Measurement of Higgs Mass and Cross Section at NLC

Haijun Yang **Keith Riles**

University of Michigan, Ann Arbor

Linear Collider Retreat

University of California, Santa Cruz

June 27-29, 2002

Monte Carlo Generator & Simulation

- MC Generator: PANDORA V2.2, PYTHIAV3.1
  Using NLC Beam Energy Spread (1%)
  ⇒ Thanks to Michael E. Peskin, Masako Iwasaki.

- Analysis Platform: JAVA Analysis Studio V2.2.5
  ⇒ Thanks to Tony Johnson, Mike Ronan,
  Wolfgang Walkowiak.

- Full MC comes from SLAC lcddata server
  ⇒ Thanks to Gary Bower, Norman Graf.

- Detectors: LDMAR01(LD), SDMAR01(SD)

- $e^+e^- \rightarrow ZH \rightarrow l^+l^-X(\gamma)$
  $\sqrt{S} = 350,\ 500$ GeV
  $M_H = 120,\ 140,\ 160$ GeV
  $\mathcal{L} = 500 fb^{-1}$

Signal and Background

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

$\sqrt{S}(GeV)$	M_H	σ(fb)	Exp. Events
350	120	5.19	2590
350	140	4.37	2185
350	160	3.61	1805
500	120	2.65	1325
500	140	2.45	1225
500	160	2.15	1075

- Background: ZZ, WW (fast MC only)

$\sqrt{S}(GeV)$	BKGD	σ(fb)	Exp. Events
350	ZZ	878.4	439K
500	ZZ	561.9	281K
350	WW	21.8K	11M
500	WW	14.3K	7M

Selection Cuts

1). Energy of $l^{\pm}$ from Track: $E_l > 10\text{GeV}$

2). Polar angle of $l^{\pm}$: $|\cos(\theta_l)| < 0.9$

3). No. of $l^{\pm}$ satisfy 1) & 2): $N_l \geq 2$

4). Inv. mass of l^+l^-: $|M_{l^+l^-} - M_{Z^0}| < 5\text{GeV}$

5). Polar angle of $Z^0(l^+l^-)$: $|\cos(\theta_{l^+l^-})| < 0.6$

6). Angle between l^+l^-: $\cos(\theta_{l^+ \leftrightarrow l^-}) > -0.7$

Recoil mass of l^+l^- system:

$$M_H = \sqrt{S - 2 \bullet \sqrt{S} \bullet E_{l^+l^-} + M^2_{l^+l^-}}$$

Selection Efficiency

- $e^+e^- \to ZH \to \mu^+\mu^- X(\gamma)$

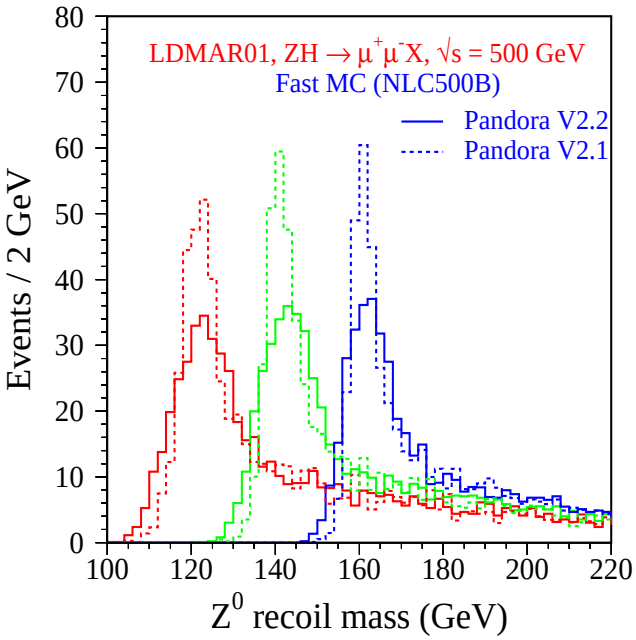
$\sqrt{s}$	m_{higgs}	fast MC		full MC	
(GeV)	(GeV)	LD	SD	LD	SD
500	120	55.2	55.2	55.5	49.7
	140	55.4	55.4	55.9	49.6
	160	55.2	55.3	56.8	50.4
350	120	49.9	50.0	48.2	41.2
	140	48.2	48.2	48.6	40.8
	160	48.0	47.9	47.6	38.7

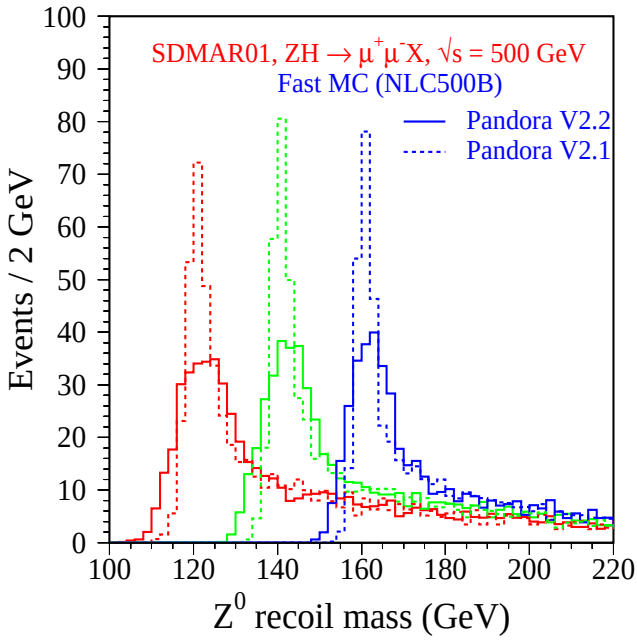
$\Rightarrow$ At $\sqrt{s} = 500$ GeV, Eff. is $\sim 55\%$.

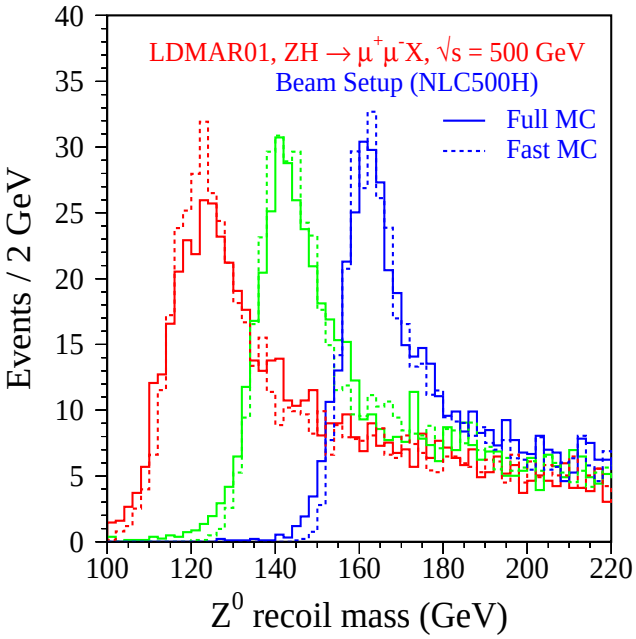
$\Rightarrow$ At $\sqrt{s} = 350$ GeV, Eff. is $\sim 48\%$.

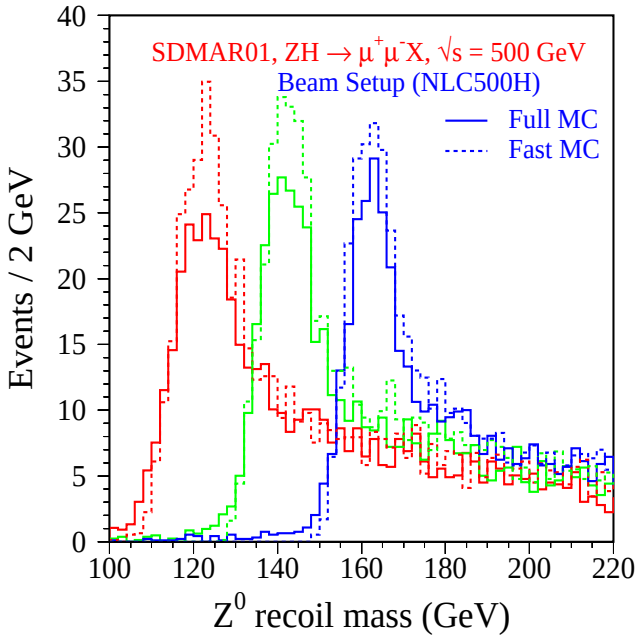
$\Rightarrow$ For full SD, Eff. is degrading $6 \sim 8\%$ because of low track reconstruction efficiency in SD forward region.

Higgs Mass Distr. After Selection





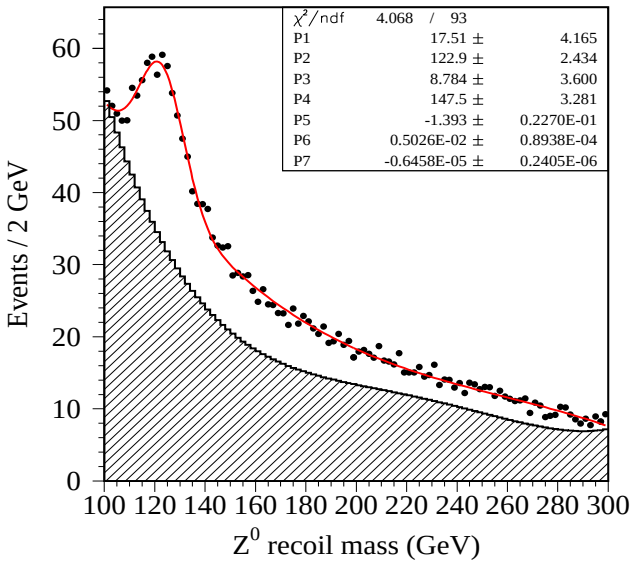




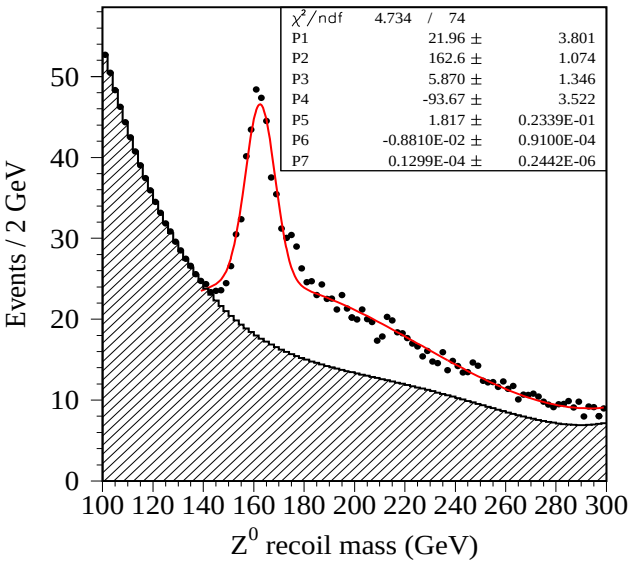
- Comparison of Pandora V2.1 & V2.2.
- Comparison of Fast & Full MC of Pandora V2.2.

Measurement of Higgs Mass

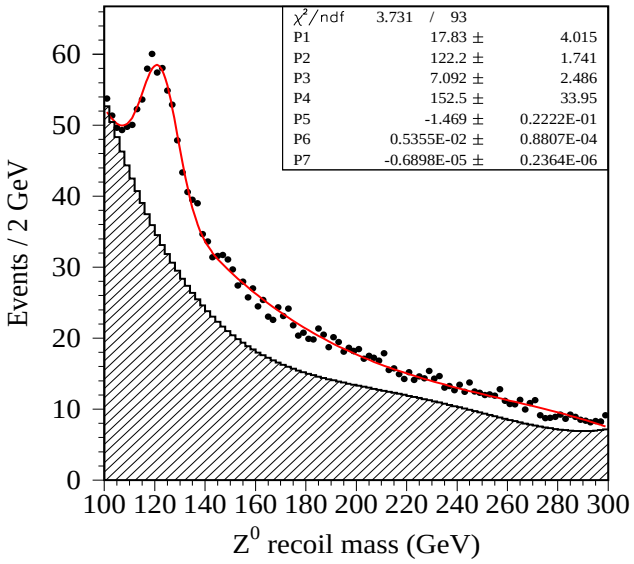
NLC500H(Full) - M_h=120 GeV, LDMAR01



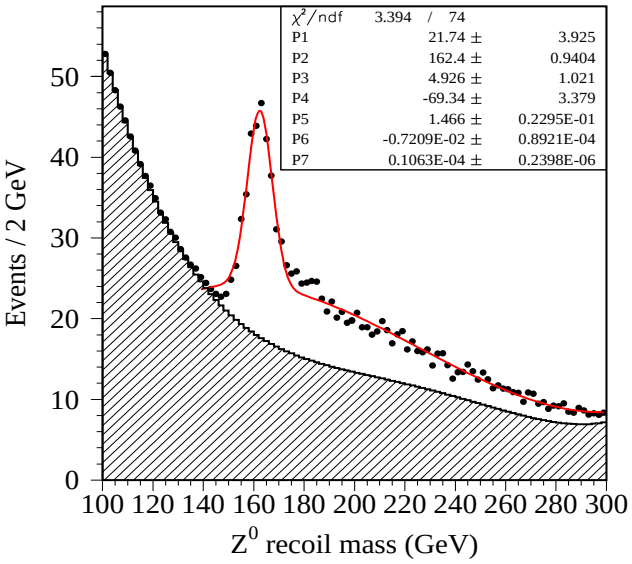
NLC500H(Full) - M_h=160 GeV, LDMAR01



NLC500H(Full) - M_h=120 GeV, SDMAR01



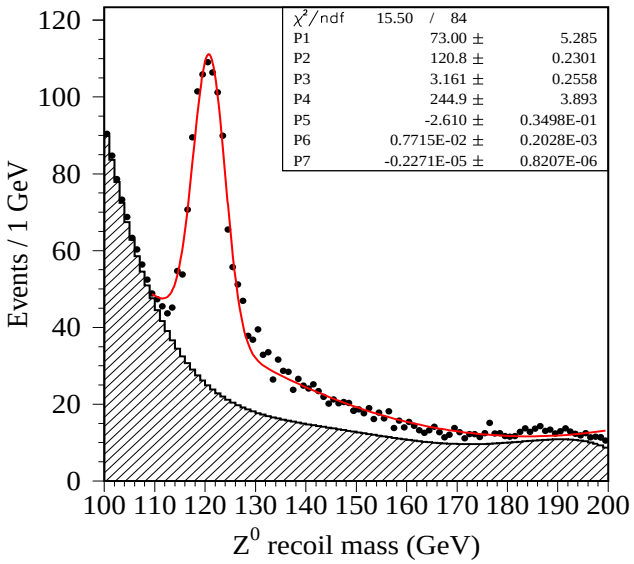
NLC500H(Full) - M_h=160 GeV, SDMAR01



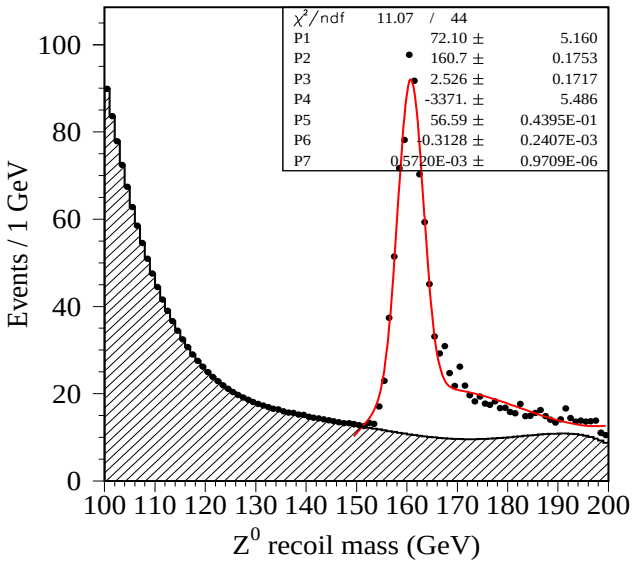
- $e^+e^- \rightarrow ZH \rightarrow \mu^+\mu^- X(\gamma)$
- Fitting Function: Gaussian + Polynomial(P3)

Measurement of Higgs Mass

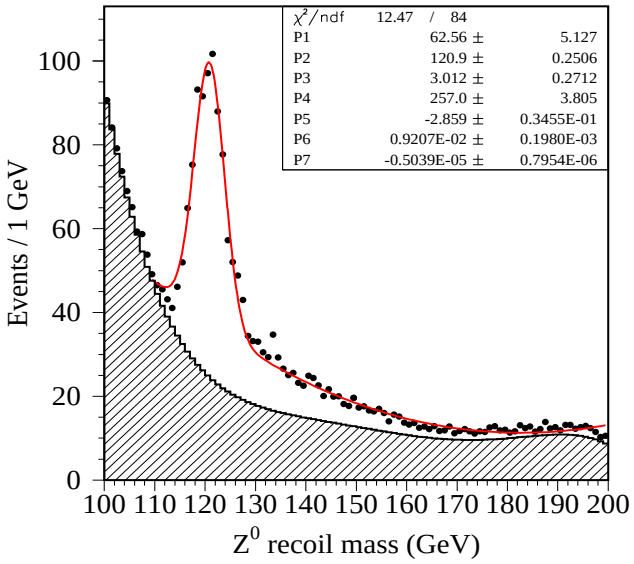
NLC350(Full) - M_h=120 GeV, LDMAR01



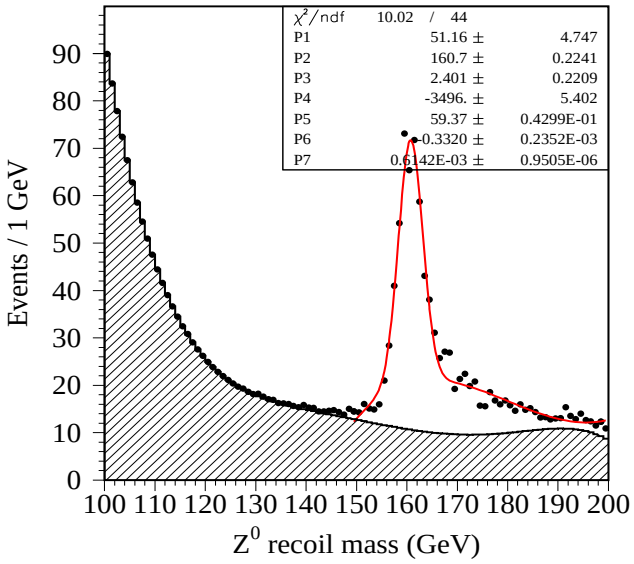
NLC350(Full) - M_h=160 GeV, LDMAR01



NLC350(Full) - M_h=120 GeV, SDMAR01

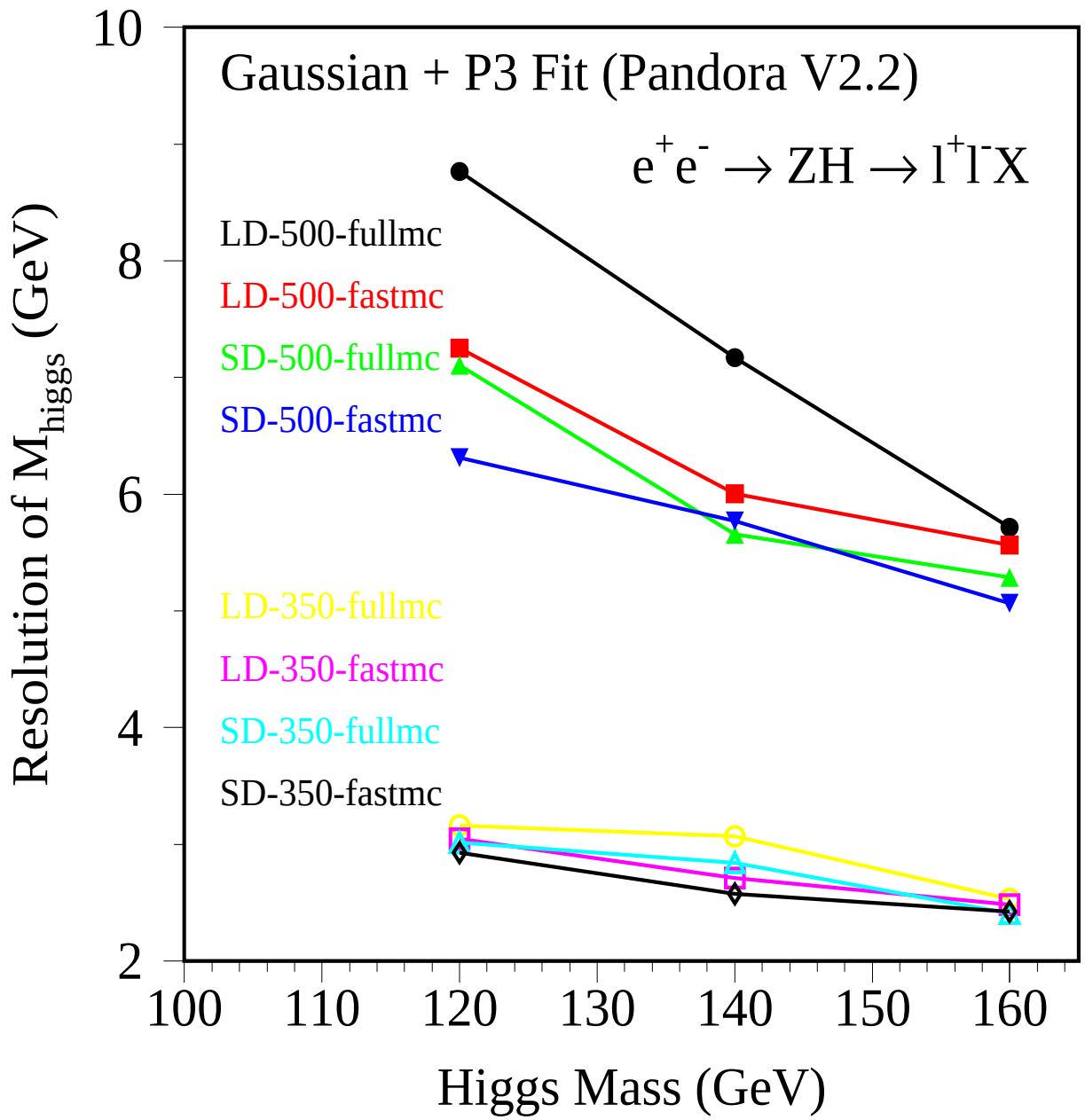


NLC350(Full) - M_h=160 GeV, SDMAR01



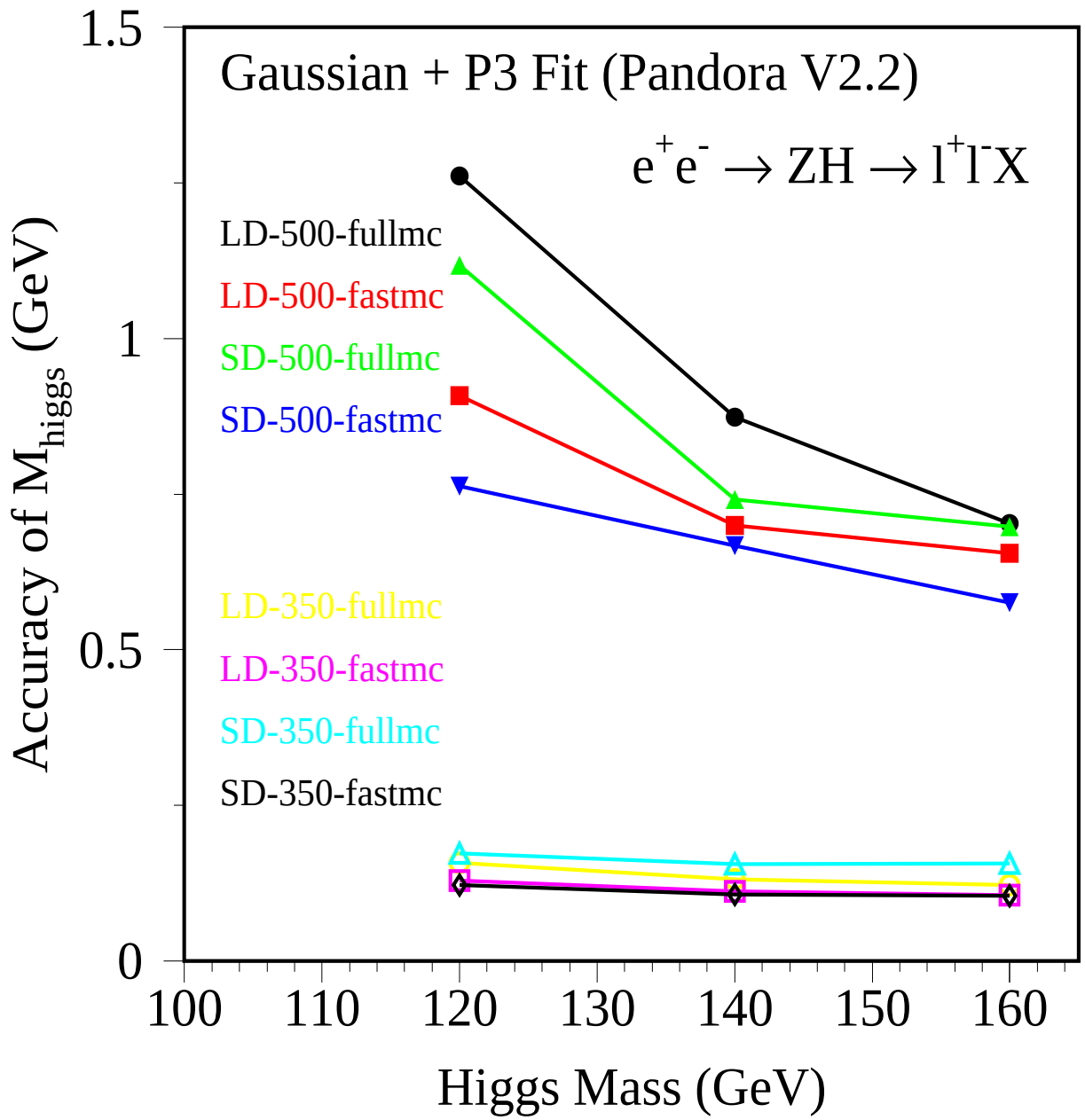
- $e^+e^- \to ZH \to \mu^+\mu^- X(\gamma)$
- Fitting Function: Gaussian + Polynomial(P3)

Resolution of Higgs Mass



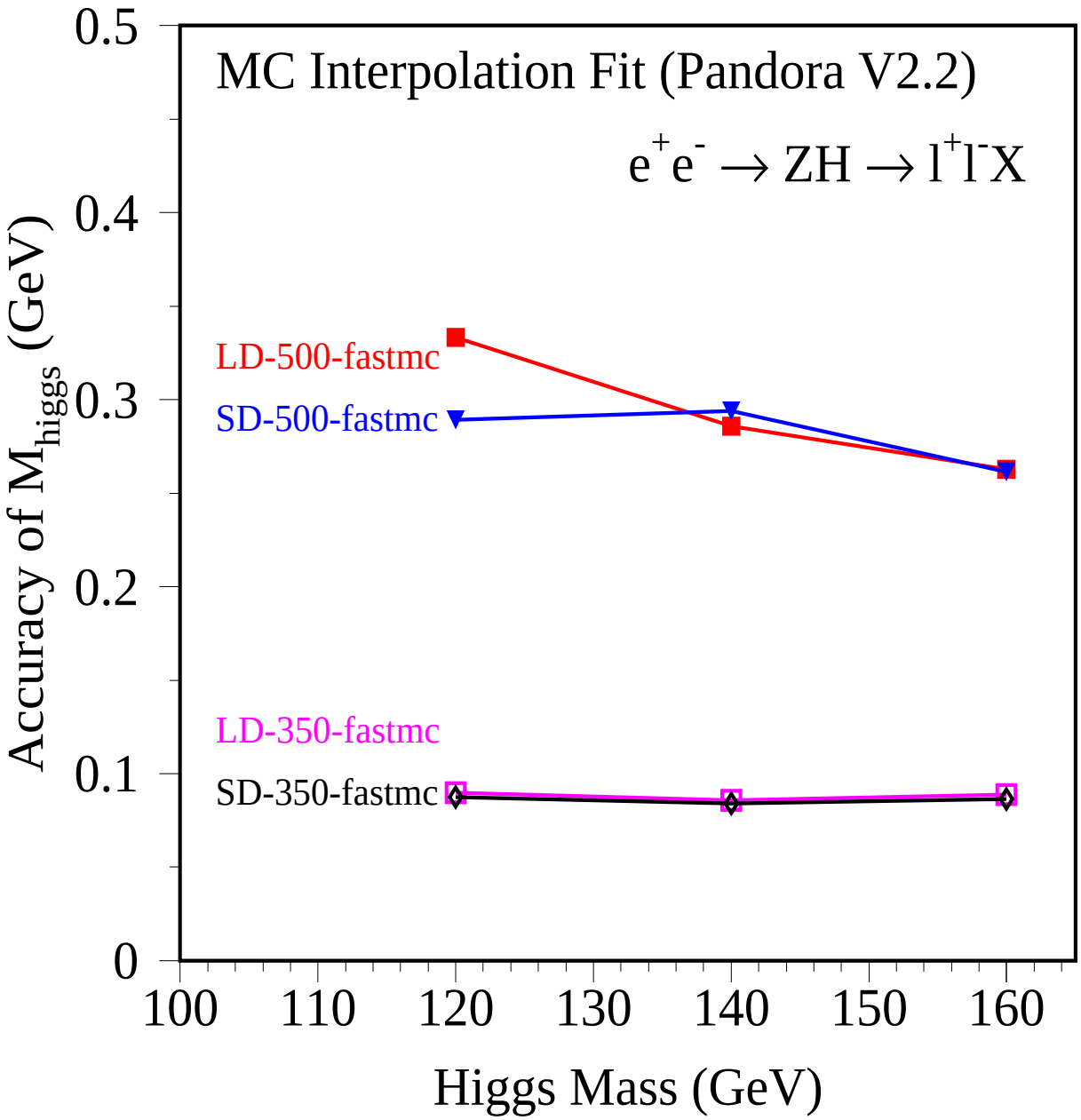
- Gaussian + Polynomial(P3) fit:
  - $\Rightarrow \sigma_{M_{higgs}}$ at 350 GeV: 2.5$\sim$ 3.5 GeV.
  - $\Rightarrow \sigma_{M_{higgs}}$ at 500 GeV: 5$\sim$ 8 GeV.

Accuracy of Higgs Mass



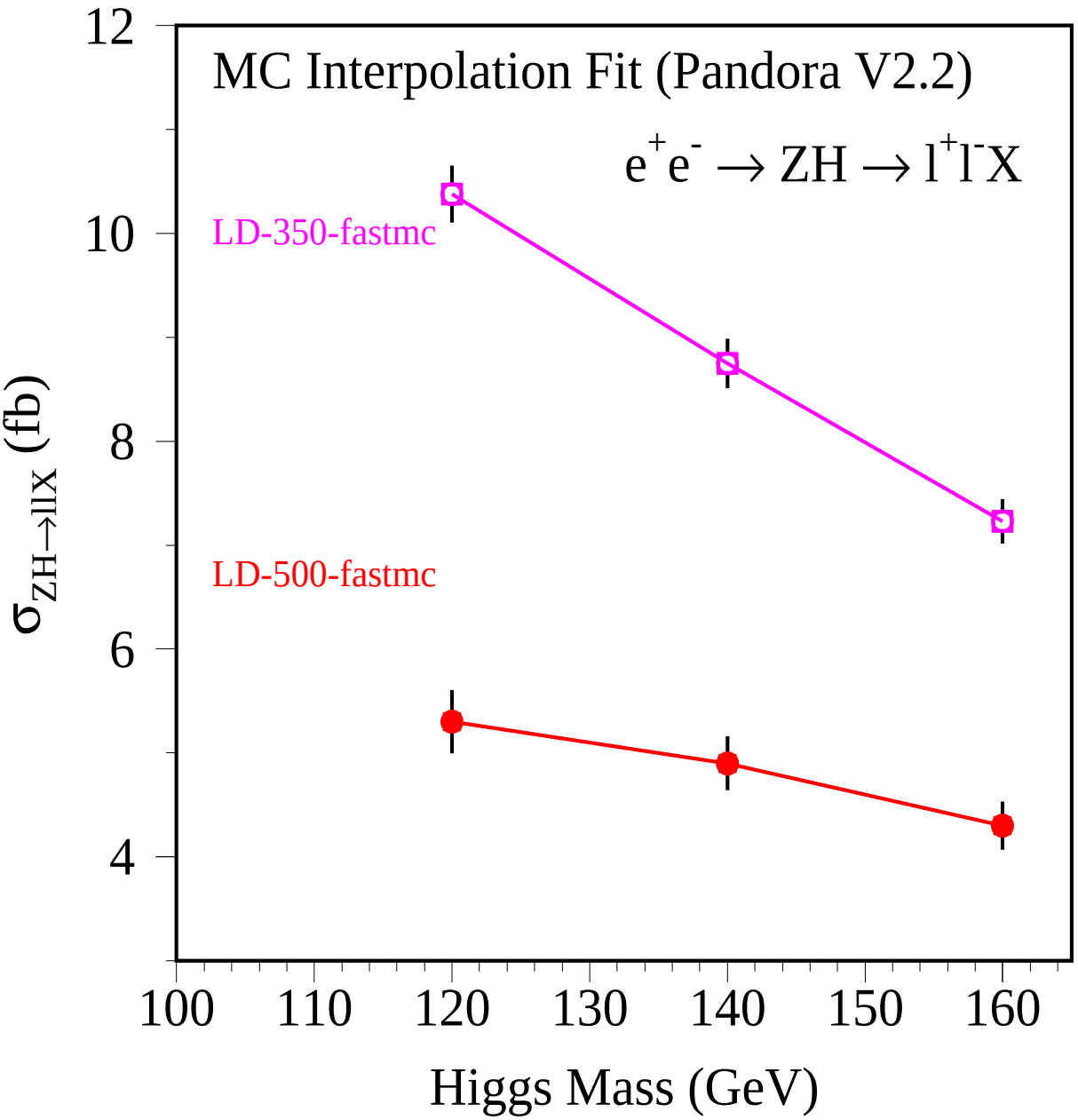
- Gaussian + Polynomial(P3) fit:
  - $\Rightarrow \Delta M_{higgs}$ at 350 GeV: 110$\sim$ 160 MeV.
  - $\Rightarrow \Delta M_{higgs}$ at 500 GeV: 600 $\sim$ 1200 MeV.

Accuracy of Higgs Mass



- Monte Carlo Interpolation Method
  - $\Rightarrow \Delta M_{higgs}$ at 350 GeV: $\sim$ 90 MeV.
  - $\Rightarrow \Delta M_{higgs}$ at 500 GeV: $\sim$ 300 MeV.

Cross Section of $ZH \to l^+l^- X(\gamma)$



- Monte Carlo Interpolation Method
  - $\Rightarrow \Delta\sigma/\sigma$ at 350 GeV: $\sim$ 3%.
  - $\Rightarrow \Delta\sigma/\sigma$ at 500 GeV: $\sim$ 5.5%.

Summary

- Fast & Full MC, LDMAR01 & SDMAR01
- $e^+e^- \to ZH \to l^+l^-X(\gamma)$
  $\sqrt{S} = 350,\ 500$ GeV and $\mathcal{L} = 500 fb^{-1}$
  $M_H = 120,\ 140,\ 160$ GeV
- Gaussian + Polynomial(P3) fit
  - $\Rightarrow \Delta M_{higgs}$ at 350 GeV: 110$\sim$ 160 MeV (*100).
  - $\Rightarrow \Delta M_{higgs}$ at 500 GeV: 600 $\sim$ 1200 MeV(300-400).
  - $\Rightarrow \sigma_{M_{higgs}}$ at 350 GeV: 2.5$\sim$ 3.5 GeV(1.6).
  - $\Rightarrow \sigma_{M_{higgs}}$ at 500 GeV: 5$\sim$ 8 GeV(3.0).
- MC interpolation method
  - Accuracy of higgs mass
    - $\Rightarrow \Delta M_{higgs}$ at 350 GeV: $\sim$ 90 MeV(60).
    - $\Rightarrow \Delta M_{higgs}$ at 500 GeV: $\sim$ 300 MeV(120).
  - Cross section of $e^+e^- \to ZH \to l^+l^-X(\gamma)$
    - $\Rightarrow \Delta\sigma/\sigma$ at 350 GeV: $\sim$ 3%(3).
    - $\Rightarrow \Delta\sigma/\sigma$ at 500 GeV: $\sim$ 5.5%(4.7).

* numbers in parentheses are for Pandora V2.1.