Search for Higgs bosons in e^+e^- interactions with the L3 detector at LEP

The L3 Collaboration

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PHENO2000
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Outline

- Introduction
- Standard Model Higgs Boson
- MSSM neutral Higgs Bosons
- Charged Higgs Boson
- Invisible Higgs Boson Decays
- Fermiophobic Higgs Boson
- Conclusions

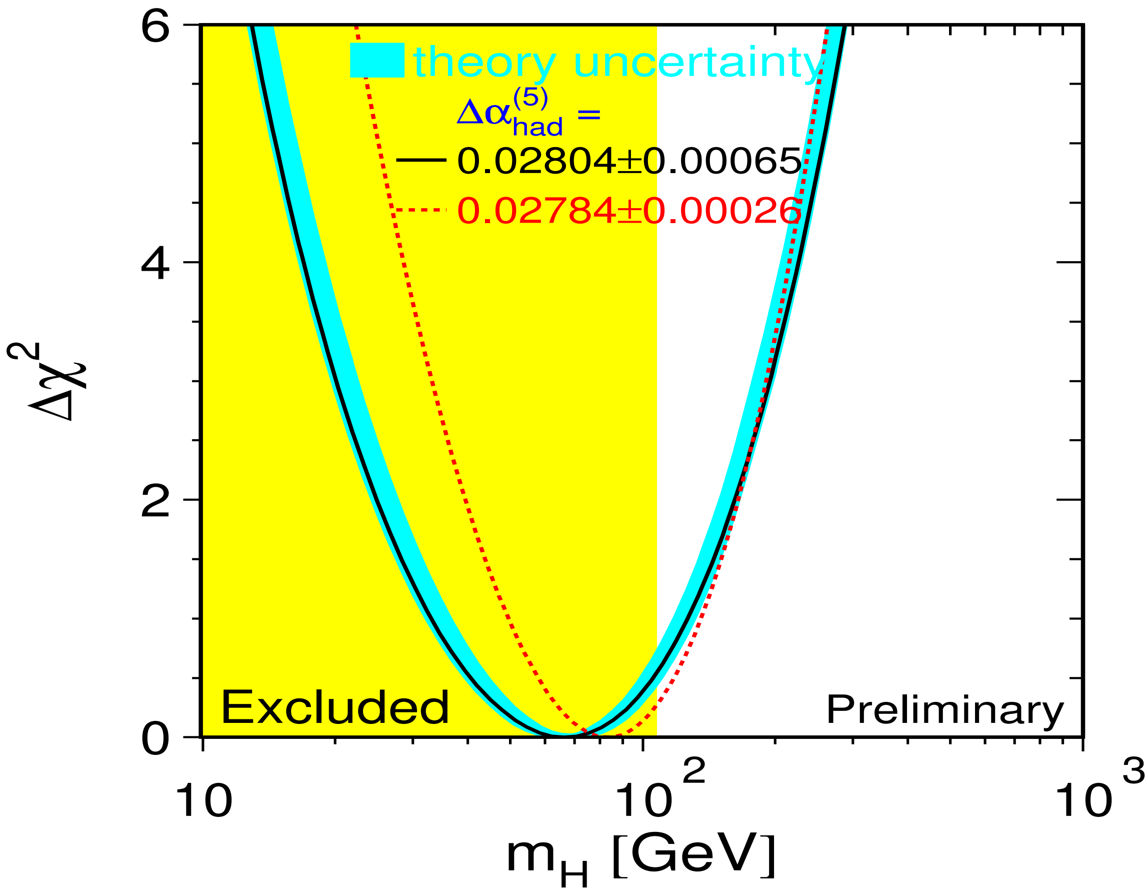
All the results are preliminary

Thanks to the members of the L3 Higgs WG

INTRODUCTION

- **Indirect Constraints on M_H (LEPEWWG)**

from EW Precision Data (LEP, TEVATRON, SLC)



$$\begin{cases} M_H = 67^{+60}_{-33}\ \text{GeV}, \\ M_H < 188\ \text{GeV},\ \text{both at } 95\%\ \text{CL}, \end{cases}$$

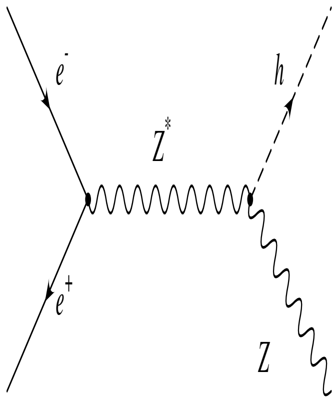
- **Previous Limit From Direct Searches in L3**

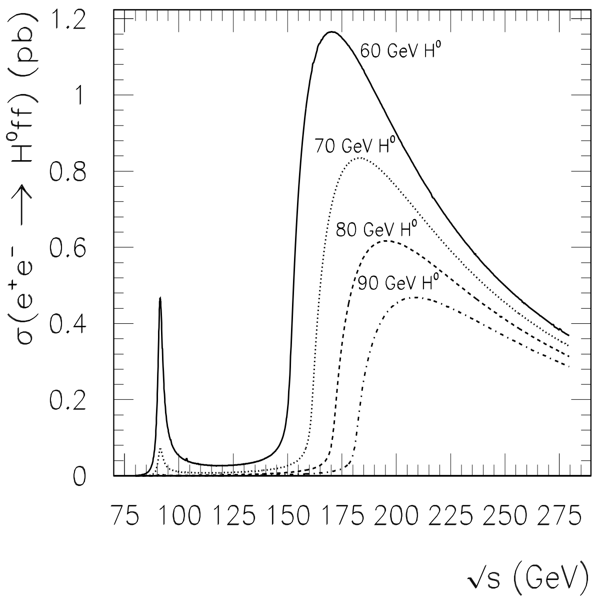
M_H >95.2 GeV at 95% CL

(Phys. Lett. B462 (1999) 376-386)

STANDARD MODEL HIGGS BOSON

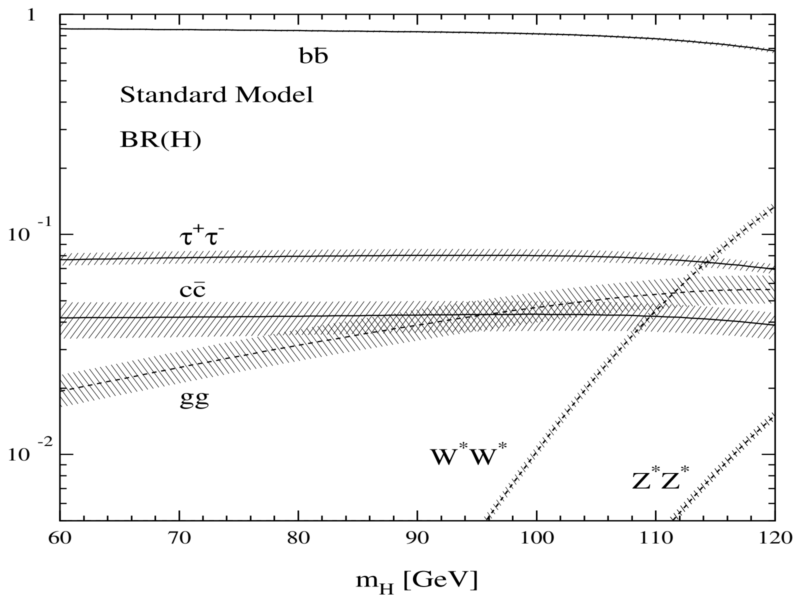
- **Production Mechanisms**





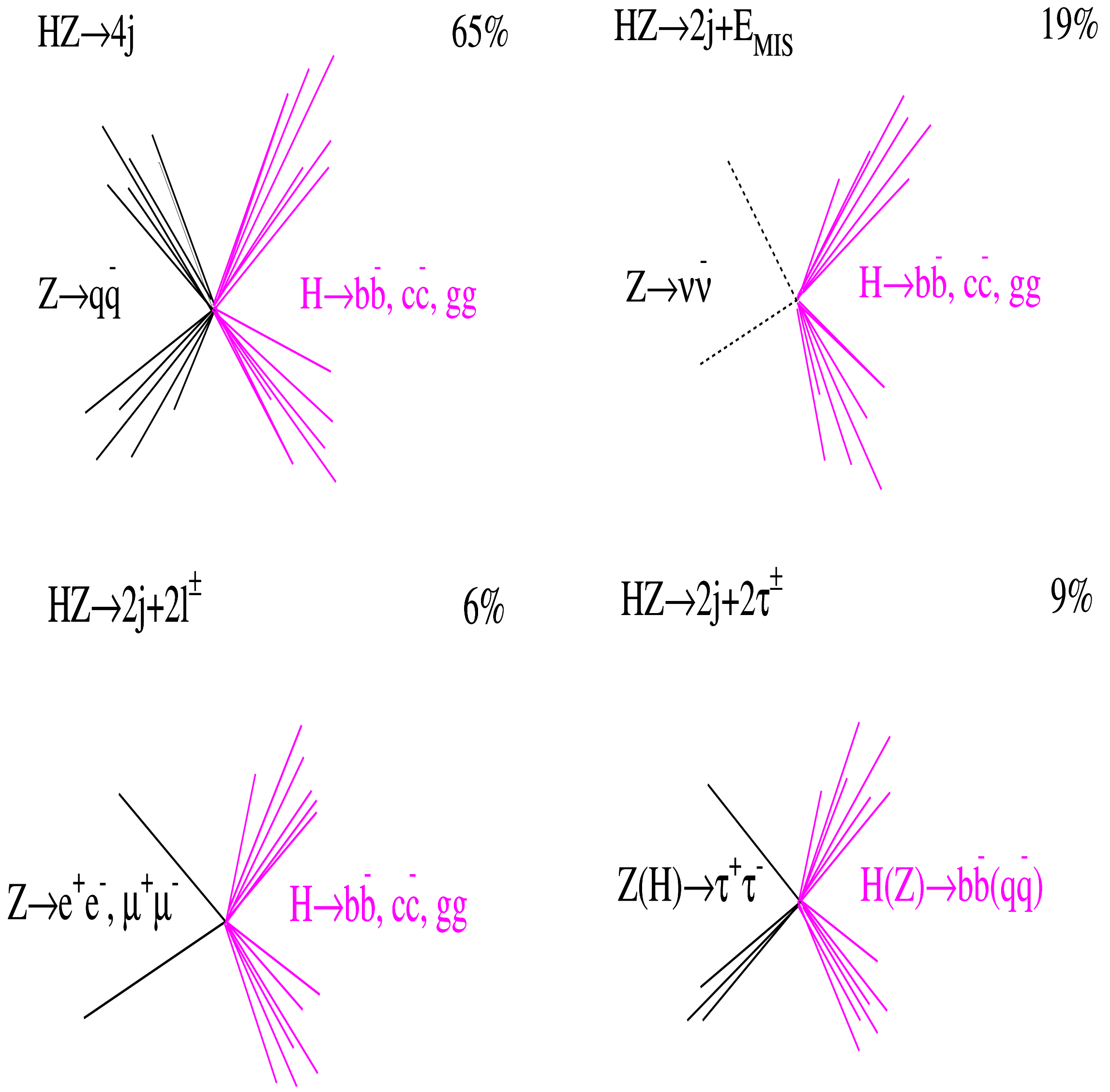
W/Z fusion also taken into account

- **Decay Modes**



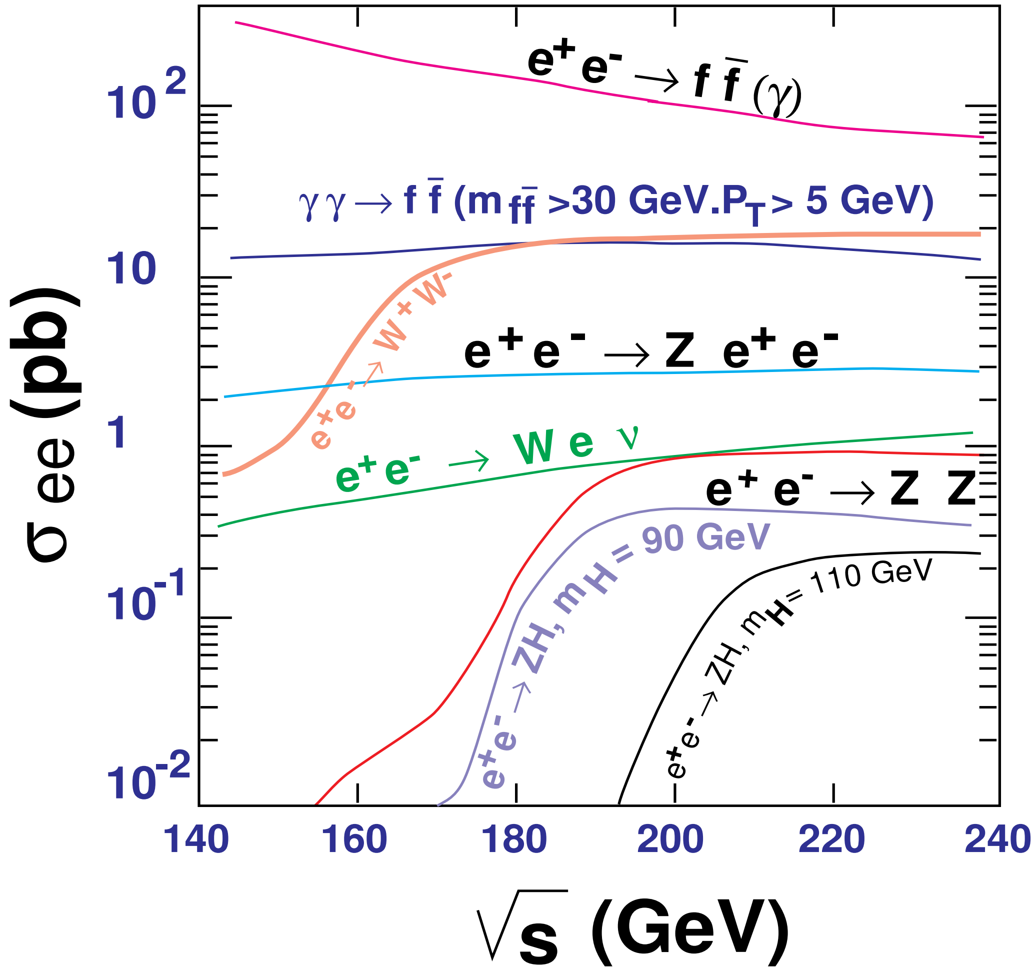
b-tagging is very important

- **Different Topologies**



Total coverage $\approx 98\%$ **of HZ decay modes**

- **Background Processes**

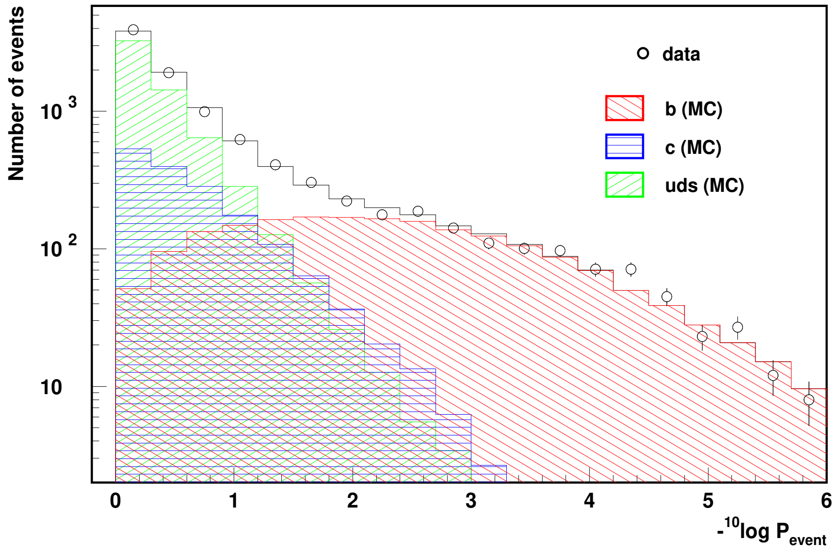


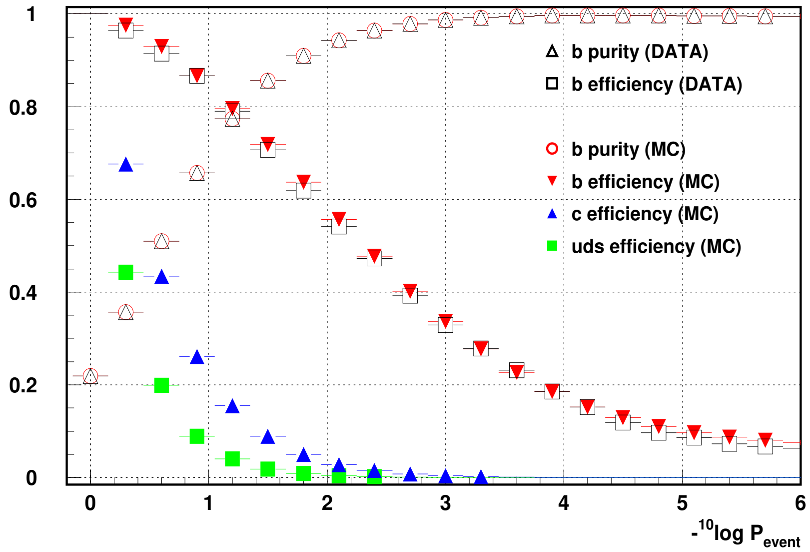
- **L3 1999 Data Samples**

$\sqrt{s}$ (GeV)	$\int \mathcal{L}$dt (pb^{-1})
192	29.7
196	83.7
200	82.8
202	37.0

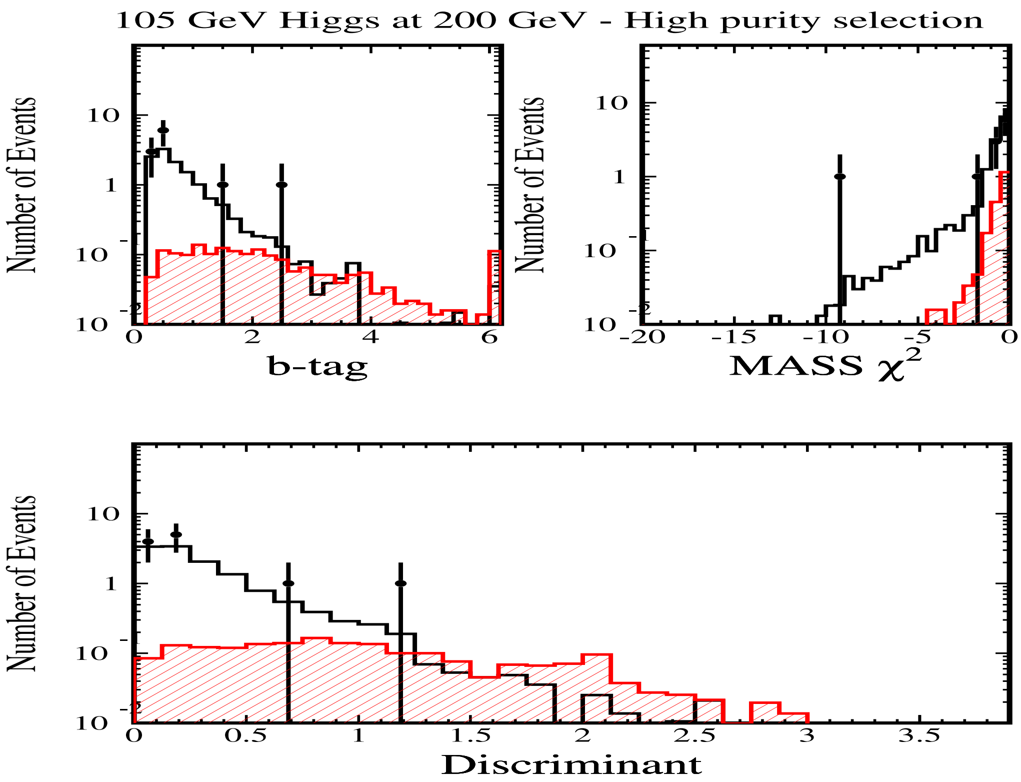
- **B-Tagging**

→ B hadron features: long lived, hard fragmentation, inclusive leptons
→ Used as NN_{in} to get a jet tag
→ Combine jet tags to get an event tag





- **Analysis Procedures**
  - $\rightarrow$ **Preselection to reduce the most copious background** $e^+e^- \rightarrow e^+e^- q\bar{q}$
  - $\rightarrow$ **Tighter cuts for each studied topology**
  - $\rightarrow$ **Build a global variable (i.e: NN$_{out}$, likelihood ratio) combining event shape, multiplicity,... and b-tagging informations**
  - $\rightarrow$ **Build a mass variable using the kinematical constraint: M$_{f\bar{f}} \approx M_z$**
  - $\rightarrow$ **Combine this global variable with the mass information to make a final discriminant**
  - $\rightarrow$ **Use the full final discriminant distribution to calculate CL for each mass hypothesis**
- **The 4 jet channel**



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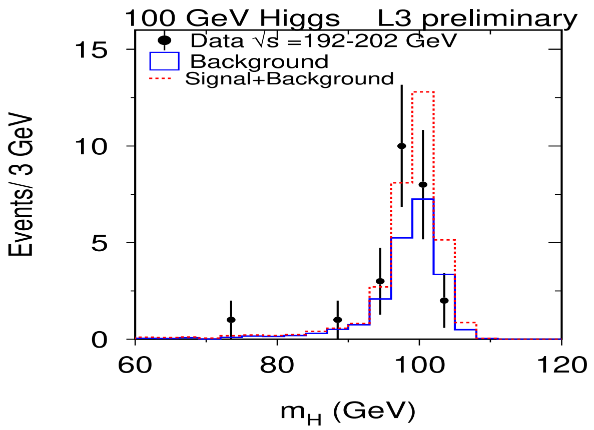
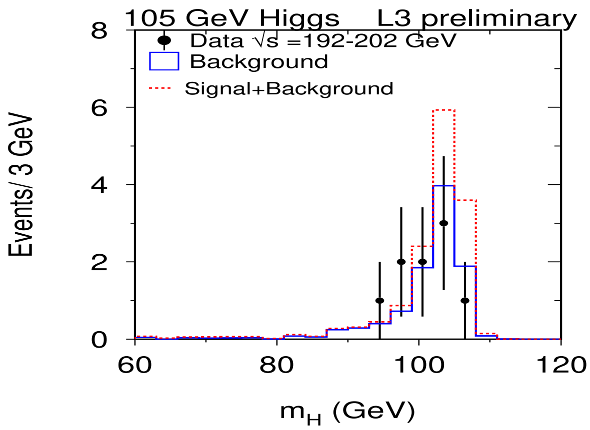
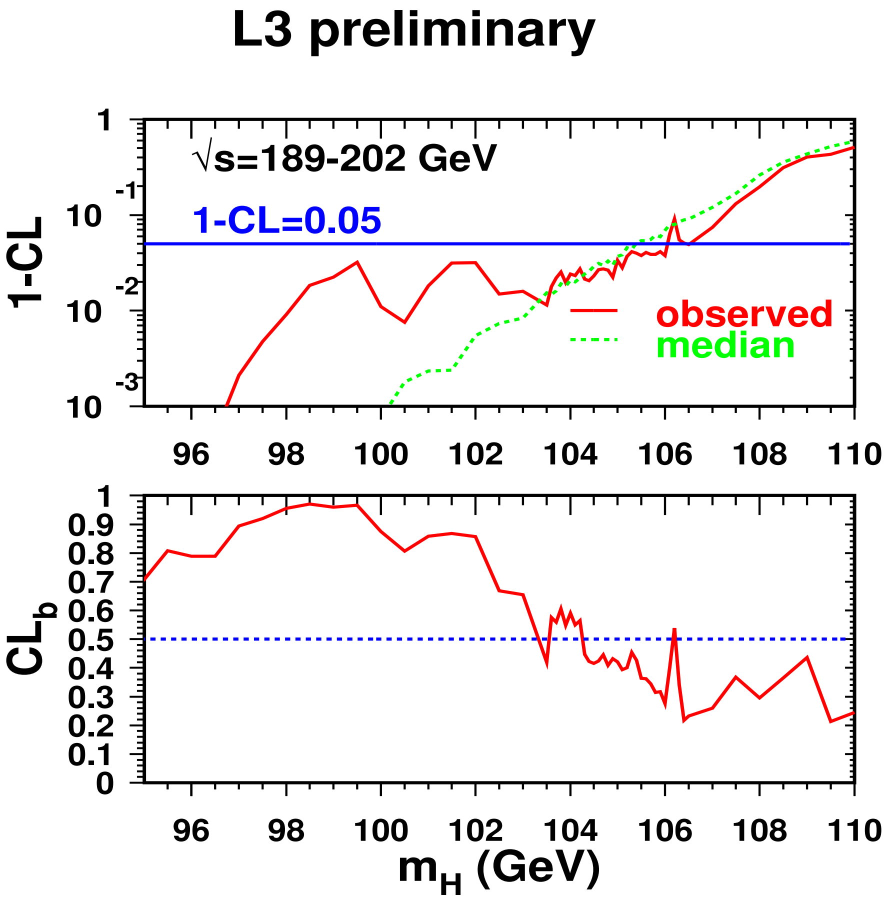
- **Combined Mass Distributions**





- **Limit on M_H**



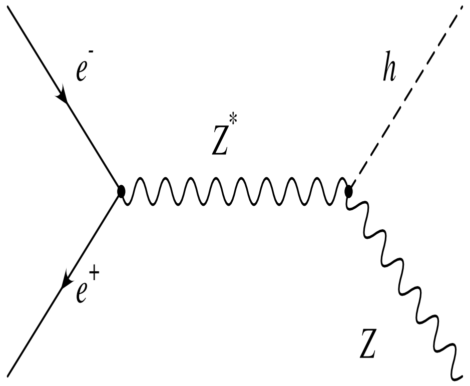
$M_H > 106\ GeV\ at\ 95\%\ CL$

MSSM NEUTRAL HIGGS BOSONS

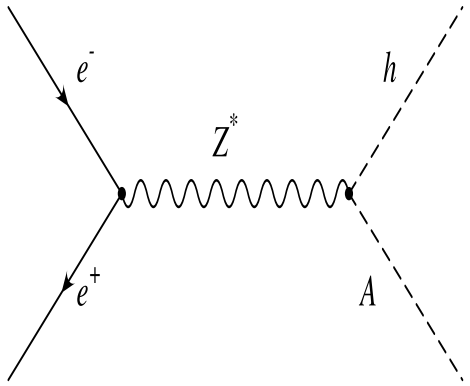
- **MSSM Higgs Sector**
  - $\rightarrow$ **Two Higgs Doublet Model**
  - $\rightarrow$ 5 Physical Higgses : h^0,$\mathbf{A}^0$,$\mathbf{H}^0$,$\mathbf{H}^\pm$
  - $\rightarrow$ **governed at tree level: $\mathbf{M}_A$, tanβ**
  - $\rightarrow$ **with radiative corrections:** $\mathrm{A_t}, \mu, \mathrm{M_2}, \mathrm{m_0}$
  - $\rightarrow M_h^2 \leq M_Z^2 cos^2(2\beta) + \frac{3g^2 M_t^4}{8\pi^2 M_W^2} Ln \frac{M_{\tilde{t}_1}^2 M_{\tilde{t}_2}^2}{M_t^4} + \ldots$

- **Production Mechanisms**

$\sigma \sim sin^2(\beta-\alpha) \cdot \sigma_{SM,hZ}$



$\sigma = \bar{\lambda} cos^2(\beta-\alpha) \cdot \sigma_{hZ}^{SM}$



- **Decay Modes**

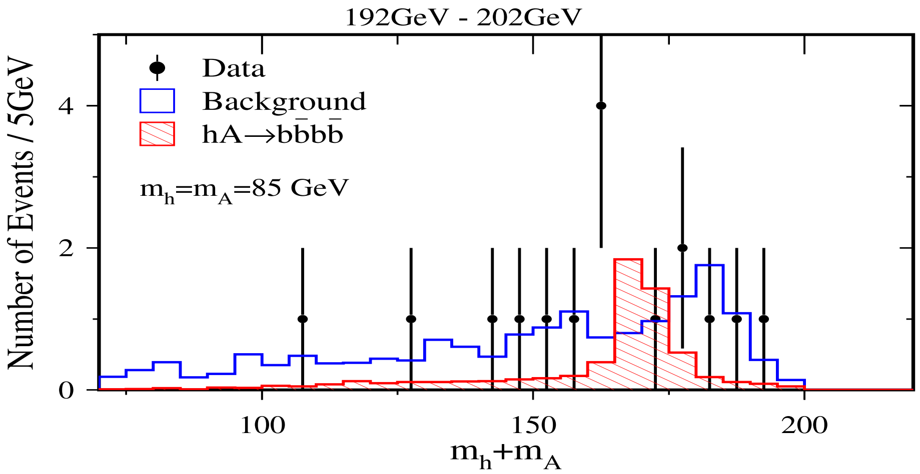
$$\begin{cases} h \rightarrow b\bar{b}, \tau^\pm\tau^\mp \\ A \rightarrow b\bar{b}, \tau^\pm\tau^\mp \end{cases} \qquad \begin{cases} BR(h, A \rightarrow b\bar{b}) \approx 85\% \\ BR(h, A \rightarrow \tau^\pm\tau^\mp) \approx 8\% \end{cases}$$

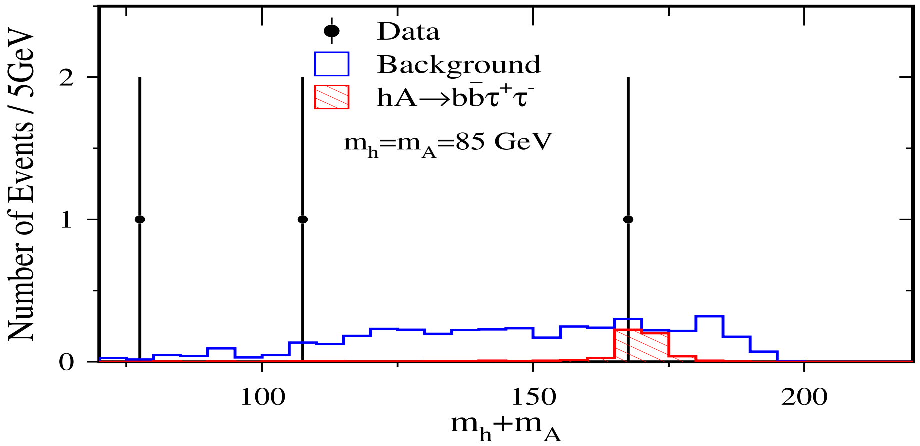
- **Background Processes**

  Same as for the SM Higgs search

- **Two independent analyses**
  hZ analysis: similar to the SM one
  hA analysis: two topologies studied
  $hA \to b\bar{b}b\bar{b}, b\bar{b}\tau^+\tau^-$

- **Mass Distributions for hA analysis**





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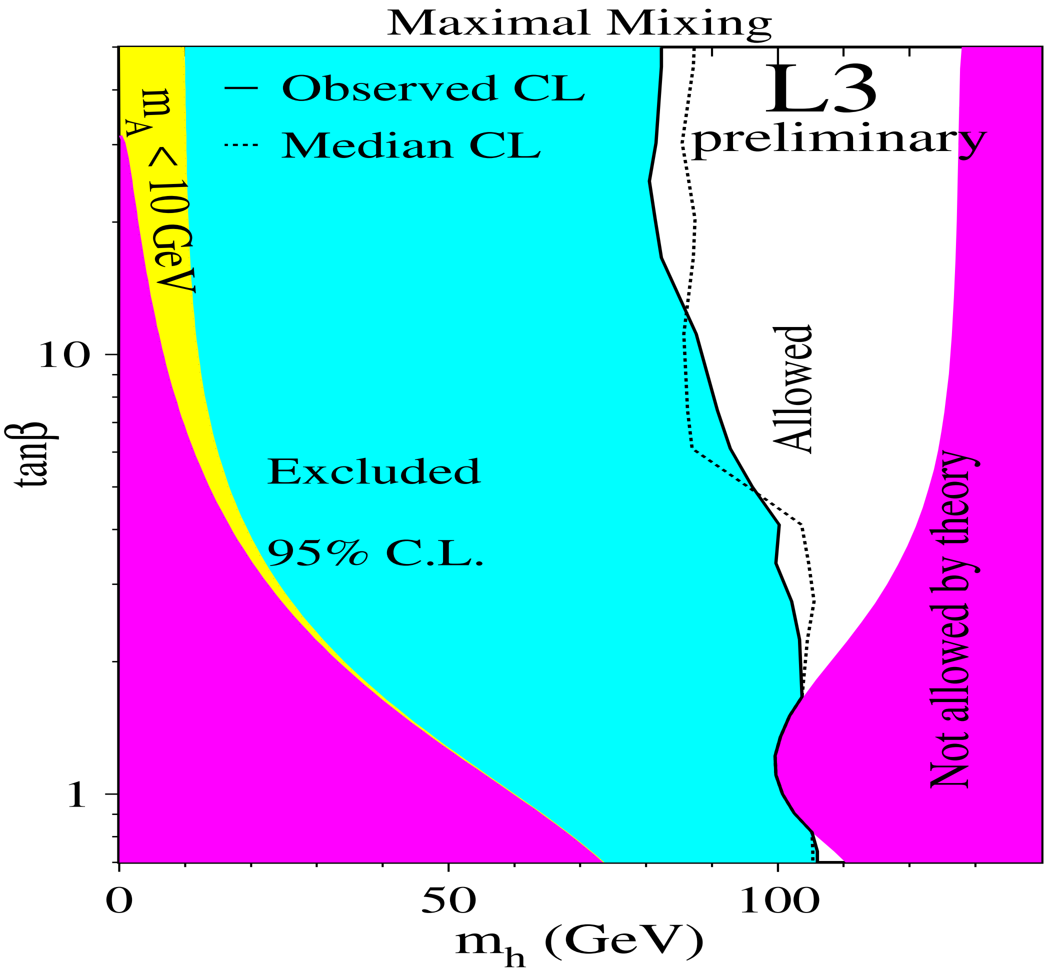


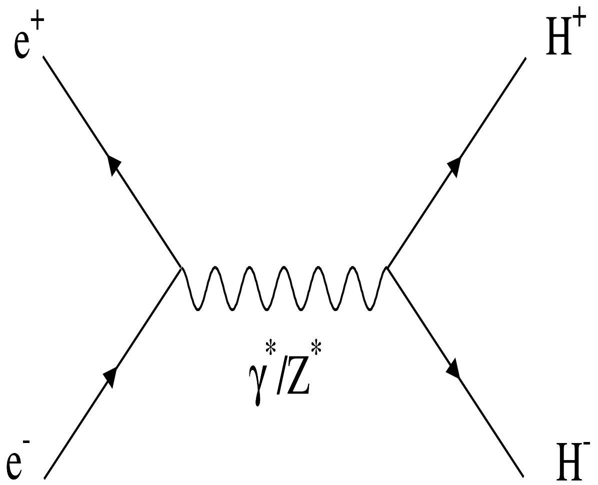
$M_h > 80.5$ GeV and $M_A > 81$ GeV

at 95% CL for $\tan\beta > 1$

(Max. mixing hypothesis in the stop sector yields the most conservative limit on M_h in the MSSM)

CHARGED HIGGS BOSON

- **Production**



- **Decay Modes**

  $H^+H^- \rightarrow c\bar{s}c\bar{s}, c\bar{s}\tau^-\bar{\nu}_\tau, \tau^+\nu_\tau\tau^-\bar{\nu}_\tau$

  All channels covered so the results can be expressed independently of $\mathrm{BR}(\mathrm{H}^\pm \rightarrow \tau^\pm\nu_\tau)$

- **Background processes**

  W^+W^- **is the main,**

  plus all the other background processes of the SM search

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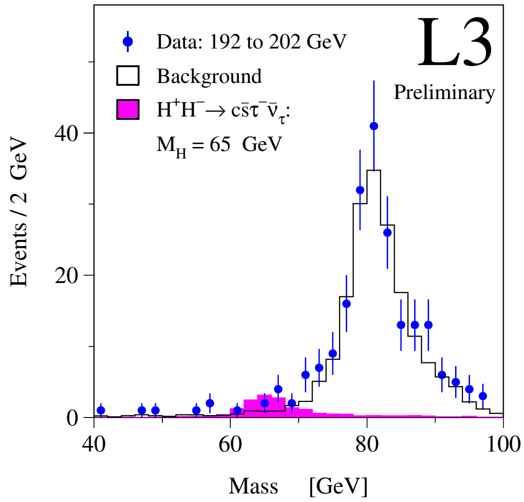
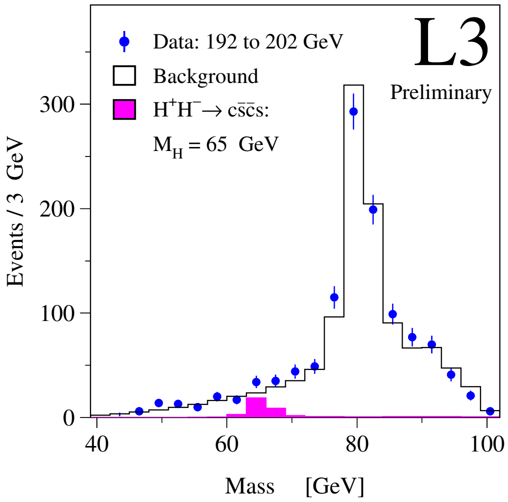
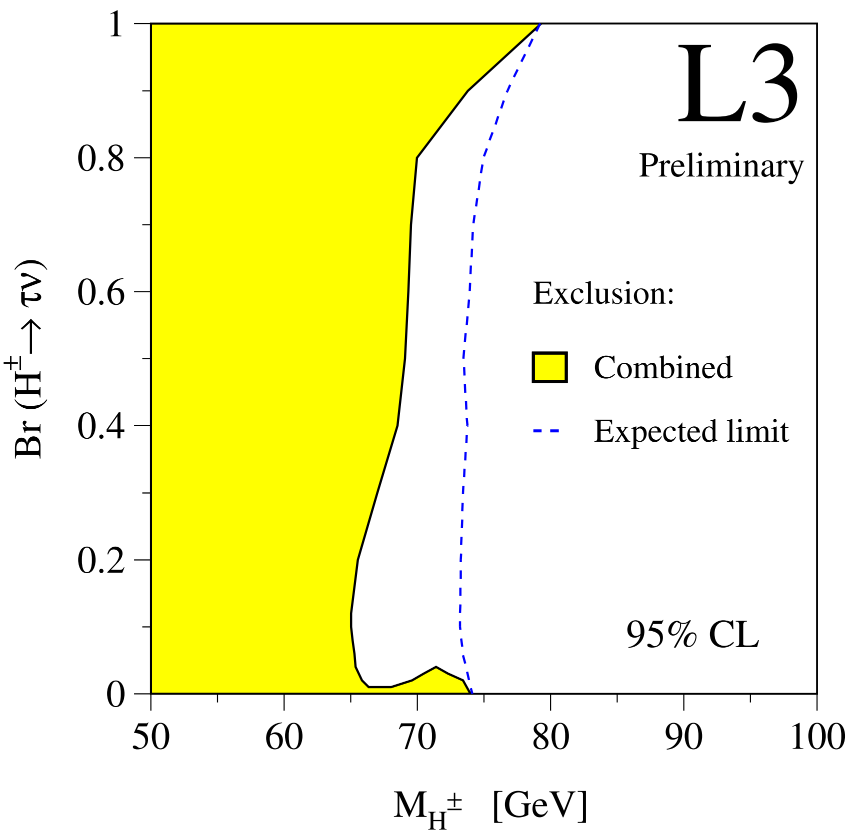
• Results



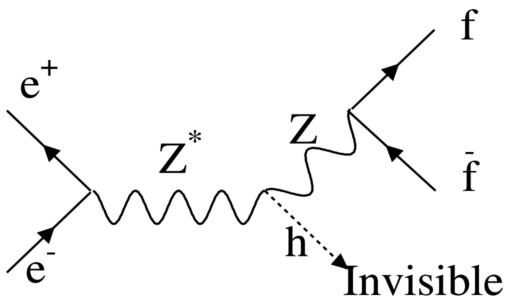




$M_{H^\pm} > 65$ GeV at 95% CL

INVISIBLE HIGGS BOSON DECAYS

- **Production Mechanism**



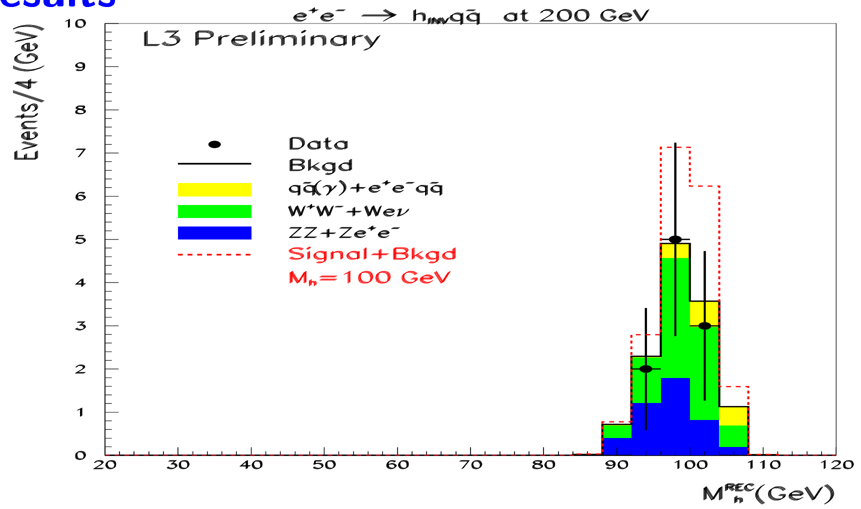
- **Decay Modes**
  $Z \to q\bar{q}, e^+e^-, \mu^+\mu^-$
  and for ex. $h \to \tilde{\chi}^0_1\tilde{\chi}^0_1$ **in SUSY models**

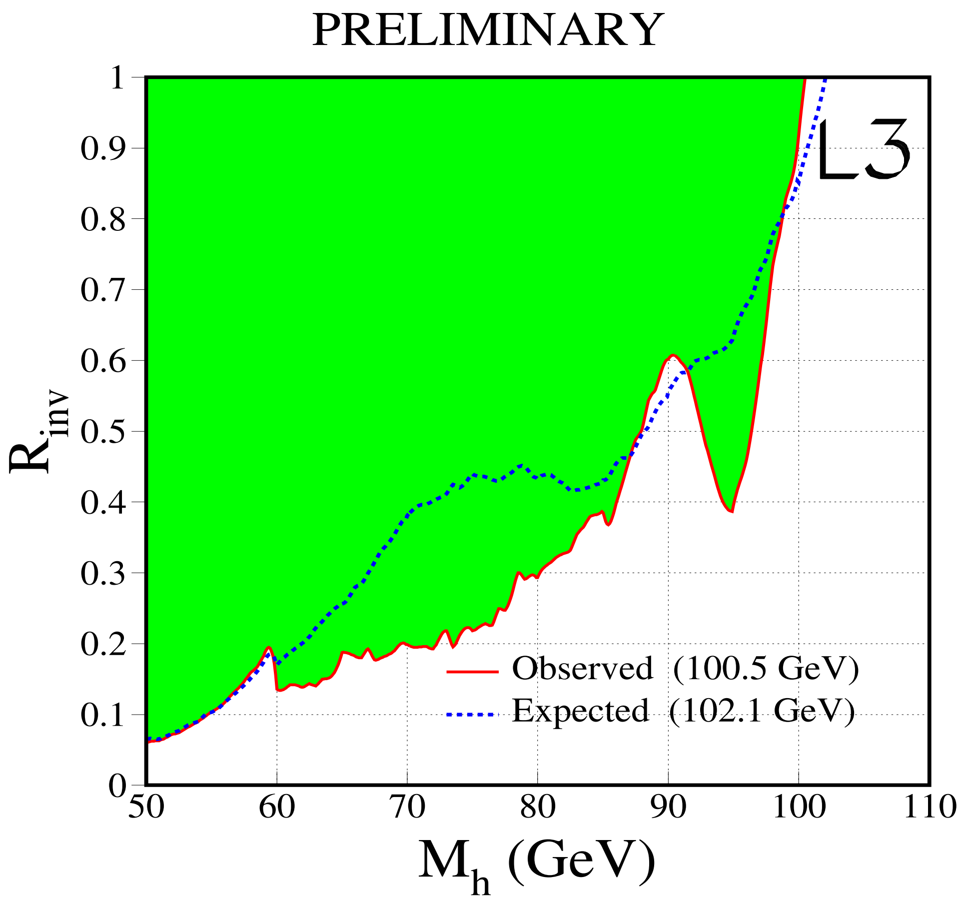
- **Studied Topologies**
  $q\bar{q} + E_{MIS}$, **flavor independent (no b-tagging)**
  $\ell^+\ell^- + E_{MIS}$,**(**$\ell^\pm = e^\pm, \mu^\pm$**)**
  Use the kinematical constraint: $M_{f\bar{f}} \approx M_Z$

- **Backgrounds Processes**
  Same as in the SM search

- **Rate of h$_{inv}$ Production**
  (wrt to the SM HZ production)
  $\mathbf{R}_{inv} = \frac{\sigma(e^+e^- \to hZ)}{\sigma(e^+e^- \to HZ)} \times BR(h \to inv.)$

- **Results**





$M_h > 100.5\ GeV$ at 95% CL (R_{inv}=1)

FERMIOPHOBIC HIGGS BOSON

- **Introduction**
  In the SM H$\rightarrow \gamma\gamma$ at the one-loop level,
  In some extension of the SM, the coupling of Higgs to fermions is null at tree level
  $\Rightarrow$ the BR(H$\rightarrow \gamma\gamma$) is enhanced

- **Production mechanism**
  $e^+e^- \rightarrow HZ$

- **Decay Modes**
  Z$\rightarrow q\bar{q}$ and H$\rightarrow \gamma\gamma$

- **Background Processes**
  $e^+e^- \rightarrow q\bar{q}(\gamma\gamma)$ is the dominant background

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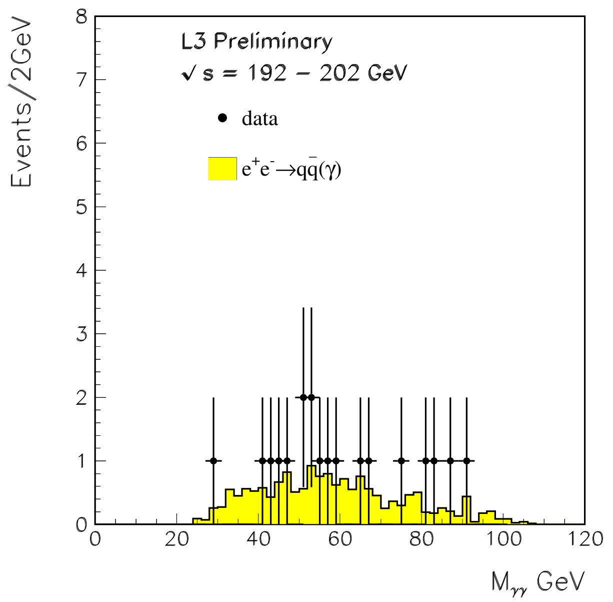
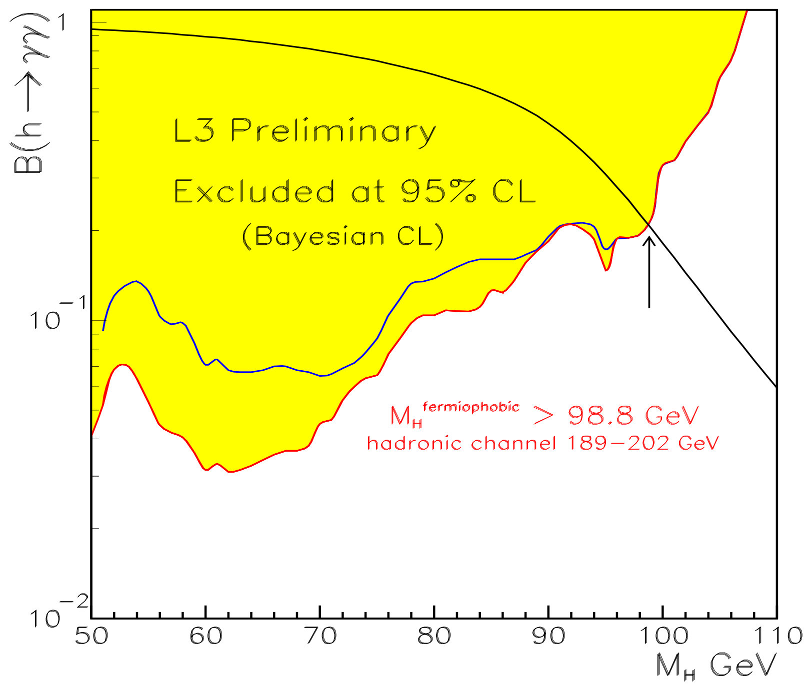
- **Mass Distribution**



- **Limit on M_H**



$M_H > 98.8\ GeV\ at\ 95\%\ CL$

CONCLUSION

- No evidence of a Higgs boson signal is found

- All the results at 192$\leq \sqrt{s} \leq$202 GeV are preliminary
  The study of systematic uncertainties is underway
  Final results should be available soon

- We look forward to this year's high energy data,...
  may be the Higgs boson is around the corner

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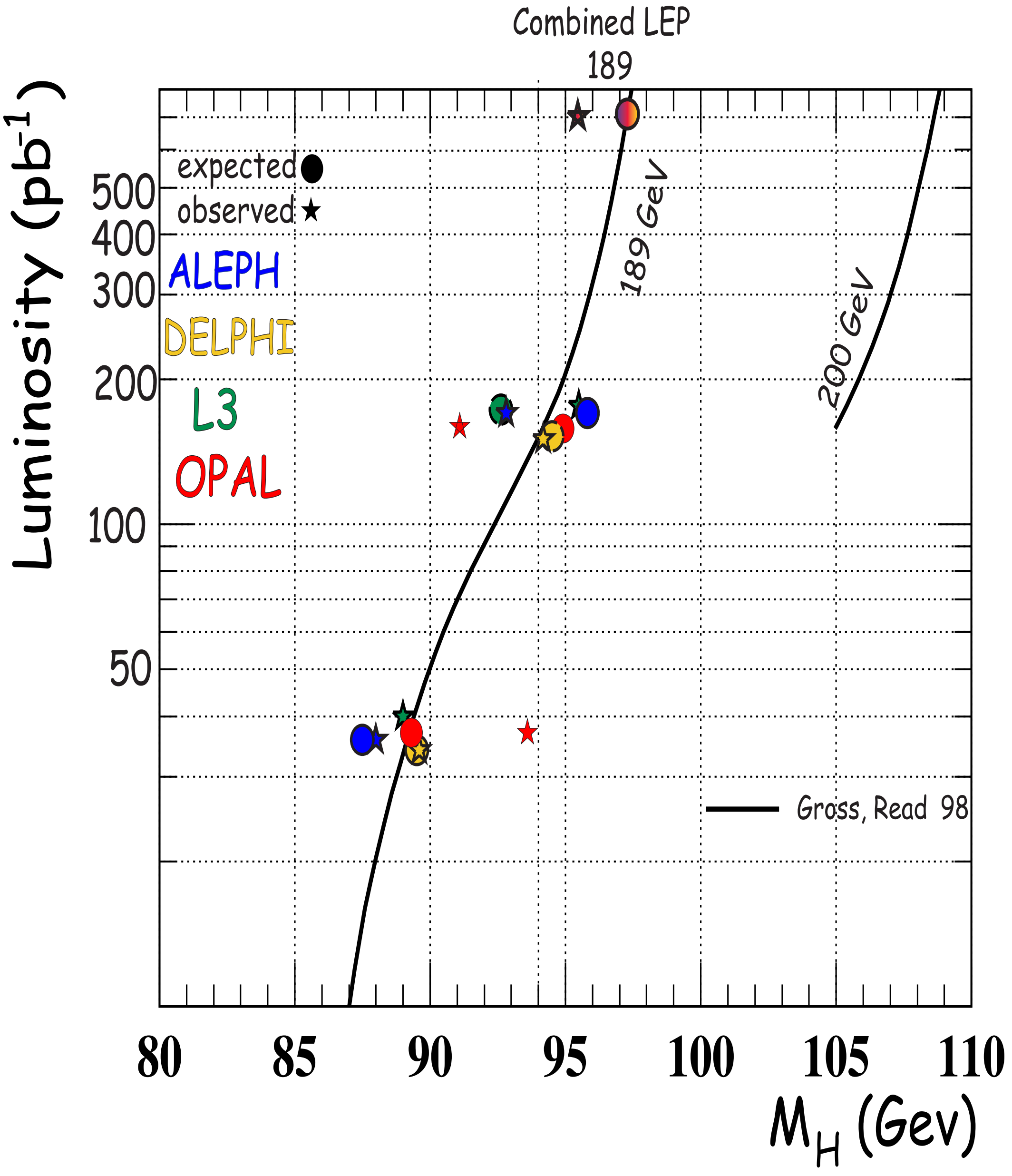
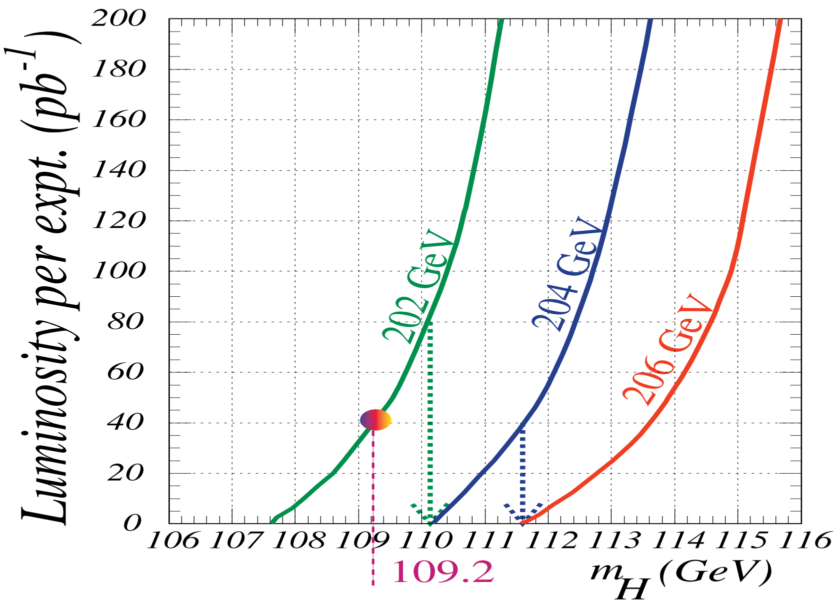
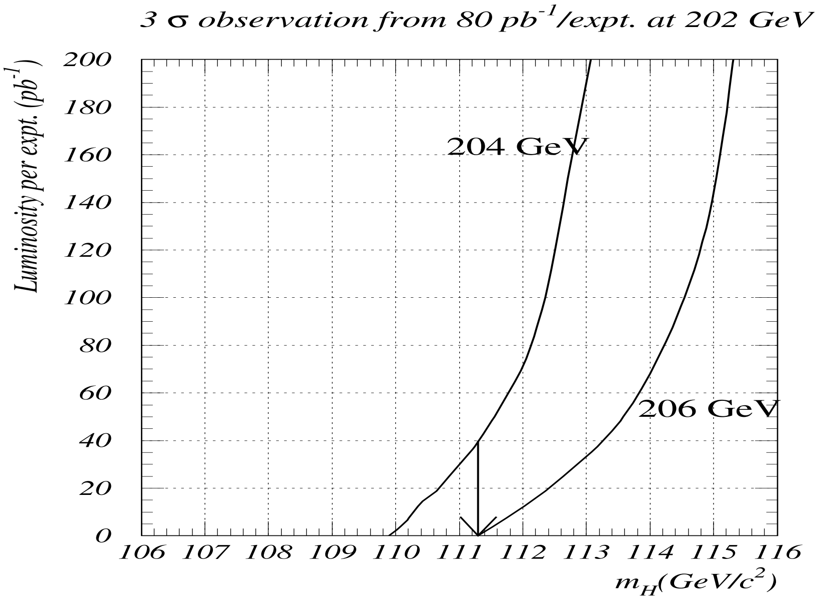
PROSPECTS

- **For the SM Higgs Boson Search**



(E. Gross and A.L. Read, CERN-EP-2000-034)





Ultimately, M_H <113.7 GeV could be excluded at 95% CL and M_H <113.2 GeV could be observed at 3σ with 40 pb^{-1}/expt collected at $\sqrt{s}$ =202, 204 and 206 GeV

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