Chapter 1

Quality Assurances (QA) for High transverse momentum particles in ALICE

1.1 Introduction

High transverse momentum particles (HPT) are for the large Ion collider detector (ALICE), those beyond the decay of a typical transverse-momentum (pT) distribution, of course it depends of the energy of the interaction, in Fig 1.3 and 1.8 are showed the distribution for 900 GeV and 14 TeV center mass interactions, the last one is the expected maximum attainable energy at the Large Hadron Collider(LHC).

The importance of HPT is that they are rare probes to a energy scale still not well understood, in the stardan Model their production and correlations can lead to hints of new physics **??**, also this particles may be part of jets. So a uncorrect determination not only affect the particle, but also the energy and the direction of the Jet.

The way to detect this HPT in the ALICE experiment depends of the nature of the particle, in this note we are interested in charged particles that are detected using the subdetectors the following subdetectors: inner tracking system (ITS) and the time projection chamber (TPC).

For this kind of detectors inmerssed in a magnetic field, what is reconstructed is the trajectory of the particle, the reconstructed objects is called a track, that is very similar to a particle but without mass determination,

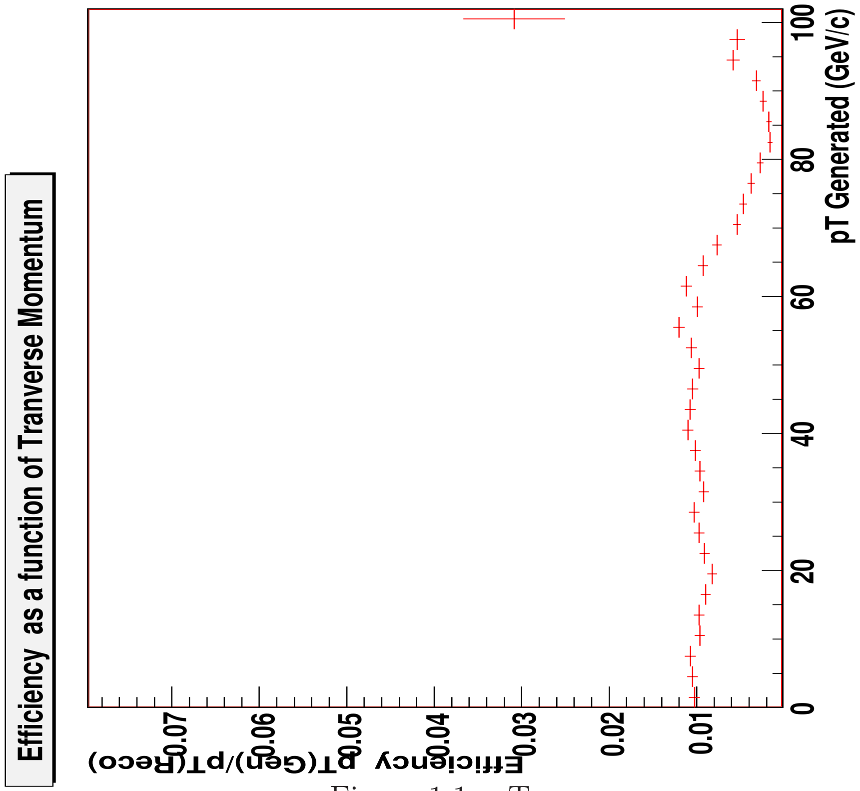

Figure 1.1: pT

also there is a chossen parametrization for a detailed explanations see ??.

One of the problems in the simulation of the HPT, It is the high statistic required to study them, so make estudies will require an enormus amount of simulated data, for this reason we decide to use a nonphysical distribution, consistent in a flat distribution of the total momentum of the particles, to obtain the results for the 900 GeV and 14 TeV we will use a rejection method an also compare with 900 GeV and 14 TeV produced data to validate our results.

1.2 Monte Carlo Samples

The framework used in ALICE is composed of three modules: Root, a widely used software in C++ used in High Energy Physics, Geant for transport and AliRoot the software that make the generation simulation and data

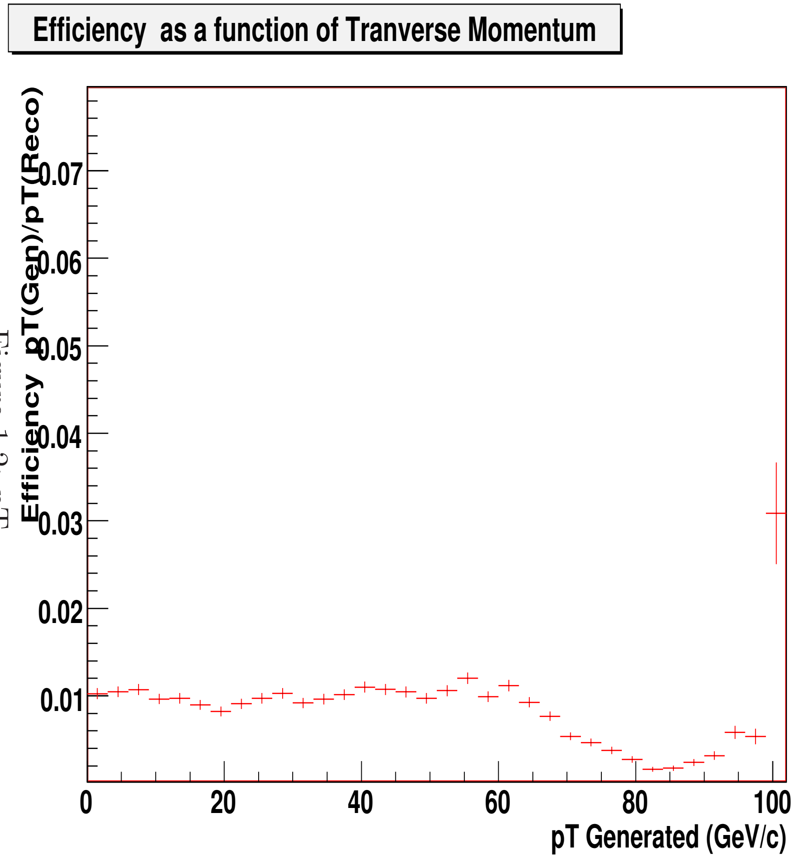
Efficiency as a function of Tranverse Momentum
Efficiency pT(Gen)/pT(Reco)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
20
40
60
80
100
pT Generated (GeV/c)

Figure 1.2: pT

management for more of the framework see **??**

In this case we generated 4 different samples with flat distribution in Total Momentum (P), for each sample we generated the same amount of protons, pions and kaons. The main parameters of the generation are displayed in 1.1. We use the aceptance of the TPC the primary vertex was generated at (0,0,0) and the decay of the pion and kaon is supressed.

For the pp distribution we used the PDG06.

Sample	# of particles	P range	pseudorapidity(η)	Polar angle (ϕ)
$S900$	900	0-100 GeV/c	$(-0.9, 0.9)$	$(0, 2\pi)$
$S3000$	3000	0-100 GeV/c	$(-0.9, 0.9)$	$(0, 2\pi)$
$S4500$	4500	0-100 GeV/c	$(-0.9, 0.9)$	$(0, 2\pi)$
$S6000$	6000	0-100 GeV/c	$(-0.9, 0.9)$	$(0, 2\pi)$

Table 1.1: Parameter for the AliGenBox generation

1.3 Reconstruction

For the reconstruction we use the ITS and the TPC detectors, the Config file is in appendix A.

1.4 Variables

The resulting tracks after the reconstruction will only have cuts from the algorithm in the reconstrucction and for now are the most loose posible, we can see the spectrum of pT generated (X axis) vs the pT reconstructed (Y axis). With no cuts, The ideal case when the pT reconstructed is identical to the generated is straight line correspondent to a perfect reconstruction.

The real case is that sometimes in the reconstruction one assign the wrong cluster to the track or sometimes the particle does not deposit enough energy to be reconstructed, resulting in a different measurement of the pT, the purpose of this note is to quantify this effects and try to minimize them. As the pT increase such cases adquire more relevance, also the detectors have a limited range of validity.

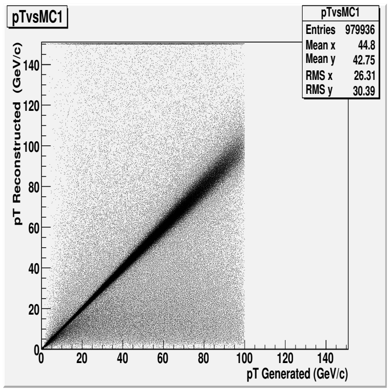

Figure 1.3: pT generated (X axis) vs the pT reconstructed (Y axis), for ilustration all tracks with pT reconstructed beyond 150 GeV/c are make to 150 Gev/c.

The variables that we consider are in the table 1.2, We can cut directly in them or in a combination for example in the significance pf the pT intead of the pT an the uncertainty in it. Since there are correlations we do not expect these variables to be independent an actually that will help us since our only corcen is the determination of the pT.

1.5 Resolution an pulls

The resolution for a variable tell you what is the dispersion for this variable in this case the resolution depends of the pT, so we separate in bins of pT at generation level and then we make the following distribution for the resolution in pT

$$Res(pT_{GEN}) = pT_{Gen} - pT_{Rec} \tag{1.1}$$

In this selection we discard the kink tracks since this are assigned to the particle mother and then the comparation with the reconstructed track in meaningles, One question arising is why find kinks if the decay is turned off but is relationed with the validity of the kink algorithm and their fake ratio, which study is not done here.

We separate in the bins of 1 GeV/c from 0 GeV/c to 10 GeV/c and in bins of 10 Gev/c for the range betwwen 10 GeV/c and 100 GeV/c.

variable	Range
ITSRefit	true or false
TPCRefit	true or false
kinks Hypothesys	is a kink ,have kink daugthers, does not have kink daugthers
# of ITS clusters	0 to 6
# of TPC clusters	0 to 259
uncertainty in y	0 to
uncertainty in z	
uncertainty in $sen\phi$	
uncertainty in $tan\lambda$	
uncertainty in q/pT	
DCAxy	
DCAz	
uncertainty DCAxy	
uncertainty DCAz	

Table 1.2: Parameters of the tracking

The resolution distribution is showed in figure 1.4, for two representative bins the fisrt and the last one for the rande considerated. We fitted a gaussian to the each distribution. The width for each bin is the resolution for that range and from that we did a resolution function as function of the pT, this one is showed in figure **??**, this resolution will change with the cuts but is an indication of the quality of our cuts.

What is important is to see if the errors in the tracks are well calculated, for this we calculate the pull for each bin using the following standar equation:

$$Pull(pT^{-1}_{GEN}) = \frac{{pT_{Gen}}^{-1} - {pT_{Rec}}^{-1}}{\sigma(pT^{-1}_{Rec})} \tag{1.2}$$

Pull distribution are showed for the two representative bins in figure 1.4 we fit a gaussian to it shoul have a width of 1, a value diferent means we overestimate or underestimate the uncertainties, in these cases we can see points a way beyond 3σ for our distributions, they represent the points where the uncertainty was underestimated and thsi point are our main concern for example a 10 GeV/c particle that was reconstructed as a 40 GeV/c and the uncertainty is less than 30 GeV/c, for real data this will be very bad since there we will only have the recontructed part. For this reason we have separated the data in 2 types:

- High Quality $< 3\sigma$;
- low Quality $> 3\sigma$;

The objective is find the cuts to minimize the low quality tracks while maximizing the Efficiency, there is also the option to modify the reconstruction algorithm but we will not do that in this note.

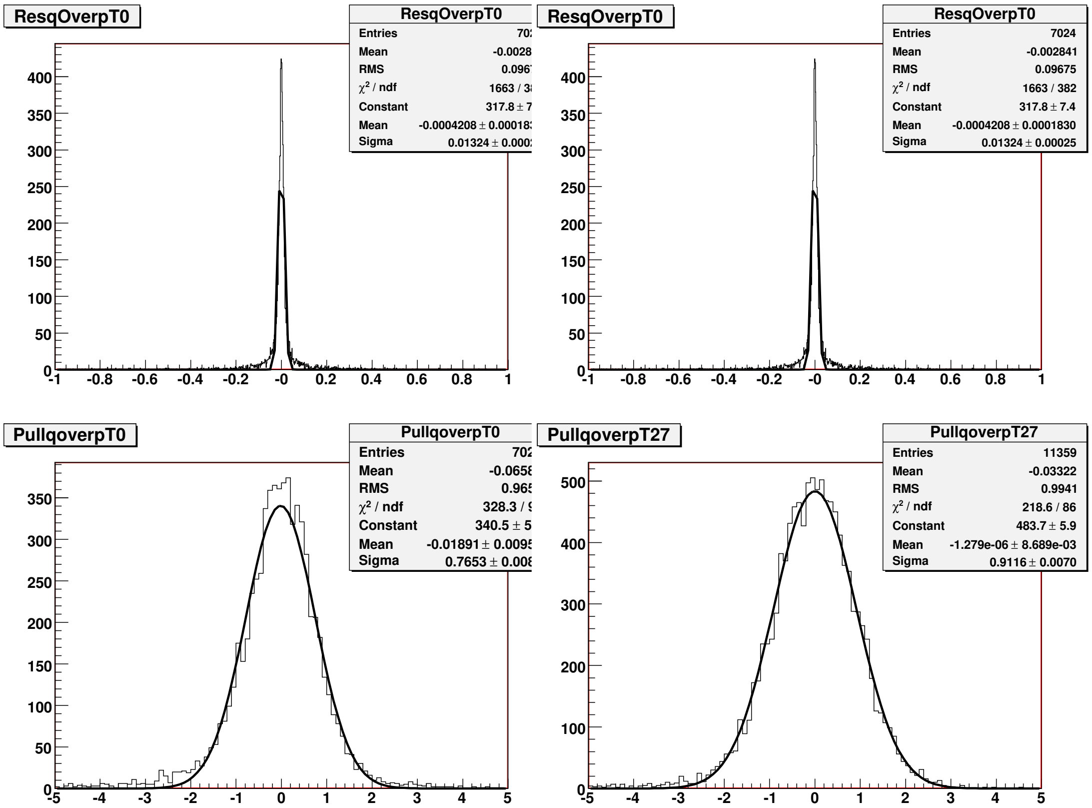

Figure 1.4: Resolution for pT^{-1}: Top resolution for first and last bin, Bottom pull for first and last bin.

1.6 Pulls

Before try to do any cut in any variable we need to do some basic checking, to see if the uncertainties are well calculated. For this we make the pulls for all the parameters as function of the pT getting the, and example of the distributions are in figures 1.5 and the width as funtion of the pT are in figure 1.6, From the plots we see that the pulls for them are not very bad and we can cut in the uncertainties.

1.7 Cut implementation

The implementation of the cuts was done in the following way. The first cut we used was the TPC refit since this indicate if the track was succesfully recontructed in the TPC, the second one is the ITSRefit that indicates that the track was reconstructed in the ITS, whith this 2 we can make the resolution again to see the change in it this is similar to the results presented in the PPR, as we can see in figures **??** there is a great improvemment, in the resolution as we include these two restrictions.

The next thing we will do is the cut in the uncertainty in the pT, this should remove all tracks with a very big difference in pT between the reconstructed, we can not make a general cuts since for example a 6% for 100 GeV tracks is is not the same as for a $500MeV$ tracks so we use the resolution in $1/pT$ from equation 1.3

$$Res(pT^{-1}_{GEN}) = pT^{-1}_{Gen} - pT^{-1}_{Rec} \tag{1.3}$$

and supposing that the tracks with pT grater than 100 GeV is the same as for 100 GeV,after we fitted a 9 degree polynomial creating a function $FRes(pT)$ .We can also build this as a funcion of the pT^{-1}. Both representations are equivalents and $FRes(pT)$ is easy to visualize. The fit and the points are in **??**.

The cut in the uncertainty is as follows:

$$\begin{array}{ll} \sigma(pT^{-1}_{Rec}) < 3 * FRes(pT_{Rec}) & Accept \\ \sigma(pT^{-1}_{Rec}) > 3 * FRes(pT_{Rec}) & Reject \end{array} \tag{1.4}$$

We plot the TPC and ITS cluster distribution for both qualities see fig **??**, from there we can see that if we cut in the 100 we eliminate about half of the low quality tracks but just a few of the high.

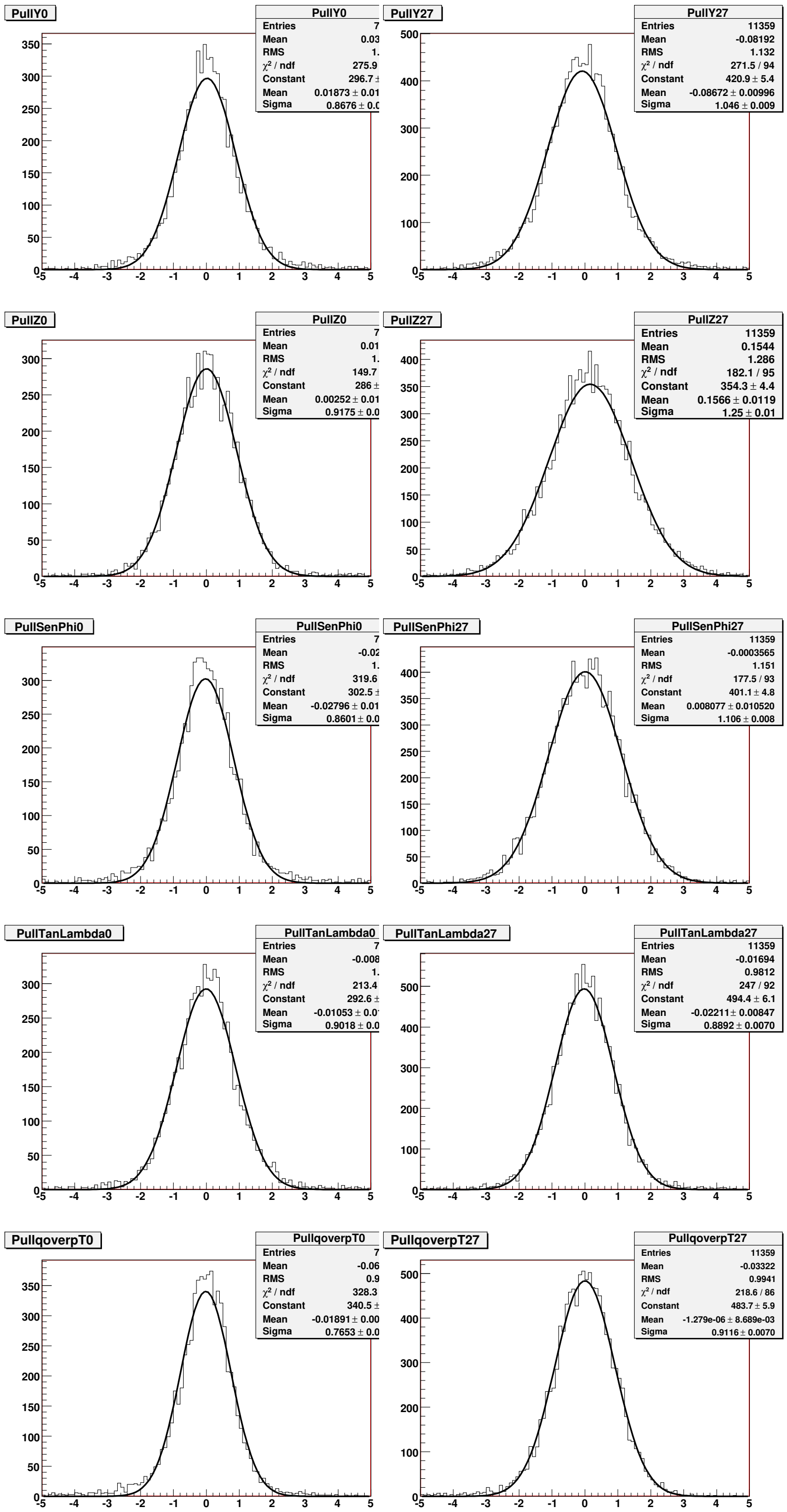

Figure 1.5: Pulls distribution for first and last bin of pT.

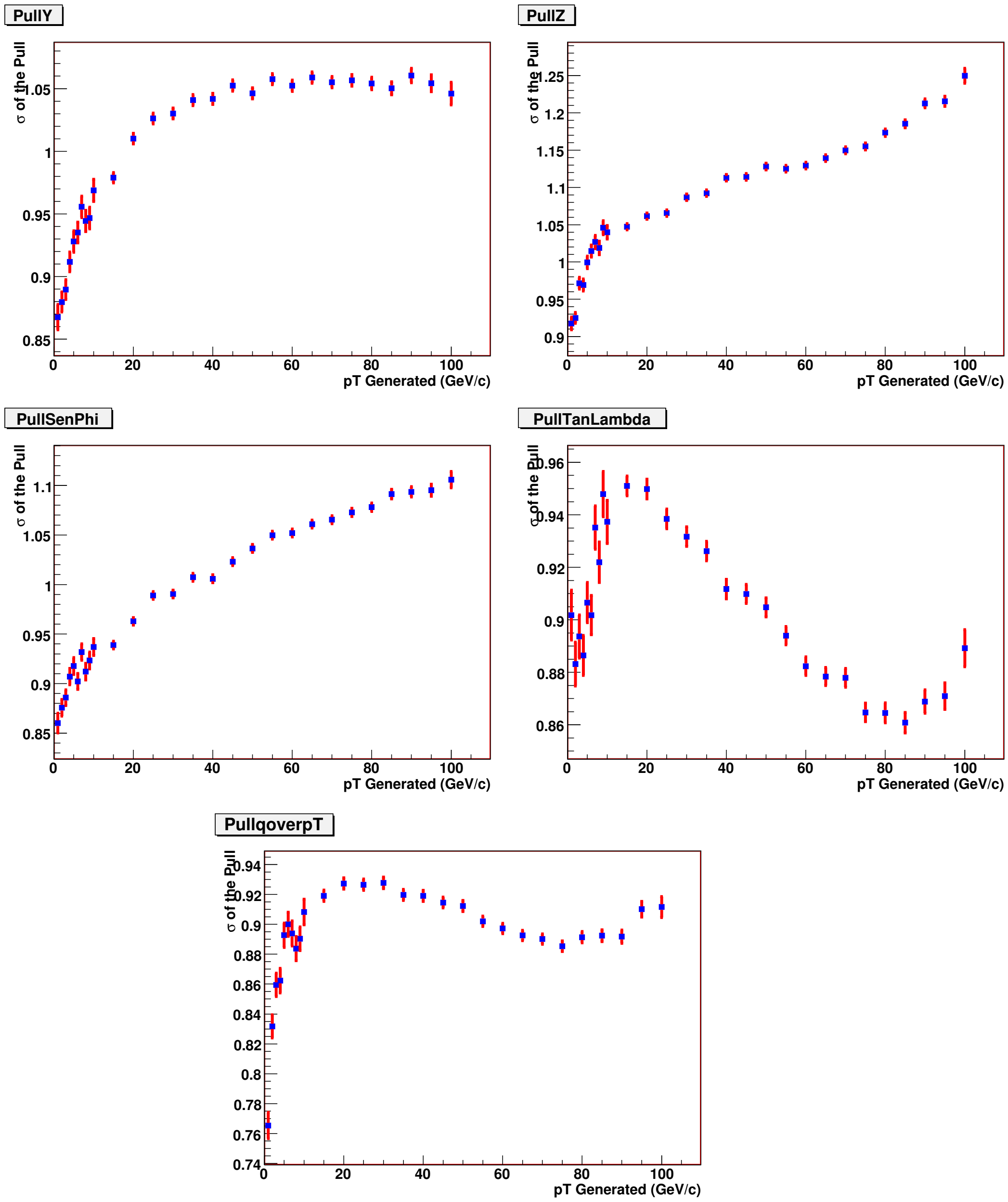

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Figure 1.6: Pull as function of pT^{-1} for all parameters.

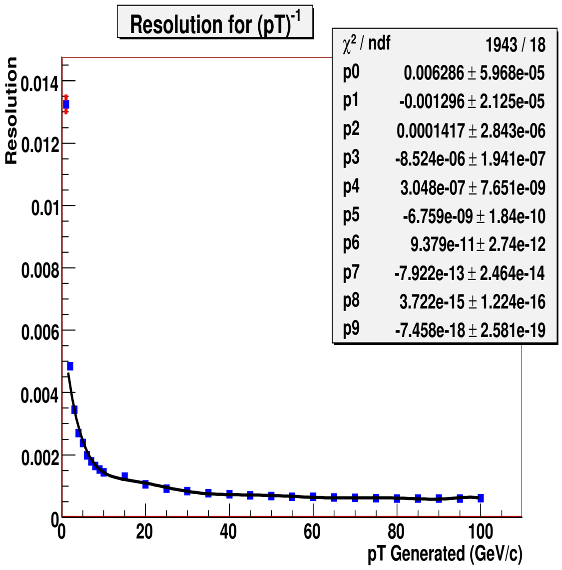

Figure 1.7: pT

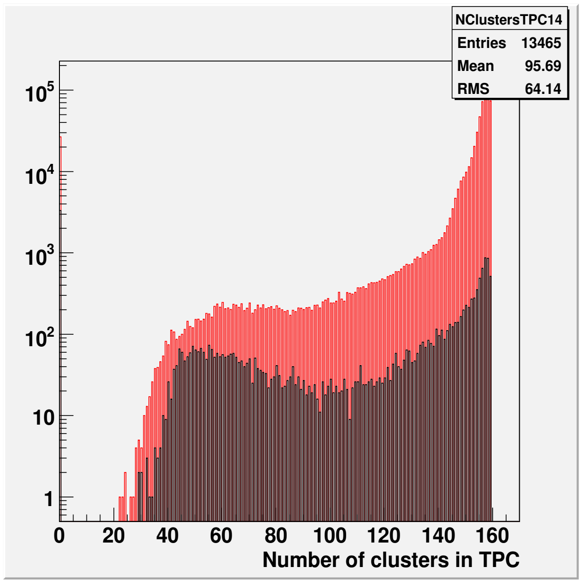

Figure 1.8: TPC Clusters Red one: High Quality, Black One : Low Quality

1.8 Cuts in uncertainties

1.9 Cut optimization

1.10 pp at 900 and pp at 14 TeV

1.11 Results an conclusions