Validation of CMS 2010 Open Data

Analysis Summary

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CMS 2010 Open Data

- The various primary datasets in AOD format can be found at http://opendata.cern.ch/collection/CMS-Primary-Datasets
- I have been working on the Minimum Bias, MuOnia, Mu and Electron samples.
- My code and histograms can be found at /afs/desy.de/user/d/duttaire/public

Minimum Bias dataset

Reference paper : **“Transverse momentum and pseudorapidity distributions of charged hadrons in pp collisions at $\sqrt{s}$ = 7 TeV”** by **The CMS Collaboration.**

Work Done

- p_T distributions for various eta ranges.

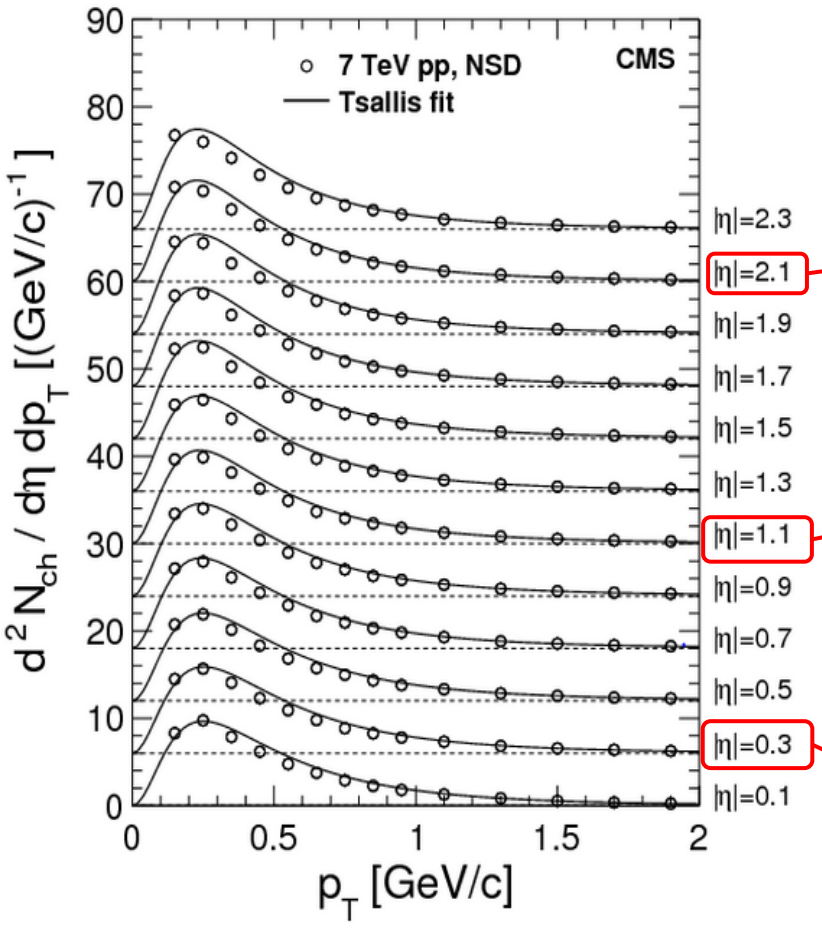
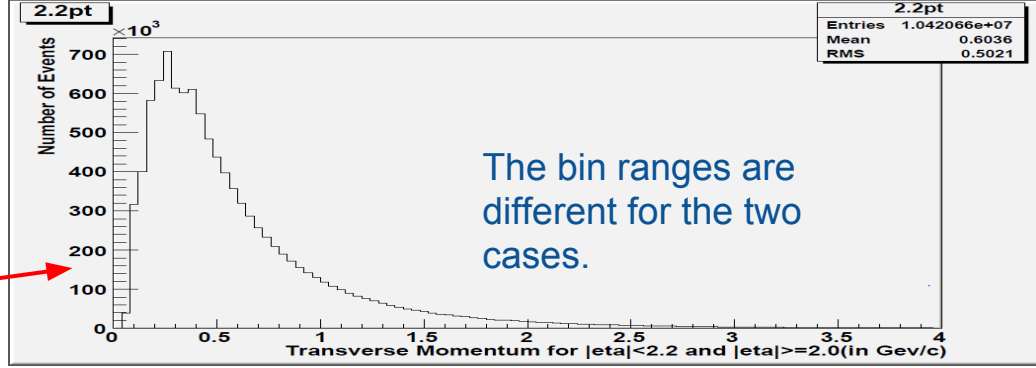
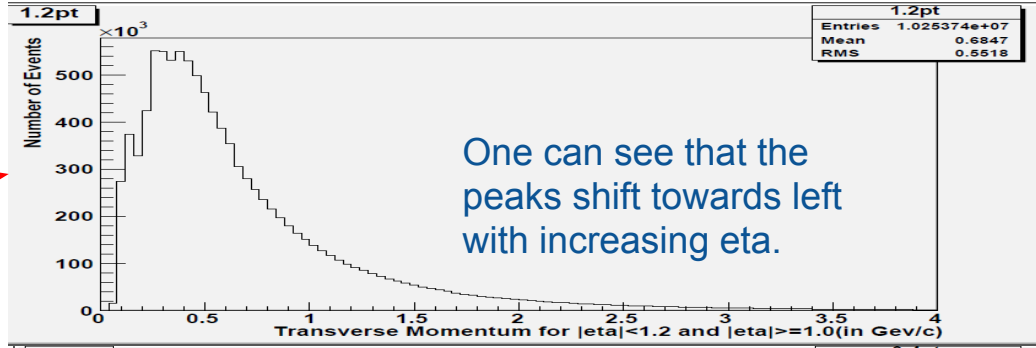


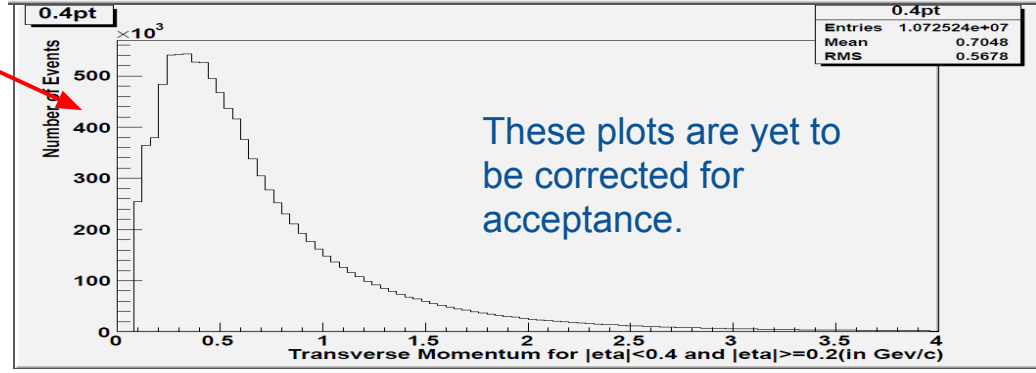
Figure 1: Differential yield of charged hadrons in the range $|\eta| < 2.4$ in 0.2-unit-wide bins of $|\eta|$ in NSD events. The solid curves represent fits of Eq. 1 to the data. The measurements with increasing η are successively shifted by six units along the vertical axis.



The bin ranges are different for the two cases.



One can see that the peaks shift towards left with increasing eta.



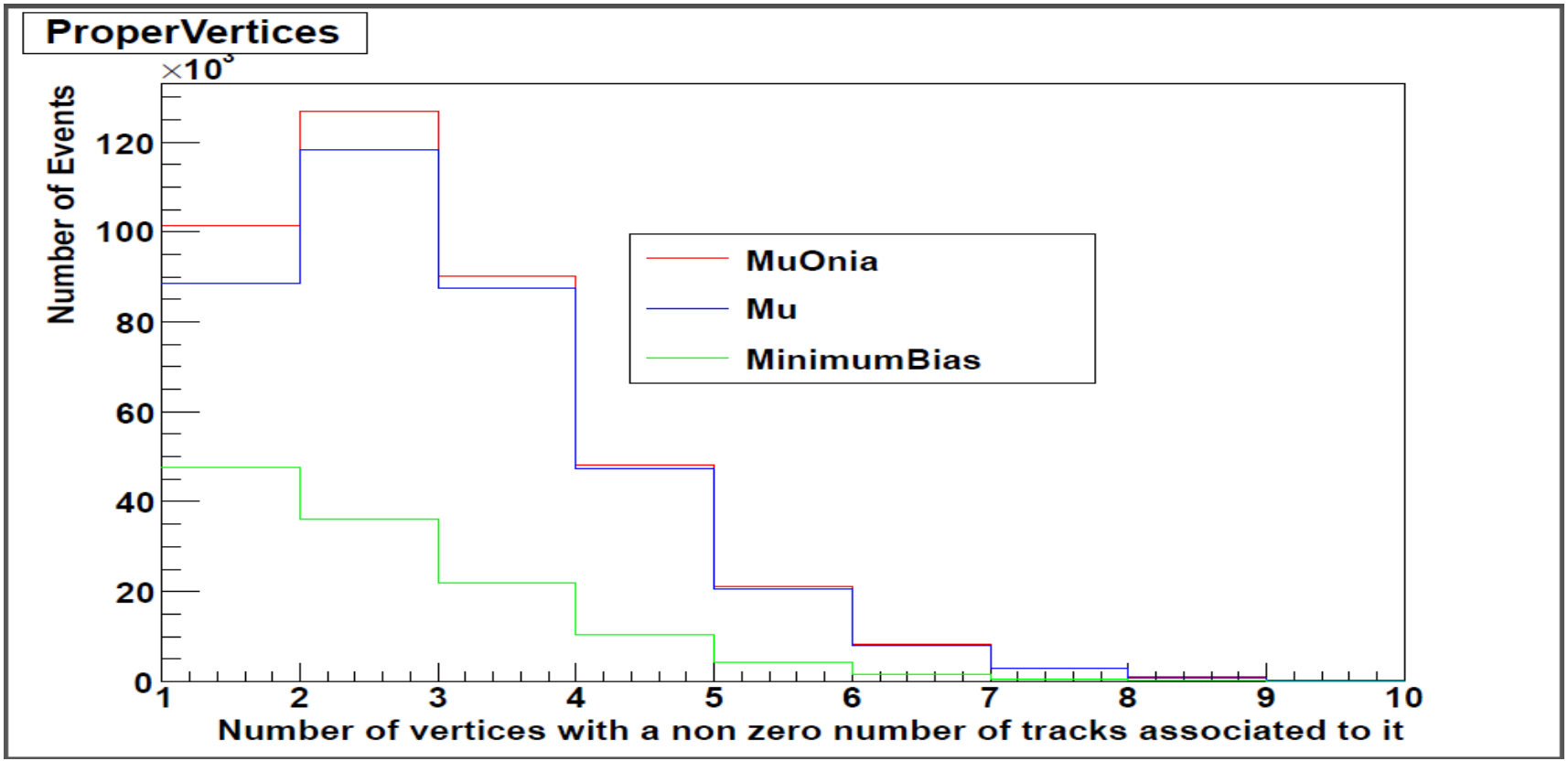
These plots are yet to be corrected for acceptance.

Minimum Bias dataset

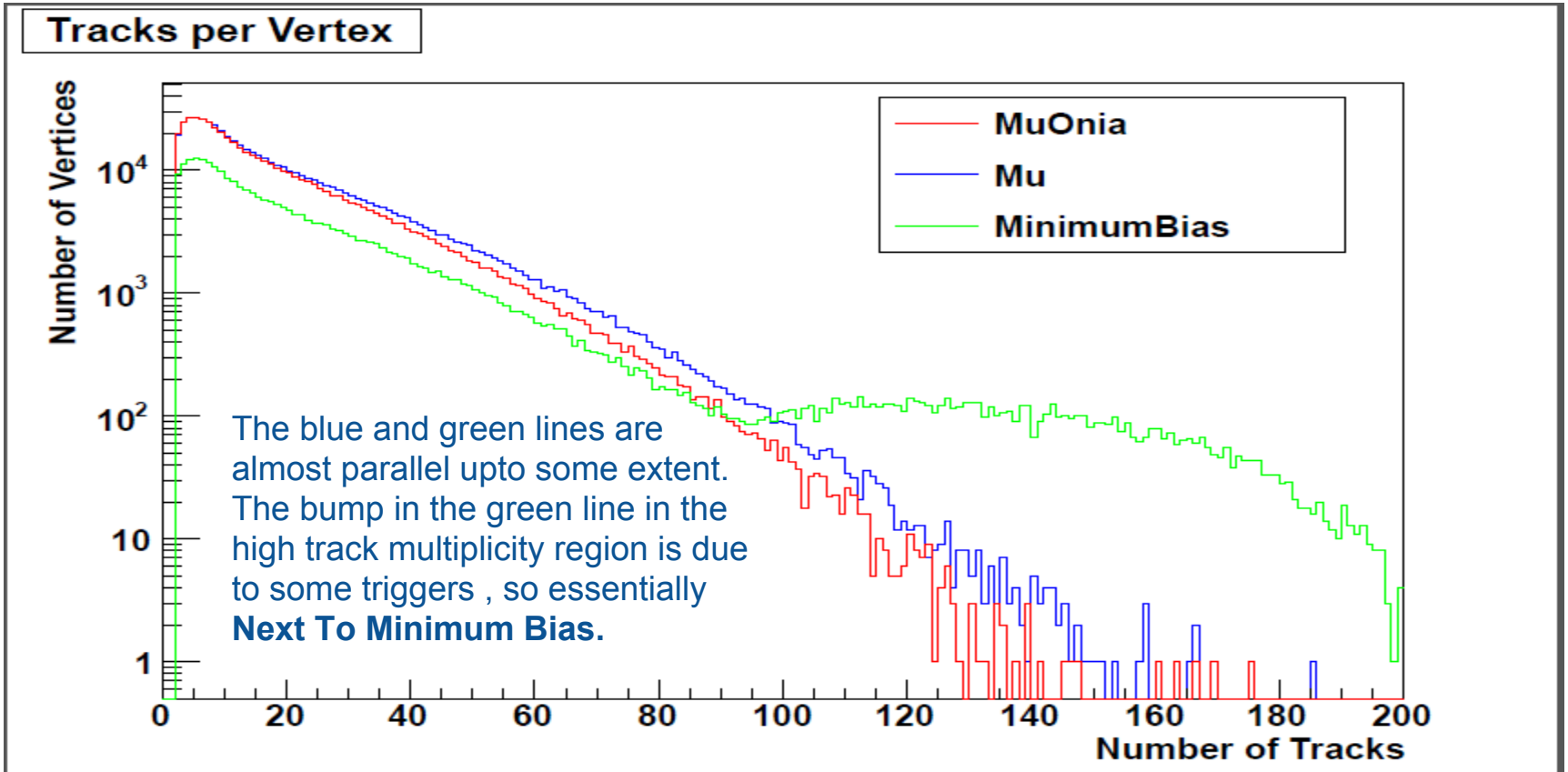
Work Done

- **New Hypothesis:** If one removes muon vertices from the Mu or the MuOnia sample, the remaining should contribute for distributions that look very similar to those in the minimum bias sample.

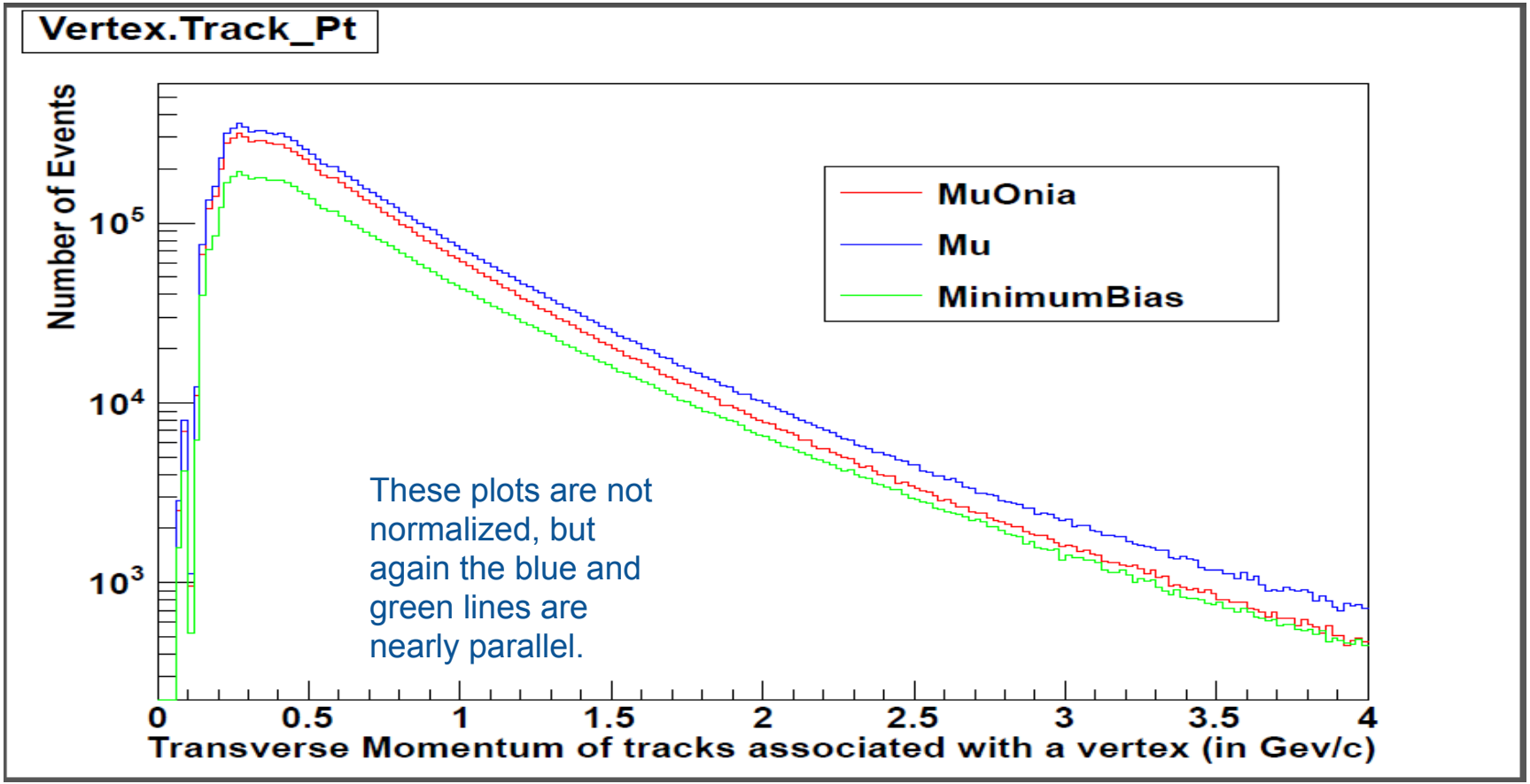
Vertex multiplicity



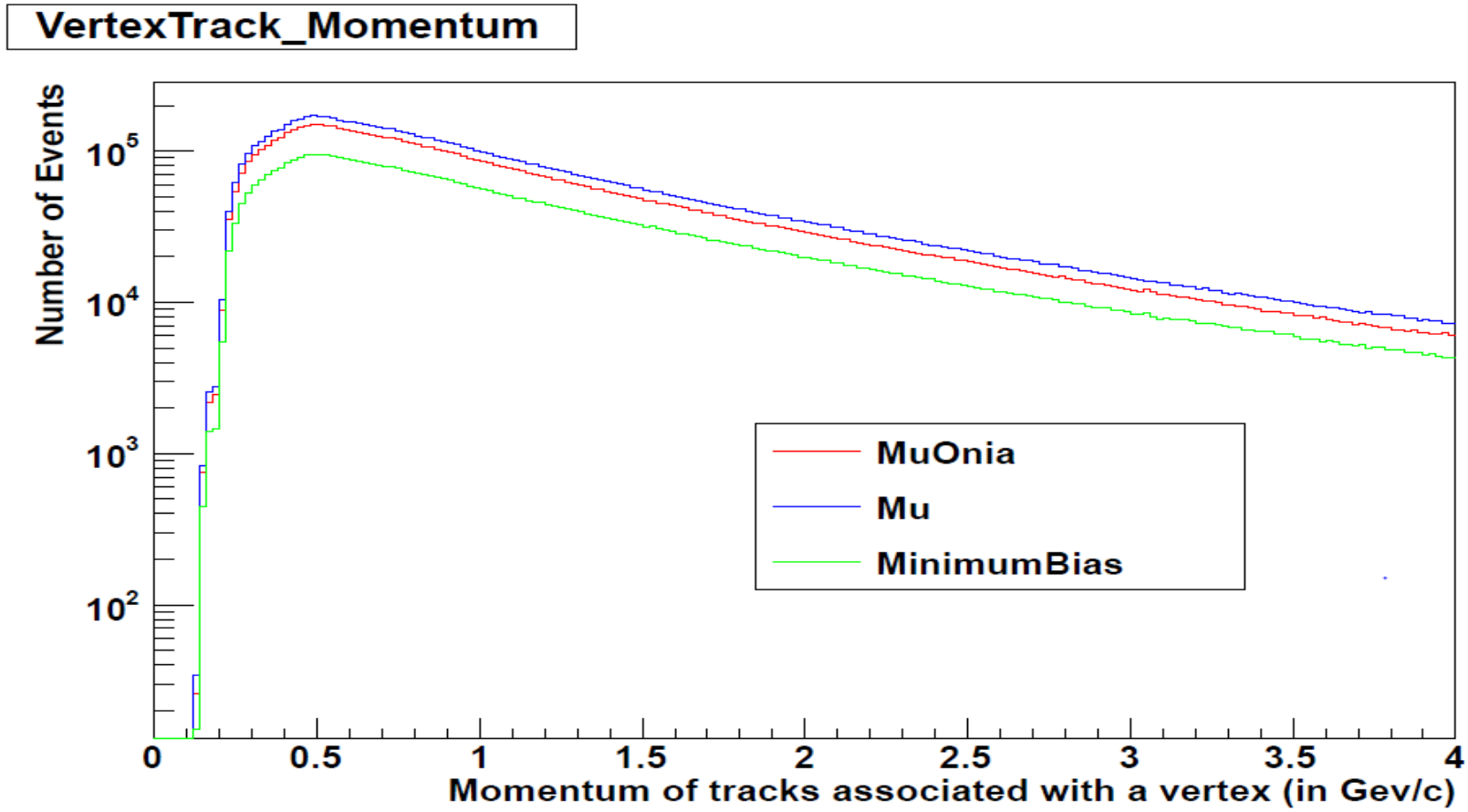
Track multiplicity per vertex



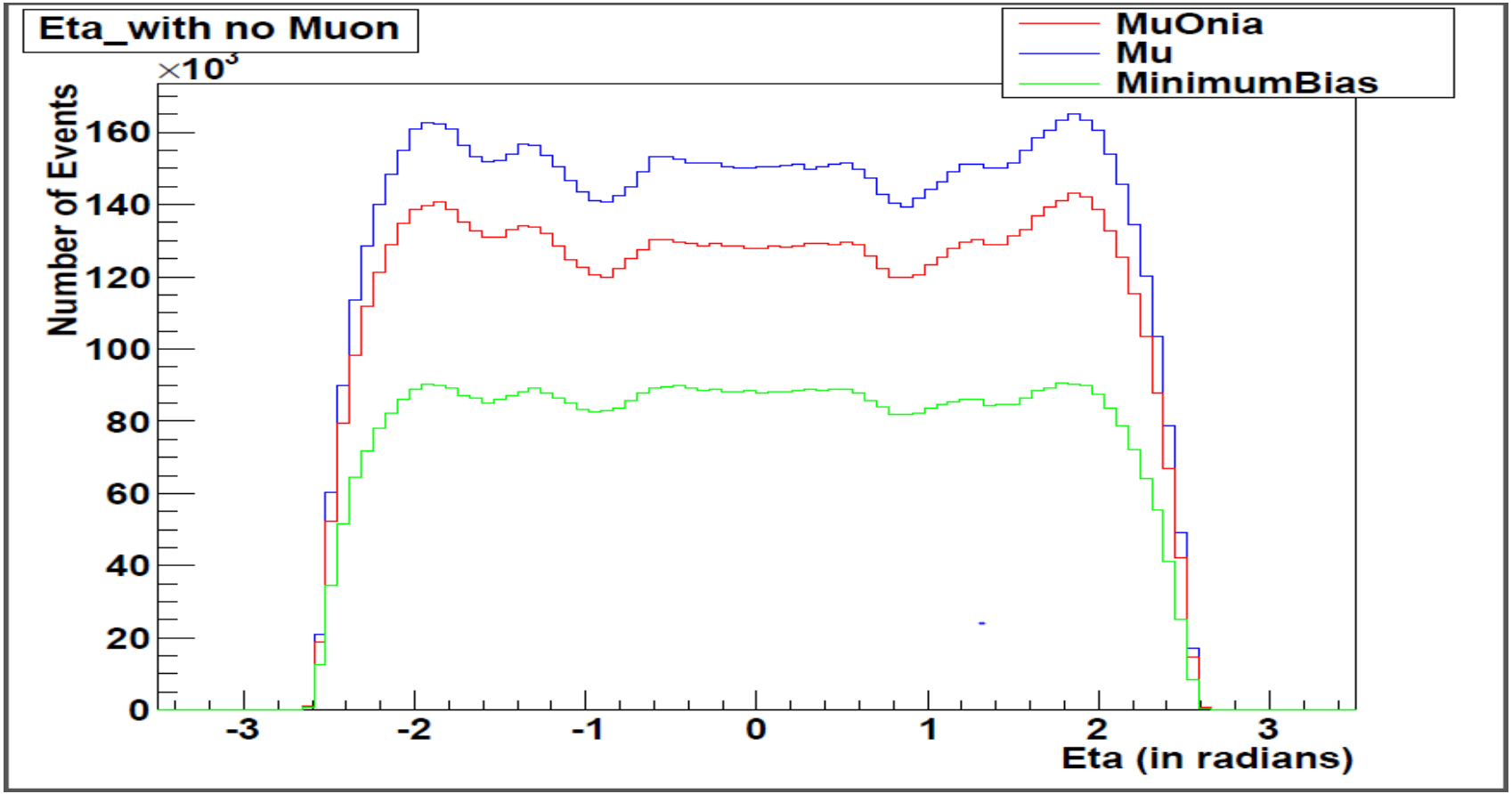
Track p_T


Vertex.Track_Pt
Number of Events
10⁵
10⁴
10³
MuOnia
Mu
MinimumBias
These plots are not normalized, but again the blue and green lines are nearly parallel.
0
0.5
1
1.5
2
2.5
3
3.5
4
Transverse Momentum of tracks associated with a vertex (in Gev/c)

Track momentum



η


Eta_with no Muon
MuOnia
Mu
MinimumBias
×10³
Number of Events
160
140
120
100
80
60
40
20
0
-3
-2
-1
0
1
2
3
Eta (in radians)

Minimum Bias dataset

Something very similar has also been done in "**Measurement of the inelastic pp cross section at $\sqrt{s}$ = 7 TeV with the CMS Detector**" by **The CMS Collaboration** in CMS PAS FWD-11-001.

Future Goals

- Acceptance correction
- Trigger cuts

MuOnia dataset

Reference paper: “**Prompt and non-prompt J/ψ production in pp collisions at $\sqrt{s}$ = 7 TeV**” by **The CMS Collaboration**.

Work Done

- Implementation of cuts, as given in the paper.

MuOnia dataset

Type of muon	Tracker
Number of Valid tracker hits (pixel+strips)	≥12
Number of matched muon stations	≥2
Number of pixel hits	≥2
χ^2/ndof	<4.0
Resolving ambiguity of multiple muons sharing segments	TrackerMuonArbitrated
Relative isolation of the muon(cone of radius R=0.3)	<0.15
“Tight Muon”	TMLastStationAngTight

MuOnia dataset

Cuts continued….

For the muons to be within the geometrical acceptance of the detectors,

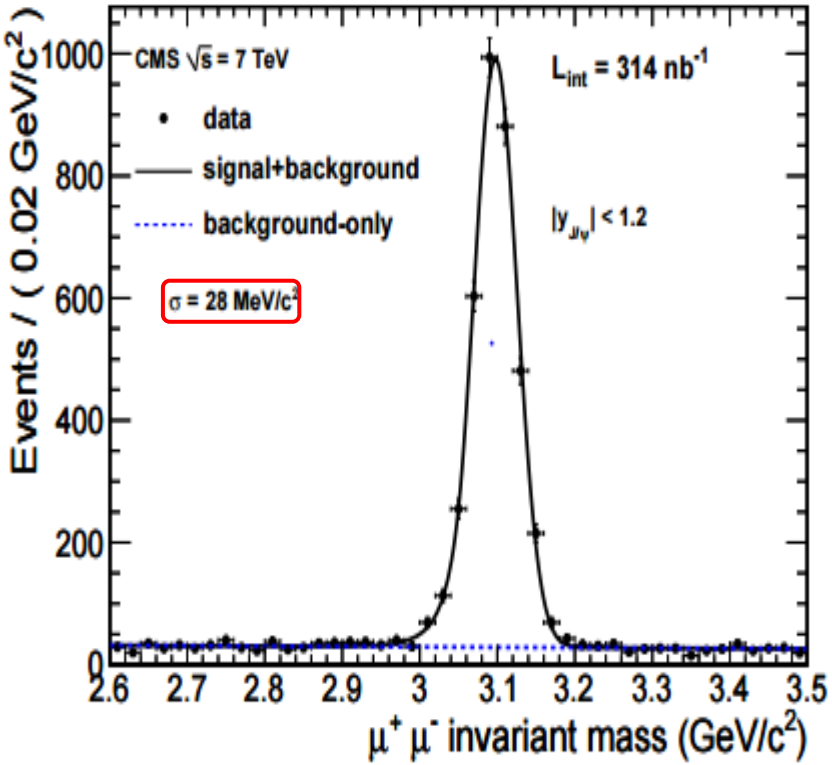
- p_T>3.3 GeV/c for |η|<1.3
- p>2.9 GeV/c for 1.3<|η|<2.2
- p_T>2.4 GeV/c for 2.2<|η|<2.4

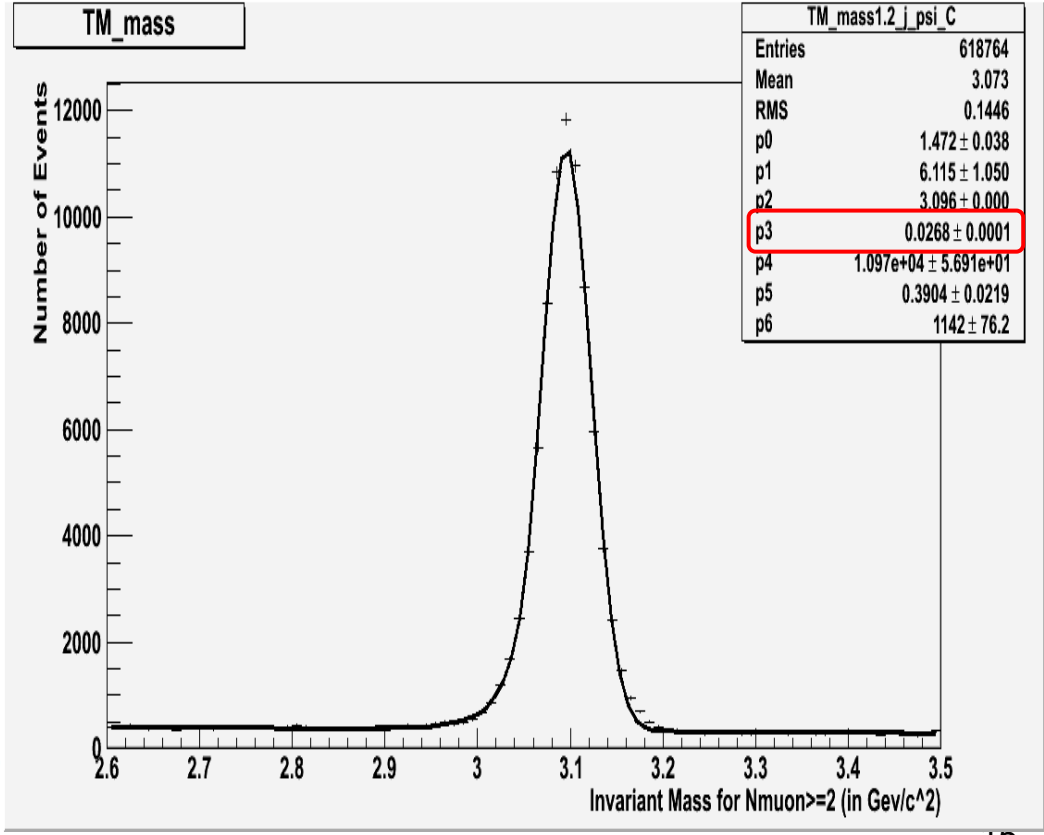
Transverse momentum correction:

$p_T^{corr}=(1+a_1+a_2\eta^2)p_T^{meas}$, where p_T^{meas} is the measured muon transverse momentum with a_1 and a_2 values being $(3.8\pm1.9)10^{-4}$ and $(3.0\pm 0.7)10^{-4}$

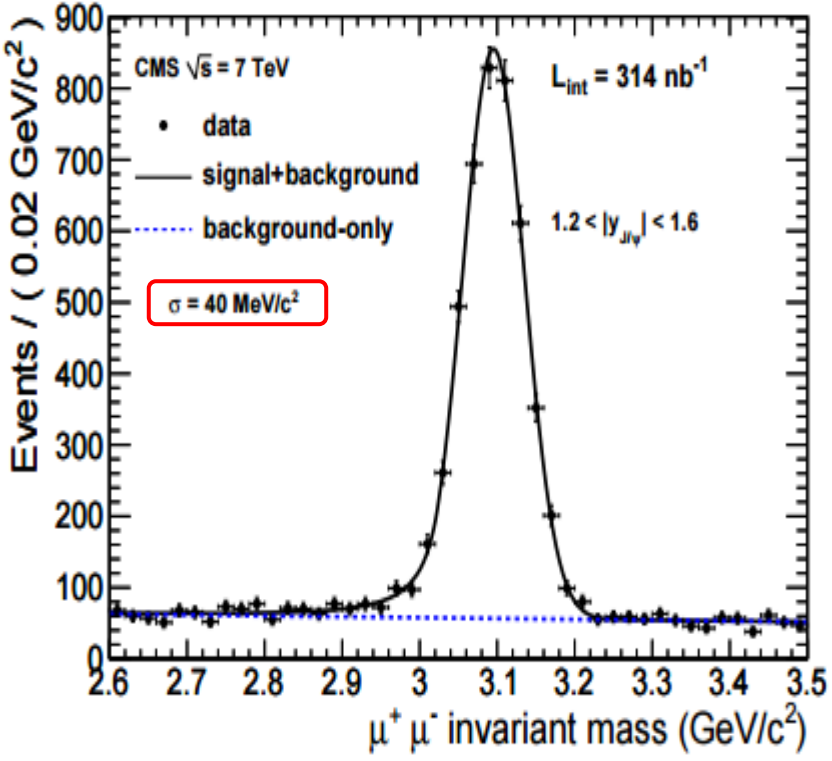
.

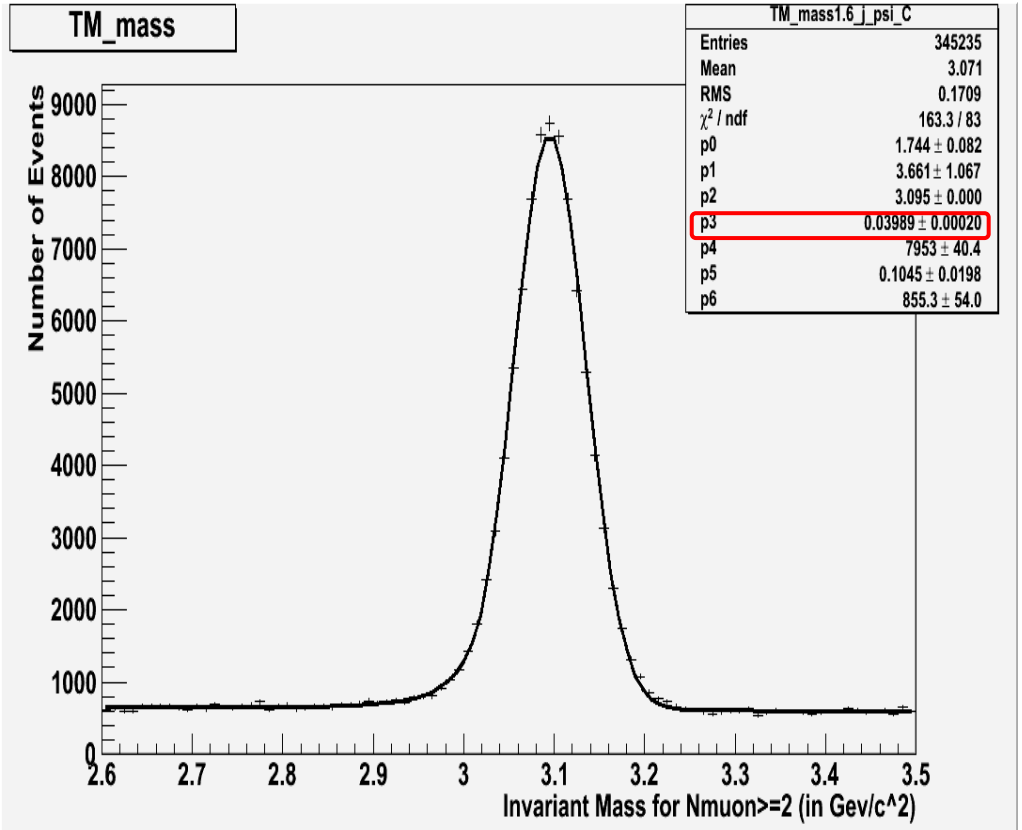
Invariant mass for |y|<1.2



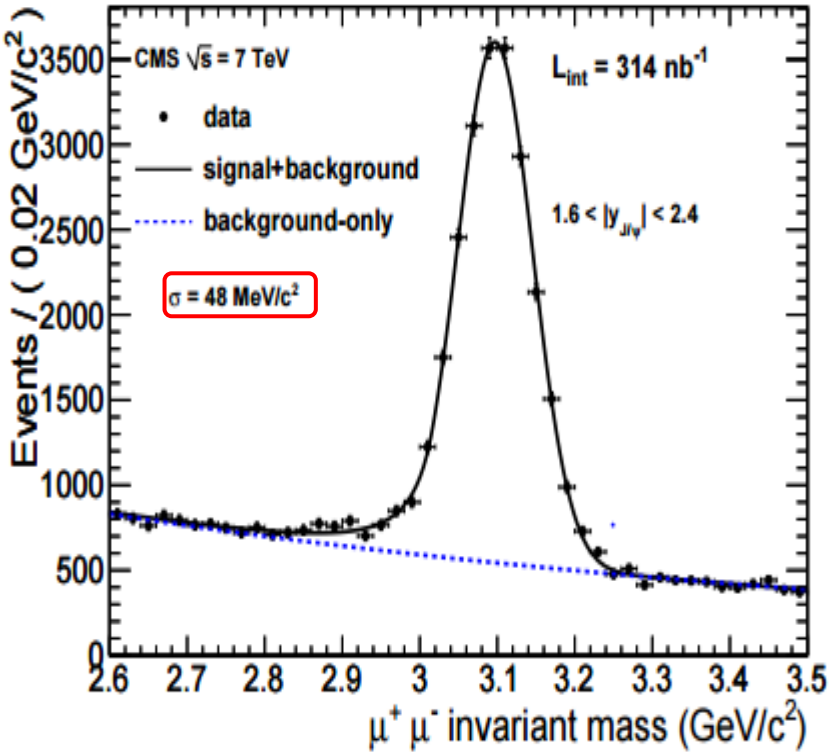


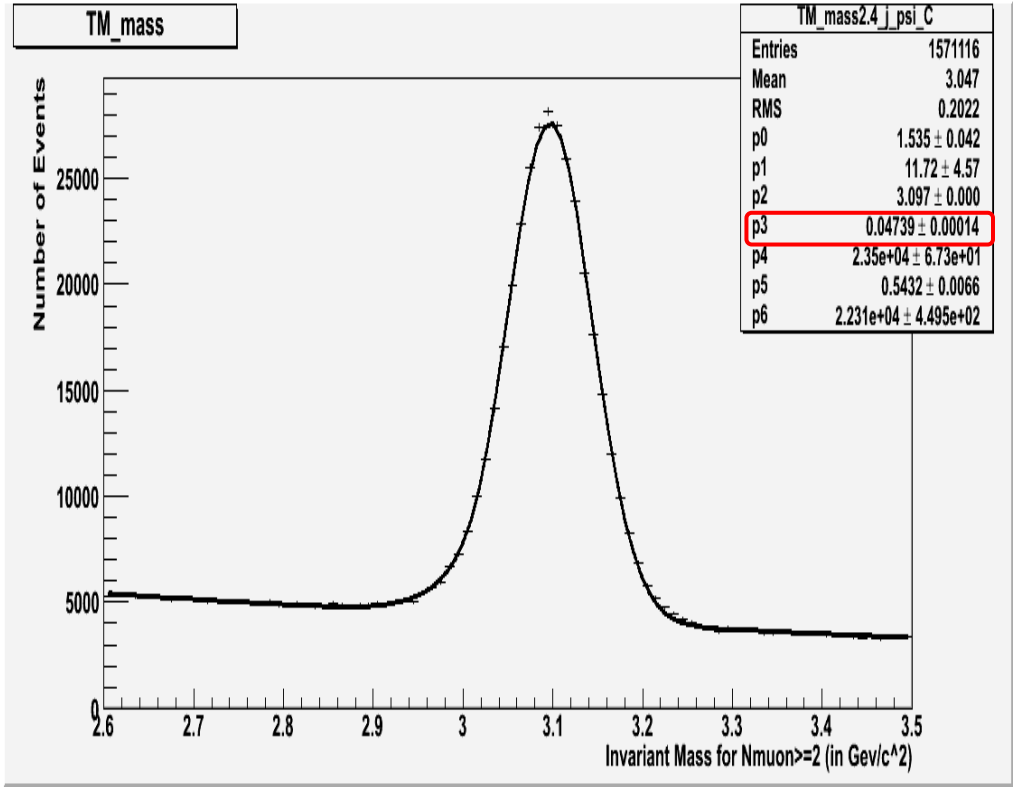
Invariant mass for 1.2<|y|<1.6





Invariant mass for 1.6<|y|<2.4





MuOnia dataset

Reference Paper: "Measurement of the Inclusive Upsilon production cross section in pp collisions at √s=7TeV" by **The CMS Collaboration**

Work Done

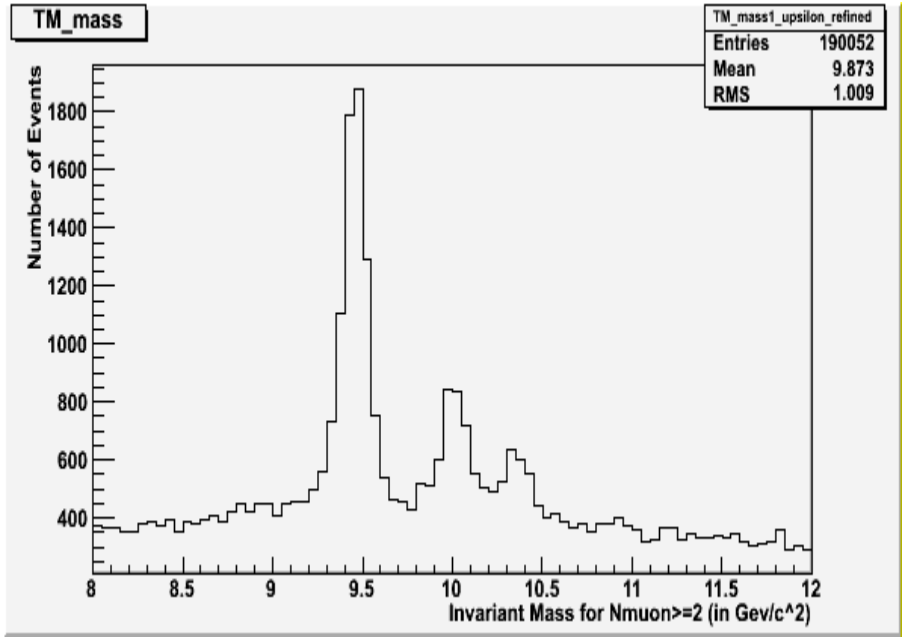
- A first look at the dimuon invariant mass in the upsilon mass range, without any cuts except ..

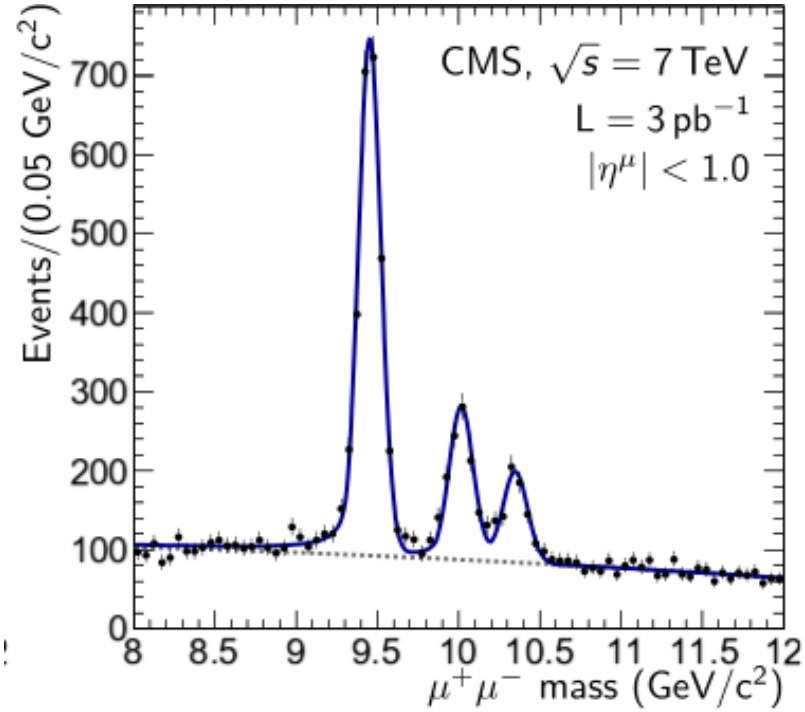
Transverse momentum correction:

$p_T^{corr}=(1+a_1+a_2\eta^2)p_T^{meas}$, where p_T^{meas} is the measured muon transverse momentum with a_1 and a_2 values being $(3.8\pm1.9)10^{-4}$ and $(3.0\pm 0.7)10^{-4}$

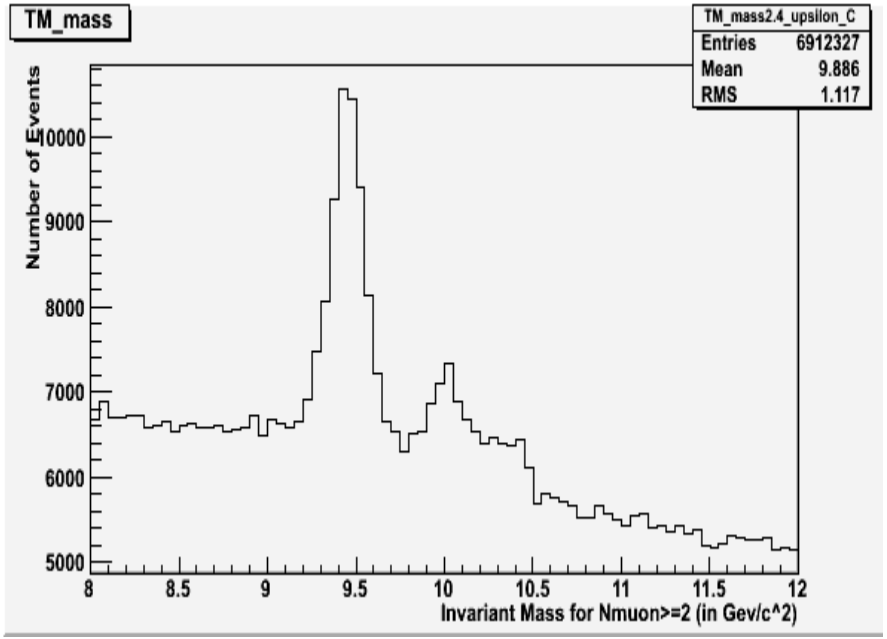
.

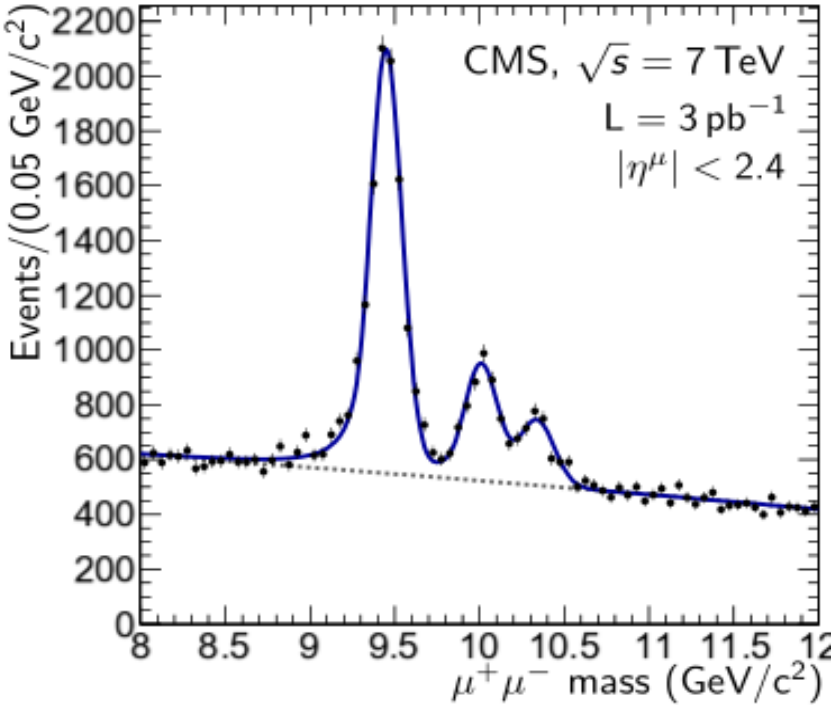
Invariant mass for |y|< 1.0





Invariant mass for 1.0<|y|<2.4





MuOnia datset

Future Goals

- Implementation of trigger cuts.
- Upsilon peak with all cuts.

Mu sample

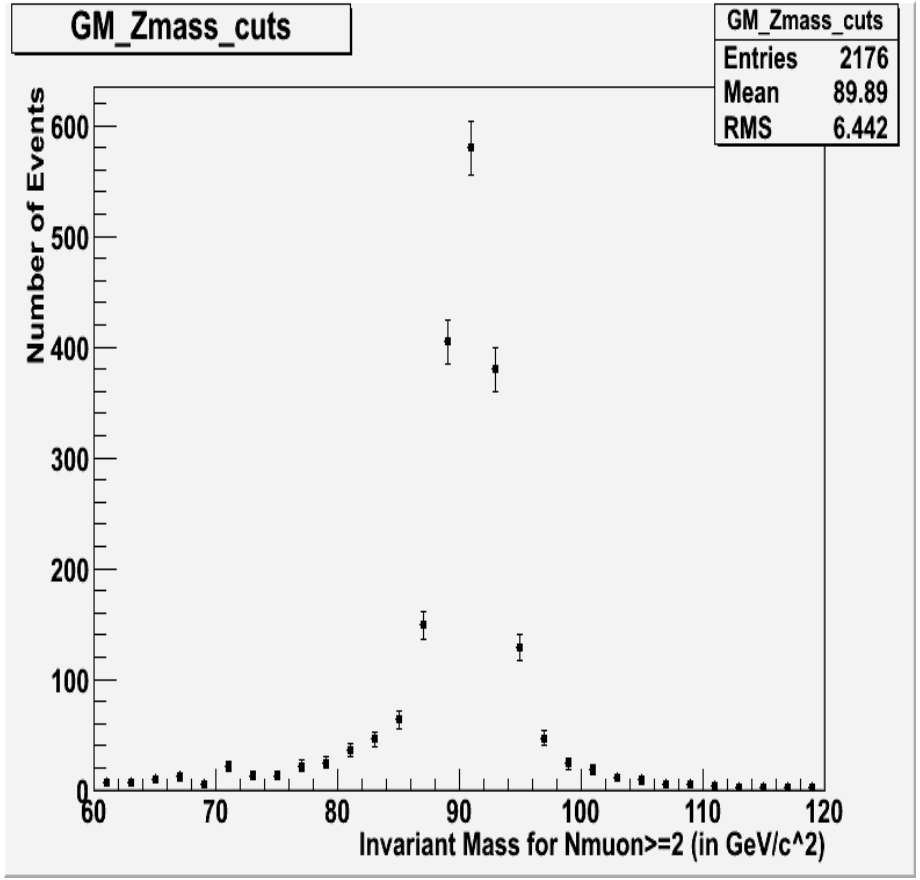
$Z \longrightarrow \mu^+\mu^-$

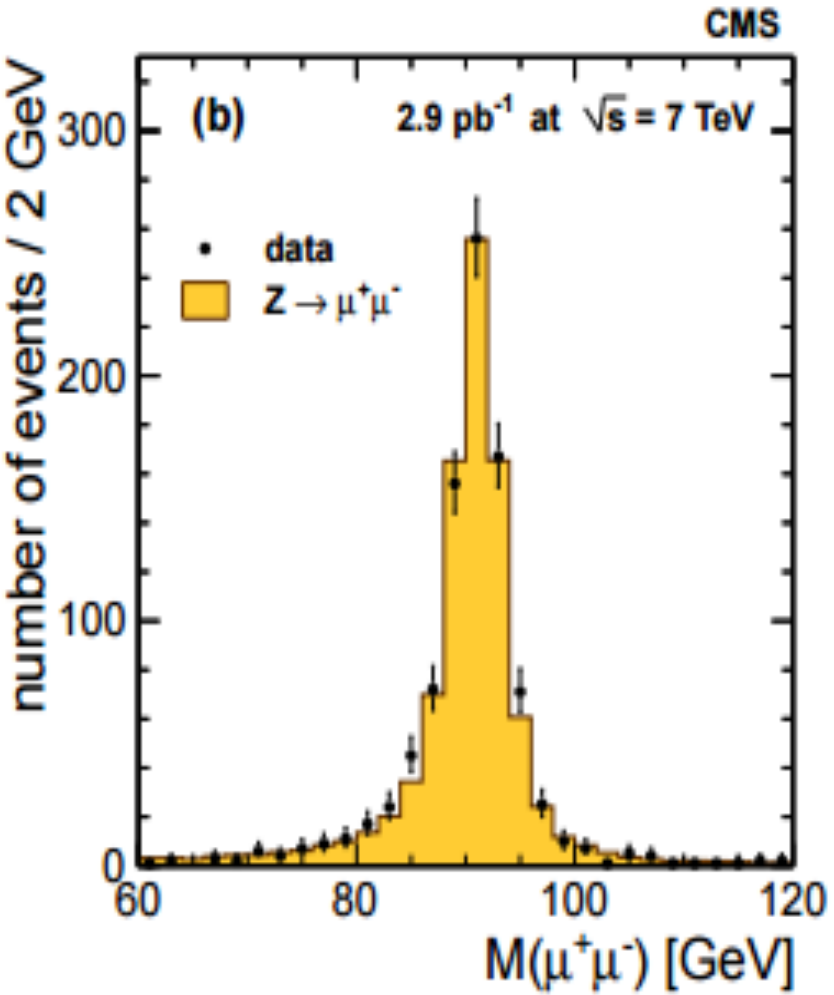
Reference Paper: “Measurements of the Inclusive W and Z Cross Sections at 7 TeV” by **“The CMS Collaboration”**

Work Done

- Implementation of cuts, as given in the paper.

Type of muon	Both Global and Tracker
Number of global muon chamber hits	≥1
Number of matched muon stations (for Tracker muons)	≥2
Number of hits in the inner tracker	≥10
Number of pixel hits	≥1
χ^2/ndof	<10
Transverse impact parameter (w.r.t. beam spot)	$\lvert d_{xy} \rvert$<2 mm
Relative isolation of the muon(cone of radius R=0.3)	<0.15
"Tight Muon"	TMLastStationTight
p_T	>20 GeV
$\lvert\eta\rvert$	<2.1


GM_Zmass_cuts
GM_Zmass_cuts
Entries 2176
Mean 89.89
RMS 6.442
Number of Events
0
100
200
300
400
500
600
60
70
80
90
100
110
120
Invariant Mass for Nmuon>=2 (in GeV/c^2)


CMS
(b)
2.9 pb-1 at √s = 7 TeV
data
Z → μ+μ-
number of events / 2 GeV
0
100
200
300
60
80
100
120
M(μ+μ-) [GeV]

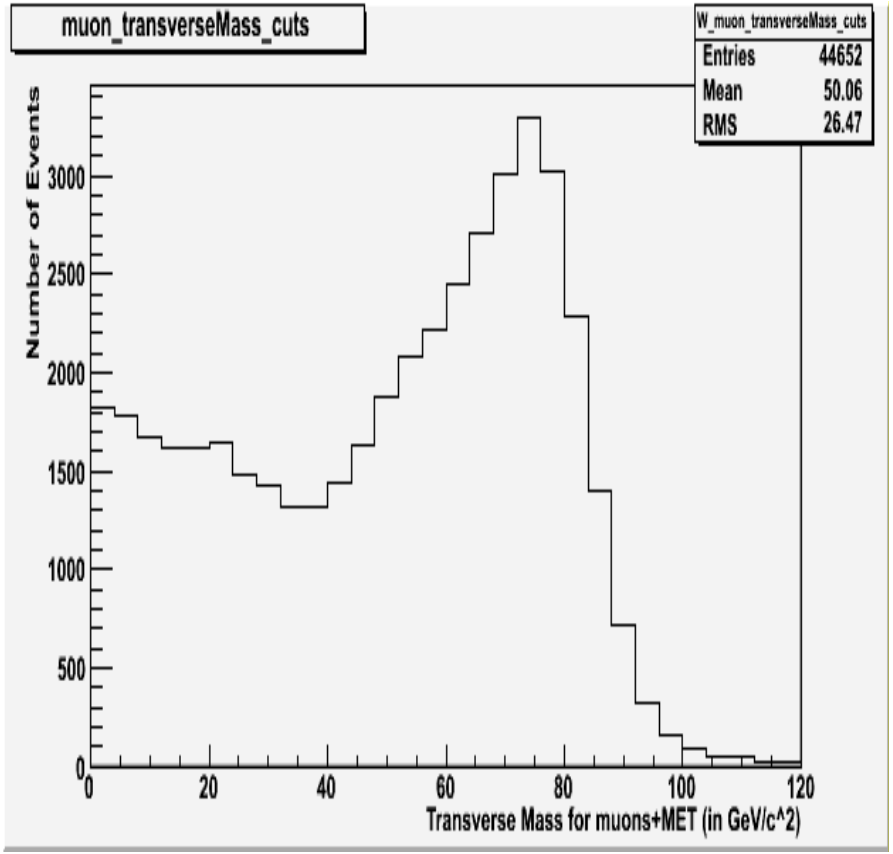
Mu sample

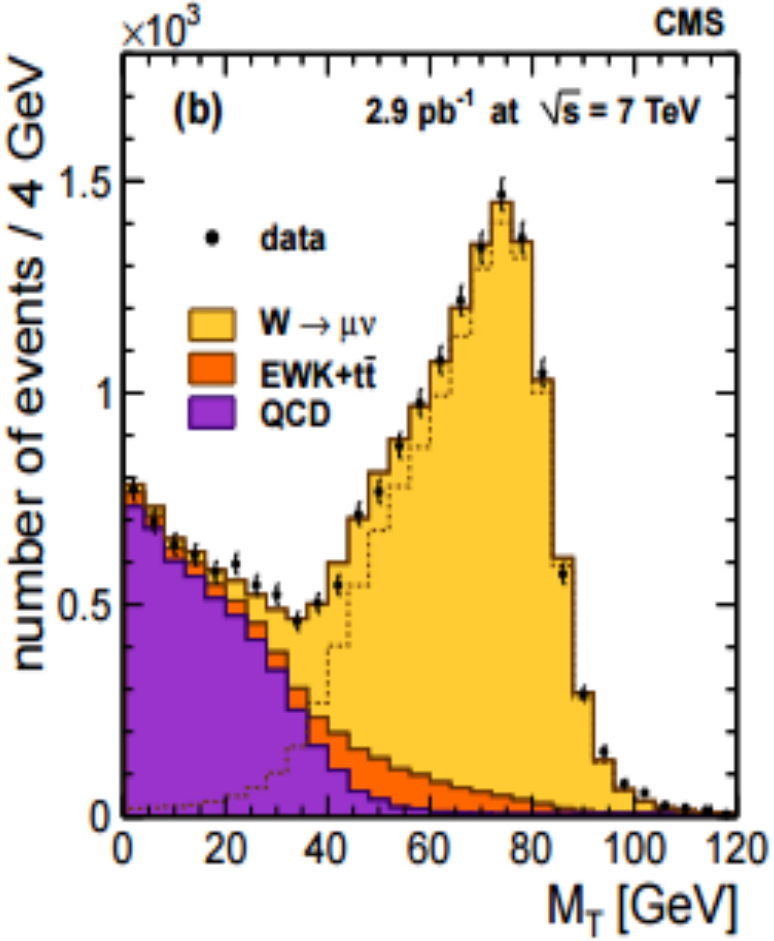
$W \rightarrow \mu\nu$

Reference Paper: "Measurements of the Inclusive W and Z Cross Sections at 7 TeV" by **"The CMS Collaboration"**

Work Done

- Implementation of cuts, as given in the paper.
- Cuts are same as that for the Z, except that events with a second muon with p_T>10 GeV are rejected.


muon_transverseMass_cuts
W_muon_transverseMass_cuts
Entries 44652
Mean 50.06
RMS 26.47
Number of Events
0
500
1000
1500
2000
2500
3000
0
20
40
60
80
100
120
Transverse Mass for muons+MET (in GeV/c^2)


CMS
×10³
(b)
2.9 pb⁻¹ at √s = 7 TeV
data
W → μν
EWK+tt̄
QCD
number of events / 4 GeV
0
0.5
1
1.5
0
20
40
60
80
100
120
M_T [GeV]

Electron sample

$Z \rightarrow e^+e^-$

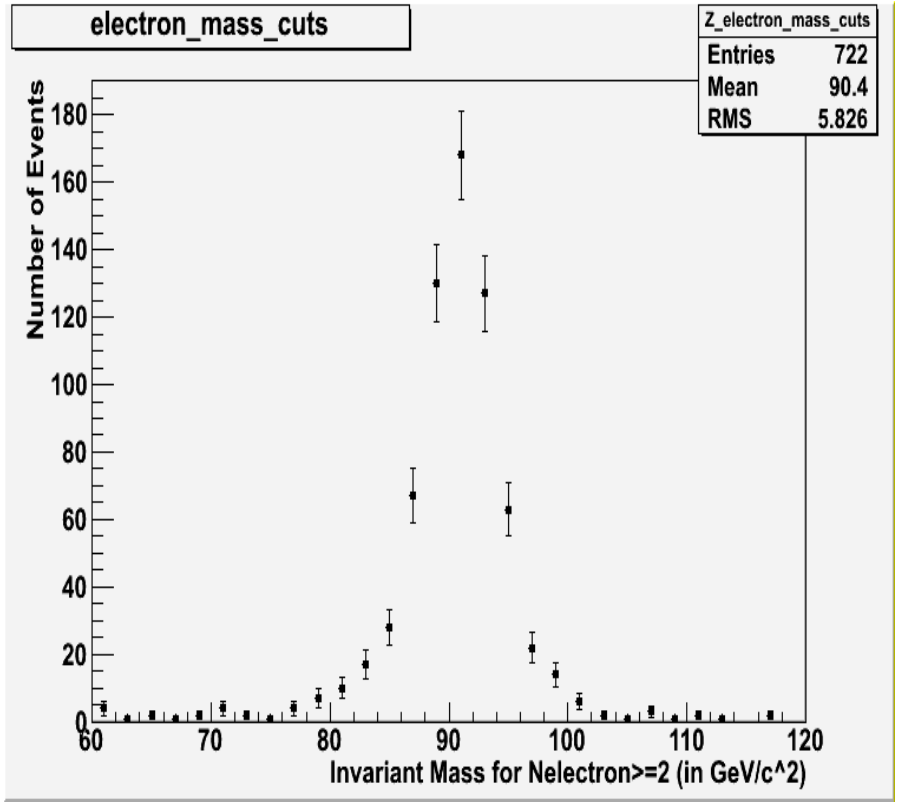
Reference Paper: “Measurements of the Inclusive W and Z Cross Sections at 7 TeV” by **“The CMS Collaboration”**

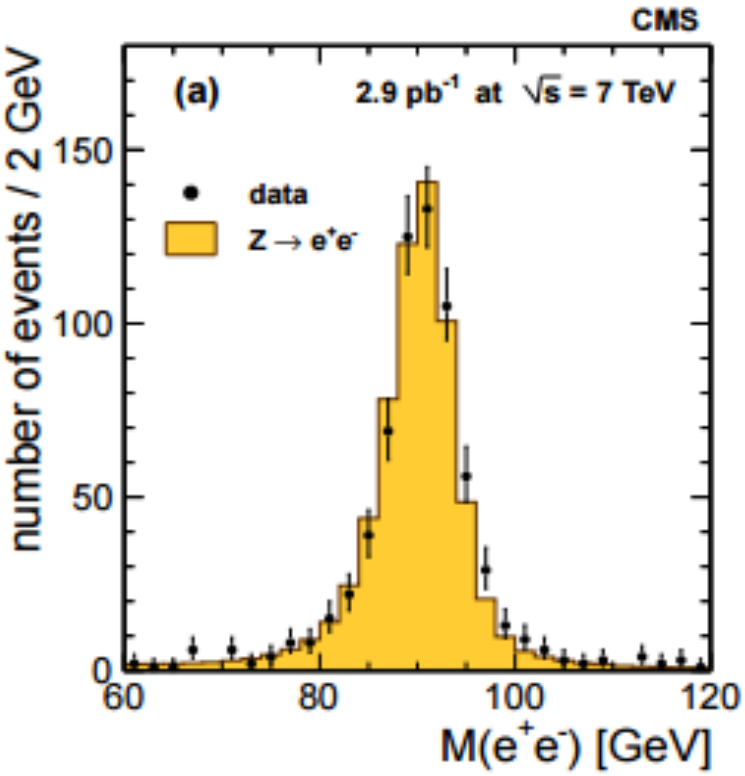
Work Done

- Implementation of cuts, as given in the paper.

WP80 cuts (in a cone of radius 0.3)

	Barrel	Endcap
I_{trk}/E_T	0.09	0.04
I_{ECAL}/E_T	0.07	0.05
I_{HCAL}/E_T	0.10	0.025
Missing Hits≤	0	0
Dcot	0.02	0.02
Dist	0.02	0.02
$\sigma_{i\eta i\eta}$	0.01	0.03
$\Delta\Phi_{in}$	0.06	0.03
$\Delta\eta_{in}$	0.004	-
H/E	0.04	0.025


electron_mass_cuts
Z_electron_mass_cuts
Entries 722
Mean 90.4
RMS 5.826
Number of Events
Invariant Mass for Nelectron>=2 (in GeV/c^2)


CMS
(a)
2.9 pb-1 at √s = 7 TeV
data
Z → e+e-
number of events / 2 GeV
M(e+e-) [GeV]

Electron sample

$W \rightarrow e\nu$

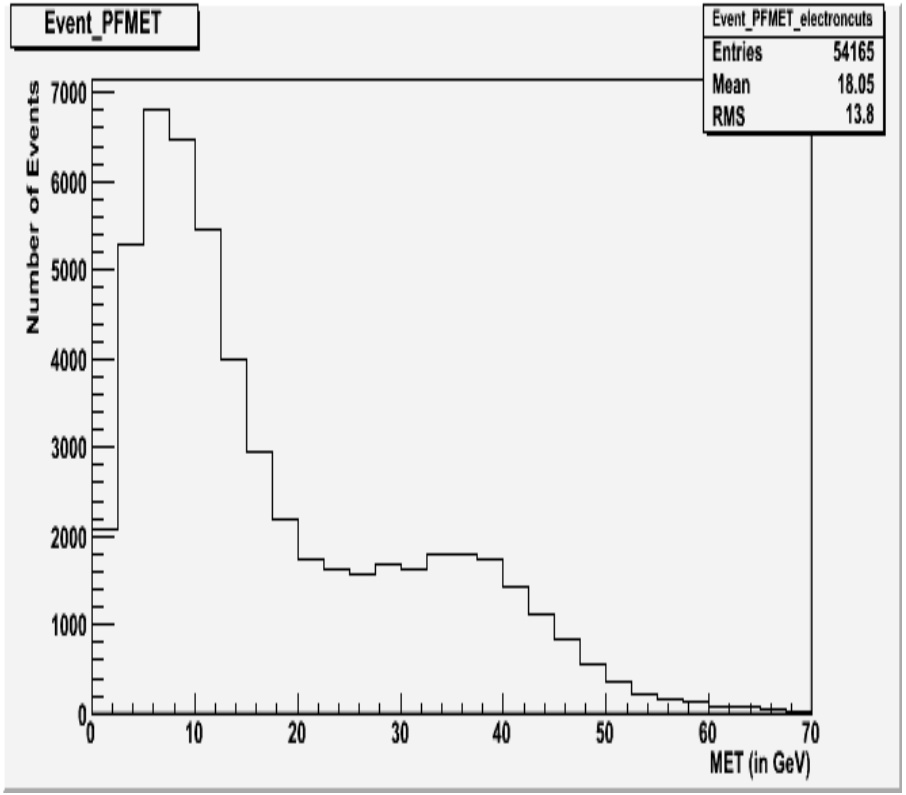
Reference Paper: "Measurements of the Inclusive W and Z Cross Sections at 7 TeV" by **"The CMS Collaboration"**

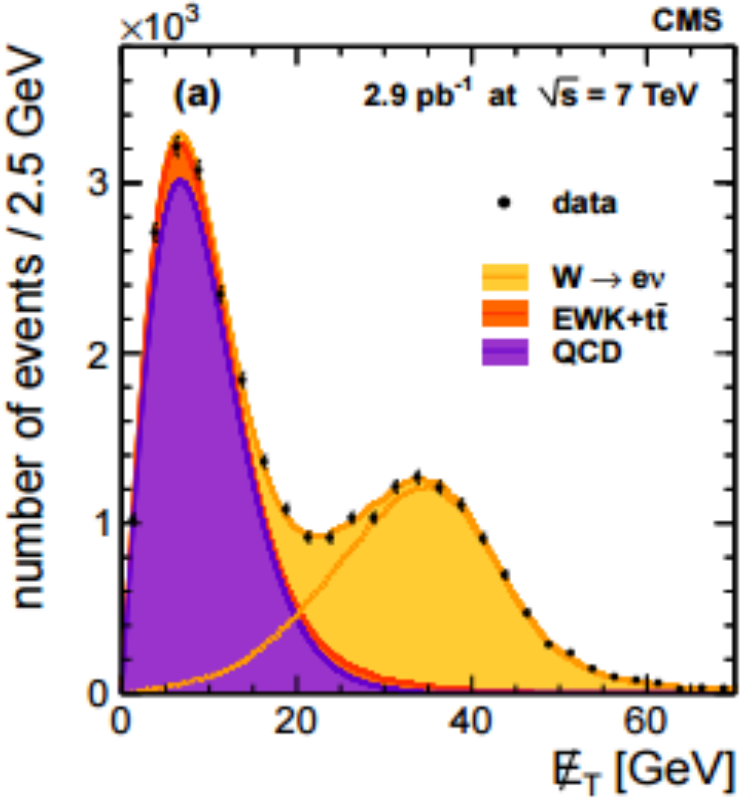
Work Done

- Implementation of cuts, as given in the paper. The first electron is selected using WP80. Events with a second electron are rejected if the second electron satisfies WP95, a looser set of criteria.

WP95 cuts (in a cone of radius 0.3)

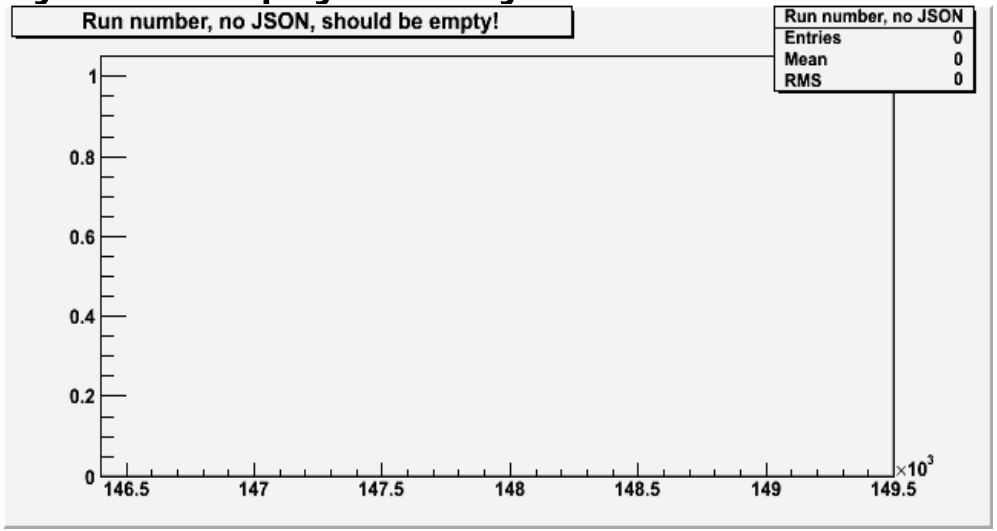
	Barrel	Endcap
I_{trk}/E_T	0.15	0.08
I_{ECAL}/E_T	2.0	0.06
I_{HCAL}/E_T	0.12	0.05
Missing Hits≤	1	1
Dcot	-	-
Dist	-	-
$\sigma_{i\eta i\eta}$	0.01	0.03
$\Delta\Phi_{in}$	-	-
$\Delta\eta_{in}$	0.007	-
H/E	0.15	0.07


Event_PFMET
Event_PFMET_electroncuts
Entries 54165
Mean 18.05
RMS 13.8
Number of Events
MET (in GeV)

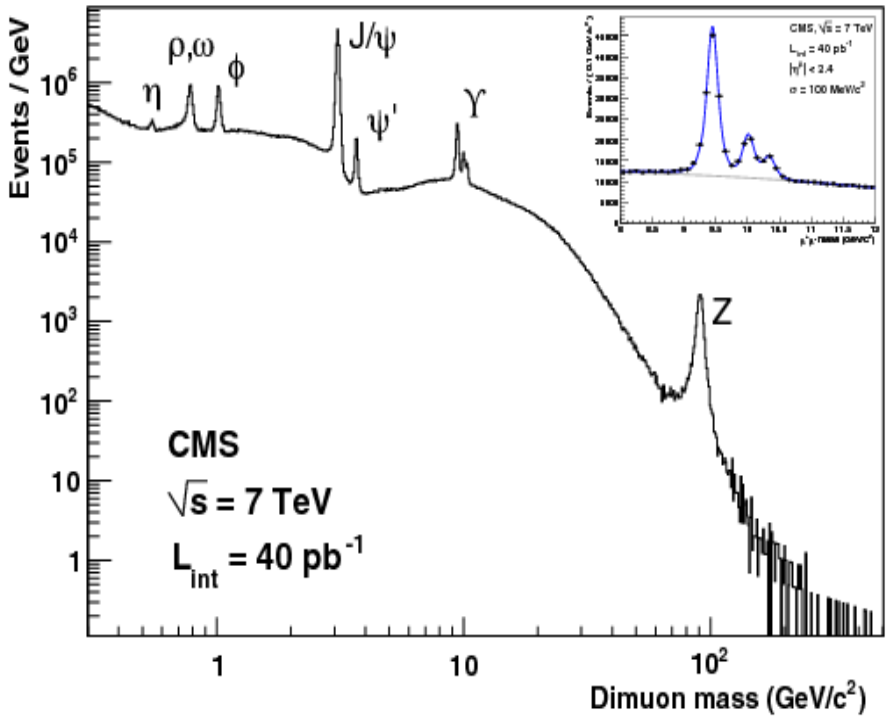

CMS
(a)
2.9 pb-1 at √s = 7 TeV
data
W → eν
EWK+tt̄
QCD
number of events / 2.5 GeV
E_T [GeV]

Other stuff….

- Addition of the JSON file, to read only good events.
- In fact we have a warning histogram, that should normally be empty if only JSON events are read.



A nice di-muon invariant mass distribution from the Mu sample!(global muons only)



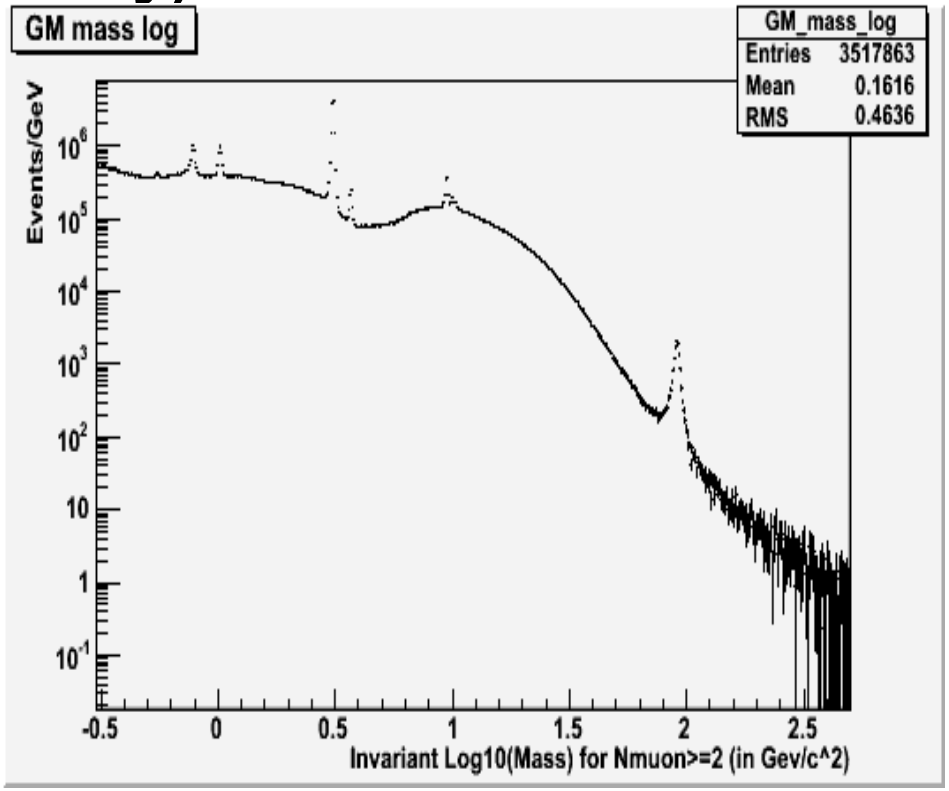


Figure taken from "**Performance of CMS muon reconstruction in pp collision events at √s=7 TeV**" by **The CMS Collaboration**

And now from the Mu Monitor sample (global muons only)

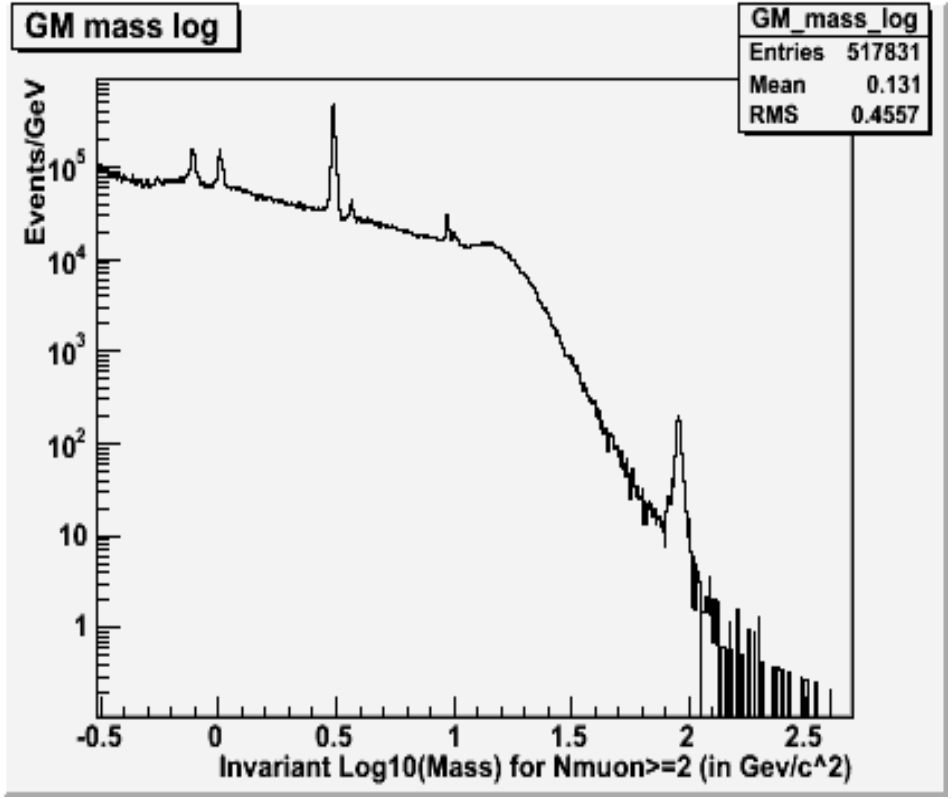


Figure taken from "**Performance of CMS muon reconstruction in pp collision events at $\sqrt{s}$=7 TeV**" by **The CMS Collaboration**

Our work's impact….

We have given the following presentations :

- A. Geiser, I. Dutta, et al., Data preservation and open access meeting, CMS week, 8.5.2015
- A. Geiser, I. Dutta, CMS week communications session, 25.6.2015

Our work was presented here:

- K. Lassila-Perini, CMS week, Collaboration Board Meeting, 26.6.2015

Future Goals

- We have some Monte Carlo now, which can be used to generate acceptance corrections.
- Secondary vertex reconstruction.

Danke Schön