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High P_T Physics with the STAR Experiment at RHIC

(**S***olenoidal* **T***racker* **A***t* **R***hic*)

Will Cover:

- Introduction
- Detector
- High P_T Measurements
- Summary & Future

RHIC

Starting in Fall 1999:
RHIC will provide collisions of ions from p to Au at $\sqrt{s}$ up to 500 GeV (p beams) and 200 GeV (Au beams)

Year 1: expect 10% of design luminosity by end of year
- $\rightarrow$ run $AuAu$ collisions
- $\rightarrow$ possibly beam or energy change

Year 2: full design luminosity by end of year

$L = 2 \cdot 10^{26}\ \mathrm{cm}^{-2}/\mathrm{s}^{-1}$

$\longrightarrow \approx$ 2000 collisions/sec

STAR Physics Program

$\longrightarrow$ study high temperature, high energy density nuclear matter

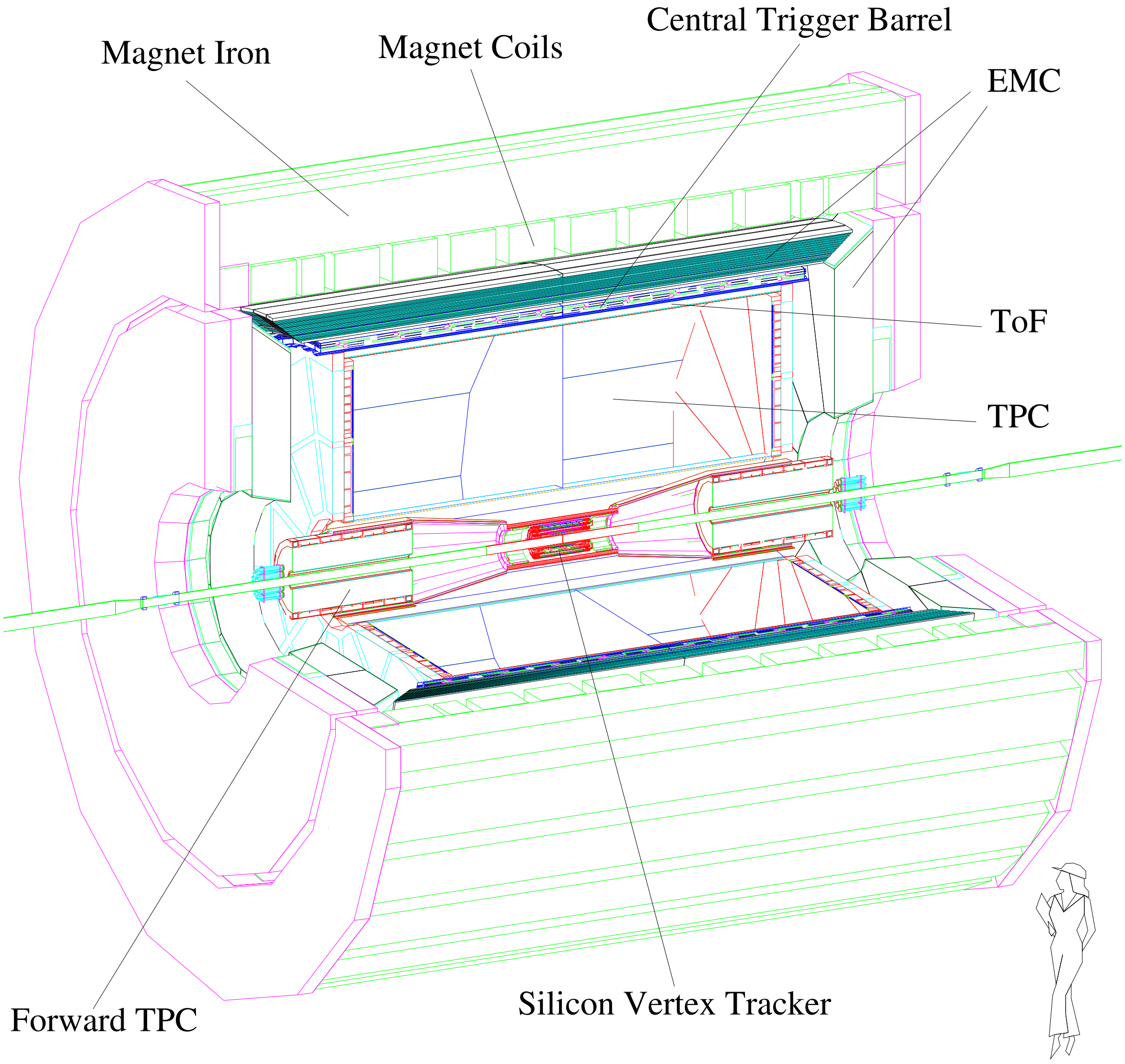
$\longrightarrow$ search for Quark Gluon Plasma (QGP):
deconfined state of quarks and gluons, predicted by QCD to exist at high energy densities

Topics:

- $\star$ Event-by-Event Measurements
- $\star$ Spectra (P_T,η) & Ratio Measurements
- $\star$ Low P_T probes
- $\star$ High P_T probes
- $\star$ Rare Hadronic probes
- $\star$ HBT
- $\star$ Signal Correlations
- $\star$ Peripheral Collisions
- $\star$ Spin Program (using polarized pp running)

This talk will concentrate on:
High-P_T Physics at STAR from heavy-ion interactions

STAR Detector



STAR Detector

STAR has full azimuthal coverage and large η range. Heart of detector is TPC & 0.5 Tesla solenoidal magnet.

- TPC:
  - tracking and individual track PID
  - $|\eta| < 2$, $\Delta\phi = 2\pi$
  - momentum resolution: $\sigma_p/p \leq 1\%$ for $p < 5$ GeV
- RICH:
  - limited angular coverage
  - $0 < \eta < 0.3$, $\Delta\phi \approx 20°$
  - extends PID to $\approx 3 - 5$ GeV
- SVT:
  - vertex tracking, PID
- FTPC:
  - $2.4 < |\eta| < 4.0$
  - 1 side in first year
- EMC:
  - Pb-scintillator sampling EM calorimeter, + preshower & shower max detector
  - segmentation 0.05×0.05 in $\Delta\eta \times \Delta\phi$
  - resolution $\approx 15\%/\sqrt{E}$
  - 4800 projective towers
  - 36,000 shower max pads at $5X_\circ$
  - barrel: $|\eta| < 1$, $\Delta\phi = 2\pi$
    (10% in Year1 +30% added each year)
  - endcap: $1.05 < \eta < 2$, $\Delta\phi = 2\pi$ (> Year2)

STAR Detector

Can measure:

- single charged hadrons with PID $\rightarrow$ TPC, SVT
- single neutral hadrons (π^0) $\rightarrow$ EMC
- $e, \gamma \rightarrow$ EMC + TPC
- jets and/or leading particles $\rightarrow$ EMC + tracking
- jet correlations
- J/ψ
- particle production ratios

Triggers:

L0: hardware, multiplicity trigger (CTB+MWC)

L3: software, ready in Year2?
- needed for J/ψ & enhances range of high-P_T

Rates:

- Max Central Collision Rate ≈ 100 Hz
  ($\approx 5\%$ of collisons are central)
- DAQ rate to tape ≈ 1 Hz

Why Study High-P_T at STAR?

$\star$ study dense nuclear matter

- How does production behave in high energy density matter compared to nucleon-nucleon collisions?
- At RHIC energies, can make predictions using QCD + effects for heavy nuclei (shadowing...) !!

$\star$ search for Quark Gluon Plasma (QGP)

- Look for changes in production compared to expectations:
  jet quenching due to dE/dX energy loss
  $\longrightarrow$ softening of P_T spectum

Basic Program using High-P_T production:

$\longrightarrow$ study production and correlations of quantities and look for changes in production as function of:

- how much dense matter it's gone thru
  (i.e. centrality)
- different types of beams: AuAu, SiSi ... pp
- different beam energies

$\longrightarrow$ use pp and pA data as baseline for measurements

High P_T Charged Hadron Production

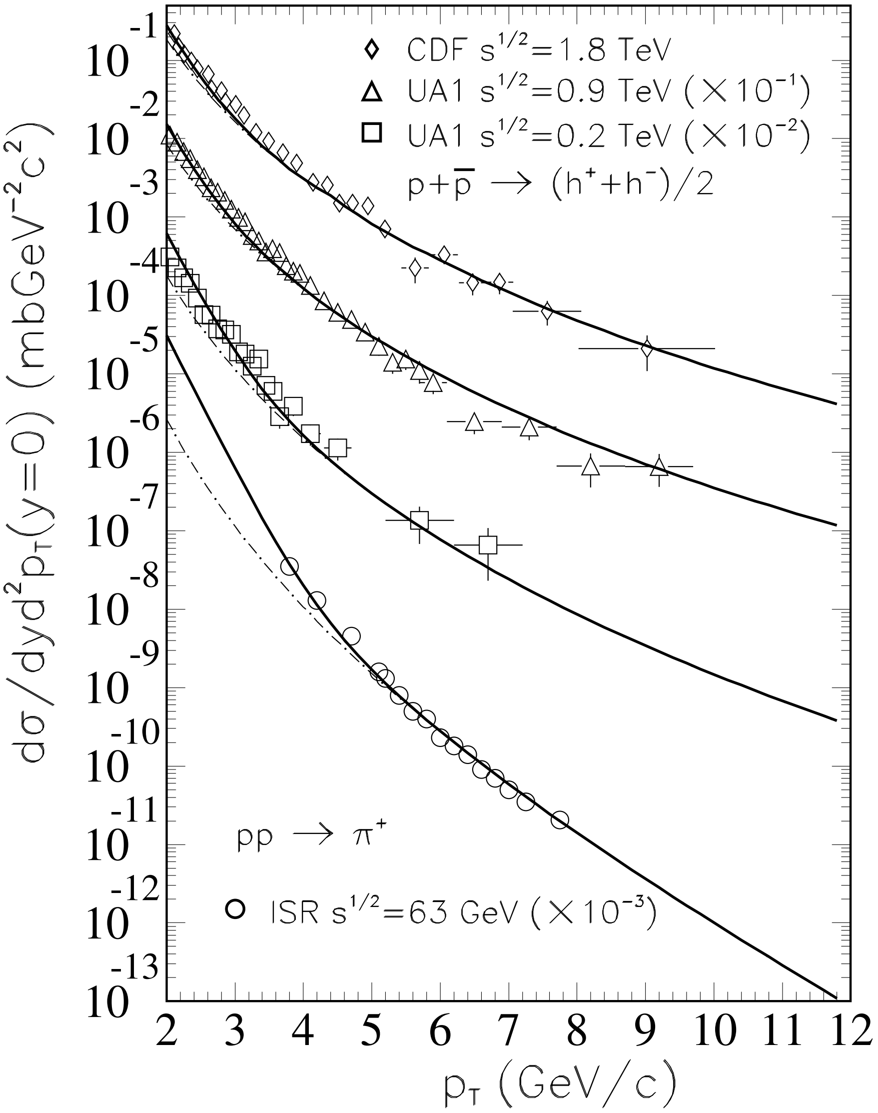


Figure 1: From pQCD calculation - Wang, Phys Rev **C58** (1998)2321 Can see that pQCD predictions are accurate at RHIC energies for nucleon-nucleon collisions

Partons in High Energy Density Environment

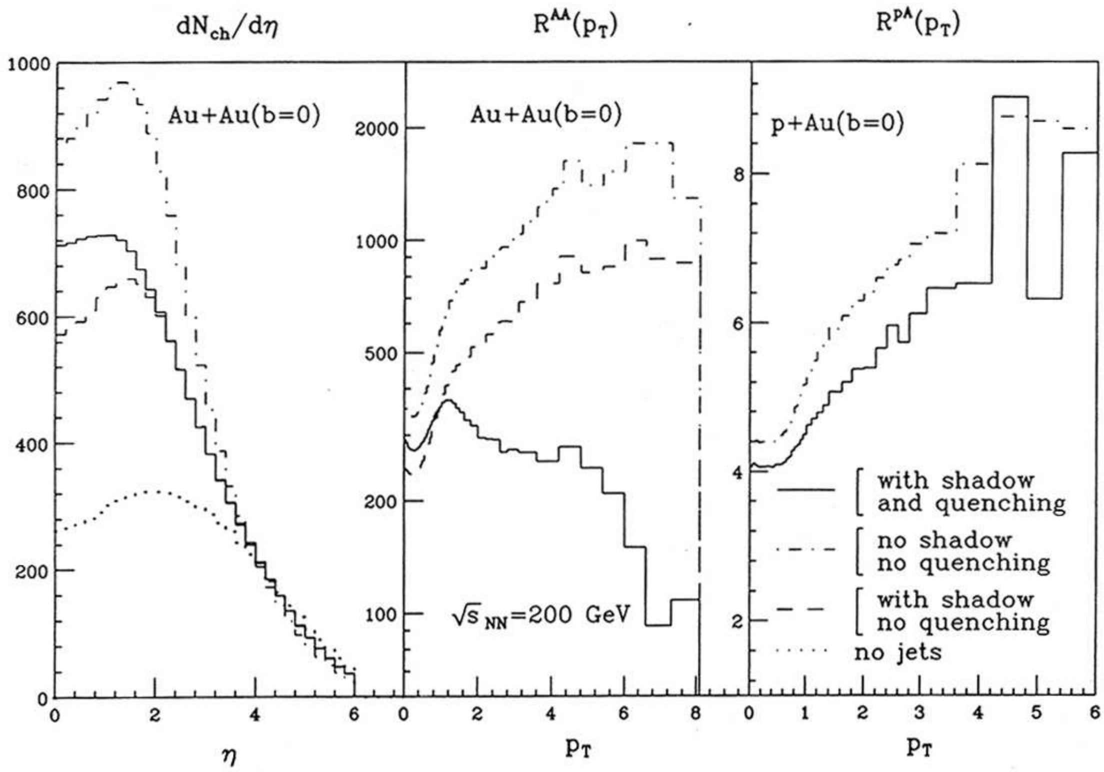


Figure 2: Inclusive charged particle spectra (HIJING) dependence on mini-jet production. R is ratio of nucleus-nucleus collisions to *pp* collisions. Gyulassy & Wang, PRL **68** (1992) 1480.

Heavy Ion vs. *pp* Interactions

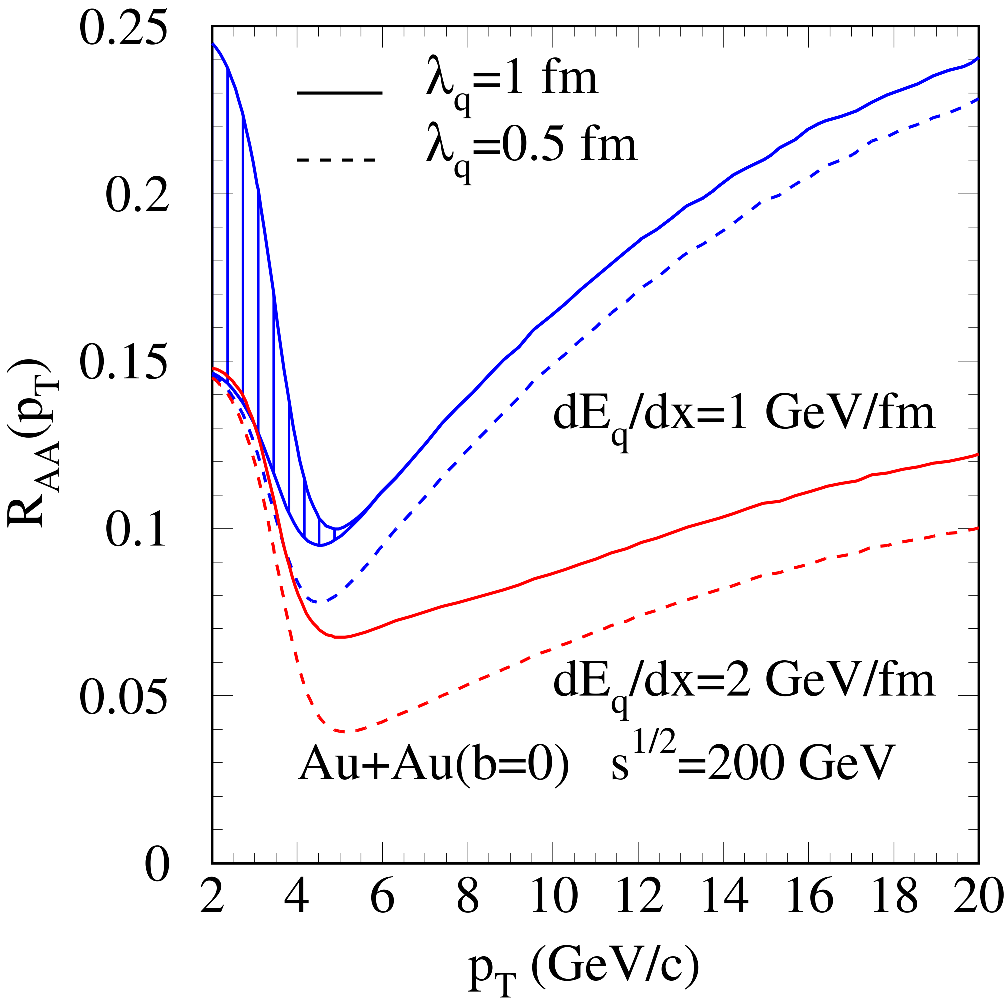


Figure 3: pQCD calculation showing ratio of charged particle P_T spectrum in central AuAu vs. pp at $\sqrt{s}$ = 200 GeV,normalized to effective total number NN collisions in a central AA collision (this is effectively the suppression). If nuclear effects (shadowing & jet quenching) are not taken into account, ratio $\approx$ 1 at large P_T. Wang, Phys. Rev. **C58**(1998)2321.

Charged Hadron Ratios

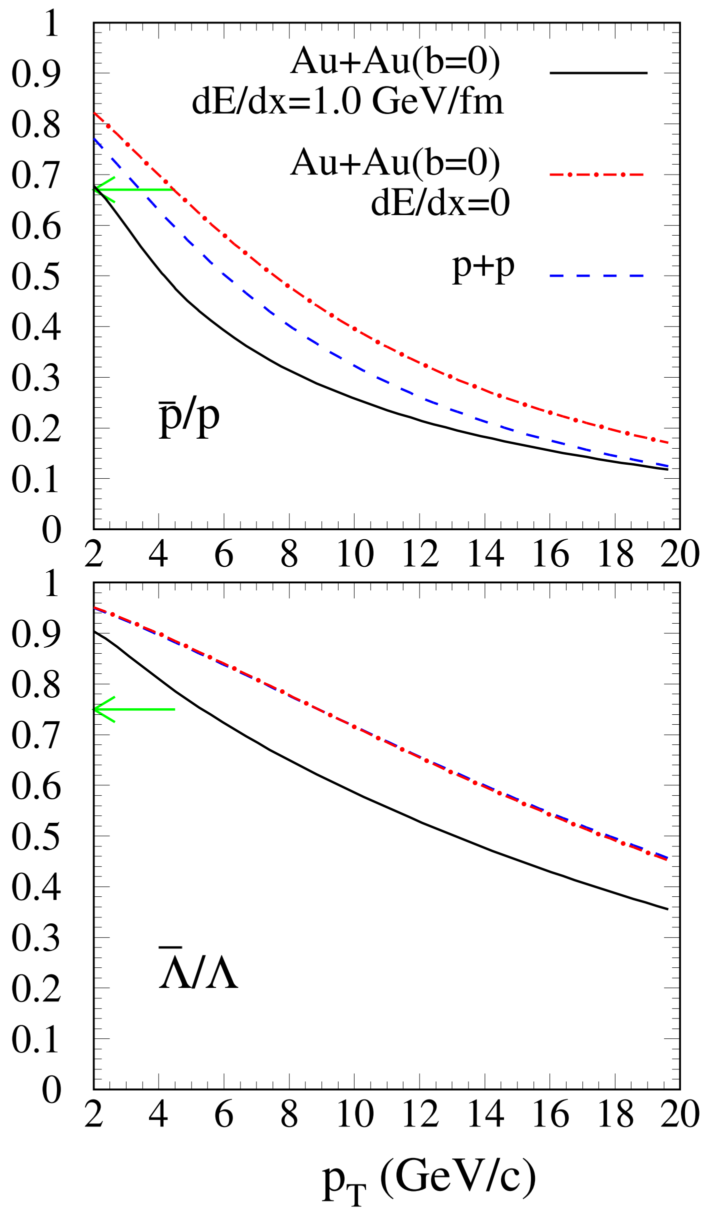


Figure 4: Ratio of charged hadron production vs. P_T with different energy loss schemes. From pQCD calculation by Wang, Phys. Rev.**C58**(1998)2321.

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.

π^0 Spectra

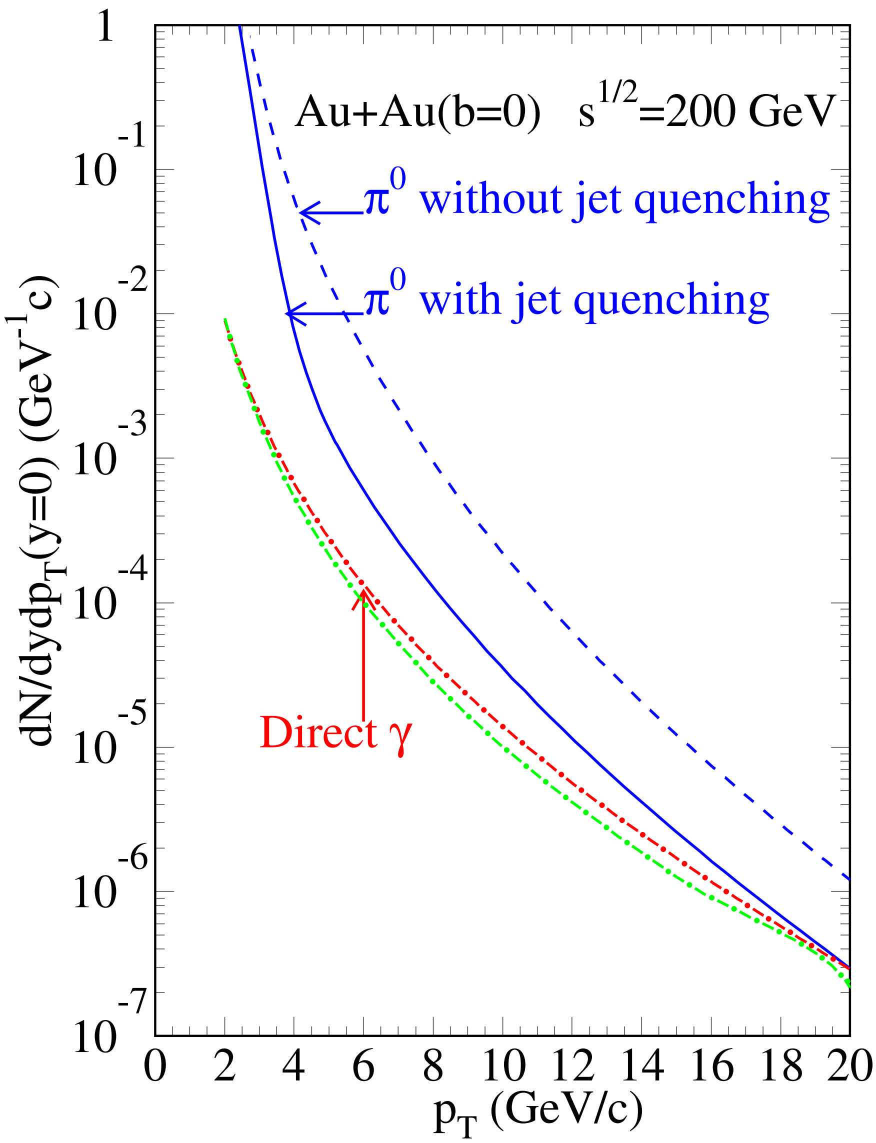
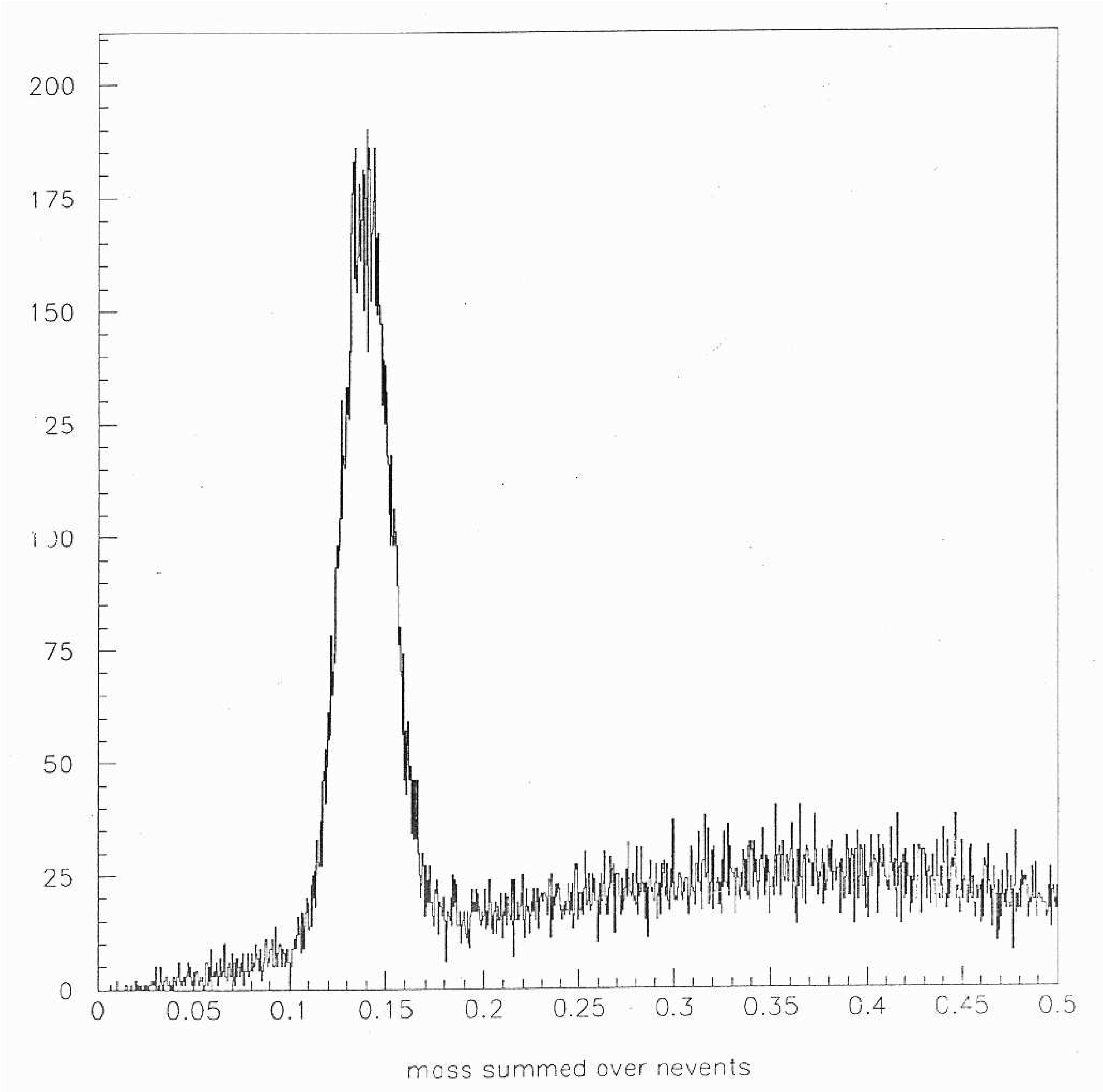


Figure 5: pQCD calculation of inclusive P_T distribution. $\mathrm{dE_q/dx} = 1$ GeV/fm and mean-free path $\lambda_q = 1$ fm assumed. Wang, Phys. Rev. **C58**(1998)2321.

$\longrightarrow$ Year1 measurement using EMC:
expect $\approx 2500(25)$ events at $P_T = 5(10)$ GeV

STAR: $\pi^0 \rightarrow \gamma\gamma$ mass peak - Year1 Statistics



$\longrightarrow$ Year1 measurement using EMC:
expect $\approx 2500, 25$ events at $P_T = 5, 10$ GeV (T. Cormier)

J/ψ Production - Year 2 Statistics

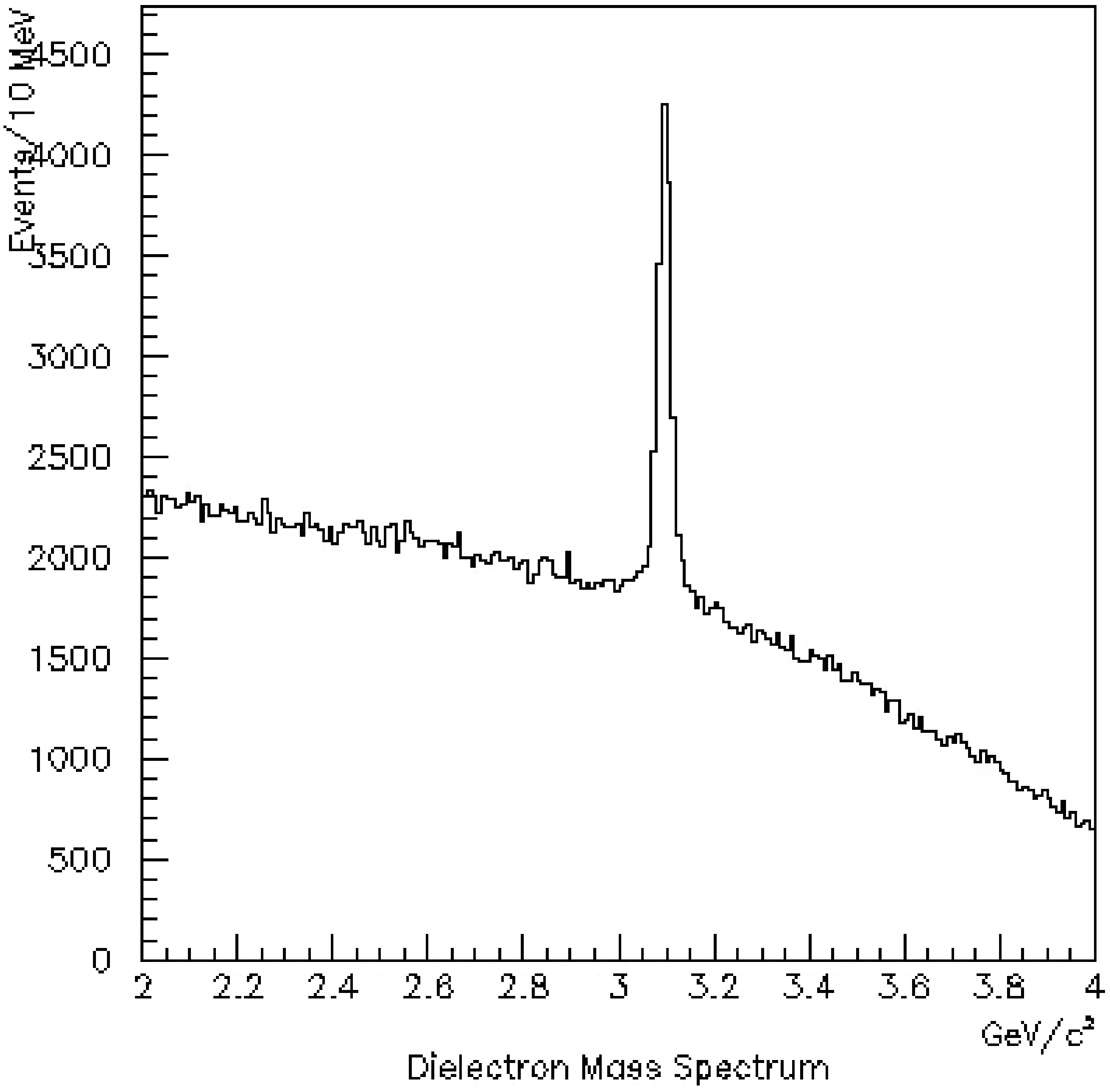


Figure 6: T. LeCompte

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

Other High-P_T Probes

- $\star$ direct γ's - sensitive to gluon distributions; don't interact with strongly with hadronic matter
- $\star$ leading particle distributions $\rightarrow$ may be easier/cleaner to measure than jets
  problem is accurately measuring jet energy
- $\star$ γ+jet events; tag the γ and measure jet
  (better handle on jet energy at LO)
- $\star$ jet production - may be more difficult because of large underlying event energies at RHIC
- $\star$ sphericity of event
- $\star$ angular correlations
- $\star$ di-jet production

High-P_T Program - Long Term

$\rightarrow$ In order to fully understand results will need to:

- $\star$ measure gluon structure functions using pp and pA collisions
- $\star$ measure production at pp, pA and as function of beam energy and centrality and extrapolate to AA collisions

Summary

High P_T Physics at STAR:

$\star$ charged hadron spectra

$\star$ particle ratios

$\star$ π^0 spectra

$\star$ angular correlations

$\star$ J/ψ

$\star$ leading hadrons

$\star$ direct γ's

$\star$ jet production

Future

- Looking forward to Data-Taking in Fall-1999 and to...
- Many new exciting & unexpected(?) results!!