Light flavor results in p-Pb collisions with ALICE

Antonio Ortiz Velásquez for the ALICE Collaboration
(Universidad Nacional Autónoma de México)

September 28, 2015
Kobe, Japan
Outline

- Introduction
- Particle identification in ALICE
- Light flavor production in $\sqrt{s_{NN}} = 5.02$ TeV p-Pb collisions
  - $\pi, K, K^0_S, K^*, p, \phi, \Lambda, \Xi, \Omega$
  - Similarities between p-Pb and Pb-Pb collisions
- Summary
INTRODUCTION
p-A collisions together with pp were playing the role of control experiments. Why?

- To disentangle the so-called cold nuclear matter effects from those attributed to the hot and dense QCD medium (sQGP) produced in central heavy-ion collisions
But how cold is the “cold matter”?  
Striking findings in high multiplicity p-Pb events

- Long-range angular correlations on the near and away side
- Flow-like patterns
- Azimuthal flow

ALICE, PLB 719 (2013) 29-41
CMS, PLB 718 (2013) 795
ALICE, PLB 726 (2013) 164-177
ALICE, PLB 728 (2014) 25-38

ALI−PUB−52116

ALI−PUB−46246
THE ALICE DETECTORS
The ALICE apparatus

More information:
ALICE, IJMPA 29,1430044 (2014)
The ALICE apparatus

Forward detectors
V0 (trigger, multiplicity)
T0 (timing)

V0A detector: $2.8 < \eta_{\text{lab}} < 5.1$, positioned in the Pb-going direction
For small systems, the impact parameter \((b)\) is weakly correlated with the number of participants \((N_{\text{part}})\).

Particle production is therefore studied in intervals of event multiplicity. We use the same estimator \((V0A)\) used in the first ALICE publication on identified hadron production in \(p-Pb\) collisions.

ALICE, PLB 728 (2014) 25-38
The ALICE apparatus

Central barrel:
$2\pi$ tracking and PID
$|\eta|<1$, $B = 0.5$ T
(HMPID RICH: $|\eta|<0.6$, $\Delta\phi=57^\circ$)

Different PID techniques

Decay Topology

- TPC $dE/dx$
- HMPID
- TOF
- TPC $dE/dx$
- ITS $dE/dx$
Charged pion, kaon and (anti)proton yields extraction using different detectors

TOF
Fits to time of flight distributions

TPC
Fits to TPC dE/dx distributions

Topological identification

- $\Xi^-$ → $\Lambda\pi^-$
- $\Omega^-$ → $\Lambda K^-$
- $\Lambda$ → $p\pi^-$

Tracking:
TPC and ITS

PID:
TPC dE/dx

Resonances

- $\phi$ → $K^+K^-$
- $K^*^0$ → $K^+\pi^-$

Tracking:
TPC and ITS

PID:
TOF
TPC dE/dx

Data, like-sign bkg subtracted
Breit-Wigner peak fit
Residual background
Statistical uncertainties
RESULTS
$p_T$ spectra vs. multiplicity

Similarities to Pb-Pb results are observed:
- A multiplicity- and mass-dependent flattening of the $p_T$ spectra at low $p_T$ ($< 2$ GeV/c)

$\pi^+ + \pi^-$

$\nu(p-Pb, \sqrt{s_{NN}} = 5.02 \text{ TeV})$

$p + \bar{p}$

$\nu(p-Pb, \sqrt{s_{NN}} = 5.02 \text{ TeV})$

$0<y_{\text{cms}}<0.5$ for $p_T < 2.0$ GeV/c

$0<y_{\text{cms}}<0.3$ for $p_T > 2.0$ GeV/c

$0<y_{\text{cms}}<0.5$ for $p_T < 3.0$ GeV/c

$0<y_{\text{cms}}<0.3$ for $p_T > 3.0$ GeV/c

V0A multiplicity
- 0-5% (64x)
- 5-10% (32x)
- 10-20% (16x)
- 20-40% (8x)
- 40-60% (4x)
- 60-80% (2x)
- 80-100% (1x)
Blast-Wave fit results

To study the multiplicity evolution of the spectral shapes we made a simultaneous Blast-Wave fit to $\pi$, K, p and $\Lambda$ $p_T$ spectra

- Qualitatively similar behavior observed for p-Pb and Pb-Pb collisions
- Larger radial flow parameter obtained in p-Pb than in Pb-Pb collisions for a similar multiplicity
Blast-Wave fit results

To study the multiplicity evolution of the spectral shapes we made a simultaneous Blast-Wave fit to $\pi$, $K$, $p$ and $\Lambda$ $p_T$ spectra.

But care needs to be taken with the interpretation because the model also describes the $p_T$ spectra of $pp$ events generated with Pythia 8, where no hydro expansion is assumed.

PRL 111 (2013) 4, 042001
Blast-Wave fit results

To study the multiplicity evolution of the spectral shapes we made a simultaneous Blast-Wave fit to $\pi$, $K$, $p$ and $\Lambda$ $p_T$ spectra. But care needs to be taken with the interpretation because the model also describes the $p_T$ spectra of pp events generated with Pythia 8, where no hydro expansion is assumed.

PRL 111 (2013) 4, 042001

ALICE, PLB 728 (2014) 25-38

ALICE, Pb-Pb, $\sqrt{s_{NN}} = 5.02$ TeV
V0A Multiplicity Classes (Pb-side)
ALICE, Pb-Pb, $\sqrt{s_{NN}} = 2.76$ TeV
ALICE, pp, $\sqrt{s} = 7$ TeV
PYTHIA8, $\sqrt{s} = 7$ TeV (with Color Reconnection)
PYTHIA8, $\sqrt{s} = 7$ TeV (without Color Reconnection)
The Blast-wave model is compared to the $p_T$ distributions of $\Xi^-$ and $\Omega^-$.

- Using the parameters obtained from the simultaneous fit to $\pi$, $K$, $p$ and $\Lambda$, the model describes the $\Xi^-$ and $\Omega^-$ $p_T$ spectra.

Common kinetic freeze-out describes the spectra in high multiplicity p-Pb collisions.

- This feature is also observed in pp events simulated with Pythia 8.

- In central heavy-ion collisions, the multi-strange particles experience less transverse flow.

**V0A Multiplicity Class: 0-5%**

- ALICE Preliminary, p-Pb, $\sqrt{s_{NN}} = 5.02$ TeV
- V0A Multiplicity Class (Pb-side): 0-5%

**Data / Model**

- $1/N_{ev} \cdot 1/2p_Td^2N/d^2y$ [GeV/(c)$^2$]
- $p_T$ range: 0.5-1.0 GeV/c

**ALICE**

September 28, 2015
Antonio Ortiz for the ALICE Collaboration

**Quark Matter 2015**
At intermediate $p_T$ (2<$p_T<$10 GeV/c), the proton-to-pion ratio increases with event multiplicity.

The behavior of this increase is qualitatively similar to that observed in Pb-Pb collisions.

At high $p_T$ (>10 GeV/c) the particle ratios in p-Pb and Pb-Pb are consistent.
At intermediate $p_T$ the proton $R_{p\text{Pb}}$ shows a Cronin-like enhancement, while pions and kaons show little or no nuclear modification.

At higher $p_T$, the pion, kaon and proton $R_{p\text{Pb}}$ are consistent with unity.
The reduction of the $K^*/K^-$ ratio going from pp to central Pb-Pb collisions is usually attributed to be a consequence of re-scattering of $K^*$ decay daughters in the hadronic phase. *ALICE, PRC 91 (2015) 024609*

Results for p-Pb collisions are consistent with peripheral Pb-Pb collisions
Summary

Several similarities between p-Pb and Pb-Pb collisions have been reported

- $p_T$ spectra show flow-like behavior
- Multiplicity dependence of the proton-to-pion ratio vs. $p_T$ in p-Pb collisions is qualitatively similar to the centrality evolution of this ratio in Pb-Pb collisions
- Indication of strangeness enhancement in pp and p-Pb collisions (not covered here but the results will be presented by Livio Bianchi: 29/09/2015, 15:20)
- See also: Natasha Sharma’s talk on nuclei production in p-Pb (28/09/2015, 12:35)
At intermediate $p_T$ (2\textless{}$p_T$\textless{}10 GeV/c), the proton-to-pion ratio increases with the event multiplicity. The behavior of this increase is qualitatively similar to that observed in Pb-Pb collisions. At high $p_T$ (>10 GeV/c) the particle ratios in p-Pb and Pb-Pb are consistent.

Also in INEL $\sqrt{s} = 2.76$ TeV pp collisions the “bump” at intermediate $p_T$ is observed.