Strangeness production in pp collisions at $\sqrt{s}$ = 13 TeV measured with ALICE

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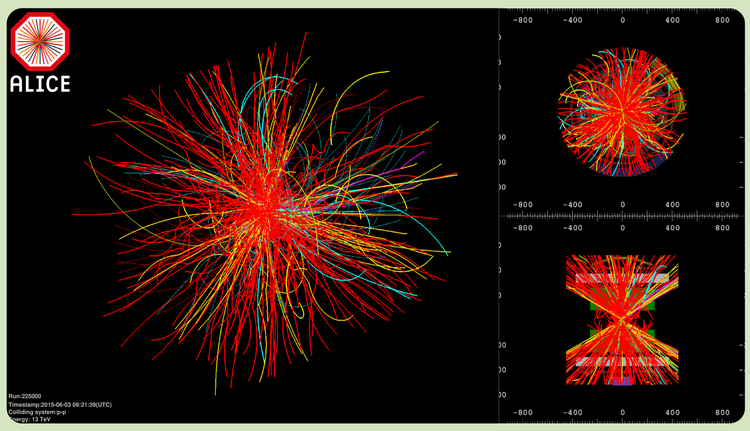
PHYSICS MOTIVATION

- Strange hadrons are useful probes to investigate particle production mechanisms in high-energy collisions. Since there is no net strangeness content in the colliding system, all particles with non-zero strangeness quantum number are created in the course of the collision.
- In the context of the strangeness enhancement [J. Rafelski and B. Müller, PRL 48, 1066 (1982); P. Koch, J. Rafelski and W. Greiner, PLB 123, 151 (1983)], the study of the excitation function for strange and especially multi-strange particles is of particular interest.
- A recent study of the strangeness production in pp collisions at $\sqrt{s}$ = 7 TeV as a function of multiplicity reveals the importance of such measurements in understanding changes in production mechanisms and in understanding the larger colliding systems.
- A further interesting observable to be investigated at this energy is the baryon/meson ratio of Λ/K^0_S to study the baryon-to-meson anomaly.



IDENTIFICATION OF STRANGE PARTICLES IN ALICE

We measure the strange hadrons [K^0_S, Λ, Ξ^- and Ω^-] and their anti-particles, which are identified in ALICE via the detection of their weak decay products. The Λ and K^0_S are characterized by a distinctive V-shaped decay topology and are known as **V⁰**, while the Ξ^- or Ω^- decay into a charged meson and a Λ, which further decays into a proton and a pion. Since the reconstruction of a Ξ^- and Ω^- requires the detection of the three charged daughter tracks, these are known as **cascades**.

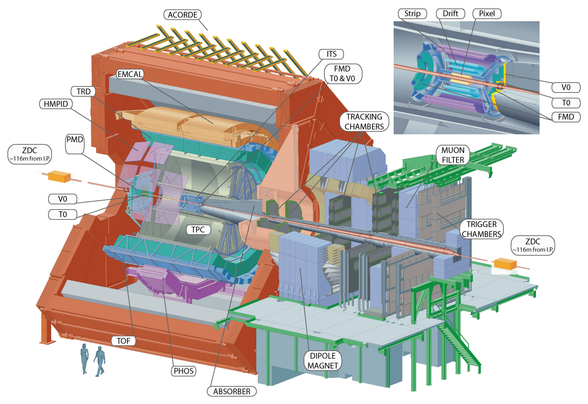
$$K^0_S \rightarrow \pi^+\pi^- \quad (B.R.\ 69.2\%)$$
$$\Lambda(\bar{\Lambda}) \rightarrow p\pi^-(\bar{p}\pi^+) \quad (B.R.\ 63.9\%)$$
$$\Xi^-(\bar{\Xi}^+) \rightarrow \Lambda\pi^-(\bar{\Lambda}\pi^+) \quad (B.R.\ 99.9\%)$$
$$\Omega^-(\bar{\Omega}^+) \rightarrow \Lambda K^-(\bar{\Lambda}K^+) \quad (B.R.\ 67.8\%)$$

The V^0 finding procedure consists of the following steps:

1. charged tracks reconstructed using the ITS and TPC and having a large impact parameter (IP) to the primary vertex are selected as candidate decay daughter (denoted 'secondary' here) tracks
2. all these tracks are combined with other secondary tracks having opposite charge
3. specific ionization in the TPC (Figure 1) is used to identify daughter particles
4. selections based on topological variables, such as distance of closest approach (DCA) between the two tracks, fiducial volume for the secondary vertex position and cosine of pointing angle (PA) are applied (pictorial representation in Figure 2)

The cascade finding procedure consists in:

1. looking for all V^0 candidates that has a large impact parameter with respect to the primary vertex, point to the cascade decay vertex and has a reconstructed mass within a window around the PDG mass value
2. combining these V^0 candidates with all possible secondary tracks (bachelor candidates) using TPC PID also for these tracks
3. applying selections based on topological variables are applied: impact parameter of the bachelor, distance of closest approach between V^0 mother trajectory and the bachelor and cosine of pointing angle



Inner Tracking System [ITS] – 6 layers of silicon detectors (2 SPD, 2 SDD and 2 SSD) implementing 3 different technologies (pixels, drift and micro-strip) devoted to the primary and secondary vertex reconstruction and tracking at low p_T

Time Projection Chamber [TPC] - large cylindrical drift detector having end-caps equipped with 36 multi-wire proportional chambers devoted to tracking and particle identification through measurement of energy deposition in the gas volume (dE/dx)

V0 - two scintillator hodoscopes placed on either side of the interaction region devoted to trigger and background suppression

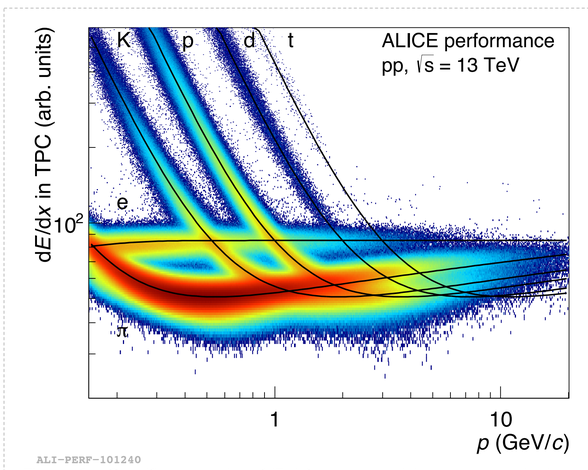


Figure 1 – Specific energy loss (dE/dx) versus particle momentum in the TPC. The lines show the parametrizations of the expected mean energy loss for pp collisions at $\sqrt{s}$ = 13 TeV.

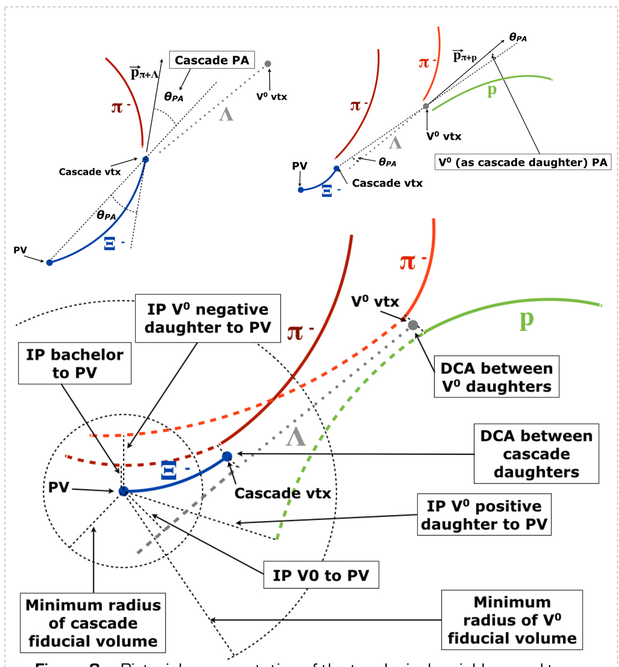


Figure 2 – Pictorial representation of the topological variables used to identify the cascade, similarly defined for the V^0.

DATA TAKING AND PERFORMANCE

Experimental data sample and event selections

The following results have been obtained using the first data collected by ALICE in pp collisions at $\sqrt{s}$ = 13 TeV delivered by LHC at the beginning of June 2015. Data were collected requiring a hit in the SPD or in one of the two V0 scintillators. Events with the following characteristics have been selected:

- vertex reconstructed not only using the TPC but also the SPD
- reconstructed vertex no more than 10 cm away from the center of ALICE in the z direction
- no pile-up present based on the SPD

About 55x10⁶ events have been analyzed, resulting in 49x10⁶ events after all the selections.

Signal extraction and MC data sample generation

To ensure tracks used for secondary vertex determination are of sufficient quality, the following set of track selections has been applied:

- tracks whose parameters have been successfully determined in all the steps of the reconstruction procedure based on a Kalman filter algorithm
- tracks that have been reconstructed using information from at least 70 clusters in the TPC (out of a maximum possible value of 159)
- $|\eta_{\text{daughter tracks}}| < 0.8$

In both cases (V^0 and cascade) the selection cuts are optimized in a second step to improve the signal over background ratio; the adopted values for cut on the topological variables are reported in Table 1. The invariant-mass distributions shown in Figure 3 are integrated in the full measured transverse momentum range and in rapidity range $|y| < 0.5$. The values of S/B and significance, estimated fitting the invariant mass distribution with a Gaussian plus a first degree polynomial function, are reported in Table 2.

For the acceptance-efficiency factor calculation a production using the Monte Carlo (MC) Event generator PYTHIA6 (tune Perugia-2011) has been considered for the V^0. In the case of multi-strange baryons, due to low yields, special MC productions have been generated reconstructing only events that contain at least one cascade in order to use computing resources more effectively. All the simulated particles are propagated through full ALICE geometry with the GEANT3 transport code.

Outlook

- Measure the transverse momentum spectra with statistical error in the bins containing lowest number of entries not greater than 5%
- Extract the yields and compare to the lower energy collision measurements to study their excitation function
- Compare the p_T shape of the spectra and the yields to predictions of MC event generators inspired on perturbative QCD, such as PYTHIA.

Table 1	K^0_S	Λ	Ξ	Ω
Max DCA V^0 daughters (cm)	1.0	1.0	1.6	1.6
Min V^0 cosine PA	0.97	0.995	0.97	0.97
Min V^0 radius fiducial volume (cm)	0.5	0.5	1.4	1.4
Min V^0 IP (cm)	--	--	0.07	0.07
Min V^0 positive daughter IP (cm)	0.06	0.06	0.04	0.03
Min V^0 negative daughter IP (cm)	0.06	0.06	0.04	0.03
Competing decay rejection (GeV/c²)	±0.005	±0.01	--	±0.008
Max V^0 proper lifetime (cm)	20	30	--	--
Max DCA cascade daughters (cm)	--	--	1.6	1.0
Min cascade bachelor IP (cm)	--	--	0.05	0.05
Min cascade cosine PA	--	--	0.97	0.97
Min cascade radius fiducial volume (cm)	--	--	0.8	0.6
Window around Λ mass (GeV/c²)	--	--	±0.008	±0.008

Table 2	K^0_S	Λ	$\bar{\Lambda}$	Ξ^-	$\bar{\Xi}^+$	Ω^-	$\bar{\Omega}^+$
Signal(S) / Background(B)	12.0	10.7	10.5	7.5	8.0	1.0	1.0
Significance (S / (S+B))	1568.4	802.3	783.2	217.9	215.9	37.5	37.9

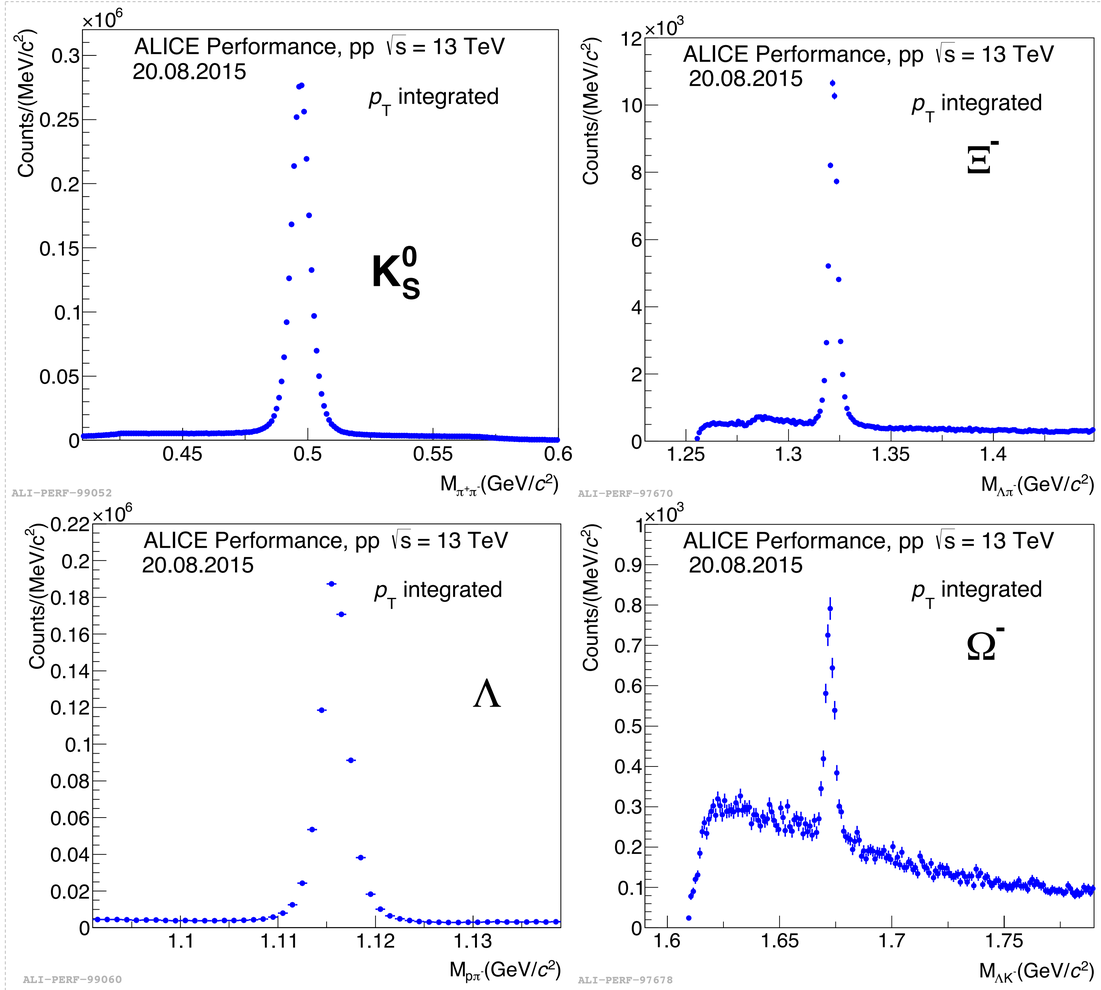


Figure 3 – Invariant-mass distributions for K^0_S, Λ, Ξ^- and Ω^- in pp collisions at $\sqrt{s}$ = 13 TeV.

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