D^{*+} production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV measured by the STAR experiment

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Abstract

One of the goals of heavy-ion collisions is to search for the Quark-Gluon Plasma (QGP) and study its properties. Due to their large masses, heavy quarks are mainly produced in the initial hard scatterings during the early stage of heavy-ion collisions and experience the entire space-time evolution of the system. At the STAR experiment, utilizing high-precision secondary vertex reconstruction provided by the Heavy Flavor Tracker (HFT), D^0 mesons have been comprehensively studied to investigate the charm quark transport in the QGP. Measurement of D^{*+} production is complementary to the D^0 measurement in studying the medium modification to the open charm meson production. It also provides useful information on feed-down contributions to the D^0 yields. In this poster, measurement of D^{*+} production at mid-rapidity ($|y|<1$) in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV is reported. D^{*+} are reconstructed via the hadronic decay channel ($D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$, and its charge conjugate channel) utilizing the STAR HFT detector. The invariant yields of D^{*+} and the ratios of D^{*+}/D^0 yields are shown as a function of transverse momentum in different centralities.

Motivation

◊ Charm mesons as a sensitive probe of QGP via energy loss measurements;

◊ Study the D^{*+}/D^0 ratio;

(1) $c \rightarrow D^0$ (61.41% ± 0.73%), $c \rightarrow D^{*+/-}$ (23.86% ± 0.46%) [1];

(2) D^{*+} feed-down contribution to D^0 yields;

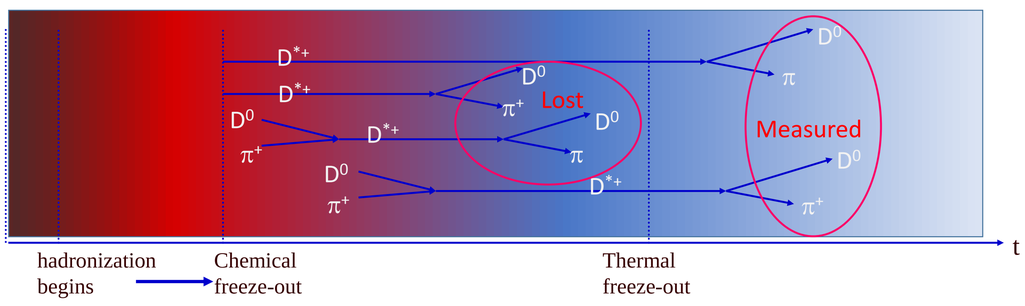
$$D^{*+} \rightarrow D^0\pi^+_{soft}$$

(3) Hot medium effects :

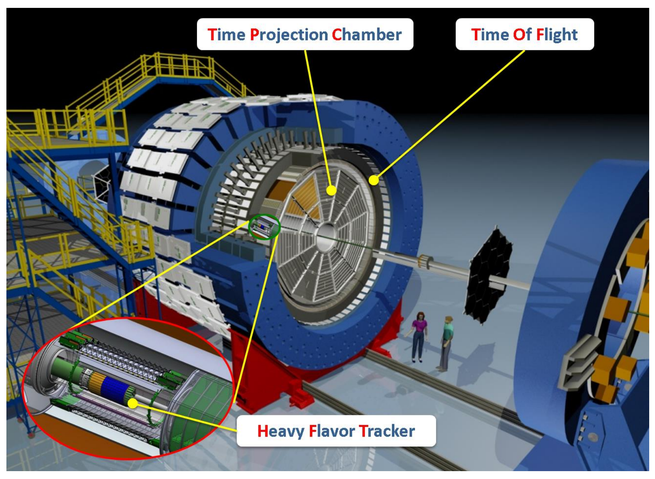
-- D^{*+} life time could become shorter in hot medium [5];

-- Regeneration and re-scattering [2].

Resonance	K*(892)	D^{*+}(2010)
Decay channel	K π	$D^0\pi$
Branching Ratio %	~100	67.7
Width	50.7 MeV	83.3 KeV
Life time	4 [fm/c]	~2[pm/c]



STAR Detector



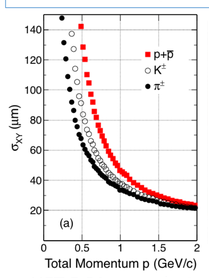
Heavy Flavor Tracker

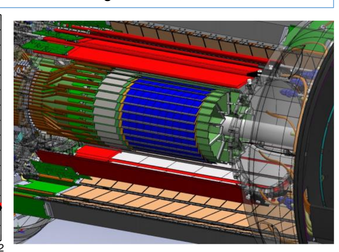
Inner tracking system (2014-2016):

◊ Silicon Strip Detector: r ~22 cm

◊ Intermediate Silicon Tracker: r ~14 cm

◊ PIXEL detector: r ~2.8 & 8 cm, MAPS, 20.7x20.7 μm², 0.5%X_0 thick, air-cooled





HFT DCA_{XY} resolution

D^{*+} reconstruction

◊ **Dataset:**

Au+Au @ 200 GeV recorded in 2014;

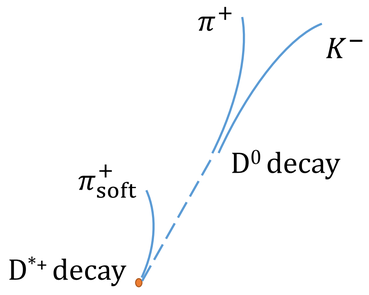
~900Million minimum-bias events.

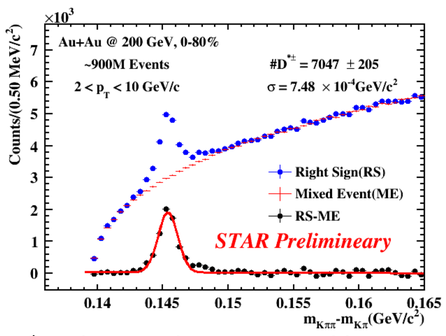
◊ **Reconstruction method**

$D^{*+} \rightarrow D^0\pi^+_{soft}(B.R. = 67.7\%)$,

$D^0 \rightarrow K^-\pi^+(\mathrm{B.R.} = 3.89\%)$,

and its charge conjugate channel.





✓Background is estimated by a mixed-event method.

◊ **D^0 reconstruction cuts:**

$|y|_{D^0}$<1;

K/π : p_T > 0.3 GeV/c;

K/π : $|\eta|$ < 1;

K/π : at least one hit in each layer of PXL and IST;

K/π PID : if TOF available, TOF && TPC;

otherwise TPC only.

D^0 topological cuts:

D^0 p_T (GeV/c)	0-1	1-2	2-3	3-5	5-15
decay length (μm) >	145	181	212	247	259
DCA between 2 daughters (μm) <	84	66	57	50	60
DCA between D^0 and PV (μm) >	61	49	38	38	40
DCA between π and PV (μm) >	110	111	86	81	62
DCA between K and PV (μm) >	103	91	95	79	58

◊ **Kπ invariant mass range for D^0 candidates:**

1.83 GeV/c² < M(Kπ) < 1.90 GeV/c²

◊ **π_{soft} cuts:**

DCA_{PV} ≤ 3 cm, not refitted with the PV;

At least 20 space points in the TPC,

(no requirement to leave hits in HFT);

p_T > 0.15 GeV/c;

$|\eta|$ < 1;

PID: TOF and TPC if TOF is available, otherwise TPC only.

Reconstruction Efficiency

◊ **D^{*+} efficiency**

D^0 efficiency ⊗ π_{soft} efficiency;

Vertex resolution correction;

◊ **D^0 efficiency**

D^0 reconstruction efficiency ← data-driven simulation;

Mass cut efficiency ← Real data D^0 signal;

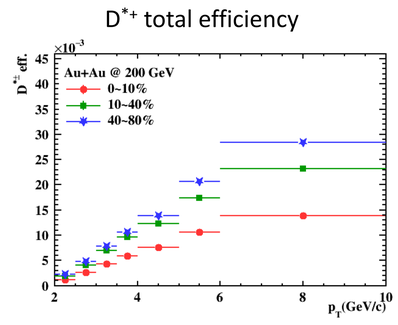
◊ **π_{soft} efficiency**

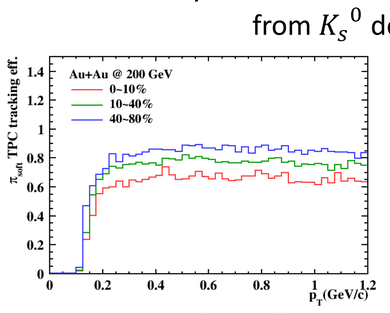
TPC tracking efficiency ← TPC embedding;

TOF matching efficiency ← Real data;

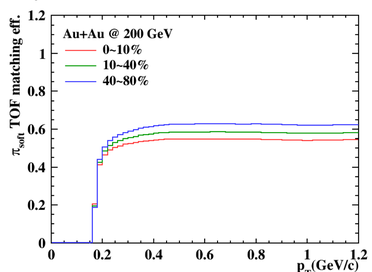
PID efficiency ← Extracted using the pure pion sample from K_s^0 decay.

D^{*+} total efficiency

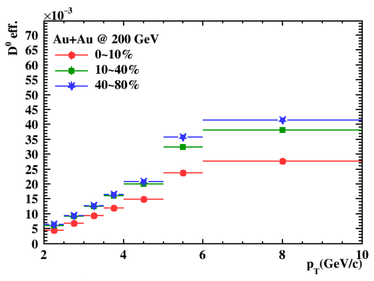




π_{soft} TPC tracking efficiency

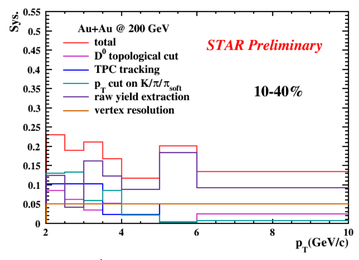


π_{soft} TOF matching efficiency

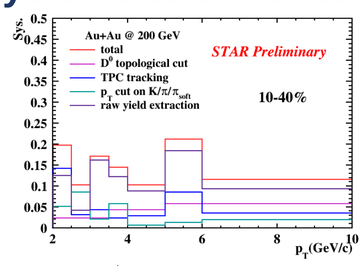


D^0 reconstruction efficiency

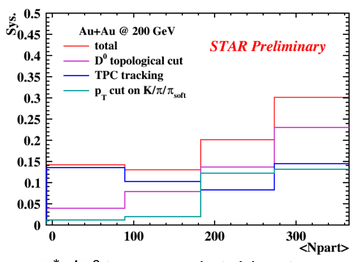
Systematic Uncertainties



D^{*+} spectra sys. uncert.

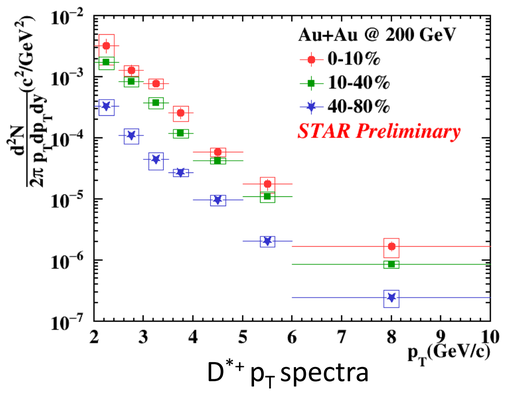


D^{*+}/D^0 ratio sys. uncert.

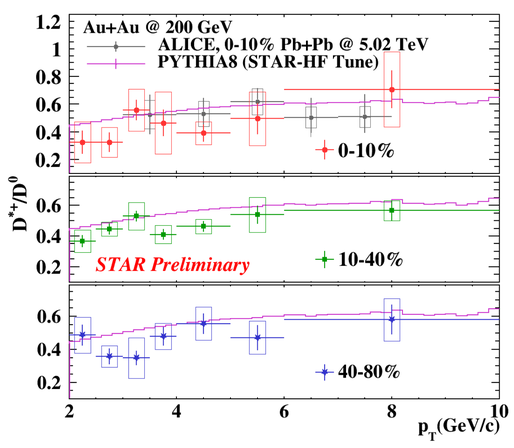


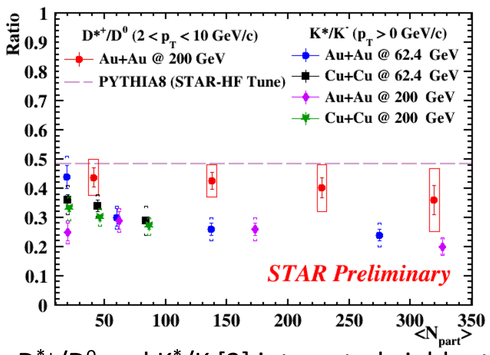
D^{*+}/D^0 integrated yield ratio sys. uncert.

Results



D^{*+} p_T spectra





D^{*+}/D^0 and K^*/K [2] integrated yield ratios

✓ D^{*+}/D^0 ratio in Au+Au collisions at 200 GeV is consistent with that in Pb+Pb collisions at 5.02 TeV [4].

✓ The p_T dependence of D^{*+}/D^0 ratio shows similar trend in different centrality bins.

✓ D^{*+}/D^0 ratio as a function of p_T is consistent with PYTHIA8 (STAR-HF Tune) prediction.

✓ Ratio of integrated yields (2 < p_T < 10 GeV/c) of D^{*+} to D^0 shows no strong dependence on centrality. No significant effect of hot medium on the D^{*+} life time has been observed.

Summary

✓ D^{*+} p_T spectra and D^{*+}/D^0 ratio have been measured for different centralities of Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV;

✓ The dependence of D^{*+}/D^0 ratio on p_T is similar in different centrality bins, and is compatible to that in Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV.

✓ Ratio of integrated yields (2 < p_T < 10 GeV/c) of D^{*+} to D^0 shows no strong dependence on centrality. No significant effect of hot medium on the D^{*+} life time has been observed.

Reference

[1] M. Lisovyi, et. al., Eur. Phys. J. C (2016) 76: 397.

[2] M. M. Aggarwal *et al.* Phys. Rev. C (2011) 84.3: 034909.

[3] L. Adamczyk et al. Phys. Rev. Lett. (2017) 118.21: 212301.

[4] ALICE Collaboration. arXiv:1804.09083.

[5] arXiv: 0903.1096.