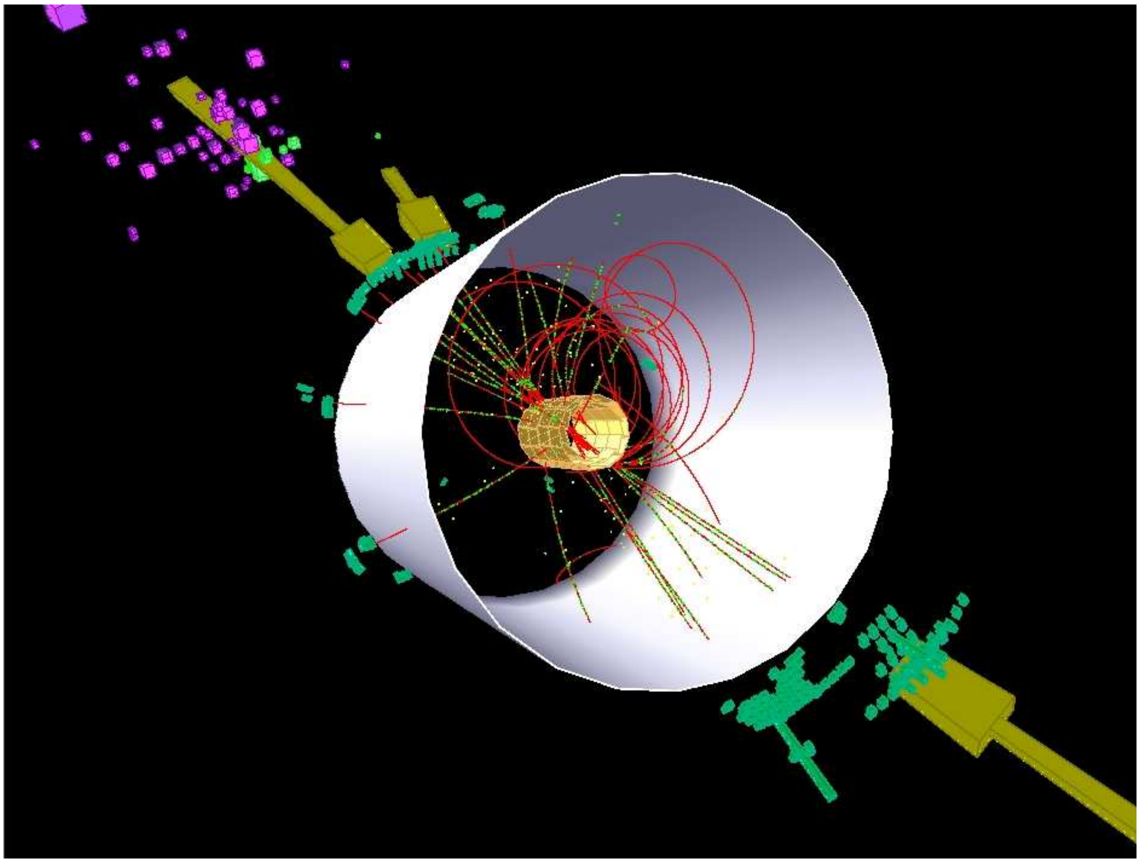
Standard Model Higgs search strategy at LEP

Pablo García-Abia

CERN and University of Basel

on behalf of the LEP Collaborations



XXXVI Rencontres de Moriond, QCD and High Energy Hadronic Interactions

Les Arcs, March 17-24, 2001

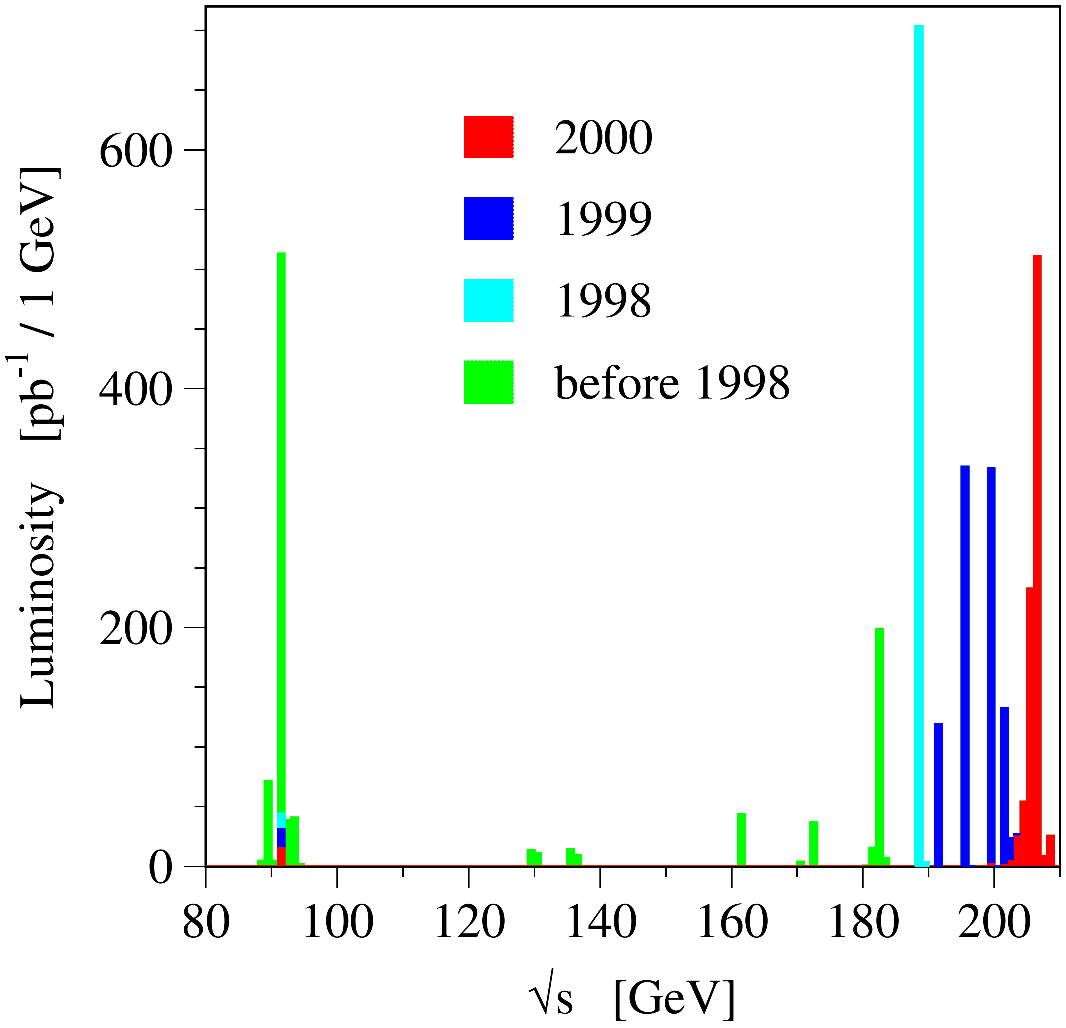
The running of LEP

In 12 years of running, LEP has produced e^+e^- collisions in four interactions points:

ALEPH, DELPHI, L3 and OPAL

in a wide range of centre-of-mass energies:

$$\sqrt{s} \simeq 90 - 210 \ \text{GeV}$$



The SM has proven to be very successful, but...

Why the Higgs mechanism ?

In a gauge invariant theory all fundamental particles should be massless

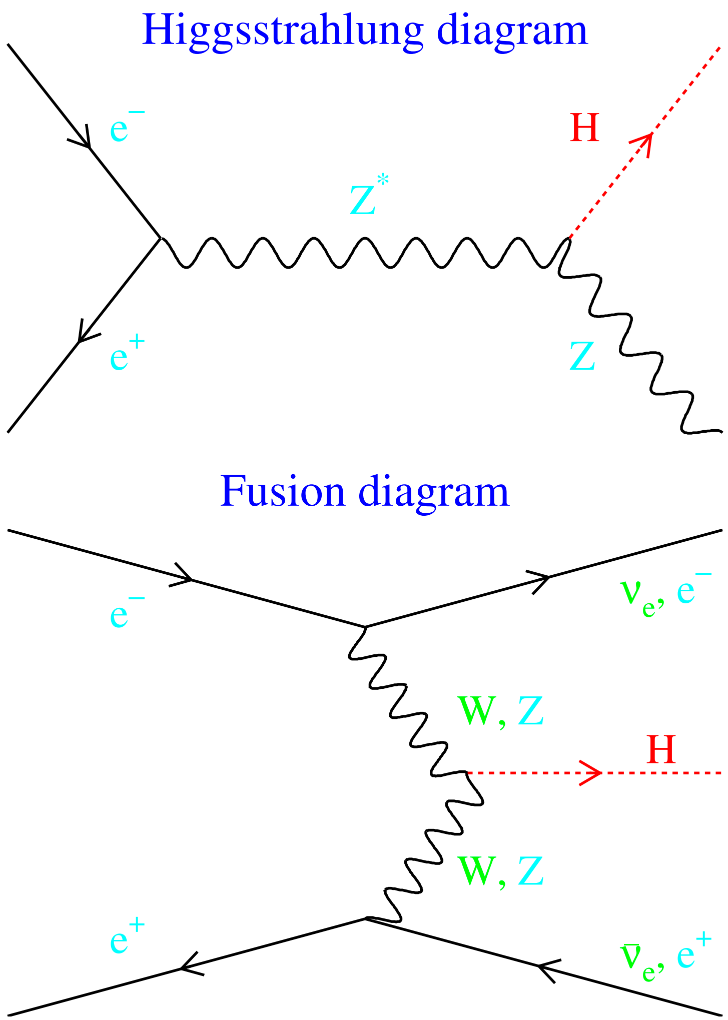
No direct evidence how Electroweak symmetry is broken

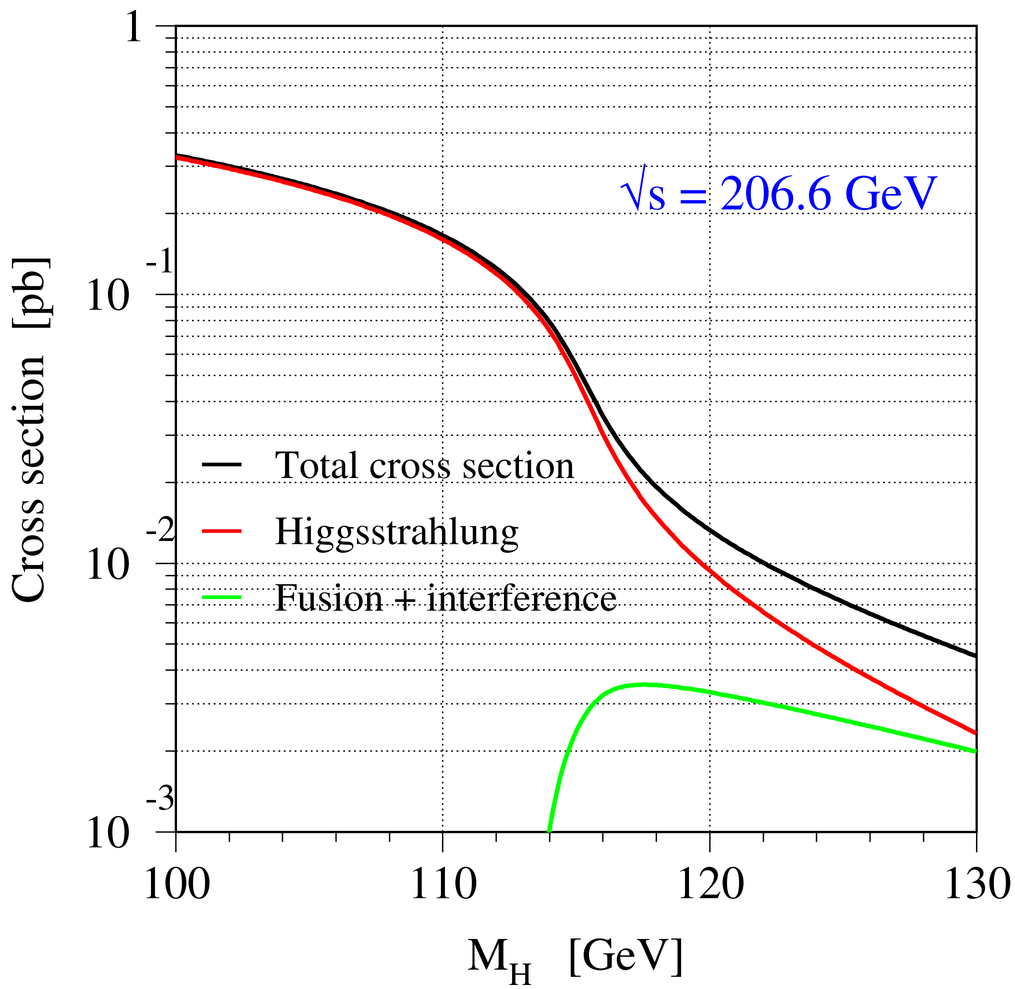
The Higgs mechanism: particles acquire mass by interaction with the Higgs field

There should be a new particle, of a completely new kind: the Higgs boson

The mass of the Higgs boson is not predicted by the theory: *search at LEP*

Higgs production at LEP





Higgs mass reach in year 2000

$e^+e^- \to$ ZH: $m_Z \sim 91$ GeV

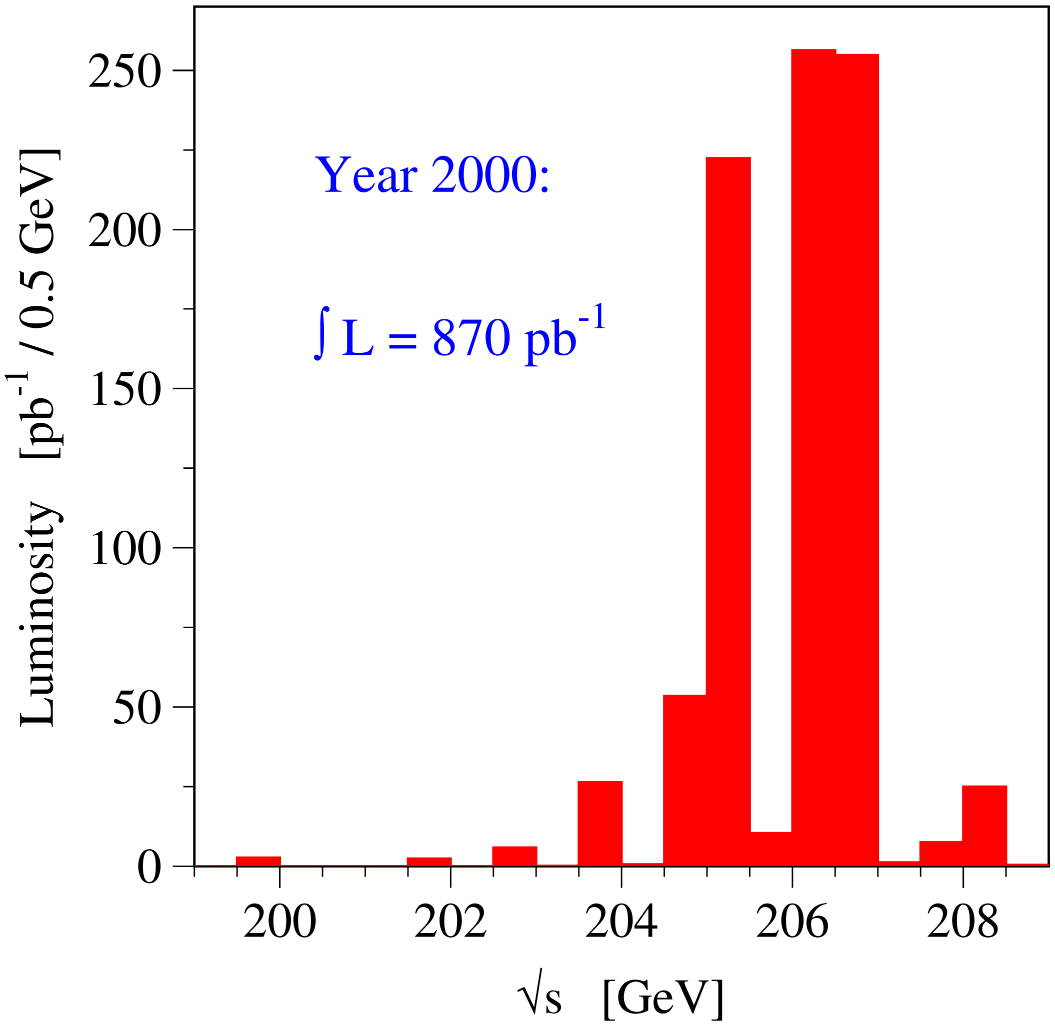
$\sqrt{s} \sim 207$ GeV

Maximum mass: $m_H \sim 116$ GeV

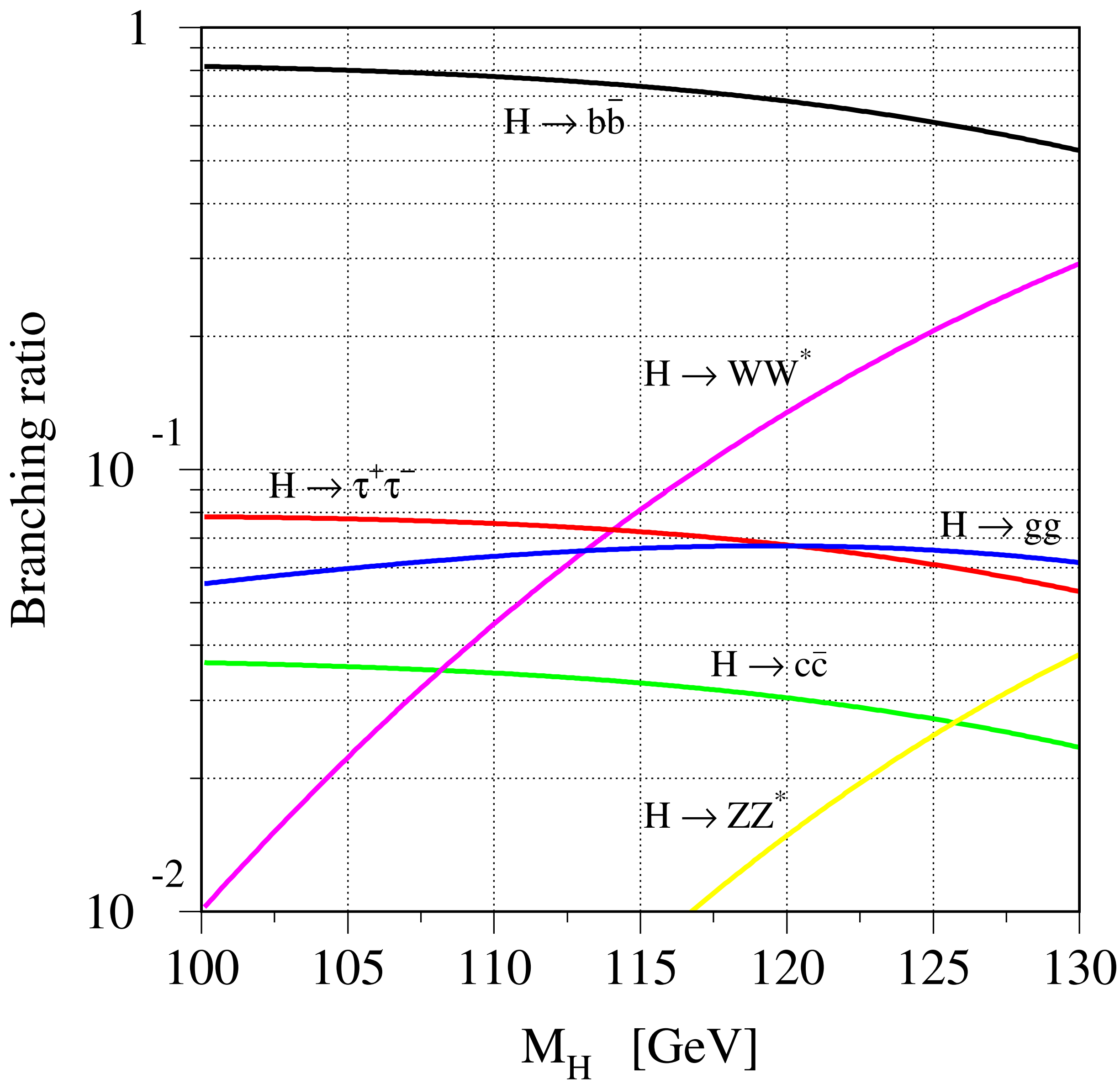
As an example, assuming

$$\begin{aligned} m_H &= 115 \text{ GeV} \\ \sqrt{s} &= 207 \text{ GeV} \\ \mathcal{L} &= 500 \text{ pb}^{-1} \\ \varepsilon &= 50\ \% \end{aligned}$$

the number of events expected is 12.5



Higgs and Z decay branching ratios

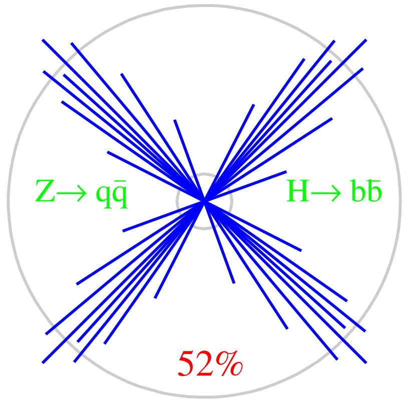


Br ($Z \to$ hadrons)	**=**	**69.9%**
Br ($Z \to$ invisible)	**=**	**20.0%**
Br ($Z \to \ell^+\ell^-$)	**=**	**3.4%**

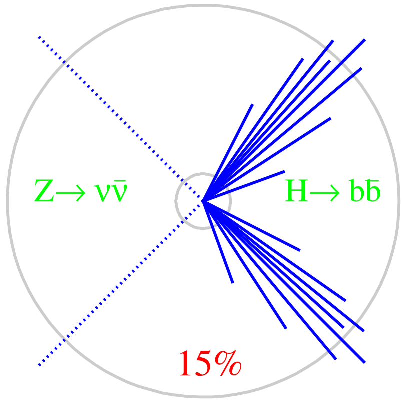
Final states

About 80% of the final states exploited

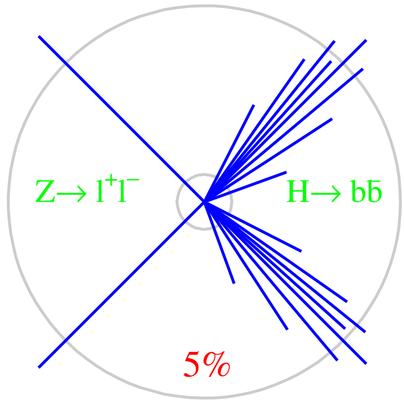
4-jet



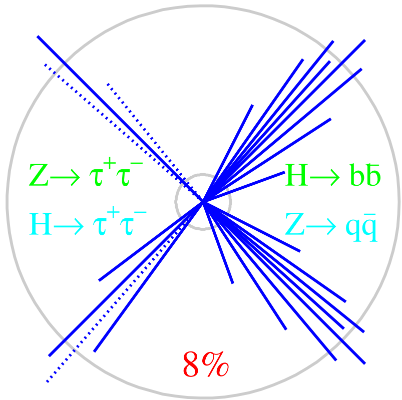
missing energy



leptons (e+μ)



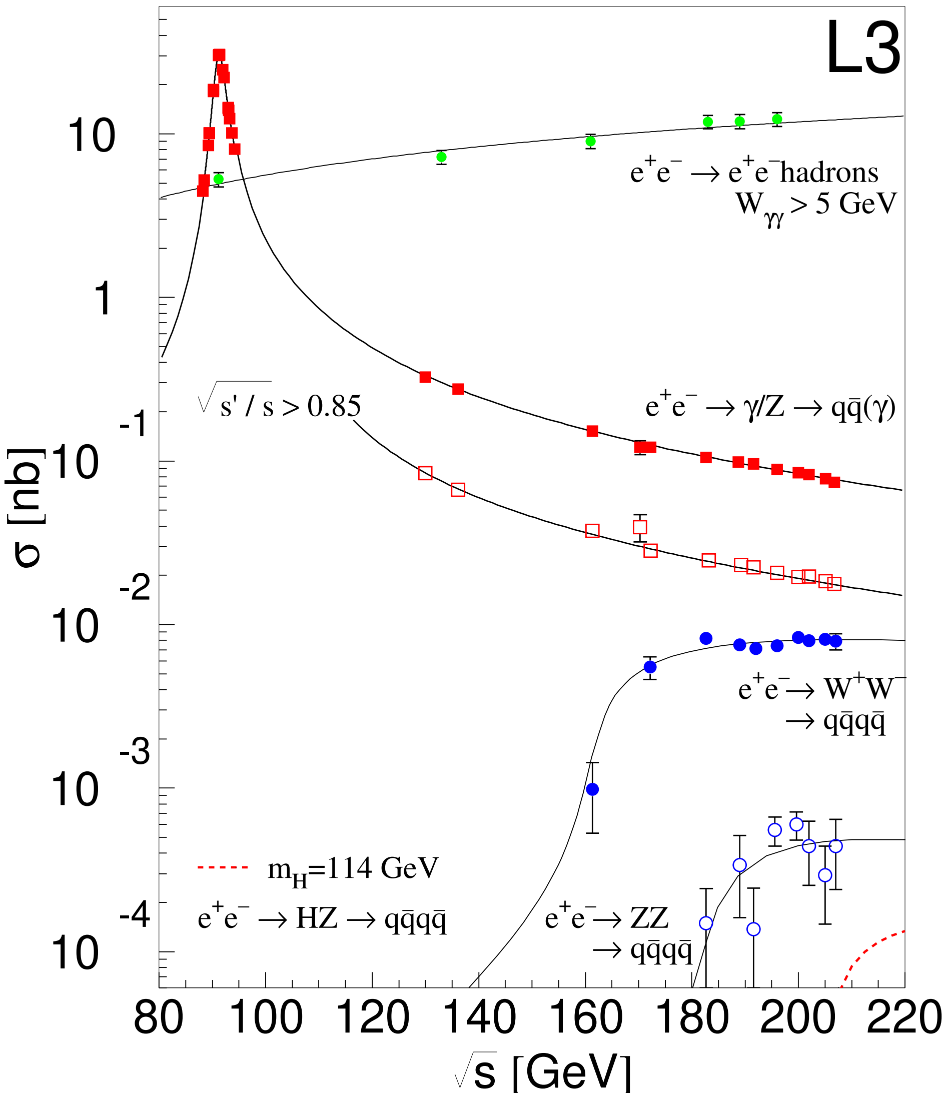
taus



Expected signal events for a $m_{\mathrm{H}} = 115\ \mathrm{GeV}$ Higgs:

4-jet	**=**	**6.5**
missing energy	**=**	**1.9**
taus	**=**	**1.0**
leptons (e+μ)	**=**	**0.6**
All channels	**=**	**10**

Background from Standard Model processes



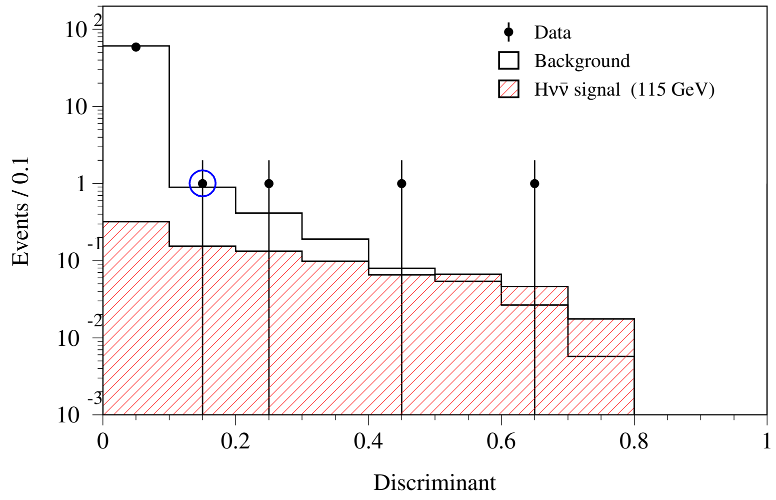
The main backgrounds are:

$e^+e^- \longrightarrow q\bar{q}(\gamma)$, W^+W^- **and ZZ**

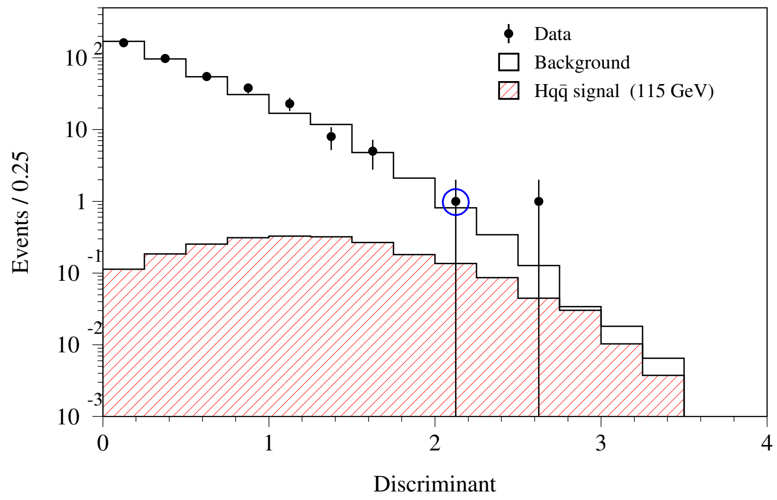
B-tagging is essential

Few hundred background events expected

Combination of channels



Combine channels with equal s/b ratio

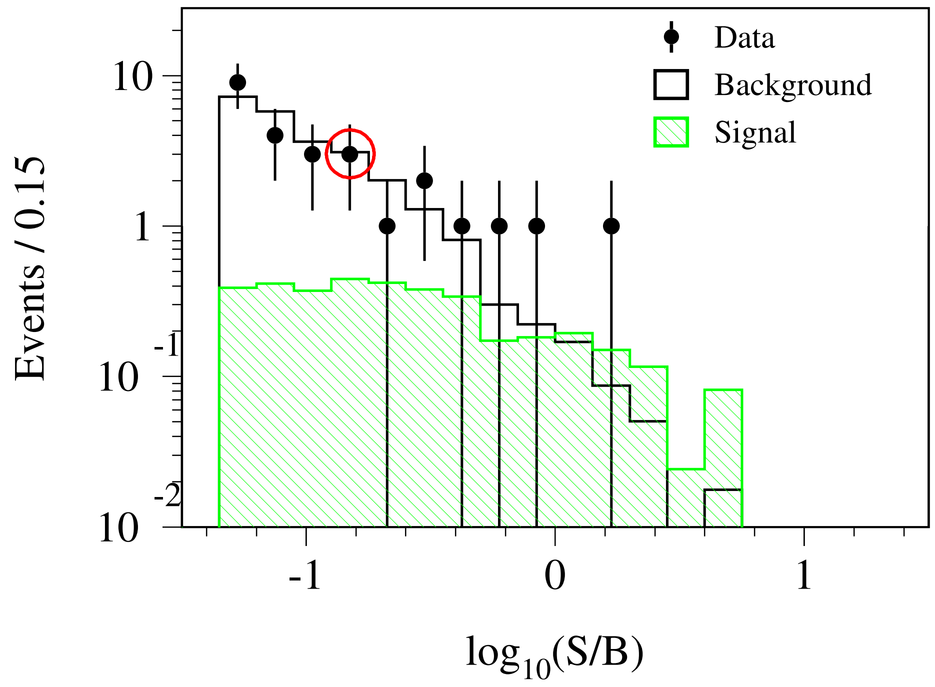


LEP treated as a single analysis:

4 experiments × 4 channels × 15 beam energies

=

240 analyses combined



The shape of the distributions depends on the Higgs mass hypothesis !

Statistical Method: -2ln(Q)

Likelihood Ratio test-statistic:

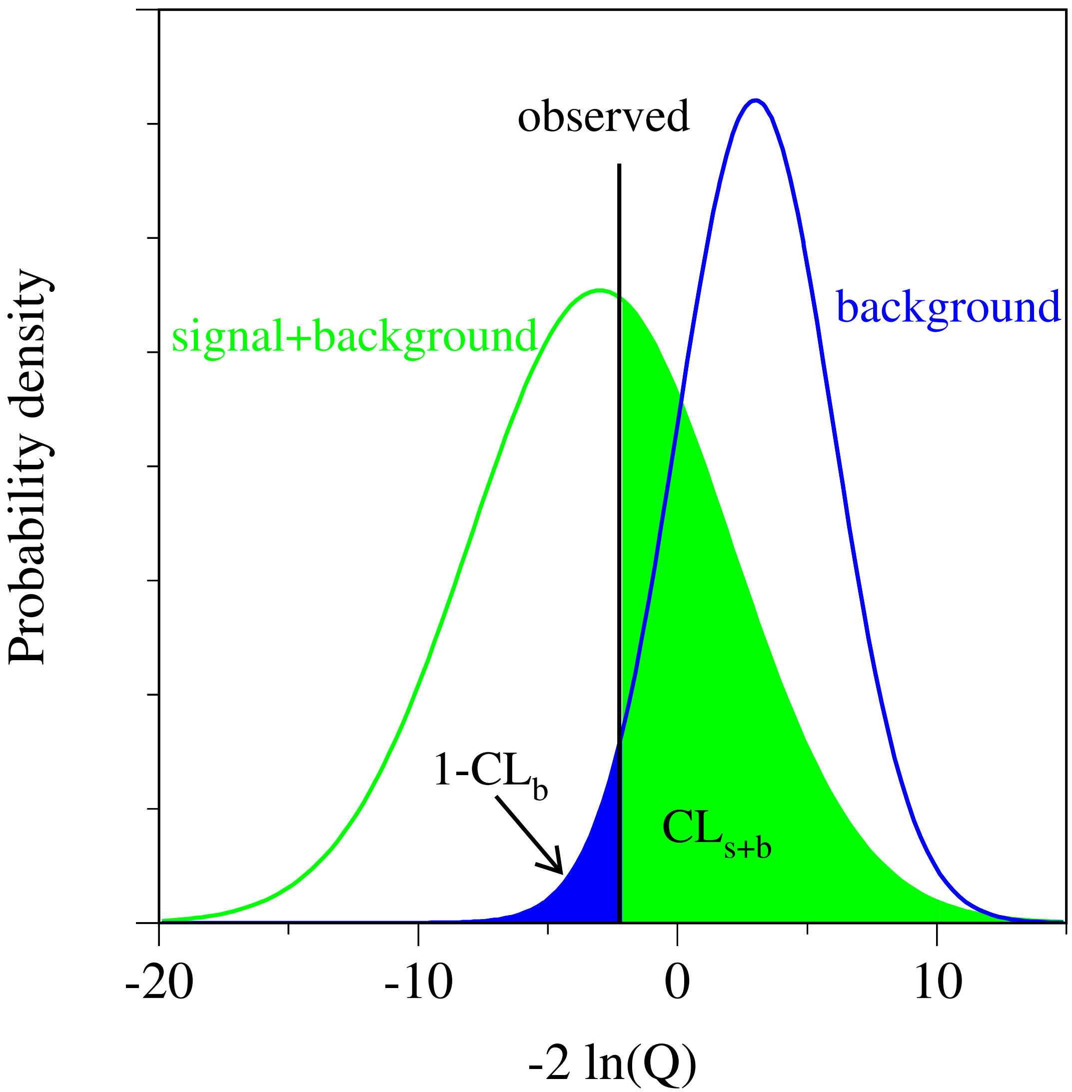
$$Q = \frac{\mathcal{L}(s+b)}{\mathcal{L}(b)}$$

Each bin (i) in the final variable is treated as a Poisson counting experiment:

$$\ln(Q) = -s_{tot} + \sum_{i=1}^{N} n_i \ln\left(1 + \frac{s_i}{b_i}\right)$$

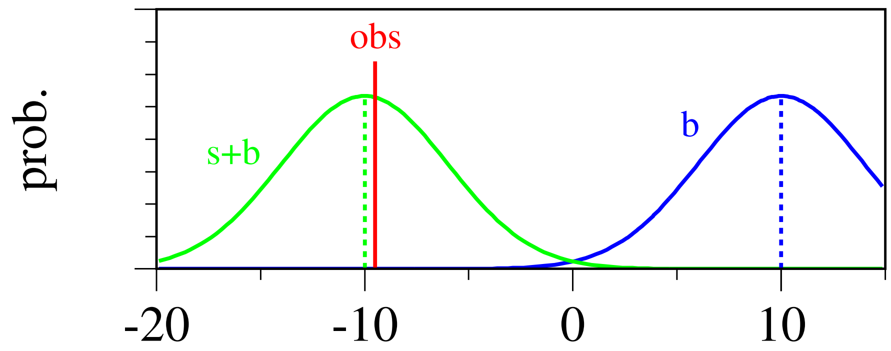
In the high statistics limit:

$$-2\ln(Q) \rightarrow \Delta\chi^2$$

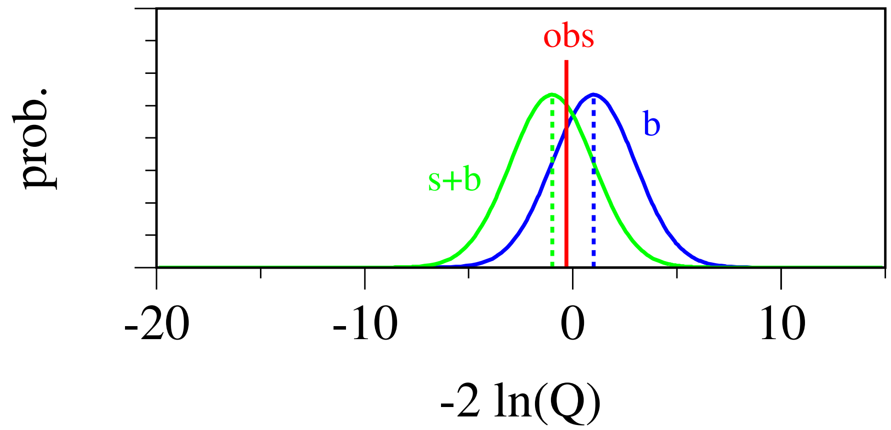


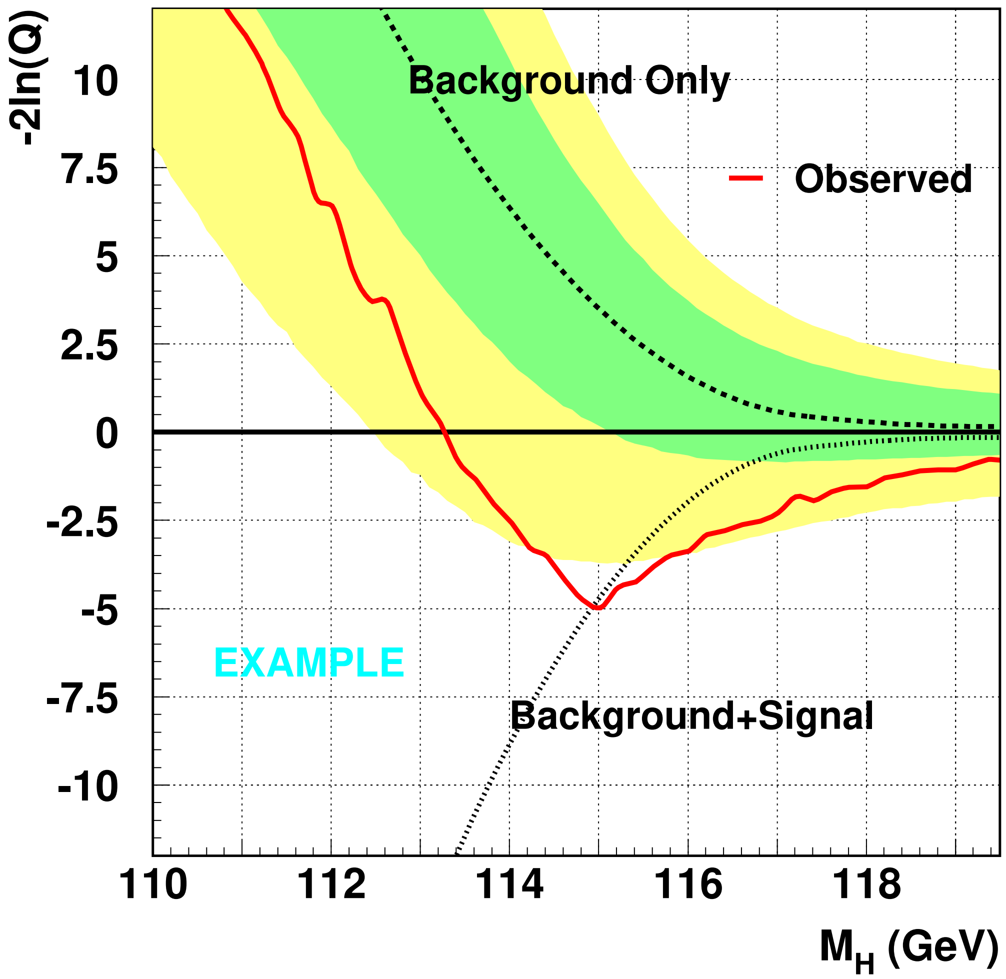
More on the Likelihood Ratio

Low mass: high sensitivity



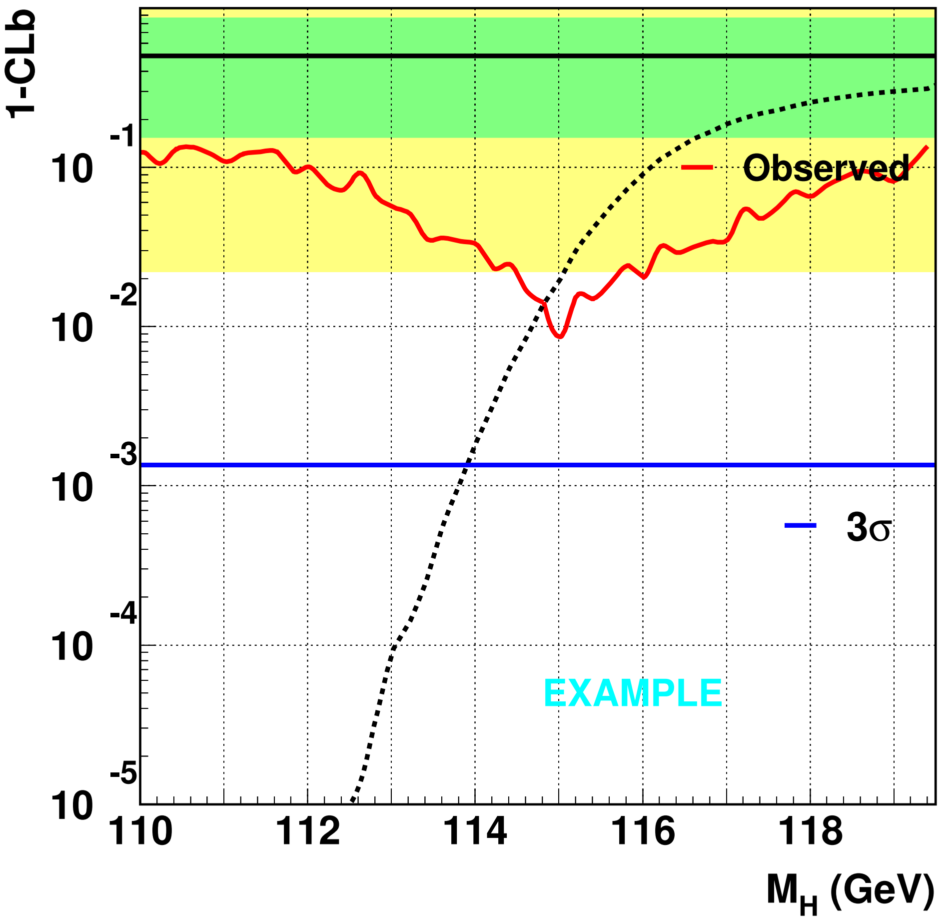
High mass: low sensitivity



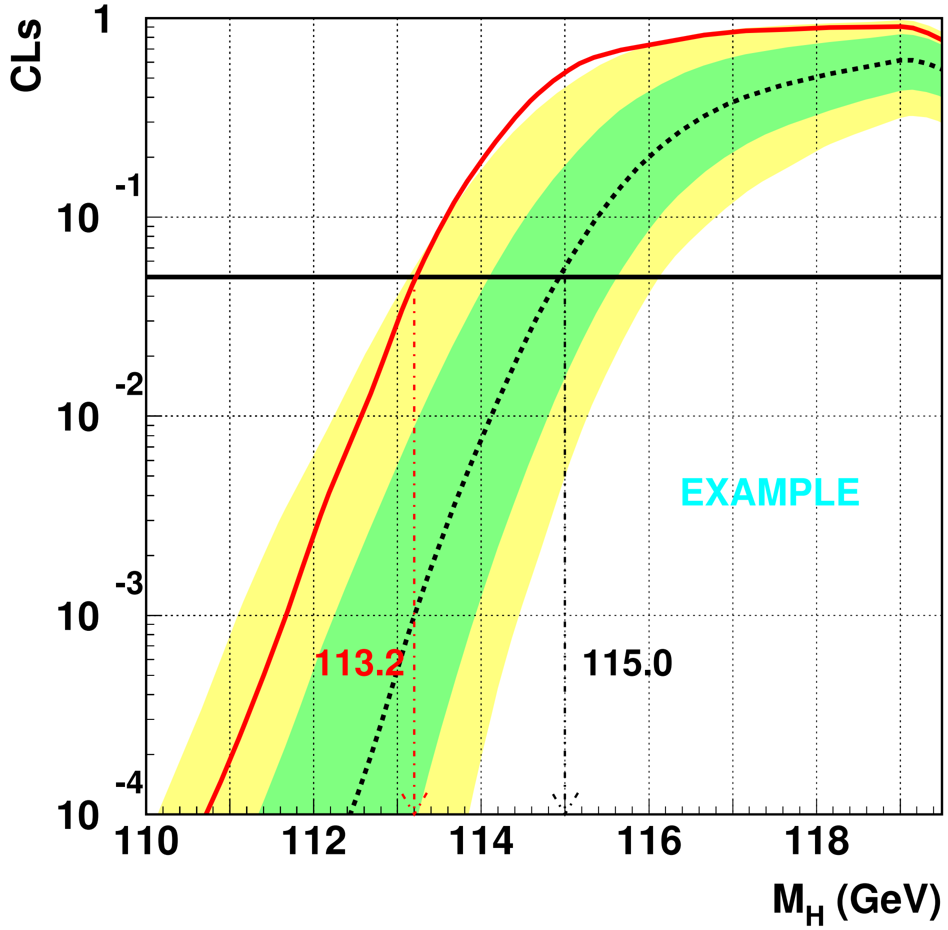


CL_b and CL_s

Discovery: no signal dependent



Exclusion: $CL_s = CL_{s+b}/CL_b$



Summary

What you know:

- why we search for the Higgs
- what we expect to see if it exists
- how we combine the analyses
- which statistical method we use

What you don't know:

- **Details of the search:**

Gavin J. Davies	4-jet channel
Enrico Piotto	other channels

- **Results of the combination:**

Anna N. Okpara

Please, keep questions for the end...