Identified Charged Single Particle Spectra at RHIC-PHENIX

Tatsuya Chujo (BNL)
for the PHENIX Collaboration

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Physics of Identified Hadron Spectrum

From identified single particle spectra,

- **Hydro-dynamical collective expansion velocity (β).**
- **Thermal freeze-out temperature (T_{th}).**

→ **Inverse slope**

- **Chemical freeze-out temperature and chemical potential (T_{ch}, μ_B, μ_s)**

→ **dN/dy**

- **Jet quenching effect at high p_T by parton energy loss in medium (dE/dx).**

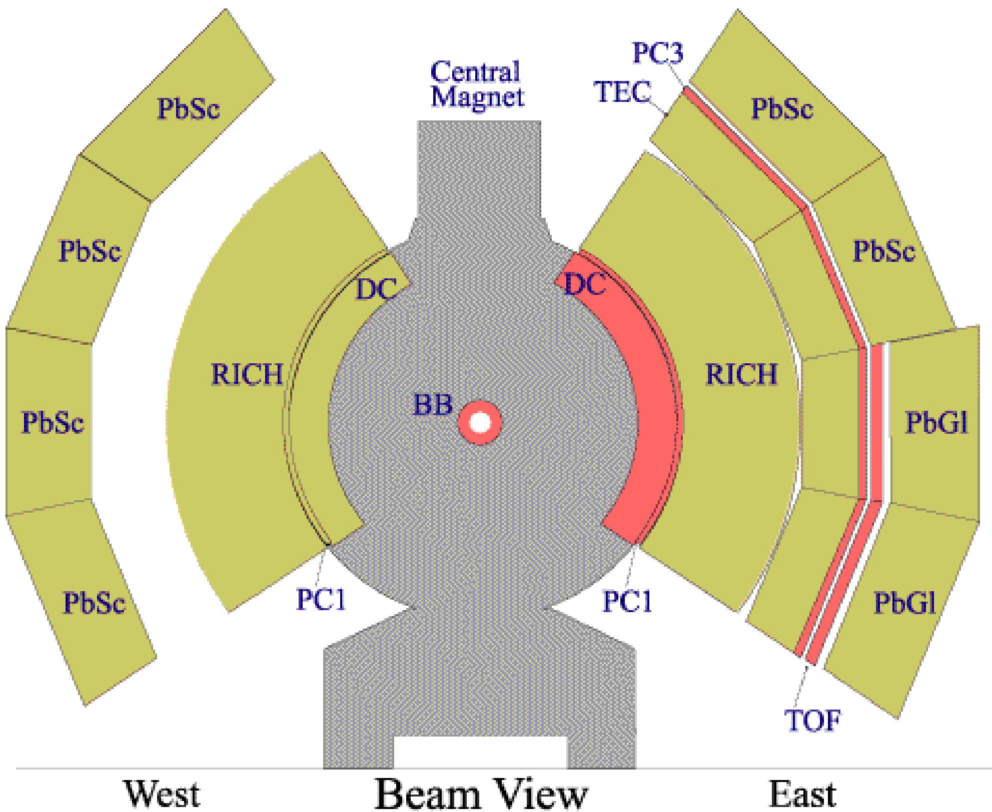
→ **High p_T spectra**

↓

Shed light on QGP formation at RHIC

In this talk, we present identified (charged) single particle spectra as a function of centrality, measured at RHIC-PHENIX.

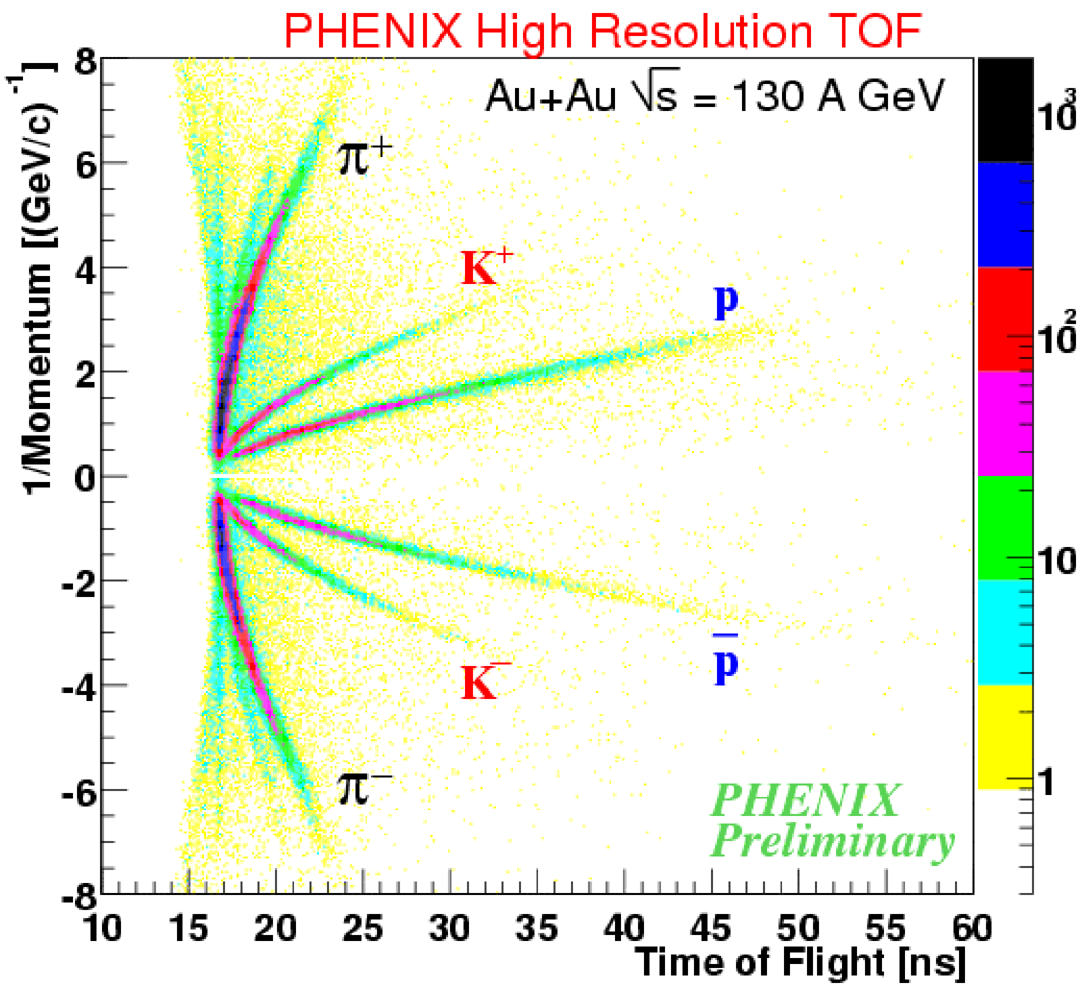
PHENIX Detector Setup



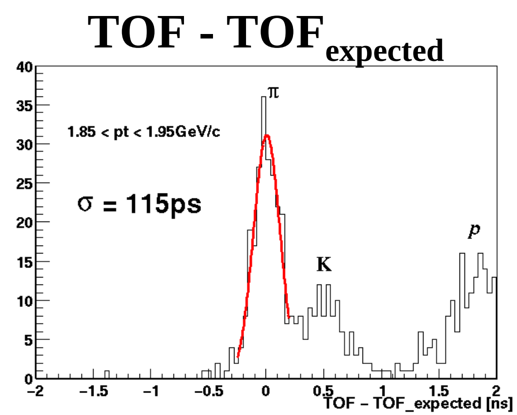
In this analysis, we use

- **Beam-Beam Counter (BBC)**
  z-vertex, start timing for TOF
- **Time-of-Flight (TOF)**
  stop timing measurement
- **Drift Chamber (Dch)**
  momentum, flight path length
- **Pad Chamber 1 (PC1)**
  additional track z-information to Dch

Particle Identification by TOF

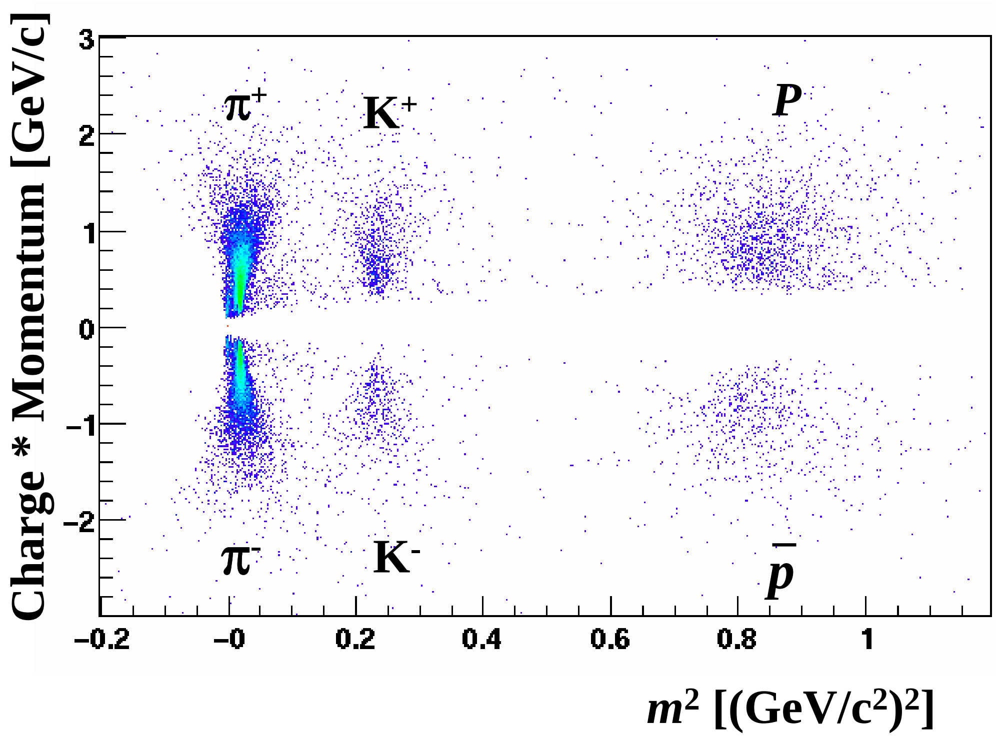


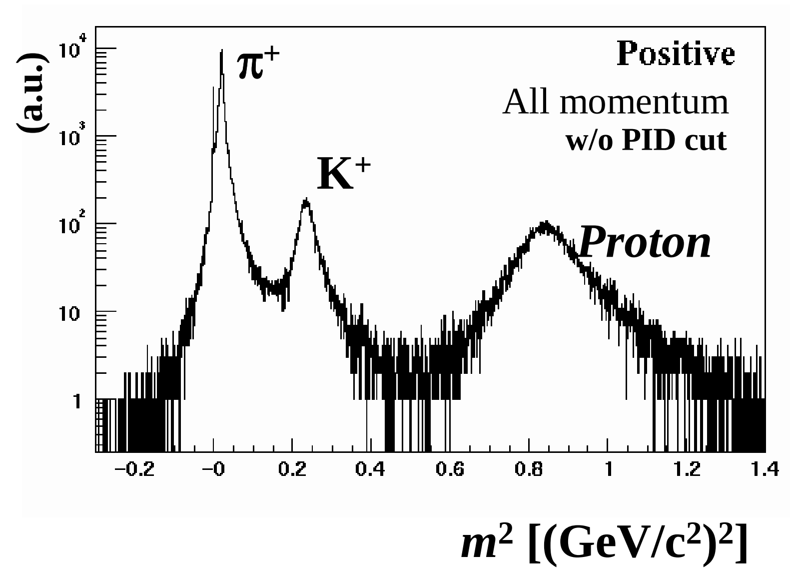
- **Demonstrated Clear PID by TOF**
- **Time-of-Flight resolution σ_{TOF} ~ 110-120 ps**



* Fitted π^+ region

PID Cut Criteria

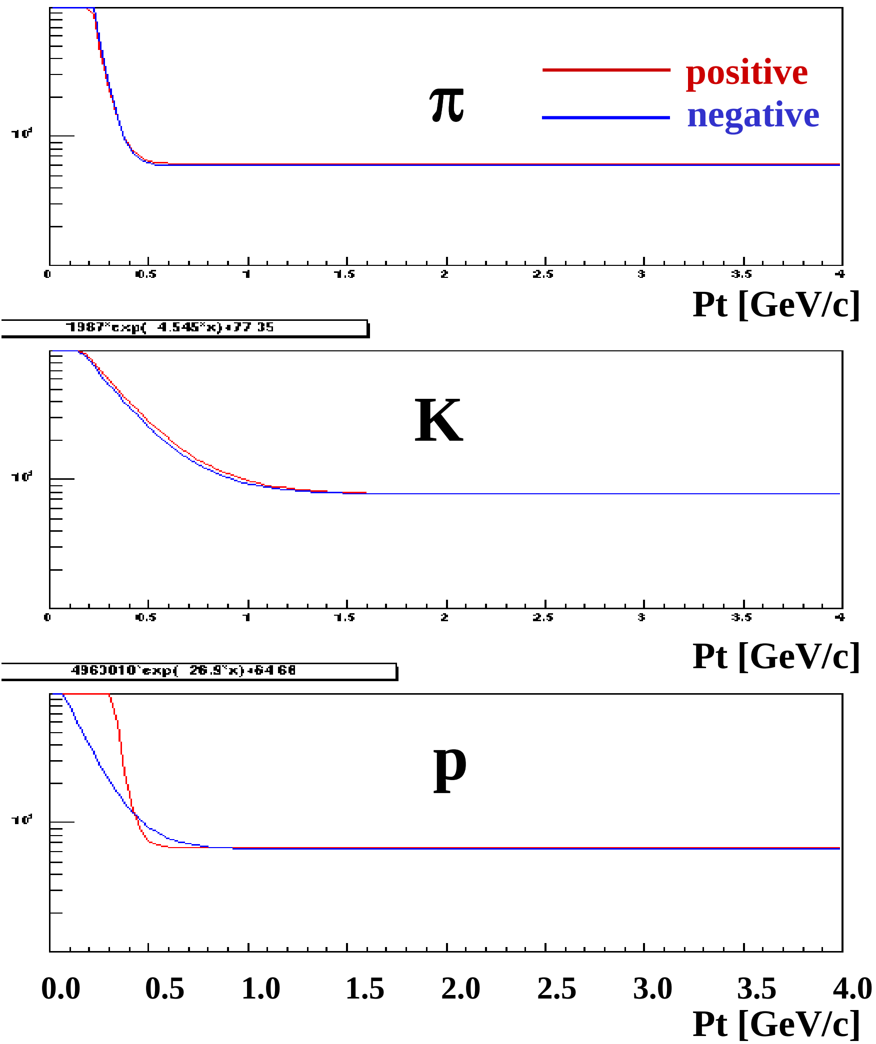




- PID by m^2 vs. momentum space
- $|m^2_{\mathrm{measured}} - m^2_0| < 2.5\sigma_m^2$
- Momentum cutoff →

- **π : 0.1 < *p* < 2.0 GeV/*c***
- **K : 0.2 < *p* < 2.0 GeV/*c***
- **p/pbar : 0.2 < *p* < 4.0 GeV/*c***

Correction factor for raw spectra

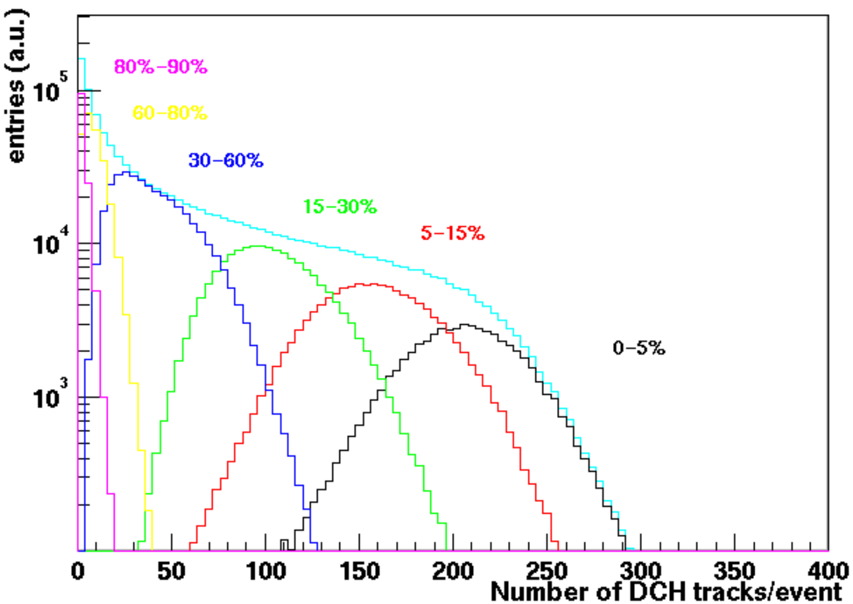


- **Based on single particle Monte Carlo simulation.**
- **Included overall effects**
  1. Tracking efficiency
  2. Geometrical acceptance
  3. Multiple scattering
  4. Decay in flight
  5. Hadronic int.
  6. Dead area of detectors
- **Confirmed that the multiplicity dep. is small by track embedding method in real data.**

Centrality Classes

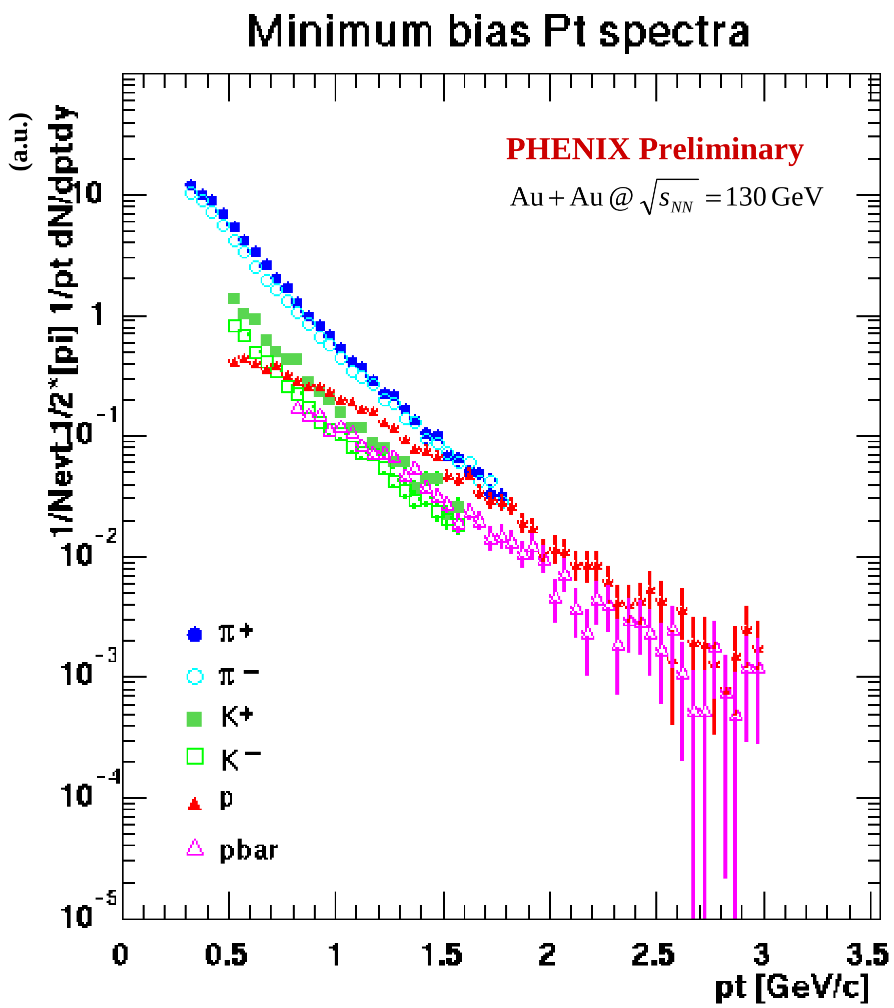
• Used correlation between BBC charge and ZDC energy to define centrality.
• Extracted N_{part} based on Glauber model

Dch raw multiplicity distributions



Centrality	Participants
0-5%	$347 \pm 15\%$
5-15%	$271 \pm 15\%$
15-30%	$178 \pm 15\%$
30-60%	$76 \pm 15\%$
60-80%	$19 \pm 60\%$
80-92%	$5 \pm 60\%$

Results : Minimum bias p_T spectra

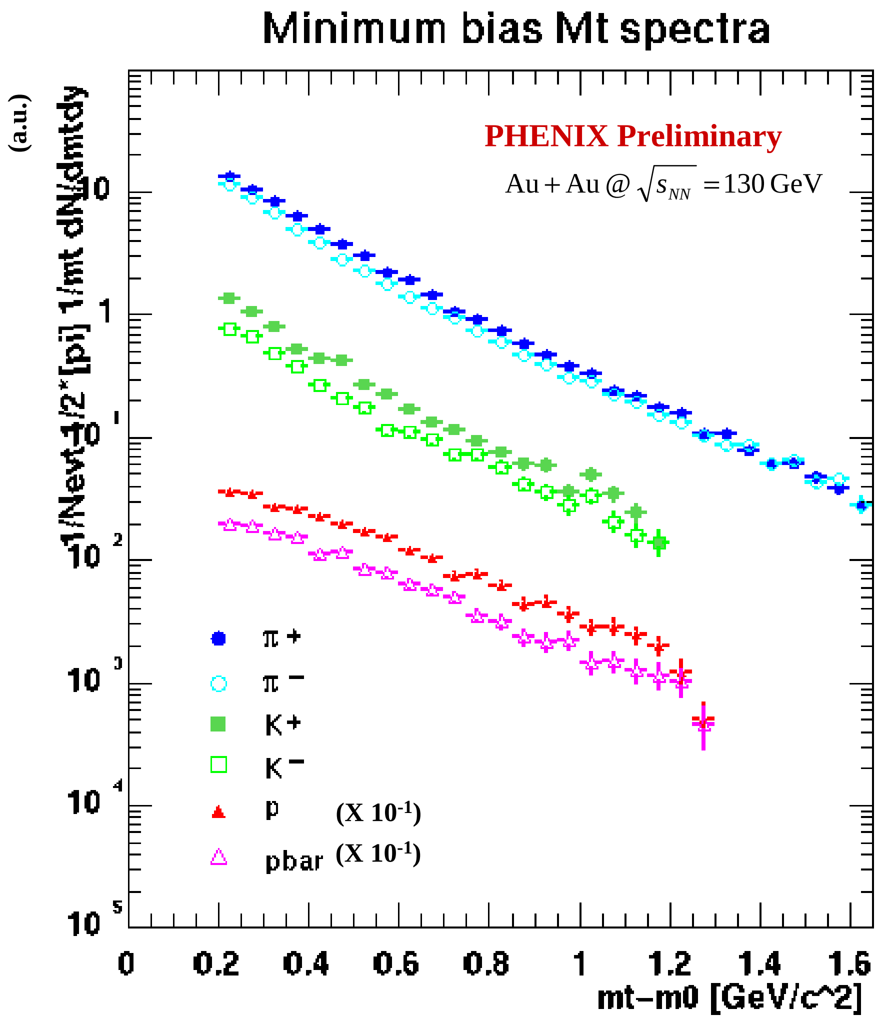


particle	p_T range
π	0.3 - 1.8 GeV/c
K	0.5 - 1.6 GeV/c
proton	0.5 - 3.0 GeV/c
pbar	0.8 - 3.0 GeV/c

- **pions yield ~ proton and pbar yield @ p_T~ 2 GeV/c**

→ Large proton and anti-proton contributions at high p_T.

Minimum bias M_T spectra



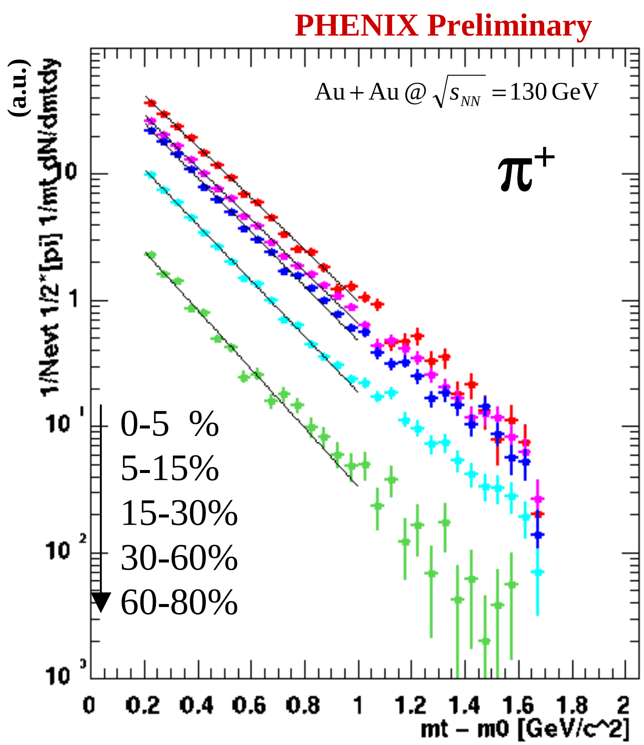
- In $0.2 < m_t - m_0 < 1.2$ [GeV/c^2], spectra for all species scale by single exp. function.
- Similar inverse slope for π and K.
- $T_{proton} > T_{\pi}$

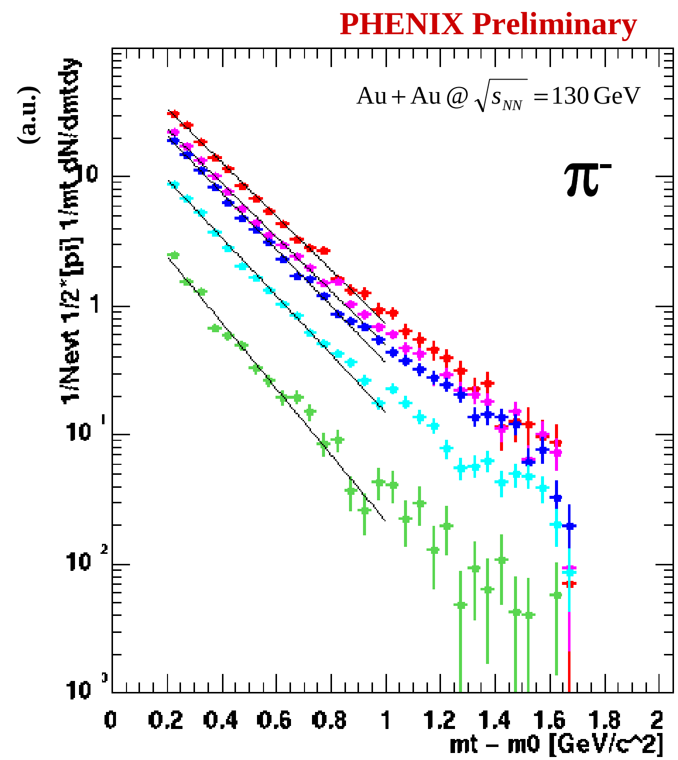
☆Fitting results by single exp. function

$$\frac{1}{m_T}\frac{dN}{dm_T} \propto A\exp\left(-\frac{m_T - m_0}{T}\right)$$

$\pi^{\pm}$	~ 205±5 (stat.) ±15 (sys.)	MeV
$K^{\pm}$	~ 215±5 (stat.) ±20 (sys.)	MeV
p, $\overline{p}$	~ 320±10 (stat.) ±20 (sys.)	MeV

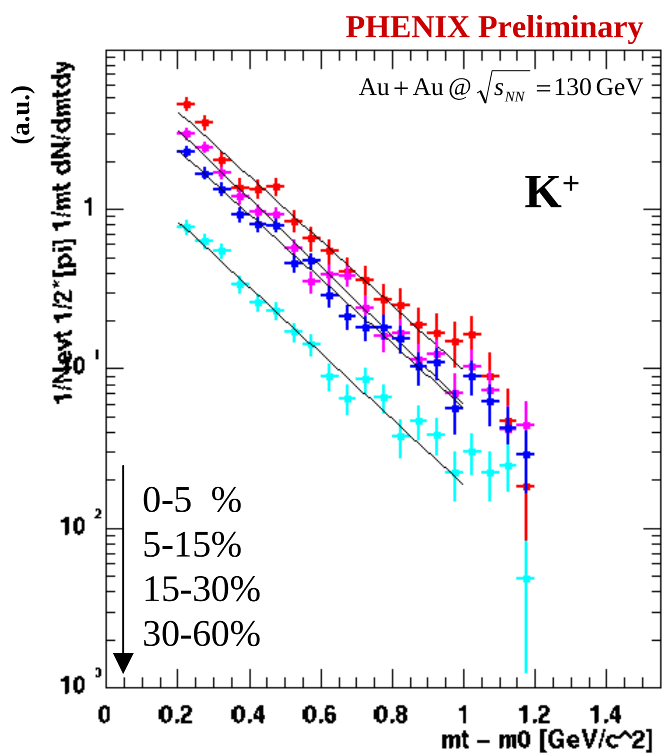
Centrality Dependence of M_T Spectra for pions

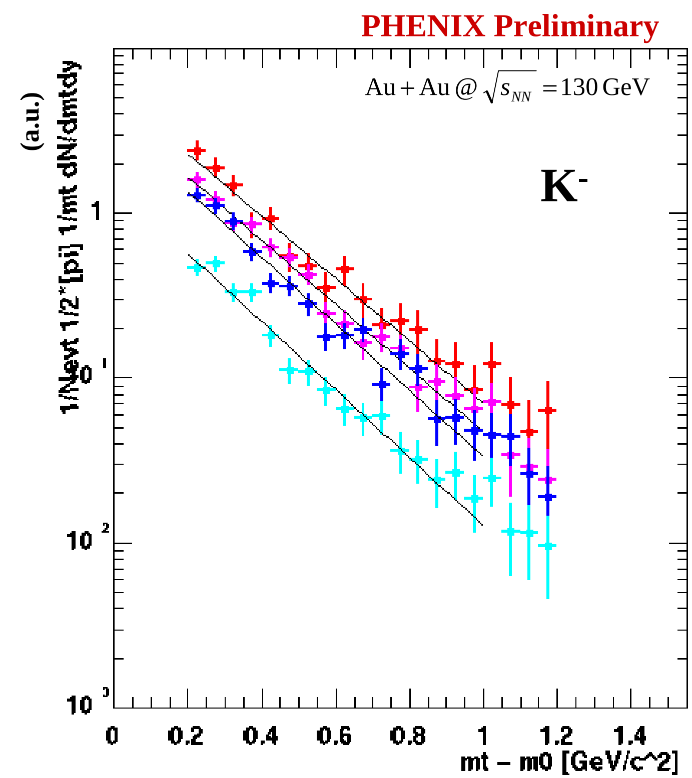




- Single exponential scaling at 0.2 -1.0 GeV in m_t-m_0.
- Almost parallel among all centrality classes.
- T_π (central 0-5%) ~ 210 MeV ±5 (stat.) ±15 (sys.) MeV

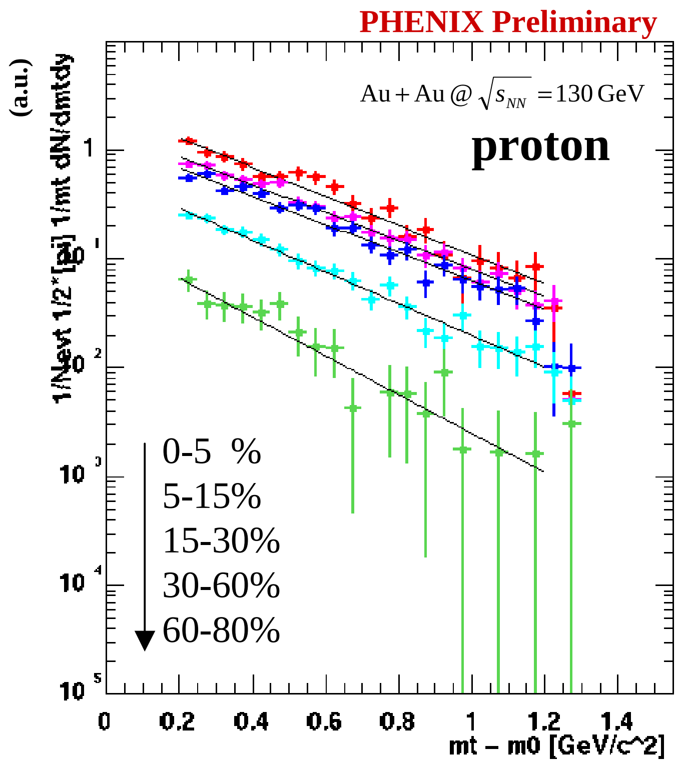
Centrality Dependence of M_T Spectra for kaons

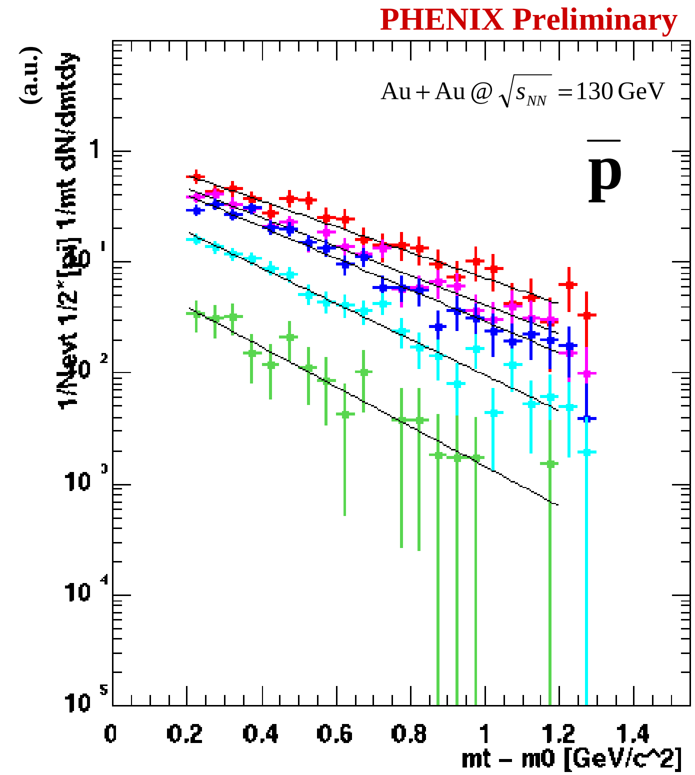




- Single exponential scaling at 0.2 -1.0 GeV in m_t-m_0.
- Parallel slope among all centrality classes.
- T_K (central 0-5%) ~ 217 MeV ±5 (stat.) ±20 (sys.) MeV.
  $\cong T_\pi$

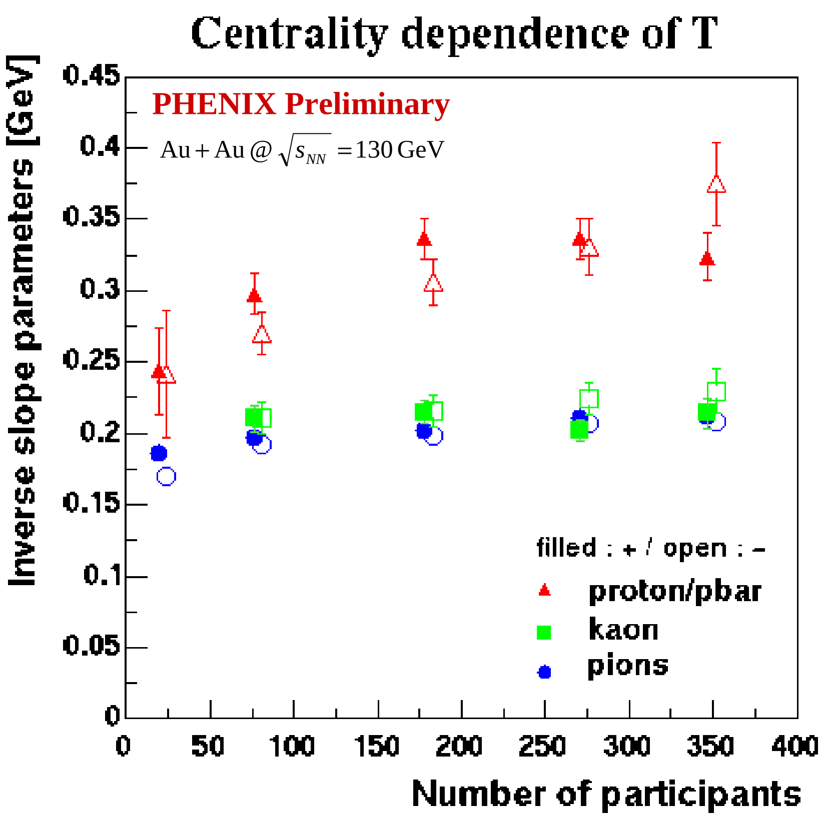
Centrality Dependence of M_T Spectra for p/pbar





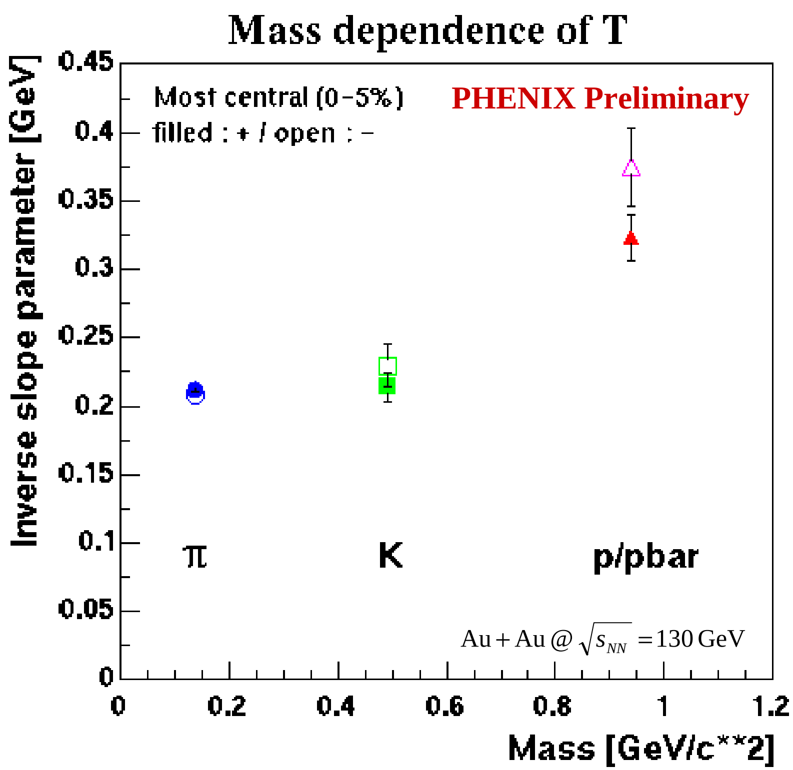
- Single exponential scaling at 0.2 -1.2 GeV in m_t-m_0.
- Gradual increase from centrality 60-80% to 30-60%.
- T_{proton} (central 0-5%) ~ 325 MeV ±17 (stat.) ±20 (sys.) MeV > T_π.

Centrality dependence of T



- Weak centrality dependence for T_π and T_K.
- Gradual rise of T_{proton} and T_{pbar} from peripheral to mid-central collisions.
- $T_\pi \cong T_K < T_{proton}$

Mass Dependence of *T*

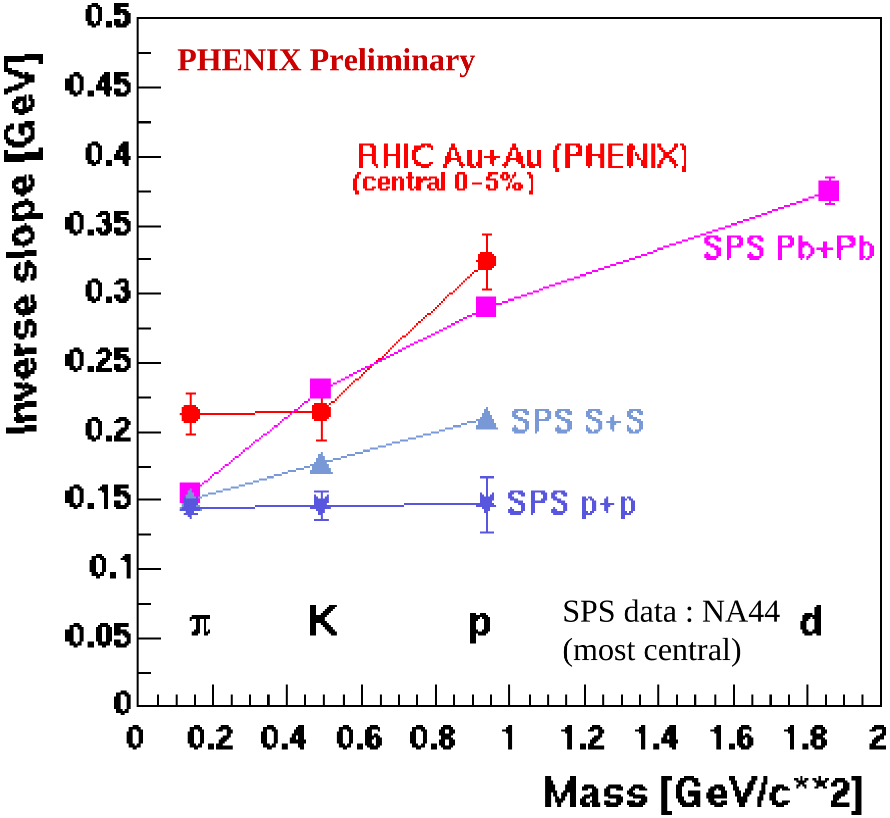


★Intuitive explanation of mass dependence of *T*

$$T \propto T_{\text{theremal}} + m \cdot < \beta_t >^2$$

β_t : Transverse expansion velocity

Comparison with CERN Energy



- The slopes of pions and protons at RHIC are higher than that of Pb+Pb collisions at SPS.
- Kaon’s slope is almost same at SPS Pb+Pb.

Conclusions

- Single particle spectra for $\pi^{\pm}$, $K^{\pm}$, protons and anti-protons in each centrality class are studied.
- In p_T spectra, a large proton and anti-proton contributions at high $p_{T.}$
- Weak centrality dependence of slopes for T_{π} and T_K.
- Gradual rise of T_{proton} and T_{pbar} from peripheral to mid-central collisions.
- $T_{\pi} \cong T_K < T_{proton}$ at all centrality classes.
- The slope of pions and protons at RHIC are higher than that of Pb+Pb collisions at SPS.
- Kaon’s slope at RHIC is almost same at SPS Pb+Pb.