Data Analysis of Supplemental Data in *Beam Energy Dependence of Jet-Quenching Effects in Au+Au Collisions at* $\sqrt{s_{NN}}$ *= 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV*

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1 Introduction

This is a data analysis of the supplemental paper data from the paper published by the STAR Collaboration, titled *Beam Energy Dependence of Jet-Quenching Effects in Au+Au Collisions at* $\sqrt{s_{NN}}$ *= 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV*. The data from both the published paper and supplemental paper are compiled in HEPData here: `https://www.hepdata.net/record/100537`. A thorough step-by-step process of the supplemental data analysis can be found on the Jupyter notebook located here: `https://github.com/jaanita/Beam_Energy_Dependence_Analysis`.

2 Possible Issues with the Data

The main concerns of the data are the following. Corrections to some issues ((1), (3), (4)) are attempted.

(1) Tables 20 - 109 might be mislabelled as centralities in increasing order instead of revered order.
(2) Tables 2 and 4 might have problematic data points at high N_{part}/centralities.
(3) Tables 20 - 109 might be mislabelled as $\frac{1}{2\pi p_T} * \frac{d^2N}{d\eta dp_T}$ instead of $\frac{1}{2\pi p_T} * \frac{d^2N}{dy dp_T}$.
(4) Tables 6 - 109 might be off by a factor of 2.

3 Plots

The plots below provide evidence for (1), (2), (3), and (4).

3.1 (1) Tables 20 - 109 might be mislabelled as centralities in increasing order instead of revered order.

As collision centralities and N_{part} increase, we expect charge multiplicity to increase as well. Charge multiplicity was calculated at each centrality by integrating over momentum spectra (p_T) and multiplying by $2\pi p_T$ and $\frac{2}{N_{part}}$ to get charge multiplicity units in $\frac{dN}{d\eta}\frac{2}{N_{part}}$.

Tables 6 - 19 (Charged Hadron spectra) are what we expect, shown below in Figure 1.

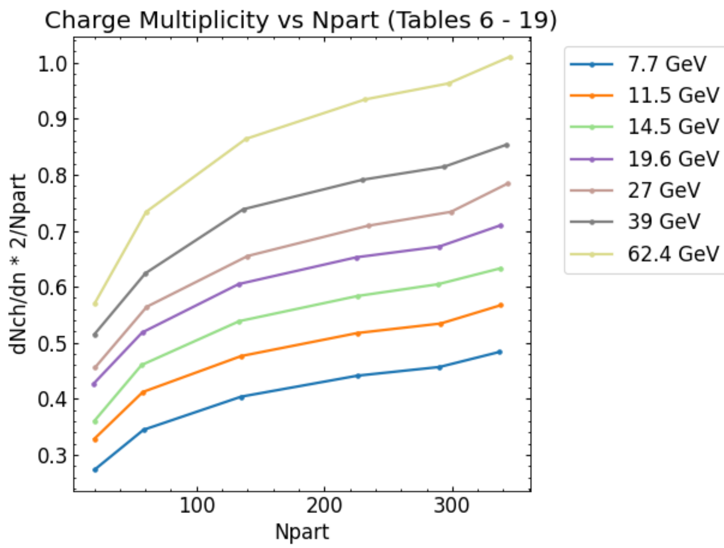

Figure 1. Charge Multiplicity vs N_{part} for Tables 6 - 19 (Charged Hadron spectra).

Tables 20 - 109 (Individual Particle Species) are not what we expect, shown below in Figure 2. Each energy is the summation of all particle types.

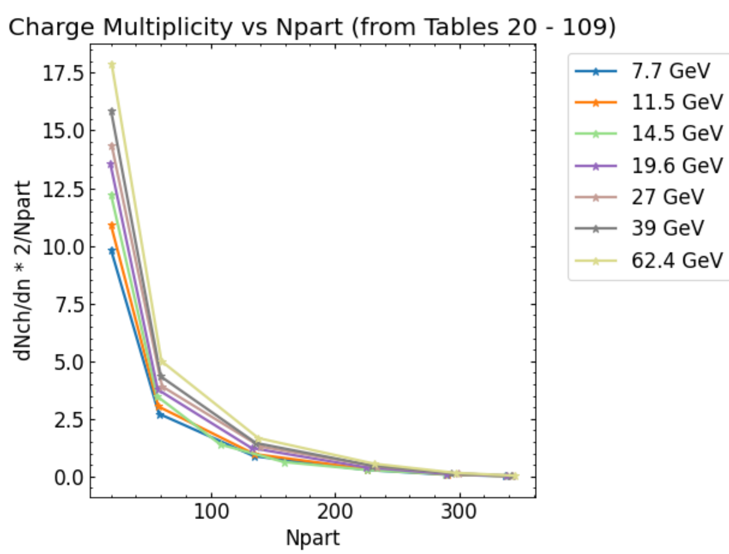

Figure 2. Charge Multiplicity vs N_{part} for Tables 20 - 109 (Individual Particle Species spectra, summed).

The unexpected decrease in particle multiplicity at increasing N_part can be fixed by reversing the centralities, i.e. the x-axis. For example, instead of the data tables being labelled as 0-5%, 5-10%, 10-20%, 20-40%, 40-60%, 60-80%, they are now labelled as 60-80%, 40-60%, 20-40%, 10-20%, 5-10%, 0-5%. The new plot for Tables 20 - 109 with reversed centralities is shown below in Figure 3.

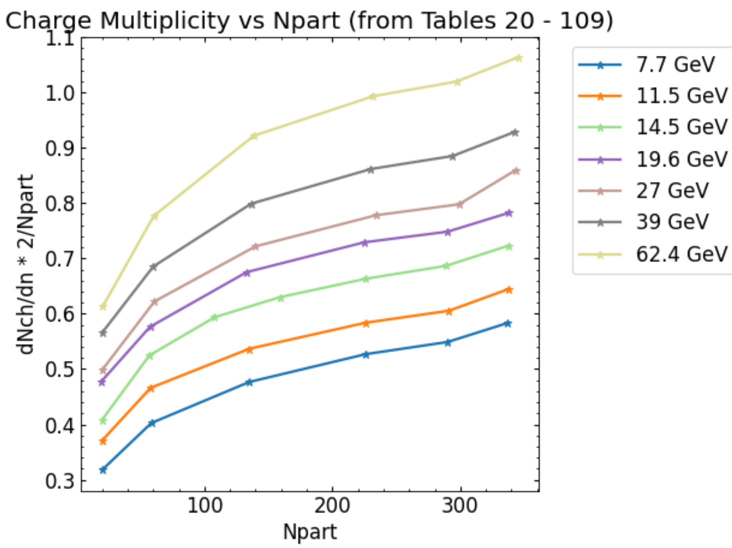

Figure 3. Charge Multiplicity vs N_{part} for Tables 20 - 109 with reversed centralities (Individual Particle Species, summed).

The plots look much better, with the expected upward trend.

3.2 (2) Tables 2 and 4 might have problematic data points at high N_{part}/centralities.

Table 2 is N_{ch} at each centrality for each energy. Table 4 is N_{part} at each centrality for each energy. The plot below, shown in Figure 4, shows $\frac{dN_{ch}}{d\eta} * \frac{2}{N_{part}}$. The term $\frac{dN_{ch}}{d\eta}$ is approximated as N_{ch} extracted from Table 2 since it is usually measured at midrapidity where $\eta \approx 0$. The term $\frac{2}{N_{part}}$ is extracted from Table 4.

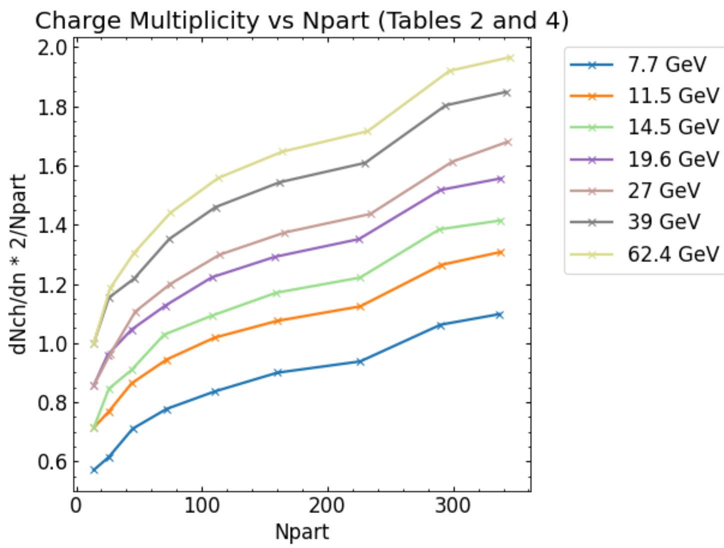

Figure 4. Charge Multiplicity vs N_{part} from Table 2 (N_{ch}) and Table 4 (N_{part}).

There is an unexpected spike, at high N_{part}, particularly in the centrality bins 0-5% and 5-10%. Notably, these are the only 5% wide bins, compared to the rest of the bins being 10% or 20% wide. This might be a factor causing the spike.

3.3 (3) Tables 20 - 109 might be mislabelled as $\frac{1}{2\pi p_T} * \frac{d^2N}{d\eta dp_T}$ instead of $\frac{1}{2\pi p_T} * \frac{d^2N}{dydp_T}$.

The data tables in the supplemental paper were labelled as $\frac{1}{2\pi p_T} * \frac{d^2N}{d\eta dp_T}$ while their counterpart graphs were labelled as $\frac{1}{2\pi p_T} * \frac{d^2N}{dydp_T}$. If the data tables are mislabelled, this might explain the slight deviation of charge multiplicy when integrating charged hadron spectra (Tables 6 - 19) vs when integrating individual particle spectra (Tables 20 - 109). The deviation is shown below in Figure 5.

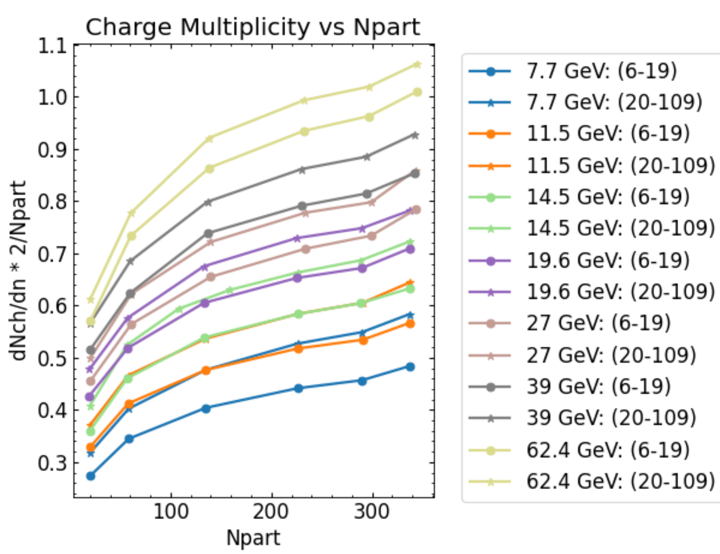

Figure 5. Charge Multiplicity vs N_{part} from Tables 6 - 19 (Charged hadron spectra) and Tables 20 - 109 (Individual particle species spectra, summation).

A Jacobian factor is applied at each data point in the momentum spectra for Tables 20 - 109 in order to transform the suspected $\frac{1}{2\pi p_T} * \frac{d^2N}{dydp_T}$ into $\frac{1}{2\pi p_T} * \frac{d^2N}{d\eta dp_T}$. The Jacobian factor is as follows.

$$\frac{dN}{d\eta dp_T} = \sqrt{1 - \frac{m^2}{m_T^2 cosh^2 y}} \frac{dN}{dydp_T}$$

We will assume $cosh^2 y$ 1, if we approximate y 0. So, the Jacobian reduces to:

$$\frac{dN}{d\eta dp_T} = \sqrt{1 - \frac{m^2}{m_T^2}} \frac{dN}{dydp_T} \text{ where } m_T = \sqrt{m^2 + p_T^2}$$

Adding the Jacobian to Tables 20 - 109 makes the plot of the individual particle species (summation over all particle types) very close to the charged hadrons (almost directly on top of each other), shown below in Figure 6. The data tables in the supplemental paper may need to be relabelled as $\frac{1}{2\pi p_T} * \frac{d^2N}{dydp_T}$ in order to match the graph labels as well as for the summation to be comparable with the charged hadron data.

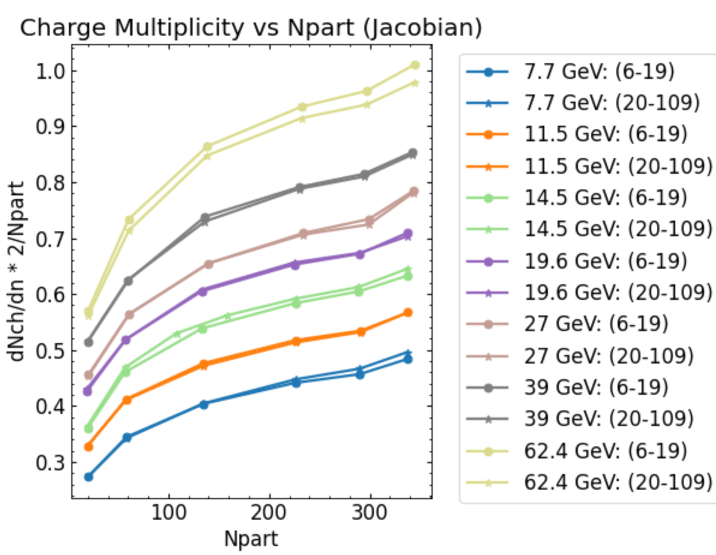

Figure 6. Charge Multiplicity vs N_{part} from Tables 6 - 19 (Charged hadron spectra) and Tables 20 - 109 (Individual particle species spectra, summation with Jacobian).

3.4 (4) Tables 6 - 109 might be off by a factor of 2.

When plotting Charge Multiplicity vs N_{part} from all three sources: Tables 2 and 4, Tables 6 - 19, and Tables 20 - 109, there appears to be a factor of 2 difference between the plots of Tables 2 and 4 (N_{ch} and N_{part}) and the plots from integrating momentum spectra of both Tables 6 - 19 (Charged hadron spectra) and Tables 20 - 109 (Individual particle species spectra, summation over all particle types with Jacobian). The discrepancy is shown below in Figure 7.

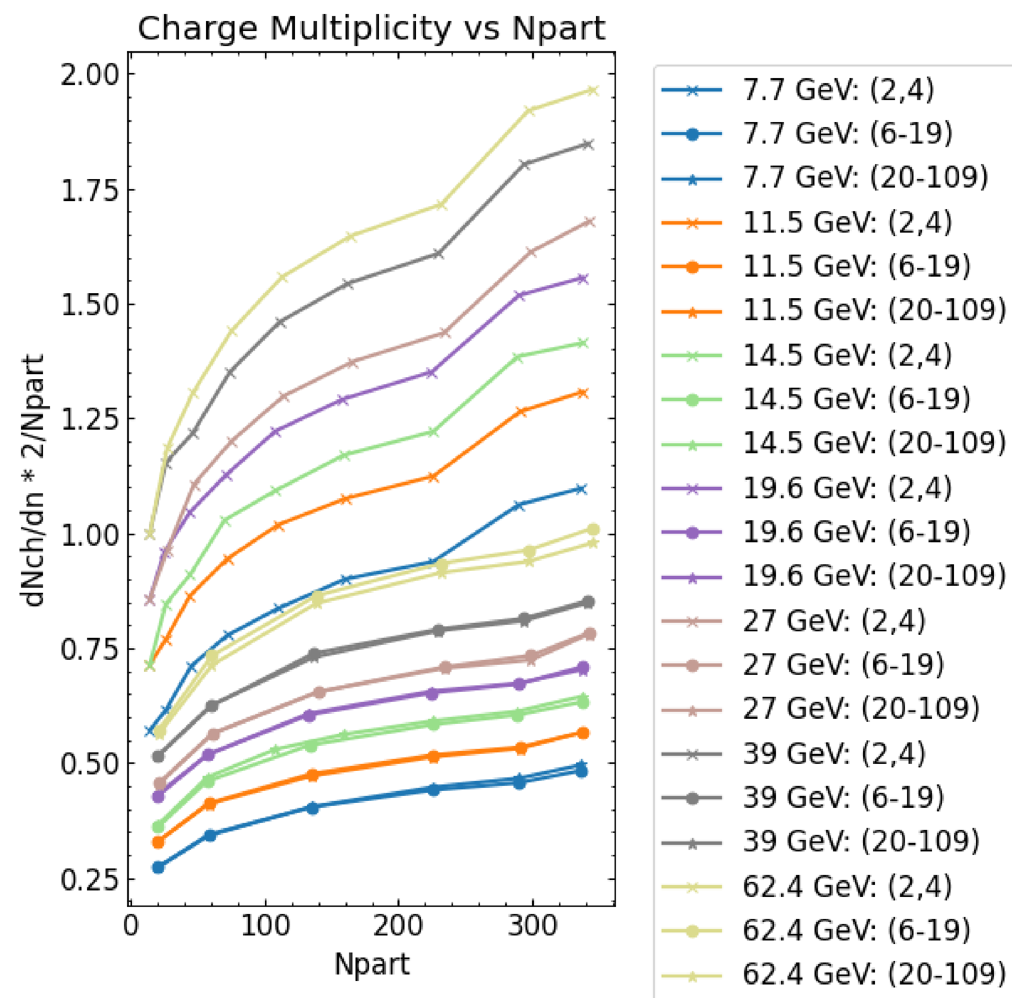

Figure 7. Charge Multiplicity vs N_{part} from Tables 2 and 4 (N_{ch} and N_{part}), Tables 6 - 19 (Charged hadron spectra), and Tables 20 - 109 (Individual particle species spectra, summation with Jacobian).

By applying a factor of 2 to Tables 6 - 19 and Tables 20 - 109, the plots become closer, as shown in Figure 8. This is the least of the concerns, because the factor of 2 decrease may be due to a lack of extrapolation to low momentum, for which the data is currently being analyzed.

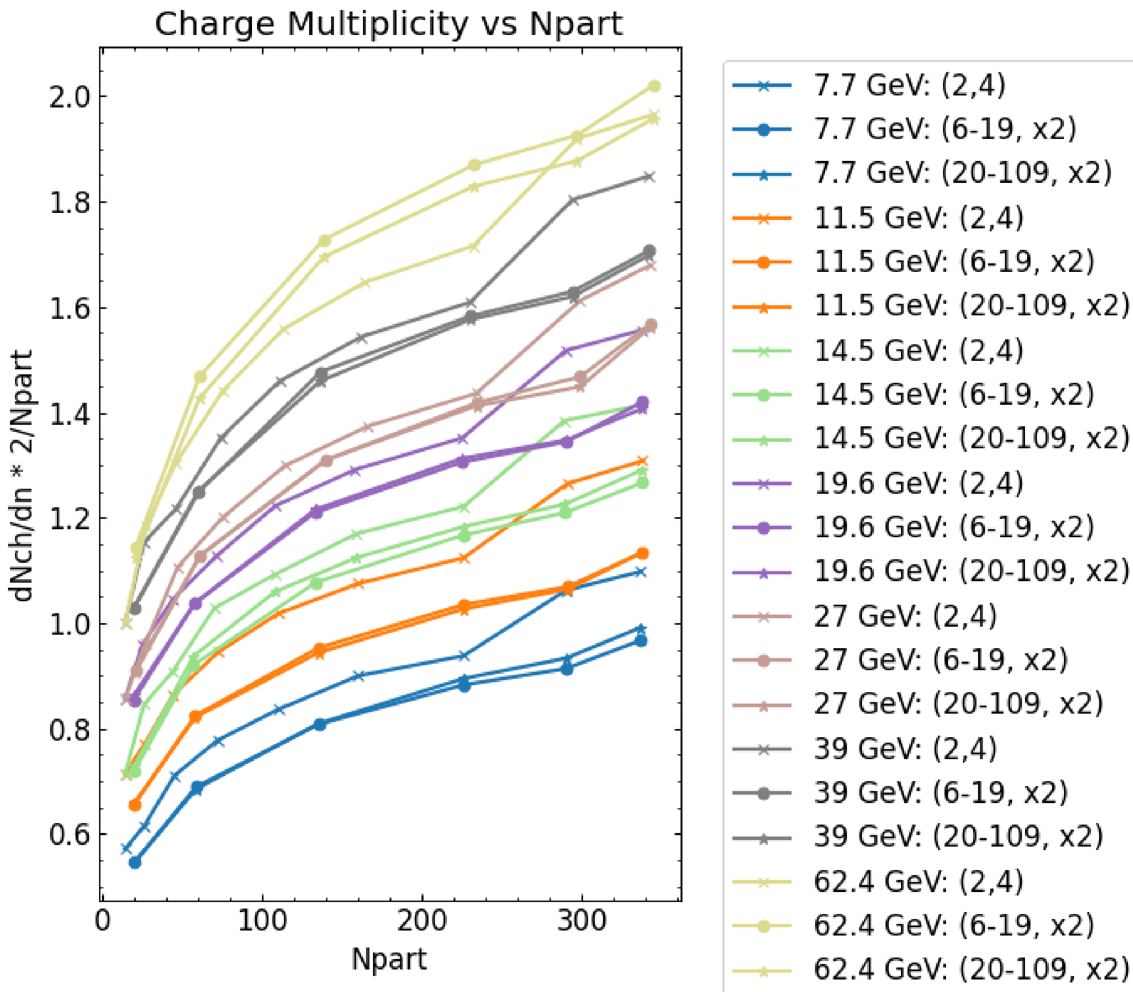

Figure 8. Charge Multiplicity vs N_{part} from Tables 2 and 4 (N_{ch} and N_{part}), Tables 6 - 19 (Charged hadron spectra, x2), and Tables 20 - 109 (Individual particle species spectra, summation with Jacobian, x2).