

Analysis Note for the STAR Publication:
“Harmonic decomposition of three-particle azimuthal correlations at RHIC”

PA's: Ron Longacre, Paul Sorensen, Jim Thomas, and
 Prithwish Tribedy.

<https://drupal.star.bnl.gov/STAR/content/three-particle-harmonic-decomposition>

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Data sets and QA:

We've analyzed data from 7.7, 11.5, 14.5, 19.6, 27, 39, 62.4, and 200 GeV. For the 200 GeV data analysis we've used Run 4 data and Run 11 data. For the 62.4 GeV analysis, we've attempted to use run 10 data but found the data set to be of such poor quality that we rely only on Run 4 data for 62.4 GeV. The primary problem for this data set seems to be related to the sector that was masked out. Although this is a safe step for preventing bad results for high pt spectra, it's disastrous for correlations analyses.

The remaining energies were taken in the 2010, 2011, and 2014 BES-I runs.

This analysis makes use of the binary data sets generated by Hui Wang. As such, the QA and data set information is identical to that in the STAR notes:

https://drupal.star.bnl.gov/STAR/system/files/balance_analysis_notes_v1.07.pdf and also to the analysis note for the BES v3 paper:

<https://drupal.star.bnl.gov/STAR/starnotes/private/psn0627>

The list of good runs can be found at:

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/7GeV.txt>

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/11GeV.txt>

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/14GeV.txt>

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/19GeV.txt>

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<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/39GeV.txt>

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/62GeV.txt>

<http://www.star.bnl.gov/protected/bulkcorr/wanghui6/Run list/200GeV run11.txt>

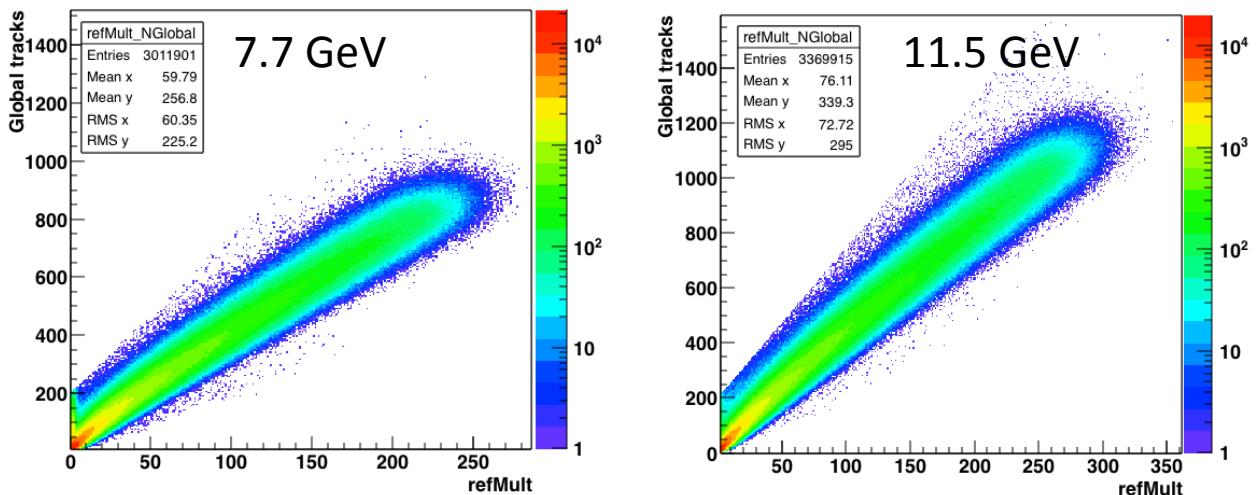
Below, we tabulate the total number of events analyzed for each energy after cuts and QA. In some cases, the best portions of data sets have been analyzed. Especially where statistical errors were not problematic, we've focused on data quality over quantity.

200 GeV	62.4	39	27	19.6	14.5	11.5	7.7
300M	4M	10M	19M	16M	18M	3.5M	3M

Event and Track selection criteria:

The z-vertex ranges allowed in the analysis varies with energy. The choices were made to balance the need for statistics vs reducing systematic biases arising from variation with z-vertex. We apply a $|Vz| < 2$ cm cut (1cm for 14.5 GeV) and an energy dependent NtracksGlobal vs refMult cut. For all but the 2004 data, we require at least two tracks to have a TOF matched hit. Track cuts are varied to estimate the systematic uncertainties but the standard cuts include $p_T > 0.2$ GeV, $|\eta| < 1$, $N_{\text{hits}} > 15$ and $DCA < 3.0$ cm.

7.7 GeV	$ Vz < 40$ cm	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
11.5	40	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
14.5	40	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
19.6	40	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
27	20	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
39	40	$N_{\text{Global}} < (200 + 5.5 * \text{refMult})$
62.4	20	-----
200	20	TOFmatchedTrack > 2



Analysis Procedure:

We are interested in measuring three particle azimuthal correlations of the form $\langle \cos(m\varphi_1 + n\varphi_2 - (m+n)\varphi_3) \rangle$ where the average runs over all possible combinations of three particles. The easiest way to perform this calculation would be to explicitly loop over all sets of triplets but that would be too computationally costly since we would need to evaluate a cosine function $N(N-1)(N-2)/3!$ times. The next easiest method is to use Q-vector algebra to solve for the correlation where

$$Q_x, n = \sum_i w_i \cos(n\varphi_i)$$

$$Q_y, n = \sum_i w_i \sin(n\varphi_i)$$

Then the sought after observable can be calculated using

$$\langle \cos(m\varphi_1(p_T) + n\varphi_2 - (m+n)\varphi_3) \rangle = \sum_i \frac{P_{m,i} (Q'_{n,1,i} Q'^*_{m+n,1,i} - Q'^*_{n,2,i})}{w_i (S'_{2,1,i} - S'_{1,2,i})}$$

$$Q'_{m,p,i} = Q_{m,p} - (w_i)^p P_{m,i}$$

$$S'_{m,p,i} = S_{m,p} - (w_i)^p$$

This method is computationally much faster since the Q-vectors are calculated in a single loop over the tracks in a given event. But, the results are less differential than is necessary. Even though we can select the p_T of one of the tracks for example, we can't study the $\Delta\eta$ dependence of the correlation which we've found is essential for removing the effects of track merging from the observable. We are also interested in the $\Delta\eta$ dependence of the correlations because they provide important clues to the origin of the correlations.

For this reason, we use an analysis technique based on a combination of Q-vectors and explicit loops over tracks. We loop over all pairs of particles and make use of trigonometric identities and products of $\cos\varphi_1, \sin\varphi_1, \cos\varphi_2, \sin\varphi_2$, with Q_x and Q_y to calculate $\cos(m\varphi_1 + n\varphi_2 - (m+n)\varphi_3)$. This way we reduce the nesting of for-loops from 3 nested loops to 2 nested loops so that the computational time goes from $N(N-1)(N-2)/6!$ down to $N(N-1)/2!$ which is crucial for larger data sets. For a small number of events, we explicitly used nested for-loops and compared the results (event-by-event) to the results from Q-cumulants and our hybrid Q*2-particle method. The numbers matched to double precision showing that our code and algebra was indeed giving us precisely what we wanted to calculate.

Analysis Procedure:

As an example of the Q-vector algebra which may help explain that procedure, we include below the explicit argument that would be evaluated in the two-particle loop over (i,j)

```
double Q1xp = Qsum1[1][0] - wi*cos1i - wj*cos1j;
double Q1yp = Qsum1[1][1] - wi*sin1i - wj*sin1j;
double Q2xp = Qsum1[2][0] - wi*cos2i - wj*cos2j;
double Q2yp = Qsum1[2][1] - wi*sin2i - wj*sin2j;
double Q3xp = Qsum1[3][0] - wi*cos3i - wj*cos3j;
double Q3yp = Qsum1[3][1] - wi*sin3i - wj*sin3j;
cos123_12[detaBin] += wi*wj*(Q3xp*(cos1i*cos2j - sin1i*sin2j) + Q3yp*(sin1i*cos2j + cos1i*sin2j));
cos123_12[detaBin] += wi*wj*(Q3xp*(cos1j*cos2i - sin1j*sin2i) + Q3yp*(sin1j*cos2i + cos1j*sin2i));
```

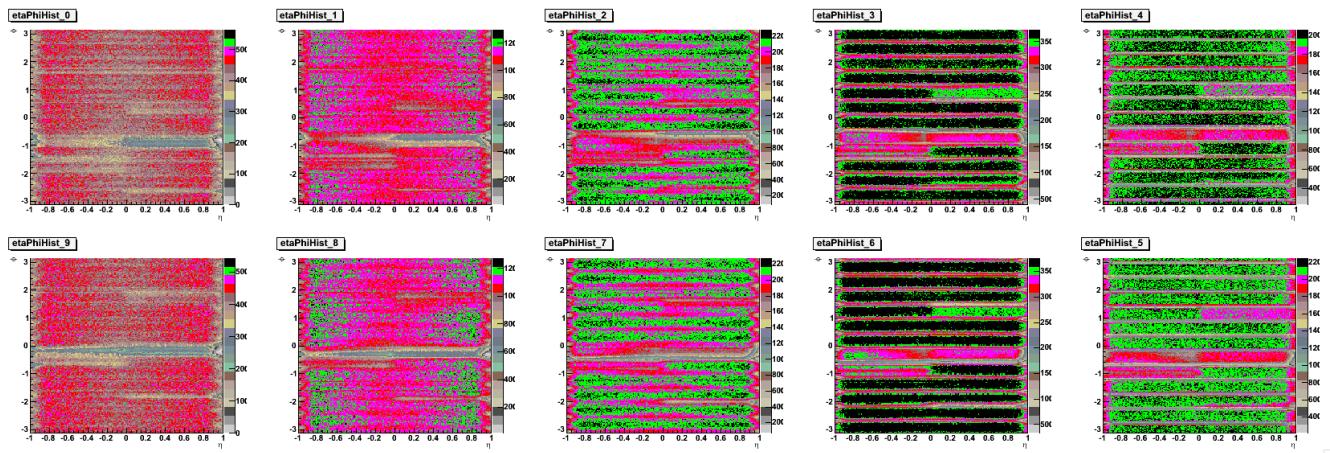
For each track, $\cos n\phi$ and $\sin n\phi$ are stored so that cosine and sine do not need to be evaluated in the 2-particle loop. $Qsum[n][0,1]$ are the x and y components of the nth harmonic Q vector which are calculated as a weighted sum over all tracks. When averaging over events we weight each event by the number of combinations in that event.

In the process of trying to achieve satisfactory agreement between Run 4 data and Run 11 data we developed a procedure to perform differential, track-by-track, corrections. This procedure is most important for differential cumulant measurements where an average correction will over-correct one part of the correlation function and under-correct another. While the integrated cumulant may be correct, it's differential form can be skewed. The use of weights also makes it possible for us to apply p_T dependent efficiency corrections to the cumulants.

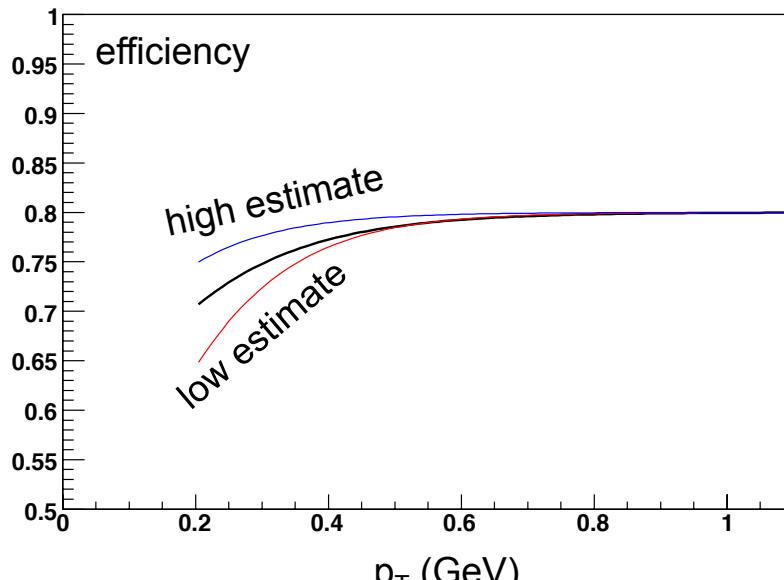
As in our analysis, the differential correction is performed using weights $w_{i,j,k}$ track-by-track weights that are used to correct for detector acceptance and efficiency. The weighting procedure involves first binning particles in ϕ and η and averaging over all events. Since acceptance will depend on particle charge, track curvature (related to p_T), z-vertex, and centrality, we create separate η vs ϕ histograms for events with different z-vertex, centrality, and magnetic field when appropriate, and for tracks with different sagita (curvature) and charge. z-vertex bins are 20 cm wide with selections from $-40 < Vz < -20$, $-20 < Vz < 0$, $0 < Vz < 20$, $20 < Vz < 40$. Narrower bins were tried where statistics were available but did not change the results. We use the standard centrality definitions to divide up our weights by centrality. The Sagita of a track is calculated from it's p_T , the size of the TPC and the magnetic field. The sagita is: $S = \text{charge} * ((20.*p_T/3.) - \sqrt{\text{pow}(20.*p_T/3.,2.) - \text{pow}(0.75,2.)})$.

Analysis Procedure:

Below we show an example of the η, ϕ weights for one centrality and one energy. The top row shows negatively charged track distributions, the bottom row shows positively charged track distributions. The left side has the largest sagita (curvature) and therefore the lowest p_T , the right bins have the smallest curvature (highest p_T). The less curved tracks clearly show the effect of sector boundaries while the more curved tracks are less likely to be lost in sector boundaries. The histograms clearly illustrate that the acceptance depends strongly on η and ϕ .

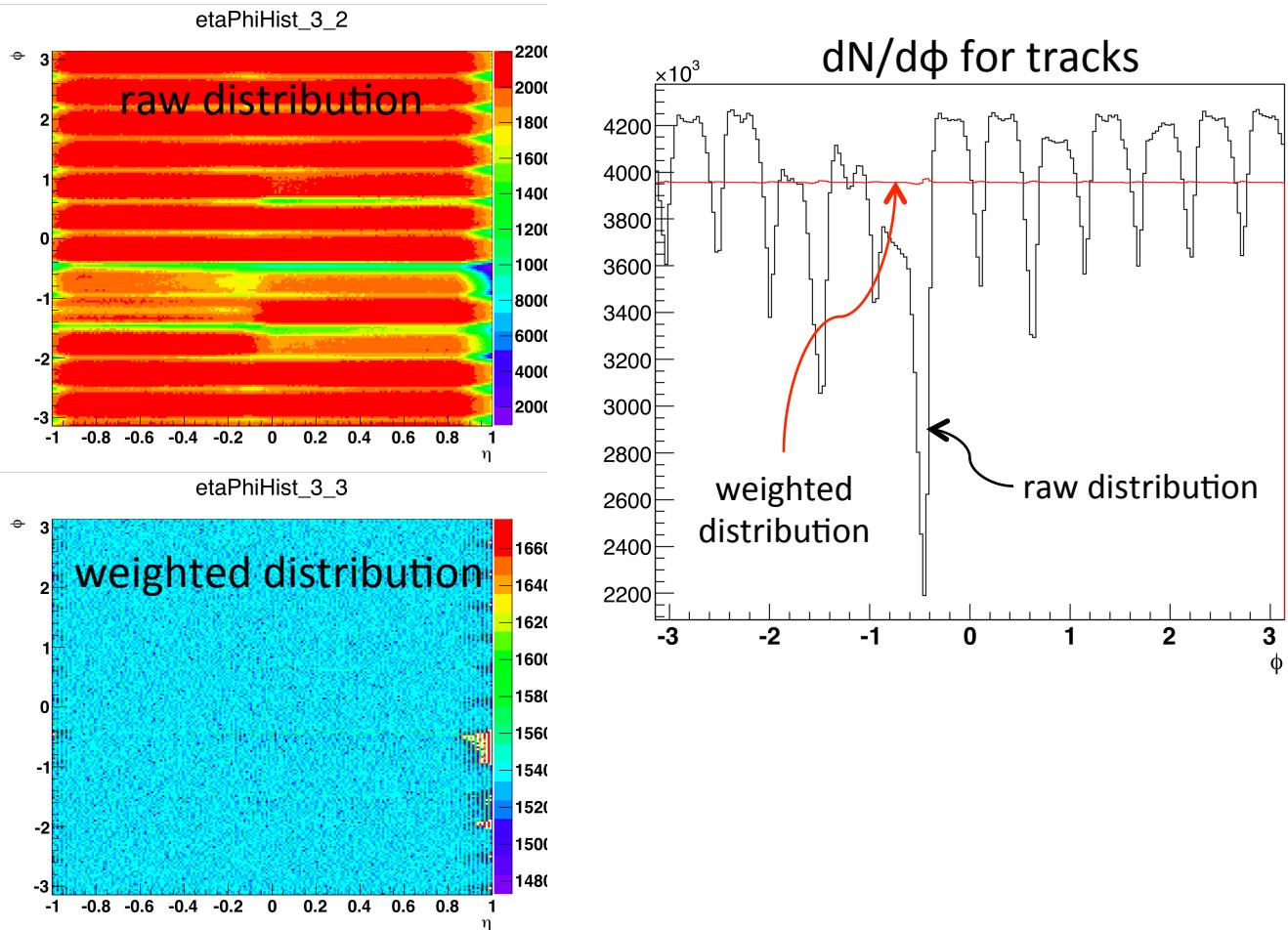


Below, we also show the efficiency parameterizations we use to correct for the p_T dependent efficiency. The black curve is a fit to efficiency from embedding. The blue and red show two extremes that were used to estimate systematic uncertainties. Only the p_T dependence of the efficiency matters since a constant efficiency offset will cancel out in the numerator and denominator for this analysis.



Analysis Procedure:

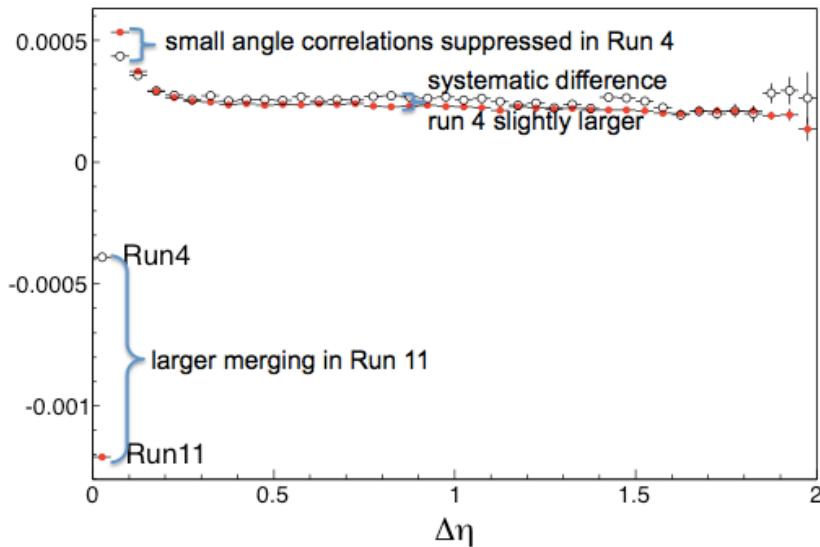
After weighting, we verify that the distribution of tracks is flat. Once the $v_n\{2\}$ data has been corrected for acceptance with weights, the residual corrections $\langle \cos n\phi \rangle^2 + \langle \sin n\phi \rangle^2$ are also verified to be very small (in almost all cases consistent with zero and in all cases smaller than a few % of the signal).



Not all holes in the acceptance can be corrected. Especially just on the edge of the acceptance. These holes affect a very small fraction of the pairs of tracks though so their affect is negligible as can be assessed from the $\langle \cos n\phi \rangle^2 + \langle \sin n\phi \rangle^2$ correction.

Run 11 vs Run 4 and Track Merging:

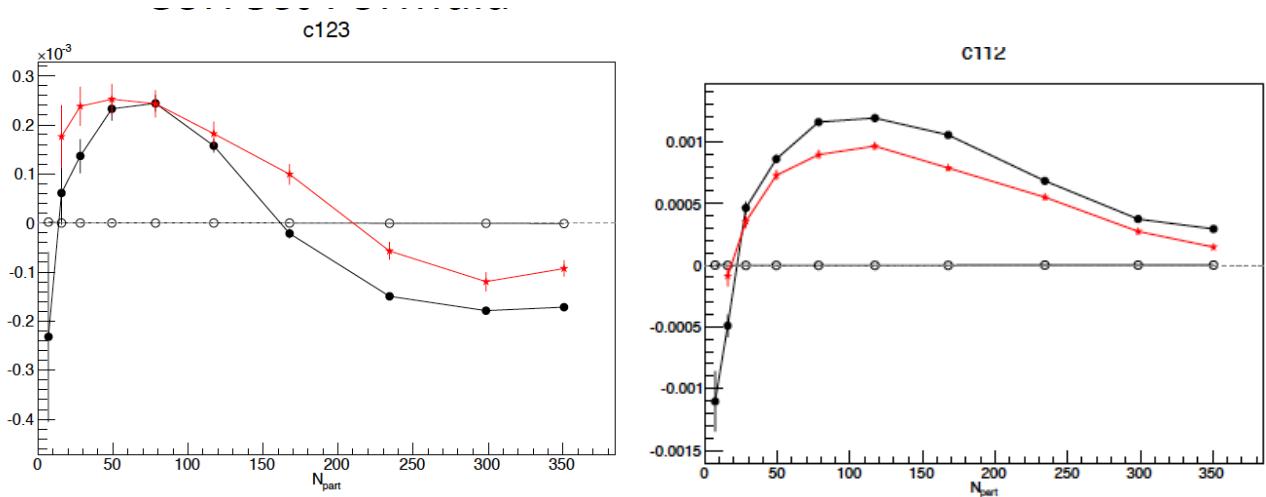
For over 10 years now the data from Run 4 have been considered the gold standard for bulk correlations analyses because of the relatively large size of the data set and the quality of the data. Larger subsequent data sets have been found to generally be of poorer quality for various reasons (more material, higher luminosity, bad RDO's, etc.). Part of the goal of this analysis is to develop analyses techniques that allow us to make use of newer much larger data sets. This requires demonstrating that systematic differences between measurements in Run 4 and Run 11 can be understood and eliminated. While many changes were made to the analysis procedure, including differential weights, the main effect that caused discrepancies between Run 4 and Run 11 were changes in track-merging and other differences at small angle. These can arise because the tracking algorithm changed, cluster sizes changed, and run conditions changed. The upshot is that Track merging is MUCH worse in Run 11 than Run 4 (nearly a factor of 2), but small angle correlations seem to be suppressed in Run 4 compared to Run 11. The figure below shows $\langle \cos(3\Delta\varphi) \rangle$ vs $\Delta\eta$.



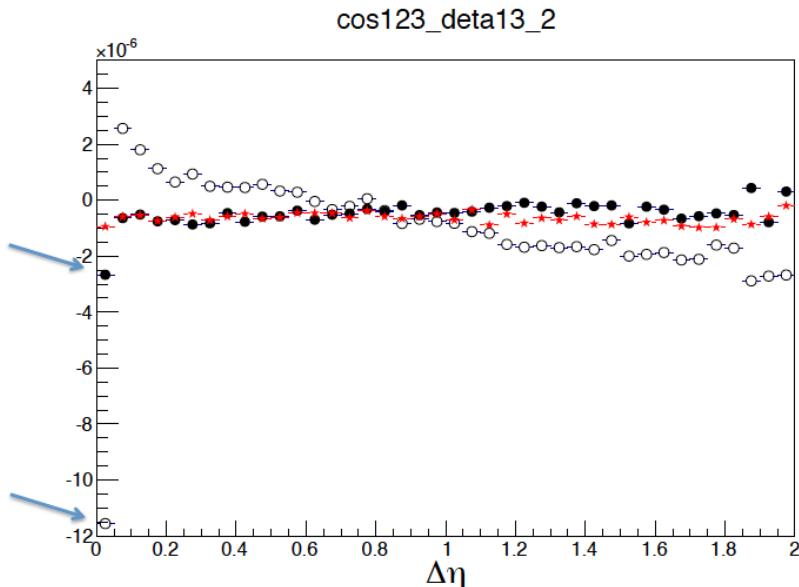
We will also look at how track merging affects that 3-particle correlations.

Run 11 vs Run 4 and Track Merging:

A significant discrepancy was observed in three particle correlations between run 11 and run 4. Below is $\cos(123)$ and $\cos(112)$.

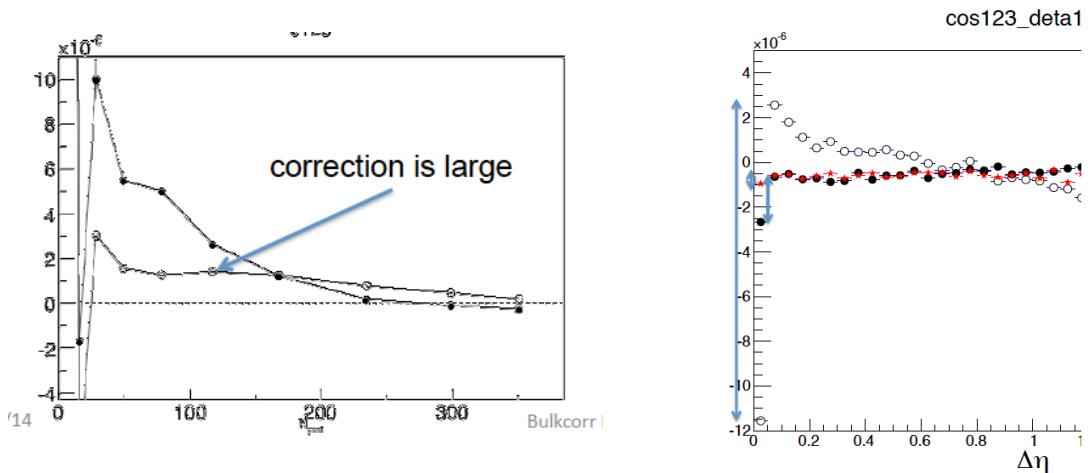


We know that track merging is a bigger problem in Run 11 than Run 4. Here is what track merging does to the three particle $\cos(123)$ correlation; notice the large dip in the first $\Delta\eta$ bin which is especially prominent for $\eta_1-\eta_3$. For other combinations, that effect is distributed across all the bins. Since we know track merging changes a lot from run 4 to run 11, perhaps it is causing part of the discrepancy between those years. We will show how to correct for it.

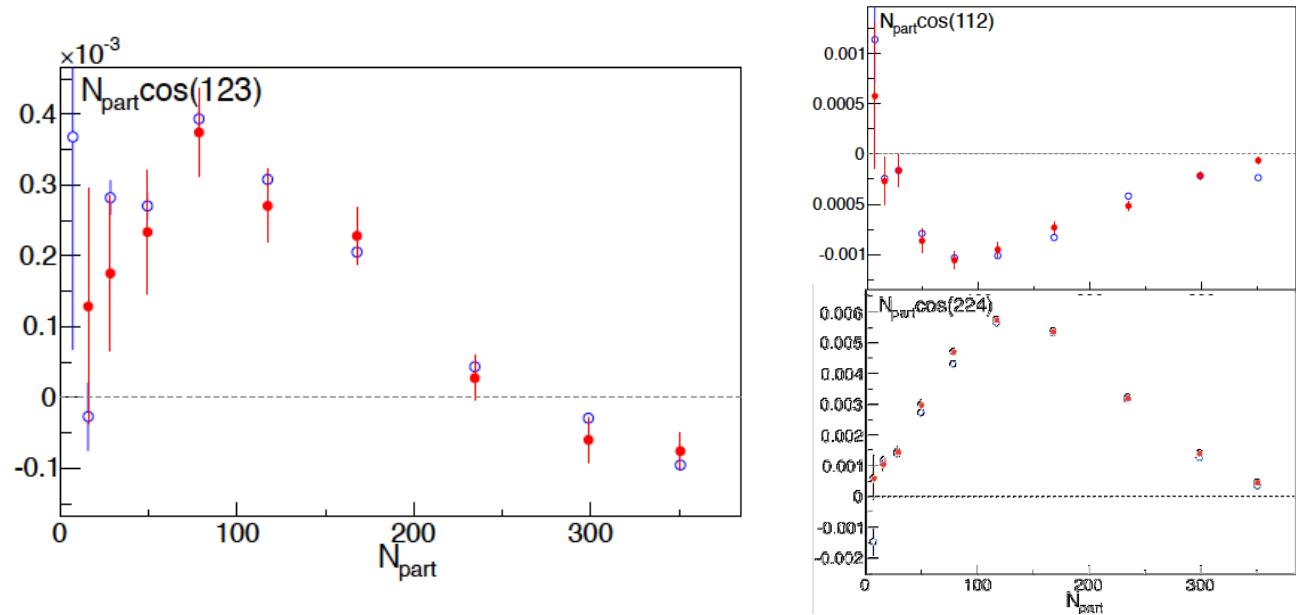


Run 11 vs Run 4 and Track Merging:

Although for $\cos(123)$, track merging is most visible for $\eta_1-\eta_3$, it is present in all combinations. To correct for this effect, we add back the contributions to the total correlation that we should have had from the missing combinations. It works out that the correction is the sum of the difference between the expected and observed correlation for each combination $\eta_1-\eta_1$, $\eta_1-\eta_3$, and $\eta_2-\eta_3$. Given that track merging creates a sharp dip in the correlation in a very narrow $\Delta\eta$ range, it's easy to define the "expected" correlation by projecting the slightly larger $\Delta\eta$ bins to the small $\Delta\eta$ bin where track merging affects the correlation. This fairly trivial projection, allows us to correct the integrated and even the differential results for the combinations of tracks that are missing due to track merging.



Once we apply this correction, we find that Run 4 and Run 11 data agree quite well.



Systematic Uncertainty Estimates:

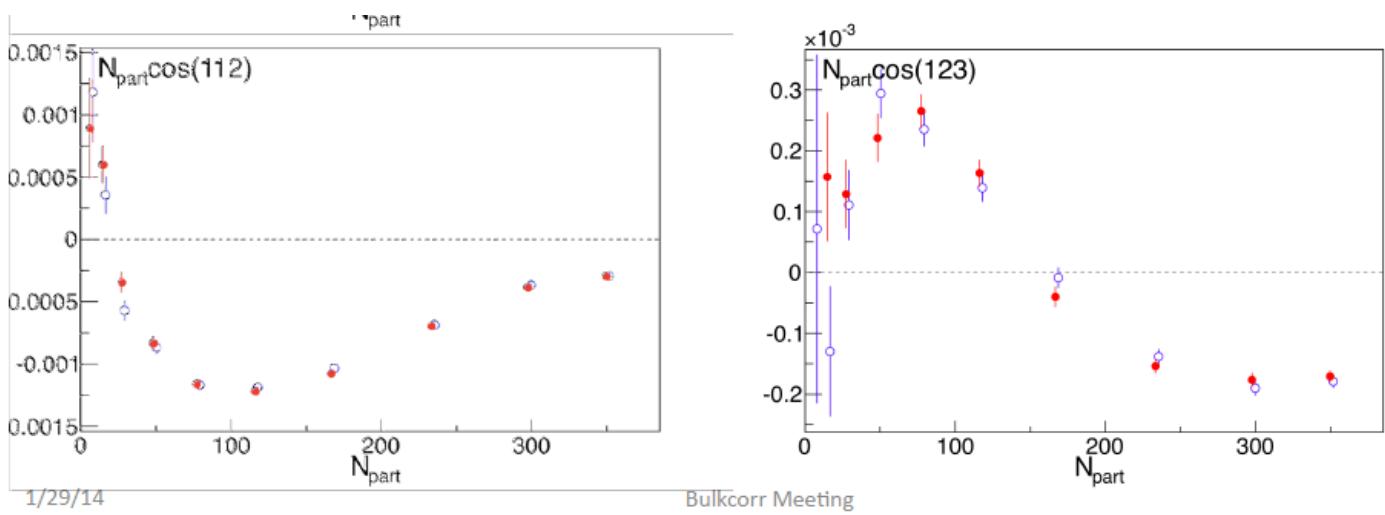
We checked the systematic uncertainties of our results by comparing run 4 with run 11, by changing the DCA cut from 3 to 2 cm, by comparing events with different z-vertex positions, by checking early parts of the run with late parts of the run, by using a high estimate for the efficiency vs a low estimate, and by comparing events where there were different numbers of bad RDO boards in the TPC. Our strategy is to compare all these checks to the standard analysis and use the largest result and lowest result as the upper and lower edge of the systematic error bands.

We also assign an error that is 10% of the residual average acceptance corrections (these are small after the track-by-track acceptance corrections are applied so this error is small). We have decided to exclude the positive z-vertex vs negative z-vertex from the final systematic error calculation. We've found that because those two are statistically independent of each other, the differences between them seem to be more related to statistical fluctuations than a systematic difference. Including that spread in the final calculation would simply double count the statistical errors. We assume the systematic errors are symmetric. As an example of our reasoning, if changing the DCA from 3 to 2 causes the result to go one way, then it's a good assumption that if we had changed it from 3 to 4 it would have gone the other way.

The final systematic errors are generated by adding all errors in quadrature. We present in the following some specific studies along with trend plots that show the final errors for each energy and centrality. The $Vz > 0$ and $Vz < 0$ data are shown on the trend plots but are not part of the final calculation.

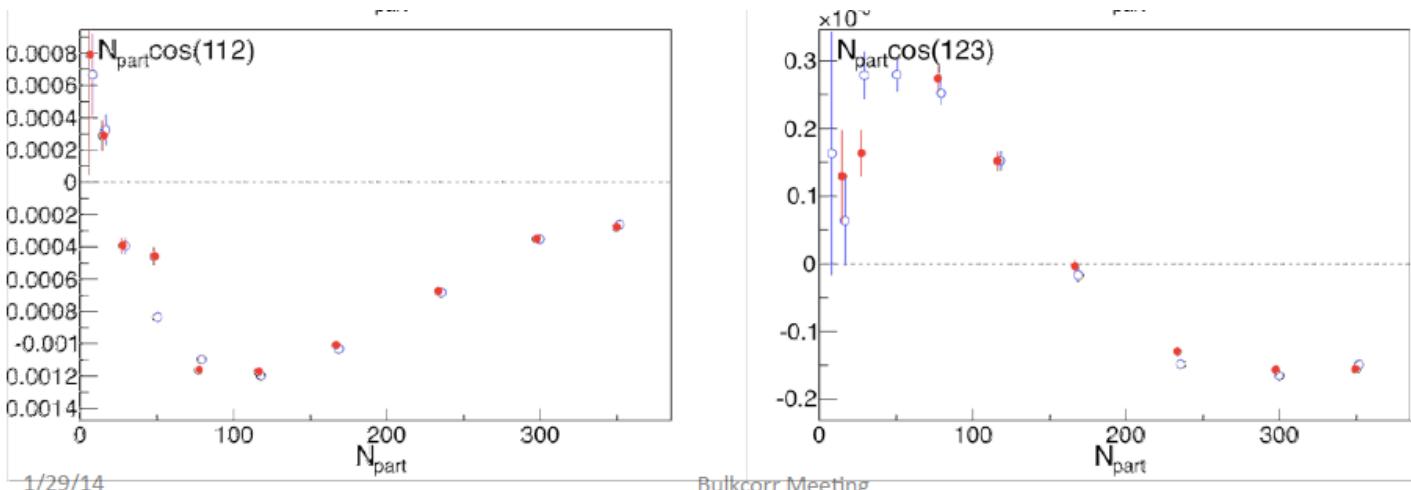
Number of Dead RDO's 4 vs 6:

After applying track-by-track corrections, we don't see a big change in the data when we compare events with 4 dead RDO's to those with 6 dead RDO's.



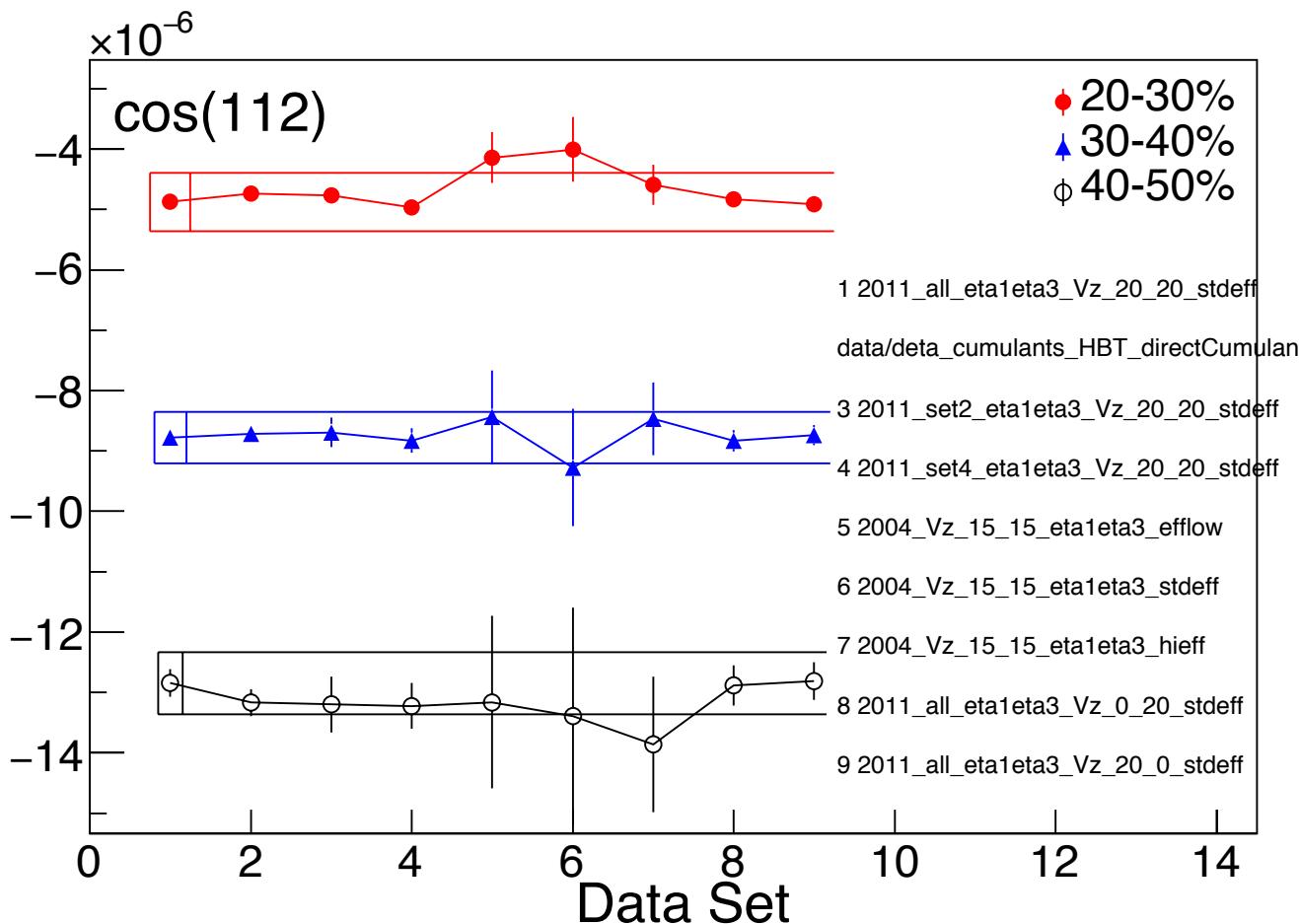
$0 < V_z < 20$ vs $-20 < V_z < 0$:

We also don't see a big difference for events with a negative z-vertex compared with those with a positive z-vertex.

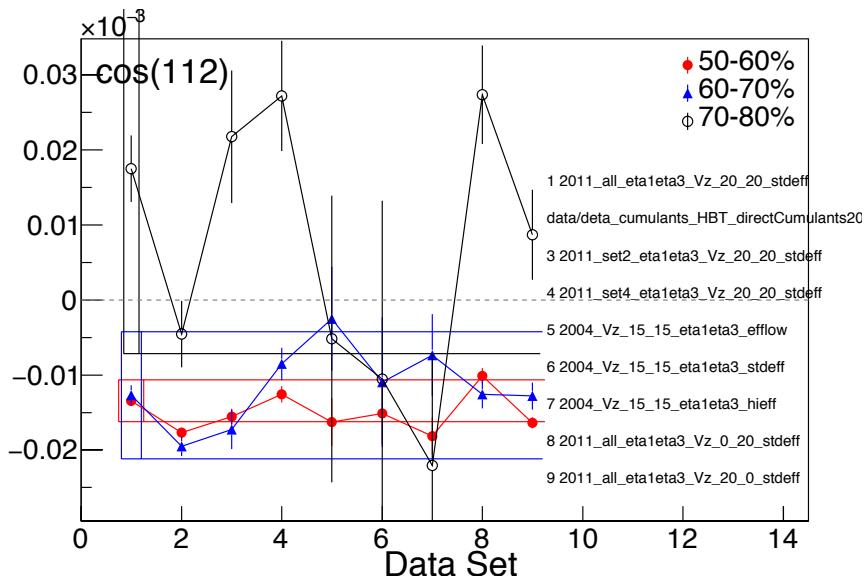
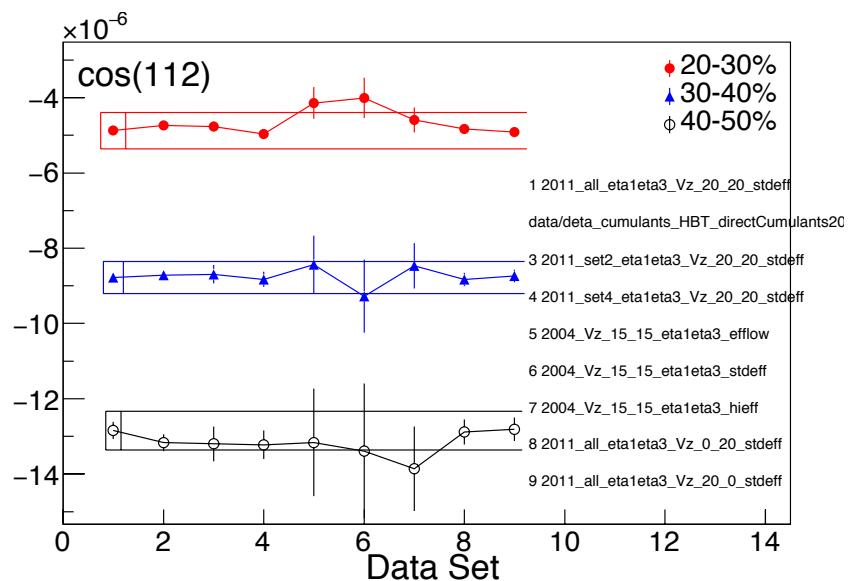
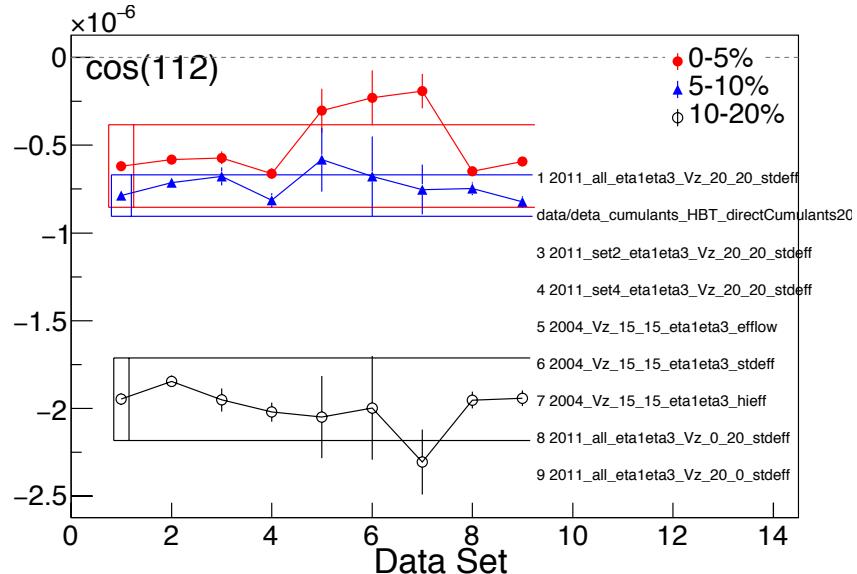


Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 200 GeV

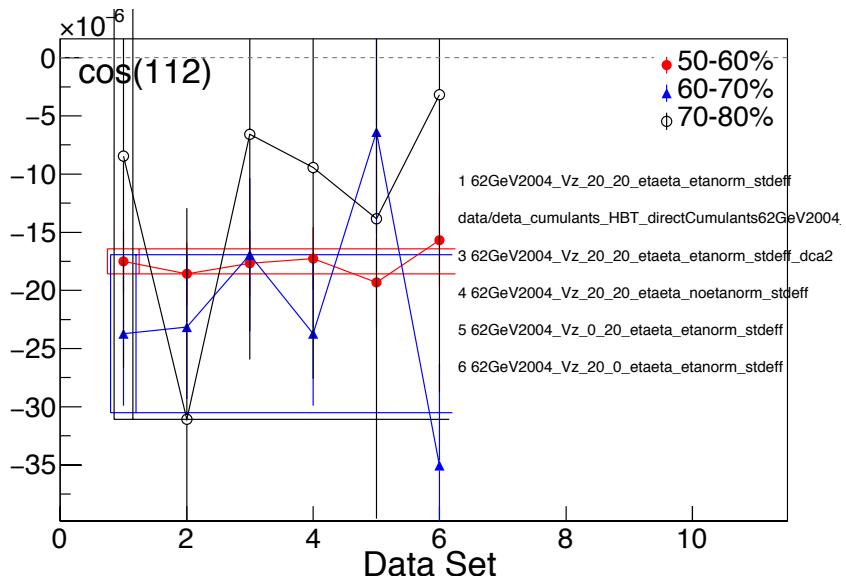
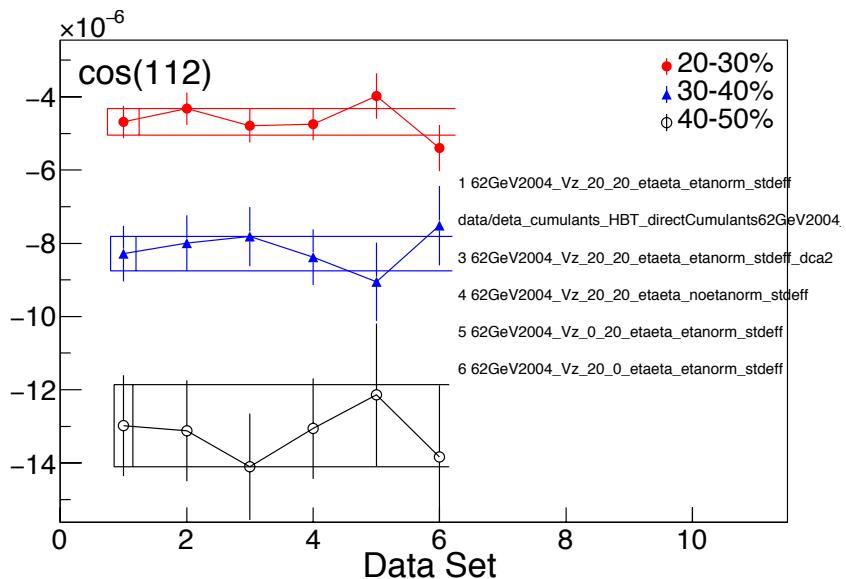
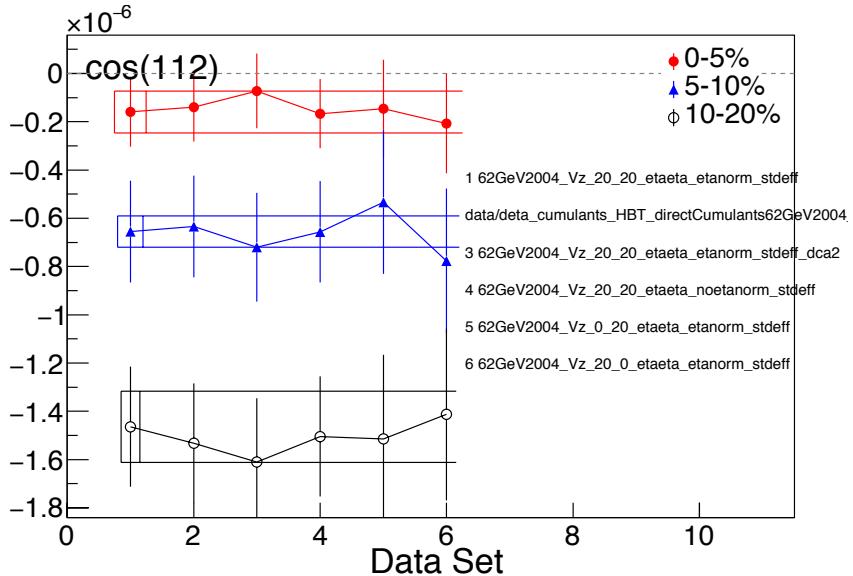
In the plots that follow, each point along the x-axis represents a different analysis of the same quantity. The change in the analysis is usually evident from the label on the side of the plot. We start with $\cos(112)$ at 200 GeV. The box on the left and the horizontal lines represent the systematic error. The first point is the standard analysis value which is reported as the central value.



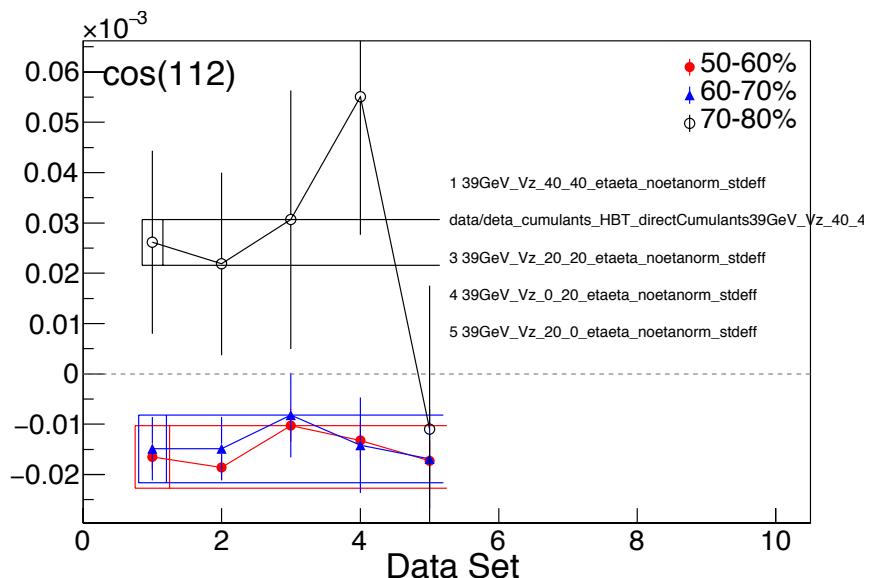
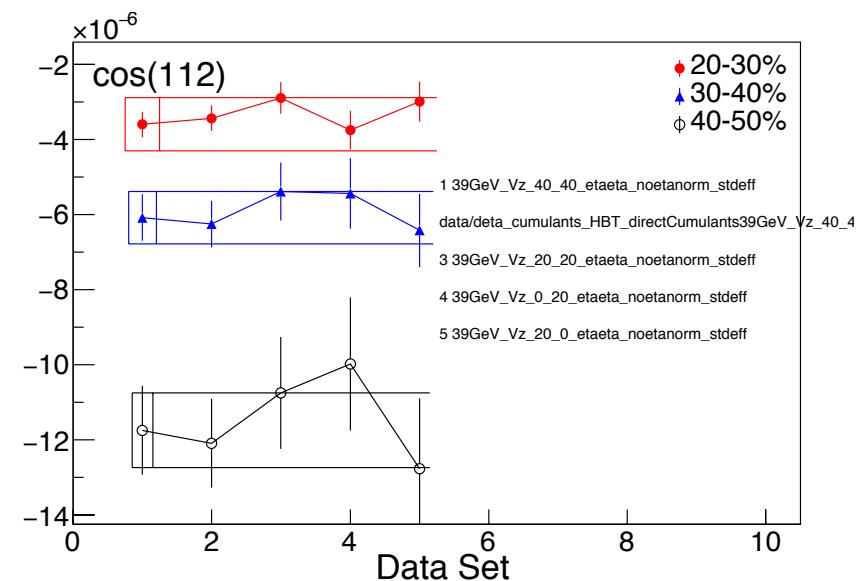
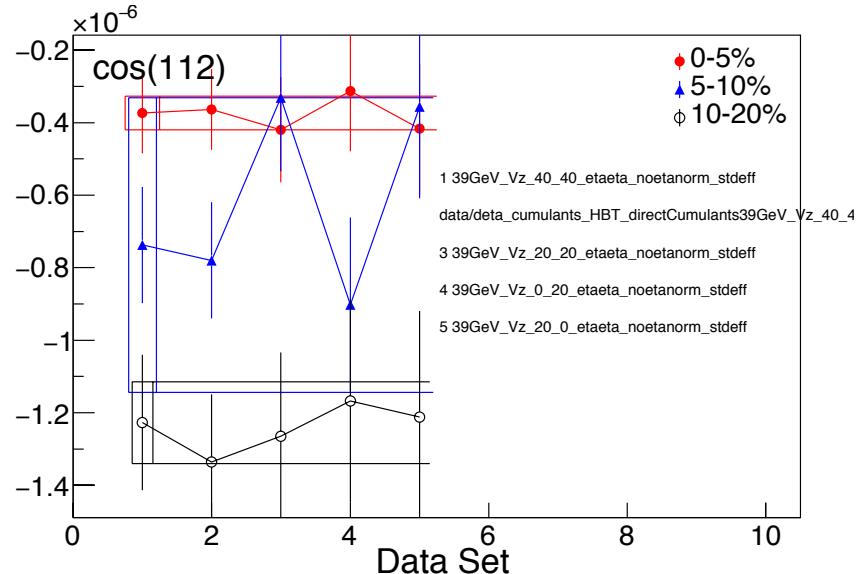
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 200 GeV



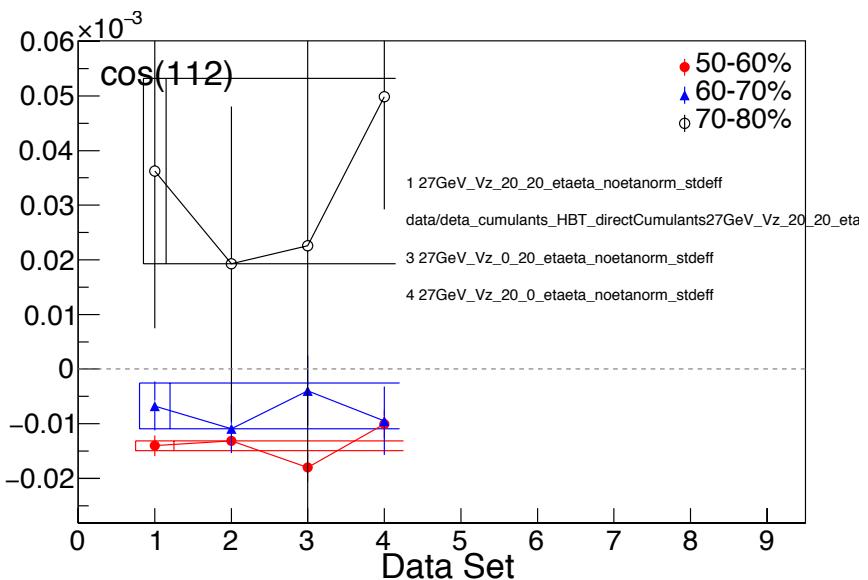
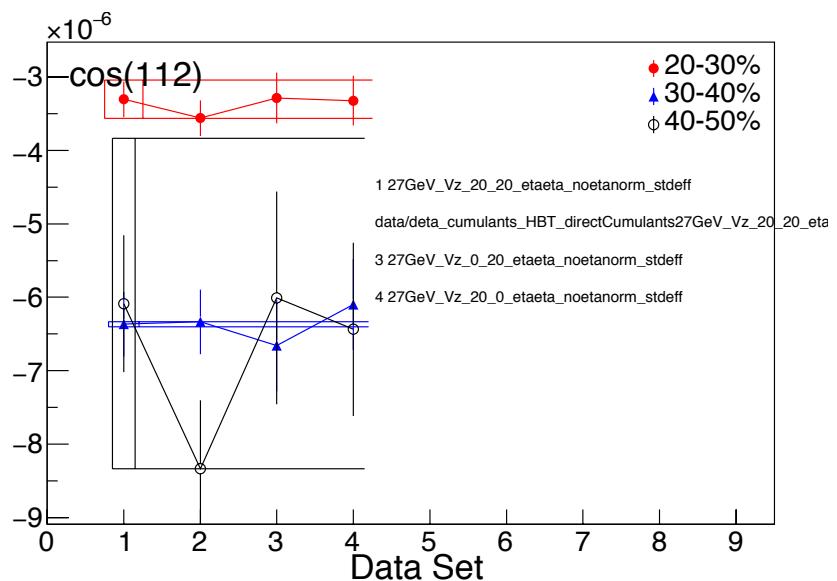
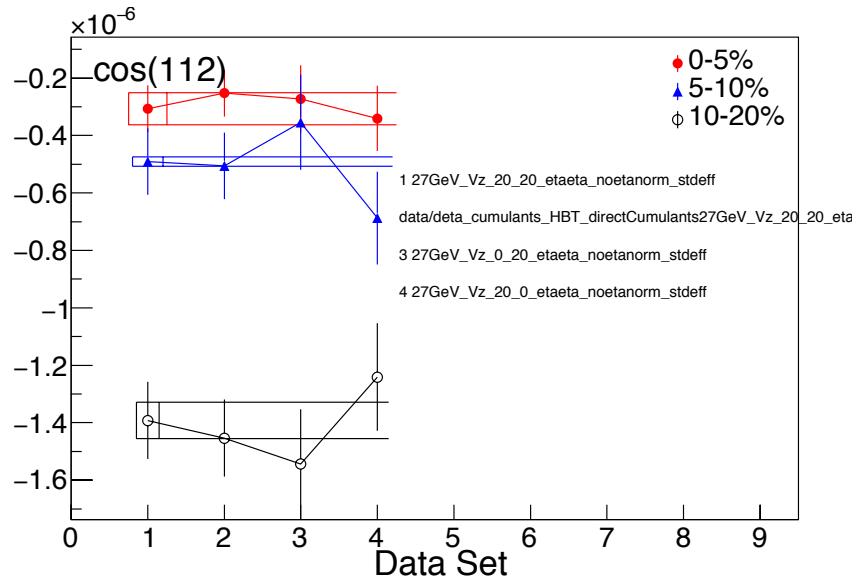
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 62.4 GeV



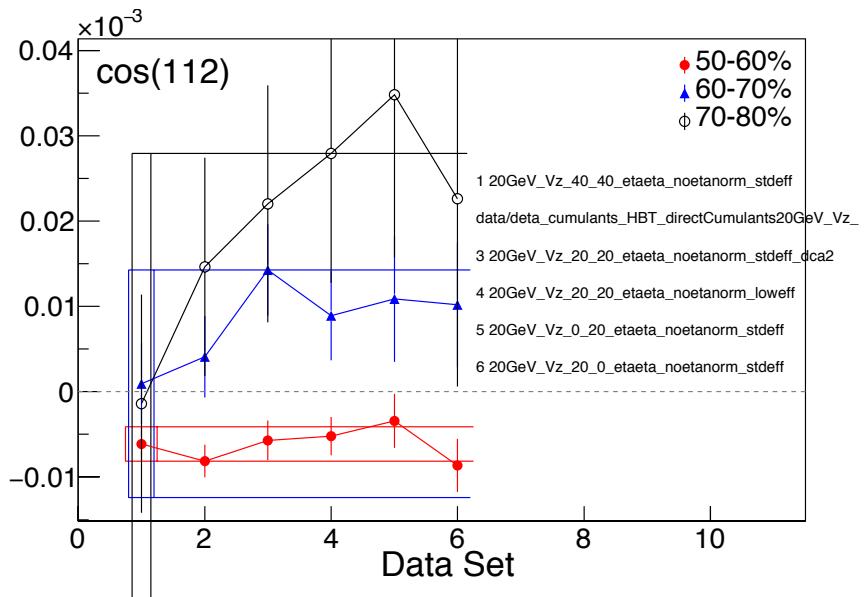
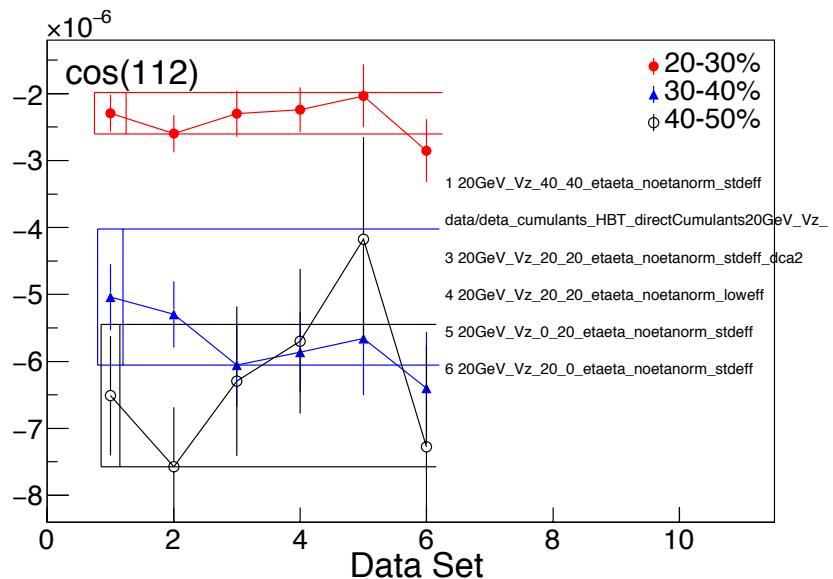
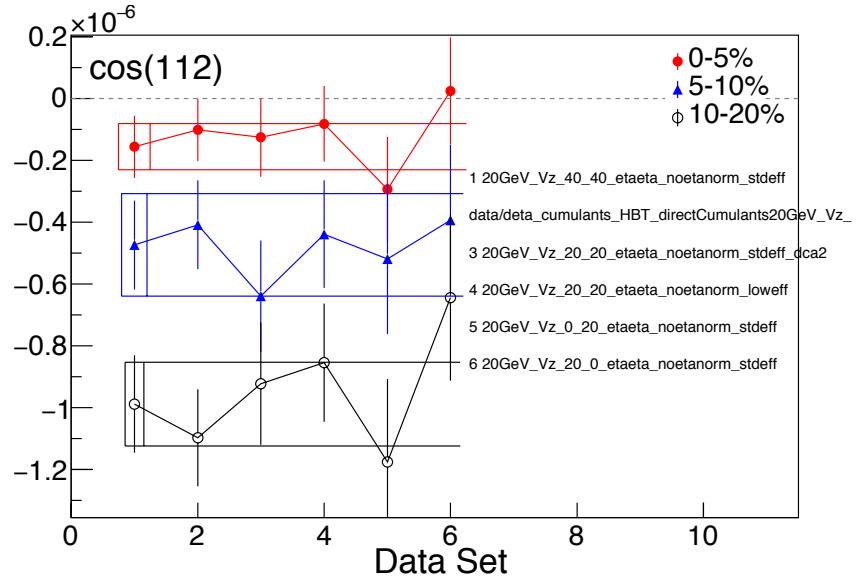
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 39 GeV



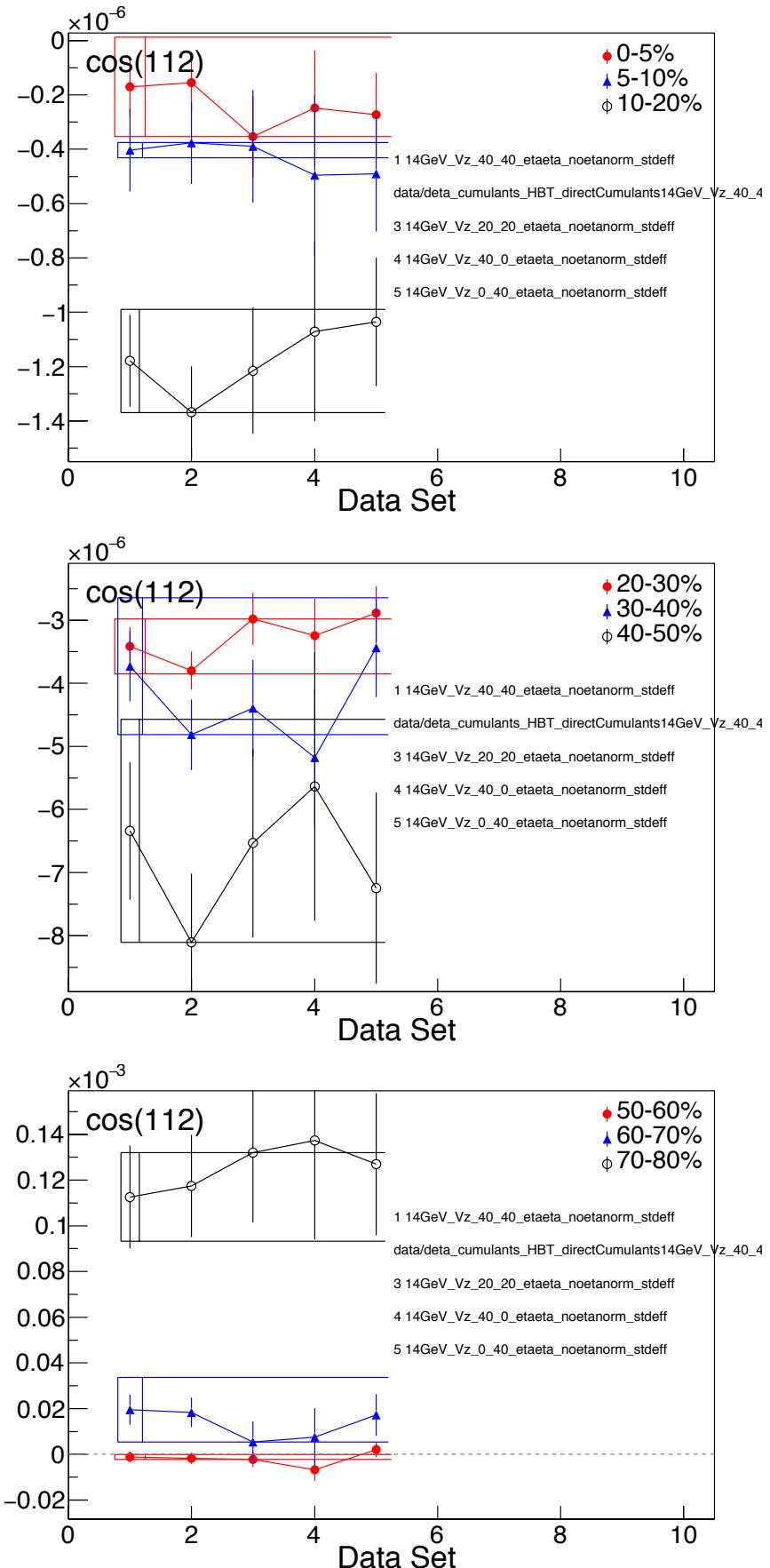
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 27 GeV



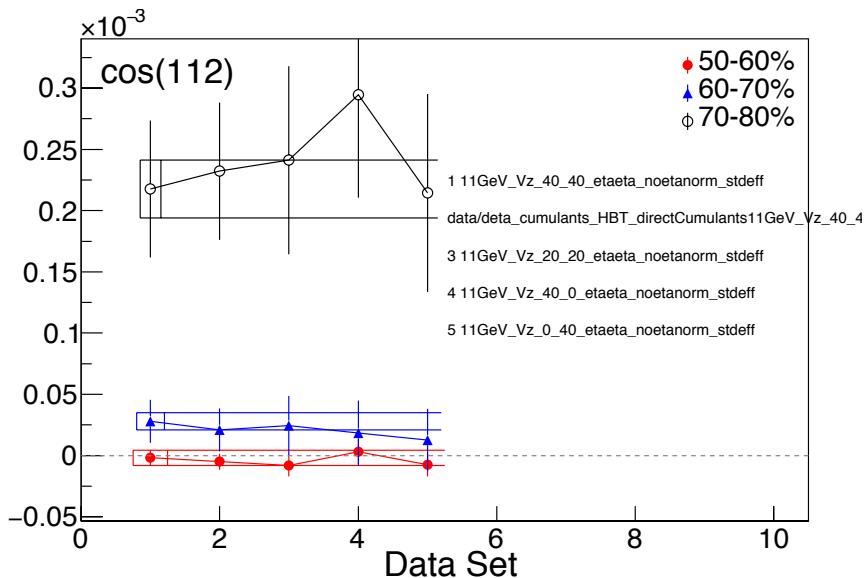
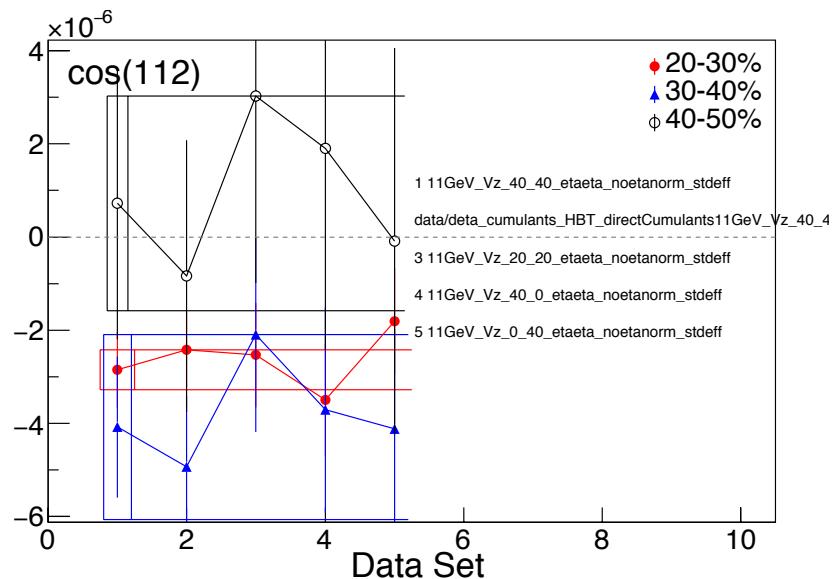
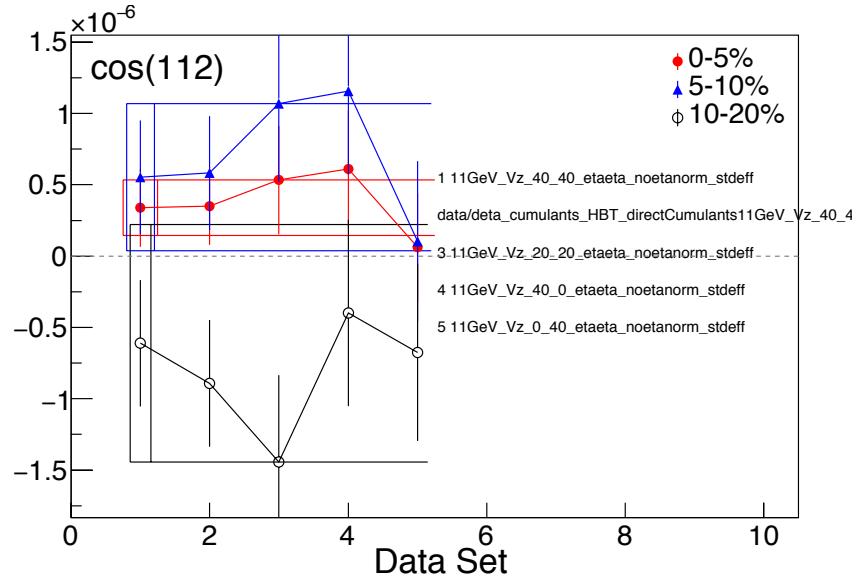
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 19.6 GeV



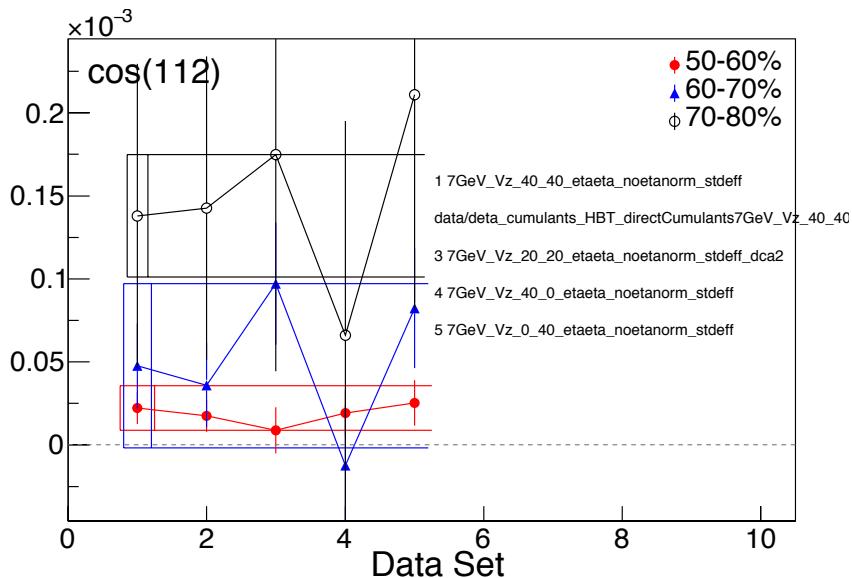
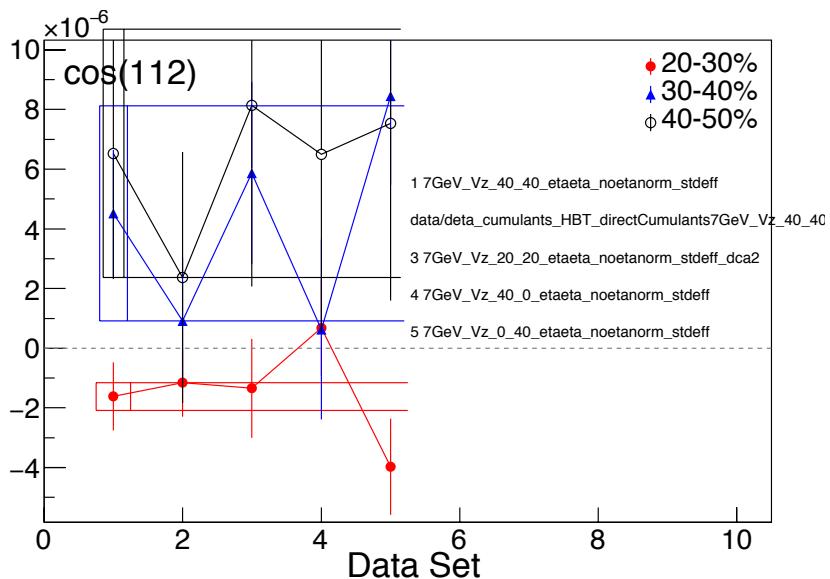
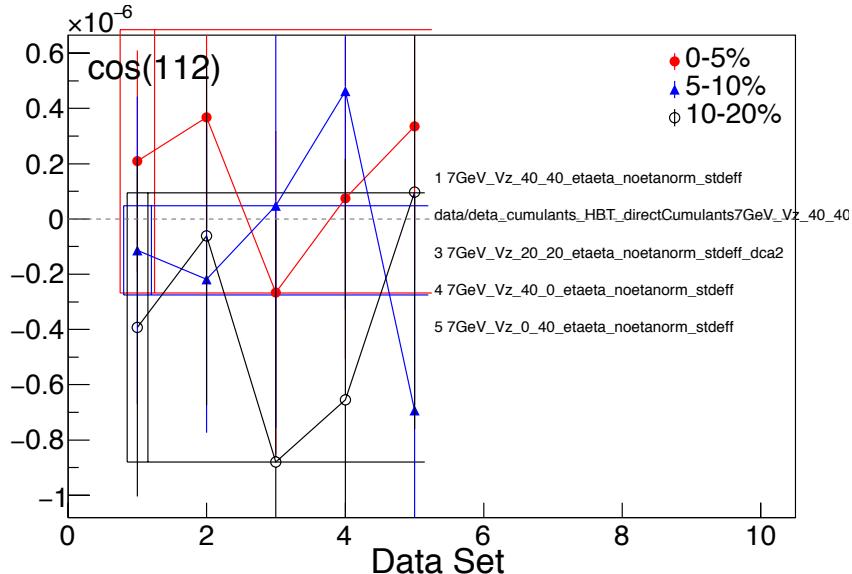
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 14.5 GeV



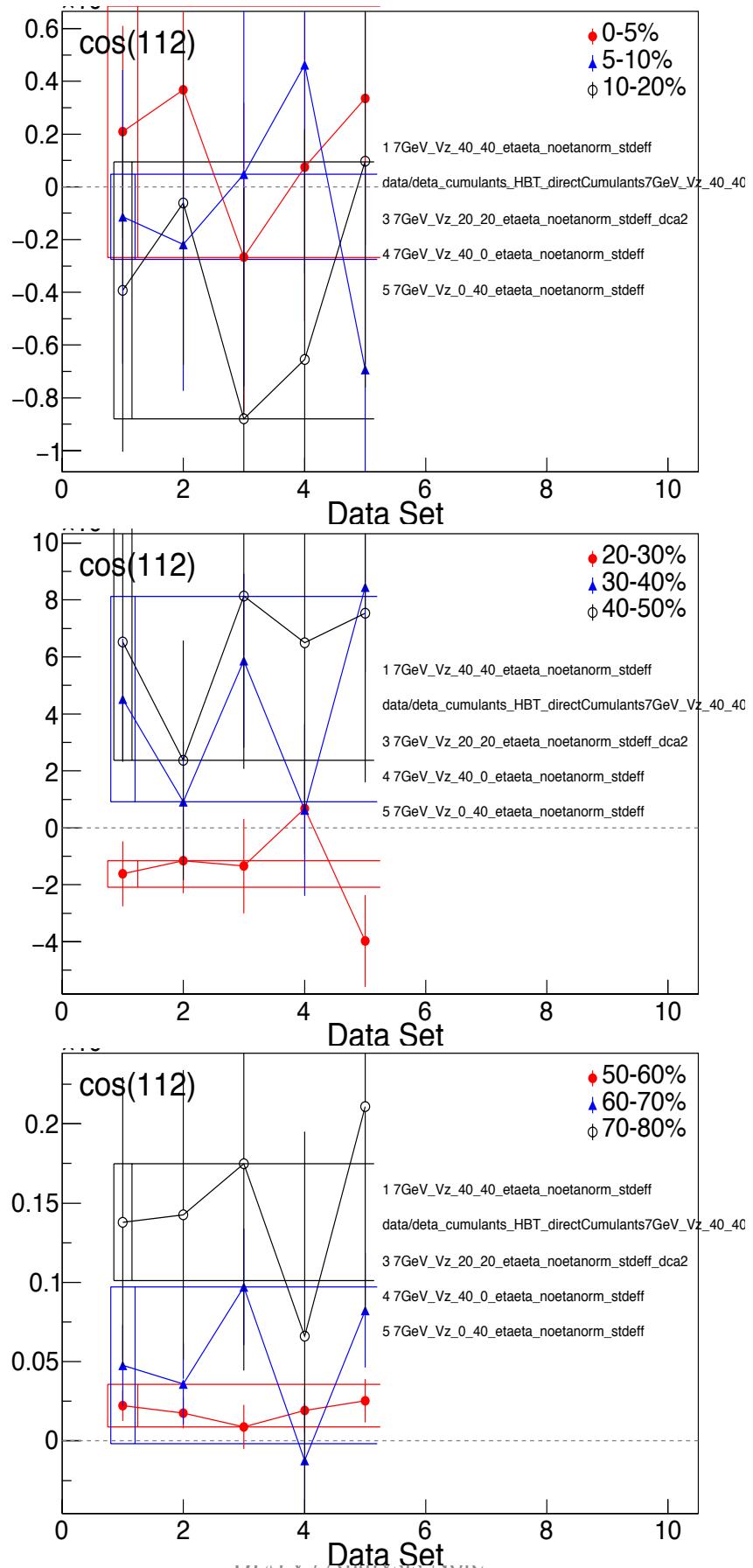
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 11.5 GeV



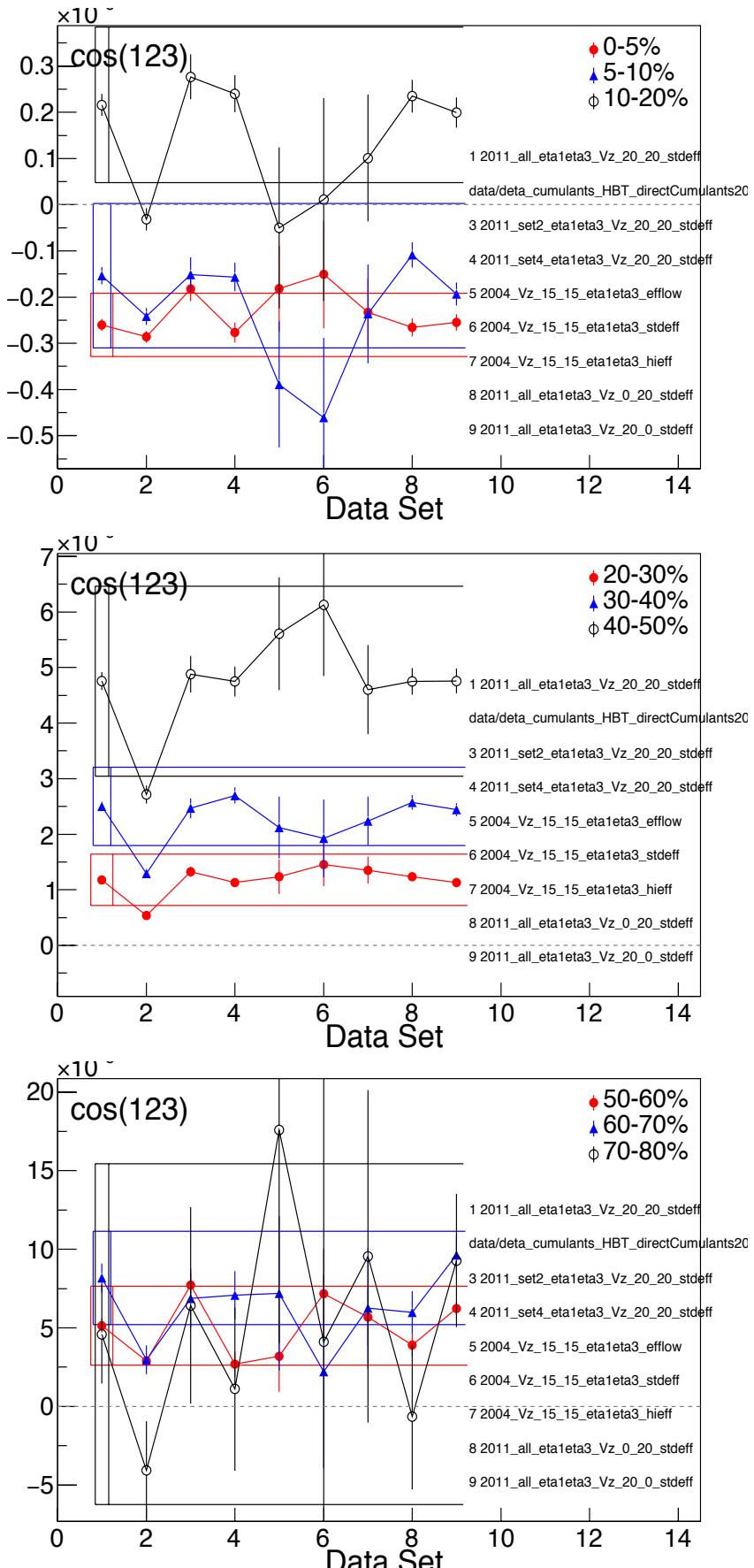
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 7.7 GeV



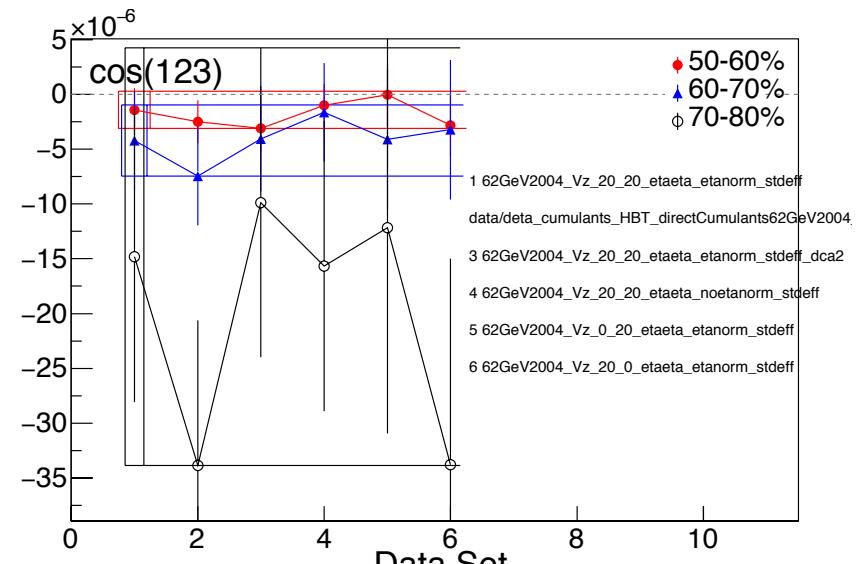
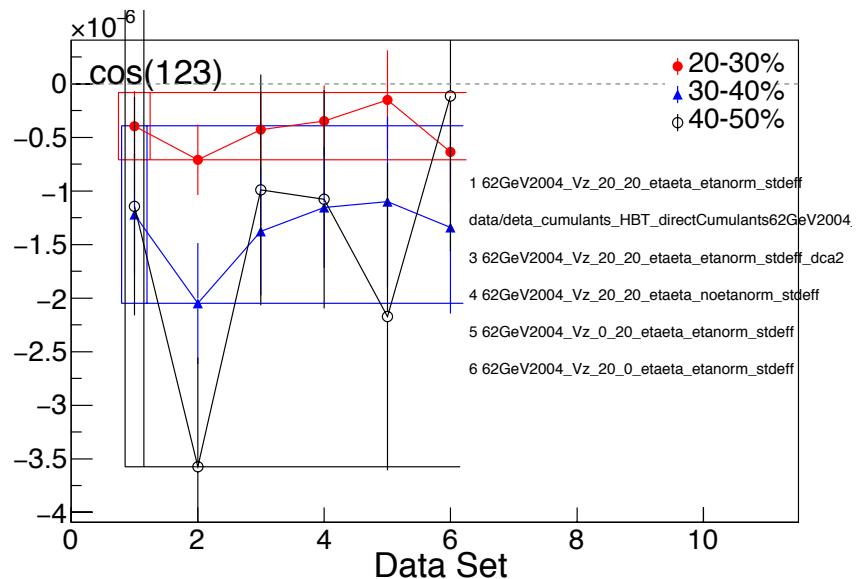
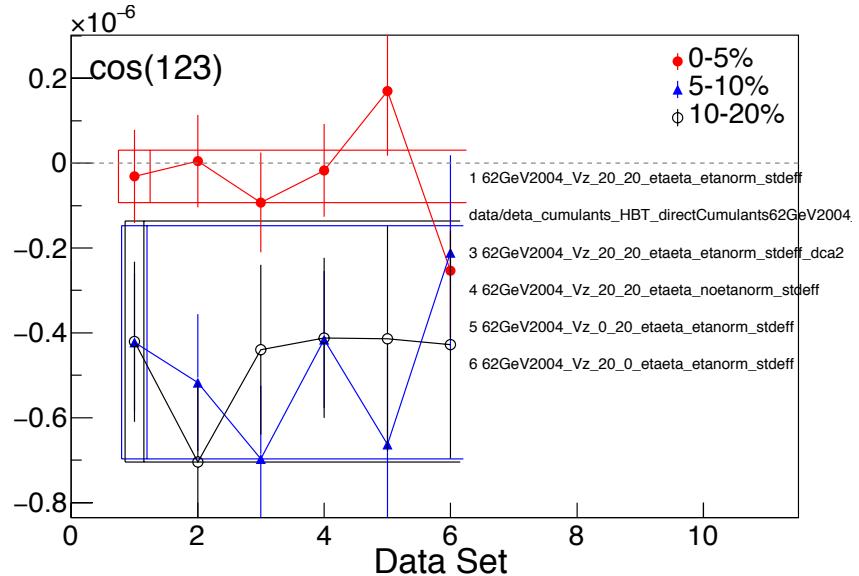
Systematic Errors and Trend Plots: $\cos(1\phi_1+1\phi_2-2\phi_3)$ 7.7 GeV



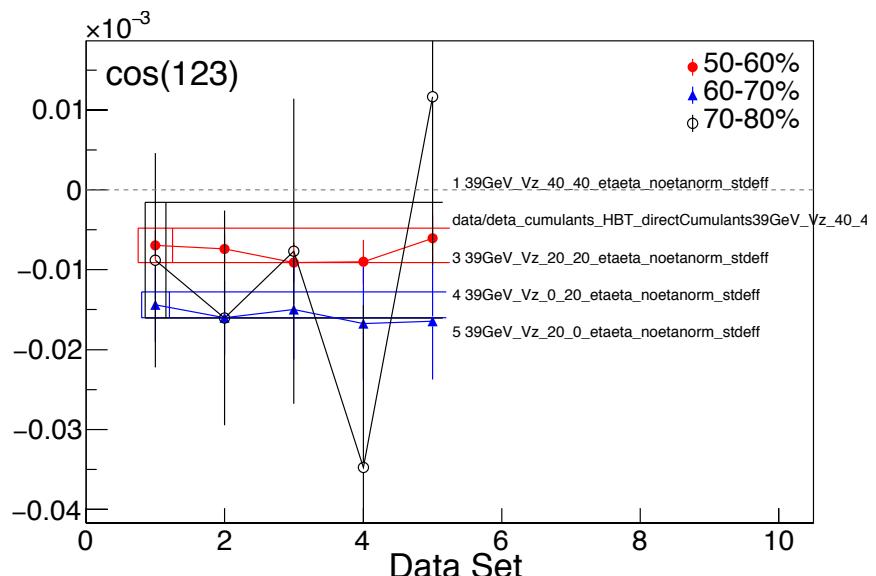
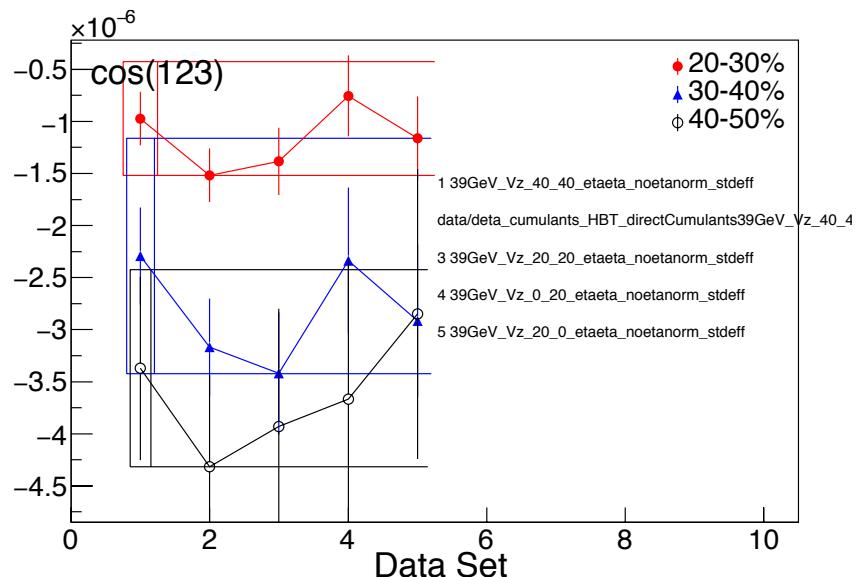
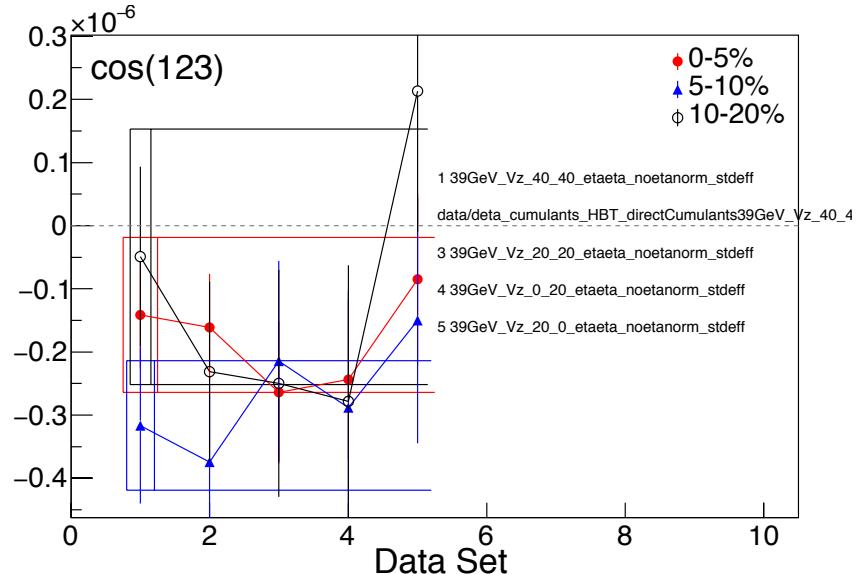
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 200 GeV



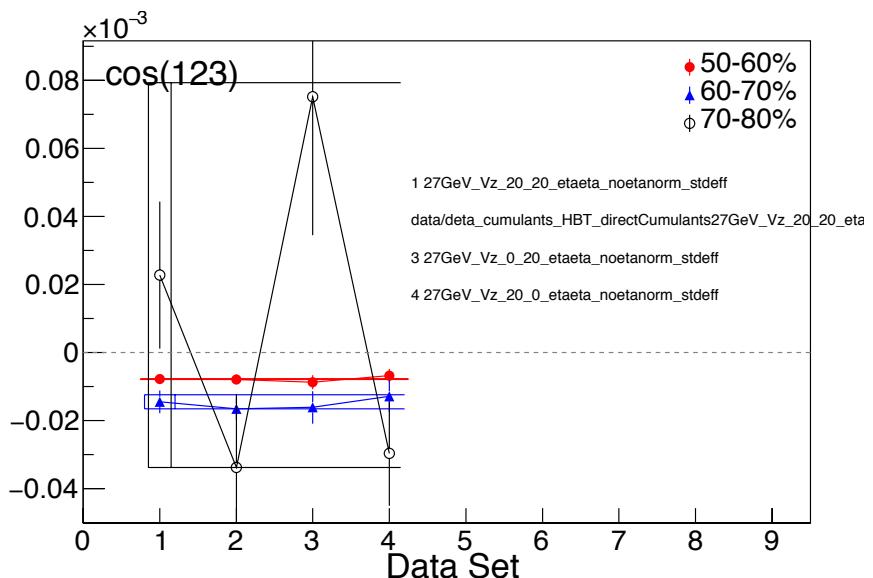
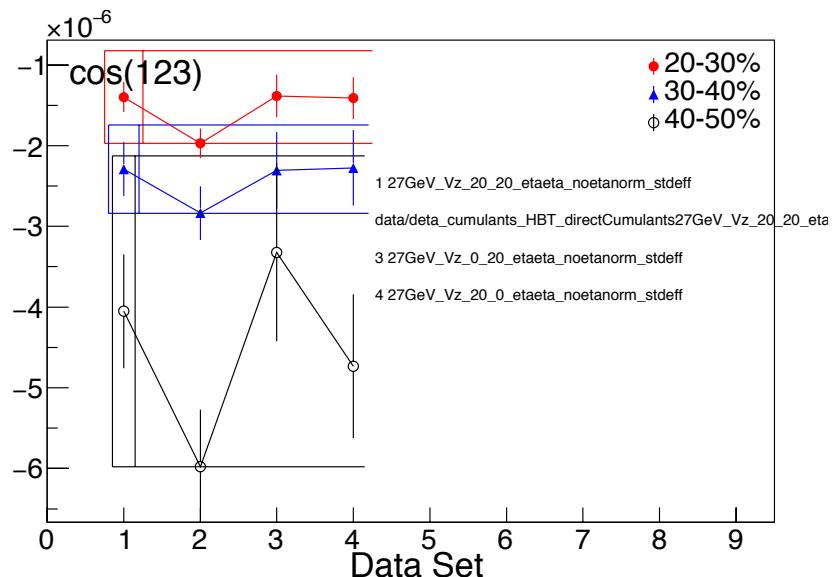
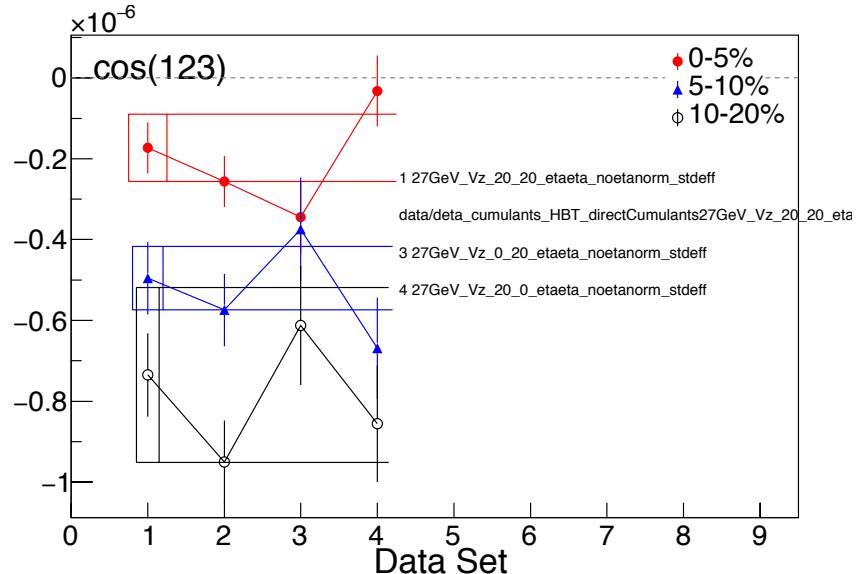
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 62.4 GeV



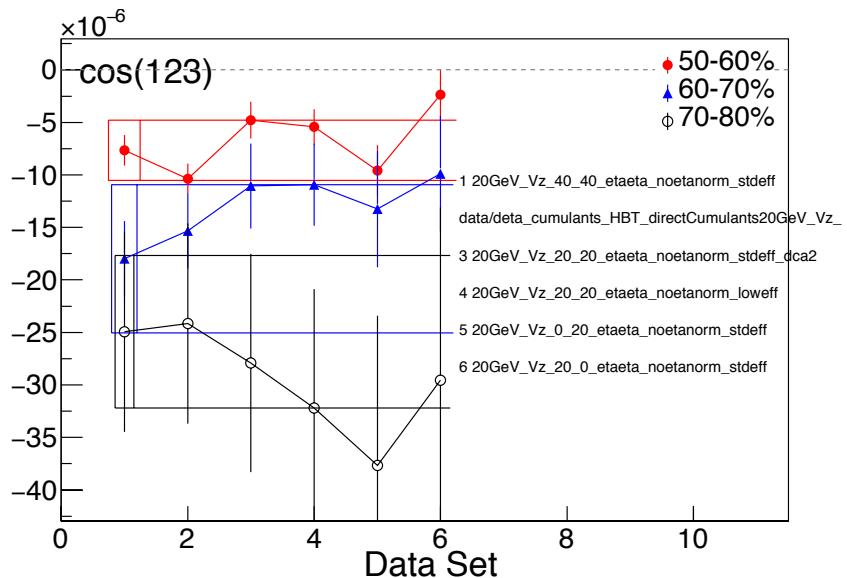
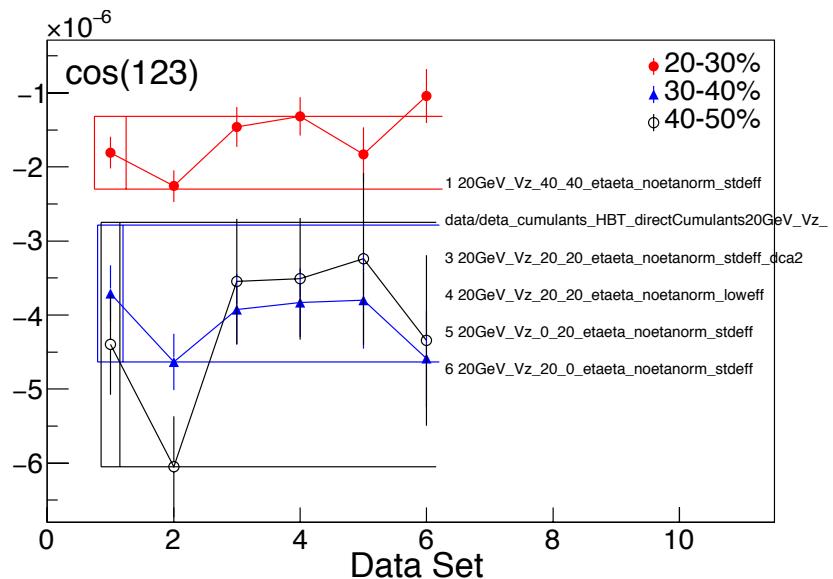
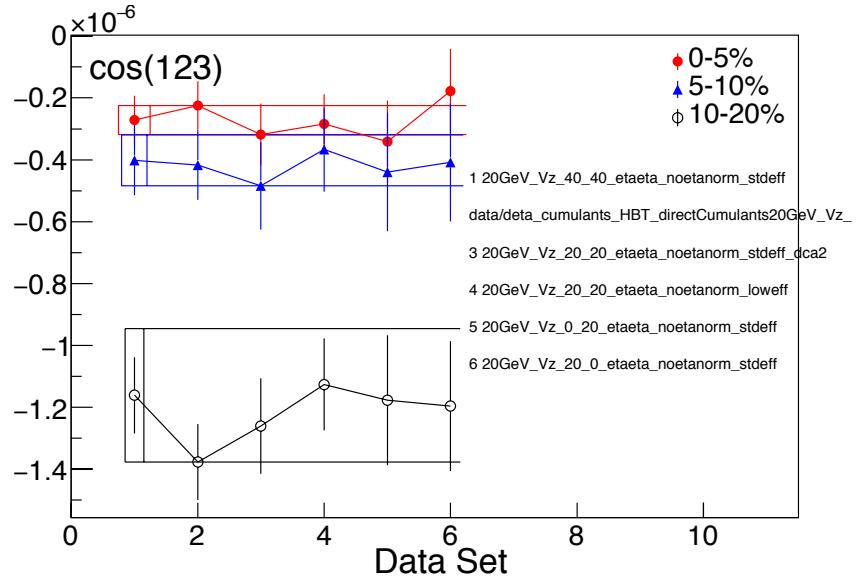
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 39 GeV



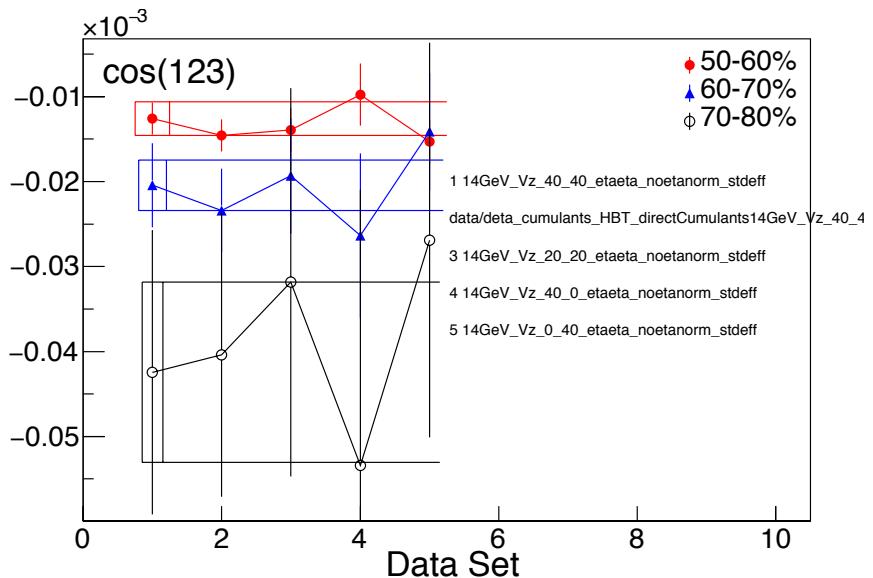
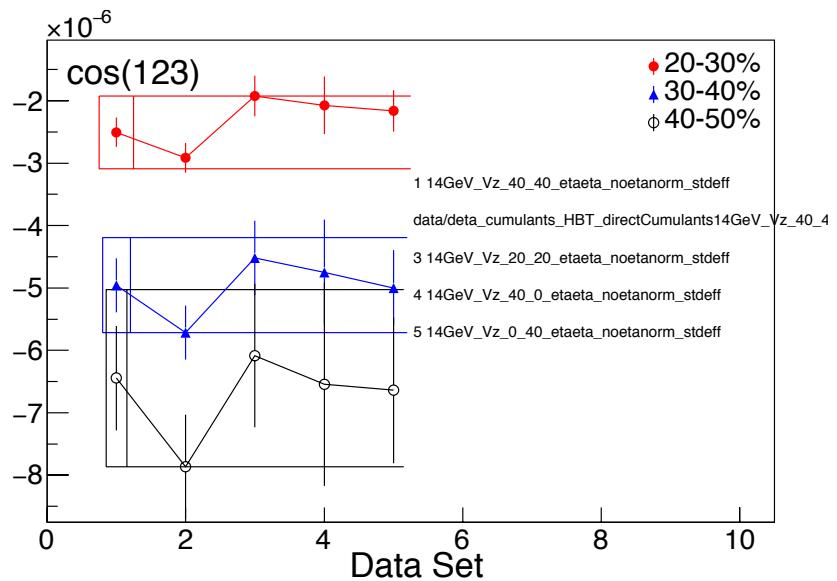
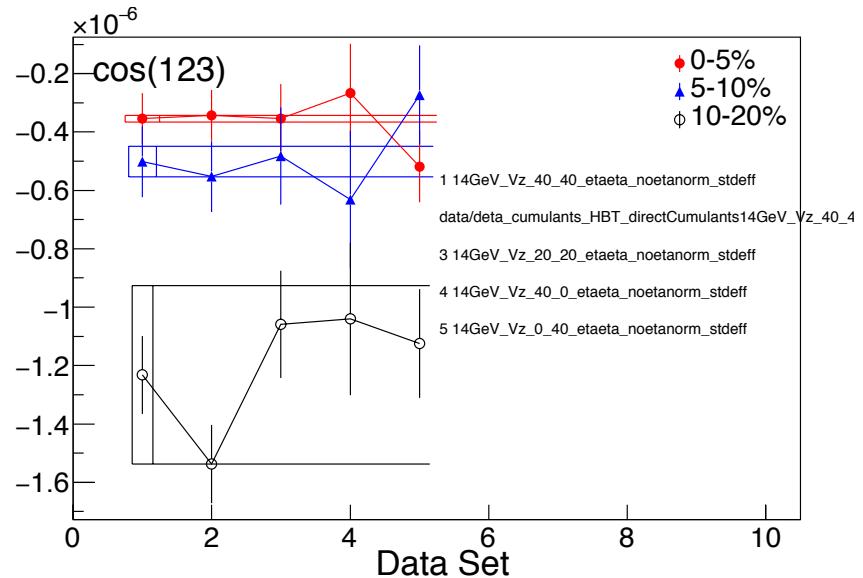
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 27 GeV



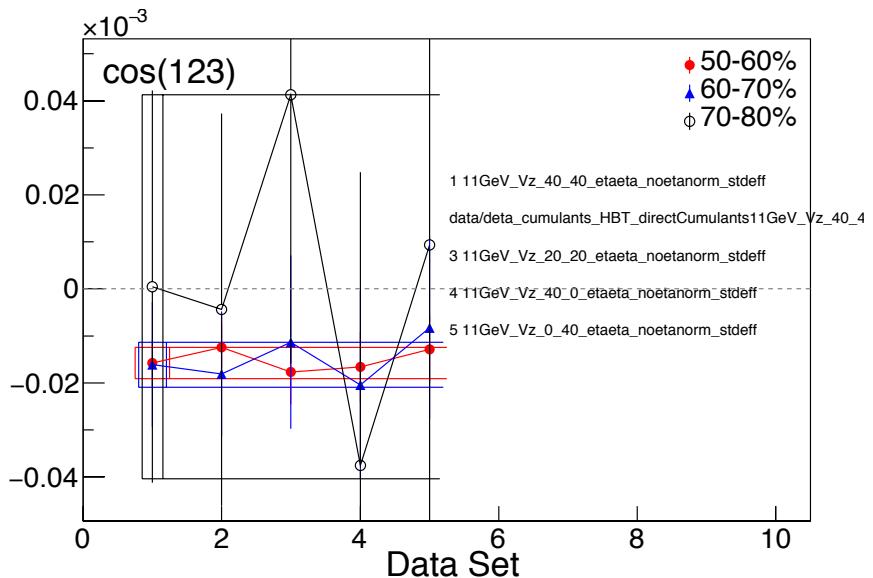
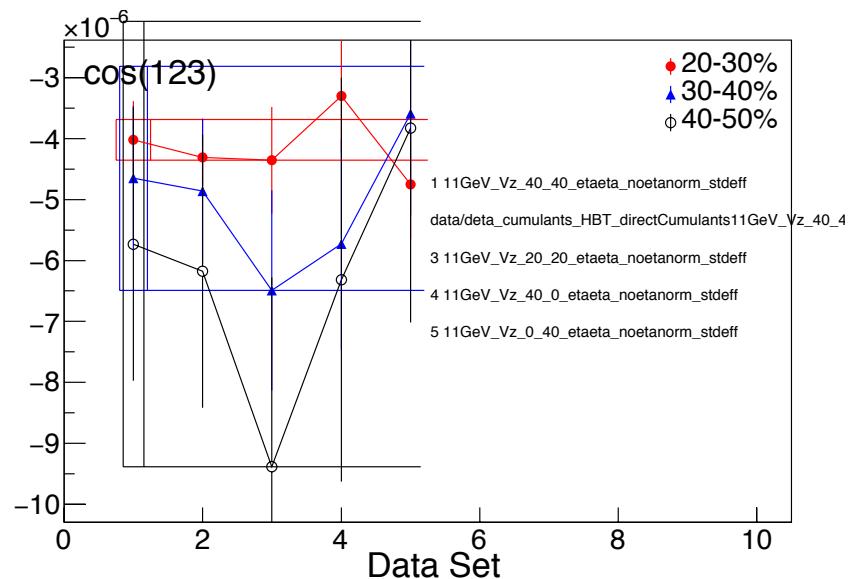
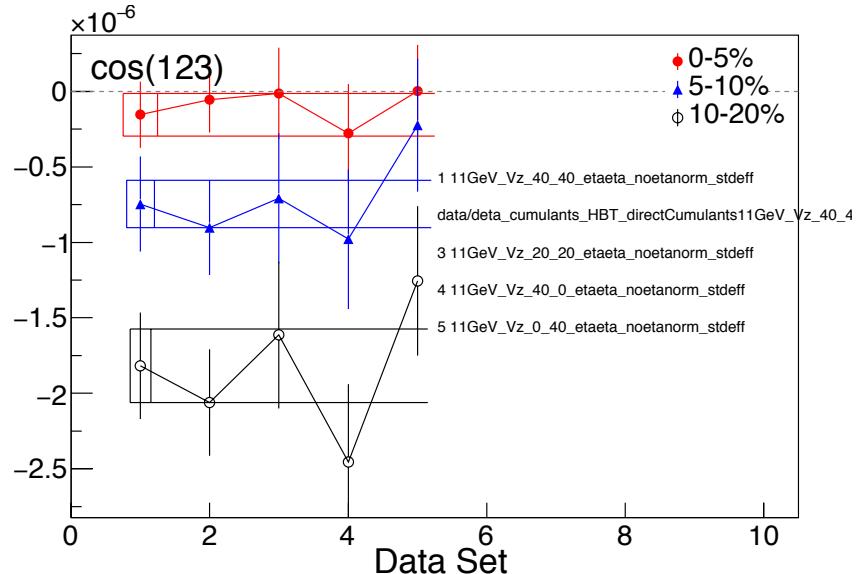
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 19.6 GeV



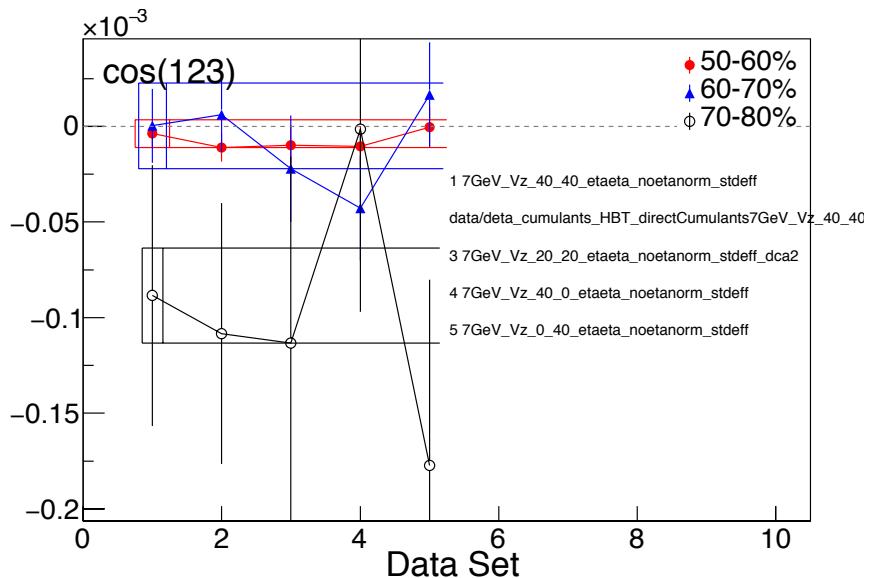
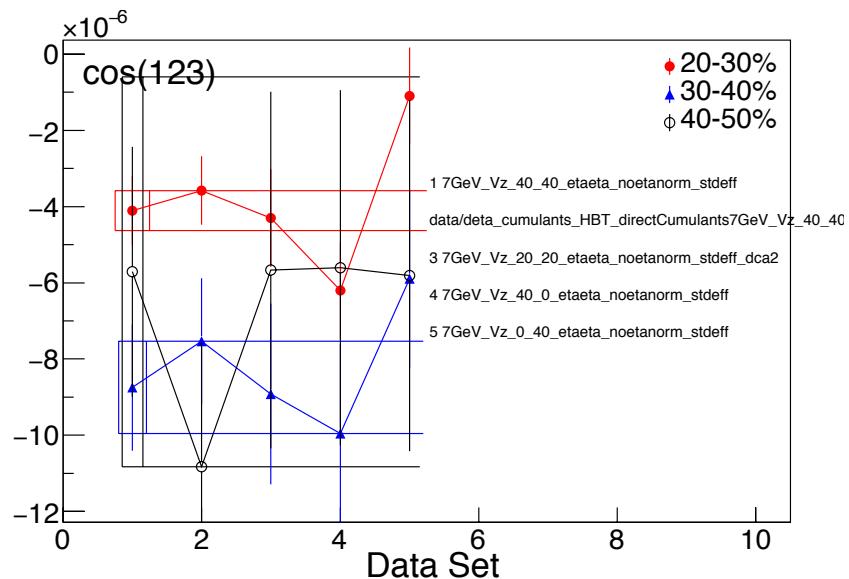
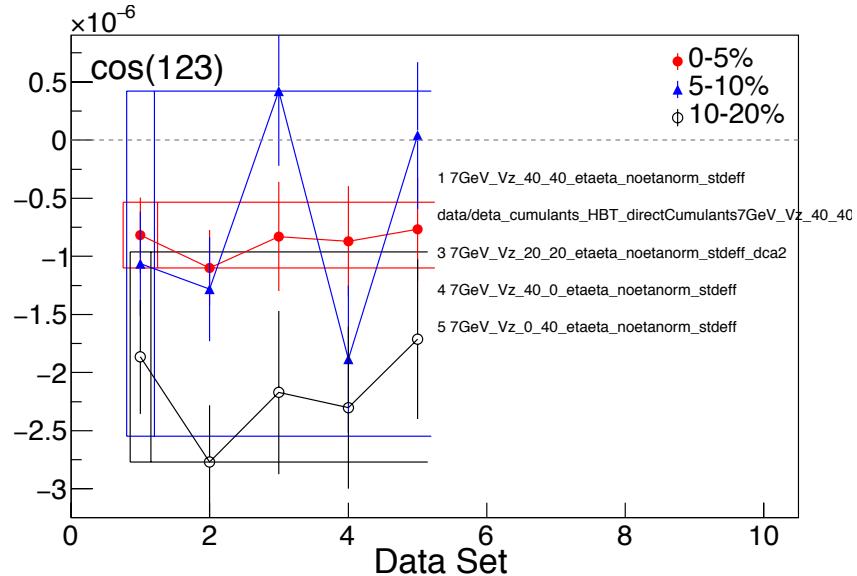
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 14.5 GeV



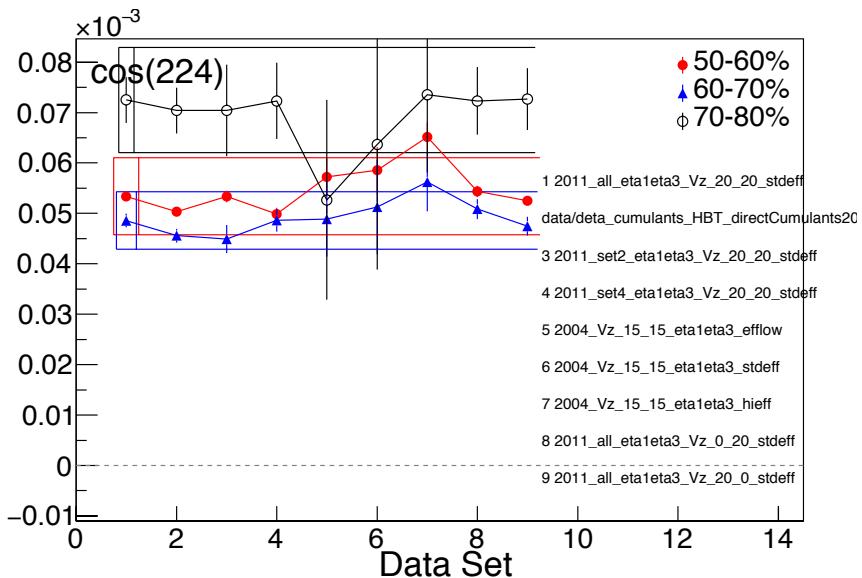
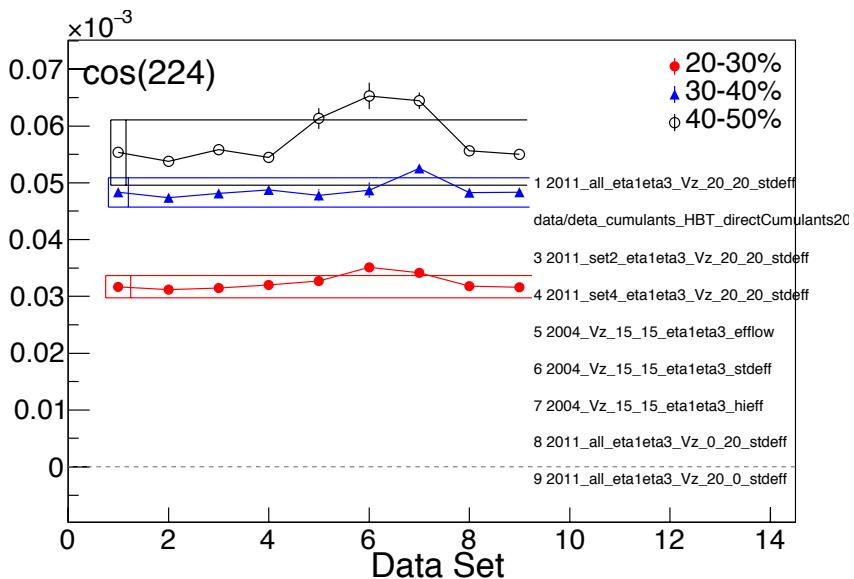
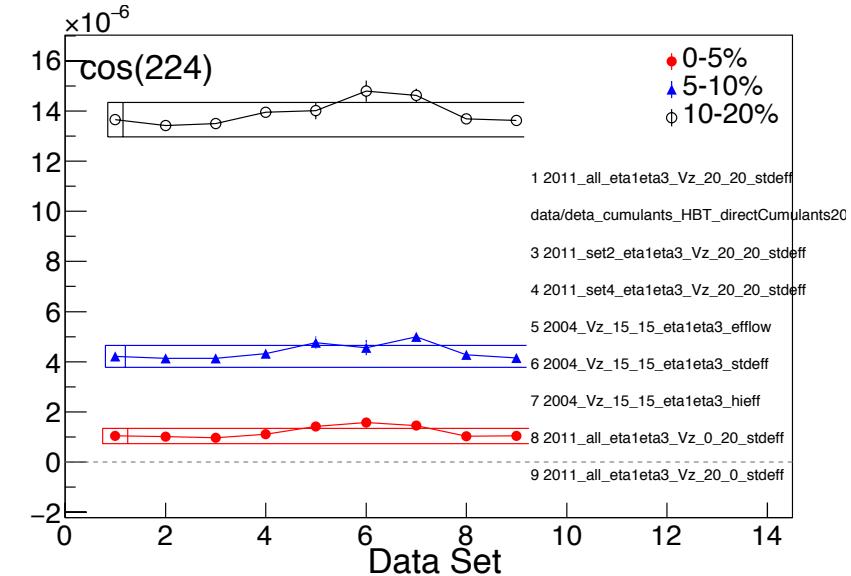
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 11.5 GeV



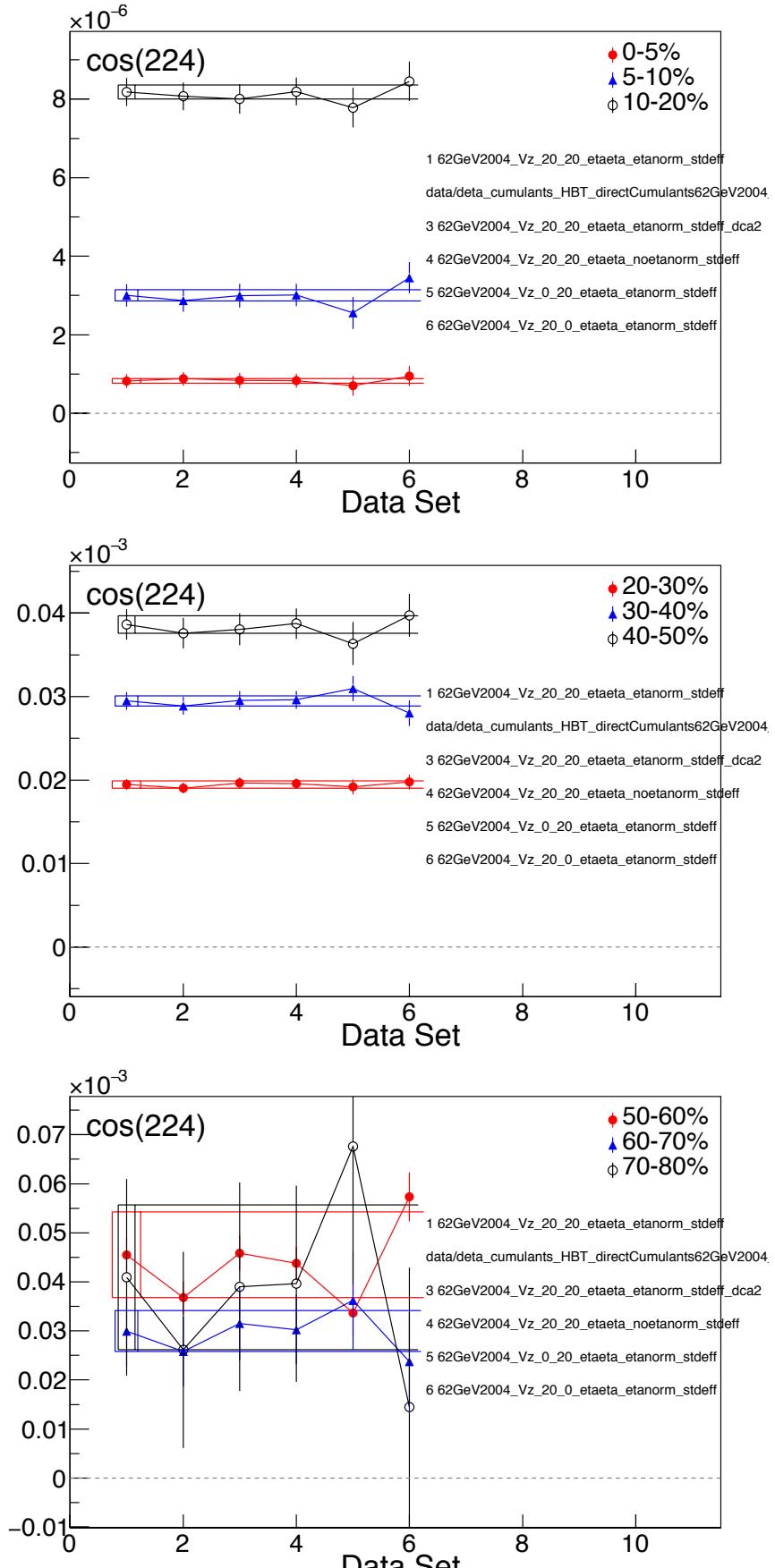
Systematic Errors and Trend Plots: $\cos(1\phi_1+2\phi_2-3\phi_3)$ 7.7 GeV



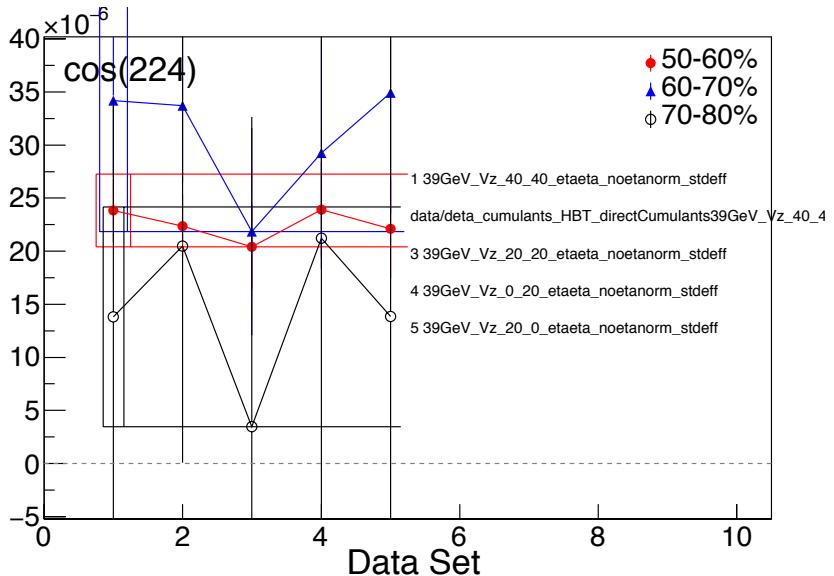
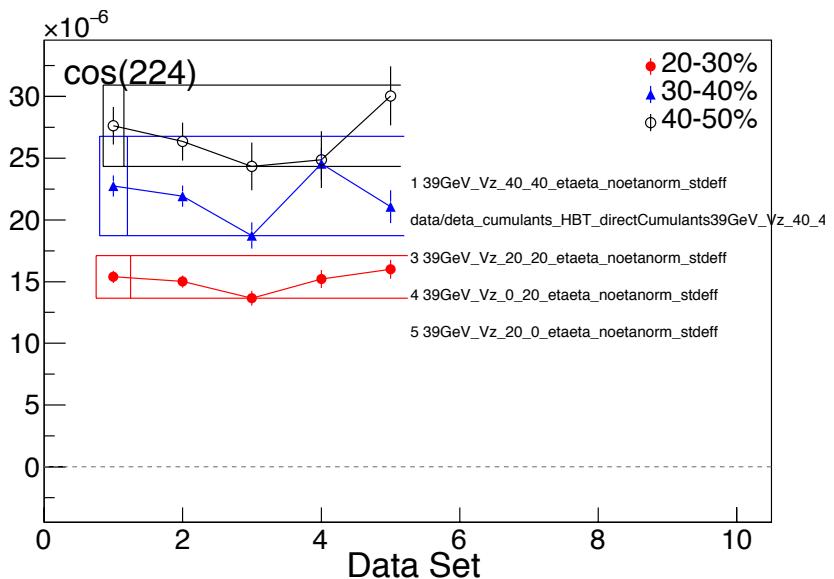
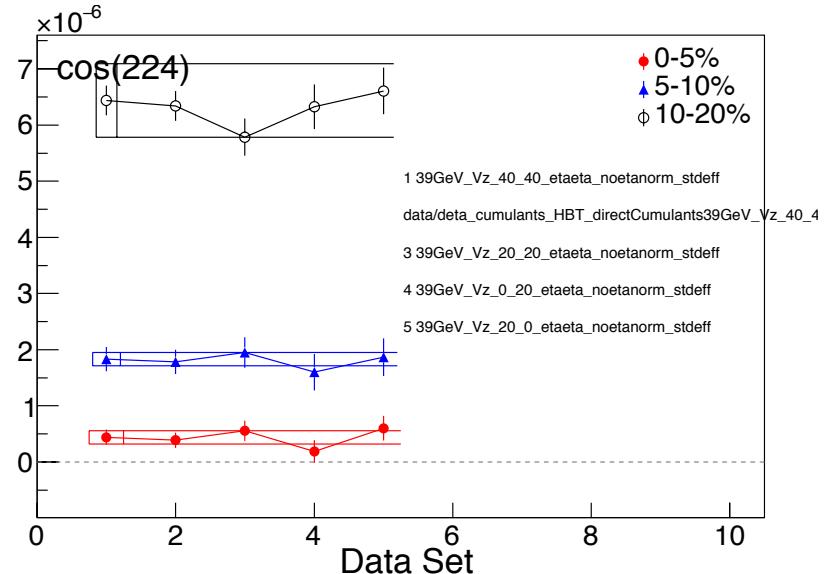
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 200 GeV



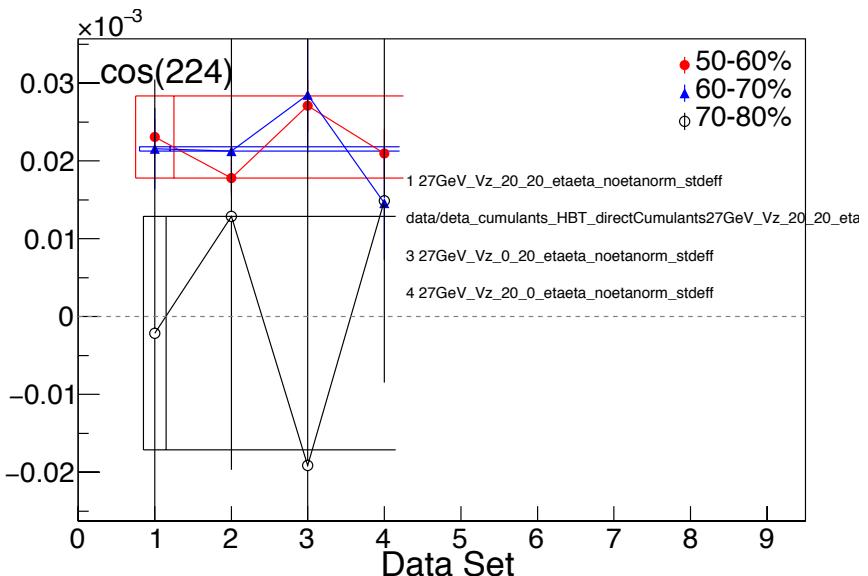
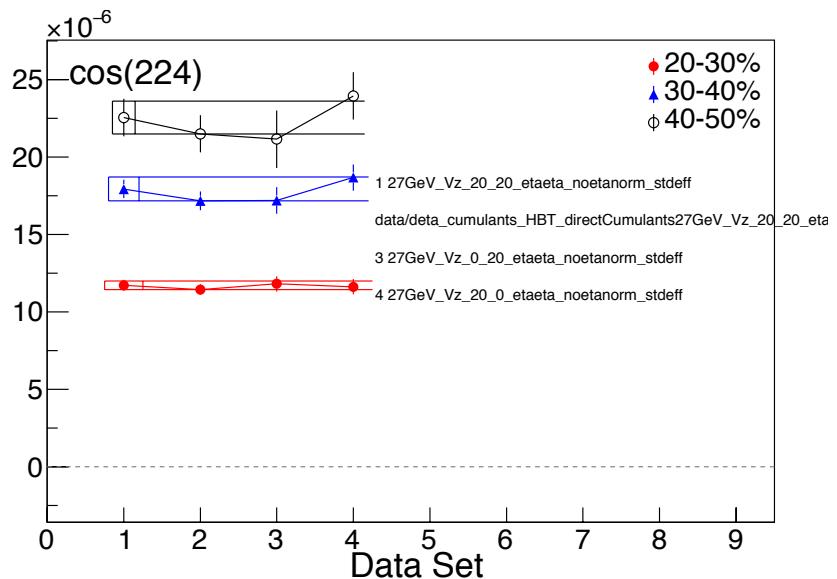
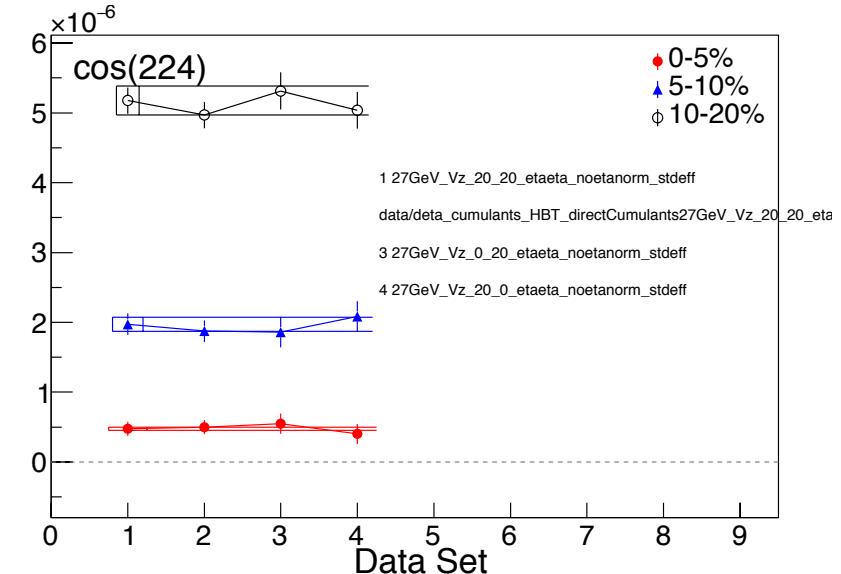
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 62.4 GeV



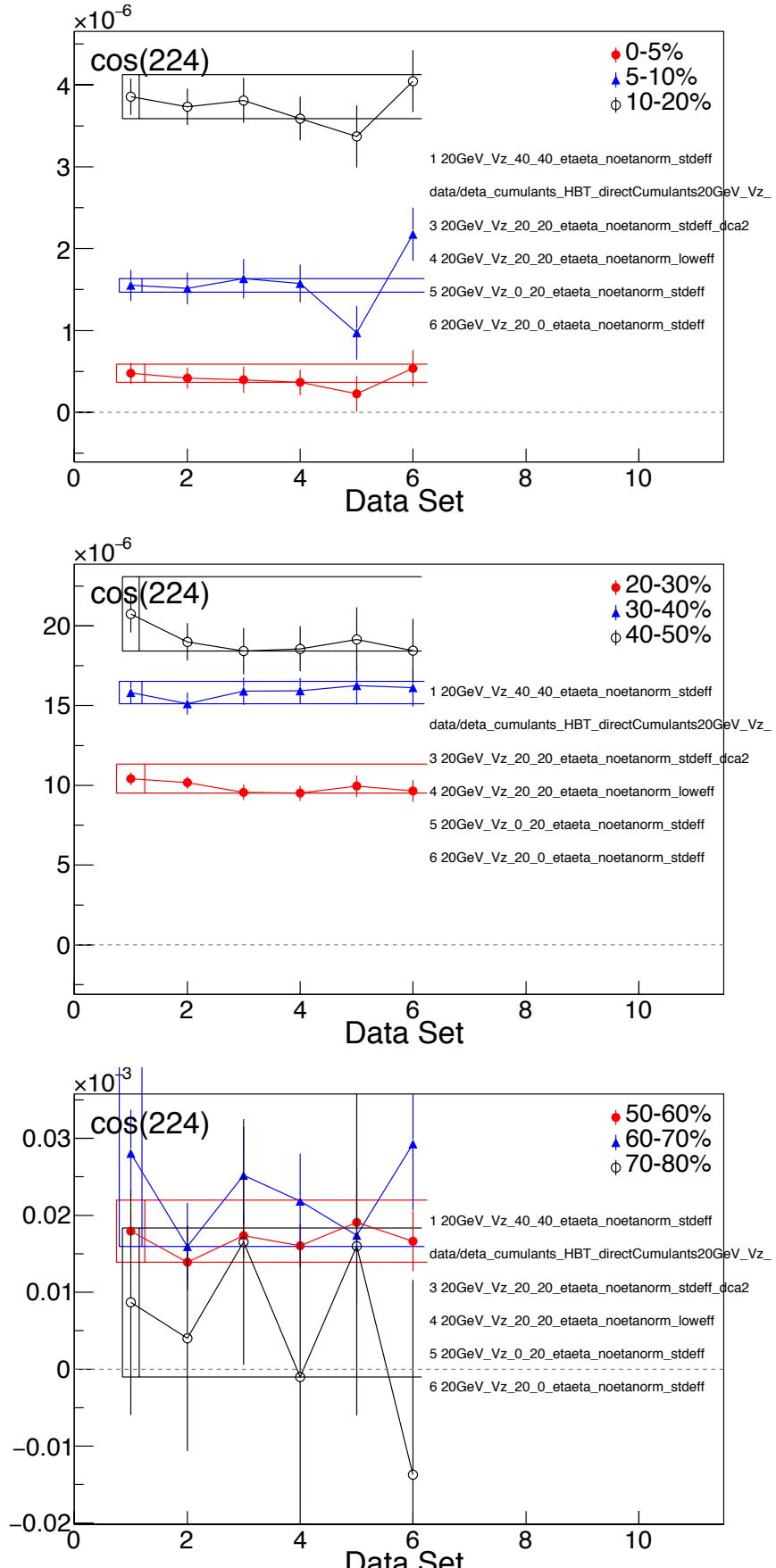
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 39 GeV



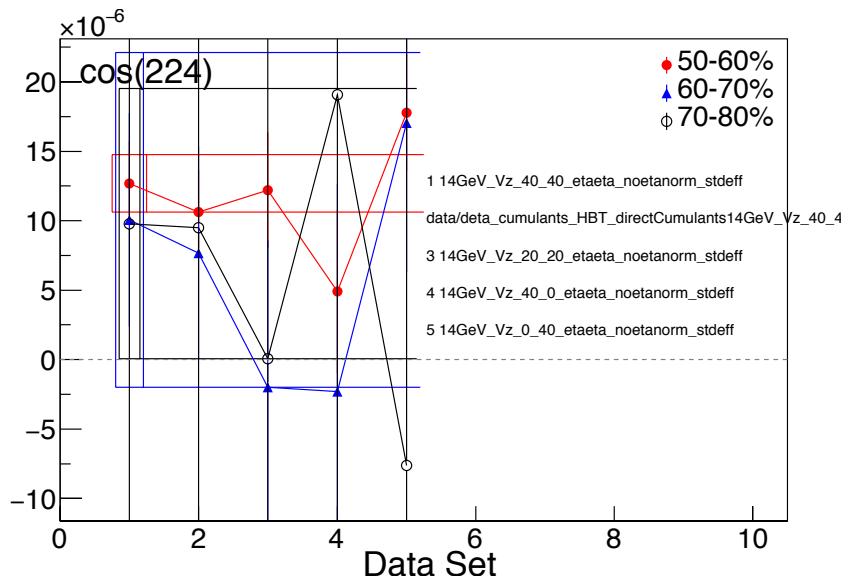
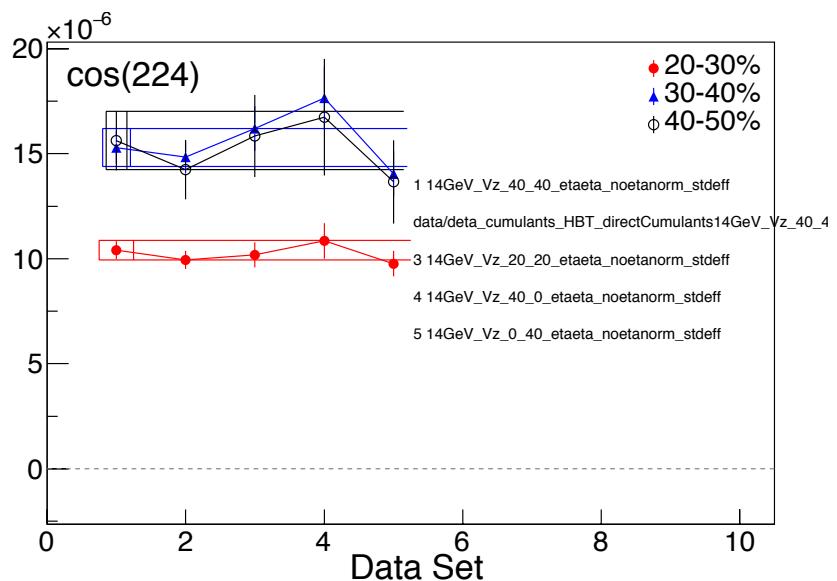
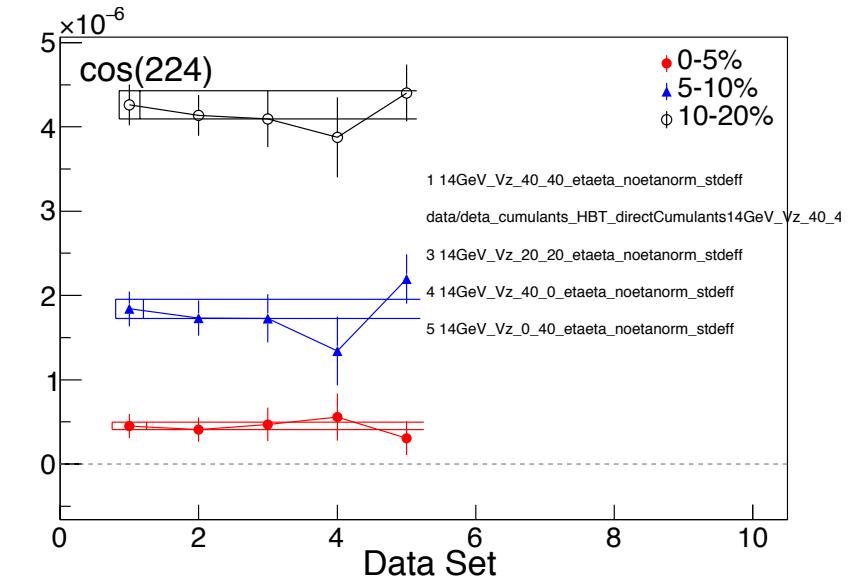
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 27 GeV



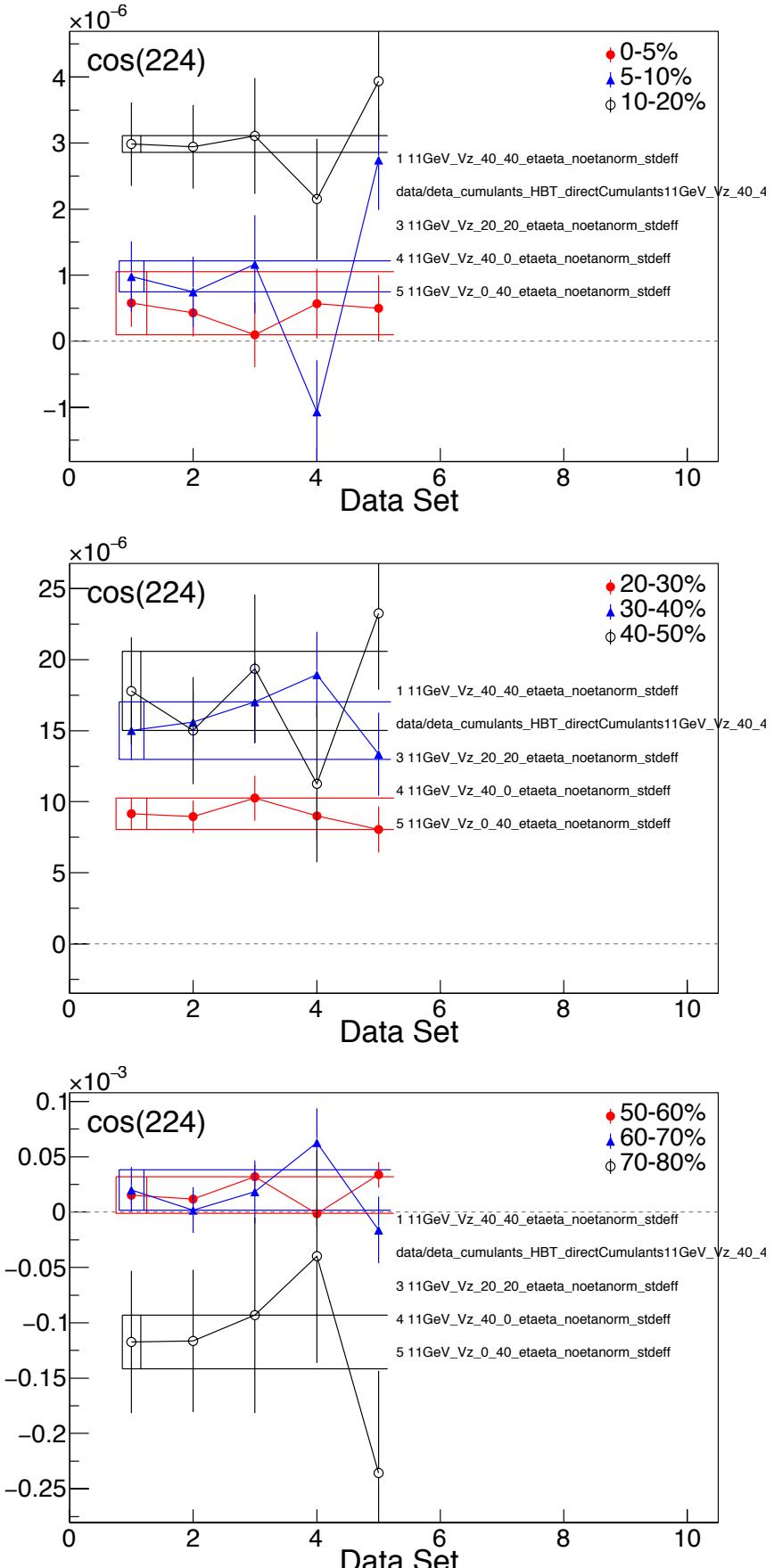
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 19.6 GeV



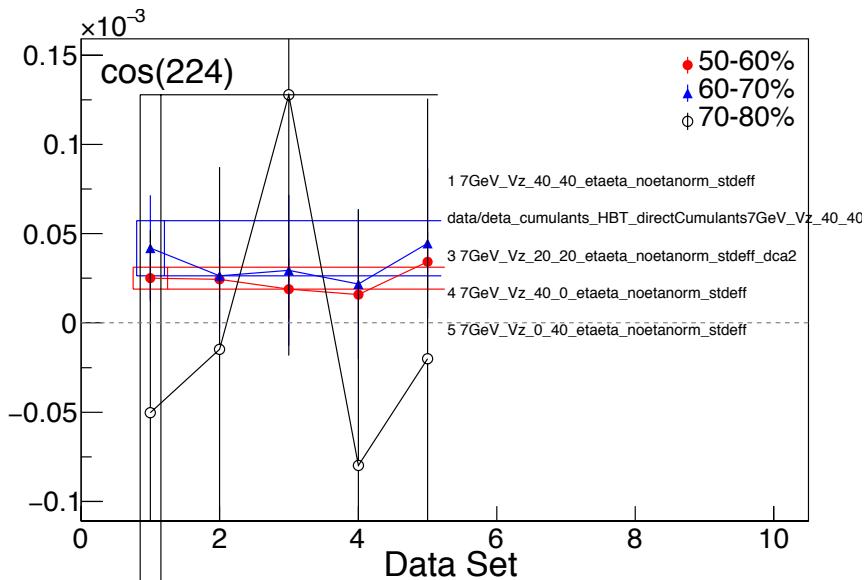
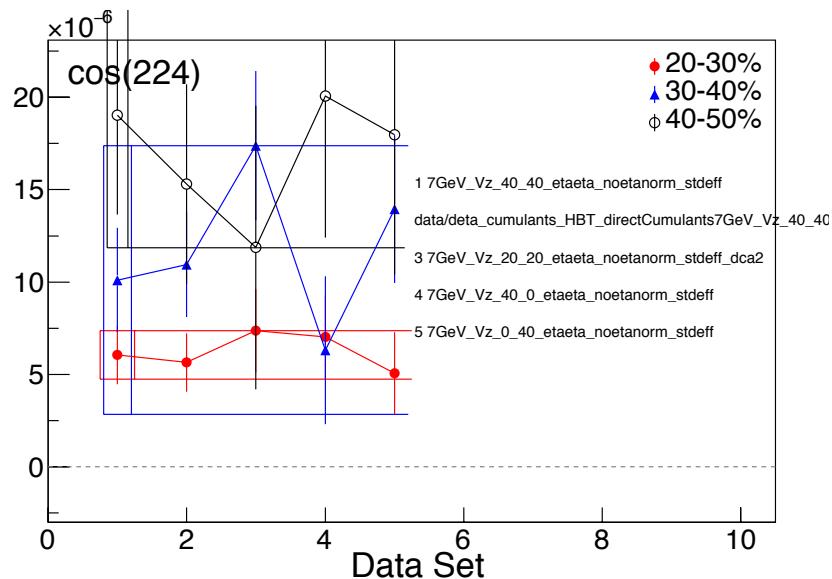
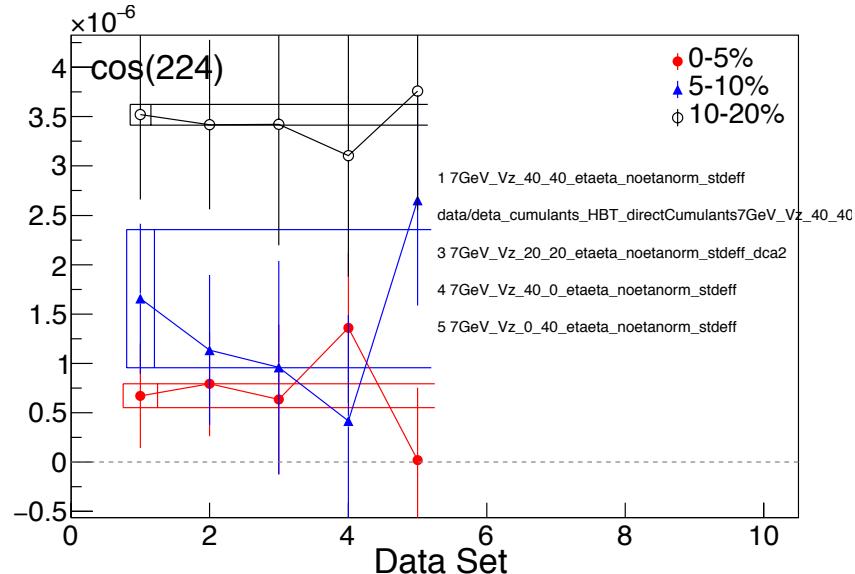
Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 14.5 GeV



Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 11.5 GeV



Systematic Errors and Trend Plots: $\cos(2\phi_1+2\phi_2-4\phi_3)$ 7.7 GeV



Figures 1, 2, 3, and 4:

The purpose of the first 4 figures of the paper is to study the $\Delta\eta$ dependence of the three particle correlations. These figures also serve to explain how the HBT and track merging corrections are applied.

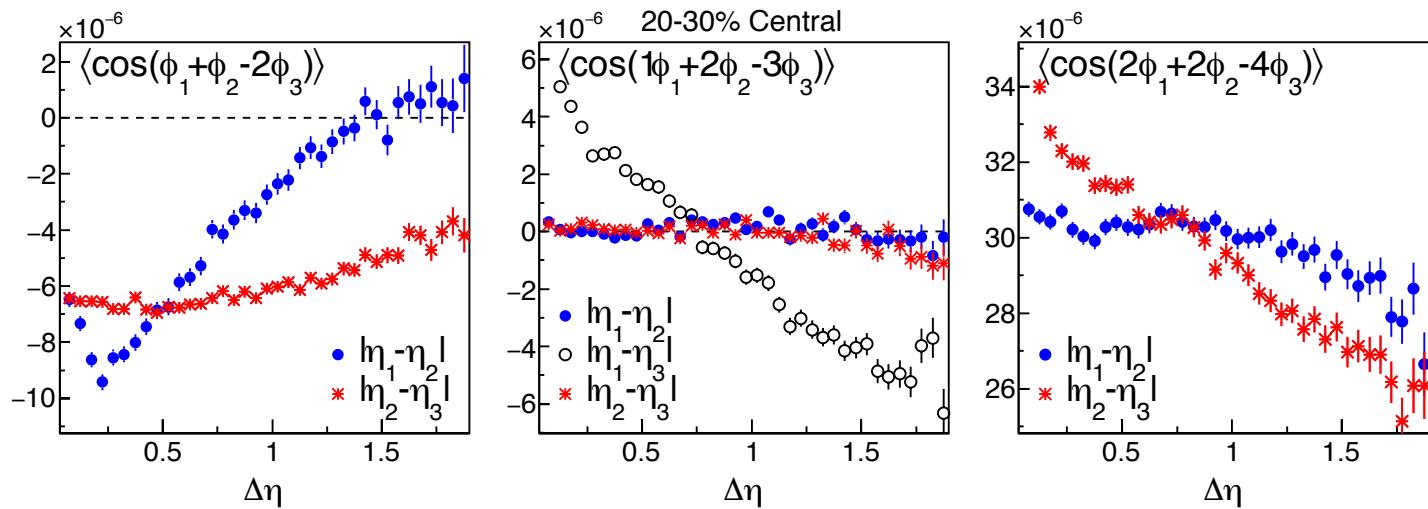
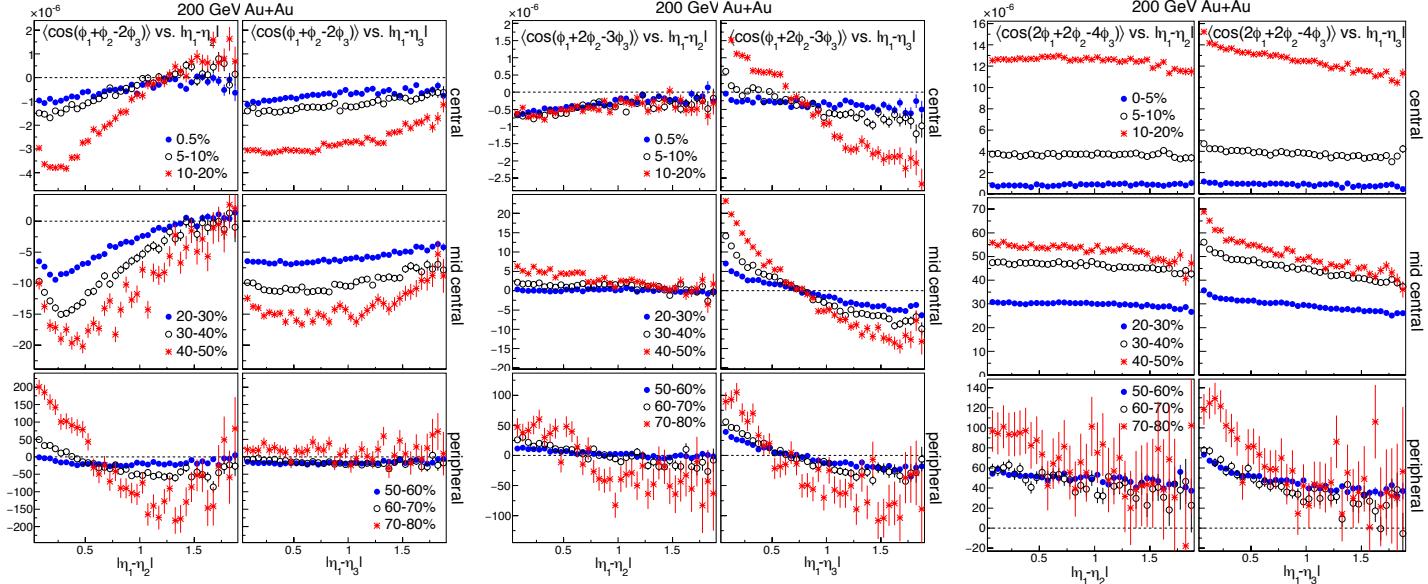


Figure 5:

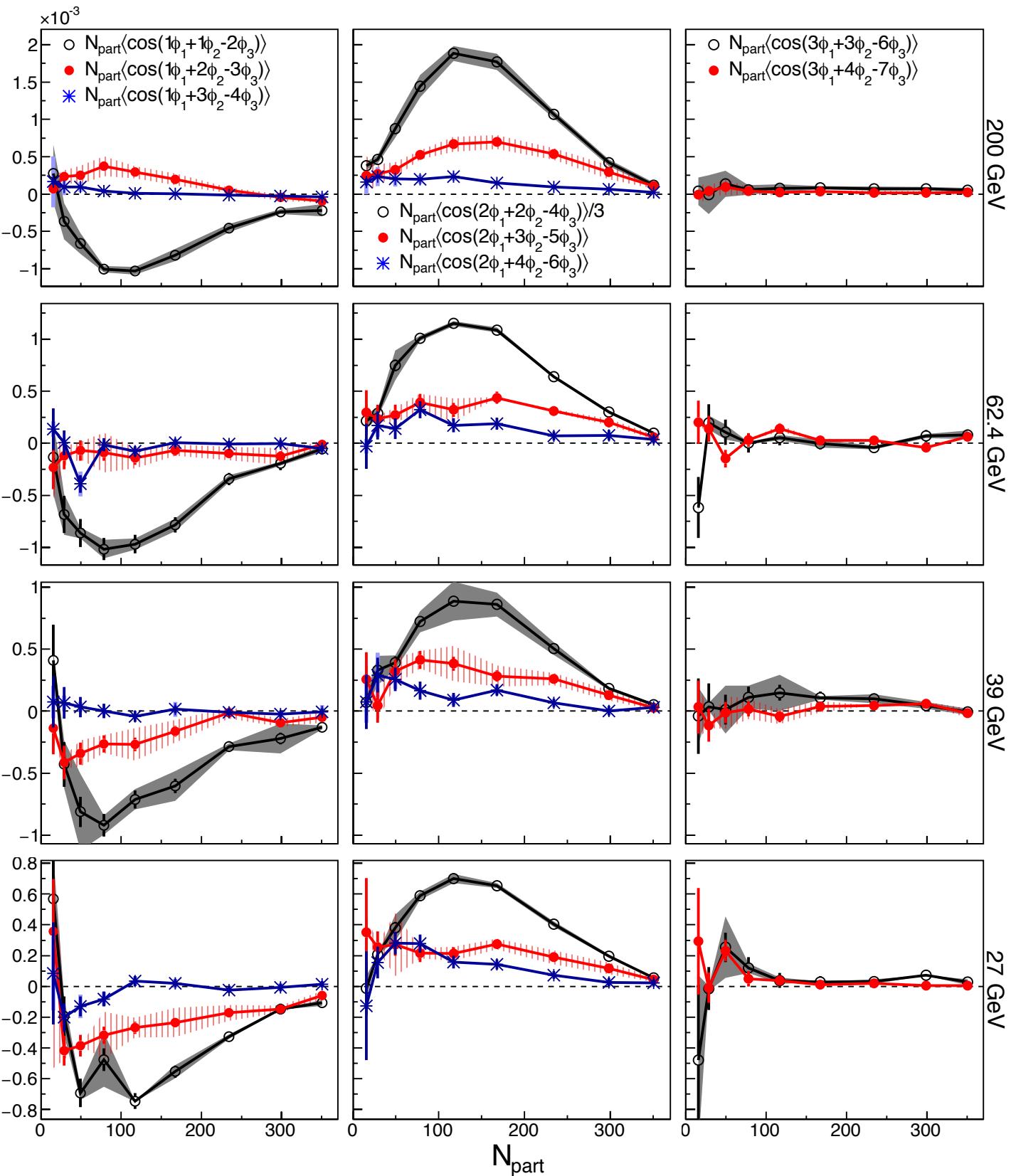
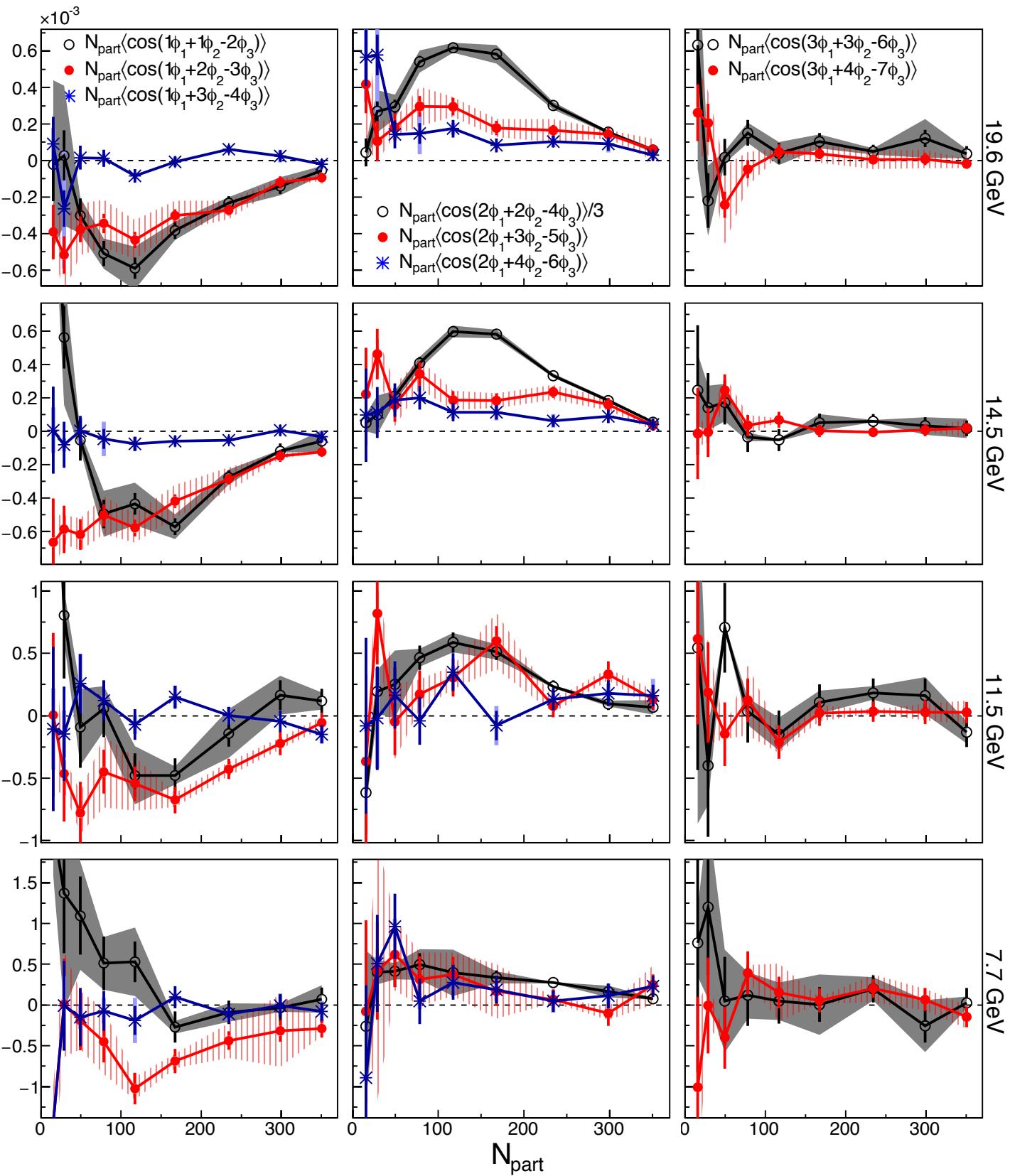
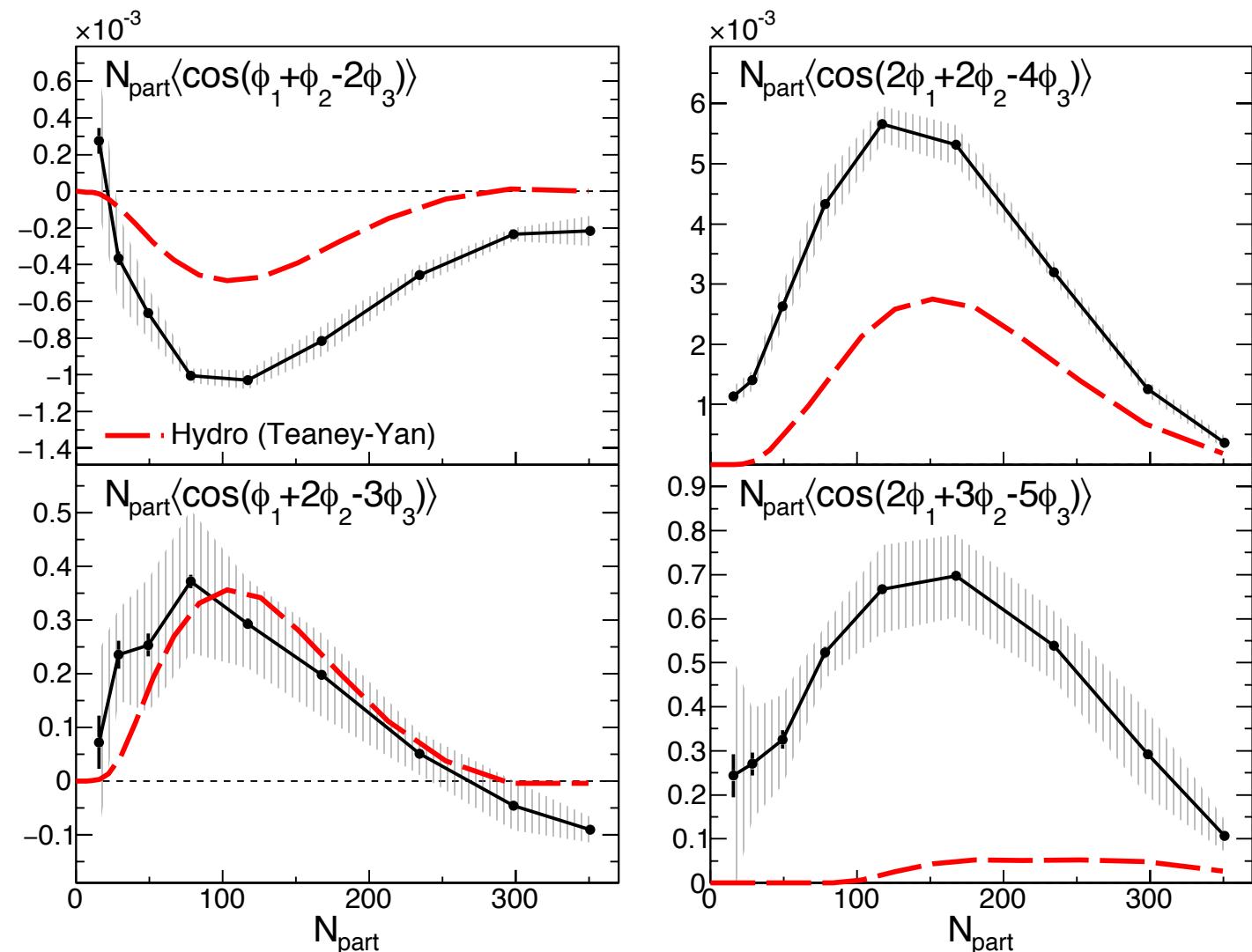


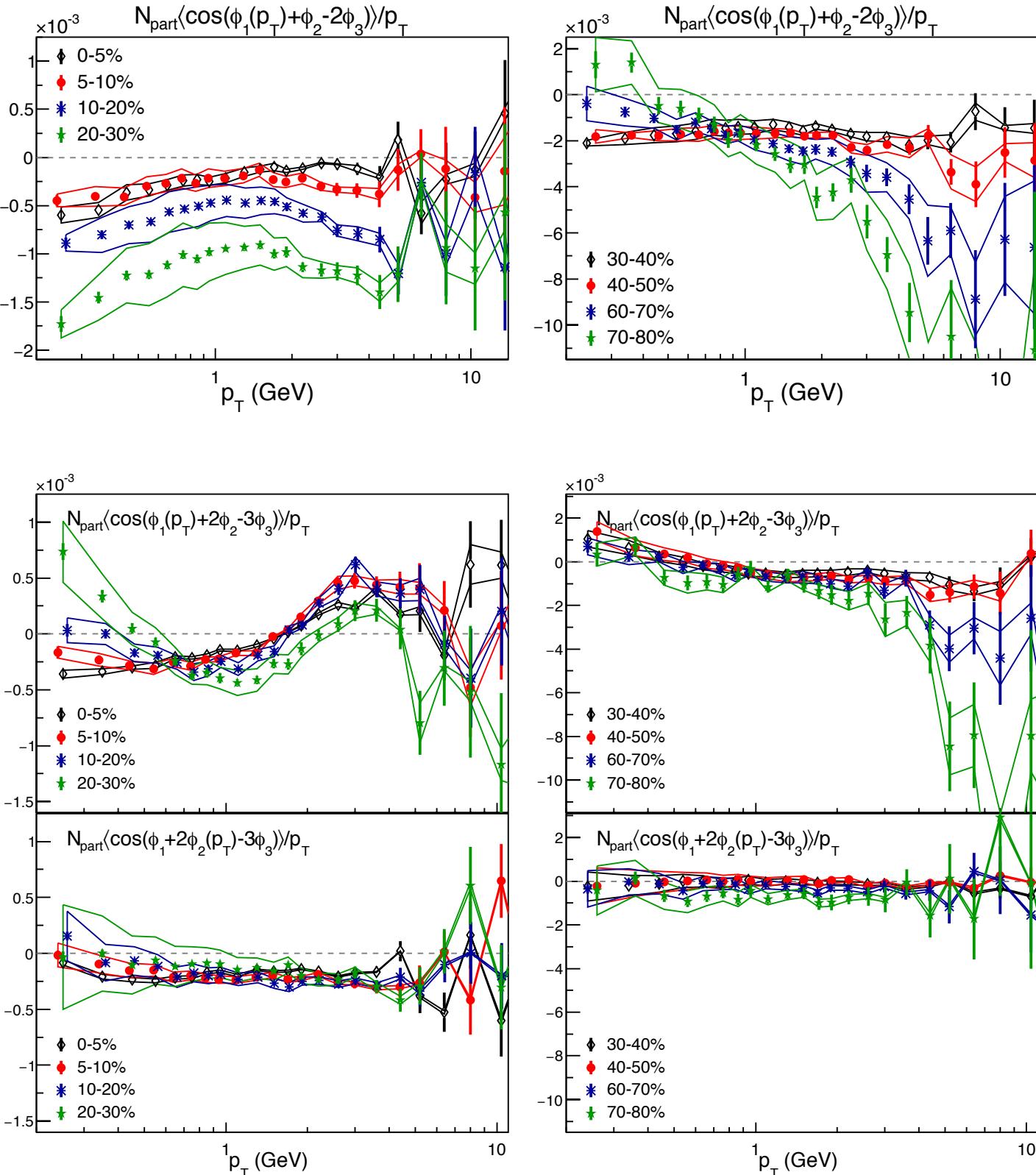
Figure 6:



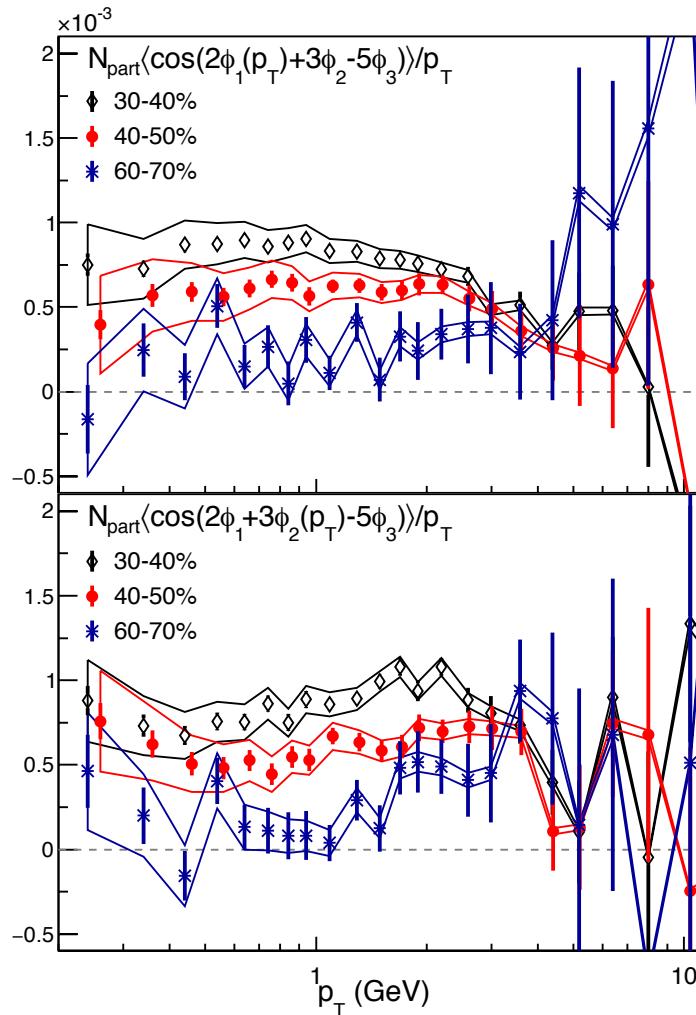
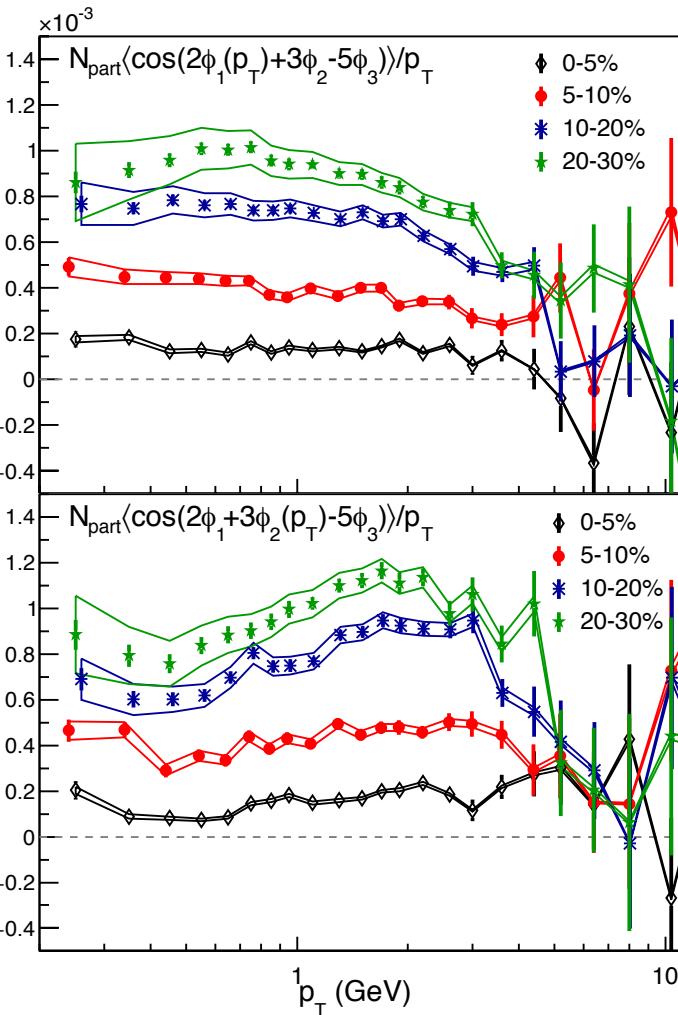
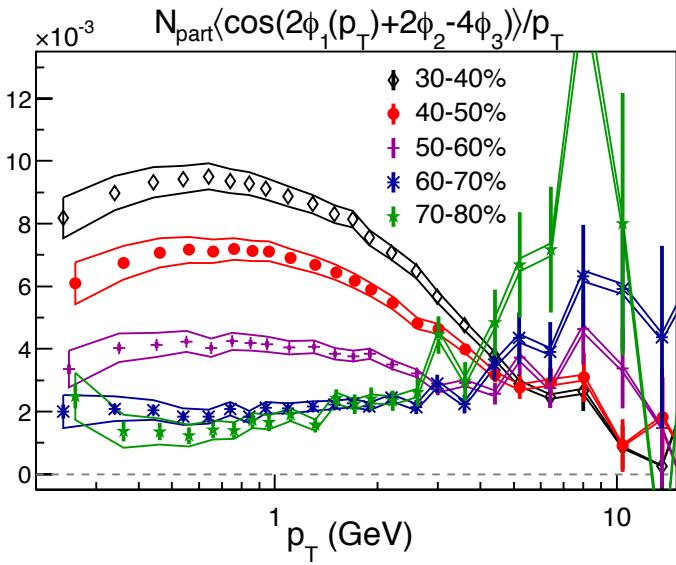
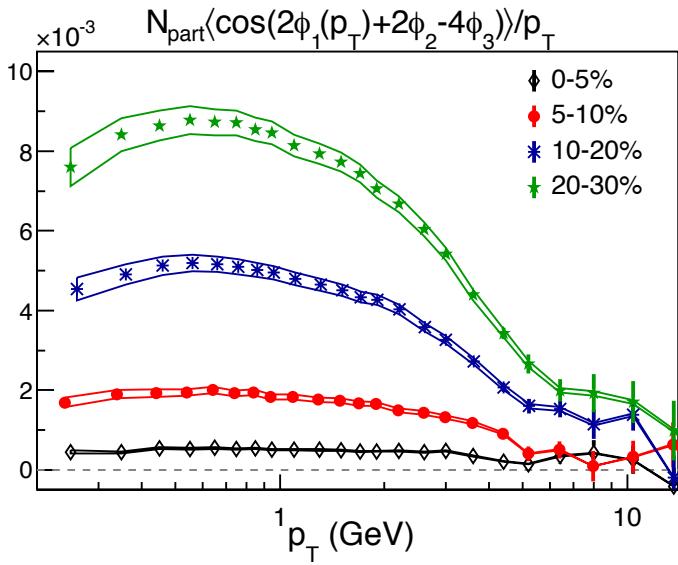
Old Figure 7 (now part of the short paper):



Figures 7 and 8:



Figures 9 and 10:



Figures 11 and 12:

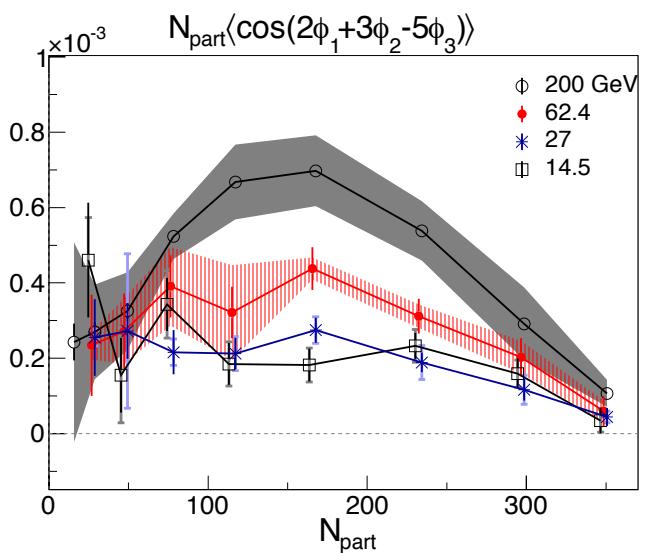
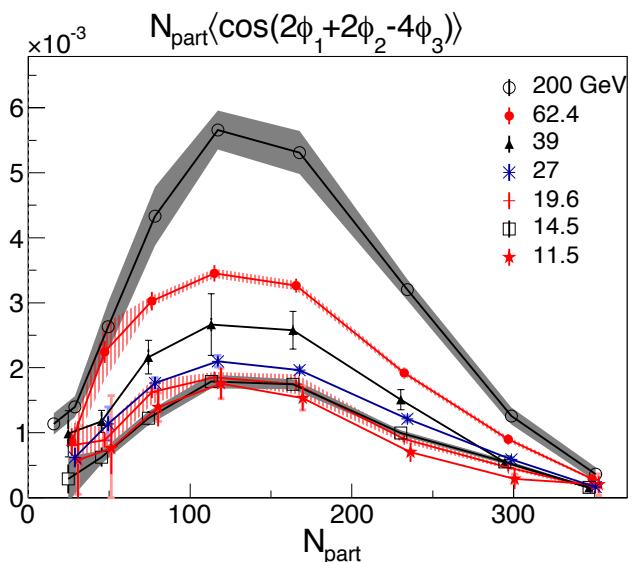
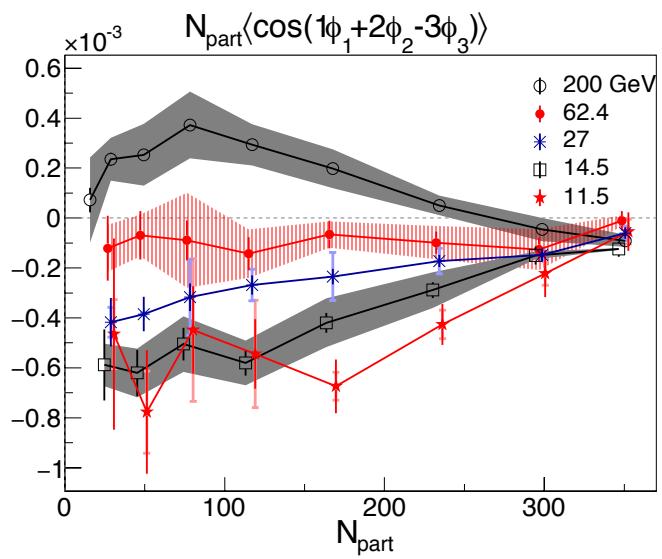
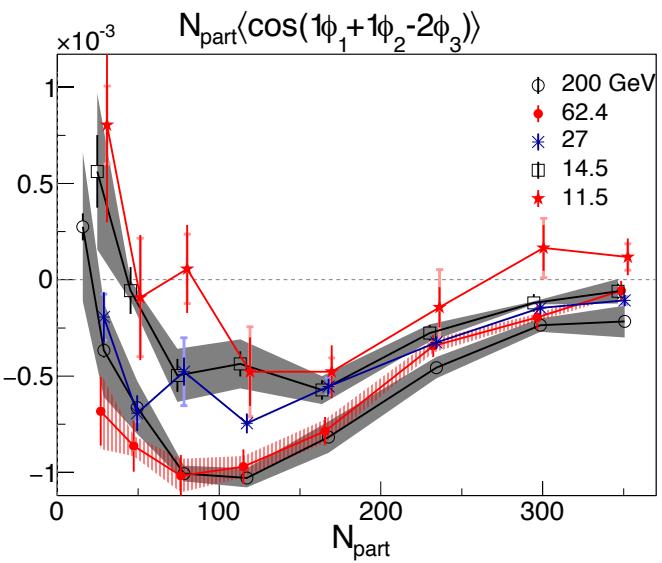
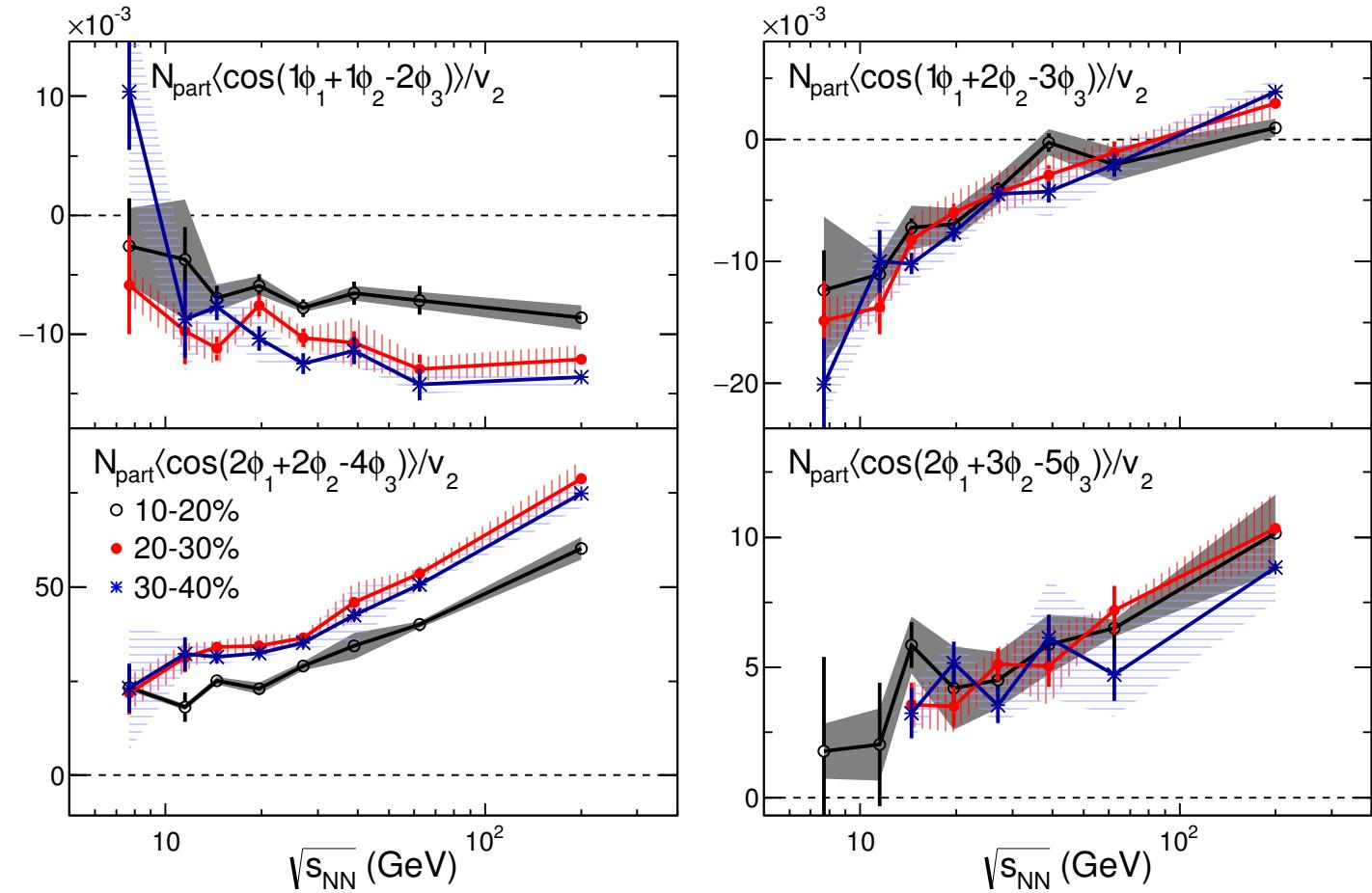
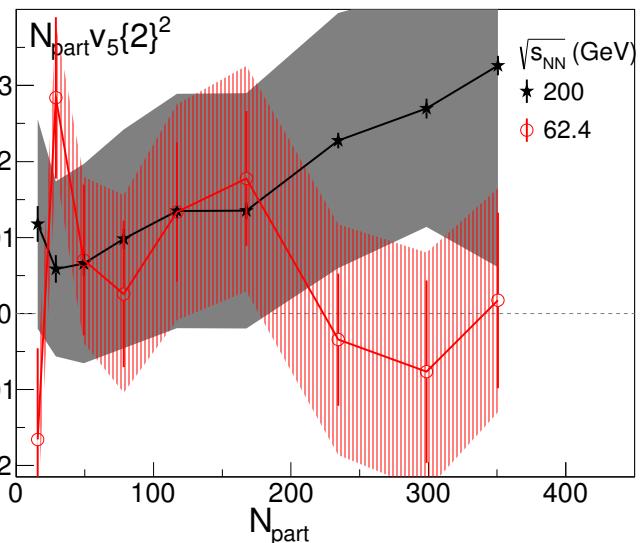
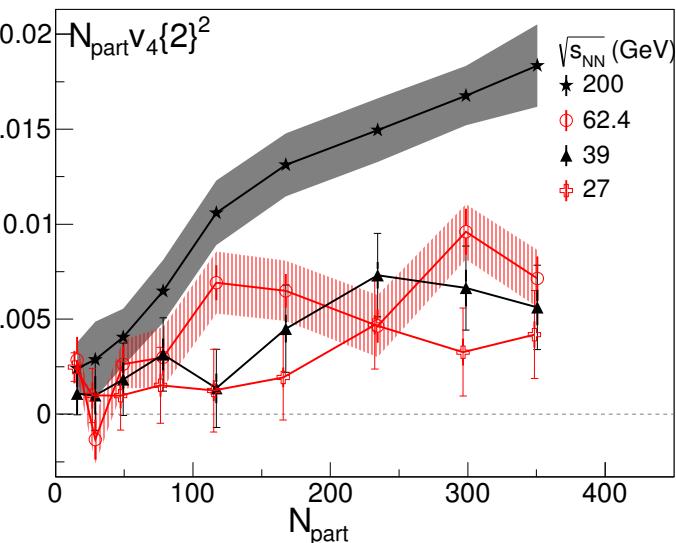
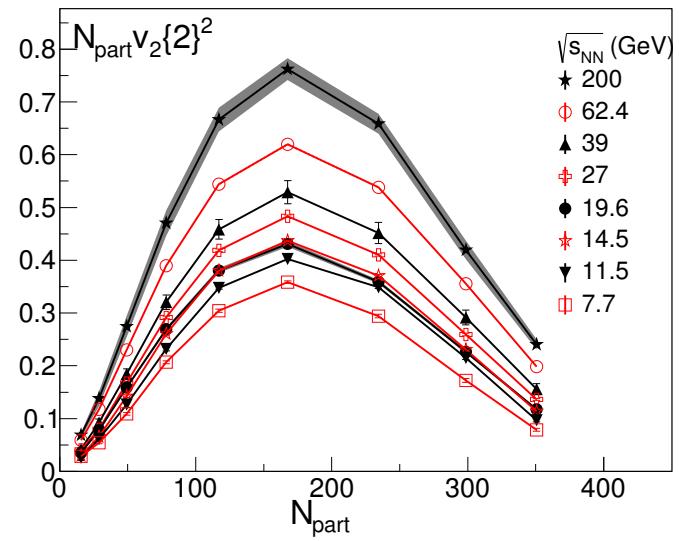
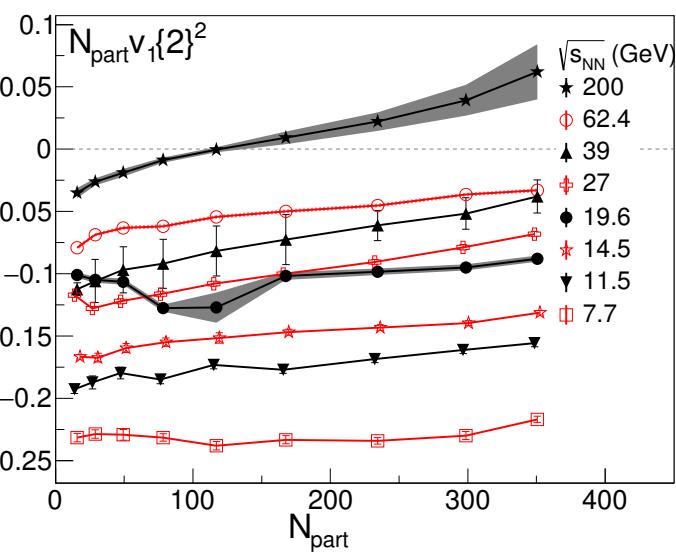


Figure 13:

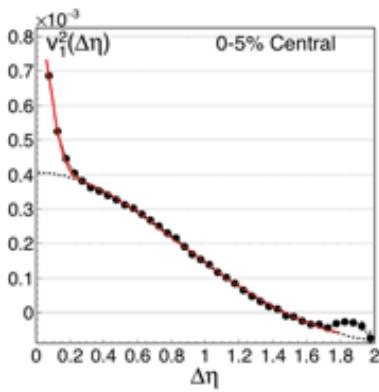


Appendix Figures v_n:

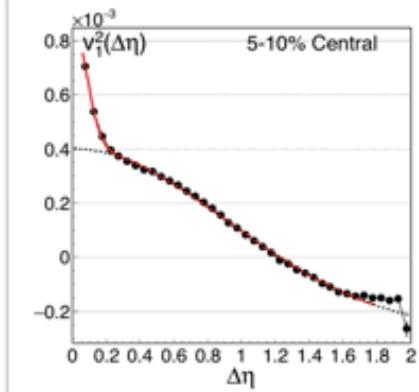
The final figures of the draft present the three particle correlations scaled by v2. Here we show v2 along with v1, v4, and v5. v3 was already published. Although not central to the paper, these two-particle measurements are important baselines for the three particle correlations and are useful for understanding trends in the three particle correlations. In the pages of this note following these figures, we also present all the fits that were used to extract this data. The details of the fits are described in the BES v3 analysis note: <https://drupal.star.bnl.gov/STAR/starnotes/private/psn0627>



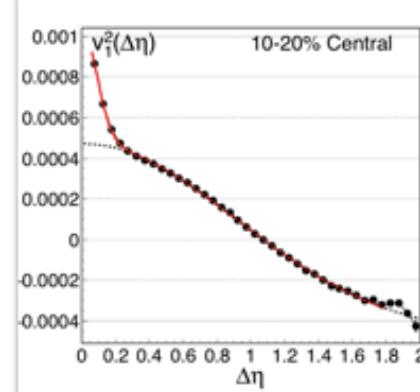
Appendix supporting material $v_1^2\{2\}$ fits 200 GeV:



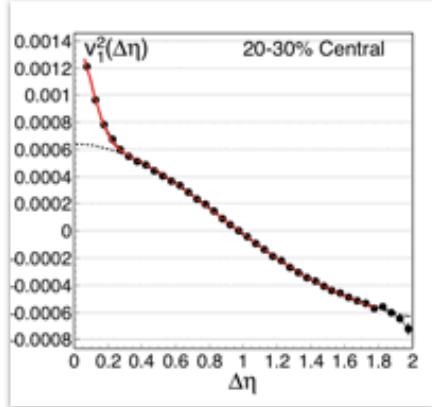
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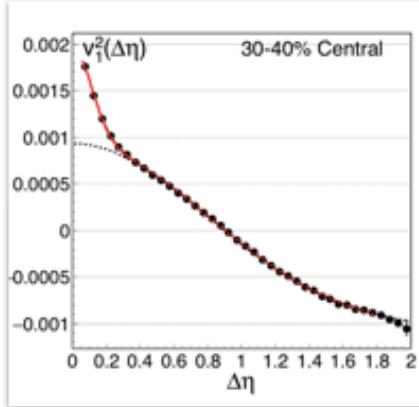
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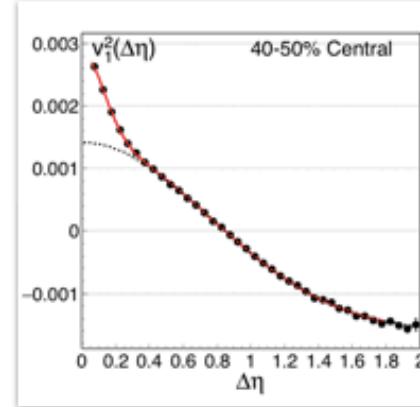
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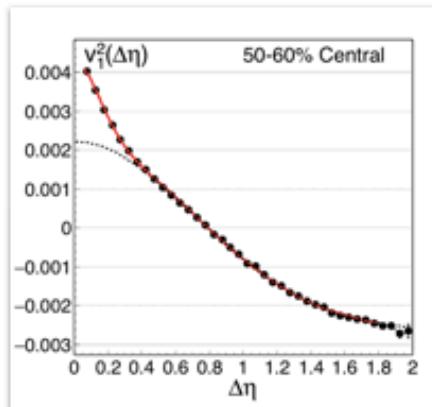
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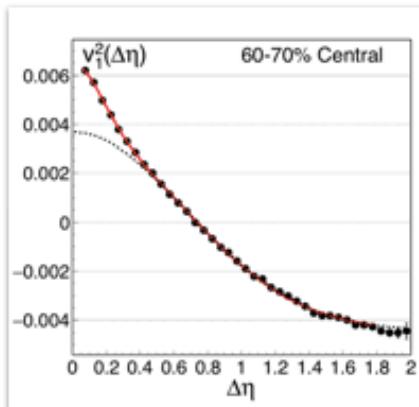
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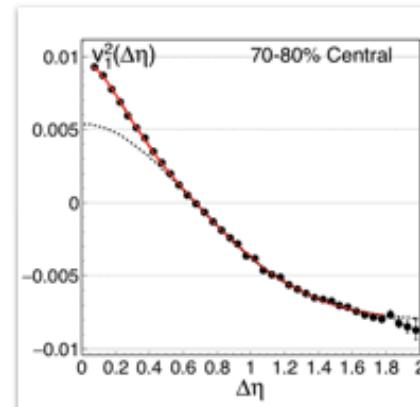
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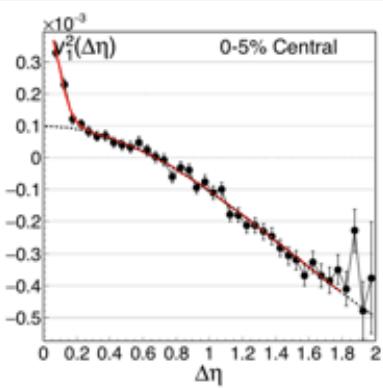


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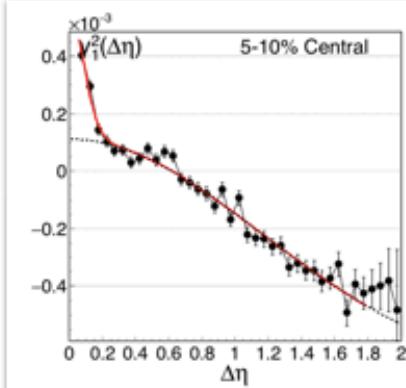


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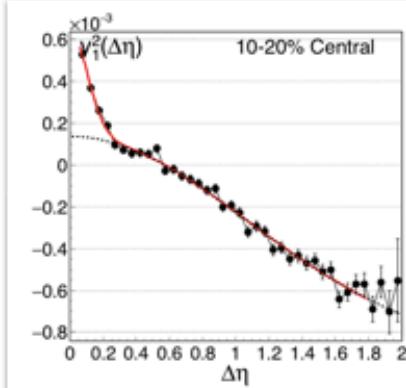
Appendix supporting material $v_1^2\{2\}$ fits 62.4 GeV:



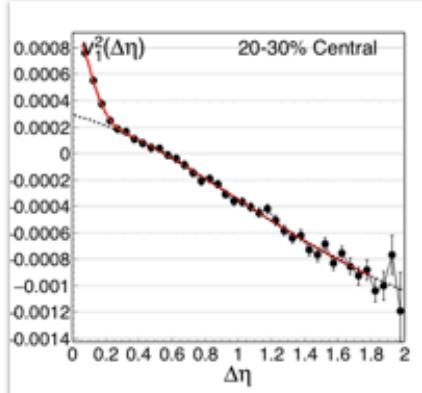
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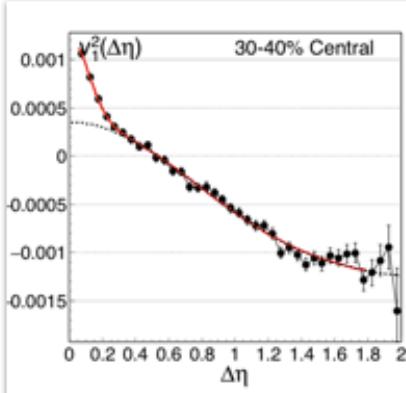
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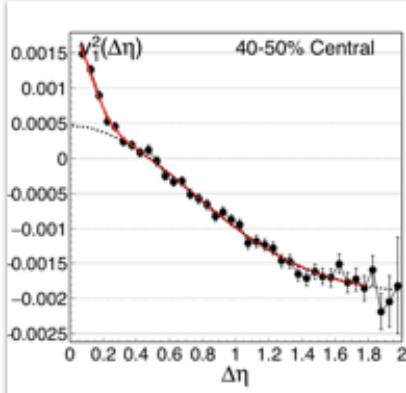
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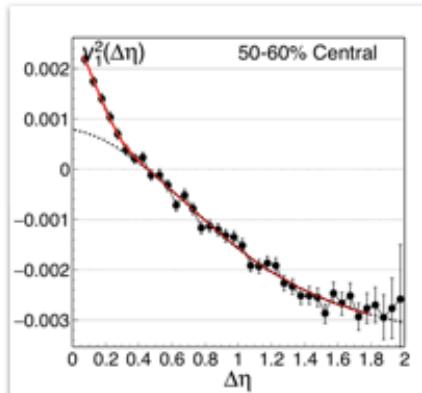
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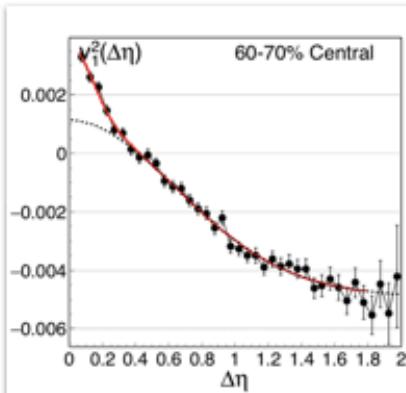
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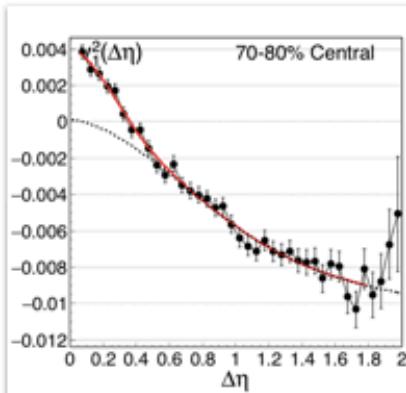
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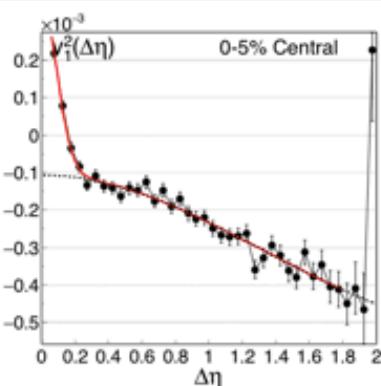


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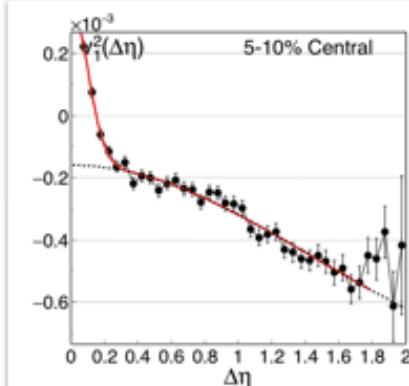


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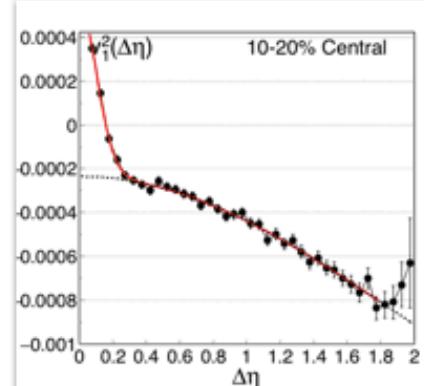
Appendix supporting material $v_1^2\{2\}$ fits 39 GeV:



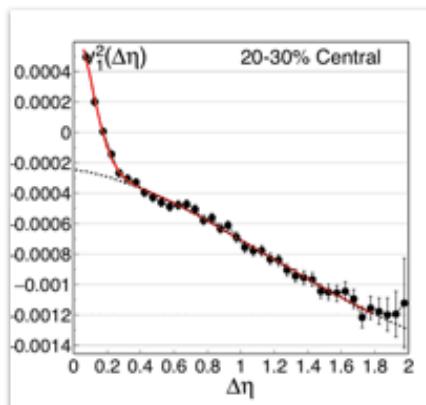
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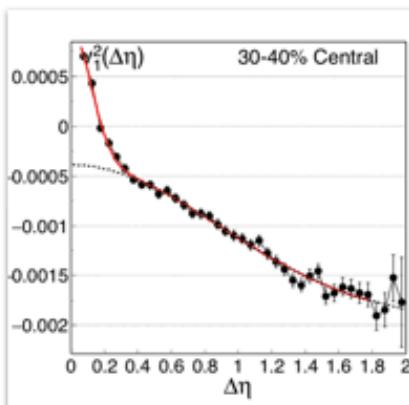
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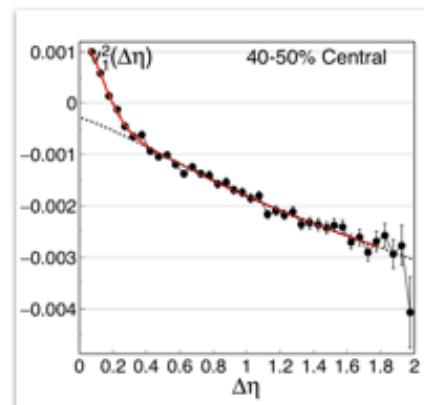
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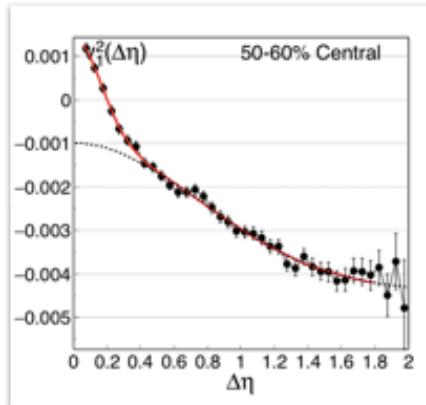
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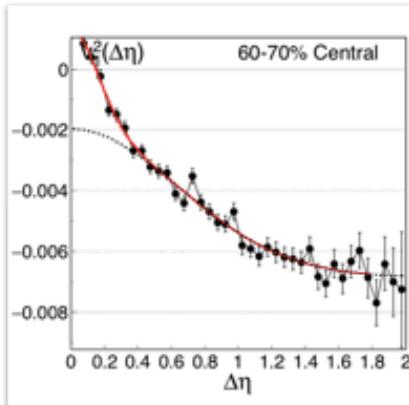
fitwidth_directCumulants39GeV_Vz_20_20_eta..._5_integrated.gif



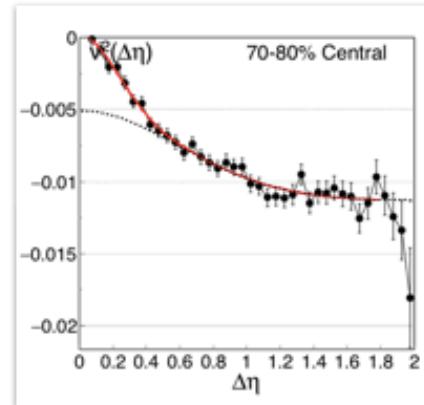
fitwidth_directCumulants39GeV_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants39GeV_Vz_20_20_eta..._7_integrated.gif

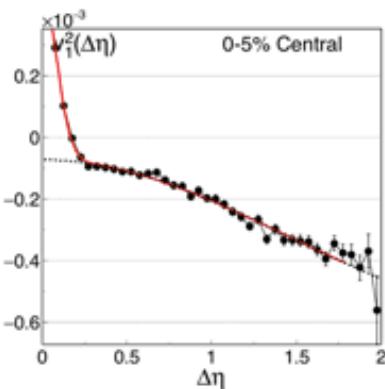


fitwidth_directCumulants39GeV_Vz_20_20_eta..._8_integrated.gif

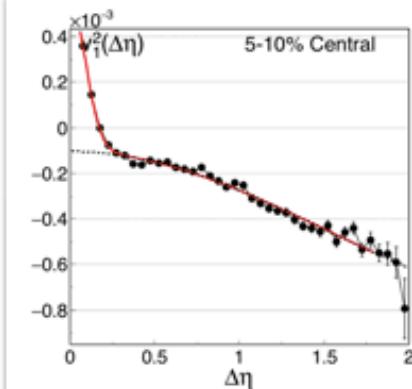


fitwidth_directCumulants39GeV_Vz_20_20_eta..._9_integrated.gif

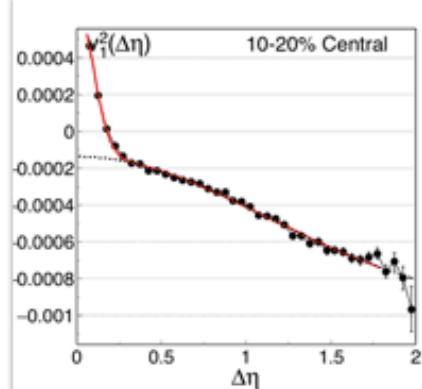
Appendix supporting material $v_1^2\{2\}$ fits 27 GeV:



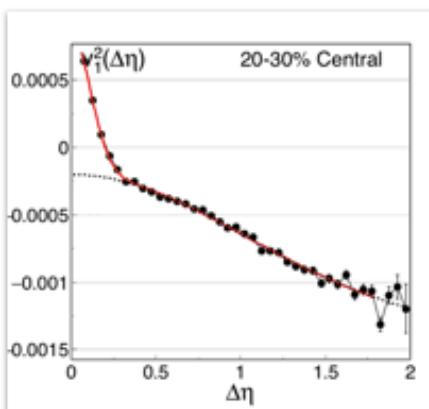
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._1_integrated.gif`



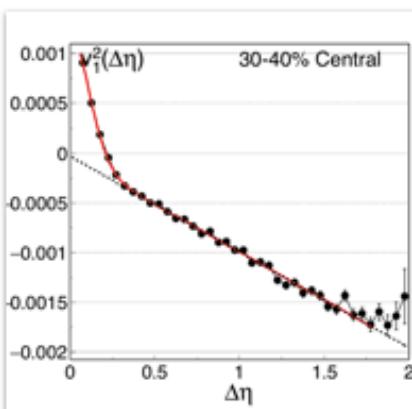
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._2_integrated.gif`



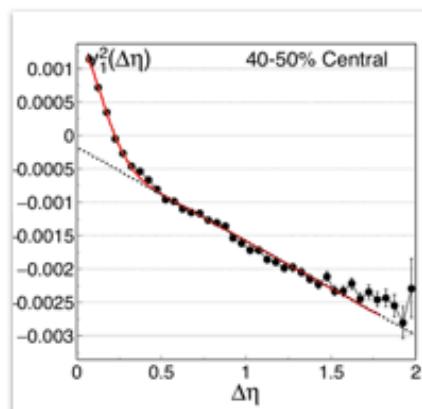
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._3_integrated.gif`



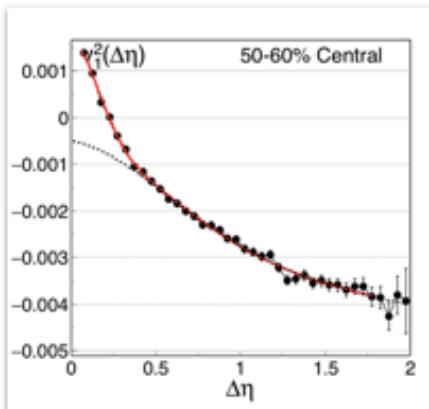
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._4_integrated.gif`



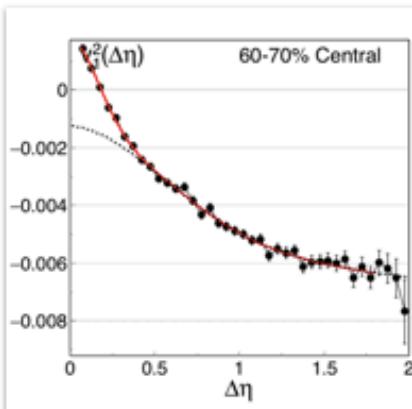
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._5_integrated.gif`



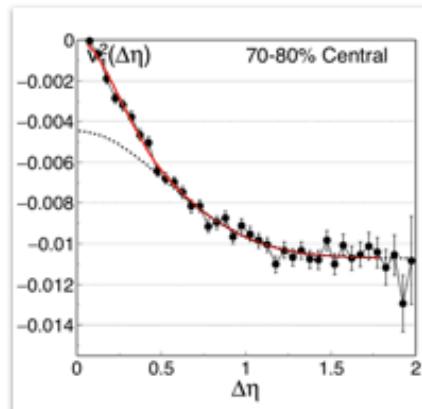
`fitwidth_directCumulants27GeV_Vz_20_20_eta..._6_integrated.gif`



`fitwidth_directCumulants27GeV_Vz_20_20_eta..._7_integrated.gif`

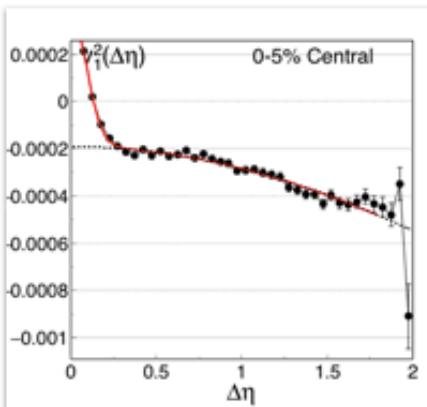


`fitwidth_directCumulants27GeV_Vz_20_20_eta..._8_integrated.gif`

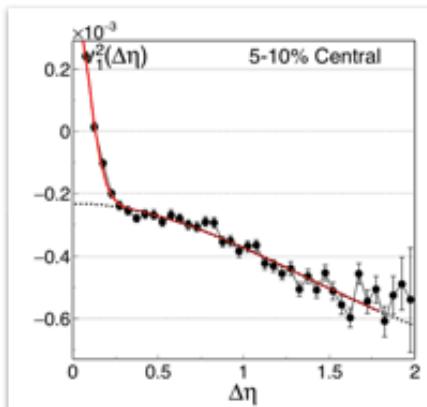


`fitwidth_directCumulants27GeV_Vz_20_20_eta..._9_integrated.gif`

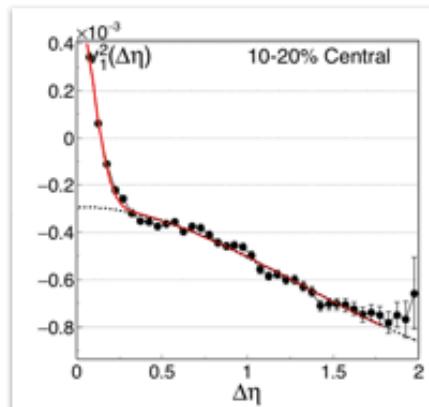
Appendix supporting material $v_1^2\{2\}$ fits 19.6 GeV:



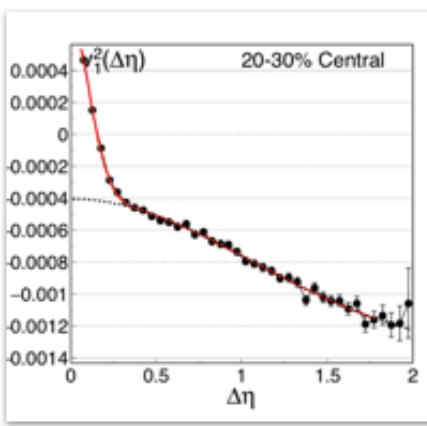
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._1_integrated.gif



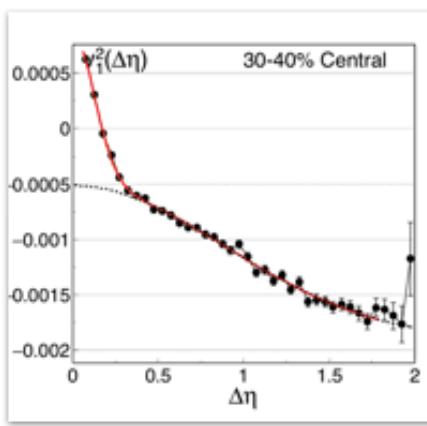
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._2_integrated.gif



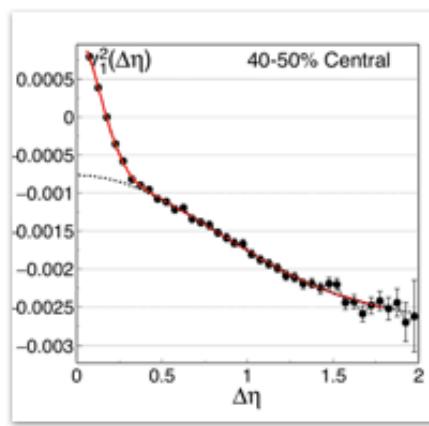
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._3_integrated.gif



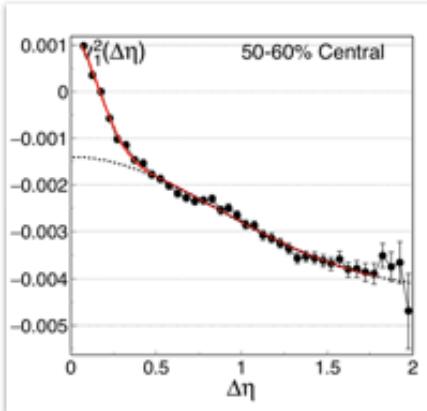
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._4_integrated.gif



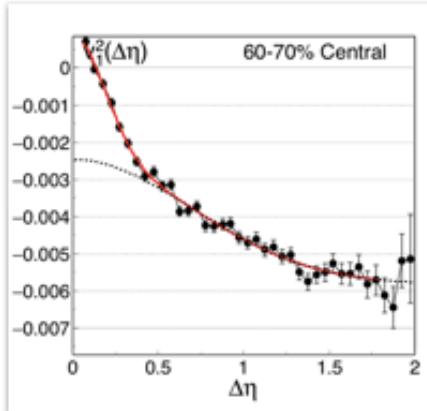
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._5_integrated.gif



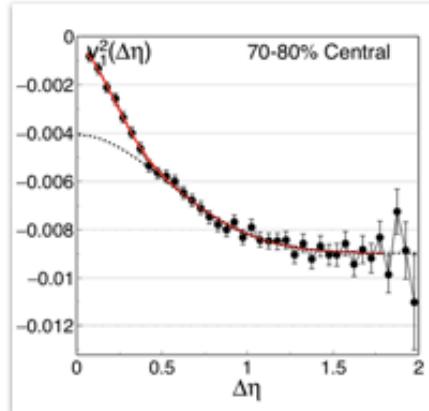
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants20GeV
_Vz_40_40_eta..._7_integrated.gif

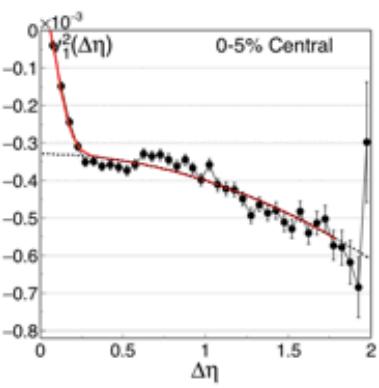


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._8_integrated.gif

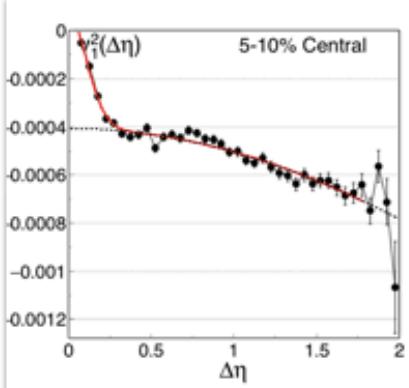


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._9_integrated.gif

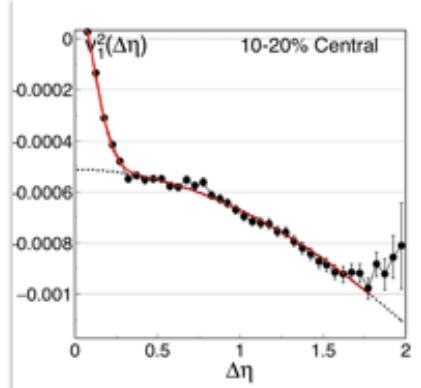
Appendix supporting material $v_1^2\{2\}$ fits 14.5 GeV:



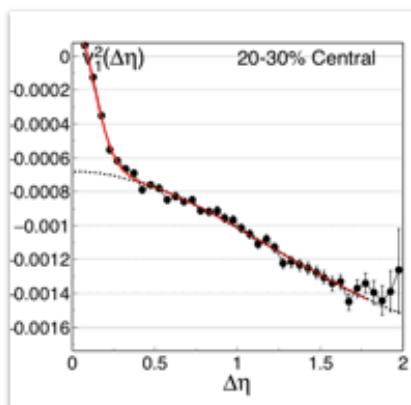
fitwidth_directCumulants14GeV_Vz_40_40_eta..._1_integrated.gif



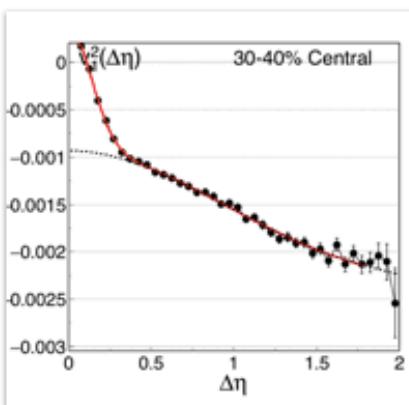
fitwidth_directCumulants14GeV_Vz_40_40_eta..._2_integrated.gif



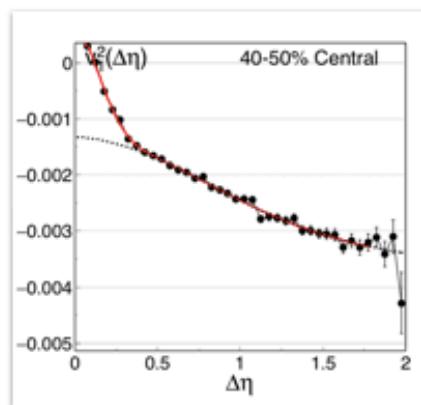
fitwidth_directCumulants14GeV_Vz_40_40_eta..._3_integrated.gif



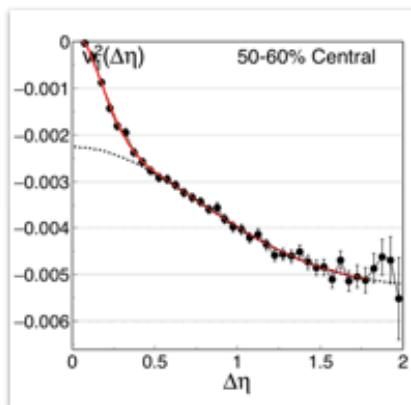
fitwidth_directCumulants14GeV_Vz_40_40_eta..._4_integrated.gif



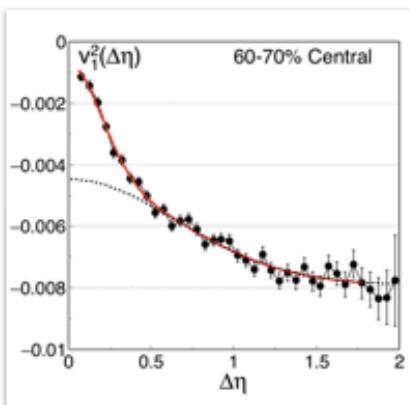
fitwidth_directCumulants14GeV_Vz_40_40_eta..._5_integrated.gif



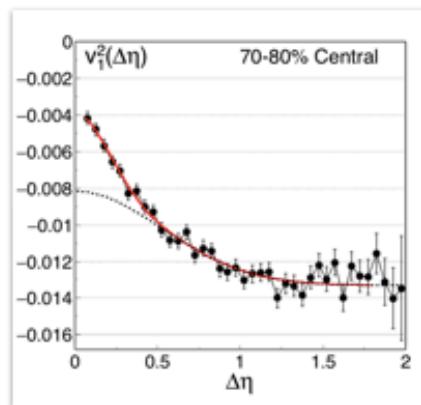
fitwidth_directCumulants14GeV_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants14GeV_Vz_40_40_eta..._7_integrated.gif

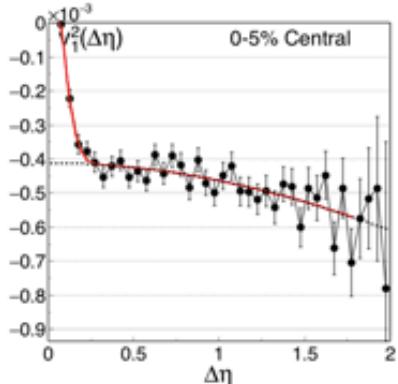


fitwidth_directCumulants14GeV_Vz_40_40_eta..._8_integrated.gif

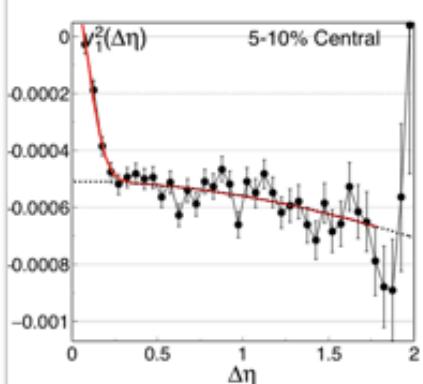


fitwidth_directCumulants14GeV_Vz_40_40_eta..._9_integrated.gif

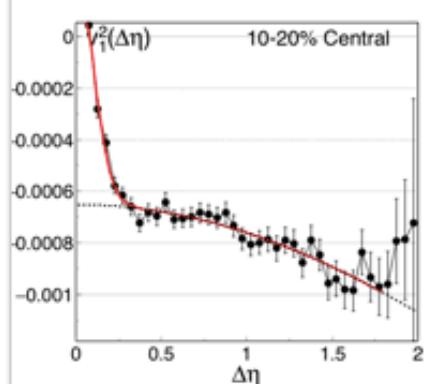
Appendix supporting material $v_1^2\{2\}$ fits 11.5 GeV:



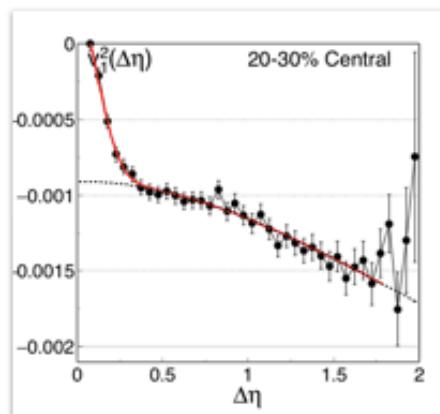
[fitwidth_directCumulants11GeV_Vz_40_40_etaet...1_integrated.gif](#)



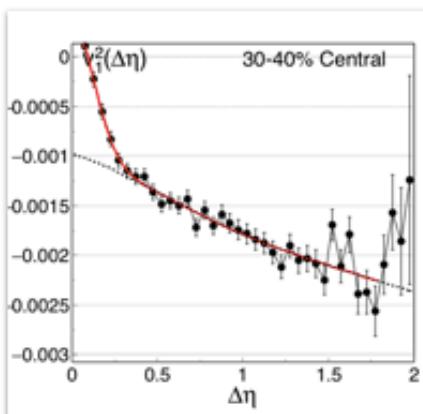
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



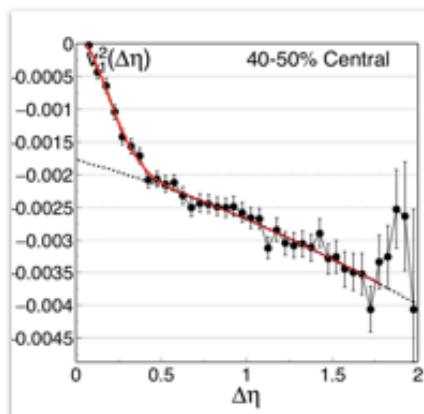
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



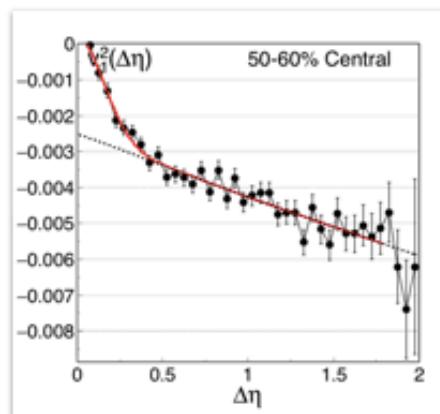
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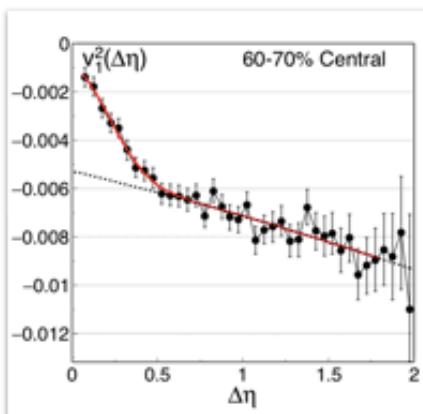
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



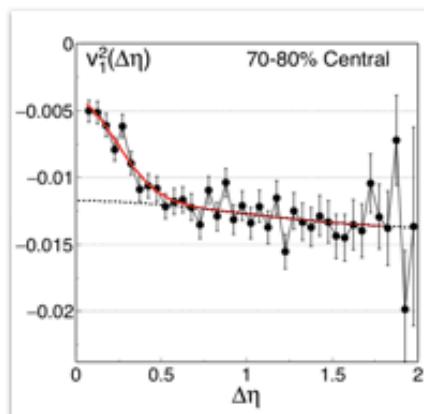
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants11GeV_Vz_40_40_etaet...7_integrated.gif](#)

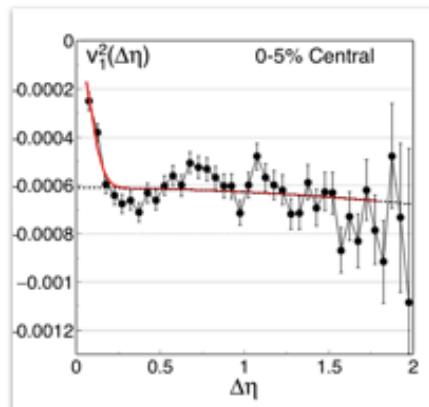


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

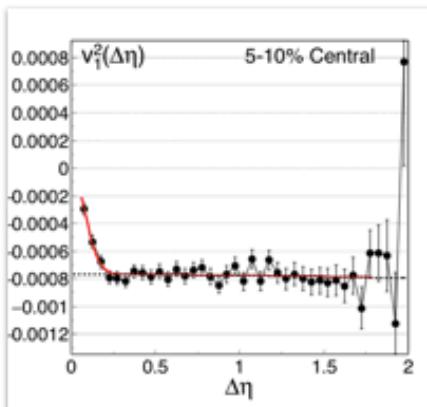


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

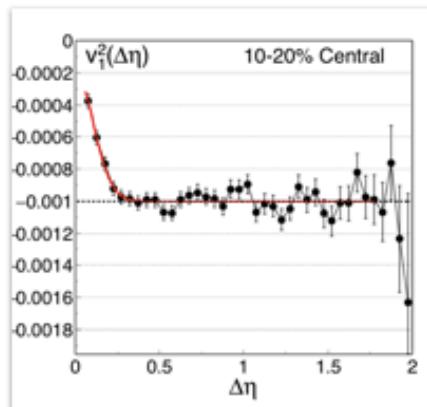
Appendix supporting material $v_1^2\{2\}$ fits 7.7 GeV:



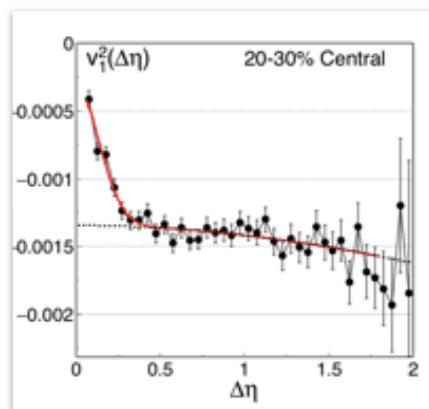
[fitwidth_directCumulants7GeV_Vz_40_40_etaet...1_integrated.gif](#)



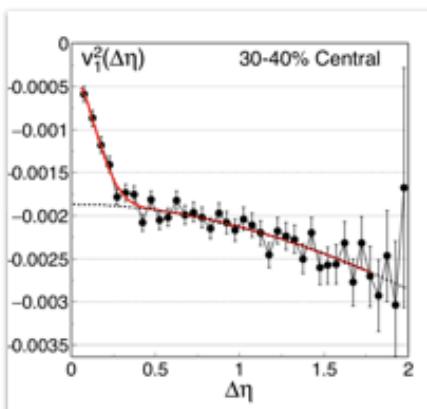
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



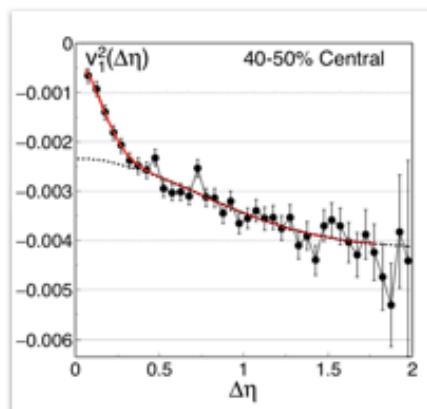
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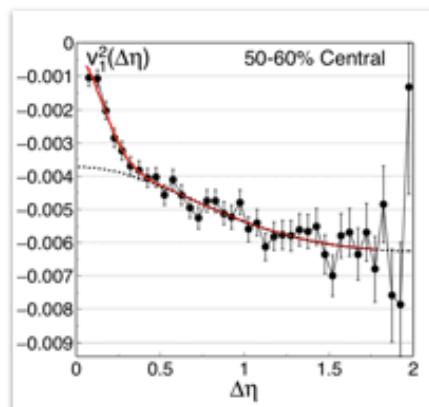
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



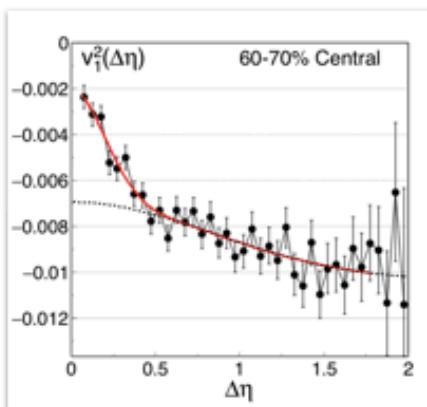
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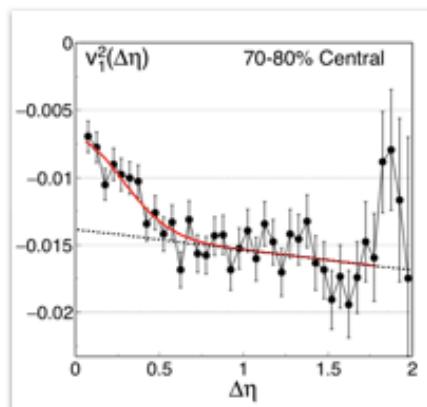
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants7GeV_Vz_40_40_etaet...7_integrated.gif](#)

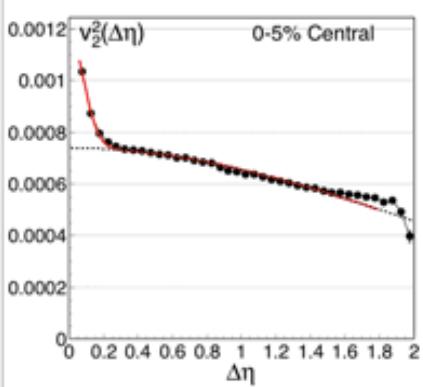


[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)

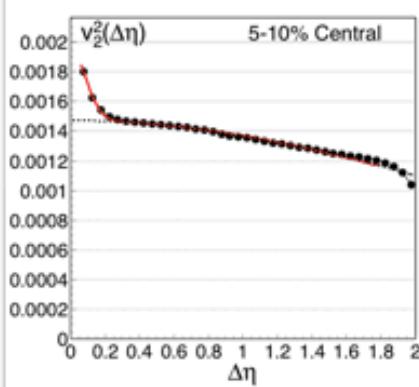


[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)

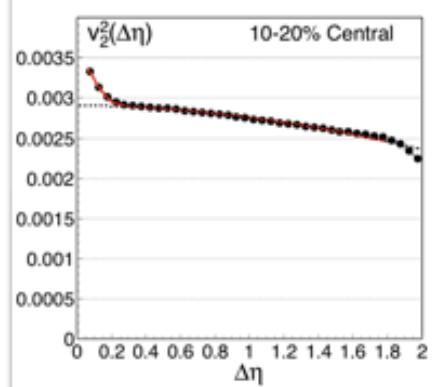
Appendix supporting material $v_2^2\{2\}$ fits 200 GeV:



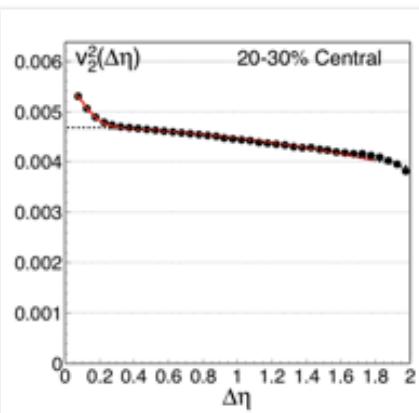
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._1_integrated.gif



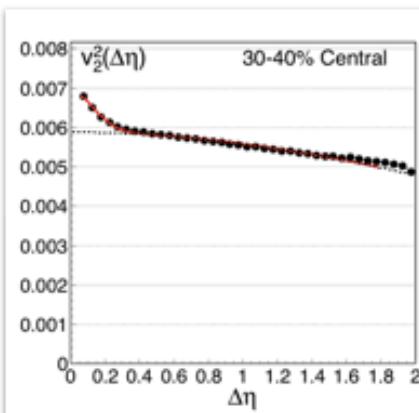
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._2_integrated.gif



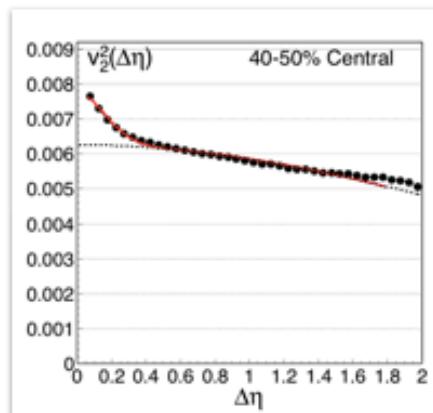
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._3_integrated.gif



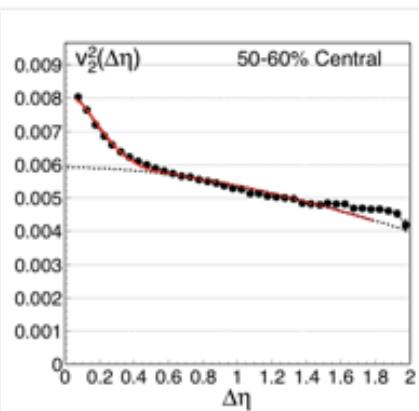
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._4_integrated.gif



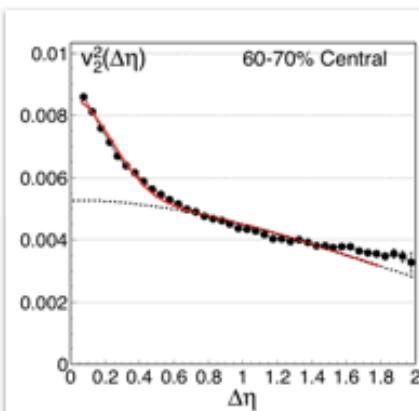
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._5_integrated.gif



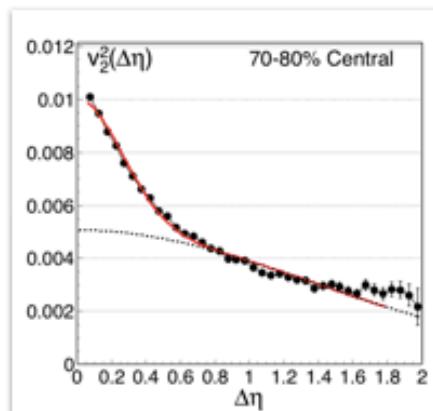
fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._6_integrated.gif



fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._7_integrated.gif

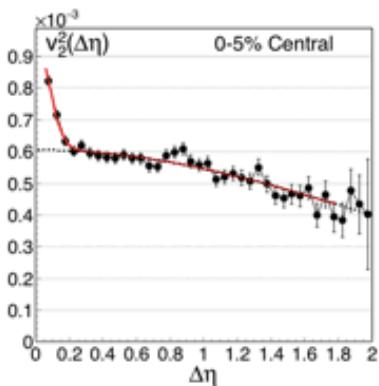


fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._8_integrated.gif

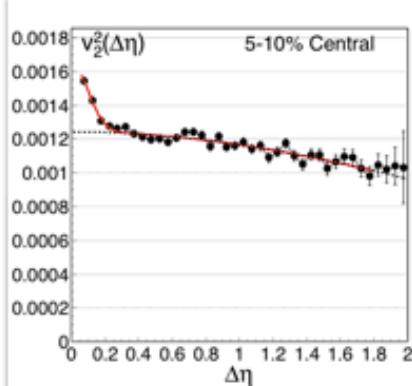


fitwidth_directCumulants2011_a
ll_eta1eta3_Vz_..._9_integrated.gif

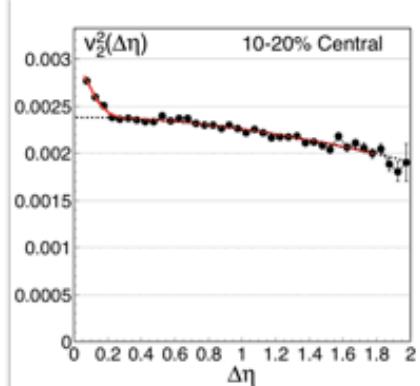
Appendix supporting material $v_2^2\{2\}$ fits 62.4 GeV:



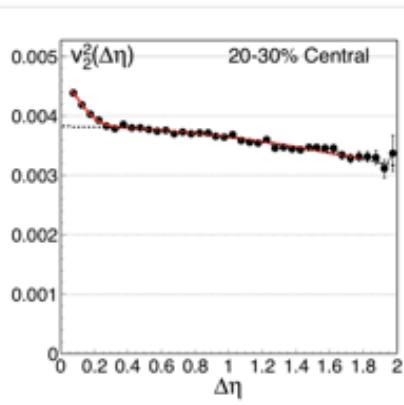
fitwidth_directCumulants62GeV
2004_Vz_20_2..._1_integrated.gif



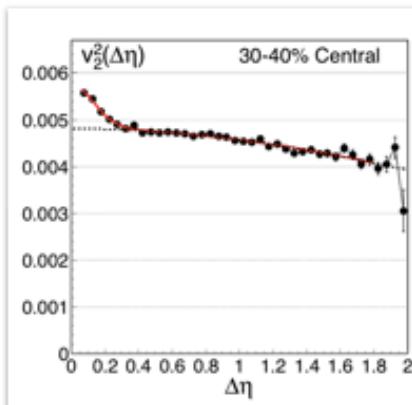
fitwidth_directCumulants62GeV
2004_Vz_20_2..._2_integrated.gif



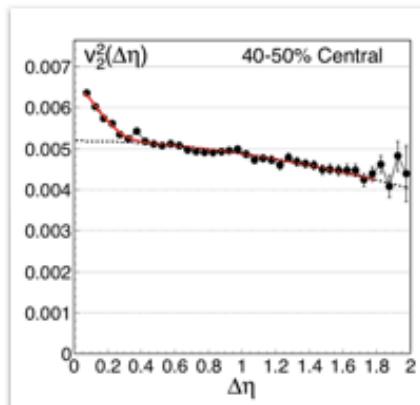
fitwidth_directCumulants62GeV
2004_Vz_20_2..._3_integrated.gif



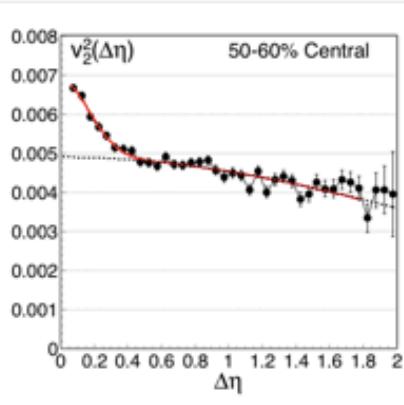
fitwidth_directCumulants62GeV
2004_Vz_20_2..._4_integrated.gif



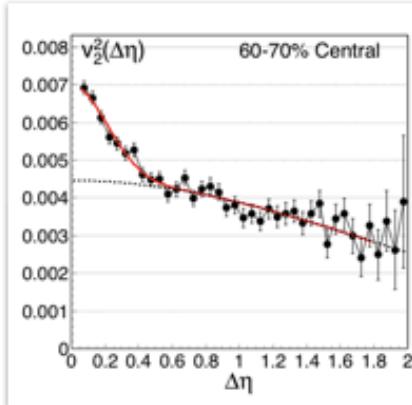
fitwidth_directCumulants62GeV
2004_Vz_20_2..._5_integrated.gif



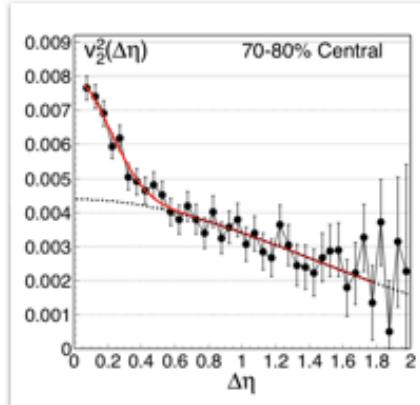
fitwidth_directCumulants62GeV
2004_Vz_20_2..._6_integrated.gif



fitwidth_directCumulants62GeV
2004_Vz_20_2..._7_integrated.gif

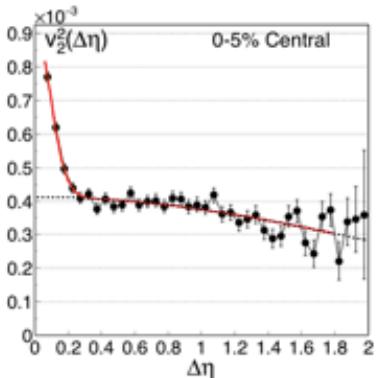


fitwidth_directCumulants62GeV
2004_Vz_20_2..._8_integrated.gif

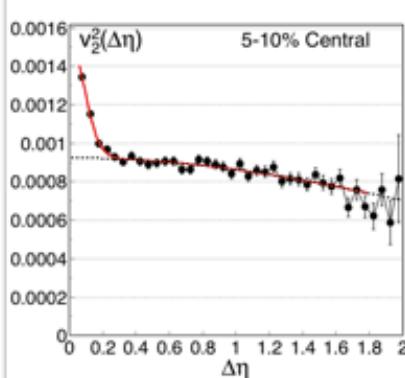


fitwidth_directCumulants62GeV
2004_Vz_20_2..._9_integrated.gif

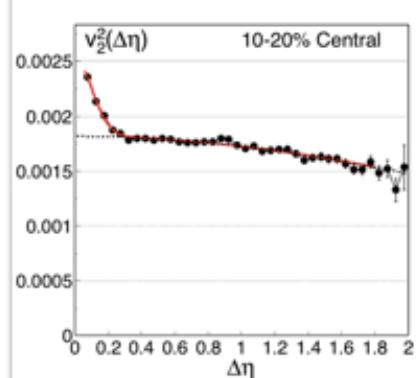
Appendix supporting material $v_2^2\{2\}$ fits 39 GeV:



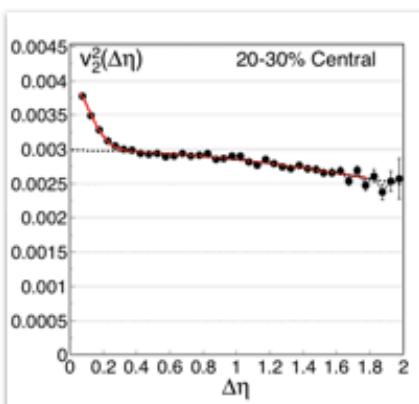
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._1_integrated.gif



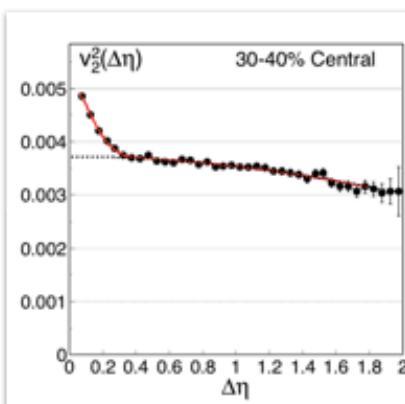
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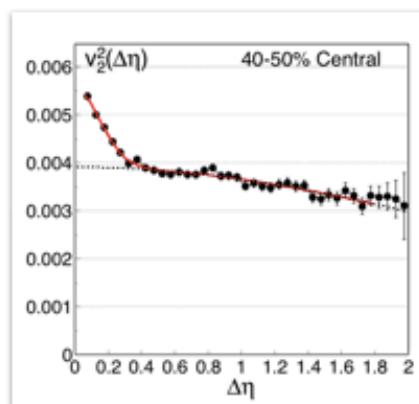
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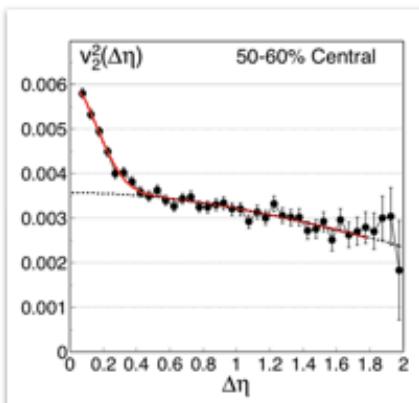
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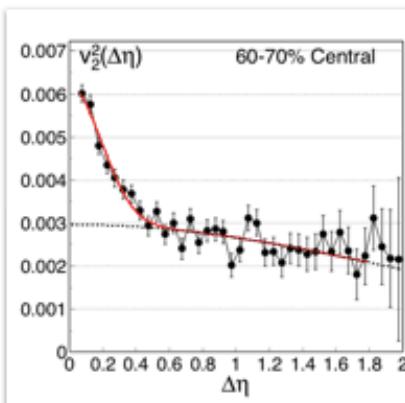
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_Vz_20_20_eta..._5_integrated.gif



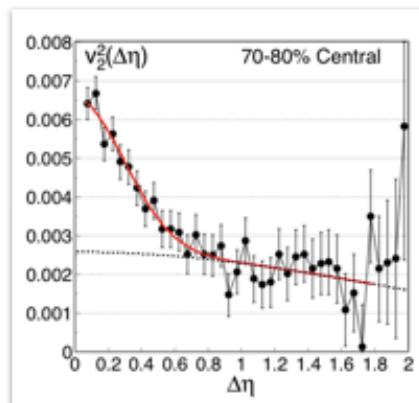
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants39GeV
_Vz_20_20_eta..._7_integrated.gif

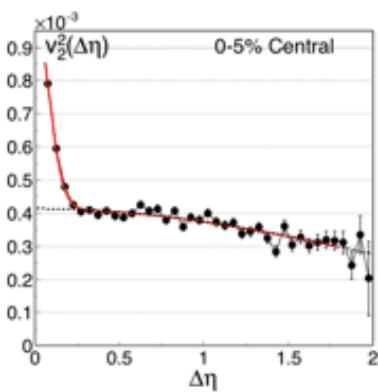


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._8_integrated.gif

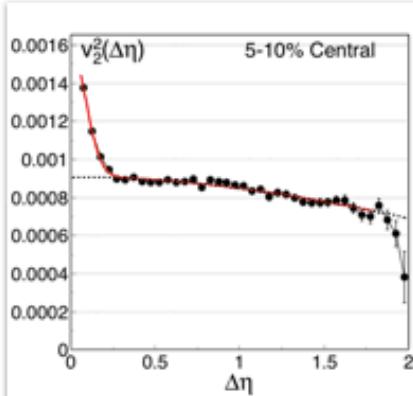


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._9_integrated.gif

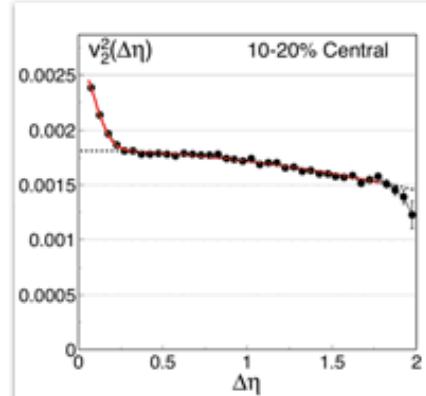
Appendix supporting material $v_2^2\{2\}$ fits 27 GeV:



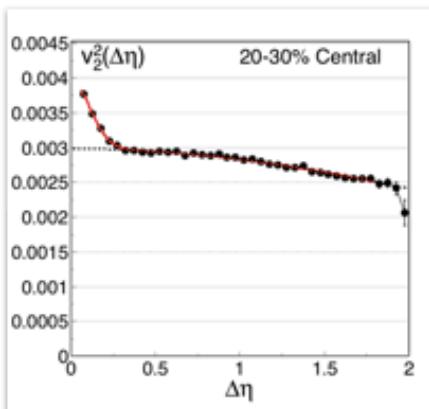
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._1_integrated.gif



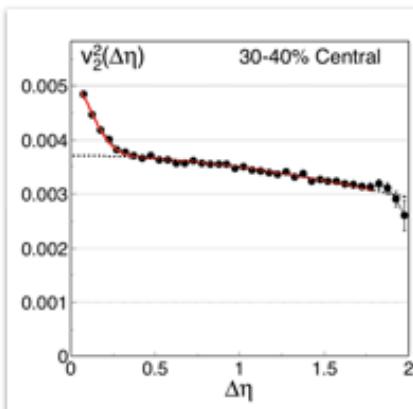
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._2_integrated.gif



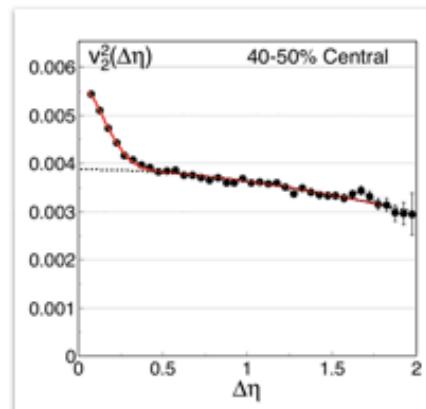
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._3_integrated.gif



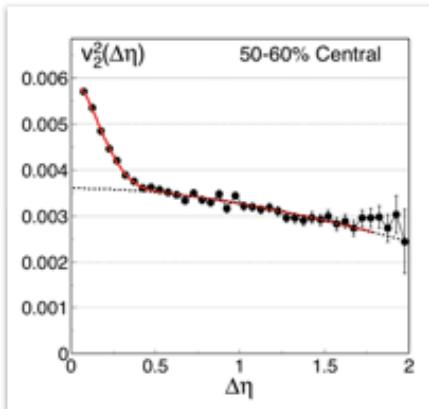
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._4_integrated.gif



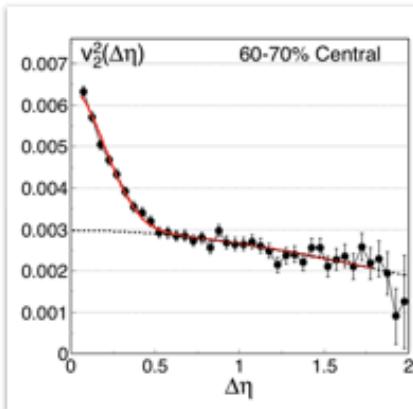
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._5_integrated.gif



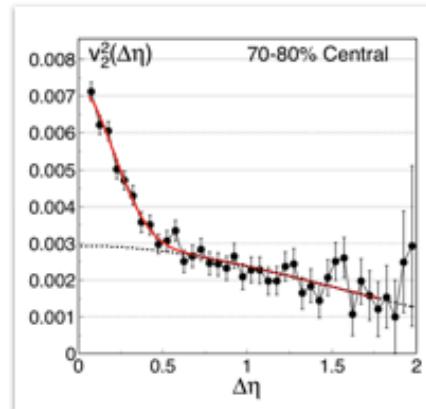
fitwidth_directCumulants27GeV
_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants27GeV
_Vz_20_20_eta..._7_integrated.gif

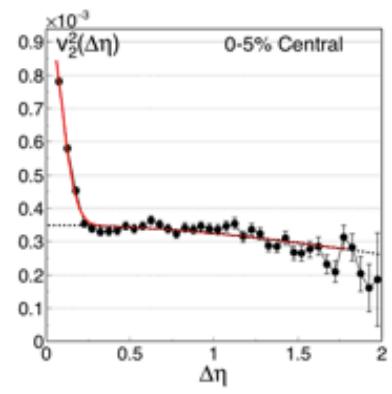


fitwidth_directCumulants27GeV
_Vz_20_20_eta..._8_integrated.gif

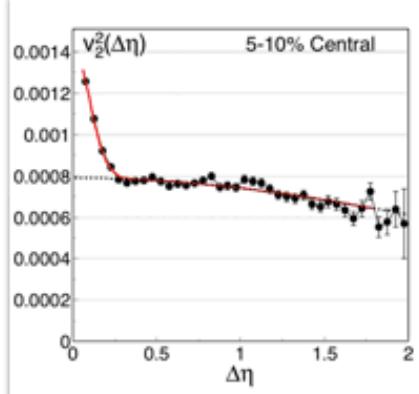


fitwidth_directCumulants27GeV
_Vz_20_20_eta..._9_integrated.gif

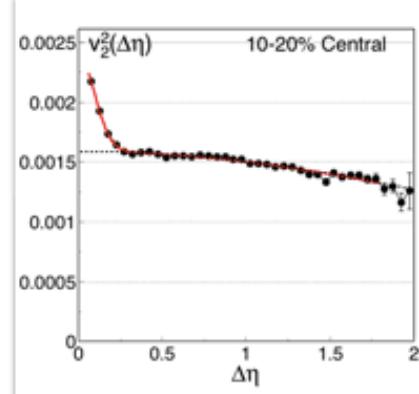
Appendix supporting material $v_2^2\{2\}$ fits 19.6 GeV:



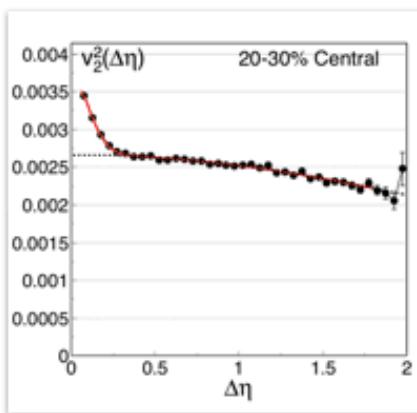
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._1_integrated.gif



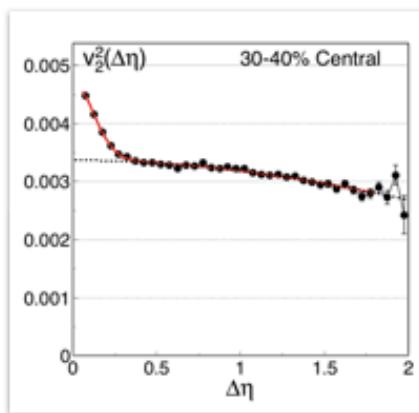
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._2_integrated.gif



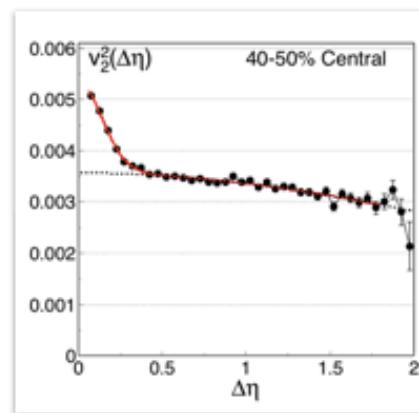
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._3_integrated.gif



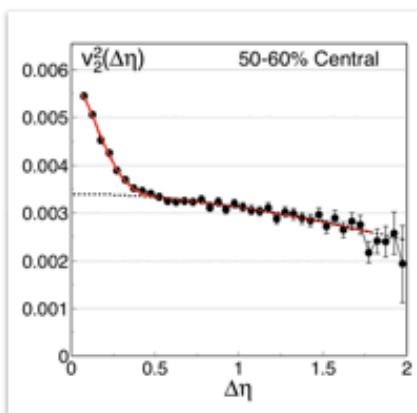
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._4_integrated.gif



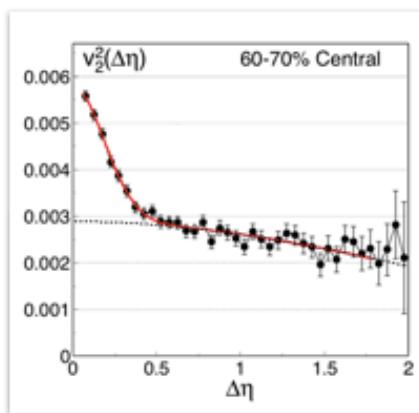
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._5_integrated.gif



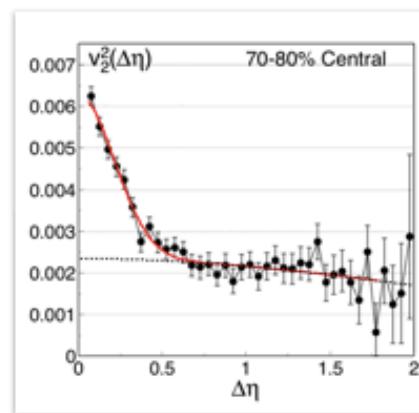
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants20GeV
_Vz_40_40_eta..._7_integrated.gif

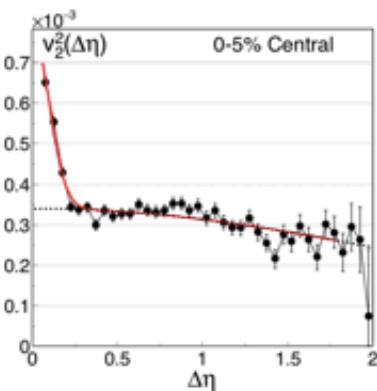


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._8_integrated.gif

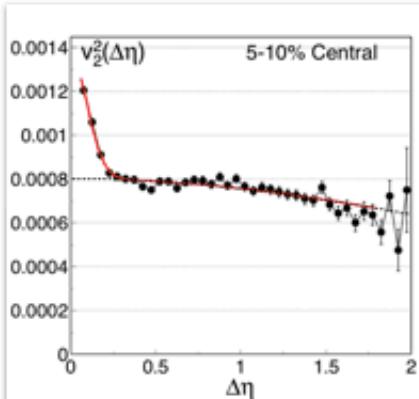


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._9_integrated.gif

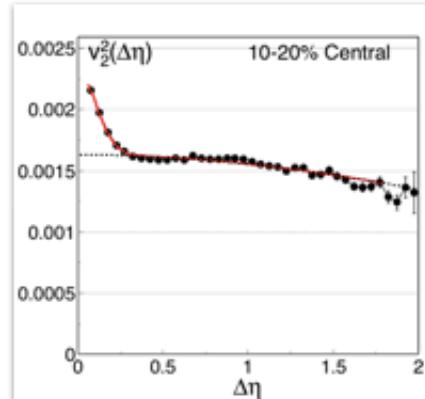
Appendix supporting material $v_2^2\{2\}$ fits 14.5 GeV:



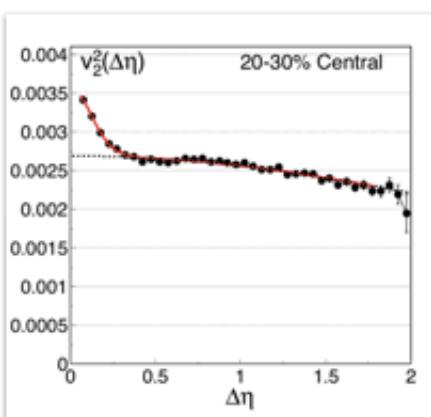
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._1_integrated.gif



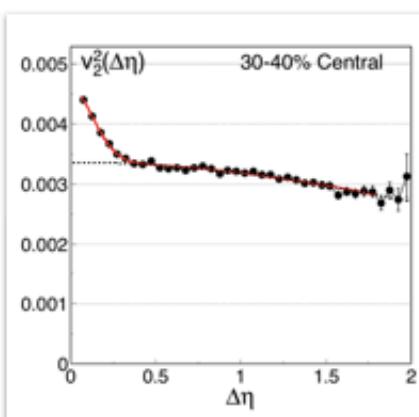
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._2_integrated.gif



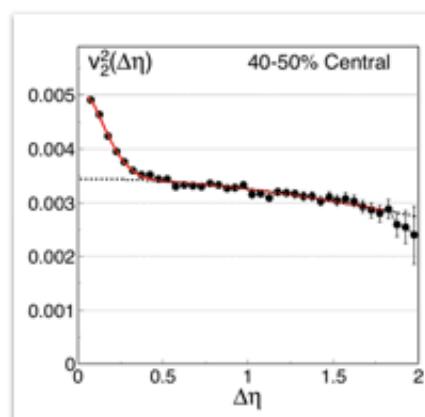
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._3_integrated.gif



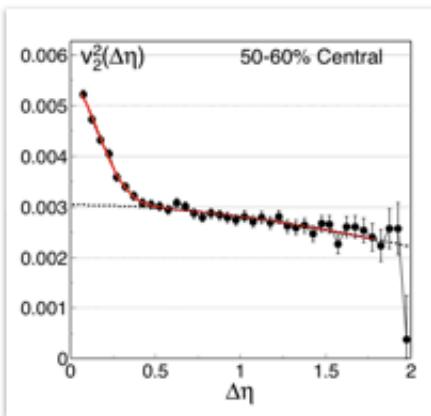
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._4_integrated.gif



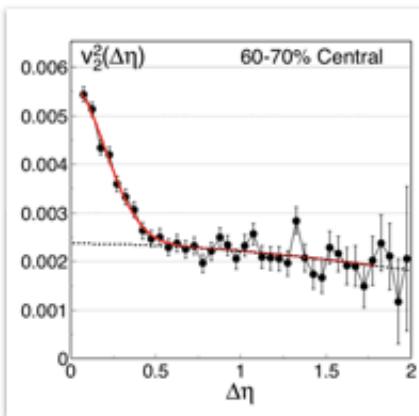
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._5_integrated.gif



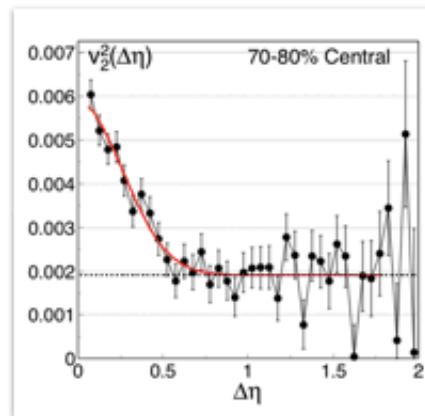
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants14GeV
_Vz_40_40_eta..._7_integrated.gif

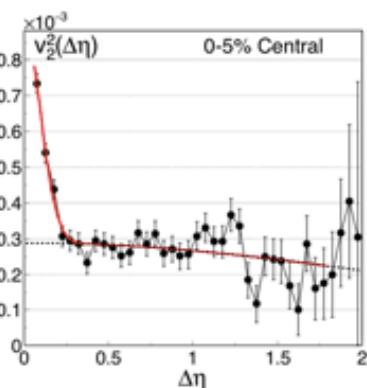


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._8_integrated.gif

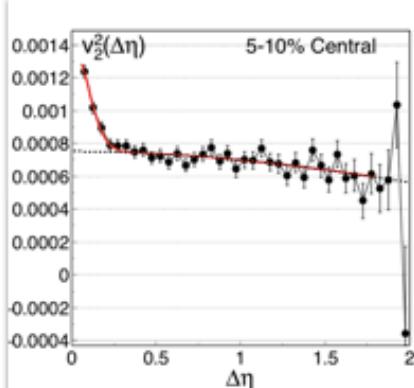


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._9_integrated.gif

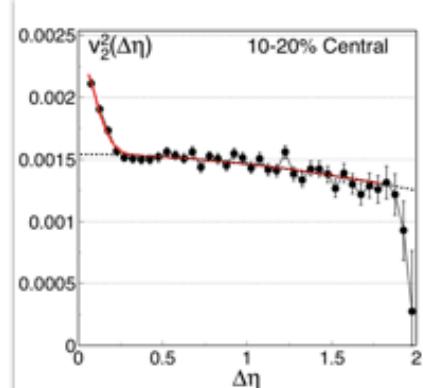
Appendix supporting material $v_2^2\{2\}$ fits 11.5 GeV:



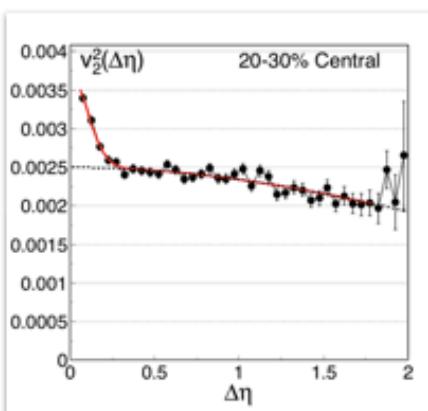
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._1_integrated.gif](#)



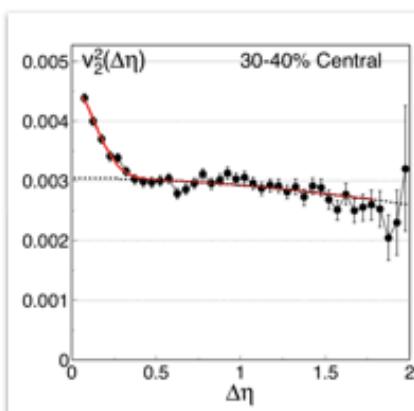
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



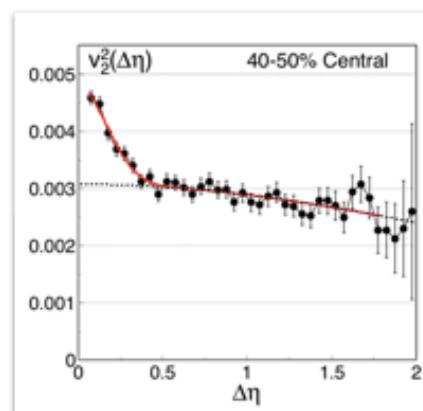
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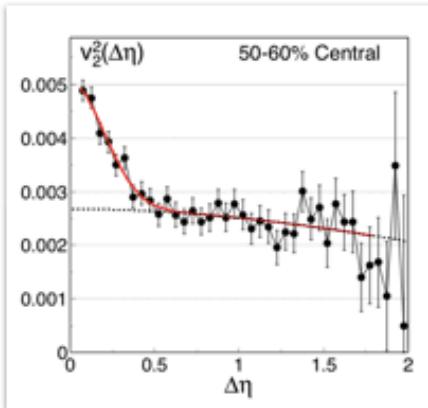
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



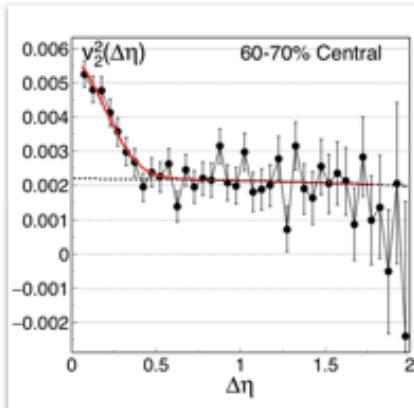
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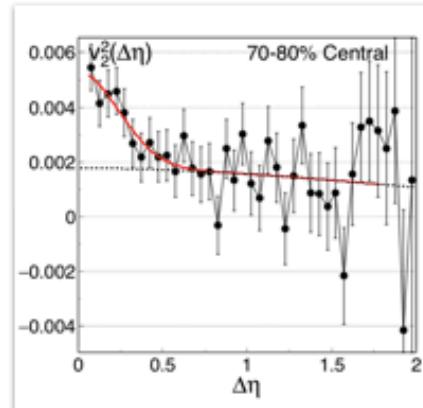
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._7_integrated.gif](#)

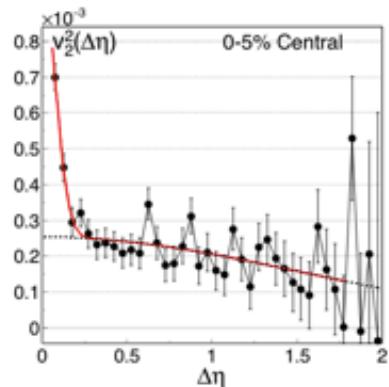


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

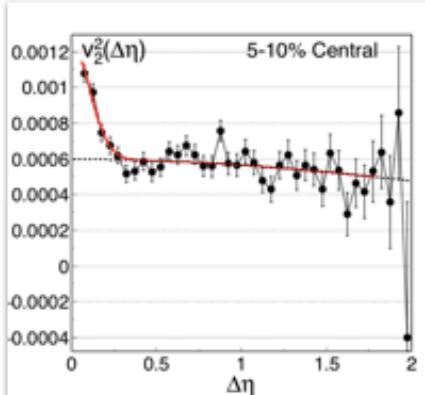


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

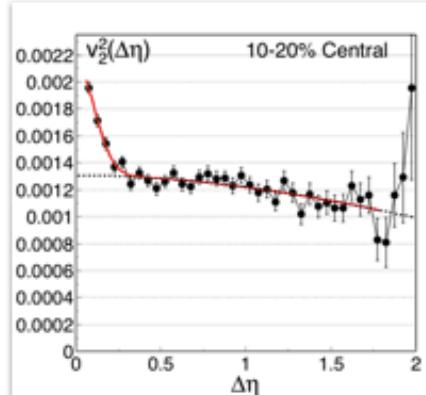
Appendix supporting material $v_2^2\{2\}$ fits 7.7 GeV:



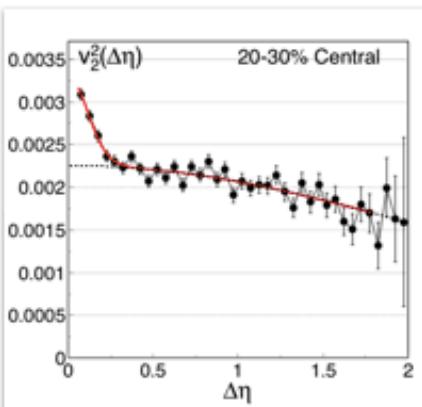
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._1_integrated.gif](#)



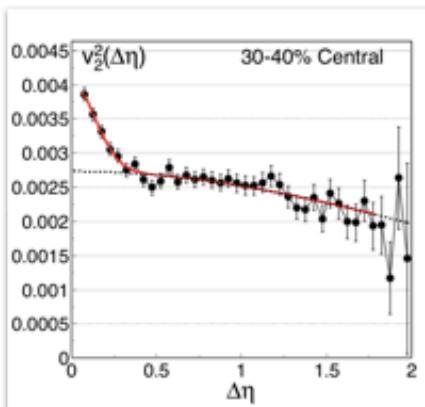
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



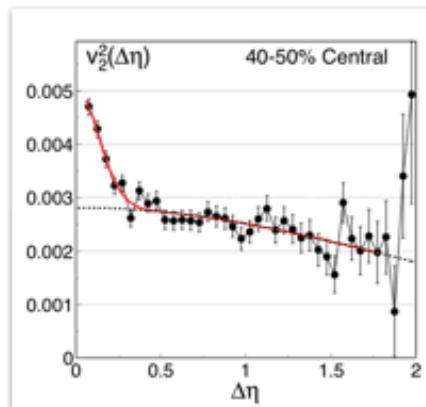
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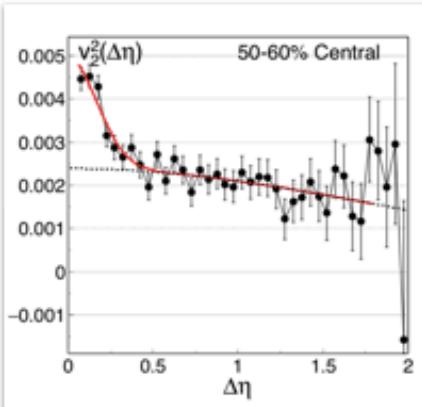
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



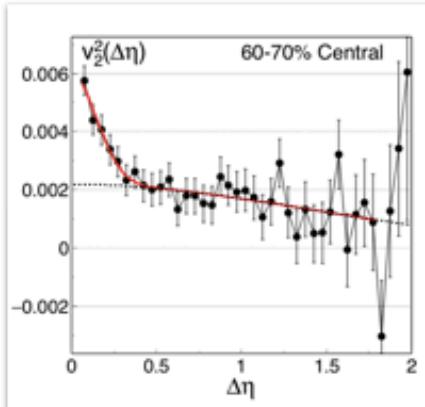
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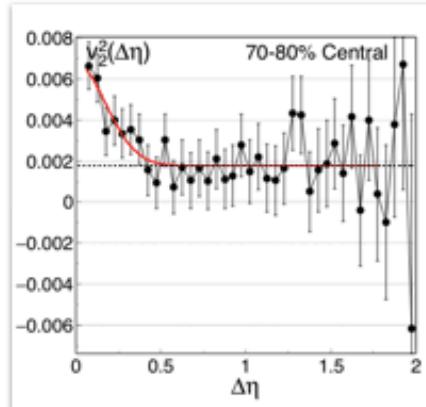
[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._7_integrated.gif](#)

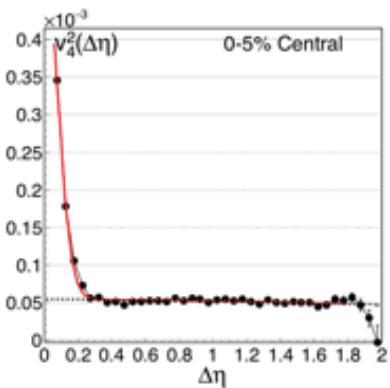


[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)

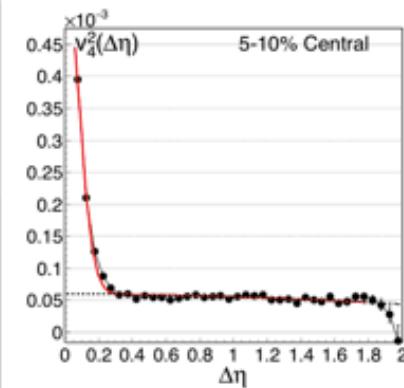


[fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif](#)

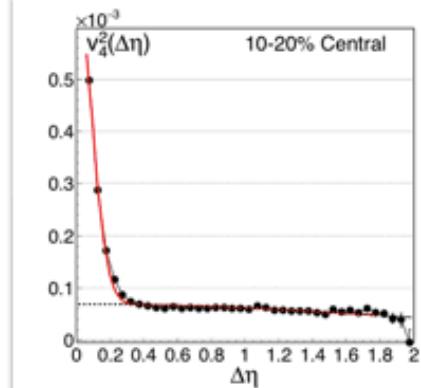
Appendix supporting material $v_4^2\{2\}$ fits 200 GeV:



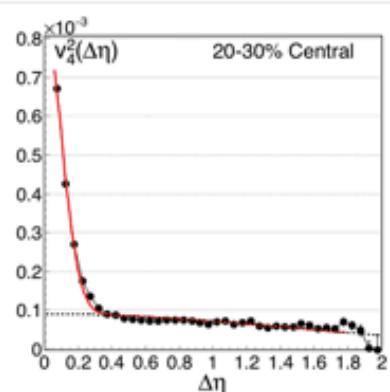
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._1_integrated.gif



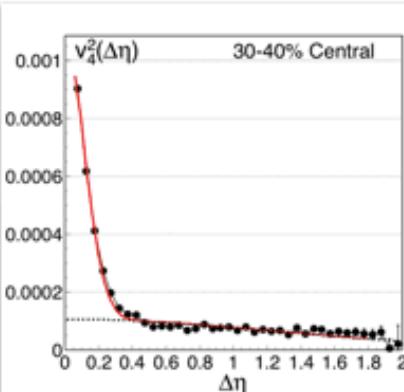
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._2_integrated.gif



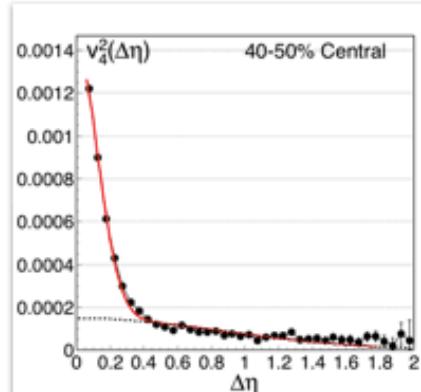
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._3_integrated.gif



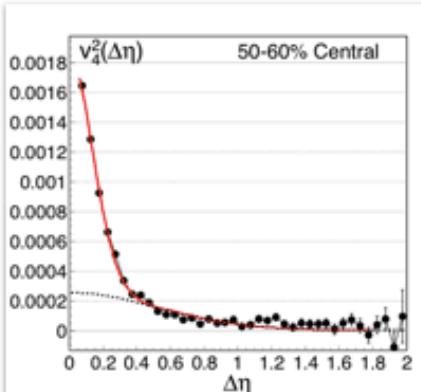
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._4_integrated.gif



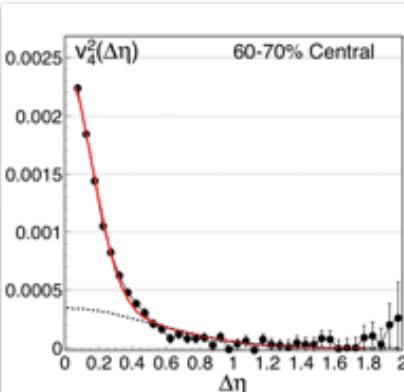
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._5_integrated.gif



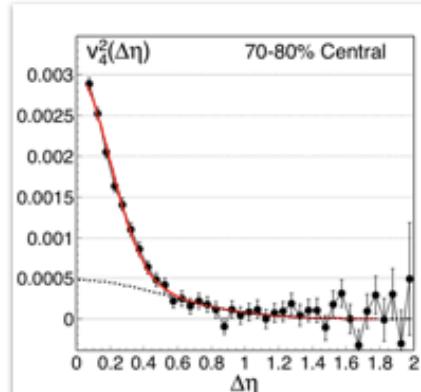
fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._6_integrated.gif



fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._7_integrated.gif

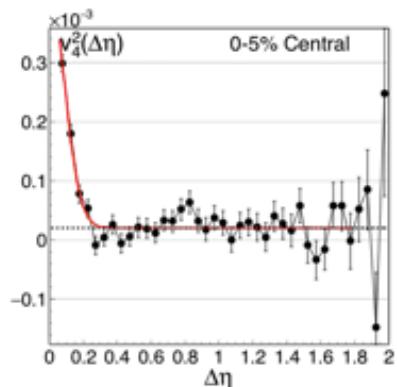


fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._8_integrated.gif

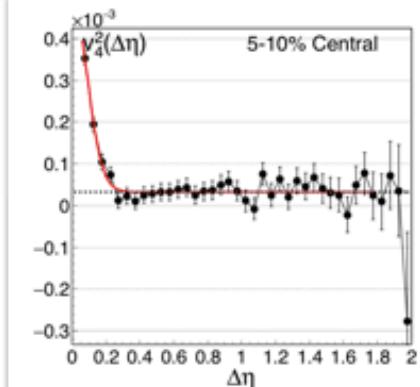


fitwidth_directCumulants2011_a_ll_eta1eta3_Vz_..._9_integrated.gif

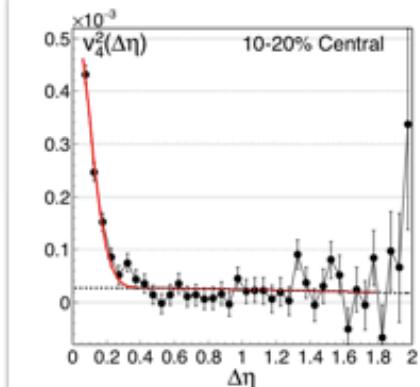
Appendix supporting material $v_4^2\{2\}$ fits 62.4 GeV:



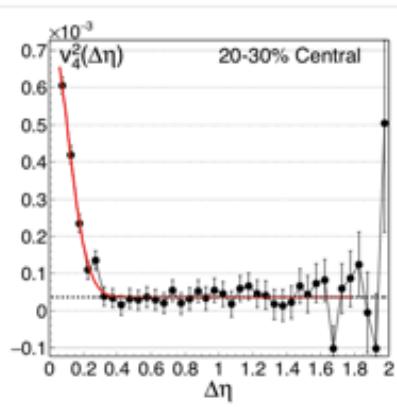
fitwidth_directCumulants62GeV
2004_Vz_20_2..._1_integrated.gif



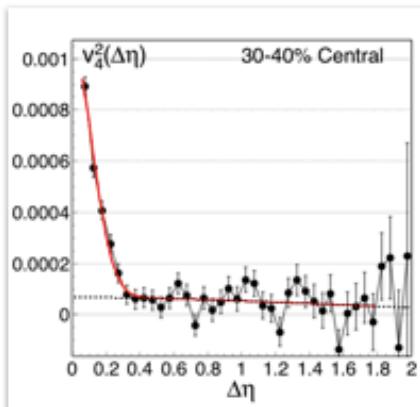
fitwidth_directCumulants62GeV
2004_Vz_20_2..._2_integrated.gif



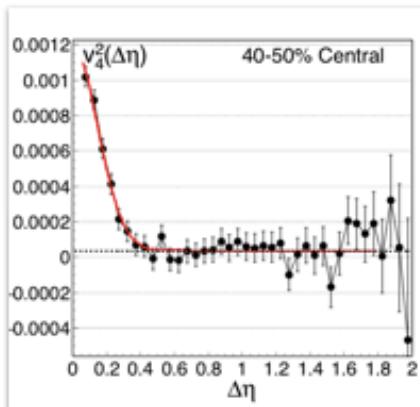
fitwidth_directCumulants62GeV
2004_Vz_20_2..._3_integrated.gif



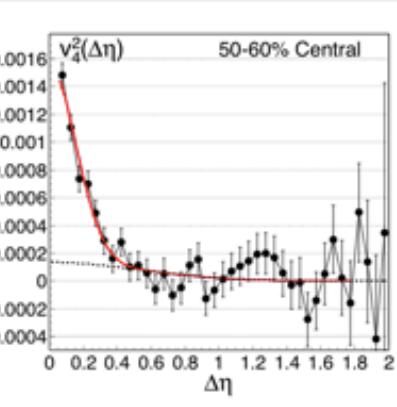
fitwidth_directCumulants62GeV
2004_Vz_20_2..._4_integrated.gif



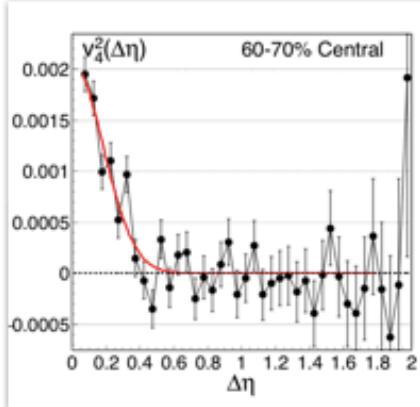
fitwidth_directCumulants62GeV
2004_Vz_20_2..._5_integrated.gif



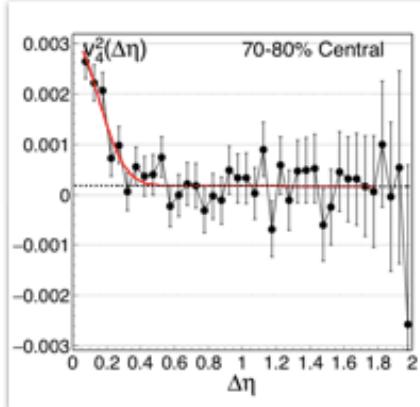
fitwidth_directCumulants62GeV
2004_Vz_20_2..._6_integrated.gif



fitwidth_directCumulants62GeV
2004_Vz_20_2..._7_integrated.gif

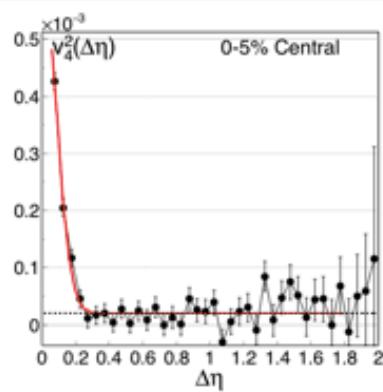


fitwidth_directCumulants62GeV
2004_Vz_20_2..._8_integrated.gif

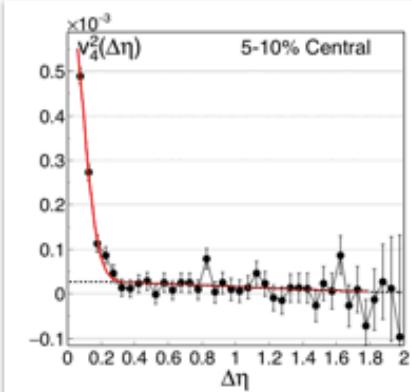


fitwidth_directCumulants62GeV
2004_Vz_20_2..._9_integrated.gif

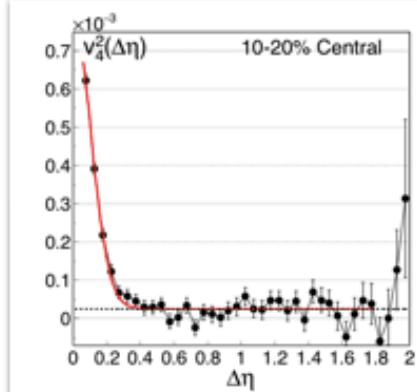
Appendix supporting material $v_4^2\{2\}$ fits 39 GeV:



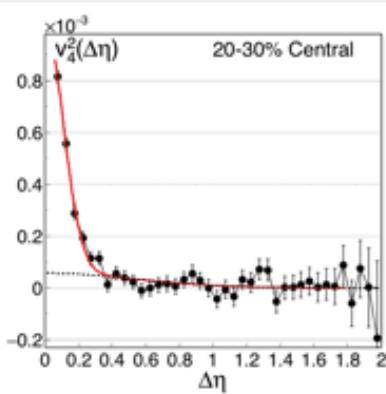
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._1_integrated.gif



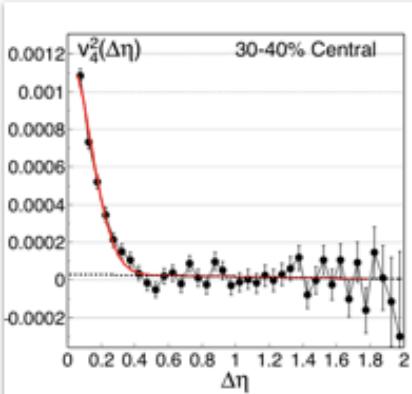
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._2_integrated.gif



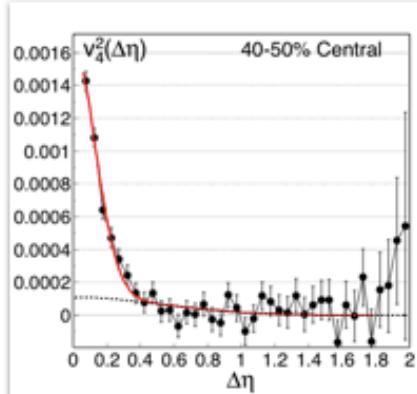
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._3_integrated.gif



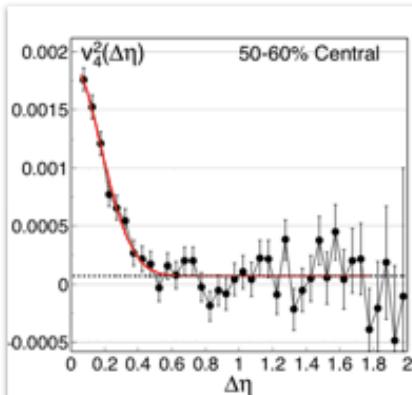
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._4_integrated.gif



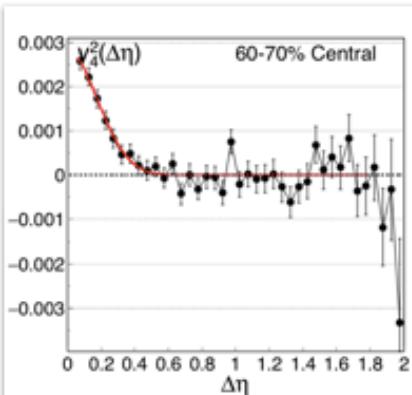
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._5_integrated.gif



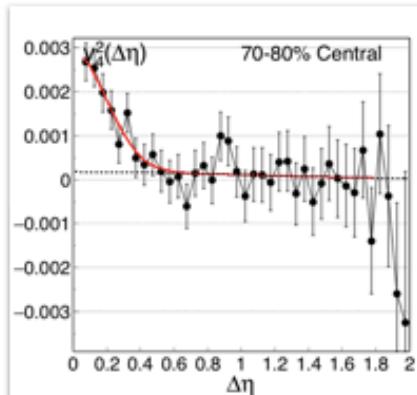
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants39GeV
_Vz_20_20_eta..._7_integrated.gif

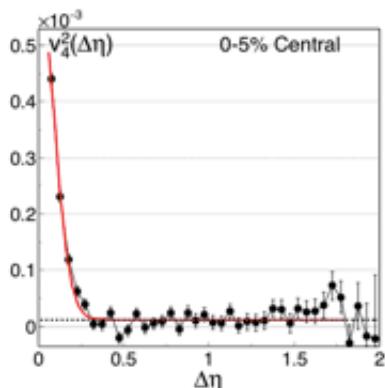


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._8_integrated.gif

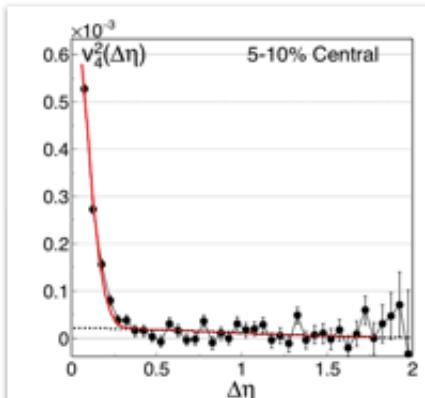


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._9_integrated.gif

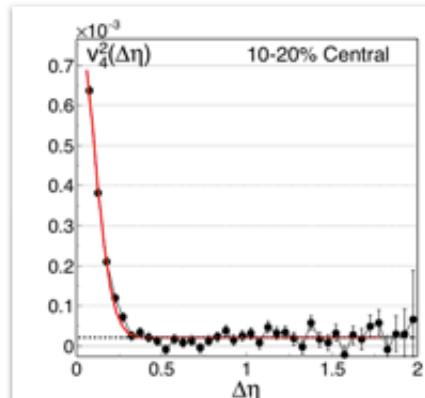
Appendix supporting material $v_4^2\{2\}$ fits 27 GeV:



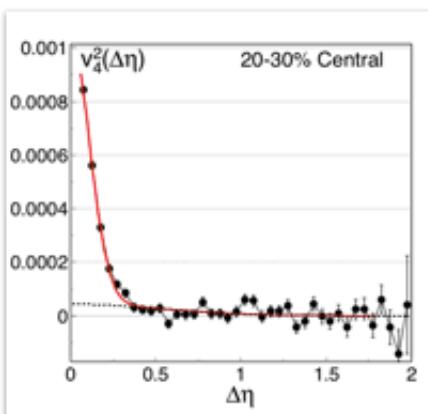
fitwidth_directCumulants27GeV_Vz_20_20_eta..._1_integrated.gif



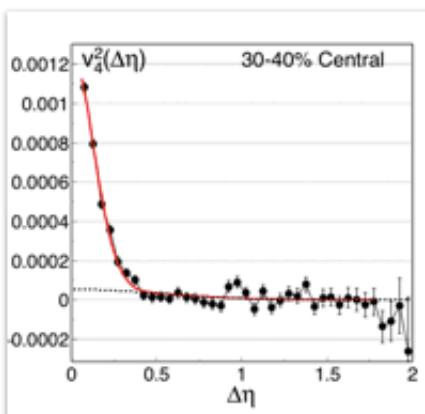
fitwidth_directCumulants27GeV_Vz_20_20_eta..._2_integrated.gif



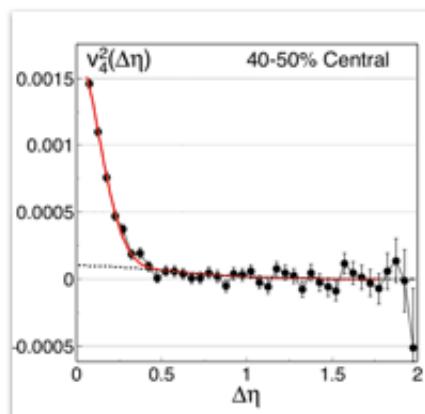
fitwidth_directCumulants27GeV_Vz_20_20_eta..._3_integrated.gif



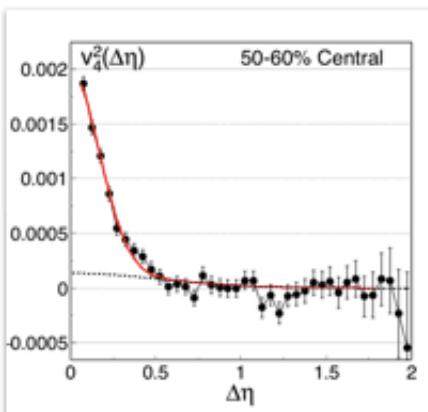
fitwidth_directCumulants27GeV_Vz_20_20_eta..._4_integrated.gif



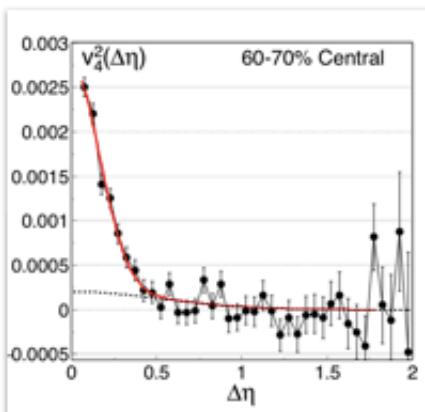
fitwidth_directCumulants27GeV_Vz_20_20_eta..._5_integrated.gif



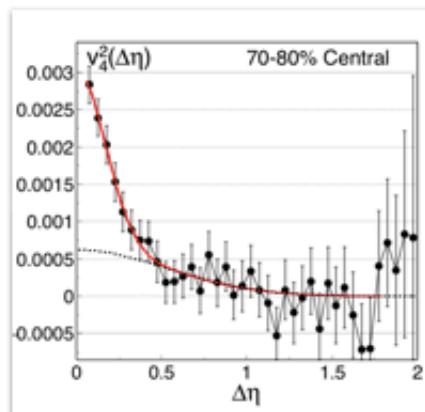
fitwidth_directCumulants27GeV_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants27GeV_Vz_20_20_eta..._7_integrated.gif

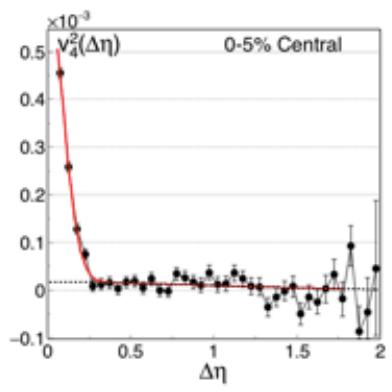


fitwidth_directCumulants27GeV_Vz_20_20_eta..._8_integrated.gif

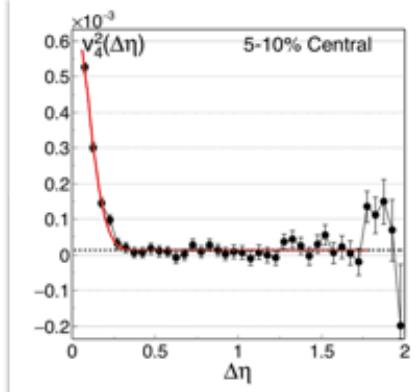


fitwidth_directCumulants27GeV_Vz_20_20_eta..._9_integrated.gif

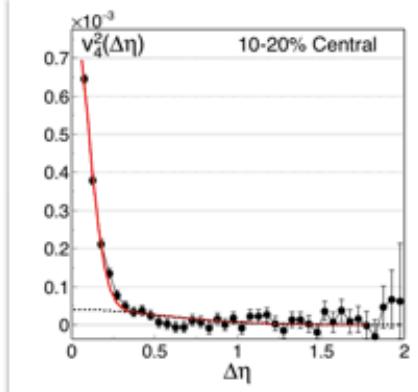
Appendix supporting material $v_4^2\{2\}$ fits 19.6 GeV:



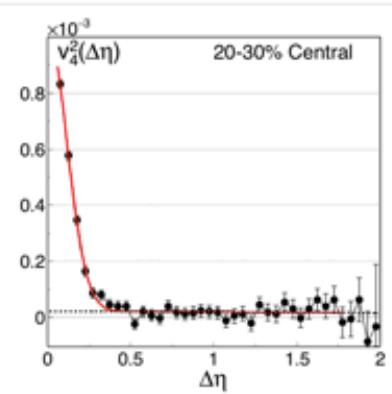
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._1_integrated.gif`



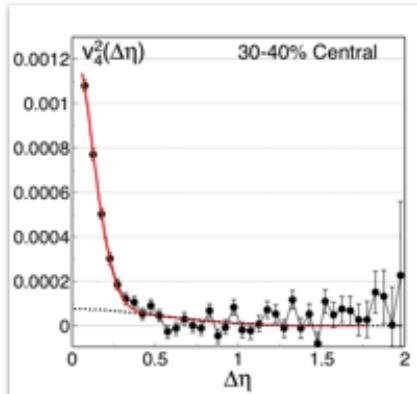
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._2_integrated.gif`



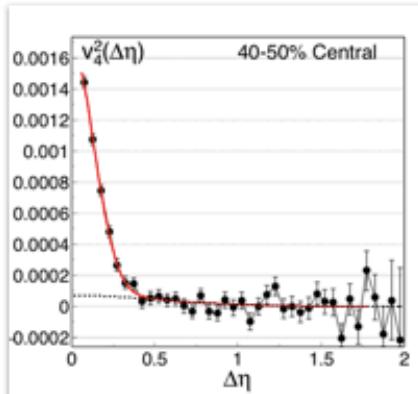
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._3_integrated.gif`



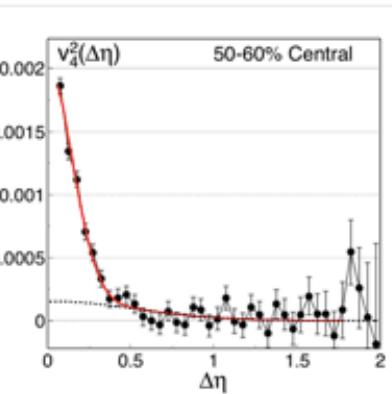
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._4_integrated.gif`



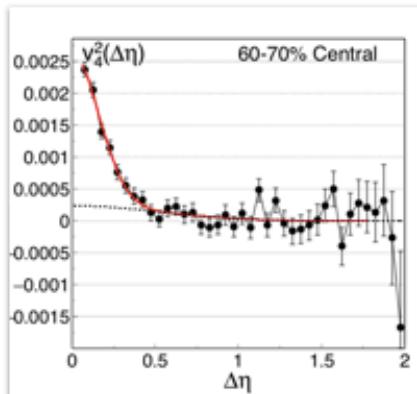
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._5_integrated.gif`



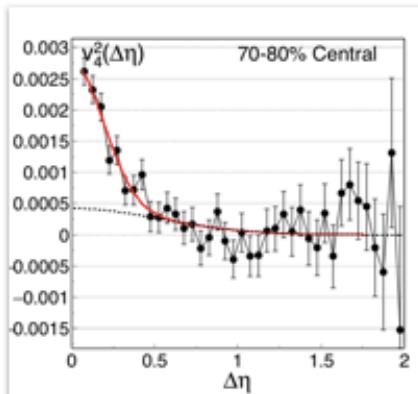
`fitwidth_directCumulants20GeV_Vz_40_40_eta..._6_integrated.gif`



`fitwidth_directCumulants20GeV_Vz_40_40_eta..._7_integrated.gif`

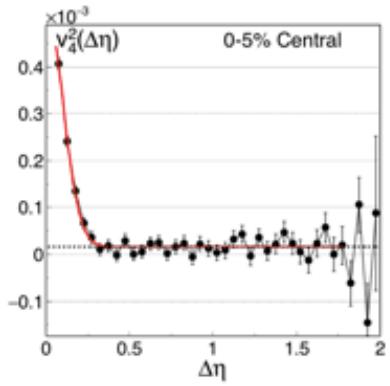


`fitwidth_directCumulants20GeV_Vz_40_40_eta..._8_integrated.gif`

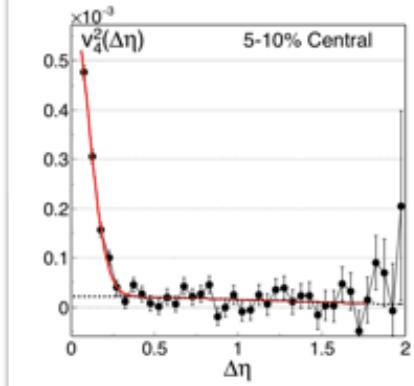


`fitwidth_directCumulants20GeV_Vz_40_40_eta..._9_integrated.gif`

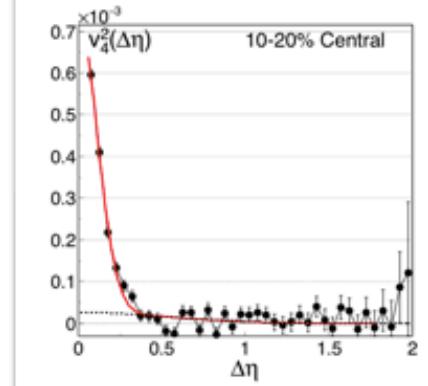
Appendix supporting material $v_4^2\{2\}$ fits 14.5 GeV:



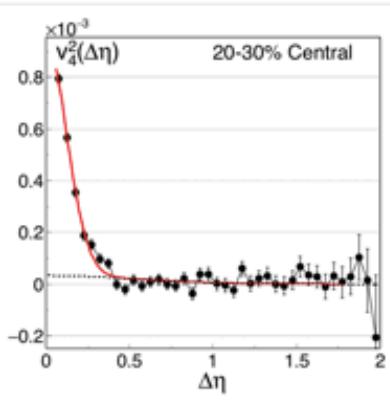
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._1_integrated.gif



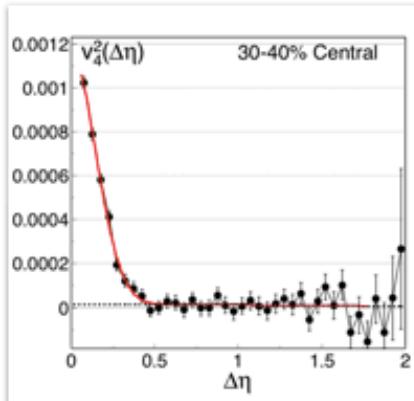
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._2_integrated.gif



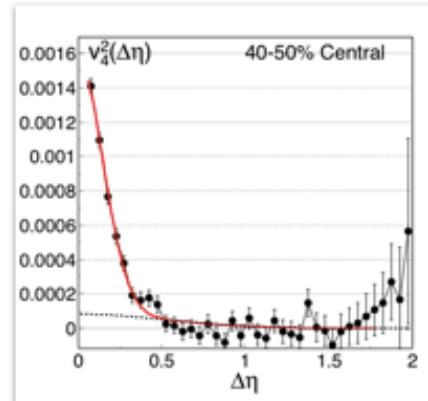
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._3_integrated.gif



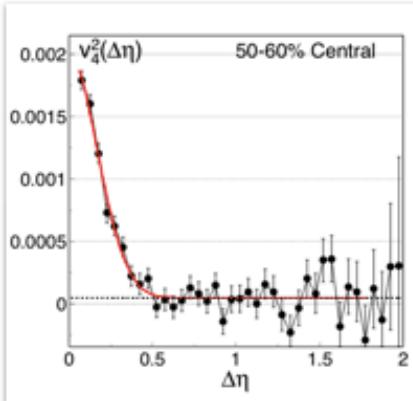
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._4_integrated.gif



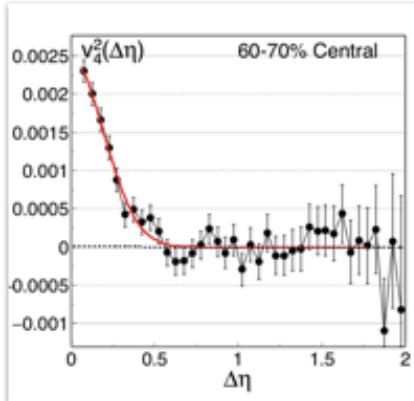
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._5_integrated.gif



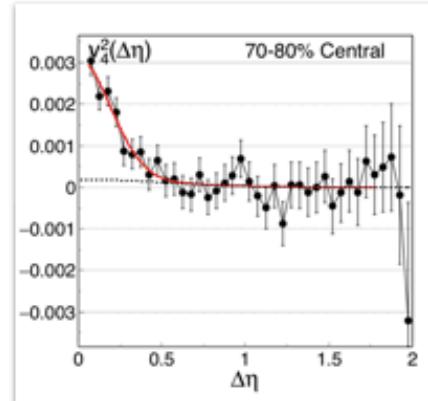
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants14GeV
_Vz_40_40_eta..._7_integrated.gif

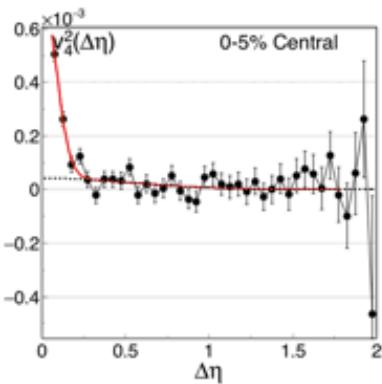


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._8_integrated.gif

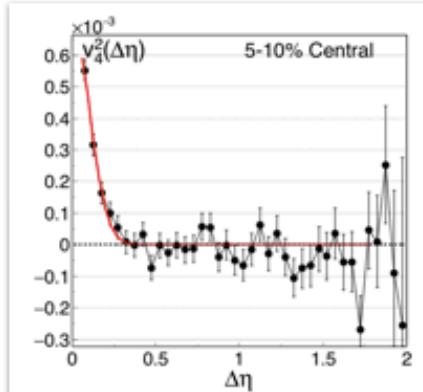


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._9_integrated.gif

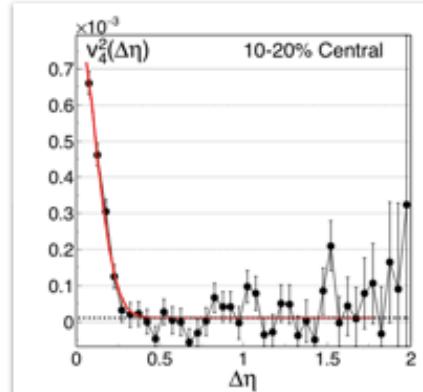
Appendix supporting material $v_4^2\{2\}$ fits 11.5 GeV:



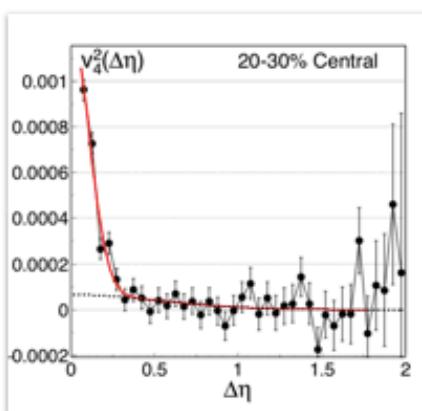
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._1_integrated.gif](#)



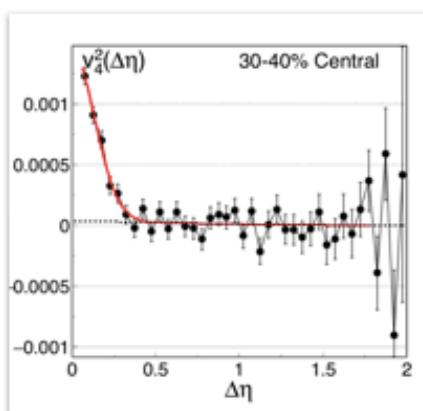
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



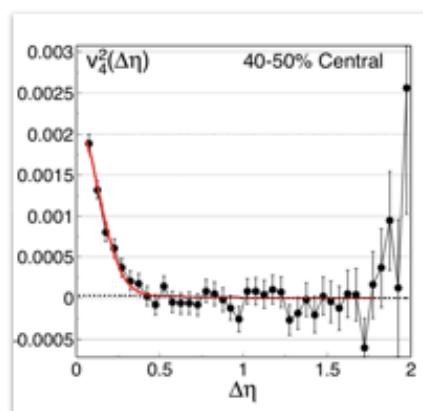
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



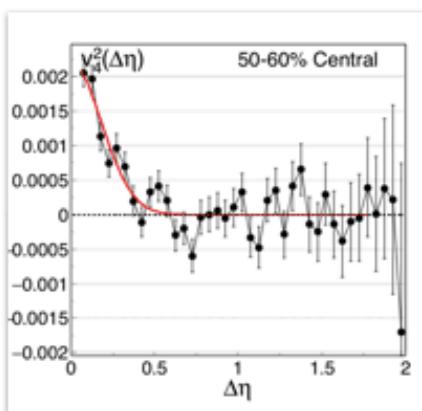
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



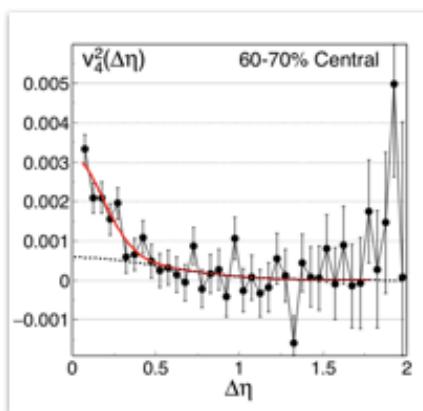
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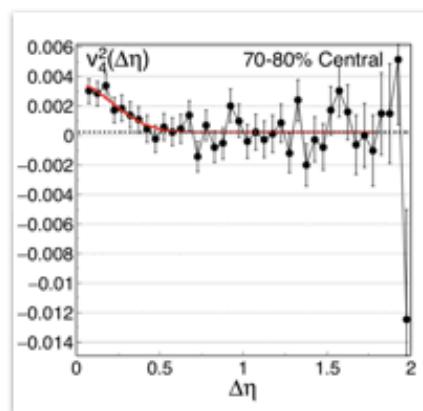
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._7_integrated.gif](#)

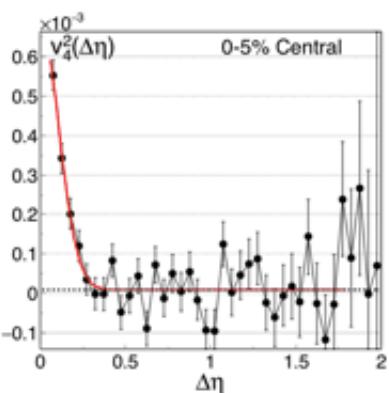


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

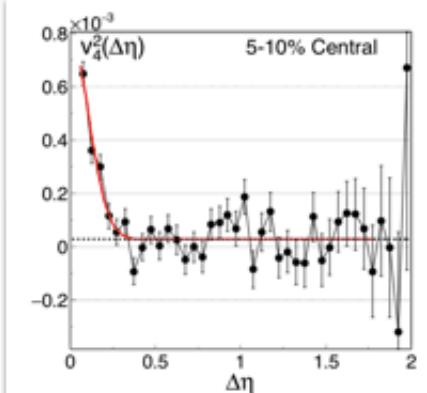


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

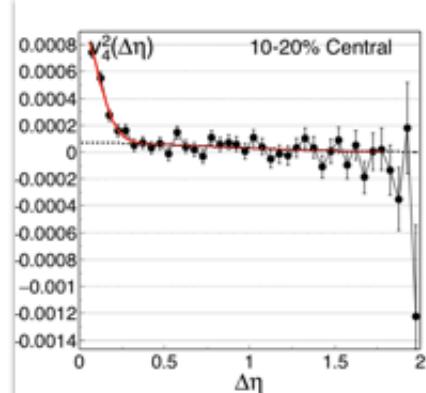
Appendix supporting material $v_4^2\{2\}$ fits 7.7 GeV:



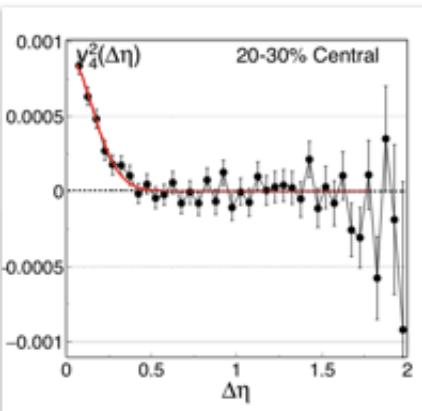
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._1_integrated.gif



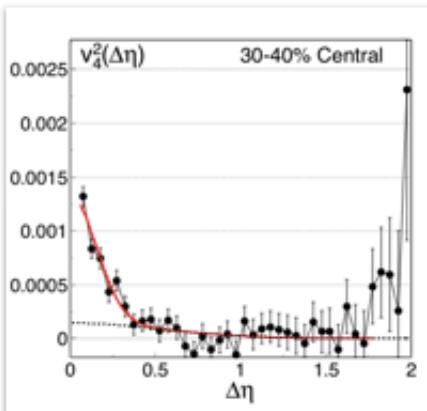
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



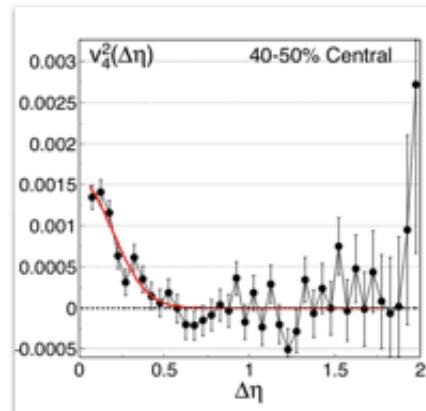
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



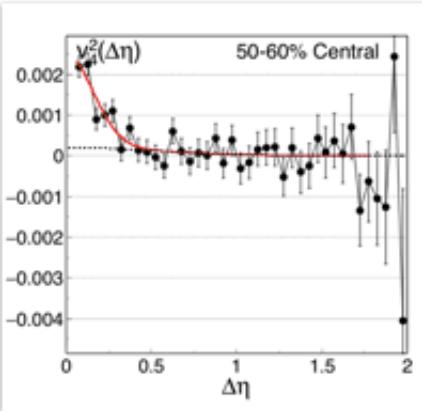
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



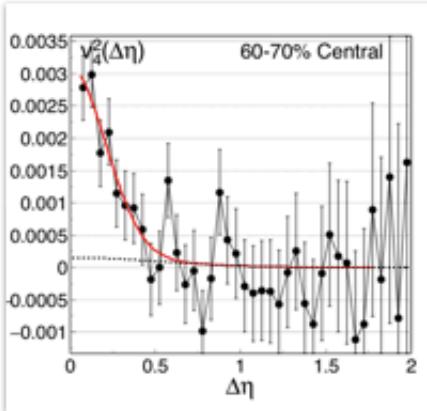
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



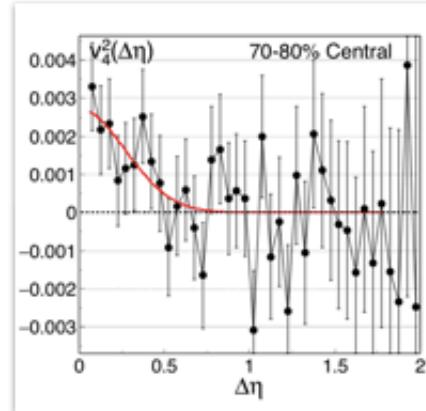
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



fitwidth_directCumulants7GeV_Vz_40_40_etaet..._7_integrated.gif

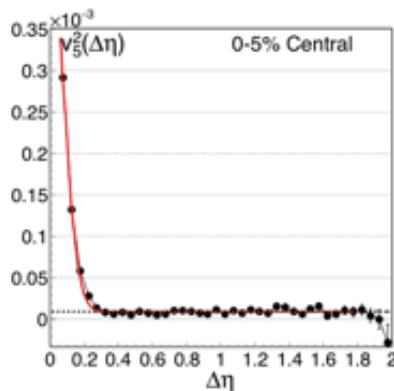


fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif

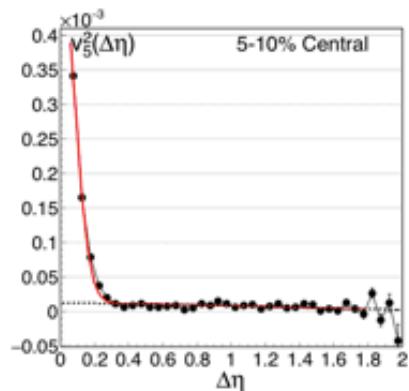


fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif

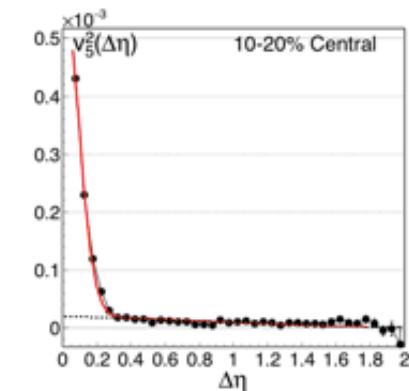
Appendix supporting material $v_5^2\{2\}$ fits 200 GeV:



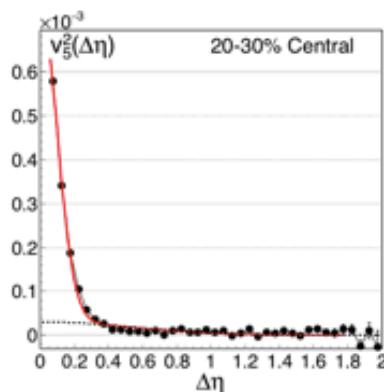
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._1_integrated.gif



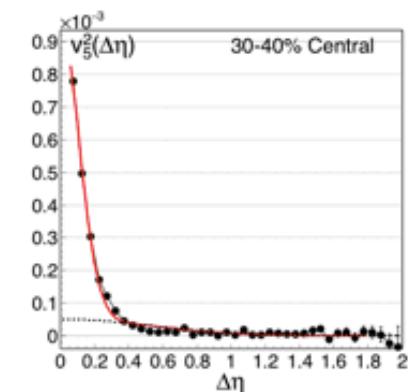
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._2_integrated.gif



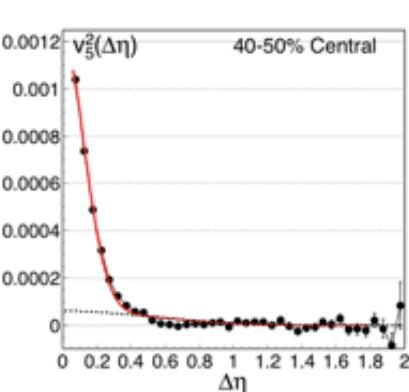
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._3_integrated.gif



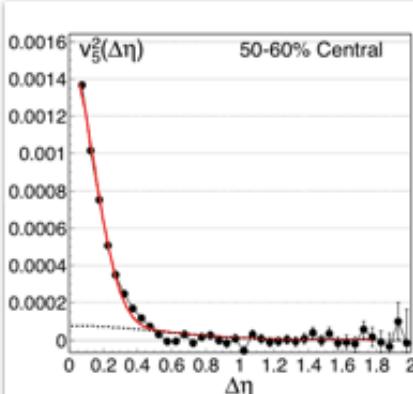
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._4_integrated.gif



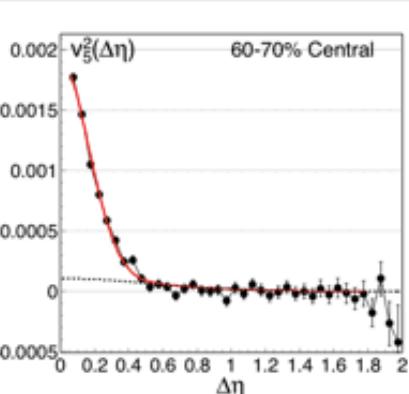
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._5_integrated.gif



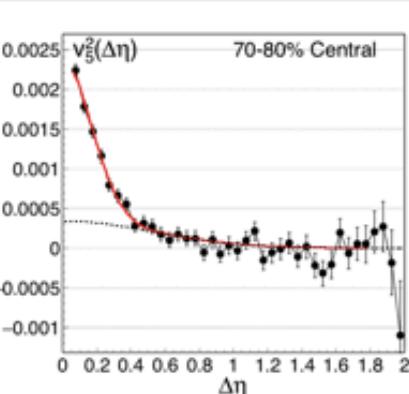
fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._6_integrated.gif



fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._7_integrated.gif

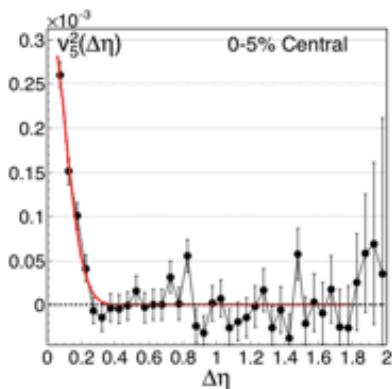


fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._8_integrated.gif

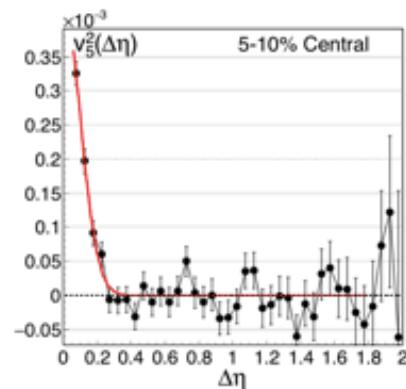


fitwidth_directCumulants2011_a
||_eta1eta3_Vz_..._9_integrated.gif

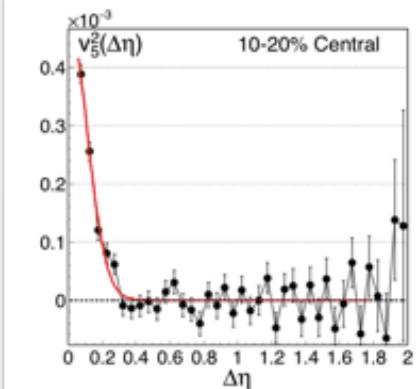
Appendix supporting material $v_5^2\{2\}$ fits 62.4 GeV:



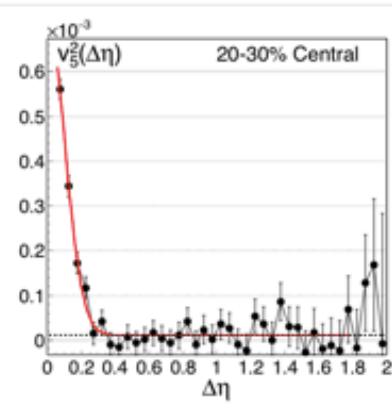
fitwidth_directCumulants62GeV
2004_Vz_20_2..._1_integrated.gif



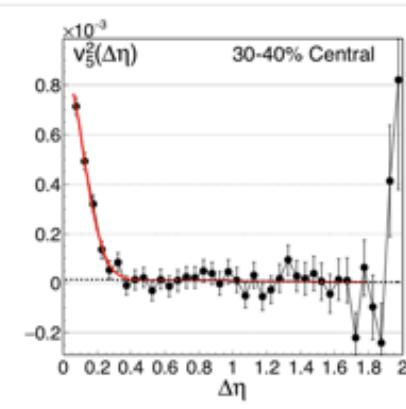
fitwidth_directCumulants62GeV
2004_Vz_20_2..._2_integrated.gif



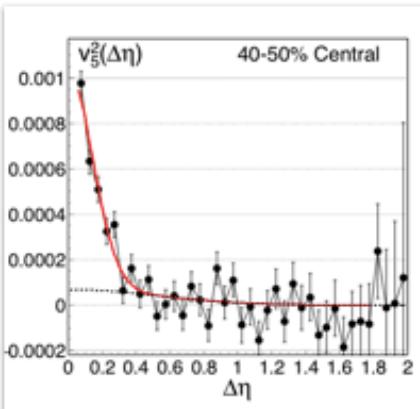
fitwidth_directCumulants62GeV
2004_Vz_20_2..._3_integrated.gif



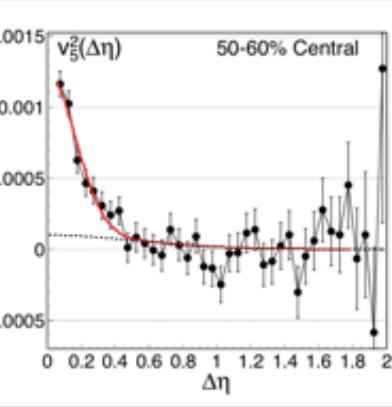
fitwidth_directCumulants62GeV
2004_Vz_20_2..._4_integrated.gif



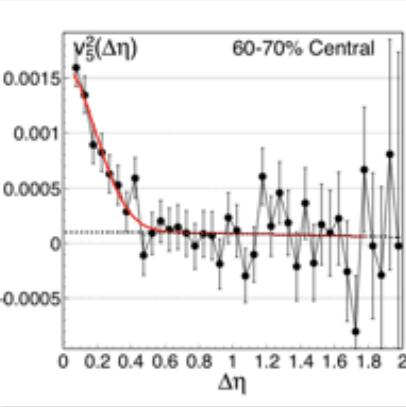
fitwidth_directCumulants62GeV
2004_Vz_20_2..._5_integrated.gif



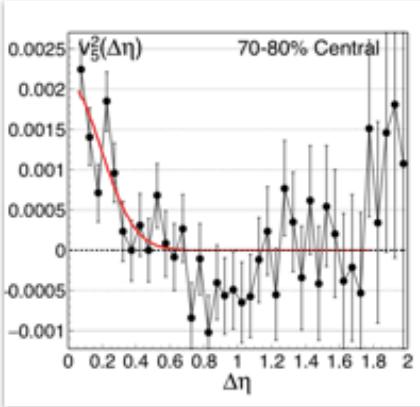
fitwidth_directCumulants62GeV
2004_Vz_20_2..._6_integrated.gif



fitwidth_directCumulants62GeV
2004_Vz_20_2..._7_integrated.gif

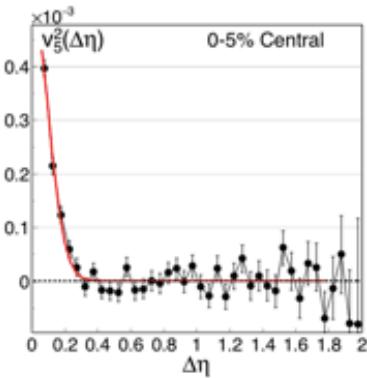


fitwidth_directCumulants62GeV
2004_Vz_20_2..._8_integrated.gif

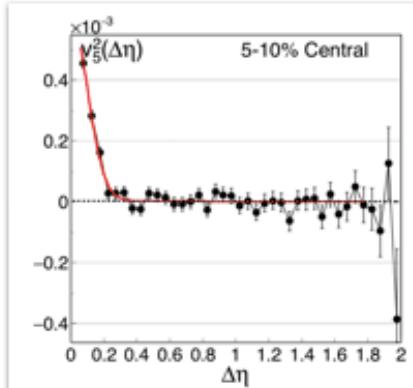


fitwidth_directCumulants62GeV
2004_Vz_20_2..._9_integrated.gif

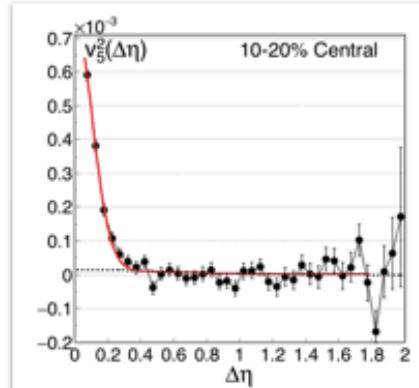
Appendix supporting material $v_5^2\{2\}$ fits 39 GeV:



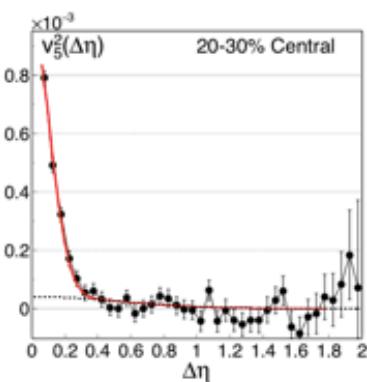
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._1_integrated.gif



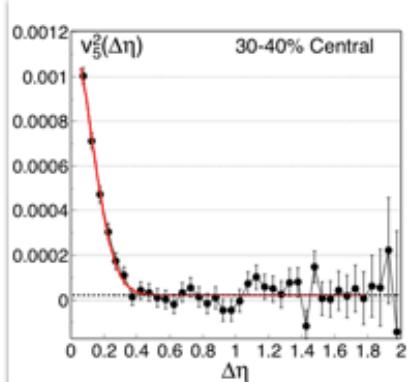
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._2_integrated.gif



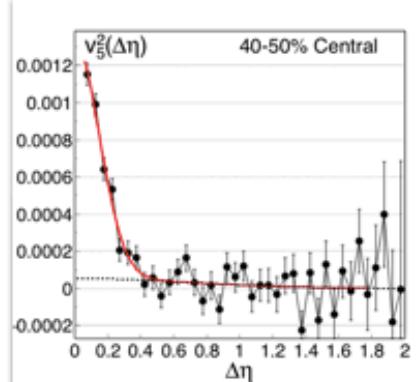
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._3_integrated.gif



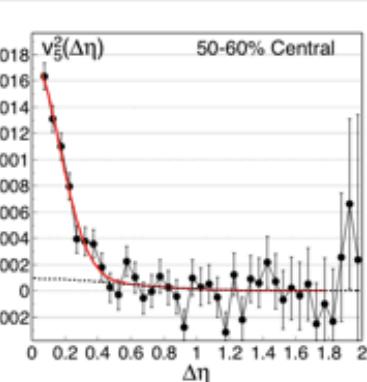
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._4_integrated.gif



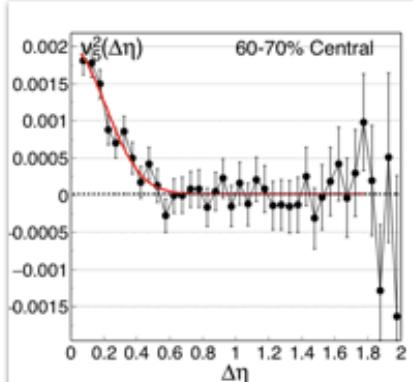
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._5_integrated.gif



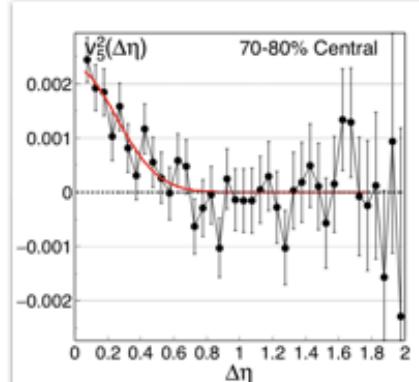
fitwidth_directCumulants39GeV
_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants39GeV
_Vz_20_20_eta..._7_integrated.gif

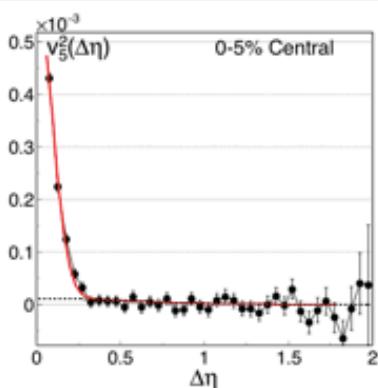


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._8_integrated.gif

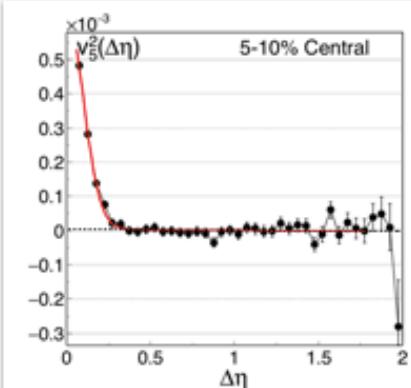


fitwidth_directCumulants39GeV
_Vz_20_20_eta..._9_integrated.gif

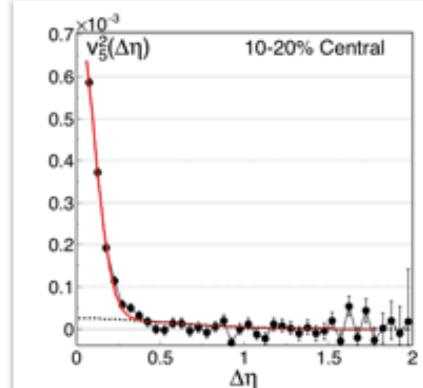
Appendix supporting material $v_5^2\{2\}$ fits 27 GeV:



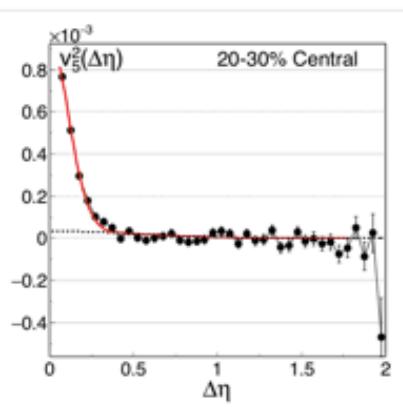
fitwidth_directCumulants27GeV_Vz_20_20_eta..._1_integrated.gif



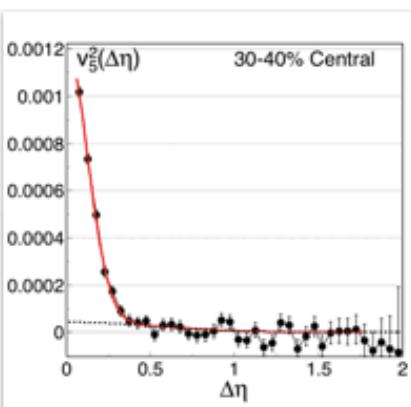
fitwidth_directCumulants27GeV_Vz_20_20_eta..._2_integrated.gif



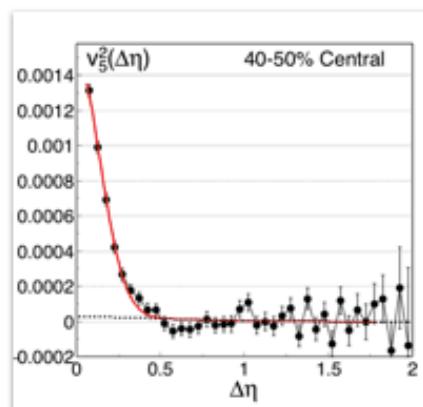
fitwidth_directCumulants27GeV_Vz_20_20_eta..._3_integrated.gif



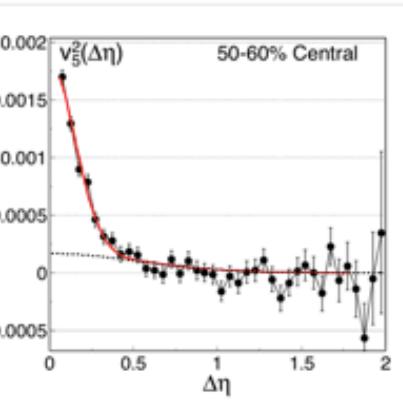
fitwidth_directCumulants27GeV_Vz_20_20_eta..._4_integrated.gif



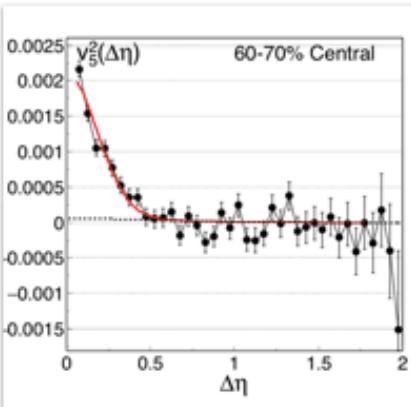
fitwidth_directCumulants27GeV_Vz_20_20_eta..._5_integrated.gif



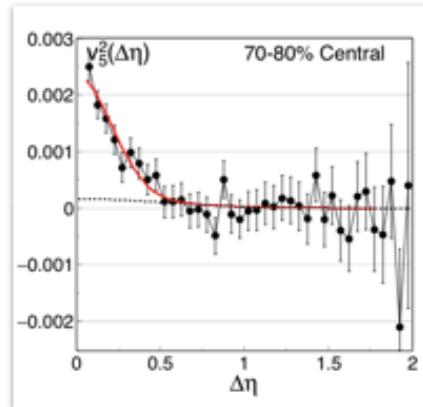
fitwidth_directCumulants27GeV_Vz_20_20_eta..._6_integrated.gif



fitwidth_directCumulants27GeV_Vz_20_20_eta..._7_integrated.gif

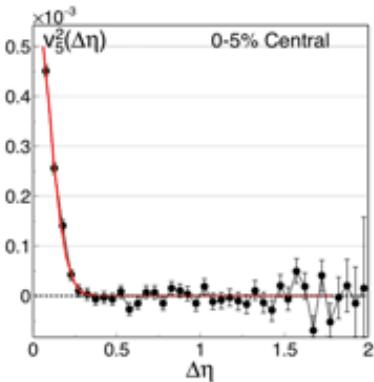


fitwidth_directCumulants27GeV_Vz_20_20_eta..._8_integrated.gif

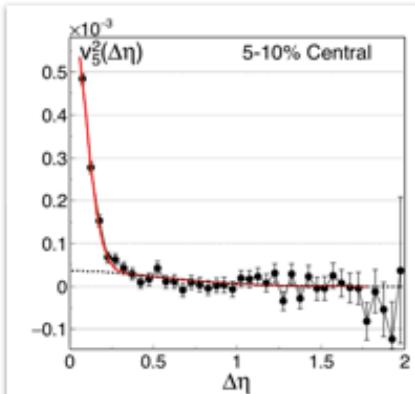


fitwidth_directCumulants27GeV_Vz_20_20_eta..._9_integrated.gif

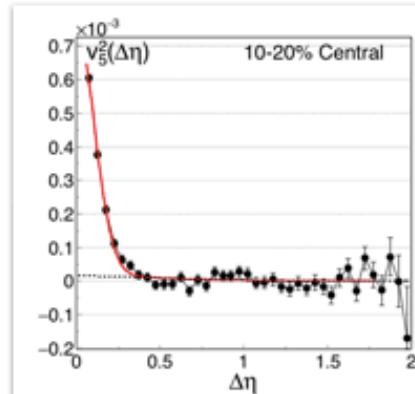
Appendix supporting material $v_5^2\{2\}$ fits 19.6 GeV:



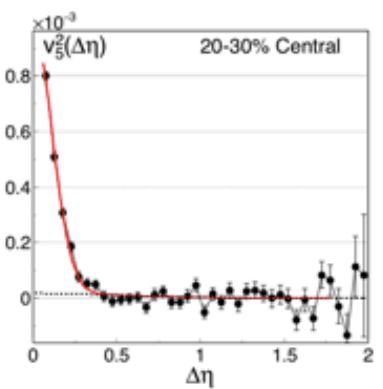
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._1_integrated.gif



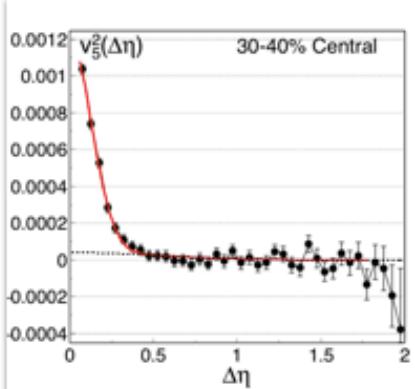
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._2_integrated.gif



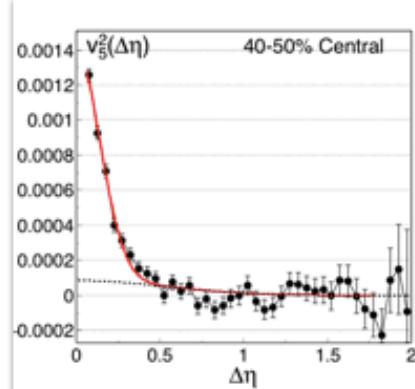
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._3_integrated.gif



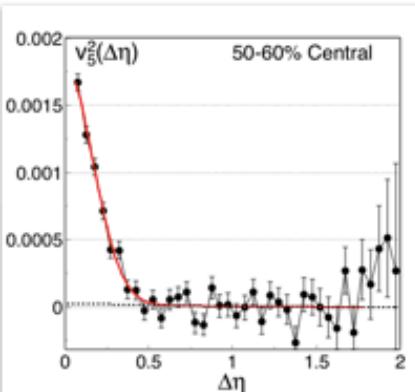
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._4_integrated.gif



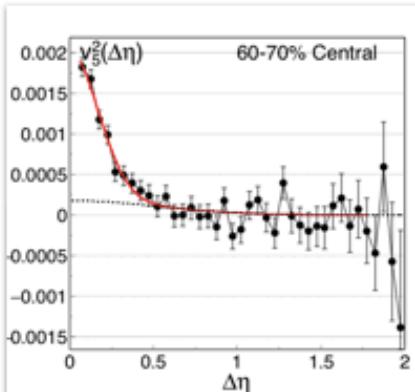
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._5_integrated.gif



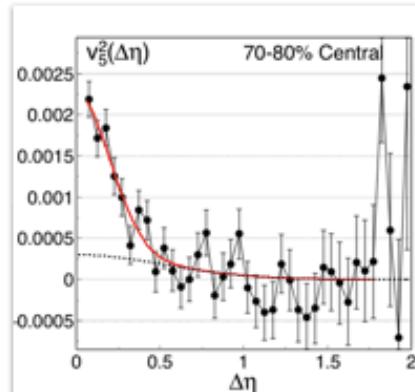
fitwidth_directCumulants20GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants20GeV
_Vz_40_40_eta..._7_integrated.gif

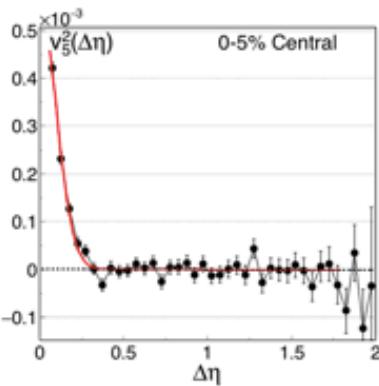


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._8_integrated.gif

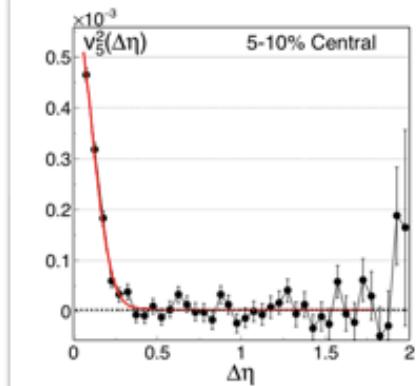


fitwidth_directCumulants20GeV
_Vz_40_40_eta..._9_integrated.gif

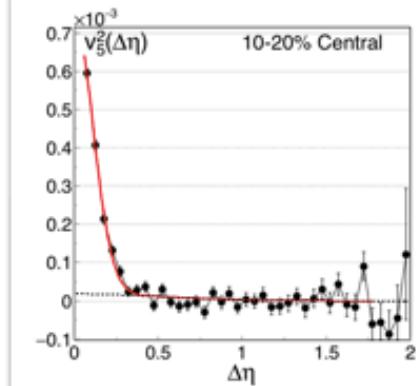
Appendix supporting material $v_5^2\{2\}$ fits 14.5 GeV:



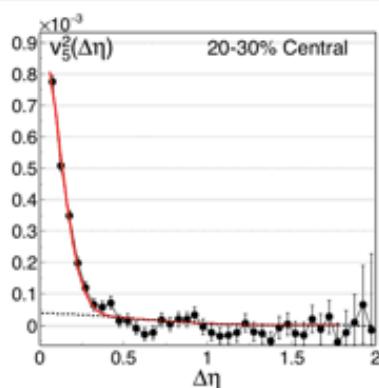
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._1_integrated.gif



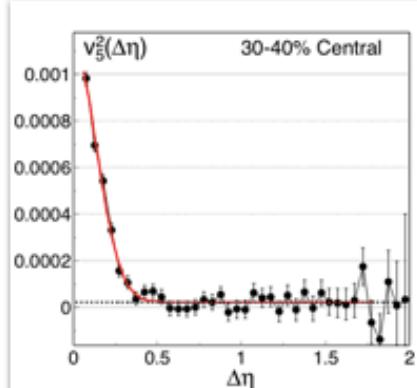
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._2_integrated.gif



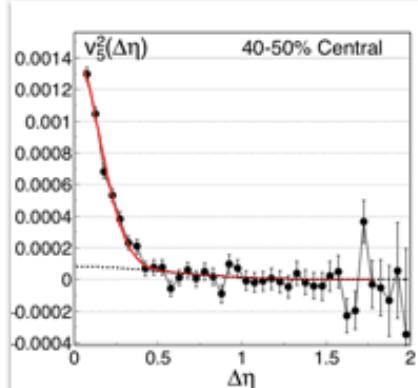
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._3_integrated.gif



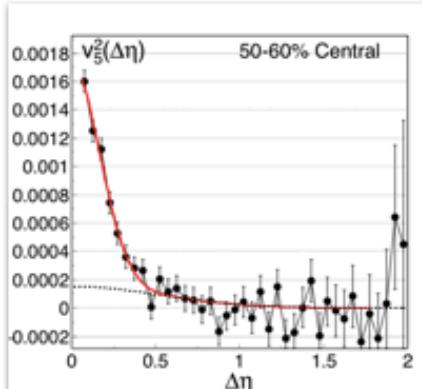
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._4_integrated.gif



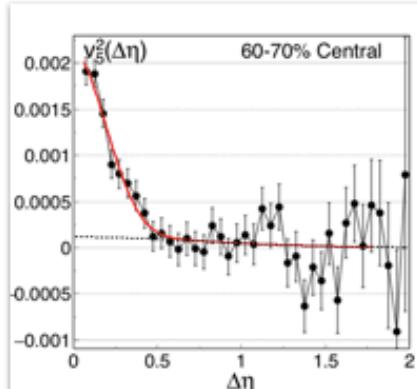
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._5_integrated.gif



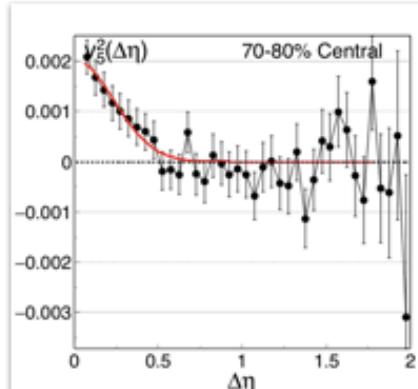
fitwidth_directCumulants14GeV
_Vz_40_40_eta..._6_integrated.gif



fitwidth_directCumulants14GeV
_Vz_40_40_eta..._7_integrated.gif

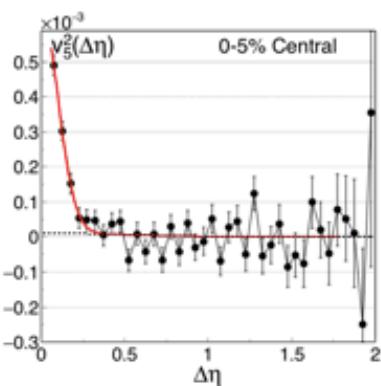


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._8_integrated.gif

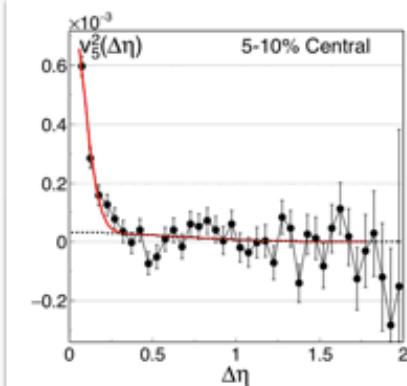


fitwidth_directCumulants14GeV
_Vz_40_40_eta..._9_integrated.gif

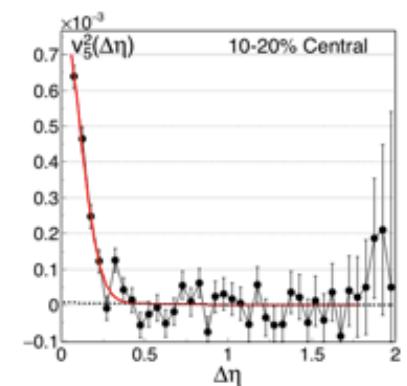
Appendix supporting material $v_5^2\{2\}$ fits 11.5 GeV:



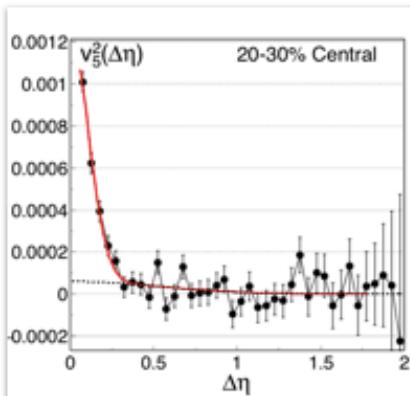
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._1_integrated.gif](#)



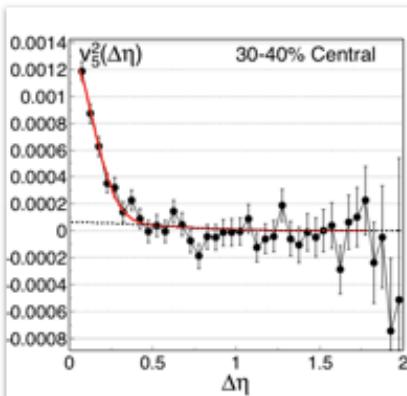
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



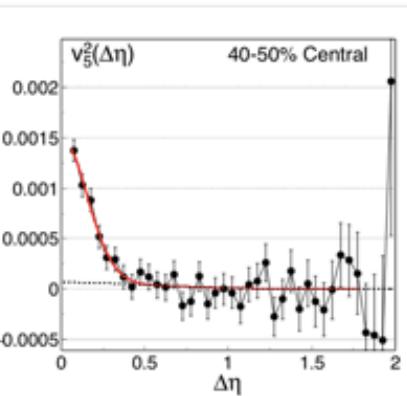
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



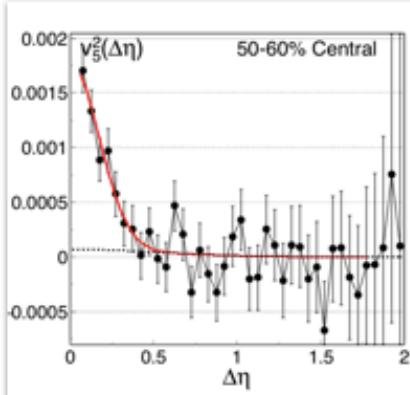
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



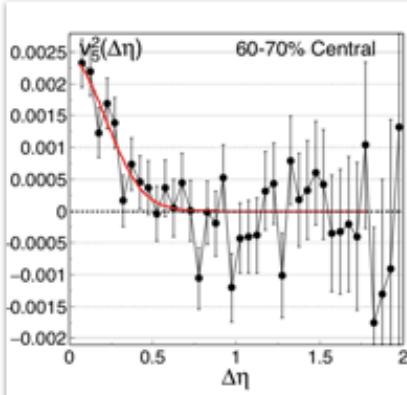
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



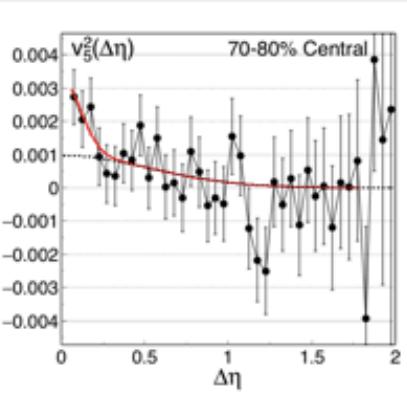
[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)



[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._7_integrated.gif](#)

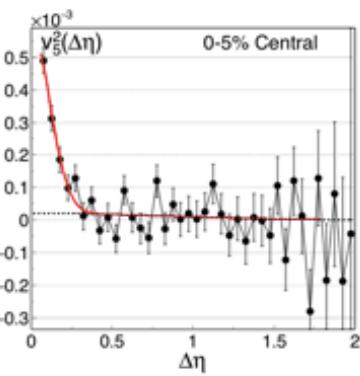


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

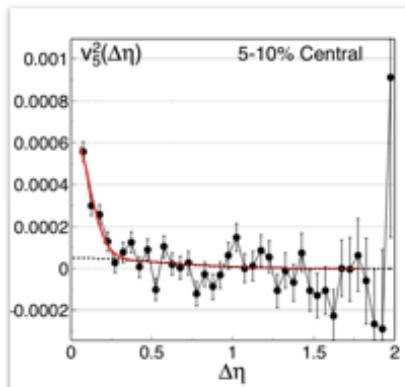


[fitwidth_directCumulants11GeV_Vz_40_40_etaet..._integrated.gif](#)

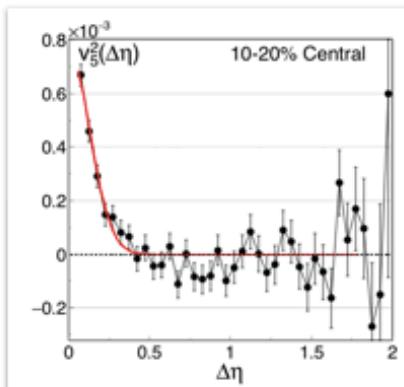
Appendix supporting material $v_5^2\{2\}$ fits 7.7 GeV:



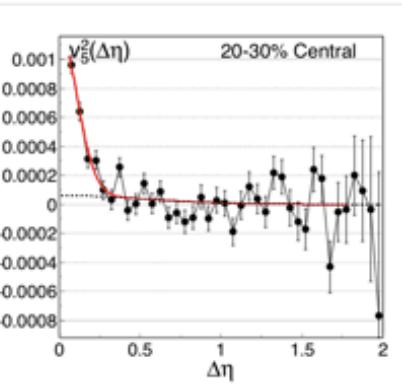
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._1_integrated.gif



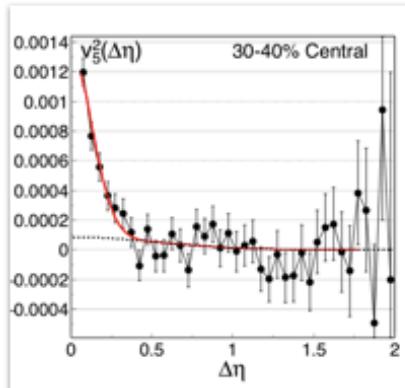
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._Scale document down_integrated.gif



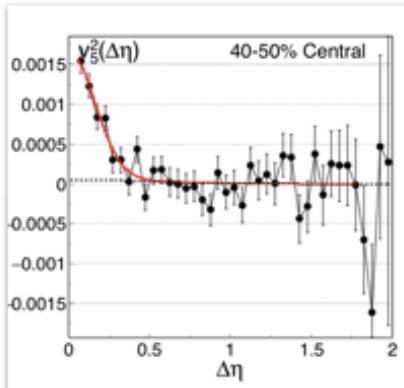
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



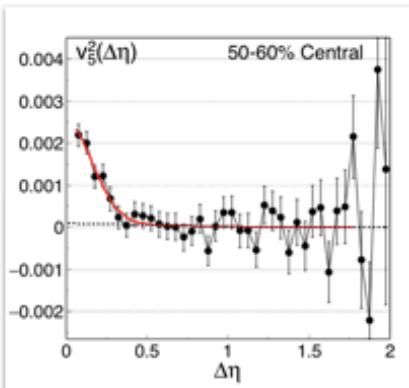
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



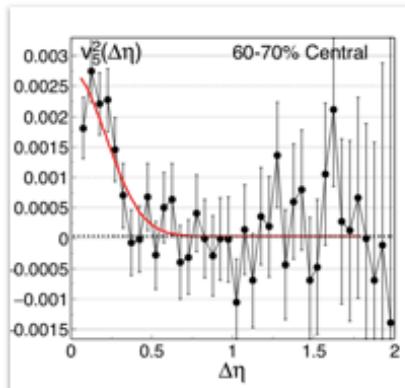
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



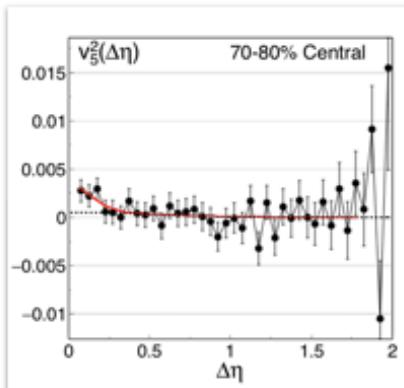
fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif



fitwidth_directCumulants7GeV_Vz_40_40_etaet..._7_integrated.gif

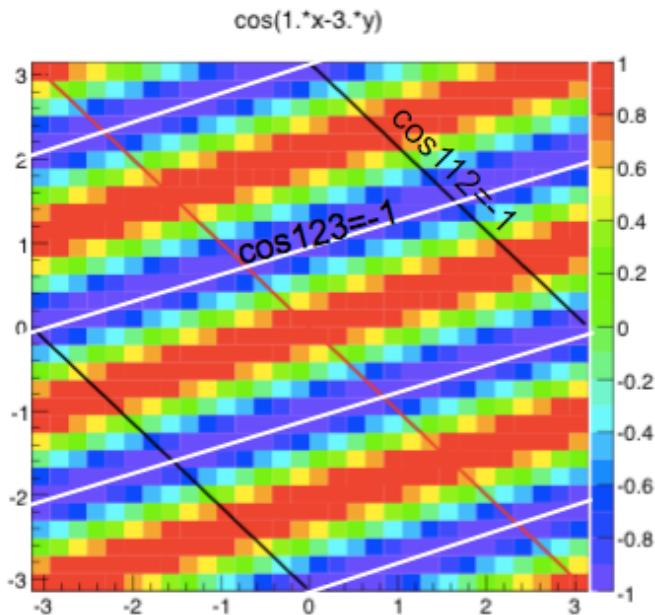


fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif

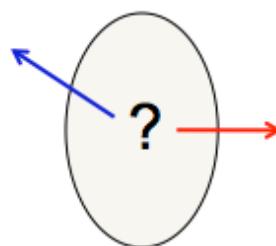


fitwidth_directCumulants7GeV_Vz_40_40_etaet..._integrated.gif

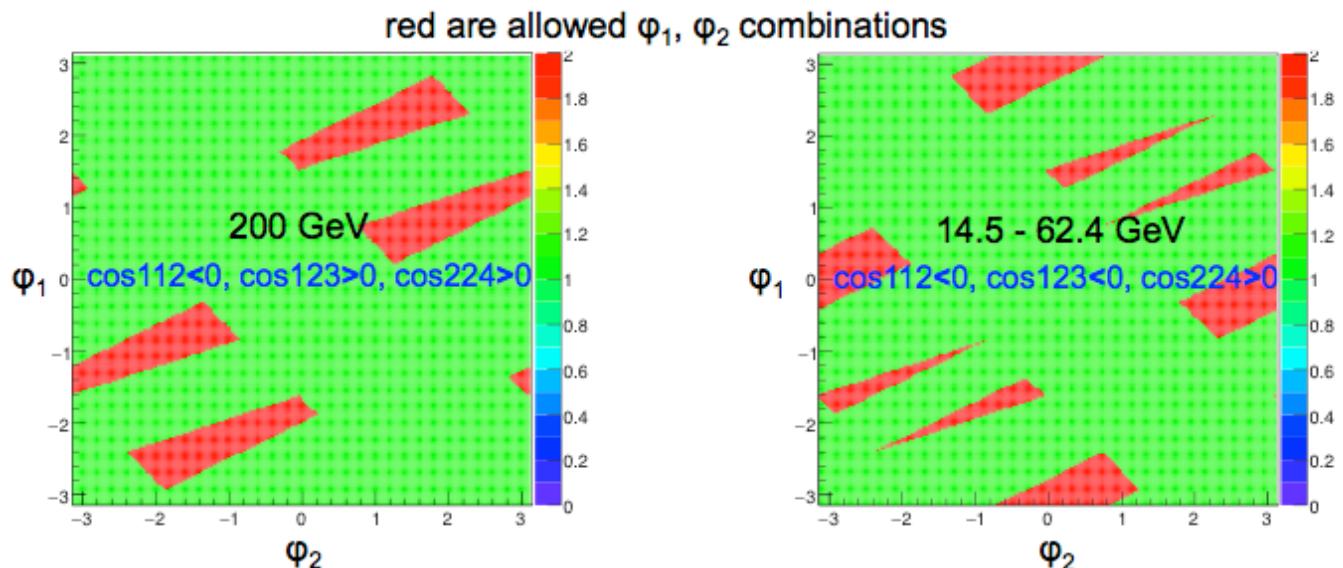
Auxiliary Studies:



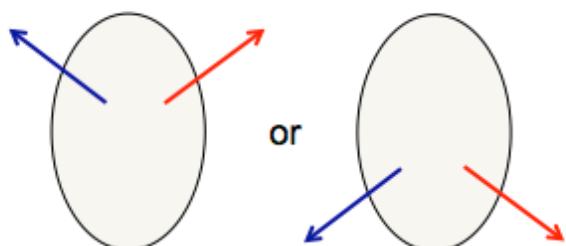
$n=2$ is dominated by the reaction plane
so taking $\varphi' = \varphi - \Psi_2$
 $\langle \cos(1\varphi + 2\varphi - 3\varphi) \rangle \approx \langle \cos(1\varphi' - 3\varphi') \rangle$
 $\langle \cos(1\varphi + 1\varphi - 2\varphi) \rangle \approx \langle \cos(1\varphi' + 1\varphi') \rangle$



The data in the previous slides can determine how particle pairs are emitted relative to the reaction plane:



At high energies this is dominant:



At lower \sqrt{s}_{NN} they are more back-to-back:

