Measuring of the invariant top mass

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Abstract

The top quark mass was measured on a small dataset of the CMS detector at CERN. Therfore a selection of the data was performed and tested by a Monte Carlo (MC) simulation. First the cross section was measured then the Z-boson mass and the W-boson mass. At the end the top mass was measured out of the hadronic part of the decay and a second measuerement out of the semi-leptonic part of the decay.

Contents

1 Introduction

To measure the mass of the top quark a selection has been performed to selected events of the form:

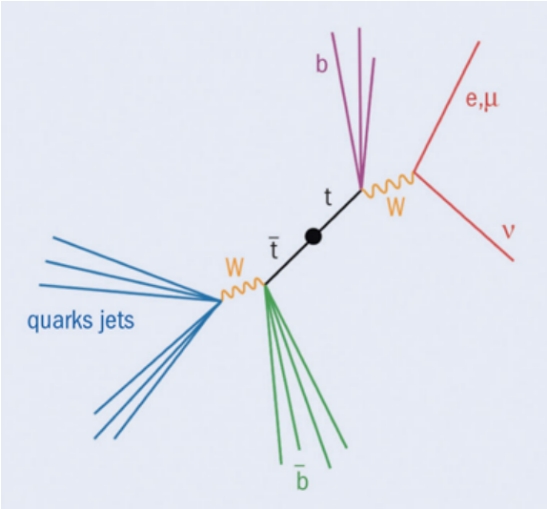

Figure 1: Hadronic and Semileptonic decay of a top, anti top pair

In the following plots one can see the Number of Jets, the Number of b tagged jets and the missing transverse energy distribution bevor the selection and after.
An event is accepted if:

1. It has 4 Jets in the final state
2. It has at least one isolated muon in the final state
3. It has at least two b-tagged jets

This selection leads to the following numbers:

Name	Value	Error
Total number of MC simulated events	240601	490
Number of MC triggerd events	208175	456
Total number of MC simulated $t\bar{t}$ events	36941	192
Number of MC accepted $t\bar{t}$ events	506	23
Number of expected $t\bar{t}$-events in Data	6429	80
Number of accepted events in Data	75	9

Table 1: Summary of number of events

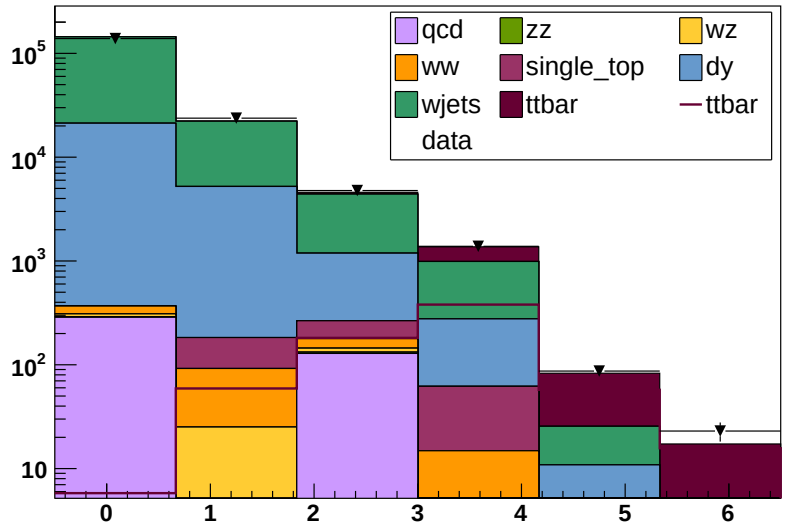

Figure 2: Number of jets before selection

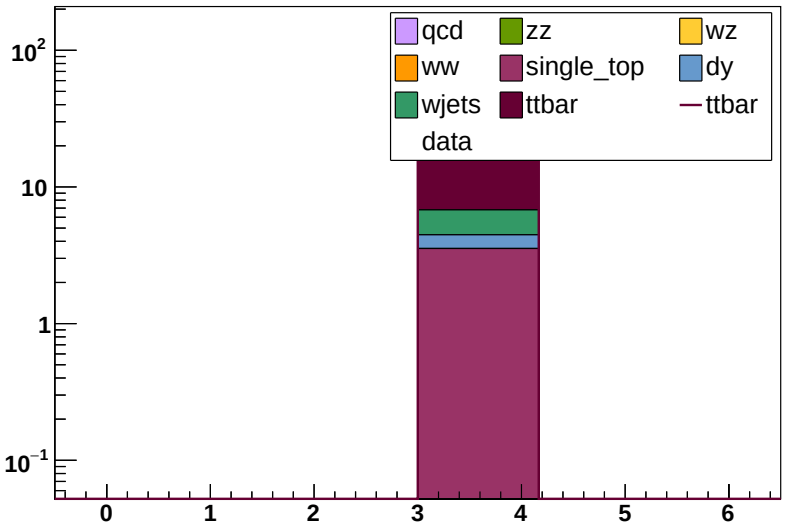

Figure 3: Number of jets after selection

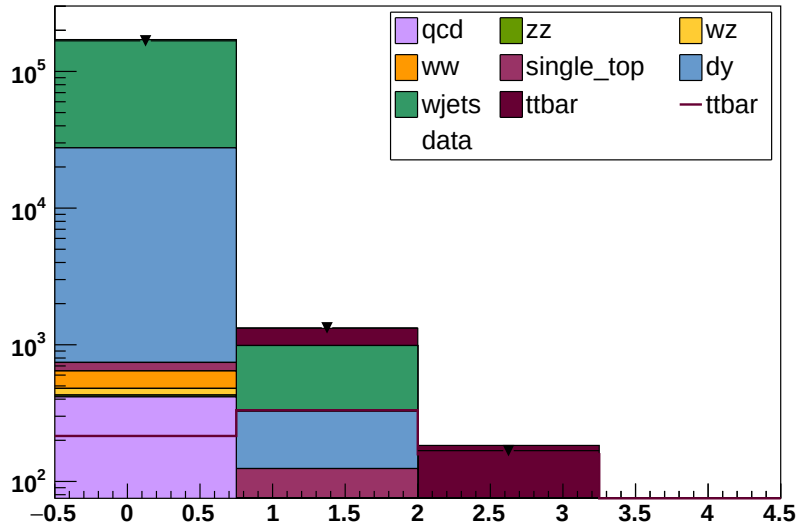

Figure 4: Number of b-jets before selection

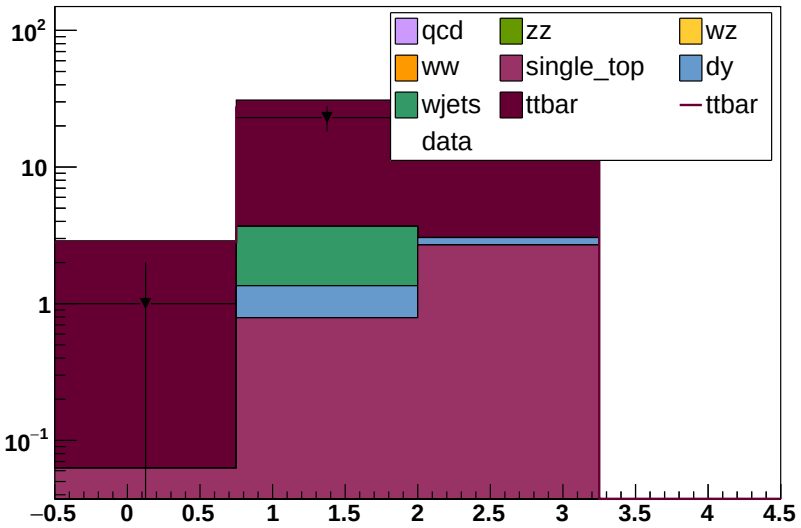

Figure 5: Number of b-jets after selection

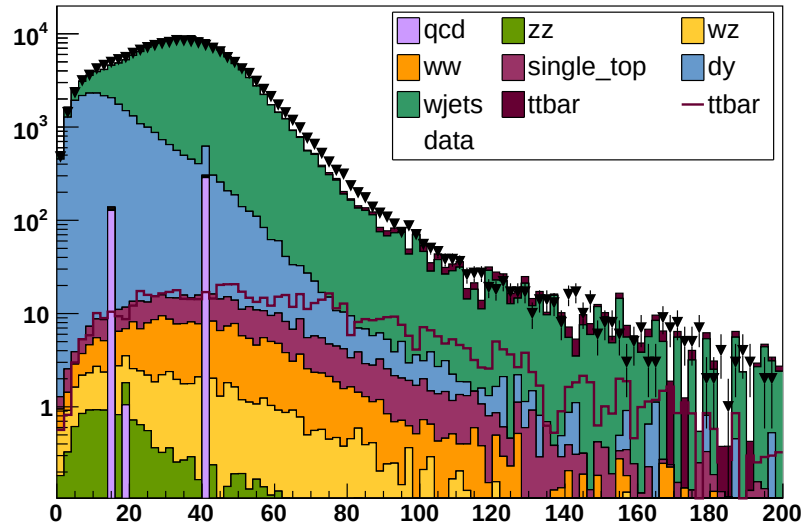

Figure 6: Missing transverse energy distribution before selection

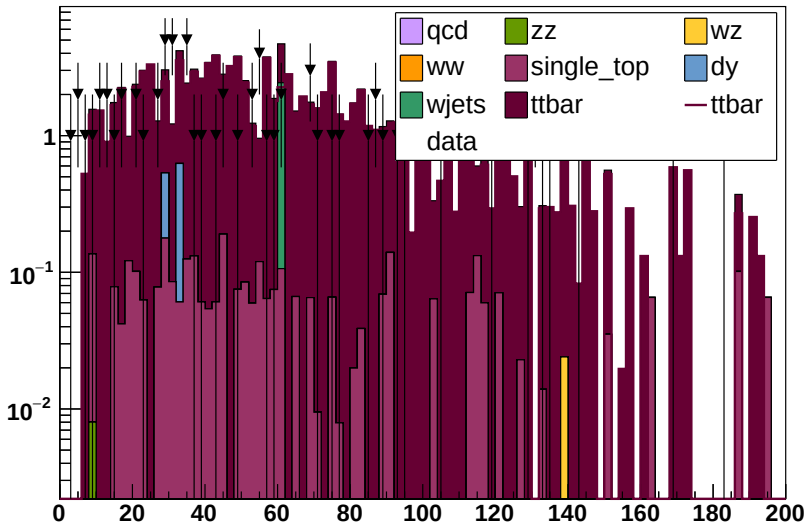

Figure 7: Missing transverse energy distribution after selection

2 Cross section

In this section the cross section for $\sigma_{t\bar{t}}$ at 7 TeV is calculated:

$$\sigma_{t\bar{t}} = \frac{N}{\epsilon_{trigger} \cdot L \cdot A_{t\bar{t}}} \tag{1}$$

where N is number of accepted events in the Data, $\epsilon_{trigger}$ is the trigger efficiency, L is the luminosity and $A_{t\bar{t}}$ the acceptenace rate.
To get the trigger effiency just MC was used. It is the quotient between the number of, in the MC as triggerd marked events and the total number of events:

$$\epsilon_{trigger} = \frac{N_{triggerd}}{N_{total}} = 0.86 \pm 0.09 \tag{2}$$

To get the acceptance rate for $t\bar{t}$ events just MC was used. It is the quotient between the number of selected $t\bar{t}$ events and the total number of simulated $t\bar{t}$ events:

$$A_{t\bar{t}} = \frac{N_{selected}}{N_{total}} = 0.0137 \pm 0.0006 \tag{3}$$

The luminosity is given by the detector:

$$L = 50 \pm 5 \text{ fb}^{-1} \tag{4}$$

Putting everything together one gets the following cross section:

$$\sigma_{t\bar{t}} = 127 \pm 20 \text{ fb} \tag{5}$$

That is confirms the thoretical prediction:

$$\sigma_{t\bar{t}}^{theory} = 167^{+17}_{-18} \text{ fb} \tag{6}$$

3 Z-mass

To select events with a Z, two isolated muons are required. After selection a Breit-Wigner fit is performed to measure the Z-mass.

$$Z_{mass} = 90.9 \pm 3.7 \text{ GeV} \tag{7}$$

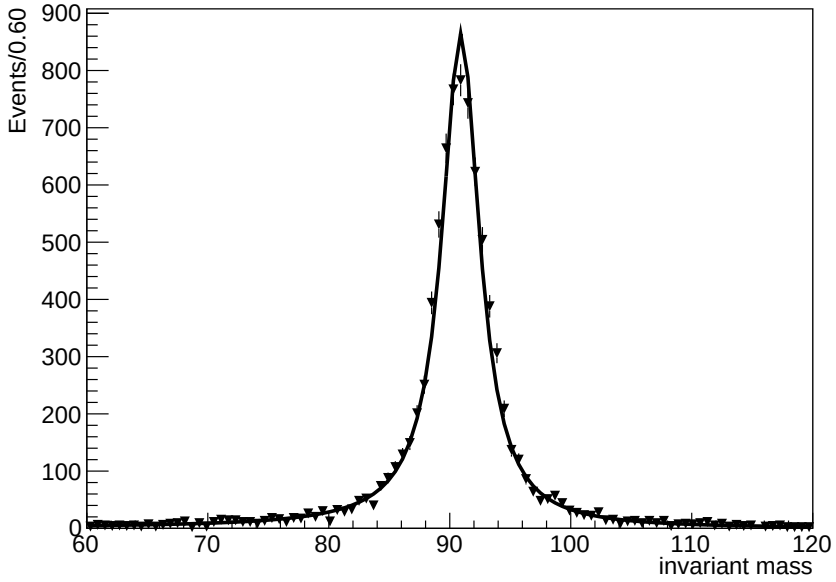

Figure 8: Breit Wigner fit over the invariant mass of two isolated muons. The peak is near the Z-mass.

In addition a 2D likelihood-scan of the signal strength and the mass of the Z has been performed. The signal strength is equal to the measured cross section devided by the theoretical cross section from the MC simulation. In the MC simulation a $M_Z = 91.188$ GeV had been assumed.

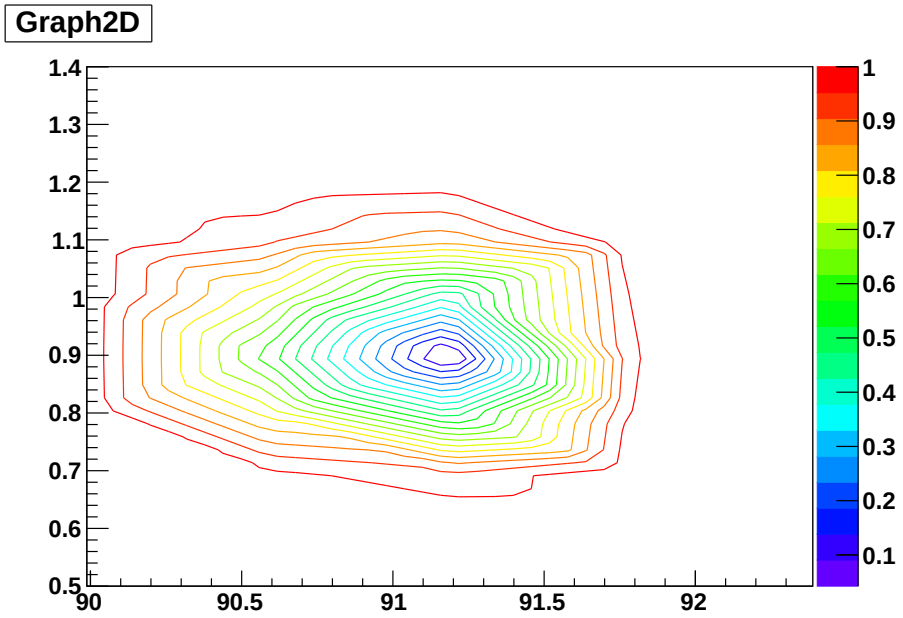

Figure 9: 2D likehood-scan of the singal strength vs mass for the Z mass

4 W-mass

From the selection for top mass events the W mass is calculated by taking the invariant mass of the isolated muon together with the missing transvers energy:

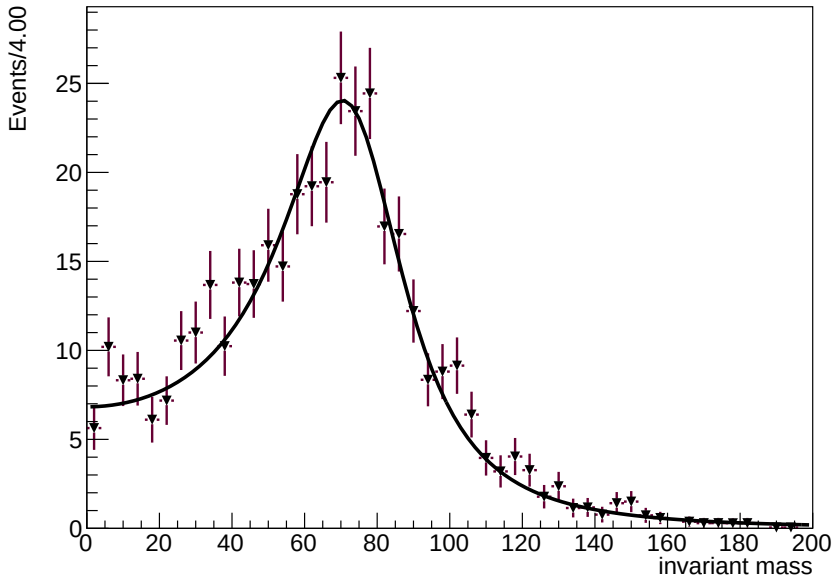

Figure 10: Breit Wigner fit over the invariant mass of the isolated muon and the missing transverse energy

The Breit-Wigner fit leads to:

$$m_W = 83 \pm 52 \text{ GeV} \tag{8}$$

5 Top-mass

After slection is apllied, the two light jets together with the nearest b-jet give the invaraint mass of the top.

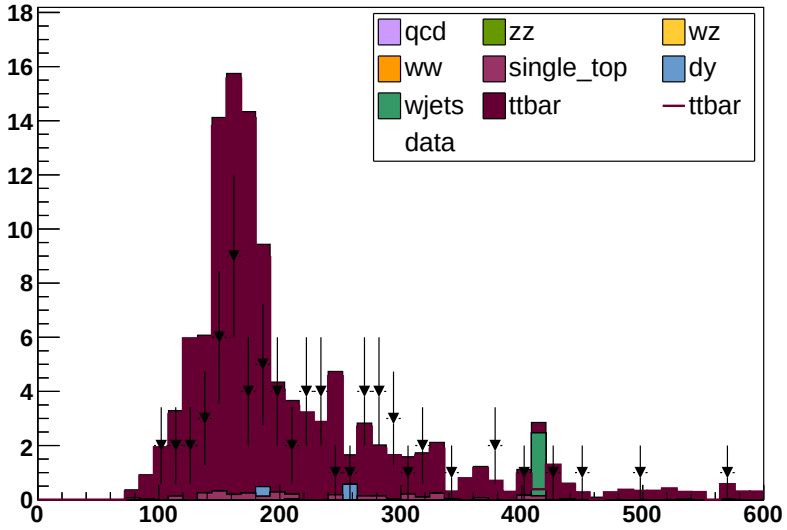

Figure 11: Histogram of the ivariant mass of the two light jets together with the nearest b-jet

The fit leads to the following mass at one σ confidence level:

$$m_{t\bar{t}}^{had} = 172^{+60}_{-24} \text{ GeV} \tag{9}$$

On the other hand there is the ivaraint mass of the semileptonic decay. The invaraint mass of the muon and the nearest b-jet are added up together with the missing transverse energy:

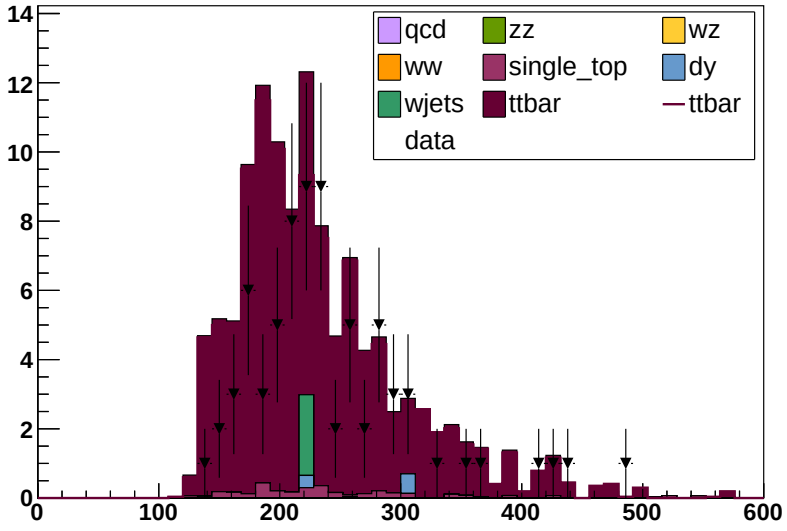

Figure 12: Ivariant mass of the muon the nearest b-jet and the missing transverse energy

The fit leads to the following mass at one σ confidence level:

$$m_{t\bar{t}}^{lep} = 184^{+48}_{-48} \text{ GeV} \tag{10}$$