Particle production as a function of system size and underlying-event activity measured with ALICE at the LHC

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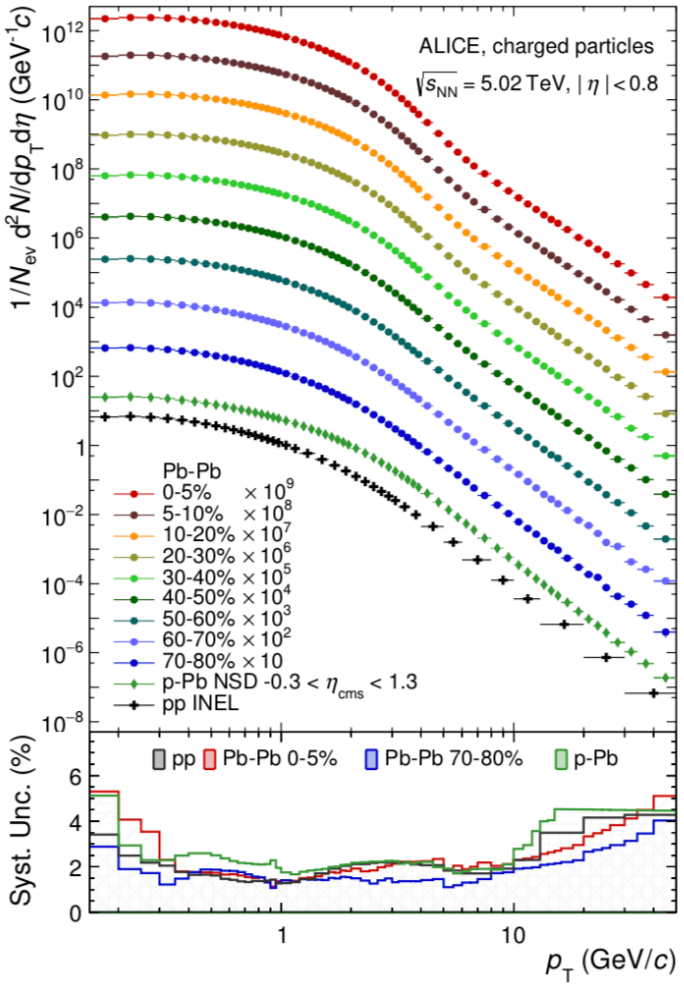
ALICE

Particle Production at the LHC

- ALICE experiment:

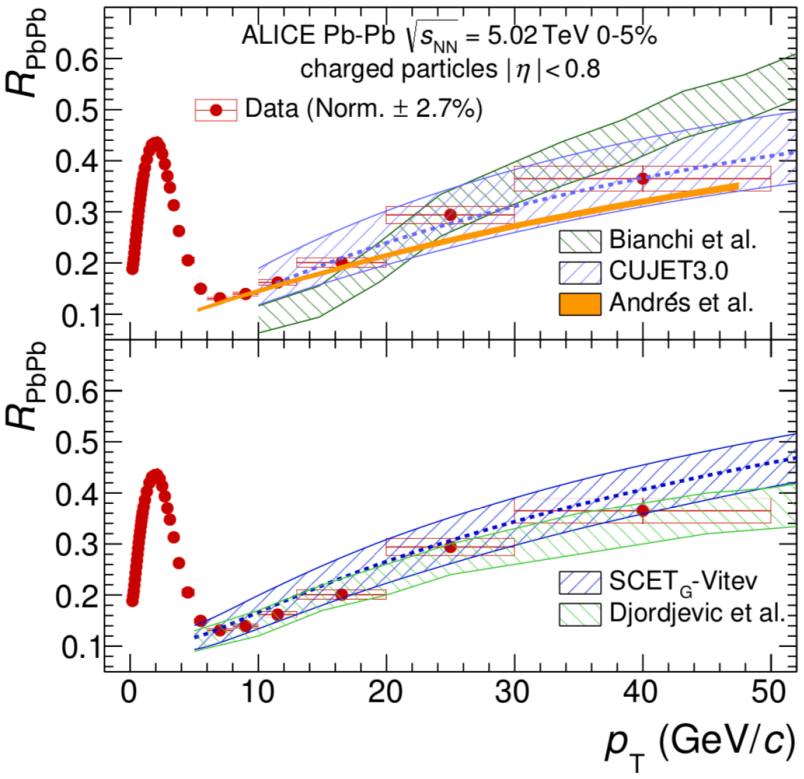
  study of properties of QGP



J. High Energ. Phys. (2018) 2018: 13

Particle Production at the LHC

- ALICE experiment:
  study of properties of QGP
- pp serves as baseline measurement
  for Pb-Pb to eg. study parton energy loss in deconfined medium (R_{AA})
- high transverse momentum particle production accessible via pQCD
- bulk particle production governed by soft QCD processes
  → non-pertubative phenomenology needed



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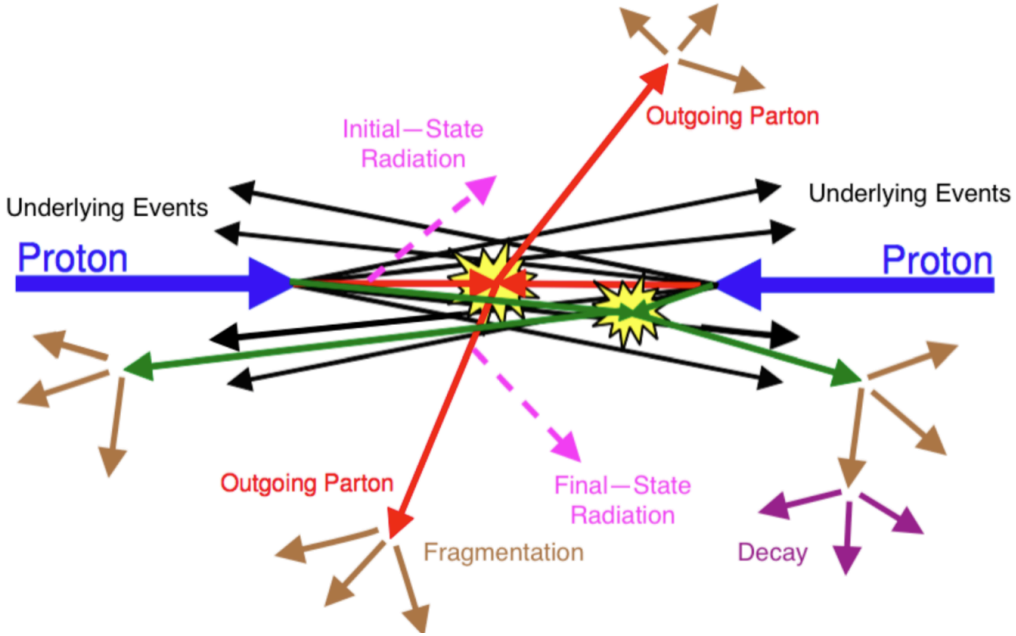
Particle Production at the LHC



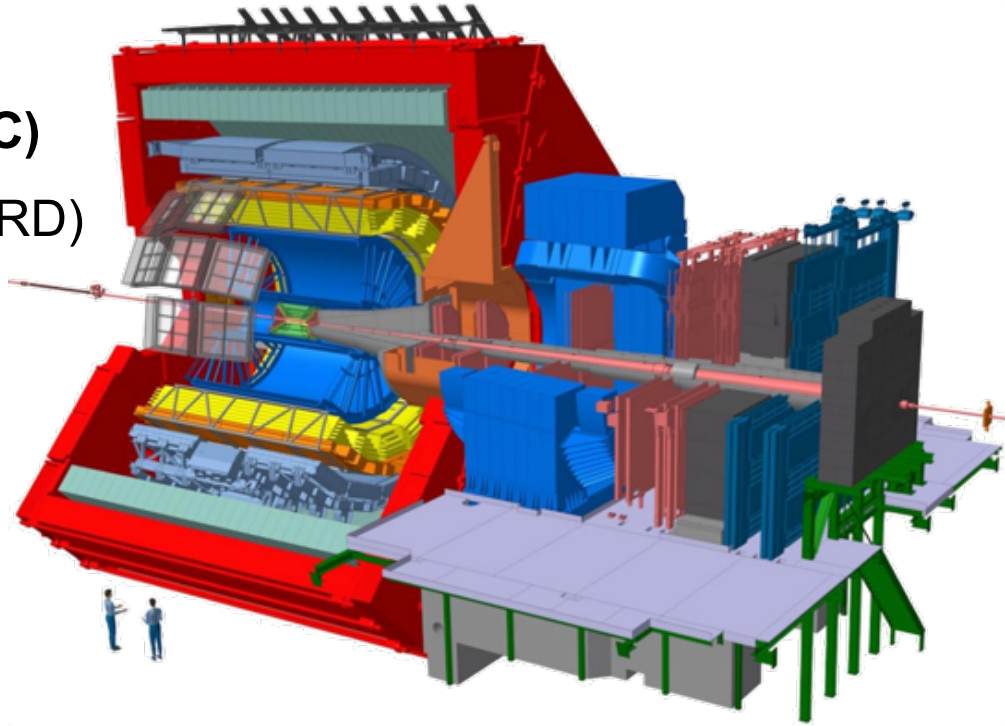
Adapted from Eur.Phys.J. C62 (2009) 237-242

- sensitive observable: transverse-momentum spectra vs. particle multiplicity per event

- underlying event (UE): particles not originating from hardest initial scattering
- multi-parton-interactions (MPI)
- color reconnection (CR)
- semi-hard and soft physics

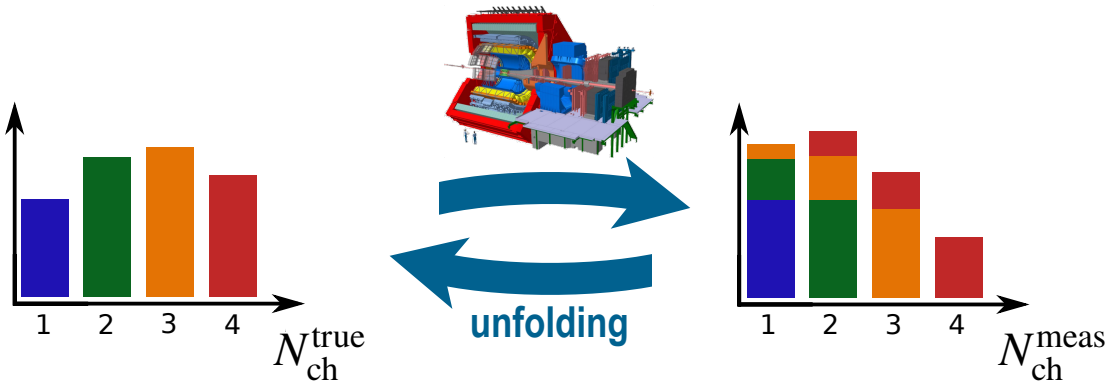
ALICE

- ALICE detectors:
  - **Inner Tracking System (ITS)**
  - **Time Projection Chamber (TPC)**
  - Transition Radiation Detector (TRD)
  - Time of Flight Detector (TOF)
  - **V0 detector (V0A and V0C)**
- primary charged particles
  - p_T < 0.15 GeV/c
  - $|\eta|$ < 0.8



$$p_{\mathrm{T}}^{\mathrm{meas}} \text{ vs. } N_{\mathrm{ch}}^{\mathrm{meas}}$$

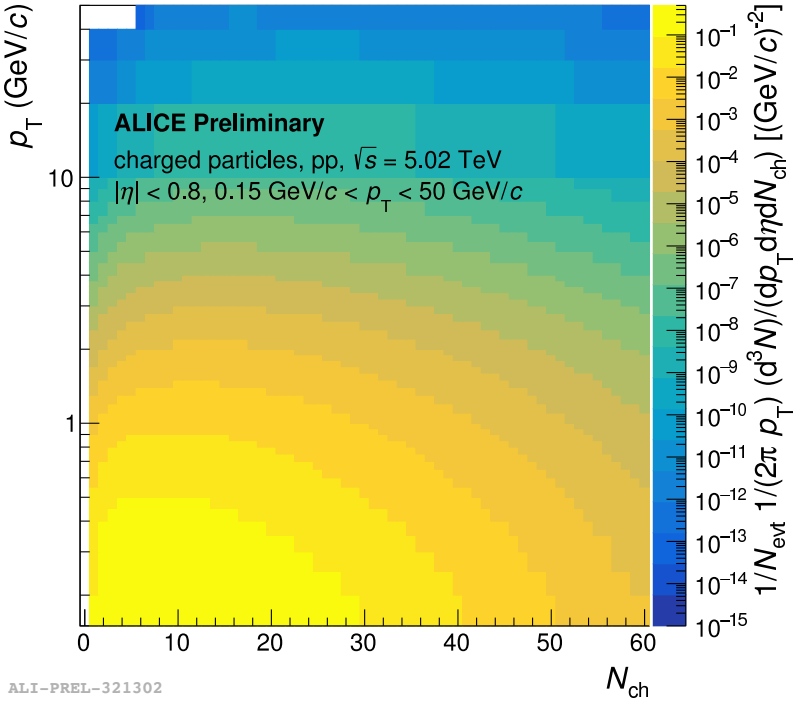
p_T Spectra vs. Multiplicity



- measured multiplicity and p_T smeared due to detector effects (efficiency, resolution)
- 2d unfolding procedure recovers true correlation between p_T and N_{ch}
- result:

  p_T spectra in multiplicity intervals

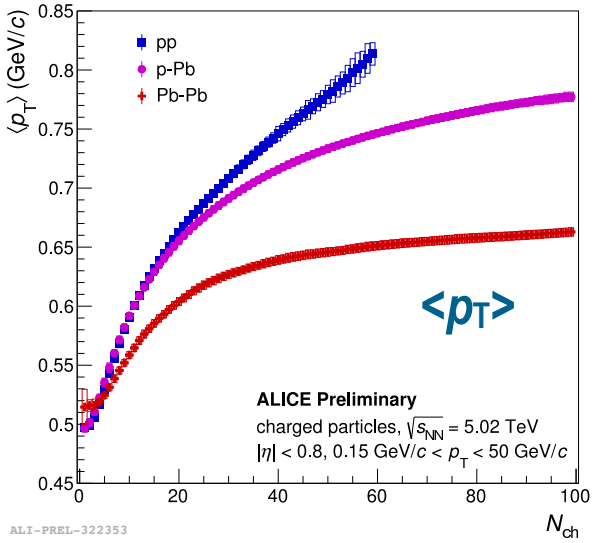
  → best possible resolution for $\Delta N_{ch} = 1$

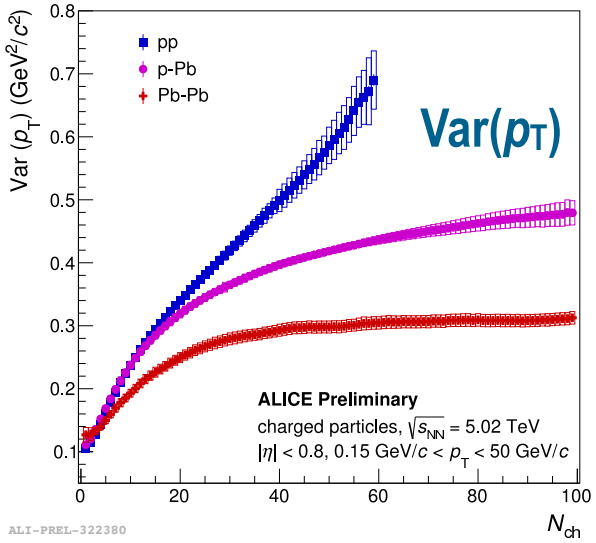


System Size Dependence

- <p_T> and variance defining shape of p_T-spectra
- comparison of shape at same collision energy and charged-particle multiplicity
- clear hierarchy of the systems
  - pp: strong N_{ch} dependence
  - Pb-Pb: weaker N_{ch} dependence
    re-scattering effects?
  - p-Pb: in between

$$N_{ch} < 100$$





System Size Dependence

- <p_T> and variance defining shape of p_T-spectra
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- clear hierarchy of the systems
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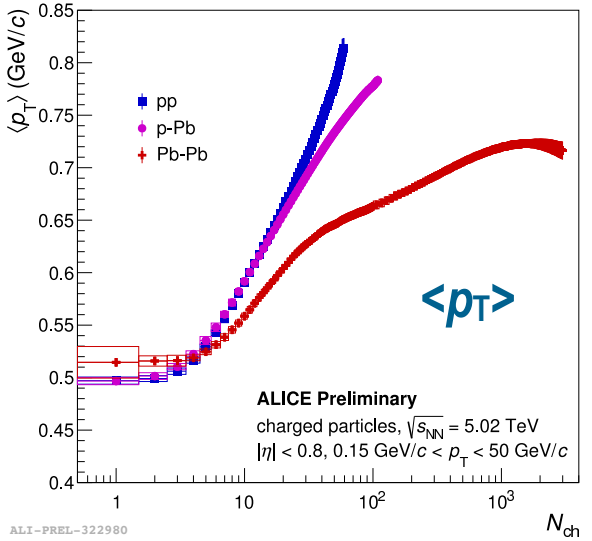
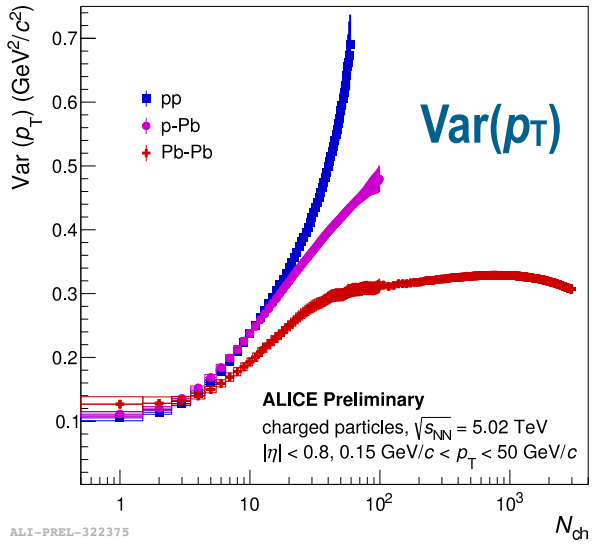
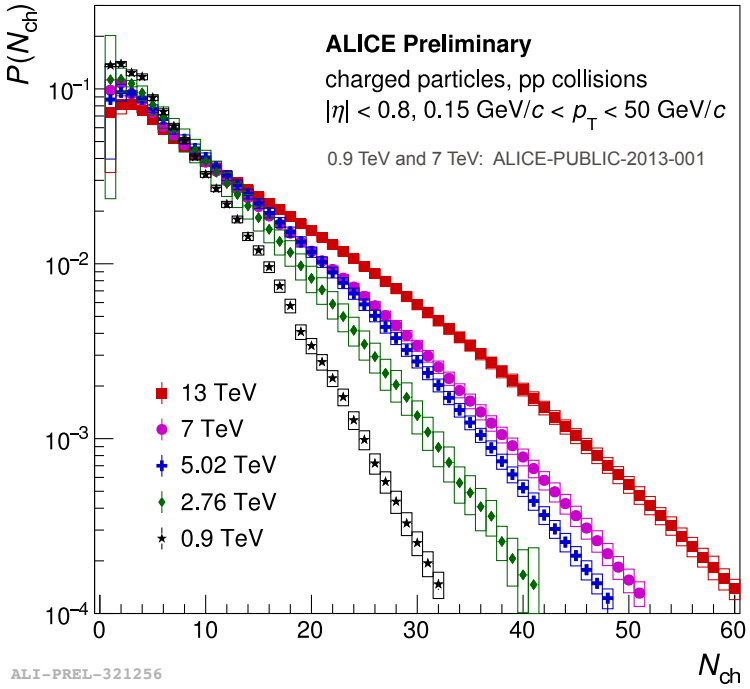
  - p-Pb: in between

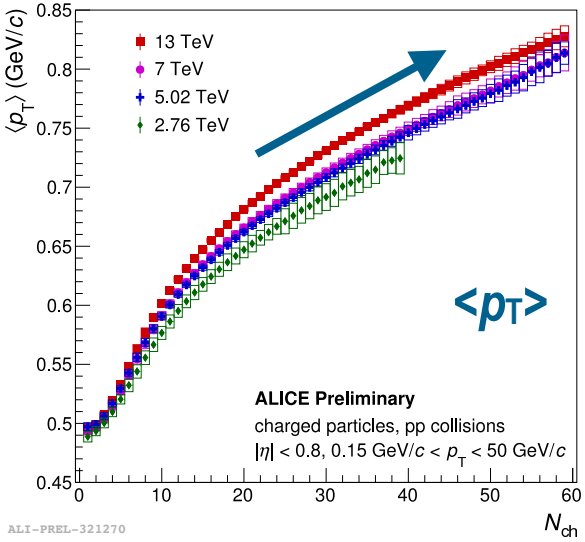
$$N_{ch} < 3000$$

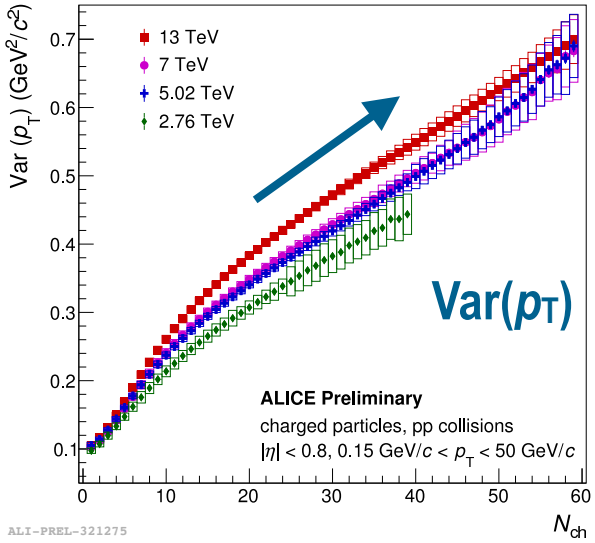




Energy dependence in pp

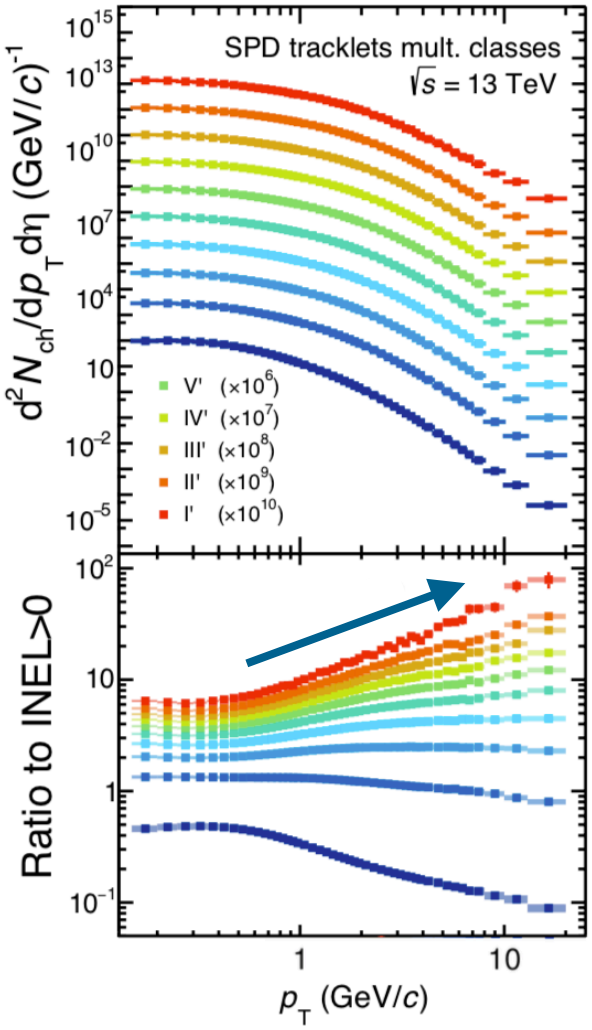






- multiplicity density for large variety of energies
- clear ordering with energy
- spectra become harder and broader with multiplicity

Multiplicity dependence of p_T Spectra



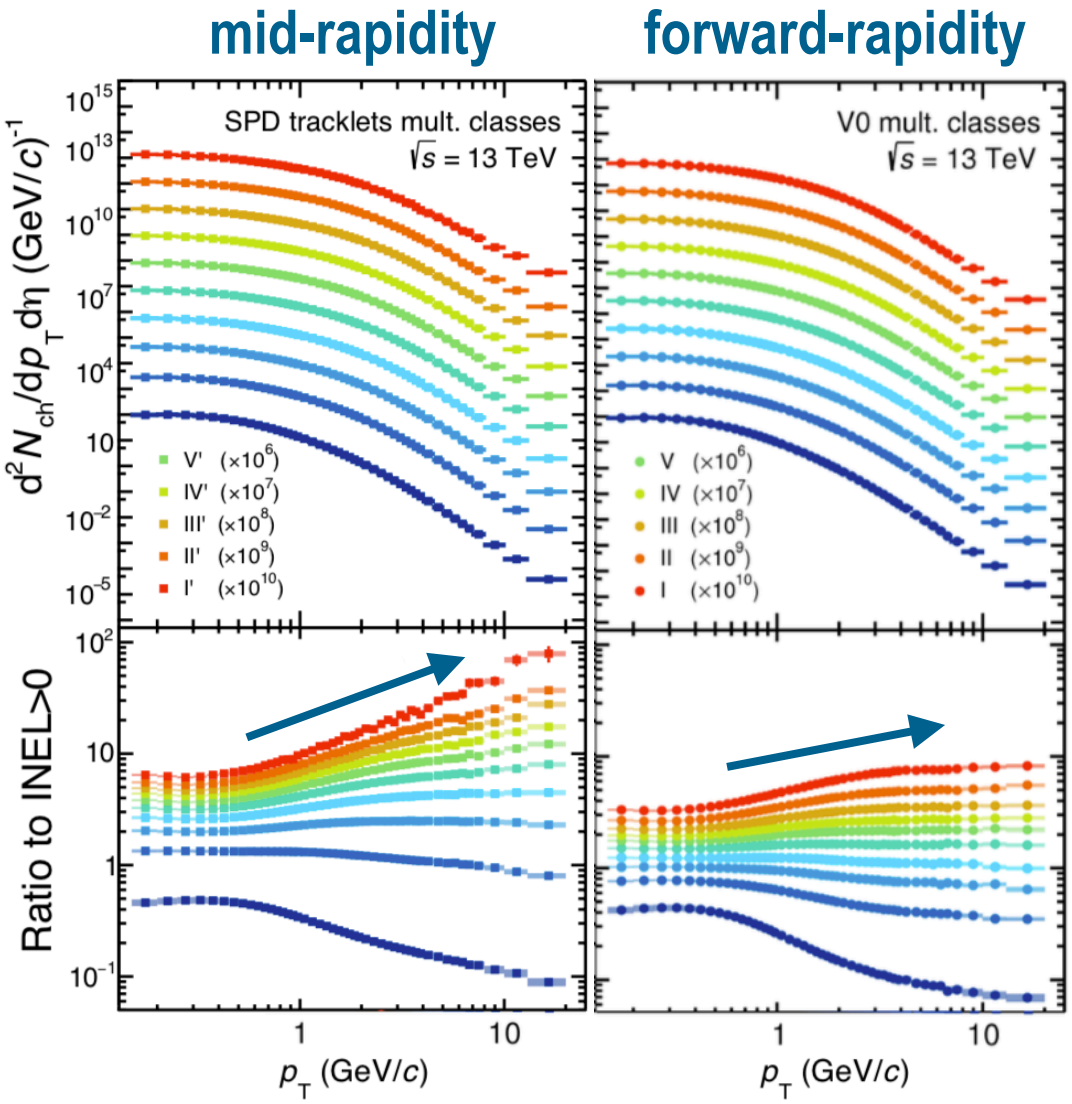
$\langle dN_{ch}/d\eta \rangle = 54.1$

$\langle dN_{ch}/d\eta \rangle = 2.91$

- increase of high p_T particle production with multiplicity
- do jets bias the selection?

arXiv:1905.07208

Multiplicity dependence of p_T Spectra



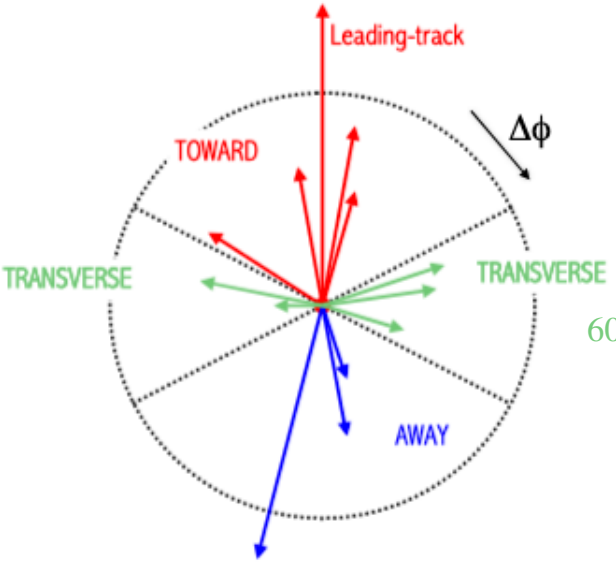
- increase of high p_T particle production with multiplicity
- do jets bias the selection?
- multiplicity selection at forward-rapidity: effect less pronounced
- can we define a jet-free multiplicity estimator?

arXiv:1905.07208

Multiplicity selection in the underlying event

- activity in the underlying event can be quantified via transverse activity classifier:

$$R_{\mathrm{T}} = \frac{N_{\mathrm{ch,T}}}{\langle N_{\mathrm{ch,T}} \rangle}$$

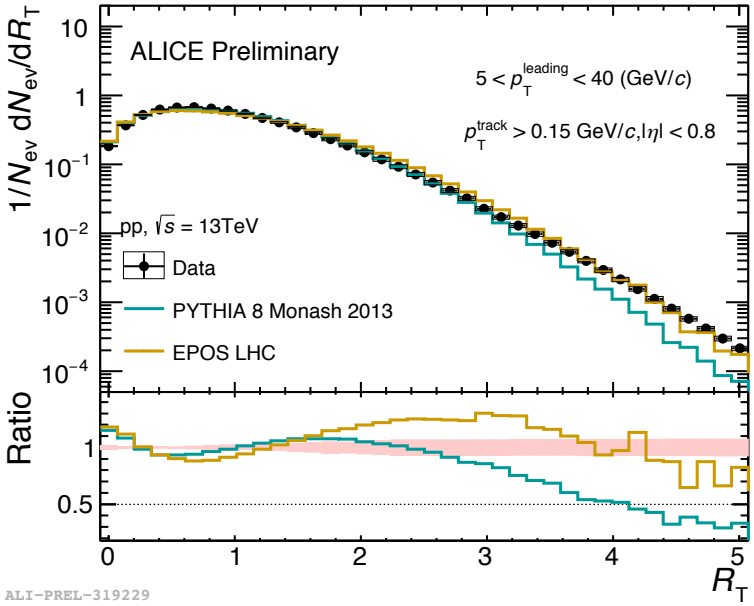


$|\Delta\phi| < 60°$

$60° < |\Delta\phi| < 120°$

$|\Delta\phi| > 120°$

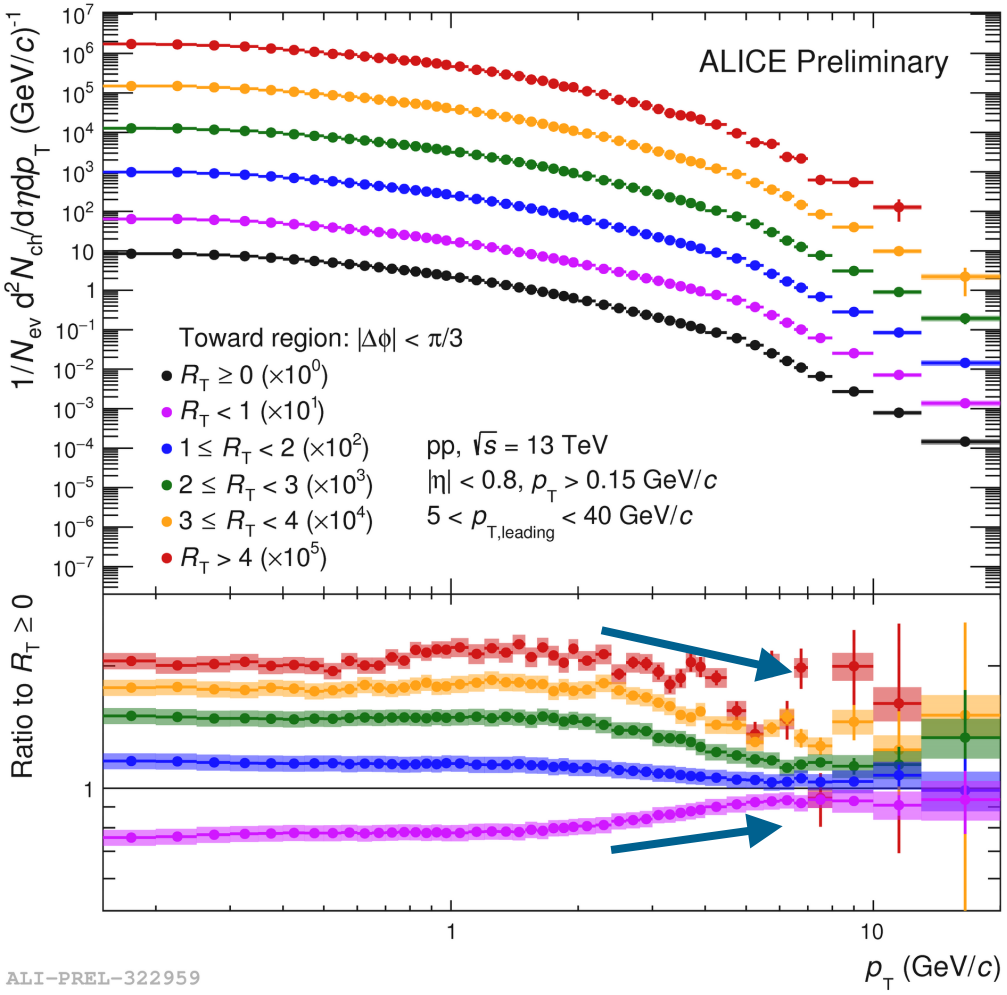
J. High Energ. Phys. (2012) 2012: 116



→ use as multiplicity estimator for p_{T} spectra in regions towards and transverse to the jet

Multiplicity selection in the underlying event

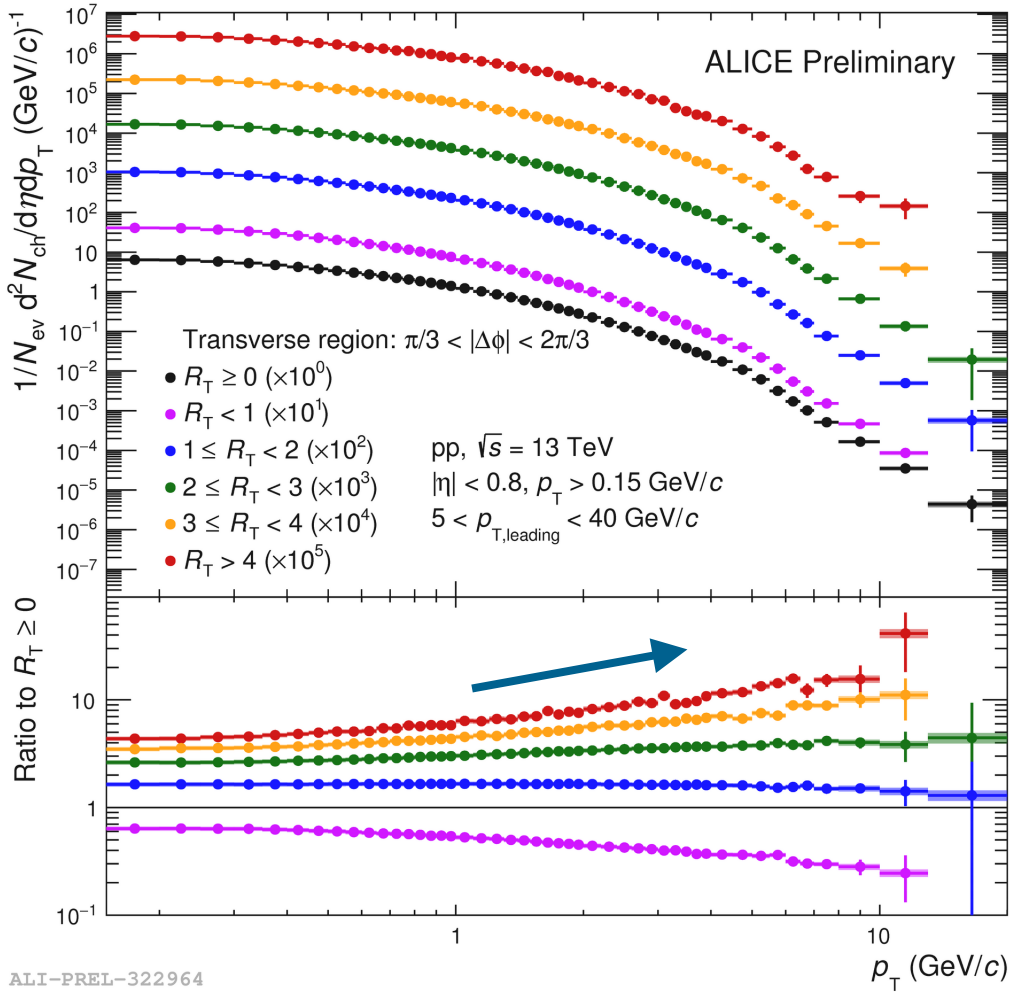
spectra in region towards jet



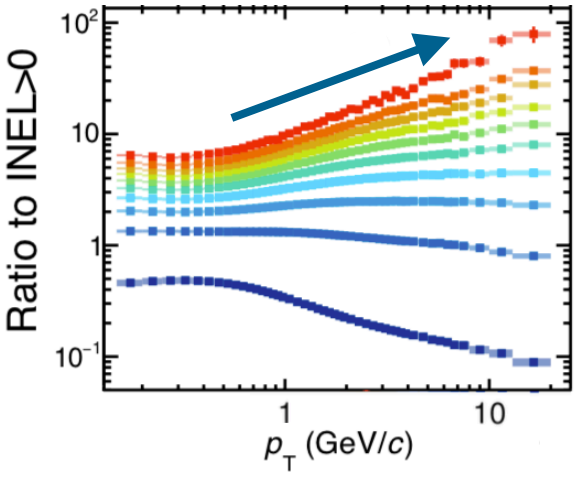
- high p_T:
  - convergence with p_T to the jet spectrum
  - spectra hardly depend on UE activity
  - good separation between soft and hard particle production

Multiplicity selection in the underlying event

spectra in region transverse to jet



- jet **excluded** in spectra and multiplicity estimator
- hardening of spectra with R_T in the underlying event
- similar to results including the jet



Summary

- high-precision measurements of p_T spectra vs. multiplicity for variety of energies and different collision systems
- along the jet axis, soft and hard particle production mechanisms separated at high p_T
- spectra in area transverse to the jet show same pattern of hardening as mid-rapidity minimum bias results