Study of Heavy Neutral SUSY Higgs Bosons

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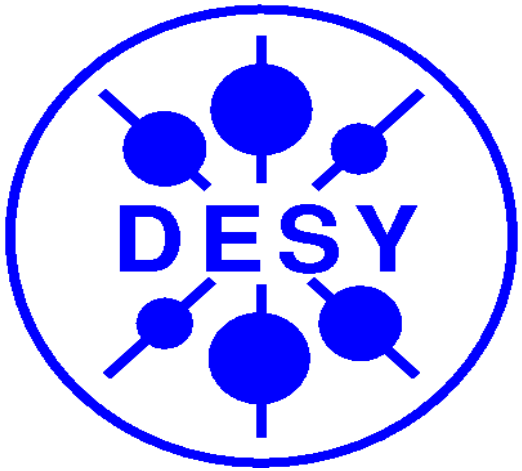


LC Workshop, Paris 22/4/2004

Motivation

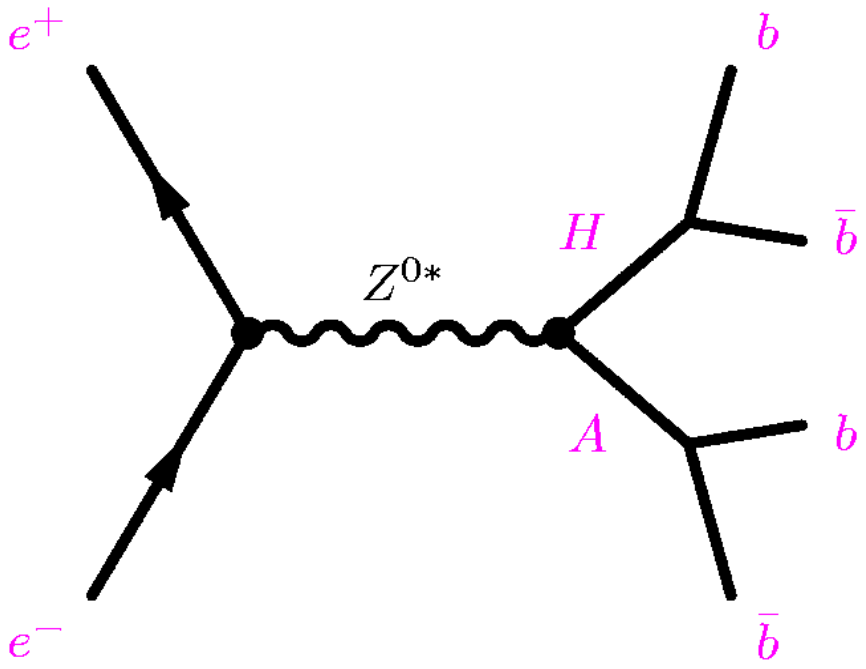
- MSSM : 5 physical states h, H, A, $H^{\pm}$
- $e^+e^- \rightarrow HA$: additional channel to study Higgs sector
- Decoupling limit ($\cos^2(\beta-\alpha) \rightarrow 0$, $\sin^2(\beta-\alpha) \rightarrow 1$)
  - $e^+e^- \rightarrow HZ$, Hee, Hνν suppressed, rate of $e^+e^- \rightarrow HA$ is maximal
  - $m_H \approx m_A$

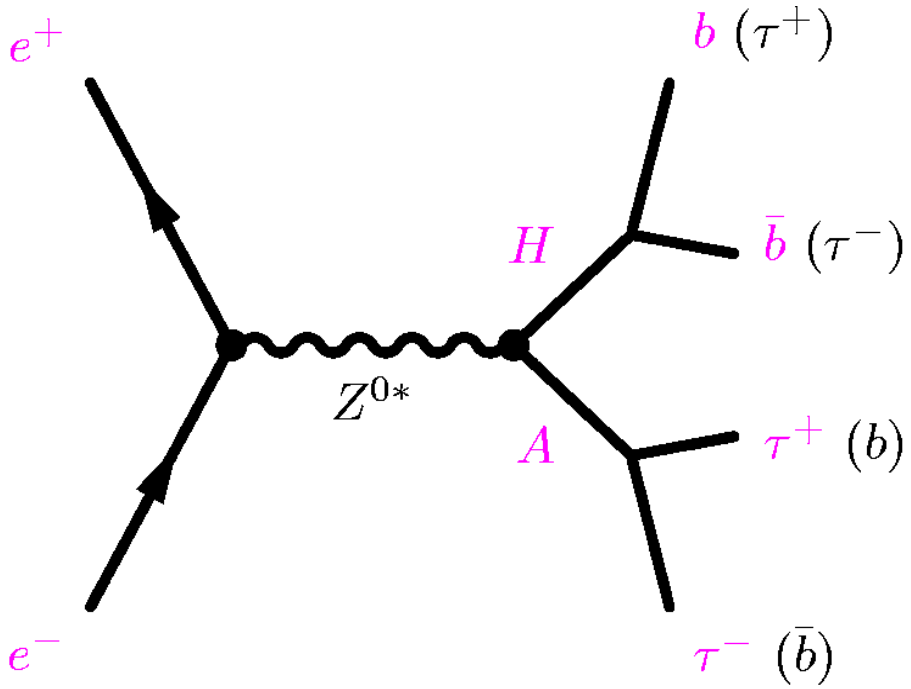
    $\rightarrow$ study of degenerate mass scenario
- Issues to be addressed
  - discovery reach?
  - precision of mass, cross-section, width measurement?
  - indirect constraints on SUSY parameters?
- Basis for quantitative comparison with $\gamma\gamma \rightarrow$ H,A at photon collider
- CPV models : mixing between CP eigenstates

  sizable mass splitting between H_1, H_2, H_3

  $\rightarrow$ non-equal mass scenario should be studied as well

Studied Topologies





$\sqrt{s}$ = 500, 800 GeV

L = 500 fb^{-1} at each energy

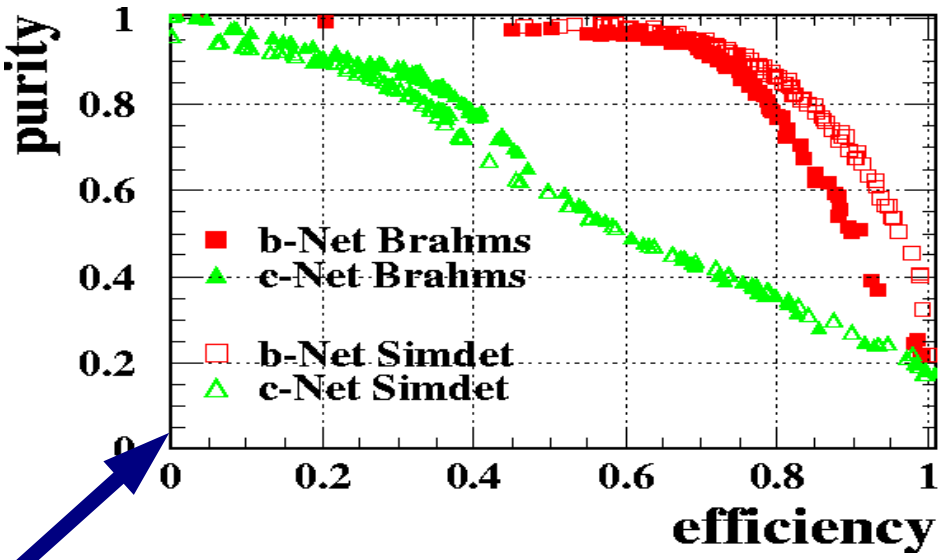
$(\sigma * Br)$ - ?

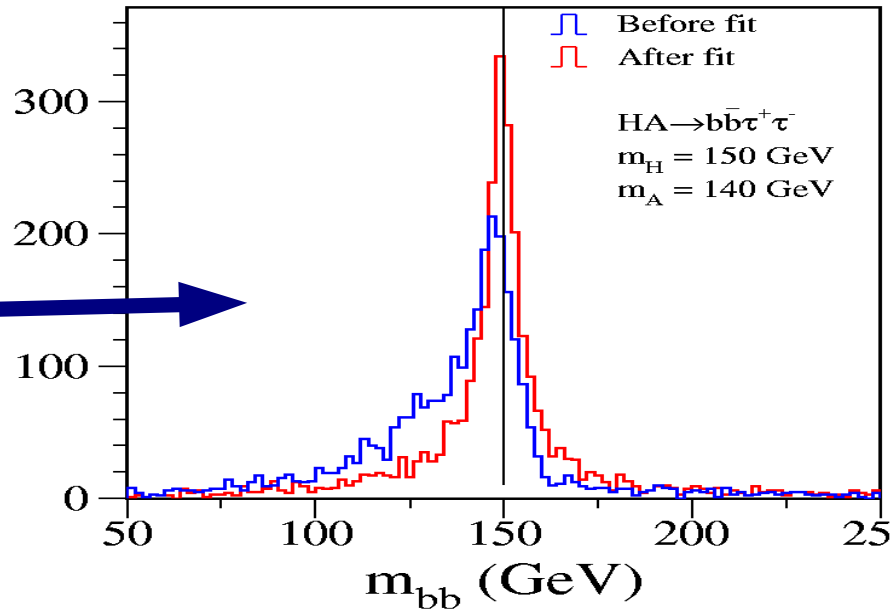
m_H, m_A - ?

Γ_H, Γ_A - ?

Analysis Tools

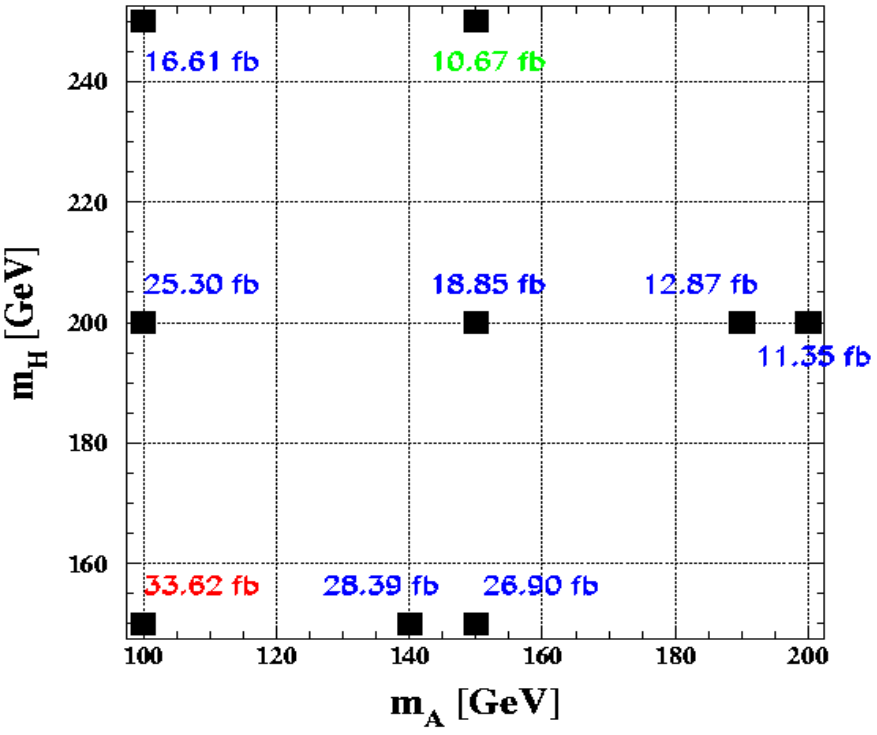
- PYTHIA : signal and background
- CIRCE : beamstrahlung
- SIMDET 4.01 : detector response
- ZV-TOP (from SLD adapted to LC studies) : heavy flavor tagging
- Kinematic fit (from DELPHI adapted to LC studies) : improvement of mass resolution
- Lepton and photon ID



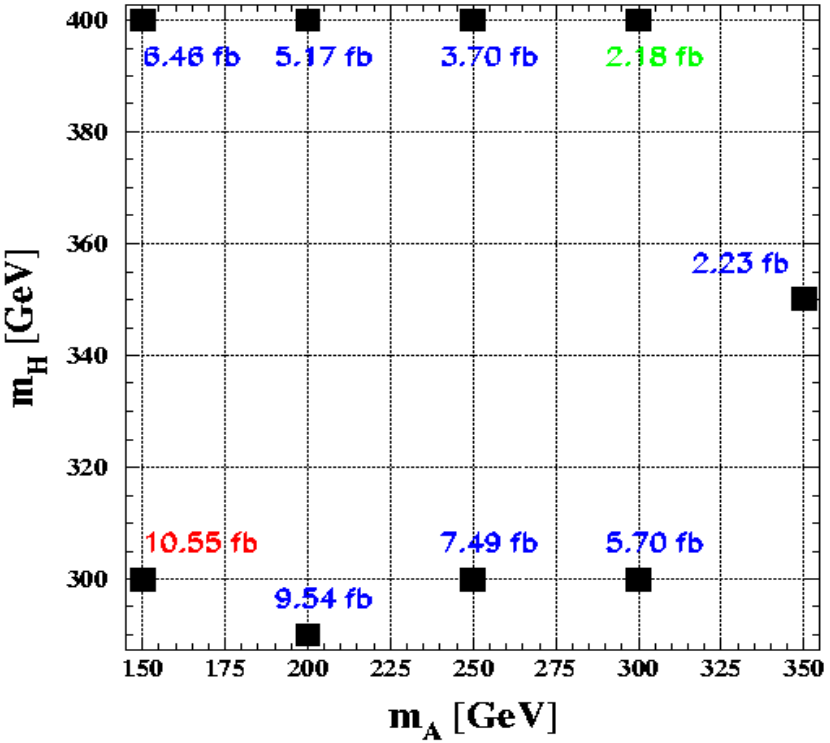


Signal samples

500 GeV



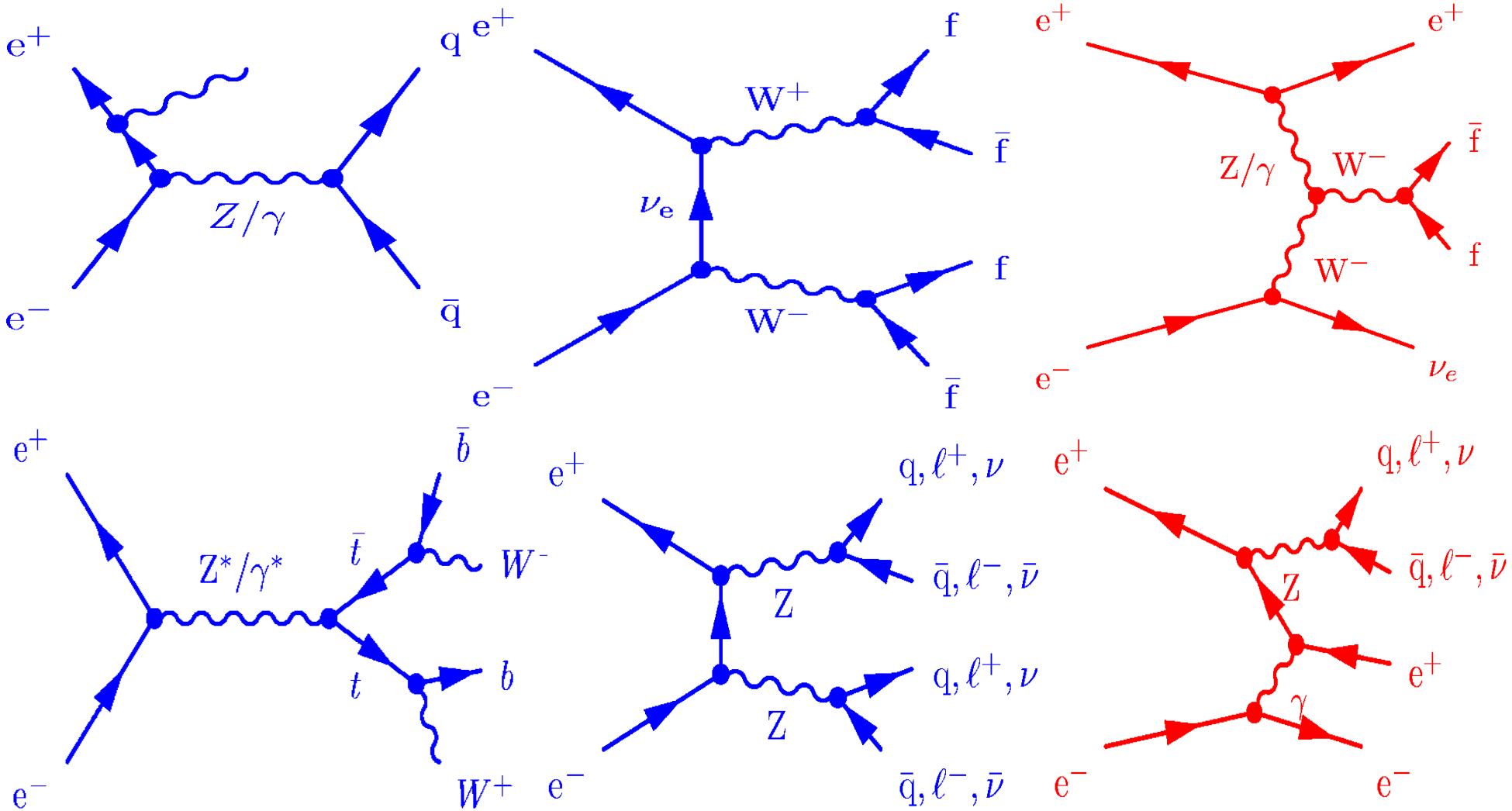
800 GeV



$$\sigma_{HA} = \sin^2(\beta-\alpha)\lambda(m_H, m_A, \sqrt{s})\sigma_{HZ}(SM)$$

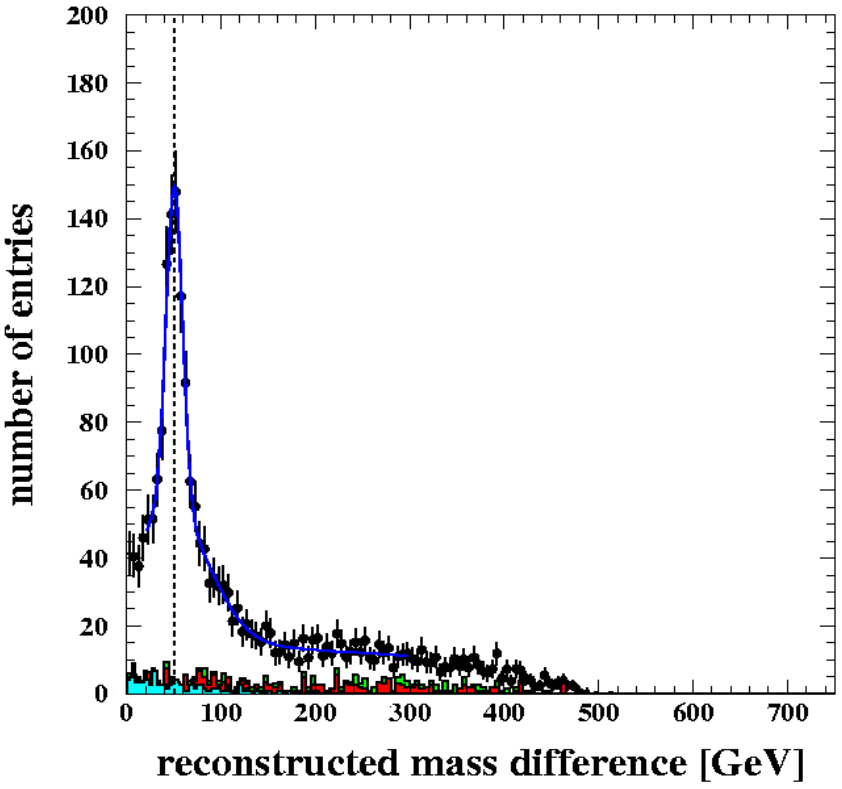
Assumptions : $\sin^2(\beta-\alpha) = 1$, $Br(H,A\rightarrow\tau\tau) = 10\%$, $Br(H,A\rightarrow bb) = 90\%$

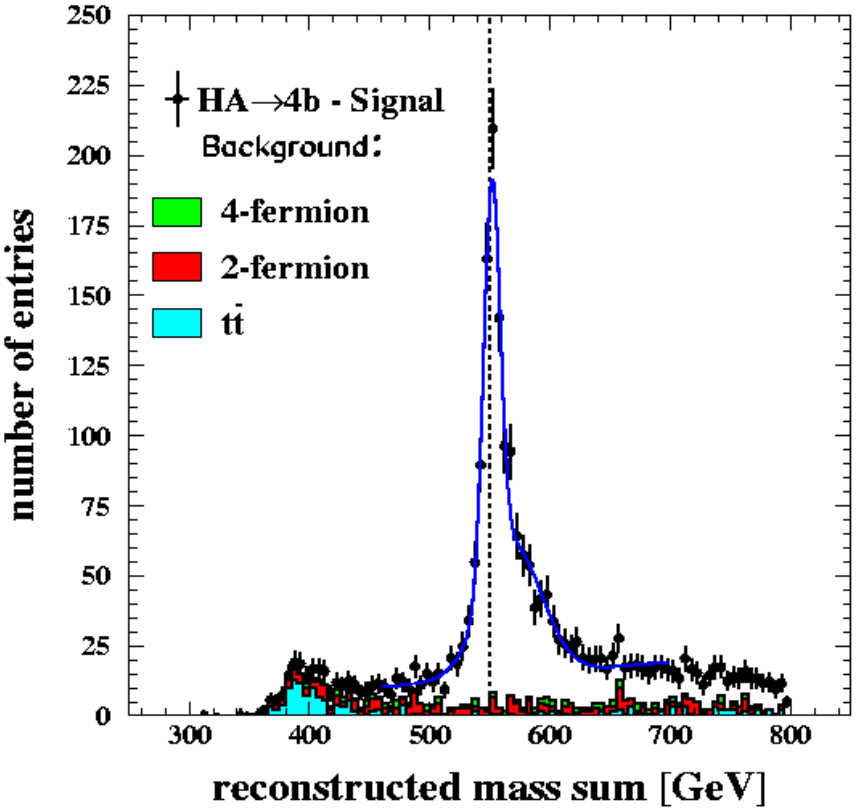
Studied Backgrounds



Four Jet Channel

$m_H = 300$ GeV, $m_A = 250$ GeV, $\sqrt{s} = 800$ GeV

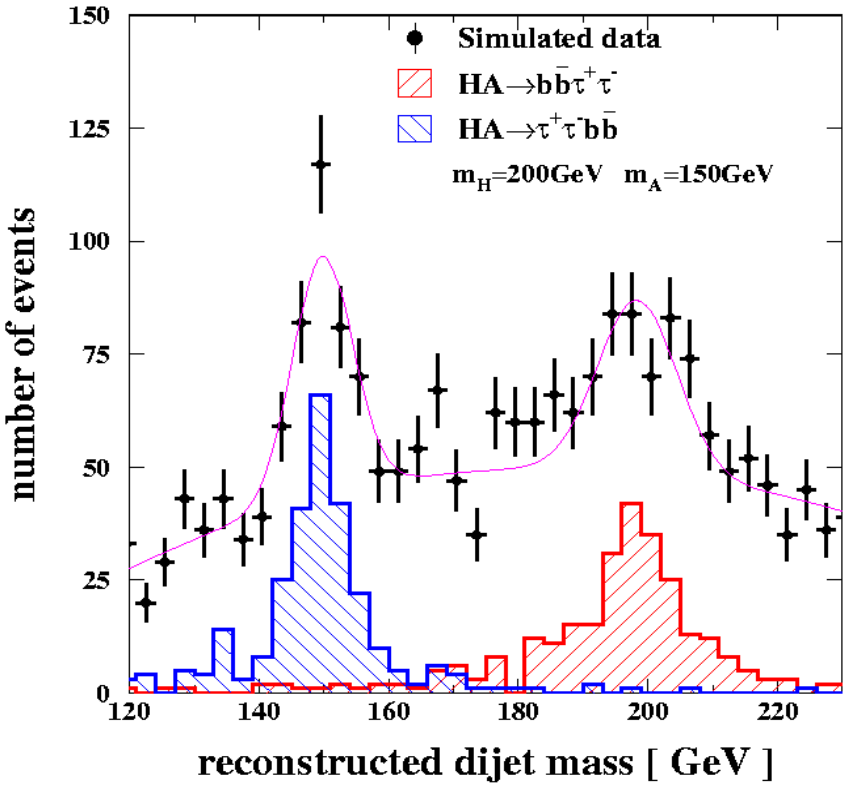


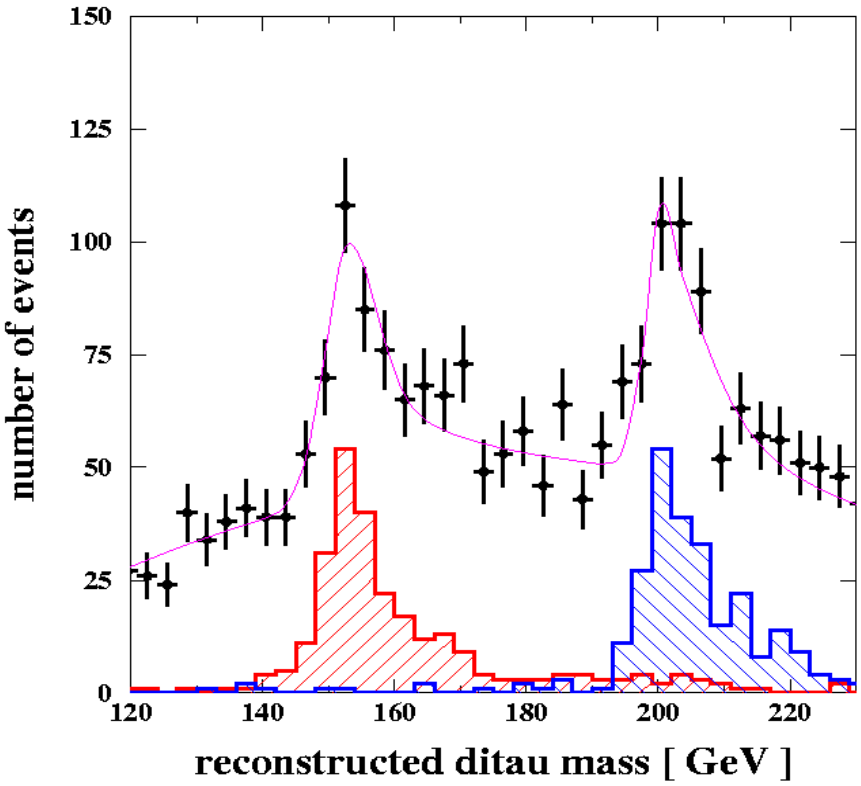


$m_H = (\Sigma+\Delta)/2$, $m_A = (\Sigma-\Delta)/2$, $\delta m_{H,A} = \delta\Sigma \oplus \delta\Delta$

Tau Channels (Large Mass Splitting)

$m_H = 200$, $m_A = 150$, $\sqrt{s} = 500$ GeV

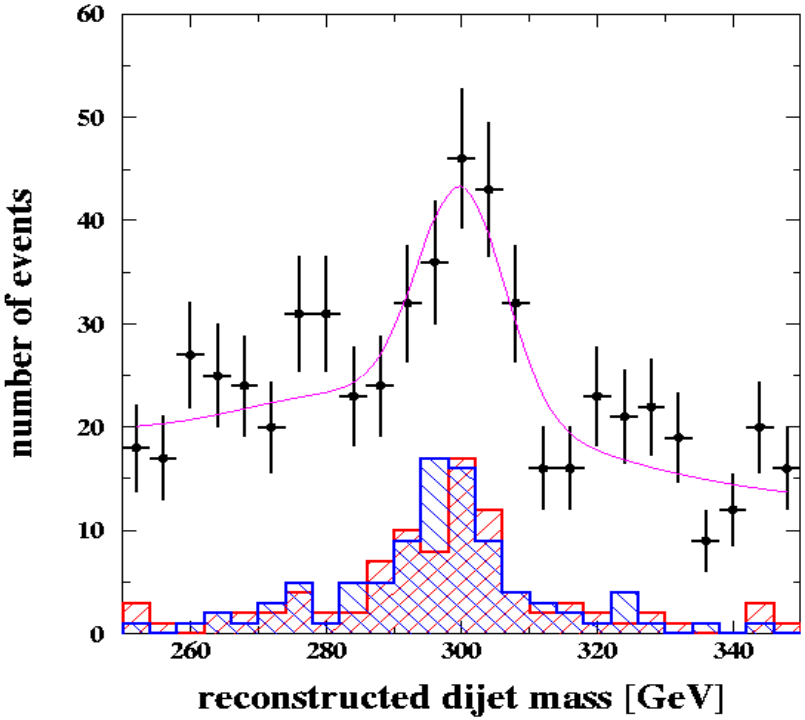


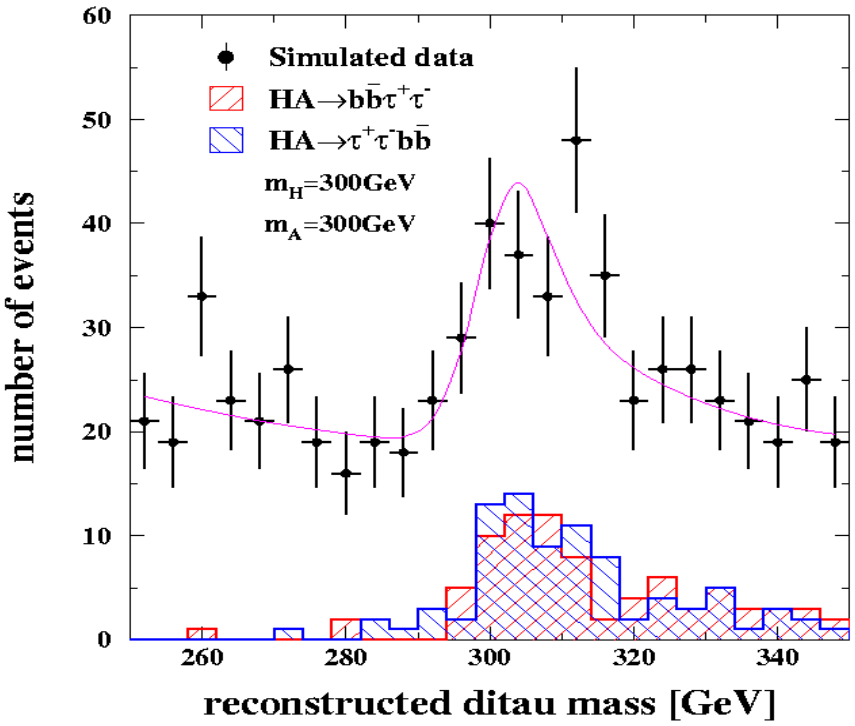


Simultaneous fit of m_{bb} and $m_{\tau\tau}$ spectra with m_H, m_A, $N_{bb\tau\tau}$, $N_{\tau\tau bb}$ as free parameters

Tau Channels (Mass Degeneracy Scenario)

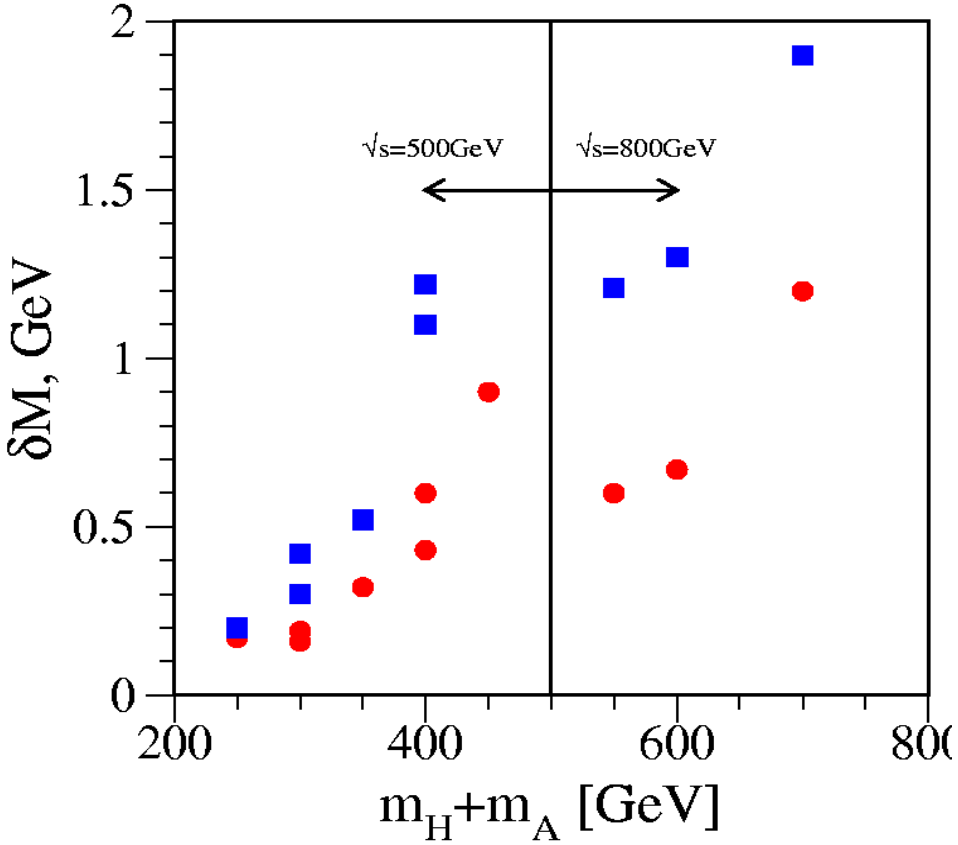
$m_H = 300$, $m_A = 300$, $\sqrt{s} = 800$ GeV

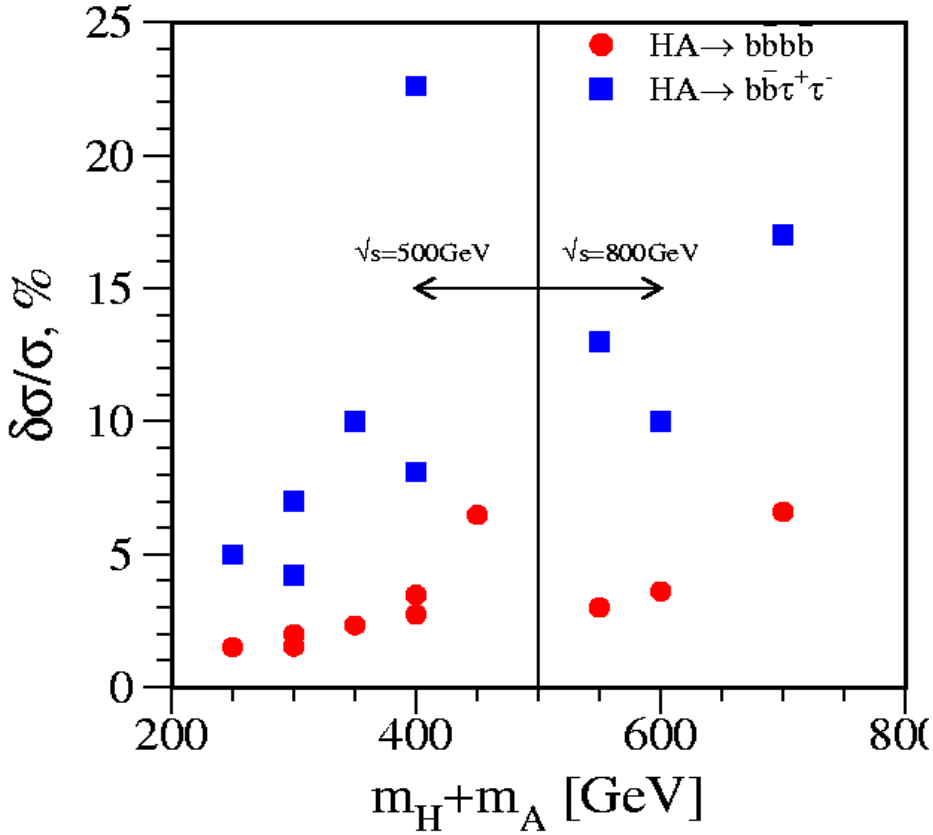




Assume $N_{bb\tau\tau} = N_{\tau\tau bb} = N_0$: fit m_{bb} and $m_{\tau\tau}$ spectra with m_H, m_A, N_0 as free parameters

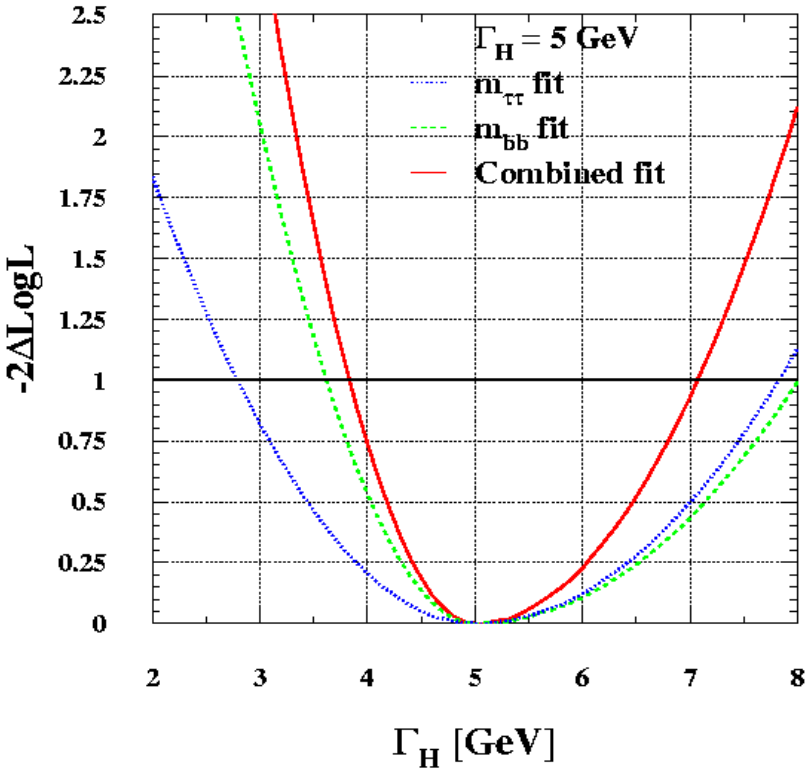
Results

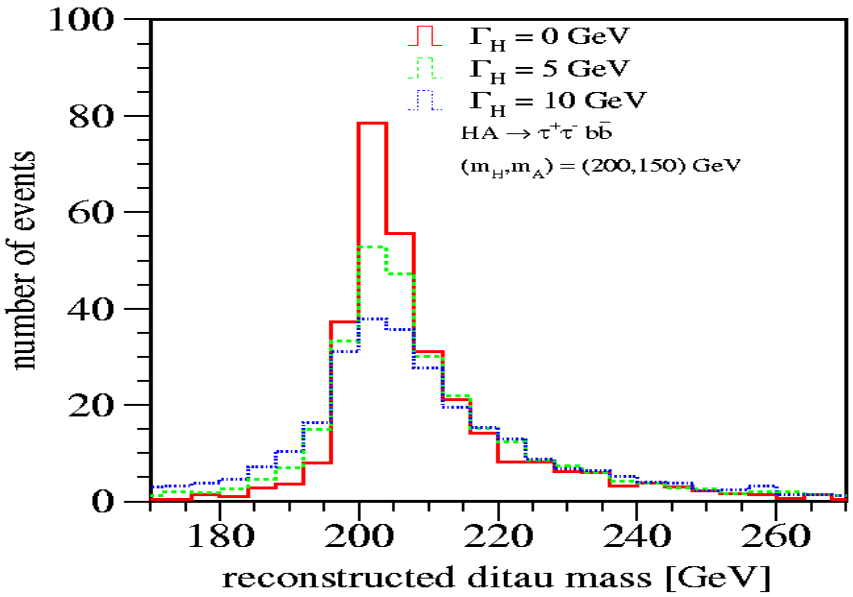

δM, GeV
√s=500GeV
√s=800GeV
m_H+m_A [GeV]


δσ/σ, %
HA→ bbbb
HA→ bbτ⁺τ⁻
√s=500GeV
√s=800GeV
m_H+m_A [GeV]

Width Measurement (Large Mass Splitting Scenario)

bbπchannels are exploited to measure Higgs widths





* take m_H, m_A as measured in bbbb
* parametrize mass lineshapes as a function of Γ_H and Γ_A
* log-likelihood fit of mass spectra with Γ_H, Γ_A, $N_{bb\tau\tau}$ and $N_{\tau\tau bb}$ as free parameters

$\delta\Gamma/\Gamma \sim$ 10 - 40%

Width Measurement (Mass Degeneracy Case)

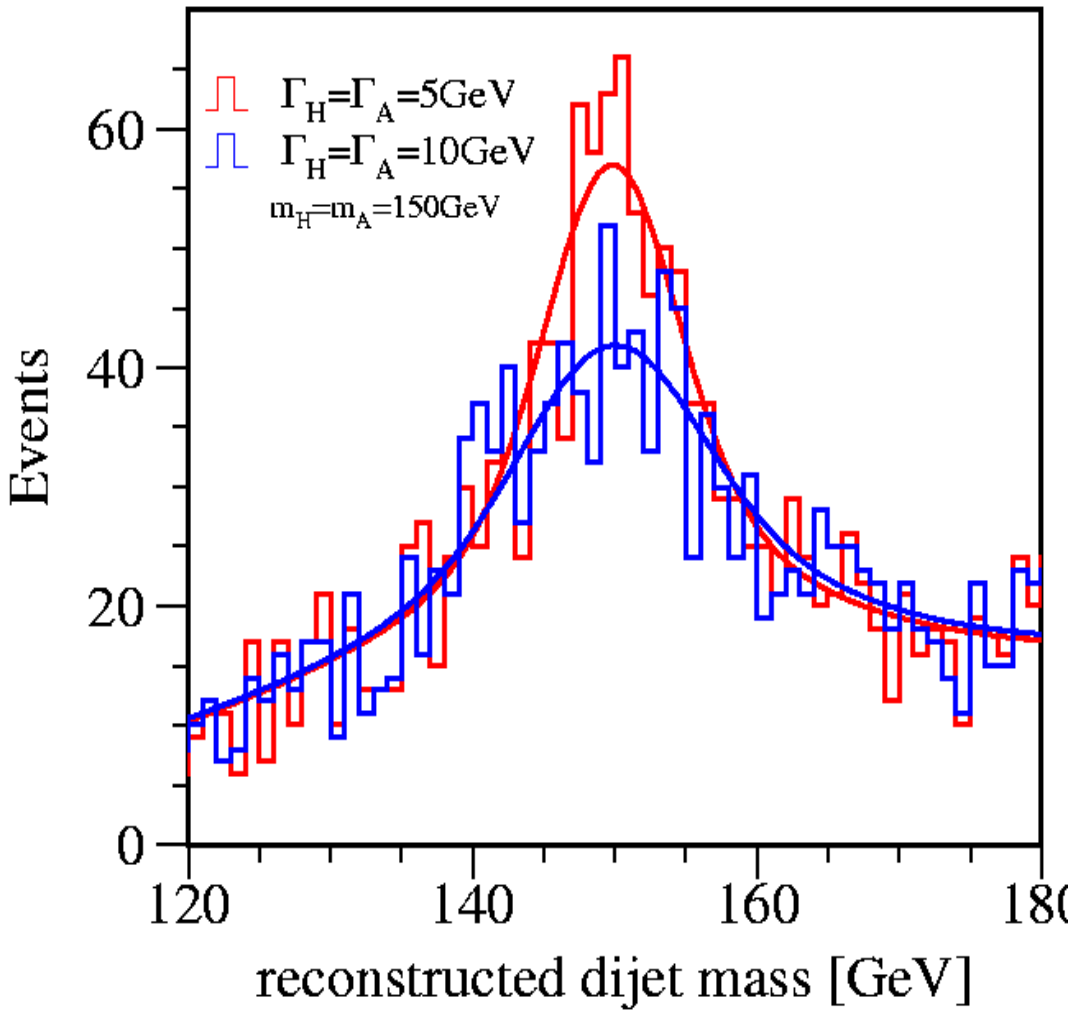
Strategy

* fix mass sum to value measured in bbbb channel
* assume $N_{bb\tau\tau} = N_{\tau\tau bb} = N_0$

  $\Gamma_H = \Gamma_A = \Gamma$
* fit of m_{bb} and $m_{\tau\tau}$ spectra with N_0, Γ and Δm as free parameters

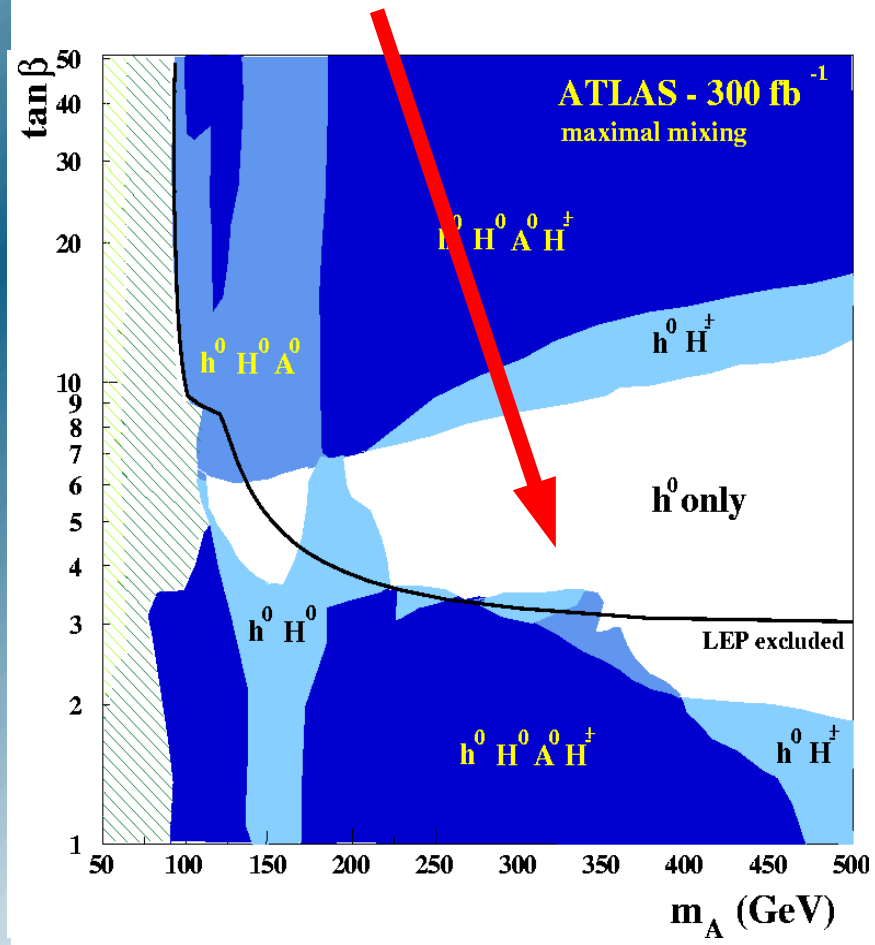
$\delta\Gamma/\Gamma \sim 10 - 30\%$

$\delta(\Delta m) \sim 0.4 - 1.5$ GeV

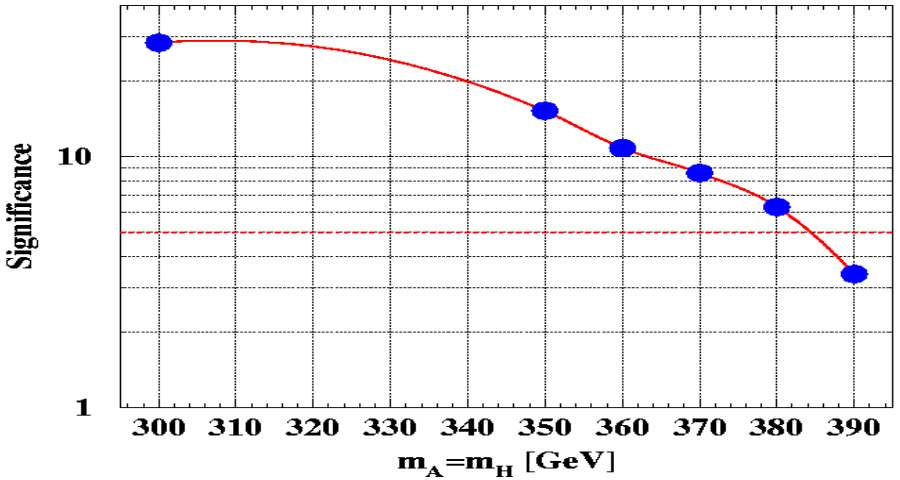


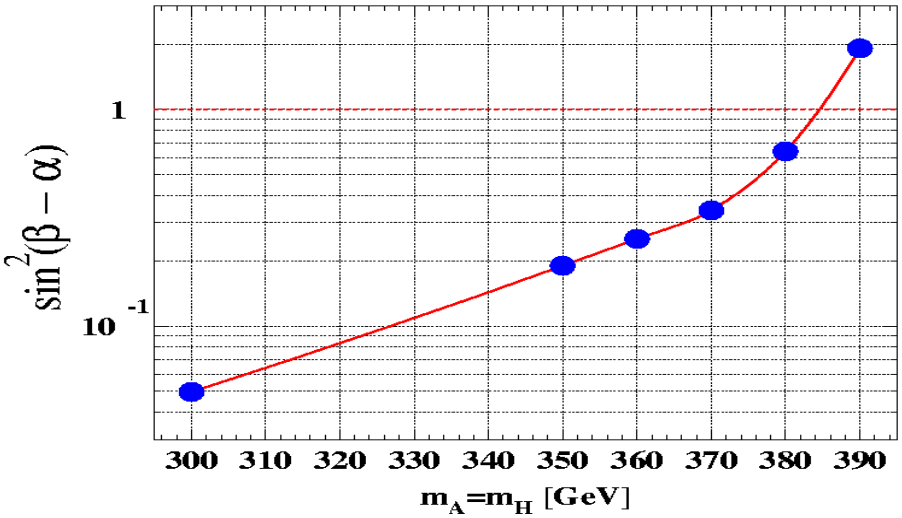
Discovery Potential

LHC "wedge" region



TESLA : 800GeV, 500fb^{-1}





Summary

- Simulation study of heavy SUSY Higgs bosons : LC Note LC-PHSM-2004-006
- Rates of bbbb and bbπ can be measured with % level accuracy
- Masses can be measured to O(1 GeV) precision up to few tens of GeV close to threshold
- Total width (lineshape) can be determined with precision of few tens of % if enough rate from bbπ
- Discovery reach up to $m_H+m_A \sim \sqrt{s} - 15$ GeV in mass-degenerate case (large coverage of LHC wedge region)
- Also non-degenerate mass case is studied (input to CP violation study)