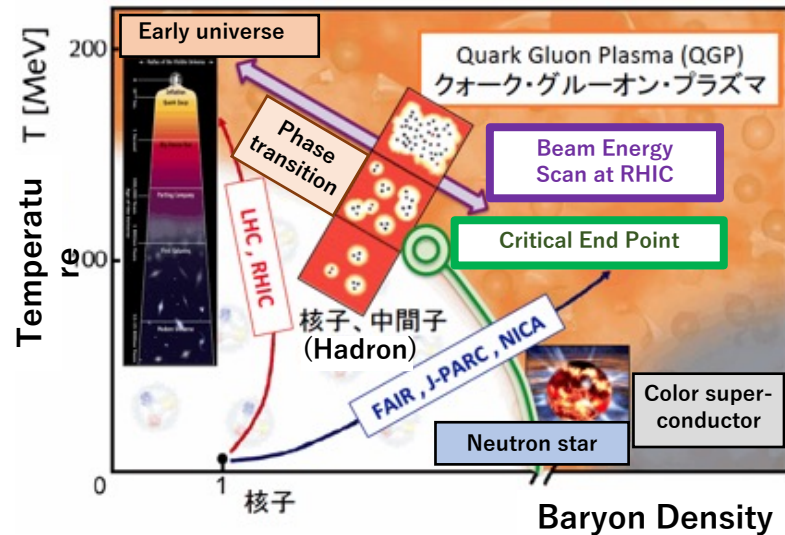


STAR BES and HADES results on Fluctuation and Correlation

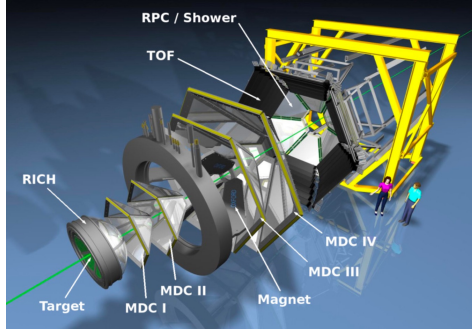
Shinichi Esumi

Institute of Physics, University of Tsukuba

Tomonaga Center for the History of the Universe (TCHoU)



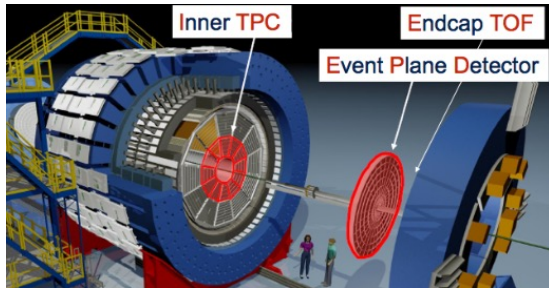
- HADES and STAR measurements
- Experimental pile-up removal and/or correction
- Tracking efficiency corrections
- Centrality determination and volume fluctuation
- Acceptance and beam energy dependence



PHYSICAL REVIEW C **102**, 024914 (2020)

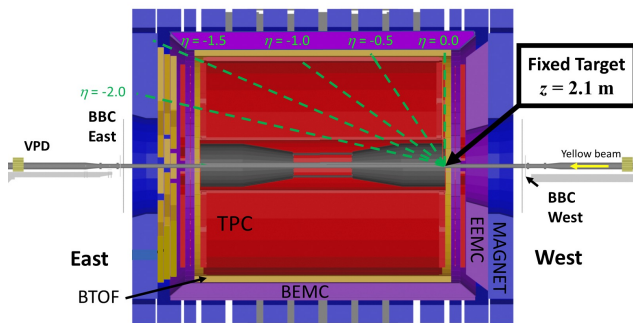
Editors' Suggestion

Proton-number fluctuations in $\sqrt{s_{NN}} = 2.4$ GeV Au + Au collisions studied with the High-Acceptance DiElectron Spectrometer (HADES)



PHYSICAL REVIEW C **104**, 024902 (2021)

Cumulants and correlation functions of net-proton, proton, and antiproton multiplicity distributions in Au+Au collisions at energies available at the BNL Relativistic Heavy Ion Collider



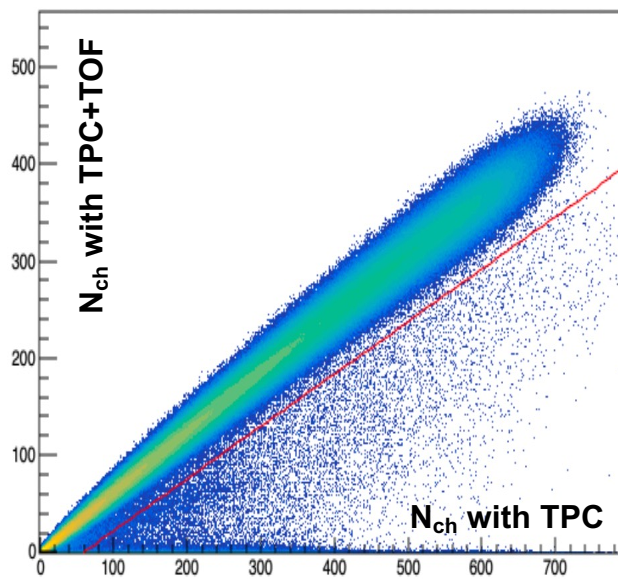
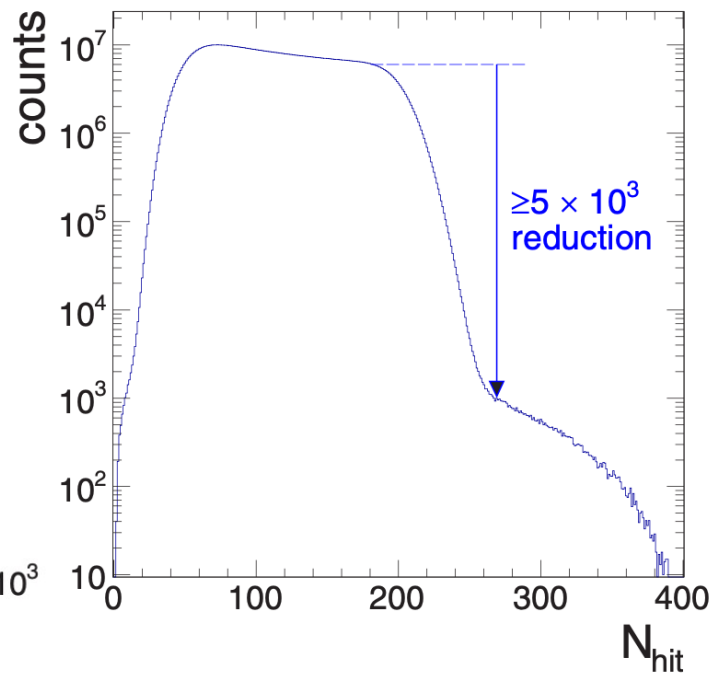
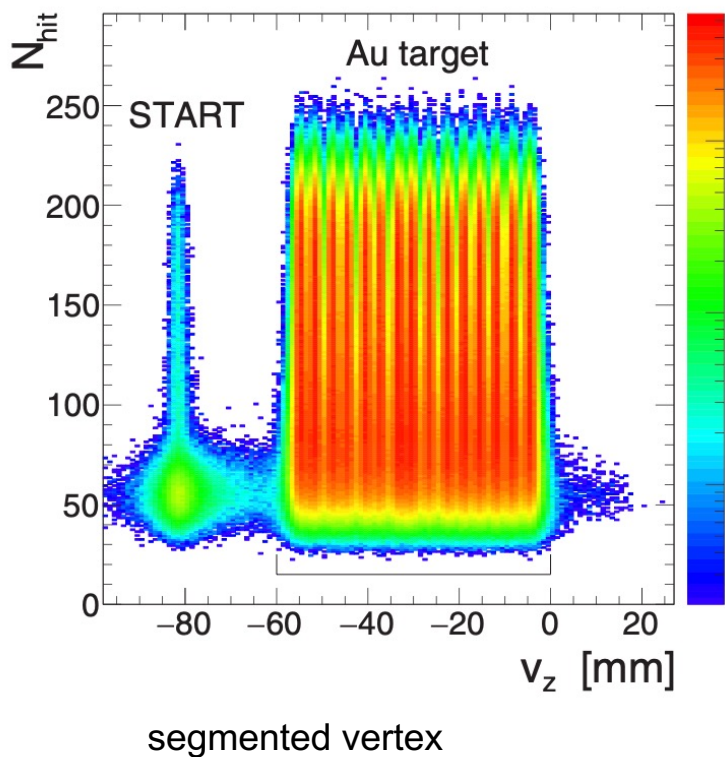
PHYSICAL REVIEW C **107**, 024908 (2023)

Editors' Suggestion

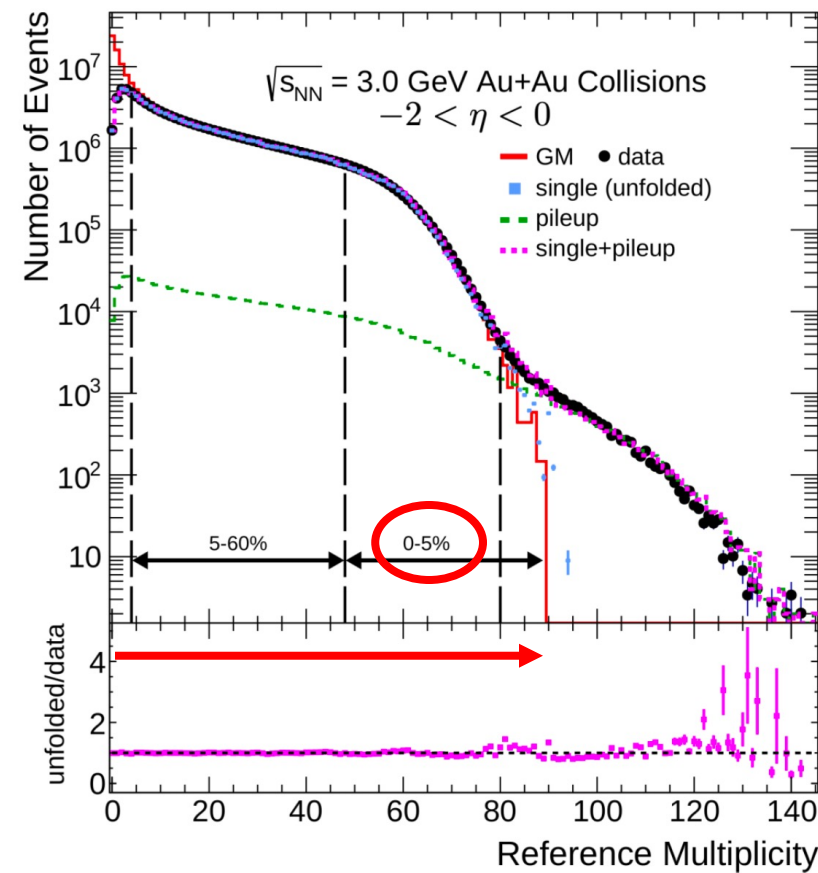
Higher-order cumulants and correlation functions of proton multiplicity distributions in $\sqrt{s_{NN}} = 3$ GeV Au+Au collisions at the RHIC STAR experiment

Pile-up events from high rate measurements

Au+Au 2.4 GeV HADES



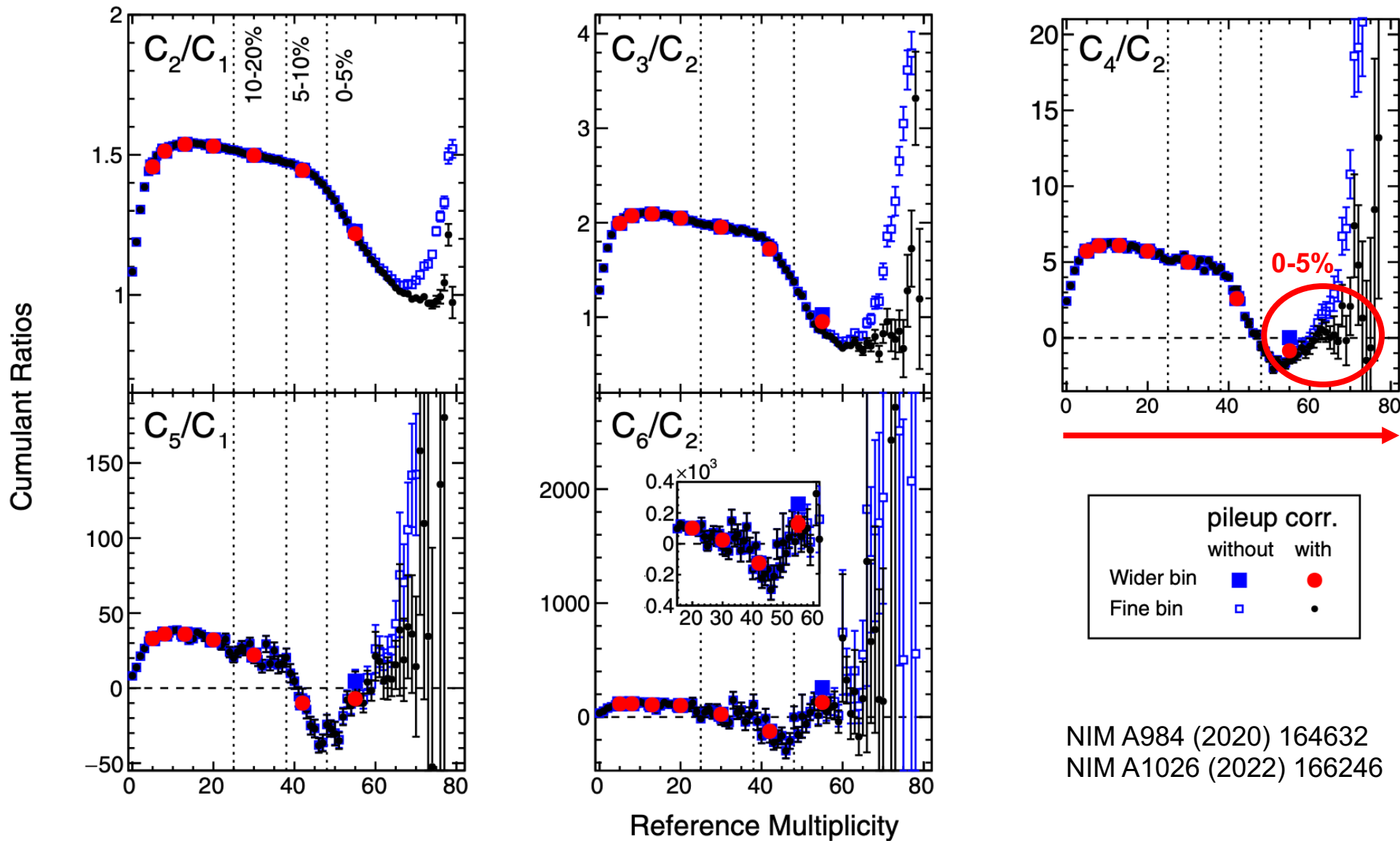
Au+Au 3 GeV STAR



- with/without TOF hit requirement
- Pile-up correction (next slide)

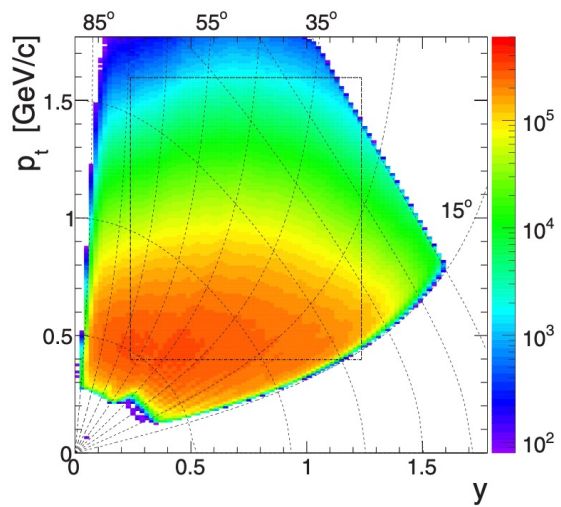
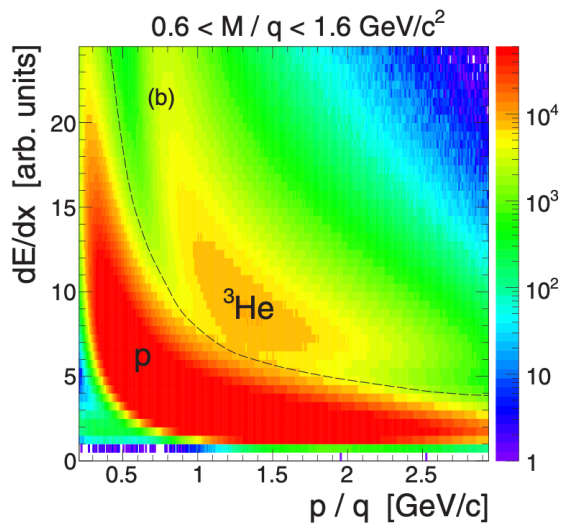
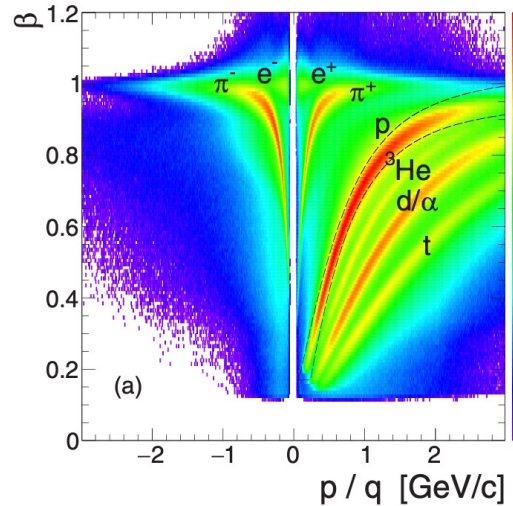
Au+Au 27 GeV STAR

With/without pile-up correction on cumulant ratio

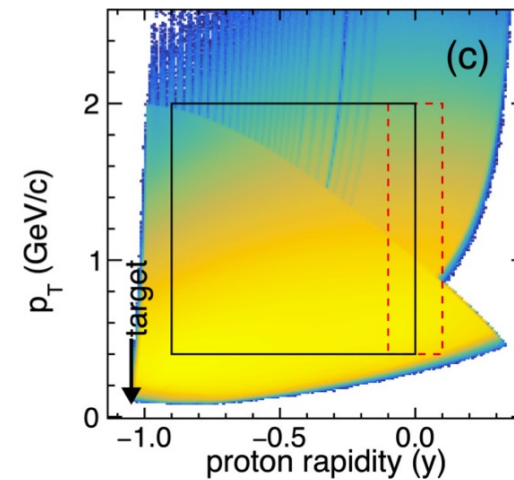
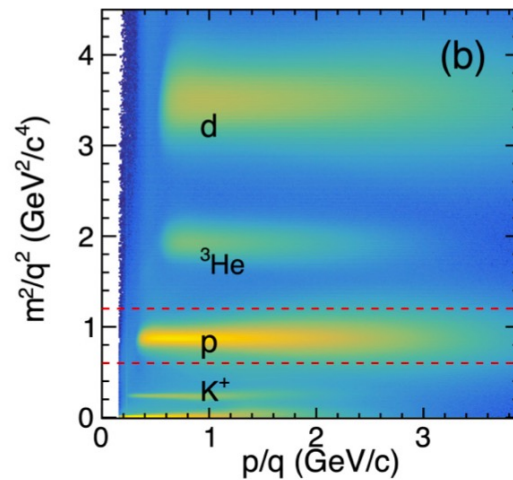
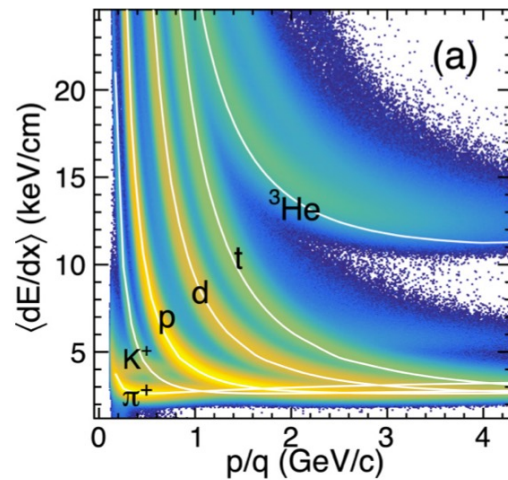


Particle identification and acceptance

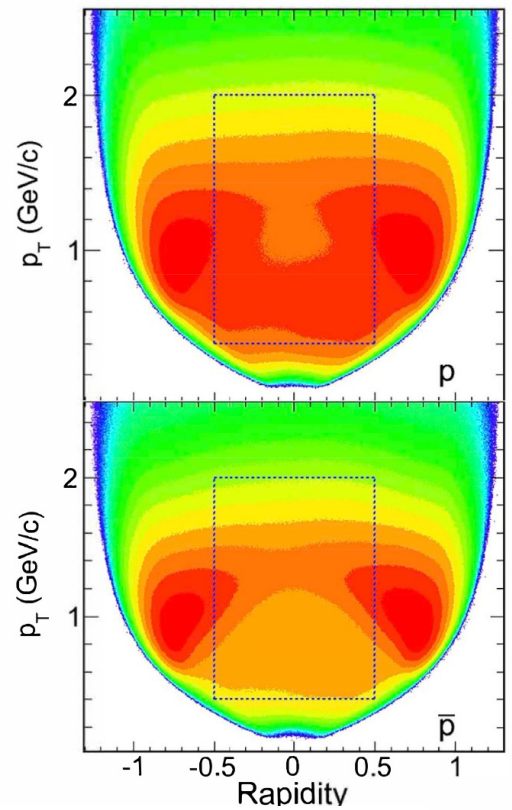
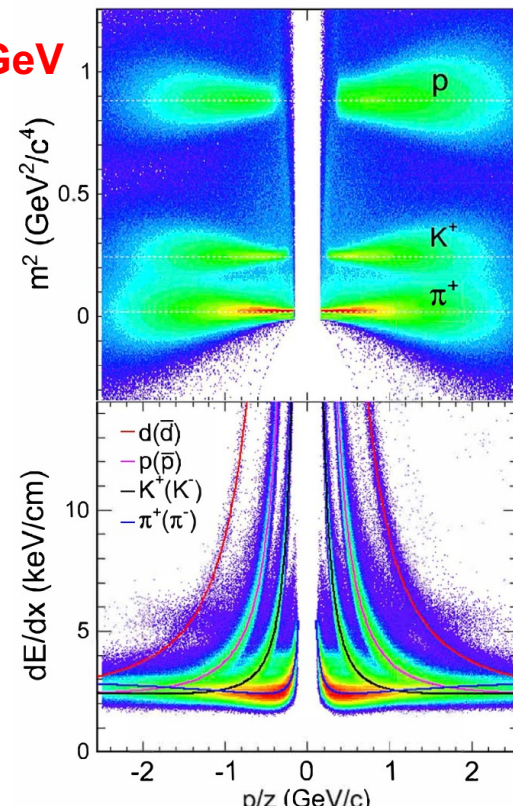
Au+Au 2.4 GeV HADES



Au+Au 3 GeV STAR

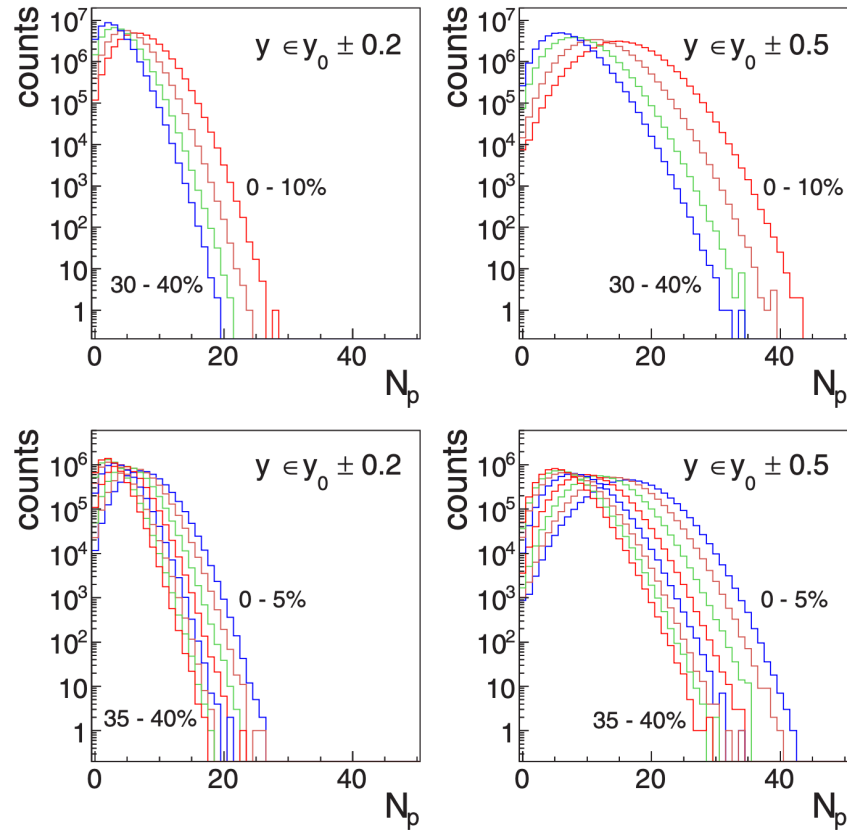


Au+Au 39 GeV STAR

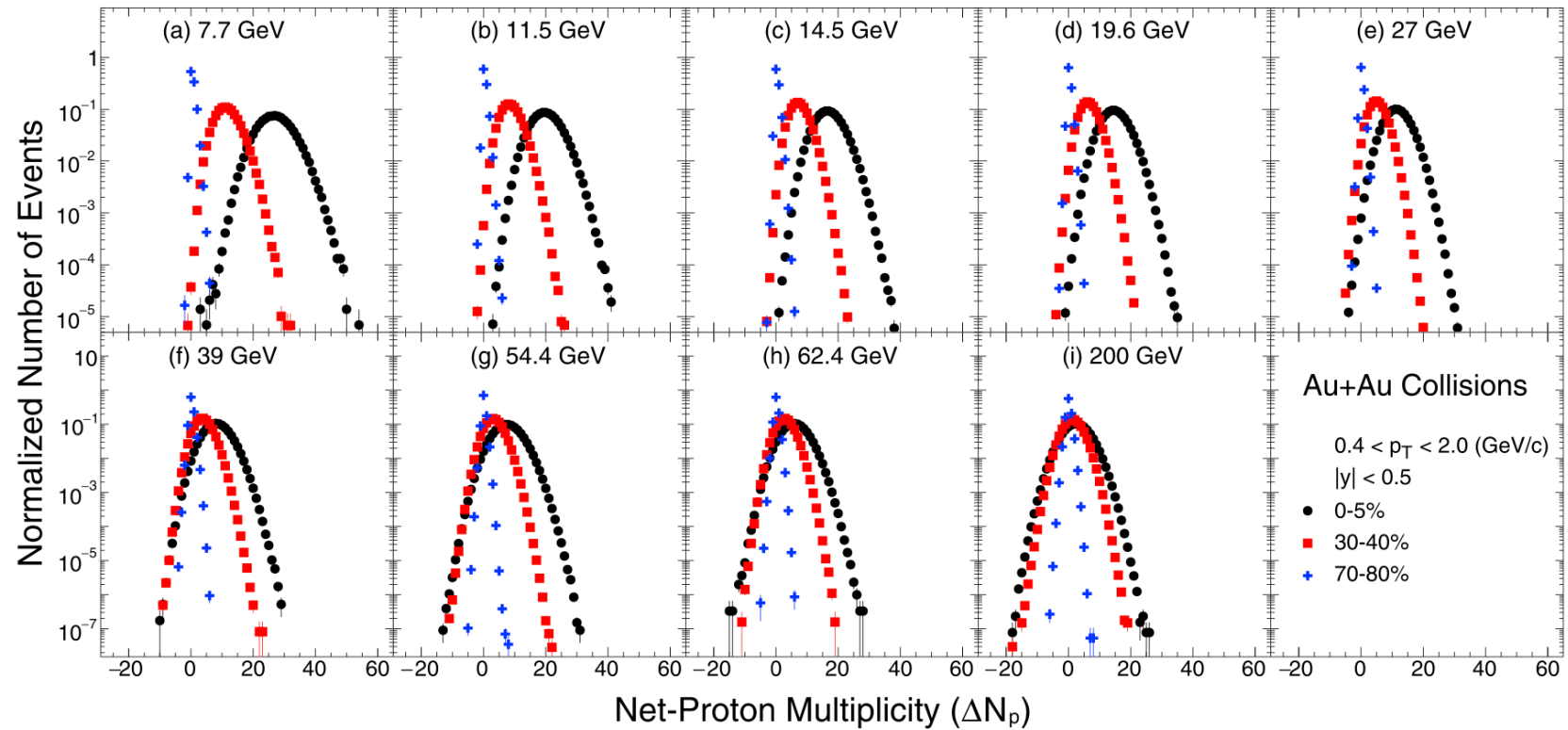


Measured (un-corrected) (net-) proton distribution

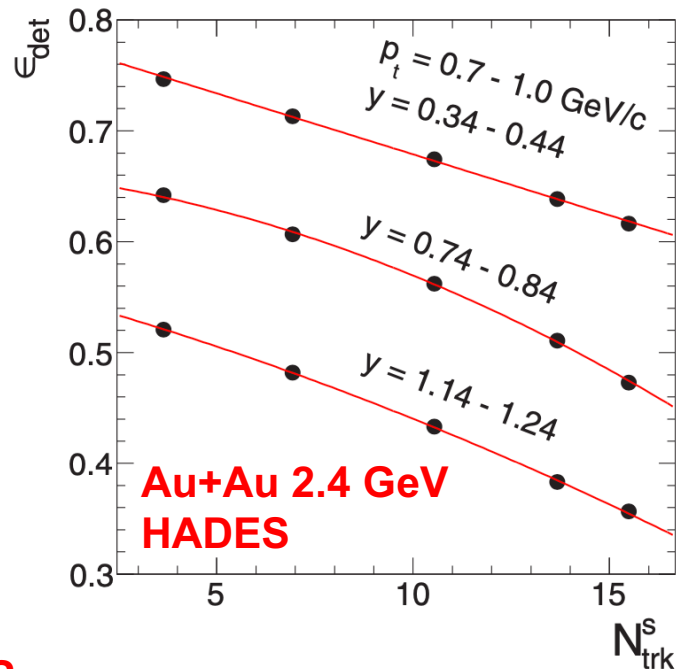
Au+Au 2.4 GeV HADES



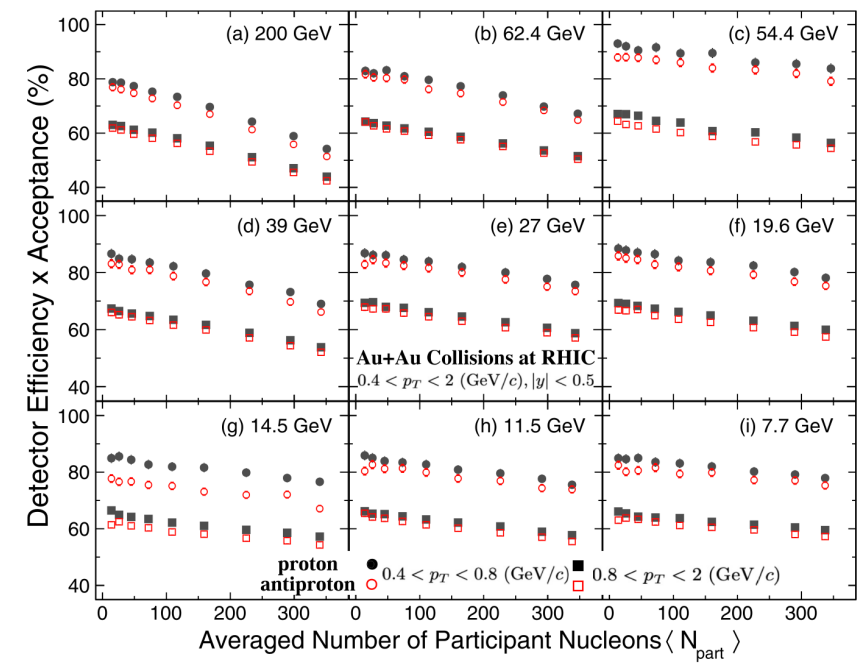
STAR BES1



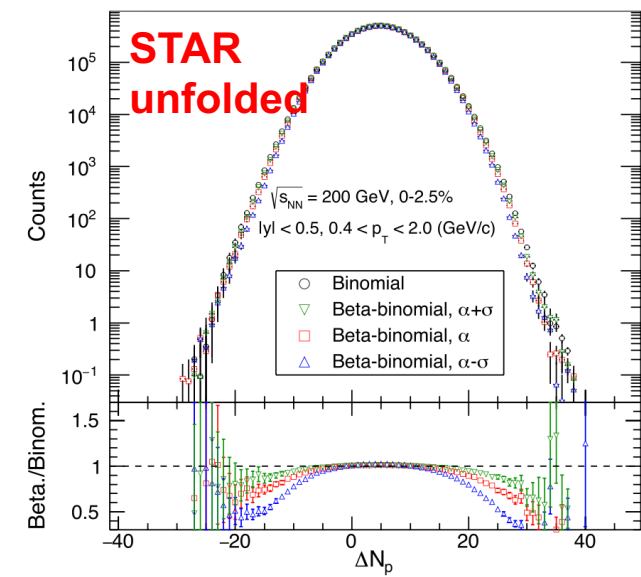
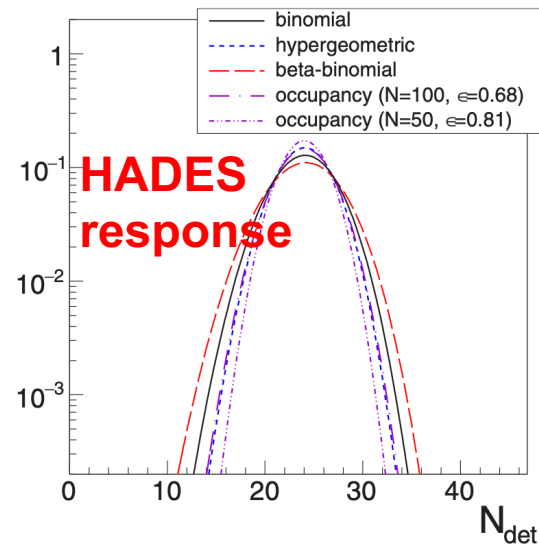
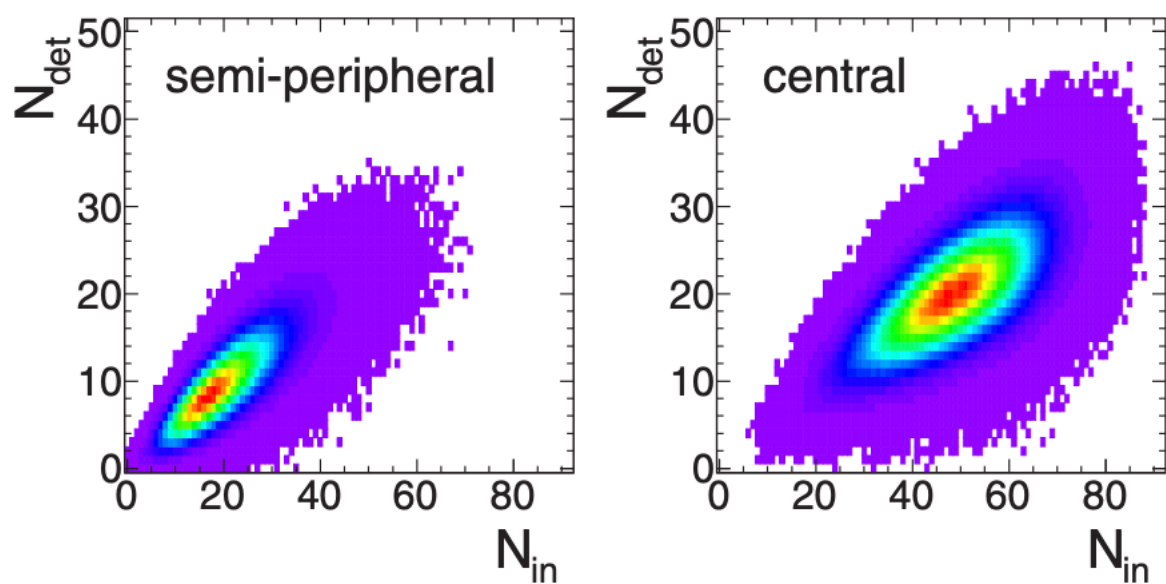
Tracking efficiency and response matrix for unfolding correction



STAR BES1

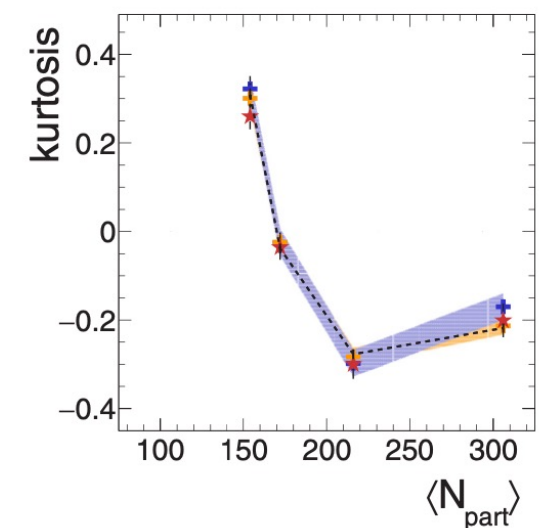
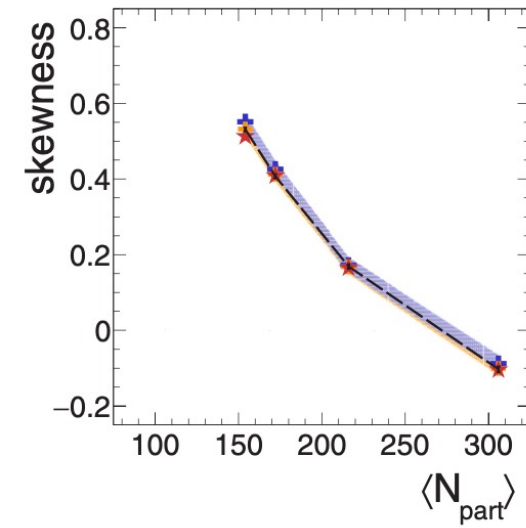
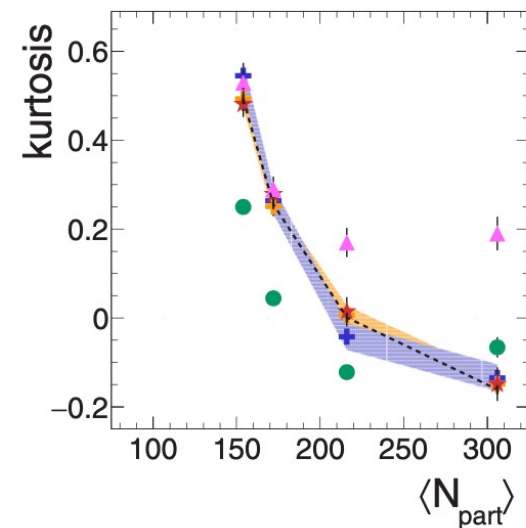
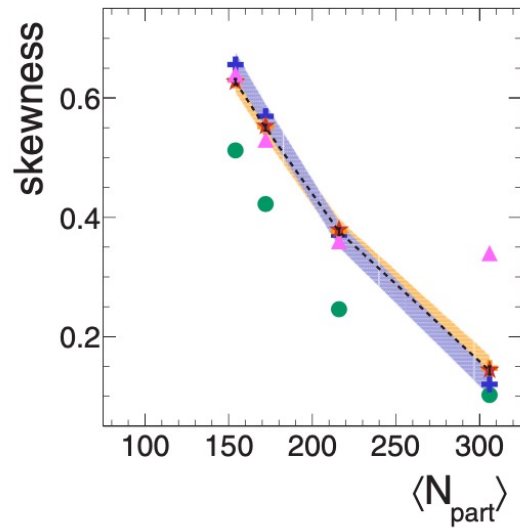
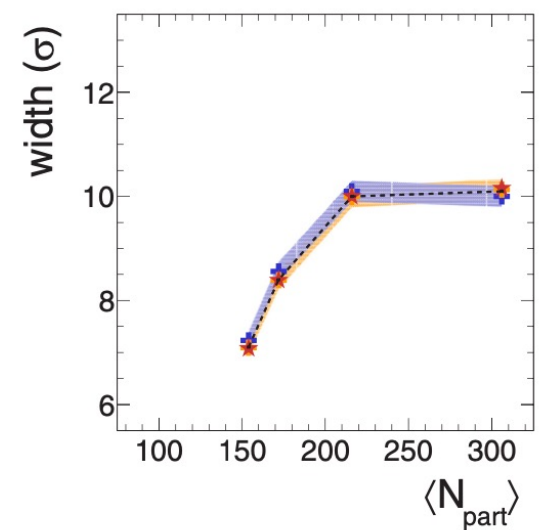
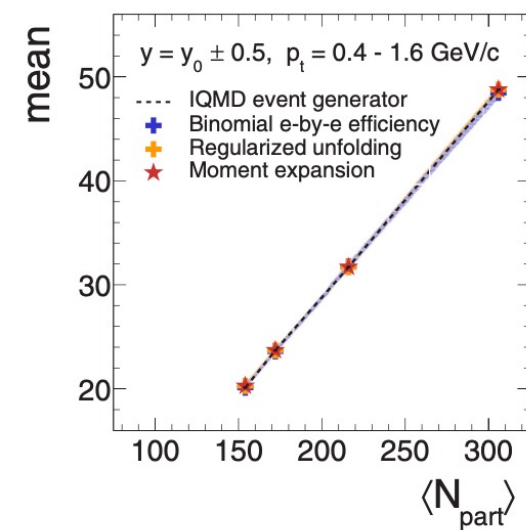
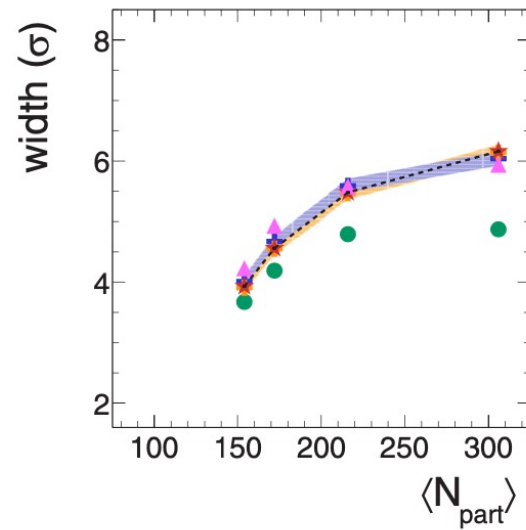
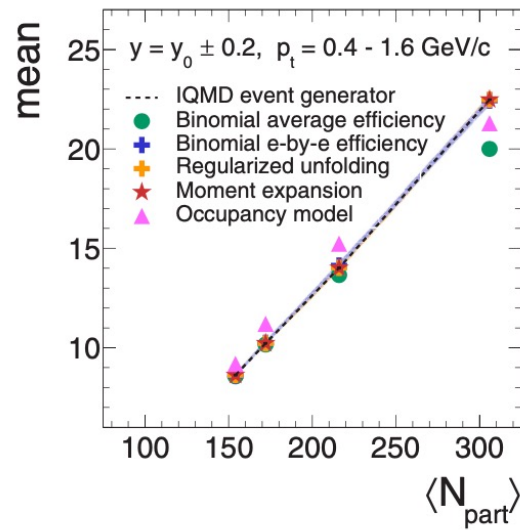


Au+Au 2.4 GeV HADES



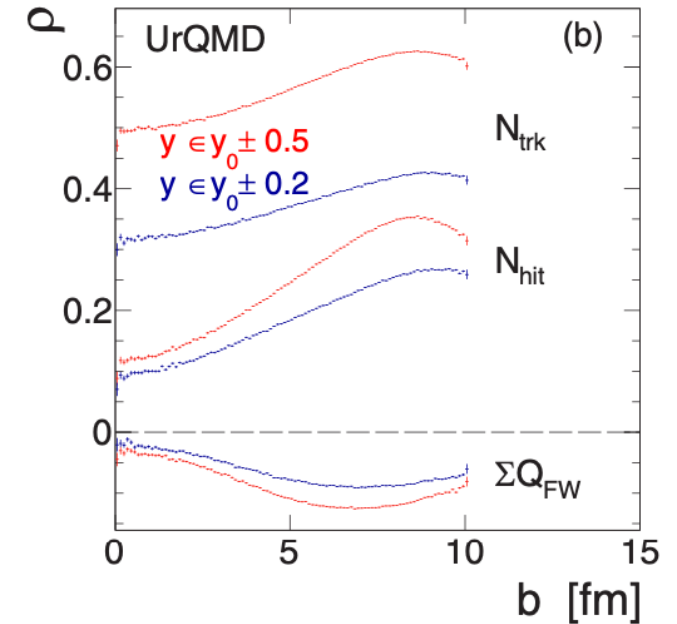
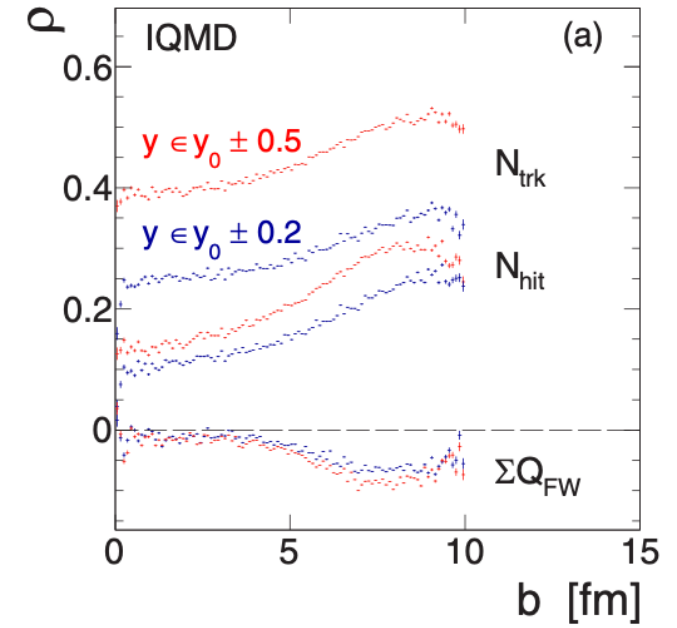
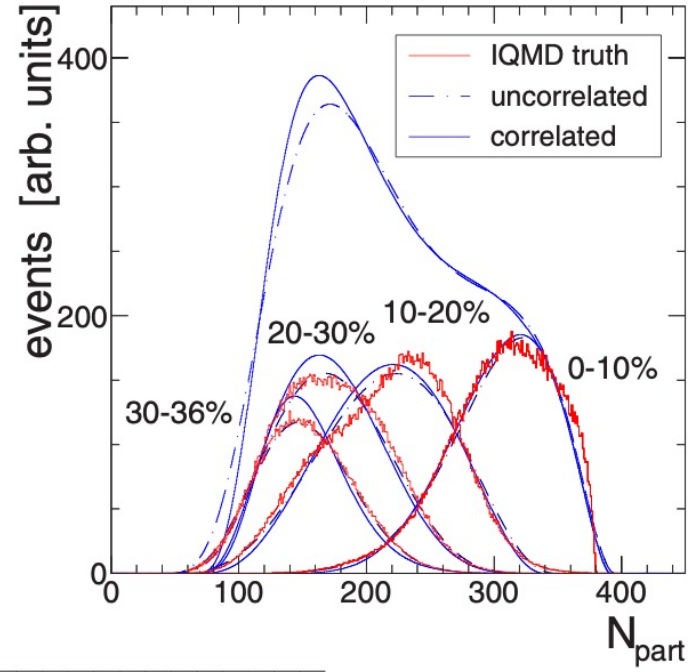
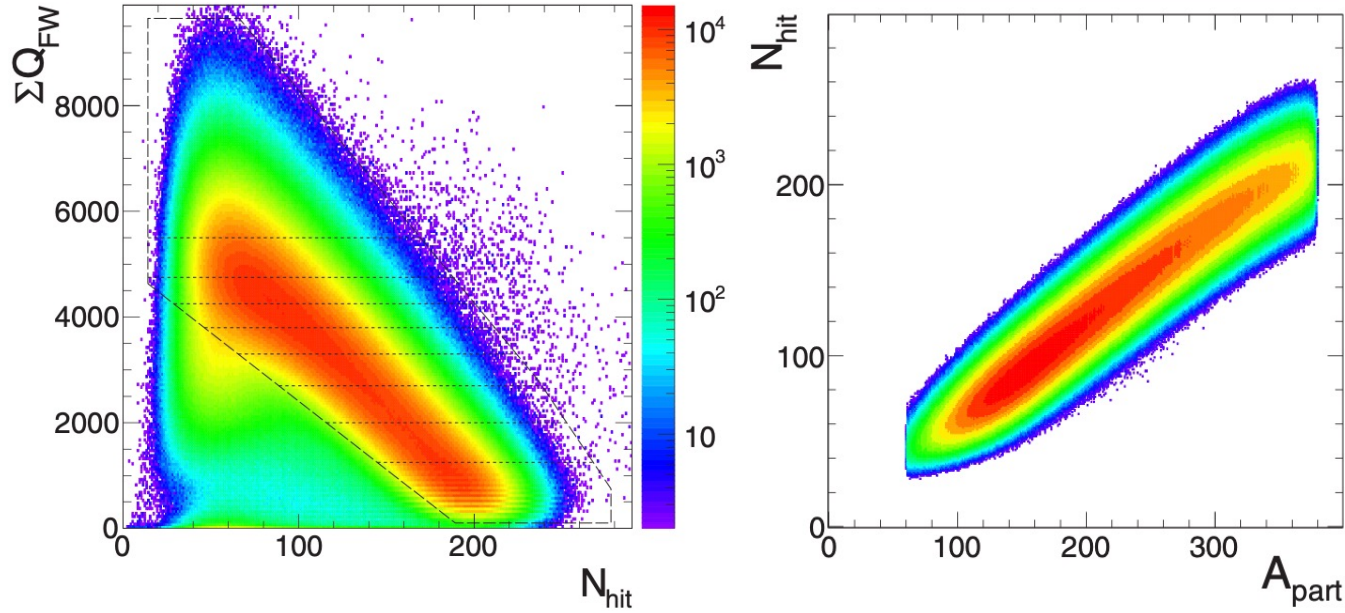
Test of efficiency corrections in HADES

non-binomial correction models seem to work well in HADES sim.



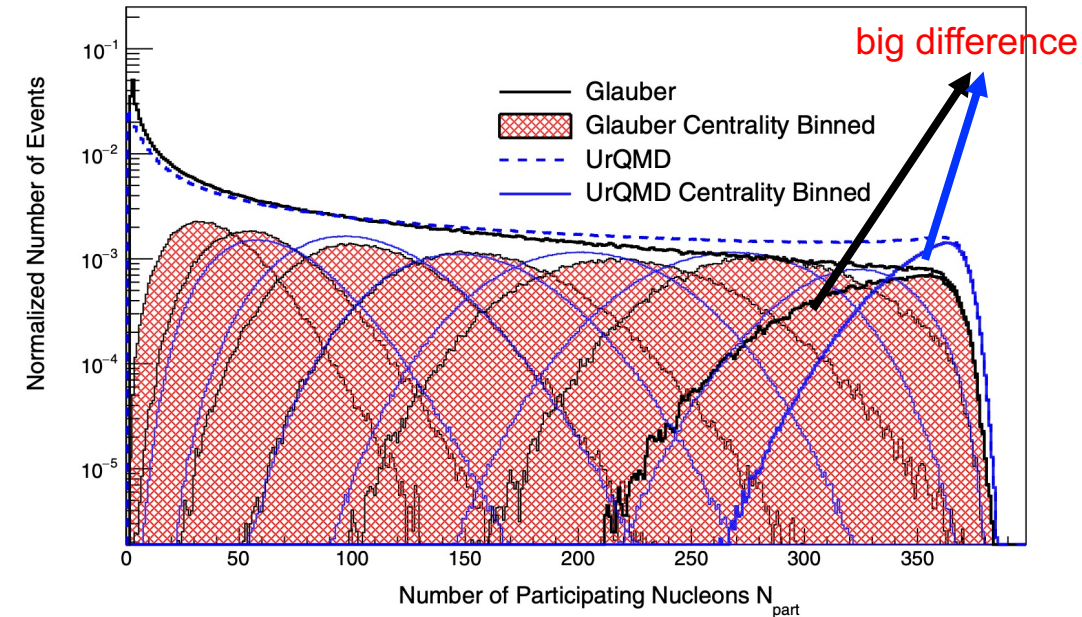
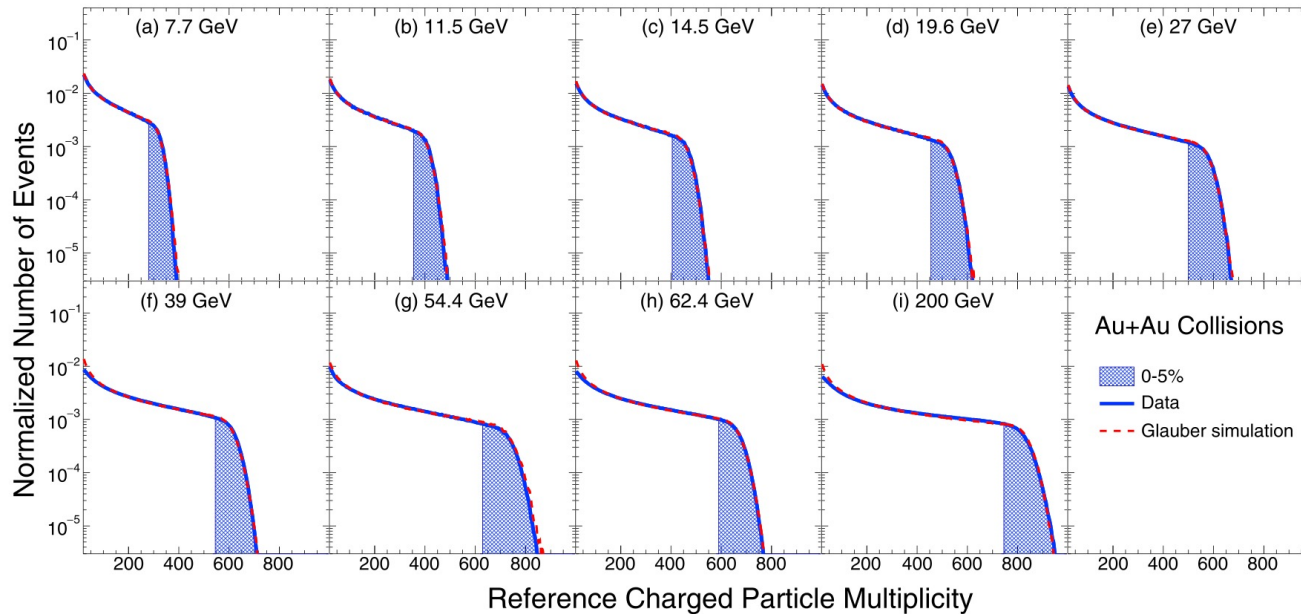
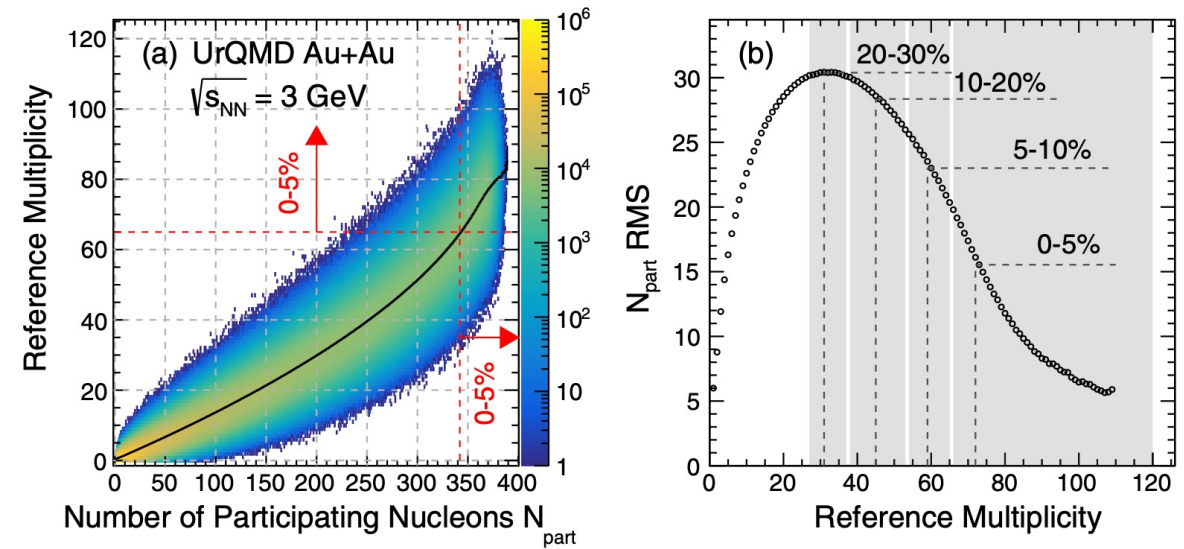
Centrality determination in HADES experiment

$\rho(N_{\text{prot}}, \Sigma Q_{\text{FW}})$. Unfortunately, such a complete model is not yet at hand, and we have hence taken the pragmatic approach to (1) use the centrality selector with lowest correlations and (2) modify the volume cumulants based on the resulting N_{hit} distributions such as to express the correlation-affected N_{part} distributions.

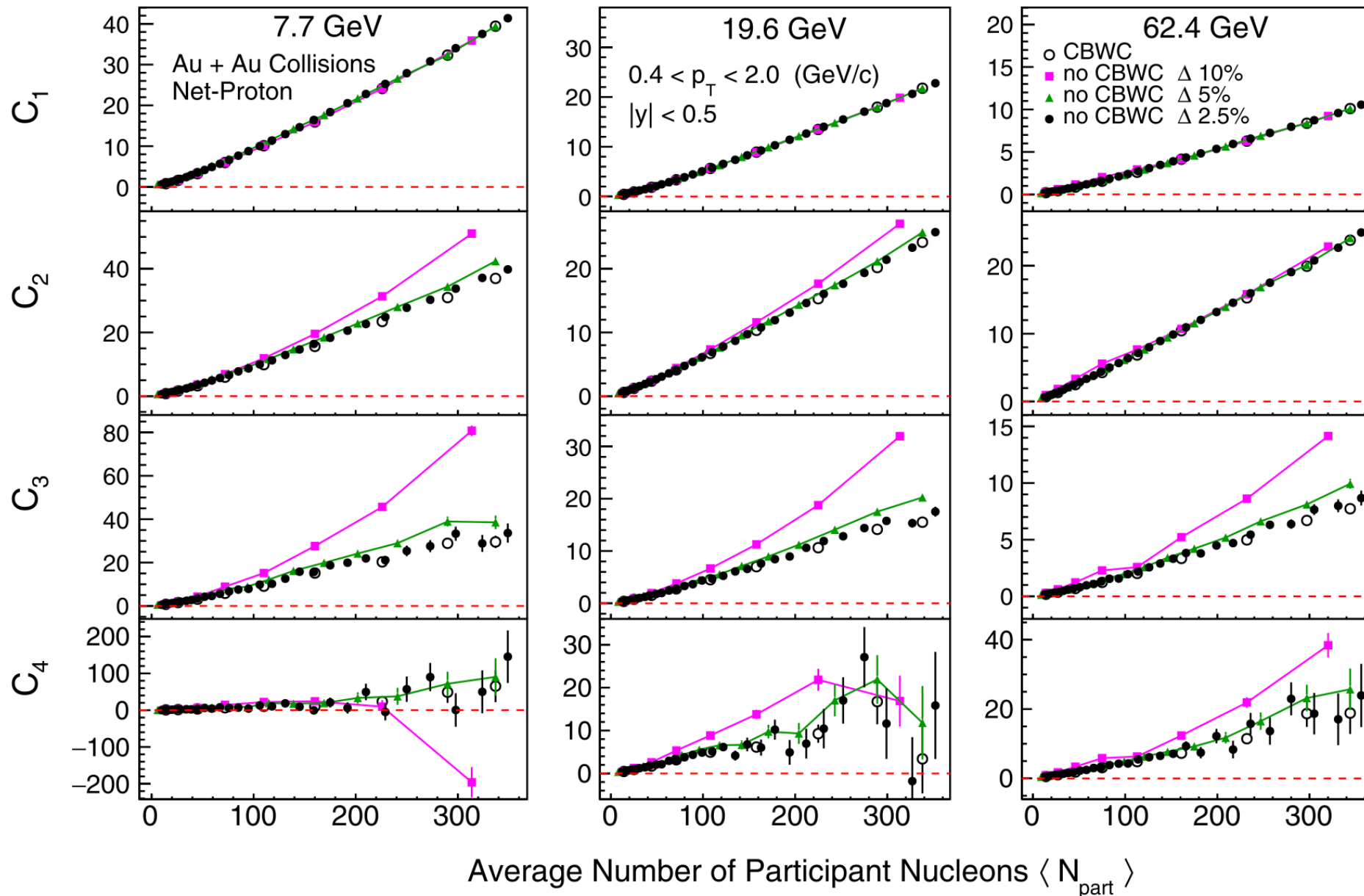


Centrality determination in STAR experiment

trying to improve the centrality resolution by increasing the number of charged particle (as much as in the TPC even in the case of Fixed target mode) excluding protons with Centrality Bin Width Correction (CBWC)



Test of Centrality Bin Width Correction (CBWC)



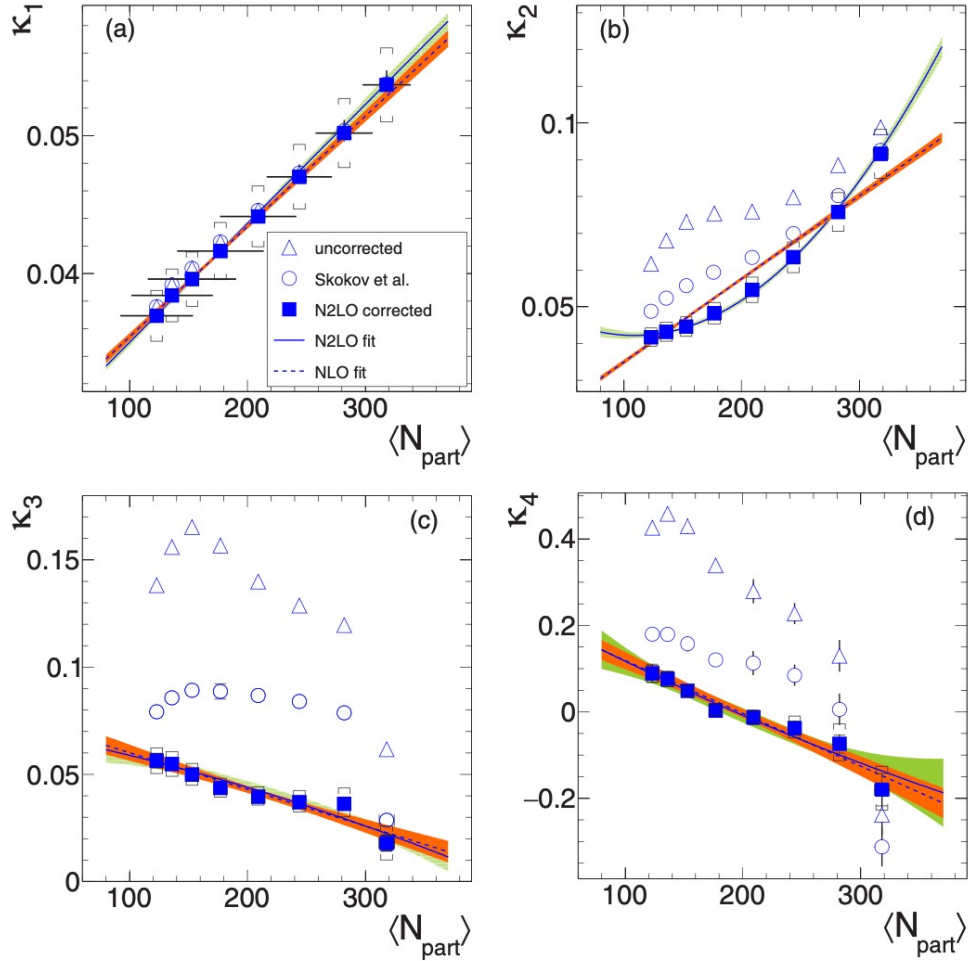
The results approach to the CBWC result.

It does not mean the volume fluctuation is excluded, as centrality resolution limits.

Over correction, because of the use of same rapidity acceptance information. (The model test indicates the effect is small, though.)

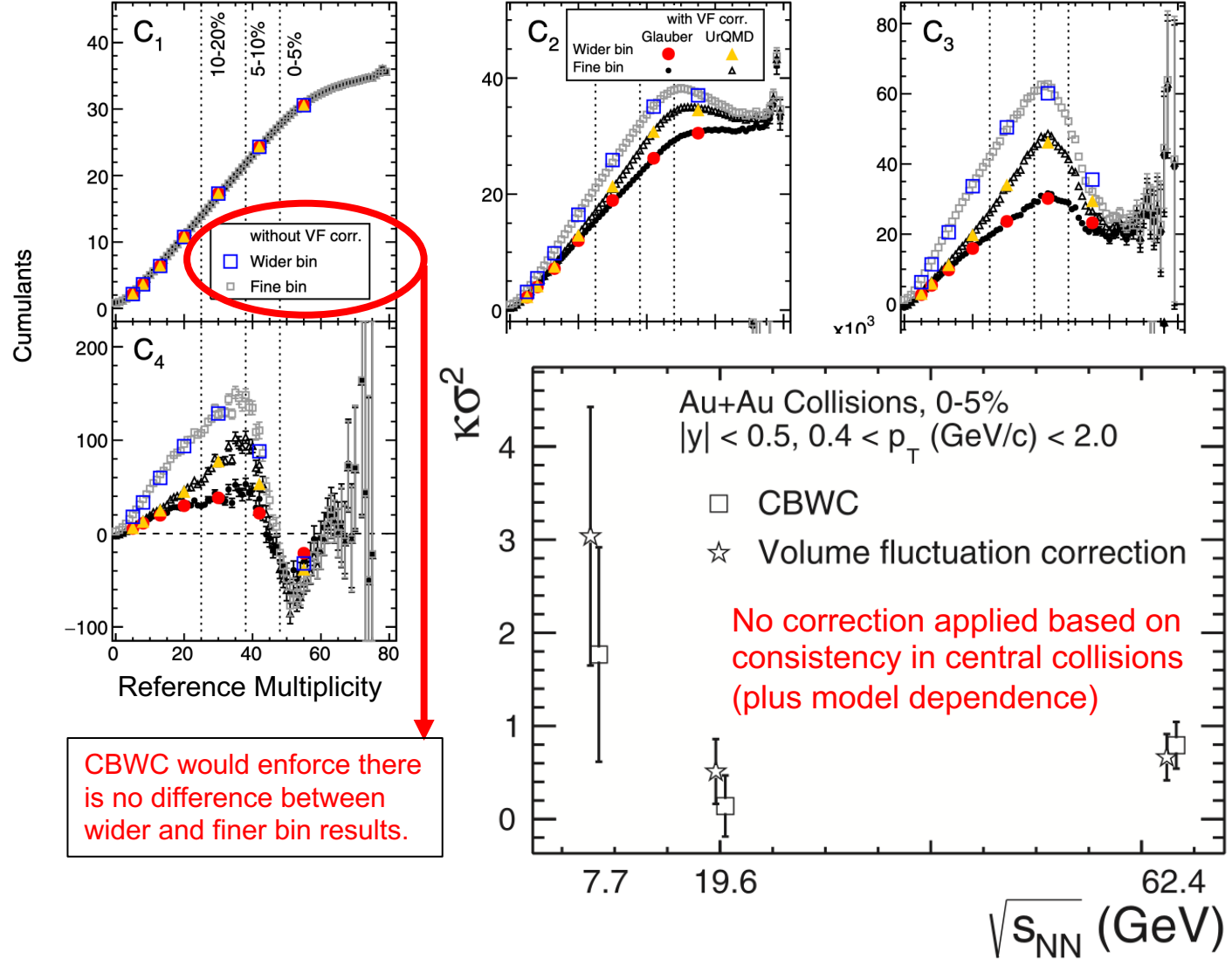
Test of various volume fluctuation (VF) corrections

HADES: centrality based on spectators

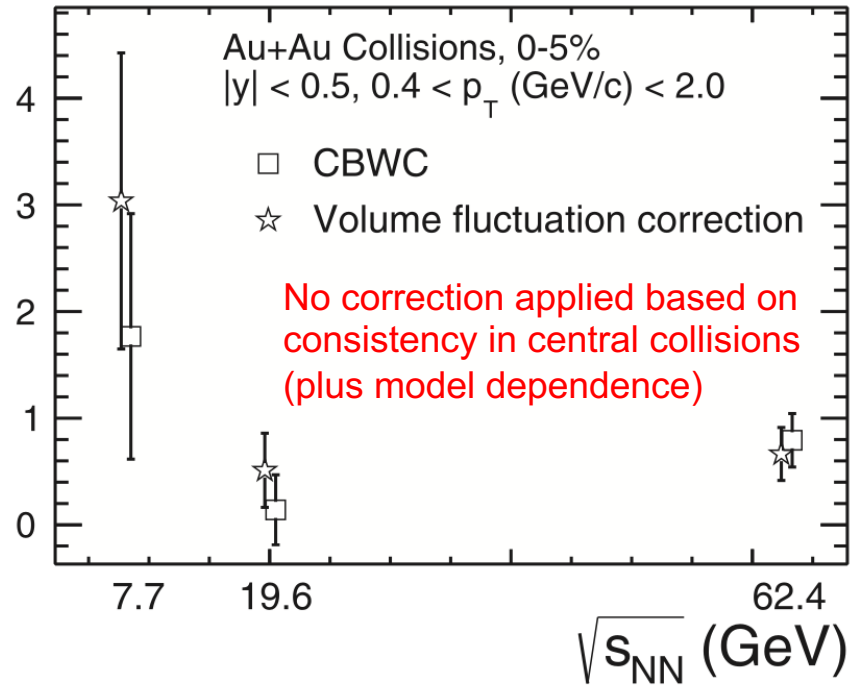


reduced cumulant : $\kappa_n = K_n / N_{part}$

STAR: centrality based on participants

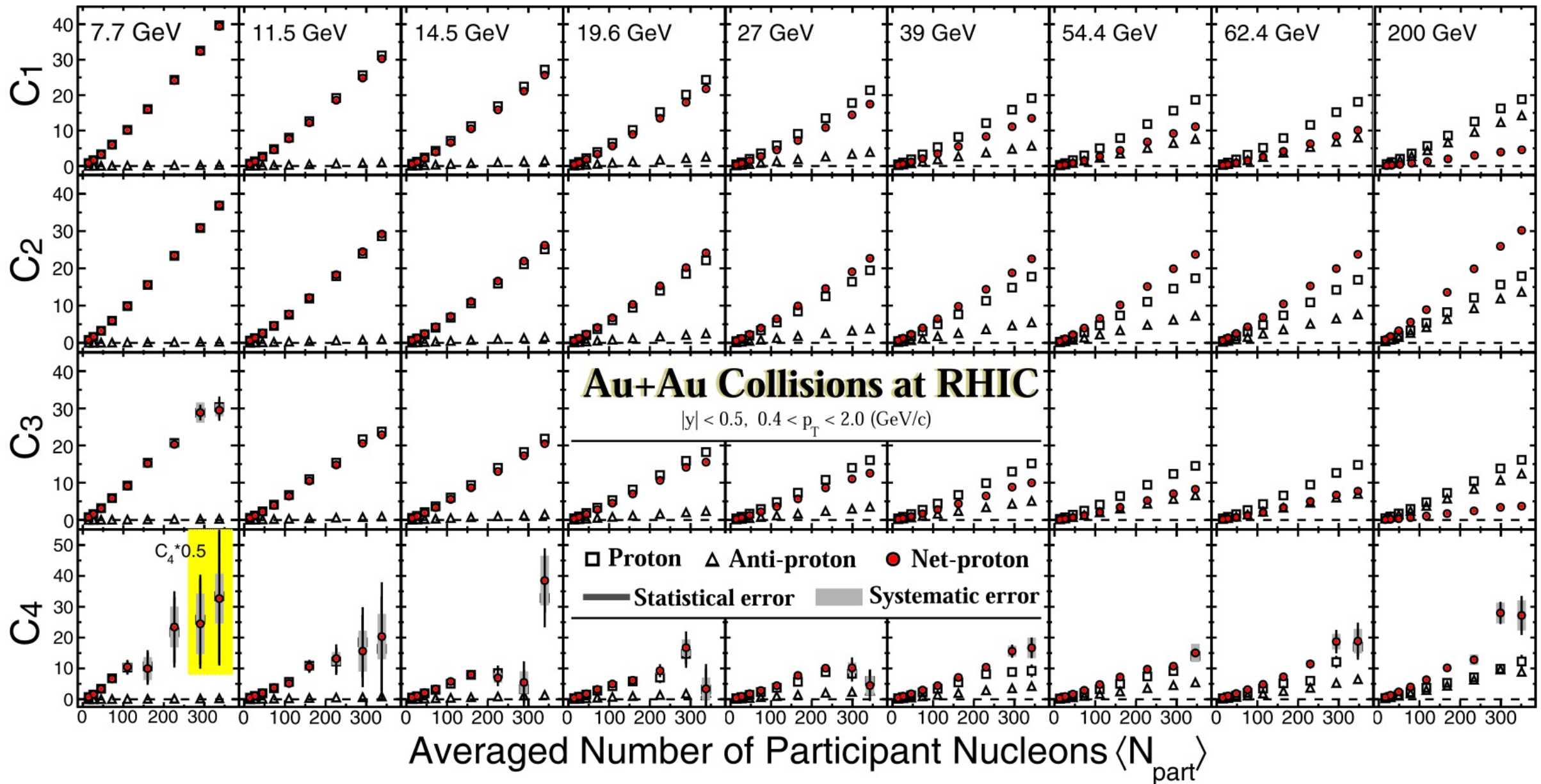


CBWC would enforce there is no difference between wider and finer bin results.



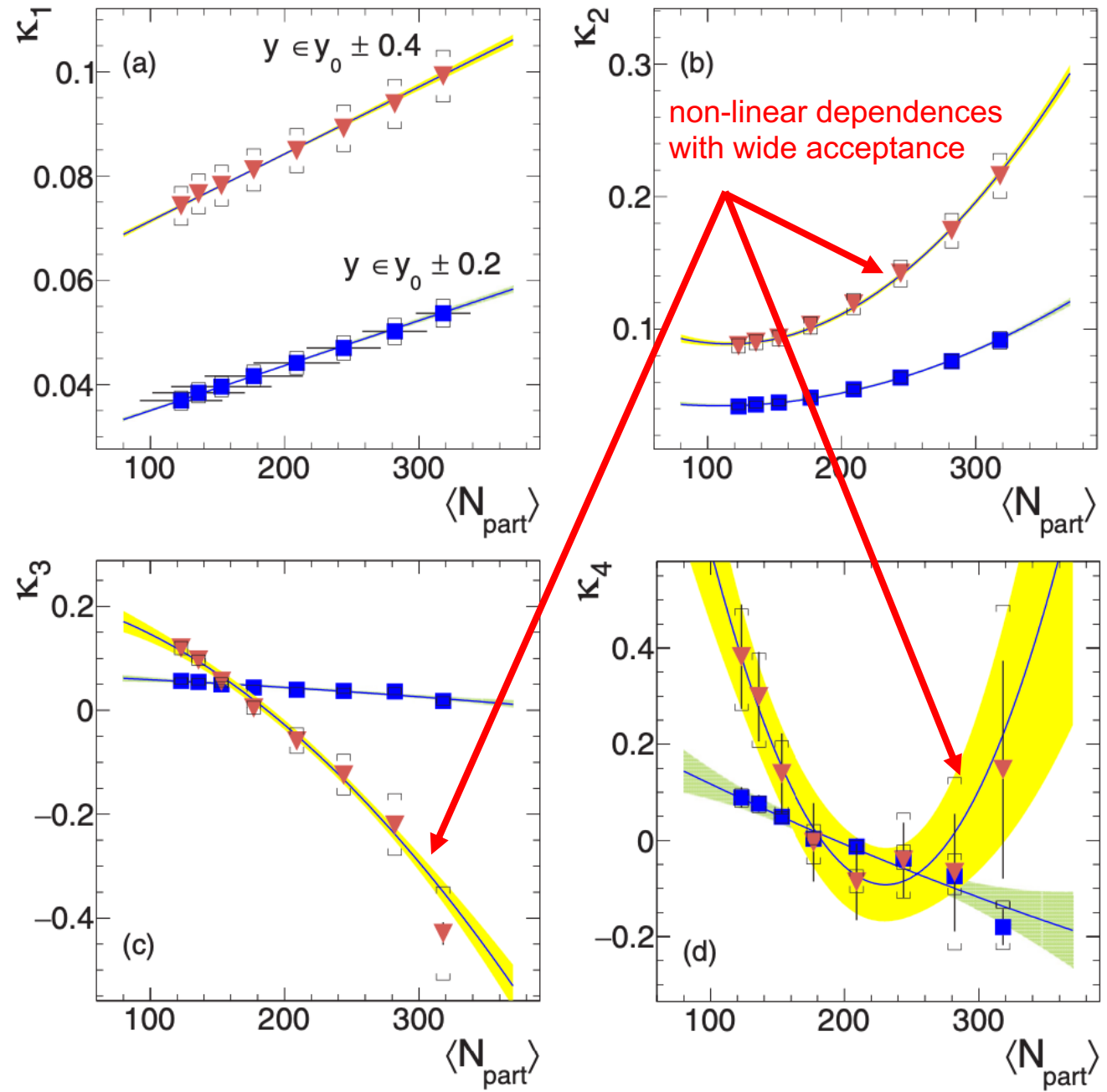
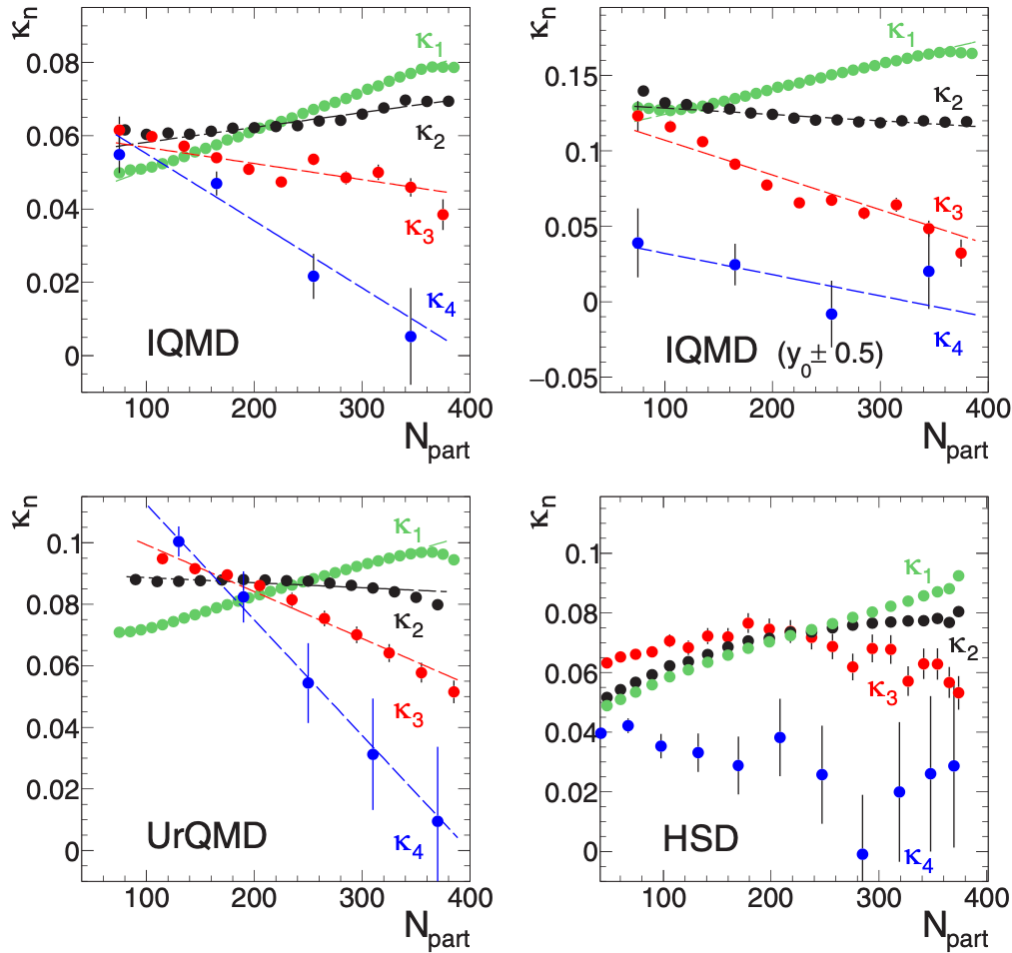
CBWC only

Centrality dependence of cumulant in STAR BES1

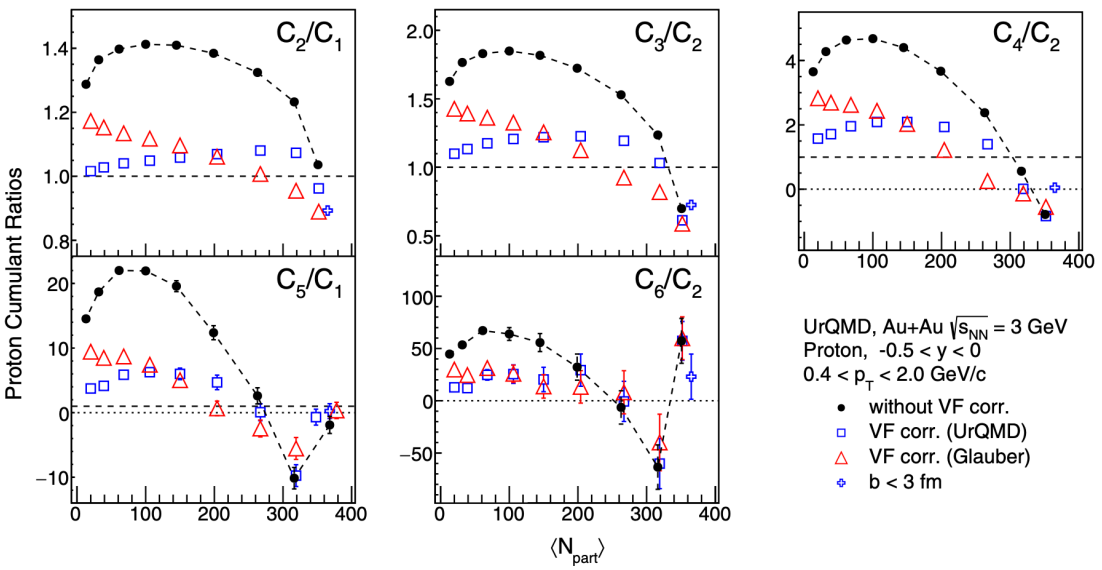
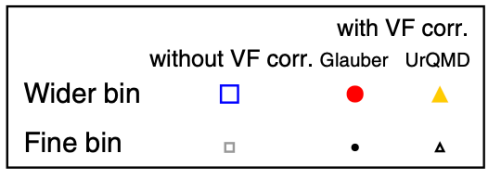
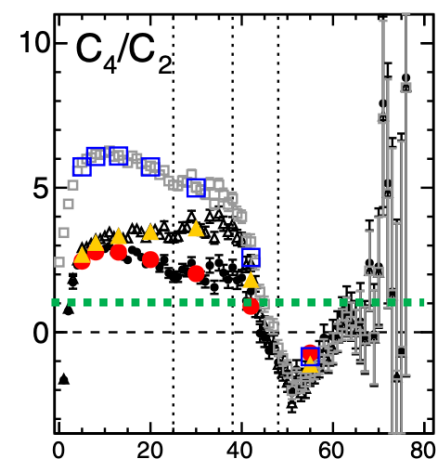
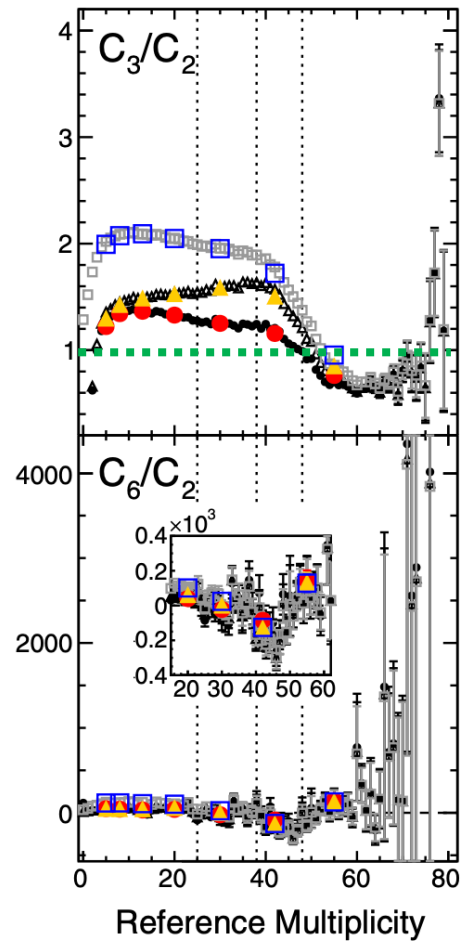
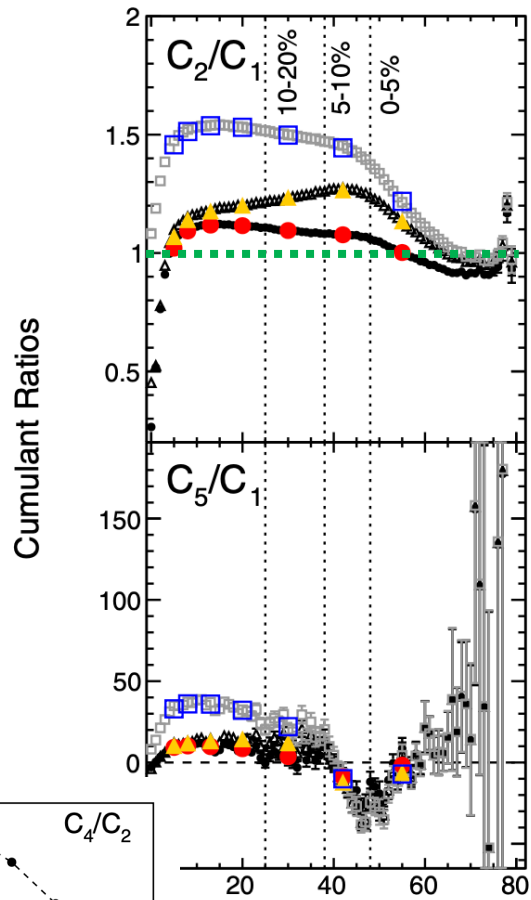


Centrality dependence of cumulant in Au+Au 2.4 GeV at HADES and models

Models catch the trends of experimental data.
Where is the volume dependence of the cumulant?



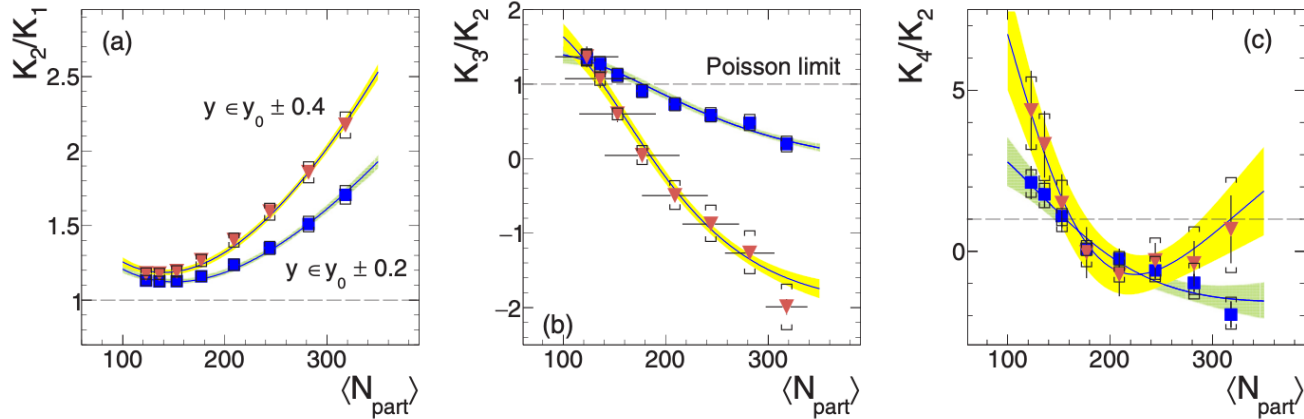
Centrality dependence of cumulant ratio in Au+Au 3 GeV at STAR and UrQMD with/without VF corrections



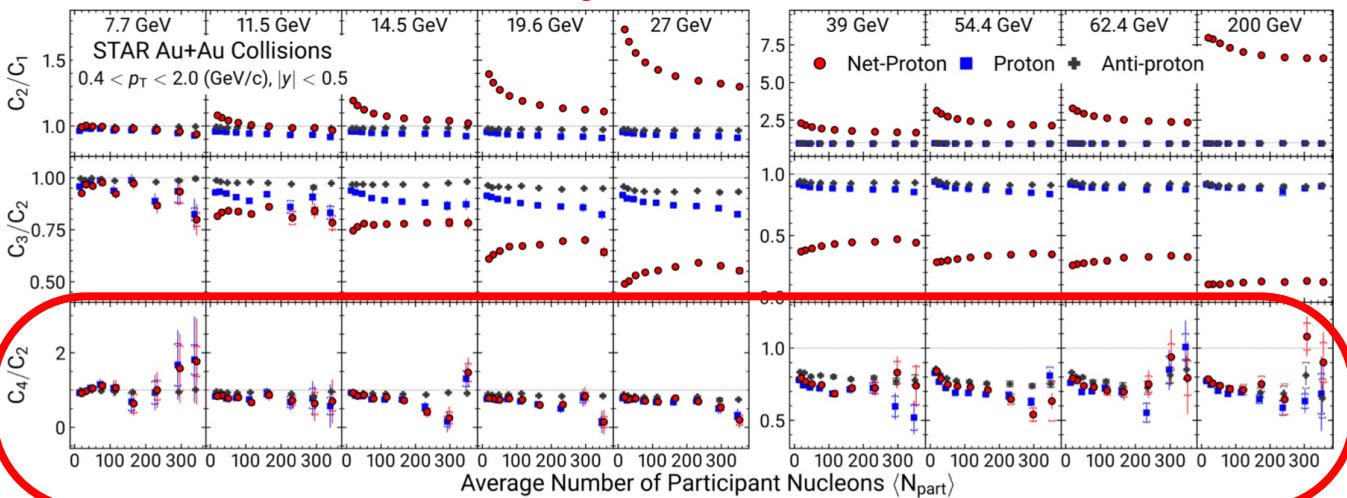
The model dependent volume effects are mostly reproduced. The final results are given without correction.

Centrality dependence of cumulant ratio

Au+Au 2.4 GeV HADES with spectator based centrality with volume correction

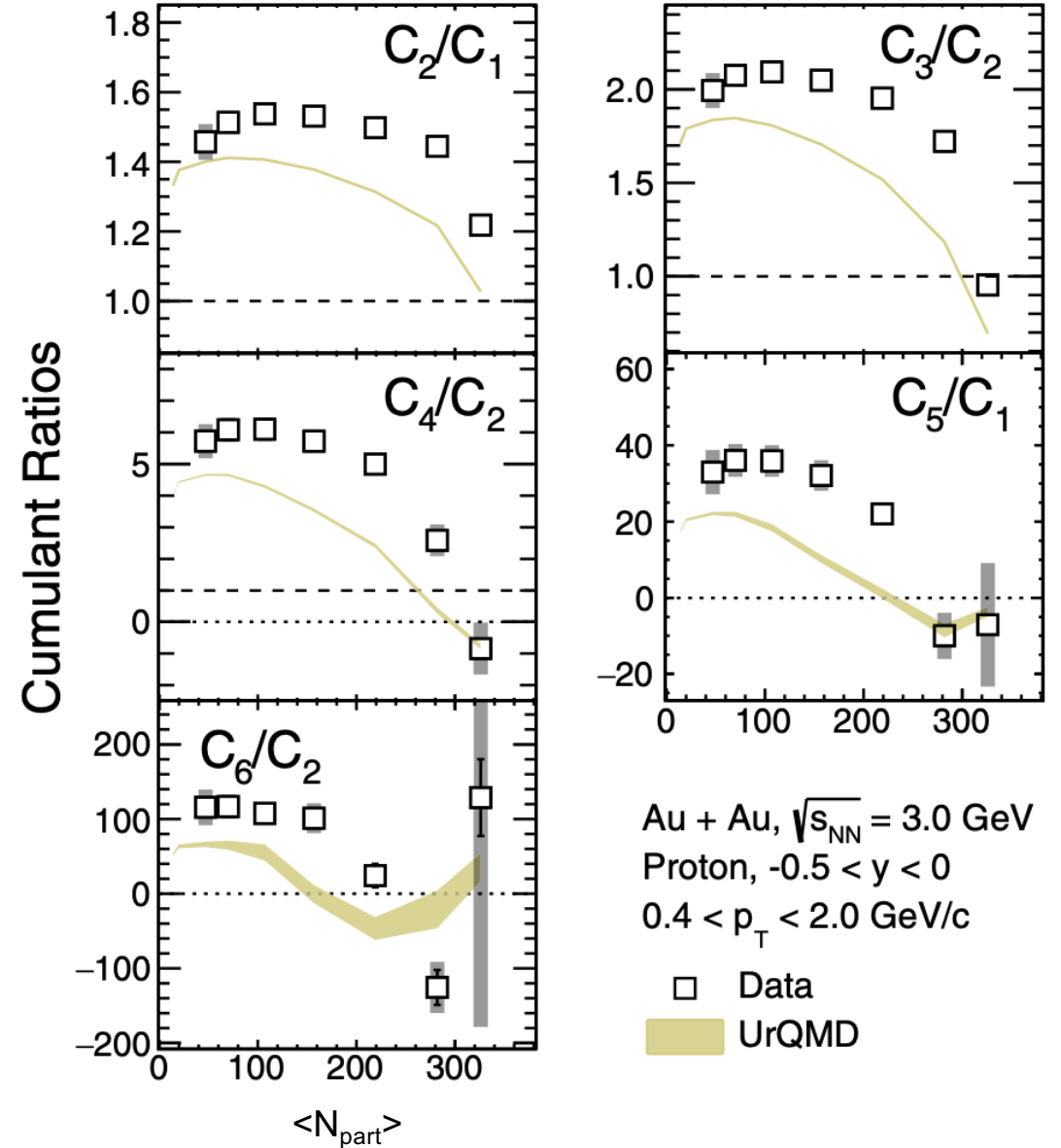


STAR BES1: CBWC only



Au+Au 3 GeV STAR: CBWC only

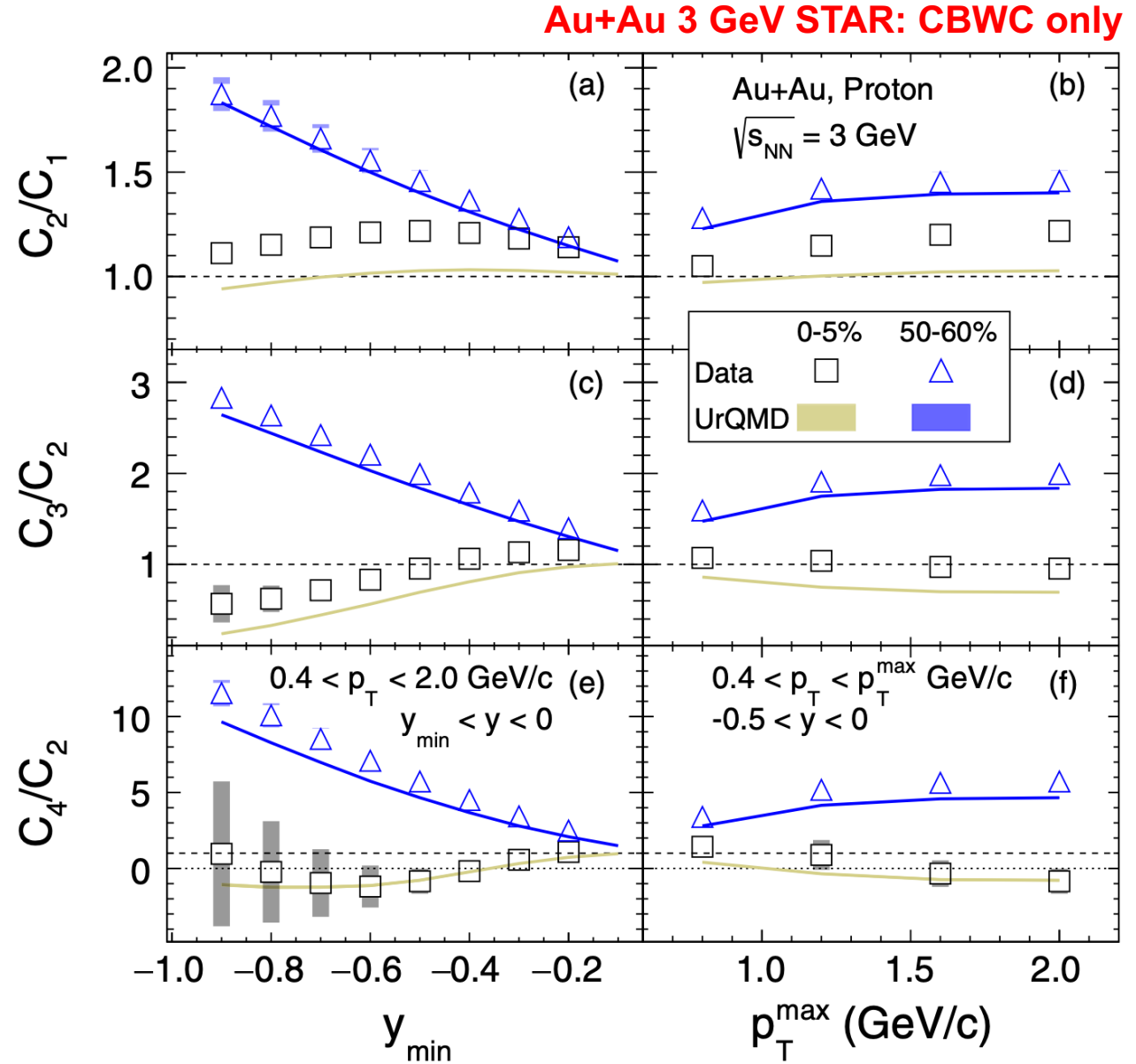
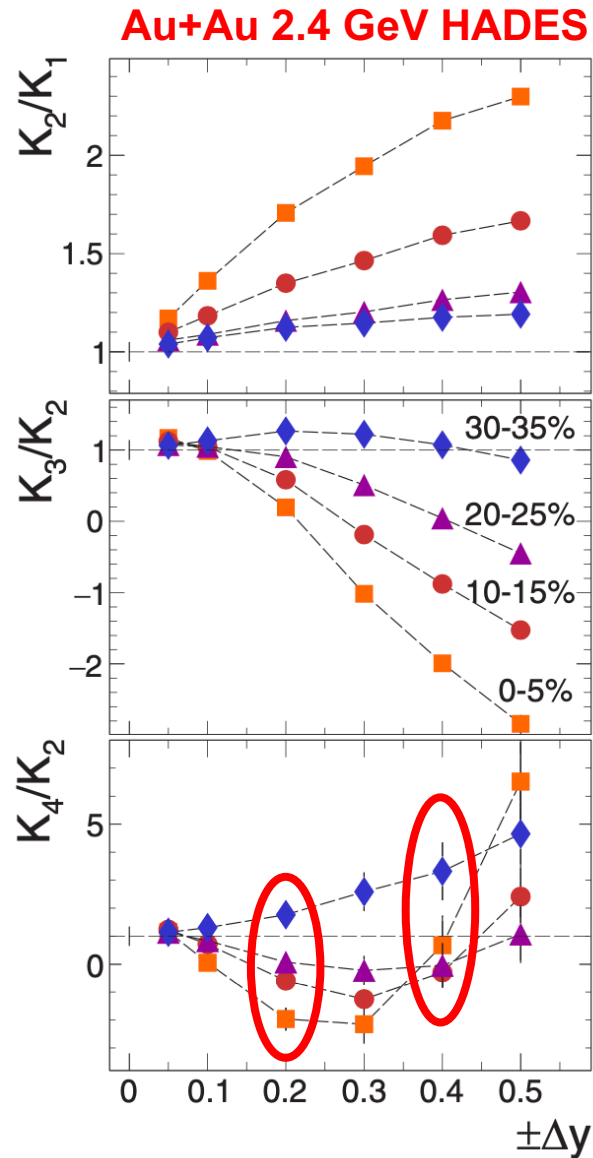
with participant based centrality without volume correction



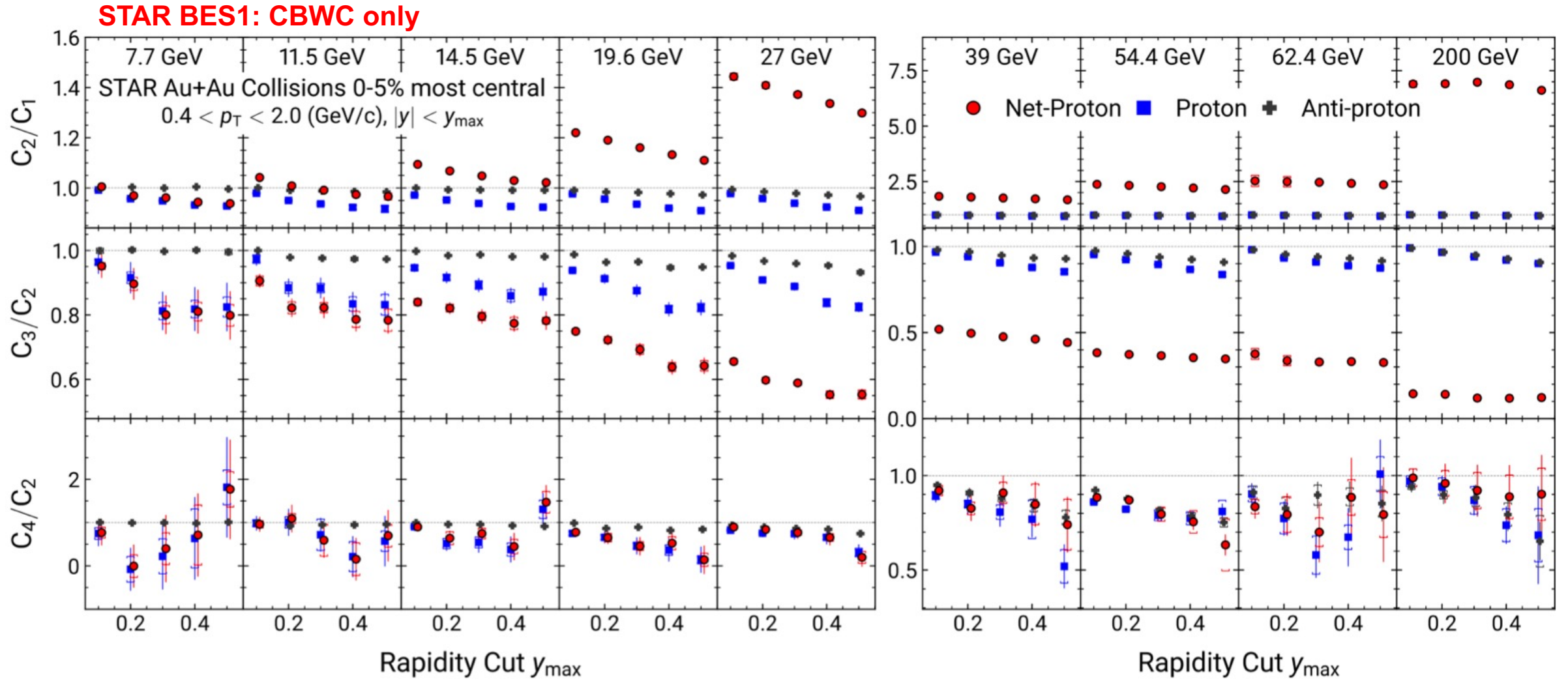
Au + Au, $\sqrt{s_{NN}} = 3.0$ GeV
 Proton, $-0.5 < y < 0$
 $0.4 < p_T < 2.0$ GeV/c

□ Data
 ■ UrQMD

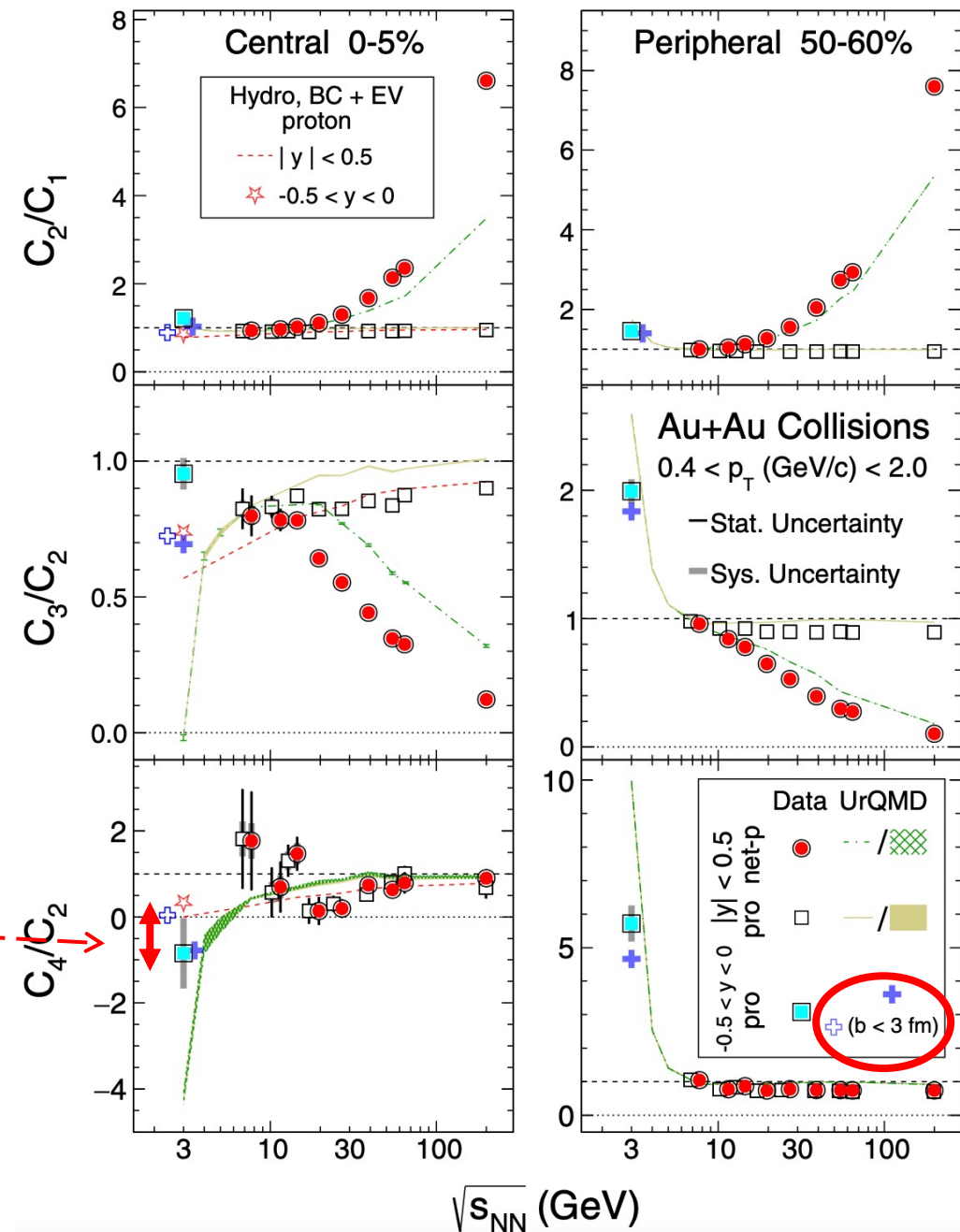
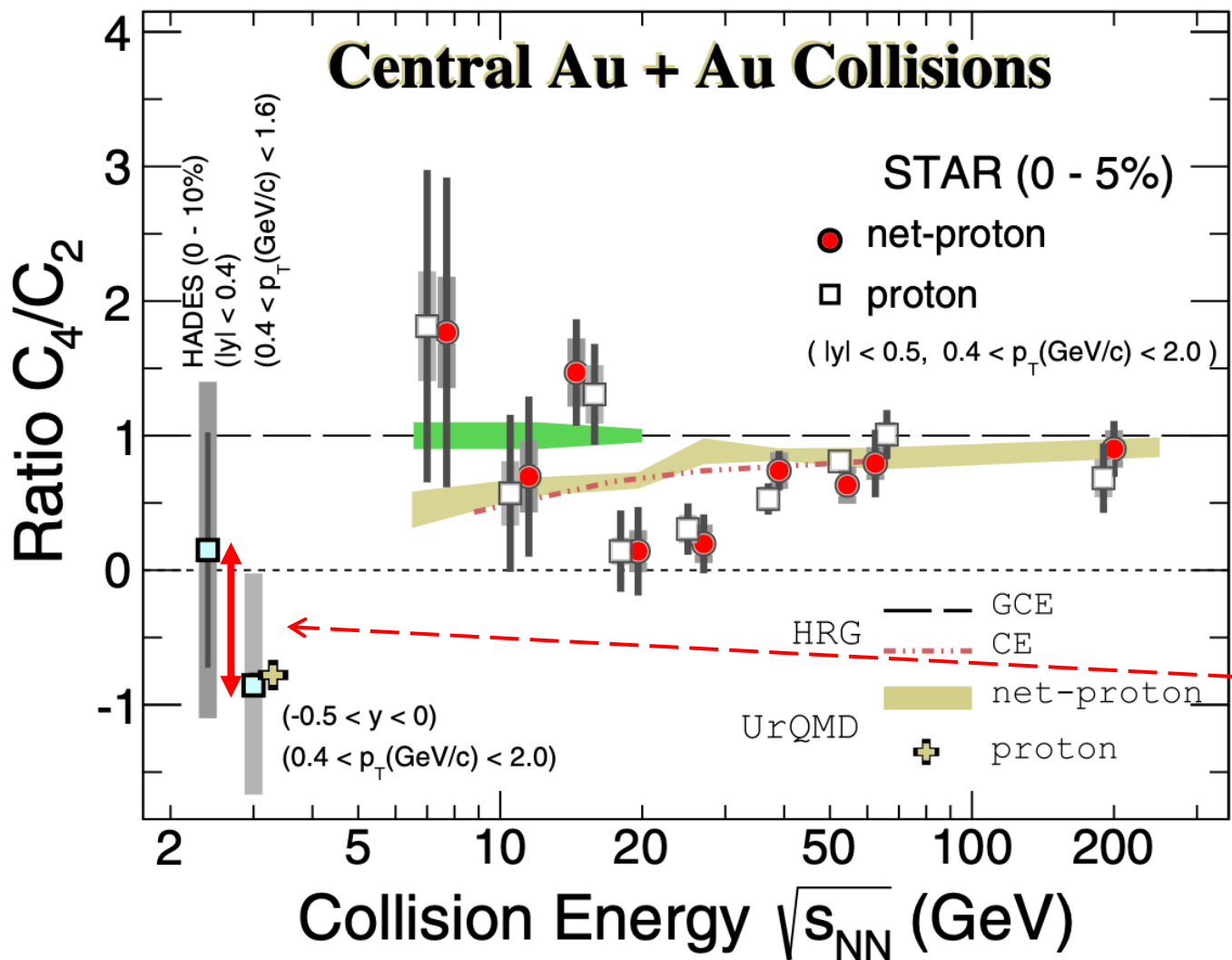
Acceptance dependence of cumulant ratio



Acceptance dependence of cumulant ratio



Beam energy dependence of cumulant ratio



Summary

- HADES and STAR measurements
- Experimental pile-up removal and/or correction
- Tracking efficiency corrections
- Centrality determination and volume fluctuation
- Acceptance and beam energy dependence