Higgs Recoil Mass Measurement and ZH Cross Section

Tim Barklow, Awatif Belymam
SLAC

Mar 2, 2009

Simulation

- CM Energy: 250 GeV
- Higgs mass: 120 GeV and 119.7 GeV

- Signal
  - $e^+e^- \to ZH \to \mu^+\mu^- X, e^+e^- X$
  - 250 fb^{-1}: +80e-__-30e+
  - 125 fb^{-1}: +80e-__-30e+ and -80e-__+30e+
  - 300,000 events

- Background
  - 7M events

Analysis

- Higgs Recoil Mass: $m^2_{recoil} = s + m^2_Z - 2.E_Z.\sqrt{s}$
- Cross Section: $\sigma = N_{signal+background} / L.\varepsilon$
- Estimation of measurement accuracies of the Higgs mass and σ(ZH)

Event Selection

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

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

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

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

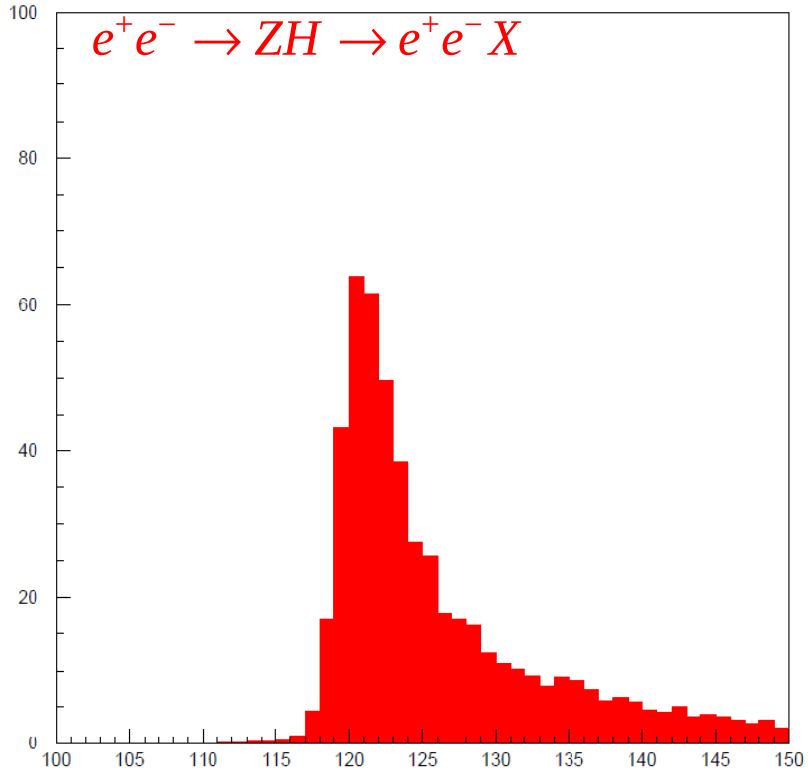
$|\cos\theta_{\mu^+\mu^-}| < 0.85$

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

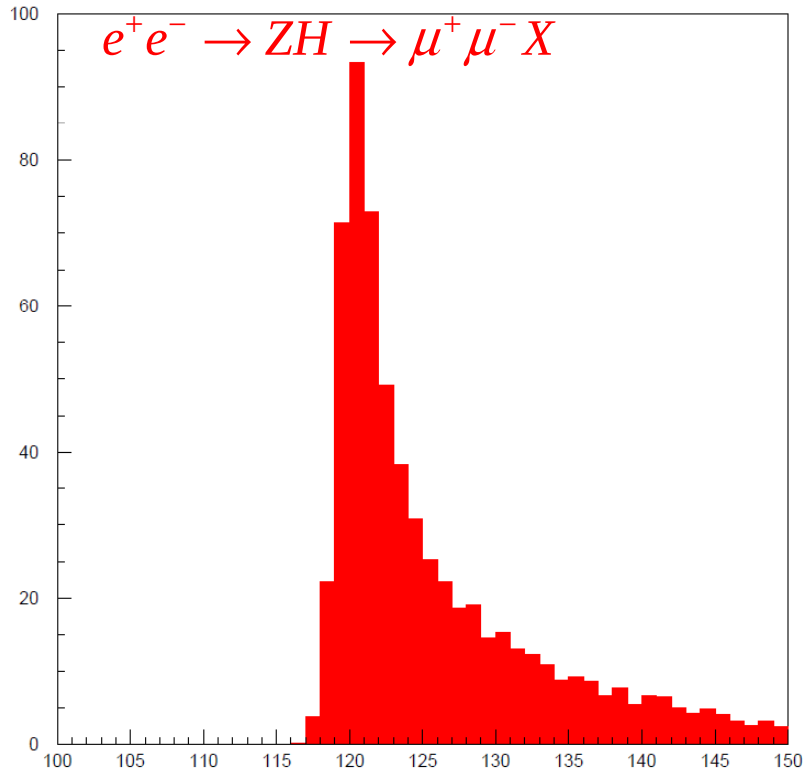
$|\cos\theta_{\text{missing}}| < 0.99$ (Only cut involving all visible particles; we believe ZH efficiency for this cut is independent of H decay mode.)

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

Signal after Event Selection



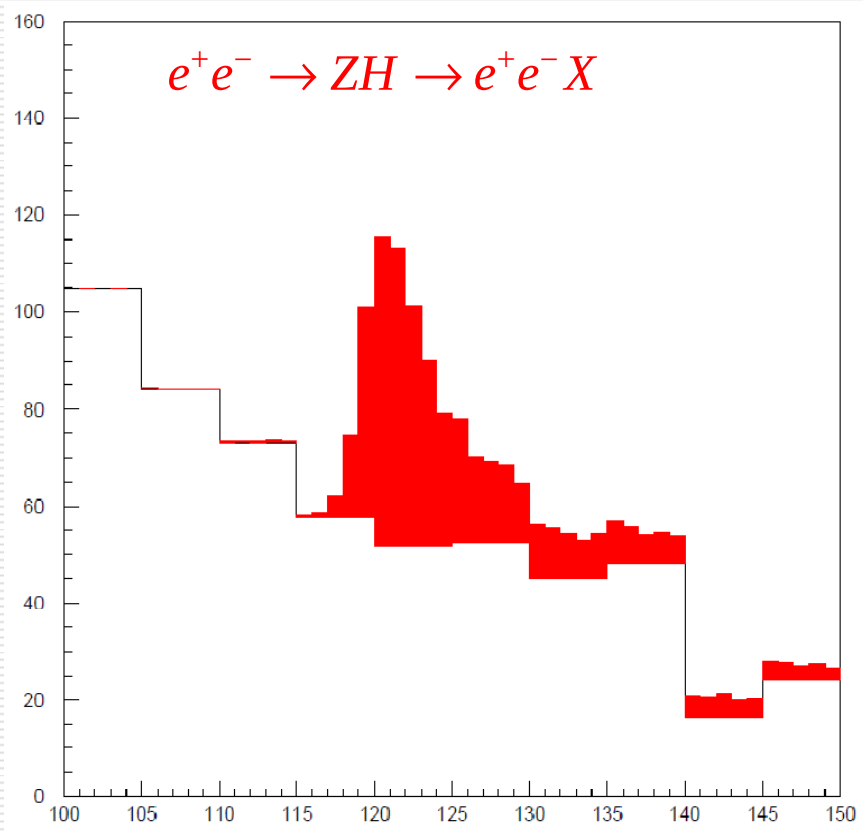
$M_{recoil}\ (GeV)$

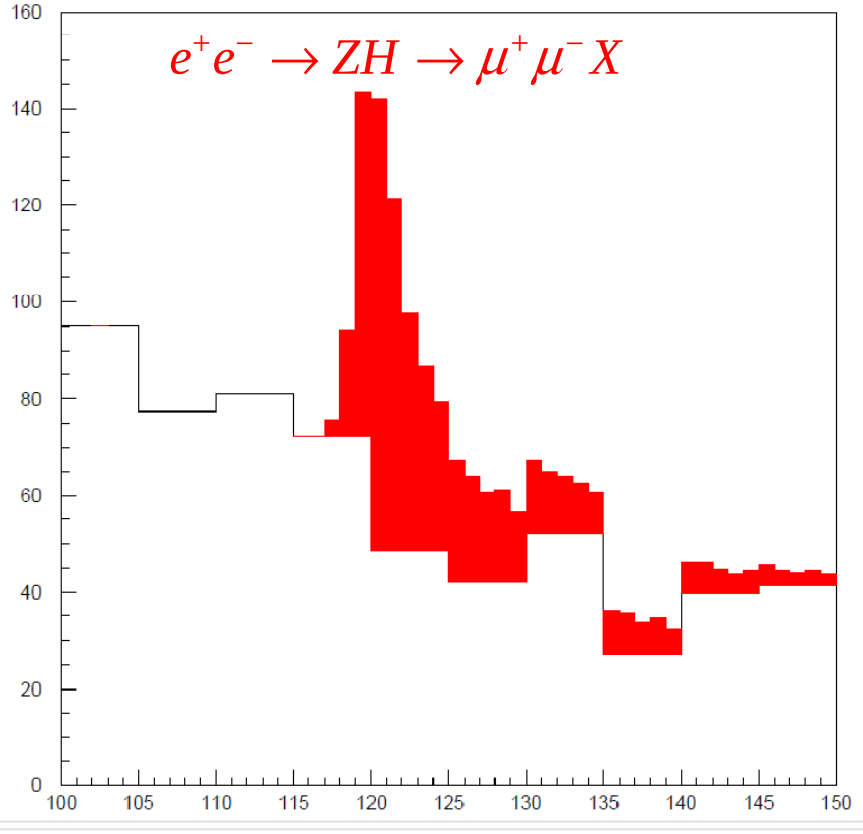


$M_{recoil}\ (GeV)$

Background from $e^+e^- \to W^+W^- \to \mu^+\nu_\mu\,\mu^-\bar{\nu}_\mu$ is surprisingly large. It is easy to remove using a cut on total visible energy if we assume Standard Model Higgs decays. However, to maintain model independence we cannot do this. For now suppress this background by assuming

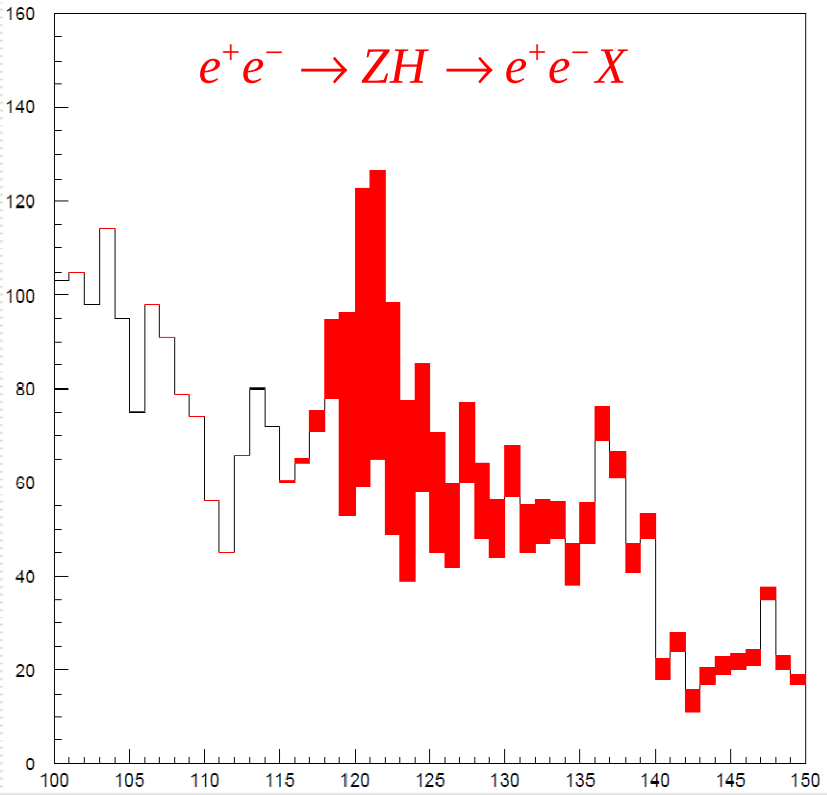
$250\ \text{fb}^{-1}\ e^-_{pol}/e^+_{pol} = +0.8/-0.3$ & $0\ \text{fb}^{-1}\ e^-_{pol}/e^+_{pol} = -0.8/+0.3$

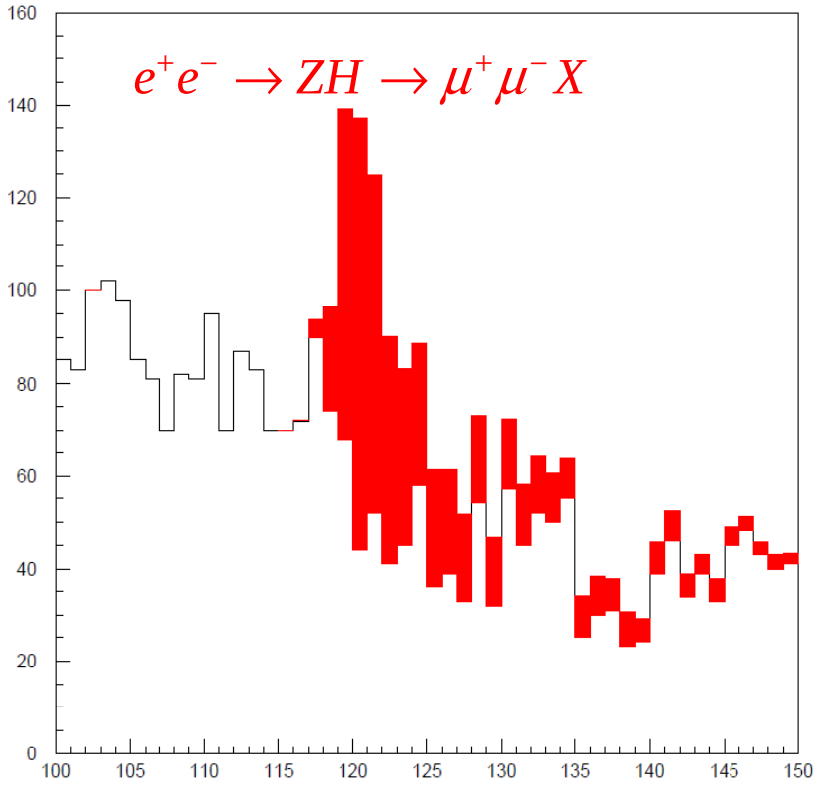




Background from $e^+e^- \to W^+W^- \to \mu^+\nu_\mu\,\mu^-\bar{\nu}_\mu$ is surprisingly large. It is easy to remove using a cut on total visible energy if we assume Standard Model Higgs decays. However, to maintain model independence we cannot do this. For now suppress this background by assuming

$$250\ \text{fb}^{-1}\ e^-_{pol}/e^+_{pol} = +0.8/-0.3 \qquad \& \qquad 0\ \text{fb}^{-1}\ e^-_{pol}/e^+_{pol} = -0.8/+0.3$$





Recoil mass

- Muon channel, 250 fb^{-1}

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

$$\Delta M_h = 0.067 GeV$$

$$\hat{N}_i(M_h) = \hat{N}_{ibkdg} + \hat{N}_{isignal} + \frac{\partial \hat{N}_i}{\partial M_h}(M_h - 120)$$

$$\chi^2(M_h) = \sum_i \frac{(N_i - \hat{N}_i(M_h))^2}{\sigma_i^2}$$

$$\sigma_i = \sqrt{\hat{N}_{ibkdg} + \hat{N}_{isignal}}$$

Recoil Mass Error vs Bin Size

Bin size (GeV):	1	0.5	0.2	0.05	0.01	.005	.002
$eeH\ \Delta M_H(GeV)$ stat only:	.151	.133	.098	.057	.038	.038	.038
$eeH\ \Delta M_H(GeV)$ stat+sys:	.154	.134	.100	.061	.047	.046	.046
$\mu\mu H\ \Delta M_H(GeV)$ stat only:	.143	.129	.104	.063	.034	.034	.034
$\mu\mu H\ \Delta M_H(GeV)$ stat+sys:	.145	.130	.105	.065	.041	.042	.042

ZH Cross-Section

$$\sigma_{\mathrm{ZH(i)}} = \frac{N_{tot(i)}}{L\eta_{ZH(i)}} - \frac{\sigma_{bgnd(i)}}{\eta_{ZH(i)}}$$

$$(\Delta\sigma_{\mathrm{ZH(i)}})^2 = \left(\frac{N_{tot(i)}}{L\eta_{ZH(i)}}\right)^2 \left(\frac{1}{N_{tot(i)}} + \frac{(\Delta L)^2}{L^2}\right)$$

$$= \left(\sigma_{\mathrm{ZH(i)}} + \frac{\sigma_{bgnd(i)}}{\eta_{ZH(i)}}\right)^2 \left(\frac{1}{N_{tot(i)}} + \frac{(\Delta L)^2}{L^2}\right)$$

$$\eta_{ZH\to\mu\mu H}(+80e^-, -30e^+) = 0.304$$

$$\sigma_{ZH\to\mu\mu H}(+80e^-, -30e^+) = 7.02 \pm 0.21 \text{ fb}$$

Further Work

- Understand Recoil Mass Error ; currently muon and electron channel errors are too similar. Is asymptotic 40-50 MeV real? We will use four untouched independent 250 fb-1 Higgs samples to address this problem.