Comments from the UIC group:

General comments:

The abstract/text (section E) states that the measurements are compared to the theoretical calculations. However, no explanations/hints are offered for why the modeling of the data is not fully successful. Providing some insights on this would be useful.

Answer: The last sentence in the abstract is now modified as:

Change “All of the measurements are compared to state of the art theoretical calculations for transverse-momentum-dependent parton distribution functions and fragmentation functions.”

To:

All the measurements are compared to QCD-based theoretical calculations for transverse-momentum-dependent parton distribution functions and fragmentation functions. Some discrepancies in particular in understanding the origin of isolated $\pi^0$ TSSA are found, which indicates new mechanism might be involved.

One of the main messages of the paper is that there is no energy dependence from 19.6--500GeV, but it seems like this observation comes from a mixture of different pT and xF bins, so we are not sure how this statement should be interpreted (plus a significant discrepancy between old/new STAR data creates an additional hurdle here; we further comment on this below).

A: The general statement of no energy dependence of A\_N up to 200 GeV is already a consensus before this measurement, and this measurement presents new data at 200 and 200 and 500 GeV. The detailed comparison in different x\_F bin versus p\_T in Fig. 5 indeed shows a good consistency of 200 GeV and 500 GeV data within statistics.

The conclusions of the paper are not very clear (quite possible due to our lack of expertise on the topic). The papers punchline is: "the observed small TSSA... suggest that the Collins effect itself cannot account for the observed pi0  TSSA. On the other hand, the observed small TSSA for em jets indicates the contribution from the Sivers effect cannot be the dominant source of pi0 TSSA." This may be obvious to the experts, but would you please kindly educate the rest of us on the subject (who tend to think "it must be Collins or Sivers")?

A: In the summary, we mostly summarized what we observed from data and some direct indications. As we put some discussion( Lines 654-662 new version), most of the current theoretical frame works assume pi0 come from parton fragmentation after partonic scattering, which is thus related to Collins or Sivers effect. But our measurements on either Collins or Sivers are found to be much smaller than expected to explain the observed pi0 TSSA. This pointed to a possibility that those non-isolated pi0’s with larger TSSA are not from hard partonic process, but rather probably some new process like diffractive process. We tend not to put too strong statement, as this mostly will need theory efforts and more data to confirm. But, we agree to provide slightly more information by adding a new sentence at the end of the paragraph (Line846-851 in the new version):

“The sizable TSSA for isolated $\pi^0$ thus indicates a new mechanism, likely diffractive process could be a significant source for the $\pi^0$ TSSA in polarized proton-proton collisions at STAR, and more theory efforts and dedicated measurements are called for to have a complete understanding on this aspect.”

Other comments:

title: Measurement of transverse single-spin asymmetries of π0 and electromagnetic jets at 200 and 500 GeV in polarized proton-proton collisions at forward rapidities at STAR

->

Measurement of transverse single-spin asymmetries of π0 and electromagnetic jets at forward rapidity in 200 and 500 GeV polarized proton-proton collisions at STAR

 Done

For consistency: consider updating all "transverse momentum" mentioning to "pT" except the definition

 A: Done.

The "transverse single-spin asymmetry" and "TSSA" appear intermittently in the text; please update for consistency.

 A: Done . Now the full term only appeared once in the summary, and others appear in the figure caption.

l.118 at center-of-mass energies, consider adding \sqrt(s\_{NN}) the use it latter

 A: We prefer to use the words.

L.126: define \pi^{0} back in line 118

Done, changed “neutral pion” to \pi^{0}

L.179-184: It appears the paper states that extracted ETQS-function and Sivers function, when assuming the initial-state effect as the main source of the TSSA, do not coincide. We suggest to make it more explicit by e.g., replacing "However" by "When assuming this,"

 A: The assumption only applies to hadron-hadron collisions and Sivers functions extraction in SIDIS does not need this assumption. Since this paper only discuss the TSSA in hadron-hadron collisions, we feel it is OK.

L.202 and 204, the 222: Spell out "STAR (Solenoidal Tracker At RHIC) Collaboration at Relativistic Heavy Ion Collider (RHIC)" the first time it is mentioned in 202 ,for the rest  use just "STAR Collaboration" or "RHIC," as needed

 Done

L.219: Would be good to add a brief description of upcoming sections

A: We added one paragraph at the end of the introduction (L224-233 in new version):

The rest of the paper is organized as the following. Section II provides the analysis details including brief overview of RHIC and FMS detector used for this analysis, event selection, $\pi^0$ and jet reconstruction, and the methods of spin asymmetry calculation. The correction and systematic uncertainty studies are discussed in Section III. Section IV gives the TSSA results for inclusive $\pi^0$, isolated $\pi^0$ and jets, and the Collins asymmetry results for $\pi^0$. Finally, Section V presents a summary of the measurements.

L. 273 trigger was -> triggers were

 Done

L. 293-295 What is the z-vertex resolution by BBC? How does the limited z-vertex resolution affect the reconstructed pi0 and EM jet kinematics? Have the uncertainties been reflected in the x-axis of the asymmetry figures?

 A: z-vertex resolution by BBC should be about the level of 20cm. z-vertex do affect the reconstructed pi0 and EM jet kinematics by affecting the incident angle. The bias , however, is way smaller. So the effect is very small considering it is far less than 20 cm over 700 cm which is the distance of the FMS. We have discussed in the GPC that the uncertainties in the x-axis are better left no shown in the figures, and they are discussed with details in Sec. III-A.

L.302 "a combination of cuts to the sub-detectors." – pure jargon, please rephrase along the lines that selections were made based on information from the sub-detectors.

 A: changed to (L313-315 in the new version):

“ These events are removed effectively with selections based on information from sub-detectors BBC and ToF.”

L.308 Does the requirement on TOF multiplicity have any bias on the asymmetry measurement? Why or why not?

  A: The requirement on TOF multiplicity was to eliminate the non-collision background. So it does not introduce bias but help us to get the correct asymmetries. And since this non-collision background only takes a few percent in the dataset, the change of asymmetries are very small.

L.345:  the signal shape and background shape->the signal and background shapes

 Done

L.350 Eq.(1) -- Alpha function in Eq.1 is not defined, please fix

Done

L.358: In this analysis->In this analysis,

 Done

L.361 Define R. Please add a note what motivated the choice of R? Also, add space before/after "=" (as in other in-text equations).

A:  added “radius parameters R”. R=0.7 is our choice as STAR spin jet analysis.

L.371-372 Sec. III-C states that the jet energy is corrected to the particle level, where final state particles after removing charged hadrons are used for particle level jet reconstruction in PYTHIA. This suggests that the constituents of such particle level jets not only include photons, but also charged leptons, and charge neutral hadrons. This is inconsistent with the statement here that only photons are used. Please be explicit (to photon level?) or clarify what is meant.

 A: Here the particle level particles are actually photons. To make this more clear, we add “…stable particles (photons for EM-jet)….”

L.414 This subsection describes not only Collins asymmetry but also jet TSSA. The title should reflect it.

 Done. We moved to previous subsection and modified accordingly.

L.425-428 We suggest moving these two sentences to the beginning of the next paragraph.

 Done.

L.428 Eq. 5 define A\_UT

 Done. Added in the beginning of subsection.

L.438-440 We are not completely sure about this sentence. What nature of pi0 reconstruction algorithm makes it OK to forgot background subtraction? How the resulting effects mitigated?

 A: We modified the sentence to “For this way of $\pi^0$ reconstruction, we do not perform a background subtraction for the Collins asymmetry. The possible influence from background is studied through the mass dependence of the asymmetry as discussed in Sec. IV-D”. See L474-478 in the new version.

L.443 Energy uncertainty – the sub-section states some numbers for uncertainties (different between years) and provides no slight detail (or reference) on how those were estimated and validated. We find this deficiency critical and of high priority to address.

 A: We think they are very detailed information on each part of these uncertainties, which can be found in Zhanwen’s thesis, so we add a reference to it for those readers who are interested in them, see L502 in the new version:

“The details on these energy uncertainties can found be in Ref. \cite{Zhanwen-thesis}”

L.484 "this uncertainty is less than 5.8% of the magnitude .., and therefore  is not drawn in the final results." – though we understand this uncertainty is too small to affect the physics interpretations, we find the choice of picking some uncertainties over others questionable. The sentence should just stop after "the magnitude." And the error simply added with the rest in quadrature.

 A: We removed “ and therefore is not drawn in the final results”. This part is the only systematic uncertainty for pi0 A\_N, and it is smaller than the size of markers, thus invisible. We add sentence “Please note that it is invisible in the TSSA result plots in next section as it is smaller than the marker size.” (L532-533 in the new version), and also mention it in the figure captions of Fig.4,5,7, “A Systematic uncertainty up to 5.8 % of AN for each point is invisible, as they are smaller than the size of the markers.”

L.453 which differ for every case? -> Does "which" refer to "energy uncertainties", "energy" or "photon"? If change "which" to "and"

 A: changed "which" to "and"

L.488 What is the origin of these very-high energy jets? Please add an explanation.  What is the relative pT dependence of these non-physical events? (the text says that shape is "approximately linear" which is vague)

 A: The jet background is possibly from pile up of non-collision background to normal events. The pT spectra of jet background is shown in Fig. 8.7 of page 71 in the analysis note, and the relative pT dependence in the region of >120 GeV is following the linear trend. We modified the sentences accordingly.

L.497-504 It is unclear how this approach of background estimation is justified, where it is assumed that the background jet spectrum is linear and can be extrapolated from 120 GeV to the lower jet energy region down to 20 GeV. Please clarify.

  A: The extrapolation approach is a reasonable way in providing an estimation of the background, based on the observed linear trend of the background >120 GeV. There is no better way of doing it so far. Since the highest fraction is just a few percent (~3%), we do not assign a systematic uncertainty related with this background estimation.

L.511 add space before/after "=" (as in other in-text equations).

 Done.

L.518 Specify the PYTHIA version and tune. If it is the same one as line 353, make it clear.

 Done.

L.589: The lower panel in Fig. (6)->The lower panel of Fig. (6)

 Done.

L.581+  It is argued that the earlier 200 GeV STAR results are lower than the new ones due to lower mean pT. However, as plotted in Fig 6, the mean pT from E704/PHENIX/RHICf are also lower than those measurement in this paper, yet the AN result are somehow stay on the same trend. How do we understand/reconcile this?

  A: This was also discussed in GPC carefully. Previously the dependence of A\_N versus x\_F has been mostly studied, and pT dependence was also investigated in particular by STAR data in 2008 with some surprise. Like in Figure 5, the trend versus pT is understood by the model calculation, but the magnitude not well produced. The previous and current STAR data cover very similar pseudo-rapidity range, their difference can be understood by the pT difference. For the comparison with E704/PHENIX/RHICf, the details on pseudo-rapidity, pT etc need to be considered also. At the end as mentioned in our summary, the real physics mechanism still needs more efforts for a complete understanding on forward pi0 TSSA, in particular those isolated pi0.

To the above point, it seems from Fig. 4, the AN from 200 and 500 GeV are consistent, but the mean pT is quite different. This seems contradict to the argument mean-pt argument, or the interplay of energy/pt is more complicated (most likely) and the difference old/new STAR data could not be just brushed off to this.

 A: For a detailed comparison on x\_F and p\_T dependence of 200 GeV and 500 GeV data, one should look at Fig. 5 with better binning on them, where the comparison is in quite reasonable agreement. There is binning effect in Fig. 4 for p\_T dependence.

L.671 within statistics -> within experimental uncertainties

 Done.

L.688 particle's transverse momentum -> particles' transverse momenta

 A: The Collins effect is defined for a single hadron, so will added as “a particle's transverse momentum”.

L.703 Choice of dR cut – please specify if that was optimized based on MC or using some data—driven methods.

 A: It is optimized as explained in previous sentence: “The value of this cut has to be balanced between the benefit of excluding those events and their large uncertainty or the loss of statistics at high z”. This value is also the same as used in previous STAR paper, so we also mention it to this reference.

L.705 remove extra space in "Sec. II-E.2"

 Done.

L.712 In the previous sentence, there are two mass regions. It is unclear "this region" is referred to here. Please clarify.

 A: Here “this region” meant [0,0.2GeV] and [0.2,0.3GeV]. We modified this sentence to:

“A comparison of the Collins results in the region of (0, 0.2) GeV/$c^2$ and those in the region of (0.2, 0.3) GeV/$c^2$...” See L748-750 in the new version.

L.746 We cannot say the theoretic calculations overestimate the TSSA at higher xF for 500GeV data, because there is no 500 GeV data at high xF.

  A: This is true. We modified the sentence to:

“They underestimate the $\pi^0$ TSSA in the lower Feynman-$x$ region for both 200 and 500 GeV data, but overestimate it in the higher Feynman-$x$ region where 200 GeV data are available.” See L782-785 in the new version.

L.777 highest statistics -> largest data sample

 Done.

L.802, 805 can not -> cannot

 Done.

FIGURES:

General: most figures could use bigger/filled symbols to help follow the trends; this becomes critical for figures with multiple dataset overlays.

A: We enlarged the marker in Fig2, change the marker to solid in fig5. In figures 7 ,8 ,9, 11, the open marker was meant to separate the different category in the same year, for example isolated/non-isolated(fig7,8) , this paper/other paper(fig6). As for figure6 ,11, too many filled symbols make it hard to distinguish. As for the marker size, we think in most figures the size is modest.

The style of the axis title is not always the same (brackets of units to be square or round; whether the slash line in the unit makes the unit into 2 separate lines, whether there should be a slash between the unit and the variable, etc). Please update throughout for consistency.

 Done

Figs.4-7 and 9 add (a), (b).... to the different panels

A: We did such changes to Fig5, where the 3 panels meant for same messages with different kinematics. For the rest of figures, the panels for Asymmetries and panels for Pt value are so different that it barely causes any confusion. So, we keep them unchanged.

Fig.1: add the titles for x and y axis

A: We think it is not necessary to do so, considering it is just the same figure we cite from the last FMS paper

Fig.2: add the title for y axis

 Done

Legend: Style consistency: There are light gray frames around the line for combined fit, pi0 signal, background, but isn't any for data.

 Done

Replace "data" with "STAR" (or "500 GeV pp")

 Done

Figure 4: Do the error bar represent total (stat+syst) uncertainties? Please state this in the figure caption.

A: We added “The error bars are statistical uncertainties only. A systematic uncertainty up to 5.8~\% of $A\_N$ for each point are invisible, as they are smaller than the size of the markers.” to all relevant figure captions.

Fig 5: the legend on y-axis needs more space and the lower limit of y-axis should be -0.05 if I read correctly. Also, the font sizes on x-axis are different, the middle one is clearly smaller than others (but this might not matter).

Done

There is a large gap between "not shown" and "3.0/3.4 ...". Suggest to move "not shown" into the same panel and below "3.0/3.4 ..."

 Done

Fig. 8 Please change the y-axis label to "pi0 fraction" for clarity

A:  We think this is not necessary since the legend points out those are all meant for pion.

Fig.9, Cosmetic: the results from ANDY (black crosses) are practically invisible in this figure; it hard to tell if they are consistent with 0 or not. Please increase/brighten the symbols and consider adding a dashed line at 0 to guide the eye.

Done , and we change the statement into ANDY result has small asymmetries instead of consistent with 0.