Physics of Beam Energy Scan II

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what can we learn from BES-II
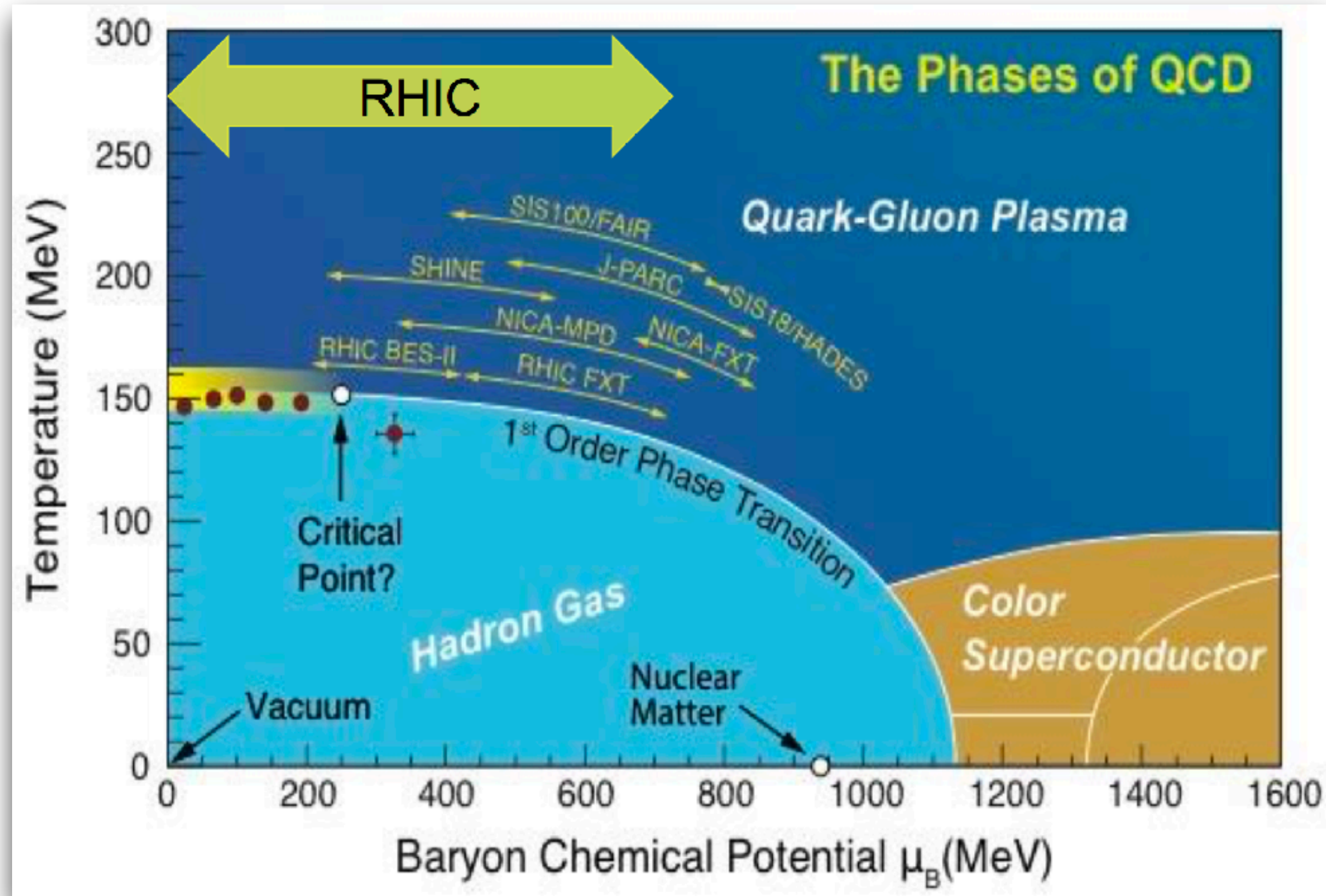
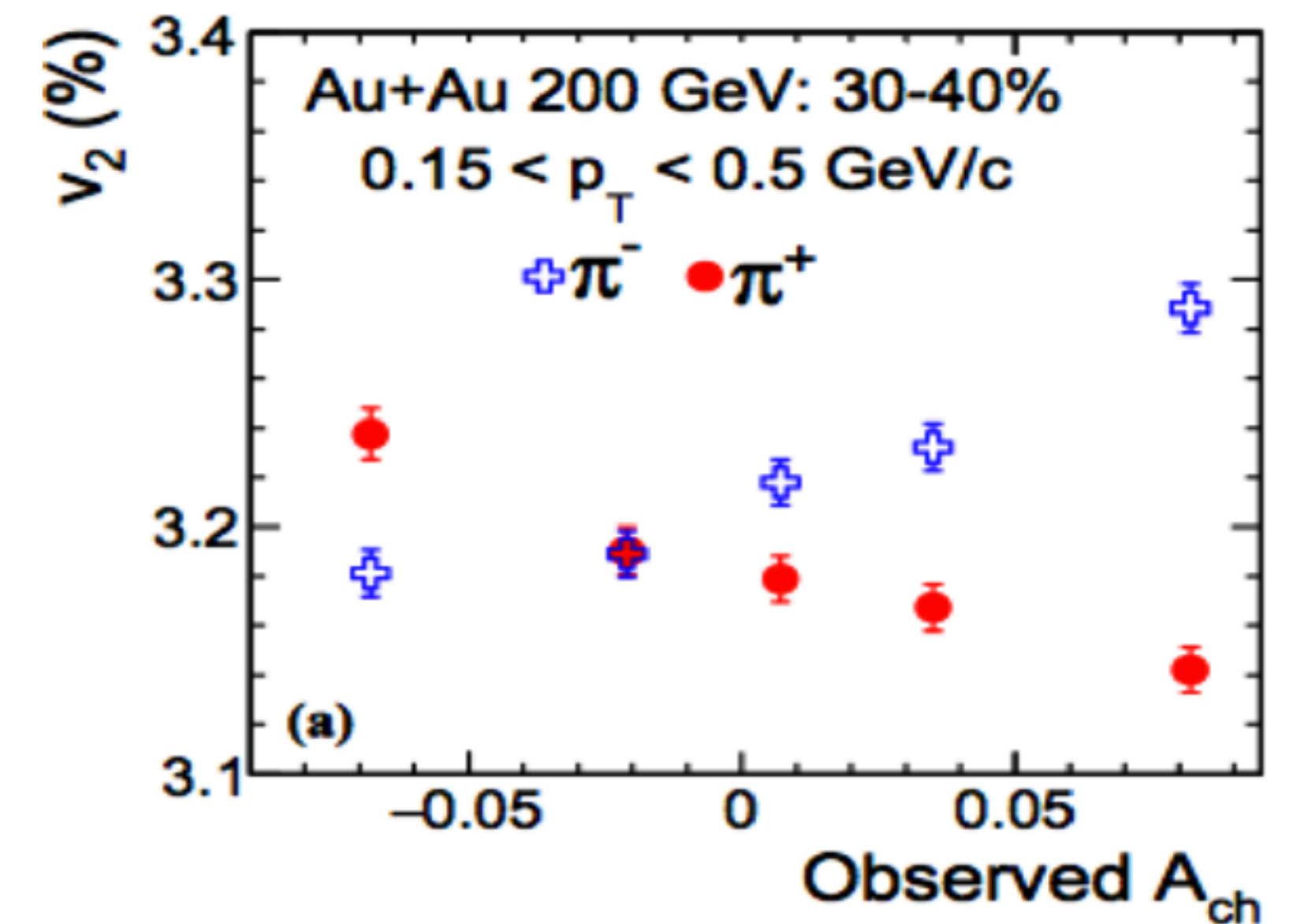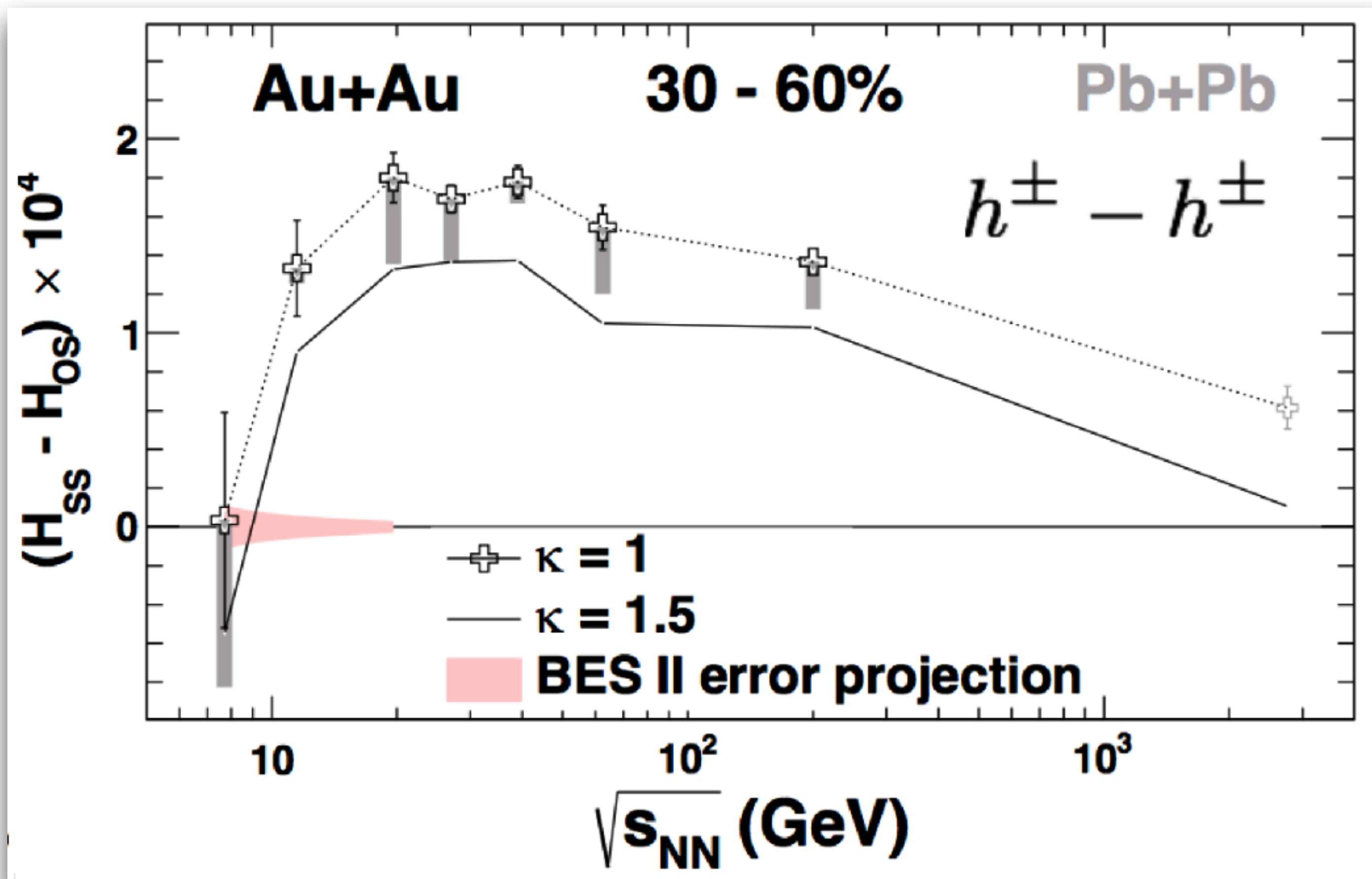QCD critical point & phase diagram

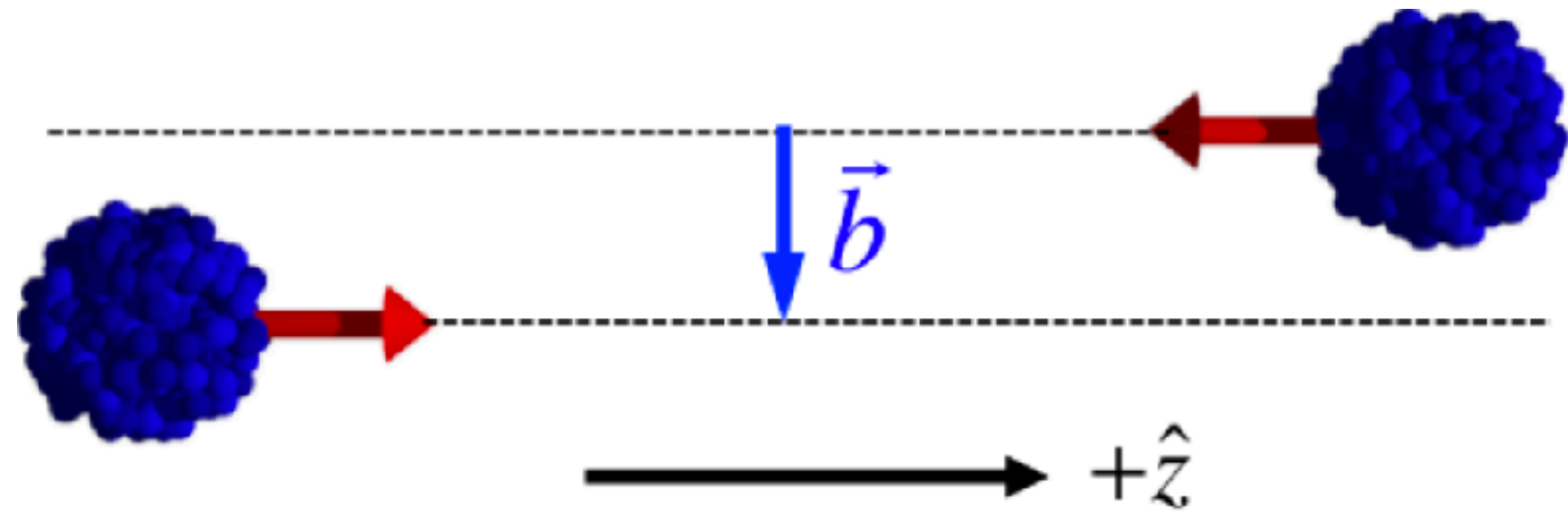properties of baryon-rich QGP

onset of chiral symmetry restoration

unexpected new phenomena

onset of chiral symmetry restoration: key observables

— through correlations related to anomalous hydrodynamic effects in QGP
— non-vanishing signals for CME, CVE etc. imply presence of chiral quarks

unexpected new phenomena

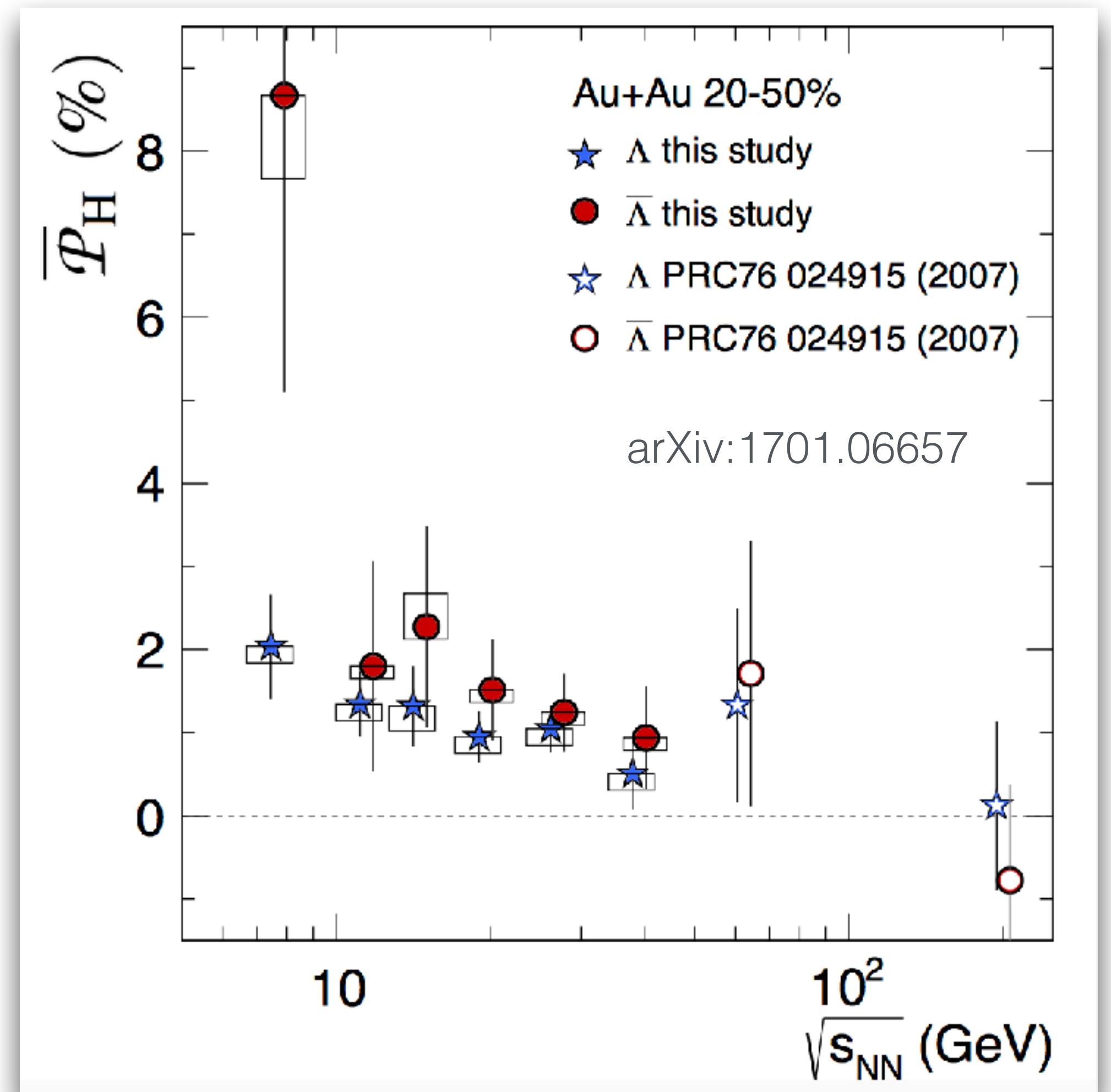## global polarization of Lambda baryons
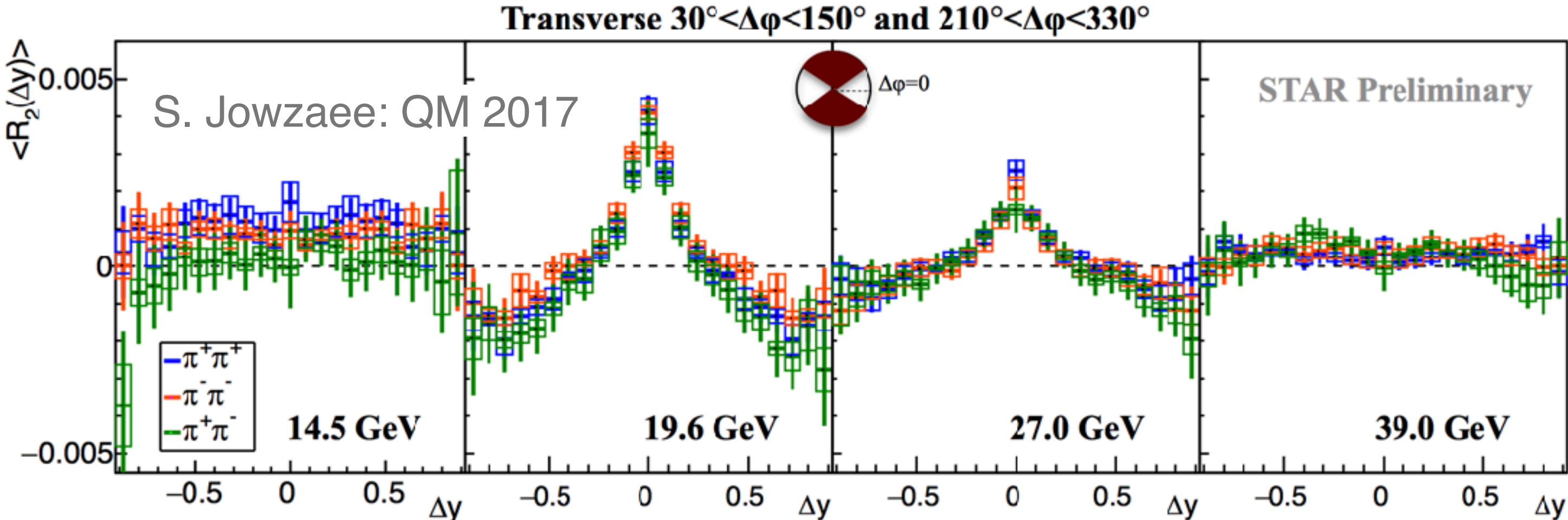

RHIC can create the most vortical fluid

$$\omega = (9 \pm 1) \times 10^{21} \ s^{-1}$$

persisting magnetic field at late times ?

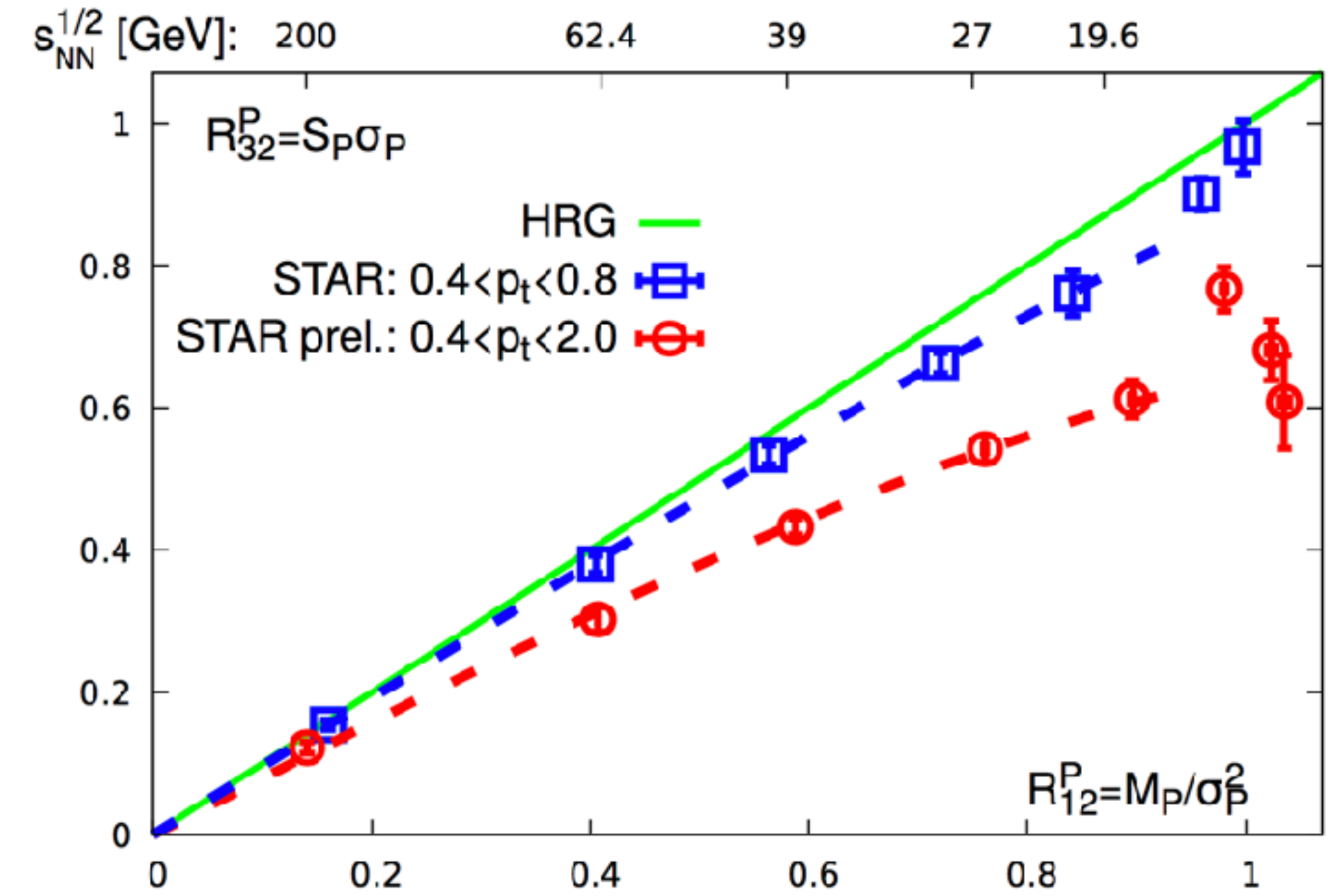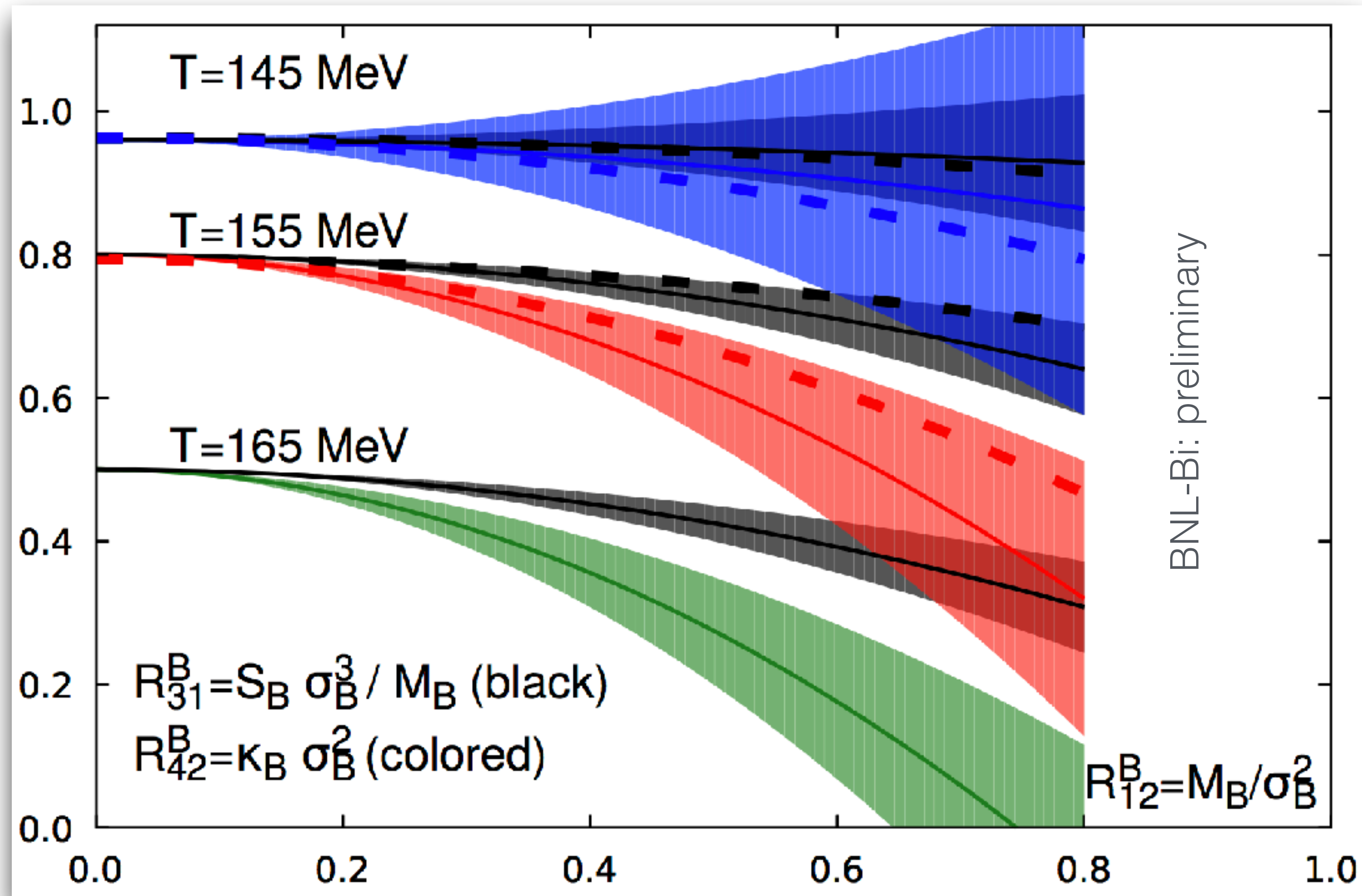# *QCD critical point:* key observables
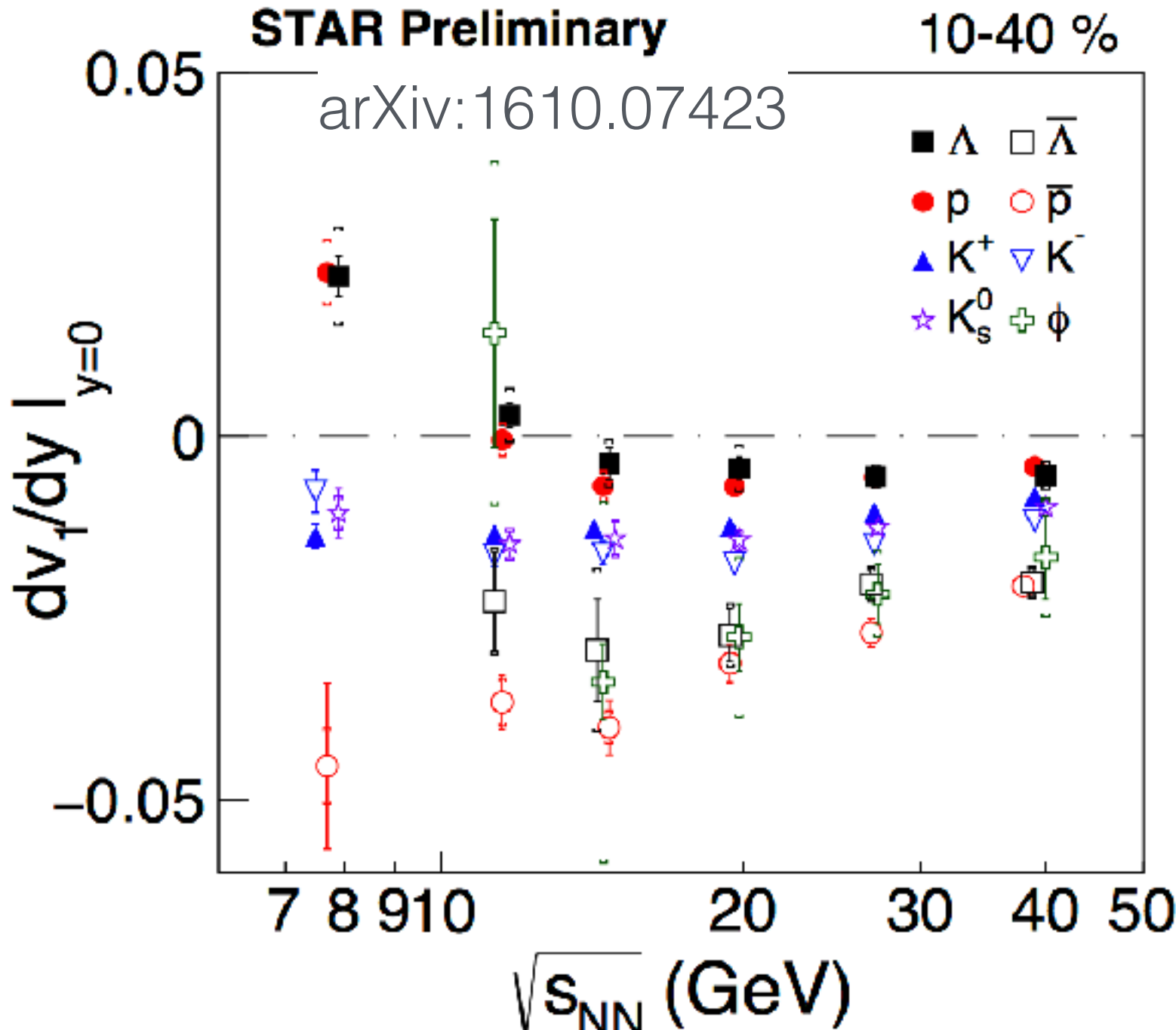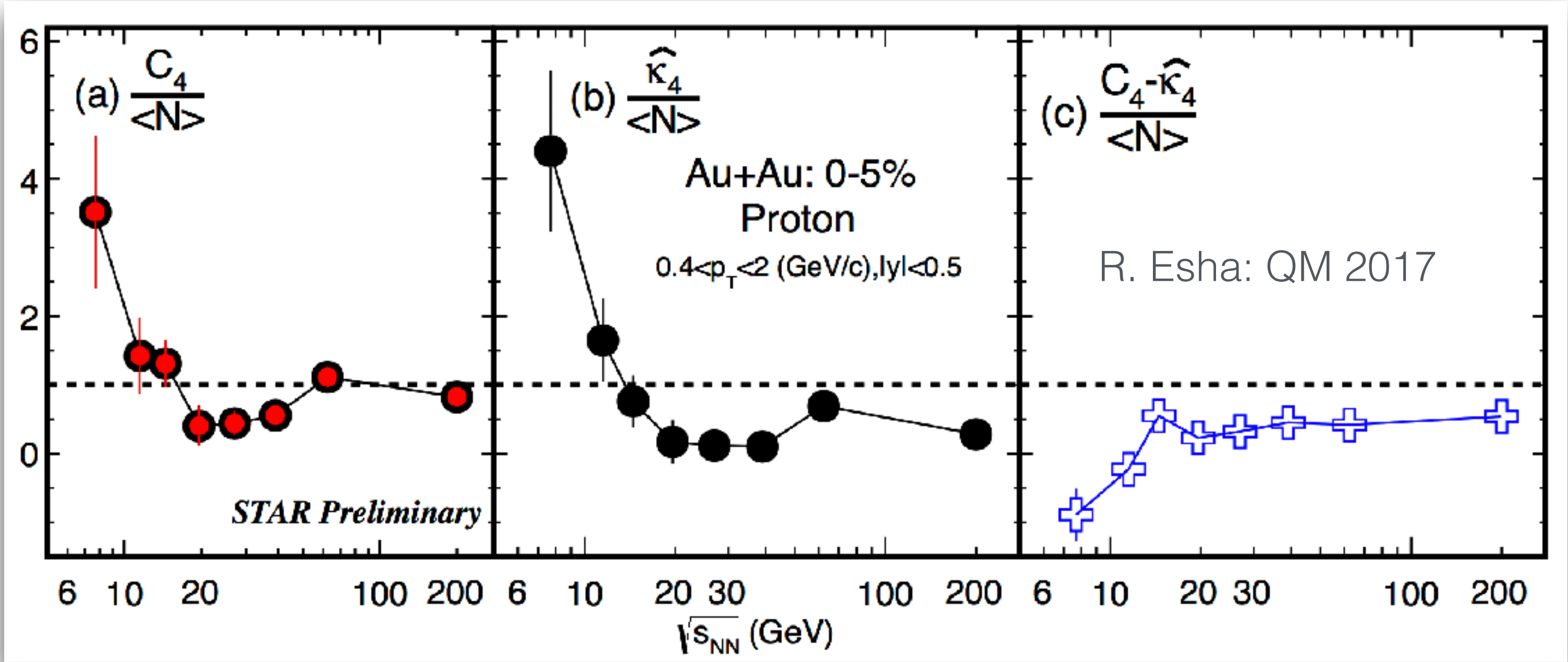
cumulants of net-B fluctuations
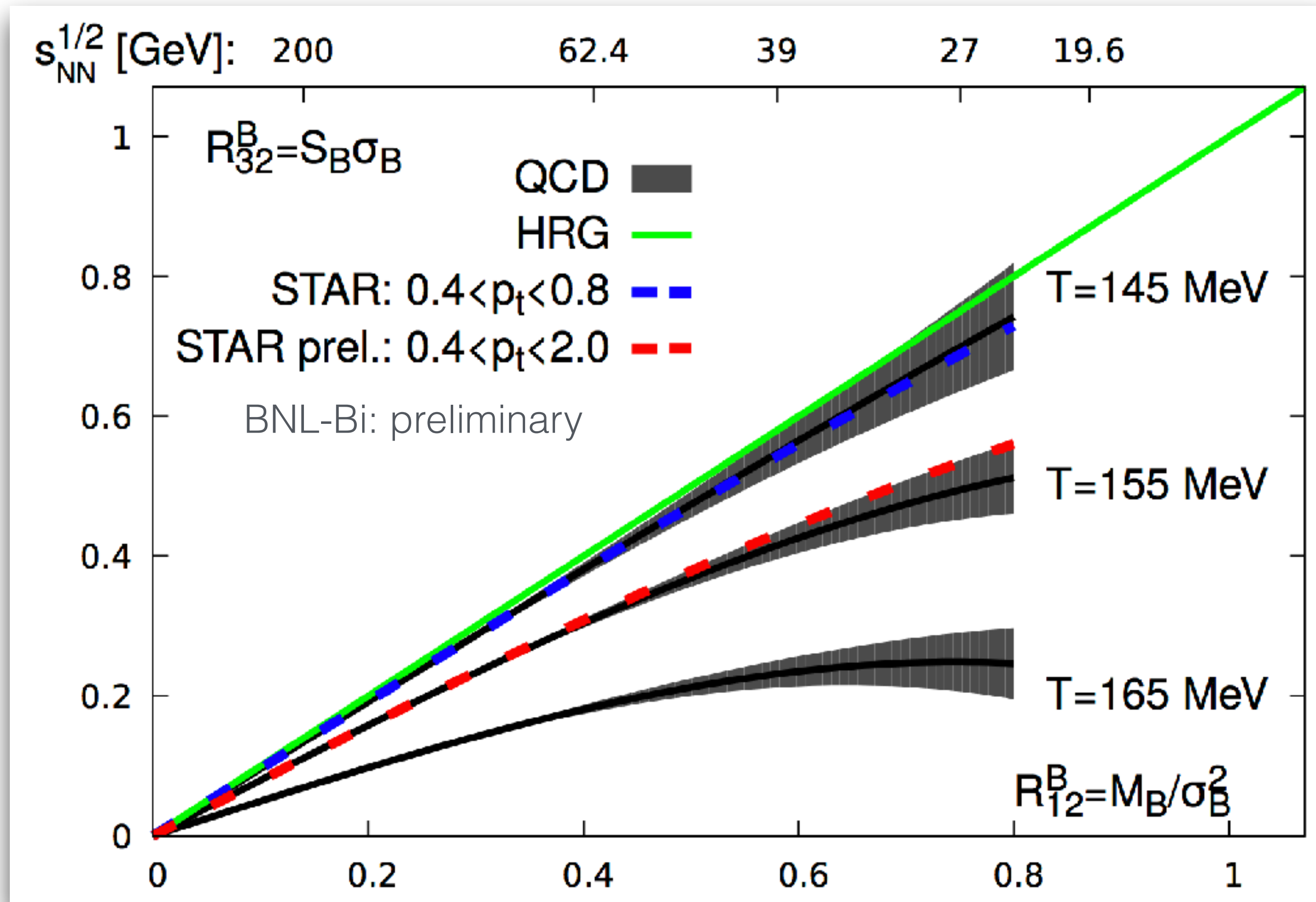
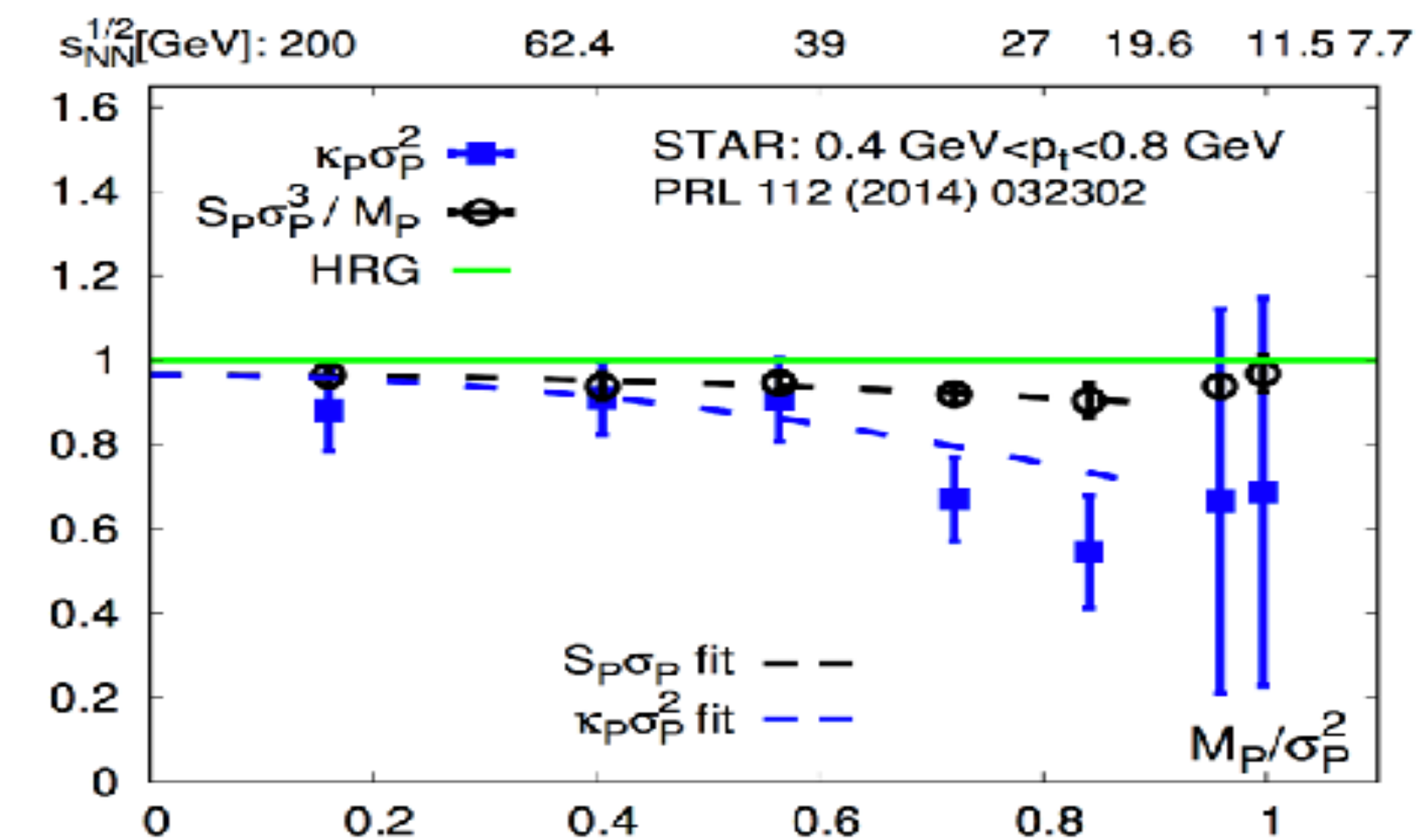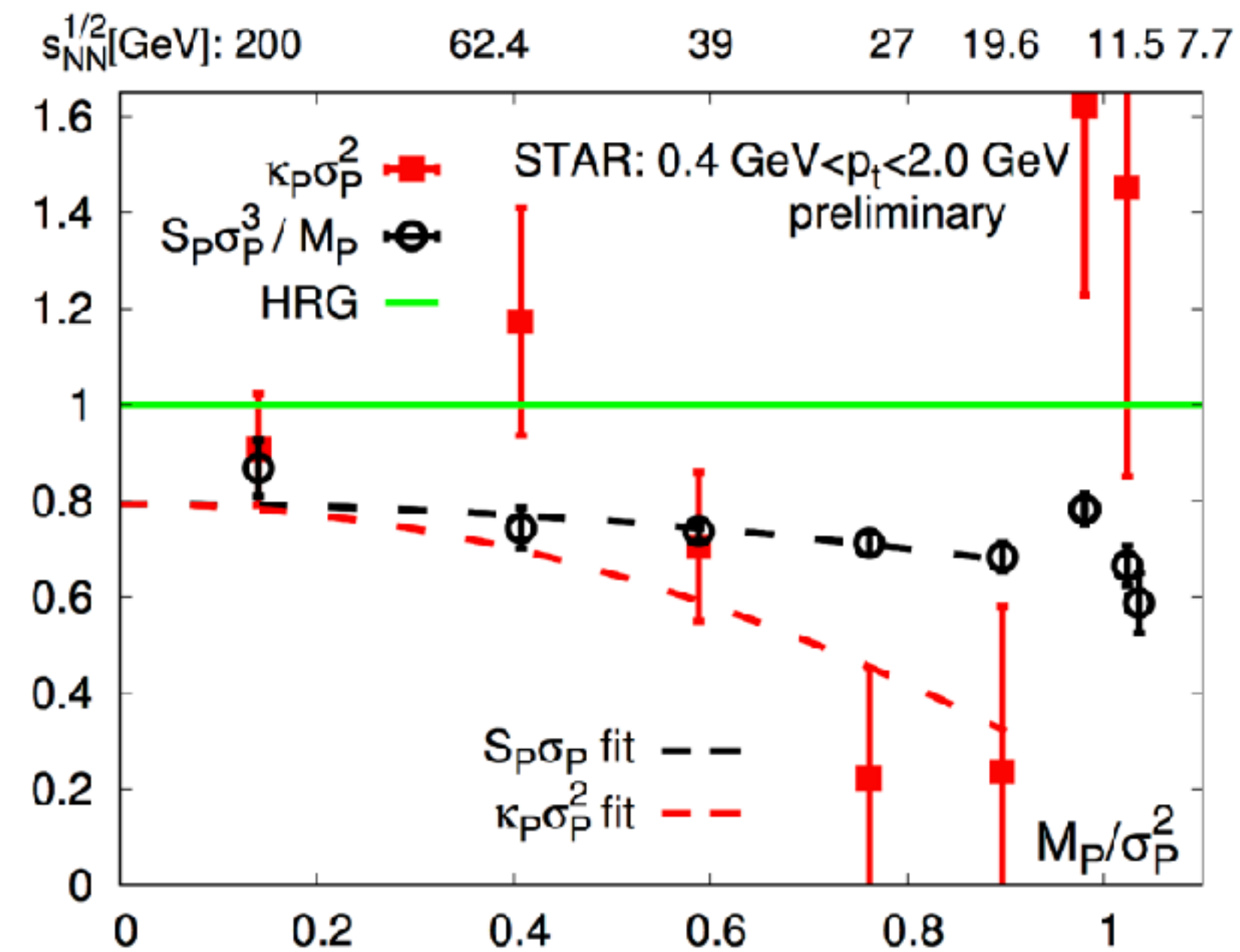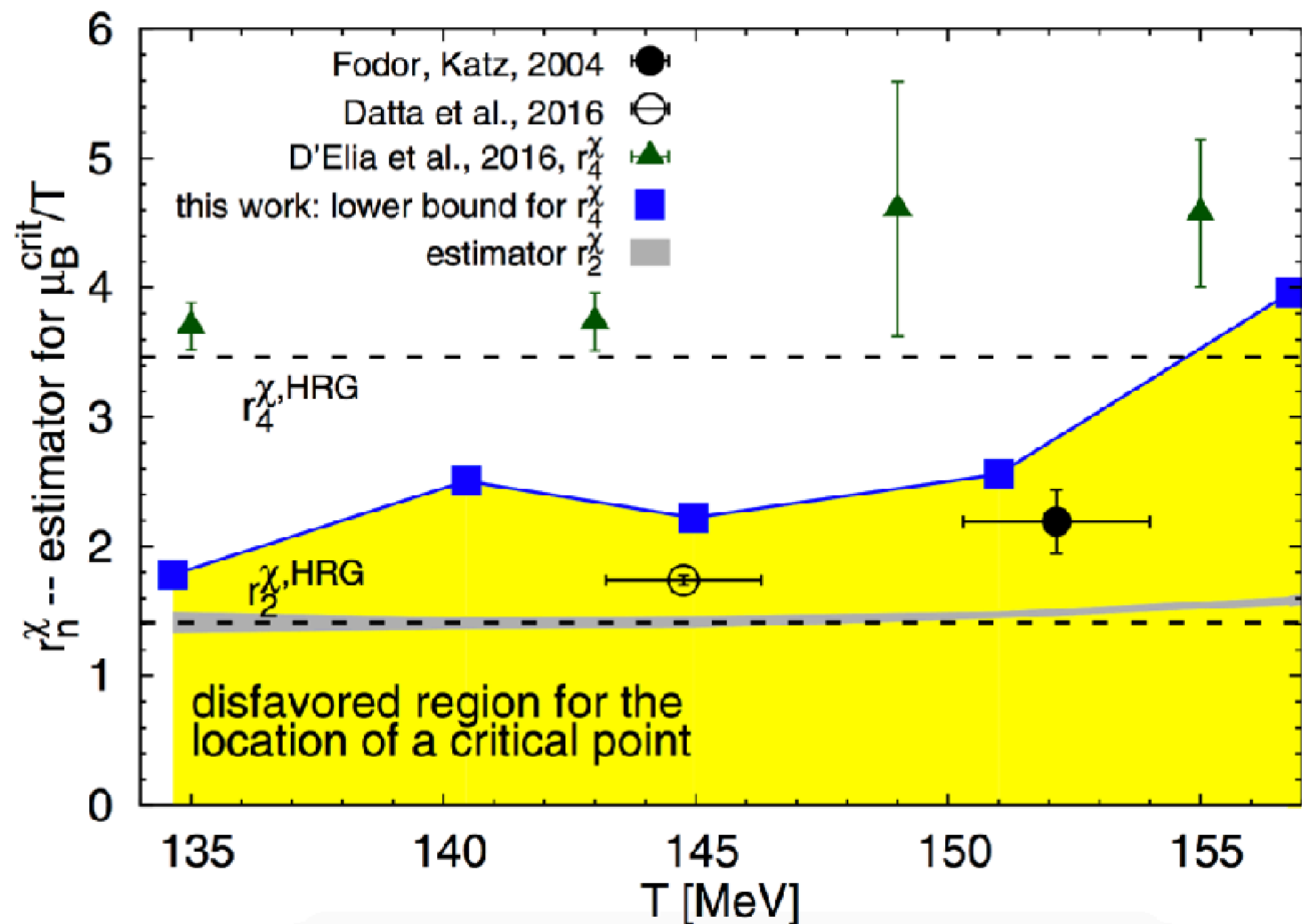## cumulants of net-p fluctuations

$$M_P/\sigma_p^2, M_B/\sigma_B^2 \leftrightarrow \mu_B/T$$

$\sqrt{s} \gtrsim 27~GeV$: cumulants of net-p fluctuations are consistent with equilibrium (L)QCD, no sign of criticality
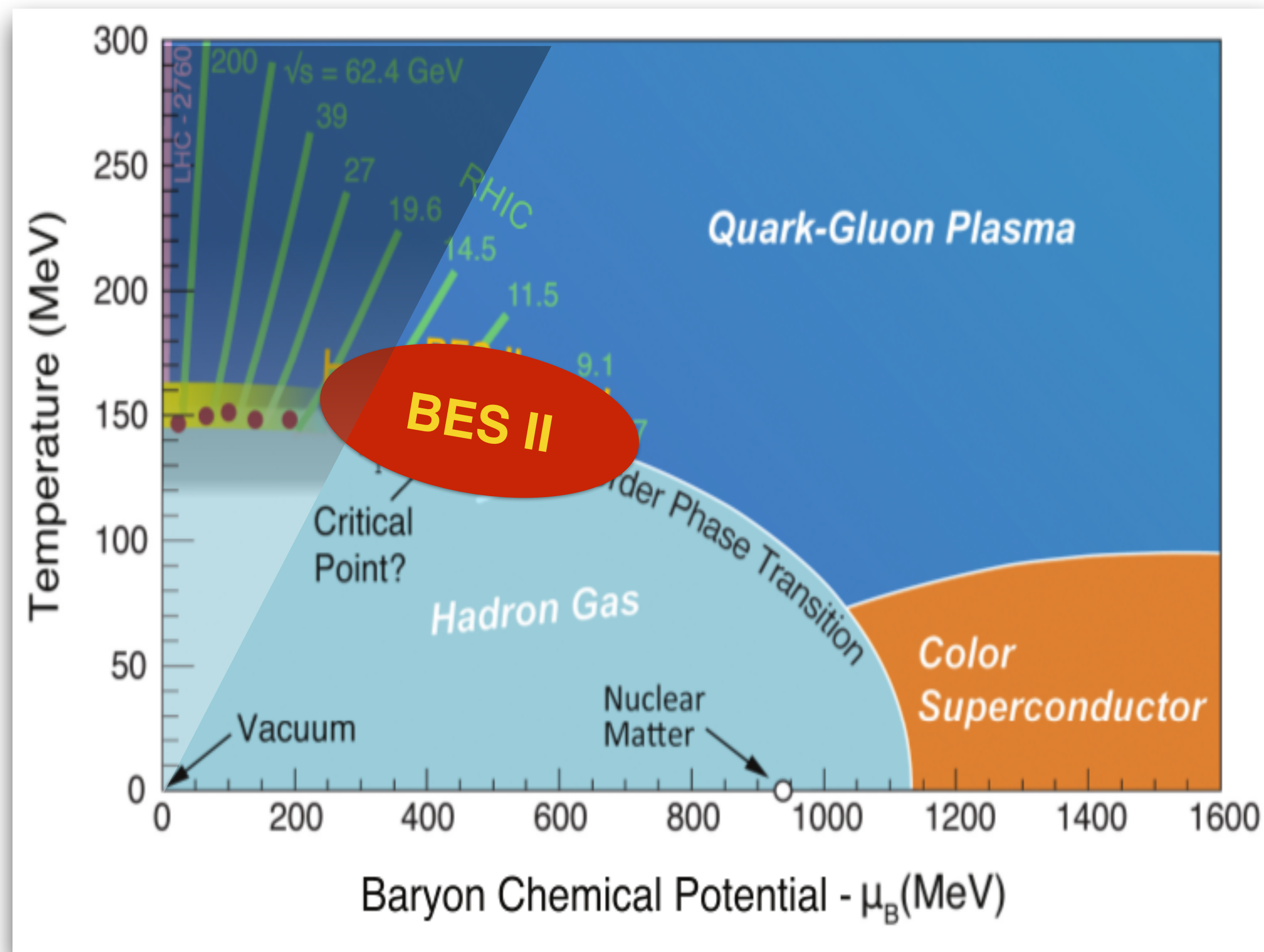
LQCD, location of critical point:
$\mu_B/T \lesssim 2$ presently disfavored

- analyzing radius of convergence

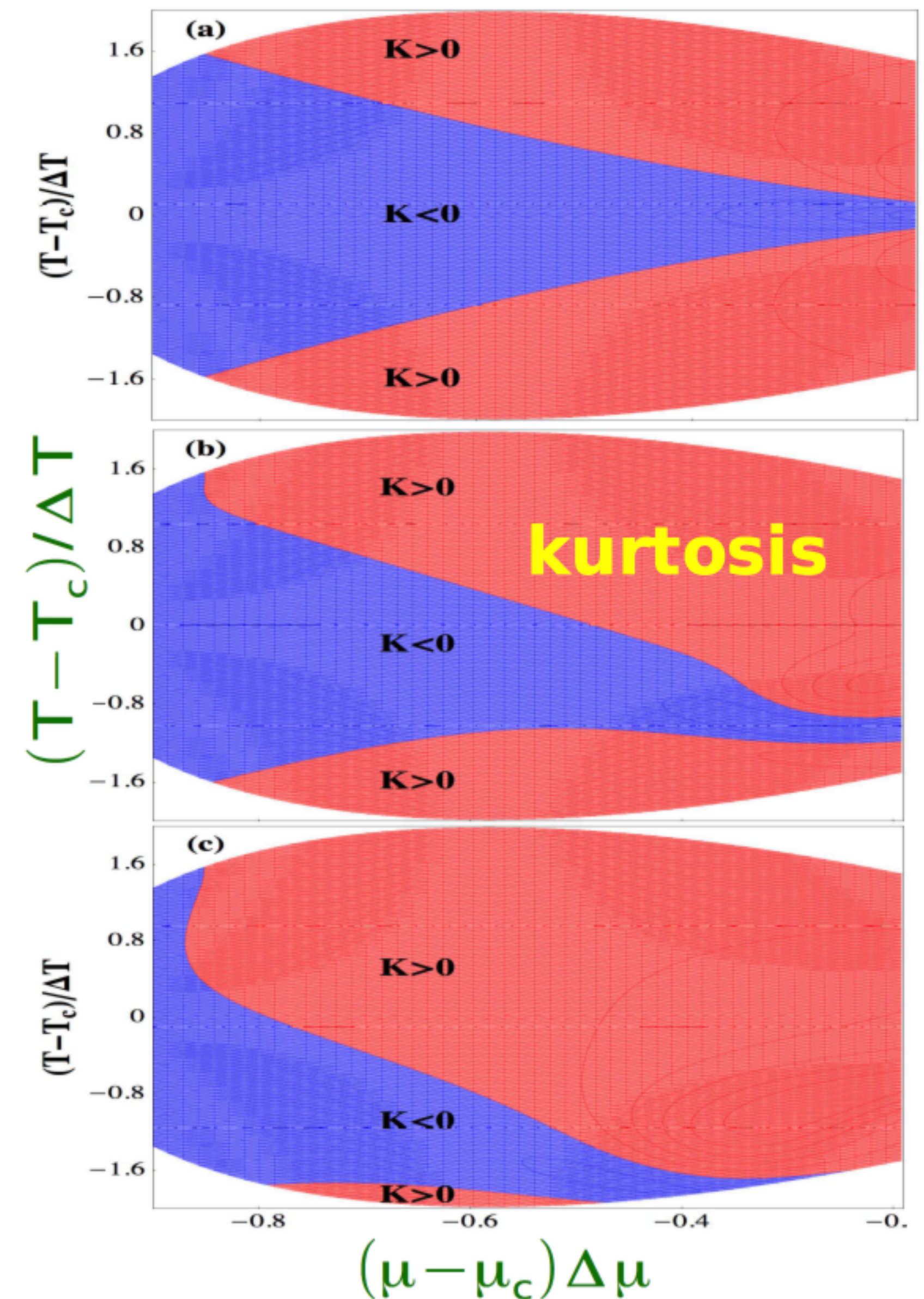$$r^\chi_{2n} = \left| \frac{2n(2n-1)\chi^B_{2n}}{\chi^B_{2n+2}} \right|, \ r_c = \lim_{n\to\infty} r^\chi_{2n}$$

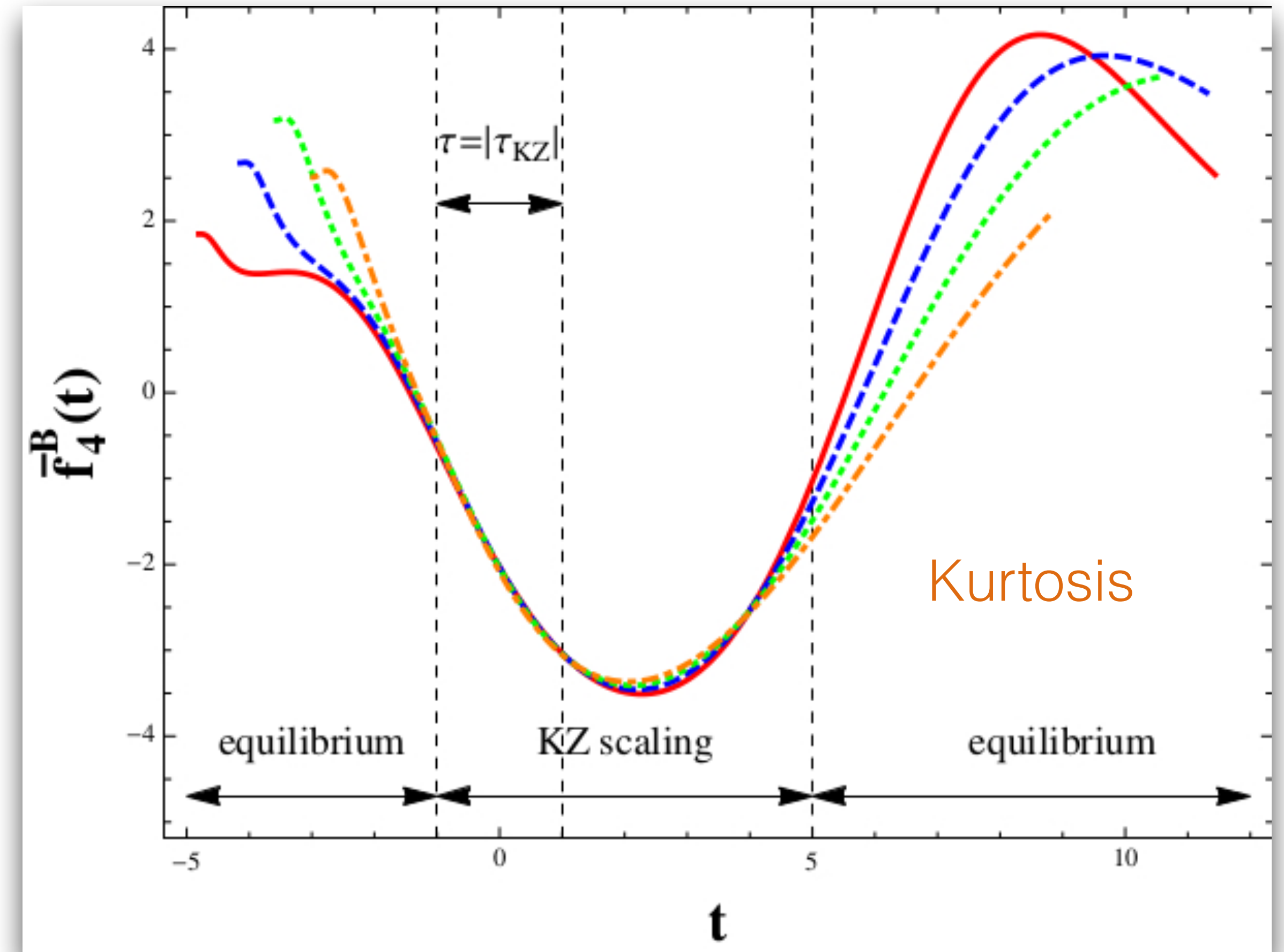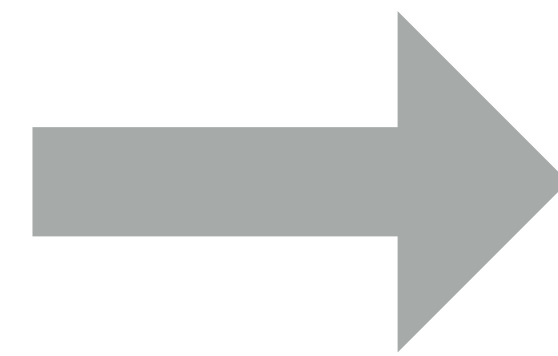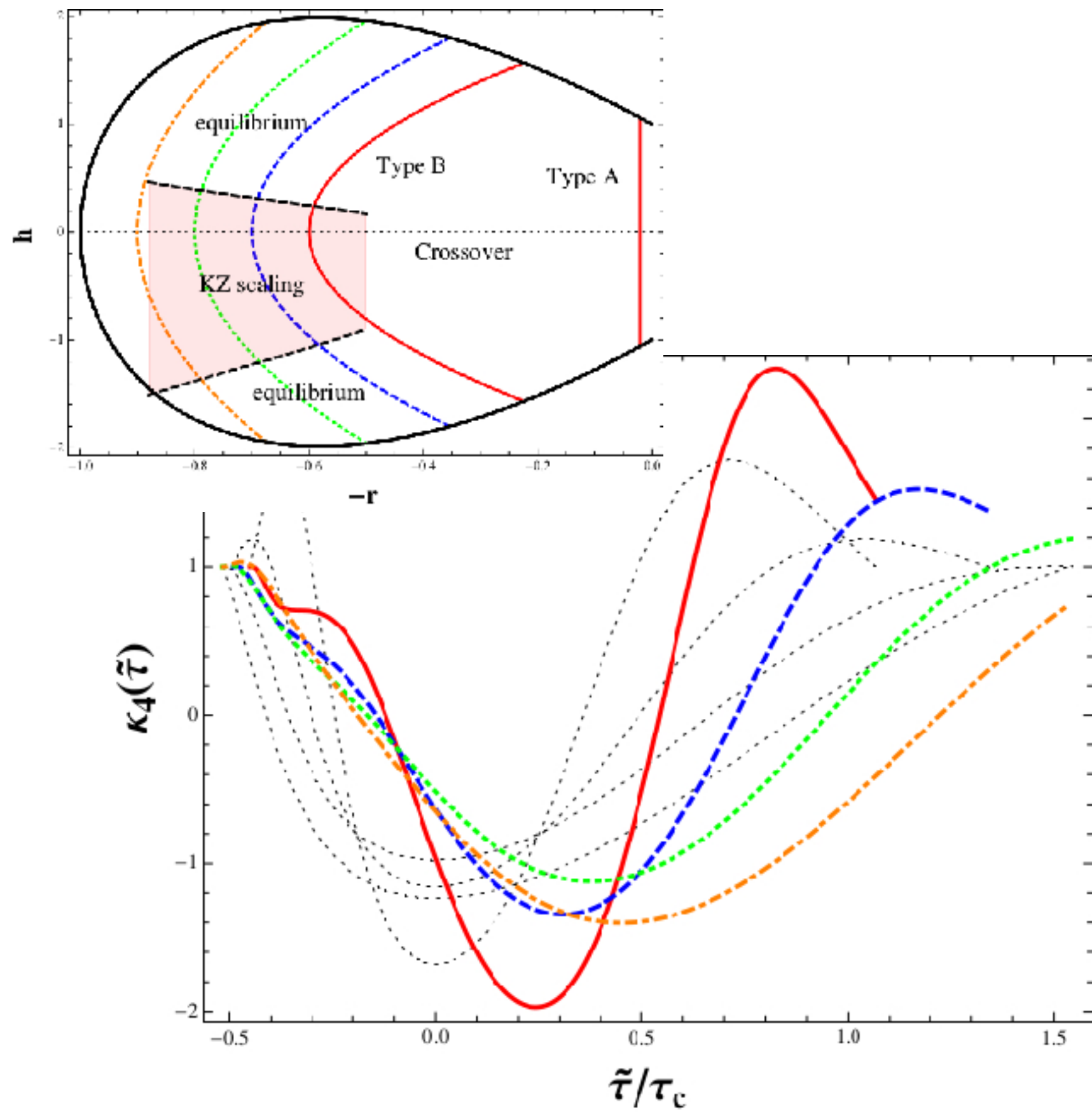signs of cumulants near the critical point are universal, only in equilibrium

Stephanov: arXiv:1104.1627

dynamics can lead to different signs, universality lost

Mukherjee et. al.: Phys. Rev. C92, no.3, 034912 (2015)

off-equilibrium Kibble-Zurek scaling, universality regained
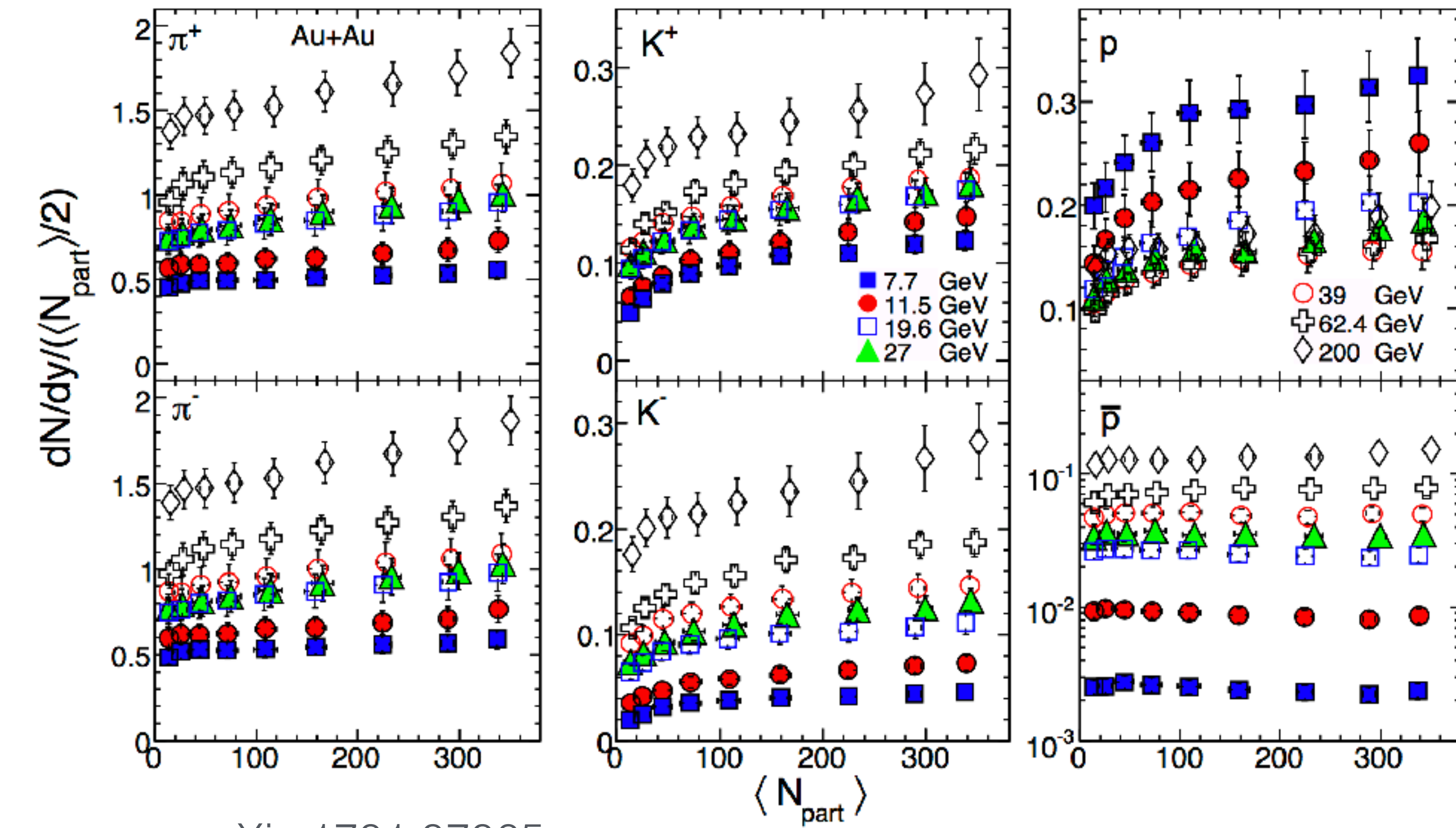

Mukherjee et. al.: Phys. Rev. Lett. 117, no.22, 222301 (2016)
(editor's suggestion)
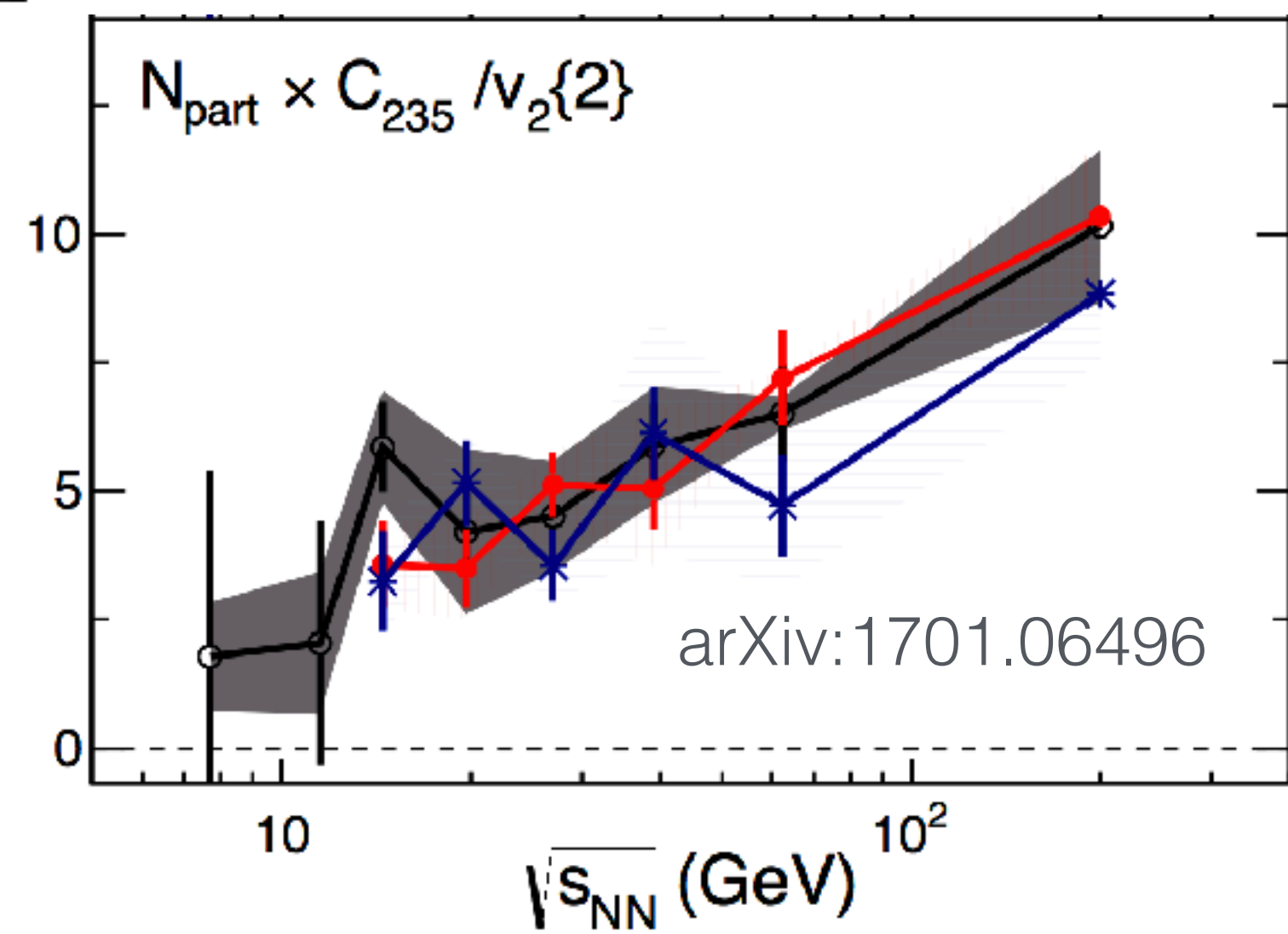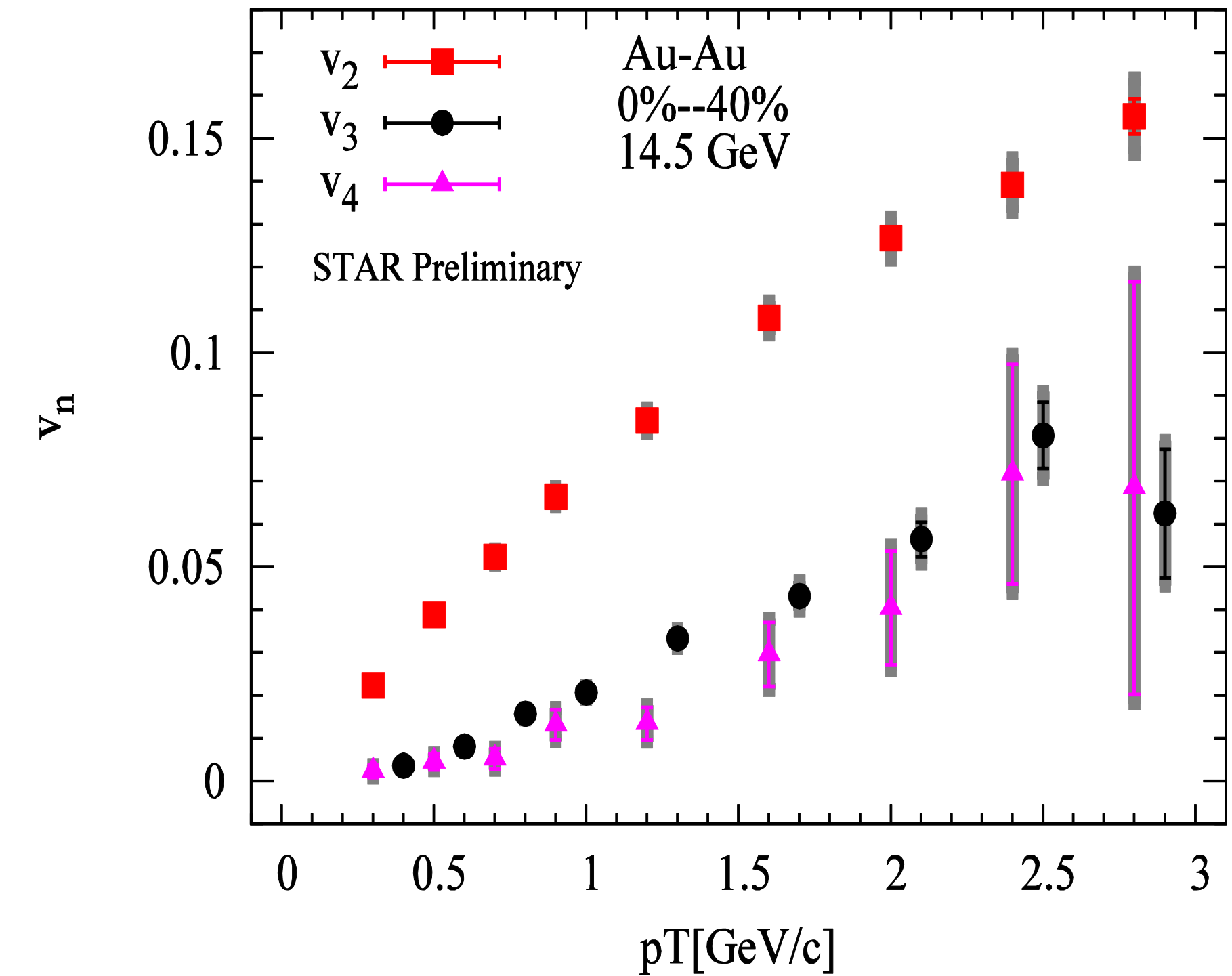
Kurtosis

insensitive to the initial condition

$$\tilde{\tau} = \tau - \tau_c, \; t = \tilde{\tau}/\tau_{KZ}$$

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arXiv:1701.07065

arXiv:1701.06496

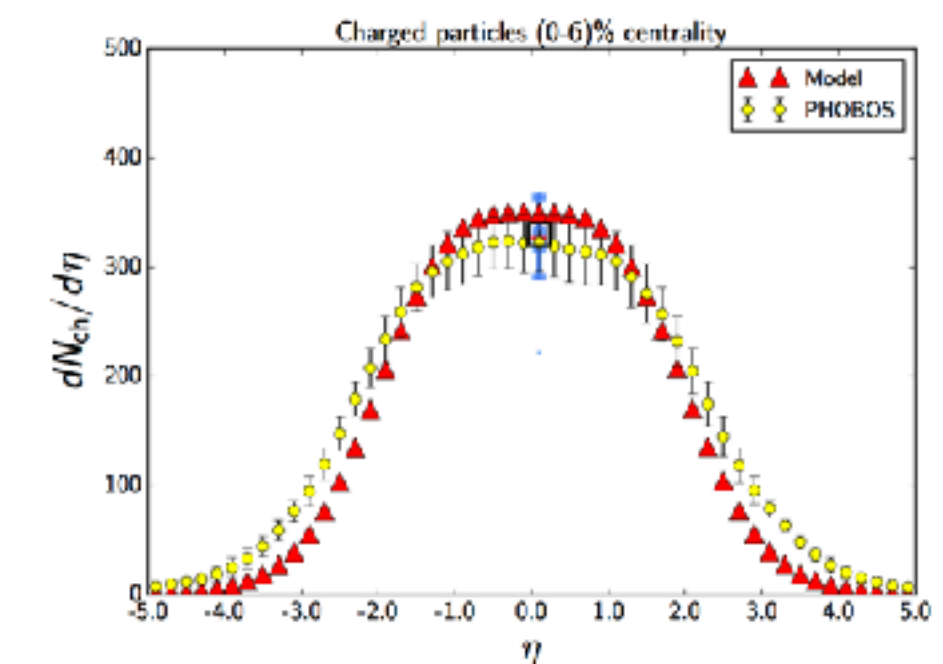# global data analysis using Bayesian inference

hydrodynamics-based modeling

Auvinen et. al.: arXiv:1706.03666

$$\sqrt{s} = 19.6\ GeV$$
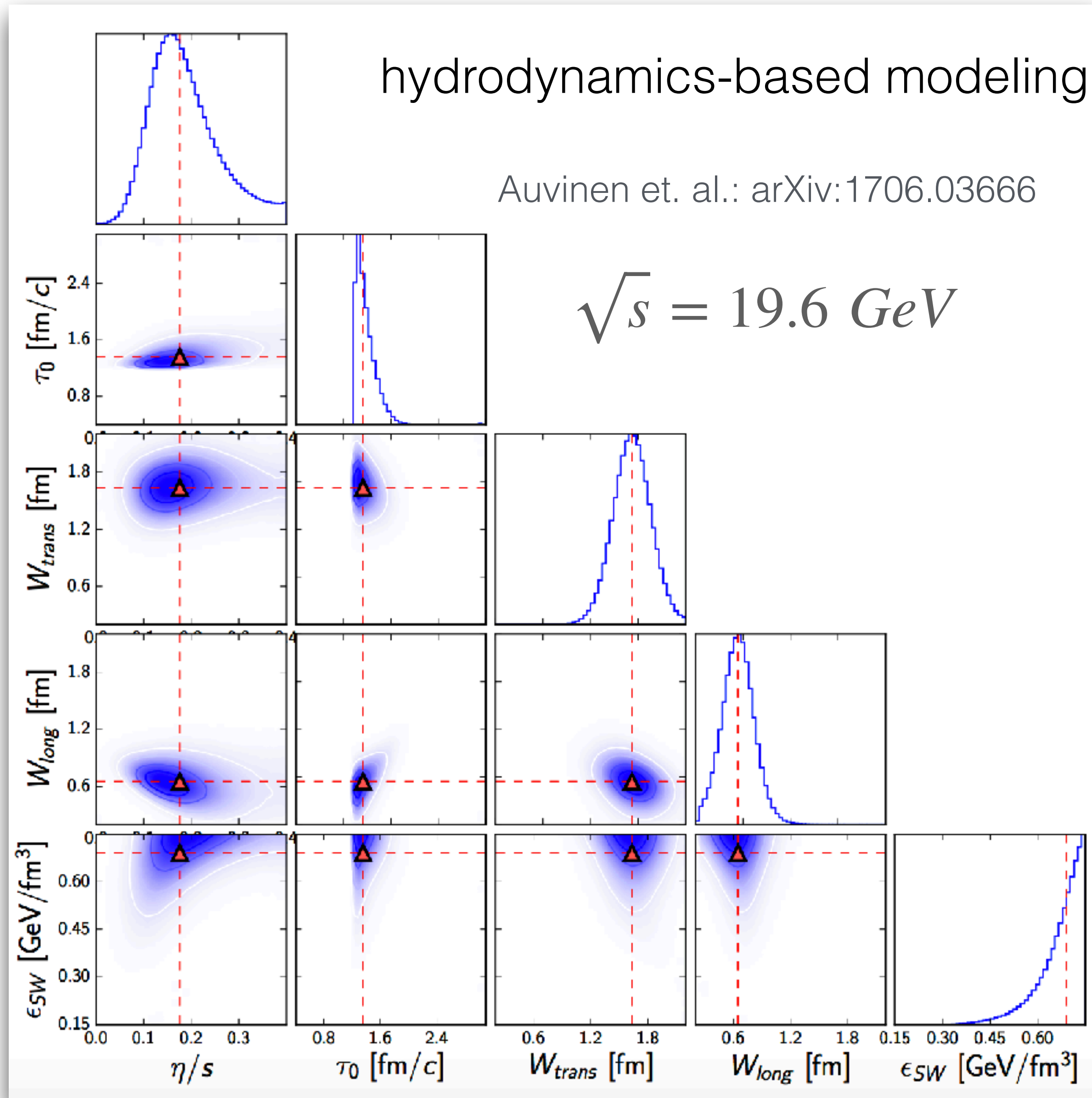
dependence of shear viscosity
baryon chemical potential
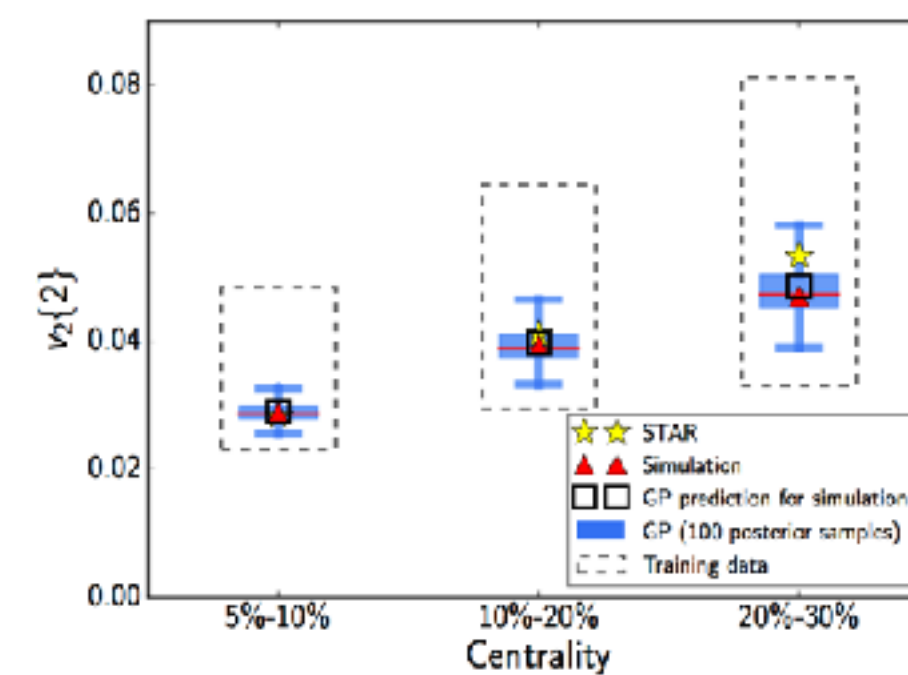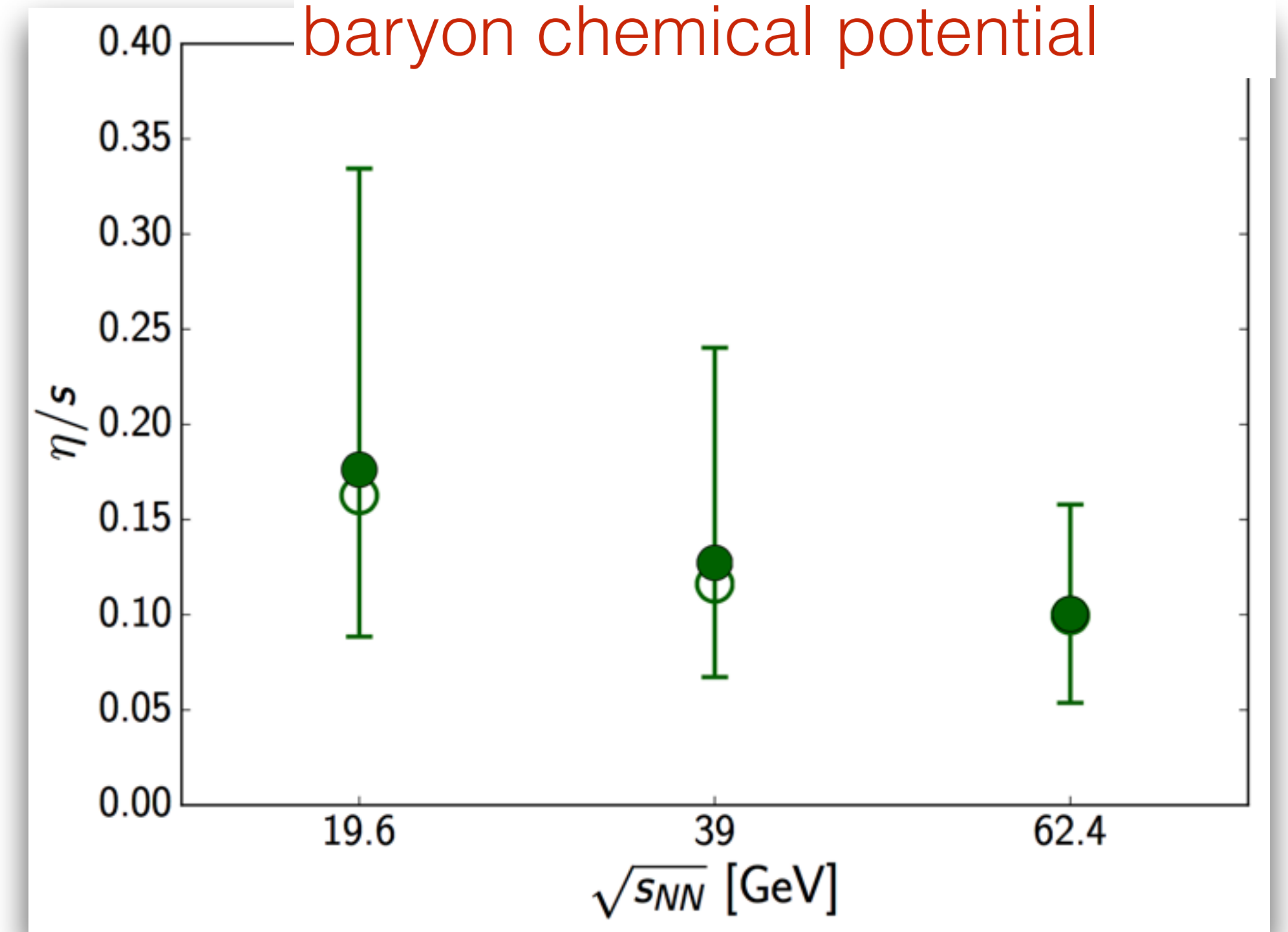
hydrodynamics-based modeling including baryon diffusion

C. Shen: QM 2017
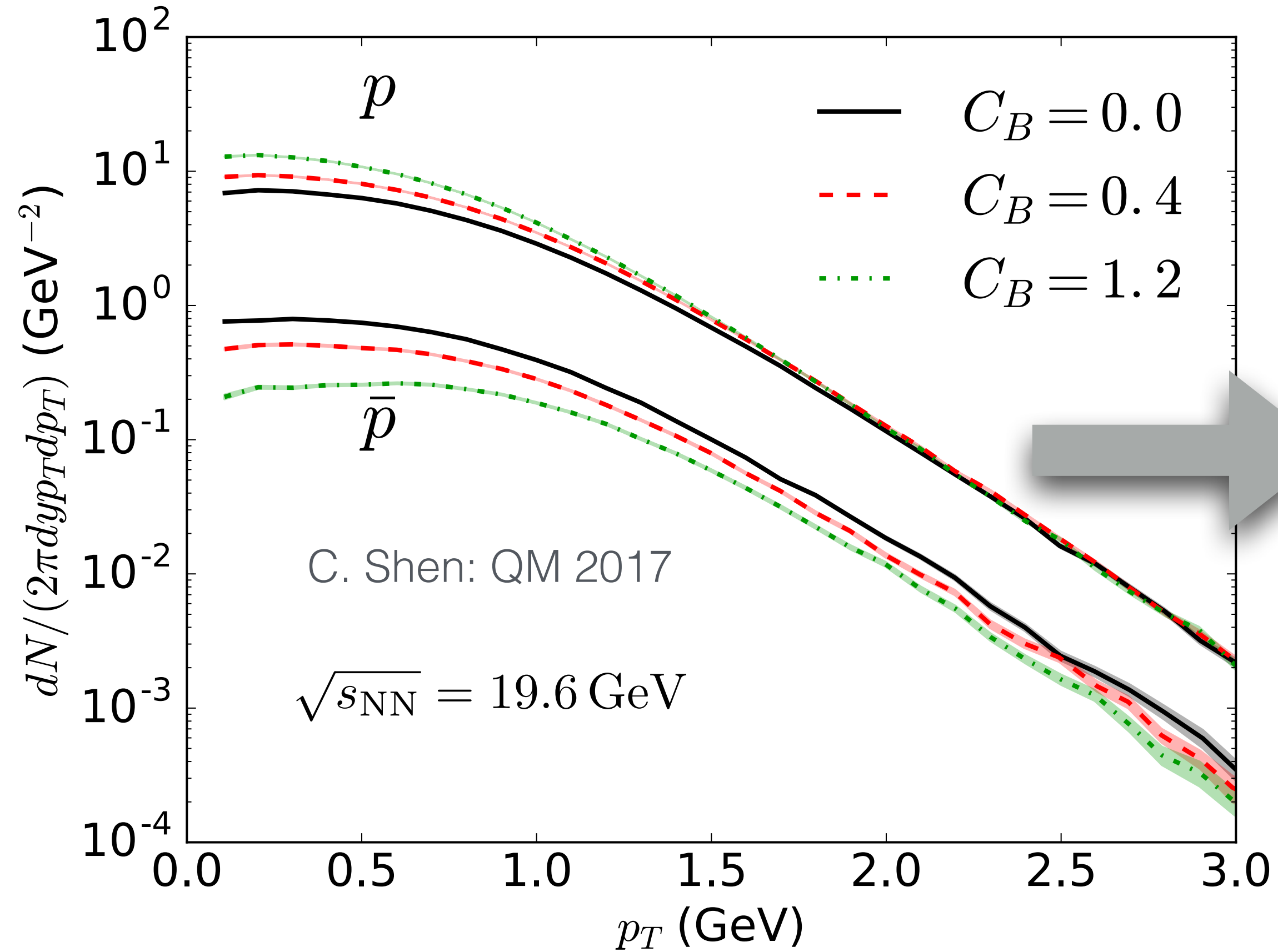
	$C_B = 0.0$	$C_B = 0.4$	$C_B = 1.2$
$\langle p_\perp \rangle^{\bar{p}} - \langle p_\perp \rangle^{p}$ (GeV)	0.044	0.091	0.198

constrains baryon diffusion constant

presently, many important physics are absent in theory framework

by 2020: a comprehensive theory framework
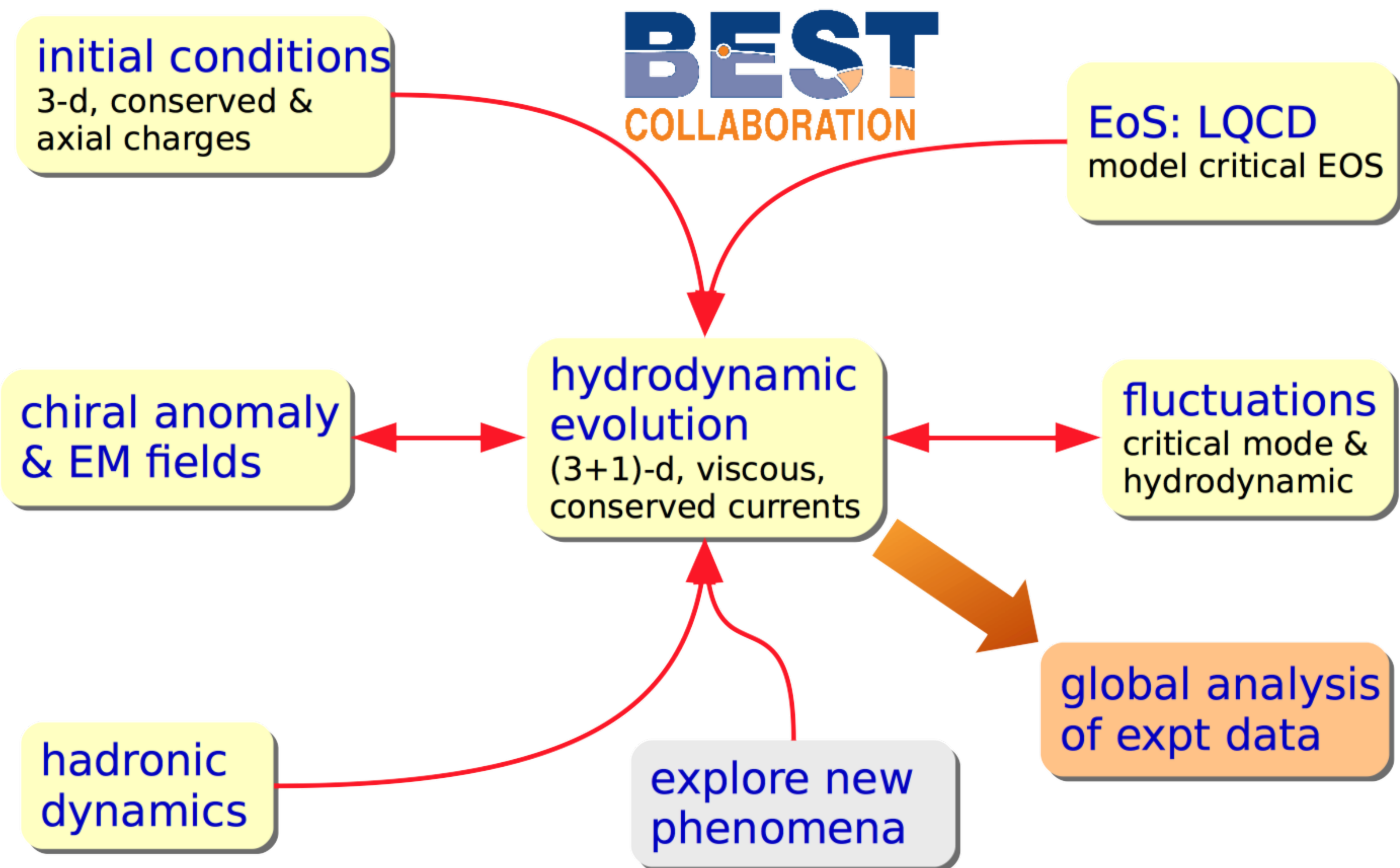
precise data from BES-II for an extended range
& a comprehensive theory framework

discover or put constraints on the existence of a critical point in the QCD phase diagram

shear and bulk viscosities, baryon diffusion constant, EoS etc. of baryon-rich QGP with changing baryon doping

chiral symmetry restoration by observing correlations related to anomalous hydrodynamic effects

possible unexpected new physics