

# Investigating system size dependence of strange hadron production at 200 GeV at STAR

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## Abstract

There are significant discussions in the field about the initial conditions, including the size of the system, needed to generate a quark-gluon plasma (QGP). Strangeness production serves as a sensitive probe into the properties of the QGP. It is expected that the  $\Omega/\phi$  ratios in different colliding systems may reveal the minimum colliding system size required to produce QGP.

In this poster, we will present the transverse-momentum ( $p_T$ ) spectra of strange hadron ( $\phi, \Omega, \bar{\Omega}$ ) in isobar (Ru+Ru and Zr+Zr) and O+O collisions at  $\sqrt{s_{NN}} = 200$  GeV at mid-rapidity ( $|y| < |0.5|$ ) and the  $\Omega/\phi$  ratios in those colliding systems. The O+O system has the extended kinematic coverage benefit from the iTPC upgrade, which extended the rapidity coverage and enhanced the particle identification capability compared with previous results.

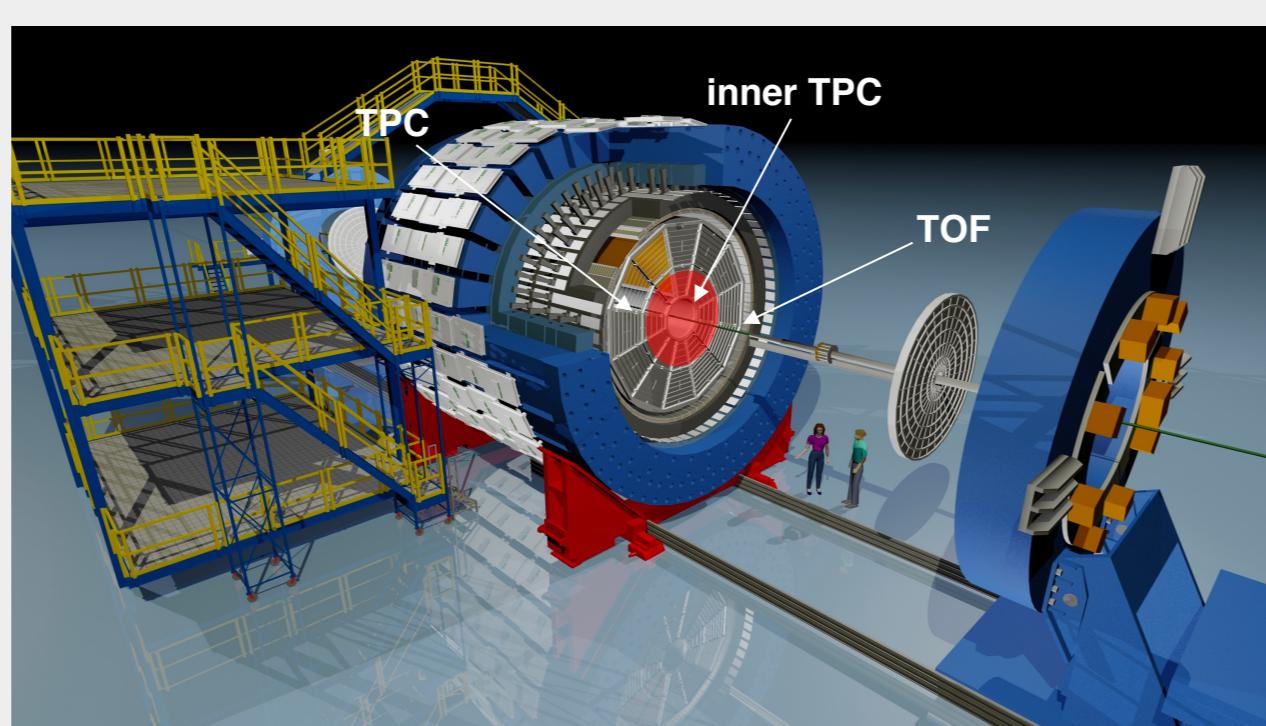
## Motivation

- Update  $\Omega/\phi$  ratio as a function of  $p_T$  in different colliding systems to explore the minimum colliding system size required to produce QGP.
- Precise measurement of  $\Omega(\bar{\Omega})$  yields to investigate the system size dependence of strangeness production.

## STAR Detector

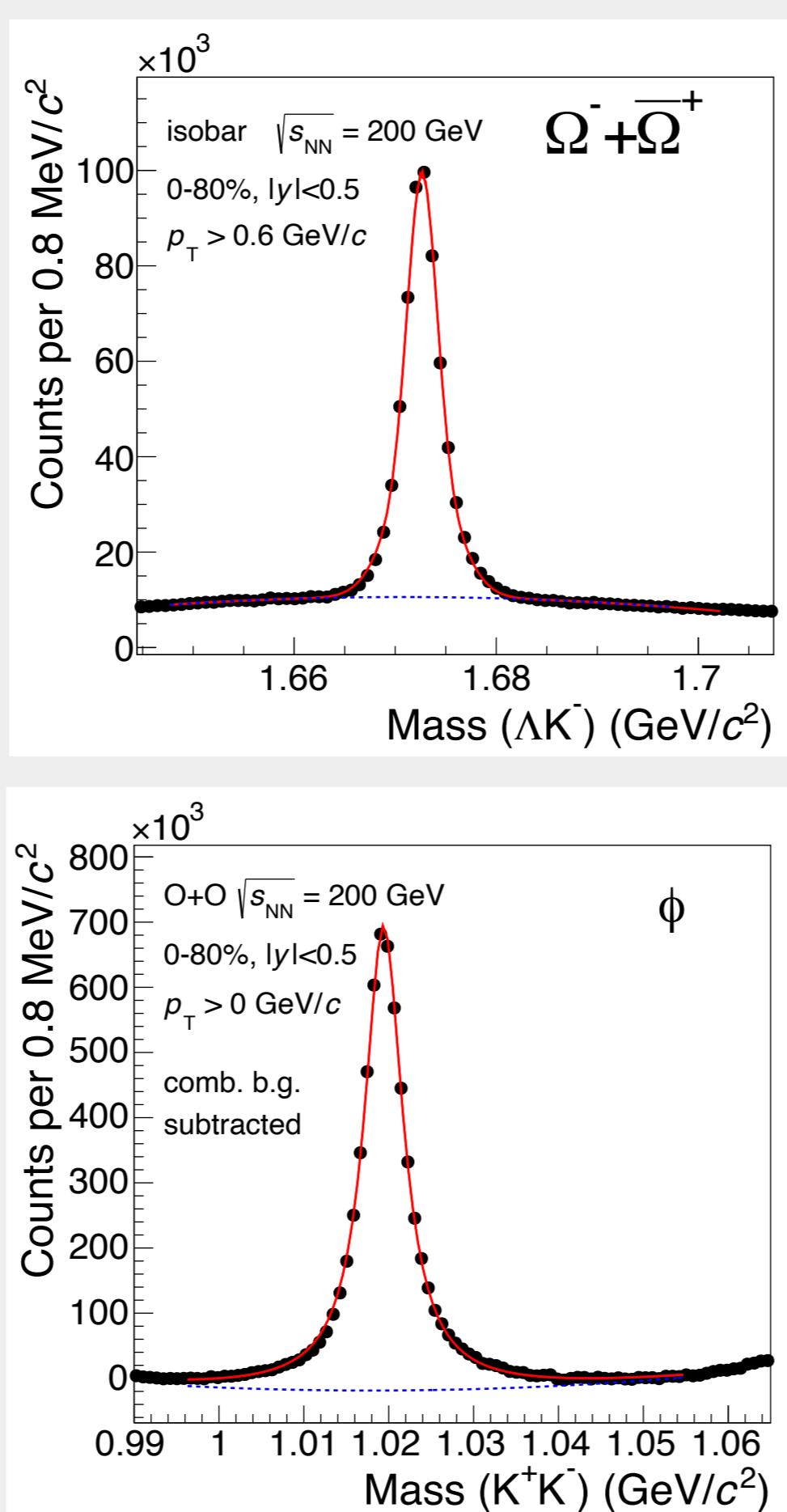
iTPC (STAR Inner Sector TPC Upgrade) :

- Larger rapidity coverage —  $|y|$  from 1.0 to 1.5
- Better PID — improved dE/dx resolution
- Lower  $p_T$  limit — from 125 to 60 MeV/c
- Efficiency of strangeness reconstruction improved significantly



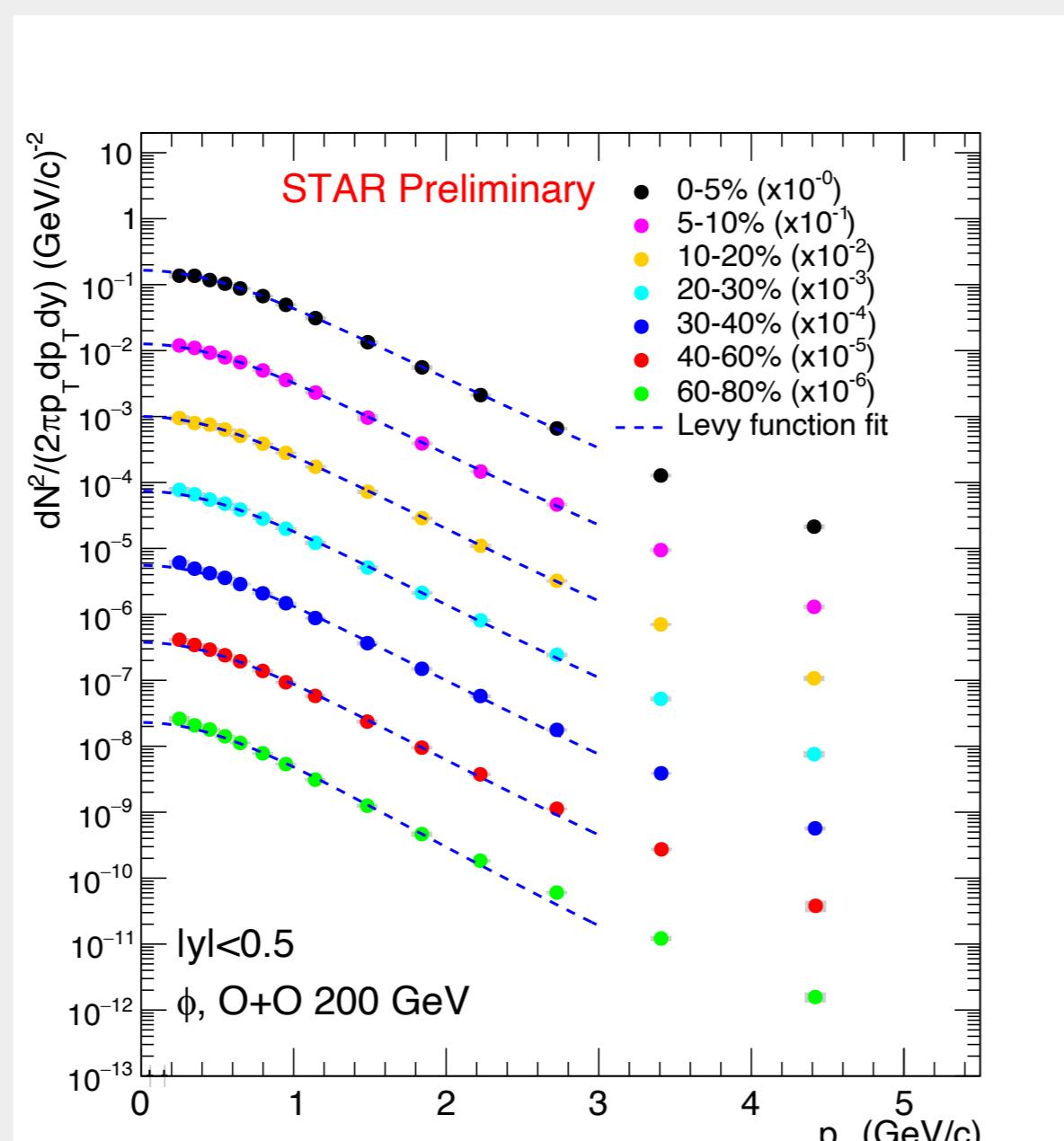
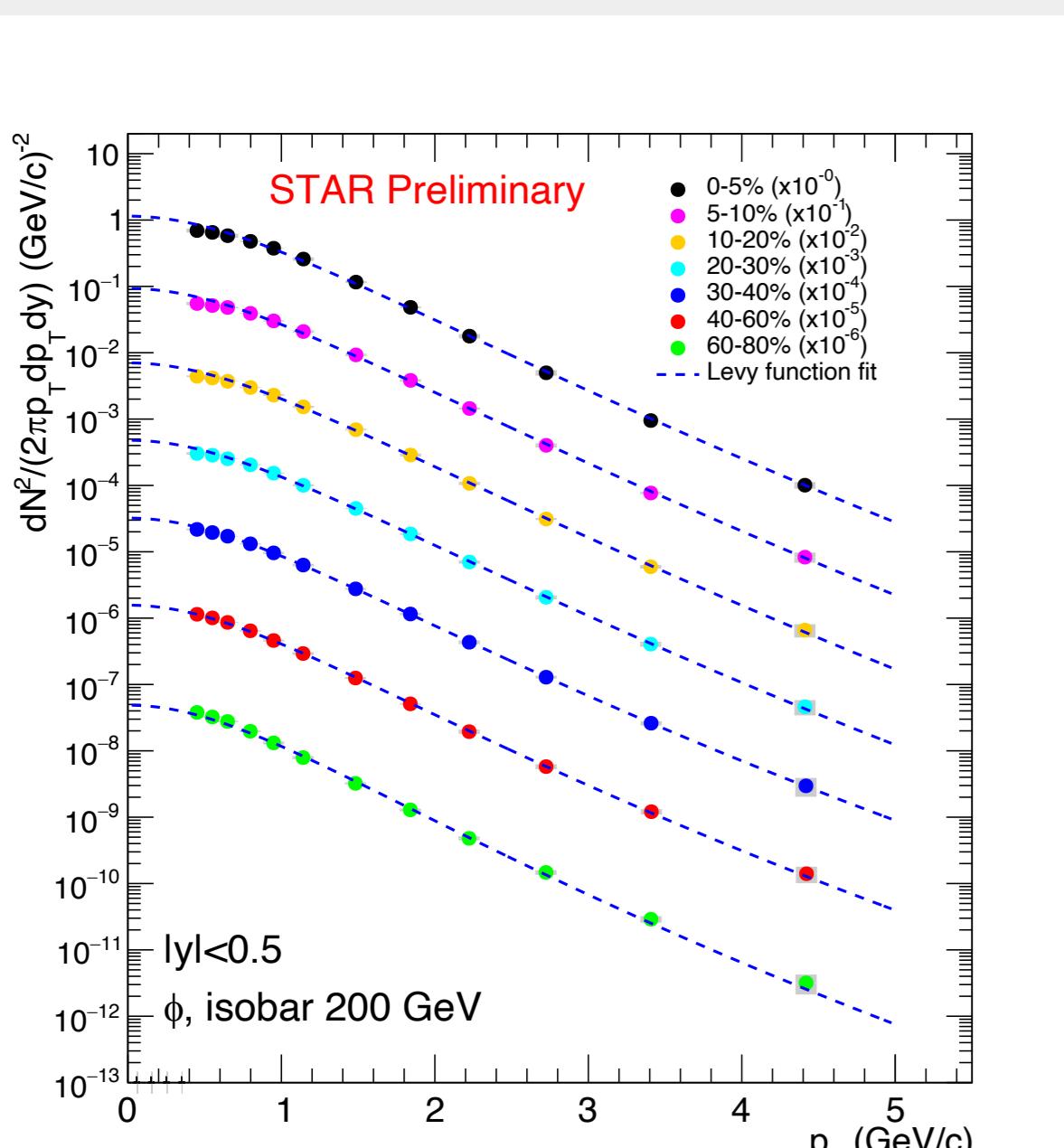
## Analysis

- Dataset: Run18 isobar 200 GeV and Run21 O+O 200 GeV
- $\sim 730M$  minimum bias events for isobar
- $\sim 370M$  minimum bias events for O+O
- Particle identification with TPC(dE/dx) and TOF( $1/\beta$ )
- KFParticle method used in  $\Omega$  reconstruction — efficiency improved at high  $p_T$
- $p_T$  region of  $\Omega$ :  $0.8 \sim 4.6$  GeV/c
- $p_T$  region of  $\phi$ :  $0.4 \sim 5.0$  GeV/c
- Signal extraction: rotational (for  $\Omega$ ) and mix-event (for  $\phi$ ) for combinational background, polynomial fit for residual background & double gaussian fit for signal



## $\phi$ Meson $p_T$ Spectra

- Precise measurement for 7 centrality (parameter indicating how central the event is) bins
- Maximum  $p_T \sim 4.5$  GeV/c



Supported in part by the

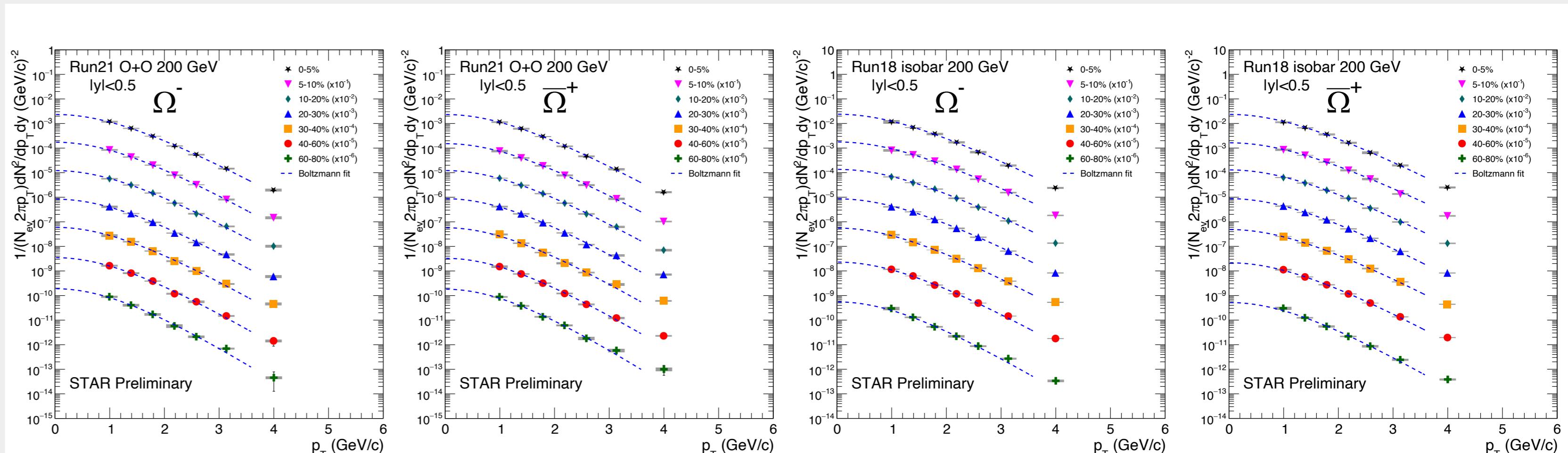
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## $\Omega$ Baryon $p_T$ Spectra

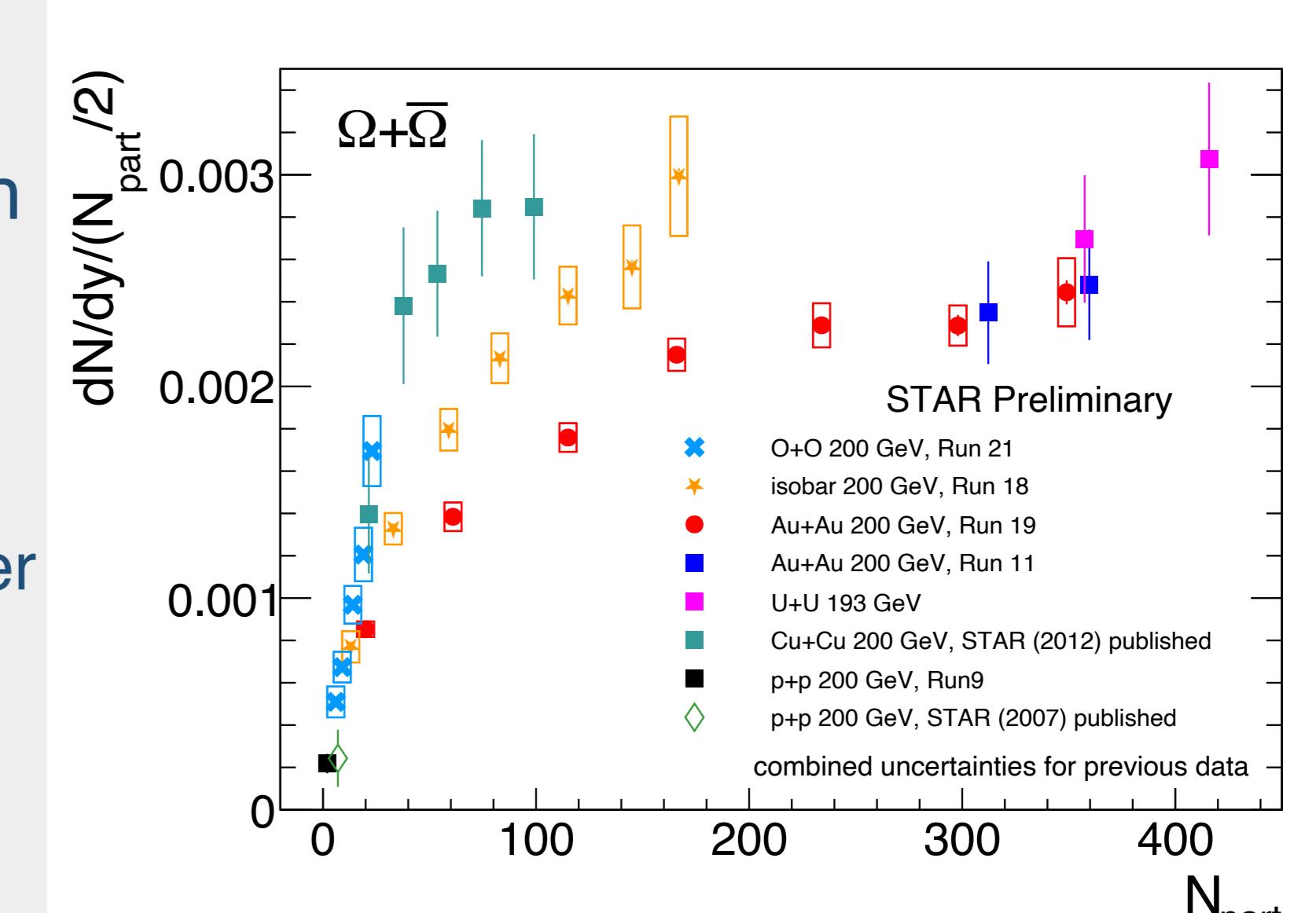
- Precise measurement for 7 centrality bins
- Maximum  $p_T \sim 4$  GeV/c
- Fraction of the integral yield covered by the measured data points:  $62 \sim 70\%$



## dN/dy Yields

- $N_{part}$  scaled  $\Omega$  yields increase faster with the increasing  $N_{part}$  from large (Au+Au) towards small (O+O) systems.
- May result from higher  $N_{coll}$  (number of binary collisions) corresponding to the same  $N_{part}$  in smaller systems.

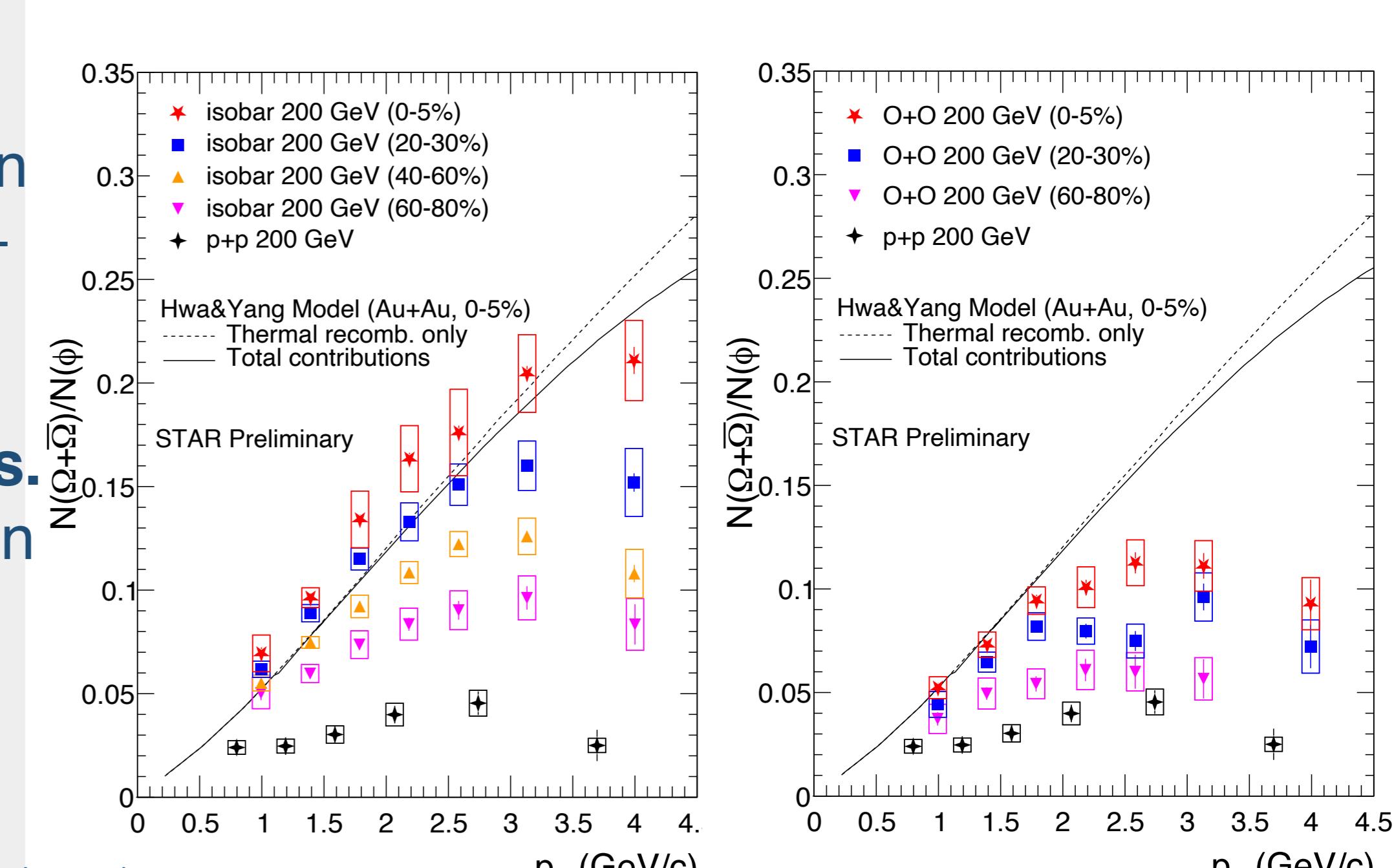
Run11 data points  $N_{part}$  shifted for clarity  
 $p+p$ : STAR, Phys. Rev. C 75 (2007) 064901  
 $Cu+Cu$ : STAR, Phys. Rev. Lett. 108 (2012) 072301



## $\Omega/\phi$ Ratio

- Significant  $\Omega$  over  $\phi$  enhancement observed in central isobar collisions — compatible with the **existence of QGP in central isobar collisions**.
- Moderate enhancement in central O+O, consistent with 40-60% isobar (similar  $N_{part} \sim 30$ ).

$p+p$  200 GeV  $\Omega$  and  $\bar{\Omega}$ : X. Zhu, QM2014;  
 $p+p$  200 GeV  $\phi$ : STAR, Phys. Rev. C 79(2009) 064903  
Theory: Phys. Rev. C, 2007, 75: 054904.



## Summary and Outlook

- Precise measurement of  $\phi, \Omega, \bar{\Omega}$   $p_T$  spectra and  $\Omega, \bar{\Omega}$  yields in isobar and O+O collisions at 200 GeV are achieved.
- $N_{part}$  scaled  $\Omega$  yield increases faster with the increasing  $N_{part}$  from large (Au+Au) towards small (O+O) system.
- Significant  $\Omega$  over  $\phi$  enhancement at intermediate  $p_T$  is observed in central isobar collisions — compatible with the **existence of QGP in central isobar collisions**.
- Moderate  $\Omega$  over  $\phi$  enhancement in central O+O is observed, consistent with 40-60% isobar, where  $N_{part}$  is similar  $\sim 30$ ; analysis with high-multiplicity triggered O+O events is ongoing.



The STAR  
Collaboration