ALICE results on light flavour hadron production in p-Pb collisions at the LHC

Philipp Lüttig
for the ALICE collaboration
Rencontres de Moriond
March 2014
Motivation

• differentiate between initial and final state effects
  • challenge at LHC: $dN_{ch}/d\eta$ in p-Pb comparable to semi-peripheral Au-Au at RHIC
    ➢ final state dense matter effects cannot be neglected

• extend probed part of nuclear wave function to very low $x$ and high gluon densities
  ➢ saturation, parton shadowing

• probe different momentum transfer regions by selecting different particle masses
The ALICE Experiment

Tracking: ITS + TPC  PID: TPC/TOF  Multiplicity: VZERO

\[ p_T > 0.15 \text{ GeV/c} \]
\[ |\eta| < 0.8 \]
Spectra at low $p_T$
Average Transverse Momentum
of inclusive charged particles

- clear difference between collision systems
- \( pp \): difference in beam energy small wrt. p-Pb
- multiplicity dependence in p-Pb:
  - \( N_{\text{ch}} < 15 \): similar to pp
  - \( N_{\text{ch}} > 15 \): shape similar to Pb-Pb
  - potential superposition of pp and Pb-Pb

\[ \langle p_T \rangle (\text{GeV/c}) \]

\[ \begin{align*}
\text{ALICE, charged particles} \\
|\eta| < 0.3, 0.15 < p_T < 10.0 \text{ GeV/c}
\end{align*} \]

\[ \begin{align*}
\text{pp } \sqrt{s} = 7 \text{ TeV} \\
p-Pb \sqrt{s_{NN}} = 5.02 \text{ TeV} \\
Pb-Pb \sqrt{s_{NN}} = 2.76 \text{ TeV}
\end{align*} \]
Average Transverse Momentum

Model Comparison

- **pp:**
  - color reconnection needed to describe data

- **p-Pb:**
  - EPOS fits data best
  - Glauber MC (superposition of pp collisions) underpredicts data

- **Pb-Pb:**
  - models cannot describe data
  - most models reproduce shape, but magnitude is underestimated
Particle Identification

- identify π, K, p via specific energy loss in the TPC and velocity in TOF
- strange hadrons via secondary decay vertex
Transverse Momentum Spectra
Identified Particles - Model Comparison

- transverse momentum spectra of different particles
- comparison to models:
  - Blast-Wave
  - EPOS-LHC
  - Krakow
  - DPMJET
Transverse Momentum Spectra
Identified Particles - Model Comparison

- DPMJET as QCD-inspired model can describe multiplicity distribution in p-Pb (not shown), but fails to describe $p_T$ spectra
- Krakow: hydrodynamical model including initial fluctuations describes spectra for low $p_T$
- EPOS reproduces $\pi$ and $p$ over measured range, but larger deviations for $K^0_s$ and $\Lambda$
Average Transverse Momentum
of identified charged particles

- multiplicity in V0A as selector for different event classes
- good agreement between charged and neutral K
- increase with multiplicity for all particle species
- slope stronger for higher particle masses
- similar mass ordering seen for pp and Pb-Pb
Particle Ratios of identified particles

- p/π ratio vs. \( p_T \)
  - p-Pb: increase at intermediate \( p_T \) and depletion at low \( p_T \) with multiplicity
  - Pb-Pb: similar effects as in p-Pb, but more pronounced

- \( \Lambda/K^0_s \) ratio vs. \( p_T \)
  - similar for p-Pb and Pb-Pb:
    - increase at intermediate \( p_T \) for larger multiplicity
    - depletion at low \( p_T \)
High $p_T$ Results
Transverse Momentum Spectra
Identified Particles – $\pi^+ + \pi^-$

- multiplicity in V0A as selector for different event classes
- identification at high $p_T$ based on statistical analysis of particle abundance in the relativistic rise in the TPC
- hardening of spectra with increasing multiplicity
Transverse Momentum Spectra
Identified Particles – $K^+ + K^-$

- multiplicity in V0A as selector for different event classes
- identification at high $p_T$ based on statistical analysis of particle abundance in the relativistic rise in the TPC
- hardening of spectra with increasing multiplicity, stronger than for pions

$p$-Pb, $\sqrt{s_{NN}} = 5.02$ TeV

$0 < y_{cm} < 0.5$ for $p_T < 2.8$ GeV/c

$|y_{cm}| < 0.3$ for $p_T > 2.8$ GeV/c
Transverse Momentum Spectra
Identified Particles – $p + \bar{p}$

- multiplicity in V0A as selector for different event classes
- identification at high $p_T$ based on statistical analysis of particle abundance in the relativistic rise in the TPC
- hardening of spectra with increasing multiplicity, even stronger than for $K$
Transverse Momentum Spectra
of inclusive charged particles

- based on data from 2012 (pilot run)
- limited statistics (only up to $p_T = 20$ GeV/c)
Transverse Momentum Spectra
of inclusive charged particles

• higher statistics by including data from 2013
• forward $\eta$ added, slightly harder spectrum
• measurement extended to $p_T = 50$ GeV/c
• reduced statistical errors
• in ratio, correlated uncertainties are cancelled
NB: pp Reference Spectrum

no measurement available at $\sqrt{s} = 5.02$ TeV:

- $p_T < 5$ GeV/c: interpolation of cross section for fixed $p_T$ as function of energy

- $p_T > 5$ GeV/c: scaling of measured data at $\sqrt{s} = 7$ TeV with relative change from NLO-pQCD

- $p_T > 20$ GeV/c: parametrization with power law
Nuclear Modification Factor
for p-Pb collisions

\[ R_{pPb} = \frac{d^2 N_{pPb} / dp_T d\eta}{\langle T_{AA} \rangle d^2 \sigma_{pp} / dp_T d\eta} \]

- reference in \(|\eta| < 0.8\)
- \(p_T < 1 \text{ GeV}/c\): suppression
- \(1 \text{ GeV}/c < p_T < 3 \text{ GeV}/c\): Cronin-like enhancement
- \(p_T > 3 \text{ GeV}/c\): consistent with unity
Summary

Spectra at low $p_T$:

- $<p_T>$ as function of multiplicity for (un)identified charged hadrons
  - increase with multiplicity
  - rise stronger with higher particle mass
- Models incorporating final state effects give a better description of the data
- clear evolution with multiplicity of $p_T$ spectra, reminiscent of Pb-Pb behaviour
  (usually attributed to collective phenomena)

High $p_T$ Results:

- $p_T$ spectra of charged pions, Kaons and protons up to $p_T = 15$ GeV/c for different multiplicity classes
- $p_T$ spectra and nuclear modification factor for inclusive charged hadrons
  - up to $p_T = 50$ GeV/c
  - $R_{pPb}$ consistent with unity at high $p_T$