Abstract

The present work addresses concern over the validity of the standard mixed-event method for correcting two-particle correlations. New methods for finite-acceptance correction are developed and tested in Monte Carlo simulations.

Introduction

• Two-particle pair-wise correlation analysis is based on the simultaneous measurement of pairs of particles in each event.
• Single and pair densities:
  \[ p_i(x_i) = \frac{dN_i}{dy_i dx_i}, \quad p_{ij}(x_i, x_j) = \frac{dN_{ij}}{dy_i dx_i dy_j dx_j} \]
• Current definition of the correlation function:
  \[ C_{ij}(y_i, y_j; \Delta y) = \frac{p_{ij}(y_i, y_j)}{p_i(y_i) p_j(y_j)} \]
• Experimentally,
  \[ C_{ij}(y_i, y_j; \Delta y) = \frac{1}{N_{nuc}^i N_{nuc}^j} \int dy_i dy_j p_{ij}(y_i, y_j) \]
  \[ N_{nuc}^i = \int dy_i p_i(y_i) \]
  \[ \Delta y = y_j - y_i \]

\[ \rightarrow \text{it is roughly equivalent to the ratio between correlated production and uncorrelated production.} \]

New Method Derivation

• Modeling particle correlations in a jet which correspond to near-side jet structure.

**If we have an infinite acceptance**

\[ C_{ij}(x_i) = \frac{\int dx_i d\Omega_i f(x_i)(x_i - x_i) f(x_i + \Delta x_i)}{\int dx_i d\Omega_i f(x_i)(x_i - x_i) f(x_i + \Delta x_i)} \]
\[ N_{nuc} = \int dx_i d\Omega_i f(x_i)(x_i - x_i) \]

\[ X : \text{common reference point of triggered and associated particle distributions in each event (-jet-axis)} \]
\[ f(x_{ij}) : \text{Trigger-particle distribution in a single event with respect to } x_{ij} \]
\[ f(x_{ij} + \Delta x_{ij}) : \text{Associated particle distribution in a single event, with respect to } x_{ij} + \Delta x_{ij} \]
\[ g(x) : \text{Each event has } x \text{ value, and } g(x) \text{ represents the distribution of } x \text{ over all events} \]

**If we have a finite acceptance**

\[ C_{ij}(x_i) = \frac{1}{N_{nuc}} \int d\Omega_i f(x_i)(x_i - x_i) f(x_i + \Delta x_i)(x_i - x_i + \Delta x_i) \]
\[ A_{ij}=1 \text{ if } -d < x < d \text{ and } A_{ij}=0 \text{ if others} \]

• We can find analytic formulas in certain cases.
  \[ C_{ij}(x_i) = \text{rat}(A)C_{ij}(x_i) \]

**If } g(x) \text{ is constant, } \alpha(x) = \frac{1}{2a} \int A(x) dx \text{ Method 1} \]
**If } f(x_{ij}) \text{ is a delta-function (jet-shape for associated particles) } \alpha(x) = \frac{1}{N_{nuc}} \int d\Omega_i f(x_i)(x_i - x_i) f(x_i + \Delta x_i) dx \text{ Method 2} \]

• Modeling away-side structure in di-jet events,

**If we have an infinite acceptance**

\[ C_{ij}(x_i) = \frac{1}{N_{nuc}} \int d\Omega_i f(x_i)(x_i - x_i) f(x_i + \Delta x_i)(x_i - x_i + \Delta x_i) \]
\[ \alpha(x) = \frac{1}{2a} \int A(x) dx \text{ Same as Method 1} \]

• There is no general formula which can always connect \[ C_{ij}(x_i) \text{ and } A(x) \text{. But above methods can work as approximate formulas and their validities depend on the signal type.} \]

Finite-acceptance Effects

• Finite-acceptance effects in pair measurements are more complicated than the effects in single particle measurements.
• Example in 1D (acceptance [-a, a] in x)

![Single particle measurement](image1)

![Pair measurement](image2)

What we can see,

![Diagram](image3)

• Finite-acceptance effects in two-particle correlation analysis mean that pairs are not counted depending on the correlated particle positions, and we need to correct for those missing pairs.
• Current per-trigger associated particle yield is divided by normalized mixed-event function for finite-acceptance correction, but this procedure produces a ratio function instead of working as a correction.
• Correlation functions or per-trigger associated particle yields have two dimensions, (ΔpT, Δη), but we assume full azimuthal acceptance for the detector in this study. Dimension of finite-acceptance correction is 1, only in Δη.
• If yields or ΔpT-projections are considered in the analysis, ratio function might produce different results from the intended per-trigger associated particle yields.

PYTHIA Simulation

• Correlation function shapes from p-p collisions are generally dominated by di-jet signals.
  • If η-acceptance is [-2, 2],

  \[ C_{ij}(x_i) = \frac{1}{N_{nuc}} \int dy_i dy_j p_{ij}(y_i, y_j) \]
  \[ N_{nuc} = \int dy_i p_i(y_i) \]
  \[ A_{ij} = 1 \text{ if } -d < y < d \text{ and } A_{ij} = 0 \text{ if others} \]

Collective MC Simulation

• Collective Toy MC simulation with Δη-dependent \[ v_2 \]

![Diagram](image4)

• Correlation function’s yield at each Δη-bin works as weighting factor in ΔpT-projection. Integrated \[ v_2 \] which is evaluated after ΔpT-projection, depends on correlation function yields if \[ v_2 \] is dependent on Δη.

Conclusion

• The current finite-acceptance correction method produces a ratio function (=correlated/uncorrelated).
• New methods are developed and tested with the MC simulations, and they:
  ✓ analytically work for specific cases, (constant trigger location distribution over all events or delta-function-like trigger distribution …)
  ✓ work as approximation in other cases.
• Analysis concerning yields or ΔpT-projection largely depend on finite-acceptance correction method.