$D_S^{\pm}$ meson production in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV in STAR

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Overview of the talk

• Motivation

• Experimental Setup
  - Heavy Flavor Tracker

• Physics results in Au+Au collisions
  - Analysis method
  - Nuclear modification factor ($R_{AA}$)
  - Elliptic flow ($v_2$)

• Summary
Why strange charmed meson?

- Better constrain total charm yield
- Study hadronization mechanism
  - The medium created in heavy-ion collisions enhances strange quark production
  - $R_{AA}$ of $D_s$ meson is expected to be larger than non-strange D meson if charm quarks hadronize via coalescence in the medium
- More sensitive to properties of Quark Gluon Plasma
  - Elliptic flow of $D_s$ is expected to be smaller than that of non-strange D meson as a result of earlier freeze-out for $D_s$ meson.

Experimental Setup

- Excellent PID and tracking
- Full azimuthal coverage
- Pseudo-rapidity coverage ~ ±1
HFT detector

- Four-layer silicon detector
- Resolution of Distance of Closest Approach (DCA)
  - $\sim 30 \mu m$ at high $p_T$
  - $< 50 \mu m$ for 750 MeV/c kaons
$D_s$ reconstruction

- **Dataset**
  - Au+Au collisions at $\sqrt{s_{NN}} = 200\text{GeV}$ recorded in 2014
  - 750M minimum bias events (~70% of collected data in 2014)

- **Event Selection**
  - $|\text{Vertex Z}| < 6 \text{ cm}$

- **Decay channel of interest**
  - $D_s \rightarrow \phi(1020) + \pi \rightarrow K^+ + K^- + \pi$
  - Branch ratio : 2.32 %
  - Decay length : $c\tau = 149.9 \mu m$

- **Reconstruction strategy**
  - Use HFT to reconstruct secondary vertex
  - Topological cuts to suppress background
  - Require $M_{KK}$ in $\phi$ meson mass range

2016/9/24
Long Zhou / USTC & BNL

Courtesy of Peter Filip
Particle identification using TPC

TPC PID: Using energy loss (dE/dx)
Particle identification using TOF

TPC PID: Using energy loss ($dE/dx$)

TOF PID: Using time-of-flight ($\beta$)*

*TOF PID is applied only when $\beta$ information is available.
\[ p_T \] integrated \( D_s \) signal

- First \( D_s \) meson signal observed at RHIC.
Mean and width

- Mean is consistent with PDG value.
- Width is consistent with simulation.
**$D_S$ meson spectrum and $R_{AA}$**

- pp reference was obtained from charm cross-section measured by STAR scaled by $c \rightarrow D_S$ fragmentation factor$^1$


- The $R_{AA}$ of $D_S$ is higher than $D^0$ $R_{AA}$ but statistically not significant.
Model calculation for $D_s R_{AA}$

- Both $D_s$ and $D^0 R_{AA}$ are consistent with model calculations within uncertainty.
- Hint of enhancement in $D_s$ meson production.
The ratio $D_s/D^0$ seems to be higher than the prediction for p+p collisions from PYTHIA, but not significant.
Mass effect on $D_s/D^0$ ratio

Blast-wave model:
- Blast-wave parameters obtained from fitting $D^0$ spectra\(^1\)
- Mass effect is small, and it alone can not account for the difference in $D_s/D^0$ ratio between PYTHIA and data.

$D_S/D^0$ ratio: RHIC vs. LHC

- Consistent with ALICE, they following the same trend.
- Need measurements with better precision.
Elliptic flow $v_2$

- First measurement of $D_s$ $v_2$ in heavy-ion experiment.
Summary and outlook

• $D_s$ meson is a good probe to study the mechanism of charm hadronization and the properties of Quark-Gluon Plasma

• We have observed a clear signal of $D_s$ meson at RHIC for the first time.

• $D_s$ in 10-40% central Au+Au collisions at $\sqrt{s_{NN}} = 200$:
  - The $R_{AA}$ of $D_s$ is higher than $D^0$ but statistically not significant
  - $D_s/D^0$ ratio seems to be higher compared to PYTHIA, indicating coalescence between charm and strange quarks in the medium.

• Stay tuned for Run 14+16 data with increased statistics and improved detector efficiency + resolution
  - A factor of 2 improved HFT tracking efficiency in re-processed data was obtained after fixing a bug in PXL decoder software.
  - We will also use this decay channel ($D_s \rightarrow K^*(892) + K \rightarrow K^+ + K^- + \pi$) to improve our measurement precision.
  - Run14 + Run16(3B MB events) : observing the splitting of $R_{AA}$ and $v_2$ for $D_s$ and $D^0$ may be possible.
Back up
Blast wave

Fragmentation factor:

\[ c \rightarrow D^0 \quad c \rightarrow D_s \]

Compare to k/π ratio

![Graph comparing D_s/D^0 to k/π ratios]