Ω production in p+p, Au+Au and U+U collisions at STAR

Xianglei Zhu (Tsinghua University)
For the STAR Collaboration
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Outline

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- STAR detector and $\Omega$ reconstruction
- $\Omega$ spectra
- Strangeness enhancement factors
- Particle ratios
- Nuclear modification factors
- Summary
Motivation

• Strange quark
  • current mass $\sim 100 \text{ MeV} < T_c$
  • pair produced in heavy-ion collisions (total $S = 0$)
• Baryon with only strange quarks: $\Omega (sss)$, $\bar{\Omega}(\bar{s}\bar{s}\bar{s})$
  • small hadronic cross section
  • no feed down from excited states
  • sensitive to the early stage dynamics of the medium
• Key observables:
  • Strangeness enhancement factors – canonical suppression
  • Particle ratios – chemical equilibration
  • Nuclear modification factors – interplay of strange quark energy loss and recombination/coalescence
Motivation

- $\Omega$ in $p+p$ 200 GeV
- provide the baseline for strangeness enhancement study

Large errors (2001-2002 data)

$\sim$18 times more $p+p$ data were taken in year 2009!

Motivation

- $\Omega$ in $\text{Au+Au}$ vs in $\text{U+U}$
  - $\text{U+U}$ collisions expected to have 20% higher energy density
  - How is the $\Omega$ enhancement in $\text{U+U}$?
  - $\Omega$ yield suppressed at high $p_T$ in $\text{Au+Au}$? and even more suppressed in $\text{U+U}$?


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The **Solenoidal Tracker At RHIC** (STAR)

<table>
<thead>
<tr>
<th>Year</th>
<th>System</th>
<th>$\sqrt{s_{NN}}$ (GeV)</th>
<th>Minimum bias events in Million</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>p+p</td>
<td>200</td>
<td>~ 107 M</td>
</tr>
<tr>
<td>2011</td>
<td>Au+Au</td>
<td>200</td>
<td>~ 480 M</td>
</tr>
<tr>
<td>2012</td>
<td>U+U</td>
<td>193</td>
<td>~ 270 M</td>
</tr>
</tbody>
</table>
Ω reconstruction in STAR

- $\Omega \rightarrow \Lambda + K \rightarrow (p+\pi) + K$
- $\pi, K, p$ are identified with TPC $dE/dx$
- reconstruct the secondary vertex

STAR preliminary

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**p_T spectra**

* |y| < 0.5, statistical error only


**STAR, Phys. Rev. Lett. 98 (2007) 062301**

* only central (0-5, 5-10%) new Au+Au and U+U data available so far

- Maximum p_T ~ 6 GeV/c for both Au+Au and U+U central collisions
- Yields (U+U > Au+Au)
Centrality dependence of yields

|y| < 0.5 for new p+p, Au+Au and U+U data

Systematic errors dominate


- Ω baryon yield per participant increases with N_{part}
Strangeness enhancement factor

- Significantly reduced reference uncertainty at RHIC
- Larger enhancement than LHC, lower than SPS
- Larger enhancement in central (0-5%) U+U than in central (0-5%) Au+Au (strangeness enhancement not saturated)

New p+p 200 GeV data as reference for both new Au+Au 200 GeV and U+U 193 GeV


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Ratios to pion

- RHIC data is lower than LHC
- Lower than thermal model fitting results for RHIC
- $\Omega/\pi$ (LHC>RHIC) in p+p, canonical suppression

Thermal models:
- Fitting to LHC, Stachel, et al., arXiv: 1311.4662
Nuclear modification factor ($R_{AA}$)

\[ R_{AA} = \frac{\sigma_{NN}^{\text{inel}}}{N_{\text{bin}}^{AA}} \frac{d^2N_{AA}/dyd \, p_T}{d^2\sigma_{pp}/dyd \, p_T} \]

- $\Omega$ baryon $R_{AA}$ much larger than proton/pion up to 4 GeV/c
  - Interplay of strange quark energy loss and coalescence or recombination

Statistical error only for $\Omega$

$\pi^+ + \pi^-$ and $p + \bar{p}$: 0-12%,

$K^\pm + p(\bar{p})$: 0-12%,

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The energy density in central U+U is expected to be 20% higher, but $N_{bin}$-scaled high $p_T$ $\Omega$ yield is not suppressed

$\rightarrow \Omega$ formed through coalescence/recombination up to $p_T \sim 6$ GeV/c?
Summary

- Precision measurement for $\Omega$ was made at STAR with high statistics p+p, Au+Au, U+U at top RHIC energies
- $\Omega$ enhancement factors from RHIC are in between SPS and LHC
- $\Omega$ canonical suppression may still remain in central Au+Au collisions
  - Larger strangeness enhancement in central U+U
  - Lower $\Omega/\pi$ ratio than LHC and thermal model
- $\Omega$ $R_{AA}$ (0-5%) is above 3 up to 4 GeV/c and $R_{UU}/R_{AuAu}$ (0-10%) does not show suppression up to 6 GeV/c
  - $\Omega$ formation in central collisions may be dominated by strange quark coalescence/recombination up to $p_T \sim 6$ GeV/c