# Measurements of $D^0$ and D* production in p+p collisions at $\sqrt{s}$ = 510 GeV in STAR experiment

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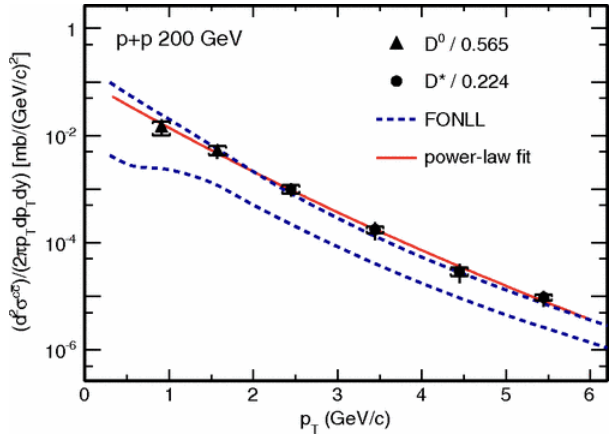
# Introduction

## ❑ Motivation:

- Studying charm meson production allows for comparisons between experimental results and theoretical models (e.g., perturbative QCD, factorization frameworks).

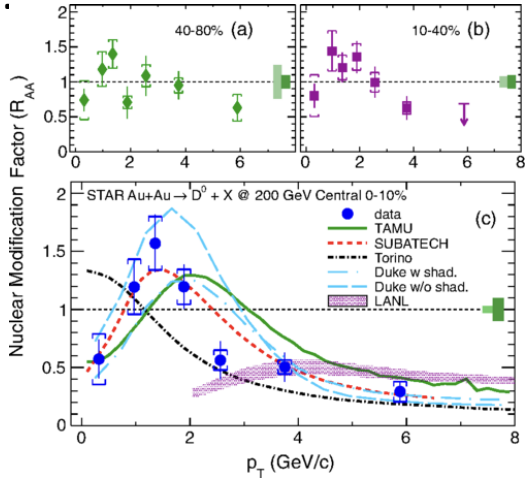



*$p_T$-differential $c\bar{c}$ production cross-sections compared with FONLL pQCD calculations*

[Phys. Rev. D 86, 072013]

$$D^{*\pm} \xrightarrow{B.R.=67.7\%} D^0(\overline{D^0})\pi_s^{\pm} \xrightarrow{B.R.=3.89\%} K^{\mp}\pi^{\pm}\pi_s^{\pm}$$

- Modifications of the charm meson production in heavy-ion collisions with respect to p+p provide insights into QGP.



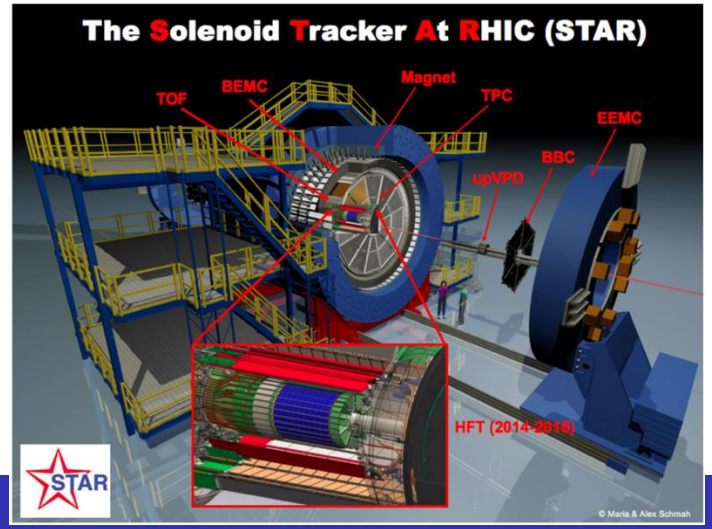

*$D^0$ meson nuclear modification factor $R_{AA}$*

[Phys. Rev. Lett. 113, 142301]

## ❑ STAR detector:

**Time Projection Chamber (TPC):** main tracking detector, momentum determination, particle identification via ionization energy loss (dE/dx).

**Time Of Flight (TOF**): particle identification via velocity (β).



# Results

$$D^{*\pm} \xrightarrow{B.R.=67.7\%} D^0(\overline{D^0})\pi_s^{\pm} \xrightarrow{B.R.=3.89\%} K^{\mp}\pi^{\pm}\pi_s^{\pm}$$

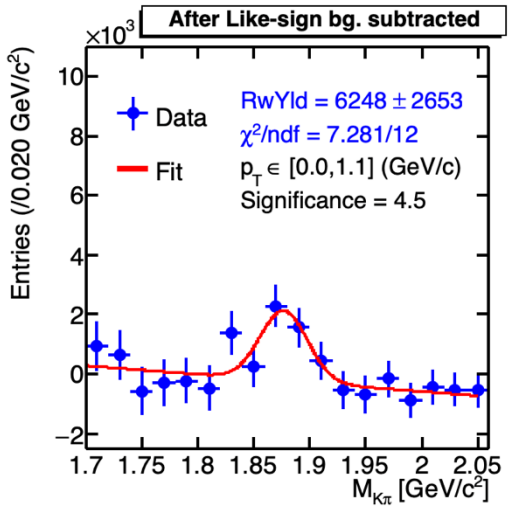
## ❑ $D^0$ signal extraction:

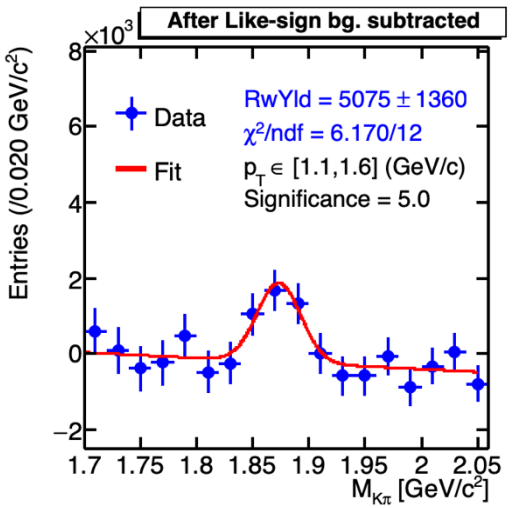
- Unlike-sign pions and kaons are paired.

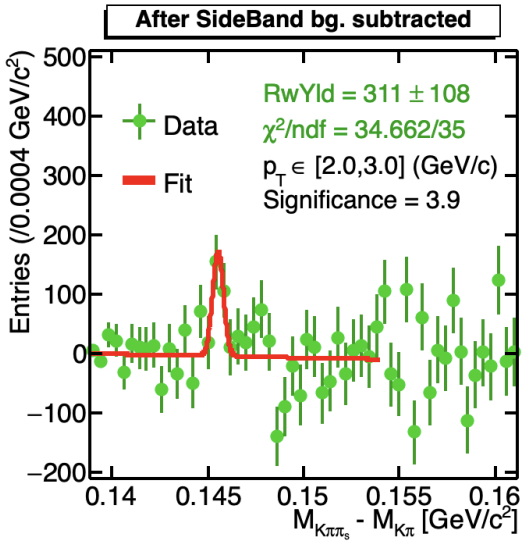
| | $p_T \leq 1.6$ GeV/c | $p_T > 1.6$ GeV/c |
|---|---|---|
| **Kaons** | $-2.5 < n\sigma_K^{dE/dx} < 3.0$<br>$p$ dependent cut on $n\sigma_K^{1/\beta}$ | $-2.5 < n\sigma_K^{dE/dx} < 3.0$<br>$p$ dependent cut on $n\sigma_K^{1/\beta}$ |
| **Pions** | $-3.0 < n\sigma_\pi^{dE/dx} < 3.0$<br>$p$ dependent cut on $n\sigma_\pi^{1/\beta}$ | $-3.0 < n\sigma_\pi^{dE/dx} < 3.0$ if TOF matched<br>$p$ dependent cut on $n\sigma_\pi^{1/\beta}$ if TOF matched<br>$-2.5 < n\sigma_\pi^{dE/dx} < 2.5$ if no TOF info |

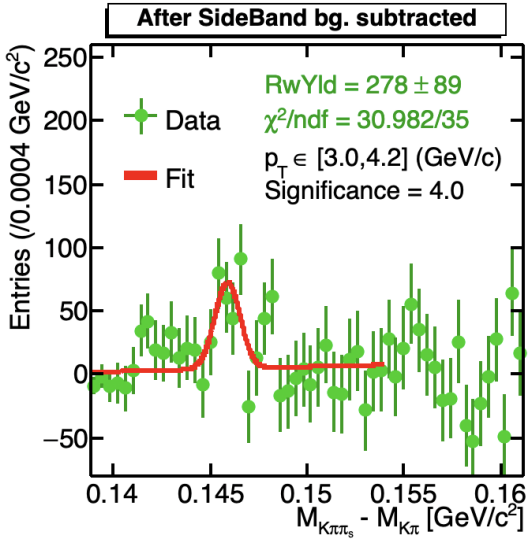
## ❑ $D^*$ signal extraction:

- Histogram was populated with the mass difference: $M_{K\pi\pi_s} - M_{K\pi}$
- Wrong-Sign Combination and Side-Band Method were used to reconstruct background to extract the D* signal.



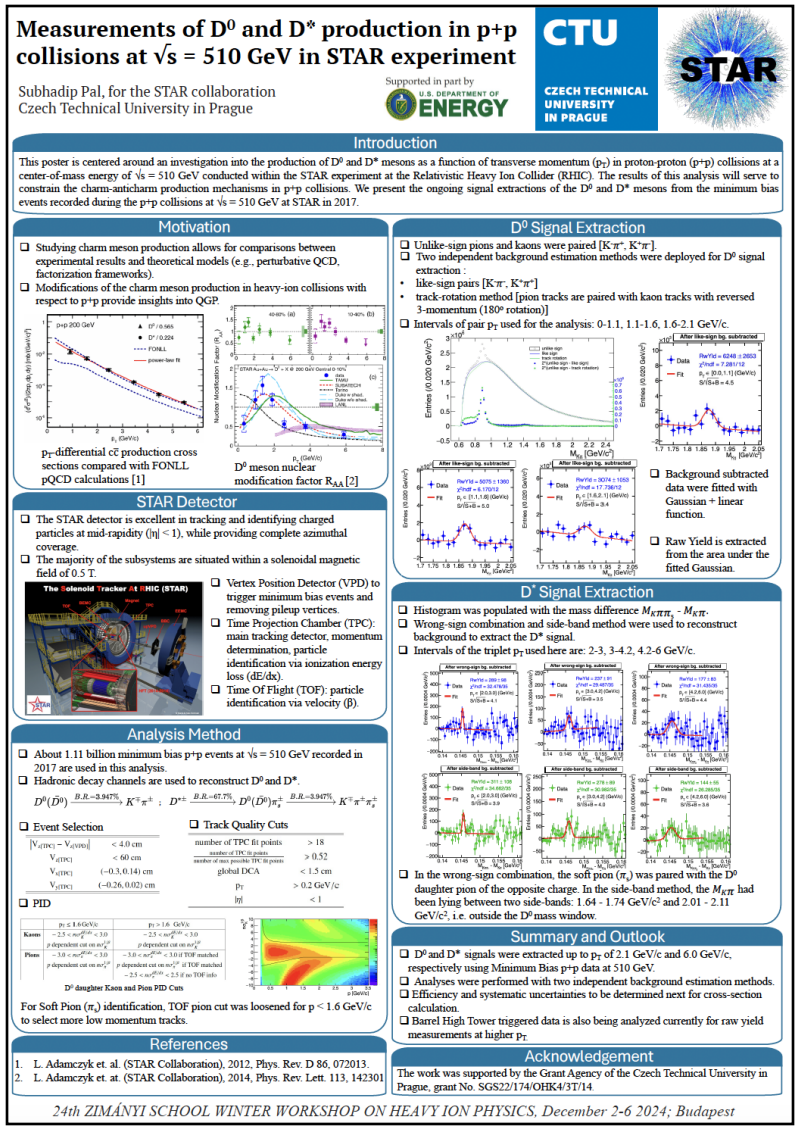



# Thank you for your attention

See you at my poster



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CTU CZECH TECHNICAL UNIVERSITY IN PRAGUE

STAR

**Introduction**

This poster is centered around an investigation into the production of $D^0$ and $D^*$ mesons as a function of transverse momentum ($p_T$) in proton-proton (p+p) collisions at a center-of-mass energy of $\sqrt{s}$ = 510 GeV conducted within the STAR experiment at the Relativistic Heavy Ion Collider (RHIC). The results of this analysis will serve to constrain the charm-anticharm production mechanisms in p+p collisions. We present the ongoing signal extractions of the $D^0$ and $D^*$ mesons from the minimum bias events recorded during the p+p collisions at $\sqrt{s}$ = 510 GeV at STAR in 2017.

**Motivation**

- Studying charm meson production allows for comparisons between experimental results and theoretical models (e.g., perturbative QCD, factorization frameworks).
- Modifications of the charm meson production in heavy-ion collisions with respect to p+p provide insights into QGP.

$p_T$-differential $c\bar{c}$ production cross sections compared with FONLL pQCD calculations [1]

$D^0$ meson nuclear modification factor $R_{AA}$ [2]

**STAR Detector**

- The STAR detector is excellent in tracking and identifying charged particles at mid-rapidity ($|\eta| < 1$), while providing complete azimuthal coverage.
- The majority of the subsystems are situated within a solenoidal magnetic field of 0.5 T.
- Vertex Position Detector (VPD) to trigger minimum bias events and removing pileup vertices.
- Time Projection Chamber (TPC): main tracking detector, momentum determination, particle identification via ionization energy loss (dE/dx).
- Time Of Flight (TOF): particle identification via velocity (β).

**Analysis Method**

- About 1.11 billion minimum bias p+p events at $\sqrt{s}$ = 510 GeV recorded in 2017 are used in this analysis.
- Hadronic decay channels are used to reconstruct $D^0$ and $D^*$.

$$D^0(\bar{D}^0) \xrightarrow{B.R.=3.947\%} K^{\mp}\pi^{\pm} \quad ; \quad D^{*\pm} \xrightarrow{B.R.=67.7\%} D^0(\bar{D}^0)\pi_s^{\pm} \xrightarrow{B.R.=3.947\%} K^{\mp}\pi^{\pm}\pi_s^{\pm}$$

- Event Selection

| | |
|---|---|
| $\lvert V_{z(\mathrm{TPC})} - V_{z(\mathrm{VPD})}\rvert$ | < 4.0 cm |
| $V_{r(\mathrm{TPC})}$ | < 60 cm |
| $V_{z(\mathrm{TPC})}$ | (−0.3, 0.14) cm |
| $V_{y(\mathrm{TPC})}$ | (−0.26, 0.02) cm |

- Track Quality Cuts

| | |
|---|---|
| number of TPC fit points | > 18 |
| number of TPC fit points / number of max possible TPC fit points | > 0.52 |
| global DCA | < 1.5 cm |
| $p_T$ | > 0.2 GeV/c |
| $\lvert\eta\rvert$ | < 1 |

- PID

| | $p_T \le 1.6$ GeV/c | $p_T > 1.6$ GeV/c |
|---|---|---|
| Kaons | $-2.5 < n\sigma_K^{dE/dx} < 3.0$ p dependent cut on $n\sigma_K^{1/\beta}$ | $-2.5 < n\sigma_K^{dE/dx} < 3.0$ p dependent cut on $n\sigma_K^{1/\beta}$ |
| Pions | $-3.0 < n\sigma_\pi^{dE/dx} < 3.0$ p dependent cut on $n\sigma_\pi^{1/\beta}$ | $-3.0 < n\sigma_\pi^{dE/dx} < 3.0$ if TOF matched; p dependent cut on $n\sigma_\pi^{1/\beta}$ if TOF matched; $-2.5 < n\sigma_\pi^{dE/dx} < 2.5$ if no TOF info |

$D^0$ daughter Kaon and Pion PID Cuts

For Soft Pion ($\pi_s$) identification, TOF pion cut was loosened for $p < 1.6$ GeV/c to select more low momentum tracks.

**$D^0$ Signal Extraction**

- Unlike-sign pions and kaons were paired [$K^-\pi^+$, $K^+\pi^-$].
- Two independent background estimation methods were deployed for $D^0$ signal extraction :
  - like-sign pairs [$K^-\pi^-$, $K^+\pi^+$]
  - track-rotation method [pion tracks are paired with kaon tracks with reversed 3-momentum (180° rotation)]
- Intervals of pair $p_T$ used for the analysis: 0-1.1, 1.1-1.6, 1.6-2.1 GeV/c.
- Background subtracted data were fitted with Gaussian + linear function.
- Raw Yield is extracted from the area under the fitted Gaussian.

**$D^*$ Signal Extraction**

- Histogram was populated with the mass difference $M_{K\pi\pi_s} - M_{K\pi}$.
- Wrong-sign combination and side-band method were used to reconstruct background to extract the $D^*$ signal.
- Intervals of the triplet $p_T$ used here are: 2-3, 3-4.2, 4.2-6 GeV/c.
- In the wrong-sign combination, the soft pion ($\pi_s$) was paired with the $D^0$ daughter pion of the opposite charge. In the side-band method, the $M_{K\pi}$ had been lying between two side-bands: 1.64 - 1.74 GeV/c² and 2.01 - 2.11 GeV/c², i.e. outside the $D^0$ mass window.

**Summary and Outlook**

- $D^0$ and $D^*$ signals were extracted up to $p_T$ of 2.1 GeV/c and 6.0 GeV/c, respectively using Minimum Bias p+p data at 510 GeV.
- Analyses were performed with two independent background estimation methods.
- Efficiency and systematic uncertainties to be determined next for cross-section calculation.
- Barrel High Tower triggered data is also being analyzed currently for raw yield measurements at higher $p_T$

**References**

1. L. Adamczyk et. al. (STAR Collaboration), 2012, Phys. Rev. D 86, 072013.
2. L. Adamczyk et. al. (STAR Collaboration), 2014, Phys. Rev. Lett. 113, 142301

**Acknowledgement**

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