Search for a fermiophobic Higgs at LEP 2 (update)

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Abstract

Higgs bosons decaying into two photons were searched for in the data collected with the DELPHI detector at centre-of-mass energies ranging from 183 to 209 GeV, corresponding to a total integrated luminosity of nearly 650 pb^{-1}. Upper limits on the cross-section of the process $e^+e^- \rightarrow h^0 Z^0$ with h^0 decaying to photons were derived as a function of the Higgs boson mass. Assuming SM couplings of the Higgs to gauge bosons but no coupling to fermions, a lower mass limit of 104.1 GeV/c^2 is obtained at 95% CL.

1 Introduction

This note is an update of the analysis reported in [1]. It presents results of the search for a fermiophobic Higgs boson, produced in association with a Z^0 and decaying into two photons.

The data collected with the DELPHI detector at centre-of-mass energies ranging from 183 to 209 GeV, and corresponding to a total integrated luminosity of about 650 pb^{-1}, were analysed. All the possible decays of the Z^0 boson were considered, leading to $q\bar{q}\gamma\gamma$, $\nu\bar{\nu}\gamma\gamma$ and $l^+l^-\gamma\gamma$ final states.

The final analyses of $q\bar{q}\gamma\gamma$ and $l^+l^-\gamma\gamma$ were unchanged with the respect to the ones described in [1], but new data samples were included. For $q\bar{q}\gamma\gamma$, the main change in the results is due to the change of the $q\bar{q}(\gamma)$ background generator from Pythia [2] to KK2f [3] – with a more detailed description of initial state radiation. Two more events were found in the 189 GeV data, due to the change to the final processing.

The $\nu\bar{\nu}\gamma\gamma$ analysis is very similar to that of [1], but some of the criteria have undergone slight changes. The most relevant one was the constraint on the quality of the kinematic fit imposing the missing mass to be equal to M_{Z^0}, the $\chi^2/ndof$ was required to have a maximum value of 5, instead of 10. Signal selection efficiency and number of expected background events are stable with respect to the previous version. Concerning the data, one more event was found (in the 202 GeV data set) and two events were lost (from the 189 GeV and 200 GeV data sets).

2 Results

A good agreement between data and SM expectations was found, with a total of 54 events selected and 51 $\pm$1 expected. The detailed numbers per channel and centre-of-mass energy are shown in table 1.

$\sqrt{s}$ (GeV)	$\mathcal{L}$ (pb^{-1})	$q\bar{q}\gamma\gamma$ DATA	MC	$\nu\bar{\nu}\gamma\gamma$ DATA	MC	$l^+l^-\gamma\gamma$ DATA	MC
183	49	4	2.64 ±0.12	2	1.59 ±0.65	–	–
189	153	8	6.85 ±0.33	5	4.82 ±0.55	1	1.70 ±0.44
192	26	0	1.17 ±0.05	1	0.93 ±0.13	0	0.27 ±0.07
196	77	4	3.24 ±0.15	2	2.29 ±0.26	2	0.62 ±0.15
200	85	4	3.15 ±0.15	2	2.31 ±0.24	0	0.60 ±0.15
202	42	3	1.66 ±0.08	1	0.99 ±0.15	0	0.25 ±0.07
205	78	3	3.13 ±0.10	2	2.46 ±0.16	0	0.61 ±0.16
206.5	55	3	2.20 ±0.10	4	1.58 ±0.53	0	0.29 ±0.07
207	84	3	3.11 ±0.14	0	2.49 ±0.16	0	0.69 ±0.17
TOT	647	32	27.2 ±0.5	19	19 ±1	3	5.0 ±0.6

Table 1: Selected data and background expectations for the three topologies and all data samples considered. The errors on the background are from MC statistics.

Limits on the production cross-section of h^0Z^0 with $h^0 \to \gamma\gamma$ were obtained combining all channels. Figure 1 shows the 95% CL upper limit on the ratio of the h^0Z^0 production

cross-section to the Standard Model (SM) one, multiplied by the branching ratio $\mathrm{BR}(h^0 \to \gamma\gamma)$, as a function of the Higgs boson mass. The cross-section ratio is constant (equal to $\sin^2(\alpha - \beta)$) in the fermiophobic 2HDM model [4]. For this model and the range of masses studied, the width of the higgs boson is always below the mass resolution of the analysis.

In a model where the Higgs couplings to bosons have SM values, but the couplings to fermions vanish, a 95% CL limit on the Higgs boson mass (given by the intersection of the cross-section limit with the BR curve, also shown in figure 1) is set at 104.1 GeV/c^2, while the expected limit is of 104.6 GeV/c^2.

3   Conclusions

Around 650 pb^{-1} of LEP2 data, corresponding to centre-of-mass energies ranging from 183 to 209 GeV, were analysed in the search for $h^0 Z^0$ production with subsequent decay of the Higgs boson to two photons. All possible Z^0 decays were analysed.

A good agreement with the SM expectations was found and limits were set on the production cross-section and $\mathrm{BR}(h^0 \to \gamma\gamma)$ for masses between 10 and 115 GeV/c^2.

References

[1] S. Andringa *et al*, "Search for a fermiophobic Higgs at LEP 2", DELPHI-2001-073 CONF 501 (2001)

[2] T. Sjöstrand, Comp. Phys. Comm. **135** (2001) 238

[3] S. Jadach and B.F.L. Ward and Z.Wąs, Comp. Phys. Comm. **130** (2000) 260

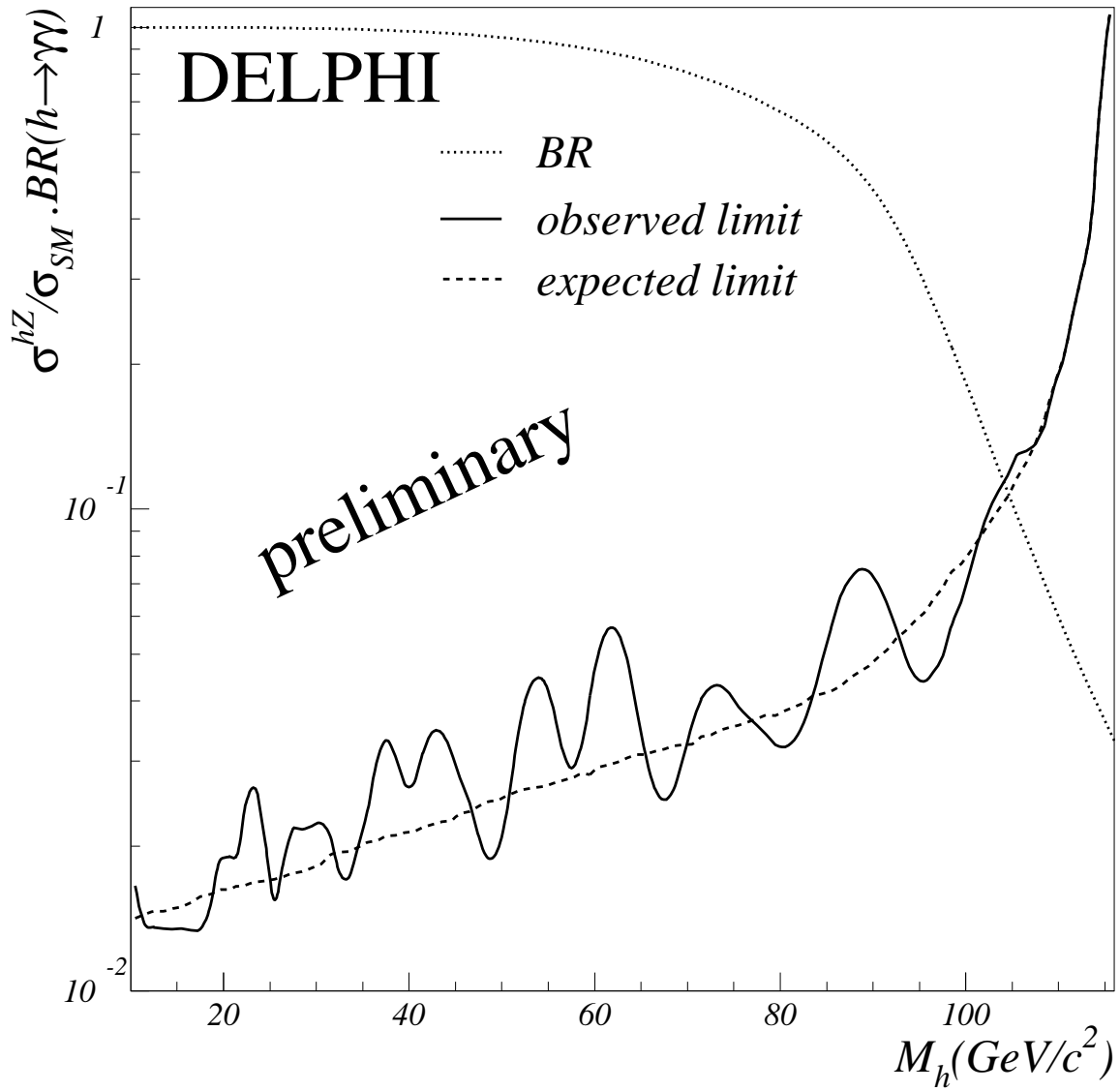[4] A. Barroso, L. Brücher, R. Santos, Phys. Rev. **D60** (1999) 035005

Figure 1: 95% CL limit on the $h^0 Z^0$ production cross-section normalized to the SM value $\times$ BR($h \to \gamma\gamma$). The observed limit (full line) and the expected limit (dashed line) are shown. Also shown is the fermiophobic BR (dotted line), obtained by keeping the SM couplings of the Higgs to boson pairs and setting the $h^0 f\bar{f}$ couplings to 0.