H->ZZ->4l (4mu) channel with the CMS experiment

FP7-EENPP, Coordination meeting

22-1-2014

Nicola De Filippis – Ahmed Abdelalim – Simranjit Chhibra

- Reham Aly

Helwan University

For WP1 group.

Outlines

- Introduction
- Background estimation
- Muon Efficiency
- Final result
- P- value test
- Future work

Introduction

- Data: integrated luminosity of 5 fb-1 at 7 TeV in 2011, 19.8 fb-1 at 8 TeV in 2012
- Signatures: 4l(mu) final state "Golden channel"
- backgrounds:
  - irreducible ZZ
  - reducible Zbb, tt with leptons from b/c hadrons decays
  - reducible Z+jets, W+jets, QCD with fake leptons
- Selection strategy and observables:
  - 4 well reconstructed and isolated leptons
  - leptons coming from the primary vertex
- Results:
  - 4l invariant mass
  - p-value for discovery
  - sigma95/sigma SM for exclusion
  - discrimination of spin/parity hypotheses

Background

- irreducible ZZ background (From MC)
- Reducible Background

Zbb, tt , Z+jets, W+jets and QCD

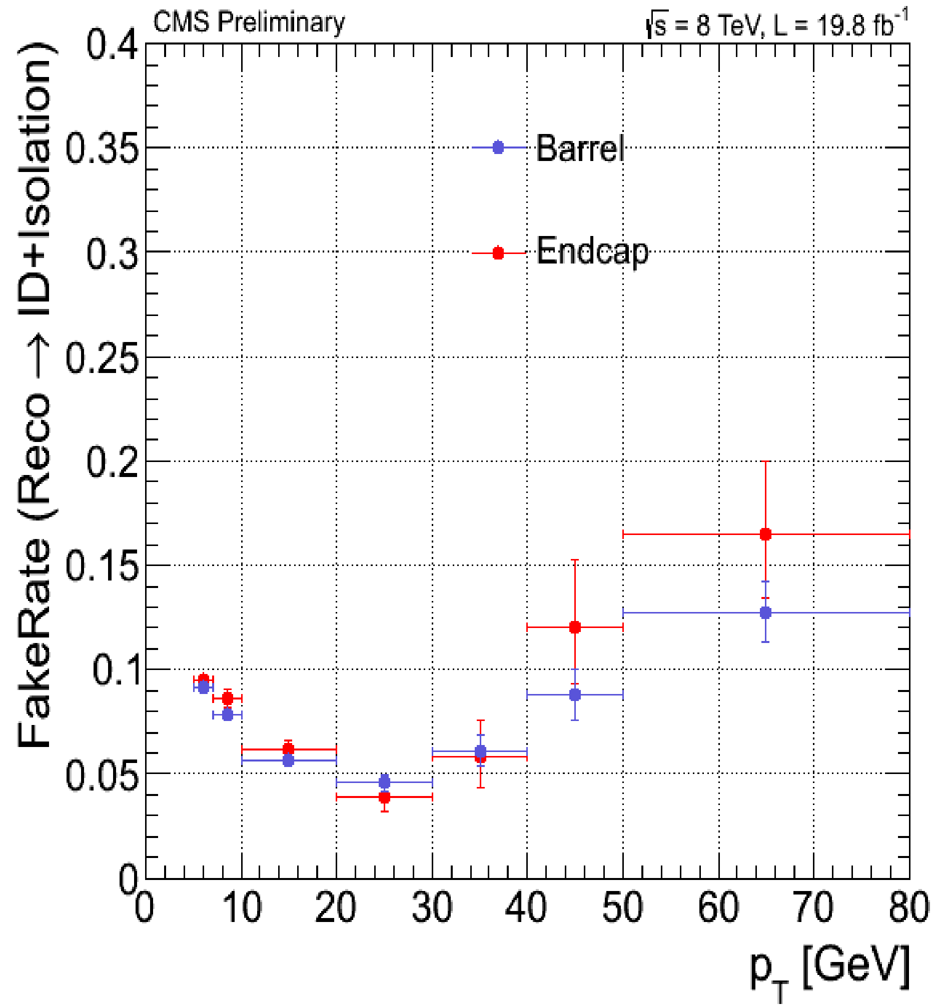
We estimate these background from data by Fake rate method (FR)

Estimation of Z+X background from data using Fake rate method

- Step1: Measuring the fake rate in 3 lepton phase space

(Leading Z + one object)

- FR = No. of Jets passing identification and iso. / Total no. of jets
- Jet $\rightarrow$ μ fake rate: measured using Z $\rightarrow$ μ μ + μ and Z $\rightarrow$ ee + μ events



Reham.M.Aly

Estimation of Z+X background from data using Fake rate method

Applying the measured FR in the regions defined as

- •Leading Z + 2 opposite charge objects
- •M 4l > 70 GeV

➢Cat 0 (2P2F) : Leading Z + 2 fakeable objects (O1 and O2)

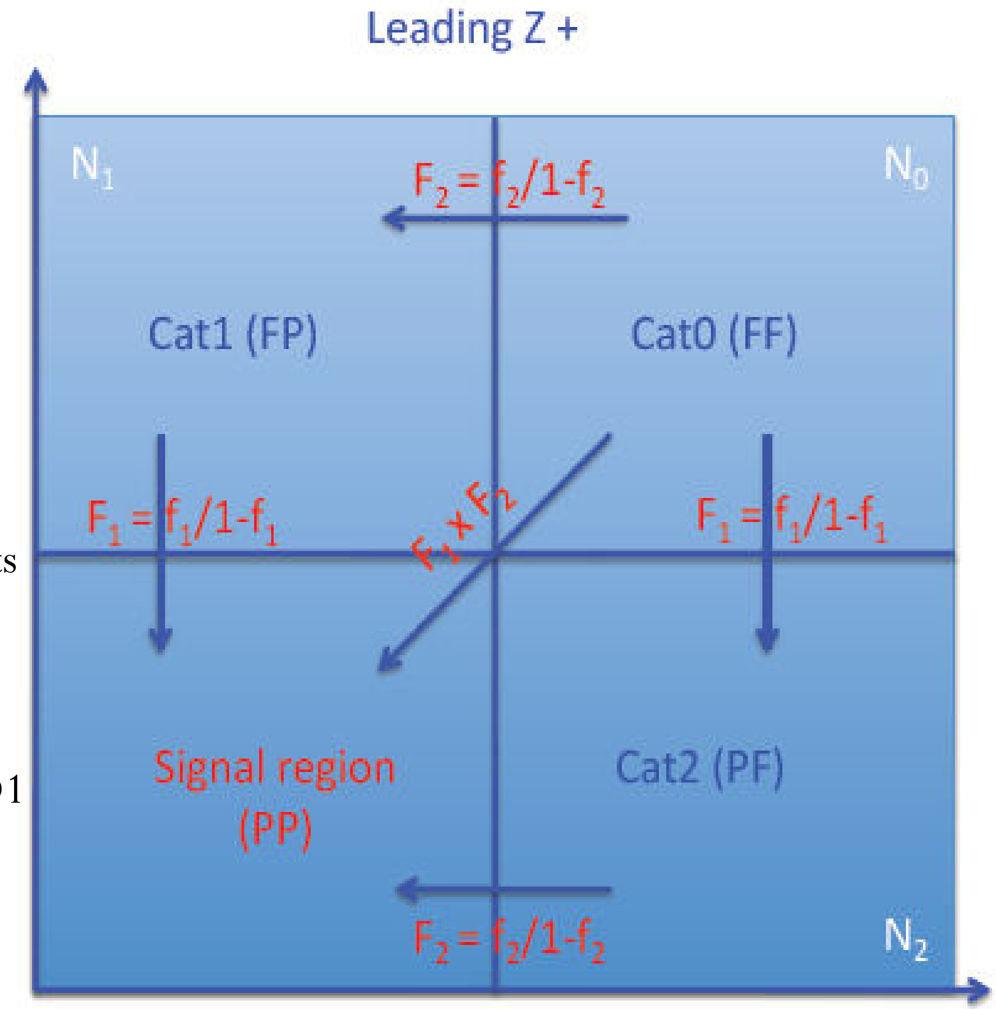
▪Both O1 and O2 should fail ID or ISo

➢Cat 1 (3P1F) : Leading Z + 1fakeable objects (O1) + 1 real object (O2)

▪O2 should pass ID and ISO & O1 should fail eithe ID or ISO

➢Cat 2 (3P1F) : Leading Z + 1 real objects(O1) + 1 fakeable object (O2)

▪O1 should pass ID and ISO & O2 should fail eithe ID or ISO

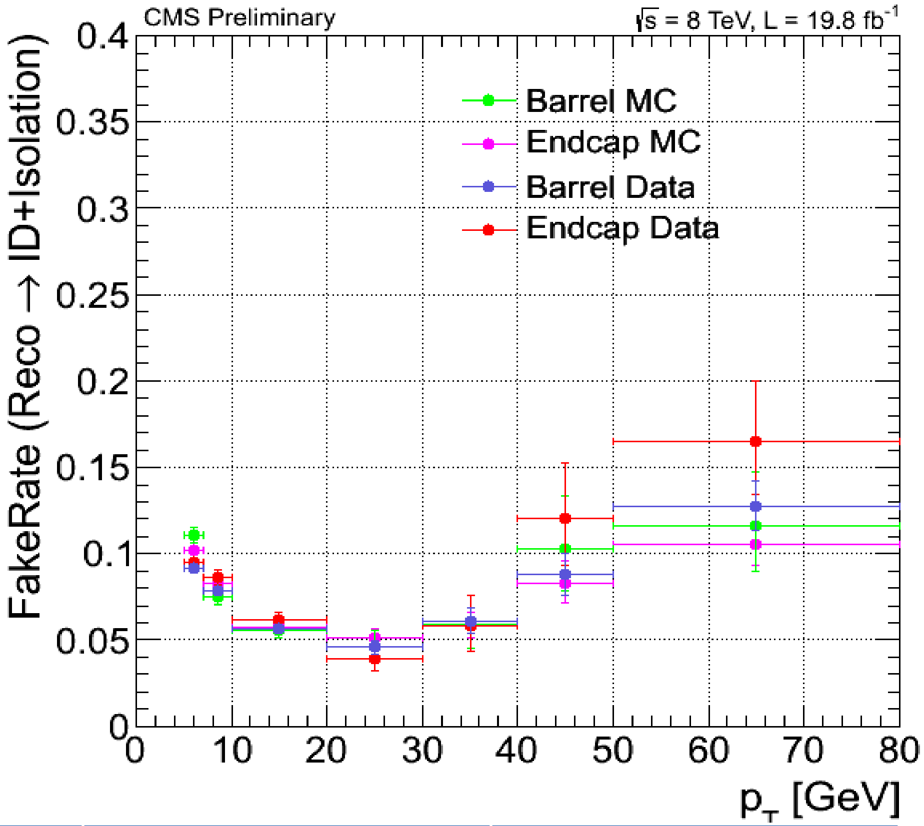


Final Estimation :

$$N_{tot}^{est} = N_0 \times F_1 \times F_2 + (N_1 - N_0 \times F_2) \times F_1 + (N_2 - N_0 \times F_1) \times F_2 = N_1 \times F_1 + N_2 \times F_2 - N_0 \times F_1 \times F_2$$

Estimation of Z+X background from data using Fake rate method

- ZZ part is the fraction of zz estimated by the same FR method from MC and subtracted from data
- Then we calculate the fake rate also for MC by same way
- Similar behavior but Not good agreement between Data & MC .



Data

8TeV	Data	ZZ part	Final Estimation
4 μ	4.03	1.26	2.77 ±0.67

MC

8TeV	Final Estimation
4 μ	1.41 ± 0.53

Selection Strategy

- Firstly : Muon selection "Good Muons"
  - PF muon
  - Global || tracker
  - $PT > 5$ GeV
  - $|\eta|<2.4$
  - Significance of the Impact Parameter $SIP < 4$
  - Relative $PFIso < 0.4$

Muon efficiency
Tag & probe method

- This method for measuring the efficiency of muon in different stages of muon identification, SIP, Isolation and trigger for the muons used in the 4mu final state.
- Tag muon :Pass tight selection (PT>20)
- Probe :Loose selection (PT>5)
- Tag&&Probe Pair

Tag &Probe (TnP) pair with opposite charge & inv.Mass in70<M<130GeV

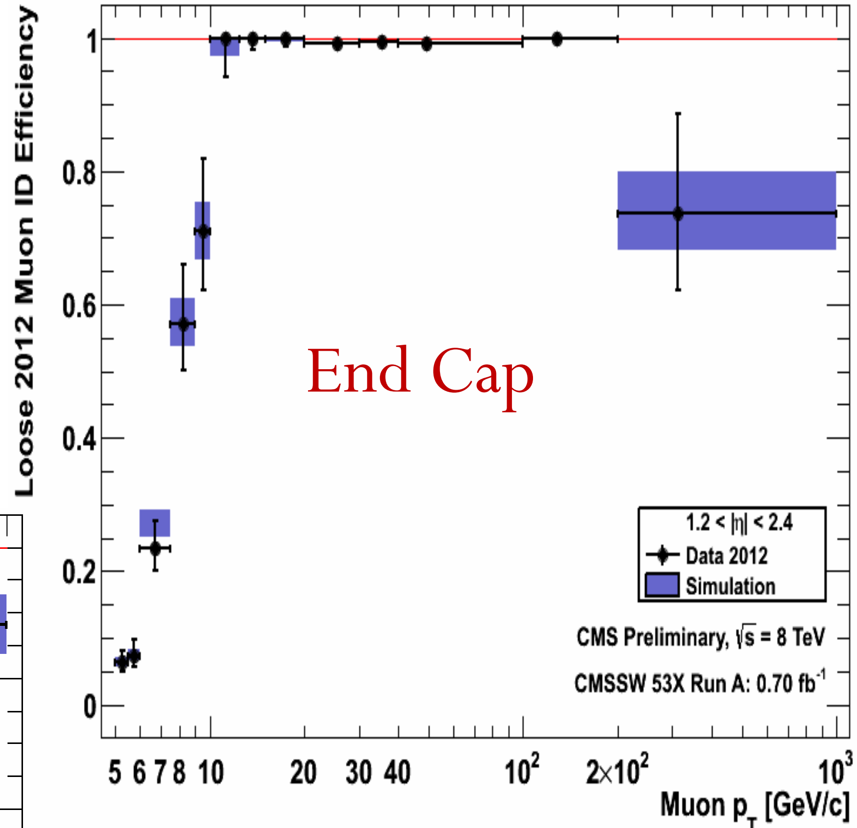
- Typical decomposition of Muon efficiency

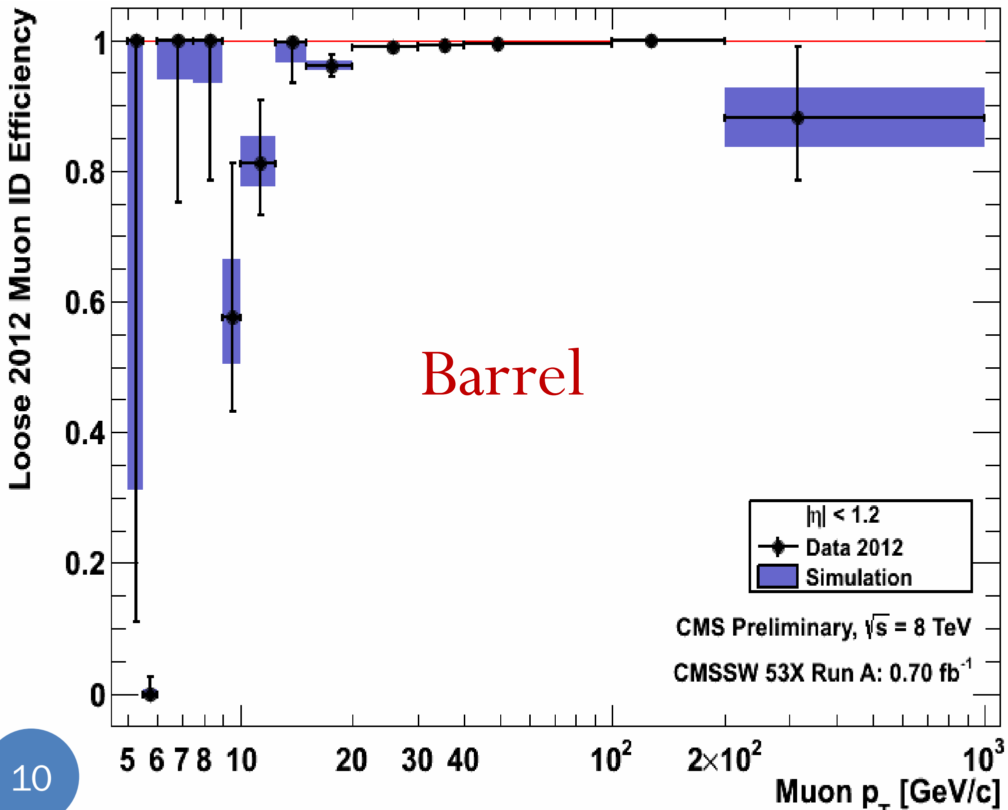
$$\varepsilon = \varepsilon(\text{Tracking}) \times \varepsilon(\text{ID}|\text{Tracking}) \times \varepsilon(\text{SIP}|\text{ID}) \times \varepsilon(\text{ISO}|\text{SIP}) \times \varepsilon(\text{trg}|\text{ISO})$$

  - Tracking efficiency ⟶ provided by Tracking POG
  - Loose Muon ID efficiency
  - SIP efficiency
  - Isolation efficiency
  - Trigger efficiency

➢Loose 2012 Identification (ID)

- Loose2012 =
  PF muon &&(Global ||TrackerMuon)
- Є (Loose2012 Muon ID|Tracks) =
  Loose2012 Muon ID/All Tracks





➢ Binning

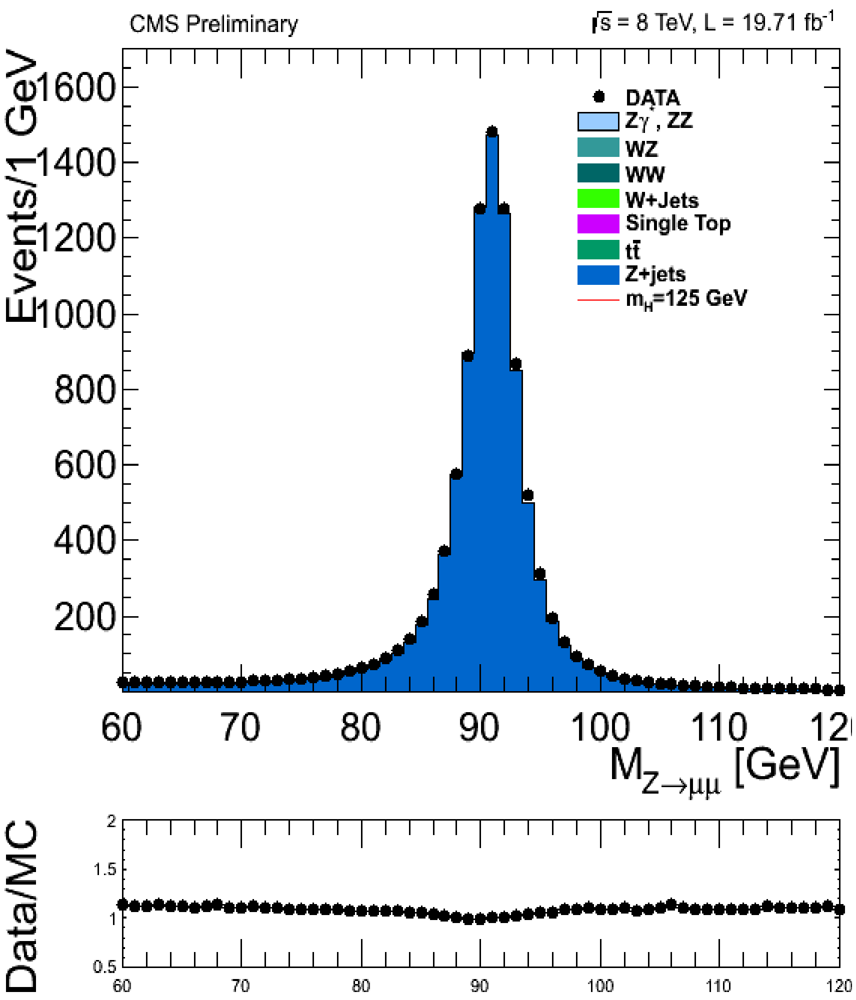
- abseta = (0.0, 1.2, 2.4)
- pt = (5.0, 5.5, 6.0, 7.5, 9.0, 10, 12.5, 15, 20, 30, 40, 100, 200, 1000)

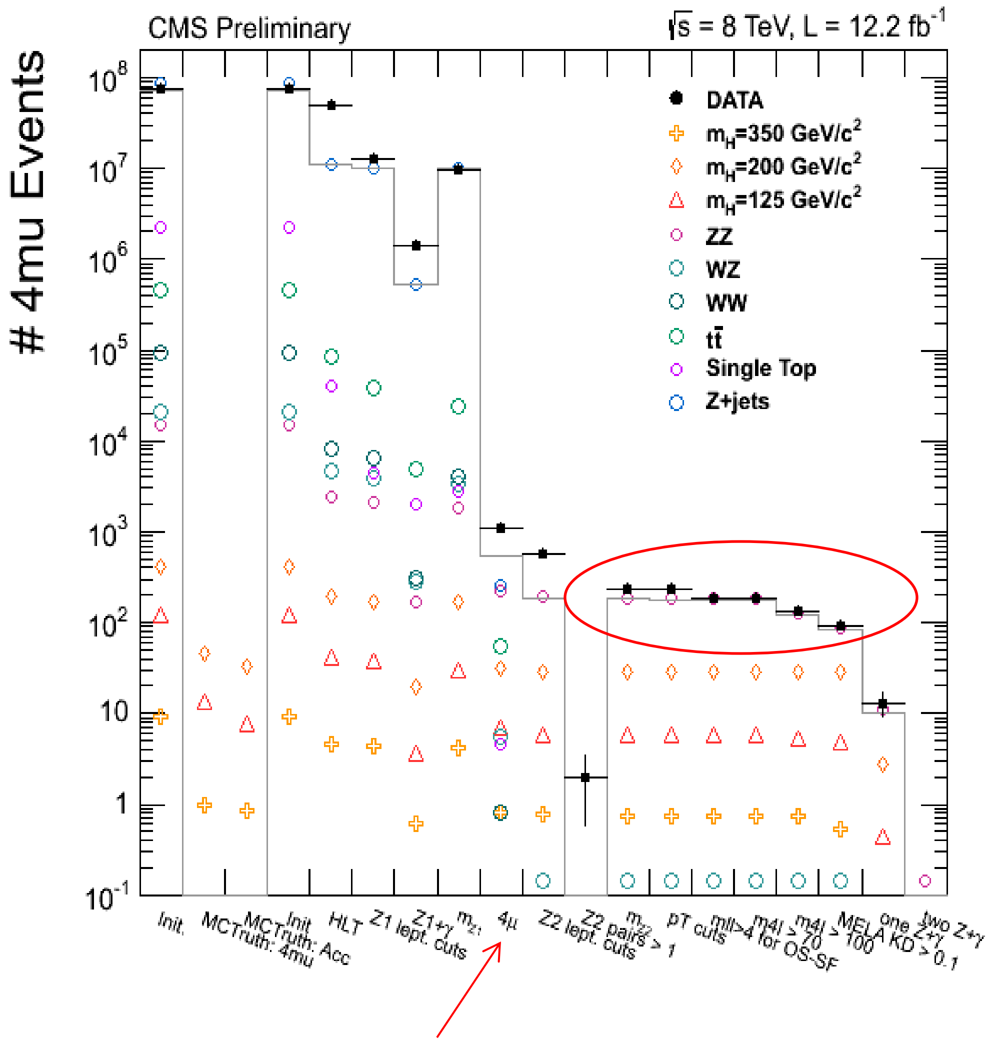
Selection Strategy

Secondly : Full selection

- Z1 lept. cuts" - Good leptons with mll closest to mZ
- Z1+#gamma" - Include FSR in mll
  - Photon cleaning: (if photon –electron deltaR<0.15 photon is removed, select closest mass to Z (mll or mllgamma)).
- m_{Z1} cut" - 40 < mll < 120 (Step 3)
- at least 4l" - Four good leptons
- Z2 lept. cuts" - Second pair with mll closest to mZ
- Z2 pairs > 1" - Is there more than 1 Z2 pair?
- m_{Z2}" - 4 < mll < 100
- mll>4 for OS-SF" - All OS-SF pairs have mll > 4
- m4l > 100

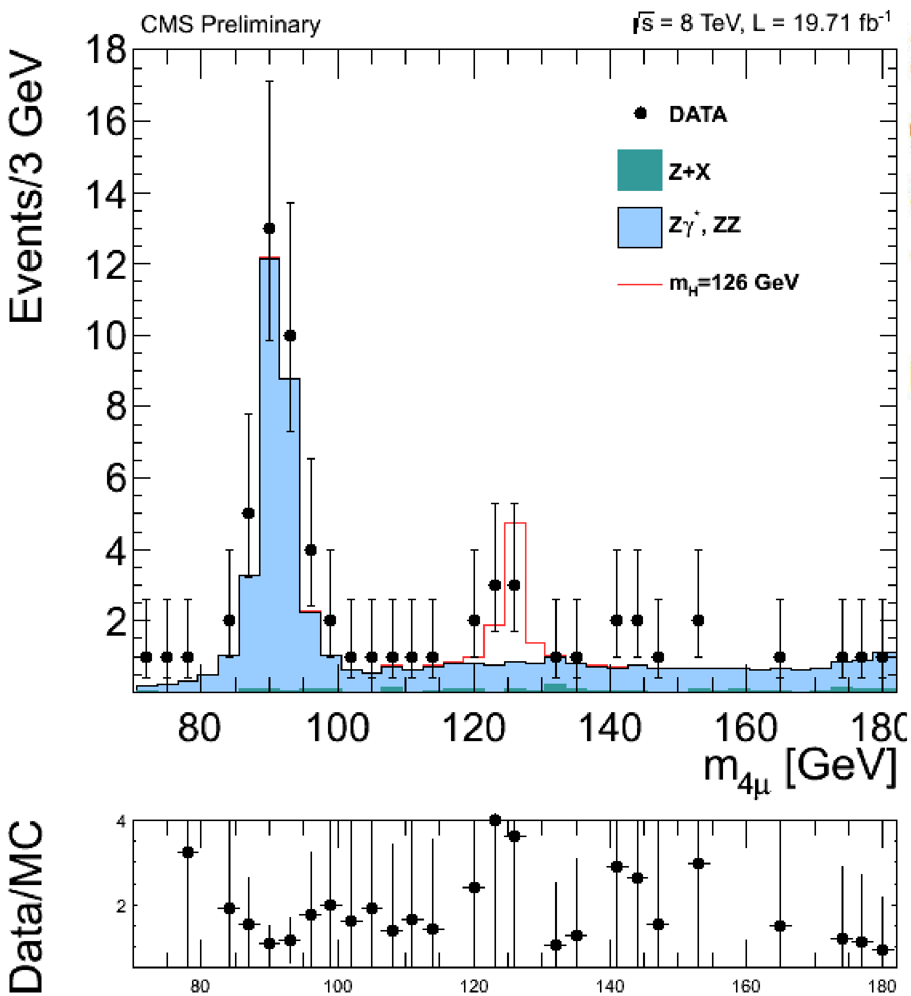
- ➢ Step 3
- Good leptons with mll closest to mZ
- 40 < mll < 120

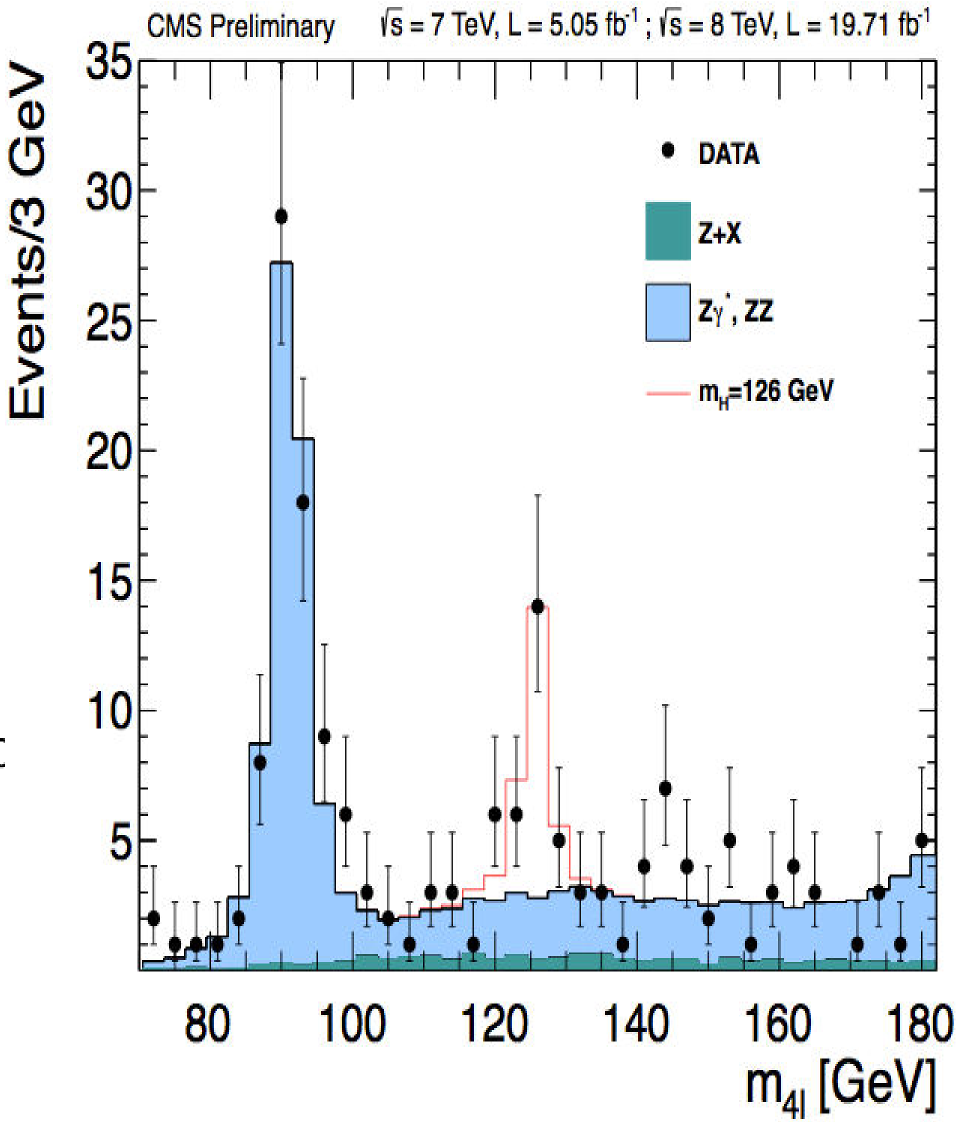




Reham.M.Aly

Final Result @ 7+8 TeV (4L)





- Ratio between Data && Bkg
- Signal H=126

Reham.M.Aly

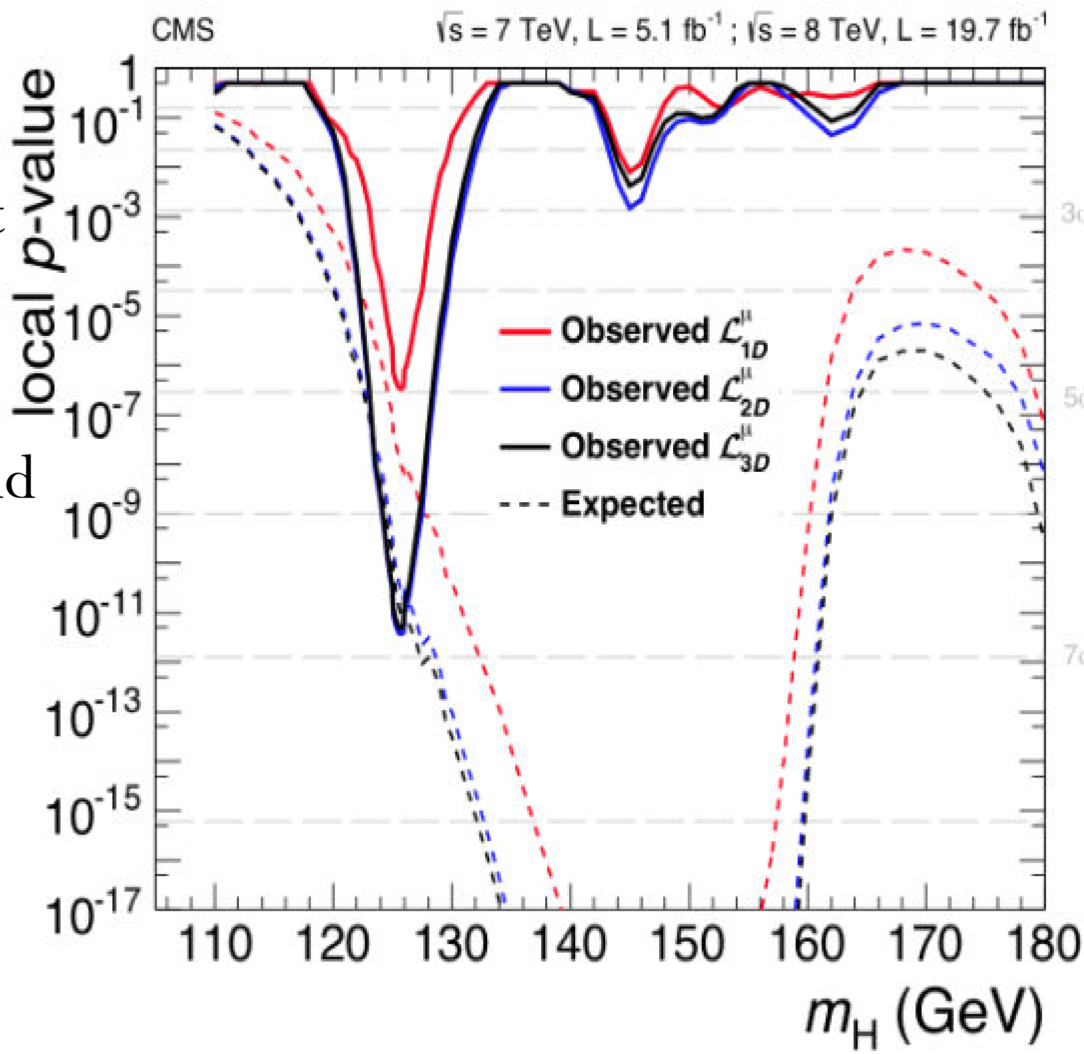
Final Result @ 7+8 TeV (4L)

Table 1: The number of estimated background and signal events and number of observed candidates, after final inclusive selection, in the full measurement range $121.5 < m_{4l} < 130.5$ GeV. Signal and ZZ background are estimated from Monte Carlo simulation, while Z+X is estimated from data

Channel	$4e$	4μ	$2e2\mu$
$5.05\ \mathrm{fb}^{-1}$ @ 7 TeV			
ZZ background	0.3 ± 0.0	0.5 ± 0.0	0.7 ± 0.0
Z + X	0.1 ± 0.0	0.0 ± 0.0	0.2 ± 0.0
All background expected	0.3 ± 0.0	0.6 ± 0.0	0.9 ± 0.0
$m_H = 125$ GeV	0.5 ± 0.0	1.1 ± 0.0	1.3 ± 0.0
$m_H = 126$ GeV	0.5 ± 0.0	1.1 ± 0.0	1.4 ± 0.0
Observed	0	2	3
$19.71\ \mathrm{fb}^{-1}$ @ 8 TeV			
ZZ background	0.9 ± 0.0	2.2 ± 0.1	2.9 ± 0.1
Z + X	0.3 ± 0.0	0.2 ± 0.0	0.6 ± 0.0
All background expected	1.2 ± 0.0	2.4 ± 0.1	3.5 ± 0.1
$m_H = 125$ GeV	2.3 ± 0.0	5.0 ± 0.0	6.1 ± 0.0
$m_H = 126$ GeV	2.6 ± 0.0	5.6 ± 0.0	7.1 ± 0.1
Observed	4	6	10
$5.05\ \mathrm{fb}^{-1}$ @ 7 TeV and $19.71\ \mathrm{fb}^{-1}$ @ 8 TeV			
ZZ background	1.1 ± 0.0	2.8 ± 0.1	3.6 ± 0.1
Z + X	0.4 ± 0.0	0.2 ± 0.0	0.8 ± 0.0
All background expected	1.5 ± 0.0	3.0 ± 0.1	4.4 ± 0.1
$m_H = 125$ GeV	2.8 ± 0.0	6.0 ± 0.0	7.4 ± 0.0
$m_H = 126$ GeV	3.1 ± 0.0	6.7 ± 0.0	8.4 ± 0.1
Observed	4	8	13

Final Result @ 7+8 TeV

- P- value test :
  - "What are the chances that the higgs boson doesn't exist given my data "
  - Probability that background fluctuate to give an excess of events equal or larger than what observed



Reham.M.Aly

Future plan

- Spin/parity hypotheses study for Higgs
- Muon efficiency on full data (Run ABCD)
- High mass Higgs boson
- Data cards for Significance of discovery and exclusion

Thanks To

- Nicola De Filippis
- Ahmed Abdelalim
- Simranjit Chhibra

Thank You!