Heavy Flavor Tracker (HFT) : A new Silicon Tracker for STAR experiment at RHIC*

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The HFT is a new central silicon upgrade for the STAR experiment at RHIC. It is replacing the decommissioned silicon drift detector with active pixel technology in order to achieve about an order of magnitude better track pointing (DCA) resolution. This will allow for a direct and full topological reconstruction of charmed meson decays (e.g. D^0 etc.) and a better determination of B - meson spectra. Key measurements are D^0 elliptic flow determination, especially in the lower transverse momenta (p_T) region and detailed identified heavy quark suppression studies at high p_T (R_{CP}/R_{AA}).

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1. Introduction

Due to their large masses, heavy flavor (c and b) quarks are produced in the early stages of heavy ion collisions where the full initial energy is available for particle production [1]. Radiative energy loss in dense partonic matter is thought to be inversely proportional to the quark mass. Early measurements of heavy flavor energy loss at RHIC using the decay-electron spectra of D and B mesons showed a suppression similar to that of light quarks [2]. This puzzling result lead theorists to re-speculate the cause of this effect. Experimentally it is difficult to separate the charm and bottom contributions in the electron spectra. The two major experiments at RHIC, PHENIX and STAR both decided to upgrade their silicon vertex detectors in order to be able to improve their measuring capabilities. The STAR approach and goal is to obtain a precise measurement of heavy flavor production by identifying the decay of charmed mesons using direct topological reconstruction and thus disentangling the c and b contributions.

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The Heavy Flavor Tracker (HFT) is a state-of-the-art micro-vertex detector utilizing active pixel sensors and silicon strip technology. The HFT will significantly extend the physics reach of the STAR experiment for precision measurements of the yields and spectra of particles containing heavy quarks. This will be accomplished through topological identification of mesons and baryons containing charm quarks, such as D^0 and Λ_C, by the reconstruction of their displaced decay vertices with a precision of approximately 50 μm in p+p, d+A, and A+A collisions. The combined measurements of directly identified charm hadrons and of the total non-photonic electrons will enable us to identify the bottom production at RHIC, including the bottom production cross section and R_{AA} and v_2 of the decay electrons. The HFT consists of 4 layers of silicon detectors grouped into three subsystems with different technologies, guaranteeing increasing resolution when tracking from the TPC towards the vertex of the collision. The Silicon Strip Detector (SSD) is an existing detector in double-sided strip technology. It forms the outermost layer of the HFT. The Intermediate Silicon Tracker (IST), consisting of a layer of single-sided strip-pixel detectors, is located inside the SSD. Two layers of silicon pixel detector (PXL) are inside the IST. The pixel detectors have the resolution necessary for a precision measurement of the displaced vertex. With the HFT, the Time-of-Flight detector and the TPC we will study the physics of mid-rapidity charm and bottom production. The pixel detector will use CMOS Active Pixel Sensors (APS), an innovative technology never used before in a collider experiment [3]. The APS sensors are only 50 μm thick with the first layer at a distance of only 2.5 cm from the interaction point. This opens up a new realm of possibilities for physics measurements. In particular, a thin detector (0.4 – 0.5% of a radiation length per layer) in STAR makes it possible to do the direct topological reconstruction of open charm hadrons down to very low transverse momentum by the identification of the charged daughters of the hadronic decay.

Table 1. Characteristics of each silicon layer of the HFT

Detector	Radius (cm)	Technology	Silicon thickness (μm)	Hit resolution $R/\phi - Z$ (μm - μm)	Thickness in X_0
SSD	23	2-side strips	300	30 - 857	1.0%
IST	14	strip-pads	300	170 -1700	1.2%
PIXEL	2.5, 8	Active Pixels	50	10 - 10	0.4%

2. Physics performance

Simulations presented in this proceedings were performed using the full STAR geometry package with 10k AuAu HIJING central events at $\sqrt{s_{NN}}$ = 200 GeV embedded with D^0 and $\Lambda_{\rm c}$ particles, forced to decay to their hadronic channels ($D^0 \to K^-\pi^+$, $\Lambda_{\rm c} \to K^-\pi^+ p$). Their reconstruction efficiencies are based on particle identification of daughter particles provided by the TPC and extended to higher $p_{\rm T}$ with the Time of Flight detector (TOF) : K-π and $(K+\pi)$-p separations were done up to $p_{\rm T} \leq 1.6$ GeV/c and $p_{\rm T} \leq 3$ GeV/c, respectively. Topological cuts have been also applied to the D^0 candidates. The effect of *out of time* events is included in the PIXEL simulation at a rate corresponding to RHIC-II luminosity.

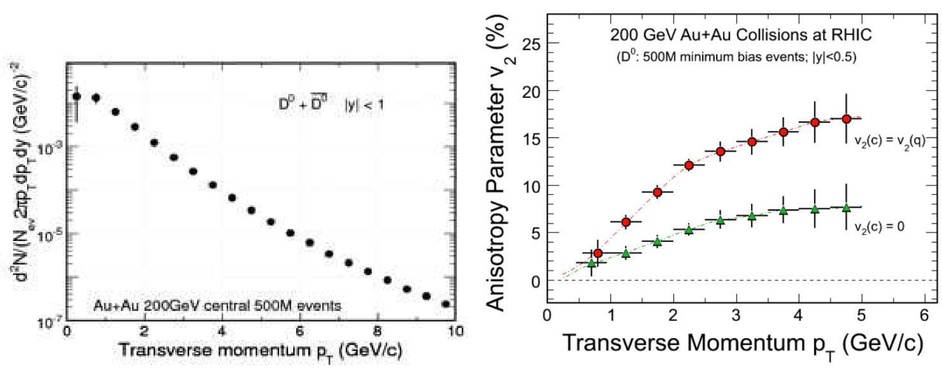

Fig. 1. Projections of key measurements with HFT

3. Estimated D^0 and $\Lambda_{\rm c}$ reconstruction performances

Figure 3 shows the statistical error projections for the key measurements with the HFT in 500 M minimum bias AuAu collisions. Fig. 3(left) is the flow parameter v_2, shown for two extreme scenarios [charm quark flow equal to light quark flow (red circles) and charm quark does not flow (green triangles)]. The HFT will be able to distinguish with great accuracy these 2 cases. Figure 3(middle) shows the suppression factor $R_{\rm CP}$ of D^0: the HFT will be able to measure it directly for $p_{\rm T} \leq 10$ GeV/c via the hadronic channel thus avoiding the indirect method using non-photonic electrons. A measurement of $\Lambda_{\rm c}$ is important to perform since the $\Lambda_{\rm c}/D^0$ ratio may be enhanced, indicating a similar pattern to the baryon/meson ratio involving light quarks in the intermediate $p_{\rm T}$ region [4]. Two scenarios are investigated for the $\Lambda_{\rm c}/D^0$ ratio [5] : no enhancement and same enhancement as $\Lambda/K^0_{\rm s}$. We see from Fig. 3(right) that the statistical errors are sufficiently small,

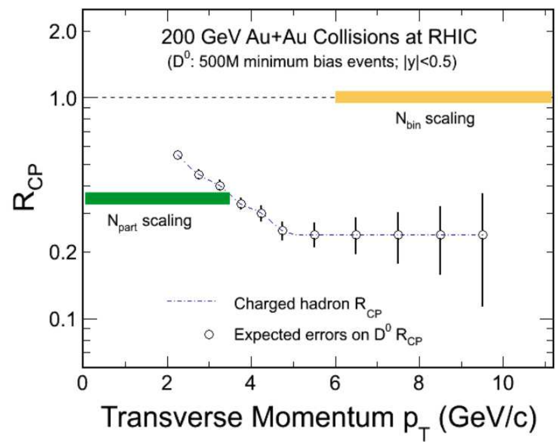

Fig. 2. Projections of key measurements with HFT

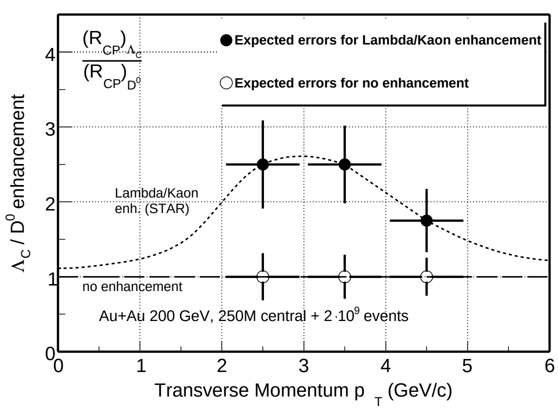

Fig. 3. Projections of key measurements with HFT

making a measurement of baryon/meson ratio in charm sector with good precision in heavy ion collisions.

4. Summary

The HFT, by using low mass CMOS sensors, will be able to directly reconstruct charm hadrons over a large momentum range and, thus, study flow and energy loss of heavy flavor particles. Several physics capabilities such as baryon/meson ratio in the charm sector have been studied.

5. Next section

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5.1. Subsection

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