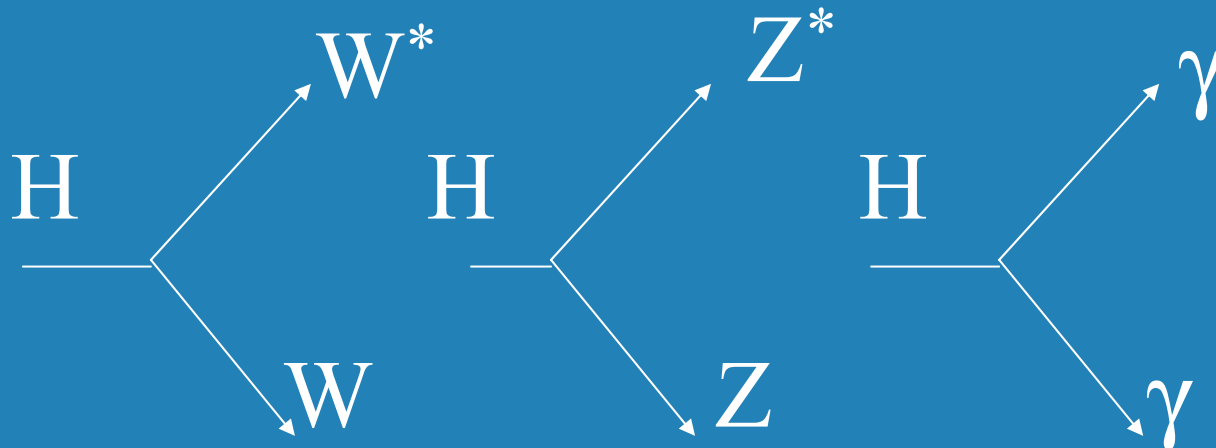
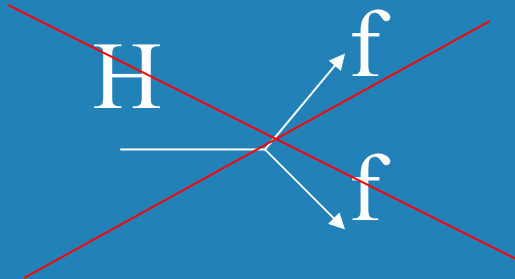


Searching for fermiophobic HIGGS in OPAL data.

What is the femiophobic Higgs.

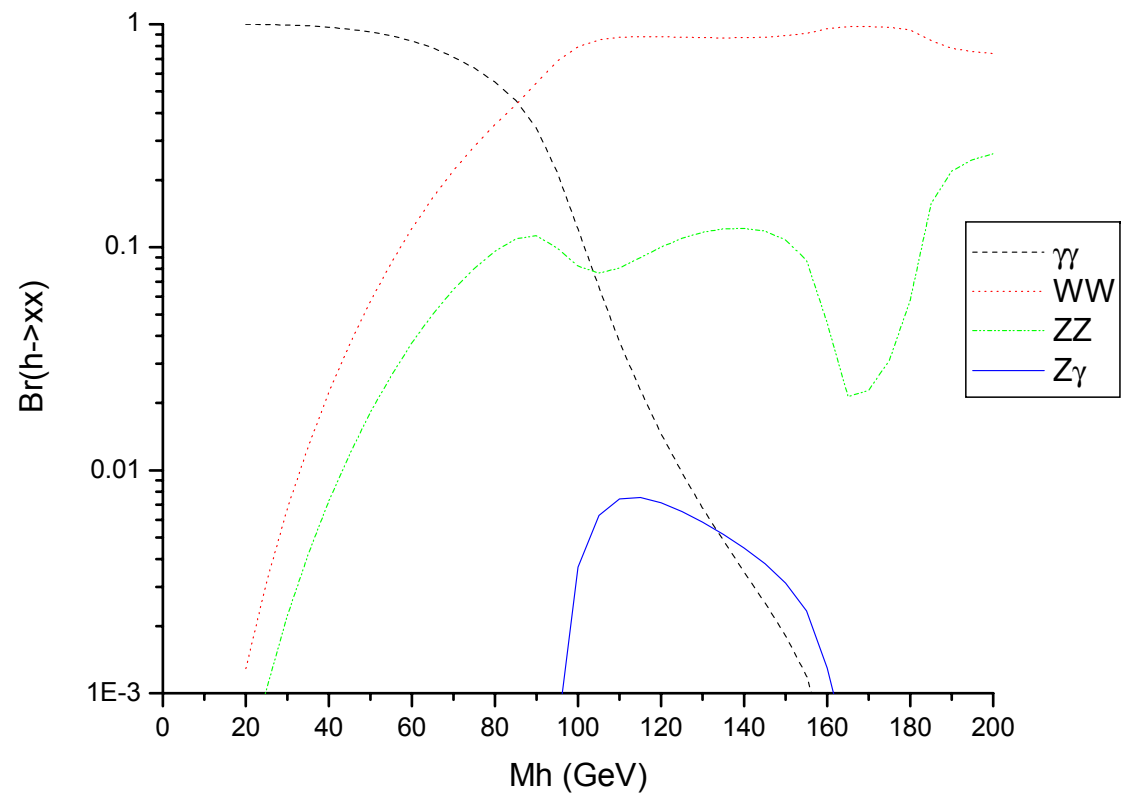
- **Doesn't couple to fermions.**
- **Couples just to vector bosons.**



Higgs production.

- Higgsstrahlung is the main production channel.
 - In $eejjjj$ and $\nu_e \nu_e jjjj$ vector boson fusion interferes.
- **Three possible final states:**
 1. **$ZH \rightarrow ZWW$**
 2. **$ZH \rightarrow ZZZ$**
 3. **$ZH \rightarrow Z\gamma\gamma$**
- **We consider first two channels (two photon channel has been considered by the OPAL collaboration already)**
- **Each of vector bosons decays into two fermions-
>6 fermion final state.**

Main Signal Channels



Higgs production.

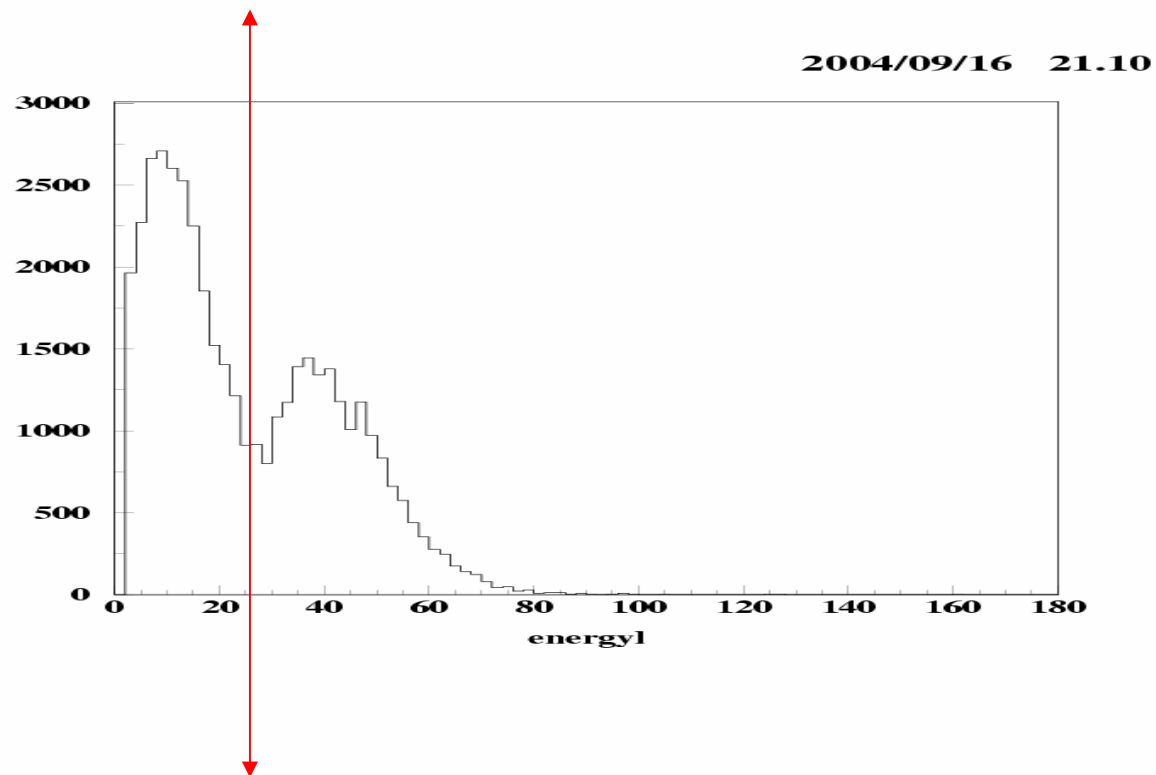
- The main channels are: (ZWW)->...
- Z->jj channels (multihadronic)
 - W->jj;W->jj **6 jet channel** **26.83 events**
 - W->jj;W->l ν **4 jets+l+ ν channel** **25.04 events**
 - W->l ν ;W->l ν **4 jets + 2l channel** **5.84 events**
- Z-> missing energy channels (missing energy)
 - W->jj;W->jj **4jet + E_{miss} channel** **9.35 events**
 - W->jj;W->l ν **2jet + l + 3 ν channel** **8.72 events**

1 lepton channels

We look at 1l channels:

- **Multihadronic channel**
 - $W \rightarrow jj; W \rightarrow l\nu$ **4 jets+l+ ν channel** **25.04 events**
- **Missing energy channel**
 - $W \rightarrow jj; W \rightarrow l\nu$ **2 jets+l+E_{miss} channel** **8.72 events**
- The lepton can come either from on-shell W or from off-shell W^* . Of course, those leptons have different energies. So, for each channel we split our analysis into two parts: hard lepton and soft lepton part.

That how it looks.



Our channels

- **Our channels:**
 1. **1l multihadronic high pt channel**
 2. **1l multihadronic low pt channel**
 3. **1l missing E high p channel**
 4. **1l missing E low p channel**
 5. **2l multihadronic channel**
 6. **4q missing E channel**
 7. **6q multihadronic channel**

Background.

- **High multiplicity bg**
 1. **$2q$**
 2. **$WW \rightarrow qqE_{\text{miss}}; WW \rightarrow qqqq$**
 3. **$ZZ \rightarrow qqll; ZZ \rightarrow qqE_{\text{miss}}; ZZ \rightarrow qqqq$**
 4. **$\gamma\gamma$**

The analysis: channel by channel:

1I multihadronic high E channel

1. 1 isolated lepton high pt lepton $p_t > 25\text{GeV}$
2. $P_t > 15\text{GeV}$ to reduce $\gamma\gamma$
3. $N_c > 15$ to reduce low multiplicity events
4. $E_{\text{obs}} > 150\text{GeV}$ to separate from Emiss events
5. $Y_{23} > 0.25$ to ensure at least three jets
6. Event is split into three jets. Each of them should contain at least 3 charged tracks. Reduces $\tau\tau$ bg.
7. $M_W * 1.3 < m_r < 150\text{GeV}$. Where m_r is the mass of the system which recoils against lepton. To reduce ZZ and WW bg.
8. $P_r < \sqrt{\epsilon^2/4 - M_W^2} - 0.2 * M_W$

The analysis: channel by channel:

1I multihadronic low E channel

1. 1 isolated lepton high pt lepton $8 < p_t < 25 \text{ GeV}$
2. $P_t > 15 \text{ GeV}$ to reduce $\gamma\gamma$
3. $N_c > 10$ to reduce low multiplicity events
4. $E_{\text{obs}} > 150 \text{ GeV}$ to separate from Emiss events
5. $Y_{34} > 0.15$ to ensure at least four jets
6. Event is split into three jets. Each of them should contain at least 3 charged tracks. Reduces $\tau\tau$ bg.
7. $M_r > 1.6 m_W$
8. $m_{\text{lv}} > 10 \text{ GeV}$, where m_{lv} is the invariant mass of the lepton neutrino system. This cut reduces tau bg.

The analysis: channel by channel:

1l missing E high E channel

1. 1 isolated lepton high p lepton $p_l > 25\text{GeV}$
2. $P_t > 15\text{GeV}$ to reduce $\gamma\gamma$
3. $\text{Abs}(p_z) < 40\text{GeV}$ and $f_w < 2\text{GeV}$ and $sw < 5\text{GeV}$ and $gc < 5\text{GeV}$ to reduce $\gamma\gamma$
4. $N_c > 3$
5. $E_{\text{obs}} < 85\text{GeV}$ to separate from Emiss events
6. $M_{W'} > 0.85m_W$ where $M_{W'}$ is the reconstructed mass of the W boson, assuming signal scenario.
7. Event is split into two jets. $E_1/E_2 < 5$, where E_1 and E_2 are jet's energies. To kill events, containing soft leptons misidentified as jets.

The analysis: channel by channel:

1l missing E low E channel

1. 1 isolated l low E lepton $3 < E_l < 25 \text{ GeV}$
2. $P_t > 15 \text{ GeV}$ to reduce $\gamma\gamma$
3. $\text{Abs}(p_z) < 40 \text{ GeV}$ and $f_w < 2 \text{ GeV}$ and $s_w < 5 \text{ GeV}$ and $g_c < 5 \text{ GeV}$ to reduce $\gamma\gamma$
4. $N_c > 3$
5. $E_{\text{obs}} < 120 \text{ GeV}$ to separate from Emiss events
6. $P_r < \sqrt{E^2/4 - M_W^2} - 0.1 * M_W$
7. $10 \text{ GeV} < m_{l\nu} < 60 \text{ GeV}$, where $m_{l\nu}$ stands for the invariant mass of l and ν system. Lower cut kills taus. Upper cut kills WW and ZZ bg.
8. $0.2 - 0.1 * (m_H - 105) < \cos(\text{ljj}, \nu) < 0.65 - 0.1 * (m_H - 105)$, where $\cos(\text{ljj}, \nu)$ stands for the angle between ljj system and the neutrino (assuming signal hypothesis is correct)

The analysis: channel by channel:

01 multihadronic 6 quark channel

1. 0 isolated leptons
2. $\langle P_t \rangle > 50 \text{ GeV}$. Events are splitted into 4 jets. Their average pt should be higher, than 50GeV. Very strong cut, used to kill $\gamma\gamma \rightarrow 4q$. Usual usual Pt does not help here because of no missing energy.
3. $N_c > 25$ to reduce low multiplicity events
4. $E_{\text{obs}} > 180 \text{ GeV}$ to separate from Emiss events
5. $Y_{45} > 0.25$ to ensure at least five jets
6. Event is split into three jets. Each of them should contain at least 3 charged tracks. Reduces $\tau\tau$ bg.
7. Events are splitted into 5 jets. Look for the pair with invariant mass, closest to Z mass. The difference should be not higher than 15
8. After applying step 6, take remaining 3 jets and find the mass closes to that of W. The difference should be less, than 40

The analysis: channel by channel:

01 multihadronic 4 quark channel

- 1. 0 isolated leptons**
- 2. $P_t > 15 \text{ GeV}$**
- 3. P_z and fw cuts**
- 4. $N_c > 25$ to reduce low multiplicity events**
- 5. $100 < E_{\text{obs}} < 120 \text{ GeV}$ to separate from Emiss events**
- 6. $M_{\text{vis}} > M_W * 1.2$. The invariant mass of event is M_h for the signal and m_W for bg.**
- 7. $P_{\text{vis}} < \sqrt{(E_{\text{cms}}^2 - m_W^2)} - 0.35 * m_W$**
- 8. Missing mass $> M_Z * 0.9$. To kill $W W$ and ZZ bg.**

The analysis: channel by channel:

2l multihadronic 2 quark channel

1. 2 isolated leptons
2. $P_t > 10 \text{ GeV}$
3. $N_c > 5$ to reduce low multiplicity events
4. $E_{\text{obs}} < 180 \text{ GeV}$ to separate from Emiss events
5. $E_{l1} > 25$ and $3 \text{ GeV} < E_{l2} < 25 \text{ GeV}$. To isolate high and low energy leptons.
6. $P_r < \sqrt{(e_{\text{cms}}^2 - m_W^2)} - 0.15 \cdot m_Z$

Here we are done. Results for each channel for Higgs mass of 105GeV

	High pt after cuts	Low pt after cuts	High pt after cuts	Low pt after cuts	6q after cuts	4q after cuts	2l after cuts	resultexp	resultsreal
signal	0.74	0.79	0.83	0.49	0.79	1.10	0.25	4.2	2.2
bq	0.14	0.18	0.05	0.09	43.09	0.90	0.00		
data	0.00	0.00	0.00	0.00	50.00	1.00	0.00		

Our and others results:

We: Expected exclusion is at 105.9 GeV
Observed exclusion is at 108.2 GeV
(no $\gamma\gamma$ Study).

OPAL: $M_H > 105.5$ GeV (just $\gamma\gamma$) channel. [hep-ex/0212038](#)

? Somebody should combine these two studies: should not be difficult.

A3: Expected exclusion for WW is at 107.5 GeV
Observed exclusion is at 104.6 GeV [hep-ex/0204029](#)

DELPHI: $M_H > 104.1$ GeV (just $\gamma\gamma$) channel [hep-ex/0406012](#)
Combined $\gamma\gamma$: $M_H > 109.7$ GeV