

Measurement of the Higgs mass using 4-jet events

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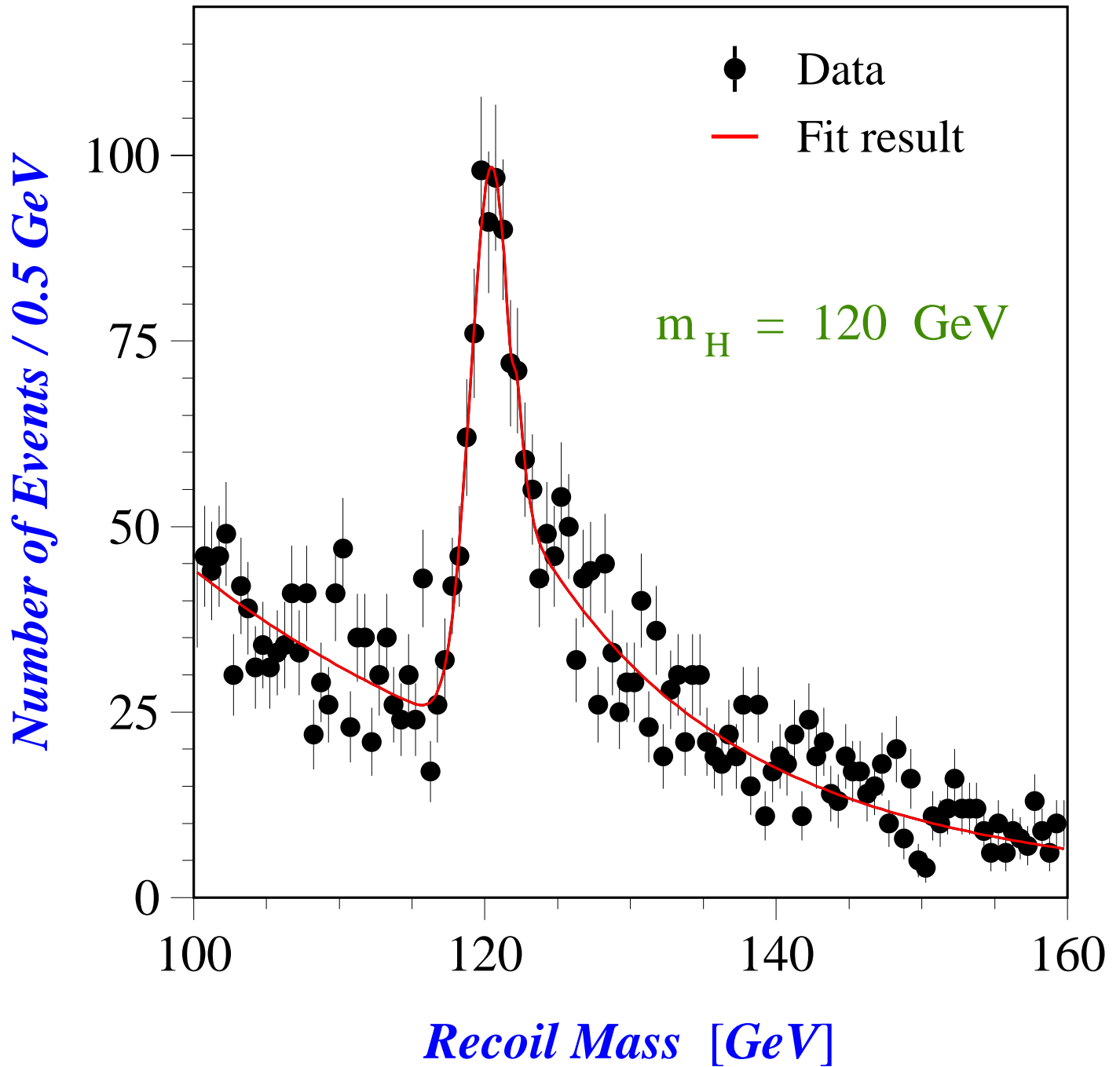
DESY Zeuthen

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$$e^+e^- \rightarrow ZH \rightarrow \ell^+\ell^-X : \Delta\sigma/\sigma \lesssim 3\%$$

$$\Delta M_H \simeq 150 \text{ MeV}$$

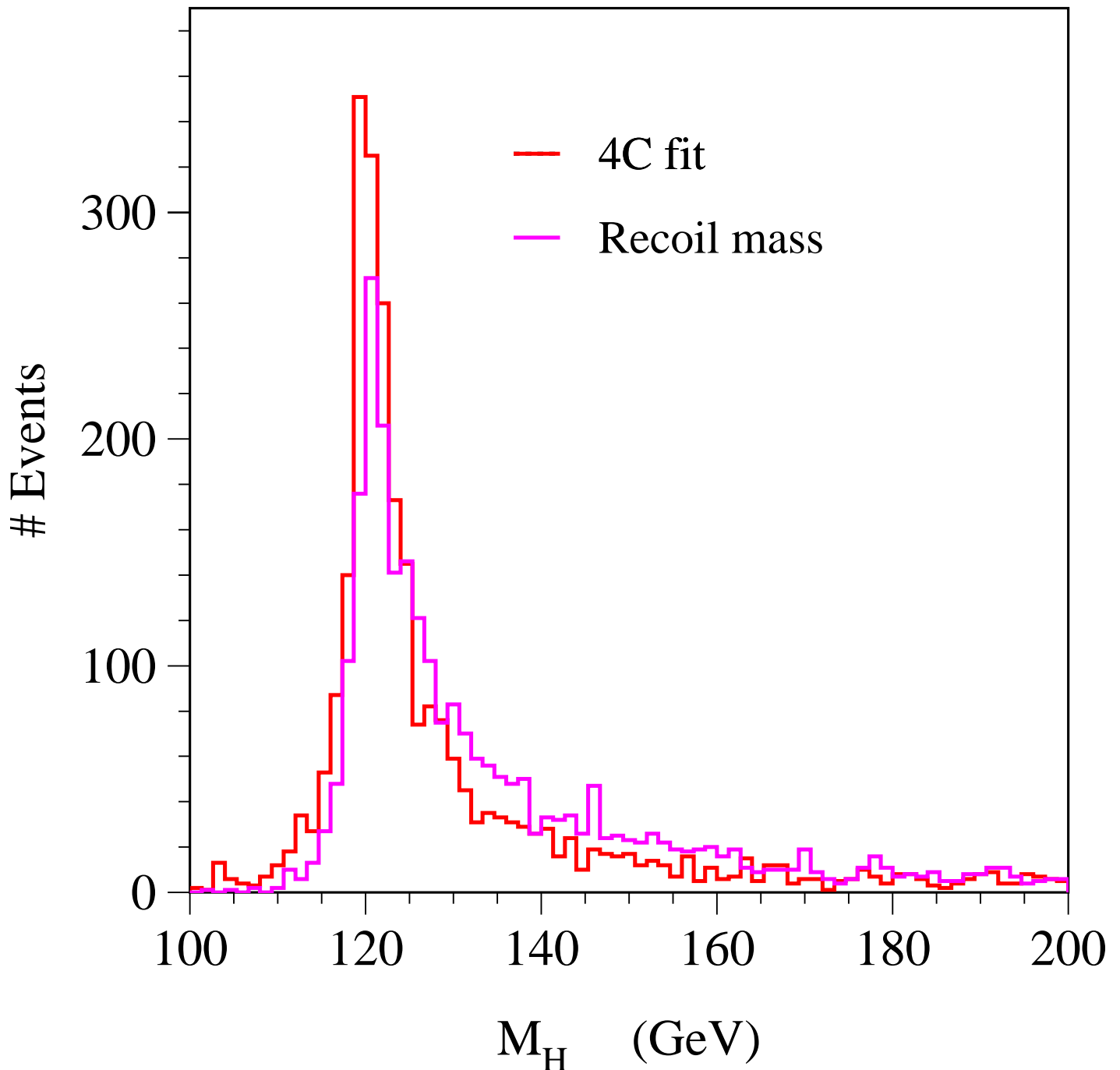


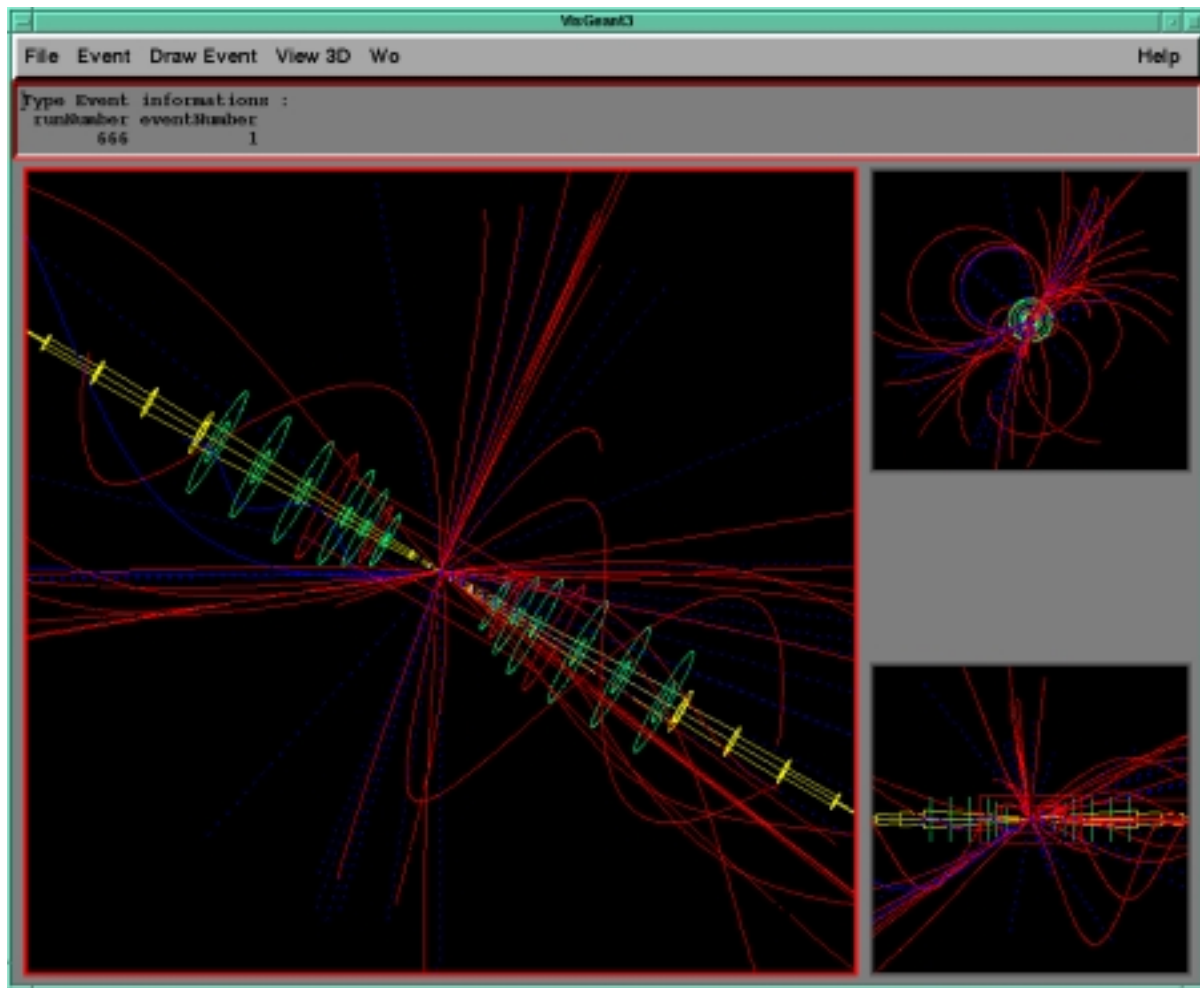
Ref: [P. Garcia-Abia and W. Lohmann, EPJdirect C2 \(2000\) 1-6](#)

$$e^+e^- \rightarrow ZH \rightarrow \ell^+\ell^-\bar{b}b, \quad \ell = e, \mu$$

Recoil mass method: $\Delta M_H \simeq 150 \text{ MeV}$

Mass from 4C fit: $\Delta M_H \simeq 80 \text{ MeV}$





- * We want to determine M_H using 4-jet events:

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

- * large background contributions from $Z \rightarrow q\bar{q}(\gamma)$, ZZ and WW events
- * M_H is determined from the dijet masses after a 5C kinematic fit
- * Study done at $\sqrt{s} = 350$ GeV and $\mathcal{L} = 500$ fb $^{-1}$:

$$M_H = 120 \text{ GeV}$$

- **Signal:** $e^+e^- \rightarrow ZH \rightarrow q\bar{q}b\bar{b}$, $M_H = 120 \text{ GeV}$

$$\begin{aligned} \sigma &= 79.6 \text{ fb} \\ \# \text{ of events} &= 4 \times 10^4 \end{aligned}$$

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

| Background | σ (fb) | # of events |
|---|-------------------|-----------------|
| $e^+e^- \rightarrow \gamma, Z \rightarrow q\bar{q}$ | 2.7×10^4 | 2×10^7 |
| $e^+e^- \rightarrow ZZ$ | 1.0×10^3 | 5×10^5 |
| $e^+e^- \rightarrow W^+W^-$ | 1.3×10^4 | 7×10^6 |

- **Cut based selection:**

topological cuts, Y_{34} , **NO b-tag**

$$\text{Efficiency} = 50 \%$$

$$\text{Signal events} = 20 \text{ K} \quad (15 \text{ K})$$

$$\text{Background events} = 180 \text{ K} \quad (90 \text{ K})$$

* Signal and Background processes simulated with

PYTHIA V6.136

* Beamstrahlung accounted for using:

CIRCE V6

* Generated events go through the fast simulation program:

SIMDET V3.2

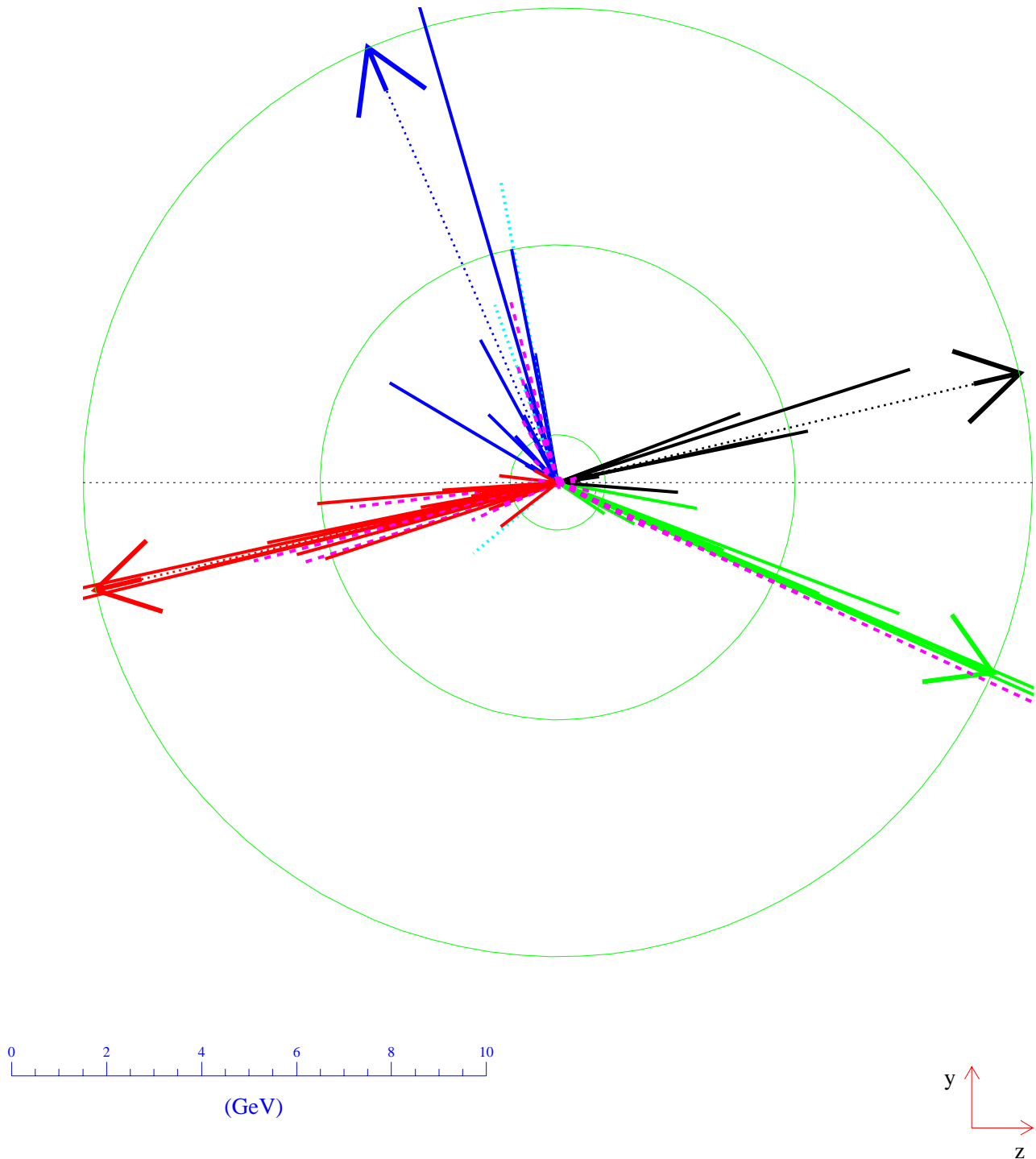
* Jet reconstruction, Cambridge algorithm:

CAMJET

* Number of generated events:

| Background | # of events |
|---|-------------------|
| $e^+e^- \rightarrow \gamma, Z \rightarrow q\bar{q}(\gamma)$ | 2.5×10^5 |
| $e^+e^- \rightarrow W^+W^-$ | 1×10^5 |
| $e^+e^- \rightarrow ZZ$ | 1×10^5 |

4-jet event reconstructed with CAMJET



* Jet resolutions are obtained from the output of SIMDET and CAMJET:

- $\frac{\Delta E}{E} = \frac{0.2}{\sqrt{E}}$

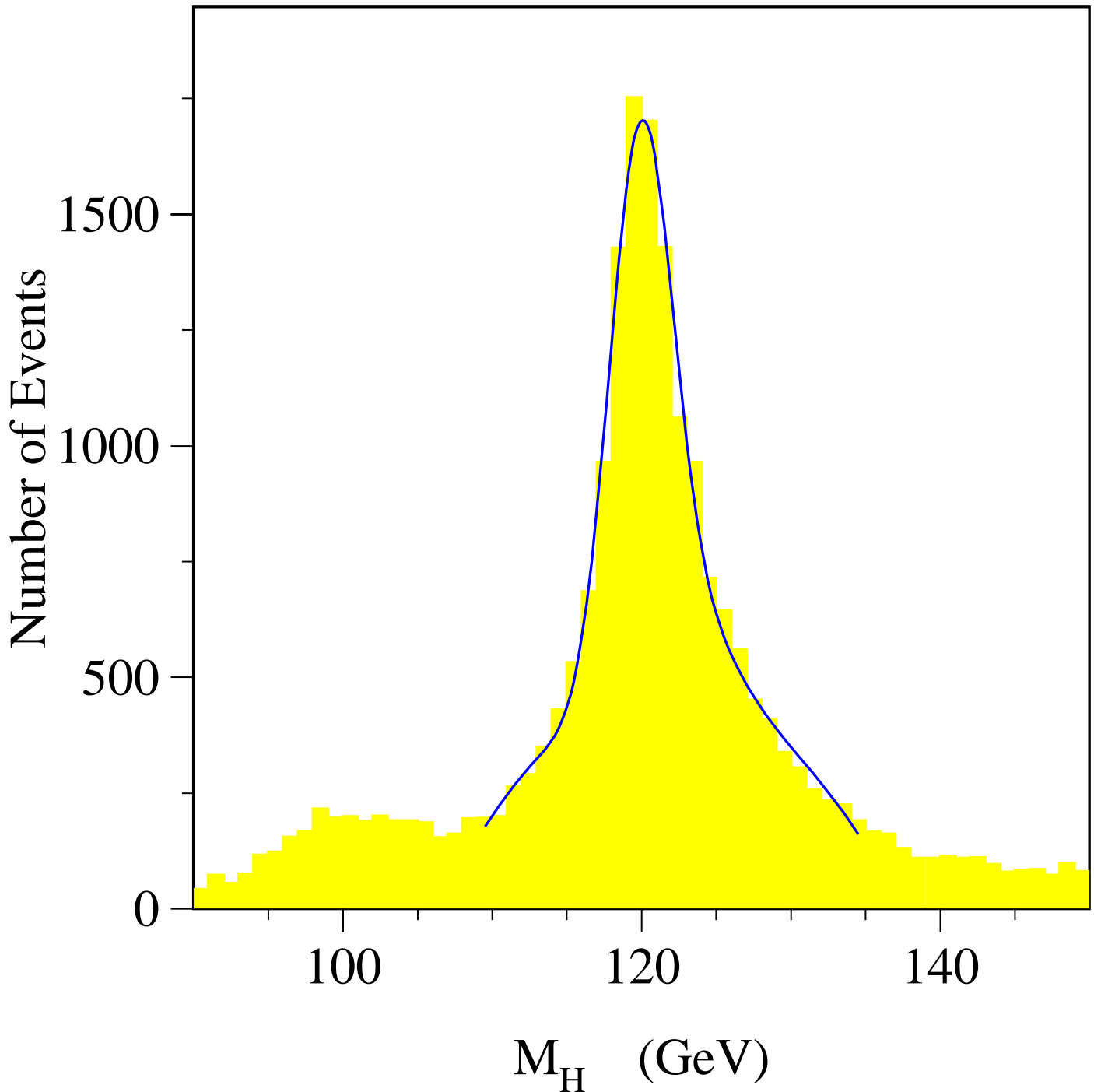
- $\Delta\theta = 10 \text{ mrad}$

- $\Delta\phi = \frac{10}{\sin\theta} \text{ mrad}$

* Kinematic fit is done with V. Blobel's program

$$e^+e^- \rightarrow ZH \rightarrow q\bar{q}b\bar{b}, \quad q = u, d, c, s, b$$

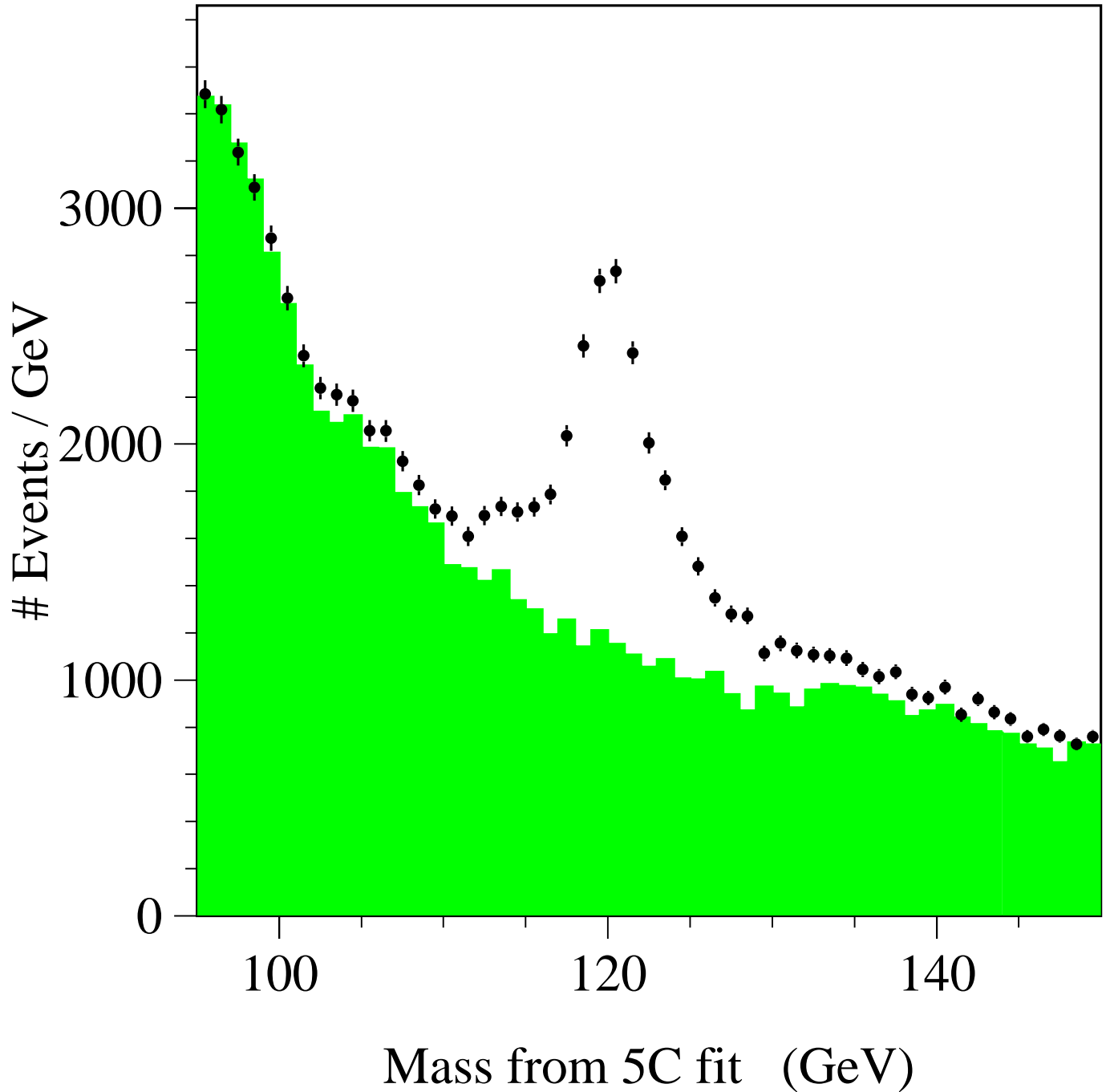
Mass from 5C fit: $\Delta M_H \simeq 45 \text{ MeV}$



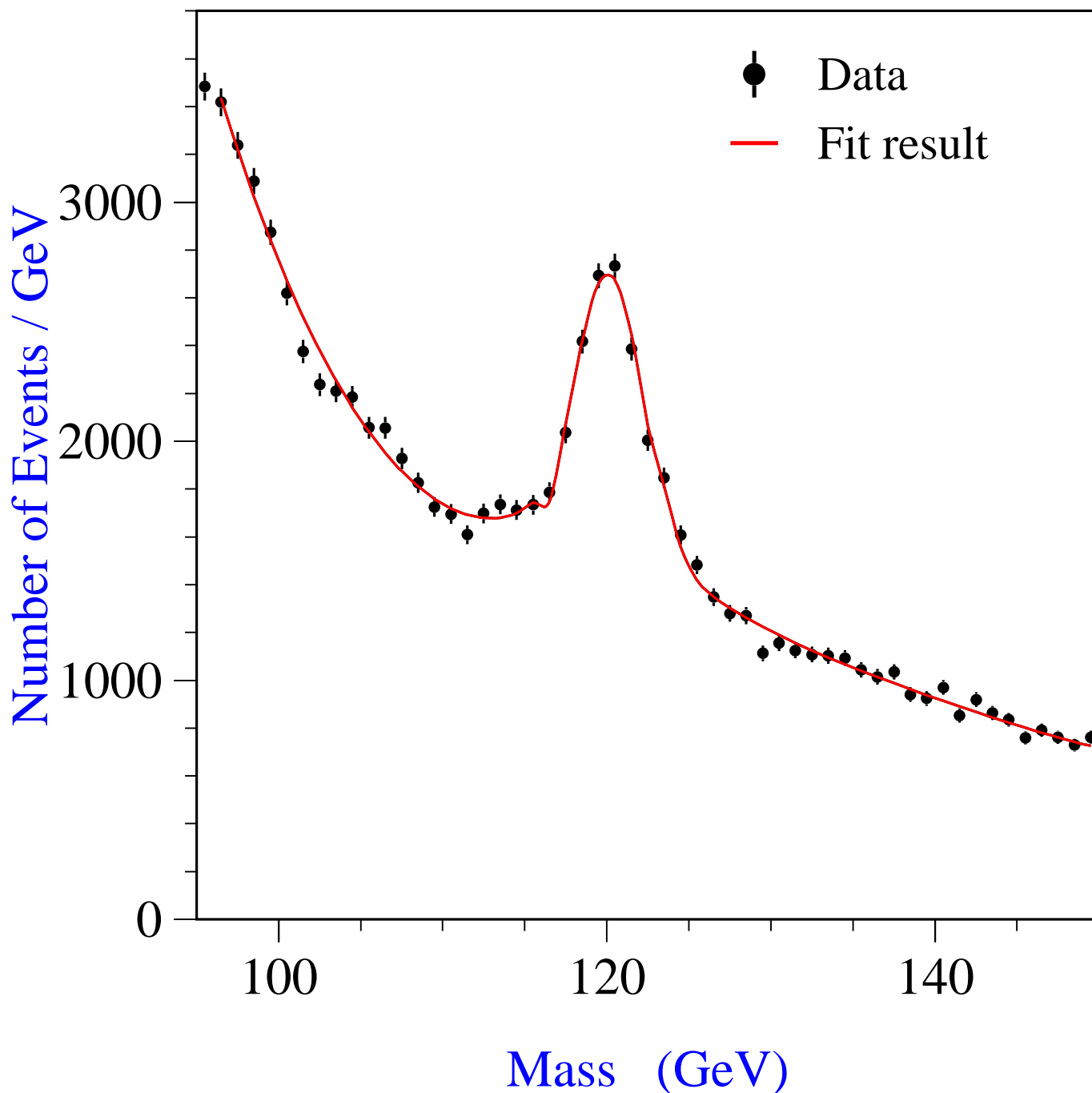
signal events = 15 K

background events = 90 K

23% $q\bar{q}(\gamma)$ 30% ZZ 47% WW

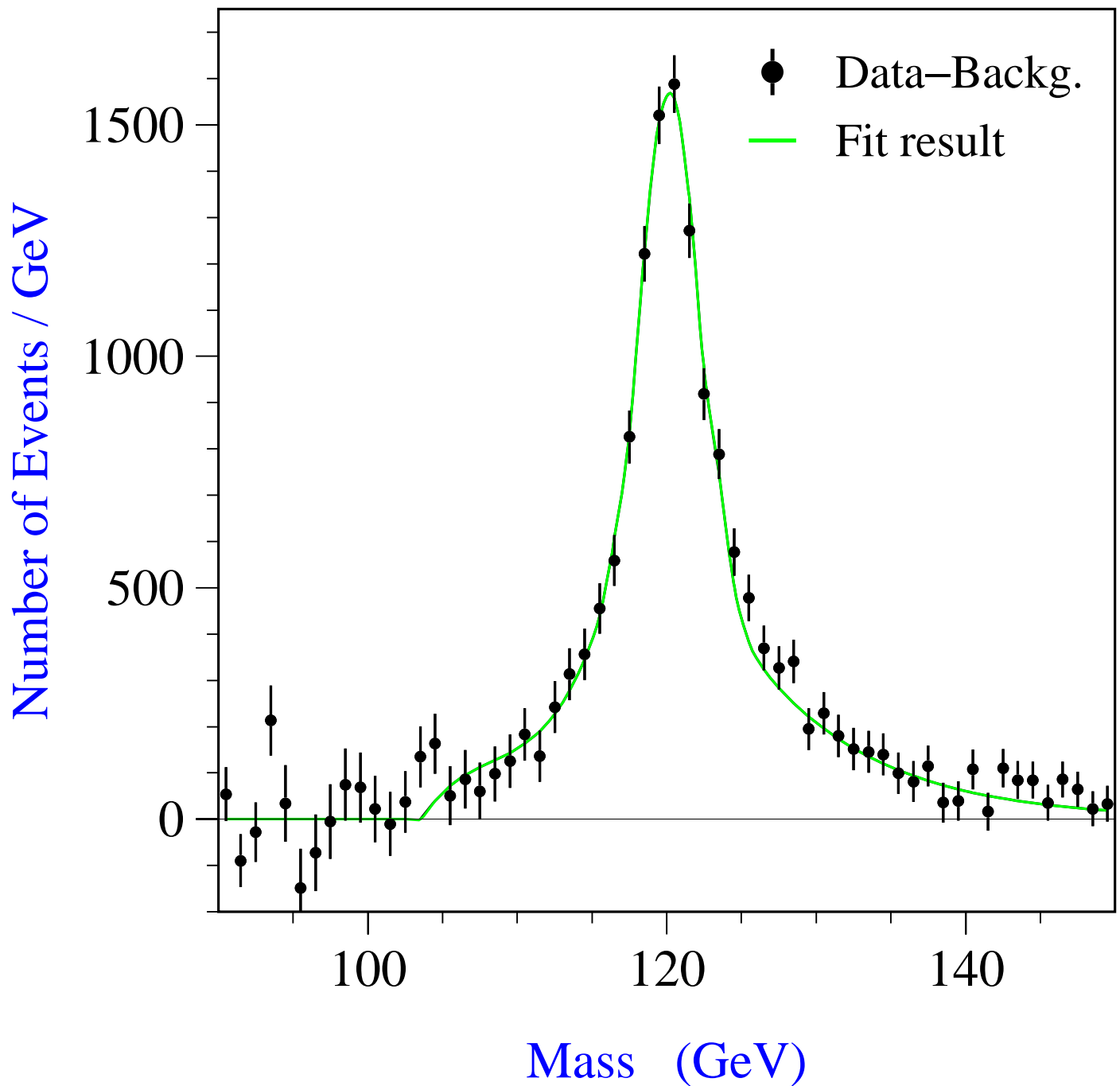


- * Higgs mass (120 GeV): $\Delta M_H \simeq 50 \text{ MeV}$
- * Higgs mass resolution: $\sigma_H \simeq 2.4 \text{ GeV}$
- * Cross section $ZH \rightarrow q\bar{q}b\bar{b}$: $\Delta\sigma/\sigma \approx 1.5 \%$



[Several parametrisations used in the description of signal and background]

Cross-check: fit to the mass distribution after background subtraction (uncorrelated)



[Again, several parametrisations used in the description of signal and background]

* Cut based selection of $ZH \rightarrow q\bar{q}b\bar{b}$

No b-tag for the time being. . .

* Higgs mass (120 GeV): $\Delta M_H \simeq 50 \text{ MeV}$

* Higgs mass resolution: $\sigma_H \simeq 2.4 \text{ GeV}$

* $e^+e^- \rightarrow ZH \rightarrow q\bar{q}b\bar{b}$: $\Delta\sigma/\sigma \approx 1.5 \%$



* To do: the analysis for $M_H = 150$ and 180 GeV

* $H \rightarrow WW$ and $H \rightarrow ZZ$: 6 jet events