Multidimensional Hadron Attenuation

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SIDIS

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\[ x_{Bj} = \frac{Q^2}{2 \cdot M_N \cdot \nu} \]

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\[ p_t: \text{ hadron momentum component transverse to } \gamma^* \]
\[ Q^2 \equiv -q^2 = (k - k')^2 \]

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\[ x_B j = \frac{Q^2}{2M_N\nu} \]

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\[ p_t: \text{ hadron momentum component transverse to } \gamma^* \]

\[ \sigma^{eN \rightarrow eh} \propto \sum_f e_f^2 \cdot q_f(x_B j, Q^2) \cdot \sigma^{eq \rightarrow eq} \cdot D_f^h(z_h, Q^2) \]
Nuclear Effects
Nuclear Effects

Partonic Effects
Nuclear Effects

Partonic Effects

- Gluon Radiation
- Parton Rescattering
Nuclear Effects

Partonic Effects

- Gluon Radiation
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Hadronic Effects
Nuclear Effects

Partonic Effects
- Gluon Radiation
- Parton Rescattering

Hadronic Effects
- Colorless Prehadron Interaction
- Hadronic Final State Interaction
Nuclear Effects
Nuclear Effects

Partonic Effects

Hadronic Effects
Nuclear Effects

Partonic Effects

Hadronic Effects

Nuclear Attenuation

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Nuclear Effects

Partonic Effects

Hadronic Effects

\[ R^h_A(\nu, Q^2, z, p_t^2, \phi) = \frac{N^h(\nu, Q^2, z, p_t^2, \phi)}{N^e(\nu, Q^2)} A \left( \frac{N^h(\nu, Q^2, z, p_t^2, \phi)}{N^e(\nu, Q^2)} \right)_D \]
Experiment

- $e^\pm$ beam of 27.6 GeV energy
- Nuclear Target ($D$, $Ne$, $Kr$, $Xe$)
- Good Momentum Resolution ($\Delta p/p < 2\%$)
- Excellent Particle Identification Capabilities
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Multidimensional representation of $R_{hA}^h$
Results

Multidimensional representation of $R_A^h$

- $\nu$ for three $z$ slices
- $z$ for three $\nu$ slices
- $p_t^2$ for three $z$ slices
- $z$ for three $p_t^2$ slices
Results

Multidimensional representation of $R_A^{h}$

- $\nu$ for three $z$ slices
- $z$ for three $\nu$ slices
- $p_t^2$ for three $z$ slices
- $z$ for three $p_t^2$ slices

Results

\[ R_A^h \]

\( \text{Ne} \)
\( \text{Kr} \)
\( \text{Xe} \)

\( z = 0.2 - 0.4 \)
\( z = 0.4 - 0.7 \)
\( z > 0.7 \)

\( \pi^+ \)
\( \text{K}^+ \)
\( p \)

\( v \ [\text{GeV}] \)
Results

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Attenuation is larger for heavy nuclei.
Results

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$R_{K^+}^A$ is different from $R_{\pi^+}^A$, $R_{\pi^-}^A$ and $R_{K^-}^A$. 

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Attenuation is larger for heavy nuclei. $R^h_{K^+}$ is different from $R^{\pi^+}$, $R^{\pi^-}$ and $R^{K^-}$. Protons behave very differently from the other hadrons.
Results

$n = 4-12$ GeV
$n = 12-17$ GeV
$n = 17-23.5$ GeV

$p^+$
$p^-$
$K^+$
$K^-$

$R_A^h$ vs $z$ for Ne, Kr, and Xe at different energy ranges.
Results

\[ R_A^{K^+} \text{ is different from } R_A^{K^-} \text{ at small values of } z. \]
\( R^{K^+} \) is different from \( R^{K^-} \) at small values of \( z \).

Strong dependence of \( R^p \) on heavy nuclei.
Results

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Reduction of $R_A^h$ with increasing of $z$. 

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Reduction of $R_{A}^{h}$ with increasing of $z$.
Strong dependence of $R_{A}^{h}$ on $p_t^2$ at small values of $z$ for heavy nuclei.
Results

\[ R_A^h \]

\begin{align*}
\text{Ne} & \quad z = 0.2-0.4 \\
\text{Kr} & \quad z = 0.4-0.7 \\
\text{Xe} & \quad z > 0.7
\end{align*}

\[ p_t^2 \text{ [GeV}^2\text{]} \]

\[ \pi^+ \]

\[ K^+ \]
The Cronin effect is larger for protons.
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Multidimensional kinematic dependencies of $R_A^h$ for $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$ and $\bar{p}$ on Ne, Kr and Xe targets.
Summary

- Multidimensional kinematic dependencies of $R_A^h$ for $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$ and $\bar{p}$ on Ne, Kr and Xe targets.
- $R_A^h$ is similar for $\pi^+$ and $\pi^-$.
Multidimensional kinematic dependencies of $R_A^h$ for $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$ and $\bar{p}$ on Ne, Kr and Xe targets.

$R_A^h$ is similar for $\pi^+$ and $\pi^-$.

Negatively charged kaons behave similarly to pions.
Summary

- Multidimensional kinematic dependencies of $R^h_A$ for $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$ and $\bar{p}$ on Ne, Kr and Xe targets.
- $R^h_A$ is similar for $\pi^+$ and $\pi^-$.
- Negatively charged kaons behave similarly to pions.
- $\nu$ dependence of $R^K_A$ for positively charged kaons is different from $R^{\pi^+}_A$, $R^{\pi^-}_A$ and $R^{K^-}_A$ in different $z$ slices.
Summary

- Multidimensional kinematic dependencies of $R_A^h$ for $\pi^+$, $\pi^-$, $K^+$, $K^-$, $p$ and $\bar{p}$ on Ne, Kr and Xe targets.

- $R_A^h$ is similar for $\pi^+$ and $\pi^-$.

- Negatively charged kaons behave similarly to pions.

- $\nu$ dependence of $R_A^{K^+}$ for positively charged kaons is different from $R_A^{\pi^+}$, $R_A^{\pi^-}$ and $R_A^{K^-}$ in different $z$ slices.

- $R_A^P$ for protons is very different compared with the other hadrons.