Ω and $\bar{\Omega}$ production in Au+Au collisons at 200 GeV with the STAR experiment

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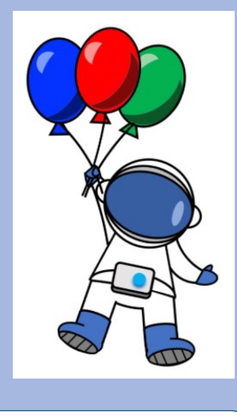


Abstract

$\Omega(\bar{\Omega})$, composed of three strange quarks, serves as a sensitive probe into the characteristics of the quark-gluon plasma (QGP). Measurement of its production can be used to extract the temperature and baryon chemical potential at the chemical freeze-out with the thermal model, providing information on the QCD phase diagram. Also, the Ω/ϕ ratio as a function of transverse momentum (p_{T}) can be utilized to test hadronization model predictions and to possibly extract the strange quark p_{T} distribution at hadronization.

In this poster, we will present p_{T} spectra and yields of $\Omega(\bar{\Omega})$ in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV. The data analyzed were collected by STAR in 2019, when the iTPC was in operation. The iTPC extends the rapidity coverage and enhances the particle identification capability compared to previous results.

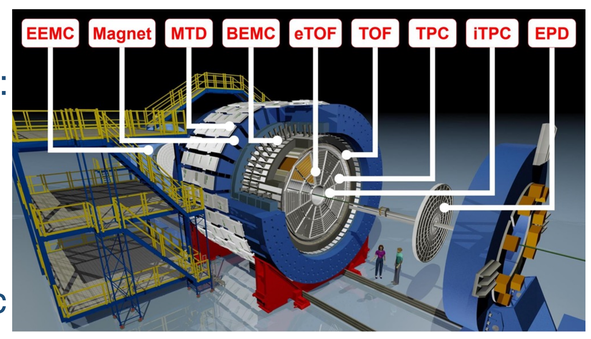
Motivation

- Precise measurement of $\Omega(\bar{\Omega})$ — baryon with only strange quarks — production with larger statistics and upgraded detector.
- Update Ω/ϕ ratio as a function of p_{T} to test the recombination model.
- Extract the strange quark p_{T} distribution at hadronization based on the recombination model.

STAR Detector

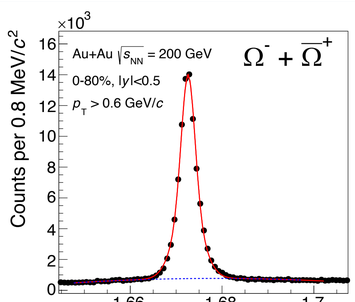
iTPC (STAR Inner Sector TPC Upgrade) :

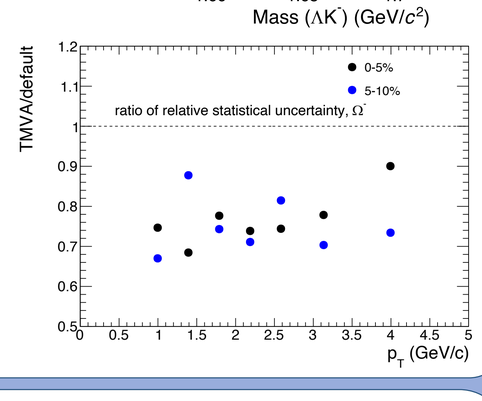
- Larger rapidity coverage — |η| from 1.0 to 1.5
- Better PID — improved dE/dx resolution
- Lower p_{T} limit — from 125 to 60 MeV/c
- Efficiency of Ω reconstruction improved significantly



Analysis

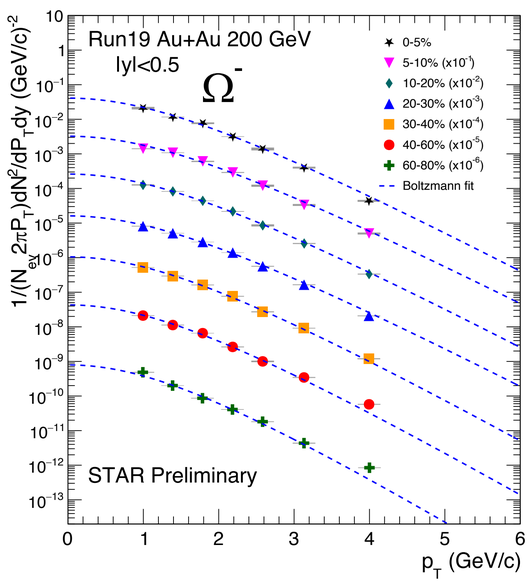
- Dataset: Run19 Au+Au 200GeV
- ~76M minimum bias events
- Tracks reconstructed with 25 or more hits
- Particle identification with TPC dE/dx
- Reconstruct the secondary vertex
- p_{T} region of Ω: 0.8 ~ 4.6 GeV/c
- Signal extraction: rotational background subtracted, polynomial fit background & double gaussian fit signal
- TMVA optimization to improve signal significance — topological variables used for training, e.g. the DCA between Λ and PV.

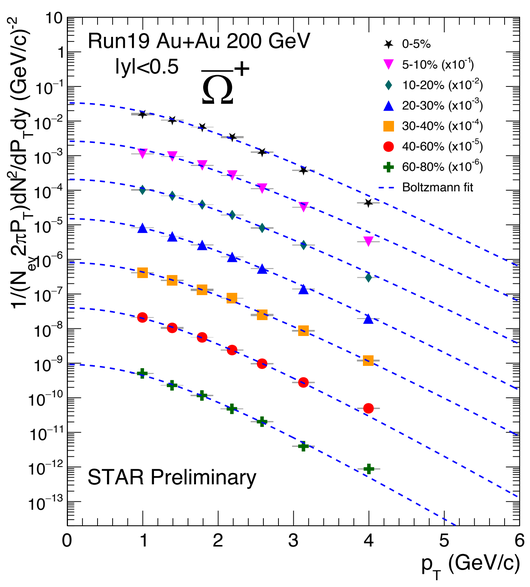




p_T Spectra

- Precise measurement for 7 centrality bins
- Maximum p_{T} ~ 4 GeV/c
- The fraction of the yield the data points cover: 68 ~ 72%

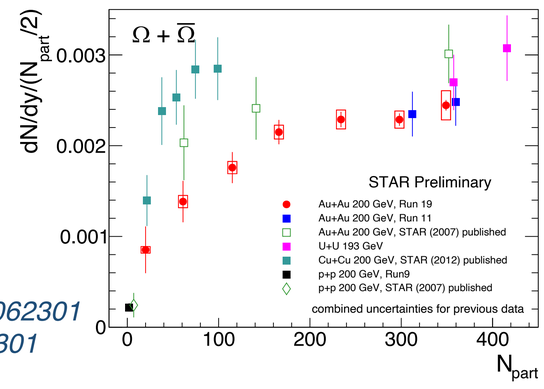




dN/dy Yields

N_{part} scaled Ω yields smoothly increase from p+p towards central Au+Au collisions.

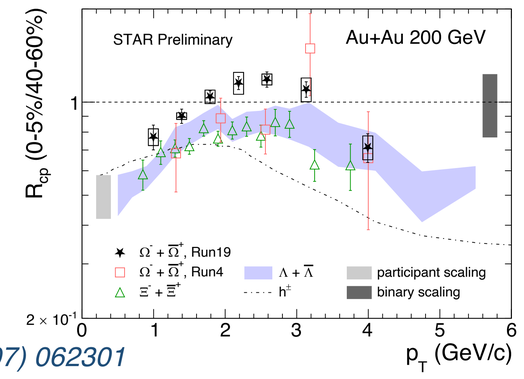
Run11 data points N_{part} shifted for clarity



p+p: STAR, Phys. Rev. C 75 (2007) 064901
pub. Au+Au: STAR, Phys. Rev. Lett. 98 (2007) 062301
Cu+Cu: STAR, Phys. Rev. Lett. 108 (2012) 072301

Nuclear Modification Factor

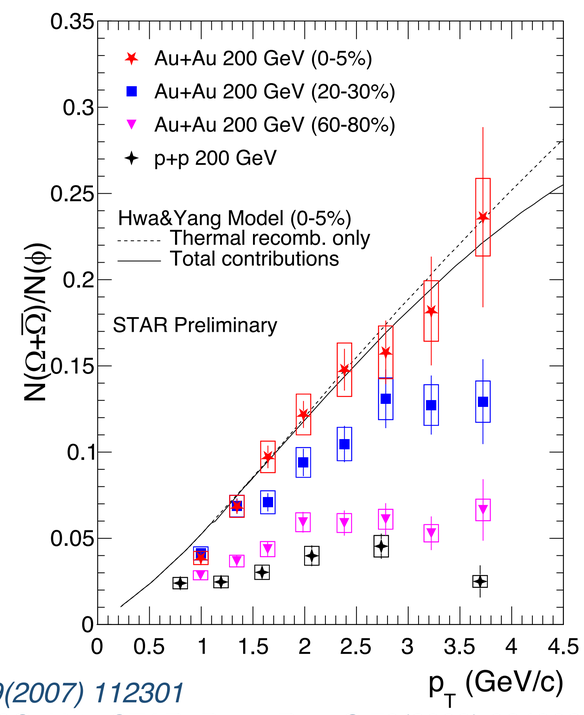
- With the change of p_{T}, R_{CP} of Ω follows the same trend as that of Λ and Ξ, as expected by recombination model.
- The higher R_{CP} of Ω implies the faster increase of Ω yields with the increasing centrality.



$\Omega + \bar{\Omega}$ Run4 & $\Xi + \bar{\Xi}$: STAR, Phys. Rev. Lett. 98 (2007) 062301
$\Lambda + \bar{\Lambda}$: STAR, Phys. Rev. Lett. 92 (2004) 052302
$h^{\pm}$ (charged hadrons): STAR, Phys. Rev. Lett. 91 (2003) 172302

Ω/ϕ Ratio

- At intermediate p_{T}, ratio increases gradually with increasing system size. Significant Ω **enhancement** over ϕ is observed.
- Good agreement between data and calculations from recombination model — **Ω and ϕ are predominantly produced through the recombination of thermalized strange quarks in QGP.**



Ω p_{T} binning adapted to match ϕ data.
Au+Au 200 GeV ϕ: STAR, Phys. Rev. Lett. 99(2007) 112301
p+p 200GeV $\Omega + \bar{\Omega}$: X. Zhu, QM2014; p+p 200GeV ϕ: STAR, Phys. Rev. C 79(2009) 064903
Theory: Phys. Rev. C, 2007, 75: 054904. Calculations are available for central collisions only

Conclusion

- Precise measurement of $\Omega(\bar{\Omega})$ p_{T} spectra and yields in Au+Au collisions at 200 GeV are achieved, with TMVA optimization applied to reduce statistical uncertainties and iTPC upgrade to reduce systematic uncertainties.
- Ω production enhancement compared to p+p is noted through dN/dy yields per participant.
- Nuclear modification factor of Ω follows the hyperon trend.
- Ω-to-ϕ enhancement at intermediate p_{T} is observed and agrees with recombination model calculations at central collisions — **strange quark recombination hadronization**.

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The STAR Collaboration
https://drupal.star.bnl.gov/STAR/presentations