Event shape and multiplicity dependence of $K^{*}(892)^\pm$ at midrapidity in pp collisions at $\sqrt{s} = 13$ TeV with ALICE at the LHC

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- Resonances are the perfect probes to characterize the system formed in heavy-ion collisions at ultrarelativistic energies.

- $K^{*\pm}$ resonance is particularly interesting because of its very short lifetime ($\sim 4$ fm/c), comparable to the one of the hadronic phase → it may be sensitive to the competing rescattering and regeneration mechanisms.

- An event shape observable like transverse spherocity ($S_0$) is sensitive to hard ($S_0 = 0$) and soft processes ($S_0 = 1$). Such an observable can be used as a tool to disentangle pp collisions into isotropic (dominated by soft QCD) and jetty (dominated by hard QCD) events.

- Although pp collisions are used as a baseline for heavy-ion collisions, recent preliminary results for $K^{*\pm}$ production as a function of multiplicity and spherocity in pp collisions at $\sqrt{s} = 13$ TeV show the onset of phenomena typical of heavy-ion collisions, like collective behaviour and suppression of the yield ratios of resonances to stable particles.
**K^{*±} resonance reconstruction**

- Signal reconstructed via **invariant mass distribution** of the decay daughters: \( K^{*±} \rightarrow π^± + K^0_S \); \( K^0_S \) identified via \( K^0_S \rightarrow π^+ + π^- \), and \( π^± \) via \( dE/dx \) in the TPC.
- **Uncorrelated background** estimated via event mixing technique.
- After the uncorrelated background subtraction, the remaining distribution is fitted with a **NR Breit-Wigner + residual background** (expol) function \( F_{BG} \):

\[
F_{BC}(M_{Kπ}) = \frac{A}{2π(M_{Kπ} - M_0)^2 + \Gamma_0^2} + F_{BG}
\]

\[
F_{BC}(M_{Kπ}) = [M_{Kπ} - (m_π + m_K)]^n \exp(A + BM_{Kπ} + CM_{Kπ}^2)
\]
$K^\pm p_T$ spectra, $\langle p_T \rangle$, and $dN/dy$

- $p_T$ spectra get harder with increasing multiplicity → flow-like effect
- Lower panel: ratios of $p_T$ spectra to INEL>0. For $p_T < 5$ GeV/c spectra increase from low to high multiplicity classes. Same spectral shape for $p_T > 5$ GeV/c → Process dominant at low $p_T$

Comparable results for $K^{\pm}$ and $K^0$ with lower systematic uncertainties for $K^{\pm}$ measurements
The \( K^{*0} / K_S^0 \) trend in pp collisions at \( \sqrt{s} = 13 \text{ TeV} \) confirms the \( K^{*0} / K_S^0 \) suppression even within the systematic uncertainties \( \rightarrow \) rescattering effects in small systems?

\( K^{*0} (K^{*0} \rightarrow K^+ \pi^\pm) \) results have been confirmed and even improved by \( K^{*\pm} \) measurements thanks to the higher precision reached. In the inclusive analysis of \( K^{*\pm} \) production in pp collisions (\textit{Phys.Lett.B 828 (2022) 137013}) this has been attributed to the different strategies used for \( K_S^0 \) and \( K^\pm \) identification in ALICE.
Transverse spherocity results for high multiplicity events

$p_T$ spectra

**Upper panel :** $p_T$ spectra considering 20% (A) and 10% (B) spherocity classes; **Lower panel :** Ratio with integrated events.

**Observation:** Clear dominance of isotropic events for both (A) and (B). This dominance seems to decrease with increasing $p_T$ within systematic uncertainties and jetty events take over at high $p_T$.

\[
\begin{align*}
\text{(A)} & \quad \text{ALICE Preliminary} \\
\text{pp, } \sqrt{s} = 13 \text{ TeV} \\
(1-3) \text{ VOM Mult. class} \\
(K^+ + K^-)/2, |y| < 0.5 \\
\text{Ratio to } S_{0,1}^{\text{int.}} \\
\end{align*}
\]

\[
\begin{align*}
\text{(B)} & \quad \text{ALICE Preliminary} \\
\text{pp, } \sqrt{s} = 13 \text{ TeV} \\
(1-3) \text{ VOM Mult. class} \\
(K^+ + K^-)/2, |y| < 0.5 \\
\text{Ratio to } S_{0,1}^{\text{int.}} \\
\end{align*}
\]

Particle ratios

**Upper panel :** $K^*\pm$ ratio to (C) kaon and (D) proton with spherocity class; **Lower panel :** Ratio of event shape with integrated event.

**Observation:** No significant dependence on the event shape classes except the first three $p_T$ bins for both (C) and (D).

**Summary and Conclusions**

- First measurements of $K^{*}\pm$ production at $|y| < 0.5$ in pp collisions at $\sqrt{s} = 13$ TeV at different $S_0$ and VOM classes have been reported here.
- Preliminary results show the typical onset of collective-like phenomena (hardening of the $p_T$ spectra and suppression of $K^{*\pm}/K_S^0$) → possible hadronic phase in small systems too?