Measurement of strange and multi-strange hadron production in high-multiplicity pp collisions at 13 TeV with ALICE

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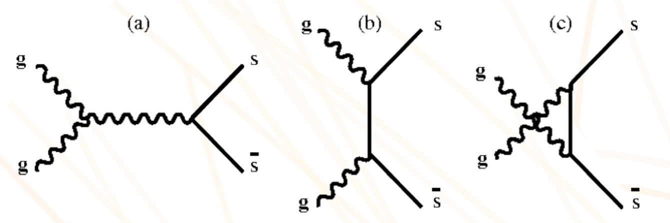
Abstract

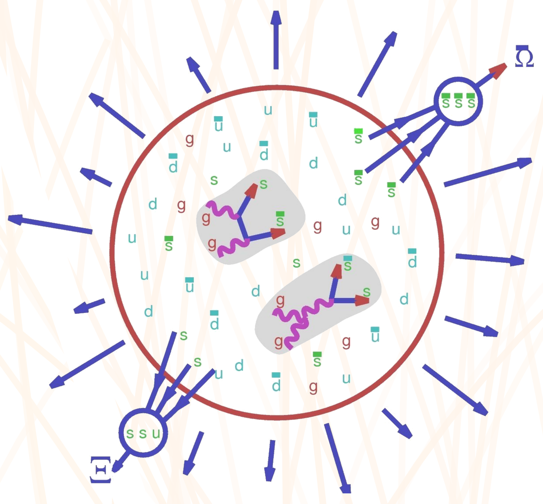
Measurements of identified particle production as a function of the event multiplicity in proton-proton (pp) and proton-nucleus collisions have recently gained interest for the investigation of particle production mechanisms in small systems and how they relate to those in the larger system created in nucleus-nucleus collisions. In particular, recent results reported by the ALICE Collaboration show a progressive increase of the hyperon-to-pion ratios as a function of charged particle multiplicity at mid-rapidity from pp up to Pb-Pb collisions. In this work, we present new results on strange and multi-strange hadron production as a function of multiplicity, based on the analysis of a large sample of high-multiplicity triggered events in pp collisions at $\sqrt{s}$ = 13 TeV collected by ALICE in 2016. These measurements extend the previous reach in multiplicity obtained from the analysis of the minimum bias sample, allowing for a wider overlap with the multiplicity range spanned with p-Pb collisions as well as approaching multiplicities present in peripheral Pb-Pb collisions.

Introduction and Physics Motivation

→ Strangeness enhancement

- The enhanced production of strangeness relative to *u* and *d* quarks was one of the first proposed signatures of QGP formation
  - *Thermal strangeness equilibration in a QGP regime can be achieved due to gluon fusion processes*





J. Rafelski and B. Müller, PRL48, 1066 (1982)
P. Koch, B. Müller, J. Rafelski, Phys. Rep. 142, 167 (1986)
J. Rafelski, Eur. Phys. J. A51, no.9, 114 (2015)

→ Strangeness canonical suppression (in a *hadronic* equilibrium thermal model)

- In small systems, multi-strange baryons should be highly suppressed
  - *Conservation laws must be implemented locally – Canonical Formulation*
  - *The canonical conservation of the strangeness quantum number severely reduces the phase space available for strange particle production*

S. Hamieh, K. Redlich, A. Tounsi, Phys. Lett. B 486 (2000) 61
A. Tounsi, K. Redlich, arXiv:hep-ph/0111159

Measurement of Strange Hadrons

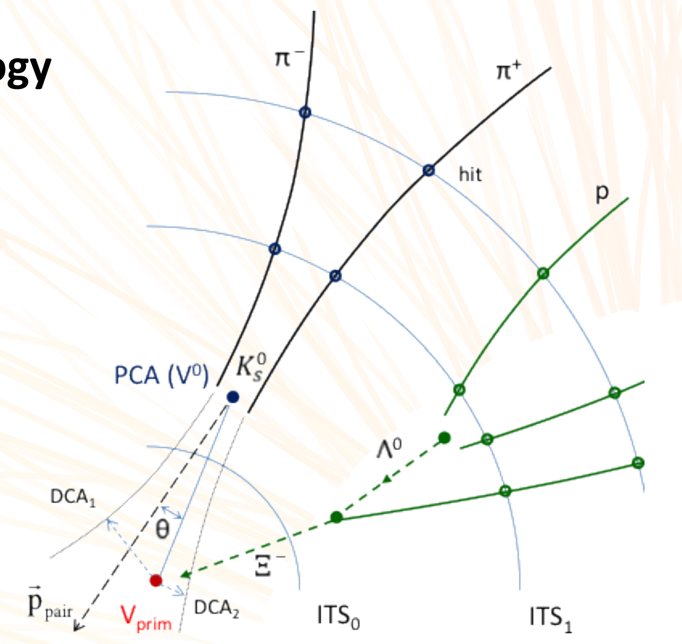
→ V⁰s and Cascades reconstruction via decay topology

$K^0_S \rightarrow \pi^+ + \pi^-$
- **mass:** 497.611 MeV/c^2
- **$c\tau$:** 2.6844 cm
- **B.R.:** 69.2%

$\Xi^- \rightarrow \Lambda + \pi^-$
- **mass:** 1321.71 MeV/c^2
- **$c\tau$:** 4.91 cm
- **B.R.:** 99.9%

$\Lambda \rightarrow p + \pi^-$
- **mass:** 1115.683 MeV/c^2
- **$c\tau$:** 7.89 cm
- **B.R.:** 63.9%

$\Omega^- \rightarrow \Lambda + K^-$
- **mass:** 1672.45 MeV/c^2
- **$c\tau$:** 2.461 cm
- **B.R.:** 67.8%



Preliminary Results (pp 7 and 13 TeV – *Min. Bias Trigger*)

- Significant enhancement of strange to non-strange hadron production observed in pp collisions
- Consistent pattern observed as a function of multiplicity between pp, p-Pb and Pb-Pb collisions
- MC models fail to describe the behavior of the data
- The observed enhancement is stronger for hadrons with higher strangeness content

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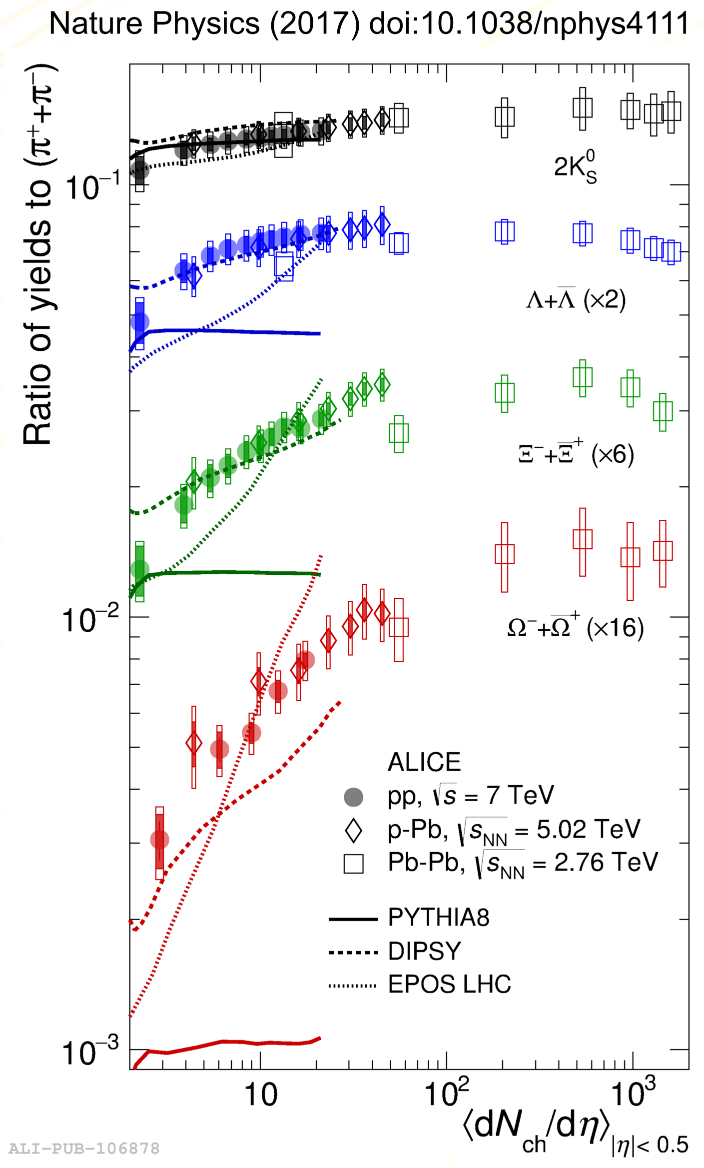
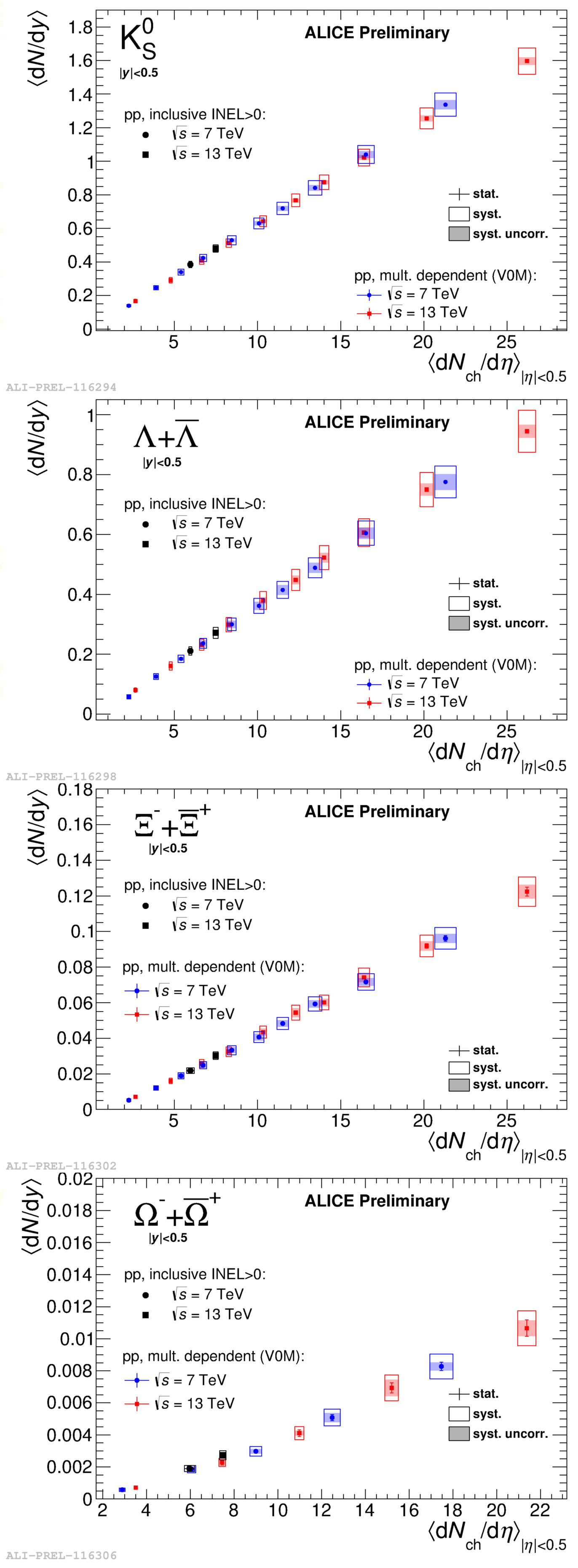


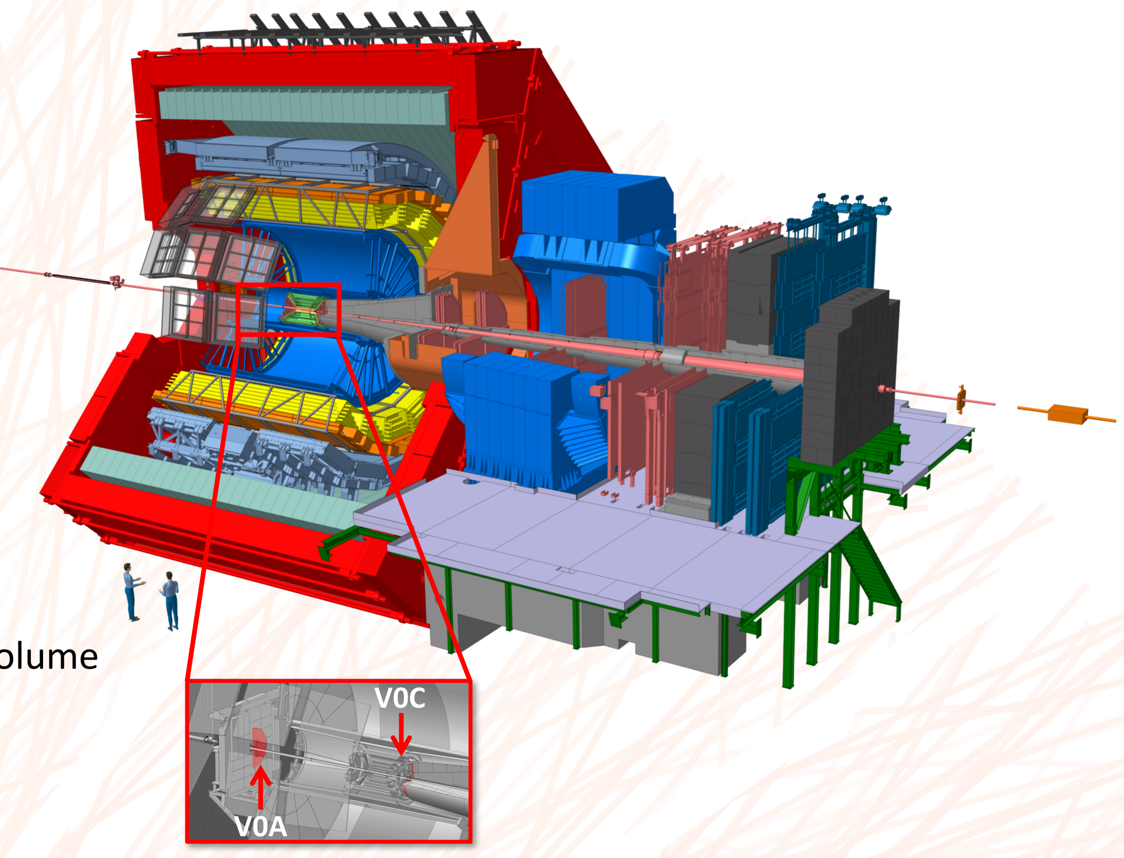


Comparison between results from pp collisions at 7 and 13 TeV shows that very similar production rates are observed for a given final state multiplicity

The ALICE Experiment

→ Dedicated experiment to study QGP properties

Optimized for charged particle tracking and **hadron identification**



ITS (|η|<0.9)
- 6 Layers of silicon detectors
- Trigger, tracking, vertexing, Particle Identification

TPC (|η|<0.9)
- Gas-filled ionization detection volume
- Tracking, vertexing, PID (d*E*/d*x*)

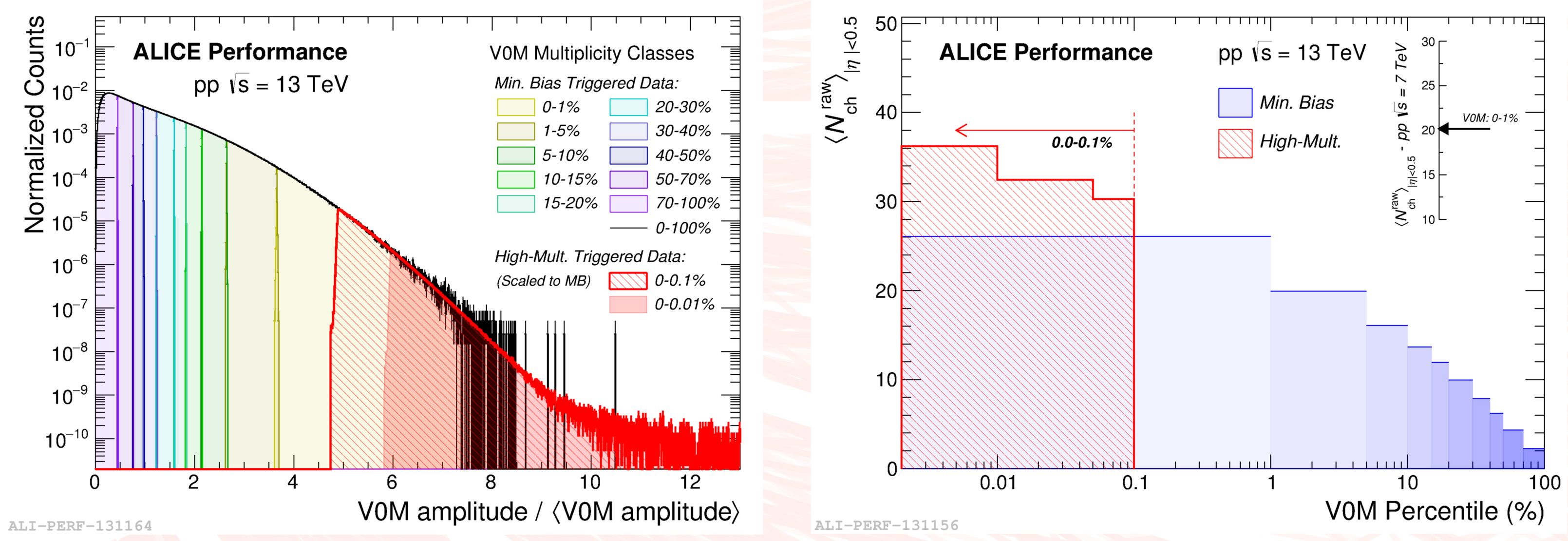
TOF (|η|<0.9)
- Multi-gap resistive plate chambers
- Particle Identification

V0 [V0A (2.8<η<5.1) & V0C (-3.7<η<-1.7)]
- Forward arrays of scintillators
- Trigger, beam gas rejection
- *Multiplicity estimator*

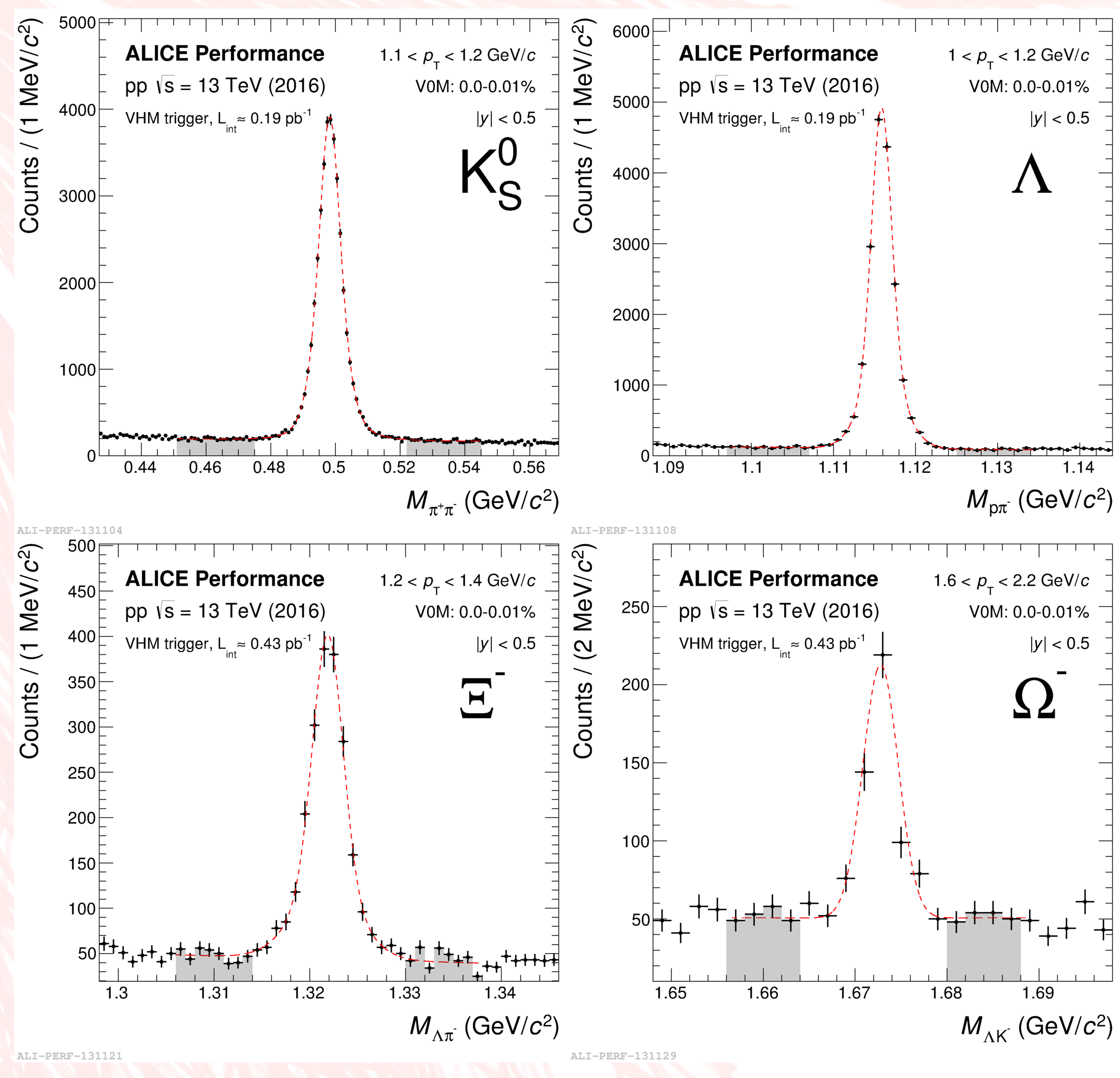
Forward Multiplicity Estimator
- Event selection based on total charge deposited in the **V0A** and **V0C** detectors ("**V0M**")
- $\langle dN_{ch}/d\eta \rangle$ estimated as the average number of primary charged tracks in $|\eta| < 0.5$

Preliminary Results (pp 13 TeV – *High-Mult. Trigger*)

- High multiplicity triggered data collected by the ALICE experiment during 2016 significantly expand the reach in multiplicity compared to min. bias pp at 7 and 13 TeV



- *Invariant mass distributions for V⁰s and Cascades reconstructed for selected p_T bins*
- *Topological selection criteria tuned to optimize signal to background ratio and reconstruction efficiency*
- *Clear signal observed for all strange hadrons (K^0_S, Λ, Ξ and Ω) in the highest 0-0.01% multiplicity selection within the INEL>0 event class*



Summary and Outlook

→ Enhancement of strange and multi-strange hadron production is observed towards high multiplicity pp events

→ Comparisons between results from 7 and 13 TeV pp collisions show that strange hadron production is governed by the final state multiplicity independently of the collision energy

→ High multiplicity triggered data will allow to explore a wider overlap between pp and p-Pb data, in particular for multi-strange hadrons, and perhaps even approach the multiplicities of peripheral Pb-Pb collisions

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