Searches for the Standard Model Higgs Boson using the L3 Detector at LEP

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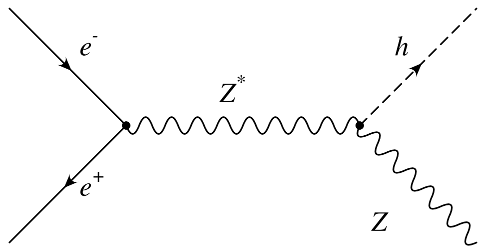
Talk Outline:

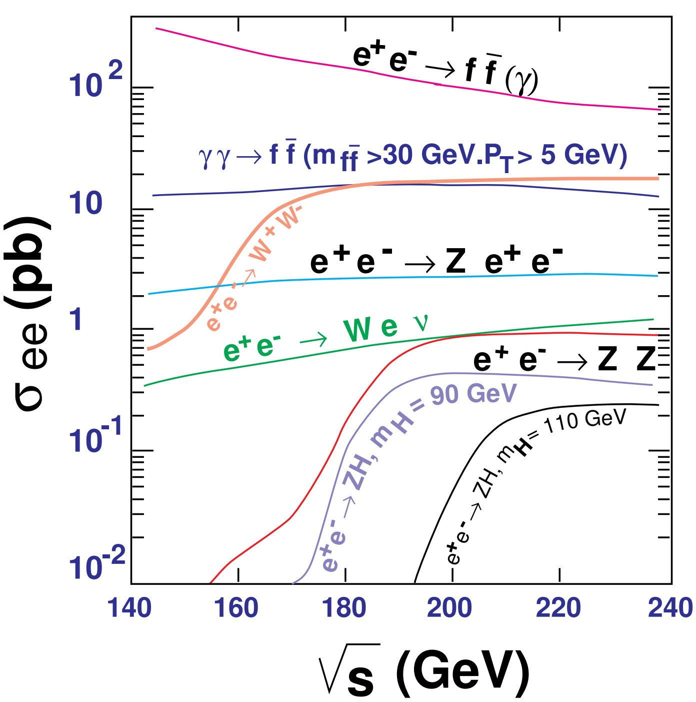
- Higgs Production
- Higgs Decay
- Analysis Overview
  - Four-Jet Channel
  - Missing Energy Channel
  - Leptonic Channels
  - Tau Channels
- Results

Higgs Production

Higgs-Strahlung process



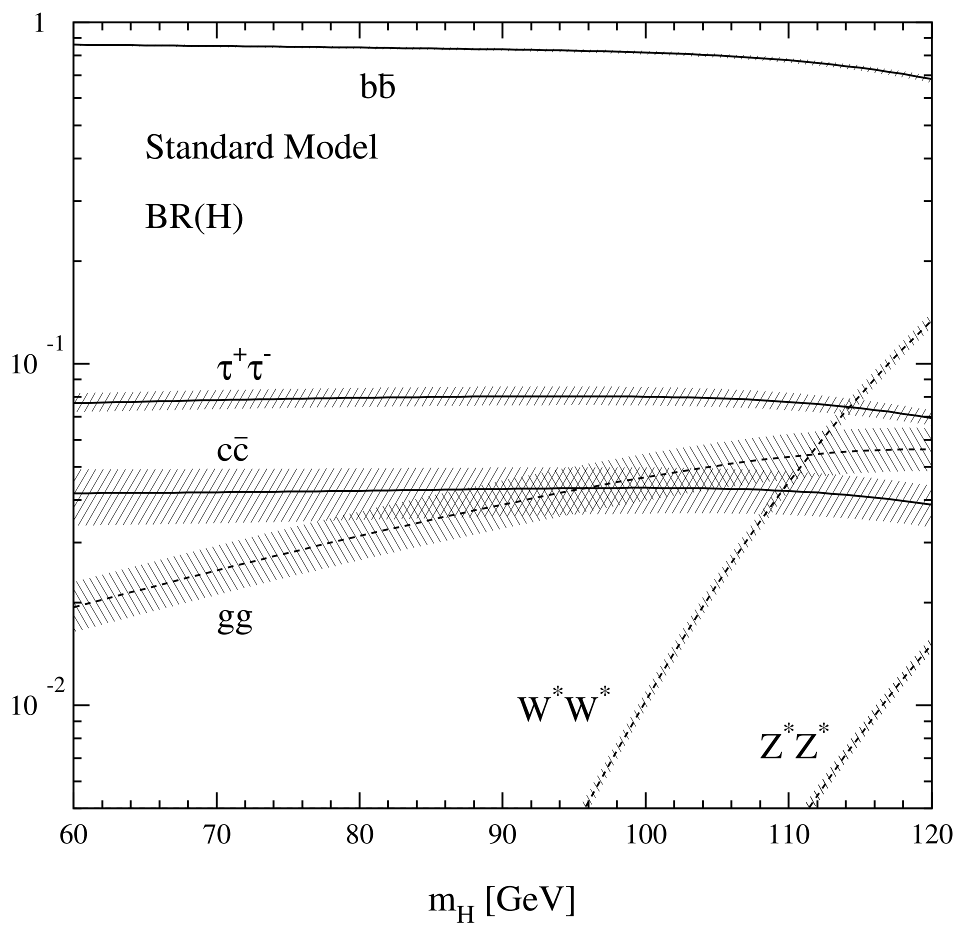
$$e^+e^- \rightarrow Z^* \rightarrow HZ$$



⇒ Higgs cross section is much smaller than that of Standard Model events

Higgs Decay

Higgs Boson decays preferably to
the heaviest kinematically allowed particles



⇒ b-tag is a very effective discriminant

Analysis Overview

Four main decay channels are searched, covering over 90% of all possible decay channels.

- Four-Jet Channel: $HZ \rightarrow b\bar{b}q\bar{q}$
- Missing Energy Channel: $HZ \rightarrow b\bar{b}\nu\bar{\nu}$
- Lepton Channels: $HZ \rightarrow b\bar{b}e^+e^-$ or $b\bar{b}\mu^+\mu^-$
- Tau Channels: $HZ \rightarrow b\bar{b}\tau^+\tau^-$ or $\tau^+\tau^-q\bar{q}$

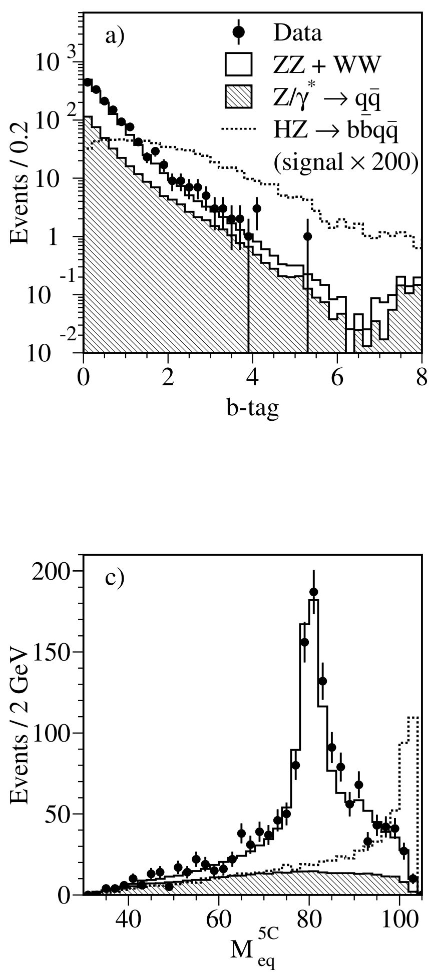
Data collected during 2000 LEP run by L3:

Average E_{CM}	Luminosity (pb^{-1})
202.8	2.7
203.8	7.6
205.1	68.1
206.3	66.9
206.6	63.7
208.0	8.2
208.6	0.1
Total	217.3

Four-Jet Channel

- Largest final state fraction ($\sim 55\%$)
- Look for four-jet events with two jets containing b-quarks
- Main background sources include $q\overline{q}$ with gluons, W^+W^- and ZZ
- After high multiplicity hadronic preselection, several discriminating variables are combined into a likelihood. (Ex. b-tag, maximum jet energy difference, minimum jet energy, fitted Higgs mass, etc.)
- An optimized cut is applied on the likelihood.
- Event b-tag, mass χ^2 and "event category" based on b-tag characteristics are combined to form the final discriminant.

Four-Jet Channel

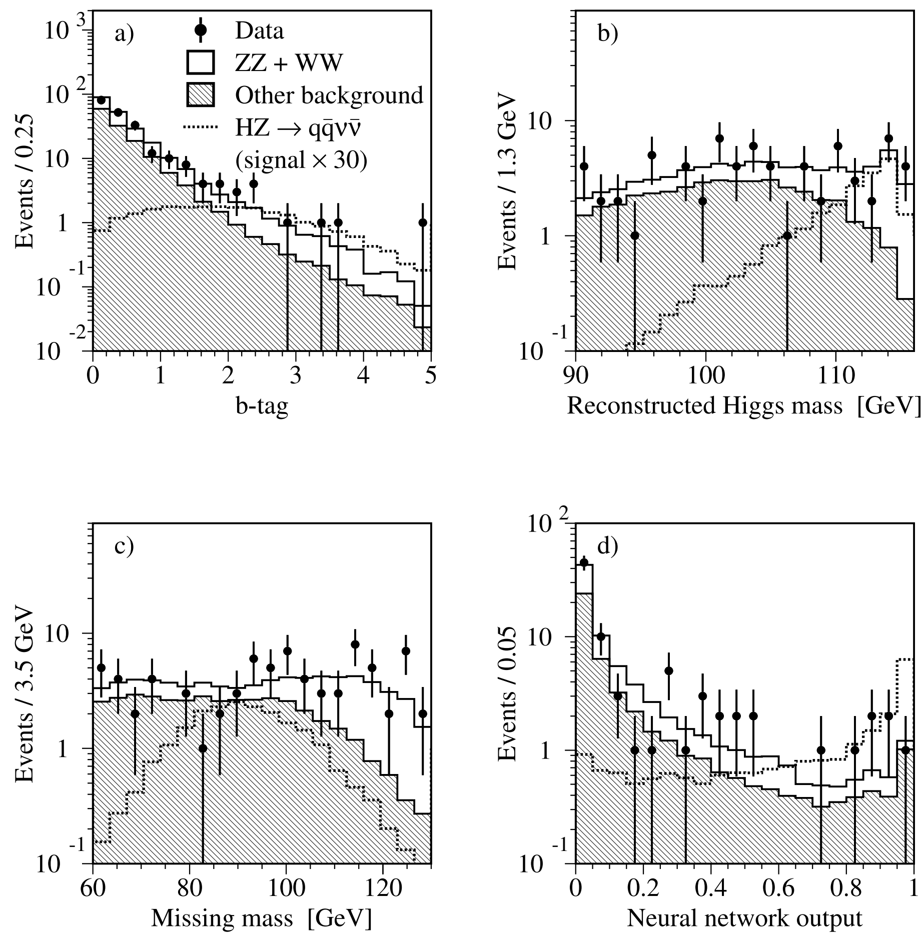


Figures: Distributions of (a) the b-tag, (b) the cosine of the Boson production angle, (c) 5C equal mass fit and (d) the likelihood. The points are data collected at $E_{CM} > 206$ GeV, open and hatched regions are SM backgrounds and the dashed region is the 115 GeV Higgs signal multiplied by 200.

Missing Energy Channel

- Smaller final state fraction ($\sim 15\%$) but cleaner event sample
- Look for events with two acoplanar jets containing b-quarks and large missing transverse energy
- ZZ events constitute the largest source of background
- After hadronic preselection, events are forced into two jets
- Cuts on the minimum jet mass and the missing energy are used to reduce lepton pair and $q\overline{q}$ backgrounds, respectively
- Event b-tag and mass-independent neural network output are combined to form the final discriminant

Missing Energy Channel



Figures: Distributions of (a) the b-tag, (b) the reconstructed Higgs mass, (c) the missing mass and (d) the neural network output. The points are data collected at $E_{CM} > 206$ GeV, open and hatched regions are SM backgrounds and the dashed region is the 115 GeV Higgs signal multiplied by 30.

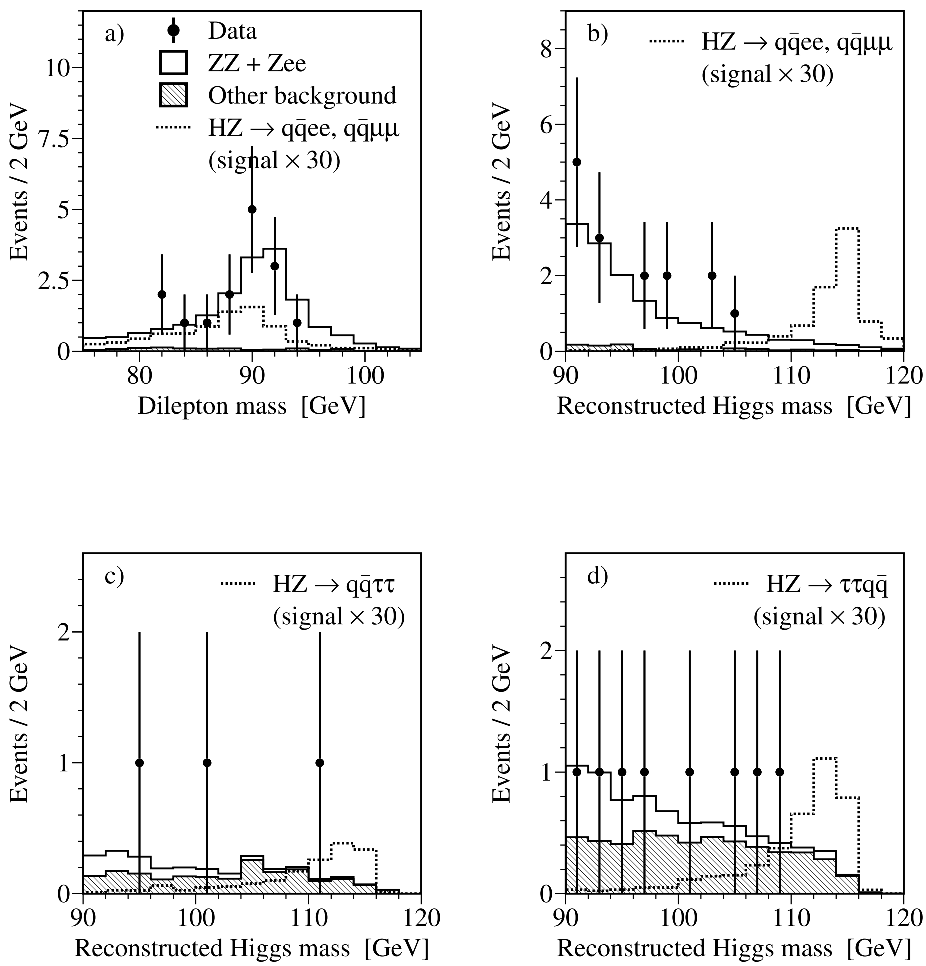
Lepton Channels

- Small final state fraction ($\sim 3\%$ each)
- Look for events with a pair of high energy electrons or muons along with two jets containing b-quarks
- Ze^+e^- (for electrons) and semi-leptonic W^+W^- (for muons), as well as ZZ events make up most of the background
- Event is forced into two jets after the electron or the muon pair is removed
- Cuts on dijet and dilepton opening angles and on reconstructed masses are used to reduce backgrounds
- Hadronic jet b-tags and the 5C reconstructed Higgs mass are combined to form the final discriminant

Tau Channels

- Two similar event topologies: $HZ \to b\bar{b}\tau^+\tau^-$ ($\sim 3\%$) and $\tau^+\tau^-q\bar{q}$ ($\sim 6\%$)
- Tau leptons are identified as "clean" leptons or as low multiplicity jets
- The largest background sources are semi-leptonic W^+W^- and ZZ events
- b-tags and the 5C rec. Higgs mass are combined to form the final discriminant for the $b\bar{b}\tau^+\tau^-$ topology while only the 5C rec. Higgs mass is used for the $\tau^+\tau^-q\bar{q}$ topology
- There is a significant overlap of event candidates in the two topologies; if an event passes both $b\bar{b}\tau^+\tau^-$ and $\tau^+\tau^-q\bar{q}$, it is assigned to the one with a higher signal likelihood

Leptonic and Tau Channels

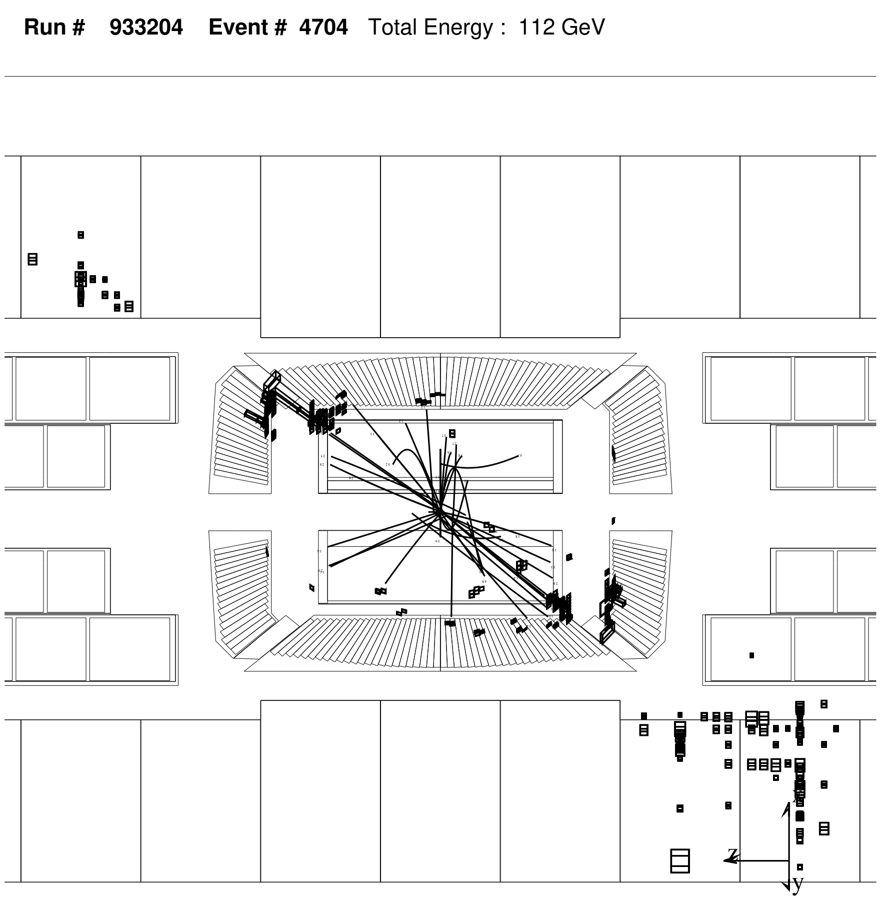


Figures: Distributions of (a) the dilepton mass in He^+e^- and H$\mu^+\mu^-$ and the reconstructed Higgs masses in the (b) He^+e^- and H$\mu^+\mu^-$, (c) H$\tau^+\tau^-$ and (d) $\tau^+\tau^- q\bar{q}$. The points are the data, open and hatched regions are SM backgrounds and the dashed region is the 115 GeV Higgs signal multiplied by 30.

Higgs Candidate

An $HZ \to b\bar{b}\nu\bar{\nu}$ Candidate:

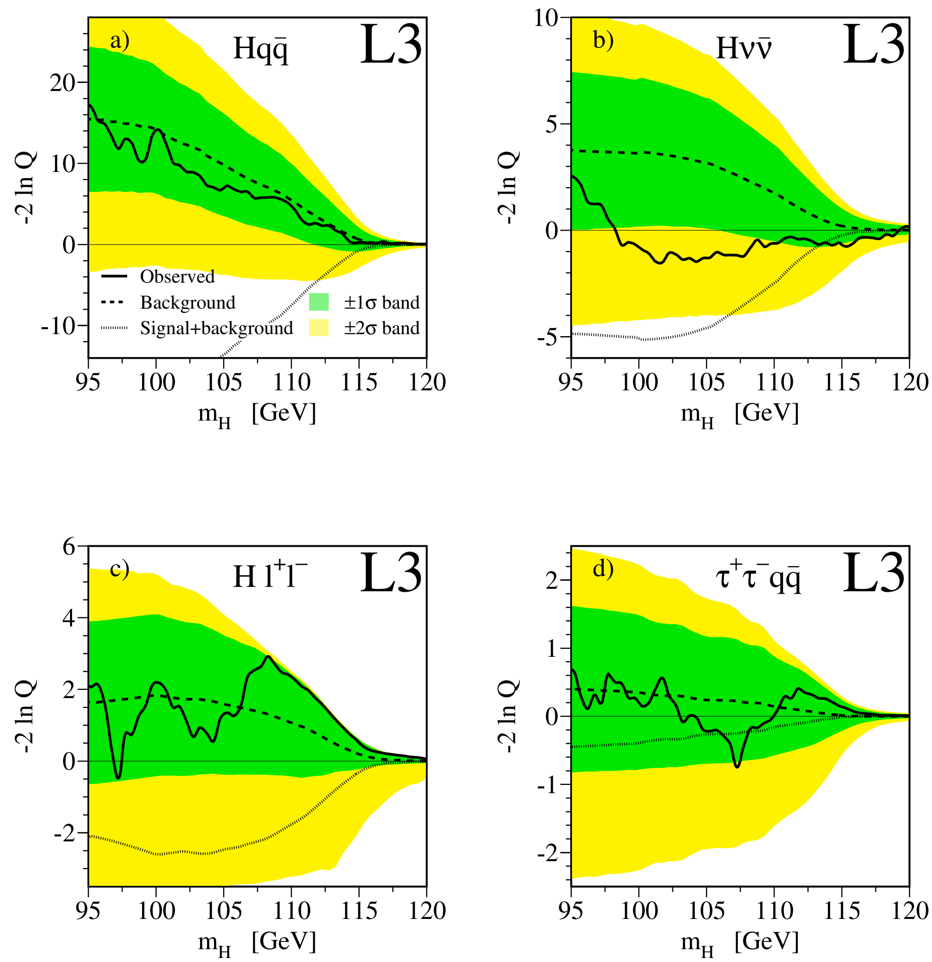
a)



$$E_{CM} = 206.4 \text{ GeV}$$
$$NN_{out} = 0.995$$
$$M_H = 115.0 \text{ GeV}$$

Results

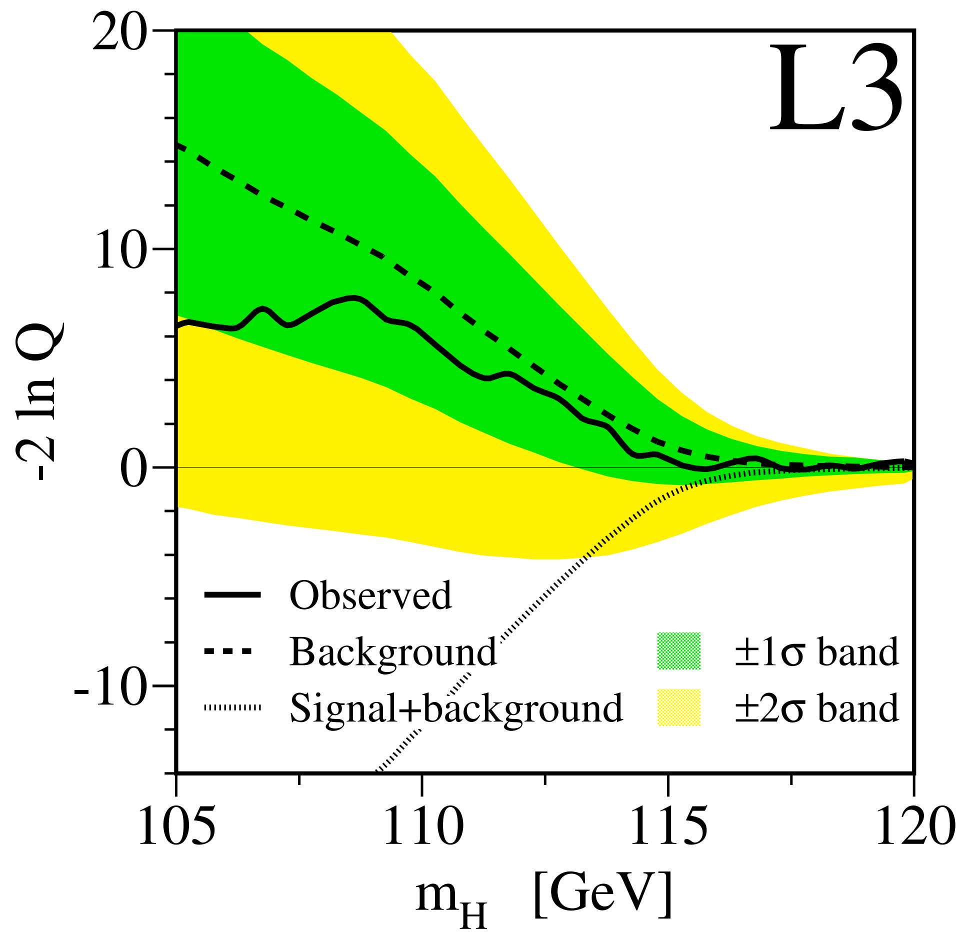
Results from four search channels:



The log-likelihood ratio, -2 ln $\mathcal{Q}$, as a function of the Higgs mass hypothesis. (a) $Hq\bar{q}$, (b) $H\nu\bar{\nu}$, (c) Hl^+l^- and (d) $\tau^+\tau^-q\bar{q}$.

Results

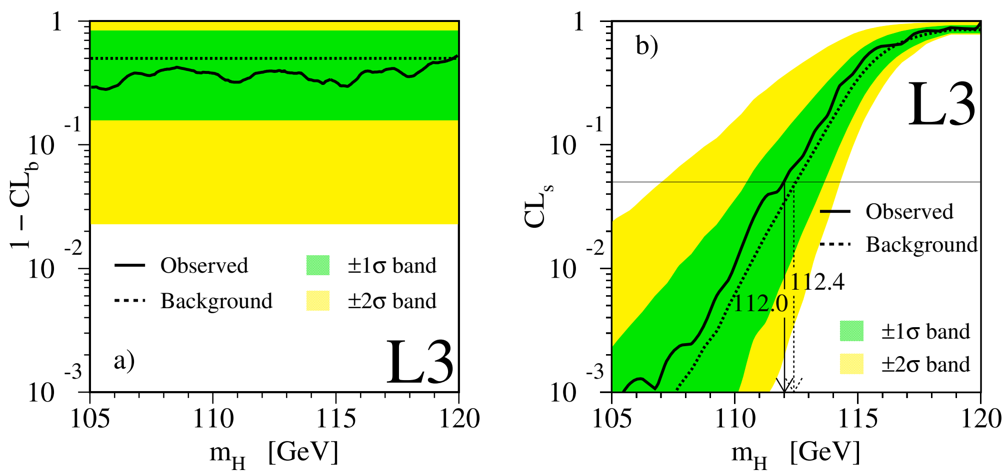
Results from four search channels combined:



⇒ **No evidence of Higgs signal is seen**

Results

A confidence level on the absence of a signal is calculated:



⇒ The lower limit on the Standard Model Higgs Boson mass is set at:

$$\boxed{m_H > 112.0/112.4 \text{ GeV (obs/exp) at 95\% CL}}$$

Figures: (a) The background CL ($1 - CL_b$) and (b) the signal CL (CL_s). 1998 and 1999 data (at 189-202 GeV) are also included.