

Probing the interplay of multiplicity and effective energy on strangeness production in pp collisions with ALICE

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Istituto Nazionale di Fisica Nucleare



ALMA MATER STUDIORUM
UNIVERSITA DI BOLOGNA

INTERNATIONAL SCHOOL OF SUBNUCLEAR PHYSICS

58th Course:

GRAVITY AND MATTER
IN THE SUBNUCLEAR WORLD

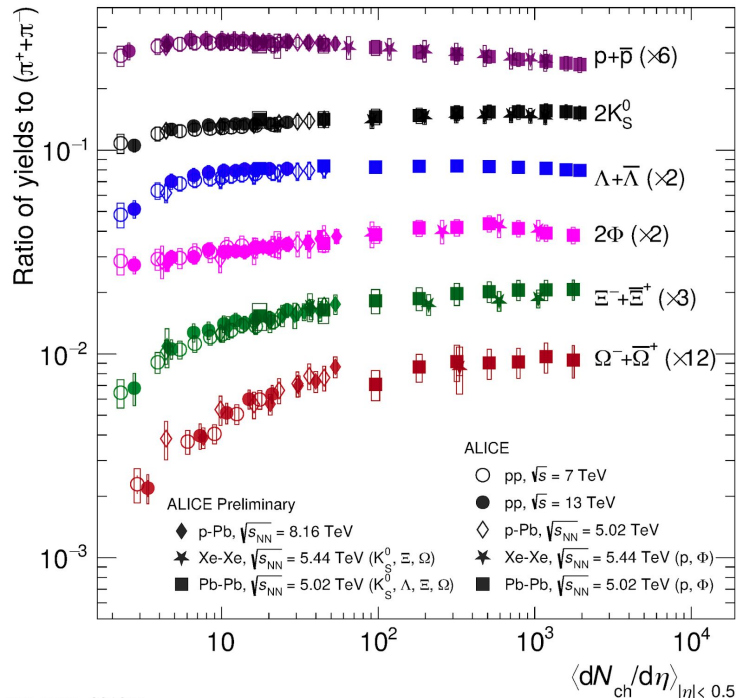
ERICE-SICILY: 15 – 24 June 2022





Strangeness production across collision systems

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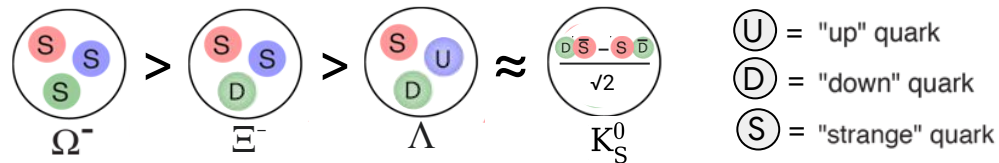
ALI-PREL-321075

ALICE Collaboration, Nature Phys 13, 535-539 (2017)
ALICE Collaboration, Eur. Phys. J. C 80, 167 (2020)

The **enhanced production of strange hadrons** in heavy-ion collisions relative to pp is expected because of **QGP effects**

ALICE observed that the ratio of strange to non-strange hadron yields (h/π):

- **increases with multiplicity**
- **smoothly evolves across different collision systems**
- **shows a hierarchy with the hadron strangeness content**





The **charged-particle multiplicity** produced in a pp collision is:

- characteristic of the **hadronic final state**
- strongly correlated to the **initial effective energy**

EFFECTIVE ENERGY

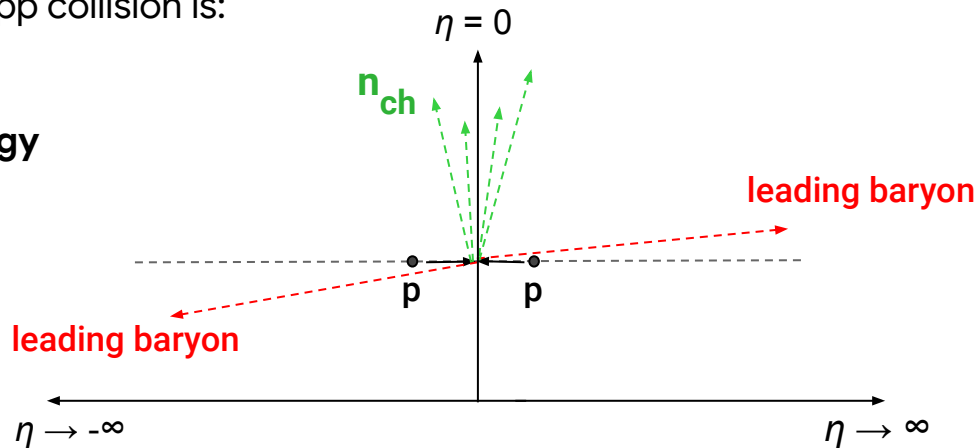
Energy available for particle production in the **initial stages** of the pp collision



Reduced w.r.t. $\sqrt{s}$ because of the **leading baryon effect**
(high probability to emit forward baryons with large p_L)

$$E_{\text{effective}} = \sqrt{s} - E_{\text{leading}}$$

A. Akindinov et al., Eur. Phys. J. C 50, 341-352 (2007)





Physics motivation

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- characteristic of the **hadronic final state**
- strongly correlated to the **initial effective energy**

EFFECTIVE ENERGY

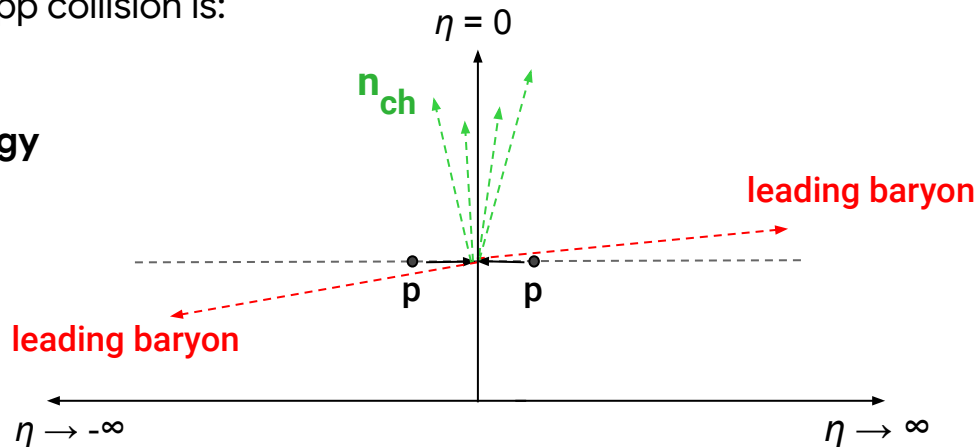
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The observed strangeness enhancement with multiplicity could be ascribed to the effective energy!



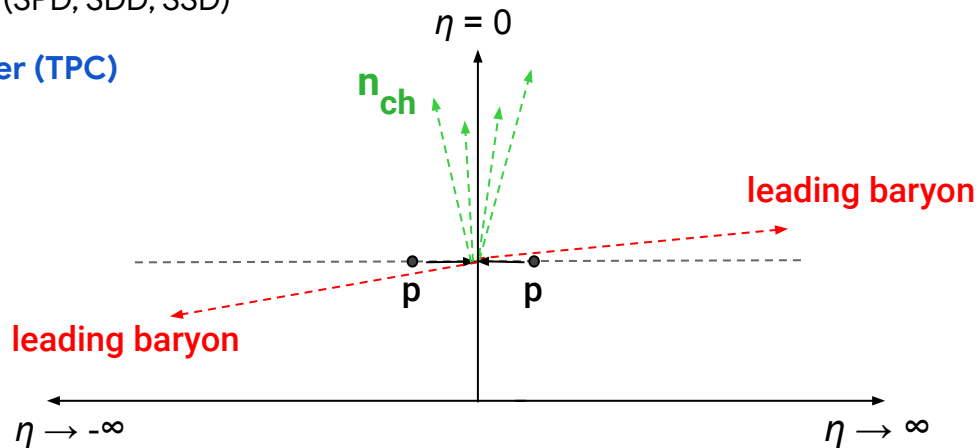
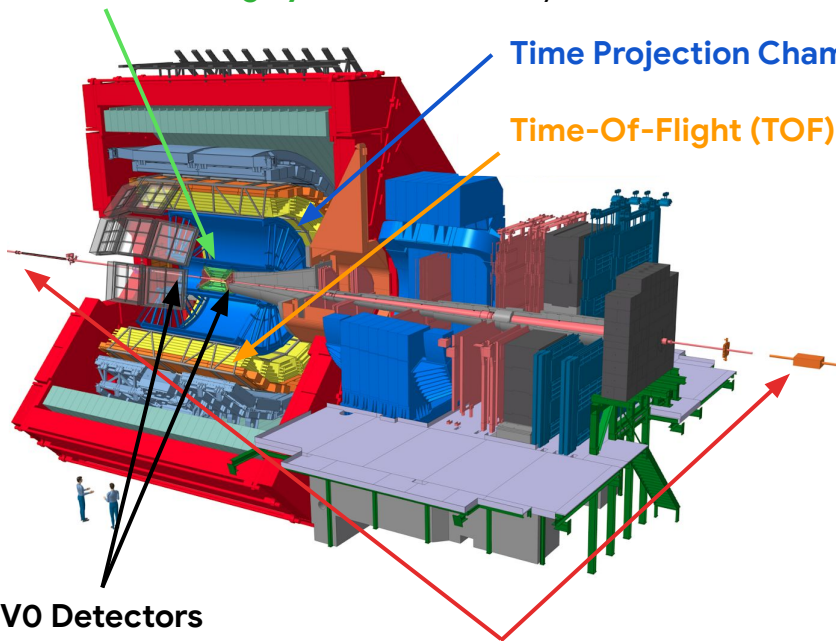
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ALICE: A Large Ion Collider Experiment

Inner Tracking System (ITS), six layers of silicon detector (SPD, SDD, SSD)

Time Projection Chamber (TPC)

Time-Of-Flight (TOF)



Zero Degree Calorimeters (ZDC)



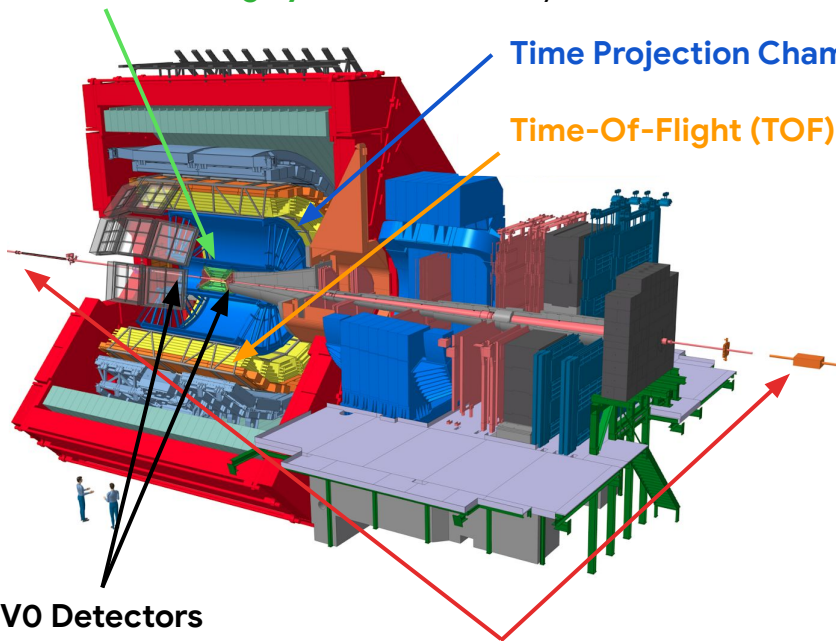
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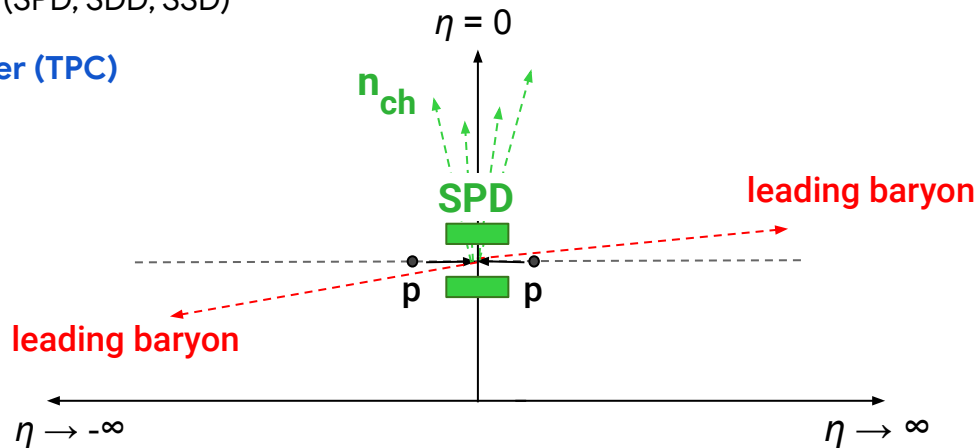
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Zero Degree Calorimeters (ZDC)



ALICE can measure:

- midrapidity multiplicity (**SPD**)



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- ALICE**

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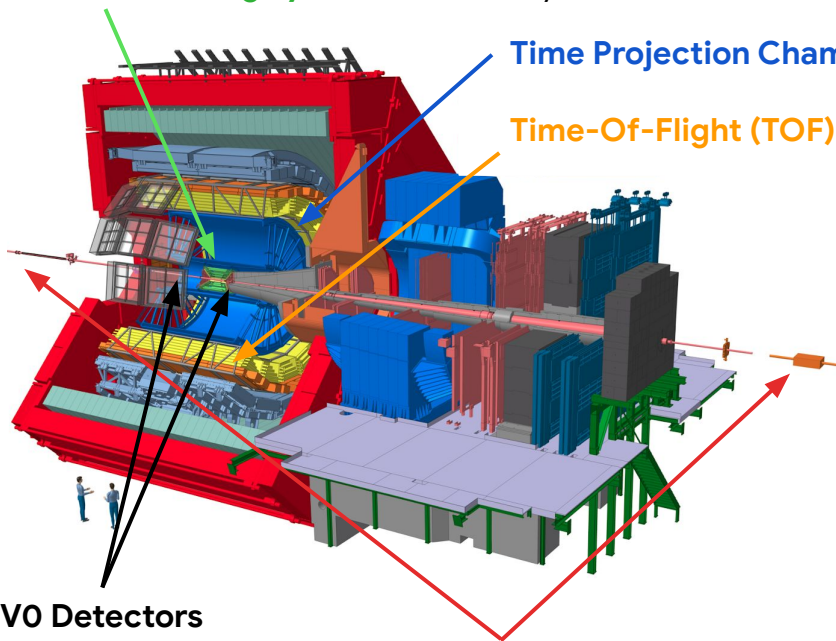
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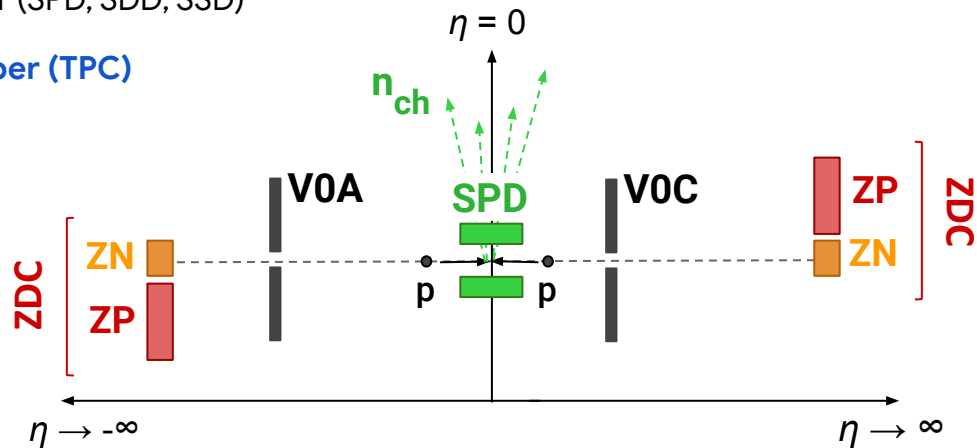
Inner Tracking System (ITS), six layers of silicon detector (SPD, SDD, SSD)

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Zero Degree Calorimeters (ZDC)



ALICE can measure:

- midrapidity multiplicity (**SPD**)
- leading energy (**ZDC**)

$$E_{\text{eff}} = \sqrt{s} - E_{\text{leading}} \approx \sqrt{s} - E_{\text{ZDC}}$$

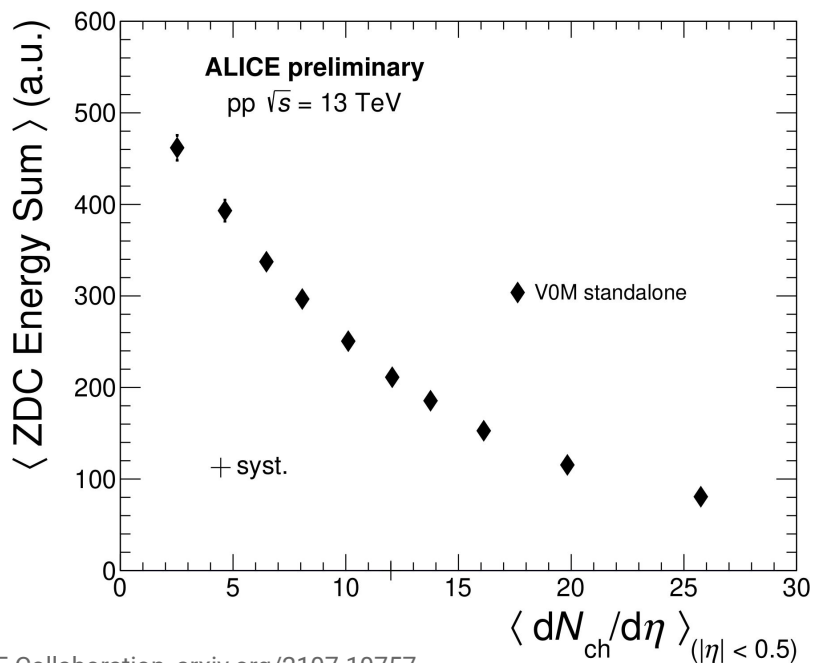
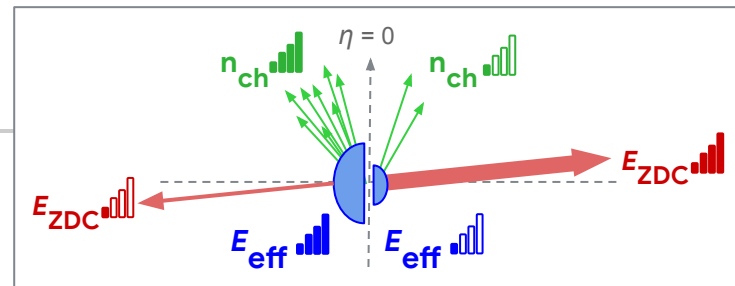
- forward multiplicity (**VOM** = VOA+VOC)



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Leading energy vs multiplicity

ALICE measured that the **forward** energy **decreases** with **increasing particle** multiplicity produced at **midrapidity**



◆ Standalone V0 event classes

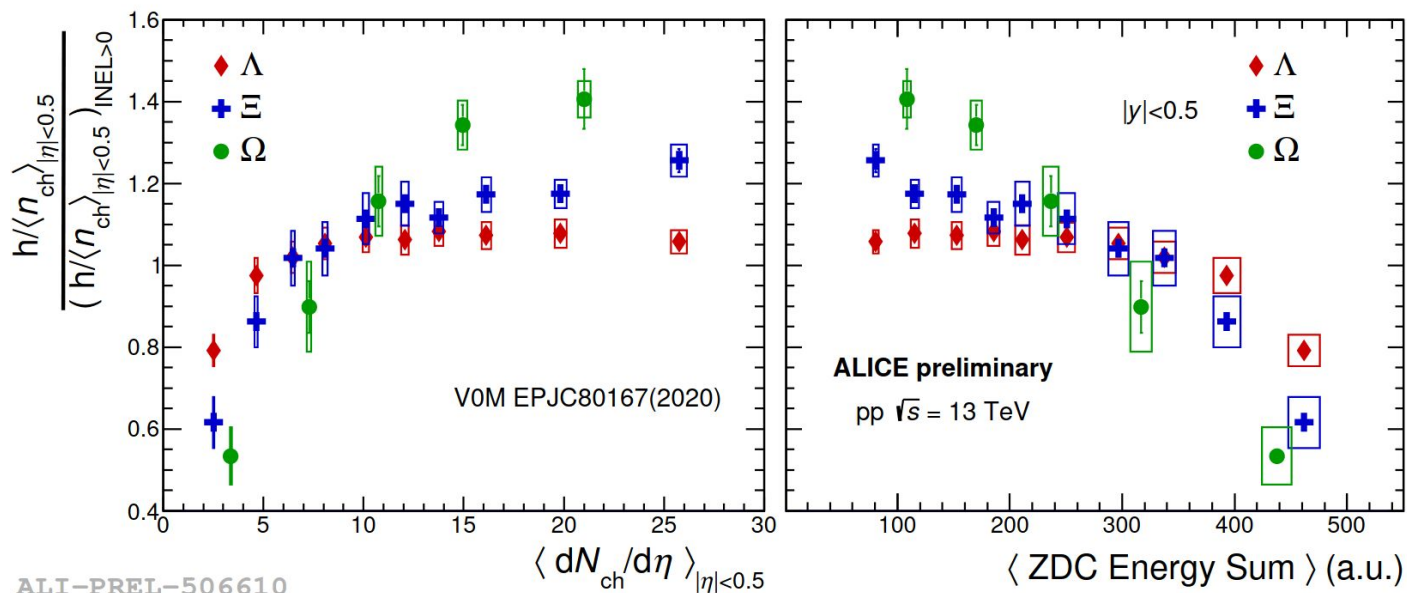
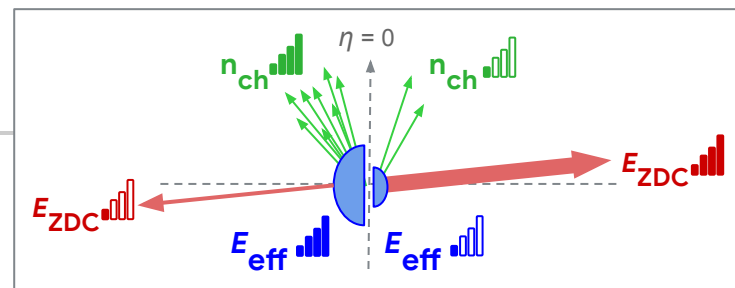


Strangeness vs leading energy

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Strangeness production:

- **increases** with midrapidity **multiplicity** (left)
- is **anti-correlated** with the **leading energy** (right)



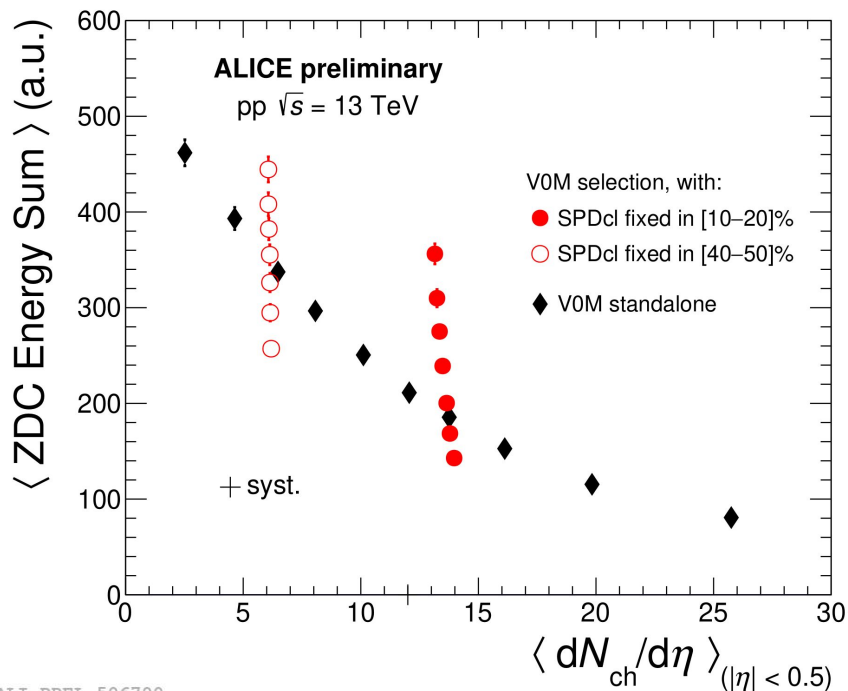
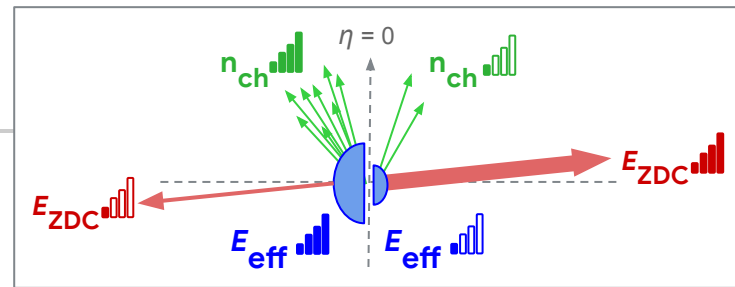
ALI-PREL-506610



Leading energy vs multiplicity

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ALICE measured that the **forward energy decreases with increasing particle multiplicity** produced at **midrapidity**



◆ **Standalone V0 event classes**

Event classes defined using V0 and SPD (clusters):

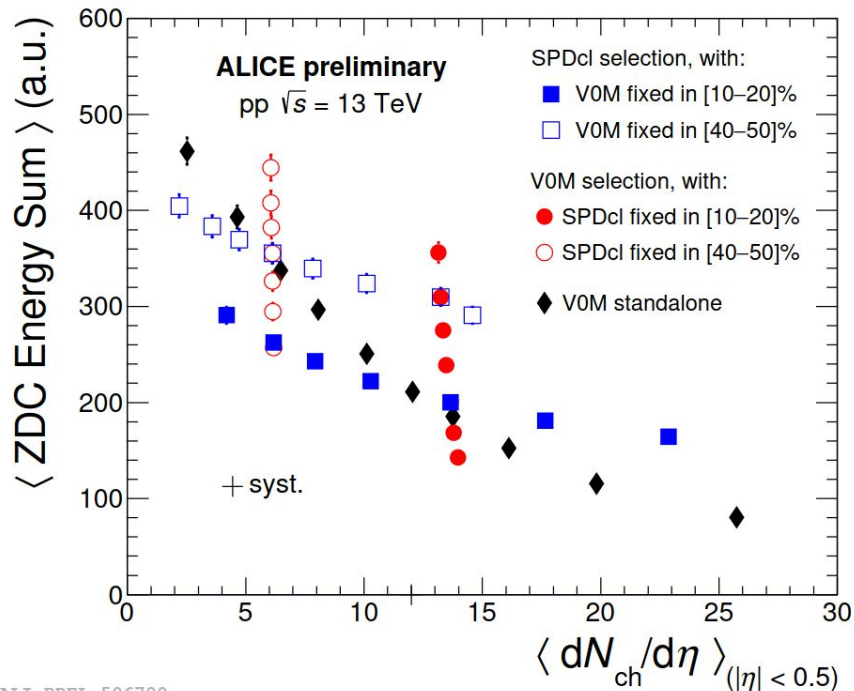
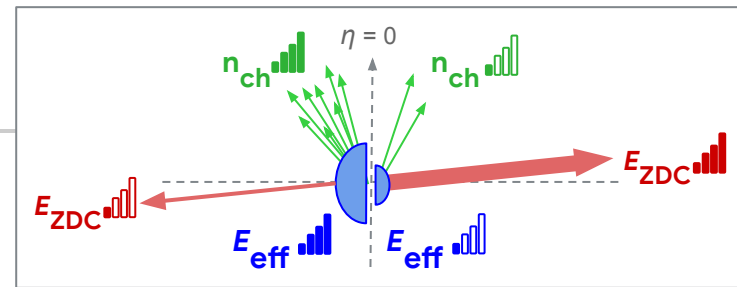
● ○ **Fixed multiplicity at midrapidity + different forward energy deposits in the ZDC**



Leading energy vs multiplicity

ALICE

ALICE measured that the **forward energy decreases with increasing particle multiplicity** produced at **midrapidity**



◆ Standalone V0 event classes

Event classes defined using V0 and SPD (clusters):

- ○ **Fixed multiplicity** at midrapidity + different forward energy deposits in the ZDC
- □ **ZDC energy fixed in a small range** + different multiplicity produced in the event

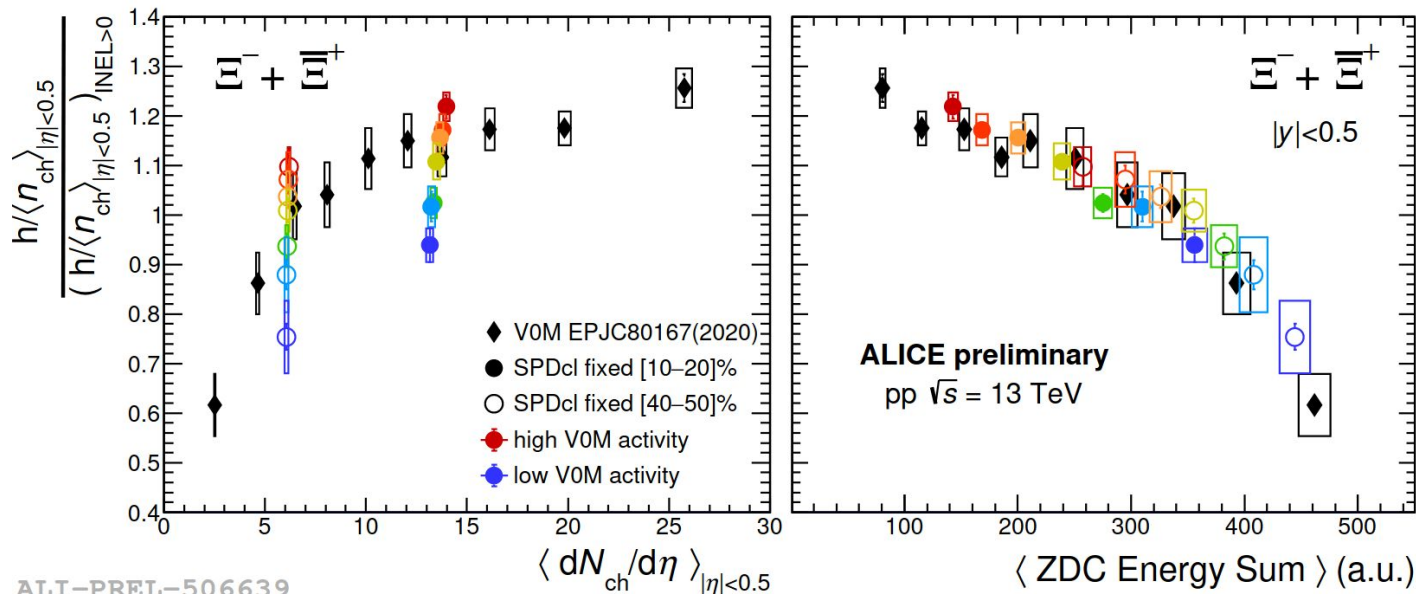


Strangeness production at fixed multiplicity

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In events with the same charged particle multiplicity produced:

- **increase** in Ξ production per charged particle is observed for **decreasing forward energy (ZDC)**
- scaling trends with ZDC energy are **compatible within uncertainties**



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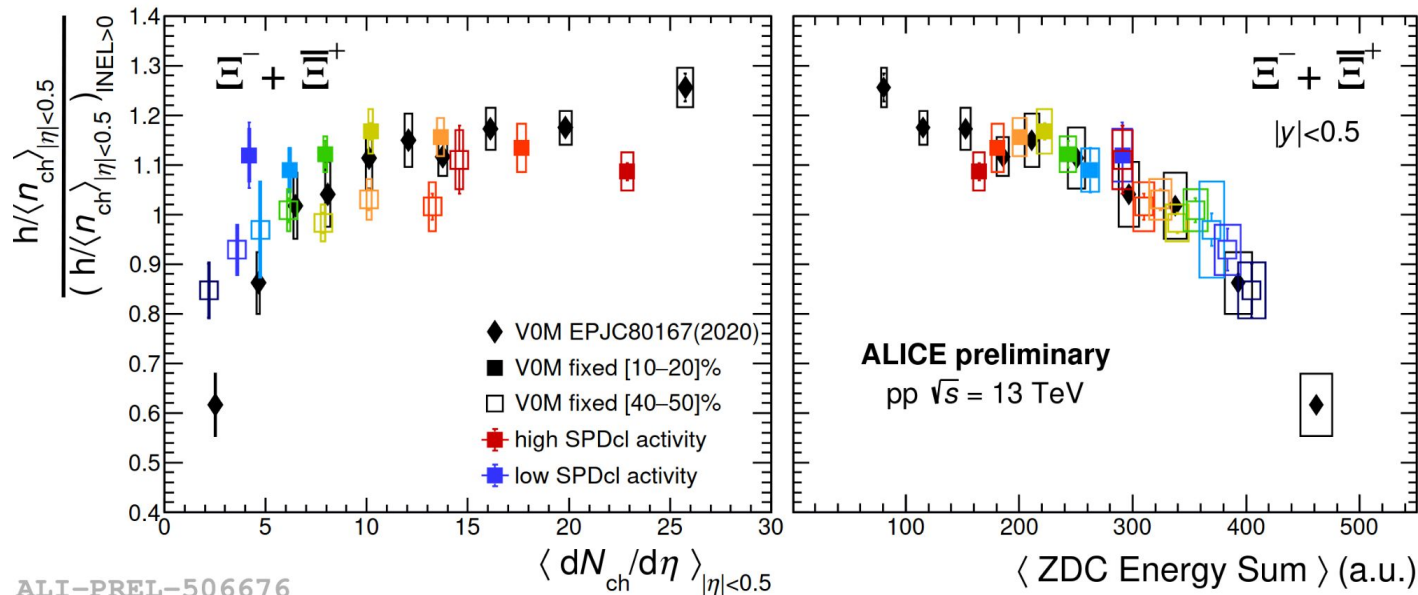


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Strangeness production at fixed ZDC energy

In events with ZDC energy deposits fixed in a small range:

- strangeness **enhancement with multiplicity is reduced** (left)
- within the small ZDC energy range, scaling **trends are compatible** within uncertainties (right)





Summary

In pp collisions strangeness production is found to **increase with midrapidity multiplicity** and to be **anti-correlated with the leading energy**

ALICE exploits a **multi-differential approach** to disentangle the contribution of multiplicity and effective energy to strange particle production:

- ➡ an **increase** in strangeness production is **observed at fixed midrapidity multiplicity**
- ➡ strangeness production shows a **strong correlation with the effective energy** following a **universal trend** with the leading energy detected by the ZDC