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

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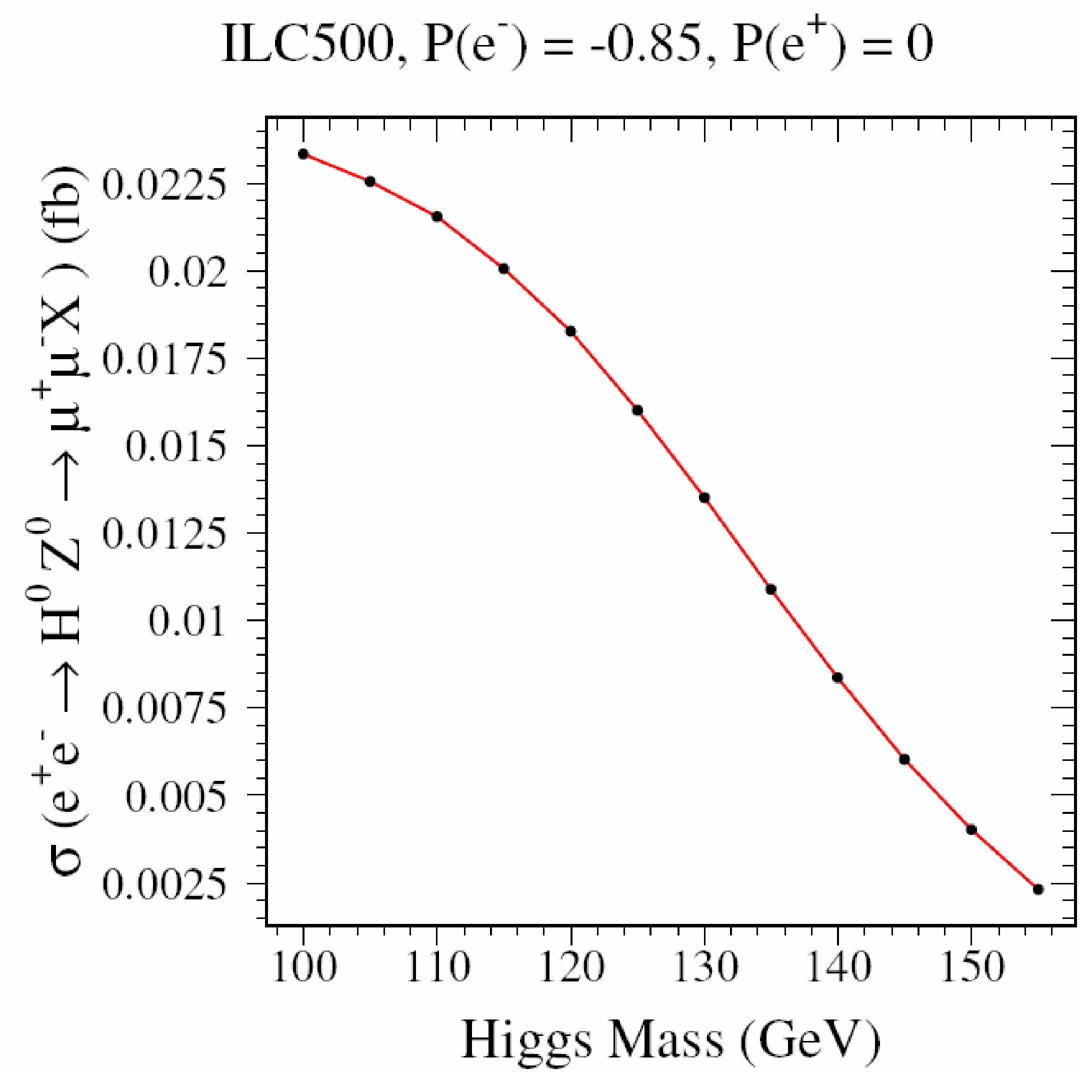
Physics Motivation

➔To determine the suitable ILC SiD tracker momentum resolution which is capable to make direct measurement of

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

- Based on ILC500 beam setup
- Polarization of **e**$^-$ is -85%, **e**$^+$ is 0
- PandoraV2.3 (modified for H→ $\mu^+\mu^-$ decay, thanks to Michael E. Peskin) and PythiaV3.3
- Java Analysis Studio V2.2.5
- SDMar01, Fast MC Simulation and 1000 fb^{-1}

Cross Section of HZ → $\mu^+\mu^-$ X



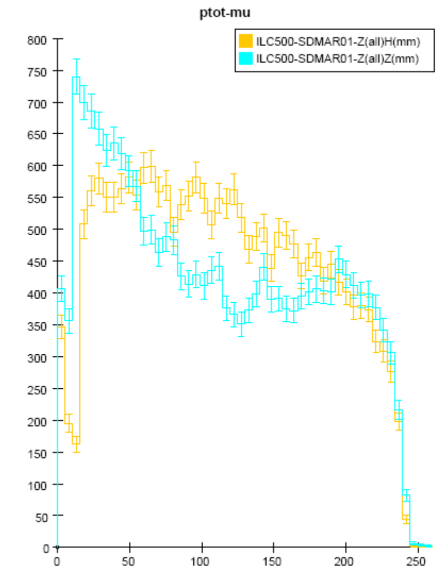
Monte Carlo Samples

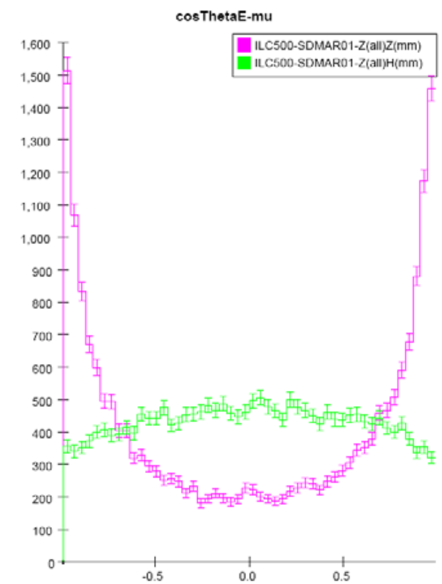
- Signal – 10K
  - $e^+e^- \rightarrow H^0Z^0 \rightarrow \mu^+\mu^- X$
  - Cross section is 0.018278 fb for M_H=120 GeV
  - 18 signal events expected for 1000 fb^{-1}
- Background $W^+W^- \rightarrow \mu^+\mu^-\nu\nu$ – 400 K
  - Cross section is 149.68 fb
  - 149680 WW events expected for 1000 fb^{-1}
- Background $Z^0Z^0 \rightarrow \mu^+\mu^-X$ – 100 K
  - Cross section is 31.6 fb
  - 31600 ZZ events expected for 1000 fb^{-1}

Preselection Cuts

- "Good" μ:
  - a) $P_{\mu} > 20$ GeV
  - b) $|\cos \Theta_{\mu}| < 0.8$
- At least 2 "Good" μ

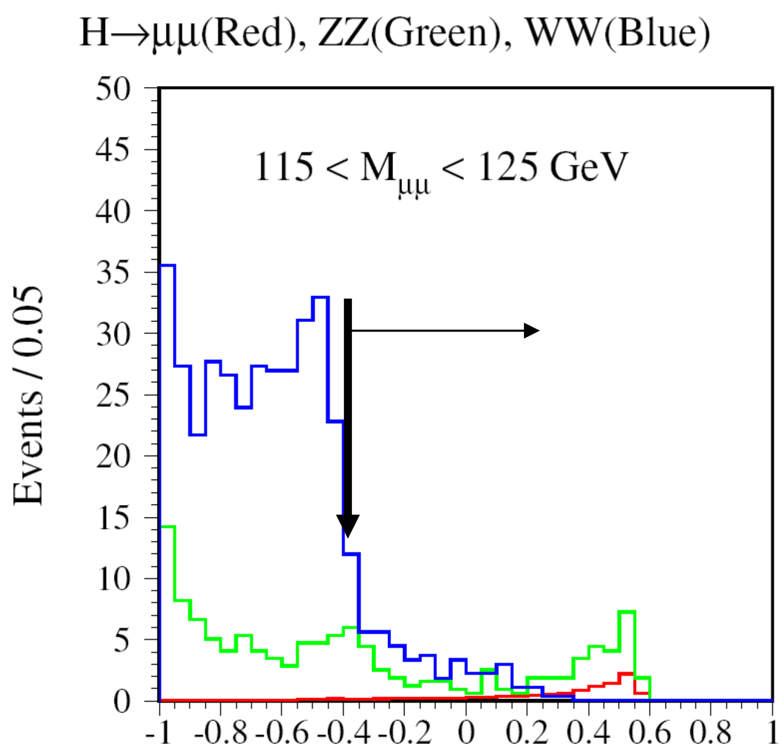
- For $| M_{\mu\mu} - 120 | < 5$ GeV
  - Signal 10K → 6442
    Eff_signal = 64.42%
  - Bkgd ZZ 100K →382
    Eff_zz = 0.382%
  - Bkgd WW 400K → 1019
    Eff_ww = 0.25475%



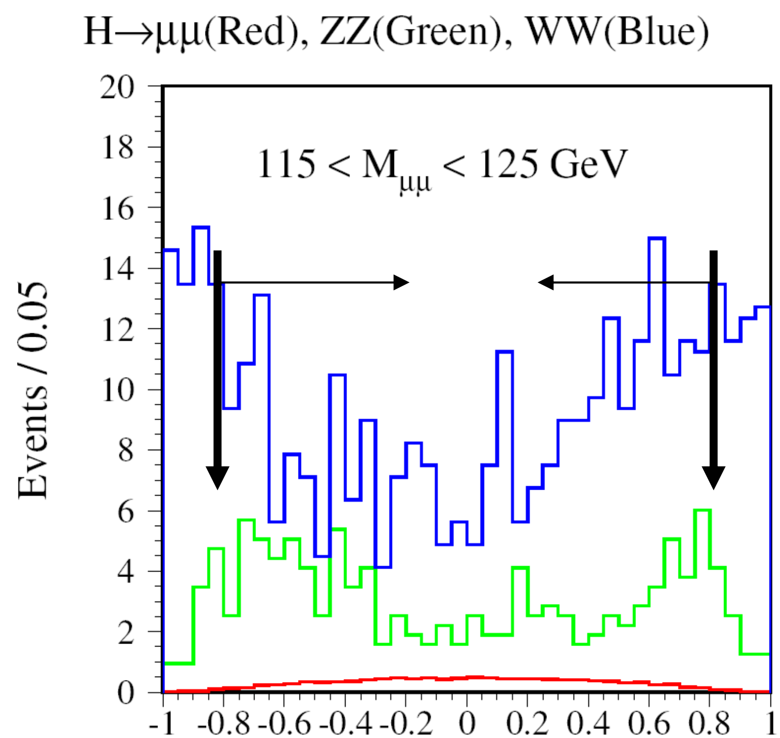


Additional Selection Cuts

$H \to \mu\mu$:	10K →	6442 →	5959 →	5780 →	10.57 (exp)
ZZ Bkgd:	100K →	382 →	164 →	141 →	44.8 (exp)
WW Bkgd:	400K →	1019 →	135 →	47 →	17.6 (exp)

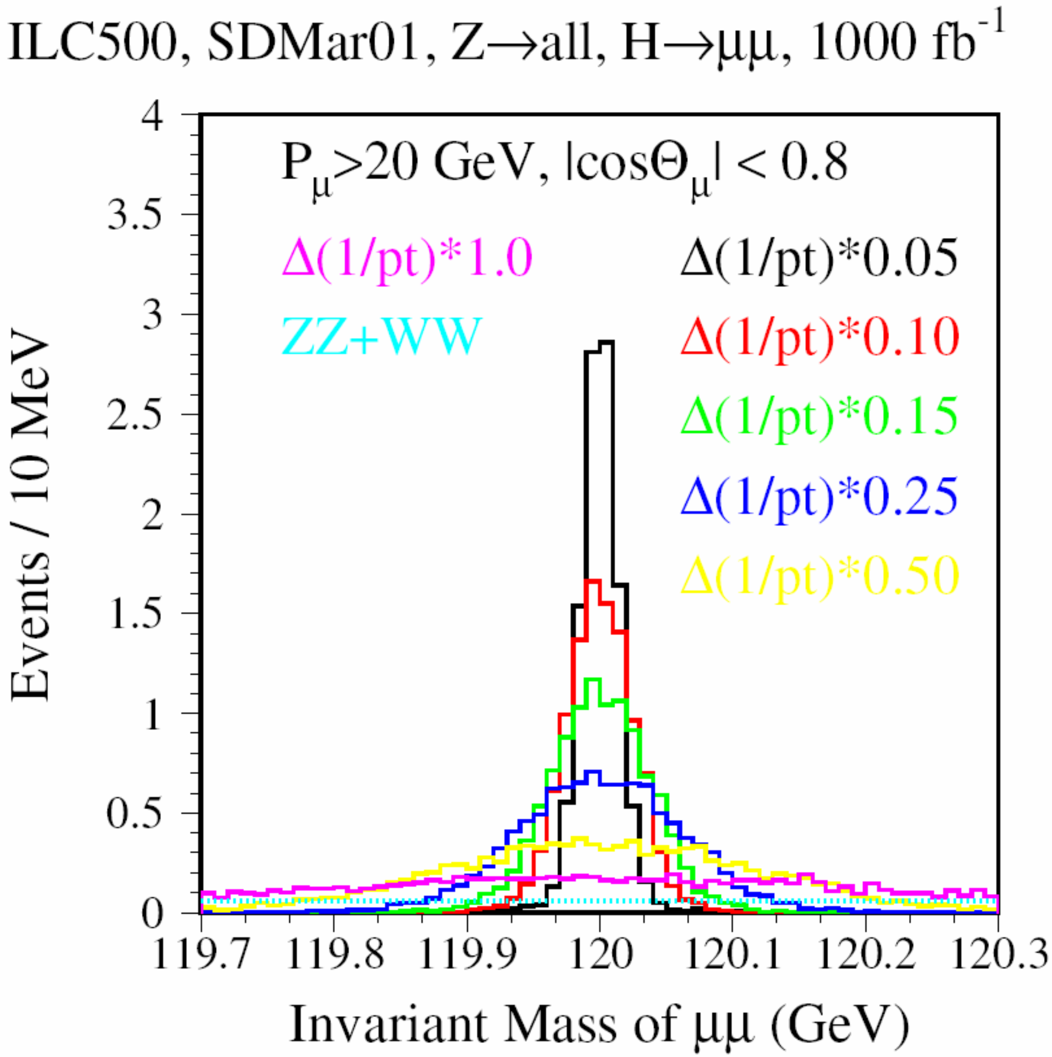


Angle between two μ $\cos\Theta_{\mu\text{-}\mu}$



Polar angle of two μ $\cos\Theta_{\mu\mu}$

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



Signal Events - Detection Significance

➔ The $H \rightarrow \mu\mu$ significance is improved with better track resolution.

Rescaling factor of $\Delta(1/pt)$	$\lvert M_{\mu\mu}-120\rvert<0.2$ (GeV) N_{bkgd}= 2.4, N_s	$N_s / \sqrt{N_{bkgd}}$ (Significance)	$\lvert M_{\mu\mu}-120\rvert<0.1$ (GeV) N_{bkgd}= 1.2, N_s	$N_s / \sqrt{N_{bkgd}}$ (Significance)
1.0	6.3	4.1	3.35	3.1
0.50	9.5	6.1	6.2	5.7
0.25	10.5	6.8	9.5	8.7
0.15	10.5	6.8	10.4	9.5
0.10	10.5	6.8	10.5	9.6
0.05	10.5	6.8	10.5	9.6

Branching Ratio Uncertainty

➔With the SiD's nominal momentum resolution, one can measure Br(H➔μμ) to 47%. The precision improves only modestly with improved track resolution.

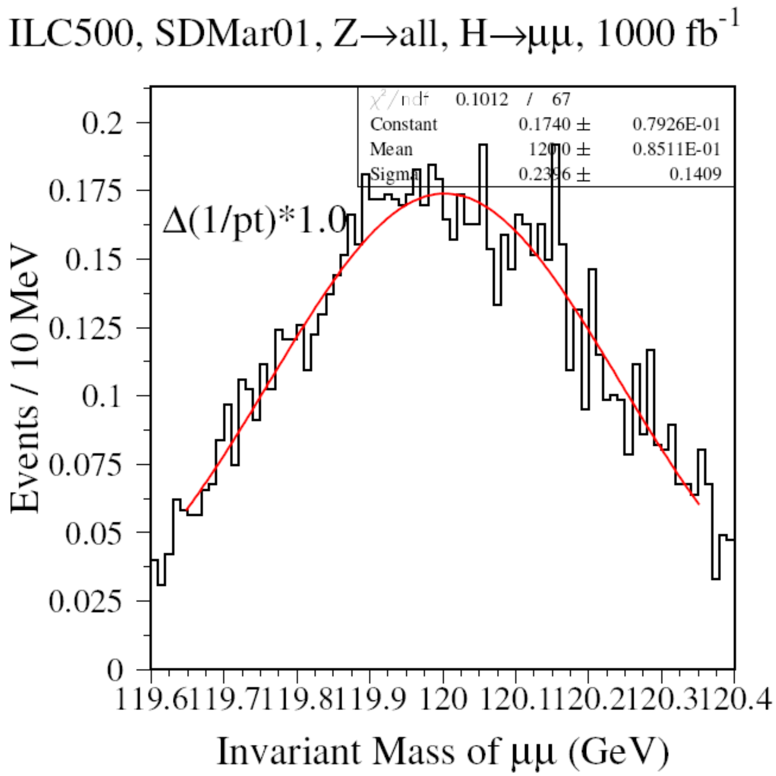
Rescaling factor of Δ(1/pt)	$\lvert M_{\mu\mu}$-120$\rvert$<0.2 (GeV) N_{bkgd}= 2.4, N_s	$\sqrt{}(N_s + N_{bkgd})/ N_s$ (Uncertainty)	$\lvert M_{\mu\mu}$-120$\rvert$<0.1 (GeV) N_{bkgd}= 1.2, N_s	$\sqrt{}(N_s + N_{bkgd})/N_s$ (Uncertainty)
1.0	6.3	46.7%	3.35	63.7%
0.50	9.5	36.0%	6.2	43.9%
0.25	10.5	34.0%	9.5	34.4%
0.15	10.5	34.0%	10.4	32.7%
0.10	10.5	34.0%	10.5	32.6%
0.05	10.5	34.0%	10.5	32.6%

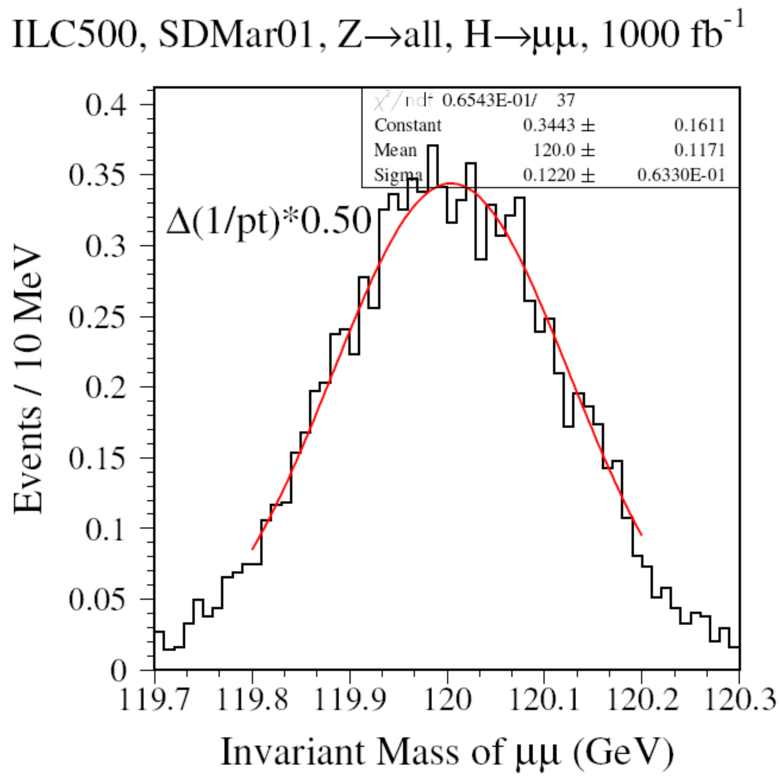
Higgs Mass Resolution & Accuracy

➔Better Higgs mass resolution with better track resolution.

Rescaling factor of Δ(1/pt)	Mass resolution (MeV)	Mass Accuracy (GeV)	χ^2 / n.d.f
1.0	239.6 ± 140.9	120.0 ± 0.09	0.10 / 67
0.50	117.6 ± 63.3	120.0 ± 0.12	0.065 / 37
0.25	59.9 ± 16.3	120.0 ± 0.09	0.046 / 27
0.15	36.6 ± 9.5	120.0 ± 0.09	0.044 / 17
0.10	25.4 ± 6.4	120.0 ± 0.09	0.074 / 15
0.05	13.8 ± 3.6	120.0 ± 0.1	0.022 / 5

Fit $M_{\mu\mu}$ Distributions





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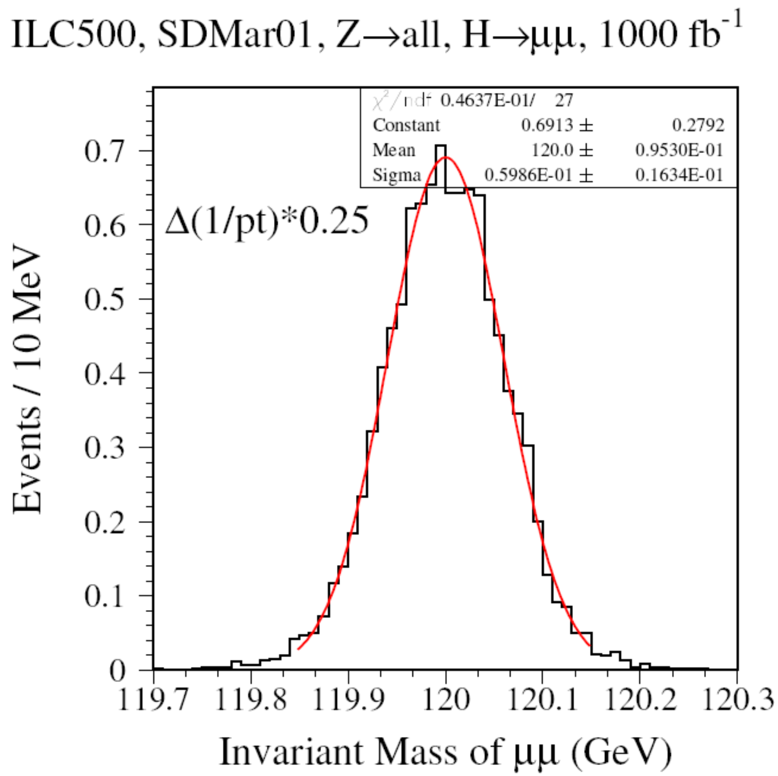
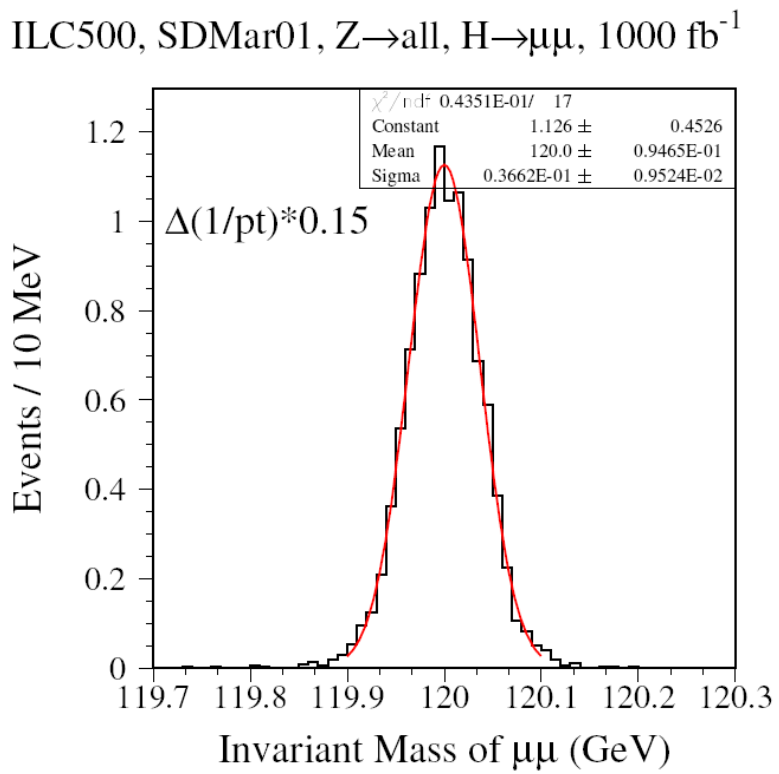
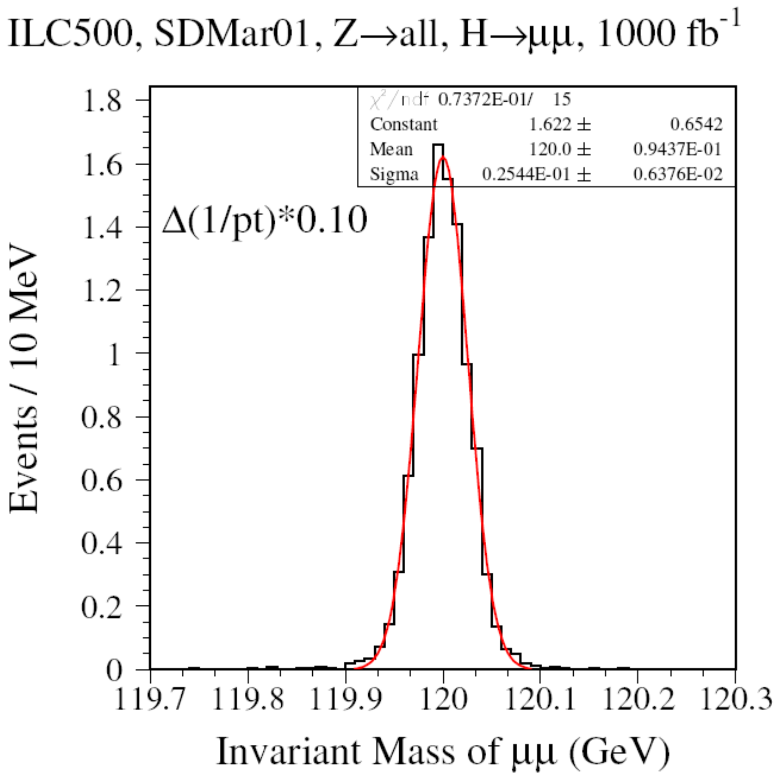
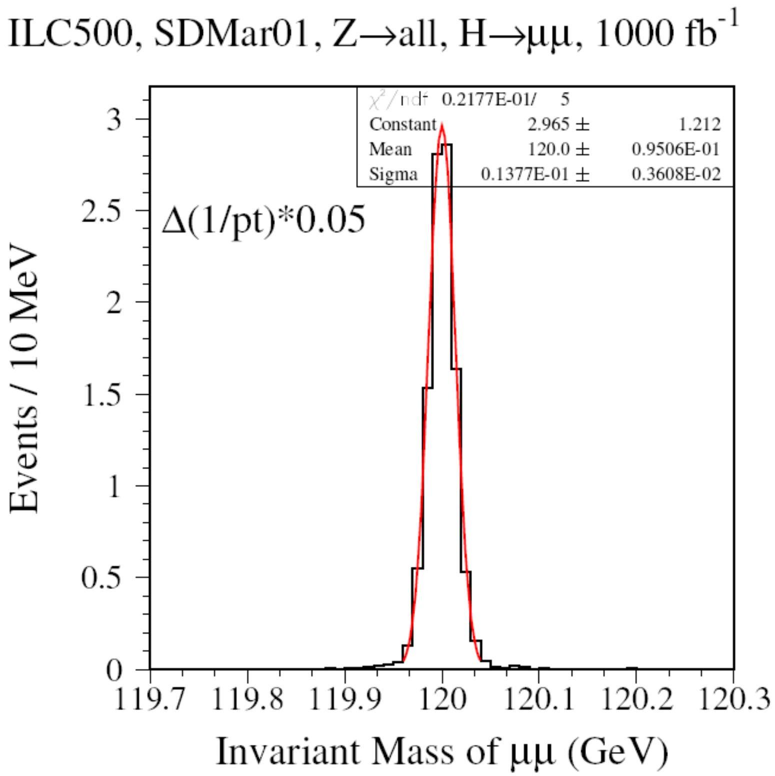




Fit $M_{\mu\mu}$ Distributions





Preliminary Conclusions

- ➔With the SiD's nominal track momentum resolution, one can establish detection of $H \rightarrow \mu\mu$ with 4-sigma significance and can measure $Br(H \rightarrow \mu\mu)$ to 47%.

- ➔The detection significance improves significantly with improved track momentum resolution, but branching ratio of $H \rightarrow \mu\mu$ improves only modestly.