Collision event plane determination in sPHENIX at RHIC

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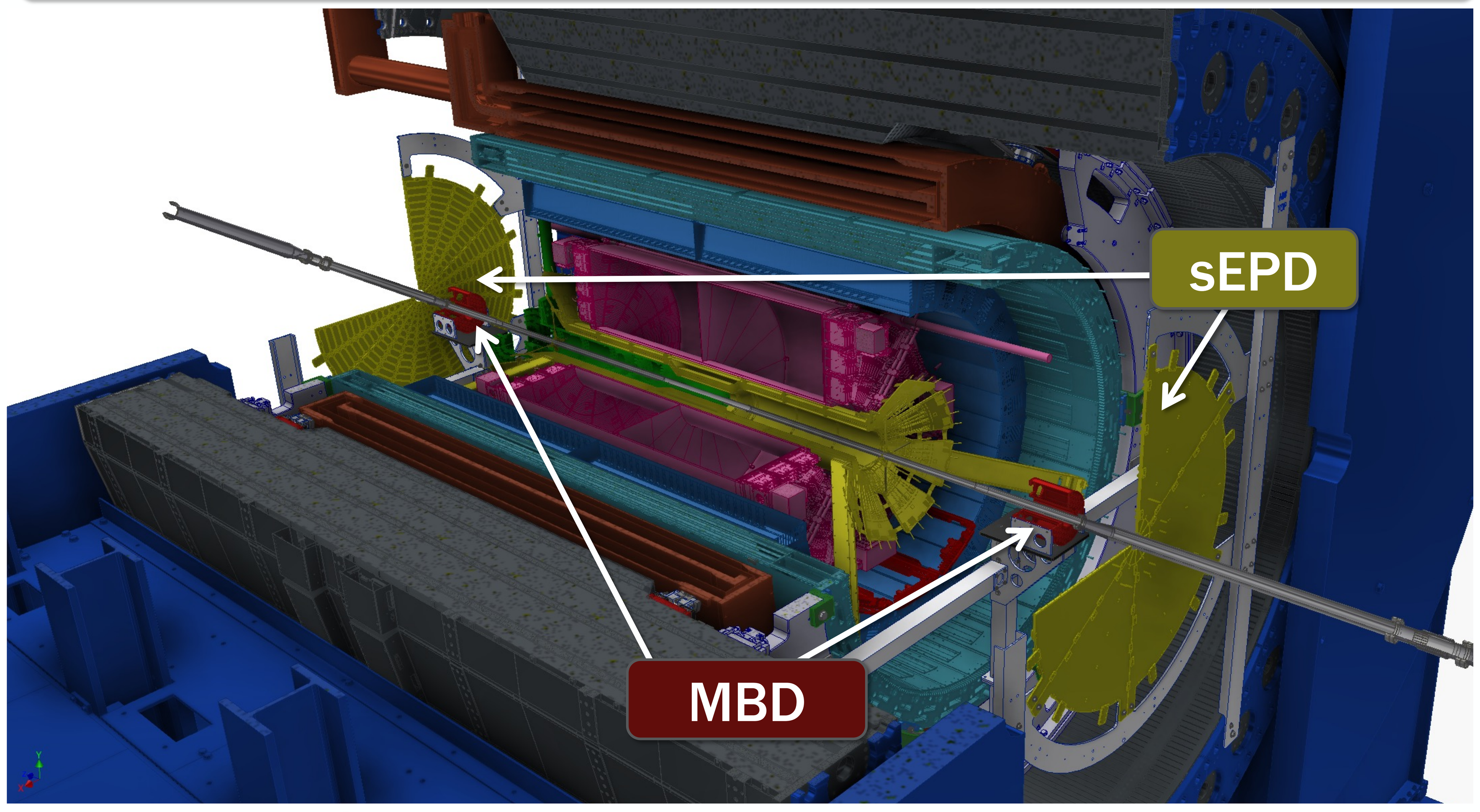
Abstract

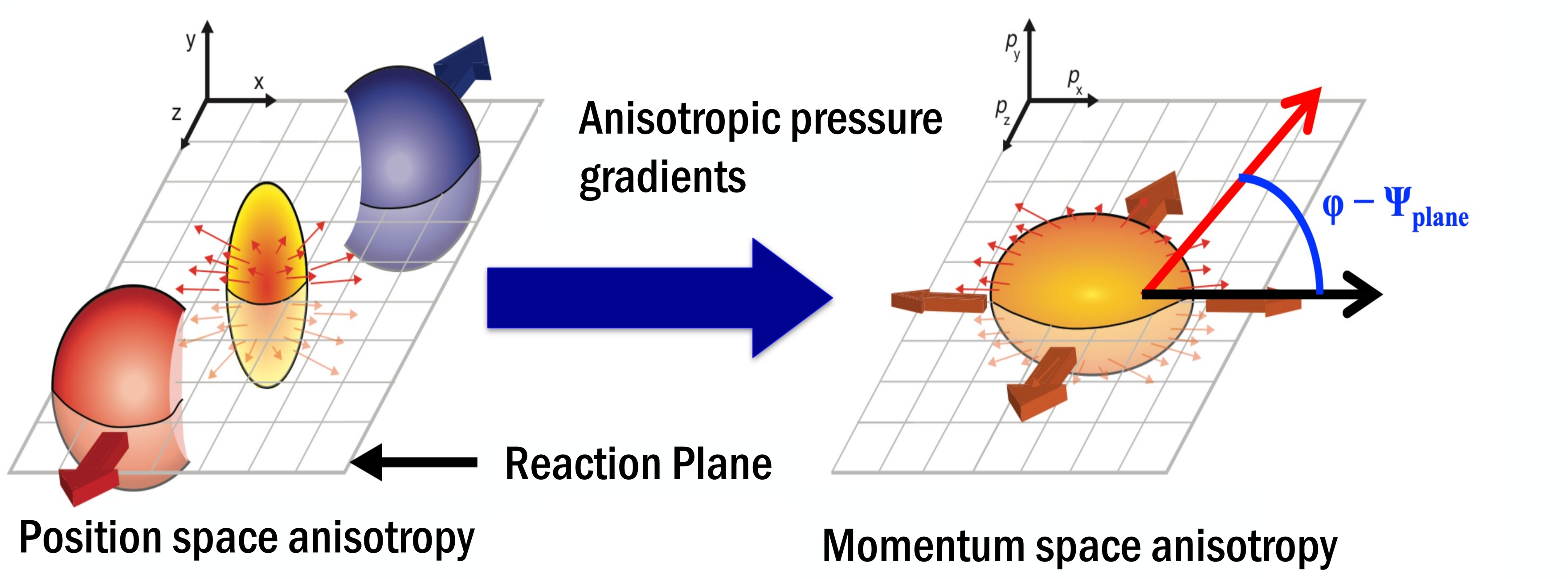
Many physics observables of interest in heavy-ion collisions require knowledge of the collision geometry. Geometric fluctuations lead to different symmetry planes of the initial geometry for each harmonic number, called participant planes. As the produced medium evolves, pressure gradients transform the initial state spatial anisotropy into final state momentum anisotropy. The angular distribution of particles can be described via Fourier coefficients v_n. The participant planes can be approximated via event planes, ψ_n, which are determined from measured azimuthal distribution of particles produced in the collision. This poster reports the methods used for event plane determination in sPHENIX as well as the performance using a variety of sPHENIX subsystems based on simulation using a realistic GEANT description of the experiment. Initial results from the first data run are also discussed.

sPHENIX Experiment at RHIC



The subsystems used for the ψ_2 determination are the Minimum Bias Detector (MBD), and the sPHENIX Event Plane Detector (sEPD), covering $3.5 < |\eta| < 4.5$ and $2.0 < |\eta| < 4.9$ respectively. The MBD ψ_2 results are with Au+Au at 200 GeV data, while the sEPD ψ_2 is with HIJING and flow after burner.

Event plane determination



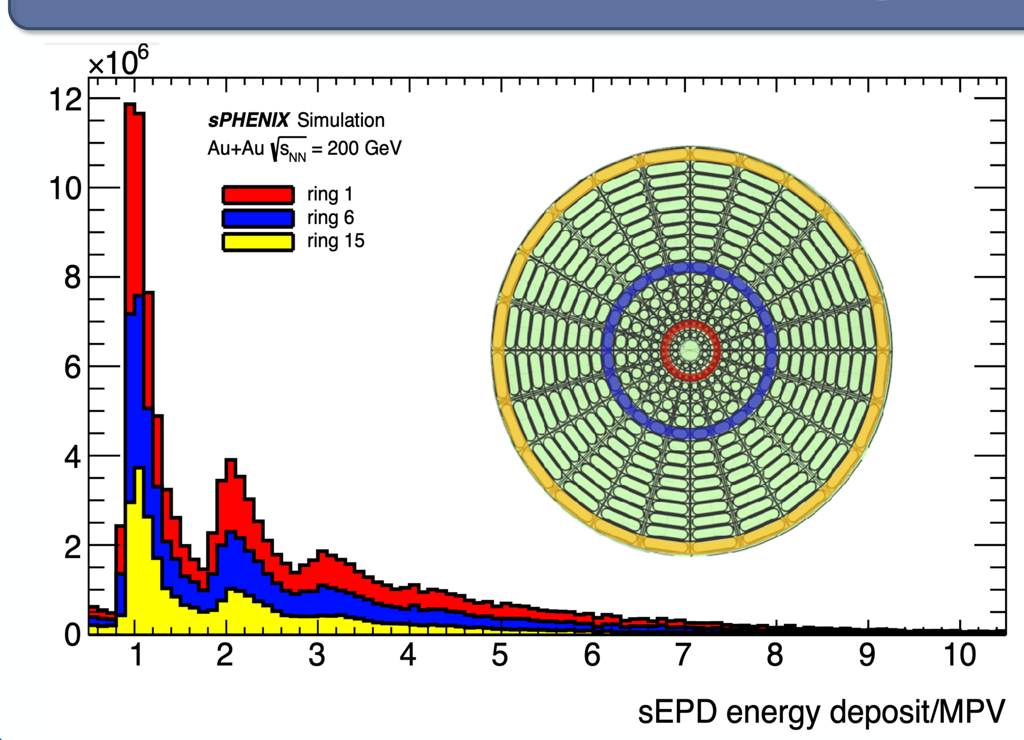
The method used to estimate the reaction plane uses the anisotropic flow itself to determine the event plane [1]. The event flow vector, Q_n and the event plane angle, ψ_n are defined by the following equations:

$$Q_n \sin(n\psi_n) = Y_n = \sum_i w_i \sin(n\phi_i)$$
$$Q_n \cos(n\psi_n) = X_n = \sum_i w_i \cos(n\phi_i)$$

$$n\psi_n = \tan^{-1}\left(Y_n/X_n\right)$$

where, ϕ_i is the azimuthal angle of *ith* particle; w_i and n are the weights and order respectively.

Flow vector weights optimization

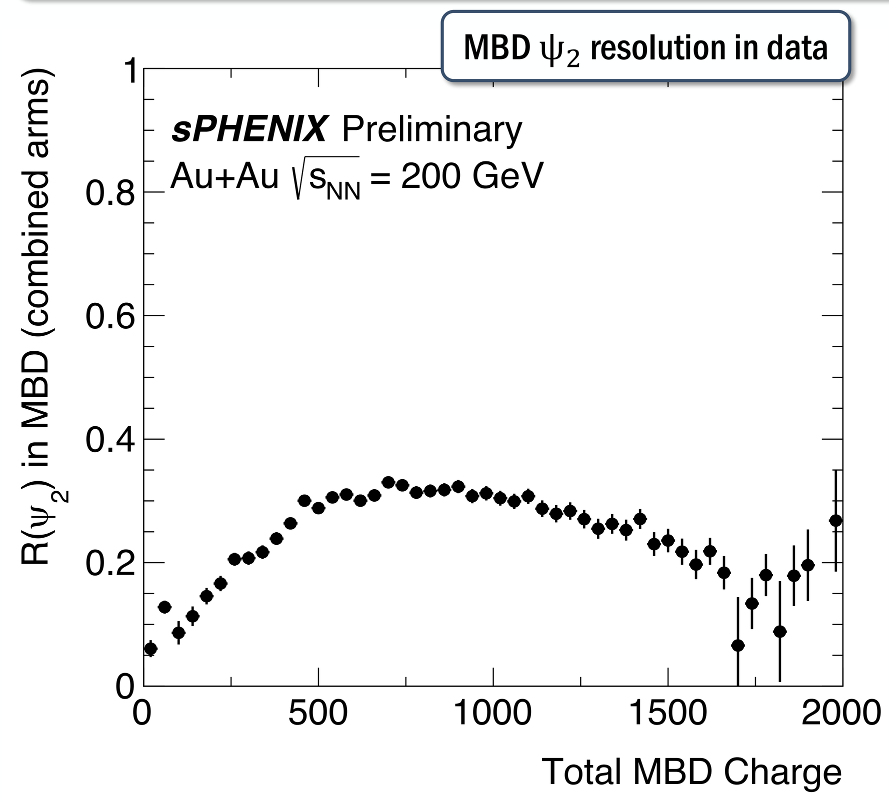


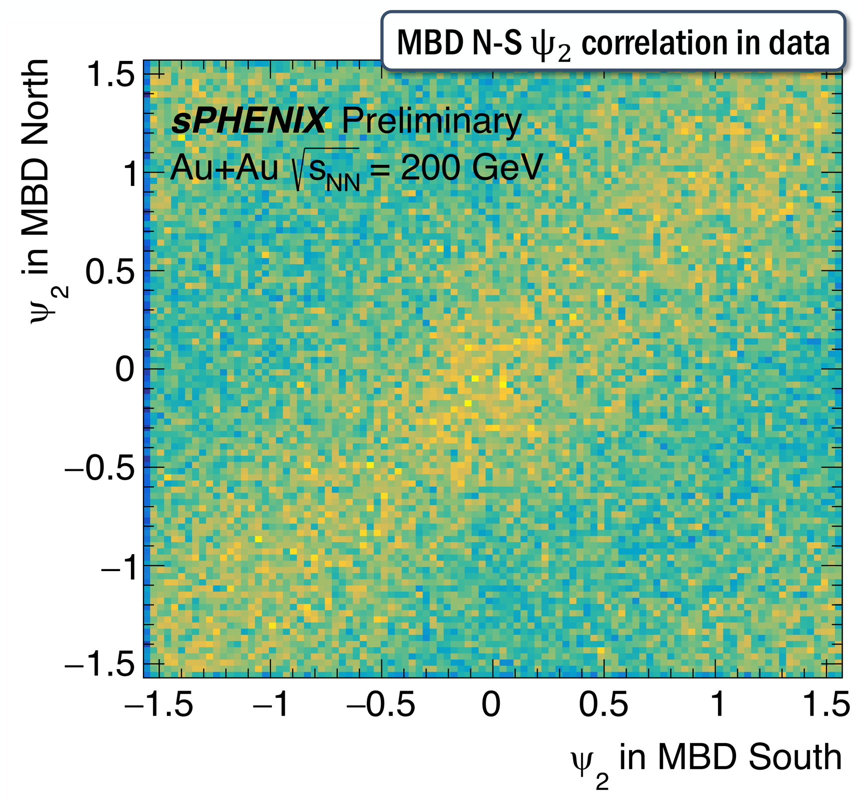
The weights used for the flow vector are the signal in each channel normalized by its MPV, also known as nMIP.

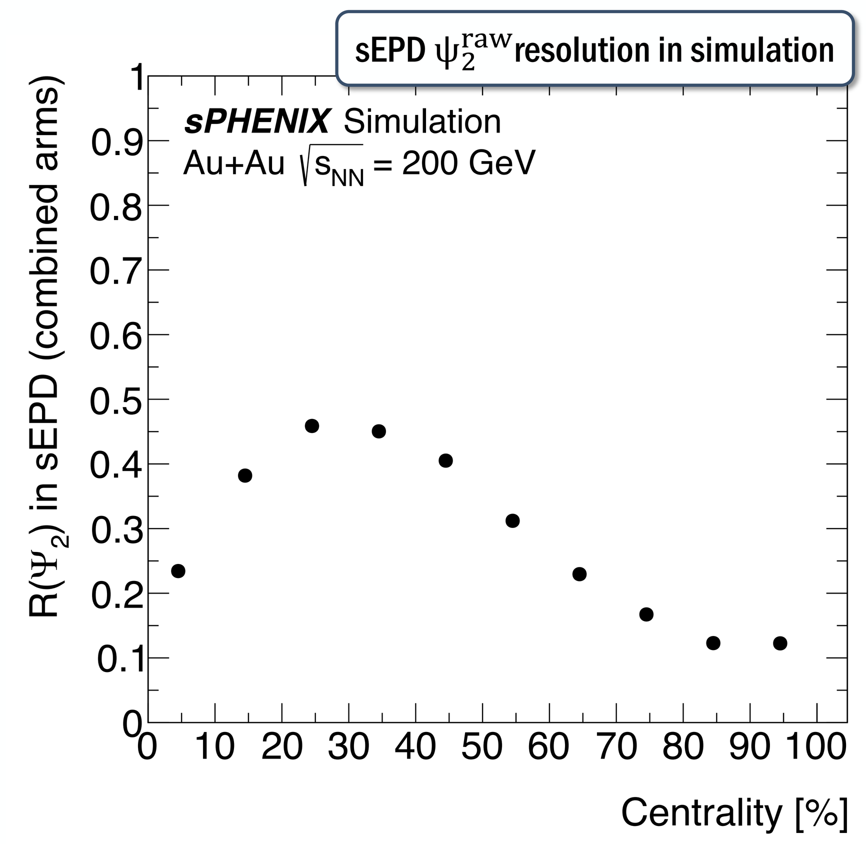
The sEPD includes a further truncation of the weights in each ring to reduce Landau fluctuations, which degrades the event plane resolution [2].

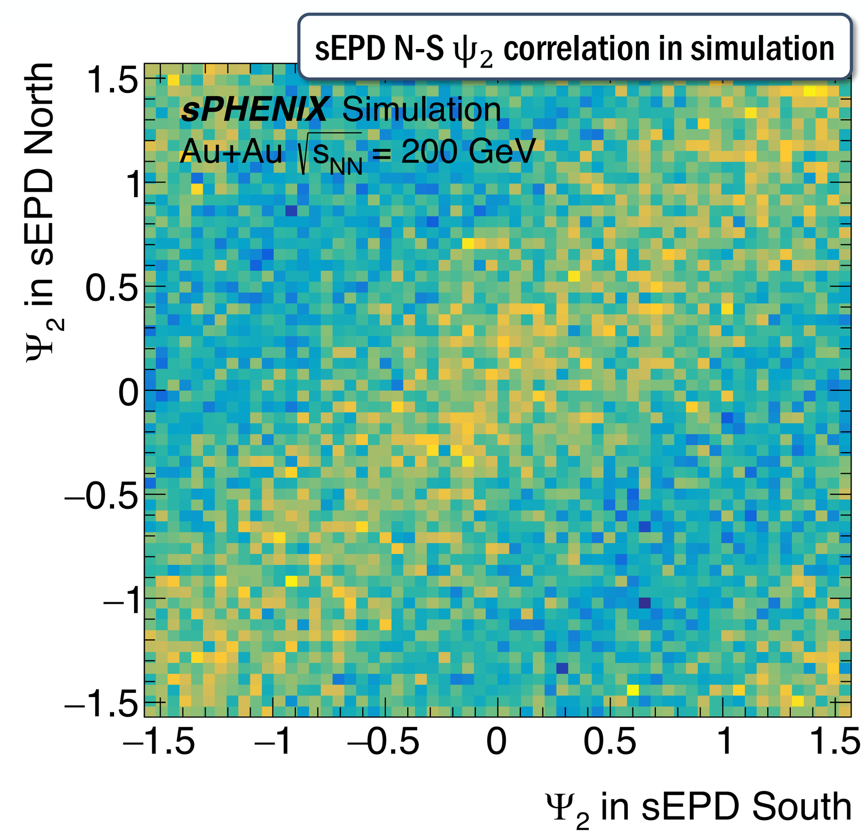
$$(\text{sEPD})\ \text{nMIP}^{\text{truncation}} = \begin{cases} \text{nMIP} & \text{if nMIP} < 6 \\ 6 & \text{otherwise} \end{cases}$$

ψ_2 results

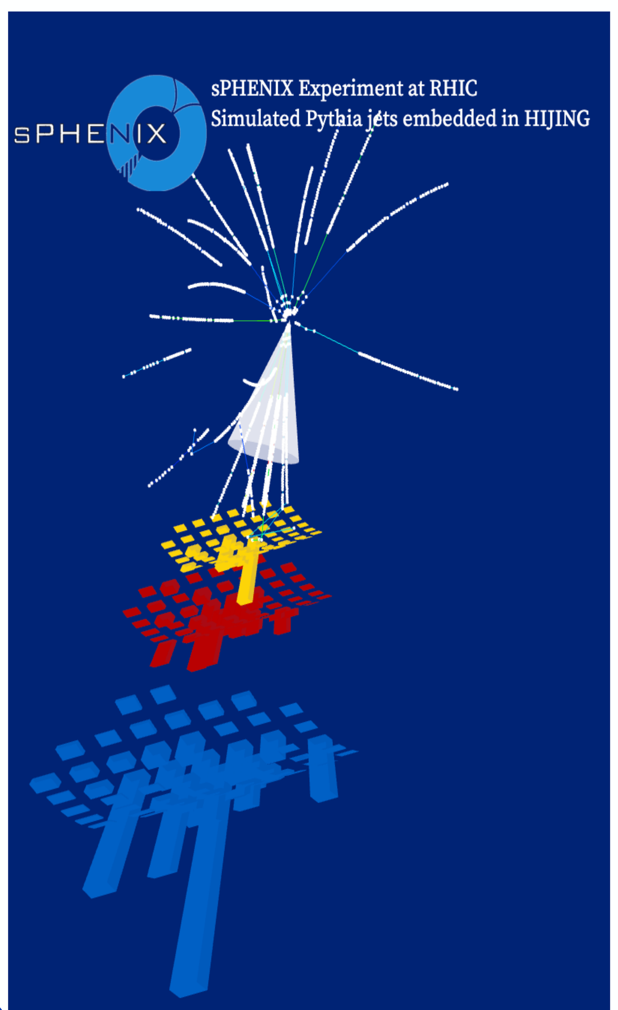






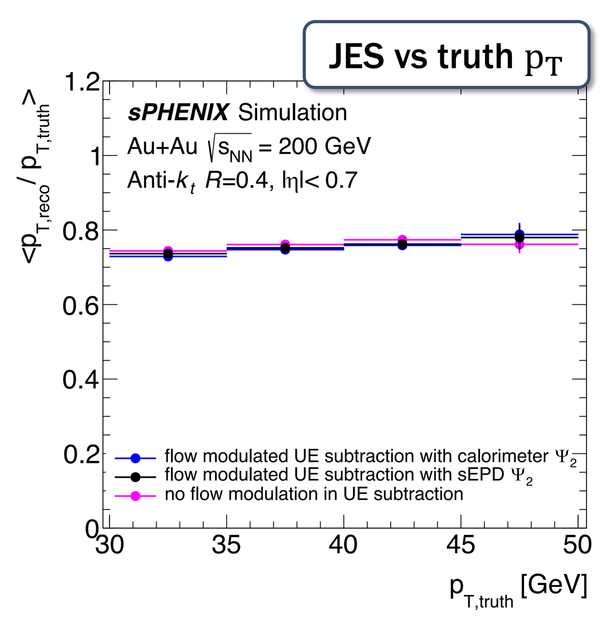


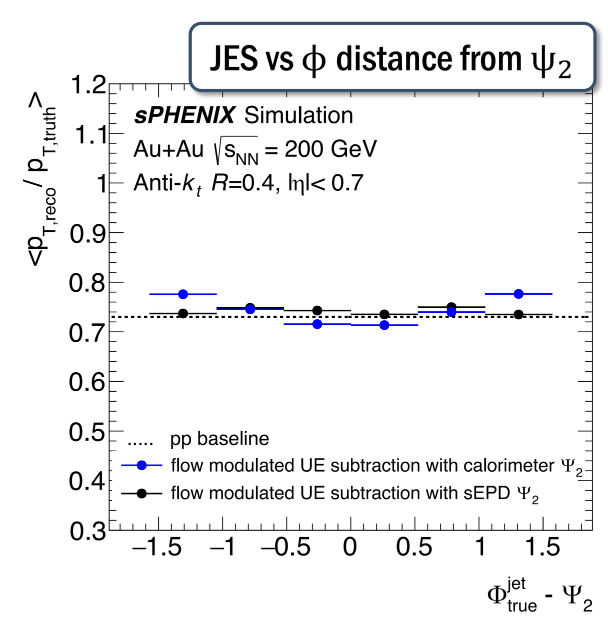
sEPD ψ_2 performance in flow modulated jet UE subtraction



$$\frac{d^2E_T}{d\eta d\phi} = \frac{dE_T}{d\eta}\left[1 + 2\sum_n v_n \cos(n(\phi - \psi_n))\right]$$

flow modulation





- Clear dependence on the azimuthal distance from the event plane in the jet energy scale when the calorimeter (with areas excluded where there are jet candidates) is used to determine ψ_2
- The dependence is due to auto-correlation induced by using the calorimeter both for jet measurement and event plane determination
- The sEPD large pseudo rapidity gap from jet candidates do not show dependence on $\phi - \psi_2$

Summary

- The second order event plane angle (ψ_2) was measured with the MBD using sPHENIX first data
- Results of the ψ_2 using the sEPD was determined with simulated HIJING and flow afterburner events
- The sEPD ψ_2 used to benchmark the flow modulated jet UE subtraction (where the default is the calorimeter ψ_2), show comparable results to the default in the JES vs p_T, but has no significant dependence on the event plane

References

[1] A. M. Poskanzer and S. A. Voloshin. Methods for analyzing anisotropic flow in relativistic nuclear collisions. PR C, 58(3):1671–1678, September 1998.

[2] Skipper Kagamaster, Rosi Reed, and Michael Lisa. Centrality determination with a forward detector in the RHIC beam energy scan. PR C, 103(4), April 2021