Search for the Standard Model Higgs Boson in e^+e^- Interactions at 189 GeV

Steve Muanza
IPN Lyon France
CNRS/IN2P3
Université Claude Bernard

American Physical
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L3 Collaboration

Outline

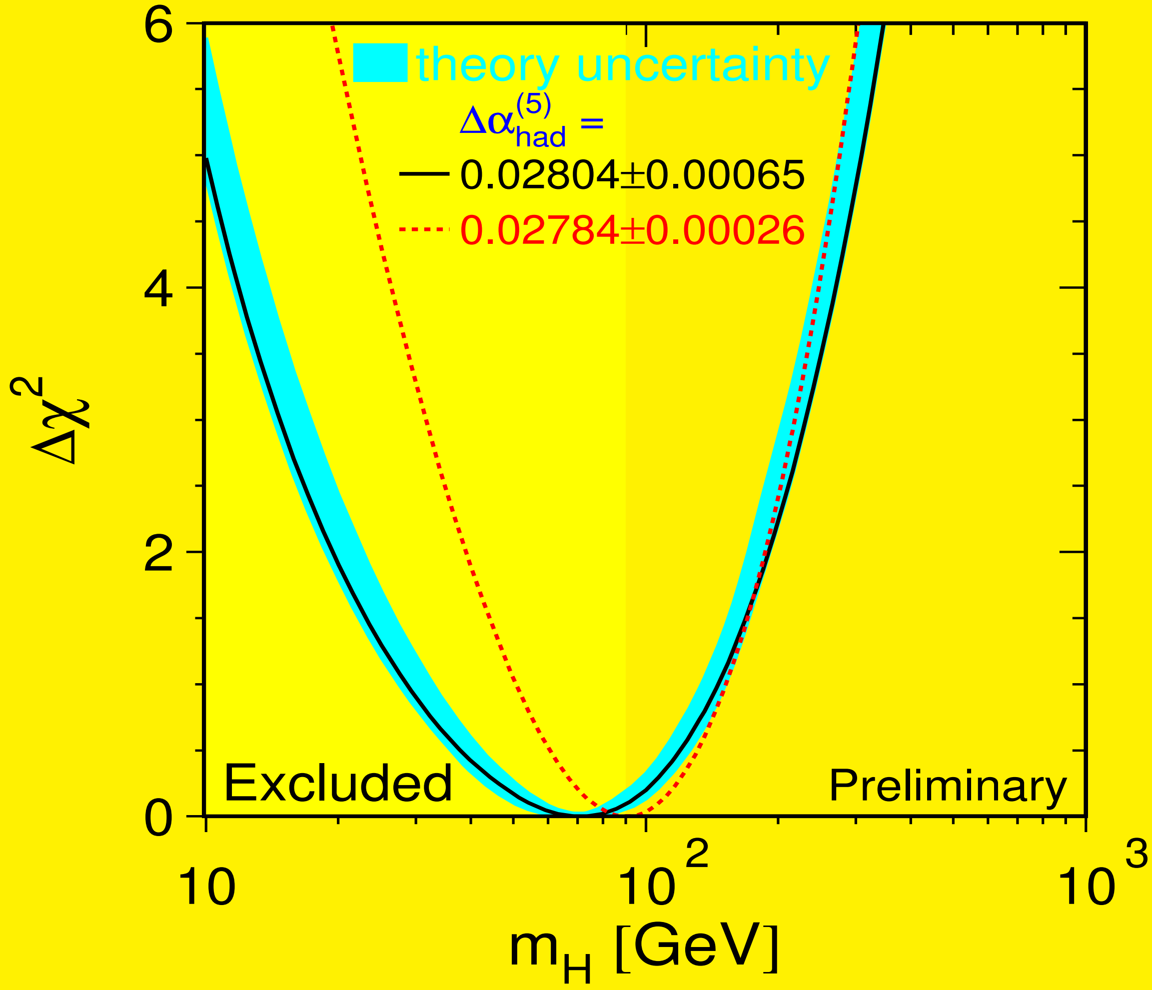
- Introduction
- Higgs Production and Decay Modes
- Search Topologies and Background Processes
- Conclusion and Present Limit on M_H
- Prospects for 1999-2000

Many Thanks to the L3 Higgs WG Members

INTRODUCTION

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

from EW Precision Data (LEP, TEVATRON, SLC)



$M_H = 71^{+75}_{-42} \pm 5$ GeV and $M_H <$220 GeV at 95% CL

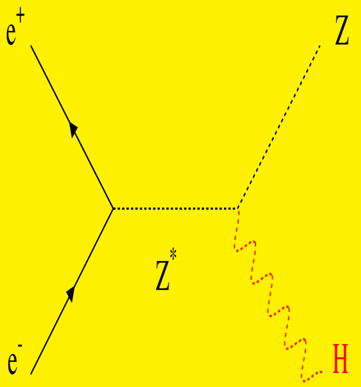
- **Previous Limit From Direct Searches**

$M_H >$89.8 GeV at 95% CL
(from ADLO [a], $\sqrt{s} \leq$183 GeV, 1995-1997)

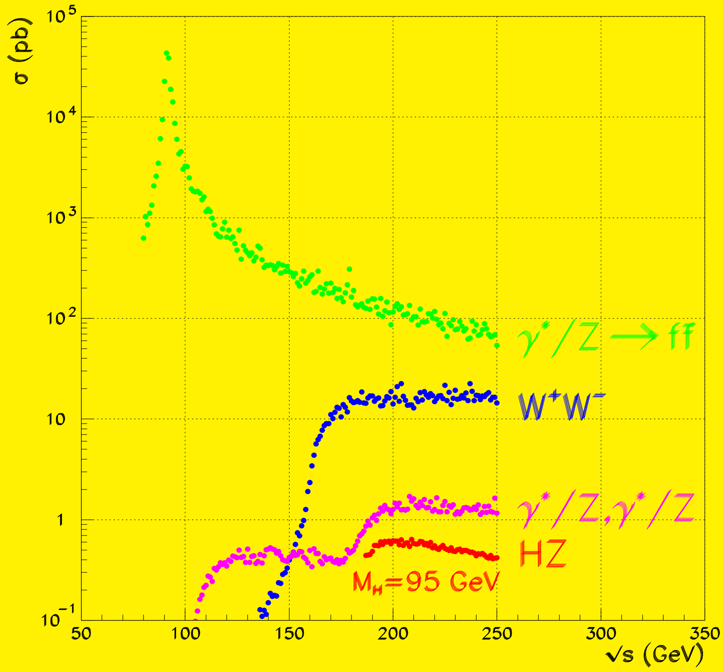
[a] ALEPH 98-069, DELPHI 98-144, L3 Note 2310, OPAL TN-558

HIGGS PRODUCTION AND DECAY MODES

- **Production**



HIGGS-STRAHLUNG PROCESS



HZ Production Threshold: $\sqrt{s} > M_Z + M_H$

L3 1998: $\int \mathcal{L}dt = 176.4\ \mathrm{pb}^{-1}$ at $\sqrt{\mathrm{s}}$ =**189 GeV**

- **Decay Modes**

Example: M$_H$ =95 GeV

$$\left\{\begin{array}{l} BR(H \to b\bar{b}) \approx 83.9\% \\ BR(H \to \tau^+\tau^-) \approx 7.9\% \\ BR(H \to gg) \approx 5.0\% \\ BR(H \to c\bar{c}) \approx 3.7\% \end{array}\right. \otimes \left\{\begin{array}{l} BR(Z \to q\bar{q}) \approx 69.9\% \\ BR(Z \to \nu\bar{\nu}) \approx 20.0\% \\ BR(Z \to \ell^+\ell^-) \approx 10.1\% \end{array}\right.$$

B-Tagging Very Important

Steve MUANZA
IPN Lyon, FRANCE

SEARCH TOPOLOGIES AND BACKGROUND PROCESSES

4 Jets

- **Signal: H$q\bar{q}$**

  $\mathrm{BR(H \to b\bar{b}) \times BR(Z \to q\bar{q}) \approx 58.6\%}$

- **Background Processes**

  $\mathrm{q\bar{q}(\gamma);\ W^+W^-;\ ZZ;\ W^\pm e^\mp \nu_e;\ Ze^+e^-}$

- **Analysis Procedure: Neural Network Method**

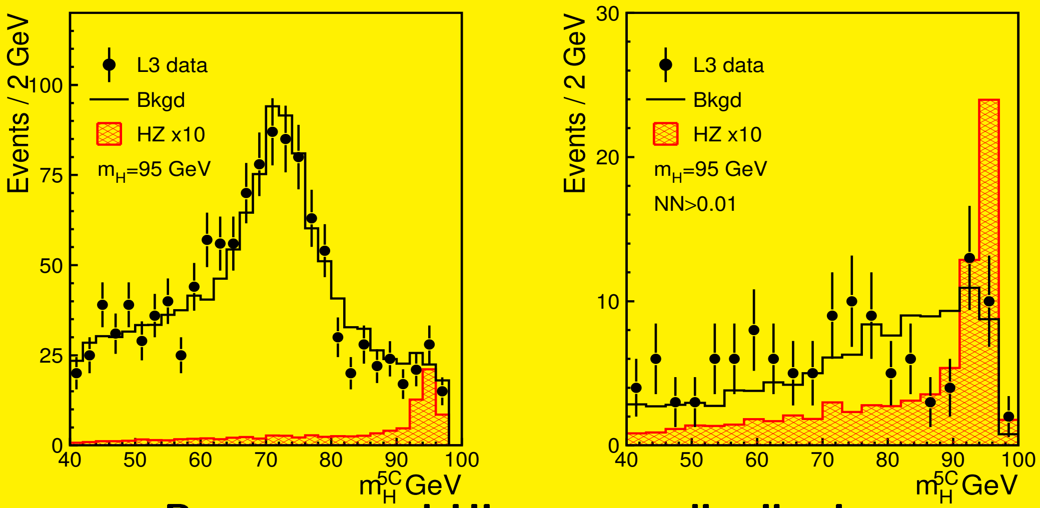
  Preselection:

  . **Full energy, high multiplicty hadronic events,**

  . **Kinematic 5C fit: 1 jet pair forced to $M_{q\bar{q}} = M_Z$**

  . **From the other pair, with high b-tag, one gets M^H_{REC} with better resolution**

  . **NN inputs have weak dependance on Higgs mass**



Reconstructed Higgs mass distributions

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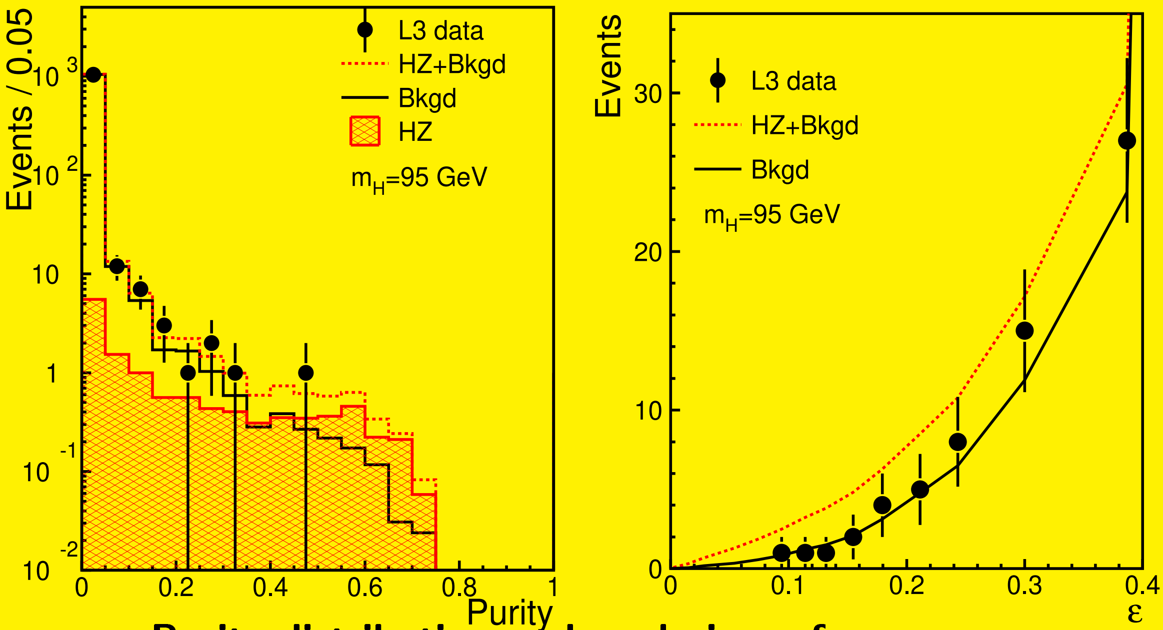
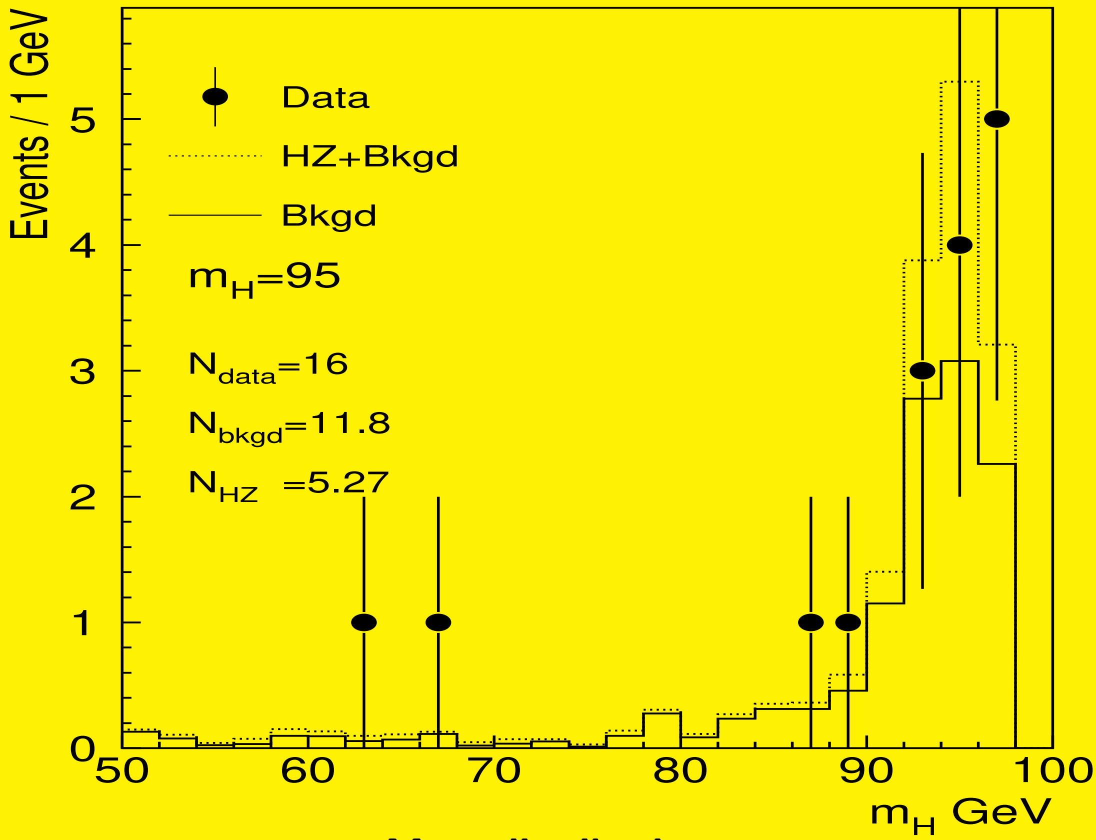
IPN Lyon, FRANCE

Purity variable: combination of NN$_{out}$ and 5C M^H_{REC}

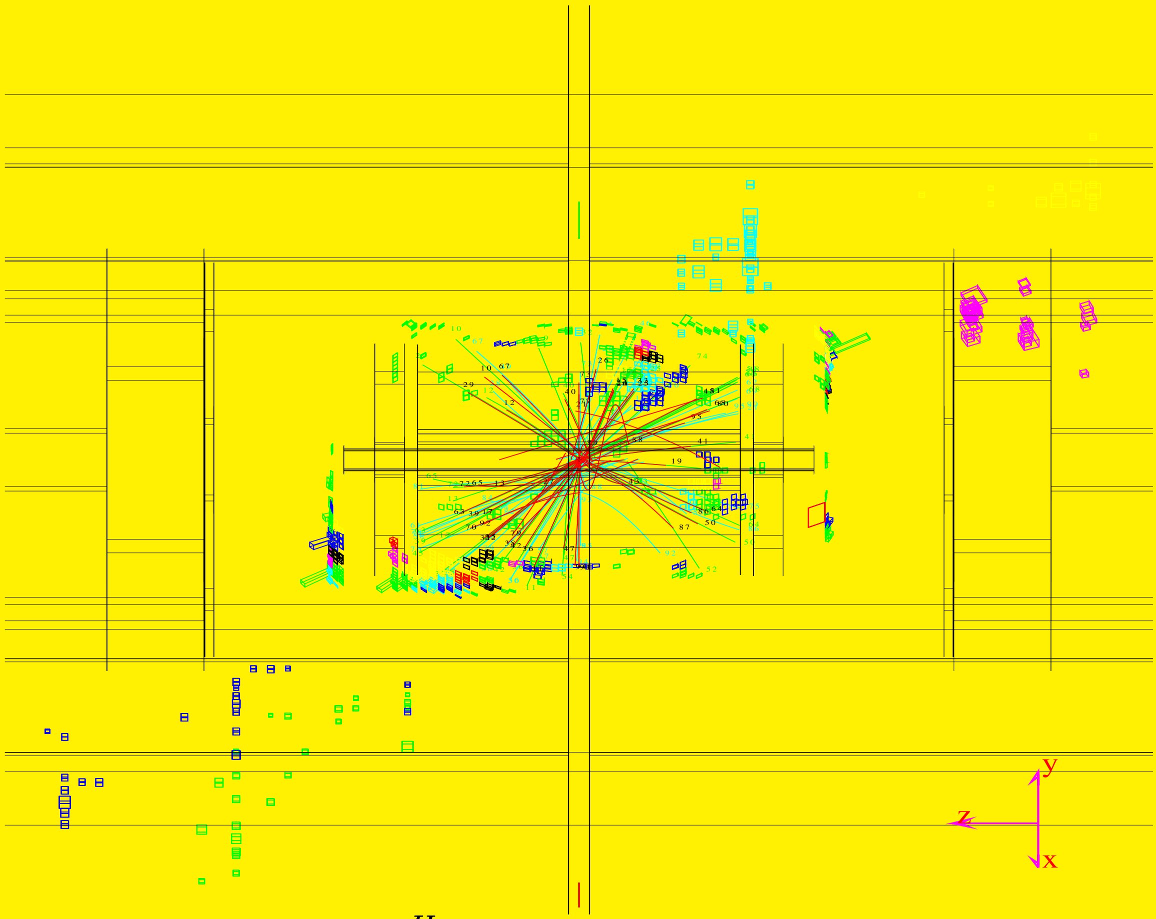


Purity distribution and analysis performance

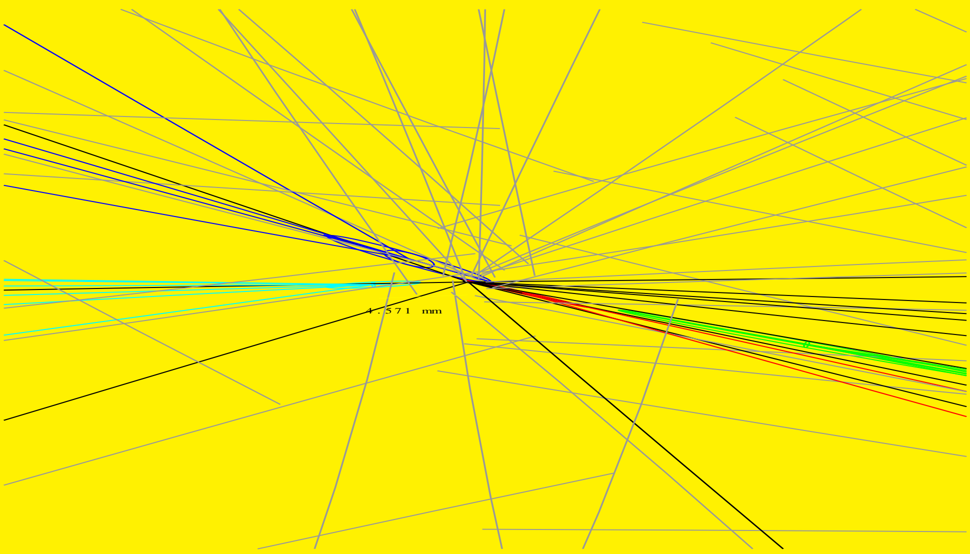


Mass distribution

Run # 697803 Event # 4765



4j candidate: M^{H}_{REC} =92.6 GeV (5C), B-TAG=4.



Event primary and secondary vertices

2 Jets $+\not{E}$

- **Signal: H$\nu\bar{\nu}$**

  $BR(H \to b\bar{b}) \times BR(Z \to \nu\bar{\nu}) \approx 16.8\%$

- **Background Processes**

  $\mathrm{W^+W^-; W^\pm e^\mp \nu_e;\ ZZ;\ Ze^+e^-; \gamma\gamma \to e^+e^-q\bar{q};\ q\bar{q}(\gamma)}$

- **Analysis Procedure: Neural Network Method**

  Preselection:

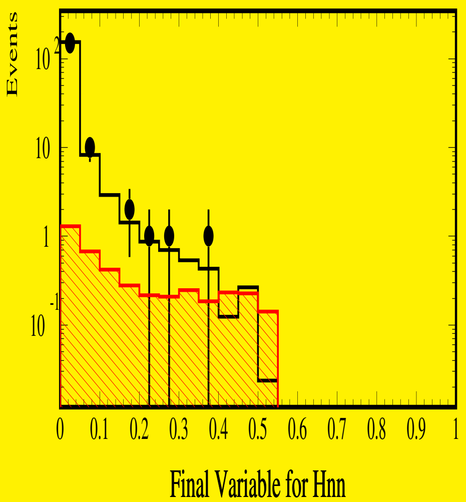
  . **2 acoplanar hadronic jets, $\not{E}$, moderate multiplicity**

  . **Kinematic fit: $\not{M} = M_z$**

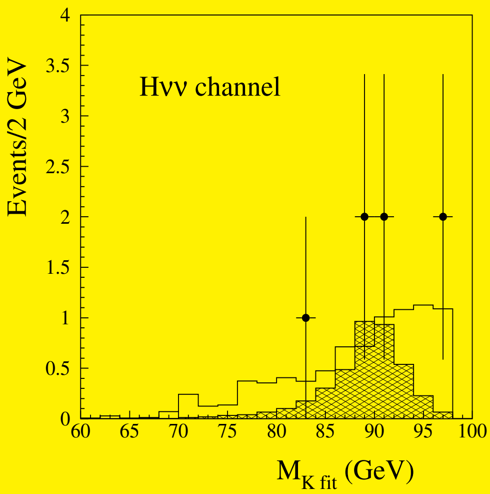
  . **Jet pair with high b-tag, M^H_{REC} with better resolution**

  Purity variable:

  . **Combination of M^H_{REC} and NN$_{out}$**



Purity



M$^H_{REC}$

Steve MUANZA
IPN Lyon, FRANCE

2 Leptons + 2 Jets

- **Signal: H$\ell^+\ell^-$ ($\ell^\pm$: $e^\pm$ *or* $\mu^\pm$)**
  $\mathrm{BR}(\mathrm{H} \to \mathrm{b\bar{b}}) \times \mathrm{BR}(\mathrm{Z} \to \ell^+\ell^-) \approx 5.6\%$

- **Background Processes**
  $\mathrm{W^+W^-}$; ZZ; $\mathrm{q\bar{q}}(\gamma)$

- **Analysis Procedure: Max. Likelihood Method**

  Preselection:

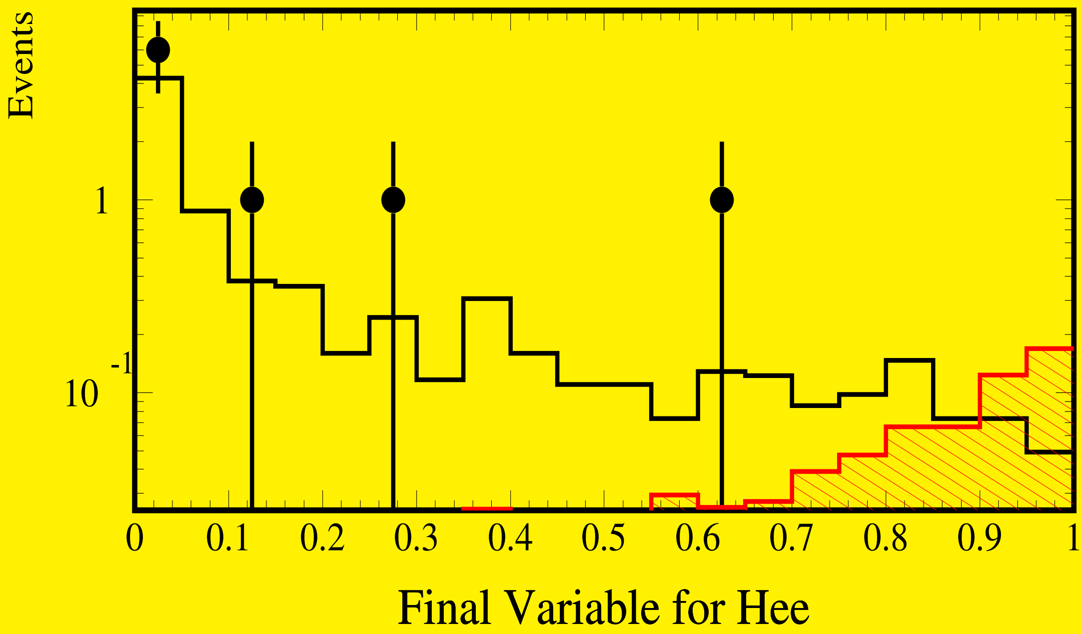
  . **Full energy, high multiplicty, 2$\ell^\pm$ + 2 hadronic jets**

  . **Kinematic 5C fit: dilepton mass $M_{\ell^+\ell^-} = M_Z$**

  . **Jet pair with high b-tag, M^H_{REC} with better resolution**

  Final discriminant:

  . **M$_{b\bar{b}}$ and b-tag combined in a binned likelihood**



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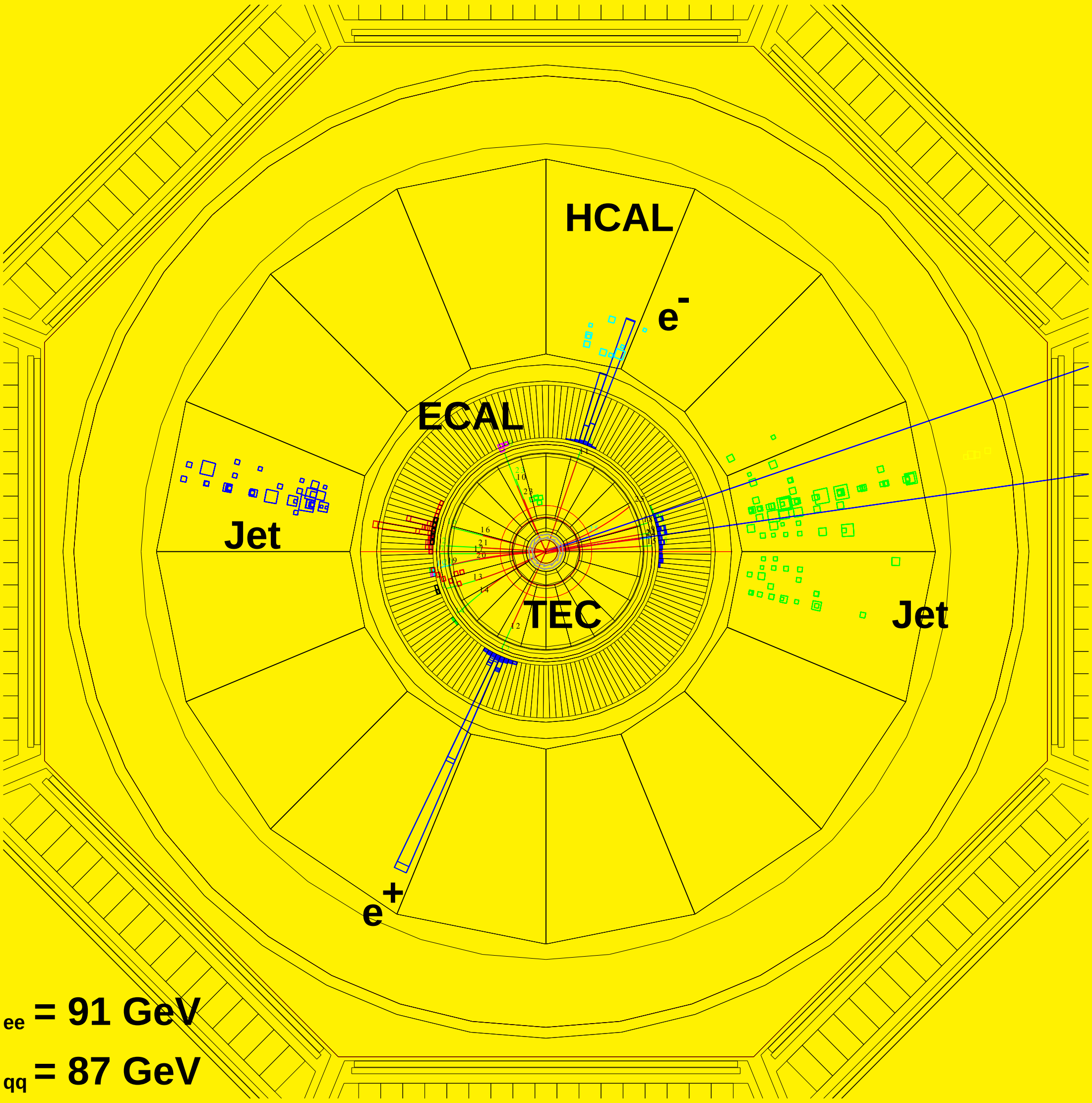
IPN Lyon, FRANCE

Run # 727101 Event # 3545

L3



M_{ee} = 91 GeV

M_{qq} = 87 GeV

M_{5C} = 89 GeV

2 Taus + 2 Jets

- **Signal: H$\tau^+\tau^-$ or $\tau^+\tau^- q\bar{q}$**

  . $\mathrm{BR(H \to b\bar{b}) \times BR(Z \to \tau^+\tau^-) \approx 2.8\%}$

  . $\mathrm{BR(H \to \tau^+\tau^-) \times BR(Z \to q\bar{q}) \approx 5.5\%}$

- **Background Processes**

  $\mathrm{W^+W^-;\ ZZ;\ q\bar{q}(\gamma)}$

- **Analysis Procedure: $\tau^\pm$ ID or jet based selections**

  Common Preselection:

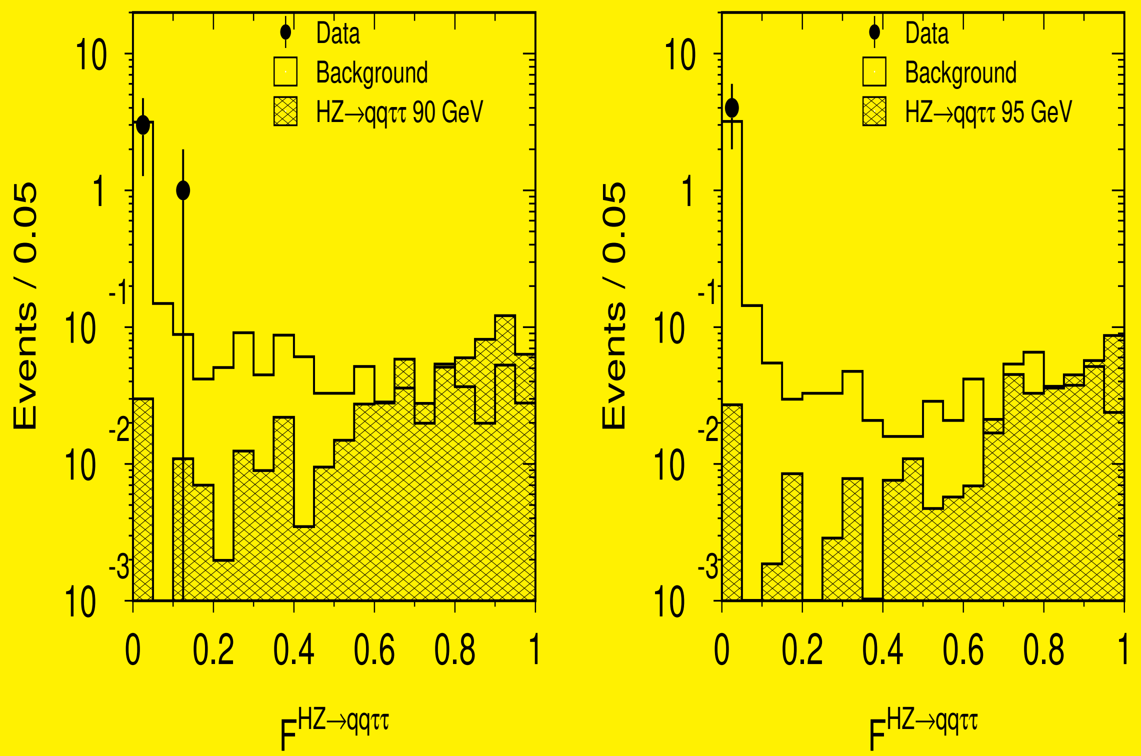
  . **missing energy, high multiplicty events**

  . **Kinematic fit: $M_{\tau\tau} = M_Z$ or $M_{q\bar{q}} = M_Z$**

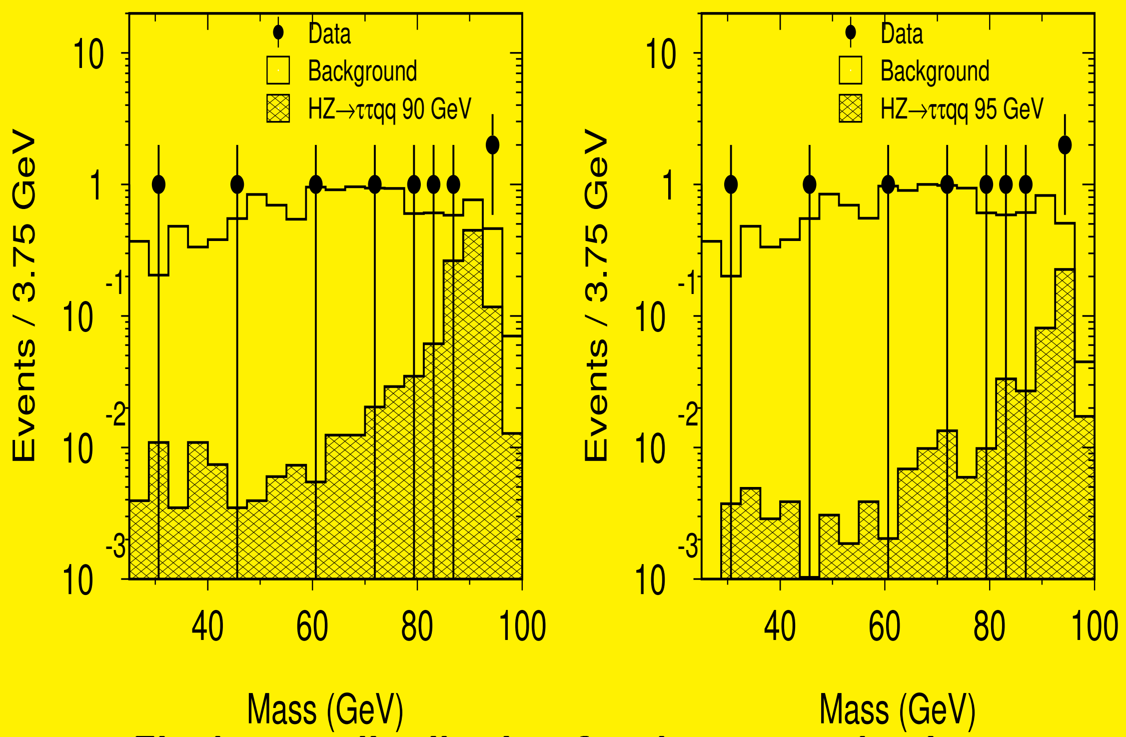
  . **Jet pair with high b-tag, M^H_{REC} with better resolution or jet pair from Z and $M_{\tau\tau} \approx M^H_{REC}$**

  Final discriminant:

  . **Likelihood or M$_{\tau\tau}$**



Final likelihood distributions for the H$\tau\tau$ selection

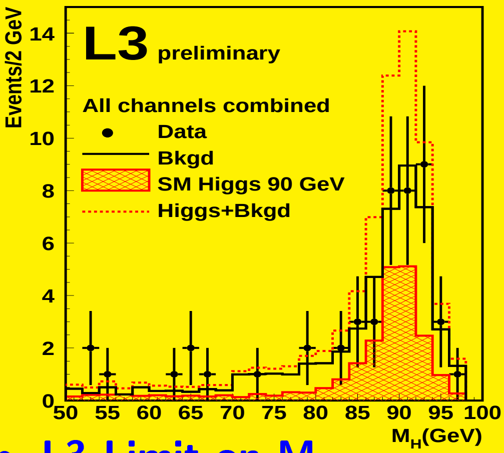


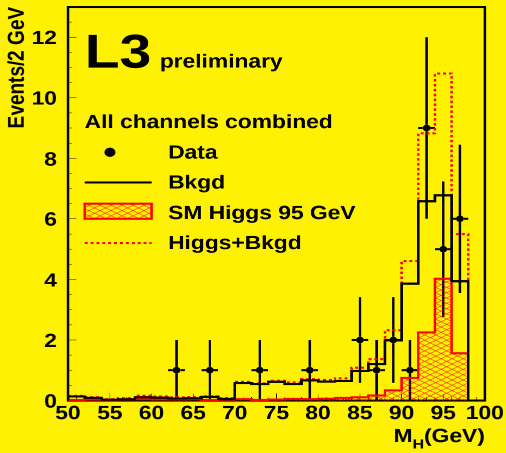
Final mass distribution for the $\tau\tau q\bar{q}$ selection

CONCLUSION

- **Combined Topologies Final Results (176.4 pb^{-1})**

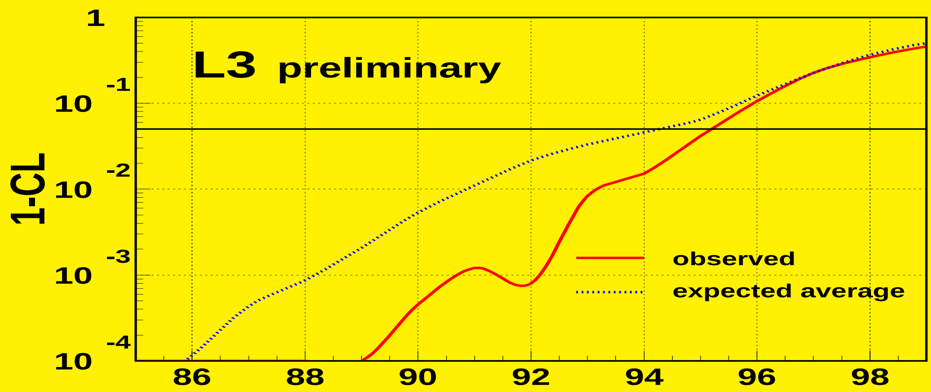
M_H (GeV)	DATA	BKGD	N_H
90	47	47.6	22.
95	30	30.3	9.9

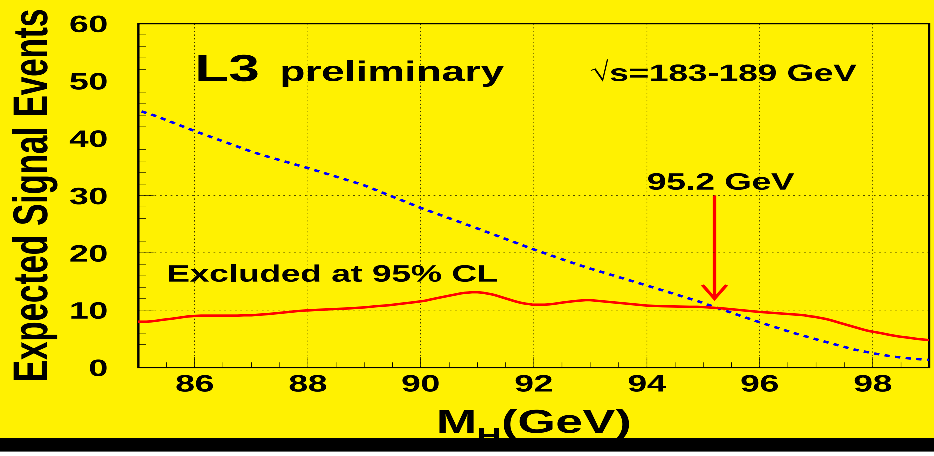




- **L3 Limit on M_H**

M_H >95.2 GeV (Observ.), (94.4 GeV Expect.) at 95% CL





PROSPECTS

- **1999 LEP Energy Increase**

  Energy steps: $\sqrt{s}$ =**192, 196, 200 GeV**

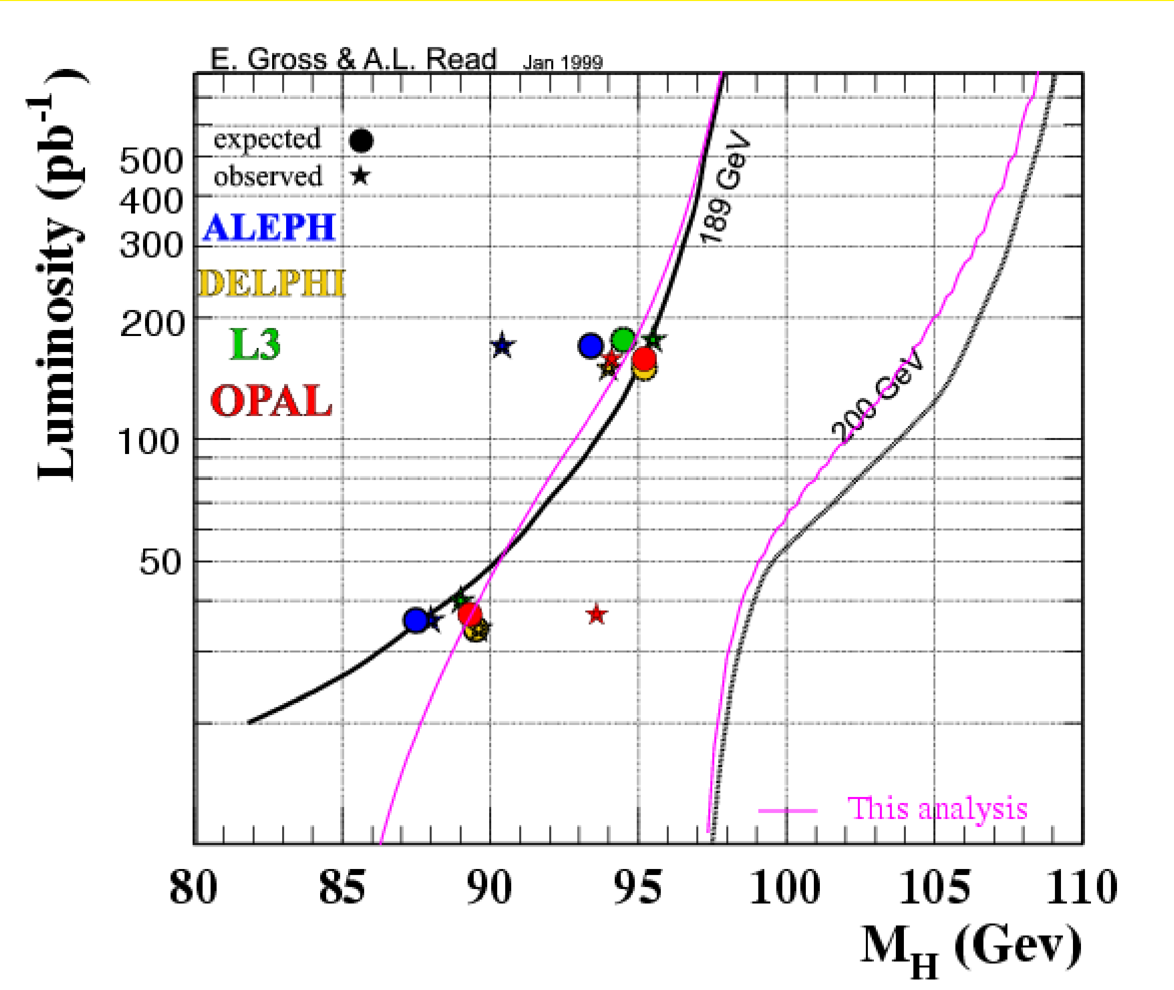
  Luminosity: $\int \mathcal{L}\mathrm{dt} \geq 150\ \mathrm{pb}^{-1}/\mathrm{expt}\ (?)$

- **Run in 2000**

  Energy: $\sqrt{s}$ =**200 GeV**

  Luminosity: $\int \mathcal{L}\mathrm{dt} \approx 200\ \mathrm{pb}^{-1}/\mathrm{expt}\ (?)$

- **Reach of the 200 GeV Run**



Prospective analysis done by E. Gross et al. (CERN-EP/98-094) and by P. Janot (CERN-SL-99-007 DI)

RESULTS FROM THE OTHER LEP COLLABORATIONS

- **ALEPH**
  - . **Expected Limit: M$_H > 95.7$ GeV**
  - . **Observed Limit: M$_H > 90.2$ GeV**
- **DELPHI**
  - . **Expected Limit: M$_H > 94.8$ GeV**
  - . **Observed Limit: M$_H > 95.2$ GeV**
- **OPAL**
  - . **Expected Limit: M$_H > 94.9$ GeV**
  - . **Observed Limit: M$_H > 91.0$ GeV**

95% CL Limits (PRELIMINARY)