Estimation of the Reducible background from data for Mono-Higgs search

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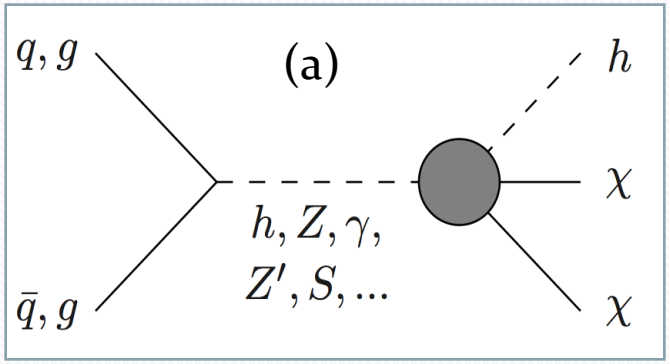
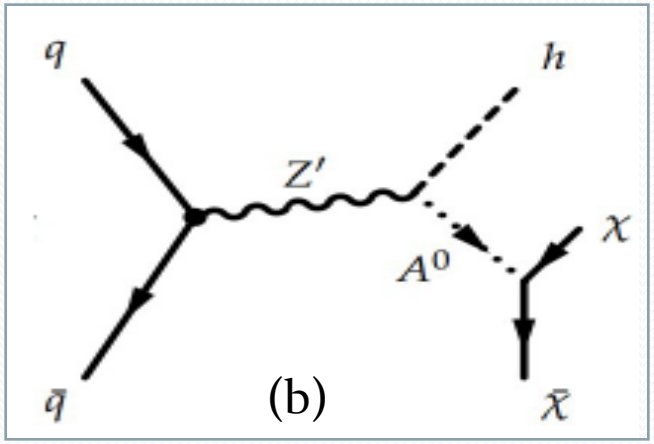
8/3/2016

Mono Higgs search

- DM searches at LHC have been performed with various mono-X + missing Et signatures (where X=W, Z, jet or γ)
- Here, X could be emitted directly from a quark as ISR or as part of new effective vertex coupling of DM to SM
- Unlike W, Z, jet, or γ, Higgs ISR is highly suppressed → mono-Higgs signal could probe directly the structure of the effective DM SM coupling
- One of the models is simplified model "Zp2HDM"
- <u>Experimental signature:</u> MET + 4l from H decay





Backgrounds

- All processes which give same final state as signal.

Backgrounds

- Irreducible: ZH, Z→νν and H→ZZ→4l or Z→ll and H→ZZ→2l2ν "MC"
- Reducible :
- Non-resonant ZZ→4l + MET: Reducible with MET cut
- Others: Z+jets, WZ+jets, ttbar, : Estimate from control regions in data using Fake Rate Method .

Fake-rate (FR) method

- The FR method is Data Driven Method used to estimate reducible background from data.
- The reducible background, which called “Z + X”, originates from processes which contain one or more non-prompt leptons in the four lepton final state.
- The main sources of these non-prompt leptons are non-isolated leptons coming from decays of heavy-flavor mesons & mis-reconstructed jets (from light-flavor quarks).
- So we define “fake lepton” as any jet mis-reconstructed as a lepton and any lepton originating from a heavy meson decay.
- The fake rate is the probability for these fake object to pass the final selection criteria to signal region.
- This method has 2 steps :
  - Measuring the FR
  - Applying the measured FR on different control regions

Fake-rate (FR) method (|)

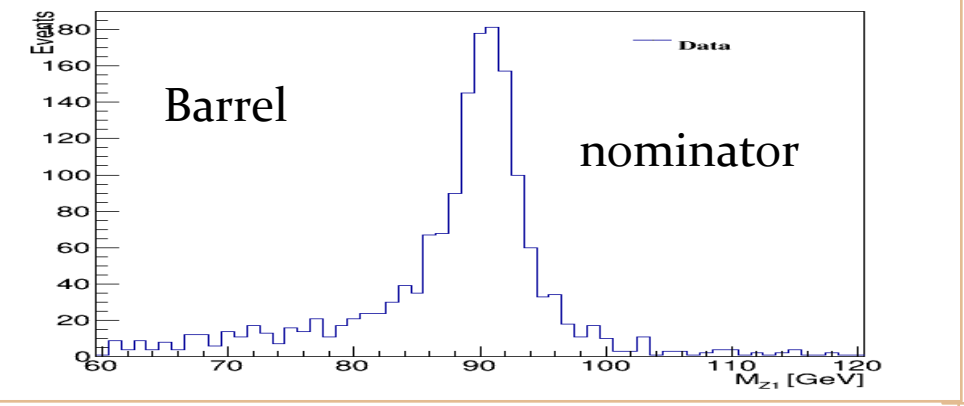
- Measuring the fake rate in 3 lepton phase space(Leading Z + one loose object)
- The leading Z is selected from two same flavor, opposite charge leptons with pT > 20/10 GeV passing the tight selection criteria.
- Mass window $| M_{inv(l1,l2)} - M_Z | < 7$ GeV.
- Loose object (jet) ⟶ Pass loose selection

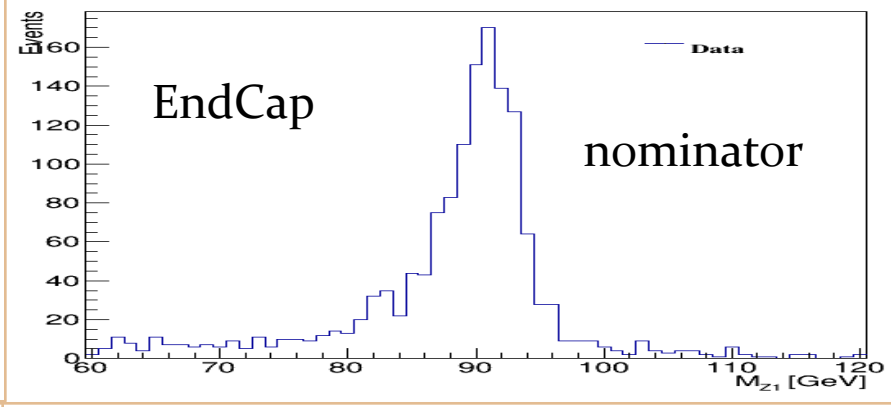
  FR = No. of Jets passing tight identification and isolation/ Total no. of jets

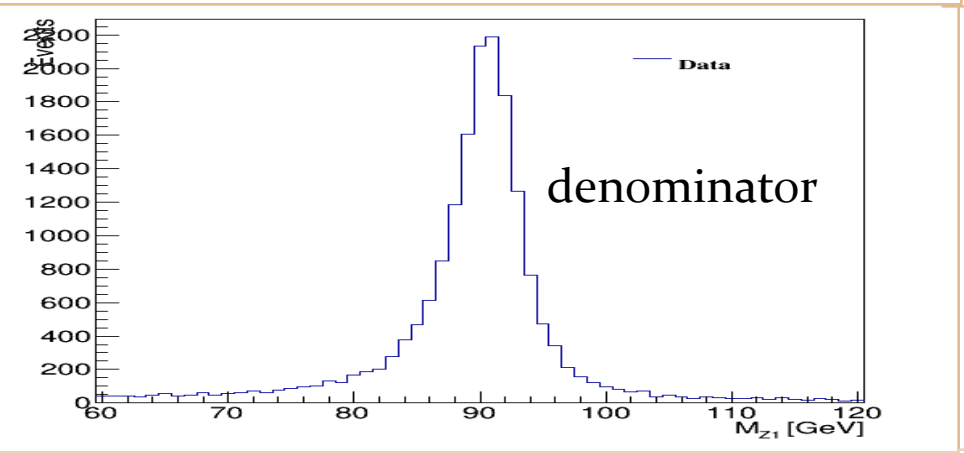
  Jet → μ fake rate: measured using Z → μ μ + μ and Z → ee + μ events

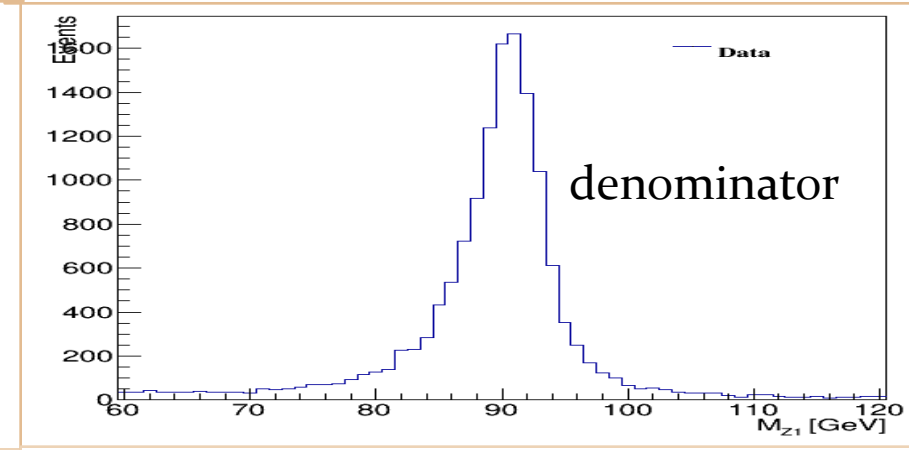
  Jet → e fake rate: measured using Z → ee + e and Z → μ μ + e events
- $E_{Tmiss} < 25$ GeV "supress WZ "
- We measure fake rate as a function of loose lepton p_T

Loose & Tight selection in Backup



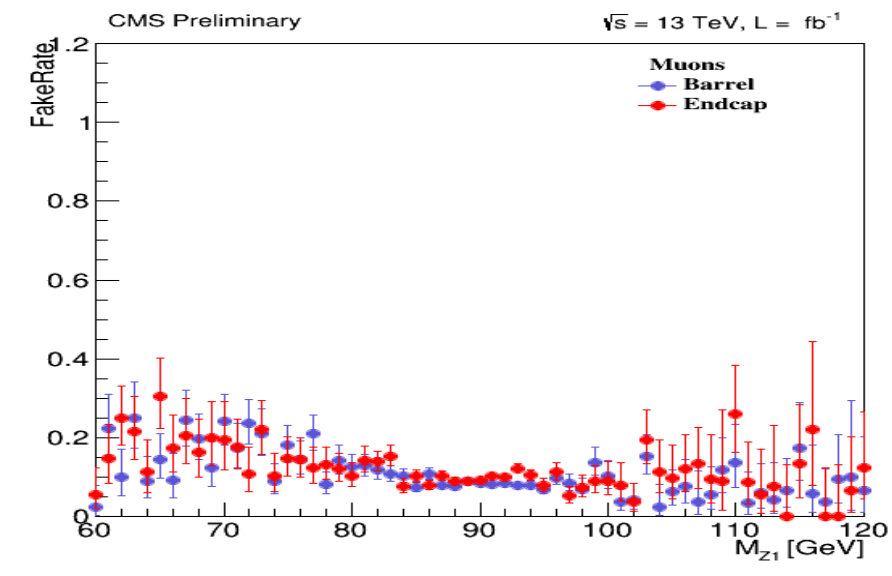


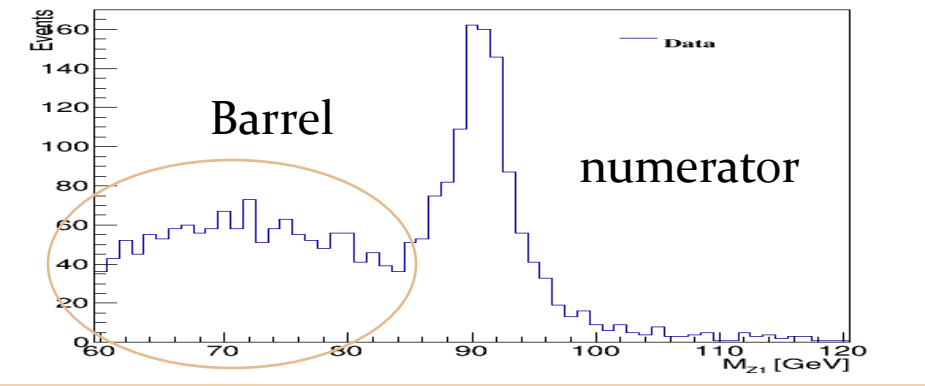


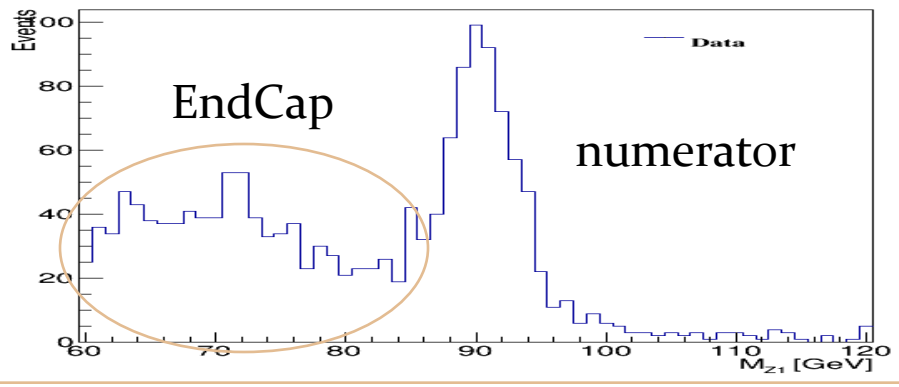


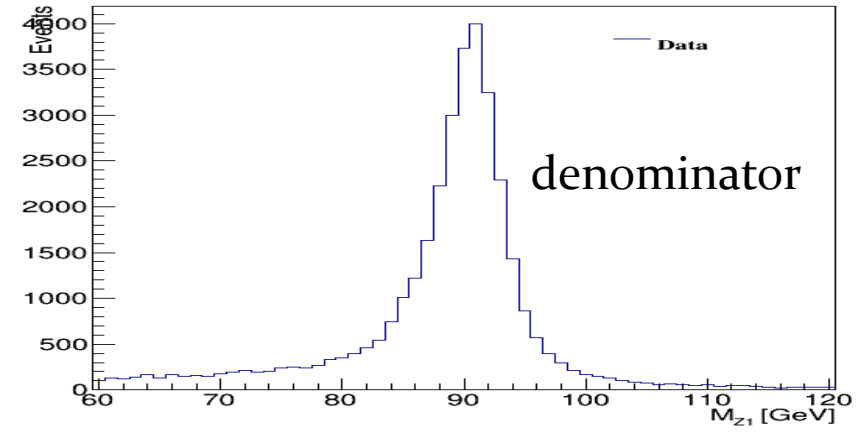
Muons

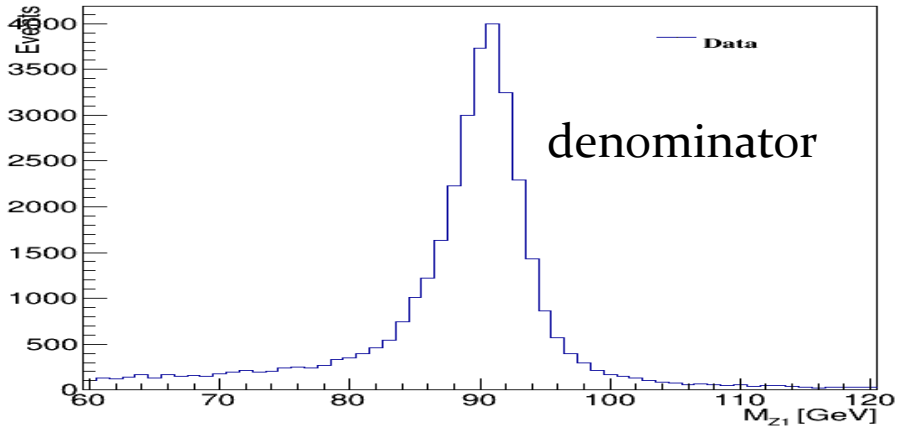
- Muon Fake Rate as a function of mZ1
- Dependence of muon fake rate on mZ1
- Tight cut $| M_{inv(l1,l2)} - M_Z | < 7$ GeV





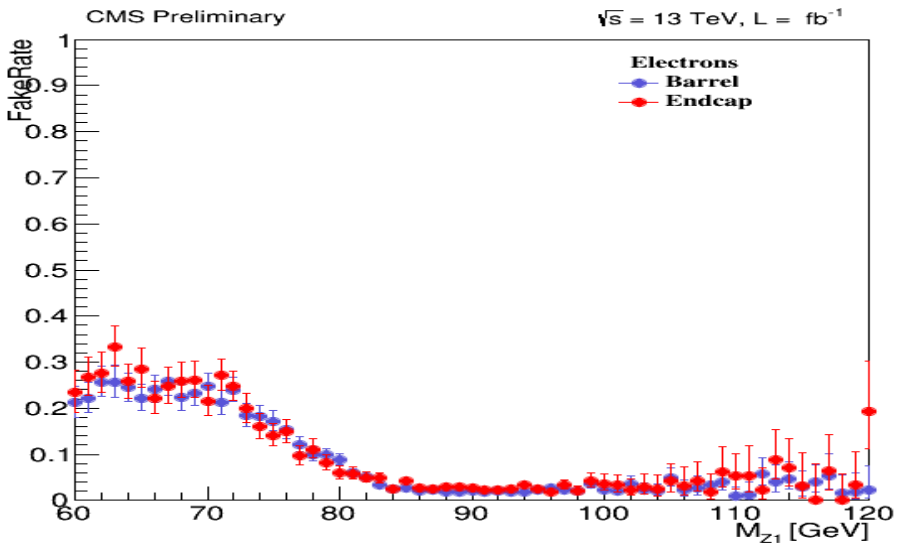


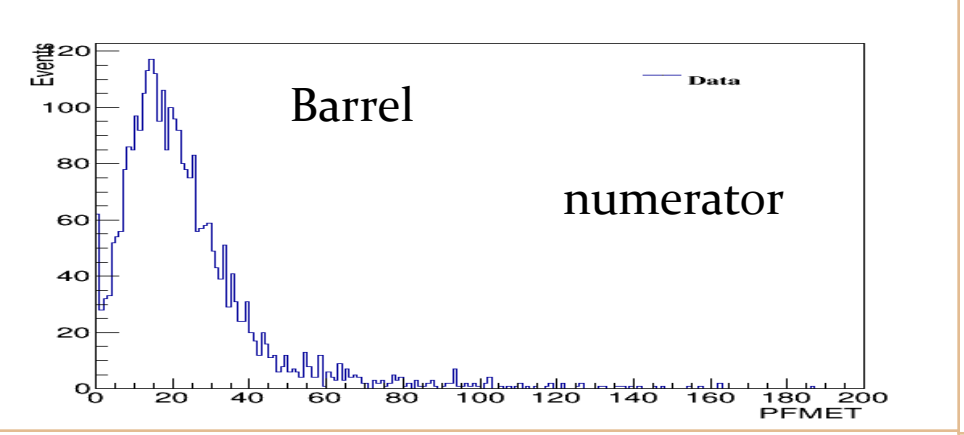


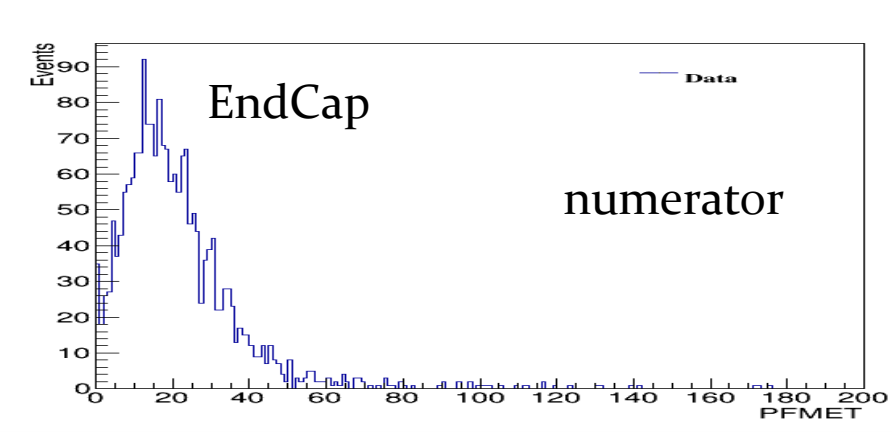


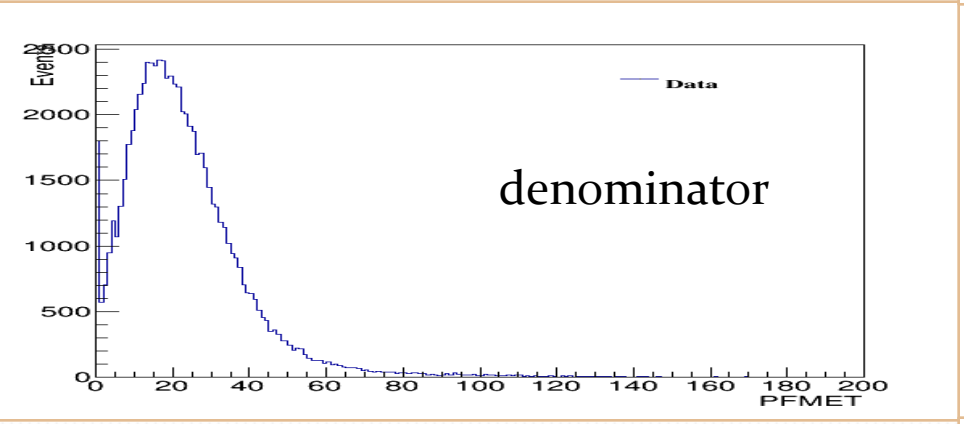
Electrons

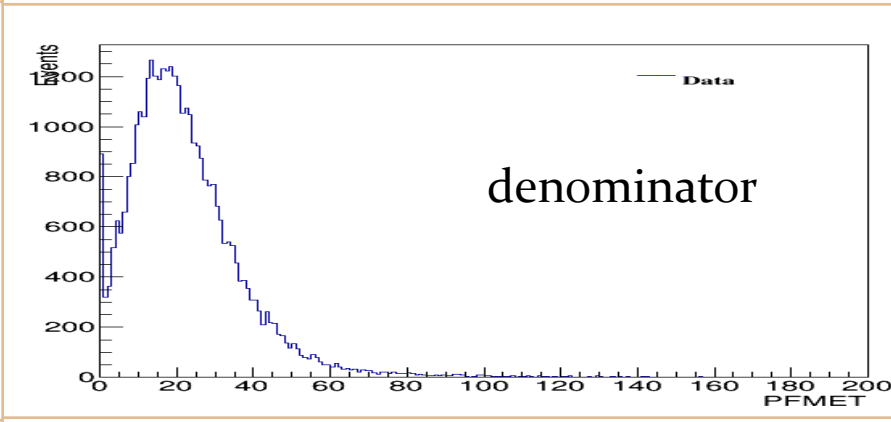
- Fake Rate as a function of mZ1
- Dependence of electron fake rate on mZ1
- Tight cut $| M_{inv(l1,l2)} - M_Z | < 7$ GeV





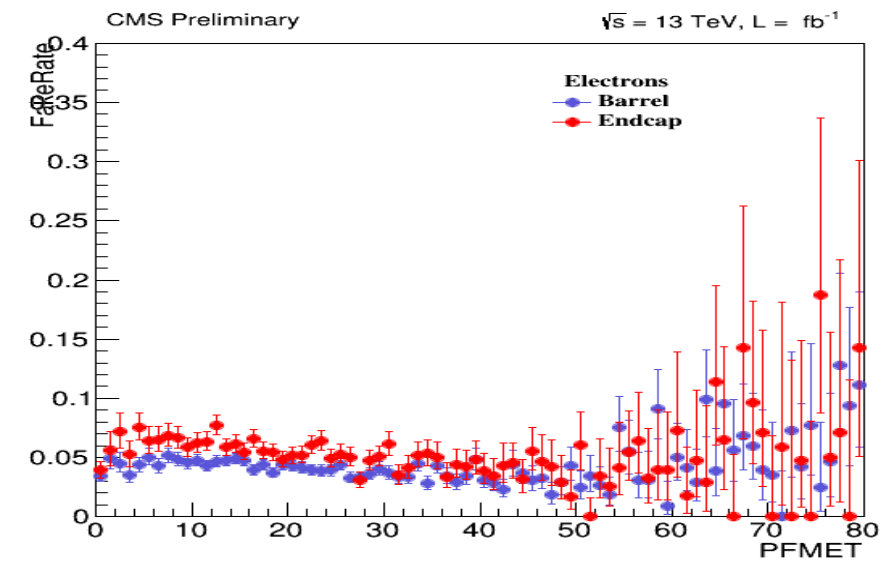


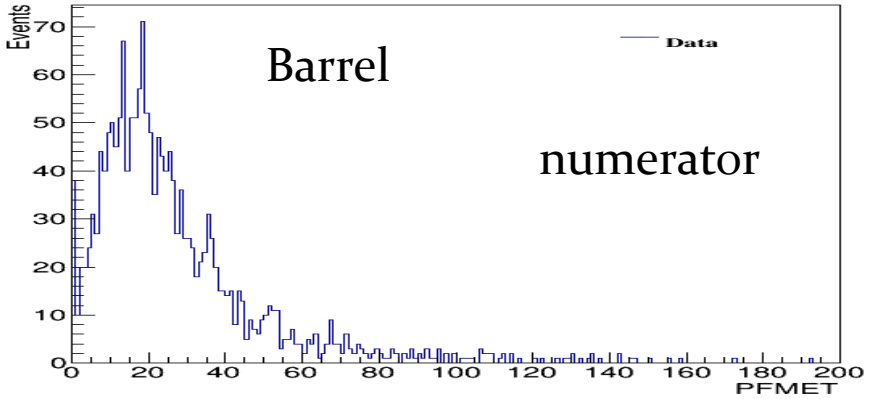


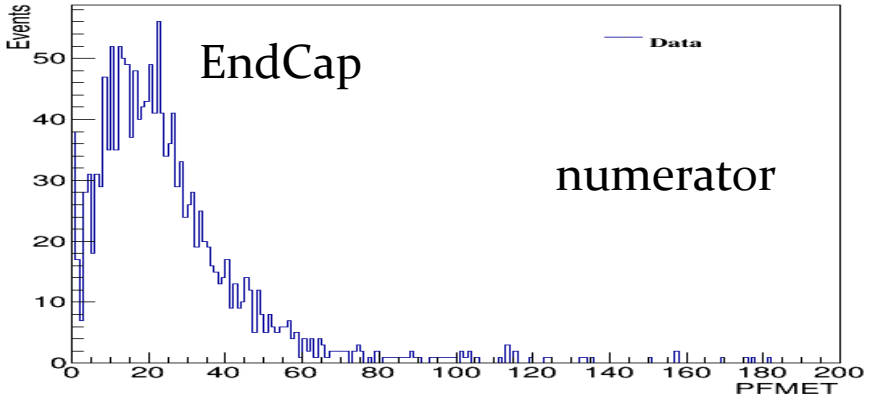


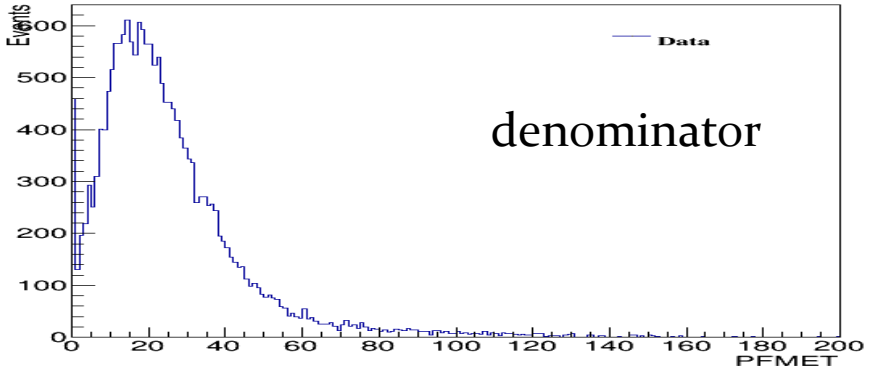
Electrons

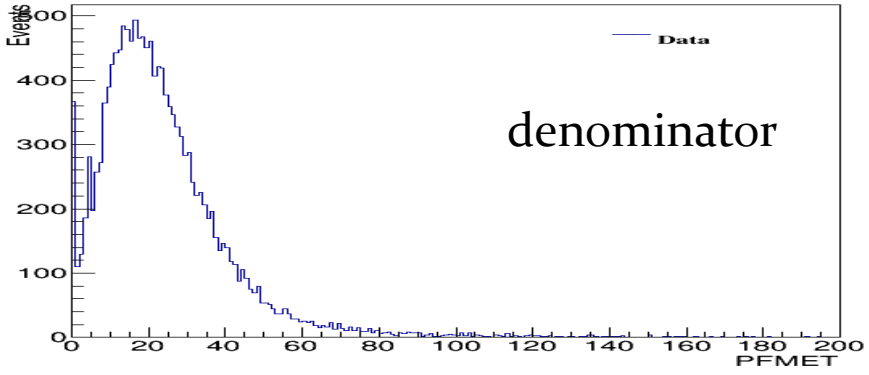
- Fake Rate as a function of MET
- Dependence of electron fake rate on MET
- $E_{Tmiss} < 25$ GeV





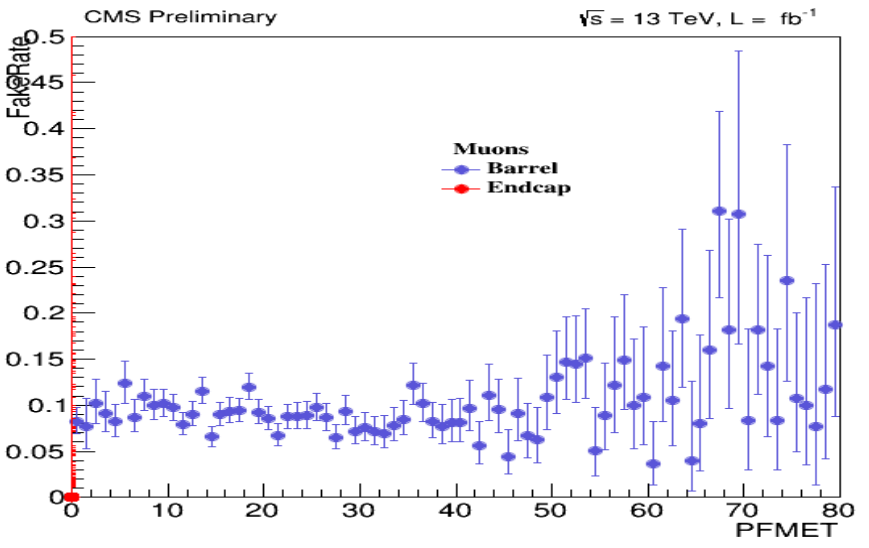


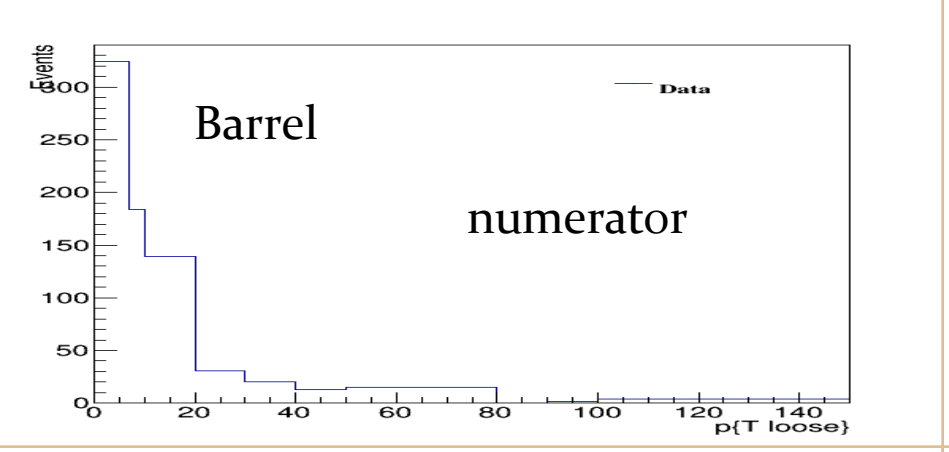


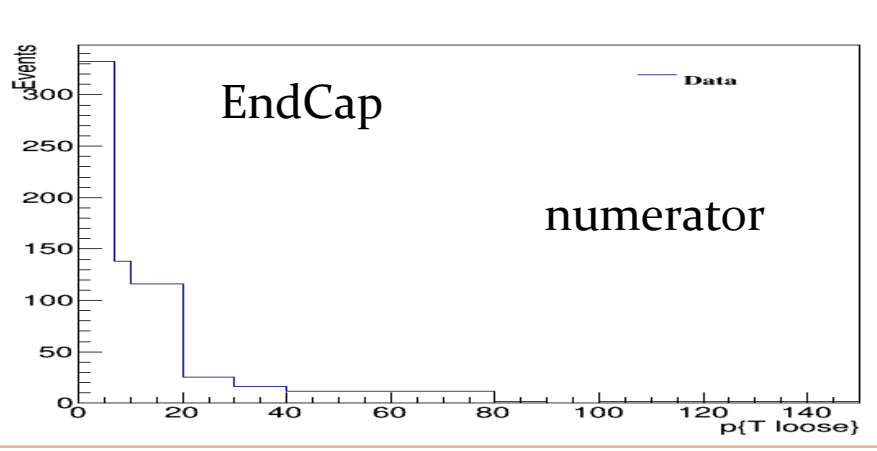


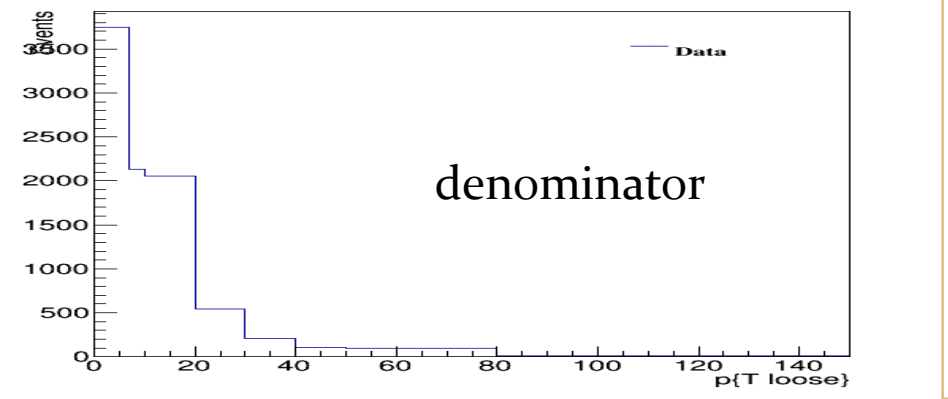
Muons

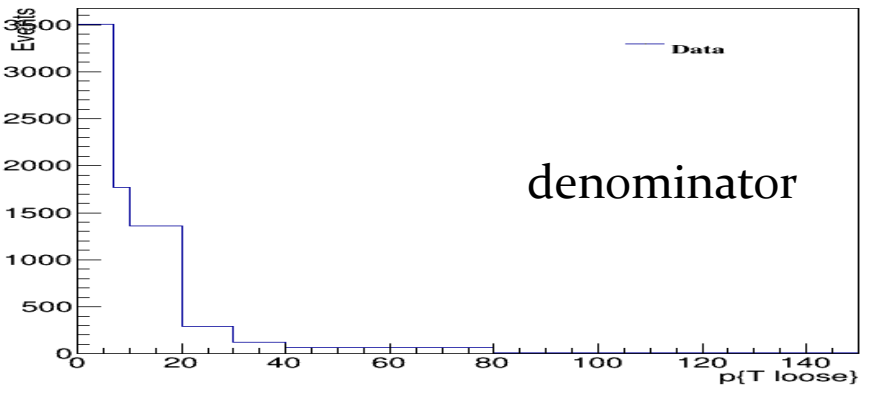
- Fake Rate as a function of MET
- Dependence of Muons fake rate on MET
- $E_{Tmiss} < 25$ GeV





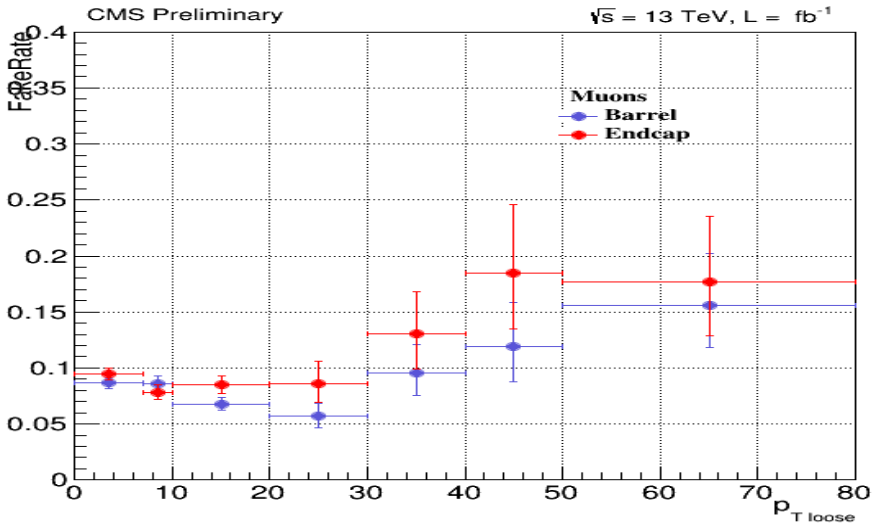


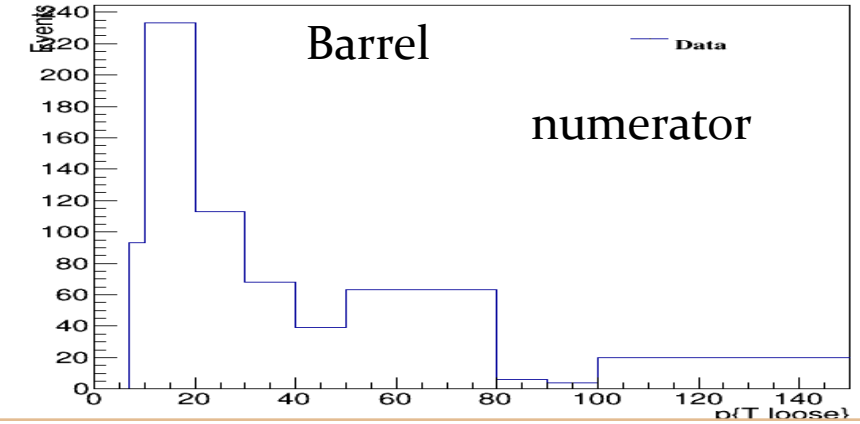


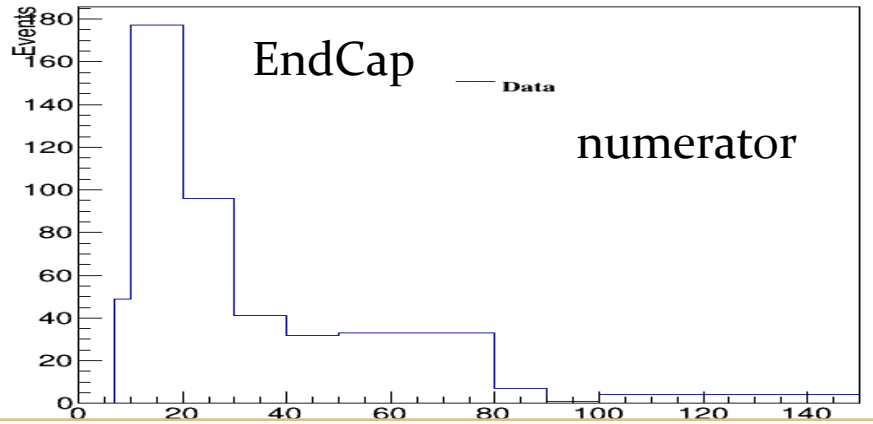


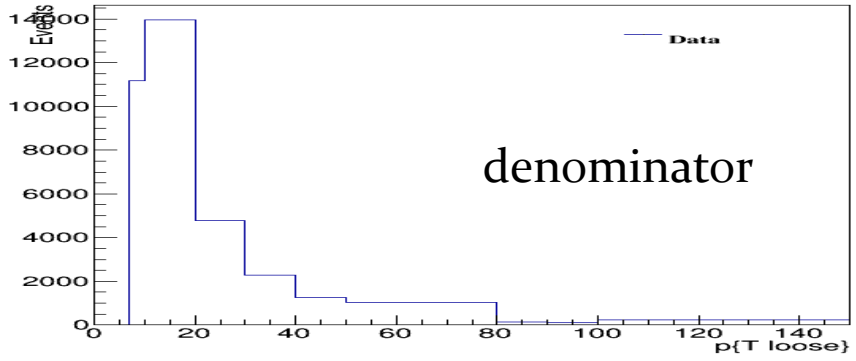
Muons

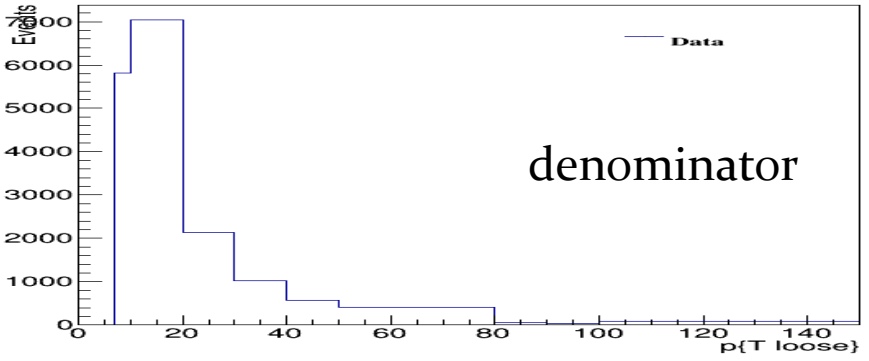
- Fake Rate as a function of Loose muon pT
- Tight cut | $M_{inv(l1,l2)} - M_Z$ | < 7 GeV
- E_{Tmiss} < 25 GeV





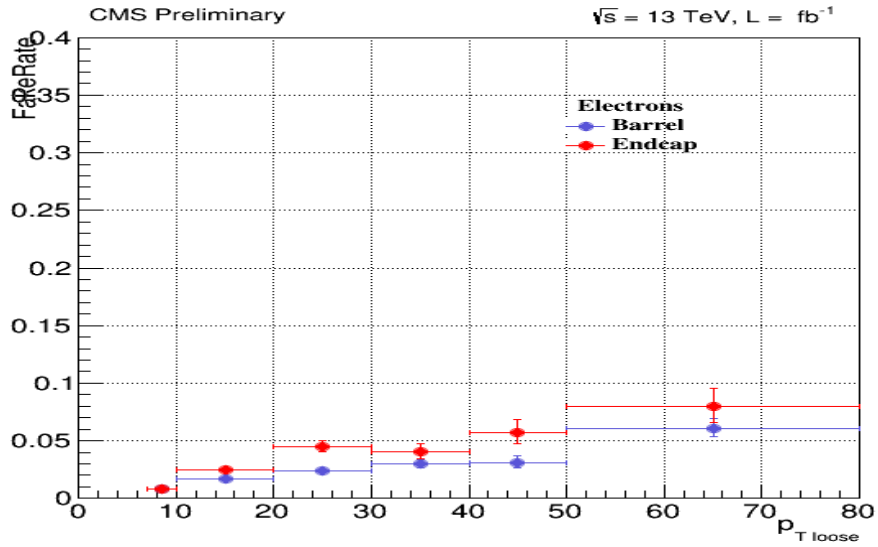






Electrons

- Fake Rate as a function of Loose electron pT
- Tight cut $| M_{inv(l1,l2)} - M_Z | < 7$ GeV
- $E_{Tmiss} < 25$ GeV



Fake-rate (FR) 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)

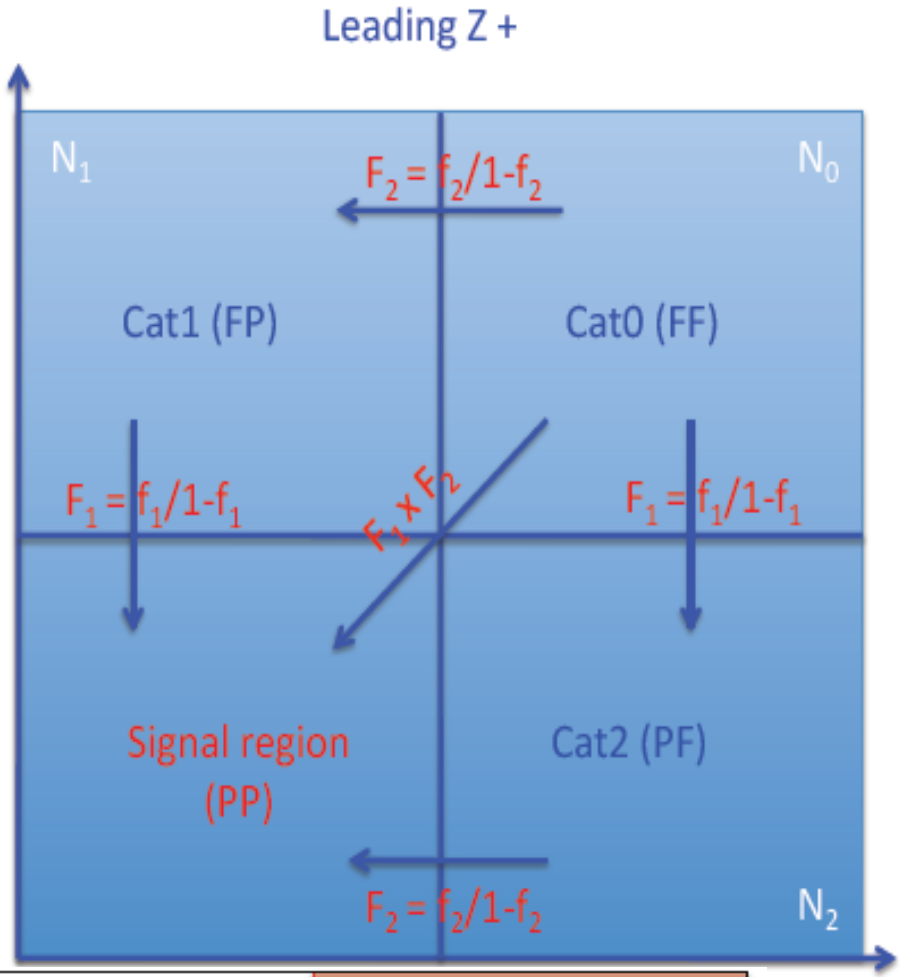
- Both O1 and O2 should fail ID or ISo

➢ Cat 1 (3P1F) : Leading Z + 1fakeable object (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 :

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

Est(Cat1)+Est(Cat2) - Est(Cat0)

Fake-rate (FR) method (||)

- The background estimation in different channels

13 TeV Data

Channel	4μ	4e	2μ2e	2e2μ
Data	1.47859 ± 0.3989	1.50732 ± 0.20572	1.178 ± 0.19546	2.77 ± 0.59328

To Do list

- Run FR method for all background for fake rate region to decide the MET cut && also for different control regions (2p2f && 3p1f).
- Run FR method for ZZ background to subtract from data.
- Migrate FR code to CMSSW_7_6_X .
- Change FR code from arrays to Vectors for all the channels.

Backup

Lepton Identification & Isolation

Loose + Tight Muons

- **Loose Muon**
- Algorithm: (isGlobalMuon || (isTrackerMuon && numberOfMatches>0)) && muonBestTrackType! =2
- dxy < 0.5 & dz < 1.0
- pT > 5 GeV/c & |η| < 2.4
- SIP < 4
- **Tight Muon**
- PF Muon
- PF relative isolation < 0.4

(Including FSR photons substraction)

Loose + Tight electrons

- **Loose Electron**
- dxy < 0.5 & dz <1.0
- pT > 7 GeV/c & | η | < 2.5
- SIP < 4
- **Tight Electron**
- Pass Egamma ID
- PF relative isolation < 0.5
- (Including FSR photons subtraction)