

# Search for collective phenomena in high-multiplicity pp and p-Pb collisions with the ALICE experiment

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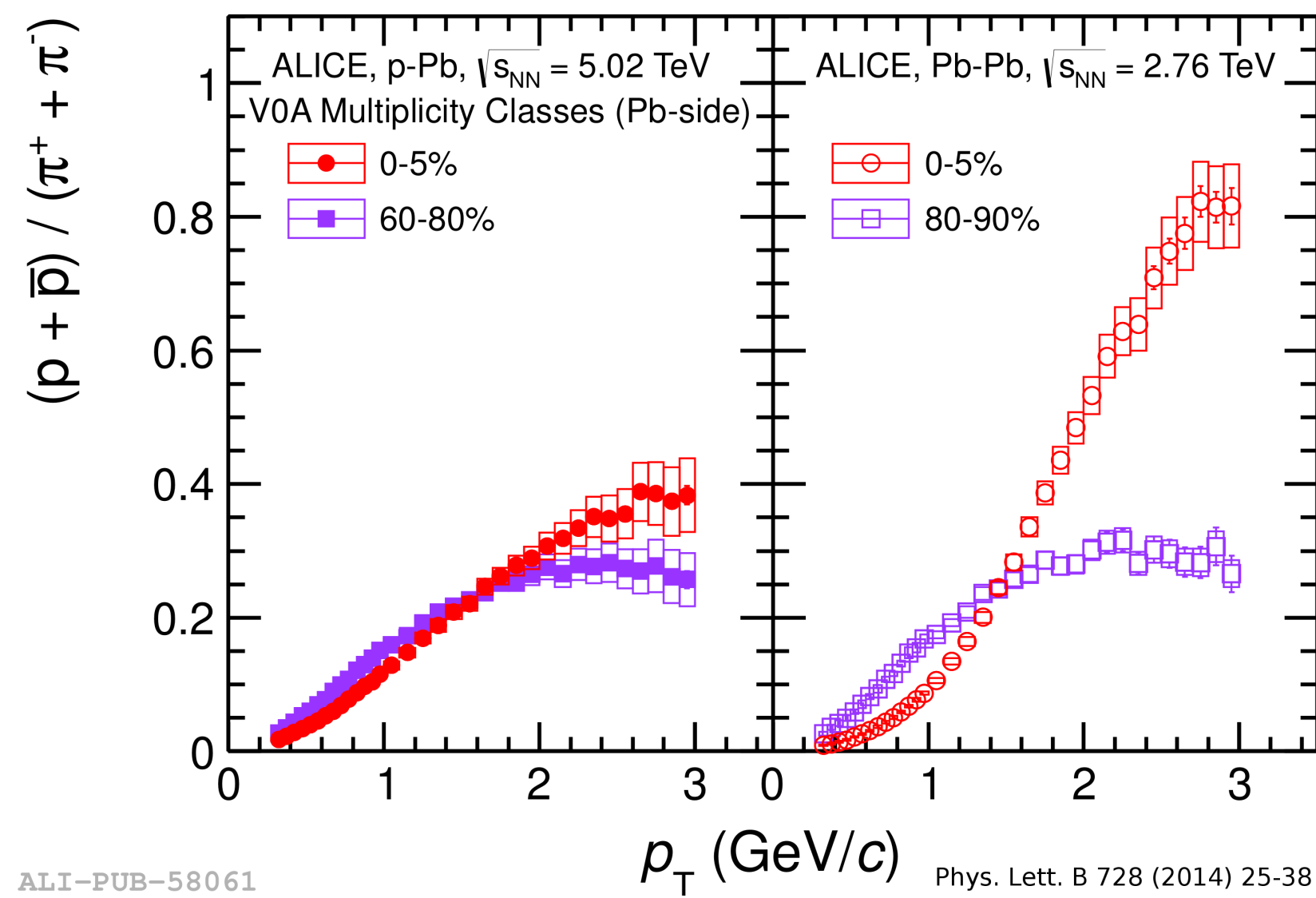
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ALICE

## Introduction

Recent particle production measurements in high-multiplicity proton-lead (p-Pb) collisions have shown features that are reminiscent of lead-lead (Pb-Pb) phenomenology. These observations warrant a detailed study of identified particle production also in high-multiplicity proton-proton (pp) collisions, as differences or similarities of such measurements in the three systems may shed light on the particle production mechanisms at play.



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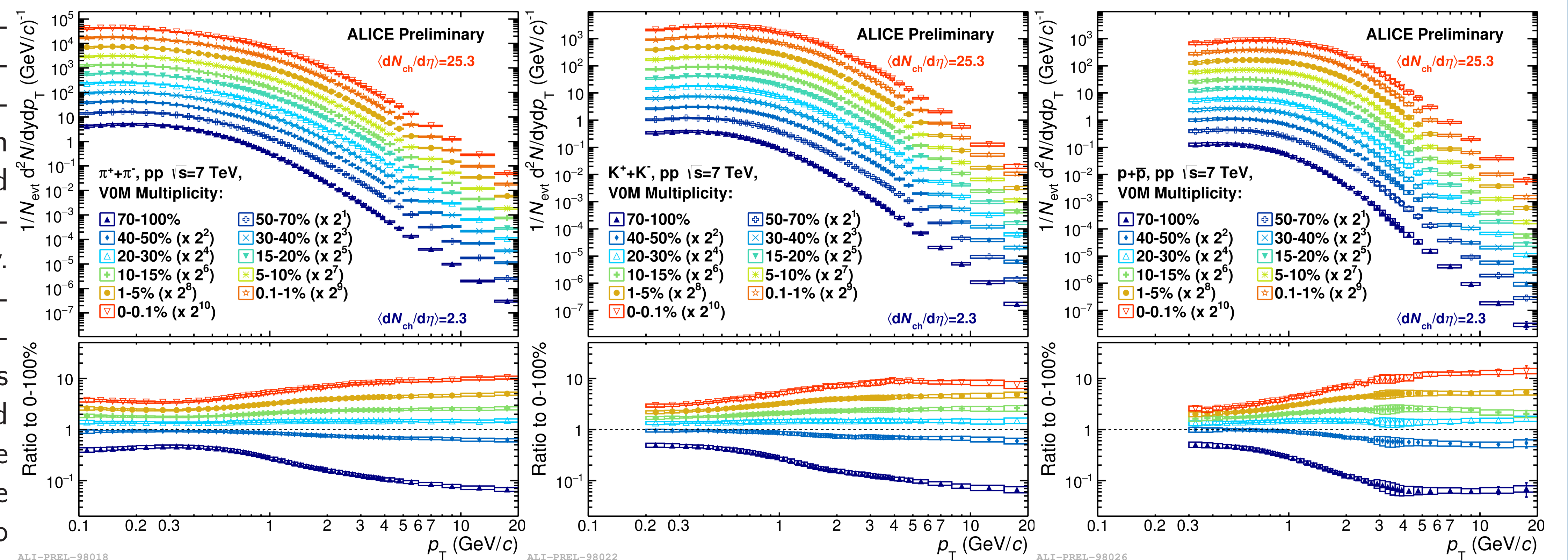
## Detector and analyses

The ALICE detector employs a large variety of particle identification techniques in order to cover the widest transverse momentum ( $p_T$ ) range possible. In this work, a number of different techniques and detectors were used to achieve a  $p_T$  range of 0.1 to 20 GeV/c. The presented spectra were obtained by combining data analyses that employ the Inner Tracking System (ITS), the Time-Projection Chamber (TPC) and the Time-of-Flight (TOF). Events were classified according to their total charged particle multiplicities as measured in the forward regions by the VOA and V0C scintillators, located at  $2.8 < \eta < 5.1$  and  $-3.7 < \eta < -1.7$ , respectively. The multiplicity percentiles used in analyses and the corresponding  $\langle dN_{ch}/d\eta \rangle$  are given in the table below.

VOM	$\langle dN_{ch}/d\eta \rangle$	VOM	$\langle dN_{ch}/d\eta \rangle$
0-0.1%	$25.3 \pm 0.8$	0.1-1%	$20.8 \pm 0.6$
1-5%	$16.5 \pm 0.5$	5-10%	$13.5 \pm 0.4$
10-15%	$11.5 \pm 0.3$	15-20%	$10.1 \pm 0.3$
20-30%	$8.4 \pm 0.3$	30-40%	$6.7 \pm 0.2$
40-50%	$5.4 \pm 0.2$	50-70%	$3.9 \pm 0.1$
70-100%	$2.3 \pm 0.1$	0-100%	$6.0 \pm 0.2$

## Results

Identified particle spectra were measured in the central region ( $|y| < 0.5$ ) in order to avoid autocorrelations of measurements and the event multiplicity estimator, which is taken to be the sum of VOA and V0C signals and is denoted as VOM. The  $p_T$ -differential spectra become harder with increasing multiplicity. This effect is more pronounced for protons than for pions, indicating the flow-like mass ordering and showing patterns reminiscent of those observed in p-Pb and Pb-Pb collisions. The spectral shapes are seen to be unaltered at high  $p_T$ , where the ratios to the inclusive spectra are seen to be independent of momentum.

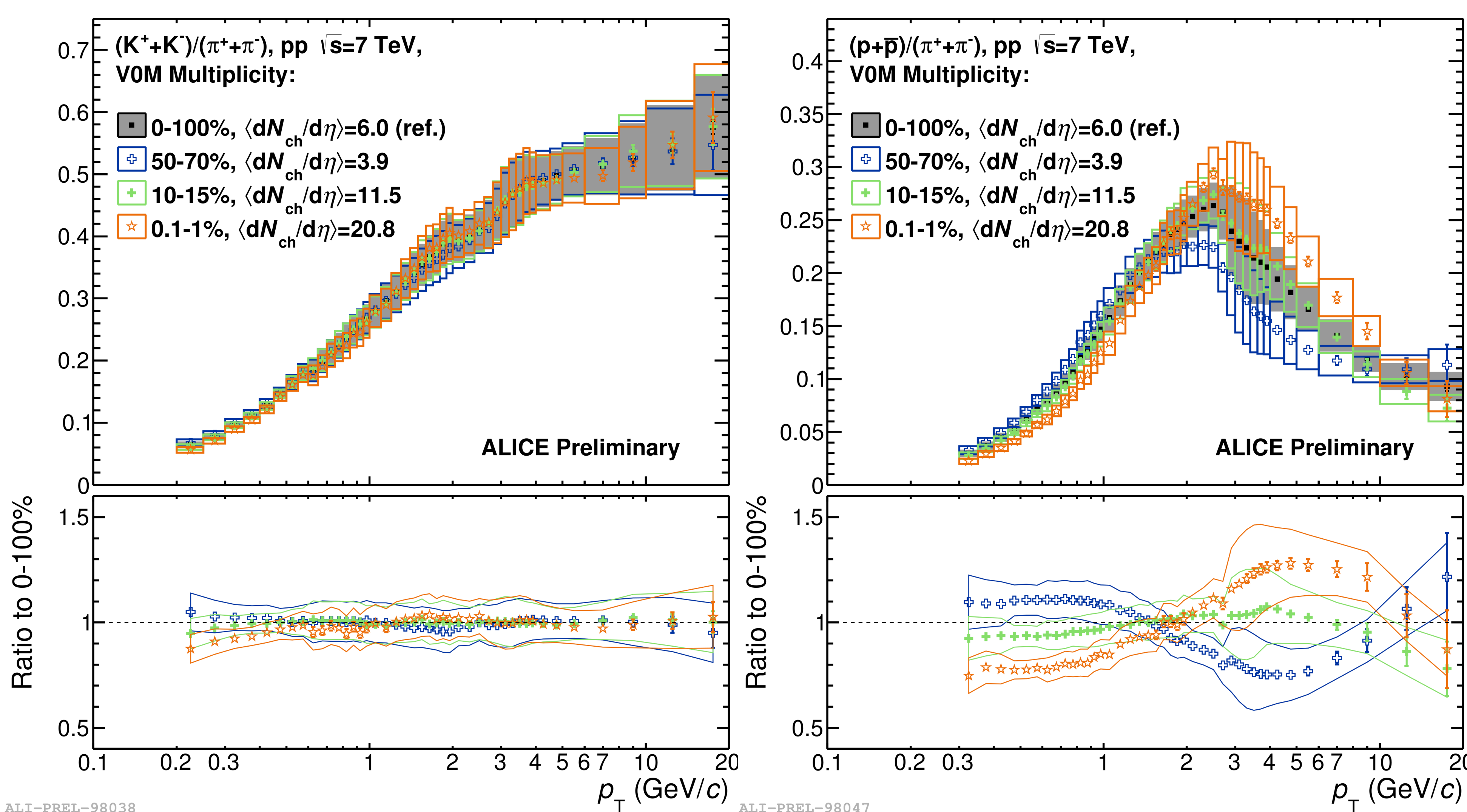


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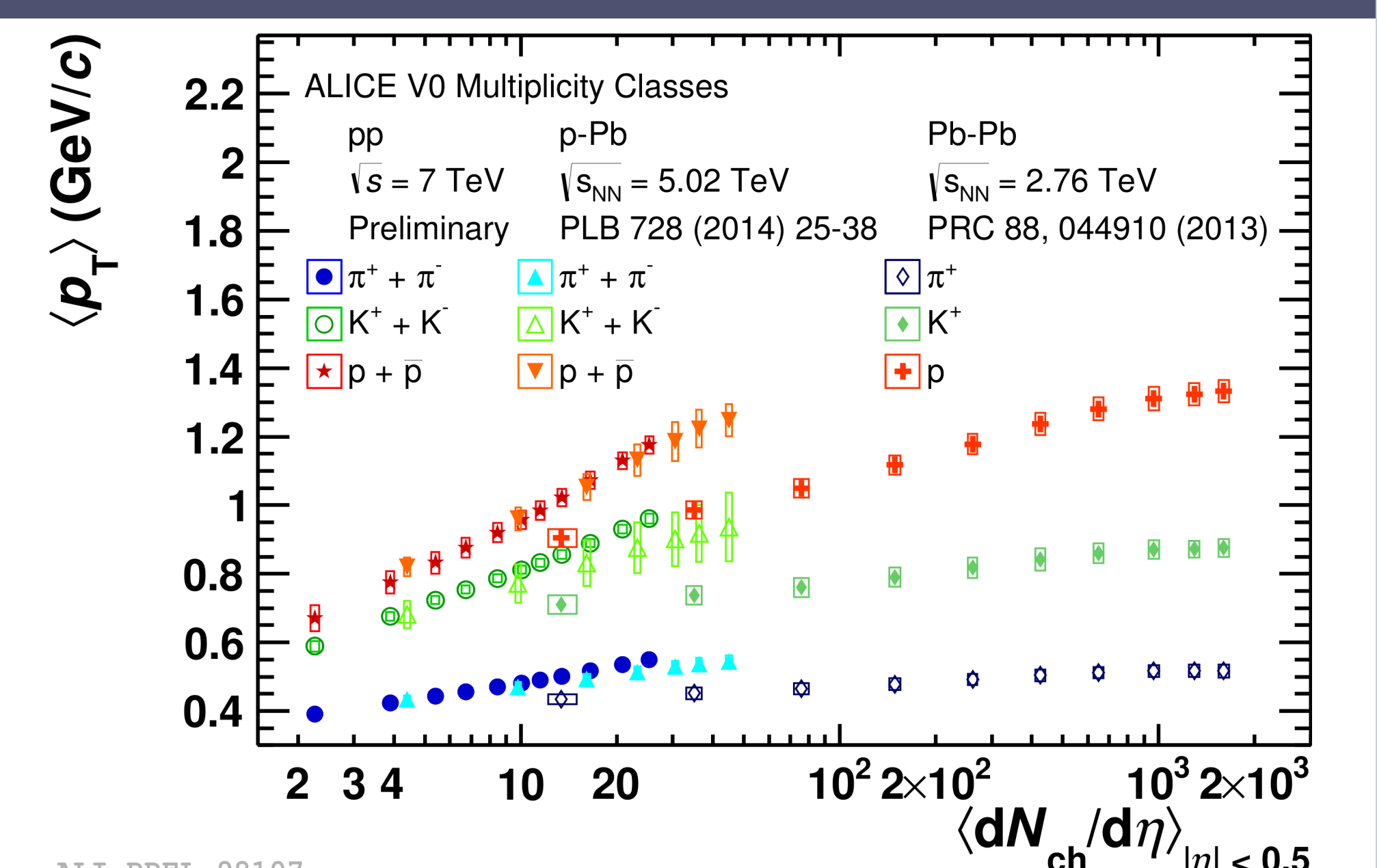
## Discussion



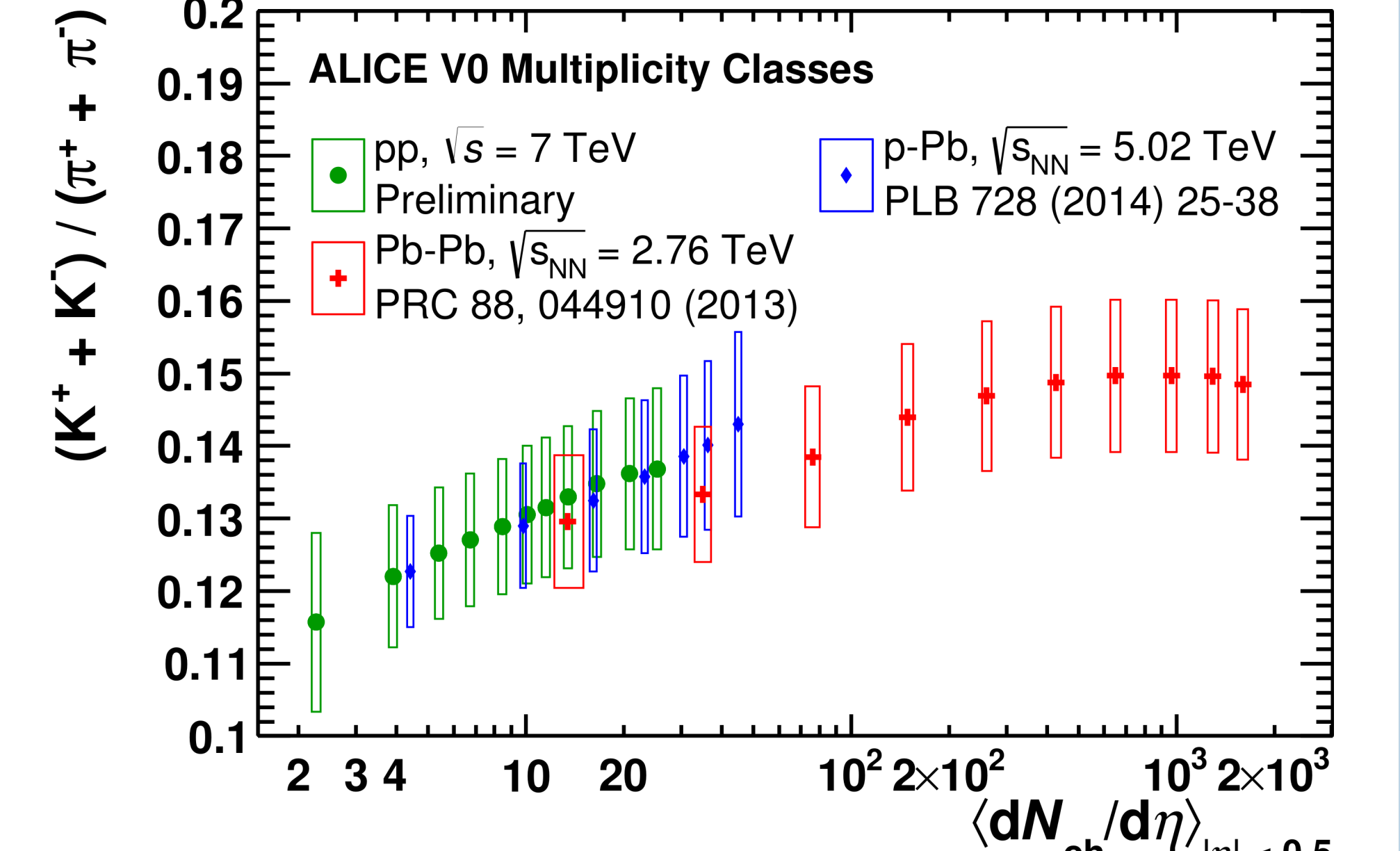
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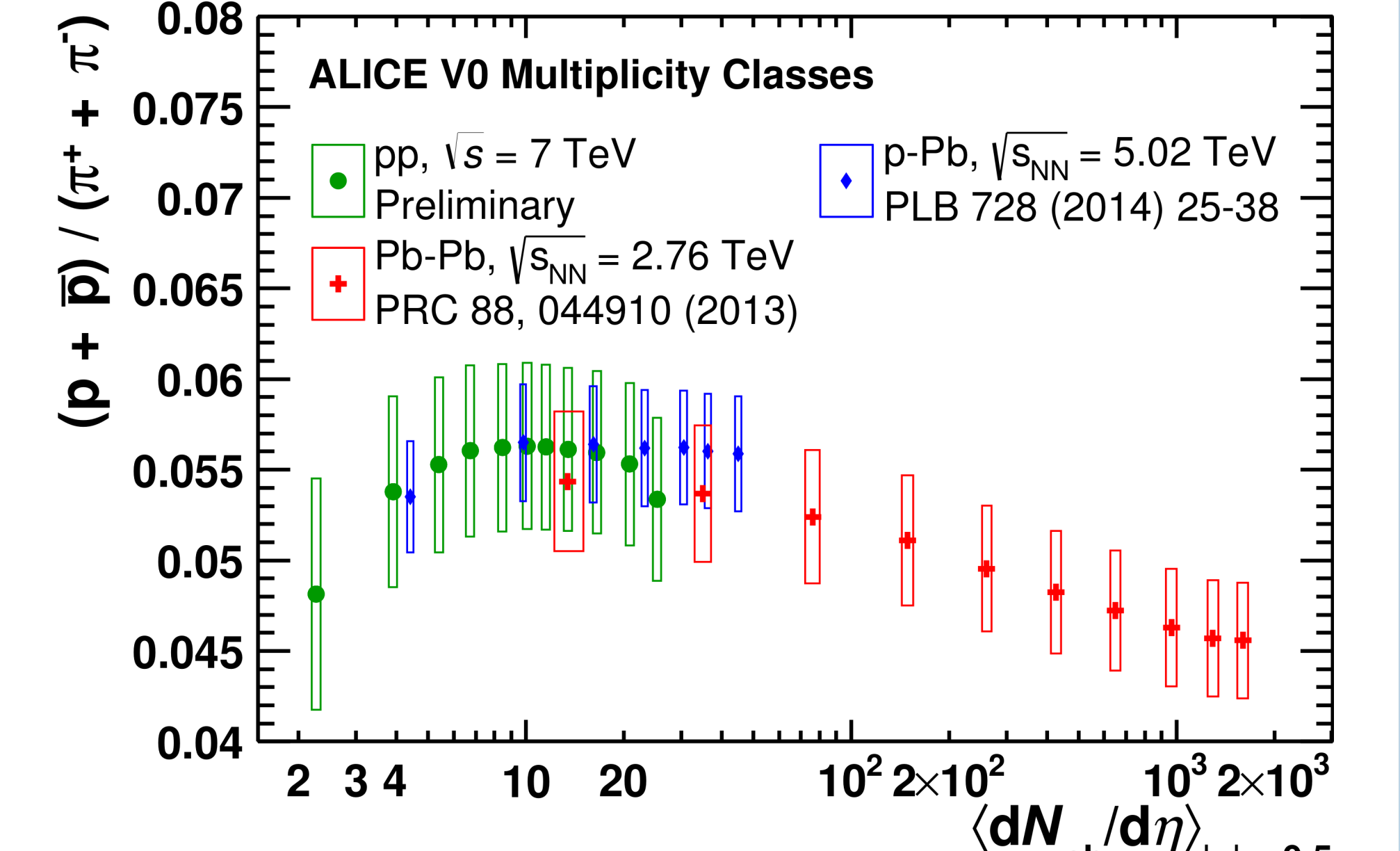
- ▶ In contrast to the  $K/\pi$  ratio, the  $p/\pi$  ratio shows a significant evolution from low to high multiplicity with a common crossing point around  $p_T \approx 1.5$  GeV/c. The same qualitative behaviour is observed in p-Pb and Pb-Pb collisions.
- ▶ The  $\langle p_T \rangle$  is seen to increase with multiplicity in a more pronounced way for heavier hadrons.
- ▶ The ratios of yields  $K/\pi$  and  $p/\pi$  in pp collisions are in good agreement with those of p-Pb and Pb-Pb.
- ▶ In summary, the identified particle production is observed to depend on multiplicity in pp, p-Pb and Pb-Pb collisions in qualitatively similar ways. These studies will help to constrain models that describe particle production in the three collision systems, especially those employing a unified approach.



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