Analysis of ZH recoil mass

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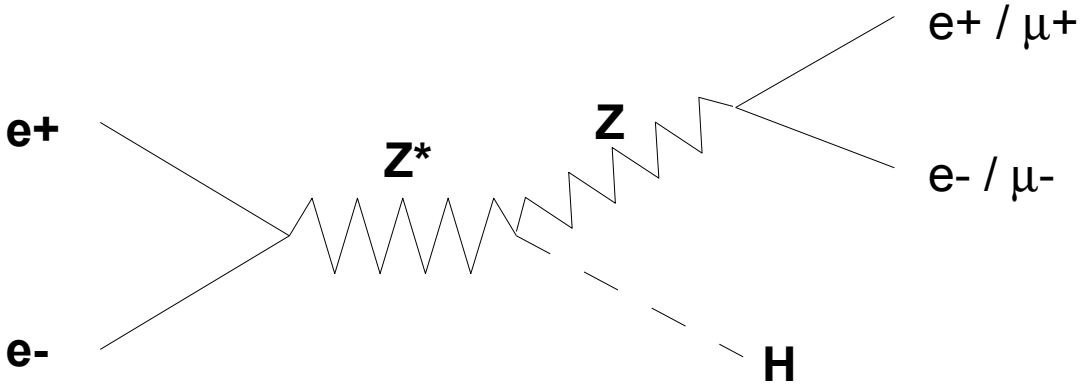
Introduction

- **Motivation of the recoil mass study.**
  - e+e- → ZH → l+l-X is the golden channel for measurement of Higgs mass and coupling of ZH.
  - Higgs mass is reconstructed by using only charged leptons from Z.



- **Today's topic.**
  - Reconstruction of recoil mass.
  - Estimation of the measurement accuracy for the ZH cross section and Higgs mass.

Simulation setup

- **CM energy : 250 GeV**
- **Detector model : LDCPrime_02Sc**
- **Event generator : Pythia**

- **Signal**
  - ee → ZH → ee X (7.5 fb)
  - ee → ZH → μμ X (7.5 fb)
    - Luminosity : 1300fb^{-1} (10k events)
- **Background**
  - ee → ZZ → ee X (78.7 fb)
  - ee → ZZ → μμ X (79.0 fb)
    - Luminosity : 127 fb-1 (10k events)

The number of events are scaled to 250 fb^{-1}.

Analysis outline

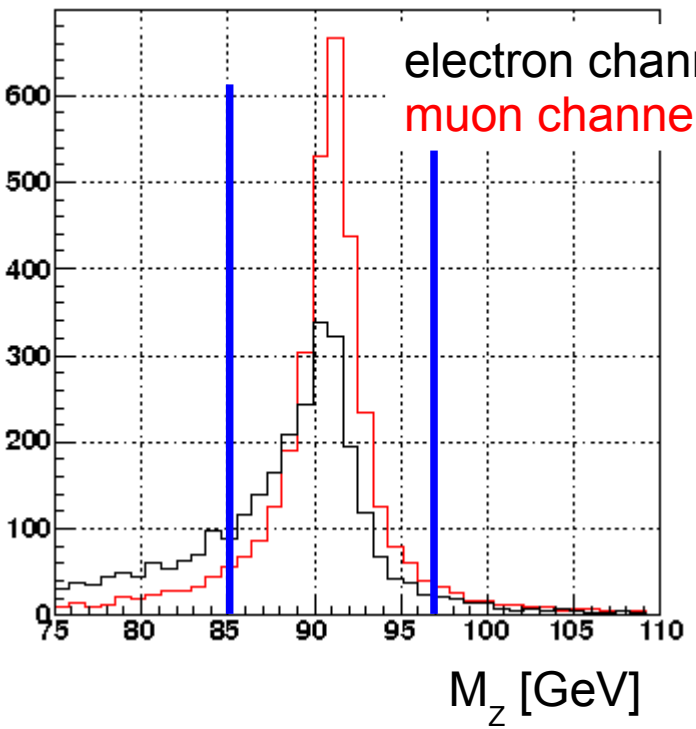
1. **Selection of 2 lepton tracks from Z.**
   - Two tracks have the least χ^2 value for M_Z.
2. **Selection of well-reconstructed events.**
3. **Reconstruction of Higgs recoil mass.**
4. **Estimation of measurement accuracies for $\sigma(ZH)$ and M_H.**
   - These accuracies were obtained by fitting.

The selection and fitting function are shown.

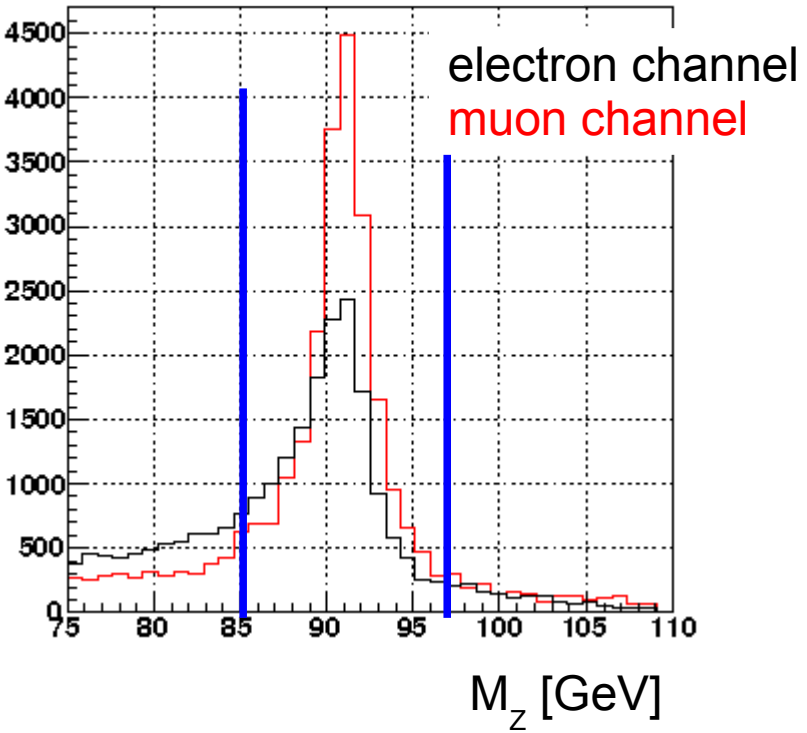
Mz cut

- **Mz is reconstructed with the selected two lepton tracks.**
- **Events with Mz of 85-97 GeV are selected.**

Signal (ZH)

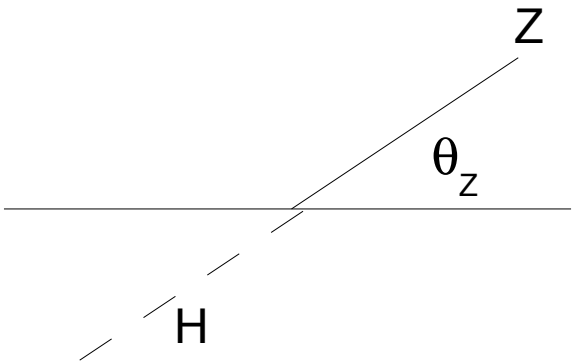


ZZ background

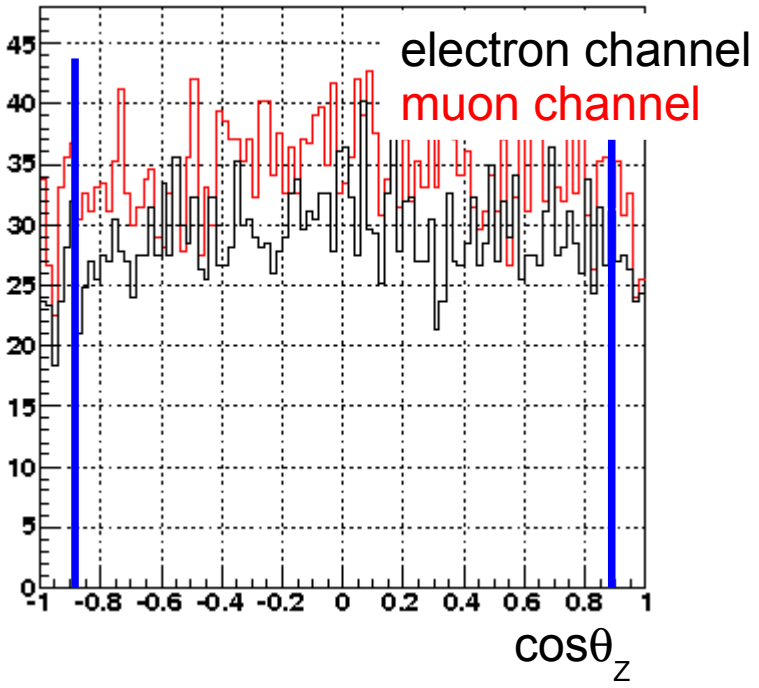


cosθz cut

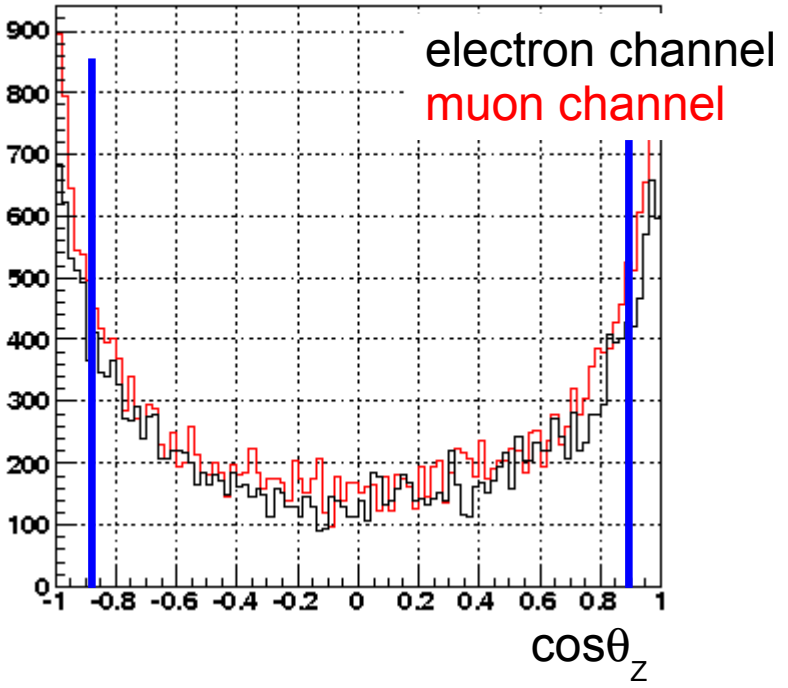
- **The Z production angle cut is applied.**
  - The events with the range of $|\cos\theta_Z| < 0.9$ are selected.



Signal (ZH)



ZZ background



Reduction summary

- **M_z and $\cos\theta_z$ cuts reduce the ZZ background.**

e-channel	signal (ZH)	ZZ
No cut	10000	10000
Pre-cut	7706 (77.1%)	6061 (60.6%)
$85 < M_Z < 97$ GeV	5537 (55.4%)	3985 (39.9%)
$\lvert \cos\theta_{lepton} \rvert < 0.95$	5028 (50.3%)	3627 (36.3%)
$\lvert \cos\theta_Z \rvert < 0.9$	4631 (46.3%)	2874 (28.7%)

μ-channel	signal (ZH)	ZZ
No cut	10000	10000
Pre-cut	9183 (91.8%)	7010 (70.1%)
$85 < M_Z < 97$ GeV	7958 (79.6%)	5515 (55.2%)
$\lvert \cos\theta_{lepton} \rvert < 0.95$	7184 (71.8%)	4994 (49.9%)
$\lvert \cos\theta_Z \rvert < 0.9$	6581 (65.8%)	3891 (38.9%)

Pre-selection cut:

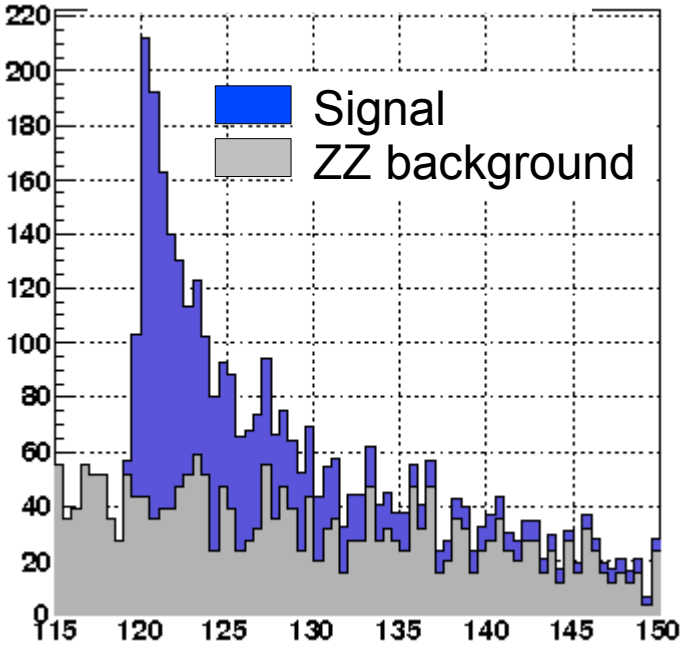
$E_{lepton} > 10$ GeV

$73 < M_z < 109$ GeV

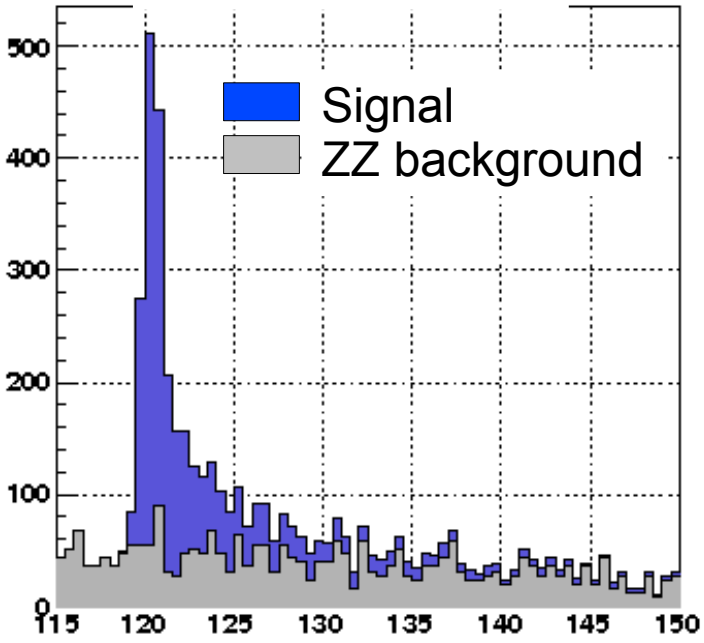
Reconstructed recoil mass

- The recoil mass is reconstructed after applying all the cuts.
- A peak is observed at 120 GeV for signal events.
- There is a tail from ZZ background at Higgs mass.

electron channel



muon channel



Fitting function for signal

- **Signal distribution is fitted by the empirical function.**
  - F_H is convoluted with Gaussian.
  - The convolution function is multiplied by a correction term.

$$F(m) = N\, e^{-Am} \int F_H(m+t)\, e^{\frac{-t^2}{2\sigma^2}}\, dt$$

Correction term

F_H is inspired from the bremsstrahlung and beamstrahlung spectra.

$$F_H(m) = \left(\frac{m - M_H}{\sqrt{s} - M_H}\right)^{\beta},$$

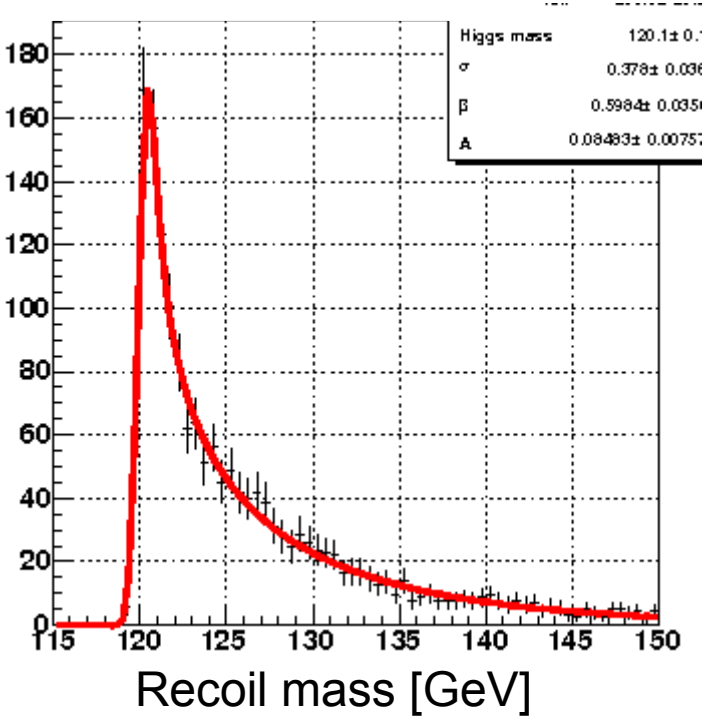
$$where\ M_H < m < \sqrt{s}$$

Fitting result (signal only)

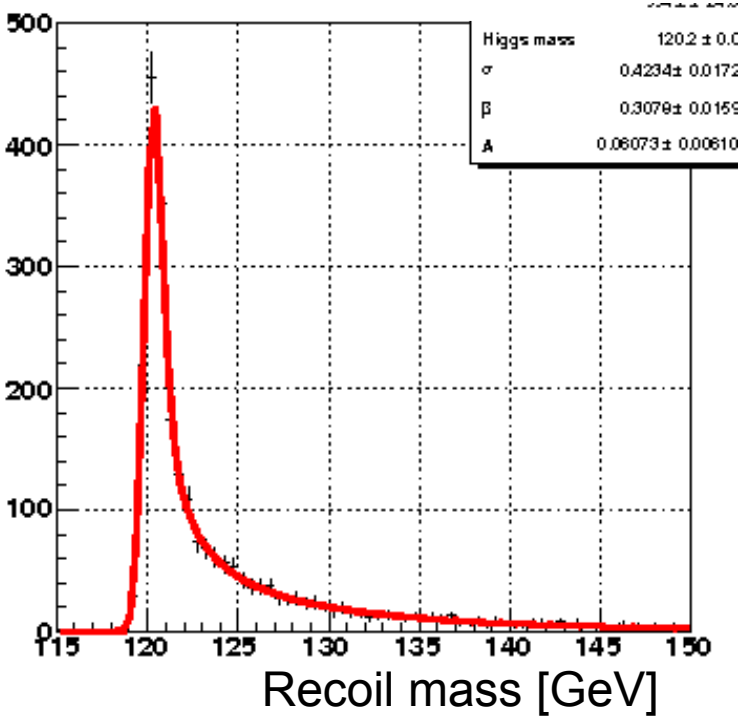
- **Signal distribution is fitted by the empirical function.**

$$F(m) = N\, e^{-Am} \int F_H(m+t)\, e^{\frac{-t^2}{2\sigma^2}}\, dt$$

electron channel



muon channel

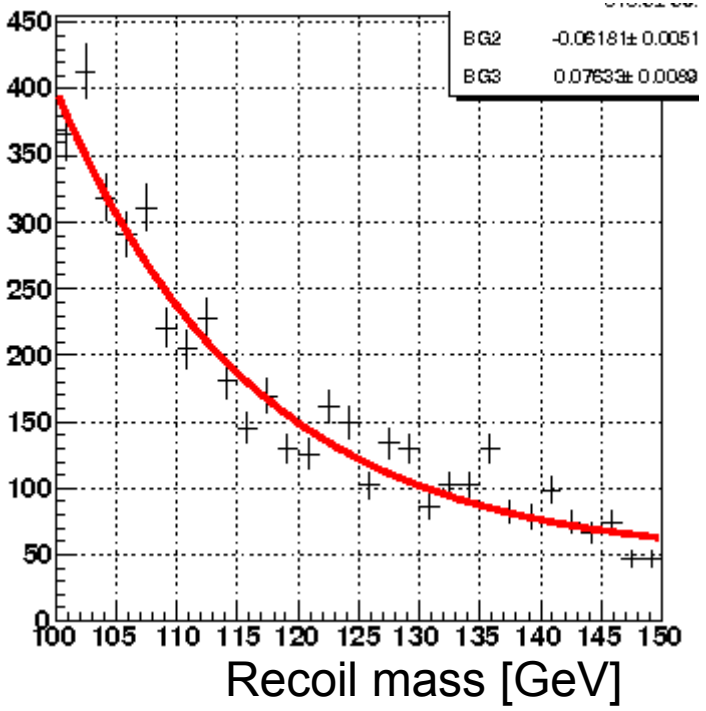


Fitting result seems to be good.

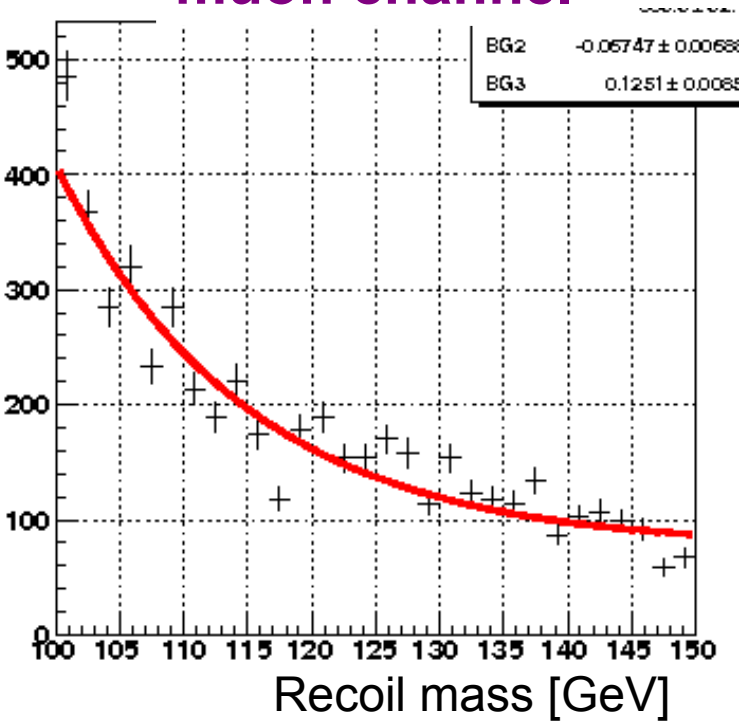
Fitting function for background

- **ZZ background is fitted with exponential function.**

electron channel



muon channel

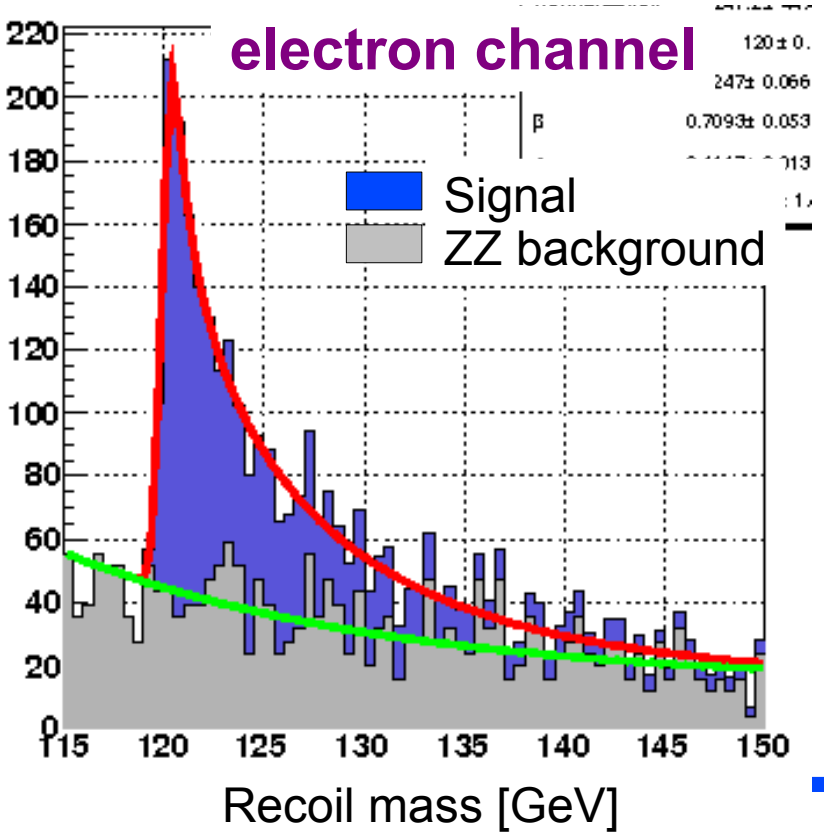


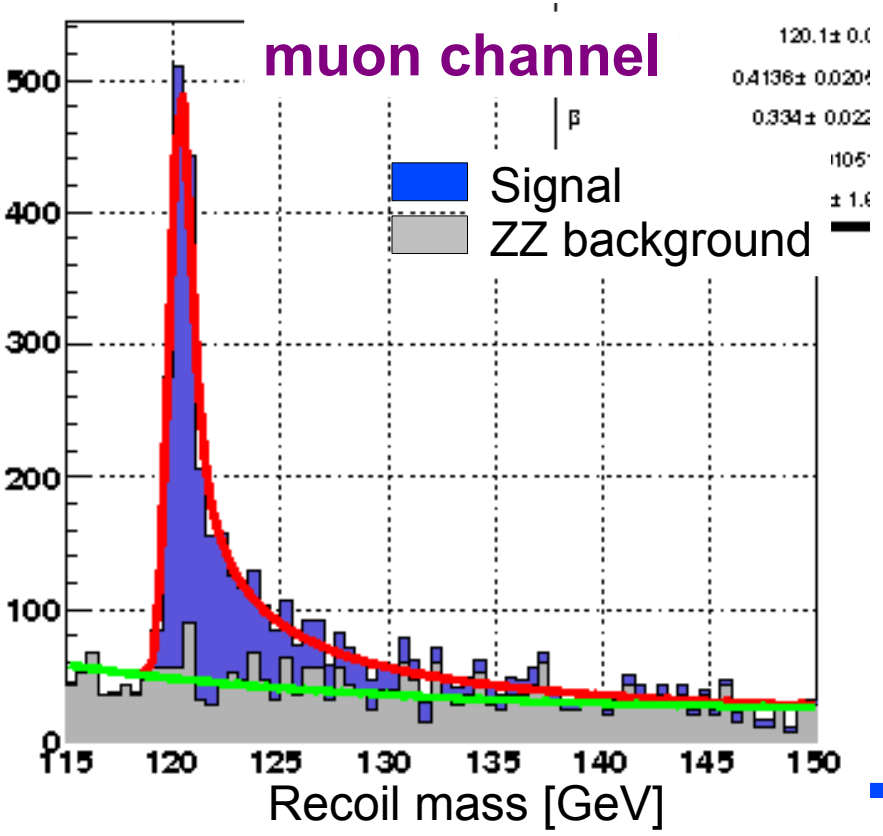
Then, "Signal + Background" is fitted.

- Background parameter is fixed except for the normalization.

Measurement accuracy

- **Signal + B.G. is fitted.**
  - Measurement accuracies for electron channel.
    - M_H = 120.0 +/- 0.10 GeV
    - σ(ZH) = 7.5 +/- 0.35 fb
  - Measurement accuracies for muon channel.
    - M_H = 120.1 +/- 0.041 GeV
    - σ(ZH) = 7.7 +/- 0.29 fb





Summary

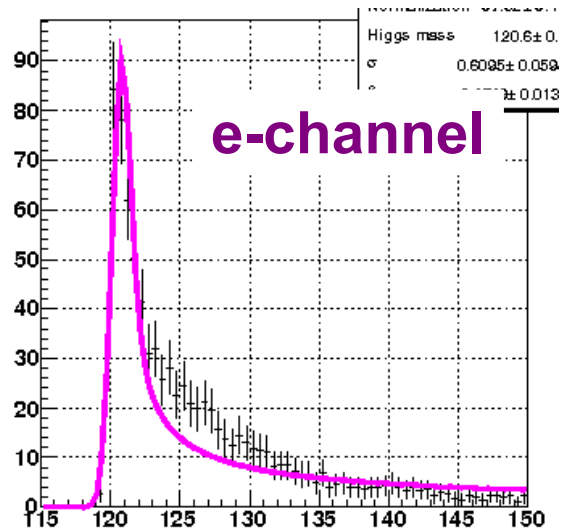
- **Status of the recoil-mass study was shown.**
  - ZZ background is only included.
  - To include other backgrounds (bhabha, WW, etc.) is the next step.
- **This analysis is the model independent.**
  - After including the other backgrounds, we will try to apply the model independent analysis for LOI.
- **Measurement accuracies were estimated for 250 fb^{-1}.**
  - Higgs mass:
    - 0.10 GeV for the electron channel.
    - 0.041 GeV for the muon channel.
  - Cross-section for the ZH:
    - 4.7% for the electron channel.
    - 3.8% for the muon channel.

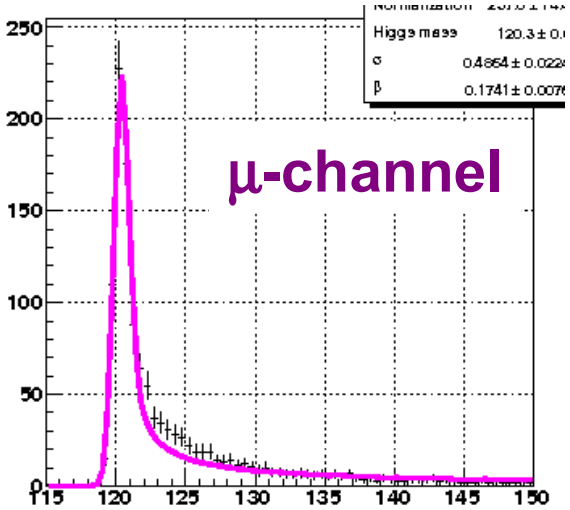
Backup slides

Fitting of signal distribution

$$F(m) = N \int F_H(m+t) e^{\frac{-t^2}{2\sigma^2}} dt$$

$$F(m) = N\, e^{-Am} \int F_H(m+t) e^{\frac{-t^2}{2\sigma^2}} dt$$





Add correction term

$$e^{-Am}$$