Charged Hadron Spectra in Cu+Cu Collisions at $\sqrt{S_{NN}} = 22.4$ GeV with STAR at RHIC

Orpheus Mall

UC Davis

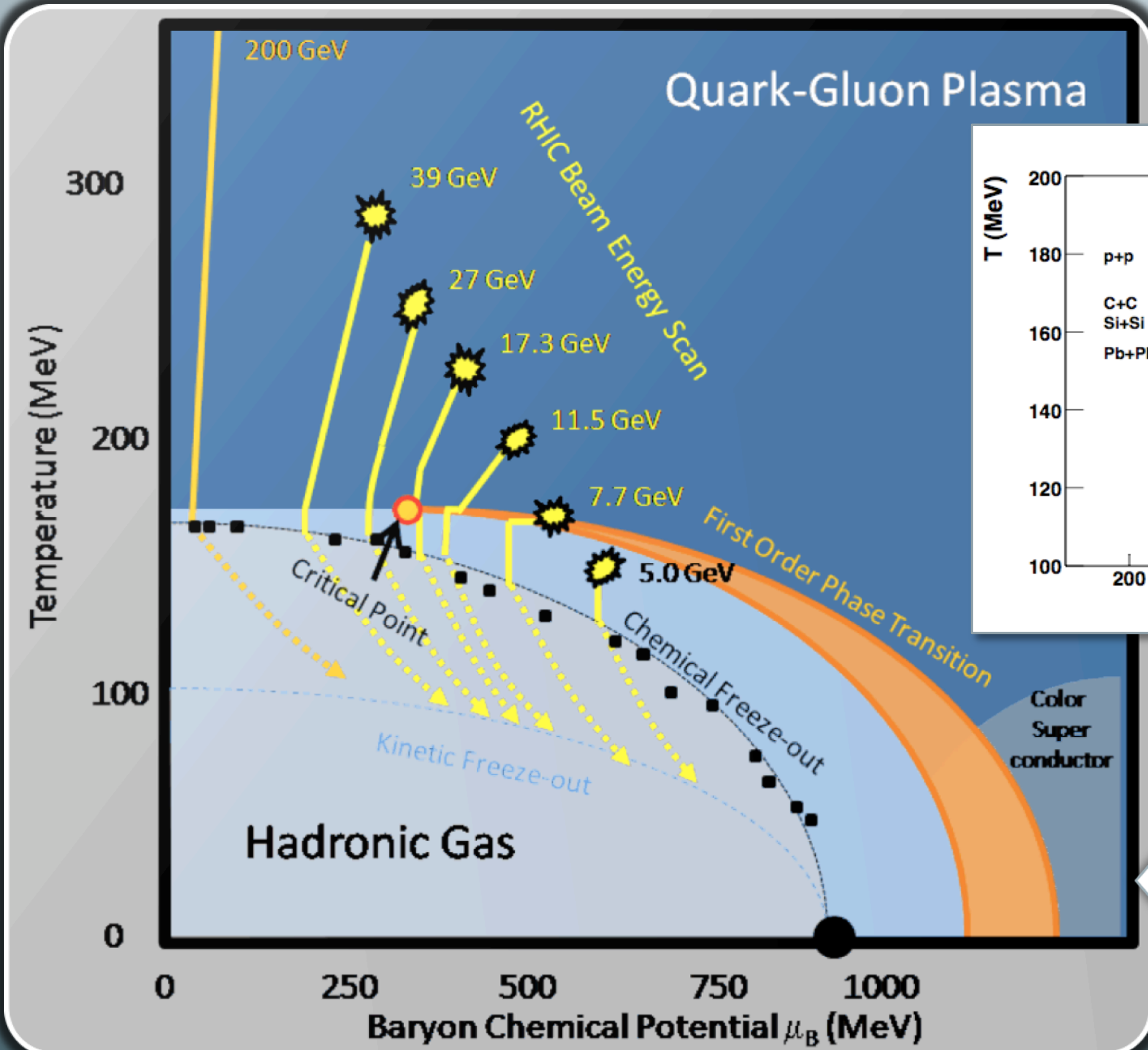
for the STAR Collaboration

American Physical Society April Meeting

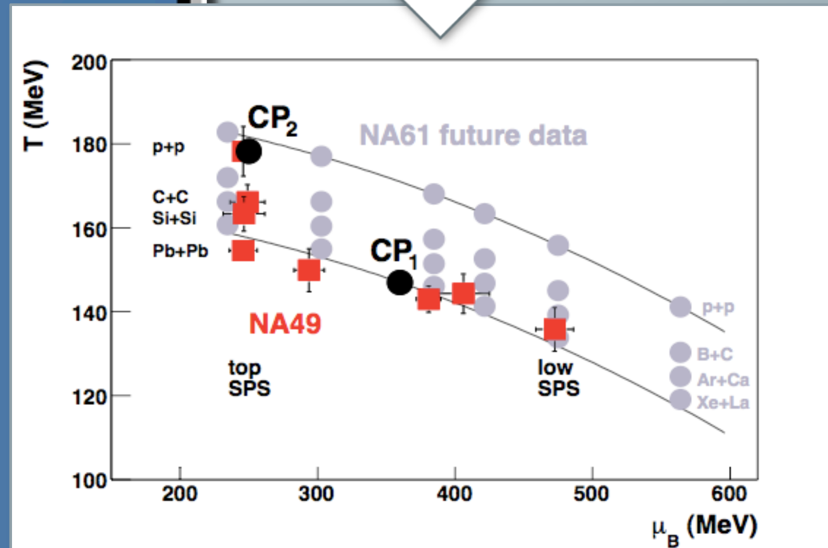
Outline

- Introduction
- Motivation
- Results
  - Particle Identification
  - $\pi^{\pm}$, $K^{\pm}$, p, $\bar{p}$ Spectra
  - Yields vs. Centrality
  - Mean p_T
  - Chemical Potential Fits
- Conclusions / Outlook

Introduction



NA61-Shine Proposal [3]



RHIC Beam Energy Scan Proposal [1]:
Dark points are data from SIS, AGS, SPS and RHIC overlaid on a QGP Phase diagram drawing [2]

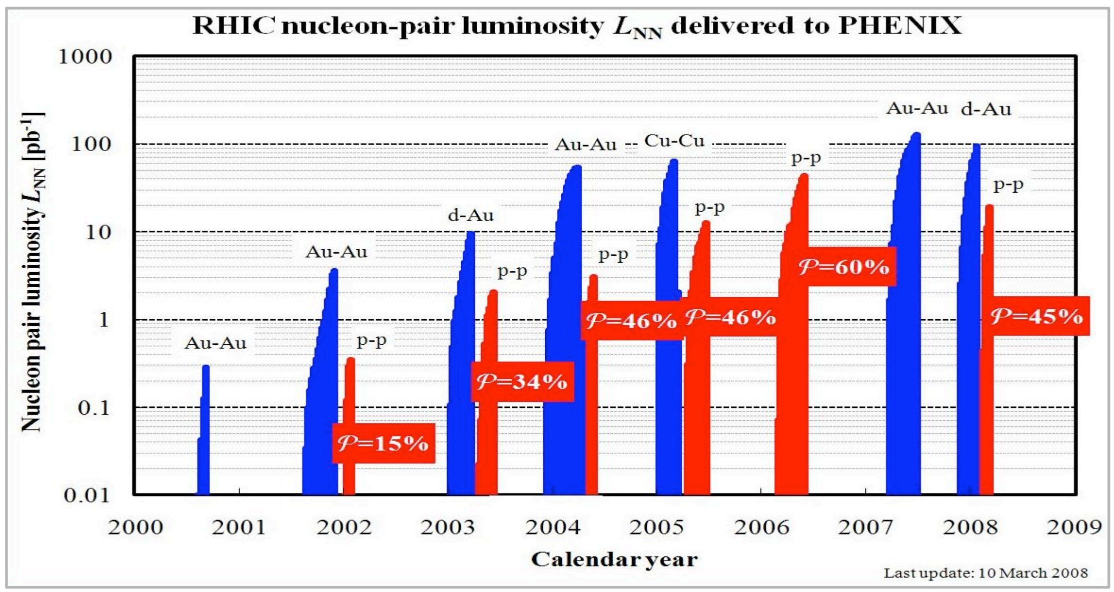
Motivation

- Effect of ion species and collision energy on T_{ch} and μ_B
- Effect of ion species and collision energy on chemical and kinetic freezeout
- These parameters can be studied via particle spectra and yield ratios
- RHIC Cu+Cu 22.4 GeV collisions – Run 5 “test” run [4]

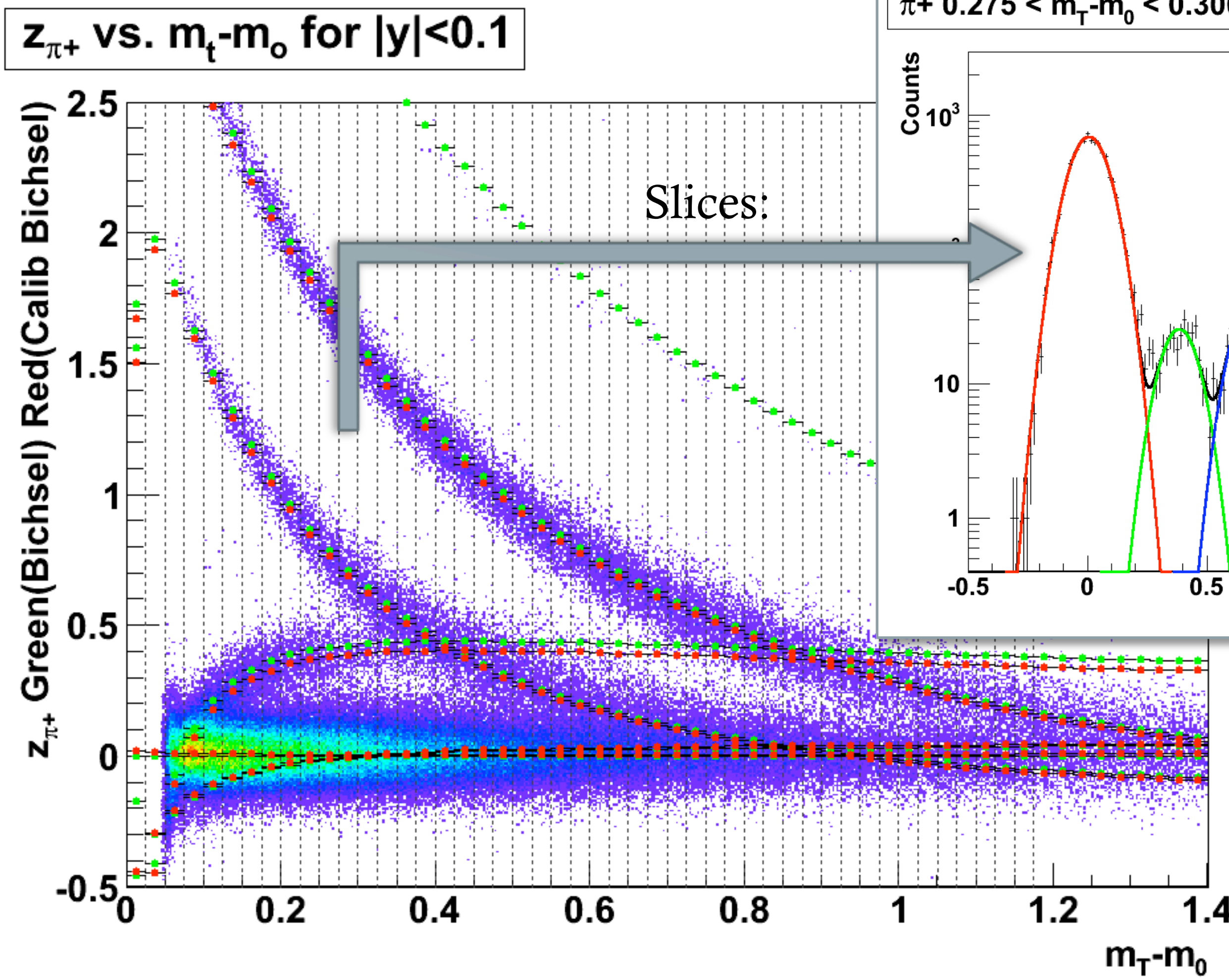
L_{peak} [$cm^{-2}s^{-1}$]	$L_{store\ avg}$ [$cm^{-2}s^{-1}$]	L_{week} [nb^{-1}]
2.5×10^{26}	0.5×10^{26}	0.02

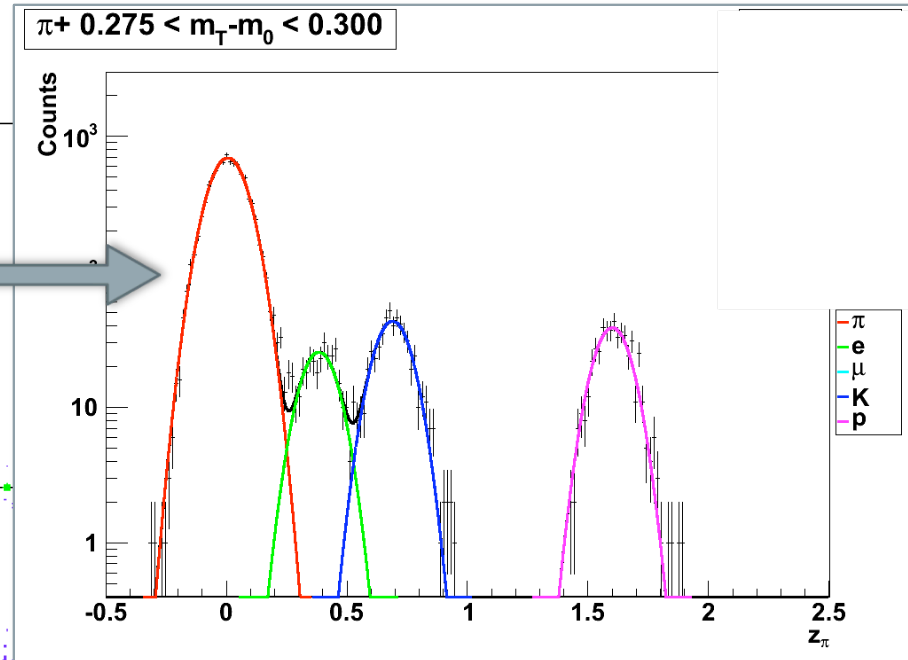
Total delivered integrated luminosities:

Experiment	β^* [m]	Luminosity [nb^{-1}]
PHENIX	3.0	0.006
STAR	3.0	0.006
BRAHMS	3.0	0.002
PHOBOS	3.0	0.004



Particle Spectra – PID via dE/dx





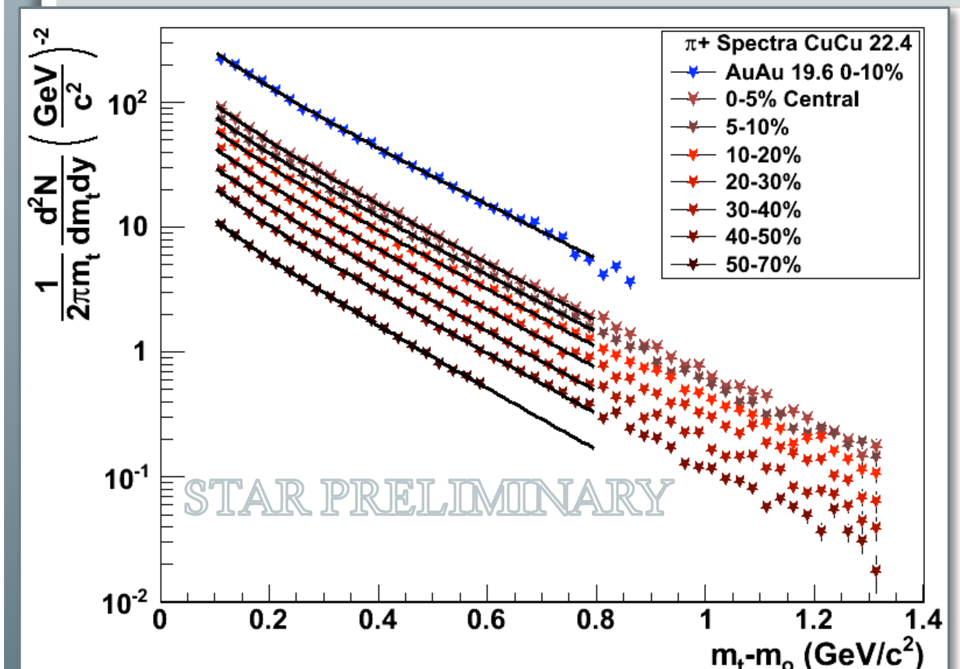
Multi Gaussian Fit

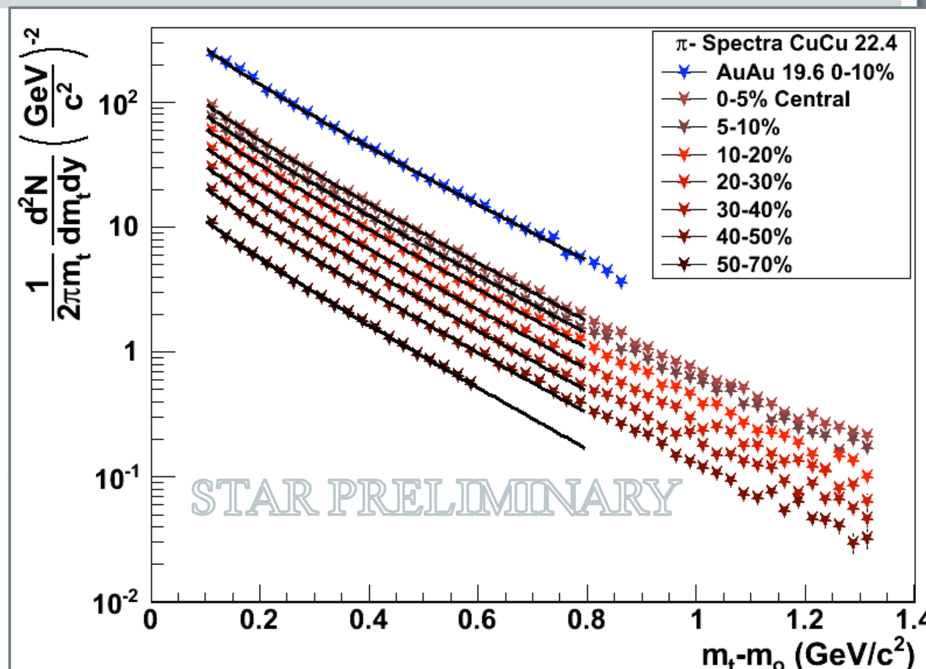
$$z_\pi = \ln\left(\frac{dE/dx_{meas}}{dE/dx_{Bich}}\right)$$

Bichsel Particle Energy Loss: [5]

Particle Spectra and yields π^+ and π^-

Au+Au 19GeV Magnetic Field = 0.25T, Cu+Cu 22.4 GeV Magnetic Field = 0.5T



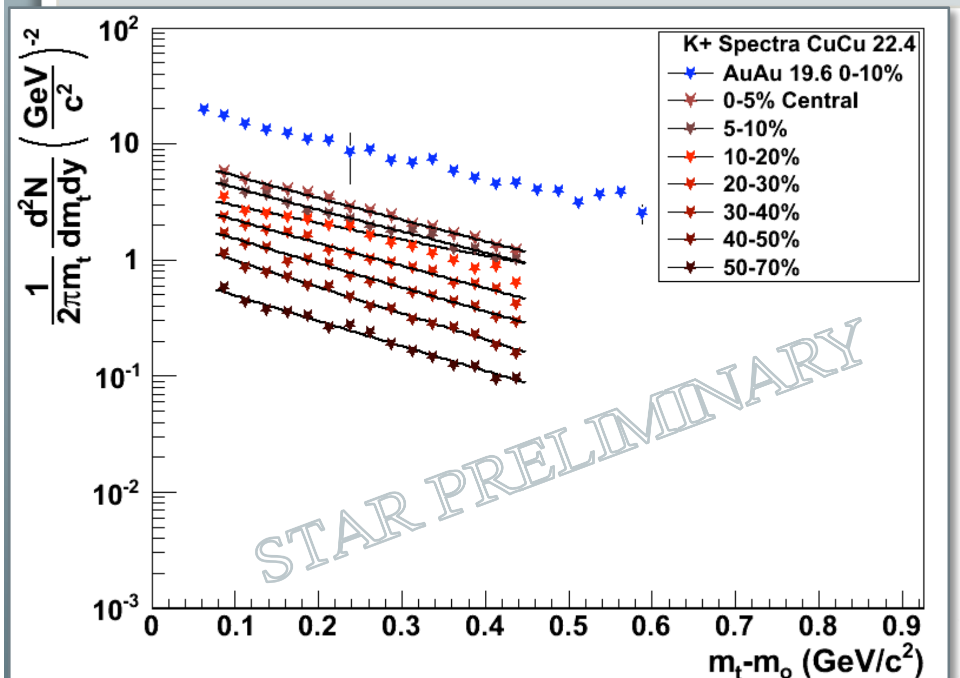


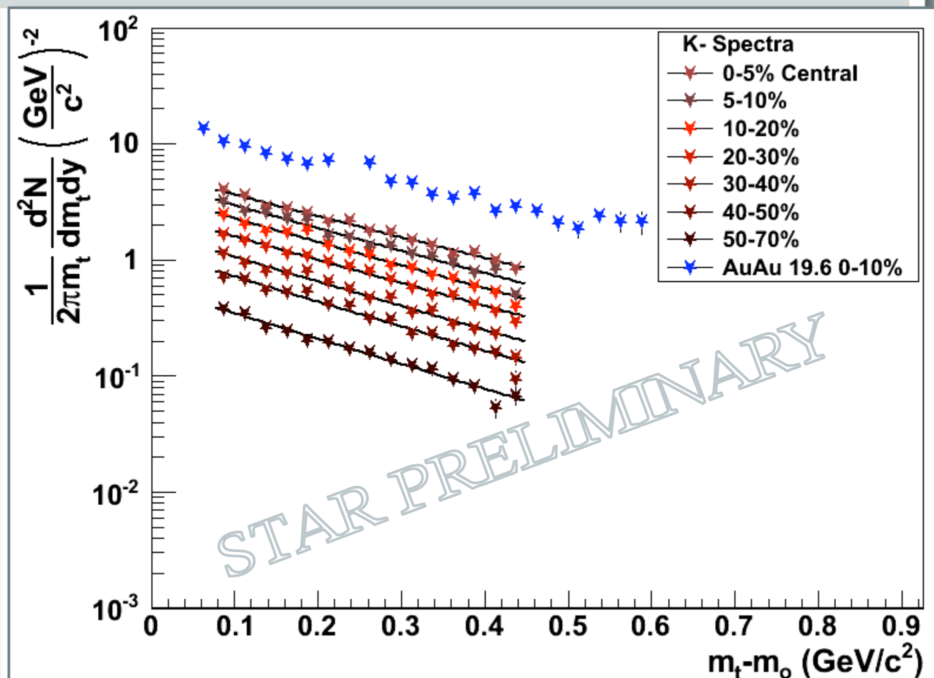
$$f_{\text{Bose-Einstein}} = \frac{A}{\exp(E/T)-1}$$

Note: The pion yields at 0.8<mt-m0<1.35 GeV are under investigation

The Systematic Uncertainty is under study

Particle Spectra and yields K^+ and K^-



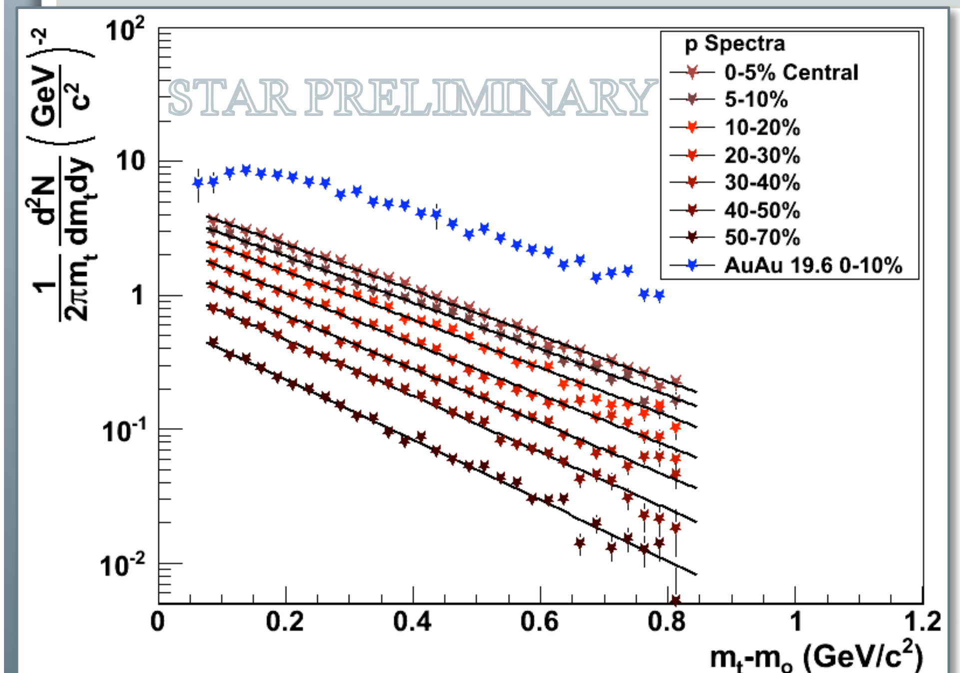


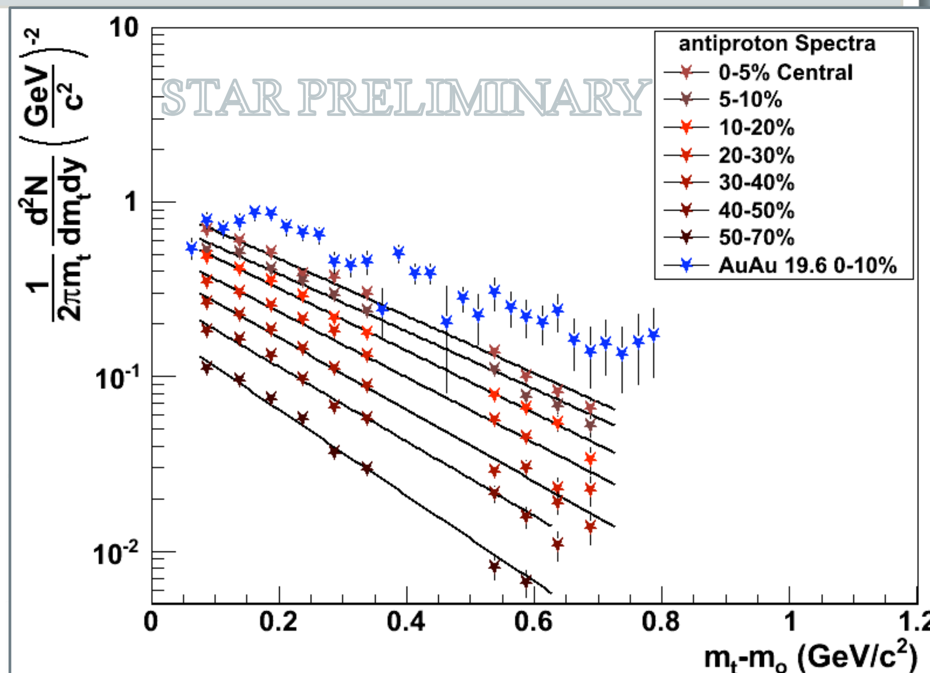
$$f_{\text{Bose-Einstein}} = \frac{A}{\exp(E/T)-1}$$

At such low statistics, the electron subtraction is hard.

The Systematic Uncertainty is under study

Particle Spectra and yields p and $\bar{p}$

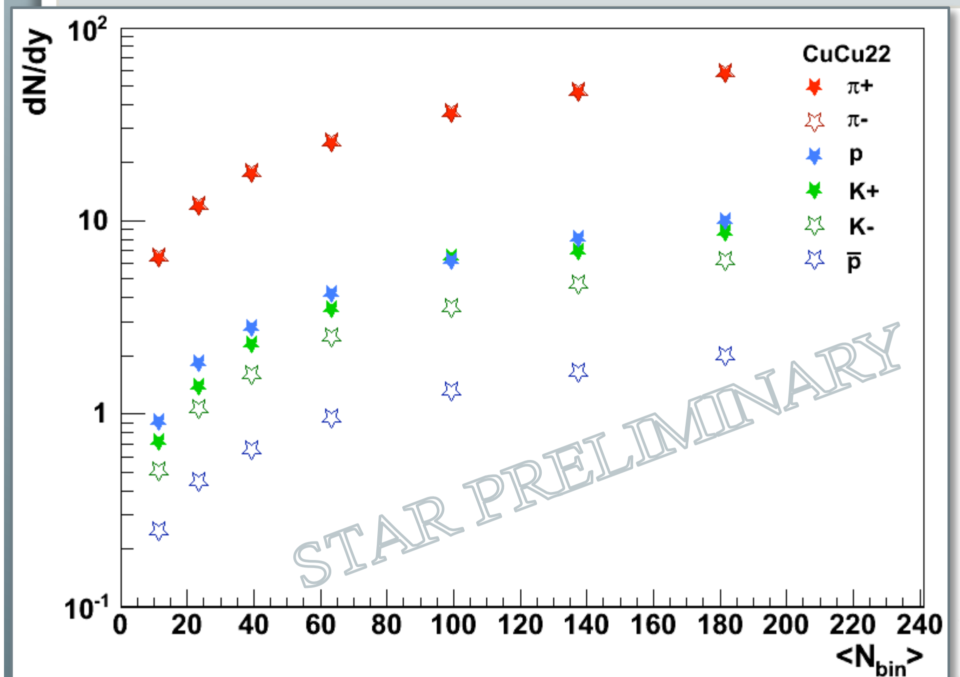


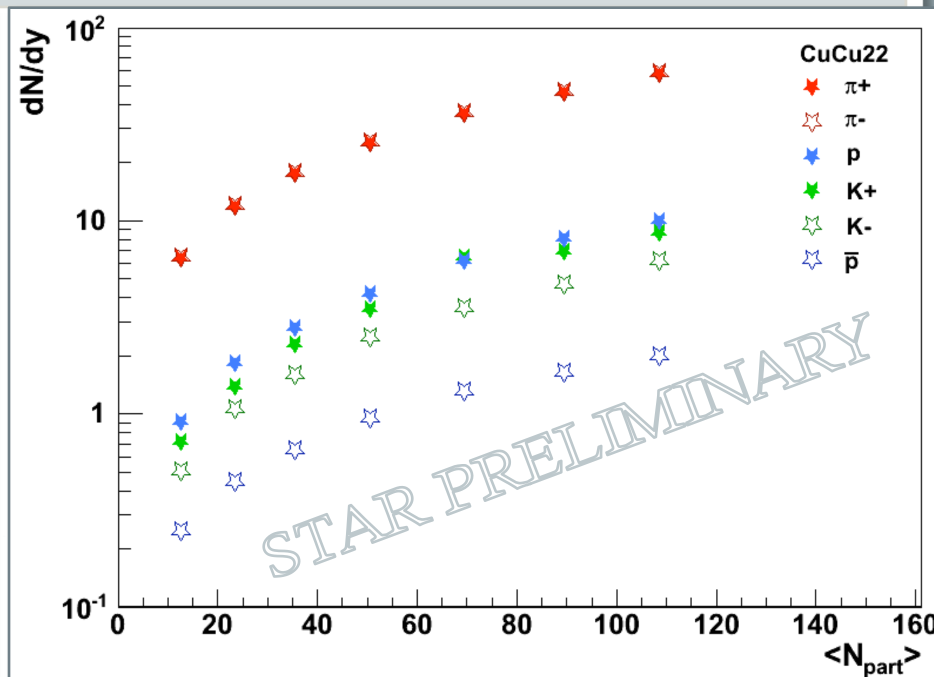


$$f_{\text{Fermi-Dirac}} = \frac{A}{\exp(E/T)+1}$$

The Systematic Uncertainty is under study

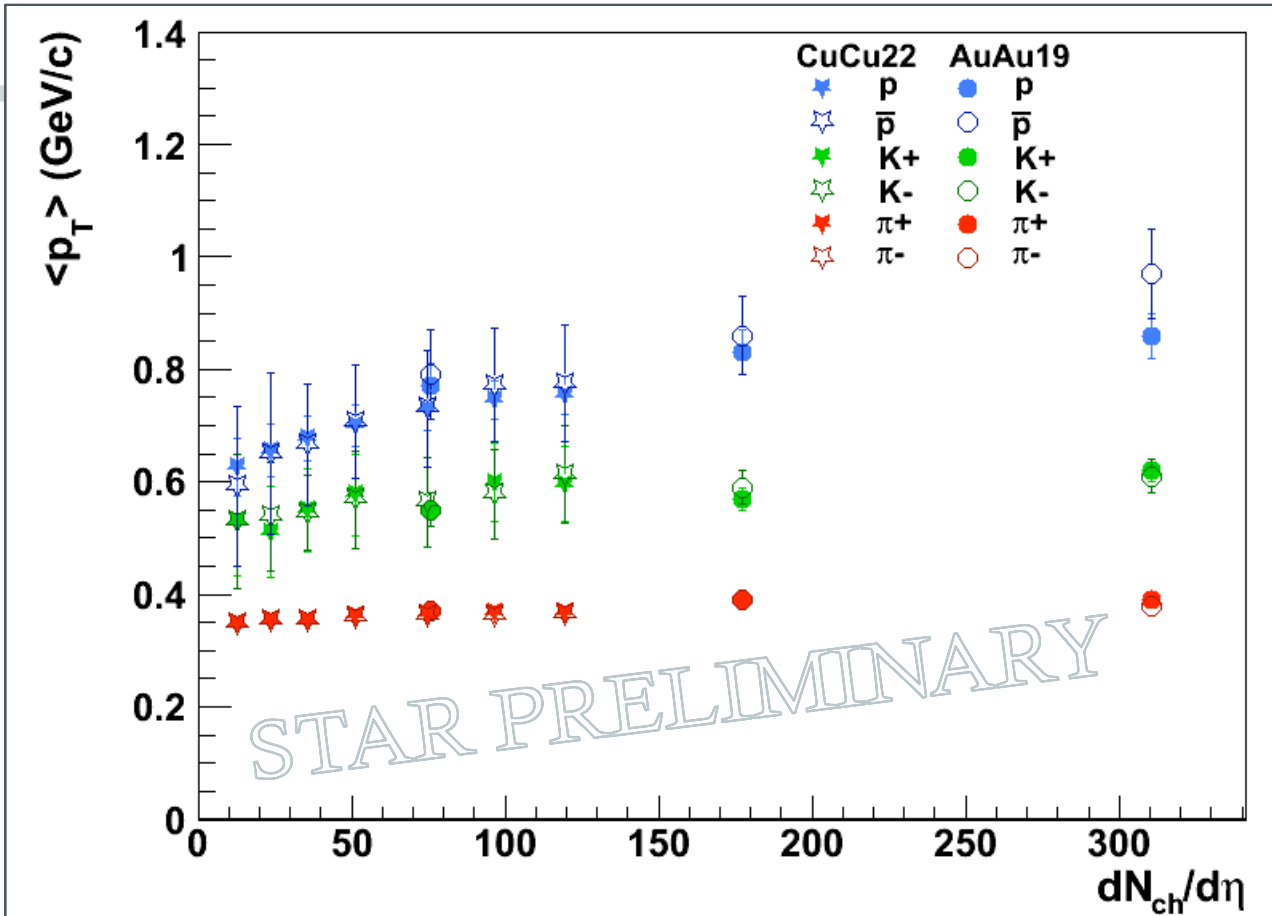
Yields vs N_{bin} and N_{part}





Particle yields are given as a function of # of binary collision and # of participants.
Centrality from left to right (50-70%, 40-50%, 30-40%, 20-30%, 10-20%, 5-10%, 0-5%)
The Systematic Uncertainty is under study

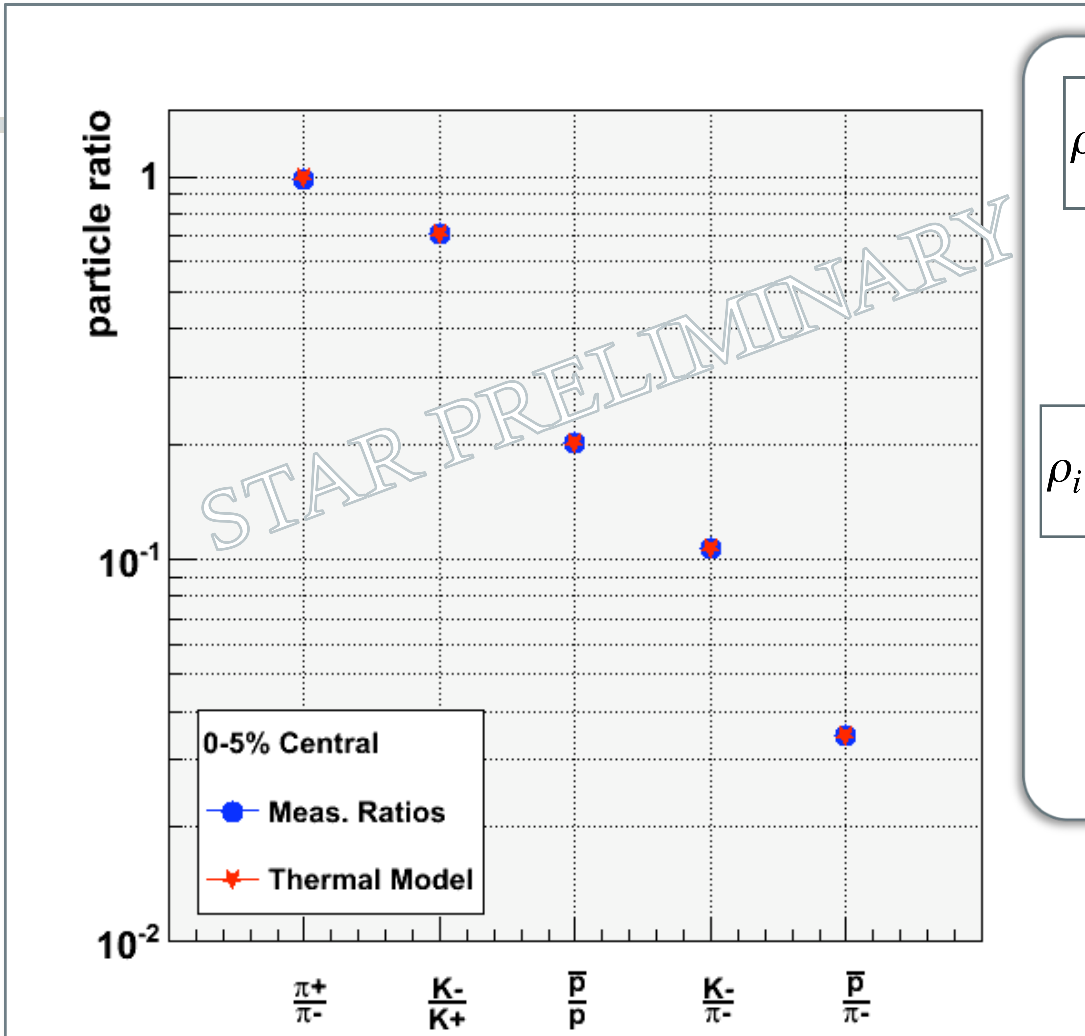
Particle $<p_T>$ vs. Centrality



Particle mean pT is within errors in comparison with Au+Au

The Systematic Uncertainty is under study

Particle Ratios



The Systematic Uncertainty is under study

$$\rho_i = \frac{g_i}{2\pi^2}\int_0^\infty \frac{p^2 dp}{\exp((E_i(p)-\mu_i)/T)\pm 1}$$

$$\mu_i = \mu_B B_i - \mu_S S_i - \mu_{I_3} I_i^3$$

$$\rho_i = \frac{g_i}{2\pi^2}\gamma_s^{\langle s+\bar{s}\rangle_i} T_{ch} m_i^2 K_2\left(\frac{m_i}{T_{ch}}\right)\lambda_q^{Q_i}\lambda_s^{s_i}$$

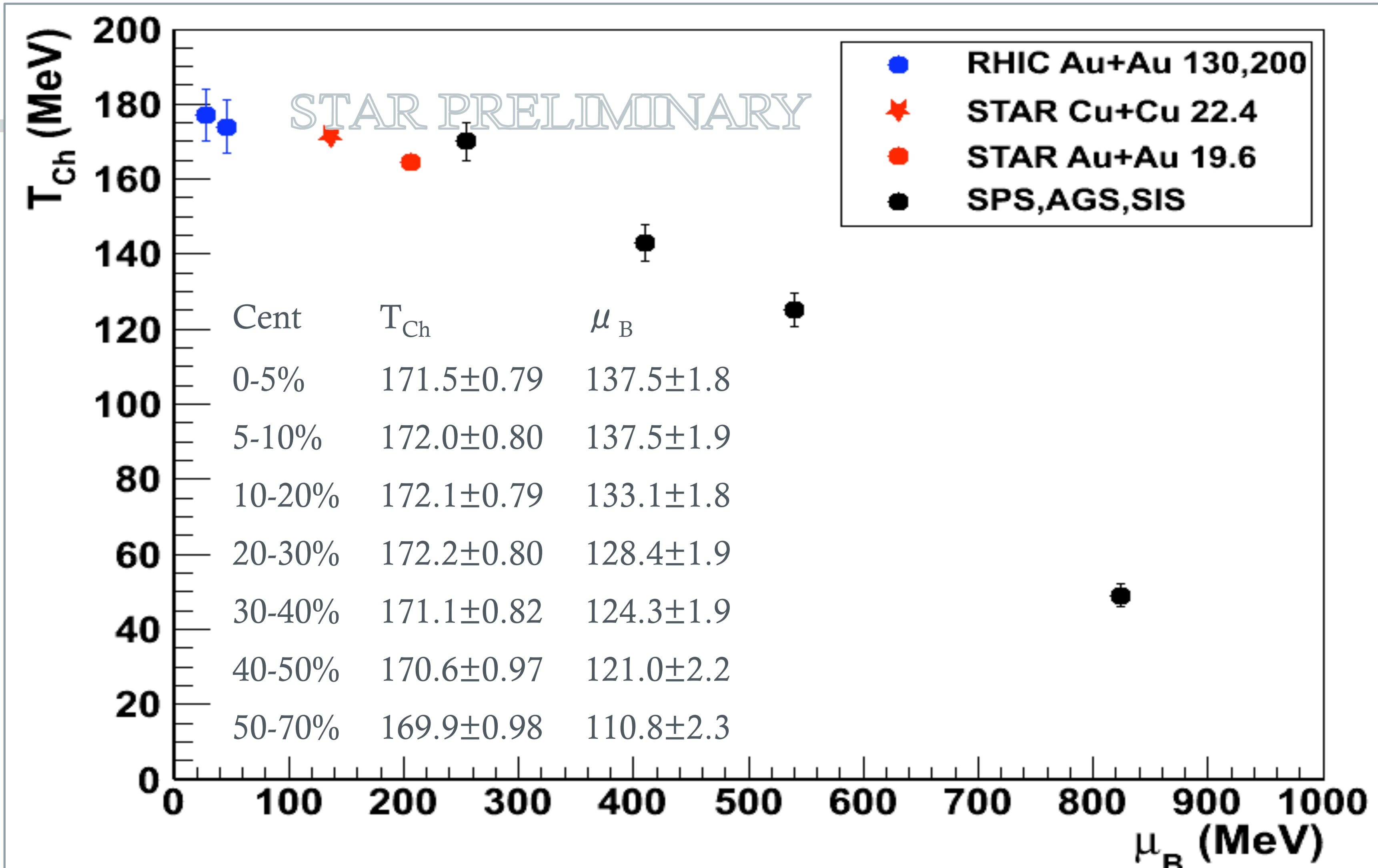
$$\lambda_q \equiv e^{\mu_q/T_{ch}} \quad , \quad \lambda_s \equiv e^{\mu_s/T_{ch}}$$

$$\gamma_s = e^{\mu_{\langle s+\bar{s}\rangle}/T_{ch}}$$

K_2 : 2nd kind Bessel function

A Thermal Model [7] is used to extract T_{ch} and μ_B. For mid-rapidity particle ratios are used in the fit [8]

Statistical Model Fit



Cent	T_{Ch}	μ_B
0-5%	171.5±0.79	137.5±1.8
5-10%	172.0±0.80	137.5±1.9
10-20%	172.1±0.79	133.1±1.8
20-30%	172.2±0.80	128.4±1.9
30-40%	171.1±0.82	124.3±1.9
40-50%	170.6±0.97	121.0±2.2
50-70%	169.9±0.98	110.8±2.3

The Systematic Uncertainty is under study

Conclusion / Outlook

- Within statistical errors, it appears that the Cu+Cu system at 22.4 GeV is higher in temperature and lower in Baryon Chemical potential than Au+Au at 19.6 GeV at Chemical freezeout. (Systematic uncertainties not included)
- We notice features of proton spectra that might indicate a difference in kinetic freezeout parameters. A Blast-wave model fit will be applied to study this effect.
- Outlook:
  - Complete study of Hadronic and Kinetic freeze-out parameters
  - Analysis of systematic uncertainties
  - Further comparisons of results with world data
  - Comparisons of results with various transport and thermal models

Links / Sources

[1] H. Caines, The RHIC Beam Energy Scan – STAR's perspective. [arXiv:0906.0305v1]

[2] J. Cleymans, H. Oeschler and K. Redlich, J. Phys. **G25**, 281 (1999), [nucl-th/9809031]

[3] Marek Gazdzicki et al 2009 J. Phys. G: Nucl. Part. Phys. 36 064039 (6pp)

[4] RHIC Run5 Information: http://www.agsrhichome.bnl.gov/RHIC/Runs/index.html#Run-5

[5] H. Bichsel – Nuclear Inst. And Methods in Physics Research, **A**, 2006

[6] D. Cebra for the STAR Collaboration [arxiv:0903.4702v1]

[7] P. Braun-Munzinger, I. Heppe and J. Stachel, Phys. Lett. B465, 15 (1999), [nucl-th/9903010]

[8] M. Kaneta and N. Xu, Quark Matter 2004 [nucl-th/0405068]