



Measurement of the J/ψ in pp collisions at $\sqrt{s}=7$ TeV with the CMS experiment

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Abstract

The goal of this research is to discover J/ψ candidates in the distribution of the invariant mass of two leptons (e^+ and e^-) and the selection of optimal cuts for this analysis. Also different electron selections are considered. As leptons from J/ψ candidates have a very low p_T , these events are a very good testing ground for low p_T electrons. Low p_T electrons might be important for some SUSY scenarios and therefore have to be studied closer.

I. Introduction

The J/ψ is a subatomic particle, a flavor-neutral meson consisting of a charm quark and a charm antiquark. Mesons formed by a bound state of a charm quark and a charm anti-quark are generally known as "charmonium". The J/ψ is the first excited state of charmonium (i.e, the form of the charmonium with the second-smallest rest mass).

There are 4 principal decay modes of the J/ψ -particles:

$J/\psi \rightarrow \text{hadrons}$

$J/\psi \rightarrow \text{virtual } \gamma \rightarrow \text{hadrons}$

$J/\psi \rightarrow \mu^+ \mu^-$

$J/\psi \rightarrow e^+ e^-$

We are interested in the last one, with the fraction of decay

$$\Gamma_{e^+e^-}/\Gamma = (5.93 \pm 0.06)\%.$$

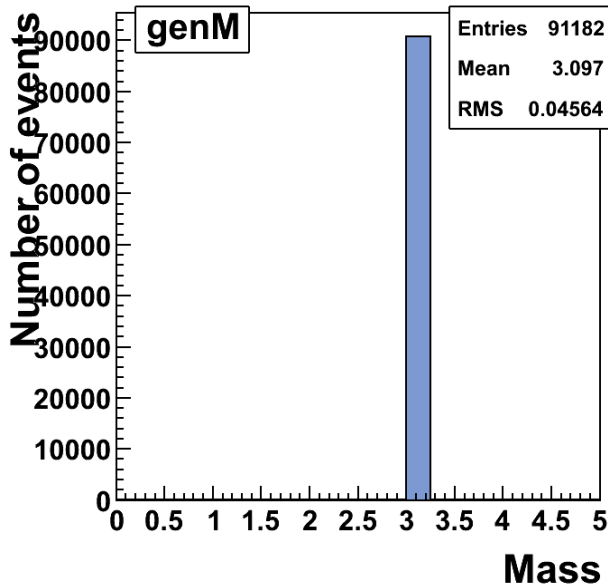


Fig.1 MC true without cuts

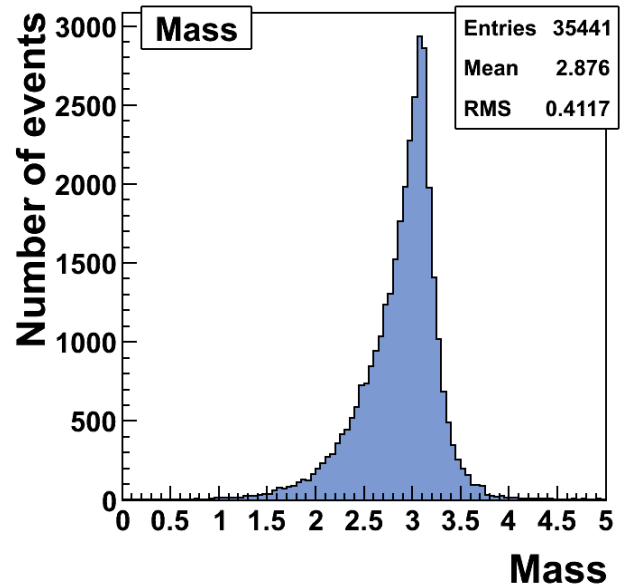


Fig.2 MC reconstructed without cuts

The J/ψ has a mean lifetime of 7.2×10^{-21} s and an invariant mass of (3096.916 ± 0.011) MeV/c². The last value we can observe as peaks on the distributions of the invariant mass of two leptons (e^+ and e^- in our case). Compared to the plot for MC (Monte Carlo) true (Fig.1), the MC reconstructed peak (Fig.2) has a certain width because of the resolution of the detector. Especially on the left side we see a longer tail due to the bremsstrahlung of the electrons, leading to the reconstruction of too low electron momentum.

II. Running jobs using CRAB

The analysis is done using the sample which has been created by me running jobs using CRAB. The technical information about it is following:

Dataset name: /JPsiEE/Spring10-START3X_V26_S09-v1/GENSIM-RECO

Number of events: 133.458;

xsec: 13,420,000 pb⁻¹;

NAF location: /scratch/hh/current/cms/user/erofem/ntuples/JPsiEE/Spring10-START3X_V26_S09-v1/GEN-SIM-RECO/V00-13-06

III. Distributions for electrons

The analysed data samples are located on the NAF:

- /pnfs/desy.de/cms/tier2/store/user/schettle/data/EG/Jul15th;
- /pnfs/desy.de/cms/tier2/store/user/schettle/data/EG/Jun9th;
- /pnfs/desy.de/cms/tier2/store/user/schettle/data/EG/Run2010A-PromptReco-v4_137437-144112.

The distribution of the invariant mass of two leptons on a scale from 0 to 100 (Fig.3) was created first, and we cannot see in this plot any peak for J/ψ candidates.

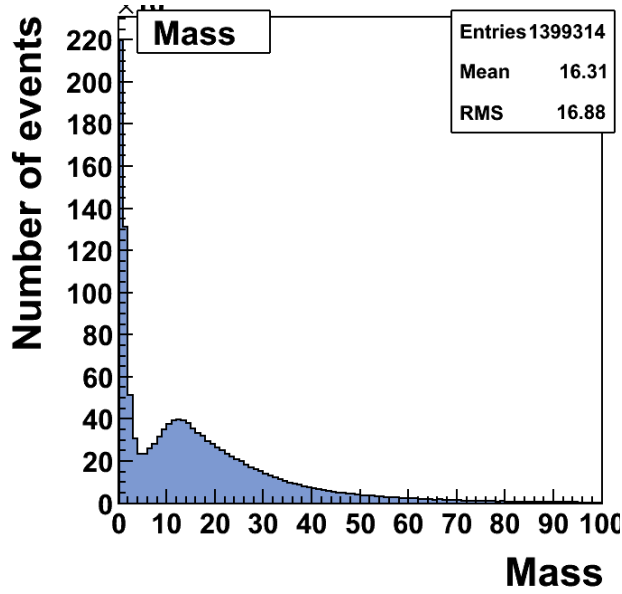


Fig.3 Data without cuts

Let's see distributions for electrons of p_T (Fig.4-6), η (Fig.7-9) and two-dimensional $p_T(\eta)$ (Fig.10-12) for MC true, MC reconstructed and data without any cuts. On p_T and η distributions with the grey line are marked cuts which will be applied later.

p_T distributions for electrons

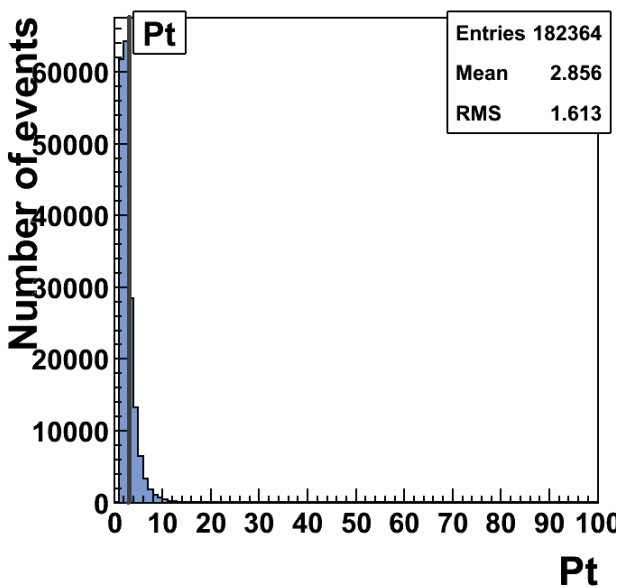


Fig.4 MC true without cuts

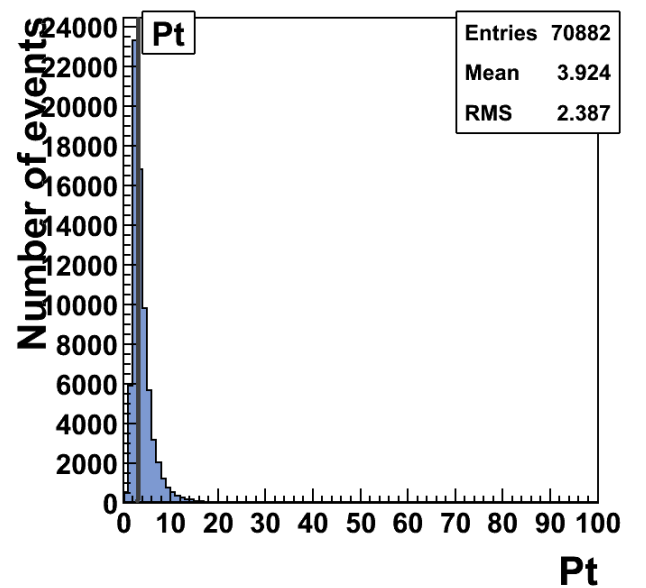


Fig.5 MC reconstructed without cuts

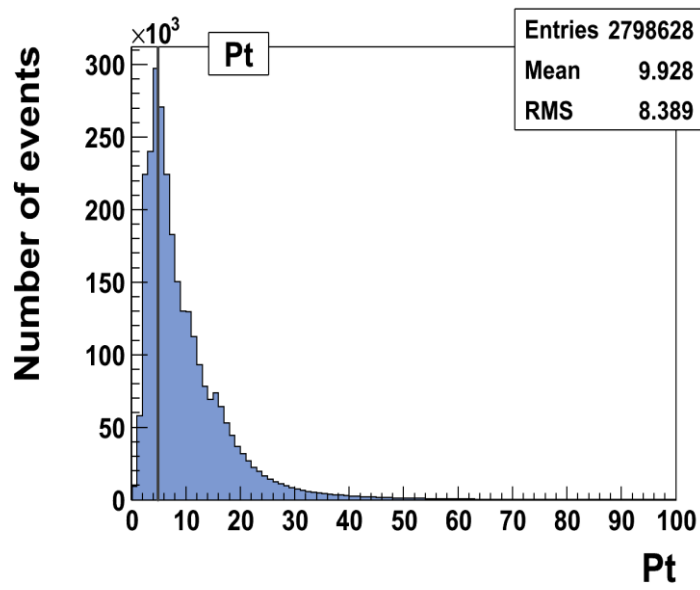


Fig.6 Data without cuts

η distributions for electrons

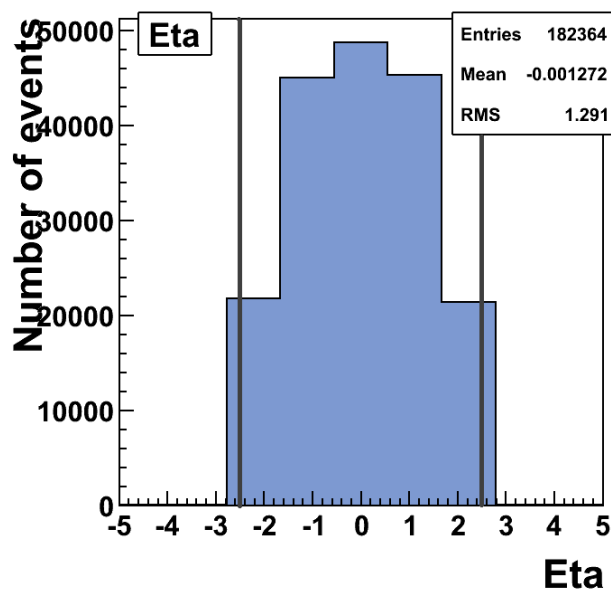


Fig.7 MC true without cuts

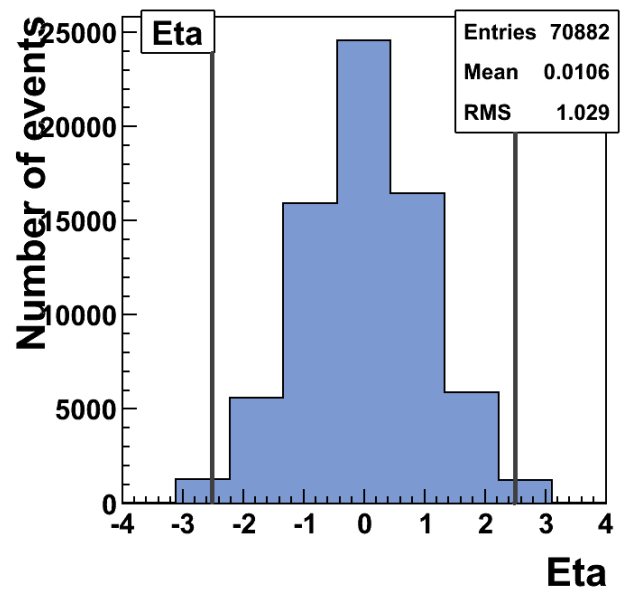


Fig.8 MC reconstructed without cuts

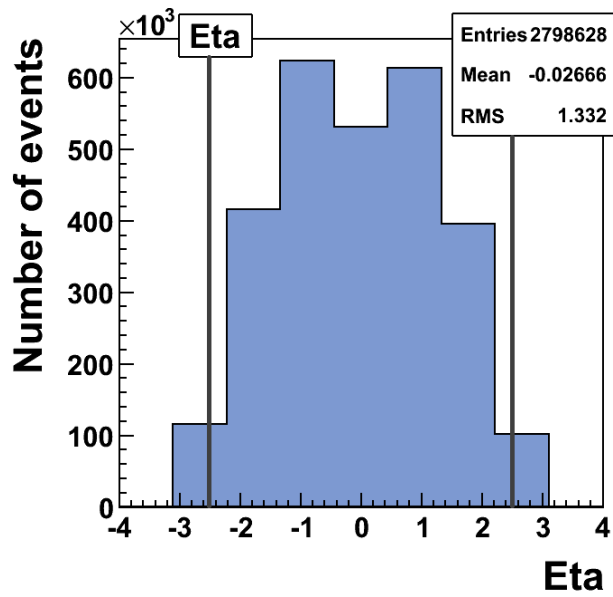


Fig.9 Data without cuts

$p_T(\eta)$ distributions for electrons

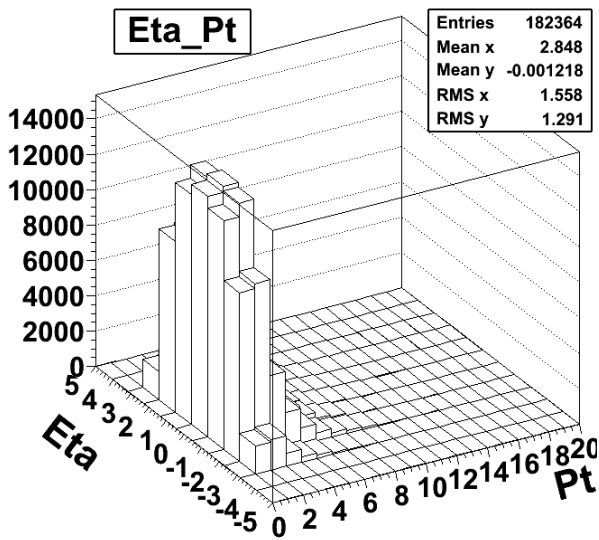


Fig.10 MC true without cuts

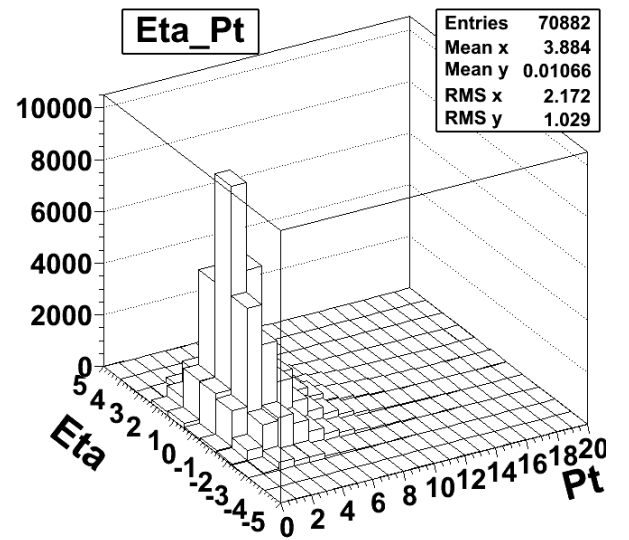


Fig.11 MC reconstructed without cuts

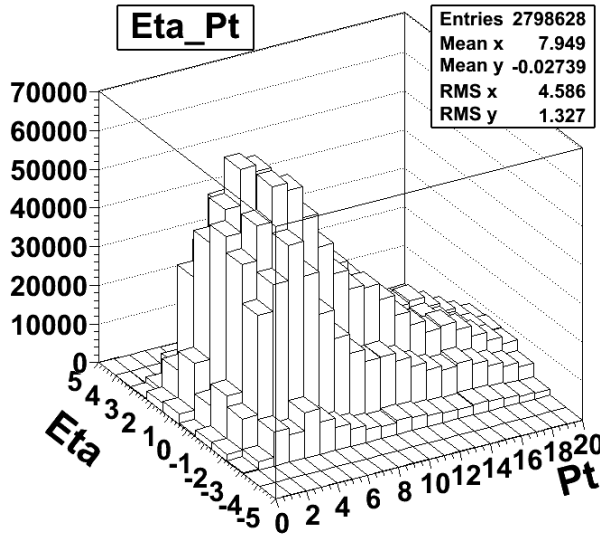


Fig.12 Data without cuts

IV. Invariant mass of J/ψ

Then I applied the following cuts for data samples mentioned hereinbefore:

- $|\eta| < 2.5$;
- $p_T > 3 \text{ GeV}$;
- leptons marked as electronEIDRobustLoosePat.

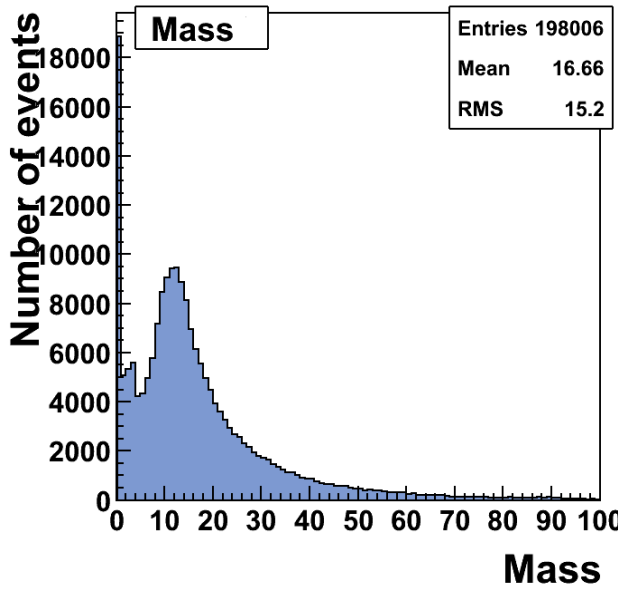


Fig.13 Data with cuts

After the increasing of the scale a small peak for J/ψ candidates can be observed even on the distribution of the invariant mass of two leptons without cuts (Fig.14). And, of course, after application of cuts this peak becomes more evident (Fig.15).

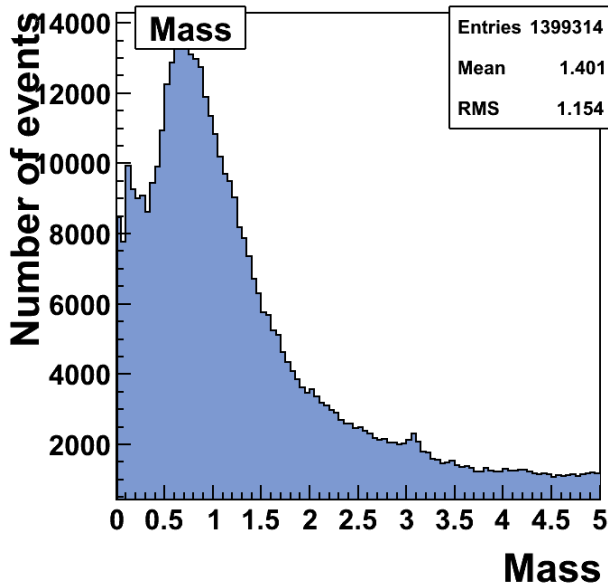


Fig.14 Data without cuts

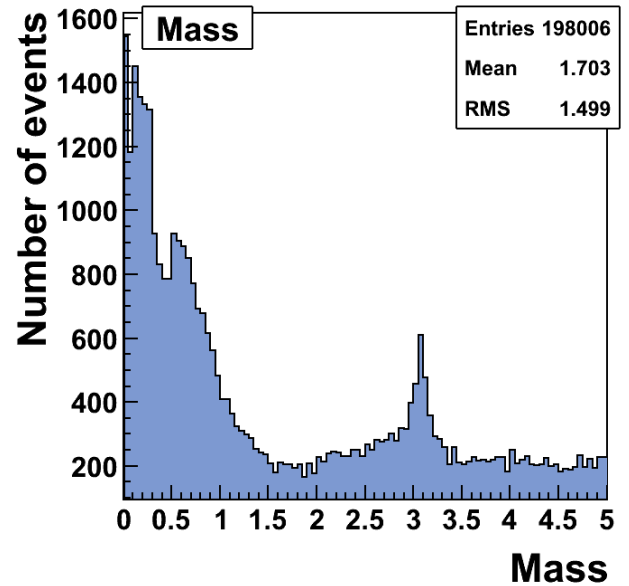


Fig.15 Data without cuts

V. Electron ID in CMS

For the plots shown above we use a cut on electron ID, which is possible in the CMS Software. As mentioned before, we choose only leptons marked as `electronEIDRobustLoosePat`.

Also other types of leptons exist. The special algorithm gives two yes/no outputs for each electron candidate for 9 defined severity levels:

- VeryLoose;
- Loose;
- Medium;
- Tight;
- SuperTight;
- HyperTight1;
- HyperTight2;
- HyperTight3;
- HyperTight4.

We decided to compare results which were received from different types of electrons. For that I used data samples and applied p_T , η and electron ID cuts. As an example I got plots for Loose (Fig.16) and Tight (Fig.17) electrons.

On the first plot the number of entries is greater and the background is higher. So for Tight electrons the peak for J/ψ candidates is more evident.

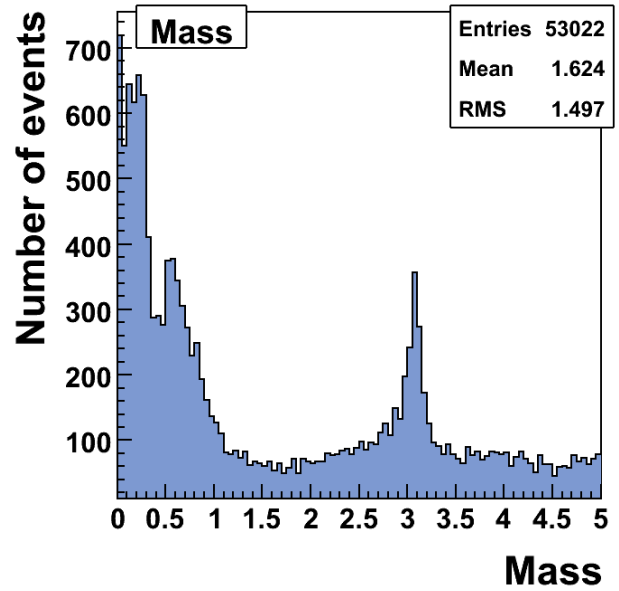
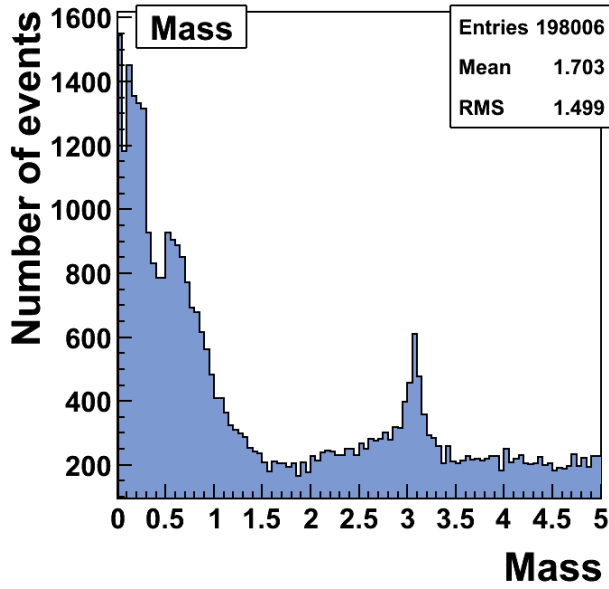


Fig.16 Data with cuts: *electronEIDRobustLoosePat* Fig.17 Data with cuts: *electronEIDRobustTightPat*

VI. Summary/Outlook

- The electron selection can be improved, but the J/ψ -signal can be seen with the selection shown before.
- Different electron ID selections lead to different results: for the tight electron ID the J/ψ -signal is more evident than for the Loose.
- A next step would be to calculate the J/ψ cross section.

Acknowledgements

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