Vertex Determination in sPHENIX

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Abstract

The open heavy flavor program of the sPHENIX experiment at RHIC requires precise determination of the location of individual tracks in the region around the interaction vertex. Three layers of MAPS based pixels (the MVTX) surrounding the beam line are designed to provide a precision of about 10 μm for higher momentum tracks. The tracking system [1] also contains two layers of silicon strip detectors (the INTT) for pattern recognition, and a time-projection chamber (TPC) for momentum measurement. The beam crossing for each track is determined from the precise timing of the INTT detector.

In addition to measuring the track momentum, the physics program requires determining the event vertex, finding the displacement of individual tracks from the event vertex, and locating and reconstructing decays of neutral particles that occur before the radius of the silicon pixel detectors. This poster describes the vertex determination process.

Event vertex determination

The large volume of data to be processed requires all components of the sPHENIX track reconstruction software to be optimized for speed. This prompted the development of a new, fast, event vertexing algorithm.

Event vertex finding occurs after track fitting is complete. Only tracks that include three hits in the MVTX are used. After quality cuts, the vertexer finds all pairs of tracks with a distance of closest approach below 80 μm, with a point of closest approach to the nominal beam position of less than 2 mm in the transverse plane. It makes lists of all connected tracks, each list being a collision vertex candidate. Each track pair provides two measurements of the vertex position. Because there are many more track pairs than tracks, there are many measurements of the vertex position. For each vertex, tracks that fall more than 100 μm from the median are excluded from the final calculation of the collision vertex position. The final vertex position is an unweighted average of the PCA values of all remaining tracks.

The performance of the algorithm has been compared with that of RAVE [2] RAVE uses a more sophisticated algorithm in which the contribution of tracks to the calculated vertex position is weighted, and it performs very well. We focus here on a comparison using simulations of p+p collisions triggered on jet events. Figure 1 shows the vertex resolution (reconstructed - truth) for single Pythia jet events for the sPHENIX vertexing algorithm and RAVE. The Distribution is integrated over all events. The overall resolution is similar, with RAVE producing slightly better resolution. The average time to process a minimum bias Au+Au event is 0.09 s. In our tests, this is a factor of 14 faster than we obtained with RAVE.

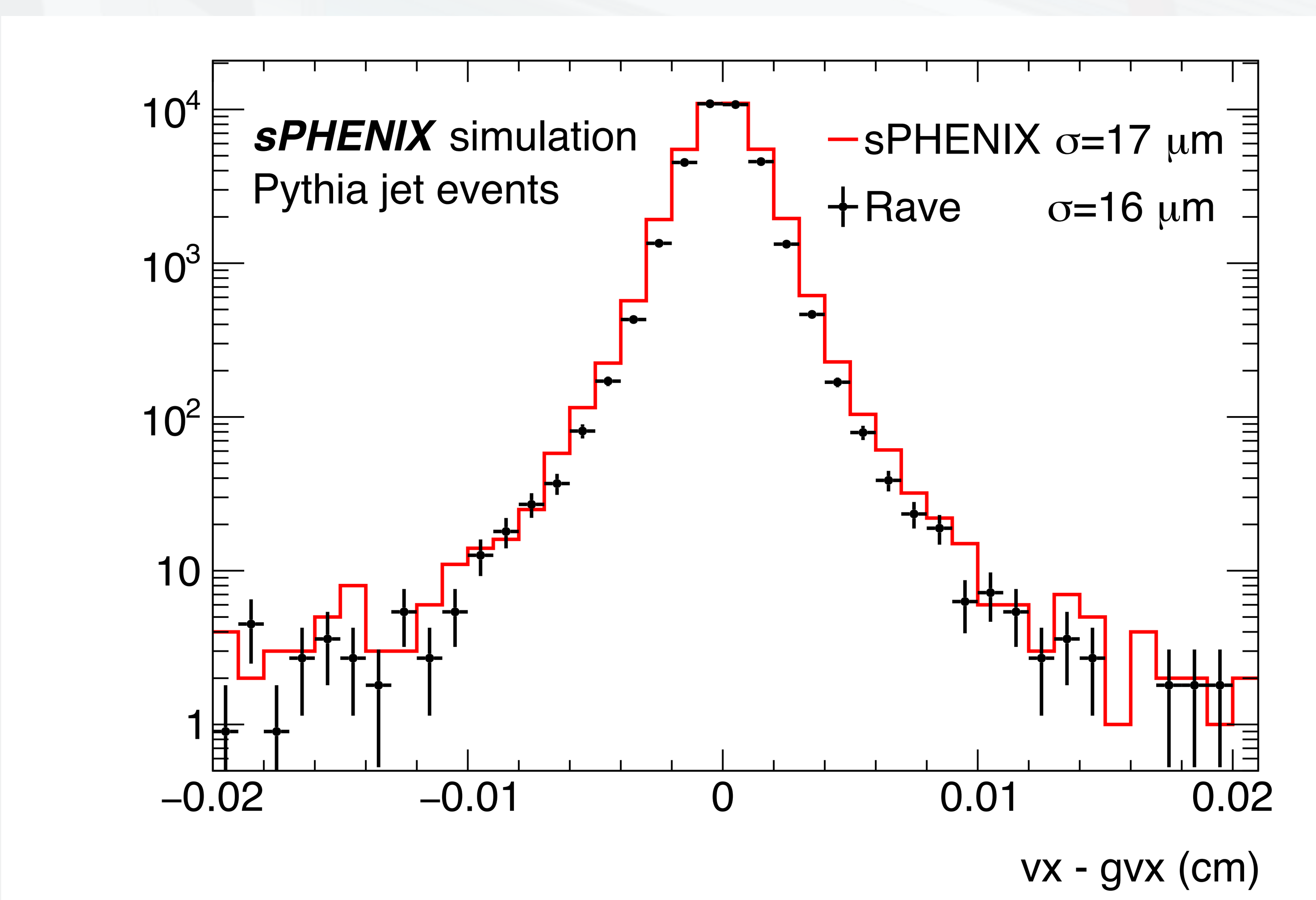

Figure 1. Reconstructed vertex resolution for Pythia jet events, comparing the sPHENIX and RAVE algorithms.

Figure 2 shows the RMS vertex resolution versus number of tracks from single Pythia jet events or single Pythia D^0. At the same track multiplicity the vertex resolution is poorer by ~ 20% for the D^0 case, due to the lower average track p_T in D^0 events - the vertex resolution is improved by the presence of higher p_T tracks.

Event vertex determination (cont.)

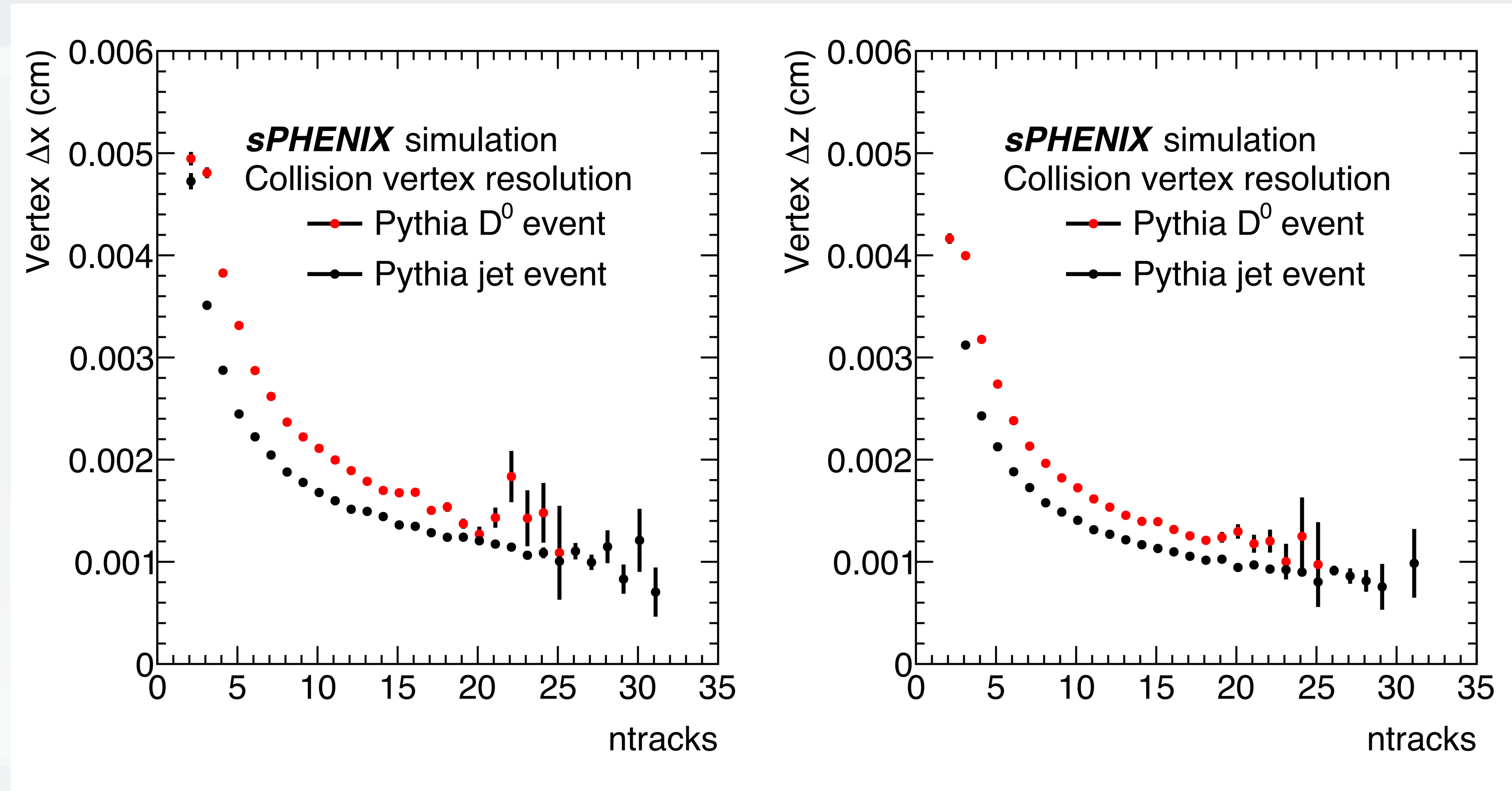

Figure 2. Reconstructed vertex resolution for Pythia single jet events (black) and Pythia D^0 events (red) versus track multiplicity.

Track DCA performance

The measurement of the distance of closest approach (DCA) of tracks to the collision vertex requires both precise collision vertex determination and precise projection of individual tracks to the region of the collision vertex. The track DCA is obtained from the final fitted track, projected by the Acts tracking package to the perigee surface defined by the event vertex.

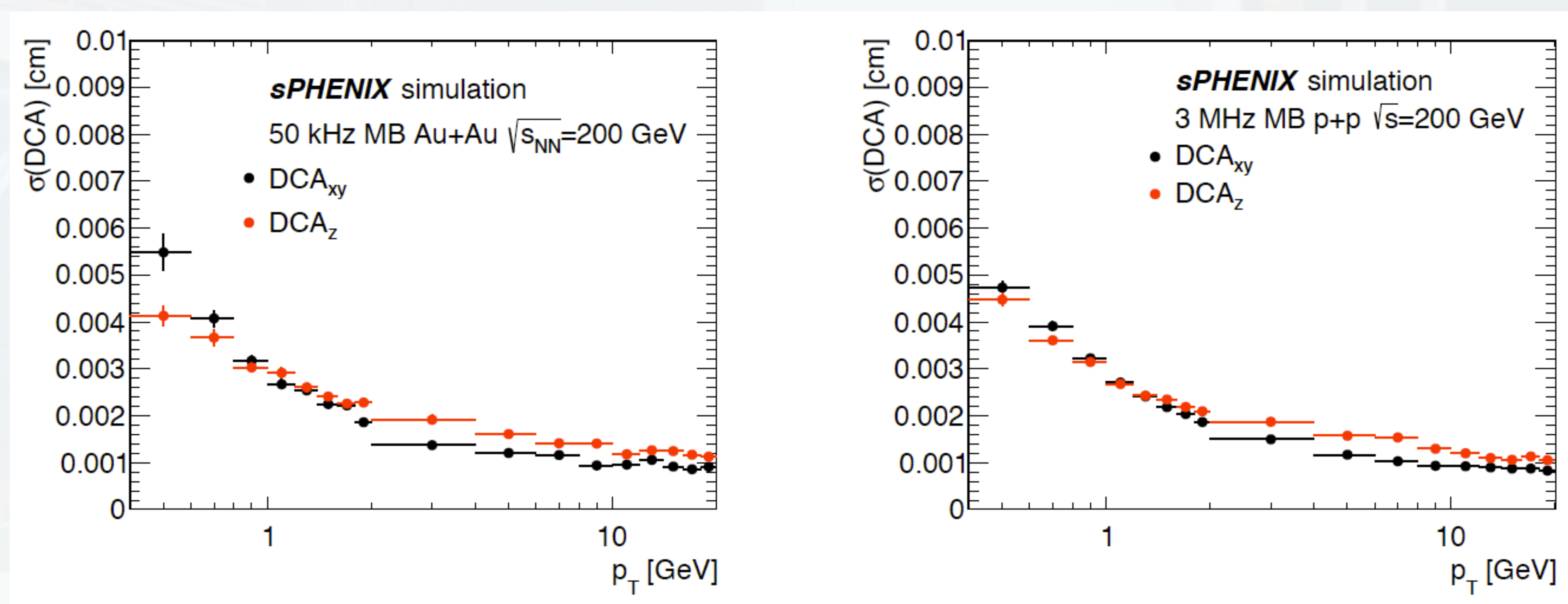

Figure 3. Track DCA to the event vertex in Au+Au and p+p collisions.

Secondary vertex determination

Identifying secondary vertices due to decays is an important part of the heavy flavor physics program. This is accomplished using the KFParticle analysis package [3]. Because there is no particle ID information, the secondary vertex identification relies on kinematic reconstruction, and the track pair DCA plays an important role.

Figure 4 shows the two-track DCA distribution for decays of D^0 mesons in Pythia minimum bias events. A cut of 40 μm gives full efficiency in these simulated events.

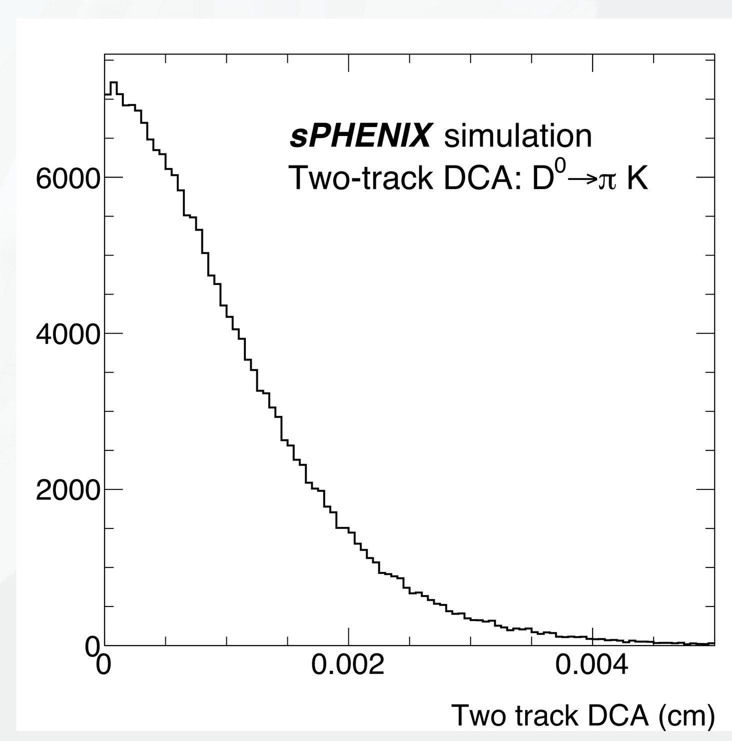

Figure 4. Two track resolution for simulated decays of D^0 mesons to π and K mesons.

References

1) Joe Osborn, Track reconstruction with the sPHENIX detector, poster #517.
2) https://rave.hepforge.org/
3) https://sphenix-collaboration.github.io/doxygen/d0/d49/classKFParticle.html

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