1. Physics Motivation

- Short-lived hadronic resonances are considered as sensitive probes of the hadronic medium present in the late stages of heavy-ion collisions.
- As their lifetimes are comparable to that of hadronic medium, the measurable yields of hadronic resonances can be affected by elastic re-scattering of their decay daughters and regeneration in the hadronic phase.
- The study of the nuclear modification factor ($R_{AA}$) provides information on parton energy loss in the medium.
- Recently, measurements of the $\rho$, $K^{*0}$, $\phi$, $\Lambda(1520)$ and $\Xi^{0}$ resonances have been carried out in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV using ALICE at the LHC.

<table>
<thead>
<tr>
<th>Particle</th>
<th>$\rho$</th>
<th>$K^{*0}$</th>
<th>$\phi$</th>
<th>$\Lambda(1520)$</th>
<th>$\Xi^{0}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass (GeV/c$^2$)</td>
<td>0.775</td>
<td>0.891</td>
<td>1.019</td>
<td>1.519</td>
<td>1.531</td>
</tr>
<tr>
<td>Mean Lifetime (fm/c)</td>
<td>1.3</td>
<td>4.2</td>
<td>46.2</td>
<td>12.6</td>
<td>21.7</td>
</tr>
</tbody>
</table>

2. A Large Ion Collider Experiment (ALICE)

Detectors used for these analyses:
- Inner Tracking system (ITS)
- Tracking
- Vertexing
- V0 detectors (V0A & V0C)
- Centrality determination in Pb-Pb collisions
- Time Projection Chamber (TPC)
- Main tracking detector
- Particle identification (PID)
- Momentum measurement
- Time of Flight (TOF)
- PID via time of flight measurement

Schematic drawing of the ALICE detector at the LHC

3. Hadronic resonance production

- Measurement performed in the rapidity range $|y| < 0.5$ for different centrality classes.

4. Mean transverse momentum ($<p_T>$)

- Steeper increase of $<p_T>$ is observed for $K^{*0}$ and $\phi$ in smaller systems compared to Pb-Pb collisions.
- $<p_T>$ is same for $K^{*0}$, proton and $\phi$ in central Pb-Pb collisions, which is consistent with what we would expect from a common hydrodynamical expansion of the system.
- Splitting of $<p_T>$ is observed for proton and $\phi$ in peripheral Pb-Pb collisions.
- $<p_T>$ of $\Lambda(1520)$ increases with system size, which is well described by EPOS with UrQMD. Without re-scattering interactions in the hadronic phase (UrQMD off), the EPOS model fails to describe the data.

5. Particle Ratios

- Suppression of $\rho$, $K^{*0}$ and $\Lambda(1520)/$Pb-Pb collisions, which is consistent with what we would expect from a common hydrodynamical expansion of the system.
- No significant dependence of $\Sigma^{0}$/system size, significant suppression with respect to thermal model is observed.
- EPOS can qualitatively describe the suppression of the $p$/Pb-Pb and $\Lambda(1520)/$Pb-Pb ratios as well as the flat behavior of the $\phi$/Pb-Pb and $\Xi^{0}$/Pb-Pb ratios.
- Suppression in Pb-Pb collisions can be interpreted as dominance of re-scattering.
- $K^{*0}$/Pb-Pb and $K^{0}$/Pb-Pb ratios at low $p_T$ are lower in Pb-Pb than in pp. However, the $\phi$/Pb-Pb and $\Xi^{0}$/Pb-Pb ratios at low $p_T$ are consistent for pp and Pb-Pb. These results suggest re-scattering for $K^{*0}$.

6. Nuclear Modification factor ($R_{AA}$)

- $R_{AA}$ is defined as the ratio of yields in Pb-Pb collisions to those in pp, scaled by number of binary nucleon-nucleon collisions.
- $R_{AA} = 1$ implies no medium modification.
- Strong suppression with respect to pp collisions is observed for $K^{*0}$, $\phi$ and $\rho$ as well as for stable hadrons.
- At high $p_T$, all the light-flavor hadrons are suppressed by the same amount.

7. Summary

- New results on hadronic resonances in Pb-Pb collisions at 2.76 TeV are presented.
- Steeper increase in $<p_T>$ is observed in small systems compared to Pb-Pb collisions.
- Suppression of short-lived resonance yields is observed from peripheral to central Pb-Pb collisions, which suggest the presence of re-scattering effects in hadronic phase. $\phi$ behaves instead as a long-lived particle.
- The study of nuclear modification factor for light flavor hadrons is suggestive of flavor-independent parton energy loss at high $p_T$.

8. References

1. ALICE Collaboration, J. Adam et al., “$K^{(892)}$ and $\rho(1020)$ meson production at high transverse momentum in pp and Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV”, arXiv: 1702.00555 [nucl-ex].