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The event plane calibration in the MBD in the 2023 commissioning data

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Abstract

This is a short approval note in support of the event plane calibration process of the MBD event plane during Run 2023.

Introduction

The event plane is used in many physics analyses of interest to the collaboration. We refer the reader to our previous note linked [here], which describes the event plane determination and first order correction by recentering the flow vectors. In the previous note, the event plane shifting procedure is implemented for the plots shown in the result section of that note. In this note, we explicitly describe the event plane shifting procedure and extract the Ψ_n distributions employing calibration steps described in the previous and current note. The event-by-event shifting of the planes requires that one fits the non-flat distribution of the event planes summed over all events to a Fourier expansion and devise the shift necessary to force a flat distribution.

The equation for the shift is [1]:

$$n\Delta\Psi_n = \sum_{i}^{i_{max}} = \frac{2}{i}(-\langle sin(in\Psi_n)\rangle cos(in\Psi_n) + \langle cos(in\Psi_n)\rangle sin(in\Psi_n)) \quad (1)$$

This short note goes through the two correction procedures and shows the corrected second order event plane angles employing both correction procedures.

Run selection and code

The code used for this analysis is linked [here]. The plots in this note use run 23543 and production build DST_ana395_2023p007.

Results

Recentering results

The one dimensional second order event plane distributions shown in this section are within $|z - vertex_{MBD}| < 20$ cm. The event plane is calibrated in bins of MBD total charge with a width of 5. The relevant equations for recentering can be found in Eqs. 8-13 of our previous note linked [here]. The left plot of figure 2 shows the MBD z-vertex distribution and a total number of 78663 events in the shaded region used for this analysis. The event plane resolution is shown on the right plot. The plots requested for preliminary status are in Figure 1 only, i.e. the raw and recentered second order event plane angle distributions of the MBD north and MBD south.

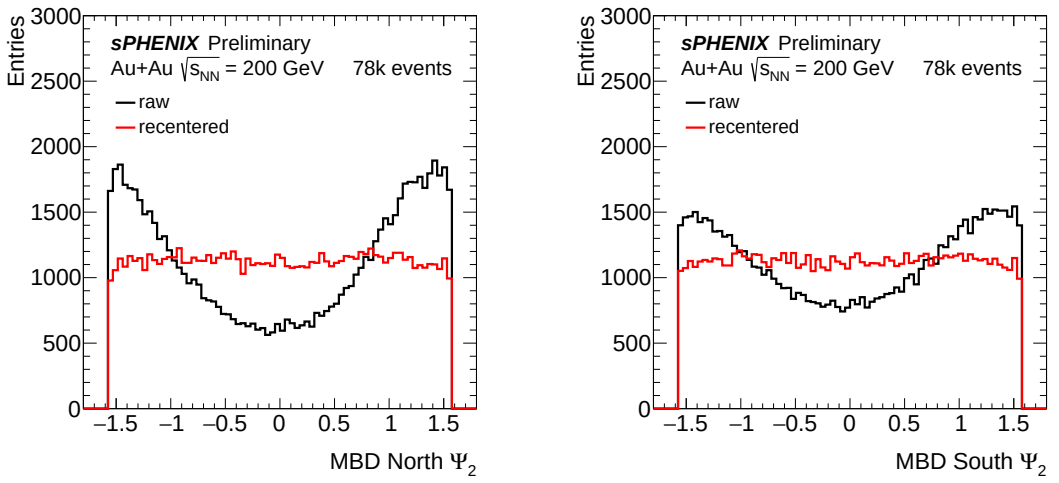

Figure 1: Event plane calibration steps of the second order event plane angle using the MBD north arm (left); showing the raw and recentered distributions in black and red respectively. The right figure shows the corresponding distributions using the MBD south arm.

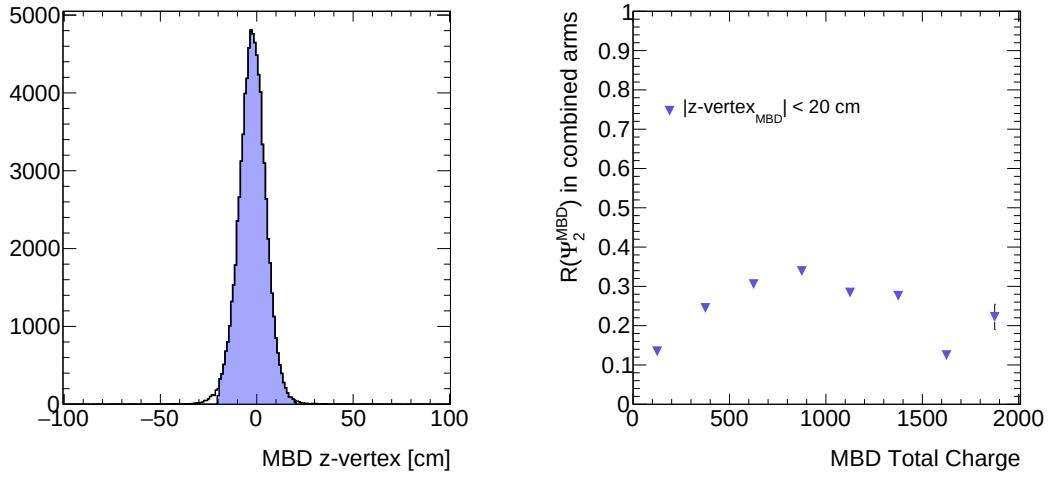

Figure 2: The left figure shows the MBD z-vertex distribution in black, and a $|z - vertex_{MBD}| < 20$ cm region in blue of selected events used in this analysis. The right figure shows the event plane resolution with the imposed z-vertex cut in run 23543.

Shifting results

The maximum order of 6 used in the angle shift in this note is the same as in the previous note. The total shift applied to the second order recentered event plane angle is formulated as:

$$\Psi_2^{'} = \Psi_2 + \Delta\Psi_2 \tag{2}$$

where $\Delta\Psi_2$ is shown in Eq. 1, with n = 2. Ψ_2 in Eq. 2 is the recentered Ψ_2. $\Psi_2^{'}$ is the recentered and shifted second order event plane angle. The procedure forces the event plane flat. However, it has been observed that this procedure requires further diagnostics as the shift shifts a small number of corrected Ψ_2 values outside $[-\frac{\pi}{2}, \frac{\pi}{2}]$, as seen in figure 3.

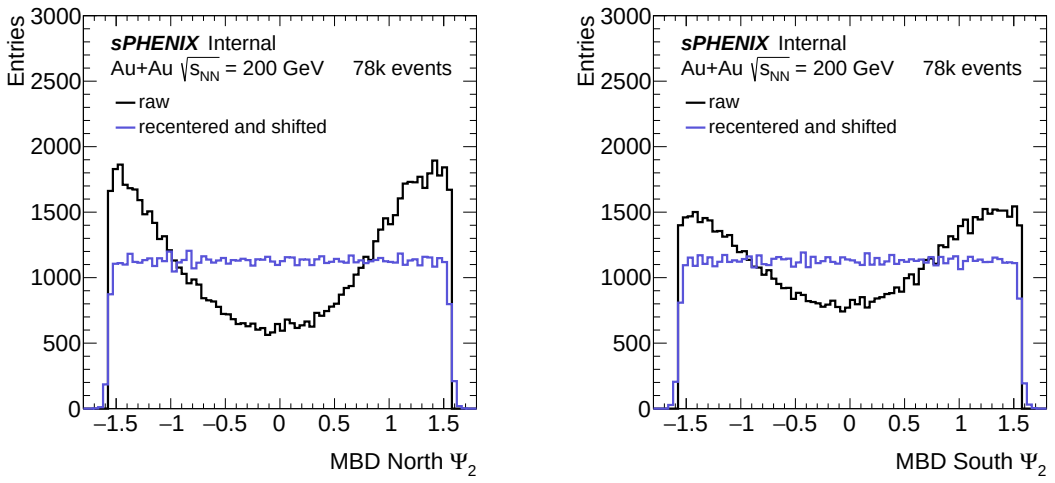

Figure 3: Event plane calibration steps of the second order event plane angle using the MBD north arm (left); showing the raw and recentered+shifted distributions in black and blue respectively. The right figure shows the corresponding distributions using the MBD south arm.

References

[1] A. M. Poskanzer and S. A. Voloshin. Methods for analyzing anisotropic flow in relativistic nuclear collisions. *Physical Review C*, 58(3):1671–1678, September 1998. URL: `http://dx.doi.org/10.1103/PhysRevC.58.1671`, `doi:10.1103/physrevc.58.1671`. (document)