SiD Study of ZH→eeH/μμH

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Event Selection

Main backgrounds: $e^+e^- \to \gamma\gamma\mu^+\mu^-$

$e^+e^- \to W^+W^- \to \mu^+\nu_\mu \mu^-\overline{\nu}_\mu$

$e^+e^- \to ZZ^* \to \mu^+\mu^- f\ \overline{f}$

$|\cos\theta_{\mu^+}| < 0.99$ $\quad |\cos\theta_{\mu^-}| < 0.99$

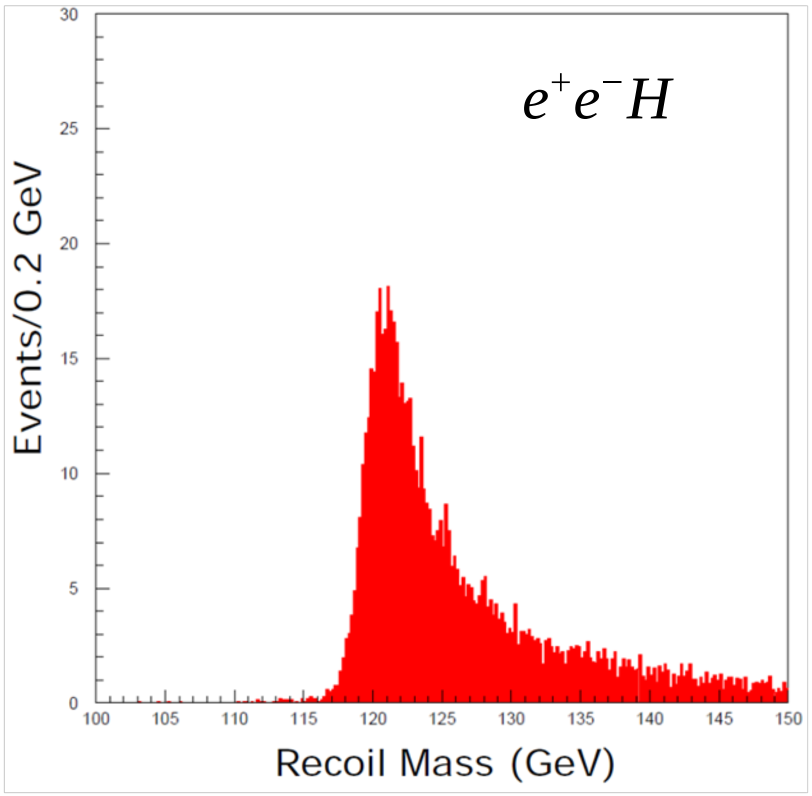
$|\cos\theta_{\mu^+\mu^-}| < 0.85$

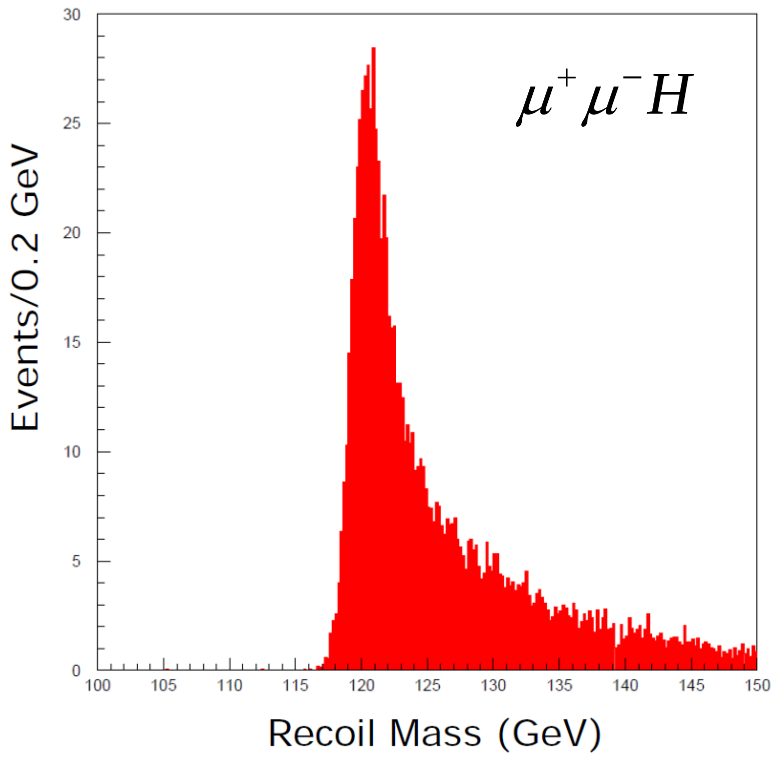
$87\ \text{GeV} < M_{\mu^+\mu^-} < 95\ \text{GeV}$

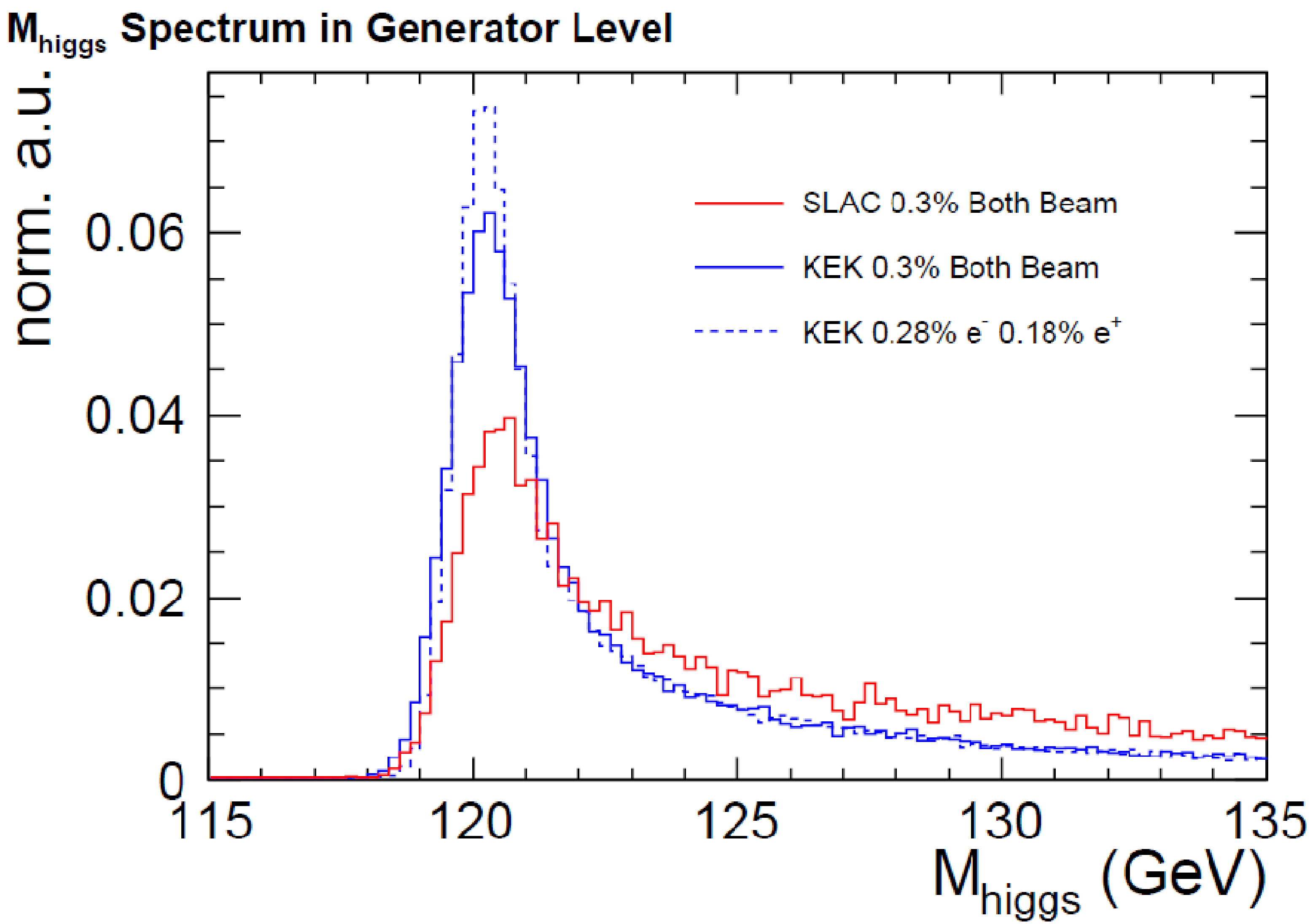
$|\cos\theta_{\text{missing}}| < 0.99$ (Only cut involving all visible particles;
we believe ZH efficiency for this cut
is independent of H decay mode.)

Cuts for e^+e^- are the same.

Signal only for 250 fb^{-1} with $e^-(80\%R)\, e^+(30\%L)$

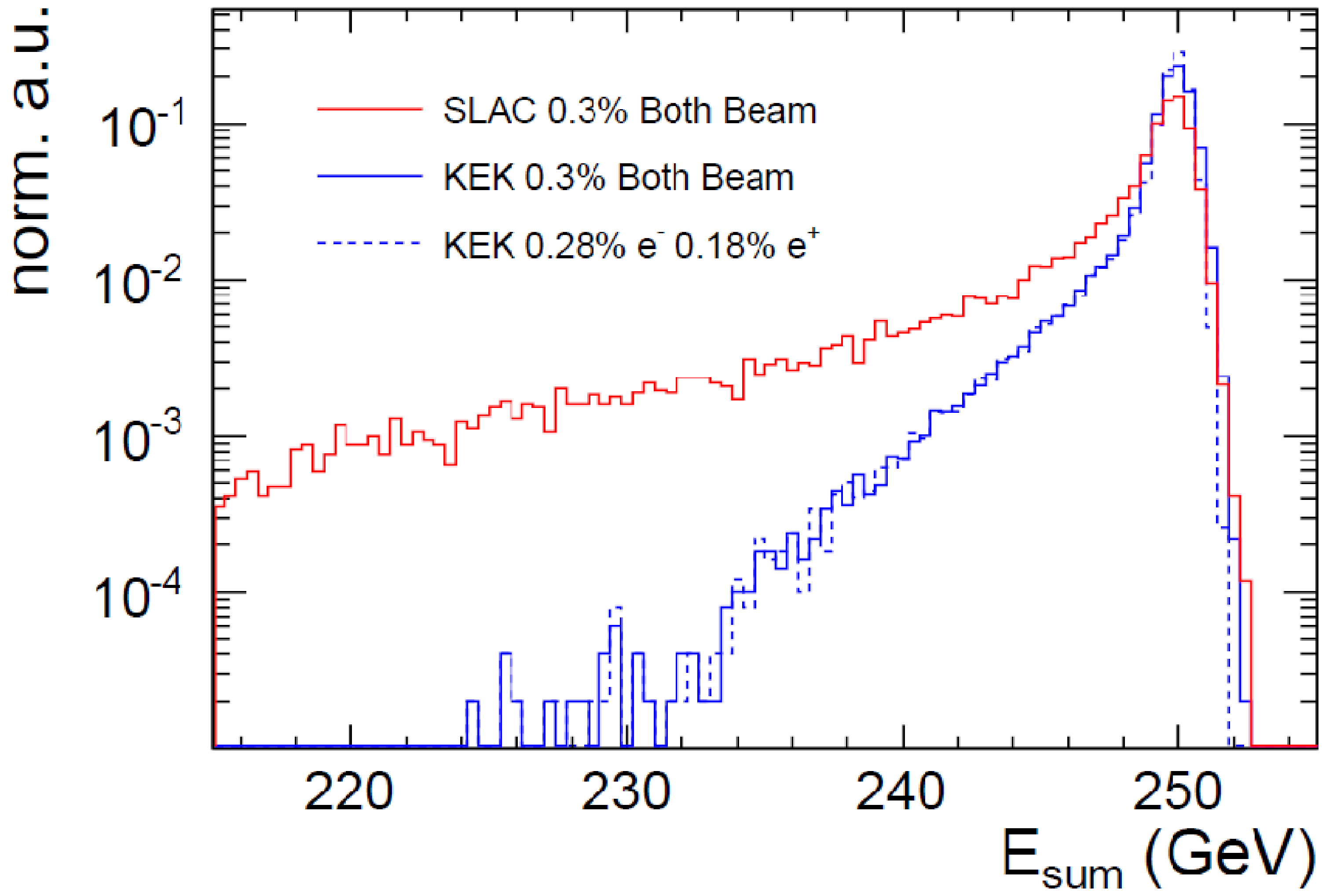




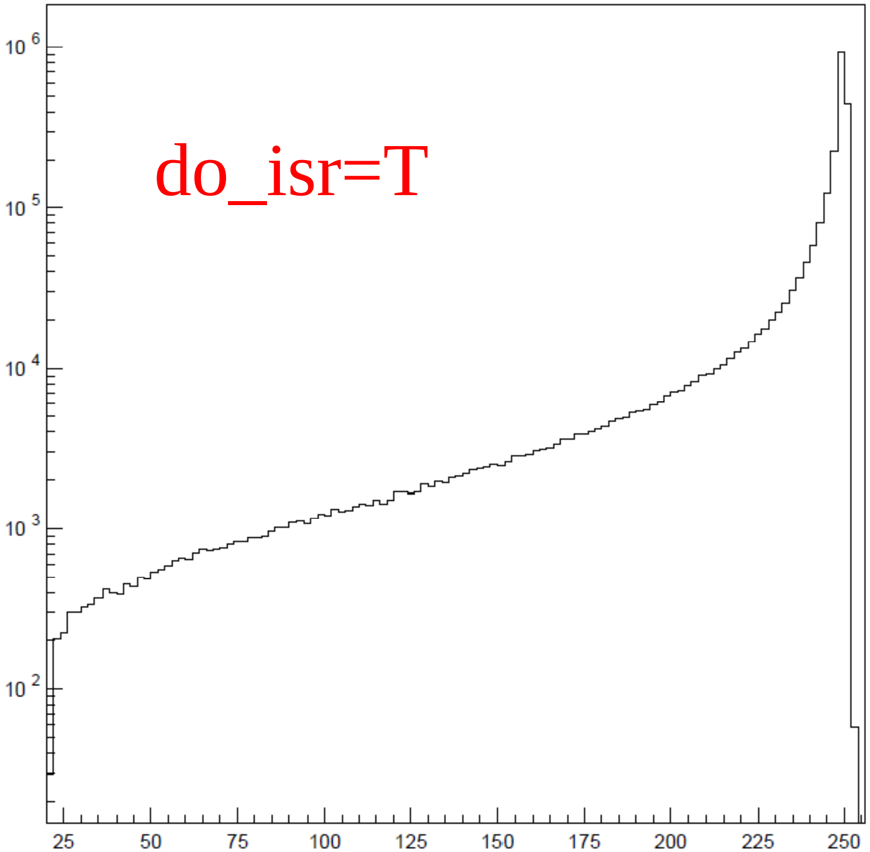


M$_{higgs}$ Spectrum in Generator Level
norm. a.u.
0.06
0.04
0.02
0
115
120
125
130
135
M$_{higgs}$ (GeV)
SLAC 0.3% Both Beam
KEK 0.3% Both Beam
KEK 0.28% e$^-$ 0.18% e$^+$

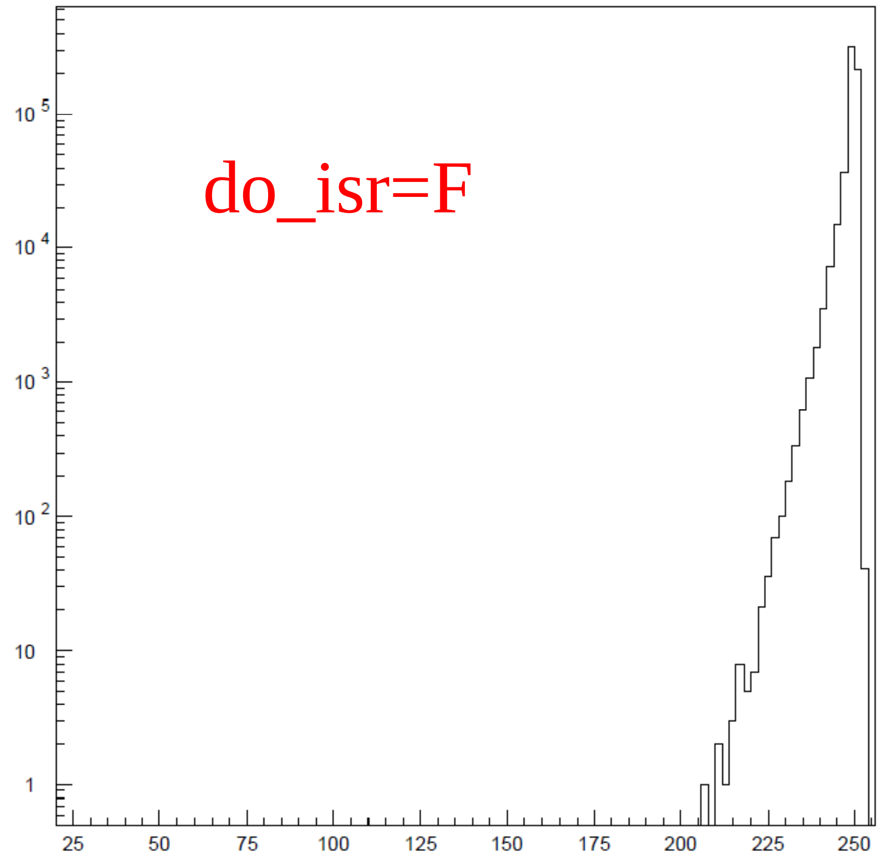
E_{sum} in Generator Level



Guinea-Pig has a parameter "do_isr" which in a number of acc.dat input files that have been passed around has "do_isr=T" . Unfortunately we picked up one of those files and used it last year to generate the 250 GeV sample. The 500 GeV sample is OK.



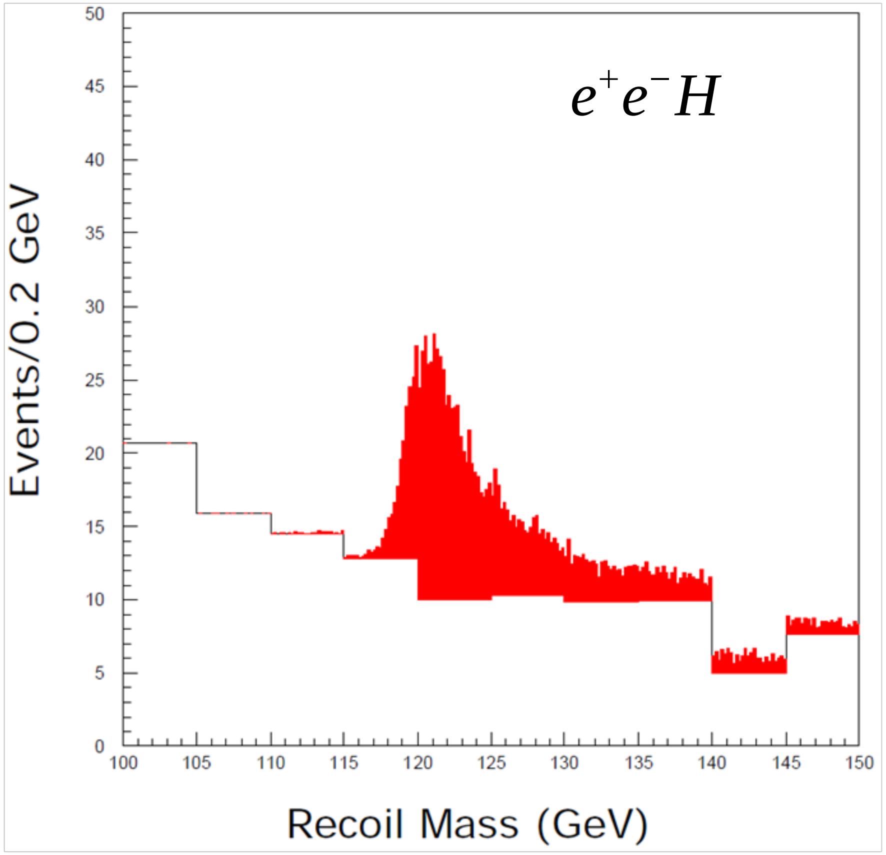
$\sqrt{s_{e^+e^-}}$ (GeV)

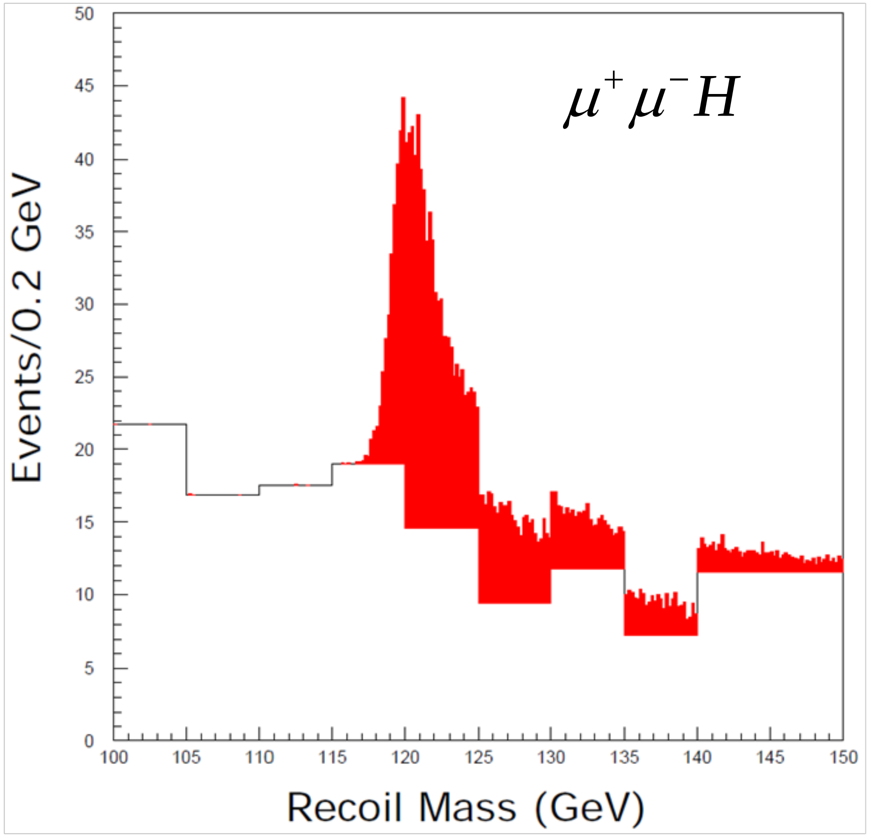


$\sqrt{s_{e^+e^-}}$ (GeV)

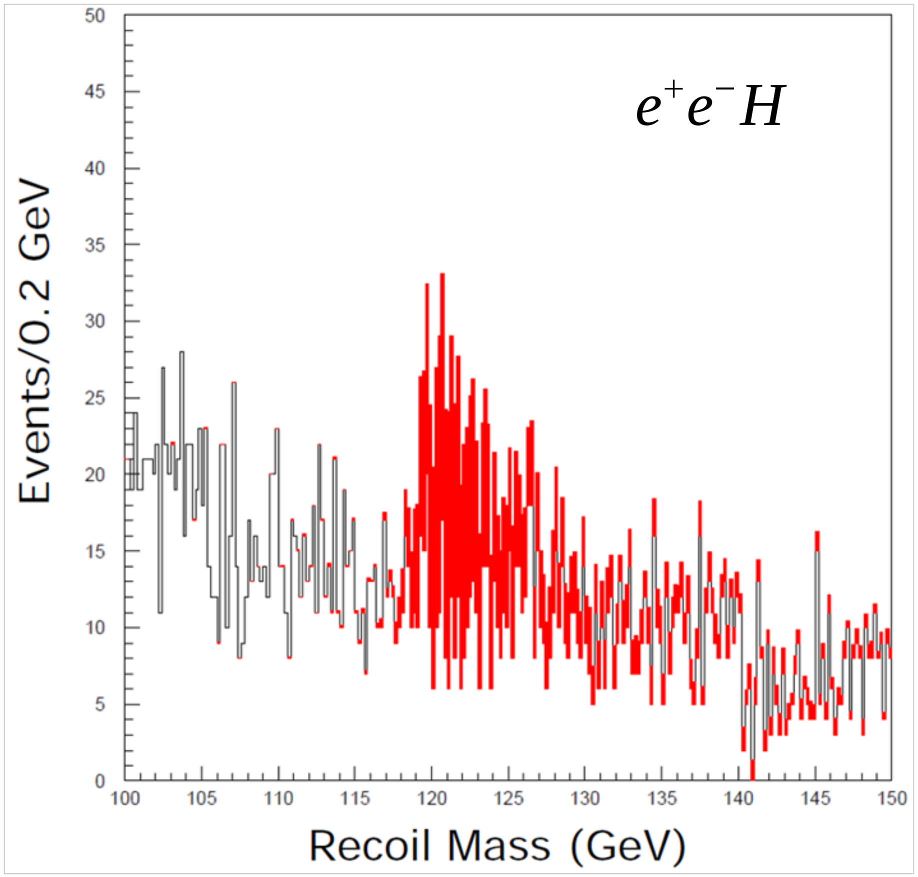
Signal and background scaled to 250 fb^{-1} with $e^{-}(80\%R)\ e^{+}(30\%L)$

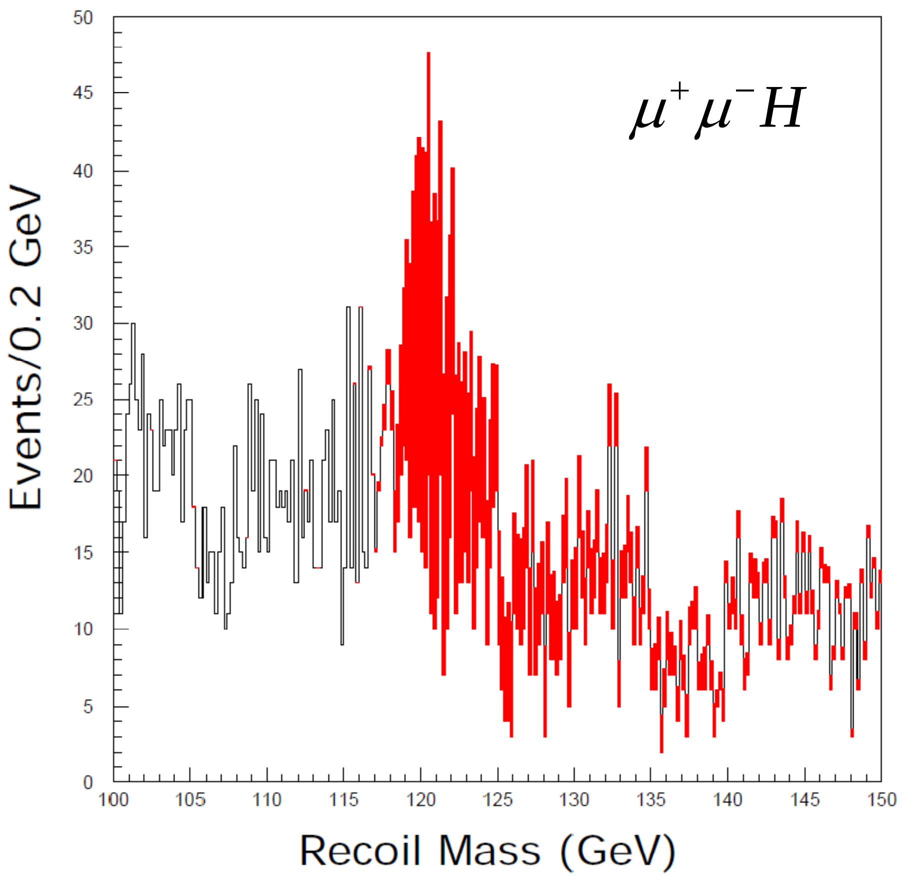
To deal with some large weight events from $e^{+}e^{-} \rightarrow \gamma\gamma l^{+}l^{-}$ and $e^{+}e^{-} \rightarrow W^{+}W^{-} \rightarrow l^{+}\nu_{l}\, l^{-}\overline{\nu}_{l}$ the background is modelled by assuming that it is constant over a 5 GeV range.



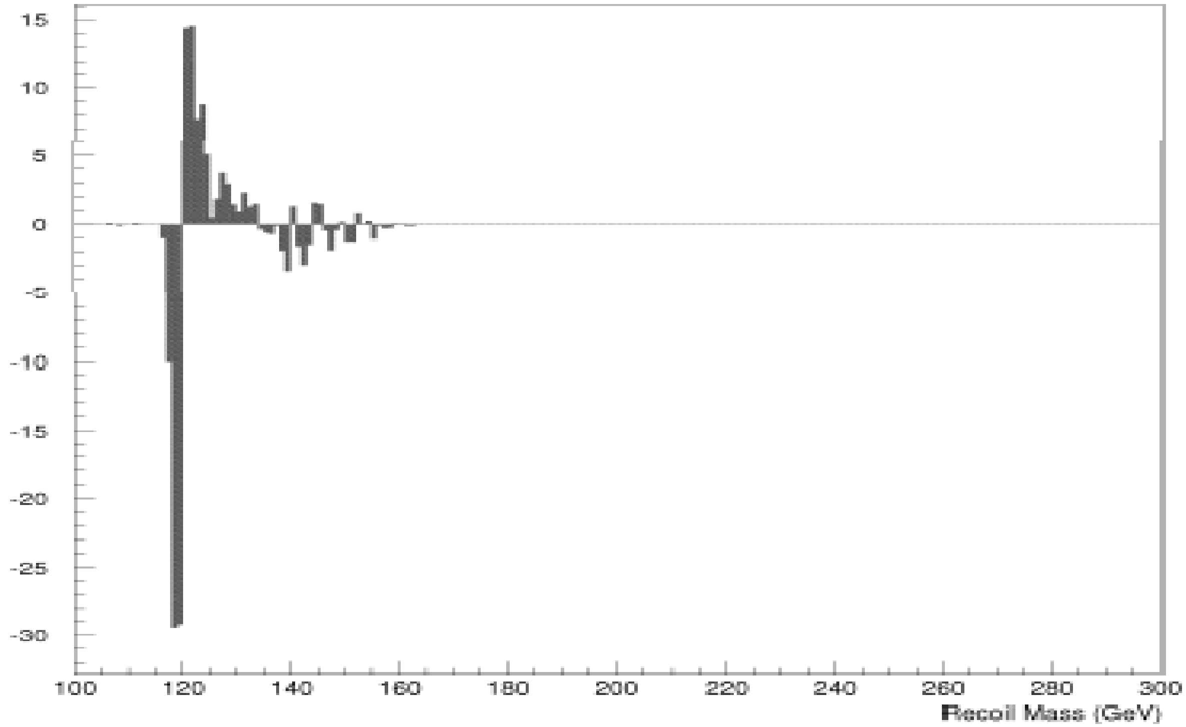


Example of unscaled signal and background for 250 fb^{-1} with $e^{-}(80\%R)\,e^{+}(30\%L)$. The background distribution on previous slide provides mean values for Poisson distributed bins on this slide. A small number of data sets like this were fitted to provide spot checks of our Higgs mass error calculation.





$$\left.\frac{d\hat{N}_{bin}}{dM_h}\right|_{Mh=120\,GeV}$$



$$\hat{N}_i(M_h) = \hat{N}_{i\,bkdg} + \hat{N}_{i\,signal} + \frac{\partial \hat{N}_i}{\partial M_h}(M_h - 120)$$

$$\chi^2(M_h) = \sum_i \frac{(N_i - \hat{N}_i(M_h))^2}{\sigma_i^2} \quad , \quad \sigma_i = \sqrt{\hat{N}_{i\,bkdg} + \hat{N}_{i\,signal}}$$

$\frac{\partial \hat{N}_i}{\partial M_h}$ calculated using training samples with $M_h = 119.7$ & 120.0 GeV

50 MeV bin size was used for final error calculation

Recoil Mass Error vs Bin Size

250 fb^{-1} $e^-_{pol}/e^+_{pol} = +0.8/-0.3$

Bin size (GeV):	1	0.5	0.2	0.05
$\mu\mu H\ \Delta M_H(GeV)$ stat only:	.117	.108	.092	.061
$\mu\mu H\ \Delta M_H(GeV)$ stat+sys:	.122	.117	.105	.075
250 fb^{-1} Fit Mh=119.7	119.54	119.49	119.59	119.65

Tight Cuts

$\mu\mu H\ \Delta M_H(GeV)$ stat only:	.125	.117	.098	.063
$\mu\mu H\ \Delta M_H(GeV)$ stat+sys:	.133	.129	.114	.077
250 fb^{-1} Fit Mh=119.7	119.50	119.56	119.43	119.63

Similar results for 250 fb^{-1} $e^-_{pol}/e^+_{pol} = -0.8/+0.3$

Higgs mass and cross section resolution

Assumptions:

- background cross-section can be calculated to arbitrary accuracy
- luminosity spectrum and polarization can be perfectly measured
- no detector systematic errors

The only sources of error:

- the statistical error in the number of events in each bin
- the systematic error due to the finite training sample statistics

80eR lumi	80eL lumi	Mode	ΔM_H (GeV)	$\Delta\sigma_{l+l-H}$ (fb)
250 fb^{-1}	0 fb^{-1}	e^+e^-H	0.102	0.620 (8.8%)
250 fb^{-1}	0 fb^{-1}	$\mu^+\mu^-H$	0.075	0.388 (5.5%)
250 fb^{-1}	0 fb^{-1}	$e^+e^-H+\mu^+\mu^-H$	0.060	0.329 (4.7%)
0 fb^{-1}	250 fb^{-1}	e^+e^-H	0.090	0.812 (7.8%)
0 fb^{-1}	250 fb^{-1}	$\mu^+\mu^-H$	0.077	0.558 (5.4%)
0 fb^{-1}	250 fb^{-1}	$e^+e^-H+\mu^+\mu^-H$	0.059	0.460 (4.4%)

Summary

- Combined error of 60 MeV for the Higgs mass and 4.4% relative error on the total ZH cross section was achieved.
- Unfortunately the mass error is dominated by incorrect beamstrahlung distribution in the MC event samples.
- Future plans include regenerating the signal with the correct beamstrahlung and generating enough signal events so that a distribution of fit values for hundreds unscaled 250 fb^{-1} samples can be plotted.