High $p_T$ Spectra of Identified Particles Produced in Pb+Pb Collisions at 158A GeV Beam Energy

Tim Schuster (Frankfurt University)

and András László (MTA-KFKI Budapest)

for the NA49 collaboration
Motivation

High $p_T$ effects

How does the transition between soft and hard physics look like?

Sketch of nuclear modification factor $R_{\text{AA}}$ for Au+Au collisions:

Interplay of different effects modifies shape of spectra at high $p_T$

→ 1. Nuclear modification factor $R_{\text{CP}}$
Motivation

High $p_T$ effects

How does the transition between soft and hard physics look like?

Sketch of nuclear modification factor $R_{AA}$ for Au+Au collisions:

Interplay of different effects modifies shape of spectra at high $p_T$

1. Nuclear modification factor $R_{CP}$

2. Baryon / meson ratios
Outline

The NA49 experiment

Particle identification: TPCs

Centrality determination: Veto calorimeter

Analysis procedure
- Charged hadrons
- Neutral strange hadrons

Preliminary results:
1. Nuclear modification factor $R_{CP}$
2. Baryon / meson ratios for Pb+Pb collisions @ 158A GeV
Analysis procedure

Particle identification at high $p_T$ (Pb+Pb collisions @ 158A GeV)

**Charged hadrons:**
Fit to energy loss ($dE/dx$) spectra

$$2.8\,\text{GeV/c} \leq p_T < 3.0\,\text{GeV/c}$$

$$-0.3 < y_{\text{CM}} < 0.7$$

**Neutral strange hadrons:**
Invariant mass fit

$$2.8\,\text{GeV/c} < p_T < 3.2\,\text{GeV/c}$$

$$-0.5 < y_{\text{CM}} < 0.5$$
Results

The preliminary results are

corrected for

- geometrical acceptance
- tracking and reconstruction efficiency

not yet corrected for

- $K^\pm$ and $\pi^\pm$ decay
- feeddown

→ systematic biases $\leq 10\%$
No indication for Cronin enhancement for pions and kaons

\( R_{\text{CP}} (\pi) < R_{\text{CP}} (K) < R_{\text{CP}} (p) \)

Enhancement for protons

Shaded bands indicate uncertainty in \( N_{\text{Coll}} \) determination: 20%
\[ R_{CP} \text{ for } \pi, K \text{ and } p \text{ in } Pb+Pb \text{ collisions @ 158A GeV} \]

Dashed lines: pQCD calculations including jet quenching (Wang, PL B 595, 165, 2004 and private communication)

- Predictions consistent within errors with NA49 measurements

Shaded bands indicate uncertainty in \( N_{\text{Coll}} \) determination: 20%
Comparison to WA98 and NA57

Consistency between experiments at SPS (within large systematic errors)

Energy dependence

$R_{CP}$ (wounded nucleon scaling) is energy independent for $p_T < 1.5$ GeV/c.

$R_{CP}$ seems to decrease with increasing energy at $p_T \approx 3$ GeV/c for both scalings.

$\sqrt{s_{NN}} = 17.3$ GeV, 62.4 GeV, 200 GeV
Results, Part 2: Baryon / meson ratios

How does the transition between soft and hard physics look like?

- Large baryon / meson ratios at intermediate $p_T$ in Au+Au collisions at $\sqrt{s_{NN}} = 200$ GeV
- Can qualitatively be explained by quark coalescence models

→ Energy dependence?

No coalescence model calculations available for $\sqrt{s_{NN}} = 17.3$ GeV yet
Baryon / meson ratios

For Pb+Pb @ 158A GeV

- Increase with \( p_T \) and centrality
- Tendency to saturate at high \( p_T \)?

NA49 preliminary
The shape of baryon / meson ratios seems to be energy independent

PHENIX: Phys. Rev. C 69, 034909 (2004); STAR: nucl-ex/0601042
Baryon / meson ratios

Comparison to models

Blast wave fit overpredicts data at $p_T > 2.0$ GeV/c

How to describe data at higher $p_T$?

No predictions of coalescence models exist for SPS energy yet

BW: Retière, Lisa, PR C 70, 044907, 2004

pQCD: Wang, PL B 595, 165, 2004 and private communication
New results on high $p_T$ hadron production in Pb+Pb collisions @ 158A GeV

1. $R_{CP}$ results from three SPS experiments (WA98, NA57, NA49) agree within a large systematic error.
2. Results are consistent with a jet quenching model.

Baryon / meson ratios increase with $p_T$

- The shape of this increase is energy independent.
- Blast wave fit overpredicts data at $p_T > 2.0$ GeV/c.
- Can this domain be described by coalescence models?
Centrality selection with Veto Calorimeter (ZDC)

\[ \frac{N_W}{N_C} = \]

Bin: 1. 2. 3. 4. 5. 6.


\[ \frac{\sigma}{\sigma_{inel}} = \]

- 0%
- 5%
- 12.5%
- 23.5%
- 33.5%
- 43.5%
- 80%

\[ E_{Veto} / E_{Beam} \] (scaled to VENUS spectator energy)
Energy dependence of $R_{AA}$

Theoretical calculations, considering:

- Cronin effect, shadowing
- Cronin effect, shadowing, + final-state parton energy loss

David d'Enterria, nucl-ex/0403055

(Vitev, Gyulassy
PRL 89 (2002) 252301)
Reach of statistics

Uncorrected spectrum, (0-5)

\[ \frac{\sigma_p}{p^2} \approx 10^{-4} \frac{1}{\text{GeV/c}} \]

dE/dx resolution: 3 – 6%