Strangeness production in Au+Au collisions at $\sqrt{s_{NN}} = 62.4$ GeV

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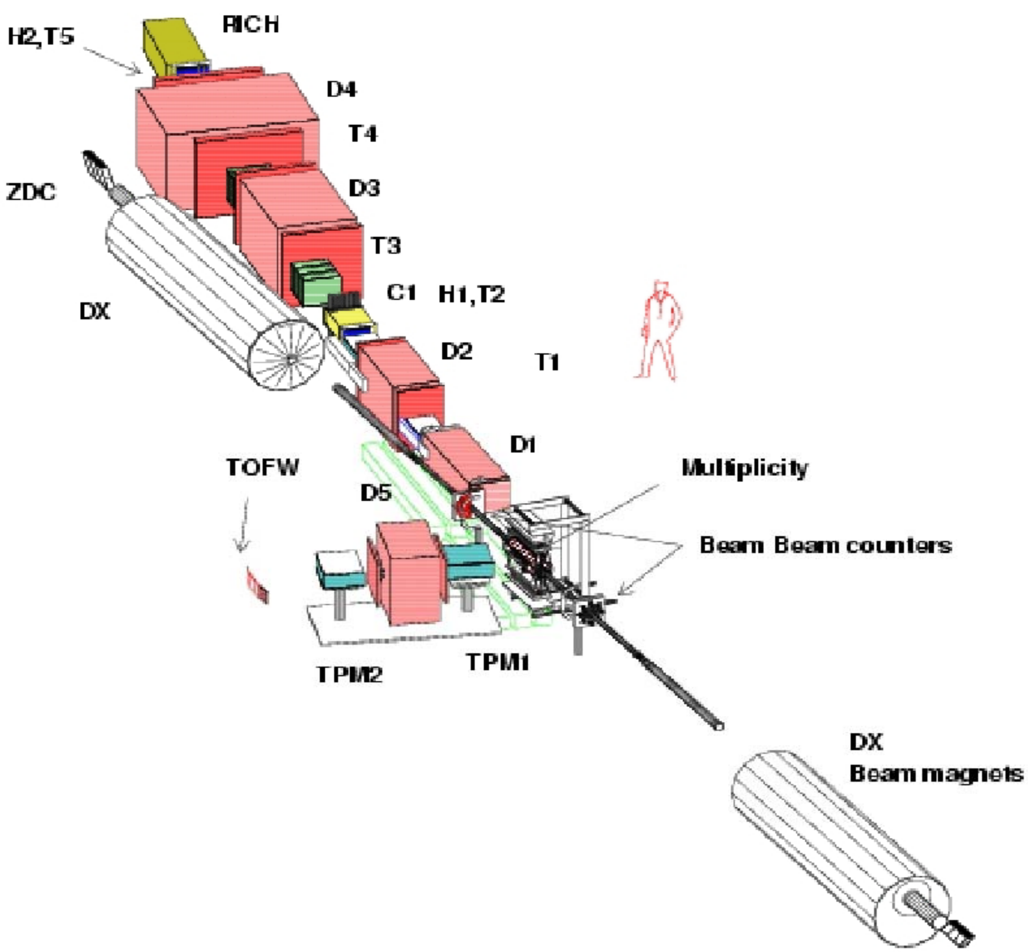
Outline

- BRAHMS setup and phase space coverage
- Introduction to strangeness enhancement
- BRAHMS data on Au+Au collisions at 62.4 GeV
- Discussion and comparisons with similar data at different energies and theoretical models
- Conclusions

BRAHMS setup



BRAHMS consists of global detectors for events characterization and of two spectrometer arms , each of them covering a different rapidity range.

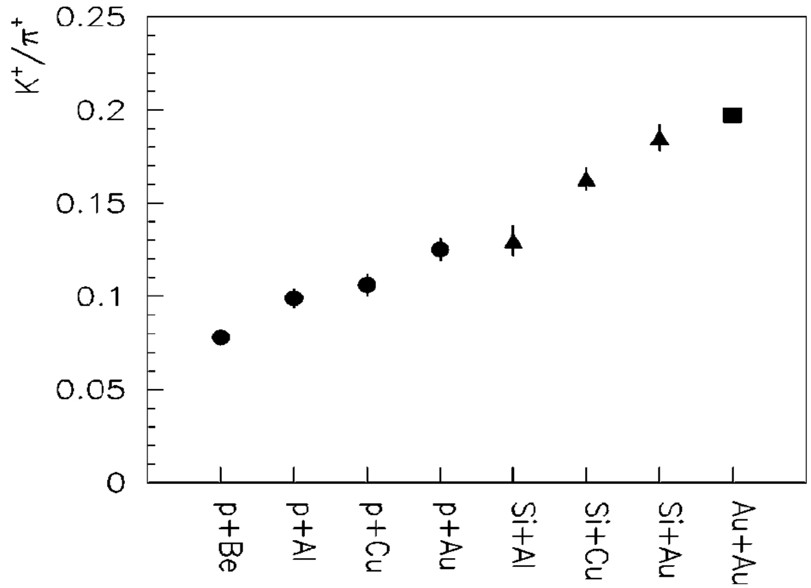
The entire setup covers angles from 90^0 (MRS) up to 2.3^0 (FS).
In the 62.4 GeV data set BRAHMS identifies charged particles up to y~3.6 (beam rapidity is y~4.2 for this dataset).

π/K separation goes up to p~2.5 GeV/c in MRS and p~20 GeV/c in FS.

K/p separation up to p~3.0 GeV/c in MRS and p~30 GeV/c in FS.

M.Adamczyk et al., BRAHMS Collaboration, Nucl. Instr. and Meth. A499 (2003) 437

Strangeness enhancement

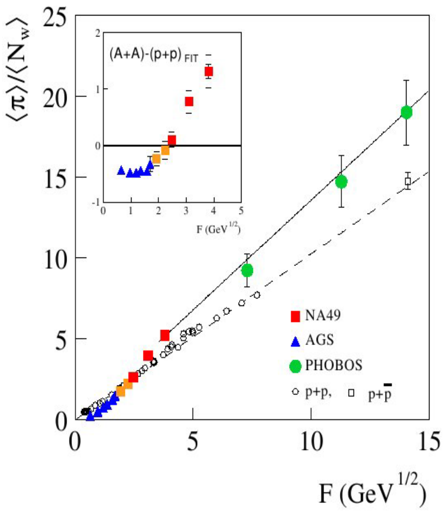


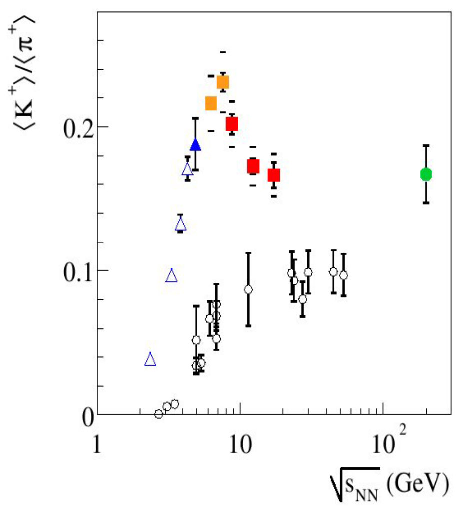
Top plot: E = 11.6GeV(lab) for Au+Au data
E = 14.6GeV(lab) for p+A and Si+Au

L.Ahle et al., Phys. Rev. C 58 (1998) Vol. 6
T.Abbott et al., Phys. Rev. D45 (1992) 3906
T.Abbott et al., Phys. Lett. B291 (1991) 341
T.Abbott et al., Phys. Rev. C50 (1994) 1024

The K^+/π^+ ratio increases with the number of participant nucleons both at AGS and SPS energies.

At AGS energies the enhanced production of strangeness was explained by hadronic cascade models, e.g. RQMD.

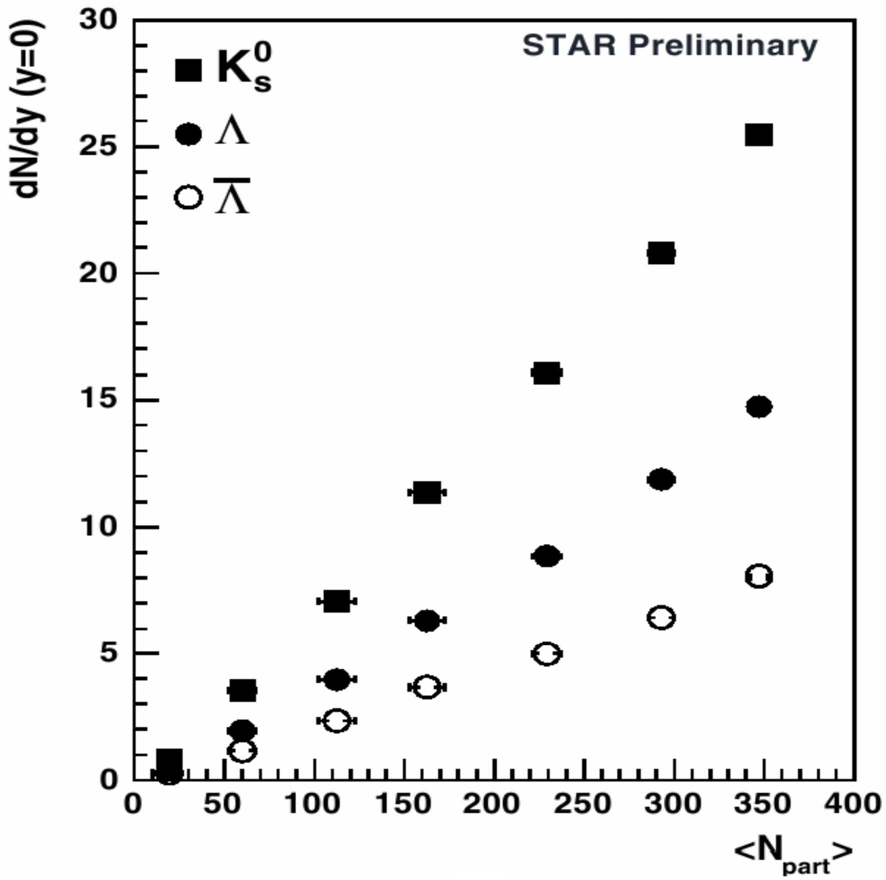




The "horn"-like dependence in the $\langle K^+\rangle/\langle\pi^+\rangle$ excitation function observed at SPS energies was proposed as a signal of the transition to QGP.

M.Gazdzicki and D.Röhrich, Z.Phys. C65 (1995) 215-223
M.Gazdzicki and M.I.Gorenstein, Acta Phys.Polon. B30 (1999) 2705
C.Alt et al., NA49 Collaboration, arXiv:0710.0118[nucl-ex]

Strangeness ratio



STAR results on K^0 and Λ hyperons in Au+Au at 62.4 GeV

The kaons and Lambda hyperons are the main strange quark carriers.

$$E_S = \frac{\langle \Lambda \rangle + \langle K + \overline{K} \rangle}{\langle \pi \rangle}$$

$$\langle K + \overline{K} \rangle = \langle K^+ \rangle + \langle K^- \rangle + 2 \cdot \langle K_S^0 \rangle$$

$$\langle K + \overline{K} \rangle = 2 \cdot (\langle K^+ \rangle + \langle K^- \rangle)$$

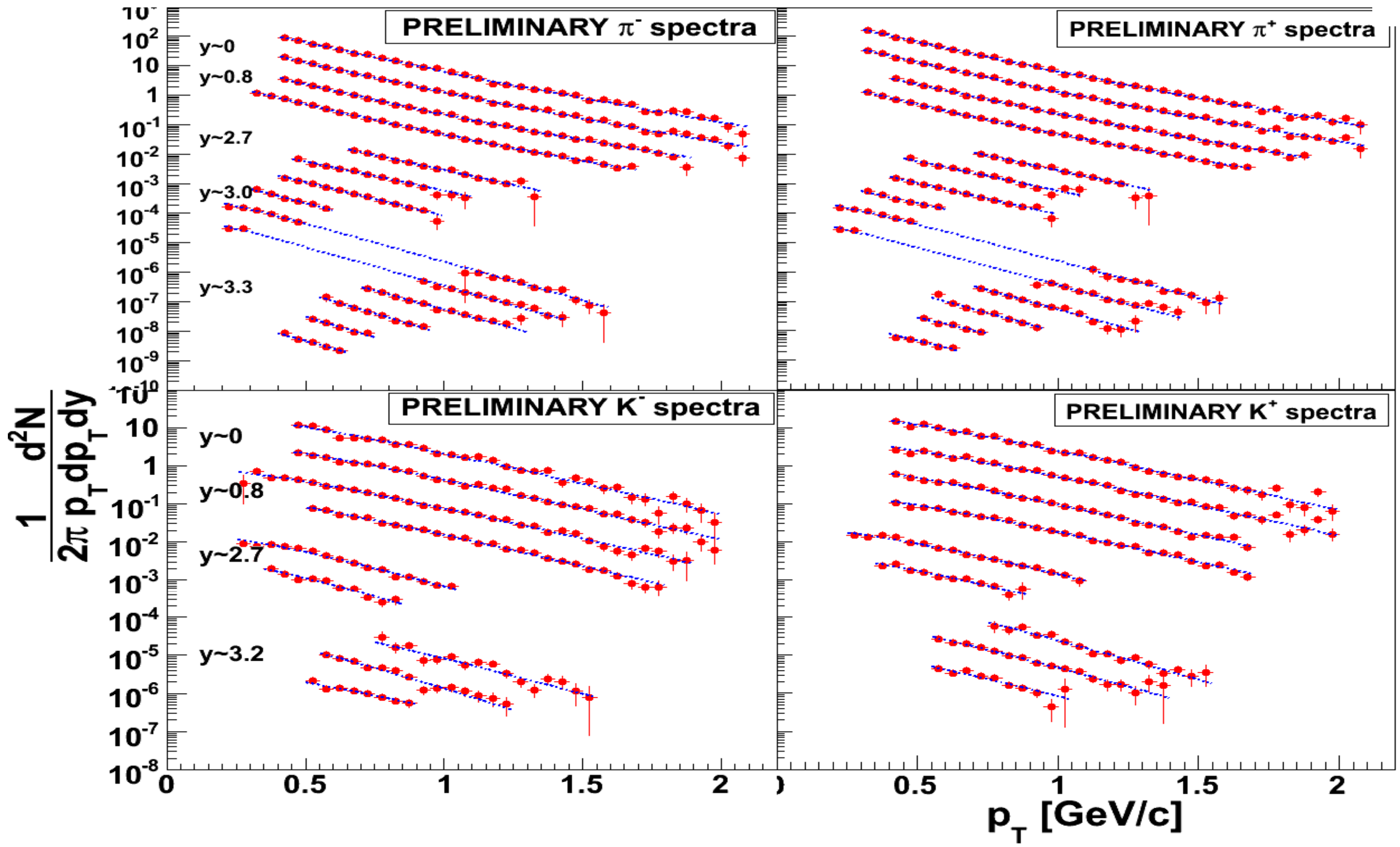
anti-Λ yield (y=0) ~ 8 (STAR preliminary)

K^+ yield (y=0) ~ 32 (BRAHMS preliminary)

At mid-rapidity, the K^+/π^+ ratio is a rough estimate of the strangeness ratio.
At forward rapidities the approximation becomes better.

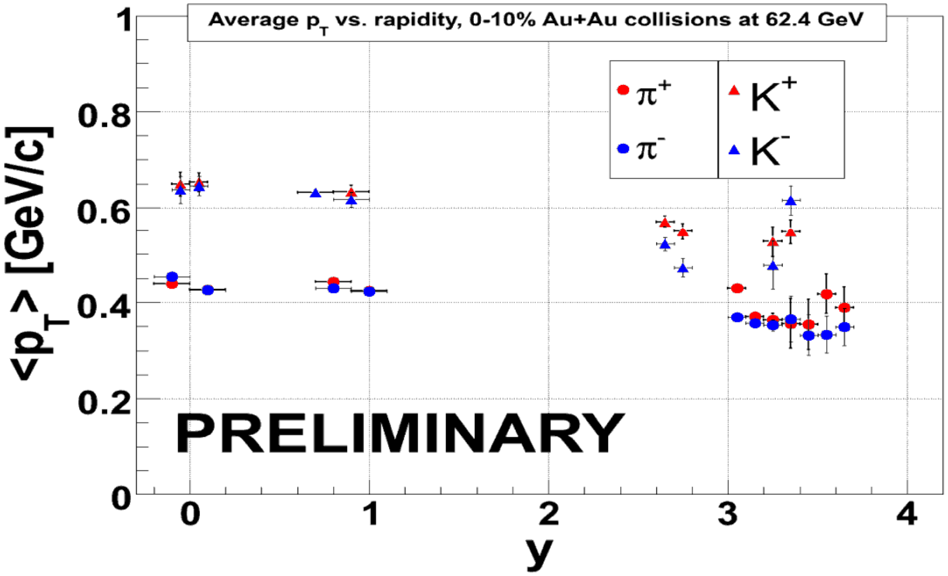
J.Takahashi et al., STAR Collaboration, J.Phys.G31 (2005) S1061-S1064

Pt spectra from 0-10% central Au+Au



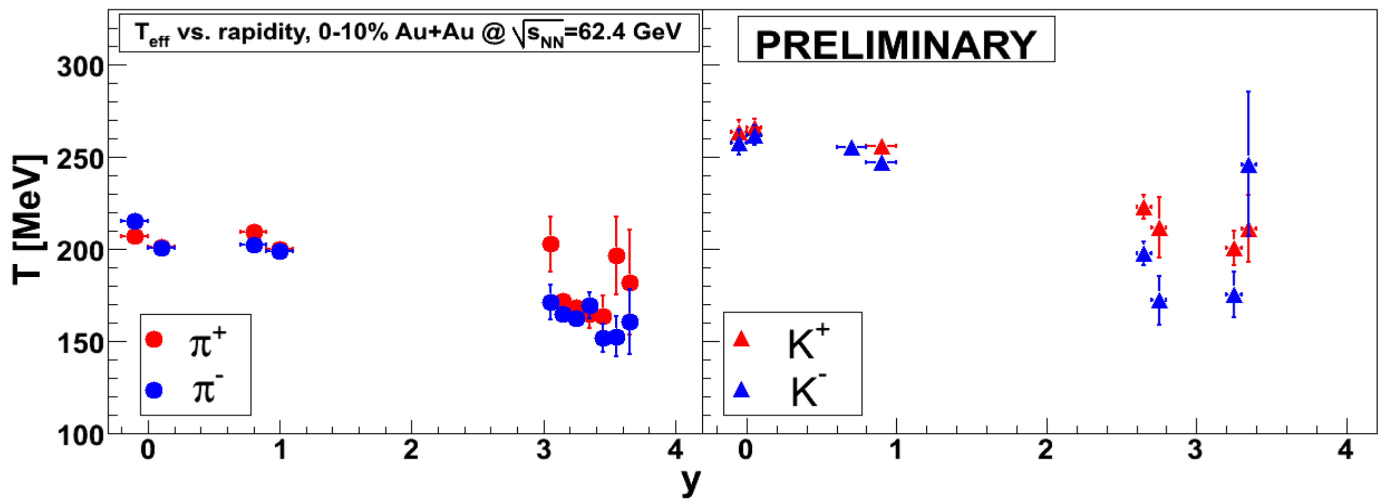
Each spectra was multiplied by a factor of $(0.2)^n$ for better visibility.
Pion spectra was fitted with a power law at mid-rapidity and mt exponentials at forward rapidities.
The kaon spectra was fitted with mt exponentials at all rapidities.
Due to incomplete momenta coverage the extrapolated yields from some slices can have large systematic errors.

Average pt and inverse slopes vs rapidity

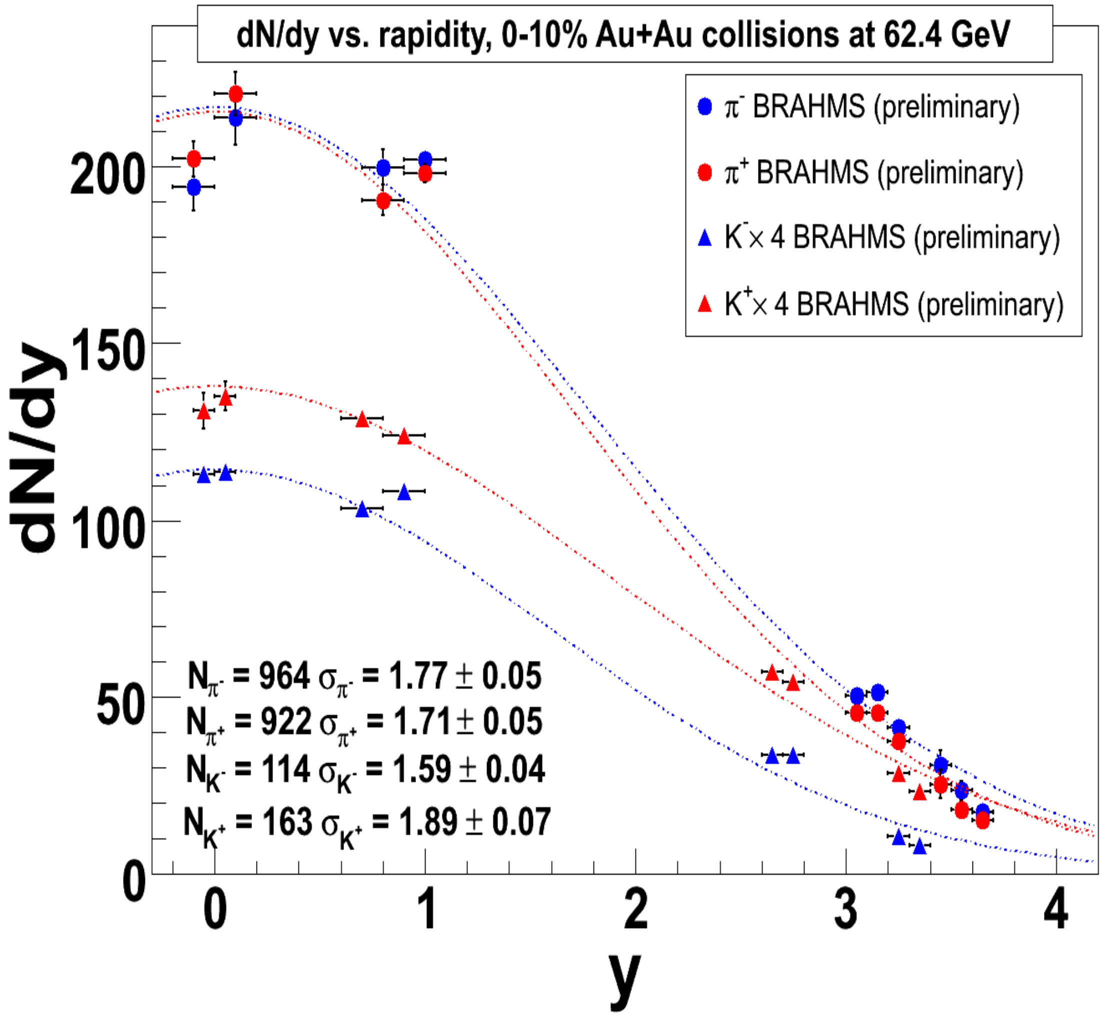


Average transverse momentum and effective temperatures decrease at high rapidity (y~3) for both pions and kaons.

The error bars are statistical only.



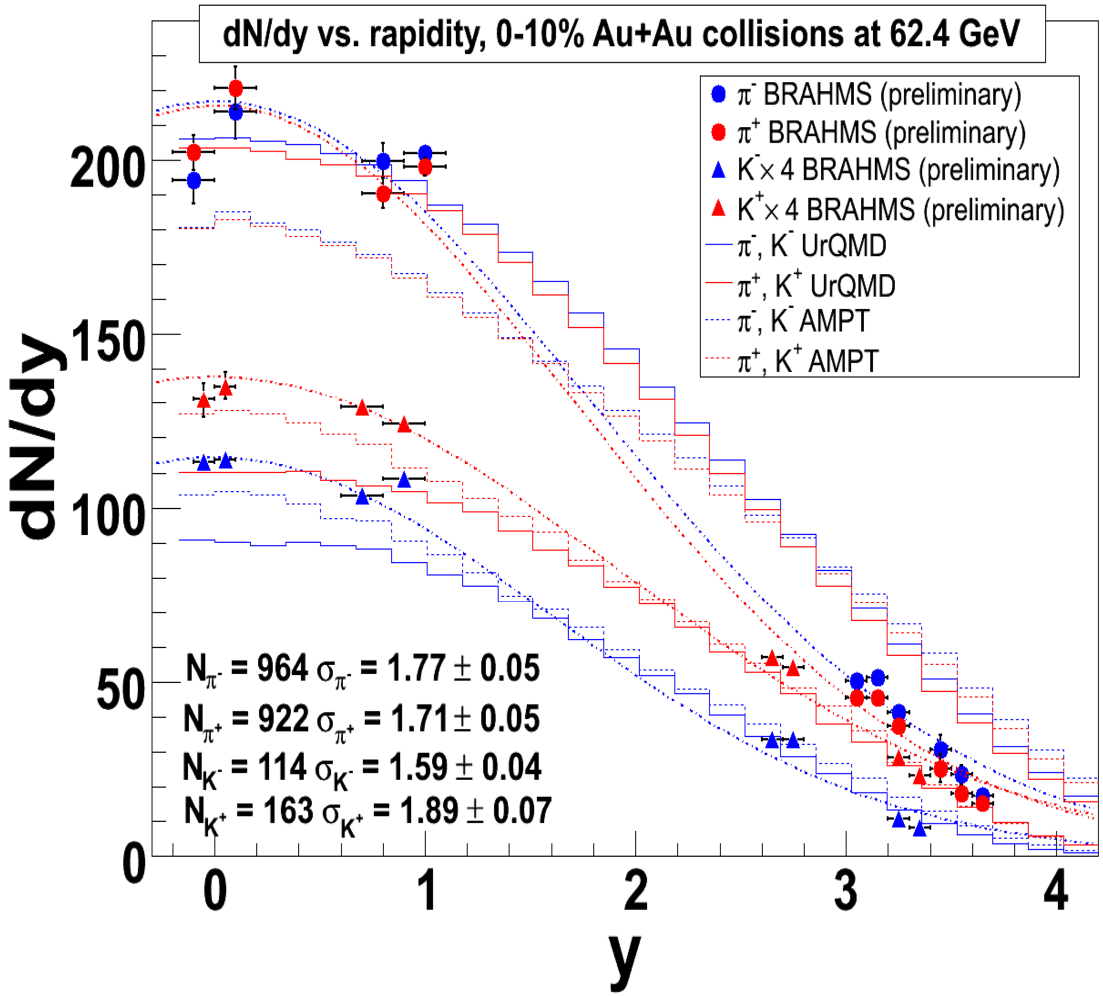
Integrated dN/dy vs rapidity



The dN/dy distributions were fitted with gaussian functions with fixed centroids at y=0.
The different kaonic widths reflect their different production mechanisms.

Integrated dN/dy vs rapidity

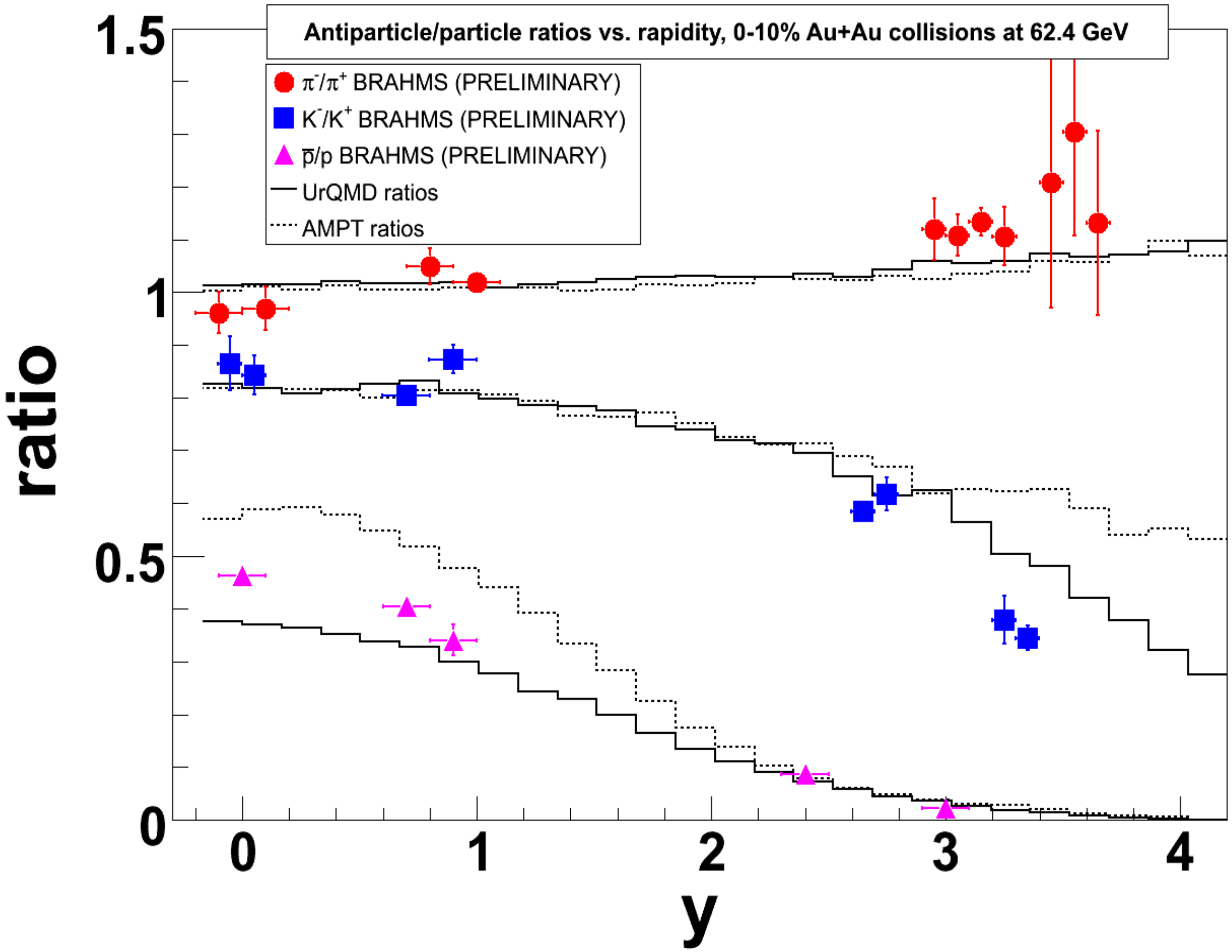
BRAHMS



UrQMD references:
S.A.Bass et al., Prog.Part.Nucl.Phys.41 (1998) 225-370
M.Bleicher, E.Zabrodin et al., J.Phys.G25 (1999) 1859-1896
AMPT references:
B.Zhang et al., Phys.Rev.C61 (2000) 067901
Z.-w. Lin et al., Nucl.Phys.A698 (2002) 375-378

The dN/dy distributions were fitted with gaussian functions with fixed centroids at y=0.
The different kaonic widths reflect their different production mechanisms.

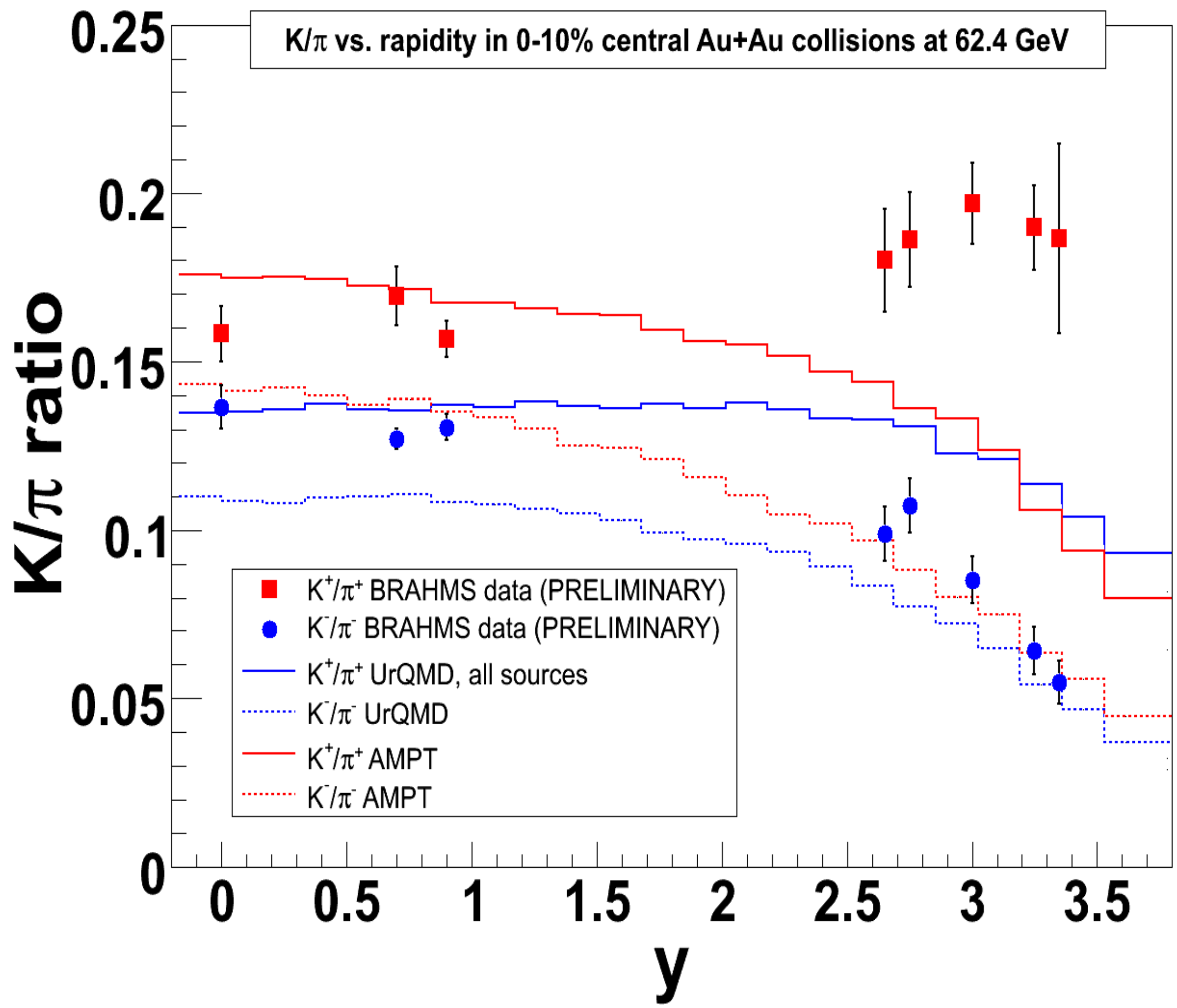
Anti-particle/particle ratios vs. y



At y~0
pbar/p ~0.47
K^-/K^+ ~ 0.85
π^-/π^+ ~ 0.98

At y~3
pbar/p~0.02 !!
K^-/K^+ ~ 0.6
π^-/π^+ ~ 1.1

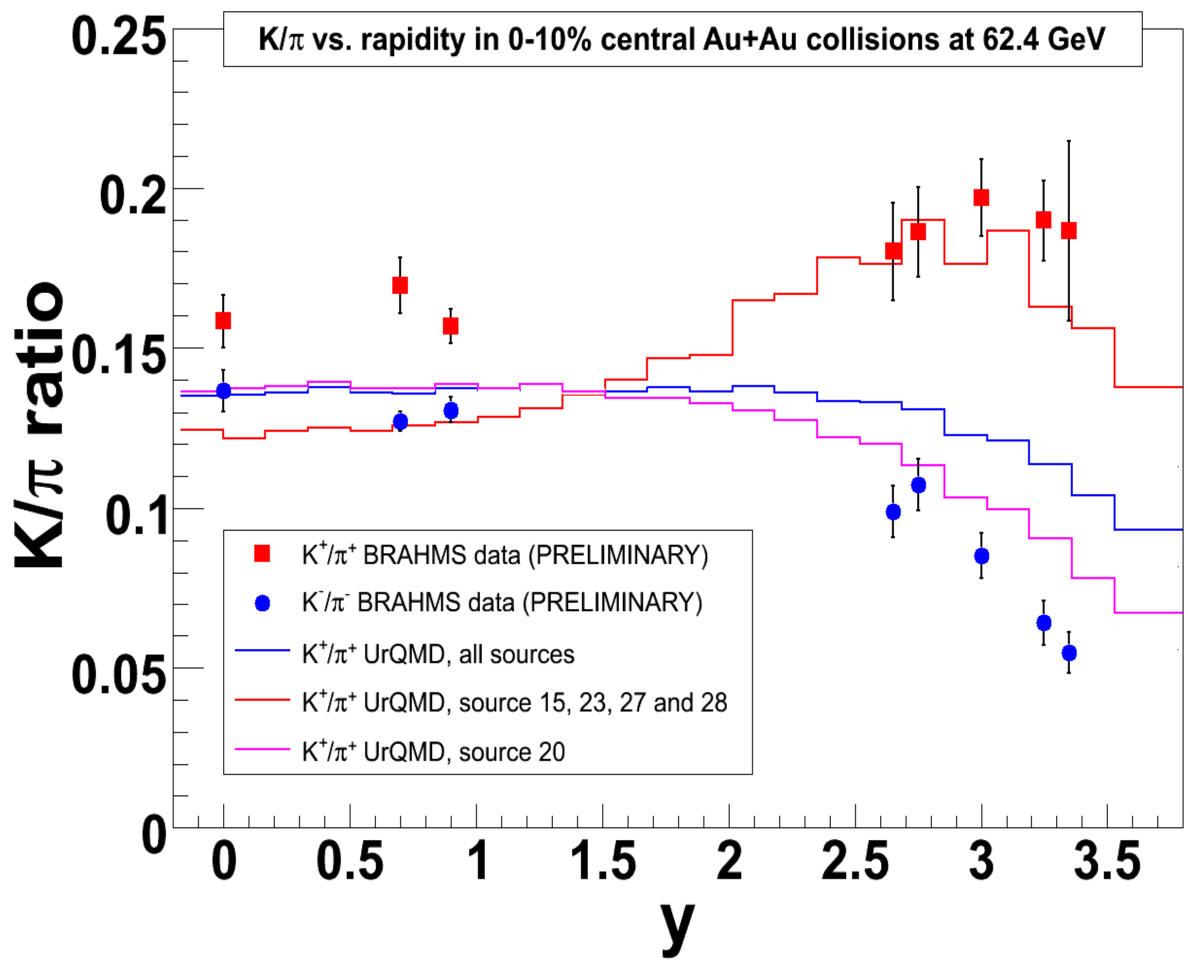
K/π ratios vs. rapidity (1)



Because the phase space covered depends on the type of particle, in two rapidity slices, y~2.7 and y~3.0, we used linear interpolation to calculate the pionic and kaonic yields respectively.

UrQMD and AMPT models fail to fit the K^+/π^+ ratio behaviour at forward rapidity. The negative ratio is reasonably explained.

K/π ratios vs rapidity (2)



Source definitions from UrQMD

15: xx -> 2 strings

20: decays

23: annihilation->string

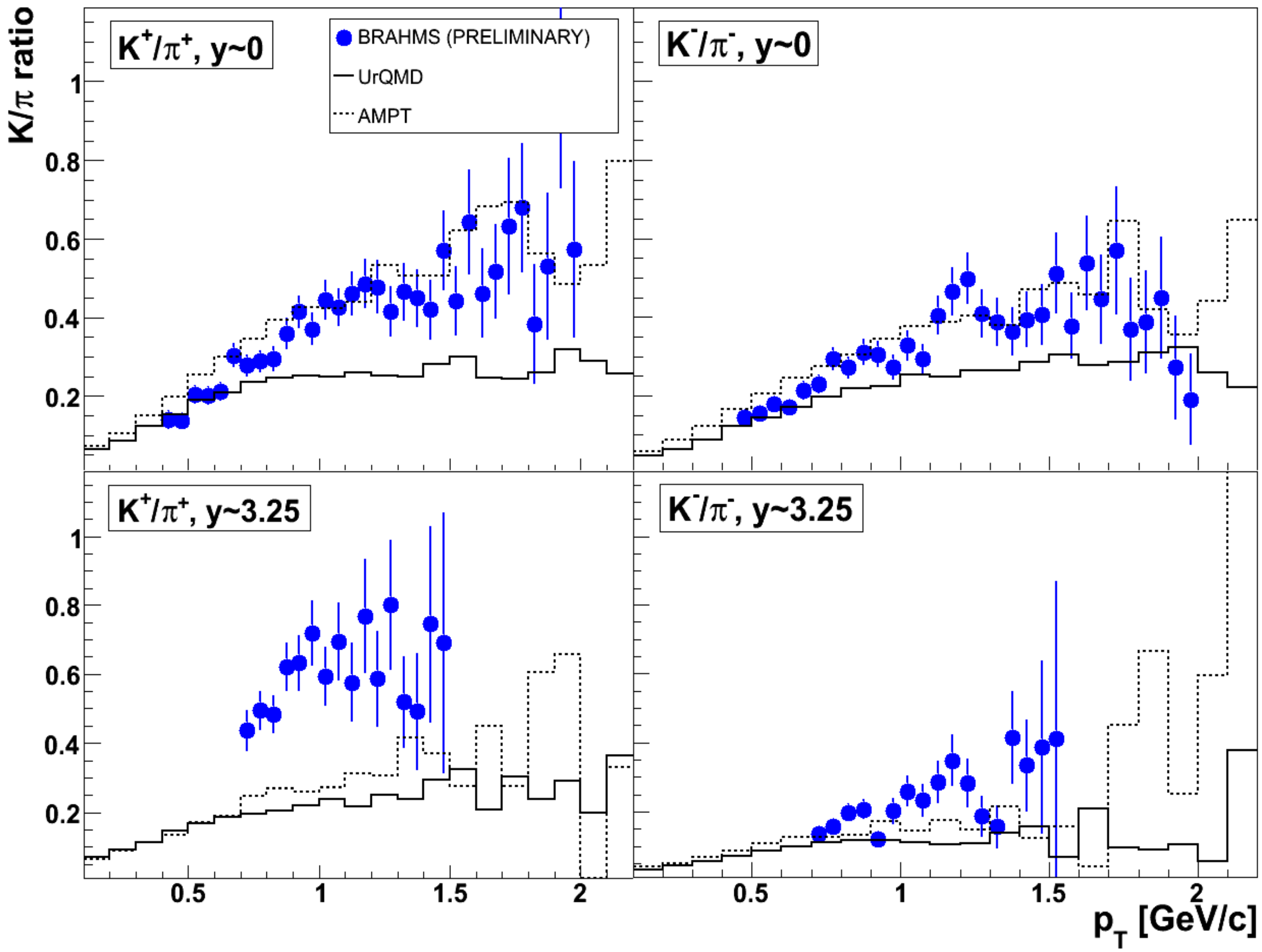
27: xx->1 string, e.g. e+e-, MB

28: MB->2 strings

In UrQMD model there are mechanisms which can qualitatively reproduce the data trend at forward rapidity, but their contribution to the total yield is small.

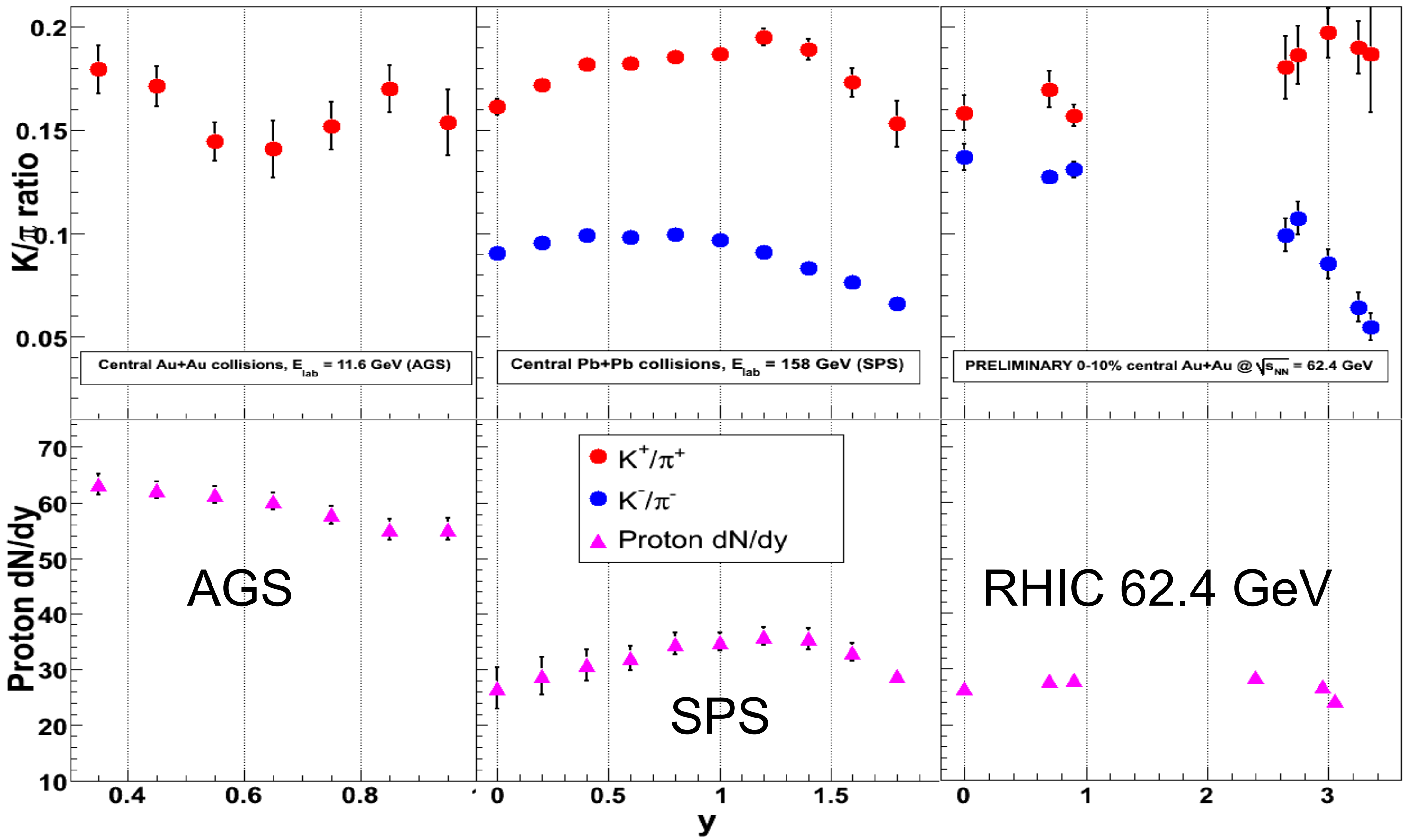
A more detailed look into the microscopic UrQMD model

K/π ratios vs pt



Forward K^+/π^+ ratio is under predicted on the entire measured pt range.

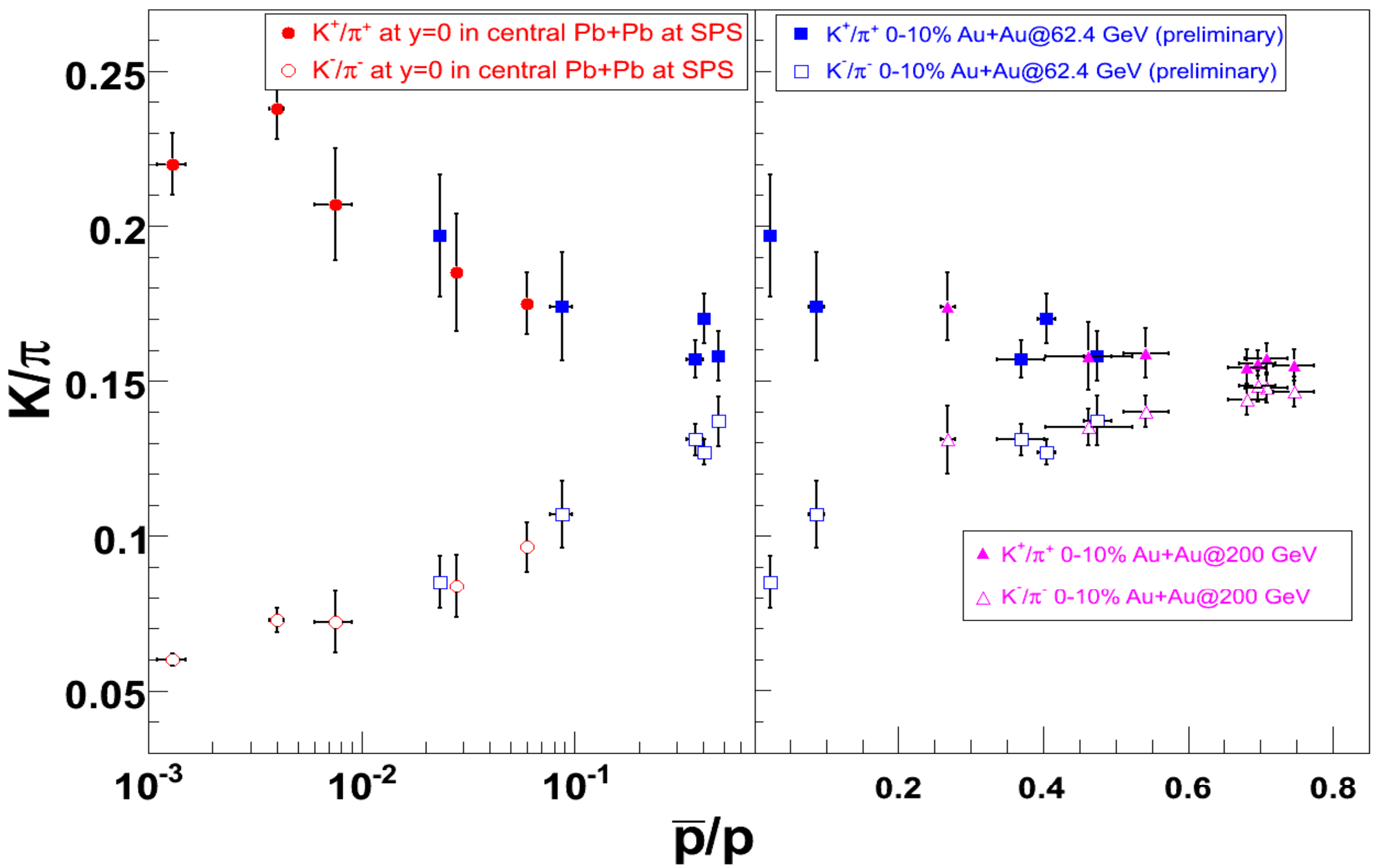
Comparison with lower energy data



At top AGS energy the K^+/π^+ ratio is significantly high. We know that this is due to hadronic scatterings in a baryon rich medium.

Both at top SPS energy and at RHIC 62.4GeV, the K^+/π^+ rapidity dependence seems to have a maximum in the fragmentation region.

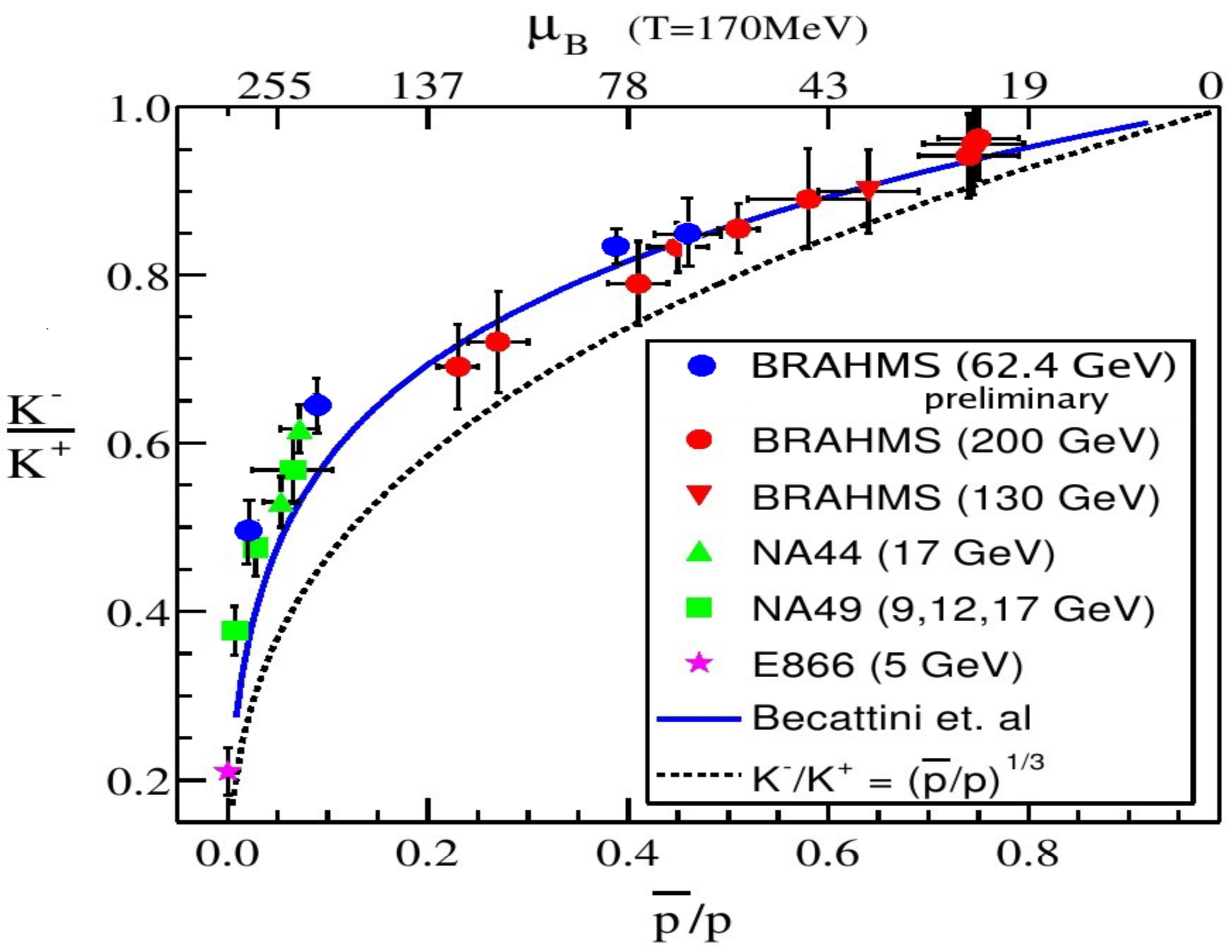
K/π vs the baryo-chemical potential



I.G.Bearden et al., BRAHMS Collaboration, Phys.Rev.Lett.94 (2005) 032301
I.Arsene et al., BRAHMS Collaboration, Nucl.Phys.A757 (2005) 1-27

K^-/K^+ vs baryo-chemical potential

BRAHMS

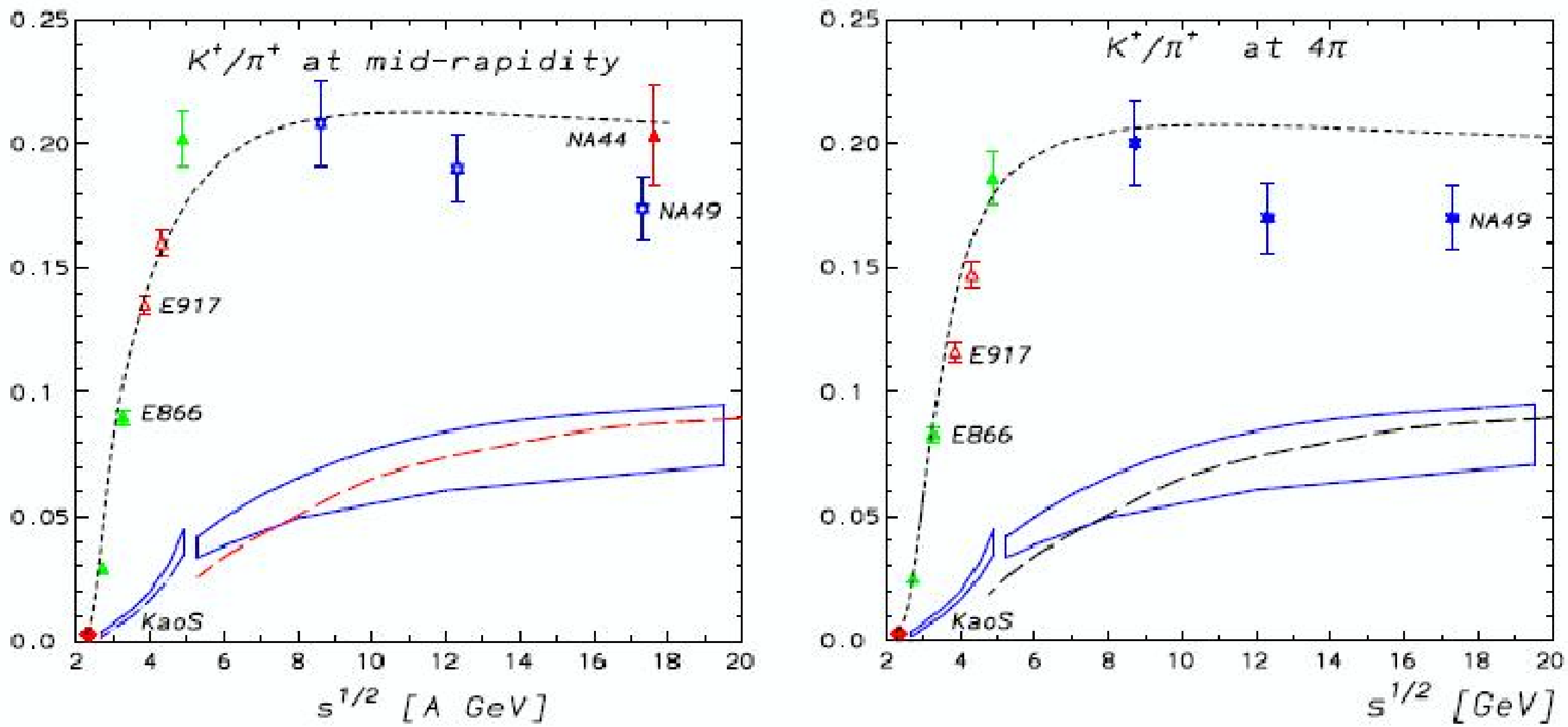


The blue curve is a statistical model calculation with a chemical freez-out temperature fixed to 170 MeV but allowing the baryo-chemical potential to vary.

I.G.Bearden et al., BRAHMS Collaboration, Phys.Rev.Lett. 90 (2003) 102301
F.Becattini et al., Phys.Rev. C64 (2001) 024901

Conclusions

- We presented experimental data on 0-10% central Au+Au collisions at $\sqrt{s_{NN}}$ =62.4GeV measured with the BRAHMS spectrometer. In this work we focused on the strange particles production dependence with rapidity.
- In this dataset BRAHMS was able to measure and identify charged particles in the fragmentation region of the beam where we observed similar conditions (e.g. pbar/p ratio) with the ones found at upper SPS energies.
- Experimentally it can be seen that the K^+/π^+ ratio is higher in the fragmentation region (y~3) and this is not explained by the theoretical models involved in this analysis (UrQMD and AMPT).
- We showed that there is a common dependence of K/π and K^-/K^+ ratios with the pbar/p ratio when looking at SPS results in mid-rapidity together with our results in different rapidity slices. Although the initial conditions for the collisions at RHIC(62.4 GeV) and SPS are expected to be substantially different, the compared systems develop the same chemistry which seems to be driven by the baryo-chemical potential.



P. Braun-Munzinger, J. Stachel, A. Andronic