D-Meson Measurements in Au+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR Using the Silicon Inner Tracker

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Abstract

Since the most likely production mechanism for charm is gluon fusion, the charm cross section should scale with the number of binary collisions. Such a scaling would indicate that the production of charm occurs during the early stages of the collision, making it a unique probe of the partonic matter. Recent measurements provide some insight of the heavy flavor spectrum. Non-photonic single electron p_T distributions measured in p+p, d+Au, and Au+Au collisions indicate the nuclear modification factor (R_{AA}) is significantly below unity for p_T between 1-4 GeV/c for central events. This implies the heavy flavor spectrum is modified by the medium. However, due to an uncertainty in the relative fraction of charm and bottom, this measurement does not enable an unambiguous determination of energy loss that charm experiences in the medium. Here we present preliminary results from direct D-meson measurements in minimum bias Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR. These measurements are performed using a secondary vertexing technique that exploits the resolution given by the silicon detectors available in STAR.

D^0 Reconstruction

- $D^0 \rightarrow K^- \pi^+$
- B.R. = 3.8%
- $c\tau$ = 123 μm

Performing the measurement

- Invariant mass analysis
- Reconstruction via combinatorial method

$$M_{inv} = \sqrt{(E_K + E_\pi)^2 - p_{D0}^2}$$

$$p_{D0}^2 = |p_{x\pi} + p_{xK}|^2 + |p_{y\pi} + p_{yK}|^2 + |p_{z\pi} + p_{zK}|^2$$

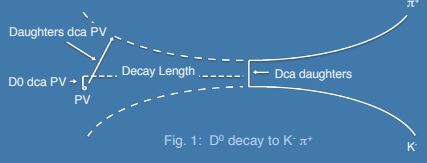

Fig. 1: D^0 decay to $K^- \pi^+$

- Secondary vertexing technique, done by pairing oppositely charged tracks and requiring the two trajectories to cross at some point. Kaons and pions are selected using dE/dx information from the TPC.

Silicon Inner Tracker

The STAR silicon inner tracker is composed of a SVT and a SSD.

SVT Barrels :

- Inner at r = 5 cm
  8 ladders - 4 wafers
- Middle at r = 10 cm
  12 ladders - 6 wafers
- Outer at r = 15 cm
  16 ladders - 7 wafers

Total length is 42 cm
242 total wafers

SSD :

- One layer at r = 23 cm
- 20 ladders


Fig. 2: The SVT, 3 layers of silicon drift detector

Tracking Performance

In order to perform a D^0 measurement the impact parameter resolution of the tracks must be comparable to the decay length. The Impact parameter is the 2D distance of closest approach (DCA) of a global track to the primary vertex.

Impact Parameter Resolution (in Au+Au data)

- TPC alone gives 3.1 mm @ pT = 1 GeV/c
- TPC+SVT+SSD gives **210 μm**

Global Track 3D DCA

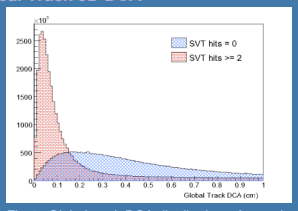

Fig 4: Global track DCA distributions, for tracks with and without silicon information.

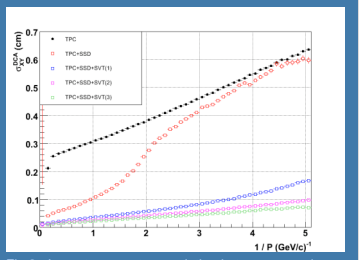

Fig 3: Impact parameter resolution in transverse plane

Geometrical Variable Distributions

In Au+Au collisions, the background/event is much greater than the expected D^0 signal/event in lyl < 1. In order to see a statistically significant signal, the background must be reduced, while retaining the signal. One approach is to cut on the geometrical variables of the decay. Below are these variable distributions (in μm) for a D^0 simulation from PYTHIA (which includes detector response based on data), and Au+Au 200 GeV data that has been normalized.

The **shaded regions** show the area that is initially cut to reduce the background (b) in the invariant mass sample, while retaining the signal (s).

However, to claim observation of a signal, the statistical significance (σ) should be near 3, where $\sigma = s/\sqrt{s+b}$

For 17 M Au+Au minimum bias events, the cuts shown are not sufficient to reach a σ = 3. Additional cut optimization has been performed (see below for optimized values).

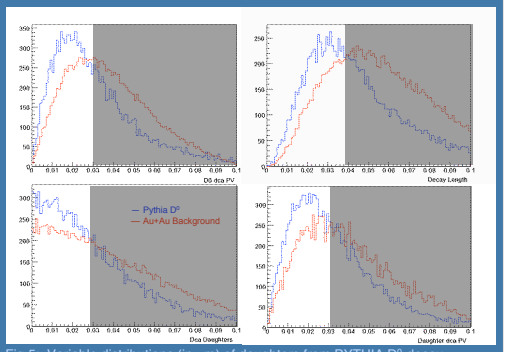

Fig 5: Variable distributions (in μm) of daughters from PYTHIA D^0 decay compared to background distributions. Shaded area shows what is cut to reduce background, while retaining signal

D^0 Invariant Mass Distribution

Using 17 M min bias Au+Au events

Optimized Geometrical Cuts:

TPChits ≥ 25
SVThits = 3
D0 dca PV ≤ 300 μm
Decay Length ≥ 150 & ≤ 350 μm
Dca Daughters ≤ 50 μm
Daughter dca PV ≥ 100 & ≤ 300 μm

The background is estimated by fitting a polynomial to 'side bands' on either side of the D^0 peak. The background is then subtracted using a 4th order polynomial. The order is chosen from χ^2/ndf minimization.

signal ~ 3000
signal/bkg = 0.006
$\sigma = s/\sqrt{(s+b)} = 4.5$

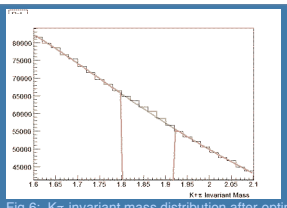

Fig 6: Kπ invariant mass distribution after optimized geometrical cuts

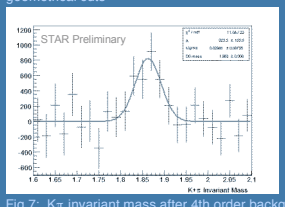

Fig 7: Kπ invariant mass after 4th order background subtraction

Summary & Outlook

- The impact parameter resolution of the silicon inner tracker (SVT+SSD) in STAR allows us to perform a direct D^0 measurement, using a secondary vertexing technique. This improves on the previous mixed event method which is a TPC only analysis.
- With an additional 30 M events to analyze we estimate that we can reach a p_T of 4 GeV/c. This will enables us to determine the D meson R_{AA} and v_2 unambiguously.

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