Analysis of Low Energy Pion Spectra

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Purpose

- Low p_t pion enhancement is either from Δ resonance contribution or Coulomb interaction.
- Near pion production threshold energy, pions are produced through Δ resonance.

$$\frac{N_{\pi^-}}{N_{\pi^+}} = \frac{5N^2 + NZ}{5Z^2 + NZ} \cong 1.94$$

- Charged pion spectra in Au+Au collision at 2, 4, 6, and 8 GeV/A by E895 Collaboration were analyzed by ellipsoidal Blastwave Model with resonance contribution & Coulomb Correction.

  $\pi-/\pi+$ is used as a fitting parameter to study beam energy dependence.

Blast-Wave Model

Cooper-Frye Formula

$$E\frac{d^3N}{d^3p} = \frac{g}{2\pi}\int_{\Sigma f} p^{\mu} d\sigma_{\mu}(x) f(x,p)$$

Lorentz-Transformed Boltzman distribution

Thermal Spectrum

$$\frac{d^2N}{m_T dm_T dy} = \frac{g}{2\pi} m_T \tau_0 \int_{-\eta_{\max}}^{+\eta_{\max}} d\eta \int_0^{r_{\max}(\eta)} r dr \cosh(y-\eta) \times \exp(-\frac{m_T \cosh(y-\eta)\cosh\rho - \mu}{T}).I_0(\frac{p_T \sinh \rho}{T})$$

Ellipsoidally expanding fireball model.

Spectrum is determined by freeze-out values.

Fit Parameters

$$T, \mu_b, \eta, \rho_0, V, P_c, \frac{\pi^-}{\pi^+}$$

π^- Parameters

Herald Dobbler et al

V is overall constant. $V_{\pi+}$, $V_{\pi-}$ each parameters are fitted.

η is longitudinal rapidity.

ρ_0 is transverse rapidity at (R_0, z=0)

Inside $\tanh^{-1} \upsilon_\perp = \rho(\eta)(\frac{r_\perp}{R_0})$

: linear transverse rapidity profile

$\rho(\eta) = \rho_0 \sqrt{1 - \frac{\eta^2}{\eta_{max}^2}}$ ellipsoidal expansion

Spectrum Calculation

$$E\frac{d^3N}{d^3p} = \text{Thermal Spectrum} \otimes \text{Coulomb Correction} + \text{Resonance Contribution}$$

$$\frac{N_{\pi^-}}{N_{\pi^+}} = \frac{5N^2 + NZ}{5Z^2 + NZ} \cong 1.94$$

N=118 ,Z=79 in Au+Au

$$V_{eff,\pi^-} = 1.94 \times V_{eff,\pi^+}$$

Resonance contribution by J. Sollfrank

Coulomb Correction

$$p_c = \Delta p_\perp \approx 2e^2 \frac{dN^{ch}}{dy} \frac{1}{R_f}$$

$$p_t = p_{t,0} \pm p_c$$

$$E\frac{d^3N}{dp^3} = \left(E\frac{d^3N}{dp^3}\right)_0 \left(\frac{dp^3}{E}\right)_0 \left(\frac{E}{dp^3}\right)$$

$\left(E\frac{d^3N}{dp^3}\right)_0$ is the unshifted invariant cross section

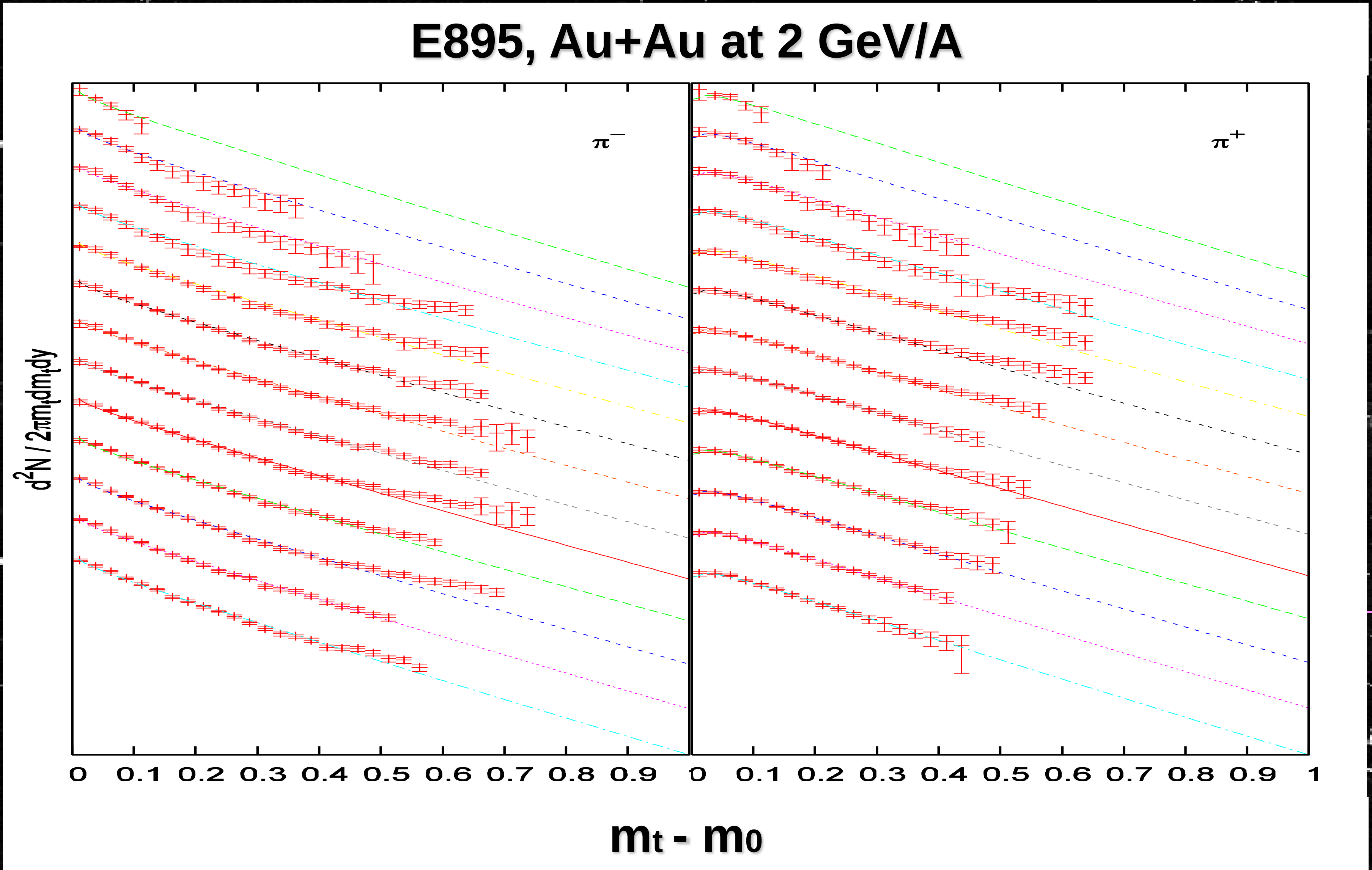
$$\frac{dN}{p_t dp_t} = \int dy \frac{d^2N}{p_{t,0} dp_{t,0} dy} \frac{p_{t,0}}{p_t}$$

$$\frac{dN}{dy} = \int m_{t,0} dm_{t,0} \left(\frac{d^2N}{p_{t,0} dp_{t,0}}\right) \frac{p_{t,0}}{p_t}$$

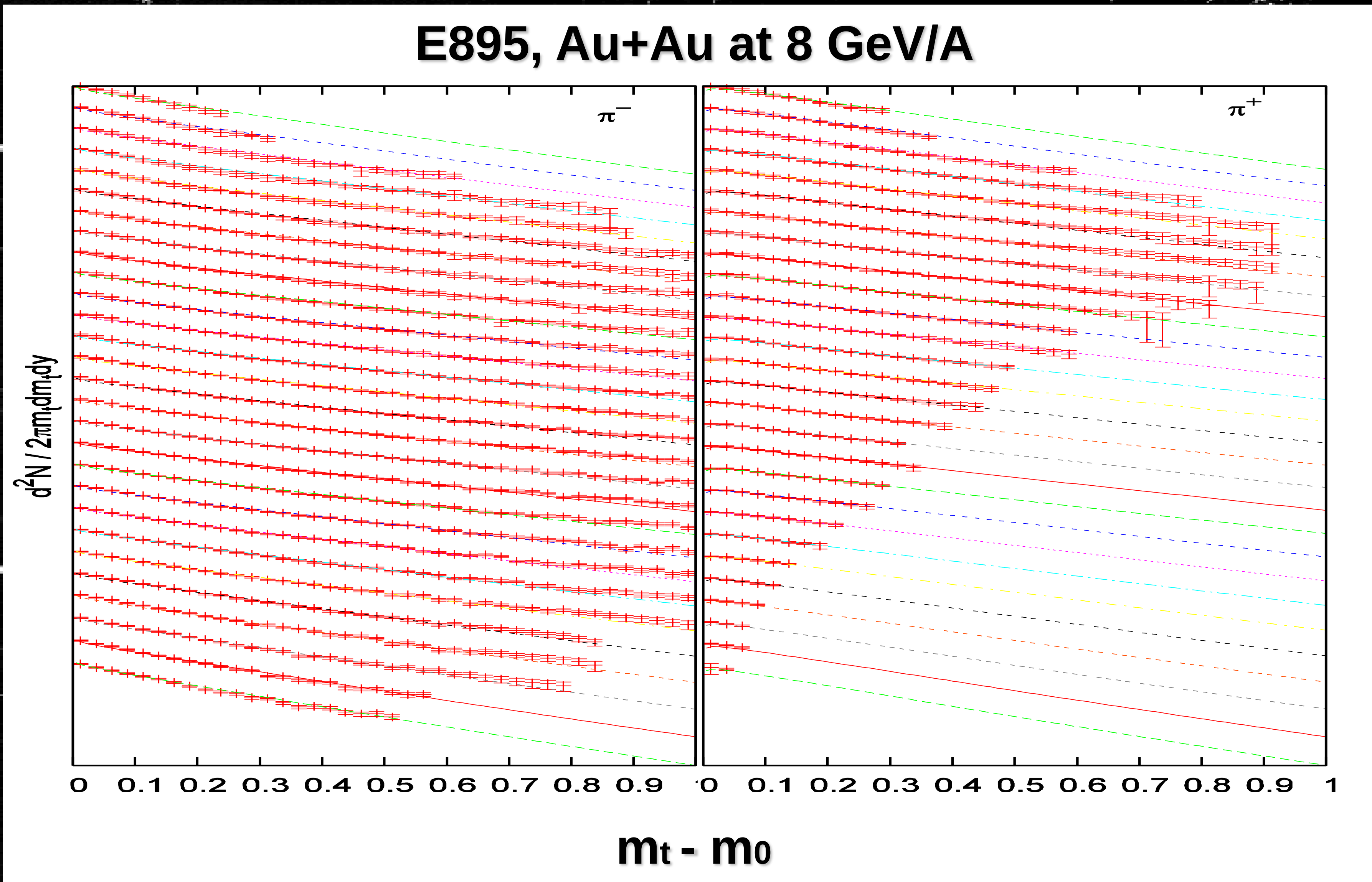
Fitted Values for each parameters

E_{beam} (GeV)	V $(\times 10^5)$	η_m	ρ_0	T (MeV)	P_c MeV/c	$\frac{\pi^-}{\pi^+}$	$\frac{\chi^2}{n}$
2	1.41	1.12	0.88	46	25	1.96	1.3
4	0.93	1.32	0.92	57	24	1.95	2.9
6	1.44	1.50	1.11	54	18	1.40	2.4
8	1.62	1.58	1.12	55	15	1.38	1.8

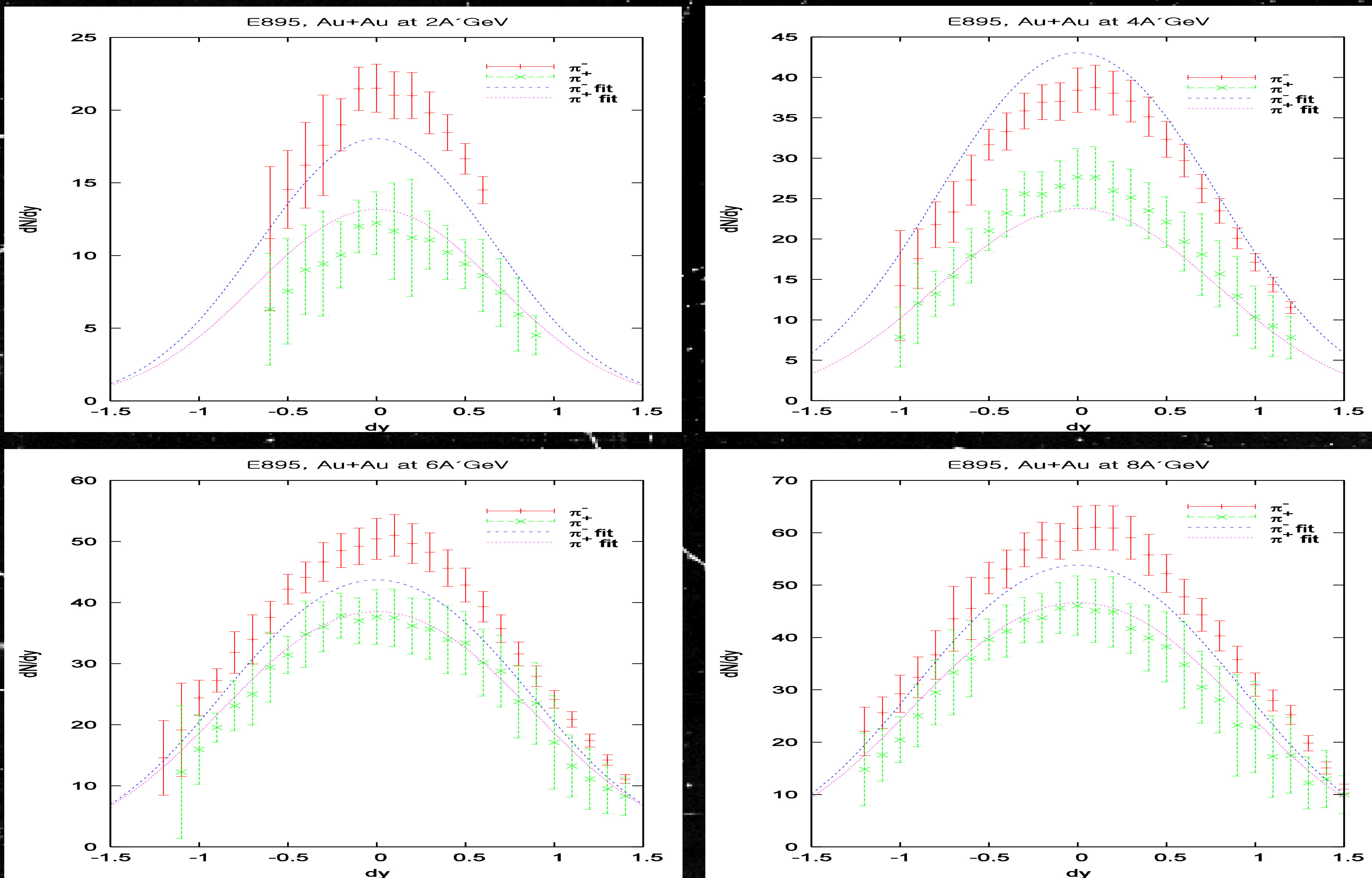
Transverse Mass Spectrum



Transverse Mass Spectrum



Rapidity Spectrum

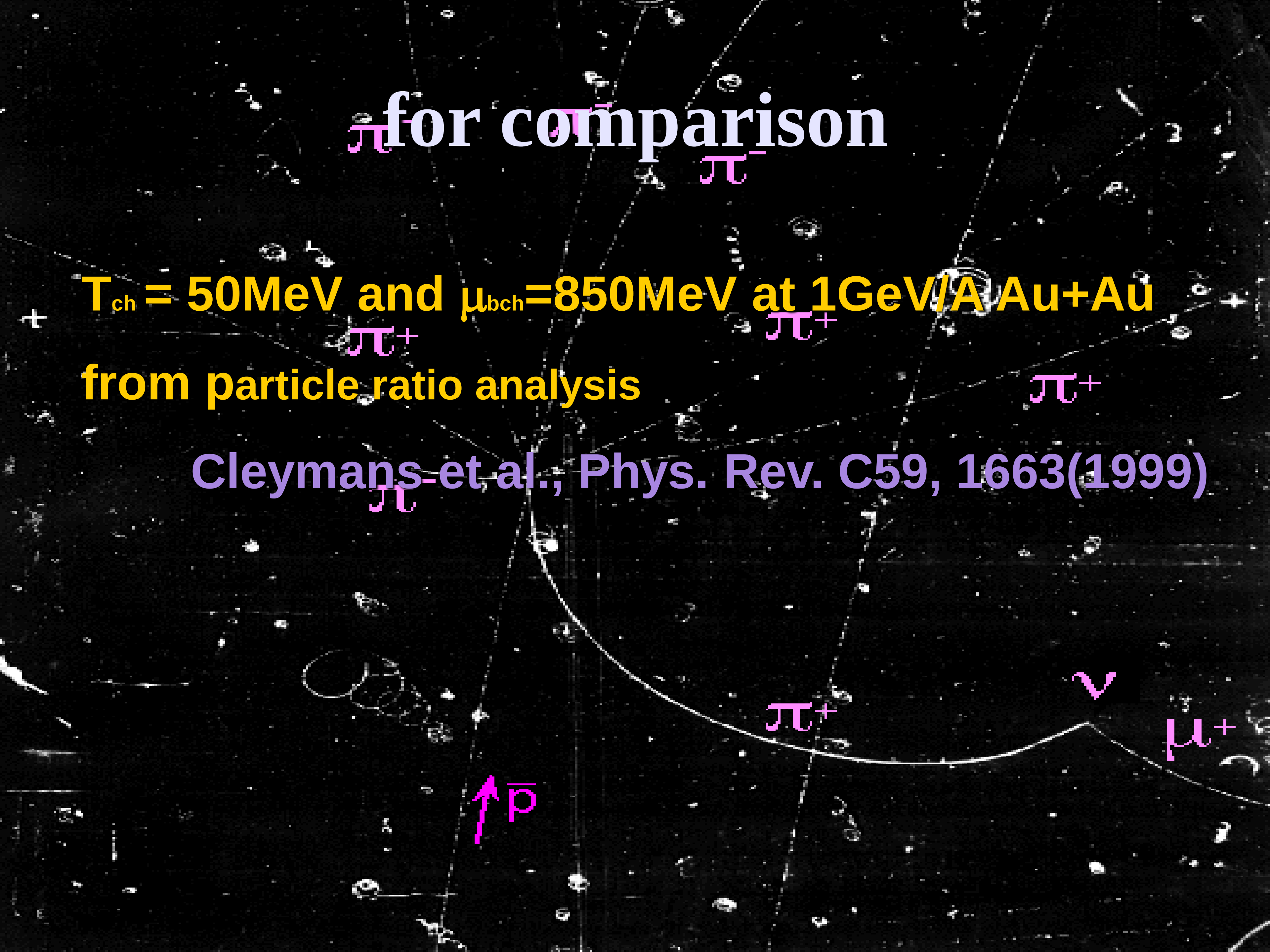


for comparison

T_{ch} = 50MeV and μ_{bch}=850MeV at 1GeV/A Au+Au

from particle ratio analysis

Cleymans et al., Phys. Rev. C59, 1663(1999)



Conclusion

1. Small freeze-out temperature with large expansion velocities are obtained and thus resonance contribution is negligible.

2. Difference in the low momentum region of the two oppositely charged pions are due to the final state Coulomb interaction. Effect of Coulomb interaction decreases as beam energy increases.

3. Near 2 GeV/A, π-/π+ is about 1.94. As energy increases the ratio decreases.