

# Long Symmetric Cumulant paper : First IRC review

We would like to thank all IRC members for the prompt reviews on the paper draft as well as for many great suggestions. The replies to all IRC comments and an outline of the changes made in the updated version of the manuscript are provided below:

Paper draft location :

[https://aliceinfo.cern.ch/ArtSubmission/sites/aliceinfo.cern.ch/ArtSubmission/files/draft/djkim/2016-Nov-11-paper\\_draft-longSC\\_v3.2.pdf](https://aliceinfo.cern.ch/ArtSubmission/sites/aliceinfo.cern.ch/ArtSubmission/files/draft/djkim/2016-Nov-11-paper_draft-longSC_v3.2.pdf)

**Reviewer : Sudhir Raniwala**

Dear Members of the Paper Committee,

It has been a pleasure to read this manuscript. This shows humongous work and

as much organization of the large number of systematic results.

Congratulations.

That symmetric cumulants are (supposedly) able to discriminate between effect

of initial conditions and of temperature dependence of the  $\eta/s$  making this study very interesting. The results, and comparison with the models is fairly detailed.

1. I did not find any statement in the manuscript that validates the use of the various models. While one is making systematic comparison of correlations between harmonics of different orders, it may be imperative to ensure that the models being used are tuned to reproduce

(i) the distribution of harmonics of each order (obtained event by event)

and

(ii) the centrality dependence of the various independent harmonics.

The sentence on lines 248-249 does not really convey what has been done. (unless I have missed something gross L).

R : “We use the models in the paper which are accepted by our HI community in general and various observables from hadron spectra to flow measurements. Those comparisons can be found in their own theory papers we are citing.

But to help the reader to see the view of validity of the models we add one more sentence for the first hydro model.

Also based on Alice’s comment (see 6<sup>th</sup> comment from Alice), the first Hydro is now named as “the event-by-event EKRT+viscous hydrodynamic calculations” and added the following sentence to this model “This model gives a good description of the charged hadron multiplicity and the low  $p_T$  region of the charged hadron spectra at RHIC and the LHC (see Fig. 11-13 in [30])” in addition to “Each of the  $\eta/s(T)$  parameterizations is adjusted to reproduce the measured  $v_n$  from central to mid-peripheral collisions (see

Fig. 14 in [30]).”

As for VISH2+1 and AMPT, the similar discussions were there in the draft. For the completeness, as we have discussed in IRC+PC meeting, we will provide  $\langle v_m^2 \rangle$   $\langle v_n^2 \rangle$  comparison later.

2. Should the manuscript contain a sentence or two providing a motivation to obtain correlations up to 5th order? Limiting it up to 5th order?

R : “The need of the higher order harmonic correlations as a general is introduced in 81-87. Unfortunately the statistics are limited above 5<sup>th</sup> order. 6<sup>th</sup> above is for next paper with the higher statistic 5 TeV data.”

3. Variable is robust, or the variable is insensitive?

Use of insensitive and robust is a delicate distinction:

Line 124: Insensitive to non-flow, and reference to results using HIJING. Is this insensitive to non-flow, or robust against non-flow?

R: "Symmetric Cumulants are not exactly free from non-flow, however they suppress it well enough (as the study based on HIJING demonstrated) that it was possible for us to declare them robust against it. Therefore, in line 124 we have used carefully the phrase 'nearly insensitive', which is much weaker than 'insensitive' alone. We maintain that 'nearly insensitive against non-flow' and 'robust against non-flow' present the same statements, but we fully agree with you that we shall refrain from making a statement that SC are insensitive to non-flow."

4. Lines 134-139: The claim is being made that in effect, the second term on the rhs of eqn.3 ( also the denominator of eqn.4) depends on the non-flow. The rhs as a whole does not depend on non-flow. Does this imply that there exists contribution from non-flow in the two terms on the rhs of eqn. 3 is numerically same? Am I missing something?

R : “SC in eq.3 is doesn’t depend on non-flow, while NSC might have very small contribution left over with the eta-gap in principle. However we have shown in PAG that the effect is very small based on the comparisons with larger eta gap or HIJING subtracted  $v_n$  in the centrality ranges used in the paper.”

5. Lines 285-291: Can one conclude that integrating over all charged particles, the  $v_2$  agrees with this version of AMPT, in spite of 25% low radial flow, but does not agree for identified hadrons? Hmmm?

Ans : The agreement of  $v_n$  for AMPT is worse than two hydro models in the paper. In various AMPT papers it was mentioned that they agree well, but it is somewhat misleading. If IRC wants, we can put some details on level of the agreement. As we have discussed in IRC+PC meeting, we will provide  $\langle v_m^2 \rangle$   $\langle v_n^2 \rangle$  comparison later.

6. Lines 296-299: The various harmonics measure the event shape in momentum shape. Can one understand the positive / negative correlation between various harmonics physically without providing detailed model calculations of different parametrisations of temperature dependence of  $\eta/s$  ?

Is there a study of the dependence of (N)SCs on values of one of the harmonics ( $v_2$ ) for a given centrality?

R: "For some cases, it can be indeed explained without providing detailed model calculations of different parametrizations of temperature dependence of  $\eta/s$ . For instance, centrality dependence of normalized SC(3,2) is insensitive to different parametrizations of  $\eta/s$  (see Fig. 2, middle, in <https://arxiv.org/pdf/1604.07663v2.pdf>), and it can be qualitatively understood only in terms of the initial conditions (see Fig. 2, bottom, the same reference). It is in this sense that we advocate throughout the paper that new SC observables can be used to discriminate between effect of initial conditions and of temperature dependence of the  $\eta/s$ .

The second question is very interesting, within given centrality  $v_2$  fluctuates, and if it was possible to measure both  $v_2$  and (N)SC on an event-by-event basis, it would be interesting to see if there exists any relation between them. However, such study is not feasible at the moment, since in their present form multi-particle correlation techniques are not suitable for event-by-event analysis, due to their low sensitivity."

7. Lines 303 to 309: May be I should read this again. The reference to the figure and the interchanging SC and NSC made the reading a little difficult. You may want to write NSC on the y-axis of the figure in the right (instead of dividing it by  $\langle v_2 \rangle$ ....but I guess it is a matter of personal choice!). Also for the lines 312 to 317: Most parts of the manuscript read much better than these two paragraphs....( I do not have an immediate better suggestion).

R : "For a moment, we will leave it as it is. If some more want to do it, we can change it quickly."

8. Lines 388-390: Yes, but this also questions the validity of use of AMPT to draw conclusions.

R : "This is model dependent statement. But since AMPT is a transport model which is generally accepted in our field. There we only emphasize the fact that the better agreement for SC shouldn't be too much focused if NSC disagree between data and model." As we have discussed in IRC+PC meeting, we will provide  $\langle v_m^2 \rangle / \langle v_n^2 \rangle$  comparison later.

9. Is there a reason for separating the results for model comparisons of lower order harmonics and higher order harmonics ? Should there be a statement mentioning the reason for limiting the  $p_T$  dependence to only lower order harmonics?

R : “Since this is an extended version of the short SC paper, we prefer this way. In addition to that, the higher order harmonic flows or correlations have been realized as a supposition of linear and non-linear hydrodynamic response to the lower orders ( $v_2$  and  $v_3$ ) and this was mentioned in the introduction.”

More with the updated version after the new results with model calculations are filled in.

R : “Yes, Harri et al promised to provide SC or NSC  $\eta/s(T)$  very soon. We will have more coherent pictures in the paper.”

Thanks.  
Sudhir Raniwala

## **Reviewer : Alice Ohlson**

Dear PC,

This paper presents a wealth of interesting new data and represents a huge amount of work, and I think it is also well-written and comprehensive, congratulations! As such, I have only a few comments and questions.

1) I thought that the difficulty in measuring  $\eta/s$  was due to it being largely model-dependent, but in the paragraph at lines 60-67 it seems to indicate that most of the model-dependence comes from the choice of initial conditions. Is this true? Relatedly, I think the statement at line 105 is rather strong (and maybe not really correct), and at least needs a reference.

R : “Yes, IC is unknown and first principle calculation is not available and phenomenological issues. However our different order SC responds to IC differently. We will have a handle on it.  
See a nice summary by S.Jeon Nuclear Physics A932(2014) 349-356

The statement in line 105 is supported by the reference [31] in the very next sentence, and we put that reference also in line 105 and also the first paper which attempted to address this issue(<https://arxiv.org/abs/1101.2442>). In particular, that the temperature dependence of  $\eta/s$  is, cite 'completely unknown' at the moment is supported by the diverse choice of  $\eta/s(T)$  parameterizations in Fig. 1 in [31], each of which is at best only qualitative! To give the credits to the previous work we added one more sentence and rephrase one sentence after line 105. 105-106 changed to  
'The temperature dependence of  $\eta/s$  in the QGP was discussed in ~\cite{Csernai:2006zz}. The effects to hadron spectra and elliptic flow were studied in ~\cite{Niemi:2011ix} for different parametrizations of  $\eta/s(T)$ \$. A more systematic study with the event-by-event EKRT+viscous hydrodynamic

calculations has been just initiated in Ref.~\cite{Niemi:2015qia}, where the first (and only rather qualitative) possibilities were investigated (see Fig.~1 therein)' "

2) Lines 137-139: Was the idea that non-flow is suppressed in SC also tested for higher harmonics? Should it be?

R : "Yes, it was tested with the higher orders. Additional  $p_T$  dependent SC was also tested with HIJING and documented in the analysis note."

3) The paragraph in lines 156-170 seems really out of place to me. I'm not sure it's necessary at all (although it is an interesting idea), but if you want to keep it in I suggest that you introduce it a bit better so it's not so jarring to the reader. For example, you could start the paragraph with "Furthermore, observables like SC may shed light on multiparticle correlation measurements in pp and p-Pb" or something like that.

R: "We agree that this paragraph is a little bit out of the context - if necessary we can therefore easily chop it off without affecting the rest of the paper much. On the other hand, given the choice of the journal we do not foresee any issue with the length of the paper. That being said, for the time being we prefer to keep this paragraph alive, to invest some additional effort to make it less jarring for the audience and instead to force it blends better with the previous paragraph. As a first step in this direction, we have now replaced

'Interpretation of flow results obtained with multiparticle correlation techniques in small colliding systems, like pp and p-Pb at LHC, remains a challenge.'

with your suggestion 'Furthermore, observables like SC may shed light on multiparticle correlation measurements in pp and p-Pb.'

In addition to that, we will try to move this to the discussion session later if we are ready.

Since it is not very relevant for the current paper, we removed it now.

4) Are line 215-217 and 231-232 talking about the same thing? Or is the first instance related to the ( $\phi$ -integrated) tracking efficiency and the second talking about the azimuthal variation in efficiency? In the paragraph at line 231 it's not clear whether you correct for the non-uniform acceptance in  $\phi$  or if it's just included in the systematic uncertainties.

R : yes line 215-217 for  $p_T$  dependent efficiency (integrated for  $\phi$  and  $\eta$ ) while 231-232 takes care of the efficiency as a function of azimuthal angle. We change to the non-uniform reconstruction efficiency to "the non-uniform reconstruction efficiency in azimuthal angle"

5) The paragraph at lines 241-243 should be removed from this section and just mention in Sec. 2.3 that HIJING+GEANT is used to evaluate the

efficiency.

R: Removed.

6) Is there a short name that can be used for the model from Niemi et al.? The results section gets confusing because this model is just referred to as "a hydrodynamics model" which is really generic, and VISH2+1 is also a hydro model for example.

R : "good point" but they don't give any name in the paper. It is bit hard to name it by ourselves. As a alternative, we named it as "event-by-event EKRT+viscous hydrodynamic calculations" for a moment until we find a better name.

7) The results section is quite challenging because there are so many observables, so many data points, and so many models. I don't yet have a good specific suggestion for making this more accessible to the reader, like breaking it up into smaller paragraphs, or organizing it by correlator or by model, or even inserting a table or a bullet list, so I need to think about this more and maybe we can discuss this on Tuesday.

R : We listed the key findings in the end of the model comparison part before the pt dependent SC.

8) I don't really understand the statement that the correlations between  $v_n$  harmonics gives "orthogonal" information to the correlations between symmetry planes. I would just say it's "additional" information.

R: We can replace ' orthogonal ' with 'additional', but perhaps even better would be 'independent' ", after getting Ilya's comment, we changed to 'independent'

9) There are many typos and English errors throughout. Since I don't expect there to be large rewriting of the text, I will also send a list of these small corrections in the next day or two. One cosmetic thing I would point out is that  $\eta/s(T)$  looks like eta divided by s(T) to me. Maybe this could be clarified by writing  $^{\eta}/_s(T)$  or some other type of slanted fraction, but I'm not sure, it's just an idea.

Ans : Yes, we tried to change as you suggested, but it doesn't look good. Until we find a better solution, we leave it as it is. Note this convention was used in the short SC paper and also in the theory paper.

Best wishes,  
Alice

**Reviewer : Ilya Selyuzhenkov**

9 : cumulant method -> correlation observables

R : Done

10 : This method -> These observables are

R : Done

12 :  $v_3-v_2$  -> correlation between  $v_2$  and  $v_3$  and  $v_2$  and  $v_4$

R : Changed to Correlations between  $v_2$  and  $v_3$ ,  $v_2$  and  $v_4$

14 : models -> model calculations.

R ; Done

14 : comparisons->comparison, models->model

R : Done

18 : same as line12

R : Changed to Correlations between  $v_2$  ,  $v_3$  and  $v_4$

19 : equilibrium distribution -> distribution of what ?

R: We expanded for now as "equilibrium distributions of hydrodynamic fields", and will check further with the theorists if more precise statement is required.

This was also corrected in 478

18--- need to add  $\eta/s$  T dependence

R: We believe that you refer to line 16. We have now replaced in this line "the shear" with "the temperature dependence of the shear" 40 : the QGP matter ->  $\eta/s$  of the QGP matter.

R : Done

40 : remove This in turn...

R : Done

41-43 : not relevant for LHC ?

R : This is an implication based on the paper cited. Sure it should be and there is no reason that  $\eta/S(T)$  is different from RHIC. Only that question is that because of the system size, which stages of the collisions contribute more to the final state particle distributions.

44 : harmonics  $v_n$  -. nth-order flow coefficients

R : Done

47 : remove N, the energy -> the particle's , remove "particle yield and total"

R : Done

48 : remove "particles"

R : Done

53 : fluctuations of the positions -> fluctuating position, remove "in turn"

R : Done

54 : the flow ->  $v_n$ , remove "has"

R : Done

55 : remove flow, as well as the correlations -> as well as to the correlation, Fourier ->  $v_n$

R : Done

56 : remove "particularly"

R : Done

57 : to the  $\eta/s$  -> to the magnitude of  $\eta/s$ , while correlations -> while  $v_n$  correlations

R : Done

58 : the two respective -> between these , remove "anisotropic..."

R : to these two respective contributions

60 : However, difficulties on -> Difficulties in, can be attributed -> are mainly stem from uncertainty  $\eta/s$  does not depend on IC.

R : Yes,  $\eta/s$  does not depend on IC but the extracting  $\eta/s$  depends in IC. Since we cited the correspond the theory papers, the current one reads better for us.

62 : in these calculations , which calculations ?

R : changed to hydrodynamic calculations

63 : history -> evolution remove "as it is known"

R : done, we will leave 2<sup>nd</sup> one as it is.

65 : temperature dependence , dependent of what ?

R : add  $\eta/s$

68 : hydrodynamic simulations -> hydrodynamic model simulations

R : Done

69 : remove "probability"

R : we think it is more correct than w/o it.

70 : remove "calculating the distributions of" , 71 : eccentricity -> eccentricities

R : We don't see why we have to remove since we show how we calculate it here.

72: comma after the eq2 ,remove where , the->The , the transverse plane-> spatial positions ? add where

R : we think the current form is better. We remove "from the nucleon position' since we talk about the energy density profile.

81,83 : viscous hydrodynamics vs viscous distributions ?

R : We use this term from the cited paper where it is clear that this is important in hydrodynamic calculation with viscosity properly implemented and we can say "viscous distributions" in a correct term, shear stress tensor and it's correction at hadronic freeze-out but we keep here more general term here. The details can be found in the cited papers.

86 : probably -> among

R : Done

87 : understood -> studied

R : studied a bit in theory side and we don't know how to constrain it experimentally and so we think understood should read better.

88-91 : should provide more details on SC already here, Move sec2.1 here ?

R : We think it is matter of preference. We prefer we have a short introduction and give some details and even we repeat it in latter section.

95: that analysis-> the analysis of SC observables. harmonic correlations -> harmonics

R : Done

97: comparisons -> comparison

R : Done

remove subsections later on,

R : Done

105 : While from existing measurements an estimate can be placed on -> The existing measurements provides an estimate of

R: Done, with minor modifications. In particular, we have replaced "While from existing measurements an estimate can be placed on" with "The existing measurements provide an estimate only of", and then started a new sentence in 106 "energies, what" => "energies. What"

108 : consensus of late -> picture



R: Done, but perhaps even better would be to use "conclusion", instead of "picture".

109 : remove "it is unlikely that" -> unlikely reveal

R: Done. We have dropped now "it is unlikely that", and prepended "unlikely" to "reveal" later in this sentence

110 : remove "In fact" and the initial study

R: Done. Done.

111 : remove "flow"

R: We kept it, since we have phrased it this way also in 109.

112 : remove "by the theorists"

R: Done. In addition, we have removed the comma before "which", to accommodate better this change.

113 : The initial success of these new -> This, was attributed to their -> have

R: Done, we have replaced "The initial success of these new" with "These", and "was attributed to their" with "have".

114 : remove "for the first time" and two respective remove '—'

R: Done. Done. Done.

115 : remove "Therefore" and "in turn"

R: We have kept "Therefore" because it blends better this way with the content of previous sentence. We have dropped "in turn".

116 : enable -> provide, verification of -> constrain on

R: Done. Done, with minor modification "verification of" => "constraints on the".

117: remove "independently" and "this advantage"

R: We kept "independently", because we maintain that it is important to stress out that we can constrain different stages independently, and not cumulatively all of them put together, like it is done with individual flow harmonics. We have replaced "Besides this advantage" with "In addition".

118 : remove "details" add "temperature", nearly insensitive-> weakly sensitive

R: Done. We have dropped "(T)" and inserted here instead "temperature". We maintain that there is no difference between "nearly insensitive" and "weakly sensitive", so perhaps we shall just flip the coin... Nevertheless, since we have "sensitive" in the first part of the sentence, we prefer a little bit more not to repeat it in this part as well.

120 : remove "technical" and "detail in Refs"

R: We have now replaced "For technical reasons, discussed in detail" with "For reasons discussed"

121 : remove "by the theorists"

R: Done.

122 : remove "Ref" and "Instead", obtained from-> based on

R: Done. We have replaced now "Instead, in" with "In" and "obtained from" with "based on".

123 : remove "to quantify... way", i.e nearly -> i.e are nearly

R: We have now replaced "were introduced to quantify in the most reliable way (i.e. nearly insensitive to nonflow) the correlation of amplitudes of two different flow harmonics." with "were introduced. SC observables are nearly insensitive to nonflow and quantify the correlation of amplitudes of two different flow harmonics."

124 : nonflow, the correlation-> and quantify

R: See previous comment.

124-125 : remove "The technical ..... while"

R: Done, and we have now replaced "the first" with ". The first"

125: released -> published

R: Done.

126: remove "Ref"

R: Done.

127: defined as : -> defined as : ( for details see Sec.4,C in[40] )

R: Done, we have now replaced ":" with "(for details see Sec.~IV~C in~[40]):"

Eq3 : remove the last one, this is not a part of a definition

R: We have decided to keep it, since only written this way it's clarified explicitly how SC observables can be related to correlated fluctuations of two different harmonics. Since this line comes straight from definition, we maintain it doesn't really hurt to keep it here.

128 : remove the last sentence.

R: Done.

130 : SC(m,n) can be normalized with the -> Here the SC(m,n) normalized by, remove "obtain normalized ....

which we denote -> is donated, remove i.e

R: We have now: a) Replaced "SC(\$m\$, \$n\$) can be normalized with the product" with "In this paper SC(\$m\$, \$n\$) normalized by the product"; b) Dropped "to obtain normalized symmetric cumulants"; c) Replaced "which we denote" by "are denoted"; d) Replaced ", i.e." with ":"

eq4 -> add " $\approx \langle v_{n2} v_{n2} \rangle / \langle v_{m2} \rangle \langle v_{n2} \rangle - 1$

R: Since we prefer to leave Eq. (3) intact, this addition to Eq. (4) we find unjustified, i.e. this relation can be trivially obtained from last line in Eq. (3).

135 : remove "and", to -> , which suppresses

R: Done. Done, we have replaced "to suppress biases" with ", which suppresses biases"

136 : few-particle nonflow -> few-particle (nonflow), "On the other hand, in"-> For

R: We maintain that "few-particle correlations" and "nonflow correlations" are not synonyms, therefore we think it's not really correct to embed nonflow in the parentheses, which would hint they are in fact the synonyms. Namely, due to collective anisotropic flow, correlations are present at any level, two-particle, three-particle, <your-lucky-number>-particle, etc. That being said, few-particle correlations can originate both from flow and nonflow, and in order to distinguish the two, we wrote "few-

particle nonflow correlations". On the other hand, we have dropped "On the other hand" ;-). Finally, we have replaced ", in" with ". For"

138: in SC observable, as the study based on HIJING .....-> This was verified by HIJING

R: Done in a different way, we have replaced now "in SC observable" with "in this case". Done, we have replaced ", as the study based on HIJING model has clearly demonstrated in Ref. [39]." with ". This was verified by HIJING model simulations in [39]."

140: first -> ALICE, remove "of SC observables have"

R: Done, we have replaced "first" with "ALICE", and we have replaced "of SC observables have" with "[39]".

141: details -> pattern

R : We think details is better here.

143 : Most importantly, the -> The observed

R: Done, we have now replaced "Most importantly, the centrality" with "The observed centrality".

144 : the temperature plays an important role in describing QGP's eta/s .... evolution -> the temperature dependence plays an important role

R: Done, well spotted! We have now replaced "dependence, indicating clearly that the temperature" with ", indicating clearly that the temperature dependence". We have dropped altogether the second part of the sentence starting with "in describing ...".

146 : remove "and"

R: Done, we have replace now "conditions and it" with "conditions. It".

147: remove "in"

R: Done.

148: add about quark degrees of freedom

R: Can you please suggest the concrete sentence/statement to be added here? Or probably we don't need to discuss it here.

149: orthogonal -> independent, to -> that obtained from

R: Done. Done.

150: remove "in Refs"

R: Done.

150-151: This statement..... can be"-> Providing different , remove "in the recent ..."

R: This comment is rather a mystery to us, can you please demystify it a bit? Telepathy unfortunately is not working well these days... ;-). we keep it as it is until we know the exact concern.

153: a concrete -> an, remove "it was discussed that"

R: Done. Done.

154:  $V_4$  and  $V_2^2$  , why capital ?, vectors , who are vectors ?

R: This is the notation and terminology from the reference [41] which is cited in this sentence.

156-170: remove , this does not belong to this paper

R: We would keep it since this is very important issue and we can address this with new pPb data.

Maybe we can have split the current summary section to "Conclusion" and

“Summary”. Then we can put 156-170 in new summary of summary. Let’s try this.

171: event and track selection -> Data Analysis

R : Done

172: The data sample -> A sample of Pb—Pb collisions at 2.76 TeV

R : Done

179: used for this analysis -> selected

R : Done

187: with the choice of low pt cut-off we are -> The pt cut-off of 0.2 GeV/c

R : Done

188: from smaller-> due to small

R : Done

189: was introduced to -> reduces

R : Done

190: Reconstructed tracks -> Reconstructed TPC tracks, 70 TPC -> 70

R : Done

192-194 :

R : change to “This reduces the contamination from secondary tracks produced in the detector material, particles from weak decays, etc.”

197: what about centrality estimators ?

R : This is a part of Event selection, so I would leave it as it is.

198-199 :

R : we don’t understand what is the suggestion ?

202; remove “then”, final value of the -> total

R : Done

203-204 : remove “of centrality determination”

R : Done

205; detectors instead of the default -> for centrality estimation

R : Done

206: were -> is

R : Done, change uncertainties to uncertainty

208: in-> along the

R : Done

209: an->a

R : Done

210: remove “for all vertices”

R : We leave as it is, it sounds more complete.

212: magnetic field polarities-> L3 magnet polarity, same for 213

R : Done

214: the results from-> variation between

R : Done

215: remove “polarized”

R : Done

215; not clear what is this about ? why jump to MC matching ?

R : We remove this and just mention the systematic uncertainty due to the pT dependent tracking efficiency.

218: Magnetic polarizations -> Magnetic polarity variation

R : Done

218-219: remove “relatively .... were”

R : Done

220: using two additional tracking criteria, first relying on -> from comparison between results for

R : Done

220: TPC tracking -> TPC tracks

R : Done

222: remove "the second.... on the"

R : Done

227: remove "results"

R : Done

228: effects on -> contribution in

R : Done

229: both ... combinations : isn't this the same ?

R: We have now replaced "between both charged combinations and like-sign combinations" with "between results obtained by selecting all charged particles and results obtained after either selecting only positively or only negatively charged particles". Btw, in the second part of the sentence, we have replaced "were" with "was" and "they were" with "it is", since this refers to "difference".  
231: One of the other largest contributions-> Another large contribution

232: the effects..... -> it's effect

R : Done

233: models -> model, remove "the details in"

R : Done

234: Then we enforce detector inefficiencies by imposing-> Detector inefficiencies was introduced to mimic, from-> in acceptance

R : Done

235; remove two " , "

R : Done

236: the uncertainties from the -> variations due to , "distribution... were" -> is

R : Done

237: Generally -> overall the

R : Done

238: ->  $SC(m,n)$ . This is because  $v_n$  are decreasing with  $n$  increasing and become more sensitive to azimuthal modulation due to detector imperfections.

R: changed to "This is because  $v_{\{n\}}$  are decreasing with  $n$  increasing and become more sensitive to azimuthal modulation due to detector imperfections."

240: This section should be reduced to the minimum needed and then embedded to the Sec.5(model comparison)

241-243 : move to sec 2.3

R : we removed this.

250: remove "is an theoretical model -> calculations, based -> are based

R : Done

253: some -> given, conditions ( like AMPT...)-> condition describe later, it could fit -> could describe

R : Done

254: many related soft hadron data, such as -> consistently describe

R : Done

257: remove “of the QGP fireball”, a mixture -> contributions

R : Done

258: remove “density profiles”

R : We would keep it.

261: fluctuations -> fluctuation

R : Done

265: changeable -> what does this mean ?

R : We meant that the Gaussian parameter can be changeable but apparently it is not well formulated. We remove “makes the typical initial fluctuation scales changeable which”

267: Finally .... of the -> T, our ->SC, by utilizing -> is compared to that in

R : Done

270; energy -> short time scales

R : Done

281: presented -> used

R : Done

269-280 ; this should be replaced by a reference to AMPT model

R : We think AMPT contains more lines but we think it conveys the message and it might help reader since we give more credits to hydro calculation elsewhere.

287,289 ; GeV -> TeV, unit accordingly # /1000

R : Done

294: remove “the recent publication”

R : Done

303; remove “however”, NSC -> the NSC

R : Done

309 ; we should have a figure for  $v_n$  in the paper + model comparison

R : As we have discussed in IRC+PC meeting, we will provide  $\langle v_n^2 \rangle$  comparison later.

315: centrality dependence -> correlation, harmonic -> harmonics, remove “correlations”

R : Done

318; obtain-> study, remove “results”, vary minimum-> change the low pt cut-off, bin-by-bin-> using independent

R : Done

320 ; need “of” between “dependence” and SC(3,2)

R : Done

325: remove “clearly”

R : Done

326: remove “may” and “does not .....results... values” -> is dominated by the pt dependence of  $\langle v_n^2 \rangle$ .

R : Done

329: As for -> While, “the” -> show, are observed -> as, however-> the

R : Done, probably we don't need “the” there

330: as the -> with increasing, remove “or the centrality increase”

R : Done

334-336 ; How do we know that this is not because of “problems’ in  $\langle v_n^2 \rangle$  used for normalization?

R : We have checked the results with lowering maximum pt cut-off as well.  
We see very similar results. If there is any remaining non-flow, it is included in the systematic uncertainty.

337-338 ; move/merge Sec.3 here

R : Done, also changed the order in the intro. We have removed “The details on AMPT setting can be found in Sec. 3” from the figure captions.

339; remove “First”

R : Done

341; remove “on the”, in->of

R : Done

345-346 : the initial ellipsoidal...characteristic , not the right way to phrase it

R : we think this is ok

349: These observed distinct -> This

R : Changed to “This observed distinct discrepancy between data and theoretical predictions indicates”

351; on-> in

R : Done

353; remove “Hence”

R : Done

354; medium is not fluctuating

R : change to “on the detailed modeling of fluctuating initial conditions”

356: the models -> calculations

R : Done

359: on the other hand, among the models -> Among the calculations

R : Done

361; as the above mentioned -> to

R : Done

362; these -> the, its signature in the-> calculation in Fig.3 that in data for 0-10%

R : change to “in the model calculations in Fig~\ref{fig:Figure\_3} is opposite to that in data in 0-10% central collisions”

368: MC-glauber initial condition with -> large, can be -> is, come to ..... model parameters-> conclude

R : changed to “the calculations with large  $\eta/s=0.20$  is ruled out. We conclude that  $\eta/s$  should be small”

370: Finally,... from -> The SC(m,n) calculated from, AMPT -> AMPT calculations, in the same way as for the data are compared -> are compared to data.

R : Done

371: settings-> calculations

R : Done

372: model somewhat -> settings , setting -> default calculation

R : Done

373: remove “NSC(3,2)..... the”, of -> and magnitude of , remove “all”

R : Done

375: capture -> reproduce, well where -. and

R : Done

377; melting configuration with -> melting configuration of AMPT without , remove “off”. remove “to quantify..”

R : change to “the string melting AMPT model cannot reproduce”, Done  
379; remove “it is”

R : Done

380-383: this is obvious because the diff between SC and NSC is exactly  $\langle v_n^2 \rangle$

R : It is just a fact that we also checked

387; remove “, where”

R : Done

391; this is equivalent to  $\sqrt{\langle v_n^2 \rangle} + \text{NSC}(m,n)$ , no need in SC.

Discussion of the  $\eta/s(T)$  dependence is missing -> will come with Fig5 data + model points.

We need to see the comparison on  $\langle v_n^2 \rangle$  in data + models, in particular  $v_n(\text{pt})$  shape and yields.

R : As we have discussed in IRC+PC meeting, we will provide  $\langle v_m^2 \rangle \langle v_n^2 \rangle$  comparison later.

430; remove “Low order harmonic” -> between  $v_2, v_3$  and  $v_2, v_4$

R : Done

447-451 ; It would really help for discussion to have the AMPT default +w/o hadronic rescattering, what is the time scale ?

R : requested

459; remove “method”, in the recent ALICE paper-> earlier in [39] reported for

R : Done

462: feature was ..... between -> measurement were compared to, hydro -> hydrodynamic

R : Done

464: We have -> It is

R : Done

465: on -> in,

R : Done

467: role of the -> effects of , remove “furthermore”

R : Done

469: i.e -> where , characteristic for -> with is dominating , remove “in the regime”

R : Done

470: remove “hence”

R : Done

471-480: it should be stressed here that AMPT “default” is very good at reproducing NSC.


R: We have now inserted in 476 before "Finally" a new sentences: "The default configuration of AMPT model describes well the normalized symmetric cumulants ( $\text{NSC}(\$m\$, \$n\$)$ ) for most of centralities and for most combinations of harmonics which were considered. Together with the measurements of individual harmonics these results provide further constraints on the system properties and help discriminating between theoretical models."

Figure comments

We don't write here all and only responses to the comments.

R : we correct typos/Label/Title fonts / Re-locate legend position fonts suggested.



As for Fig2, we will keep it as same as before instead of show the ratio where it has large error bars and we need to take care of systematic errors. Rather we clearly show them as a function of  $p_{t\_min}$  in the model comparison. Such a figure can be found in the analysis note at <https://aliceinfo.cern.ch/Notes/node/495> 

----- End of IRC comments

Additional changes

1) In addition, We have added panel ID in each subfigures a.l.a (a), (b) .... This can help readers as well. The texts have been updated accordingly.

2) Comments from Sami Rasanen are listed below and we thank him for the comments and the suggestion to line 105 to add important previous work by the theorists ( see 2<sup>nd</sup> part of 1<sup>st</sup> comment from Alice.)

129: Eq. (3)

-> fixed

131: measurements with [39] have —> measurements [39] have

-> fixed

227: add citation: " ... extremely high energy [PRL115(2015)No.18,182301], the dense matter ..."

-> done

Fig 1, caption: order up to 5th —> up to 5th order

->fixed

261: almost same —> almost the same

->fixed

Remaining todo list

1. Model comparison to EKRT+hydro  $\eta/s(T)$  plot and once we have it, just minor changes of the text are needed.
2. As we have discussed in IRC+PC meeting, we will provide  $\langle v_m^2 \rangle \langle v_n^2 \rangle$  comparison later.
3. The default AMPT w/o hadronic rescattering production was requested. Currently the string melting AMPT w/o hadronic rescattering serves a role and effect was mentioned already in the paper, this new production will provide more quantitative answer.