Testing the QGP properties at finite μ_B with heavy-ion collisions

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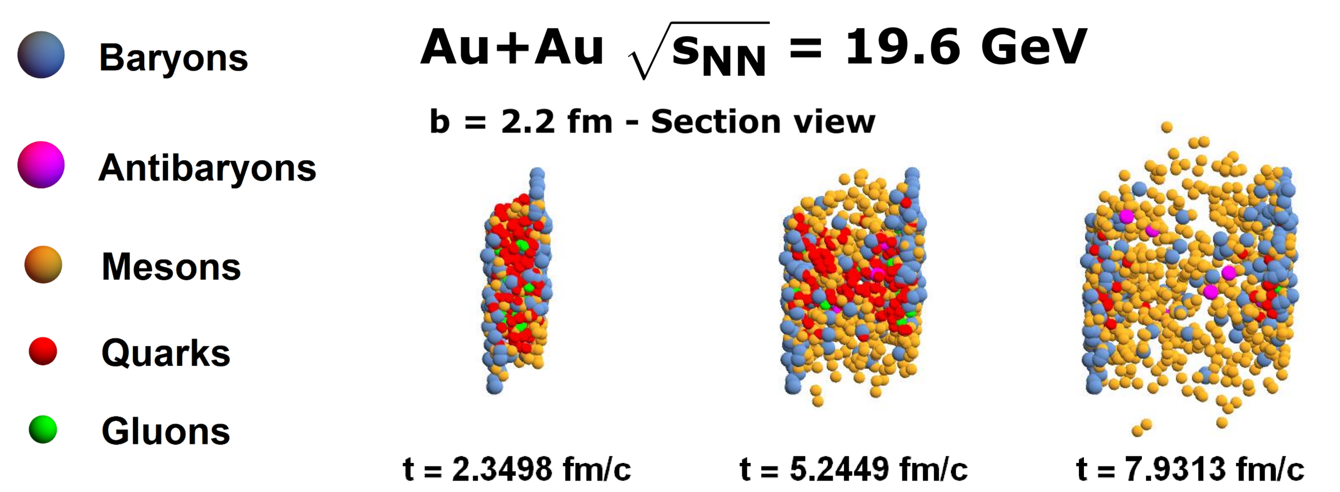
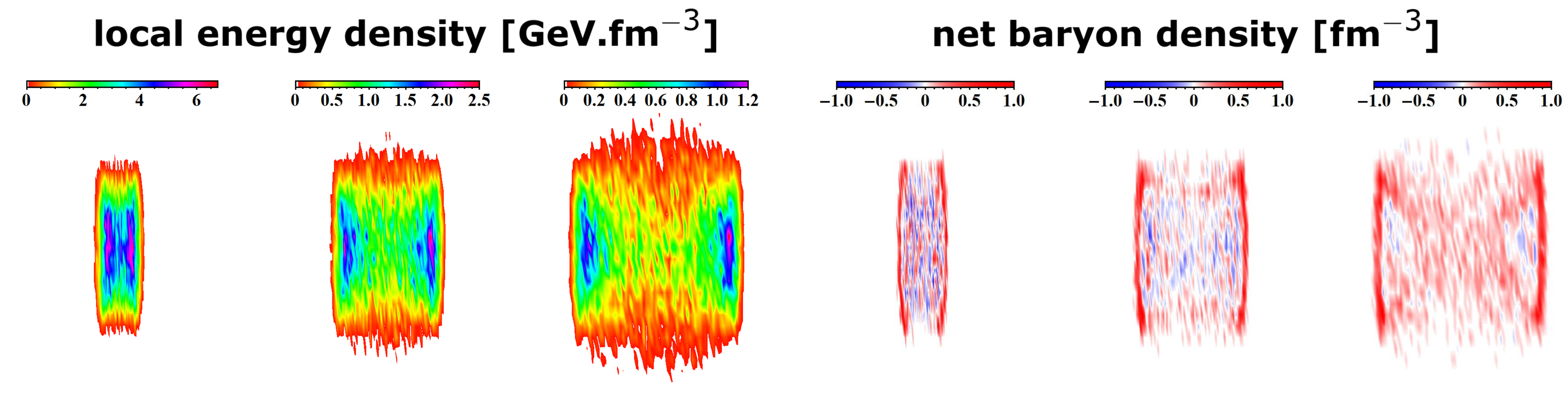
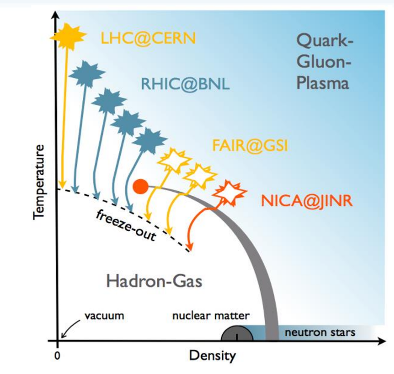




I - Motivations

- One of the main goals of heavy-ion collisions is to explore the phase diagram of strongly interacting matter, which is only known at low μ_B
- Signals of a deconfined phase of matter (QGP) at low bombarding energies is of particular interest since the baryon density is expected to be large
  - Need for microscopic models to estimate and predict signals and properties of baryon-rich matter produced in heavy-ion collisions



II – Dynamical Quasi-Particle Model (DQPM)

- DQPM is an effective model describing the QGP at finite T and μ_B
  - The d.o.f. are strongly interacting quasi-particles, whose properties are fitted to reproduce lQCD results

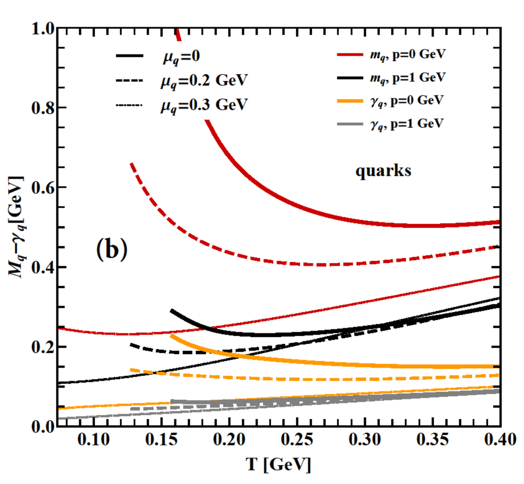
$$M_g(T,\mu_q,p) = \left(\frac{3}{2}\right)\left(\frac{g^2(T^\star/T_c(\mu_q))}{6}\left[\left(N_c+\frac{1}{2}N_f\right)T^2+\frac{N_c}{2}\sum_q\frac{\mu_q^2}{\pi^2}\right]\left[\frac{1}{1+\Lambda_g(T_c(\mu_q)/T^\star)p^2}\right]\right)^{1/2}+m_{\chi g},$$

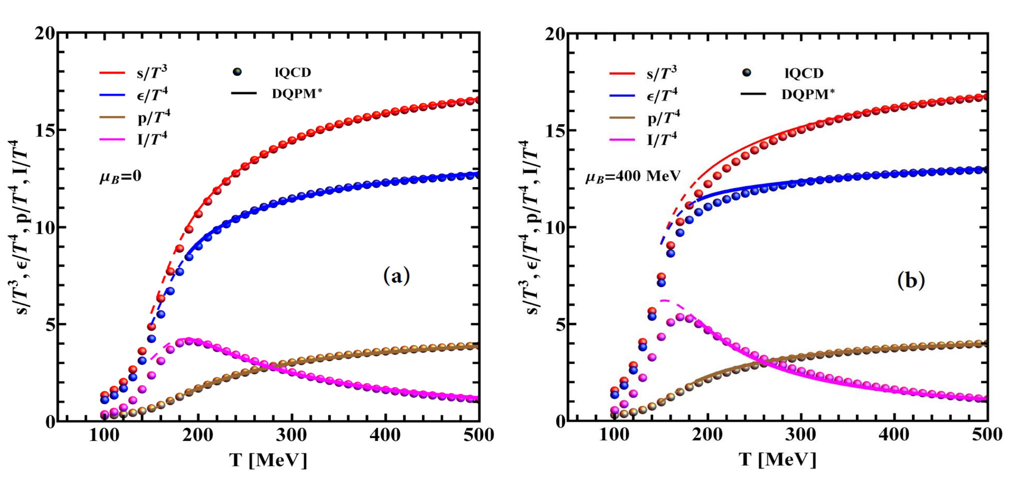
$$M_{q,\bar{q}}(T,\mu_q,p) = \left(\frac{N_c^2-1}{8N_c}g^2(T^\star/T_c(\mu_q))\left[T^2+\frac{\mu_q^2}{\pi^2}\right]\left[\frac{1}{1+\Lambda_q(T_c(\mu_q)/T^\star)p^2}\right]\right)^{1/2}+m_{\chi q},$$

$$\gamma_g(T,\mu_q,p) = N_c\frac{g^2(T^\star/T_c(\mu_q))}{8\pi}T\ln\left(\frac{2c}{g^2(T^\star/T_c(\mu_q))}+1.1\right)^{3/4}\left[\frac{1}{1+\Lambda_g(T_c(\mu_q)/T^\star)p^2}\right]^{1/2},$$

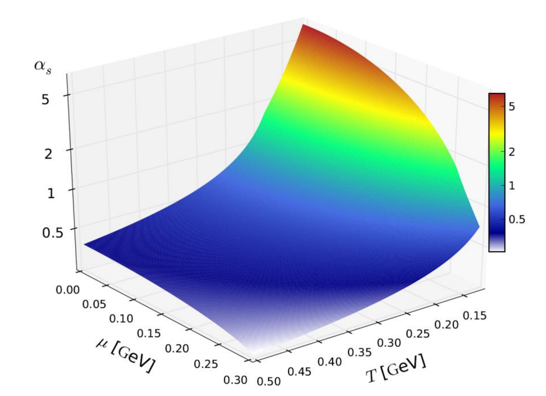
$$\gamma_{q,\bar{q}}(T,\mu_q,p) = \frac{N_c^2-1}{2N_c}\frac{g^2(T^\star/T_c(\mu_q))}{8\pi}T\ln\left(\frac{2c}{g^2(T^\star/T_c(\mu_q))}+1.1\right)^{3/4}\left[\frac{1}{1+\Lambda_q(T_c(\mu_q)/T^\star)p^2}\right]^{1/2},$$

with $T^{*2} = T^2 + \mu_q^2/\pi^2$ and $g^2 = g_0\left((s/s_B)^b - 1\right)^d$



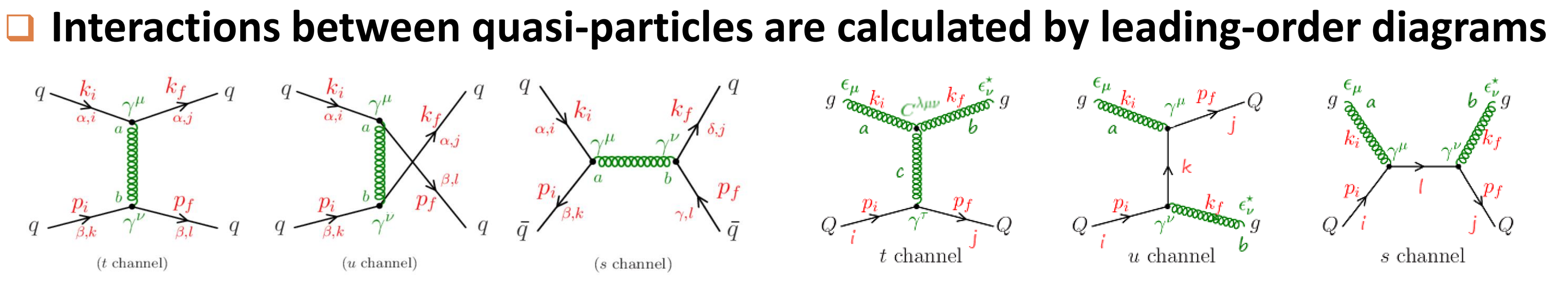


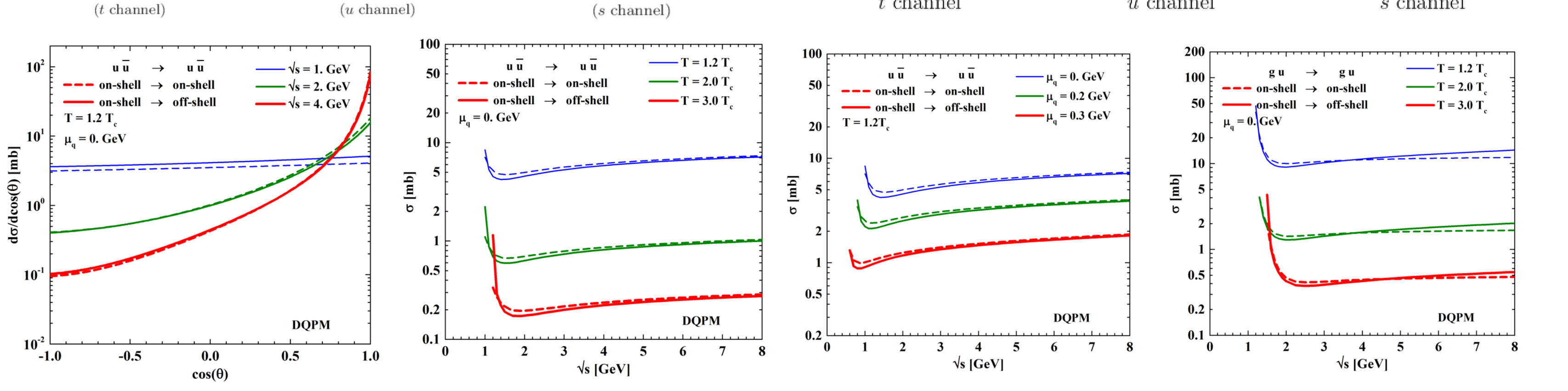
Scaling hypothesis: $g^2\left(\frac{T}{T_c}\right) \to g^2\left(\frac{T^*}{T_c(\mu)}\right)$



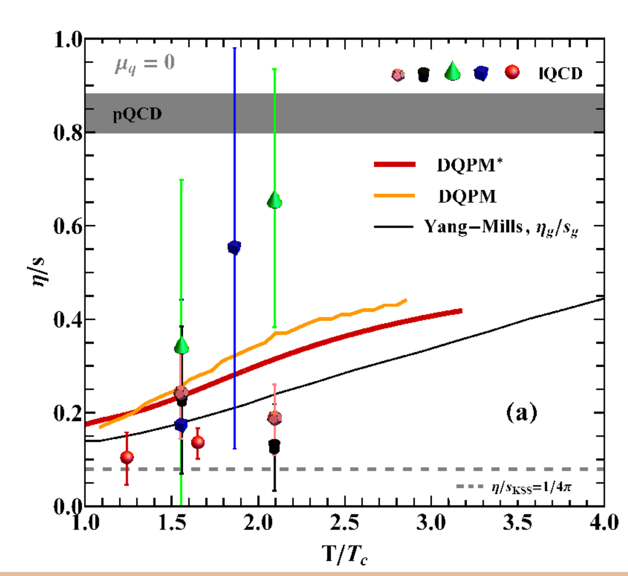
III – Cross sections and transport coefficients from DQPM

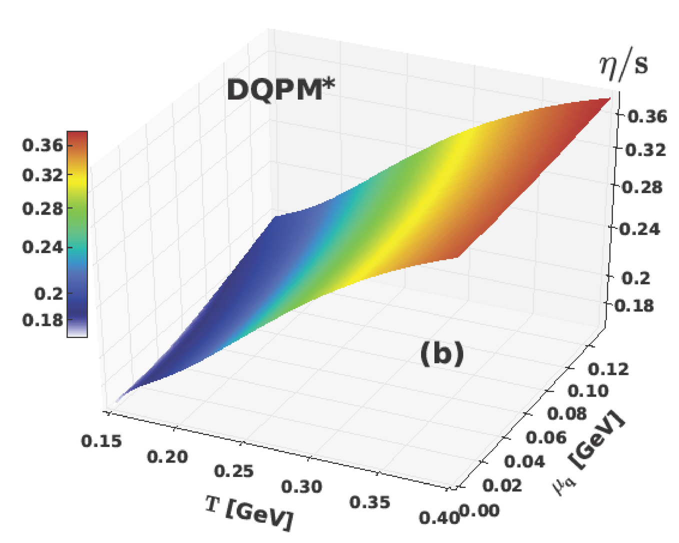
- Interactions between quasi-particles are calculated by leading-order diagrams





- Good agreement with lQCD for transport coefficients (η/s, ζ/s, σ_e/T,…)

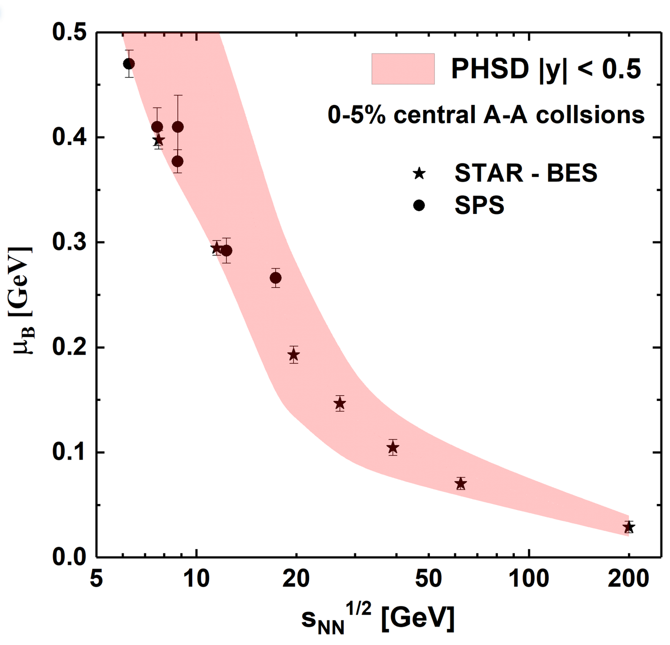




IV – PHSD: Nucleus-nucleus collisions

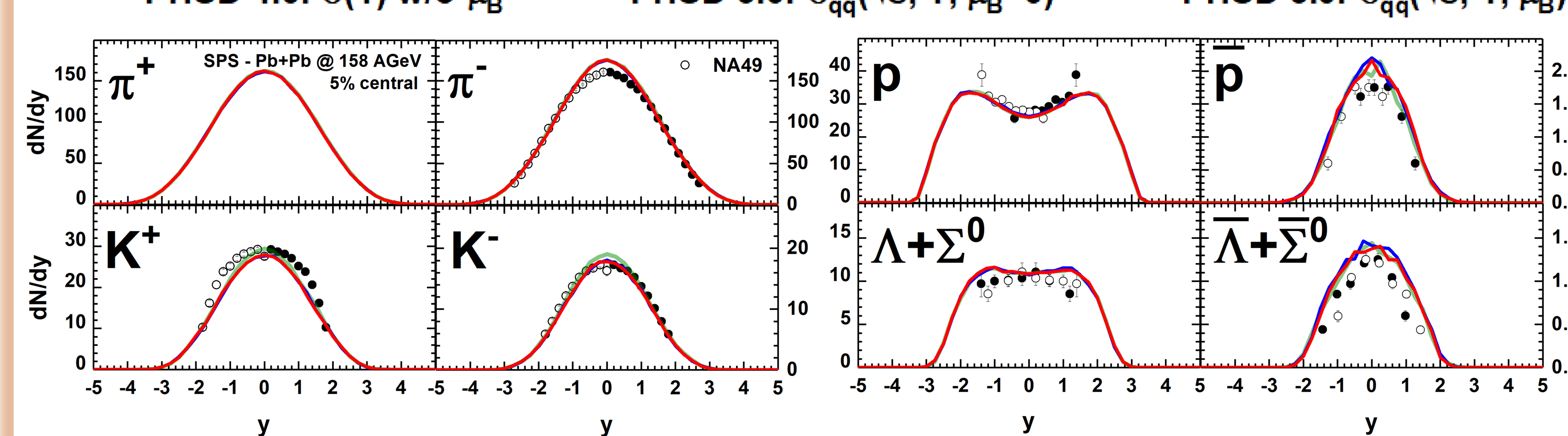
- PHSD is a covariant dynamical approach for strongly interacting systems
  - Off-shell transport equations (on the basis of Kadanoff-Baym equations) in phase-space representation govern the time evolution of the system
  - DQPM provides the proper degrees of freedom and interactions during the QGP phase
  - Hadron-string interactions for the early and late stage of heavy-ion collisions
- Conversion from energy density and net baryon density to T and μ_B using the DQPM EoS
- Baryons mainly contribute to μ_B while the QGP is almost symmetric between quarks and antiquarks

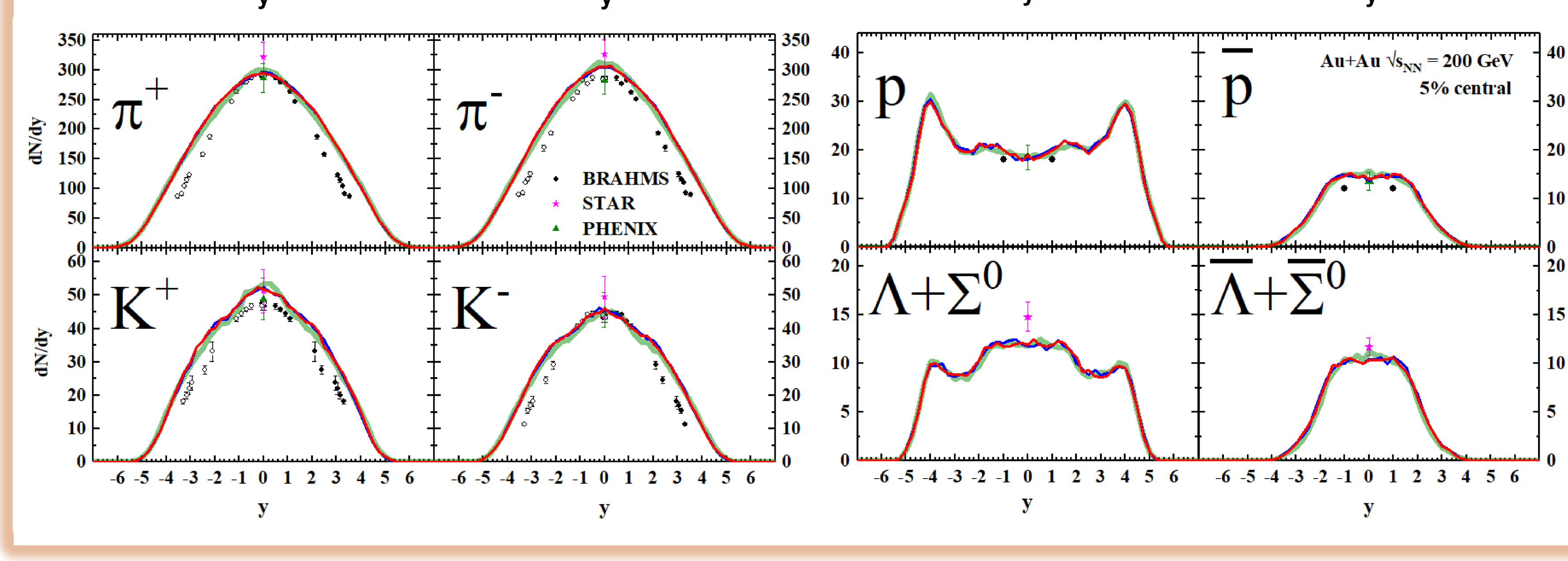
Mean μ_B from PHSD simulations taken around the chemical freeze-out temperature:



Rapidity distributions of bulk particles including the new DQPM cross sections (III):

PHSD 4.0: σ(T) w/o μ_B — PHSD 5.0: $\sigma_{qq}(\sqrt{s}, T, \mu_B=0)$ — PHSD 5.0: $\sigma_{qq}(\sqrt{s}, T, \mu_B)$





V - Conclusion / outlook

- The effect of finite μ_B in heavy-ion collisions is studied within PHSD
  - Consistent description of the QGP dynamics for all bombarding energies
- Effects of a finite μ_B are expected to be dominant at low bombarding energies although the QGP fraction is small
  - No strong dependence on μ_B are seen until now in the bulk observables
  - Other probes are needed to reveal the QGP dynamics at large μ_B (e^+e^-, $\overline{\Omega}^+$)

References

PHSD: W. Cassing, E.L. Bratkovskaya, Phys.Rev. C78 (2008) 034919; Nucl.Phys. A831 (2009) 215-242; W. Cassing, Eur. Phys. J. Spec. Top. (2009) 168: 3

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lQCD EoS: Sz. Borsanyi et al., JHEP 1208 (2012) 053

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