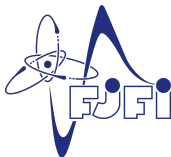


# Strange particle production in jets produced in pp, p-Pb and Pb-Pb collisions with the ALICE experiment

Ekaterina Grecká

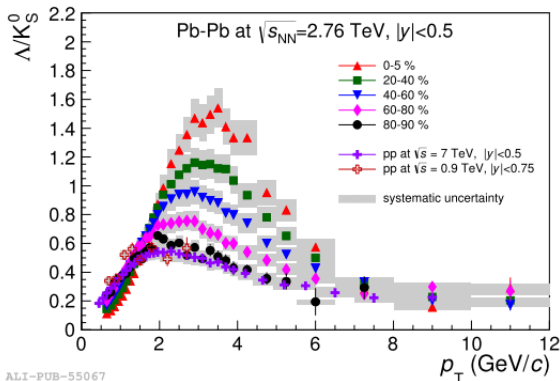
NPI CAS  
FNSPE CTU in Prague

22nd Zimányi School



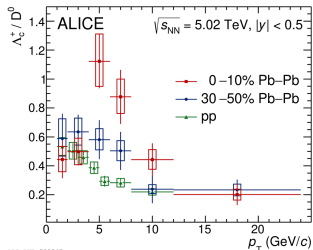
# Baryon-to-meson ratio in bulk

ALICE, PRL 111 (2013) 222301



What mechanism is behind this enhancement?

- Inclusive production of light and charm-flavor particles at intermediate  $p_T$  (2 – 6 GeV/c) in heavy-ion collisions is enhanced with respect to the ratio in pp collisions



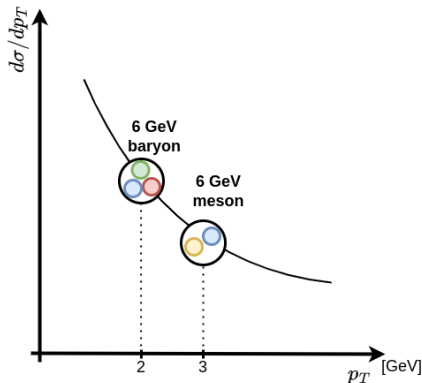
ALICE, arXiv:2112.08156

# Hadronization in medium

- QGP can modify the hadronization: parton recombination and coalescence model
- Recombination dominates at intermediate  $p_T = 2 - 6 \text{ GeV}/c$
- Fragmentation at  $p_T > 6 \text{ GeV}/c$
- Jets are assumed to be produced exclusively by fragmentation of partons created in hard scattering

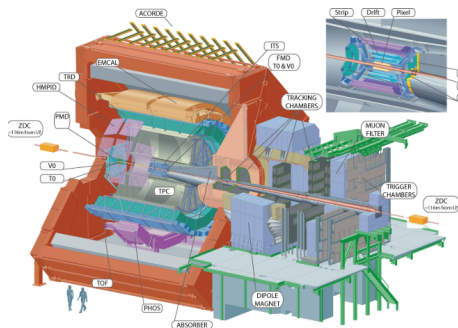
Is hadronization in jets influenced by the medium?

Fries, Müller, Nonaka, Bass: PRL 90 (2003) 202303  
Greco, Ko, Lévai: PRL 90 (2003) 202302



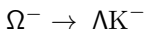
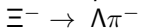
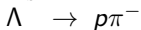
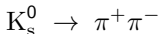
# ALICE detector

- Inner Tracking System (ITS) - tracking of charged particles in the central barrel
- Time-Projection Chamber (TPC) - momentum measurement in the range  $100 \text{ MeV}/c \leq p_T \leq 100 \text{ GeV}/c$
- ALICE has great PID capabilities

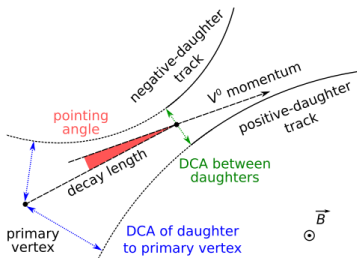


# Strange particle reconstruction

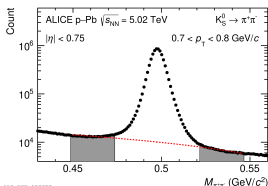
- Decay topology reconstruction



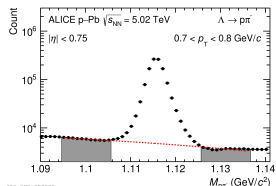
$K_S^0$  and  $\Lambda$  decay scheme



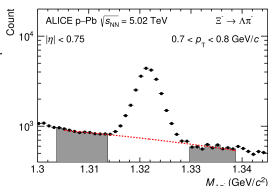
Example of invariant mass spectra in p-Pb collisions



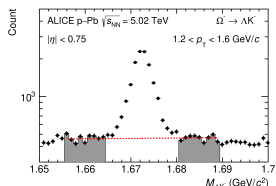
ALICE-Pb-523077



ALICE-Pb-523081



ALICE-Pb-523085

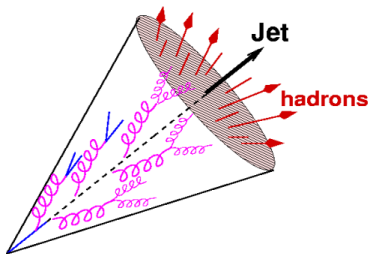


ALICE-Pb-523089

ALICE, arXiv:2112.08156

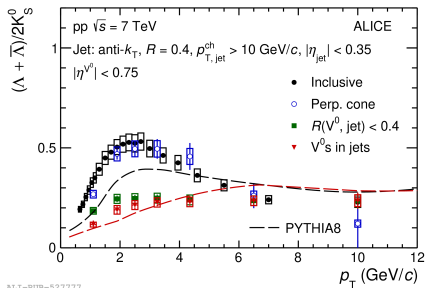
# Jet analysis

- anti- $k_t$  algorithm for charged-particle jets ( $R = 0.2 - 0.4$ )
- $k_t$  for the background estimation
- Tracks of primary charged particles:  
 $p_T \geq 150 \text{ MeV}/c$ ,  $|\eta_{\text{track}}| < 0.9$
- Association of strange particles with jets  $\rightarrow$  angular distance between strange particle momentum vector and the jet axis
- Data are corrected for reconstruction efficiency, background and feed-down ( $\Lambda$ )

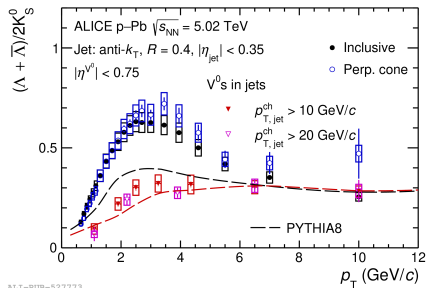


# $\Lambda/K_S^0$ ratios in pp and p-Pb collisions

- Inclusive ratio enhancement for intermediate  $p_T$  for p-Pb in comparison with pp in comparison with pp
- Ratios for the underlying event (Perp. cone) are similar to the inclusive production
- Ratios in jets resemble those in pp collisions  $\rightarrow$  hadronization unmodified
- For  $p_T > 6$  GeV/c inclusive and particle ratios in jets are consistent



ALI-PUB-527777



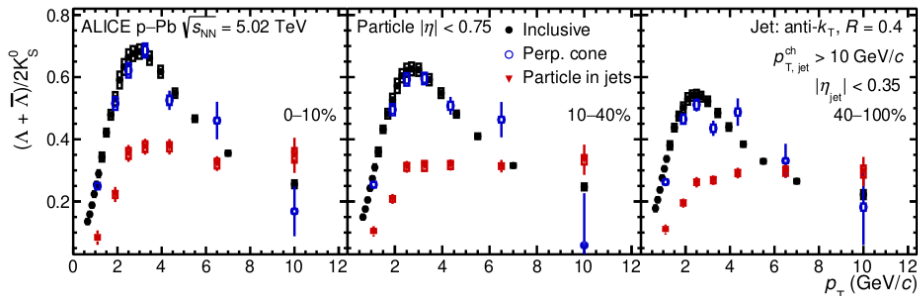
ALI-PUB-527773

Run 1: ALICE, PLB 827 (2022) 136984

# $\Lambda/K_S^0$ ratios in p-Pb: centrality dependence

- For intermediate  $p_T = (2 - 6)$  GeV/ $c$  ratio in p-Pb collisions increases with the event multiplicity  $\rightarrow$  resembles bulk-like behaviour
- Enhancement of ratio at intermediate  $p_T$  is not observed in jets  $\rightarrow$  hadronization in small collision systems unmodified

High multiplicity  $\rightarrow$  Low multiplicity

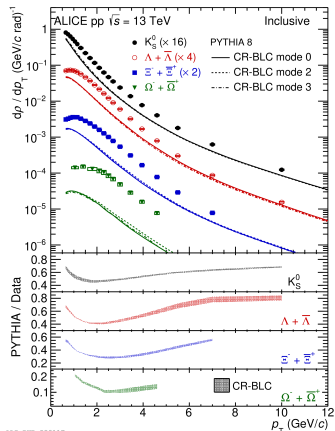


Run 2: ALICE, arXiv:2211.08936

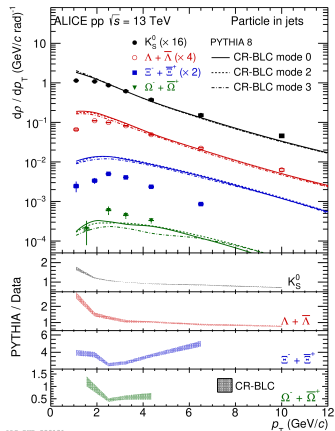


# $p_T$ spectra for strange particles in pp

- First measurement of the multi-strange baryons in jets
- PYTHIA 8 does not describe data (worsens with strangeness content)



ALICE-PHB-529117



ALICE-PHB-529121

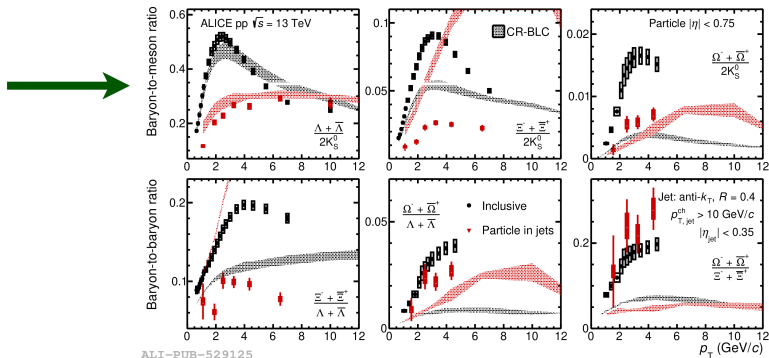
ALICE, arXiv:2211.08936

# Baryon-to-meson ratios in pp collisions

- Enhancement is not present within jets  $\rightarrow$  hadronization unmodified
- PYTHIA 8 CR-BLC: describes  $\Lambda/K_S^0$  ratio inclusive and in jets, despite it does not reproduce individual  $p_T$  spectra
- Large discrepancies between data and PYTHIA for multi-strange particles

$\rightarrow$  Data provide important constraints  
for strangeness modelling in PYTHIA

ALICE, arXiv:2211.08936



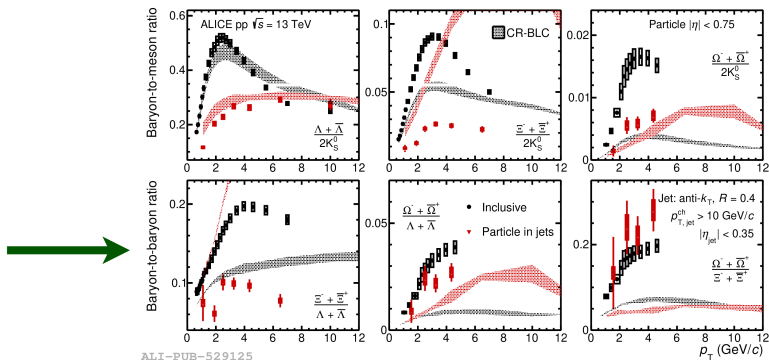
ALI-PUB-529125

# Baryon-to-baryon ratios in pp collisions

- $\Xi/\Lambda$  ratio in jets shows suppression with respect to the inclusive ratio
- $\Omega/\Lambda$  and  $\Omega/\Xi$  in jets show a similar  $p_T$  dependence as the inclusive ratio
- Large discrepancies between data and PYTHIA for all baryon-to-baryon ratios observed

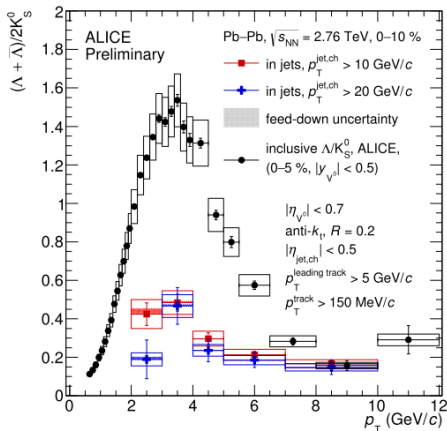
→ Data provide important constraints for strangeness modelling in PYTHIA

ALICE, arXiv:2211.08936



# $\Lambda/K_S^0$ ratios in Pb-Pb collisions

- Preliminary measurement from Pb-Pb Run 1 data at 2.76 TeV
- $\Lambda/K_S^0$  ratio in jets resembles that in pp collisions  
→ hadronization unmodified within current precision
- Higher precision analysis of Run 2 Pb-Pb data at 5.02 TeV ongoing  
→ will address possible modification of hadronization in jets in hot and dense medium



V. Kučera, CERN-THESIS-2016-206  
A. Zimmermann, CERN-THESIS-2016-183

# Summary

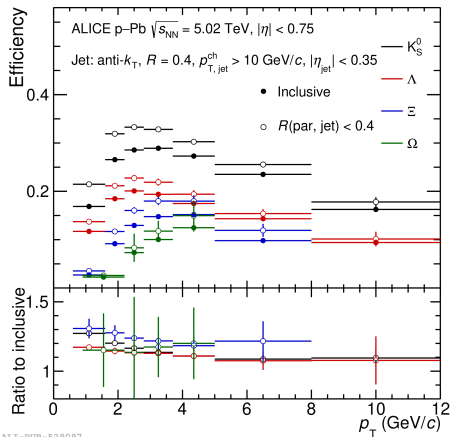
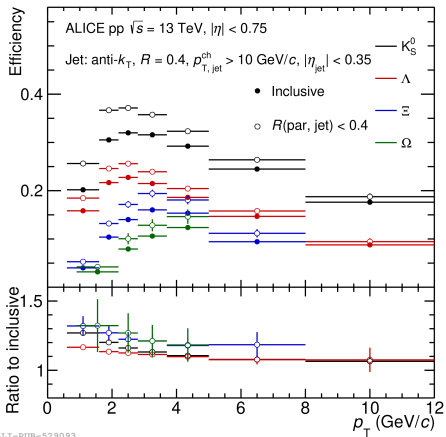
- Baryon-to-meson and baryon-to-baryon strange particle ratios measured in jets differ from the inclusive particle production for low and intermediate hadron  $p_T$  in pp, p-Pb, and Pb-Pb collisions
- Ratios measured in the underlying event are similar to those measured for inclusive particle production
- Data suggests unmodified hadronization in jets
- Data provide important constraints for strangeness production modelling
- Ongoing analysis of Run 2 high statistics data to improve precision of preliminary Pb-Pb analysis from Run 1

# Backup

# Corrections

- Reconstruction efficiency correction:
  - ▶ MC reconstructed with the same procedure as data
  - ▶  $\epsilon = \frac{\text{Reconstructed particles}}{\text{Generated particles}}$
- Underlying event subtraction:
  - ▶  $V_s^0$  in regions with negligible jet production  
→  $V_s^0$  are produced by background
  - ▶ Different methods:
    - ★ No-Jet events
    - ★ Outside Cones
    - ★ Perpendicular Cones
    - ★ Random Cones
- Feed-down correction
- $N^{\text{jet}} = \left( \frac{N^{\text{JC}}}{\mathcal{N}^{\text{JC}} \epsilon^{\text{JC}}} - \frac{N^{\text{UE}}}{\mathcal{N}^{\text{UE}} \epsilon^{\text{UE}}} \right) (1 - f^{\text{FD,jet}})$ 
  - ▶  $\mathcal{N}$  - normalization factors
  - ▶  $f^{\text{FD,jet}}$  - the feed-down fraction

# Reconstruction efficiencies for pp and p-Pb



ALICE, arXiv:2211.08936