LEP: SM Higgs Combinations

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Comments to the talk

-Combined results presented in this talk are all from Nov 3rd 2000

... and are preliminary.

-These are the last combined results approved by the LHWG.

-All four experiments have published their results in dec. 2000.

-Three experiments have delivered their inputs to the LHWG

...L3 is still working on it .

History

1989 :

After many years of planning the Electron and Positron Collider (LEP) is switched on.

The race to the (SM) Higgs begins ($m_H > 0\,GeV$)...........

1995 :

Direct searches at LEP1 give $m_H >$65 GeV @ 95% CL

Start of second phase , LEP2.

Will the SM Higgs be found?

Statistical Method

How consistent are the results with

a 'signal+background' hypothesis

or with

a 'background-only' hypothesis?

Statistical Method

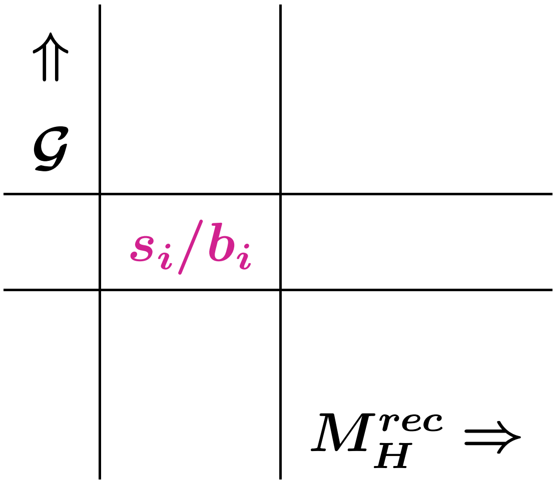
ALEPH, DELPHI, L3 and OPAL with different channels (@ different E_{cm}) and Luminosities.

Inputs per channel. Binned in two discriminating variables:

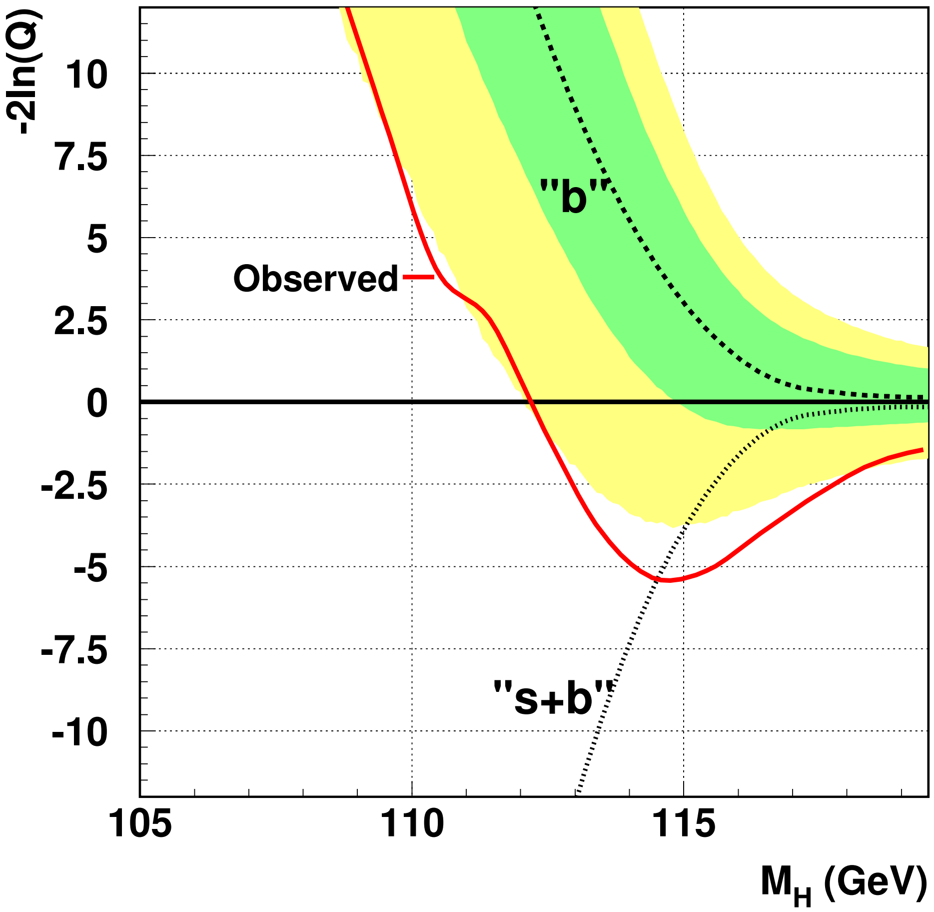
-Reconstructed Higgs mass M_H^{rec}

-Global variable $\mathcal{G}$ (b-tag, kinematics, jet-properties)

-Per bin i: Bkgd. (MC) b_i, Signal (MC) $s_i(m_H)$,
Nbr. of candidates N_i



LIKELIHOOD TEST



For test-mass m_H:

$$Q(m_H) = \mathcal{L}(s+b)/\mathcal{L}(b)$$ **Test-statistic**

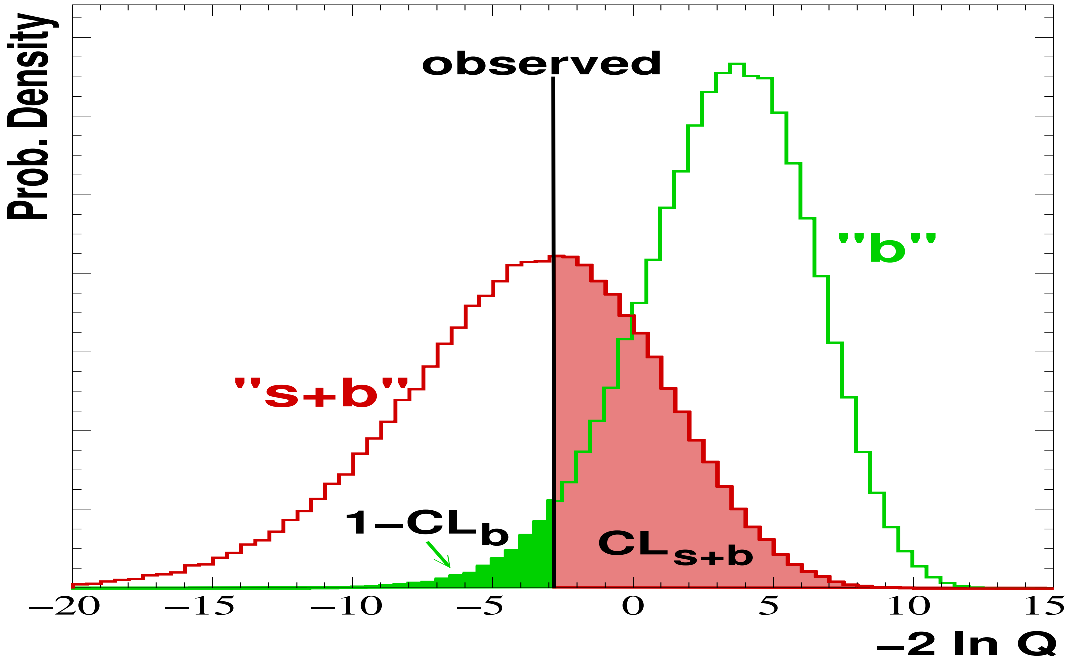
$$-2\ln Q(m_H) = 2s_{tot} - 2\sum N_i \ln[1 + s_i(m_H)/b_i]$$

Each bin is considered a statistically independent search obeying Poission statistics.

To rank the observed event configuration between $s+b$ and b hypotheses

Which world should we have more trust in?

$\longrightarrow$ CONFIDENCE LEVELS



$\Leftarrow s + b$ $b \Rightarrow$

$1 - CL_b$ ... a measure of incompatibility with b

CL_{s+b} ... a measure of compatibility with $s + b$

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

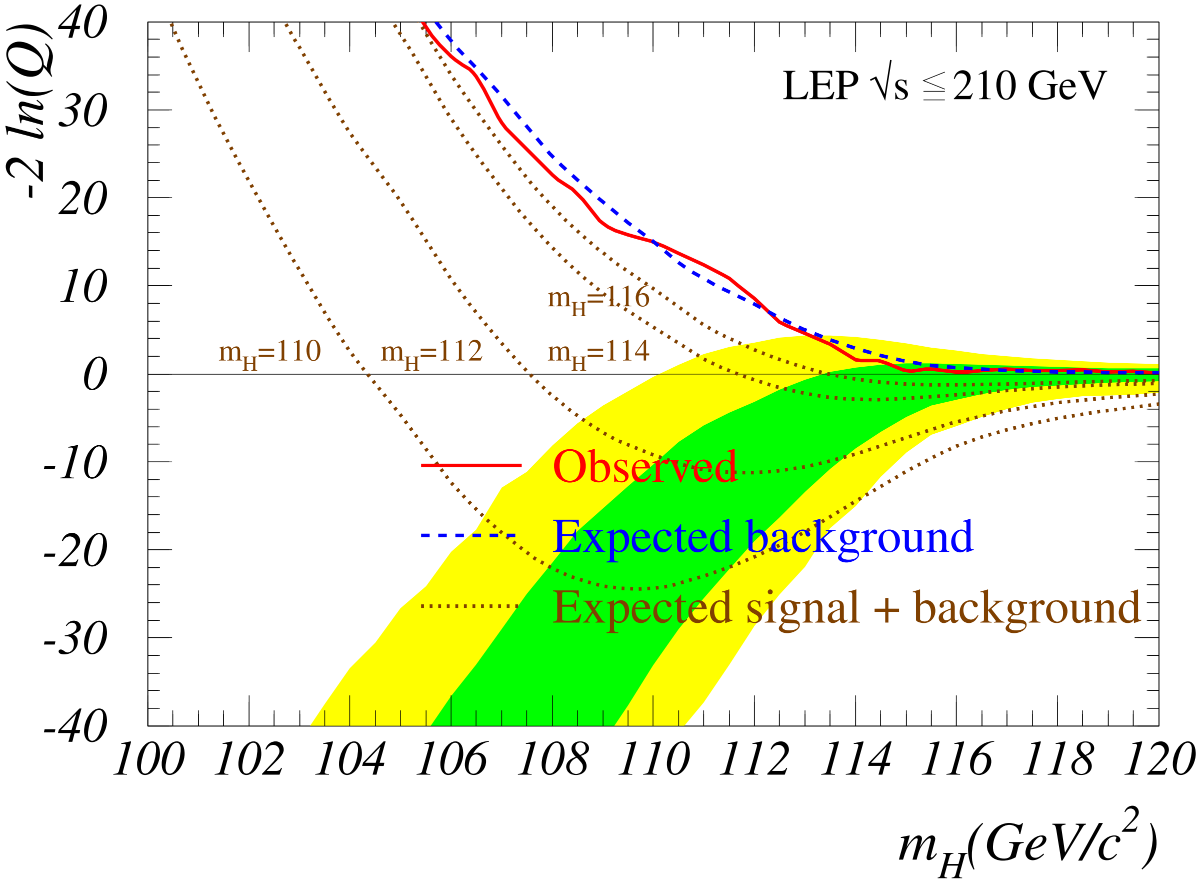
SM Higgs Story in 2000

July (LEPC):

Combination of data taken in 2000 and previous years $\longrightarrow$ No sign of the Higgs

$m_H >$ **113.3 GeV @ 95% CL**

113.4 GeV expected



LEP closure scheduled for end of September 2000.

SM Higgs Story in 2000

September:

LEPC 05.09.00 :

ALEPH excess in 4 jet channel$\longrightarrow$ 3 cand. with high significance compatible with $m_H \approx 114$ GeV (all in $E_{cm} \approx$ 206 GeV data).

14.09.00 :

LEP shutdown delayed by one month till

Nov 2 2000

$\longrightarrow$ Aim to double data at centre-of-mass energy above 206 GeV till 03.11.00

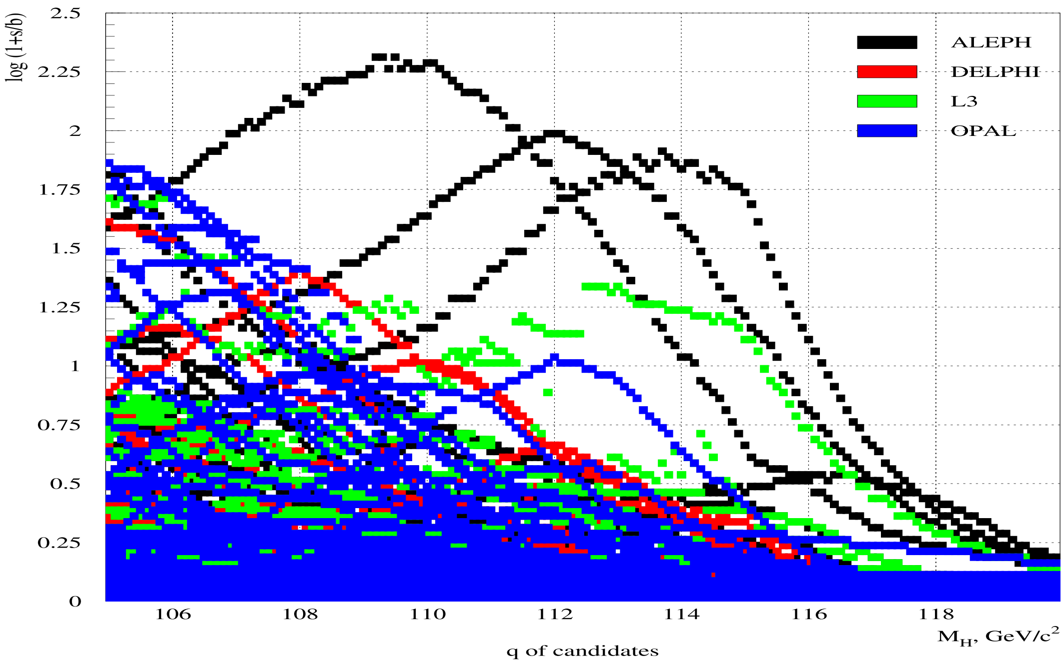
November:

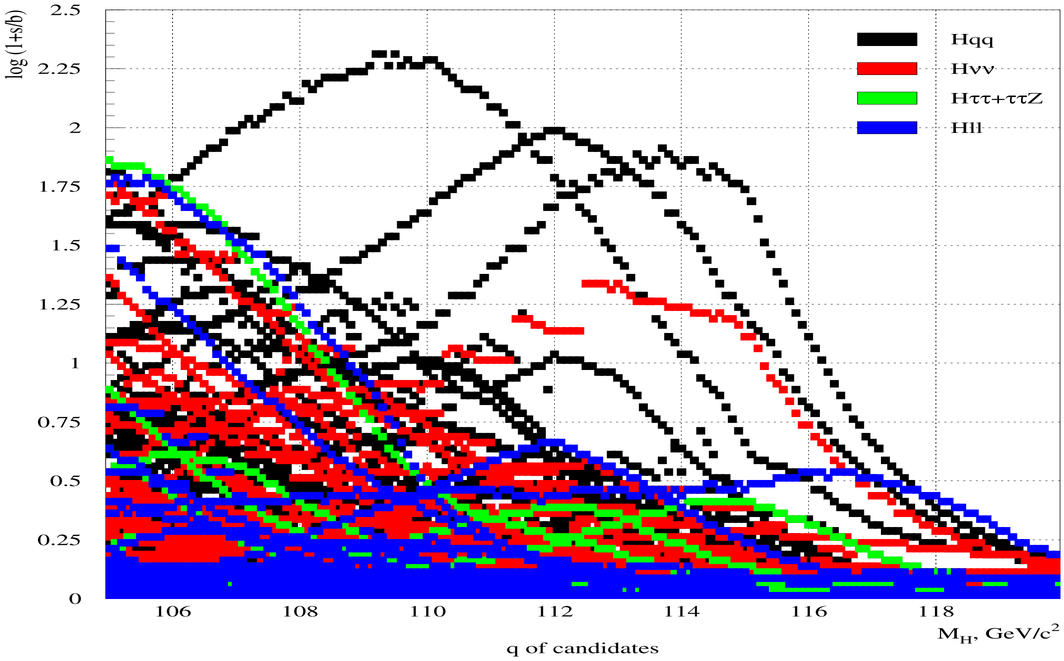
LEPC 03.11.00 :

One new L3 Missing Energy channel candidate ($E_{cm} \approx$ 206 GeV) shows up.

Contributions from Single Candidates

(Nov. 2000)





$$-2\ln(Q) \quad \sim \quad \sum \ln(1 + s_i/b_i)$$

Contributions from Single Candidates (Nov. 2000)

$$-2\ln(Q) \quad \sim \quad \sum \ln(1 + s_i/b_i)$$

$1 + s/b$ ... an indicator of event weight

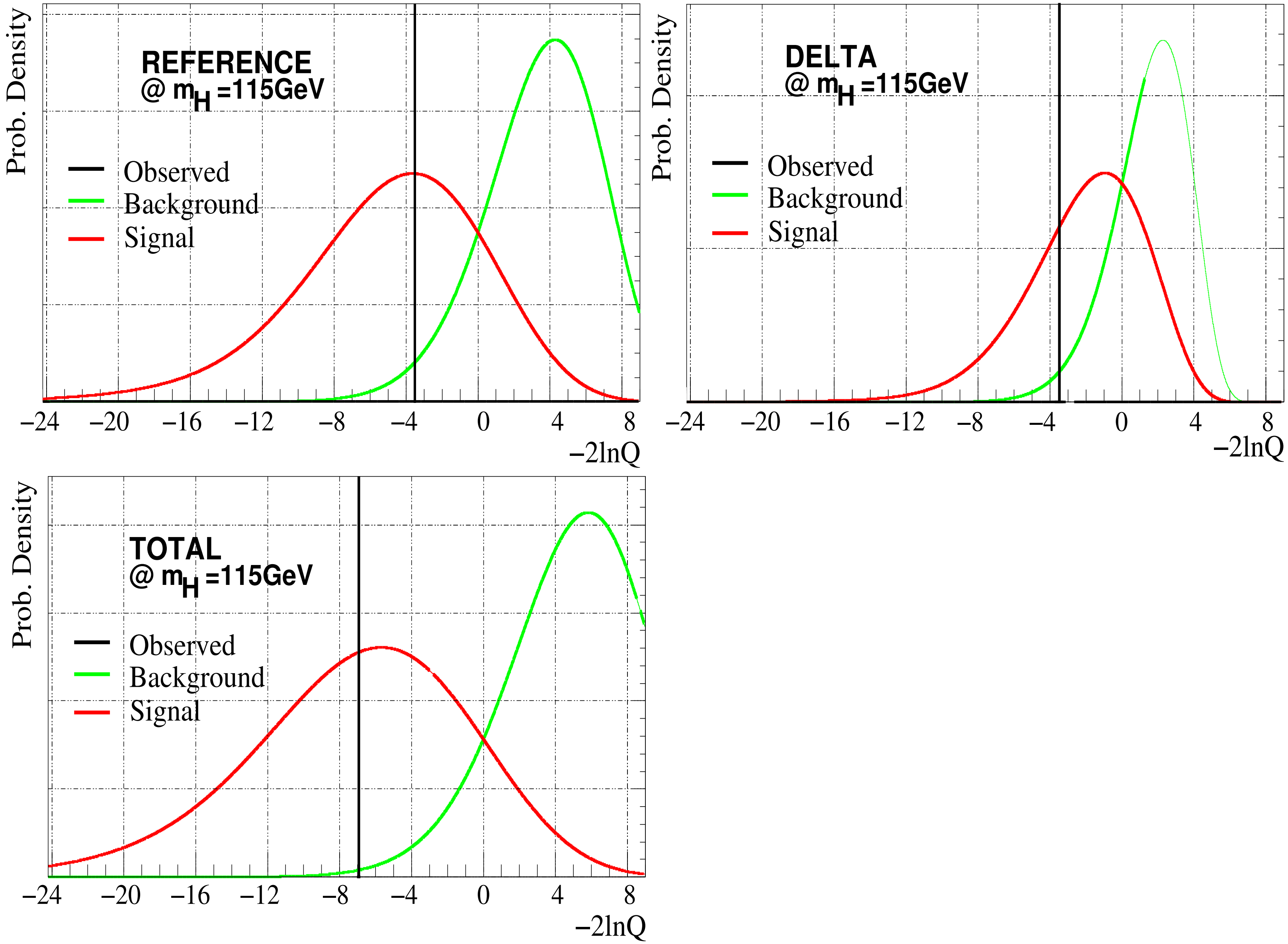
What is the contribution of a single candidate?

(What happens if one removes a candidate?)

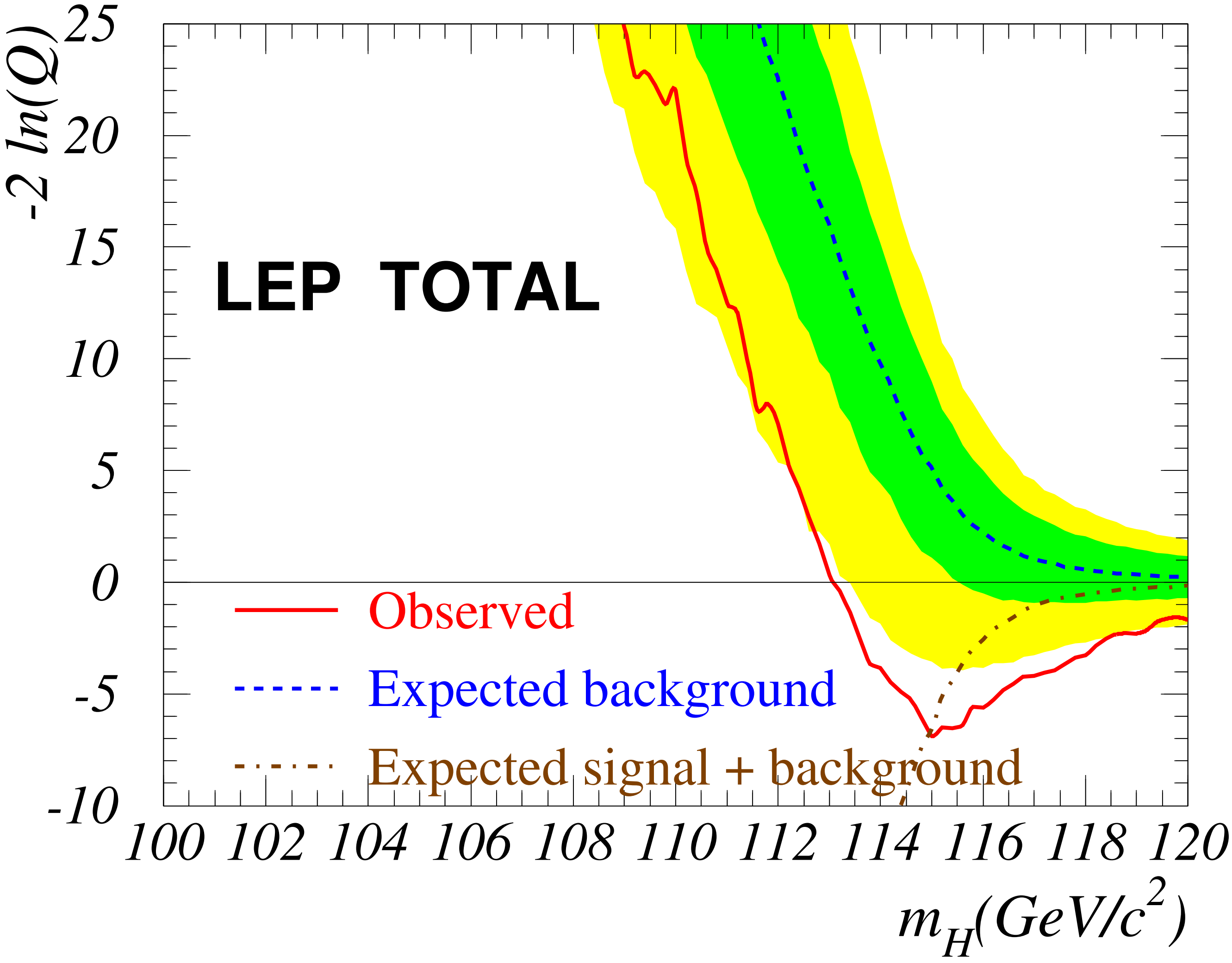
s/b	Δ ln(1+s/b)	Increase in $1 - CL_B$ @ m_H =115 GeV by a factor of
0.5	-0.41	1.6
1.0	-0.69	2.2
2.0	-1.10	3.3

The combined weight is important!.

Prob. density @$m_H = 115$ GeV (Nov. 2000)



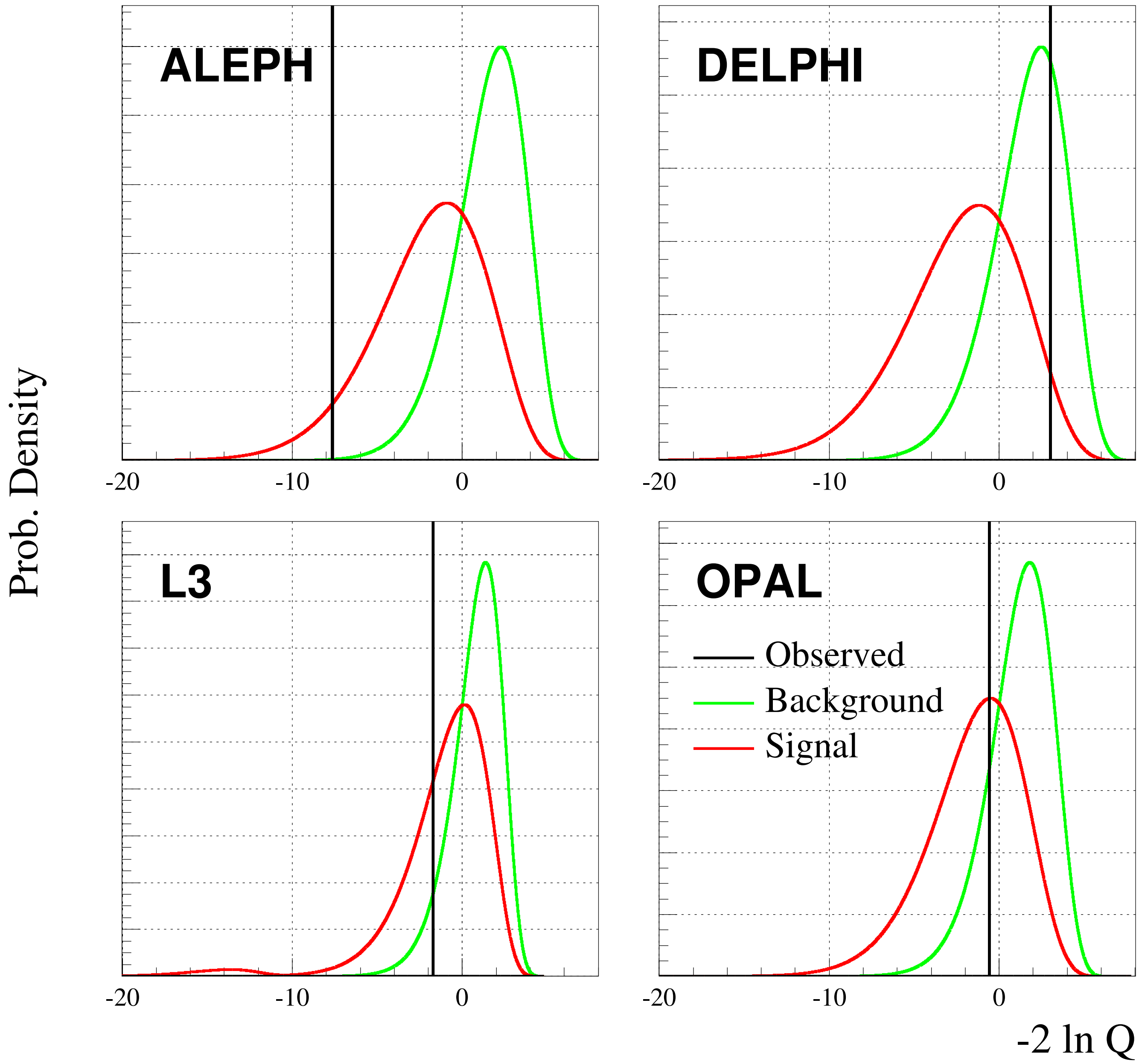
$-2\ln(Q)$ (Nov. 2000)



$$m_H = 115.0^{+1.3}_{-0.9}\ \text{GeV}$$

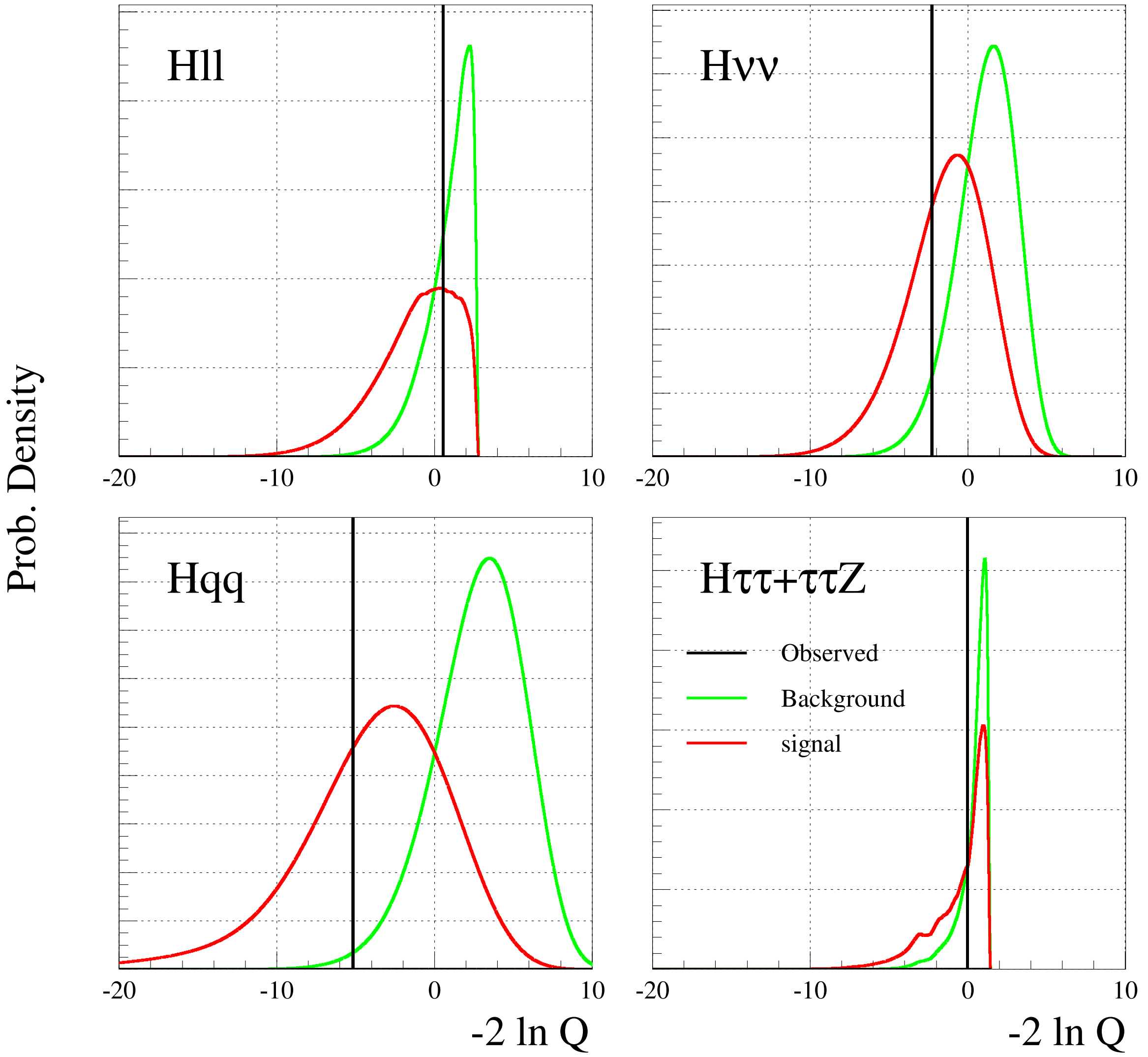
Results by Experiments (Nov 2000)

$$@\, m_H = 115 \text{ GeV}$$



Results by Channel (Nov 2000)

$$@\, m_H = 115 \text{ GeV}$$



EVOLUTION ... BY EXPERIMENT (Nov 2000)

@ $m_H = 115$ GeV

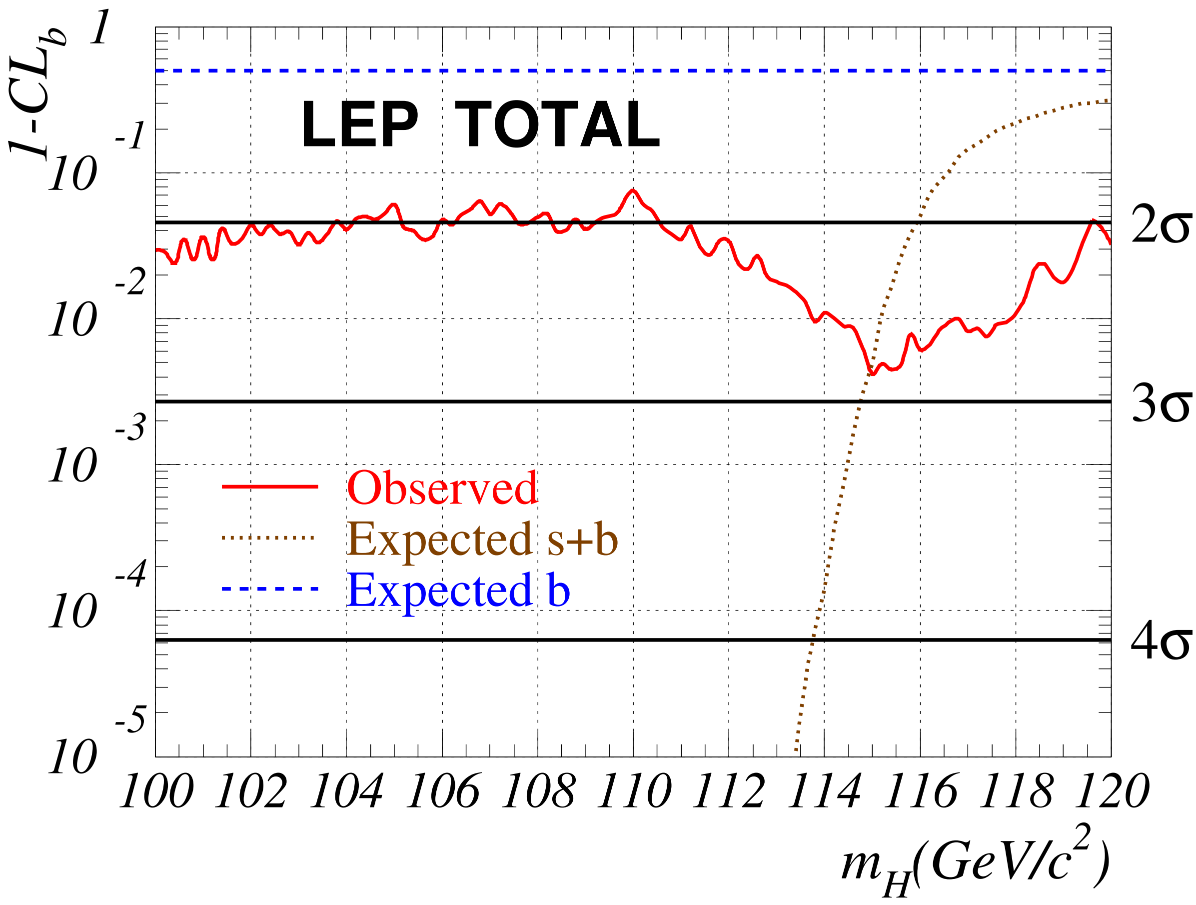
ALEPH	$1 - CL_b$
REF	1.6$\times 10^{-4}$
DEL	0.43
TOT	6.5$\times 10^{-4}$

DELPHI	$1 - CL_b$
REF	0.67
DEL	0.52
TOT	0.68

L3	$1 - CL_b$
REF	0.84
DEL	9.0$\times 10^{-3}$
TOT	6.8$\times 10^{-2}$

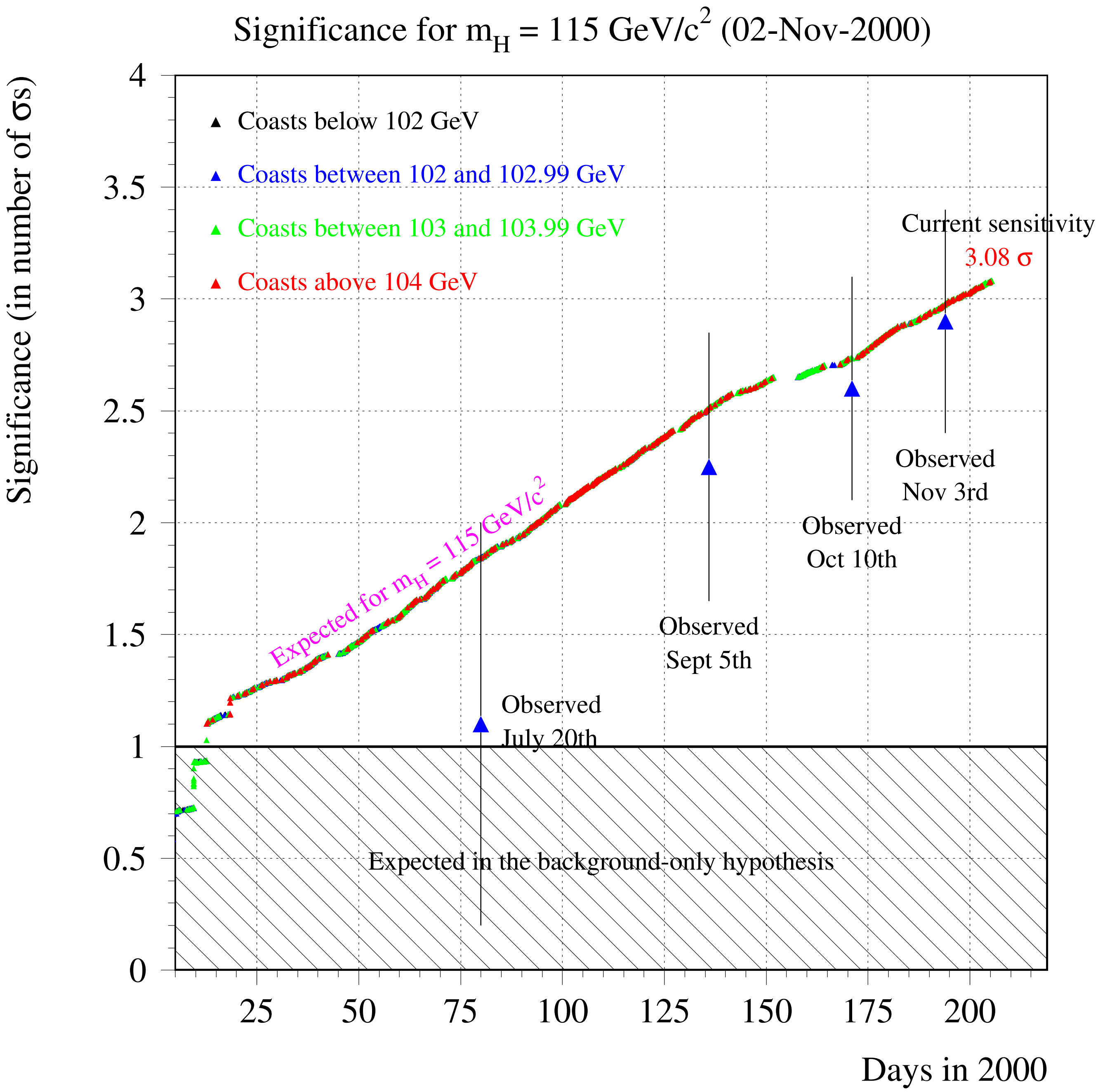
OPAL	$1 - CL_b$
REF	0.47
DEL	6.2$\times 10^{-2}$
TOT	1.9$\times 10^{-1}$

$1 - CL_b$ (Nov. 2000)



ADLO	$1 - CL_b$
REF	2.5×10^{-2}
DEL	2.2×10^{-2}
TOT	4.2×10^{-3}

History



(P.Janot)

Nov 2000 status

$m_H > 113.5$ GeV @ 95% CL

(115.3 GeV expected)

Perfect compatibility with SM Higgs cross section

for

$m_H = 115.0^{+1.3}_{-0.9}$ GeV

$\longrightarrow$ Recommendation from the

LHWG to run in year 2001:

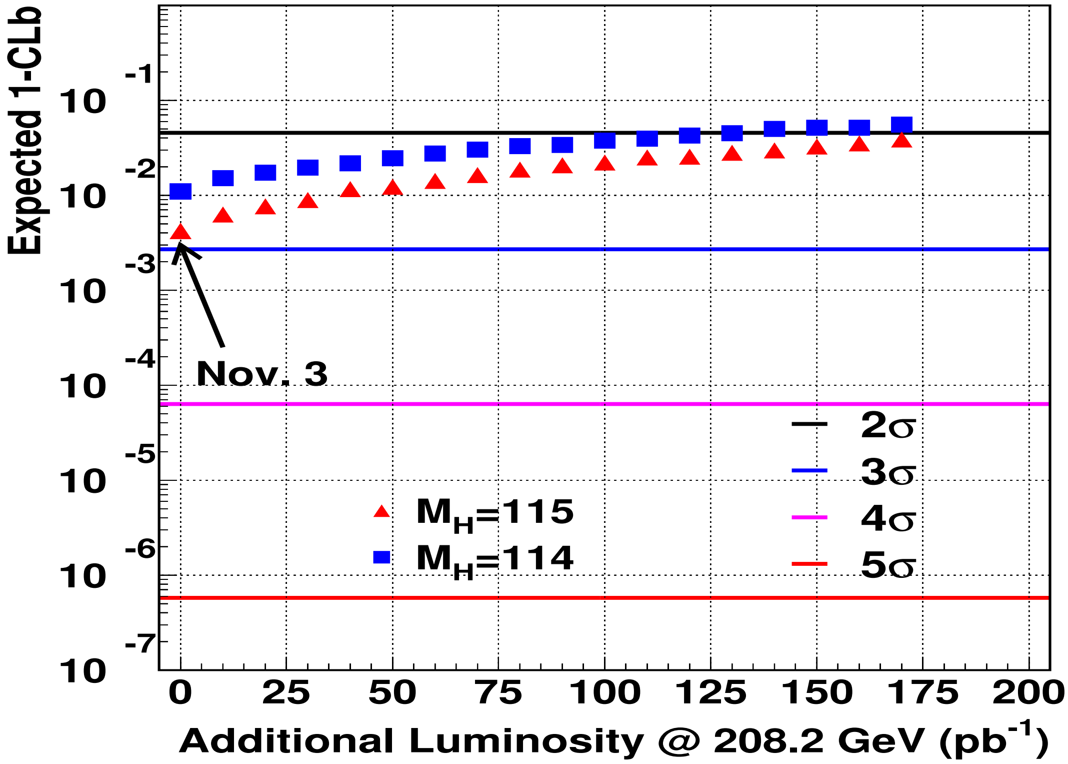
In order to collect

$\mathcal{O}$(200 pb^{-1}) at $\sqrt{s} \geq 208$ GeV.

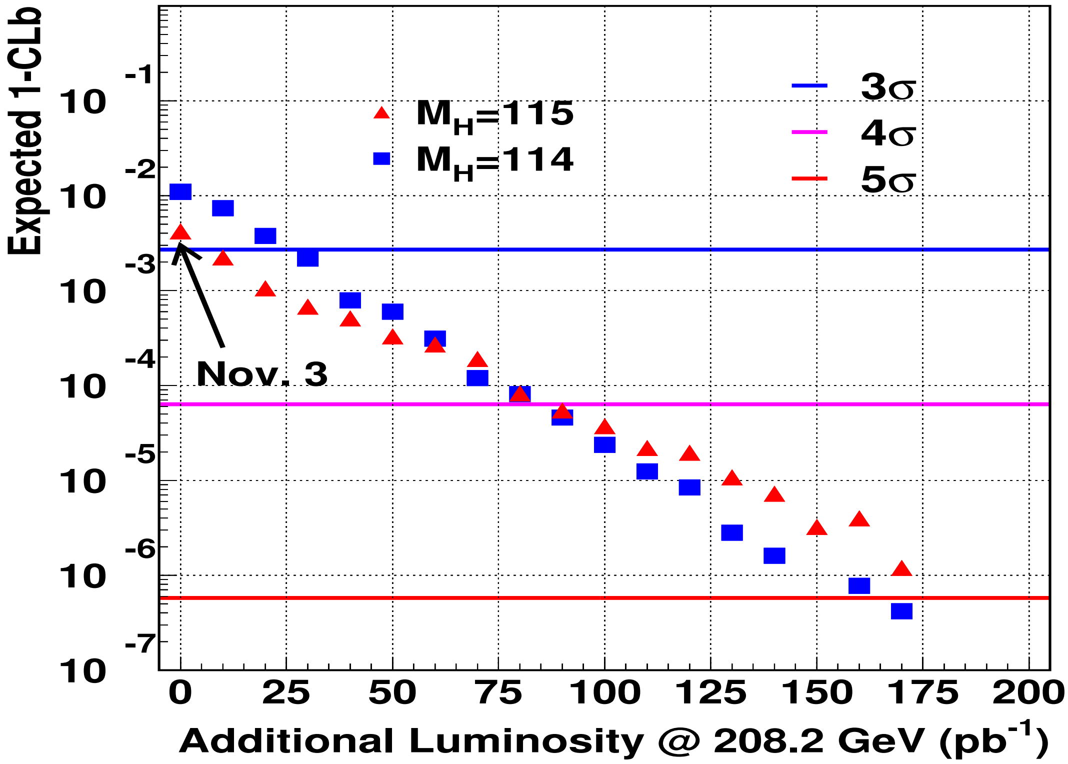
$\longrightarrow$ **LEP closed!.**

The 'Road-Map' ... Running at $E_{cm} = 208.2$ GeV

If accummulating background only ...



If accummulating signal + background ...



Publications

ALEPH :**Nov. 13, 2000,** *Phys.Lett.B495:1-17,2000*

DELPHI: **Dec. 22, 2000,** *Phys.Lett.B499:23-37,2001*

L3 :**Nov. 14, 2000,** *Phys.Lett.B495:18-25,2000*

OPAL :**Dec. 22, 2000,** *Phys.Lett.B499:38-52,2001*

EVOLUTION ... BY EXPERIMENT

@ $m_H = 115$ GeV

ALEPH	$1 - CL_b$
REF	1.6×10^{-4}
TOT	6.5×10^{-4}
Publ.$(^*)$	2.7×10^{-3}

DELPHI	$1 - CL_b$
REF	0.67
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L3	$1 - CL_b$
REF	0.84
TOT	6.8×10^{-2}
Publ.$(^*)$	9.0×10^{-2}

OPAL	$1 - CL_b$
REF	0.47
TOT	1.9×10^{-1}
Publ.$(^*)$	2.0×10^{-1}

$(^*)$ Submissions to Phys. Letters, Dec 2000, incl. 'TOTAL + LATEST' data sets

2001

Winter Conferences:

No LEP SM Higgs combinations!.

....Sorry....(Waiting for L3 inputs)

Before final publications:

-Some experiments busy optimising the analyses.

-Alternative analyses are checked for their sensitivity.

-Final calibrations
$\longrightarrow$ effects investigated and are small

-Additional MC statistics.

-Rechecking systematic errors.

Status Report

- Improvements going on till EPS'01.

- Higgs workshop from now till May 2001
    - Critical review of procedures.
    - Physics scope.

-Aspects of Archiving.

-Final LHWG results ending of 2001/2002.

-Publish before people head for

LHC and Tevatron.