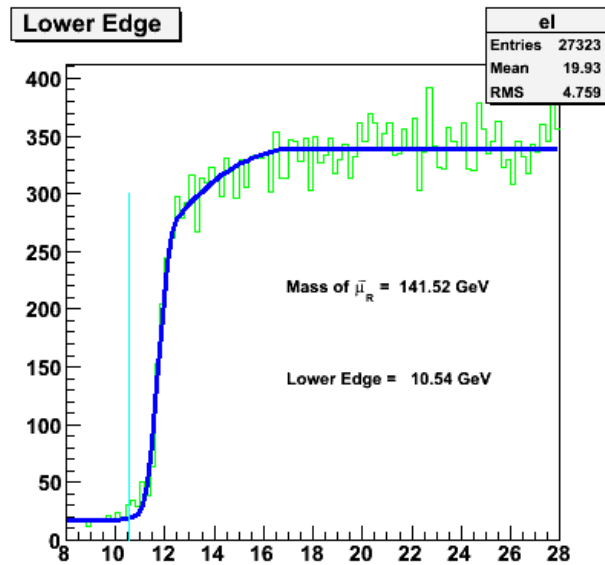
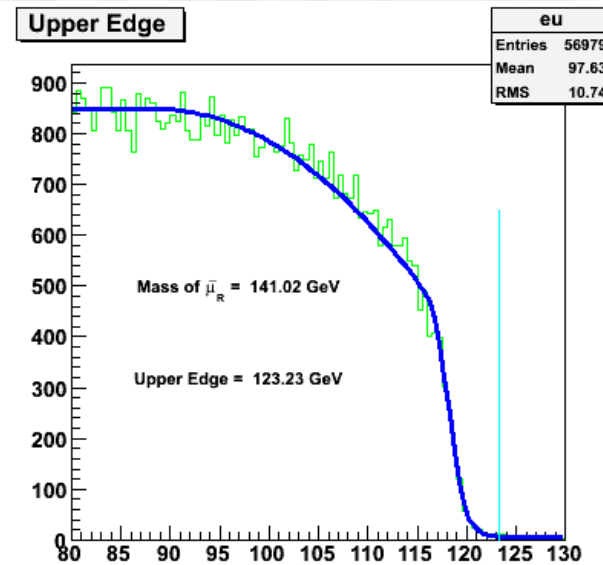
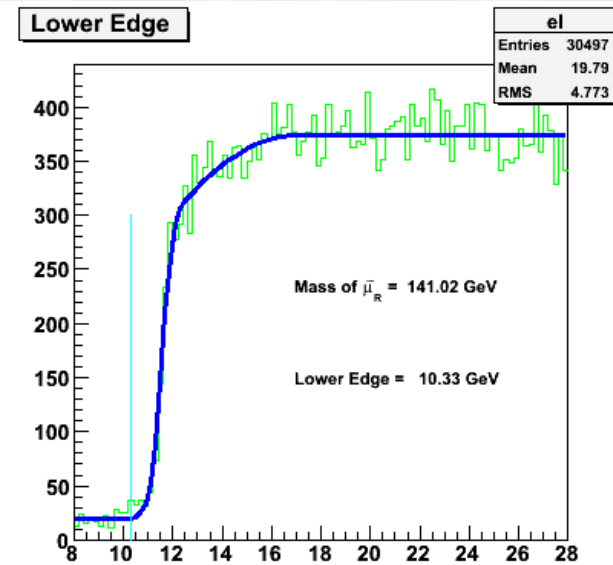


$M_{\text{recoil}} > 220 \text{ GeV}$

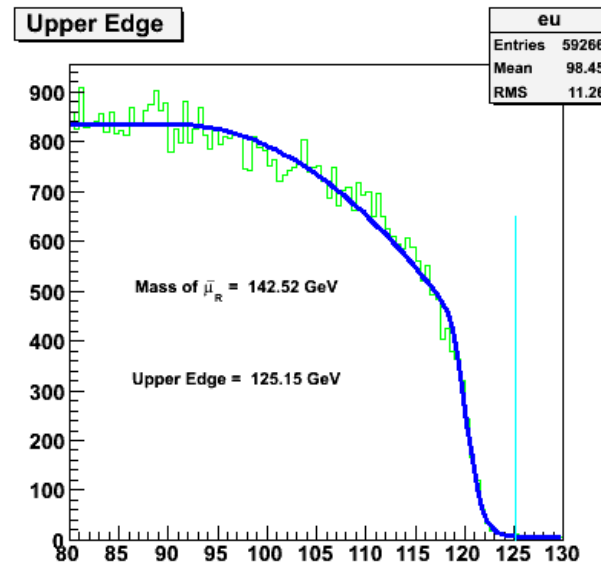
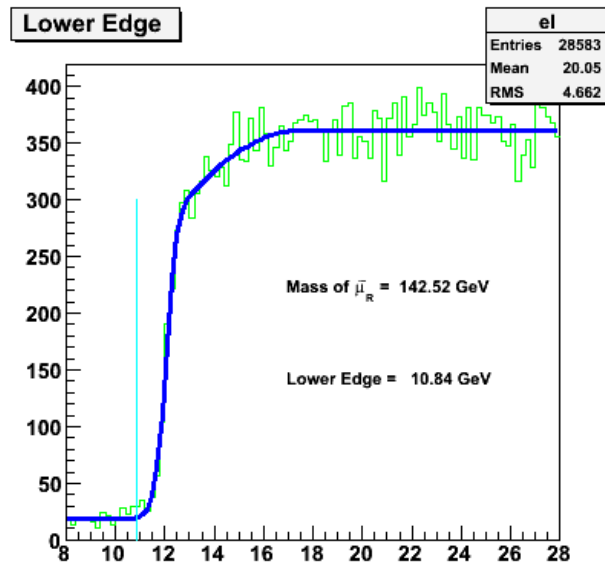
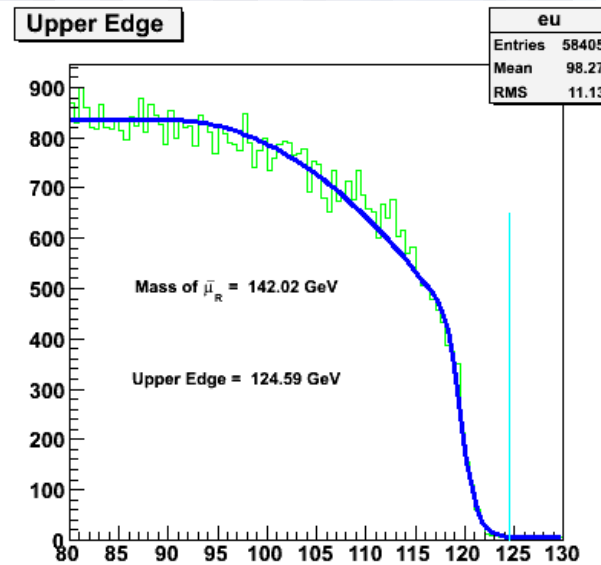
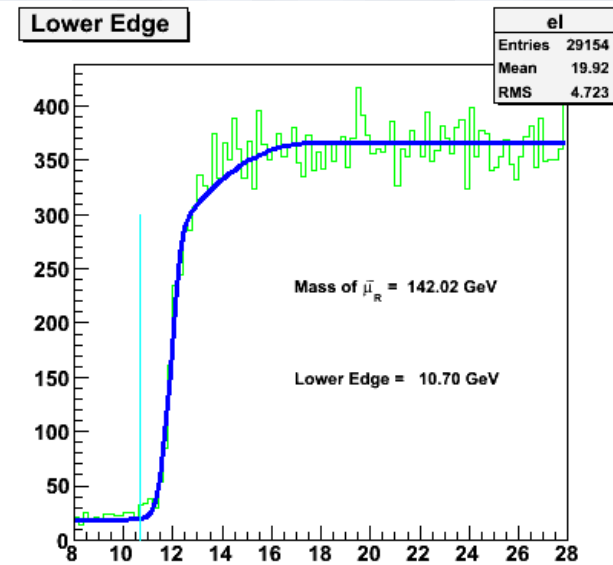
Number of events from different process:

	Singal	W pairs	Z pairs	Neutrinos	Charginos
Before Cut	10816	637	434	133	21
After Cut	10813	259	102	133	21

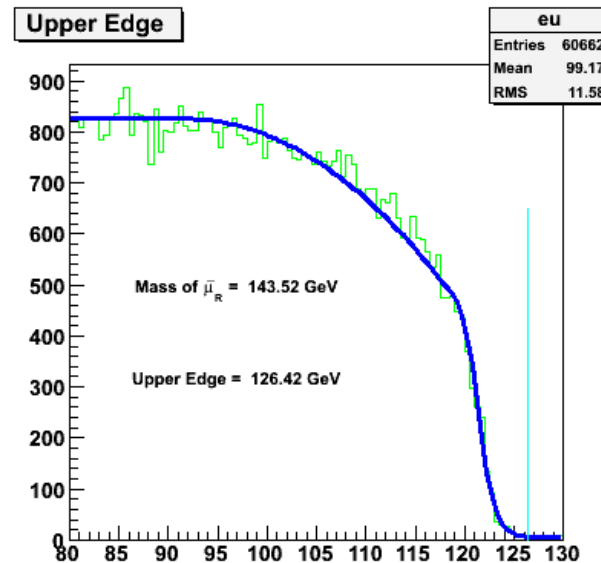
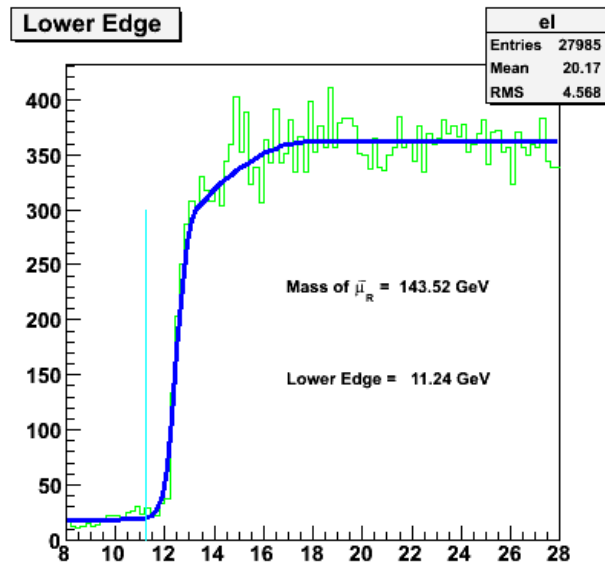
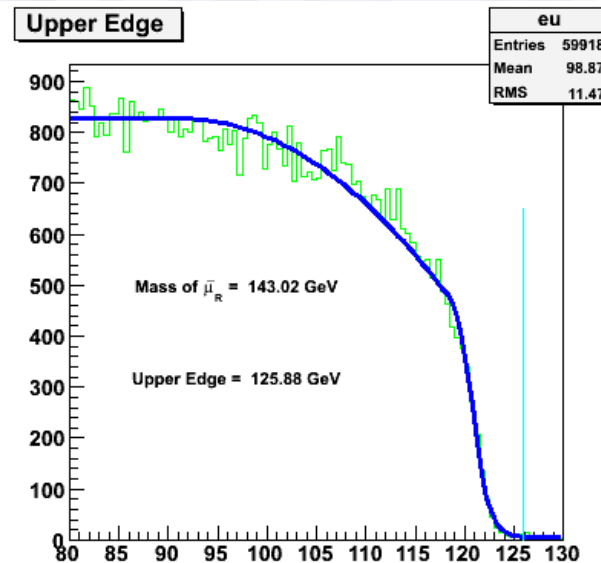
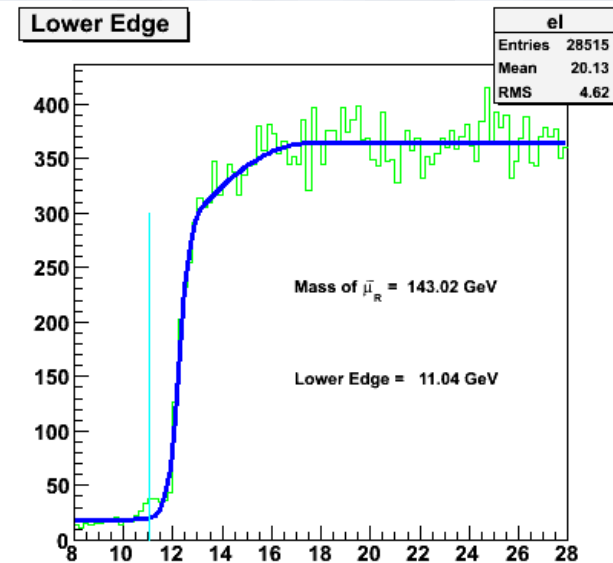
Backup Slides: Calibration(1)



Backup Slides: Calibration(2)



Backup Slides: Calibration(3)



Backup Slides: Calibration(4)

