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Introduction

* We want to determine σ(ZH) bias free:

independent of BR($\mathrm{H} \rightarrow \mathrm{X}$)

* We use $\mathrm{e^+e^-} \rightarrow \mathrm{Z\,H} \rightarrow \ell^+\ell^-\mathrm{X}$ processes, where ℓ = e, μ:

clean signature, independent of X

* $\mathrm{M_H}$ and σ(ZH) are determined from the recoiling against the $\mathrm{e^+e^-}$ and $\mu^+\mu^-$ pairs

* $\ell^{\pm}$ identification and background estimate in *realistic conditions*

* Study done at $\sqrt{s} = 350$ GeV and $\mathcal{L} = 500\ \mathrm{fb}^{-1}$:

$\mathrm{M_H} = 120,\ 140$ and 160 GeV

Signal and Background

- Signal: $e^+e^- \to ZH \to \ell^+\ell^- X\,(\gamma)$

M_H (GeV)	σ (fb)	# of events
120	5.3	2.6×10^3
140	4.3	2.1×10^3
160	3.6	1.8×10^3

- Expected background for $\mathcal{L} = 500\ \mathrm{fb}^{-1}$:

Background	σ (fb)	# of events
$\gamma\gamma \to f\bar{f}$	4.3×10^6	2×10^9
$e^+e^- \to \gamma, Z$	4.0×10^4	2×10^7
$e^+e^- \to W^+W^-$	1.3×10^4	7×10^6
$e^+e^- \to ZZ$	1.0×10^3	5×10^5

Generation and Simulation

ECFA DESY Linear Collider Workshop

* Signal and Background processes simulated with

PYTHIA V6.115

* Generated events go through the fast simulation program:

SIMDET V3.1

* Beamstrahlung accounted for using:

CIRCE V6

* Number of generated events:

Background	# of events
$\gamma\gamma \rightarrow f\bar{f}$	2×10^6
$e^+e^- \rightarrow \gamma, Z$	1×10^6
$e^+e^- \rightarrow W^+W^-$	2×10^5
$e^+e^- \rightarrow ZZ$	1×10^5

TESLA detector performance

- tracking

$$\frac{\sigma_{p_\perp}}{p_\perp} \simeq 7 \times 10^{-5}\, p_\perp \text{ (GeV)}$$

- ECAL

$$\frac{\sigma_E}{E} \simeq \frac{10\%}{\sqrt{E}} + 0.6\%$$

- $B = 3\ T$

Lepton Identification

* μ identified as MIPs in ECAL and HCAL with an associated track:

  - E_μ in HCAL $= 2.6 \pm 1.0$ GeV
  - E_μ in ECAL $= 1.25 \pm 0.20$ GeV
  - $|\cos\theta_\mu| < 0.9$

* e identified as a cluster in ECAL with an associated track:

  - $0.95 < \frac{E_e}{p_{track}} < 1.05$
  - E_e in HCAL < 2 GeV
  - $|\cos\theta_e| < 0.9$

Selection of Z $\rightarrow \ell\ell$

We require at least two leptons with $P_\ell > 10$ GeV and:

- $|\cos\theta_{\ell\ell}| < 0.6$
- $M_{\ell\ell} = \mathrm{M_Z} \pm 5$ GeV

Overall selection efficiency for electrons:

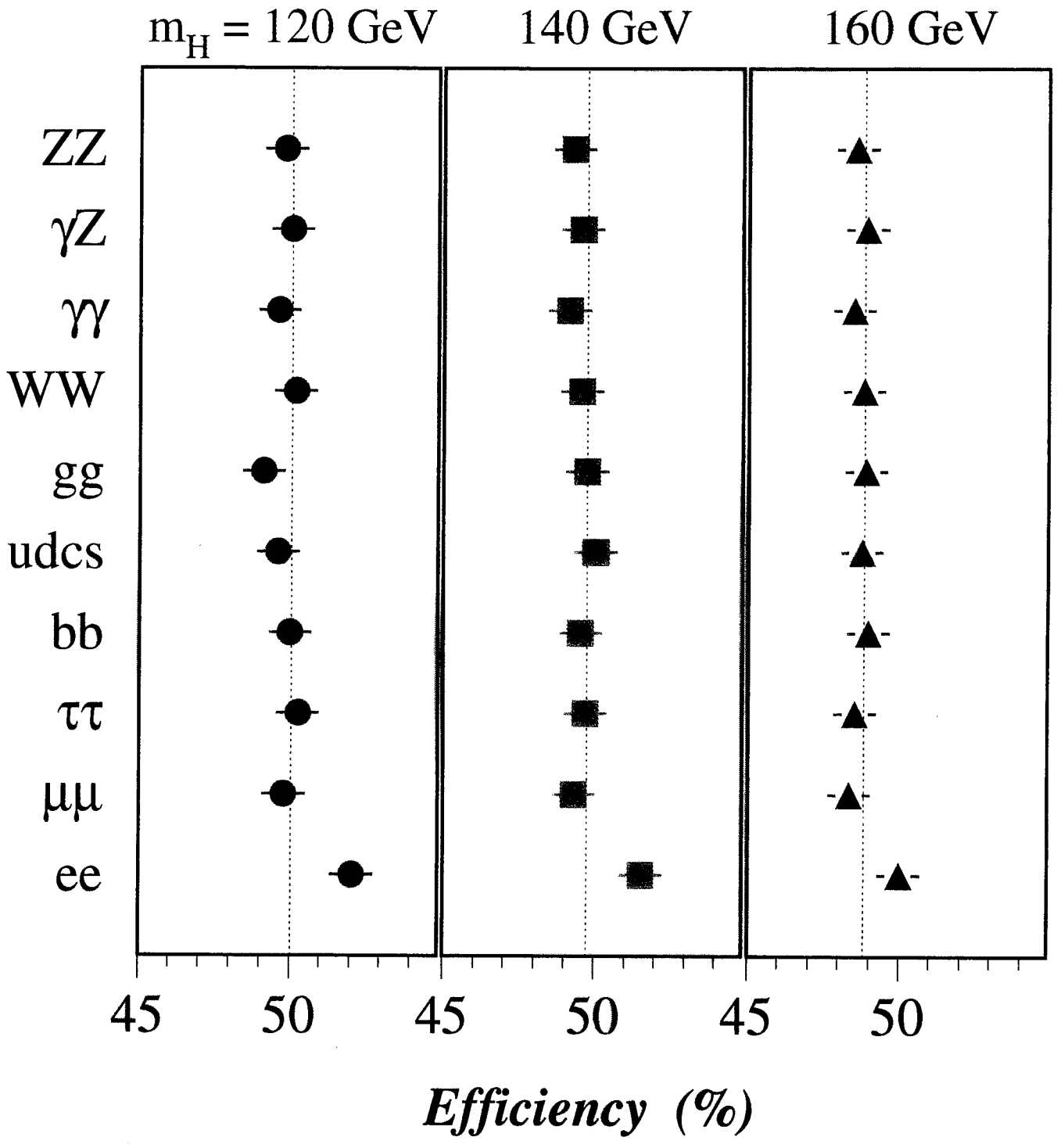
$\mathrm{M_H}$ (GeV)	eff $\pm \Delta$eff (%)
120	50.4 $\pm$ 1.0
140	49.4 $\pm$ 1.0
160	48.8 $\pm$ 1.0

Overall selection efficiency for muons:

$\mathrm{M_H}$ (GeV)	eff $\pm \Delta$eff (%)
120	52.8 $\pm$ 1.0
140	51.7 $\pm$ 1.0
160	51.3 $\pm$ 1.0

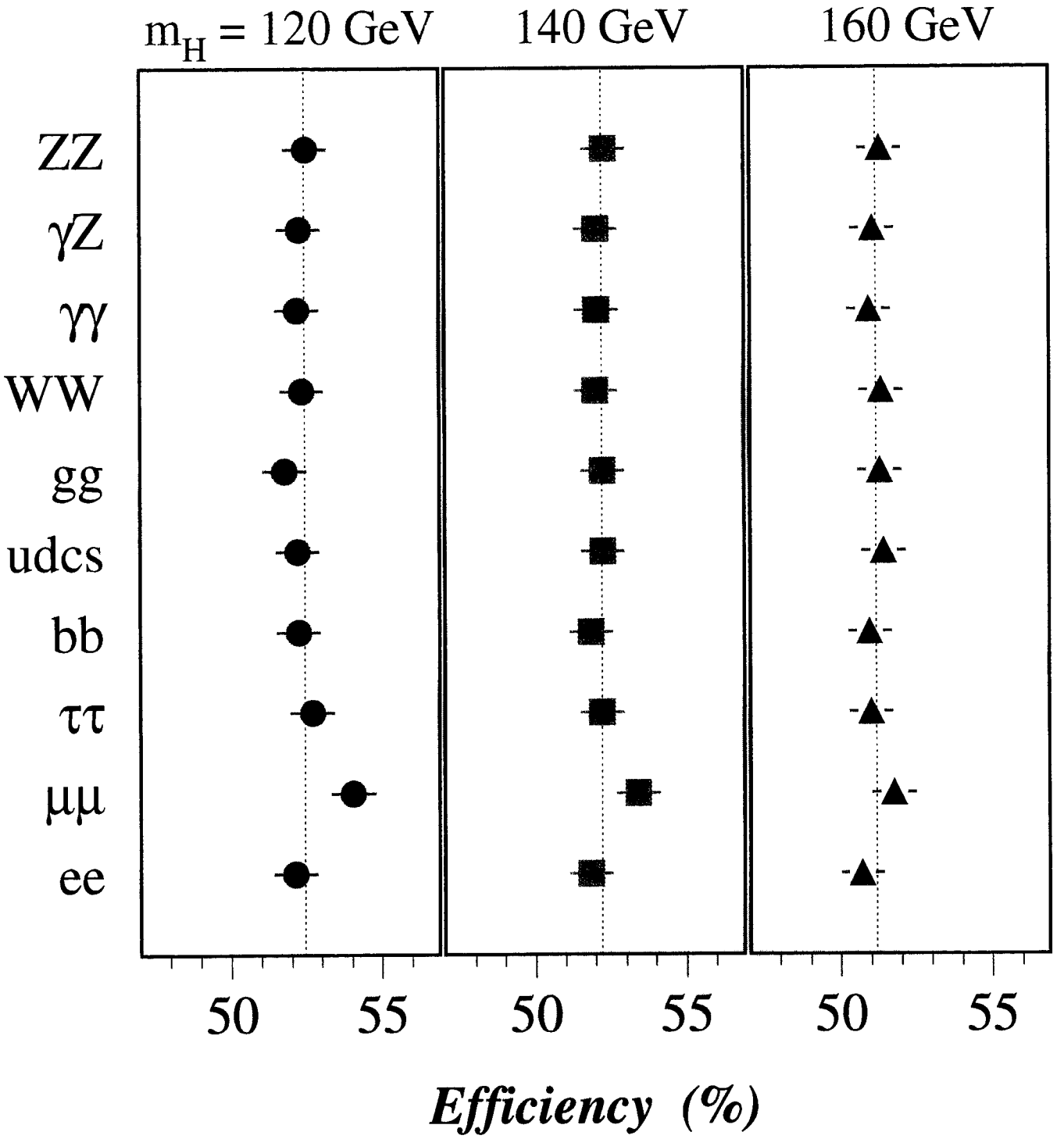
Efficiency e^+e^-

The efficiency is (almost) independent of the Higgs decay mode

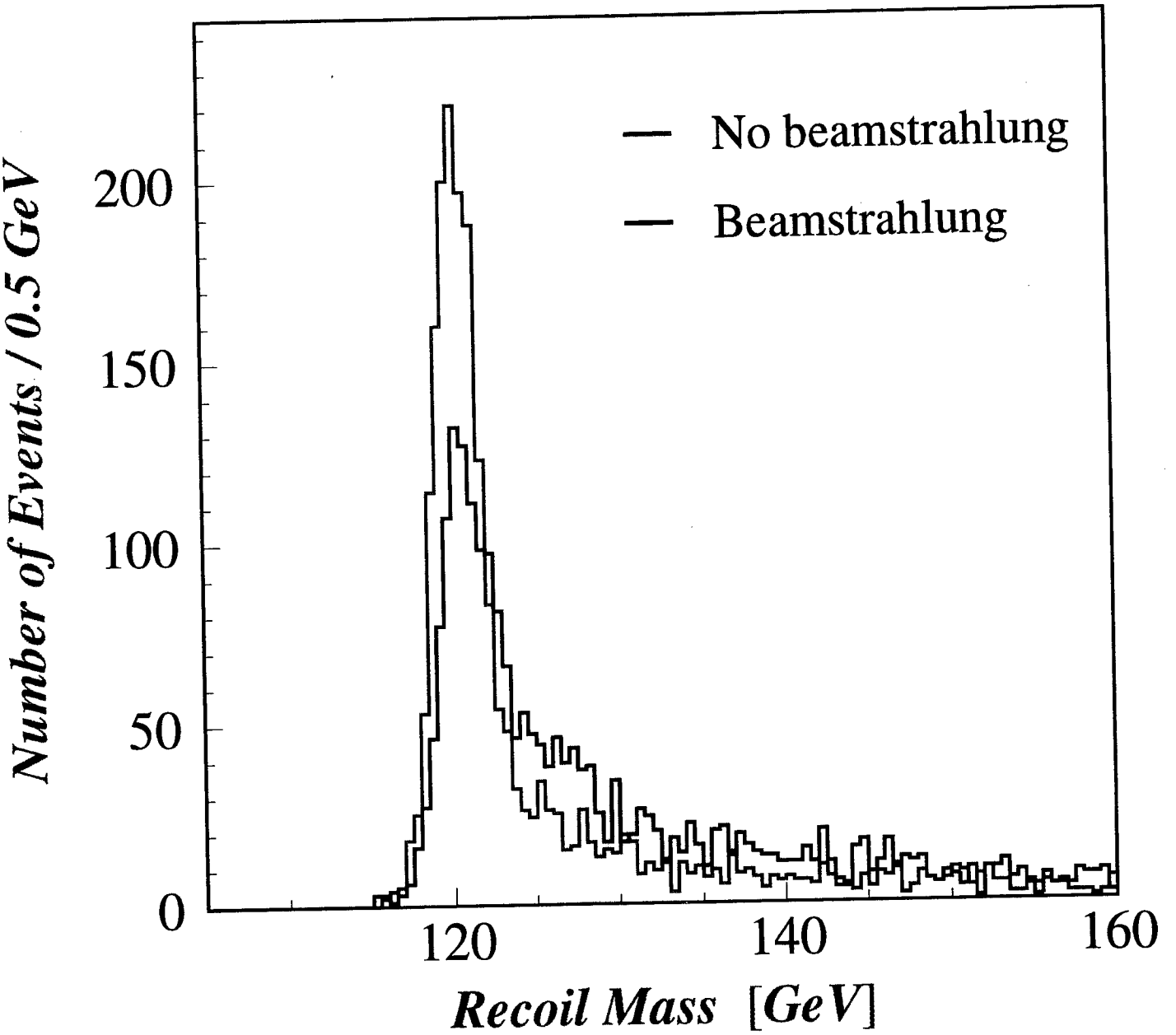


Efficiency $\mu^+\mu^-$

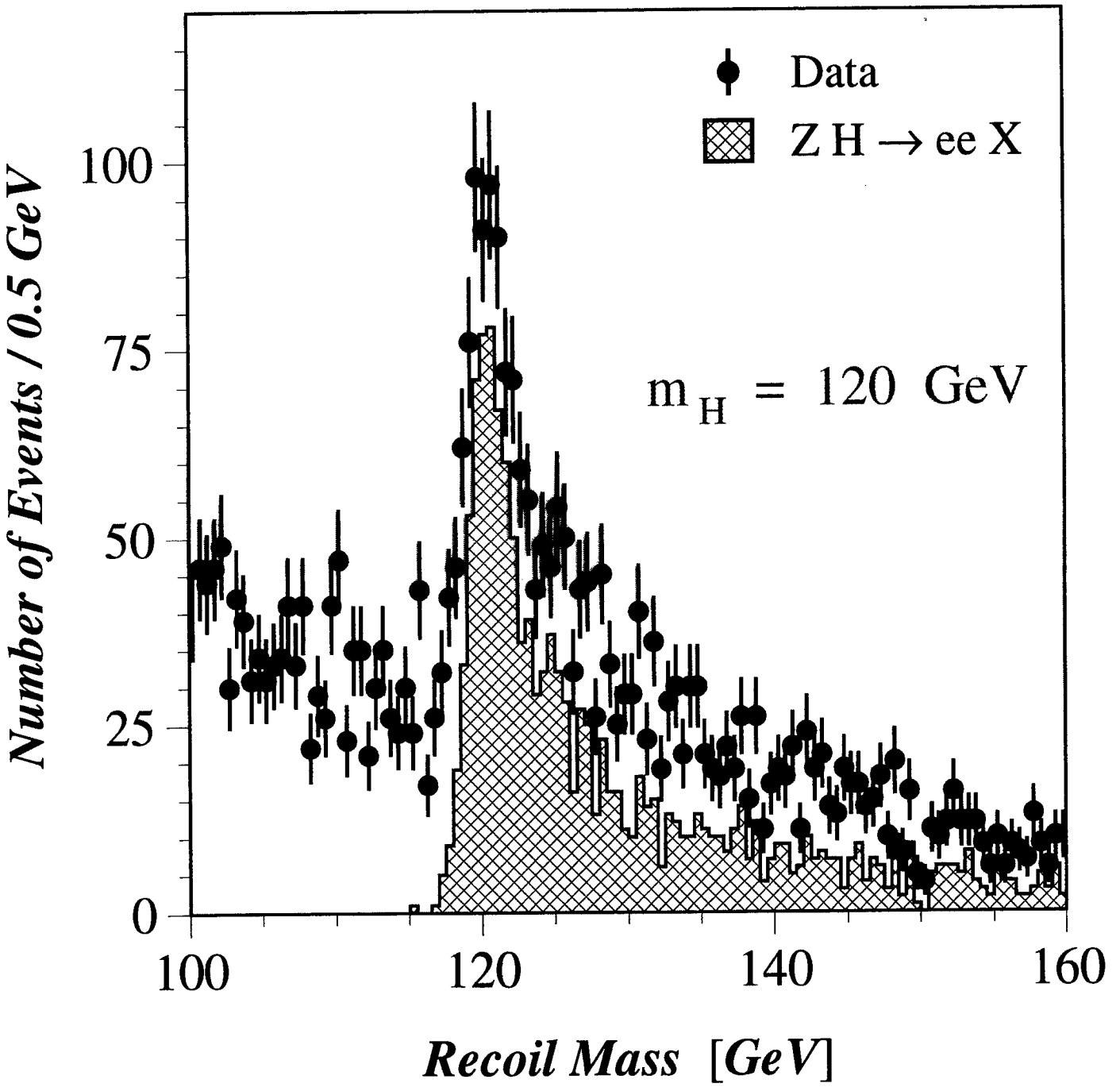
The efficiency is (almost) independent of the Higgs decay mode



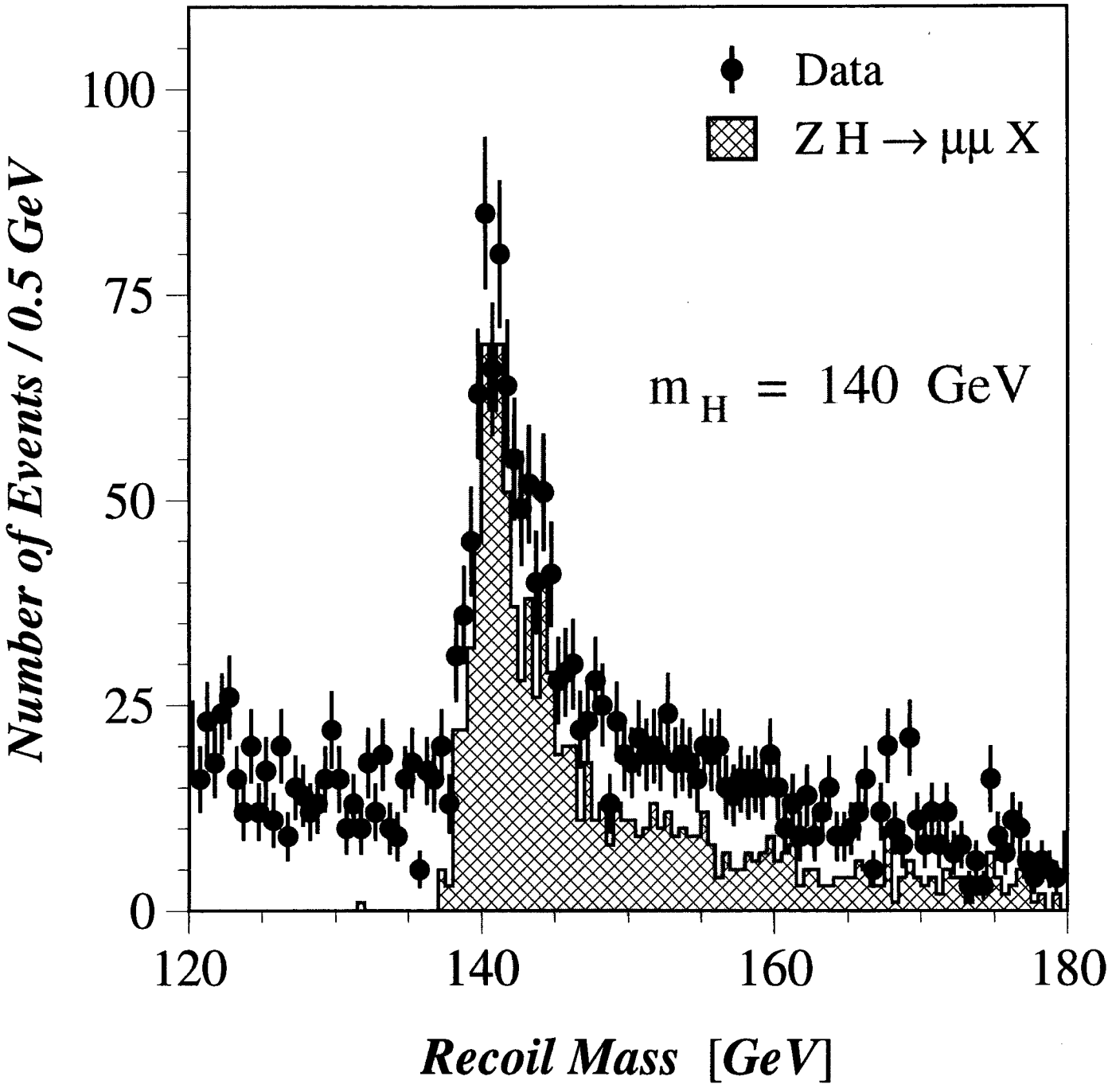
The impact of beamstrahlung on recoil mass spectra



The recoil mass spectrum from e^+e^-



The recoil mass for $\mu^+\mu^-$



Fit Procedure

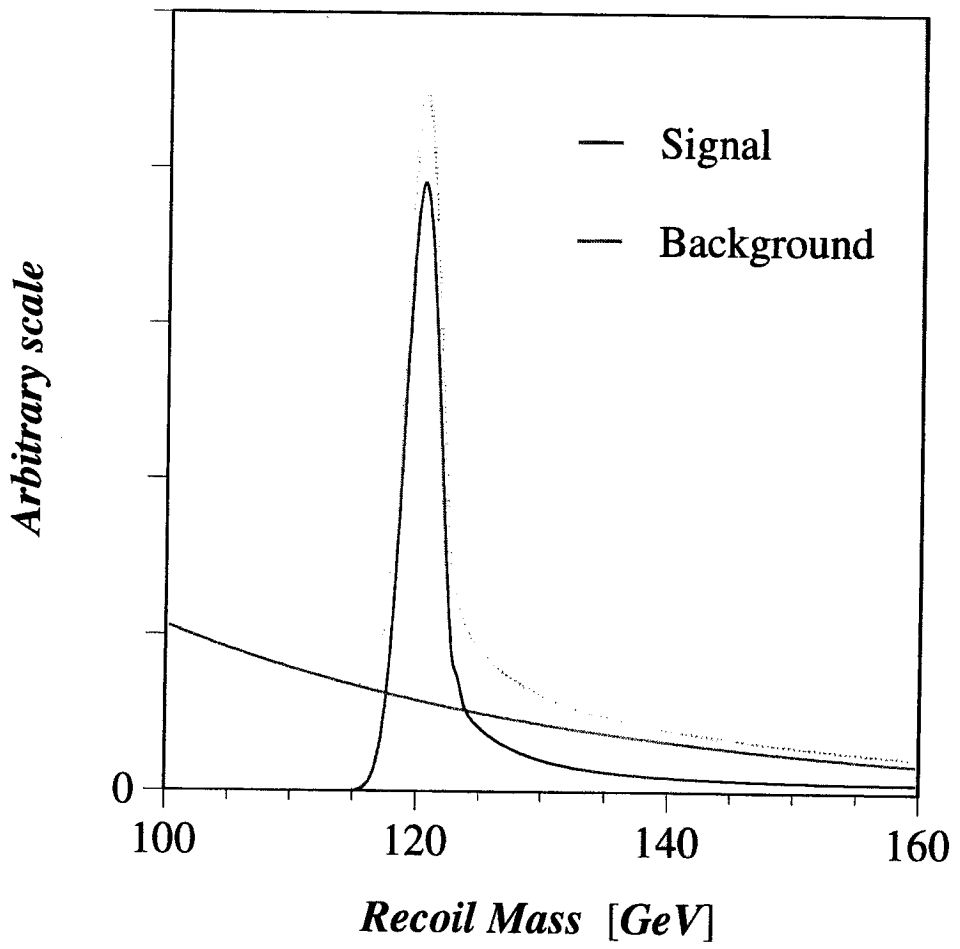
* Background mainly ZZ, parametrised by an exponential

* Shape of M_X for signal parametrised from high statistics MC:

$$M_X \approx \begin{cases} \text{left: } \textit{gaussian} \\ \text{right: } \textit{gaussian + exponential} \end{cases}$$

(also Edgeworth expansion)

* M_H , σ_H and signal normalisation free parameters

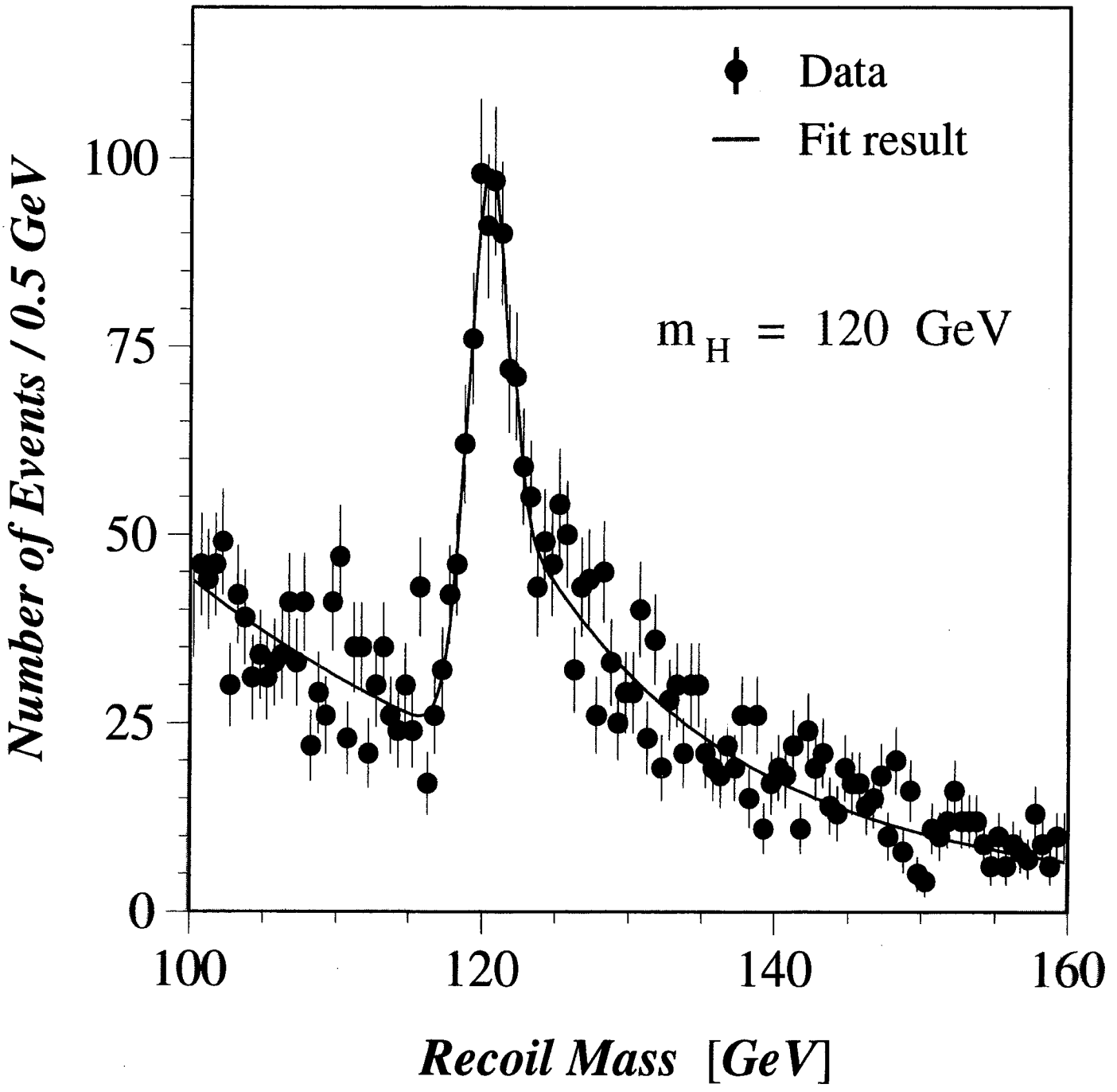


Recoil Mass Fit, e^+e^-

$$M_H = 120.48 \pm 0.14 \text{ GeV}$$

$$\sigma_H = 1.48 \pm 0.11 \text{ GeV}$$

$$\sigma(ZH \rightarrow e^+e^-X) = 5.26 \pm 0.18 \pm 0.13 \text{ fb}$$

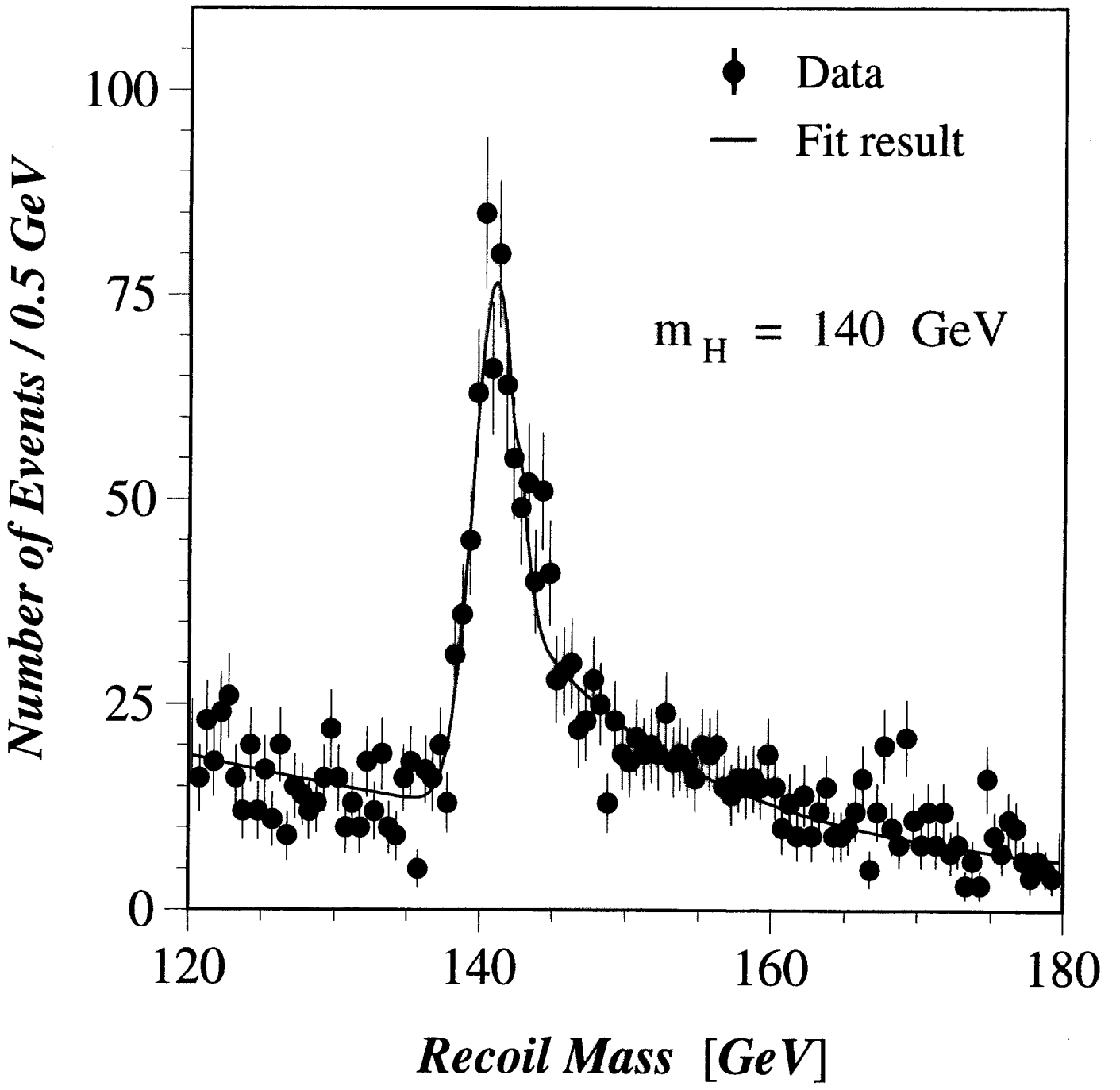


Recoil Mass Fit, $\mu^+\mu^-$

$$M_H = 141.00 \pm 0.16 \text{ GeV}$$

$$\sigma_H = 1.58 \pm 0.14 \text{ GeV}$$

$$\sigma(ZH \to \mu^+\mu^- X) = 4.39 \pm 0.17 \pm 0.10 \text{ fb}$$

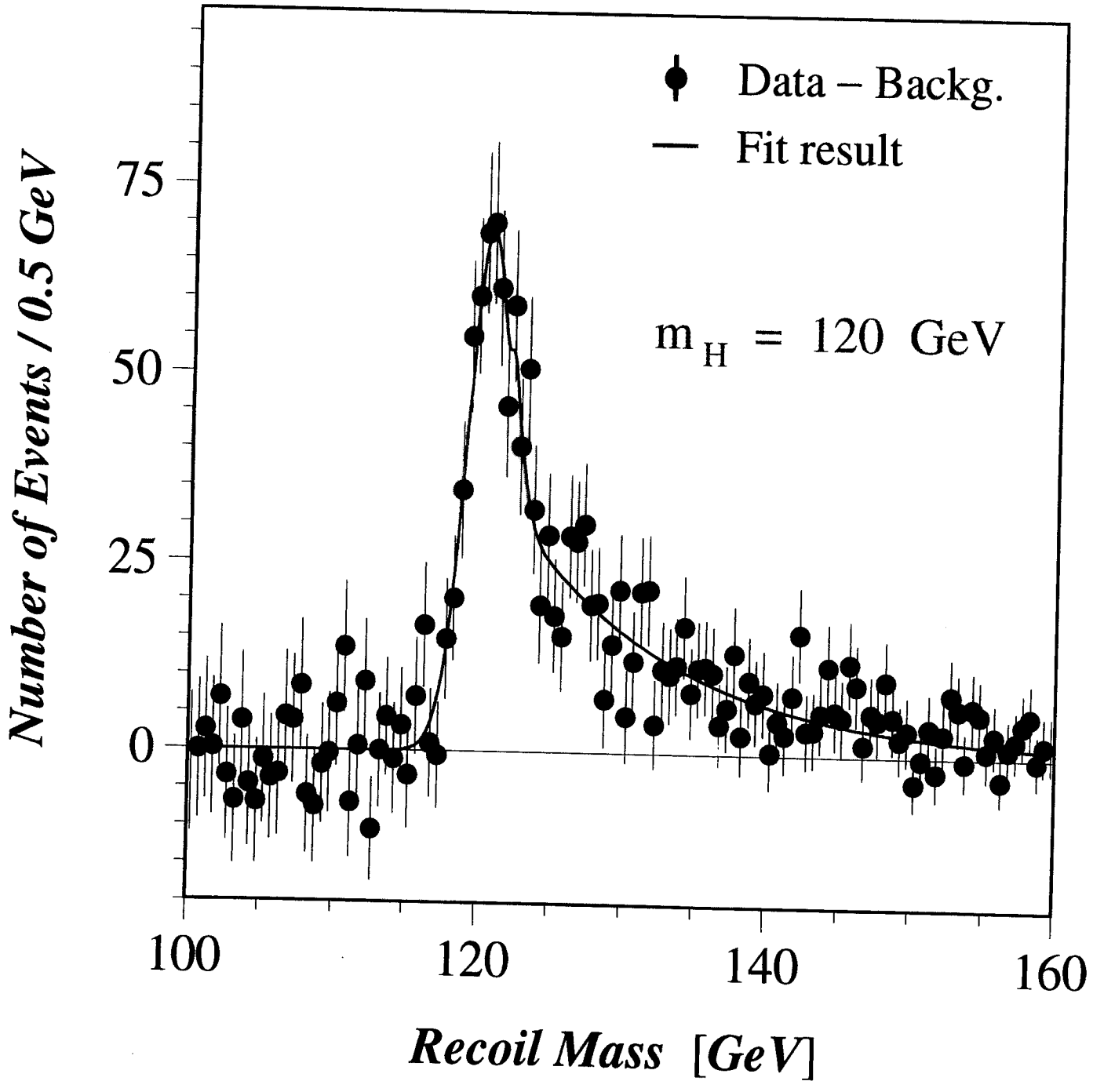


Recoil Mass Fit, $\mu^+\mu^-$

$$M_H = 120.63 \pm 0.18 \text{ GeV}$$

$$\sigma_H = 1.62 \pm 0.15 \text{ GeV}$$

$$\sigma(ZH \to \mu^+\mu^- X) = 5.35 \pm 0.21 \pm 0.13 \text{ fb}$$

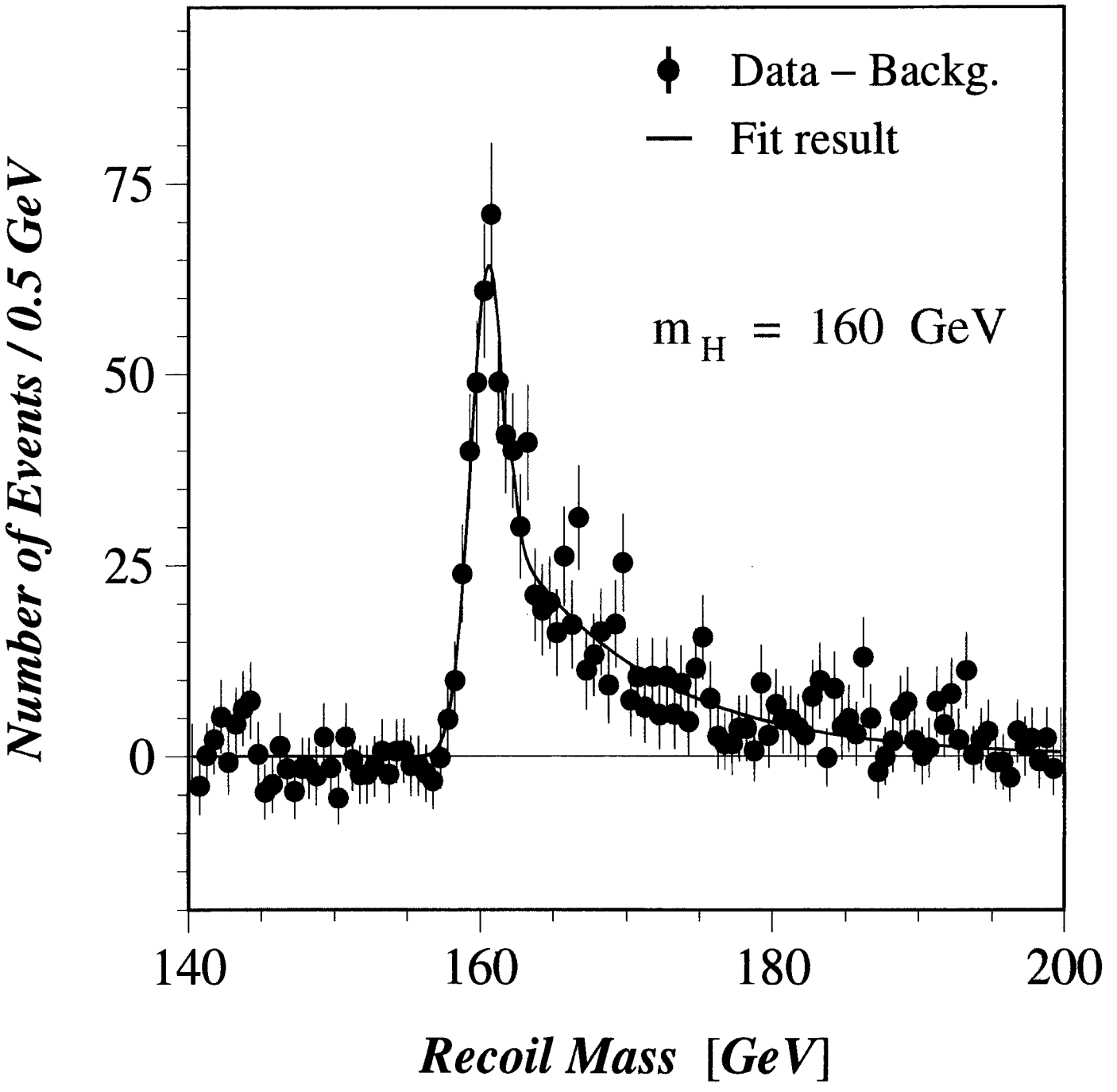


Recoil Mass Fit, e^+e^-

$$M_H = 160.58 \pm 0.12 \text{ GeV}$$

$$\sigma_H = 1.25 \pm 0.12 \text{ GeV}$$

$$\sigma\,(ZH \to e^+e^-X) = 3.68 \pm 0.17 \pm 0.09 \text{ fb}$$



Results

⋆ **Partial cross section:** $e^+e^- \to ZH \to e^+e^-X$

M_H (GeV)	σ (fb)
120	$5.26 \pm 0.18 \pm 0.13$
140	$4.38 \pm 0.18 \pm 0.11$
160	$3.68 \pm 0.17 \pm 0.09$

⋆ **Partial cross section:** $e^+e^- \to ZH \to \mu^+\mu^-X$

M_H (GeV)	σ (fb)
120	$5.35 \pm 0.21 \pm 0.13$
140	$4.39 \pm 0.17 \pm 0.10$
160	$3.52 \pm 0.15 \pm 0.08$

Relative error (*stat.*) in $\sigma \lesssim 3\,\%$

(∗) From LEP, $\Gamma_{Z\to\mu\mu}/\Gamma_Z = (3.367 \pm 0.014) \times 10^{-2}$

Summary

Clean selection of $\mathrm{Z\,H} \rightarrow \mathrm{e^+e^-X}$
and $\mathrm{Z\,H} \rightarrow \mu^+\mu^-\mathrm{X}$,
independent of the Higgs decay mode

Higgs mass peak: $\Delta \mathrm{M_H} \simeq 150$ MeV

Higgs mass resolution: $\sigma_\mathrm{H} \simeq 1.1 - 1.6$ GeV

$\mathrm{e^+e^-} \rightarrow \mathrm{Z\,H}$ cross section: $\Delta\sigma/\sigma \lesssim 3\,\%$
from $\mathrm{e^+e^-}$ and $\mu^+\mu^-$ combined