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.

Jeremiah Mans
Princeton University

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.

Jeremiah Mans
Princeton University

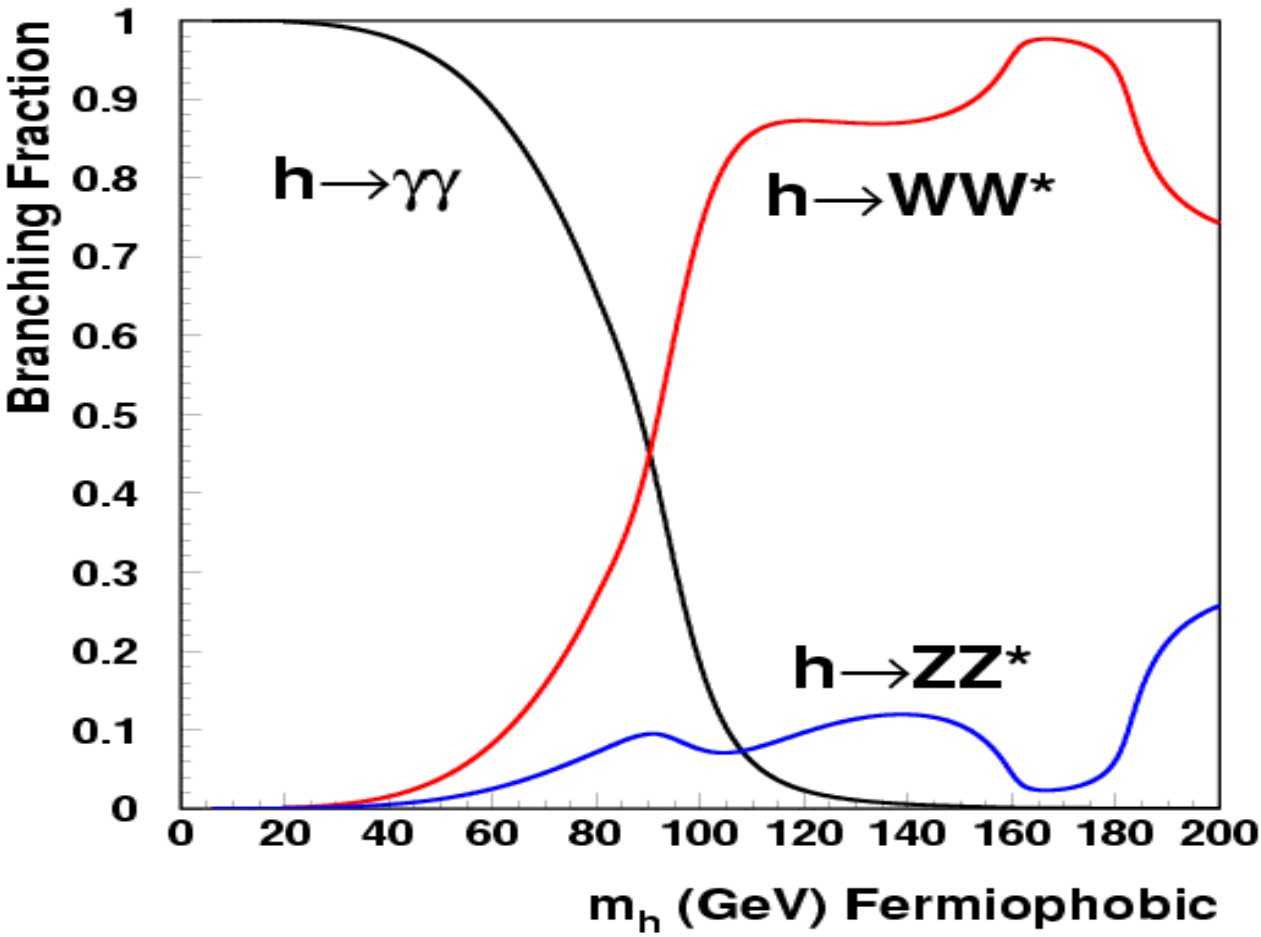
Production and Decay of a Fermiophobic Higgs

- 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

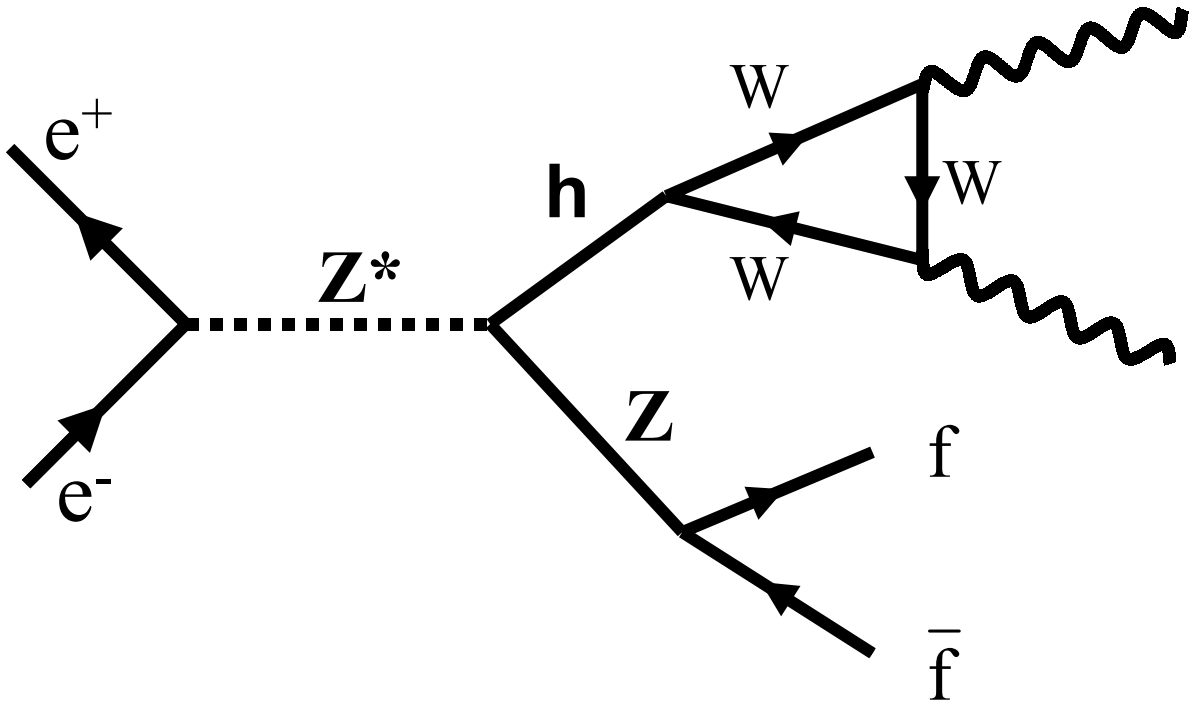
The Benchmark Fermiophobic Model



- 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

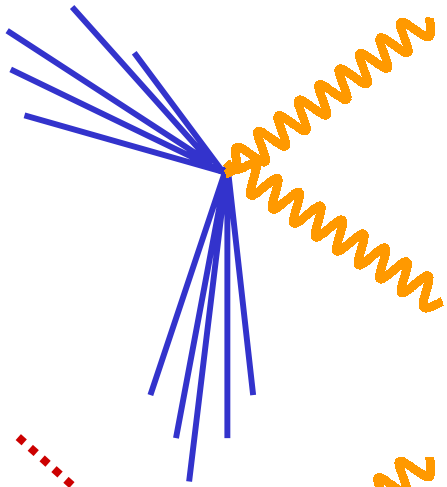
- Analyses must consider both the two photons from the h and fermion/antifermion pair from the Z.



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

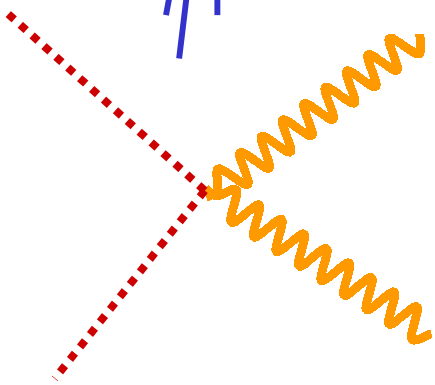
Jeremiah Mans
Princeton University

Three Physical Signatures



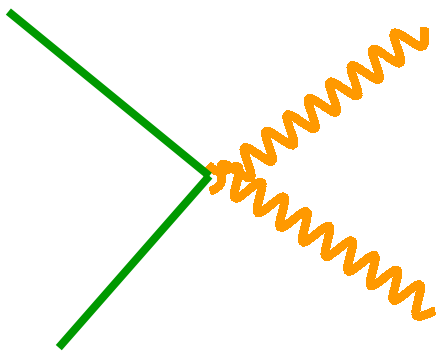
$$hZ \rightarrow \gamma\gamma\, qq$$

br=70%



$$hZ \rightarrow \gamma\gamma\, \nu\nu$$

br=20%

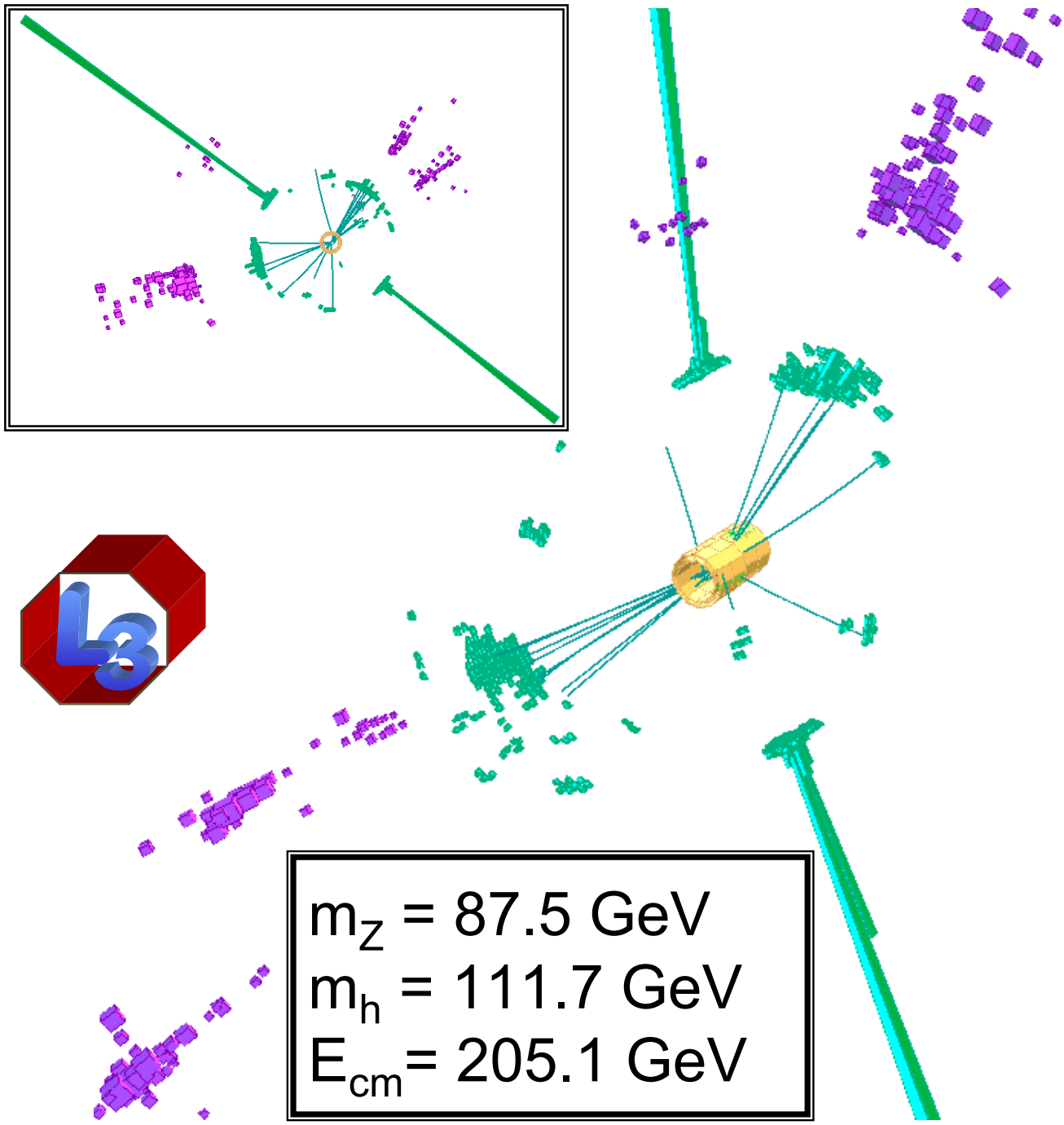


$$hZ \rightarrow \gamma\gamma\, \ell^+\ell^-$$

br=10%

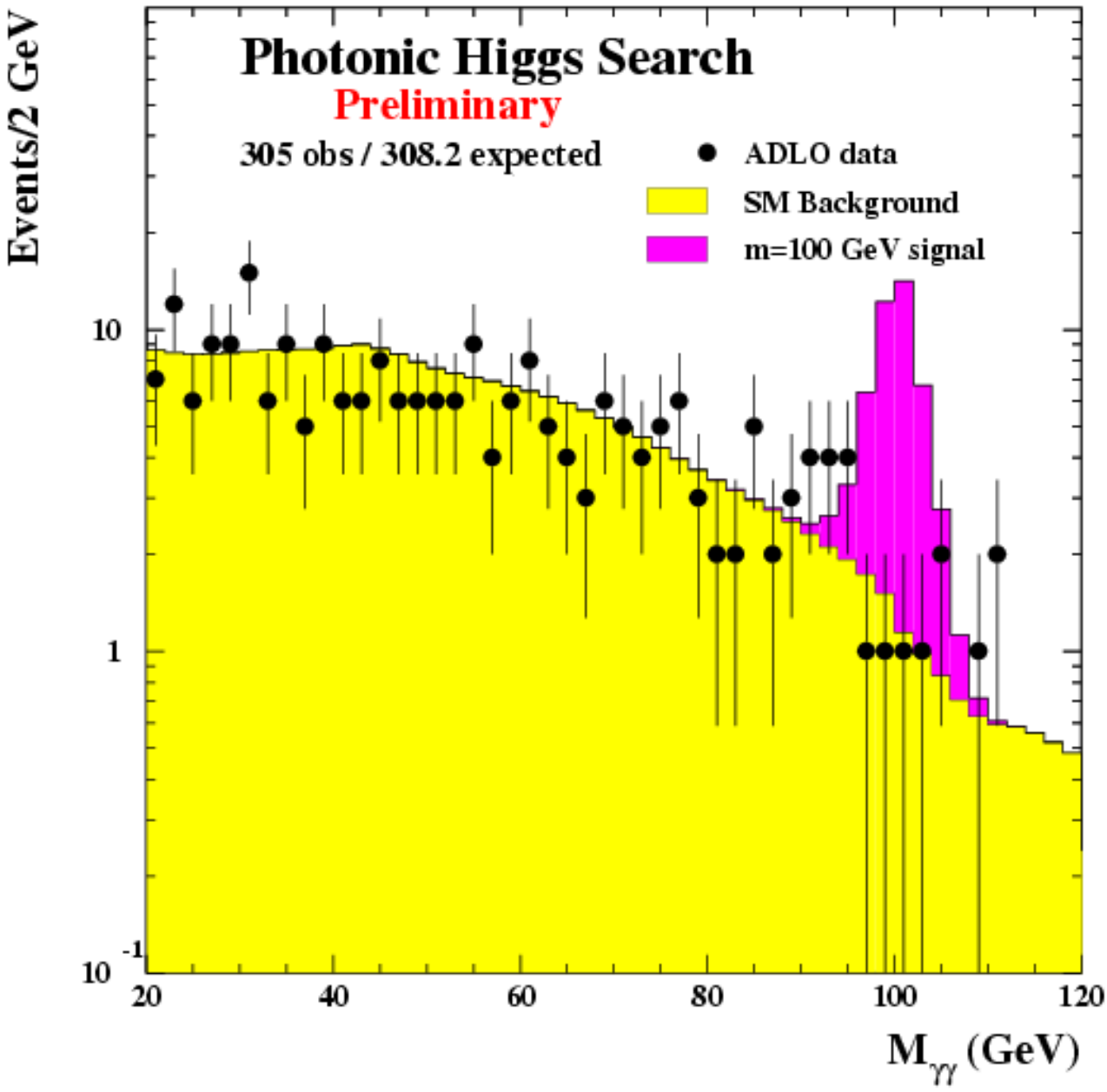
Jeremiah Mans
Princeton University

γγqq Candidate



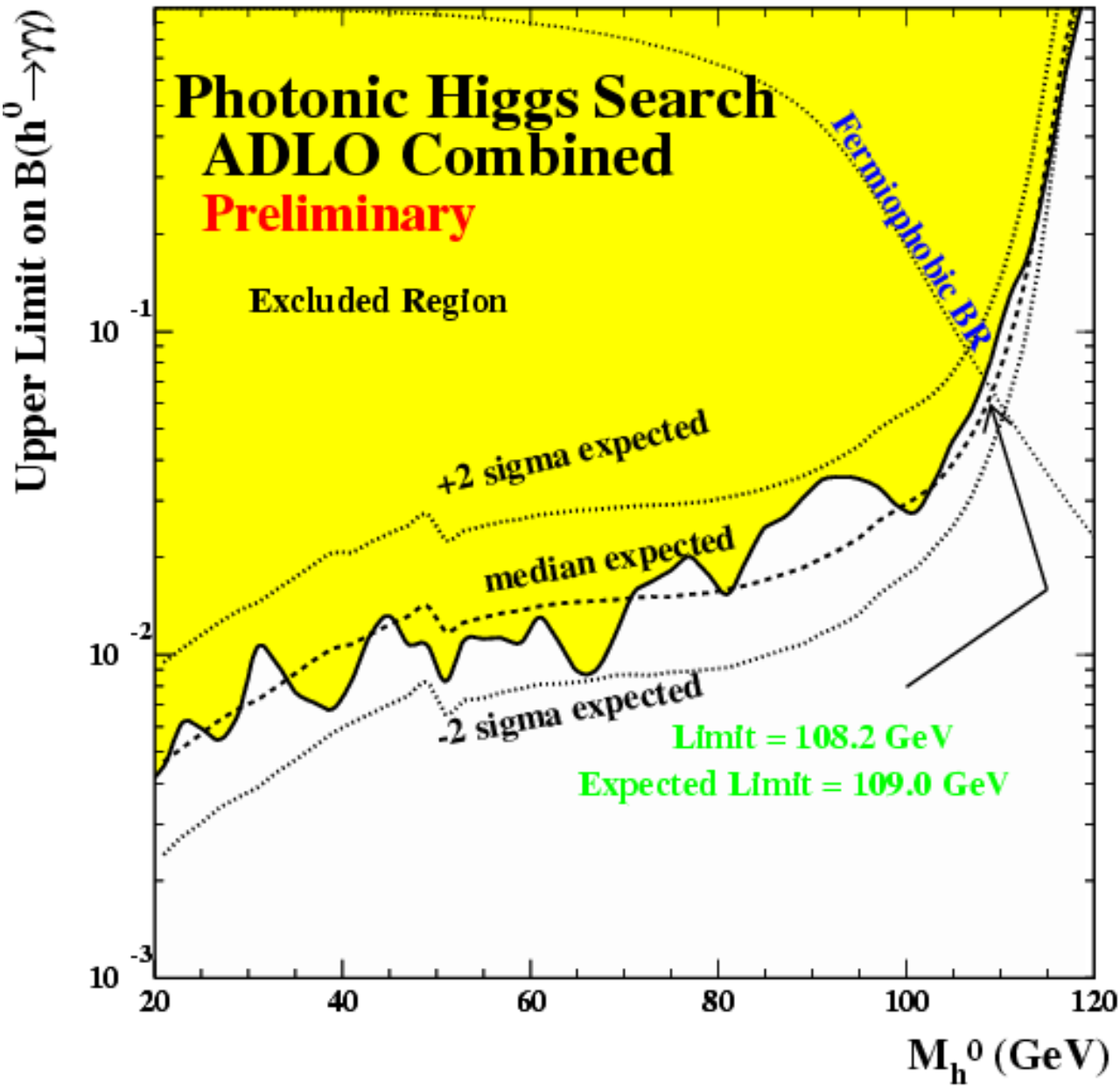
m_Z = 87.5 GeV
m_h = 111.7 GeV
E_{cm} = 205.1 GeV

Combined Mass Spectrum



Jeremiah Mans
Princeton University

Combined Limit



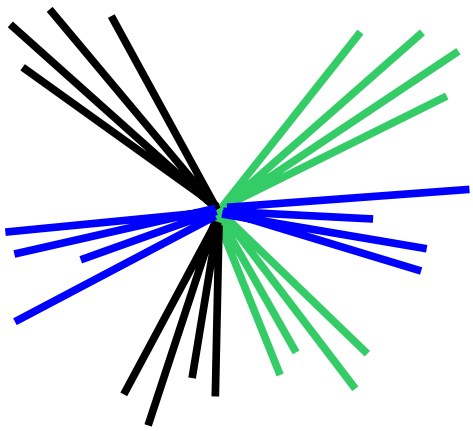
Jeremiah Mans
Princeton University

The Search in the WW* Channel

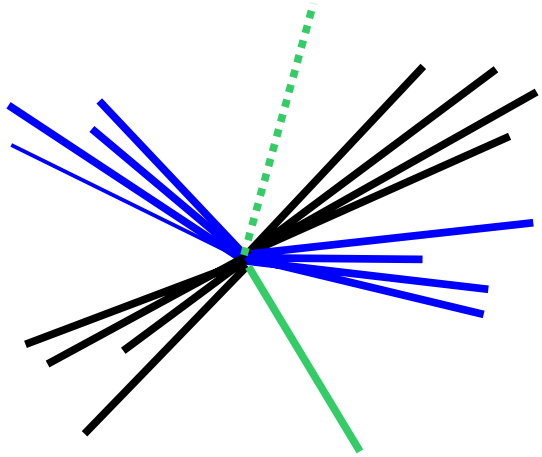
- Six fermion final state, once the decay products of the W,W*, and Z are all accounted for.
  - Some additional signal from matching processes in ZZ*. (~20% increase in effective cross-section)

- Major backgrounds come from W pair production, Z pair production, single W processes, and qq processes.

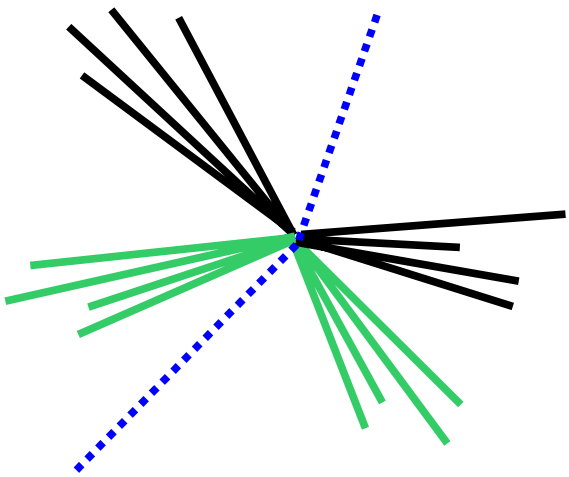
Jeremiah Mans
Princeton University



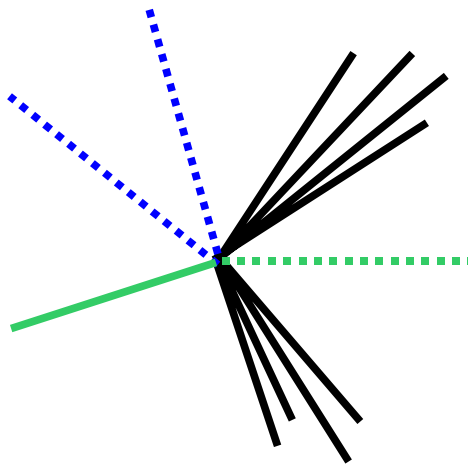
qqqq(qq) [33%]



qqlν(qq) [30%]

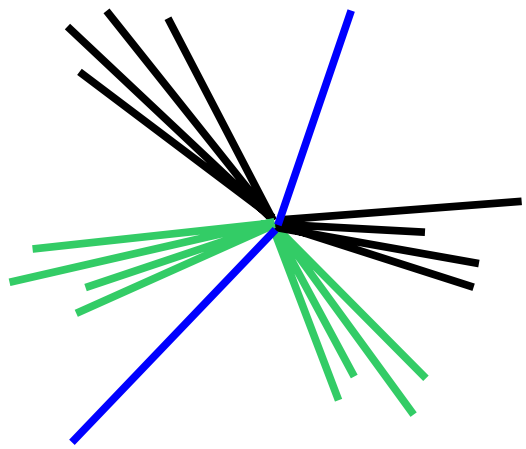


qqqq(νν) [10%]



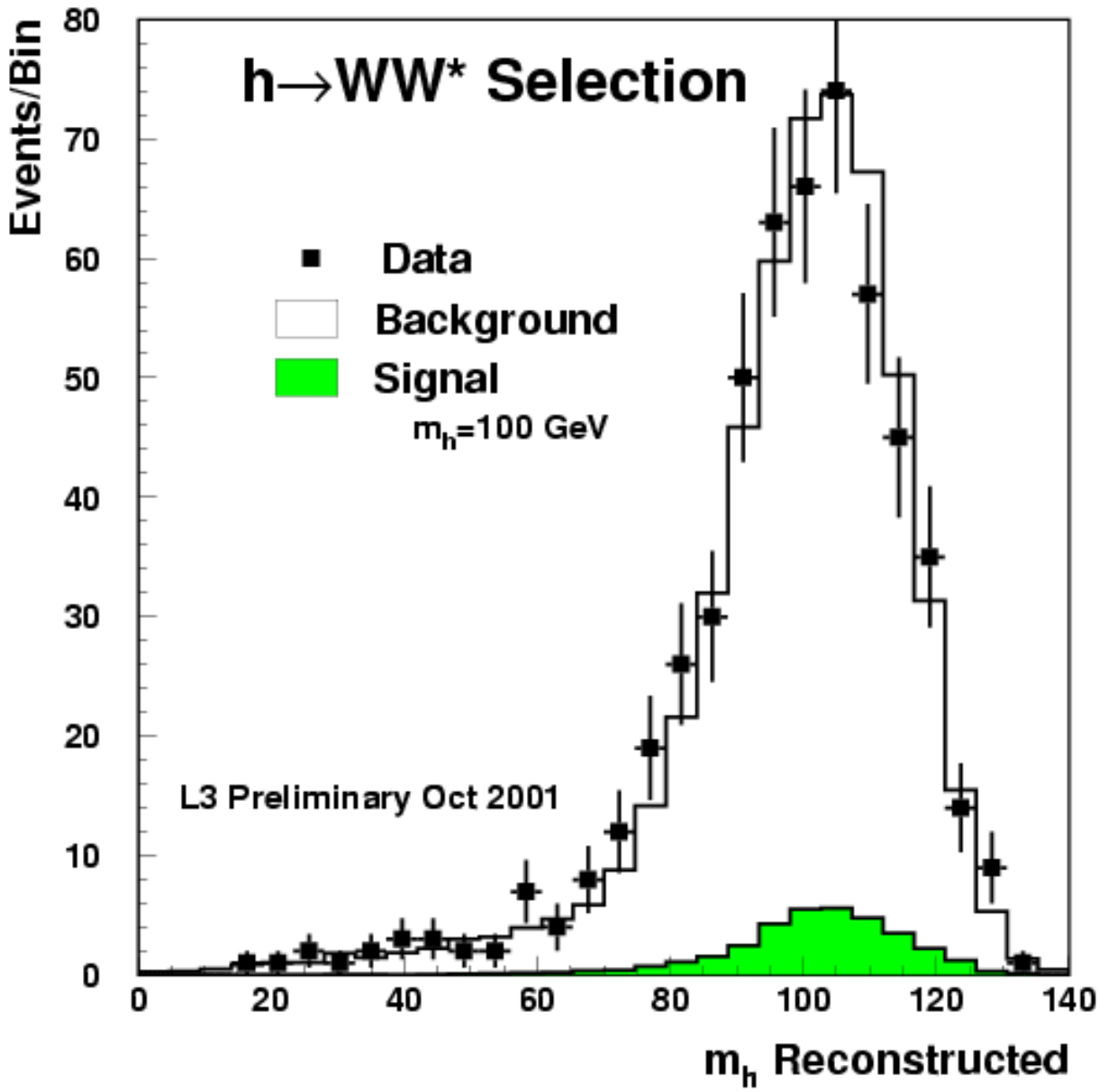
qqlν(νν) [9%]

We have developed analyses for five of the hZ → WW(ff) channels.



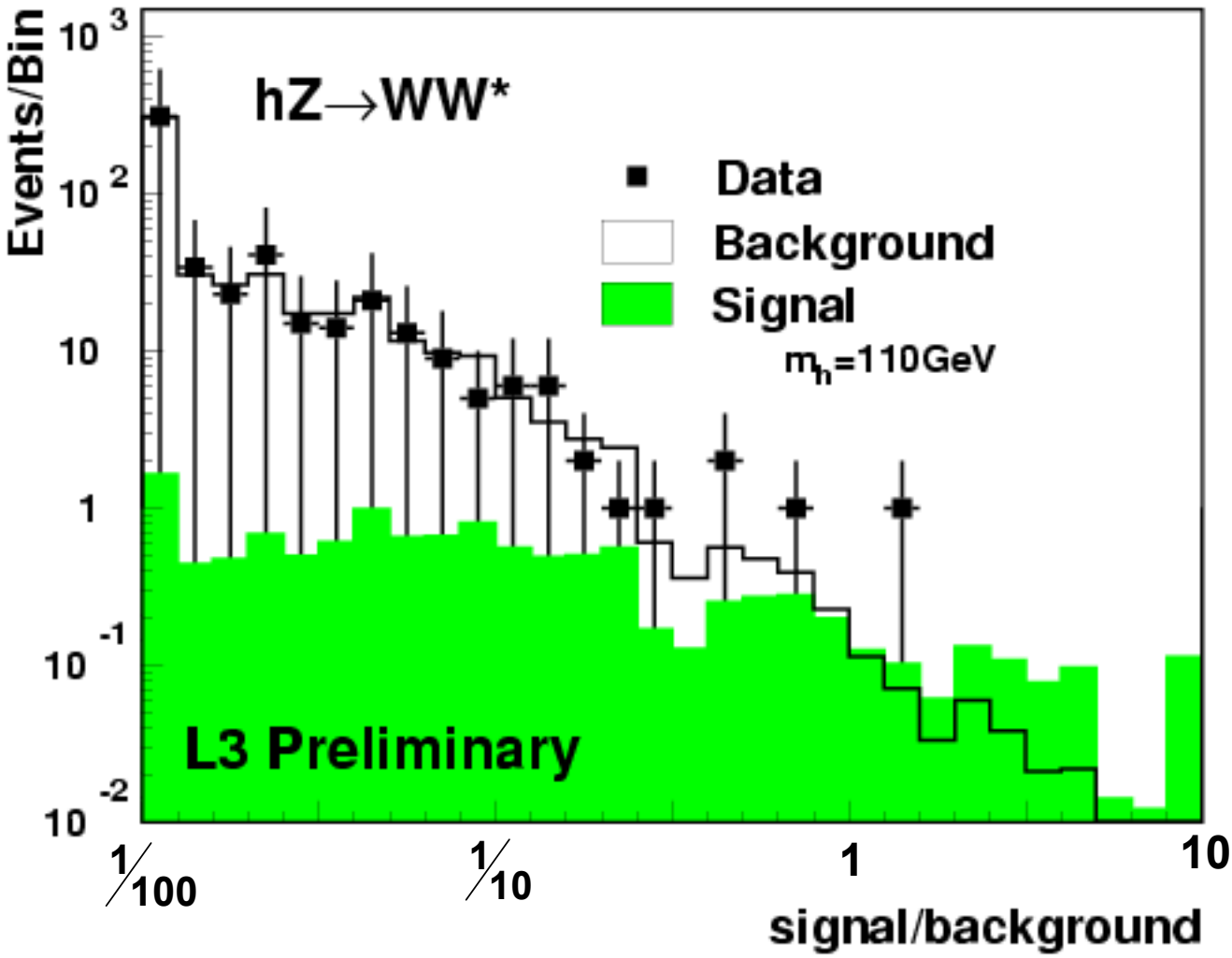
qqqq(ll) [6%]

Mass Distribution of Selected Events



Jeremiah Mans
Princeton University

Final Discriminating Variable

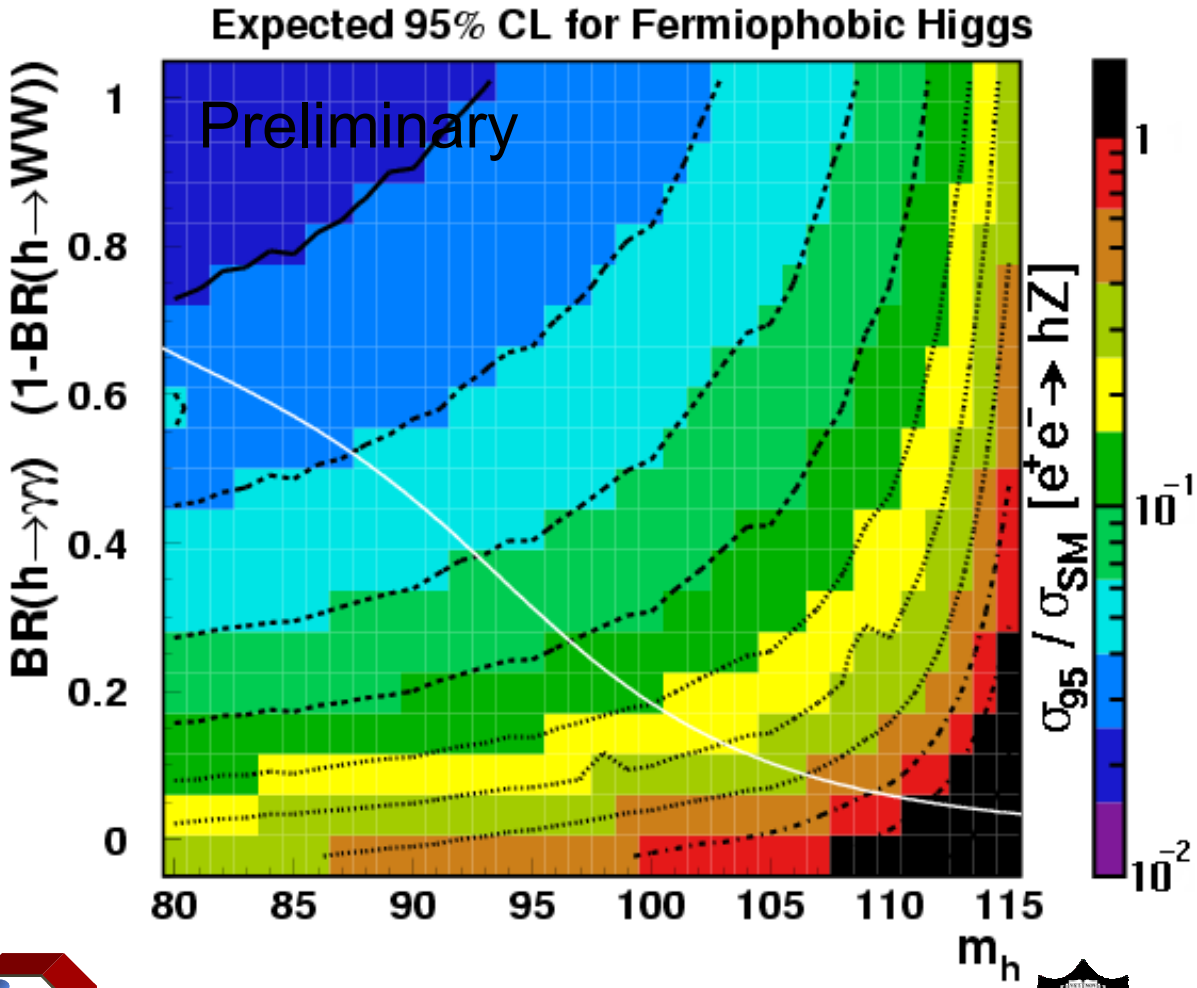


Integrated down to s/b = ½ :	Signal:	1.6
	Background:	2.0
	Data:	2

Jeremiah Mans
Princeton University

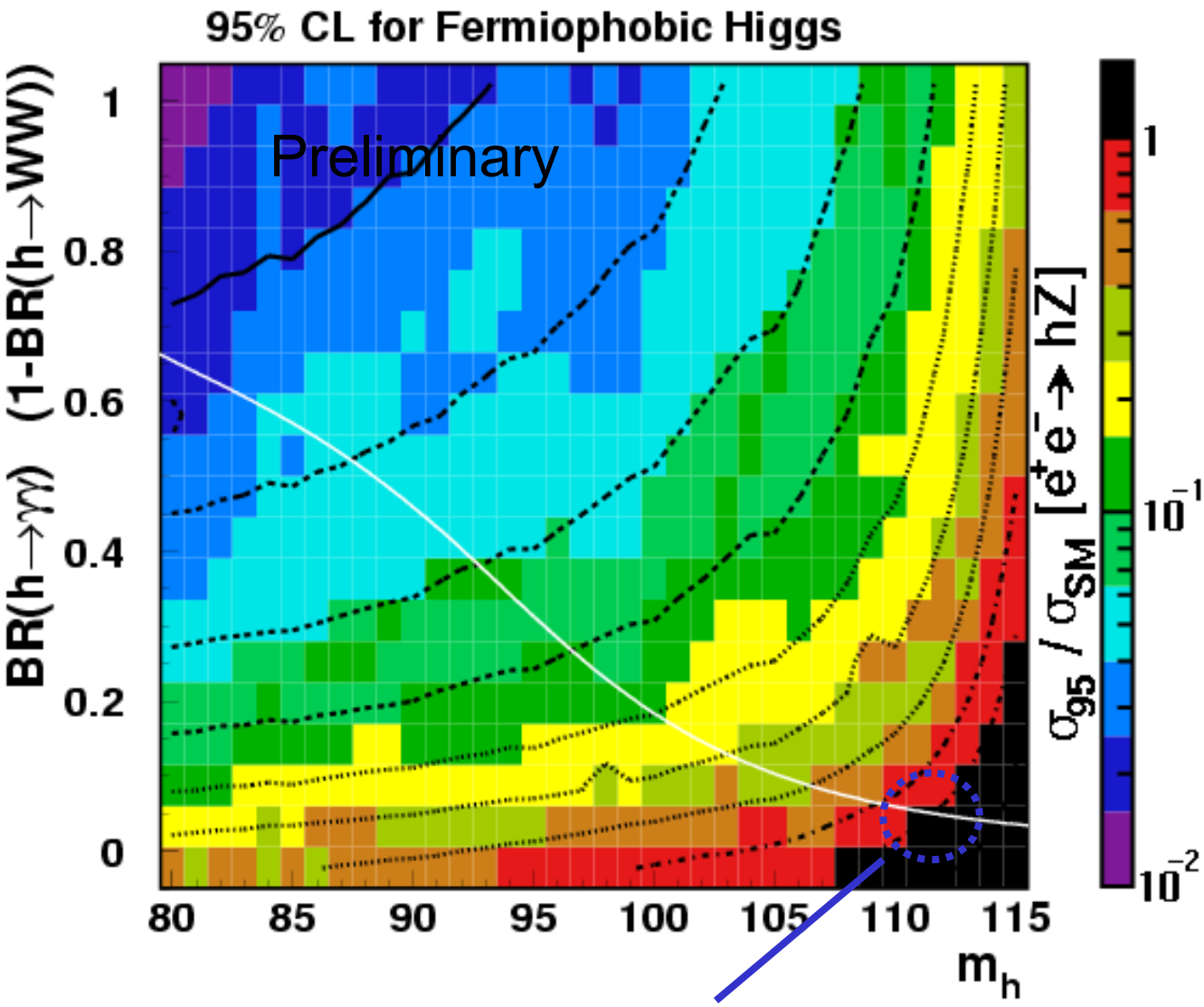
Branching Ratio Scan Against LEP $h \rightarrow \gamma\gamma$

- Combine L3 WW* with LEP $\gamma\gamma$ in a way which can be interpreted in several models.



Jeremiah Mans
Princeton University

Comparison of Expected and Observed Limits



Expected limit: **111.0 GeV** (109 GeV $\gamma\gamma$ only)

Observed limit: **108.4 GeV** (108.2 GeV $\gamma\gamma$ only)

Jeremiah Mans
Princeton University

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)

Jeremiah Mans
Princeton University