Status of the Higgs Search at Aleph

Peter McNamara
University of Wisconsin

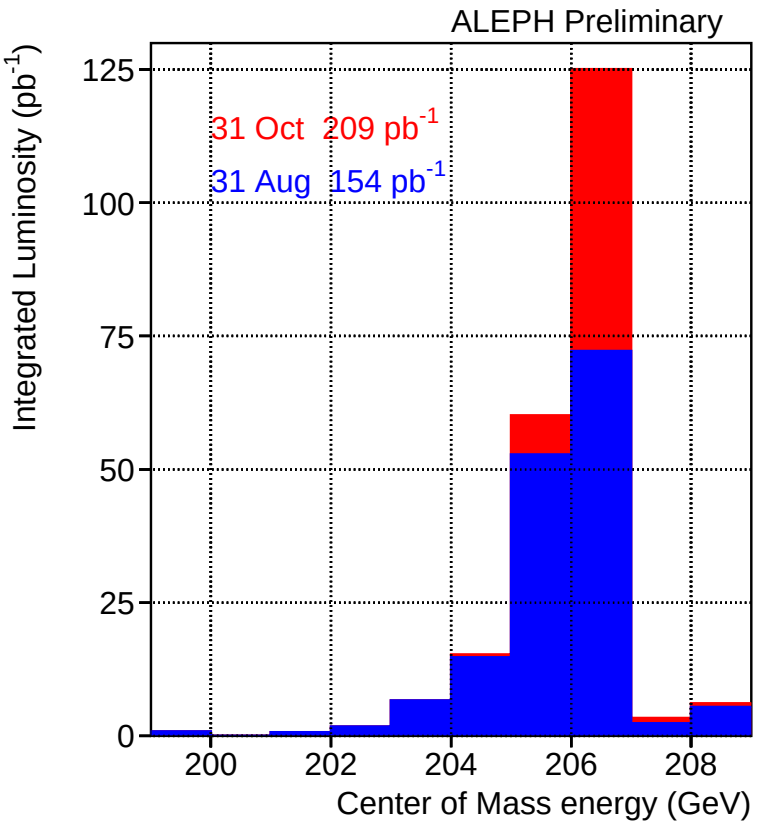
November 3, 2000
LEPC Seminar

Luminosity Collected

ALEPH has collected $\mathcal{L}$ =209 pb^{-1} above $\sqrt{s} = 200$ GeV this year (up to Oct 31).

Luminosity Collected	All Energies	Above 206
Before Sept 5	154	77
After Sept 5	55	48
Total	209	125

ALEPH efficiency has been 95.8%!



40% of luminosity above $\mathcal{L}$=206 GeV collected after September 5

THANKS LEP!

Analysis Strategy

ALEPH adopts a two-stream analysis strategy when searching for the Standard Model Higgs boson – Neural Network and Cuts.

Searches in the dominant channels, 4 jet and missing energy, are performed with these two analyses–

Charged lepton searches are common to the two streams

The two streams are complementary–
the results are partially correlated, but have
different sensitivities to systematic effects.

Data collected before September 5

At the September 5 LEPC meeting,
ALEPH reported a $3.9\sigma(3.8\sigma)$ excess
in the NN(CUT) based search

This excess was due to signal-like events
with masses above 109 GeV/c^2 collected
at energies above 206 GeV.

The analysis selections were determined before the
start of running, and remain unchanged.

Our most significant candidates have been
reprocessed using our final detector calibration,
with no significant effect on the result

All contributing events remain in our sample,
and continue to appear signal-like.

Changes since September 5

Since the September 5 LEPC Meeting, we have continued to scrutinize our data and analysis performance.

This has led to small changes in the significance of the result.

NN 4-Jet variable parametrization was improved
$\Rightarrow -0.3\sigma$ in NN stream

Correlations between mass and NN output in the 4-jet NN analysis were taken into account
$\Rightarrow -0.2\sigma$ in NN stream

$g \to bb$, $g \to cc$ rates were updated
$\Rightarrow -0.2\sigma$ in CUT stream

Definition of Significance changed to match official LEP Higgs Group convention
$\Rightarrow +0.2\sigma$ in both streams

Total change:
-0.3σ in NN, -0.0σ in CUT

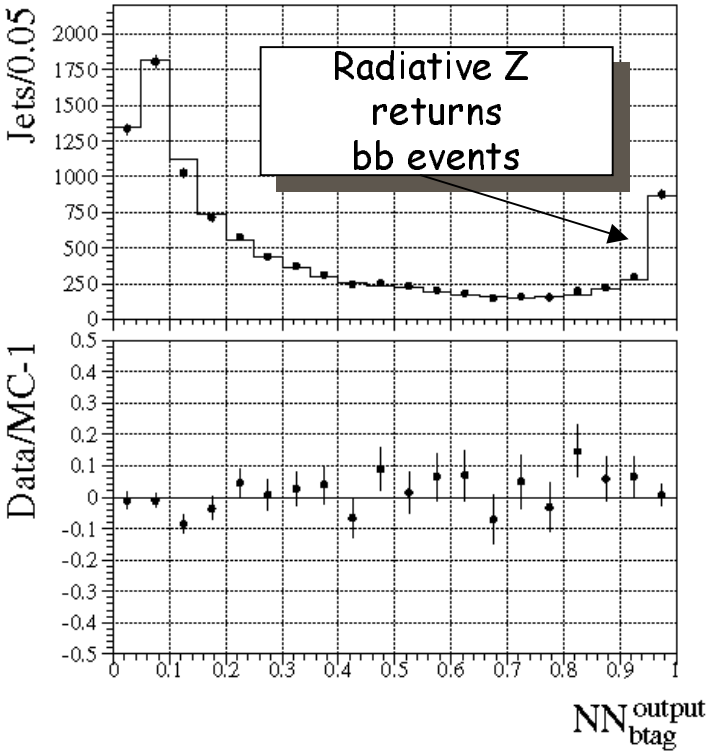
systematic checks: btag

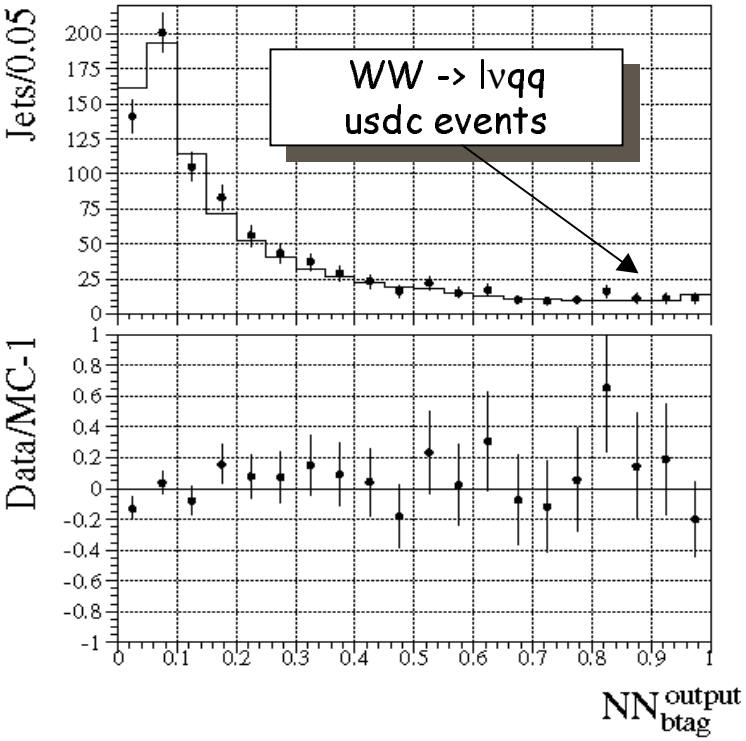
btag calibrated with y2k Zpeak data

MC *IPs smeared* until ε_{udsc} and ε_b agree with Data

agreement cross-checked with HE data

Half of the correction taken as systematic error





Effect on expected bkg

All M_H

ZZ =1% qq=1% WW=10%

Tot=3%

M_H > 109 GeV

ZZ=4 % qq=4% WW=10%

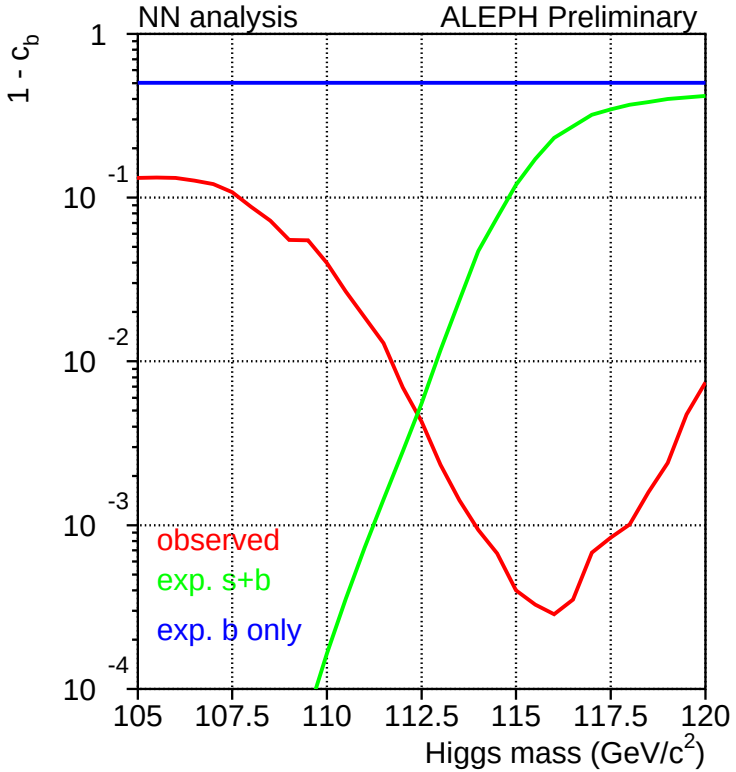
Tot=5%

Systematic checks

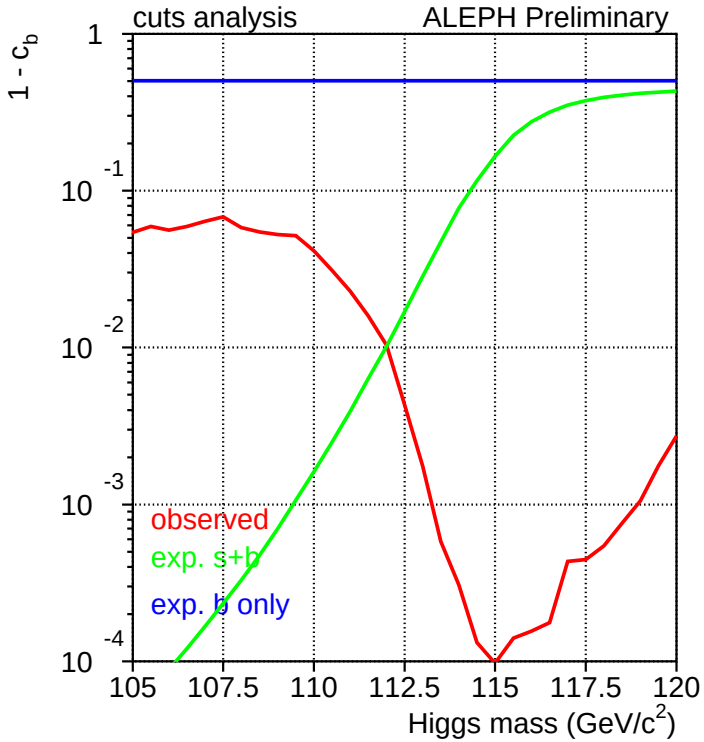
- Systematic evaluation in progress (be patient ALEPH is still in the data taking period) !
- Sources of systematic uncertainties studied up to now in the 4-jet channel:
  - btag on b and udsc jets
  - NN variables
  - gluon splitting into heavy flavors
- Preliminary systematics on expected bkg in the 4-jet channel
  - ~ 5% on ZZ (btag uncertainty + MC stat)
  - ~20% on qq (error on g->bb g->cc + MC stat)
  - ~20% on WW (btag uncertainty + MC stat)
- If bkg is increased by these quantities the impact on $(1-c_b)$ significance is small ~0.2σ
- No large effect found up to now but the work is still continuing .....

Background Consistency - Up to September 5

Both NN and CUT analyses continue to observe a significant excess in the updated analysis of reference sample



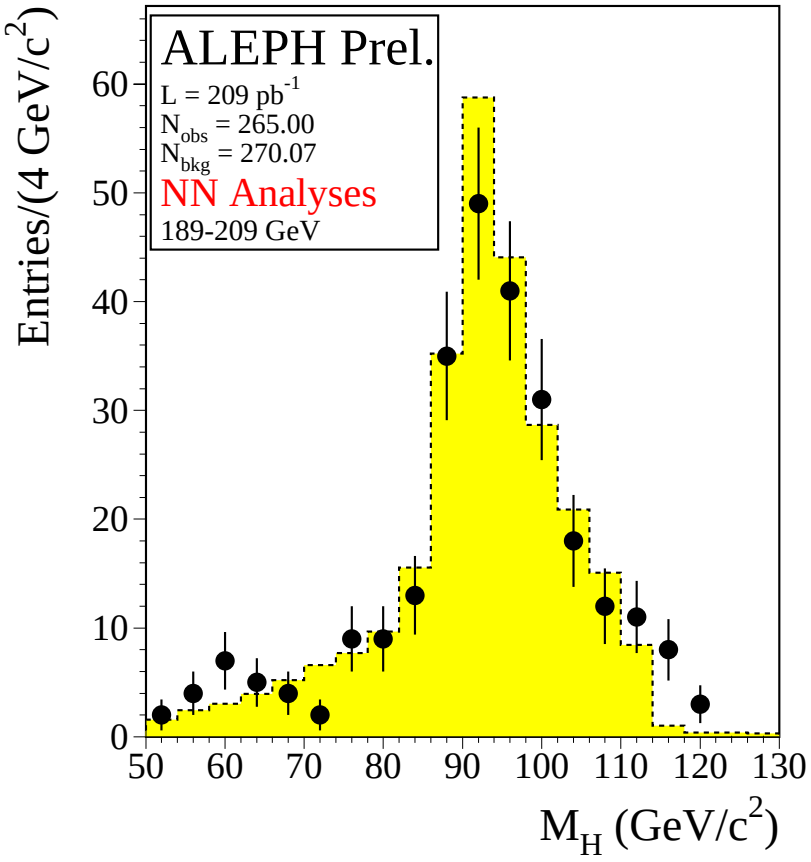
Minimum $(1 - C_b) = 2.8 \times 10^{-4}$
(equivalent to 3.6σ excess)

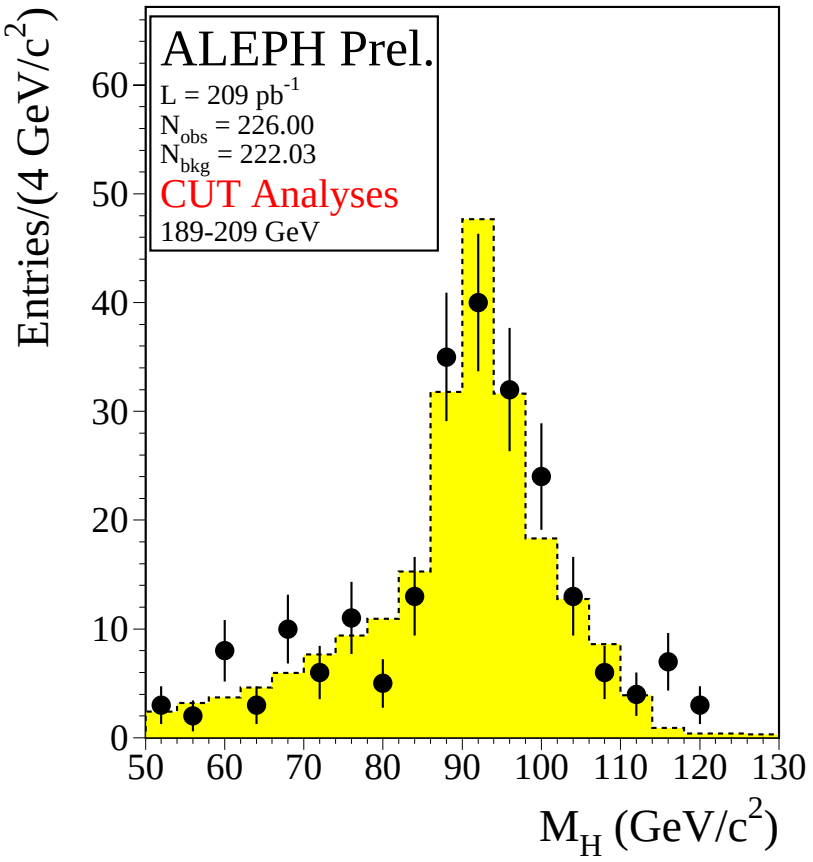


Minimum $(1 - C_b) = 1.0 \times 10^{-4}$
(equivalent to 3.8σ excess)

Mass Plot - Total Sample

When all data are combined,
the excess of high mass events remains significant in both streams.

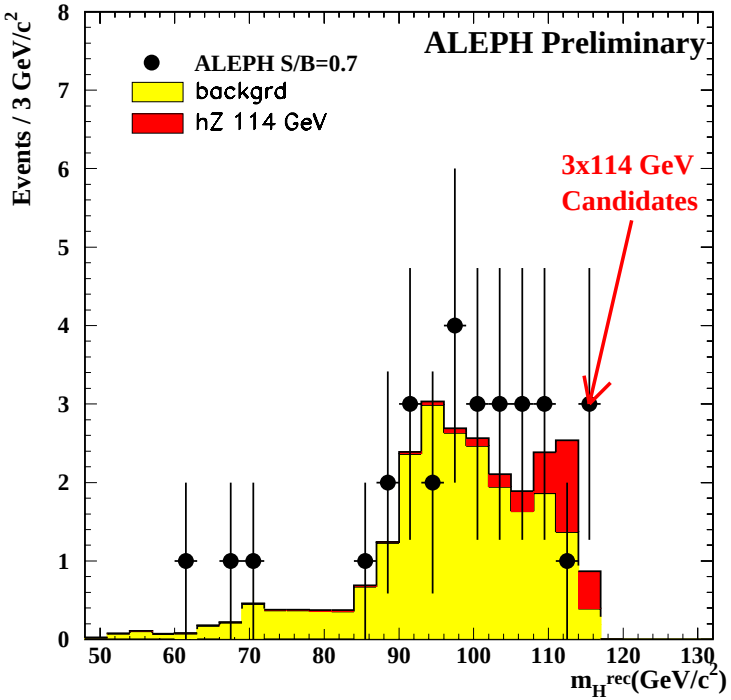


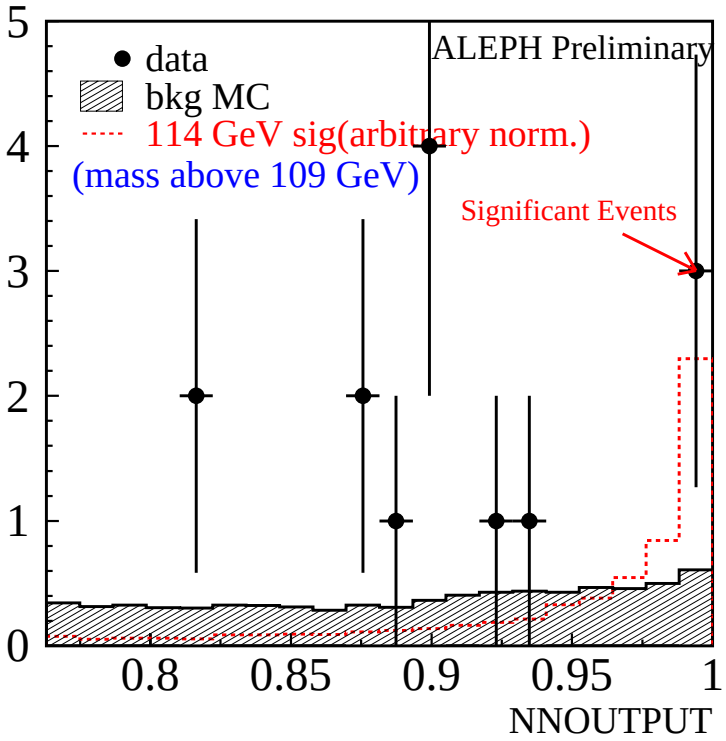


Treatment of Excess

Treatment of the high mass events in the two streams are different

In the CUT analysis, the events are given weights which depend only on their reconstructed mass.



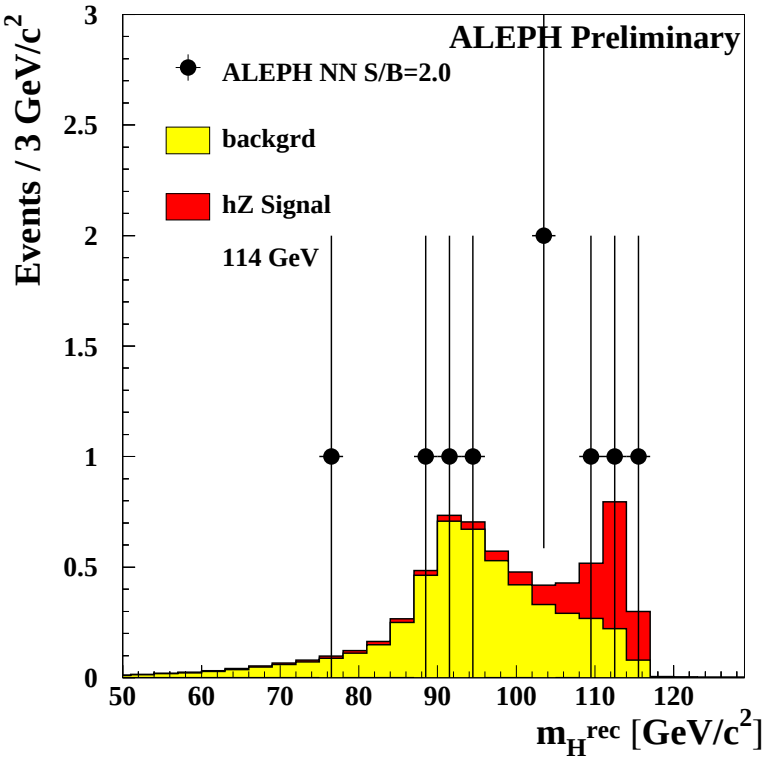


In the NN analysis, weight depends on both mass and NN output

(3 events with $M_H > 109$, NN≈ 1)

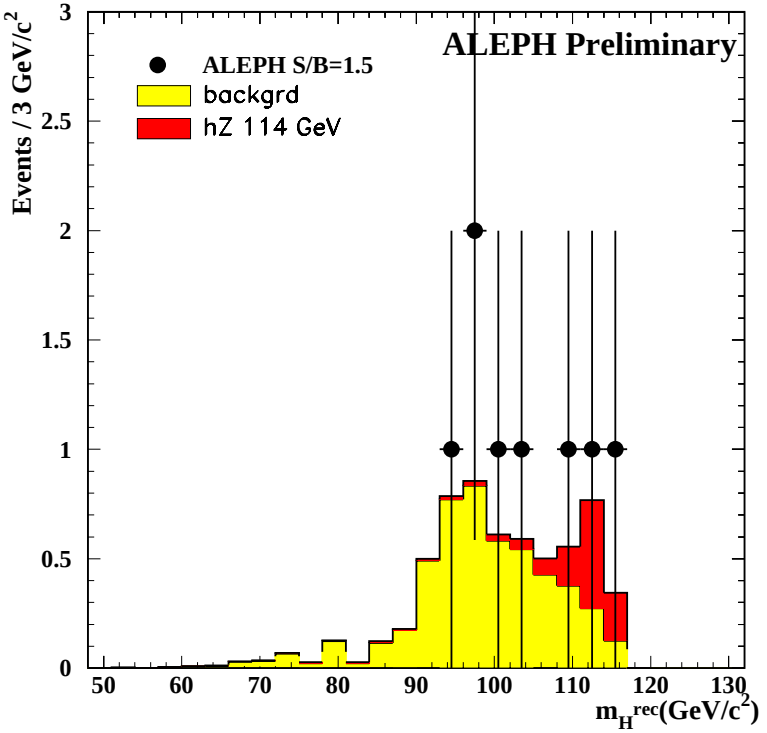
Mass Plot - Tight Cuts

NN Analysis

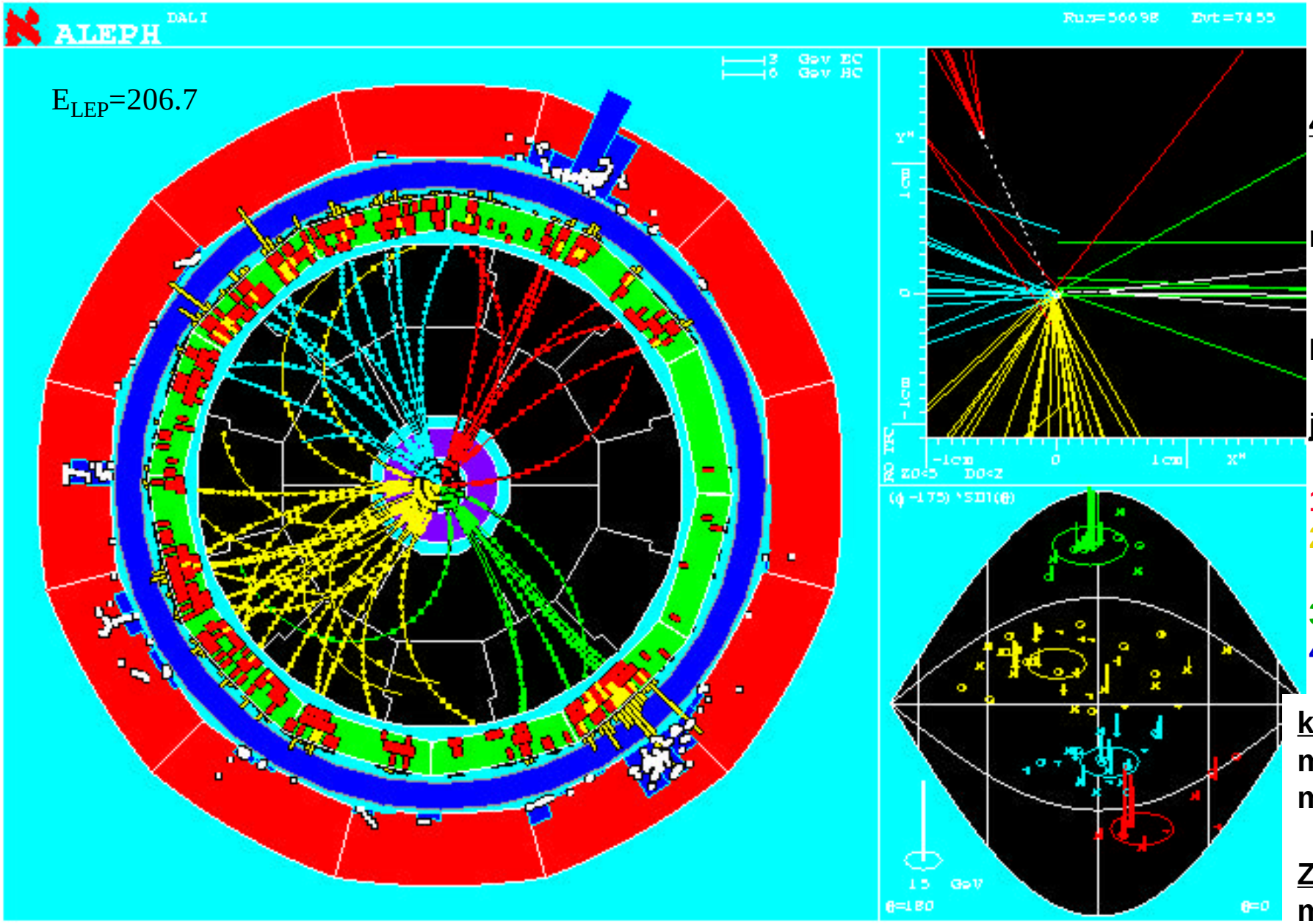


When cuts are tightened, both accept the same three four jet events with M_H >109 GeV/c^2

CUT Analysis



The survival of these three candidates indicates that they are indeed quite signal-like



4 b cand.

m_H=110 GeV ±3 GeV

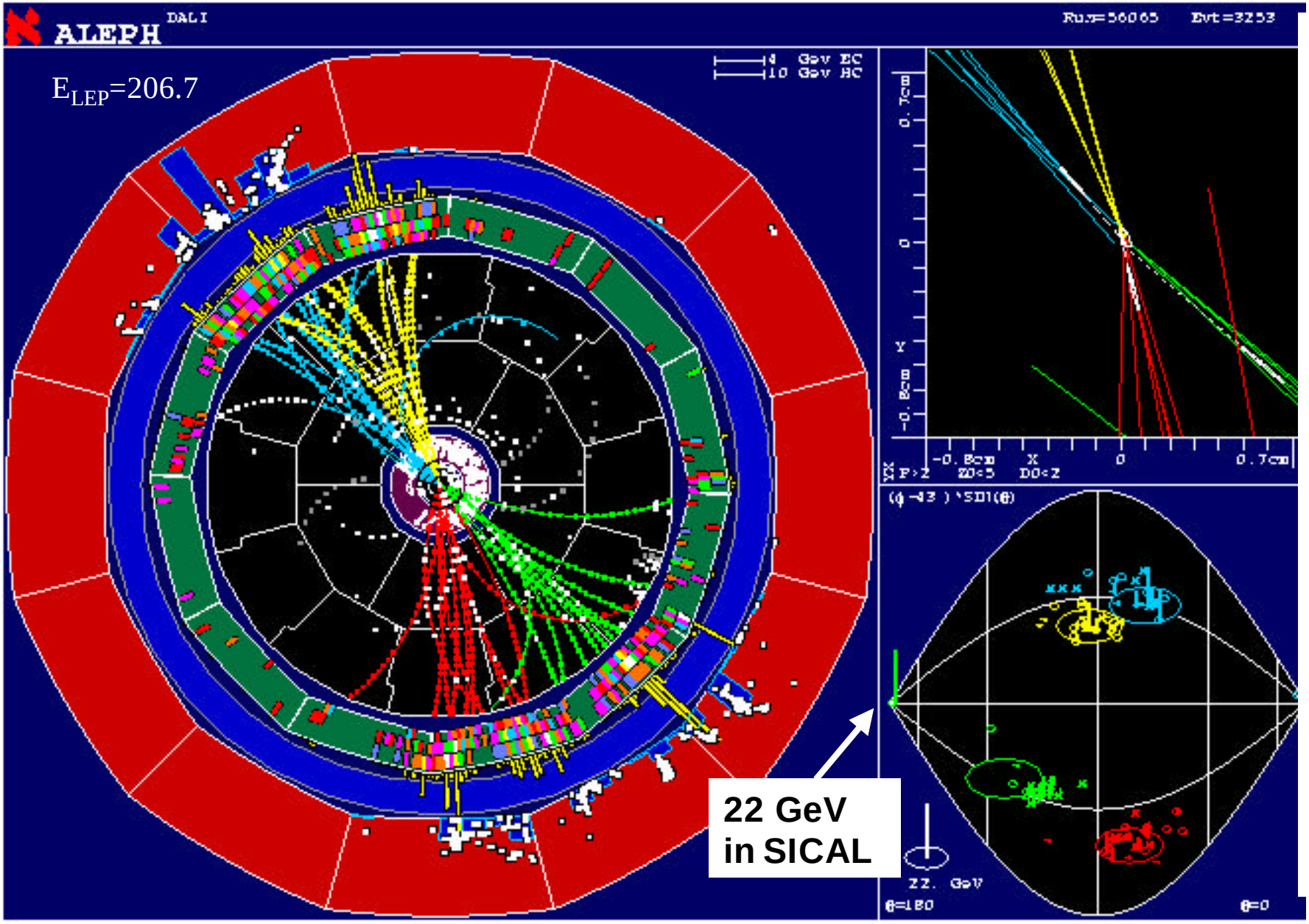
NN = 0.999

jet b-tag:

	Z
1	0.99
2	0.84
	H
3	0.99
4	0.21

kin. mass fit
m_H=109.1GeV
m_Z=92.3GeV

ZZ hyp.
m_Z=100 GeV
m_Z= 99 GeV



4 b cand.

HZ hyp.
m_H=
112.8 GeV

NN = 0.997

jet b-tag:

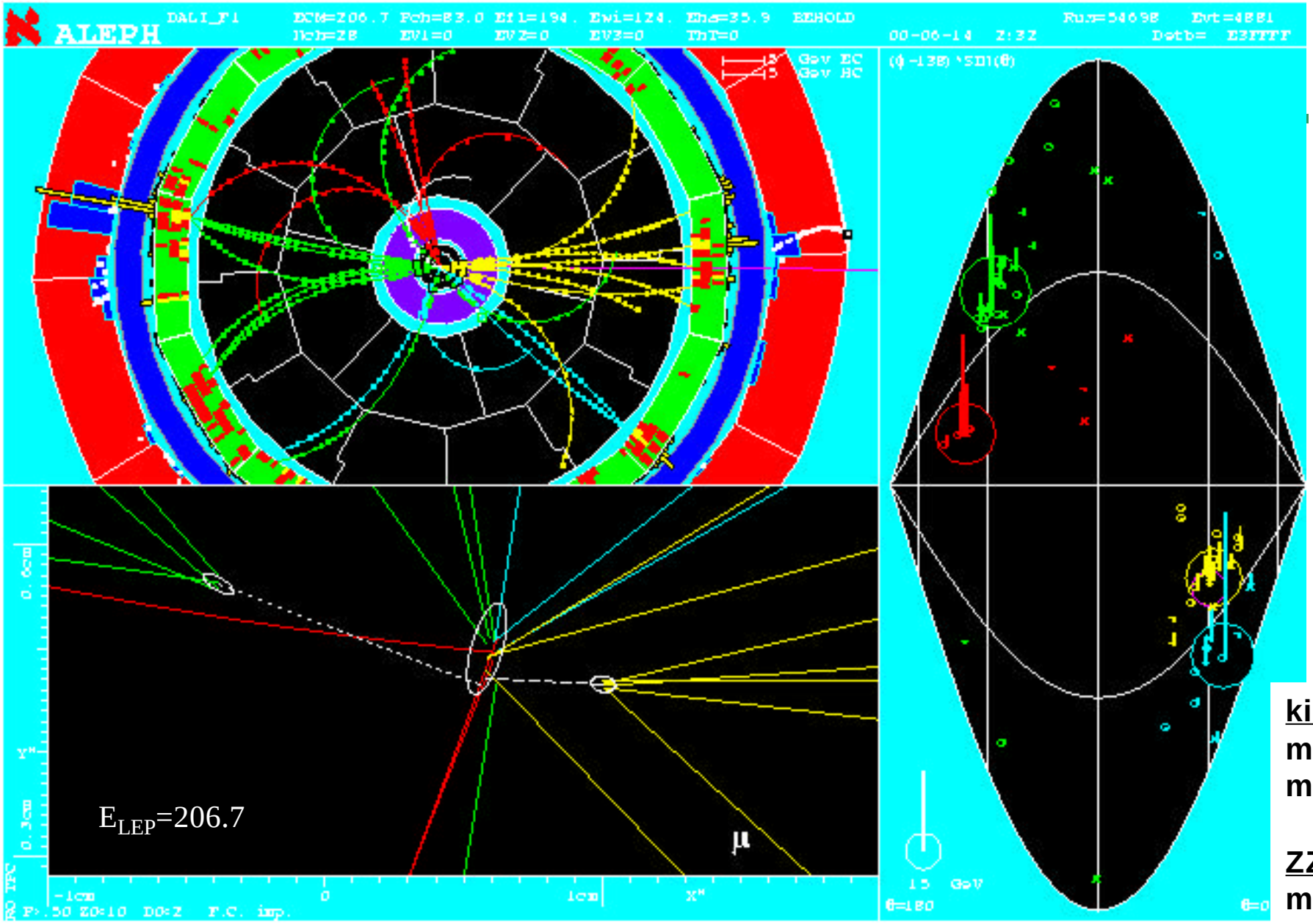
	Z
1	0.994
2	0.78
	H
3	0.993
4	0.999

Evis=
252 GeV !

very bad kin. fit!

⇒

assumption: 22 GeV in SICAL is beam related



2 b cand.

HZ hyp.
m_H=114 GeV
±3 GeV

NN = 0.996

jet b-tag:

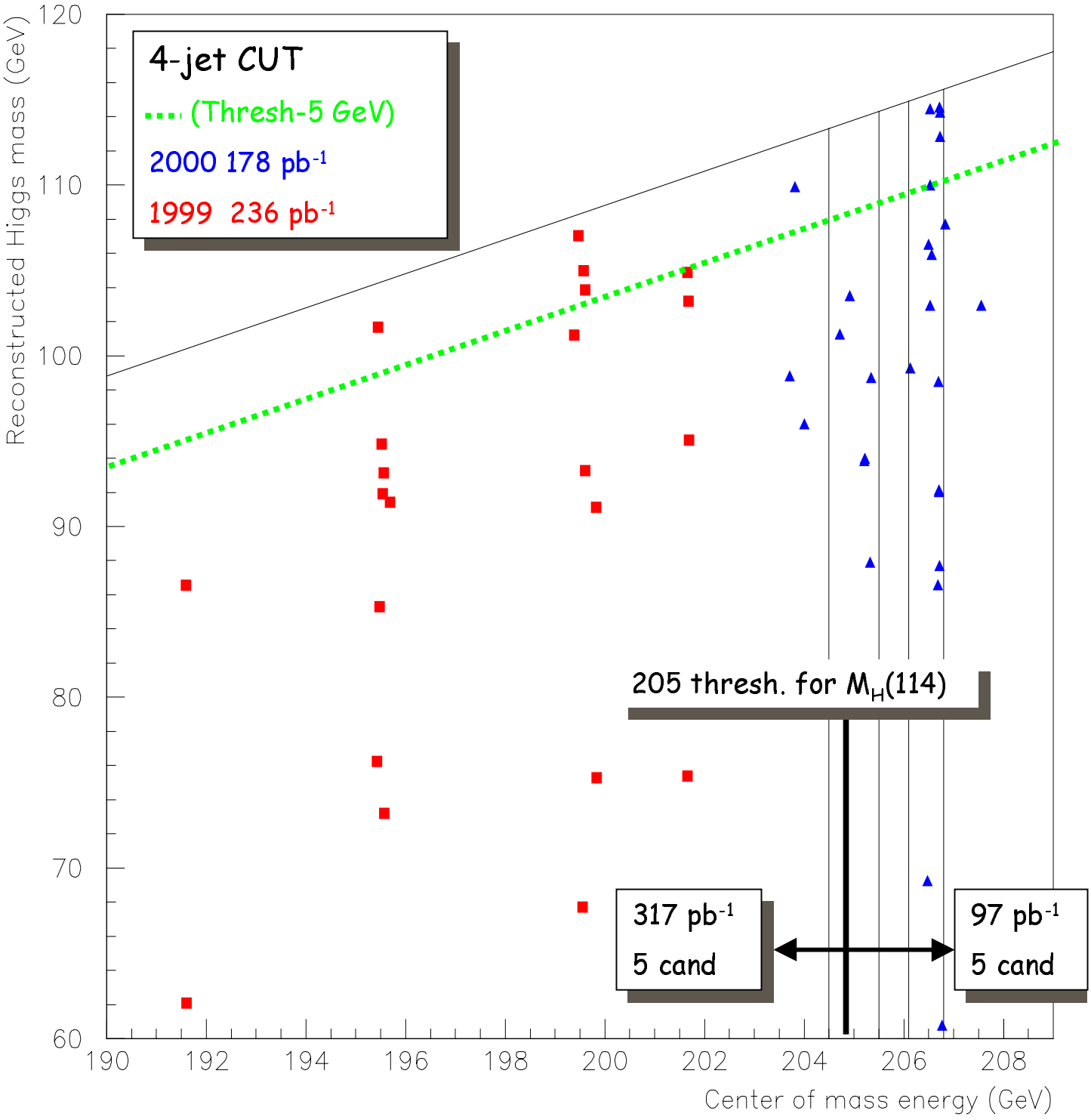
Z	
1	0.14
2	0.01
H	
3	0.99
4	0.99

kin. mass fit
m_H=112.4GeV
m_Z=93.3GeV

ZZ hyp.
m_Z=102 GeV
m_Z=91.7GeV

M_H bias cross-checks

Is there a (E_{LEP} independent) mass bias toward threshold in 4-jet channel ?



Likelihood Ratio

The Likelihood Ratio, Q, is used to evaluate compatability of the experiment with the background-only and signal+background hypotheses

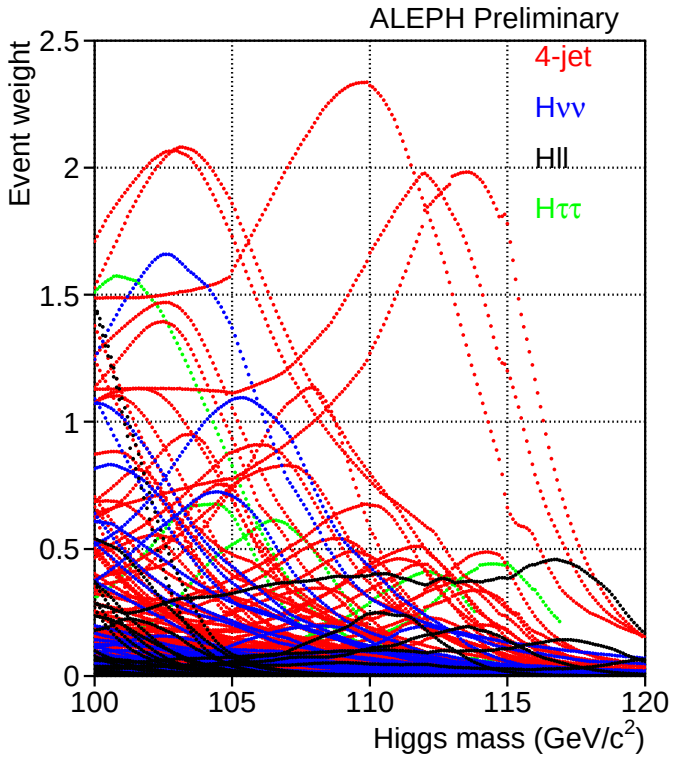
$$\ln(Q) = \ln \frac{\mathcal{L}(s+b)}{\mathcal{L}(b)} = -s + \sum Q_i$$

Where $Q_i = \ln\left(\frac{S+B}{B}\right)$ is the event weight.

Events which are very signal-like will be given large event weights, while background-like candidates will have event weights close to zero.

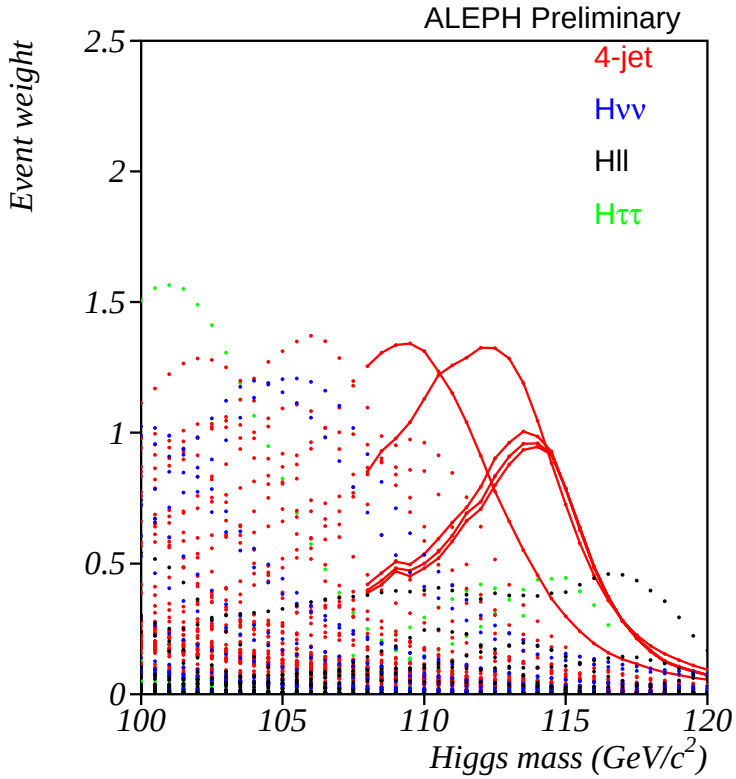
Event Weights

NN



The three large NN four jet candidates stand out clearly.

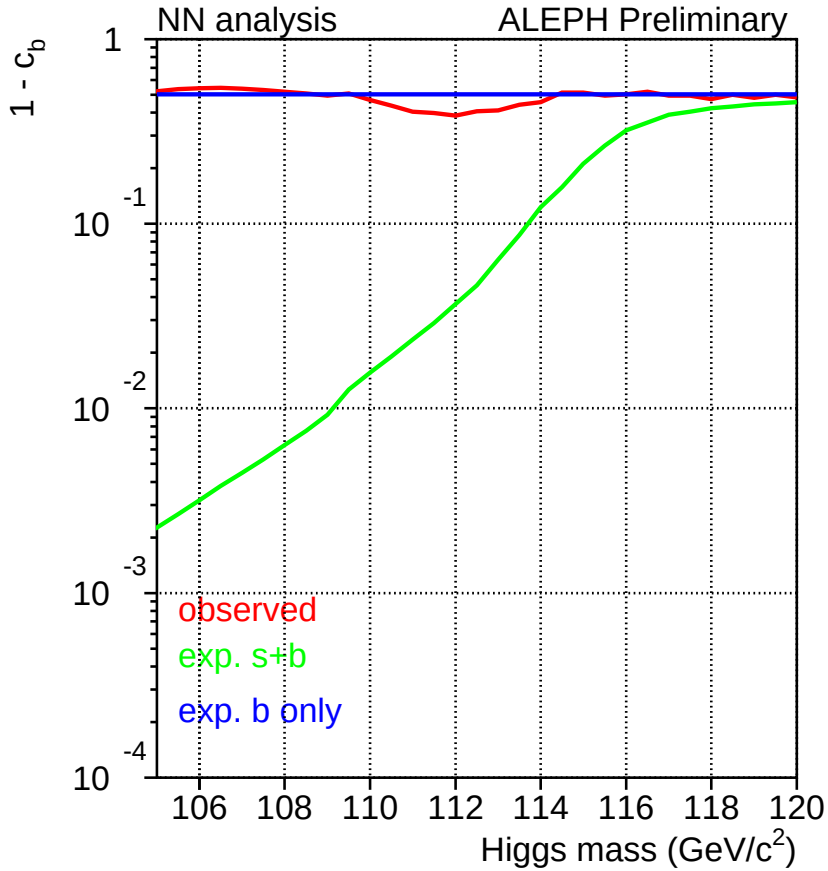
CUTS

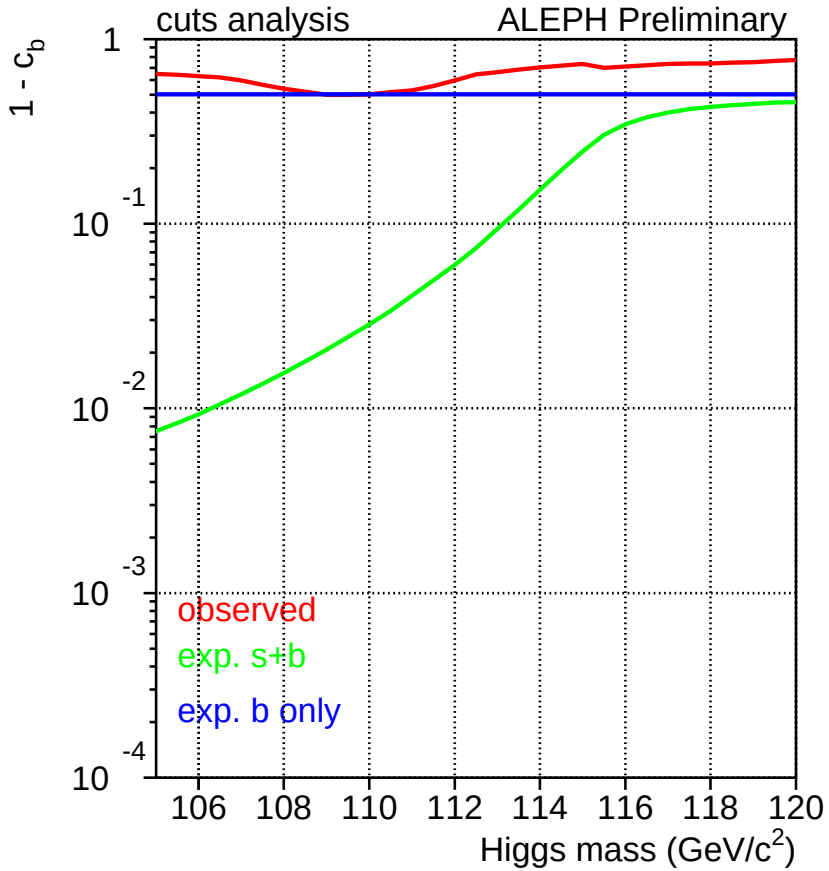


Three candidates at 114 GeV/c^2 are given same weight in CUT analysis.

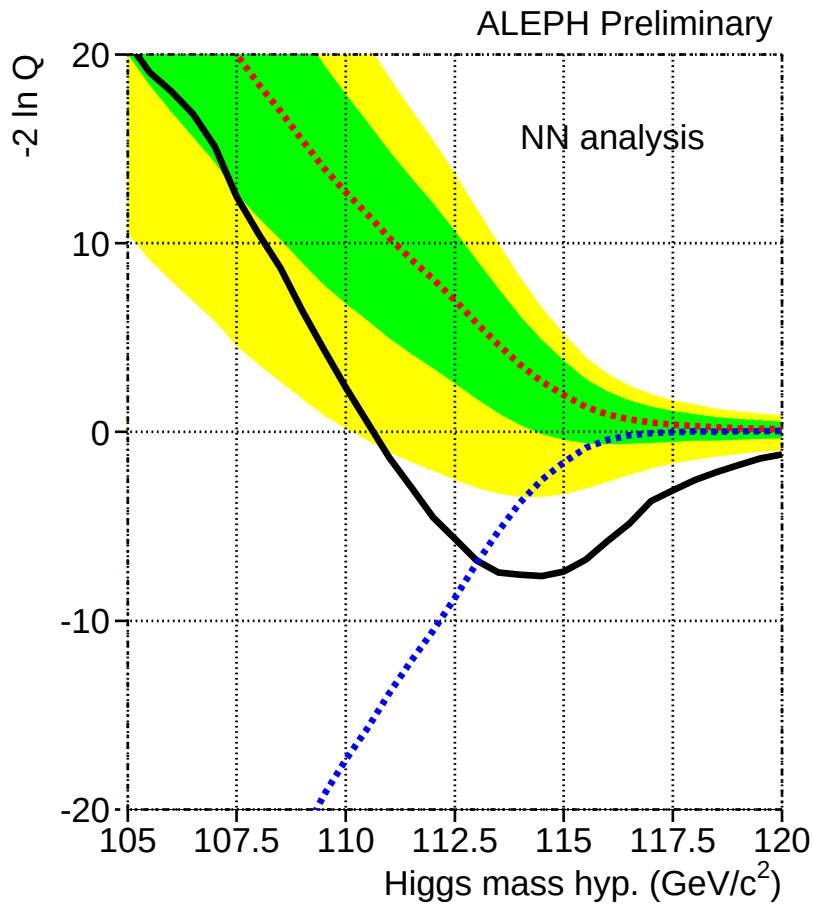
Background Consistency - After September 5

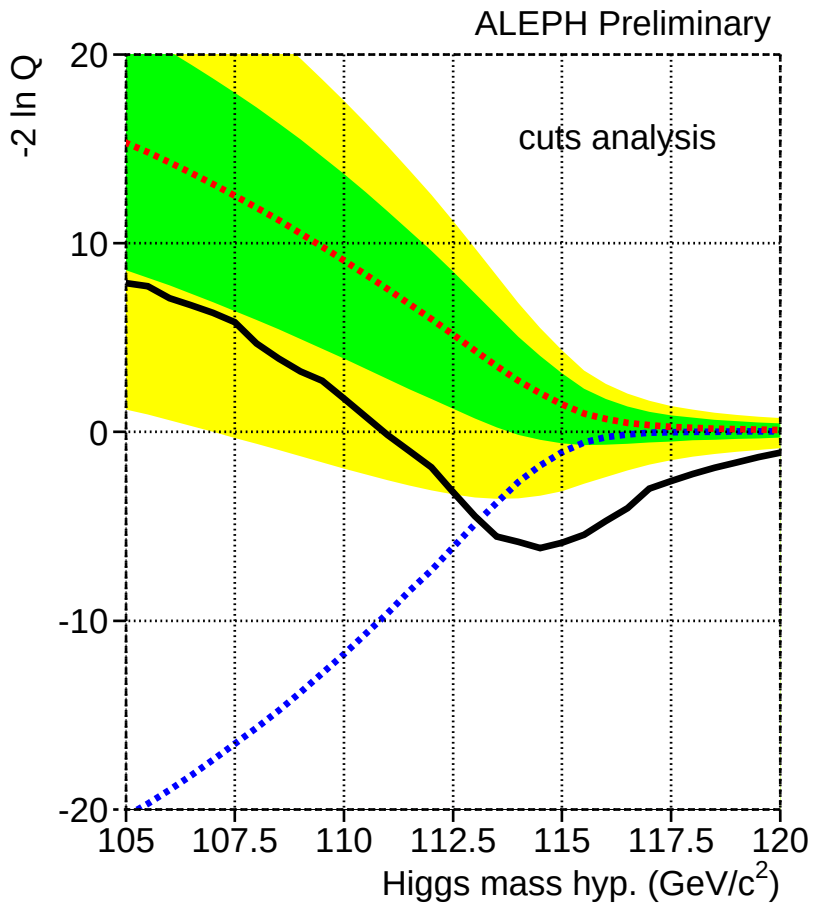
No very significant high mass candidates
were observed in the latest data–





Likelihood Ratio - Total Sample

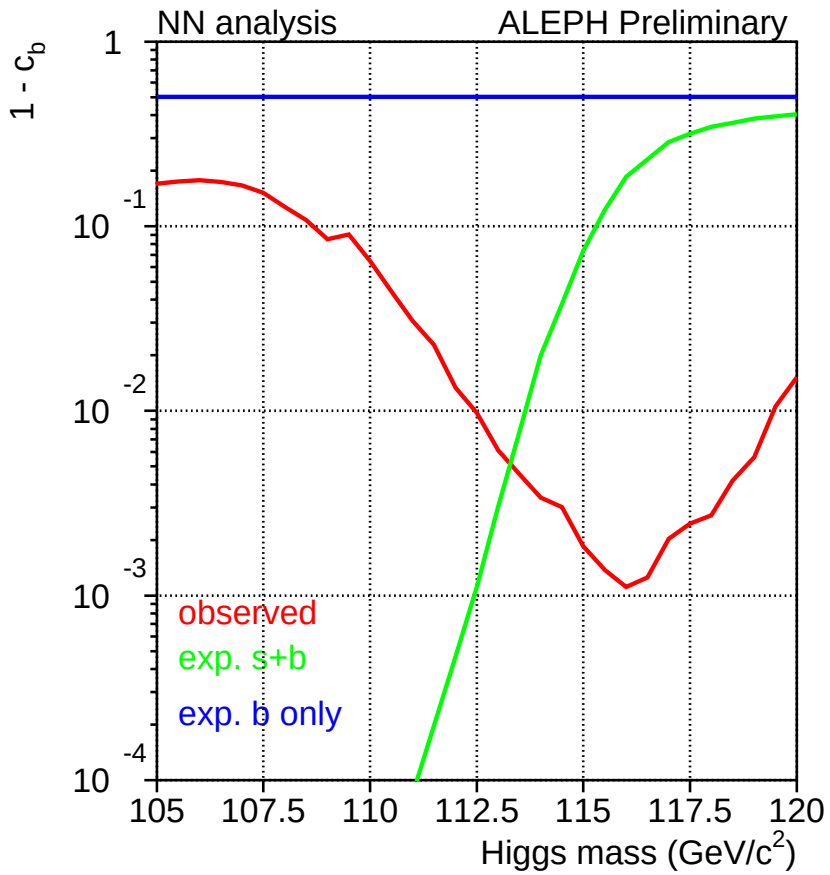




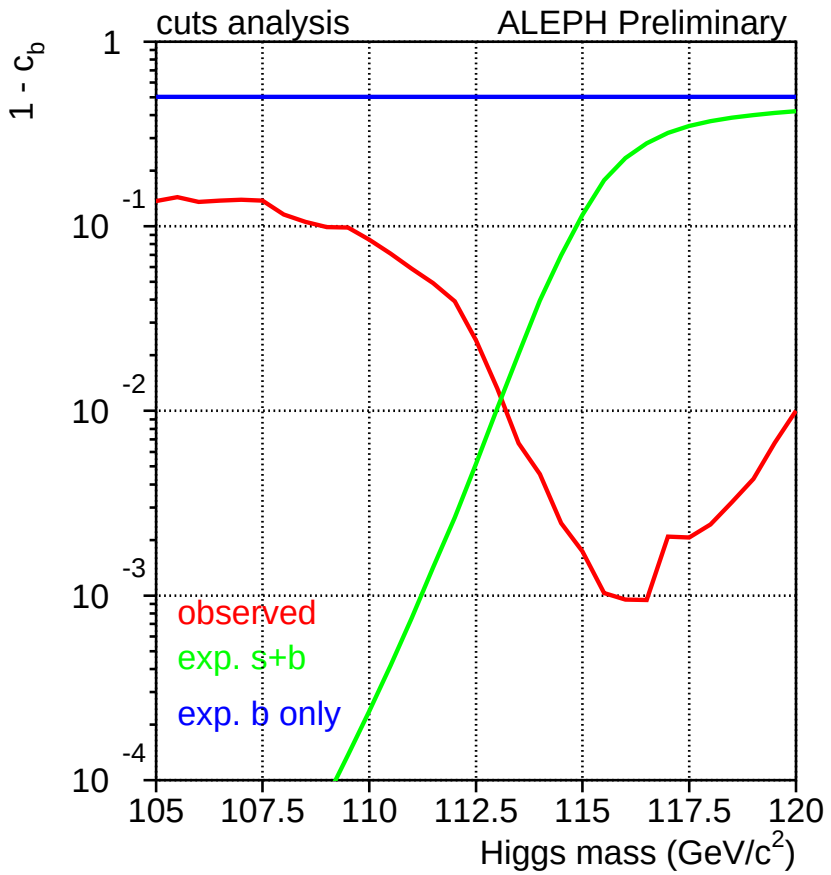
$-2\ln(Q)$ minimum for NN:
-7.5 at 114 GeV/c^2

$-2\ln(Q)$ minimum for cuts:
-6.15 at 114.5 GeV/c^2

Background Consistency - Total Sample



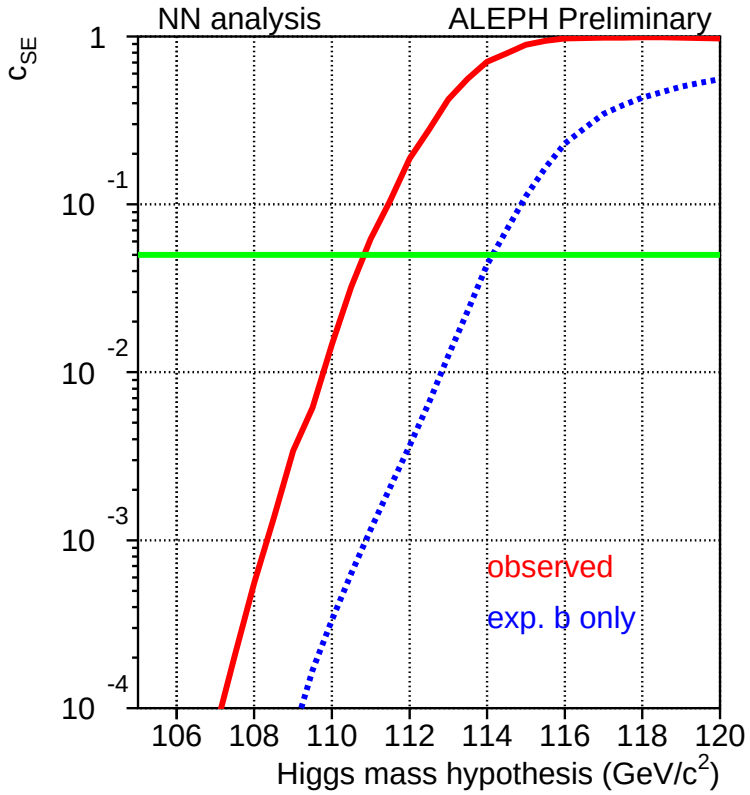
Minimum $(1 - C_b) = 1.1 \times 10^{-3}$
(equivalent to 3.3σ excess)

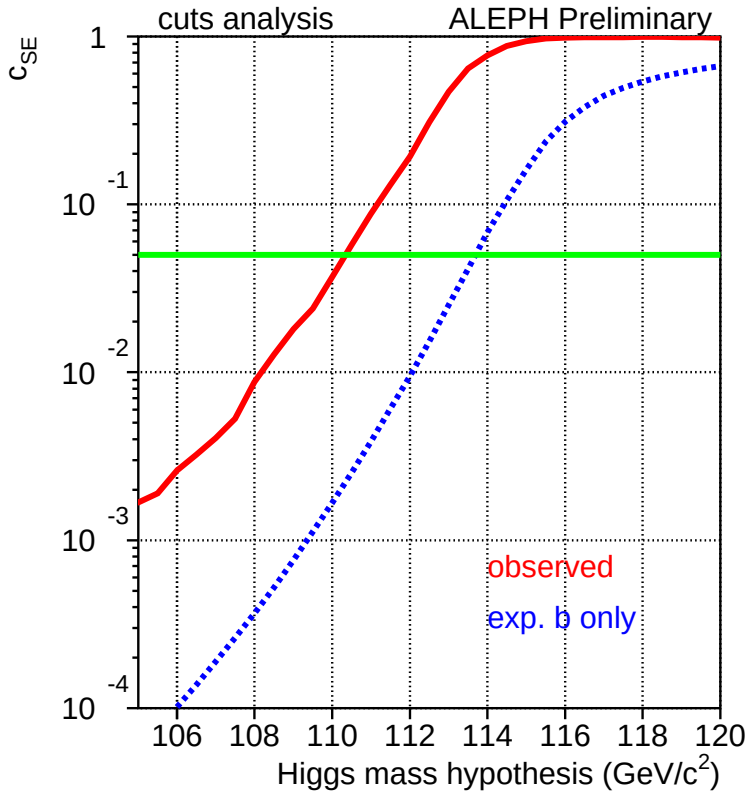


Minimum $(1 - C_b) = 9.4 \times 10^{-4}$
(equivalent to 3.3σ excess)

Exclusion Limits

Observing a large excess makes setting limits difficult!





95% Confidence Level from NN:
$M_H > 110.9$ GeV/c^2 Observed
$M_H > 114.2$ GeV/c^2 Expected

95% Confidence Level from CUTS:
$M_H > 110.4$ GeV/c^2 Observed
$M_H > 113.7$ GeV/c^2 Expected

Summary

ALEPH has analysed 209 pb^{-1} of data
with energies above $\sqrt{s} = 200$ GeV.

Three very signal-like four jet candidates
with masses above 109 GeV/c^2 were found
in two independent analyses fixed before
data taking was begun.

ALEPH data indicates an excess over Standard Model
processes consistent with a moderate (1.2σ)
upward fluctuation of a 115 GeV/c^2 signal.

The probability of observing this large an excess
from background processes is $\approx 10^{-3}(3.3\sigma)$

Conclusion

There is a good possibility that the Higgs is starting to become visible at LEP!

If this is so, then LEP has a unique opportunity, which should not be allowed to pass.

As a result of our observation, and in anticipation of the LEP result, ALEPH requests that LEP run in 2001, in order to collect ≈ 200 pb^{-1} at $\sqrt{s} \geq 208$ GeV

This would give the four experiments the potential to discover a Higgs boson around 115GeV