Recent Results from BRAHMS

- Results from Au+Au at $\sqrt{s_{NN}}$ =200 GeV (published + New)
  on Identified Charged Hadrons
  - Rapidity Dependence for Central Collisions
  - Centrality Dependence at y=0
- Run03 (d+Au,p+p)
- Summary

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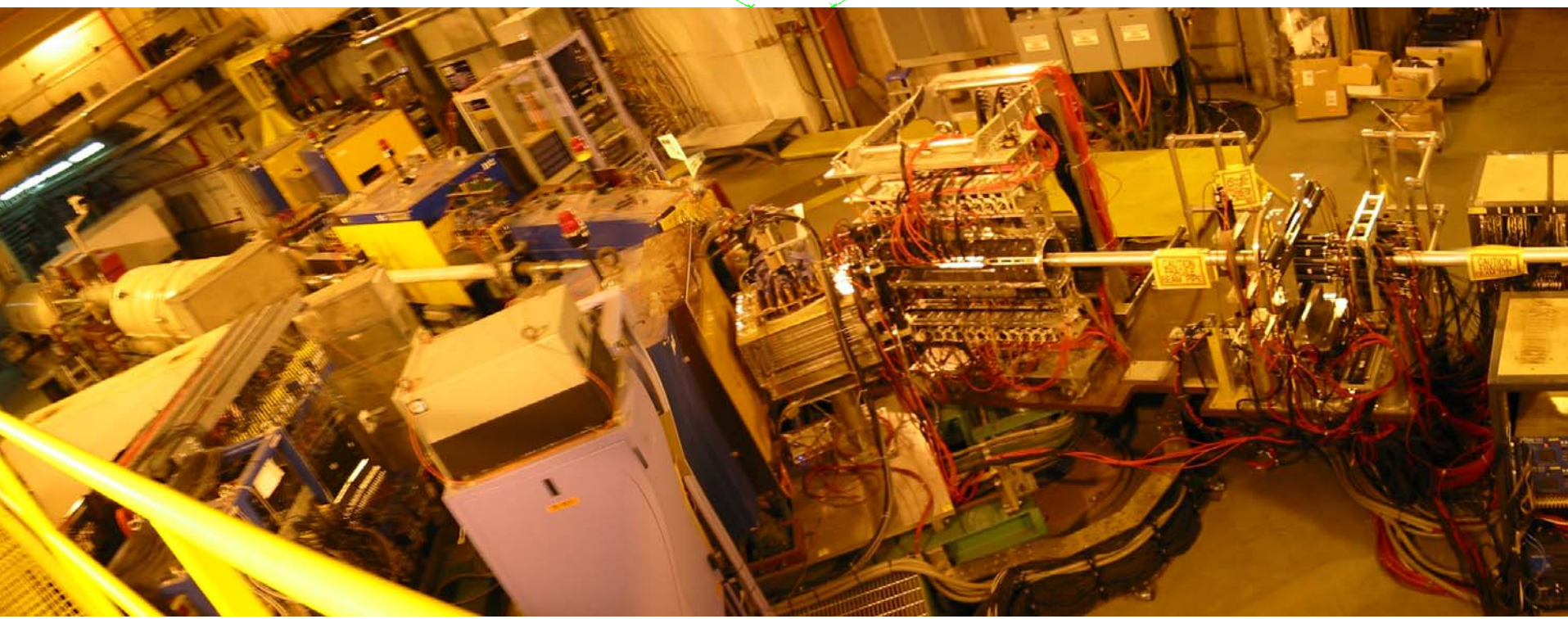
For the BRAHMS Collaboration

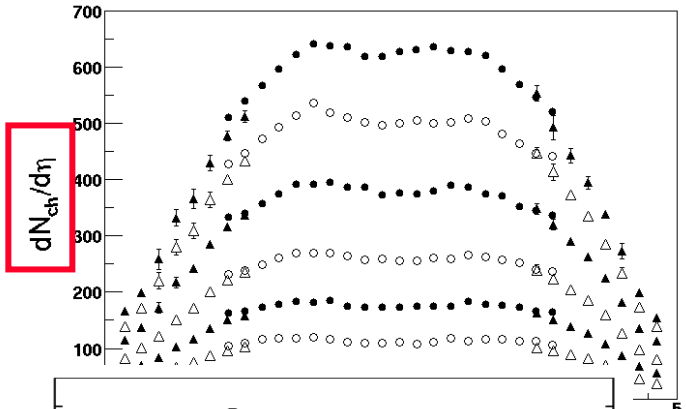
RHIC/AGS Users' Meeting
May 15 2003

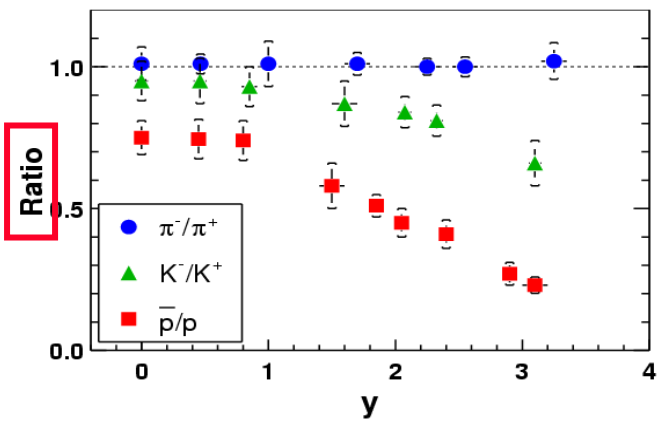


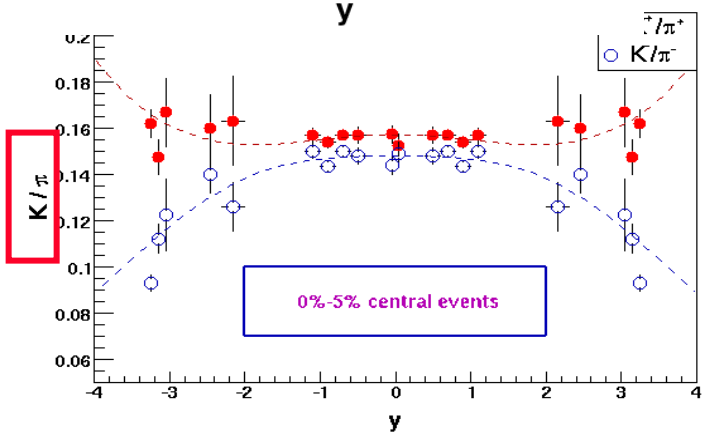
- Designed to study nuclear reactions in broad kinematic range (y-pt)
- 2 movable spectrometers with small solid angle measuring charged identified hardrons precisely
- Centrality detectors (Si+Scintillator Tiles) to characterize events
- 55 people from 10 institutions form 5 countries

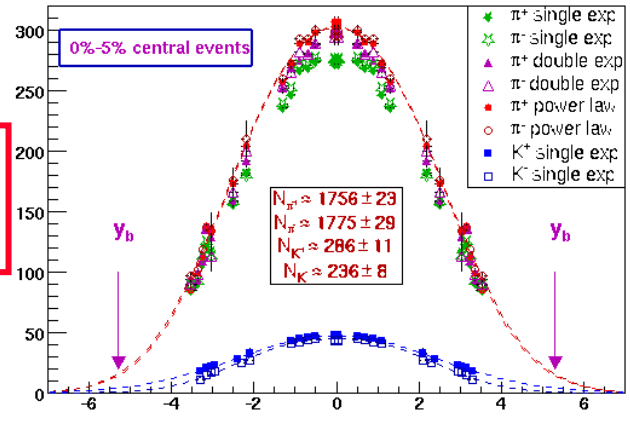
BRAHMS measures over a broad rapidity range

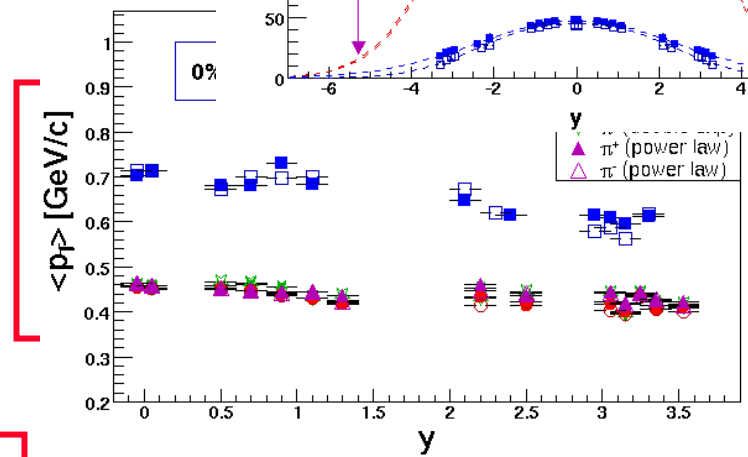
$\sqrt{s_{NN}}$=200GeV

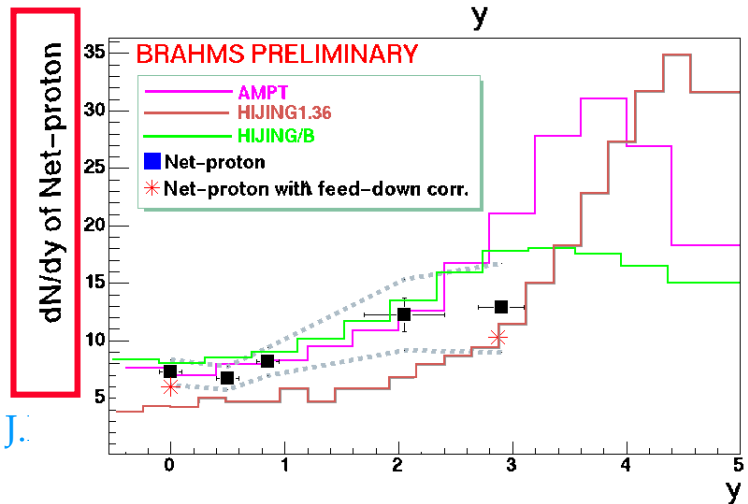








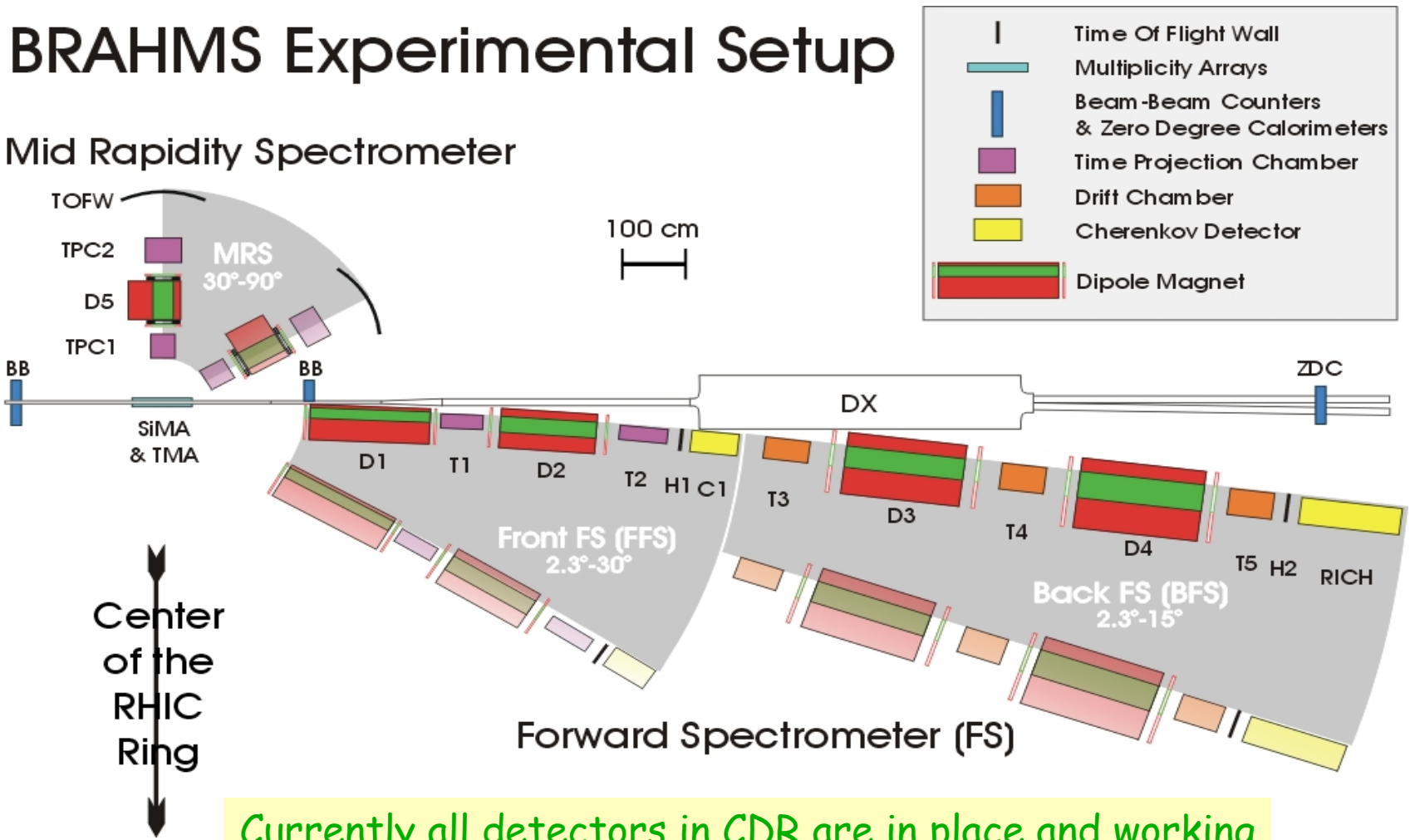




And More…

The BRAHMS experiment

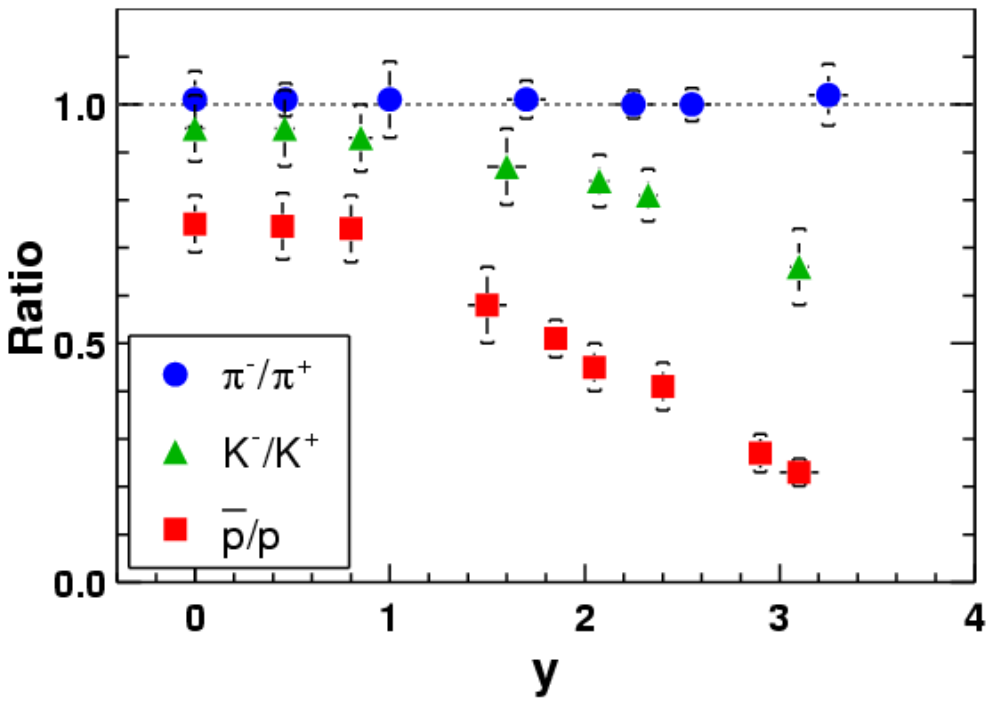
Setup used for Au+Au data in 2001-2002



Currently all detectors in CDR are in place and working

BRAHMS

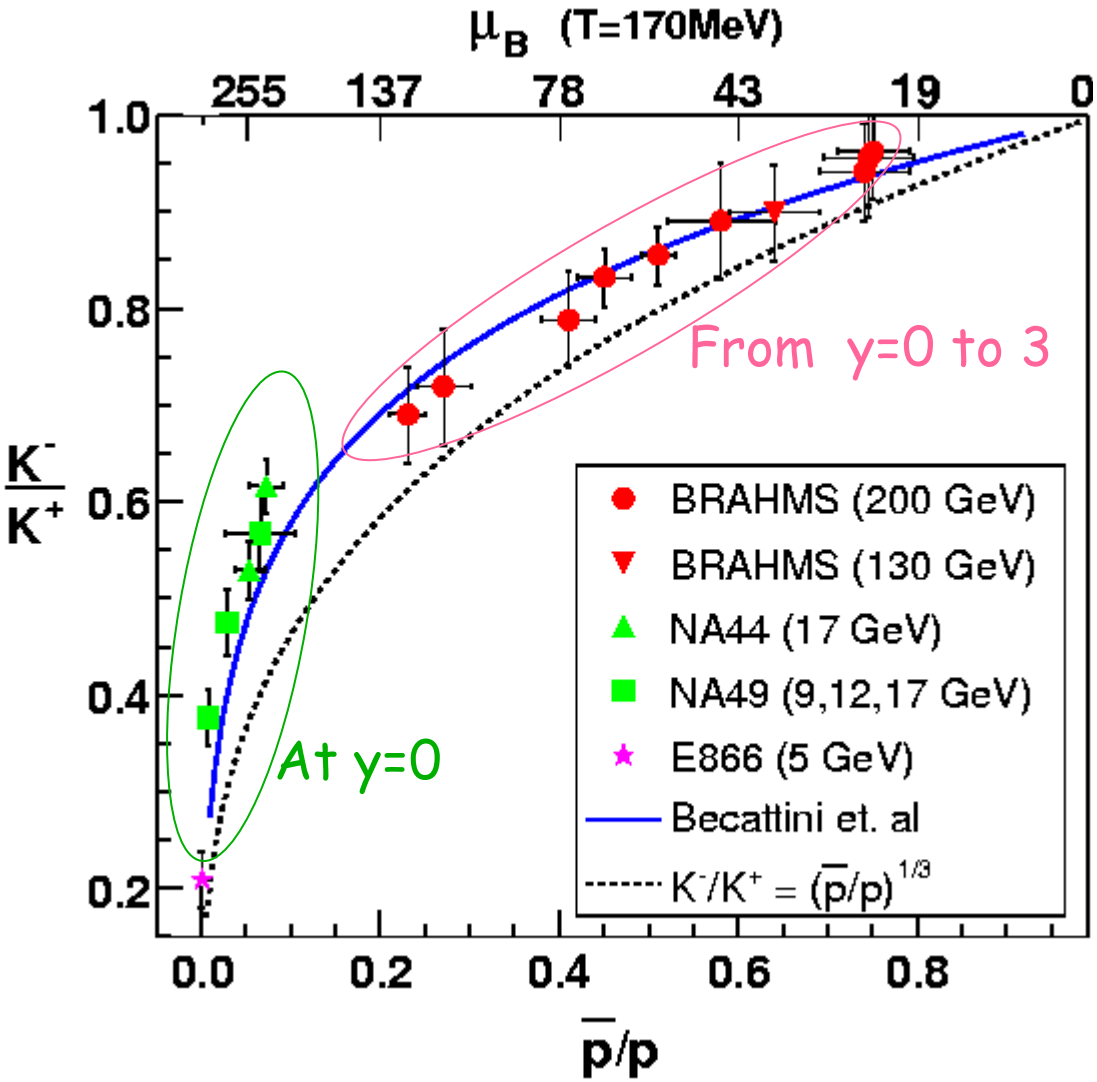
Anti-particle/particle ratios vs. rapidity at $\sqrt{S_{NN}}$=200 GeV



PRL 90 102301 (Mar. 2003)

- At y=0 (20% central)
  pbar/p = 0.75 ±0.04
  K^-/K^+ = 0.95 ±0.05
  π^-/π^+ = 1.01 ±0.04
- Highest pbar/p ratio but still incomplete transparency (~17% increase from 130 GeV)
- Ratios ~identical over +-1 unit around mid-rapidity.
- Weak centrality and p_T dependence (not shown here)
- No Hyperon feed down correction applied: less then 5% correction
- No theoretical model describes rapidity dependent ratios correctly

"Universal" Correlation in K^-/K^+ vs pbar/p?



- By simple quark counting in quark recombination

K^-/K^+

$= \exp(2\mu_s/T)\exp(-2\mu_q/T)$

$= \exp(2\mu_s/T)(\text{pbar}/p)^{1/3}$

$= (\text{pbar}/p)^{1/3}$

by assuming local (in y) strangeness conservation

- $K^-/K^+=(\text{pbar}/p)^{\alpha}$

$\alpha = 0.24\pm0.02$ for BRAHMS

$\alpha = 0.20\pm0.01$ for SPS

- Good agreement with the statistical-thermal model prediction by Beccatini et al. (PRC64 2001): Based on SPS results and assuming T=170 MeV

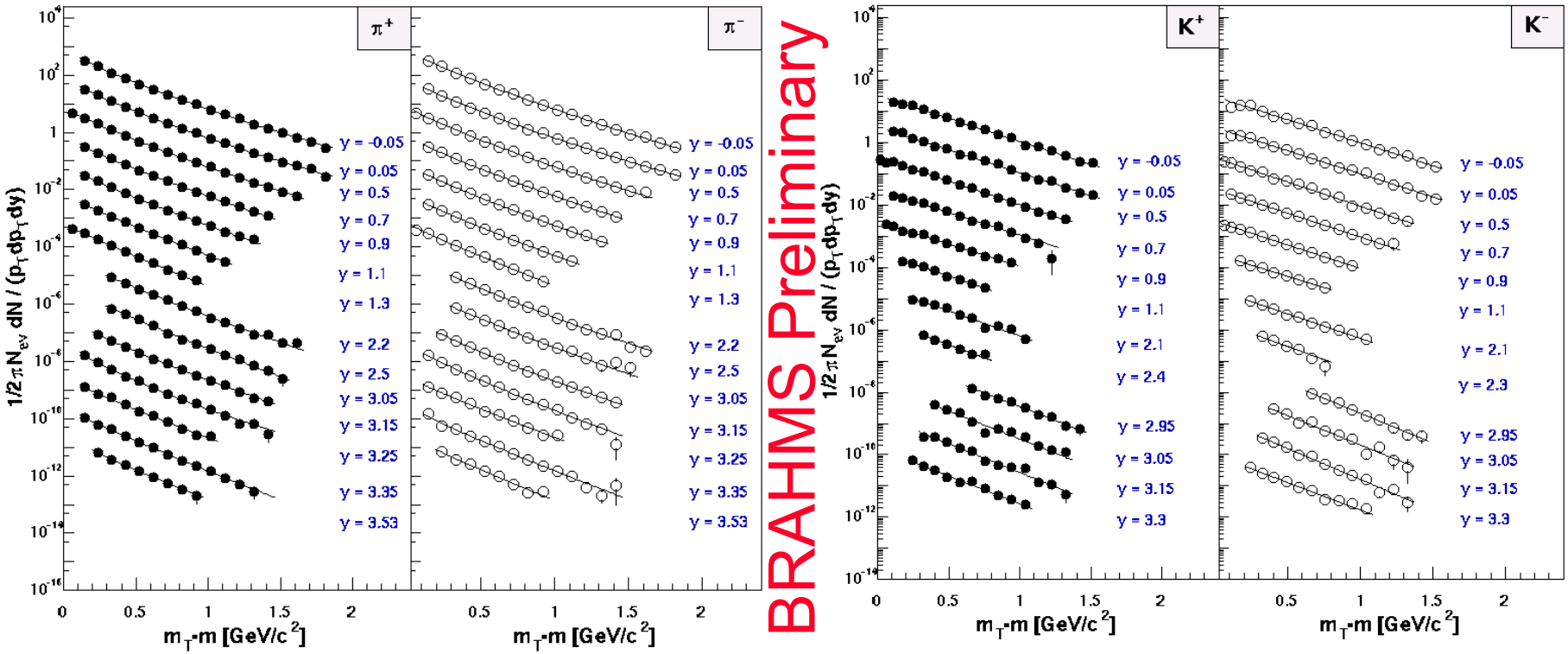
PRL 90 102301 Mar. 2003

S. V. Afanasiev *et al.*, NA49 Collaboration, nucl-ex/0205002, nucl-ex/0208014; M. Van Leeuven, Proc. Quark Matter 2002. P. Seyboth, private comm. I. G. Bearden *et al.*, NA44 Collaboration, Phys. Rev. C66, 044907 (2002).

BRAHMS

Pion and Kaon spectra in y = 0 – 3.5 for 0-5% central Au+Au

π^+ π^- K^+ K^-



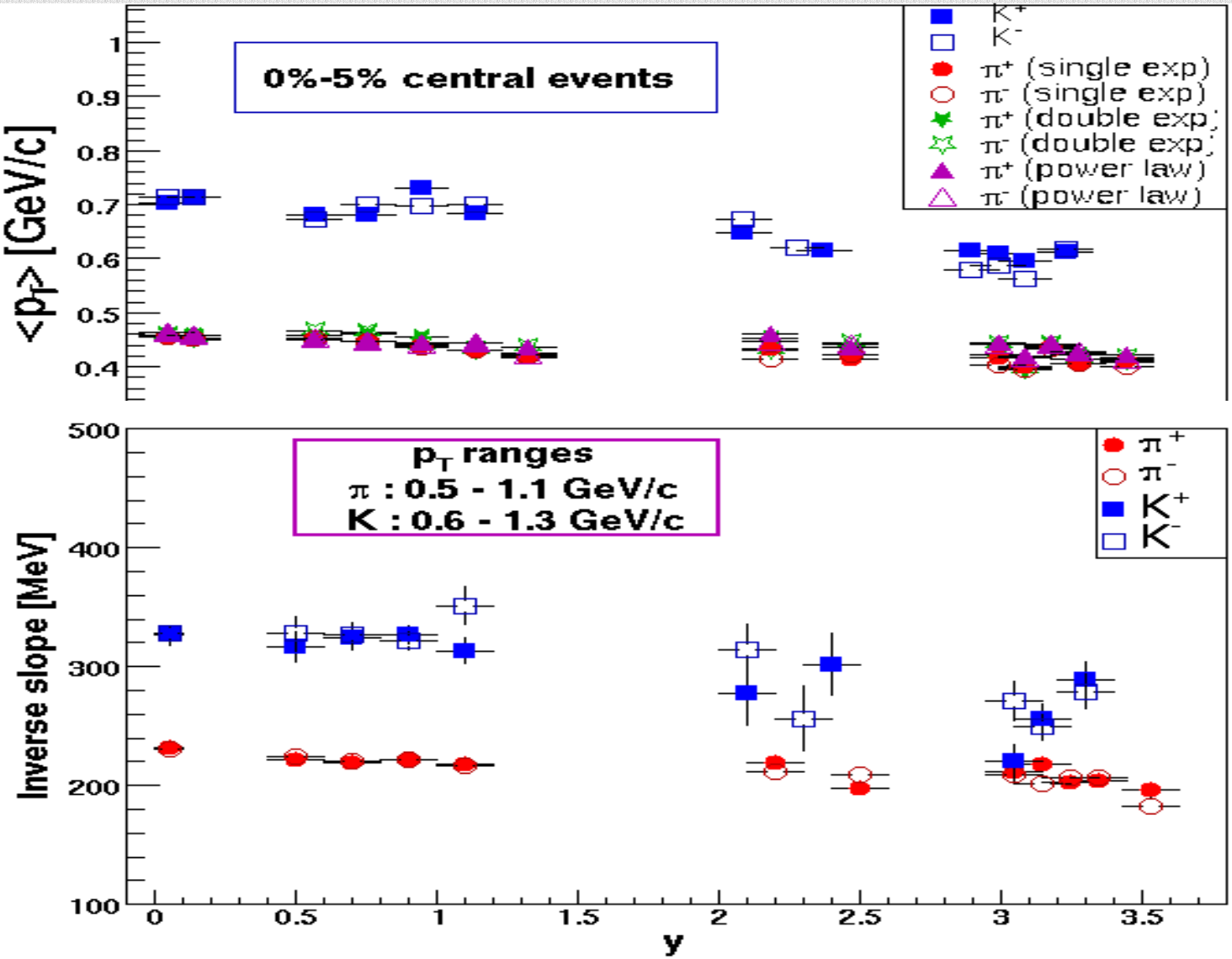
Pion: Power law fit

Kaon: m_T single exponential fit

D. Ouerdane (NBI) Thesis

<pt> vs rapidity for π and K

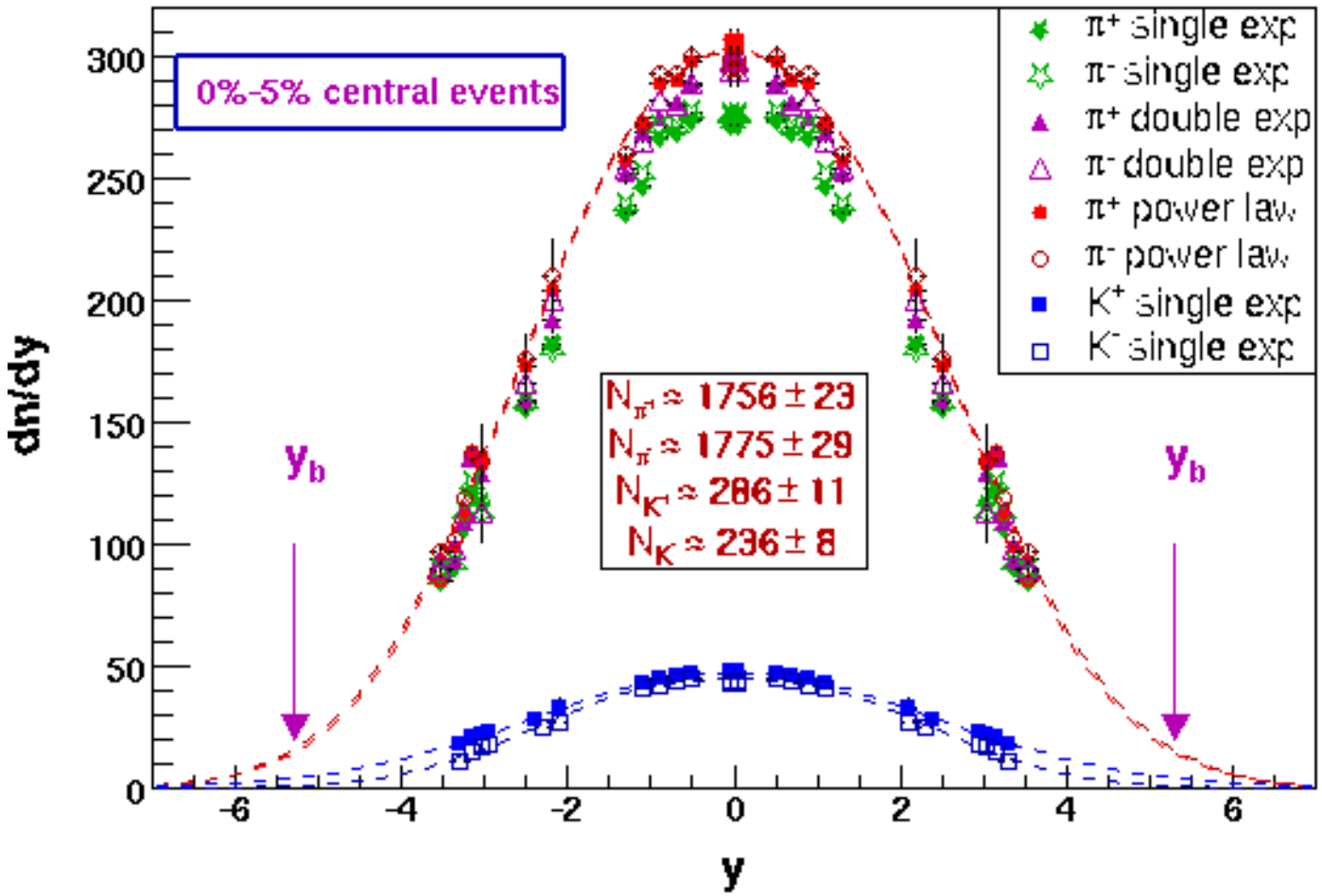
BRAHMS Preliminary



<pt> (and inverse slope) for π and K decrease slowly with rapidity (0-3: 10-15% decrease)

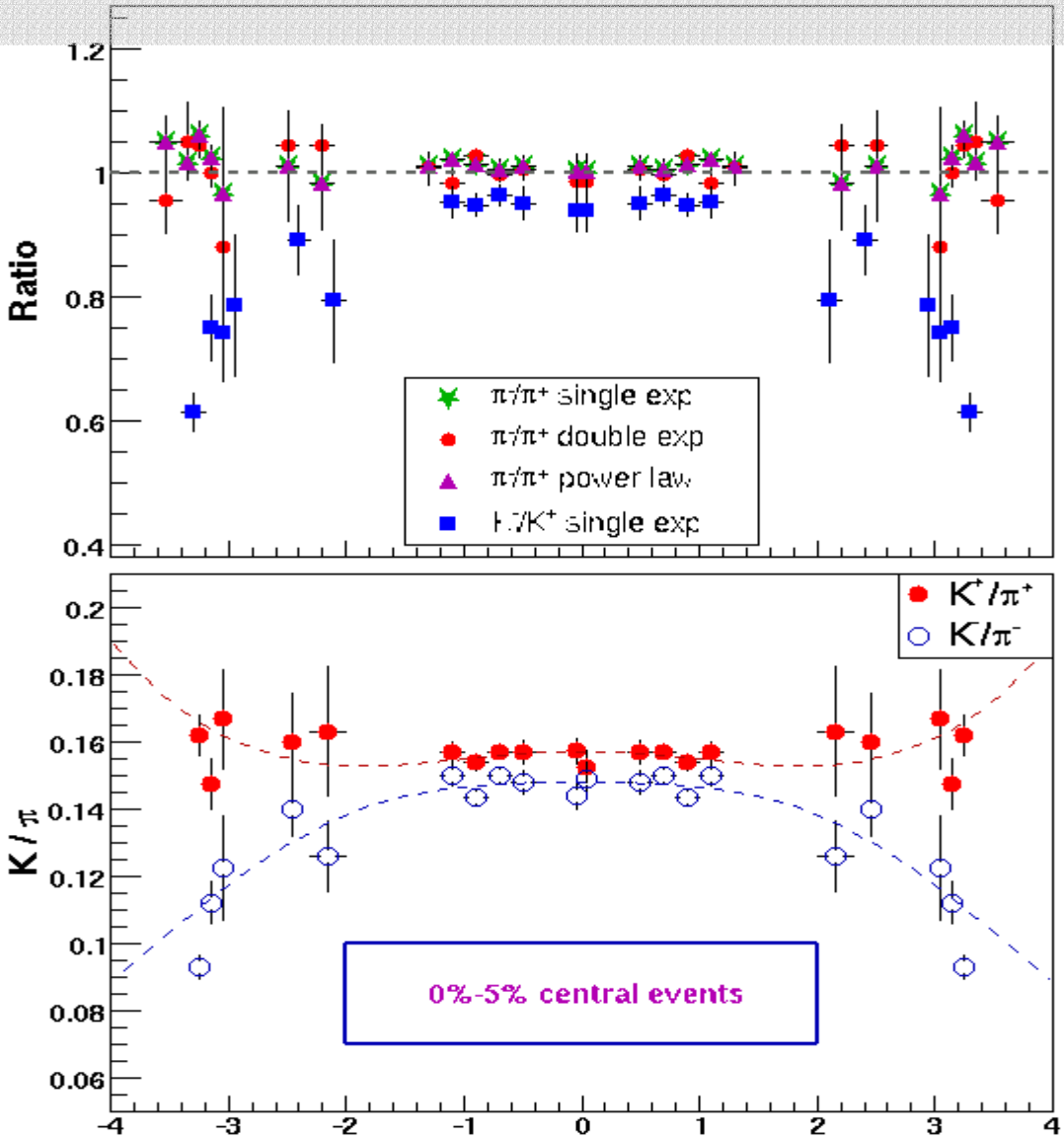
dN/dy of pion and Kaon for 0-5% Central Au+Au at $\sqrt{S_{NN}}$=200 GeV

BRAHMS Preliminary



- No clear "plateau" observed
- Rapidity dendities : Close to a Gaussian shape ($\sigma(\pi+)$ =2.35 ~ σ(K+) =2.39)
- Yield is extrapolated from a double Gaussian (better description of data)
- Total yield in agreement with pulished dN/dη measurements from multiplicity detectors

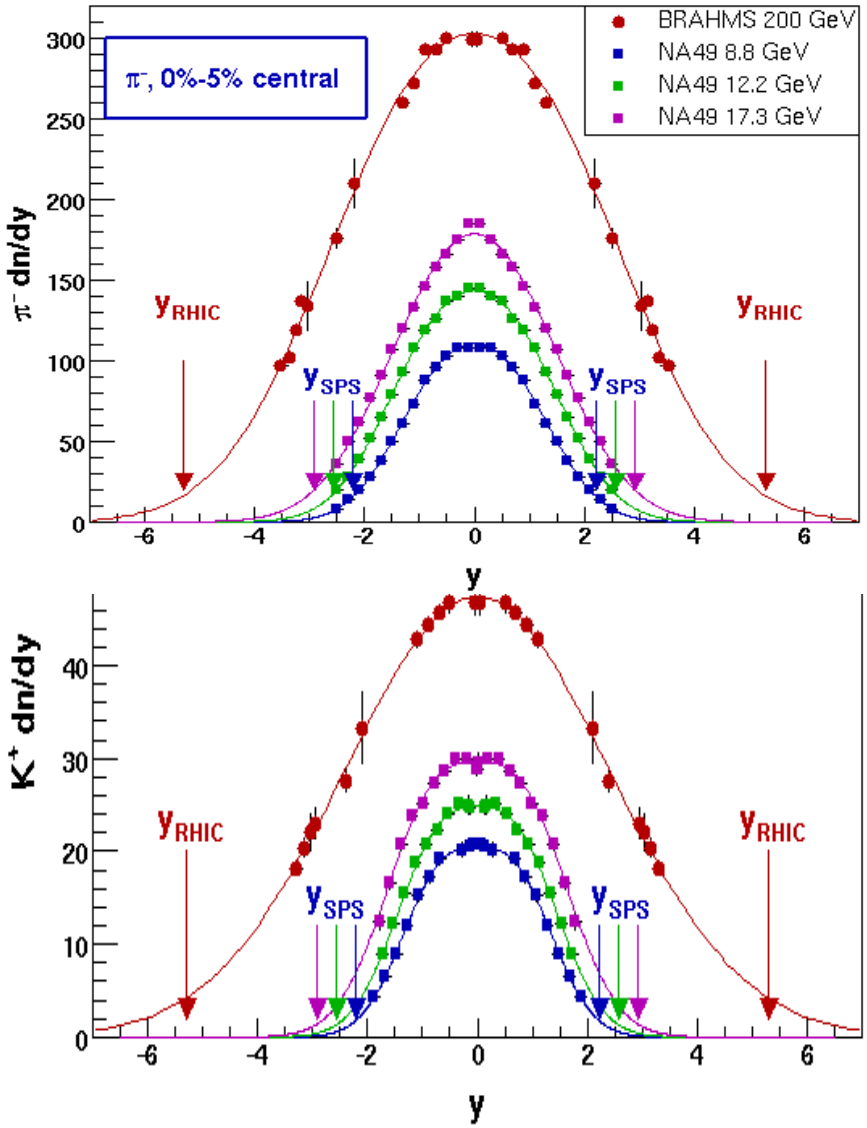
Ratios



- π−/π+, K-/K+: in agreements with BRAHMS published results
- K-/π− decrease with y while K+/π+ shows no significant dependence

BRAHMS

Comparison with SPS data

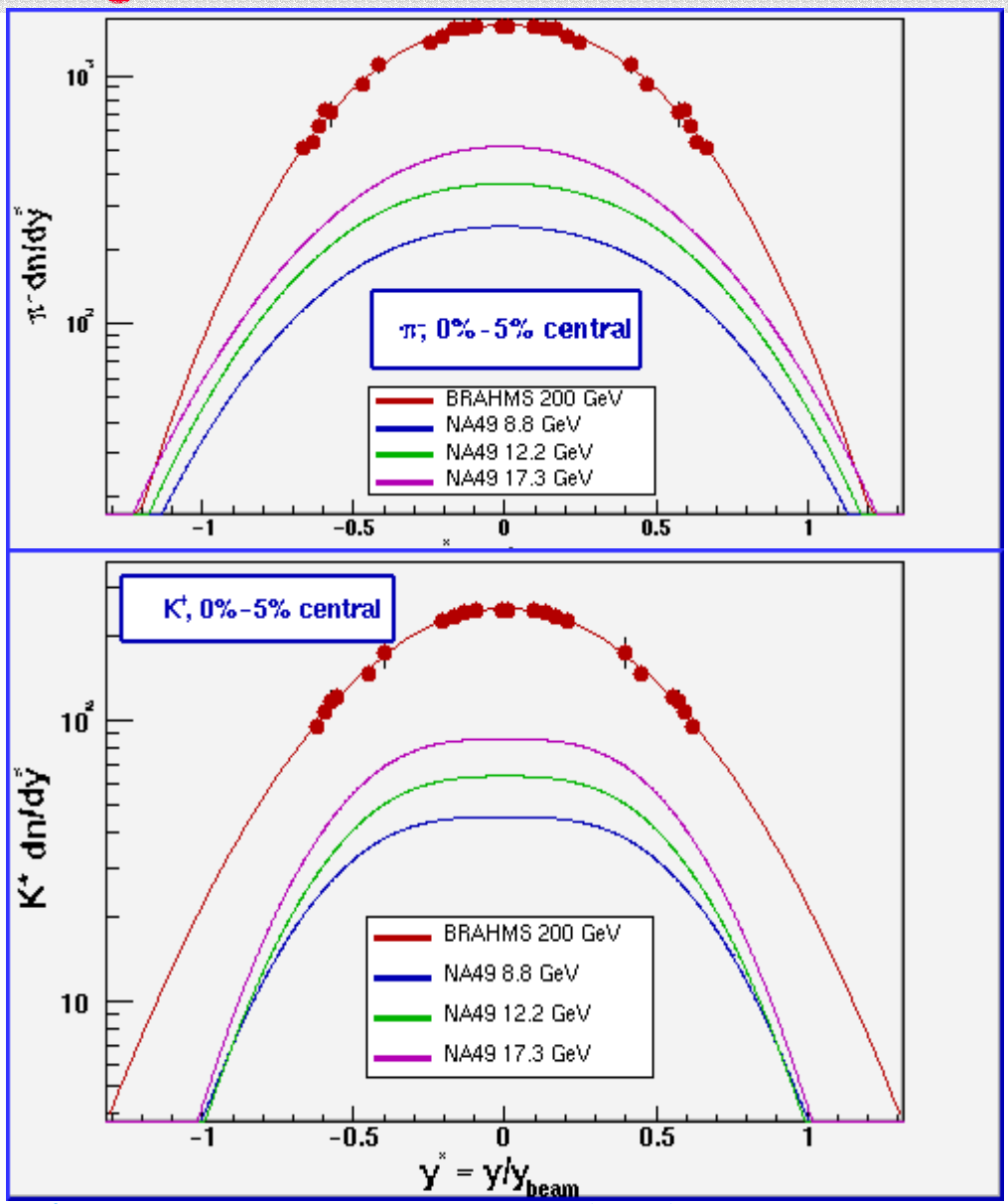


π+

K+

Rapidity density changes differently for π+ and K+ from SPS to RHIC

Rapidity scaling SPS : RHIC?



SPS->RHIC: dN/dy for π+ gets narrower, K+ similar or wider

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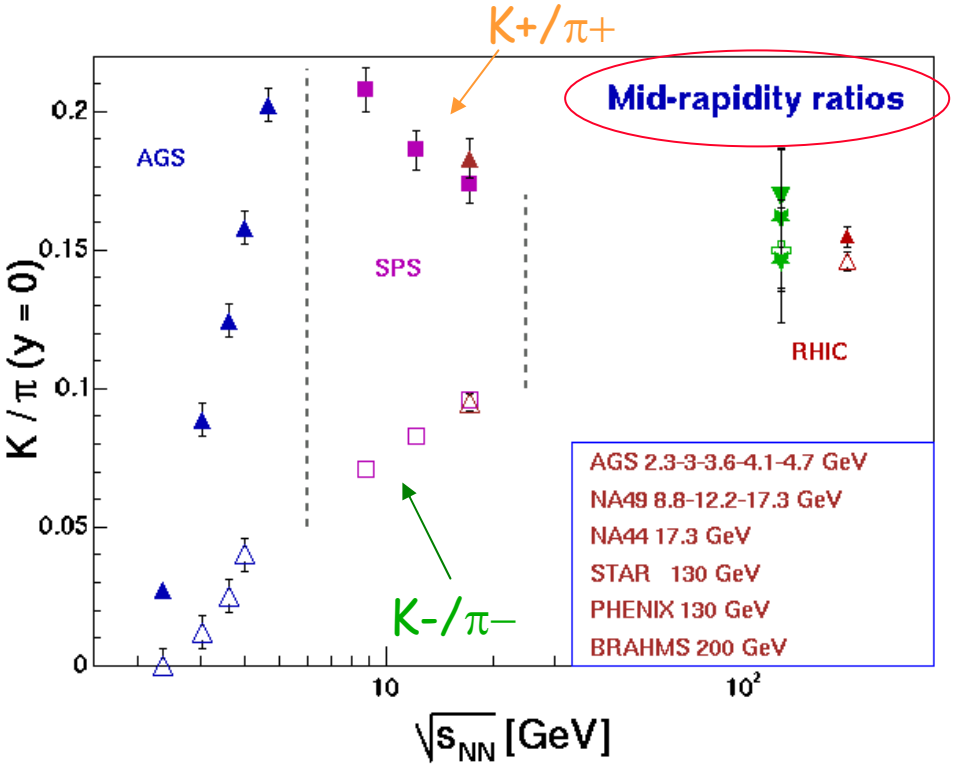
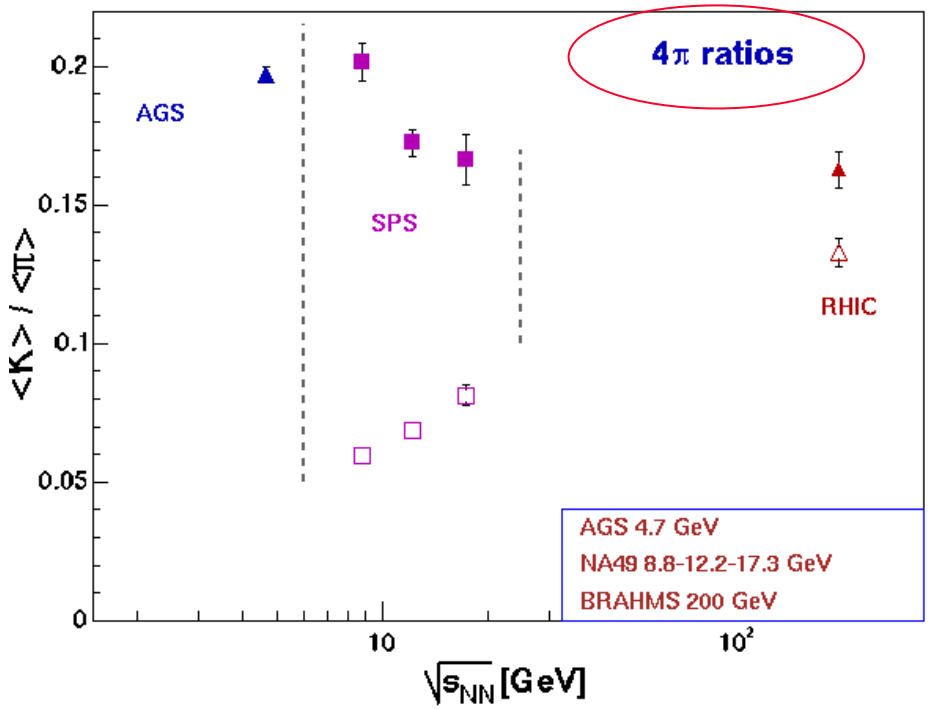
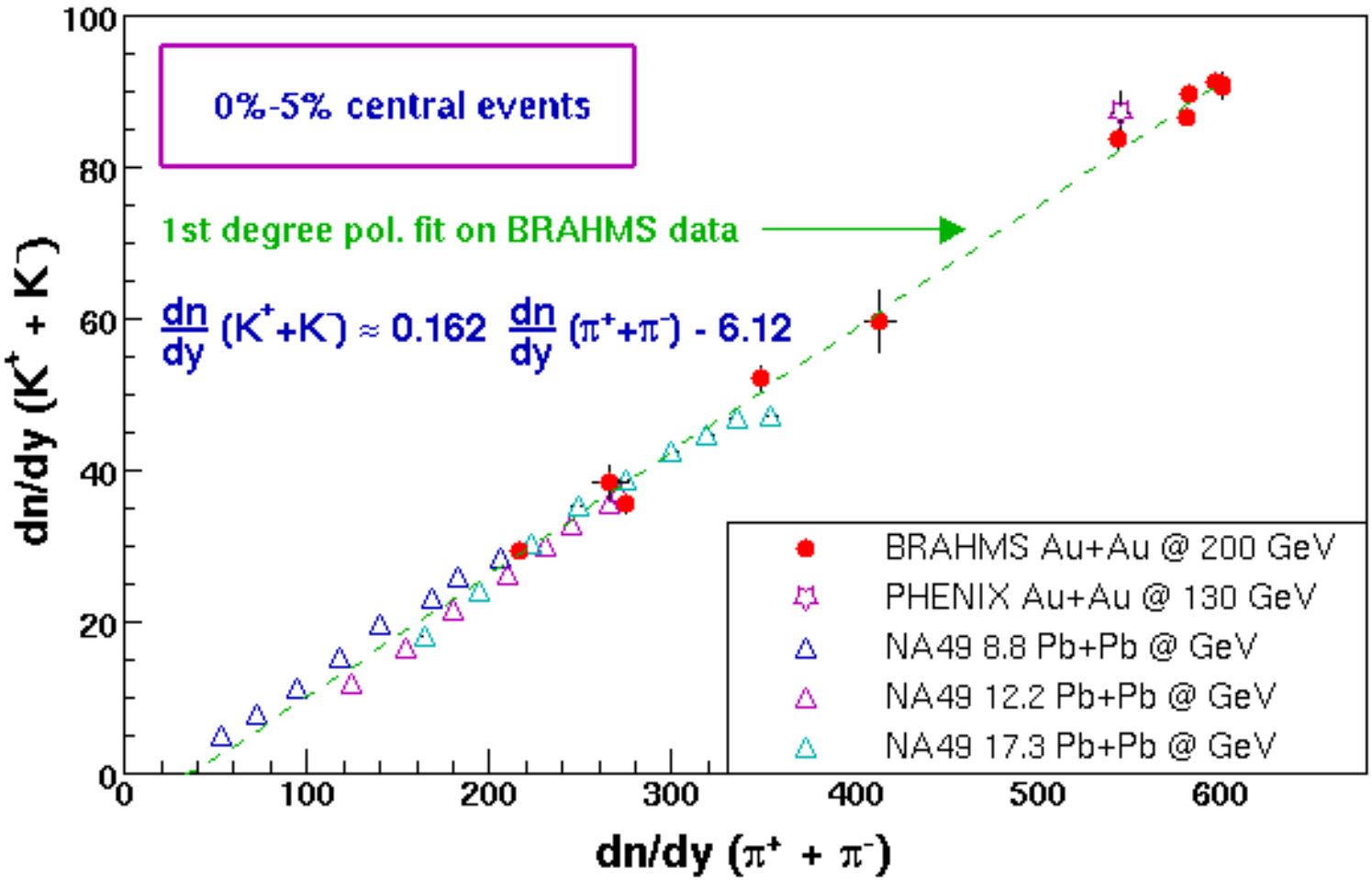
Strangeness : K/π systematics





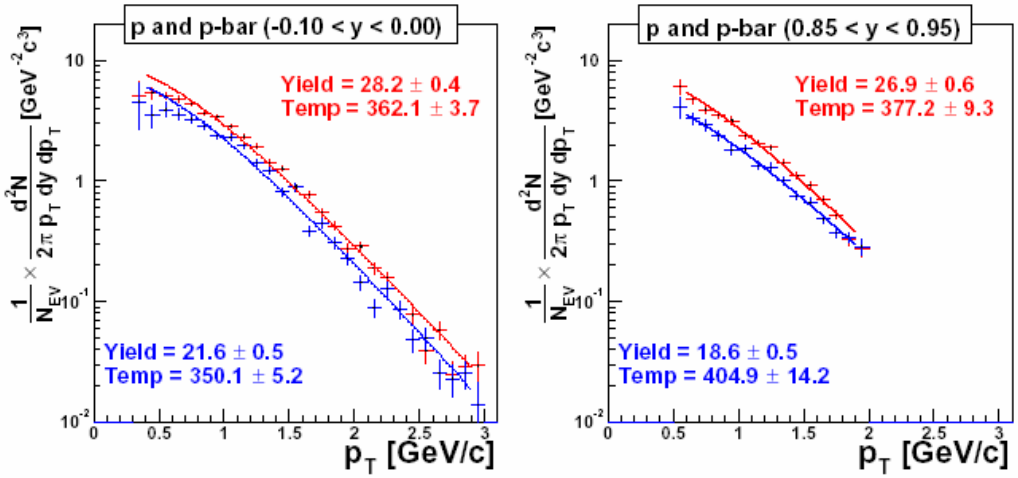
- K^+/π^+ ratio flattens at RHIC energy at y=0 and for integrated yield
- K^+/π^+ at y~3: similar to SPS (Pb+Pb Central at 17 GeV)
- K^-/π^- increases with energy

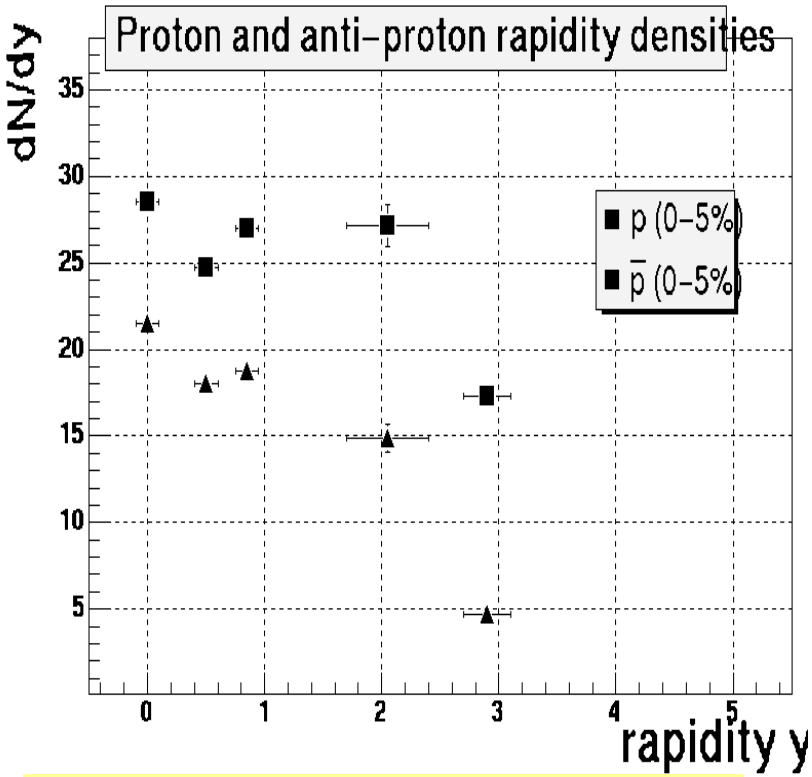
Scaling in ($K^+ + K^-$): ($\pi^+ + \pi^-$)?

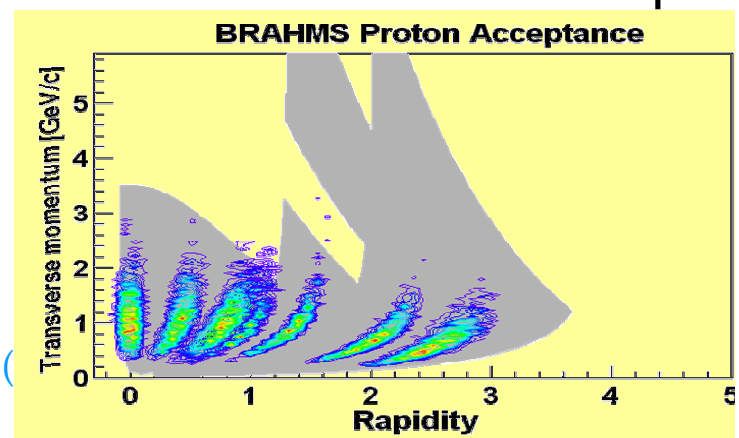


Linear Scaling between dN/dy($K^+ + K^-$):dN/dy($\pi^+ + \pi^-$) ?

p,pbar Spectra at 0-5% Central at y=0 - 3



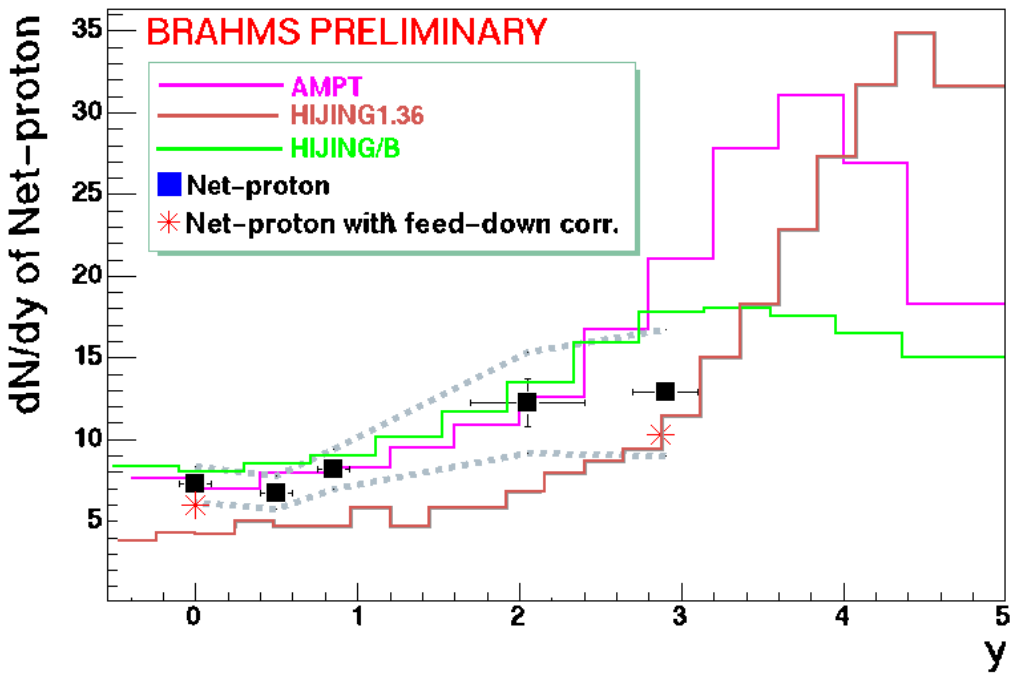




P. Christiansen (NBI) Thesis

J.H. Lee (

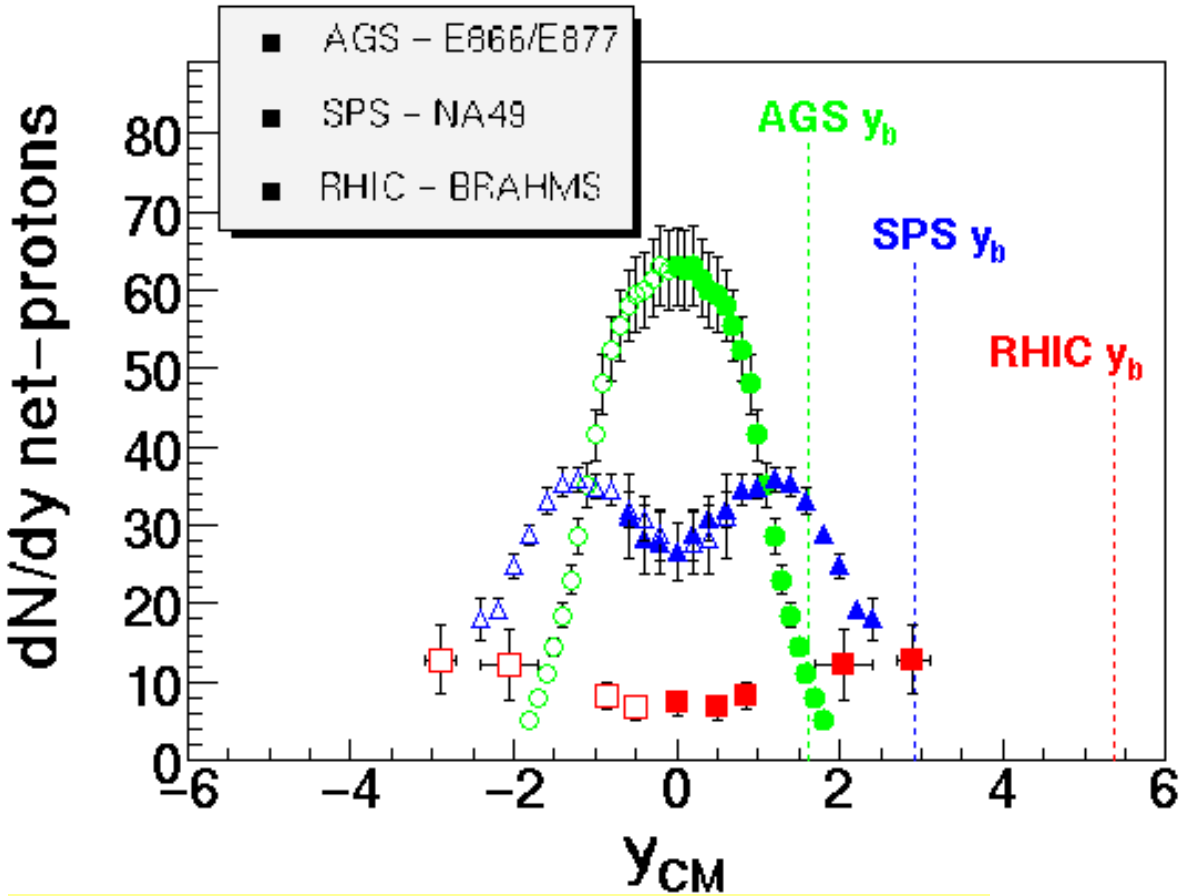
dN/dy of Net-proton and Models for 0-10% central



- "Plateau" at $|y| < \pm 1$ the yields by 18, 20% at y=0,2.9
- Net-baryon at y =0: ~16 (if N(proton)/N(neutron) ≈ 1

  N(net-Λ)=0.9N(net-proton))
- Hyperon feed down correction decrease yields 16-20%
- A range of models is still allowed with these data.

Energy dependent Net-proton



- AGS->RHIC : Stopping -> Transparency
- Net proton peak > y ~ 2

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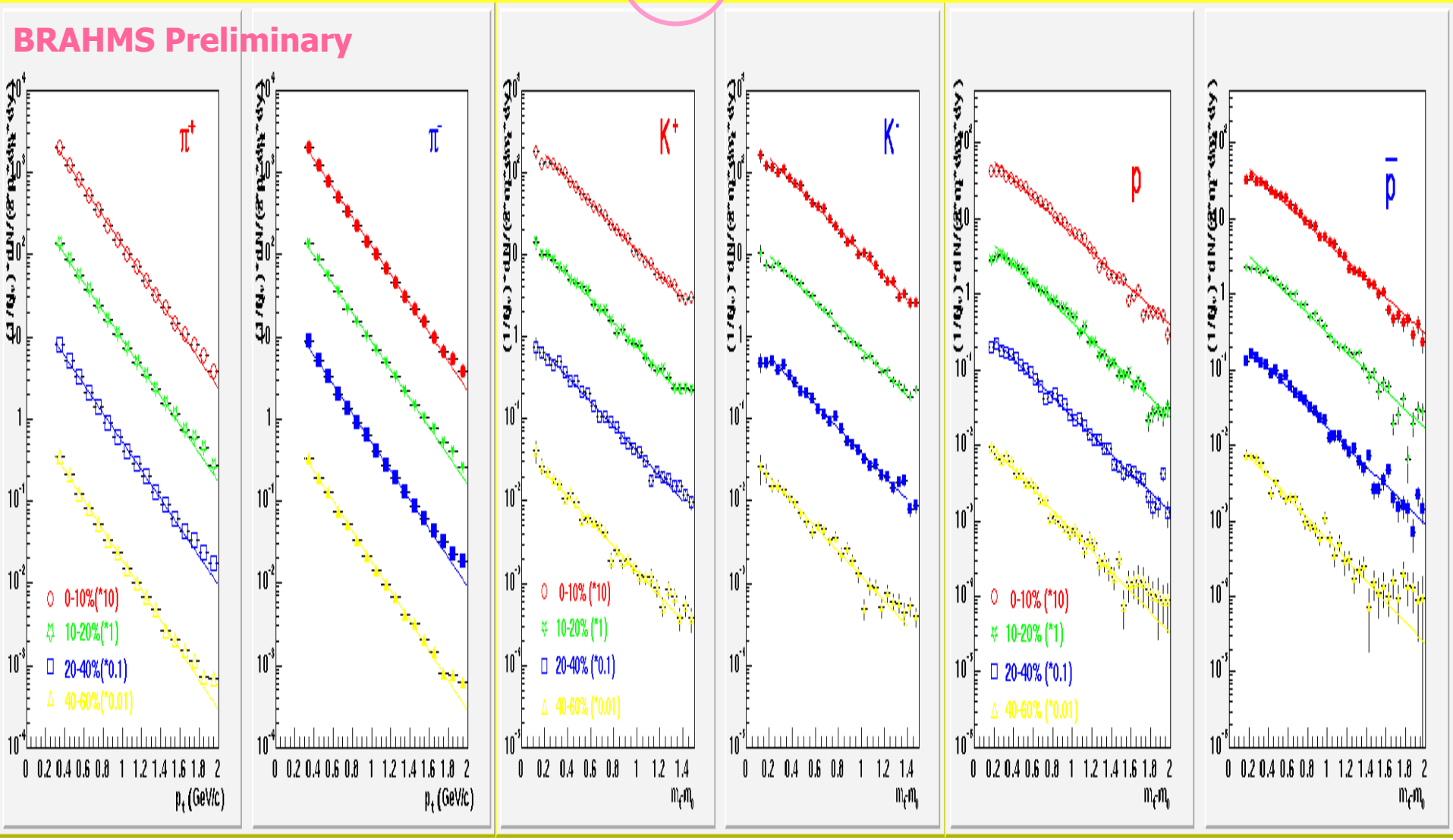
Spectra vs Centrality at y=0 $\sqrt{s_{NN}}$ =200 GeV



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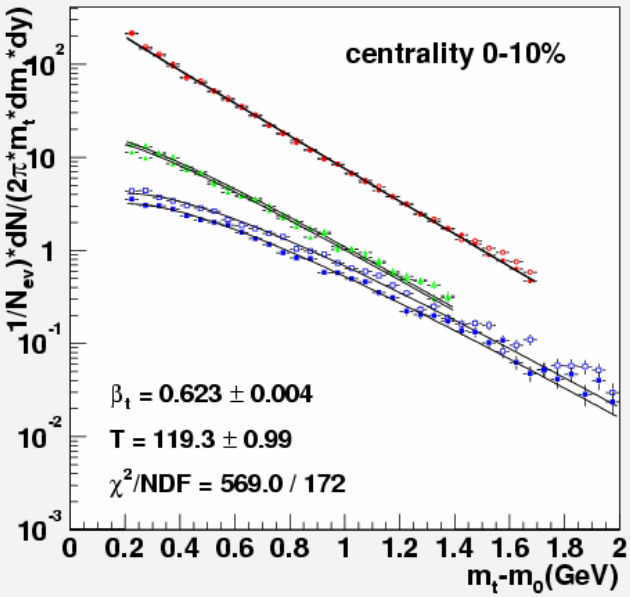
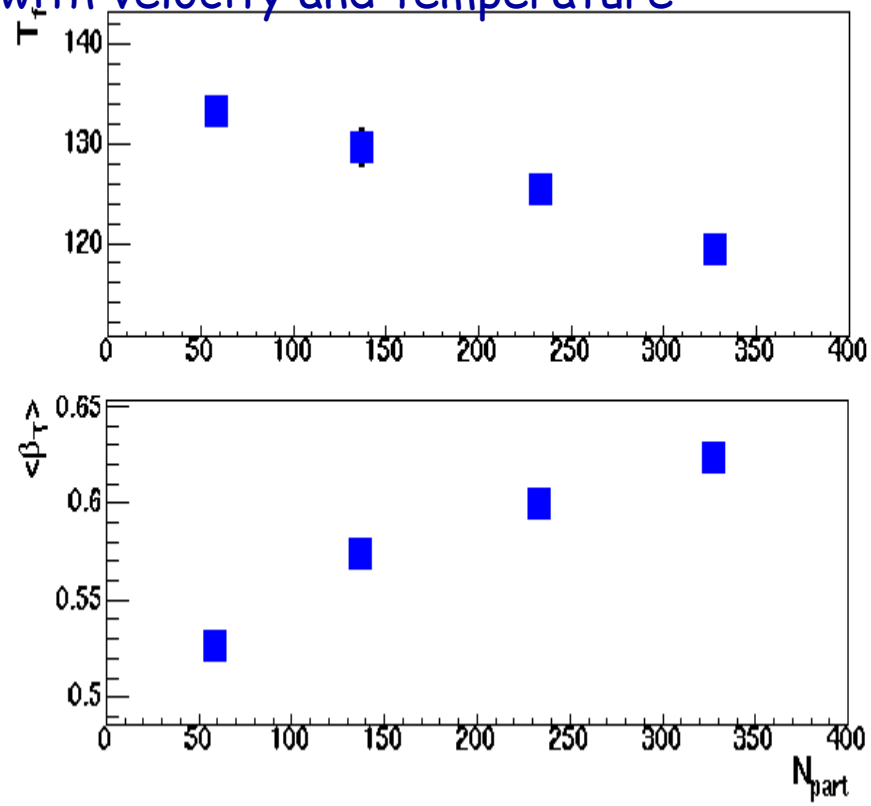
Thermal Freeze-out Parameters from Hydrodynamic Fit

Assuming local thermal equilibrated source or boosted system

Fit all particles simultaneously with velocity and temperature

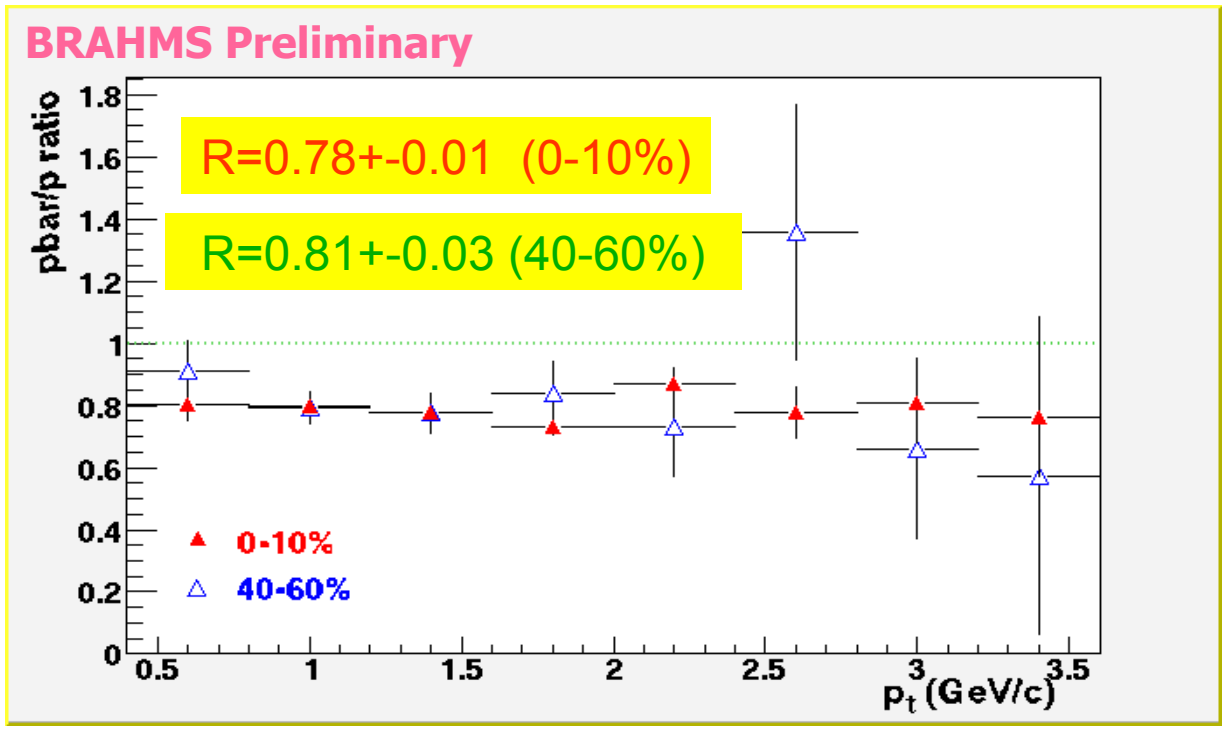




Ref. : E.Schnedermann et al, PRC48 (1993) 2462

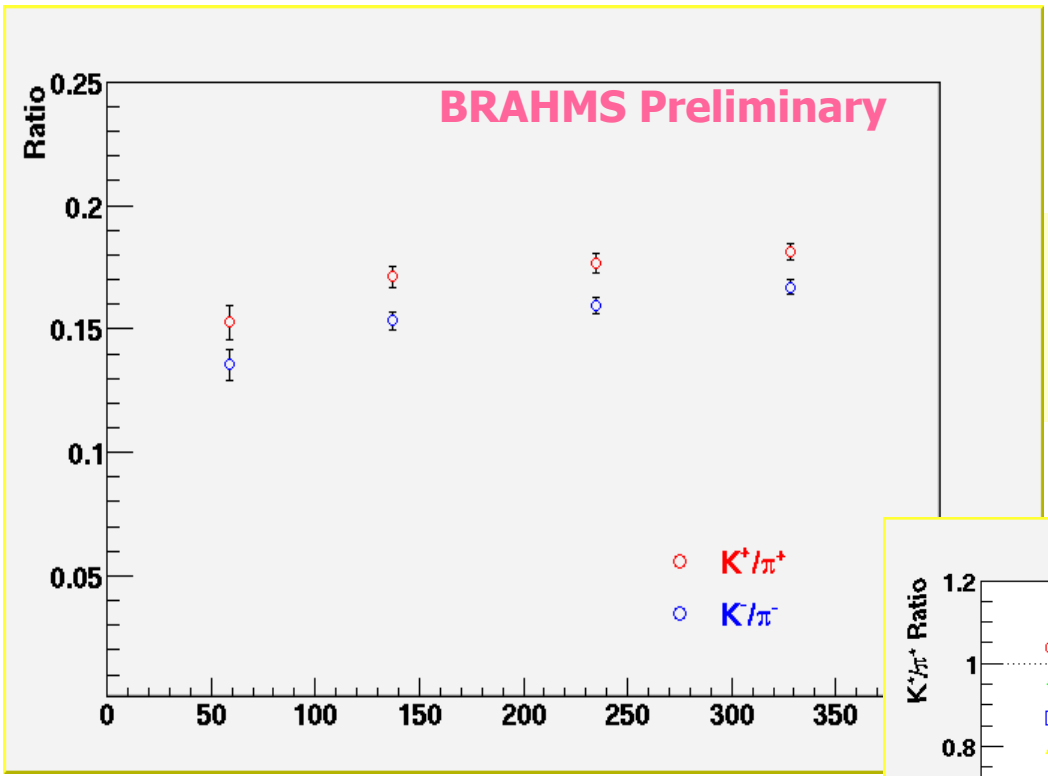
- Spectra are described by T_{FO} and $<\beta_T>$:
  - $<\beta_T>$ ~ 0.62 – 0.53, T_{FO} ~ 119 – 133 from 0-10% to 40-60% central
  - $<\beta_T>$ Increase at RHIC, T_{FO}~ AGS ~SPS?

p_T and centrality dependent pbar/p ratios at y=0

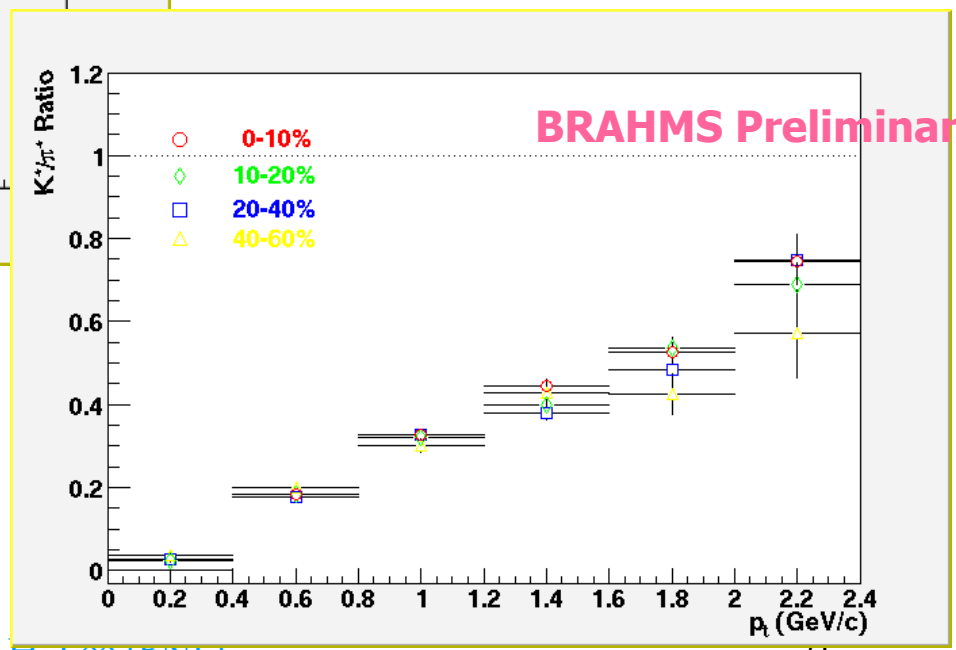


- The ratio for central events (0-10%) are almost flat over 0.5<pt<3.5GeV/c.
- R(central)~R(peripheral)

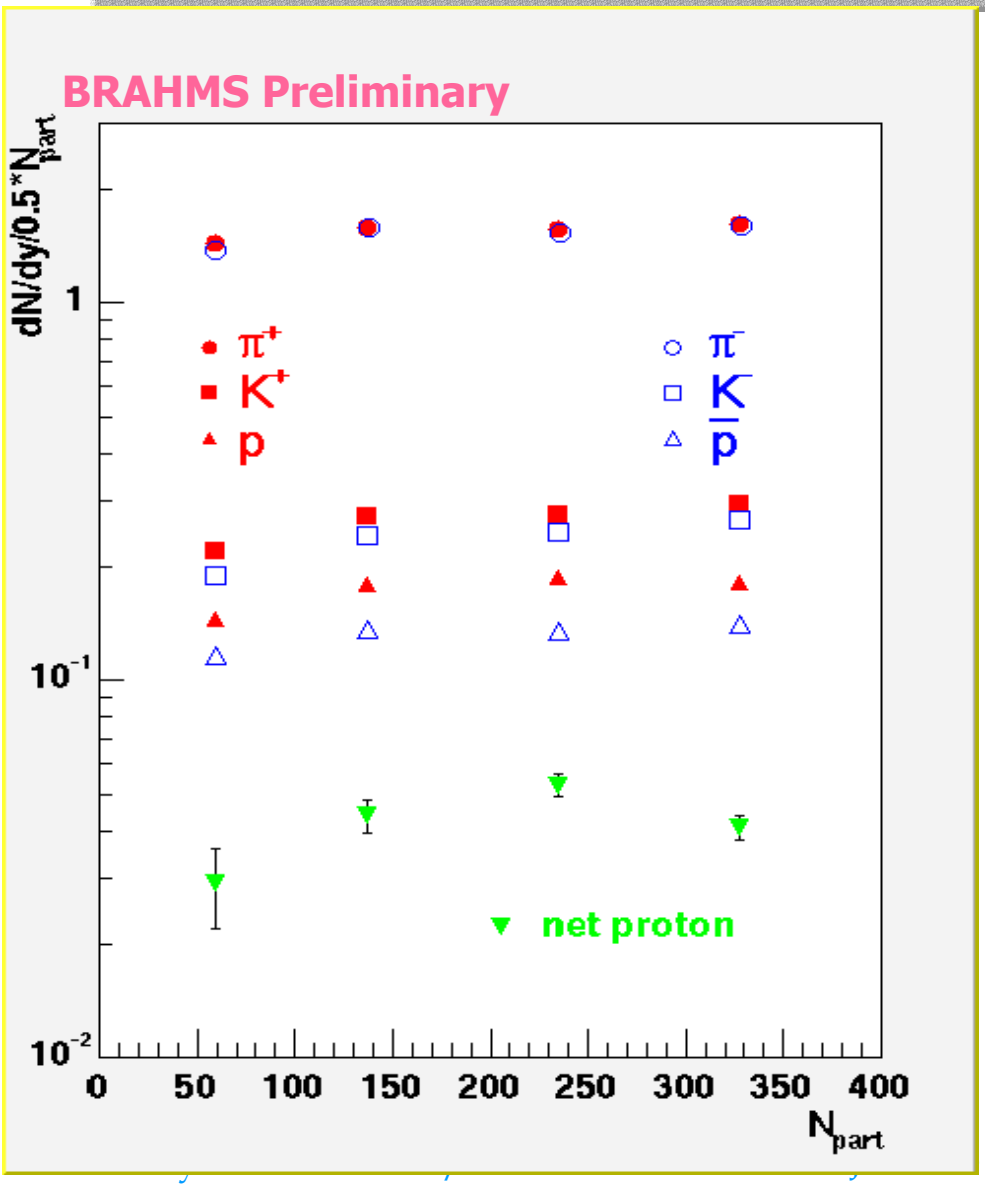
K/π ratios at y = 0 $\sqrt{s_{NN}}$ =200 GeV



K/π ratios increase with p_T and centrality at y=0

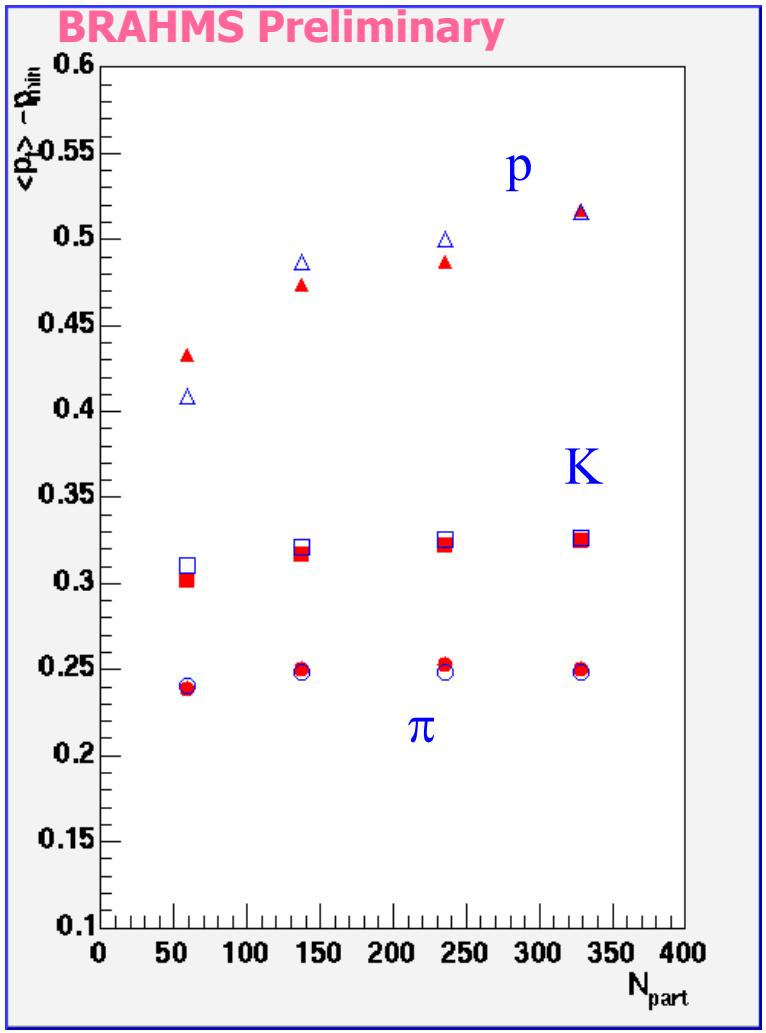


dN/dy per participant at y=0 $\sqrt{s_{NN}}$ =200 GeV



- For all the particle species, the yield per participant increase with N_{part}.
- $K^{\pm}$, p, pbar yields per participant rise faster than $\pi^{\pm}$ yield.
- Errors statistical only on plot.
- Systematic error ~10-20%
- Dominant syst. error from Npart determination, and extrapolation of yields.

<pt> vs N_{part} at y=0



- $\langle p_T \rangle - p_T^{min}$
- 0.4-2.4 for pion
- 0.6-2.2 for kaon
- 0.5-3.4 for p/pbar
- <pt> increase with $\langle N_{part} \rangle$ and mass: p and pbar increase fast with $\langle N_{part} \rangle$: consistent with radial expansion picture

Summary (Au+Au at $\sqrt{S_{NN}}$=200 GeV)

Rapidity Dependence (y =0 – 3.5) in Central Collisions

- K^-/K^+, pbar/p: approximately constant over ±1 unit of rapidity and fall off with y
- "Universal" correlations?: $K^-/K^+ \sim (pbar/p)^{1/4}$
  $dN/dy(K^+ + K^-)/dN/dy(\pi^+ + \pi^-) \sim const$
- dN/dy for π and K: ~Gaussian distribution $\sigma(\pi+) \sim \sigma(K+)$
- <pt> and Inverse slope decreases with rapidity (10-15% from y=0 to 3)
- near flat net-proton yield in y < ~ +-1 (dN/dy(net-baryon) ~16 at y=0)
  Increasing transparency with energy

Centrality Dependence at y=0

- Yields per participant increase with N_{part}. (K,p rise faster than π)
- <pt> increase with $\langle N_{part} \rangle$ and mass: consistent with radial expansion picture: Spectra are described by Hydro-fit

Rapidity dependent ups and downs for central Au+Au at $\sqrt{S_{NN}}$=200 GeV

From y ~ 0 to y ~ 3.5

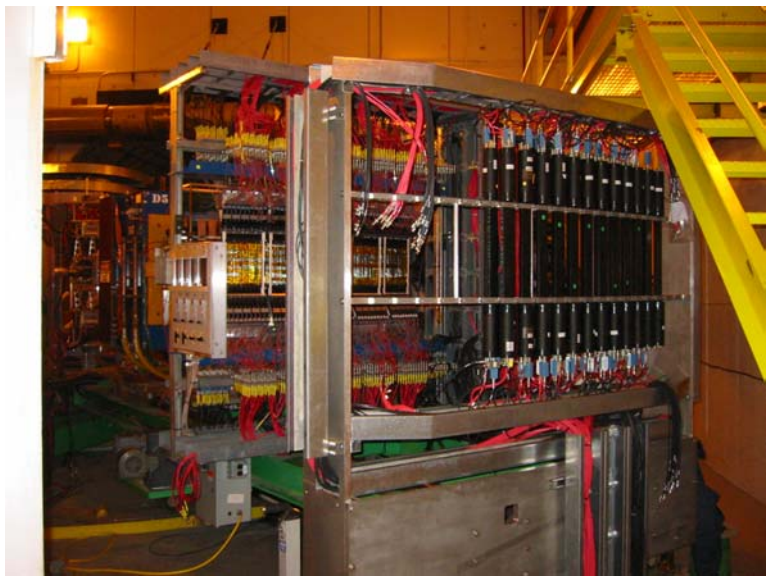
- **Decrease**
  - -dN/dy for all particles
  - - <pt> and inverse slope for π and K
  - - K^-/K^+
  - - K^-/π^-
  - - pbar/p
- **Increase**
  - - Net-proton yields
  - - Chemical potential
- **Flat**
  - - π^-/π^+
  - - K^+/π^+

More exciting measurements will come

Next Au+Au run (Run4?) with high luminosity will give

- Rapidity dependence as function of centrality
- More compelete description on stopping (net-proton)
- Rapidity dependent High-pt physics
- Rapidity dependent HBT (at selected rapidities)
- Reaction plane and rapidity dependent identified hadron yields (in discussion)

Extended PID for High pt measurements at y=0 – 1



- New Cherenkov detector C4 + TOFW2 at Mid-Rapidity Spectrometer
- Currently taking data (d+Au,p+p)
- π/K identification up to p = 8 GeV/c
- "high-pt" pion measurement up to 5 GeV at y ~ 0 (luminosity limited)

Run3 (d+Au, polarized p+p)

- **d+Au run:**
  - ~30M MRS 28M FS spectrometer triggers taken
  - reference measurements for Au+Au (y ~ 0-3)
    and small-x (y~3) physics

  Identified charged particle at y~0,1 (pt up to 5-6 GeV/c)
  at y~2,3 (pt up to 3-4 GeV/c)

- **Polarized p+p run:**
  - Data taking in progress
  - 4.5M MRS 3.5 FS spectrometer triggers taken
  - reference measurements for Au+Au (y ~ 0-3)

  and transverse asymmetry measurements (at y ~3 pt < 2.5/c)
  for one charge at current machine performance

The BRAHMS Collaboration

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BRAHMS Publications

- "Rapidity dependence of anti-proton to proton ratios in Au+Au collisions at $\sqrt{s_{nn}}$ =130 GeV"

  Phys. Rev. Lett. 87 (2001) 112305
- "Charged particle densities from Au+Au Collisions at $\sqrt{s_{nn}}$ =130 GeV"

  Phys. Lett. B 523 (2001) 227
- "Pseudorapidity distributions of charged particles from Au+Au collisions at the maximum RHIC energy"

  Phys. Rev. Lett. 88 (2002) 202301
- "Rapidity dependence of anti-particle-to-particle ratios in Au+Au collisions at $\sqrt{s_{nn}}$ =200 GeV"

  Phys. Rev. Lett. (Mar. 2003) : **nucl-ex/0207006**

- More information in http://www.rhic.bnl.gov/brahms