New insights into strange-quark hadronization measuring multiple (multi-)strange hadron production in small collision systems with ALICE

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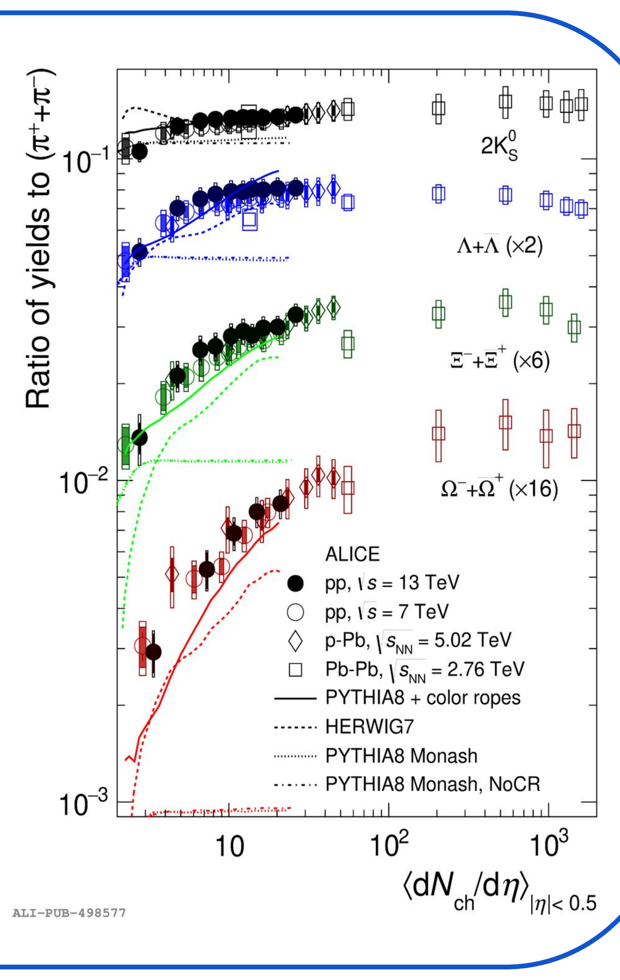
PHYSICS MOTIVATION

Strangeness Enhancement: [1,2]

- S/π increases as a function of multiplicity compatible across $\sqrt{s}$ and collision systems
- Enhancement proportional to the strangeness content in the hadron

→ More insightful information on the production of (multi-)strange particles: **strange particle multiplicity distribution $P(n_S)$**

- new test bench for production mechanisms, probing events with a large imbalance between strange and non-strange content

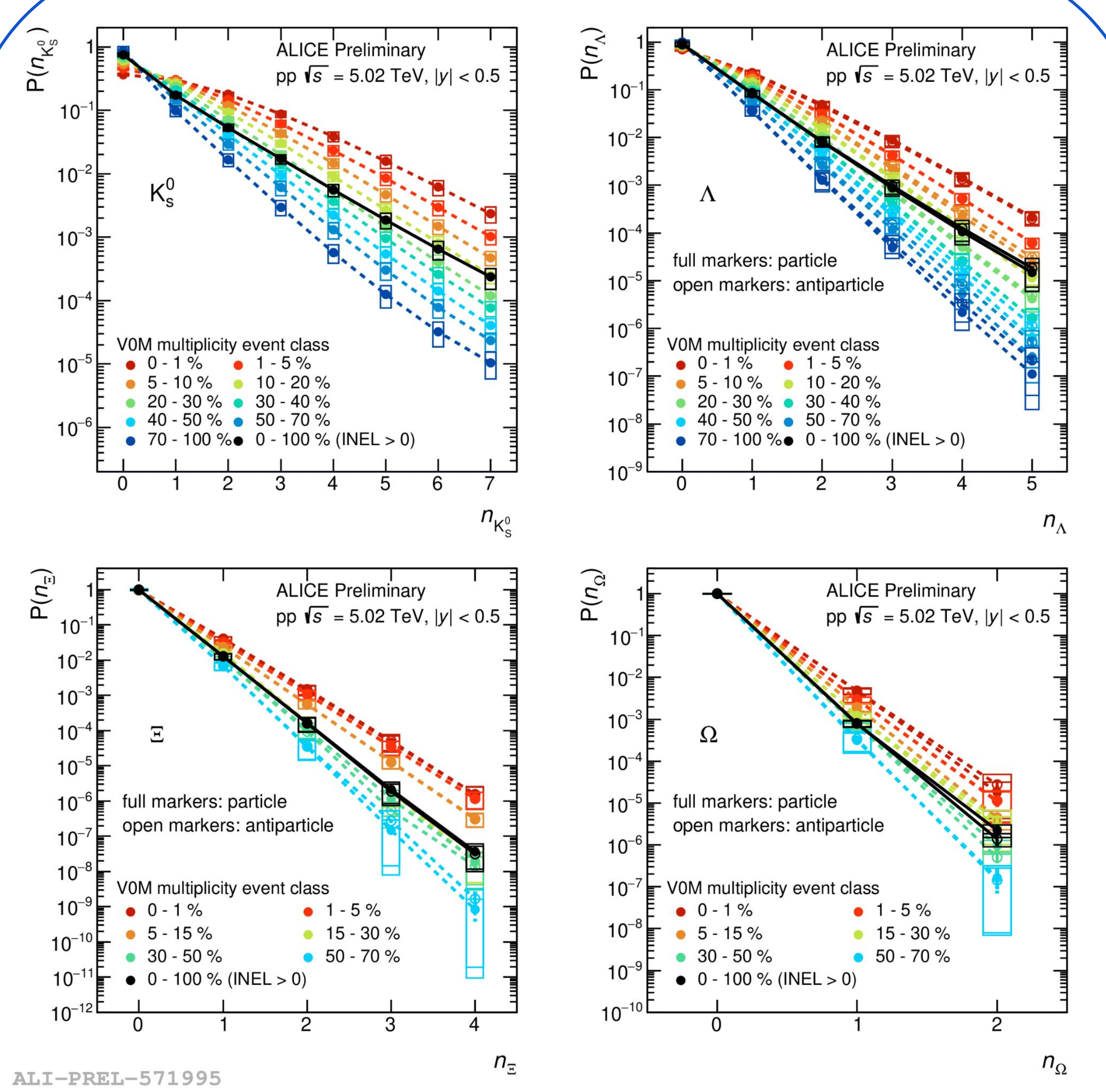


ANALYSIS TECHNIQUE

Analysis based on counting the number of strange particles event-by-event in pp collisions at $\sqrt{s}$ = 5.02 TeV

- Each candidate **weighted by *P*(sig)** or *P*(bkg) estimated by **1D** invariant mass **fit** in transverse momentum (p_T)/multiplicity bins
- **Weights** associated to each of the N candidates in the event **combined** to obtain P(all-sig), … , P(all-bkg) → For each event: full probability spectrum spanning from 0 to N
- Correction for detector response (MC production featuring realistic p_T distribution for the particles under study) → **Bayesian unfolding** procedure applied

MEASUREMENT OF $P(n_S)$



- Probability to produce *n* particles of a given species per event
- **Unique opportunity to test the connection between charged and strange particle multiplicity production all the way to extreme situations** (e.g. 7 K^0_S at low average charged-particle multiplicity, 0 K^0_S at high average charged-particle multiplicity)

NOTE: in each V0M bin the charged-particle multiplicity can fluctuate and $\langle dN_{ch}/d\eta \rangle$ can significantly change for events with small/large n_S

REFERENCES

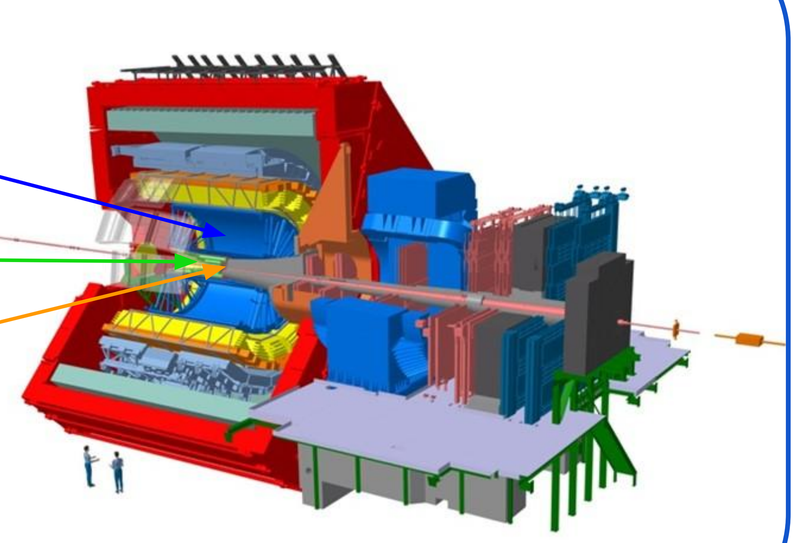
[1] ALICE, Eur.Phys.J.C 80 (2020) 2, 167
[2] ALICE, Nature Phys. 13 (2017) 535-539
[3] C.Bierlich, G.Gustafson, L.Lonnblad, A. Tarasov, JHEP 03, no 148 (2015)
[4] C.Bierlich, EPJ Web Conf. 171 (2018) 14003

THE ALICE DETECTOR IN RUN 2

Time Projection Chamber (TPC)
Gaseous detector
tracking, PID (dE/dx)

Inner Tracking System (ITS)
6 layers of silicon detectors
triggering, tracking, vertexing, PID

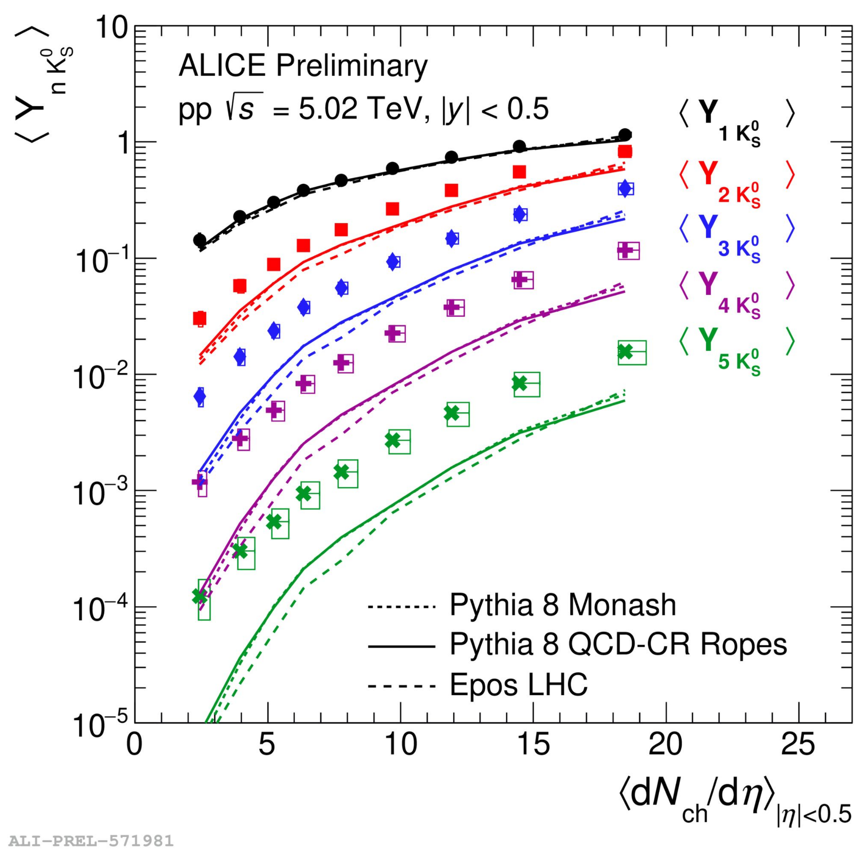
V0 detectors (V0A, V0C)
Forward-rapidity arrays of scintillators
triggering, charged-particle multiplicity estimation (V0M multiplicity $\propto \langle dN_{ch}/d\eta \rangle$)



MULTIPLE STRANGE HADRON PRODUCTION YIELDS

From the measurement of $P(n_S)$ it is possible to calculate the **average production yield of 1, 2, 3, … particles/event:**

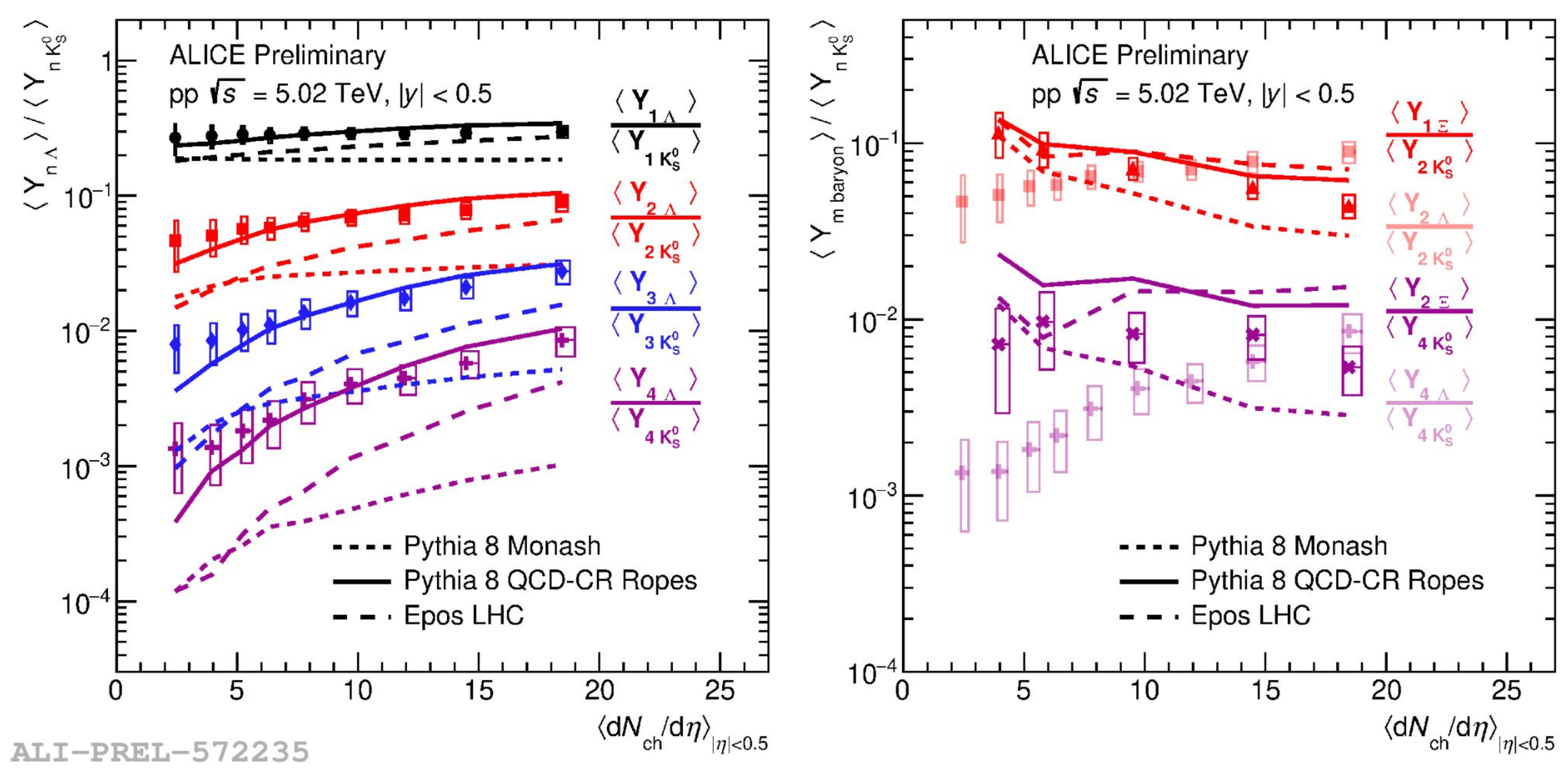
$$\langle Y_{k-part} \rangle = \sum_{n=k}^{\infty} \frac{n!}{k!(n-k)!} P(n)$$



- The increase with multiplicity of the probability for multiple strange hadrons is more than linear
- NOTE: very good agreement between $\langle Y_{1-part} \rangle$ and previous results ([1,2])
- No difference between Pythia 8 Monash [3] and Ropes [4] for K^0_S: Pythia 8 QCD-CR Ropes tends to increase baryons

YIELD RATIOS WITH ΔS = 0

Relative probability of hadronization of a specific number of *s*-quarks into different types of final hadrons



- When the strangeness remains constant, **the likelihood that the final state contains a baryon and not a meson rises with multiplicity**
- Decreasing the charged-particle multiplicity means depleting the number of light quarks, while keeping the number of *s* quarks fixed in the event → at lower multiplicities, it becomes progressively less probable to observe baryons compared to mesons
- By fixing the number of involved *s*-quarks (e.g. 2 or 4 respectively as red and magenta points), **the likelihood that the final state contains a multi-strange baryon and not a meson decreases with multiplicity**
  - High multiplicity: it is simpler to pair *s*-quarks with a light quark, which are plentiful
  - Low multiplicity: the surplus of *s*-quarks increases the probability of Ξ formation

All the trends are well reproduced by Pythia 8 QCD-CR Ropes

OUTLOOK

Ratios between the average production yield of m multi-strange baryons and n K^0_S vs multiplicity, for which ΔS moves from 2 to 5, are under preparation: **strangeness enhancement at its extremes!**