Dependence of kinematic variables and charge particle multiplicity distribution on charge asymmetry in pp collision at 13 TeV

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Contents

Abstract

The phenomena of high energy collisions are studied using particle accelerators such as the Large Hadron Collider. This helps us to ascertain the characteristics of events like proton-proton collisions and infer scientific conclusions. These experiments serve to test the principles of the Standard Model of Particle Physics. In this report, we present the analysis of the charge asymmetry distribution in proton-proton collisions in different multiplicity classes, the multiplicity distribution in charge and asymmetry regions and the p_T, η, ϕ distribution in charge symmetric and asymmetric regions. The data provided is generated using Pythia 8 Monte Carlo event generator replicating the collision events.

1 Introduction

A proton-proton collision involves two high energy proton beams undergoing a direct collision.The forces of interaction dominating in this regime are those that abide by the rules of QCD as the dominant interactions are between the different quarks.

In this report we look at three major characteristics of p-p collisions:

- Charge asymmetry distribution in different multiplicity classes.
- Multiplicity distribution in charge symmetric and asymmetric regions.
- p_T, η, ϕ distribution in charge symmetric and asymmetric regions (superposed).

The data provided is generated with Pythia 8 Monte Carlo event generator.

- Number of events under consideration : 2 million
- Collisions System : p + p at centre of mass energy 13 TeV.

1.1 Notation Used

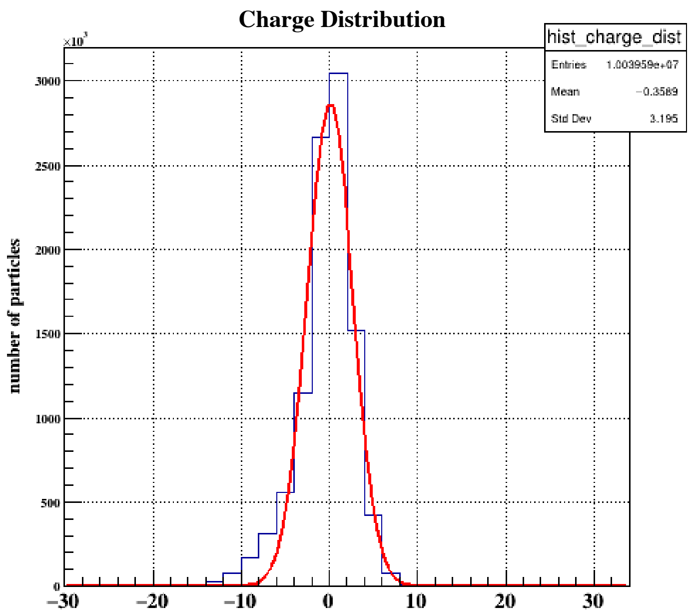
Variable	**Description**
η	**Pseudorapidity** - It is coordinate that describes the angle of a particle relative to the beam axis and is given by $\ln(\cot\frac{\theta}{2})$
p_T	**Momentum** of particle along transverse direction
ϕ	**Azimuthal Angle** - Angle from the vertical axis in the chosen co-ordinate system
θ	**Polar angle** - The angle between the particle and collision/beam axis
σ^2	**Variance**
μ	**Mean**

2 Experimental Observations

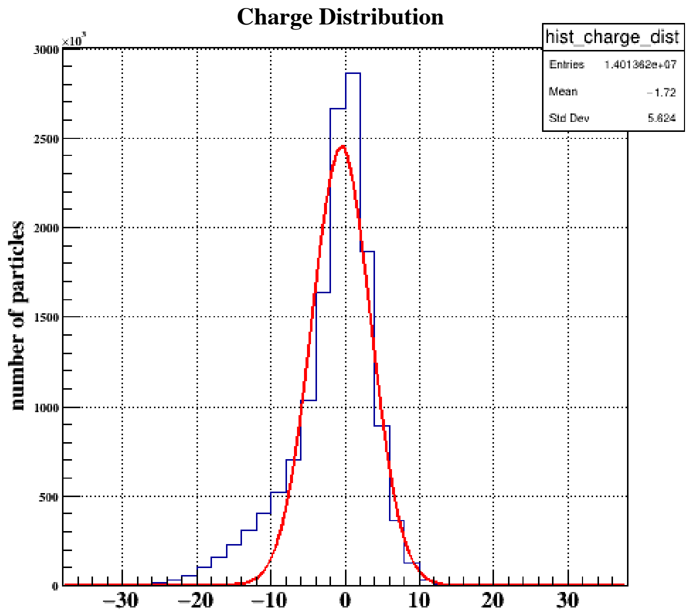
2.1 Charge asymmetry distribution in different multiplicity classes

We have plotted a distribution histogram for each of the 6 bins, corresponding to events with total multiplicities 0-20, 20-40, 40-60, 60-80, 80-100 and above 100. These graphs indicate that the distributions are Gaussian with mean zero.

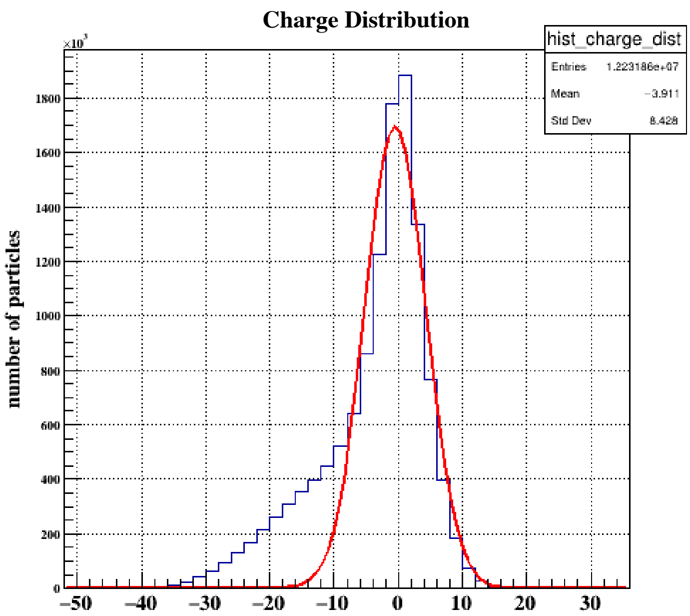
2.1.1 Multiplicity class 0-20



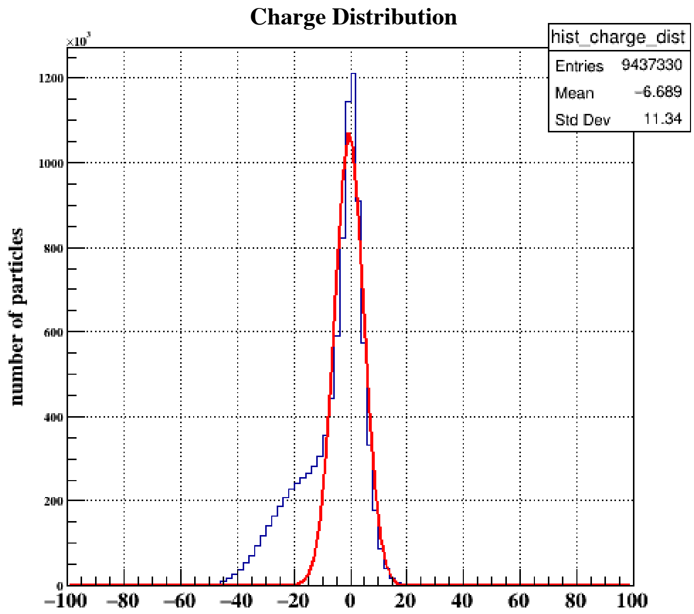
2.1.2 Multiplicity class 20-40



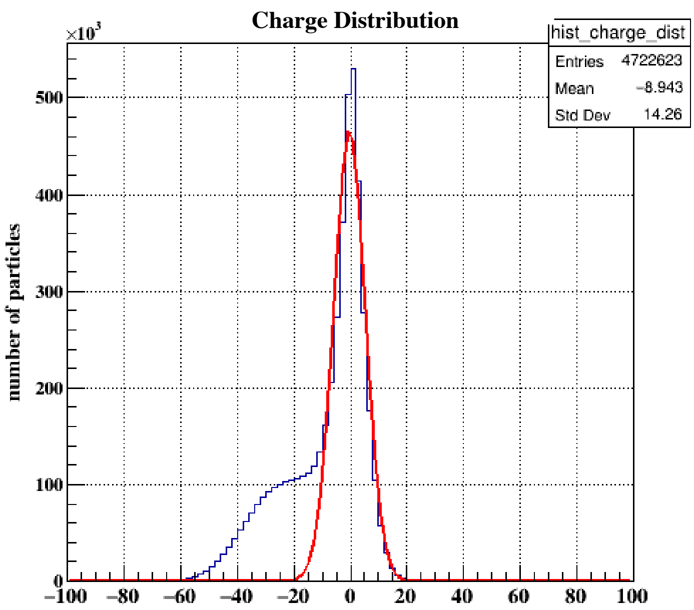
2.1.3 Multiplicity class 40-60



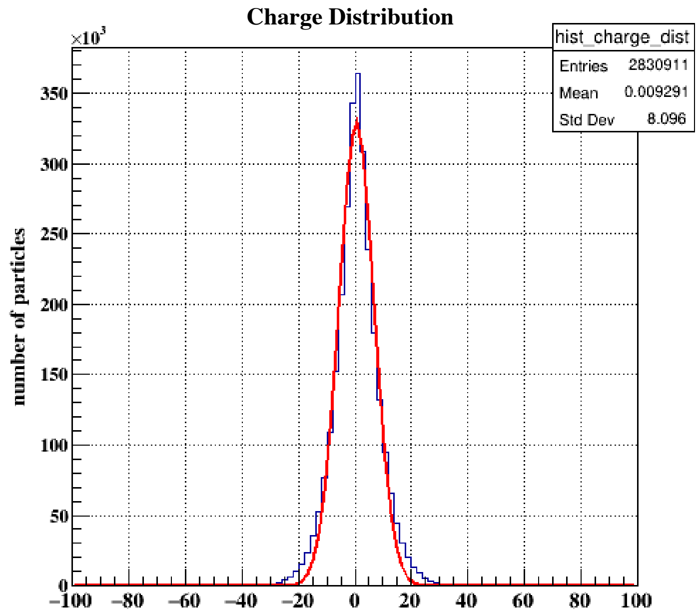
2.1.4 Multiplicity class 60-80



2.1.5 Multiplicity class 80-100



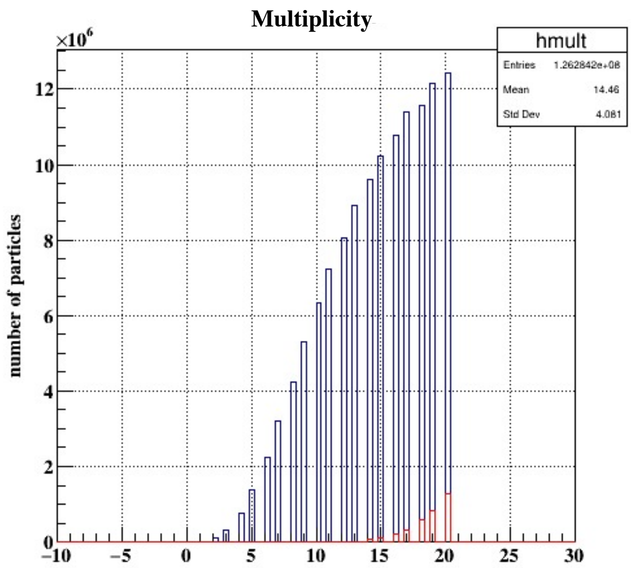
2.1.6 Multiplicity class 100 above



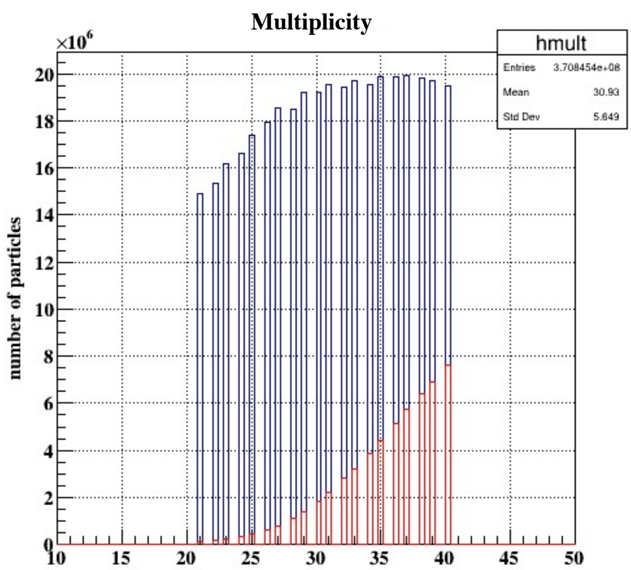
2.2 Multiplicity distribution in charge symmetric and asymmetric regions

In all of the figures below, blue graph corresponds to asymmetric region and red graph corresponds to symmetric region.

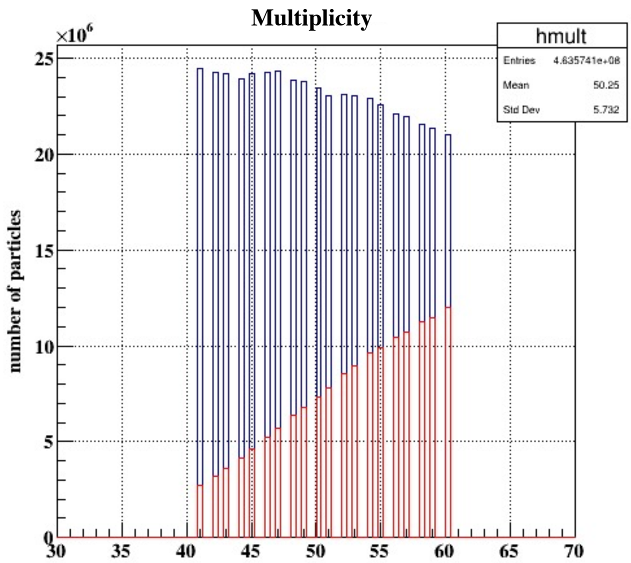
2.2.1 Multiplicity class 0-20



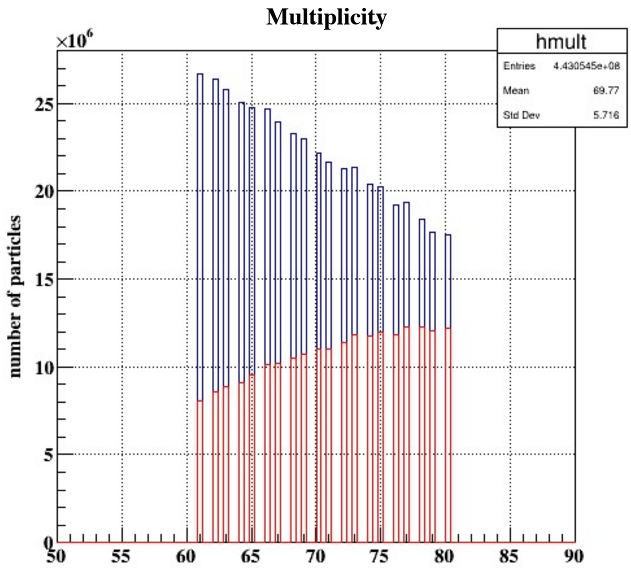
2.2.2 Multiplicity class 20-40



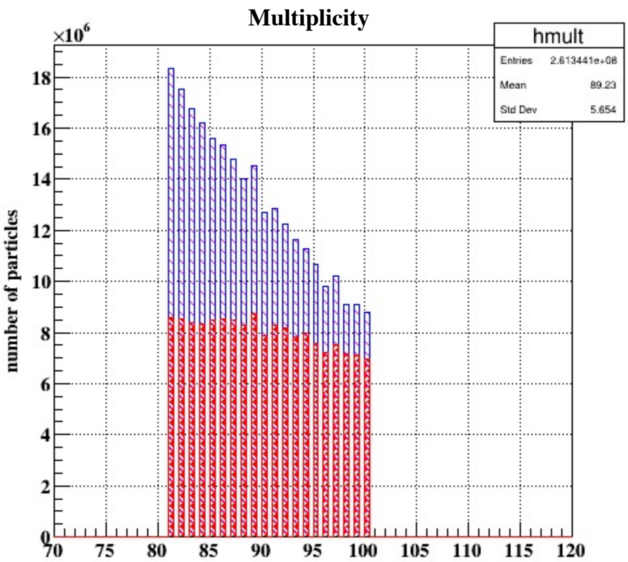
2.2.3 Multiplicity class 40-60



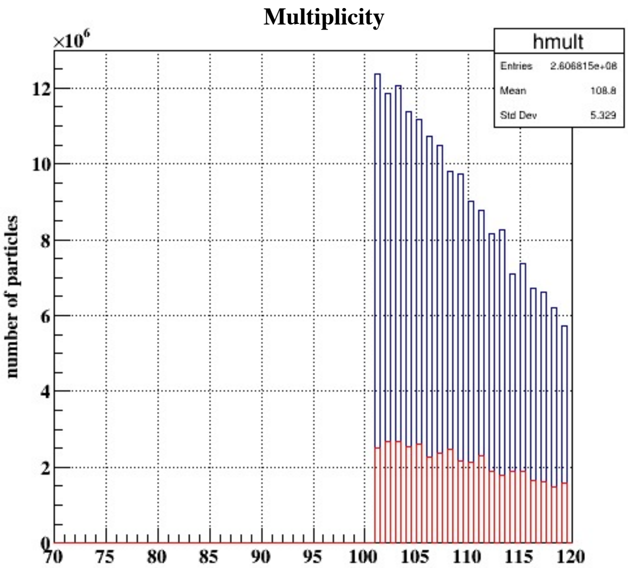
2.2.4 Multiplicity class 60-80



2.2.5 Multiplicity class 80-100



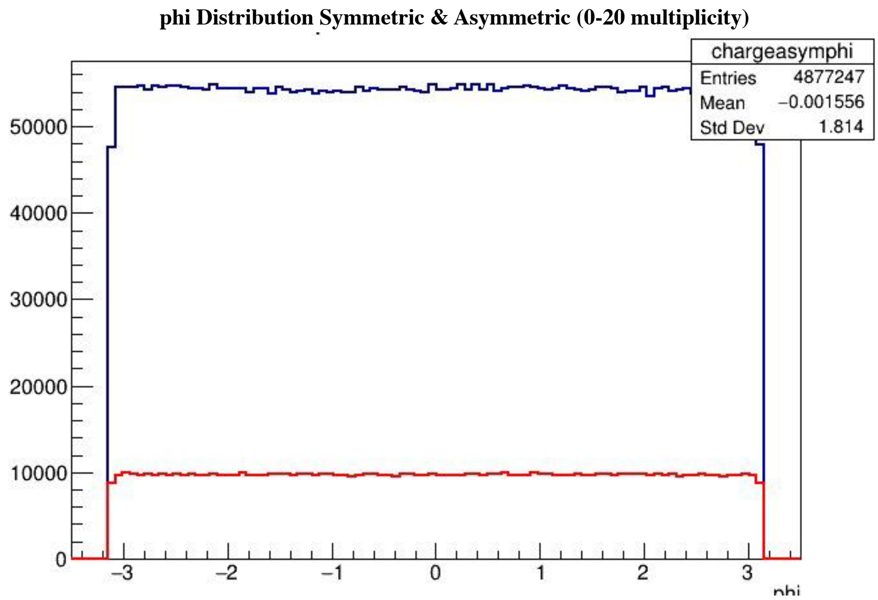
2.2.6 Multiplicity class 100 above

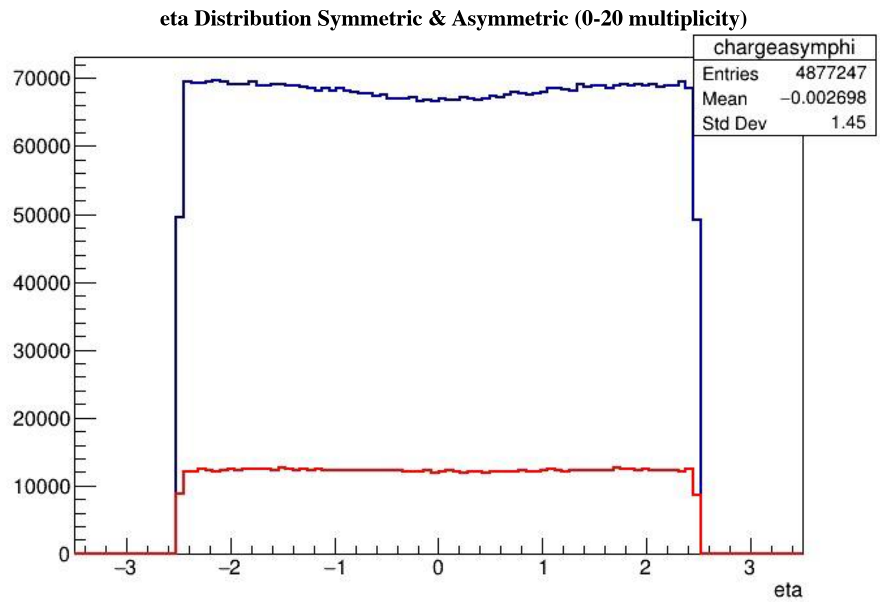


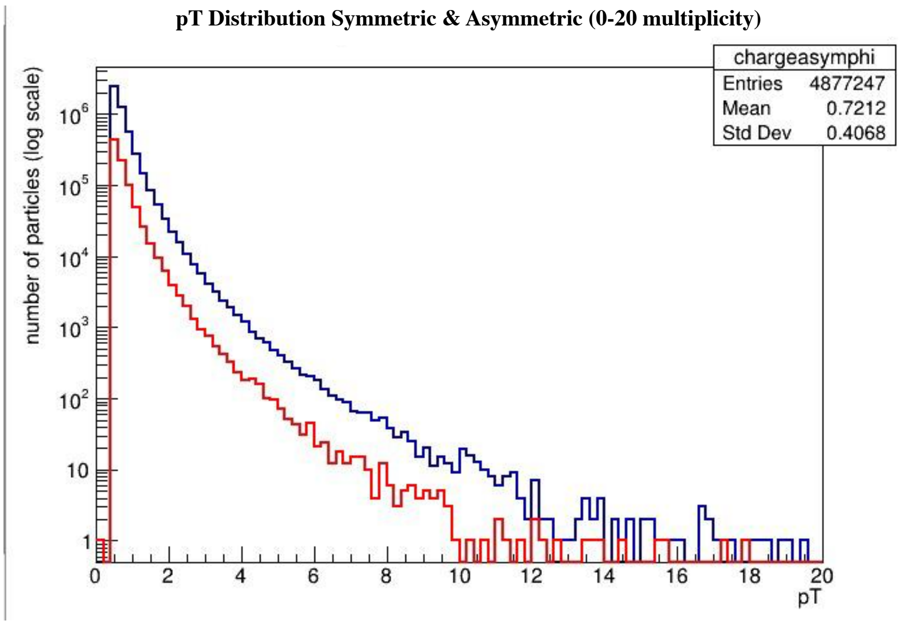
2.3 p_T, η, ϕ distribution in charge symmetric and asymmetric regions (superposed)

We plotted dependence of variables such as η, ϕ, p_T distribution in charge symmetric and asymmetric regions. Red curve represents symmetric region and blue one represents asymmetric region. We observe that asymmetric region lies above the symmetric region because of presence of more number of particles in asymmetric region, which in turn results in an equivalent curve for symmetric and asymmetric regions.

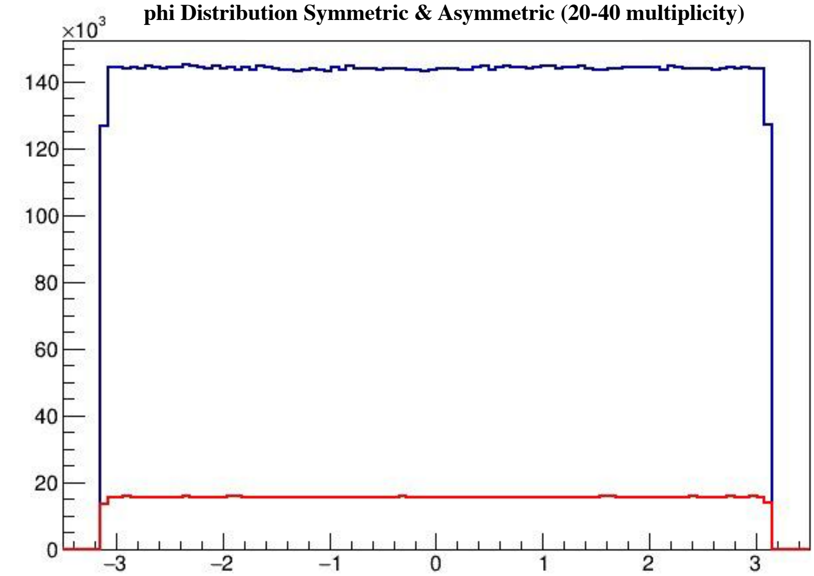
2.3.1 Multiplicity class 0-20

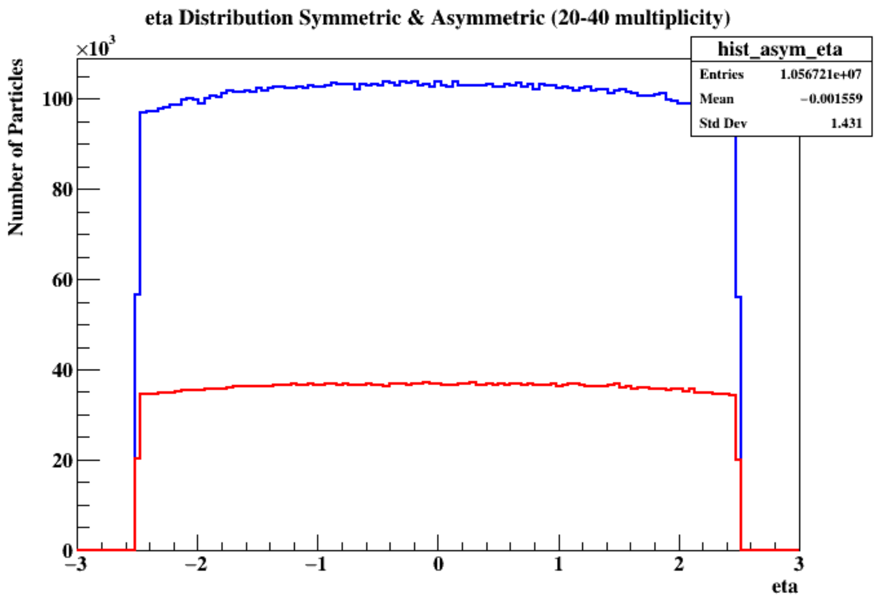


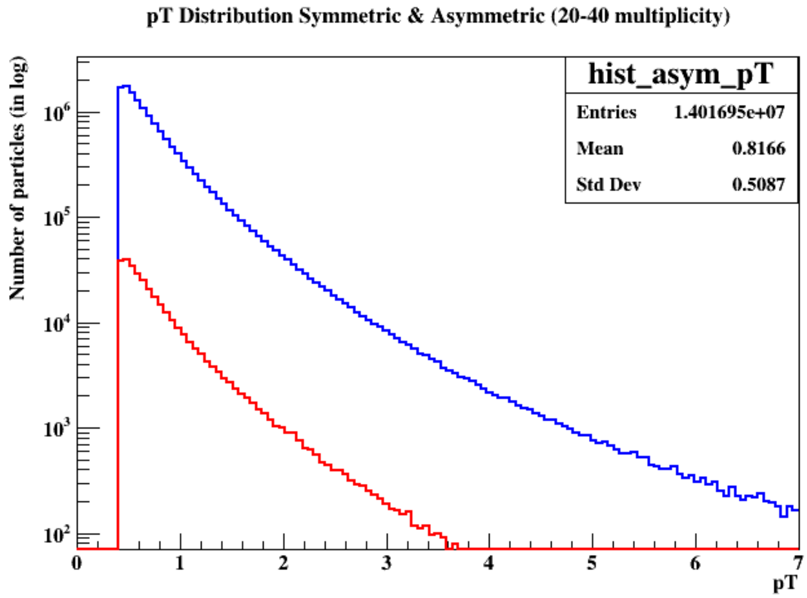



pT Distribution Symmetric & Asymmetric (0-20 multiplicity)
chargeasymphi
Entries 4877247
Mean 0.7212
Std Dev 0.4068
number of particles (log scale)
pT

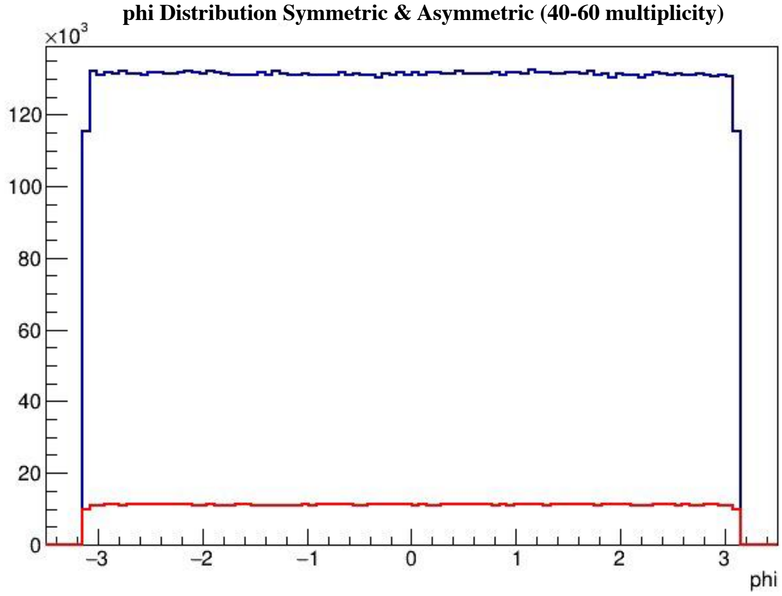
2.3.2 Multiplicity class 20-40

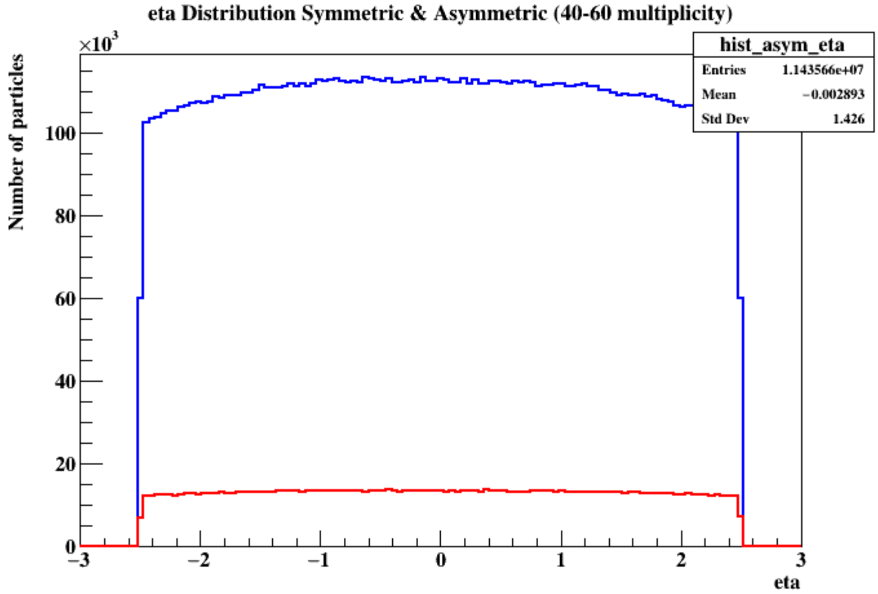


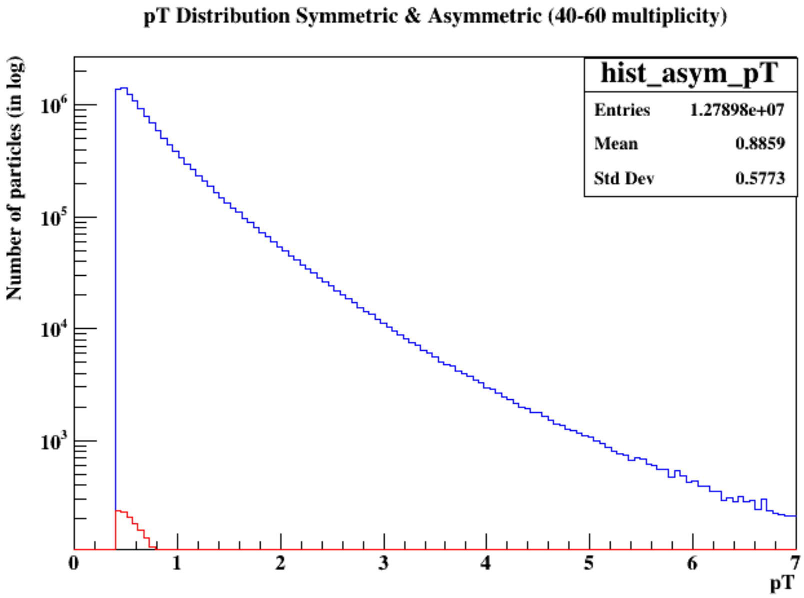



pT Distribution Symmetric & Asymmetric (20-40 multiplicity)
hist_asym_pT
Entries 1.401695e+07
Mean 0.8166
Std Dev 0.5087
Number of particles (in log)
pT

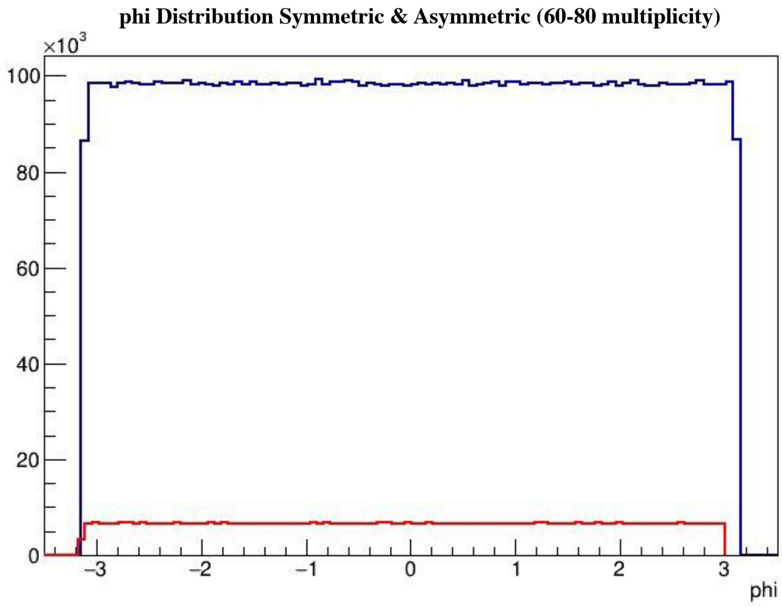
2.3.3 Multiplicity class 40-60

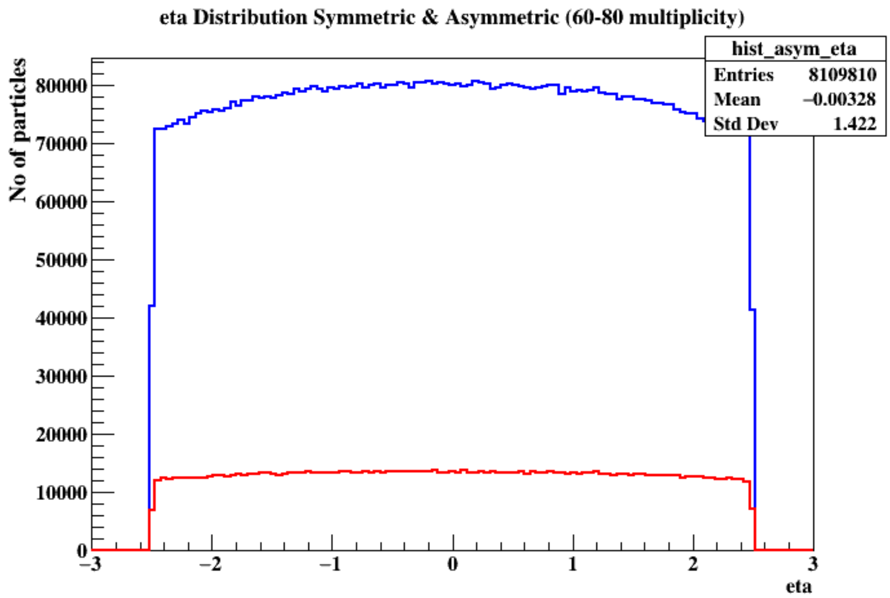


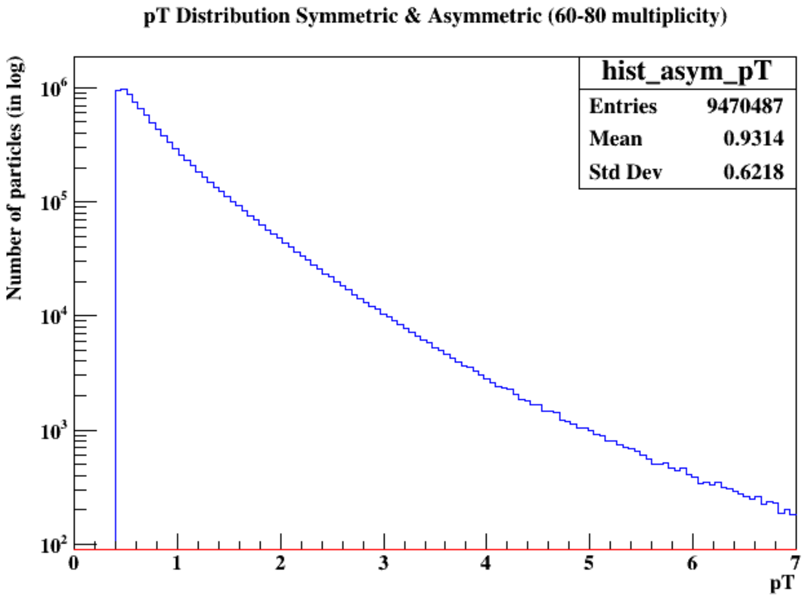



pT Distribution Symmetric & Asymmetric (40-60 multiplicity)
hist_asym_pT
Entries 1.27898e+07
Mean 0.8859
Std Dev 0.5773
Number of particles (in log)
10^6
10^5
10^4
10^3
0
1
2
3
4
5
6
7
pT

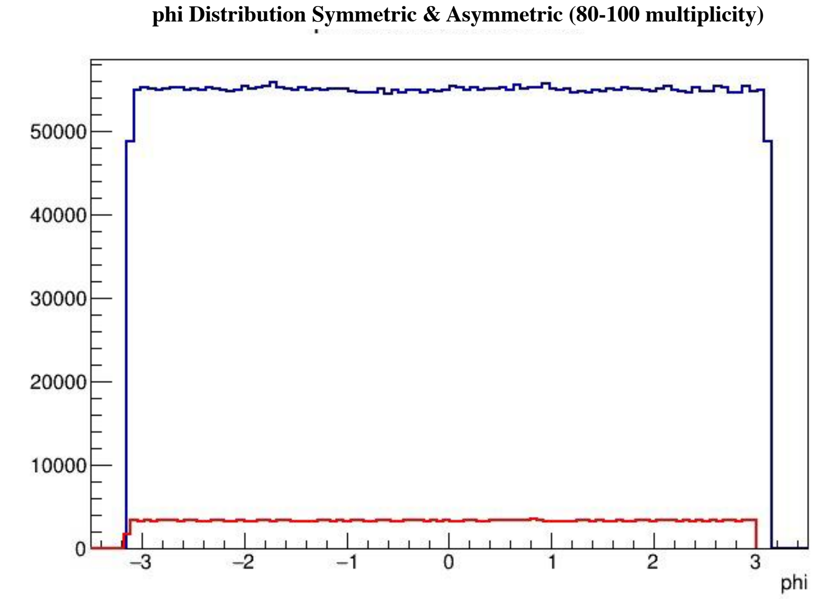
2.3.4 Multiplicity class 60-80

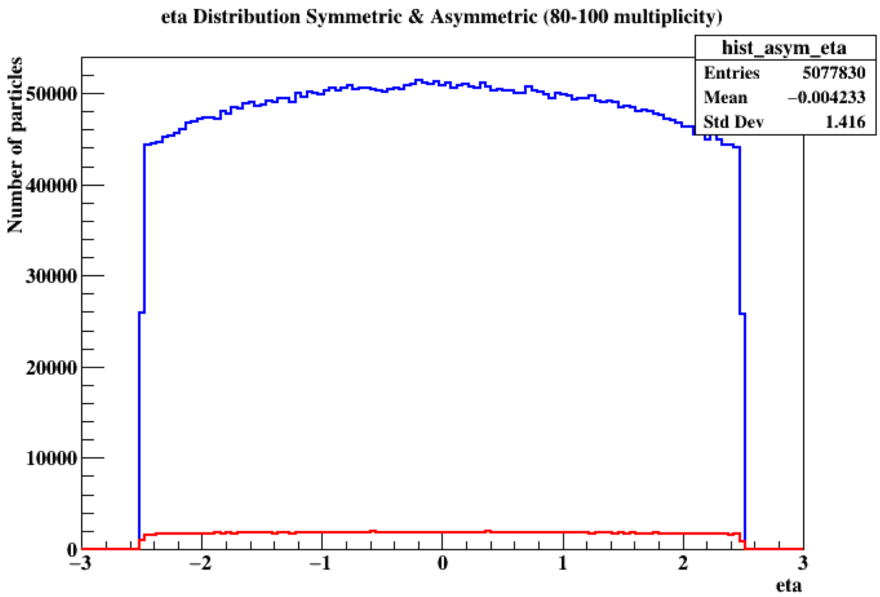


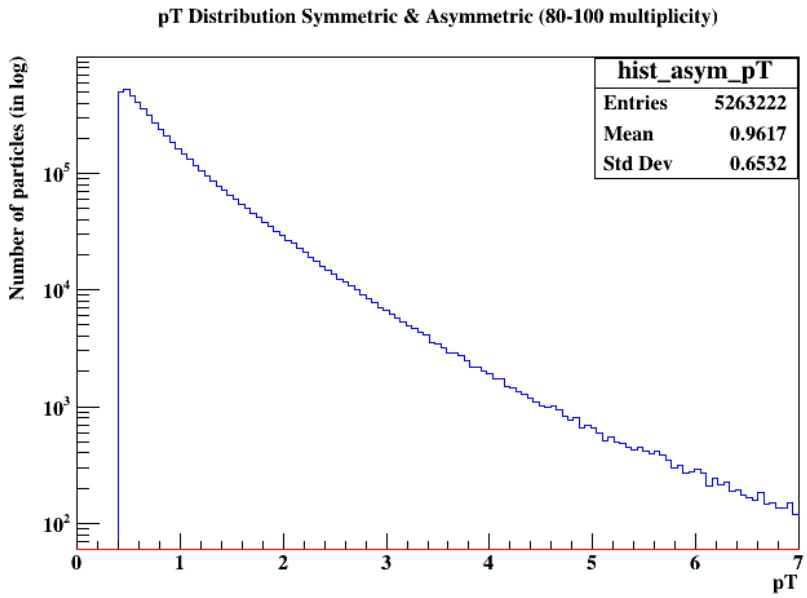



pT Distribution Symmetric & Asymmetric (60-80 multiplicity)
hist_asym_pT
Entries 9470487
Mean 0.9314
Std Dev 0.6218
Number of particles (in log)
10^6
10^5
10^4
10^3
10^2
0
1
2
3
4
5
6
7
pT

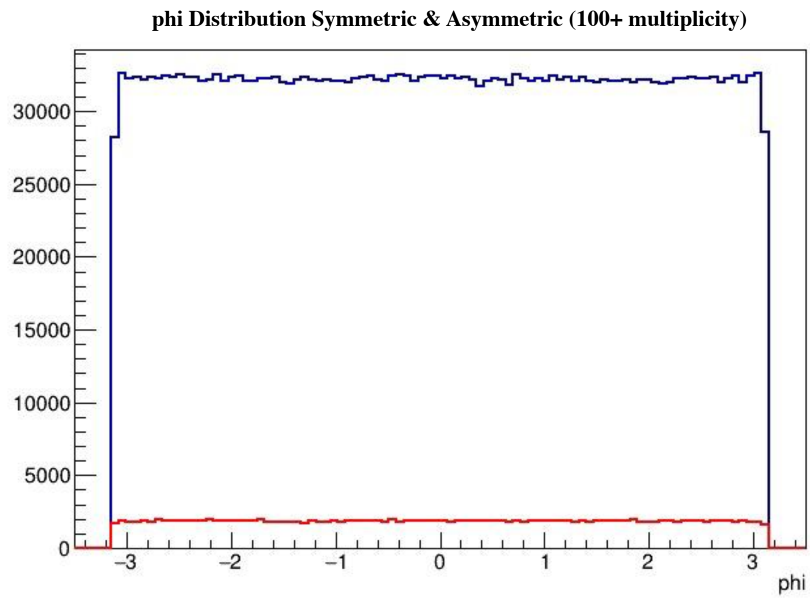
2.3.5 Multiplicity class 80-100

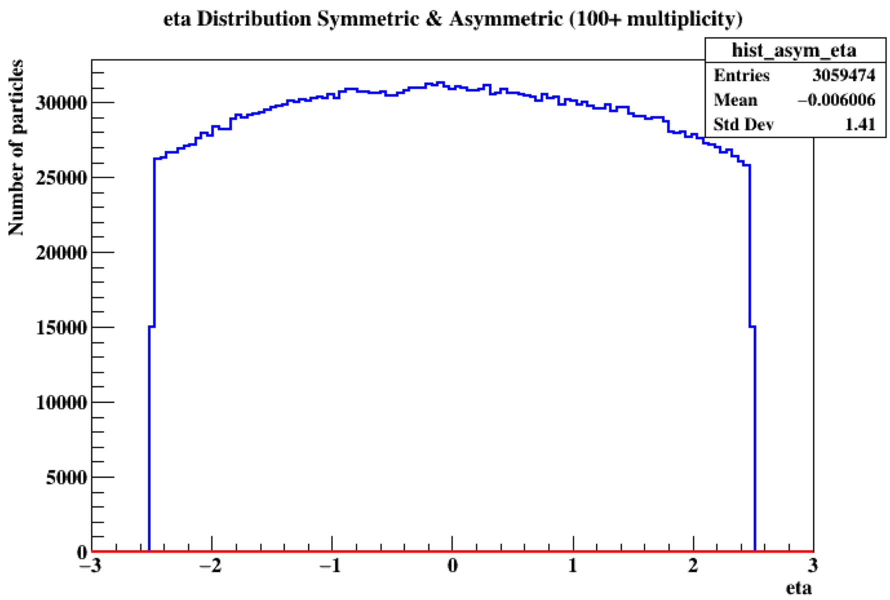


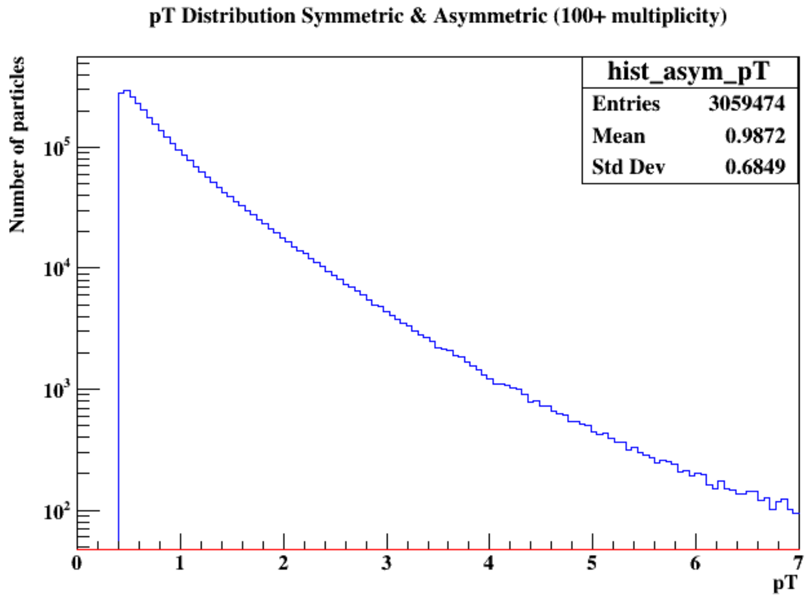



pT Distribution Symmetric & Asymmetric (80-100 multiplicity)
hist_asym_pT
Entries 5263222
Mean 0.9617
Std Dev 0.6532
Number of particles (in log)
10^5
10^4
10^3
10^2
0
1
2
3
4
5
6
7
pT

2.3.6 Multiplicity class 100 above






pT Distribution Symmetric & Asymmetric (100+ multiplicity)
hist_asym_pT
Entries 3059474
Mean 0.9872
Std Dev 0.6849
Number of particles
10^5
10^4
10^3
10^2
0
1
2
3
4
5
6
7
pT

3 Summary

We have plotted five graphs for determining the charge asymmetry distribution in different multiplicity classes, and from this we were able to infer that the distribution is **Gaussian** with **mean equal to zero**. This matches with the principle of local charge conservation. Next, we plotted multiplicity distribution in charge symmetric and asymmetric regions, which helped us conclude that multiplicity shows higher values for particles in charge asymmetric regions. Finally, we plotted the dependence of essential kinematic variables such as p_T, η, ϕ distributions in both charge symmetric and asymmetric regions. We observe that asymmetric region lies above the symmetric region because of presence of more number of particles in symmetric region, which in turn results equivalent curve for symmetric and asymmetric region. Therefore charge symmetry has no significant effect on kinematic variable described here.

References

[1] J. Adams *et al.*, (ALICE Collaboration), Nature Physics **13**, 535-539 (2017).