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The Transport Modeling Analysis of Elliptical Effluence versus Pseudo-rapidity Profile in High Energy Collision.

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Abstract: *Here an investigational study about the variation of elliptical flow as a function of pseudo-rapidity, employing A Multi Phase Transport model is reviewed. It reflects the notable difference in results of elliptical flow in middle region of rapidity, estimated using event plane technique and the reaction plane technique. On the other hand the results below and above middle rapidity with these mentioned techniques bestow matching flow magnitude, signalizes the dependability of effluence magnitude on analyses technique.*

I. Introduction

The Non-symmetrical nuclei smashing amidst comparatively lighter nuclei aimed to weighty target nuclei are established well of being an outstanding exploration track of particle re-production frameworks also for the collision progression along beam direction which pursues the preliminary colliding stage features. Till now a large number of estimations have been performed to depict the dispensation along the beam axis or called as the rapidity dispensation regarding the particles generated as a result of impacts amidst proton and nucleus. It is done by means of color strands/strings disintegration also using the counting-conventions (established on hacked/smote nucleon's count or via quark's count within the two approaching nuclei).

Apart from this the variable of elliptical effluence (v_2) is proved well for being a fantastic aid which helps in providing information about the colliding set-up shaped in preliminary phase for RHIC energies. The Elliptical effluence is imagined to become apparent as a consequence of development of pressure gradient while impinging of projectile versus target nucleus for impact-parameter having values more than Zero happen, which further accompany the consequent interplays amidst the integrants[1–3]. It has been observed that even perfectly 3-D hydro-dynamic modeling necessitate key in for dispensation of energy, lays down in early-stage also the gradients along beam axis [4]. As soon as the preliminary partonic constituents get occupied, these modeling develop the dynamics of such system. Therefore measuring the elliptical effluence dependence on pseudo-rapidity endow with the limitations on advancement along the direction of beam axis.

In The colliding nuclei arena, explained via hydrodynamics, the elliptical effluence (v_2) is found of being susceptible to EOS of the arrangement taking shape consequent to these impacts and provides azimuth direction anisotropic momenta depiction during impinging of bulky ions and labeled as the 2nd second coefficient of azimuth directional Fourier expansion of momenta-dispensation regarding the reactance plane angle (ψ_r).

$$v_2 = \langle cos\big(2(\phi - \psi_r)\big)\rangle$$
(1)

In the above expression ϕ represents the ejection azimuth direction angle [5] and ψ_r symbolizes an angle arched over the plane shaped due to impact parameter & beam direction (Z) with regards to axial direction X. In fact the accurate referencing of reactance plane is experimentally indefinite due to the inability of estimating the impact parameter (b) amidst approaching projectile & target, but it could be guesstimated via gauging of spectator's in non-centric impacts. The frequently utilized manner for reactance plane is employing the anisotropic effluence as such [5]. The reactance plane angle gauged this way is named by event plane angle (ψ). Here nth order event plane angle harmonics is enumerated through-

$$\psi_n = \frac{1}{n}\tan^{-1}\frac{\sum_i^N w_i \sin(n\phi_i)}{\sum_i^N w_i \cos(n\phi_i)}$$
(2)

In the above equation N is indicating an event's overall particle counts which are considered for calculating the event plane and w_i representing such weights, preferred for maximizing the event plane's resolution.

Many researchers' studies as well as experimental work have been performed for analyzing elliptical effluence, at plasma energies. Also various appealing observable facts are seen for measured values of elliptical effluence (v_2) and its dependence on transversal momenta values (p_T), variation with pseudorapidity (η) also with centrality. Specifically the investigation performed by PHOBOS testing with RHIC, comprehensively analyzed the inter-relation of pseudorapidity with the first as well as the second coefficient of momenta dispensation anisotropy i.e. with v_1 & v_2[6, 7]. Also the pseudorapidity dependency profile on directed flow v_1 and multiplicity (symbolized as dN/d η) are elucidated finely using theoretic deliberation [9–11, 13–15], yet sufficiently not recognized the elliptical flow's η dependency [12].

II. Depiction of the modeling utilized:

This article is reviewing the results based on dependency profile of $v_2$with η simulated with A Multi-Phase Transport modeling (AMPT). For better understanding about the substantial process, supporting the investigation, a variety of experimental findings are matched up with theoretic estimations. One of those modeling, utilized for studying smashing of bulky ions is AMPT [17] which better known as composite/ hybrid transport modeling(avails the preliminary stage set-up from HIJING) [14, 15].

It is used in dual forms, one is the default denomination like AMPT- Def, based on scattering suffered by partonic mini-jets, prior to their hadronic fragmentation phase [16], on the other hand in its string melting picture (denominated by AMPT-SM), there is an involvement of supplementary scattering happenings amidst quarks, hence the occurrence of hadronic phase via partonic coalescence technique.

Later to model the scattered partonic happenings, Zhang parton cascade [17] is employed and it performs enumeration of body-duo parton scattering with the help of getting cross section values via perturbed quantum chromo-dynamics theory, by means of screened masses. In the results reviewed here, the cross section for interplays of parton with another parton (σ_{PP}) has been opted, ranged from 3-10 mb in AMPT-SM description and the events creation is taken roughly 100 thousand with minimum-bias for smashing of gold with gold.

III. Deliberation of modeling outcomes:

When the elliptical effluence is estimated for entire rapidity expanse, it is able to provide the preliminary dynamical behavior of the arena. Here the results are taken from the PHOBOS experimental work. This has been shown with the help of the figure 1; depicting the magnitude of elliptical effluence (v_2) dependence on rapidity of charged hadrons (transversal momenta integrated) for impacts amidst gold and gold, considering $\sqrt{s_{NN}}$ values as 19.6 Giga eV, 62.4 giga eV & 2 hundred electron volt

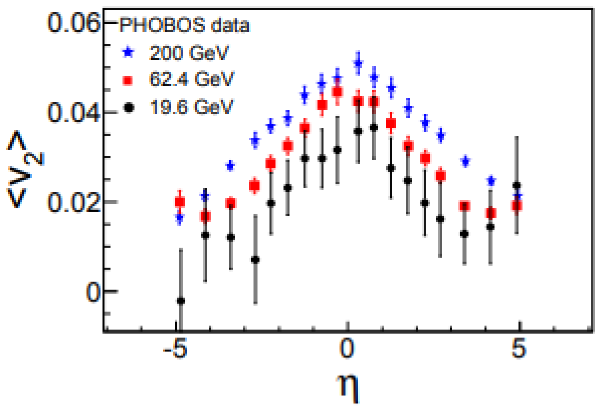

Fig.1: The elliptical effluence of hadronic charged particles and its dependence on rapidity (η) ranged from 0 to 40 percent for impacts of gold with gold at different energies shown in the figure employing PHOBOS investigation (6)

The profile depicts that $\langle v_2 \rangle$ drop too rapidly on the both side of middle pseudo-rapidity region and definitely it's pretty dissimilar to dN/dη dispensation [8] also neither the hydrodynamics based modeling is incapable of elucidating v_2 versus η dispensation profile [9] nor the AMPT & UrQMD kind of transport modeling (as suggested by earlier theories)[12]. This manuscript is appraising the v_2 computed via reaction plane's as well as event plane's technique.

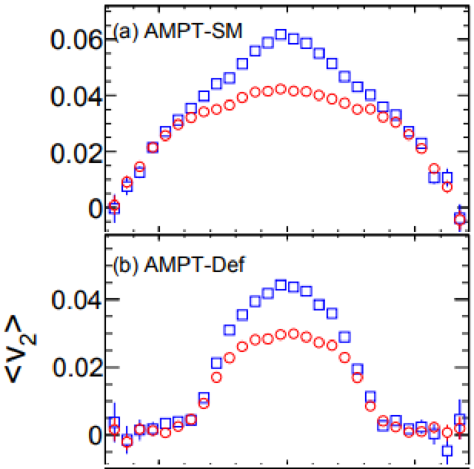

Fig. 2: The profile gives idea of dependence of elliptical effluence on rapidity at the energy $\sqrt{s_{NN}}$ equal to 2 hundred Giga eV, for charged hadronic particles, colliding gold with gold using A Multiphase Transport modeling.

In the above depiction the red colored loop structure shows flow estimation with reaction plane's technique whereas blue square shaped structure with event plane's technique. It is clear that effluence in the middle pseudo-rapidity arena is quite dissimilar by employing two techniques. On the other hand, they provide comparable results, on the both side of mid region. The probable reason of mismatching of results at middle-pseudo-rapidity is effect of non-flow as well of fluctuations. The investigational data reflects the matched value of (v_2), utilizing two- and four- particle cumulate technique, on the both side of middle region but not at middle rapidity. It has been observed that the string melting version of AMPT is able to replicate v_2 versus η profile, but not the default as well as UrQMD modeling.

Later the work performed for v_2 versus η profile experimentally, is weighed against the AMPT-SM modeling [6]. The picture 3 compares the investigational statistics with the string melting AMPT version at the energies 2 hundred & 62.4 Giga eV. Since the inaccuracy on statistics for 19.6 Giga eV energy is too significant, so here preferred to avoid that.

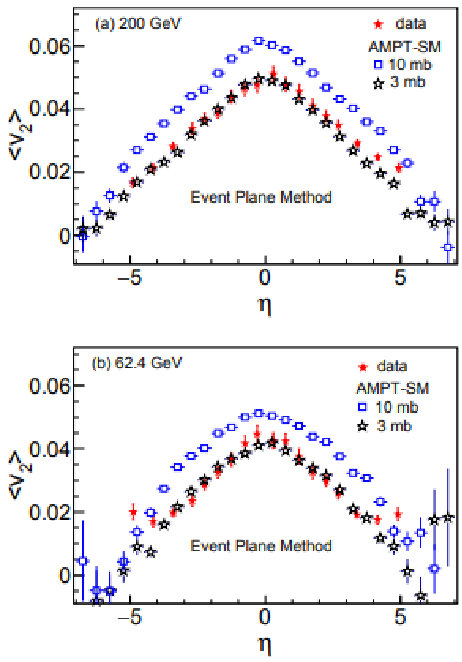

Fig. 3: Profile of Transversal momenta integrated elliptic effluence versus pseudo-rapidity, for hadronic charge particles (rapidity ranged from 0 to forty percent) in impacts amidst gold and gold, collided at 2 hundred Giga eV & 62.4 Giga eV [6].

In the above profile, red star shaped structure points to experimental statistics/data, while shapes in black and blue signifies the outcome of string melting AMPT version modeling employed via event plane's technique, with cross-sectional value for partonic interaction as three mb and ten mb correspondingly**.** The partonic interplay cross-section is accountable for creation of delimited elliptical effluence in the string melting AMPT version. So this way weighing up the investigational statistical data to string melting AMPT version, taking assorted partonic interaction cross-sectional magnitudes, is able to guesstimate the partonic interplay's sturdiness in data. The Figure 3 reflects a very good match between modeling computation data and the investigational data, by opting the partonic interaction cross-sectional magnitude as three mb, for the entire rapidity arena (at 2 hundred & 62.4 Giga eV). So overall the comparison outcome is reliable as the perturbative Quantum-chromo dynamics cross-sectional value is supposed to be around three mb [18]. The modeling computation by opting the partonic interaction cross-sectional magnitude as ten mb, gives over-expected statistics. Also the reaction plane technique for (used in string melting AMPT-version) partonic interaction cross-sectional magnitude as ten mb, portrays data only for middle of rapidity spectrum, but not the elevated rapidity value profile [12]. So it can be reviewed from the modeling performed by researchers here, that reaction plane technique used in modeling, endows quite factual averaged elliptical effluence values, while, the consequences of event plane's technique anticipates v_2, from its averaged to root mean square values according to the resolution of event-plane, non-flow effects, also the flow fluctuation [19]**.**

Thus one can predict the application of event-plane's technique, as a very good option for weighing up modeling data with investigational statistics, since $v_2$enumeration (employing EP technique) doesn't provide averaged v_2,in PHOBOS testing.

IV. Summary

The review of the simulation transport modeling work, endows for a logical explanation of dependence of elliptical effluence on pseudo-rapidity and in doing estimation with regards to identified plane of reactance also performed event plane enumeration by means of generated particles, reflects noteworthy disparities in elliptical flow magnitudes (in middle pseudo rapidity region). Yet, at elevated η both the techniques (whether EP or RP) are able to offer similar $v_2$magnitude. So one can utilize the string melting version of transport modeling like AMPT (which accounts hadronic conversion process via partonic influences & quark coalescence) for elucidating investigational data within entire pseudo-rapidity spectrum, when EP technique is employed like utilizes in investigational data interpretations. The simulation work reviewed here, clears that estimated elliptical effluence magnitude for choosing partonic interaction cross-sectional value as three mb, in string melting AMPT version, is definable over the entire spectrum of η at energies 2 hundred Giga eV & 62.4 Giga eV also the default version is incapable of clarifying the investigational data and expected results. Somehow it manifests the partonic stuff's evolution at these above mentioned energies, stated earlier. It also points out evidence of extension of partonic stuff's interaction impetuosity, far-off to the middle rapidity region.

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