

### Abstract

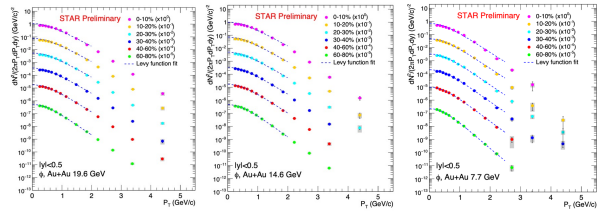
$\phi$  has relatively small hadronic interaction cross sections and it can be used to study the properties of nuclear medium at the early stage. The recombination model indicates that the  $\Omega/\phi$  ratio will be enhanced at low and medium transverse momentum ( $p_T$ ), where thermal strange quarks dominate the production of  $\Omega$  and  $\phi$  in the QGP. Therefore, the multi-strange baryon-to-meson ratio  $\Omega(sss)/\phi(s\bar{s})$  is proposed to be a sensitive probe for studying the onset of deconfinement. Because the STAR Beam Energy Scan Phase II (BES II) program has 10 times larger data size than BES I and explore the QCD phase diagram in a region which may cover the potential critical point, it offers us a great opportunity to investigate collision energy and system size dependence of  $\phi$  production in heavy-ion collisions.

In this poster, we present new measurements on  $p_T$  spectra, centrality dependence of  $\phi$  production yields ( $dN/dy$ ), resonance to non-resonance yield ratio ( $\phi/K^-$ ), nuclear modification factor ( $R_{CP}$ ), the rapidity spectra and  $\Omega(sss)/\phi(s\bar{s})$  ratio in Au+Au collisions at  $\sqrt{s_{NN}} = 7.7, 14.6$  and  $19.6$  GeV. Physics implications of these measurements will be discussed.

### Motivation

- $\phi$  has relatively small hadronic interaction cross sections and it can be used to study the QGP dynamics with partonic degrees-of-freedom
- $\phi/K^-$  ratio and its energy dependence: differentiate between grand canonical vs. canonical ensembles
- Yield: measure strangeness enhancement and probe the onset of deconfinement
- $R_{CP}$ : study the nuclear modification effects
- $\Omega(sss)/\phi(s\bar{s})$  ratio: study the onset of deconfinement

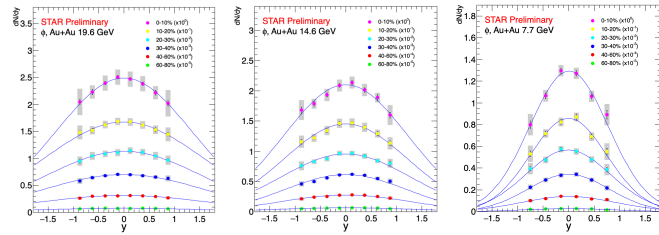
### $p_T$ spectra in Au+Au at $\sqrt{s_{NN}} = 19.6, 14.6$ and $7.7$ GeV



- $p_T$  integrated  $dN/dy$  is obtained by summing the data points in the measured region and the integral of the Levy fit functions in the unmeasured region

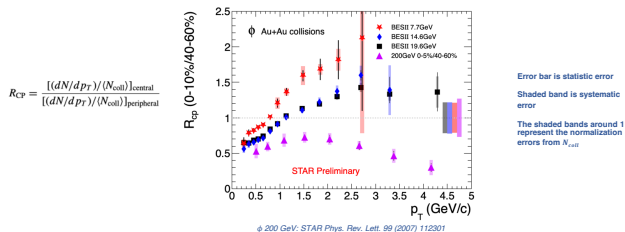
### Rapidity spectra in Au+Au at $\sqrt{s_{NN}} = 19.6, 14.6$ and $7.7$ GeV

- A Gaussian function fits the rapidity spectra well



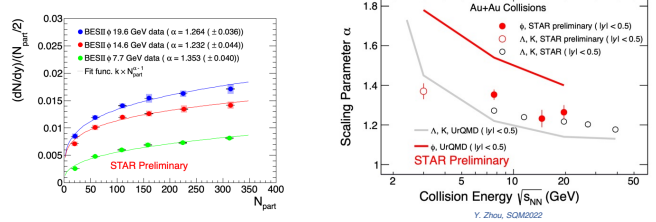
### Nuclear modification factor ( $R_{CP}$ )

- $R_{CP} < 1$  for higher  $p_T$  at  $\sqrt{s_{NN}} = 200$  GeV  $\rightarrow$  Partonic energy loss in the QGP medium
- $R_{CP} > 1$  for higher  $p_T$  at  $\sqrt{s_{NN}} = 19.6$  GeV and lower energies  $\rightarrow$  Cronin-type interactions, radial flow and/or coalescence hadronization



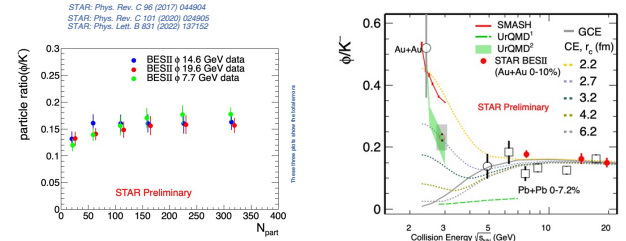
### Centrality dependence of $\phi$ yields ( $dN/dy$ )

- $(dN/dy)/(N_{part}/2) = k \times N_{part}^{\alpha-1}$
- $\alpha$  parameter for  $\phi$  is slightly larger than that for  $\Lambda, K$  and less than UrQMD predictions



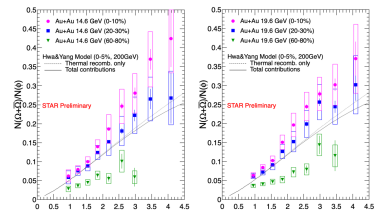
### Centrality and Energy dependence of $\phi/K^-$ ratio

- $\phi/K^-$  ratio has no obvious centrality and energy dependence from  $\sqrt{s_{NN}} = 7.7$  to  $19.6$  GeV
- $\phi/K^-$  ratio reaches the GCE limit at  $\sqrt{s_{NN}} = 7.7, 14.6$  and  $19.6$  GeV



### $\Omega(sss)/\phi(s\bar{s})$ ratio

- Similar to the observation at  $\sqrt{s_{NN}} = 200$  GeV, the  $\Omega/\phi$  ratio is enhanced from peripheral to central collisions at low and medium  $p_T$ , which indicates the existence of QGP above  $\sqrt{s_{NN}} = 14.6$  GeV



### Summary

- The  $p_T$ , centrality and rapidity dependences of  $\phi$  production at  $\sqrt{s_{NN}} = 7.7, 14.6$  and  $19.6$  GeV have been presented
- Hadronic transport model UrQMD cannot describe centrality dependence well from  $\sqrt{s_{NN}} = 7.7$  to  $19.6$  GeV
- For  $\phi/K^-$  ratio, both GCE and CE calculations agree with data from  $\sqrt{s_{NN}} = 7.7$  to  $19.6$  GeV
- The  $\phi R_{CP}$  at low energies shows the radial flow and quark coalescence effects
- The  $\Omega(sss)/\phi(s\bar{s})$  ratio favors the existence of QGP signals above  $\sqrt{s_{NN}} = 14.6$  GeV

### Outlook

- The measurements in other BESII datasets at different energies will be conducted