INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

SUBJECT

PH219: DATA ANALYSIS AND INTERPRETATION

Assignment: Multiplicity fluctuations of p-p collisions

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Abstract

Multiplicity is the number of particles coming out from a collision between two particles. Various particles with different cardinalities come from different collisions, and studying these collisions provides us with a way to analyze the fundamentals of particles. The fluctuations in the multiplicity help us understand some critical concepts during phase transition and hence are crucial and of high interest in physics.

1 Introduction

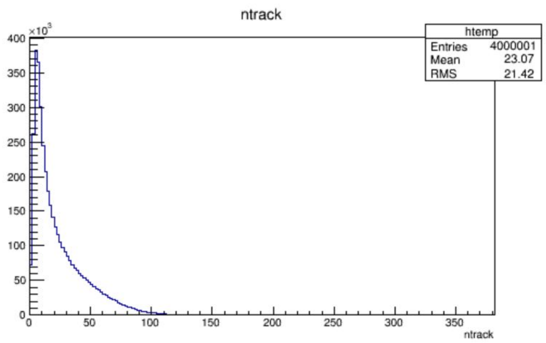
We have generated almost 4 million events of proton-proton collisions with the Monte Carlo generator, its event by event multiplicities and different measured parameters of the emitted particles. Multiplicity fluctuations have been characterised by the scaled variances of the multiplicity distributions, defined as,

$$\omega = \frac{\sigma^2}{\mu}$$

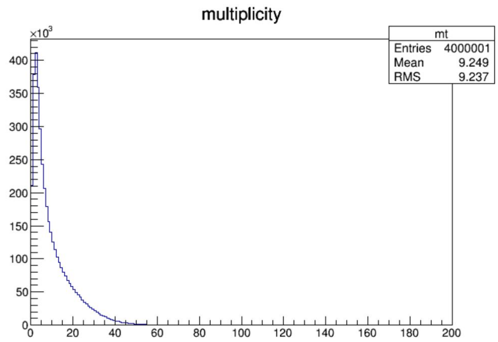
where σ^2 and μ are the variance and the mean of the multiplicity distribution, respectively. Many factors are producing these fluctuations apart from the ones we are looking for, i.e., the fundamental physics laws we are trying to decode through this experiment. So, we want to eliminate other errors to the best we can. For the same, we introduce the centrality region, which means we will take only those events that occur in a specified central part of the total collision space.

2 Centrality selection

The centrality will depend on the impact parameter between the colliding particles and the average number of particles in the specified central region, but we cannot find these parameters experimentally. So, what we do instead is apply constraints on the parameters we can measure. We can measure many parameters of the particles coming out of collisions. In this analysis, we used the constraints on the pseudorapidity (η) and the transverse momentum (P_T) of the emitted particles. Constraints on the accepted collisions are $|\eta| < 1.0$ and $P_T > 0.05$ GeV/c



(a) All collisions



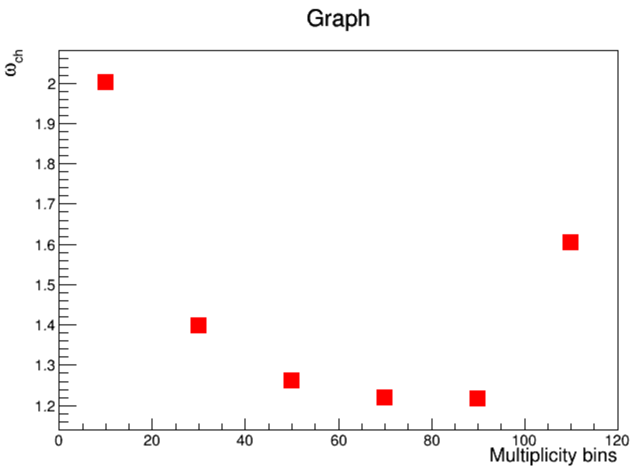
(b) Collisions in centrality only

Figure 1: plot of multiplicity vs its frequency

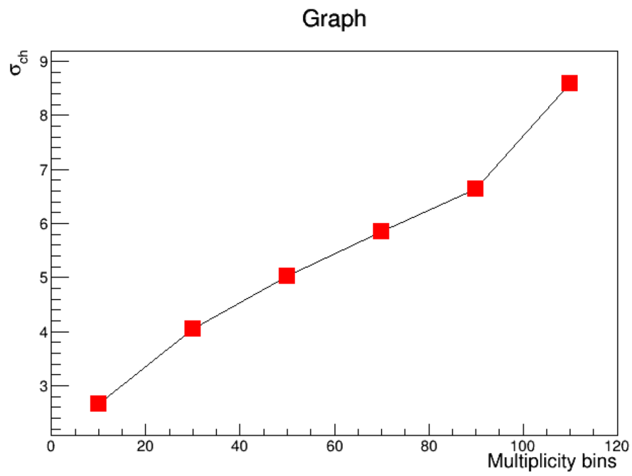
In figure 1(b), the effect of applying centrality condition can be seen in its mean and standard deviation values compared to figure 1(a), as some particles coming out of a particular event will be eliminated and thus the multiplicity value falls.

3 Multiplicity Fluctuations

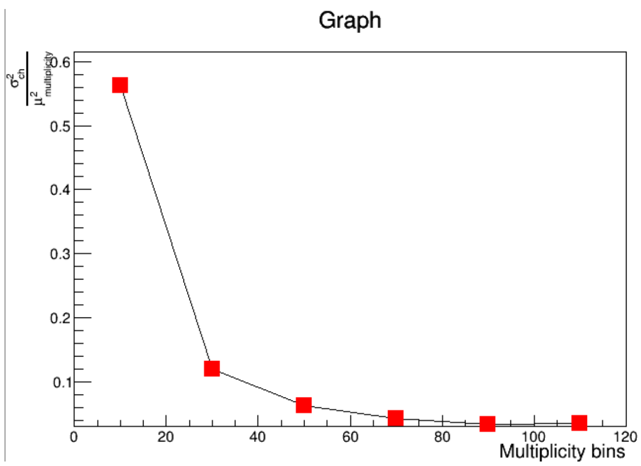
For plotting fluctuations, we made bins of multiplicity ranges (0-20, 20-40, 40-60, 60-80, 80-100, >100) and then plotted the multiplicity fluctuation plots with these bins on x-axis and multiplicity fluctuation on y-axis.



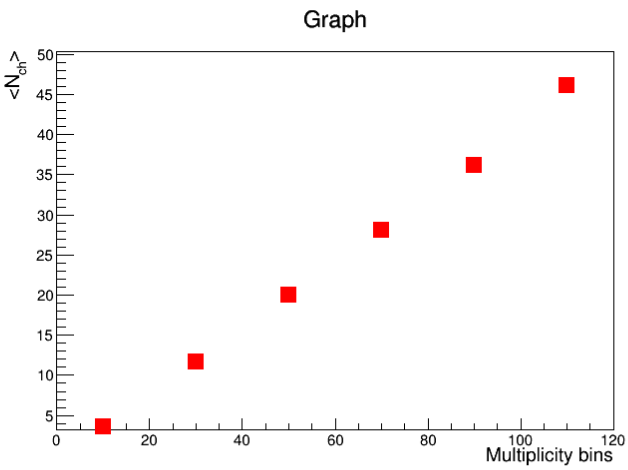
(a) multiplicity fluctuations vs multiplicity bins



(b) standard deviation vs multiplicity bins



(c) $\frac{\sigma^2}{\mu^2}$ vs multiplicity bins



(d) mean vs multiplicity bins

Figure 2: Plots of various entities verses multiplicity bins

Here, the plots of parameters other than multiplicity fluctuations (ω) are also plotted. Plotting these verses mean multiplicities of various bins also offers a way to analyse things. So, such plots are there in the next page. Notice how in figure 4, mean number of charged particles in each bin is directly proportional to the mean multiplicity value of each bin.

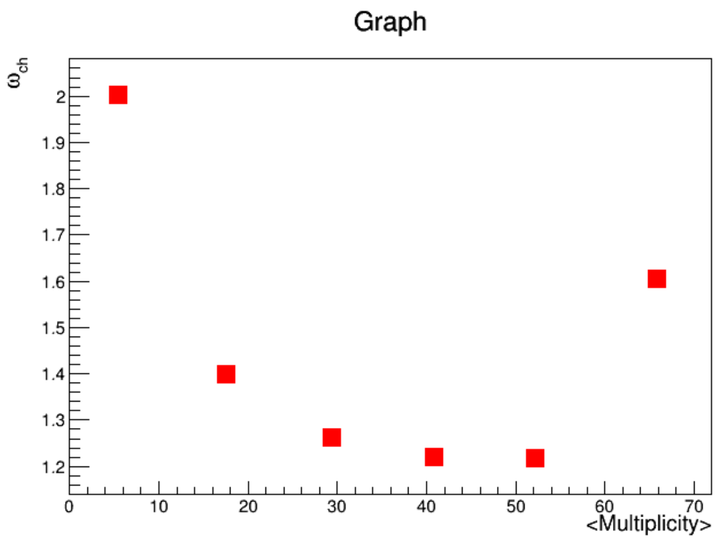


Figure 3: multiplicity fluctuations vs mean multiplicity

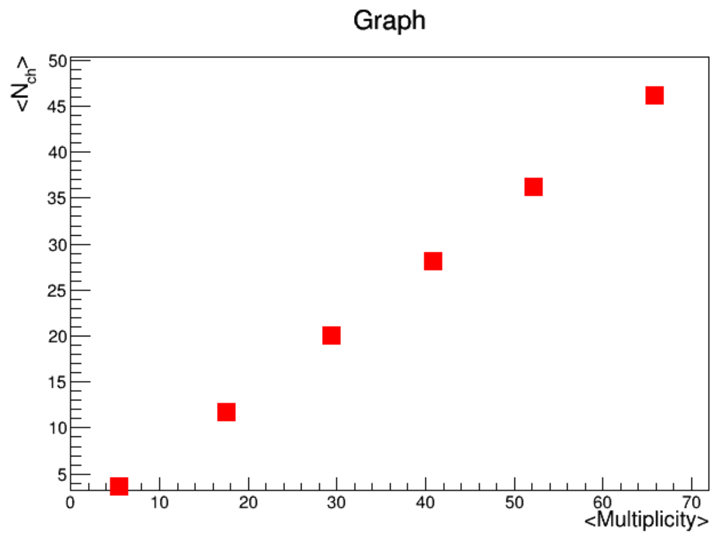


Figure 4: mean vs mean multiplicity

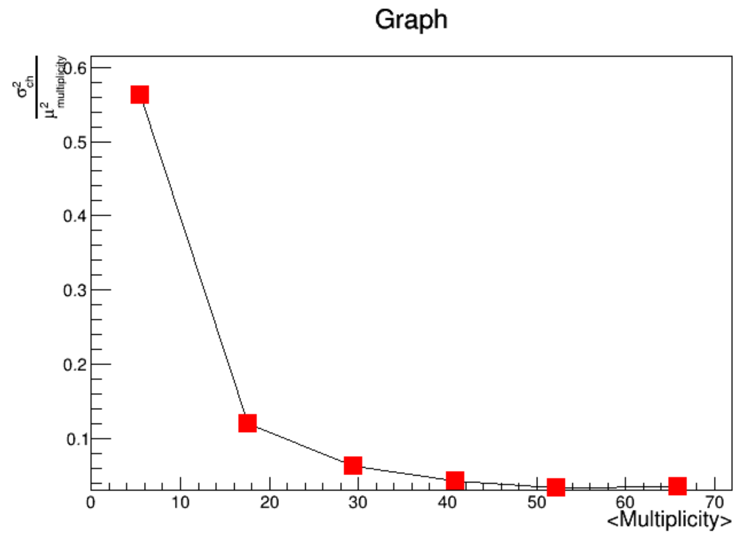
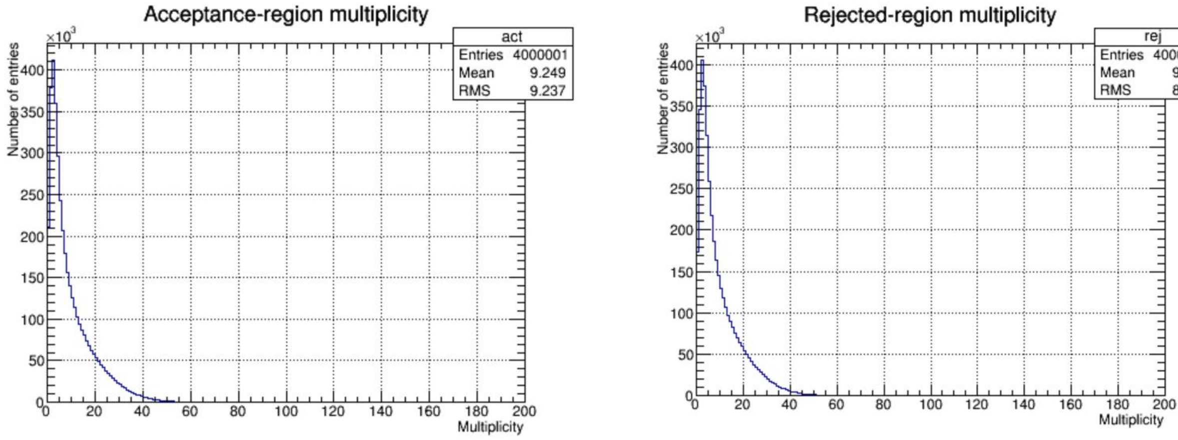


Figure 5: $\frac{\sigma^2}{\mu^2}$ vs mean multiplicity

4 Plots of accepted and rejected regions

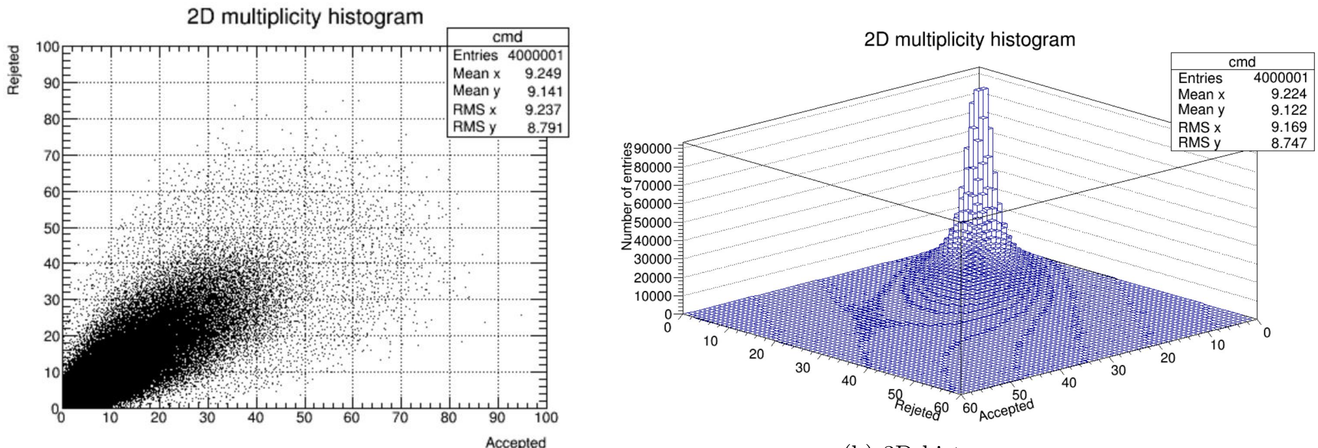
We use accepted region as those with $|\eta| < 1.0$ and $P_T > 0.05$ GeV/c and similarly we use the condition on $|\eta| > 1.5$ for rejection region of the collision.



(a) accepted

(b) rejected

Figure 6: plots showing accepted and rejected events to minimize unwanted errors

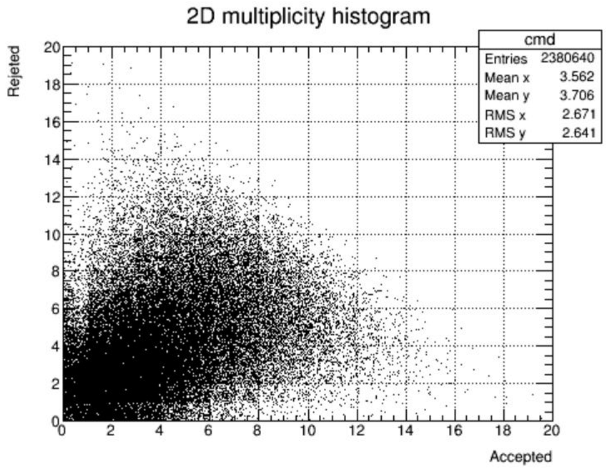


(a) scatter plot

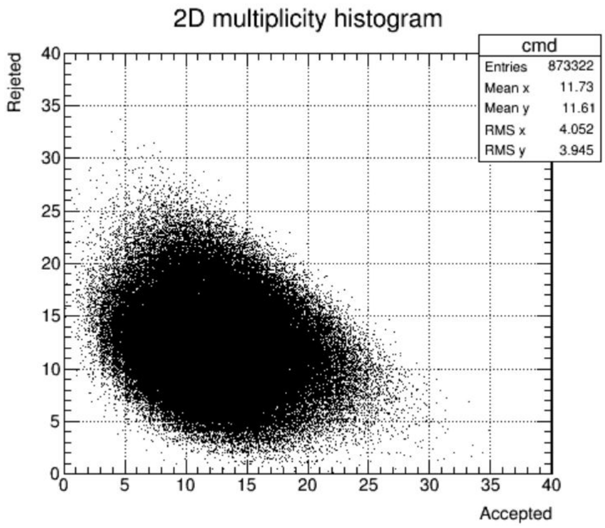
(b) 3D histogram

Figure 7: showing accepted and rejected events to minimize unwanted errors in single plot

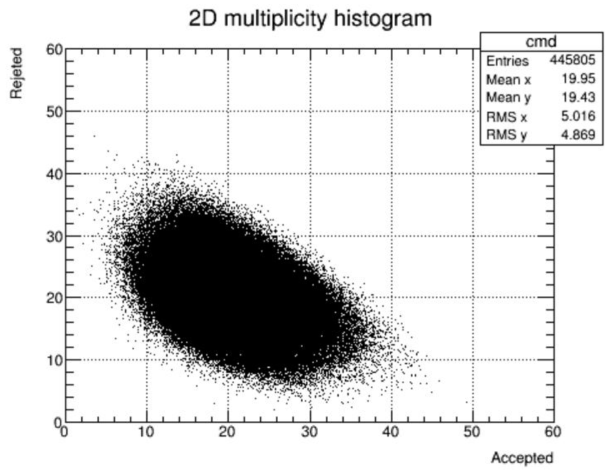
Figures 6 and 7 are showing the correlation between the accepted the rejected regions for entire events, on the following page, there are only scatter plots which are helpful for looking at the correlation for the acceptance and rejection regions for the multiplicity bins we created.



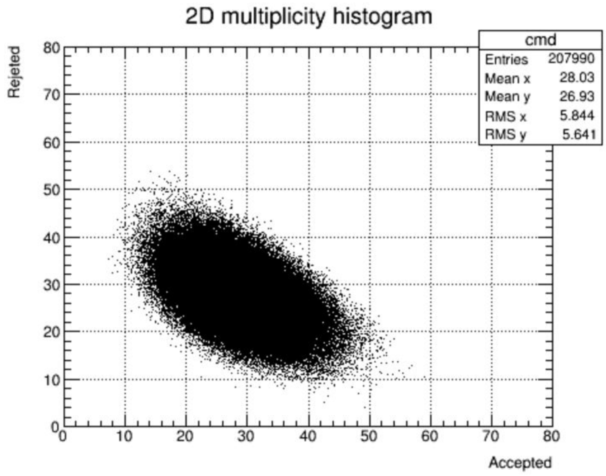
(a) multiplicity bin (0-20)



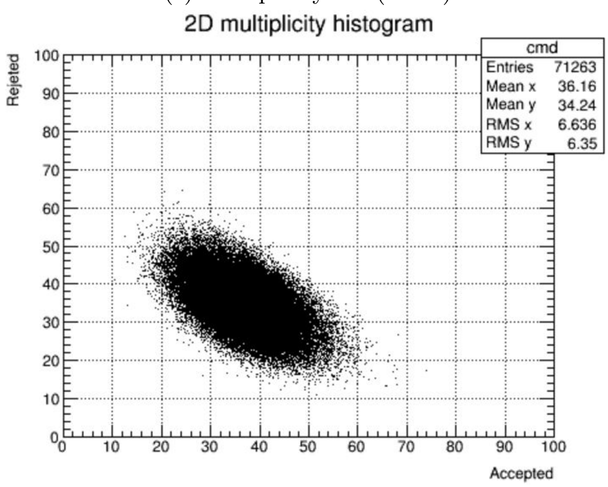
(b) multiplicity bin (20-40)



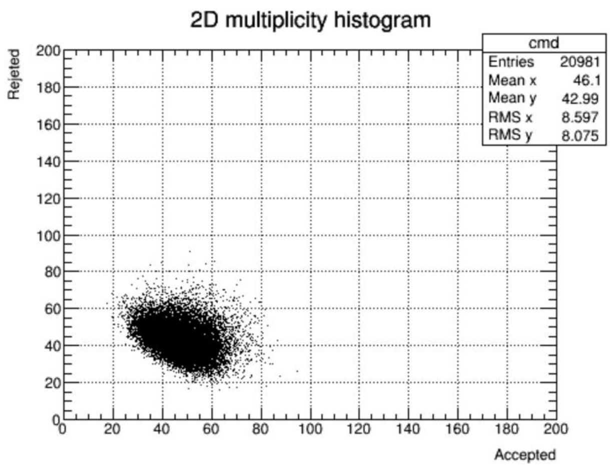
(c) multiplicity bin (40-60)



(d) multiplicity bin (60-80)



(e) multiplicity bin (80-100)



(f) multiplicity bin (>100)

Figure 8: showing accepted and rejected events to minimize unwanted errors multiplicity bin wise

Codes used in plotting the plots in this report are available here: LINK