

Measuring Branching Fractions of the SM Higgs (160)

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- $BF(H \rightarrow WW^*)$ $\frac{SM}{0.905}$
- $BF(H \rightarrow ZZ^*)$ 0.06
- $BF(H \rightarrow b\bar{b})$ 0.038
- $BF(H \rightarrow \gamma\gamma)$ $0.54 \cdot 10^{-3}$

$$\sqrt{s} = 350 \text{ GeV}$$

$$\int \mathcal{L} dt = 500 \text{ fb}^{-1}$$

$$\sigma(HZ) = 104 \text{ fb}$$

$$\boxed{BF(H_{160} \rightarrow WW)}$$

• Higgs very close to $2M(W)$

Generation

$$e^+e^- \rightarrow u\bar{d}WZ$$

$$\rightarrow u\bar{d}WZ$$

$$\rightarrow WWZ$$

with $Z \rightarrow e^+e^- / \mu^+\mu^-$

CompHEP (with ISR and beamstrahlung)

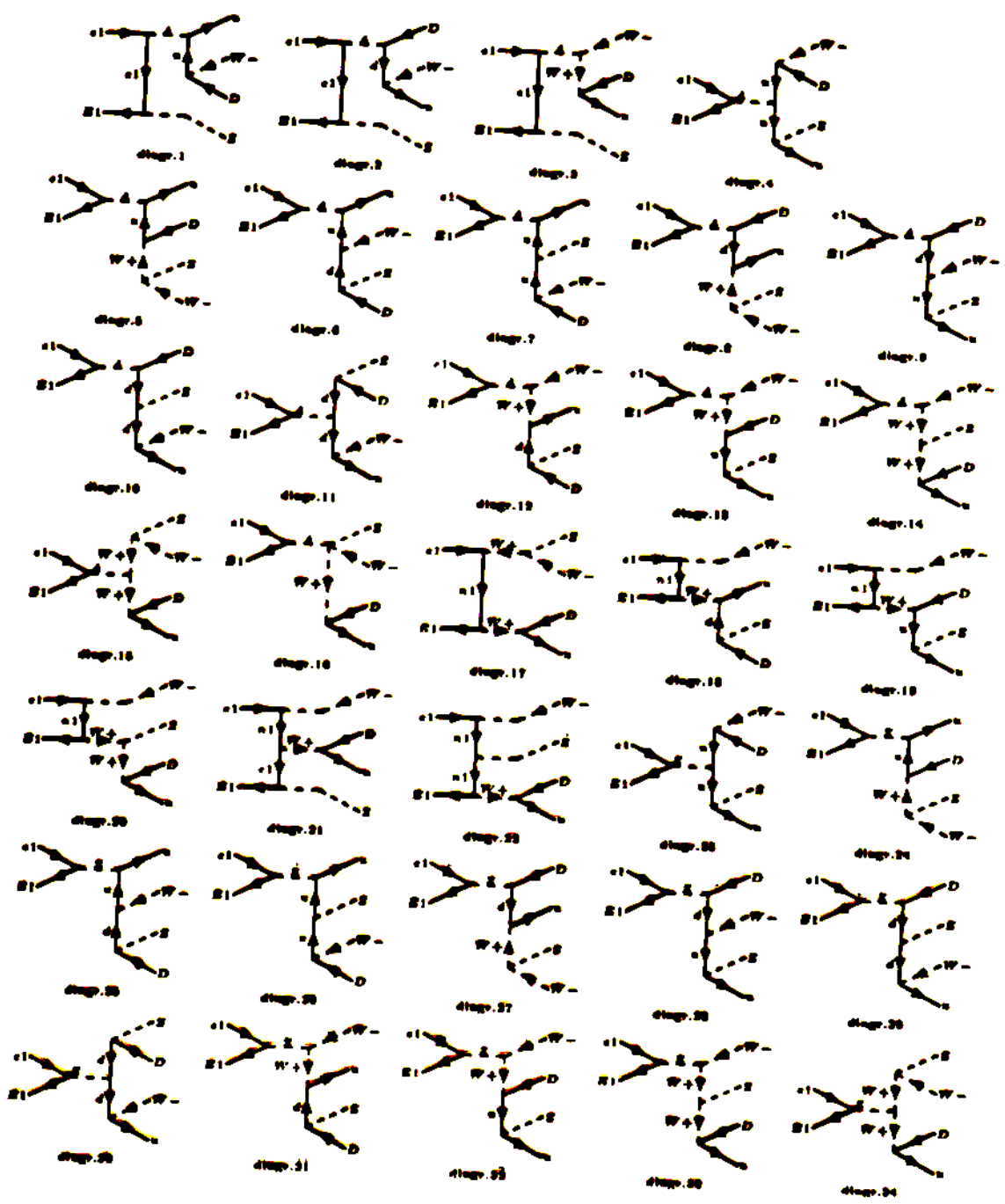
with canonical cuts

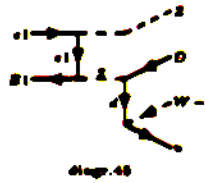
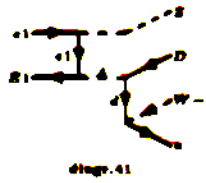
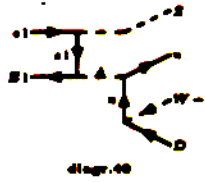
- $E(\text{particle}) > 3 \text{ GeV}$
- $\Theta(\text{particle}) > 5^\circ$
- $M(\text{part}_i, \text{part}_k) > 10 \text{ GeV}$

important:

irreducible background and
interferences included

→ 46 diagrams





After reconstruction : **sim det v3.1**

→ event analysis :

Topology : 4 jets + $\underbrace{e^+e^-/\mu^+\mu^-}_{Z}$

Selection strategy:

- $E_{vis} > 200 \text{ GeV}$
- $E_{trans} > 40 \text{ GeV}$
- # of charged particles ≥ 20
- search for $e^+e^-/\mu^+\mu^-$ pairs
with $\underbrace{M(\ell\bar{\ell}) = M_Z \pm 6 \text{ GeV}}$
provided $|\cos\theta_{\ell}| < 0.95$
- apply jet finder (LUCLUS) to all other particles and require
 - # of jets : 4
 - for each jet :
 - $E(\text{jet}) > 10 \text{ GeV}$
 - $|\cos\theta_{\text{jet}}| < 0.85$
 - $\alpha(\text{jet}_i, \text{jet}_k) > 10^\circ$
 - # of particles/jet ≥ 4

- select from all (jet_i, jet_k) pairings
the one best compatible with
 $W \rightarrow q \bar{q}$
- calculate $M(W q \bar{q})$
with $70 < M(W) < 90$ GeV

Reducible Background:

$e^+e^- \rightarrow WW \rightarrow 4 \text{ jets} : \sim 3 \text{ Mill. events}$

$e^+e^- \rightarrow ZZ \rightarrow 4 \text{ jets} : \sim 150.000 \text{ events}$

$\rightarrow ZZ \text{ events} : \text{no entry to } M(W q \bar{q})$

Results

\rightarrow Fig.

of signal events, \textcircled{S}

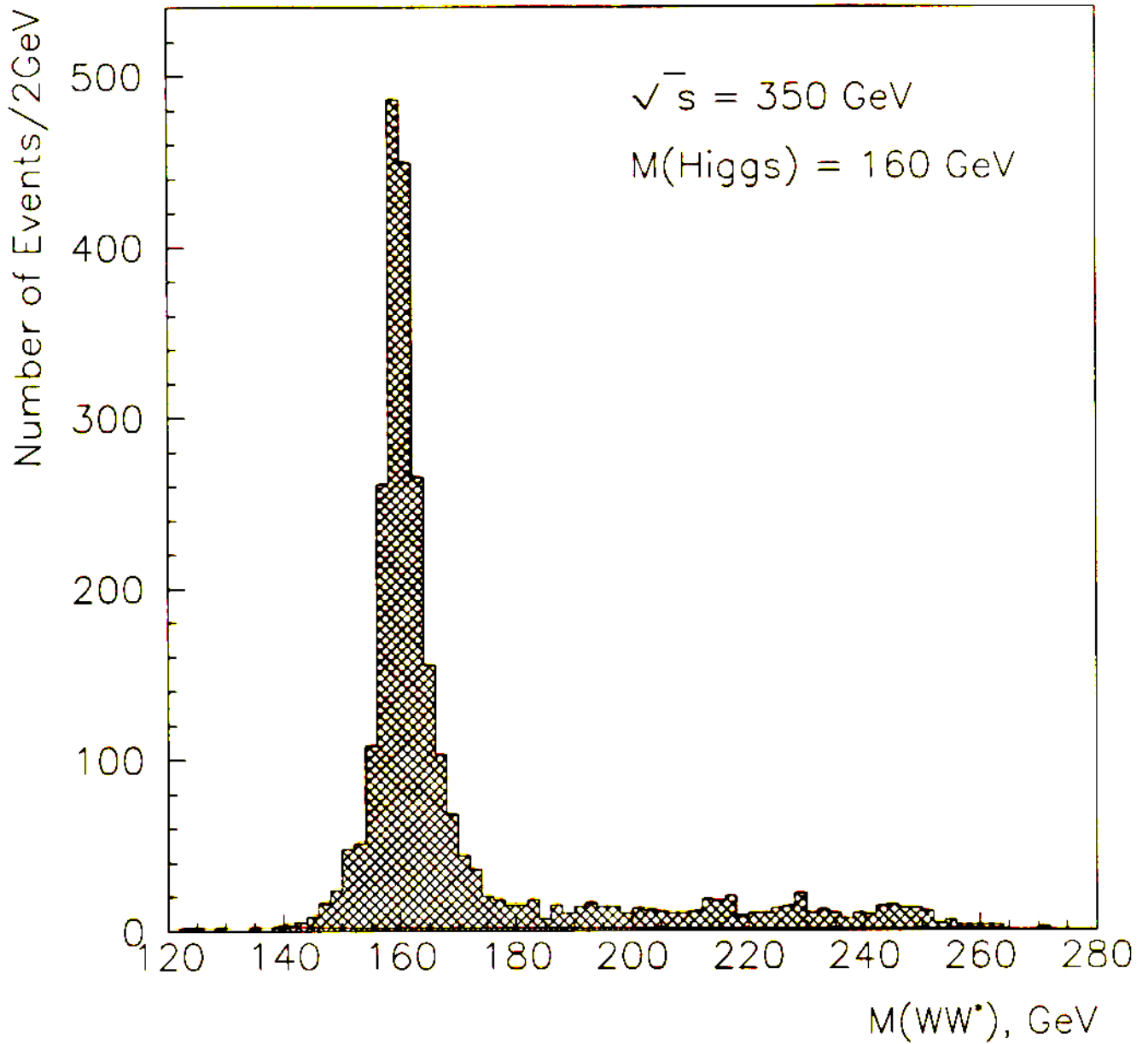
of background events, \textcircled{B}

in $148 < M(WW^*) < 172$ GeV

$\rightarrow \Delta [\sigma(HZ) \cdot \text{BF}(H \rightarrow WW)] = 2.5\%$

with $\Delta \sigma(HZ) = 2.8\%$ (scaling!)

$\rightarrow \Delta \text{BF}(H_{160} \rightarrow WW) = 3.8\%$



$$e^+e^- \rightarrow q\bar{q}WZ \rightarrow q\bar{q}W(e^+e^-/\mu^+\mu^-)$$

$$\text{BF}(H_{160} \rightarrow ZZ)$$

- $\sigma(HZ) \propto g^2(ZZH)$
- $M(ZZ^*) \rightarrow \sigma(HZ) \cdot \text{BF}(H \rightarrow ZZ)$

→ Estimated $\Delta\sigma(e^+e^- \rightarrow HZ)$
(using only $Z \rightarrow e^+e^-/\mu^+\mu^-$ events)
by means of the recoil mass technique:

$$\Delta\sigma(HZ) = 2.8\% = \Delta(g^2(ZZH))$$

For second method

- events are generated and reconstructed,
but not analyzed yet

$$\text{BF} (H_{160} \rightarrow b\bar{b})$$

Generated:

- $e^+e^- \rightarrow b\bar{b} q\bar{q}$
- $e^+e^- \rightarrow b\bar{b} \underbrace{e^+e^-/\mu^+\mu^-}_{\text{Z}}$

Signal involved

- $e^+e^- \rightarrow q\bar{q} q\bar{q}$
- $e^+e^- \rightarrow q\bar{q} \underbrace{e^+e^-/\mu^+\mu^-}_{\text{Z}}$
($q = u/d/s/c$)

background

Topology:

- 4-jet events, with 2 b-jets

- 2-jet events (\equiv b-jets)
+ $e^+e^-/\mu^+\mu^-$ pair
with $M(\ell\bar{\ell}) \approx M_Z$

After reconstruction
- event analysis

→ **4-jet events:**

- for each jet
 - $E(\text{jet}) > 12 \text{ GeV}$
 - $|\cos \theta_{\text{jet}}| < 0.85$
 - $\alpha(j_i, j_k) > 70^\circ$
 - # of particles/jet ≥ 8
- with $M(Z\bar{Z}) = M_Z \pm 10 \text{ GeV}$
the two remaining jets are required to be b-jets:
 - # of tracks with large impact parameter ≥ 3 (4)
 - large impact: $DCA/\sigma > 3$ (4)

→ **2-jet with $e^+e^-/\mu^+\mu^-$ events:**

- $M(e^+e^-/\mu^+\mu^-) = M_Z \pm 6 \text{ GeV}$
- the two jets are required to be b-jets, defined as above

Results

→ 4-jet events:

→ Fig.

of signal events, S

of background events, B

in $150 < M(b\bar{b}) < 168 \text{ GeV}$

$$\rightarrow \Delta[\sigma(HZ) \cdot \text{BF}(H \rightarrow b\bar{b})] = 16\%$$

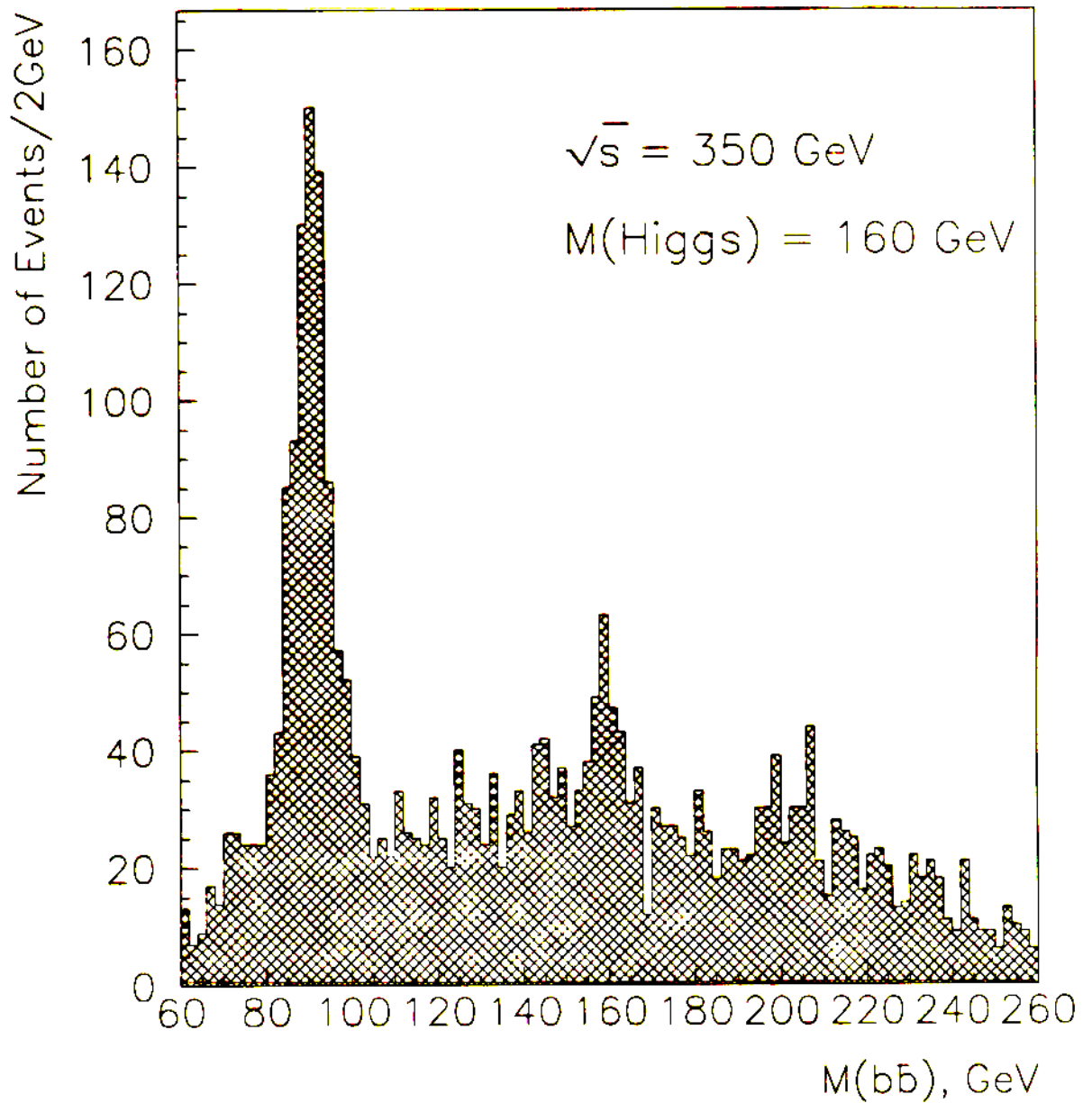
→ 2-jet dilepton events:

→ Fig.

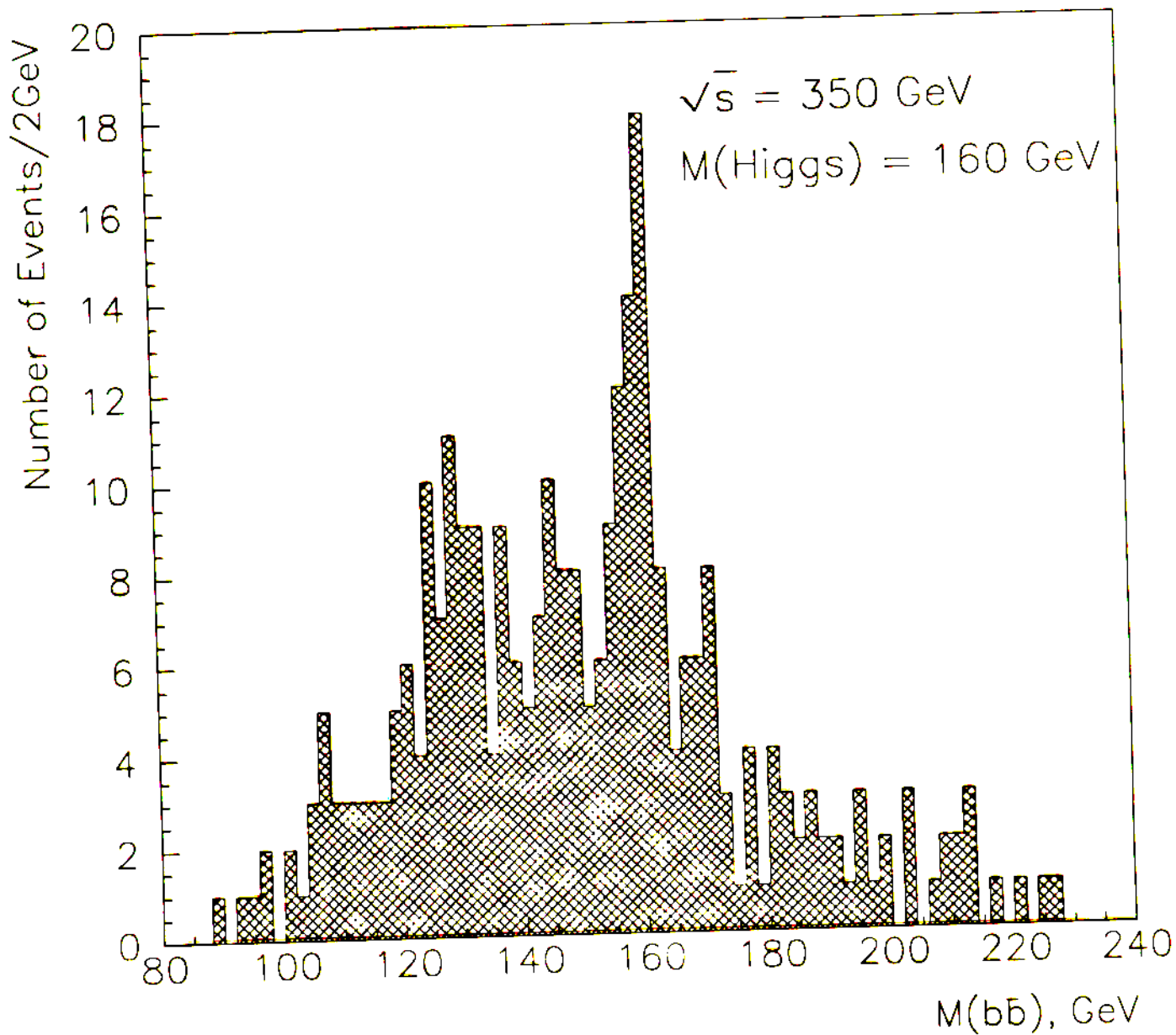
$$\rightarrow \Delta[\sigma(HZ) \cdot \text{BF}(H \rightarrow b\bar{b})] = 30\%$$

combined, and with $\Delta\sigma(HZ) = 2.2\%$,

$$\Delta \text{BF}(H_{160} \rightarrow b\bar{b}) = 12\%$$



$$e^+e^- \rightarrow b\bar{b} Z \rightarrow b\bar{b} q\bar{q}$$



$$e^+e^- \rightarrow b\bar{b} Z \rightarrow b\bar{b} (e^+e^- / \mu^+\mu^-)$$

$$BF(H_{160} \rightarrow \gamma\gamma)$$

Signal events ($e^+e^- \rightarrow HZ \rightarrow \gamma\gamma Z\bar{Z}$): 39

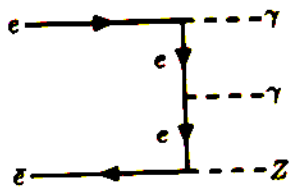
but irreducible background ($e^+e^- \rightarrow \gamma\gamma Z \rightarrow 2\gamma Z\bar{Z}$)
events

in $M(\gamma\gamma)$: 156 - 164 GeV: → Fig

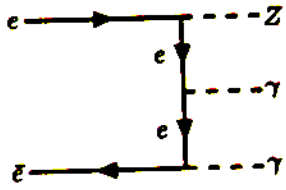
2700

most important task → eff. selection criteria

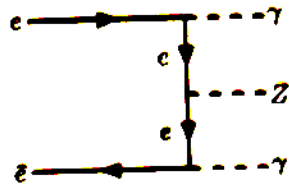
- e.g.:
- $E_{vis} > 240 \text{ GeV}$
 - $E_{trans} > 30 \text{ GeV}$
 - select photons (from Higgs)
 - $E_{trans}(\gamma_1) > E_{trans}(\gamma_2) > 20 \text{ GeV}$
 - $|\cos\theta_{\gamma_1, \gamma_2}| < 0.60$
 - $p_{\perp}(\gamma_1) + p_{\perp}(\gamma_2) > 64 \text{ GeV}$
 - apply jet finder for remaining particles
if $N(\text{jet}) = 2 \Rightarrow$ quality cuts for each jet
 - and $M(j_1 j_2) = M_Z \pm 10 \text{ GeV}$
 - and $|\cos\theta_{j_2}| < 0.70$



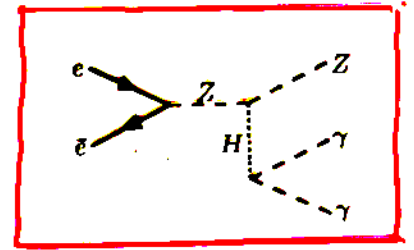
diagr.1



diagr.4



diagr.2



diagr.3

Results

→ Fig.

Background much too large

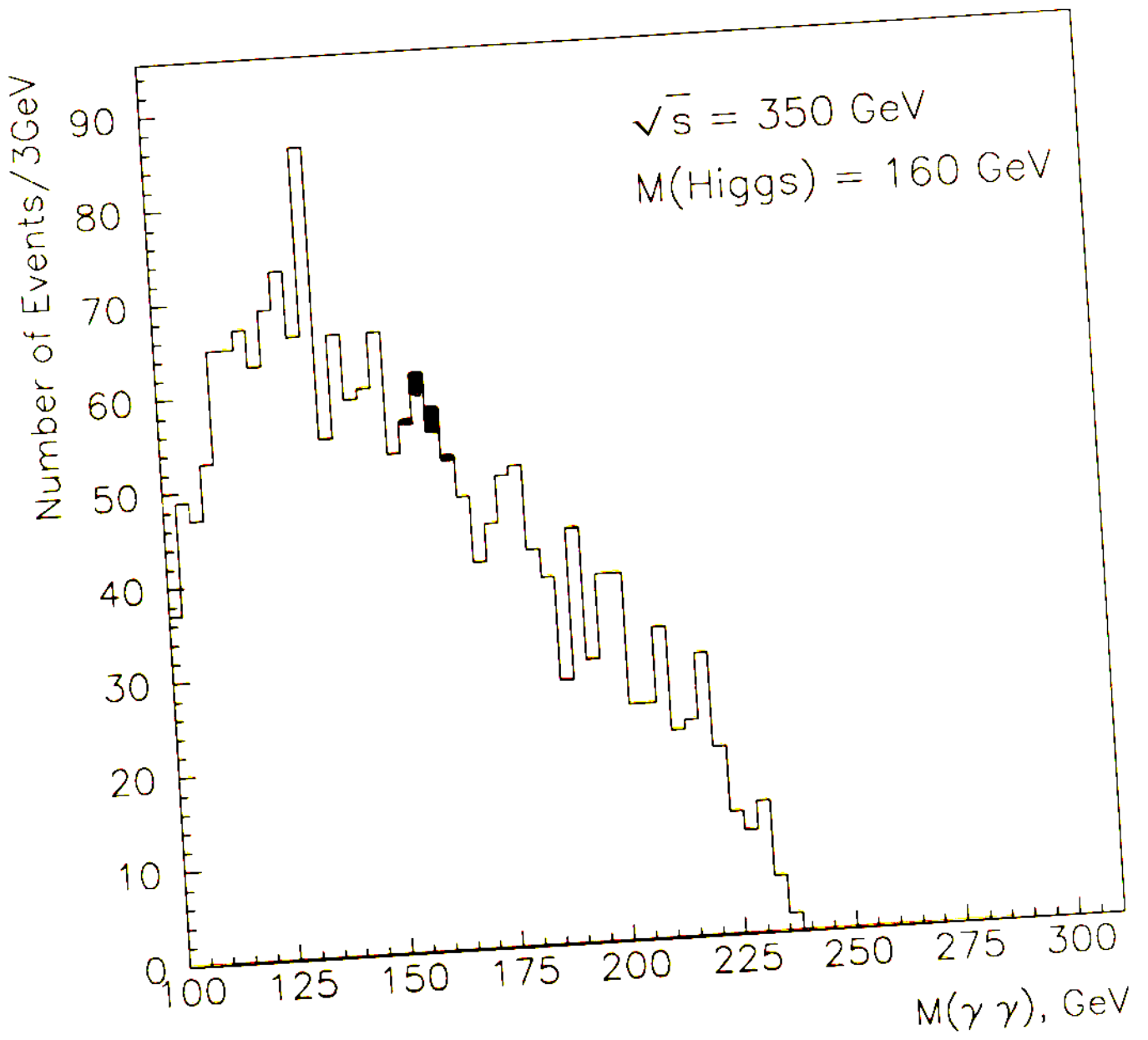
- Signal much too small

→ $\Delta BF(H_{160} \rightarrow \gamma\gamma) \quad ?$

- Selection criteria robust, simple
 - not optimized

and if detailed detector behaviour known

→ improvements



$$e^+e^- \rightarrow \gamma\gamma Z \rightarrow \gamma\gamma q\bar{q}$$