Production of light-flavoured particles in ALICE RUN 3 data for pp collisions

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(on behalf of the ALICE collaboration)

Particle production across collision system

Soft probes are very important to study properties of QGP.
Include particle production in the **low-p_T regime**, reflecting **collective behavior** in the QGP.

Strangeness Enhancement is one of the soft probes. First proposed by Johann Rafelski and Berndt Müller in 1982 at Phys. Rev. Lett. 48, 1066.

Phys. Rev. Lett. 48, 1066

Strangeness Production in the Quark-Gluon Plasma

Johann Rafelski and Berndt Müller
Institut für Theoretische Physik, Johann Wolfgang Goethe-Universität, D-6000 Frankfurt am Main, Germany
(Received 11 January 1982)

Rates are calculated for the processes $gg \to s\bar{s}$ and $u\bar{u}, d\bar{d} \to s\bar{s}$ in highly excited quark-gluon plasma. For temperature $T \geq 160$ MeV the strangeness abundance saturates during the lifetime ($\sim 10^{-23}$ sec) of the plasma created in high-energy nuclear collisions. The chemical equilibration time for gluons and light quarks is found to be less than 10^{-24} sec.

PACS numbers: 12.35.Ht, 21.65.+f

Given the present knowledge about the interactions between constituents (quarks and gluons), it appears almost unavoidable that, at sufficiently high energy density caused by compression and/or excitation, the individual hadrons dissolve in a new phase consisting of almost-free quarks and gluons.[1] This quark-gluon plasma is a highly excited state of hadronic matter that occupies a volume large as compared with all characteristic length scales. Within this volume individual color multistrange hadrons.[4] After identifying the strangeness-producing mechanisms we compute the relevant rates as functions of the energy density ("temperature") of the plasma state and compare them with those for light u and d quarks.

In lowest order in perturbative QCD $s\bar{s}$-quark pairs can be created by annihilation of light quark-antiquark pairs [Fig. 1(a)] and in collisions of two gluons [Fig. 1(b)]. The averaged total cross sections for these processes were calculated by

Particle production across collision system in RUN 2

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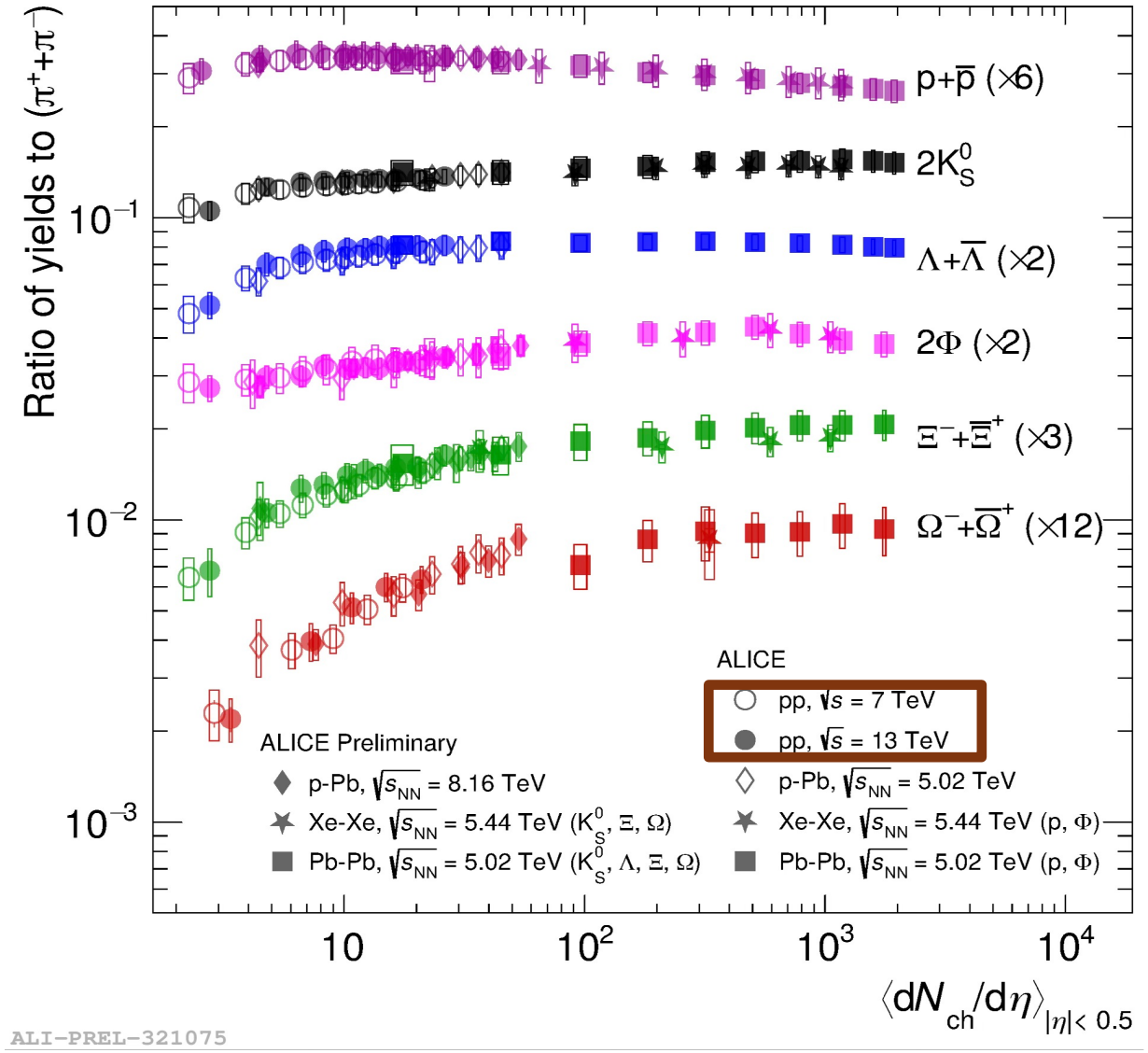
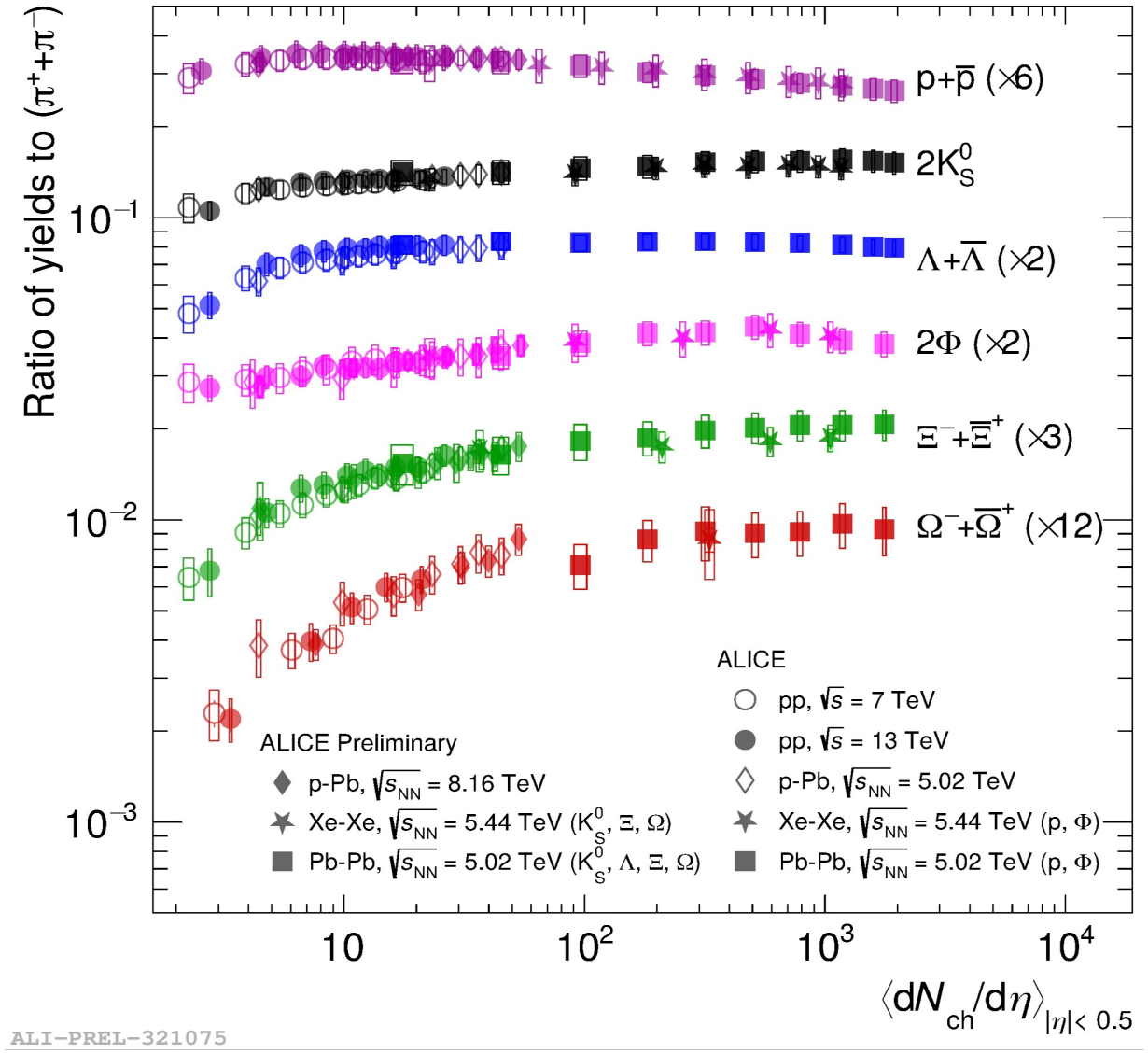
Observed in **heavy ion collisions** with respect to Minimum Bias pp collisions.
Recent observations by ALICE show continuous trend as a function of multiplicity starting from **small systems.**



Large to small system

Continuous evolution of light flavour yield ratios to pions **with the charged-particle multiplicity** observed at the LHC, smoothly connecting different collision systems and energies

$|S_p| = 0$
$|S_K| = 1$
$|S_\Lambda| = 1$
$|S_\phi| = 2$
$|S_\Xi| = 2$
$|S_\Omega| = 3$



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Strangeness production **increases with** particle **multiplicity** wrt MB pp, saturating for central Pb–Pb

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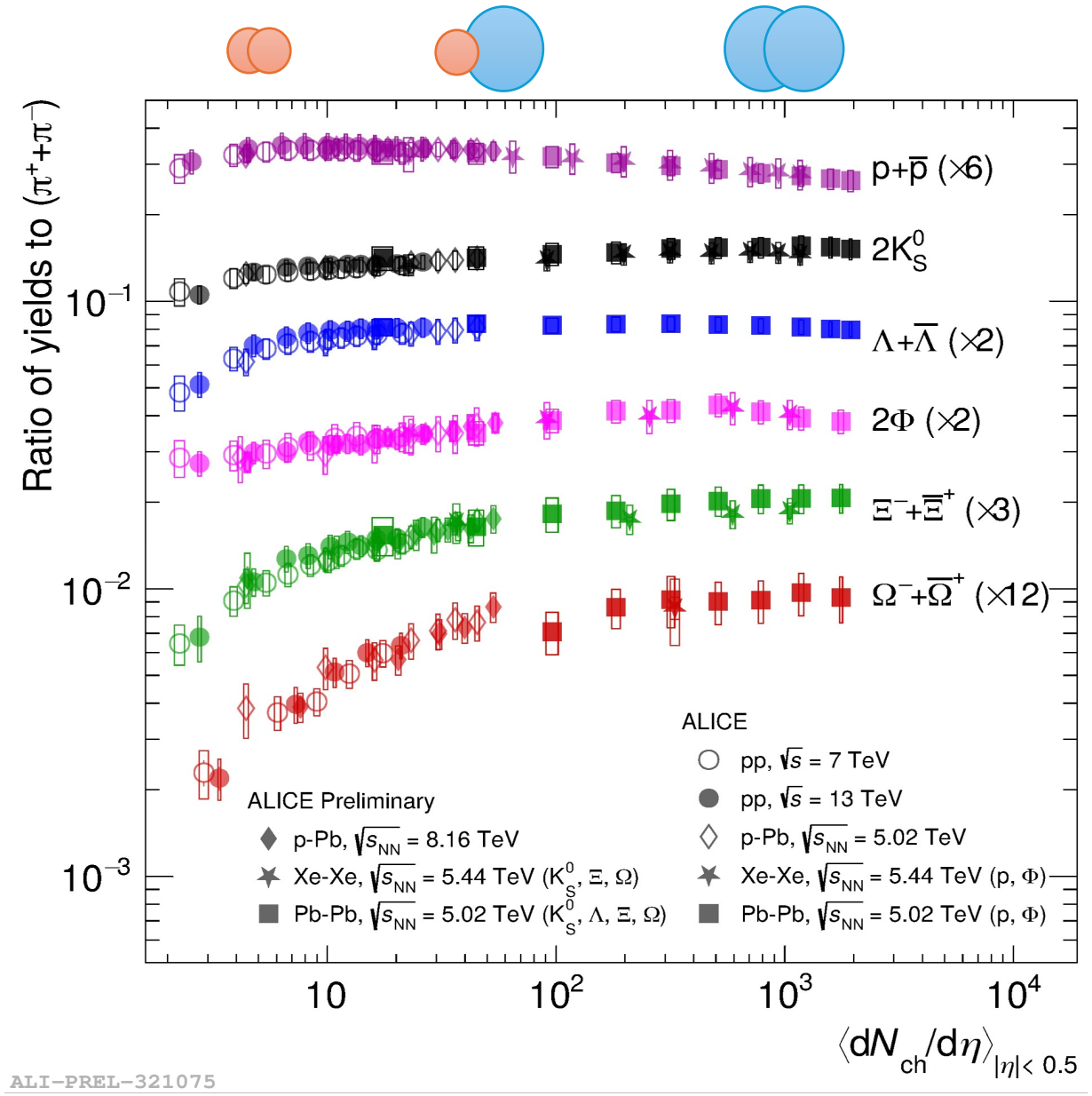

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Investigate particle production mechanism in the low-multiplicity region → test canonical suppression

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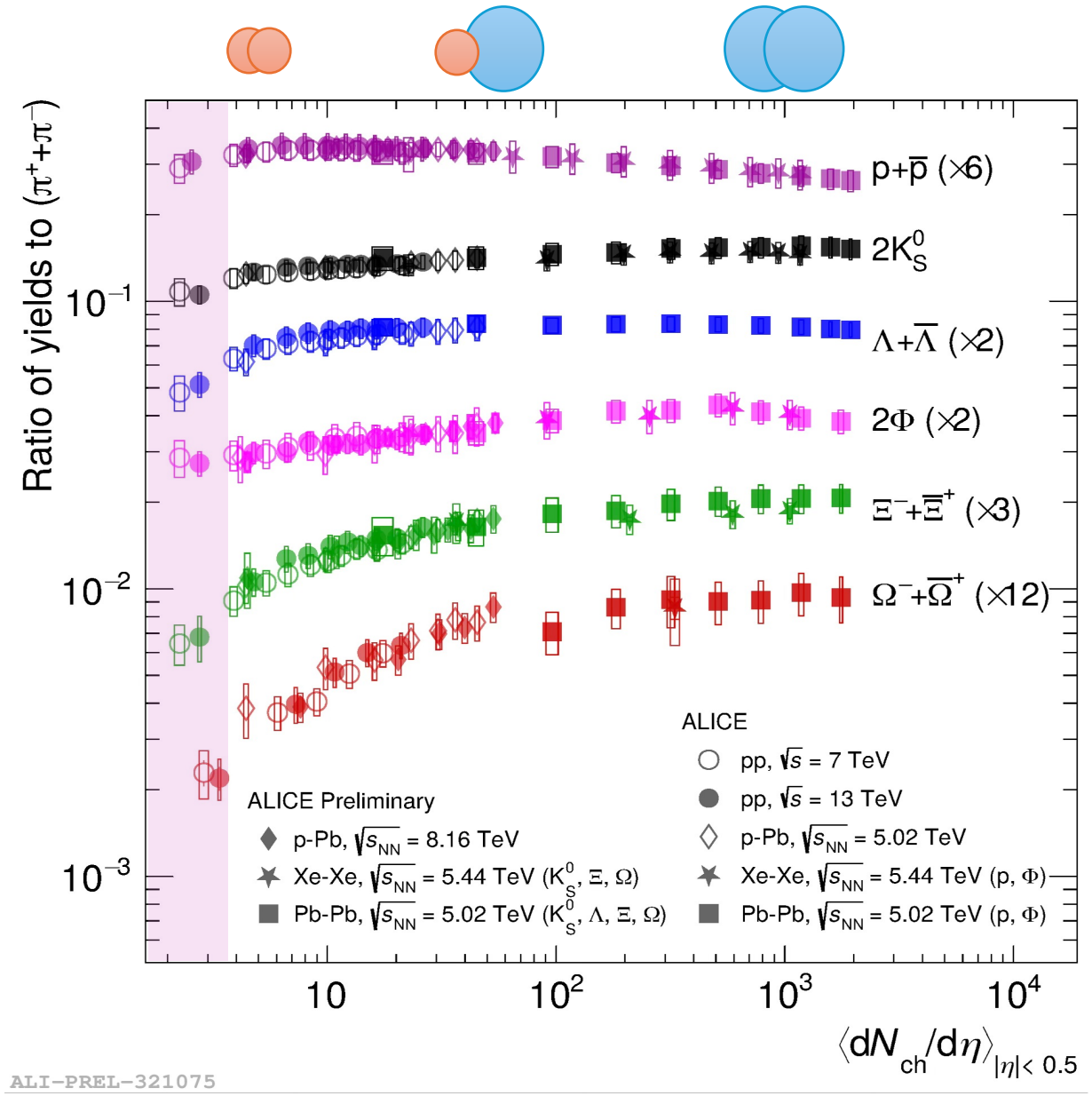

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Connecting results in small systems at high multiplicity to those observed in peripheral AA collisions → is **universal behaviour** valid in extreme multiplicity events?

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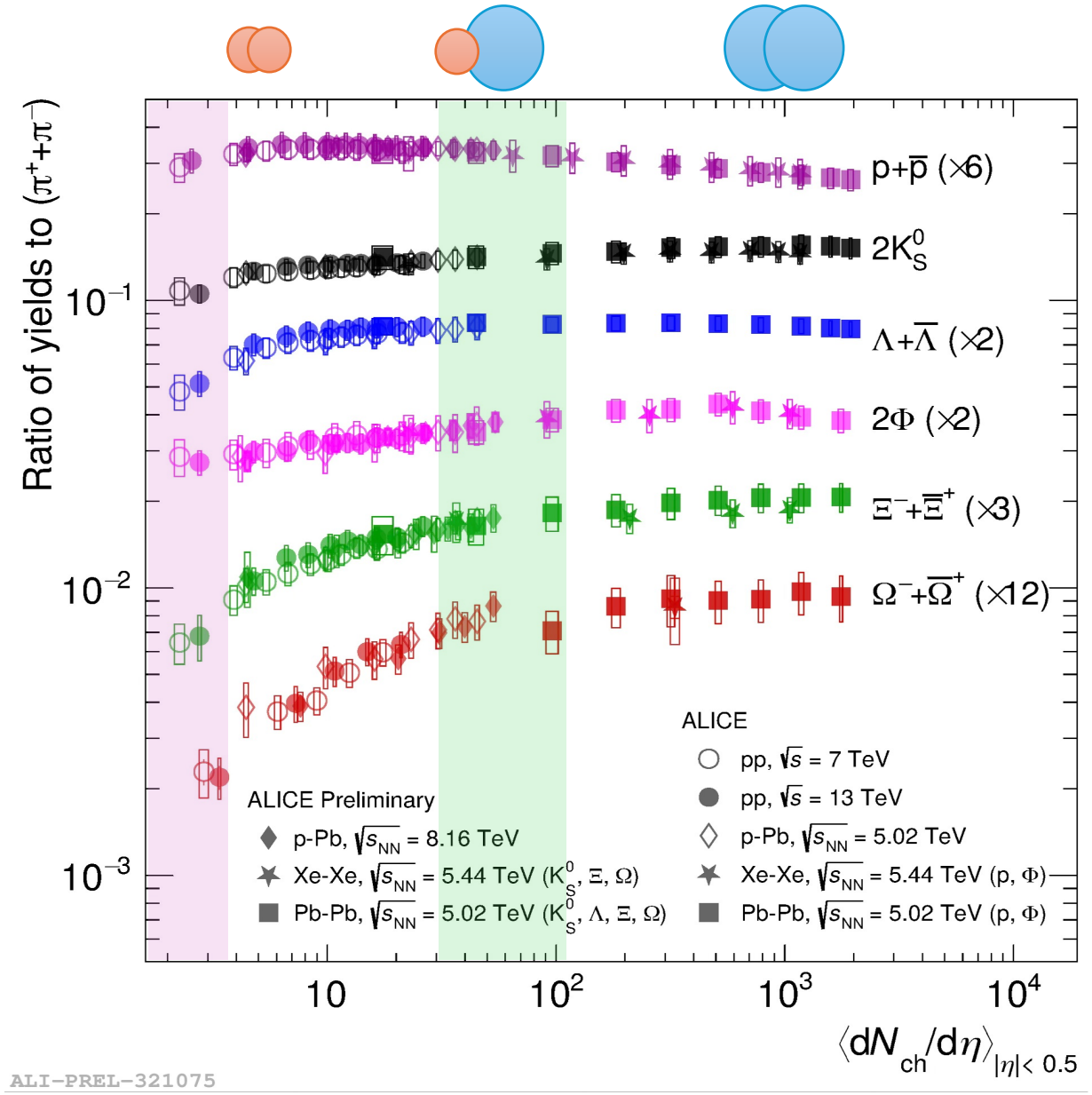
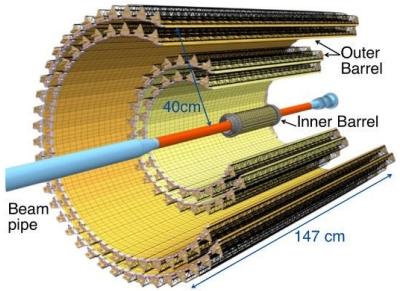


ALICE detector RUN 3 upgrades



ITS Upgrade

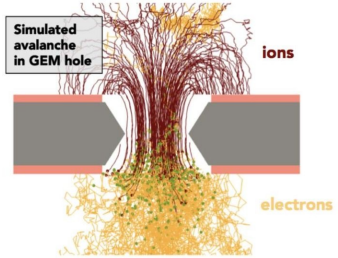
NIM 1032, 166632 (2022)

- First detection layer closer to the interaction point
- Reduced material budget with 7 layers of silicon pixel detectors

TPC Upgrade

JINST 16, P03022 (2021)

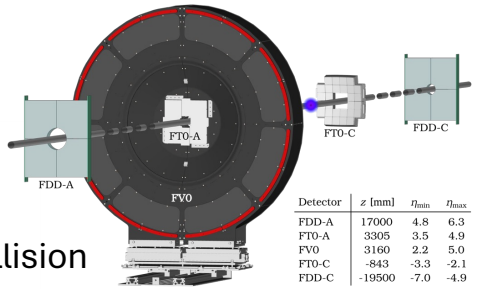
- replaced GEMs instead MWPCs
- Pb–Pb collisions at 50 kHz in continuous mode (×50 wrt Run 2)



NEW Fast Interaction Trigger (FIT)

NIM 1039, 167021 (2022)

- 4 arrays consisting of Cherenkov detectors and scintillators.
- Used for triggering, determining collision time, and centrality estimation.



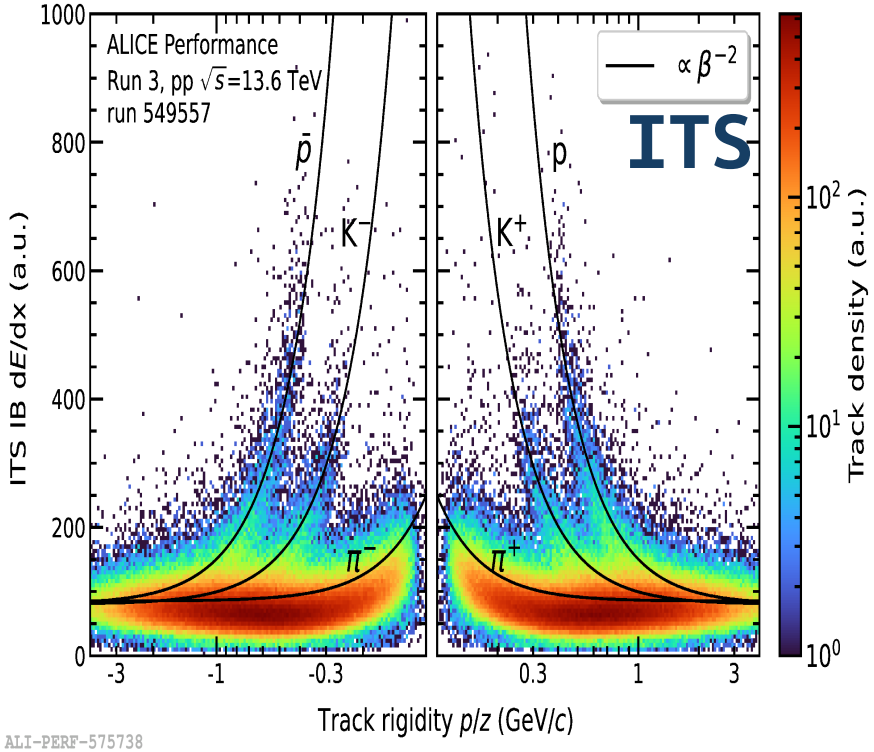
Detector	z [mm]	η_{min}	η_{max}
FDD-A	17000	4.8	6.3
FT0-A	3305	3.5	4.9
FV0	3160	2.2	5.0
FT0-C	-843	-3.3	-2.1
FDD-C	-19500	-7.0	-4.9

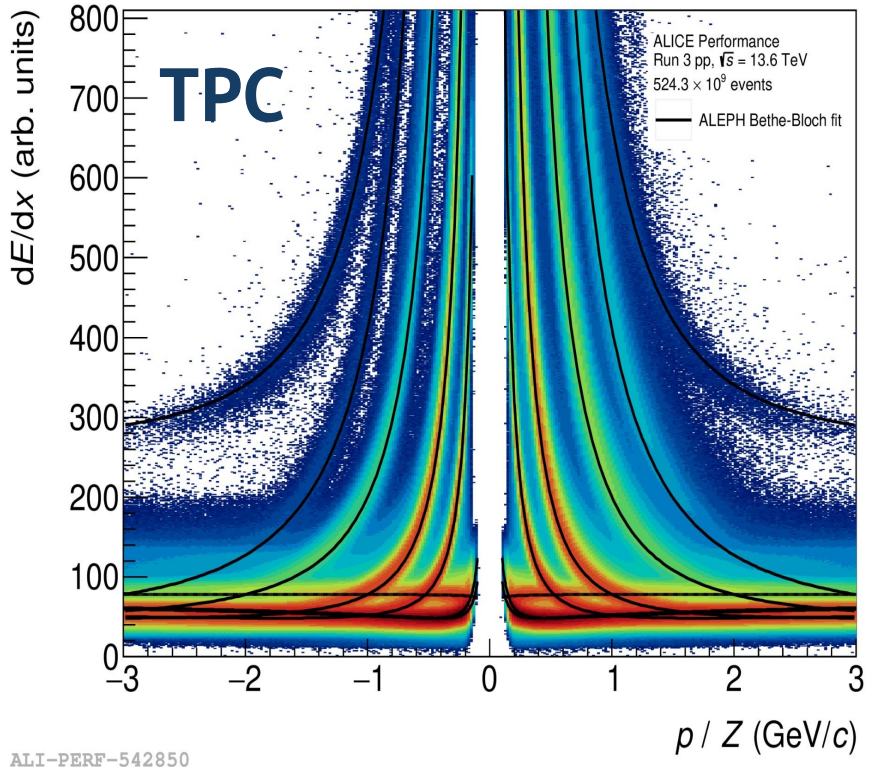
NEW O^2 framework

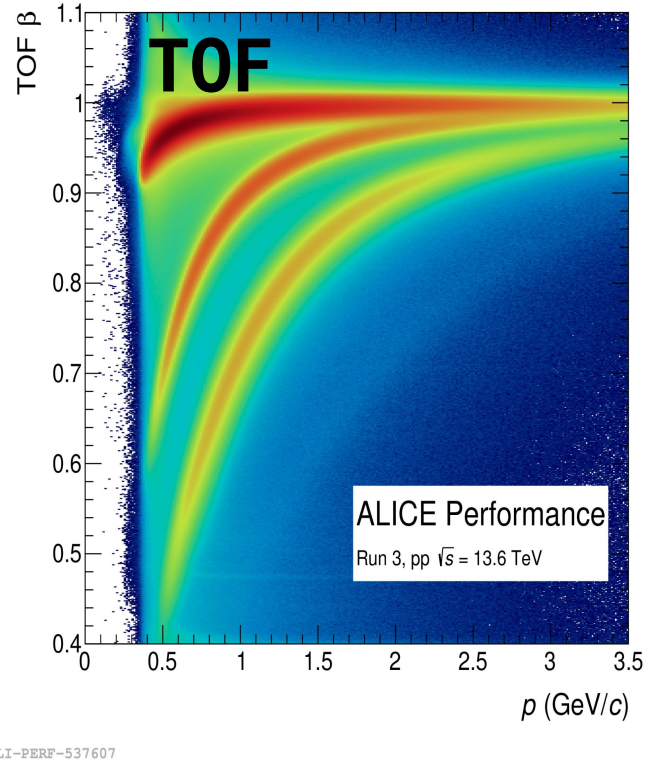
CERN-LHCC-2015-006, ALICE-TDR-019

- Increased data volume ×100 wrt Run 2
- One common Online Offline (O^2) computing system
- Faster online and offline processing

Performance plot in RUN 3



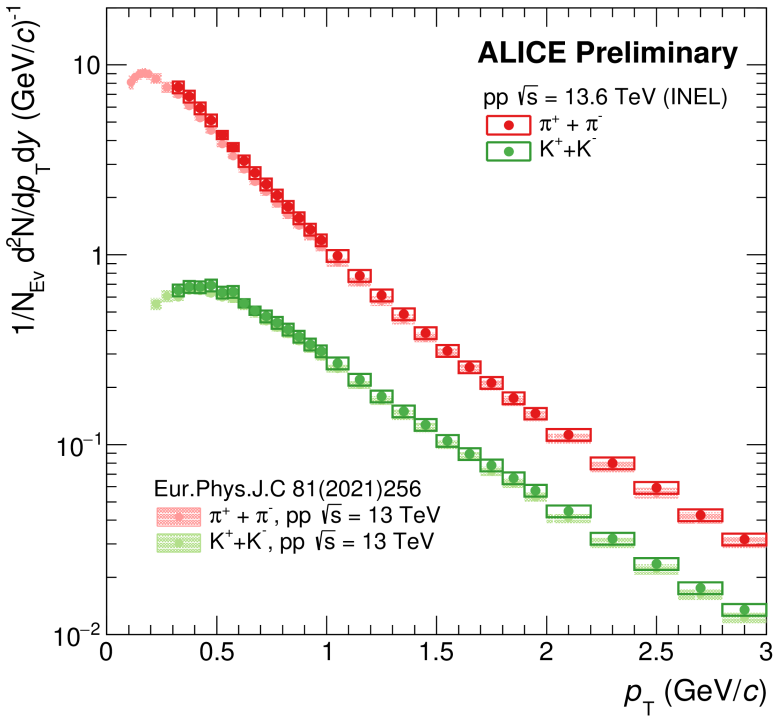




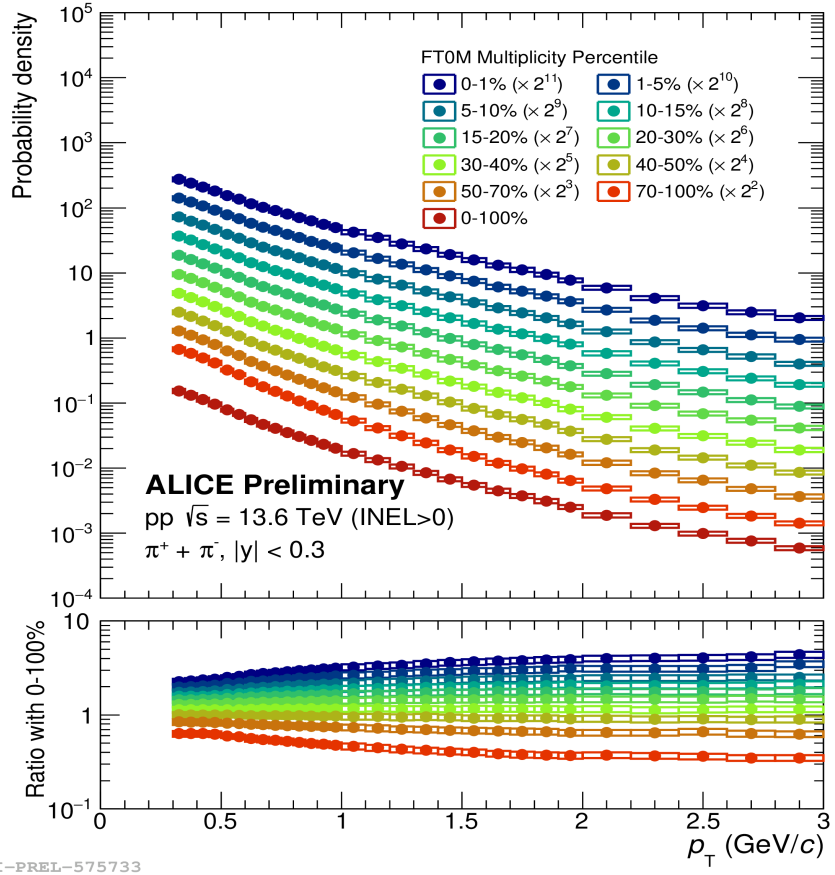
Run 3 data taking began in 2022, and ALICE has since collected nearly **1000 times** more events compared to Run 2 during proton-proton data taking, operating at approximately **500 kHz in continuous readout mode**

Excellent PID performance of the ALICE detector in Run 3

p_T-Spectra in pp collsions $\sqrt{s}$ = 13.6 TeV



NEW



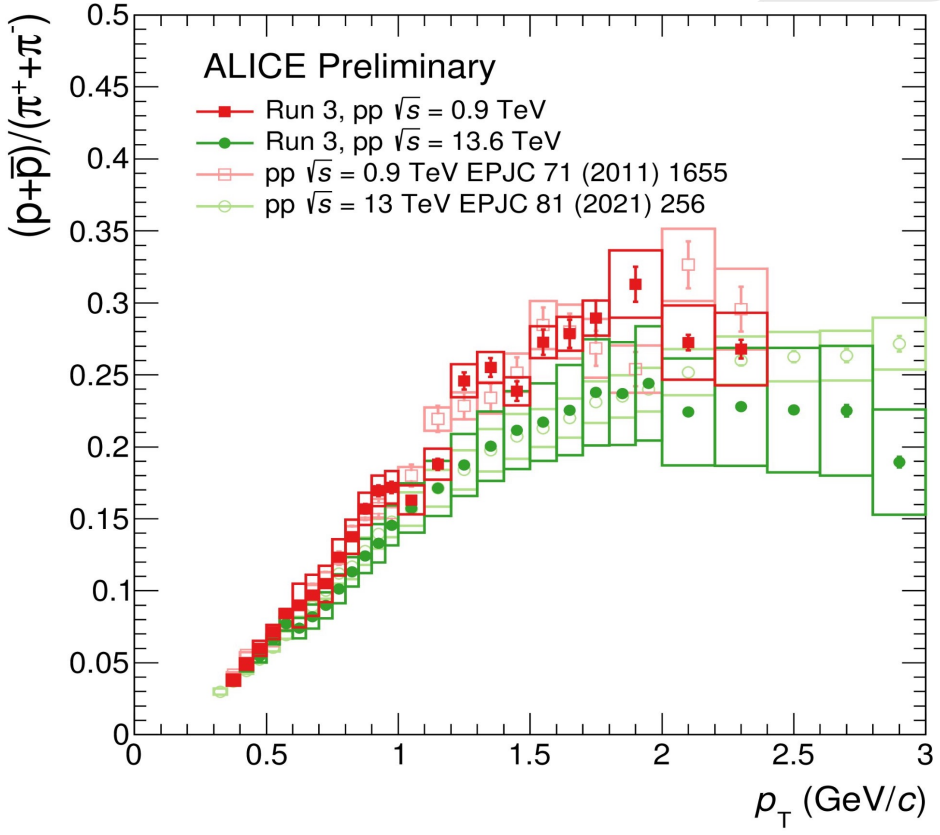
p_T-spectra for pions and kaons in INEL event compared with RUN 2

p_T-spectra for pions for different multiplicity classes

Shows hardening of **p_T-spectra** with increasing multiplicity →similar to radial flow

p_T-dependent K/π and p/π ratio

NEW



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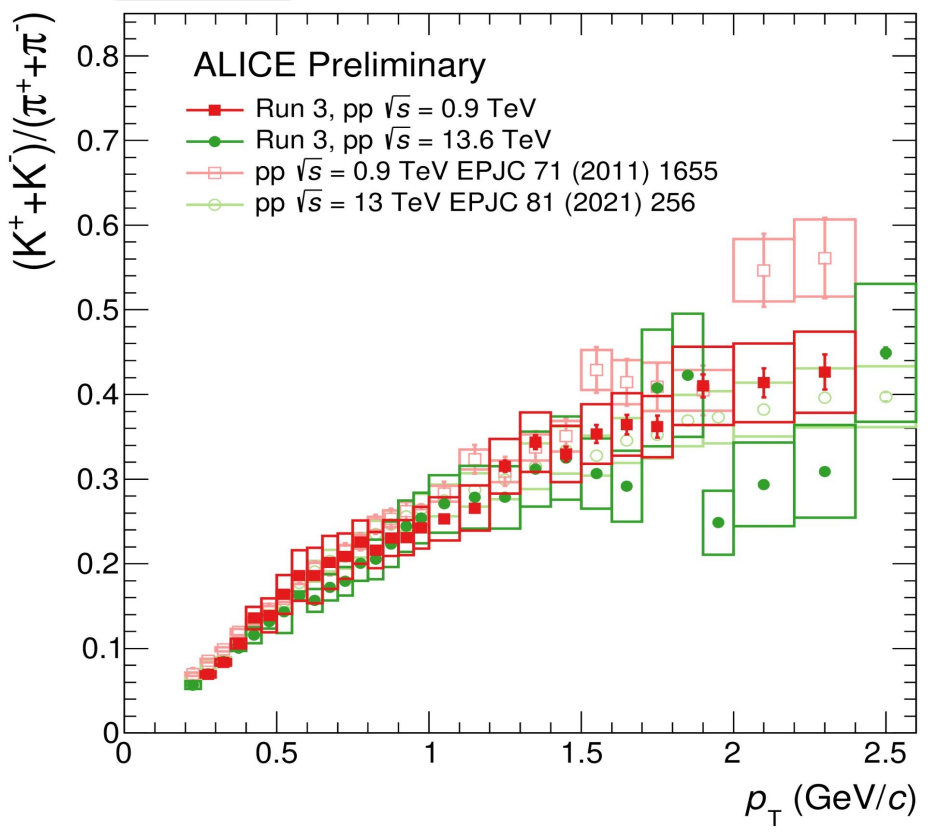

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K/π and p/π yield ratios in pp collisions at 13.6 TeV and 900 GeV collected in **Run 3**

→ **900 GeV** yields in **agreement** with published results + **improved statistical uncertainty**

→ **13.6 TeV** yields **consistent with expectations**

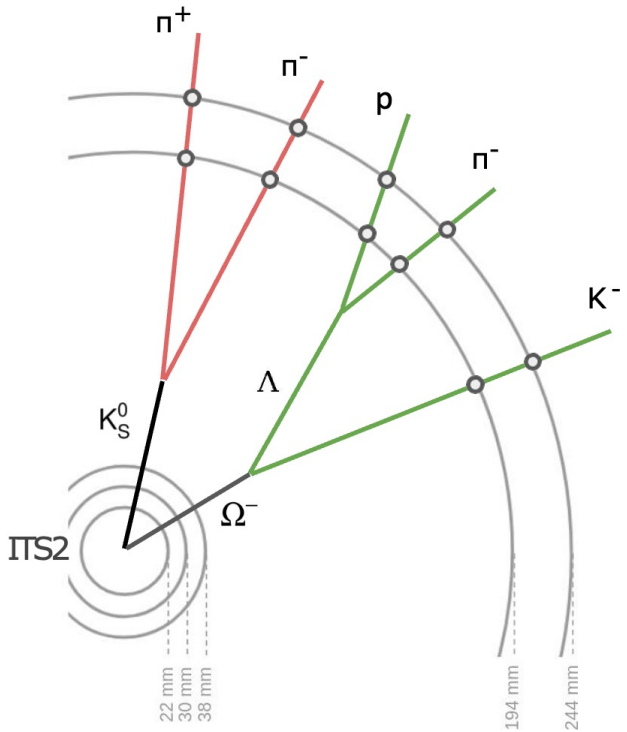
→ At the LHC no significant **collision energy dependence** for K/π but larger p/π at lower energy

Strangeness production in RUN 3

Reconstruction based on two decay topology

V^0 Neutral particle decaying into pair of charged particle

Cascade Charged particle decaying into a V^0 and charged particle



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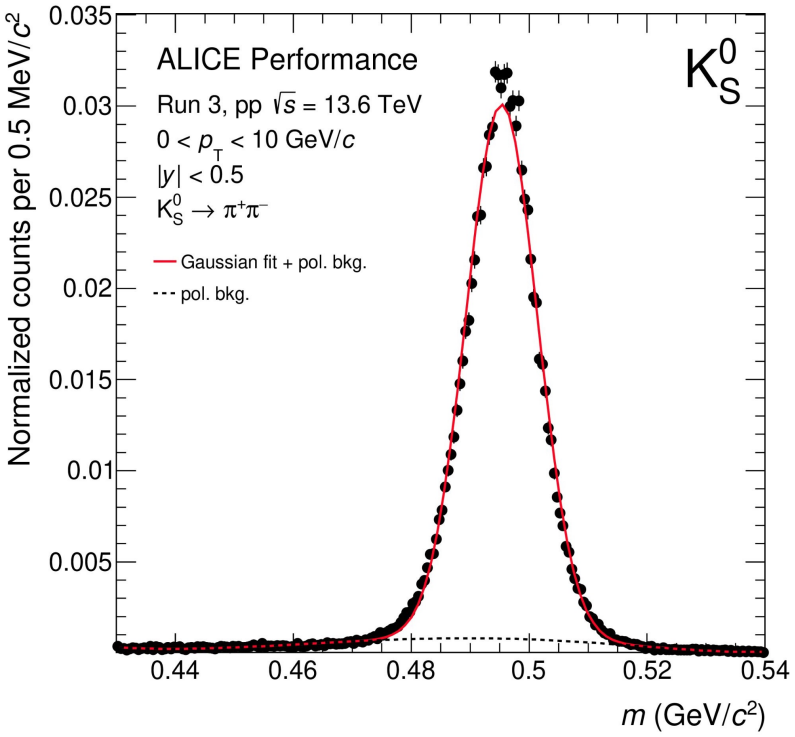

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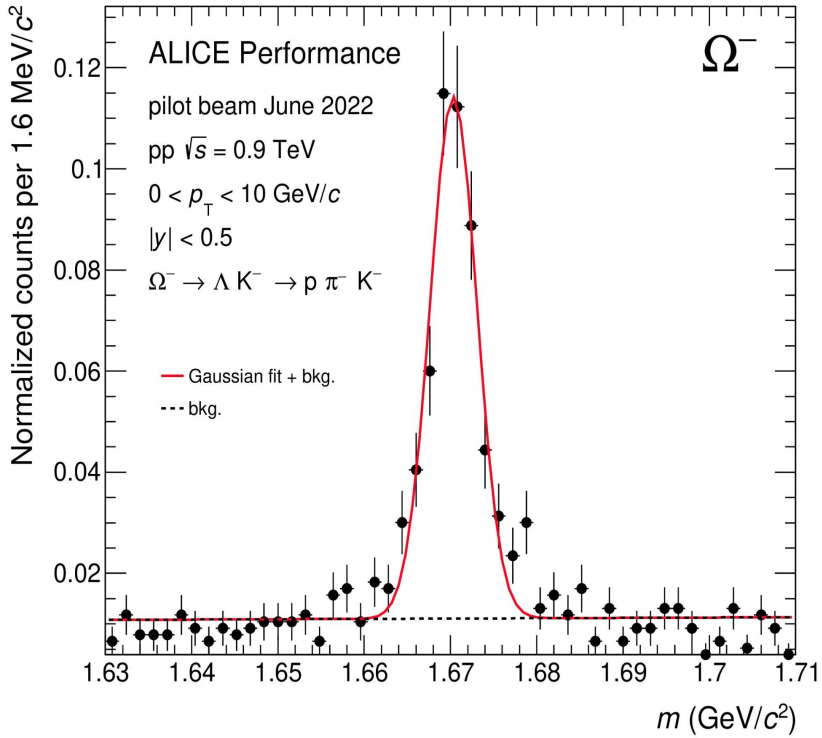

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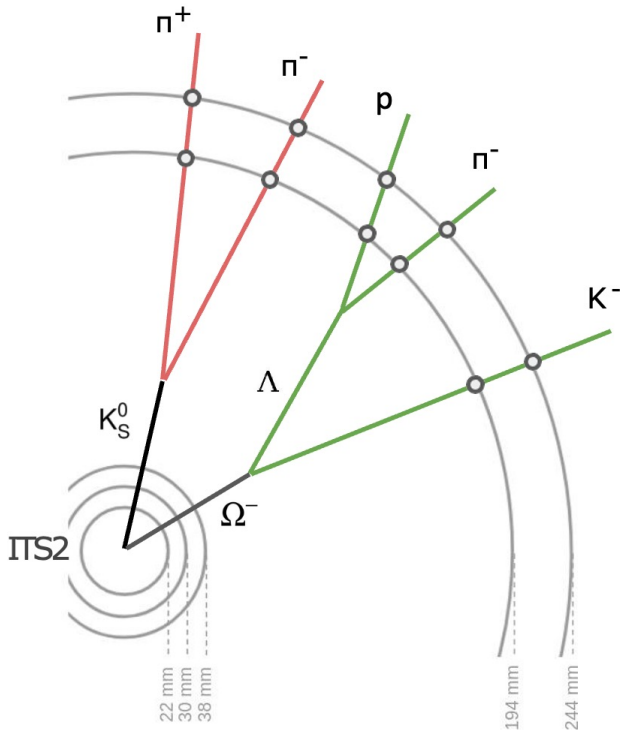
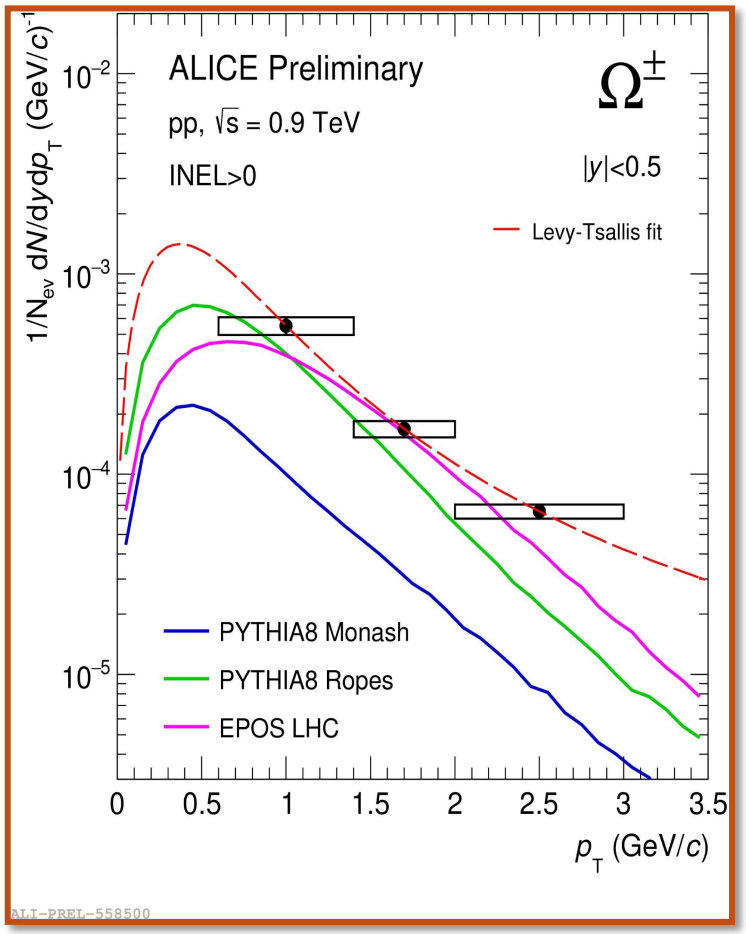


$\Omega^{\pm}$ production in RUN 3 at 900GeV



First observation of **Ω** production in proton-proton collisions at **900 GeV** at the LHC

→ The p_T-dependent yields are compared against various MC models, a general discrepancy is observed between the models and the data.

NEW

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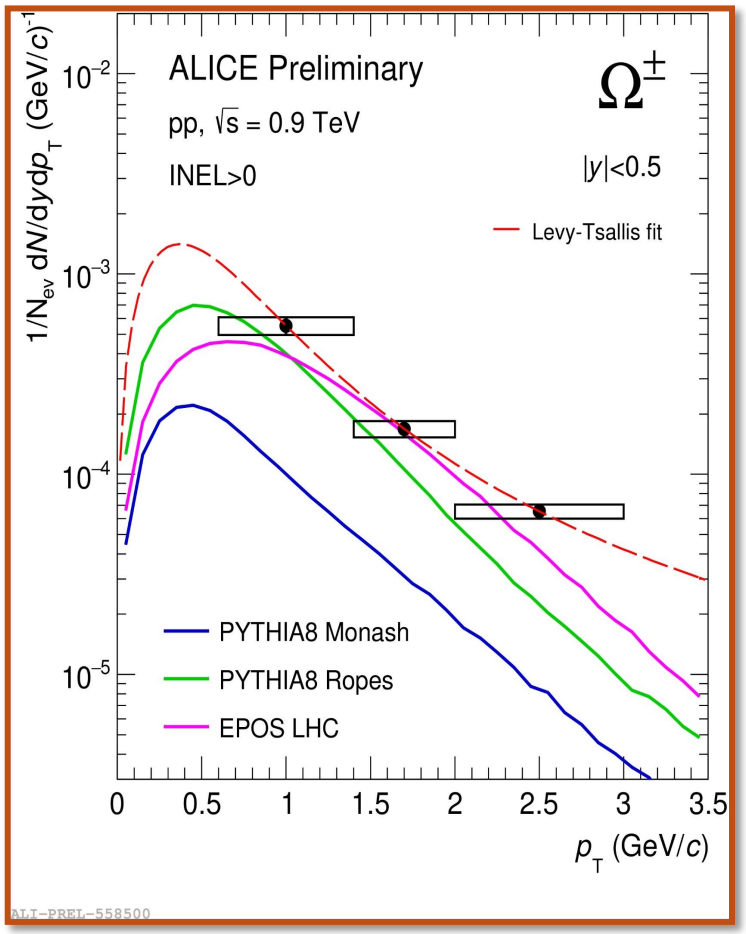

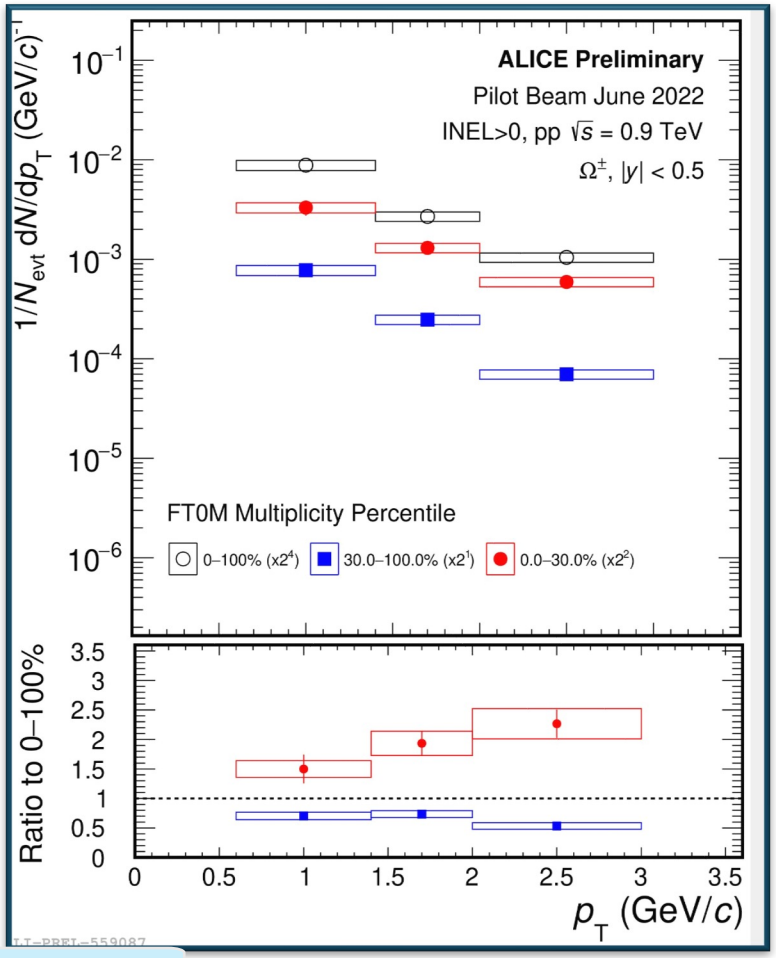

NEW

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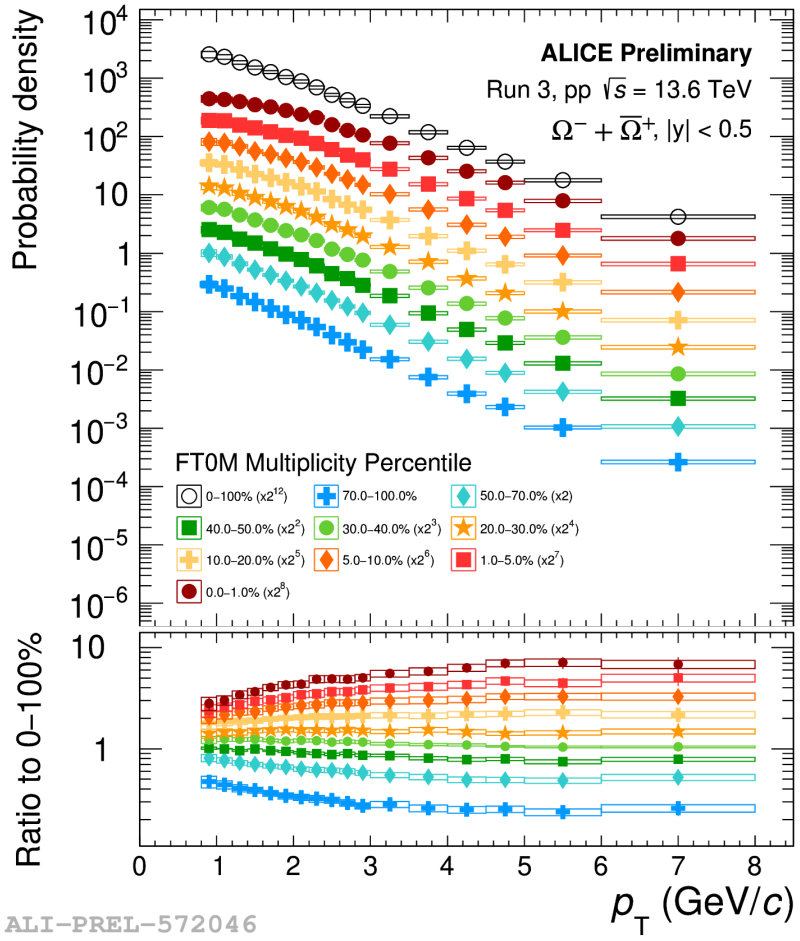
→ The p_T-dependent yields are compared against various MC models, a general discrepancy is observed between the models and the data.

Ω spectra measured for the first time across multiplicity classes (FT0A+FT0C) in proton-proton collisions at $\sqrt{s}$ = 900 GeV.

Hardening of the spectra with increasing multiplicity is observed in proton-proton collisions even at the lowest center-of-mass energy at the LHC.

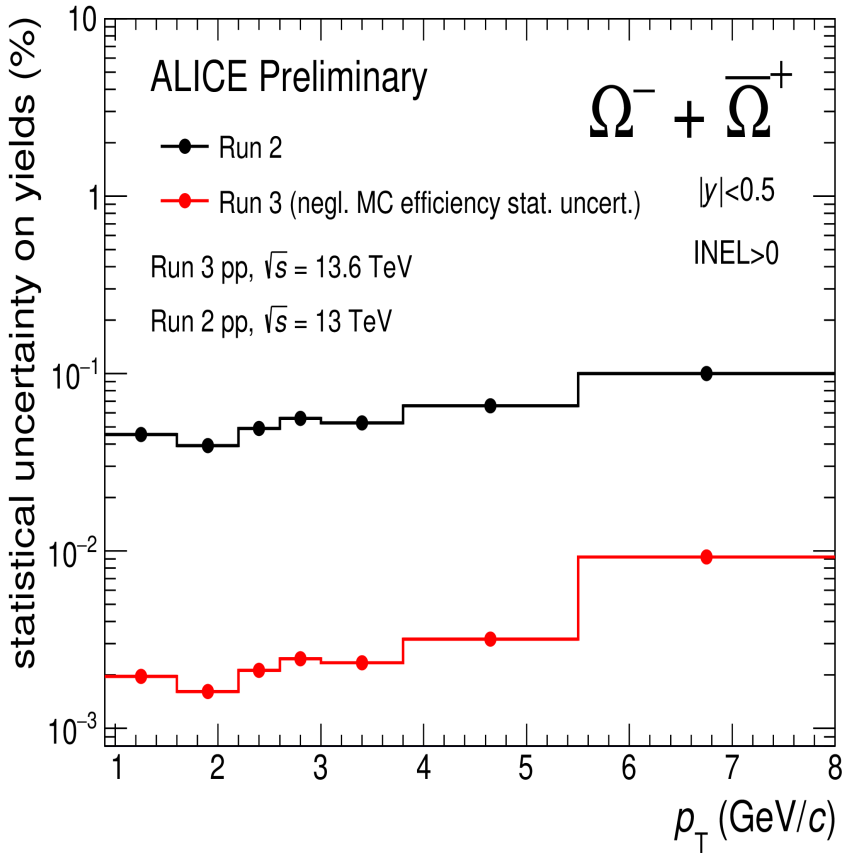
$\Omega^{\pm}$ production in RUN 3 at 13.6TeV



ALI-PREL-572046

p_T-dependent probability density of Ω in pp collisions at **√s = 13.6 TeV** is analyzed across multiplicity classes (FT0A+FT0C).

→ **Larger data sample** with respect to Run 2 → Improve statical uncertainty by a Factor > 10



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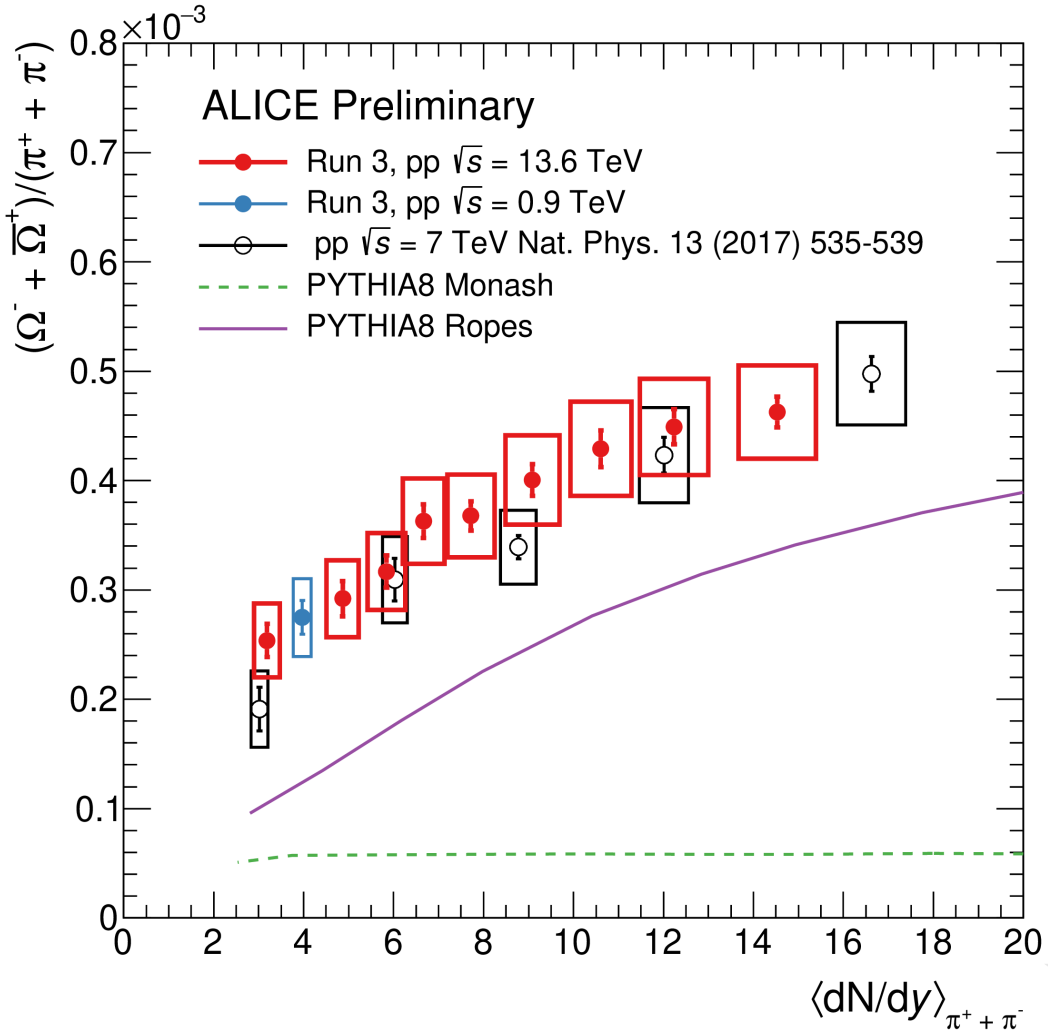
NEW

Multiplicity dependent Ω/π ratio



ALI-PREL-559079

Variation of Ω/π production with multiplicity in pp collisions at **$\sqrt{s}$ = 13.6 TeV** measured for the first time.

Measured **Ω/π ratio** as a function multiplicity for the first time in **pp at 900GeV**

Ω/π ratio increases as a function of multiplicity.

GOAL

→ Run 3 data with **high statistics** will help to increase this study to higher multiplicities

Minimum bias pp sample combined with software triggers will be used to select events with multi-strange hadrons.

NEW

Summary

→ **Light flavor particle production** in pp collisions at **highest and lowest** center of mass energy at LHC is being studied by ALICE.

→ Measured **Ω/Π** ratio in pp at **$\sqrt{s}$ = 900 GeV** for the first time as function of multiplicity.

→ Measured multiplicity dependent **Ω/Π** ratio in pp at **$\sqrt{s}$ = 13.6 TeV**.

→ Measurements are performed using the upgraded **ALICE detector in RUN 3**, enabling studies with unprecedented statistical precision, entering the high-statistics era.


THANK YOU FOR YOUR ATTENTION