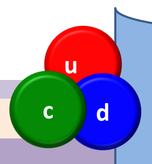
A Large Ion Collider Experiment

Università degli Studi di Salerno

Λ_c studies in pp and p-Pb collisions with ALICE at the LHC

Elisa Meninno on behalf of the ALICE Collaboration



Λ_c is the lightest open charm baryon:
Mass ~ 2286.46 MeV/c²
cτ ~ 59.9 μm

Introduction

Why study Λ_c?

- **Charm** is a very sensitive probe of the **Quark-Gluon Plasma** (QPG), produced in ultra-relativistic heavy-ion collisions. Charm quarks produced in hard parton scattering processes in the early stages of the collision, traverse the QCD medium, interact with its constituents and experience the whole evolution of the medium.
- Together with charmed mesons, the measurement of Λ_c in Pb-Pb collisions could give an insight into the hadronization mechanisms in the QGP, measuring the **baryon over meson ratio** in the heavy-quark sector [1].

Λ_c in pp collisions

- Useful test for perturbative Quantum Chromo Dynamics (pQCD)
- Total cross section of charm production at the LHC with ALICE.

Baryon cross section needed in addition to the D-meson cross section.

- Existing Λ_c measurements in pp collisions are in a different energy [2] or kinematic regime [3].
- Reference for Pb-Pb collisions.

Λ_c in p-Pb collisions

- Reference for Pb-Pb collisions.
- Study of cold nuclear matter effects not due to the QGP formation, such as modification of the Parton Distribution Functions (PDF), k_T broadening or energy loss.
- Total cross section of charm production at the LHC with ALICE.

Λ_c decay channels studied in ALICE

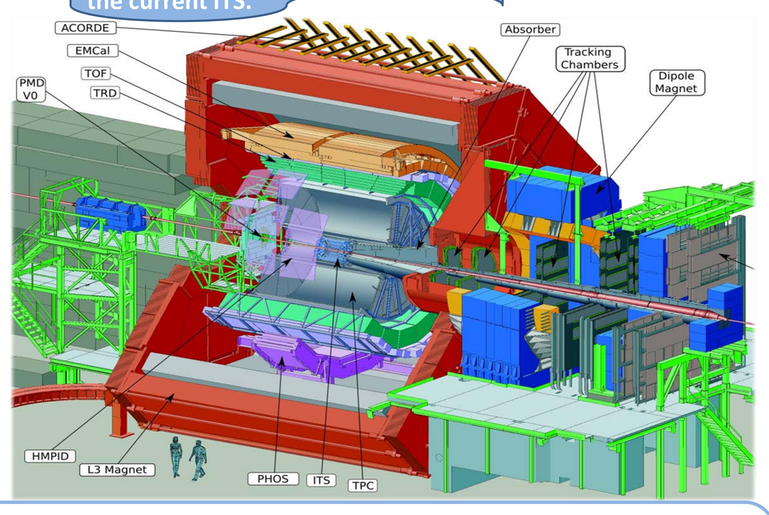
- $\Lambda_c^+ \to pK^-\pi^+$ and charge conjugate (c.c.)
  - non-resonant: B.R. = (3.8 ± 0.4)%
  - resonant: p K*(892): B.R. = (2.13 ± 0.30)%
  - Λ(1232)⁺⁺ K⁻: B.R. = (0.86 ± 0.30)%
  - Λ(1520) π⁺: B.R. = (2.4 ± 0.6)%
  - B.R. tot = $(6.84^{+0.32}_{-0.40})$%
- $\Lambda_c \to p\bar{K}^0$ and c.c.
  - K^0_S (50%)
  - $\pi^+\pi^-$: B.R.= (69.20 ± 0.05)%
  - B.R. tot = (1.11±0.10)%
- $\Lambda_c \to e^+\Lambda\nu_e$ and c. c
  - recently started, very promising study.
  - B.R. tot = (2.9±0.5)%

ALICE detectors essential for this analysis

Inner Tracking System (ITS)

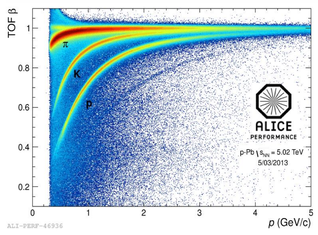
- Reconstruction of primary and secondary vertex.

Λ_c measurement in Pb-Pb collisions is challenging with the impact parameter resolution (~ 75 μm) of the current ITS.



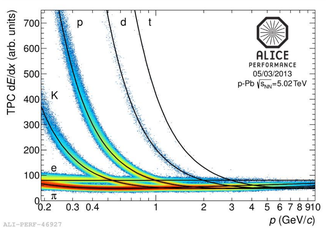
Time Of Flight (TOF)

- Particle Identification (PID) of e, π, K, p with time-of-flight measurements.



Time Projection Chamber (TPC)

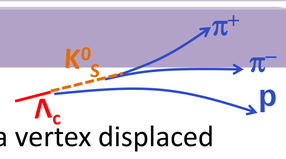
- Tracking
- Particle Identification (PID) of e, π, K and p with dE/dx measurements.



Data sample

- **pp:** ~ 3.0 x 10⁸ minimum bias events analyzed at $\sqrt{s}$ = 7 TeV.
- **p-Pb:** ~ 1.0 x 108 minimum bias events analyzed at $\sqrt{s_{NN}}$ = 5.02 TeV.

Reconstruction of $\Lambda_c \to pK^0_S$

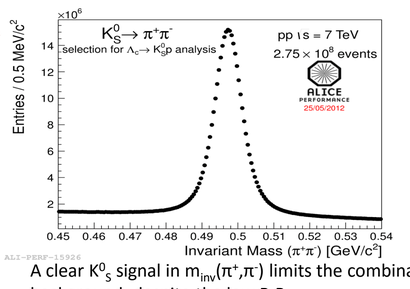


pK^0_S candidates building

- **K^0_S candidates** selected from pairs of opposite charge tracks forming a vertex displaced from the interaction vertex.

Cuts applied: high-quality single tracks cuts, DCA between tracks, radius of fiducial volume, cosine of V⁰ pointing angle.

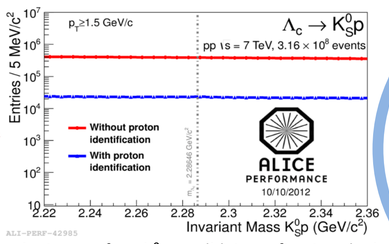
- **Proton candidates** selected according to track selection and PID, combined with selected K^0_S to build Λ_c candidates.



A clear K^0_S signal in $m_{inv}(\pi^+,\pi^-)$ limits the combinatorial background, despite the low B.R.

Particle Identification (PID)

- PID is essential to identify protons.
- Detector used: TOF and TPC.
- Used approach: number of sigma cuts and combined PID.
- Using PID the background is suppressed by a factor 20!

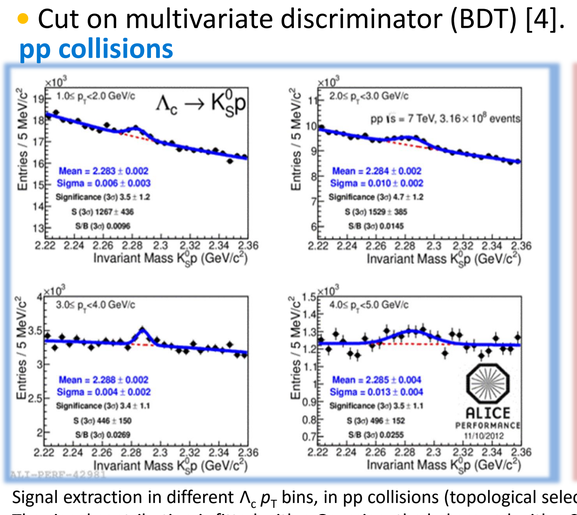


Invariant mass for pK^0_S candidates, after topological selection, with (in blue) and without (in red) PID.

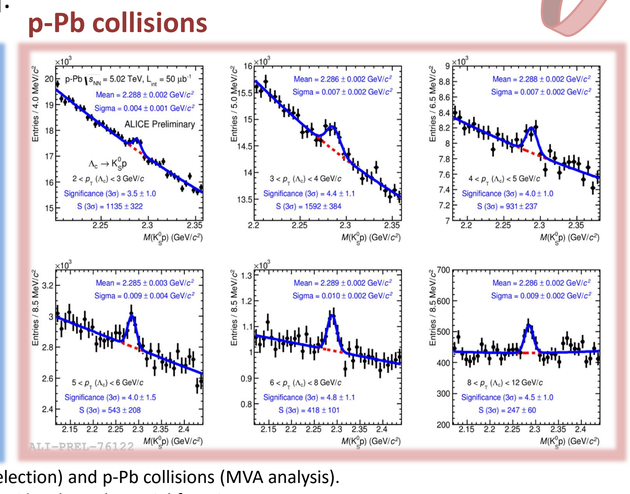
Signal extraction, after further selection:

- Standard topological cuts on variables offering good S/B separation.
- Cut on multivariate discriminator (BDT) [4].

pp collisions

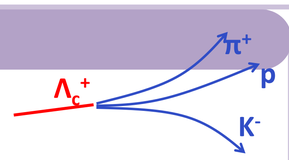


p-Pb collisions



Signal extraction in different Λ_c p_T bins, in pp collisions (topological selection) and p-Pb collisions (MVA analysis).
The signal contribution is fitted with a Gaussian, the bakground with a 2° order polynomial function.

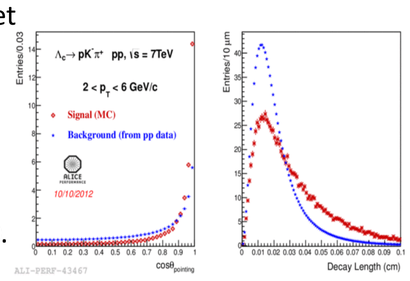
Reconstruction of $\Lambda_c \to pK\pi$



$pK\pi$ candidates building

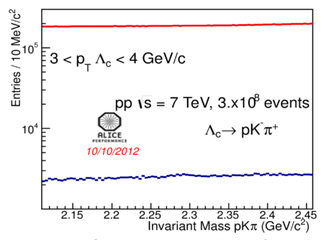
- Pairs of opposite charge tracks selected. Third track added to build a triplet and secondary vertex of the triplet estimated.

Cuts applied: high-quality single tracks cuts, cuts on daughter p_T , quality of reconstructed vertex, DCA (distance of closest approach between tracks), cosine of Λ_c pointing angle (angle between the Λ_c flight line and the momentum of the reconstructed Λ_c candidates), PID.



Particle Identification (PID)

- PID is essential to identify protons, kaons and pions.
- Detector used: TOF and TPC.
- Used approach: Bayesian PID (maximum probability criterion).
- Using PID the background is suppressed by a factor 100!

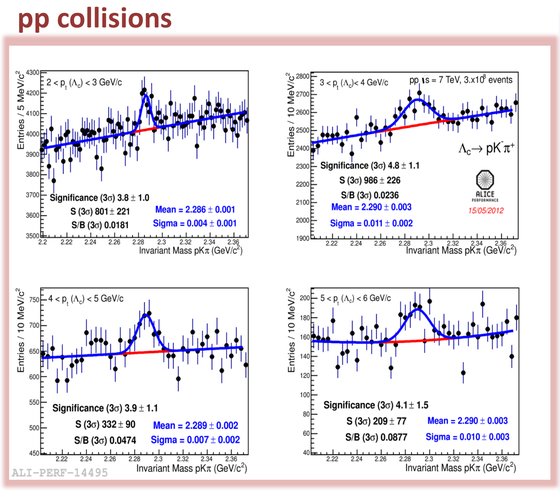


Invariant mass for pKπ candidates, after topological selection, with (in blue) and without (in red) Bayesian PID.

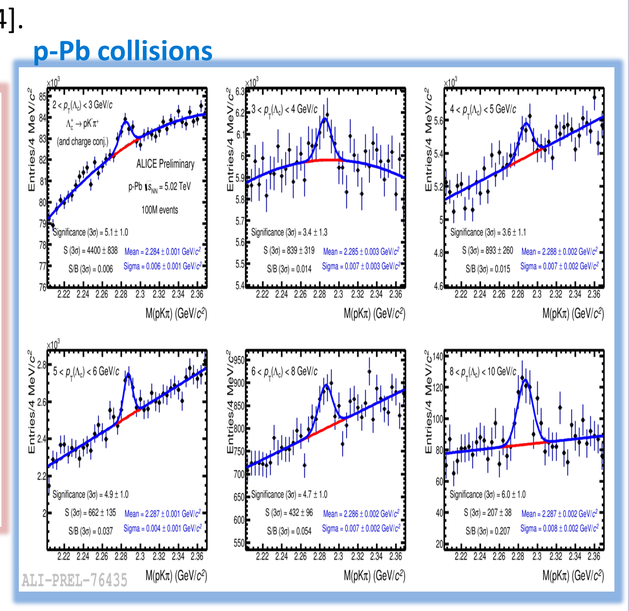
Signal extraction, after further selection

- Standard topological cuts on variables offering good S/B separation.
- Cut on multivariate discriminator (BDT) [4].

pp collisions



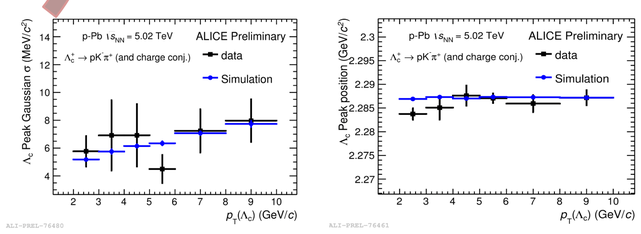
p-Pb collisions



Signal extraction in different Λ_c p_T bins, in pp collisions (topological selection) and p-Pb collisions (MVA anaylisis) .
The signal contribution is fitted with a Gaussian, the bakground with a 2° order polynomial function.

In both analyses:

- Λ_c is reconstructed in a wide momentum range.
- A good agreement with Monte Carlo expectations is observed.



The analyses are ongoing

- Beauty feed-down fraction estimated with two methods, using measured yield and expected Λ_b from theoretical calculations (FONLL predictions [5]).
- Efficiency and acceptance corrections estimated using Monte Carlo simulations.
- Systematic studies.
- Cross-checks between the measurements in the different decay channels.

Final target:
First measurement of Λ_c cross sections in pp and p-Pb collisions at mid rapidity at the LHC energies with ALICE!

References

[1] Yasui, S. et al. Indian J.Phys. 85 (2011) 1043-1046.
[2] G. Bani et al., Il Nuovo Cimento, vol. 104 A (1991).
[3] LHCb-PAPER-2012-041.
[4] A. Hoecker, P. Speckmayer, J. Stelzer, J. Therhaag, E. von Toerne, and H. Voss, TMVA - Toolkit for Multivariate Data Analysis, PoS ACAT 040 (2007), arXiv:physics/0703039.
[5] M. Cacciari et al., Journal of High Energy Physics October 2012, 2012:137.