Heavy flavor hadrons inside jets at sPHENIX

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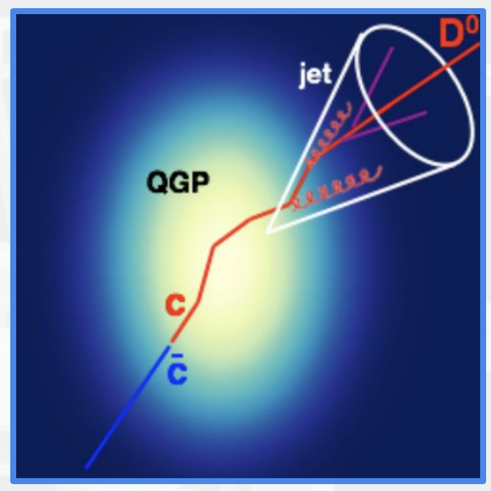
Abstract

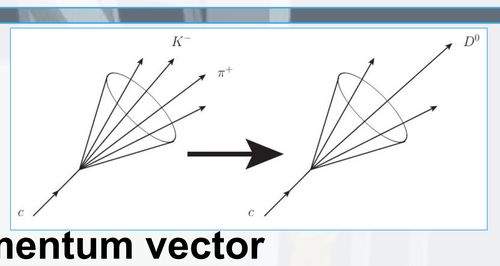
The sPHENIX experiment at RHIC began commissioning with Au+Au data in Spring 2023. The Monolithic Active Pixel Sensor (MAPS) based Vertex Detector (MVTX), the Intermediate Silicon Tracker (INTT) and the Time Projection Chamber (TPC) at sPHENIX can provide high precision primary/displaced vertex and track reconstruction in the pseudorapidity region of $|\eta|\leq 1.1$. The sPHENIX ElectroMagnetic Calorimeter (EMCal) and Hadronic Calorimeter (HCal), used for the first time at midrapidity at RHIC, will provide good energy measurements for full jet reconstruction. sPHENIX will enable an unprecedented series of high precision heavy flavor hadron and jet measurements at sPHENIX in 200 GeV p+p, p+Au and Au+Au collisions. In particular, the heavy flavor hadron inside jet production can provide vital information about the heavy quark hadronization process and how such process gets modified in a nuclear medium. Less recombination contribution to the hadron production is expected at RHIC compared to the Large Hadron Collider (LHC) measurements, which makes these measurements an unique approach to explore the universality of heavy quark fragmentation functions in different nuclear environments. We will present the performance projection of the D-meson inside jet reconstruction, the hadron-jet relative kinematic variable distributions, and projections in 200 GeV p+p and Au+Au simulations with realistic sPHENIX detector performance.

Physics motivation

- Heavy quarks
  - Produced in the early stage of high energy collisions in hard scatterings
  - p_T-differential cross section calculable with pQCD-based models
  - Study of the mass dependence of parton interaction with the quark-gluon plasma
    - Nuclear modification factor (R_{AA}), eliptic flow (v_2), etc
- D-tagged jets
  - Easier jet background rejection in comparison to inclusive jets
  - Investigation of jet spectrum down to low transverse momentum
  - Study of heavy-quark initiated jet structure and parton shower ($z_{||}$, $R(\theta)$, z_g, θ_g, etc)

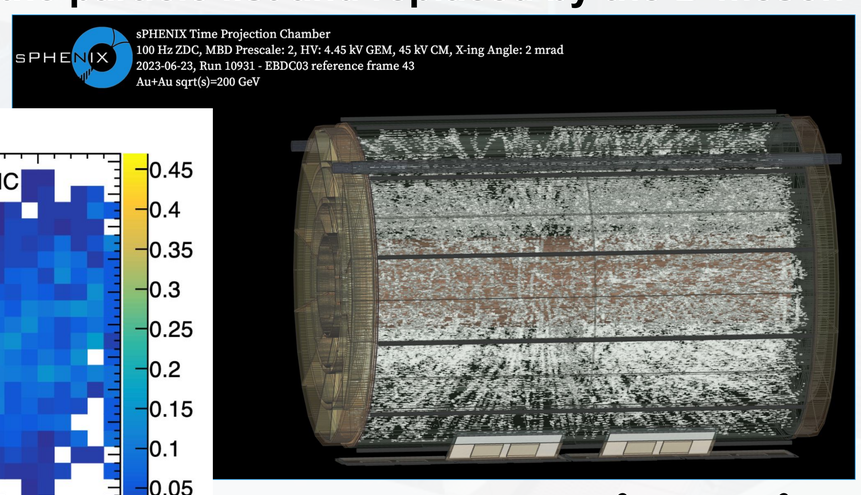


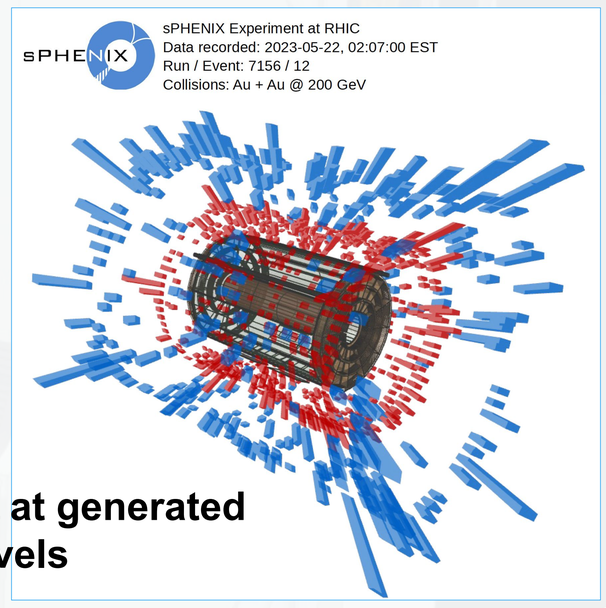
D-tagged jet reconstruction strategy

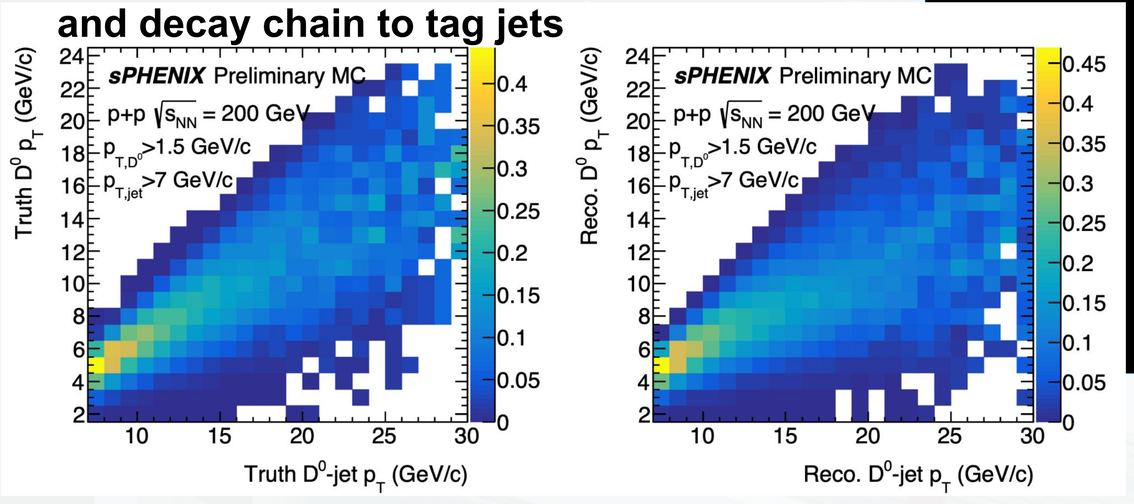


1. *D* mesons are reconstructed via $D^0 \rightarrow K^-\pi^+$ exploiting sPHENIX excellent tracking capabilities
2. Tracks and clusters from the EMCal and HCal are combined in an implementation of particle flow
3. D-meson decay daughters are removed from the particle list and replaced by the *D*-meson 4-momentum vector
4. Jets are reconstructed using FastJet

➔ Code/method extended to use any particle and decay chain to tag jets



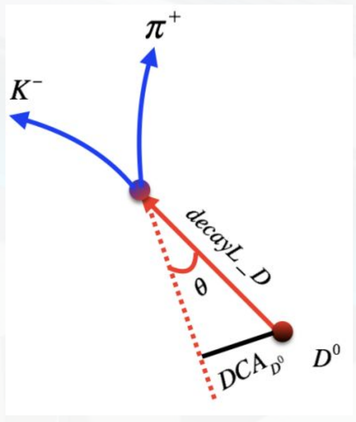


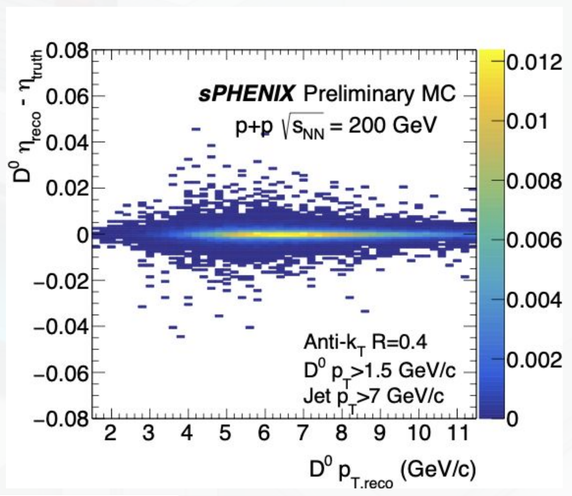


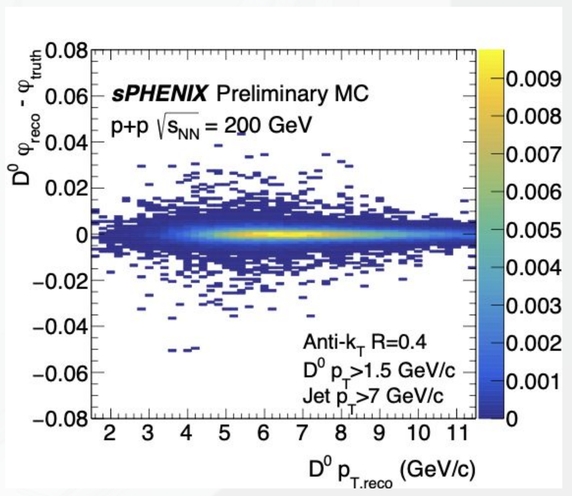
- Distributions of D^0 p_T vs D^0-jet p_T at generated (left) and reconstructed (right) levels

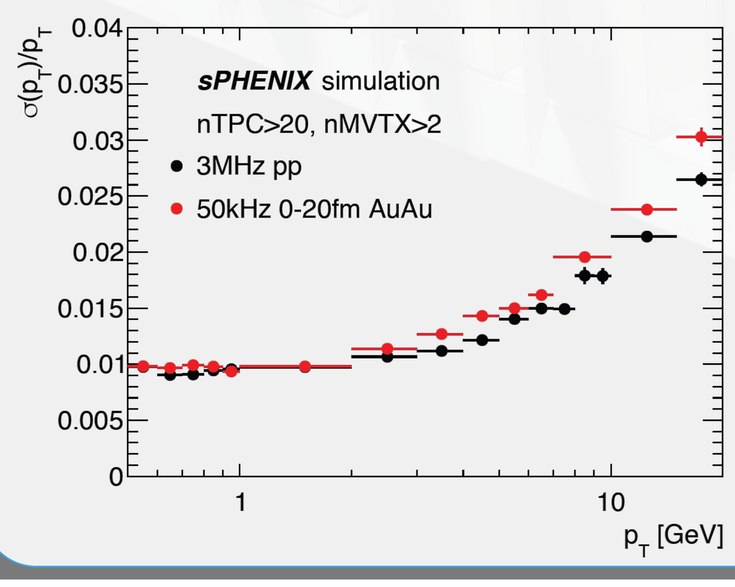
Performance

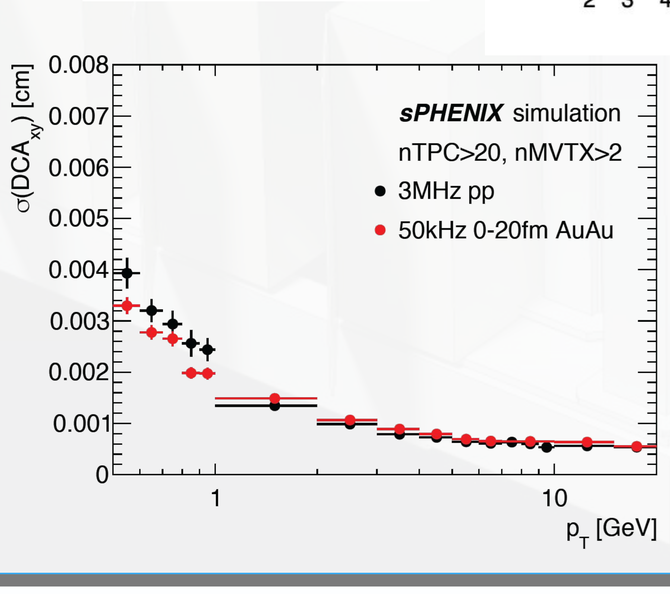
- Excellent tracking is critical for the reconstruction of the *D*-meson decay topology and momentum resolution
- p_T resolution < 2% for p_T < 10 GeV/c











- D^0 η and φ resolution as a function of D^0 p_T
- Angular resolution is a key element in the study of heavy-flavor jet structure
- Transverse DCA resolution < 40 μm for p_T > 0.5 GeV/*c*, which is crucial for separation of prompt and non-prompt *D*-meson
- Next step: commissioning of the particle flow framework

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