Charged-particle production as a function of multiplicity from small to large collision systems with ALICE at the LHC

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Motivation

- study charged particle production mechanisms and soft QCD
- alternative model descriptions:
  - interacting strings and no quark-gluon plasma (PYTHIA)
  - quark-gluon plasma / hydrodynamic flow also in small systems
- observable: correlation between transverse momentum (p_T) and multiplicity (N_{ch}) to test and tune theoretical models
- goal: provide very precise measurement with high granularity in multiplicity
- this analysis: primary charged particles, $0.15\ \mathrm{GeV}/c < p_T < 50\ \mathrm{GeV}/c$, $|\eta| < 0.8$

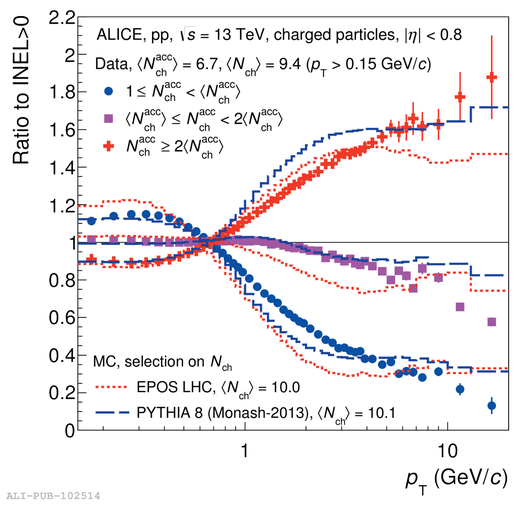


Figure 1: Ratio of p_T spectra for different multiplicity classes compared to INEL > 0 spectrum [1].

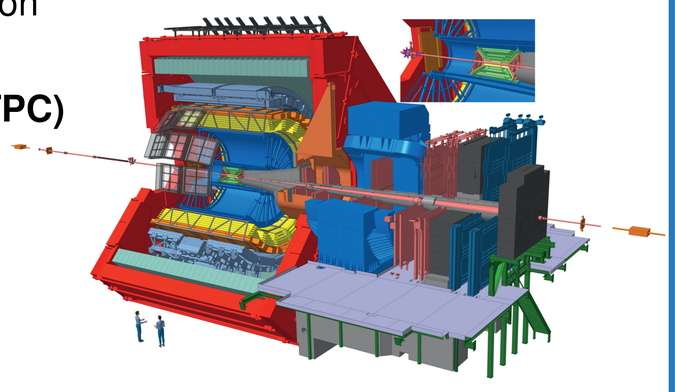
ALICE

- heavy-ion experiment dedicated to study properties of quark-gluon plasma
- data for variety of collision systems and energies collected in LHC Run 1 & 2

Inner Tracking System (ITS)
- primary vertex reconstruction
- pileup rejection

Time Projection Chamber (TPC)
- main tracking detector
- particle identification

V0 system
- triggering
- centrality determination



Analysis

- correlation between p_T and N_{ch} smeared in the experiment
- measured multiplicity affected by detector efficiency and contamination with secondary particles: $N_{ch} \rightarrow N_{acc}$
- measured p_T smeared as result of detector resolution
- experimental observable: p_T spectra as function of N_{acc}
- particles from events of different N_{ch} contribute to same N_{acc}
- N_{ch} vs. p_T correlation reconstructed via sequential 2D-unfolding based on iterative deconvolution procedure [2]

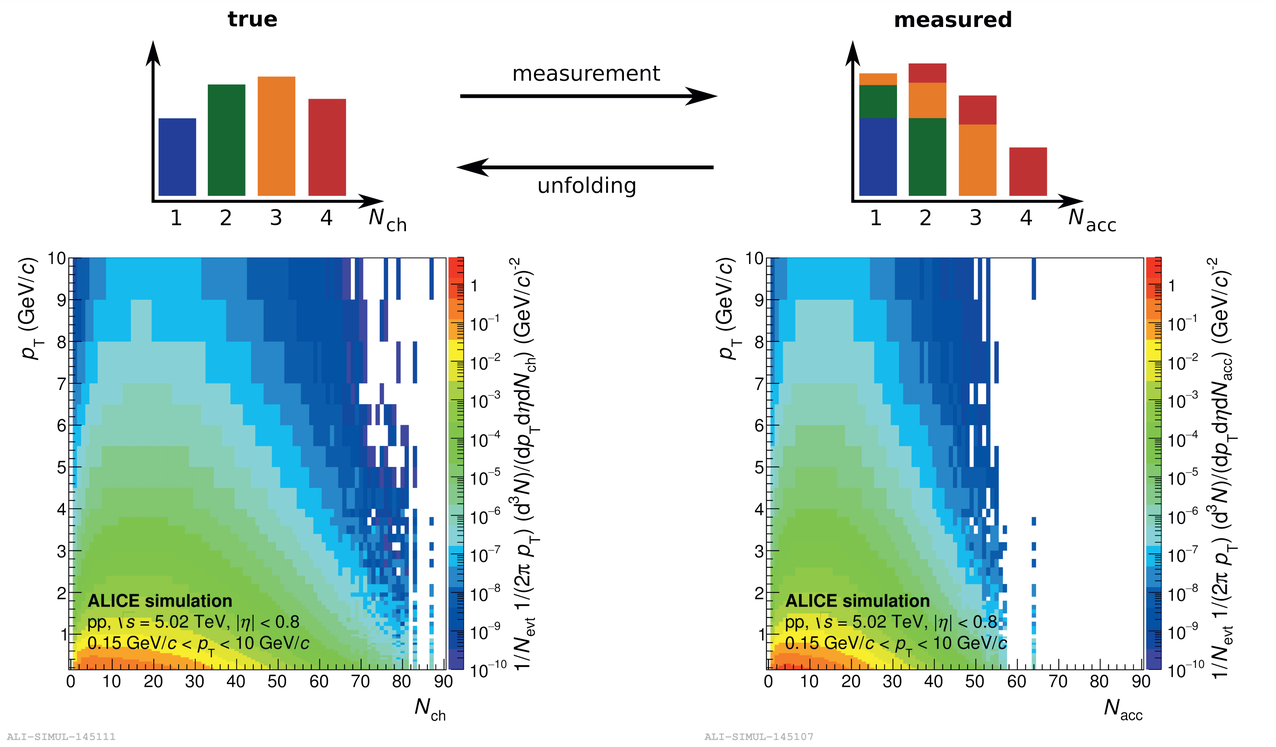


Figure 2: Transverse-momentum spectra of inclusive charged particles as function of the measured multiplicity N_{acc} (left) and as function of the true multiplicity N_{ch} (right).

Multiplicity distributions

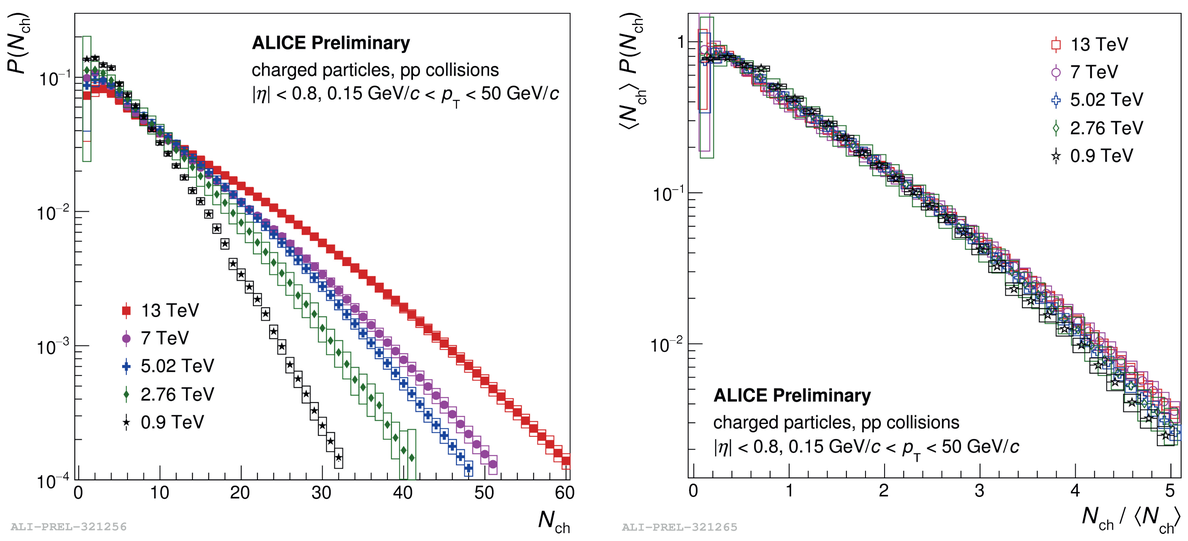


Figure 3: Unfolded multiplicity distributions (left) and their KNO-scaling form (right) for pp collisions at various centre-of-mass energies.

- energy ordering of unfolded multiplicity distributions
- KNO-scaled distributions allign for all LHC energies → similar production mechanisms

Spectral shapes

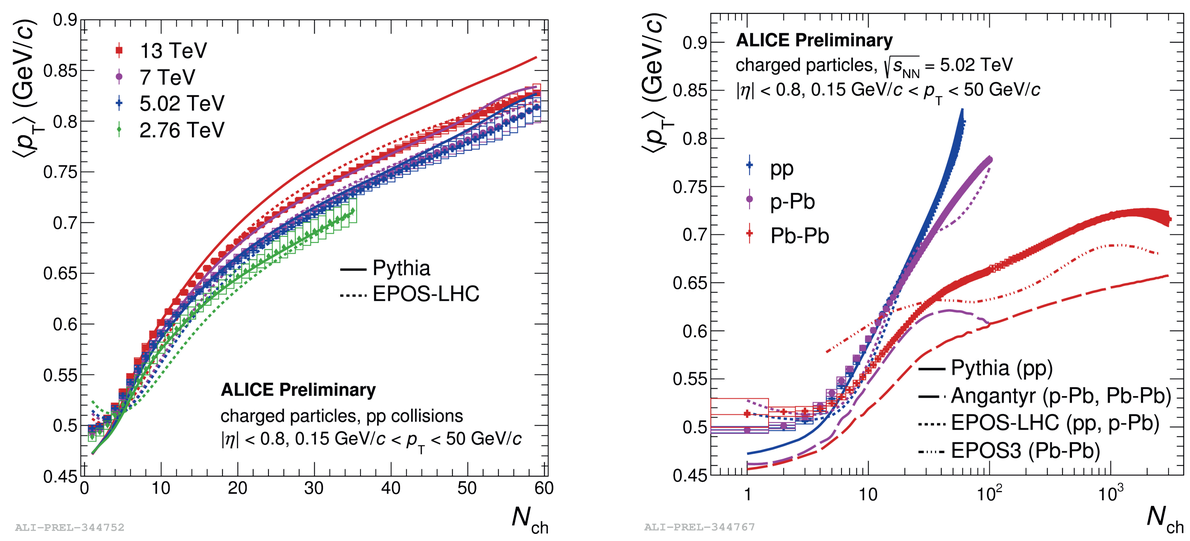


Figure 4: $\langle p_T \rangle$ vs. N_{ch} of unfolded transverse-momentum spectra for pp collisions at different energies (left) and for pp, p–Pb and Pb–Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV compared to model predictions.

- good model description of $\langle p_T \rangle$ vs N_{ch} in pp collisions
- still challenging to reproduce trend for larger collision systems → measurement can help to test and tune models

[1] ALICE Collaboration, Pseudorapidity and transverse-momentum distributions of charged particles in proton-proton collisions at $\sqrt{s} = 13$ TeV, Phys. Lett. B 753 (2016) 319-329.
[2] G. D'Agostini, A multidimensional unfolding method based on Bayes' theorem, Nucl. Instr. Meth. Phys. Res. A 362 (1995) 487-498.

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