Measuring the Higgs mass at TESLA

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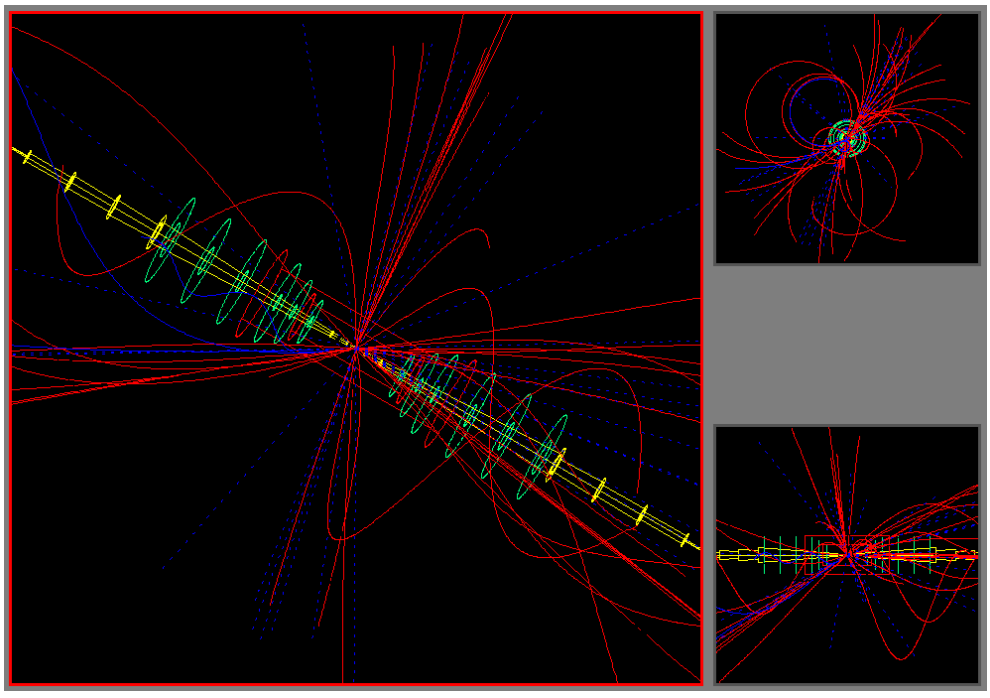


Linear Collider Workshop 2000 – Fermilab, October 24-28, 2000

Introduction

From the recoil mass[1] in $e^+e^- \to ZH \to \ell^+\ell^- X$:

$$\Delta\sigma/\sigma \lesssim 2.6 - 3.8\,\%$$

independent of $Br\,(H \to X)$

$\sqrt{s} = 350$ GeV, $\mathcal{L} = 500$ fb^{-1} **and** $m_H = 120 \ldots 180$ GeV

but $\Delta m_H \sim 110$ MeV **only !!**

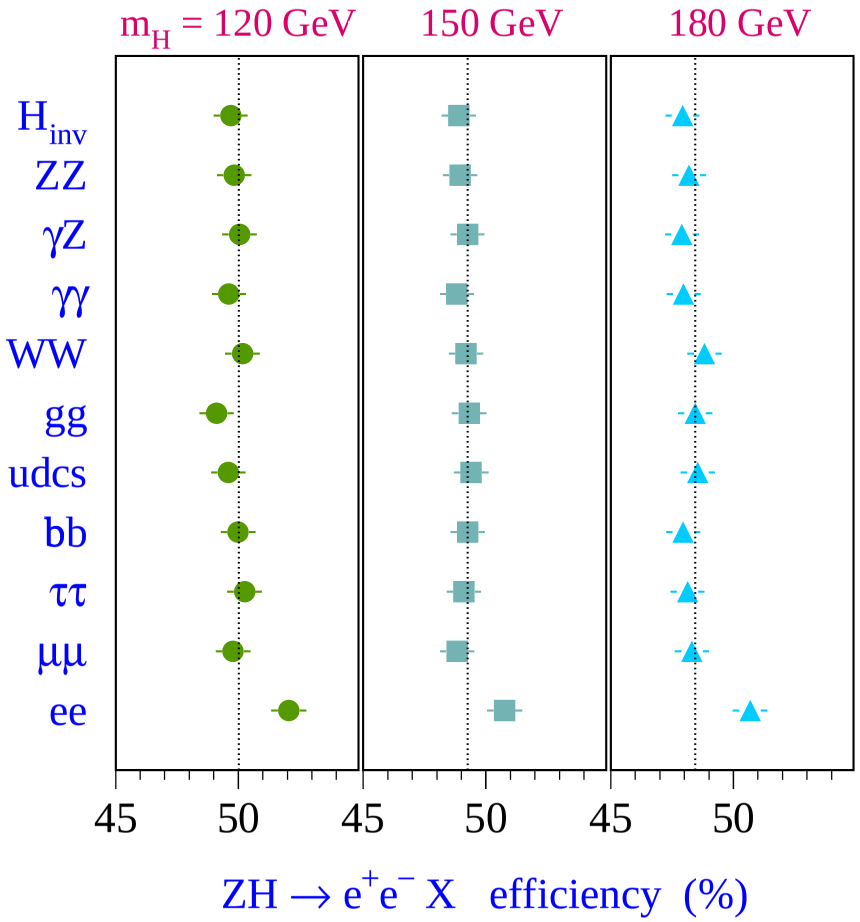
This can be improved significantly by exploiting the kinematics of the Higgs decay products (X):

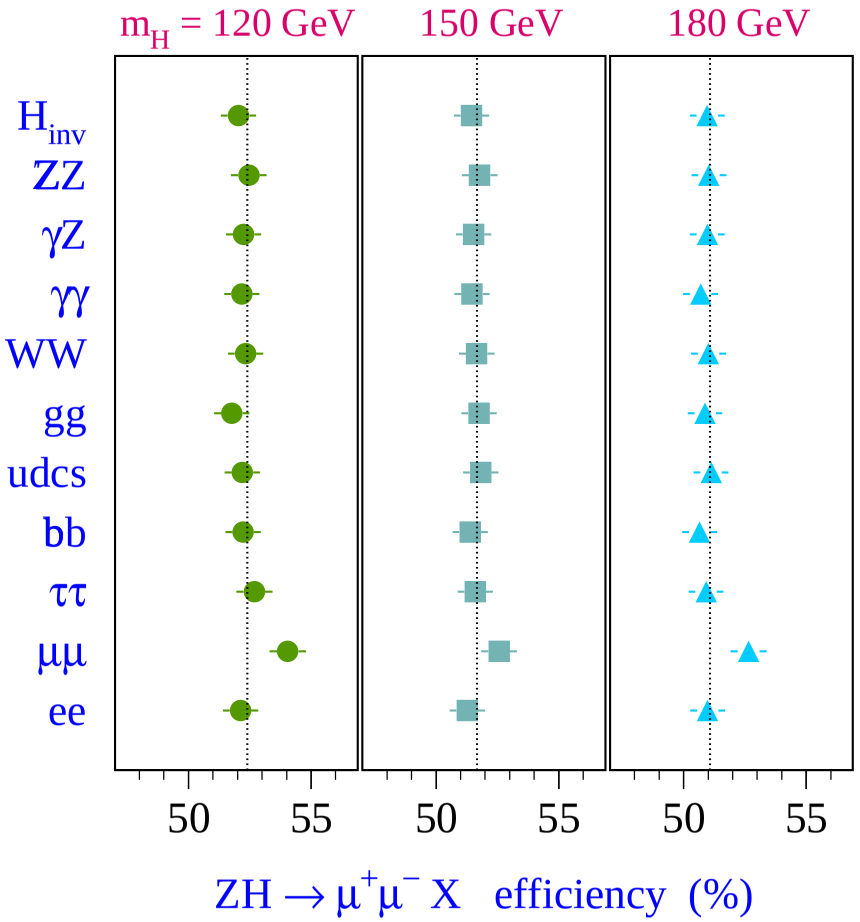
less model independent

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

Efficiency of ZH $\rightarrow e^+e^-X$ and $\mu^+\mu^-X$

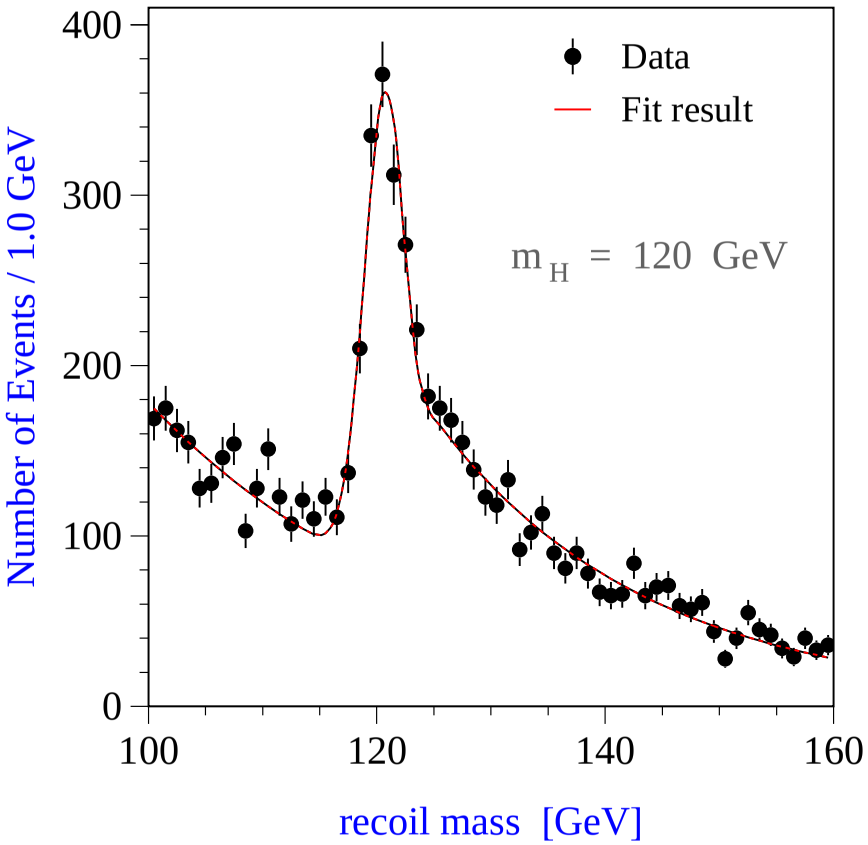
The efficiency is (almost) independent of the Higgs decay mode



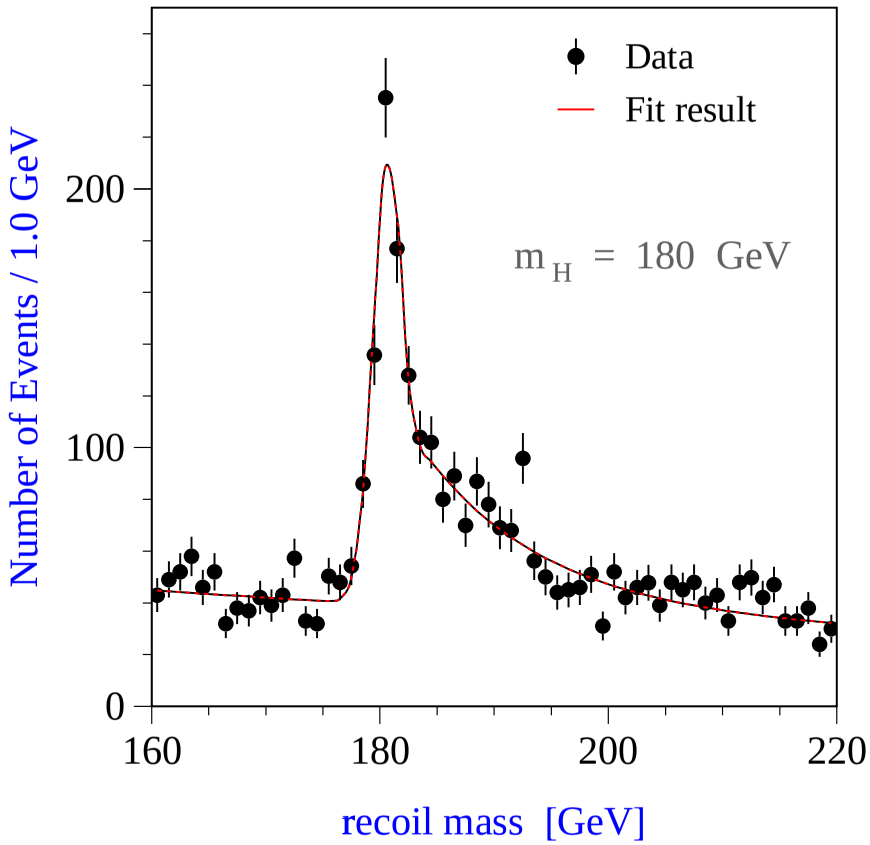


Recoil mass in $ZH \to \ell^+\ell^- X$

$\Delta m_H = 110$ MeV
$\Delta\sigma/\sigma = 2.6\,\%$



$\Delta m_H = 95$ MeV
$\Delta\sigma/\sigma = 3.8\,\%$



Analysis

Channels investigated:

— the quoted numbers are $\sigma \times$BR, the cross sections are in fb —

Decay mode	$m_H =$	120	150	180
recoil mass	2ℓ + X	10.5	7.6	5.6
$ZH \to \ell^+\ell^- q\bar{q}$	2ℓ + 2-jets	8.6	1.7	0.5
$ZH \to q\bar{q}b\bar{b}$	4-jets	79.6	16.8	0.4
$ZH \to b\bar{b}b\bar{b}$	4-jets	17.3	3.7	0.1
$ZH \to \ell^+\ell^- W^+W^-$, $W^\pm \to q\bar{q}'$	2ℓ + 4-jets	1.2	5.4	5.6
$ZH \to q\bar{q}W^+W^-$, $W^\pm \to q\bar{q}'$	6-jets	12.9	26.5	26.6

Done for $m_H = 120 \ldots 180$ GeV, $\sqrt{s} = 350$ GeV, $\mathcal{L} = 500\,\mathrm{fb}^{-1}$

Main backgrounds: $q\bar{q}(\gamma)$, W^+W^- and ZZ events

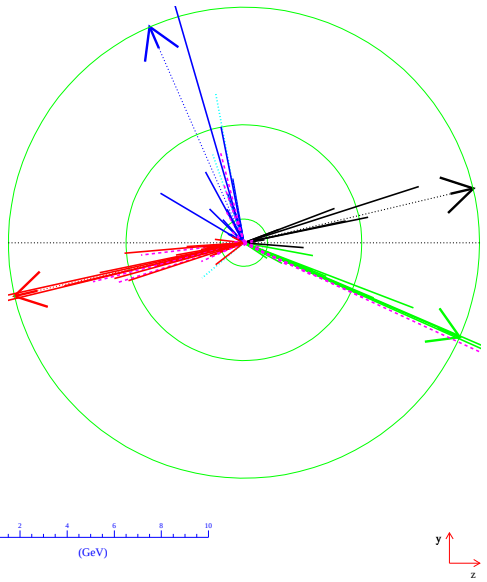
Other background sources under study: 6-fermion final states

Event generation and simulation:

- Event generator: PYTHIA 6.136
- Beamstrahlung: CIRCE V6
- Parametric Monte Carlo: SIMDET 3.2

Jet reconstruction:

- Cambridge (CAMJET) and DURHAM algorithms



Jet resolutions:

- $\frac{\Delta E}{E} = \frac{0.2}{\sqrt{E}}$
- $\Delta\theta = 10$ mrad
- $\Delta\phi = \frac{10}{\sin\theta}$ mrad

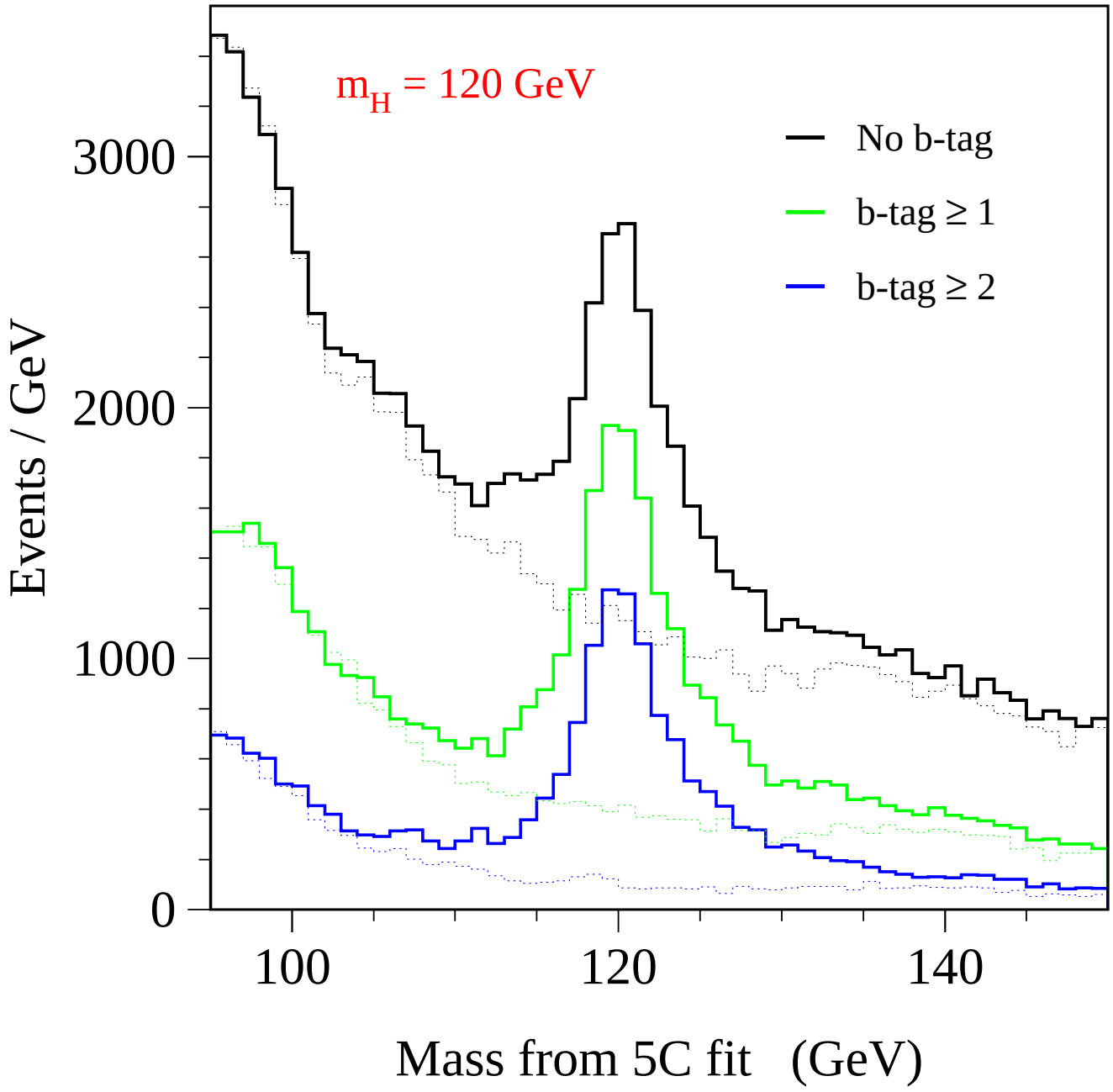
(resolution for leptons is much better !!!)

Kinematic fit: using V. Blobel's program

b-tag: parametrisations from R. Hawkings (K. Desch)

Selection: cut based, lepton-id, high multiplicity, topological variables (Y_{34}, S, H_{20}, . . .)

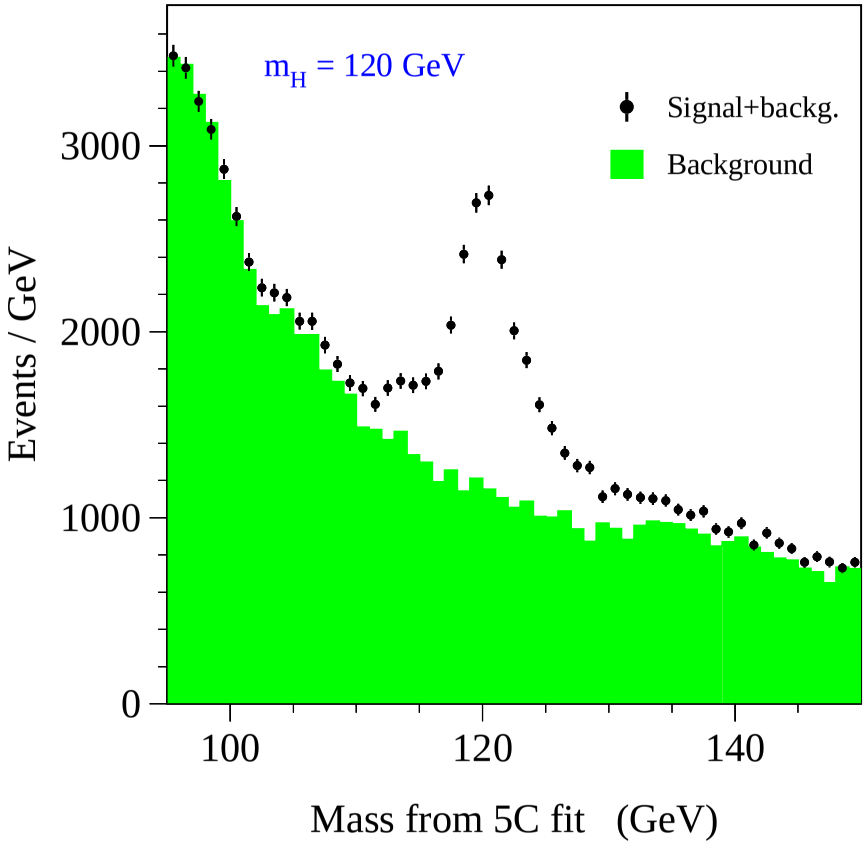
Effect of b-tag in $ZH \rightarrow q\bar{q}q\bar{q}$



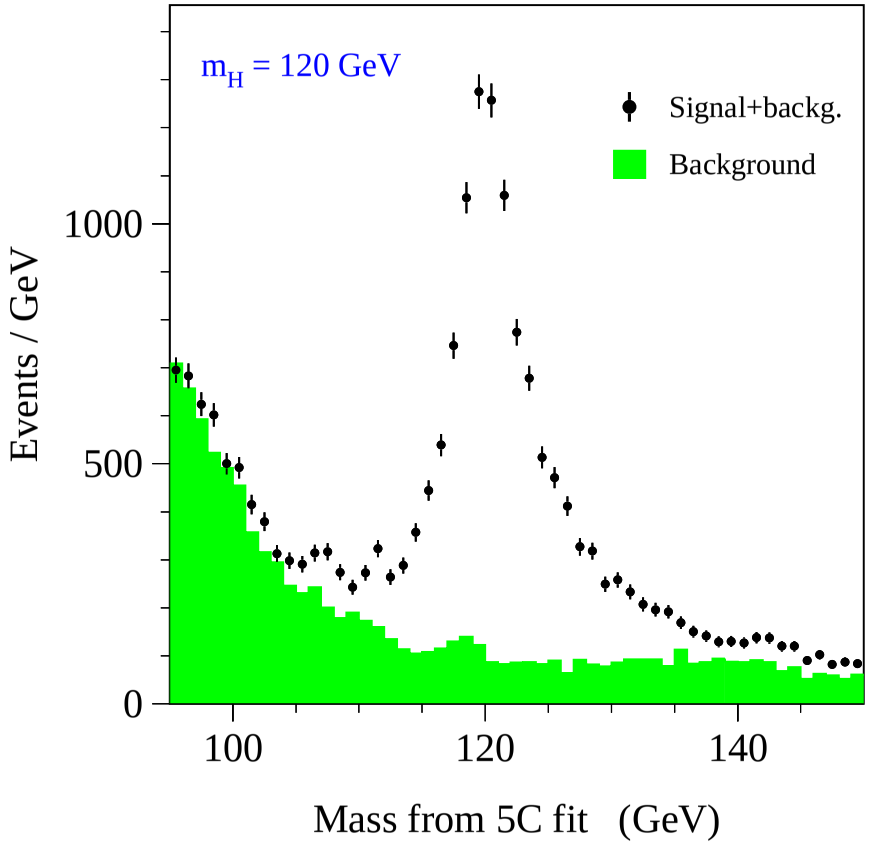
b-tag efficiency is 80% independent of the jet energy

Effect of b-tag in $ZH \rightarrow q\bar{q}q\bar{q}$

No b-jet tagged

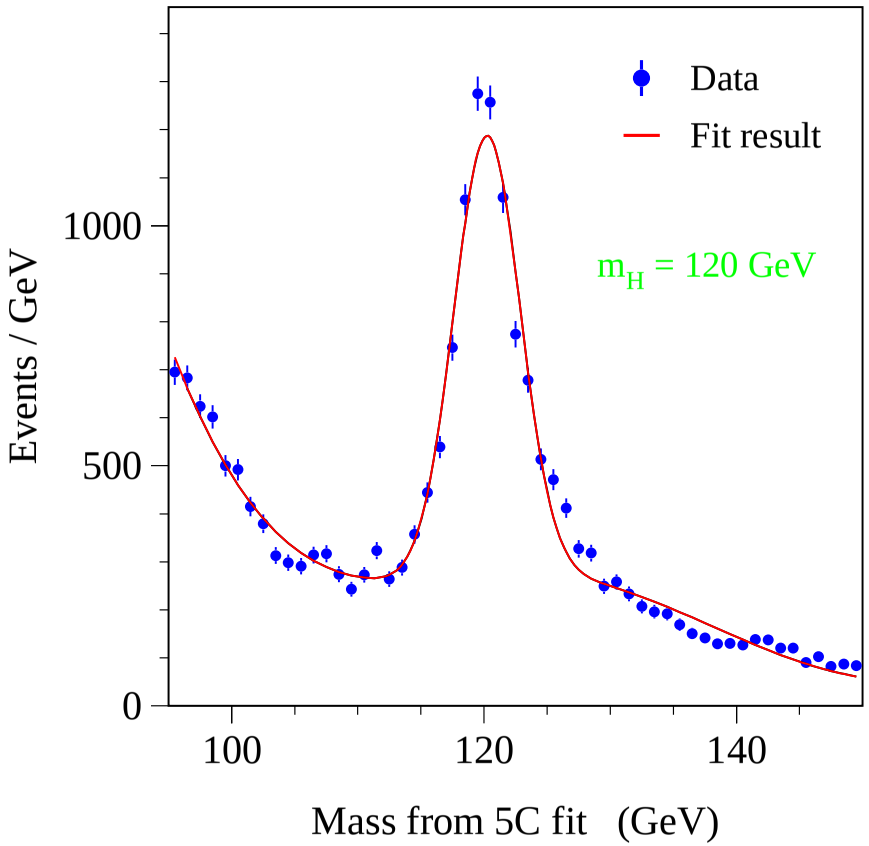


2 b-jets tagged

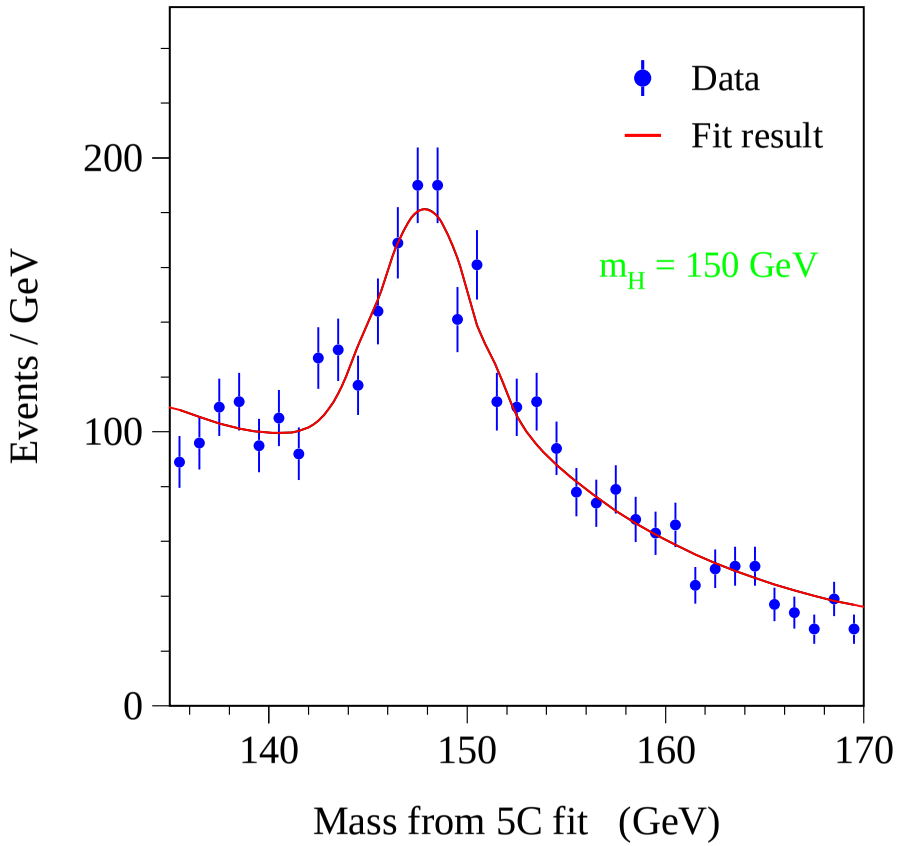


$ZH \to q\bar{q}b\bar{b}$, two b-jets tagged

$\Delta m_H = 45$ MeV
$\Delta\sigma/\sigma = 1.1\,\%$

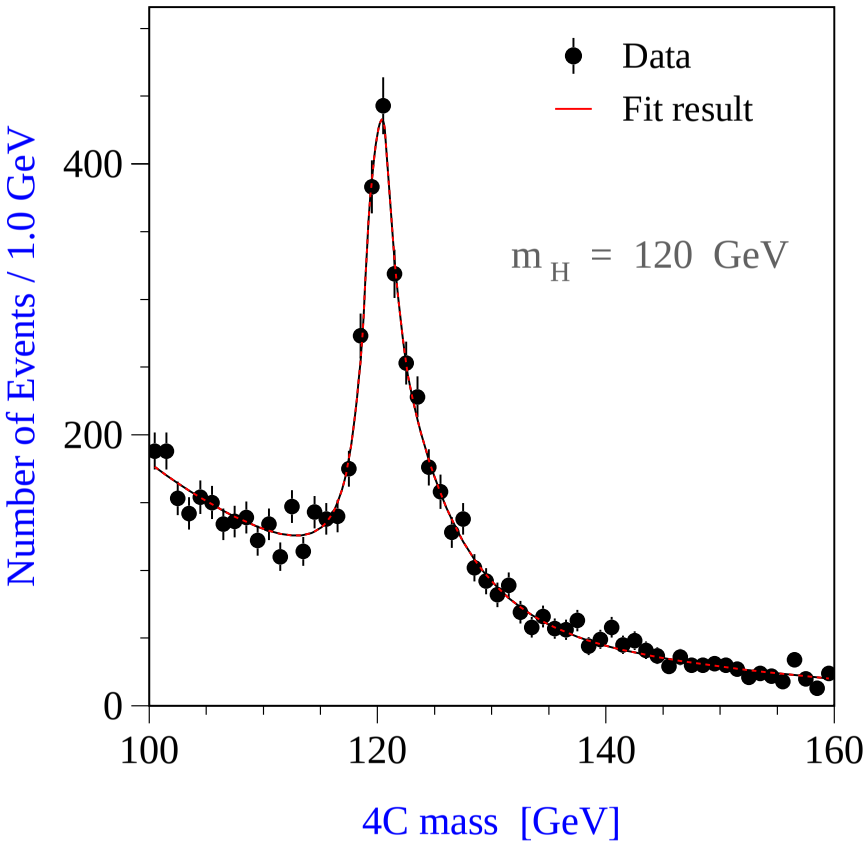


$\Delta m_H = 170$ MeV
$\Delta\sigma/\sigma = 3.4\,\%$

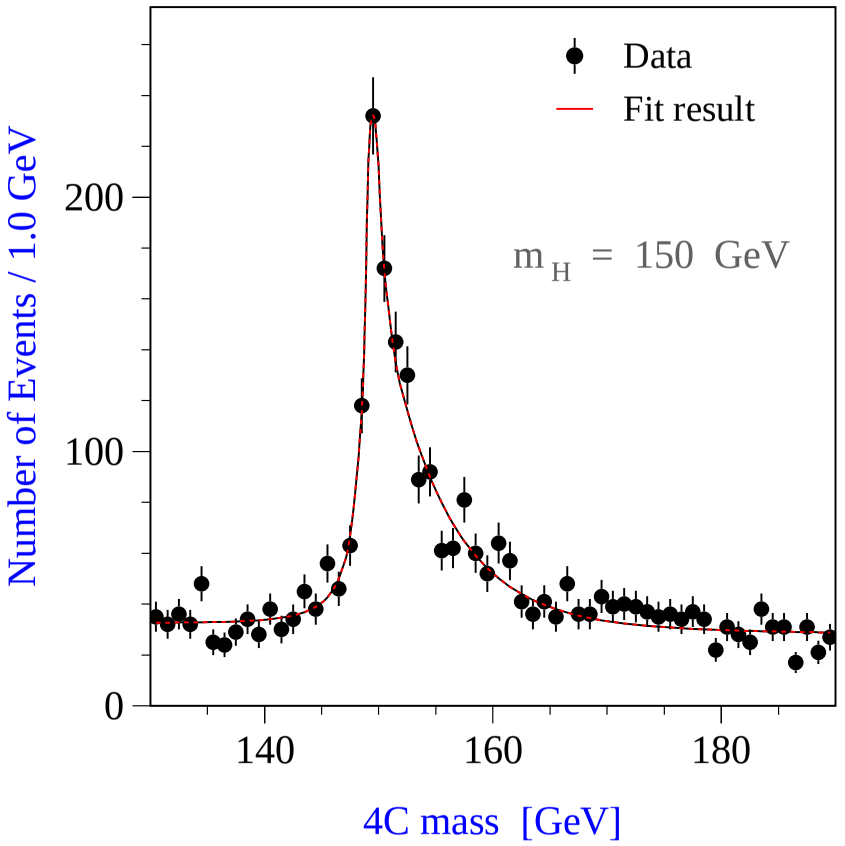


$ZH \to \ell^+\ell^- q\bar{q}$

$\Delta m_H = 70$ MeV
$\Delta\sigma/\sigma = 3.0\,\%$

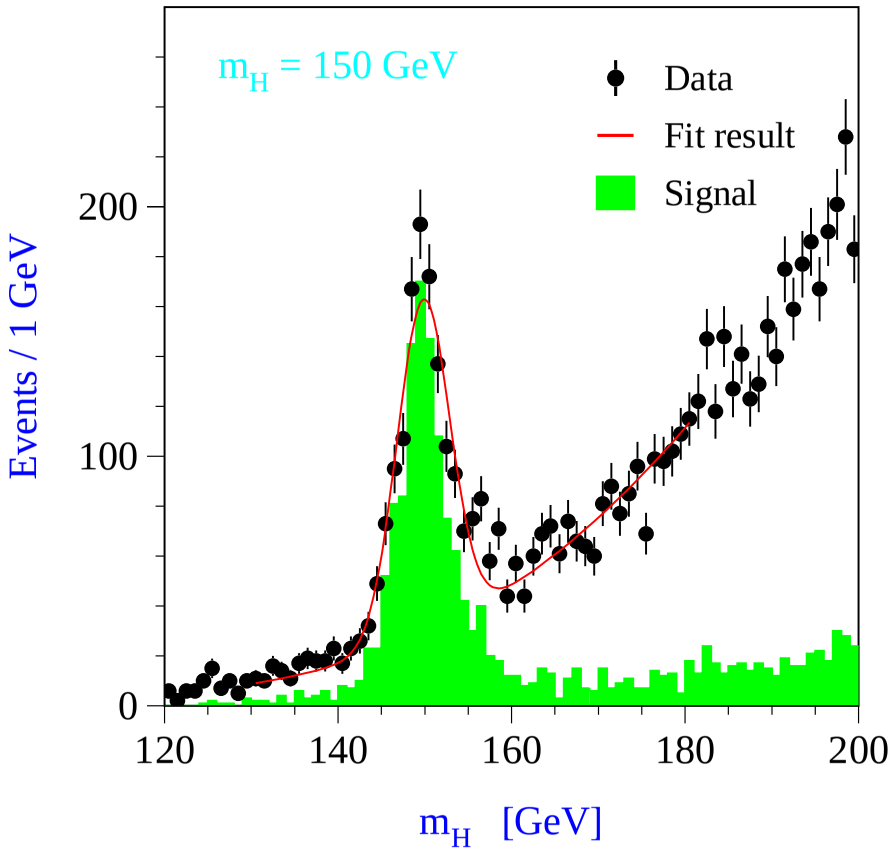


$\Delta m_H = 90$ MeV
$\Delta\sigma/\sigma = 4.7\,\%$

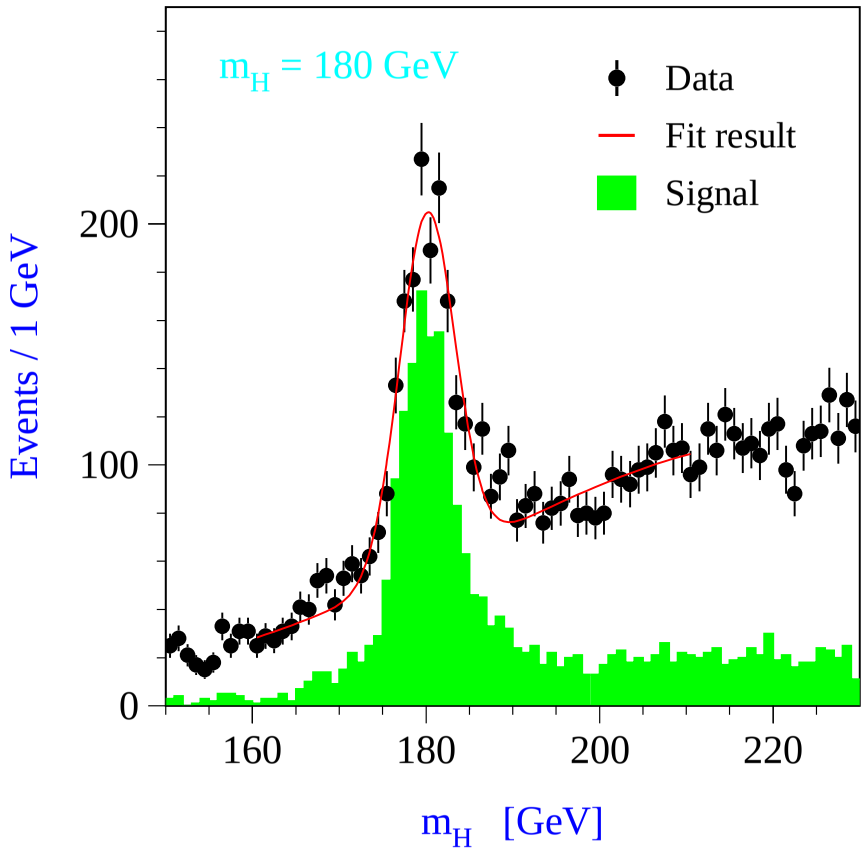


$$\mathbf{ZH \to q\bar{q}W^+W^-, \quad W^{\pm} \to q\bar{q}'}$$

$\Delta m_H = 130$ MeV
$\Delta\sigma/\sigma = 3.4\,\%$

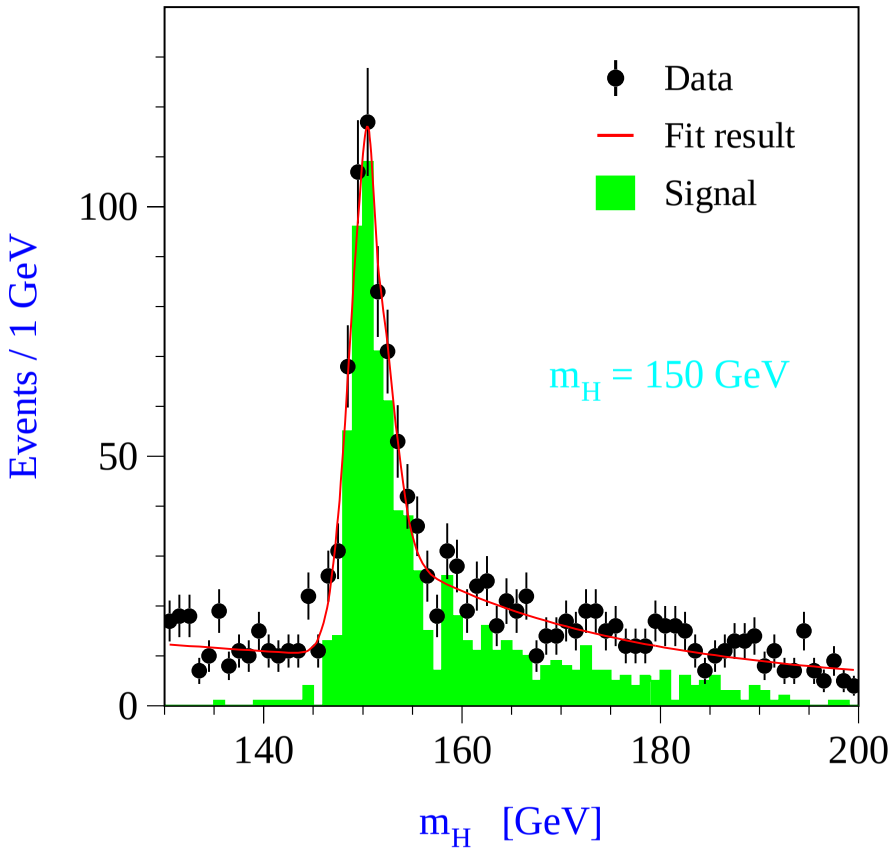


$\Delta m_H = 150$ MeV
$\Delta\sigma/\sigma = 2.9\,\%$

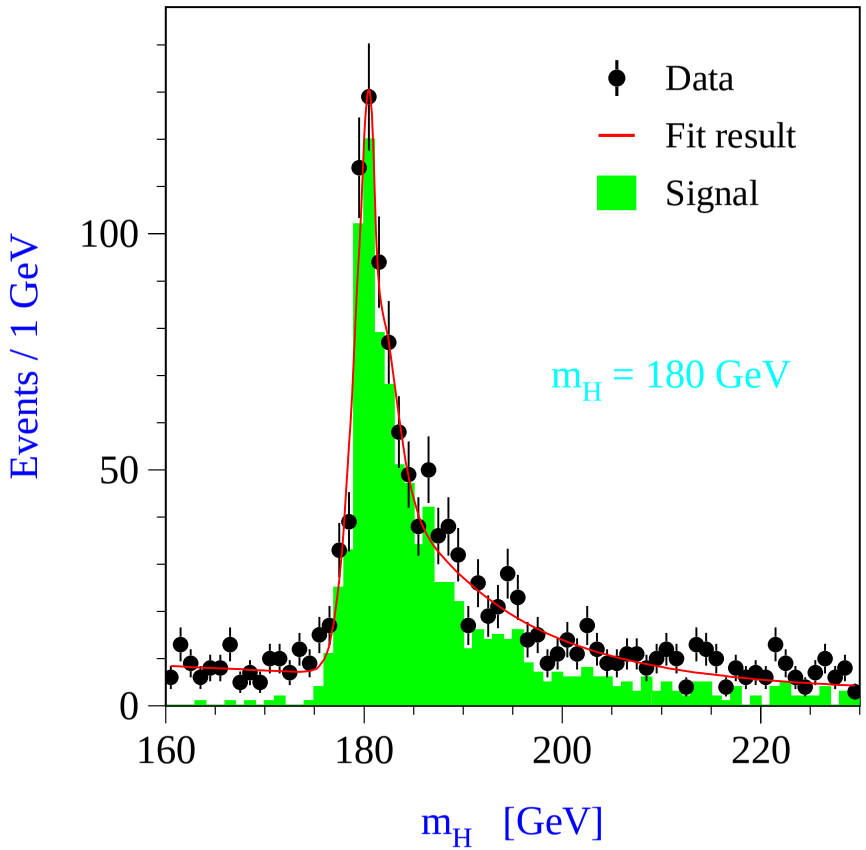


$$\mathbf{ZH \to \ell^+\ell^- W^+W^-, \quad W^\pm \to q\bar{q}'}$$

$\Delta m_H = 160$ MeV
$\Delta\sigma/\sigma = 4.0\,\%$



$\Delta m_H = 160$ MeV
$\Delta\sigma/\sigma = 3.3\,\%$



Conclusions

Absolute accuracy (in MeV) on the determination of m_H:

Decay mode $m_H =$	120	150	180
recoil mass	110	90	95
$ZH \to \ell^+\ell^- q\bar{q}$	70	90	–
$ZH \to q\bar{q}b\bar{b}$	45	170	–
$ZH \to \ell^+\ell^- W^+W^-,\ W^\pm \to q\bar{q}'$	–	160	160
$ZH \to q\bar{q}W^+W^-,\ W^\pm \to q\bar{q}'$	–	130	150

Relative accuracy (in %) on the determination of $\sigma(ZH \to X)$:

Decay mode $m_H =$	120	150	180
recoil mass	2.6	3.2	3.8
$ZH \to \ell^+\ell^- q\bar{q}$	3.0	4.7	–
$ZH \to q\bar{q}b\bar{b}$	1.1	3.4	–
$ZH \to \ell^+\ell^- W^+W^-,\ W^\pm \to q\bar{q}'$	–	4.0	3.3
$ZH \to q\bar{q}W^+W^-,\ W^\pm \to q\bar{q}'$	–	3.4	2.9