Beam Related Systematics in Higgs Mass Measurement

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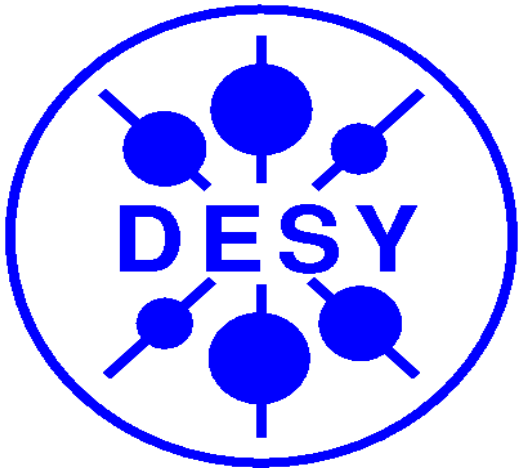

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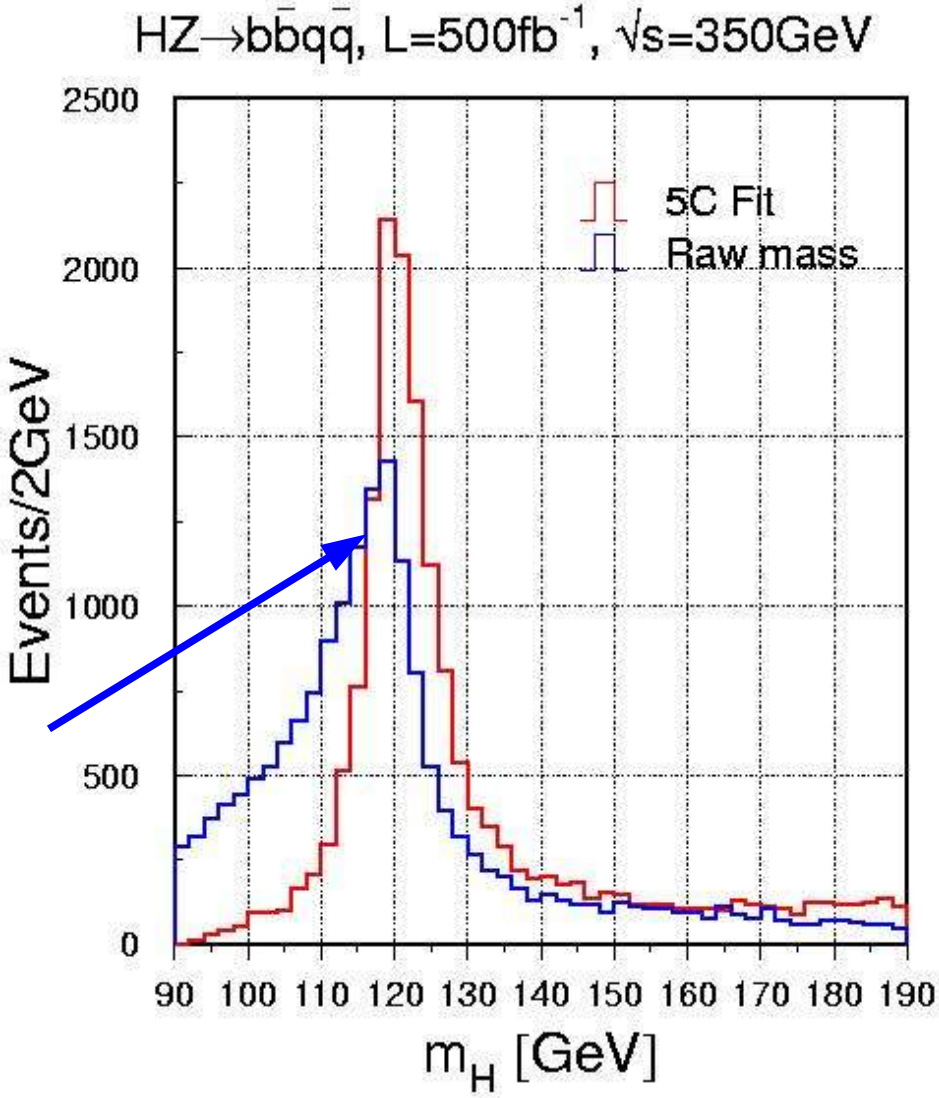
Higgs Mass Measurements (Previous Studies)

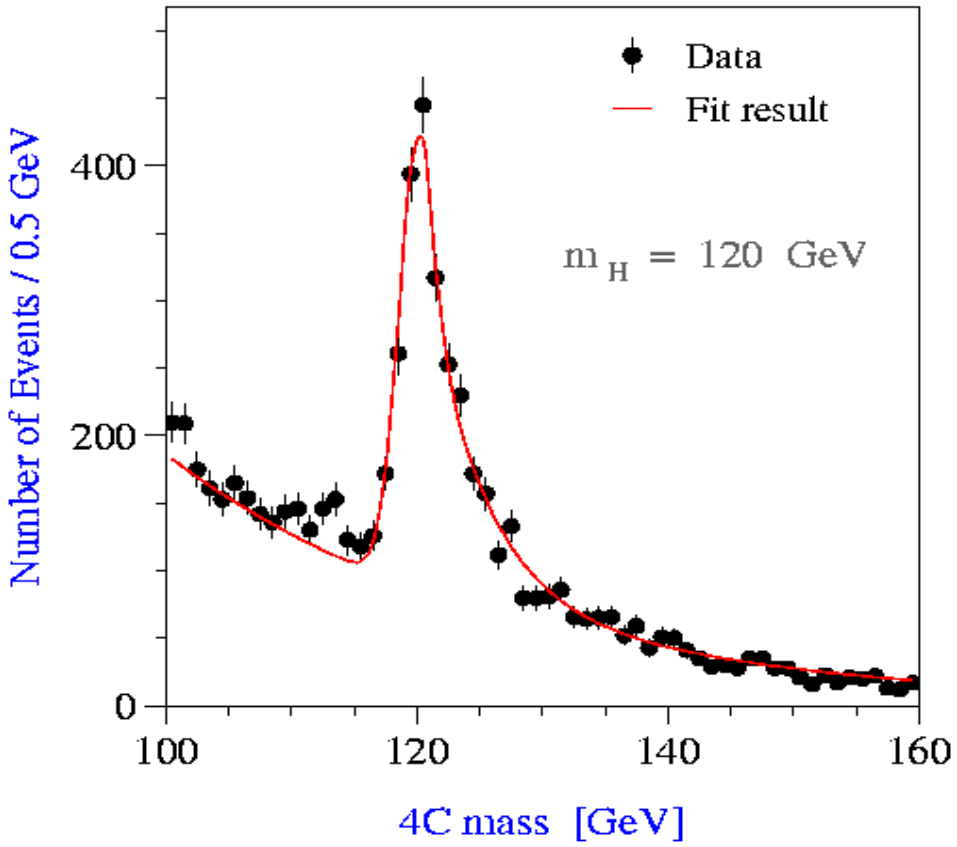
- Previous studies : W. Lohmann, P. Garcia-Abia, A. Raspereza
  LC-PHSM-2000-062
- Experimental conditions : $\sqrt{s} = 350$ GeV, $L = 500$ fb^{-1}
- Exploited channels :
  - $HZ \rightarrow bbqq$, $bbll$ @ $m_H = 120$ GeV
  - $HZ \rightarrow WWqq$, $WWll$ @ $m_H = 150, 180$ GeV
  - $HZ \rightarrow Xll$ over entire mass range
- Considered backgrounds : WW, ZZ, qq, Wev, Zee, ZZZ^*, ZWW^*
- Simulation tools :
  - PYTHIA and WHIZARD → generation of signal and background
  - CIRCE → beamstrahlung modeling
  - SIMDET version 3 → fast parametric detector response simulation

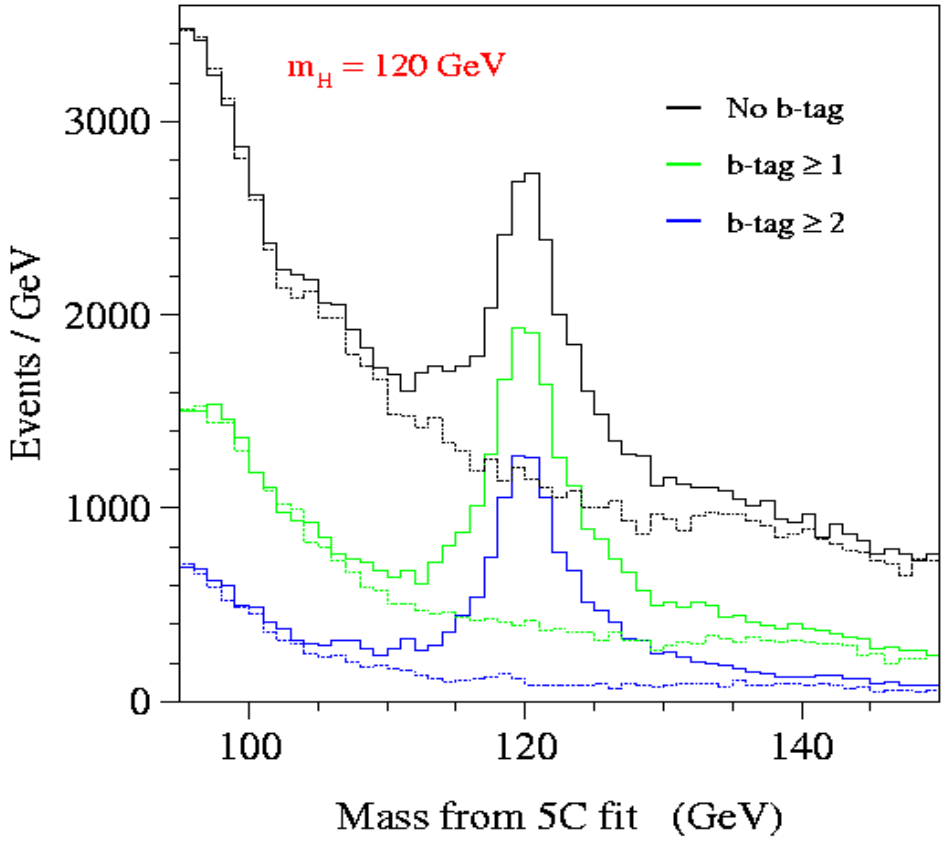
Analysis Procedures

- Selection of specific final state
  (event shapes, Z mass information,
  etc...)
- b-tagging
  parametrization from R. Hawkings
  LC-PHSM-2000-021
- Lepton ID ($Z \rightarrow ll$)
- Kinematic fit
  significantly improves mass resolution
- Analysis of mass spectrum $\rightarrow$
  Higgs mass determination



Four Fermion Channels
m_H = 120 GeV





$HZ \rightarrow$ bbee, bb$\mu\mu$

4C fit (4P) : δm_H=70MeV

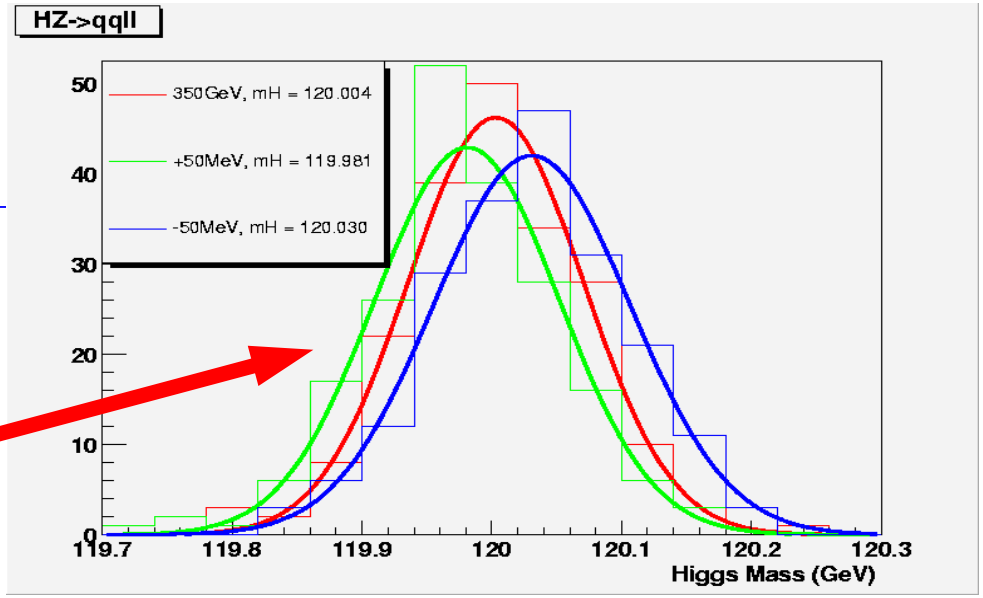
$HZ \rightarrow$ bbqq

5C fit (4P + m_Z) : δm_H=45MeV

Combination : δm_H=40MeV

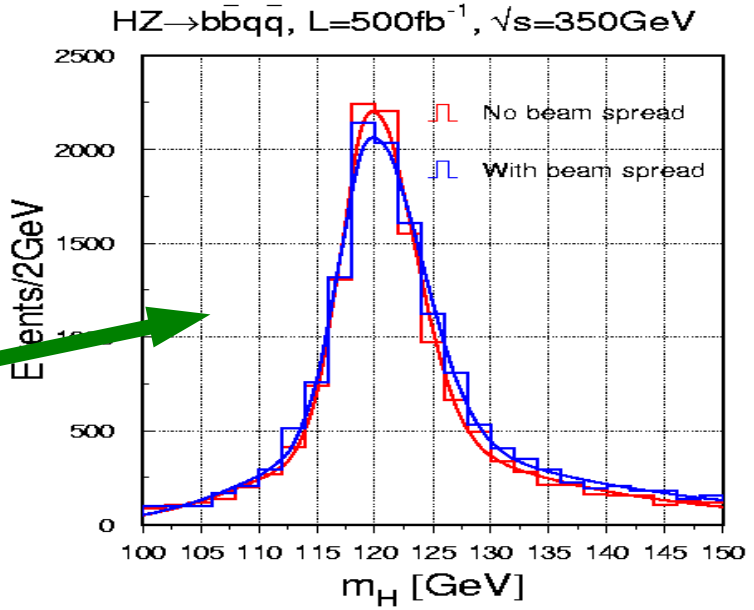
Beam Related Systematics

- Effects may come from :
  – beam energy uncertainty : $\delta E/E \sim 10^{-4}$
  – beam spread : ~ 0.032% for e^+, ~ 0.15% for e^-
- Gaussian beam spread is assumed



- $\delta E_{e+} = \delta E_{e-} = \pm 25$ MeV results in a mass shift
  ~ 25 MeV for HZ qq*ll*
  ~ 20 MeV for HZ bbqq
- Shift in mass scales with $\delta(\sqrt{s})$

- Effect of beam spread
  - statistical accuracy degrades
    from 45 to 50 MeV in HZ → bbqq channel
    from 70 to 80 MeV in HZ → bb*ll* channel
    if one assumes 0.5% beam spread for both e^+ and e^-
  - deterioration ≤ 1MeV for expected beam spread

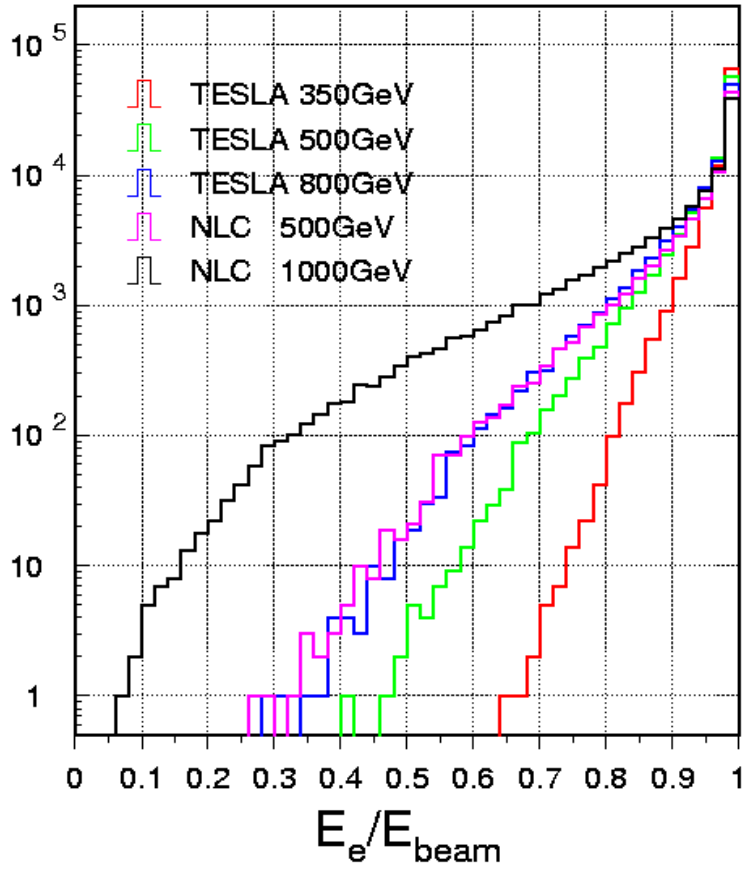


Differential Luminosity Spectrum

- Beamstrahlung → distortion of beam energy spectrum
- Parametrization :

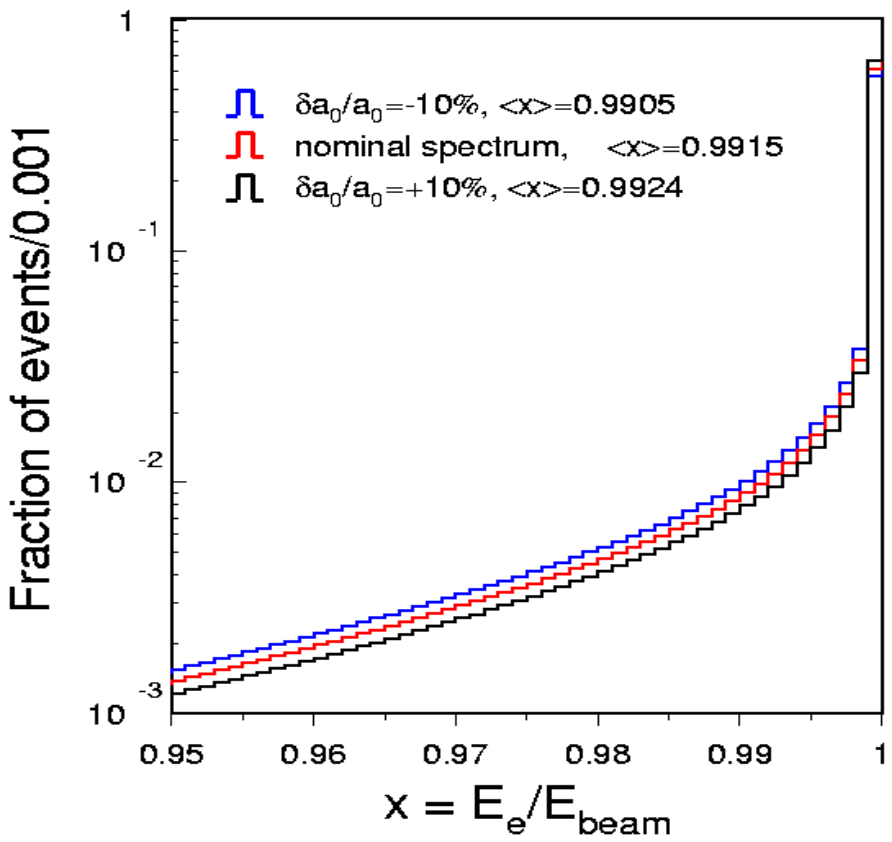
  $f(x) = a_0\delta(1-x)+a_1 x^{a2}(1-x)^{a3}$, $x=E_e/E_{beam}$
- $f(x)dx = 1$ → 3 independent parameters: a_0, a_2, a_3
- acollinearity spectrum in Bhabha events → differential luminosity spectrum measurement
- K.Moenig, LC-PHSM-2000-60 :

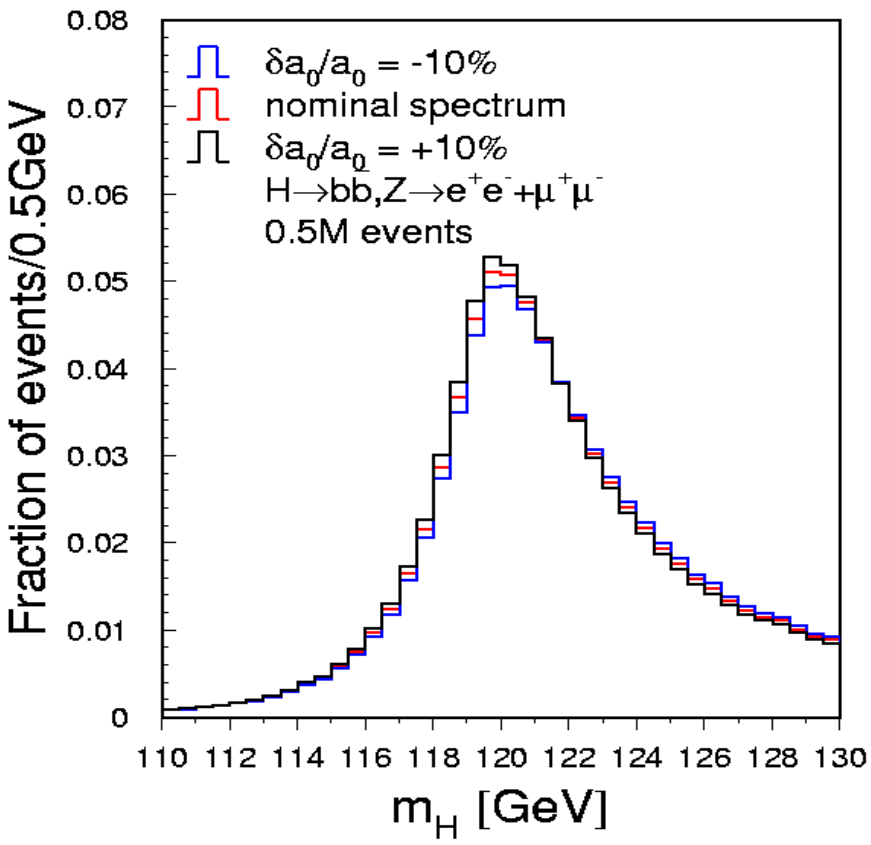
  $\delta a_i/a_i \leq 1\%$ with 3 fb^{-1} @ $\sqrt{s} = 500$ GeV



$\sqrt{s} = 350$ GeV : $a_0=0.55$, $a_1=0.59$, $a_2=20.3$, $a_3=-0.63$

Differential Luminosity Spectrum





$\delta a_i \sim 10\%$: effect O(10MeV) on Higgs mass

$\delta a_i \leq 1\%$: effect of O(MeV) on Higgs mass

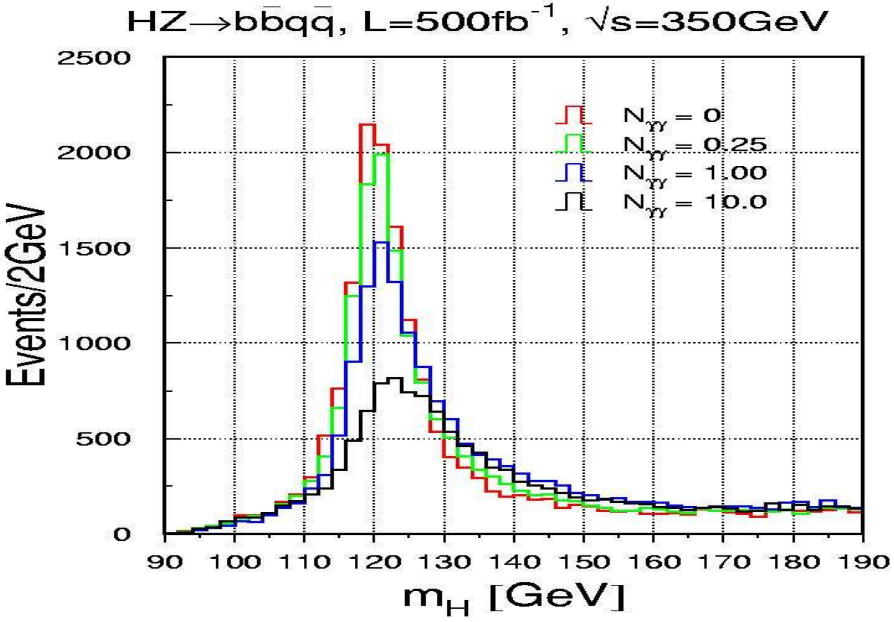
Effect of Gamma Gamma Background

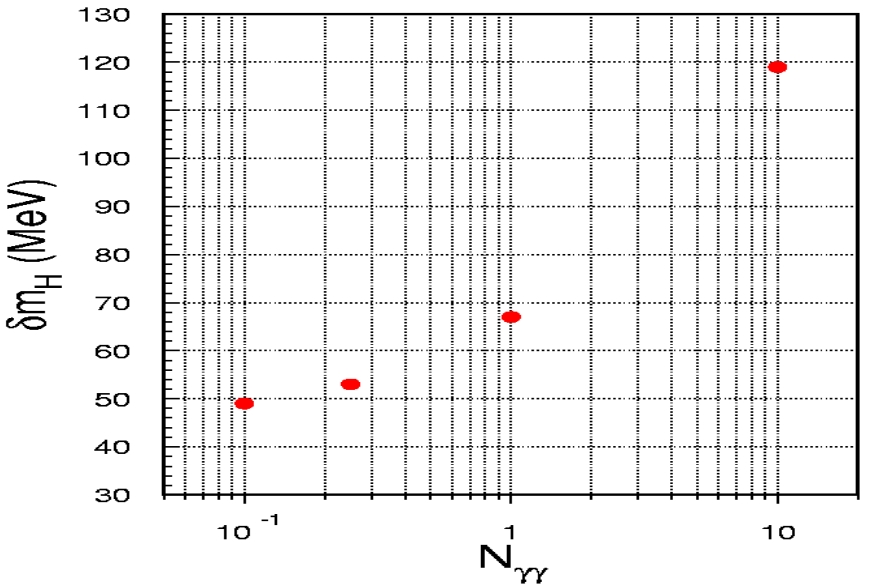
- Beamstrahlung photons may collide
  - $\gamma\gamma \rightarrow$ hadrons background
  - pile-up with physical events
  - excessive energy, excessive e-flow objects (predominantly in forward/backward region)

- TESLA : 0.25 ev/bx, 337 ns bunch separation @ 500 GeV
  $\rightarrow$bunches can be disentangled

- NLC : 0.1 ev/bx, 1.4ns bunch separation
  $\rightarrow$high time-stamp capability is required

- $\gamma\gamma$ background may have drastic effect on analysis performance
  (K. Desch will report more on this)





Summary

- Potential of future linear e^+e^- collider for measuring Higgs boson mass is studied
- Statistical uncertainty of 50 MeV is reachable for SM Higgs boson with mass $m_H = 120$ GeV ($\sqrt{s} = 350$ GeV, $L = 500$ fb^{-1})
- Beam related systematics studied :
  - systematics on beam energy measurement of $\delta E/E \leq 10^{-4}$ is required to keep systematic error on Higgs boson mass below statistical one
  - insignificant effect from beamspread and uncertainty in differential luminosity spectrum measurement
- Hadronic $\gamma\gamma$ background may have serious impact on physics analysis