Summary of Quark Matter 2022

Volodymyr Vovchenko

LBNL NSD Staff Meeting – May 3, 2022

QM2022 at a glance

- Follows the Nov 2019 QM in Wuhan, originally planned for 2021 but postponed due to COVID, held at Jagiellonian University in Krakow

- Performed in hybrid format on Zoom Events
  - 935 participants (378 onsite + 557 online)
  - Ban on Russian affiliations
  - NSD: 17 participants

- Program
  - 34 plenary + 195 parallel talks + 500 posters + 10 flash talks
  - 16 tracks
  - Student day
  - Session recordings on **YouTube** + slides on **indico**

Scientific Program

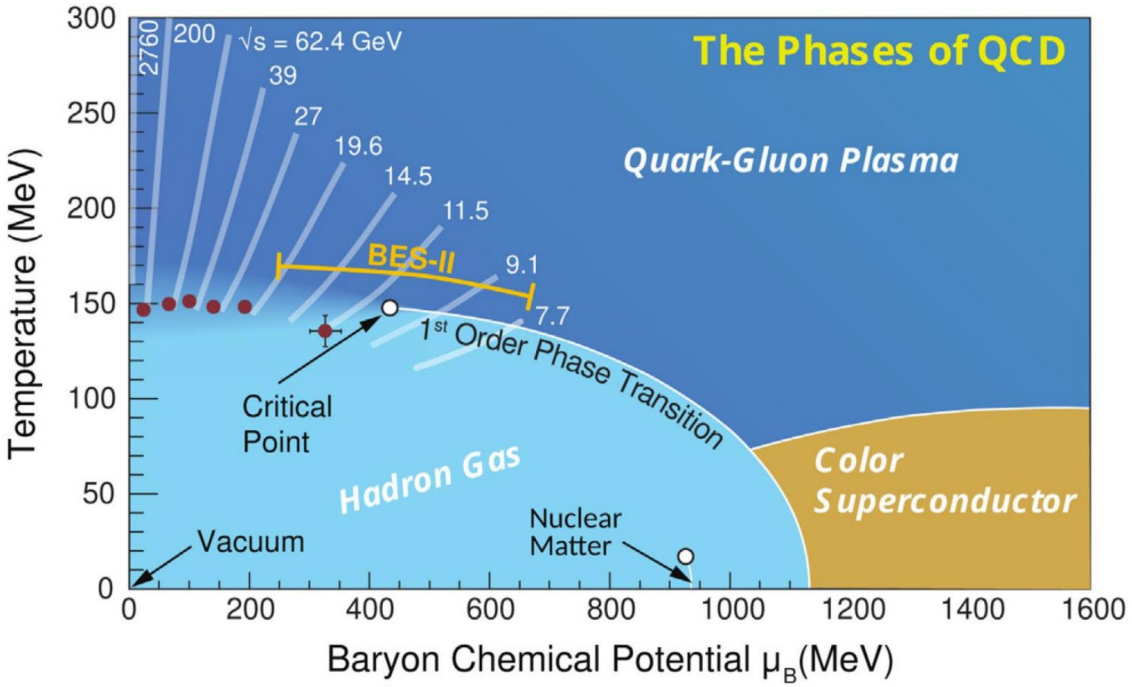
- T01: Initial state physics and approach to thermal equilibrium (13)
- T02: Chirality, vorticity and spin polarization (10)
- T03: QCD matter at finite temperature and density (15)
  - A. Sorensen, "Measuring the speed of sound using cumulants of baryon number"
- T04: Jets, high-pT hadrons, and medium response (27)
  - J. Mulligan, "Jet angularity and fragmentation measurements in heavy-ion collisions with ALICE"
  - R. Cruz Torres, "Jet acoplanarity and energy flow within jets in Pb-Pb and pp collisions with ALICE"
  - R. Ehlers, "Bayesian analysis of QGP jet transport using multi-scale modeling applied to inclusive hadron and reconstructed jet data"
  - Yue Shi Lai, "Unsupervised machine learning of heavy-ion underlying event subtraction from only ion data"
- T05: QGP in small and medium systems (13)
- T06: Lattice QCD and heavy-ion collisions (6)
- T07: Correlations and fluctuations (18)
  - Ho San Ko, "Higher-Order Cumulants of Net-Proton Multiplicity Distributions in Zr+Zr and Ru+Ru Collisions at $\sqrt{s_{NN}} = 200$ GeV by the STAR Experiment"
  - V. Vovchenko, "Proton number cumulants and correlation functions from hydrodynamics and the QCD phase diagram"

Scientific Program

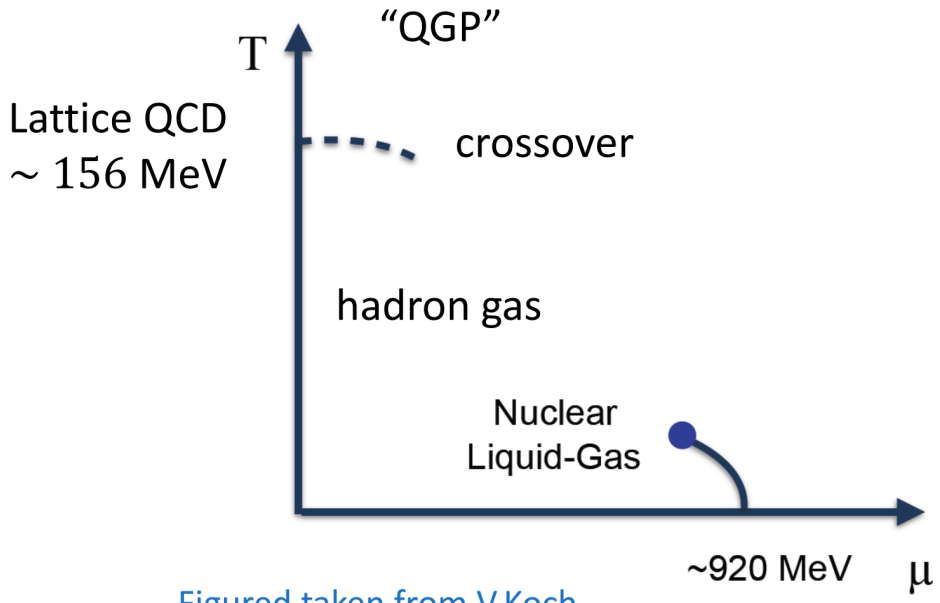
- T08: Strongly coupled systems (7)
- T09: Ultra-peripheral collisions (11)
- T10: Baryon rich matter, neutron stars, and gravitational waves (6)
- T11: Heavy flavors, quarkonia, and strangeness production (19)
  - X. Dong, "Probing Gluon Dynamics and Hadronization with Heavy Flavor Production at the Future Electron Ion Collider"
- T12: New theoretical developments (5)
- T13: Electroweak probes (12)
  - W. Fan, "Measurement of low-momentum direct photons in Au+Au collisions at 200 GeV" + **flash talk**
- T14: Hadron production and collective dynamics (12)
- T15: Future facilities and new instrumentation (11)
- T16: Light nuclei production (7)
  - Yuanjing Ji, "Measurements of $^{3}_{\Lambda}$H production and branching ratio fraction R_3 by the STAR experiment"
  - Yue-Hang Leung, "Recent Hypernuclei Measurements in the High Baryon Density Region with the STAR Experiment at RHIC"

QCD phase structure

What we hope for



What we know

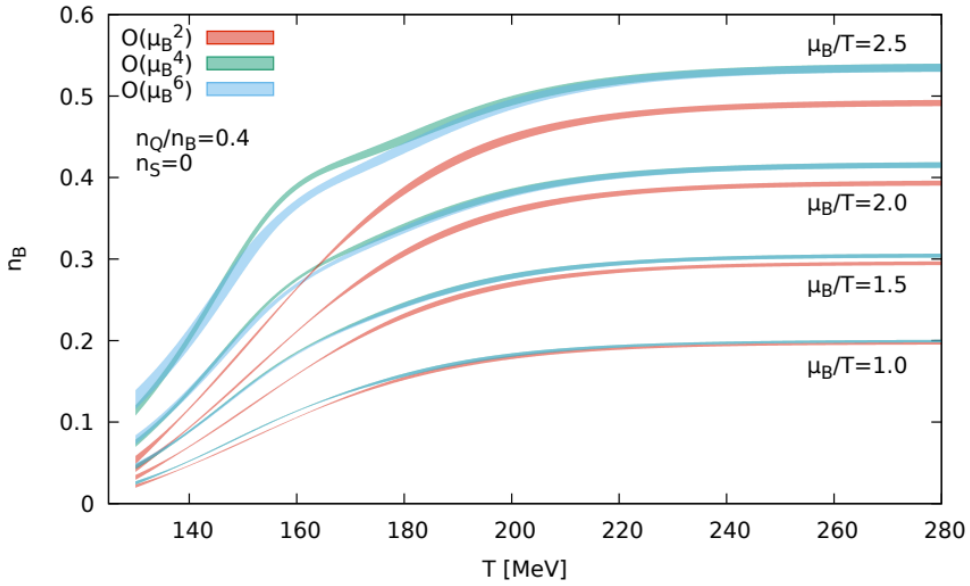


Figured taken from V.Koch

A. Bzdak, plenary

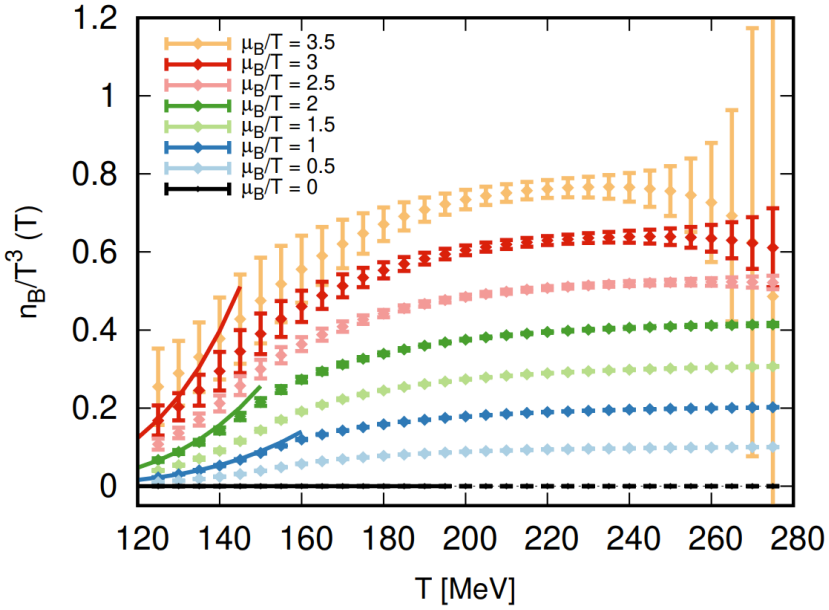
Updates on the QCD equation of state from lattice QCD

Increased precision of Taylor expansion



D. Bollweg (HotQCD), T06

Alternative expansion scheme



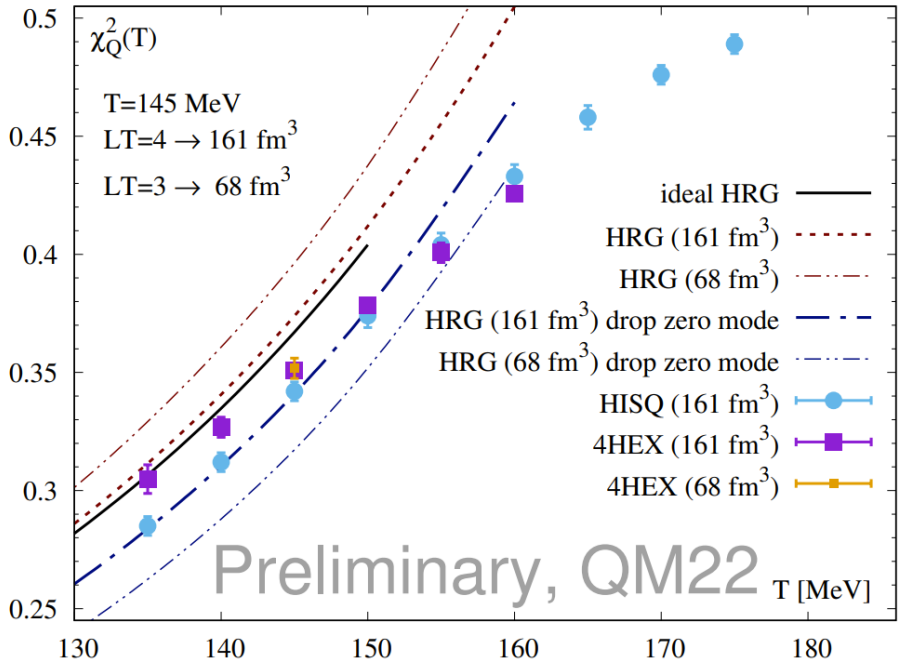
J. Gunther (BMW), T06

QCD EoS from first principles expanded to $\mu_B/T \sim 3$

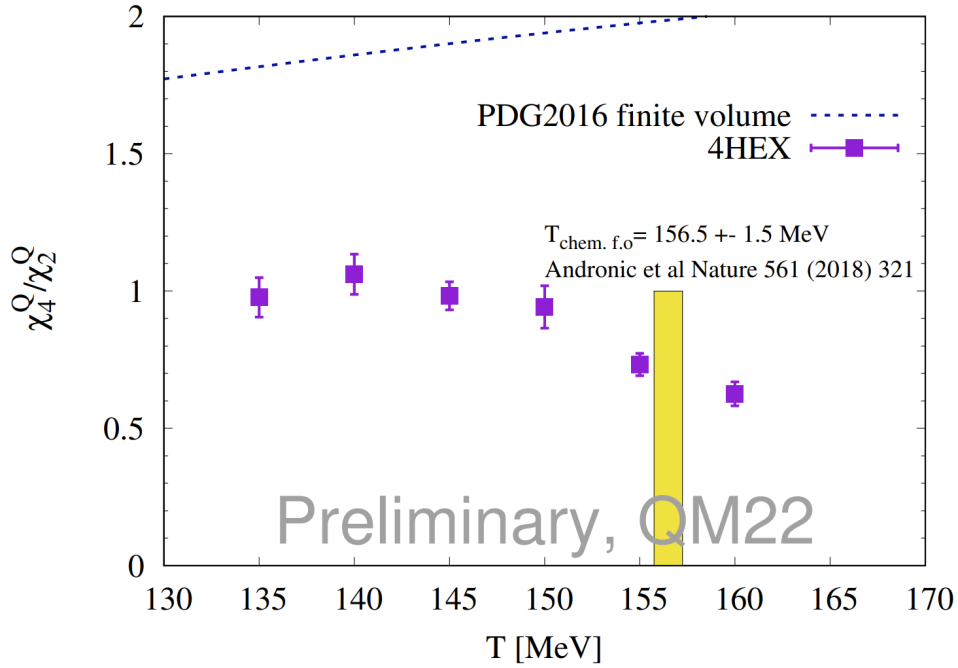
Electric charge susceptibilities from lattice QCD

S. Borsanyi (BMW), T03

Access continuum limit with new action



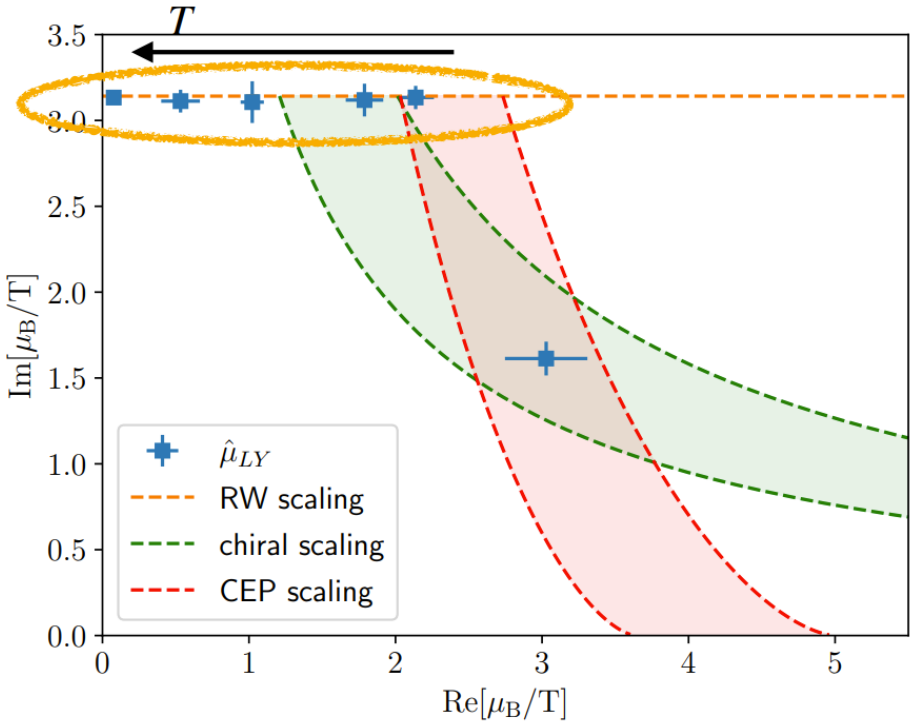
Candidate for chemical freeze-out thermometer: $\frac{\chi_4^Q}{\chi_2^Q} = \kappa\sigma^2$



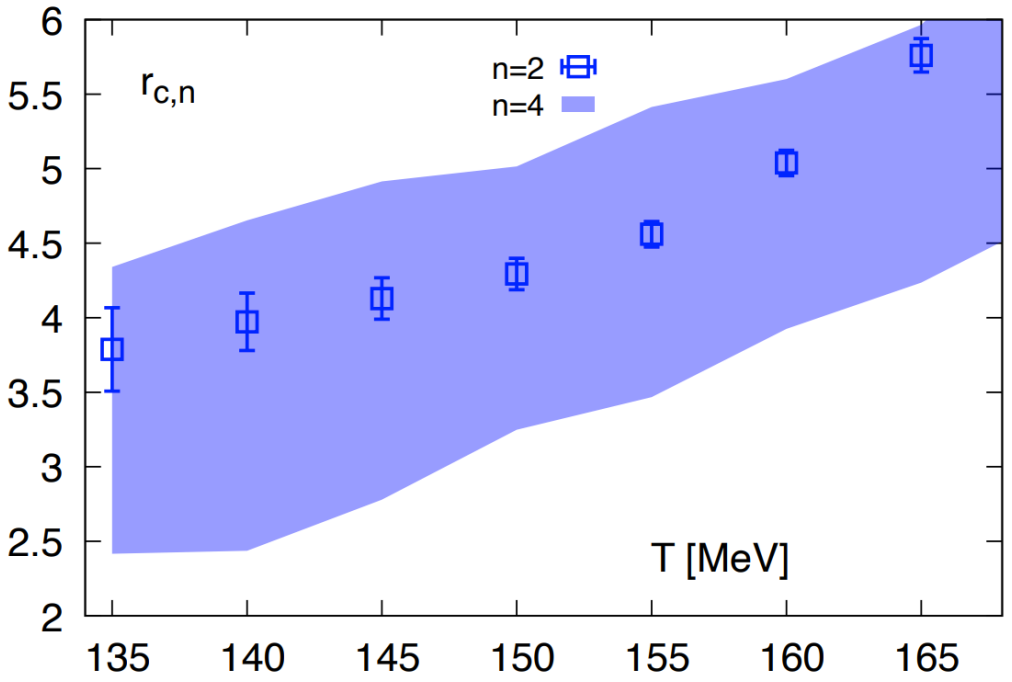
Significant deviations between QCD and hadron resonance gas at "hadronic" temperatures T = 130-160 MeV, implications for chemical freeze-out?

Searching for the critical point: lattice QCD

C. Schmidt (Bielefled-Parma), T03



J. Goswami (HotQCD), T06



In the vicinity of the critical end-point

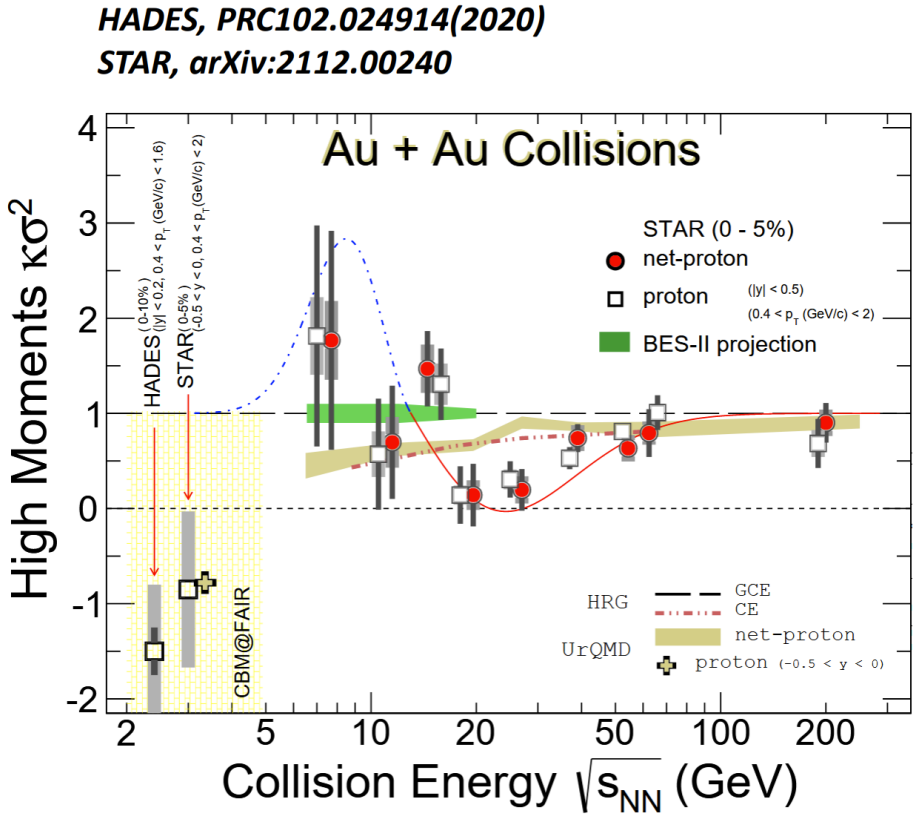
* Padé with high statistics $N_\tau = 8$ data [HotQCD]: fins singularities in compatible μ_B range, they approach the real μ_B axis, but not in consistency with universal scaling

→ Bound on the critical point: $\hat{\mu}_{cep} > 2.5$ and $T_{cep} < 135$ MeV

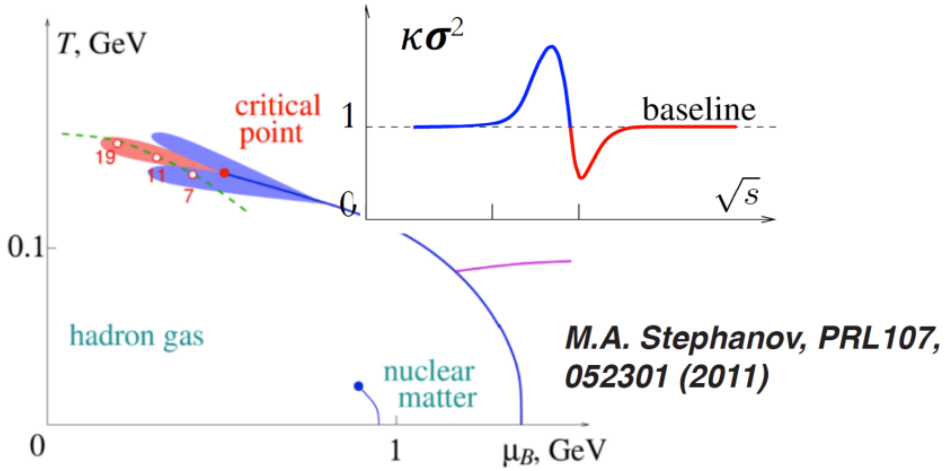
Bound for CEP is,
$\hat{\mu}_B^{CEP} > 2.5.$

Searching for the critical point: heavy-ion collisions

T. Nonaka, plenary



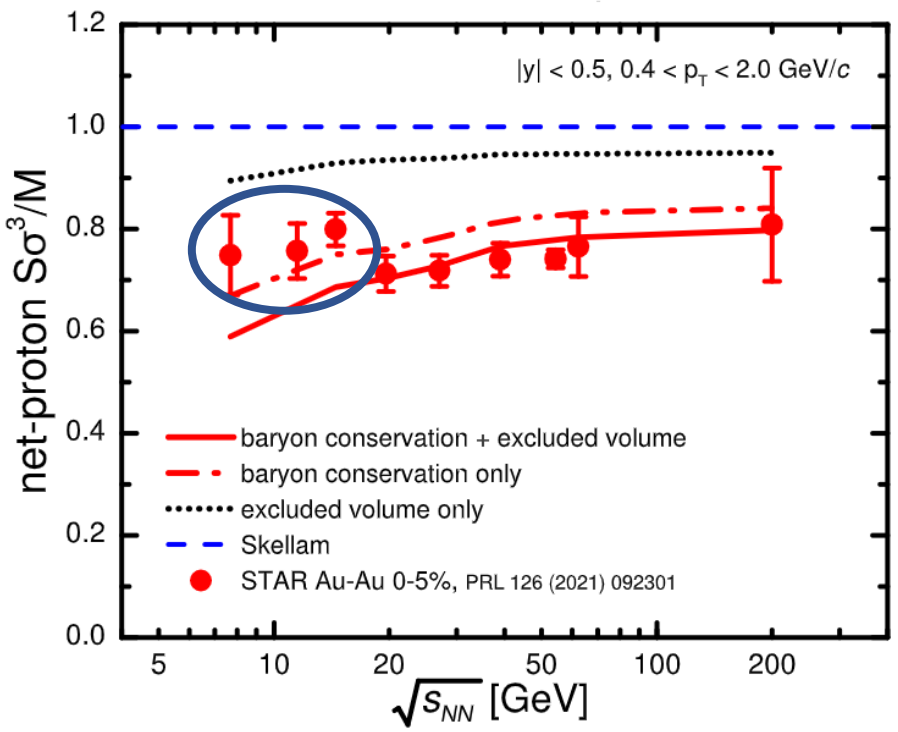
- More data will come from BES-II and FXT at STAR to fill the gap in $3<\sqrt{s_{NN}}<20$ GeV.
- More precise study will be carried out by CBM@FAIR, MPD@NICA, HIAF, and JPARC-HI.

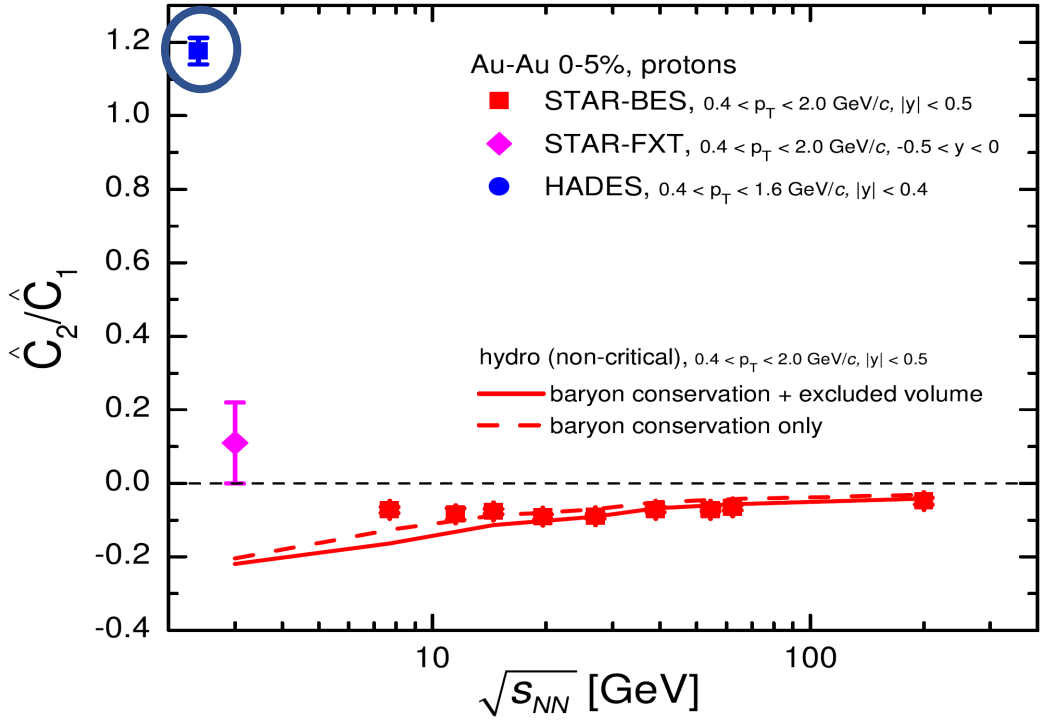


STAR-FXT 3 GeV: Y. Zhang, T03

Searching for the critical point: heavy-ion collisions

V. Vovchenko, T07

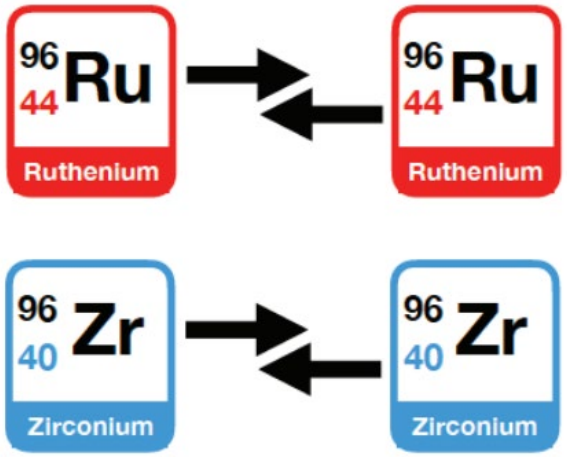


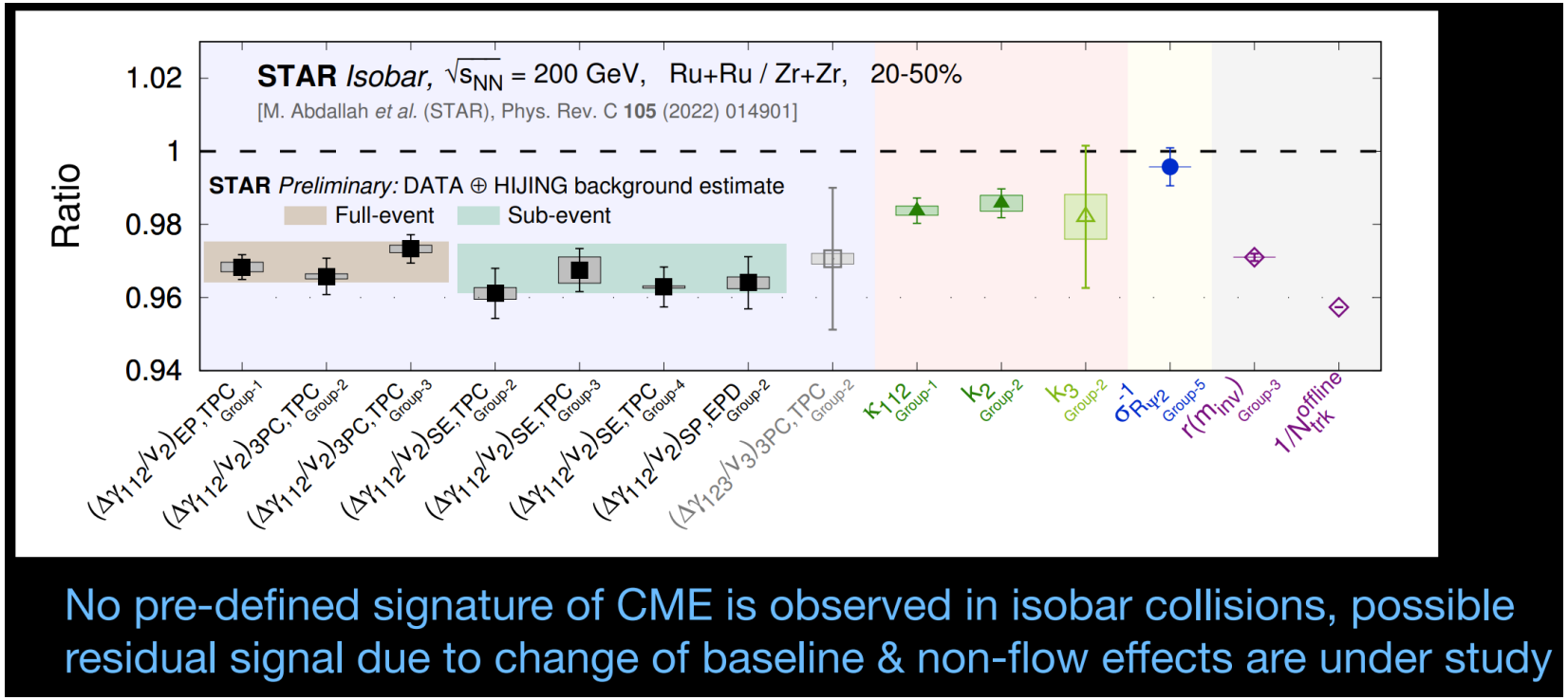


Excess of proton correlations in the data at $\sqrt{s_{NN}} < 20$ GeV which could indicate critical point at $\mu_B/T > 3$

Isobar collisions: chiral magnetic effect and other applications

Yu Hu, T02



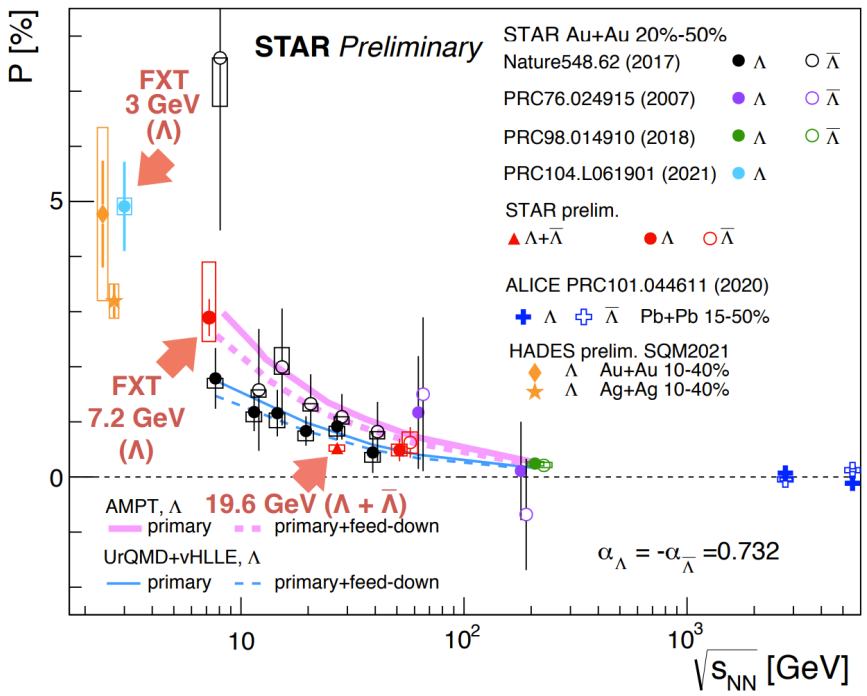


No pre-defined signature of CME is observed in isobar collisions, possible residual signal due to change of baseline & non-flow effects are under study

Other measurements: nuclear structure **(H. Xu, T01),** polarization **(J. Adams, T02)**, net-proton cumulants **(H.-S. Ko)**, etc

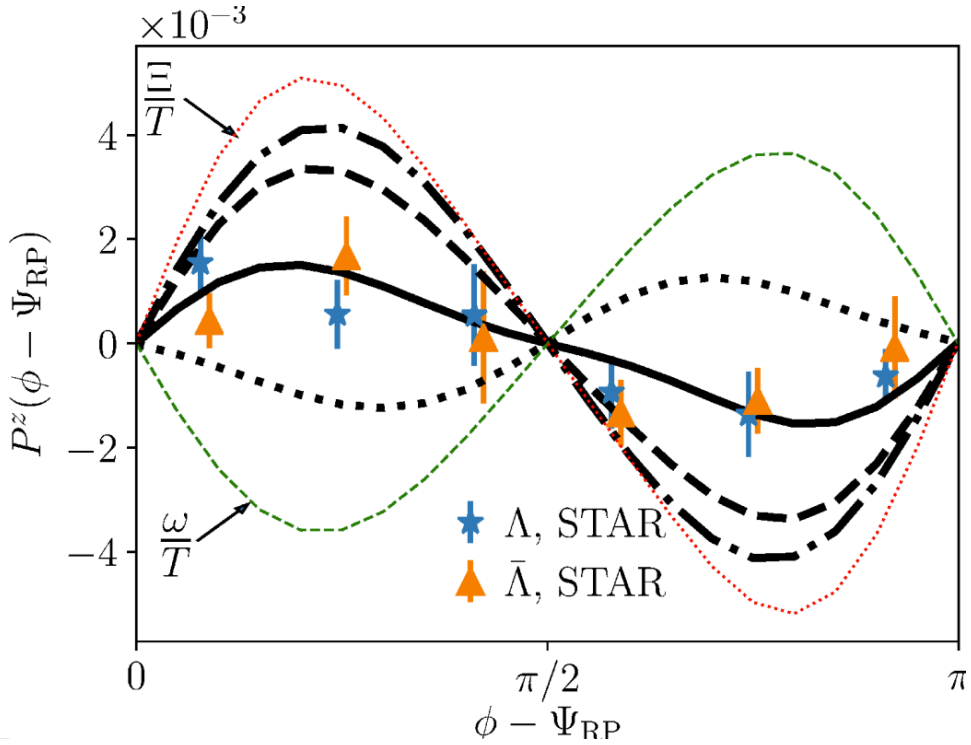
Polarization and spin

Λ polarization decreases with collision energy



D. Sarkar, plenary (exp)

Local polarization is more challenging but can be solved by adding thermal shear coupling

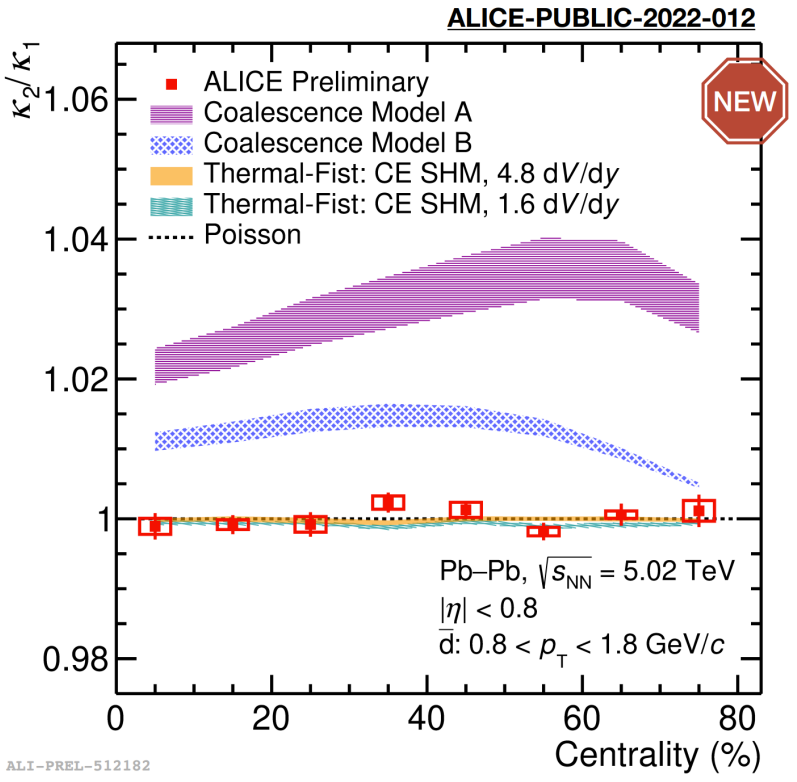


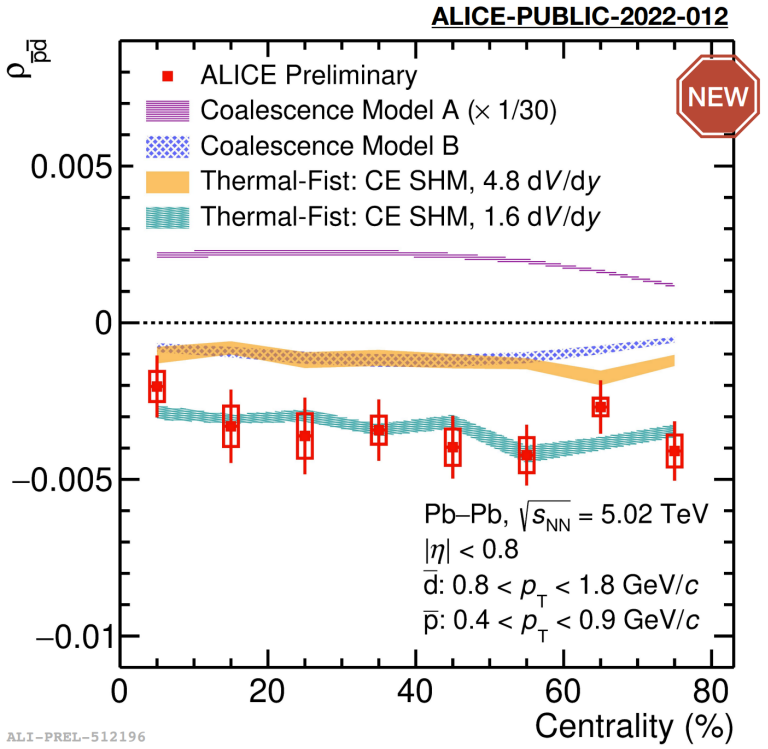
M. Buzzegoli, T02

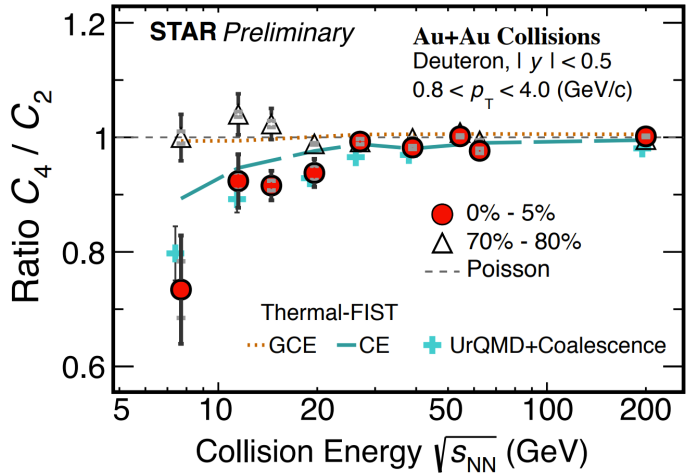
Spurred many theory developments, like **spin hydrodynamics**

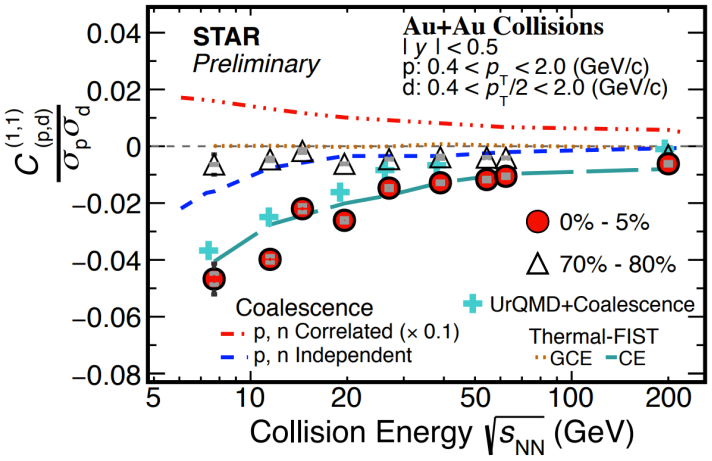
N. Weickgennant, plenary (theory)

Light nuclei: fluctuations and correlations









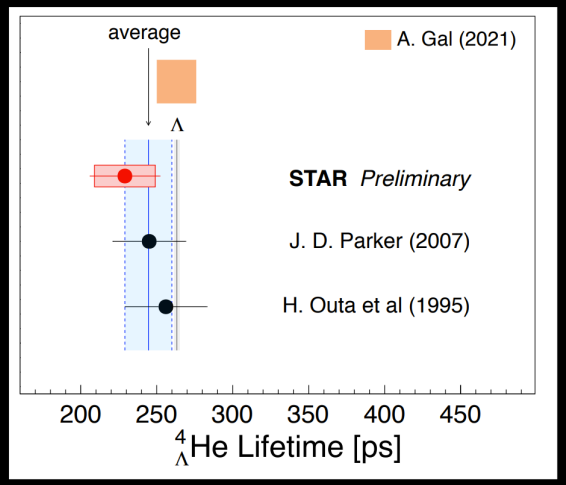
S. Kundu (ALICE), T16

D. Mallick (STAR), T07

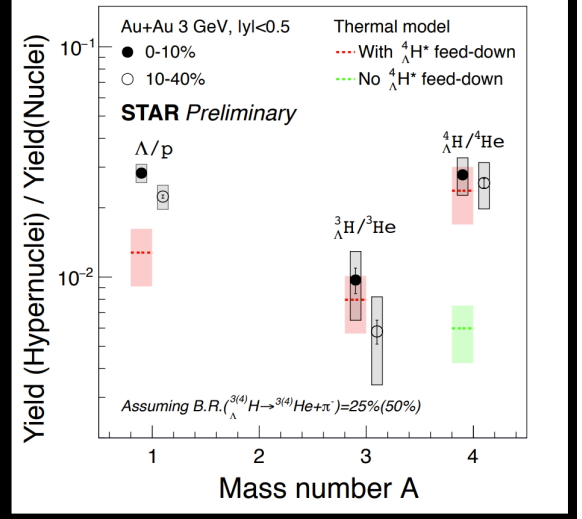
A path toward distinguishing the production mechanisms?

Hadron-hadron interactions

Hyperon-nucleon interactions with hypernuclei



The first Hyper-Helium-4 lifetime measurement in heavy ion collisions

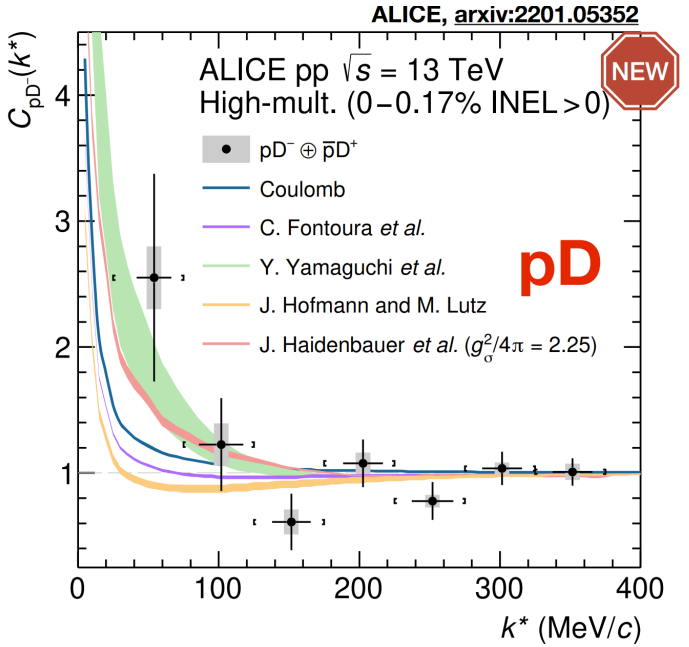


Formation of excited hypernuclei states in heavy ion collisions

Y.-H. Leung (STAR), T16

First studies of residual strong interaction between charm and light hadrons

- Data compatible with Coulomb interaction and with shallow attractive strong interaction



F. Grosa (ALICE), T08

A path toward distinguishing the production mechanisms?

Future

LHC

J. Klein, plenary

CBM at FAIR: baryon-rich matter

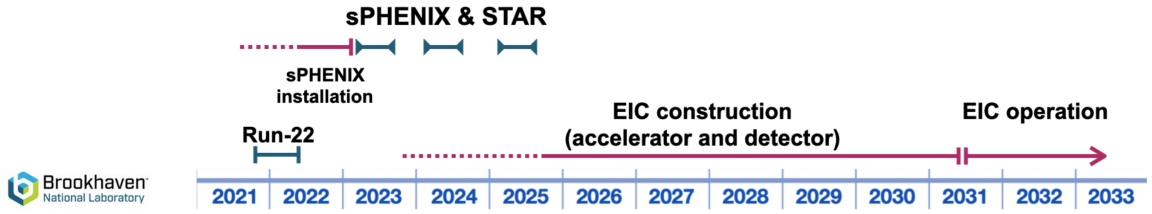
K. Agarwal, T15

RHIC/EIC

Summary: the near- and mid-term future

Guided by the still current NSAC long range plan …

- Beam energy scan completed
- Successful STAR upgrades for BES and forward measurements
- sPHENIX installation well underway; first collisions February 2023
- Major new NP facility EIC progressing toward construction start



D. Morrison, plenary