# B-Jet Tagging Algorithms for sPHENIX at RHIC

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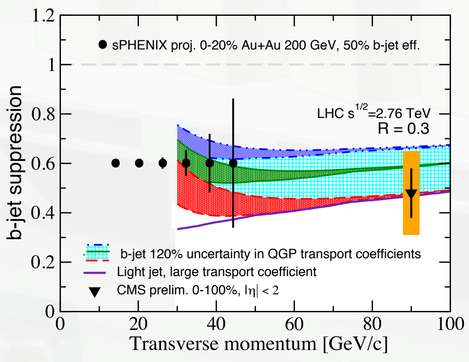
*for sPHENIX Collaboration*

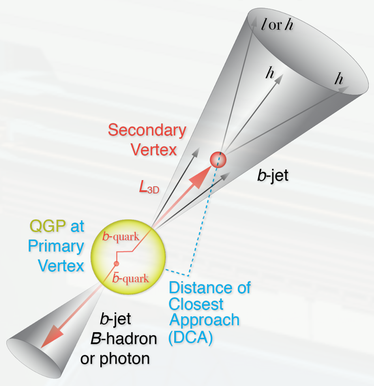
## Abstract

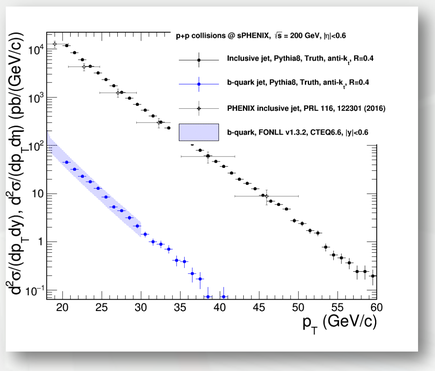
Jets that initiated from b-quarks (b-jets), which are sensitive to the collision energy loss, are unique tools to probe the quark-gluon-plasma. Among the much more abundant light-parton jets, the B-jets are identified utilizing the B-meson properties of long lifetime and leptonic decay. With the proposed sPHENIX detector at RHIC, we study a variety of B-Jet tagging algorithms that includes the track impact parameter method, secondary vertex method and the lepton tagging method. The algorithm description, their performance projection base on a comprehensive detector simulations and cross checks will be discussed.

## Introduction

- Jet: Probing QGP medium @ larger energy scale
- b-jet: unique energy loss signatures due to large mass (4.2GeV/c$^2$)
- b-jet at RHIC:
  - Reconstruct jet at energy as low as 15 GeV, where the quark mass is more important for the energy loss mechanisms
  - Main process is g+g⟶b+$\bar{b}$ or g+b⟶g+b.
- b-jet tagging at sPHENIX:
  - Very good DCA resolution (25 $\mu$m for $p_T$ 1-2 GeV/c) compared with B, D meson life time.
  - Acceptable DCA tail with preliminary HIJING embedding simulation.
  - Various tagging methods.
- Initial b-jet, l-jet cross-section from PYTHIA 8 simulation are with good consistency with previous PHENIX paper/FONLL calculation. This will be used to calculate the b-jet purity

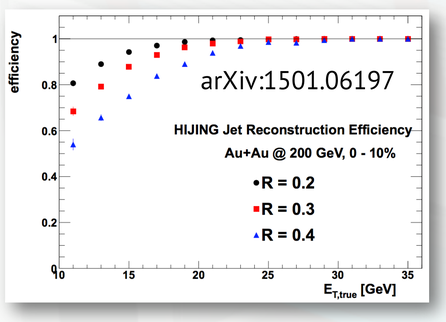


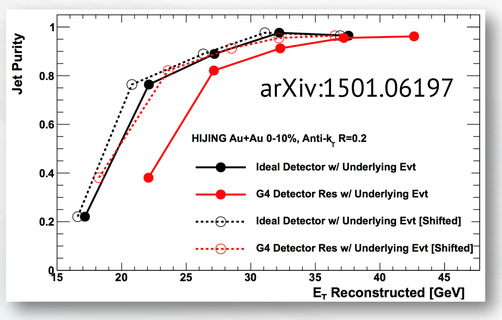




This work focuses on the flavor tagging of reconstructed jets

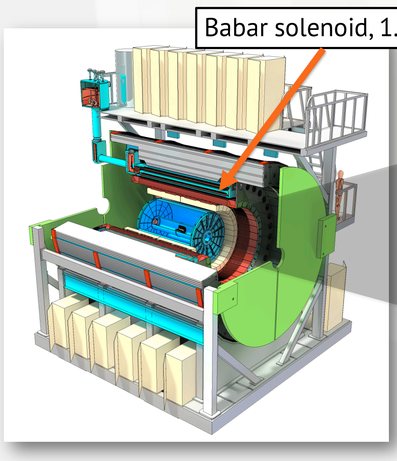
- Previous work showed the sPHENIX detector has good jet reconstruction performance
- More sPHENIX jet studies in R. Reed's poster



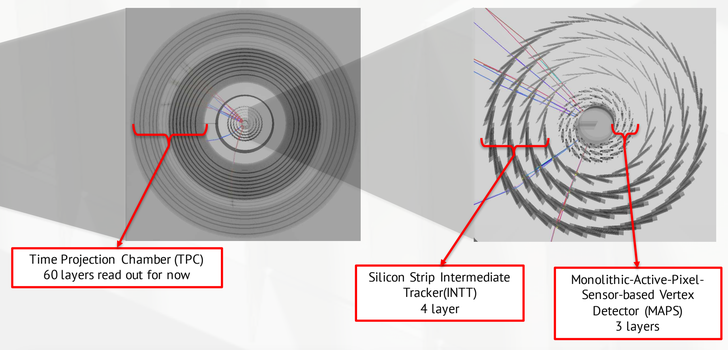




## sPHENIX Tracking System

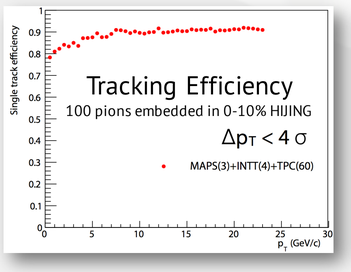
sPHENIX CAD Drawing

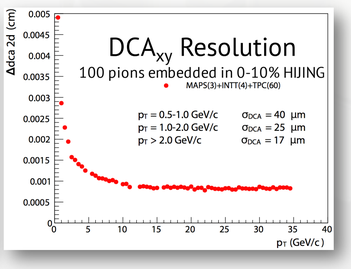



Tracker GEANT4 Implementation and Events Display




- Monolithic-Active-Pixel-Sensor-based Vertex Detector (MAPS): radius: 2.3, 3.2, 3.9cm; 20 × 20$\mu$m cell
- Silicon Strip Intermediate Tracker(INTT): radius: 6.0, 8.0, 10.0, 12.0 cm; 80$\mu$m × 1.2cm cell
- Time Projection Chamber (TPC) radius: 30-80cm, 1.5 × 1.7mm cell

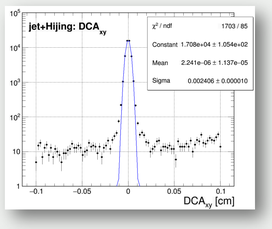



## Impact Parameter Method

Input:

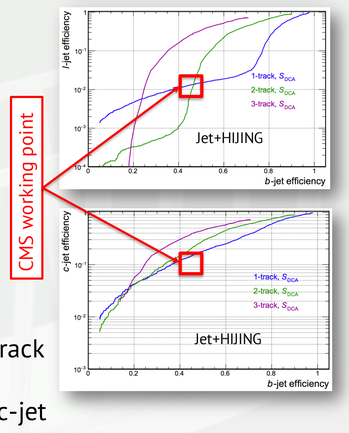
- p+p jetty event sample simulated in PYTHIA8 hard-QCD mode, jets with minimal pT of 20 GeV
- PYTHIA 8 20 GeV jets embedded into 0-4fm central HIJING events to study b-jet tagging in central Au+Au collisions




Tracker: Geant4 used to simulate response of tracking detector

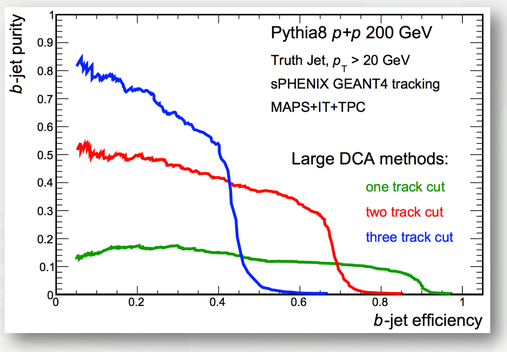
Reconstruction:

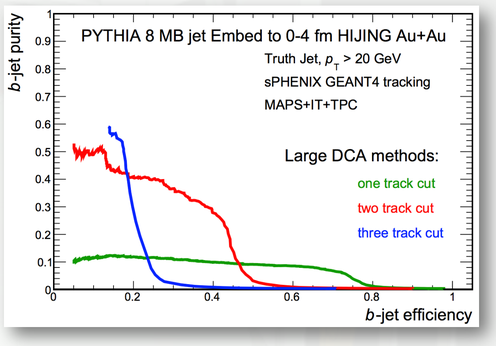
- Hough Transformation based pattern recognition
- GenFit2 based track fitting and DCA extrapolation.
- Using RAVE in single vertexing mode for vertexing
- $DCA_{xy}$ and $DCA_z$ extrapolated with regarding to reconstructed vertex




b-jet tagging:

- Define $S_{DCA} = \sqrt{\left(\frac{DCA_{xy}}{\sigma_{DCA_{xy}}}\right)^2 + \left(\frac{DCA_{xy}}{\sigma_{DCA_{xy}}}\right)^2}$
- Make different $S_{DCA}$ cut for largest, second largest, third largest $S_{DCA}$ track in a jet cone.
- From the efficiency vs. $S_{DCA,min}$ for l-jet, c-jet and b-jet, calculate l-jet/c-jet efficiency vs b-jet efficiency.
- Calculate b-jet purity vs. tagging efficiency as shown below



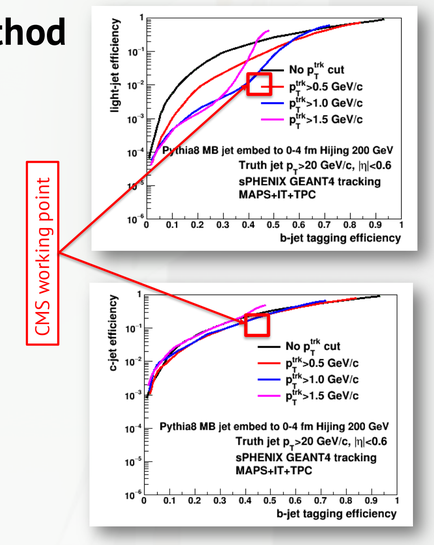



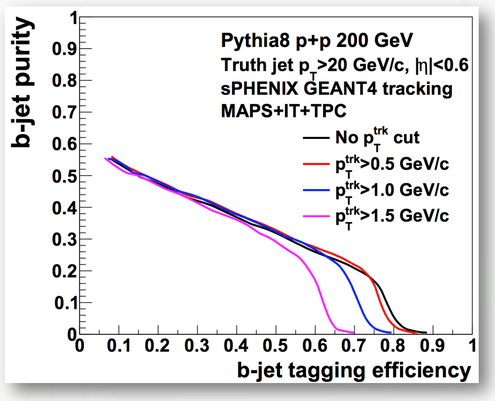

## Secondary Vertex Method

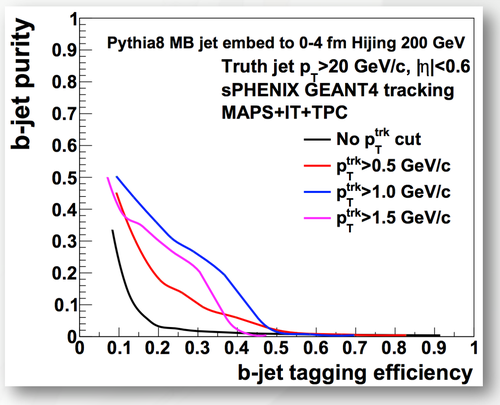
Simulation setups are identical with Impact Parameter method.

b-jet tagging:

- Running RAVE first in single vertexing mode to reconstruct primary vertex (PV).
- Running RAVE with tracks in jet cones in multiple vertexing mode to reconstruct secondary vertices (SV).
- Make cut on sigmalized distance between PV and SV.
- Calculate b-jet purity vs. tagging efficiency as shown below




## Summary and Outlook

- b-jet at RHIC energies serves as a unique probe to the QGP medium
- GEANT4 simulation + full tracking reconstruction was performed for p+p and central Au+Au events
- Preliminary b-jet tagging performance generated using impact parameter method and secondary vertex method. At this early stage, both methods showed good performance in the tagging simulations of p+p collisions
  - For jet+HIJING: the impact parameter method showed comparable performance with CMS b-jet tagging in this preliminary study
- We are expecting improvements for both methods with further optimizations.
- Currently, we assumed the factorization of jet finding and b-jet tagging and focused on developing tagging algorithms in full tracking simulation. The next stage of study will include both steps to study the interplay of jet finding and b-jet tagging

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