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

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(for the STAR Collaboration)
Outline

• Motivation
• STAR detector and analysis details
• $p_T$ spectra, particle ratio and $R_{AA}$
• Elliptic flow ($v_2$) of $D_S$
• Summary
Why Study $D_S^\pm$?

- $D_S$ meson: one charm and one strange quark
- Strangeness enhancement due to QGP is expected to affect the yield of $D_S$
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Ref: M. He et al., PRL 110, 112301 (2013)
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- $D_S$ meson: one charm and one strange quark
- Strangeness enhancement due to QGP is expected to affect the yield of $D_S$
- $R_{CP}$ or $R_{AA}$ of $D_S > D^0$ predicted
- Elliptic flow of $D_S < D^0$ is expected due to earlier freeze out of $D_S$

*Good Probe to study the hadronization and strangeness enhancement*

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STAR Detector in Year 2014

- Full $2\pi$ coverage
- Pseudorapidity coverage $\sim \pm 1$ unit
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For Details about HFT: See talk by G. Contin (Tuesday, 3.00 PM, Futute Exp. Fac. Upgr.)
Analysis Details

- Au+Au at $\sqrt{s_{NN}} = 200$ GeV in 2014
- 750 M minimum bias events analyzed (70% of collected data)
- $|V_z| \leq 6$ cm
- Centrality using raw charged particle measured in TPC and Glauber Model

- Decay Channel: $D_s^{\pm} \rightarrow \phi (\rightarrow K^+K^-) + \pi^\pm$
- Branching Ratio: $2.32 \pm 0.14$%
- Decay Length: $150 \pm 2$ μm
- Mass: $1968.47 \pm 0.33$ MeV/c$^2$

Secondary Vertex:
Using HFT

$D_s \rightarrow K^* + K$ decay channel:
See Poster by L. Zhou (ID :336)
Particle Identification

TPC PID: Using \( \frac{dE}{dx} \)

TOF PID: Using Time of Flight (\( \beta \))

*TOF PID has been applied only when \( \beta \) information is available.
Particle Identification

TPC PID: Using $dE/dx$  

TOF PID: Using Time of Flight ($\beta$) *

* TOF PID has been applied only when $\beta$ information is available.
• First measurement of $D_S$ meson at RHIC.
• We will present $D_S$ spectra for 10-40% centrality and for $2.5 < p_T < 5.0$ GeV/c.
• Lower $p_T$ and more peripheral collisions studies are underway.
Mass and width

Mass is consistent with PDG value
Width is consistent with the results from detector simulations.
The $R_{AA}$ of $D_S$ is higher than unity but statistically not significant.

$R_{AA} = \frac{1}{N_{Bin}} \times \frac{dN_{AA}^{AA}}{dp_T} \times \frac{dN_{pp}^{pp}}{dp_T}$

$D_S$ spectra for $p+p$ collision has been calculated from measured charm cross-section in STAR. Fragmentation factor from charm to $D_S$ is $0.09\pm0.01$.

**Ref:**
- H1 Collaboration, Eur.Phys.J.C38(2005)447
- ZEUS Collaboration, Eur.Phys.J.C44(2005)351

STAR $D^0 R_{AA}$: Phys. Rev. Lett. 113 (2014) 142301
The ratio $D_S/D^0$ is less than unity and seems to be higher than prediction for $p+p$ collision from PYTHIA.

STAR Au+Au $D^0$: Phys. Rev. Lett. 113 (2014) 142301
Invariant Yield and $D_S/D^0$

STAR and ALICE data are consistent with large uncertainties.
Elliptic Flow Analysis

\[ v_2 = \langle \cos(2(\phi - \psi_2)) \rangle \times R^{-1} \]

**Method:** Full Event Plane

**Event Plane:** Using TPC tracks

**Resolution:** Using Eta sub-event

\[ D_S v_2 : \]

*By fitting Yield vs (\(\phi - \psi_2\))

*With function* \( p_0(1 + 2v_{2raw} \cos(2(\phi - \psi_2))) \)

**Graphs:**
- Centralities (%): 0 to 80
- Resolution: 0 to 1
- Event Plane Angle (rad): 0 to 3
- Counts: 900 to 1070

**Parameters:**
- \( p_T = 1.5 - 5.0 \text{ GeV/c} \)
- Au+Au, 0-80%
- \( \chi^2 / \text{ndf} = 1.101 / 1 \)
- \( p_0 = 0.341 \pm 0.04496 \)
- \( v_{2raw} = 0.07676 \pm 0.0935 \)
Elliptic Flow of $D_S$

For $D^0 v_2$: See talk by M. Lomnitz (Tuesday, 9 AM, Collective Dynamics)

$\phi$-meson $v_2$
e-Print :1507.05247

First measurement of $D_S v_2$ in heavy-ion experiment. Need more statistics.
Summary

• We have observed a clear signal of $D_S$ at RHIC for the first time

• $D_S$ in Au+Au 200 GeV for 10-40% central collisions:
  - $D_S/D^0$ seems to be higher than p+p prediction (from PYTHIA 6.4) at $p_T = 2.8$ and 3.9 GeV/c
  - $R_{AA} = 2.1 \pm 0.5 \pm 0.7$ and $1.7 \pm 0.4 \pm 0.5$ at $p_T = 2.8$ and 3.9 GeV/c, respectively

• First measurement of elliptic flow of $D_S$ is presented

• Stay tuned for Run 16 Data with increased statistics and improved detector performance

Thank You
Back-up
$R_{AA}$

- $D_S$ (Au+Au 200 GeV, 10-40%)
- $D_S$ (Pb+Pb 2.76 TeV, 20-50%)
- $D^0$ (Au+Au 200 GeV, 10-40%)

$STAR$ Preliminary

$D_S$ Pb+Pb (ALICE: arXiv:1509.07287)
$D^0$Au+Au (STAR: PRL 113 (2014) 142301)
φ-meson signal