Charged Hadron Ratios

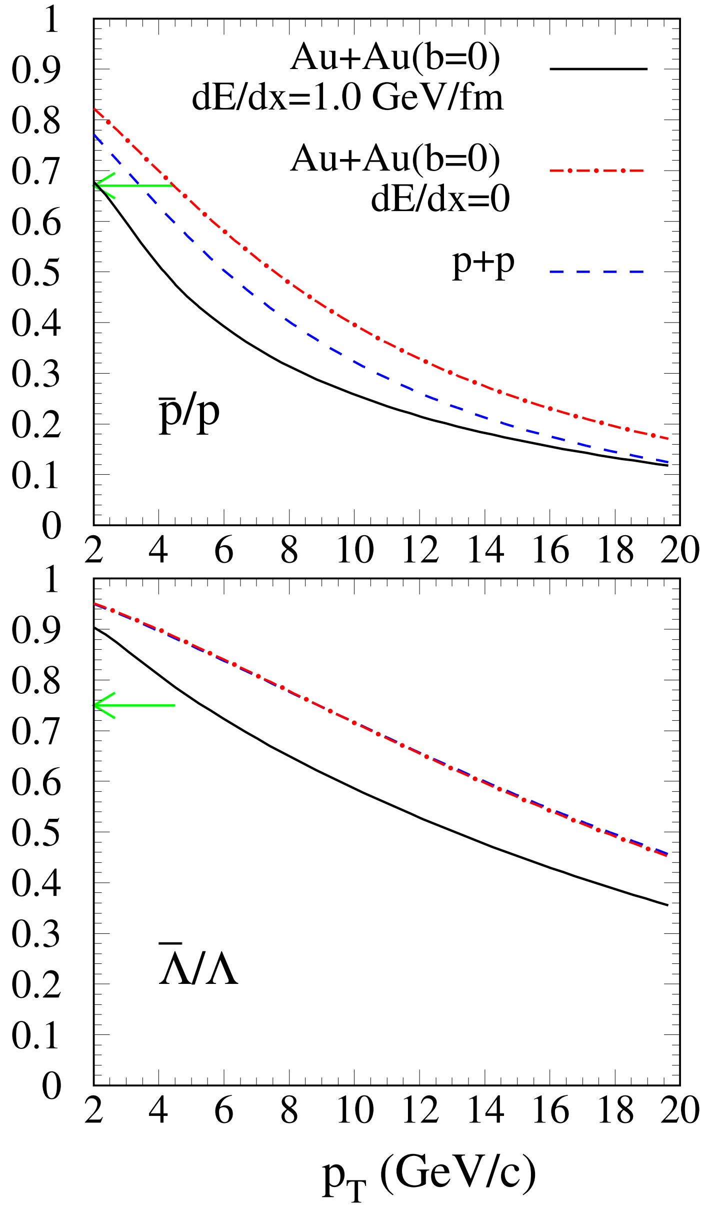

Figure 1: Ratio of charged hadron production vs. p_T with different energy loss schemes. From pQCD calculation by Wang, Phys. Rev.**C58**(1998)2321.

Possible to measure $\bar{p}/p$ ratio at high p_T with RICH detector in Year 1.
Sensitive to both difference in fragmentation and energy loss in high energy density environment.

STAR Physics Program

⟶ Study behavior of high temperature, high density nuclear matter created in RHIC collisions

⟶ Search for Quark Gluon Plasma formation - did quarks and gluons become deconfined or stay confined after the collision?

STAR focus is on:

⋆ event-by-event measurement of global observables and their correlations over a large solid angle

⋆ emphasis on hadron production

⋆ measurements of both soft and hard physics

Detector requirements:

⋆ tracking, momentum measurement and good particle identification of charged particles at mid-rapidity

⋆ accurate primary vertex determination

⋆ EM calorimetry and tracking for high p_T particle and jet measurements

Nuclear Phase Diagram

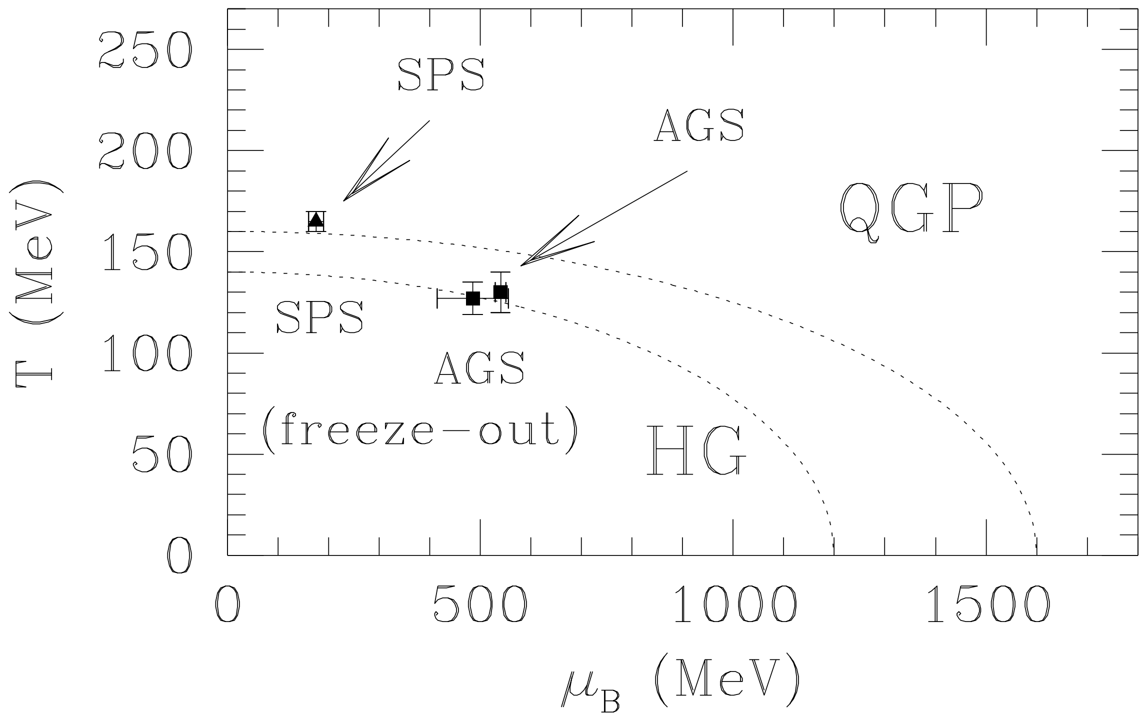

Figure 2: from Ann. Rev. Nucl. Part. Sci 46 (1996)71-107.

Quark vs. Gluon Fragmentation

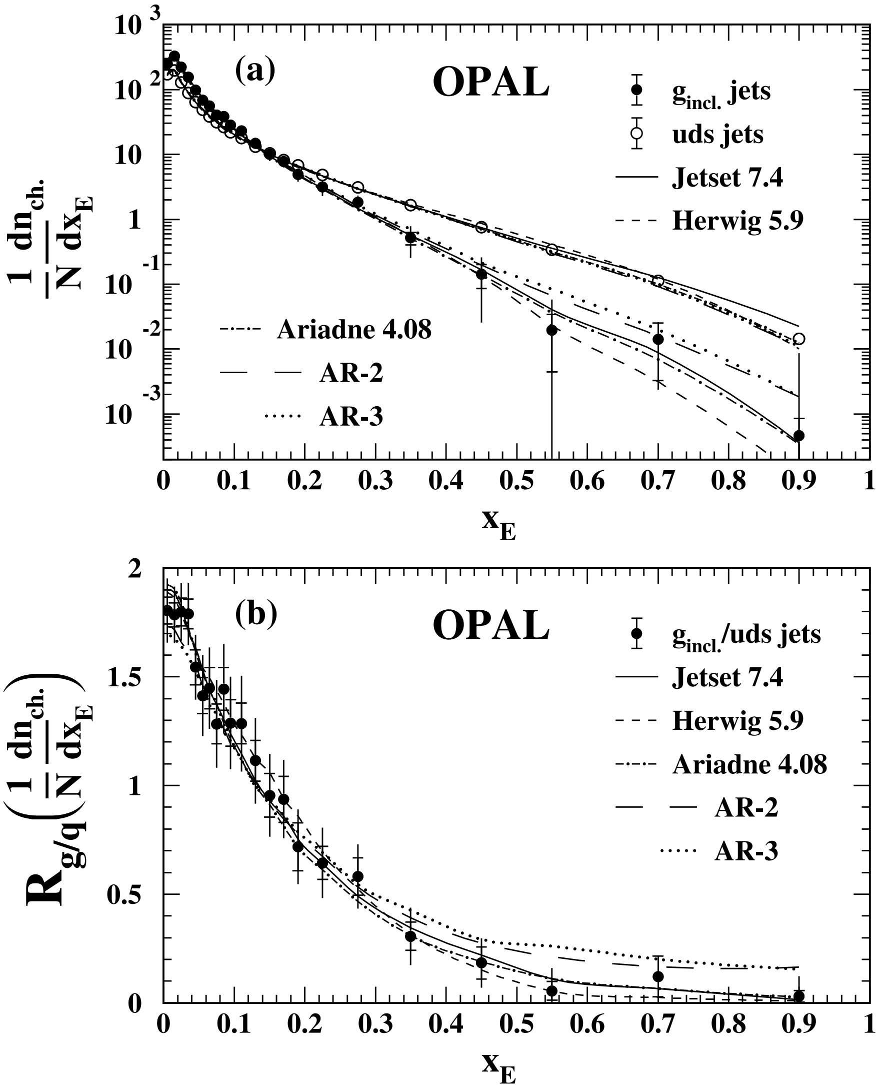

Figure 3: from OPAL experiment, hep-ex/9903027

Comparison between light (uds) quark and gluon jet fragmentation functions, and the predictions of various event generators

Fundamental Particles & Interactions

molecules $\rightarrow$ atoms $\rightarrow$ p, n, e^- $\rightarrow$ quarks,leptons $\rightarrow$??

Fundamental Particles

leptons	quarks
e	u
ν_e	d
μ	c
ν_μ	s
τ	b
ν_τ	t

Interactions

Force	Mediator
weak	$W^\pm, Z^0$
electromagnetic	γ
strong	gluon
gravity	(graviton?)

$\star$ Also have the Higgs Boson which gives mass to the fundamental particles (not yet discovered)

The Standard Model

⇒ ElectroWeak:

- unified theory describing electromagnetic and weak forces

⇒ Quantum Chromodynamics (QCD):

- theory describing strong force between colored objects (quarks and gluons)
- requires that partons exist only in color singlets, i.e. inside hadrons
- predicts that at sufficiently high density and temperature ($\approx 10^{12}$ K), there will be a phase transition to a color-deconfined state of matter: Quark Gluon Plasma (QGP)

Experimental Tests of the Standard Model

$\Rightarrow$ has survived all experimental tests so far!!

High Energy Nuclear (Relativistic Heavy Ion) Physics:

- create hot, dense matter of quarks & gluons
- how does matter behave in this environment?
- do we get phase transition to QGP as predicted?
- do Standard Model (SM) predictions hold

High Energy Particle Physics:

- aim for higher energy interactions + better precision to study more fundamental particles and interactions
- search for Higgs Boson
- why are particle masses and strengths of forces the values that they are?

$\Rightarrow$ Is the Standard Model the final answer?

Detection of Quarks and Gluons

quarks and gluons not directly observable
$\rightarrow$ if they separate, form a collimated spray "jet" of hadrons

$\rightarrow$ get jet of hadrons in same direction as parent quark or gluon

Coordinate System

Collider experiments work in r, η, ϕ coordinates
where η is the pseudo-rapidity,

$$\eta = -ln \tan \frac{\theta}{2}$$

and is used as an approximation of rapidity y for $p >> m$,

$$y = \frac{1}{2} ln(\frac{E + p_Z}{E - p_Z})$$

y is used instead of θ because

- $\star$ it changes by an additive value only under boosts in the z direction
- $\star$ hence the shape of the distribution dN/dy is invariant

Kinematic Variables:

$\rightarrow$ energy of a particle

$$E = m_T \cosh y, p_x, p_y, p_z = m_T \sinh y$$

where transverse mass is

$$m_T^2 = m^2 + p_x^2 + p_y^2$$

...identities

$$\sinh \eta = \cot \theta$$

$$\cosh \eta = 1/\sin \theta$$

$$\tanh \eta = \cos \theta$$

Particle Detection

Use detector to measure final products of collision

- **then can reconstruct event**

$\Rightarrow$ tracking system (TPC+SVT+SSD)
- charged particle tracking, vertex measurement
$\Rightarrow$ particle ID (RICH)
- particle identification to high p_T
$\Rightarrow$ calorimetry (EMC, barrel and endcap)
- energy measurement of charged and neutral particles

electrons:
$\rightarrow$ track in drift chambers
$\rightarrow$ electromagnetic shower in calorimeter

photons:
$\rightarrow$ No track in drift chambers
$\rightarrow$ electromagnetic shower in calorimeter

quarks,gluons $\longrightarrow$ "jets" of hadrons:
$\rightarrow$ hadronic shower in calorimeter

TPC Momentum Resolution

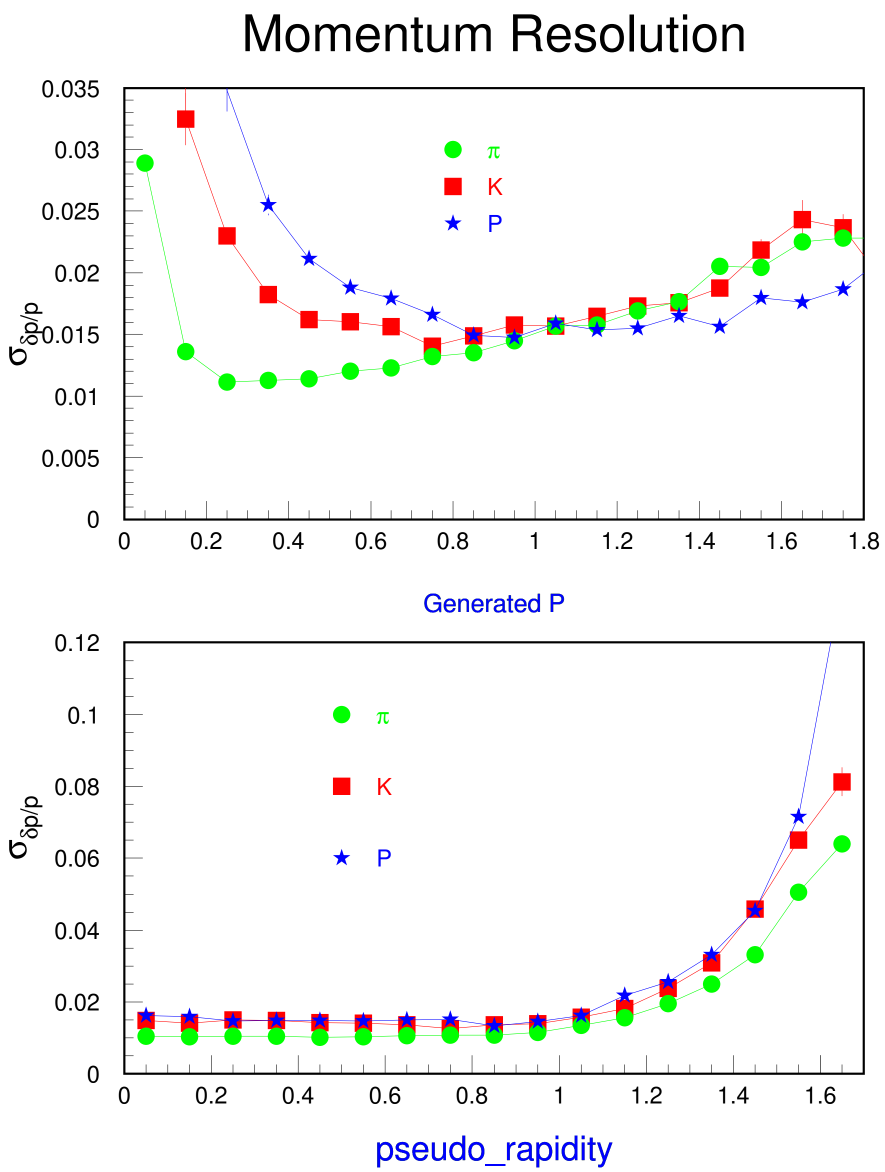

Figure 4: TPC Momentum Resolution vs momentum and η.

TPC,RICH PID Ranges

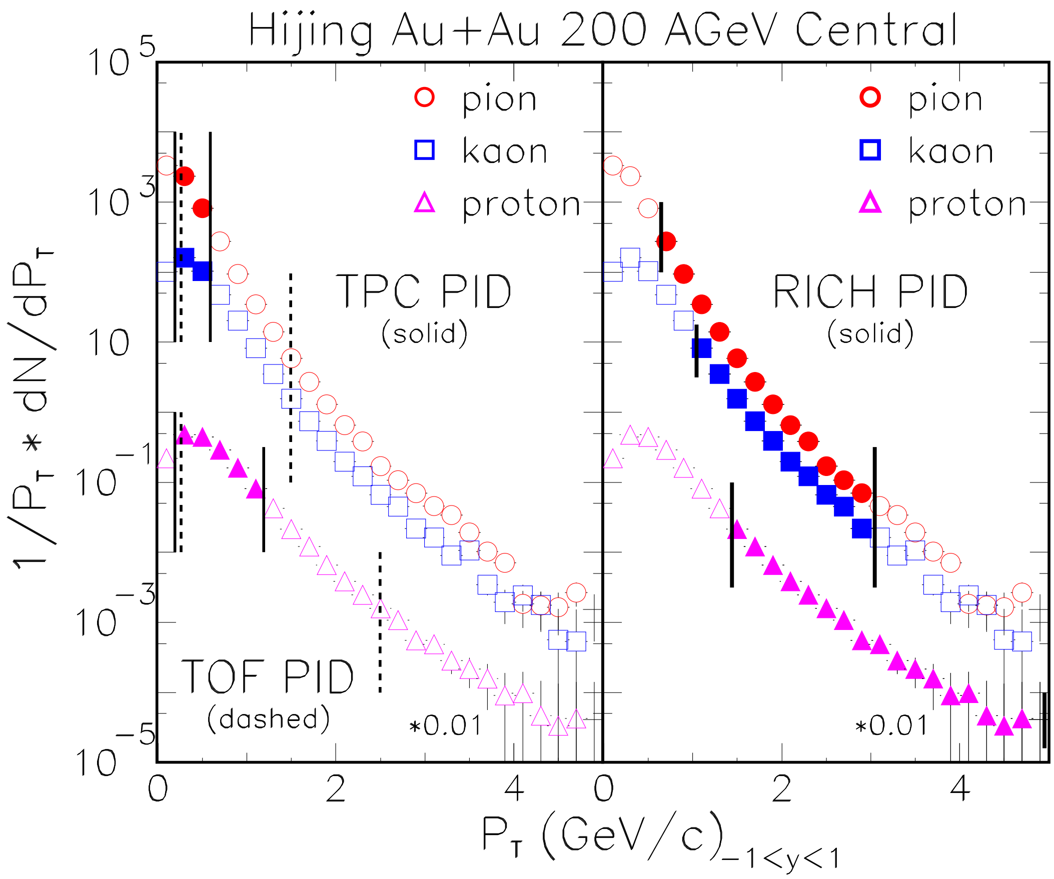

Figure 5: TPC, RICH PID ranges vs. p_T

Acceptance for π

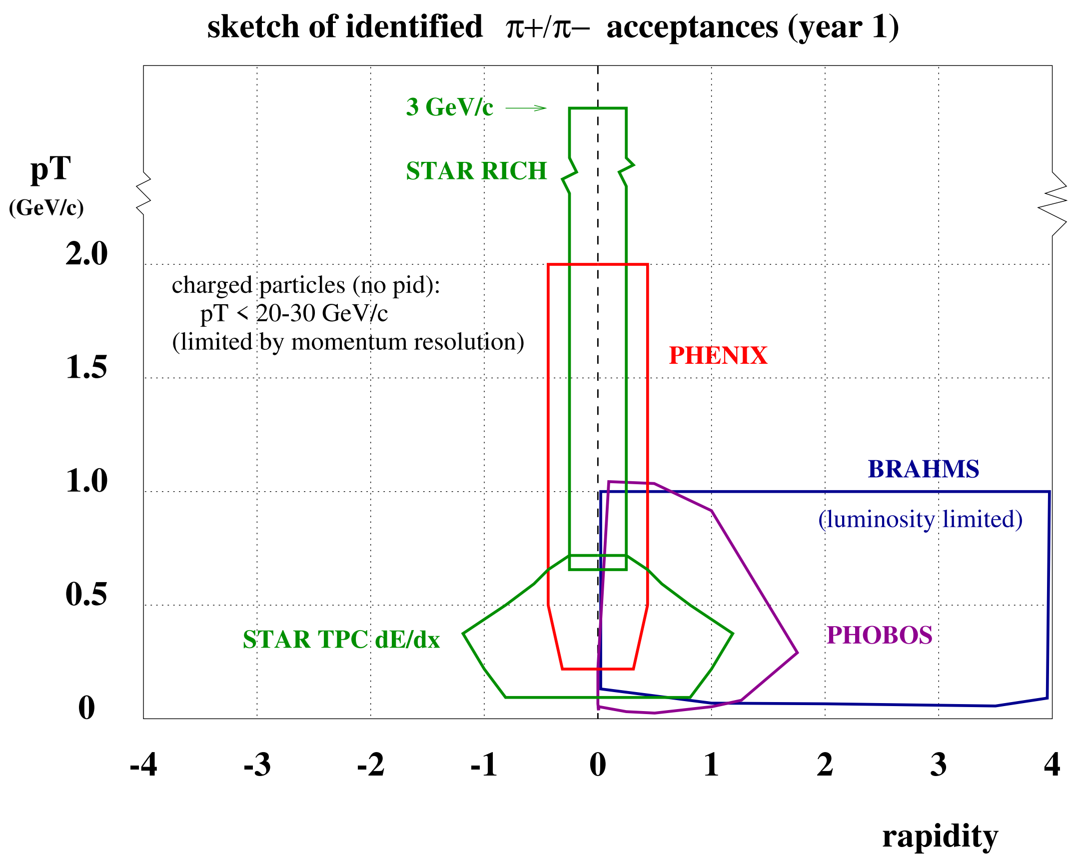

Figure 6: π acceptance range

Acceptance for K

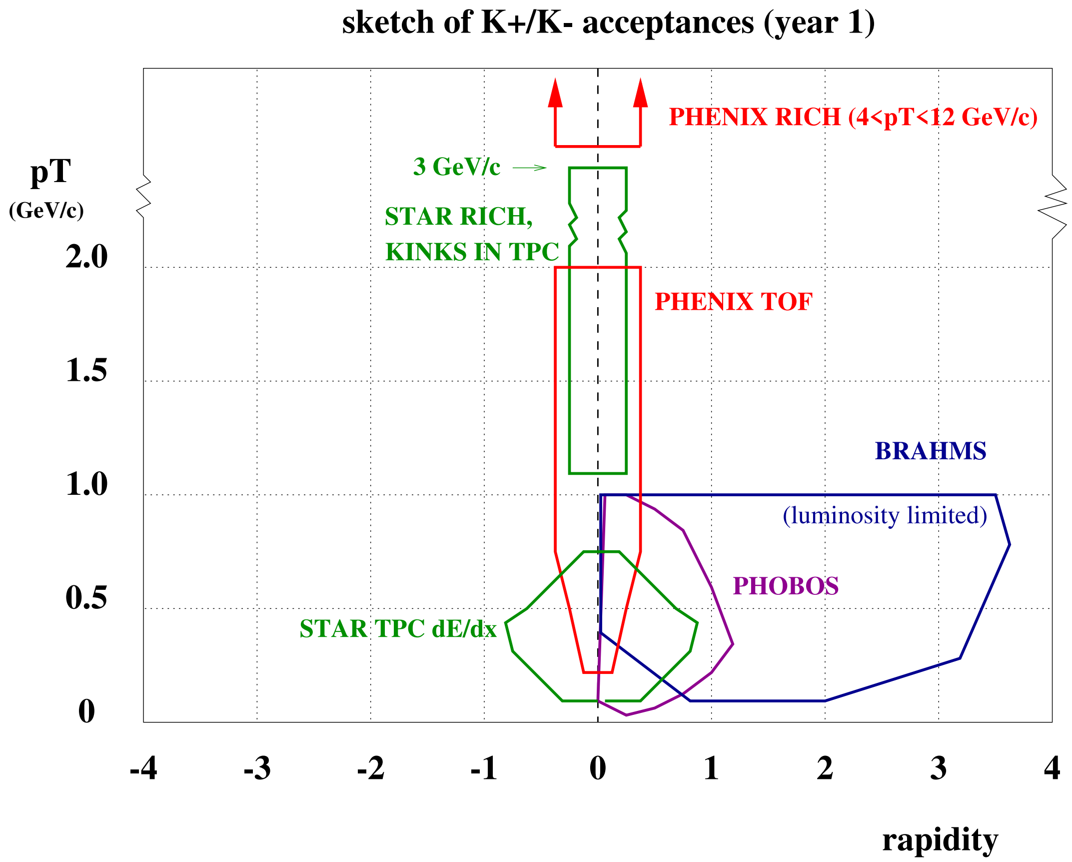

Figure 7: K acceptance range

Acceptance for p

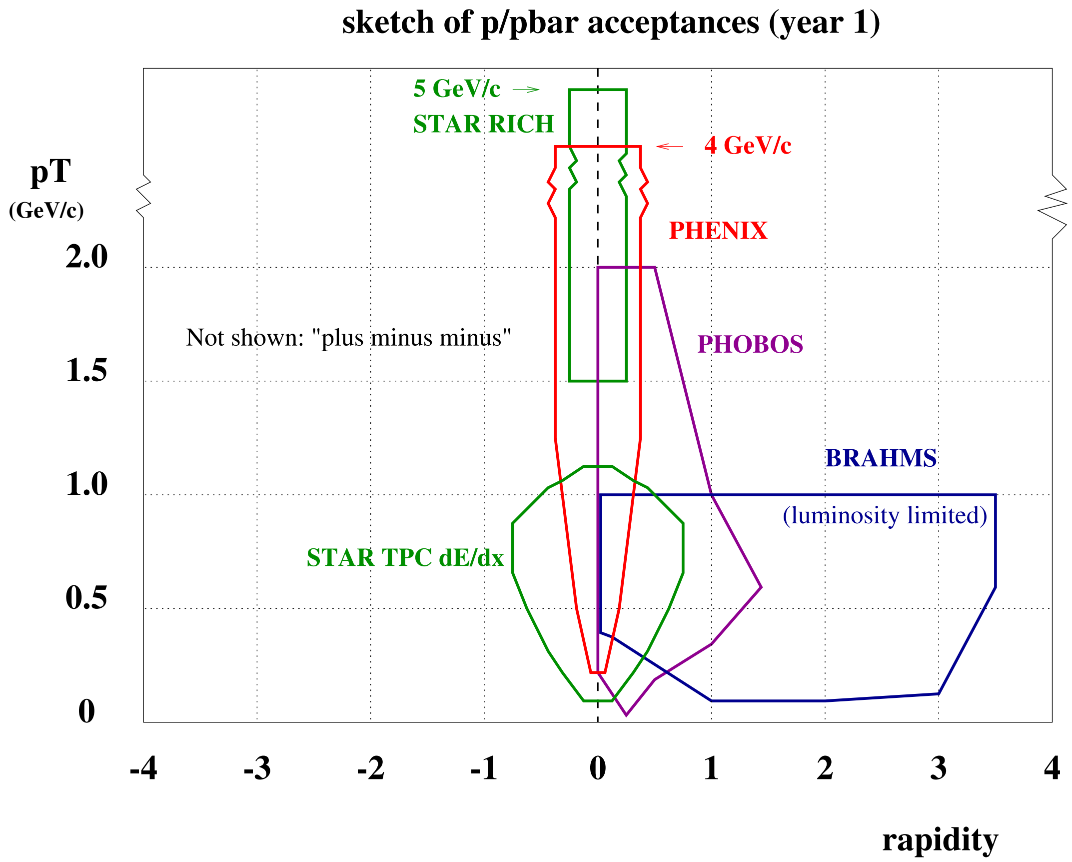

Figure 8: p acceptance range

π Production at SPS and RHIC

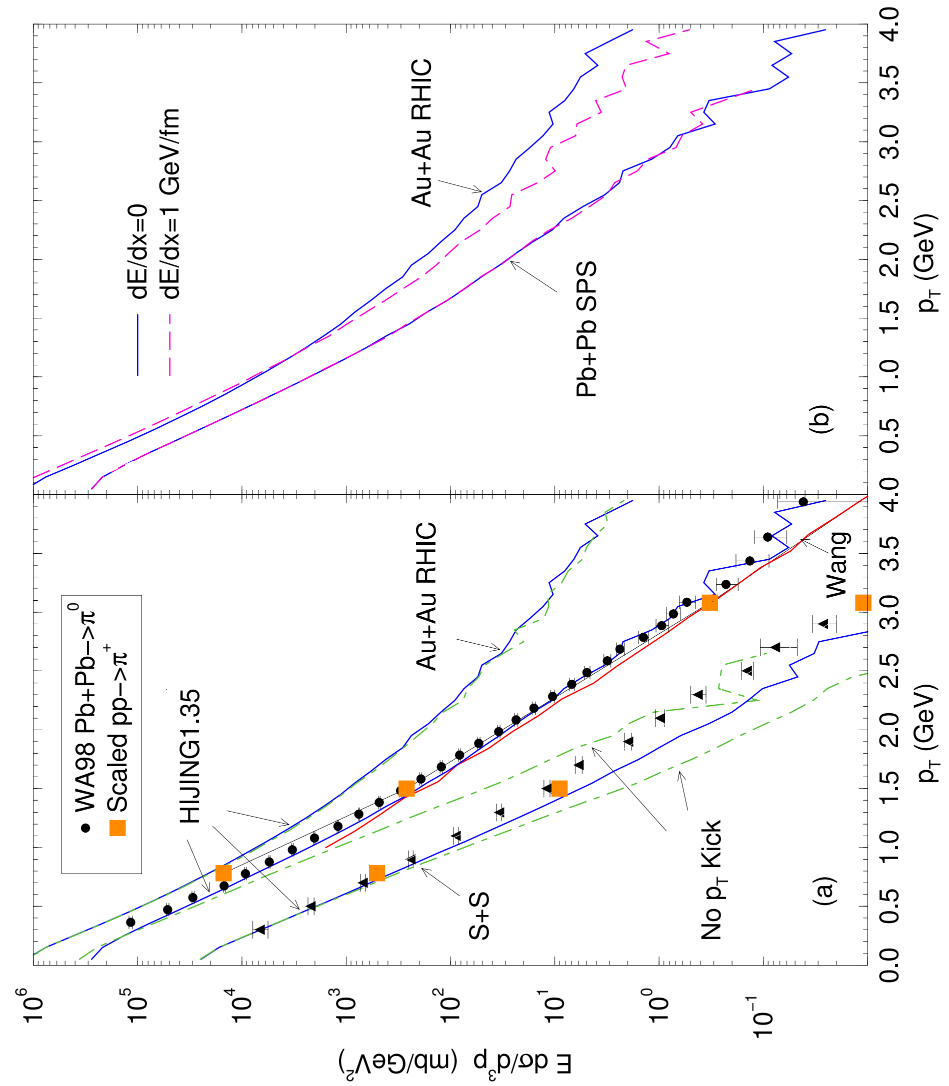

Figure 9: M. Gyulassy and P. Levai, Phys. Lett B442 (1998) 1.

Charged π production

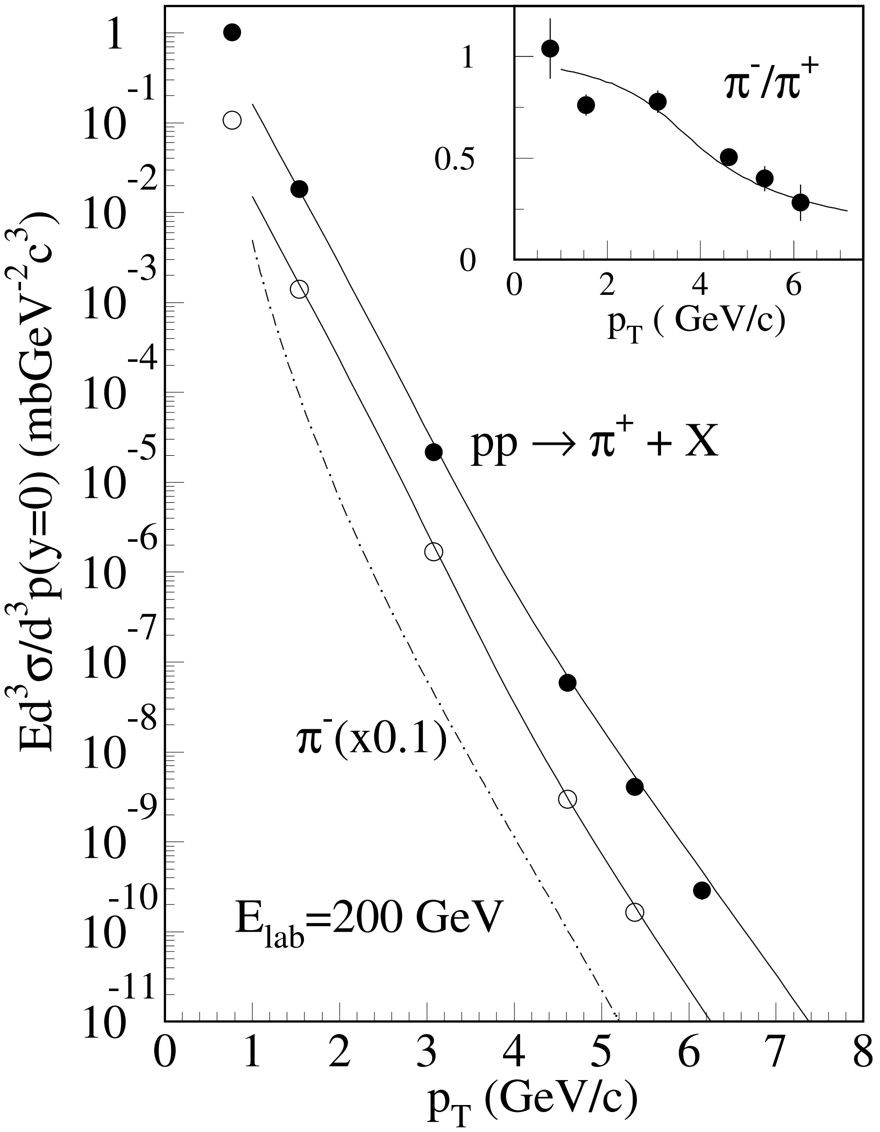

Figure 10: Inclusive π spectra compared to pQCD with and without intrinsic k_T added. Wang, nucl-th/9907093.

High p_T Program - Long Term

$\rightarrow$ In order to obtain full experimental results, we will need results from data sets (or obtain elsewhere):

$\star$ structure functions in the proton
- pp data set, select $\gamma - jet$ final state

$\star$ nuclear shadowing (modification of structure functions)
- pA data set, select $\gamma - jet$ final state

$\star$ jet fragmentation functions
- pp data set
- pA data set
- AA data set

$\star$ measure AA production as a function of beam energy and centrality

J/ψ Production - Year 2 Statistics

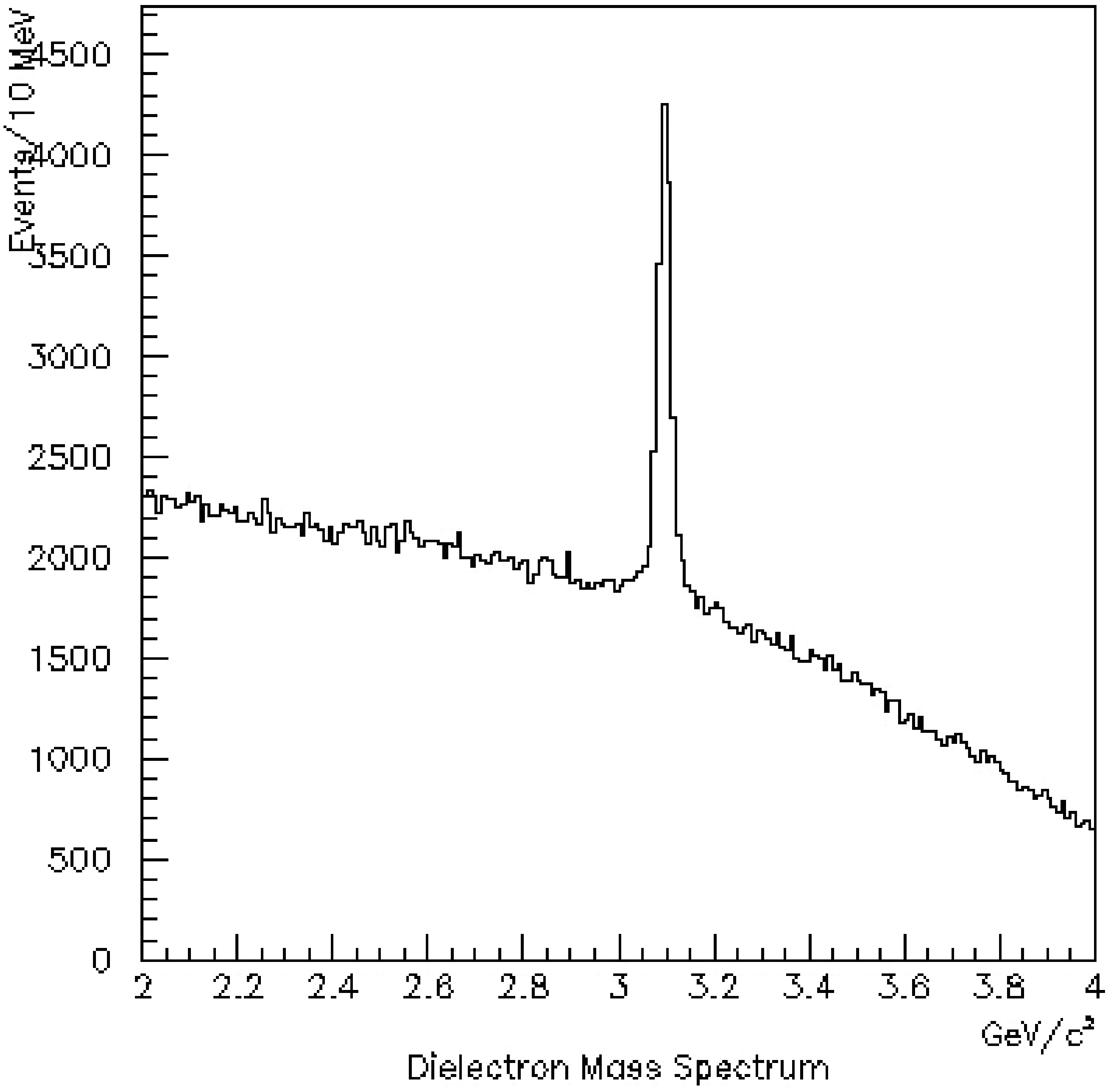

Figure 11: T. LeCompte

Year2 measurement (L3 trigger)
- simulation with all detector effects:
require $P_T > 1.5$ GeV, get $\approx 4 \times 10^4$ J/ψ's per year