Investigation of inclusive charged particle behavior in heavy ion collisions at different energies

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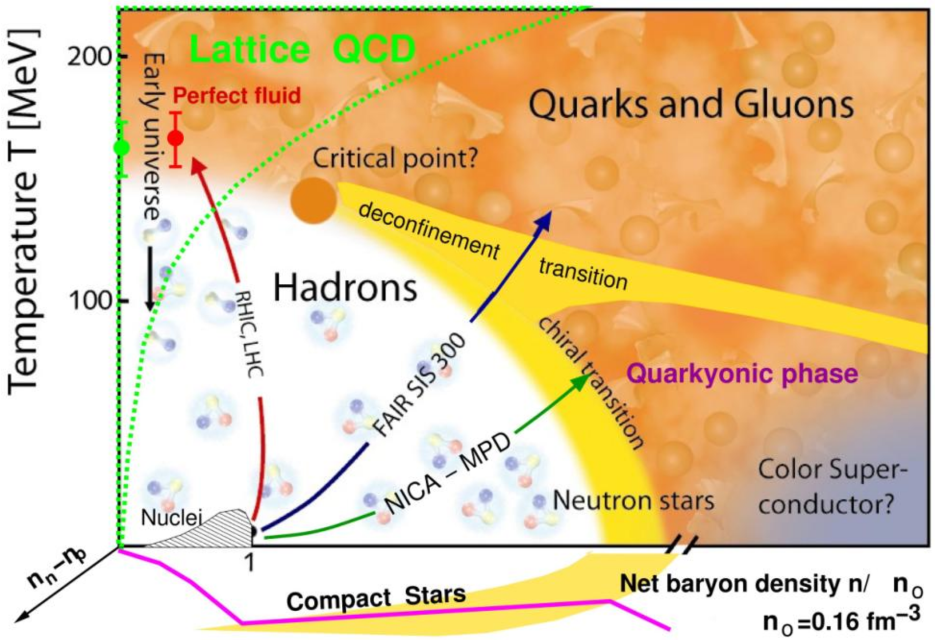
Heavy ion studies motivation I



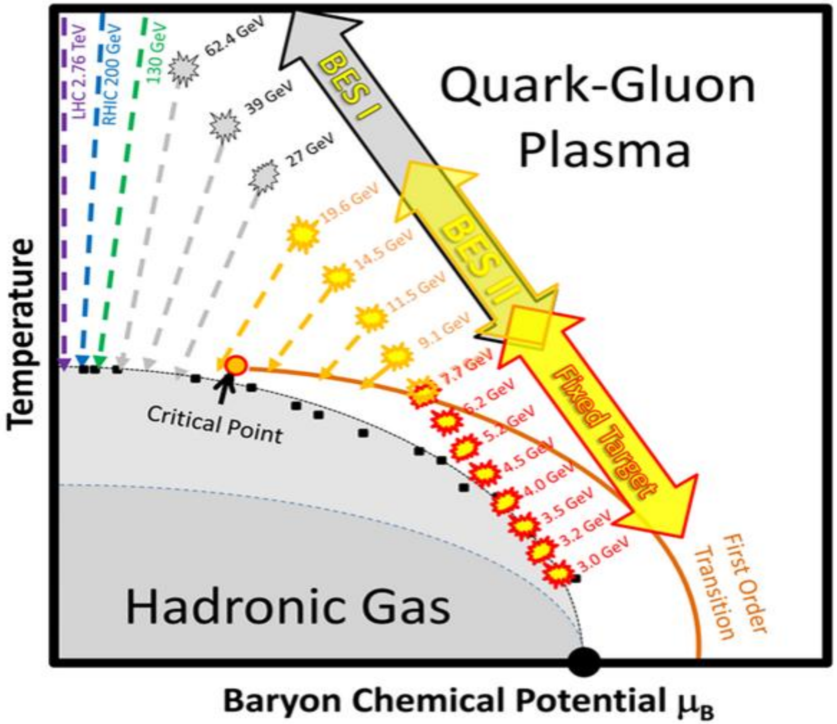
New state of matter was discovered at RHIC in gold-gold collisions at $\sqrt{S_{NN}}$ = 200 GeV and demonstrated very peculiar properties.

Nucl. Phys A757, 184 (2005)
Nucl. Phys A757, 102 (2005)

A lot of questions occurred:

1. Is it gas or fluid?
2. Where are phase boundaries?
3. More phases?

Heavy ion studies motivation II



Chi Yang, Quark Matter 2017

Studying QGP at lower RHIC energies:

1. Search for new effects compared to p+p
2. Search for turn-off of QGP signatures at higher RHIC energies
3. Signatures of Critical Point
4. Location of phase boundaries

Different methods of analysis: HBT, v1 analyses, Short range correlations, Fluctuation analyses (net-proton kurtosis), Dilepton analyses, Rcp, CME, ϕ, v2 etc.

UrQMD Модель

Ultra-relativistic Quantum Molecular Dynamic (UrQMD) – микроскопическая модель, основанная на описании ядерных реакций в терминах фазового пространства. При энергии $\sqrt{s_{NN}}$ > 5 ГэВ модель учитывает возбуждения цветовых струн, с последующей их фрагментацией в адроны. В семействе моделей QMD нуклон задается волновой функцией от шести переменных

$$\varphi_i(\bar{x};\bar{q}_i,\bar{p}_i,t)=\left(\frac{2}{L\pi}\right)^{3/4}\exp\left\{-\frac{2}{L}(\bar{x}-\bar{q}(t))^2+\frac{1}{\hbar}i\bar{p}_i(t)\bar{x}\right\}$$

Взаимодействие основано на нерелятивистском зависящем от плотности уравнении состояния типа Skyrme с дополнительными потенциалами Юкавы и Кулона.

$$H_{URQMD}=\sum_{j=1}^{N}E_j^{kin}+\frac{1}{2}\sum_{j=1}^{N}\sum_{k=1}^{N}(E_{jk}^{Sk2}+E_{jk}^{Yukawa}+E_{jk}^{Coulomb}+E_{jk}^{Pauli})+\frac{1}{6}\sum_{j=1}^{N}\sum_{k=1}^{N}\sum_{l=1}^{N}E_{jkl}^{Sk3}$$

$$\sigma(p)=A+Bp^n+C\ln^2(p)+D\ln(p)$$

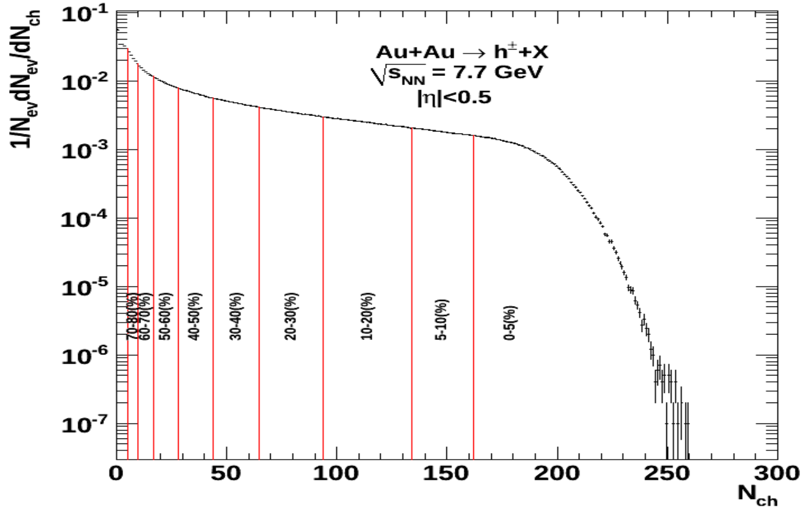
The UrQMD Model, http://urqmd.org/

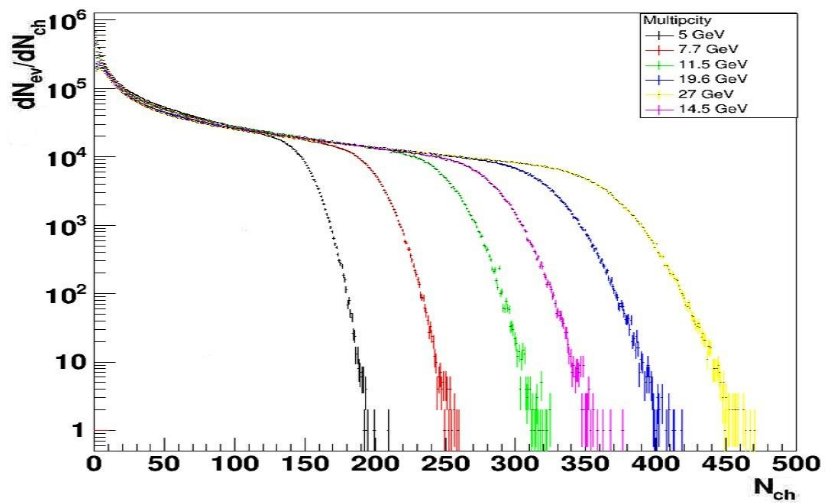
S.A. Bass et al., Prog. Part. Nucl. Phys. 41 (1998) 225.

M. Bleicher et al., J.Phys. G25 (1999) 1859.

Multiplicity of Au-Au collisions

pseudorapidity cut – 0.5 ~ 45^0 - barrel part of detector
number of charged particles varies from ~ 450 to ~ 200



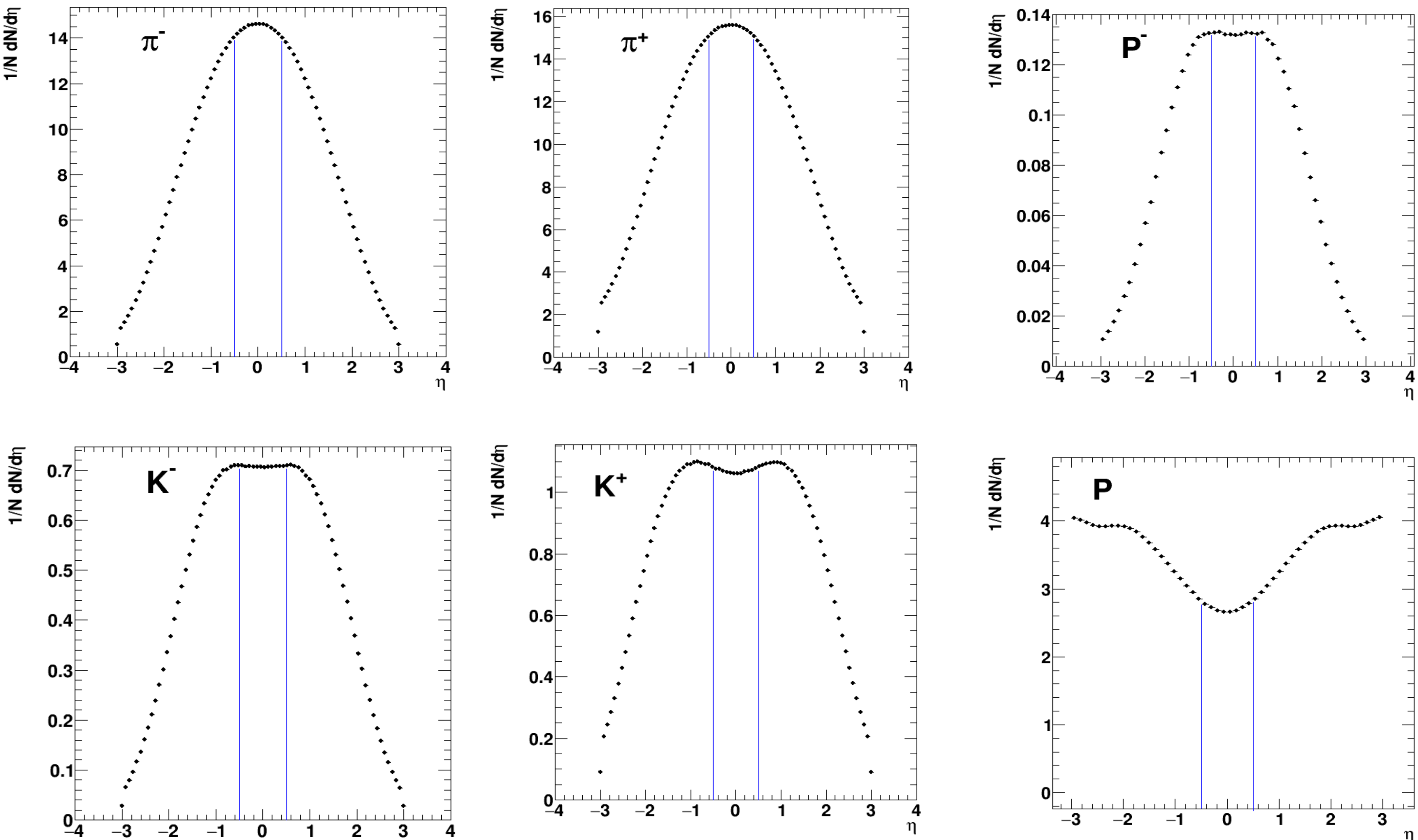


8 different centrality classes – different impact parameter

Pseudorapidity dependence

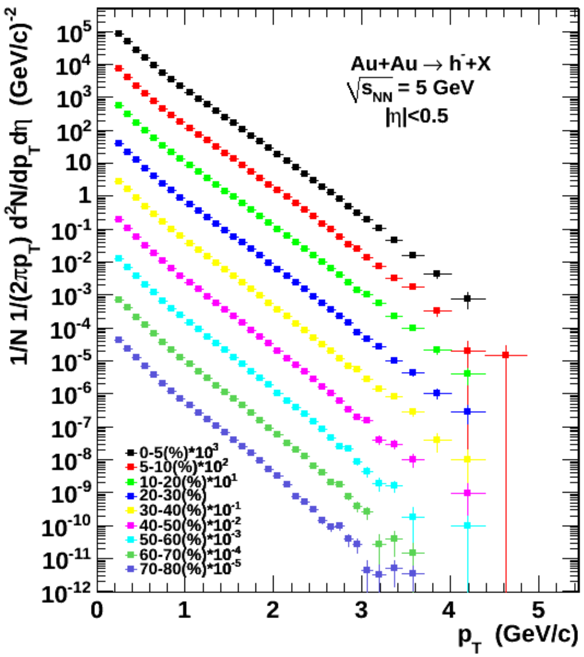
$$\eta = -\ln(tg(\vartheta/2))$$

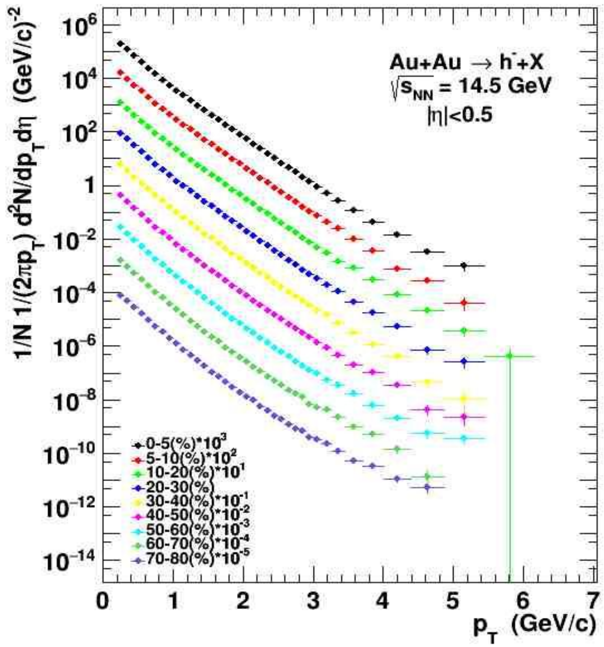
$\sqrt{S_{NN}} = 14.5$ GeV

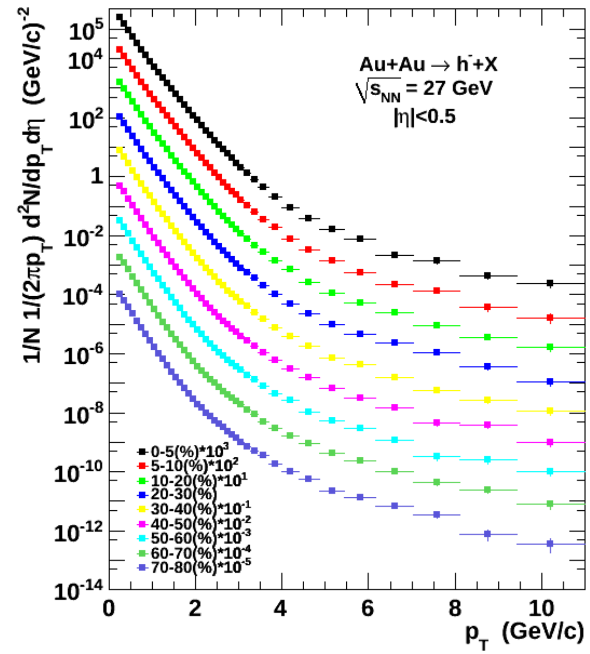


Inclusive particle spectra

Monte Carlo data of negative charged inclusive particle spectra for 8 centralities classes





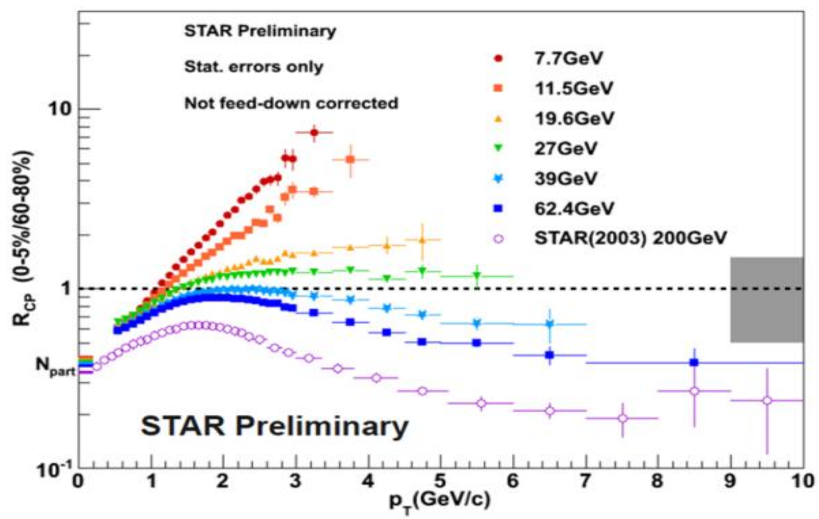


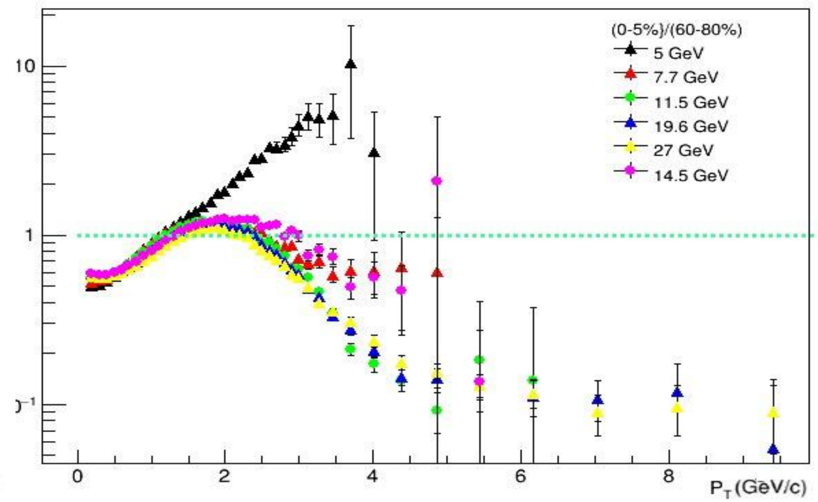
Different bins – wider bins at high P_T due to low statistics

Nuclear modification factor

$$R_{CP}(p_T) = \frac{\langle N_{coll}^{AA} \rangle_{60-80\%}}{\langle N_{coll}^{AA} \rangle_{0-5\%}} * \frac{d^2 N_{AA}^{0-5\%} / dy dp_T}{d^2 N_{AA}^{60-80\%} / dy dp_T}$$

R_{CP} should deviate near critical point





UrQMD underestimates QCD effects at energies $\sqrt{S_{NN}}$ = 7.7 - 27 GeV for particles with high P_T > 2 GeV/c

Summary

- ✓ Monte-Carlo simulation was made for Au-Au collisions for $\sqrt{S_{NN}}$ = 5 - 27 GeV
- ✓ Inclusive particle spectra were made for different types of charged particles
- ✓ Nuclear modification factor R_{CP} were calculated and compared with experimental results from STAR

Thank you for your attention!

Tsallis fit