$Z \to \mu^- \mu^+$ cross section measurement

José David Ruiz Álvarez
Supervisor: Stephanie Beauceron

CERN

August 16, 2011

Content

Goals

- Produce the data files for the analysis
- Produce some MC samples for the comparison with the data

Goals

- Produce the data files for the analysis
- Produce some MC samples for the comparison with the data
- Obtain the invariant mass plot for the Z, with the correspondent data and background fit

Goals

- Produce the data files for the analysis
- Produce some MC samples for the comparison with the data
- Obtain the invariant mass plot for the Z, with the correspondent data and background fit
- Implement the Tag and Probe method for different cuts to measure the associated efficiencies

Goals

- Produce the data files for the analysis
- Produce some MC samples for the comparison with the data
- Obtain the invariant mass plot for the Z, with the correspondent data and background fit
- Implement the Tag and Probe method for different cuts to measure the associated efficiencies
- Calculate the $Z \to \mu\mu$ inclusive cross section.

Goals

- Produce the data files for the analysis
- Produce some MC samples for the comparison with the data
- Obtain the invariant mass plot for the Z, with the correspondent data and background fit
- Implement the Tag and Probe method for different cuts to measure the associated efficiencies
- Calculate the $Z \to \mu\mu$ inclusive cross section.

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$
- The second muon has been selected requiring Isolation, Global and all the id possible cuts. In addition we have required the full combinations of this cuts.

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$
- The second muon has been selected requiring Isolation, Global and all the id possible cuts. In addition we have required the full combinations of this cuts.
- Fitting the data and the background we can obtain the number of selected events N_{sel} (events that pass the cuts) and the number of background N_{bkg}.

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$
- The second muon has been selected requiring Isolation, Global and all the id possible cuts. In addition we have required the full combinations of this cuts.
- Fitting the data and the background we can obtain the number of selected events N_{sel} (events that pass the cuts) and the number of background N_{bkg}.
- With this method we can calculate the efficiency as $\epsilon = (\epsilon_{\mu}^{id})^2 \times \epsilon_T \times \epsilon_{mass\ window}$
- Taking the integrated luminosity for the data as $1 fb^{-1}$ and taking the already calculated acceptance for the $Z \to \mu^- \mu^+$ we can obtain the cross section

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$
- The second muon has been selected requiring Isolation, Global and all the id possible cuts. In addition we have required the full combinations of this cuts.
- Fitting the data and the background we can obtain the number of selected events N_{sel} (events that pass the cuts) and the number of background N_{bkg}.
- With this method we can calculate the efficiency as $\epsilon = (\epsilon_{\mu}^{id})^2 \times \epsilon_T \times \epsilon_{mass\ window}$
- Taking the integrated luminosity for the data as $1 fb^{-1}$ and taking the already calculated acceptance for the $Z \to \mu^- \mu^+$ we can obtain the cross section

$$\sigma = \frac{N_{sel} - N_{bkg}}{A \epsilon \mathcal{L}} \tag{1}$$

Procedure

- With the usage of the GRID we can process some data and MC.
- For applying the Tag and Probe method, we first select one muon as Isolated, and additionally $20 < p_T$ and $|\eta| < 2.1$
- The second muon has been selected requiring Isolation, Global and all the id possible cuts. In addition we have required the full combinations of this cuts.
- Fitting the data and the background we can obtain the number of selected events N_{sel} (events that pass the cuts) and the number of background N_{bkg}.
- With this method we can calculate the efficiency as $\epsilon = (\epsilon_{\mu}^{id})^2 \times \epsilon_T \times \epsilon_{mass\ window}$
- Taking the integrated luminosity for the data as $1 fb^{-1}$ and taking the already calculated acceptance for the $Z \to \mu^- \mu^+$ we can obtain the cross section

$$\sigma = \frac{N_{sel} - N_{bkg}}{A \epsilon \mathcal{L}} \tag{1}$$

Efficiencies

An Efficiencie is defined in general as

$$\epsilon = \frac{N_{passed}}{N_{total}} \tag{2}$$

We can obtain the efficiency per muon for the $Z\mu\mu$ process making the mass invariant histogram, and fitting the histogram to obtain the total amount of Z's in the data before and after applying a cut over the second μ. We relate the number of Z that passed and failed the cut with the efficiency per muon as

$$\epsilon_\mu = \frac{2N^Z_{passed}}{N^Z_{failed} + 2N^Z_{passed}} \tag{3}$$

As for each Z we have a factor of 2 multiplying N^Z_{passed} and when a Z don't pass the cut is only one leg that is failing so there is no 2 factor for N^Z_{failed}

Isolation cut

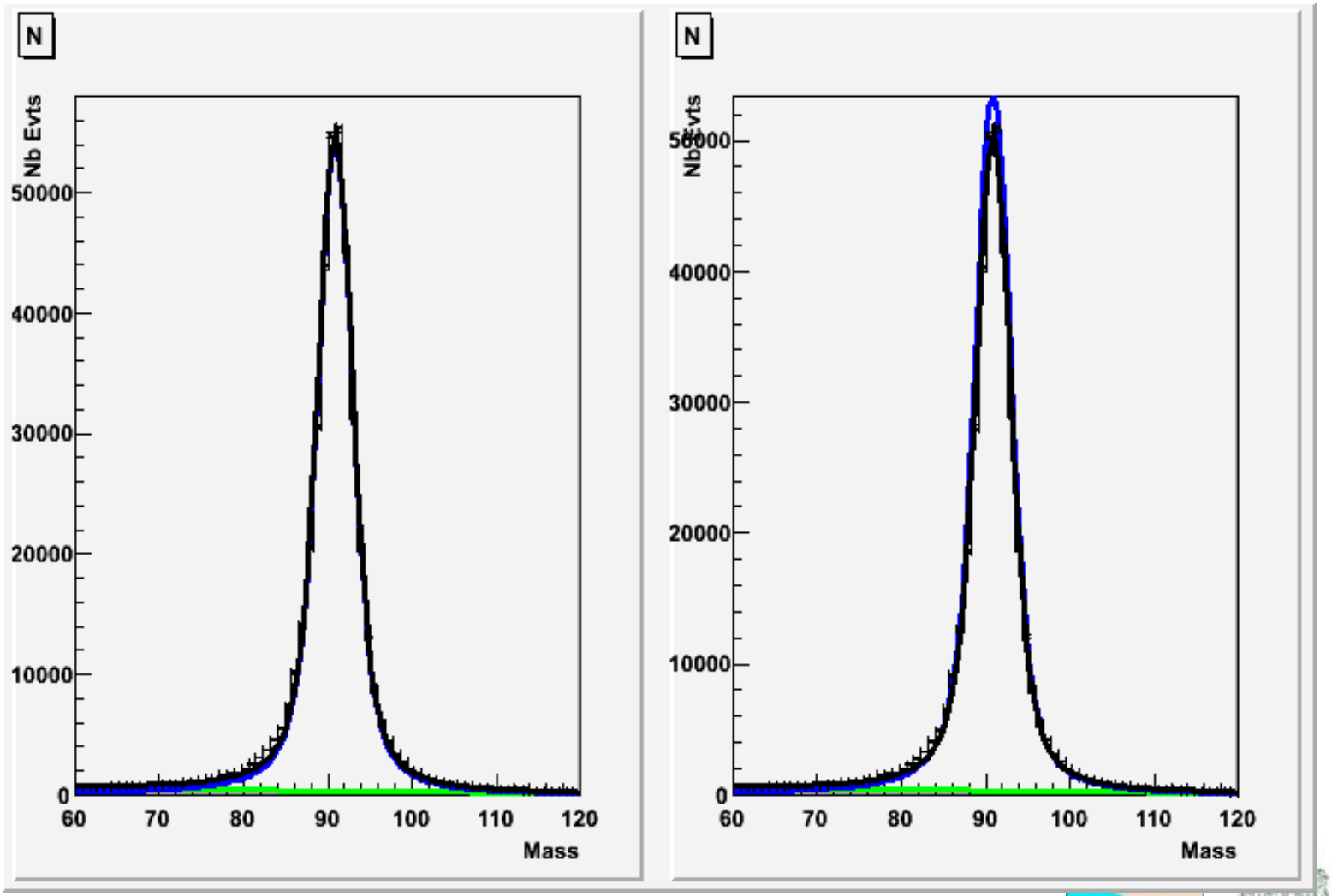

Figure: Invariant mass plot for (left) whitout cut (right) Isolation cut on the second cut

Tracker

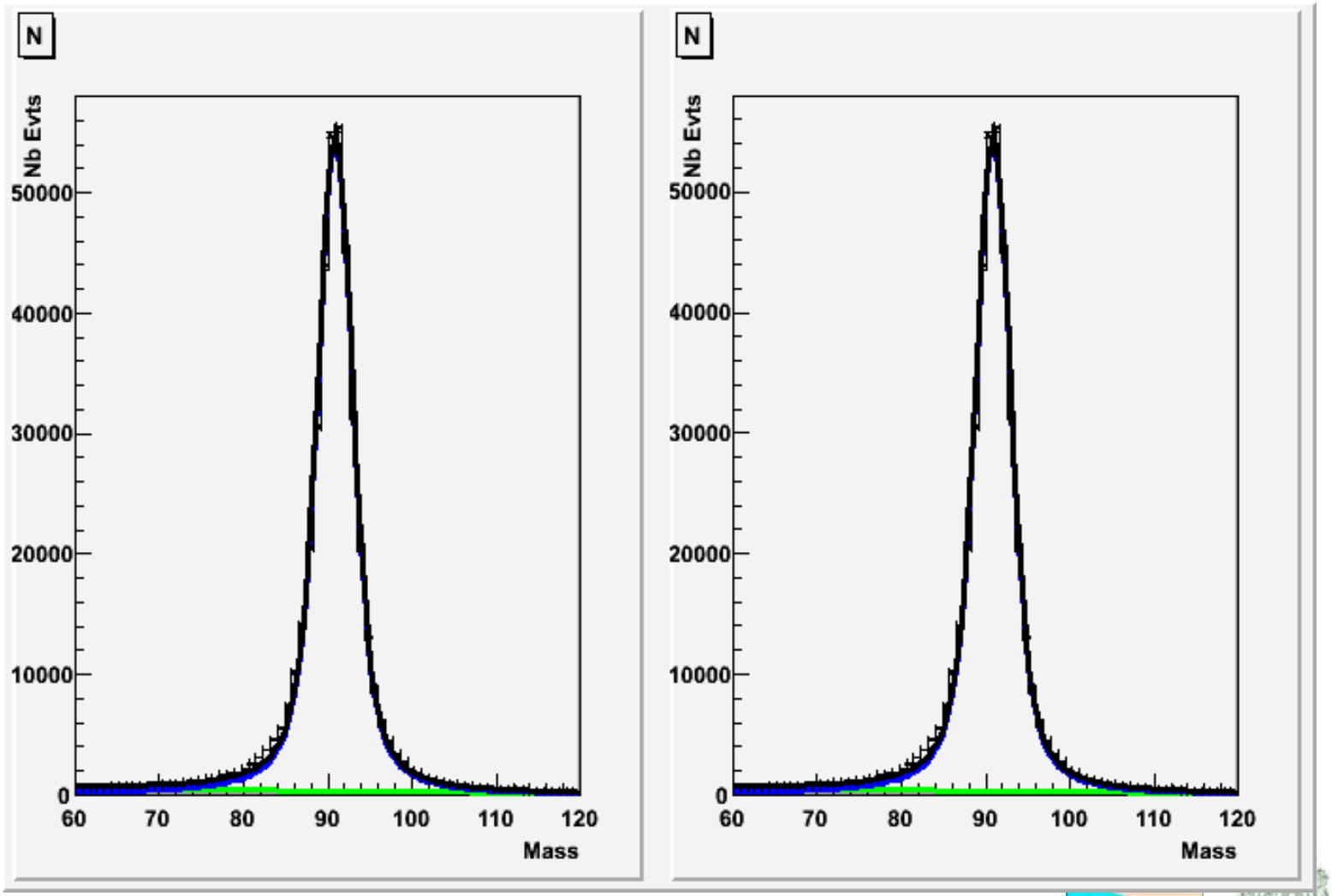

Figure: Invariant mass plot for (left) whitout cut (right) Tracker cut on the second muon

Combined

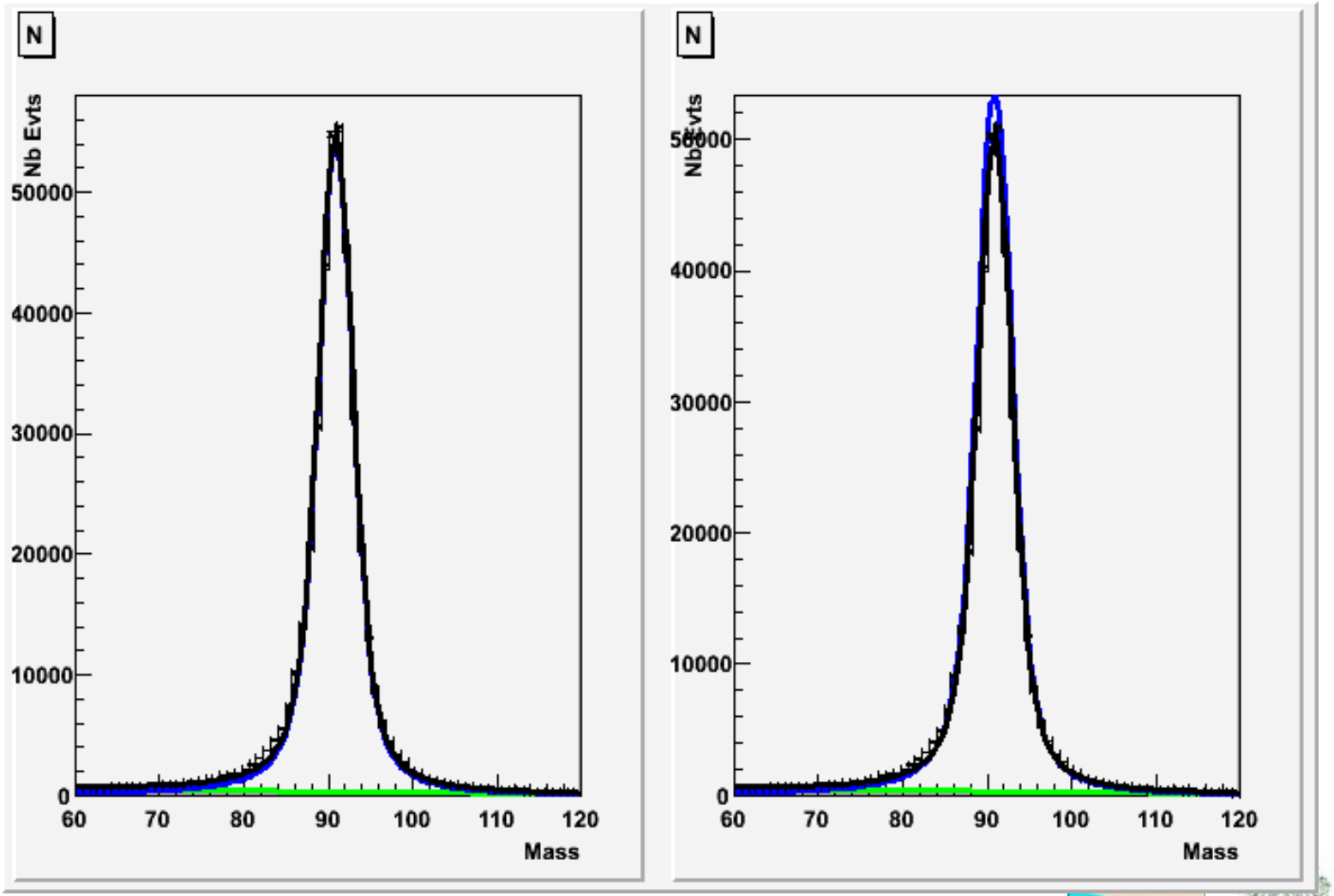

Figure: Invariant mass plot for (left) whitout cut (right) Isolation and Tracker cut on the second muon

Monte Carlo

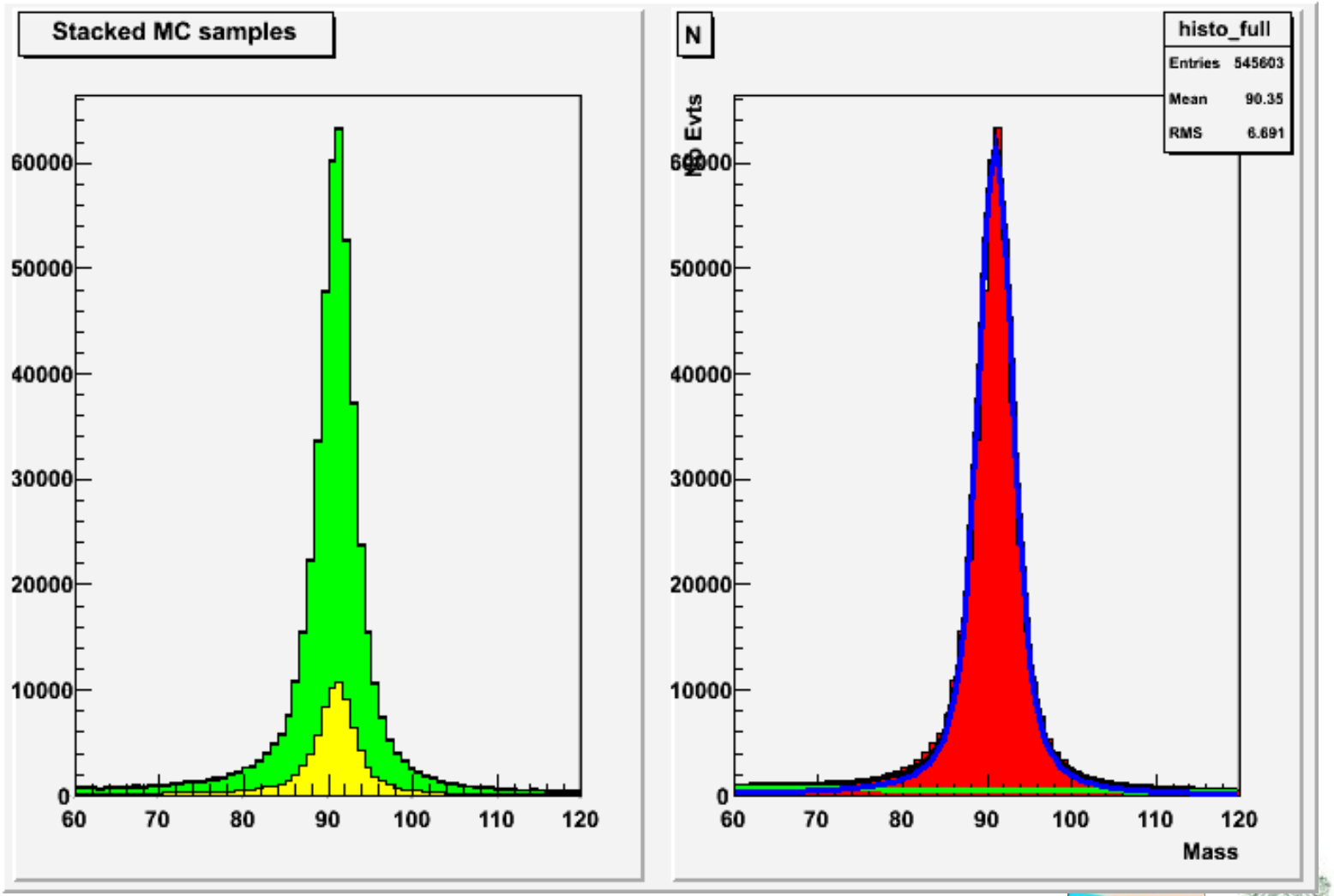

Figure: Invariant mass plot for Montecarlo simulation. Stacked plot (left), added and fitted (right) with all ID cuts. $\epsilon_\mu = 0.8979 \pm 0.0006$, $\mathcal{L} = 1.1671 \pm 0.0778$

Results

$$A = 0.3977 \pm 0.0048 \tag{4}$$

$$\mathcal{L} = 1 \pm 0.04 fb^{-1} \tag{5}$$

$$\epsilon_T = 0.876 \pm 0.04 \quad \epsilon_{Iso} = 0.9593 \quad \epsilon_{Tra} = 0.9995 \tag{6}$$

$$N_{sel} = 349957 \quad N_{bkg} = 16831.1 \quad \epsilon_{all} = 0.9573 \pm 0.0006 \tag{7}$$

$$\sigma = 0.9851 \pm 0.0957 \tag{8}$$

Conclusions

- The Isolation and Tracker cuts are good cuts for the Tag and Probe method
- The dimuon analysis is very clean from background

Conclusions

- The Isolation and Tracker cuts are good cuts for the Tag and Probe method
- The dimuon analysis is very clean from background
- The cross section for the process is in acordance with the previous experimental results and with the theoretical prediction. $\sigma = 0.9851 \pm 0.0957$, $\sigma_{past} = 0.968 \pm 0.073$, $\sigma_{pred} = 0.97 \pm 0.04$

Conclusions

- The Isolation and Tracker cuts are good cuts for the Tag and Probe method
- The dimuon analysis is very clean from background
- The cross section for the process is in acordance with the previous experimental results and with the theoretical prediction. $\sigma = 0.9851 \pm 0.0957$, $\sigma_{past} = 0.968 \pm 0.073$, $\sigma_{pred} = 0.97 \pm 0.04$

References

- http://sviret.web.cern.ch/sviret/Welcome.php?n=CMS.PHYTuto
- https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBook
- https://twiki.cern.ch/twiki/bin/view/CMS/MuonPOG
- https://twiki.cern.ch/twiki/bin/viewauth/CMS/Collisions2011Analysis
- https://twiki.cern.ch/twiki/bin/view/CMSPublic/SWGuideFrontierConditions?redirectedfrom=CMS.SWGuideFrontierConditions
- https://twiki.cern.ch/twiki/bin/view/CMSPublic/WorkBookRunningGrid?redirectedfrom=CMS.WorkBookRunningGridPrerequisites
- https://twiki.cern.ch/twiki/bin/view/CMSPublic/SWGuideCrab
- http://root.cern.ch

 CMS Draft Analysis Note. Measurement of the inclusive W and Z Cross section in pp Collisions at $\sqrt{s} = 7$ TeV: Update with full 2010 statistics. J. Alacaraz Maestre et al.

 CMS Physics. Technical Design Report.

Thanks

- Thanks to my University and Group and Home Supervisor Diego Restrepo
- Thanks to my Supervisor at CMS Stephanie Beauceron
- Thanks to Morna, Michelle, Sarah and Laura, for making possible this summer program
- All the other persons that made this possible: Jean, Élodie, Elena, Pablo, Joze, Josefina, Tona, Chris ...
- Special thanks to CERN and CMS !!!