Production of strange particles in charged jets in Pb–Pb collisions, as measured with ALICE

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Introduction

The baryon-to-meson ratio of inclusive light particles in heavy-ion collisions manifests a strong increase at intermediate p_{T} with respect to the ratio in proton–proton collisions. This phenomenon was first observed at the Relativistic Heavy Ion Collider (RHIC) and later measured in the inclusive p/π and $\Lambda/\mathrm{K}^0_{\mathrm{S}}$ ratios in ALICE (see Fig. 1). It cannot be explained by fragmentation. Other hadronisation mechanisms, like coalescence or parton recombination, have been proposed instead. The production of $\mathrm{K}^0_{\mathrm{S}}$ and Λ in jets will allow to assess whether hadronisation in jets is also affected in a similar way.

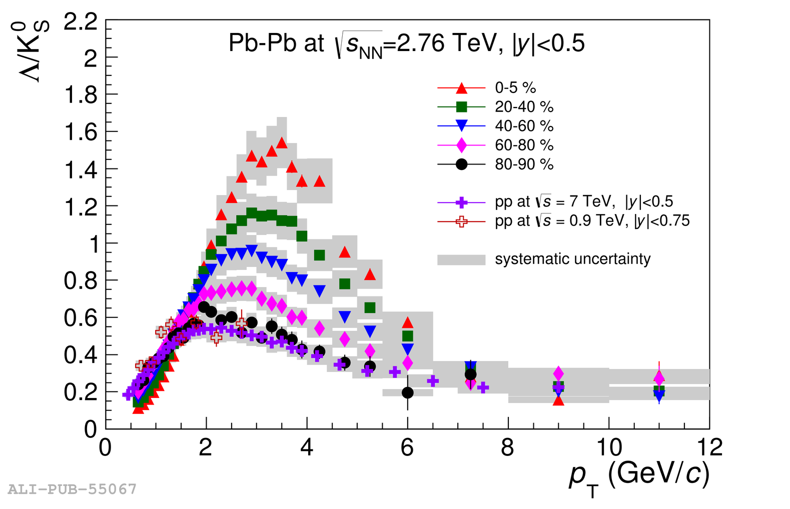


Figure 1: Inclusive $\Lambda/\mathrm{K}^0_{\mathrm{S}}$ ratio in Pb–Pb and pp collisions [1].

Measurement of neutral strange particles

$\mathrm{K}^0_{\mathrm{S}}$ mesons and Λ baryons are strange hadrons which decay by the weak interaction into two charged daughter particles. The candidates for V^0 particles are found by combining detected particles of opposite electric charges. The fraction of combinatorial background is suppressed by applying cuts on specific parameters of the decay topology (see Fig. 2). The signal yield is extracted from the resulting invariant-mass distribution.

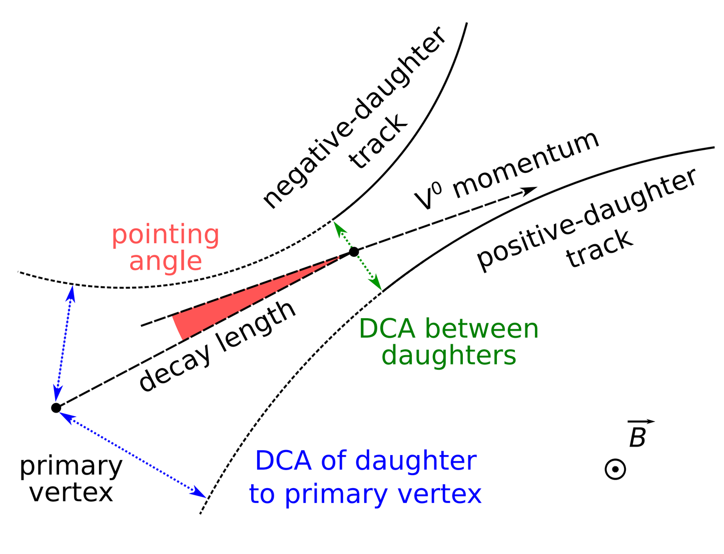


Figure 2: Topological parameters of a V^0 decay.

Measurement of particles in charged jets

A jet is a bunch of collimated hadrons produced in a hard parton scattering. The measurement of the identified-particle production at low momenta in jets allows to assess whether interactions of the jet constituents with the medium affect the particle composition in jets.

Jets are reconstructed from charged primary particles detected with the Inner Tracking System and the Time Projection Chamber within the central barrel of ALICE in a pseudorapidity acceptance of $|\eta_{\mathrm{track}}| < 0.9$. Tracks with $p_{\mathrm{T}} > 150\,\mathrm{MeV}/c$ are clustered into jets using the anti-k_{t} algorithm [2, 3] with resolution parameters $R = 0.2, 0.3$.

Jets reconstructed in heavy-ion collisions are contaminated by soft particles from the underlying event (UE). In order to suppress this contribution, the average background density is estimated in each event and subtracted from the jet momenta. Jets used for the analysis are further filtered (e.g. by requiring $p_{\mathrm{T}}^{\text{leading track}} > 5\,\mathrm{GeV}/c$) in order to increase the probability of selecting real jets originating in a hard-scattering process.

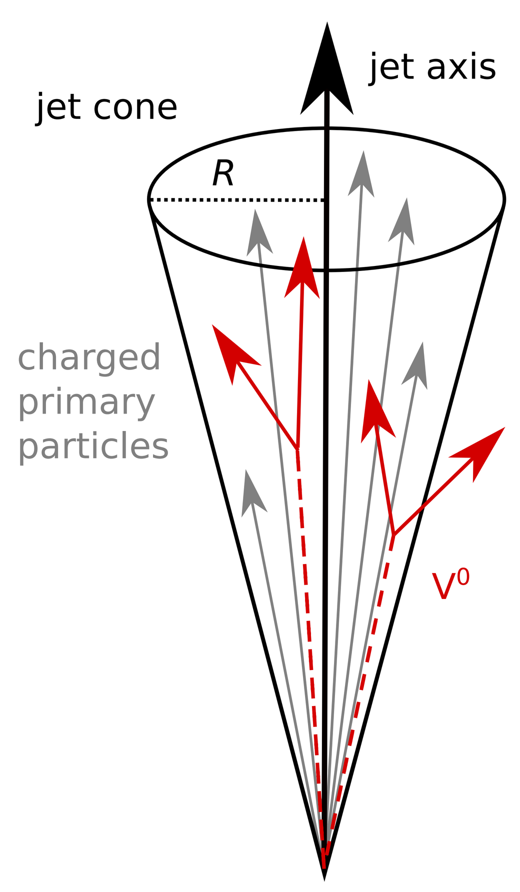
The acceptance of selected jets is required to match the acceptance of reconstructed V^0 particles which is ensured by the criterion

$$|\eta_{\mathrm{jet}}^{\mathrm{ch}}|^{\max} < |\eta_{\mathrm{V}^0}|^{\max} - R.$$

The V^0 particles are associated with the jets using a geometrical condition

$$D = \sqrt{(\varphi_{\mathrm{V}^0} - \varphi_{\mathrm{jet}}^{\mathrm{ch}})^2 + (\eta_{\mathrm{V}^0} - \eta_{\mathrm{jet}}^{\mathrm{ch}})^2}, \qquad D < R.$$

The selected particles do not come only from the jet fragmentation but also from the underlying event which has to be properly estimated and subtracted.



References

[1] ALICE Collaboration. "$\mathrm{K}^0_{\mathrm{S}}$ and Λ production in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$". Phys. Rev. Lett. **111** (2013) 222301.

[2] M. Cacciari, G. P. Salam and G. Soyez. "FastJet user manual". Eur. Phys. J. C **72** (2012) 1896.

[3] M. Cacciari, G. P. Salam and G. Soyez. "The anti-k_t jet clustering algorithm". JHEP **0804** (2008) 063.

Uncorrected spectra of $\mathrm{K}^0_{\mathrm{S}}$ and Λ in jet cones

Spectra of $\mathrm{K}^0_{\mathrm{S}}$ and Λ in jets are measured in the 0–10% most central Pb–Pb collisions for two values of the jet resolution parameter ($R = 0.2, 0.3$) and two intervals of the jet momentum ($p_{\mathrm{T,jet}}^{\mathrm{ch}} > 10\,\mathrm{GeV}/c, 20\,\mathrm{GeV}/c$). The raw p_{T} spectra are shown in Fig. 3.

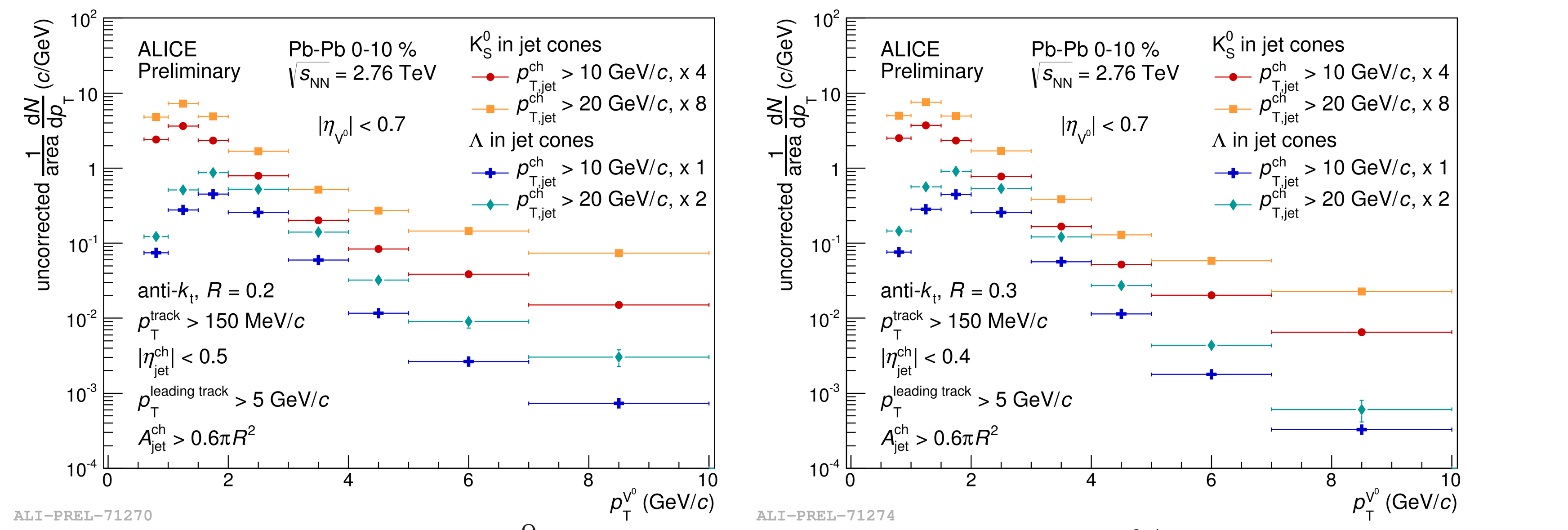


Figure 3: Raw spectra of $\mathrm{K}^0_{\mathrm{S}}$ and Λ in jet cones in the 0–10% most central Pb–Pb collisions for $R = 0.2, 0.3$.

Estimation of the underlying event

The spectra of V^0 particles in the underlying event are estimated by 5 methods, using particles:

- in events with no selected jet,
- outside jet cones,
- in random cones which do not overlap with selected jets,
- in median-cluster cones,
- in perpendicular cones.

The uncorrected spectra are compared in Fig. 4. After the efficiency correction, they differ by less than 5 % at intermediate p_{T}.

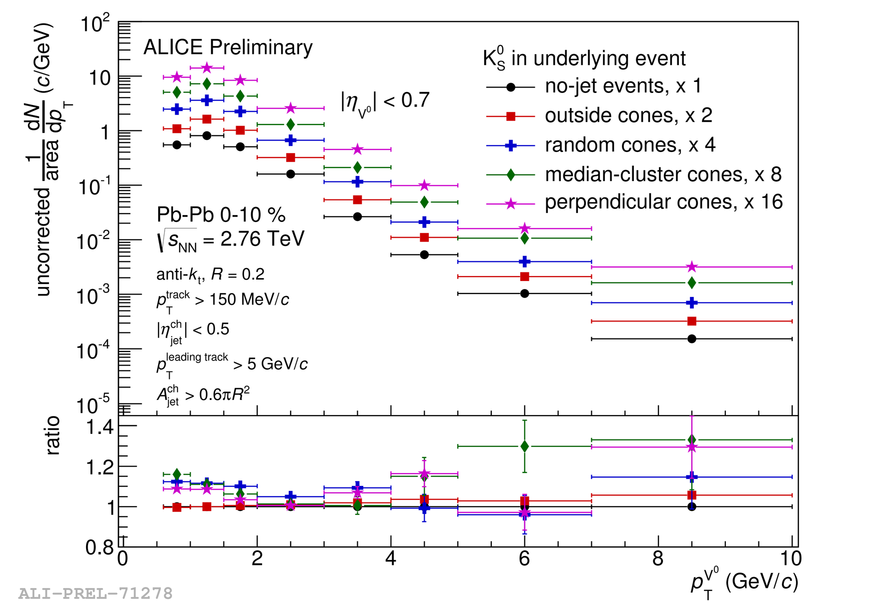


Figure 4: Estimated uncorrected spectrum of $\mathrm{K}^0_{\mathrm{S}}$ mesons in the underlying event.

Reconstruction efficiency of V^0 particles

The reconstruction efficiencies of inclusive V^0 particles are shown as a function of $p_{\mathrm{T}}^{\mathrm{V}^0}$ in Fig. 5. The efficiencies and the measured distributions of particles in jet cones and in the UE depend strongly on $p_{\mathrm{T}}^{\mathrm{V}^0}$ and on η_{V^0}. The p_{T}-dependent efficiency used for the correction must be calculated for each particle sample separately.

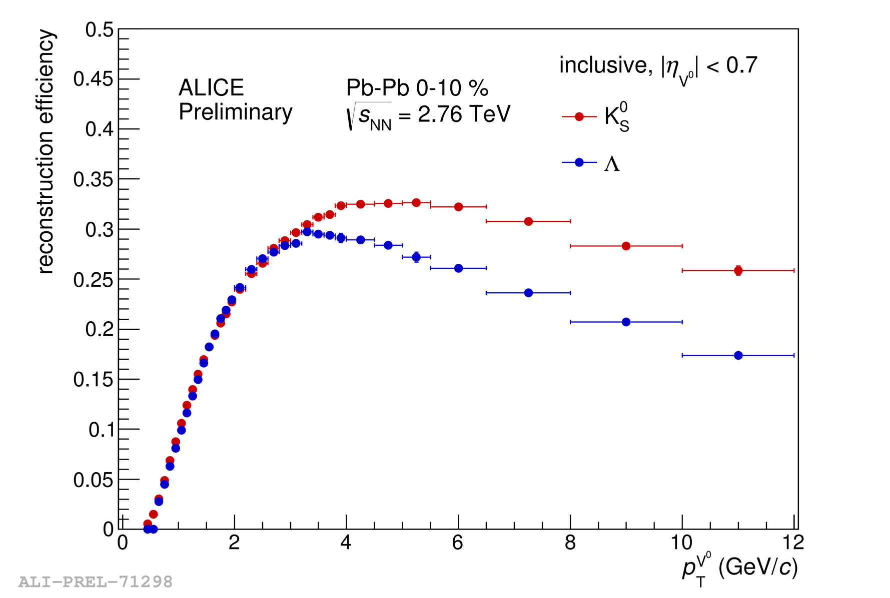


Figure 5: Reconstruction efficiency of inclusive V^0 particles.

Estimation of the feed-down fraction

The spectra of measured Λ baryons must be corrected for the feed-down contribution from the decays of $\Xi^{0,-}$ baryons. The contribution relative to the raw signal depends on the V^0-selection criteria. To determine this fraction in jets, one would need spectra of $\Xi^{0,-}$ baryons in jets, which have not been measured yet. Fig. 6 shows the fraction estimated with inclusive Λ baryons and with the Λ baryons in jets from PYTHIA 8 which can be used as a reasonable upper and lower bound for the expected values.

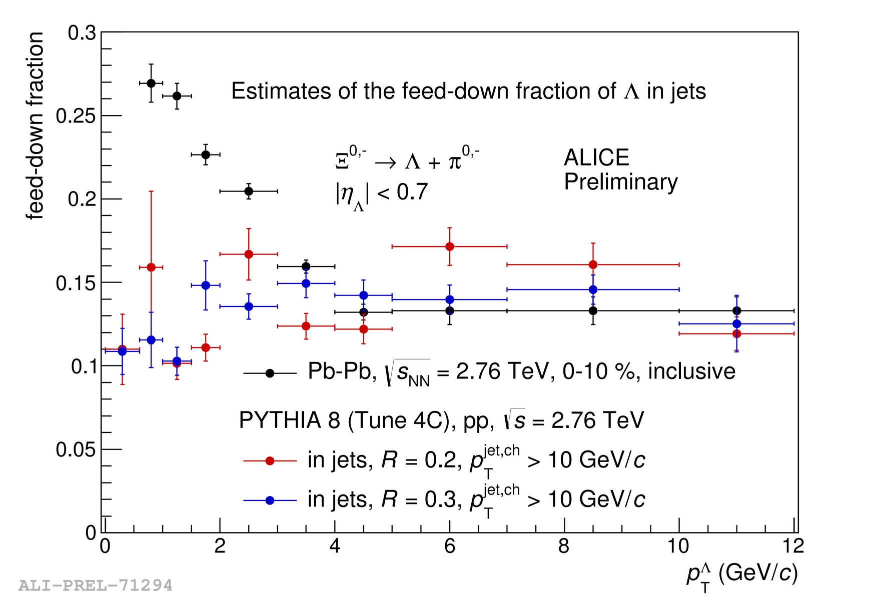


Figure 6: Estimates of the feed-down fraction of Λ baryons in jets.

Summary and Outlook

We have presented the key parts of an analysis which will lead soon to the first fully corrected spectra of $\mathrm{K}^0_{\mathrm{S}}$ mesons and Λ baryons in reconstructed charged jets in heavy-ion collisions.