

Status of LEP-wide Higgs searches

Chris Tully

Princeton



LEP working group
for Higgs boson searches



LEP-wide Higgs searches

Year 2000 High-Energy Data

August 28 Combination

Experiment	Integrated Luminosity (pb^{-1})
ALEPH	149
DELPHI	160
L3	145
OPAL	140
LEP	594

Investigated Higgs sectors:

- Standard Model Higgs
- MSSM Higgs
- 2HDM Charged Higgs
- Fermiophobic Higgs
- Invisible Higgs decays

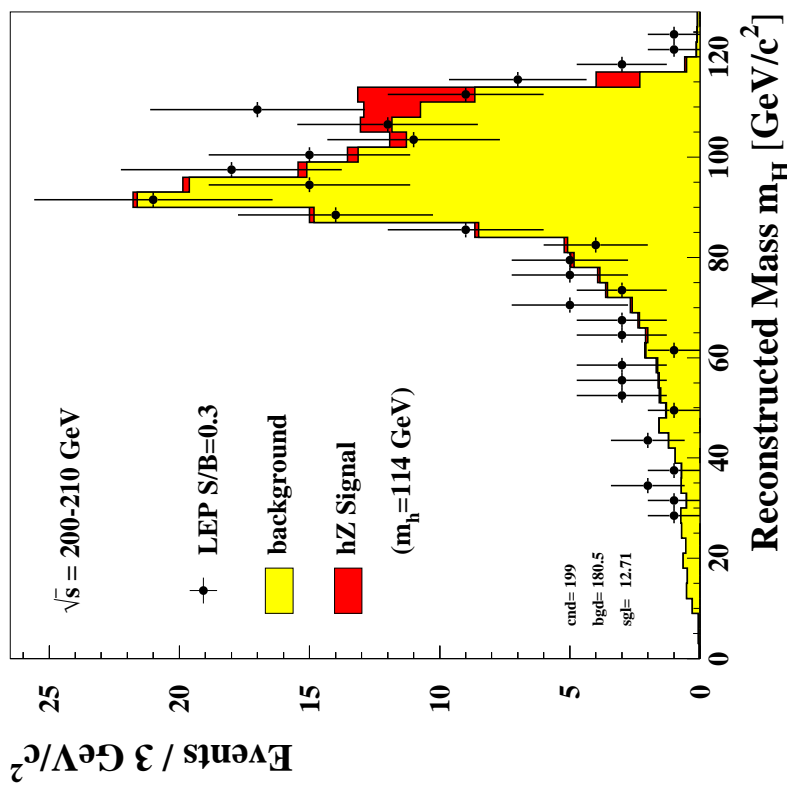
LEP-wide Higgs searches

Standard Model Higgs Mass Plots

S/B definition for mass plots:

Number of expected events for a 114 GeV Higgs signal with reconstructed mass $m_H > 109$ GeV divided by the corresponding number of selected background

$$S/B = 0.3 @ M_H = 114 \text{ GeV}$$



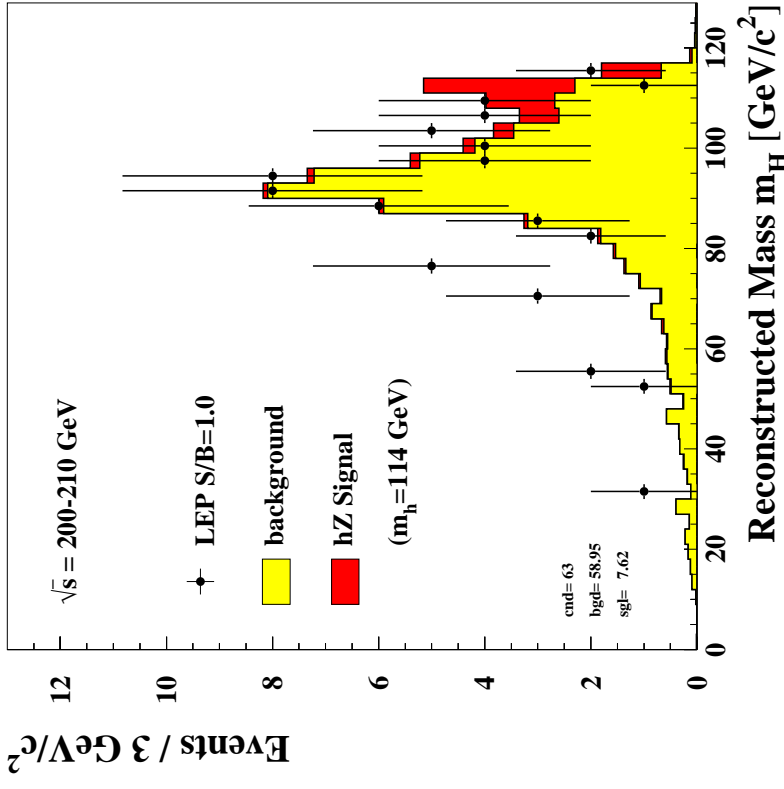
	Data	Bkgd	Signal
ALEPH	62	56.4	3.9
DELPHI	38	36.8	3.4
L3	31	34.7	2.1
OPAL	68	52.7	3.4
LEP	199	180.5	12.7

LEP-wide Higgs searches

Standard Model Higgs Mass Plots

$S/B = 1.0 @ M_H = 114 \text{ GeV}$

	Data	Bkgd	Signal
ALEPH	16	14.3	2.4
DELPHI	14	14.7	2.6
L3	11	9.7	0.7
OPAL	22	20.3	2.0
LEP	63	59.0	7.6

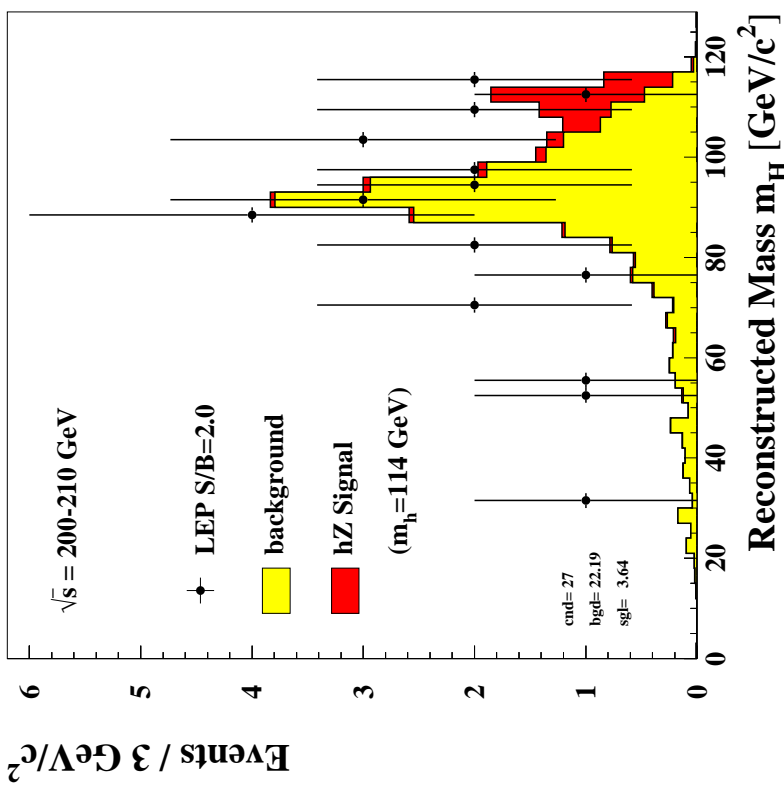


LEP-wide Higgs searches

Standard Model Higgs Mass Plots

**Excess Observed in High
Mass Region $m_H > 109$ GeV**

S/B = 2.0 @ $M_H = 114$ GeV



	Data	Bkgd	Signal
ALEPH	7	3.3	1.0
DELPHI	5	5.4	1.3
L3	4	4.0	0.3
OPAL	11	9.6	0.9
LEP	27	22.2	3.6

LEP-wide Higgs searches

Statistical Method

For Illustrative Purposes:

Likelihood Ratio test-statistic:

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

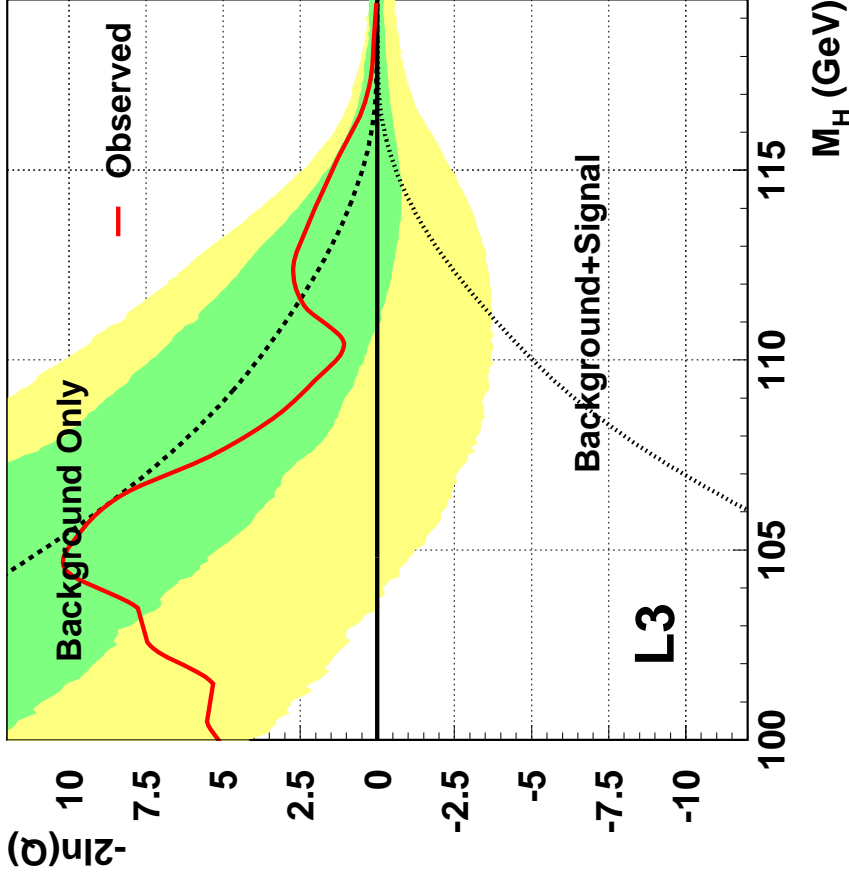
Final search variables are binned

and treated as

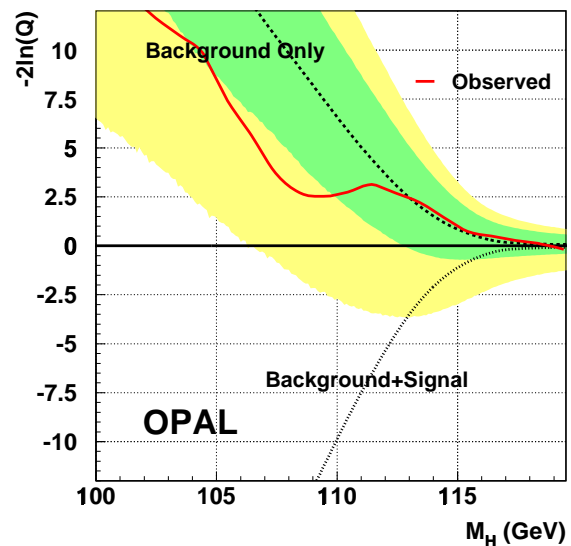
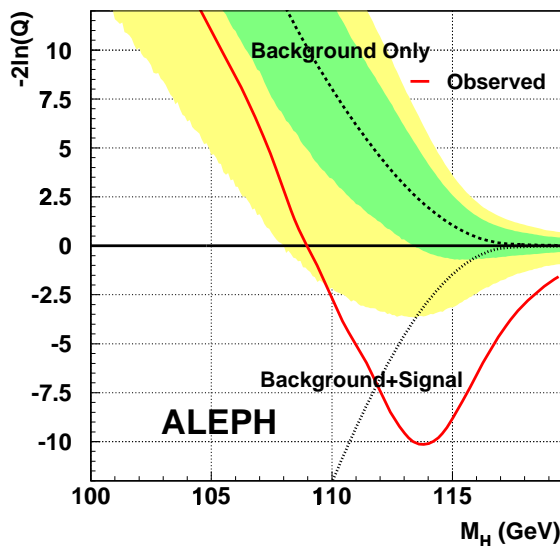
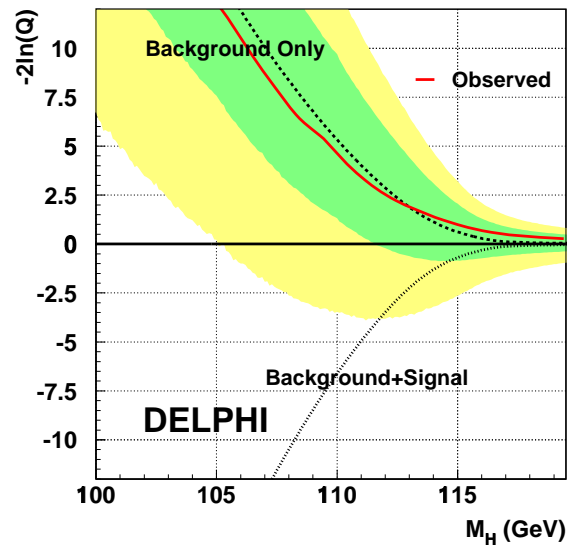
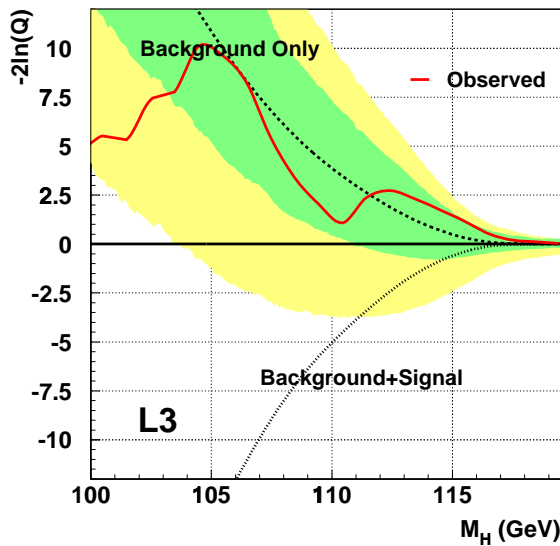
Poisson counting experiments:

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

LEP-wide Higgs searches



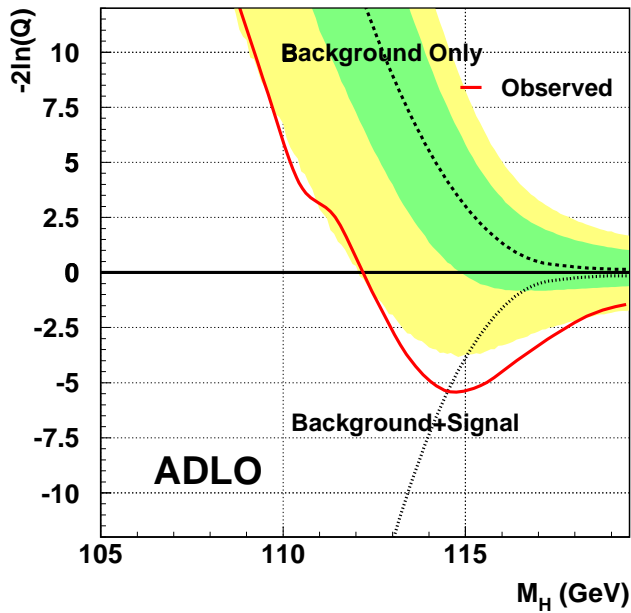
SM Results from All Experiments



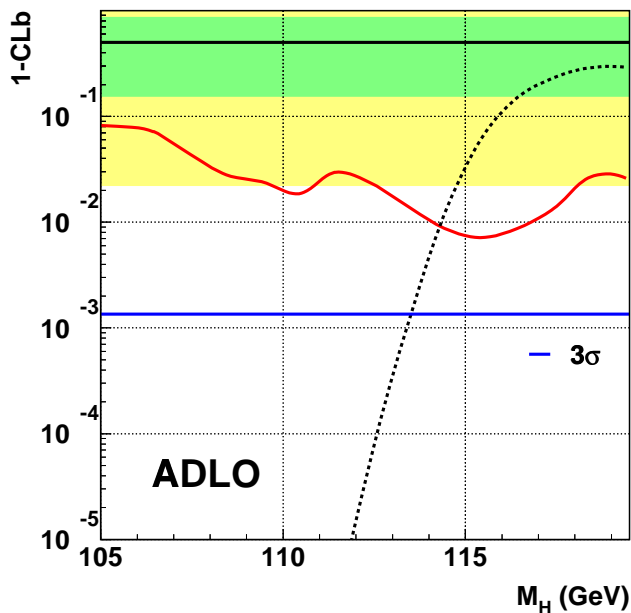
3.9 σ Excess in ALEPH Data ($1 - CL_b = 6 \cdot 10^{-5}$)

LEP-wide Higgs searches

Combined SM Results



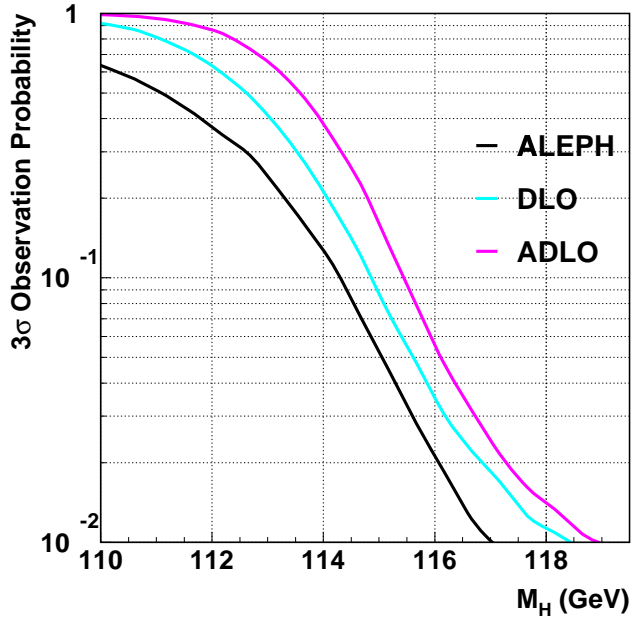
$-2\ln(Q)$ Minimum
at 114.9 GeV



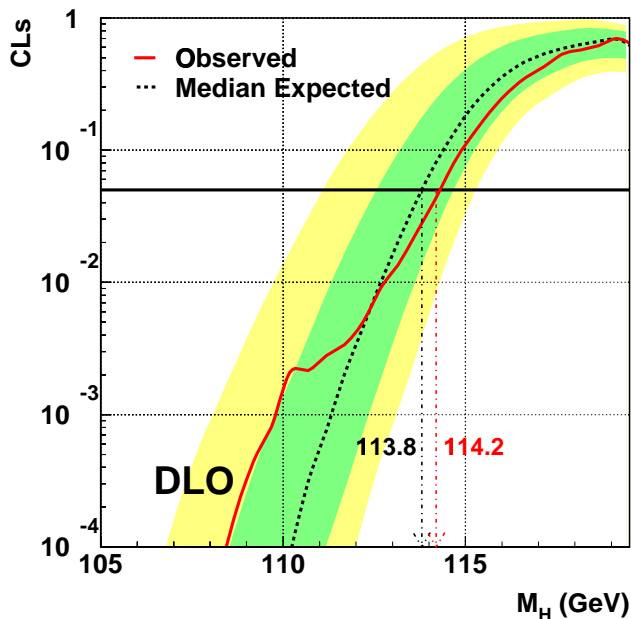
$1 - CL_b$ Minimum
at 2.6σ
Significance

LEP-wide Higgs searches

Consistency Checks (Experiments)



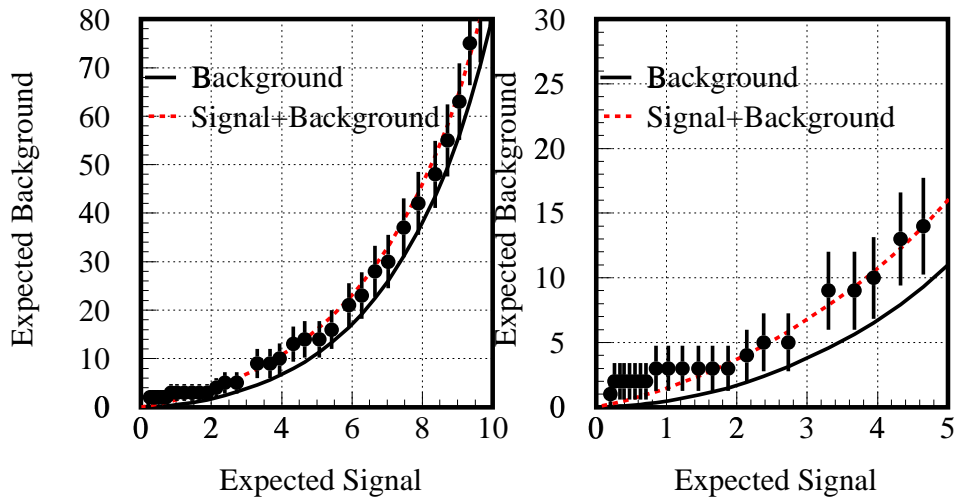
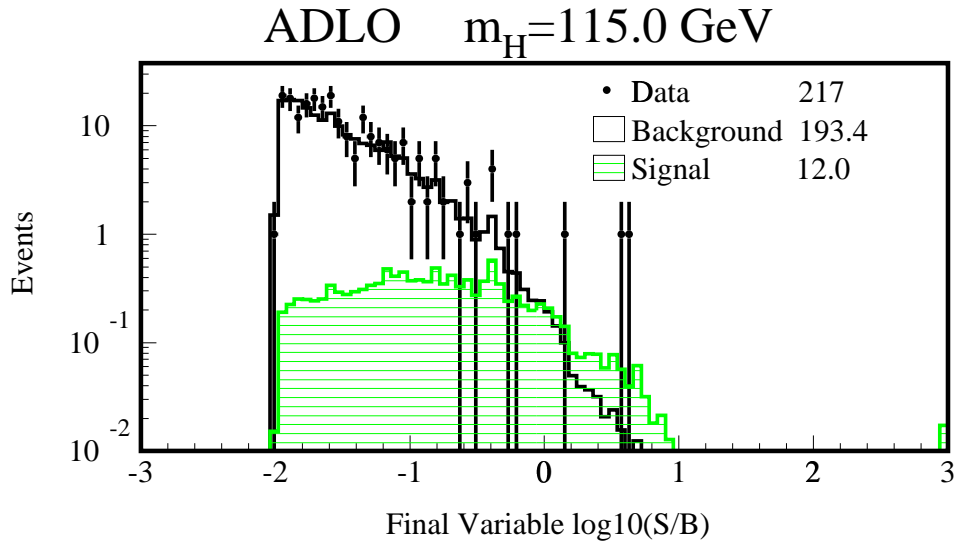
For $m_H = 114$ GeV,
ALEPH 13%
DLO 21%
ADLO 39%



DLO Mass Limit
Observed:
114.2 GeV
Median Expected:
113.8 GeV

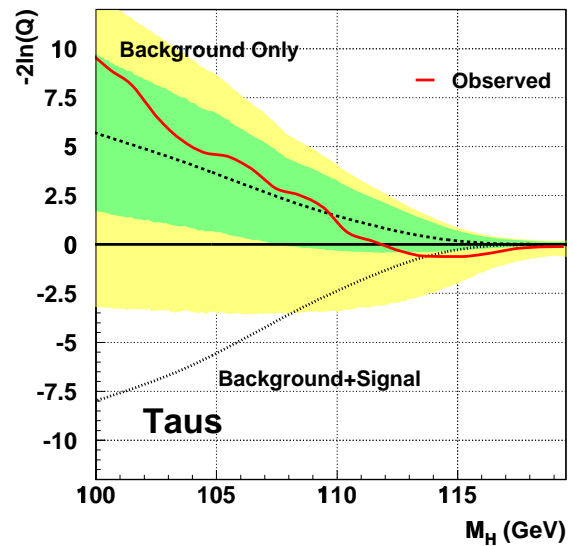
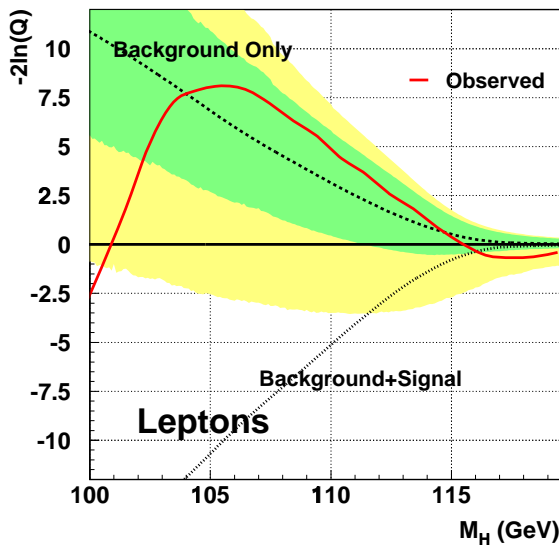
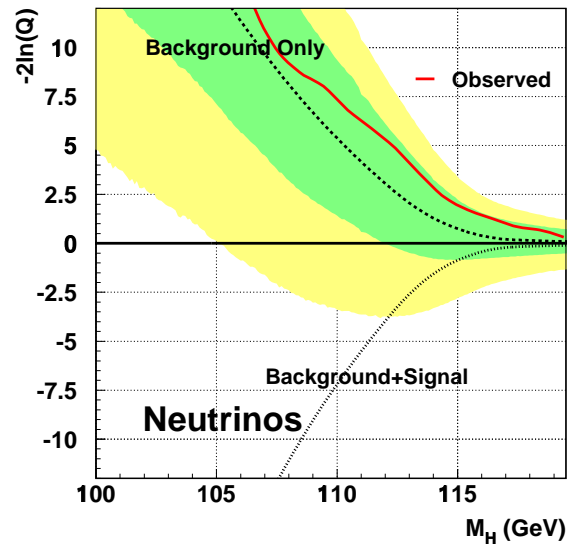
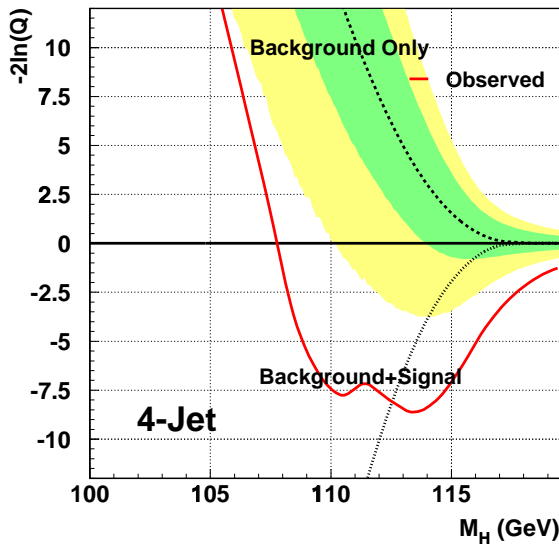
LEP-wide Higgs searches

Background-Efficiency Curve



LEP-wide Higgs searches

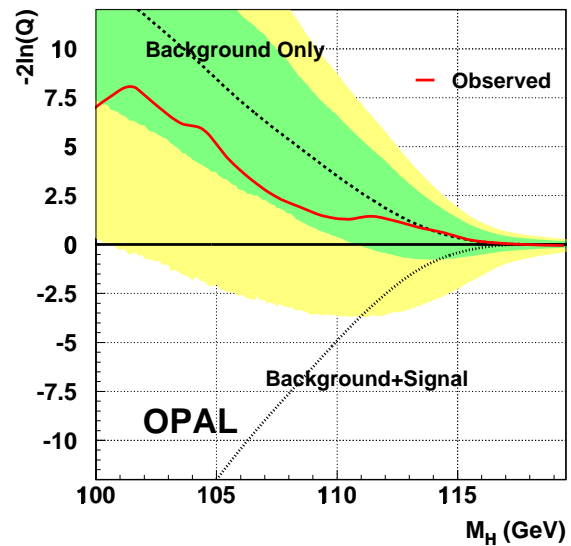
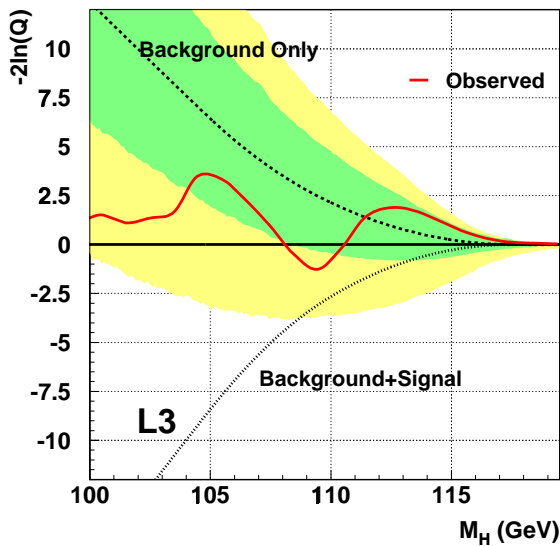
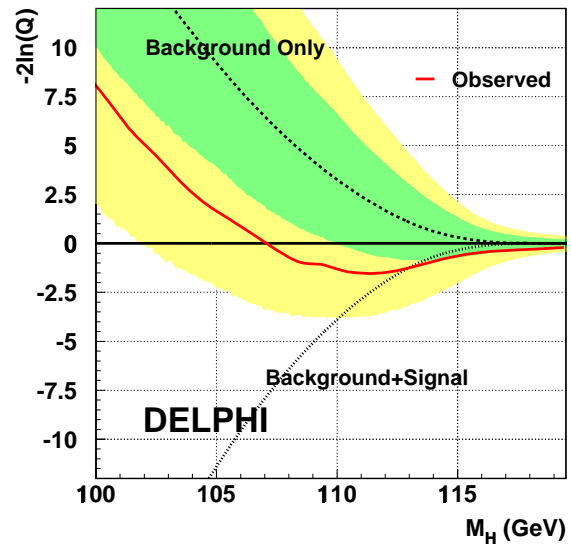
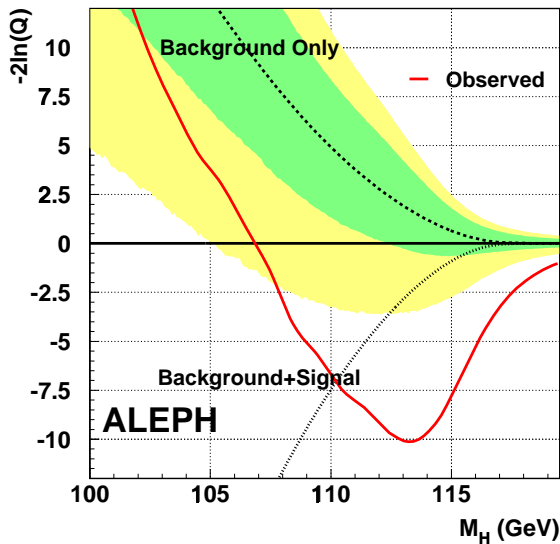
SM Results from All Channels



3.2σ 4-Jet Excess in ADLO Data ($1 - CL_b = 7 \cdot 10^{-4}$)

LEP-wide Higgs searches

4-Jet Results from All Experiments

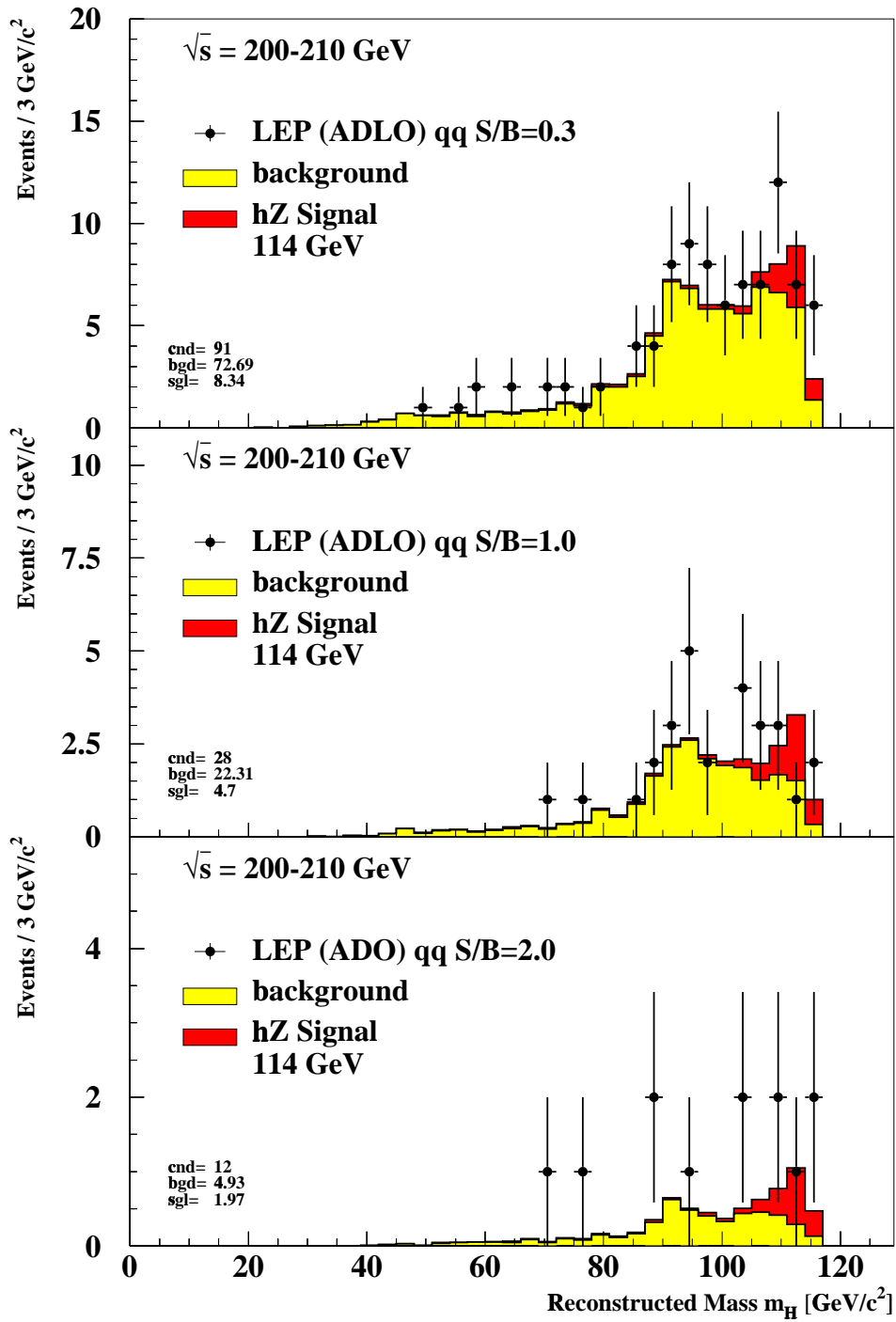


3.8σ 4-Jet Excess in ALEPH Data ($1 - CL_b = 7 \cdot 10^{-5}$)

2.0σ 4-Jet Excess in DLO Data ($1 - CL_b = 2 \cdot 10^{-2}$)

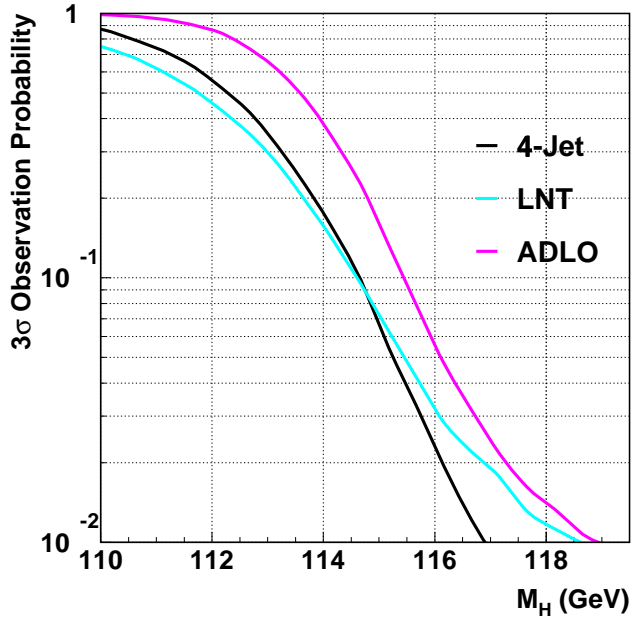
LEP-wide Higgs searches

4-Jet Mass Plots

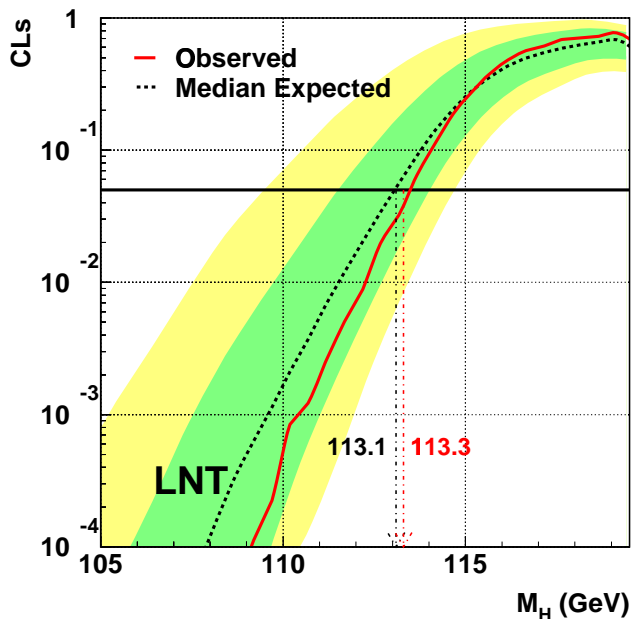


LEP-wide Higgs searches

Consistency Checks (Channels)



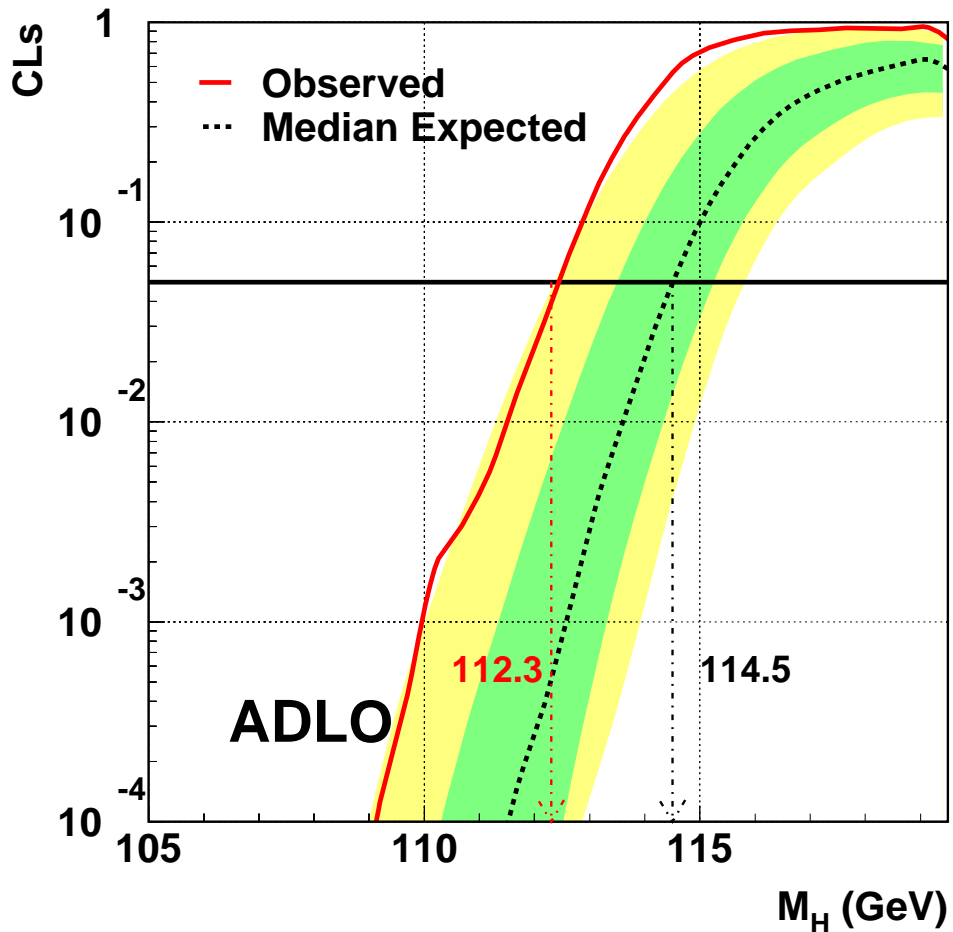
For $m_H = 114$ GeV,
4-Jet 18%
LNT 15%
ADLO 39%



LNT Mass Limit
Observed:
113.3 GeV
Median Expected:
113.1 GeV

LEP-wide Higgs searches

Combined SM Results



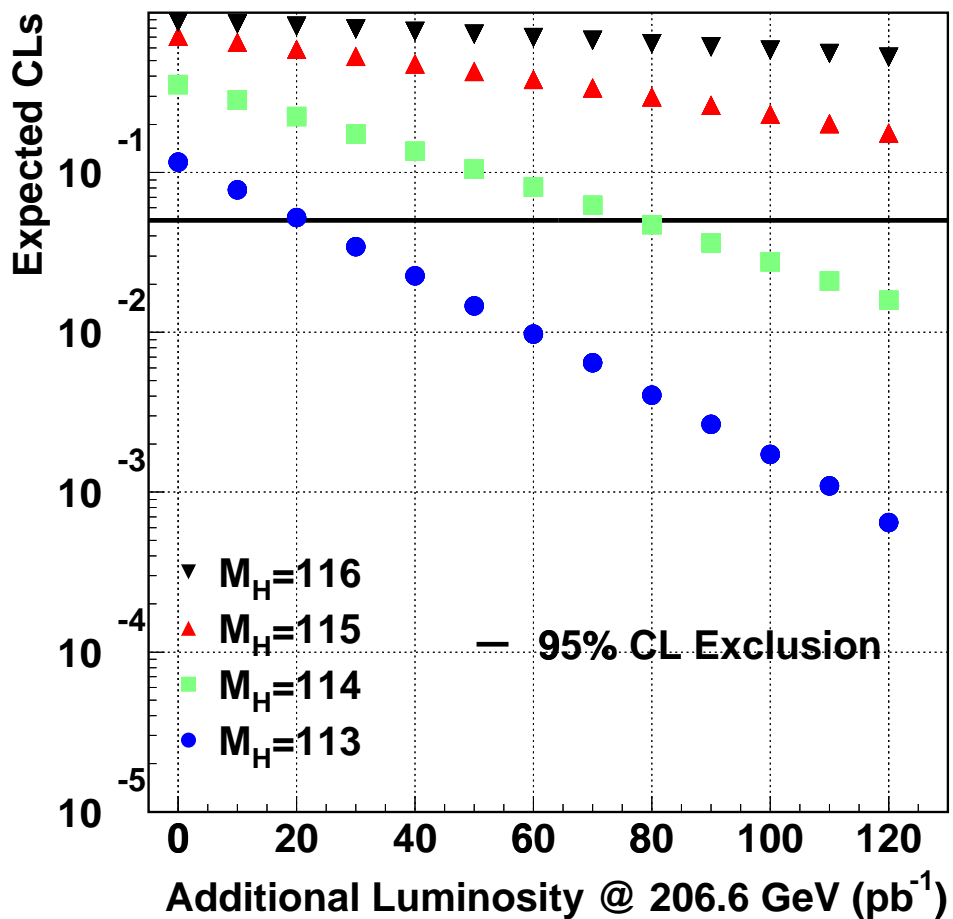
Observed Limit: 112.3 GeV

Median Expected Limit: 114.5 GeV

LEP-wide Higgs searches

Extended LEP Running

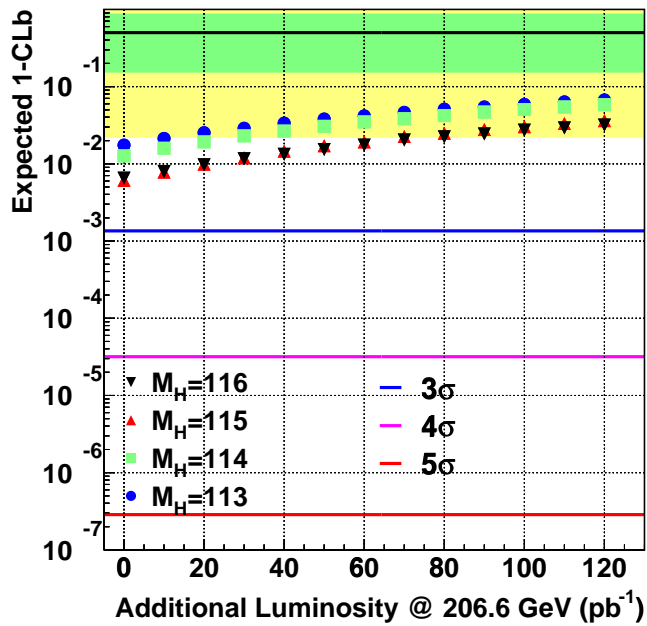
Improvement on Exclusion
in Absence of a Higgs Signal



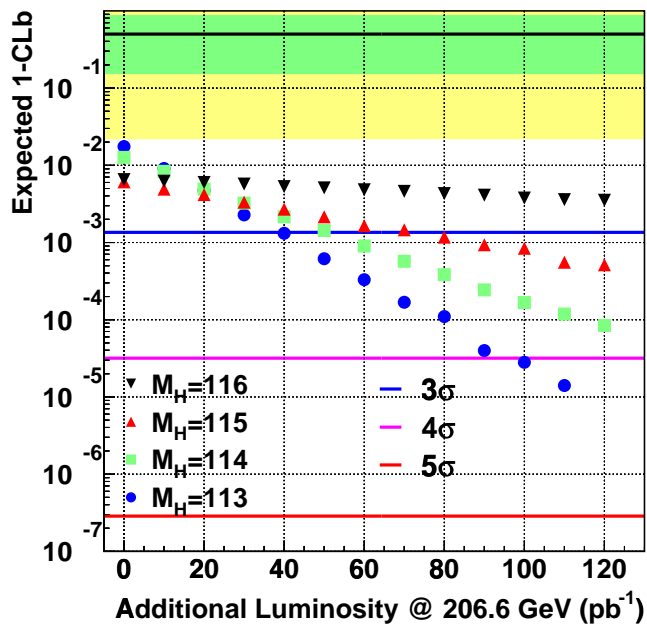
(Luminosity On-Tape)

LEP-wide Higgs searches

Case 1: Accumulating Background-Only:



Case 2: Accumulating Background+Signal:

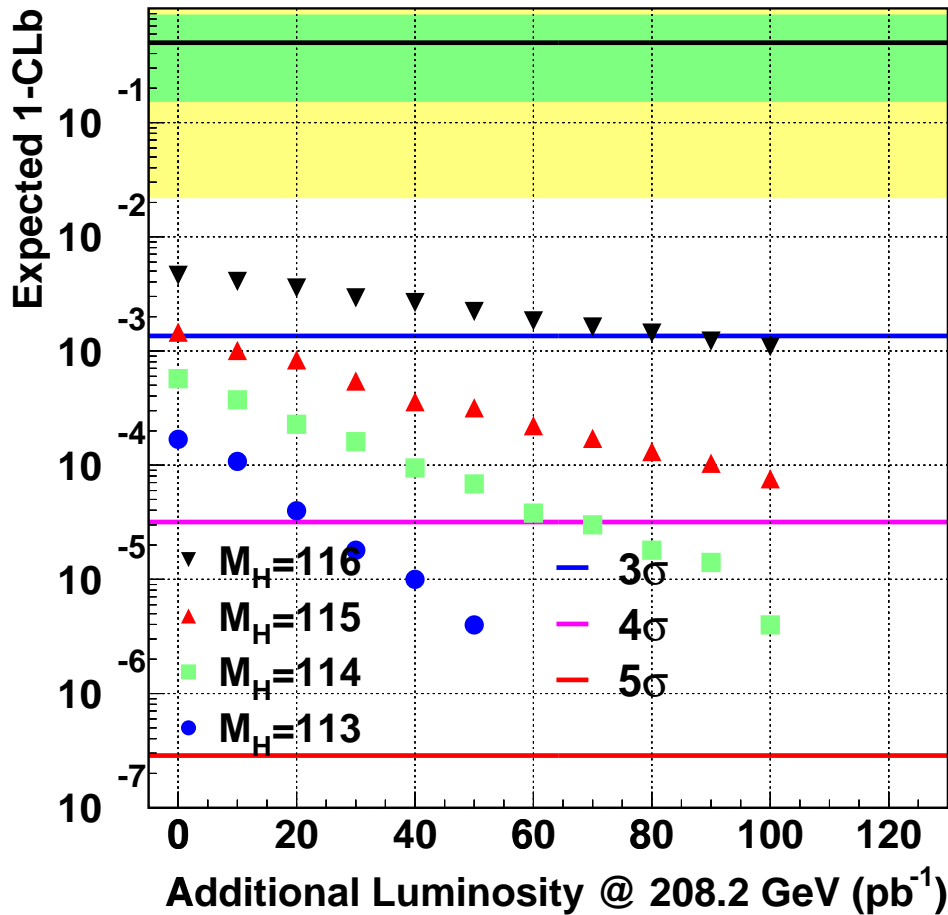


LEP-wide Higgs searches

Extended LEP Running

Road to Discovery

After Collecting 70 pb^{-1} @ 206.6 GeV:



(Luminosity On-Tape)

LEP-wide Higgs searches

Summary of Extrapolation Results

With 75 pb^{-1} @ 206.6 GeV additional luminosity on-tape per experiment relative to the Aug 28th inputs, given what has currently been measured in the data, LEP can either:

- a) 95% CL exclude up to 114 GeV, or
- b) Increase the LEP-wide excess to a 3σ observation at 115 GeV (3.3σ at 114 GeV).

If after 70 pb^{-1} @ 206.6 GeV, LEP switches to 208.2 GeV running, above 100 pb^{-1} @ 208.2 GeV per experiment, LEP will have:

- a) 3σ observation for 116 GeV, or
- b) 4σ for 115 GeV, or
- c) On road to discovery for 114 GeV.

LEP-wide Higgs searches

Summary of Standard Model Results

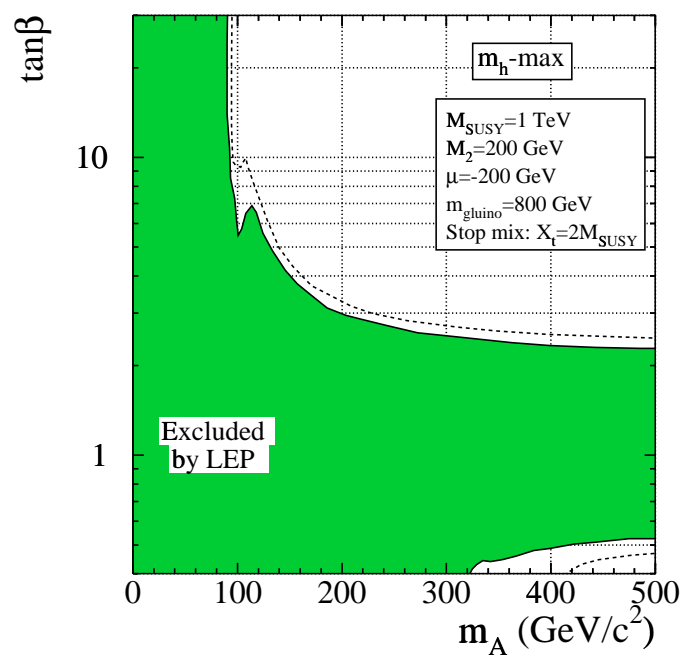
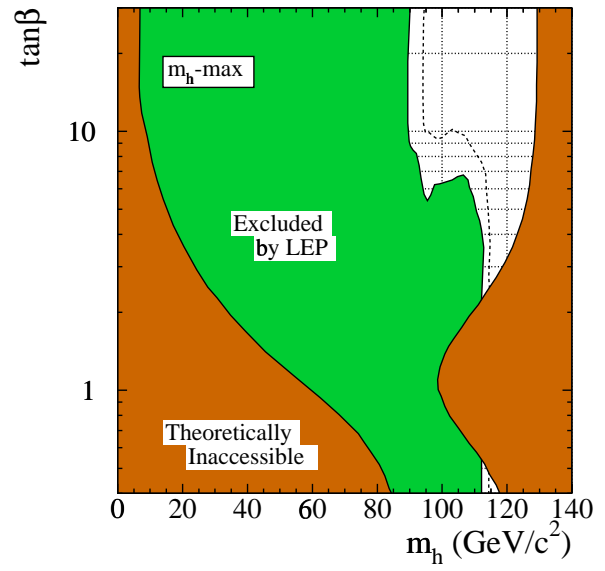
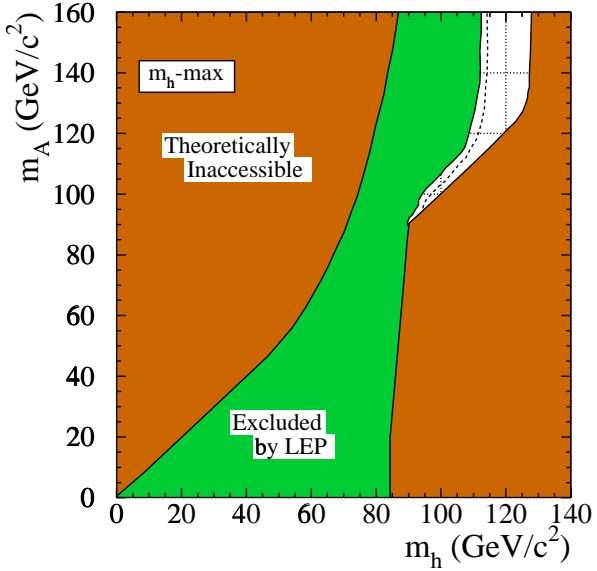
Experiment	Expected(GeV)	Observed(GeV)
ALEPH	112.5	109.1
DELPHI	110.9	110.5
L3	110.2	108.8
OPAL	111.7	109.5
Leptons	108.8	109.9(*)
Neutrinos	110.7	112.1
Taus	104.2	105.4
4 Jets	113.5	109.0
LEP	114.5	112.3

(*) Small unexcluded region below 100.7 GeV

All Results are Preliminary

LEP-wide Higgs searches

Maximal Stop Mixing



Mass Limits (GeV)

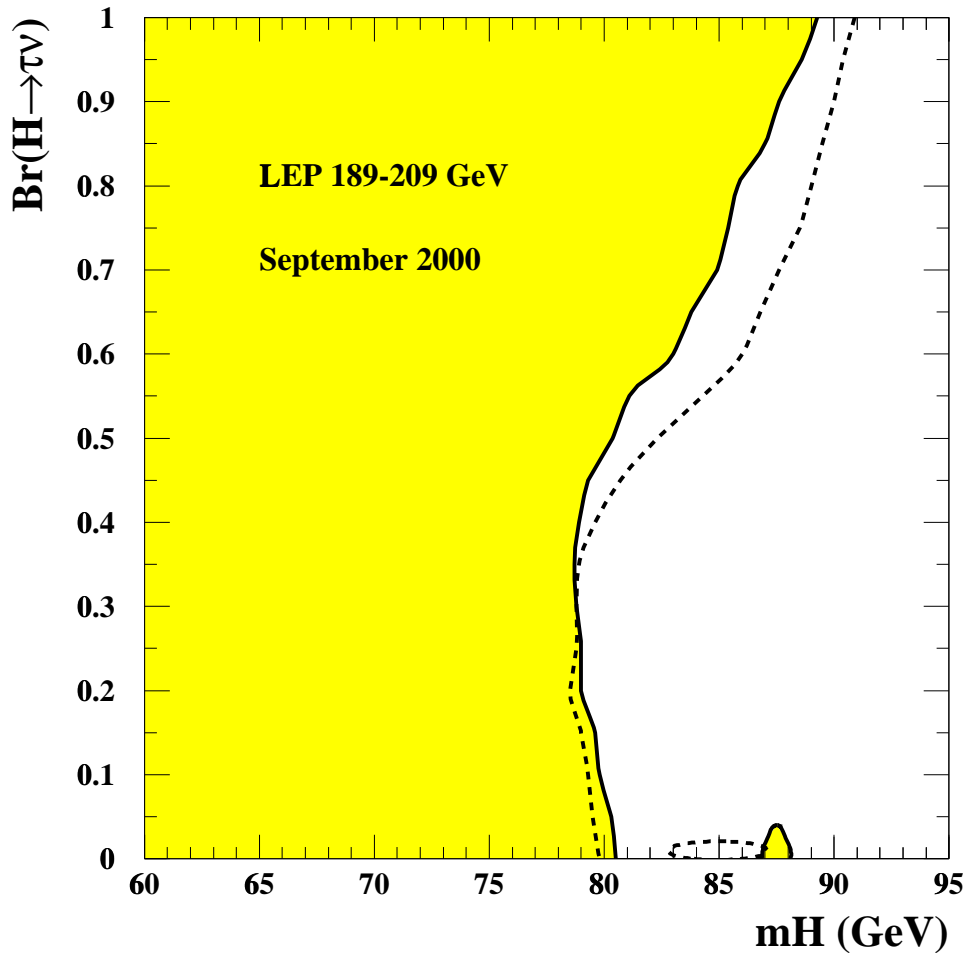
	obs.	exp.
$M_h >$	89.5	93.8
$M_A >$	90.2	94.1

tan beta Exclusion

	obs.	exp.
	0.53–2.25	0.48–2.48

LEP-wide Higgs searches

Charged Higgs Search Results

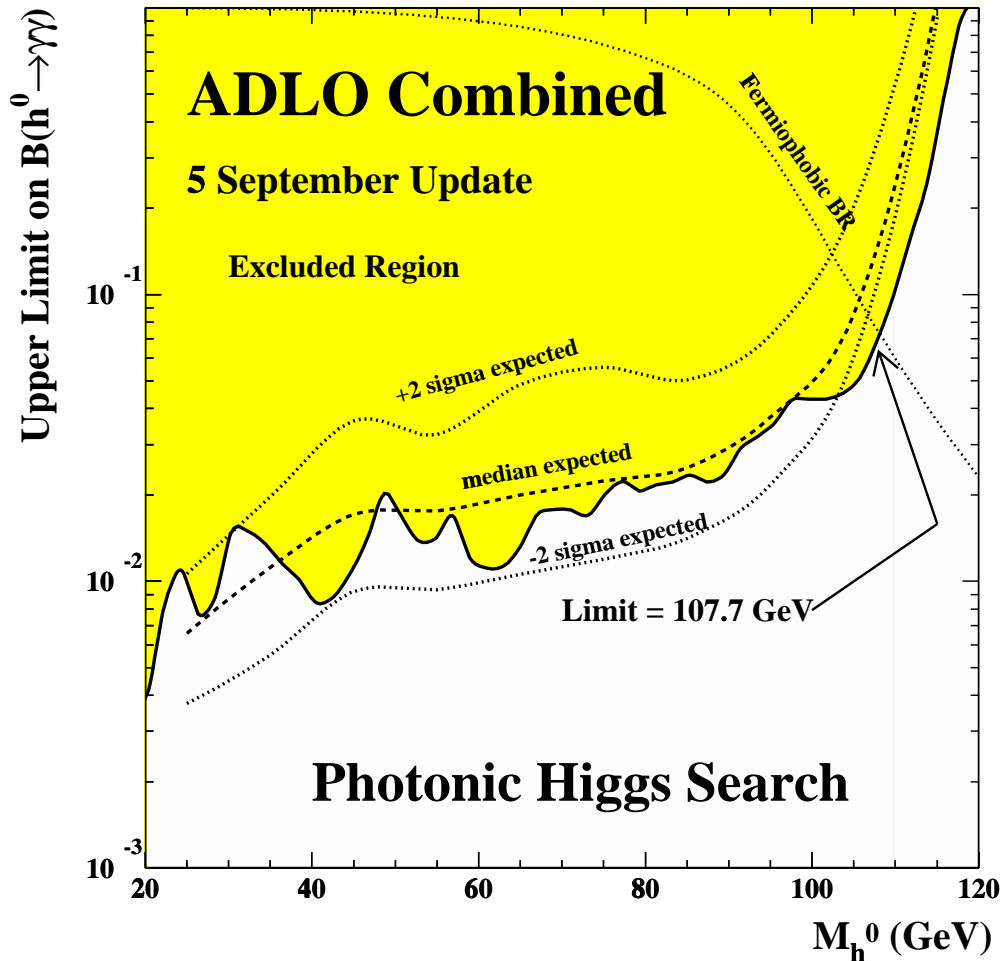


Observed(Median Expected) Limits (GeV)
for $\text{Br}(H^\pm \rightarrow \tau\nu_\tau)$

Br=0.0	Br=1.0	any Br
80.5 (79.8)	89.2 (90.9)	78.7 (78.5)

LEP-wide Higgs searches

Fermiophobic Higgs Search Results

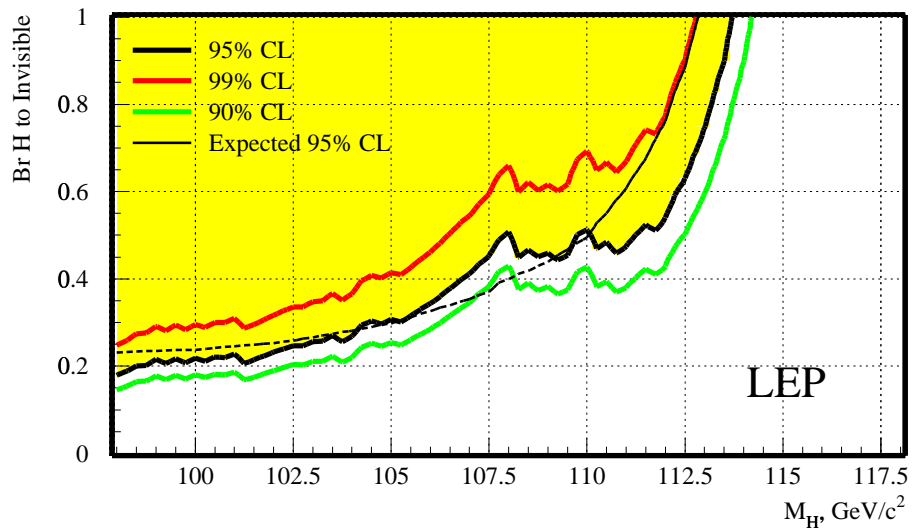
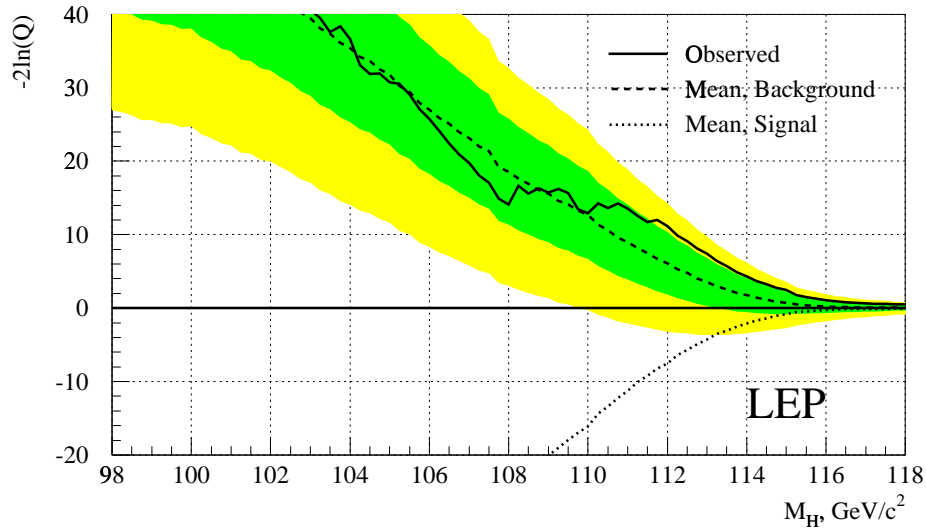


Observed Limit: 107.7 GeV

Median Expected Limit: 105.8 GeV

LEP-wide Higgs searches

Invisible Higgs decays Search Results



Observed Limit: 113.7 GeV

Median Expected Limit: 112.8 GeV

LEP-wide Higgs searches

Recommandation

Continue running LEP for 75 pb^{-1} @ 206.6 GeV additional luminosity on-tape per experiment relative to the Aug 28th inputs.

With this data, LEP can either:

- a) 95% CL exclude up to 114 GeV, or
- b) Increase the LEP-wide excess to a 3σ observation at 115 GeV (3.3σ at 114 GeV).

The search results should be re-evaluated at this time.

We all hope that what we see is the

Higgs on the horizon.

LEP-wide Higgs searches