Light Flavour Hadron Production in pp Collisions at 13 TeV with ALICE at the LHC

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Motivation

- $\phi/K$ ratios are observed to be independent of $\sqrt{s}$ in pp collisions at the LHC up to 7 TeV
- It is interesting to determine if this $\sqrt{s}$ independence will continue at 13 TeV
- Event generators describe the shape of the $K/\pi$ and $p/\pi$ ratios as a function of $p_T$, but fail to describe these ratios quantitatively
ITS: Tracking, vertexing and PID via $dE/dx$ measurement

V0: Triggering and multiplicity estimation

TOF: PID via time of flight measurement

TPC: Tracking and PID via $dE/dx$ measurement

HMPID: PID via Cherenkov angle measurement

ALICE Detector

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Identification of $\pi$, $K$, $p$

**Data Set:**
pp 13 TeV
Run II (2015)

**Trigger:** Minimum Bias

**Analyzed events:** ~48M

**ITS**
\[ \frac{dE}{dx} \propto \frac{1}{\beta^2} \]
\[ \beta = \frac{1}{\sqrt{1+m^2/p^2}} \]

**TPC**
\[ \frac{dE}{dx} \propto \frac{1}{\beta^2} \] (low $p_T$)
\[ \frac{dE}{dx} \propto \log(\beta\gamma) \] (high $p_T$)

**TOF**
\[ \beta = \frac{L}{t} \]
Invariant Mass Reconstruction

\[ K^0 \rightarrow K^+ \pi^- \]

BR: 66.6%
M = 0.896 GeV/c^2

\[ K^0 \rightarrow \phi K^- \]

BR: 48.9%
M = 1.019 GeV/c^2

\[ K^0 \rightarrow \phi K^- \]

BR: 99.9%
M = 1.3217 GeV/c^2
Particle Ratios vs $\sqrt{s}$

$K/\pi$ and $p/\pi$ ratios remain constant for $\sqrt{s} \geq 900$ GeV
Resonance to stable hadron ratios remain constant as a function of $\sqrt{s}$ in pp collisions.

Decrease of $K^*/K$ ratio in heavy-ion collisions with respect to pp collisions can be understood as hadronic medium effect.
The increase of hyperon-to-pion ratios as a function of multiplicity has been observed in pp collisions at $\sqrt{s} = 7$ TeV

In minimum bias pp collisions at $\sqrt{s} = 13$ TeV ratios are slightly larger compared to lower energies

Is it due to the increase in $<N_{\text{ch}}>$?

--- Investigated further by studying multiplicity dependence of ratios in pp collisions at $\sqrt{s} = 13$ TeV
Particle Ratio vs $p_T$

- **pp collisions:**
  - $p/\phi$ ratios are similar at $\sqrt{s} = 7$ TeV and 13 TeV
  - Decrease with increasing $p_T$.

- **Pb-Pb central collisions:**
  - $p/\phi$ ratio is flat for $p_T < 4$ GeV/c
  - Consistent with hydrodynamic evolution.

- **High-multiplicity p-Pb collisions:**
  - Same $p/\phi$ ratio as in pp collisions for $p_T > 1$ GeV/c
  - Flattening for $p_T < 1$ GeV/c
  (hint of collective behaviour in small systems like p-Pb?)
**Particle Ratios vs $p_T$**

- $p/\pi$ ratio shifts towards higher $p_T$ for higher $\sqrt{s}$
- $K/\pi$ ratio shows no significant modification

**Graph Details**

- **ALICE**
  - $pp \sqrt{s} = 2.76$ TeV
  - $pp \sqrt{s} = 7$ TeV
  - $pp \sqrt{s} = 13$ TeV (Preliminary)

**Equations**

\[
\frac{(p + \bar{p})}{(\pi^+ + \pi^-)} \quad \text{and} \quad \frac{(K^+ + K^-)}{(\pi^+ + \pi^-)}
\]
Pythia 8 describes the $p_T$ dependence of ratios qualitatively.
Summary

★ First identified particle measurements in pp collisions at $\sqrt{s} = 13$ TeV

★ $p/\pi$, $K/\pi$, $K^0/K$, $\phi/K$ ratios do not show any significant energy dependence for $\sqrt{s} \geq 900$ GeV

★ $\Xi^-/\pi$ and $\Omega^-/\pi$ ratios show a slight increase compared to lower energy measurements

★ No flattening is observed for $p/\phi$ ratio as a function of $p_T$ in inelastic pp collisions

Next steps:

★ Study the multiplicity dependence of particle production in pp at 13 TeV, with special focus on the strangeness sector where ALICE has recently observed an increase of strange particle production with multiplicity  

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THANK YOU