Impact of ILC Tracker Design on $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$ Analysis

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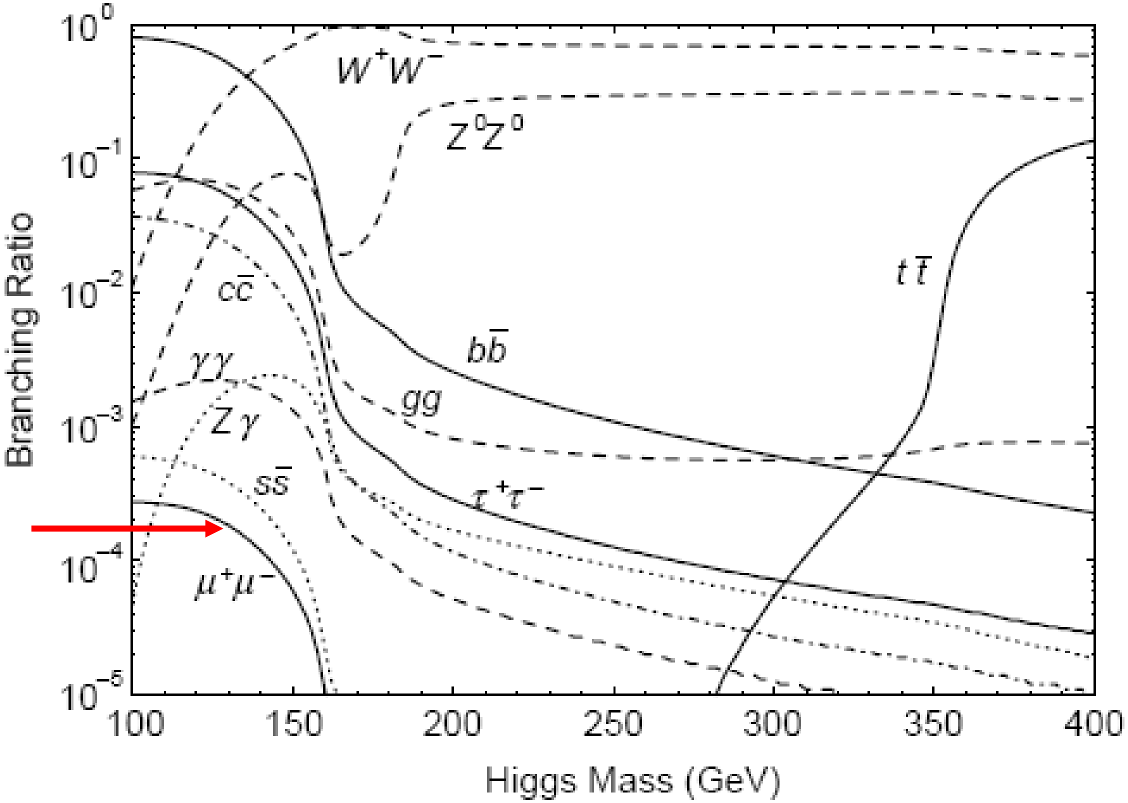
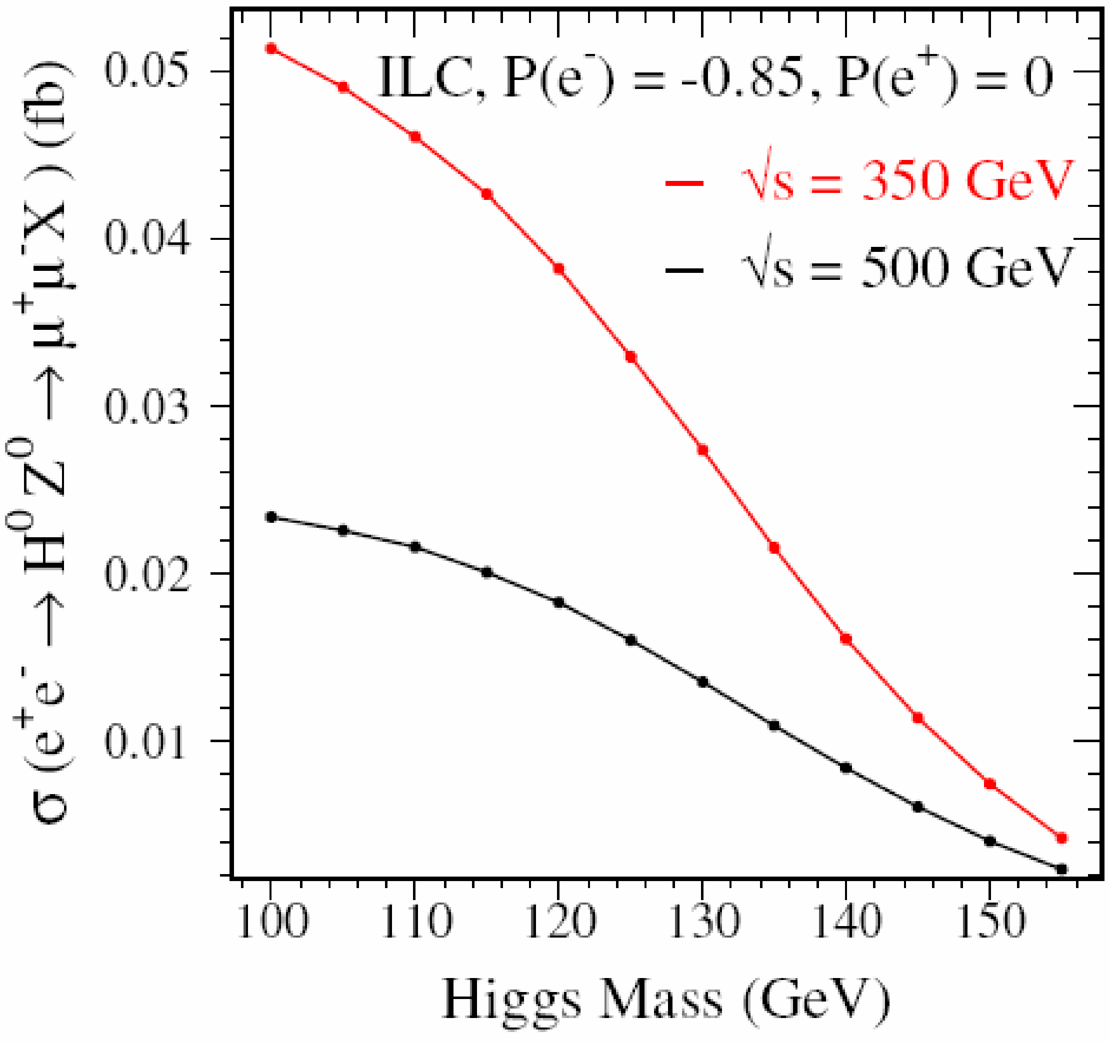
Physics Motivation

➔To determine a suitable ILC SiD tracker momentum resolution capable of making a direct measurement of $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$

Small BR
$H \rightarrow \mu^+\mu^-$



Cross Section of HZ → μ⁺μ⁻ X



MC Generator & Analysis Tool

➔ $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$

- Based on ILC350 beam setup
- Polarization of **e^-** is -85%, **e^+** is 0
- PandoraV2.3 (modified for $H \rightarrow \mu^+\mu^-$ decay, thanks to Michael E. Peskin) and PythiaV3.3
- Java Analysis Studio V2.2.5
- SDMar01, Fast MC Simulation and 1000 fb^{-1}
- Track momentum resolution for SDMar01

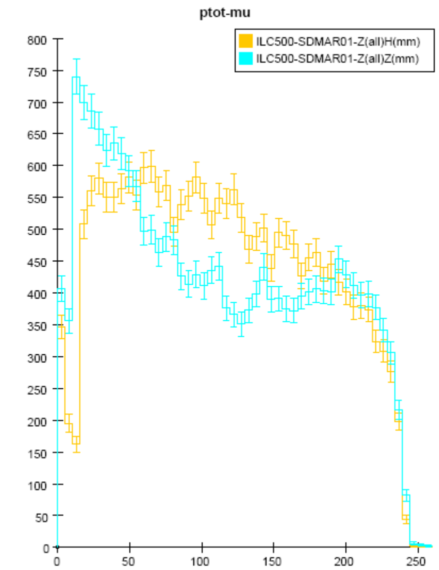
$$\Delta(1/p_t) = \sqrt{(2*10^{-5})^2 + (7*10^{-4}/p_t/\sqrt{\sin\theta})^2}$$

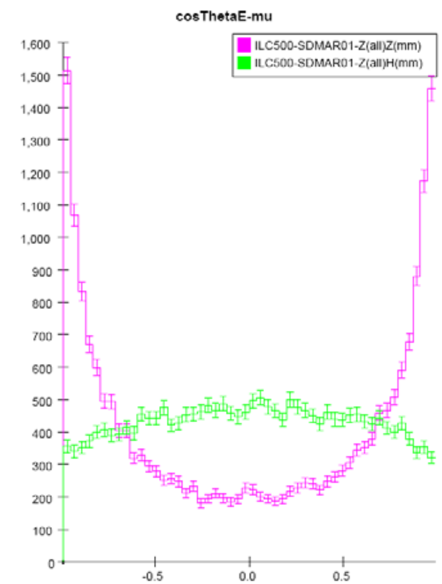
Monte Carlo Samples

- Signal – 10K: $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$
  - M_H=100, 110, 120, 130, 140, 150 GeV
  - Cross sections are 51, 46, 38, 27, 16, 7 ab, respectively.
  - Expected counts are 51, 46, 38, 27, 16, 7 for 1000 fb^{-1}
- Background $e^+e^- \rightarrow Z^0Z^0 \rightarrow \mu^+\mu^- X$ – 100 K, 31.6 fb
- Background $e^+e^- \rightarrow W^+W^- \rightarrow \mu^+\mu^-\nu\nu$ – 400 K, 149.68 fb
- Background $e^+e^- \rightarrow Z/\gamma \rightarrow \mu^+\mu^-$ - 500K, 2574.0 fb
- Background $e^+e^- \rightarrow Z\gamma \rightarrow \mu^+\mu^-\gamma$ - 400K, 416.3 fb
- Background $e^+e^- \rightarrow ZH \rightarrow \mu^+\mu^- H$
  - M_H=100, 110, 120, 130, 140, 150 GeV
  - 10K events for each Higgs mass point

Preselection Cuts

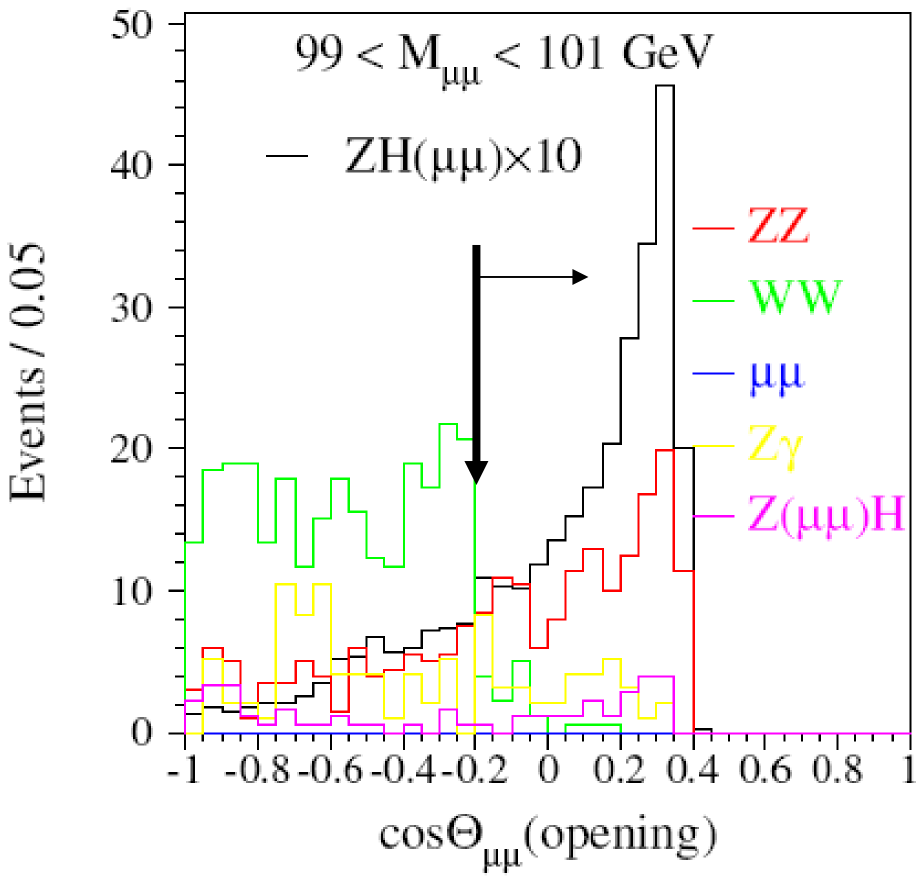
- "Good" μ:
  - a) $P_\mu > 20$ GeV
  - b) $|\cos\Theta_\mu| < 0.8$
- At least 2 "Good" μ
- Eff_signal ~ 62.4% – 65%



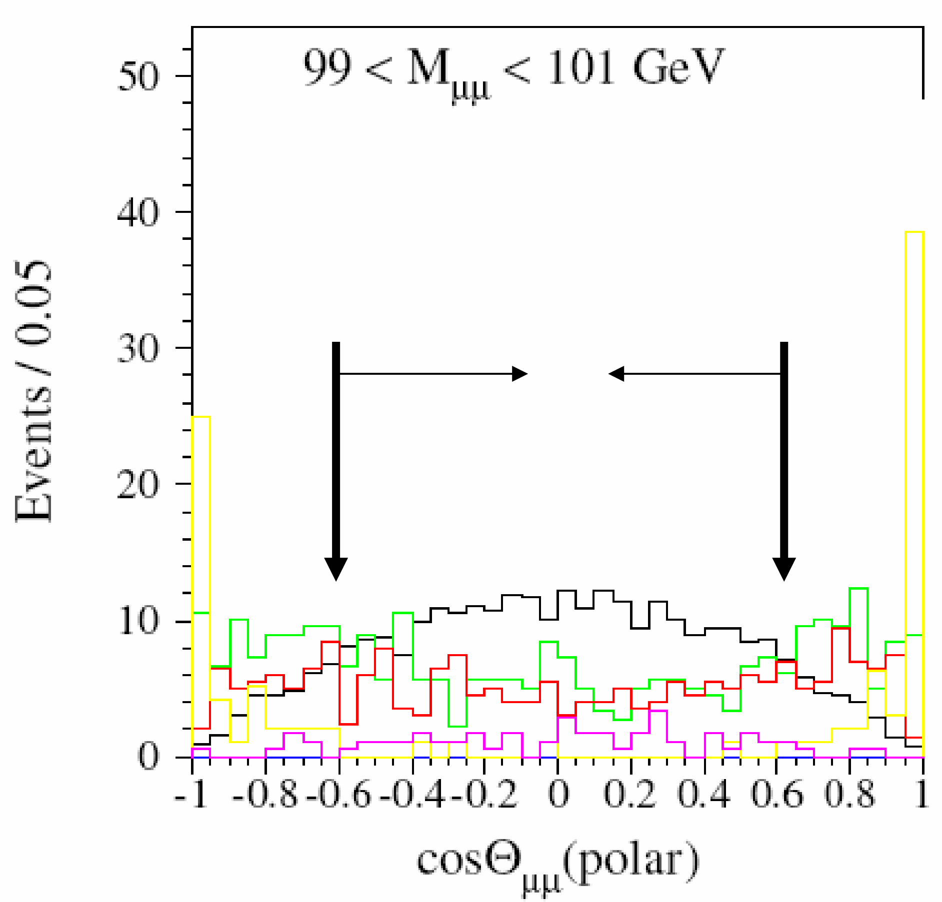


Selection Cuts (M_H=100 GeV)

Opening angle between two μ

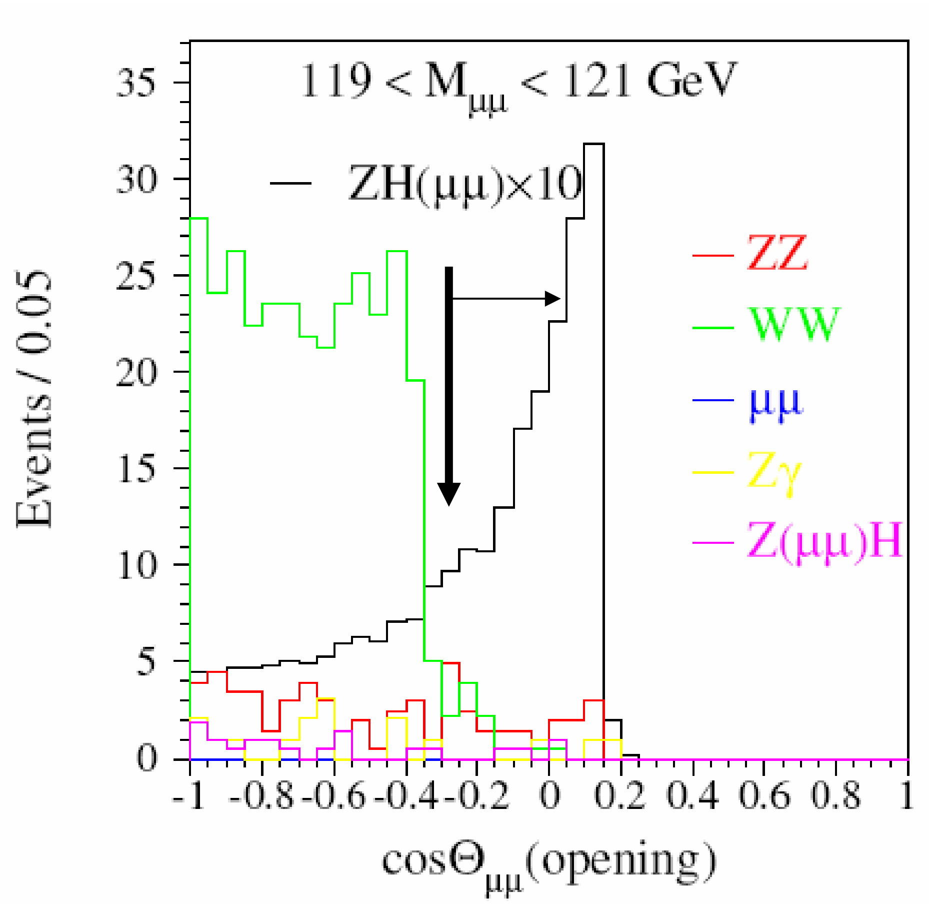


Polar angle of two μ

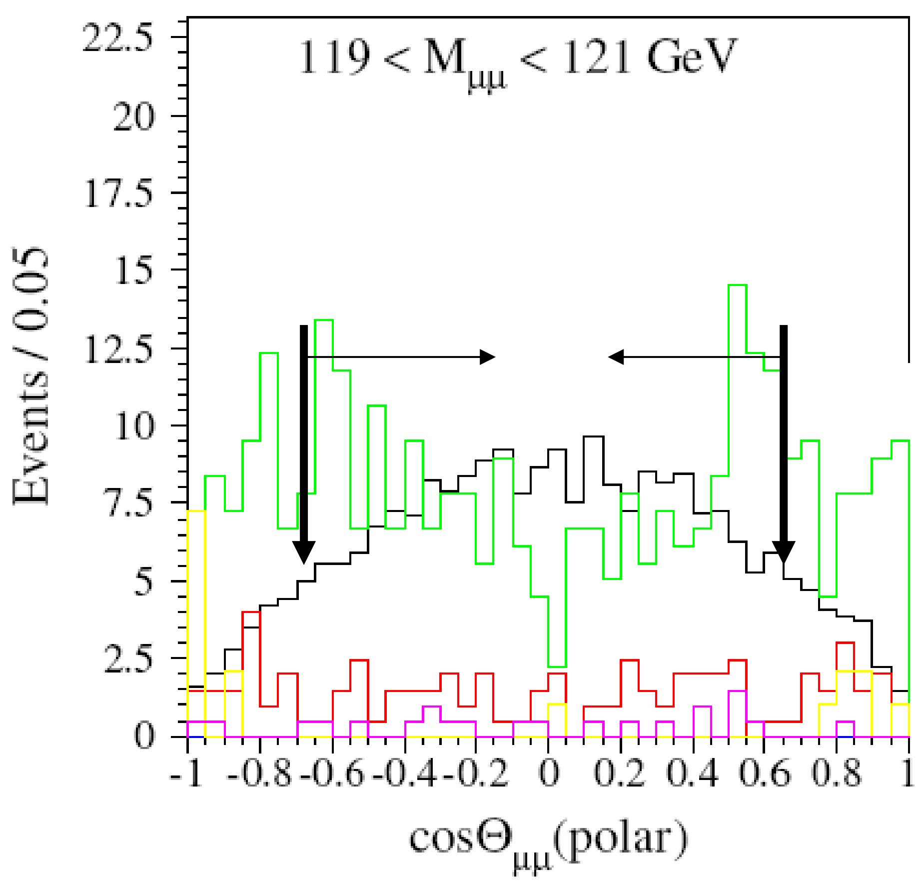


Selection Cuts (M_H=120 GeV)

Opening angle between two μ



Polar angle of two μ

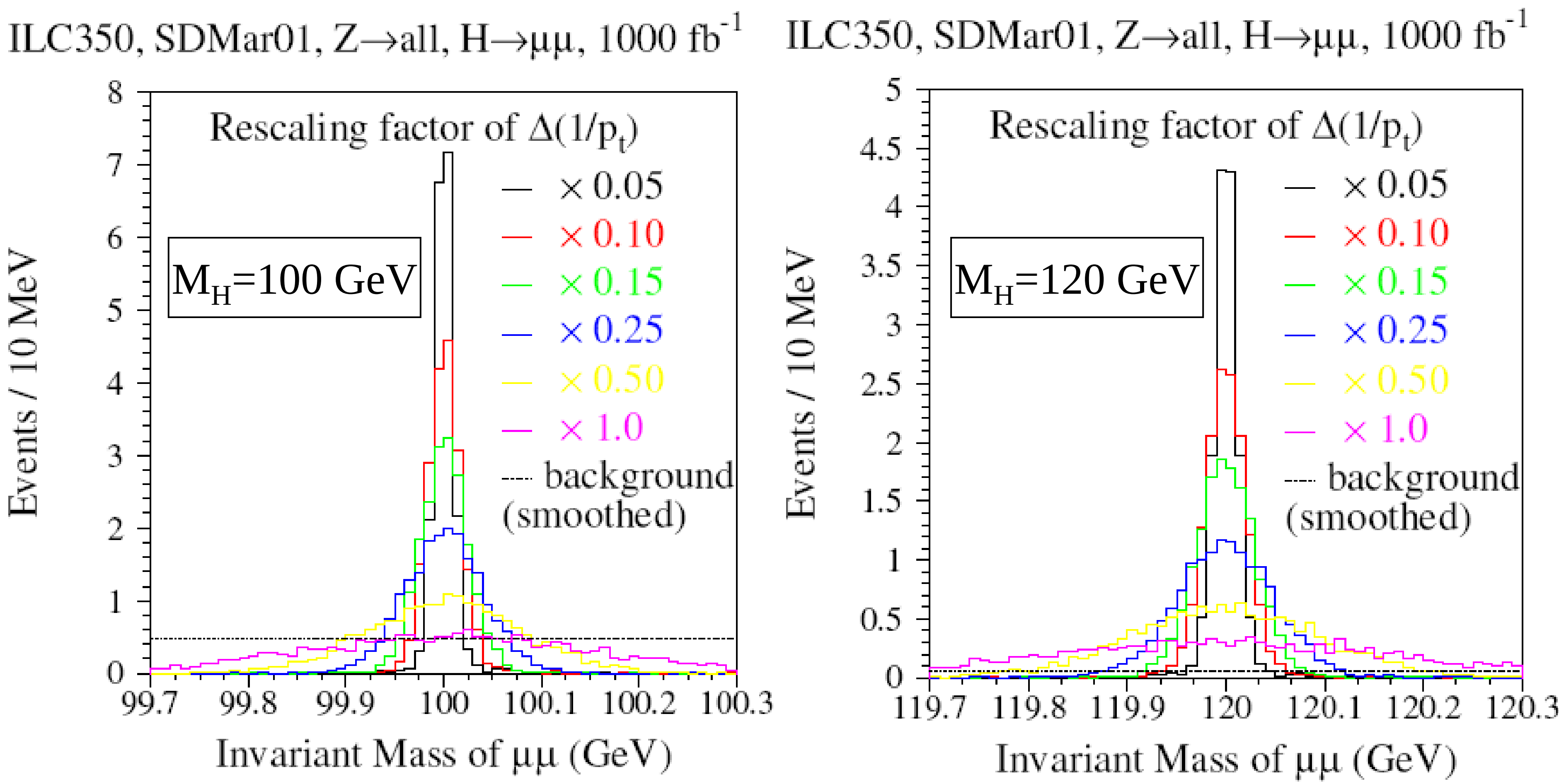


Selection Efficiency

$M_{\mu\mu}$(GeV)	$cos\theta_{\mu\mu(opening)}$	$\|cos\theta_{\mu\mu(polar)}\|$	Eff	ZH($\mu\mu$)	ZZ	WW	$\mu\mu$	Zγ	Z($\mu\mu$)H
100 ± 1	> -0.2	< 0.6	37.6%	19.3	76.6	3.4	0.0	1.04	17.0
110 ± 1	> -0.2	< 0.6	34.7%	15.9	19.4	0.0	0.0	0.0	4.2
120 ± 1	> -0.3	< 0.7	36.6%	13.9	8.95	1.12	0.0	0.0	1.5
130 ± 1	> -0.4	< 0.7	34.3%	9.4	2.5	4.5	0.0	0.0	0.9
140 ± 1	> -0.4	< 0.7	28.0%	4.5	0.5	2.8	0.0	0.0	0.8
150 ± 1	> -0.4	< 0.8	24.3%	1.8	0.0	1.24	0.0	0.0	0.0

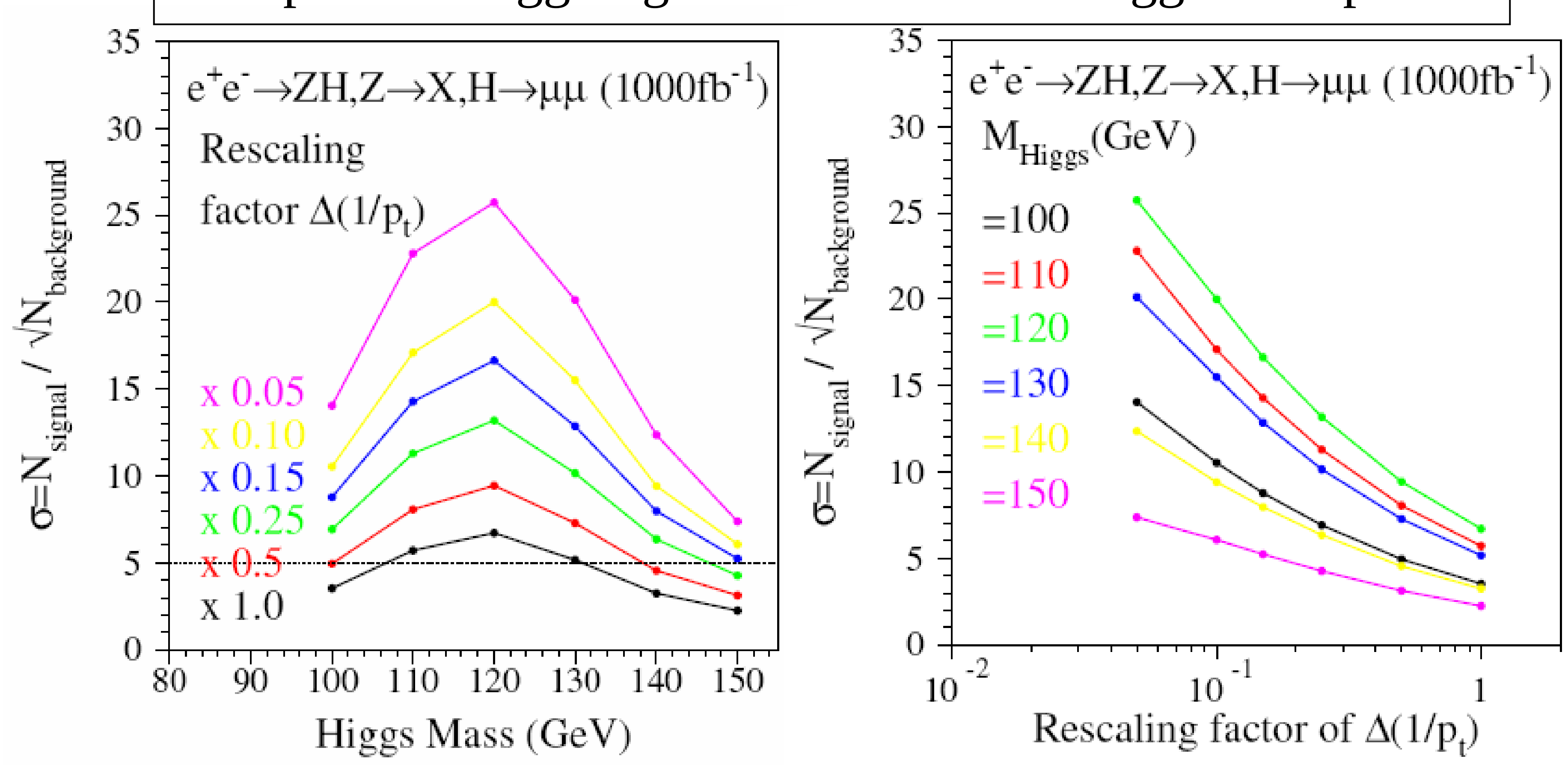
➔Lower efficiency for higher Higgs mass, which is mainly caused by wider opening angle between μμ decay from Higgs.

$M_{\mu\mu}$ vs Track Momentum Resolution



Signal Events - Detection Significance

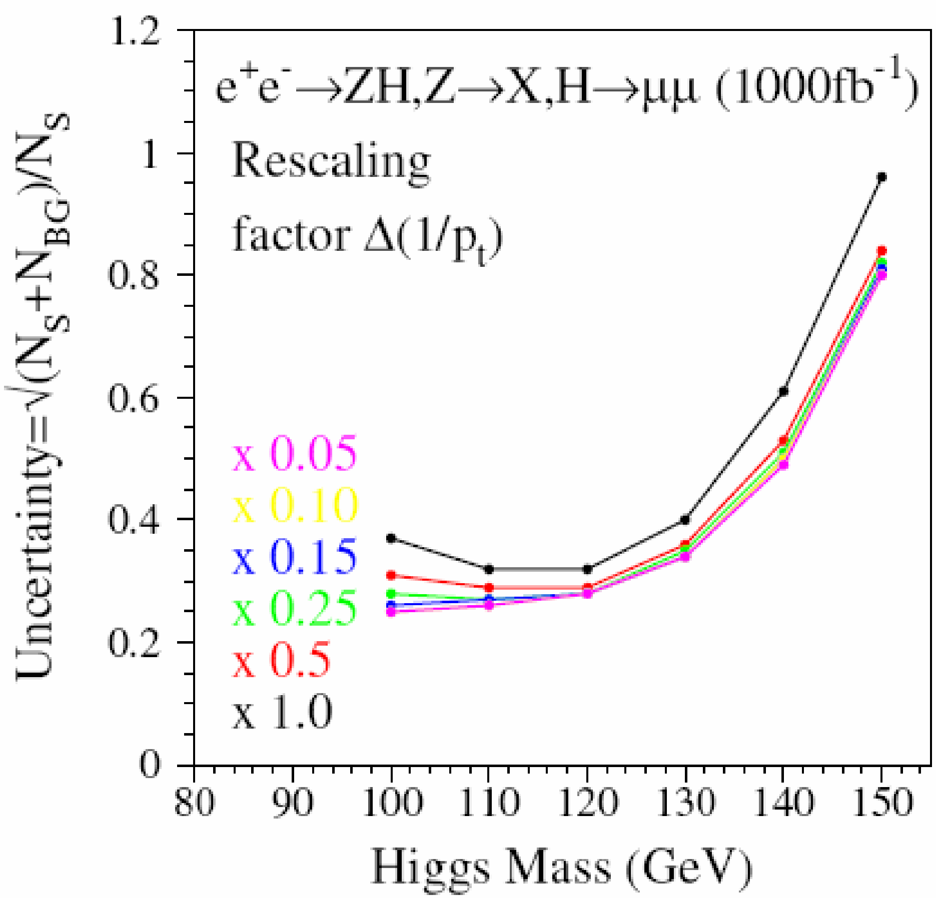
➔ Optimize Higgs significance for each Higgs mass point.

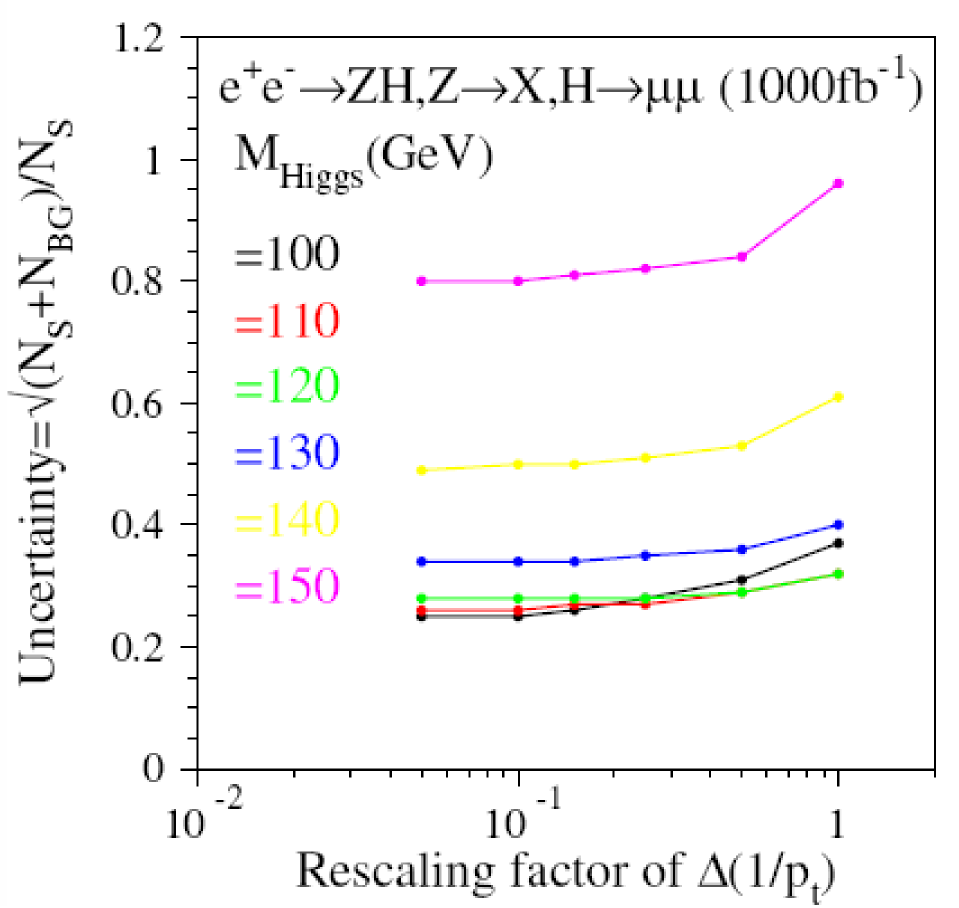


➔ The H➔μμ significance is improved with better track resolution.

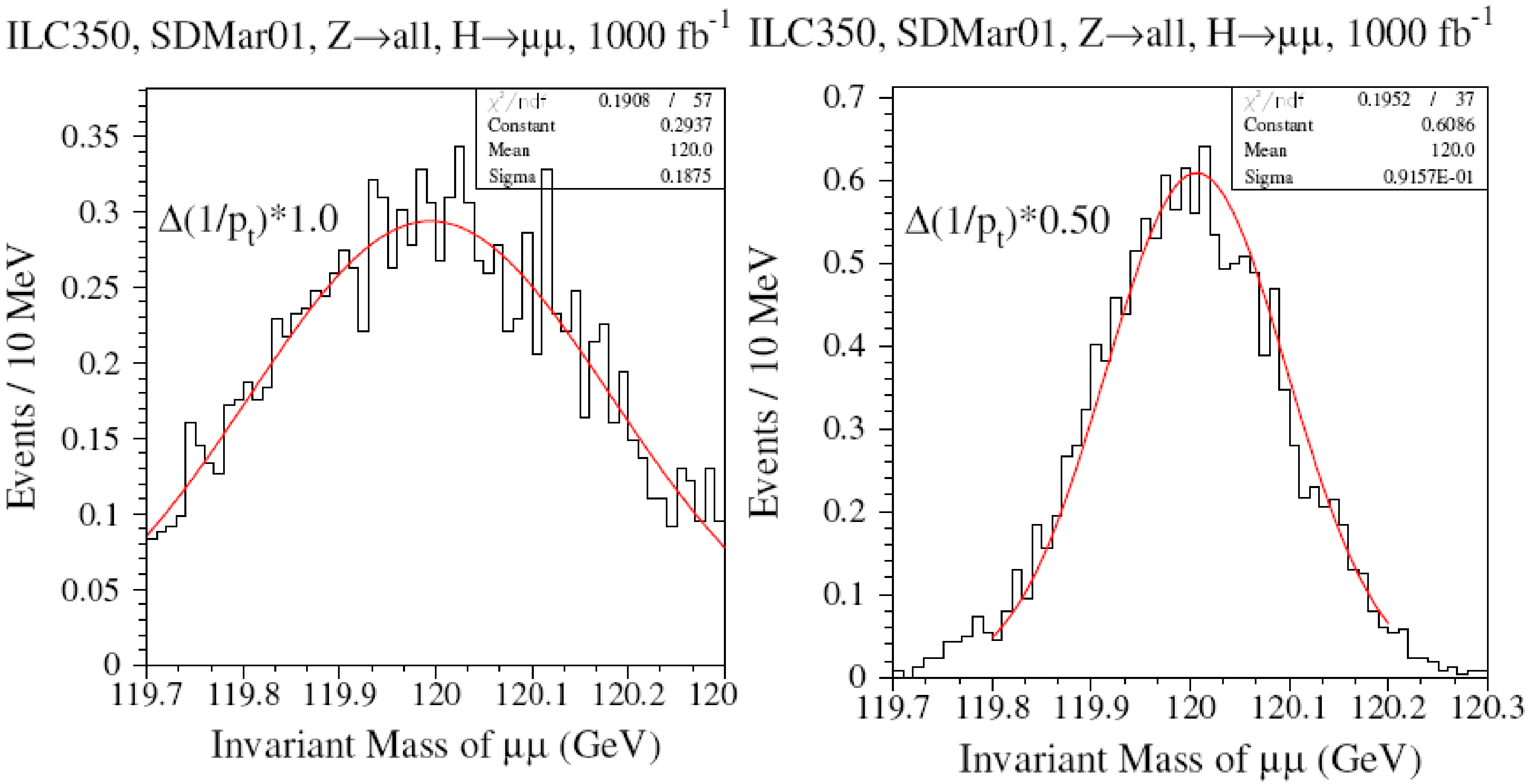
Branching Ratio Uncertainty

➔The detection significance improves significantly with improved momentum resolution, but branching ratio of H➔μμ improves only modestly.

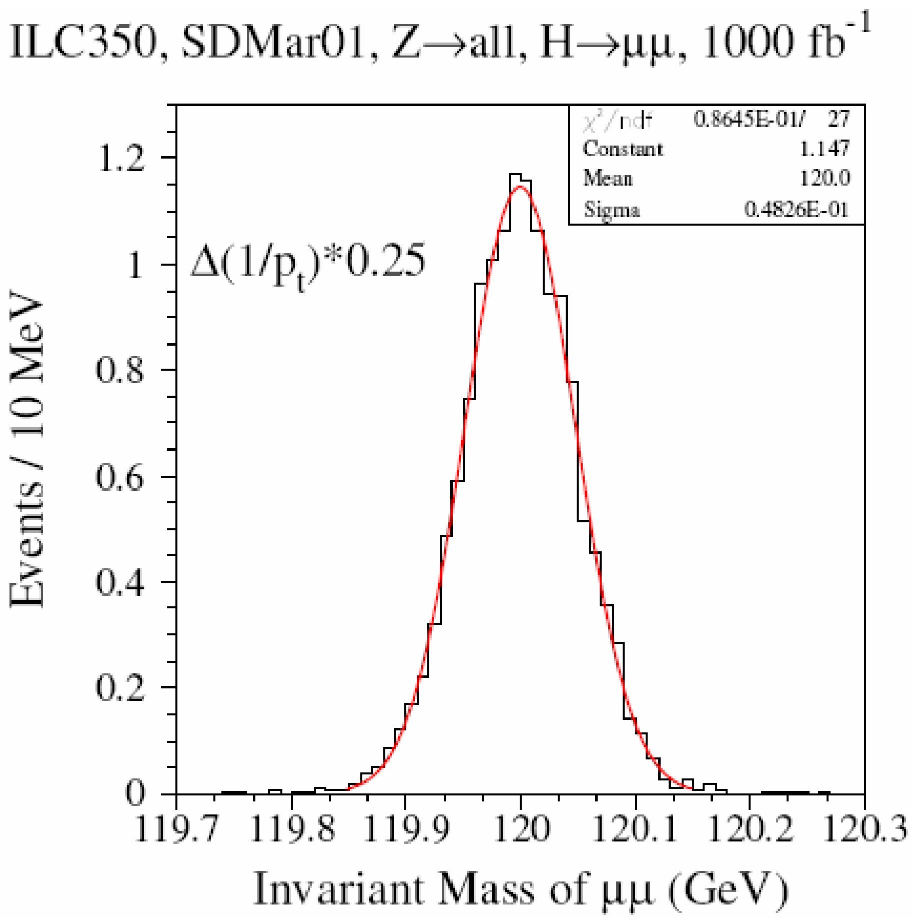


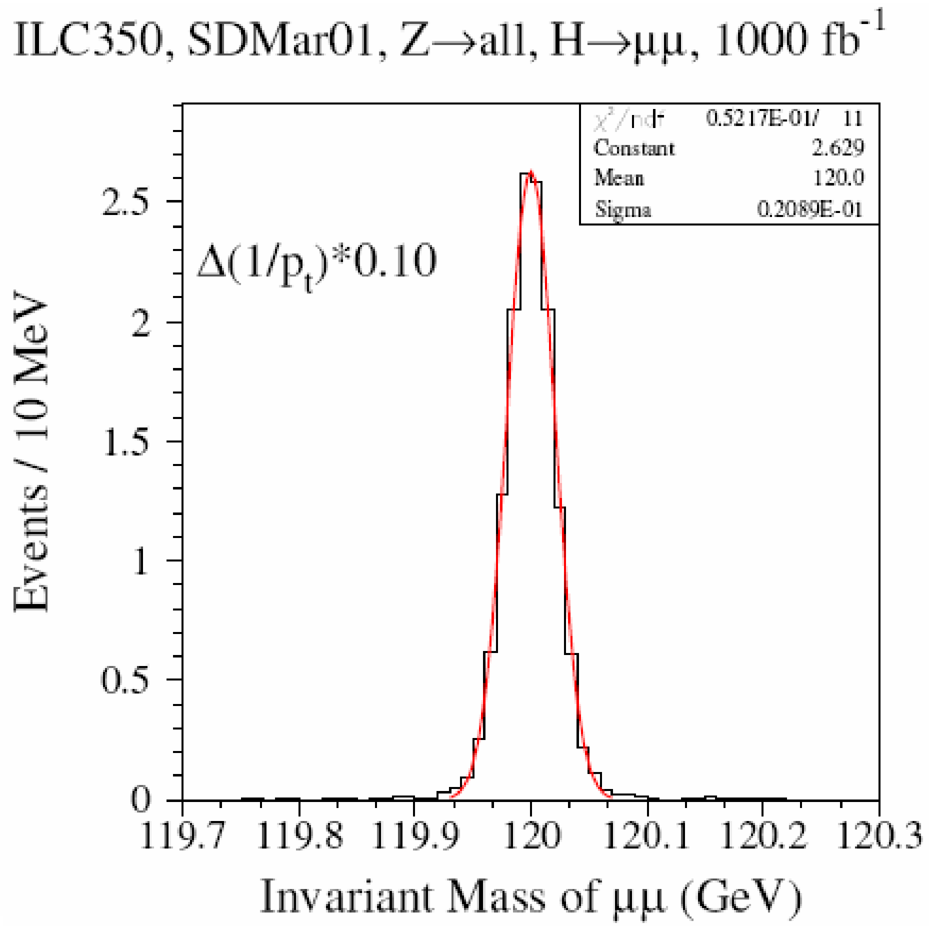


Higgs Mass Resolution



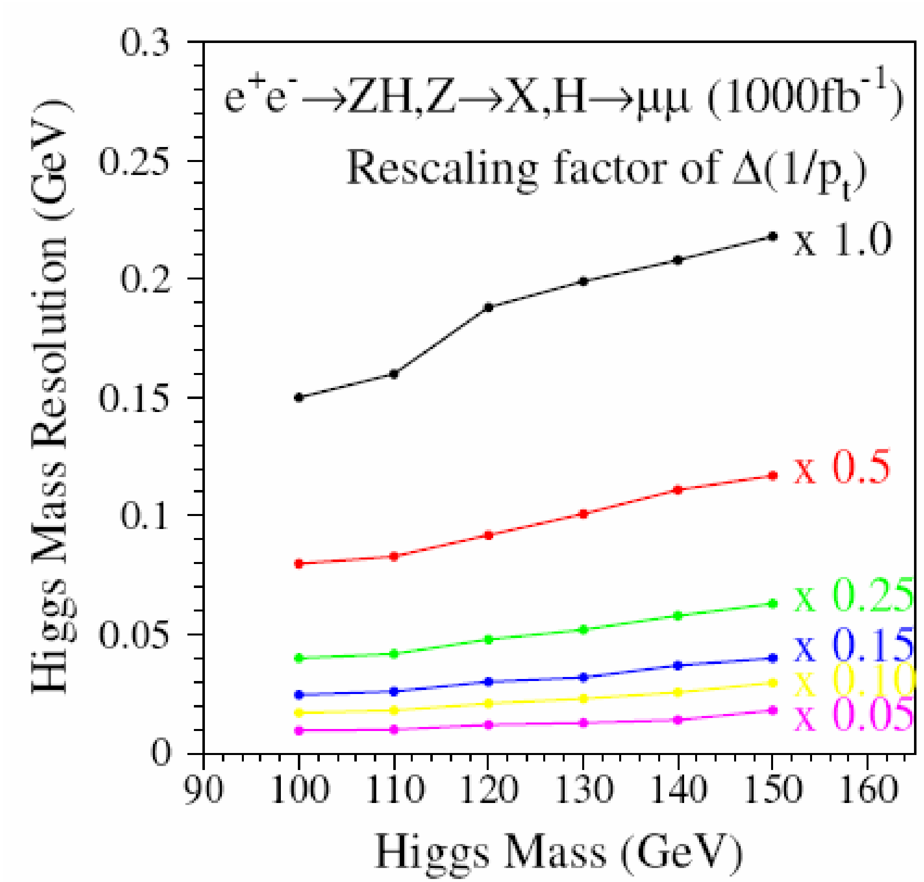
Higgs Mass Resolution

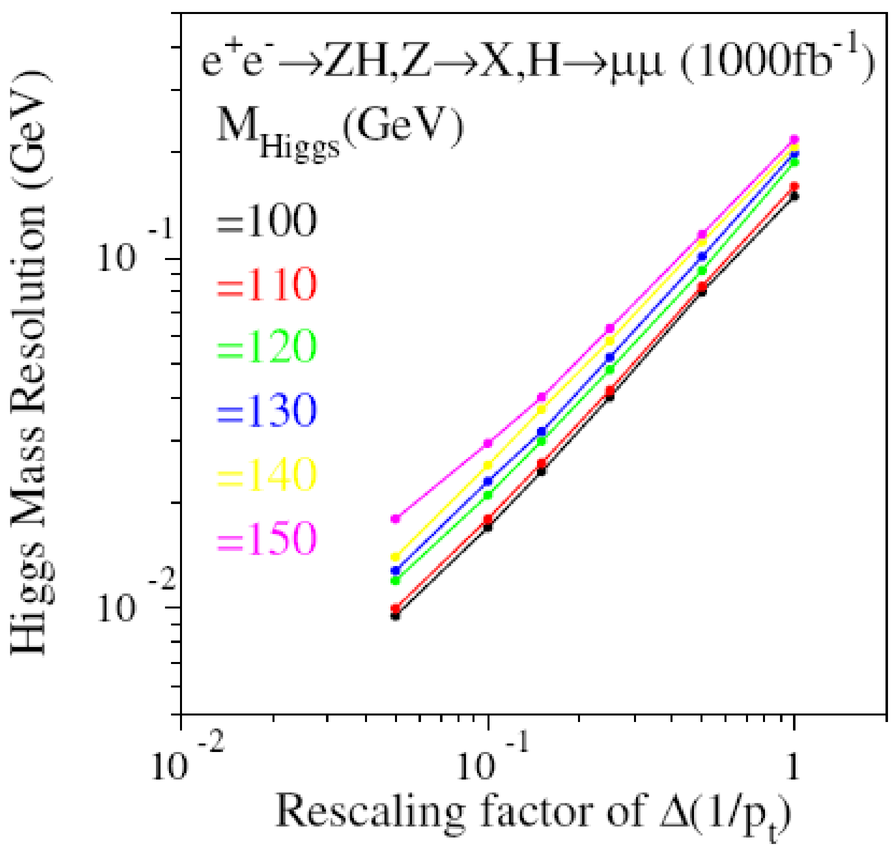




Higgs Mass Resolution

➔Better Higgs mass resolution with better track resolution.





Preliminary Conclusions

- ➔The SD tracker with nominal track momentum resolution makes it possible but still hard to measure $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$.

- ➔But the direct measurement is feasible (>5 sigma for light Higgs mass ~ 100-140GeV) if the track momentum resolution is improved by a factor of ~ 2 or more.