Transverse momentum spectra of π, K and p in small collision systems: search for collective phenomena

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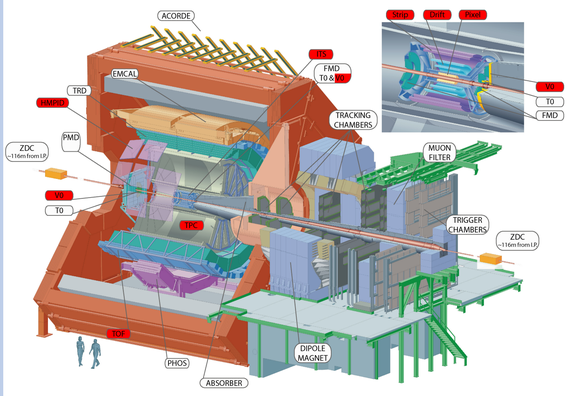
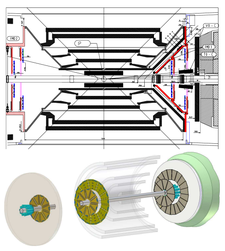
The ALICE detector



▶ VZERO detectors trigger and centrality/multiplicity



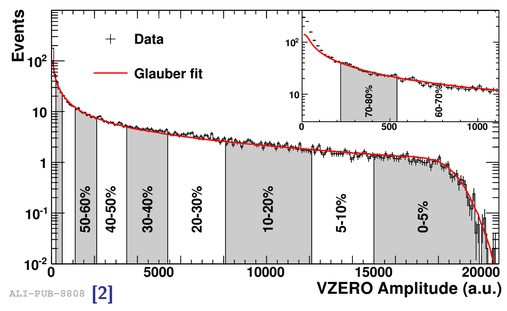
Main detectors for PID:

- ▶ Inner tracking system (ITS)
- ▶ Time projection chamber (TPC)
- ▶ Time of flight (TOF)
- ▶ High momentum PID (HMPID)

Measuring the event multiplicity

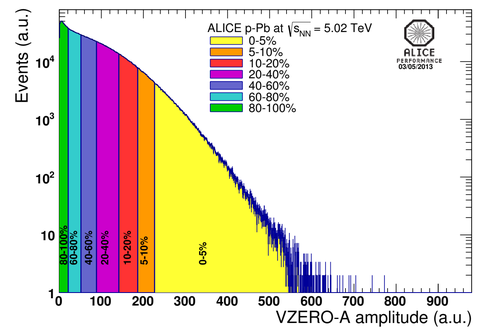
VZERO percentiles

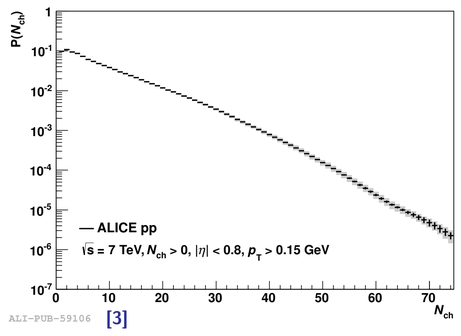
Event multiplicity at forward-rapidity obtained measuring the signal in the two V0 detectors and dividing its distribution into percentile-based classes



Counting tracks

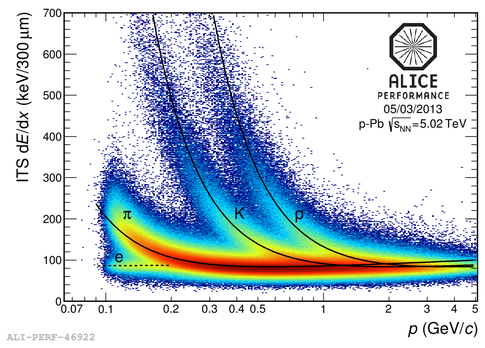
Event multiplicity at mid-rapidity ($|\eta| < 0.8$) obtained by counting tracks reconstructed in the barrel detectors and segments of tracks reconstructed with the SPD detector to increase the acceptance





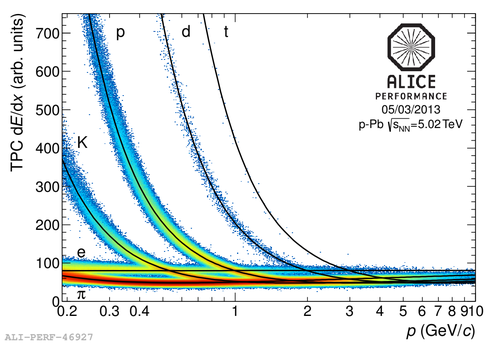
PID strategies

ITS



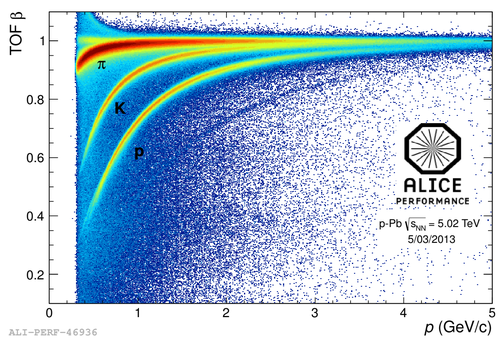
- ▶ Specific energy-loss in the ITS vs momentum
- ▶ dE/dx resolution for the ITS $\sim 10\%$ (p–Pb)

TPC



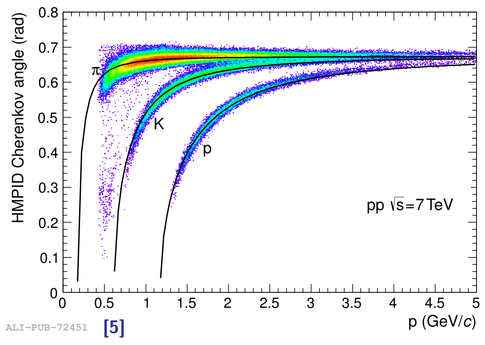
- ▶ Specific energy-loss in the TPC vs momentum
- ▶ dE/dx resolution for the TPC $\sim 5\%$ (p–Pb)

TOF



- ▶ Particle velocity β measured by TOF vs momentum
- ▶ TOF time resolution $\sim 85 - 120$ ps depending on multiplicity (p–Pb)

HMPID



- ▶ Mean Cherenkov angle vs momentum
- ▶ 3σ separation for π-K for $p_T < 3\ GeV/c$
- ▶ 3σ separation for p-K for $p_T < 5\ GeV/c$

Results

Spectra in pp

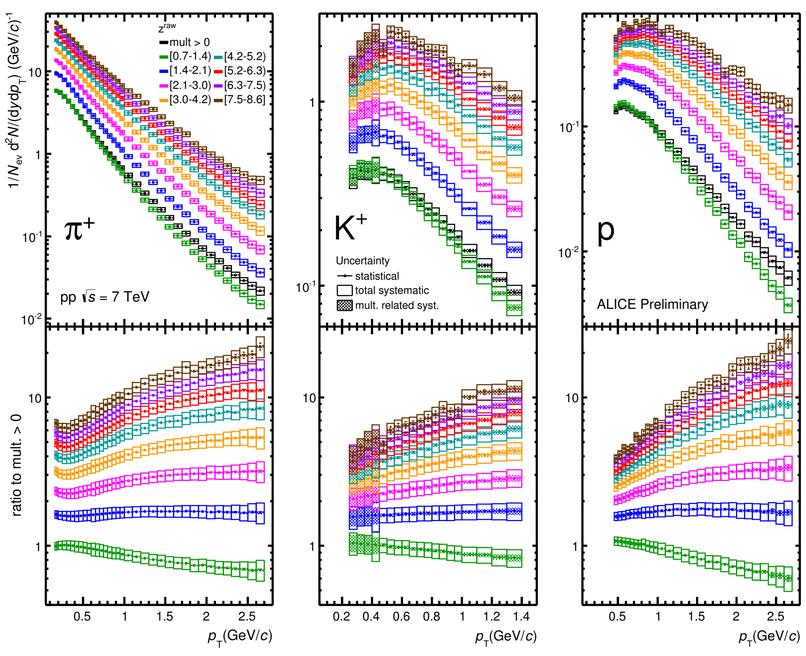
The multiplicity in pp can be quantified by the ratio:

$$z^{raw} = \frac{(N_{ch}^{raw})_{limit}}{\langle N_{ch}^{raw} \rangle_{mult>0}}$$

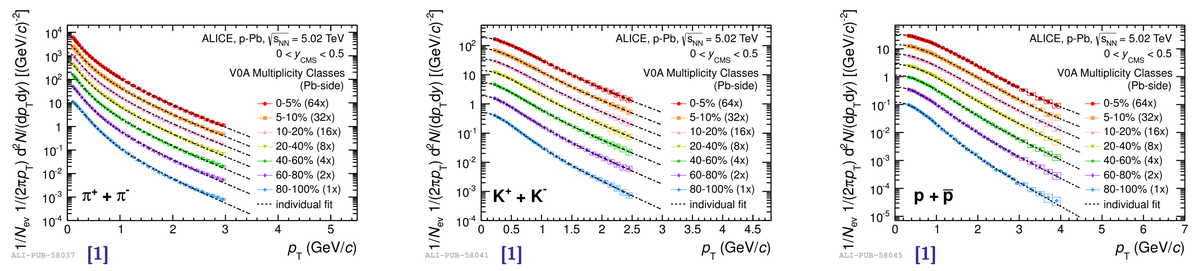
$$\langle N_{ch}^{raw} \rangle = 9.6, \ |\eta| < 0.8$$

N_{ch}^{raw}	z^{raw}
7-12	0.7-1.3
13-19	1.4-2.0
20-28	2.1-2.9
29-39	3.0-4.1
40-49	4.2-5.1
50-59	5.2-6.2
60-71	6.3-7.4
72-82	7.5-8.6

- ▶ Multiplicity dependence of the spectral shape
  - ▶ Spectra become progressively harder as a function of multiplicity and particle mass
  - → Mass ordering as expected from hydrodynamics

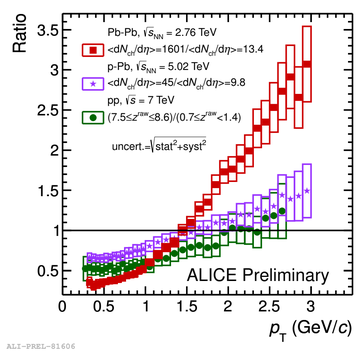


Spectra in p–Pb



Spectra evolution with multiplicity in p–Pb: shown to exhibit behaviour that is qualitatively similar to both pp and Pb–Pb

Particle ratios



$$(p/\pi)_{high\ multiplicity} / (p/\pi)_{low\ multiplicity}$$

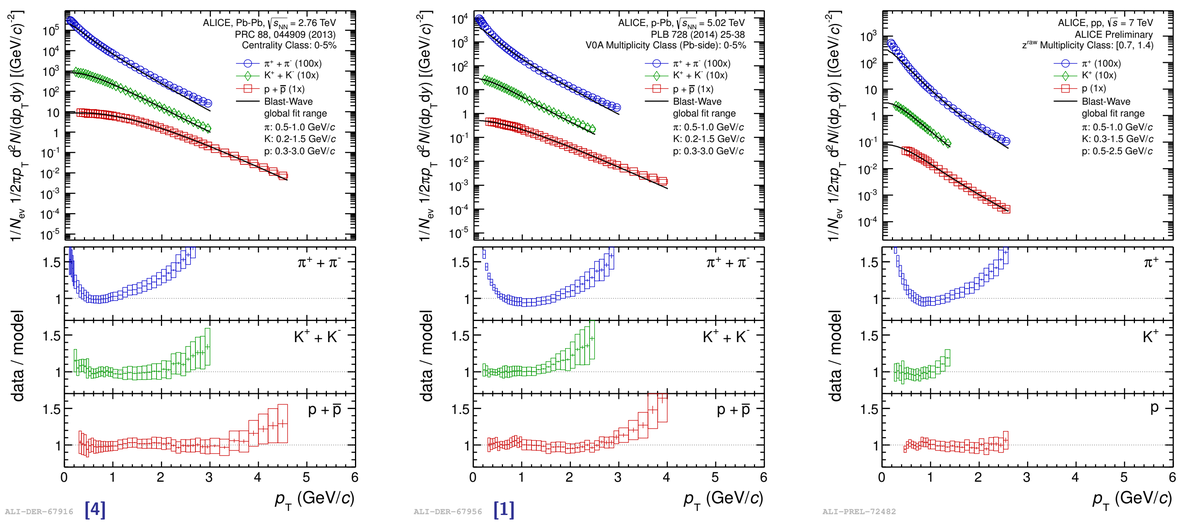
- ▶ Heavier particles have larger p_T for all the colliding systems
  - ▶ Same trend for pp and p–Pb
  - ▶ Higher increase in Pb–Pb

The Blast-Wave fits

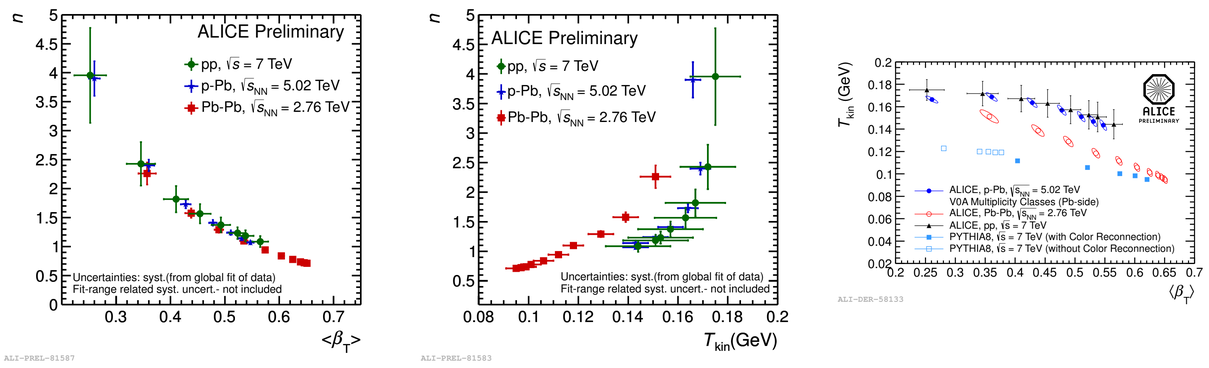
The blast-wave model is a simplified hydro model with the following functional form:

$$E\frac{d^3N}{dp^3} \sim f(p_t) = \int_0^R m_T K_1(m_T \cosh\rho / T_{fo}) I_0(p_T \sinh\rho) r dr$$

$$m_T = \sqrt{m^2 + p_T^2} \qquad \beta_r(r) = \beta_s (r/R)^n \qquad \rho = tanh^{-1}\beta_r$$



Results from BW fits



- ▶ $n - \langle\beta_t\rangle$ correlations, similar for pp, p–Pb and Pb–Pb
  - ▶ Higher multiplicity at higher $\langle\beta_t\rangle$
- ▶ $n - T_{kin}$ correlations, similar for pp and p–Pb. Pb–Pb has lower values
  - ▶ Higher multiplicity at lower T_{kin}
- ▶ Similar trends in pp and p–Pb
  - ▶ PYTHIA with CR reproduces the trend
  - ▶ Higher multiplicity at higher $\langle\beta_t\rangle$

Summary and conclusions

- ▶ π, K and p spectra measured in pp collisions at 7 TeV and p–Pb collisions at 5.02 TeV are presented
- ▶ The comparison of pp, p–Pb and Pb–Pb shows similarities for the three systems as a function of multiplicity
- ▶ Similar trends are observed for the three colliding systems and hint at collective effects in p–Pb and pp
- ▶ Serves as input for further theoretical investigation of the phenomena seen at the LHC

References

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