Search for the Fermiophobic Higgs at LEP

Jeremiah Mans
Princeton University
L3 Collaboration

Siena Seminar on the Legacy of LEP and SLC
What is the fermiophobic Higgs?

• The Standard Model postulates a minimal Higgs field with one scalar boson. The partial width of this boson to photons is very small, and for $m_H < 150$ GeV, the partial width to $WW$ and $ZZ$ is also small.

• Under extensions to the Standard Model, however, the couplings of Higgs to fermions can be suppressed and those to bosons enhanced.
2HDMs
[Two Higgs-Doublet Models]

• If we postulate two complex scalar doublets instead of one, we predict five Higgs bosons.
  – $h, H, A, H^+, H^-$

• There are four potential ways for writing the Higgs coupling to fermions. The most well known of these choices, used in the the MSSM, predicts strong couplings to the fermions.

• For another model, however, the coupling of the $h$ to fermions is suppressed by the factor $\cos \alpha$.
  – for $\alpha = \pi/2$, the coupling vanishes.
Production and Decay of a Fermiophobic Higgs

• For LEP-wide combinations, we assume the standard “Higgsstrahlung” production, where the h is produced in association with a Z.
  – hA production is also possible, but results have been published only by Delphi.

• LEP-wide, we search for the Higgs to decay to $\gamma\gamma$ through a loop.
  – L3 has also produced inputs for $h \rightarrow WW$. 

Jeremiah Mans
Princeton University
Many different fermiophobic models are possible, so the Working Group chose to assume Standard Model production rates for the Higgs, and to use the HDECAY branching ratios as a benchmark.
The Search in the Photon Channel

- Analyses must consider both the two photons from the h and fermion/antifermion pair from the Z.

- The most important background to the search is doubly-radiative Z production.
Three Physical Signatures

\[ hZ \rightarrow \gamma\gamma \; pp \quad \text{br}=70\% \]

\[ hZ \rightarrow \gamma\gamma \; \nu\nu \quad \text{br}=20\% \]

\[ hZ \rightarrow \gamma\gamma \; \ell^+\ell^- \quad \text{br}=10\% \]
$\gamma\gammaqq$ Candidate

$m_Z = 87.5 \text{ GeV}$
$m_h = 111.7 \text{ GeV}$
$E_{cm} = 205.1 \text{ GeV}$
Combined Mass Spectrum

Photonic Higgs Search
Preliminary

305 obs / 308.2 expected

- ADLO data
- SM Background
- m=100 GeV signal

Events/2 GeV

M_{\gamma\gamma} (GeV)
Combined Limit

Photonic Higgs Search
ADLO Combined
Preliminary

Excluded Region

$+2 \sigma$ expected

$-2 \sigma$ expected

Upper Limit on $B(h^0 \rightarrow \gamma\gamma)$

$\text{Limit} = 108.2 \text{ GeV}$
$\text{Expected Limit} = 109.0 \text{ GeV}$
The Search in the WW* Channel

• Six fermion final state, once the decay products of the W, W*, and Z are all accounted for.
  – Some additional signal from matching processes in ZZ*. (~20% increase in effective cross-section)

• Major backgrounds come from W pair production, Z pair production, single W processes, and qq processes.
We have developed analyses for five of the $hZ \rightarrow WW(ff)$ channels.
Mass Distribution of Selected Events

h→WW* Selection

Events/Bin

- Data
- Background
- Signal

$m_h=100$ GeV

L3 Preliminary Oct 2001

Jeremiah Mans
Princeton University
Final Discriminating Variable

Integrating down to $s/b = \frac{1}{2}$:
- Signal: 1.6
- Background: 2.0
- Data: 2

Jeremiah Mans
Princeton University
Branching Ratio Scan Against LEP $h \rightarrow \gamma\gamma$

- Combine L3 WW* with LEP $\gamma\gamma$ in a way which can be interpreted in several models.
Comparison of Expected and Observed Limits

Expected limit: **111.0 GeV** (109 GeV γγ only)
Observed limit: **108.4 GeV** (108.2 GeV γγ only)
Conclusions

• The LEP wide $\gamma\gamma$ results provide strong limits on the production of a fermiophobic Higgs.

• With the WW* (and ZZ*) channels, we have the results to study the whole range of potential fermiophobic models at LEP.

• No signal observed up to $m_h=108.4$ GeV.
  – (with sensitivity up to 111 GeV)