

Measuring the Higgs Mass with Six Jet Events



Alexei Raspereza
DESY Zeuthen

ECFA/DESY Workshop
Hamburg, September 22 - 25, 2000

- Introduction
- Selection Strategy
- Mass measurement
- Conclusion and Outlook

Our goal

Measurement of M_H using 6-jet events

$$e^+e^- \rightarrow ZH \rightarrow q\bar{q}WW \rightarrow q\bar{q}q\bar{q}q\bar{q}$$

- large background contributions from $ZZ, Z, \gamma^* \rightarrow q\bar{q}(\gamma)$ and WW
- Two Higgs mass hypotheses are considered $M_H = 150 \text{ GeV}$ and $M_H = 180 \text{ GeV}$
- Study done at $\sqrt{s} = 350 \text{ GeV}$ and $L = 500 \text{ fb}^{-1}$

Signal and Background

- **Signal:**

$$e^+e^- \rightarrow ZH \rightarrow q\bar{q}WW \rightarrow q\bar{q}q'\bar{q}'q''\bar{q}''$$

- **Features:**

High multiplicity, spherical, well balanced events with 6-jet topology and full energy in detector

- **Expected signal for $L = 500 \text{ fb}^{-1}$**

M_H	$\sigma \times \text{Br}$	# of events
150 GeV	26.5 fb	1.3×10^4
180 GeV	26.6 fb	1.3×10^4

- **Expected background for $L = 500 \text{ fb}^{-1}$**

Bkgd	σ	# of events
$Z, \gamma^* \rightarrow q\bar{q}(\gamma)$	$2.7 \times 10^4 \text{ fb}$	1.4×10^7
WW	$1.3 \times 10^4 \text{ fb}$	6.7×10^6
ZZ	$1.0 \times 10^3 \text{ fb}$	5.1×10^5

Generation and Simulation

- Signal and background simulated with
PYTHIA V6.136
- Beamstrahlung accounted for using:
CIRCE V6
- Generated events passed through program:
SIMDET V3.2
- Jets reconstructed using
Durham algorithm
- Kinematic fitting done with
Blobel's package
- Number of generated events:

Process	# of events
$Z, \gamma^* \rightarrow q\bar{q}(\gamma)$	6.8×10^5
WW	3.3×10^5
ZZ	2.6×10^4
HZ ($M_H = 150$ GeV)	1.3×10^4
HZ ($M_H = 180$ GeV)	1.3×10^4

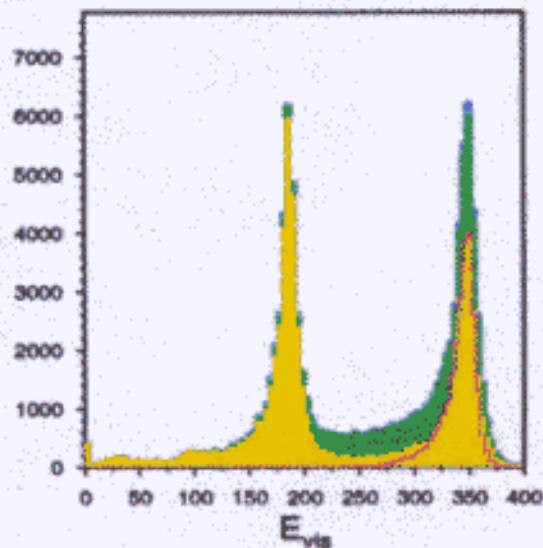
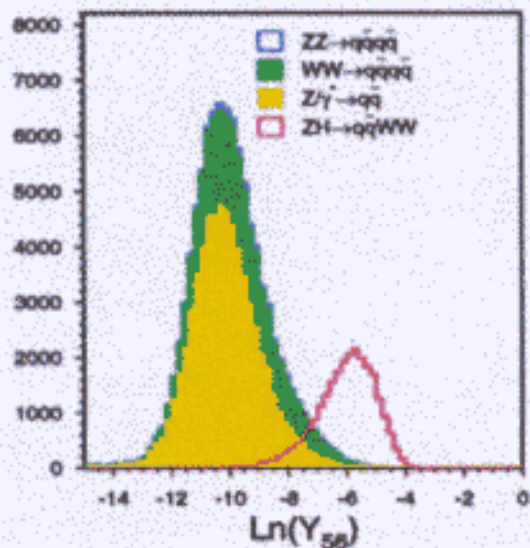
Analysis chain

- High multiplicity hadronic preselection
(events are forced into 6-jet topology)
- Likelihood selection
(based on topological variables)
- Kinematic fit (5C or 7C)
Jet resolutions used in fitting:
 - $\frac{\Delta E}{E} = \frac{0.2}{\sqrt{E}}$
 - $\Delta\theta = 10 \text{ mrad}$
 - $\Delta\phi = \frac{10}{\sin\theta} \text{ mrad}$
- Fitting mass spectra →
determination of M_H

Preselection

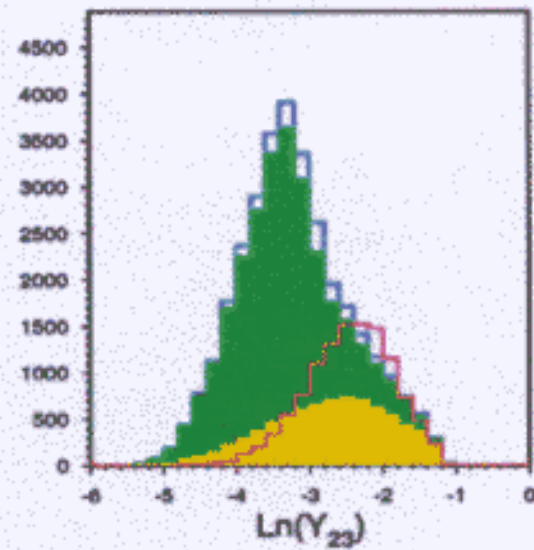
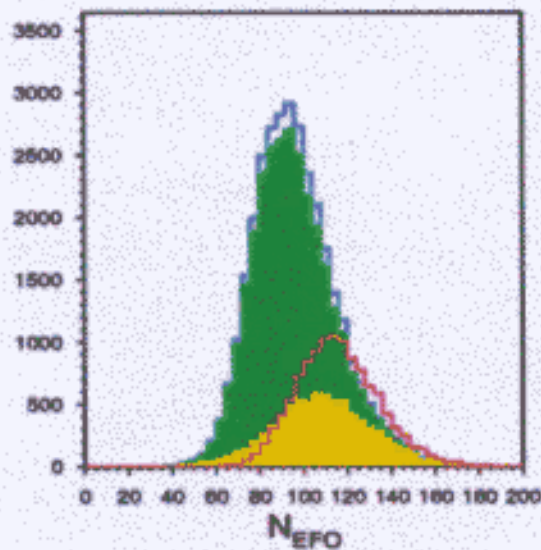
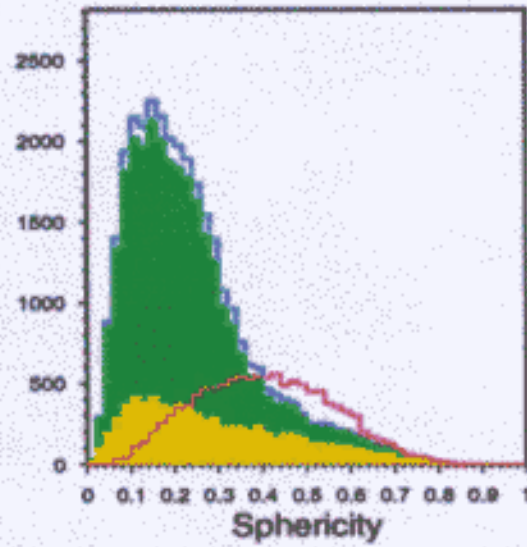
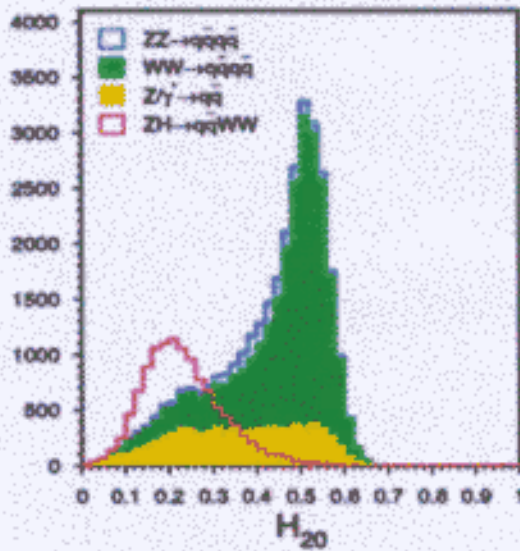
High multiplicity cut-based hadronic preselection

Variable	Cut
E_{vis}	$> 275 \text{ GeV}$
Thrust	< 0.9
$\cos\Theta_T$	< 0.95
# leptons	0
$\log Y_{56}$	> -8.0



Preselection

Process	Efficiency	# of events
$Z, \gamma^* \rightarrow q\bar{q}(\gamma)$	1.1 %	1.3×10^5
WW	6.6 %	4.4×10^5
ZZ	9.1 %	4.6×10^4
ZH ($M_H = 150$ GeV)	88.1 %	1.2×10^4
ZH ($M_H = 180$ GeV)	91.8 %	1.2×10^4



Likelihood Selection

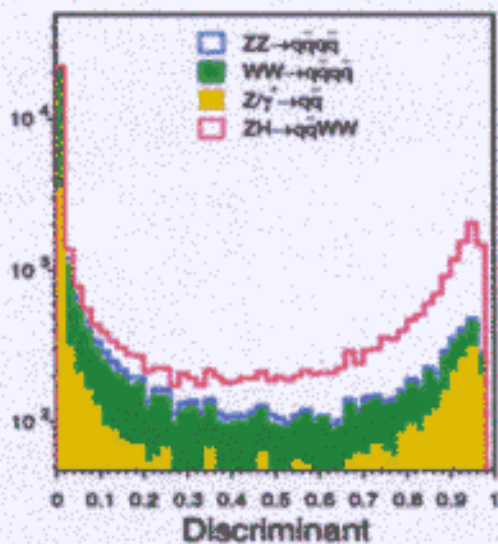
$$p_j^i = \frac{f_j^i}{\sum_k f_k^i}$$

$$L_{ZH} = \frac{\prod_i p_{ZH}^i}{\sum_k \prod_i p_k^i}$$

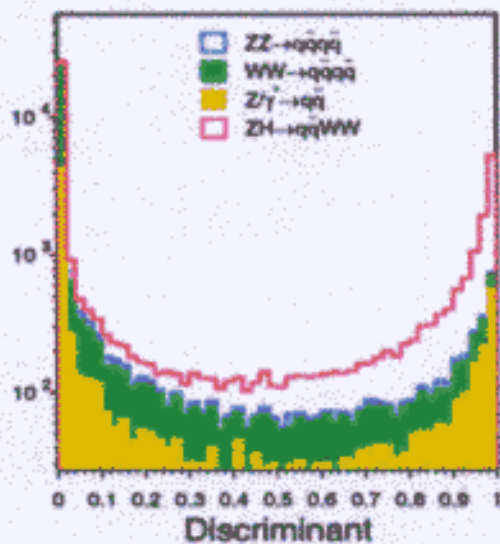
f_j^i - PDF of variable i for event class j

$i = N_{EFO}, \log(Y_{34}), \log(Y_{23}), H_{20}, S$

$j = q\bar{q}, WW, ZZ, ZH$



$M_H = 150$ GeV

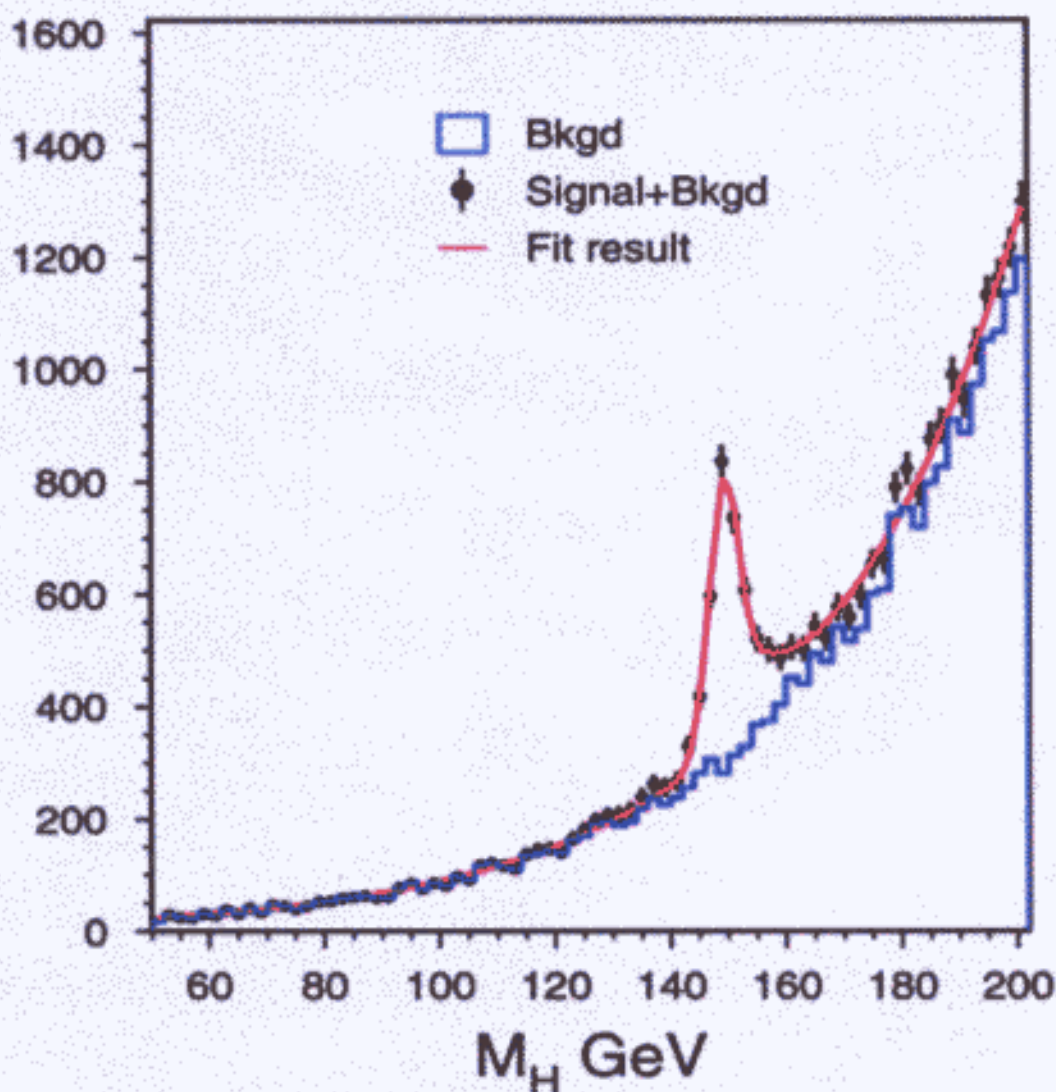


$M_H = 180$ GeV

Mass fit

$M_H = 150 \text{ GeV}$:

- 5C fit (4P + M_Z) is performed
- Events are selected if
 $L_{HZ} > 0.5$ and $\chi_{5C}^2 > 20$



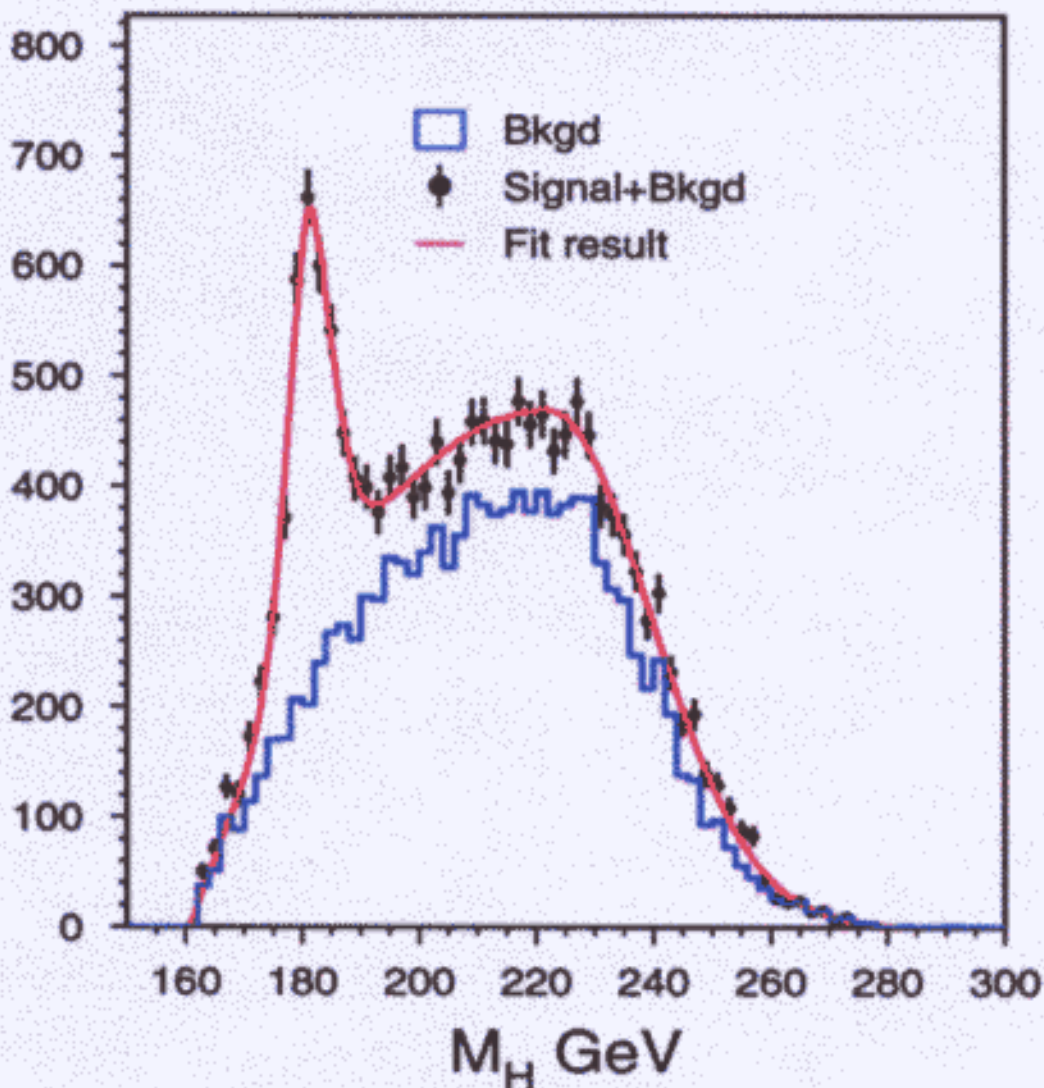
Signal is fitted with asymmetric gaussian

$$M_H = 149.76 \pm 0.13 \text{ GeV}$$
$$\sigma_l = 3.0 \text{ GeV}, \sigma_r = 3.3 \text{ GeV}$$

Mass fit

$M_H = 180 \text{ GeV}$:

- 7C fit ($4P + M_Z + 2M_W$) is performed
- Events are selected if
 $L_{HZ} > 0.8$ and $\chi_{7C}^2 > 30$



Signal is fitted with asymmetric gaussian

$$M_H = 180.68 \pm 0.16 \text{ GeV}$$
$$\sigma_l = 3.2 \text{ GeV}, \sigma_r = 3.6 \text{ GeV}$$

Summary of final samples

$M_H = 150 \text{ GeV}$

Process	# of events
$Z, \gamma^* \rightarrow q\bar{q}(\gamma)$	3.3×10^4
WW	2.4×10^4
ZZ	4.0×10^3
HZ ($M_H = 150 \text{ GeV}$)	6.7×10^3

45 % of signal events are misreconstructed

$M_H = 180 \text{ GeV}$

Process	# of events
$Z, \gamma^* \rightarrow q\bar{q}(\gamma)$	8.2×10^3
WW	3.1×10^3
ZZ	7.2×10^2
HZ ($M_H = 180 \text{ GeV}$)	4.7×10^3

34 % of signal events are misreconstructed

What is done

- Selection of $ZH \rightarrow q\bar{q}WW \rightarrow q\bar{q}q\bar{q}q\bar{q}$
- Higgs mass is determined with $\Delta M_H = 130 - 140 \text{ MeV}$
- Higgs mass resolution $\sigma(M_H) = 3.0 - 3.5 \text{ GeV}$

Still to be done

- Inclusion of $ZH \rightarrow l^+l^-WW \rightarrow l^+l^-q\bar{q}q\bar{q}$ final state
- Determination of $\text{Br}(H \rightarrow WW)$