High transverse momentum identified hadron ratios in $\sqrt{s_{NN}}$=200GeV Au+Au collisions at RHIC

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Motivation of the Study: Observation of Quark Gluon Plasma!

It is predicted from lattice QCD calculation that at high energy density, a phase transition from hadronic matter to a plasma of deconfined quarks and gluons (QGP) may occur, which is believed to exist in the early universe a few microseconds after the Big Bang. Relativistic heavy ion collisions at Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory (BNL) is expected to produce such a phase transition.

Idea on Searching QGP in Relativistic Heavy Ion Collision experiment

Estimation of energy density we expect to reach: ~2-3GeV/fm^3

- Compare Au+Au collision data with p+p collision data at the same energy per nucleon
- If there is a significant change from p+p collision data scaled by the number of participant nucleons (N_{part}) or binary collisions (N_{coll}), there will be ***an additional nuclear effect***
- Number of binary collisions: Number of underlying binary nucleon-nucleon collisions.
- Centrality: Degree of nuclear overlapping, which is associated with the number of participant nucleons (number of participated nucleons into the collisions). In Au+Au collision, 2 to 197×2

$T_A(d) = \int \rho(d,z)dz$ Thickness Function

$T_{AB}(b) = \int T_A(\vec{s}+\frac{\vec{b}}{2}) T_B(\vec{s}-\frac{\vec{b}}{2}) d\vec{s}$ Overlap Function

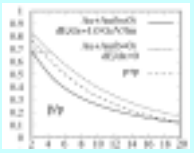
QGP state!?

Physics on QGP scoped by high transverse momentum(p_T) hadron ratios

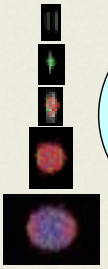
Jet Quenching

Jet will loose its energy in the dense medium

In Year-1, suppression of high p_T hadrons are seen for both π^0 and h^+, h^-
At even higher p_T, suppression expected to be more dramatic



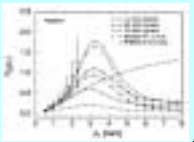
Xin-Nian, Wang, PRC Vol.58 (1998)2321



Baryon number transport

Baryon number will be transported via gluon junction that will give an another p_T kick on baryon spectra (accelerated)

- In Year-1, proton spectrum reaches close to charged π spectrum
- What will happen even more high p_T? (return to pQCD base?)

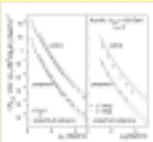


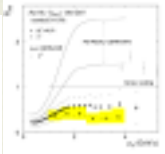
I. Vitev and M. Gyulassy, PRC65(2002)041902

Baryon/meson ratio will give an information on baryon number transport.
Jet quenching can enhance the baryon transport effect
(π^+, π^-, π^0 suppress, while pbar, p enhance)

A hint of Jet Quenching from Year-1 result

- Clear deficit is seen in π^0 yield in central collisions compared to the p+p data scaled by number of binary collisions
- Peripheral collision data is well consistent with scaled p+p data



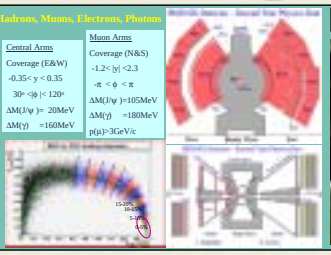


***"Suppression of Hadrons with Large Transverse Momentum in Central Au+Au Collisions at sqrt(s) = 130 GeV"*, K. Adcox et al., Phys. Rev. Lett. 88, 022301**

A complex apparatus to measure: Hadrons, Muons, Electrons, Photons

- ~30Million Minimum Bias Events @ $\sqrt{s_{NN}}$=200GeV Au+Au Collisions
- Detectors used in the analysis
  - Tracking: DC and PC
  - Identified charged hadrons: TOF
  - Neutral π: PbSc and PbGl (EMCal)
- Events triggered by BBC and ZDC
  - Centrality characterized
  - Number of participants determined by Glauber model calculation

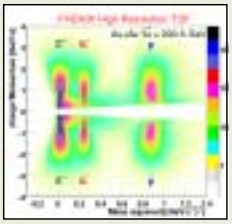
Central Arms	Muon Arms
Coverage (E&W)	Coverage (N&S)
-0.35< y < 0.35	-1.2< |y| <2.3
30< <|φ|< 120	-π < φ < π
ΔM(J/ψ)= 20MeV	ΔM(J/ψ)=105MeV
ΔM(γ) =160MeV	ΔM(γ) =180MeV
	p(μ)>3GeV/c



PHENIX Detector

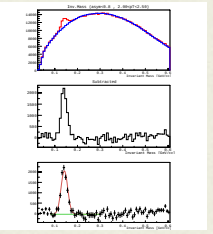
Analysis (proton, pbar and π^+, π^-)

- Using High Resolution TOF PID device and Drift Chamber.
- Making p_T dependent 2σ cut in squared mass
- Range and Systematic Error
  - proton, pbar: up to 4GeV/c
    - p_T dependent: 11%
    - Overall normalization: Central 18%, Peripheral 16.4%
  - π^+, π^- : up to 2GeV/c
    - p_T dependent 7%
    - Overall normalization: Central 14%, Peripheral 14%

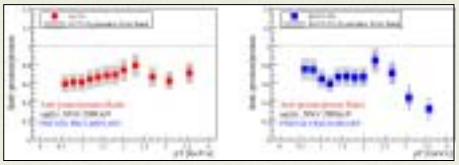


Analysis (Neutral π)

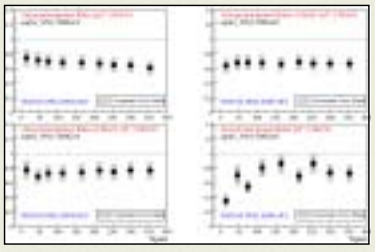
- Using Electro-magnetic Calorimeter
  - 1GeV/c<p_T<10GeV/c for π^0 !
- Calculate γγ invariant mass spectra and subtract combinatorial background
- Efficiency is evaluated by embedding simulated π^0 into real event.
- Systematic Error
  - p_T independent: 9%, Overall: 20-30%



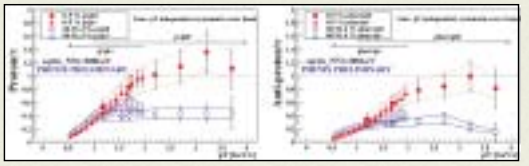
Anti-proton to proton ratios as functions of p_T and number of participant nucleons (Centrality)



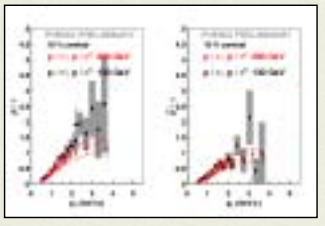
- pbar/p ratio extends up to 4GeV/c in Year-2
- Point-by-Point Error: Statistical Error
- Bands by lines: Common Systematic Error
- It is almost flat over both entire p_T and centralitie (number of participant nucleons)



Baryon to meson ratios through Anti-proton and proton to pion ratios as a function of p_T



- pbar/π , p/π ratios
  - p_T<2GeV, pbar/π, p/π^+
  - p_T>1GeV, use π^0 with π^-, π^+
- Point-by-Point Errors include point-by-point statistics+systematic errors
- Bands: p_T independent systematic errors
- Decreasing at much more high p_T?
- Data Compared to Year-1
- Both Year-1 and Year-2 are consistent within systematic error
- Another hint.
  - More π rather than protons?



Conclusion

- **Ratio of anti-proton/proton is measured up to 4GeV/c. The result is almost flat over the entire p_T and centrality within systematic error**
- **Ratio of baryon/meson through pbar/π and p/π is measured up to 4GeV/c. Hints on the effect of dense medium is seen. The result is consistent with Year-1 result within systematic error**

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